Agilent Technologies

Advanced Design System 2011.01

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Mobile WiMAX Design Library

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The following third-party libraries are used by the NlogN Momentum solver:

"This program includes Metis 4.0, Copyright © 1998, Regents of the University of Minnesota", http://www.cs.umn.edu/~metis , METIS was written by George Karypis (karypis@cs.umn.edu).

Intel@ Math Kernel Library, http://www.intel.com/software/products/mkl

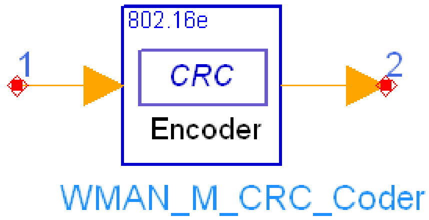
Errata The ADS product may contain references to "HP" or "HPEESOF" such as in file names and directory names. The business entity formerly known as "HP EEsof" is now part of Agilent Technologies and is known as "Agilent EEsof". To avoid broken functionality and to maintain backward compatibility for our customers, we did not change all the names and labels that contain "HP" or "HPEESOF" references.

802.16e OFDMA Channel Coding Components

The 16e channel coding models provide channel coding and scrambling in the transmitter end, and channel decoding in the receiving end.

- *WMAN M CRC Coder (802.16e OFDMA CRC Coder)* (wman_m)
- *WMAN M DL CC (802.16e OFDMA DL Convolutional Coding)* (wman_m)
- *WMAN M DL CC Decoder (802.16e OFDMA DL CC Decoding)* (wman_m)
- *WMAN M DL CTC (802.16e OFDMA DL Convolutional Turbo Coding)* (wman_m)
- *WMAN M DL CTC Decoder (802.16e OFDMA Downlink CTC Decoder)* (wman_m)
- *WMAN M DL Deinterleaver (802.16e OFDMA DL Deinterleaver)* (wman_m)
- *WMAN M DL Derandomizer (802.16e OFDMA Downlink Derandomizer)* (wman_m)
- *WMAN M DL FEC (802.16e OFDMA DL Forward Error Coding)* (wman_m)
- *WMAN M DL FECDecoder (802.16e OFDMA DL Forward Error Decoding)* (wman_m)
- *WMAN M DL Interleaver (802.16e OFDMA Downlink Interleaver)* (wman_m)
- *WMAN M DL Randomizer (802.16e OFDMA Downlink Randomizer)* (wman_m)
- *WMAN M DL Repetition (802.16e OFDMA Downlink Repetition)* (wman_m)
- *WMAN M DL SubcarrRandomizer (802.16e OFDMA DL Subcarr Randomizer)* (wman_m)
- *WMAN M Puncturer (802.16e OFDMA Puncturer and Depuncturer)* (wman_m)
- *WMAN M UL CC (802.16e OFDMA UL Convolutional Coding)* (wman_m)
- *WMAN M UL CC Decoder (802.16e OFDMA UL CC Decoding)* (wman_m)
- *WMAN M UL CTC (802.16e OFDMA UL Convolutional Turbo Coding)* (wman_m)
- *WMAN M UL CTC Decoder (802.16e OFDMA Uplink CTC Decoder)* (wman_m)
- *WMAN M UL Deinterleaver (802.16e OFDMA UL Deinterleaver)* (wman_m)
- *WMAN M UL Derandomizer (802.16e OFDMA Uplink Derandomizer)* (wman_m)
- *WMAN M UL Derepetition (802.16e OFDMA UL Repeater Removal)* (wman_m)
- *WMAN M UL FEC (802.16e OFDMA UL Forward Error Coding)* (wman_m)
- *WMAN M UL FECDecoder (802.16e OFDMA UL Forward Error Decoding)* (wman_m)
- *WMAN M UL Interleaver (802.16e OFDMA Uplink Interleaver)* (wman_m)
- *WMAN M UL Randomizer (802.16e OFDMA Uplink Randomizer)* (wman_m)
- *WMAN M UL Repetition (802.16e OFDMA Uplink Repetition)* (wman_m)
- *WMAN M UL SubcarrRandomizer (802.16e OFDMA UL Subcarr Randomizer)* (wman_m)
- *WMAN M ViterbiDecoder (802.16e OFDMA Viterbi Decoder)* (wman_m)

WMAN_M_CRC_Coder (802.16e OFDMA CRC Coder)



Description: CRC generator
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
ParityPosition	Parity bits position: Tail, Head	Tail	enum	
ReverseData	reverse the data sequence or not: NO, YES	NO	enum	
ReverseParity	reverse the parity bits or not: NO, YES	NO	enum	
ComplementParity	complement parity bits or not: NO, YES	NO	enum	
MessageLength	input message length	172	int	[1, ∞)
CRCLength	added CRC length, Polynomial's size is equal to (CRCLength+1)	12	int	[0, 64]
InitialState	initial state of encoder, the same range as generator polynomial	0 0 0 0 0 0 0 0 0 0 0 0 0	int array	
Polynomial	generator polynomial	1 1 1 1 1 0 0 0 1 0 0 1 1	int array	

Pin Inputs

Pin	Name	Description	Signal Type
1	In	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	Out	output data	int

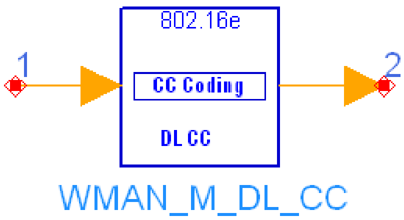
Notes/Equations

1. This model is used to add CRC bits to the input information, where the length of CRC bits can be greater than 32.
2. Each firing, (MessageLength + CRCLength) tokens are produced when MessageLength tokens are consumed. CRCLength is the length of CRC bits that is related with Polynomial, where CRCLength=Length(Polynomial)-1.
3. This mode performs the same operations as CRC_Coder. For more details, refer to CRC_Coder. The main difference is that the length of CRC bits can be greater than 32 in WMAN_M_CRC_Coder. For example, the CRC32 shall be calculated in 802.16e OFDMA using the following standard generator polynomial of degree 32:
   $G(x) = x^{32}+x^{26}+x^{23}+x^{22}+x^{16}+x^{12}+x^{11}+x^{10}+x^{8}+x^{7}+x^{5}+x^{4}+x^{2}+x+1$
   Then, Polynomial can be set to "1 0 0 0 0 0 1 0 0 1 1 0 0 0 0 0 1 0 0 0 1 1 1 0 1 1 0 1 1 0 1 1 1".

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_CC (802.16e OFDMA DL Convolutional Coding)



Description: Downlink convolutional coding
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
BurstNumOfSym	Number of symbols within burst	4	int	[1,1212]
BurstNumOfSubch	Number of subchannels within burst	1	int	[1,60]
Rate_ID	Rate ID	1	int	[0,6]
RepetitionCoding	Repetition coding	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

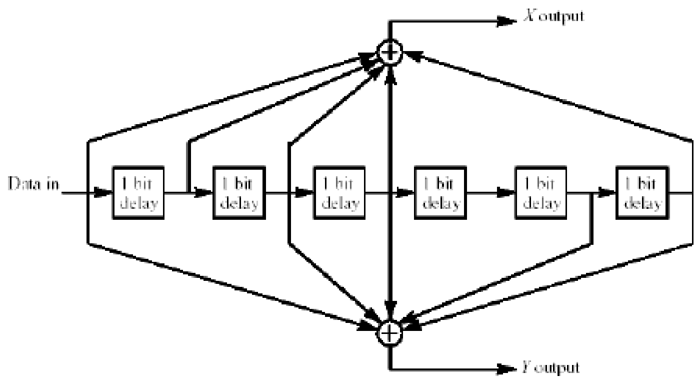
Notes/Equations

1. This model is used to perform convolutional coding on randomized data of downlink burst.
2. Each firing,
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8$ tokens are consumed at pin DataIn, where
     EffectiveSlots is the number of slots actually used to transmit data,
     i.e. EffectiveSlots = floor(AssignedSlots / R), where
     AssignedSlots is the number of slots assigned to the burst,
     R is repetition factor, which is 1, 2, 4 or 6 for QPSK and 1 for other modulation schemes,
     STCRate is the multiple due to STC encoding, which is dependent on STC_Encoder and STC_Matrix,
     UncodedSlotSize is the number of bytes within one slot before channel coding.
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8/(CodingRate)$ tokens are generated at pin DataOut, where CodingRate is coding rate.
3. Each FEC block is encoded by the binary convolutionary encoder, which shall have native rate 1/2, a constraint length equal to K = 7, and shall use the following generator polynomials codes to derive its two code bits:

   G1 = 171OCT for X

   G2 = 133OCT for Y

   The generator is depicted in the following figure.
4. The puncturing patterns and serialization order that shall be used to realize different code rates are defined in the following table. In the table, "1" means a transmitted bit and "0" denotes a removed bit, whereas X and Y are in reference to the following figure.



Convolutional Encoder of Rate 1/2

The Convolutional Code with Puncturing Configuration

Rate	1/2	2/3	3/4
dfree	10	6	5
X	1	10	101
Y	1	11	110
XY	$X_1 Y_1$	$X_1 Y_1 Y_2$	$X_1 Y_1 Y_2 Y_3$

5. The FEC block size shall depend on EffectiveSlots and modulation specified for the current transmission. Concatenation of a number of slots shall be performed in order to make larger blocks of coding where it is possible, with the limitation of not exceeding the largest supported block size for the applied modulation and coding. The following tables specify the concatenation of slots for different allocations and modulations for CC and BTC encoding scheme.

Slots Concatenation Rule for CC

Number of slots	Slots concatenated
n <= j	1 block of n slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of ceil((m+j)/2) slots
	1 block of floor((m+j)/2) slots

Encoding Slot Concatenation for Different Allocations and Modulations for CC

Modulation and rate	j
QPSK 1/2	j = 6
QPSK 3/4	j = 4
16-QAM 1/2	j = 3
16-QAM 3/4	j = 2
64-QAM 1/2	j = 2
64-QAM 2/3	j = 1
64-QAM 3/4	j = 1

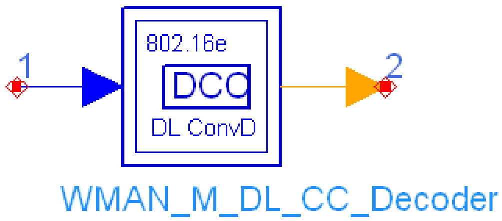
where
j: parameter dependent on the modulation and FEC rate,
n: floor(number of allocated slots/repetition factor), i.e. EffectiveSlots,
k: floor(n / j),
m: n modulo j

6. Each FEC block is encoded by a tail-biting convolutional encoder, which is achieved by initializing the encoders memory with the last data bits of the FEC block being encoded (the packet data bits numbered $b_{n-5}...b_n$).

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_CC_Decoder (802.16e OFDMA DL CC Decoding)



Description: Downlink CC decoding
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
BurstNumOfSym	Number of symbols of each burst	4	int	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	1	int	[1,60]
Rate_ID	Rate ID of each burst	1	int	[0,6]
RepetitionCoding	Repetition coding of each burst	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	

Pin Inputs

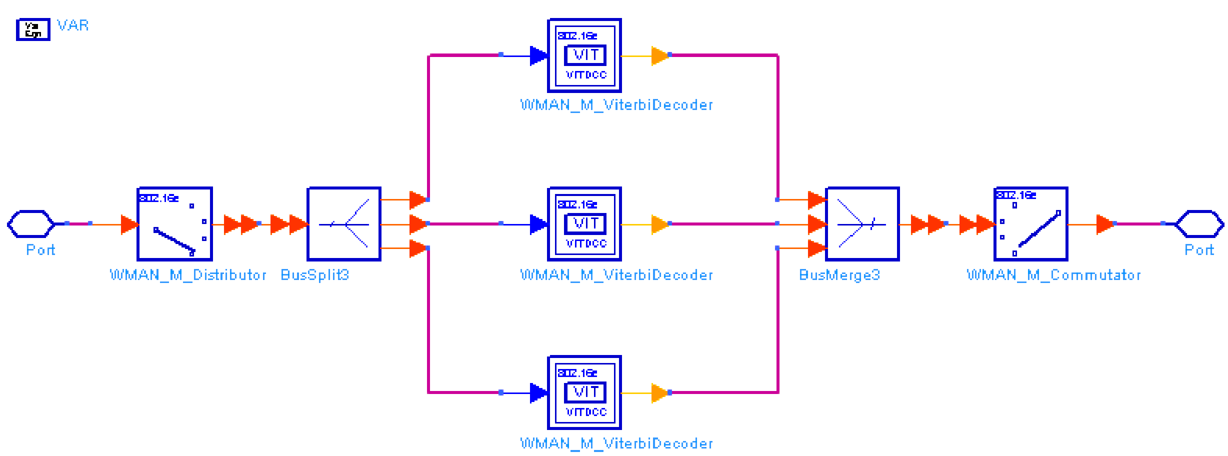
Pin	Name	Description	Signal Type
1	DataIn	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

Notes/Equations

1. This subnetwork is used to do forward error correction decoding on downlink, consisting of data distributor, convolutional decoder and data commutator.
2. The schematic of this subnetwork is shown in the following figure.



WMAN_M_DL_CC_Decoder Schematic

3. The convolutional decoder uses the viterbi decoding algorithm. The following tables specify the concatenation of slots for different allocations and modulations for CC encoding scheme.

Slots Concatenation Rule for CC

Number of slots	Slots concatenated
n <= j	1 block of n slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of ceil((m+j)/2) slots
	1 block of floor((m+j)/2) slots

Encoding Slot Concatenation for Different Allocations and Modulations for CC

Modulation and Rate	j
QPSK 1/2	j = 6
QPSK 3/4	j = 4
16-QAM 1/2	j = 3
16-QAM 3/4	j = 2
64-QAM 1/2	j = 2
64-QAM 2/3	j = 1
64-QAM 3/4	j = 1

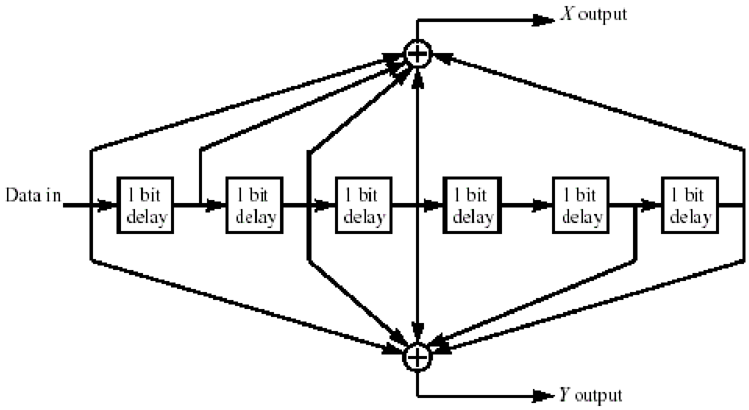
where

j: parameter dependent on the modulation and FEC rate
n: floor (number of allocated slots/repetition factor), i.e. EffectiveSlots
k: floor (n / j)
m: n modulo j

The binary convolutionary encoder, shall have native rate 1/2, a constraint length equal to K = 7, and shall use the following generator polynomials codes to derive its two code bits:

G1 = 171OCT for X
G2 = 133OCT for Y

The generator is depicted in the following figure. It's implemented by a tail-biting convolutional encoder, which is achieved by initializing the encoders memory with the last data bits of the CC block being encoded (the packet data bits numbered bn-5...bn).



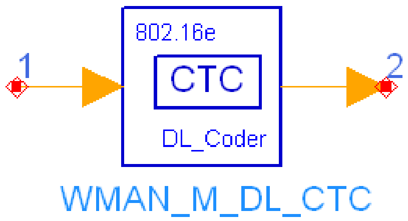
Convolutional Encoder of Rate 1/2

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4

WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_CTC (802.16e OFDMA DL Convolutional Turbo Coding)



Description: Downlink convolutional turbo coding
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
BurstNumOfSym		4	int	[1,1212]
BurstNumOfSubch		1	int	[1,60]
Rate_ID	Rate ID of each burst	1	int	[0,7]
RepetitionCoding	Preamble present	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

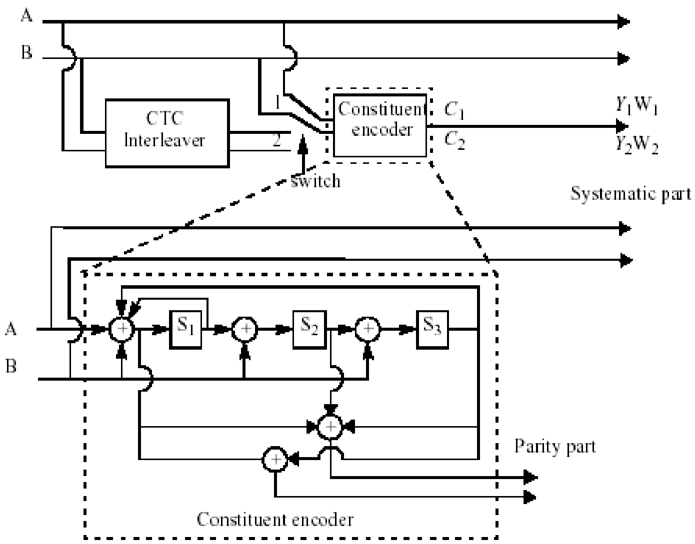
Notes/Equations

1. This model is used to perform convolutional turbo coding on randomized data on downlink.
2. Each firing,
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8$ tokens are consumed at pin DataIn, where, EffectiveSlots is the number of slots actually used to transmit data before repetition coding, i.e. EffectiveSlots = floor (AssignedSlots / R), where AssignedSlots is the number of slots assigned to the burst, For DL PUSC, $AssignedSlots = BurstNumOfSym \times BurstNumOfSubch / 2$, for DL FUSC and OFUSC, $AssignedSlots = BurstNumOfSym \times BurstNumOfSubch$, R is repetition factor, which is 1, 2, 4 or 6 for QPSK and 1 for other modulation schemes, STCRate is the multiple due to STC encoding, which is dependent on STC_Encoder and STC_Matrix, UncodedSlotSize is the number of bytes within one slot before channel coding.
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8 / CodingRate$ tokens are generated at pin DataOut, where CodingRate is shown in *Encoding Slot Concatenation for Different Rates in CTC*.
3. The CTC encoder, including its constituent encoder, is depicted in the following figure. It uses a double binary Circular Recursive Systematic Convolutional code. The bits of the data to be encoded are alternately fed to A and B, starting with the MSB of the first byte being fed to A. The encoder is fed by blocks of k bits or N couples ($k = 2 \times N$ bits). For all the frame sizes, k is a multiple of 8 and N is a multiple of 4. Further, N shall be limited to: $8 \le N/4 \le 1024$.
   The polynomials defining the connections are described in octal and symbol notations as follows:

   For the feedback branch: 0xB, equivalently 1 + D + D3 (in symbolic notation)

For the Y parity bit: 0xD, equivalently 1 + D2 + D3

For the W parity bit: 0x9, equivalently 1 + D3



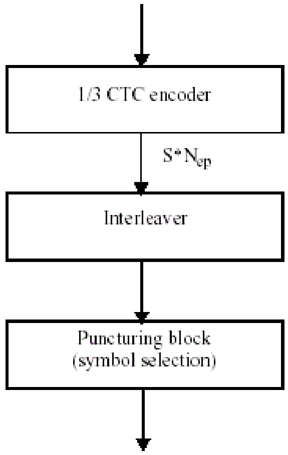
CTC Encoder

4. The state of the encoder is denoted S (!wman_m-03-05-020.gif!) with S = 4s $_1$ + 2s $_2$ + s $_3$ (see the previous figure). The circulation states Sc1 and Sc2 are determined by the following operations:
   - Initialize the encoder with state 0. Encode the sequence in the natural order for the determination of Sc $_1$ or in the interleaved order for determination of Sc $_2$. In both cases the final state of the encoder is S0 $_{N-1}$;
   - According to the length N of the sequence, use the following table to find Sc $_1$ or Sc $_2$.

Circulation State Lookup Table (Sc)

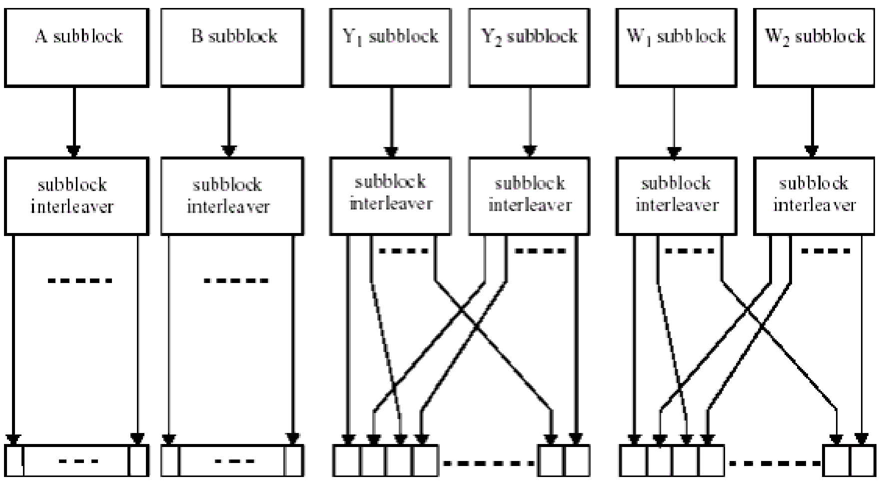
Nmod7	S0N-1							
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	0	6	4	2	7	1	3	5
2	0	3	7	4	5	6	2	1
3	0	5	3	6	2	7	1	4
4	0	4	1	5	6	2	7	3
5	0	2	5	7	1	3	4	6
6	0	7	6	1	3	4	5	2

5. The encoder (after initialization by the circulation state Sc1) is fed the sequence in the natural order (position 1) with the incremental address i = 0,... N-1. This first encoding is called C1 encoding. Then the encoder (after initialization by the circulation state Sc2) is fed by the interleaved sequence (switch in position 2) with incremental address j = 0,... N-1. This second encoding is called C2 encoding.
6. The order in which the encoded bit shall be fed into the subpacket generation block is:
   A, B, Y $_1$, Y $_2$, W $_1$, W $_2$ =A $_0$, A $_1$,..., A $_{N-1}$, B $_0$, B $_1$, ..., B $_{N-1}$, Y $_{1,0}$, Y $_{1,1}$,..., Y $_{1,N-1}$, Y $_{2,0}$, Y $_{2,1}$,..., Y $_{2,N-1}$, W $_{1,0}$, W $_{1,1}$,..., W $_{1,N-1}$, W $_{2,0}$, W $_{2,1}$,..., W $_{2,N-1}$
7. Proposed FEC structure punctures the mother codeword to generate a subpacket with various coding rates. The following figure shows a block diagram of subpacket generation. 1/3 CTC encoded codeword goes through interleaving block and the puncturing is performed.



Block Diagram of Subpacket Generation

The following figure shows block diagram of the interleaving block. The puncturing is performed to select the consecutive interleaved bit sequence that starts at any point of whole codeword. For the first transmission, the subpacket is generated to select the consecutive interleaved bit sequence that starts from the first bit of the systematic part of the mother codeword. The length of the subpacket is chosen according to the needed coding rate reflecting the channel condition. The first subpacket can also be used as a codeword with the needed coding rate for a burst where HARQ is not applied.



Block Diagram of the Interleaving Scheme

8. The FEC block size shall depend on EffectiveSlots and modulation specified for the current transmission. Concatenation of a number of slots shall be performed in order to make larger blocks of coding where it is possible, with the limitation of not exceeding the largest supported block size for the applied modulation and coding. The following table specifies the rules used for slot concatenation.

Slots Concatenation Rule for CTC

Number of Slots	Slots Concatenated
$n \le j$ n != 7	1 block of n slots
n = 7	1 block of 4 slots 1 block of 3 slots

n > *j*	If (n mod *j* = 0)
	k blocks of *j* slots
	else
	(*k*-1) blocks of *j* slots
	1 block of L_{b1} slots
	1 block of L_{b2} slots
	where
	L_{b1} = ceil((*m*+*j*)/2)
	L_{b2} = floor((*m*+*j*)/2)
	If (L_{b1} = 7) or (L_{b2} = 7)
	$L_{b1} = L_{b1} + 1$; $L_{b2} = L_{b2} + 1$

The following table specifies the concatenation of slots for different allocations and modulations.

Encoding Slot Concatenation for Different Rates in CTC

Modulation and rate	j
QPSK 1/2	10
QPSK 3/4	6
16-QAM 1/2	5
16-QAM 3/4	3
64-QAM 1/2	3
64-QAM 2/3	2
64-QAM 3/4	2
64-QAM 5/6	2

For any modulation and FEC rate, given an allocation of n slots, the following parameters are defined:

j: parameter dependent on the modulation and FEC rate
n: number of allocated slots/repetition factor
k = floor(n/j)
m = n mod j

9. The following table gives the block sizes, code rates, channel efficiency, and code parameters for the different modulation and coding schemes. As 64-QAM is optional, the codes for this modulation shall only be implemented if the modulation is implemented.

Optimal CTC Channel Coding per Modulation

Modulation	Data block size (bytes)	Encoded data block size (bytes)	Code rate	N	P0	P1	P2	P3
QPSK	6	12	1/2	24	5	0	0	0
QPSK	12	24	1/2	48	13	24	0	24
QPSK	18	36	1/2	72	11	6	0	6
QPSK	24	48	1/2	96	7	48	24	72
QPSK	30	60	1/2	120	13	60	0	60
QPSK	36	72	1/2	144	17	74	72	2
QPSK	48	96	1/2	192	11	96	48	144
QPSK	54	108	1/2	216	13	108	0	108
QPSK	60	120	1/2	240	13	120	60	180
QPSK	9	12	3/4	36	11	18	0	18
QPSK	18	24	3/4	72	11	6	0	6
QPSK	27	36	3/4	108	11	54	56	2
QPSK	36	48	3/4	144	17	74	72	2
QPSK	45	60	3/4	180	11	90	0	90
QPSK	54	72	3/4	216	13	108	0	108
16-QAM	12	24	1/2	48	13	24	0	24
16-QAM	24	48	1/2	96	7	48	24	72
16-QAM	36	72	1/2	144	17	74	72	2
16-QAM	48	96	1/2	192	11	96	48	144
16-QAM	60	120	1/2	240	13	120	60	180
16-QAM	18	24	3/4	72	11	6	0	6
16-QAM	36	48	3/4	144	17	74	72	2
16-QAM	54	72	3/4	216	13	108	0	108
64-QAM	18	36	1/2	72	11	6	0	6
64-QAM	36	72	1/2	144	17	74	72	2
64-QAM	54	108	1/2	216	13	108	0	108
64-QAM	24	36	2/3	96	7	48	24	72
64-QAM	48	72	2/3	192	11	96	48	144
64-QAM	27	36	3/4	108	11	54	56	2
64-QAM	54	72	3/4	216	13	108	0	108
64-QAM	30	36	5/6	120	13	60	0	60
64-QAM	60	72	5/6	240	13	120	60	180

10. The interleaver requires the parameters P0, P1, P2 and P3, shown in the previous table. The two-step interleaver shall be performed by:

    Step 1: Switch alternate couples
    for j = 0,... N-1
    if (j mod 2==1) let (B,A) = (A,B) (i.e., switch the couple)

    Step 2: Pi(j)
    The function Pi(j) provides the interleaved address i of the consider couple j. (i.e. InterleavedVec(j) = OriginalVec(Pi(j))).
    for j = 0,... N-1
    switch j mod 4:
    case 0: $i = (P_0 \times j + 1) mod(N)$
    case 1: $i = (P_0 \times j + 1 + N/2 + P_1) mod(N)$
    case 2: $i = (P_0 \times j + 1 + P_2) mod(N)$
    case 3: $i = (P_0 \times j + 1 + N/2 + P_3) mod(N)$
11. All of the encoded symbols shall be demultiplexed into six subblocks denoted A, B, Y_1, Y_2, W_1, and W_2. The encoder output symbols shall be sequentially distributed into six subblocks with the first $_N$ encoder output symbols going to the A subblock, the second N encoder output going to the B subblock, the third N to the Y_1 subblock, the fourth N to the Y_2 subblock, the fifth N to the W_1 subblock, the sixth N to the W_2 subblock.
12. The six subblocks shall be interleaved separately. The interleaving is performed by the unit of symbol. The sequence of interleaver output symbols for each subblock shall be generated by the procedure described

below. The entire subblock of symbols to be interleaved is written into an array at addresses from 0 to the number of the symbols minus one (N-1), and the interleaved symbols are read out in a permuted order with the i-th symbol being read from an address, ADi (i = 0,... N-1), as follows:

1. Determine the subblock interleaver parameters, m and J. The following table gives these parameters.
2. Initialize i and k to 0.
3. Form a tentative output address Tk according to the formula Tk = 2m (k mod J) + BROm(k/J) where BROm(y) indicates the bit-reversed m-bit value of y (i.e., BRO3(6) = 3).
4. If Tk is less than N, ADi = Tk and increment i and k by 1. Otherwise, discard Tk and increment k only.
5. Repeat steps 1 and 2 until all N interleaver output addresses are obtained.
   The parameters for the subblock interleavers are specified in the following table.

Parameter for the Subblock Interleavers

Block size (bits) N_{EP}	N	Subblock interleaver parameters	
		m	**J**
48	24	3	3
72	36	4	3
96	48	4	3
144	72	5	3
192	96	5	3
216	108	5	4
240	120	6	2
288	144	6	3
360	180	6	3
384	192	6	3
432	216	6	4
480	240	7	2

13. The channel interleaver output sequence shall consist of the interleaved *A* and *B* subblock sequence, followed by a symbol-by-symbol multiplexed sequence of the interleaved Y_1 and Y_2 subblock sequences, followed by a symbol-by-symbol multiplexed sequence of the interleaved W_1 and W_2 subblock sequences. The symbol-by-symbol multiplexed sequence of interleaved Y_1 and Y_2 subblock sequences shall consist of the first output bit from the Y_1 subblock interleaver, the first output bit from the Y_2 subblock interleaver, the second output bit from the Y_1 subblock interleaver, the second output bit from the Y_2 subblock interleaver, etc. The symbol-by-symbol multiplexed sequence of interleaved W_1 and W_2 subblock sequences shall consist of the first output bit from the W_1 subblock interleaver, the first output bit from the W_2 subblock interleaver, the second output bit from the W_1 subblock interleaver, the second output bit from the W_2 subblock interleaver, etc. CTC Encoder. shows the interleaving scheme.
14. Lastly, symbol selection is performed to generate the subpacket. The puncturing block is referred as symbols selection in the viewpoint of subpacket generation. Mother code is transmitted with one of subpackets. The symbols in a subpacket are formed by selecting specific sequences of symbols from the interleaved CTC encoder output sequence. The resulting subpacket sequence is a binary sequence of symbols for the modulator.
    Let

    k be the subpacket index when HARQ is enabled. k = 0 for the first transmission and increases by one for the next subpacket. k = 0 when H-ARQ is not used. When there are more than one FEC block in a burst, the subpacket index for each FEC block shall be the same.

    N_{EP} be the number of bits in the encoder packet (before encoding).

    N_{SCHk} be the number of the concatenated slots for the subpacket defined in *Slots Concatenation Rule for CTC* for non H-ARQ CTC scheme.

m_k be the modulation order for the k-th subpacket (m_k = 2 for QPSK, 4 for 16-QAM, and 6 for 64-QAM).

$SPID_k$ be the subpacket ID for the k-th subpacket, (for the first subpacket, $SPID_{k=0}$ = 0).

Also, let the scrambled and selected symbols be numbered from zero with the 0-th symbol being the first symbol in the sequence. Then, the index of the i-th symbol for the k-th subpacket shall be:

$$S_{k,i} = (F_k + i) mod(3 \times N_{EP})$$

where:

i = 0,... Lk-1,

$$L_k = 48 \times N_{SCHk} \times m_k$$

,

$$F_k = (SPID_k \times L_k) mod(3 \times N_{EP})$$

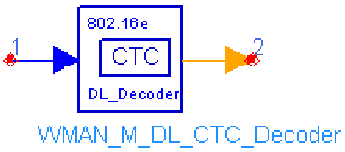
The N_{EP}, N_{SCHk}, m_k, and *SPID* values are determined by the BS and can be inferred by the SS through the allocation size in the DL-MAP and UL-MAP. The above symbol selection makes the following possible.

1. The first transmission includes the systematic part of the mother code. Thus, it can be used as the codeword for a burst where the HARQ is not applied.
2. The location of the subpacket can be determined by the SPID itself without the knowledge of previous subpacket. It is very important property for HARQ retransmission.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_CTC_Decoder (802.16e OFDMA Downlink CTC Decoder)



Description: Downlink convolutional turbo decoder
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
BurstNumOfSym	The number of symbols	4	int	[1,1212]
BurstNumOfSubch	The number of subchannels	1	int	[1,60]
Rate_ID	Rate ID	1	int	[0,7]
RepetitionCoding	Repetition coding	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	
IterationNumber	The number of iterations	8	int	[1,16]
CycleNumber	The number of decoding cycles to get circulation states	1	int	[1,16]

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

Notes/Equations

1. This component is used for convolutional turbo decoding with max-log-MAP algorithm.
2. Each firing,
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8 / CodingRate$ tokens are consumed at pin DataIn, where *CodingRate* is shown in the following table.
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8$ tokens are produced at pin DataOut, where

     EffectiveSlots is the number of slots actually used to transmit data before repetition coding, i.e. *EffectiveSlots = floor (AssignedSlots / R)*, where

     AssignedSlots is the number of slots assigned to the burst,

   For DL PUSC, $AssignedSlots = BurstNumOfSym \times BurstNumOfSubch/2$, for DL FUSC and OFUSC, $AssignedSlots = BurstNumOfSym \times BurstNumOfSubch$,

     R is repetition factor, which is 1, 2, 4 or 6 for QPSK and 1 for other modulation schemes,

     STCRate is the multiple due to STC encoding, which is dependent on *STC_Encoder* and *STC_Matrix*. When *STC_Encoder* = Yes and *STC_Matrix* = B, *STCRate* is 2; otherwise *STCRate* is 1.

     UncodedSlotSize is the number of bytes within one slot before channel coding (see the following table).

Modulation, Rate and UncodedSlotSize for Each Rate ID

Rate ID	Modulation and rate	UncodedSlotSize
0	QPSK 1/2	6
1	QPSK 3/4	9
2	16-QAM 1/2	12
3	16-QAM 3/4	18
4	64-QAM 1/2	18
5	64-QAM 2/3	24
6	64-QAM 3/4	27
7	64-QAM 5/6	30

This model performs the reverse operations against CTC encoder in the following steps:

3. Depuncturing (bit de-selection) and Bit de-grouping

   In CTC encoder, the bit selection is performed to generate the subpacket. The puncturing block is referred as bit selection in the viewpoint of subpacket generation. Then in CTC decoder, the depuncturing block (bit de-selection) is performed to generate the full sequence from the received subpacket. Furthermore, the full sequence can be divided into six subblocks (interleaved A, B, Y1, Y2, W1 and W2 subblocks) after bit de-grouping. In the full sequence, the bits punctured in CTC encoder are filled with zeros. For more information, please refer to Clause 13 and 14 in the documentation of WMAN_M_DL_CTC.

4. Deinterleaving

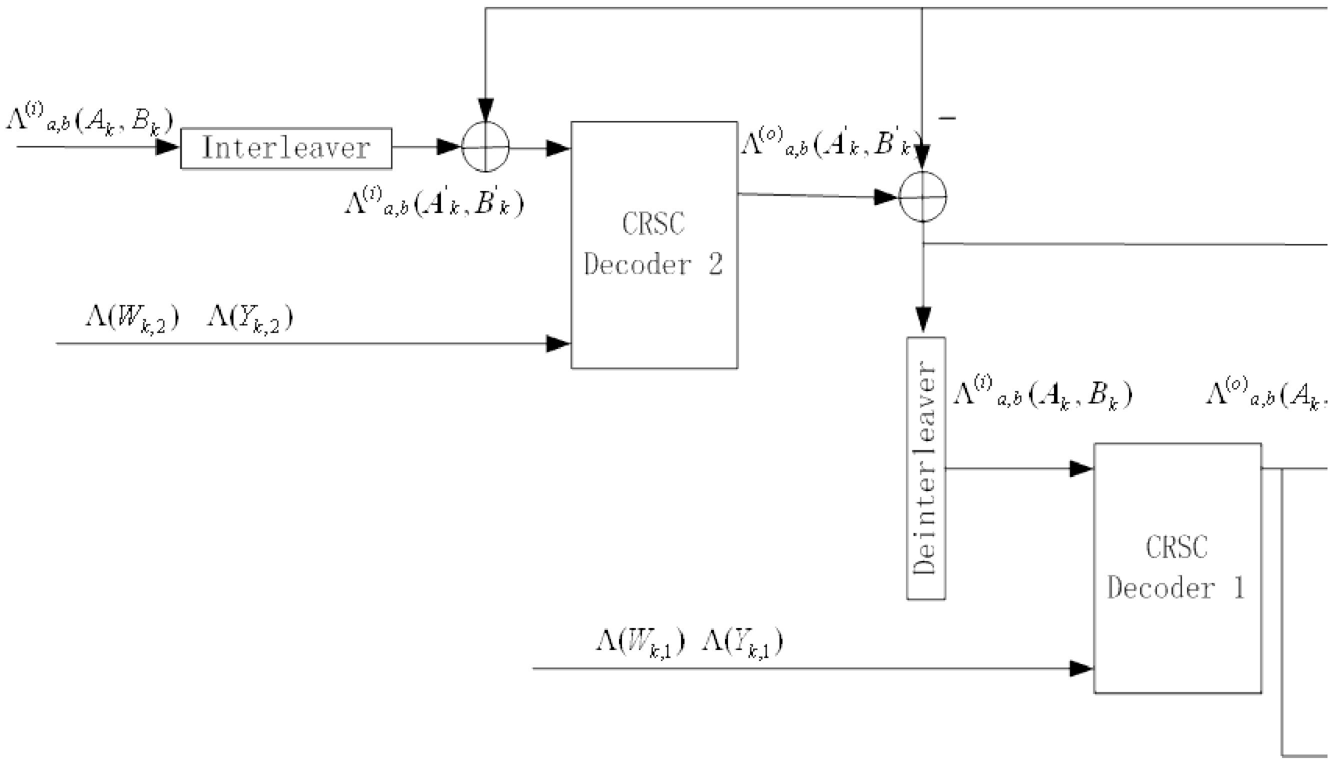
   The six subblocks after depuncturing block shall be deinterleaved separately. Similar with the interleaving, the deinterleaving is performed by the unit of bits. For more information, please refer to Clause 12 in the documentation of WMAN_M_DL_CTC. After deinterleaving block, the six subblocks denoted A, B, Y1, Y2, W1 and W2 are input into the 1/3 CTC decoder.

5. 1/3 CTC decoder

   The CTC is duobinary and circular. As with conventional turbo codes, the decoder involves the iterative exchange of extrinsic information between the two component decoders. While decoding can be performed in the probability domain, the log-domain is preferred since the low complexity max-log-MAP algorithm can then be applied [4]. The duobinary decoder needs three log-likelihood ratios (LLR). For example, the likelihood ratios for message couple (A_k, B_k) can be represented in the log-domain.

   $$\Lambda_{a,b}(A_k, B_k) = \log\frac{P(A_k = a, B_k = b)}{P(A_k = 0, B_k = 0)}$$

   where (a,b) is (0,1), (1,0) or (1,1).



Iterative CTC Decoder

6. The iterative decoder for CTC is shown in the previous figure, which includes two duobinary decoders. Each decoder is provided with along with the received values of the parity bits generated by the corresponding encoder (in LLR form), and it is able to produce the updated LLRs at its output. Then the extrinsic information is passed to the other constituent decoder instead of the raw LLRs. This prevents the positive feedback of previously resolved information. The extrinsic information is gotten by simply subtracting the appropriate input LLR from each output LLR. Note that the extrinsic information passed between the two decoders should be interleaved or deinterleaved before it sends into the decoder. The interleaver and deinterleaver should be done symbol by symbol which means the three LLRs belonging to the same couple are not separated. Each iteration has two decoding processes (Decoder 1 and Decoder 2), and the first half iteration is the Decoder 2 with the interleaved data. After a certain number of iterations defined by the parameter *IterationNumber*, a final decision on the bits is made by computing the LLRs output at Decoder 1.
7. The max-log-MAP algorithm for each decoder is briefly described in the following paragraphs.
$\gamma_k(S_i - S_j)$
denotes the branch metric corresponding to state transition Si to Sj at time k. The branch metric depends on the message and parity couples that label the branch along with the channel observation and extrinsic information at the decoder input. In particular, if transition Si to Sj is labelled by (Ak,Bk,Wk,Yk) = (a,b,w,y) then
$$\gamma_k(S_i - S_j) = \Lambda^{(i)}{}_{a,b}(A_k, B_k) + w\Lambda(W_k) + y\Lambda(Y_k)$$
The decoder shall perform the forward and backward recursion. Let $\alpha_k(S_j)$
denote the normalized forward metric at trellis stage k and state Si, while $\alpha'_{k+1}(S_j)$
is the forward metric at trellis stage k + 1 and state Sj prior to normalization. The forward recursion is
$$\alpha'_{k+1}(S_j) = max\{\alpha_k(S_i) + \gamma_k(S_i - S_j)\}$$
where the max operation is performed over the four branches Si to Sj leading into state Sj at time k + 1. Here the max-log-MAP algorithm is used.
The forward metrics are normalized with respect to the metric stored in state zero:
$$\alpha_{k+1}(S_j) = \alpha'_{k+1}(S_j) - \alpha'_{k+1}(S_0)$$
Similarly, $\beta_{k+1}(S_j)$

denotes the normalized backward metric at trellis state k+1 and state Sj and $\beta'_k(S_i)$ denotes the backward metric at trellis state k and state Si prior to normalization. The backward recursion is
$\beta'_k(S_i) = max\{\beta_{k+1}(S_j) + \gamma_k(S_i - S_j)\}$

And the backward metrics are normalized with respect to the metric stored in state zero:
$\beta_k(S_i) = \beta'_k(S_i) - \beta'_k(S_0)$

After the forward and backward recursions have been completed, The next step for the decoder is to use these metrics to compute the LLRs. Firstly the likelihood of each branch is computed as:
$z_k(S_i - S_j) = \alpha_k(S_i) + \gamma_k(S_i - S_j) + \beta_{k+1}(S_j)$

Next, the likelihood that message pair (Ak,Bk) = (a,b) is calculated as:
$t_k(a, b) = max\{Z_k\}$

where the max operator is over the eight branches labelled by message couple (a,b). Finally, the LLR at the output of the decoder is found as

$\Lambda^{(o)}{}_{a,b}(A_k, B_k) = t_k(a, b) - t_k(0, 0)$

where (a,b) is (0,1), (1,0) or (1,1).
For more information on max-log-MAP algorithm, please refer to [4].

8. After the turbo decoder has completed the number of iterations defined by *IterationNumber*, a final decision on the bits is be made by computing the LLR of each bit in the couple (Ak,Bk) according to

$$\Lambda(A_k) = max\{\Lambda^{(o)}_{1,0}(A_k, B_k), \Lambda^{(o)}_{1,1}(A_k, B_k)\} - max\{\Lambda^{(o)}_{0,0}(A_k, B_k), \Lambda^{(o)}_{0,1}(A_k, B_k)\}$$

$$\Lambda(B_k) = max\{\Lambda^{(o)}_{0,1}(A_k, B_k), \Lambda^{(o)}_{1,1}(A_k, B_k)\} - max\{\Lambda^{(o)}_{0,0}(A_k, B_k), \Lambda^{(o)}_{1,0}(A_k, B_k)\}$$

9. Another important point for CTC is that tailbiting is used to encode the codewords. To ensure that the starting state is the same as the ending state, which is called circulation state, the encoder needs two complete encoding processes which adds complexity to the encoder. Complexity is also added to this CTC decoder which introduces an additional wrap around for the forward and backward recursion of the MAP decoder. Here in order to get better performance, the minimum wrap depth is one frame length (i.e. one cycle around the trellis cylinder) with parameter *CycleNumber* =1. Users can also set longer wrap depth by setting *CycleNumber* = 2 or more for short frames.
10. CTC Decoder Simulation Results
The following table lists FER performance for CTC decoder with RateID 0 (QPSK, rate 1/2) in static additive white Gaussian channel (AWGN). The simulation is made with soft decision decoding (no quantization).
The parameters are set as follows:
    - Rate_ID = 0
    - Data block size: 60 bytes (10 slots):
    ZoneType = DL PUSC
    BurstNumOfSym = 2
    BurstNumOfSubch = 10
    RepetitionCoding = 0
    STC_Encoder = No
    - IterationNumber = 8
    - CycleNumber = 1
    - 300,000 data blocks are used for simulation.

FER Performance for CTC Decoder

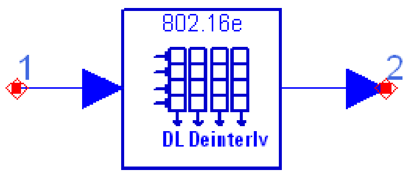
EbN0	FER
1.0 dB	6.3e-1
1.5 dB	1.5e-1
2.0 dB	9.0e-3
2.5 dB	2.8e-4

References

1. IEEE Std 802.16-2004, *Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY*, October 1, 2004.
2. IEEE Std 802.16e-2005, *Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY*, February 2006.
3. C. Berrou, C. Douillard, and M. Jezequel. *Multiple parallel concatenation of circular recursive convolutional*

(CRSC) codes. Annals of Telecommunication, 54(3-4):166-172, Mar.-Apr. 1999.
4. P. Robertson, P. Hoeher, and E. Villebrun. *Optimal and sub-optimal maximum a posteriori algorithms suitable for turbo decoding*. European Trans. on Telecommun., 8(2):119-125, Mar./Apr. 1997.

WMAN_M_DL_Deinterleaver (802.16e OFDMA DL Deinterleaver)



WMAN_M_DL_Deinterleaver

Description: Downlink deinterleaver
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
BurstNumOfSym	Number of symbols within burst	4	int	[1,1212]
BurstNumOfSubch	Number of subchannels within burst	1	int	[1,60]
Rate_ID	Rate ID	1	int	[0,6]
RepetitionCoding	Repetition coding	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	real

Notes/Equations

1. This model is used to perform Deinterleaving on demodulated data of downlink burst.
2. Each firing,
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8/(CodingRate)$ tokens are consumed at pin DataIn, and the same number of tokens are generated at pin DataOut, where

     EffectiveSlots is the number of slots actually used to transmit data,

     i.e. EffectiveSlots = floor(AssignedSlots / R), where

     AssignedSlots is the number of slots assigned to the burst,

     R is repetition factor, which is 1, 2, 4 or 6 for QPSK and 1 for other modulation schemes,

     STCRate is the multiple due to STC encoding, which is dependent on STC_Encoder and STC_Matrix,

     UncodedSlotSize is the number of bytes within one slot before channel coding.

     CodingRate is coding rate.
   - All demodulated data bits shall be deinterleaved by a block deinterleaver with a block size corresponding to the number of coded bits per the encoded block size N_{cbps}. The deinterleaver is defined by a two-step permutation. Within a received block of N_{cbps} bits, let j be the index of a received bit before the first

permutation; mj be the index of that bit after the first and before the second permutation; and let k_j be the index of that bit after the second permutation, just prior to delivering the block to the decoder.
The first permutation is defined by Equation (1):

$$m_j = s \times floor(j/s) + (j + floor(d \times j/N_{cbps}))_{mod(s)} \quad (1)$$

j = 0, 1, ..., N_{cbps} - 1, d = 16

The second permutation is defined by Equation (2):

$$k_j = d \times m_j - (N_{cbps} - 1) \times floor(d \times m_j/N_{cbps}) \quad (2)$$

j = 0, 1, ..., N_{cbps} - 1, d = 16

The first permutation in the de-interleaver is the inverse of the second permutation in the interleaver, and conversely.

3. The FEC block size shall depend on EffectiveSlots and modulation specified for the current transmission. Concatenation of a number of slots shall be performed in order to make larger blocks of coding where it is possible, with the limitation of not exceeding the largest supported block size for the applied modulation and coding. The following tables specify the concatenation of slots for different allocations and modulations for CC and BTC encoding scheme.

Slots Concatenation Rule for CC

Number of slots	Slots concatenated
n <= j	1 block of n slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of ceil((m+j)/2) slots
	1 block of floor((m+j)/2) slots

Encoding Slot Concatenation for Different Allocations and Modulations for CC

Modulation and rate	j
QPSK 1/2	j = 6
QPSK 3/4	j = 4
16-QAM 1/2	j = 3
16-QAM 3/4	j = 2
64-QAM 1/2	j = 2
64-QAM 2/3	j = 1
64-QAM 3/4	j = 1

where

j: parameter dependent on the modulation and FEC rate,

n: floor(number of allocated slots/repetition factor), i.e. EffectiveSlots,

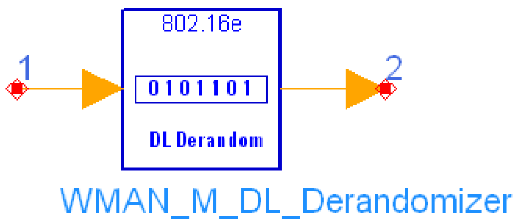
k: floor(n / j),

m: n modulo j

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_Derandomizer (802.16e OFDMA Downlink Derandomizer)



Description: Downlink derandomizer
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
BurstNumOfSym	Number of symbols within burst	4	int	[1,1212]
BurstNumOfSubch	Number of subchannels within burst	1	int	[1,60]
CodingType	Coding type	0	int	[0,1]
Rate_ID	Rate ID	1	int	[0,7]
RepetitionCoding	Repetition coding	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	
DataLength	MAC PDU payload byte length of burst	8	int	[1,∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

Notes/Equations

1. This model is used to perform derandomization on data of downlink burst.
2. Each firing,
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8$ tokens are consumed at pin DataIn, where

     EffectiveSlots is the number of slots actually used to transmit data,

     i.e. EffectiveSlots = floor(AssignedSlots / R), where

     AssignedSlots is the number of slots assigned to the burst,

     R is repetition factor, which is 1, 2, 4 or 6 for QPSK and 1 for other modulation schemes,

     STCRate is the multiple due to STC encoding, which is dependent on STC_Encoder and STC_Matrix,

     UncodedSlotSize is the number of bytes within one slot before channel coding.
   - $(DataLength + MACHeaderLength + MACCRCLength) \times 8$ tokens are generated at pin DataOut, where

     DataLength is the number of data bytes to transmit within the burst, MACHeaderLength is the number of MAC Header bytes,

MACCRCLength is the number of MAC Header CRC bytes.

3. The derandomization is initialized on each FEC block. If the amount of decoded data ($EffectiveSlots \times STCRate \times UncodedSlotSize \times 8$) does not fit exactly the amount of derandomized data ($(DataLength + MACHeaderLength + MACCRCLength) \times 8$), the remaining bits shall be removed.
4. The FEC block size shall depend on EffectiveSlots and modulation specified for the current transmission. Concatenation of a number of slots shall be performed in order to make larger blocks of coding where it is possible, with the limitation of not exceeding the largest supported block size for the applied modulation and coding. The following tables specify the concatenation of slots for different allocations and modulations for CC and BTC encoding scheme.

Slots Concatenation Rule for CC

Number of Slots	Slots Concatenated
n <= j	1 block of n slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of ceil((m+j)/2) slots
	1 block of floor((m+j)/2) slots

Encoding Slot Concatenation for Different Allocations and Modulations for CC

Modulation and rate	j
QPSK 1/2	j = 10
QPSK 3/4	j = 6
16-QAM 1/2	j = 5
16-QAM 3/4	j = 3
64-QAM 1/2	j = 3
64-QAM 2/3	j = 2
64-QAM 3/4	j = 2
64-QAM 5/6	j = 2

The following tables specify the concatenation of slots for different allocations and modulations for CTC encoding scheme.

Slots Concatenation Rule for CTC

Number of slots	Slots concatenated
n <= j n != 7	1 block of n slots
n = 7	1 block of 4 slots 1 block of 3 slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of L_{b1} slots
	1 block of L_{b2} slots
	where
	L_{b1} = ceil((m+j)/2) slots
	L_{b2} = floor((m+j)/2) slots
	If (L_{b1} = 7) or (L_{b2} = 7)
	$L_{b1} = L_{b1} + 1$; $L_{b2} = L_{b2} + 1$

Encoding Slot Concatenation for Different Allocations and Modulations for CTC

Modulation and rate	j
QPSK 1/2	j = 10
QPSK 3/4	j = 6
16-QAM 1/2	j = 5
16-QAM 3/4	j = 3
64-QAM 1/2	j = 3
64-QAM 2/3	j = 2
64-QAM 3/4	j = 2
64-QAM 5/6	j = 2

where

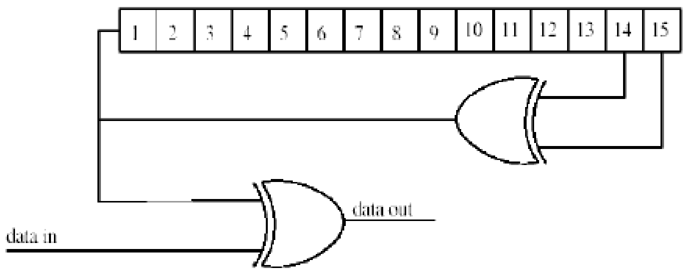
j: parameter dependent on the modulation and FEC rate

n: floor(number of allocated slots/repetition factor), i.e. EffectiveSlots

k: floor(n / j)

m: n modulo j

5. The PRBS generator shall be 1 + X14 + X15, as shown in the following figure, wherein "1" corresponds to LSB and "15" corresponds to MSB. Each decoded data byte shall enter sequentially into the derandomizer, MSB first. Preambles are not derandomized. The seed value shall be used to calculate the randomization bits, which are combined in an XOR operation with the serialized bit stream of each FEC block. The derandomizer is applied only to information bits.
The derandomizer is initialized with the factor [LSB] 0 1 1 0 1 1 1 0 0 0 1 0 1 0 1 [MSB].

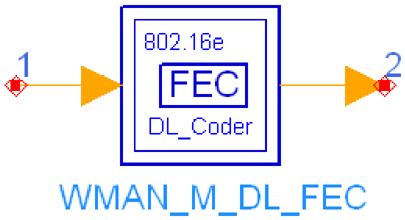


PRBS Generator for Data Randomization

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_FEC (802.16e OFDMA DL Forward Error Coding)



Description: Downlink forward error coding
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
BurstNumOfSym	Number of symbols of each burst	4	int	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	1	int	[1,60]
CodingType	Coding type: CC, CTC	0	int	[0,1]
Rate_ID	Rate ID of each burst	1	int	[0,7]
RepetitionCoding	Repetition coding of each burst	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	
DataLength	MAC PDU payload byte length of burst	8	int	[1,∞)
HARQ_Enable	Whether the burst is HARQ-enabled: NO, YES	NO	enum	

Pin Inputs

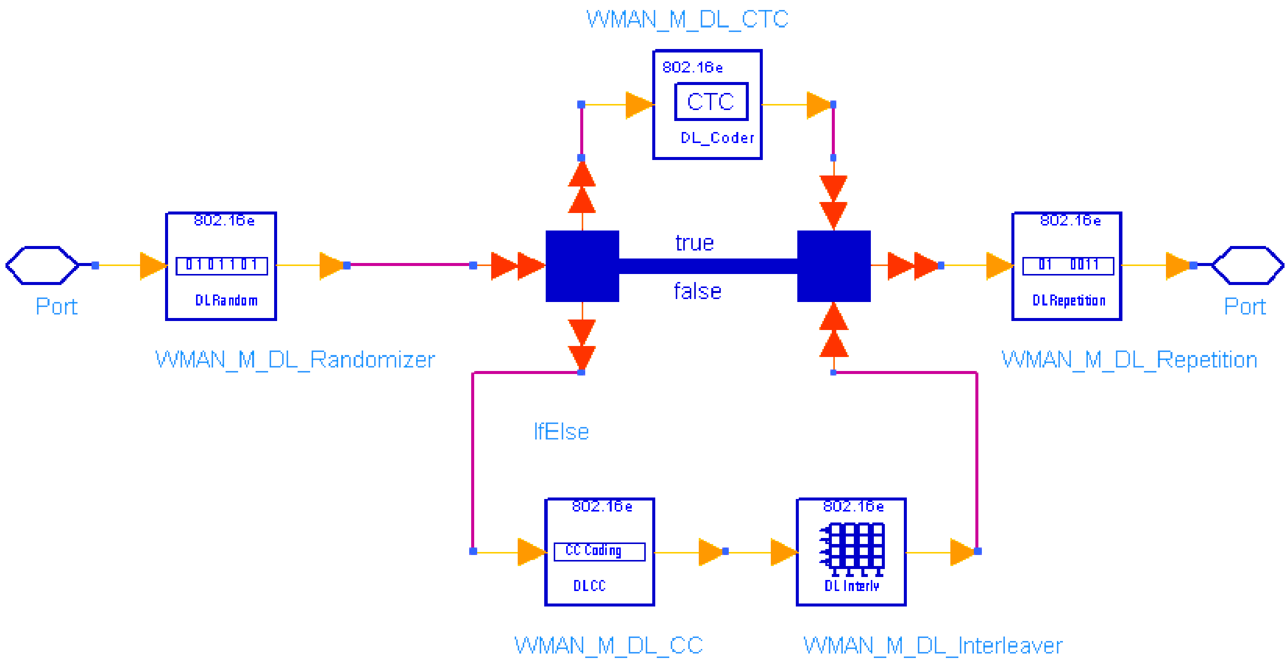
Pin	Name	Description	Signal Type
1	DataIn	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

Notes/Equations

1. This subnetwork is used to do forward error correction coding on downlink, consisting of randomizer, convolutional coder, interleaver, convolutional turbo coder and repetition.
2. The schematic of this subnetwork is shown in the following figure.



WMAN_M_DL_FEC Schematic

3. The randomization is initialized on each FEC block. If the amount of data to transmit (!wman_m-03-10-069.gif!) does not fit exactly the amount of data allocated (!wman_m-03-10-070.gif!), padding of 0xFF ("1" only) shall be added to the end of the transmission block, up to the amount of data allocated.
4. The FEC block size shall depend on EffectiveSlots and modulation specified for the current transmission. Concatenation of a number of slots shall be performed in order to make larger blocks of coding where it is possible, with the limitation of not exceeding the largest supported block size for the applied modulation and coding. The following tables specify the concatenation of slots for different allocations and modulations for CC encoding scheme.

Slots Concatenation Rule for CC

Number of Slots	Slots Concatenated
n <= j	1 block of n slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of ceil((m+j)/2) slots
	1 block of floor((m+j)/2) slots

Encoding Slot Concatenation for Different Allocations and Modulations for CC

Modulation and Rate	j
QPSK 1/2	j = 6
QPSK 3/4	j = 4
16-QAM 1/2	j = 3
16-QAM 3/4	j = 2
64-QAM 1/2	j = 2
64-QAM 2/3	j = 1
64-QAM 3/4	j = 1

The following tables specify the concatenation of slots for different allocations and modulations for CTC encoding scheme.

Slots Concatenation Rule for CTC

Number of Slots	Slots Concatenated
n <= j n != 7	1 block of n slots
n = 7	1 block of 4 slots 1 block of 3 slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of L_{b1} slots
	1 block of L_{b2} slots
	where
	L_{b1} = ceil((m+j)/2) slots
	L_{b2} = floor((m+j)/2) slots
	If (L_{b1} = 7) or (L_{b2} = 7)
	$L_{b1} = L_{b1} + 1$; $L_{b2} = L_{b2} + 1$

Encoding Slot Concatenation for Different Allocations and Modulations for CTC

Modulation and Rate	j
QPSK 1/2	j = 10
QPSK 3/4	j = 6
16-QAM 1/2	j = 5
16-QAM 3/4	j = 3
64-QAM 1/2	j = 3
64-QAM 2/3	j = 2
64-QAM 3/4	j = 2
64-QAM 5/6	j = 2

where

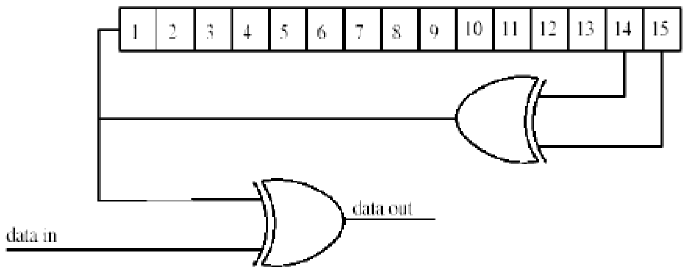
j: parameter dependent on the modulation and FEC rate

n: *floor (number of allocated slots/repetition factor)*, i.e. EffectiveSlots

k: *floor (n / j)*

m: *n modulo j*

5. The PRBS generator shall be $1 + X^{14} + X^{15}$, as shown in the following figure. Each data byte to be transmitted shall enter sequentially into the randomizer, MSB first. Preambles are not randomized. The seed value shall be used to calculate the randomization bits, which are combined in an XOR operation with the serialized bit stream of each FEC block. The randomizer is applied only to information bits.



PRBS Generator for Data Randomization

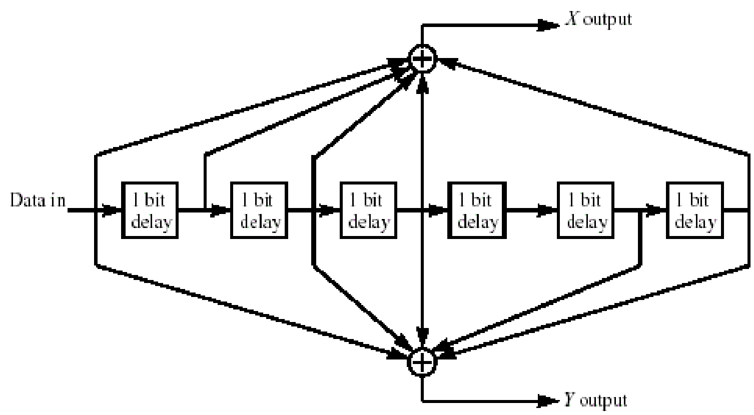
The randomizer is initialized with the factor [LSB] 0 1 1 0 1 1 1 0 0 0 1 0 1 0 1 [MSB].

6. When *CodingType* equals to 0, the branch of convolutional coding and interleaver is used. When *CodingType* equals to 1, the branch of convolutional turbo coding is used. If the value of *Rate_ID* is 7, which means 64-QAM modulation and 5/6 coding rate, the valude of *CodingType* must be 1.
The binary convolutionary encoder, shall have native rate 1/2, a constraint length equal to *K* = 7, and shall use the following generator polynomials codes to derive its two code bits:

$G_1 = 171_{OCT}$ for X

$G_2 = 133_{OCT}$ for Y

The generator is depicted in the following figure. It's implemented by a tail-biting convolutional encoder, which is achieved by initializing the encoders memory with the last data bits of the CC block being encoded (the packet data bits numbered $b_{n-5} \ldots b_n$).



Convolutional Encoder of Rate 1/2

The puncturing patterns and serialization order that shall be used to realize different code rates are defined in the following table. In the table, "1" means a transmittted bit and "0" denotes a removed bit, whereas X and Y are in reference to the figure above.

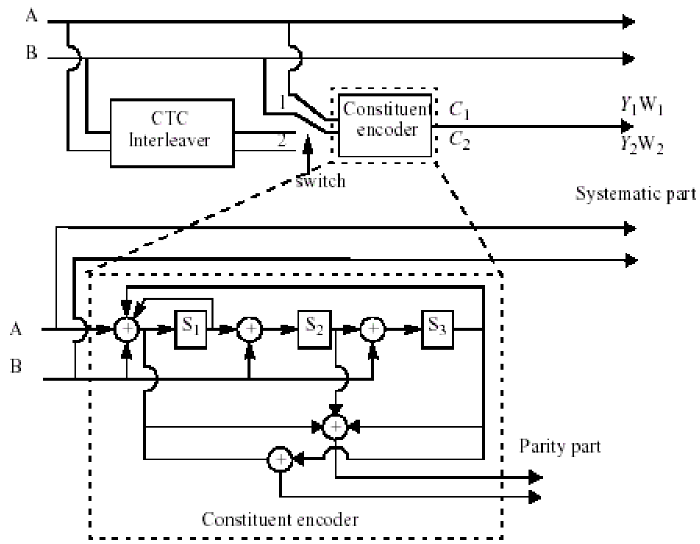
Rate	**1/2**	**2/3**	**3/4**
dfree	10	6	5
X	1	10	101
Y	1	11	110
XY	$X_1 Y_1$	$X_1 Y_1 Y_2$	$X_1 Y_1 Y_2 Y_3$

7. All convolutional encoded data bits shall be interleaved by a block interleaver with a block size corresponding to the number of coded bits per the encoded block size N_{cbps}. The interleaver is defined by a two-step permutation. The first ensures that adjacent coded bits are mapped onto nonadjacent subcarriers. The second permutation insures that adjacent coded bits are mapped alternately onto less or more significant bits of the constellation, thus avoiding long runs of lowly reliable bits.
   Let Ncpc be the number of coded bits per subcarrier, i.e., 2, 4, or 6 for QPSK, 16-QAM or 64-QAM, respectively. Let $s = N_{cpc}/2$. Within a block of N_{cbps} bits at transmission, let k be the index of the coded bit before the first permutation, m_k be the index of that coded bit after the first and before the second permutation and let j_k be the index after the second permutation, just prior to modulation mapping, and d be the modulo used for the permutation.
   The first permutation is defined by Equation (1):
   $$m_k = (N_{cbps}/d) \times k_{mod(d)} + floor(k/d) \quad (1)$$
   $k = 0,1,\ldots, N_{cbps}-1,\ d = 16$
   The second permutation is defined by Equation (2):
   $$j_k = s \times floor(m_k/s) + (m_k + N_{cbps} - floor(d \times m_k/N_{cbps}))_{mod(s)} \quad (2)$$
   $k = 0,1,\ldots, N_{cbps}-1,\ d = 16$
8. The CTC encoder, including its constituent encoder, is depicted in the following figure. It uses a double binary Circular Recursive Systematic Convolutional code. The bits of the data to be encoded are alternately fed to *A* and *B*, starting with the MSB of the first byte being fed to A. The encoder is fed by blocks of *k* bits or *N* couples (!wman_m-03-10-075.gif! bits). For all the frame sizes, *k* is a multiple of 8 and *N* is a multiple of 4. Further, *N* shall be limited to: $8 \le N/4 \le 1024$.
   The polynomials defining the connections are described in octal and symbol notations as follows:

For the feedback branch: 0xB, equivalently $1 + D + D^3$ (in symbolic notation)

For the Y parity bit: 0xD, equivalently $1 + D^2 + D^3$

For the W parity bit: 0x9, equivalently $1 + D^3$



CTC Encoder.

The state of the encoder is denoted S (!wman_m-03-10-078.gif!) with $S = 4s_1 + 2s_2 + s_3$ (see figure above). The circulation states Sc_1 and Sc_2 are determined by the following operations:

Initialize the encoder with state 0. Encode the sequence in the natural order for the determination of Sc_1 or in the interleaved order for determination of Sc_2. In both cases the final state of the encoder is $S0_{N-1}$;

According to the length *N* of the sequence, use the following table to find Sc_1 or Sc_2.

Circulation State Lookup Table (Sc)

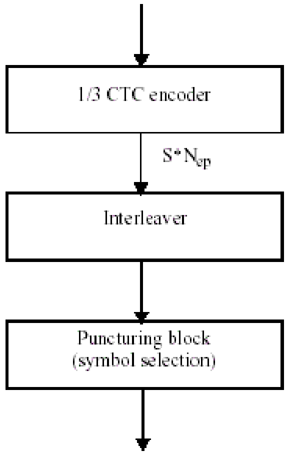
Nmod7	S0N-1							
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	0	6	4	2	7	1	3	5
2	0	3	7	4	5	6	2	1
3	0	5	3	6	2	7	1	4
4	0	4	1	5	6	2	7	3
5	0	2	5	7	1	3	4	6
6	0	7	6	1	3	4	5	2

The encoder (after initialization by the circulation state Sc_1) is fed the sequence in the natural order (position 1) with the incremental address i = 0,... N-1. This first encoding is called C_1 encoding. Then the encoder (after initialization by the circulation state Sc_2) is fed by the interleaved sequence (switch in position 2) with incremental address j = 0,... N-1. This second encoding is called C_2 encoding.

The order in which the encoded bit shall be fed into the subpacket generation block is:

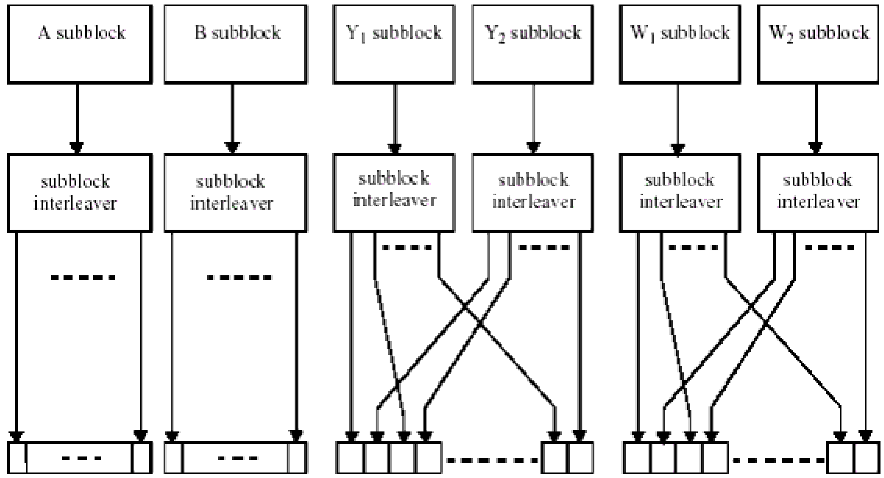
$A, B, Y_1, Y_2, W_1, W_2 = A_0, A_1, \ldots, A_{N-1}, B_0, B_1, \ldots, B_{N-1}, Y_{1,0}, Y_{1,1}, \ldots, Y_{1,N-1}, Y_{2,0}, Y_{2,1}, \ldots, Y_{2,N-1}, W_{1,0}, W_{1,1}, \ldots, W_{1,N-1}, W_{2,0}, W_{2,1}, \ldots, W_{2,N-1}$

Proposed FEC structure punctures the mother codeword to generate a subpacket with various coding rates. the following figure shows a block diagram of subpacket generation. 1/3 CTC encoded codeword goes through interleaving block and the puncturing is performed.



Block Diagram of Subpacket Generation

The following figure shows block diagram of the interleaving block. The puncturing is performed to select the consecutive interleaved bit sequence that starts at any point of whole codeword. For the first transmission, the subpacket is generated to select the consecutive interleaved bit sequence that starts from the first bit of the systematic part of the mother codeword. The length of the subpacket is chosen according to the needed coding rate reflecting the channel condition. The first subpacket can also be used as a codeword with the needed coding rate for a burst where HARQ is not applied.



Block Diagram of the Interleaving Scheme

The following table gives the block sizes, code rates, channel efficiency, and code parameters for the different modulation and coding schemes. As 64-QAM is optional, the codes for this modulation shall only be implemented if the modulation is implemented.

Optimal CTC Channel Coding per Modulation170

Modulation	Data Block Size (Bytes)	Encoded Data Block Size (Bytes)	Code Rate	N	P0	P1	P2	P3
QPSK	6	12	1/2	24	5	0	0	0
QPSK	12	24	1/2	48	13	24	0	24
QPSK	18	36	1/2	72	11	6	0	6
QPSK	24	48	1/2	96	7	48	24	72
QPSK	30	60	1/2	120	13	60	0	60
QPSK	36	72	1/2	144	17	74	72	2
QPSK	48	96	1/2	192	11	96	48	144
QPSK	54	108	1/2	216	13	108	0	108
QPSK	60	120	1/2	240	13	120	60	180
QPSK	9	12	3/4	36	11	18	0	18
QPSK	18	24	3/4	72	11	6	0	6
QPSK	27	36	3/4	108	11	54	56	2
QPSK	36	48	3/4	144	17	74	72	2
QPSK	45	60	3/4	180	11	90	0	90
QPSK	54	72	3/4	216	13	108	0	108
16-QAM	12	24	1/2	48	13	24	0	24
16-QAM	24	48	1/2	96	7	48	24	72
16-QAM	36	72	1/2	144	17	74	72	2
16-QAM	48	96	1/2	192	11	96	48	144
16-QAM	60	120	1/2	240	13	120	60	180
16-QAM	18	24	3/4	72	11	6	0	6
16-QAM	36	48	3/4	144	17	74	72	2
16-QAM	54	72	3/4	216	13	108	0	108
64-QAM	18	36	1/2	72	11	6	0	6
64-QAM	36	72	1/2	144	17	74	72	2
64-QAM	54	108	1/2	216	13	108	0	108
64-QAM	24	36	2/3	96	7	48	24	72
64-QAM	48	72	2/3	192	11	96	48	144
64-QAM	27	36	3/4	108	11	54	56	2
64-QAM	54	72	3/4	216	13	108	0	108
64-QAM	30	36	5/6	120	13	60	0	60
64-QAM	60	72	5/6	240	13	120	60	180

The interleaver requires the parameters P_0, P_1, P_2 and P_3, shown in the previous table. The two-step interleaver shall be performed by:
Step 1: Switch alternate couples

for *j = 0,... N-1*
if (*j* mod 2==1) let (*B,A*) = (*A,B*) (i.e., switch the couple)

Step 2: Pi(j)

The function Pi(j) provides the interleaved address *i* of the consider couple *j*. (i.e. InterleavedVec(j) = OriginalVec(Pi(j))).
for *j* = 0,... N-1
switch *j* mod 4:
case 0: $i = (P_0 \times j + 1) mod(N)$
case 1: $i = (P_0 \times j + 1 + N/2 + P_1) mod(N)$
case 2: $i = (P_0 \times j + 1 + P_2) mod(N)$
case 3: $i = (P_0 \times j + 1 + N/2 + P_3) mod(N)$

All of the encoded symbols shall be demultiplexed into six subblocks denoted *A*, *B*, Y_1, Y_2, W_1, and W_2. The encoder output symbols shall be sequentially distributed into six subblocks with the first *N* encoder output symbols going to the A subblock, the second N encoder output going to the B subblock, the third N to the Y_1 subblock, the fourth *N* to the Y_2 subblock, the fifth *N* to the W_1 subblock, the sixth *N* to the W_2 subblock.

The six subblocks shall be interleaved separately. The interleaving is performed by the unit of symbol. The sequence of interleaver output symbols for each subblock shall be generated by the procedure described below. The entire subblock of symbols to be interleaved is written into an array at addresses from 0 to the number of the symbols minus one (N-1), and the interleaved symbols are read out in a permuted order with the i-th symbol being read from an address, ADi (i = 0,... N-1), as follows:

1) Determine the subblock interleaver parameters, *m* and *J*. The following table gives these parameters.

2) Initialize *i* and *k* to 0.

3) Form a tentative output address T_k according to the formula $T_k = 2^m (k \bmod J) + BRO_m(k/J)$ where $BRO_m(y)$ indicates the bit-reversed m-bit value of y (i.e., $BRO_3(6) = 3$).

4) If T_k is less than N, $AD_i = T_k$ and increment *i* and *k* by 1. Otherwise, discard T_k and increment *k* only.

5) Repeat steps 1 and 2 until all N interleaver output addresses are obtained.

The parameters for the subblock interleavers are specified in the following table.

Parameter for the Subblock Interleavers

Block size (bits) NEP	N	Subblock interleaver parameters	
		m	**J**
48	24	3	3
72	36	4	3
96	48	4	3
144	72	5	3
192	96	5	3
216	108	5	4
240	120	6	2
288	144	6	3
360	180	6	3
384	192	6	3
432	216	6	4
480	240	7	2

The channel interleaver output sequence shall consist of the interleaved *A* and *B* subblock sequence, followed by a symbol-by-symbol multiplexed sequence of the interleaved Y_1 and Y_2 subblock sequences, followed by a symbol-by-symbol multiplexed sequence of the interleaved W_1 and W2 subblock sequences. The symbol-by-symbol multiplexed sequence of interleaved Y_1 and Y_2 subblock sequences shall consist of the first output bit from the Y_1 subblock interleaver, the first output bit from the Y_2 subblock interleaver, the second output bit from the Y_1 subblock interleaver, the second output bit from the Y_2 subblock interleaver, etc. The symbol-by-symbol multiplexed sequence of interleaved W_1 and W_2 subblock sequences shall consist of the first output bit from the W_1 subblock interleaver, the first output bit from the W2 subblock interleaver, the second output bit from the W_1 subblock interleaver, the second output bit from the W2 subblock interleaver, etc. The previous figure shows the interleaving scheme.

Lastly, symbol selection is performed to generate the subpacket. The puncturing block is referred as symbols selection in the viewpoint of subpacket generation. Mother code is transmitted with one of subpackets. The symbols in a subpacket are formed by selecting specific sequences of symbols from the interleaved CTC encoder output sequence. The resulting subpacket sequence is a binary sequence of symbols for the modulator.

Let,

> *k* be the subpacket index when HARQ is enabled. *k* = 0 for the first transmission and increases by one for the next subpacket. *k* = 0 when H-ARQ is not used. When there are more than one FEC block in a burst, the subpacket index for each FEC block shall be the same.
>
> N_{EP} be the number of bits in the encoder packet (before encoding).

N_{SCHk} be the number of the concatenated slots for the subpacket defined in *Slots Concatenation Rule for CTC* for non H-ARQ CTC scheme.

m_k be the modulation order for the k-th subpacket (m_k = 2 for QPSK, 4 for 16-QAM, and 6 for 64-QAM).

$SPID_k$ be the subpacket ID for the k-th subpacket, (for the first subpacket, $SPID_{k=0}$ = 0).

Also, let the scrambled and selected symbols be numbered from zero with the 0-th symbol being the first symbol in the sequence. Then, the index of the i-th symbol for the k-th subpacket shall be:

$$S_{k,i} = (F_k + i) mod(3 \times N_{EP})$$

where:

i = 0,... L_k -1,

$$L_k = 48 \times N_{SCHk} \times m_k,$$

$$F_k = (SPID_k \times L_k) mod(3 \times N_{EP})$$

The N_{EP}, N_{SCHk}, m_k, and SPID values are determined by the BS and can be inferred by the SS through the allocation size in the DL-MAP and UL-MAP. The above symbol selection makes the following possible.

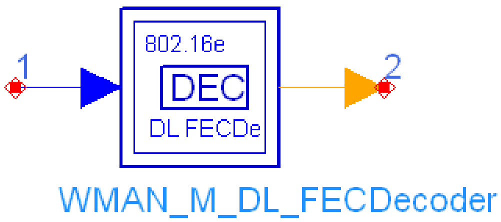
1. The first transmission includes the systematic part of the mother code. Thus, it can be used as the codeword for a burst where the HARQ is not applied.
2. The location of the subpacket can be determined by the SPID itself without the knowledge of previous subpacket. It is very important property for HARQ retransmission.

9. Repetition coding can be used to further increase signal margin over the modulation and FEC mechanisms. In the case of repetition coding, R = 2, 4, or 6, AssignedSlots shall be in the range of $[R \times EffectiveSlots, R \times EffectiveSlots + (R-1)]$. The binary data that fits into a region that is repetition coded is reduced by a factor R compared to a non-repeated region of the (!wman_m-03-10-089.gif!) slots with the same size and FEC code type. After FEC and bit-interleaving, the data is segmented into slots, and each group of bits designated to fit in a slot will be repeated R times to form R continuous slots following the normal slot ordering that is used for data mapping. If AssignedSlots is not integer multiples of R, the remaining slots (the number of them ranging from 1 to R - 1) will be padded with "1". This repetition scheme applies only to QPSK modualtion; it can be applied in all coding schemes except H-ARQ with CTC.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_FECDecoder (802.16e OFDMA DL Forward Error Decoding)



Description: Downlink forward error decoding
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
BurstNumOfSym	Number of symbols of each burst	4	int	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	1	int	[1,60]
Rate_ID	Rate ID of each burst	1	int	[0,6]
RepetitionCoding	Repetition coding of each burst	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	
DataLength	MAC PDU payload byte length of burst	8	int	[1,∞)
CodingType	Coding type	1	int	[0,1]
IterationNumber	The number of iterations	8	int	[1,16]
CycleNumber	The number of decoding cycles to get circulation states	1	int	[1,16]

Pin Inputs

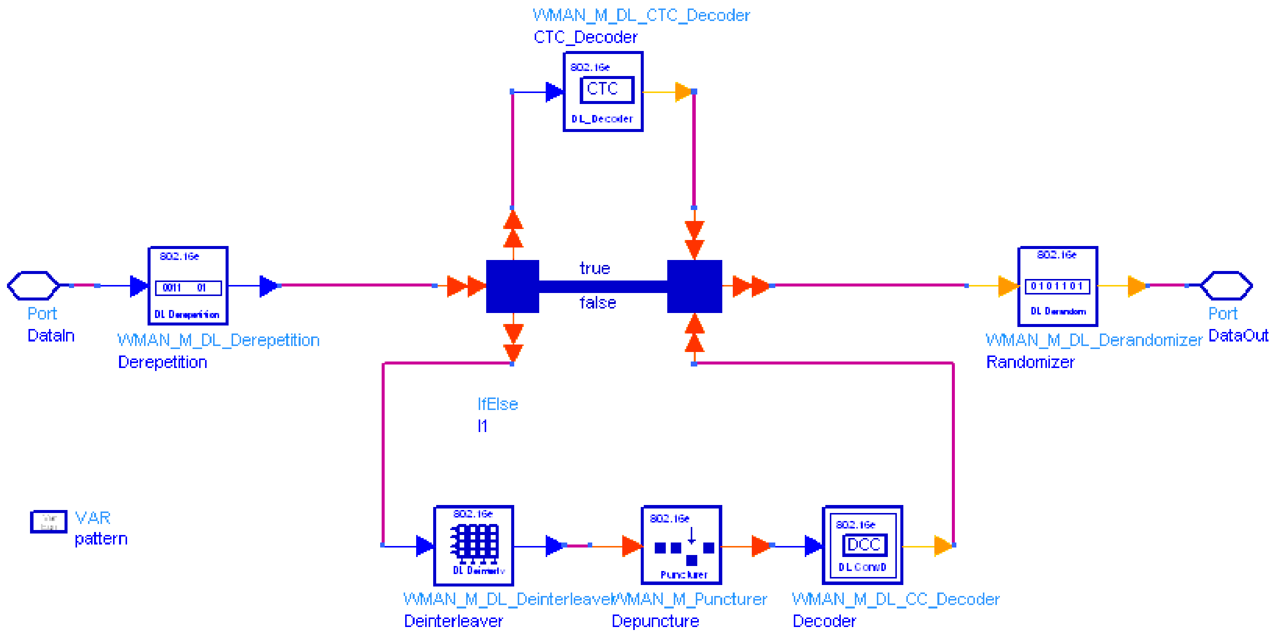
Pin	Name	Description	Signal Type
1	DataIn	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

Notes/Equations

1. This subnetwork is used to do forward error correction decoding on downlink, consisting of de-repetition, deinterleaver, depuncturer, convolutional decoder and derandomizer.
2. The schematic of this subnetwork is shown in the following figure.



WMAN_M_DL_FECDecoder Schematic

3. In the case of repetition coding, R = 2, 4, or 6, AssignedSlots shall be in the range of [$R \times EffectiveSlots$, $R \times EffectiveSlots + (R-1)$]. The output data of derepetition are the average of the input data, which are repeated R times.
4. All demodulated data bits shall be deinterleaved by a block deinterleaver with a block size corresponding to the number of coded bits per the encoded block size N_{cbps}. The deinterleaver is defined by a two-step permutation. Within a received block of N_{cbps} bits, let j be the index of a received bit before the first permutation; m_j be the index of that bit after the first and before the second permutation; and let k_j be the index of that bit after the second permutation, just prior to delivering the block to the decoder.

   The first permutation is defined by Equation (1):
   $$m_j = s \times floor(j/s) + (j + floor(d \times j/N_{cbps}))_{mod(s)} \quad (1)$$
   $j = 0, 1, \ldots, N_{cbps} - 1, d = 16$

   The second permutation is defined by Equation (2):
   $$k_j = d \times m_j - (N_{cbps} - 1) \times floor(d \times m_j / N_{cbps}) \quad (2)$$
   $j = 0, 1, \ldots, N_{cbps} - 1, d = 16$

   The first permutation in the de-interleaver is the inverse of the second permutation in the interleaver, and conversely.
5. The convolutional decoder uses the viterbi decoding algorithm. The following tables specify the concatenation of slots for different allocations and modulations for CC encoding scheme.

Slots Concatenation Rule for CC

Number of Slots	Slots Concatenated
n <= j	1 block of n slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of ceil((m+j)/2) slots
	1 block of floor((m+j)/2) slots

Encoding Slot Concatenation for Different Allocations and Modulations for CC

Modulation and rate	j
QPSK 1/2	j = 6
QPSK 3/4	j = 4
16-QAM 1/2	j = 3
16-QAM 3/4	j = 2
64-QAM 1/2	j = 2
64-QAM 2/3	j = 1
64-QAM 3/4	j = 1

where

j: parameter dependent on the modulation and FEC rate

n: floor (number of allocated slots/repetition factor), i.e. EffectiveSlots

k: floor (n / j)

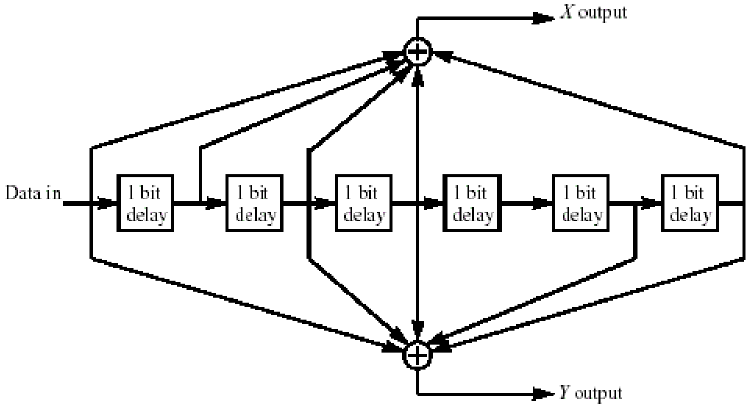
m: n modulo j

The binary convolutionary encoder, shall have native rate 1/2, a constraint length equal to K = 7, and shall use the following generator polynomials codes to derive its two code bits:

$G_1 = 171_{OCT}$ for X

$G_2 = 133_{OCT}$ for Y

The generator is depicted in the following figure. It is implemented by a tail-biting convolutional encoder, which is achieved by initializing the encoders memory with the last data bits of the CC block being encoded (the packet data bits numbered $b_{n-5} \ldots b_n$).



Convolutional Encoder of Rate 1/2

The puncturing patterns and serialization order that shall be used to realize different code rates are defined in the following table. In the table, "1" means a transmittted bit and "0" denotes a removed bit, whereas X and Y are in reference to the previous figure.

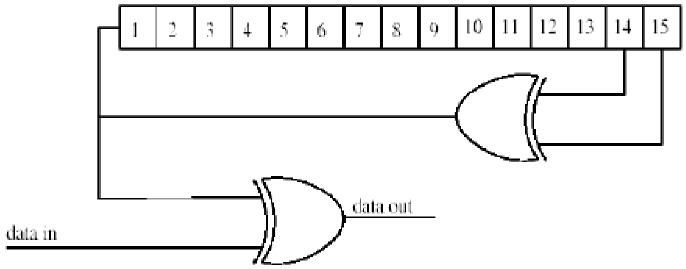
The Convolutional Code with Puncturing Configuration

Rate	1/2	2/3	3/4
dfree	10	6	5
X	1	10	101
Y	1	11	110
XY	X1Y1	X1Y1Y2	X1Y1Y2Y3

6. For the implementation of the CTC decoder, refer to the *WMAN_M_DL_CTC_Decoder (802.16e OFDMA Downlink CTC Decoder)".* (wman_m)

7. The PRBS generator shall be $1 + X^{14} + X^{15}$, as shown in the following figure, wherein "1" corresponds to LSB and "15" corresponds to MSB. Each decoded data byte shall enter sequentially into the derandomizer, MSB first. Preambles are not derandomized. The seed value shall be used to calculate the randomization bits, which are combined in an XOR operation with the serialized bit stream of each FEC block. The derandomizer is applied only to information bits.

   The derandomizer is initialized with the factor [LSB] 0 1 1 0 1 1 1 0 0 0 1 0 1 0 1 [MSB].

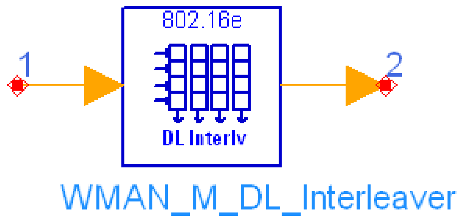


PRBS Generator

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_Interleaver (802.16e OFDMA Downlink Interleaver)



Description: Downlink interleaver
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
BurstNumOfSym	Number of symbols within burst	4	int	[1,1212]
BurstNumOfSubch	Number of subchannels within burst	1	int	[1,60]
Rate_ID	Rate ID	1	int	[0,6]
RepetitionCoding	Repetition coding	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

Notes/Equations

1. This model is used to perform interleaving on coded data of downlink burst.
2. Each firing,
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8/(CodingRate)$ tokens are consumed at pin DataIn, and the same number of tokens are generated at pin DataOut, where EffectiveSlots is the number of slots actually used to transmit data, i.e. *EffectiveSlots* = floor(*AssignedSlots/R*), where

     AssignedSlots is the number of slots assigned to the burst

     R is repetition factor, which is 1, 2, 4 or 6 for QPSK and 1 for other modulation schemes

     STCRate is the multiple due to STC encoding, which is dependent on STC_Encoder and STC_Matrix

     UncodedSlotSize is the number of bytes within one slot before channel coding

     CodingRate is coding rate
3. All encoded data bits shall be interleaved by a block interleaver with a block size corresponding to the number of coded bits per the encoded block size N_{cbps}. The interleaver is defined by a two-step permutation. The first ensures that adjacent coded bits are mapped onto nonadjacent subcarriers. The second permutation ensures that adjacent coded bits are mapped alternately onto less or more significant bits of the constellation, thus avoiding long runs of lowly reliable bits.

Let N_{cpc} be the number of coded bits per subcarrier, i.e., 2, 4, or 6 for QPSK, 16-QAM or 64-QAM, respectively. Let s = $N_{cpc}/2$. Within a block of N_{cbps} bits at transmission, let *k* be the index of the coded bit before the first permutation, m_k be the index of that coded bit after the first and before the second permutation and let j_k be the index after the second permutation, just prior to modulation mapping, and d be the modulo used for the permutation.

The first permutation is defined by Equation (1):

$$m_k = (N_{cbps}/d) \times k_{mod(d)} + floor(k/d) \quad (1)$$

k = 0,1,..., N_{cbps} -1, d = 16

The second permutation is defined by Equation (2):

$$j_k = s \times floor(m_k/s) + (m_k + N_{cbps} - floor(d \times m_k/N_{cbps}))_{mod(s)} \quad (2)$$

k = 0,1,..., N_{cbps} -1, d = 16

4. The FEC block size shall depend on EffectiveSlots and modulation specified for the current transmission. Concatenation of a number of slots shall be performed in order to make larger blocks of coding where it is possible, with the limitation of not exceeding the largest supported block size for the applied modulation and coding. The following tables specify the concatenation of slots for different allocations and modulations for CC and BTC encoding scheme.

Slots Concatenation Rule for CC

Number of Slots	Slots Concatenated
n <= j	1 block of n slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of ceil((m+j)/2) slots
	1 block of floor((m+j)/2) slots

Encoding Slot Concatenation for Different Allocations and Modulations for CC

Modulation and rate	j
QPSK 1/2	j = 6
QPSK 3/4	j = 4
16-QAM 1/2	j = 3
16-QAM 3/4	j = 2
64-QAM 1/2	j = 2
64-QAM 2/3	j = 1
64-QAM 3/4	j = 1

where

j: parameter dependent on the modulation and FEC rate

n: floor(number of allocated slots/repetition factor), i.e. EffectiveSlots

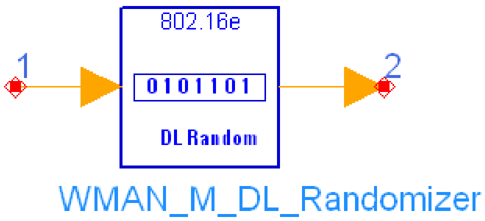
k: floor(n / j)

m: n modulo j

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_Randomizer (802.16e OFDMA Downlink Randomizer)



Description: Downlink randomizer
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
BurstNumOfSym	Number of symbols within burst	4	int	[1,1212]
BurstNumOfSubch	Number of subchannels within burst	1	int	[1,60]
CodingType	Coding type	0	int	[0,1]
Rate_ID	Rate ID	1	int	[0,7]
RepetitionCoding	Repetition coding	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	
DataLength	MAC PDU payload byte length of burst	8	int	[1,∞)
HARQ_Enable	Whether the burst is HARQ-enabled: NO, YES	NO	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

Notes/Equations

1. This model is used to perform randomization on data of downlink burst.
2. Each firing,
   - $(DataLength + MACHeaderLength + MACCRCLength) \times 8$ tokens are consumed at pin DataIn, where

     DataLength is the number of data bytes to transmit within the burst

     MACHeaderLength is the number of MAC Header bytes

     MACCRCLength is the number of MAC Header CRC bytes
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8$ tokens are generated at pin DataOut, where
     EffectiveSlots is the number of slots actually used to transmit data,
     i.e. *EffectiveSlots* = *floor(AssignedSlots/R*), where

     AssignedSlots is the number of slots assigned to the burst,

     R is repetition factor, which is 1, 2, 4 or 6 for QPSK and 1 for other modulation schemes,

     STCRate is the multiple due to STC encoding, which is dependent on *STC_Encoder* and *STC_Matrix*, *UncodedSlotSize* is the number of bytes within one slot before channel coding.

3. The randomization is initialized on each FEC block. If the amount of data to transmit (!wman_m-03-13-105.gif!) does not fit exactly the amount of data allocated (!wman_m-03-13-106.gif!), padding of 0xFF("1" only) shall be added to the end of the transmission block, up to the amount of data allocated. Note that when HARQ_Enable = YES, a two-byte HARQ CRC will be added to the end of the transmission block. Refer to *HARQ burst* (wman_m) for more information.
4. The FEC block size shall depend on EffectiveSlots and modulation specified for the current transmission. Concatenation of a number of slots shall be performed in order to make larger blocks of coding where it is possible, with the limitation of not exceeding the largest supported block size for the applied modulation and coding. The following tables specify the concatenation of slots for different allocations and modulations for CC and BTC encoding scheme.

Slots Concatenation Rule for CC

Number of slots	Slots concatenated
n <= j	1 block of n slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of ceil((m+j)/2) slots
	1 block of floor((m+j)/2) slots

Slots Concatenation Rule for CTC

Number of slots	Slots concatenated
n <= j n != 7	1 block of n slots
n = 7	1 block of 4 slots 1 block of 3 slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of L_{b1} slots
	1 block of L_{b2} slots
	where
	L_{b1} = ceil((m+j)/2) slots
	L_{b2} = floor((m+j)/2) slots
	If (L_{b1} = 7) or (L_{b2} = 7)
	$L_{b1} = L_{b1} + 1$; $L_{b2} = L_{b2} + 1$

The following tables specify the concatenation of slots for different allocations and modulations for CTC encoding scheme.

Encoding Slot Concatenation for Different Allocations and Modulations for CTC

Modulation and rate	j
QPSK 1/2	j = 10
QPSK 3/4	j = 6
16-QAM 1/2	j = 5
16-QAM 3/4	j = 3
64-QAM 1/2	j = 3
64-QAM 2/3	j = 2
64-QAM 3/4	j = 2
64-QAM 5/6	j = 2

Encoding Slot Concatenation for Different Allocations and Modulations for CC

Modulation and rate	j
QPSK 1/2	j = 6
QPSK 3/4	j = 4
16-QAM 1/2	j = 3
16-QAM 3/4	j = 2
64-QAM 1/2	j = 2
64-QAM 2/3	j = 1
64-QAM 3/4	j = 1

where

j: parameter dependent on the modulation and FEC rate

n: floor(number of allocated slots/repetition factor), i.e. EffectiveSlots

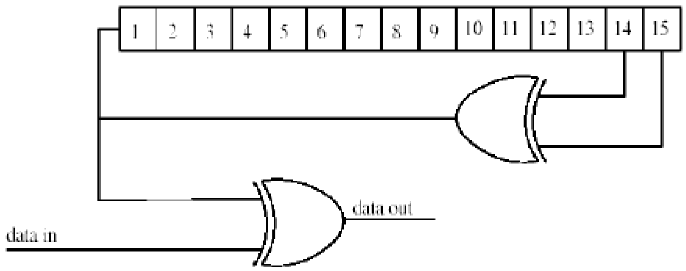
k: floor(n / j)

m: n modulo j

5. The PRBS generator shall be $1 + X^{14} + X^{15}$, as shown in the following figure, wherein "1" corresponds to LSB and "15" corresponds to MSB. Each data byte to be transmitted shall enter sequentially into the randomizer, MSB first. Preambles are not randomized. The seed value shall be used to calculate the randomization bits, which are combined in an XOR operation with the serialized bit stream of each FEC block. The randomizer is applied only to information bits.

   The randomizer is initialized with the factor

   [LSB] 0 1 1 0 1 1 1 0 0 0 1 0 1 0 1 [MSB].

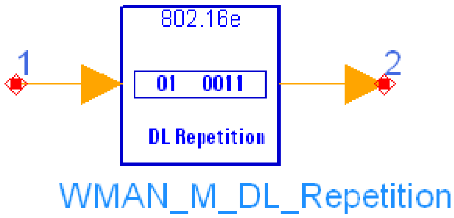


PRBS Generator for Data Randomization

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_Repetition (802.16e OFDMA Downlink Repetition)



Description: Downlink repeater
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
BurstNumOfSym	Number of symbols within burst	4	int	[1,1212]
BurstNumOfSubch	Number of subchannels within burst	1	int	[1,60]
CodingType	Coding type	0	int	[0,1]
Rate_ID	Rate ID	1	int	[0,7]
RepetitionCoding	Repetition coding	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

Notes/Equations

1. This model is used to perform repetition on interleaved data of downlink burst.
2. Each firing,
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8/(CodingRate)$ tokens are consumed at pin DataIn, where
     EffectiveSlots is the number of slots actually used to transmit data,
     i.e. *EffectiveSlots = floor(AssignedSlots/R*), where

     AssignedSlots is the number of slots assigned to the burst

     R is repetition factor, which is 1, 2, 4 or 6 for QPSK and 1 for other modulation schemes

     STCRate is the multiple due to STC encoding, which is dependent on STC_Encoder and STC_Matrix

     UncodedSlotSize is the number of bytes within one slot before channel coding

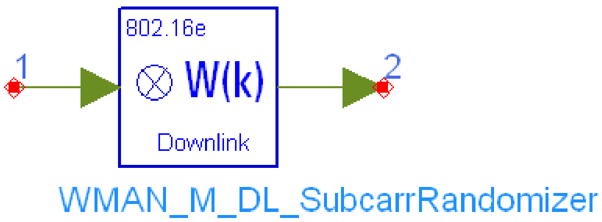
     CodingRate is coding rate
   - $AssignedSlots \times STCRate \times UncodedSlotSize \times 8/(CodingRate)$ tokens are generated at pin DataOut.
3. Repetition coding can be used to further increase signal margin over the modulation and FEC mechanisms. In the case of repetition coding, *R* = 2, 4, or 6, AssignedSlots shall be in the range of $[R \times EffectiveSlots, R \times EffectiveSlots + (R-1)]$. The binary data that fits into a region that is repetition coded is reduced by a factor *R* compared to a non-repeated region of the (!wman_m-03-14-112.gif!) slots with the

same size and FEC code type. After FEC and bit-interleaving, the data is segmented into slots, and each group of bits designated to fit in a slot will be repeated *R* times to form *R* continuous slots following the normal slot ordering that is used for data mapping. If AssignedSlots is not integer multiples of R, the remaining slots (the number of them ranging from 1 to *R* - 1) will be padded with *1*. This repetition scheme applies only to QPSK modualtion; it can be applied in all coding schemes except H-ARQ with CTC.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_SubcarrRandomizer (802.16e OFDMA DL Subcarr Randomizer)



Description: Downlink subcarrier randomizer
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
Mode	Randomizer or Derandomizer: Randomizer, Derandomizer	Randomizer	enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_2048	enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
ZoneNumOfSym	Number of OFDM symbols in zone	24	int	[1,1212]
FirstZone	First zone or not: NO, YES	NO	enum	
PreambleIndex	Preamble index	3	int	[0,113]
DL_PermBase	DL PermBase	16	int	[0,31]
PRBS_ID	PRBS ID	16	int	[0,3]
PilotPN_Phase	Pilot PN phase	0	int	[0,2047]

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	intput data	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	complex

Notes/Equations

1. This model is used to multiply (or divide) the factor $2 \times (1/2 - W_k)$ to the constellation-mapped data according to the subcarrier physical index, *k*.
2. Each firing,

    UsedCarriers tokens are consumed at pin DataIn.

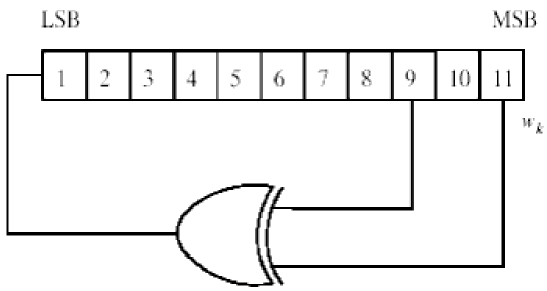
    UsedCarriers tokens are produced at pin DataOut.

    where, *UsedCarriers* is dependent on the zone type and FFT size according to the specification, shown in the following table.

    The Calculation of UsedCarriers

Zone type	FFT size	UsedCarriers
DL_PUSC	2048	1680
DL_PUSC	1024	840
DL_PUSC	512	420
DL_FUSC	2048	1702
DL_FUSC	1024	850
DL_FUSC	512	426
DL_OFUSC	2048	1728
DL_OFUSC	1024	864
DL_OFUSC	512	432

3. When *Mode* is set to Randomizer, the data will multiply the factor $2 \times (1/2 - W_k)$; When *Mode* is set to Derandomizer, the data will divide the factor $2 \times (1/2 - W_k)$. The sequence w_k is generated from the PRBS generator which is shown in the following figure.



PRBS Generator for Pilot Modulation

The initialization vector of the PRBS generator for both uplink and downlink shall be designated b10..b0, such that:

b0:b4= Five least significant bits of IDcell as indicated by the frame preamble in the first downlink zone (*FirstZone* = YES) or DL_PermBase in the other zones. For downlink and uplink, b0 is MSB and b4 is LSB, respectively.

b5:b6= Set to the segment number + 1 as indicated by the frame preamble in the first downlink zone (*FirstZone* = YES) or PRBS_ID in the other zones (*FirstZone*=NO). For downlink and uplink, b5 is MSB and b6 is LSB, respectively.

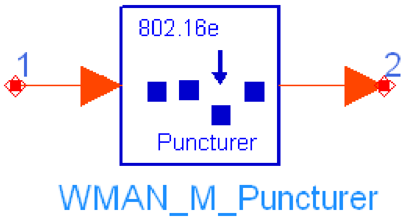
b7:b10= 0b1111 (all ones) in the downlink. For downlink and uplink, b7 is MSB and b10 is LSB, respectively.

The PRBS generator shall be clocked n times, n = *SymbolOffset* mod 32, before the generated output is applied to the subcarriers, where symbol offset is counted from the first symbol in each zone as zero in the downlink. As a result, the PRBS shall be used such that its n'th output bit will coincide with the first usable subcarrier as defined for the zone in which the symbol resides. The output bit shall be counted from zero. A new value shall be generated by the PRBS generator for every subcarrier up to the highest numbered usable subcarrier, in order of physical subcarriers, including the DC subcarrier and usable subcarriers that are not allocated.
PilotPN_Phase specifies the start phase of pilots (i.e., symbol offset). The specification requires PilotPN_Phase = 0.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_Puncturer (802.16e OFDMA Puncturer and Depuncturer)



Description: Puncturer and Depuncturer
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
NumOfBranch	Number of convolution branch	2	int	[1,3]
Pattern	Position mask code of reserved bits	{1,1}	int array	{0,1}
PunctureMode	Selection of stealing or inserting: Stealing, Inserting	Stealing	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	in	input of puncture	anytype

Pin Outputs

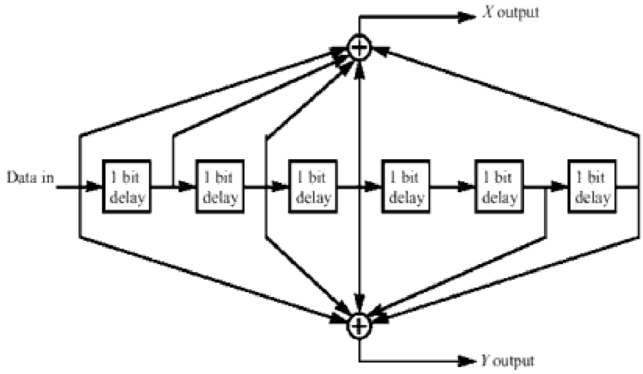
Pin	Name	Description	Signal Type
2	out	output of puncture	anytype

Notes/Equations

1. This model is used to do puncture or depuncture depending on *PunctureMode*. Depuncture is reverse of puncture. Puncturing pattern and serialization order that shall be used to realize different code rates are defined in the following table. In the table, "1" means a transmitted bit and "0" denotes a removed bit where X and Y are in reference to the following figure.

The Inner Convolutional Code with Puncturing Configuration

Rate	1/2	2/3	3/4	5/6
dfree	10	6	5	4
X	1	10	101	10101
Y	1	11	110	11010
XY	$X_1 Y_1$	$X_1 Y_1 Y_2$	$X_1 Y_1 Y_2 X_3$	$X_1 Y_1 Y_2 X_3 Y_4 X_5$

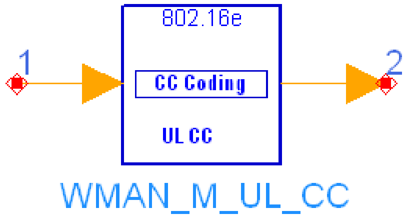


Convolutional Encoder of Rate 1/2

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_CC (802.16e OFDMA UL Convolutional Coding)



Description: Uplink convolutional coding
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
BurstAssignedSlot	Assigned slots of burst	1	int	[1,6868]
Rate_ID	Rate ID	1	int	[0,6]
RepetitionCoding	Repetition coding	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

Notes/Equations

1. This model is used to perform convolutional coding on randomized data of uplink burst.
2. Each firing,
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8$ tokens are consumed at pin DataIn, where, *EffectiveSlots* is the number of slots actually used to transmit data, i.e. *EffectiveSlots = floor(AssignedSlots / R)*, where

     AssignedSlots is the number of slots assigned to the burst

     R is repetition factor, which is 1, 2, 4 or 6 for QPSK and 1 for other modulation schemes

     STCRate is the multiple due to STC encoding, which is dependent on STC_Encoder and STC_Matrix

     UncodedSlotSize is the number of bytes within one slot before channel coding.
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8/(CodingRate)$ tokens are generated at pin *DataOut*, where *CodingRate* is coding rate.
3. Each FEC block is encoded by the binary convolutionary encoder, which shall have native rate 1/2, a constraint length equal to K = 7, and shall use the following generator polynomials codes to derive its two code bits:

   $G_1 = 171_{OCT}$ for *X*

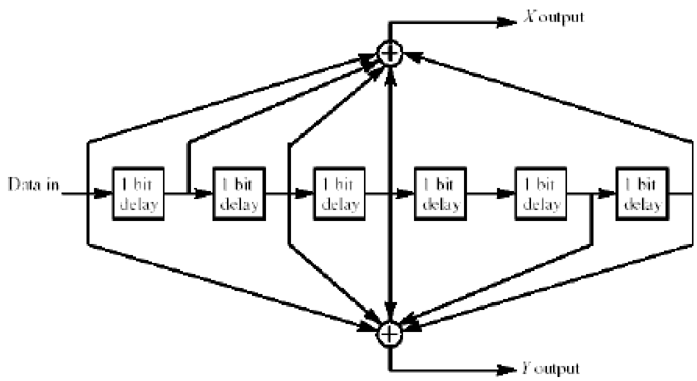
   $G_2 = 133_{OCT}$ for *Y*

   The generator is depicted in the following figure.

4. The puncturing patterns and serialization order that shall be used to realize different code rates are defined in the following table. In the table, "1" means a transmitted bit and "0" denotes a removed bit, whereas X and Y are in reference to the following figure.

The Convolutional Code with Puncturing Configuration

Code Rates	1/2	2/3	3/4
dfree	10	6	5
X	1	10	101
Y	1	11	110
XY	$X_1 Y_1$	$X_1 Y_1 Y_2$	$X_1 Y_1 Y_2 Y_3$



Convolutional Encoder of Rate 1/2

5. The FEC block size shall depend on EffectiveSlots and modulation specified for the current transmission. Concatenation of a number of slots shall be performed in order to make larger blocks of coding where it is possible, with the limitation of not exceeding the largest supported block size for the applied modulation and coding. The following tables specify the concatenation of slots for different allocations and modulations for CC and BTC encoding scheme.

Slots Concatenation Rule for CC

Number of slots	Slots concatenated
n <= j	1 block of n slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of ceil((m+j)/2) slots
	1 block of floor((m+j)/2) slots

Encoding Slot Concatenation for Different Allocations and Modulations for CC

Modulation and rate	j
QPSK 1/2	j = 6
QPSK 3/4	j = 4
16-QAM 1/2	j = 3
16-QAM 3/4	j = 2
64-QAM 1/2	j = 2
64-QAM 2/3	j = 1
64-QAM 3/4	j = 1

where

j: parameter dependent on the modulation and FEC rate,

n: floor(number of allocated slots/repetition factor), i.e. EffectiveSlots,

k: floor(n / j),

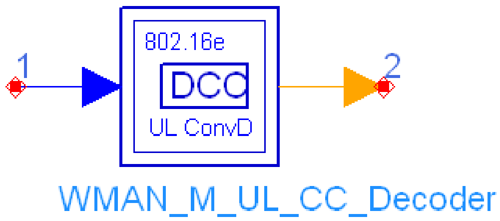
m: n modulo j

6. Each FEC block is encoded by a tail-biting convolutional encoder, which is achieved by initializing the encoders memory with the last data bits of the FEC block being encoded (the packet data bits numbered $b_{n-5}...b_{n}$).

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_CC_Decoder (802.16e OFDMA UL CC Decoding)



Description: Uplink CC decoding
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
BurstAssignedSlot	Assigned slots of burst	2	int	[1,6868]
Rate_ID	Rate ID of each burst	1	int	[0,6]
RepetitionCoding	Repetition coding of each burst	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	

Pin Inputs

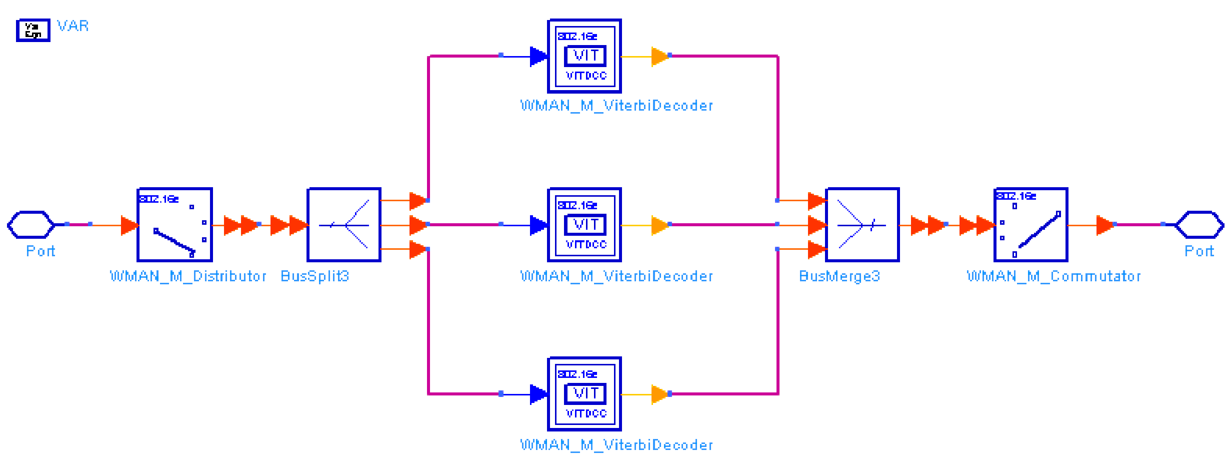
Pin	Name	Description	Signal Type
1	DataIn	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

Notes/Equations

1. This subnetwork is used to do forward error correction decoding on uplink, consisting of data distributor, convolutional decoder and data commutator.
2. The schematic of this subnetwork is shown in the following figure.



WMAN_M_UL_CC_Decoder schematic

3. The convolutional decoder uses the viterbi decoding algorithm. The following tables specify the concatenation of slots for different allocations and modulations for CC encoding scheme.

Slots Concatenation Rule for CC

Number of slots	Slots concatenated
n <= j	1 block of n slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of ceil((m+j)/2) slots
	1 block of floor((m+j)/2) slots

Encoding Slot Concatenation for Different Allocations and Modulations for CC

Modulation and rate	j
QPSK 1/2	j = 6
QPSK 3/4	j = 4
16-QAM 1/2	j = 3
16-QAM 3/4	j = 2
64-QAM 1/2	j = 2
64-QAM 2/3	j = 1
64-QAM 3/4	j = 1

where

j: parameter dependent on the modulation and FEC rate

n: floor (number of allocated slots/repetition factor), i.e. *EffectiveSlots*

k: floor (n / j)

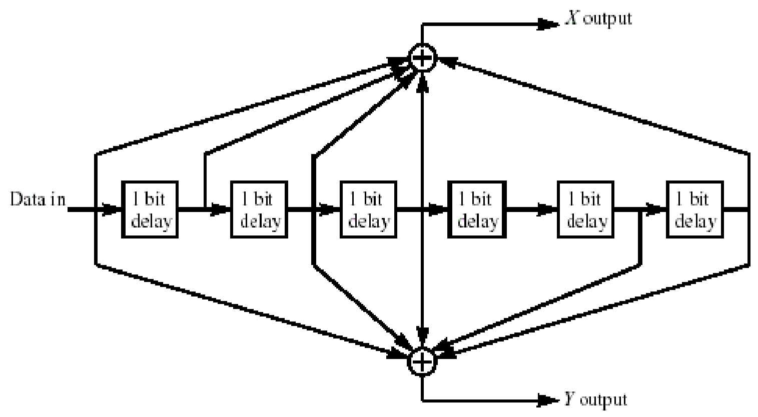
m: n modulo j

The binary convolutionary encoder, shall have native rate 1/2, a constraint length equal to K = 7, and shall use the following generator polynomials codes to derive its two code bits:

$G_1 = 171_{OCT}$ for X

$G_2 = 133_{OCT}$ for Y

The generator is depicted in the following figure. It's implemented by a tail-biting convolutional encoder, which is achieved by initializing the encoders memory with the last data bits of the CC block being encoded (the packet data bits numbered $b_{n-5}...b_n$).

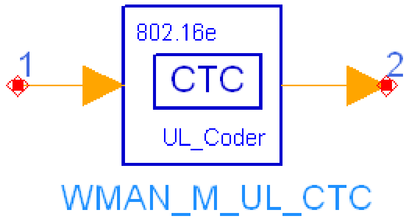


Convolutional encoder of rate 1/2

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_CTC (802.16e OFDMA UL Convolutional Turbo Coding)



Description: Uplink convolutional turbo coding
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
BurstAssignedSlot	Assigned slots of burst	96	int	[1,6868]
Rate_ID	Rate ID of each burst	1	int	[0,7]
RepetitionCoding	Preamble present	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

Notes/Equations

1. This model is used to perform convolutional turbo coding on randomized data on uplink.
2. Each firing,
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8$ tokens are consumed at pin DataIn, where, *EffectiveSlots* is the number of slots actually used to transmit data before repetition coding, i.e. *EffectiveSlots = floor (AssignedSlots / R)*, where

     AssignedSlots is the number of slots assigned to the burst,

     R is repetition factor, which is 1, 2, 4 or 6 for QPSK and 1 for other modulation schemes,

     STCRate is the multiple due to STC encoding, which is dependent on *STC_Encoder* and *STC_Matrix*,

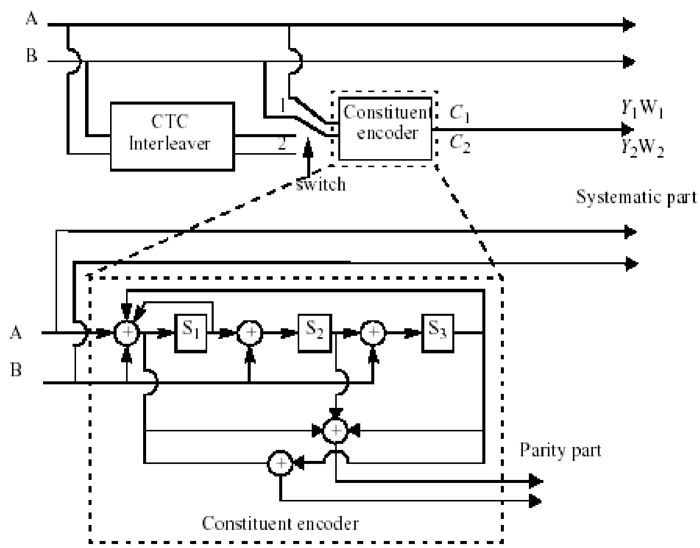
     UncodedSlotSize is the number of bytes within one slot before channel coding.
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8 / CodingRate$ tokens are generated at pin DataOut, where *CodingRate* is shown in the following table.
3. The CTC encoder, including its constituent encoder, is depicted in the following figure. It uses a double binary Circular Recursive Systematic Convolutional code. The bits of the data to be encoded are alternately fed to A and B, starting with the MSB of the first byte being fed to A. The encoder is fed by blocks of k bits or N couples (!wman_m-03-19-130.gif! bits). For all the frame sizes, k is a multiple of 8 and N is a multiple of 4. Further, N shall be limited to: $8 \le N/4 \le 1024$.
   The polynomials defining the connections are described in octal and symbol notations as follows:

   For the feedback branch: 0xB, equivalently $1 + D + D_{3}$ (in symbolic notation)

   For the Y parity bit: 0xD, equivalently $1 + D \quad + D$

2 3

For the W parity bit: 0x9, equivalently $1 + D_3$



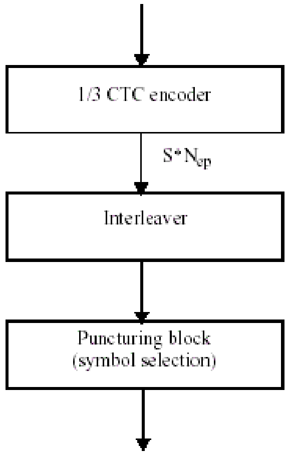
CTC Encoder.

4. The state of the encoder is denoted *S* (!wman_m-03-19-133.gif!) with $S = 4s_1 + 2s_2 + s_3$ (see the previous figure). The circulation states Sc_1 and Sc_2 are determined by the following operations:
   - Initialize the encoder with state 0. Encode the sequence in the natural order for the determination of Sc_1 or in the interleaved order for determination of Sc_2. In both cases the final state of the encoder is $S0_{N-1}$;
   - According to the length *N* of the sequence, use the following table to find Sc_1 or Sc_2.

Circulation State Lookup Table (Sc)

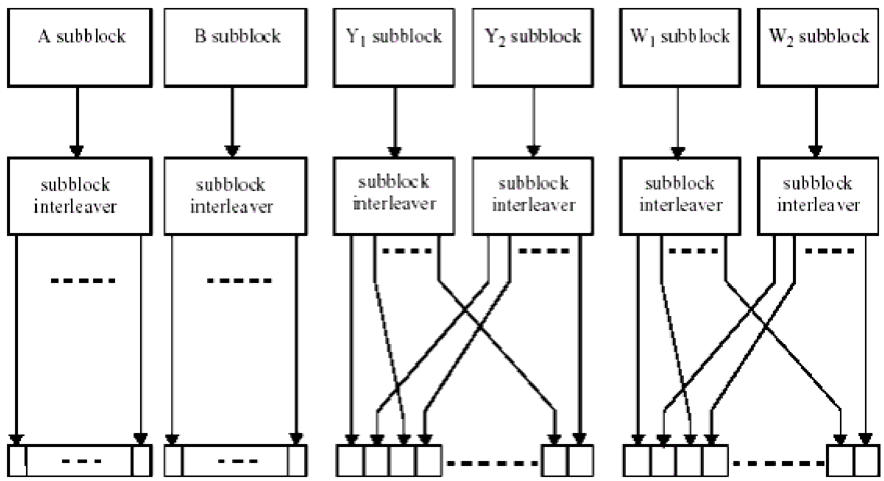
Nmod7	**S0N-1**							
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	0	6	4	2	7	1	3	5
2	0	3	7	4	5	6	2	1
3	0	5	3	6	2	7	1	4
4	0	4	1	5	6	2	7	3
5	0	2	5	7	1	3	4	6
6	0	7	6	1	3	4	5	2

5. The encoder (after initialization by the circulation state Sc_1) is fed the sequence in the natural order (position 1) with the incremental address $i = 0,\dots N-1$. This first encoding is called C_1 encoding. Then the encoder (after initialization by the circulation state Sc_2) is fed by the interleaved sequence (switch in position 2) with incremental address $j = 0,\dots N-1$. This second encoding is called C_2 encoding.
6. The order in which the encoded bit shall be fed into the subpacket generation block is:
   $A, B, Y_1, Y_2, W_1, W_2 = A_0, A_1, \dots, A_{N-1}, B_0, B_{1,} \dots, B_{N-1}, Y_{1,0}, Y_{1,1}, \dots, Y_{1,N-1}, Y_{2,0}, Y_{2,1}, \dots, Y_{2,N-1}, W_{1,0}, W_{1,1}, \dots, W_{1,N-1}, W_{2,0}, W_{2,1}, \dots, W_{2,N-1}$
7. Proposed FEC structure punctures the mother codeword to generate a subpacket with various coding rates. The following figure shows a block diagram of subpacket generation. 1/3 CTC encoded codeword goes through interleaving block and the puncturing is performed.



Block Diagram of Subpacket Generation

The following figure shows block diagram of the interleaving block. The puncturing is performed to select the consecutive interleaved bit sequence that starts at any point of whole codeword. For the first transmission, the subpacket is generated to select the consecutive interleaved bit sequence that starts from the first bit of the systematic part of the mother codeword. The length of the subpacket is chosen according to the needed coding rate reflecting the channel condition. The first subpacket can also be used as a codeword with the needed coding rate for a burst where HARQ is not applied.



Block Diagram of the Interleaving Scheme

8. The FEC block size shall depend on EffectiveSlots and modulation specified for the current transmission. Concatenation of a number of slots shall be performed in order to make larger blocks of coding where it is possible, with the limitation of not exceeding the largest supported block size for the applied modulation and coding. The following table specifies the rules used for slot concatenation.

Slots Concatenation Rule for CTC

Number of slots	Slots concatenated
$n \le j$ n != 7	1 block of n slots
n = 7	1 block of 4 slots 1 block of 3 slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of L_{b1} slots
	1 block of L_{b2} slots
	where
	L_{b1} = ceil((m+j)/2)
	L_{b2} = floor((m+j)/2)
	If (L_{b1} = 7) or (L_{b2} = 7)
	$L_{b1} = L_{b1} + 1$; $L_{b2} = L_{b2} + 1$

The following table specifies the concatenation of slots for different allocations and modulations.

Encoding Slot Concatenation for Different Rates in CTC

Modulation and rate	j
QPSK 1/2	10
QPSK 3/4	6
16-QAM 1/2	5
16-QAM 3/4	3
64-QAM 1/2	3
64-QAM 2/3	2
64-QAM 3/4	2
64-QAM 5/6	2

For any modulation and FEC rate, given an allocation of n slots, the following parameters are defined:

j: parameter dependent on the modulation and FEC rate

n: number of allocated slots/repetition factor

k = floor(n/j)

m = n mod j

9. The following table gives the block sizes, code rates, channel efficiency, and code parameters for the different modulation and coding schemes. As 64-QAM is optional, the codes for this modulation shall only be implemented if the modulation is implemented.

Optimal CTC Channel Coding per Modulation

Modulation	Data block size (bytes)	Encoded data block size (bytes)	Code rate	N	P0	P1	P2	P3
QPSK	6	12	1/2	24	5	0	0	0
QPSK	12	24	1/2	48	13	24	0	24
QPSK	18	36	1/2	72	11	6	0	6
QPSK	24	48	1/2	96	7	48	24	72
QPSK	30	60	1/2	120	13	60	0	60
QPSK	36	72	1/2	144	17	74	72	2
QPSK	48	96	1/2	192	11	96	48	144
QPSK	54	108	1/2	216	13	108	0	108
QPSK	60	120	1/2	240	13	120	60	180
QPSK	9	12	3/4	36	11	18	0	18
QPSK	18	24	3/4	72	11	6	0	6
QPSK	27	36	3/4	108	11	54	56	2
QPSK	36	48	3/4	144	17	74	72	2
QPSK	45	60	3/4	180	11	90	0	90
QPSK	54	72	3/4	216	13	108	0	108
16-QAM	12	24	1/2	48	13	24	0	24
16-QAM	24	48	1/2	96	7	48	24	72
16-QAM	36	72	1/2	144	17	74	72	2
16-QAM	48	96	1/2	192	11	96	48	144
16-QAM	60	120	1/2	240	13	120	60	180
16-QAM	18	24	3/4	72	11	6	0	6
16-QAM	36	48	3/4	144	17	74	72	2
16-QAM	54	72	3/4	216	13	108	0	108
64-QAM	18	36	1/2	72	11	6	0	6
64-QAM	36	72	1/2	144	17	74	72	2
64-QAM	54	108	1/2	216	13	108	0	108
64-QAM	24	36	2/3	96	7	48	24	72
64-QAM	48	72	2/3	192	11	96	48	144
64-QAM	27	36	3/4	108	11	54	56	2
64-QAM	54	72	3/4	216	13	108	0	108
64-QAM	30	36	5/6	120	13	60	0	60
64-QAM	60	72	5/6	240	13	120	60	180

10. The interleaver requires the parameters P_0, P_1, P_2 and P_3, shown in the previous table. The two-step interleaver shall be performed by:

    Step 1: Switch alternate couples
    for *j* = 0,... *N-1*
    if (*j* mod 2==1) let (*B,A*) = (*A,B*) (i.e., switch the couple)

    Step 2: *Pi(j)*
    The function *Pi(j)* provides the interleaved address i of the consider couple *j*. (i.e. *InterleavedVec(j) = OriginalVec(Pi(j)))*.
    for *j = 0,... N-1*
    switch *j mod 4*:
    case 0: $i = (P_0 \times j + 1) mod(N)$
    case 1: $i = (P_0 \times j + 1 + N/2 + P_1) mod(N)$
    case 2: $i = (P_0 \times j + 1 + P_2) mod(N)$
    case 3: $i = (P_0 \times j + 1 + N/2 + P_3) mod(N)$

11. All of the encoded symbols shall be demultiplexed into six subblocks denoted A, B, Y_1, Y_2, W_1, and W_2. The encoder output symbols shall be sequentially distributed into six subblocks with the first *N* encoder output symbols going to the A subblock, the second *N* encoder output going to the *B* subblock, the third *N* to the Y_1 subblock, the fourth *N* to the Y_2 subblock, the fifth *N* to the W_1 subblock, the sixth *N* to the W_2 subblock.
12. The six subblocks shall be interleaved separately. The interleaving is performed by the unit of symbol. The sequence of interleaver output symbols for each subblock shall be generated by the procedure described

below. The entire subblock of symbols to be interleaved is written into an array at addresses from 0 to the number of the symbols minus one (N-1), and the interleaved symbols are read out in a permuted order with the i-th symbol being read from an address, AD_i $(i = 0,... N-1)$, as follows:

1. Determine the subblock interleaver parameters, m and J. The following table gives these parameters.
2. Initialize i and k to 0.
3. Form a tentative output address Tk according to the formula Tk = 2m (k mod J) + BRO_m(k/J) where BROm(y) indicates the bit-reversed m-bit value of y (i.e., BRO3(6) = 3).
4. If Tk is less than N, ADi = Tk and increment i and k by 1. Otherwise, discard Tk and increment k only.
5. Repeat steps 1) and 2) until all N interleaver output addresses are obtained.
   The parameters for the subblock interleavers are specified in the following table.

Parameter for the Subblock Interleavers

Block size (bits) NEP	N	Subblock interleaver parameters	
		m	J
48	24	3	3
72	36	4	3
96	48	4	3
144	72	5	3
192	96	5	3
216	108	5	4
240	120	6	2
288	144	6	3
360	180	6	3
384	192	6	3
432	216	6	4
480	240	7	2

13. The channel interleaver output sequence shall consist of the interleaved A and B subblock sequence, followed by a symbol-by-symbol multiplexed sequence of the interleaved Y_1 and Y_2 subblock sequences, followed by a symbol-by-symbol multiplexed sequence of the interleaved W_1 and W_2 subblock sequences. The symbol-by-symbol multiplexed sequence of interleaved Y_1 and Y_2 subblock sequences shall consist of the first output bit from the Y_1 subblock interleaver, the first output bit from the Y_2 subblock interleaver, the second output bit from the Y_1 subblock interleaver, the second output bit from the Y_2 subblock interleaver, etc. The symbol-by-symbol multiplexed sequence of interleaved W_1 and W_2 subblock sequences shall consist of the first output bit from the W_1 subblock interleaver, the first output bit from the W_2 subblock interleaver, the second output bit from the W_1 subblock interleaver, the second output bit from the W_2 subblock interleaver, etc. Block Diagram of the Interleaving Scheme shows the interleaving scheme.
14. Lastly, symbol selection is performed to generate the subpacket. The puncturing block is referred as symbols selection in the viewpoint of subpacket generation. Mother code is transmitted with one of subpackets. The symbols in a subpacket are formed by selecting specific sequences of symbols from the interleaved CTC encoder output sequence. The resulting subpacket sequence is a binary sequence of symbols for the modulator.
    Let

    k be the subpacket index when HARQ is enabled. $k = 0$ for the first transmission and increases by one for the next subpacket. $k = 0$ when H-ARQ is not used. When there are more than one FEC block in a burst, the subpacket index for each FEC block shall be the same.

    N_{EP} be the number of bits in the encoder packet (before encoding).

    N_{SCHk} be the number of the concatenated slots for the subpacket defined in *Slots Concatenation Rule for CTC* for non H-ARQ CTC scheme.

m_k be the modulation order for the k-th subpacket (m_k = 2 for QPSK, 4 for 16-QAM, and 6 for 64-QAM).

$SPID_k$ be the subpacket ID for the k-th subpacket, (for the first subpacket, $SPID_{k=0} = 0$).

Also, let the scrambled and selected symbols be numbered from zero with the 0-th symbol being the first symbol in the sequence. Then, the index of the i-th symbol for the k-th subpacket shall be:
$$S_{k,i} = (F_k + i) mod(3 \times N_{EP})$$
where:

$i = 0, \ldots L_k - 1$

$$L_k = 48 \times N_{SCHk} \times m_k$$

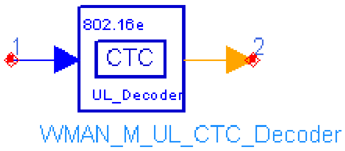
$$F_k = (SPID_k \times L_k) mod(3 \times N_{EP})$$

The N_{EP}, N_{SCHk}, m_k, and *SPID* values are determined by the BS and can be inferred by the SS through the allocation size in the DL-MAP and UL-MAP. The above symbol selection makes the following possible.
1) The first transmission includes the systematic part of the mother code. Thus, it can be used as the codeword for a burst where the HARQ is not applied.
2) The location of the subpacket can be determined by the *SPID* itself without the knowledge of previous subpacket. It is very important property for HARQ retransmission.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_CTC_Decoder (802.16e OFDMA Uplink CTC Decoder)



Description: Uplink convolutional turbo decoder
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
BurstAssignedSlot	Assigned slots	96	int	[1,6868]
Rate_ID	Rate ID	1	int	[0,7]
RepetitionCoding	Repetition coding	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	
IterationNumber	The number of iterations	8	int	[1,16]
CycleNumber	The number of decoding cycles to get circulation states	1	int	[1,16]

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

Notes/Equations

1. This component is used for convolutional turbo decoding with max-log-MAP algorithm.
2. Each firing,
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8 / CodingRate$ tokens are consumed at pin DataIn, where *CodingRate* is shown in the following table.
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8$ tokens are produced at pin DataOut, where, *EffectiveSlots* is the number of slots actually used to transmit data before repetition coding, i.e. *EffectiveSlots = floor (BurstAssignedSlots / R)*, where

     AssignedSlots is the number of slots assigned to the burst,

     R is repetition factor, which is 1, 2, 4 or 6 for QPSK and 1 for other modulation schemes,

     STCRate is the multiple due to STC encoding, which is dependent on *STC_Encoder* and *STC_Matrix*. When *STC_Encoder* = Yes and *STC_Matrix* = B, *STCRate* is 2; otherwise *STCRate* is 1.

     UncodedSlotSize is the number of bytes within one slot before channel coding (see the following table).

Modulation, Rate and UncodedSlotSize for Each Rate ID

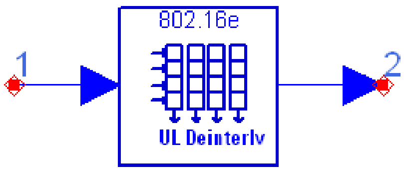
Rate ID	Modulation and rate	UncodedSlotSize
0	QPSK 1/2	6
1	QPSK 3/4	9
2	16-QAM 1/2	12
3	16-QAM 3/4	18
4	64-QAM 1/2	18
5	64-QAM 2/3	24
6	64-QAM 3/4	27
7	64-QAM 5/6	30

3. This model performs the reverse operations against CTC encoder. This mode performs the same functions as WMAN_M_DL_CTC_Decoder. For more information, please refer to the documenation of WMAN_M_DL_CTC_Decoder.

References

1. IEEE Std 802.16-2004, *Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY*, October 1, 2004.
2. IEEE Std 802.16e-2005, *Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY,* February 2006.
3. C. Berrou, C. Douillard, and M. Jezequel. *Multiple parallel concatenation of circular recursive convolutional (CRSC) codes*. Annals of Telecommunication, 54(3-4):166-172, Mar.-Apr. 1999.
4. P. Robertson, P. Hoeher, and E. Villebrun. *Optimal and sub-optimal maximum a posteriori algorithms suitable for turbo decoding*. European Trans. on Telecommun., 8(2):119-125, Mar./Apr. 1997.

WMAN_M_UL_Deinterleaver (802.16e OFDMA UL Deinterleaver)



WMAN_M_UL_Deinterleaver

Description: Uplink deinterleaver
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
BurstAssignedSlot	Assigned slots of burst	1	int	[1,6868]
Rate_ID	Rate ID	1	int	[0,6]
RepetitionCoding	Repetition coding	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	real

Notes/Equations

1. This model is used to perform Deinterleaving on demodulated data of uplink burst.
2. Each firing,
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8/(CodingRate)$ tokens are consumed at pin DataIn, and the same number of tokens are generated at pin DataOut, where *EffectiveSlots* is the number of slots actually used to transmit data, i.e. *EffectiveSlots* = floor(AssignedSlots / R), where

     AssignedSlots is the number of slots assigned to the burst,

     R is repetition factor, which is 1, 2, 4 or 6 for QPSK and 1 for other modulation schemes,

     STCRate is the multiple due to STC encoding, which is dependent on STC_Encoder and STC_Matrix,

     UncodedSlotSize is the number of bytes within one slot before channel coding.

     CodingRate is coding rate.
   - All demodulated data bits shall be deinterleaved by a block deinterleaver with a block size corresponding to the number of coded bits per the encoded block size N_{cbps}. The deinterleaver is defined by a two-step permutation. Within a received block of N_{cbps} bits, let *j* be the index of a received bit before the first permutation; m_j be the index of that bit after the first and before the second permutation; and let k_j be the index of that bit after the second permutation, just prior to delivering the block to the decoder. The first permutation is defined by the following equation:
     $$m_j = s \times floor(j/s) + (j + floor(d \times j/N_{cbps}))_{mod(s)}$$
     j = 0, 1, ..., N - 1, d = 16

cbps

The second permutation is defined by the following equation:

$$k_j = d \times m_j - (N_{cbps} - 1) \times floor(d \times m_j / N_{cbps})$$

j = 0, 1, ..., N $_{cbps}$ *- 1, d = 16*

The first permutation in the de-interleaver is the inverse of the second permutation in the interleaver, and conversely.

3. The FEC block size shall depend on EffectiveSlots and modulation specified for the current transmission. Concatenation of a number of slots shall be performed in order to make larger blocks of coding where it is possible, with the limitation of not exceeding the largest supported block size for the applied modulation and coding. The following tables specify the concatenation of slots for different allocations and modulations for CC and BTC encoding scheme.

Slots Concatenation Rule for CC

Number of slots	Slots concatenated
n <= j	1 block of n slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of ceil((m+j)/2) slots
	1 block of floor((m+j)/2) slots

Encoding Slot Concatenation for Different Allocations and Modulations for CC

Modulation and rate	j
QPSK 1/2	j = 6
QPSK 3/4	j = 4
16-QAM 1/2	j = 3
16-QAM 3/4	j = 2
64-QAM 1/2	j = 2
64-QAM 2/3	j = 1
64-QAM 3/4	j = 1

Where

j: parameter dependent on the modulation and FEC rate

n: floor(number of allocated slots/repetition factor), i.e. EffectiveSlots

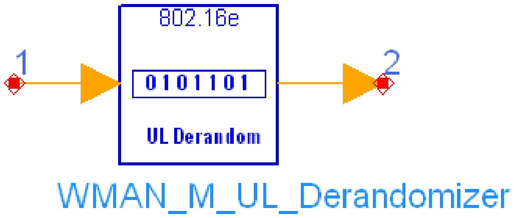
_k: floor(n / j))

m: n modulo j

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_Derandomizer (802.16e OFDMA Uplink Derandomizer)



Description: Uplink derandomizer
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
BurstAssignedSlot	Assigned slots of burst	1	int	[1,6868]
CodingType	Coding type	0	int	[0,1]
Rate_ID	Rate ID	1	int	[0,7]
RepetitionCoding	Repetition coding	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	
DataLength	MAC PDU payload byte length of burst	8	int	[1,∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

Notes/Equations

1. This model is used to perform derandomization on data of uplink burst.
2. Each firing,
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8$ tokens are consumed at pin DataIn, where EffectiveSlots is the number of slots actually used to transmit data, i.e. EffectiveSlots = floor(AssignedSlots / R), where

     AssignedSlots is the number of slots assigned to the burst

     R is repetition factor, which is 1, 2, 4 or 6 for QPSK and 1 for other modulation schemes

     STCRate is the multiple due to STC encoding, which is dependent on STC_Encoder and STC_Matrix

     UncodedSlotSize is the number of bytes within one slot before channel coding
   - $(DataLength + MACHeaderLength + MACCRCLength) \times 8$ tokens are generated at pin DataOut, where

     DataLength is the number of data bytes to transmit within the burst

     MACHeaderLength is the number of MAC Header bytes

     MACCRCLength is the number of MAC Header CRC bytes
3. The derandomization is initialized on each FEC block. If the amount of decoded data (!wman_m-03-22-153.gif!) does not fit exactly the amount of derandomized data (!wman_m-03-22-154.gif!), the remaining bits

shall be removed.

4. The FEC block size shall depend on EffectiveSlots and modulation specified for the current transmission. Concatenation of a number of slots shall be performed in order to make larger blocks of coding where it is possible, with the limitation of not exceeding the largest supported block size for the applied modulation and coding. The following tables specify the concatenation of slots for different allocations and modulations for CC and BTC encoding scheme.

Slots Concatenation Rule for CC

Number of slots	Slots concatenated
n <= j	1 block of n slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of ceil((m+j)/2) slots
	1 block of floor((m+j)/2) slots

Encoding Slot Concatenation for Different Allocations and Modulations for CC

Modulation and rate	j
QPSK 1/2	j = 10
QPSK 3/4	j = 6
16-QAM 1/2	j = 5
16-QAM 3/4	j = 3
64-QAM 1/2	j = 3
64-QAM 2/3	j = 2
64-QAM 3/4	j = 2
64-QAM 5/6	j = 2

The following tables specify the concatenation of slots for different allocations and modulations for CTC encoding scheme.

Encoding slot concatenation for different allocations and modulations for CTC

Modulation and rate	j
QPSK 1/2	j = 10
QPSK 3/4	j = 6
16-QAM 1/2	j = 5
16-QAM 3/4	j = 3
64-QAM 1/2	j = 3
64-QAM 2/3	j = 2
64-QAM 3/4	j = 2
64-QAM 5/6	j = 2

Slots Concatenation Rule for CTC

Number of slots	Slots concatenated
n <= j n != 7	1 block of n slots
n = 7	1 block of 4 slots 1 block of 3 slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of L_{b1} slots
	1 block of L_{b2} slots
	where
	L_{b1} = ceil((m+j)/2) slots
	L_{b2} = floor((m+j)/2) slots
	If (L_{b1} = 7) or (L_{b2} = 7)
	$L_{b1} = L_{b1} + 1$; $L_{b2} = L_{b2} + 1$

where

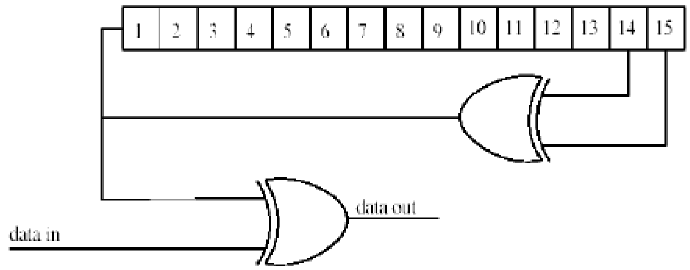
j: parameter dependent on the modulation and FEC rate

n: floor(number of allocated slots/repetition factor), i.e. EffectiveSlots

k: floor(n / j)

m: n modulo j

5. The PRBS generator shall be $1 + X^{14} + X^{15}$, as shown in the following figure, wherein "1" corresponds to LSB and "15" corresponds to MSB. Each decoded data byte shall enter sequentially into the derandomizer, MSB first. Preambles are not derandomized. The seed value shall be used to calculate the randomization bits, which are combined in an XOR operation with the serialized bit stream of each FEC block. The derandomizer is applied only to information bits.
The derandomizer is initialized with the factor [LSB] 0 1 1 0 1 1 1 0 0 0 1 0 1 0 1 [MSB].

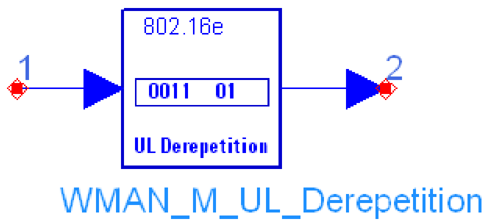


PRBS Generator for Data Randomization

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_Derepetition (802.16e OFDMA UL Repeater Removal)



Description: Uplink repeater removal
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
BurstAssignedSlot	Assigned slots of burst	1	int	[1,6868]
CodingType	Coding type	0	int	[0,1]
Rate_ID	Rate ID	1	int	[0,7]
RepetitionCoding	Repetition coding	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	real

Notes/Equations

1. This model performs the reverse process of repetition on uplink burst.
2. Each firing,
   - $AssignedSlots \times STCRate \times UncodedSlotSize \times 8 / CodingRate$ tokens are consumed at pin DataIn, where

     AssignedSlots is the number of slots assigned to the burst,

     STCRate is the multiple due to STC encoding, which is dependent on STC_Encoder and STC_Matrix,

     UncodedSlotSize is the number of bytes within one slot before channel coding,

     CodingRate is coding rate.
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8 / CodingRate$ tokens are generated at pin DataOut, where

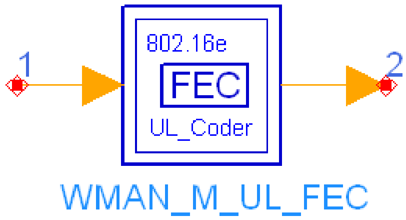
     EffectiveSlots is the number of slots actually used to transmit data before repetition coding, i.e. EffectiveSlots = floor (AssignedSlots / R), where

     R is repetition factor, which is 1, 2, 4 or 6 for QPSK and 1 for other modulation schemes.
3. In the case of repetition coding, R = 2, 4, or 6, AssignedSlots shall be in the range of [$R \times EffectiveSlots$, $R \times EffectiveSlots + (R-1)$]. The output data are the average of the input data, which are repeated R times. This repetition scheme applies only to QPSK modualtion; it can be applied in all coding schemes except H-ARQ with CTC.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_FEC (802.16e OFDMA UL Forward Error Coding)



Description: Uplink forward error coding
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
BurstAssignedSlot	Assigned slots of burst	2	int	[1,6868]
CodingType	Coding type: CC, CTC	0	int	[0,1]
Rate_ID	Rate ID of each burst	1	int	[0,7]
RepetitionCoding	Repetition coding of each burst	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	
DataLength	MAC PDU payload byte length of burst	8	int	[1,∞)
HARQ_Enable	Whether the burst is HARQ-enabled: NO, YES	NO	enum	

Pin Inputs

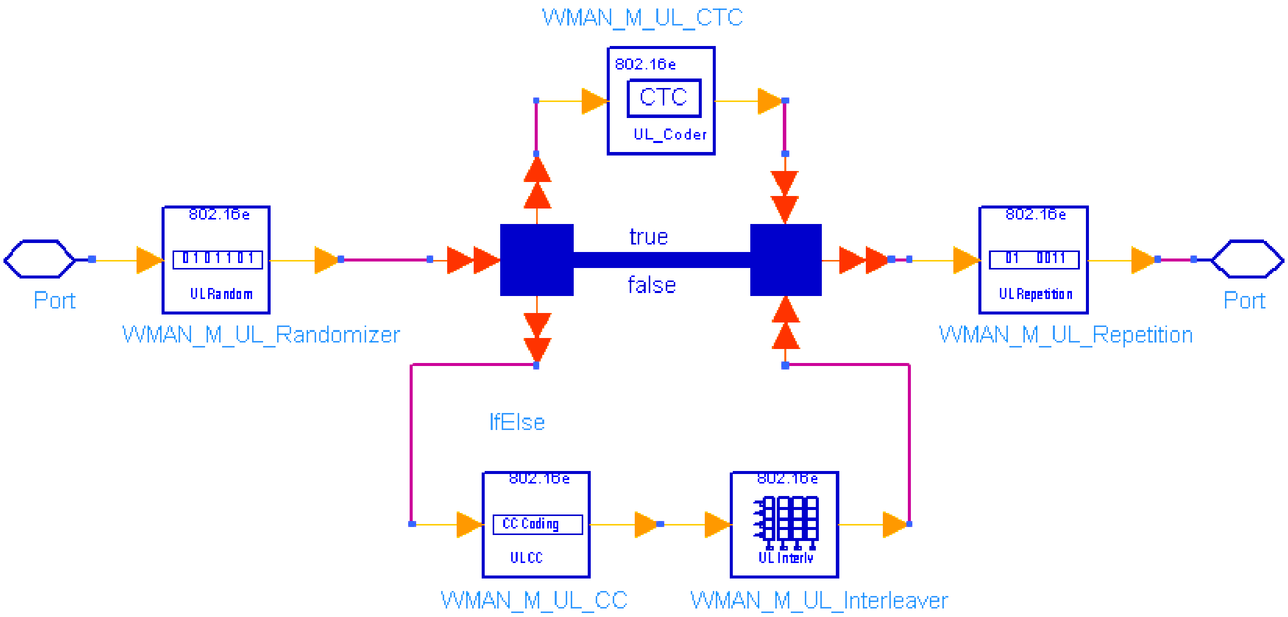
Pin	Name	Description	Signal Type
1	DataIn	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

Notes/Equations

1. This subnetwork is used to do forward error correction coding on uplink, consisting of randomizer, convolutional coder, interleaver, convolutional turbo coder and repetition.
2. The schematic of this subnetwork is shown in the following figure.



WMAN_M_UL_FEC Schematic

3. The randomization is initialized on each FEC block. If the amount of data to transmit (!wman_m-03-24-163.gif!) does not fit exactly the amount of data allocated (!wman_m-03-24-164.gif!), padding of 0xFF (*1* only) shall be added to the end of the transmission block, up to the amount of data allocated.
4. The FEC block size shall depend on EffectiveSlots and modulation specified for the current transmission. Concatenation of a number of slots shall be performed in order to make larger blocks of coding where it is possible, with the limitation of not exceeding the largest supported block size for the applied modulation and coding. The following tables specify the concatenation of slots for different allocations and modulations for CC encoding scheme.

Slots Concatenation Rule for CC

Number of slots	Slots concatenated
n <= j	1 block of n slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of ceil((m+j)/2) slots
	1 block of floor((m+j)/2) slots

Encoding Slot Concatenation for Different Allocations and Modulations for CC

Modulation and rate	j
QPSK 1/2	j = 6
QPSK 3/4	j = 4
16-QAM 1/2	j = 3
16-QAM 3/4	j = 2
64-QAM 1/2	j = 2
64-QAM 2/3	j = 1
64-QAM 3/4	j = 1

The following tables specify the concatenation of slots for different allocations and modulations for CTC encoding scheme.

Slots Concatenation Rule for CTC

Number of slots	Slots concatenated
n <= j n != 7	1 block of n slots
n = 7	1 block of 4 slots 1 block of 3 slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of L_{b1} slots
	1 block of L_{b2} slots
	where
	L_{b1} = ceil((m+j)/2) slots
	L_{b2} = floor((m+j)/2) slots
	If (L_{b1} = 7) or (L_{b2} = 7)
	$L_{b1} = L_{b1} + 1$; $L_{b2} = L_{b2} + 1$

Encoding Slot Concatenation for Different Allocations and Modulations for CTC

Modulation and rate	j
QPSK 1/2	j = 10
QPSK 3/4	j = 6
16-QAM 1/2	j = 5
16-QAM 3/4	j = 3
64-QAM 1/2	j = 3
64-QAM 2/3	j = 2
64-QAM 3/4	j = 2
64-QAM 5/6	j = 2

where

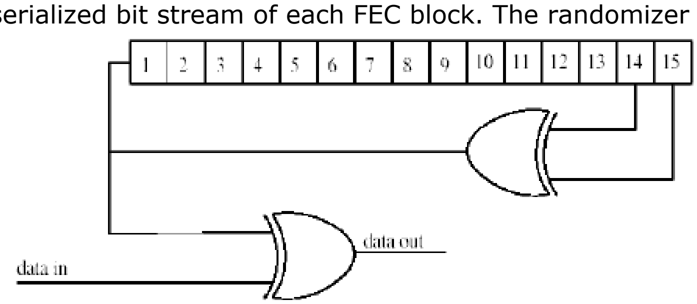
j: parameter dependent on the modulation and FEC rate

n: floor (number of allocated slots/repetition factor), i.e. EffectiveSlots

k: floor (n / j)

m: n modulo j

5. The PRBS generator shall be $1 + X^{14} + X^{15}$, as shown in the following figure. Each data byte to be transmitted shall enter sequentially into the randomizer, MSB first. Preambles are not randomized. The seed value shall be used to calculate the randomization bits, which are combined in an XOR operation with the serialized bit stream of each FEC block. The randomizer is applied only to information bits.



PRBS Generator for Data Randomization

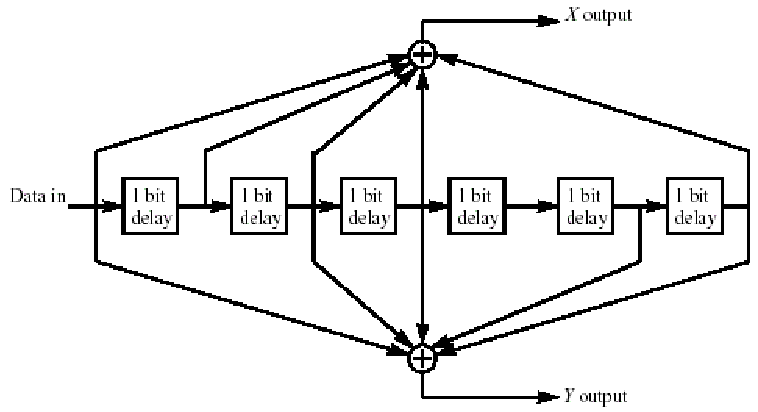
The randomizer is initialized with the factor [LSB] 0 1 1 0 1 1 1 0 0 0 1 0 1 0 1 [MSB].

6. When CodingType equals to 0, the branch of convolutional coding and interleaver is used. When CodingType equals to 1, the branch of convolutional turbo coding is used. If the value of Rate_ID is 7, which means 64-QAM modulation and 5/6 coding rate, the valude of CodingType must be 1.
The binary convolutionary encoder, shall have native rate 1/2, a constraint length equal to *K* = 7, and shall use the following generator polynomials codes to derive its two code bits:

$G_1 = 171_{OCT}$ for X

$G_2 = 133_{OCT}$ for Y

The generator is depicted in the following figure. It's implemented by a tail-biting convolutional encoder, which is achieved by initializing the encoders memory with the last data bits of the CC block being encoded (the packet data bits numbered $b_{n-5}...b_n$).



Convolutional Encoder of Rate 1/2

The puncturing patterns and serialization order that shall be used to realize different code rates are defined in the following table. In the table, "1" means a transmittted bit and "0" denotes a removed bit, whereas X and Y are in reference to the previous figure.

Convolutional Code with Puncturing Configuration

Rate	**1/2**	**2/3**	**3/4**
dfree	10	6	5
X	1	10	101
Y	1	11	110
XY	$X_1 Y_1$	$X_1 Y_1 Y_2$	$X_1 Y_1 Y_2 Y_3$

Each FEC block is encoded by a tail-biting convolutional encoder, which is achieved by initializing the encoders memory with the last data bits of the FEC block being encoded (the packet data bits numbered $b_{n-5}...b_n$).

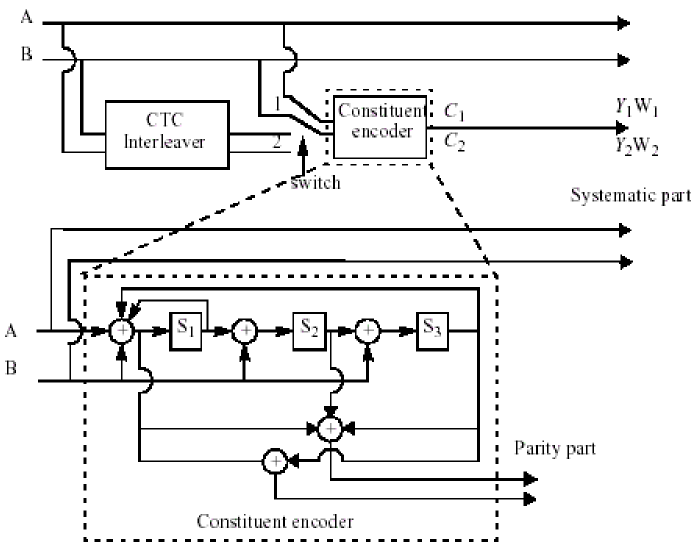
7. All convolutional encoded data bits shall be interleaved by a block interleaver with a block size corresponding to the number of coded bits per the encoded block size N_{cbps}. The interleaver is defined by a two-step permutation. The first ensures that adjacent coded bits are mapped onto nonadjacent subcarriers. The second permutation insures that adjacent coded bits are mapped alternately onto less or more significant bits of the constellation, thus avoiding long runs of lowly reliable bits.
Let N_{cpc} be the number of coded bits per subcarrier, i.e., 2, 4, or 6 for QPSK, 16-QAM or 64-QAM, respectively. Let $s = N_{cpc}/2$. Within a block of N_{cbps} bits at transmission, let k be the index of the coded bit before the first permutation, m_k be the index of that coded bit after the first and before the second permutation and let j_k be the index after the second permutation, just prior to modulation mapping, and d be the modulo used for the permutation.
The first permutation is defined by the following equation:
$$m_k = (N_{cbps}/d) \times k_{mod(d)} + floor(k/d)$$
$k = 0,1,..., N_{cbps} -1, d = 16$
The second permutation is defined by the following equation:
$$j_k = s \times floor(m_k/s) + (m_k + N_{cbps} - floor(d \times m_k/N_{cbps}))_{mod(s)}$$
$k = 0,1,..., N_{cbps} -1, d = 16$
8. The CTC encoder, including its constituent encoder, is depicted in the following figure. It uses a double binary

Circular Recursive Systematic Convolutional code. The bits of the data to be encoded are alternately fed to *A* and *B*, starting with the MSB of the first byte being fed to A. The encoder is fed by blocks of *k* bits or *N* couples (!wman_m-03-24-169.gif! bits). For all the frame sizes, *k* is a multiple of 8 and *N* is a multiple of 4. Further, *N* shall be limited to: $8 \le N/4 \le 1024$.
The polynomials defining the connections are described in octal and symbol notations as follows:

For the feedback branch: 0xB, equivalently $1 + D + D^3$ (in symbolic notation)

For the Y parity bit: 0xD, equivalently $1 + D^2 + D^3$

For the W parity bit: 0x9, equivalently $1 + D^3$



CTC Encoder

The state of the encoder is denoted S (!wman_m-03-24-172.gif!) with $S = 4s_1 + 2s_2 + s_3$ (see the previous figure). The circulation states Sc_1 and Sc_2 are determined by the following operations:

Initialize the encoder with state 0. Encode the sequence in the natural order for the determination of Sc_1 or in the interleaved order for determination of Sc_2. In both cases the final state of the encoder is $S0_{N-1}$;

According to the length *N* of the sequence, use the following table to find Sc_1 or Sc_2.

Circulation State Lookup Table (Sc)

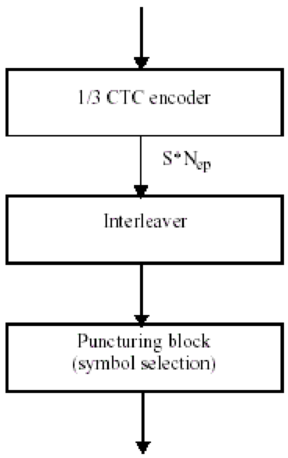
Nmod7	S0N-1							
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	0	6	4	2	7	1	3	5
2	0	3	7	4	5	6	2	1
3	0	5	3	6	2	7	1	4
4	0	4	1	5	6	2	7	3
5	0	2	5	7	1	3	4	6
6	0	7	6	1	3	4	5	2

The encoder (after initialization by the circulation state Sc_1) is fed the sequence in the natural order (position

1) with the incremental address $i = 0,\dots N-1$. This first encoding is called C_1 encoding. Then the encoder (after initialization by the circulation state Sc_2) is fed by the interleaved sequence (switch in position 2) with incremental address $j = 0,\dots N-1$. This second encoding is called C_2 encoding.

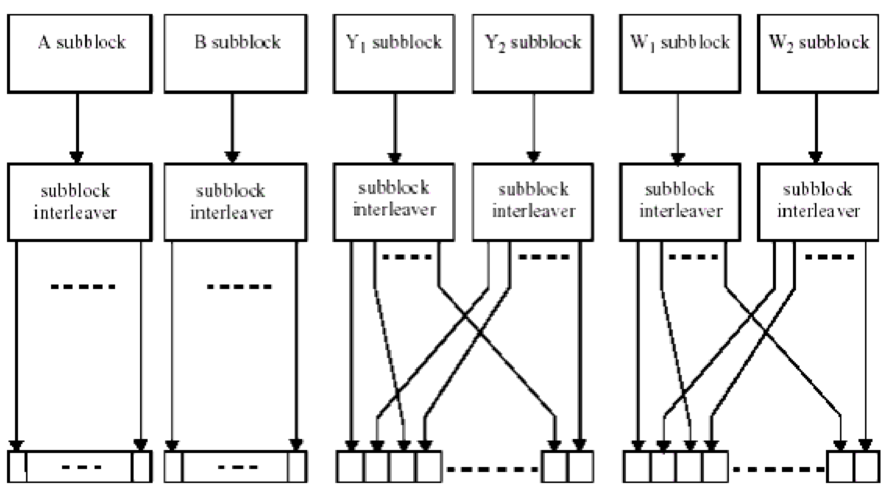
The order in which the encoded bit shall be fed into the subpacket generation block is:
$A, B, Y_1, Y_2, W_1, W_2 = A_0, A_1, \dots, A_{N-1}, B_0, B_1, \dots, B_{N-1}, Y_{1,0}, Y_{1,1}, \dots, Y_{1,N-1}, Y_{2,0}, Y_{2,1}, \dots, Y_{2,N-1}, W_{1,0}, W_{1,1}, \dots, W_{1,N-1}, W_{2,0}, W_{2,1}, \dots, W_{2,N-1}$

Proposed FEC structure punctures the mother codeword to generate a subpacket with various coding rates. The following figure shows a block diagram of subpacket generation. 1/3 CTC encoded codeword goes through interleaving block and the puncturing is performed.



Block Diagram of Subpacket Generation

The following figure shows block diagram of the interleaving block. The puncturing is performed to select the consecutive interleaved bit sequence that starts at any point of whole codeword. For the first transmission, the subpacket is generated to select the consecutive interleaved bit sequence that starts from the first bit of the systematic part of the mother codeword. The length of the subpacket is chosen according to the needed coding rate reflecting the channel condition. The first subpacket can also be used as a codeword with the needed coding rate for a burst where HARQ is not applied.



Block Diagram of the Interleaving Scheme

The following table gives the block sizes, code rates, channel efficiency, and code parameters for the different modulation and coding schemes. As 64-QAM is optional, the codes for this modulation shall only be implemented if the modulation is implemented.

Optimal CTC Channel Coding per Modulation

Modulation	Data block size (bytes)	Encoded data block size (bytes)	Code rate	N	P0	P1	P2	P3
QPSK	6	12	1/2	24	5	0	0	0
QPSK	12	24	1/2	48	13	24	0	24
QPSK	18	36	1/2	72	11	6	0	6
QPSK	24	48	1/2	96	7	48	24	72
QPSK	30	60	1/2	120	13	60	0	60
QPSK	36	72	1/2	144	17	74	72	2
QPSK	48	96	1/2	192	11	96	48	144
QPSK	54	108	1/2	216	13	108	0	108
QPSK	60	120	1/2	240	13	120	60	180
QPSK	9	12	3/4	36	11	18	0	18
QPSK	18	24	3/4	72	11	6	0	6
QPSK	27	36	3/4	108	11	54	56	2
QPSK	36	48	3/4	144	17	74	72	2
QPSK	45	60	3/4	180	11	90	0	90
QPSK	54	72	3/4	216	13	108	0	108
16-QAM	12	24	1/2	48	13	24	0	24
16-QAM	24	48	1/2	96	7	48	24	72
16-QAM	36	72	1/2	144	17	74	72	2
16-QAM	48	96	1/2	192	11	96	48	144
16-QAM	60	120	1/2	240	13	120	60	180
16-QAM	18	24	3/4	72	11	6	0	6
16-QAM	36	48	3/4	144	17	74	72	2
16-QAM	54	72	3/4	216	13	108	0	108
64-QAM	18	36	1/2	72	11	6	0	6
64-QAM	36	72	1/2	144	17	74	72	2
64-QAM	54	108	1/2	216	13	108	0	108
64-QAM	24	36	2/3	96	7	48	24	72
64-QAM	48	72	2/3	192	11	96	48	144
64-QAM	27	36	3/4	108	11	54	56	2
64-QAM	54	72	3/4	216	13	108	0	108
64-QAM	30	36	5/6	120	13	60	0	60
64-QAM	60	72	5/6	240	13	120	60	180

The interleaver requires the parameters P_0, P_1, P_2 and P_3, shown in the previous table. The two-step interleaver shall be performed by:

Step 1: Switch alternate couples
for *j = 0,... N-1*
if (*j* mod 2==1) let (*B,A*) = (*A,B*) (i.e., switch the couple)

Step 2: Pi(j)
The function *Pi(j)* provides the interleaved address i of the consider couple *j*. (i.e. *InterleavedVec(j) = OriginalVec(Pi(j)))*.
for *j* = 0,... *N-1*
switch *j mod 4*:
case 0: $i = (P_0 \times j + 1) mod(N)$
case 1: $i = (P_0 \times j + 1 + N/2 + P_1) mod(N)$
case 2: $i = (P_0 \times j + 1 + P_2) mod(N)$
case 3: $i = (P_0 \times j + 1 + N/2 + P_3) mod(N)$

All of the encoded symbols shall be demultiplexed into six subblocks denoted *A, B,* Y_1, Y_2, W_1, and W_2. The encoder output symbols shall be sequentially distributed into six subblocks with the first *N* encoder output symbols going to the A subblock, the second *N* encoder output going to the B subblock, the third *N* to the Y_1 subblock, the fourth *N* to the Y_2 subblock, the fifth *N* to the W_1 subblock, the sixth *N* to the W_2 subblock.

The six subblocks shall be interleaved separately. The interleaving is performed by the unit of symbol. The sequence of interleaver output symbols for each subblock shall be generated by the procedure described below. The entire subblock of symbols to be interleaved is written into an array at addresses from 0 to the number of the symbols minus one (N-1), and the interleaved symbols are read out in a permuted order with the *i*-th symbol being read from an address, AD_i (i = 0,... N-1), as follows:

1) Determine the subblock interleaver parameters, *m* and *J*. The following table gives these parameters.
2) Initialize *i* and *k* to 0.
3) Form a tentative output address T_k according to the formula $T_k = 2^m (k \bmod J) + BRO_m(k/J)$
where $BRO_m(y)$ indicates the bit-reversed m-bit value of *y* (i.e., $BRO_3(6) = 3$).
4) If T_k is less than N, $AD_i = T_k$ and increment i and *k* by 1. Otherwise, discard T_k and increment *k* only.
5) Repeat steps 1) and 2) until all *N* interleaver output addresses are obtained.
The parameters for the subblock interleavers are specified in the following table.

Parameter for the Subblock Interleavers

Block size (bits) NEP	N	Subblock interleaver parameters	
		m	**J**
48	24	3	3
72	36	4	3
96	48	4	3
144	72	5	3
192	96	5	3
216	108	5	4
240	120	6	2
288	144	6	3
360	180	6	3
384	192	6	3
432	216	6	4
480	240	7	2

The channel interleaver output sequence shall consist of the interleaved *A* and *B* subblock sequence, followed by a symbol-by-symbol multiplexed sequence of the interleaved Y_1 and Y_2 subblock sequences, followed by a symbol-by-symbol multiplexed sequence of the interleaved W_1 and W_2 subblock sequences. The symbol-by-symbol multiplexed sequence of interleaved Y_1 and Y_2 subblock sequences shall consist of the first output bit from the Y1 subblock interleaver, the first output bit from the Y_2 subblock interleaver, the second output bit from the Y_1 subblock interleaver, the second output bit from the Y2 subblock interleaver, etc. The symbol-by-symbol multiplexed sequence of interleaved W_1 and W_2 subblock sequences shall consist of the first output bit from the W_1 subblock interleaver, the first output bit from the W_2 subblock interleaver, the second output bit from the W_1 subblock interleaver, the second output bit from the W_2 subblock interleaver, etc. The previous figure shows the interleaving scheme.
Lastly, symbol selection is performed to generate the subpacket. The puncturing block is referred as symbols selection in the viewpoint of subpacket generation. Mother code is transmitted with one of subpackets. The symbols in a subpacket are formed by selecting specific sequences of symbols from the interleaved CTC encoder output sequence. The resulting subpacket sequence is a binary sequence of symbols for the modulator.
Let

k be the subpacket index when HARQ is enabled. *k* = 0 for the first transmission and increases by one for the next subpacket. *k* = 0 when H-ARQ is not used. When there are more than one FEC block in a burst, the subpacket index for each FEC block shall be the same.

N_{EP} be the number of bits in the encoder packet (before encoding).

N_{SCHk} be the number of the concatenated slots for the subpacket defined in the following table for non H-ARQ CTC scheme.

m_k be the modulation order for the *k*-th subpacket (m_k = 2 for QPSK, 4 for 16-QAM, and 6 for 64-QAM).

$SPID_k$ be the subpacket ID for the *k*-th subpacket, (for the first subpacket, $SPID_{k=0}$ = 0).

Also, let the scrambled and selected symbols be numbered from zero with the 0-th symbol being the first symbol in the sequence. Then, the index of the *i*-th symbol for the *k*-th subpacket shall be:
$$S_{k,i} = (F_k + i) mod(3 \times N_{EP})$$
where:

$i = 0, \dots L_k - 1$

$$L_k = 48 \times N_{SCHk} \times m_k$$

$$F_k = (SPID_k \times L_k) mod(3 \times N_{EP})$$

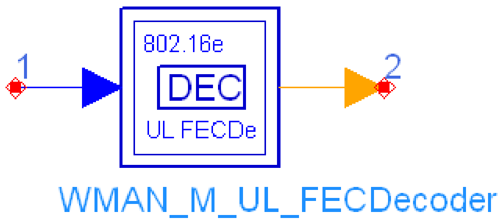
The N_{EP}, N_{SCHk}, m_k, and SPID values are determined by the BS and can be inferred by the SS through the allocation size in the DL-MAP and UL-MAP. The above symbol selection makes the following possible.
1) The first transmission includes the systematic part of the mother code. Thus, it can be used as the codeword for a burst where the HARQ is not applied.
2) The location of the subpacket can be determined by the SPID itself without the knowledge of previous subpacket. It is very important property for HARQ retransmission.

9. Repetition coding can be used to further increase signal margin over the modulation and FEC mechanisms. In the case of repetition coding, *R* = 2, 4, or 6, *AssignedSlots* shall be in the range of $[R \times EffectiveSlots, R \times EffectiveSlots + (R-1)]$. The binary data that fits into a region that is repetition coded is reduced by a factor *R* compared to a non-repeated region of the (!wman_m-03-24-183.gif!) slots with the same size and FEC code type. After FEC and bit-interleaving, the data is segmented into slots, and each group of bits designated to fit in a slot will be repeated *R* times to form *R* continuous slots following the normal slot ordering that is used for data mapping. If *AssignedSlots* is not integer multiples of R, the remaining slots (the number of them ranging from 1 to *R* - 1) will be padded with "1". This repetition scheme applies only to QPSK modualtion; it can be applied in all coding schemes except H-ARQ with CTC.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_FECDecoder (802.16e OFDMA UL Forward Error Decoding)



Description: Uplink forward error decoding
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
BurstAssignedSlot	Assigned slots of burst	2	int	[1,6868]
Rate_ID	Rate ID of each burst	1	int	[0,6]
RepetitionCoding	Repetition coding of each burst	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	
DataLength	MAC PDU payload byte length of burst	8	int	[1,∞)
CodingType	Coding type	1	int	[0,1]
IterationNumber	The number of iterations	8	int	[1,16]
CycleNumber	The number of decoding cycles to get circulation states	1	int	[1,16]

Pin Inputs

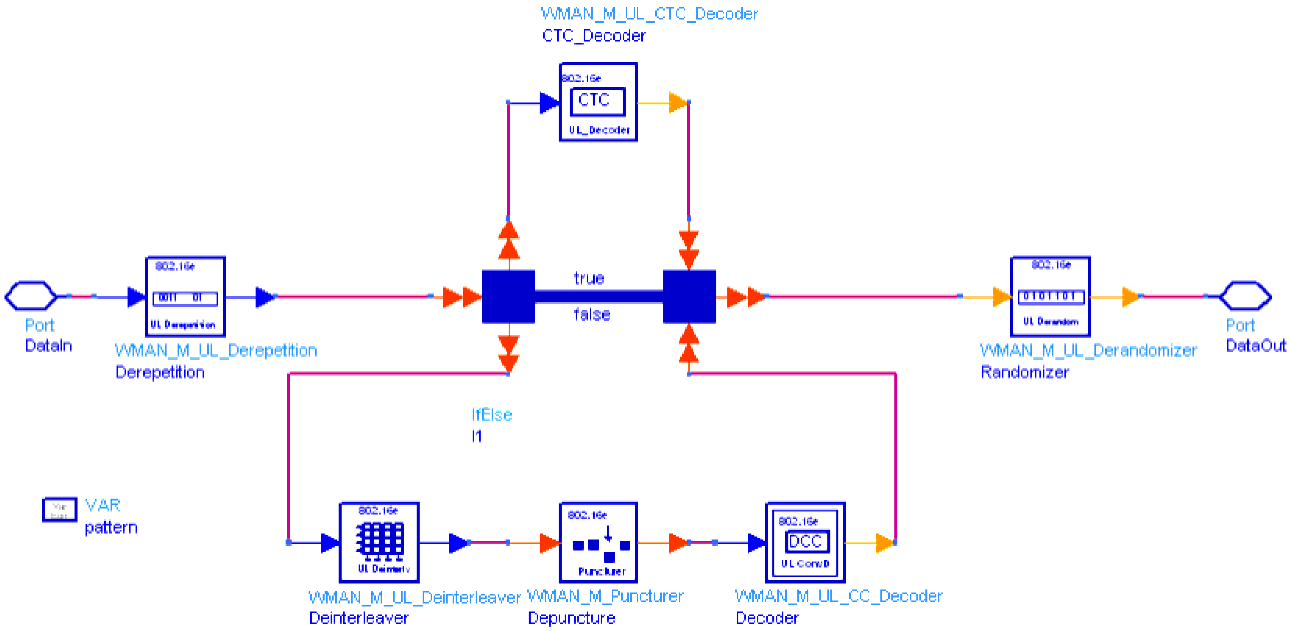
Pin	Name	Description	Signal Type
1	DataIn	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

Notes/Equations

1. This subnetwork is used to do forward error correction decoding on uplink, consisting of de-repetition, deinterleaver, depuncturer, convolutional decoder and derandomizer.
2. The schematic of this subnetwork is shown in the following figure.



WMAN_M_UL_FECDecoder Schematic

3. In the case of repetition coding, *R* = 2, 4, or 6, AssignedSlots shall be in the range of [$R \times EffectiveSlots$, $R \times EffectiveSlots + (R-1)$]. The output data of derepetition are the average of the input data, which are repeated *R* times.
4. All demodulated data bits shall be deinterleaved by a block deinterleaver with a block size corresponding to the number of coded bits per the encoded block size N_{cbps}. The deinterleaver is defined by a two-step permutation. Within a received block of N_{cbps} bits, let *j* be the index of a received bit before the first permutation; m_j be the index of that bit after the first and before the second permutation; and let k_j be the index of that bit after the second permutation, just prior to delivering the block to the decoder.
The first permutation is defined by the following equation:
$$m_j = s \times floor(j/s) + (j + floor(d \times j/N_{cbps}))_{mod(s)}$$
j = 0, 1, ..., N_{cbps} - 1, *d* = 16
The second permutation is defined by the following equation:
$$k_j = d \times m_j - (N_{cbps} - 1) \times floor(d \times m_j / N_{cbps})$$
j = 0, 1, ..., N_{cbps} - 1, *d* = 16
The first permutation in the de-interleaver is the inverse of the second permutation in the interleaver, and conversely.
5. The convolutional decoder uses the viterbi decoding algorithm. The following tables specify the concatenation of slots for different allocations and modulations for CC encoding scheme.

Slots Concatenation Rule for CC

Number of Slots	Slots Concatenated
n <= j	1 block of n slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of ceil((m+j)/2) slots
	1 block of floor((m+j)/2) slots

Encoding Slot Concatenation for Different Allocations and Modulations for CC

Modulation and Rate	j
QPSK 1/2	j = 6
QPSK 3/4	j = 4
16-QAM 1/2	j = 3
16-QAM 3/4	j = 2
64-QAM 1/2	j = 2
64-QAM 2/3	j = 1
64-QAM 3/4	j = 1

where

j: parameter dependent on the modulation and FEC rate

n: floor (number of allocated slots/repetition factor), i.e. *EffectiveSlots*

k: floor (n/j)

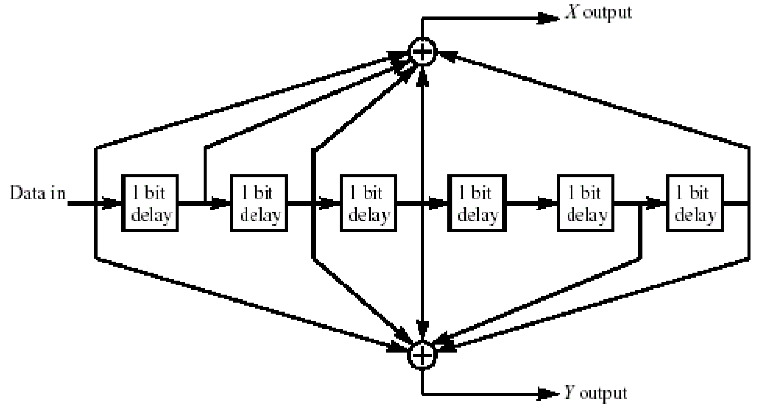
m: n modulo j

The binary convolutionary encoder, shall have native rate 1/2, a constraint length equal to *K* = 7, and shall use the following generator polynomials codes to derive its two code bits:

$G_1 = 171_{OCT}$ for X

$G_2 = 133_{OCT}$ for Y

The generator is depicted in the following figure. It's implemented by a tail-biting convolutional encoder, which is achieved by initializing the encoders memory with the last data bits of the CC block being encoded (the packet data bits numbered $b_{n-5}...b_n$).



Convolutional Encoder of Rate 1/2

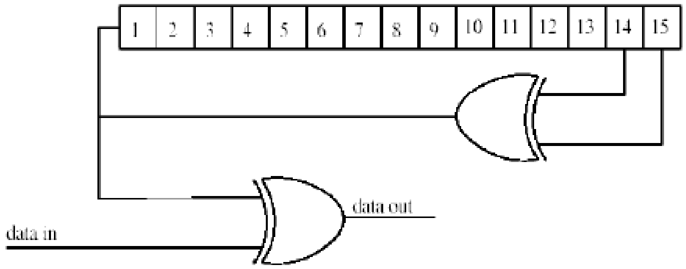
The puncturing patterns and serialization order that shall be used to realize different code rates are defined in the following table. In the table, "1" means a transmittted bit and "0" denotes a removed bit, whereas X and Y are in reference to the previous figure.

Convolutional Code with Puncturing Configuration

Rate	1/2	2/3	3/4
dfree	10	6	5
X	1	10	101
Y	1	11	110
XY	$X_1 Y_1$	$X_1 Y_1 Y_2$	$X_1 Y_1 Y_2 Y_3$

6. For the implementation of the CTC decoder, refer to the *WMAN_M_UL_CTC_Decoder (802.16e OFDMA Uplink CTC Decoder)".* (wman_m)

7. The PRBS generator shall be 1 + X ^{14} + X ^{15}, as shown in the following figure, wherein "1" corresponds to LSB and "15" corresponds to MSB. Each decoded data byte shall enter sequentially into the derandomizer, MSB first. Preambles are not derandomized. The seed value shall be used to calculate the randomization bits, which are combined in an XOR operation with the serialized bit stream of each FEC block. The derandomizer is applied only to information bits.
   The derandomizer is initialized with the factor [LSB] 0 1 1 0 1 1 1 0 0 0 1 0 1 0 1 [MSB].

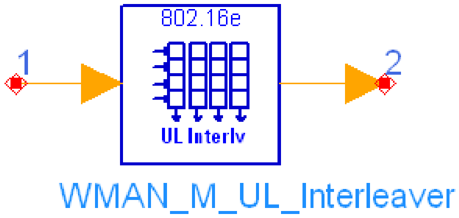


PRBS Generator

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_Interleaver (802.16e OFDMA Uplink Interleaver)



Description: Uplink interleaver
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
BurstAssignedSlot	Assigned slots of burst	1	int	[1,6868]
Rate_ID	Rate ID	1	int	[0,6]
RepetitionCoding	Repetition coding	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

Notes/Equations

1. This model is used to perform interleaving on coded data of uplink burst.
2. Each firing,
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8/(CodingRate)$ tokens are consumed at pin DataIn, and the same number of tokens are generated at pin DataOut, where *EffectiveSlots* is the number of slots actually used to transmit data, i.e. *EffectiveSlots = floor(AssignedSlots / R)*, where

     AssignedSlots is the number of slots assigned to the burst,

     R is repetition factor, which is 1, 2, 4 or 6 for QPSK and 1 for other modulation schemes,

     STCRate is the multiple due to STC encoding, which is dependent on STC_Encoder and STC_Matrix,

     UncodedSlotSize is the number of bytes within one slot before channel coding.

     CodingRate is coding rate.
3. All encoded data bits shall be interleaved by a block interleaver with a block size corresponding to the number of coded bits per the encoded block size N_{cbps}. The interleaver is defined by a two-step permutation. The first ensures that adjacent coded bits are mapped onto nonadjacent subcarriers. The second permutation ensures that adjacent coded bits are mapped alternately onto less or more significant bits of the constellation, thus avoiding long runs of lowly reliable bits.

   Let N_{cpc} be the number of coded bits per subcarrier, i.e., 2, 4, or 6 for QPSK, 16-QAM or 64-QAM, respectively. Let $s = N_{cpc}/2$. Within a block of Ncbps bits at transmission, let *k* be the index of the coded bit before the first permutation, m_k be the index of that coded bit after the first and before the second permutation and let j_k be the index after the second permutation, just prior to modulation mapping, and d be the modulo used for the permutation.

The first permutation is defined by the following equation:

$$m_k = (N_{cbps}/d) \times k_{mod(d)} + floor(k/d)$$

k = 0,1,..., N $_{cbps}$ *-1, d = 16*

The second permutation is defined by the following equation:

$$j_k = s \times floor(m_k/s) + (m_k + N_{cbps} - floor(d \times m_k/N_{cbps}))_{mod(s)}$$

k = 0,1,..., N $_{cbps}$ *-1, d = 16*

4. The FEC block size shall depend on *EffectiveSlots* and modulation specified for the current transmission. Concatenation of a number of slots shall be performed in order to make larger blocks of coding where it is possible, with the limitation of not exceeding the largest supported block size for the applied modulation and coding. The following tables specify the concatenation of slots for different allocations and modulations for CC and BTC encoding scheme.

Slots Concatenation Rule for CC

Number of Slots	Slots Concatenated
n <= j	1 block of n slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of ceil((m+j)/2) slots
	1 block of floor((m+j)/2) slots

Encoding Slot Concatenation for Different Allocations and Modulations for CC

Modulation and Rate	j
QPSK 1/2	j = 6
QPSK 3/4	j = 4
16-QAM 1/2	j = 3
16-QAM 3/4	j = 2
64-QAM 1/2	j = 2
64-QAM 2/3	j = 1
64-QAM 3/4	j = 1

where

j: parameter dependent on the modulation and FEC rate,

n: floor(number of allocated slots/repetition factor), i.e. *EffectiveSlots*,

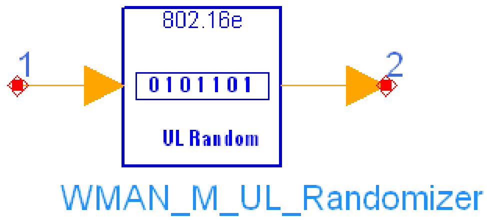
k: floor(n / j),

m: n modulo j

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_Randomizer (802.16e OFDMA Uplink Randomizer)



Description: Uplink randomizer
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
BurstAssignedSlot	Assigned slots of burst	1	int	[1,6868]
CodingType	Coding type	0	int	[0,1]
Rate_ID	Rate ID	1	int	[0,7]
RepetitionCoding	Repetition coding	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	
DataLength	MAC PDU payload byte length of burst	8	int	[1,∞)
HARQ_Enable	Whether the burst is HARQ-enabled: NO, YES	NO	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

Notes/Equations

1. This model is used to perform randomization on data of uplink burst.
2. Each firing,
   - $(DataLength + MACHeaderLength + MACCRCLength) \times 8$ tokens are consumed at pin DataIn, where

     DataLength is the number of data bytes to transmit within the burst

     MACHeaderLength is the number of MAC Header bytes

     MACCRCLength is the number of MAC Header CRC bytes
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8$ tokens are generated at pin DataOut, where EffectiveSlots is the number of slots actually used to transmit data, i.e., *EffectiveSlots = floor(AssignedSlots / R)*, where

     AssignedSlots is the number of slots assigned to the burst

     R is repetition factor, which is 1, 2, 4 or 6 for QPSK and 1 for other modulation schemes

     STCRate is the multiple due to STC encoding, which is dependent on *STC_Encoder* and *STC_Matrix*

     UncodedSlotSize is the number of bytes within one slot before channel coding
3. The randomization is initialized on each FEC block. If the amount of data to transmit (!wman_m-03-27-

199.gif!) does not fit exactly the amount of data allocated (!wman_m-03-27-200.gif!), padding of 0xFF(*1* only) shall be added to the end of the transmission block, up to the amount of data allocated. Note that when HARQ_Enable = YES, a two-byte HARQ CRC will be added to the end of the transmission block. Refer to *HARQ burst* (wman_m) for more information.

4. The FEC block size shall depend on EffectiveSlots and modulation specified for the current transmission. Concatenation of a number of slots shall be performed in order to make larger blocks of coding where it is possible, with the limitation of not exceeding the largest supported block size for the applied modulation and coding. The following tables specify the concatenation of slots for different allocations and modulations for CC and BTC encoding scheme.

Slots Concatenation Rule for CC

Number of slots	Slots concatenated
n <= j	1 block of n slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of ceil((m+j)/2) slots
	1 block of floor((m+j)/2) slots

Encoding Slot Concatenation for Different Allocations and Modulations for CC

Modulation and rate	j
QPSK 1/2	j = 6
QPSK 3/4	j = 4
16-QAM 1/2	j = 3
16-QAM 3/4	j = 2
64-QAM 1/2	j = 2
64-QAM 2/3	j = 1
64-QAM 3/4	j = 1

The following tables specify the concatenation of slots for different allocations and modulations for CTC encoding scheme.

Slots Concatenation Rule for CTC

Number of slots	Slots concatenated
n <= j n != 7	1 block of n slots
n = 7	1 block of 4 slots 1 block of 3 slots

n > j	If (n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of L_{b1} slots
	1 block of L_{b2} slots
	where
	L_{b1} = ceil((m+j)/2) slots
	L_{b2} = floor((m+j)/2) slots
	If (L_{b1} = 7) or (L_{b2} = 7)
	$L_{b1} = L_{b1} + 1$; $L_{b2} = L_{b2} + 1$

Encoding Slot Concatenation for Different Allocations and Modulations for CTC

Modulation and rate	j
QPSK 1/2	j = 10
QPSK 3/4	j = 6
16-QAM 1/2	j = 5
16-QAM 3/4	j = 3
64-QAM 1/2	j = 3
64-QAM 2/3	j = 2
64-QAM 3/4	j = 2
64-QAM 5/6	j = 2

where

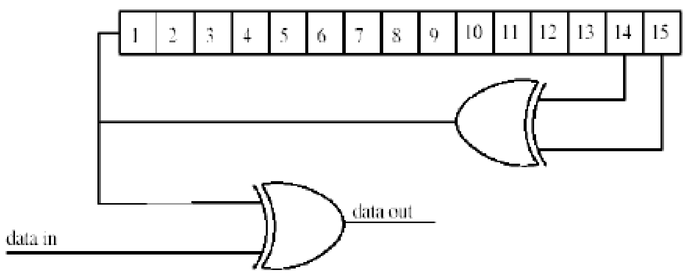
j: parameter dependent on the modulation and FEC rate

n: floor(number of allocated slots/repetition factor), i.e. *EffectiveSlots*

k: floor(n / j)

m: n modulo j

5. The PRBS generator shall be 1 + X ^{14} + X ^{15}, as shown in the following figure, wherein "1" corresponds to LSB and "15" corresponds to MSB. Each data byte to be transmitted shall enter sequentially into the randomizer, MSB first. Preambles are not randomized. The seed value shall be used to calculate the randomization bits, which are combined in an XOR operation with the serialized bit stream of each FEC block. The randomizer is applied only to information bits.
The randomizer is initialized with the factor
[LSB] 0 1 1 0 1 1 1 0 0 0 1 0 1 0 1 [MSB].

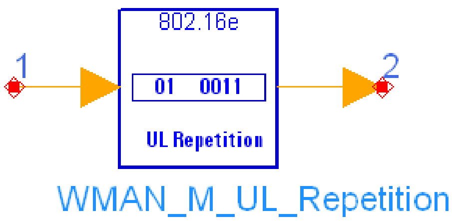


PRBS Generator for Data Randomization

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_Repetition (802.16e OFDMA Uplink Repetition)



Description: Uplink repeater
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
BurstAssignedSlot	Assigned slots of burst	1	int	[1,6868]
CodingType	Coding type	0	int	[0,1]
Rate_ID	Rate ID	1	int	[0,7]
RepetitionCoding	Repetition coding	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

Notes/Equations

1. This model is used to perform repetition on interleaved data of uplink burst.
2. Each firing,
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8/(CodingRate)$ tokens are consumed at pin DataIn, where
     EffectiveSlots is the number of slots actually used to transmit data,
     i.e. *EffectiveSlots = floor(AssignedSlots / R)*, where

     AssignedSlots is the number of slots assigned to the burst

     R is repetition factor, which is 1, 2, 4 or 6 for QPSK and 1 for other modulation schemes

     STCRate is the multiple due to STC encoding, which is dependent on *STC_Encoder* and *STC_Matrix*

     UncodedSlotSize is the number of bytes within one slot before channel coding

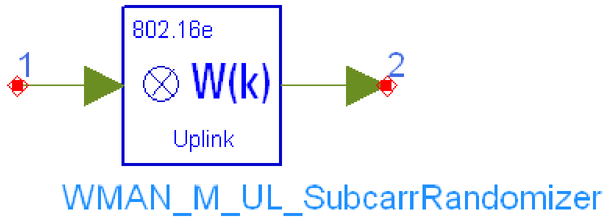
     CodingRate is coding rate
   - $AssignedSlots \times STCRate \times UncodedSlotSize \times 8/(CodingRate)$ tokens are generated at pin DataOut.
3. Repetition coding can be used to further increase signal margin over the modulation and FEC mechanisms. In the case of repetition coding, R = 2, 4, or 6, AssignedSlots shall be in the range of $[R \times EffectiveSlots, R \times EffectiveSlots + (R-1)]$. The binary data that fits into a region that is repetition coded is reduced by a factor R compared to a non-repeated region of the (!wman_m-03-28-206.gif!) slots with the same size and FEC code type. After FEC and bit-interleaving, the data is segmented into slots, and each group of bits designated to fit in a slot will be repeated R times to form R continuous slots following the normal slot ordering that is used for data mapping. If AssignedSlots is not integer multiples of *R*, the remaining slots (the

number of them ranging from 1 to *R - 1*) will be padded with "1". This repetition scheme applies only to QPSK modualtion; it can be applied in all coding schemes except H-ARQ with CTC.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_SubcarrRandomizer (802.16e OFDMA UL Subcarr Randomizer)



Description: Uplink subcarrier randomizer
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
Mode	Randomizer or Derandomizer: Randomizer, Derandomizer	Randomizer	enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_2048	enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC	enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24	int	[3,1212]
ZoneSymOffset	Symbol offset in zone	0	int	[0,1211]
PreambleIndex	Preamble index	3	int	[0,113]
FrameNumber	Frame number	0	int	[0,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO	enum	
PilotPN_Phase	Pilot PN phase	0	int	[0,2047]

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	intput data	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	complex

Notes/Equations

1. This model is used to multiply (or divide) the factor $2 \times (1/2 - W_k)$ to the constellation-mapped data according to the subcarrier physical index, *k*.
2. Each firing,

   UsedCarriers tokens are consumed at pin DataIn.

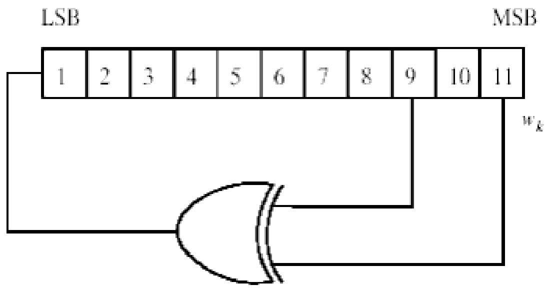
   UsedCarriers tokens are produced at pin DataOut.

   where, *UsedCarriers* is dependent on the zone type and FFT size according to the specification, shown in the following table.

   Calculation of UsedCarriers

Zone type	FFT size	UsedCarriers
UL_PUSC	2048	1680
UL_PUSC	1024	840
UL_PUSC	512	408
UL_OPUSC	2048	1728
UL_OPUSC	1024	864
UL_OPUSC	512	432

3. When Mode is set to Randomizer, the data will multiply the factor $2 \times (1/2 - W_k)$; When Mode is set to Derandomizer, the data will divide the factor $2 \times (1/2 - W_k)$. The sequence w_k is generated from the PRBS generator which is shown in the following figure.



PRBS Generator for Pilot Modulation

The initialization vector of the PRBS generator for both uplink and downlink shall be designated b10..b0, such that:

b0:b4= Five least significant bits of UL_IDcell (as determined by the preamble) in the uplink. For downlink and uplink, b0 is MSB and b4 is LSB, respectively.

b5:b6= Set to 0b11 inthe uplink. For downlink and uplink, b5 is MSB and b6 is LSB, respectively.

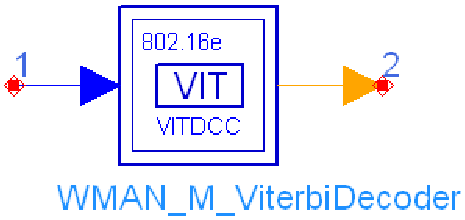
b7:b10= Four least significant bits of the Frame Number in the uplink. For downlink and uplink, b7 is MSB and b10 is LSB, respectively.

The PRBS generator shall be clocked n times, n = *SymbolOffset* mod 32, before the generated output is applied to the subcarriers, where symbol offset is counted from the first symbol from Allocation start time in the uplink (i.e. the first symbol in the uplink subframe is indexed 0). As a result, the PRBS shall be used such that its n'th output bit will coincide with the first usable subcarrier as defined for the zone in which the symbol resides. The output bit shall be counted from zero. A new value shall be generated by the PRBS generator for every subcarrier up to the highest numbered usable subcarrier, in order of physical subcarriers, including the DC subcarrier and usable subcarriers that are not allocated.
PilotPN_Phase specifies the start phase of pilots (i.e. symbol offset). The specification requires PilotPN_Phase = 0.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_ViterbiDecoder (802.16e OFDMA Viterbi Decoder)



Description: Viterbi decoder
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
EncodedBits	encoded bits	144	int	[1,+∞]
Rate_ID	Rate ID of each burst	1	int	[0,6]

Pin Inputs

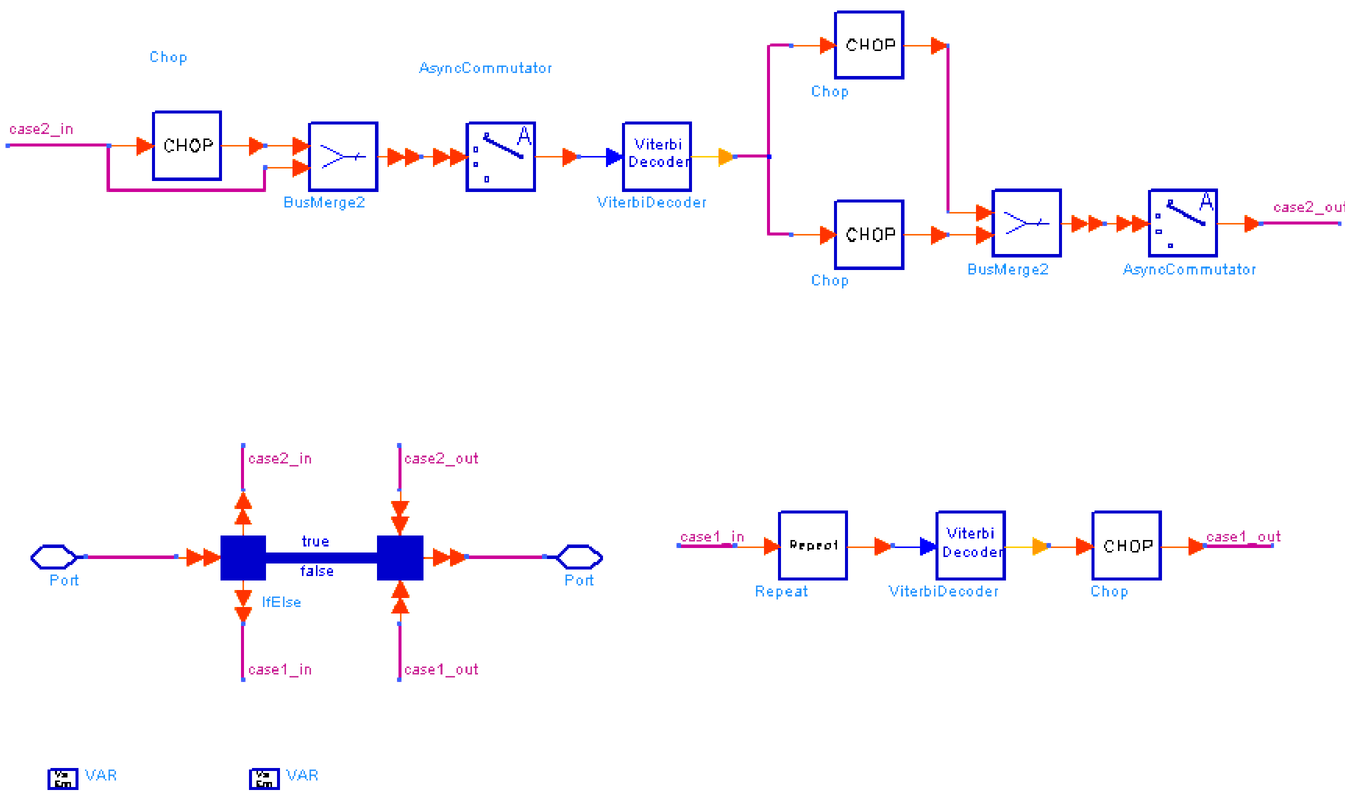
Pin	Name	Description	Signal Type
1	DataIn	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	int

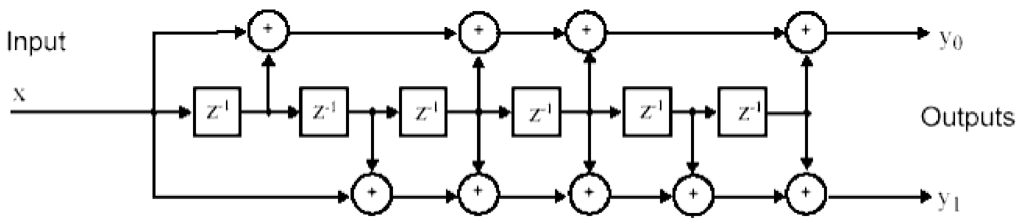
Notes/Equations

1. This subnetwork is used to do 16e viterbi decoding.
2. The schematic of this subnetwork is shown in the following figure.



WMAN_M_ViterbiDecoder schematic

3. The convolutional decoder uses viterbi algorithm. In communications system, generally there are two ways to implement convolutional code. One is to code an semi-infinite long bit sequence. The initial state of the encoder could be zero-state or non-zero-state and the final state is not cared. Another way is to code block by block by appending some zero tails after bit blocks so that the initial state and final state of encoder are both zero state. An parameter ZeroTail is used to distinguish the two case. If ZeroTail is YES, then the zero tails should be appended in advance before fed into this model.
   Each firing, If ZeroTail is set to YES, BitSequenceLength Out tokens are produced, when BitSequenceLength/R In tokens consumed; If ZeroTail is NO, 1 Out tokens are produced, when 1/R In tokens consumed.
   For example, in CDMA access channel, CC(3,1,9) with zero tail is used in which the convolutional code rate R is 1/3 and the bit sequence length is 96. CodingRate is set to *rate 1/3* , ZeroTail is set to YES and BitSequenceLength is set to 96. In that case, each firing, 96 Out tokens are produced when 288 In tokens are consumed.
4. Some detailed information about parameter is list below.
   - Polynomail is the generator function of convolutional code. In general, the generator matrix for a convolutional code is semi-infinite since the input sequence is a semi-infinite in length. As an alternative to specifying the generator matrix, we shall use a functionally equivalent representation in which we specify a set of n vectors, one vector for each of the n modulo-2 adder. A 1 in the ith position of the vector indicates that the corresponding stage in the shift register is connected to the modulo-2 adder and a 0 in a given position indicates that no connection exists between that stage and the modulo-2 adder.



Convolutional Code CC(3,1,7)

   To be specific, let us consider the binary convolutional encoder with constraint length K=3, k=1, and n=7, which is shown in the previous figure. The connection for y0 is (1, 0, 1, 1, 0, 1, 1) from Outputs to Input, while it is (1, 1, 1, 1, 1, 0, 1) for y1. The generators for this code are more conveniently given in octal form as (0133, 0175). We conclude that, when k=1, we require n generators, each of dimension K to specify the encoder.
   - ZeroTail is used to specify the character of input sequence of encoder. If ZeroTail is YES, the input sequence of encoder should be divided into blocks. The length of the block is BitSequenceLength. After each block, K-1 zeros have to be appended as tail bits. That is, the total block length of encoder is (BitSequenceLength + K - 1). In decoder, the know information will be used to get better performance.
   - BitSequenceLength is used to specify the information bit length, which indicates the length of uncoded bits. By use this parameter, it is possible that the same parameter with the same value can be used in both encoder and decoder. This parameter is valid only if ZeroTail is set to YES.
   - MaxSurvivorLength is the maximum length of survivor that is stored in memory. The decoding delay in decoding a long information sequence that has been convolutionally encoded is usually too long for most practical applications. Moreover, the memory required to store the entire length of surviving sequences is large and expensive. A solution to this problem is to modify the Viterbi algorithm in a way which results in a fixed decoding delay without significantly affecting the optimal performance of the algorithm. The modification is to retain at any given time t only the most recent δ decoded informations bits in each surviving sequence. As each new information bit is received, a final decision is make on the bit received δ branches back in the trellis, by comparing the metrics in the surviving sequences and deciding in favor of the bit in the sequence having the largest metric. If δ is chosen sufficiently large, all surviving sequences will contain the identical decoded bit δ branches back in time. That is, with high probability, all surviving sequences at time t stem from the same one as t-δ. It has been found experimentally (computer simulation) that a delay $\delta \geq 5K$ results in a negligible degradation in the performance relative to the optimum Viterbi algorithm.
   - Polarity is used to specify the mapping mode from the bit (0, 1) to the level of NRZ signal. Generally, bit 0 is mapped into level 1 and bit 1 is mapped into level -1. An alternative is bit 0 to level -1 and bit 1 to level 1.

- InitialState is used to specify the character of coded sequence. If the initial state of encoder is zero-state, the know information can be used to get better performance. If the initial state is not sure to be zero, InitialState should be set to Non-zero state.
- IgnoreNumber is used to specify how many data will be ignored by this model. In communications systems, delay may caused by devices or transmission. Since it is possible that the delay will be inserted between encoder and decoder in the form of meaningless data, the information have to be set in IgnoreNumber. If ZeroTail is YES, the value of IgnoreNumber is !wman_m-03-30-216.gif!(N is integer, !wman_m-03-30-217.gif!), and no extra delay will be introduced by this model, since it is assumed the input sequence is frame synchronization before fed into this model. If ZeroTail is NO, the delay is an integer number N. That means the symbol synchronization is achieved before this model. If N/R is also an integer, then the delay of output bit sequence will be N/R in bits. Other wise, the delay will be the minimum integer larger than N/R.

5. The requirement for input sequence.
   If ZeroTail is YES,

   The input sequence must be frame synchronized. That is, the Ignore Number must be $N \times (BitSequenceLength)/R$ (N is integer, !wman_m-03-30-219.gif!) and the first valid data must be the first symbol of the first codeword in that frame.

   The input sequence must be encoded from blocks each of which has K-1 zero tails, so that the initial state and final state are all zero-state.

   If ZeroTail is NO,

   The input sequence must be bit synchronized. That is, the first valid data must be the first symbol of a codeword.

   If InitialState is set to Zero state, the first valid symbol should be encoded with zero initial state.
6. Implementation
   Viterbi Decoding Algorithm

   The following is the Viterbi algorithm for decoding a CC(n,k,K) code, where K is the constraint length of convolutional code. In our components, the convolutional code is processed with k=1.

   Branch Metric Calculation

   The branch metric $m_j^{(\alpha)}$, at the J th instant of the α path through the trellis is defined as the logarithm of the joint probability of the received n-bit symbol $r_{j1} r_{j2} \ldots r_{jn}$ conditioned on the estimated transmitted n-bit symbol $c_{j1}^{(\alpha)} c_{j2}^{(\alpha)} \ldots c_{jn}^{(\alpha)}$ for the α path. That is,

$$m_j^{(\alpha)} = \ln\left(\prod_{i=1}^{n} P(r_{ji} | c_{ji}^{(\alpha)})\right) = \sum_{i=1}^{n} \ln P(r_{ji} | c_{ji}^{(\alpha)}).$$

   If Rake receiver is regarded as a part of the channel, for the Viterbi decoder the channel can be considered as an AWGN channel. Therefore,

$$m_j^{(\alpha)} = \sum_{i=1}^{n} r_{ji} c_{ji}$$

   Path Metric Calculation

   The path metric $M^{(\alpha)}$ for the α path at the J th instant is the sum of the branch metrics belonging to the α path from the first instant to the J th instant. Therefore,

$$M^{(\alpha)} = \sum_{j=1}^{J} m_j^{(\alpha)}$$

Information Sequence Update

There are 2^k merging paths at each node in the trellis and the decoder selects from the paths $\alpha_1, \alpha_2, \ldots, \alpha_{2^k}$, the one having the largest metric, namely,

$$max(M^{(\alpha_1)}, M^{(\alpha_2)}, \ldots, M^{(\alpha_{2^k})})$$

and this path is known as the survivor.

Decoder Output

When the two survivors have been determined at the *J* th instant, the decoder outputs the (*J-L*)th information symbol from its memory of the survivor with the largest metric.

References

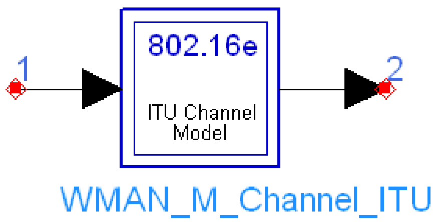
1. S. Lin and D. J. Costello, Jr., *Error Control Coding Fundamentals and Applications* , Prentice Hall, Englewood Cliffs NJ, 1983.
2. John G. Proakis, Digital Communications (Third edition), Publishing House of Electronics Industry, Beijing, 1998.
3. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
4. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

802.16e OFDMA Channel Model Components

The 16e channel models provide fixed WiMAX channel model (SUI channel model), ITU 1225 model and 3GPP MIMO model.

- *WMAN M Channel ITU (802.16e OFDMA ITU Channel Model)* (wman_m)
- *WMAN M Channel MIMO (802.16e OFDMA MIMO Channel Model)* (wman_m)
- *WMAN M Channel SUI (802.16e OFDMA SUI Channel Model)* (wman_m)

WMAN_M_Channel_ITU (802.16e OFDMA ITU Channel Model)



Description: 802.16e channel model
Library: WMAN 16e, Channel Model

Parameters

Name	Description	Default	Unit	Type	Range
RIn	Input resistance	50 Ohm	Ohm	int	(0,∞)
ROut	Output resistance	50 Ohm	Ohm	int	(0,∞)
ModelType	the ITU-R M.1225 Channel number or User defined Channel: Pedestrian_A, Pedestrian_B, Vehicular_A, Vehicular_B, UserDefined	Vehicular_A		enum	
Delay	the delay of each tap in usec, effective only when ModelType is set as UserDefined	{0.0 , 0.31 , 0.71 , 1.09 , 1.73 , 2.51 }	sec	real array	[0,1000.0]
Power	the power in each tap in dB, effective only when ModelType is set as UserDefined	{0.0 dB, -1.0 dB, -9.0 dB, -10.0 dB, -15.0 dB, -20.0 dB}		real array	(-∞,0]
Ricean_factor	the Ricean K-factor in linear scale of each tap, effective only when ModelType is set as UserDefined	{0.0, 0.0, 0.0, 0.0, 0.0, 0.0}		real array	[0.0,1000.0]
Velocity	the velocity of mobile station	120		real	[0.001,200]
PathLoss	option for inclusion of large-scale pathloss: NO, YES	NO		enum	
PropDistance	the distance of BS and UE in meter, effective only when PassLoss is set as YES	1000	m	real	[200,5000]
PwrNormal	option for normalization of the output power: NO, YES	NO		enum	
PwrMeasPeriod	The period of power measurement in order to normalize the output power	1 msec	sec	real	(0,∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	input	channel input signal	timed

Pin Outputs

Pin	Name	Description	Signal Type
2	output	channel output signal	timed

Notes/Equations

1. This model is used to generate channel models for mobile wireless applications.
2. This model is implemented following Rec.ITU-R M.1225.

   A set of 4 modified International Telecommuniction Union(ITU) channel models are constructed to simulate the multipath fading of the channel. The multipath fading is modeled as a tapped-delay line with 6 taps with non-uniform delays. The gain associated with each tap is characterized by a distribution (Ricean with a K-factor>0, or Rayleigh with K-factor=0) and the maximum Doppler frequency. For each tap, we use the method of filtered noise to generate channel coefficients with the specified distribution and spectral power density.

   The definition of the four specific ITU channels is shown in the following tables:

Outdoor to Indoor and Pedestrian Test Environment Tapped-delay-line Parameters

Tap	Channel A		Channel B		Doppler Spectrum
	Relative Delay (ns)	Average Power (dB)	Relative Delay (ns)	Average Power (dB)	
1	0	0	0	0	Classic
2	110	-9.7	200	-0.9	Classic
3	190	-19.2	800	-4.9	Classic
4	410	-22.8	1200	-8.0	Classic
5	™™	™™	2300	-7.8	Classic
6	™™	™™	3700	-23.9	Classic

Vehicular Test Environment Tapped-delay-line Parameters

Tap	Channel A		Channel B		Doppler Spectrum
	Relative Delay (ns)	Average Power (dB)	Relative Delay (ns)	Average Power (dB)	
1	0	0.0	0	-2.5	Classic
2	310	-1.0	300	0	Classic
3	710	-9.0	8900	-12.8	Classic
4	1090	-10.0	12900	-10.0	Classic
5	1730	-15.0	17100	-25.2	Classic
6	2510	-20.0	20000	-16.0	Classic

The total channel gain is normalized by adding the specified Normalization Factor to each tap.
The specified Doppler is the maximum Doppler frequency parameter (f_m) of the rounded spectrum which has the power spectral density (PSD) function as follows:

$$S(f) = \begin{cases} \dfrac{1}{\pi\sqrt{1-f_0^2}} & |f_0| \le 1 \\ 0 & |f_0| > 1 \end{cases}$$

where
$f_0 = \dfrac{f}{f_m}$ and $f_m = \dfrac{v}{c}f$, v
is the mobile's velocity relative to base station.
The set of ITU channel models specify statistical parameters of microscopic effects. To simulate the real channel, these statistics have to be combined with macroscopic channel effects, i.e. the path loss (including shadowing) which will be introduced in the later section.
The COST 207 model with a correction term is used to simulate the path loss for both pedestrian and vehicular environments if the PathLoss is ON and other parameters are set according to the specific environment.
A new feature is introduced in this model. The output power can be constant (normalized to the input power) by setting *PwrNormal* to YES. *PwrMeasPeriod* specifies the resolution time for the power measurement. The method for adjusting the ouput power is that, assuming the power level measured in two contiguous time periods with *PwrMeasPeriod* seconds is identical, a gain, calculated on the power level measured in the (i-1)th time period, is multiplied to the signal in the ith time period to ensure that the output power in the ith time period is equal to the input power, and so on for the (i+1)th time period. Hence the first time period with *PwrMeasPeriod* seconds remain unadjusted.

3. Parameter Details
    - *ModelType* specifies the type of ITU channel.
      The relationship of the channel type and the terrain type is shown in the following table.
      ModelType A and *B* are outdoor to indoor and pedestrian enviroment, while Type *C* and *D* are vehicular environment. Type *User-Defined* is used to construct user defined channel model.
    - *Velcocity* specifies the mobile's velocity relative to base station.
    - *PropDistance* specifies the distance between base station and mobile station.
    - *PathLoss* identifies whether the large-scale pathloss is included.
      if $PathLoss = NO$, the path loss is not included in this model and the parameters describing the environment are unused.
      if $PathLoss = YES$, the path loss for both urban and suburban environments is modeled by the COST 207 model with a correction term. There are three terms which make up the model:

Path Loss model for outdoor to indoor and pedestriant test environment
$L = 40\log R + 30\log f + 49$
where R is the propogation distance and f is the frequency.
Path Loss model for vehicular test enviroment
$L = [40(1 - 4 \times 10^{-3}\Delta h_b)]\log R - 18\log \Delta h_b + 21\log f + 80$

where R is the propogation distance and f is the frequency, Δh_b
is the height between base station antenna and mobile.

- *Delay, Power* and *Ricean_factor* specify the delay, power and ricean factor for each path when *ModelType* selected as *UserDefined.*
- *PwrNormal* specifies whether the ouput power is normalized to the input power.
  if $PwrNormal = NO$, the ouput power is not normalized.
  if $PwrNormal = YES$, the ouput power is normalized to ensure that the output power is equal to the input power with the resolution of *PwrMeasPeriod*.
- *PwrMeasPeriod* specifies the resolution time for the power measurement. This value is vaild when *PwrNormal* is YES.

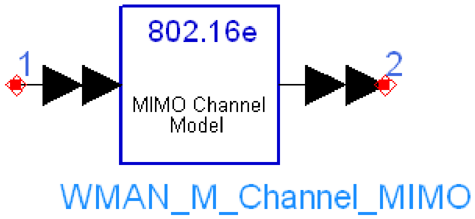
4. Output delay

   A delay of 64 tokens is introduced in this model.

References

1. Rec.ITU-R M.1225, Guidelines For Evaluation Of Radio Transmission Technologies For IMT-2000, 1997

WMAN_M_Channel_MIMO (802.16e OFDMA MIMO Channel Model)



Description: Mobile WiMAX MIMO channel model
Library: WMAN 16e, Channel Model

Parameters

Name	Description	Default	Unit	Type	Range
Direction	Direcion (Downlink, Uplink): Downlink, Uplink	Downlink		enum	
NumTxAntennas	Number of transmit antennas	2		int	(1,∞)
TxAntsPosition	the position in unit of wavelengths for each antenna in the linear transmitter array	{0.0, 4.0}	sec	real array	[0,1000.0]
NumRxAntennas	Number of receive antennas	2		int	(1,∞)
RxAntsPosition	the position in unit of wavelengths for each antenna in the linear receiver array	{0.0, 0.5}	sec	real array	[0,1000.0]
ModelType	the ITU-R M.1225 Channel number or User defined Channel: Pedestrian_A, Pedestrian_B, Vehicular_A, Vehicular_B, Modified_Vehicular_A, UserDefined	Vehicular_A		enum	
CorrelationType	the channel correlation type: High, Medium, Low, None	High		enum	
BsAzimuthSpread	the per-tap azimuth spread with all taps on BS side	2		real	[0,360]
MsAzimuthSpread	the per-tap azimuth spread with all taps on MS side	35		real	[0.00,360]
PolarPowerRatio	the per-tap power ratio in dB between vertical-to-horizontal and vertical-to-vertical polarisations	-8		real	[-∞,∞]
RayOffsetAngles	the ray offset angles within a tap	{0.0447, -0.0447, 0.1413, -0.1413, 0.2492, -0.2492, 0.3715, -0.3715, 0.5129, -0.5129, 0.6797, -0.6797, 0.8844, -0.8844, 1.1481, -1.1481, 1.5195, -1.5195, 2.1551, -2.1551 }		real array	[0,360]
Delay	the delay for each tap in usec, effective only when ModelType is set as UserDefined	{0.0, 0.31, 0.71, 1.09, 1.73, 2.51 }	sec	real array	[0,1000.0]
Power	the power in each tap in dB, effective only when ModelType is set as UserDefined	{0.0 dB, -1.0 dB, -9.0 dB, -10.0 dB, -15.0 dB, -20.0 dB}		real array	(-∞,0]
Ricean_factor	the Ricean K-factor in linear scale for each tap, effective only when ModelType is set as UserDefined	{0.0, 0.0, 0.0, 0.0, 0.0, 0.0}		real array	[0.0,1000.0]
MeanAoA	the mean AoA for each tap, effective only when ModelType is set as UserDefined	{ 142.22, 13.92, 110.94, 45.25, 98.38, 50.41 }		real array	[0.0,360.0]
MeanAoD	the mean AoD for each tap, effective only when ModelType is set as UserDefined	{ 165.11, 170.43, 182.2, 162.44, 170.6, 155.68 }		real array	[0.0,360.0]
Velocity	the velocity of mobile station	60		real	[0.001,200]
PathLoss	option for inclusion of large-scale pathloss: NO, YES	NO		enum	
PropDistance	the distance of BS and UE in meter, effective only when PassLoss is set as YES	1000	m	real	[200,5000]

Pin Inputs

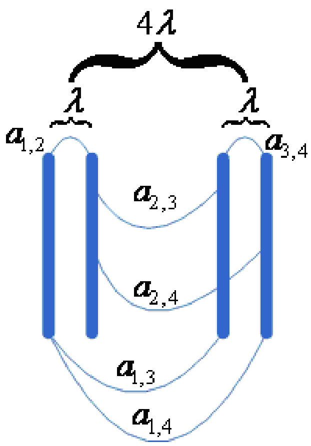
Pin	Name	Description	Signal Type
1	TxSig	Signals supplied to transmit array	multiple timed

Pin Outputs

Pin	Name	Description	Signal Type
2	RxSig	Signals at output of receive array	multiple timed

Notes/Equations

1. The implementation in this model strictly follows the definition in Appendix 4 of Reference[3].
2. The WiMAX MIMO channel is extended from ITU models (Ped-B & Veh-A) by adding the definition of a per-tap spatial correlation. Three levels of channel correlation (high, medium and low) have been defined to serve as three options for the RCTs.
3. Multiple antenna configurations are supported, such as 2x1, 2x2, 2x3 and so on. Up to 4x4 antenna configuration can be supported.
4. NumTxAntennas and NumRxAntennas parameters specify the number of antennas at transmitter and receiver side respectively, while TxAntsPosition and RxAntsPosition parameters specify the antenna configurations at transmitter and receiver side respectively. For example, choosing transmitter antenna configuration as follows:



For this configuration the spacing between antennas are:

$D_{1,2} = D_{3,4} = \lambda$

$D_{2,3} = 3\lambda$

$D_{1,3} = D_{2,4,} = 4\lambda$

$D_{1,4} = 5\lambda$

Then the proper settings for NumTxAntennas and TxAntsPosition parameters for this configuration are:

NumTxAntennas = 4
TxAntsPosition = {0, 1, 4, 5}

5. ModelType parameter specifies the ITU propagation model selected from Pedestrian A, Pedestrian B, Vehicular A, Vehicular B, modified Vehicular A and user-defined model. Each ITU propagation model defines the power delay profiles (PDP). The Doppler spectra and amplitude distributions are in all the cases Classical and Rayleigh respectively. For modified vehicular A channel, the last tap is moved from 2510 ns to 10,000 ns where its magnitude remains the same (-20dB) as vehicular A channel. Pedestrian models have the following mean AoA and mean AoD as described in Reference[3]:

Path	Mean AoA	Mean AoD
1	147.34	18.11
2	50.84	24.48
3	139.08	21.11
4	49.5	6.47
5	260.03	23.85
6	128.93	24.24
Total AS	67.91	4.99

Vehicular models have the following mean AoA and mean AoD as described in Reference[3]:

Path	Mean AoA	Mean AoD
1	142.22	165.11
2	13.92	170.43
3	110.94	182.2
4	45.25	162.44
5	98.38	170.6
6	50.41	155.68
Total AS	69.9	4.99

In the user-defined model, the power delay profiles (PDP) is defined by the user as follows:

- Delay, Power and Ricean_factor parameters specify the delay, power and ricean factor for each path when ModelType is selected as *UserDefined*.
- MeanAoA and MeanAoD parameters specify the mean AoA and mean AoD for each tap when ModelType selected as *UserDefined*. Note that when Direction = *Downlink*, MeanAoD is used for BS' spatial correlation computation while MeanAoA is used for MS' spatial correlation computation; When Direction = *Uplink*, MeanAoD is used for MS' spatial correlation computation while MeanAoA is used for BS' spatial correlation computation.

6. Spatial correlation can be calculated based on antenna geometry and the power azimuth spectrum (PAS). Per tap azimuth spread in both scenarios and with all taps is assumed 2 degrees on the BS side and 35 degrees on the MS side. Power azimuth spectrum with all taps is assumed Laplacian shaped. Laplacian PAS with 1 degree rms azimuth spread is modelled by 20 offset angles. Finally, offset angles $\Delta\theta_K$ with rms azimuth spread Υ are calculated by,

$$\Delta\theta_k = Y\omega_k$$

Spatial correlation between two antenna elements is calculated by,

$$\rho(D) = \frac{1}{K}\sum_{k=1}^{K}\exp\left(-j2\pi D\sin\left(\theta_0 + \Delta\theta_k\right)\right)$$

where D is the separation of antenna elements in wave lengths, K = 20, θ_0 is the mean AoA (AoD) and $\Delta\theta_K$ is the k th offset angle in radians. Per tap azimuth spread on the BS side and MS side can be changed by users in BsAzimuthSpread and MsAzimuthSpread parameters respectively. The offset angles for modelling Laplacian PAS with 1 degree rms azimuth spread can be changed by using the RayOffsetAngles parameter.
Taking the 2x2 antenna configuration as an example, the correlation matrix of the BS antenna array is:

$$\mathbf{R}_{BS} = \begin{bmatrix} 1 & \alpha \\ \alpha^* & 1 \end{bmatrix}$$

where α is calculated from the equation above.
The correlation matrix of the MS antenna array is:

$$\mathbf{R}_{MS} = \begin{bmatrix} 1 & \beta^* \\ \beta^* & 1 \end{bmatrix}$$

where β
is also calculated from the equation above.
The WiMAX MIMO channel supports polarization correlation between polarized antennas resulting from the cross polarization power ratio (XPR). The polarization matrix is given by,

$$\mathbf{S} = \begin{bmatrix} s_{vv} & s_{vh} \\ s_{hv} & s_{hh} \end{bmatrix}$$

where v denotes vertical and h horizontal polarization, the first index denoting the polarization at BS and the second the polarization at MS. In the ITU scenarios, we assume -8 dB per-tap power ratio between vertical-to-horizontal and vertical-to-vertical polarizations (also PolarPowerRatio = -8dB). This ratio can also be changed by using the PolarPowerRatio parameter.
The final normalized polarization correlation matrix for the 2x2 antenna configuration is:

$$\mathbf{R}_{MIMO} = \begin{bmatrix} 1 & \gamma & 0 & 0 \\ \gamma & 1 & 0 & 0 \\ 0 & 0 & 1 & -\gamma \\ 0 & 0 & -\gamma & 1 \end{bmatrix}$$

7. The CorrelationType parameter specifies the spatial correlation between antenna elements. The high, medium, and low correlations are defined as described in Reference[3].
   - The downlink MIMO correlation matrix for 2x2 antenna configuration "high correlation" is:

     $$\mathbf{R}_{MIMO} = \mathbf{R}_{BS} \otimes \mathbf{R}_{MS} = \begin{bmatrix} \mathbf{R}_{MS} & \alpha\mathbf{R}_{MS} \\ \alpha^* \mathbf{R}_{MS} & \mathbf{R}_{MS} \end{bmatrix} = \begin{bmatrix} 1 & \beta & \alpha & \alpha\beta \\ \beta^* & 1 & \alpha\beta^* & \alpha \\ \alpha^* & \alpha^*\beta & 1 & \beta \\ \alpha^*\beta^* & \alpha^* & \beta^* & 1 \end{bmatrix}$$

     In this kind of spatial correlation, up to 4x4 antenna configuration can be supported.
     When Direction=Uplink, the positions for RBS and RMS in the equation above will be exchanged.
   - Obtained from a cross polarized MS antenna and a slant cross-polarized BS antenna, the MIMO correlation matrix for 2x2 antenna configuration "medium correlation" is:

     $$\mathbf{R}_{MIMO} = \begin{bmatrix} 1 & 0 & \gamma & 0 \\ 0 & 1 & 0 & -\gamma \\ \gamma & 0 & 1 & 0 \\ 0 & -\gamma & 0 & 1 \end{bmatrix}$$

     In this kind of spatial correlation, up to a 2x2 antenna configuration can be supported.
   - Obtained with the same spatial parameters as in the high configuration but with cross-polarized antennas, the downlink MIMO correlation matrix for the 2x2 antenna configuration "low correlation" is:

     $$\mathbf{R}_{MIMO} = \begin{bmatrix} 1 & 0 & \gamma\alpha & 0 \\ 0 & 1 & 0 & -\gamma\alpha \\ \gamma\alpha^* & 0 & 1 & 0 \\ 0 & -\gamma\alpha^* & 0 & 1 \end{bmatrix}$$

     In this kind of spatial correlation, up to a 2x2 antenna configuration can be supported.
     When Direction = Uplink, the value α for BS in the equation above will be replace with β for MS.
   - When CorrelationType = None, the signals between antenna elements are uncorrelated. Up to a 4x4 antenna configuration can be supported.
8. Velocity specifies the mobile unit's velocity (!wman_m-04-3-73rev1.gif!) relative to the base station. The specified Doppler is the maximum Doppler frequency parameter (fm) of the rounded spectrum which has the power spectral density (PSD) function as follows:

   $$S(f) = \begin{cases} \dfrac{1}{\pi\sqrt{1-f_0^2}} & |f_0| \le 1 \\ 0 & |f_0| > 1 \end{cases}$$

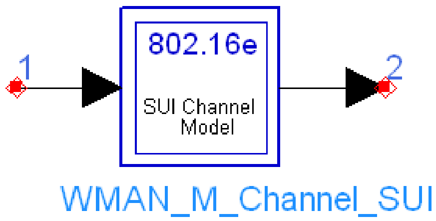
   where $f_0 = \dfrac{f}{f_m}$ and $f_m = \dfrac{v}{c}f$.
9. PathLoss specifies whether the large-scale pathloss is included.
   If $PathLoss = NO$, the pass loss is not included in this model;
   If $PwrNormal = YES$, the pass loss is included in this model. The path loss for both urban and suburban environments is modeled by the COST 207 model with a correction term.
   - The Path Loss model for outdoor to indoor and pedestriant test environment is:
     $L = 40\log R + 30\log f + 49$
     where R is the propagation distance and f is the frequency.
   - The Path Loss model for vehicular test environment is:
     $L = [40(1 - 4 \times 10^{-3}\Delta h_b)]\log R - 18\log\Delta h_b + 21\log f + 80$ where R is the propagation distance and f is the frequency, Δh_b is the height between base station antenna and mobile in units of meter. Δh_b is fixed to be 15 in this model.
10. For detailed information about the WiMAX MIMO channel, refer to Reference[3].

11. Output delay: A delay of 64 tokens is introduced in this model.

References

1. IEEE Std 802.16-2004, *Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY,* October 1, 2004.
2. IEEE Std 802.16e-2005, *Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY,* February 2006.
3. WiMAX Forum, *Mobile Radio Conformance Tests Amendment: Wave 2 Tests, Ver 0.5.0,* May 2007.

WMAN_M_Channel_SUI (802.16e OFDMA SUI Channel Model)



Description: WMAN 16e SUI channel model
Library: WMAN 16e, Channel Model

Parameters

Name	Description	Default	Unit	Type	Range
RIn	Input resistance	50 Ohm	Ohm	int	(0,∞)
ROut	Output resistance	50 Ohm	Ohm	int	(0,∞)
ModelType	the SUI Channel number or User defined Channel: SUI_1, SUI_2, SUI_3, SUI_4, SUI_5, SUI_6, UserDefined	SUI_3		enum	
RxAntBeamwidth	the receive antenna beamwidth: omni, thirty	omni		enum	
CellCoverPercentage	the percentage of the cell location have Ricean_factors greater or equal to the Ricean_factor value specified: percent_90, percent_75, percent_50	percent_90		enum	
Delay	the delay of each tap in usec, effective only when ModelType is set as UserDefined	{0.0 , 0.4 , 0.9 }	sec	real array	[0,1000.0]
Power	the power in each tap in dB, effective only when ModelType is set as UserDefined	{0.0 dB, -5.0 dB, -10.0 dB}		real array	(-∞,0]
Ricean_factor	the Ricean K-factor in linear scale of each tap, effective only when ModelType is set as UserDefined	{1.0, 0.0, 0.0}		real array	[0.0,1000.0]
DopplerFreq	the Doppler maximal frequency of each tap in Hz, effective only when ModelType is set as UserDefined	{0.4, 0.3, 0.5 }	Hz	real array	[0.0,1000.0]
GainReductionFactor	the total mean power reduction for a non-omni antenna compared to an omni antenna in dB which should be added to the path loss, effective only when ModelType is set as UserDefined	0.0 dB		real	[0.0,1000.0]
PathLoss	option for inclusion of large-scale pathloss: NO, YES	NO		enum	
PropDistance	the distance of BS and UE in meter, effective only when PassLoss is set as YES	1000	m	real	[200,5000]
Env	environment type options, effective only when PassLoss is set as YES: SuburbCentOrMediCity, MetropolitanCent	SuburbCentOrMediCity		enum	
Hroof	mean value of building heigh in meter, effective only when PassLoss is set as YES	20	m	real	(10,500]
BldgSpace	mean value of building spacing in meter, effective only when PassLoss is set as YES	50	m	real	[1,500]
StreetWidth	mean value of widths of street in meter, effective only when PassLoss is set as YES	30	m	real	[1,500]
StreetOrient	the orientation of the road with respect to the Tx-Rx line, effective only when PassLoss is set as YES	90	deg	real	[0,90]
AntHeigh_UE	UE antenna height above X-Y plane in meter, effective only when PassLoss is set as YES	6	m	real	[2,10]
AntHeigh_BS	BS antenna height above X-Y plane in meter, effective only when PassLoss is set as YES	30	m	real	[4,50]

Pin Inputs

Pin	Name	Description	Signal Type
1	input	channel input signal	timed

Pin Outputs

Pin	Name	Description	Signal Type
2	output	channel output signal	timed

Notes/Equations

1. This model is used to generate channel models for fixed wireless applications.
2. This model is implemented following IEEE 802.16a-03/01.
   A set of 6 modified Standford University Interim (SUI) channel models are constructed to simulate the multipath fading of the channel. The multipath fading is modeled as a tapped-delay line with 3 taps with non-uniform delays. The gain associated with each tap is characterized by a distribution (Ricean with a K-factor>0, or Rayleigh with K-factor=0) and the maximum Doppler frequency. For each tap, we use the method of filtered noise to generate channel coefficients with the specified distribution and spectral power density.

   The definition of the 6 specific SUI channels is shown in the following tables:

   SUI-1 Channel

	Tap 1	Tap 2	Tap 3	Units
Delay	0	0.4	0.9	μs
Power (omni ant.) 90% K-fact. (omni) 75% K-fact. (omni)	0 4 20	-15 0 0	-20 0 0	dB
Power ($30°$ ant.) 90% K-fact. ($30°$) 75% K-fact. ($30°$)	0 16 72	-21 0 0	-32 0 0	dB
Doppler	0.4	0.3	0.5	Hz
Antenna Correlation: $\rho_{ENV} = 0.7$ **Gain Reduction Factor: GRF=0 dB** **Normalization Factor:** $F_{omni} = -0.1771dB$ $F_{30°} = -0.0371dB$		Terrain Type: C	Terrain Type: C	Terrain Type: C

   SUI-2 Channel

	Tap 1	Tap 2	Tap 3	Units
Delay	0	0.4	1.1	μs
Power (omni ant.) 90% K-fact. (omni) 75% K-fact. (omni)	0 2 11	-12 0 0	-15 0 0	dB
Power ($30°$ ant.) 90% K-fact. ($30°$) 75% K-fact. ($30°$)	0 8 36	-18 0 0	-27 0 0	dB
Doppler	0.2	0.15	0.25	Hz
Antenna Correlation: $\rho_{ENV} = 0.5$ **Gain Reduction Factor: GRF=2 dB** **Normalization Factor:** $F_{omni} = -0.3930dB$ $F_{30°} = -0.0768dB$		Terrain Type: C	Terrain Type: C	Terrain Type: C

   SUI-3 Channel

	Tap 1	Tap 2	Tap 3	Units
Delay	0	0.4	0.9	μs
Power (omni ant.) 90% K-fact. (omni) 75% K-fact. (omni)	0 1 7	-5 0 0	-10 0 0	dB
Power ($30°$ ant.) 90% K-fact. ($30°$) 75% K-fact. ($30°$)	0 3 19	-11 0 0	-22 0 0	dB
Doppler	0.4	0.3	0.5	Hz
Antenna Correlation: $\rho_{ENV} = 0.4$ **Gain Reduction Factor: GRF=3 dB** **Normalization Factor:** $F_{omni} = -1.5113dB$ $F_{30°} = -0.3573dB$		Terrain Type: B	Terrain Type: B	Terrain Type: B

   SUI-4 Channel

	Tap 1	Tap 2	Tap 3	Units
Delay	0	1.5	4	μs
Power (omni ant.) 90% K-fact. (omni) 75% K-fact. (omni)	0 0 1	-4 0 0	-8 0 0	dB
Power ($30°$ ant.) 90% K-fact. ($30°$) 75% K-fact. ($30°$)	0 1 5	-10 0 0	-20 0 0	dB
Doppler	0.2	0.15	0.25	Hz
Antenna Correlation: $\rho_{ENV} = 0.3$ **Gain Reduction Factor: GRF=4 dB** **Normalization Factor:** $F_{omni} = -1.9218dB$ $F_{30°} = -0.4532dB$		Terrain Type: B	Terrain Type: B	Terrain Type: B

SUI-5 Channel

	Tap 1	Tap 2	Tap 3	Units
Delay	0	4	10	μs
Power (omni ant.) 90% K-fact. (omni) 75% K-fact. (omni) 50% K-fact. (omni)	0 0 0 2	-5 0 0 0	-10 0 0 0	dB
Power ($30°$ ant.) 90% K-fact. ($30°$) 75% K-fact. ($30°$) 50% K-fact. ($30°$)	0 0 2 7	-11 0 0 0	-22 0 0 0	dB
Doppler	0.4	0.3	0.5	Hz
Antenna Correlation: $\rho_{ENV} = 0.3$ **Gain Reduction Factor: GRF=4 dB** **Normalization Factor:** $F_{omni} = -1.5113dB$ $F_{30°} = -0.3573dB$		Terrain Type: A	Terrain Type: A	Terrain Type: A

SUI-6 Channel

	Tap 1	Tap 2	Tap 3	Units
Delay	0	14	20	μs
Power (omni ant.) 90% K-fact. (omni) 75% K-fact. (omni) 50% K-fact. (omni)	0 0 0 1	-10 0 0 0	-14 0 0 0	dB
Power ($30°$ ant.) 90% K-fact. ($30°$) 75% K-fact. ($30°$) 50% K-fact. ($30°$)	0 0 2 5	-16 0 0 0	-26 0 0 0	dB
Doppler	0.4	0.3	0.5	Hz
Antenna Correlation: $\rho_{ENV} = 0.3$ **Gain Reduction Factor: GRF=4 dB** **Normalization Factor:** $F_{omni} = -0.5683dB$ $F_{30°} = -0.1184dB$		Terrain Type: A	Terrain Type: A	Terrain Type: A

The total channel gain is normalized by adding the specified Normalization Factor to each tap.
The specified Doppler is the maximum Doppler frequency parameter (fm) of the rounded spectrum which has the power spectral density (PSD) function as follows:

$$S(f) = \begin{cases} 1 - 1.72f_0^{\,2} + 0.785f_0^{\,4} & |f_0| \le 1 \\ 0 & |f_0| > 1 \end{cases}$$

where $f_0 = \dfrac{f}{f_m}$.

The Gain Reduction Factor (GRF) is the total mean power reduction for a $30°$ antenna compared to an omni antenna. If $30°$ antennas are used and $PathLoss = YES$ the specified GRF should be added to the path loss.

K-factors for the 90% and 75% cell coverage are shown in the tables, i.e. 90% and 75% of the cell locations have K-factors greater or equal to the K-factor value specified, respectively. For the SUI-5 and SUI-6, 50% K-factor values are also shown.

The Antenna Correlation, which has to be considered if multiple channels are simulated, is not used in this model.

The set of SUI channel models specify statistical parameters of microscopic effects. To simulate the real channel, these statistics have to be combined with macroscopic channel effects, i.e. the path loss (including shadowing) which are common to all 6 models in the set.

The COST 231 WALFISCH-IKEGAMI model with a correction term is used to simulate the path loss for both urban and suburban environments if the PathLoss is ON and other parameters are set according to the specific environment.

3. Parameter Details
    - ModelType specifies the type of SUI channel.
      The relationship of the channel type and the terrain type is shown in *The Relationship Between Channel Type and the Terrain Type*.

Terrain Type	SUI Channel
C	SUI-1, SUI-2
B	SUI-3, SUI-4
A	SUI-5, SUI-6

      Terrain Type A is hilly terrain with moderate-to-heavy tree densities, while Terrain Type C is mostly flat terrain with light tree densities.
      ModelType working with RxAntBeamwidth and CellCoverPercentage specifies the SUI channel type and all the microscopic statistical parameters as shown in the corresponding table.
    - RxAntBeamwidth specifies the receive antenna beamwidth: omnidirectional ($360°$) and $30°$.
    - CellCoverPercentage specifies the percentage of the cell location with Ricean_factors greater or equal to the Ricean_factor value specified.
    - PathLoss identifies whether the large-scale pathloss is included.
      if $PathLoss = NO$, the path loss is not included in this model and the parameters describing the environment are unused.
      if $PathLoss = YES$, the path loss for both urban and suburban environments is modeled by the COST 231 W-I model with a correction term. There are three terms which make up the model:
      $L_b = L_0 + L_{rts} + L_{msd}$
      L0 = free space loss
      Lrts= roof top to street diffraction
      Lmsd= multi-screen loss
      The correction term added to the COST 231 W-I model is given as follows:

      $$(h_m) = -\left[\left(1.1\log\left(\frac{f}{MHz}\right) - 0.7\right)H_{UE} - \left(1.56\log\left(\frac{f}{MHz}\right) - A\right) + 20\log(H_{roof} - H_{UE}) - 20\log(H_{roof} - 3.5)\right.$$

      where
      $A = 1.56\log\left(\frac{f}{MHz}\right) - \left(1.1\log\left(\frac{f}{MHz}\right) - 0.7\right)3.5$
      HUE is the antenna height of the SS and the Hroof is the mean value of building height of this environment.
      Details about COST 231 W-I model can be found in reference[1]
    - PropDistance specifies the distance of BS and SS.
    - Env specifies the propagation environment type including urban and suburban.
    - Hroof specifies the mean value of building height in the chosen environment.
    - BldgSpace specifies the mean value of building spacing in the chosen environment.
    - StreetWidth specifies the mean value of widths of street in the chosen environment.
    - StreetOrient specifies the orientation of the road with respect to the Tx-Rx line.
    - AntHeigh_UE and AntHeigh_BS specify the antenna height of the SS and BS.
      PropDistance, Env, Hroof, BldgSpace, StreetWidth, StreetOrient, AntHeigh_UE, AntHeigh_BS are used to calculate the path loss when the PathLoss is ON.
4. Output delay

   A delay of 64 tokens is introduced in this model.

References

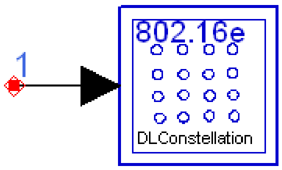
1. IEEE 802.16a-03/01, Channel Models for Fixed Wireless Applications, June 27, 2003.

802.16e OFDMA Measurement Components

The 16e measurement models provide basic measurements (such as EVM, CCDF and etc.).

- *WMAN M DL Constellation RF (802.16e Downlink Constellation RF)* (wman_m)
- *WMAN M DL EVM (EVM Measurement for 802.16e Downlink Signals)* (wman_m)
- *WMAN M DL RF CCDF (802.16e OFDMA DL RF CCDF)* (wman_m)
- *WMAN M DL SpecFlat (802.16e Downlink Spectral Flatness)* (wman_m)
- *WMAN M UL Constellation RF (Uplink Constellation Measurement)* (wman_m)
- *WMAN M UL EVM (Uplink EVM (RCE) Measurement)* (wman_m)
- *WMAN M UL RF CCDF (Uplink CCDF Measurement)* (wman_m)
- *WMAN M UL SpecFlat (802.16e OFDMA Uplink Spectrum Flatness)* (wman_m)

WMAN_M_DL_Constellation_RF (802.16e Downlink Constellation RF)



WMAN_M_DL_Constellation_RF

Description: Downlink constellation
Library: WMAN 16e, Measurement

Parameters

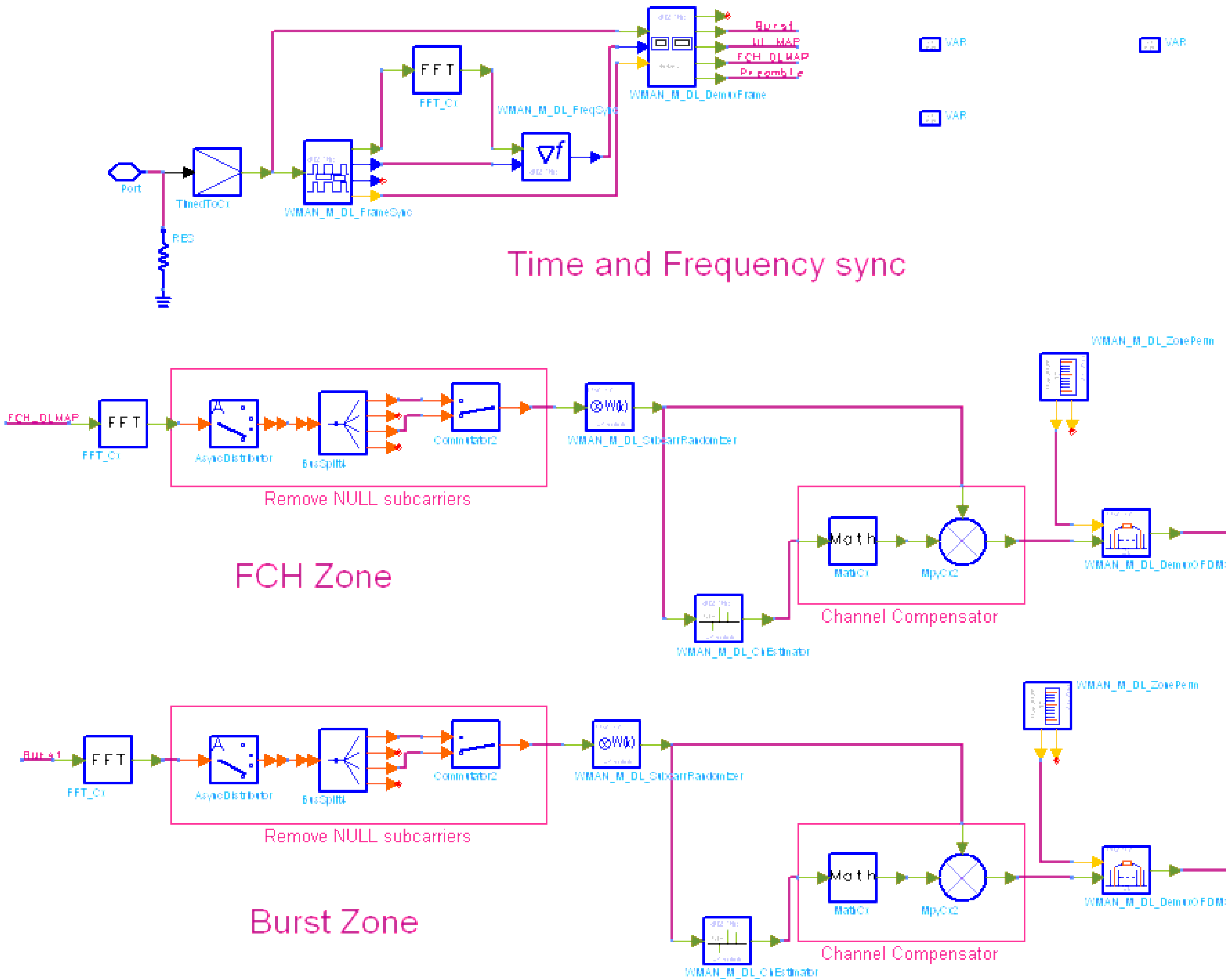
Name	Description	Default	Unit	Type	Range
RIn	Input resistance	50 Ohm	Ohm	int	(0,∞)
RTemp	TEMPERATURE	- 273.15	Celsius	real	[-273.15,∞]
Bandwidth	Nominal bandwidth	3.5 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01 , 0.99]
FrameDuration	Frame duration: time 2ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 10 ms		enum	
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[0,20000]
PreambleIndex	Preamble index	3		int	[0,113]
DL_PermBase	Downlink permutation base	9		int	[0,31]
PRBS_ID	PRBS ID	0		int	[0,3]
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	24		int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array	[0,1]
NumberOfBurst	Number of Bursts	2		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5, 1}		int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6, 14}		int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15, 18}		int array	[1,60]
DataLength	MAC PDU payload byte length of each burst	{200, 300}		int array	[1,∞)
Rate_ID	Rate ID of each burst	{5, 5}		int array	[0,7]
PowerBoosting	Power boosting of each burst in dB	{0, 0}		real array	[-∞,∞]
start	Frame Number	1200		int	[0,∞)
stop	Frame Number	2399		int	[start,∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	RF	input of RF signal	timed

Notes/Equations

1. This subnetwork is used to show the constellation of 802.16e OFDMA downlink RF signal. The schematic for this subnetwork is shown in the following illustration.



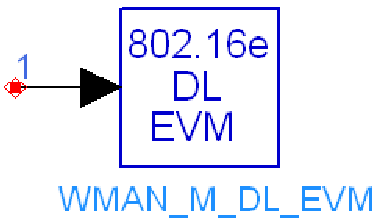
WMAN_M_DL_Constellation_RF Schematic

2. The input timed signal is converted from RF to baseband by TimedToCx. Then, frame synchronization, frequency offset, frame demultiplex are completed by WMAN_M_DL_FrameSync, WMAN_M_DL_FreqSync, WMAN_M_DL_DemuxFrame respectively. After frame demultiplex the signal are split into two branches, one for FCH and another for DL bursts. Then channel estimation and channel compensation for the two branches are completed by WMAN_M_DL_ChEstimator respectively. The equalized data are collected by the Sink named FCH_Constellation and Data_Constellation respectively.
The constellations for FCH start from 96 and stop at 192. The constellations for data displayed in Data Display window depend on the parameters start, stop which decide which part of signal is measured and the number of constellation points.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_EVM (EVM Measurement for 802.16e Downlink Signals)



Description: WMAN 802.16e OFDMA Data Burst Analysis Downlink EVM Measurement
Library: WMAN 16e, Measurement

Parameters

Name	Description	Default	Symbol	Unit	Type	Range
RLoad	Load resistance	DefaultRLoad		Ohm	real	(0,∞)
RTemp	Load resistance physical temperature	DefaultRTemp		Celsius	real	[-273.15,∞)
FCarrier	Carrier frequency	3407 MHz		Hz	real	(0,∞)
MirrorSpectrum	Mirror frequency spectrum?: NO, YES	NO			enum	
Start	Data collection start time	DefaultTimeStart		sec	real	[0,∞)
AverageType	Average type: Off, RMS (Video)	Off			enum	
FramesToAverage	Frames to average (if AverageType is not Off)	5			int	[1,∞)
FrameDuration	Frame time duration: time 2.0 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 10 ms			enum	
Bandwidth	Bandwidth	3.5 MHz		Hz	int	(0,∞)
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024			enum	
CyclicPrefix	Cyclic prefix	0.125	G		real	[0,1]
PreambleIndex	Preamble index	3			int	[0,113]
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC			enum	
ZoneSymOffset	Zone offset in symbols	1			int	[0,∞)†
ZoneNumOfSym	Zone length in symbols	24			int	[1,∞)†
DL_PermBase	Zone permutation base	9			int	[0,31]
PRBS_ID	Prbs ID	0			int	[0,3]
GroupBitmask	Group bitmask	{1, 1, 1, 1, 1, 1}			int array	[0,1]
NumberOfBursts	Number of bursts	2			int	[1,16]
BurstSymOffset	Symbol offset for each burst	{4, 10}			int array	[0,∞)‡
BurstSubchOffset	Subchannel offset for each burst	{5, 1}			int array	[0,∞)‡
BurstNumOfSym	Number of symbols for each burst	{6, 14}			int array	[1,∞)‡
BurstNumOfSubch	Number of subchannels for each burst	{15, 18}			int array	[1,∞)‡
BurstRate_ID	Data tone modulation format for each burst (0=QPSK 1/2, 1=QPSK 3/4, 2=QAM16 1/2, 3=QAM16 3/4, 4=QAM64 1/2, 5=QAM64 2/3, 6=QAM64 3/4, 7=QAM64 5/6)	{5, 5}			int array	[0,7]‡
BurstPowerBoosting	Power boosting for each burst in dB	{0, 0}			real array	(-∞,∞)‡
PulseSearch	Perform pulse search?: NO, YES	YES			enum	
SymbolTimingAdjust	Symbol timing adjustment (in % of FFT time)	-3.125			real	[-G*100,0]
TrackAmplitude	Track amplitude?: NO, YES	NO			enum	
TrackPhase	Track phase?: NO, YES	YES			enum	
TrackTiming	Track timing?: NO, YES	NO			enum	
EqualizerTraining	Equalizer training method: Chan Estimation Seq Only, Chan Estimation Seq & Data, Chan Estimation Seq & Pilots	Chan Estimation Seq Only			enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3			enum	

† ZoneSymOffset and ZoneNumOfSym must satisfy the following condition
‡ The number of elements in these arrays must be equal to NumberOfBursts. In addition, corresponding elements of the BurstSymOffset, BurstNumOfSym, BurstSubchOffset, and BurstNumOfSubch arrays must satisfy the following conditions
BurstSymOffset[i] + BurstNumOfSym[i] <= ZoneNumOfSym.
For a zone of type DL_PUSC, all the elements of the arrays BurstSymOffset and BurstNumOfSym must be integer multiples of 2.
BurstSubchOffset[i] + BurstNumOfSubch[i] <= ZoneNumOfSubch.
ZoneNumOfSubch depends on ZoneType, FFTSize.
For a zone of type DL_PUSC, ZoneNumOfSubch also depends on GroupBitmask.
Defined bursts cannot have overlapping slots.

Pin Inputs

Pin	Name	Description	Signal Type
1	input	input signal	timed

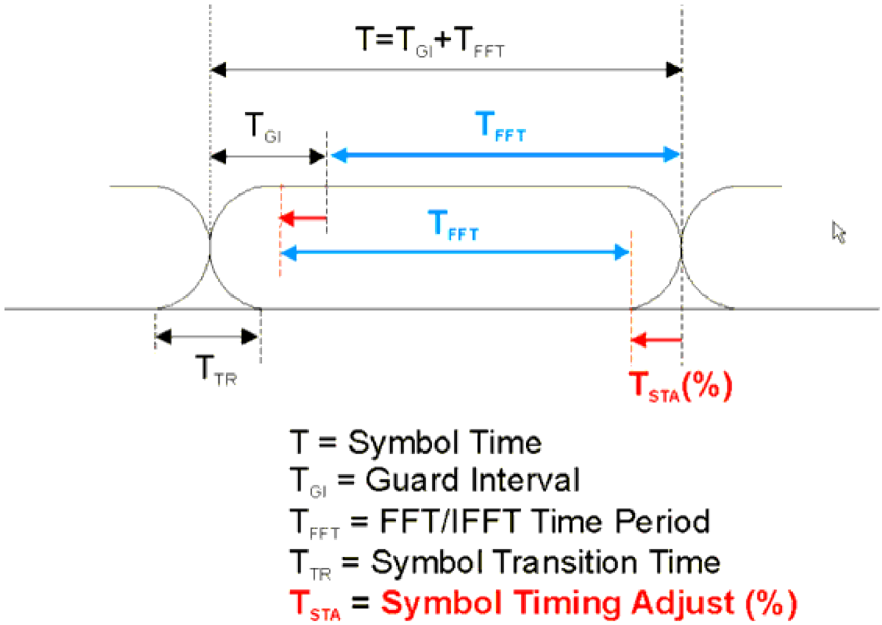
Notes/Equations

1. This component performs an EVM measurement for a WiMax 802.16e (OFDMA) downlink signal. The input signal must be a timed RF (complex envelope) signal or the component will error out. The available results from this measurement are:
   - Avg_RCE_dB: average Relative Constellation Error (EVM) in dB
   - RCE_dB: Relative Constellation Error (EVM) in dB versus frame
   - Avg_RCE_rms_percent: average Relative Constellation Error (EVM) in %
   - RCE_rms_percent: Relative Constellation Error (EVM) in % versus frame
   - Avg_DataRCE_dB: average Relative Constellation Error (EVM) for data subcarriers in dB
   - DataRCE_dB: Relative Constellation Error (EVM) for data subcarriers in dB versus frame
   - Avg_DataRCE_rms_percent: average Relative Constellation Error (EVM) for data subcarriers in %
   - DataRCE_rms_percent: Relative Constellation Error (EVM) for data subcarriers in % versus frame
   - Avg_Pilot_RCE_dB: average Relative Constellation Error (EVM) for pilot subcarriers in dB
   - Pilot_RCE_dB: Relative Constellation Error (EVM) for pilot subcarriers in dB versus frame
   - Avg_CPE_rms_percent: average Common Pilot Error in %
   - CPE_rms_percent: Common Pilot Error in % versus frame
     Results prefixed with *Avg_* are averaged over the number of frames specified by the user (if AverageType is set to *RMS* (*Video*)). Results that are not prefixed with *Avg_* are results versus frame. To use any of the results in an ael expression or in the *Goal* expression in an optimization setup, you must prefix them with the instance name of the component followed by a dot, for example *W1.Avg_DataRCE_dB* .
     All the results mentioned above are saved in the simulation dataset as well as displayed in the status window. The following results are only displayed in the status window:
   - RCE Peak in % and symbol number where peak occurred
   - DataRCE Peak in % pk and symbol number where peak occurred
   - Freq Err in Hz
   - SymClkErr in ppm
   - IQ Offset in dB
   - IQ Skew in sec
   - Quad Err in deg
   - Gain Imb in dB
   - Sync Corr
   - Power in dB, RCE in dB, and DataRCE in dB for each analyzed data burst are also displayed on the status window.

     Following is a brief description of the algorithm used in this component and a detailed description of its parameter usage.
2. Starting at the time instant specified by the Start parameter, the component captures a signal segment of length 2 × FrameDuration. If PulseSearch is set to YES, this signal segment is searched in order for an RF burst to be detected. If the signal has multiple RF bursts in a FrameDuration then the first one detected is the one that will be analyzed. Some 802.16e OFDMA signals do not have RF burst characteristics, rather they look like a series of bursts with no "off" time between them. These signals resemble a "continually on" signal with embedded preambles. To demodulate signals that do not appear to be made up of RF bursts, PulseSearch should be set to OFF and Start should be set to the beginning of the downlink subframe you want to analyze. Otherwise, no pulse will be detected and no measurement will be performed.
   After an RF burst is detected, the I and Q envelopes of the input signal are extracted. The FCarrier parameter sets the frequency of the internal local oscillator signal for the I and Q envelope extraction. Then the I and Q envelopes are passed to a complex algorithm that performs synchronization, demodulation, and EVM analysis. The algorithm that performs the synchronization, demodulation, and EVM analysis is the same as the one used in the Agilent 89600 VSA.
3. If AverageType is set to *OFF* , only one frame is analyzed. If AverageType is set to *RMS* (*Video*), after the first frame is analyzed the signal segment corresponding to it is discarded and new signal samples are collected from the input to fill in the signal buffer of length 2 × FrameDuration. A second frame is analyzed and the process repeats until FramesToAverage frames are processed.
   If a frame is misdetected for any reason the results from its analysis are discarded. The EVM results obtained from all successfully detected, demodulated, and analyzed frames are averaged to give the final averaged results. The EVM results from each successfully analyzed pulse are also recorded (in the variables that are not prefixed with *Avg_*).
4. The MirrorSpectrum parameter allows the user to invert the Q envelope (when set to YES) in order to properly demodulate signals whose frequency spectrums have been mirrored (flipped) about the center frequency. This

spectrum mirroring can be the result of the mixer configuration used in your system.

5. The FrameDuration parameter sets the duration of a frame, which is used to capture a long enough signal segment for an analysis to be performed.
6. The Bandwidth parameter sets the nominal channel bandwidth.
7. The FFTSize parameter sets the FFT size.
8. The CyclicPrefix parameter (also referred to as Guard Interval) sets the cyclic prefix time as a fraction of the inverse FFT time. The cyclic prefix time is used to eliminate inter-symbol and inter-carrier interference. Each OFDMA symbol is transmitted for a slightly longer time than the active (or useful) symbol time. This extra time is the cyclic prefix time.
9. The PreambleIndex parameter sets the preamble sequence as well as the associated IDCell and Segment values (as defined in the standard).
10. The ZoneType, ZoneSymOffest, and ZoneNumOfSym parameters define the zone that will be analyzed:
    - ZoneType sets the zone type (PUSC, FUSC, OFUSC)
    - ZoneSymOffset sets the zone offset (in number of symbols) from the beginning of the frame
    - ZoneNumOfSym sets the zone length (in number of symbols)
11. The DL_PermBase parameter sets the PermBase value used in the zone to be analyzed. For a DL_PUSC zone with ZoneSymOffset equal to 1 the value of the DL_PermBase parameter is ignored and the PermBase value used in the analysis is always 0.
12. The PRBS_ID parameter sets the pseudo-random binary sequence ID value for the zone to be analyzed. PRBS_ID is only used for zones with ZoneSymOffset greater than 1. If ZoneSymOffset equals 1 (i.e. the first DL_PUSC zone), PRBS_ID is ignored.
13. The GroupBitmask parameter sets the subchannel groups that are allocated to the zone. This parameter is only used for DL_PUSC zones. DL_PUSC zone definition provides 6 subchannel groups which specify the number of used subchannels and how they are mapped to subcarriers for analysis of DL_PUSC data bursts.
14. The NumberOfBursts parameter sets the number of data bursts that will be analyzed in the defined zone.
15. The BurstSymOffset, BurstSubchOffset, BurstNumOfSym, and BurstNumOfSubch parameters define the data bursts that will be analyzed. These parameter are arrays and they should have NumberOfBursts elements. Only rectangular shaped bursts are supported. BurstSymOffset is with respect to the beginning of the zone.
16. The BurstRate_ID parameter is an array parameter with NumberOfBursts elements that sets the data tone modulation format and coding rate for each burst (0 for QPSK 1/2, 1 for QPSK 2/3, 2 for 16-QAM 1/2, 3 for 16-QAM 2/3, 4 for 64-QAM 1/2, 5 for 64-QAM 2/3, and 6 for 64-QAM 3/4, 7 for 64-QAM 5/6).
17. The BurstPowerBoosting parameter is an array parameter with NumberOfBursts elements that sets the power boosting (in dB) for each burst.
18. The SymbolTimingAdjust parameter sets the percentage of symbol time by which we back away from the symbol end before we perform the FFT. Normally, when demodulating an OFDMA symbol, the cyclic prefix time (guard interval) is skipped and an FFT is performed on the last portion of the symbol time. However, this means that the FFT will include the transition region between this symbol and the following symbol. To avoid this, it is generally beneficial to back away from the end of the symbol time and use part of the guard interval. The SymbolTimingAdjust parameter controls how far the FFT part of the symbol is adjusted away from the end of the symbol time. The value is in terms of percent of the used (FFT) part of the symbol time. Note that this parameter value is negative, because the FFT start time is moved back by this parameter. SymbolTimingAdjust Definition. explains this concept. When setting this parameter, be careful to not back away from the end of the symbol time too much because this may make the FFT include corrupt data from the transition region at the beginning of the symbol time.

18. 

SymbolTimingAdjust Definition

19. The TrackAmplitude, TrackPhase, and TrackTiming parameters specify whether the analysis will track amplitude, phase, and timing changes in the pilot subcarriers. 802.16e performs demodulation relative to the data in pilot carriers embedded in the signal. These pilot carriers replace data-carrying elements of the signal and allow some kinds of impairments to be removed or "tracked out". Many impairments will be common to all pilot carriers and can be measured as the "common pilot error". When these parameters are set to YES the analysis will track amplitude, phase, and timing changes in the pilot subcarriers and apply corrections to the pilot and data subcarriers.
    The flexibility to allow users to individually enable or disable tracking functions, provides useful troubleshooting capability, since modulation errors can be examined with and without the benefit of particular types of pilot tracking.
20. The EqualizerTraining parameter sets the type of training used for the equalizer. When demodulating an 802.16e signal, an equalizer is used to correct for linear impairments in the signal path, such as multi-path. When "Chan Estimation Seq Only" is selected the equalizer is trained using the Channel Estimation Sequence in the preamble of the OFDMA burst. After this initialization, the equalizer coefficients are held constant while demodulating the rest of the burst. This equalizer training method complies with the description in the "Transmit constellation error and test method" section (8.4.12.3) of the 802.16-2004 standard. However, for signals whose impairments change during the burst it might result in measured RCE (EVM) values that are higher compared to if the equalizer were trained over the entire burst.
    When "Chan Estimation Seq & Data" is selected the equalizer is trained by analyzing the entire OFDMA burst and using the Channel Estimation Sequence (contained in the preamble) and the all the subcarriers in the Data symbols. This type of equalizer training generally gives a more accurate estimate of the true response of the transmission channel and so results in lower RCE (EVM) measured values. However, it is more complicated and more computationally expensive to implement and therefore less likely to be used in practical receivers.
    When "Chan Estimation Seq & Pilots" is selected the equalizer is trained by analyzing the entire OFDMA burst and using the Channel Estimation Sequence (contained in the preamble) and the pilot subcarriers in the Data symbols. This gives results very similar to the "Chan Estimation Seq & Data" option without the excessive computational complexity.

WMAN_M_DL_RF_CCDF (802.16e OFDMA DL RF CCDF)

Description: CCDF measurment
Library: WMAN 16e, Measurement

Parameters

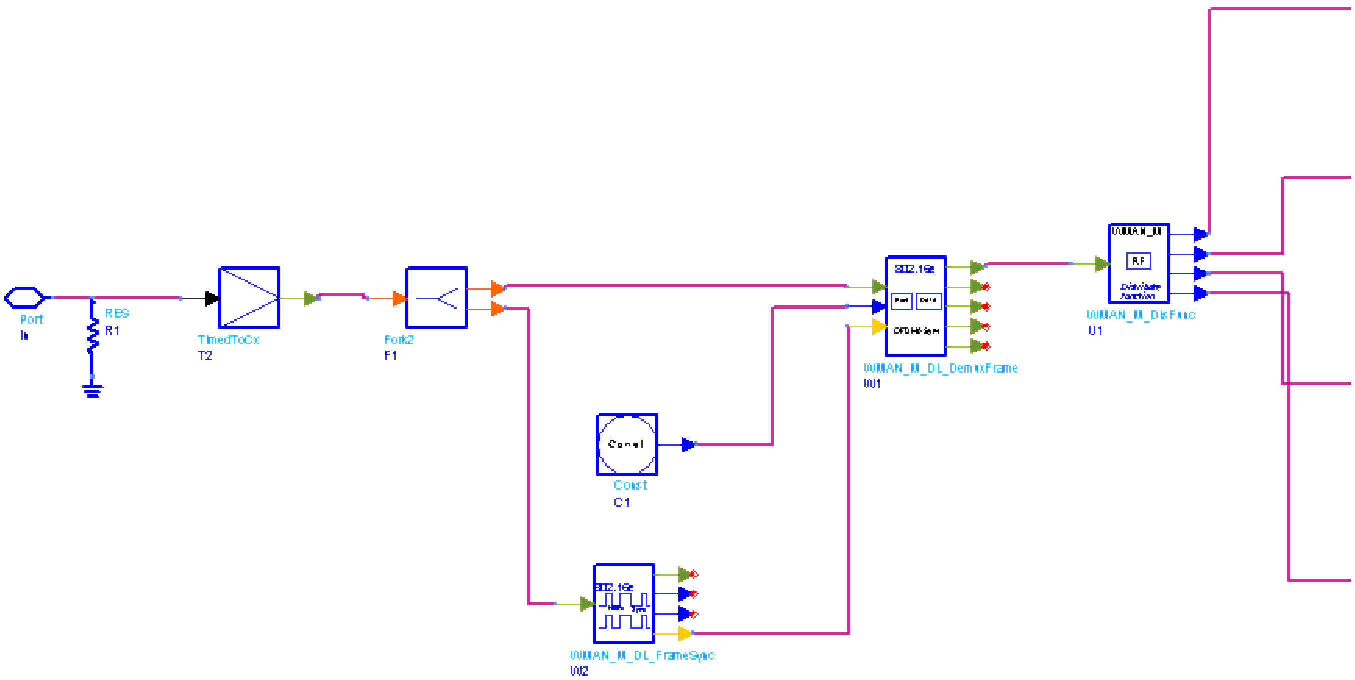
Name	Description	Default	Unit	Type	Range
RLoad	Source resistance	50 Ohm	Ohm	int	(0,∞)
RTemp	TEMPERATURE	- 273.15	Celsius	real	[-273.15,∞]
RefR	Reference resistance	50 Ohm	Ohm	real	
StartSample	Sample from which measurement begin	0		int	
SymLen	length of input signal symbol	2560		int	
SymNum	Number of symbols	1		int	
OutputPoint	Indicate output precision	100		int	
Bandwidth	Bandwidth	1.75 MHz	Hz	int	(0,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 1		enum	
CyclicPrefix	Cyclic prefix	0.25		real	[0,1]
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
FFTSize	: FFT_2048, FFT_1024, FFT_512	FFT_2048		enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC	DL_PUSC		enum	
ZoneNumOfSym	Number of symbol in zone	24		int	[1,1212]
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
FrameStartSym	Start symbol number of frame	0		int	[0,1212]
FrameStopSym	Stop symbol number of frame	0		int	[0,1212]

Pin Inputs

Pin	Name	Description	Signal Type
1	RF_Signal	received RF signal to be measured	timed

Notes/Equations

1. This subnetwork measures the complementary cumulative distribution function (CCDF) of the RF signal, PeakPower and MeanPower.
2. $Samples_{Frame}$ (will explained later) tokens are consumed at pin input and $SymLen \times SymNum$ tokens are used for measurement. The distribution range is divided into segments according to the OutputPoint parameter and is sent to the SignalRange_dB NumericSink. The corresponding distribution probability is calculated based on these segments and sent to the CCDF NumericSink. Peak power of 99.9% probability and average power of input signals are calculated. These results are collected by the PeakPower and AvgPower NumericSinks.
3. The schematic for this subnetwork is shown in the following illustration.



WMAN_M_DL_RF_CCDF Schematic

4. Note that the units of PeakPower and AvgPower are dBm; SignalRange is the transient absolute signal power minus AvgPower, so the unit of SignalRange is dB.
5. $Samples_{Frame}$ is the total sample of one downlink frame including zero padding and calculated as follows:

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

where $Samples_{idle}$ is the samples of IdleInterval and calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

Fs is the sampling frequency decided by Bandwidth, OversamplingOption and related sampling factor (!wman_m-05-4-13.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

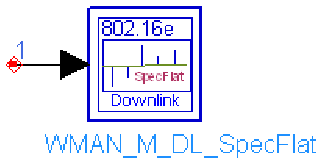
The sampling factors are listed in the following table:

Sampling factor n	Bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.

WMAN_M_DL_SpecFlat (802.16e Downlink Spectral Flatness)



Description: Downlink spectrum flatness
Library: WMAN 16e, Measurement

Parameters

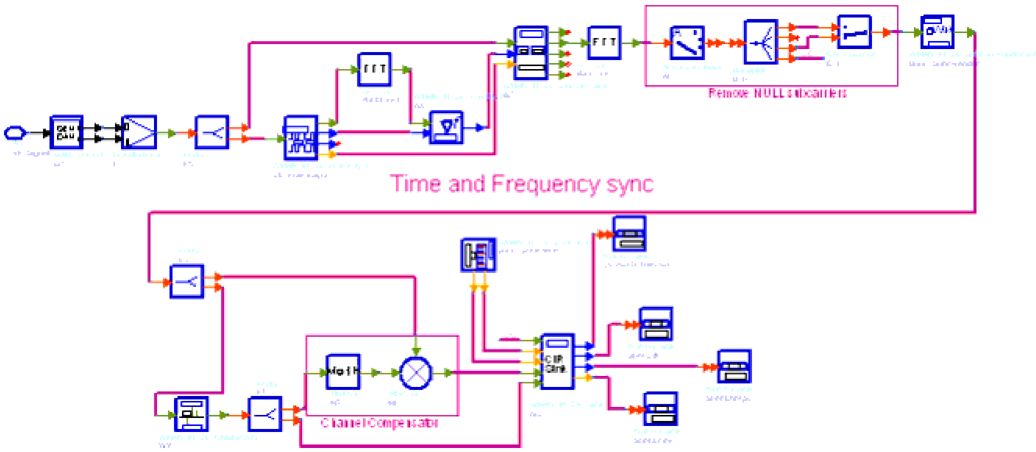
Name	Description	Default	Unit	Type	Range
RIn	Input resistance	50 Ohm	Ohm	int	(0,∞)
RTemp	TEMPERATURE	- 273.15	Celsius	real	[-273.15,∞]
FCarrier	Carrier frequency	3407 MHz	Hz	real	(0,∞)
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
DLMAP_Enable	DLMAP is inserted or not: NO, YES	NO		enum	
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[0,0.02]
PreambleIndex	Preamble index	3		int	[0,113]
DL_PermBase	Downlink permutation base	9		int	[0,31]
PRBS_ID	PRBS ID	0		int	[0,3]
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	22		int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array	[0,1]
NumberOfBurst	Number of Bursts	2		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}		int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,12}		int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}		int array	[1,60]
CodingType	Coding type of each burst	{0,0}		int array	[0,1]
Rate_ID	Rate ID of each burst	{5,5}		int array	[0,7]
FramesToAverage	Number of frames for the average CIR	1		int	[1,∞)
SpectrumEstimation	The method for spectrum estimation: Estimation on pilots, Estimation on data & pilots	Estimation on data & pilots		enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	FrameData	input of RF signal	timed

Notes/Equations

1. This subnetwork is used to measure the spectral flatness of Mobile WiMAX downlink subframe. The schematic for this subnetwork is shown in the following illustration.



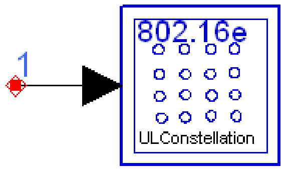
WMAN_M_DL_SpecFlat Schematic

2. According the standard, the data for measuring spectral flatness shall be taken from the channel estimation step. In RCT (Reference [3]), more specifications are listed: by observing the amplitude deviations from the constellation points this function estimates the flatness as a function of frequency from ordinary data transmission signals.
3. In this subnetwork, two methods are provided to get the data for measuring spectral flatness.
    1. *SpectrumEstimation is Estimation on pilots*
    In this method, the CIRs are estimated only on pilot subcarriers. The CIRs on data subcarriers are interpolated by the CIRs on pilot subcarriers.
    2. *SpectrumEstimation is Estimation on data & pilots*
    This method follows the requirement by RCT (Reference [3]). By observing the received amplitude deviations from the nearest constellation points in data and pilot subcarriers, this method estimates the flatness as a function of frequency from ordinary data transmission signals. The spectral flatness for each subcarrier across the whole data zone is averaged to remove spectral fluctuation due to modulation. Above measurement is applied only for the active subcarriers. When one subcarrier is non-allocated across the whole data zone, a fixed value (0) is output for this subcarrier (spectral line) to Sink SpecEnergy. The difference energy output to Sink SpecDiff is obtained by comparing amplitudes within the CIRs obtained in above measurement for all subcarriers with neighboring subcarriers excluding all non-allocated subcarriers.
    Note that this method is only applied for DL PUSC.
4. The results shall be the average of FramesToAverage downlink subframes, where FramesToAverage is set by users. The measurement results are output to Sink SpecEnergy. Meanwhile the difference energy between adjacent subcarriers from -Nused/2 to Nused/2 are output to Sink SpecDiff, and spectral lines from -Nused/2 to Nused/2 are output to Sink SpecLines. The ratio of the power at spectral line 0 to the total power is output to Sink DCPwrToTranPwr.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. WiMAX Forum, Mobile Radio Conformance Tests (MRCT), October 2006.

WMAN_M_UL_Constellation_RF (Uplink Constellation Measurement)



Description: Uplink constellation
Library: WMAN 16e, Measurement

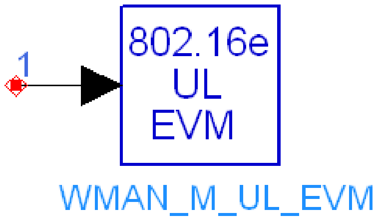
Parameters

Name	Description	Default	Unit	Type	Range
RIn	Input resistance	DefaultRIn	Ohm	int	(0,∞)
RTemp	Temperature, in degrees C	DefaultRTemp	Celsius	real	[-273.15,∞]
Bandwidth	Nominal bandwidth	3.5 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01 , 0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 10 ms		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[0,1000]
PreambleIndex	Preamble index	3		int	[0,1024]
FrameNumber	Frame number	0		int	[1,0xffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
UL_PermBase	UL PermBase	0		int	[0 , 31]
ZoneType	Zone type: UL_PUSC, UL_OPUSC	UL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24		int	[3,1212]
ZoneSymOffset	Symbol offset in zone	0		int	[0,1211]
NumberOfBurst	Number of Bursts	1		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}		int array	[1,6868]
DataLength	MAC PDU payload byte length of each burst	{300}		int array	[1,∞)
Rate_ID	Rate ID of each burst	{3}		int array	[0,7]
start	Frame Number	1200		int	[0,∞)
stop	Frame Number	2399		int	[start,∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	RF	input of RF signal	timed

WMAN_M_UL_EVM (Uplink EVM (RCE) Measurement)



Description: WMAN 802.16e OFDMA Data Burst Analysis Uplink EVM Measurement
Library: WMAN 16e, Measurement

Parameters

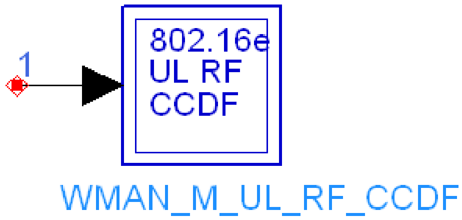
Name	Description	Default	Symbol	Unit	Type	Range
RLoad	Load resistance	DefaultRLoad		Ohm	real	(0,∞)
RTemp	Load resistance physical temperature	DefaultRTemp		Celsius	real	[-273.15,∞)
FCarrier	Carrier frequency	3407 MHz		Hz	real	(0,∞)
MirrorSpectrum	Mirror frequency spectrum?: NO, YES	NO			enum	
Start	Data collection start time	DefaultTimeStart		sec	real	[0,∞)
AverageType	Average type: Off, RMS (Video)	Off			enum	
FramesToAverage	Frames to average (if AverageType is not Off)	5			int	[1,∞)
FrameDuration	Frame time duration: time 2.0 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 10 ms			enum	
Bandwidth	Bandwidth	3.5 MHz		Hz	int	(0,∞)
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024			enum	
CyclicPrefix	Cyclic prefix	0.125	G		real	[0,1]
PreambleIndex	Preamble index	3			int	[0,113]
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC			enum	
ZoneSymOffset	Zone offset in symbols	0			int	[0,∞)†
ZoneNumOfSym	Zone length in symbols	24			int	[1,∞)†
UL_PermBase	Zone permutation base	0			int	[0,69]
NumberOfBursts	Number of bursts	1			int	[1,16]
BurstSymOffset	Symbol offset for each burst	{0}			int array	[0,∞)‡
BurstSubchOffset	Subchannel offset for each burst	{0}			int array	[0,∞)‡
BurstAssignedSlots	Number of assigned slots for each burst	{96}			int array	[1,∞)‡
BurstRate_ID	Data tone modulation format for each burst (0=QPSK 1/2, 1=QPSK 3/4, 2=QAM16 1/2, 3=QAM16 3/4, 4=QAM64 1/2, 5=QAM64 2/3, 6=QAM64 3/4, 7=QAM64 5/6)	{3}			int array	[0,7]‡
BurstPowerOffset	Power offset for each burst in dB	{0}			real array	(-∞,∞)‡
PulseSearch	Perform pulse search?: NO, YES	YES			enum	
SymbolTimingAdjust	Symbol timing adjustment (in % of FFT time)	-3.125			real	[-G*100,0]
TrackAmplitude	Track amplitude?: NO, YES	YES			enum	
TrackPhase	Track phase?: NO, YES	YES			enum	
TrackTiming	Track timing?: NO, YES	YES			enum	
ExtendFrequencyLockRange	Extend frequency lock range?: NO, YES	NO			enum	
EqualizerTraining	Equalizer training method: Chan Estimation Seq Only, Chan Estimation Seq & Data, Chan Estimation Seq & Pilots	Chan Estimation Seq & Pilots			enum	
EnableRangingDetection	auto detect FFB and Ranging allocation whether RNG have power or not: NO, YES	NO			enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3			enum	

† ZoneSymOffset and ZoneNumOfSym must satisfy the following condition
‡ The number of elements in these arrays must be equal to NumberOfBursts. In addition, corresponding elements of BurstSymOffset, BurstSubchOffset, and BurstAssignedSlots arrays must satisfy the following conditions
BurstSymOffset[i] <= ZoneNumOfSym.
All the elements of the array BurstSymOffset must be integer multiples of 3.
BurstSubchOffset[i] <= ZoneNumOfSubch.
ZoneNumOfSubch depends on ZoneType, FFTSize.
(BurstSubchOffset[i] x ZoneNumOfSym + BurstSymOffset) / 3 + BurstAssignedSlots[i] <= ZoneNumOfSlots.
ZoneNumOfSlots = ZoneNumOfSubch x ZoneNumOfSym / 3.
Defined bursts cannot have overlapping slots.

Pin Inputs

Pin	Name	Description	Signal Type
1	input	input signal	timed

WMAN_M_UL_RF_CCDF (Uplink CCDF Measurement)



Description: CCDF measurment
Library: WMAN 16e, Measurement

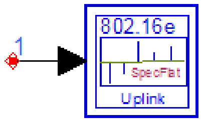
Parameters

Name	Description	Default	Unit	Type	Range
RLoad	Source resistance	50 Ohm	Ohm	int	(0,∞)
RTemp	TEMPERATURE	- 273.15	Celsius	real	[-273.15,∞]
RefR	Reference resistance	50 Ohm	Ohm	real	
StartSample	Sample from which measurement begin	0		int	
SymLen	length of input signal symbol	2560		int	
SymNum	Number of symbols	1		int	
OutputPoint	Indicate output precision	100		int	
Bandwidth	Bandwidth	1.75 MHz	Hz	int	[1,1e9]
CyclicPrefix	Cyclic prefix	0.25		real	[0,1]
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration (ms): time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_2048		enum	
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 1		enum	
ZoneNumOfSym	Number of symbol in zone	15		int	[3,1212]
ZoneType	Zone type: UL_PUSC, UL_OPUSC	UL_PUSC		enum	
NumberOfBurst	Number of Burst	1		int	[1,8]
BurstSymOffset	Symobol offset of each burst	{0}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{1}		int array	[1,6868]
FrameStartSym	Start symbol number of frame	0		int	[0,1212]
FrameStopSym	Stop symbol number of frame	0		int	[0,1212]

Pin Inputs

Pin	Name	Description	Signal Type
1	RF_Signal	received RF signal to be measured	timed

WMAN_M_UL_SpecFlat (802.16e OFDMA Uplink Spectrum Flatness)



WMAN_M_UL_SpecFlat

Description: Uplink spectrum flatness
Library: WMAN 16e, Measurement

Parameters

Name	Description	Default	Unit	Type	Range
RIn	Input resistance	50 Ohm	Ohm	int	(0,∞)
RTemp	TEMPERATURE	- 273.15	Celsius	real	[-273.15,∞]
FCarrier	Carrier frequency	3407 MHz	Hz	real	(0,∞)
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24		int	[3,1212]
PreambleIndex	Preamble index	3		int	[0,113]
FrameNumber	Frame number	0		int	[1,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
UL_PermBase	Uplink permutation base	0		int	[0 , 69]
NumberOfBurst	Number of Bursts	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}		int array	[1,6868]
Rate_ID	Rate ID of each burst	3		int array	[0,7]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
FramesToAverage	Number of frames for the average CIR	1		int	[1,∞)
SpectrumEstimation	The method for spectrum estimation: Estimation on pilots, Estimation on data & pilots	Estimation on data & pilots		enum	

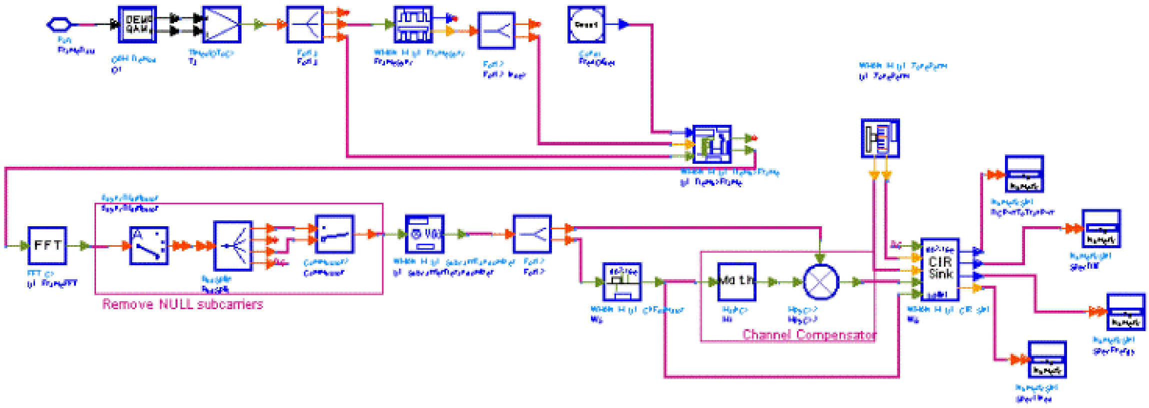
Pin Inputs

Pin	Name	Description	Signal Type
1	FrameData	input of RF signal	timed

Notes/Equations

1. This subnetwork is used to measure the spectral flatness of Mobile WiMAX uplink subframe. The schematic for this subnetwork is shown in the following illustration.

WMAN_M_UL_SpecFlat schematic



1. According the standard, the data for measuring spectral flatness shall be taken from the channel estimation step. In Mobile Radio Conformance Tests (see the reference below), more specifications are listed: by observing the amplitude deviations from the constellation points this function estimates the flatness as a function of frequency from ordinary data transmission signals.
2. In this subnetwork, two methods are provided to get the data for measuring spectral flatness.
    1. *SpectrumEstimation is Estimation on pilots*
    In this method, the CIRs are estimated only on pilot subcarriers. The CIRs on data subcarriers are interpolated by the CIRs on pilot subcarriers. Note that this method can be applied for UL PUSC, OPUSC and AMC.
    2. *SpectrumEstimation is Estimation on data & pilots*
    This method follows the requirement by Mobile Radio Conformance Tests (see the reference below). By observing the received amplitude deviations from the nearest constellation points in data and pilot subcarriers, this method estimates the flatness as a function of frequency from ordinary data transmission signals. The spectral flatness for each subcarrier across the whole data zone is averaged to remove spectral fluctuation due to modulation. Above measurement is applied only for the active subcarriers. When one subcarrier is non-allocated across the whole data zone, a fixed value (0) is output for this subcarrier (spectral line) to Sink SpecEnergy. The difference energy output to Sink SpecDiff is obtained by comparing amplitudes within the CIRs obtained in above measurement for all subcarriers with neighboring subcarriers excluding all non-allocated subcarriers.
    Note that this method can be applied for UL PUSC, OPUSC and AMC.
3. The results shall be the average of FramesToAverage uplink subframes, where FramesToAverage is set by users. The measurement results are output to Sink SpecEnergy. Meanwhile the difference energy between adjacent subcarriers from -Nused/2 to Nused/2 are output to Sink SpecDiff, and spectral lines from -Nused/2 to Nused/2 are output to Sink SpecLines. The ratio of the power at spectral line 0 to the total power is output to Sink DCPwrToTranPwr.
4. Unlike Mobile WiMAX downlink subframe, the pilots will not transmit in the uplink subframe if the tile for PUSC and OPUSC (or the bin for AMC) that the pilots belong to is not assigned to any of bursts. In this case, The CIRs for this tile (or bin) cannot be obtained even when SpectrumEstimation = Estimation on pilots. It is suggested that all the tiles in the whole data zone are assigned to the bursts.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. WiMAX Forum, Mobile Radio Conformance Tests (MRCT), October 2006.

802.16e OFDMA MIMO Measurement Components

The 16e MIMO measurement models provide basic MIMO measurements (such as CCDF and etc.).

- *WMAN M DL MIMO RF CCDF (802.16e OFDMA DL MIMO RF CCDF)* (wman_m)
- *WMAN M UL MIMO RF CCDF (802.16e OFDMA UL MIMO RF CCDF)* (wman_m)

WMAN_M_DL_MIMO_RF_CCDF (802.16e OFDMA DL MIMO RF CCDF)

Description: CCDF measurment
Library: WMAN 16e, MIMO Measurement

Parameters

Name	Description	Default	Unit	Type	Range
RLoad	Source resistance	50 Ohm	Ohm	int	(0,∞)
RTemp	TEMPERATURE	- 273.15	Celsius	real	[-273.15,∞]
RefR	Reference resistance	50 Ohm	Ohm	real	
StartSample	Sample from which measurement begin	0		int	
SymLen	length of input signal symbol	2560		int	
SymNum	Number of symbols	1		int	
OutputPoint	Indicate output precision	100		int	
Bandwidth	Bandwidth	10 MHz	Hz	int	(0,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_2048		enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of symbol in zone	22		int	[1,1212]
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
MidamblePresent	MIMO midamble present or not: NO, YES	NO		enum	
FrameStartSym	Start symbol number of frame	0		int	[0,1212]
FrameStopSym	Stop symbol number of frame	0		int	[0,1212]

Pin Inputs

Pin	Name	Description	Signal Type
1	Ant1_RF_Signal	input of Ant1 RF signal	timed
2	Ant2_RF_Signal	input of Ant2 RF signal	timed

Notes/Equations

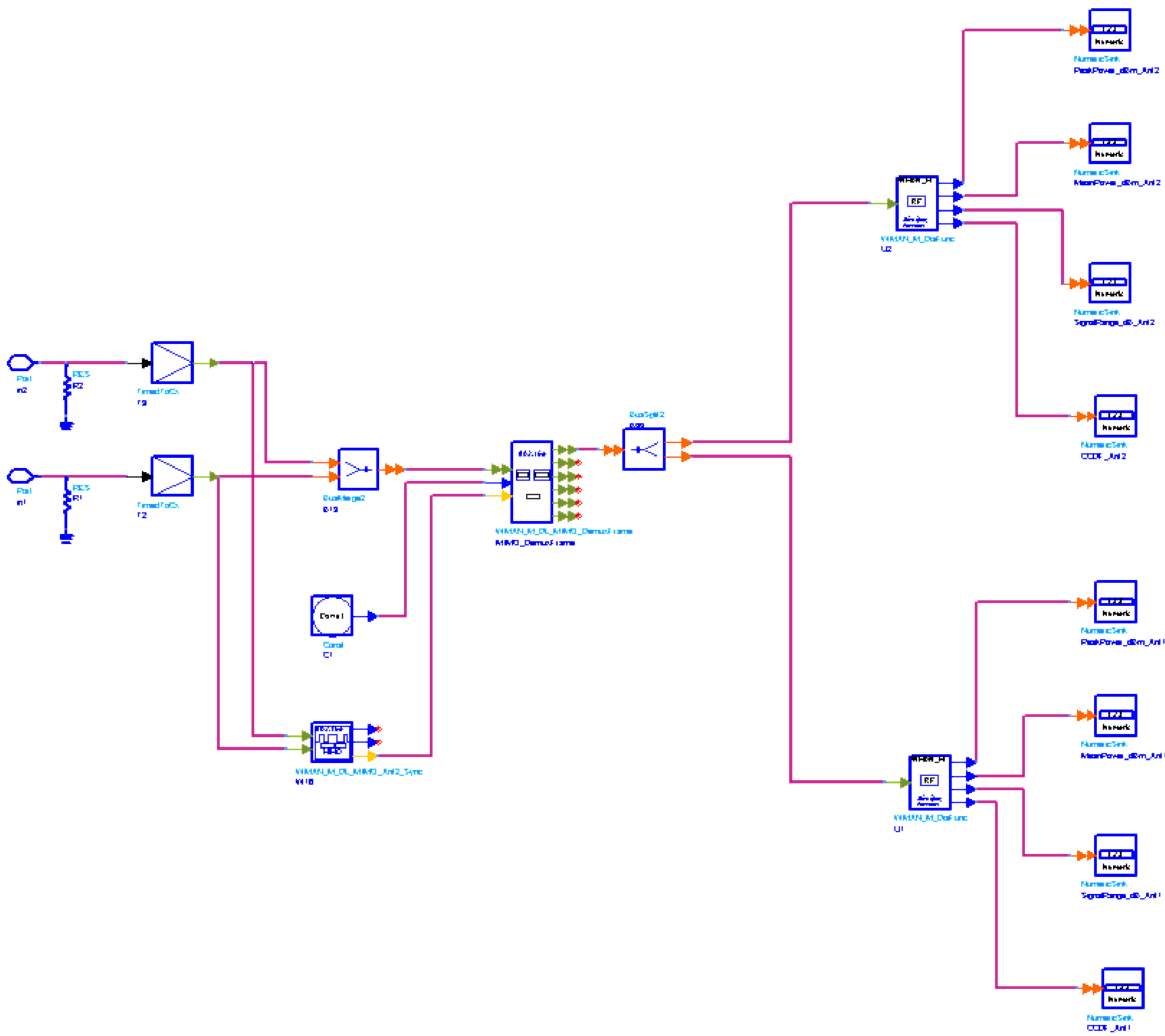
1. This subnetwork measures the complementary cumulative distribution function (CCDF) of the RF signal, PeakPower and MeanPower for Downlink MIMO transmitter.
2. $Samples_{Frame}$ (will explained later) tokens are consumed at pin input and $SymLen \times SymNum$ tokens are used for measurement. The distribution range is divided into segments according to the OutputPoint parameter and is sent to the SignalRange_dB NumericSink. The corresponding distribution probability is calculated based on these segments and sent to the CCDF NumericSink. Peak power of 99.9% probability and average power of input signals are calculated. These results are collected by the PeakPower and AvgPower NumericSinks.
   FrameStartSym and FrameStopSym are two parameters that decide which part of the whole frame is used for measurement. The WMAN_M_DL_MIMO_DemuxFrame model use these two parameters.
   - When FrameStartSym=0 and FrameStopSym=0

$Samples_{FFTSize} \times (1 + CP) \times N_{FrameSymbol}$ tokens are produced at pin frame, where $N_{FrameSymbol}$ is the number of OFDMA symbols of the entire downlink frame excluding zero padding and idle interval. $N_{FrameSymbol}$ is decided by ZoneNumOfSym and ZoneType as follows.

$$N_{FrameNumber} = 3 + ZoneNumOfSym$$

- When FrameStartSym < FrameStopSym
  $Samples_{FFTSize} \times (1 + CP) \times (FrameStopSym - FrameStartSym)$ tokens are produced at pin frame.

3. The schematic for this subnetwork is shown in WMAN_M_DL_MIMO_RF_CCDF Schematic.



WMAN_M_DL_MIMO_RF_CCDF Schematic

4. Note that the units of PeakPower and AvgPower are dBm; SignalRange is the transient absolute signal power minus AvgPower, so the unit of SignalRange is dB.
5. $Samples_{Frame}$ is the total sample of one downlink frame including zero padding and calculated as follows:

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

where $Samples_{idle}$ is the samples of IdleInterval and calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

Fs is the sampling frequency decided by Bandwidth, OversamplingOption and related sampling factor (!wman_m-06-2-14.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

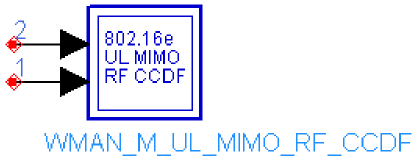
The sampling factors are listed in the following table.

sampling factor n	**bandwidth**
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_MIMO_RF_CCDF (802.16e OFDMA UL MIMO RF CCDF)



Description: CCDF measurment
Library: WMAN 16e, MIMO Measurement

Parameters

Name	Description	Default	Unit	Type	Range
RLoad	Source resistance	50 Ohm	Ohm	int	(0,∞)
RTemp	TEMPERATURE	- 273.15	Celsius	real	[-273.15,∞]
RefR	Reference resistance	50 Ohm	Ohm	real	
StartSample	Sample from which measurement begin	0		int	
SymLen	length of input signal symbol	2560		int	
SymNum	Number of symbols	1		int	
OutputPoint	Indicate output precision	100		int	
Bandwidth	Bandwidth	1.75 MHz	Hz	int	[1,1e9]
CyclicPrefix	Cyclic prefix	0.25		real	[0,1]
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration (ms): time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_2048		enum	
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 1		enum	
ZoneNumOfSym	Number of symbol in zone	15		int	[3,1212]
ZoneType	Zone type: UL_PUSC, UL_OPUSC	UL_PUSC		enum	
NumberOfBurst	Number of Burst	1		int	[1,8]
BurstSymOffset	Symobol offset of each burst	{0}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{1}		int array	[1,6868]
FrameStartSym	Start symbol number of frame	0		int	[0,1212]
FrameStopSym	Stop symbol number of frame	0		int	[0,1212]

Pin Inputs

Pin	Name	Description	Signal Type
1	Ant1_RF_Signal	input of Ant1 RF signal	timed
2	Ant2_RF_Signal	input of Ant2 RF signal	timed

Notes/Equations

1. This subnetwork measures the complementary cumulative distribution function (CCDF) of the RF signal, PeakPower and MeanPower for Uplink MIMO transmitter.
2. $Samples_{Frame}$ (will explained later) tokens are consumed at pin input and $SymLen \times SymNum$ tokens are used for measurement. The distribution range is divided into segments according to the OutputPoint parameter and is sent to the SignalRange_dB NumericSink. The corresponding distribution probability is calculated based on these segments and sent to the CCDF NumericSink. Peak power of 99.9% probability and

average power of input signals are calculated. These results are collected by the PeakPower and AvgPower NumericSinks.

FrameStartSym and FrameStopSym are two parameters that decide which part of the whole frame is used for measurement. The WMAN_M_UL_MIMO_DemuxFrame model use these two parameters.

- When FrameStartSym=0 and FrameStopSym=0

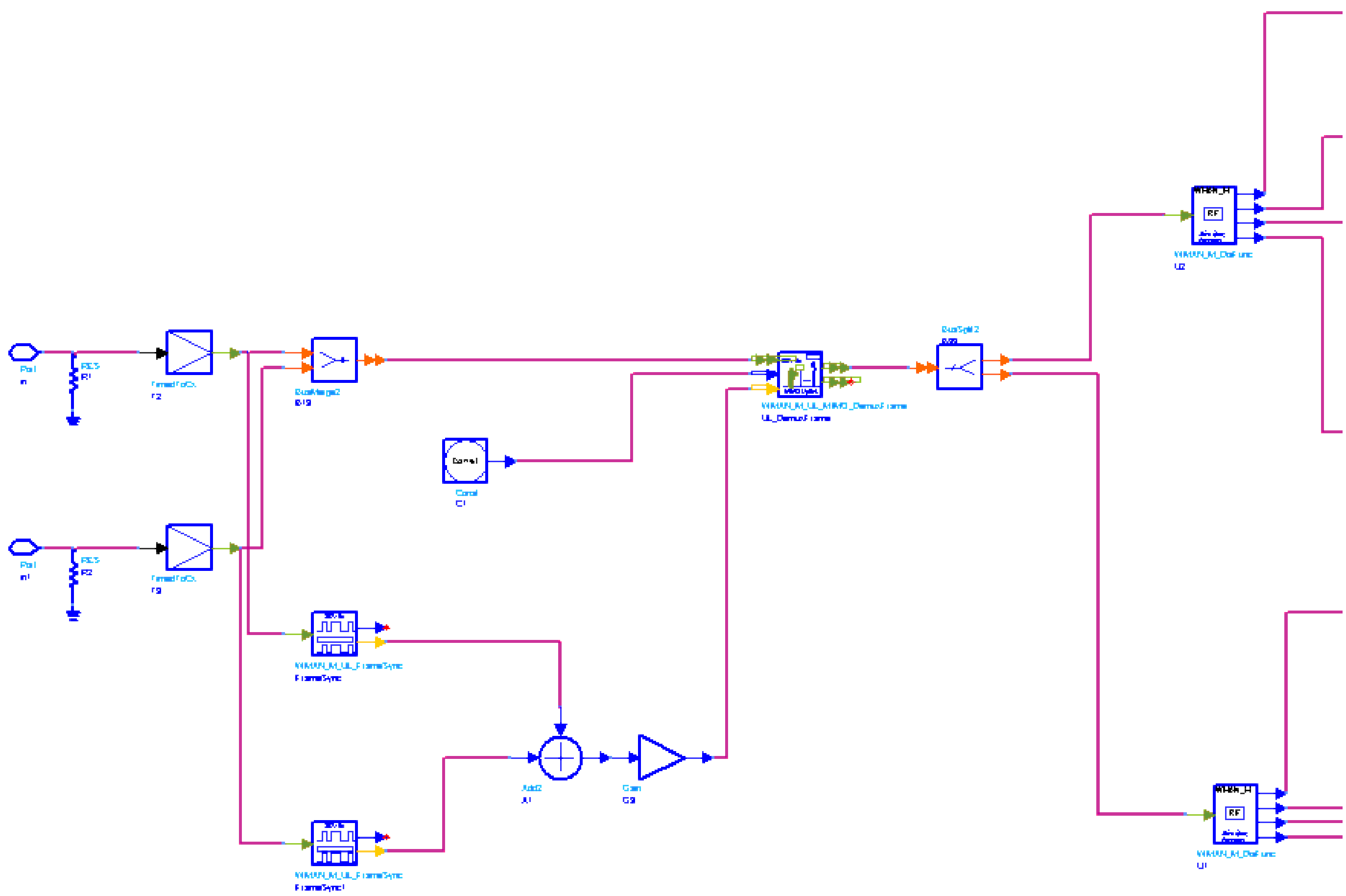
  $Samples_{FFTSize} \times (1+CP) \times N_{FrameSymbol}$ tokens are produced at pin Frame, where $N_{FrameSymbol}$ is the number of OFDMA symbols of the entire uplink frame excluding zero padding and idle interval. $N_{FrameSymbol}$ is decided by ZoneNumOfSym as follows.

  $$N_{FrameSymbol} = ZoneNumOfSym$$

  When FrameStartSym < FrameStopSym

  $Samples_{FFTSize} \times (1+CP) \times (FrameStopSym - FrameStartSym)$ tokens are produced at pin frame.

3. The schematic for this subnetwork is shown in WMAN_M_UL_MIMO_RF_CCDF Schematic.



WMAN_M_UL_MIMO_RF_CCDF Schematic

4. Note that the units of PeakPower and AvgPower are dBm; SignalRange is the transient absolute signal power minus AvgPower, so the unit of SignalRange is dB.
5. $Samples_{Frame}$ is the total sample of one downlink frame including zero padding and calculated as follows:

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

where $Samples_{idle}$ is the samples of IdleInterval and calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

Fs is the sampling frequency decided by Bandwidth, OversamplingOption and related sampling factor (!wman_m-06-3-29.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in the following table.

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

References

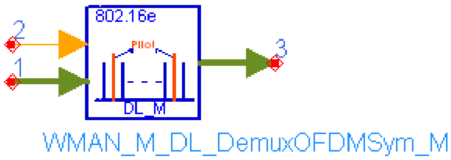
1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

802.16e OFDMA MIMO Receiver Components

The 16e MIMO receiver models provide channel estimator, frame synchronization and frequency synchronization, top level baseband receivers and top level RF receivers.

- *WMAN M DL DemuxOFDMSym M (802.16e OFDMA Downlink Demux OFDM symbols in Matrix)* (wman_m)
- *WMAN M DL MIMO Ant2 Rx (802.16e OFDMA DL MIMO Receiver)* (wman_m)
- *WMAN M DL MIMO Ant2 Rx RF (802.16e OFDMA DL MIMO RF Receiver)* (wman_m)
- *WMAN M DL MIMO Ant2 Sync (802.16e OFDMA DL MIMO Ant2 Sync)* (wman_m)
- *WMAN M DL MIMO ChEstimator (802.16e OFDMA DL MIMO ChEstimator)* (wman_m)
- *WMAN M DL MIMO DemuxFrame (802.16e OFDMA DL MIMO Frame Demuxer)* (wman_m)
- *WMAN M DL STC Ant1 Rx (802.16e OFDMA DL MIMO Receiver)* (wman_m)
- *WMAN M DL STC Ant1 Rx RF (802.16e OFDMA DL MIMO RF Receiver)* (wman_m)
- *WMAN M DL STCDecoder (802.16e OFDMA DL STC Decoder)* (wman_m)
- *WMAN M MIMO CSI Gen (802.16e OFDMA MIMO CSI Generator)* (wman_m)
- *WMAN M OFDM Demodulator (802.16e OFDMA OFDM Demodulator)* (wman_m)
- *WMAN M UL DemuxOFDMSym M (802.16e OFDMA UL DemuxOFDMSym in Matrix)* (wman_m)
- *WMAN M UL MIMO Ant2 Rx (802.16e OFDMA UL MIMO Receiver)* (wman_m)
- *WMAN M UL MIMO Ant2 Rx RF (802.16e OFDMA UL MIMO Receiver)* (wman_m)
- *WMAN M UL MIMO ChEstimator (802.16e OFDMA UL MIMO ChEstimator)* (wman_m)
- *WMAN M UL MIMO DemuxFrame (802.16e OFDMA UL MIMO Frame Demuxer)* (wman_m)
- *WMAN M UL STCDecoder (802.16e OFDMA UL STC Decoder)* (wman_m)

WMAN_M_DL_DemuxOFDMSym_M (802.16e OFDMA Downlink Demux OFDM symbols in Matrix)



Description: Downlink OFDM symbol demuxtiplexer with matrix
Library: WMAN 16e, MIMO Receiver

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbols in zone	24	int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}	int array	[0,1]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
NumberOfBurst	Number of Bursts	2	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}	int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,14}	int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}	int array	[1,60]
PowerBoosting	Power boosting of each burst in dB	{0,0}	real array	(-∞,∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	DL_OFDMSym	output of DL OFDM symbols	complex matrix
2	BurstPos	input of the position of bursts	int

Pin Outputs

Pin	Name	Description	Signal Type
3	DL_Bursts	input of DL bursts	complex matrix

Notes/Equations

1. This model is used to de-multiplex the physical subcarriers into the constellation-mapped data sequences and pilots according to the zone permutation. The function of this model is the same as WMAN_M_DL_DemuxOFDMSym except data sequences at pin DL_OFDMSym and pin DL_Bursts are both in matrix.The dimension and array architecture of the matrix at pin DL_Bursts and pin DL_OFDMSym are the same.
2. Each firing,
$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 / N_{SymPerSlot}$$
tokens are consumed at pin BurstPos.
$(ZoneNumOfSym) \times UsedCarriers$ tokens are consumed at pin DL_OFDMSym in matrix.
$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 / N_{SymPerSlot}$$
tokens are produced at pin DL_Bursts in matrix.

where, $N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC. *NumOfPilotSubcarrier* is dependent on the zone type and FFT size according to the specification, shown in the following table.

The Calculation of NumOfPilotSubcarrier

Zone type	FFT size	NumOfPilotSubcarrier
DL_PUSC	2048	8*60
DL_PUSC	1024	8*30
DL_PUSC	512	8*15
DL_FUSC	2048	166
DL_FUSC	1024	82
DL_FUSC	512	42
DL_OFUSC	2048	192
DL_OFUSC	1024	96
DL_OFUSC	512	48

UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in the following table.

The Calculation of UsedCarriers

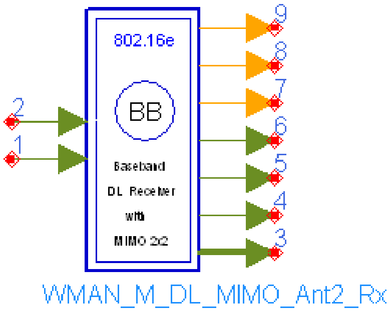
Zone type	FFT size	UsedCarriers
DL_PUSC	2048	1680
DL_PUSC	1024	840
DL_PUSC	512	420
DL_FUSC	2048	1702
DL_FUSC	1024	850
DL_FUSC	512	426
DL_OFUSC	2048	1728
DL_OFUSC	1024	864
DL_OFUSC	512	432

3. This mode performs the reverse operations against WMAN_M_DL_MuxOFDMSym_M. For more details, refer to WMAN_M_DL_MuxOFDMSym_M.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_MIMO_Ant2_Rx (802.16e OFDMA DL MIMO Receiver)



Description: Downlink baseband receiver for 2x2 MIMO
Library: WMAN 16e, MIMO Receiver

Parameters

Name	Description	Default	Unit	Type	Range
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
DLMAP_Enable	DLMAP is inserted or not: NO, YES	NO		enum	
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[0,0.02]
PreambleIndex	Preamble index	3		int	[0,113]
DL_PermBase	Downlink permutation base	9		int	[0,31]
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00, 0X00, 0X01}		int array	[0,255]
PRBS_ID	PRBS ID	0		int	[0,3]
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	20		int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array	[0,1]
NumberOfBurst	Number of Bursts	2		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}		int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,10}		int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}		int array	[1,60]
DataLength	MAC PDU payload byte length of each burst	{200,300}		int array	[1,∞)
Rate_ID	Rate ID of each burst	{5,5}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0,0}		int array	[0,3]
PowerBoosting	Power boosting of each burst in dB	{0,0}		real array	[-∞,∞]
MidamblePresent	MIMO midamble present or not: NO, YES	NO		enum	
MidambleBoosting	MIMO midamble boosting in dB	0		real	[-∞,∞]
DecoderType	Soft decision viterbi decoding type: Hard, Soft, CSI	Soft		enum	
STCDecoder	STC(MIMO) decoding type: ZF, MMSE	MMSE		enum	
SNR	Signal noise ratio per receiver antenna in dB.	15		real	[-∞ ,∞]
Tmax	The maximum delay of multi-path channel.	1.0 usec	sec	real	[0,∞]
Fmax	The maximum doppler frequency.	100 Hz	Hz	real	[0,∞]
BurstFEC_CodingType	Coding type for the burst with FEC-encoding: CC, CTC	CC		enum	
IterationNumber	The number of iterations (only for CTC decoder)	8		int	[1,16]
CycleNumber	The number of decoding cycles to get circulation states (only for CTC decoder)	1		int	[1,16]

Pin Inputs

Pin	Name	Description	Signal Type
1	Ant1Data	input of Ant1 signal	complex
2	Ant2Data	input of Ant2 signal	complex

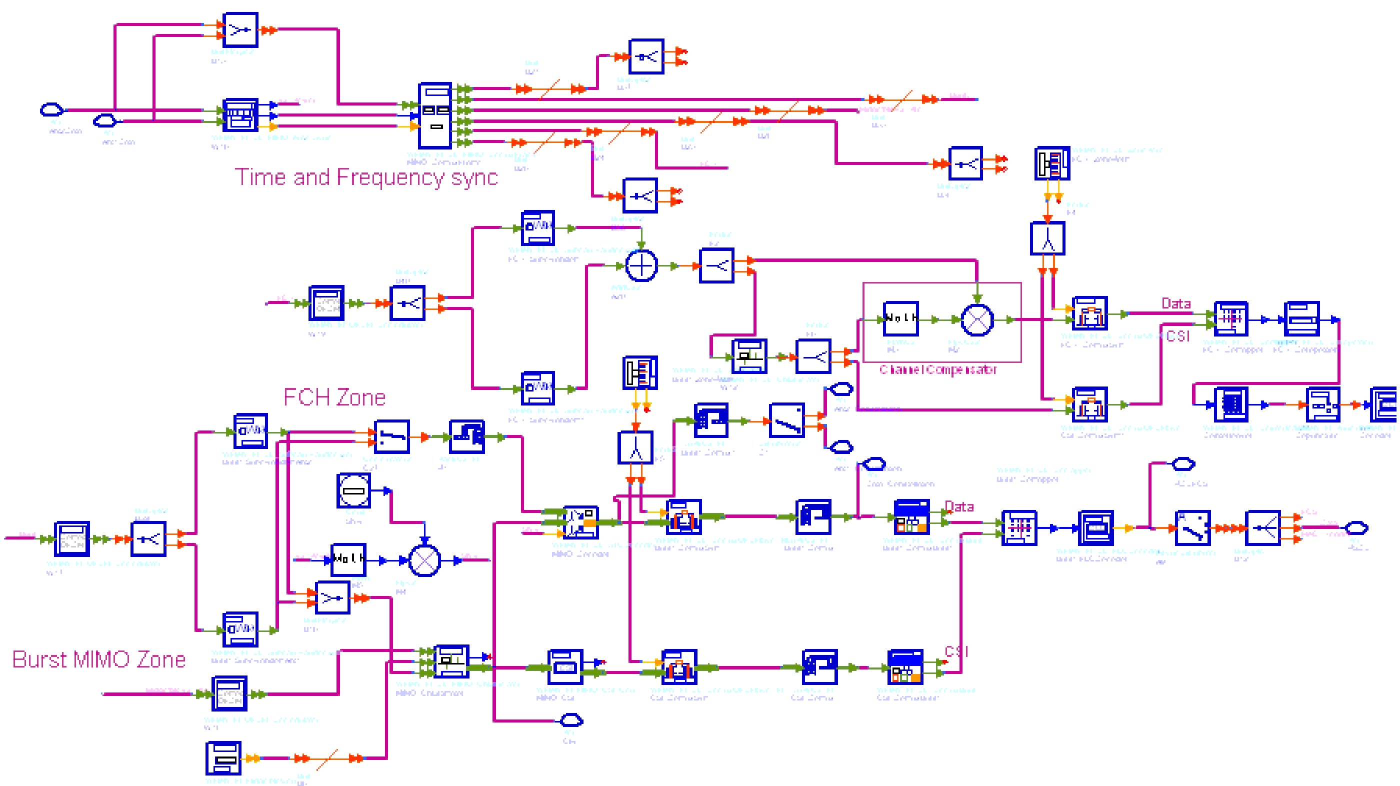
Pin Outputs

Pin	Name	Description	Signal Type
3	CIR	output of channel estimation of all bursts	complex matrix
4	Ant1_Constellation	output of modulated data in antenna 1	complex
5	Ant2_Constellation	output of modulated data in antenna 2	complex
6	Data_Constellation	output of modulated data before mapping to antennas	complex
7	PDUFCS	output of MAC PDU data of burst with FEC	int
8	PSDU	output of PSDU bits	int
9	DLFP	output of DLFP bits	int

Notes/Equations

1. This subnetwork generates an 802.16e OFDMA downlink MIMO 2x2 baseband receiver. The schematic for this subnetwork is shown in the following figure.

WMAN_M_DL_MIMO_Ant2_Rx Schematic

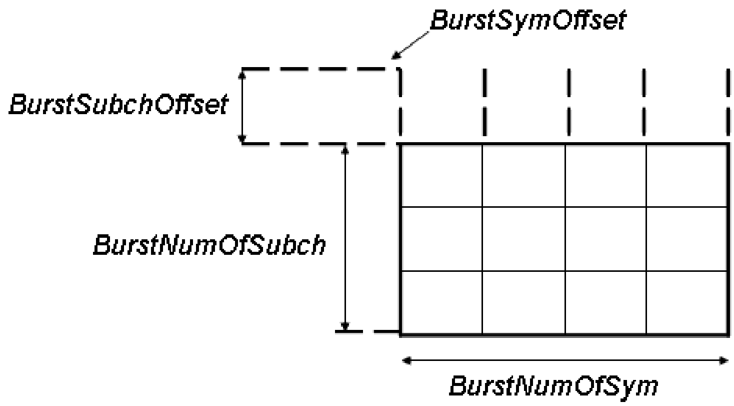


2. Receiver functions are implemented as follows:
Start of frame is detected. WMAN_M_DL_MIMO_Ant2_Sync calculates the correlation of the received signal in antenna 0 and antenna 1 respectively, then the index with the maximum correlation value is selected as the frame start for each antenna. The MRC (Maximal Ratio Combining) algorithm is employed to get the composite frame start from two antennas.
Meanwhile frequency offset is estimated also in WMAN_M_DL_MIMO_Ant2_Sync. Frequency offset in each antenna is estimated in WMAN_M_DL_FreqSync.
The packet is de-rotated according to the estimated frequency offsets (frequency synchronization) which is compensated by WMAN_M_DL_MIMO_DemuxFrame. WMAN_M_DL_MIMO_DemuxFrame outputs the preamble, FCH (including DL-MAP), UL-MAP, midamble, data bursts and frame data. The WMAN_M_DL_MIMO_DemuxFrame component introduces one frame delay.
The FCH and data bursts are sent to perform FFT transformation (in WMAN_M_OFDM_Demodulator) respectively.
The factors of randomzier appended to the subcarriers are removed in WMAN_M_DL_SubcarrRandomizer.
Then the complex channel impulse responses (CIR) are estimated and interpolated for each subcarrier in WMAN_M_DL_MIMO_ChEstimator. The channel estimator can be based on midamble symbol or scattered

pilots in data symbols, and if on midamble symbol, phase tracking may be employed by estimating phase deviation in scattered pilots.
With the received symbols and estimated channel responses, a ZF or MMSE decoder is employed in WMAN_M_DL_STCDecoder to restore the transmit symbols (one transmit symbol per each antenna). The restored symbols at antenna 0 are output at pin Ant1_Constellation while symbols at antenna 1 are output at pin Ant2_Constellation. WMAN_M_DL_DemuxOFDMSym transfers the physical subcarriers to logical data sequences and pilot sequences for each burst where the physical indices of data subcarriers and pilot subcarriers for each burst are calculated by WMAN_M_DL_ZonePerm. Then the two data sequences are sequentially merged into one data sequences which are output at pin Data_Constellation. The signal at pin Data_Constellation can be used to show the demodulated constellation and to calculate the RCE (relative constellation error) or EVM.
The burst with FEC-encoded is separated from the multi-bursts in WMAN_M_DL_DemuxBurst. The demodulated OFDM symbols of burst with FEC are then de-mapped by WMAN_M_Demapper. Three demapper types (CSI, Soft and Hard) are supported in WMAN_M_Demaper.
After WMAN_M_FECDecoder, the MAC PDU data are achieved, which are divided into MAC header, MAC PDU payloads and CRC. The MAC PDU and its payloads are output at pin PDUFCS and PSDU respectively. The de-repetition, de-interleaving, CC decoding, de-randomizing are performed in WMAN_M_FECDecoder.
For FCH and DL-MAP, the de-mapped data are only passed through the de-repetition, de-interleaving, CC decoding, and only the decoded DLFP (FCH) is output at pin DLFP.

3. When CDD (cyclic delay diversity) is applied in the STC/MIMO source, the frame (timing) synchronization may have a little mismatch due to the effect of CDD. A workaround is as follows:
   - Disconnect the connection lines at the ports Index and DeltaF in the model WMAN_M_DL_MIMO_DemuxFrame.
   - Connect the port Index in the model WMAN_M_DL_MIMO_DemuxFrame to a ConstInt model. The value in ConstInt is set to the actual index of the frame (the default value is 0).
   - Connect the port DeltaF in the model WMAN_M_DL_MIMO_DemuxFrame to a Const model. The value in Const is set to 0 which means no frequency offset will be compensated in WMAN_M_DL_MIMO_DemuxFrame.
4. Parameter Details
   - Bandwidth determines the nominal channel bandwidth.
   - OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
   - FFTSize specifies the size of FFT. Sizes 2048, 1024 and 512 are supported.
   - CyclicPrefix specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
   - FrameMode specifies the duplexing method which should be FDD or TDD. In FDD transmission, the downlink occupies the entire frame and the respective gaps (zeros) are automatically adjusted to fill the frame
   - DL_Ratio specifies the percentage (1 to 99) of the frame time to be used for the downlink subframe. The parameter is only active when the FrameMode is TDD.
   - FrameDuration determines the frame durations (ms) of the generated waveform. There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
   - DLMAP_Enable specifies whether the DL-MAP burst is inserted in the downlink subframe.
   - ULMAP_Enable specifies whether the UL-MAP burst is inserted in the downlink subframe.
   - IdleInterval specifies the time of idle interval between the two continuous frames. The default value is 0.
   - PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to the standard.
   - DL_PermBase specifies the basis of downlink permutation to be used in initialization vector of the PRBS generator for subchannel randomization in the zone and in STC_DL_Zone_IE() in DL-MAP message.
   - BSID specifies the base station ID which is used in DL-MAP message.
   - PRBS_ID specifies the PRBS ID which may be used in initialization vector of the PRBS generator for subchannel randomization and in STC_DL_Zone_IE() in DL-MAP message.
   - ZoneType specifies the zone type which can be set to PUSC, FUSC or OFUSC.
   - ZoneNumOfSym specifies the symbol number for the zone. The value must be a multiple of two for DL_PUSC, and be a multiple of one for DL_FUSC and DL_OFUSC.
   - GroupBitmask specifies which groups of subchannel are used on the PUSC zone. This parameter uses 1 for assigned groups and 0 for unassigned groups.
   - NumberOfBurst specifies the number of active downlink bursts.
   - BurstWithFEC specifies the downlink burst FEC.
   - BurstSymOffset, BurstSubchOffset, BurstNumOfSym and BurstNumOfSubch specify the position and range for each rectangular burst, as shown in the following figure.

Downlink rectangular burst structure



- DataLength specifies MAC PDU payload byte length for each burst.
- Rate_ID specifies the rate ID for each burst. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in the following table. Here CC and CTC are supported in the downlink MIMO receiver.

The Relation between Coding Type and Rate ID

Coding type	Rate ID	Modulation/ Coding Rate
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in the following table.

The Meaning of Repetition Coding

Repetition coding	meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4used on the burst
3	Repetition coding of 6used on the burst

- PowerBoosting specifies the power boosting for each burst. Each value is defined in units of dB.
- MidamblePresent specifies whether a midamble symbol is inserted in front of STC zone.
- MidambleBoosting specifies the power boosting for the midamble symbol in units of dB.
- DecoderType specifies the Viterbi decoder type chosen from CSI, Soft and Hard. CSI (Channel State Information) is a channel estimate profile. This decision is neither hard or soft; it is adaptive based on where you are in the channel profile.

- STCDecoder specifies the MIMO decoder type chosen from ZF and MMSE.
- SNR specifies the signal noise ratio per receiver antenna in dB. This parameter is useful for the channel estimator and MMSE MIMO decoder.
- Tmax specifies the maximum echo delay in multi-path channel. This parameter is useful for the channel estimator.
- Fmax specifies the maximum Doppler frequency. This parameter is useful for the channel estimator.
- BurstFEC_CodingType specifies the coding type for the burst with FEC-encoding. CC means convolutional coding while CTC means convolutional turbo coding.
- IterationNumber specifies the number of iterations for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).
- CycleNumber specifies the number of decoding cycles in order to get circulation states for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).

5. Samples per frame
The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-07-03-011.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in the following table.

Sampling factor Requirement

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval(!wman_m-07-03-013.gif!) is calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

So, the total samples of one downlink frame $Samples_{Frame}$ is

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

6. Output Pin Delay Adjustment
This model works frame by fame. Each firing, $Samples_{Frame}$ tokens are consumed at Pin FrameData.
Pin Ant1_Constellation and Ant2_Constellation have one frame delay. The two pins output the transmit symbols at all the subcarriers. Each firing, pin Ant1_Constellation and Ant2_Constellation produces $UsedCarriers \times N_{Sym}$ respectively, where UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in the following table. Nsym is ZoneNumOfSym for PUSC and FUSC.

The Calculation of UsedCarriers

Zone type	FFT size	UsedCarriers
DL_PUSC	2048	1680
DL_PUSC	1024	840
DL_PUSC	512	420
DL_FUSC	2048	1702
DL_FUSC	1024	850
DL_FUSC	512	426
DL_OFUSC	2048	1728
DL_OFUSC	1024	864
DL_OFUSC	512	432

Moreover, one frame delay at pin Ant1_Constellation and Ant2_Constellation is $UsedCarriers \times N_{Sym}$.
Pin CIR also has one frame delay. Each firing, pin CIR produces $UsedCarriers \times N_{Sym}$ tokens. One frame delay at pin CIR is $UsedCarriers \times N_{Sym}$.
Pin Data_Constellation has one frame delay. Each firing, pin Data_Constellation produces

$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 \times STCRate / N_{SymPerSlot}$$

tokens, where $N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC; $STCRate$ is 2 for MIMO 2x2. Moreover, one frame delay at pin Data_Constellation is

$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 \times STCRate / N_{SymPerSlot}$$

Pin PDUFCS has one frame delay. This pin outputs demodulated PSDU and FCS information bits after decoding. So, the delay of PDUFCS is $8 \times DataLength[BurstWithFEC] + 80$

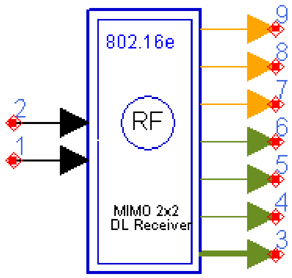
Pin PSDU also has one frame delay. This pin outputs demodulated PSDU information bits after decoding. So, the delay of PSDU is $8 \times DataLength[BurstWithFEC]$

Pin DLFP also has one frame delay. Each firing, pin DLFP produces 192 tokens. One frame delay at pin DLFP is 192.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_MIMO_Ant2_Rx_RF (802.16e OFDMA DL MIMO RF Receiver)



WMAN_M_DL_MIMO_Ant2_Rx_RF

Description: Downlink RF receiver for 2x2 MIMO
Library: WMAN 16e, MIMO Receiver

Parameters

Name	Description	Default	Unit	Type	Range
RIn	Input resistance	DefaultRIn	Ohm	int	(0,∞)
RTemp	Temperature, in degrees C	DefaultRTemp	Celsius	real	[-273.15,∞]
FCarrier	Carrier frequency	3407 MHz	Hz	real	(0,∞)
Sensitivity	voltage output sensitivity, Vout/Vin	1		real	(-∞,∞)
Phase	Reference phase in degrees	0.0	deg	real	(-∞,∞)
GainImbalance	Gain imbalance in dB, Q channel relative to I channel	0.0		real	(-∞,∞)
PhaseImbalance	Phase imbalance in degrees, Q channel relative to I channel	0.0		real	(-∞,∞)
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
DLMAP_Enable	DLMAP is inserted or not: NO, YES	NO		enum	
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
PreambleIndex	Preamble index	3		int	[0,113]
DL_PermBase	Downlink permutation base	9		int	[0,31]
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00, 0X00, 0X01}		int array	[0,255]
PRBS_ID	PRBS ID	0		int	[0,3]
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	20		int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array	[0,1]
NumberOfBurst	Number of Bursts	2		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}		int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,10}		int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}		int array	[1,60]
DataLength	MAC PDU payload byte length of each burst	{200,300}		int array	[1,∞)
Rate_ID	Rate ID of each burst	{5,5}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0,0}		int array	[0,3]
PowerBoosting	Power boosting of each burst in dB	{0,0}		real array	[-∞,∞]
MidamblePresent	MIMO midamble present or not: NO, YES	NO		enum	
MidambleBoosting	MIMO midamble boosting in dB	0		real	[-∞,∞]
DecoderType	Soft decision viterbi decoding type: Hard, Soft, CSI	Soft		enum	
STCDecoder	STC(MIMO) decoding type: ZF, MMSE	MMSE		enum	
SNR	Signal noise ratio per receiver antenna in dB.	15		real	[-∞ ,∞]
Tmax	The maximum delay of multi-path channel.	1.0 usec	sec	real	[0,∞]
Fmax	The maximum doppler frequency.	100 Hz	Hz	real	[0,∞]
BurstFEC_CodingType	Coding type for the burst with FEC-encoding: CC, CTC	CC		enum	
IterationNumber	The number of iterations (only for CTC decoder)	8		int	[1,16]
CycleNumber	The number of decoding cycles to get circulation states (only for CTC decoder)	1		int	[1,16]

Pin Inputs

Pin	Name	Description	Signal Type
1	Ant1_RF_Signal	input of Ant1 RF signal	timed
2	Ant2_RF_Signal	input of Ant2 RF signal	timed

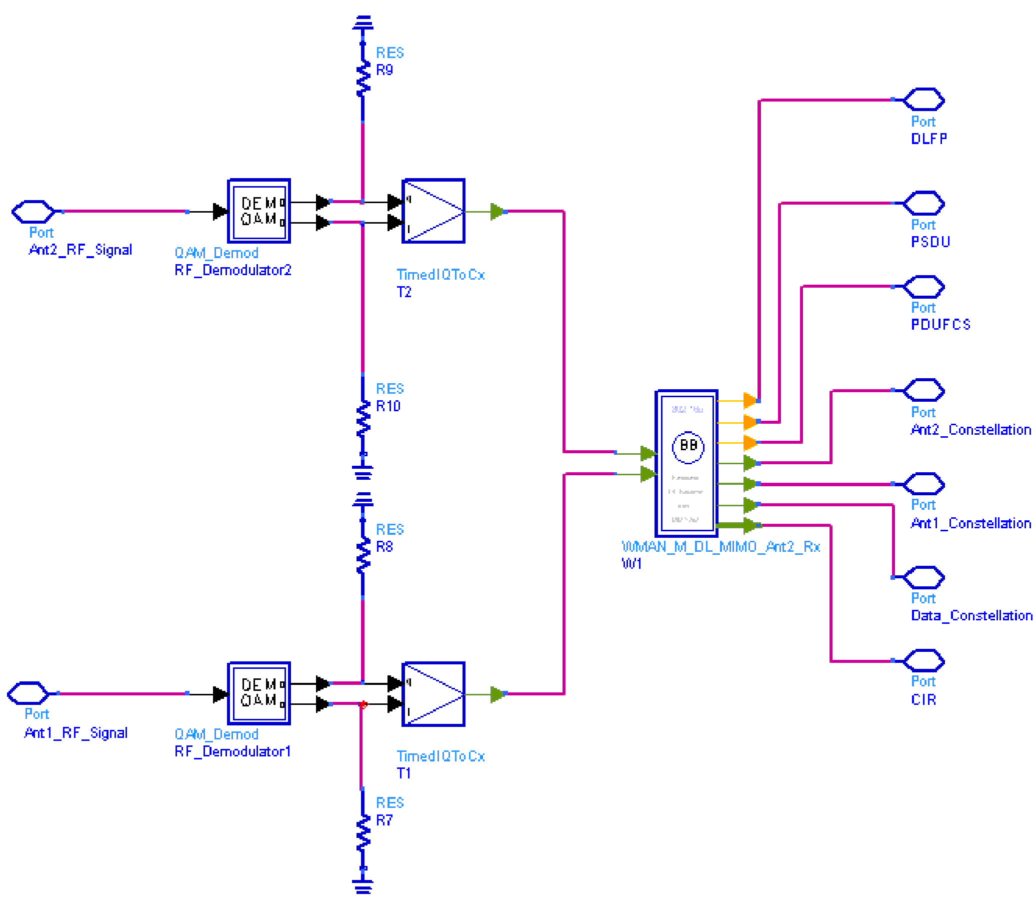
Pin Outputs

Pin	Name	Description	Signal Type
3	CIR	output of channel estimation of all bursts	complex matrix
4	Ant1_Constellation	output of modulated data in antenna 1	complex
5	Ant2_Constellation	output of modulated data in antenna 2	complex
6	Data_Constellation	output of modulated data before mapping to antennas	complex
7	PDUFCS	output of MAC PDU data of burst with FEC	int
8	PSDU	output of PSDU bits	int
9	DLFP	output of DLFP bits	int

Notes/Equations

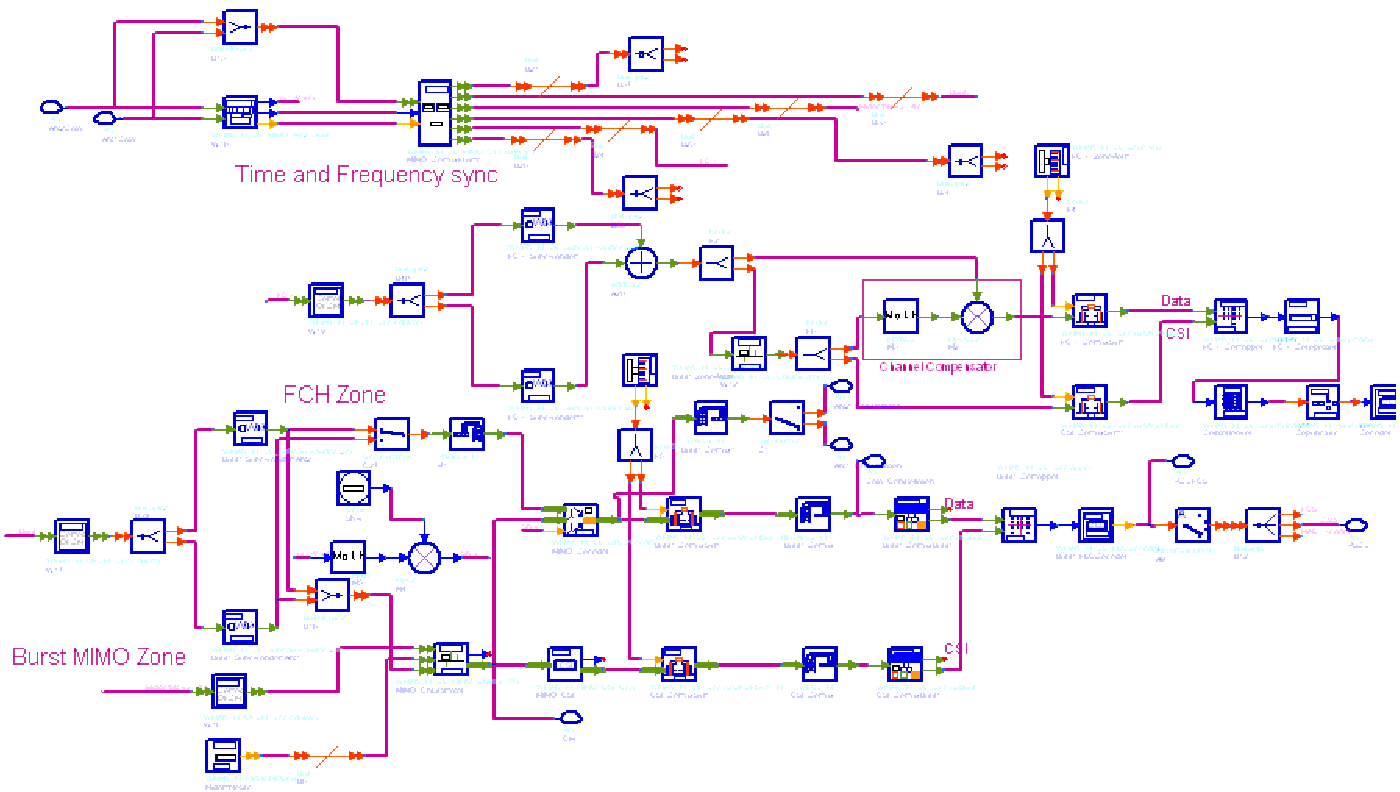
1. This subnetwork generates an 802.16e OFDMA downlink MIMO 2x2 subsystem RF receiver. The subnetwork includes WMAN_M_DL_MIMO_Ant2_Rx, and two RF_Demodulator. The schematic for this subnetwork is shown in the following figure.

WMAN_M_DL_MIMO_Ant2_Rx_RF Schematic



2. The base model WMAN_M_DL_MIMO_Ant2_Rx generates an 802.16e OFDMA downlink MIMO 2x2 baseband receiver. The schematic for this subnetwork is shown in the following figure.

r WMAN_M_DL_MIMO_Ant2_Rx Schematic

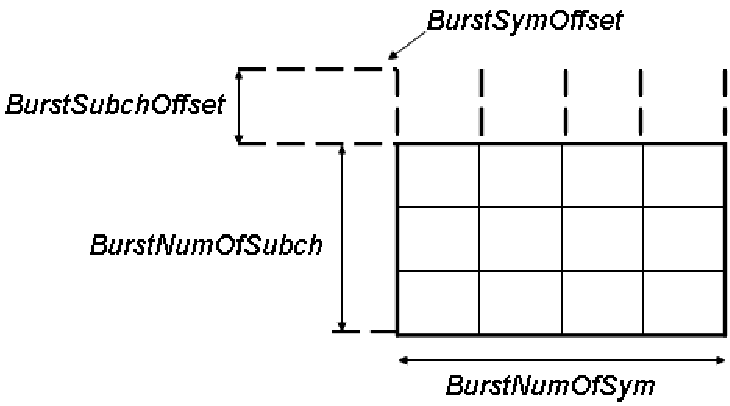


3. The baseband receiver functions are implemented as follows:
Start of frame is detected. WMAN_M_DL_MIMO_Ant2_Sync calculates the correlation of the received signal in antenna 0 and antenna 1 respectively, then the index with the maximum correlation value is selected as the frame start for each antenna. The MRC (Maximal Ratio Combining) algorithm is employed to get the composite frame start from two antennas.
Meanwhile frequency offset is estimated also in WMAN_M_DL_MIMO_Ant2_Sync. Frequency offset in each antenna is estimated in WMAN_M_DL_FreqSync.
The packet is de-rotated according to the estimated frequency offsets (frequency synchronization) which is compensated by WMAN_M_DL_MIMO_DemuxFrame. WMAN_M_DL_MIMO_DemuxFrame outputs the preamble, FCH (including DL-MAP), UL-MAP, midamble, data bursts and frame data. The WMAN_M_DL_MIMO_DemuxFrame component introduces one frame delay.
The FCH and data bursts are sent to perform FFT transformation (in WMAN_M_OFDM_Demodulator) respectively.
The factors of randomzier appended to the subcarriers are removed in WMAN_M_DL_SubcarrRandomizer. Then the complex channel impulse responses (CIR) are estimated and interpolated for each subcarrier in WMAN_M_DL_MIMO_ChEstimator. The channel estimator can be based on midamble symbol or scattered pilots in data symbols, and if on midamble symbol, phase tracking may be employed by estimating phase deviation in scattered pilots.
With the received symbols and estimated channel responses, a ZF or MMSE decoder is employed in WMAN_M_DL_STCDecoder to restore the transmit symbols (one transmit symbol per each antenna). The restored symbols at antenna 0 are output at pin Ant1_Constellation while symbols at antenna 1 are output at pin Ant2_Constellation. WMAN_M_DL_DemuxOFDMSym transfers the physical subcarriers to logical data sequences and pilot sequences for each burst where the physical indices of data subcarriers and pilot subcarriers for each burst are calculated by WMAN_M_DL_ZonePerm. Then the two data sequences are sequentially merged into one data sequences which are output at pin Data_Constellation. The signal at pin Data_Constellation can be used to show the demodulated constellation and to calculate the RCE (relative constellation error) or EVM.
The burst with FEC-encoded is separated from the multi-bursts in WMAN_M_DL_DemuxBurst. The demodulated OFDM symbols of burst with FEC are then de-mapped by WMAN_M_Demapper. Three demapper types (CSI, Soft and Hard) are supported in WMAN_M_Demaper.
After WMAN_M_FECDecoder, the MAC PDU data are achieved, which are divided into MAC header, MAC PDU payloads and CRC. The MAC PDU and its payloads are output at pin PDUFCS and PSDU respectively. The de-repetition, de-interleaving, CC decoding, de-randomizing are performed in WMAN_M_FECDecoder.
For FCH and DL-MAP, the de-mapped data are only passed through the de-repetition, de-interleaving, CC

decoding, and only the decoded DLFP (FCH) is output at pin DLFP.

4. Parameter Details
    - RIn is the RF input resistance.
    - RTemp is the RF output resistance temperature in Celsius and sets the noise density in the RF output signal to (k(RTemp+273.15)) Watts/Hz, where k is Boltzmann's constant.
    - FCarrier is the RF output signal frequency.
    - Sensitivity is the voltage output sensitivity (Vout/Vin) of the internal oscillator that generates the reference carrier signal used to demodulate the RF signal.
    - Phase is the reference phase in degrees of the reference carrier signal.
    - GainImbalance and PhaseImbalance add certain impairments to the ideal output RF signal. Impairments are added as described here.
      The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:
      $$V_3(t) = A\left(V_1(t)\cos(\omega_c t) - gV_2(t)\sin\left(\omega_c t + \frac{\Phi\pi}{180}\right)\right)$$
      where V1(t) is the in-phase RF envelope, V2(t) is the quadrature phase RF envelope, g is the gain imbalance:
      $$g = 10^{\frac{GainImbalance}{20}}$$
      and, ϕ (in degrees) is the phase imbalance.
    - Bandwidth determines the nominal channel bandwidth.
    - OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
    - FFTSize specifies the size of FFT. Sizes 2048, 1024 and 512 are supported.
    - CyclicPrefix specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
    - FrameMode specifies the duplexing method which should be FDD or TDD. In FDD transmission, the downlink occupies the entire frame and the respective gaps (zeros) are automatically adjusted to fill the frame
    - DL_Ratio specifies the percentage (1 to 99) of the frame time to be used for the downlink subframe. The parameter is only active when the FrameMode is TDD.
    - FrameDuration determines the frame durations (ms) of the generated waveform. There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
    - DLMAP_Enable specifies whether the DL-MAP burst is inserted in the downlink subframe.
    - ULMAP_Enable specifies whether the UL-MAP burst is inserted in the downlink subframe.
    - IdleInterval specifies the time of idle interval between the two continuous frames. The default value is 0.
    - PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to the standard.
    - DL_PermBase specifies the basis of downlink permutation to be used in initialization vector of the PRBS generator for subchannel randomization in the zone and in STC_DL_Zone_IE() in DL-MAP message.
    - BSID specifies the base station ID which is used in DL-MAP message.
    - PRBS_ID specifies the PRBS ID which may be used in initialization vector of the PRBS generator for subchannel randomization and in STC_DL_Zone_IE() in DL-MAP message.
    - ZoneType specifies the zone type which can be set to PUSC, FUSC or OFUSC.
    - ZoneNumOfSym specifies the symbol number for the zone. The value must be a multiple of two for DL_PUSC, and be a multiple of one for DL_FUSC and DL_OFUSC.
    - GroupBitmask specifies which groups of subchannel are used on the PUSC zone. This parameter uses 1 for assigned groups and 0 for unassigned groups.
    - NumberOfBurst specifies the number of active downlink bursts.
    - BurstWithFEC specifies the downlink burst FEC.
    - BurstSymOffset, BurstSubchOffset, BurstNumOfSym and BurstNumOfSubch specify the position and range for each rectangular burst, seen in the following figure.

Downlink rectangular burst structure



- DataLength specifies MAC PDU payload byte length for each burst.
- Rate_ID specifies the rate ID for each burst. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in the following table. Here CC and CTC are supported in the downlink MIMO receiver.

The relation of Coding type and Rate ID

Coding type	Rate ID	Modulation/ Coding Rate
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in the following table.

The meaning of repetition coding

Repetition coding	meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4used on the burst
3	Repetition coding of 6used on the burst

- PowerBoosting specifies the power boosting for each burst. Each value is defined in units of dB.
- MidamblePresent specifies whether a midamble symbol is inserted in front of STC zone.
- MidambleBoosting specifies the power boosting for the midamble symbol in units of dB.
- DecoderType specifies the Viterbi decoder type chosen from CSI, Soft and Hard. CSI (Channel State Information) is a channel estimate profile. This decision is neither hard or soft; it is adaptive based on where you are in the channel profile.
- STCDecoder specifies the MIMO decoder type chosen from ZF and MMSE.
- SNR specifies the signal noise ratio per receiver antenna in dB. This parameter is useful for the channel estimator and MMSE MIMO decoder.
- Tmax specifies the maximum echo delay in multi-path channel. This parameter is useful for the channel

estimator.
- Fmax specifies the maximum Doppler frequency. This parameter is useful for the channel estimator.
- BurstFEC_CodingType specifies the coding type for the burst with FEC-encoding. CC means convolutional coding while CTC means convolutional turbo coding.
- IterationNumber specifies the number of iterations for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).
- CycleNumber specifies the number of decoding cycles in order to get circulation states for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).

5. Samples per frame
The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-07-04-035.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in the following table.

Sampling Factor Requirement

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval (!wman_m-07-04-037.gif!) is calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

So, the total samples of one downlink frame $Samples_{Frame}$ is

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

6. Output Pin Delay Adjustment
This model works frame by fame. Each firing, $Samples_{Frame}$ tokens are consumed at Pin FrameData.
Pin Ant1_Constellation and Ant2_Constellation have one frame delay. The two pins output the transmit symbols at all the subcarriers. Each firing, pin Ant1_Constellation and Ant2_Constellation produces $UsedCarriers \times N_{Sym}$ respectively, where UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in the following table. Nsym is ZoneNumOfSym for PUSC and FUSC.

The calculation of UsedCarriers

Zone type	FFT size	UsedCarriers
DL_PUSC	2048	1680
DL_PUSC	1024	840
DL_PUSC	512	420
DL_FUSC	2048	1702
DL_FUSC	1024	850
DL_FUSC	512	426
DL_OFUSC	2048	1728
DL_OFUSC	1024	864
DL_OFUSC	512	432

Moreover, one frame delay at pin Ant1_Constellation and Ant2_Constellation is $UsedCarriers \times N_{Sym}$.
Pin CIR also has one frame delay. Each firing, pin CIR produces $UsedCarriers \times N_{Sym}$ tokens. One frame delay at pin CIR is $UsedCarriers \times N_{Sym}$.
Pin Data_Constellation has one frame delay. Each firing, pin Data_Constellation produces

$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 \times STCRate/N_{SymPerSlot}$$

tokens, where

$N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC; $STCRate$ is 2 for MIMO 2x2. Moreover, one frame delay at pin Data_Constellation is

$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 \times STCRate/N_{SymPerSlot}$$

Pin PDUFCS has one frame delay. This pin outputs demodulated PSDU and FCS information bits after decoding. So, the delay of PDUFCS is $8 \times DataLength[BurstWithFEC] + 80$.

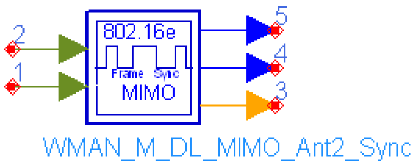
Pin PSDU also has one frame delay. This pin outputs demodulated PSDU information bits after decoding. So, the delay of PSDU is $8 \times DataLength[BurstWithFEC]$.

Pin DLFP also has one frame delay. Each firing, pin DLFP produces 192 tokens. One frame delay at pin DLFP is 192.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_MIMO_Ant2_Sync (802.16e OFDMA DL MIMO Ant2 Sync)



Description: Downlink timing and frequency synchronization for STC and MIMO
Library: WMAN 16e, MIMO Receiver

Parameters

Name	Description	Default	Unit	Type	Range
IdleInterval	Idle interval	0 usec	sec	real	[0,0.02]
Bandwidth	Bandwidth	1.75 MHz	Hz	int	(0,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 1		enum	
CyclicPrefix	Cyclic prefix	0.25		real	[0,1]
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
FFTSize	: FFT_2048, FFT_1024, FFT_512	FFT_2048		enum	
ZoneNumOfSym	Number of symbol in zone	24		int	[1,1212]
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC		enum	
PreambleIndex	Preamble index	0		int	[0,113]
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A		enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	Input1	Ant1 downlink frame	complex
2	Input2	Ant2 downlink frame	complex

Pin Outputs

Pin	Name	Description	Signal Type
3	OutIndex	synchronization frame start position	int
4	Freq	frequency offset	real
5	Power	signal power	real

Notes/Equations

1. This Model is used to achieve MIMO downlink frame synchronization and estimate frequency offset.
2. Each firing:
   - $Samples_{Frame}$ tokens are consumed at pin input, where $Samples_{Frame}$ is the total sample of one downlink frame including zero padding and calculated as follows:

     $$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

     where $Samples_{idle}$ is the samples of IdleInterval and calculated as follows:

     $$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

Fs is the sampling frequency decided by Bandwidth, OversamplingOption and related sampling factor (!wman_m-07-05-058.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in the following table.

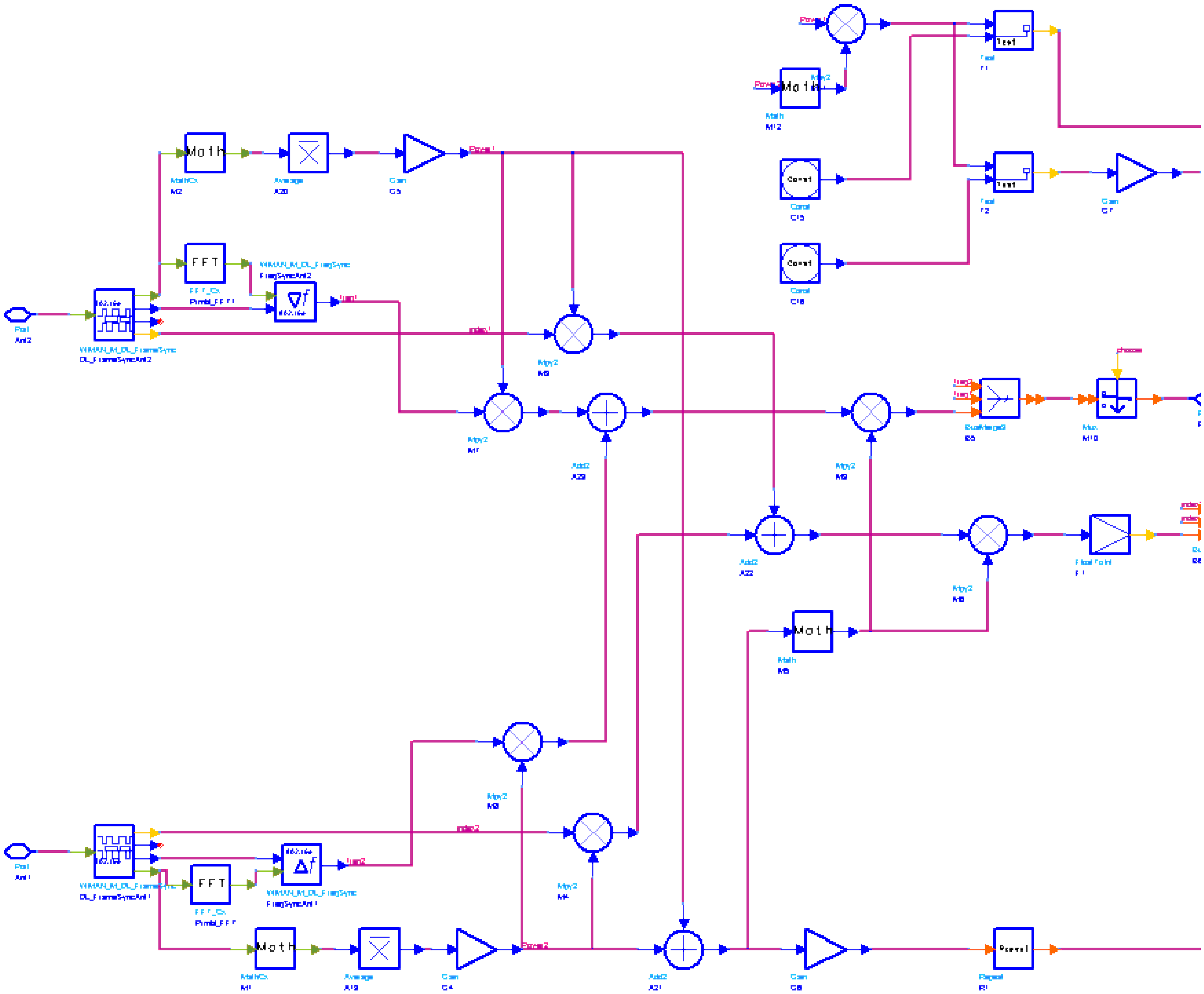
Sampling Factor Requirement

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

- *1* token is produced at pin OutIndex which indicates the value of synchronization index.
- *2* tokens are produced at pin Freq. The first one indicates the value of carrier frequency offset (including integer and fraction frequency offset) and the second one indicates the phase difference between adjacent subcarriers caused by coarse time synchronization.
- When *STC_Matrix=Matrix_A*
  ZoneNumOf Sym tokens are produced at pin Power indicating the value of signal power.
- When *STC_Matrix=Matrix_B*
  $2 \times ZoneNumOfSym$ tokens are produced at pin Power indicating the value of signal power.

3. First,frame synchronization and frequency synchronization are achieved seperately in each antenna.Then the results are averaged according to the signal power in each antenna.The schematic for this subnetwork is shown in the following figure.

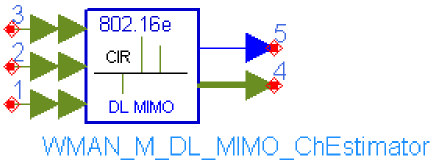
WMAN_M_DL_MIMO_Ant2_Sync Schematic



References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_MIMO_ChEstimator (802.16e OFDMA DL MIMO ChEstimator)



Description: Downlink channel estimator for STC and MIMO
Library: WMAN 16e, MIMO Receiver

Parameters

Name	Description	Default	Unit	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_2048		enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	6		int	[1,1212]
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
NumOfTxAnt	Number of transmitting antennas: Ant1, Ant2, Ant4	Ant2		enum	
STC_Encoder	STC encoder or not: NO, YES	YES		enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B, Matrix_C	Matrix_A		enum	
MidamblePresent	MIMO midamble present or not: NO, YES	NO		enum	
MidambleBoosting	MIMO midamble boosting in dB	0		real	(-∞,∞)
SNR	SNR in dB. (used by Wiener filter in PUSC)	15		real	(-∞ ,∞)
Tmax	The maximum delay of multi-path channel. (used by Wiener filter in PUSC)	1.0 usec	sec	real	[0,∞)
Fmax	The maximum doppler frequency. (used by Wiener filter in PUSC)	100 Hz	Hz	real	[0,∞)
Phasetrack	Phase track or not: NO, YES	NO		enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	input	output signals from FFT	multiple complex
2	MdmblTx	Midamble transmitted	multiple complex
3	MdmblRx	Midamble received	multiple complex

Pin Outputs

Pin	Name	Description	Signal Type
4	Coef	channel coefficient in active subcarriers	complex matrix
5	Theta	phase difference between current CIR and estimated CIR	real

Notes/Equations

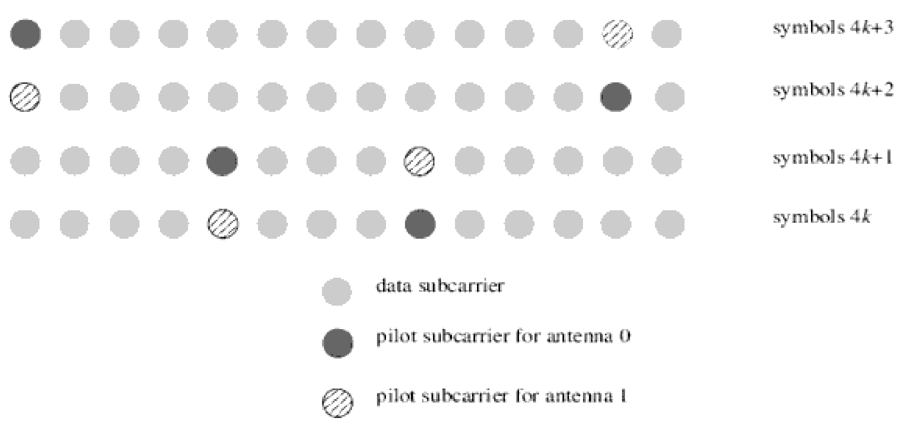
1. This model is used to calculate downlink channel estimation based on the pilot channels and output the active subcarriers estimated channel impulse response (CIR) for STC/MIMO.
2. Each firing,
   $ZoneNumOfSym \times UsedCarriers$ tokens are consumed at pin Input;
   $UsedCarriers$ tokens are consumed at pin MdmblTx;
   $UsedCarriers$ tokens are consumed at pin MdmblRx;
   $ZoneNumOfSym \times UsedCarriers$ tokens are produced at pin Coef;
   $ZoneNumOfSym$ tokens are produced at pin Theta, where UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in the following table.

   The Calculation of UsedCarriers.

Zone type	FFT size	UsedCarriers
DL_PUSC	2048	1680
DL_PUSC	1024	840
DL_PUSC	512	420
DL_FUSC	2048	1702
DL_FUSC	1024	850
DL_FUSC	512	426
DL_OFUSC	2048	1728
DL_OFUSC	1024	864
DL_OFUSC	512	432
DL_AMC	2048	1728
DL_AMC	1024	864
DL_AMC	512	432

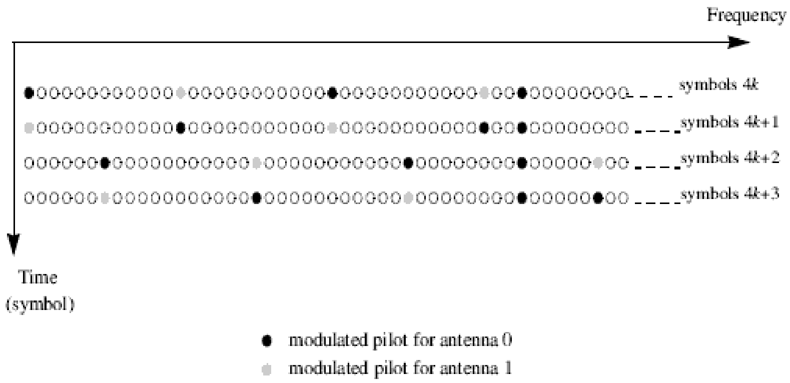
3. DL PUSC, FUSC and AMC are supported in this model.
4. For DL PUSC, the channel estimator is performed on the modified STC cluster for each channel path from transmitter to receiver, by employing the well-known two-dimensional MMSE estimator (Reference [3]) which is based on maximum Doppler frequency (Fmax), maximum echo delay (Tmax) and SNR. Each cluster has four symbols and 14 subcarriers where four pilot subcarriers are for antenna 0 and other four pilot subcarriers are for antenna 1. The cluster structure is illustrated in the following figure.

Cluster Structure for DL STC PUSC

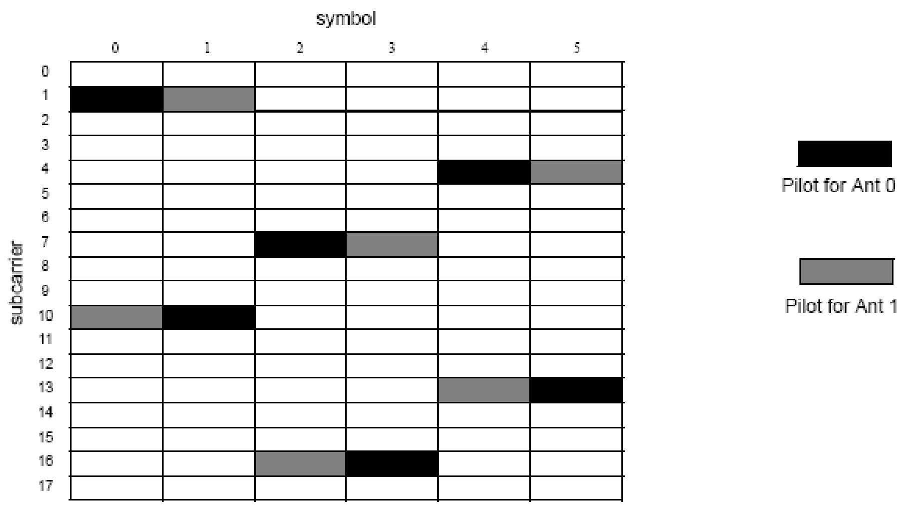


5. For DL FUSC, the pilots within the symbols shall be divided between the antennas - antenna 0 uses VariableSet#0 and ConstantSet#0 for even symbols while antenna 1 uses VariableSet#1 and ConstantSet#1 for even symbols, antenna 0 uses VariableSet#1 and ConstantSet#0 for odd symbols while antenna 1 uses VariableSet#0 and ConstantSet#1 for odd symbols (symbol counting starts at the starting point of the relevant STC zone). The two-dimensional MMSE estimator (Reference [3]) is employed in DL PUSC. The cluster structure is illustrated in the following figure.

The Structure for DL STC FUSC

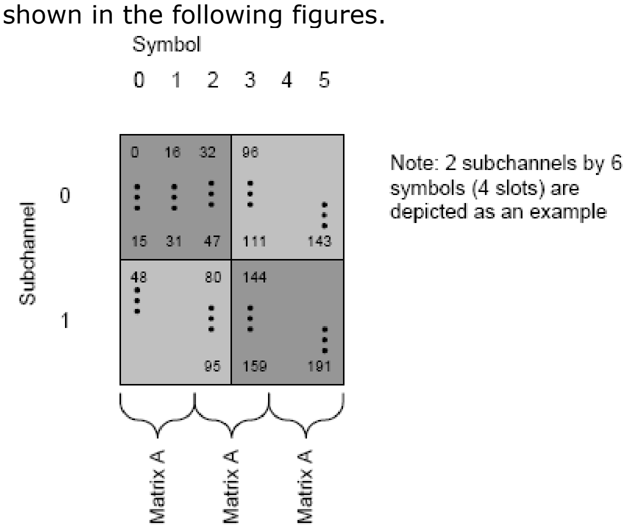


6. AMC permutation in STC zone also adopts the well-known two-dimensional MMSE estimator (Reference [3]) for each channel path from transmitter to receiver, which is based on maximum Doppler frequency (Fmax), maximum echo delay (Tmax) and SNR, the same as DL PUSC STC zone. For DL AMC STC zone, 2x3 (2 bins by 3 symbols) format is used, following P802.16Rev2/D5 (June 2008).
   - The pilot allocation for 2-antenna BS for AMC zone is shown in the following figure.

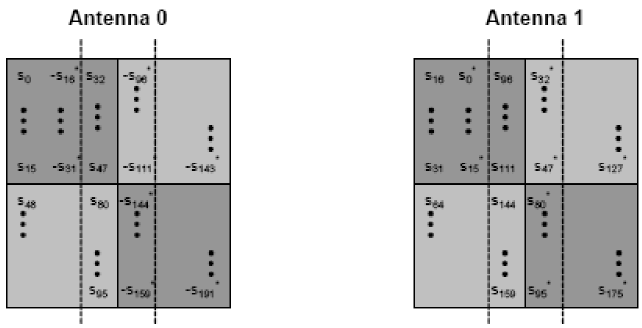


Pilot allocation for 2-antenna BS for the AMC zone

   - For 2-antenna matrix A the bursts are required to have 6 symbol granularity and begin on a 6 symbol boundary. In the first stage the data is first mapped frequency-first to each 2x3 slot, and frequencyfirst over the slots of the allocation as depicted in Figure 223. Then at the second stage matrix A encoding is performed over each pair of QAM symbols which were assigned to the same subcarrier index over two symbols. The symbol pairs for matrix A encoding numbered from the beginning of the STC zone are 2n, 2n+1 (n 0). Note that since the slot duration does not divide by 2, the matrix A encoding involves QAM symbols potentially belonging to different slots. An illustration of the mapping rule for the antenna #0 is shown in the following figures.



2-antenna matrix A step 1: mapping QAM symbols to subcarriers



2-antenna matrix A step 2: matrix A encoding over pairs of symbols

- For 2-antenna vertically encoded matrix B in the AMC permutation, the bursts are also required to begin on a 6 symbol boudary in ADS. The modulated data symbols shall be sequentially mapped for two Tx antennas along the subcarriers of the first symbol in antenna-first order. The mapping inside the AMC slot continues in an ascending manner in subcarriers first and then proceeds to the next symbol in time. An illustration of the mapping rule for the antenna #0 is shown in the following figure, assuming 2 Tx with vertically encoded matrix B for a block of 2 slots in one subchannel.

Antenna #0
with vertical encoding

s_0	s_{32}	s_{64}	s_{96}	s_{128}	s_{160}
		s_{66}	s_{98}	s_{130}	s_{162}
s_2	s_{34}	s_{68}	s_{100}	s_{132}	s_{164}
s_4	s_{36}	s_{70}	s_{102}	s_{134}	s_{166}
s_6	s_{38}	s_{72}	s_{104}		
s_8	s_{40}	s_{74}	s_{106}	s_{136}	s_{168}
s_{10}	s_{42}	s_{76}	s_{108}	s_{138}	s_{170}
s_{12}	s_{44}			s_{140}	s_{172}
s_{14}	s_{46}	s_{78}	s_{110}	s_{142}	s_{174}
s_{16}	s_{48}	s_{80}	s_{112}	s_{144}	s_{176}
		s_{82}	s_{114}	s_{146}	s_{178}
s_{18}	s_{50}	s_{84}	s_{116}	s_{148}	s_{180}
s_{20}	s_{52}	s_{86}	s_{118}	s_{150}	s_{182}
s_{22}	s_{54}	s_{88}	s_{120}		
s_{24}	s_{56}	s_{90}	s_{122}	s_{152}	s_{184}
s_{26}	s_{58}	s_{92}	s_{124}	s_{154}	s_{186}
s_{28}	s_{60}			s_{156}	s_{188}
s_{30}	s_{62}	s_{94}	s_{126}	s_{158}	s_{190}

2-antenna matrix B mapping

7. Two operation modes are supported in this model: STC 2x1 and MIMO 2x2.
   - 1. STC 2x1 (NumOfTxAnt=Ant2, STC_Encoder=Yes, STC_Matrix=Matrix_A)
     The number of ports at pin input is 1.
     The number of ports at pin MdmblTx is 2.
     The number of ports at pin MdmblRx is 1.
     The dimension of the complex matrix at pin Coef is 2x1. The complex matrix is

$$\begin{bmatrix} H_{11} \\ H_{21} \end{bmatrix}$$

     where H_{ij} is the CIR from the ith transmit antenna to the jth receiver antenna.
   - 2. MIMO 2x2 (NumOfTxAnt=Ant2, STC_Encoder=Yes, STC_Matrix=Matrix_B)
     The number of ports at pin input is 2.
     The number of ports at pin MdmblTx is 2.
     The number of ports at pin MdmblRx is 2.

The dimension of complex matrix at pin Coef is 2x2. The complex matrix is

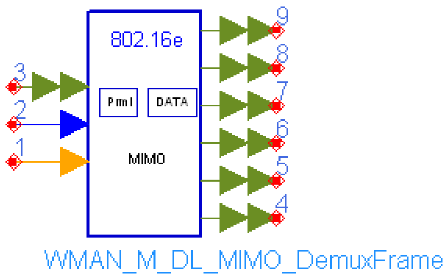
$$\begin{bmatrix} H_{11} & H_{21} \\ H_{12} & H_{22} \end{bmatrix}$$

8. If MidamblePresent=Yes, the channel estimator is based on the midamble symbol, and if Phasetrack=Yes, phase tracking is employed by estimating phase deviation in the pilots subcarriers.
9. If MidamblePresent=No, the channel estimator for DL PUSC is performed on the modified STC cluster for each channel path from transmitter to receiver in the following manner:
    1. The Wiener filter coefficients (W_{A0} and W_{A1}) are calculated by employing the well-known two-dimensional MMSE estimator (Reference [3]) which is based on maximum Doppler frequency (Fmax), maximum echo delay (Tmax) and SNR. Here coefficients W_{A0} are for pilots in antenna 0 and W_{A1} for pilots in antenna 1.
    2. The CIRs in the pilot subcarriers are obtained. For each cluster, per port at pin Input, two groups of CIRs are obtained. One is from pilots in antenna 0 and the other from pilots in antenna 1.
    3. The CIRs in all the subcarriers are the product of Wiener filter and the CIRs in the pilot subcarriers.
10. If MidamblePresent=No, the channel estimator for DL FUSC and DL AMC is performed in the same manner as that for DL PUSC.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. P. Hoeher, S. Kaiser, and P. Robertson. "Two-Dimensional Pilot-Symbol-Aided Channel Estimation by Wiener Filtering". Proc. IEEE ICASSP '97, Munich, Germany, pp. 1845-1848, Apr. 1997.
4. P802.16 Rev2/D5, June, 2008.

WMAN_M_DL_MIMO_DemuxFrame (802.16e OFDMA DL MIMO Frame Demuxer)



Description: Downlink frame demultiplexer for STC and MIMO
Library: WMAN 16e, MIMO Receiver

Parameters

Name	Description	Default	Unit	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of symbol in zone	6		int	[1,1212]
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
IdleInterval	Idle interval	10 usec	sec	real	[0,20000]
Bandwidth	Bandwidth	3.5 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 1		enum	
CyclicPrefix	Cyclic prefix	0.25		real	[0,1]
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
MidamblePresent	MIMO midamble present or not: NO, YES	NO		enum	
STC_Encoder	STC encoder or not: NO, YES	NO		enum	
FrameStartSym	Start symbol number of frame	0		int	[0,1212]
FrameStopSym	Stop symbol number of frame	0		int	[0,1212]
WindowLength	The length for the window in unit of chips (without oversampling)	16		int	[0,96]

Pin Inputs

Pin	Name	Description	Signal Type
1	index	synchronization index	int
2	DeltaF	carrier frequency offset	real
3	input	input of downlink frame	multiple complex

Pin Outputs

Pin	Name	Description	Signal Type
4	preamble	output preamble	multiple complex
5	FCH	output FCH and DL_MAP if enable	multiple complex
6	UL_MAP	output UL_MAP	multiple complex
7	midamble	output midamble for channel estimation	multiple complex
8	data	output data sequence	multiple complex
9	frame	output frame data with cyclic prefix and frequency offset	multiple complex

Notes/Equations

1. This model is used to demultiplex downlink frame into data symbol and preamble which is used for synchronization. Idle interval, cyclic prefix and zero padding are removed, and time and carrier frequency

offsets are compensated before demultiplexing.
2. Each firing:
 - $Samples_{Frame}$ tokens are consumed at pin input, where $Samples_{Frame}$ is the total sample of one downlink frame including zero padding and calculated as follows:

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

where $Samples_{idle}$ is the samples of IdleInterval and calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

Fs is the sampling frequency decided by *Bandwidth*, *OversamplingOption*, and related sampling factor (!wman_m-07-07-083.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in the following table.

Sampling Factor Requirement

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

 - *1* token is consumed at pin index which indicates the value of synchronization index.
 - *2* tokens are consumed at pin DeltaF. The first indicates the value of carrier frequency offset and the second indicates the phase used to achieve fine time synchronization.
 - $Samples_{FFTSize}$ tokens are produced at pin preamble, where $Samples_{FFTSize}$ decided by *FFTSize* and *OversamplingOption* and calculated as follows:

$$Samples_{FFTSize} = 2048/(2^{FFTSize}) \times 2^{OversamplingOption}$$

 - $Samples_{FFTSize} \times 2$ tokens are produced at pin FCH.
 - $Samples_{FFTSize} \times 2$ ~~ tokens are produced at pin UL_MAP, if the parameter *ULMAP_Enable* is set to "No", the output sequences are zeros.
 - $Samples_{FFTSize}$ tokens are produced at pin midamble
 - $Samples_{FFTSize} \times N_{DataSymbol}$ tokens are produced at pin data, where $N_{DataSymbol}$ is the number of OFDMA symbols of all the downlink bursts in the zone. $N_{DataSymbol}$ is decided by *ZoneType* and *ZoneNumOfSym*.

$$N_{DataSymbol} = ZoneNumOfSym$$

 - When *FrameStartSym=0* and *FrameStopSym=0* $Samples_{FFTSize} \times (1 + CP) \times N_{FrameSymbol}$ tokens are produced at pin frame, where $N_{FrameSymbol}$ is the number of OFDMA symbols of the entire downlink frame excluding zero padding and idle interval. $N_{FrameSymbol}$ is decided by ZoneNumOfSym and ZoneType as follows.

$$N_{FrameNumber} = 3 + ZoneNumOfSym$$

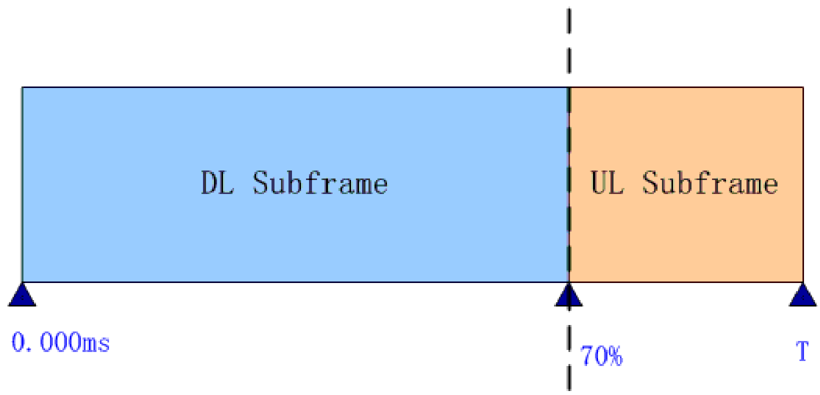
When *FrameStartSym* < *FrameStopSym*

$Samples_{FFTSize} \times (1 + CP) \times (FrameStopSym - FrameStartSym)$ tokens are produced at pin frame.

Time and carrier frequency offsets are not compensated to the output sequences.

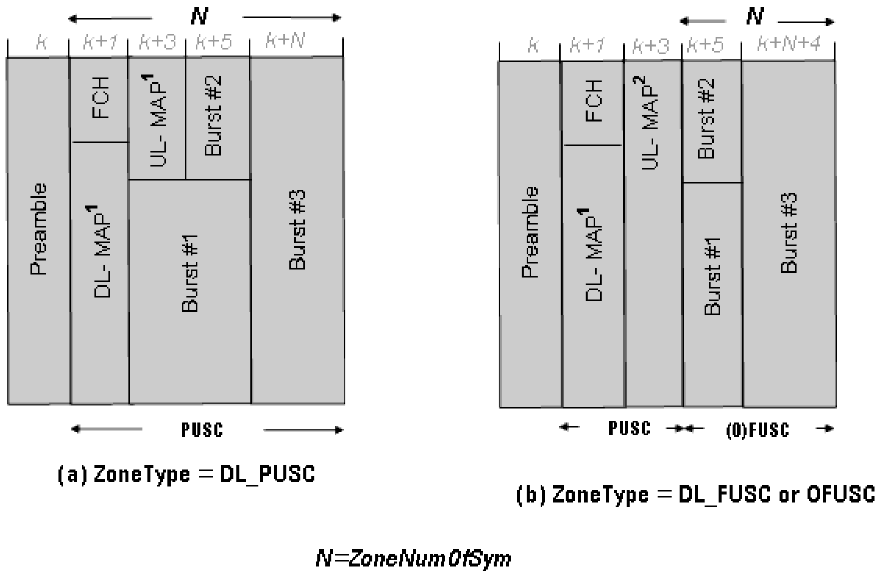
3. Frame structure:
   The following figure shows the frame format in TDD mode which allocates 70% frame time for the downlink subframe. If *FrameMode* is set to FDD, *100%* frame time will be used for the downlink subframe and the parameter DL_Ratio will be noneffective.

802.16e OFDMA Frame Structure for TDD Mode



The following figure shows the downlink frame format, which includes: preamble, FCH, DL_MAP and UL_MAP if enabled and one or multiple downlink bursts each transmitted with different burst profile.

WMAN DL Subframe Structure



The downlink preamble is transmitted in one OFDMA symbols.
FCH is transmitted by two OFDMA symbols in PUSC mode.

4. Output pin delay adjustment
   Because of the transmission delay, a detected frame usually falls into 2 consecutive received blocks, so the buffer length for input Pin is $2 \times Samples_{Frame}$. The second element of DeltaF is the phase difference between adjacent subcarriers (!wman_m-07-07-103.gif!) caused by coarse time synchronization and used to calculate index dithering (!wman_m-07-07-104.gif!) for pin Index. The start point of the detected frame(Index $_f$) is determined by the input signal at pin index combined with the $\Delta Index$. Only after receiving the second input

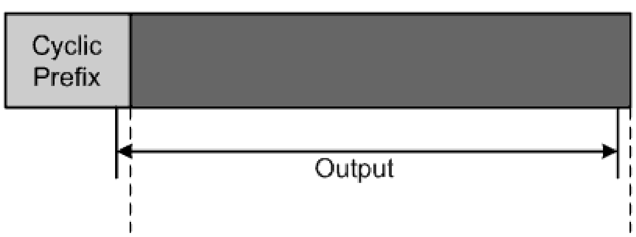
block, this model can output one actual frame. So this model causes one frame delay.

5. The first element of DeltaF pin inputs the estimated frequency offset (!wman_m-07-07-106.gif!) of each received frame. The i-th estimated frequency offset (!wman_m-07-07-107.gif!) compensates for the phase in the current frame only. Assume $x_0, x_1, \ldots, x_{Samples_{Frame}-1}$ sequences are the input signals from the input pin, $y_0, y_1, \ldots, y_{Samples_{Frame}-1}$ are the sequences, whose phase caused by frequency offset, are removed, then:

$$y_k = x_k \times e^{-j2\pi\Delta f_i k T_{Step}}$$

where
Δf_i is frequency offset of the i-th received frame which is the input at pin DeltaF,
$T_{Step} = \frac{1}{F_s \times 2^{OversamplingOption}}$ is the sample time interval in the system.
After making frequency offset compensation, the preamble, FCH , UL_MAP and data will be extracted and output at pin preamble, FCH , UL_MAP and data respectively. The total frame sequences discarding idle and zero padding are output at pin frame without time and frequency offset compensation. The output sequences from pin frame can be used to calculate CCDF.
Pin Index inputs the start point of a detected downlink frame (including idle).
$\Delta Index = (FFTSize \times \omega)/2\pi \times OversamplingOption$
The fine index (Index $_f$) is used to extract data sequences where $Index_f = Index + \Delta Index$. The output data sequences extracted from the OFDMA symbols begin from the CP, i.e. $Samples_{FFT} \times CyclicPrefix$. The cyclic prefix removal process is shown in the following figure.

Cyclic Prefix removal

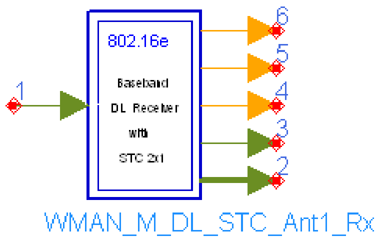


To decrease the influence caused by WMAN_M_SymWindow, an offset is used to extract the data sequences of one OFDM symbol. The Offset is calculated as follows:
if $WindowLength > 1.75 \times CyclicPrefix$ then!wman_m-07-07-118.gif!
else then!wman_m-07-07-119.gif!.
the output sequence is
if $k > Samples_{FFT} - Offset \times OversamplingOption$ then
$z_k = y_{k + Index_f + Samples_{FFT} \times CyclicPrefix - Samples_{FFT}}$
else $z_k = y_{k + Index + Samples_{FFT} \times CyclicPrefix}, k = 0, \ldots, Samples_{Frame} - 1$
where $k = 0, \ldots, Samples_{Frame} - 1$.
$z_0, z_1, \ldots, z_{Samples_{FFT} \times N_{FrameSymbol} - 1}$ sequences including data payload and preamble.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_STC_Ant1_Rx (802.16e OFDMA DL MIMO Receiver)



Description: Downlink baseband receiver for 2x1 STC
Library: WMAN 16e, MIMO Receiver

Parameters

Name	Description	Default	Unit	Type	Range
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
DLMAP_Enable	DLMAP is inserted or not: NO, YES	NO		enum	
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[0,0.02]
PreambleIndex	Preamble index	3		int	[0,113]
DL_PermBase	Downlink permutation base	9		int	[0,31]
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00, 0X00, 0X01}		int array	[0,255]
PRBS_ID	PRBS ID	0		int	[0,3]
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	20		int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array	[0,1]
NumberOfBurst	Number of Bursts	2		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}		int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,10}		int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}		int array	[1,60]
DataLength	MAC PDU payload byte length of each burst	{200,300}		int array	[1,∞)
Rate_ID	Rate ID of each burst	{5,5}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0,0}		int array	[0,3]
PowerBoosting	Power boosting of each burst in dB	{0,0}		real array	[-∞,∞]
MidamblePresent	MIMO midamble present or not: NO, YES	NO		enum	
MidambleBoosting	MIMO midamble boosting in dB	0		real	[-∞,∞]
DecoderType	Soft decision viterbi decoding type: Hard, Soft, CSI	Soft		enum	
SNR	Signal noise ratio per receiver antenna in dB.	15		real	[-∞ ,∞]
Tmax	The maximum delay of multi-path channel.	1.0 usec	sec	real	[0,∞]
Fmax	The maximum doppler frequency.	100 Hz	Hz	real	[0,∞]
BurstFEC_CodingType	Coding type for the burst with FEC-encoding: CC, CTC	CC		enum	
IterationNumber	The number of iterations (only for CTC decoder)	8		int	[1,16]
CycleNumber	The number of decoding cycles to get circulation states (only for CTC decoder)	1		int	[1,16]

Pin Inputs

Pin	Name	Description	Signal Type
1	Ant1Data	input of Ant1 signal	complex

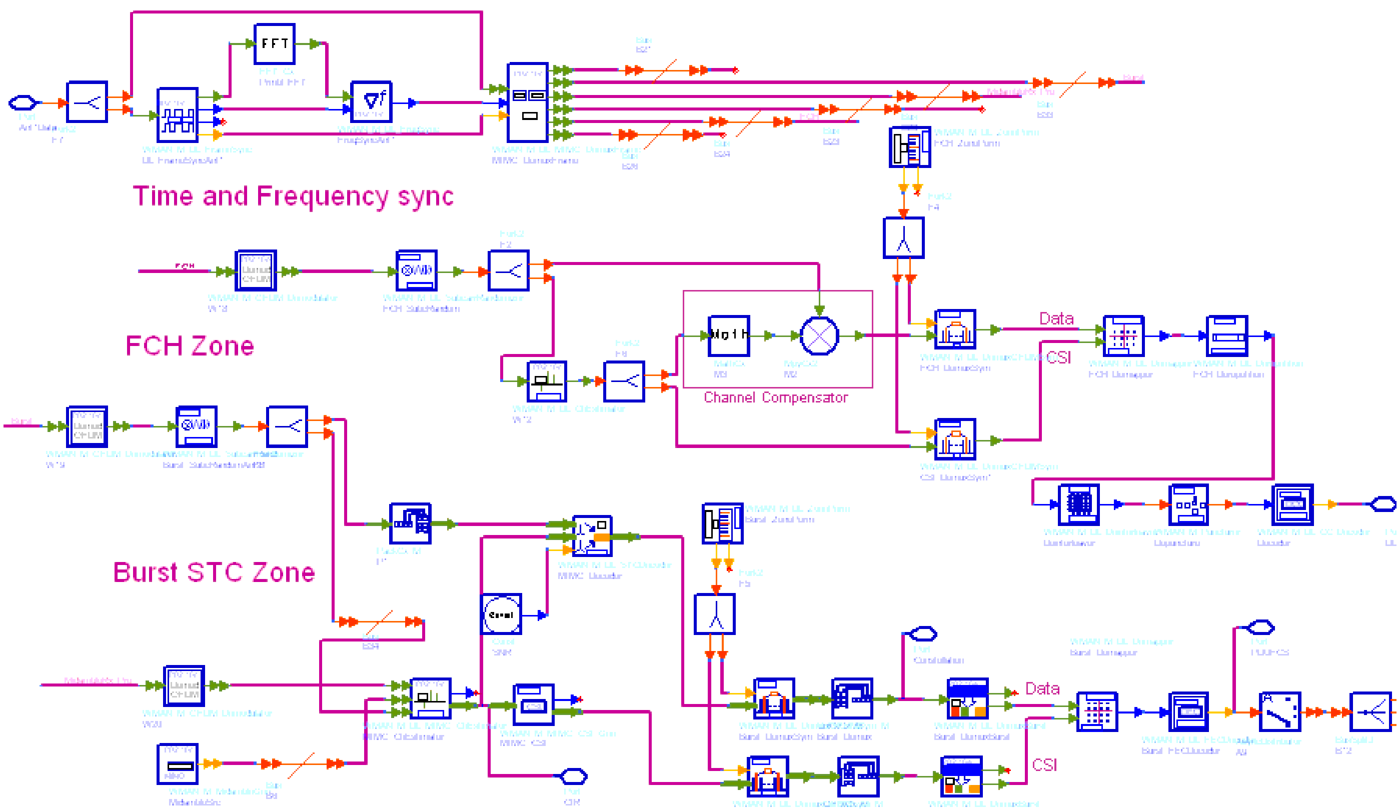
Pin Outputs

Pin	Name	Description	Signal Type
2	CIR	output of channel estimation of all bursts	complex matrix
3	Constellation	output of Modulated data of all bursts	complex
4	Demapped	output of demapped data for the burst with FEC	real
5	PSDU	output of PSDU bits	int
6	DLFP	output of DLFP bits	int

Notes/Equations

1. This subnetwork generates an 802.16e OFDMA downlink STC 2x1 baseband receiver. The schematic for this subnetwork is shown in the following diagram.

WMAN_M_DL_MIMO_Ant2_Rx Schematic

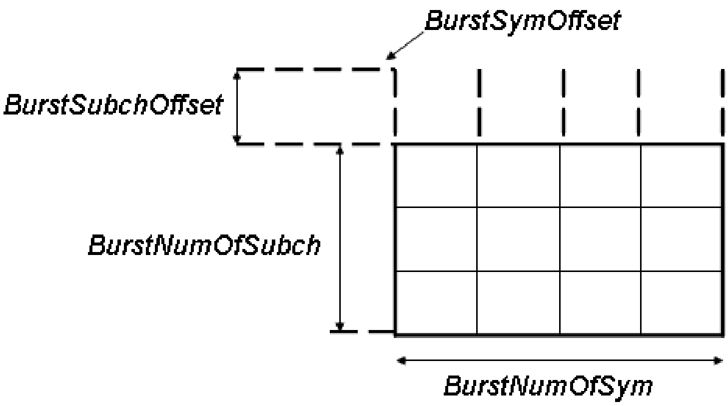


2. Receiver functions are implemented as follows:
Start of frame is detected. WMAN_M_DL_FrameSync calculates the correlation of the received signal, and selects the index with the maximum correlation value as the start of frame.
Frequency offset is estimated. WMAN_M_DL_FreqSync calculates the frequency offset and makes frequency synchronization using the preamble.
The packet is de-rotated according to the estimated frequency offsets (frequency synchronization) which is compensated by WMAN_M_DL_MIMO_DemuxFrame. WMAN_M_DL_MIMO_DemuxFrame outputs the preamble, FCH (including DL-MAP), UL-MAP, midamble, data bursts and frame data. The WMAN_M_DL_MIMO_DemuxFrame component introduces one frame delay.
The FCH and data bursts are sent to perform FFT transformation (in WMAN_M_OFDM_Demodulator) respectively.
The factors of randomzier appended to the subcarriers are removed in WMAN_M_DL_SubcarrRandomizer. Then the complex channel impulse responses (CIR) are estimated and interpolated for each subcarrier in WMAN_M_DL_MIMO_ChEstimator. The channel estimator can be based on midamble symbol or scattered pilots in data symbols, and if on midamble symbol, phase tracking may be employed by estimating phase deviation in scattered pilots.
With the received symbols and estimated channel responses, a STC Alamouti decoder is employed in

WMAN_M_DL_STCDecoder to restore the transmit symbols. WMAN_M_DL_DemuxOFDMSym transfers the physical subcarriers to logical data sequences and pilot sequences for each burst where the physical indices of data subcarriers and pilot subcarriers for each burst are calculated by WMAN_M_DL_ZonePerm. Then the data sequences are output at pin Data_Constellation. The signal at pin Data_Constellation can be used to show the demodulated constellation and to calculate the RCE (relative constellation error) or EVM.
The burst with FEC-encoded is separated from the multi-bursts in WMAN_M_DL_DemuxBurst. The demodulated OFDM symbols of burst with FEC are then de-mapped by WMAN_M_Demapper. Three demapper types (CSI, Soft and Hard) are supported in WMAN_M_Demaper.
After WMAN_M_FECDecoder, the MAC PDU data are achieved, which are divided into MAC header, MAC PDU payloads and CRC. The MAC PDU and its payloads are output at pin PDUFCS and PSDU respectively. The de-repetition, de-interleaving, CC decoding, de-randomizing are performed in WMAN_M_FECDecoder.
For FCH and DL-MAP, the de-mapped data are only passed through the de-repetition, de-interleaving, CC decoding, and only the decoded DLFP (FCH) is output at pin DLFP.

3. Refer to *CDD effects on STC/MIMO receiver* (wman_m) for the CDD effects.
4. Parameter Details
    - Bandwidth determines the nominal channel bandwidth.
    - OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
    - FFTSize specifies the size of FFT. Sizes 2048, 1024 and 512 are supported.
    - CyclicPrefix specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
    - FrameMode specifies the duplexing method which should be FDD or TDD. In FDD transmission, the downlink occupies the entire frame and the respective gaps (zeros) are automatically adjusted to fill the frame.
    - DL_Ratio specifies the percentage (1 to 99) of the frame time to be used for the downlink subframe. The parameter is only active when the FrameMode is TDD.
    - FrameDuration determines the frame durations (ms) of the generated waveform. There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
    - DLMAP_Enable specifies whether the DL-MAP burst is inserted in the downlink subframe.
    - ULMAP_Enable specifies whether the UL-MAP burst is inserted in the downlink subframe.
    - IdleInterval specifies the time of idle interval between the two continuous frames. The default value is 0.
    - PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to the standard.
    - DL_PermBase specifies the basis of downlink permutation to be used in initialization vector of the PRBS generator for subchannel randomization in the zone and in STC_DL_Zone_IE() in DL-MAP message.
    - BSID specifies the base station ID which is used in DL-MAP message.
    - PRBS_ID specifies the PRBS ID which may be used in initialization vector of the PRBS generator for subchannel randomization and in STC_DL_Zone_IE() in DL-MAP message.
    - ZoneType specifies the zone type which can be set to PUSC, FUSC or OFUSC.
    - ZoneNumOfSym specifies the symbol number for the zone. The value must be a multiple of two for DL_PUSC, and be a multiple of one for DL_FUSC and DL_OFUSC.
    - GroupBitmask specifies which groups of subchannel are used on the PUSC zone. This parameter uses 1 for assigned groups and 0 for unassigned groups.
    - NumberOfBurst specifies the number of active downlink bursts.
    - BurstWithFEC specifies the downlink burst FEC.
    - BurstSymOffset, BurstSubchOffset, BurstNumOfSym and BurstNumOfSubch specify the position and range for each rectangular burst, see the following figure.

Downlink Rectangular Burst Structure



- DataLength specifies MAC PDU payload byte length for each burst.
- Rate_ID specifies the rate ID for each burst. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in the following table. Here CC and CTC are supported in the downlink MIMO receiver.

The Relation between Coding Type and Rate ID

Coding type	Rate ID	Modulation/ Coding Rate
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in the following table.

The Meaning of Repetition Coding

Repetition coding	meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4used on the burst
3	Repetition coding of 6used on the burst

- PowerBoosting specifies the power boosting for each burst. Each value is defined in units of dB.
- MidamblePresent specifies whether a midamble symbol is inserted in front of STC zone.
- MidambleBoosting specifies the power boosting for the midamble symbol in units of dB.
- DecoderType specifies the Viterbi decoder type chosen from CSI, Soft and Hard. CSI (Channel State Information) is a channel estimate profile. This decision is neither hard or soft; it is adaptive based on where you are in the channel profile.
- SNR specifies the signal noise ratio per receiver antenna in dB. This parameter is useful for the channel estimator and MMSE MIMO decoder.
- Tmax specifies the maximum echo delay in multi-path channel. This parameter is useful for the channel estimator.

- Fmax specifies the maximum Doppler frequency. This parameter is useful for the channel estimator.
- BurstFEC_CodingType specifies the coding type for the burst with FEC-encoding. CC means convolutional coding while CTC means convolutional turbo coding.
- IterationNumber specifies the number of iterations for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).
- CycleNumber specifies the number of decoding cycles in order to get circulation states for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).

5. Samples per frame
The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-07-08-128.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in the following table.

Sampling Factor Requirement

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval(!wman_m-07-08-130.gif!) is calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

So, the total samples of one downlink frame $Samples_{Frame}$ is

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

6. Output Pin Delay Adjustment
This model works frame by fame. Each firing, $Samples_{Frame}$ tokens are consumed at Pin FrameData.
Pin CIR has one frame delay. Each firing, pin CIR produces $UsedCarriers \times N_{Sym}$ tokens where *UsedCarriers* is dependent on the zone type and FFT size according to the specification, shown in the following table. *Nsym* is *ZoneNumOfSym* for PUSC and FUSC.

The calculation of UsedCarriers

Zone type	FFT size	UsedCarriers
DL_PUSC	2048	1680
DL_PUSC	1024	840
DL_PUSC	512	420
DL_FUSC	2048	1702
DL_FUSC	1024	850
DL_FUSC	512	426
DL_OFUSC	2048	1728
DL_OFUSC	1024	864
DL_OFUSC	512	432

One frame delay at pin CIR is $UsedCarriers \times N_{Sym}$.
Pin Constellation has one frame delay. Each firing, pin Data_Constellation produces

$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 \times STCRate/N_{SymPerSlot}$$

tokens, where
$N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC;
$STCRate$ is 1 for STC 2x1.
Moreover, one frame delay at pin Constellation is

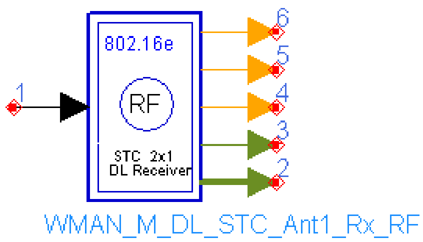
$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 \times STCRate / N_{SymPerSlot}$$

Pin PDUFCS has one frame delay. This pin outputs demodulated PSDU and FCS information bits after decoding. So, the delay of PDUFCS is $8 \times DataLength[BurstWithFEC] + 80$.
Pin PSDU also has one frame delay. This pin outputs demodulated PSDU information bits after decoding. So, the delay of PSDU is $8 \times DataLength[BurstWithFEC]$.
Pin DLFP also has one frame delay. Each firing, pin DLFP produces 192 tokens. One frame delay at pin DLFP is 192.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_STC_Ant1_Rx_RF (802.16e OFDMA DL MIMO RF Receiver)



Description: Downlink RF receiver for 2x1 STC
Library: WMAN 16e, MIMO Receiver

Parameters

Name	Description	Default	Unit	Type	Range
RIn	Input resistance	DefaultRIn	Ohm	int	(0,∞)
RTemp	Temperature, in degrees C	DefaultRTemp	Celsius	real	[-273.15,∞]
FCarrier	Carrier frequency	3407 MHz	Hz	real	(0,∞)
Sensitivity	voltage output sensitivity, Vout/Vin	1		real	(-∞,∞)
Phase	Reference phase in degrees	0.0	deg	real	(-∞,∞)
GainImbalance	Gain imbalance in dB, Q channel relative to I channel	0.0		real	(-∞,∞)
PhaseImbalance	Phase imbalance in degrees, Q channel relative to I channel	0.0		real	(-∞,∞)
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
DLMAP_Enable	DLMAP is inserted or not: NO, YES	NO		enum	
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
PreambleIndex	Preamble index	3		int	[0,113]
DL_PermBase	Downlink permutation base	9		int	[0,31]
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00, 0X00, 0X01}		int array	[0,255]
PRBS_ID	PRBS ID	0		int	[0,3]
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	20		int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array	[0,1]
NumberOfBurst	Number of Bursts	2		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}		int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,10}		int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}		int array	[1,60]
DataLength	MAC PDU payload byte length of each burst	{200,300}		int array	[1,∞)
Rate_ID	Rate ID of each burst	{5,5}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0,0}		int array	[0,3]
PowerBoosting	Power boosting of each burst in dB	{0,0}		real array	[-∞,∞]
MidamblePresent	MIMO midamble present or not: NO, YES	NO		enum	
MidambleBoosting	MIMO midamble boosting in dB	0		real	[-∞,∞]
DecoderType	Soft decision viterbi decoding type: Hard, Soft, CSI	Soft		enum	
SNR	Signal noise ratio per receiver antenna in dB.	15		real	[-∞ ,∞]
Tmax	The maximum delay of multi-path channel.	1.0 usec	sec	real	[0,∞]
Fmax	The maximum doppler frequency.	100 Hz	Hz	real	[0,∞]
BurstFEC_CodingType	Coding type for the burst with FEC-encoding: CC, CTC	CC		enum	
IterationNumber	The number of iterations (only for CTC decoder)	8		int	[1,16]
CycleNumber	The number of decoding cycles to get circulation states (only for CTC decoder)	1		int	[1,16]

Pin Inputs

Pin	Name	Description	Signal Type
1	RF_Signal	input of RF signal	timed

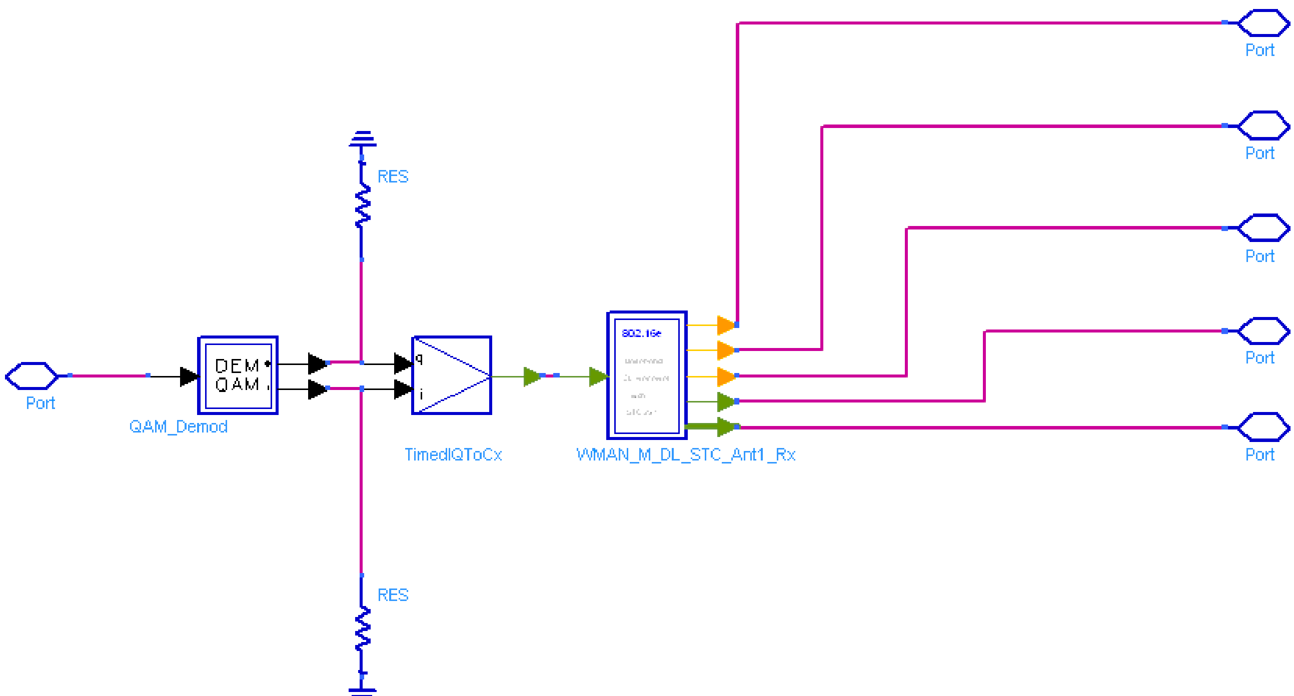
Pin Outputs

Pin	Name	Description	Signal Type
2	CIR	output of channel estimation of all bursts	complex matrix
3	Constellation	output of Modulated data of all bursts	complex
4	Demapped	output of demapped data for the burst with FEC	real
5	PSDU	output of PSDU bits	int
6	DLFP	output of DLFP bits	int

Notes/Equations

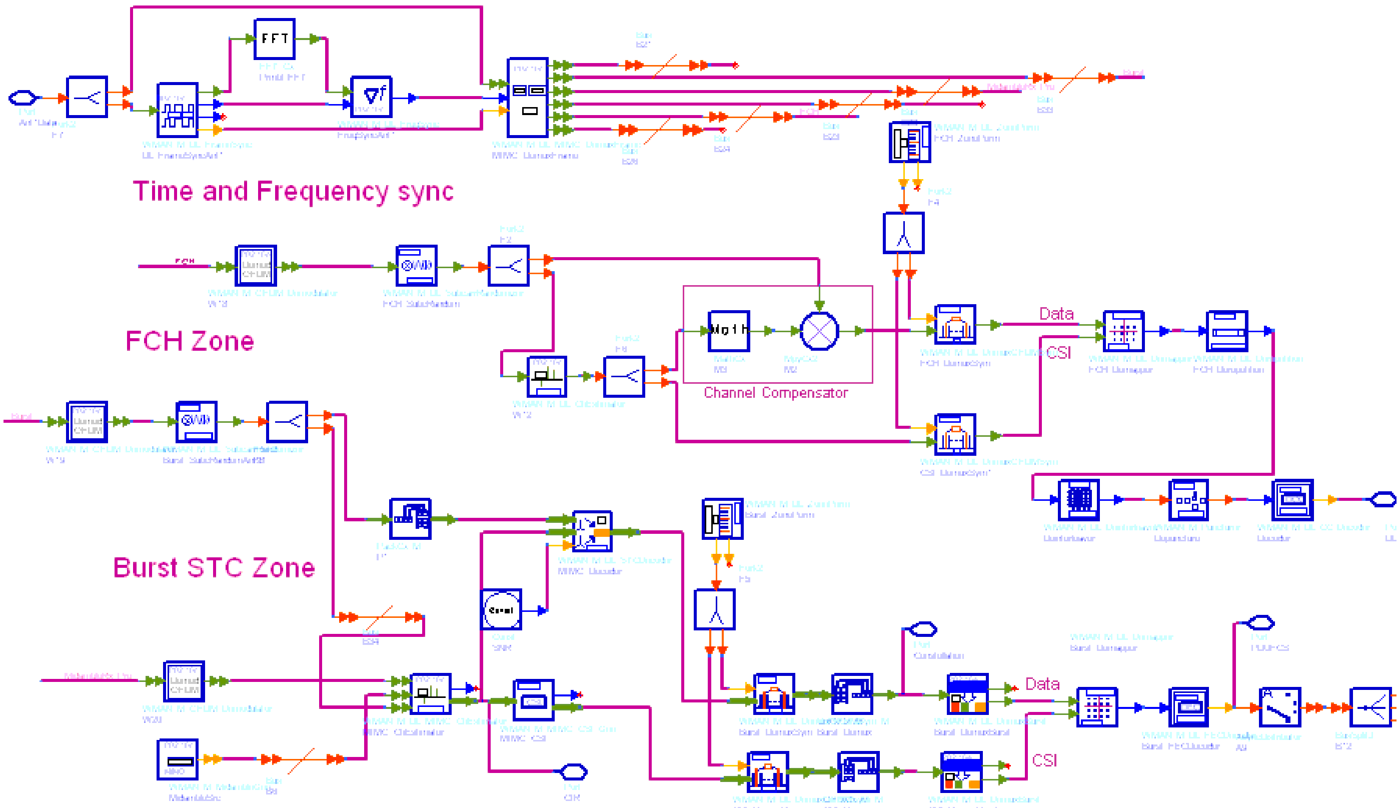
1. This subnetwork generates an 802.16e OFDMA downlink STC 2x1 RF receiver. The schematic for this subnetwork is shown in the following figure. The RF_Demodulator inverts the input RF signal to baseband signal and delivers it to WMAN_M_DL_STC_Ant1_Rx.

WMAN_M_DL_STC_Ant1_Rx_RF Schematic



2. The WMAN_M_DL_STC_Ant1_Rx generates an 802.16e OFDMA downlink subsystem baseband receiver. The schematic is shown in the following figure.

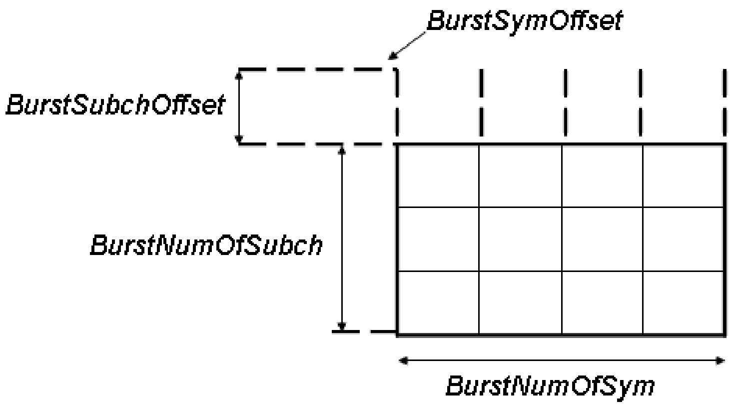
WMAN_M_DL_STC_Ant1_Rx Schematic



3. Receiver functions are implemented as follows:
   Start of frame is detected. WMAN_M_DL_FrameSync calculates the correlation of the received signal, and selects the index with the maximum correlation value as the start of frame.
   Frequency offset is estimated. WMAN_M_DL_FreqSync calculates the frequency offset and makes frequency synchronization using the preamble.
   The packet is de-rotated according to the estimated frequency offsets (frequency synchronization) which is compensated by WMAN_M_DL_MIMO_DemuxFrame. WMAN_M_DL_MIMO_DemuxFrame outputs the preamble, FCH (including DL-MAP), UL-MAP, midamble, data bursts and frame data. The WMAN_M_DL_MIMO_DemuxFrame component introduces one frame delay.
   The FCH and data bursts are sent to perform FFT transformation (in WMAN_M_OFDM_Demodulator) respectively.
   The factors of randomzier appended to the subcarriers are removed in WMAN_M_DL_SubcarrRandomizer.
   Then the complex channel impulse responses (CIR) are estimated and interpolated for each subcarrier in WMAN_M_DL_MIMO_ChEstimator. The channel estimator can be based on midamble symbol or scattered pilots in data symbols, and if on midamble symbol, phase tracking may be employed by estimating phase deviation in scattered pilots.
   With the received symbols and estimated channel responses, a STC Alamouti decoder is employed in WMAN_M_DL_STCDecoder to restore the transmit symbols. WMAN_M_DL_DemuxOFDMSym transfers the physical subcarriers to logical data sequences and pilot sequences for each burst where the physical indices of data subcarriers and pilot subcarriers for each burst are calculated by WMAN_M_DL_ZonePerm. Then the data sequences are output at pin Data_Constellation. The signal at pin Data_Constellation can be used to show the demodulated constellation and to calculate the RCE (relative constellation error) or EVM.
   The burst with FEC-encoded is separated from the multi-bursts in WMAN_M_DL_DemuxBurst. The demodulated OFDM symbols of burst with FEC are then de-mapped by WMAN_M_Demapper. Three demapper types (CSI, Soft and Hard) are supported in WMAN_M_Demaper.
   After WMAN_M_FECDecoder, the MAC PDU data are achieved, which are divided into MAC header, MAC PDU payloads and CRC. The MAC PDU and its payloads are output at pin PDUFCS and PSDU respectively. The de-repetition, de-interleaving, CC decoding, de-randomizing are performed in WMAN_M_FECDecoder.
   For FCH and DL-MAP, the de-mapped data are only passed through the de-repetition, de-interleaving, CC decoding, and only the decoded DLFP (FCH) is output at pin DLFP.
4. Parameter Details
   - RIn is the RF input resistance.
   - RTemp is the RF output resistance temperature in Celsius and sets the noise density in the RF output signal to (k(RTemp+273.15)) Watts/Hz, where k is Boltzmann's constant.
   - FCarrier is the RF output signal frequency.

- Sensitivity is the voltage output sensitivity (Vout/Vin) of the internal oscillator that generates the reference carrier signal used to demodulate the RF signal.
- Phase is the reference phase in degrees of the reference carrier signal.
- GainImbalance and PhaseImbalance add certain impairments to the ideal output RF signal. Impairments are added as described here.
  The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:
  $$V_3(t) = A\left(V_1(t)\cos(\omega_c t) - gV_2(t)\sin\left(\omega_c t + \frac{\Phi\pi}{180}\right)\right)$$
  where V1(t) is the in-phase RF envelope, V2(t) is the quadrature phase RF envelope, g is the gain imbalance:
  $$g = 10^{\frac{GainImbalance}{20}}$$
  and, ϕ (in degrees) is the phase imbalance.
- Bandwidth determines the nominal channel bandwidth.
- OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
- FFTSize specifies the size of FFT. Sizes 2048, 1024 and 512 are supported.
- CyclicPrefix specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
- FrameMode specifies the duplexing method which should be FDD or TDD. In FDD transmission, the downlink occupies the entire frame and the respective gaps (zeros) are automatically adjusted to fill the frame
- DL_Ratio specifies the percentage (1 to 99) of the frame time to be used for the downlink subframe. The parameter is only active when the FrameMode is TDD.
- FrameDuration determines the frame durations (ms) of the generated waveform. There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
- DLMAP_Enable specifies whether the DL-MAP burst is inserted in the downlink subframe.
- ULMAP_Enable specifies whether the UL-MAP burst is inserted in the downlink subframe.
- IdleInterval specifies the time of idle interval between the two continuous frames. The default value is 0.
- PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to the standard.
- DL_PermBase specifies the basis of downlink permutation to be used in initialization vector of the PRBS generator for subchannel randomization in the zone and in STC_DL_Zone_IE() in DL-MAP message.
- BSID specifies the base station ID which is used in DL-MAP message.
- PRBS_ID specifies the PRBS ID which may be used in initialization vector of the PRBS generator for subchannel randomization and in STC_DL_Zone_IE() in DL-MAP message.
- ZoneType specifies the zone type which can be set to PUSC, FUSC or OFUSC.
- ZoneNumOfSym specifies the symbol number for the zone. The value must be a multiple of two for DL_PUSC, and be a multiple of one for DL_FUSC and DL_OFUSC.
- GroupBitmask specifies which groups of subchannel are used on the PUSC zone. This parameter uses 1 for assigned groups and 0 for unassigned groups.
- NumberOfBurst specifies the number of active downlink bursts.
- BurstWithFEC specifies the downlink burst FEC.
- BurstSymOffset, BurstSubchOffset, BurstNumOfSym and BurstNumOfSubch specify the position and range for each rectangular burst, seen the following figure.

Downlink Rectangular Burst Structure



- DataLength specifies MAC PDU payload byte length for each burst.
- Rate_ID specifies the rate ID for each burst. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in the following table. Here CC and CTC are supported in the downlink MIMO receiver.

The Relation between Coding Type and Rate ID

Coding type	Rate ID	Modulation/ Coding Rate
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in the following table.

The Meaning of Repetition Coding

Repetition coding	meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4used on the burst
3	Repetition coding of 6used on the burst

- PowerBoosting specifies the power boosting for each burst. Each value is defined in units of dB.
- MidamblePresent specifies whether a midamble symbol is inserted in front of STC zone.
- MidambleBoosting specifies the power boosting for the midamble symbol in units of dB.
- DecoderType specifies the Viterbi decoder type chosen from CSI, Soft and Hard. CSI (Channel State Information) is a channel estimate profile. This decision is neither hard or soft; it is adaptive based on where you are in the channel profile.
- SNR specifies the signal noise ratio per receiver antenna in dB. This parameter is useful for the channel estimator and MMSE MIMO decoder.
- Tmax specifies the maximum echo delay in multi-path channel. This parameter is useful for the channel estimator.

- Fmax specifies the maximum Doppler frequency. This parameter is useful for the channel estimator.
- BurstFEC_CodingType specifies the coding type for the burst with FEC-encoding. CC means convolutional coding while CTC means convolutional turbo coding.
- IterationNumber specifies the number of iterations for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).
- CycleNumber specifies the number of decoding cycles in order to get circulation states for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).

5. Samples per frame
The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-07-09-150.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in the following table.

Sampling Factor Requirement

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval ($Samples_{idle}$) is calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

So, the total samples of one downlink frame $Samples_{Frame}$ is

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

6. Output Pin Delay Adjustment
This model works frame by fame. Each firing, $Samples_{Frame}$ tokens are consumed at Pin Ant1Data.
Pin CIR has one frame delay. Each firing, pin CIR produces $UsedCarriers \times N_{Sym}$ tokens where UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in the following table. *Nsym* is *ZoneNumOfSym* for PUSC and FUSC.

The Calculation of UsedCarriers

Zone type	FFT size	UsedCarriers
DL_PUSC	2048	1680
DL_PUSC	1024	840
DL_PUSC	512	420
DL_FUSC	2048	1702
DL_FUSC	1024	850
DL_FUSC	512	426
DL_OFUSC	2048	1728
DL_OFUSC	1024	864
DL_OFUSC	512	432

One frame delay at pin CIR is $UsedCarriers \times N_{Sym}$.
Pin Constellation has one frame delay. Each firing, pin Data_Constellation produces

$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 \times STCRate / N_{SymPerSlot}$$

tokens, where $N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC; $STCRate$ is 1 for STC 2x1. Moreover, one frame delay at pin Constellation is

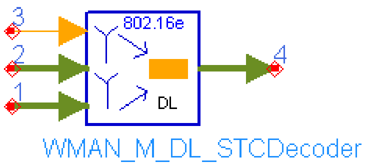
$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 \times STCRate / N_{SymPerSlot}$$

Pin PDUFCS has one frame delay. This pin outputs demodulated PSDU and FCS information bits after decoding. So, the delay of PDUFCS is $8 \times DataLength[BurstWithFEC] + 80$.
Pin PSDU also has one frame delay. This pin outputs demodulated PSDU information bits after decoding. So, the delay of PSDU is $8 \times DataLength[BurstWithFEC]$.
Pin DLFP also has one frame delay. Each firing, pin DLFP produces 192 tokens. One frame delay at pin DLFP is 192.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_STCDecoder (802.16e OFDMA DL STC Decoder)



Description: Downlink STC decoder
Library: WMAN 16e, MIMO Receiver

Parameters

Name	Description	Default	Type
NumOfTxAnt	Number of antenna: Ant1, Ant2, Ant4	Ant1	enum
STC_Matrix	STC matrix: Matrix_A, Matrix_B, Matrix_C	Matrix_A	enum
DecoderType	decoding type for Spatial Multiplexing: ZF, MMSE	ZF	enum
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512, FFT_128	FFT_2048	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	STC_Symbol	input of STC-enabled symbols	complex matrix
2	STC_CIR	input of STC CIR	complex matrix
3	SNR	Signal noise ratio per receiver antenna in dB	real

Pin Outputs

Pin	Name	Description	Signal Type
4	OFDM_Symbol	output of OFDM symbols	complex matrix

Notes/Equations

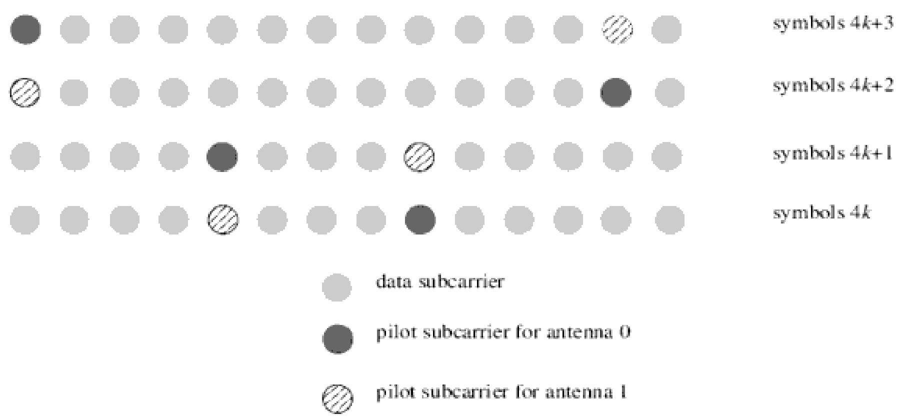
1. This model is used to do UL STC/MIMO decoder.
2. Each firing,
   When in STC mode (NumOfTxAnt=Ant2, STC_Encoder=Yes, STC_Matrix=Matrix_A)
   $2 \times UsedCarriers$ tokens are consumed at pin STC_Symbol;
   $2 \times UsedCarriers$ tokens are consumed at pin STC_CIR;
   1 token is consumed at pin SNR;
   $2 \times UsedCarriers$ tokens are produced at pin OFDM_Symbol.
   When in MIMO mode (NumOfTxAnt=Ant2, STC_Encoder=Yes, STC_Matrix=Matrix_B)
   $UsedCarriers$ tokens are consumed at pin STC_Symbol;
   $UsedCarriers$ tokens are consumed at pin STC_CIR;
   1 token is consumed at pin SNR;
   $UsedCarriers$ tokens are produced at pin OFDM_Symbol.
   UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in the following table.

   The Calculation of UsedCarriers

Zone type	FFT size	UsedCarriers
UL_PUSC	2048	1680
UL_PUSC	1024	840
UL_PUSC	512	408
UL_OPUSC	2048	1728
UL_OPUSC	1024	864
UL_OPUSC	512	432

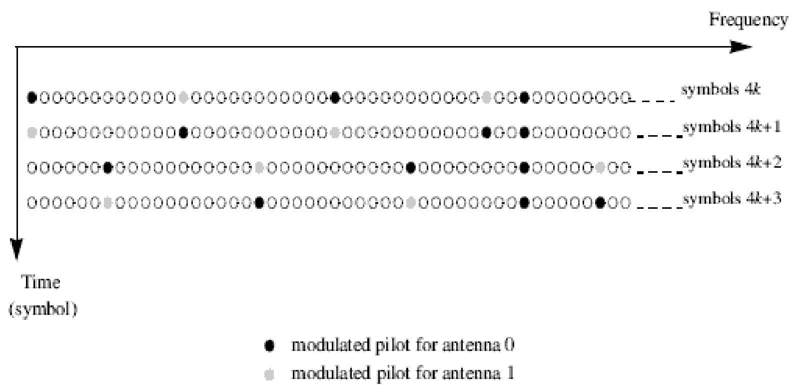
3. DL PUSC and FUSC are supported in this model.
4. For DL PUSC, the channel estimator is performed on the modified STC cluster. Each cluster has four symbols and 14 subcarriers where four pilot subcarriers are for antenna 0 and other four pilot subcarriers are for antenna 1. The cluster structure is illustrated in the following figure.

Cluster structure for DL STC PUSC



For DL FUSC, the pilots within the symbols shall be divided between the antennas - antenna 0 uses VariableSet#0 and ConstantSet#0 for even symbols while antenna 1 uses VariableSet#1 and ConstantSet#1 for even symbols, antenna 0 uses VariableSet#1 and ConstantSet#0 for odd symbols while antenna 1 uses VariableSet#0 and ConstantSet#1 for odd symbols (symbol counting starts at the starting point of the relevant STC zone). The cluster structure is illustrated in the following figure.

The Structure for DL STC FUSC



5. Two operation modes are supported in this model: STC 2x1 and MIMO 2x2.
   1. STC 2x1 (NumOfTxAnt=Ant2, STC_Encoder=Yes, STC_Matrix=Matrix_A)
      The dimension of the complex matrix at pin Coef is 2x1. The complex matrix H is

$$\begin{bmatrix} H_{11} \\ H_{21} \end{bmatrix}$$

where H_{ij} is the CIR from the ith transmit antenna to the jth receiver antenna.
In DL STC mode, the CIRs in ajacent symbol are almost the same. H_{11} means CIR of the 1st transmiter antenna to the receiver antenna and H_{21} means CIR of the 2st transmiter antenna to the receiver antenna. The received signal can be expressed as

$S_1H_{11} - S_2H_{21} = R_1$

$S*_2H_{11} + S*_1H_{21} = R_2$

We can get the original signal as following

$$S_1 = \frac{R_1H*_{11} + R*_2H_{21}}{H*_{11}H_{11} + H*_{21}H_{21}}$$

$$S_2 = \frac{R_2H*_{11} + R*_1H_{21}}{H*_{11}H_{11} + H*_{21}H_{21}}$$

2. MIMO 2x2 (NumOfTxAnt=Ant2, STC_Encoder=Yes, STC_Matrix=Matrix_B)
   The dimension of complex matrix at pin Coef is 2x2. The complex matrix is

$$\begin{bmatrix} H_{11} & H_{21} \\ H_{12} & H_{22} \end{bmatrix}$$

The Zero Forcing Algorithm

$S_{est} = (H*H)^{-1}H*R$

The Minimum Mean Square Error Algorithm

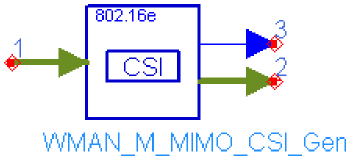
$S_{est} = (\alpha I + H*H)^{-1}H*R$

H is channel matrix , R is received signal and α is SNR per antenna.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_MIMO_CSI_Gen (802.16e OFDMA MIMO CSI Generator)



Description: CSI generator for STC and MIMO
Library: WMAN 16e, MIMO Receiver

Parameters

Name	Description	Default	Type
NumOfTxAnt	Number of transmitting antennas: Ant1, Ant2, Ant4	Ant2	enum
STC_Encoder	STC encoder or not: NO, YES	YES	enum
STC_Matrix	STC matrix: Matrix_A, Matrix_B, Matrix_C	Matrix_A	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	input	Channel coefficients	complex matrix

Pin Outputs

Pin	Name	Description	Signal Type
2	output	CSI	complex matrix
3	Corr	Correlation coefficients	real

Notes/Equations

1. This model is used to generate the channel status information (CSI) based on the channel estimation for STC/MIMO.
2. Each firing,
   1 token is consumed at pin input;
   1 token is produced at pin output;
   1 token is produced at pin Corr.
3. In this model, the post-processed SNR is taken as the CSI for each received symbol. The ZF post-processed SNR for the ith received symbols is given by

   $$SNR_i = h_i^H \times h_i$$

   where $\boldsymbol{h}_i$ is the ith column of the channel matrix $\boldsymbol{H}$.
   The ouput at pin Corr is the correlation of the channel matrix $\boldsymbol{H}$.
   When the channel correlation is near 1 (e.g. > 0.96), the SNR obtained from the equation above is less creditable. In this case, CSI will be decreased.
4. Two operation modes are supported in this model: STC 2x1 and MIMO 2x2.
   1. STC 2x1 (NumOfTxAnt=Ant2, STC_Encoder=Yes, STC_Matrix=Matrix_A)
      The dimension of the complex matrix at pin input is 2x1. The complex matrix $\boldsymbol{H}$ is

      $$\boldsymbol{H} = \begin{bmatrix} H_{11} \\ H_{21} \end{bmatrix}$$

      where H_{ij} is the CIR from the ith transmit antenna to the jth receiver antenna.
      The dimension of complex matrix at pin output is 2x1. Note that the above equation of SNR generation in STC 2x1 needs to modify such that the $\boldsymbol{h}_i$ is the ith row of the channel matrix $\boldsymbol{H}$.
   2. MIMO 2x2 (NumOfTxAnt=Ant2, STC_Encoder=Yes, STC_Matrix=Matrix_B)

The dimension of complex matrix at pin input is 2x2. The complex matrix $\boldsymbol{H}$ is

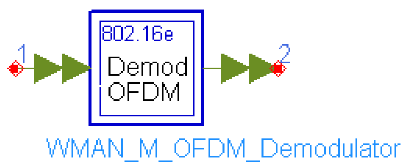
$$\boldsymbol{H} = \begin{bmatrix} H_{11} & H_{21} \\ H_{12} & H_{22} \end{bmatrix}$$

The dimension of complex matrix at pin output is 2x1.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_OFDM_Demodulator (802.16e OFDMA OFDM Demodulator)



Description: OFDM symbols demodulator
Library: WMAN 16e, MIMO Receiver

Parameters

Name	Description	Default	Type	Range
NumOfRxAnt	Number of Rx antennas	2	int	[1,4]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2	enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
UsedCarriers	Number of used subcarriers	840	int	[1,2048]

Pin Inputs

Pin	Name	Description	Signal Type
1	Input	input data	multiple complex

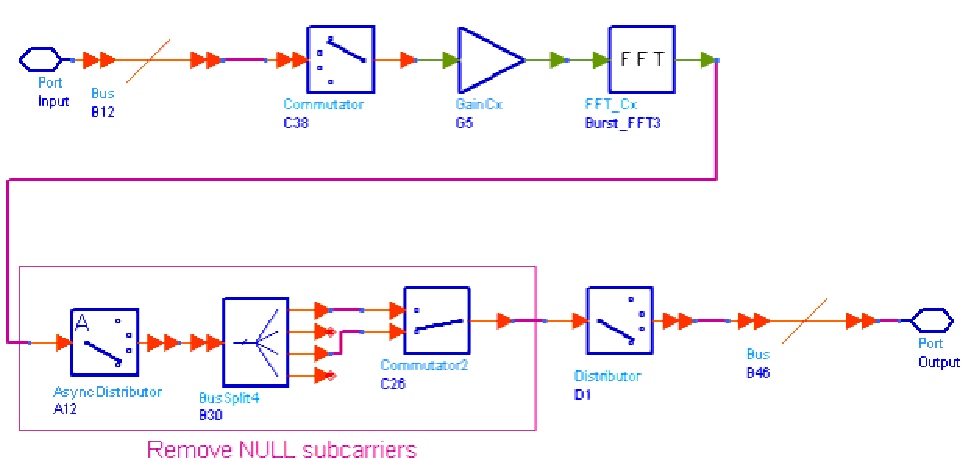
Pin Outputs

Pin	Name	Description	Signal Type
2	Output	output data	multiple complex

Notes/Equations

1. This subnetwork is used to do FFT and to remove null subcarriers including DC, left and right guard subcarriers, then useful subcarriers are output.
2. The schematic of this subnetwork is shown in the following figure.

WMAN_M_OFDM_Demodulator schematic



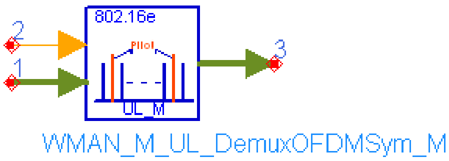
3. The Pin Input and Output support multi-ports. A Gain is inserted in this subnetwork to compensate the amplitude adjustment in the source.
4. Each firing,
$2^{11-FFTSize+OversamplingOption}$ tokens are consumed at Pin Input;

UsedCarriers tokens are produced at Pin Output.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.

WMAN_M_UL_DemuxOFDMSym_M (802.16e OFDMA UL DemuxOFDMSym in Matrix)



Description: Uplink OFDM symobl demultiplexer with matrix
Library: WMAN 16e, MIMO Receiver

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24	int	[3,1212]
NumberOfBurst	Number of Bursts	1	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}	int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}	int array	[1,6868]

Pin Inputs

Pin	Name	Description	Signal Type
1	UL_OFDMSym	input of UL OFDM symbol	complex matrix
2	BurstPos	input of the position of bursts	int

Pin Outputs

Pin	Name	Description	Signal Type
3	UL_Bursts	output of UL bursts	complex matrix

Notes/Equations

1. This model is used to demultiplex OFDMA symbols into data and pilot subcarriers in the uplink. The function of this model is the same as WMAN_M_UL_DemuxOFDMSym except data sequences at pin UL_OFDMSym and pin UL_Bursts are both in matrix. The dimension and array architecture of the matrix at pin UL_Bursts and pin UL_OFDMSym are the same. The data locations for each bursts are calculated by WMAN_M_UL_ZonePerm and input at pin dataPosition in order. The OFDMA symbols after left, right and DC carriers removal are input at pin UL_OFDMSym. This is inverse function of WMAN_M_UL_MuxOFDMSym_M.
2. Each firing,
   - $N_{UsedCarrier} \times ZoneNumOfSymbol$ tokens are consumed at pin UL_OFDMSym in matrix, where $N_{UsedCarrier}$ is the number of data and pilots subcarriers used within a symbol, excluding DC carrier.
     $N_{UsedCarrier}$ is decided by *FFTSize* and *ZoneType* as shown in *WMAN_M_DL_MIMO_Ant2_Sync Schematic* (wman_m).

Calculation of N $_{UsedCarrier}$

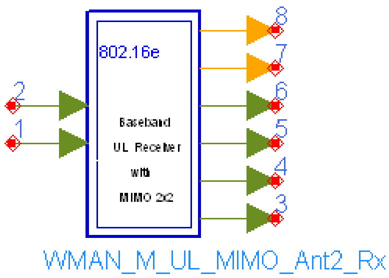
N $_{UsedCarrier}$	FFT_2048	FFT_1024	FFT_512
PUSC	1680	840	408
OPUSC	1728	864	432

- $\sum_{i=1}^{NumberOfBurst} BurstAssignedSlot[i] \times 48$ tokens are consumed at pin dataPosition.
- $\sum_{i=1}^{NumberOfBurst} BurstAssignedSlot[i] \times 48$ tokens are produced at pin UL_Bursts in matrix.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_MIMO_Ant2_Rx (802.16e OFDMA UL MIMO Receiver)



Description: Uplink baseband receiver fpr MIMO
Library: WMAN 16e, MIMO Receiver

Parameters

Name	Description	Default	Unit	Type	Range
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01 , 0.99]
FrameDuration	Frame duration: time 2ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[0,20000]
PreambleIndex	Preamble index	3		int	[0,113]
FrameNumber	Frame number	0		int	[1,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
UL_PermBase	Uplink permutation base	0		int	[0 , 69]
ZoneType	Zone type: UL_PUSC	UL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24		int	[3,1212]
ZoneSymOffset	Symbol offset in zone	0		int	[0,1211]
NumberOfBurst	Number of Bursts	1		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}		int array	[1,6868]
DataLength	MAC PDU payload byte length of each burst	{300}		int array	[1,∞)
Rate_ID	Rate ID of each burst	{3}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0}		int array	[0,3]
DecoderType	Demapping type: Hard, Soft, CSI	CSI		enum	
STCDecoder	STC(MIMO) decoding type: ZF, MMSE	MMSE		enum	
Collaborative	Two SSs collaborative spatial multiplexing or not (valid only when NumOfAnt is Ant2 and STC_Matrix is Matrix_B): NO, YES	NO		enum	
TilePattern	The uplink tile pattern used by the SS (valid only when Collaborative is valid and is YES): Pattern_A, Pattern_B	Pattern_A		enum	
SNR	Signal noise ratio in dB.	15		real	[-∞ ,∞]
Tmax	The maximum delay of multi-path channel.	1.0 usec	sec	real	[0,∞]
Fmax	The maximum doppler frequency.	100 Hz	Hz	real	[0,∞]
BurstFEC_CodingType	Coding type for the burst with FEC-encoding: CC, CTC	CC		enum	
IterationNumber	The number of iterations (only for CTC decoder)	8		int	[1,16]
CycleNumber	The number of decoding cycles to get circulation states (only for CTC decoder)	1		int	[1,16]

Pin Inputs

Pin	Name	Description	Signal Type
1	Ant1Data	input of Ant1 signal	complex
2	Ant2Data	input of Ant2 signal	complex

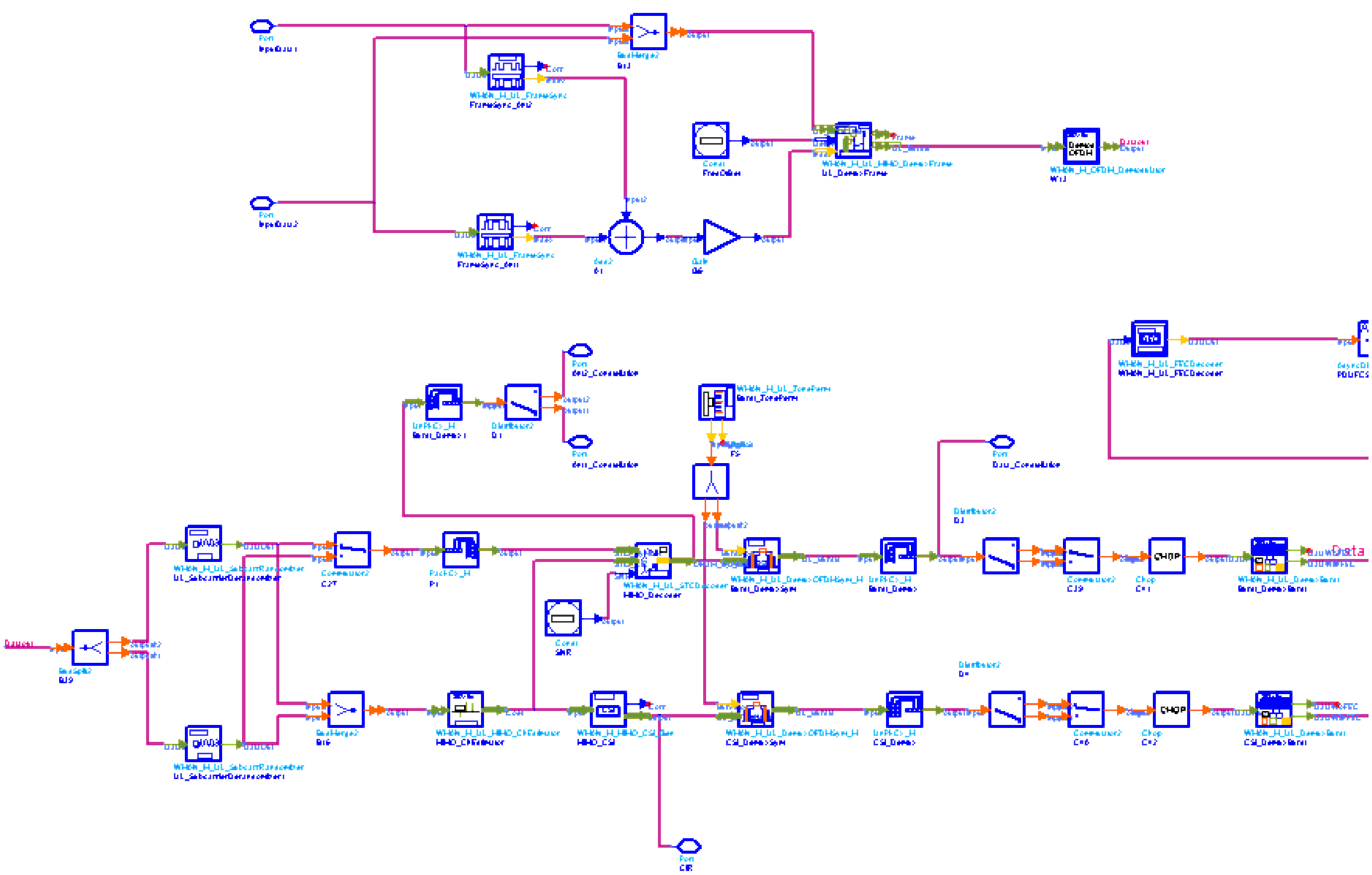
Pin Outputs

Pin	Name	Description	Signal Type
3	CIR	output of channel pulse response	complex
4	Ant1_Constellation	output of modulated data in antenna 1	complex
5	Ant2_Constellation	output of modulated data in antenna 2	complex
6	Data_Constellation	output of modulated data before mapping to antennas	complex
7	PDUFCS	output of MAC data of burst with FEC	int
8	PSDU	output of MAC PDU data of burst with FEC	int

Notes/Equations

1. This subnetwork generates an 802.16e OFDMA uplink MIMO 2x2 baseband receiver. The schematic for this subnetwork is shown in the following figure.

WMAN_M_UL_MIMO_Ant2_Rx Schematic



2. Receiver functions are implemented as follows:
Start of frame is detected. WMAN_M_DL_FrameSync calculates the correlation of the received signal in antenna 0 and antenna 1 respectively, then the index of each antenna is averaged. To reduce simulation time, frequency offset is set zero.
The packet is de-rotated according to the estimated frequency offsets (frequency synchronization) which is compensated by WMAN_M_UL_MIMO_DemuxFrame. WMAN_M_UL_MIMO_DemuxFrame outputs data bursts and frame data. The WMAN_M_DL_MIMO_DemuxFrame component introduces one frame delay.
The data bursts are sent to perform FFT transformation (in WMAN_M_OFDM_Demodulator).
The factors of randomzier appended to the subcarriers are removed in WMAN_M_UL_SubcarrRandomizer.
Then the complex channel impulse responses (CIR) are estimated and interpolated for each subcarrier in WMAN_M_UL_MIMO_ChEstimator. The channel estimator is based on the scattered pilots in data symbols.

With the received symbols and estimated channel responses, a ZF or MMSE decoder is employed in WMAN_M_UL_STCDecoder to restore the transmit symbols (one transmit symbol per each antenna). The restored symbols at antenna 0 are output at pin Ant1_Constellation while symbols at antenna 1 are output at pin Ant2_Constellation. WMAN_M_UL_DemuxOFDMSym transfers the physical subcarriers to logical data sequences and pilot sequences for each burst where the physical indices of data subcarriers and pilot subcarriers for each burst are calculated by WMAN_M_UL_ZonePerm. Then the two data sequences are sequentially merged into one data sequences which are output at pin Data_Constellation. The signal at pin Data_Constellation can be used to show the demodulated constellation and to calculate the RCE (relative constellation error) or EVM.
The burst with FEC-encoded is separated from the multi-bursts in WMAN_M_UL_DemuxBurst. The demodulated OFDM symbols of burst with FEC are then de-mapped by WMAN_M_Demapper. Three demapper types (CSI, Soft and Hard) are supported in WMAN_M_Demaper.
After WMAN_M_FECDecoder, the MAC PDU data are achieved, which are divided into MAC header, MAC PDU payloads and CRC. The MAC PDU and its payloads are output at pin PDUFCS and PSDU respectively. The de-repetition, de-interleaving, CC decoding, de-randomizing are performed in WMAN_M_FECDecoder.

3. Parameter Details
    - Bandwidth determines the nominal channel bandwidth.
    - OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
    - FFTSize specifies the size of FFT. Sizes 2048, 1024 and 512 are supported.
    - CyclicPrefix specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
    - FrameMode specifies the duplexing method which should be FDD or TDD. In FDD transmission, the downlink occupies the entire frame and the respective gaps (zeros) are automatically adjusted to fill the frame
    - DL_Ratio specifies the percentage (1 to 99) of the frame time to be used for the downlink subframe. The parameter is only active when the FrameMode is TDD.
    - FrameDuration determines the frame durations (ms) of the generated waveform. There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
    - IdleInterval specifies the time of idle interval between the two continuous frames. The default value is 0.
    - PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to the standard.
    - ZoneType specifies the zone type which can be set to PUSC, FUSC or OFUSC.
    - ZoneNumOfSym specifies the symbol number for the zone. The value must be a multiple of three.
    - NumberOfBurst specifies the number of active downlink bursts.
    - BurstWithFEC specifies the downlink burst FEC.
    - BurstSymOffset, BurstSubchOffset and BurstAssignedSlot specify the position and range for each burst
    - DataLength specifies MAC PDU payload byte length for each burst.
    - Rate_ID specifies the rate ID for each burst. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in the following table. Here CC and CTC are supported in the downlink MIMO receiver.

The Relation between Coding Type and Rate ID

Coding type	Rate ID	Modulation/ Coding Rate
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in the following table.

The Meaning of Repetition Coding

Repetition coding	meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4used on the burst
3	Repetition coding of 6used on the burst

- PowerBoosting specifies the power boosting for each burst. Each value is defined in units of dB.
- MidamblePresent specifies whether a midamble symbol is inserted in front of STC zone.
- MidambleBoosting specifies the power boosting for the midamble symbol in units of dB.
- DecoderType specifies the Viterbi decoder type chosen from CSI, Soft and Hard. CSI (Channel State Information) is a channel estimate profile. This decision is neither hard or soft; it is adaptive based on where you are in the channel profile.
- STCDecoder specifies the MIMO decoder type chosen from ZF and MMSE.
- Collaborative specifies whether collaborative spatial multiplexing is employed or not. This parameter is valid only when NumOfAnt is Ant2 and STC_Matrix is Matrix_B.
- TilePattern specifies the uplink tile pattern used by the SS. This parameter is valid only when Collaborative is valid and is set to YES.
- SNR specifies the signal noise ratio per receiver antenna in dB. This parameter is useful for the channel estimator and MMSE MIMO decoder.
- Tmax specifies the maximum echo delay in multi-path channel. This parameter is useful for the channel estimator.
- Fmax specifies the maximum Doppler frequency. This parameter is useful for the channel estimator.
- BurstFEC_CodingType specifies the coding type for the burst with FEC-encoding. CC means convolutional coding while CTC means convolutional turbo coding.
- IterationNumber specifies the number of iterations for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).
- CycleNumber specifies the number of decoding cycles in order to get circulation states for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).

4. Samples per frame
   The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-07-14-211.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

   The sampling factors are listed in the following table.

Sampling Factor Requirement

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

   The samples of IdleInterval($Samples_{idle}$) is calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

   So, the total samples of one downlink frame $Samples_{Frame}$ is!wman_m-07-14-216.gif!

5. Output Pin Delay Adjustment
   This model works frame by fame. Each firing, $Samples_{Frame}$ tokens are consumed at Pin FrameData. Pin Ant1_Constellation and Ant2_Constellation have one frame delay. The two pins output the transmit symbols at all the subcarriers. Each firing, pin Ant1_Constellation and Ant2_Constellation produces $UsedCarriers \times N_{Sym}$ respectively, where *UsedCarriers* is dependent on the zone type and FFT size according to the specification, shown in the following table. *Nsym* is *ZoneNumOfSym* for PUSC and FUSC.

The Calculation of UsedCarriers

Zone type	FFT size	UsedCarriers
DL_PUSC	2048	1680
DL_PUSC	1024	840
DL_PUSC	512	420
DL_FUSC	2048	1702
DL_FUSC	1024	850
DL_FUSC	512	426
DL_OFUSC	2048	1728
DL_OFUSC	1024	864
DL_OFUSC	512	432

Moreover, one frame delay at pin Ant1_Constellation and Ant2_Constellation is $UsedCarriers \times N_{Sym}$.
Pin CIR also has one frame delay. Each firing, pin CIR produces $UsedCarriers \times N_{Sym}$ tokens. One frame delay at pin CIR is $UsedCarriers \times N_{Sym}$.
Pin Data_Constellation has one frame delay. Each firing, pin Data_Constellation produces

$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 \times STCRate / N_{SymPerSlot}$$

tokens, where $N_{SymPerSlot}$ is 3; $STCRate$ is 2 for MIMO 2x2. Moreover, one frame delay at pin Data_Constellation is

$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 \times STCRate / N_{SymPerSlot}$$

Pin PSDUFCS has one frame delay. This pin outputs demodulated PSDU and FCS information bits after decoding.

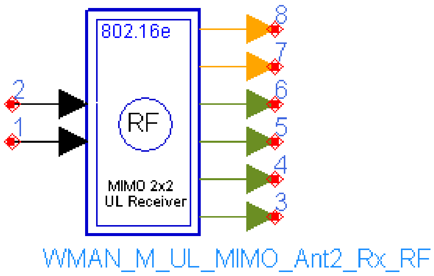
So, the delay of PSDUFCS is $\times DataLength[BurstWithFEC] + 8($.
Pin PSDU also has one frame delay. This pin outputs demodulated PSDU information bits after decoding.

So, the delay of PSDUFCS is $8 \times DataLength[BurstWithFEC]$.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_MIMO_Ant2_Rx_RF (802.16e OFDMA UL MIMO Receiver)



Description: Uplink RF receiver for MIMO
Library: WMAN 16e, MIMO Receiver

Parameters

Name	Description	Default	Unit	Type	Range
RIn	input resistance	DefaultRIn	Ohm	int	(0,∞)
RTemp	TEMPERATURE	DefaultRTemp	Celsius	real	[-273.15,∞]
FCarrier	Carrier frequency	3407 MHz	Hz	real	(0,∞)
Sensitivity	voltage output sensitivity, Vout/Vin	1		real	(-∞,∞)
Phase	Reference phase in degrees	0.0	deg	real	(-∞,∞)
GainImbalance	Gain imbalance in dB Q channel relative to I channel	0.0		real	(-∞,∞)
PhaseImbalance	Phase imbalance in dB Q channel relative to I channel	0.0		real	(-∞,∞)
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01 , 0.99]
FrameDuration	Frame duration: time 2ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[0,20000]
PreambleIndex	Preamble index	3		int	[0,113]
FrameNumber	Frame number	0		int	[1,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
UL_PermBase	Uplink permutation base	0		int	[0 , 69]
ZoneType	Zone type: UL_PUSC	UL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24		int	[3,1212]
ZoneSymOffset	Symbol offset in zone	0		int	[0,1211]
NumberOfBurst	Number of Bursts	1		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}		int array	[1,6868]
DataLength	MAC PDU payload byte length of each burst	{300}		int array	[1,∞)
Rate_ID	Rate ID of each burst	{3}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0}		int array	[0,3]
DecoderType	Demapping type: Hard, Soft, CSI	CSI		enum	
STCDecoder	STC(MIMO) decoding type: ZF, MMSE	MMSE		enum	
Collaborative	Two SSs collaborative spatial multiplexing or not (valid only when NumOfAnt is Ant2 and STC_Matrix is Matrix_B): NO, YES	NO		enum	
TilePattern	The uplink tile pattern used by the SS (valid only when Collaborative is valid and is YES): Pattern_A, Pattern_B	Pattern_A		enum	
SNR	Signal noise ratio in dB.	15		real	[-∞ ,∞]
Tmax	The maximum delay of multi-path channel.	1.0 usec	sec	real	[0,∞]
Fmax	The maximum doppler frequency.	100 Hz	Hz	real	[0,∞]
BurstFEC_CodingType	Coding type for the burst with FEC-encoding: CC, CTC	CC		enum	
IterationNumber	The number of iterations (only for CTC decoder)	8		int	[1,16]
CycleNumber	The number of decoding cycles to get circulation states (only for CTC decoder)	1		int	[1,16]

Pin Inputs

Pin	Name	Description	Signal Type
1	Ant1Data	input of Ant1 signal	timed
2	Ant2Data	input of Ant2 signal	timed

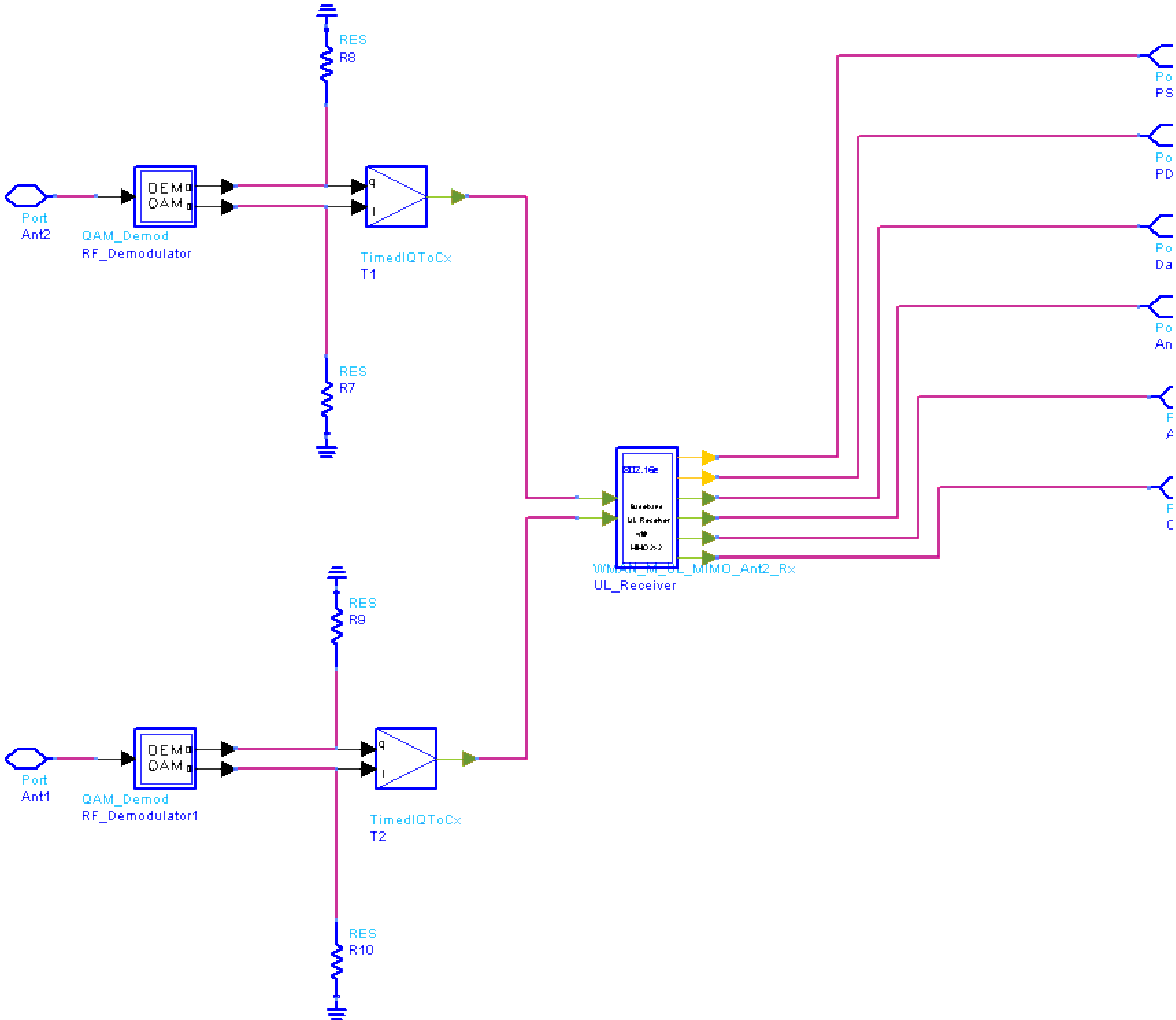
Pin Outputs

Pin	Name	Description	Signal Type
3	CIR	output of channel pulse response	complex
4	Ant1_Constellation	output of modulated data in antenna 1	complex
5	Ant2_Constellation	output of modulated data in antenna 2	complex
6	Data_Constellation	output of modulated data before mapping to antennas	complex
7	PDUFCS	output of MAC data of burst with FEC	int
8	PSDU	output of MAC PDU data of burst with FEC	int

Notes/Equations

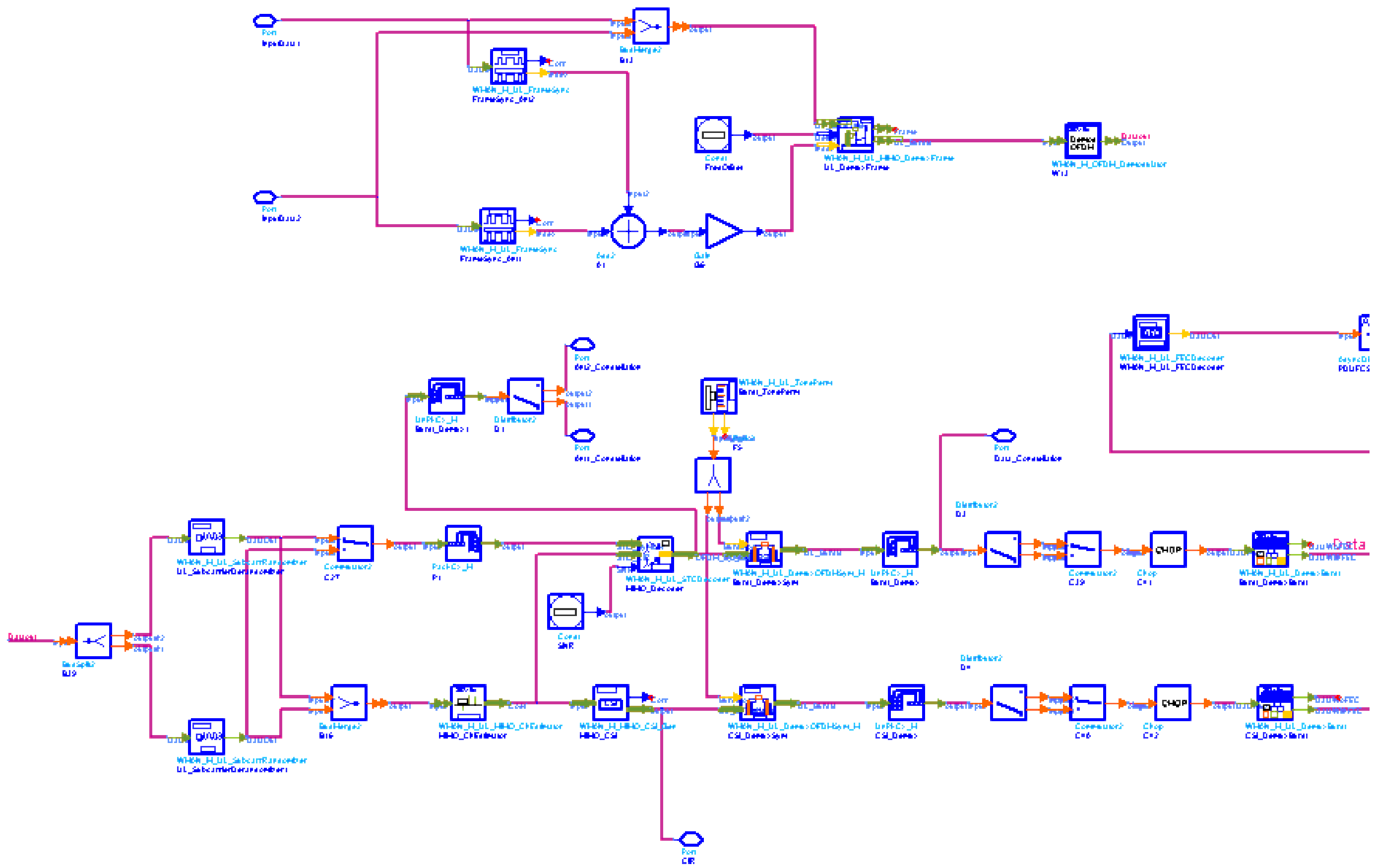
1. This subnetwork generates an 802.16e OFDMA uplink MIMO 2x2 subsystem RF receiver. The subnetwork includes WMAN_M_UL_MIMO_Ant2_Rx, and two RF_Demodulator. The schematic for this subnetwork is shown in the following figure.

WMAN_M_UL_MIMO_Ant2_Rx_RF Schematic



2. This subnetwork generates an 802.16e OFDMA uplink MIMO 2x2 baseband receiver. The schematic for this subnetwork is shown in the following figure.

WMAN_M_UL_MIMO_Ant2_Rx Schematic



3. Receiver functions are implemented as follows:
   Start of frame is detected. WMAN_M_DL_FrameSync calculates the correlation of the received signal in antenna 0 and antenna 1 respectively, then the index of each antenna is averaged. To reduce simulation time, frequency offset is set zero.
   The packet is de-rotated according to the estimated frequency offsets (frequency synchronization) which is compensated by WMAN_M_UL_MIMO_DemuxFrame. WMAN_M_UL_MIMO_DemuxFrame outputs data bursts and frame data. The WMAN_M_DL_MIMO_DemuxFrame component introduces one frame delay.
   The data bursts are sent to perform FFT transformation (in WMAN_M_OFDM_Demodulator).
   The factors of randomzier appended to the subcarriers are removed in WMAN_M_UL_SubcarrRandomizer.
   Then the complex channel impulse responses (CIR) are estimated and interpolated for each subcarrier in WMAN_M_UL_MIMO_ChEstimator. The channel estimator is based on the scattered pilots in data symbols.
   With the received symbols and estimated channel responses, a ZF or MMSE decoder is employed in WMAN_M_UL_STCDecoder to restore the transmit symbols (one transmit symbol per each antenna). The restored symbols at antenna 0 are output at pin Ant1_Constellation while symbols at antenna 1 are output at pin Ant2_Constellation. WMAN_M_UL_DemuxOFDMSym transfers the physical subcarriers to logical data sequences and pilot sequences for each burst where the physical indices of data subcarriers and pilot subcarriers for each burst are calculated by WMAN_M_UL_ZonePerm. Then the two data sequences are sequentially merged into one data sequences which are output at pin Data_Constellation. The signal at pin Data_Constellation can be used to show the demodulated constellation and to calculate the RCE (relative constellation error) or EVM.
   The burst with FEC-encoded is separated from the multi-bursts in WMAN_M_UL_DemuxBurst. The demodulated OFDM symbols of burst with FEC are then de-mapped by WMAN_M_Demapper. Three demapper types (CSI, Soft and Hard) are supported in WMAN_M_Demaper.
   After WMAN_M_FECDecoder, the MAC PDU data are achieved, which are divided into MAC header, MAC PDU payloads and CRC. The MAC PDU and its payloads are output at pin PDUFCS and PSDU respectively. The de-repetition, de-interleaving, CC decoding, de-randomizing are performed in WMAN_M_FECDecoder.
4. Parameter Details
   - RIn is the RF input resistance.
   - RTemp is the RF output resistance temperature in Celsius and sets the noise density in the RF output

signal to (k(RTemp+273.15)) Watts/Hz, where k is Boltzmann's constant.

- FCarrier is the RF output signal frequency.
- Sensitivity is the voltage output sensitivity (Vout/Vin) of the internal oscillator that generates the reference carrier signal used to demodulate the RF signal.
- Phase is the reference phase in degrees of the reference carrier signal.
- GainImbalance and PhaseImbalance add certain impairments to the ideal output RF signal. Impairments are added as described here.
  The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:
  $$V_3(t) = A\left(V_1(t)\cos(\omega_c t) - gV_2(t)\sin\left(\omega_c t + \frac{\Phi\pi}{180}\right)\right)$$
  where V1(t) is the in-phase RF envelope, V2(t) is the quadrature phase RF envelope, g is the gain imbalance:
  $$g = 10^{\frac{GainImbalance}{20}}$$
  and, ϕ (in degrees) is the phase imbalance.
- Bandwidth determines the nominal channel bandwidth.
- OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
- FFTSize specifies the size of FFT. Sizes 2048, 1024 and 512 are supported.
- CyclicPrefix specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
- FrameMode specifies the duplexing method which should be FDD or TDD. In FDD transmission, the downlink occupies the entire frame and the respective gaps (zeros) are automatically adjusted to fill the frame
- DL_Ratio specifies the percentage (1 to 99) of the frame time to be used for the downlink subframe. The parameter is only active when the FrameMode is TDD.
- FrameDuration determines the frame durations (ms) of the generated waveform. There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
- IdleInterval specifies the time of idle interval between the two continuous frames. The default value is 0.
- PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to the standard.
- ZoneType specifies the zone type which can be set to PUSC, FUSC or OFUSC.
- ZoneNumOfSym specifies the symbol number for the zone. The value must be a multiple of three.
- NumberOfBurst specifies the number of active downlink bursts.
- BurstWithFEC specifies the downlink burst FEC.
- BurstSymOffset, BurstSubchOffset and BurstAssignedSlot specify the position and range for each burst
- DataLength specifies MAC PDU payload byte length for each burst.
- Rate_ID specifies the rate ID for each burst. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in the following table. Here CC and CTC are supported in the downlink MIMO receiver.

The Relation between Coding Type and Rate ID

Coding type	Rate ID	Modulation/ Coding Rate
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in the following table.

The Meaning of Repetition Coding

Repetition coding	meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4used on the burst
3	Repetition coding of 6used on the burst

- PowerBoosting specifies the power boosting for each burst. Each value is defined in units of dB.
- MidamblePresent specifies whether a midamble symbol is inserted in front of STC zone.
- MidambleBoosting specifies the power boosting for the midamble symbol in units of dB.
- DecoderType specifies the Viterbi decoder type chosen from CSI, Soft and Hard. CSI (Channel State Information) is a channel estimate profile. This decision is neither hard or soft; it is adaptive based on where you are in the channel profile.
- STCDecoder specifies the MIMO decoder type chosen from ZF and MMSE.
- Collaborative specifies whether collaborative spatial multiplexing is employed or not. This parameter is valid only when NumOfAnt is Ant2 and STC_Matrix is Matrix_B.
- TilePattern specifies the uplink tile pattern used by the SS. This parameter is valid only when Collaborative is valid and is set to YES.
- SNR specifies the signal noise ratio per receiver antenna in dB. This parameter is useful for the channel estimator and MMSE MIMO decoder.
- Tmax specifies the maximum echo delay in multi-path channel. This parameter is useful for the channel estimator.
- Fmax specifies the maximum Doppler frequency. This parameter is useful for the channel estimator.
- BurstFEC_CodingType specifies the coding type for the burst with FEC-encoding. CC means convolutional coding while CTC means convolutional turbo coding.
- IterationNumber specifies the number of iterations for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).
- CycleNumber specifies the number of decoding cycles in order to get circulation states for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).

5. Samples per frame
   The sampling frequency (Fs) implemented in the design is decided by *Bandwidth* and related sampling factor (!wman_m-07-15-234.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

   The sampling factors are listed in the following table.

Sampling Factor Requirement

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval($Samples_{idle}$) is calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

So, the total samples of one downlink frame $Samples_{Frame}$ is

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

6. Output Pin Delay Adjustment

   This model works frame by fame. Each firing, $Samples_{Frame}$ tokens are consumed at Pin FrameData. Pin Ant1_Constellation and Ant2_Constellation have one frame delay. The two pins output the transmit symbols at all the subcarriers. Each firing, pin Ant1_Constellation and Ant2_Constellation produces $UsedCarriers \times N_{Sym}$ respectively, where *UsedCarriers* is dependent on the zone type and FFT size according to the specification, shown in the following table. *Nsym* is *ZoneNumOfSym* for PUSC and FUSC.

   The Calculation of UsedCarriers

Zone type	FFT size	UsedCarriers
DL_PUSC	2048	1680
DL_PUSC	1024	840
DL_PUSC	512	420
DL_FUSC	2048	1702
DL_FUSC	1024	850
DL_FUSC	512	426
DL_OFUSC	2048	1728
DL_OFUSC	1024	864
DL_OFUSC	512	432

   Moreover, one frame delay at pin Ant1_Constellation and Ant2_Constellation is $UsedCarriers \times N_{Sym}$.
   Pin CIR also has one frame delay. Each firing, pin CIR produces $UsedCarriers \times N_{Sym}$ tokens. One frame delay at pin CIR is $UsedCarriers \times N_{Sym}$.
   Pin Data_Constellation has one frame delay. Each firing, pin Data_Constellation produces

$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 \times STCRate / N_{SymPerSlot}$$

   tokens, where $N_{SymPerSlot}$ is 3; $STCRate$ is 2 for MIMO 2x2. Moreover, one frame delay at pin Data_Constellation is

$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 \times STCRate / N_{SymPerSlot}$$

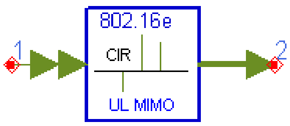
   Pin PSDUFCS has one frame delay. This pin outputs demodulated PSDU and FCS information bits after decoding.
   So, the delay of PSDUFCS is $8 \times DataLength[BurstWithFEC] + 80$.
   Pin PSDU also has one frame delay. This pin outputs demodulated PSDU information bits after decoding.
   So, the delay of PSDUFCS is $8 \times DataLength[BurstWithFEC]$.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed

and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_MIMO_ChEstimator (802.16e OFDMA UL MIMO ChEstimator)



WMAN_M_UL_MIMO_ChEstimator

Description: Uplink channel estimator for STC and MIMO
Library: WMAN 16e, MIMO Receiver

Parameters

Name	Description	Default	Unit	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_2048		enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC	UL_PUSC		enum	
ZoneNumOfSym	Number of symbols in ZONE	16		int	[1,1024]
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
NumOfTxAnt	Number of transmitting antennas: Ant1, Ant2, Ant4	Ant2		enum	
STC_Encoder	STC encoder or not: NO, YES	YES		enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B, Matrix_C	Matrix_A		enum	
SNR	SNR in dB. (used by Wiener filter in PUSC)	15		real	(-∞,∞)
Tmax	The maximum delay of multi-path channel. (used by Wiener filter in PUSC)	1e-6		real	[0,∞)
Fmax	The maximum doppler frequency. (used by Wiener filter in PUSC)	100 Hz	Hz	real	[0,∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	Input	output signals from FFT	multiple complex

Pin Outputs

Pin	Name	Description	Signal Type
2	Coef	channel coefficient in subcarriers	complex matrix

Notes/Equations

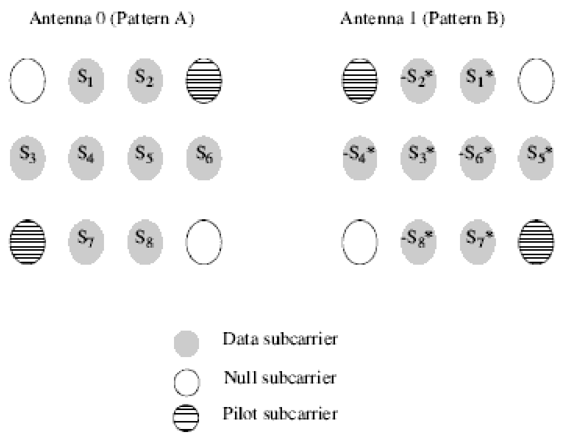
1. This model is used to calculate uplink channel estimation based on the pilot channels and output the active subcarriers estimated channel impulse response (CIR) for STC/MIMO.
2. Each firing,
   $3 \times UsedCarriers$ tokens are consumed at pin Input;
   $3 \times UsedCarriers$ tokens are produced at pin Coef, where UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in the following table.

   The Calculation of UsedCarriers

Zone type	FFT size	UsedCarriers
UL_PUSC	2048	1680
UL_PUSC	1024	840
UL_PUSC	512	408
UL_OPUSC	2048	1728
UL_OPUSC	1024	864
UL_OPUSC	512	432

3. Only UL PUSC is supported in this model.
4. The channel estimator is performed on the tile one by one. Each tile has four pilot subcarriers and eight data subcarriers whose configuration is illustrated in the following figure.

Tile Structure for UL PUSC



5. Two operation modes are supported in this model: STC 2x1 and MIMO 2x2.
   1. STC 2x1 (NumOfTxAnt=Ant2, STC_Encoder=Yes, STC_Matrix=Matrix_A)
      The number of ports at pin input is 1.
      The dimension of the complex matrix at pin Coef is 2x1. The complex matrix is

$$\begin{bmatrix} H_{11} \\ H_{21} \end{bmatrix}$$

      where H_{ij} is the CIR from the ith transmit antenna to the jth receiver antenna.
   2. MIMO 2x2 (NumOfTxAnt=Ant2, STC_Encoder=Yes, STC_Matrix=Matrix_B)
      The number of ports at pin input is 2.
      The dimension of complex matrix at pin Coef is 2x2. The complex matrix is

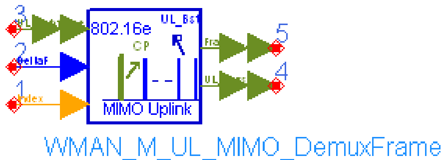
$$\begin{bmatrix} H_{11} & H_{21} \\ H_{12} & H_{22} \end{bmatrix}$$

6. The channel estimator for PUSC is performed in the following manner:
   1. The Wiener filter coefficients (!wman_m-07-16-258.gif! and W_B) are calculated by employing the well-known two-dimensional MMSE estimator (Reference [3]) which is based on maxinum Doppler frequency (Fmax), maximum echo delay (Tmax) and SNR. Here coefficients W_A are for pilot pattern A and W_B for pilot pattern B.
   2. The CIRs in the pilot subcarriers are obtained. For each tile, per port at pin Input, two groups of CIRs are obtained. One is from pilot pattern A and the other from pilot pattern B.
   3. The CIRs in all the subcarriers are the product of Wiener filter and the CIRs in the pilot subcarriers.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. P. Hoeher, S. Kaiser, and P. Robertson. "Two-Dimensional Pilot-Symbol-Aided Channel Estimation by Wiener Filtering". Proc. IEEE ICASSP '97, Munich, Germany, pp. 1845-1848, Apr. 1997.

WMAN_M_UL_MIMO_DemuxFrame (802.16e OFDMA UL MIMO Frame Demuxer)



Description: Uplink frame demultiplexer for STC and MIMO
Library: WMAN 16e, MIMO Receiver

Parameters

Name	Description	Default	Unit	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24		int	[3,1212]
NumberOfBurst	Number of Bursts	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}		int array	[1,6868]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 1		enum	
Bandwidth	Bandwidth	10 MHz	Hz	int	(0,1e9]
CyclicPrefix	Cyclic prefix	0.25		real	[0,1]
IdleInterval	Idle Interval	10 usec	sec	real	[0,1000]
FrameDuration	Frame duration (ms): time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Frame mode	0.5		real	[0,01,0.99]
FrameStartSym	Start symbol number of frame	0		int	[0,1212]
FrameStopSym	Stop symbol number of frame	0		int	[0,1212]
WindowLength	The length for the window in unit of chips (without oversampling)	16		int	[0,96]

Pin Inputs

Pin	Name	Description	Signal Type
1	Index	synchronization index of each burst	int
2	DeltaF	carrier frequency offset	real
3	UL_Subframe	received frame signals	multiple complex

Pin Outputs

Pin	Name	Description	Signal Type
4	UL_Bursts	output of uplink data symbol	multiple complex
5	Frame	output of Frame	multiple complex

Notes/Equations

1. This model is used to demultiplex uplink frame into data symbol which is used for synchronization. Idle interval, cyclic prefix and zero padding are removed, and time and carrier frequency offsets are compensated before demultiplexing.
2. Each firing,
   - $Samples_{Frame}$ tokens are consumed at pin input,

where $Samples_{Frame}$ is the total sample of one uplink frame including zero paddings and calculated as follows:

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

where $Samples_{idle}$ is the samples of Idle Interval and calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

Fs is the sampling frequency decided by Bandwidth, OversamplingOption and related sampling factor (!wman_m-07-17-268.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in the following table.

Sampling Factor Requirement

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

- 1 token is consumed at pin index which indicates the value of synchronization index.
- 1 token is consumed at pin DeltaF which indicates the value of carrier frequency offset.
- $Samples_{FFTSize} \times N_{DataSymbol}$ tokens are produced at pin UL_Bursts, where $N_{DataSymbol}$ is the number of OFDMA symbols of all the uplink bursts in the zone. $N_{DataSymbol}$ is decided by ZoneNumOfSym.

$$N_{DataSymbol} = ZoneNumOfSym$$

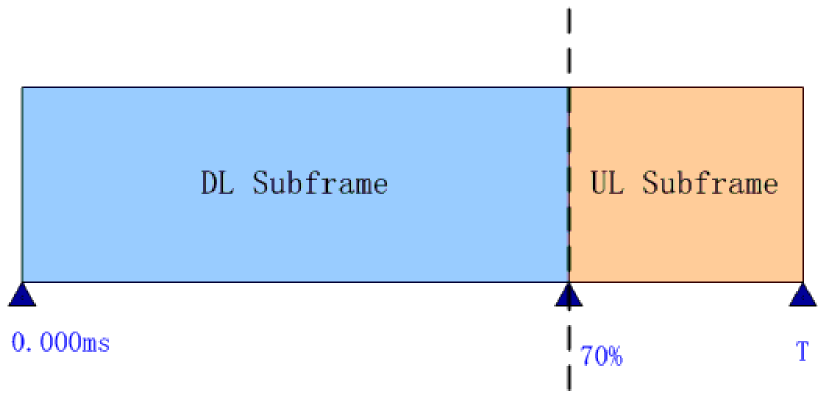
- When FrameStartSym=0 and FrameStopSym=0
$Samples_{FFTSize} \times (1 + CP) \times N_{FrameSymbol}$ tokens are produced at pin Frame, where $N_{FrameSymbol}$ is the number of OFDMA symbols of the entire uplink frame excluding zero padding and idle interval.
$N_{FrameSymbol}$ is decided by ZoneNumOfSym as follows.

$$N_{FrameSymbol} = ZoneNumOfSym$$

When FrameStartSym < FrameStopSym
$Samples_{FFTSize} \times (1 + CP) \times (FrameStopSym - FrameStartSym)$
tokens are produced at pin frame.
Time and carrier frequency offsets are not compensated to the output sequences.

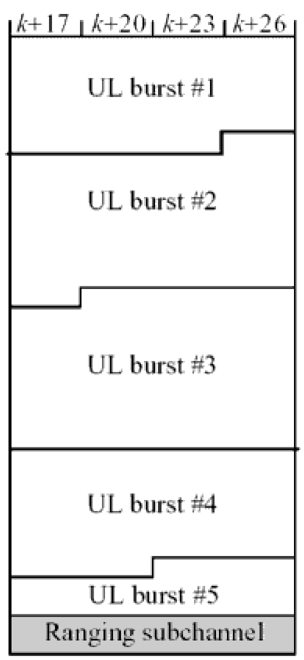
3. Frame structure:
The following figure shows the frame format in TDD mode which allocates 70% frame time for the downlink subframe filled will zeros. If FrameMode is set to FDD, 100% frame time will be used for the uplink subframe and the parameter DL_Ratio will be noneffective.

802.16e OFDMA Frame Structure for TDD Mode



The following figure shows the uplink subframe format, which includes: one or multiple uplink bursts each transmitted with different burst profile.

WMAN 16e OFDMA UL Subframe Structure



4. Output pin delay adjustment
   Because of the transmission delay, a detected frame usually falls into 2 consecutive received blocks, so the buffer length for input Pin is $2 \times Samples_{Frame}$. The start point of the detected frame is determined by the input signal at pin index. Only after receiving the second input block, this model can output one actual frame. So this model causes one frame delay.
5. The DeltaF pin inputs the estimated frequency offset (!wman_m-07-17-282.gif!) of each received frame.The ith estimated frequency offset (!wman_m-07-17-283.gif!) compensates for the phase in the current frame only. Assume $x_0, x_1, \ldots, x_{Samples_{Frame}-1}$ sequences are the input signals from the input pin, $y_0, y_1, \ldots, y_{Samples_{Frame}-1}$ are the sequences, whose phase caused by frequency offset, are removed, then:

$$y_k = x_k \times e^{-j2\pi\Delta f_i k T_{Step}}$$

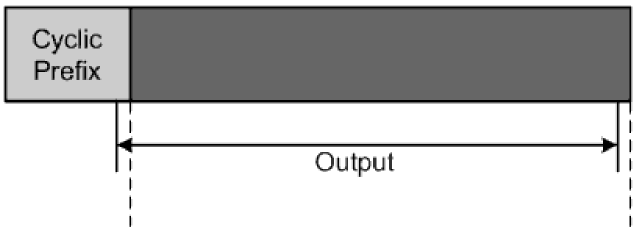
where Δf_i is frequency offset of the i-th received frame which is the input at pin DeltaF,

$T_{Step} = \dfrac{1}{F_s \times 2^{OversamplingOption}}$ is the sample time interval in the system.

After making frequency offset compensation, the preamble, FCH , UL_MAP and data will be extracted and output at pin preamble, FCH , UL_MAP and data respectively. The total frame sequences discarding idle and zero paddings are output at pin frame without time and frequency offset compensation. The output sequences from pin frame can be used to calculate CCDF.

Pin Index inputs the start point of a detected uplink frame (including Idle). The output data sequences extracted from the OFDMA symbols begin from the CP, i.e. $Samples_{FFT} \times CyclicPrefix$. The cyclic prefix removal process is shown in the following figure.

Cyclic Prefix Removal



To decrease the influence caused by WMAN_M_SymWindow, an offset is used to extract the data sequences of one OFDM symbol. The Offset is calculated as follows:

if $WindowLength > 1.75 \times CyclicPrefix$

then $Offset = CyclicPrefix$

else then $Offset = (WindowLength)/2 + (CyclicPrefix)/8$

the output sequences is

if $k > Samples_{FFT} - Offset \times OversamplingOption$

then $z_k = y_{k + Index_f + Samples_{FFT} \times CyclicPrefix - Samples_{FFT}}$

else $z_k = y_{k + Index + Samples_{FFT} \times CyclicPrefix}, k = 0, ..., Samples_{Frame} - 1$

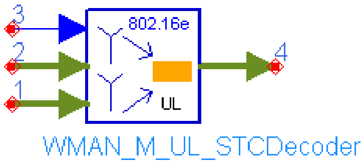
where $k = 0, ..., Samples_{Frame} - 1$

$z_0, z_1, ..., z_{Samples_{FFT} \times N_{FrameSymbol} - 1}$ sequences include data payload.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE P802.16-2004/Cor1/D3, Corrigendum to IEEE Standard for Local and Metropolitan Area Networks - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, May 2005.
3. IEEE P802.16e/D8, Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, May 2005.
4. IEEE P802.16-2004/Cor1/D5, Corrigendum to IEEE Standard for Local and Metropolitan Area Networks - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, September 2005.

WMAN_M_UL_STCDecoder (802.16e OFDMA UL STC Decoder)



Description: Upink STC decoder
Library: WMAN 16e, MIMO Receiver

Parameters

Name	Description	Default	Type
NumOfTxAnt	Number of antenna: Ant1, Ant2, Ant4	Ant1	enum
STC_Matrix	STC matrix: Matrix_A, Matrix_B, Matrix_C	Matrix_A	enum
DecoderType	decoding type for Spatial Multiplexing: ZF, MMSE	ZF	enum
ZoneType	Zone type: UL_PUSC, UL_OPUSC	UL_PUSC	enum
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512, FFT_128	FFT_2048	enum

Pin Inputs

Pin	Name	Description	Signal Type
1	STC_Symbol	input of STC-enabled symbols	complex matrix
2	STC_CIR	input of STC CIR	complex matrix
3	SNR	Signal noise ratio per receiver antenna in dB	real

Pin Outputs

Pin	Name	Description	Signal Type
4	OFDM_Symbol	output of OFDM symbols	complex matrix

Notes/Equations

1. This model is used to do UL STC/MIMO decoder.
2. Each firing,
   When in STC mode (NumOfTxAnt=Ant2, STC_Encoder=Yes, STC_Matrix=Matrix_A)
   $3 \times UsedCarriers$ tokens are consumed at pin STC_Symbol;
   $3 \times UsedCarriers$ tokens are consumed at pin STC_CIR;
   1 token is consumed at pin SNR;
   $3 \times UsedCarriers$ tokens are produced at pin OFDM_Symbol.
   When in MIMO mode (NumOfTxAnt=Ant2, STC_Encoder=Yes, STC_Matrix=Matrix_B)
   $UsedCarriers$ tokens are consumed at pin STC_Symbol;
   $UsedCarriers$ tokens are consumed at pin STC_CIR;
   1 token is consumed at pin SNR;
   $UsedCarriers$ tokens are produced at pin OFDM_Symbol.
   UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in the following table.

   The Calculation of UsedCarriers

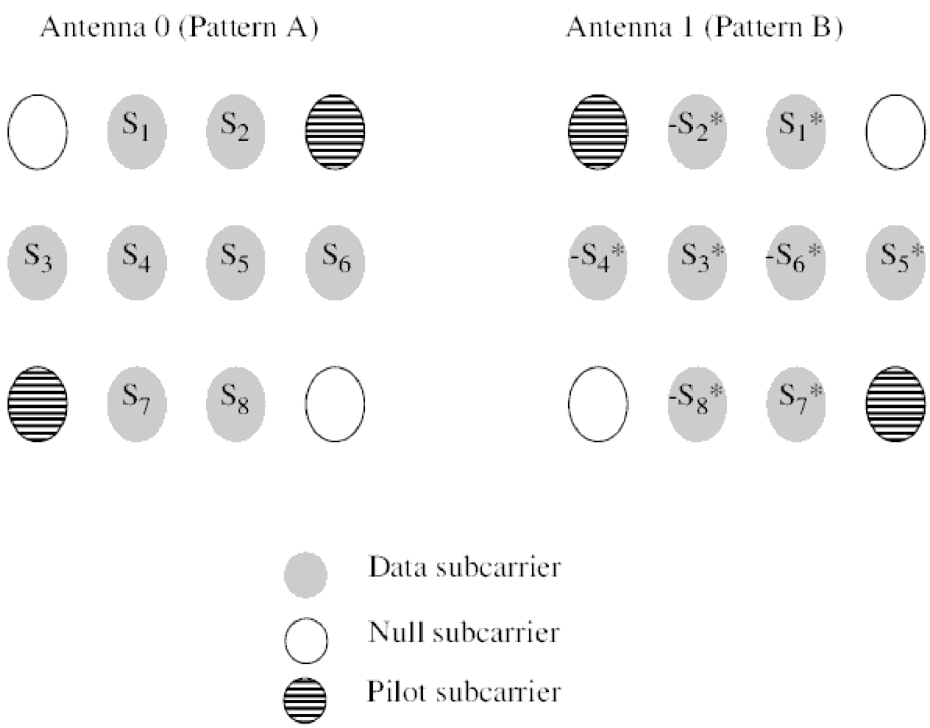
Zone type	FFT size	UsedCarriers
UL_PUSC	2048	1680
UL_PUSC	1024	840
UL_PUSC	512	408
UL_OPUSC	2048	1728
UL_OPUSC	1024	864
UL_OPUSC	512	432

3. Only UL PUSC is supported in this model.
4. Two operation modes are supported in this model: STC 2x1 and MIMO 2x2.
   1. STC 2x1 (NumOfTxAnt=Ant2, STC_Encoder=Yes, STC_Matrix=Matrix_A)
      The dimension of the complex matrix at pin Coef is 2x1. The complex matrix H is

$$\begin{bmatrix} H_{11} \\ H_{21} \end{bmatrix}$$

      where H_{ij} is the CIR from the ith transmit antenna to the jth receiver antenna.

      Mapping of Data Subcarriers in STTD Mode



      In UL STTD mode, the CIRs in ajacent channel are almost the same. H_{11} means CIR of the 1st transmiter antenna to the receiver antenna and H_{21} means CIR of the 2st transmiter antenna to the receiver antenna. The received signal can be expressed as

$$S_1H_{11} - S*_2H_{21} = R_1$$
$$S_2H_{11} + S*_1H_{21} = R_2$$

      We can get the original signal as following

$$S_1 = \frac{R_1H*_{11} + R*_2H_{21}}{H*_{11}H_{11} + H*_{21}H_{21}}$$

$$S_2 = \frac{R_2H*_{11} + R*_1H_{21}}{H*_{11}H_{11} + H*_{21}H_{21}}$$

   2. MIMO 2x2 (NumOfTxAnt=Ant2, STC_Encoder=Yes, STC_Matrix=Matrix_B)
      The dimension of complex matrix at pin Coef is 2x2. The complex matrix is

$$\begin{bmatrix} H_{11} & H_{21} \\ H_{12} & H_{22} \end{bmatrix}$$

The Zero Forcing Algorithm

$$S_{est} = (H^*H)^{-1}H^*R$$

The Minimum Mean Square Error Algorithm

$$S_{est} = (\alpha I + H^*H)^{-1}H^*R$$

H is channel matrix , R is received signal and α is SNR per antenna.

References

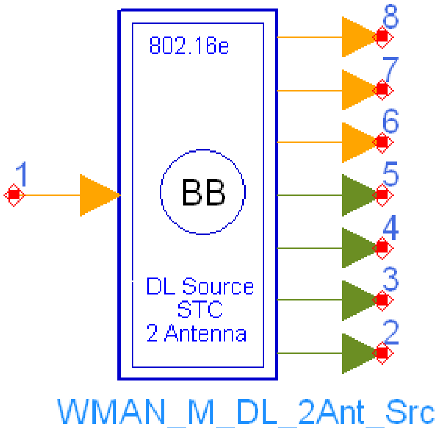
1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE P802.16e/D8, Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, May 2005.
3. IEEE P802.16-2004/Cor1/D5, Corrigendum to IEEE Standard for Local and Metropolitan Area Networks - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, September 2005.
4. P. Hoeher, S. Kaiser, and P. Robertson. "Two-Dimensional Pilot-Symbol-Aided Channel Estimation by Wiener Filtering". Proc. IEEE ICASSP '97, Munich, Germany, pp. 1845-1848, Apr. 1997.

802.16e OFDMA MIMO Source Components

The 16e MIMO signal source models provide models to generate downlink and uplink signal sources.

- *WMAN M DL 2Ant Src (802.16e OFDMA Downlink Signal Source with 2 Antennas)* (wman_m)
- *WMAN M DL 2Ant Src RF (802.16e OFDMA DL 2 Antennas Source RF)* (wman_m)
- *WMAN M DL MuxOFDMSym M (802.16e OFDMA Downlink Mux OFDM symbols in Matrix)* (wman_m)
- *WMAN M DL STCEncoder (802.16e OFDMA Downlink STC Encoder)* (wman_m)
- *WMAN M MidambleGen (802.16e OFDMA Midamble)* (wman_m)
- *WMAN M UL 2Ant Src (802.16e OFDMA Uplink 2 Antenna Source)* (wman_m)
- *WMAN M UL 2Ant Src RF (802.16e OFDMA UL 2 Antenna RF Src)* (wman_m)
- *WMAN M UL Ant1 Co Src (802.16e OFDMA Uplink Signal Source)* (wman_m)
- *WMAN M UL Ant1 Co Src RF (802.16e OFDMA Uplink RF Source)* (wman_m)
- *WMAN M UL MuxOFDMSym M (802.16e OFDMA Uplink Mux OFDM symbols in Matrix)* (wman_m)
- *WMAN M UL STCEncoder (802.16e OFDMA Uplink STC Encoder)* (wman_m)

WMAN_M_DL_2Ant_Src (802.16e OFDMA Downlink Signal Source with 2 Antennas)



Description: Downlink baseband signal source with 2 antenna
Library: WMAN 16e, MIMO Source

Parameters

Name	Description	Default	Unit	Type	
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[(
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[
PreambleIndex	Preamble index	3		int	[
FrameNumber	Frame number	0		int	[
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
DL_PermBase	DL PermBase	9		int	[
DCD_Count	DCD count	1		int	[
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00, 0X00, 0X01}		int	[
PRBS_ID	PRBS ID	0		int	[
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	YES		enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array	[
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	20		int	[
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array	[
NumberOfBurst	Number of Bursts	2		int	[
BurstWithFEC	The number of burst with FEC	1		int	[
BurstSymOffset	Symbol offset of each burst	{4,10}		int array	[

BurstSubchOffset	Subchannel offset of each burst	{5,1}		int array	[
BurstNumOfSym	Number of symbols of each burst	{6,10}		int array	[
BurstNumOfSubch	Number of subchannels of each burst	{15,18}		int array	[
DataLength	MAC PDU payload byte length of each burst	{200,300}		int array	[
CodingType	Coding type of each burst	{0,0}		int array	[
Rate_ID	Rate ID of each burst	{5,5}		int array	[
RepetitionCoding	Repetition coding of each burst	{0,0}		int array	[
PowerBoosting	Power boosting of each burst in dB	{0,0}		real array	[
MidamblePresent	MIMO midamble present or not: NO, YES	NO		enum	
MidambleBoosting	MIMO midamble boosting in dB	0		real	[
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A		enum	
DLMAP_Enable	DLMAP is inserted or not: NO, YES	NO		enum	
Compressed_DLMap	Compressed DL_MAP or not if enabled: NO, YES	NO		enum	
DLMAP_CodingType	Coding type of DLMAP	0		int	[
DLMAP_RepetitionCoding	Repetition coding of DLMAP	0		int	[
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
Compressed_ULMap	Compressed UL_MAP or not if appended: NO, YES	NO		enum	
ULMAP_CodingType	Coding type of ULMAP	0		int	[
ULMAP_Rate_ID	Rate ID of ULMAP	0		int	[
ULMAP_RepetitionCoding	Repetition coding of UL_MAP	0		int	[
ULMAP_PowerBoosting	Power boosting of UL_MAP	0		real	[
UL_ZoneType	UL zone type: UL_PUSC, UL_OPUSC	UL_PUSC		enum	
UL_ZoneSymOffset	Symbol offset in UL zone	0		int	[
UL_ZoneNumOfSym	Number of OFDMA symbols in the UL subframe	24		int	[
UL_PermBase	Uplink permutation base	0		int	[
UL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum	
UCD_Count	UCD count	1		int	[
UL_NumberOfBurst	Number of Bursts in uplink	1		int	[
UL_CID	Uplink CID	{1}		int array	[
UL_CodingType	Uplink coding type of each burst	{0}		int array	[
UL_Rate_ID	Uplink rate ID	{0}		int array	[
UL_BurstAssignedSlot	Assigned slots of each burst in uplink	{96}		int array	[
UL_RepetitionCoding	Repetition coding of each burst in uplink	{0}		int array	[
UL_HARQ_ACK_Enable	HARQ ACK channel enabled or not: NO, YES	NO		enum	
UL_HARQ_ACK_Allocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 12, 3, 6}		int array	[
UL_RangingEnable	Ranging channel enabled or not: NO, YES	NO		enum	
UL_RangingAllocation	Rectangular allocation: (SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 0, 3, 6}		int array	[
UL_RangingMethod	Ranging mode: Initial/Handover_2 symbols, Initial/Handover_4 symbols, BW Request/Periodic_1 symbol, BW Request/Periodic_3 symbol	Initial/Handover_2 symbols		enum	
UL_FastFeedBackEnable	Fast feedback channel enabled or not: NO, YES	NO		enum	
UL_FastFeedBackAllocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 6, 3, 6}		int array	[
UL_CQICH_Enable	CQICH channel enabled or not: NO, YES	NO		enum	
UL_CQICH_ID	CQICH ID, set to fixed 6 bits	0		int	[
UL_CQICH_AllocationOffset	CQICH channel allocation offset	0		int	[

UL_CQICH_Period	CQICH channel period	0		int	[
UL_CQICH_FrameOffset	CQICH channel frame offset	0		int	[
UL_CQICH_Duration	CQICH channel duration	0		int	[
UL_CQICH_FeedbackType	CQICH channel feedback type: physical CINR feedback, effective CINR feedback	physical CINR feedback		enum	
UL_CQICH_CINR_Type	CQICH channel CINR preamble report type: Frequency reuse factor = 1 config, Frequency reuse factor = 3 config	Frequency reuse factor = 1 config		enum	
UL_CQICH_AvgParamIncluded	CQICH channel average parameter included for physical CINR feedback: NO, YES	NO		enum	
UL_CQICH_AvgParam	CQICH channel average parameter for physical CINR feedback	0		int	[
UL_CQICH_MIMO_FeedbackCycle	CQICH channel MIMO permutation feedback cycle	0		int	[
UL_MIMO_Enable	MIMO enabled IE or not in uplink zone: NO, YES	NO		enum	
UL_Collaborative_SM_Indicator	Uplink collaborative SM indicator: non collaborative SM, collaborative SM	non collaborative SM		enum	
UL_MIMO_Control	Uplink MIMO mode, effective when collaborative_SM_Indicator = non: STTD, SM	STTD		enum	
UL_CID_B	Uplink CID that shall use pilot pattern B	{1}		int array	[
UL_CodingType_B	Uplink coding type of each burst that shall use pilot pattern B	{0}		int array	[
UL_Rate_ID_B	Uplink rate ID that shall use pilot pattern B	{0}		int array	[
DL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum	
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupied, Burst power with allocated subchs): Peak power, Burst power when all subchs occupied, Burst power with allocated subchs	Burst power when all subchs occupied		enum	
DIUC_RateID	Mapping from DIUC (0-12) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}, {1,3}, {1,4}, {1,5		int array	[
UIUC_RateID	Mapping from UIUC (1-10) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2		int array	[
DedicatedPilot	Is the dedicated pilot mode employed for DL STC AMC zone: NO, YES	NO		enum	
CDD_Enable	Whether CDD is applied on preamble and the first PUSC zone: NO, YES	NO		enum	
CDD_NumTaps	The number of delay taps that are used on one each physical antenna, valid only when CDD_Enable=YES	1		int	[
CDD_PowerRatio	The ratio of the power on first tap relative to the power on the second tap in dB, valid only when CDD_Enable=YES and CDD_NumTaps=2	0		real	(
CDD_Tap1Delay	The delay in samples in the first tap for the two physical antennas, valid only when CDD_Enable=YES	{0, 16}		int array	[
CDD_Tap2Delay	The delay in samples in the second tap for the two physical antennas, valid only when CDD_Enable=YES and CDD_NumTaps=2	{16, 32}		int array	[
CDD_Tap2Phase	The phase in degrees in the second tap for the two physical antennas, valid only when CDD_Enable=YES and CDD_NumTaps=2	{0, 90}		real array	[

Pin Inputs

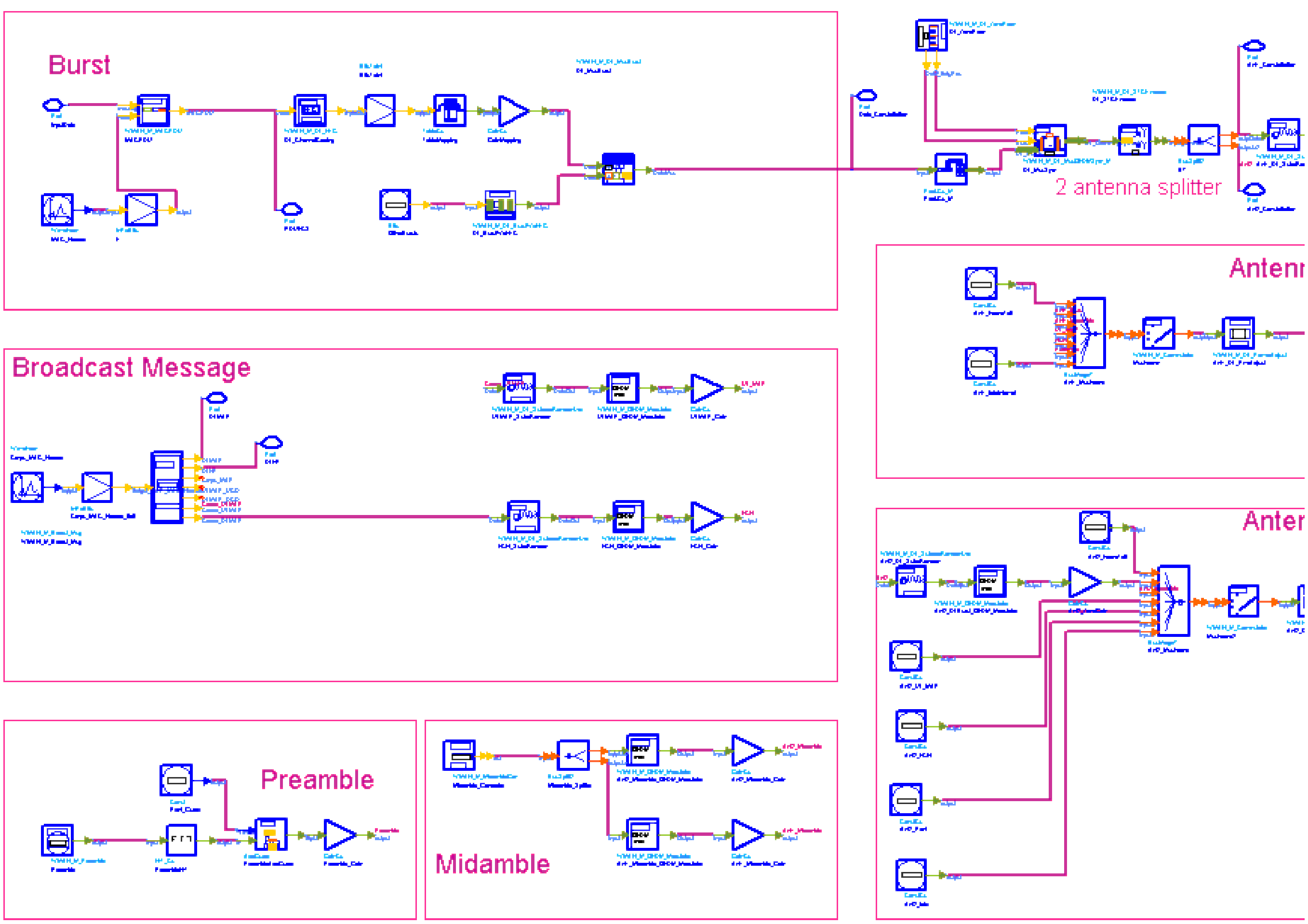
Pin	Name	Description	Signal Type
1	InputData	input of raw data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	Ant1_Data	antenna 1 downlink subframe	complex
3	Ant2_Data	antenna 2 downlink subframe	complex
4	Ant1_Constellation	output of modulated data in antenna 1	complex
5	Ant2_Constellation	output of modulated data in antenna 2	complex
6	Data_Constellation	output of modulated data before mapping to antennas	complex
7	PDUFCS	output of MAC PDU data of burst with FEC	int
8	DLFP	output of DLFP data	int
9	DLMAP	output of DLMAP data	int

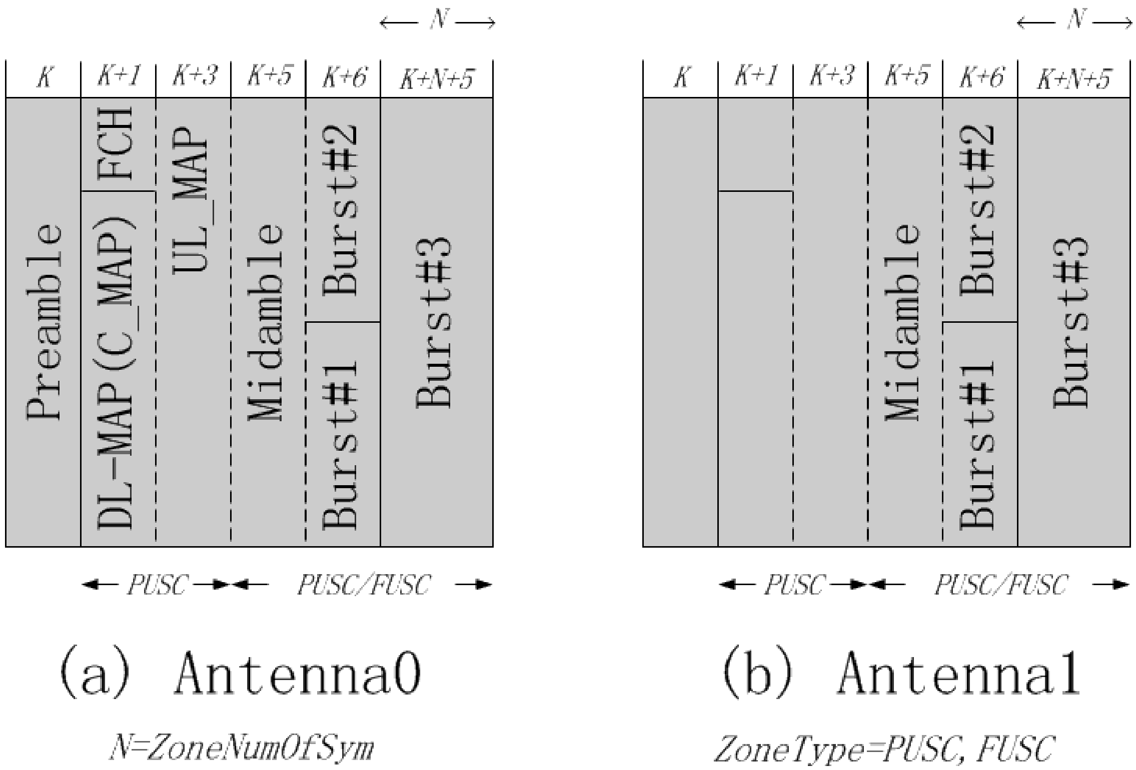
Notes/Equations:

1. This subnetwork is to implement 802.16e OFDMA STC downlink baseband source with 2 antennas. The schematic for this subnetwork is shown in the following figure.



WMAN_M_DL_2Ant_Src Schematic

2. WMAN_M_DL_2Ant_Src is implemented according to the specification. The following figure shows the STC downlink frame format.



802.16e OFDMA STC downlink subframe structure

> **Note**
> The figure above shows the STC downlink frame structure when CDD_Enable = NO in which the regular zone (Preamble, FCH/MAP zone) transmits only on the first antenna. When CDD_Enable = YES, the regular zone (Preamble, FCH/MAP zone) transmits on both two antennas with cyclic delay diversity (CDD). Refer to *Cyclic delay diversity* (wman_m) for more information.

The downlink subframe starts with one preamble. Then the PUSC zone where FCH, DL-MAP and UL-MAP are allocated. The FCH information will be sent on the first four adjacent subchannels with successive logical subchannel numbers in the PUSC zone. The DL-MAP message (or compressed map message)immediately follows FCH. The UL-MAP message is always allocated on the third and fourth OFDM symbols if *ULMAP_Enable* is set to YES and *Compressed_ULMap* is set to No.
The first 3 symbols (premable, FCH and DL-MAP) or 5 symbols (preamble, FCH and DL-MAP, UL-MAP)should be just transmitted on Antenna 0 and Antenna 1 just transmits 3 or 5 NULL symbols. Then, both Antenna 0 and 1 begins to transmit midamble in 1 symbol when *MidamblePresent* is set to YES, and then transmit information bits in number of bursts. As the standard defined, a compressed UL-MAP is appended to the current compressed DL-MAP data structure. The map message format and parameter settings are listed in the following table.

Broadcast Message Format

DLMAP_Enable	Compressed_DLMap	ULMAP_Enable	Compressed_ULMap	MAP Msg Format	Occupied slots
No	No	No	No	None	0
No	No	No	Yes	None	0
No	No	Yes	No	Normal UL-MAP	27
No	No	Yes	Yes	Error	0
No	Yes	No	No	None	0
No	Yes	No	Yes	None	0
No	Yes	Yes	No	Normal UL-MAP	27
No	Yes	Yes	Yes	Error	0
Yes	No	No	No	Normal DL-MAP	26
Yes	No	No	Yes	Normal DL-MAP	26
Yes	No	Yes	No	Normal DL-MAP+ Normal UL-MAP	DL:26 UL:27
Yes	No	Yes	Yes	Error	DL:26 UL:0
Yes	Yes	No	No	Cmps DL-MAP	12
Yes	Yes	No	Yes	Cmps DL-MAP	12
Yes	Yes	Yes	No	Cmps DL-MAP+ Normal UL-MAP	DL:12 UL:27
Yes	Yes	Yes	Yes	Cmps MAP (including Cmps DL-MAP+ Cmps UL-MAP)	24

If ZoneType is DL_PUSC, then two PUSC zones are defined. If ZoneType is DL_FUSC or DL_AMC, then two zones are defined: one is the PUSC zone where FCH is allocated, the other is the FUSC or AMC zone for allocating data bursts. ZoneNumOfSym is defined as the number of OFDM symbols for the zone which is allocated data bursts. One downlink frame contains maximum 8 data bursts except FCH and DL-MAP, and each burst contains only one MAC PDU. Among these bursts, only one FEC-encoded burst is supported which is randomized, CC/CTC coded and interleaved. Other bursts will be provided PN sequences as their coded source respectively.
For DL_PUSC, the total number of symbols in the downlink subframe is (1+2+UL_MAP_Pst*2+MidamblePresent*1+ZoneNumOfSym); For DL_FUSC or DL_AMC, the total number of symbols in the downlink subframe is (1+2+UL_MAP_Pst*2+MidamblePresent*1+ZoneNumOfSym), where the first 1 is for the preamble, the first 2 is for the FCH and DL-MAP, the second 2 is for normal UL-MAP, the second 1 is for midamble; UL_MAP_Pst equals to 1 when ULMAP_Enalbe is set to YES and Compressed_ULMap is set to No, otherwise, UL_MAP_Pst equals to 0.

> **Note**
> For DL AMC permutation in STC zone, ADS Mobile WiMAX library follows P802.16Rev2/D5 (June 2008). Refer to *Downlink AMC in STC zone* (wman_m) for the pilot pattern and data mapping in AMC STC zone.

The FEC-encoded burst is coded in the following manner:

Add MAC header with parameter MAC_Header or generate MAC header automatically by WMAN_M_MACPDU.

Randomized by WMAN_M_DL_Randomizer.

If the coding type is CC, then CC encoded, punctured and interleaved by WMAN_M_DL_FEC; If the coding type is CTC, then CTC encoded by WMAN_M_DL_FEC.

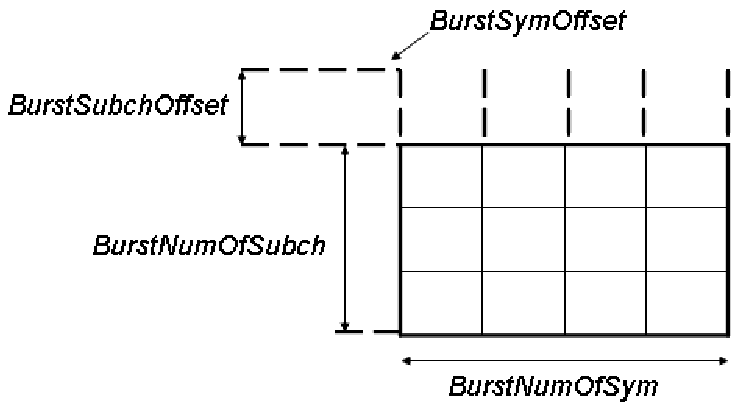
Repeated by WMAN_M_DL_Repetition in WMAN_M_DL_FEC.

After encoding, the encoded burst is mapped to the constellation. Other bursts without FEC, are provided PN sequence as their coded bits and mapped to the constellation according to their Rate_ID by WMAN_M_DL_BurstWoFEC. The FEC-encoded burst is concatenated with non-coded bursts by WMAN_M_DL_MuxBurst. Then MIMO encoder are implemented by PackCx_M.
The physical indices of data subcarriers and pilot subcarriers for each burst are calculated by WMAN_M_DL_ZonePerm. The data sequences and pilot sequences are placed to their physical subcarrier location by WMAN_M_DL_MuxOFDMSym_M. The STC encoder are implemented by WMAN_M_DL_STCEncoder. Then data sequences are split into two parts for antenna one and antenna two. For each antenna, the useful subcarriers are randomized by WMAN_M_DL_SubcarrRandomizer, after IFFT and cyclic prefix insertion, the idle interval and downlink payloads (Bursts, FCH & DL-MAP) are combined with zero padding bits if needed by

WMAN_M_Commutator. In addition, uplink position will be preserved and filled with zeros after downlink payload if FrameMode is TDD. Then power adjustment are implemented by WMAN_M_DL_PowerAdjust. At last, WMAN_M_SymWindow is employed to smooth out the transition from one OFDMA symbol to the next symbol.

Parameter Details

- Bandwidth determines the nominal channel bandwidth.
- OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
- FFTSize specifies the size of FFT. Sizes 2048, 1024 and 512 are supported.
- CyclicPrefix specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
- FrameMode specifies the duplexing method which should be FDD or TDD. In FDD transmission, the downlink occupies the entire frame and the respective gaps (zeros) are automatically adjusted to fill the frame
- DL_Ratio specifies the percentage (1 to 99) of the frame time to be used for the downlink subframe. The parameter is only active when the FrameMode is TDD.
- FrameDuration determines the frame durations (ms) of the generated waveform.There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
- IdleInterval specifies the time of idle interval between the two continuous frames. the default value is 0.
- PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to the standard.
- FrameNumber specifies the starting frame number in the downlink subframe.
- FrameIncreased specifies whether the frame number for the downlink subframe is increased. When FrameIncreased is set to YES, then the frame numbers in Frame#0, Frame#1, Frame#2, Frame#3 will be FrameNumber, FrameNumber+1, FrameNumber+2, FrameNumber+3. When FrameIncreased is set to NO, then the frame numbers in Frame#0, Frame#1, Frame#2, Frame#3 will be FrameNumber, FrameNumber, FrameNumber, FrameNumber.
- DL_PermBase specifies the basis of downlink permutation to be used in initialization vector of the PRBS generator for subchannel randomization in the zone and in STC_DL_Zone_IE() in DL-MAP message.
- DCD_Count specifies the DCD count which is used in DL-MAP and DCD messages. This is increased by one (modulo 256) whenever there is a downlink configuration change.
- BSID specifies the base station ID which is used in DL-MAP message.
- PRBS_ID specifies the PRBS ID which may be used in initialization vector of the PRBS generator for subchannel randomization and in STC_DL_Zone_IE() in DL-MAP message.
- AutoMACHeaderSetting specifies whether the MAC header is automatically generated or input by users. If it is set to NO, data sequences in parameter MAC_Header will be used before data content, otherwise MAC_Header content will be calculated with parameter DataLength and CID and be used before data content.
- MAC_Header specifies 6 bytes of MAC header before the data contents. The cell is only active when the AutoMACHeaderSetting is set to NO.
- CRC32_Mode specifies the method for CRC32 calculation appended to MAC PDU. For consistency with 802.16-2004 Cor1/D5, it shall be set to MSB first while shall be set to LSB first for consistency with 802.16-2004 Cor1/D3.
- ZoneType specifies the zone type which can be set to PUSC, FUSC or AMC.
- ZoneNumOfSym specifies the symbol number for the zone. The value must be a multiple of two for DL_PUSC, and be a multiple of one for DL_FUSC and DL_OFUSC.
- GroupBitmask specifies which groups of subchannel are used in the PUSC zone. This parameter uses 1 for assigned groups and 0 for unassigned groups.
- NumberOfBurst specifies the number of active downlink bursts.
- BurstWithFEC specifies the downlink burst FEC.
- BurstSymOffset, BurstSubchOffset, BurstNumOfSym and BurstNumOfSubch specify the position and range for each rectangular burst, seen in the following figure. BurstSymOffset is calculated from the first symbol of the zone; that is, BurstSymOffset for the first symbol in the zone is 0.



Downlink rectangular burst structure

- DataLength specifies MAC PDU payload byte length for each burst.
- CodingType specifies the coding type for each burst. Each coding type can be selected from 0 to 1, whose meaning is shown in the following table.

The meaning of coding type

Coding type	meaning
0	Convolutional coding (CC)
1	Convolutional turbo coding (CTC)

- Rate_ID specifies the Rate ID for each burst. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in the following table.

The relation of Coding type and Rate ID

Coding type	Rate ID	Modulation and Coding rate
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in the following table.

The meaning of repetition coding

Repetition coding	meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4 used on the burst
3	Repetition coding of 6 used on the burst

- PowerBoosting specifies the power boosting for each burst. Each value is defined in units of dB.
- MidamblePresent specifies whether the midamble is inserted or not.
- MidambleBoosting specifies the power boosting for midamble. This parameter is defined in units of dB.
- STC_Matrix specifies the transmission format for 2 antenna signal source.
- DLMAP_Enable specifies whether the DL-MAP burst is inserted in the downlink subframe.
- Compressed_DLMap specifies the message format of the DL-MAP.
- DLMAP_CodingType specifies the rate ID for the burst carrying DL-MAP and DCD messages.
- DLMAP_RepetitionCoding specifies the repetition coding for the burst carrying DL-MAP and DCD messages. This parameter can be selected from 0 to 3, whose meaning is shown in the preceding table, The meaning of repetition coding.
- ULMAP_Enable specifies whether the UL-MAP burst is inserted in the downlink subframe.
- Compressed_ULMap specifies the message format of the UL-MAP.
- ULMAP_CodingType specifies the rate ID for the burst carrying UL-MAP and UCD messages.
- ULMAP_Rate_ID specifies the rate ID for the burst carrying UL-MAP and UCD messages.
- ULMAP_RepetitionCoding specifies the repetition coding for the burst carrying UL-MAP and UCD messages. This parameter can be selected from 0 to 3, whose meaning is shown in the preceding table, The meaning of repetition coding.
- ULMAP_PowerBoosting specifies the power boosting for the burst carrying UL-MAP and UCD messages. This parameter is defined in units of dB.
- UL_ZoneType specifies the uplink zone permutation. This parameter is used in the UL_Zone_IE () IE.
- UL_ZoneSymOffset specifies the offset of the OFDMA symbol in which the uplink zone starts, the offset value is defined in units of OFDMA symbols and is relevant to the Allocation Start Time field given in the UL-MAP message. This parameter is used in the UL_Zone_IE() IE.
- UL_ZoneNumOfSym specifies the number of OFDM symbols in the uplink subframe. This parameter is used in the OFDMA UL_MAP IE.
- UL_PermBase specifies the basis of uplink permutation. This parameter is used in the UL_Zone_IE() IE.
- UL_AllSCIndicator specifies whether all subchannel shall be used. When the UL_AllSCIndicator is set to 0, subchannels indicated by allocated subchannel bitmap in UCD shall be used. Otherwise all subchannels shall be used. This parameter is used in the UL_Zone_IE() IE.
- UCD_Count specifies the UCD count which is used in the UL_MAP and UCD messages. It is increased by one (modulo 256) whenever there is an uplink configuration change.
- UL_NumberOfBurst specifies the number of the uplink bursts. This parameter is used to determine the number of OFDMA UL-MAP IE in UL-MAP message.
- UL_CID specifies the Connection Identifier (CID) for each uplink burst. This parameter is used in the OFDMA UL-MAP IE.
- UL_CodingType specifies the coding type for each uplink burst. Each coding type can be selected from 0 to 1, where 0 is CC and 1 is CTC. This parameter is used in the OFDMA UL-MAP IE.
- UL_Rate_ID specifies the rate ID for each uplink burst. UL_Rate_ID, along with UL_CodingType, determines the modulation, coding rate. This parameter is used in the OFDMA UL-MAP IE.
- UL_BurstAssignedSlot specifies the duration for each uplink burst in units of OFDMA slots. This parameter is used in the OFDMA UL-MAP IE.
- UL_RepetitionCoding specifies the repetition coding for each uplink burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in the preceding table, The meaning of repetition coding. This parameter is used in the OFDMA UL-MAP IE.
- UL_HARQ_ACK_Enable specifies whether the UL HARQ_ACK allocation IE is inserted in the UL_MAP IE.
- UL_HARQ_ACK_Allocation specifies the rectangular allocation:(symbol offset, subchannel offset,number of symbols, number of subchannels) for the uplink HARQ ACK channel.
- UL_RangingEnable specifies whether the ranging allocation information is inserted in the UL_MAP IE.
- UL_RangingAllocation specifies the rectangular allocation:(symbol offset, subchannel offset,number of symbols, number of subchannels) for the uplink ranging channel.
- UL_RangingMethod specifies uplink ranging mode.
- UL_FastFeedBackEnable specifies whether the FAST-FEEDBACK allocation IE is inserted in the UL_MAP IE.
- UL_FastFeedBackAllocation specifies the rectangular allocation:(symbol offset, subchannel offset,number of symbols, number of subchannels) for the uplink fast feedback channel.
- UL_CQICH_Enable specifies whether the CQICH alloc IE is inserted in the UL_MAP IE.
- UL_CQICH_ID specifies the value of `CQICH_ID' inserted in CQICH alloc IE.
- UL_CQICH_AllocationOffset specifies the value of `Allocation offset' inserted in CQICH alloc IE.
- UL_CQICH_Period specifies the value of `Period' inserted in CQICH alloc IE.

- UL_CQICH_FrameOffset specifies the value of `Frame offset' inserted in CQICH alloc IE.
- UL_CQICH_Duration specifies the value of `Duration' inserted in CQICH alloc IE.
- UL_CQICH_FeedbackType specifies the value of `Feedback Type' inserted in CQICH alloc IE.
- UL_CQICH_CINR_Type specifies the value of `CINR preamble report type' inserted in CQICH alloc IE.
- UL_CQICH_AvgParamIncluded specifies the value of `Averaging parameter included' inserted in CQICH alloc IE.
- UL_CQICH_AvgParam specifies the value of `Averaging parameter' inserted in CQICH alloc IE.
- UL_CQICH_MIMO_FeedbackCycle specifies the value of `MIMO_permutation_feedback_cycle' inserted in CQICH alloc IE.
- UL_MIMO_Enable specifies whether the MIMO UL basic IE is inserted in the UL_MAP IE. If this parameter is set to Yes, the UL HARQ_ACK allocation IE, the ranging allocation information, the FAST-FEEDBACK allocation IE and the CQICH alloc IE won't inserted in the UL_MAP IE in spite of the corresponding Enable is set to Yes.
- UL_Collaborative_SM_Indicator specifies the value of `Collaborative_SM_Indicator' inserted in MIMO UL basic IE.
- UL_MIMO_Control specifies the value of `MIMO_Control' inserted in MIMO UL basic IE.
- UL_CID_B specifies the value of `CID_B' inserted in MIMO UL basic IE.
- UL_CodingType_B and UL_Rate_ID_B specifies the value of `UIUC_B' inserted in MIMO UL basic IE.
- DL_AllSCIndicator specifies whether all subchannels shall be used. When the DL_AllSCIndicator is set to 0, subchannels are indicated by the allocated subchannel bitmap in GroupBitmask. Otherwise, all subchannels shall be used and the parameter GroupBitmask will be useless. This parameter is used in the STC_DL_Zone_IE() IE. This parameter is only supported in downlink two antenna signal source.
- PowerType specifies the exact meaning of the parameter Power in RF source. Three types are defined in downlink (Type I: Peak power; Type II: Burst power when all subchs occupied; Type III: Burst power with allocated subchs). Type I is recommended for transmitter measurement; Type II is recommended for receiver measurement; Type III is recommended for hardware measurement. For more information, please refer to *Transmit Power Definition* (wman_m).
- DIUC_RateID specifies the mapping from DIUC (0-12) to coding type and modulation/rate. The default value is { {0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}, {1,3}, {1,4}, {1,5} }. The first element (i.e. array {0,0}) is mapped to DIUC 0, and the second (i.e. array {0,1}) is mapped to DIUC 1, and so on. Each element represents {coding type, modulation and rate (Rate ID)}. For example, {1,2} means coding type is CTC (here 0: CC, 1:CTC) and Rate ID is 2 (16QAM rate 1/2). This parameter is used in DCD and DL-MAP IE. Note that if the coding type and modulation/rate for an allocated downlink burst is not mapped to a DIUC in this parameter, the DIUC field in DL-MAP IE will be filled with 0.
- UIUC_RateID specifies the mapping from UIUC (1-10) to coding type and modulation/rate. The default value is { {0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2} }. The first element (i.e. array {0,0}) is mapped to UIUC 1, and the second (i.e. array {0,1}) is mapped to UIUC 2, and so on. Each element represents {coding type, modulation and rate (Rate ID)}. For example, {1,2} means coding type is CTC (here 0: CC, 1:CTC) and Rate ID is 2 (16QAM rate 1/2). This parameter is used in UCD and UL-MAP IE. Note that if the coding type and modulation/rate for an allocated uplink burst is not mapped to a UIUC in this parameter, the UIUC field in UL-MAP IE will be filled with 0.
- DedicatedPilot specifies whether the pilots are dedicated for DL STC AMC zone. When DedicatedPilot = NO, all the pilots are transmitted; when DedicatedPilot = YES, only the pilots bleonging to the bursts allocated are transmitted. Note that this parameter is valid only when ZoneType = DL_AMC.
- CDD_Enable specifies whether the CDD (cyclic delay diversity) is applied on the Preamble, FCH PUSC zone. When CDD is applied in the source, the frame (timing) synchronization in the receiver will introduce some mismatch. Refer to *CDD effects on STC/MIMO receiver* (wman_m).
- CDD_NumTaps defines the number of delay taps used on each transmit antenna. CDD_NumTaps can be 1 or 2. This parameter is valid when CDD_Enable = YES.
- CDD_PowerRatio specifies the ratio of the power on first tap relative to the power on the second tap in dB while the total power on the two taps is fixed to 1. This parameter is valid when CDD_Enable = YES and CDD_NumTaps = 2.
- CDD_Tap1Delay specifies the delay in samples on each transmit antenna (the delay on the first antenna is fixed to 0). This parameter is valid when CDD_Enable = YES.
- CDD_Tap2Delay specifies the delay in samples on each transmit antenna. This parameter is valid when CDD_Enable = YES and CDD_NumTaps = 2.
- CDD_Tap2Phase specifies the phase in degrees on each transmit antenna. This parameter is valid when CDD_Enable = YES and CDD_NumTaps = 2.

3. Samples per frame
The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-08-02-005.gif!) as follows,
$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$
The sampling factors are listed in the following table.

sampling factor requirement

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval($Samples_{idle}$) is calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

So, the total samples of one downlink frame $Samples_{Frame}$ is

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

This model works frame by frame. Each firing, $8 \times DataLength[BurstWithFEC]$ tokens are consumed at pin InputData,
$Samples_{Frame}$ tokens are produced at pin Ant1_Data and pin Ant2_Data,
$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times STCRate \times 48/N_{SymPerSlot}$ tokens are produced at pin Data_Constellation,
$ZoneNumOfSym \times N_{usedCarriers}$ tokens are produced at pin Ant1_Constellation and Ant2_Constellation.
$8 \times DataLength[BurstWithFEC]] + 80$ tokens are produced at pin PDUFCS,
where $N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC.
$N_{usedCarriers}$ is decided by FFTSize and ZoneType and listed in the following table.

Used carriers and FFTSize

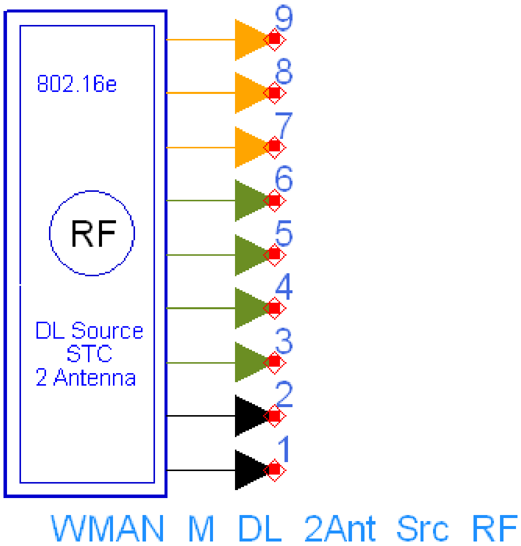
ZoneType	FFTSize	$N_{UsedCarriers}$
PUSC	2048	1680
PUSC	1024	840
PUSC	512	420
FUSC	2048	1702
FUSC	1024	850
FUSC	512	426

4. Output delay
No delay is introduced by WMAN_M_SymWindow in the design WMAN_M_DL_2Ant_Src.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. P802.16 Rev2/D5, June, 2008.

WMAN_M_DL_2Ant_Src_RF (802.16e OFDMA DL 2 Antennas Source RF)



Description: Downlink RF signal source with 2 antennas
Library: WMAN 16e, MIMO Source

Parameters

Name	Description	Default	Unit	Type
ROut	Source resistance	DefaultROut	Ohm	int
RTemp	TEMPERATURE	DefaultRTemp	Celsius	real
FCarrier	Carrier frequency	3407 MHz	Hz	real
Ant1Power	Transmit power at Ant1 (the meaning of Power is defined in Parameter PowerType)	0.01 W	W	real
Ant1GainImbalance	Gain imbalance in dB Q channel relative to I channel at transmit antenna 1	0.0		real
Ant1PhaseImbalance	Phase imbalance in dB Q channel relative to I channel at transmit antenna 1	0.0		real
Ant2Power	Transmit power at Ant2 (the meaning of Power is defined in Parameter PowerType)	0.01 W	W	real
Ant2GainImbalance	Gain imbalance in dB Q channel relative to I channel at transmit antenna 2	0.0		real
Ant2PhaseImbalance	Phase imbalance in dB Q channel relative to I channel at transmit antenna 2	0.0		real
Bandwidth	Nominal bandwidth	10 MHz	Hz	int
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum
CyclicPrefix	Cyclic prefix	0.125		real
FrameMode	Frame mode: FDD, TDD	TDD		enum
DL_Ratio	Downlink ratio	0.5		real
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum
PreambleIndex	Preamble index	3		int
FrameNumber	Frame number	0		int
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum
DL_PermBase	DL PermBase	9		int
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00,		int

		0X00, 0X01}		
PRBS_ID	PRBS ID	0		int
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	YES		enum
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_AMC	DL_PUSC		enum
ZoneNumOfSym	Number of OFDM symbols in zone	20		int
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array
NumberOfBurst	Number of Bursts	2		int
BurstWithFEC	The number of burst with FEC	1		int
BurstSymOffset	Symbol offset of each burst	{4,10}		int array
BurstSubchOffset	Subchannel offset of each burst	{5,1}		int array
BurstNumOfSym	Number of symbols of each burst	{6,10}		int array
BurstNumOfSubch	Number of subchannels of each burst	{15,18}		int array
DataLength	MAC PDU payload byte length of each burst	{200,300}		int array
CodingType	Coding type of each burst	{0,0}		int array
Rate_ID	Rate ID of each burst	{5,5}		int array
RepetitionCoding	Repetition coding of each burst	{0,0}		int array
PowerBoosting	Power boosting of each burst in dB	{0,0}		real array
MidamblePresent	MIMO midamble present or not: NO, YES	NO		enum
MidambleBoosting	MIMO midamble boosting in dB	0		real
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A		enum
DLMAP_Enable	DLMAP is inserted or not: NO, YES	NO		enum
DataPattern	WMAN Data Pattern: PN9, PN15, FIX4, _4_1_4_0, _8_1_8_0, _16_1_16_0, _32_1_32_0, _64_1_64_0, S_QPSK, S_16-QAM, S_64-QAM	PN9		enum
Compressed_DLMap	Compressed DL_MAP or not if enabled: NO, YES	NO		enum
DLMAP_CodingType	Coding type of DLMAP	0		int
DLMAP_RepetitionCoding	Repetition coding of DLMAP	0		int
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum
Compressed_ULMap	Compressed UL_MAP or not if appended: NO, YES	NO		enum
ULMAP_CodingType	Coding type of ULMAP	0		int
ULMAP_Rate_ID	Rate ID of ULMAP	0		int
ULMAP_RepetitionCoding	Repetition coding of UL_MAP	0		int
ULMAP_PowerBoosting	Power boosting of UL_MAP	0		real
UL_ZoneType	UL zone type: UL_PUSC, UL_OPUSC	UL_PUSC		enum
UL_ZoneSymOffset	Symbol offset in UL zone	0		int
UL_ZoneNumOfSym	Number of OFDMA symbols in the UL subframe	24		int
UL_PermBase	Uplink permutation base	0		int
UL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum
UCD_Count	UCD count	1		int
UL_NumberOfBurst	Number of Bursts in uplink	1		int
UL_CID	Uplink CID	{1}		int array
UL_CodingType	Uplink coding type of each burst	{0}		int array
UL_Rate_ID	Uplink rate ID	{0}		int array
UL_BurstAssignedSlot	Assigned slots of each burst in uplink	{96}		int

				array
UL_RepetitionCoding	Repetition coding of each burst in uplink	{0}		int array
UL_HARQ_ACK_Enable	HARQ ACK channel enabled or not: NO, YES	NO		enum
UL_HARQ_ACK_Allocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 12, 3, 6}		int array
UL_RangingEnable	Ranging channel enabled or not: NO, YES	NO		enum
UL_RangingAllocation	Rectangular allocation: (SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 0, 3, 6}		int array
UL_RangingMethod	Ranging mode: Initial/Handover_2 symbols, Initial/Handover_4 symbols, BW Request/Periodic_1 symbol, BW Request/Periodic_3 symbol	Initial/Handover_2 symbols		enum
UL_FastFeedBackEnable	Fast feedback channel enabled or not: NO, YES	NO		enum
UL_FastFeedBackAllocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 6, 3, 6}		int array
UL_CQICH_Enable	CQICH channel enabled or not: NO, YES	NO		enum
UL_CQICH_ID	CQICH ID, set to fixed 6 bits	0		int
UL_CQICH_AllocationOffset	CQICH channel allocation offset	0		int
UL_CQICH_Period	CQICH channel period	0		int
UL_CQICH_FrameOffset	CQICH channel frame offset	0		int
UL_CQICH_Duration	CQICH channel duration	0		int
UL_CQICH_FeedbackType	CQICH channel feedback type: physical CINR feedback, effective CINR feedback	physical CINR feedback		enum
UL_CQICH_CINR_Type	CQICH channel CINR preamble report type: Frequency reuse factor = 1 config, Frequency reuse factor = 3 config	Frequency reuse factor = 1 config		enum
UL_CQICH_AvgParamIncluded	CQICH channel average parameter included for physical CINR feedback: NO, YES	NO		enum
UL_CQICH_AvgParam	CQICH channel average parameter for physical CINR feedback	0		int
UL_CQICH_MIMO_FeedbackCycle	CQICH channel MIMO permutation feedback cycle	0		int
UL_MIMO_Enable	MIMO enabled IE or not in uplink zone: NO, YES	NO		enum
UL_Collaborative_SM_Indicator	Uplink collaborative SM indicator: non collaborative SM, collaborative SM	non collaborative SM		enum
UL_MIMO_Control	Uplink MIMO mode, effective when collaborative_SM_Indicator = non: STTD, SM	STTD		enum
UL_CID_B	Uplink CID that shall use pilot pattern B	{1}		int array
UL_CodingType_B	Uplink coding type of each burst that shall use pilot pattern B	{0}		int array
UL_Rate_ID_B	Uplink rate ID that shall use pilot pattern B	{0}		int array
DL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupied, Burst power with allocated subchs): Peak power, Burst power when all subchs occupied, Burst power with allocated subchs	Burst power when all subchs occupied		enum
DIUC_RateID	Mapping from DIUC (0-12) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}, {1,3}, {1,4}, {1,5		int array
UIUC_RateID	Mapping from UIUC (1-10) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2		int array
DedicatedPilot	Is the dedicated pilot mode employed for DL STC AMC zone: NO, YES	NO		enum
CDD_Enable	Whether CDD is applied on preamble and the first PUSC zone: NO, YES	NO		enum
CDD_NumTaps	The number of delay taps that are used on one each physical antenna, valid only when CDD_Enable=YES	1		int
CDD_PowerRatio	The ratio of the power on first tap relative to the power on the second tap in dB, valid only when CDD_Enable=YES and CDD_NumTaps=2	0		real
CDD_Tap1Delay	The delay in samples in the first tap for the two physical antennas, valid only when CDD_Enable=YES	{0, 16}		int array

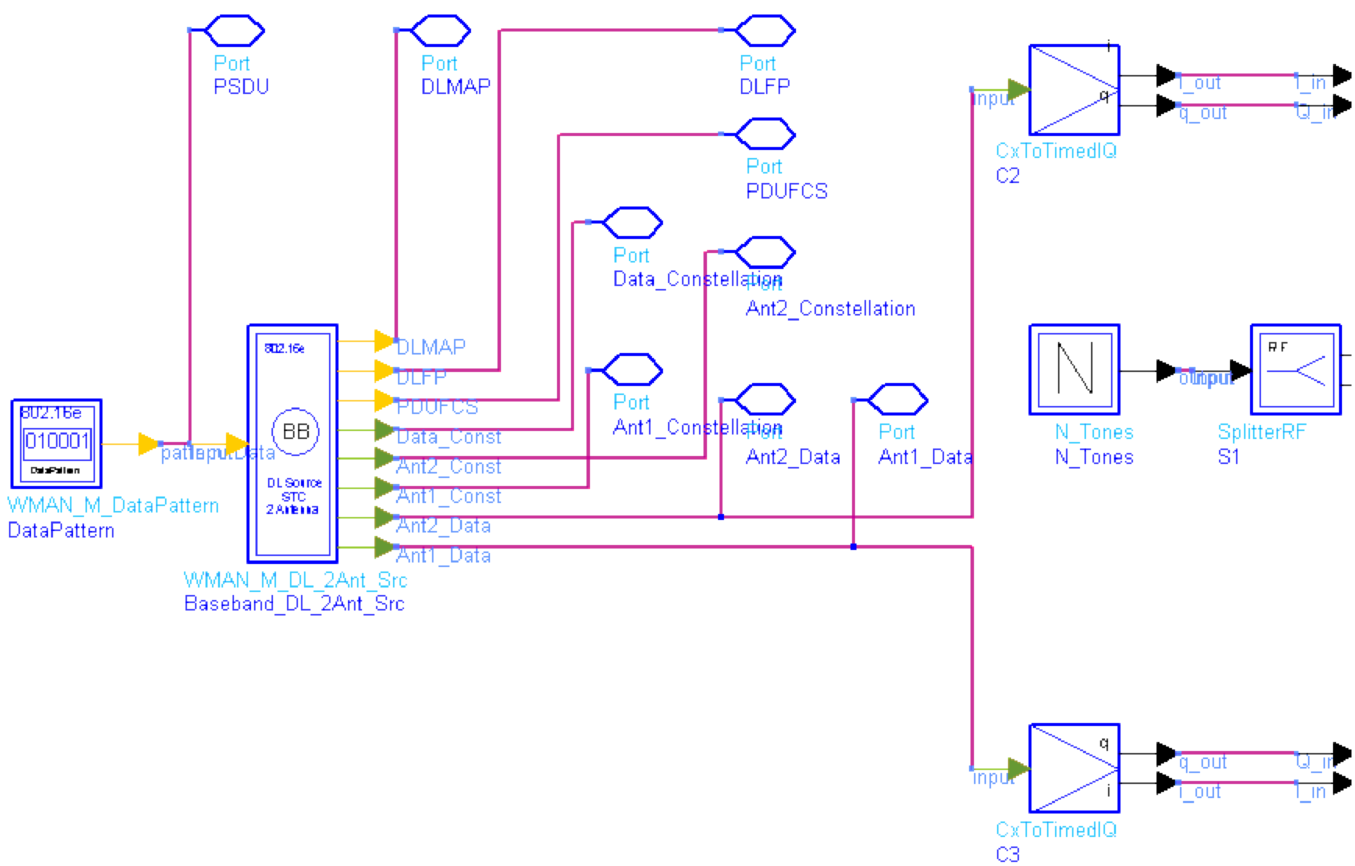
CDD_Tap2Delay	The delay in samples in the second tap for the two physical antennas, valid only when CDD_Enable=YES and CDD_NumTaps=2	{16, 32}		int array
CDD_Tap2Phase	The phase in degrees in the second tap for the two physical antennas, valid only when CDD_Enable=YES and CDD_NumTaps=2	{0, 90}		real array

Pin Outputs

Pin	Name	Description	Signal Type
1	RF_Signal1	antenna 1 RF signal	timed
2	RF_Signal2	antenna 2 RF signal	timed
3	Ant1_Data	antenna 1 downlink subframe	complex
4	Ant2_Data	antenna 2 downlink subframe	complex
5	Ant1_Constellation	output of modulated data in antenna 1	complex
6	Ant2_Constellation	output of modulated data in antenna 2	complex
7	Data_Constellation	output of modulated data before mapping to antennas	complex
8	PDUFCS	output of MAC PDU data of burst with FEC	int
9	DLFP	output of DLFP data	int
10	DLMAP	output of DLMAP data	int
11	PSDU	output of MAC PDU data	int

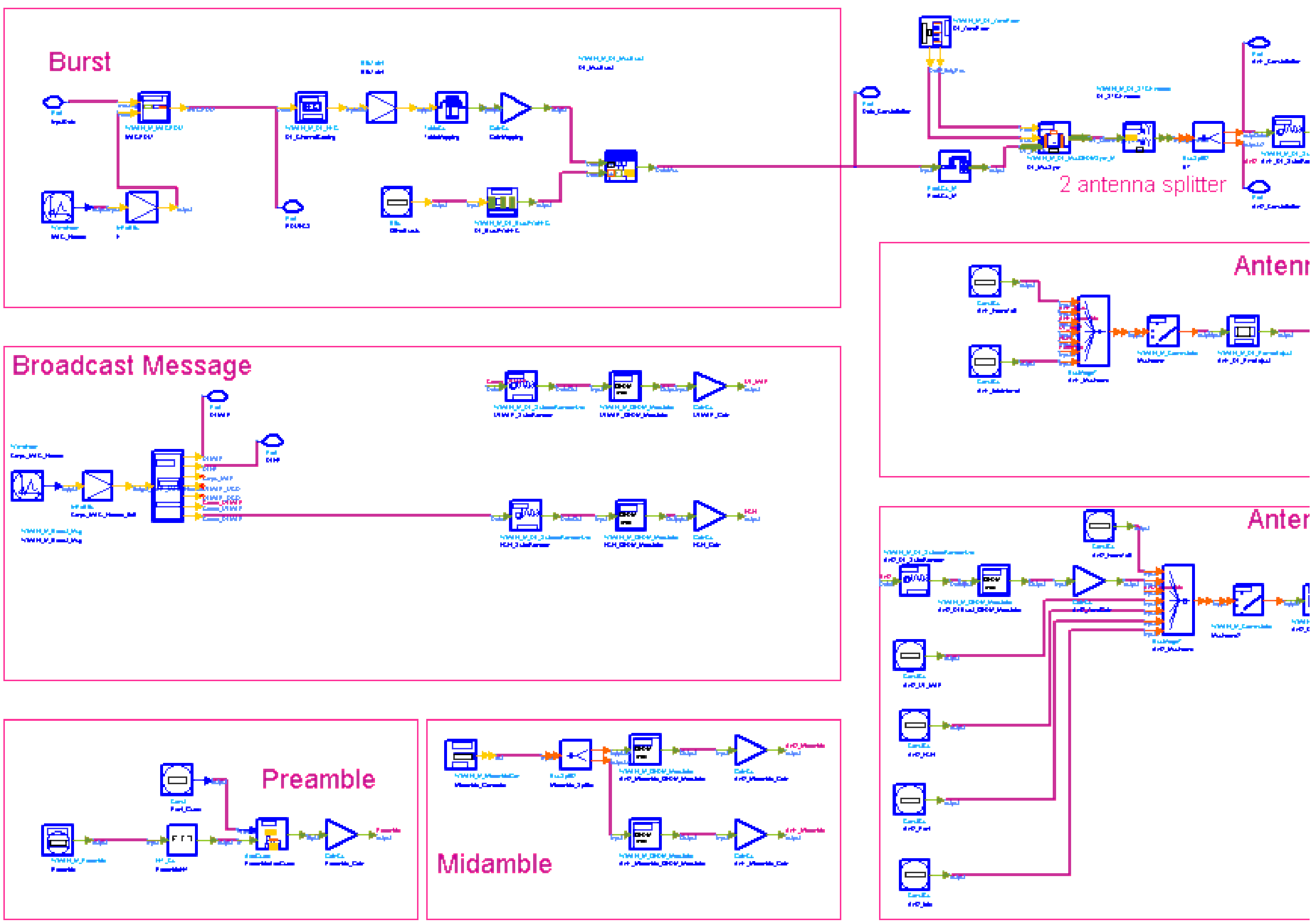
Notes/Equations

1. This subnetwork generates RF signal for 802.16e OFDMA Downlink subsystem with 2 antennas. The subnetwork includes WMAN_M_DL_2Ant_Src, WMAN_M_DataPattern, CxToTimedIQ, N_Tones and QAM_ModExtOsc. The schematic for this subnetwork is shown in the following figure.



WMAN_M_DL_2Ant_Src_RF Schematic

2. WMAN_M_DL_2Ant_Src is to implement 802.16e OFDMA STC downlink baseband source with 2 antennas. The schematic for this subnetwork is shown in the following figure. For more information, refer to *Downlink MIMO baseband source* (wman_m).



WMAN_M_DL_2Ant_Src Schematic

3. Parameter Details
    - ROut is the RF output resistance.
    - RTemp is the RF output resistance temperature in Celsius and sets the noise density in the RF output signal to (k(RTemp+273.15)) Watts/Hz, where k is Boltzmann's constant.
    - FCarrier is the RF output signal frequency.
    - Power is used to set the modulator output RF power. This is true for an ideal transmitted signal (no impairments added) or when small impairments are added. If large impairments are added to the signal (using GainImbalance, I_OriginOffset, and Q_OriginOffset parameters) the output RF power may be different from the value of the Power parameter.
    - MirrorSpectrum is used to mirror the RF_out signal spectrum about the carrier. This is equivalent to conjugating the complex RF envelope voltage. Depending on the configuration and number of mixers in an RF transmitter, the RF output signal from hardware RF generators can be inverted. If such an RF signal is desired, set this parameter to YES.
    - GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation are used to add certain impairments to the ideal output RF signal. Impairments are added in the order described here.
    The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given

$$V_{RF}(t) = A\left(V_I(t)\cos(\omega_c t) - gV_Q(t)\sin\left(\omega_c t + \frac{\Phi\pi}{180}\right)\right)$$

by:
where A is a scaling factor based on the Power and ROut parameters specified by the user, VI(t) is the in-phase RF envelope, VQ(t) is the quadrature phase RF envelope, g is the gain imbalance

$$g = 10^{\frac{GainImbalance}{20}}$$

and, !wman_m-08-03-024.gif!(in degrees) is the phase imbalance.
Next, the signal VRF(t) is rotated by IQ_Rotation degrees. The I_OriginOffset and Q_OriginOffset are then applied to the rotated signal. Note that the amounts specified are percentages with respect to the output rms voltage. The output rms voltage is given by sqrt(2×ROut×Power).

- For baseband parameters, refer to *Downlink MIMO baseband parameters* (wman_m).

4. Samples per frame
The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-08-03-026.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in the following table.

sampling factor requirement

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval($Samples_{idle}$) is calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

So, the total samples of one downlink frame $Samples_{Frame}$ is

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

This model works frame by frame. Each firing, $8 \times DataLength[BurstWithFEC]$ tokens are consumed at pin InputData,
$Samples_{Frame}$ tokens are produced at pin Ant1_Data and pin Ant2_Data,
$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times STCRate \times 48/N_{SymPerSlot}$ tokens are produced at pin Data_Constellation,
$ZoneNumOfSym \times N_{usedCarriers}$ tokens are produced at pin Ant1_Constellation and Ant2_Constellation.
$8 \times DataLength[BurstWithFEC]] + 80$ tokens are produced at pin PDUFCS, where $N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC.
$N_{usedCarriers}$ is decided by FFTSize and ZoneType and listed in the following table.

Used carriers and FFTSize

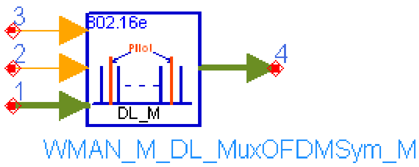
ZoneType	FFTSize	$N_{usedCarriers}$
PUSC	2048	1680
PUSC	1024	840
PUSC	512	420
FUSC	2048	1702
FUSC	1024	850
FUSC	512	426

5. Output delay
   No delay is introduced by WMAN_M_SymWindow in the design WMAN_M_DL_2Ant_Src_RF.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. P802.16 Rev2/D5, June, 2008.

WMAN_M_DL_MuxOFDMSym_M (802.16e OFDMA Downlink Mux OFDM symbols in Matrix)



Description: Downlink OFDM symbol multiplexer with Matrix
Library: WMAN 16e, MIMO Source

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbols in zone	24	int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}	int array	[0,1]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
NumberOfBurst	Number of Bursts	2	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}	int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,14}	int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}	int array	[1,60]
PowerBoosting	Power boosting of each burst in dB	{0,0}	real array	(-∞,∞)
PilotInserting	Pilot inserting or not: NO, YES	NO	enum	
PreambleIndex	Preamble index	4	int	[0,113]
DedicatedPilot	Is the dedicated pilot mode employed for DL PUSC or AMC zone: NO, YES	NO	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DL_Bursts	input of DL bursts	complex matrix
2	BurstPos	input of the position of bursts	int
3	PilotPos	input of the position of pilots	int

Pin Outputs

Pin	Name	Description	Signal Type
4	DL_OFDMSym	output of DL OFDM symbols	complex matrix

Notes/Equations

1. This model is used to multiplex the constellation-mapped data sequences and pilots into the physical subcarriers according to the zone permutation. The function of this model is the same as WMAN_M_DL_MuxOFDMSym except data sequences at pin DL_Bursts and pin DL_OFDMSym are both in matrix. The dimension and array architecture of the matrix at pin DL_Bursts and pin DL_OFDMSym are the same.
2. Each firing,
$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 / N_{SymPerSlot}$$
tokens are consumed at pin DL_Bursts in matrix.

$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 / N_{SymPerSlot}$$

tokens are consumed at pin BurstPos.

$(ZoneNumOfSym)/N_{SymPerSlot} \times NumOfPilotSubcarrier$

tokens are consumed at pin PilotPos.

$(ZoneNumOfSym) \times UsedCarriers$

tokens are produced at pin DL_OFDMSym in matrix.

where, $N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC. NumOfPilotSubcarrier is dependent on the zone type and FFT size according to the specification, shown in the following table.

The Calculation of NumOfPilotSubcarrier

Zone type	FFT size	NumOfPilotSubcarrier
DL_PUSC	2048	8*60
DL_PUSC	1024	8*30
DL_PUSC	512	8*15
DL_FUSC	2048	166
DL_FUSC	1024	82
DL_FUSC	512	42
DL_OFUSC	2048	192
DL_OFUSC	1024	96
DL_OFUSC	512	48

UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in the following table.

The calculation of UsedCarriers

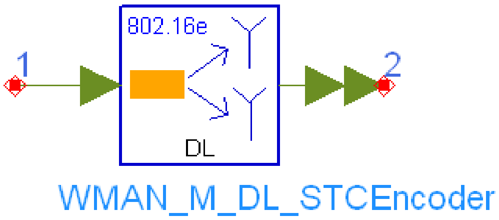
Zone type	FFT size	UsedCarriers
DL_PUSC	2048	1680
DL_PUSC	1024	840
DL_PUSC	512	420
DL_FUSC	2048	1702
DL_FUSC	1024	850
DL_FUSC	512	426
DL_OFUSC	2048	1728
DL_OFUSC	1024	864
DL_OFUSC	512	432

3. The i-th constellation-mapped point from pin DL_Bursts is mapped onto the position (indexed by [SymbolIndex, SubcarrierIndex]) which is defined by the i-th value from pin BurstPos. BurstPos is the index of symbol and subcarrier for the constellation-mapped data in each burst. The 11 least significant bits of BurstPos is defined as the index of subcarrier, and the 21 most significant bits of BurstPos is defined as the index of symbol.
4. If PilotInserting is set to YES, the constant gain (4.0/3) is mapped onto the positions (indexed by [SymbolIndex, SubcarrierIndex]) which is defined by the values from pin PilotPos. PilotPos is the index of symbol and subcarrier for the pilots. The 11 least significant bits of PilotPos is defined as the index of subcarrier, and the 21 most significant bits of PilotPos is defined as the index of symbol.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_STCEncoder (802.16e OFDMA Downlink STC Encoder)



Description: Downlink STC encoder
Library: WMAN 16e, MIMO Source

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_2048	enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
ZoneNumOfSym	Number of symbols of the zone	16	int	[1,1212]
NumOfAnt	Number of transmitting antennas: Ant1, Ant2, Ant4	Ant1	enum	
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B, Matrix_C	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	OFDM_Symbol	input of OFDM symbols	complex matrix

Pin Outputs

Pin	Name	Description	Signal Type
2	STC_Symbol	output of STC-enabled symbols	multiple complex

Notes/Equations

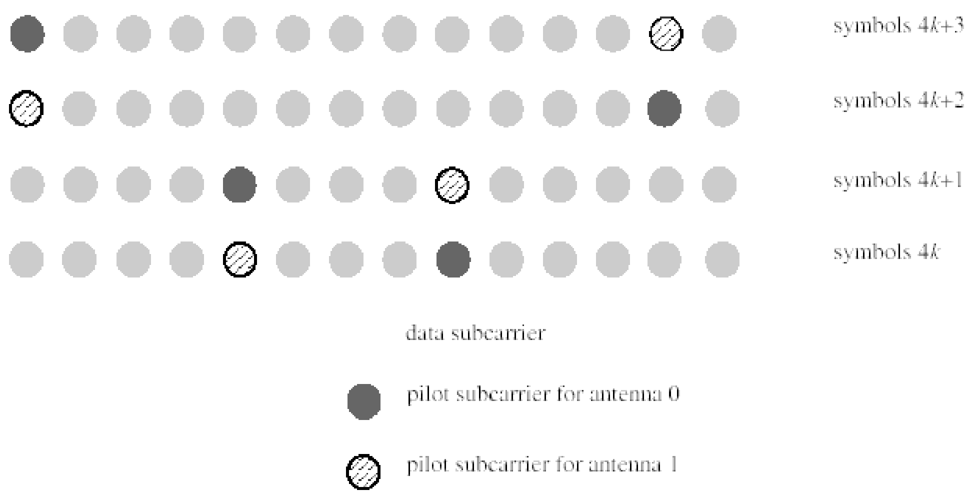
1. This model is used to encode the downlink bursts with STC 2x1 and MIMO 2x2.
2. Each firing,
    1. when STC_Encoder is set to YES, $2 \times UsedCarriers$ tokens are consumed at pin OFDM_Symbol; $2 \times UsedCarriers$ tokens are produced at pin STC_Symbol.
    2. when STC_Encoder is set to NO, UsedCarriers tokens are consumed at pin OFDM_Symbol; UsedCarriers tokens are produced at pin STC_Symbol.
    UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in the following table.

    The Calculation of UsedCarriers

Zone type	FFT size	UsedCarriers
DL_PUSC	2048	1680
DL_PUSC	1024	840
DL_PUSC	512	420
DL_FUSC	2048	1702
DL_FUSC	1024	850
DL_FUSC	512	426
DL_OFUSC	2048	1728
DL_OFUSC	1024	864
DL_OFUSC	512	432

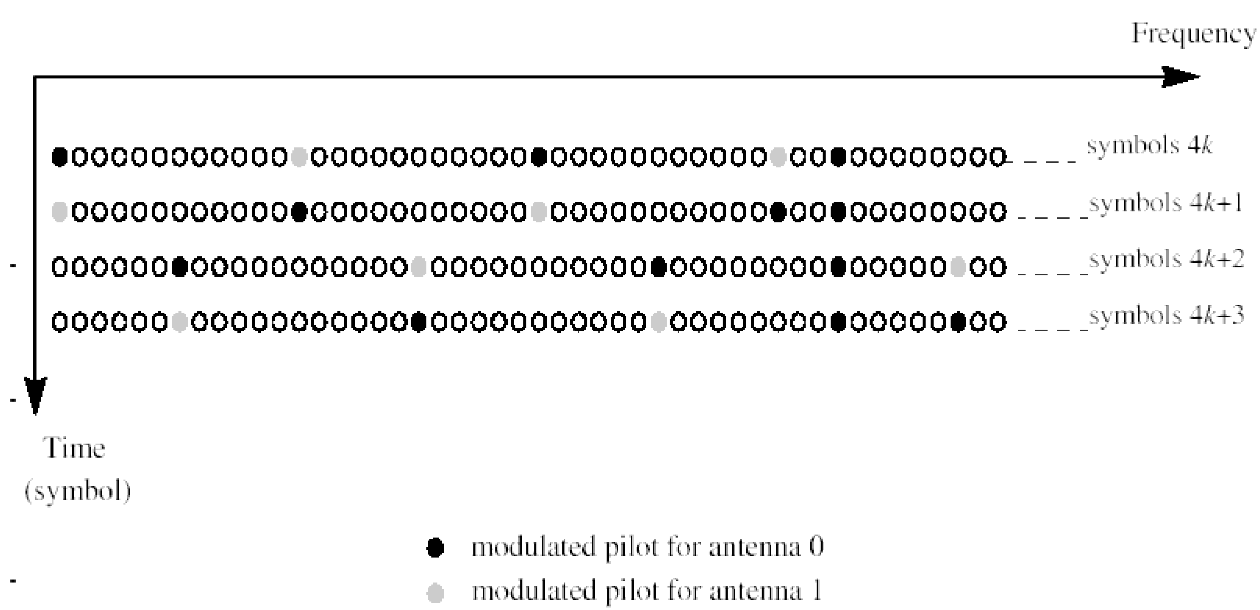
3. For DL PUSC, the STC encoder is performed on the cluster one by one. The cluster structure for STC PUSC using 2 antennas is shown in the following figure (taken from Figure 245 in 802.16e-2005). The pilot locations

change in period of 4 symbols. Symbols are counted from the beginning of the current zone. The first symbol in the zone is even. STC encoding is done on each pair of symbols 2n, 2n+1 (n = 0,1,..).



Cluster structure for STC PUSC using 2 Antennas

4. The structure for DL FUSC using 2 antennas is shown in the following figure (taken from Figure 247 in 802.16e-2005). The pilots within the symbols shall be divided between the antennas - antenna 0 uses VariableSet#0 and ConstantSet#0 for even symbols while antenna 1 uses VariableSet#1 and ConstantSet#1 for even symbols, antenna 0 uses VariableSet#1 and ConstantSet#0 for odd symbols while antenna 1 uses VariableSet#0 and ConstantSet#1 for odd symbols (symbol counting starts at the starting point of the relevant STC zone). In STC transmission, the FUSC_SymbolNumber in equation (110) (see 802.16e-2005) is replaced with floor(FUSC_SymbolNumber/2), so that variable pilots shall move every 2nd symbol. The transmission of the data shall be performed in pairs of symbols as illustrated in the following figure.



Structure for STC FUSC using 2 Antennas

5. Two operation modes are supported in this model: STC 2x1 and MIMO 2x2. DL PUSC and FUSC permutations are supported in both the modes.
   1. STC 2x1 (NumOfTxAnt=Ant2, STC_Encoder=Yes, STC_Matrix=Matrix_A)
      The dimension of the complex matrix at pin OFDM_Symbol is 1x1.
      The number of ports at pin STC_Symbol is 2. The first port at output pin is for antenna 0 and the second port is for antenna 1.
      In this mode, Alamouti algorithm is employed. STC rate 1 encoding shall be performed after constellation

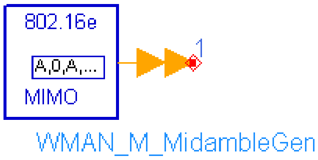
mapping and before subcarrier randomization. s1 and s2 represent two subcarriers at the same frequency in two consecutive OFDMA symbols (each OFDMA subcarrier is referred to as a channel use). The STC rate 1 coding is done on all data subcarriers that belong to an STC coded burst in the two OFDMA symbols.
Pilot subcarriers are not encoded and are transmitted from either antenna 0 or antenna 1. In STC mode with DL PUSC permutations, the power of pilot subcarriers shall be further scaled so that the total power transmitted by each antenna, is equal to the total power transmitted in non-STC mode, ignoring data boosting. Consequently the power of pilot subcarriers are boosted by 3dB if they are transmitted from either antenna 0 or antenna 1.

2. MIMO 2x2 (NumOfTxAnt=Ant2, STC_Encoder=Yes, STC_Matrix=Matrix_B)
   The dimension of the complex matrix at pin OFDM_Symbol is 2x1.
   The number of ports at pin STC_Symbol is 2. The first port at output pin is for antenna 0 and the second port is for antenna 1.
   The data symbols in the first row of complex matrix at the input pin OFDM_Symbol are mapped to antenna 0 and those in the second row are mapped to antenna 1. The data mapping to antennas is same as that in non-STC mode except pilots.
   The transmission of pilot subcarriers is the same as that in STC 2x1 mode.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_MidambleGen (802.16e OFDMA Midamble)



Description: MIMO Midamble generator
Library: WMAN 16e, MIMO Source

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
PreambleIndex	Preamble index	0	int	[0,113]
NumOfAnt	Number of Antenna: Ant2, Ant3, Ant4	Ant2	enum	
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}	int array	[0,1]
MidambleBoosting	MIMO midamble boosting in dB	0	real	(-∞,∞)

Pin Outputs

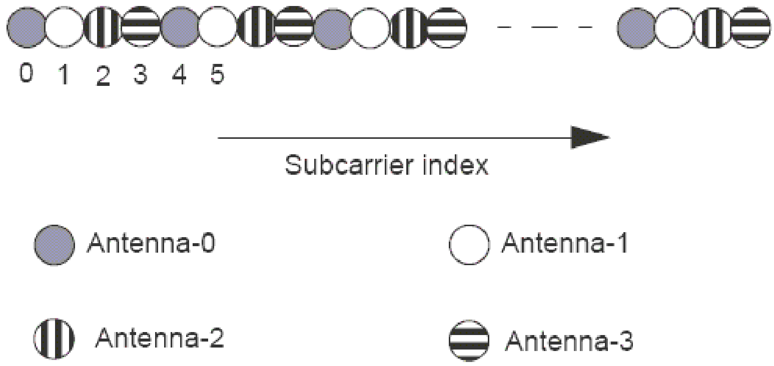
Pin	Name	Description	Signal Type
1	out	midamble	multiple int

Notes/Equations

1. This model is used to generate the 802.16e MIMO midamble sequence.
2. The MIMO midamble consists of one OFDM symbol that is maped onto multiple antennas. No-overlapping subcarriers are allocated to the transmit antennas.
3. For FUSC and optical FUSC, the antenna to subcarrier mapping is shown in the following figure. Subcarriers index starts from the first one after the left guard band. DC subcarriers is also included in the numbering but nulled prior to tarnsmission. The midamble carrier-set is defined using the following formula:

$$MidambleCarrierSet = -(N_{used}/2) + n + 2k\left\lceil \frac{N_t}{2} \right\rceil$$

   where
   N_t is the number of transmit antennas(2,3,or 4)
   n is the antenna index (0,1,...N_t-1)
   k is the subcarrier running index.
   The subcarriers to antenna mapping is depicted in the next figure. The midamble sequence has the identical IDcell and segment mapping as the preamble.

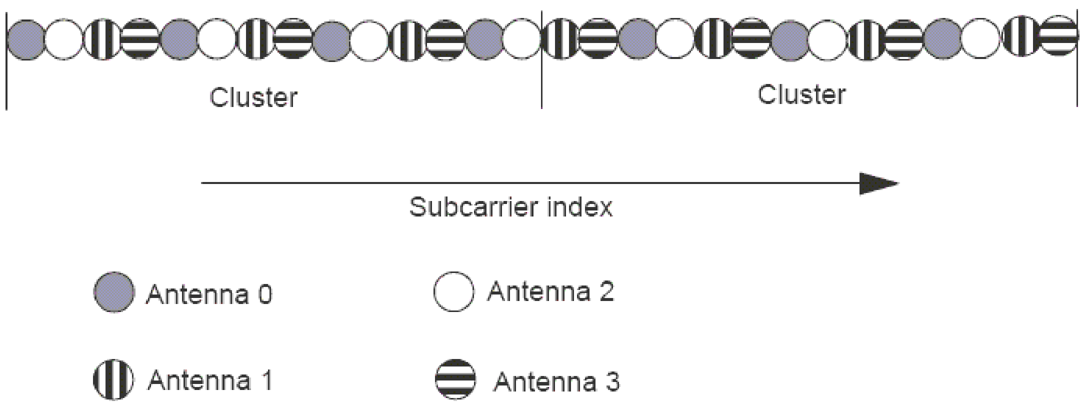


Midamble FUSC Structure (Frequency Domain)

4. For PUSC, the subchannel permutations and grouping remain same as for the data. Instead all the subcarriers are used as pilot. Only one symbol is used as the midamble. The midamble is allocated to the subcarriers and antennas as follows.

$$MidambleCarrierSet = -(N_{used}/2) + n + 2k\left\lceil\frac{N_t}{2}\right\rceil$$

where
N_t is the number of transmit antennas(2,3,or 4)
n is the antenna index (0,1,...N_t-1)
k is the subcarrier running index.

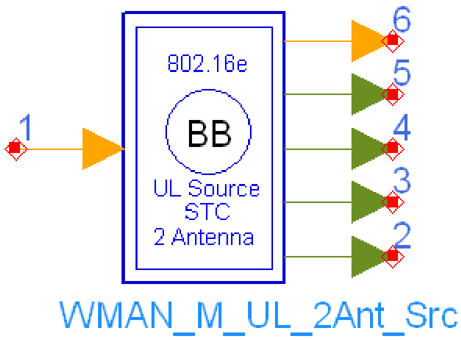


Midamble PUSC Structure

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_2Ant_Src (802.16e OFDMA Uplink 2 Antenna Source)



Description: Uplink signal source with 2 antenna
Library: WMAN 16e, MIMO Source

Parameters

Name	Description	Default	Unit	Type	Range
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01 , 0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[0,0.02]
PreambleIndex	Preamble index	3		int	[0,113]
FrameNumber	Frame number	0		int	[1,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
UL_PermBase	Uplink permutation base	0		int	[0 , 69]
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	YES		enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array	[0,255]
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum	
ZoneType	Zone type: UL_PUSC	UL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24		int	[3,1212]
ZoneSymOffset	Symbol offset in zone	0		int	[0,1212]
NumberOfBurst	Number of Bursts	1		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}		int array	[1,6868]
DataLength	MAC PDU payload byte length of each burst	{300}		int array	[1,∞)
CodingType	Coding type of each burst	{0}		int array	[0,1]
Rate_ID	Rate ID of each burst	{3}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0}		int array	[0,3]
BurstPowerOffset	Power offset of each burst in dB	{0}		real array	[-∞,∞]
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A		enum	
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupiedd): Peak power, Burst power when all subchs occupied	Burst power when all subchs occupied		enum	

Pin Inputs

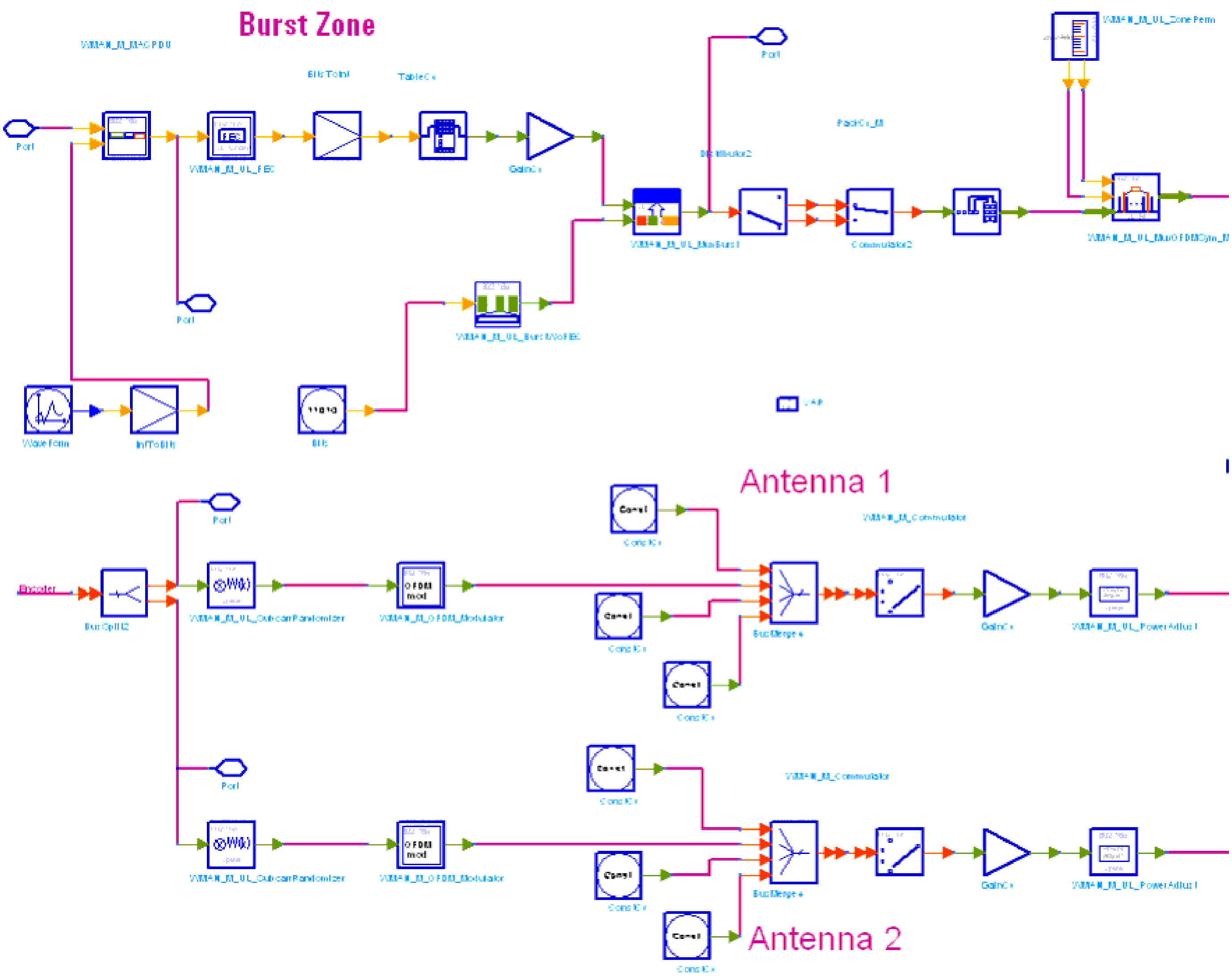
Pin	Name	Description	Signal Type
1	InputData	input of raw data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	Ant1_Data	antenna 1 uplink subframe	complex
3	Ant2_Data	antenna 2 uplink subframe	complex
4	Ant1_Constellation	output of modulated data in antenna 1	complex
5	Ant2_Constellation	output of modulated data in antenna 2	complex
6	Data_Constellation	output of modulated data before mapping to antennas	complex
7	PDUFCS	output of MAC PDU data of burst with FEC	int

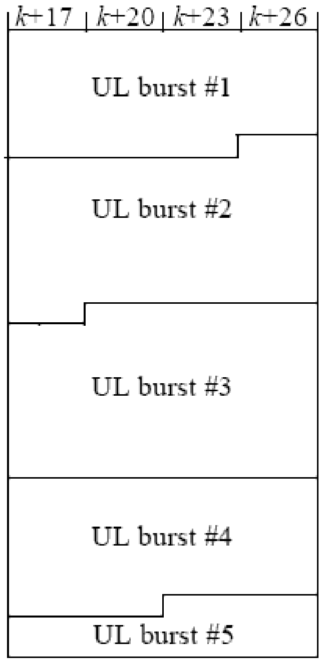
Notes/Equations

1. This subnetwork acts as WMAN OFDMA Uplink baseband signal source with two antennas. The schematic for this subnetwork is shown in the following figure.



WMAN_M_UL_2Ant_Src Schematic

2. The input of this subnetwork is MAC PDU data of the FEC-encoded burst; MAC header data can be either specified by MAC_Header or generated automatically.
3. WMAN_M_UL_2Ant_Src is implemented according to specification. The following figure shows the uplink frame format. It includes only one zone (alternative PUSC or OPUSC) which contains maximum 8 bursts carrying one MAC PDU each. Among these bursts, only one burst is FEC-encoded whose coding type can be set to CC or CTC. Other bursts are provided PN sequences as their coded source respectively. Both TDD mode and FDD mode can be supported for the uplink source.



WMAN OFDMA UL Frame Structure

The CC-encoded burst is coded in the following manner:

Add MAC header with parameter MAC_Header or generate MAC header automatically by WMAN_M_MACPDU.

Randomized by WMAN_M_UL_Randomizer.

CC encoded and punctured by WMAN_M_UL_CC.

Interleaved by WMAN_M_UL_Interleaver.

Repeated by WMAN_M_UL_Repetition.

The CTC-encoded burst is coded in the following manner:

Add MAC header with parameter MAC_Header or generate MAC header automatically by WMAN_M_MACPDU.

Randomized by WMAN_M_UL_Randomizer.

CTC encoded by WMAN_M_UL_CTC.

Repeated by WMAN_M_UL_Repetition.

After encoding, the encoded burst is mapped to the constellation. Other bursts without FEC, are provided PN sequence as their coded bits and mapped to the constellation according to their Rate_ID by WMAN_M_UL_BurstWoFEC. The FEC-encoded burst is concatenated with non-coded bursts by WMAN_M_UL_MuxBurst.
The physical indices of data subcarriers and pilot subcarriers for each burst are calculated by WMAN_M_UL_ZonePerm. The data sequences and pilot sequences are placed to their physical subcarrier location by WMAN_M_UL_MuxOFDMSym_M.
WMAN_M_UL_STCEncoder performs STC encoding and generates two STC encoded data streams for the two antennas respectively.
Then the useful subcarriers are randomized by WMAN_M_UL_SubcarrRandomizer. After IFFT and cyclic prefix insertion, the idle interval and uplink payload are combined with zero padding bits if needed by WMAN_M_Commutator. In addition, downlink position will be preserved and filled with zeros before uplink

payload if FrameMode is TDD.
At last, a symbol windowing is implemented to smooth the transitions between the consecutive OFDM symbols in the subframe.

4. Parameter Details.
   - Bandwidth determines the nominal channel bandwidth.
   - OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
   - FFTSize indicates the FFT point size (512, 1024, or 2048). The FFT size is independent of the selected bandwidth.
   - CyclicPrefix (G) specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
   - FrameMode determines what will actually be included in the generated waveform. FDD Mode means the entire frame is used for the uplink and the uplink starts at the beginning of the frame. TDD Mode means only the uplink is included in the generated waveform and it starts at some delay from the frame start time based on the Downlink Ratio setting.
   - DL_Ratio set the percentage (1 to 99) of the frame time to be used for the downlink and also set the start time for the uplink. The parameter is only active when the frame mode is TDD.
   - FrameDuration determines the frame durations (ms) of the generated waveform. There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
   - IdleInterval specifies the time of idle interval between two consecutive frames.
   - PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to Table 309 in the specification.
   - FrameNumber specifies the frame number (0 to 0xffffff) of the uplink frame.
   - FrameIncreased indicates whether the frame number of the generated waveform is increased one by one.
   - UL_PermBase specifies the permutation base that will be used in this uplink zone. Accepted values are 0 to 69.
   - AutoMACHeaderSetting indicates whether the MAC Header is calculated automatically. If it is set to NO, data sequences in parameter MAC_Header will be used before data content, otherwise MAC_Header content will be calculated with parameter DataLength and CID and be used before data content.
   - MAC_Header specifies 6 bytes of MAC header before the data contents. The parameter is only active when the AutoMACHeaderSetting is set to NO.
   - CRC32_Mode specifies the method for CRC32 calculation appended to MAC PDU.
   - ZoneType specifies the zone type which can be set to PUSC or OPUSC.
   - ZoneNumOfSym specifies the number of symbols in the zone. The value must be a multiple of three because the uplink zone is divided into slots of 3 symbols x 1 subchannel. The maximum number of symbols available depends on the Bandwidth, FrameDuration, DL_Ratio, FFTSize, and CyclicPrefix.
   - NumberOfBurst specifies the number of active uplink bursts.
   - BurstWithFEC specifies the uplink burst FEC.
   - BurstSymOffset positions each burst on the horizontal axis (x), if necessary, to avoid any burst overlap. The parameter is an array element .
   - BurstSubchOffset positions each burst on the vertical axis (y), if necessary, to avoid any burst overlap. The parameter is an array element.
   - BurstAssignedSlot specifies the total available slots in each burst. The parameter is an array element.
   - DataLength is the array of each burst's MAC PDU payload data length in bytes.
   - CodingType is the array of each burst's coding type which can be set to CC or CTC.
   - Rate_ID is the array of each burst's Rate ID, whose range is from 0 to 6 for CC encoding and from 0 to 7 for CTC encoding. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in the following table.

The Relation of Coding Type and Rate ID

Coding type	Rate ID	Modulation-Coding rate
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the number of times the coded or uncoded data is repeated for each burst. The parameter is an array element and only available when QPSK 1/2 or QPSK 3/4 is selected as the burst profile (Rate ID). Each repetition coding can be selected from 0 to 3, whose meaning is shown in the following table.

The Meaning of Repetition Coding

Repetition Coding	Meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4 used on the burst
3	Repetition coding of 6 used on the burst

- BurstPowerOffset determines the power offset of each burst in dB. The parameter is an array element.
- PowerType specifies the exact meaning of the parameter Power in RF source. Two types are defined in uplink (Type I: Peak power; Type II: Burst power when all subchs occupied). Type I is recommended for transmitter measurement; Type II is recommended for receiver measurement. For more information, please refer to *Transmit Power Definition* (wman_m).

5. Samples per frame
The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-08-07-062.gif!) as follows,
$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$
The sampling factors are listed in the following table.

Sampling Factor Requirement

Sampling Factor n	Bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval(!wman_m-08-07-064.gif!) is calculated as follows:
$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$
So, the total samples of one uplink frame $Samples_{Frame}$ is
$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$
This model works on frame by frame. Each firing, $8 \times DataLength$ tokens are consumed at pin MAC_PDU, $Samples_{Frame}$ tokens are produced at pin FrameData,
$$\sum_{i=1}^{NumberOfBurst} BurstAssignedSlot[i] \times 48$$
tokens are produced at pin ForEVM,

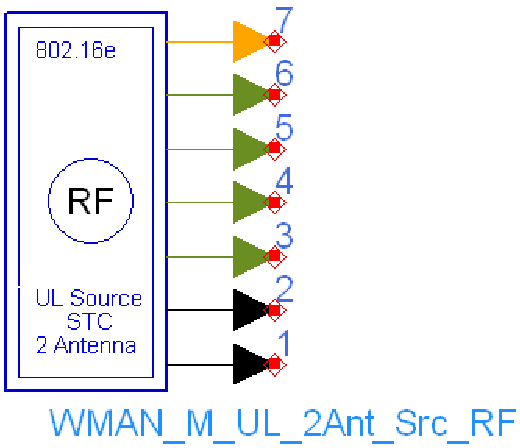
$8 \times DataLength + 80$ tokens are produced at pin PDUFCS.

6. Output delay
No delay is introduced by WMAN_M_SymWindow in this design.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_2Ant_Src_RF (802.16e OFDMA UL 2 Antenna RF Src)



Description: Uplink RF signal source with 2 antenna
Library: WMAN 16e, MIMO Source

Parameters

Name	Description	Default	Unit	Type	Range
ROut	Source resistance	DefaultROut	Ohm	int	(0,∞)
RTemp	TEMPERATURE	- 273.15	Celsius	real	[-273.15,∞]
FCarrier	Carrier frequency	3407 MHz	Hz	real	(0,∞)
Ant1Power	Transmit power at Ant1 (the meaning of Power is defined in Parameter PowerType)	0.01 W	W	real	(0,∞)
Ant1GainImbalance	Gain imbalance in dB Q channel relative to I channel at transmit antenna 1	0.0		real	(-∞,∞)
Ant1PhaseImbalance	Phase imbalance in dB Q channel relative to I channel at transmit antenna 1	0.0		real	(-∞,∞)
Ant2Power	Transmit power at Ant2 (the meaning of Power is defined in Parameter PowerType)	0.01 W	W	real	(0,∞)
Ant2GainImbalance	Gain imbalance in dB Q channel relative to I channel at transmit antenna 2	0.0		real	(-∞,∞)
Ant2PhaseImbalance	Phase imbalance in dB Q channel relative to I channel at transmit antenna 2	0.0		real	(-∞,∞)
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01 , 0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
PreambleIndex	Preamble index	3		int	[0,113]
FrameNumber	Frame number	0		int	[1,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
UL_PermBase	Uplink permutation base	0		int	[0 , 69]
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	YES		enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array	[0,255]
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum	
ZoneType	Zone type: UL_PUSC	UL_PUSC		enum	

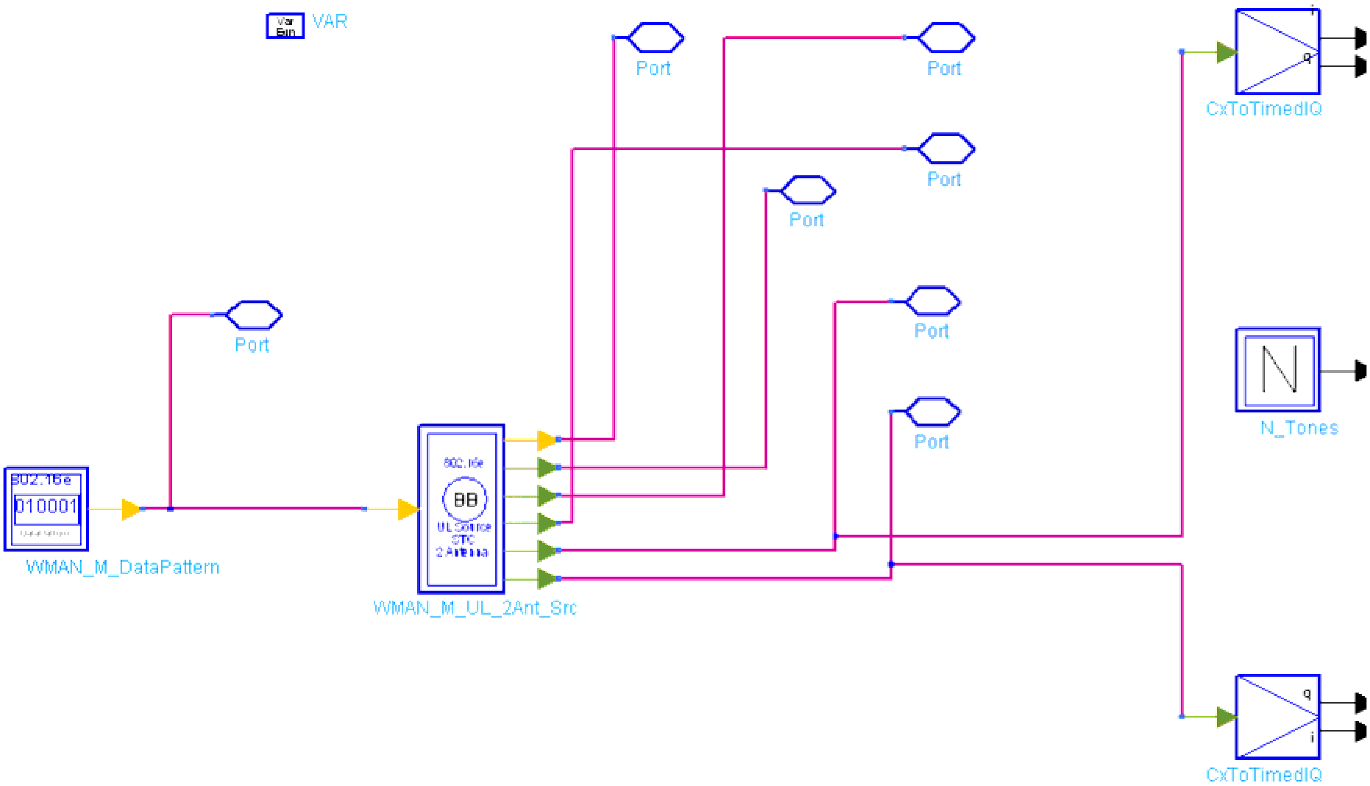
ZoneNumOfSym	Number of OFDM symbol in zone	24		int	[3,1212]
NumberOfBurst	Number of Bursts	1		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}		int array	[1,6868]
DataLength	MAC PDU payload byte length of each burst	{300}		int array	[1,∞)
CodingType	Coding type of each burst	{0}		int array	[0,1]
Rate_ID	Rate ID of each burst	{3}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0}		int array	[0,3]
BurstPowerOffset	Power offset of each burst in dB	{0}		real array	[-∞,∞]
DataPattern	WMAN16e data pattern: PN9, PN15, FIX4, _4_1_4_0, _8_1_8_0, _16_1_16_0, _32_1_32_0, _64_1_64_0, S_QPSK, S_16-QAM, S_64-QAM	PN9		enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A		enum	
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupiedd): Peak power, Burst power when all subchs occupied	Burst power when all subchs occupied		enum	

Pin Outputs

Pin	Name	Description	Signal Type
1	RF_Signal1	output of RF signal	timed
2	RF_Signal2	output of RF signal	timed
3	Ant1_Data	antenna 1 uplink subframe	complex
4	Ant2_Data	antenna 2 uplink subframe	complex
5	Ant1_Constellation	output of modulated data in antenna 1	complex
6	Ant2_Constellation	output of modulated data in antenna 2	complex
7	Data_Constellation	output of modulated data before mapping to antennas	complex
8	PDUFCS	output of MAC PDU data of burst with FEC	int
9	PSDU	output of MAC PDU data	int

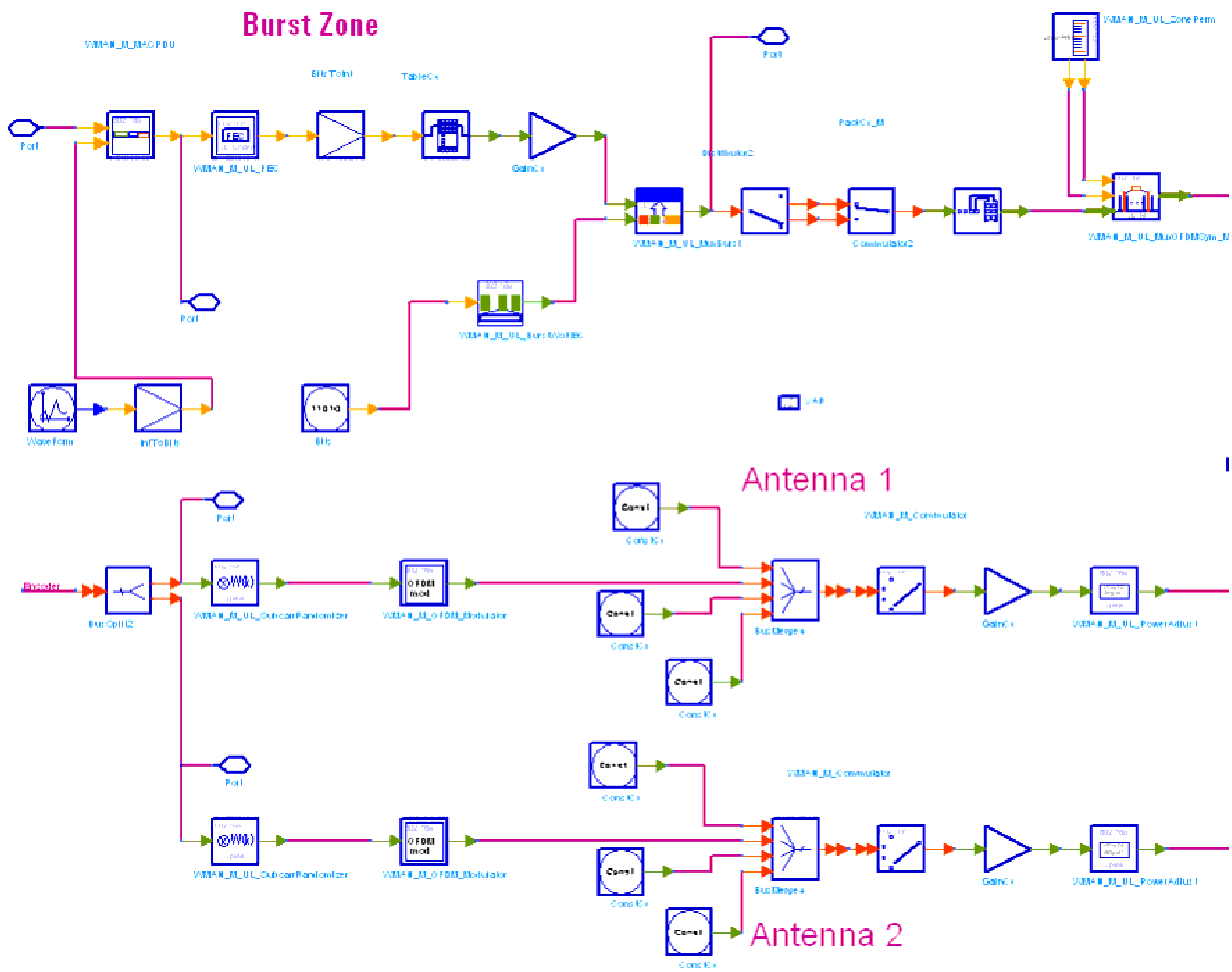
Notes/Equations

1. This subnetwork generates 2 Antenna RF signal of uplink. It includes DataPattern module, Baseband module and RF modulator.



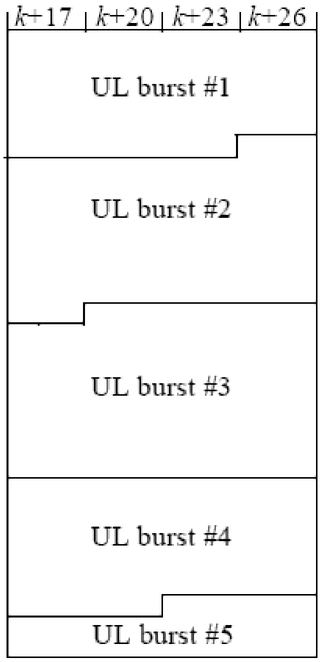
Schematic of WMAN_M_UL_2Ant_Src_RF

2. The schematic for the Baseband source is shown in the following figure.



WMAN_M_UL_2Ant_Src Schematic

3. The input of this subnetwork is MAC PDU data of the FEC-encoded burst; MAC header data can be either specified by MAC_Header or generated automatically.
4. WMAN_M_UL_2Ant_Src is implemented according to specification. The following figure shows the uplink frame format. It includes only one zone (alternative PUSC or OPUSC) which contains maximum 8 bursts carrying one MAC PDU each. Among these bursts, only one burst is FEC-encoded whose coding type can be set to CC or CTC. Other bursts are provided PN sequences as their coded source respectively. Both TDD mode and FDD mode can be supported for the uplink source.



WMAN OFDMA UL Frame Structure

The CC-encoded burst is coded in the following manner:

Add MAC header with parameter MAC_Header or generate MAC header automatically by WMAN_M_MACPDU.

Randomized by WMAN_M_UL_Randomizer.

CC encoded and punctured by WMAN_M_UL_CC.

Interleaved by WMAN_M_UL_Interleaver.

Repeated by WMAN_M_UL_Repetition.

The CTC-encoded burst is coded in the following manner:

Add MAC header with parameter MAC_Header or generate MAC header automatically by WMAN_M_MACPDU.

Randomized by WMAN_M_UL_Randomizer.

CTC encoded by WMAN_M_UL_CTC.

Repeated by WMAN_M_UL_Repetition.

After encoding, the encoded burst is mapped to the constellation. Other bursts without FEC, are provided PN sequence as their coded bits and mapped to the constellation according to their Rate_ID by WMAN_M_UL_BurstWoFEC. The FEC-encoded burst is concatenated with non-coded bursts by WMAN_M_UL_MuxBurst.
The physical indices of data subcarriers and pilot subcarriers for each burst are calculated by WMAN_M_UL_ZonePerm. The data sequences and pilot sequences are placed to their physical subcarrier location by WMAN_M_UL_MuxOFDMSym_M.
WMAN_M_UL_STCEncoder performs STC encoding and generates two STC encoded data streams for the two antennas respectively.
Then the useful subcarriers are randomized by WMAN_M_UL_SubcarrRandomizer. After IFFT and cyclic prefix insertion, the idle interval and uplink payload are combined with zero padding bits if needed by WMAN_M_Commutator. In addition, downlink position will be preserved and filled with zeros before uplink

payload if FrameMode is TDD.
At last, a symbol windowing is implemented to smooth the transitions between the consecutive OFDM symbols in the subframe.

5. Parameter Details.
    - ROut is the RF output resistance.
    - RTemp is the RF output resistance temperature in Celsius and sets the noise density in the RF output signal to (k(RTemp+273.15)) Watts/Hz, where k is Boltzmann's constant.
    - FCarrier is the RF output signal frequency.
    - Power is used to set the modulator output RF power. This is true for an ideal transmitted signal (no impairments added) or when small impairments are added. If large impairments are added to the signal (using GainImbalance, I_OriginOffset, and Q_OriginOffset parameters) the output RF power may be different from the value of the Power parameter.
    - MirrorSpectrum is used to mirror the RF_out signal spectrum about the carrier. This is equivalent to conjugating the complex RF envelope voltage. Depending on the configuration and number of mixers in an RF transmitter, the RF output signal from hardware RF generators can be inverted. If such an RF signal is desired, set this parameter to YES.
    - GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation are used to add certain impairments to the ideal output RF signal. Impairments are added in the order described here.
    The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:
    $$V_{RF}(t) = A\left(V_I(t)\cos(\omega_c t) - gV_Q(t)\sin\left(\omega_c t + \frac{\Phi\pi}{180}\right)\right)$$
    where A is a scaling factor based on the Power and ROut parameters specified by the user, VI(t) is the in-phase RF envelope, VQ(t) is the quadrature phase RF envelope, g is the gain imbalance
    $$g = 10^{\frac{GainImbalance}{20}}$$
    and, ϕ (in degrees) is the phase imbalance.
    Next, the signal VRF(t) is rotated by IQ_Rotation degrees. The I_OriginOffset and Q_OriginOffset are then applied to the rotated signal. Note that the amounts specified are percentages with respect to the output rms voltage. The output rms voltage is given by sqrt(2×ROut×Power).
    - Bandwidth determines the nominal channel bandwidth.
    - OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
    - FFTSize indicates the FFT point size (512, 1024, or 2048). The FFT size is independent of the selected bandwidth.
    - CyclicPrefix (G) specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
    - FrameMode determines what will actually be included in the generated waveform. FDD Mode means the entire frame is used for the uplink and the uplink starts at the beginning of the frame. TDD Mode means only the uplink is included in the generated waveform and it starts at some delay from the frame start time based on the Downlink Ratio setting.
    - DL_Ratio set the percentage (1 to 99) of the frame time to be used for the downlink and also set the start time for the uplink. The parameter is only active when the frame mode is TDD.
    - FrameDuration determines the frame durations (ms) of the generated waveform. There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
    - IdleInterval specifies the time of idle interval between two consecutive frames.
    - PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to Table 309 in the standard.
    - FrameNumber specifies the frame number (0 to 0xffffff) of the uplink frame.
    - FrameIncreased indicates whether the frame number of the generated waveform is increased one by one.
    - UL_PermBase specifies the permutation base that will be used in this uplink zone. Accepted values are 0 to 69.
    - AutoMACHeaderSetting indicates whether the MAC Header is calculated automatically. If it is set to NO, data sequences in parameter MAC_Header will be used before data content, otherwise MAC_Header content will be calculated with parameter DataLength and CID and be used before data content.
    - MAC_Header specifies 6 bytes of MAC header before the data contents. The parameter is only active when the AutoMACHeaderSetting is set to NO.
    - CRC32_Mode specifies the method for CRC32 calculation appended to MAC PDU.
    - ZoneType specifies the zone type which can be set to PUSC or OPUSC.
    - ZoneNumOfSym specifies the number of symbols in the zone. The value must be a multiple of three because the uplink zone is divided into slots of 3 symbols x 1 subchannel. The maximum number of

symbols available depends on the Bandwidth, FrameDuration, DL_Ratio, FFTSize, and CyclicPrefix.

- NumberOfBurst specifies the number of active uplink bursts.
- BurstWithFEC specifies the uplink burst FEC.
- BurstSymOffset positions each burst on the horizontal axis (x), if necessary, to avoid any burst overlap. The parameter is an array element .
- BurstSubchOffset positions each burst on the vertical axis (y), if necessary, to avoid any burst overlap. The parameter is an array element.
- BurstAssignedSlot specifies the total available slots in each burst. The parameter is an array element.
- DataLength is the array of each burst's MAC PDU payload data length in bytes.
- CodingType is the array of each burst's coding type which can be set to CC or CTC.
- Rate_ID is the array of each burst's Rate ID, whose range is from 0 to 6 for CC encoding and from 0 to 7 for CTC encoding. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in the following table.

The Relation of Coding Type and Rate ID

Coding type	Rate ID	Modulation-Coding rate
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the number of times the coded or uncoded data is repeated for each burst. The parameter is an array element and only available when QPSK 1/2 or QPSK 3/4 is selected as the burst profile (Rate ID). Each repetition coding can be selected from 0 to 3, whose meaning is shown in the following table.

The Meaning of Repetition Coding

Repetition coding	Meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4used on the burst
3	Repetition coding of 6used on the burst

- BurstPowerOffset determines the power offset of each burst in dB. The parameter is an array element.
- PowerType specifies the exact meaning of the parameter Power in RF source. Two types are defined in uplink (Type I: Peak power; Type II: Burst power when all subchs occupied). Type I is recommended for transmitter measurement; Type II is recommended for receiver measurement. For more information, please refer to *Transmit Power Definition* (wman_m).

6. Samples per frame
   The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-08-08-079.gif!) as follows,
   $F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$
   The sampling factors are listed in the following table.

Sampling Factor n	Bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval(!wman_m-08-08-081.gif!) is calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

So, the total samples of one uplink frame $Samples_{Frame}$ is

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

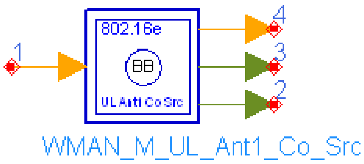
This model works on frame by frame. Each firing, $8 \times DataLength$ tokens are consumed at pin MAC_PDU, $Samples_{Frame}$ tokens are produced at pin FrameData, $\sum_{i=1}^{NumberOfBurst} BurstAssignedSlot[i] \times 48$ tokens are produced at pin ForEVM, $8 \times DataLength + 80$ tokens are produced at pin PDUFCS.

7. Output delay
   No delay is introduced by WMAN_M_SymWindow in this design.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_Ant1_Co_Src (802.16e OFDMA Uplink Signal Source)



Description: Uplink collaborative baseband signal source
Library: WMAN 16e, MIMO Source

Parameters

Name	Description	Default	Unit	Type	Range
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01 , 0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[0,20000]
PreambleIndex	Preamble index	3		int	[0,113]
FrameNumber	Frame number	0		int	[1,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
UL_PermBase	Uplink permutation base	0		int	[0 , 69]
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	YES		enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array	[0,255]
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum	
ZoneType	Zone type: UL_PUSC	UL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24		int	[3,1212]
ZoneSymOffset	Symbol offset in zone	0		int	[0,1211]
NumberOfBurst	Number of Bursts	1		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}		int array	[1,6868]
DataLength	MAC PDU payload byte length of each burst	{300}		int array	[1,∞)
CodingType	Coding type of each burst	{0}		int array	[0,1]
Rate_ID	Rate ID of each burst	{3}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0}		int array	[0,3]
BurstPowerOffset	Power offset of each burst in dB	{0}		real array	[-∞,∞]
TilePattern	The uplink tile pattern used by the SS (valid only when Collaborative is valid and is YES): Pattern_A, Pattern_B	Pattern_A		enum	
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupiedd): Peak power, Burst power when all subchs occupied	Burst power when all subchs occupied		enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	InputData	input of raw data	int

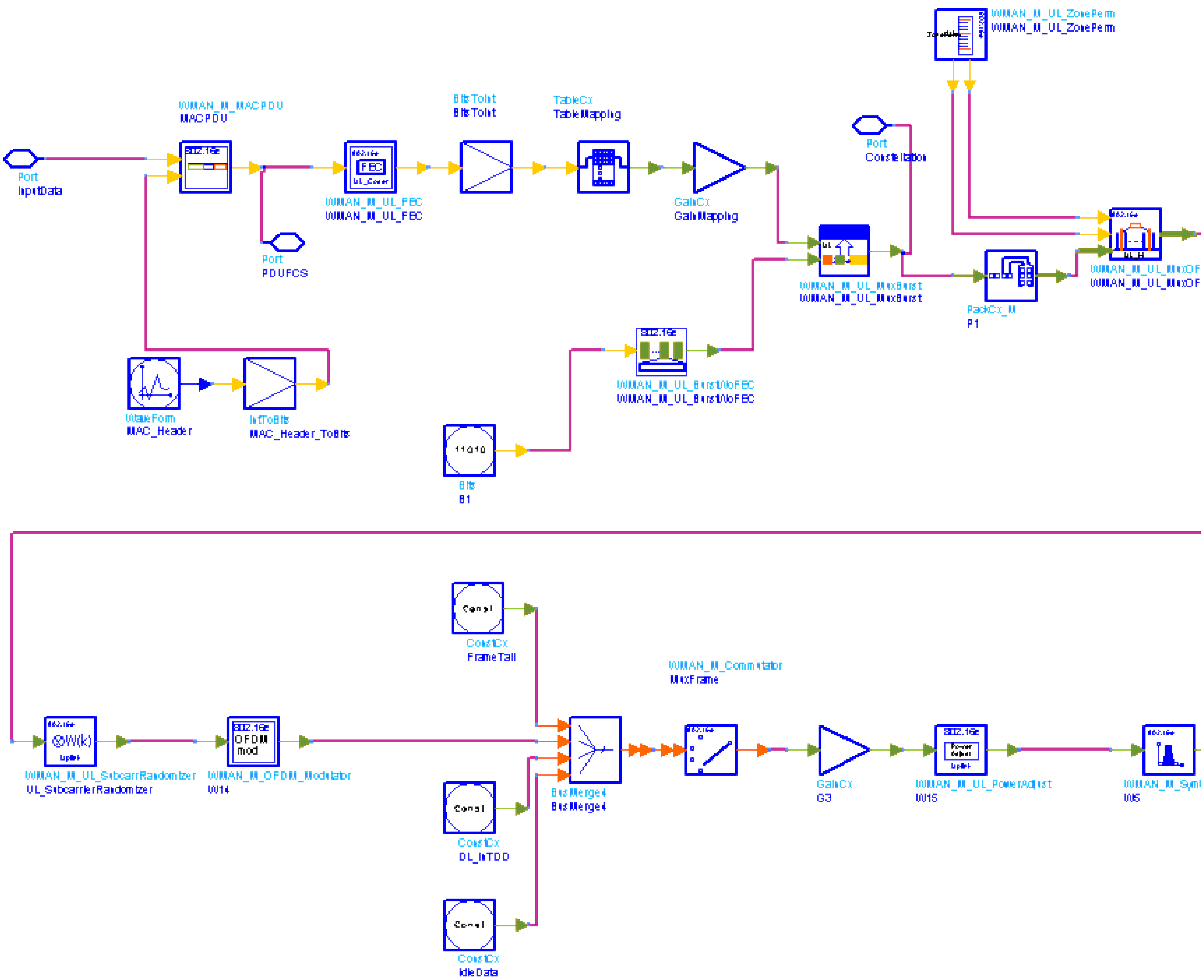
Pin Outputs

Pin	Name	Description	Signal Type
2	FrameData	output of uplink Subframe	complex
3	Constellation	output of Modulated data of all bursts	complex
4	PDUFCS	output of MAC PDU data of burst with FEC	int

Notes/Equations

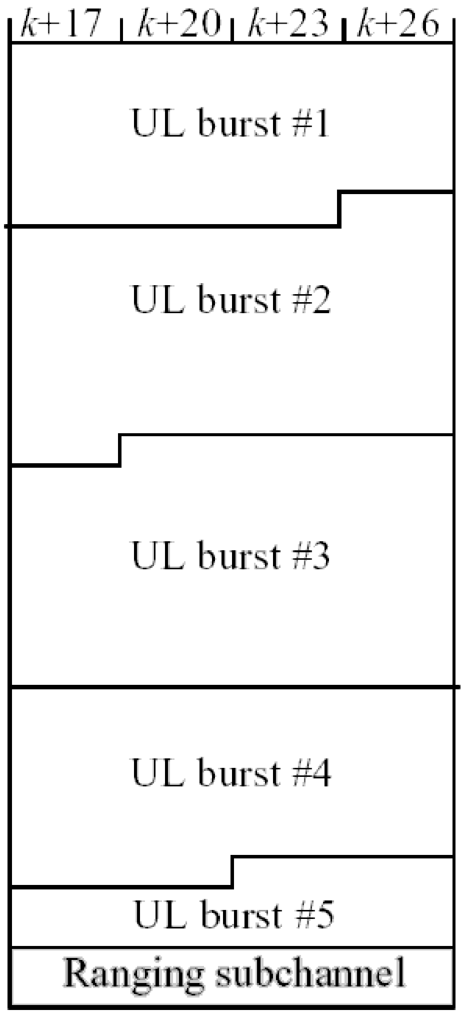
1. This subnetwork generates an 802.16e OFDMA Uplink subsystem baseband signal. The schematic for this

subnetwork is shown in the following figure.



WMAN_M_UL_Ant1_Co_Src Schematic

2. The input of this subnetwork is MAC PDU data of the FEC-encoded burst; MAC header data can be either specified by MAC_Header or generated automatically.
3. WMAN_M_UL_Ant1_Co_Src is implemented according to specification. The following figure shows the uplink frame format. It includes only one zone (alternative PUSC or OPUSC) which contains maximum 8 bursts carrying one MAC PDU each. Among these bursts, only one FEC-encoded burst is supported whose coding type can be set to CC or CTC. Other bursts are provided PN sequences as their coded source respectively. Both TDD mode and FDD mode can be supported for the uplink source.



WMAN OFDMA UL Frame Structure

The CC-encoded burst is coded in the following manner:

- Add MAC header with parameter MAC_Header or generate MAC header automatically by WMAN_M_MACPDU.
- Randomized by WMAN_M_UL_Randomizer.
- CC encoded and punctured by WMAN_M_UL_CC.
- Interleaved by WMAN_M_UL_Interleaver.
- Repeated by WMAN_M_UL_Repetition.

The CTC-encoded burst is coded in the following manner:

- Add MAC header with parameter MAC_Header or generate MAC header automatically by WMAN_M_MACPDU.
- Randomized by WMAN_M_UL_Randomizer.
- CTC encoded by WMAN_M_UL_CTC.
- Repeated by WMAN_M_UL_Repetition.

After encoding, the encoded burst is mapped to the constellation. Other bursts without FEC, are provided PN sequence as their coded bits and mapped to the constellation according to their Rate_ID by WMAN_M_UL_BurstWoFEC. The FEC-encoded burst is concatenated with non-coded bursts by WMAN_M_UL_MuxBurst.
The physical indices of data subcarriers and pilot subcarriers for each burst are calculated by WMAN_M_UL_ZonePerm. The data sequences and pilot sequences are placed to their physical subcarrier location by WMAN_M_UL_MuxOFDMSym_M. A WMAN_M_UL_STCEncoder is used to encoder pilot subcarriers according to TilePattern. Then the useful subcarriers are randomized by WMAN_M_UL_SubcarrRandomizer.
After IFFT and cyclic prefix insertion, the idle interval and uplink payload are combined with zero padding bits if needed by WMAN_M_Commutator. In addition, downlink position will be preserved and filled with zeros before uplink payload if FrameMode is TDD.
At last, a symbol windowing is implemented to smooth the transitions between the consecutive OFDM symbols in the subframe.

4. Parameter Details.
    - Bandwidth determines the nominal channel bandwidth.
    - OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
    - FFTSize indicates the FFT point size (512, 1024, or 2048). The FFT size is independent of the selected bandwidth.
    - CyclicPrefix (G) specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
    - FrameMode determines what will actually be included in the generated waveform. FDD Mode means the entire frame is used for the uplink and the uplink starts at the beginning of the frame. TDD Mode means only the uplink is included in the generated waveform and it starts at some delay from the frame start time based on the Downlink Ratio setting.
    - DL_Ratio set the percentage (1 to 99) of the frame time to be used for the downlink and also set the start time for the uplink. The parameter is only active when the frame mode is TDD.
    - FrameDuration determines the frame durations (ms) of the generated waveform. There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
    - IdleInterval specifies the time of idle interval between two consecutive frames.
    - PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to Table 309 in the standard.
    - FrameNumber specifies the frame number(0 to 0xffffff) of the uplink frame.
    - FrameIncreased indicates whether the frame number of the generated waveform is increased one by one.
    - UL_PermBase specifies the permutation base that will be used in this uplink zone. Accepted values are 0 to 69.
    - AutoMACHeaderSetting indicates whether the MAC Header is calculated automatically. If it is set to NO, data sequences in parameter MAC_Header will be used before data content, otherwise MAC_Header content will be calculated with parameter DataLength and CID and be used before data content.
    - MAC_Header specifies 6 bytes of MAC header before the data contents. The parameter is only active when the AutoMACHeaderSetting is set to NO.
    - CRC32_Mode specifies the method for CRC32 calculation appended to MAC PDU. For consistency with 802.16-2004 Cor1/D5, it shall be set to MSB first while shall be set to LSB first for consistency with 802.16-2004 Cor1/D3.
    - ZoneType specifies the zone type which can be set to PUSC or OPUSC.
    - ZoneNumOfSym specifies the number of symbols in the zone. The value must be a multiple of three because the uplink zone is divided into slots of 3 symbols x 1 subchannel (section 8.4.3.1 in 802.16-2004/Cor/D3). The maximum number of symbols available depends on the Bandwidth, frame length, DL_Ratio, FFTSize, and CyclicPrefix.
    - NumberOfBurst specifies the number of active uplink bursts.
    - BurstWithFEC specifies the uplink burst FEC.
    - BurstSymOffset positions each burst on the horizontal axis (x), if necessary, to avoid any burst overlap. The parameter is an array element .
    - BurstSubchOffset positions each burst on the vertical axis (y), if necessary, to avoid any burst overlap. The parameter is an array element.
    - BurstAssignedSlot specifies the total available slots in each burst. The parameter is an array element.
    - DataLength is the array of each burst's MAC PDU payload data length in bytes.
    - CodingType is the array of each burst's coding type which can be set to CC or CTC.
    - Rate_ID is the array of each burst's Rate ID, whose range is from 0 to 6 for CC encoding and from 0 to 7 for CTC encoding. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in the following table.

The Relation between Coding Type and rate ID

Coding type	Rate ID	Modulation-Coding rate
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. The parameter is an array element and only available when QPSK 1/2 or QPSK 3/4 is selected as the burst profile (Rate_ID). Each repetition coding can be selected from 0 to 3, whose meaning is shown in the following table.

The Meaning of Repetition Coding

Repetition coding	meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4used on the burst
3	Repetition coding of 6used on the burst

- BurstPowerOffset determines the power offset of each burst in dB. The parameter is an array element.
- PowerType specifies the exact meaning of the parameter Power in RF source. Two types are defined in uplink (Type I: Peak power; Type II: Burst power when all subchs occupied). Type I is recommended for transmitter measurement; Type II is recommended for receiver measurement. For more information, please refer to *Transmit Power Definition* (wman_m).

5. Samples per frame
The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-08-09-092.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in the following table.

Sampling Factor Requirement

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval(!wman_m-08-09-094.gif!) is calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

So, the total samples of one uplink frame $Samples_{Frame}$ is

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

This model works frame by frame. Each firing,
$8 \times DataLength[BurstWithFEC]$ tokens are consumed at pin MAC_PDU,

$Samples_{Frame}$ tokens are produced at pin FrameData,

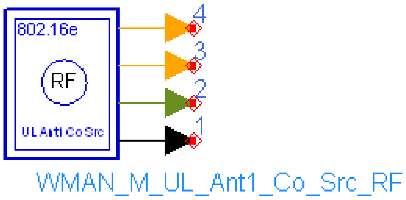
$\sum_{i=1}^{NumberOfBurst} BurstAssignedSlot[i] \times 48$ tokens are produced at pin Constellation,

$8 \times DataLength[BurstWithFEC] + 80$ tokens are produced at pin PDUFCS.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_Ant1_Co_Src_RF (802.16e OFDMA Uplink RF Source)



Description: Uplink collaborative RF signal source
Library: WMAN 16e, MIMO Source

Parameters

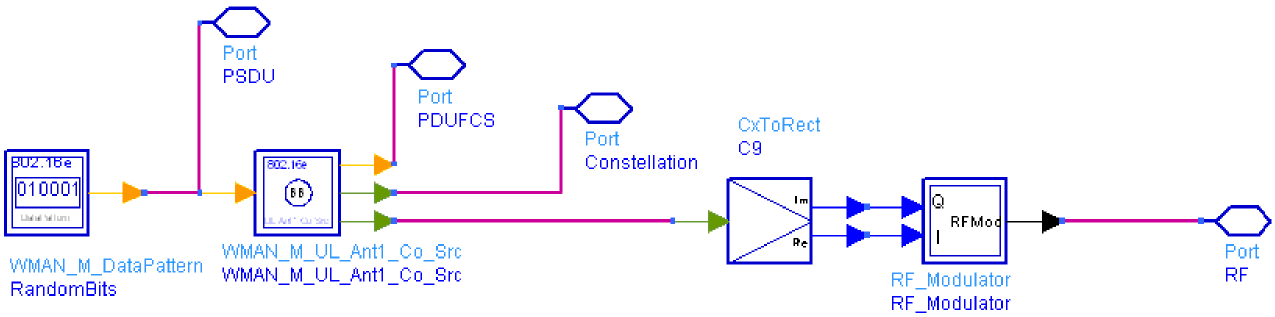
Name	Description	Default	Unit	Type	Range
ROut	Output resistance	DefaultROut	Ohm	int	(0,∞)
RTemp	Temperature, in degrees C	DefaultRTemp	Celsius	real	[-273.15,∞]
FCarrier	Carrier frequency	3407 MHz	Hz	real	(0,∞)
Power	Transmit power (the meaning of Power is defined in Parameter PowerType)	0.01 W	W	real	(0,∞)
MirrorSpectrum	Mirror spectrum about carrier?: NO, YES	NO		enum	
GainImbalance	Gain imbalance in dB, Q channel relative to I channel	0.0		real	(-∞,∞)
PhaseImbalance	Phase imbalance in degrees, Q channel relative to I channel	0.0		real	(-∞,∞)
I_OriginOffset	I origin offset in percent with repect to output rms voltage	0.0		real	(-∞,∞)
Q_OriginOffset	Q origin offset in percent with repect to output rms voltage	0.0		real	(-∞,∞)
IQ_Rotation	IQ rotation in degrees	0.0		real	(-∞,∞)
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
PreambleIndex	Preamble index	3		int	[0,113]
FrameNumber	Frame number	0		int	[0,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
UL_PermBase	Uplink permutation base	0		int	[0 , 69]
DataPattern	WMAN data pattern: PN9, PN15, FIX4, _4_1_4_0, _8_1_8_0, _16_1_16_0, _32_1_32_0, _64_1_64_0, S_QPSK, S_16-QAM, S_64-QAM	PN9		enum	
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	YES		enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array	[0,255]
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC	UL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24		int	[3,1212]
NumberOfBurst	Number of bursts	1		int	[1,8]
BurstWithFEC	Number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}		int array	[1,6868]
DataLength	MAC PDU payload byte length of each burst	{300}		int array	[1,∞)
CodingType	Coding type of each burst	{0}		int array	[0,1]
Rate_ID	Rate ID of each burst	{3}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0}		int array	[0,3]
BurstPowerOffset	Power offset of each burst in dB	{0}		real array	(-∞,∞)
TilePattern	The uplink tile pattern used by the SS: Pattern_A, Pattern_B	Pattern_A		enum	
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupiedd): Peak power, Burst power when all subchs occupied	Burst power when all subchs occupied		enum	

Pin Outputs

Pin	Name	Description	Signal Type
1	RF	output of RF signal	timed
2	Constellation	output of modulated data of all bursts	complex
3	PDUFCS	output of MAC PDU data of burst with FEC	int
4	PSDU	output of PSDU bits	int

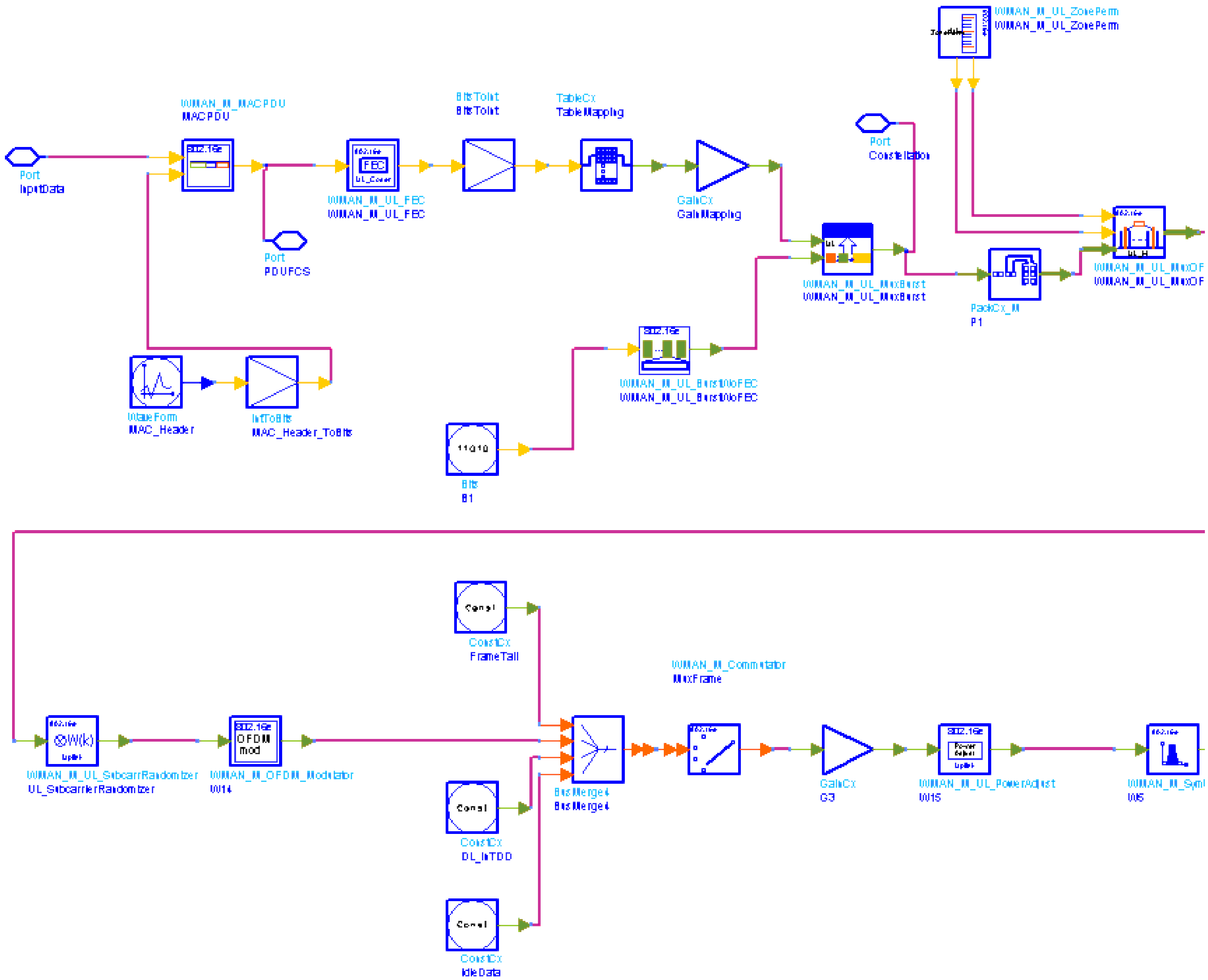
Notes/Equations

1. This subnetwork generates an 802.16e OFDMA uplink collaborative SM subsystem RF signal. The subnetwork includes WMAN_M_UL_Ant1_Co_Src, which generates the uplink collaborative SM baseband signal of 802.16e subsystem, and the RF_Modulator. The schematic for this subnetwork is shown in the following figure.



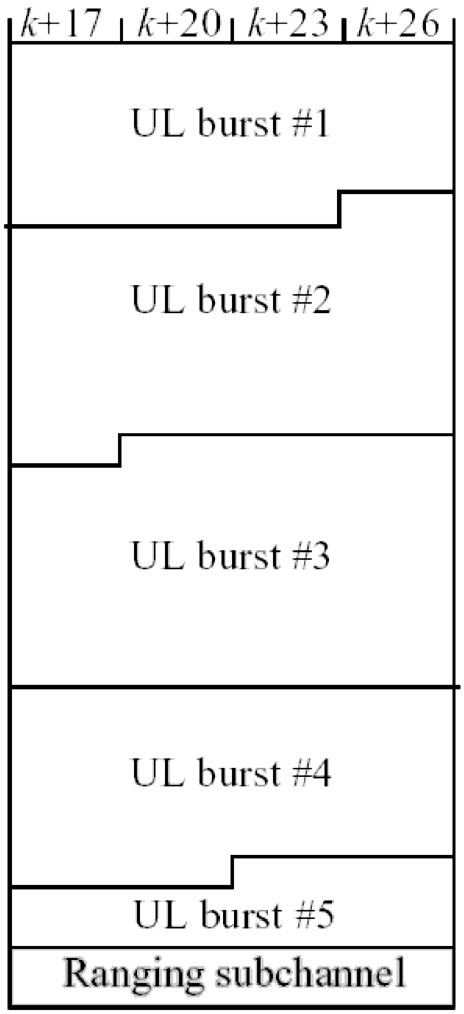
WMAN_M_UL_Ant1_Co_Src_RF Schematic

2. The uplink baseband signal source WMAN_M_UL_Ant1_Co_Src follows the specification. The schematic is shown in the following figure.



WMAN_M_UL_Ant1_Co_Src Schematic

3. WMAN_M_UL_Ant1_Co_Src is implemented according to specification. The following figure shows the uplink frame format. It includes only one zone (UL PUSC) which contains maximum 8 bursts carrying one MAC PDU each. Among these bursts, only one FEC-encoded burst is supported whose coding type can be set to CC or CTC. Other bursts are provided PN sequences as their coded source respectively. Both TDD mode and FDD mode can be supported for the uplink source.



WMAN OFDMA UL Frame Structure

The CC-encoded burst is coded in the following manner:

Add MAC header with parameter MAC_Header or generate MAC header automatically by WMAN_M_MACPDU.

Randomized by WMAN_M_UL_Randomizer.

CC encoded and punctured by WMAN_M_UL_CC.

Interleaved by WMAN_M_UL_Interleaver.

Repeated by WMAN_M_UL_Repetition.

The CTC-encoded burst is coded in the following manner:

Add MAC header with parameter MAC_Header or generate MAC header automatically by WMAN_M_MACPDU.

Randomized by WMAN_M_UL_Randomizer.

CTC encoded by WMAN_M_UL_CTC.

Repeated by WMAN_M_UL_Repetition.

After encoding, the encoded burst is mapped to the constellation. Other bursts without FEC, are provided PN sequence as their coded bits and mapped to the constellation according to their Rate_ID by WMAN_M_UL_BurstWoFEC. The FEC-encoded burst is concatenated with non-coded bursts by WMAN_M_UL_MuxBurst.
The physical indices of data subcarriers and pilot subcarriers for each burst are calculated by WMAN_M_UL_ZonePerm. The data sequences and pilot sequences are placed to their physical subcarrier location by WMAN_M_UL_MuxOFDMSym_M. A WMAN_M_UL_STCEncoder is used to encoder pilot subcarriers according to TilePattern. Then the useful subcarriers are randomized by WMAN_M_UL_SubcarrRandomizer. After IFFT and cyclic prefix insertion, the idle interval and uplink payload are combined with zero padding bits if needed by WMAN_M_Commutator. In addition, downlink position will be preserved and filled with zeros before uplink payload if FrameMode is TDD.
At last, a symbol windowing is implemented to smooth the transitions between the consecutive OFDM symbols in the subframe.

4. Parameter Details.
    - ROut is the RF output resistance.
    - RTemp is the RF output resistance temperature in Celsius and sets the noise density in the RF output signal to (k(RTemp+273.15)) Watts/Hz, where k is Boltzmann's constant.
    - FCarrier is the RF output signal frequency.
    - Power is used to set the modulator output RF power. This is true for an ideal transmitted signal (no impairments added) or when small impairments are added. If large impairments are added to the signal (using GainImbalance, I_OriginOffset, and Q_OriginOffset parameters) the output RF power may be different from the value of the Power parameter.
    - MirrorSpectrum is used to mirror the RF_out signal spectrum about the carrier. This is equivalent to conjugating the complex RF envelope voltage. Depending on the configuration and number of mixers in an RF transmitter, the RF output signal from hardware RF generators can be inverted. If such an RF signal is desired, set this parameter to YES.
    - GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation are used to add certain impairments to the ideal output RF signal. Impairments are added in the order described here.
      The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:
      $$V_{RF}(t) = A\left(V_I(t)\cos(\omega_c t) - gV_Q(t)\sin\left(\omega_c t + \frac{\Phi\pi}{180}\right)\right)$$
      where A is a scaling factor based on the Power and ROut parameters specified by the user, VI(t) is the in-phase RF envelope, VQ(t) is the quadrature phase RF envelope, g is the gain imbalance
      $$g = 10^{\frac{GainImbalance}{20}}$$
      and, !wman_m-08-10-108.gif!(in degrees) is the phase imbalance.
      Next, the signal VRF(t) is rotated by IQ_Rotation degrees. The I_OriginOffset and Q_OriginOffset are then applied to the rotated signal. Note that the amounts specified are percentages with respect to the output rms voltage. The output rms voltage is given by sqrt(2×ROut×Power).
    - Bandwidth determines the nominal channel bandwidth.
    - OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
    - FFTSize indicates the FFT point size (512, 1024, or 2048). The FFT size is independent of the selected bandwidth.
    - CyclicPrefix (G) specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
    - FrameMode determines what will actually be included in the generated waveform. FDD Mode means the entire frame is used for the uplink and the uplink starts at the beginning of the frame. TDD Mode means only the uplink is included in the generated waveform and it starts at some delay from the frame start time based on the Downlink Ratio setting.
    - DL_Ratio set the percentage (1 to 99) of the frame time to be used for the downlink and also set the start time for the uplink. The parameter is only active when the frame mode is TDD.
    - FrameDuration determines the frame durations (ms) of the generated waveform. There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
    - IdleInterval specifies the time of idle interval between two consecutive frames.
    - PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to Table 309 in the standard.
    - FrameNumber specifies the frame number(0 to 0xffffff) of the uplink frame.
    - FrameIncreased indicates whether the frame number of the generated waveform is increased one by one.
    - UL_PermBase specifies the permutation base that will be used in this uplink zone. Accepted values are 0

to 69.

- AutoMACHeaderSetting indicates whether the MAC Header is calculated automatically. If it is set to NO, data sequences in parameter MAC_Header will be used before data content, otherwise MAC_Header content will be calculated with parameter DataLength and CID and be used before data content.
- MAC_Header specifies 6 bytes of MAC header before the data contents. The parameter is only active when the AutoMACHeaderSetting is set to NO.
- CRC32_Mode specifies the method for CRC32 calculation appended to MAC PDU. For consistency with 802.16-2004 Cor1/D5, it shall be set to MSB first while shall be set to LSB first for consistency with 802.16-2004 Cor1/D3.
- ZoneType specifies the zone type which can be set to PUSC or OPUSC.
- ZoneNumOfSym specifies the number of symbols in the zone. The value must be a multiple of three because the uplink zone is divided into slots of 3 symbols x 1 subchannel (section 8.4.3.1 in 802.16-2004/Cor/D3). The maximum number of symbols available depends on the Bandwidth, frame length, DL_Ratio, FFTSize, and CyclicPrefix.
- NumberOfBurst specifies the number of active uplink bursts.
- BurstWithFEC specifies the uplink burst FEC.
- BurstSymOffset positions each burst on the horizontal axis (x), if necessary, to avoid any burst overlap. The parameter is an array element .
- BurstSubchOffset positions each burst on the vertical axis (y), if necessary, to avoid any burst overlap. The parameter is an array element.
- BurstAssignedSlot specifies the total available slots in each burst. The parameter is an array element.
- DataLength is the array of each burst's MAC PDU payload data length in bytes.
- CodingType is the array of each burst's coding type which can be set to CC or CTC.
- Rate_ID is the array of each burst's Rate ID, whose range is from 0 to 6 for CC encoding and from 0 to 7 for CTC encoding. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in the following table.

The Relation between Coding Type and Rate ID

Coding type	Rate ID	Modulation-Code rating
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. The parameter is an array element and only available when QPSK 1/2 or QPSK 3/4 is selected as the burst profile (Rate_ID). Each repetition coding can be selected from 0 to 3, whose meaning is shown in the following table.

The Meaning of Repetition Coding

Repetition coding	meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4 used on the burst
3	Repetition coding of 6 used on the burst

- BurstPowerOffset determines the power offset of each burst in dB. The parameter is an array element.
- PowerType specifies the exact meaning of the parameter Power in RF source. Two types are defined in uplink (Type I: Peak power; Type II: Burst power when all subchs occupied). Type I is recommended for

transmitter measurement; Type II is recommended for receiver measurement. For more information, please refer to *Transmit Power Definition* (wman_m).

5. Samples per frame
The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-08-10-109.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in the following table.

Sampling Factor Requirement

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval(!wman_m-08-10-111.gif!) is calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

So, the total samples of one uplink frame $Samples_{Frame}$ is

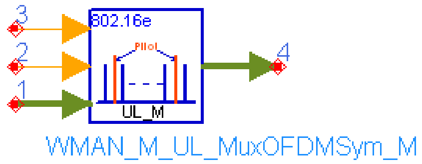
$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

This model works frame by frame. Each firing,
$8 \times DataLength[BurstWithFEC]$ tokens are consumed at pin MAC_PDU,
$Samples_{Frame}$ tokens are produced at pin FrameData,
$\sum_{i=1}^{NumberOfBurst} BurstAssignedSlot[i] \times 48$ tokens are produced at pin Constellation,
$8 \times DataLength[BurstWithFEC] + 80$ tokens are produced at pin PDUFCS.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_MuxOFDMSym_M (802.16e OFDMA Uplink Mux OFDM symbols in Matrix)



Description: Uplink OFDM symbol multiplexer with matrix
Library: WMAN 16e, MIMO Source

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24	int	[3,1212]
NumberOfBurst	Number of Bursts	1	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}	int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}	int array	[1,6868]
BurstPowerOffset	Power offset of each burst in dB	{0}	real array	(-∞,∞)
RangingBurst	The input is ranging burst or not: NO, YES	NO	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	UL_Bursts	input of UL bursts	complex matrix
2	BurstPos	input of the position of bursts	int
3	PilotPos	input of the position of pilots	int

Pin Outputs

Pin	Name	Description	Signal Type
4	UL_OFDMSym	output of UL OFDM symbols	complex matrix

Notes/Equations

1. This model is used to multiplex the uplink constellation-mapped data sequences and pilots into the physical subcarriers according to the zone permutation. The function of this model is the same as WMAN_M_UL_MuxOFDMSym except data sequences at pin UL_Bursts and pin UL_OFDMSym are both in matrix. The dimension and array architecture of the matrix at pin UL_Bursts and pin UL_OFDMSym are the same.
2. Each firing,
   $$\sum_{i=1}^{NumberOfBurst} (BurstAssignedSlot[i]) \times 48$$ tokens are consumed at pin UL_Bursts in matrix.
   $$\sum_{i=1}^{NumberOfBurst} (BurstAssignedSlot[i]) \times 48$$ tokens are consumed at pin BurstPos.
   $$\sum_{i=1}^{NumberOfBurst} (BurstAssignedSlot[i]) \times NumOfPilotSubcarrier$$ tokens are consumed at pin PilotPos.
   $(ZoneNumOfSym) \times UsedCarriers$ tokens are produced at pin UL_OFDMSym in matrix.

where, NumOfPilotSubcarrier is dependent on the zone type and FFT size according to the specification, shown in the following table.

The Calculation of NumOfPilotSubcarrier

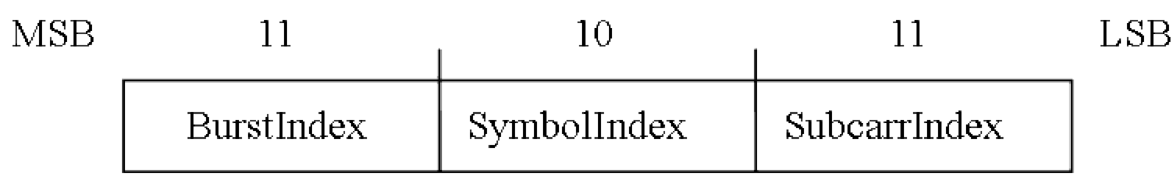
Zone type	FFT size	NumOfPilotSubcarrier
UL_PUSC	2048	24
UL_PUSC	1024	24
UL_PUSC	512	24
UL_OPUSC	2048	6
UL_OPUSC	1024	6
UL_OPUSC	512	6

UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in the following table.

The Calculation of UsedCarriers

Zone type	FFT size	UsedCarriers
UL_PUSC	2048	1680
UL_PUSC	1024	840
UL_PUSC	512	408
UL_OPUSC	2048	1728
UL_OPUSC	1024	864
UL_OPUSC	512	432

3. The i-th constellation-mapped point from pin UL_Bursts is mapped onto the position (indexed by [SymbolIndex, SubcarrierIndex]) which is defined by the i-th value from pin BurstPos. BurstPos is the index of symbol and subcarrier for the constellation-mapped data in each burst. The format of BurstPos is defined in the following figure.



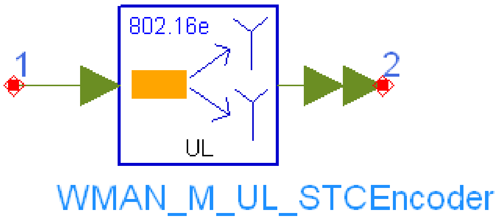
The Format of BurstPos and PilotPos

4. The constant gain (1 for UL_PUSC and 4/3 for UL_OPUSC) is mapped onto the positions (indexed by [SymbolIndex, SubcarrierIndex]) which is defined by the values from pin PilotPos. PilotPos is the index of symbol and subcarrier for the pilots which is defined in the previous figure.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_STCEncoder (802.16e OFDMA Uplink STC Encoder)



Description: Uplink STC encoder
Library: WMAN 16e, MIMO Source

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_2048	enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC	UL_PUSC	enum	
ZoneNumOfSym	Number of symbols of the zone	16	int	[3,1212]
NumOfAnt	Number of transmitting antennas: Ant1, Ant2, Ant4	Ant1	enum	
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	
Collaborative	Two SSs collaborative spatial multiplexing or not (valid only when NumOfAnt is Ant2 and STC_Matrix is Matrix_B): NO, YES	NO	enum	
TilePattern	The uplink tile pattern used by the SS (valid only when Collaborative is valid and is YES): Pattern_A, Pattern_B	Pattern_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	OFDM_Symbol	input of OFDM symbols	complex matrix

Pin Outputs

Pin	Name	Description	Signal Type
2	STC_Symbol	output of STC-encoded symbols	multiple complex

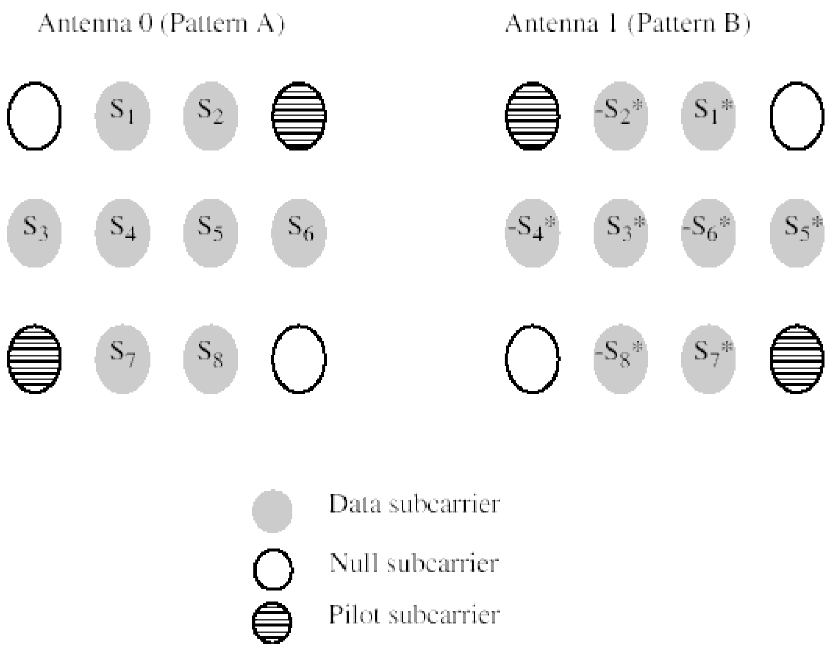
Notes/Equations

1. This model is used to encode the uplink bursts with STC 2x1, collaborative SM and MIMO 2x2.
2. Each firing,
    1. when STC_Encoder is set to YES, $3 \times UsedCarriers$ tokens are consumed at pin OFDM_Symbol; $3 \times UsedCarriers$ tokens are produced at pin STC_Symbol.
    2. when STC_Encoder is set to NO, UsedCarriers tokens are consumed at pin OFDM_Symbol; UsedCarriers tokens are produced at pin STC_Symbol.
    UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in the following table.

    The Calculation of UsedCarriers

Zone type	FFT size	UsedCarriers
UL_PUSC	2048	1680
UL_PUSC	1024	840
UL_PUSC	512	408
UL_OPUSC	2048	1728
UL_OPUSC	1024	864
UL_OPUSC	512	432
3. The STC encoder is performed on the tile one by one. The pilots in each tile shall be split between the two

antennas and the data subcarriers shall be encoded in pairs after constellation mapping, as depicted in the following figure. The tile structure for STC PUSC using 2 antennas is shown in the figure (taken from Figure 249 in 802.16e-2005).



Tile structure for STC PUSC in 2 Antennas and STTD mode

4. Three operation modes are supported in this model: STC 2x1, Two-user collaborative SM and MIMO 2x2. Only UL PUSC permutations is supported in all the modes.
    1. STC 2x1 (NumOfTxAnt=Ant2, STC_Encoder=Yes, STC_Matrix=Matrix_A, Collaborative=NO)
       The dimension of the complex matrix at pin OFDM_Symbol is 1x1.
       The number of ports at pin STC_Symbol is 2. The first port at output pin is for antenna 0 and the second port is for antenna 1.
       In this mode, Alamouti algorithm is employed. STC rate 1 encoding shall be performed after constellation mapping and before subcarrier randomization. The STC rate 1 coding is done on all data subcarriers according to the tile pattern in the previous figure.
       Pilot subcarriers are not encoded and are transmitted from either antenna 0 or antenna 1. In STC mode with UL PUSC permutations, the power of pilot subcarriers shall be further scaled so that the total power transmitted by each antenna, is equal to the total power transmitted in non-STC mode, ignoring data boosting. Consequently the power of pilot subcarriers are boosted by 3dB if they are transmitted from either antenna 0 or antenna 1.
    2. Two-user collaborative SM (Spatial Multiplexing) (NumOfTxAnt=Ant1, STC_Encoder=Yes, STC_Matrix=Matrix_B, Collaborative=Yes)
       The dimension of the complex matrix at pin OFDM_Symbol is 1x1.
       The number of ports at pin STC_Symbol is 1.
       In this mode, the input data symbols are mapped to antenna 0 (Pattern A) or antenna 1 (Pattern B) according to the parameter TilePattern. The data mapping to antennas is same as that in non-STC mode except pilots.
       The transmission of pilot subcarriers is the same as that in STC 2x1 mode.
    3. MIMO 2x2 (NumOfTxAnt=Ant2, STC_Encoder=Yes, STC_Matrix=Matrix_B, Collaborative=NO)
       The dimension of the complex matrix at pin OFDM_Symbol is 2x1.
       The number of ports at pin STC_Symbol is 2. The first port at output pin is for antenna 0 and the second port is for antenna 1.
       The data symbols in the first row of complex matrix at the input pin OFDM_Symbol are mapped to antenna 0 and those in the second row are mapped to antenna 1. The data mapping to antennas is same as that in non-STC mode except pilots.
       The transmission of pilot subcarriers is the same as that in STC 2x1 mode.

References

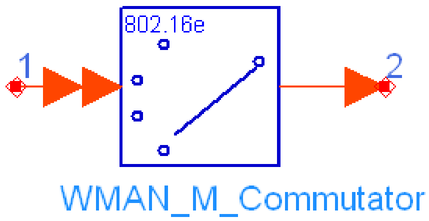
1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

802.16e OFDMA Multiplex Components

The 16e multiplex models provide framing and de-framing in 802.16e OFDMA transceiver.

- *WMAN M Commutator (802.16e OFDMA Commutator)* (wman_m)
- *WMAN M Distributor (802.16e OFDMA Distributor)* (wman_m)
- *WMAN M DL BurstWoFEC (802.16e OFDMA Downlink Burst Without FEC Generator)* (wman_m)
- *WMAN M DL DemuxBurst (802.16e OFDMA Downlink Demultiplex Burst)* (wman_m)
- *WMAN M DL DemuxFrame (802.16e OFDMA DL Frame Demuxer)* (wman_m)
- *WMAN M DL DemuxOFDMSym (802.16e OFDMA Downlink Demux OFDM Symbols)* (wman_m)
- *WMAN M DL MuxBurst (802.16e OFDMA Downlink Multiplex Burst)* (wman_m)
- *WMAN M DL MuxOFDMSym (802.16e OFDMA Downlink Mux OFDM Symbols)* (wman_m)
- *WMAN M UL BurstWoFEC (802.16e OFDMA Uplink Burst Without FEC Generator)* (wman_m)
- *WMAN M UL DemuxBurst (802.16e OFDMA Uplink DemuxBurst)* (wman_m)
- *WMAN M UL DemuxFrame (802.16e OFDMA UL Frame Demuxer)* (wman_m)
- *WMAN M UL DemuxOFDMSym (802.16e OFDMA UL DemuxOFDMSym)* (wman_m)
- *WMAN M UL MuxBurst (802.16e OFDMA Uplink MuxBurst)* (wman_m)
- *WMAN M UL MuxOFDMSym (802.16e OFDMA Uplink Mux OFDM Symbols)* (wman_m)

WMAN_M_Commutator (802.16e OFDMA Commutator)



Description: Data commutator
Library: WMAN 16e, Multiplex

Parameters

Name	Description	Default	Type	Range
BlockSizes	Block sizes read from each input	{1}	int array	[0,∞)
BlockEnable	If each block is enabled to output (0: disable, 1: enable)	{1}	int array	[0,1]

Pin Inputs

Pin	Name	Description	Signal Type
1	input	input signal	multiple anytype

Pin Outputs

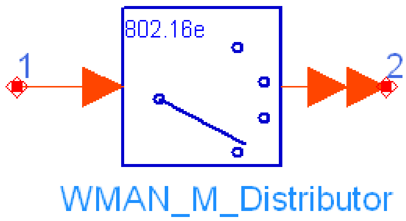
Pin	Name	Description	Signal Type
2	output	output signal	anytype

Notes/Equations

1. This model is used to take N input streams, where N is the input bus width, and asynchronously combines the streams into one output stream.

Each firing, Bi input particles are consumed from input #i (i=1, ... , N), where Bi are the elements of the BlockSizes parameter. It produces $\sum_{i=1}^{N} BlockEnable[i] \times B_i$ particles on the output, where the particles from i-th input stream are put into the output stream if BlockEnable[i] is set to 1 (Yes) and the particles are discarded if BlockEnable[i] is set to 0 (No). The first B1 particles on the output come from the first input if BlockEnable[1] is 1, and the next B2 particles come from the second input if BlockEnable[2] is 1, and so on.

WMAN_M_Distributor (802.16e OFDMA Distributor)



Description: Data distributor
Library: WMAN 16e, Multiplex

Parameters

Name	Description	Default	Type	Range
BlockSizes	Block sizes for each output	{1}	int array	[0,∞)
BlockEnable	If each block is enabled to output (0: disable, 1: enable)	{1}	int array	[0,1]

Pin Inputs

Pin	Name	Description	Signal Type
1	input	input signal	anytype

Pin Outputs

Pin	Name	Description	Signal Type
2	output	output signal	multiple anytype

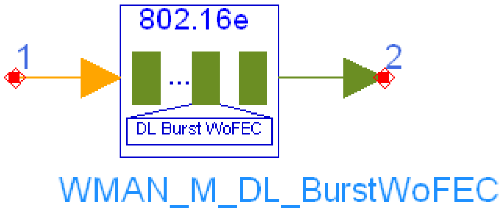
Notes/Equations

1. This model is used to take one input streams and asynchronously splits it into N output streams, where N is the output bus width.

   Each firing,

   It consumes $\sum_{i=1}^{N} BlockEnable[i] \times B_i$ particles from the input, where Bi (i=1, ... , N) are the elements of the BlockSizes parameter. Bi output particles on output#i (i= 1, ... , N) are produced, where the Bi particles come from the input if *BlockEnable[i]* is set to 1 (Yes), and the Bi particles are set to zeros if *BlockEnable[i]* is set to 0 (No).
   The particles on the first output are the first B1 particles of the input if *BlockEnable[1]* is 1, and the particles on the second output are the next B2 particles of the input *BlockEnable[2]* is 1, and so on.

WMAN_M_DL_BurstWoFEC (802.16e OFDMA Downlink Burst Without FEC Generator)



Description: Downlink bursts without FEC generator
Library: WMAN 16e, Multiplex

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbols in zone	24	int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}	int array	[0,1]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
NumberOfBurst	Number of Bursts	2	int	[1,8]
BurstWithFEC	The number of burst with FEC	1	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}	int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,14}	int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}	int array	[1,60]
DataLength	MAC PDU payload byte length of each burst	200 300	int array	[1,∞)
CodingType	Coding type of each burst	0 0	int array	[0,1]
Rate_ID	Rate ID of each burst	5 5	int array	[0,7]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	input	input data bits	int

Pin Outputs

Pin	Name	Description	Signal Type
2	output	signal after constellation mapping	complex

Notes/Equations

1. This model is used to generate data signal after constellation mapper of the bursts without FEC.
2. Each firing,

   if $NumberOfBurst = 1$, 1 tokens are consumed and produced and the output is 0.

If $NumberOfBurst > 1$, Nbits tokens are consumed, where Nbits is defined as follows:

$$N_{bits} = \sum_{i=1, i \neq BurstWithFEC}^{NumberOfBurst} N_{slot}[i] \times 48 \times N_{bitspersymbol}[i]$$

where, Nslot[i] is the number of slots of the i-th burst and can be computed as:

$$N_{slot}[i] = BurstNumOfSym[i] \times BurstNumOfSubch[i] / N_{SymPerSlot}$$

$N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC.

Nbitspersymbol[i] is the number of bits of the i-th burst according to constellation mapping and the data-rate-dependent parameters are defined in the following table:

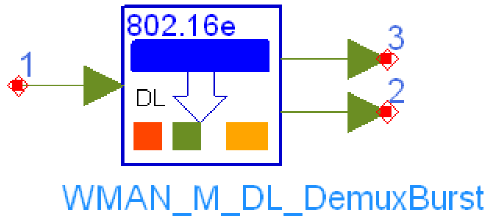
Data-Rate-dependent Parameters

Rate ID	Modulation	bits/symbol
0	QPSK	2
1	QPSK	2
2	16-QAM	4
3	16-QAM	4
4	64-QAM	6
5	64-QAM	6
6	64-QAM	6
7	64-QAM (only for CTC)	6

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_DemuxBurst (802.16e OFDMA Downlink Demultiplex Burst)



Description: Downlink burst demultiplexer
Library: WMAN 16e, Multiplex

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbols in zone	24	int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}	int array	[0,1]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
NumberOfBurst	Number of Bursts	2	int	[1,8]
BurstWithFEC	The number of burst with FEC	1	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}	int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,14}	int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}	int array	[1,60]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataMux	input data including the data with FEC coding and without FEC coding	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	DataWithFEC	output data with FEC	complex
3	DataWoFEC	output data without FEC	complex

Notes/Equations

1. This model is used to demultiplex one downlink complete sequence into downlink coded burst and uncoded bursts.
2. Each firing:

$$\left(\sum_{i=1}^{NumberOfBurst} N_{AssignedSlot}[i]\right) \times 48$$

tokens are consummed at pin DataMux,

where!wman_m-09-05-013.gif! is the number of slots assigned to the i-th burst.

$N_{AssignedSlot}[i]$ is decided by BurstNumOfSym, BurstNumOfSubch and ZoneType as follows:

$$N_{AssignedSlot}[i] = floor((BurstNumOfSym[i])/N_{SymbolsPerSlot}) \times BurstNumOfSubch[i]$$

$N_{SymbolsPerSlot}$ is the number of OFDMA symbols within one downlink slot which is decided by ZoneType.

If ZoneType is set to "PUSC",

then $N_{SymbolsPerSlot}$ equals to two,

else $N_{SymbolsPerSlot}$ equals to one.

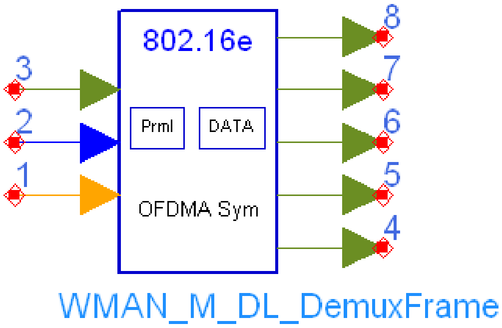
$N_{AssignedSlot}[BurstWithFEC] \times 48$ tokens are produced at pin DataWithFEC.

$$\left(\sum_{i=1, i \neq BurstWithFEC}^{NumberOfBurst} N_{AssignedSlot}[i] \right) \times 48$$ tokens are produced at pin DataWoFEC.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_DemuxFrame (802.16e OFDMA DL Frame Demuxer)



Description: Downlink frame demultiplexer
Library: WMAN 16e, Multiplex

Parameters

Name	Description	Default	Unit	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of symbol in zone	6		int	[1,1212]
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
IdleInterval	Idle interval	10 usec	sec	real	[0,20000]
Bandwidth	Bandwidth	3.5 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 1		enum	
CyclicPrefix	Cyclic prefix	0.25		real	[0,1]
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
FrameStartSym	Start symbol number of frame	0		int	[0,1212]
FrameStopSym	Stop symbol number of frame	0		int	[0,1212]
WindowLength	The length for the window in unit of chips (without oversampling)	16		int	[0,96]

Pin Inputs

Pin	Name	Description	Signal Type
1	index	synchronization index	int
2	DeltaF	carrier frequency offset	real
3	input	input of downlink frame	complex

Pin Outputs

Pin	Name	Description	Signal Type
4	preamble	output preamble for channel estimation	complex
5	FCH	output FCH and DL_MAP if enable	complex
6	UL_MAP	output UL_MAP	complex
7	data	output data sequence	complex
8	frame	output frame data with cyclic prefix and frequency offset	complex

Notes/Equations

1. This model is used to demultiplex downlink frame into data symbol and preamble which is used for synchronization. Idle interval, cyclic prefix and zero padding are removed, and time and carrier frequency offsets are compensated before demultiplexing.
2. Each firing:

$Samples_{Frame}$ tokens are consumed at pin input,

where $Samples_{Frame}$ is the total sample of one downlink frame including zero padding and calculated as follows:

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

where $Samples_{idle}$ is the samples of *IdleInterval* and calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

Fs is the sampling frequency decided by Bandwidth, OversamplingOption and related sampling factor N_{factor} as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in the following table:

Sampling Factor Requirement

Sampling Factor n	Bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

- 1 token is consumed at pin index which indicates the value of synchronization index.
- 2 tokens are consumed at pin DeltaF. The first indicates the phase difference between adjacent subcarriers caused by coarse time synchronization and used to achieve fine time synchronization and the second indicates the value of carrier frequency offset.
- $Samples_{FFTSize}$ tokens are produced at pin preamble, where $Samples_{FFTSize}$ decided by FFTSize and OversamplingOption and calculated as follows:
  $$Samples_{FFTSize} = 2048/(2^{FFTSize}) \times 2^{OversamplingOption}$$
- $Samples_{FFTSize} \times 2$ tokens are produced at pin FCH.
- $Samples_{FFTSize} \times 2$ tokens are produced at pin UL_MAP, if the parameter ULMAP_Enable is set to "No", the output sequences are zeros.
- $Samples_{FFTSize} \times N_{DataSymbol}$ tokens are produced at pin data, where $N_{DataSymbol}$ is the number of OFDMA symbols of all the downlink bursts in the zone. $N_{DataSymbol}$ is decided by ZoneType and ZoneNumOfSym. If the ZoneType is set to "PUSC", then
  $N_{DataSymbol} = ZoneNumOfSym - 2$
  else
  $N_{DataSymbol} = ZoneNumOfSym$
- $Samples_{FFTSize} \times (1 + CP) \times N_{FrameSymbol}$ tokens are produced at pin frame, where $N_{FrameSymbol}$ is the number of OFDMA symbols of the entire downlink frame excluding zero padding and idle interval. $N_{FrameSymbol}$ is decided by ZoneNumOfSym and ZoneType as follows.
  - When FrameStartSym=0 and FrameStopSym=0
    When ZoneType is set to "PUSC" then

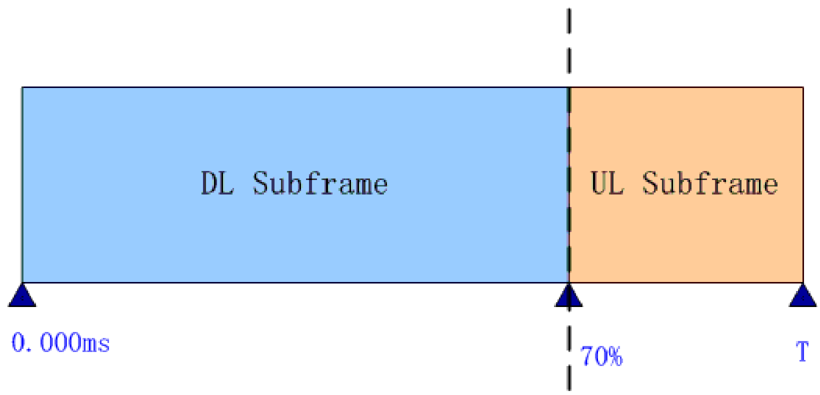
    else

  - When FrameStartSym < FrameStopSym

    Carrier frequency offsets are not compensated to the output sequences.

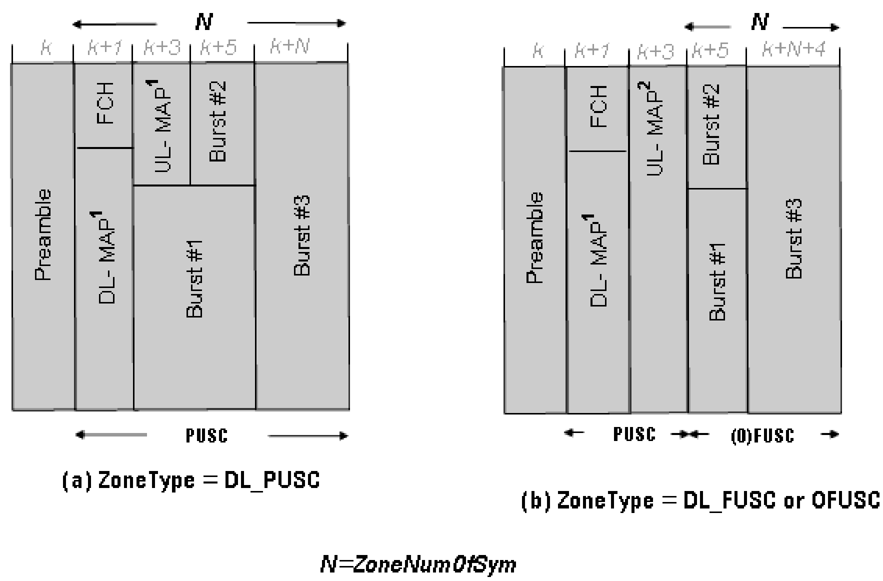
3. Frame structure:
   The next illustration shows the frame format in TDD mode which allocates 70% frame time for the downlink

subframe. If FrameMode is set to FDD, 100% frame time will be used for the downlink subframe and the parameter DL_Ratio will be noneffective.



802.16e OFDMA Frame Structure for TDD Mode

The following illustration shows the downlink frame format, which includes: preamble, FCH, DL_MAP and UL_MAP if enabled and one or multiple downlink bursts each transmitted with different burst profile.



WMAN DL Subframe Structure

The downlink preamble is transmitted in one OFDMA symbols.
FCH is transmitted by two OFDMA symbols in PUSC mode.

4. Output pin delay adjustment
   Because of the transmission delay, a detected frame usually falls into 2 consecutive received blocks, so the buffer length for input Pin is $2 \times Samples_{Frame}$. The first element of DeltaF is the phase difference between adjacent subcarriers ω caused by coarse time synchronization and used to calculate index dithering $\Delta Index$ for pin Index. The start point of the detected frame ($Index_f$) is determined by the input signal at pin index combined with the $\Delta Index$. Only after receiving the second input block, this model can output one actual frame. So this model causes one frame delay.
5. The second element of DeltaF pin inputs the estimated frequency offset Δf_i of each received frame.

The i-th estimated frequency offset Δf_i compensates for the phase in the current frame only. Assume

$x_0, x_1, \ldots, x_{Samples_{Frame}-1}$ sequences are the input signals from the input pin, $y_0, y_1, \ldots, y_{Samples_{Frame}-1}$ are the sequences, whose phase caused by frequency offset, are removed, then:

$$y_k = x_k \times e^{-j2\pi\Delta f_i k T_{Step}}$$

where:

Δf_i is frequency offset of the i-th received frame which is the second element of the input Pin DeltaF,

$T_{Step} = \dfrac{1}{F_s \times 2^{OversamplingOption}}$ is the sample time interval in the system.

After making frequency offset compensation, the preamble, FCH , UL_MAP and data will be extracted and output at pin preamble, FCH , UL_MAP and data respectively.

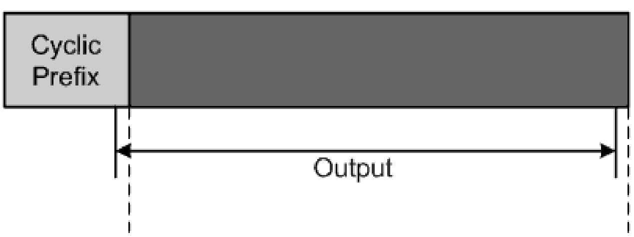
The total frame sequences discarding idle and zero padding are output at pin frame. The output sequences from pin frame is only time synchronized and can be used to calculate CCDF.Pin Index inputs the start point of a detected downlink frame (including idle).

$\Delta Index = (FFTSize \times \omega)/2\pi \times OversamplingOption$.

The fine index (Index $_f$) is used to extract data sequences where $Index_f = Index - \Delta Index$.

The output data sequences extracted from the OFDMA symbols begin from the CP; that is, $Samples_{FFT} \times CyclicPrefix$.

The cyclic prefix removal process is shown in the following illustration:



Cyclic Prefix Removal

To decrease the influence caused by WMAN_M_SymWindow, an offset is used to extract the data sequences of one OFDM symbol.

The Offset is calculated as follows:

if $WindowLength > 1.75 \times CyclicPrefix$

then $Offset = CyclicPrefix$

else then $Offset = (WindowLength)/2 + (CyclicPrefix)/8$.

The output sequence is:

if $k > Samples_{FFT} - Offset \times OversamplingOption$

then $z_k = y_{k + Index_f + Samples_{FFT} \times CyclicPrefix - Samples_{FFT}}$

else $z_k = y_{k + Index + Samples_{FFT} \times CyclicPrefix}, k = 0, \ldots, Samples_{Frame} - 1$

where $k = 0, \ldots, Samples_{Frame} - 1$.

$z_0, z_1, \ldots, z_{Samples_{FFT} \times N_{FrameSymbol} - 1}$ sequences including data payload and preamble.

The input Index is used to extract data sequences for pin Frame.

Assume:

sequences are the output sequences for the output pin Frame, so

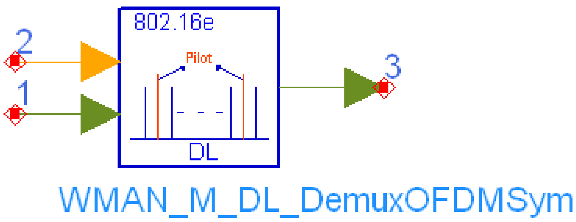
where:

.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_DemuxOFDMSym (802.16e OFDMA Downlink Demux OFDM Symbols)



Description: Downlink demux OFDM symbol
Library: WMAN 16e, Multiplex

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbols in zone	24	int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}	int array	[0,1]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
NumberOfBurst	Number of Bursts	2	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}	int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,14}	int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}	int array	[1,60]
PowerBoosting	Power boosting of each burst in dB	{0,0}	real array	(-∞,∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	DL_OFDMSym	output of DL OFDM symbols	complex
2	BurstPos	input of the position of bursts	int

Pin Outputs

Pin	Name	Description	Signal Type
3	DL_Bursts	input of DL bursts	complex

Notes/Equations

1. This model is used to de-multiplex the physical subcarriers into the constellation-mapped data sequences and pilots according to the zone permutation.
2. Each firing,

$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48/N_{SymPerSlot}$$

tokens are consumed at pin BurstPos.

$(ZoneNumOfSym) \times UsedCarriers$ tokens are consumed at pin DL_OFDMSym.

$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48/N_{SymPerSlot}$$

tokens are produced at pin DL_Bursts.

where, $N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC. NumOfPilotSubcarrier is dependent on the zone type and FFT size according to the specification, shown in "The Calculation of NumOfPilotSubcarrier".

The Calculation of NumOfPilotSubcarrier

Zone type	FFT size	UsedCarriers
DL_PUSC	2048	1680
DL_PUSC	1024	840
DL_PUSC	512	420
DL_FUSC	2048	1702
DL_FUSC	1024	850
DL_FUSC	512	426
DL_OFUSC	2048	1728
DL_OFUSC	1024	864
DL_OFUSC	512	432

UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in "The Calculation of UsedCarriers".

The Calculation of UsedCarriers

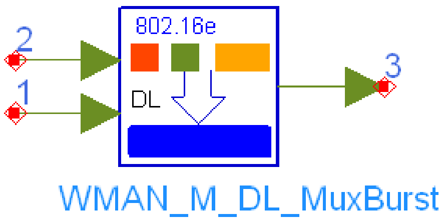
Zone type	FFT size	NumOfPilotSubcarrier
DL_PUSC	2048	8*60
DL_PUSC	1024	8*30
DL_PUSC	512	8*15
DL_FUSC	2048	166
DL_FUSC	1024	82
DL_FUSC	512	42
DL_OFUSC	2048	192
DL_OFUSC	1024	96
DL_OFUSC	512	48

3. This mode performs the reverse operations against WMAN_M_DL_MuxOFDMSym. For more details, refer to WMAN_M_DL_MuxOFDMSym.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_MuxBurst (802.16e OFDMA Downlink Multiplex Burst)



Description: Downlink burst multiplexer
Library: WMAN 16e, Multiplex

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbols in zone	24	int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}	int array	[0,1]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
NumberOfBurst	Number of Bursts	2	int	[1,8]
BurstWithFEC	The number of burst with FEC	1	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}	int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,14}	int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}	int array	[1,60]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataWithFEC	input data with FEC	complex
2	DataWoFEC	input data without FEC	complex

Pin Outputs

Pin	Name	Description	Signal Type
3	DataMux	output data including the data with FEC coding and without FEC coding	complex

Notes/Equations

1. This model is used to multiplex downlink coded burst and uncoded bursts into one downlink complete sequence in frequency domain. The coded burst can occupy anywhere of downlink bursts.
2. Each firing:

$$\left(\sum_{i=1}^{NumberOfBurst} N_{AssignedSlot}[i]\right) \times 48$$

tokens are produced at pin DataMux,

where!wman_m-09-08-077.gif! is the number of slots assigned to the i-th burst.

$N_{AssignedSlot}[i]$ is decided by BurstNumOfSym, BurstNumOfSubch and ZoneType as follows:

$$N_{AssignedSlot}[i] = floor((BurstNumOfSym[i])/N_{SymbolsPerSlot}) \times BurstNumOfSubch[i]$$

$N_{SymbolsPerSlot}$ is the number of OFDMA symbols within one downlink slot which is decided by ZoneType.

If ZoneType is set to "PUSC",

then $N_{SymbolsPerSlot}$ equals to two, else $N_{SymbolsPerSlot}$ equals to one.

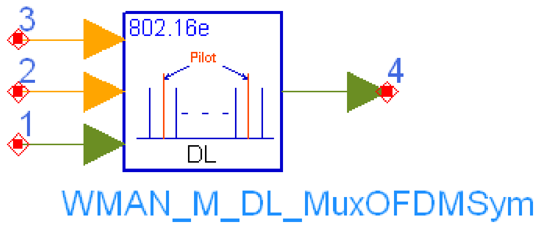
$N_{AssignedSlot}[BurstWithFEC] \times 48$ tokens are consumed at pin DataWithFEC.

$$\left(\sum_{i=1, i \neq BurstWithFEC}^{NumberOfBurst} N_{AssignedSlot}[i] \right) \times 48$$ tokens are consumed at pin DataWoFEC.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.

WMAN_M_DL_MuxOFDMSym (802.16e OFDMA Downlink Mux OFDM Symbols)



Description: Downlink mux OFDM symbol
Library: WMAN 16e, Multiplex

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbols in zone	24	int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}	int array	[0,1]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
NumberOfBurst	Number of Bursts	2	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}	int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,14}	int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}	int array	[1,60]
PowerBoosting	Power boosting of each burst in dB	{0,0}	real array	(-∞,∞)
PilotInserting	Pilot inserting or not: NO, YES	NO	enum	
PreambleIndex	Preamble index	4	int	[0,113]
DedicatedPilot	Is the dedicated pilot mode employed for DL PUSC or AMC zone: NO, YES	NO	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DL_Bursts	input of DL bursts	complex
2	BurstPos	input of the position of bursts	int
3	PilotPos	input of the position of pilots	int

Pin Outputs

Pin	Name	Description	Signal Type
4	DL_OFDMSym	output of DL OFDM symbols	complex

Notes/Equations

1. This model is used to multiplex the constellation-mapped data sequences and pilots into the physical subcarriers according to the zone permutation.
2. Each firing,

$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 / N_{SymPerSlot}$$

tokens are consumed at pin DL_Bursts and at pin BurstPos.

$(ZoneNumOfSym)/N_{SymPerSlot} \times NumOfPilotSubcarrier$ tokens are consumed at pin PilotPos.

$(ZoneNumOfSym) \times UsedCarriers$ tokens are produced at pin DL_OFDMSym.

where, $N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC. NumOfPilotSubcarrier is dependent on the zone type and FFT size according to the specification, shown in "The Calculation of NumOfPilotSubcarrier".

The Calculation of NumOfPilotSubcarrier

Zone type	FFT size	NumOfPilotSubcarrier
DL_PUSC	2048	8*60
DL_PUSC	1024	8*30
DL_PUSC	512	8*15
DL_FUSC	2048	166
DL_FUSC	1024	82
DL_FUSC	512	42
DL_OFUSC	2048	192
DL_OFUSC	1024	96
DL_OFUSC	512	48

UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in "The calculation of UsedCarriers".
The calculation of UsedCarriers

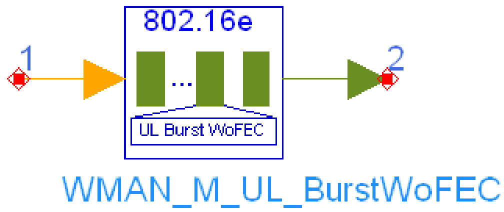
Zone type	FFT size	UsedCarriers
DL_PUSC	2048	1680
DL_PUSC	1024	840
DL_PUSC	512	420
DL_FUSC	2048	1702
DL_FUSC	1024	850
DL_FUSC	512	426
DL_OFUSC	2048	1728
DL_OFUSC	1024	864
DL_OFUSC	512	432

3. The i-th the constellation-mapped point from pin DL_Bursts is mapped onto the position (indexed by [SymbolIndex, SubcarrierIndex]) which is defined by the i-th value from pin BurstPos. BurstPos is the index of symbol and subcarrier for the constellation-mapped data in each burst. The 11 least significant bits of BurstPos is defined as the index of subcarrier, and the 21 most significant bits of BurstPos is defined as the index of symbol.
4. If PilotInserting is set to YES, the constant gain (4/3) is mpped onto the positions (indexed by [SymbolIndex, SubcarrierIndex]) which is defined by the values from pin PilotPos. PilotPos is the index of symbol and subcarrier for the pilots. The 11 least significant bits of PilotPos is defined as the index of subcarrier, and the 21 most significant bits of PilotPos is defined as the index of symbol.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_BurstWoFEC (802.16e OFDMA Uplink Burst Without FEC Generator)



Description: Uplink bursts without FEC generator
Library: WMAN 16e, Multiplex

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24	int	[3,1212]
NumberOfBurst	Number of Bursts	1	int	[1,8]
BurstWithFEC	The number of burst with FEC	1	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}	int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}	int array	[1,6868]
DataLength	MAC PDU payload byte length of each burst	300	int array	[1,∞)
CodingType	Coding type of each burst	0	int array	[0,1]
Rate_ID	Rate ID of each burst	3	int array	[0,7]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B, Matrix_C	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	input	input data bits	int

Pin Outputs

Pin	Name	Description	Signal Type
2	output	signal after constellation mapping	complex

Notes/Equations

1. This model is used to generate data signal after constellation mapper of the bursts without FEC.
2. Each firing,

   if $NumberOfBurst = 1$, 1 tokens are consumed and produced and the output is 0.

   If $NumberOfBurst > 1$, Nbits tokens are consumed, where Nbits is defined as follows:

$$N_{bits} = \sum_{i=1, i \neq BurstWithFEC}^{NumberOfBurst} BurstAssignedSlot[i] \times 48 \times N_{bitspersymbol}[i]$$

where, BurstAssignedSlot[i] is the number of slots of the i-th burst.

Nbitspersymbol[i] is the number of bits of the i-th burst according to constellation mapping and the data-rate-dependent parameters are defined in "Data-Rate-dependent Parameters".

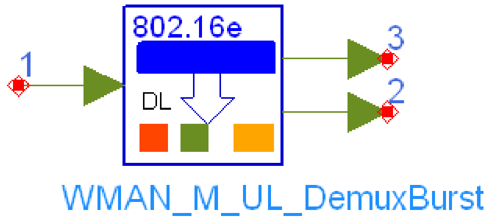
Data-Rate-dependent Parameters

Rate ID	Modulation	Bits/symbol
0	QPSK	2
1	QPSK	2
2	16-QAM	4
3	16-QAM	4
4	64-QAM	6
5	64-QAM	6
6	64-QAM	6
7	64-QAM (only for CTC)	6

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_DemuxBurst (802.16e OFDMA Uplink DemuxBurst)



Description: Uplink burst demultiplexer
Library: WMAN 16e, Multiplex

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24	int	[3,1212]
NumberOfBurst	Number of Bursts	1	int	[1,8]
BurstWithFEC	The number of burst with FEC	1	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}	int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}	int array	[1,6868]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B, Matrix_C	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataMux	output data including the data with and without FEC coding	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	DataWithFEC	input data with FEC	complex
3	DataWoFEC	input data without FEC	complex

Notes/Equations

1. This model is used to demultiplex one complete uplink sequence into coded burst and uncoded bursts in frequency domain. The coded burst can occupy anywhere of uplink bursts.
2. Each firing,

$N_{AssignedSlot}[BurstWithFEC] \times 48$ tokens are produced at pin DataWithFEC.

$$\left(\sum_{i=1, i \neq BurstWithFEC}^{NumberOfBurst} N_{AssignedSlot}[i] \right) \times 48$$

tokens are produced at pin DataWoFEC.

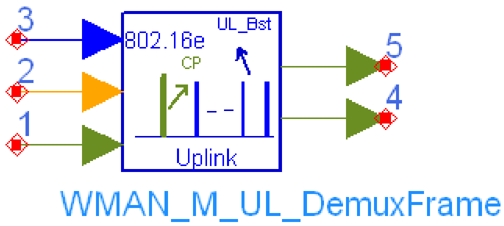
$$\left(\sum_{i=1}^{NumberOfBurst} N_{AssignedSlot}[i] \right) \times 48$$

tokens are consumed at pin DataMux,
where $N_{AssignedSlot}[i]$ is the number of slots assigned to the i-th burst.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_DemuxFrame (802.16e OFDMA UL Frame Demuxer)



Description: Uplink frame demultiplexer
Library: WMAN 16e, Multiplex

Parameters

Name	Description	Default	Unit	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24		int	[3,1212]
NumberOfBurst	Number of Bursts	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}		int array	[1,6868]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 1		enum	
Bandwidth	Bandwidth	10 MHz	Hz	int	(0,1e9]
CyclicPrefix	Cyclic prefix	0.25		real	[0,1]
IdleInterval	Idle Interval	10 usec	sec	real	[0,1000]
FrameDuration	Frame duration (ms): time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Frame mode	0.5		real	[0,01,0.99]
FrameStartSym	Start symbol number of frame	0		int	[0,1212]
FrameStopSym	Stop symbol number of frame	0		int	[0,1212]
WindowLength	The length for the window in unit of chips (without oversampling)	16		int	[0,96]

Pin Inputs

Pin	Name	Description	Signal Type
1	UL_Subframe	received frame signals	complex
2	Index	synchronization index of each burst	int
3	DeltaF	carrier frequency offset	real

Pin Outputs

Pin	Name	Description	Signal Type
4	UL_Bursts	output of uplink data symbol	complex
5	Frame	output of Frame	complex

Notes/Equations

1. This model is used to demultiplex uplink frame into data symbol which is used for synchronization. Idle interval, cyclic prefix and zero padding are removed, and time and carrier frequency offsets are compensated before demultiplexing.
2. Each firing,

$Samples_{Frame}$ tokens are consumed at pin input,
where $Samples_{Frame}$ is the total sample of one uplink frame including zero paddings and calculated as follows:

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

where $Samples_{idle}$ is the samples of Idle Interval and calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

Fs is the sampling frequency decided by Bandwidth, OversamplingOption and related sampling factor (!wman_m-09-12-105.gif!) as follows:

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in the following table.

Sampling Factor Requirement

Sampling Factor n	Bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

1 token is consumed at pin index which indicates the value of synchronization index.
1 token is consumed at pin DeltaF which indicates the value of carrier frequency offset.
$Samples_{FFTSize}$ $Samples_{FFTSize} \times N_{DataSymbol}$ tokens are produced at pin UL_Bursts, where $N_{DataSymbol}$ is the number of OFDMA symbols of all the uplink bursts in the zone. $N_{DataSymbol}$ is decided by ZoneNumOfSym.

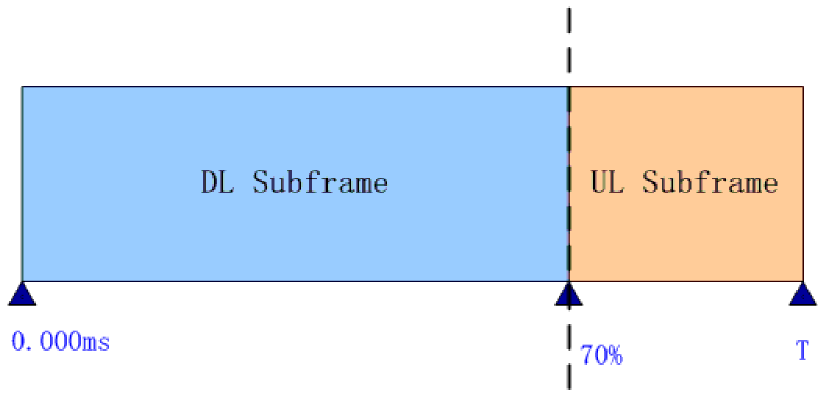
$$N_{DataSymbol} = ZoneNumOfSym$$

When *FrameStartSym=0* and *FrameStopSym=0*
$Samples_{FFTSize} \times (1 + CP) \times N_{FrameSymbol}$ tokens are produced at pin Frame, where $N_{FrameSymbol}$ is the number of OFDMA symbols of the entire uplink frame excluding zero padding and idle interval.
$N_{FrameSymbol}$ is decided by ZoneNumOfSym as follows:

$$N_{FrameSymbol} = ZoneNumOfSym$$

When *FrameStartSym < FrameStopSym*
$Samples_{FFTSize} \times (1 + CP) \times (FrameStopSym - FrameStartSym)$ tokens are produced at pin frame.
Time and carrier frequency offsets are not compensated to the output sequences.

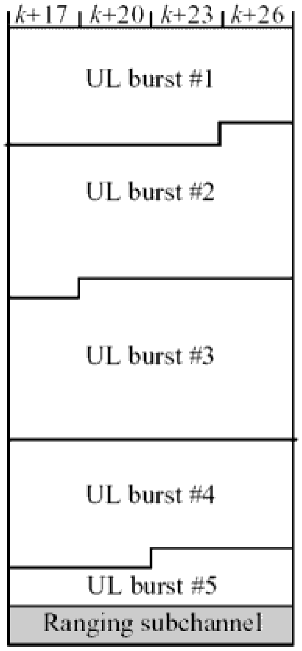
3. Frame structure:
The following illustration shows the frame format in TDD mode which allocates 70% frame time for the downlink subframe filled will zeros. If FrameMode is set to FDD, 100% frame time will be used for the uplink subframe and the parameter DL_Ratio will be noneffective.



802.16e OFDMA Frame Structure for TDD Mode

802.16e OFDMA Frame Structure for TDD Mode

The next illustration shows the uplink subframe format, which includes: one or multiple uplink bursts each transmitted with different burst profile.



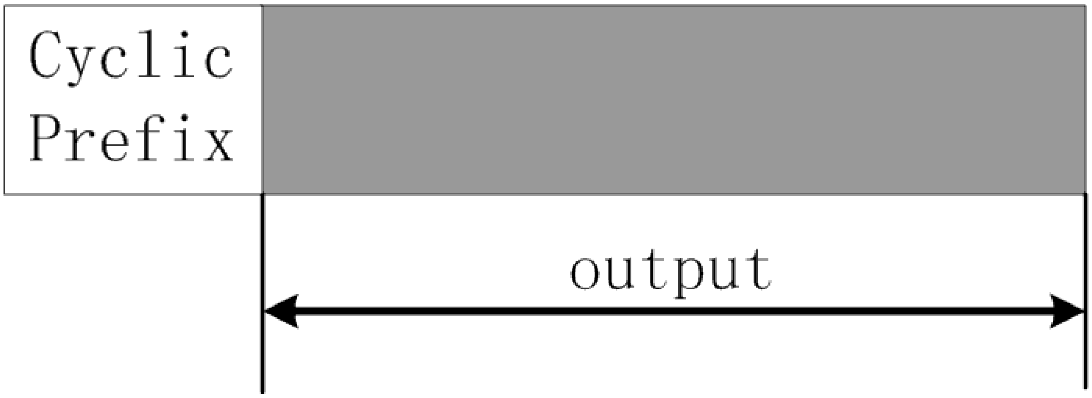
WMAN 16e OFDMA UL subframe structure

4. Output pin delay adjustment:
   Because of the transmission delay, a detected frame usually falls into 2 consecutive received blocks, so the buffer length for input Pin is $2 \times Samples_{Frame}$. The start point of the detected frame is determined by the input signal at pin index. Only after receiving the second input block, this model can output one actual frame. So this model causes one frame delay.
5. The *DeltaF* pin inputs the estimated frequency offset (!wman_m-09-12-120.gif!) of each received frame. The ith estimated frequency offset (!wman_m-09-12-121.gif!) compensates for the phase in the current frame only.
   Assume $x_0, x_1, \ldots, x_{Samples_{Frame}-1}$ sequences are the input signals from the input pin, $y_0, y_1, \ldots, y_{Samples_{Frame}-1}$ are the sequences, whose phase caused by frequency offset, are removed, then: $y_k = x_k \times e^{-j2\pi\Delta f_i k T_{Step}}$

where Δf_i is frequency offset of the i-th received frame which is the input at pin DeltaF, $T_{Step} = \dfrac{1}{F_s \times 2^{OversamplingOption}}$ is the sample time interval in the system.

After making frequency offset compensation, the preamble, FCH , UL_MAP and data will be extracted and output at pin preamble, FCH , UL_MAP and data respectively. The total frame sequences discarding idle and zero paddings are output at pin frame without time and frequency offset compensation. The output sequences from pin frame can be used to calculate CCDF.

Pin Index inputs the start point of a detected uplink frame (including Idle). The output data sequences extracted from the OFDMA symbols begin from the CP, (i.e., $Samples_{FFT} \times CyclicPrefix$). The cyclic prefix removal process is shown in the following illustration.



Cyclic Prefix Removal

The equation is:

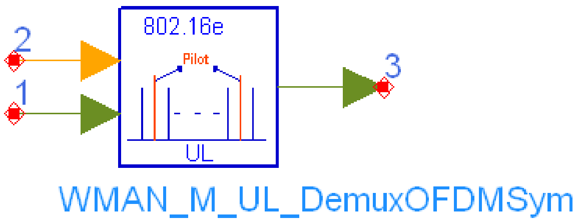
$z_k = y_{k + Index + Samples_{FFT} \times CyclicPrefix}, k = 0, \ldots, Samples_{Frame} - 1$

$z_0, z_1, \ldots, z_{Samples_{FFT} \times N_{FrameSymbol} - 1}$ sequences include data payload.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_DemuxOFDMSym (802.16e OFDMA UL DemuxOFDMSym)



Description: Uplink demux OFDM symobl
Library: WMAN 16e, Multiplex

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24	int	[3,1212]
NumberOfBurst	Number of Bursts	1	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}	int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}	int array	[1,6868]

Pin Inputs

Pin	Name	Description	Signal Type
1	UL_OFDMSym	input of UL OFDM symbol	complex
2	BurstPos	input of the position of bursts	int

Pin Outputs

Pin	Name	Description	Signal Type
3	UL_Bursts	output of UL bursts	complex

Notes/Equations

1. This model is used to demultiplex OFDMA symbols into data and pilot subcarriers in the uplink. The data locations for each bursts are calculated by WMAN_M_UL_ZonePerm and input at pin dataPosition in order. The OFDMA symbols after left, right and DC carriers removal are input at pin UL_OFDMSym. This is inverse function of WMAN_M_UL_MuxOFDMSym.
2. Each firing,

   $N_{UsedCarrier} \times ZoneNumOfSymbol$ tokens are consumed at pin UL_OFDMSym,

   where $N_{UsedCarrier}$ is the number of data and pilots subcarriers used within a symbol, excluding DC carrier.

   $N_{UsedCarrier}$ is decided by *FFTSize* and *ZoneType* as shown in following.

   The Calculation of NusedCarriers

$N_{usedCarriers}$	FFT_2048	FFT_1024	FFT_512
PUSC	1680	840	408
OPUSC	1728	864	432

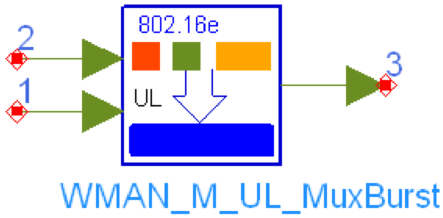
$$\sum_{i=1}^{NumberOfBurst} BurstAssignedSlot[i] \times 48$$ tokens are consumed at pin *dataPosition*.

$$\sum_{i=1}^{NumberOfBurst} BurstAssignedSlot[i] \times 48$$ tokens are produced at pin UL_Bursts.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_MuxBurst (802.16e OFDMA Uplink MuxBurst)



Description: Uplink burst multiplexer
Library: WMAN 16e, Multiplex

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24	int	[3,1212]
NumberOfBurst	Number of Bursts	1	int	[1,8]
BurstWithFEC	The number of burst with FEC	1	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}	int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}	int array	[1,6868]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B, Matrix_C	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataWithFEC	input data with FEC	complex
2	DataWoFEC	input data without FEC	complex

Pin Outputs

Pin	Name	Description	Signal Type
3	DataMux	output data including the data with and without FEC coding	complex

Notes/Equations

1. This model is used to multiplex coded burst and uncoded bursts into one complete uplink sequence in frequency domain. The coded burst can occupy anywhere of uplink bursts.
2. Each firing:

$$\left(\sum_{i=1}^{NumberOfBurst} N_{AssignedSlot}[i]\right)\times 48$$

tokens are produced at pin DataMux,

where $N_{AssignedSlot}[i]$ is the number of slots assigned to the i-th burst.

$N_{AssignedSlot}[BurstWithFEC]\times 48$ tokens are consumed at pin DataWithFEC.

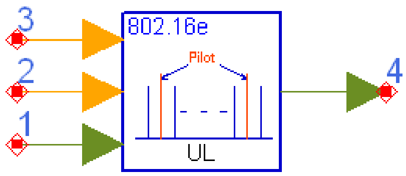
$$\left(\sum_{i=1, i \neq BurstWithFEC}^{NumberOfBurst} N_{AssignedSlot}[i]\right) \times 48$$

tokens are consumed at pin DataWoFEC.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_MuxOFDMSym (802.16e OFDMA Uplink Mux OFDM Symbols)



Description: Uplink mux OFDM symbol
Library: WMAN 16e, Multiplex

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24	int	[3,1212]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
NumberOfBurst	Number of Bursts	1	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}	int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}	int array	[1,6868]
BurstPowerOffset	Power offset of each burst in dB	{0}	real array	(-∞,∞)
RangingBurst	The input is ranging burst or not: NO, YES	NO	enum	
FFB_ACK_Burst	The input is FFB (or ACK) burst or not: NO, YES	NO	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	UL_Bursts	input of UL bursts	complex
2	BurstPos	input of the position of bursts	int
3	PilotPos	input of the position of pilots	int

Pin Outputs

Pin	Name	Description	Signal Type
4	UL_OFDMSym	output of UL OFDM symbols	complex

Notes/Equations

1. This model is used to multiplex the constellation-mapped data sequences and pilots into the physical subcarriers according to the zone permutation.
2. Each firing:

$$\sum_{i=1}^{NumberOfBurst} (BurstAssignedSlot[i]) \times 48$$

tokens are consumed at pin UL_Bursts and at pin BurstPos.

$$\sum_{i=1}^{NumberOfBurst} (BurstAssignedSlot[i]) \times NumOfPilotSubcarrier$$

tokens are consumed at pin PilotPos.

$(ZoneNumOfSym) \times UsedCarriers$ tokens are produced at pin UL_OFDMSym.

where, NumOfPilotSubcarrier is dependent on the zone type and FFT size according to the specification, shown in the following table.

The Calculation of NumOfPilotSubcarrier

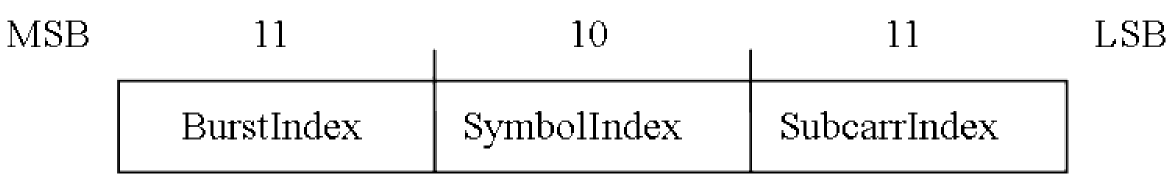
Zone type	FFT size	NumOfPilotSubcarrier
UL_PUSC	2048	24
UL_PUSC	1024	24
UL_PUSC	512	24
UL_OPUSC	2048	6
UL_OPUSC	1024	6
UL_OPUSC	512	6

UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in the following table.

The Calculation of UsedCarriers

Zone type	FFT size	UsedCarriers
UL_PUSC	2048	1680
UL_PUSC	1024	840
UL_PUSC	512	408
UL_OPUSC	2048	1728
UL_OPUSC	1024	864
UL_OPUSC	512	432

3. The i-th the constellation-mapped point from pin UL_Bursts is mapped onto the position (indexed by [*SymbolIndex, SubcarrierIndex*]) which is defined by the i-th value from pin BurstPos. BurstPos is the index of symbol and subcarrier for the constellation-mapped data in each burst. The format of BurstPos is defined in the following illustration.



The format of BurstPos and PilotPos

4. The constant gain (1 for UL_PUSC and 4/3 for UL_OPUSC) is mpped onto the positions (indexed by [*SymbolIndex, SubcarrierIndex*]) which is defined by the values from pin PilotPos. PilotPos is the index of symbol and subcarrier for the pilots which is defined in the preceding illistration.

References

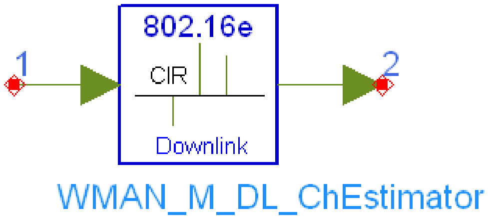
1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

802.16e OFDMA Receiver Components

The 16e receiver models provide channel estimator, frame synchronization and frequency synchronization, top level baseband receivers and top level RF receivers.

- *WMAN M DL ChEstimator (802.16e OFDMA Downlink Channel Estimator)* (wman_m)
- *WMAN M DL Demapper (802.16e OFDMA downlink soft demapper)* (wman_m)
- *WMAN M DL FrameSync (802.16e OFDMA DL Frame Synchronization)* (wman_m)
- *WMAN M DL FreqSync (802.16e OFDMA DL Frequency Synchronization)* (wman_m)
- *WMAN M DL Receiver (802.16e OFDMA Downlink Receiver)* (wman_m)
- *WMAN M DL Receiver RF (802.16e OFDMA Downlink RF Receiver)* (wman_m)
- *WMAN M UL ChEstimator (802.16e OFDMA Uplink Channel Estimator)* (wman_m)
- *WMAN M UL Demapper (802.16e OFDMA Uplink Soft Demapper)* (wman_m)
- *WMAN M UL FrameSync (802.16e OFDMA Uplink Frame Synchronization)* (wman_m)
- *WMAN M UL FreqSync (802.16e OFDMA UpLink Frequency Synchronization)* (wman_m)
- *WMAN M UL FreqSyncFraction (802.16e OFDMA Uplink Fractional Frequency Synchronization)* (wman_m)
- *WMAN M UL FreqSyncInteger (802.16e OFDMA Uplink Integer Frequency Synchronization)* (wman_m)
- *WMAN M UL Receiver (802.16e OFDMA UL Receiver)* (wman_m)
- *WMAN M UL Receiver RF (802.16e OFDMA Uplink Receiver RF)* (wman_m)

WMAN_M_DL_ChEstimator (802.16e OFDMA Downlink Channel Estimator)



Description: Downlink channel estimator
Library: WMAN 16e, Receiver

Parameters

Name	Description	Default	Unit	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_2048		enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC		enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	6		int	[1,1212]
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
SNR	SNR in dB. (used by Wiener filter in PUSC)	15		real	(-∞,∞)
Tmax	The maximum delay of multi-path channel. (used by Wiener filter in PUSC)	1e-6		real	[0,∞)
Fmax	The maximum doppler frequency. (used by Wiener filter in PUSC)	100 Hz	Hz	real	[0,∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	input	output signals from FFT	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	Coef	channel coefficient in active subcarriers	complex

Notes/Equations

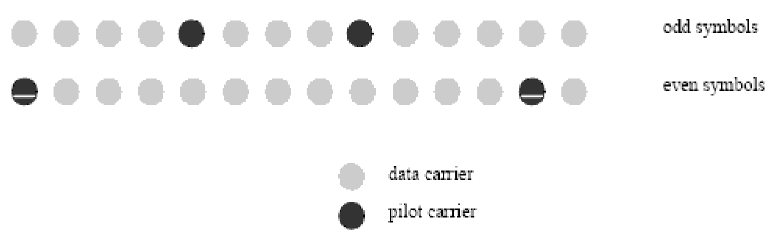
1. This model is used to estimate 802.16e OFDMA downlink channel impulse response (CIR) with the pilot symbols assisted.
2. Each firing,
   $ZoneNumOfSym \times UsedCarriers$ tokens are consumed at pin input;
   $ZoneNumOfSym \times UsedCarriers$ tokens are produced at pin Coef,
   where UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in *The Calculation of UsedCarriers*.

Zone type	FFT size	UsedCarriers
DL_PUSC	2048	1680
DL_PUSC	1024	840
DL_PUSC	512	420
DL_FUSC	2048	1702
DL_FUSC	1024	850
DL_FUSC	512	426
DL_OFUSC	2048	1728
DL_OFUSC	1024	864
DL_OFUSC	512	432
DL_AMC	2048	1728
DL_AMC	1024	864
DL_AMC	512	432

3. DL PUSC, FUSC, OFUSC and AMC are supported in this model.
4. Firstful, the least-squares CR estimate at a pilot location (!wman_m-10-02-004.gif!) can be obtained as:

   $$H_i = \frac{Y_i}{X_i}$$

   where Y_i is the received Pilot symbol and X_i is the transmitted Pilot symbol on the ith subcarrier. After getting the CIRs at pilot locations, we use an interpolation algorithm to estimate all the active subcarriers.
5. For DL PUSC, the channel estimator is performed on the cluster. Each cluster has four symbols and 14 subcarriers where four pilot subcarriers are for antenna 0 and other four pilot subcarriers are for antenna 1. The cluster structure is illustrated in DL PUSC cluster structure.

   DL PUSC cluster structure

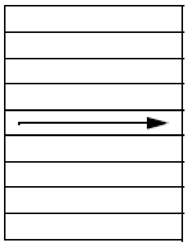
   The channel responses are estimated in the following manner:

   1. The Wiener filter coefficients (!wman_m-10-02-010.gif!) are calculated by employing the well-known two-dimensional MMSE estimator (Reference [3]) which is based on maximum Doppler frequency (Fmax), maximum echo delay (Tmax) and SNR.
   2. The CIRs in the pilot subcarriers are obtained by the LS (Least Squares) algorithm.
   3. The CIRs in all the subcarriers are the product of Wiener filter W and the CIRs in the pilot subcarriers.
6. In DL FUSC, There are two variable pilot-sets and two constant pilot-sets. In FUSC, each segment uses both sets of variable/constant pilot-sets. The Variable set of pilots embedded within the symbol of each segment shall obey the following rule:

   PilotsLocation = VariableSet#x + 6 *(FUSC_SymbolNumber mod 2)

   where FUSC_SymbolNumber counts the FUSC symbols used in the transmission starting from 0. In DL OFUSC, Nused subcarriers except the DC subcarrier are divided into 9 contiguous subcarriers in which one pilot carrier is allocated. The position of the pilot carrier in 9 contiguous subcarriers varies according to the index of OFDMA symbol which contains the subcarriers. If the 9 contiguous subcarriers indexed as 0...8, the index of the pilot carrier shell be 3l+1, where l = m mod 3 (m is the symbol index).
   In both DL FUSC and OFUSC, a pre-defined multi-tap FIR filter is employed to estimate the CIRs in all the active subcarriers based on those in the pilot subcarriers.
7. For DL AMC, symbol data within a subchannel is assigned to adjacent subcarriers and the pilot and data subcarriers are assigned fixed positions in the frequency domain within an OFDMA symbol. This permutation is the same for both UL and DL. To define adjacent subcarrier permutation, a bin, which is a set of nine contiguous subcarriers within an OFDMA symbol, is a basic allocation unit both in DL and UL, as shown in the

following figure. Note that the pilot location in the bin varies along with OFDMA symbol index.

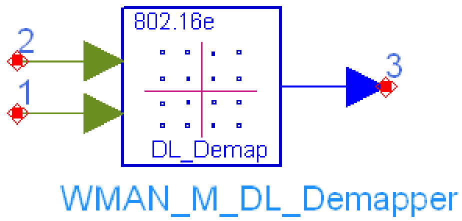


An AMC slot consists of N bins by M symbols where N x M =6. Three AMC modes are supported: 1 bins by 6 symbols (1x6), 2 bins by 3 symbols (2x3) and 3 bins by 2 symbols (3x2).
For DL AMC, the channel estimator is performed on N bins by M symbols where N and M could be 1x6, 2x3 and 3x2 according to AMC mode. The well-known two-dimensional MMSE estimator (Reference [3]\ is employed, the same as DL PUSC.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. P. Hoeher, S. Kaiser, and P. Robertson. "Two-Dimensional Pilot-Symbol-Aided Channel Estimation by Wiener Filtering". Proc. IEEE ICASSP '97, Munich, Germany, pp. 1845-1848, Apr. 1997.

WMAN_M_DL_Demapper (802.16e OFDMA downlink soft demapper)



Description: 16e downlink soft demapper
Library: WMAN 16e, Receiver

Parameters

Name	Description	Default	Type	Range
Rate_ID	Rate ID of each burst	1	int	[0,7]
DecoderType	Demapping type: Hard, Soft, CSI	CSI	enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
BurstNumOfSym	Number of symbols of each burst	4	int	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	1	int	[1,60]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	input	signal to be demodulated	complex
2	CSIBits	channel state information	complex

Pin Outputs

Pin	Name	Description	Signal Type
3	output	decision bits	real

Notes/Equations

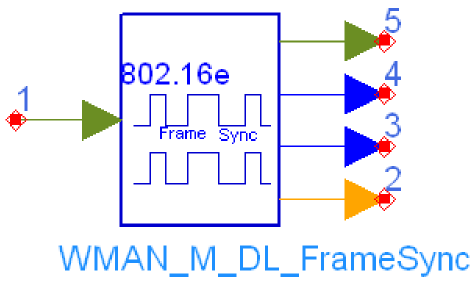
1. This model de-maps uniform QPSK, 16-QAM and 64-QAM to determine the soft-bit information that is used by Viterbi decoding on downlink. When Rate_ID equals to 0 or 1, QPSK demapper is used. When Rate_ID equals to 2 or 3, 16-QAM demapper is used. When Rate_ID equals to 4, 5 or 6, 64-QAM demapper is used.
2. Each firing
   - The CSIBits and input pins consume Ndemodulation tokens each;
   - $2 \times N_{demodulation}$ tokens for QPSK, $4 \times N_{demodulation}$ tokens for 16-QAM, or $6 \times N_{demodulation}$ tokens for 64-QAM are generated at pin output.
     For DL PUSC, $N_{demodulation} = BurstNumOfSym \times BurstNumOfSubch \times 24$
     For DL FUSC and OFUSC, $N_{demodulation} = BurstNumOfSym \times BurstNumOfSubch \times 48$
3. decision equations:
   - If input is multiplied by sqrt(42) and I is the real part of product and Q is the imaginary part, the decision equations for 64-QAM are:
     b0 = 2.0-|b1|; b1 = 4 - |Q|; b2 = -Q; b3 = 2.0-|b4|; b4 = 4 - |I|; b5 = -I.
   - If input is multiplied by sqrt(10) and I is the real part of product and Q is the imaginary part, the decision equations for 16-QAM are:
     b0 = 2.0-|b1|; b1 = -Q; b2 = 2.0-|b3|; b3 = -I.
   - If input is multiplied by sqrt(2) and I is the real part of product and Q is the imaginary part, the decision equations for QPSK are:
     b0 = -Q; b1 = -I.
4. Based on the above calculations, let any one of decision bits equal b:
   - when DecoderType is set to Hard, if b < 0, -1.0 is output, otherwise 1.0 is output.
   - when DecoderType is set to Soft, if b < -1.0, -1.0 is output; if b > 1.0, 1.0 is output, otherwise, b is output directly.

- when DecoderType is set to CSI, b is multiplied by CSI (normalized channel response estimation) and output. Different bits which form one constellation have the same CSI.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_FrameSync (802.16e OFDMA DL Frame Synchronization)



Description: Downlink frame synchronization
Library: WMAN 16e, Receiver

Parameters

Name	Description	Default	Unit	Type	Range
IdleInterval	Idle interval	0 usec	sec	real	[0,0.02]
Bandwidth	Bandwidth	1.75 MHz	Hz	int	(0,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 1		enum	
CyclicPrefix	Cyclic prefix	0.25		real	[0,1]
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
FFTSize	FFT Size: FFT_2048, FFT_1024, FFT_512	FFT_2048		enum	
ZoneNumOfSym	Number of symbol in zone	24		int	[1,1212]
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC		enum	
SearchType	Synchronization search range: All_Frame, Preamble	All_Frame		enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	input	downlink frame	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	OutIndex	synchronization frame start position	int
3	corr	correlation result	real
4	DeltaFreq	frequency offset	real
5	OutPreamble	Preamble	complex

Notes/Equations

1. This Model is used to achieve downlink frame synchronization and estimate fraction frequency offset.
2. Each firing,
   - $Samples_{Frame}$ tokens are consumed at pin input,

     where $Samples_{Frame}$ is the total sample of one downlink frame including zero padding and calculated as follows:

     $$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

     where $Samples_{idle}$ is the samples of IdleInterval and calculated as follows:

$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$

Fs is the sampling frequency decided by Bandwidth, OversamplingOption and related sampling factor (!wman_m-10-04-024.gif!) as follows,

$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$

The sampling factors are listed in the following table.

Sampling Factor n	Bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

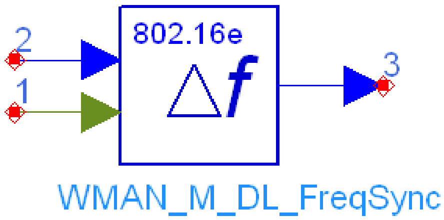
- 1 token is produced at pin OutIndex which indicates the value of synchronization index.
- 1 token is produced at pin DeltaFreq which indicates the value of carrier frequency offset.
- $Samples_{FFTSize}$ tokens are produced at pin preamble, where $Samples_{FFTSize}$ decided by FFTSize and OversamplingOption and calculated as follows:
  $Samples_{FFTSize} = 2048/(2^{FFTSize}) \times 2^{OversamplingOption}$
- $Samples_{Frame}$ tokens are produced at pin corr indicating the correlation results.

3. The first symbol of the downlink transmission is the preamble. There are 3 types of preamble carrier-sets, those are defined as follows:
   $PreambleCarrierSet_n = n + 3 \cdot k$
   where n is the number of the preamble carrier-set indexed 0...2, k is a running index 0...567. Those subcarriers are modulated using a boosted BPSK modulation with a specific Pseudo-Noise(PN) code.
4. In time domain, the preamble is divided into 3 parts roughly. Although each part is not exactly same, the correlation between the repetitive parts can still be used for frame synchronization. Autocorrelation is calculated between two sequences. The sequences length are
   $L = 2^{OversamplingOption} \times (FFTLength \times (1 + G) - FFTLength/3)$. The distance between the first sequence and the second sequence is $N = 2^{OversamplingOption} \times FFTLength/3$. So In the absence of noise autocorrelation get maximum when the first sequence is at the start of the preamble. Autocrrelation is calculated as below:
   $$Correlation_i = \left|\sum_{l=0}^{L-1} Sample_{i+l} \times (Sample)^*_{i+N+l}\right|$$
   i= 0... $Samples_{Frame} - L - N + 1$
   from the second frame, the synchronization only search the maximum around the maximum point of last frame.
5. Fraction frequency offset is calculated using the cyclic prefix. Sequence length is
   $L = 2^{OversamplingOption} \times (FFTLength \times G - 20)$
   Distance between the two sequences is $N = 2^{OversamplingOption} \times FFTLength$
   $start = index + 10 \times 2^{OversamplingOption}$ the first 10 sample and last 10 sample are not used for robustness to multipath delay. $F_s = (floor((N_{factor} \times Bandwidth)/8000) \times 8000)$
   $$\Delta f = -\arg\left(\sum_{l=0}^{L-1} Sample_{start+l} \times (Sample)^*_{start+N+l}\right) \times F_s/(2\pi \times FFTLength)$$

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_FreqSync (802.16e OFDMA DL Frequency Synchronization)



Description: Downlink frequency synchronizer
Library: WMAN 16e, Receiver

Parameters

Name	Description	Default	Unit	Type	Range
PreambleIndex	Preamble index	0		int	[0,113]
FFTSize	FFT Size: FFT_2048, FFT_1024, FFT_512	FFT_2048		enum	
OversamplingOption	Oversampling ratio: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 1		enum	
Bandwidth	Bandwidth	1.75 MHz	Hz	int	(0,1e9]

Pin Inputs

Pin	Name	Description	Signal Type
1	preamble	Preamble	complex
2	DeltaFreq	fractional frequency offset	real

Pin Outputs

Pin	Name	Description	Signal Type
3	freq	frequency offset	real

Notes/Equations

1. This Model is used to estimate integer frequency offset in downlink.
2. Each firing:
   - $Samples_{FFTSize}$ tokens are consumed at pin preamble
   - 1 token is consumed at pin DeltaFreq which indicates the fraction frequency offset
   - 2 tokens are produced at pin freq. The first one indicates the value of carrier frequency offset (including integer and fraction frequency offset) and the second one indicates the phase difference between adjacent subcarriers caused by coarse time synchronization.
3. The first symbol of the downlink transmission is the preamble. There are 3 types of preamble carrier-sets, those are defined as follows:

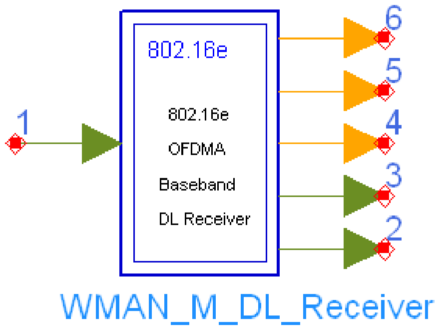
   $$PreambleCarrierSet_n = n + 3 \cdot k$$

   where n is the number of the preamble carrier-set indexed 0...2, k is a running index 0...567. Those subcarriers are modulated using a boosted BPSK modulation with a specific Pseudo-Noise(PN) code.
4. Fraction frequency offset has been corrected before preamble sequence enters into this module. The remaining integer frequency offset may cause the subcarrier rotation in frequency domain. Correlation between local preamble sequence and received preamble sequence in frequency domain may be utilized to estimate integer frequency offset. To eliminate the influence of selective fading channel, differential correlation is utilized in this module.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_Receiver (802.16e OFDMA Downlink Receiver)



Description: Downlink receiver
Library: WMAN 16e, Receiver

Parameters

Name	Description	Default	Unit	Type	Range
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
DLMAP_Enable	DLMAP is inserted or not: NO, YES	NO		enum	
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[0,0.02]
PreambleIndex	Preamble index	3		int	[0,113]
DL_PermBase	Downlink permutation base	9		int	[0,31]
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00, 0X00, 0X01}		int array	[0,255]
PRBS_ID	PRBS ID	0		int	[0,3]
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	22		int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array	[0,1]
NumberOfBurst	Number of Bursts	2		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}		int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,12}		int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}		int array	[1,60]
DataLength	MAC PDU payload byte length of each burst	{200,300}		int array	[1,∞)
Rate_ID	Rate ID of each burst	{5,5}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0,0}		int array	[0,3]
PowerBoosting	Power boosting of each burst in dB	{0,0}		real array	[-∞,∞]
DecoderType	Soft decision viterbi decoding type: Hard, Soft, CSI	Soft		enum	
SNR	SNR in dB.	15		real	[-∞,∞]
Tmax	The maximum delay of multi-path channel.	1e-6		real	[0,∞]
Fmax	The maximum doppler frequency.	100 Hz	Hz	real	[0,∞]
BurstFEC_CodingType	Coding type for the burst with FEC-encoding: CC, CTC	CC		enum	
IterationNumber	The number of iterations (only for CTC decoder)	8		int	[1,16]
CycleNumber	The number of decoding cycles to get circulation states (only for CTC decoder)	1		int	[1,16]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	

Pin Inputs

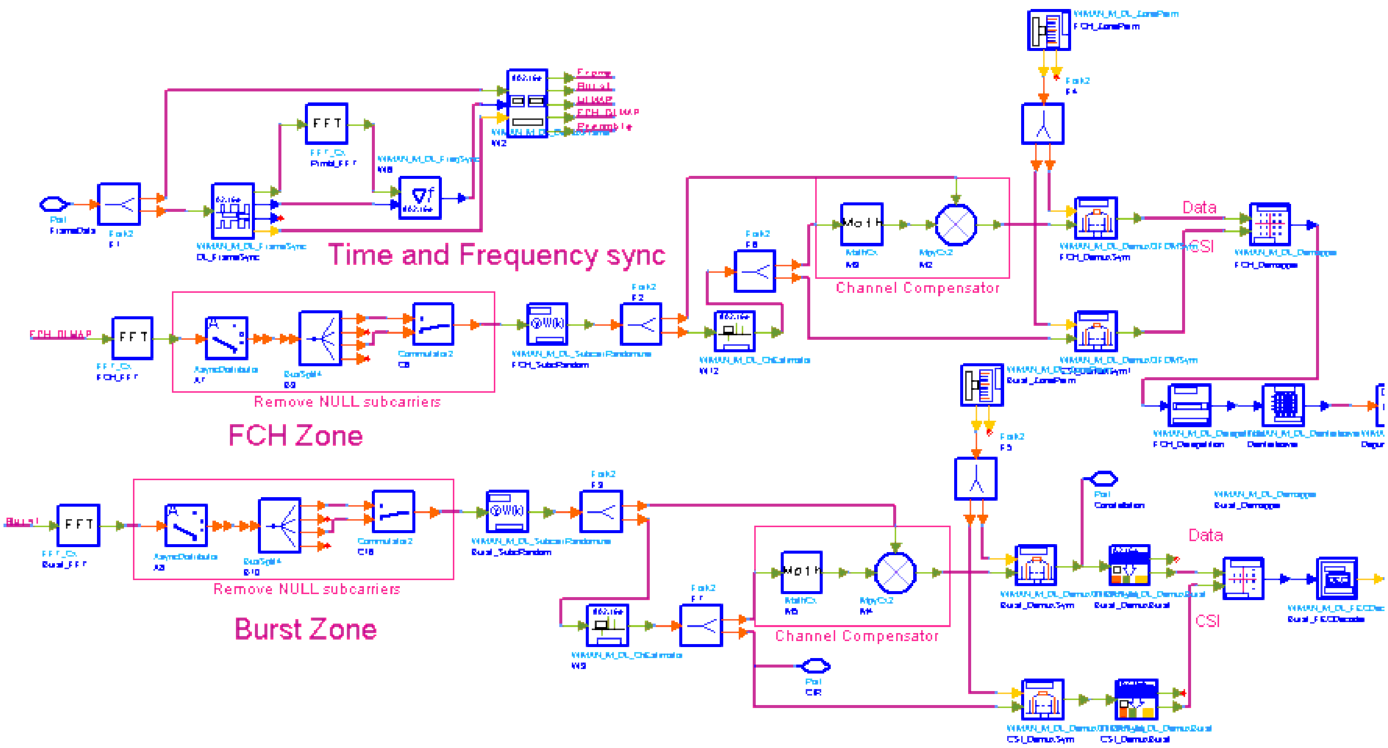
Pin	Name	Description	Signal Type
1	FrameData	input of RF signal	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	CIR	output of channel estimation of all bursts	complex
3	Constellation	output of Modulated data of all bursts	complex
4	PDUFCS	output of MAC PDU data of burst with FEC	int
5	PSDU	output of PSDU bits	int
6	DLFP	output of DLFP bits	int

Notes/Equations

1. This subnetwork generates an 802.16e OFDMA downlink subsystem baseband receiver. The schematic for this subnetwork is shown in the following figure.

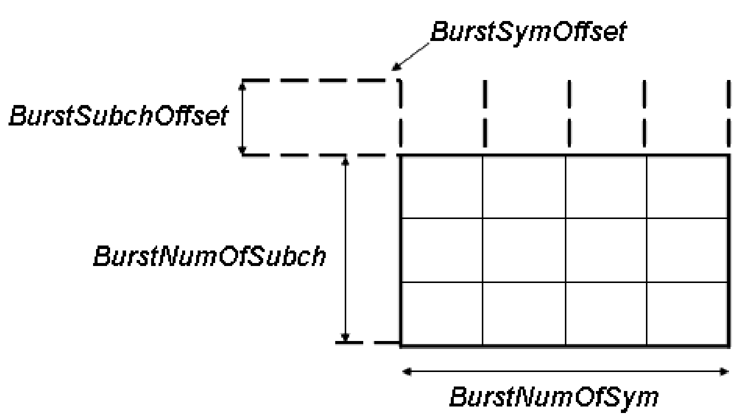


WMAN_M_DL_Receiver Schematic

2. Receiver functions are implemented as follows:
Start of frame is detected. WMAN_M_DL_FrameSync calculates the correlation between the received signal, and selects the index with the maximum correlation value as the start of frame.
Frequency offset is estimated. WMAN_M_DL_FreqSync calculates the frequency offset and makes frequency synchronization using the preamble.
The packet is de-rotated according to the estimated frequency offsets (frequency synchronization) which is compensated by WMAN_M_DL_DemuxFrame. WMAN_M_DL_DemuxFrame outputs the preamble, FCH (including DL-MAP), UL-MAP and data bursts. The WMAN_M_DL_DemuxFrame component introduces one frame delay.
The FCH and data bursts are sent to perform FFT transformation respectively.
The factors of randomzier appended to the subcarries are removed in WMAN_M_DL_SubcarrRandomizer. Then the complex channel impulse responses (CIR) are estimated and interpolated for each subcarrier (channel estimation). First, WMAN_M_DL_ChEstimator gets CIRs for the pilot subcarriers. Then, WMAN_M_DL_ChEstimator gets CIRs for the data subcarriers by interpolation. These CIRs are output at pin CIR.
Each value in the subcarrier is divided by a complex estimated channel response coefficient. The simple one-tap frequency domain channel response compensation is implemented in the receiver.
After equalization, WMAN_M_DL_DemuxOFDMSym transfers the physical subcarriers to logical data sequences and pilot sequences for each burst where the physical indices of data subcarriers and pilot subcarriers for each burst are calculated by WMAN_M_DL_ZonePerm. The data sequences after WMAN_M_DL_DemuxOFDMSym are output at pin Constellation. The signal can be used to show the demodulated constellation and to calculate

the RCE (relative constellation error) or EVM.
The burst with FEC-encoded is separated from the multi-bursts in WMAN_M_DL_DemuxBurst. The demodulated OFDM symbols of burst with FEC are then de-mapped by WMAN_M_Demapper. Three demapper types (CSI, Soft and Hard) are supported in WMAN_M_Demaper.
After WMAN_M_FECDecoder, the MAC PDU data are achieved, which are divided into MAC header, MAC PDU payloads and CRC. The MAC PDU and its payloads are output at pin PDUFCS and PSDU respectively. The de-repetition, de-interleaving, CC decoding, de-randomizing are performed in WMAN_M_FECDecoder.
For FCH and DL-MAP, the de-mapped data are only passed through the de-repetition, de-interleaving, CC decoding, and only the decoded DLFP (FCH) is output at pin DLFP.

3. Parameter Details
   - Bandwidth determines the nominal channel bandwidth.
   - OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
   - FFTSize specifies the size of FFT. Sizes 2048, 1024 and 512 are supported.
   - CyclicPrefix specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
   - FrameMode specifies the duplexing method which should be FDD or TDD. In FDD transmission, the downlink occupies the entire frame and the respective gaps (zeros) are automatically adjusted to fill the frame
   - DL_Ratio specifies the percentage (1 to 99) of the frame time to be used for the downlink subframe. The parameter is only active when the FrameMode is TDD.
   - FrameDuration determines the frame durations (ms) of the generated waveform. There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
   - DLMAP_Enable specifies whether the DL-MAP burst is inserted in the downlink subframe.
   - ULMAP_Enable specifies whether the UL-MAP burst is inserted in the downlink subframe.
   - IdleInterval specifies the time of idle interval between the two continuous frames. The default value is 0.
   - PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to the standard.
   - DL_PermBase specifies the basis of downlink permutation to be used in initialization vector of the PRBS generator for subchannel randomization in the zone and in STC_DL_Zone_IE() in DL-MAP message.
   - BSID specifies the base station ID which is used in DL-MAP message.
   - PRBS_ID specifies the PRBS ID which may be used in initialization vector of the PRBS generator for subchannel randomization and in STC_DL_Zone_IE() in DL-MAP message.
   - ZoneType specifies the zone type which can be set to PUSC, FUSC, OFUSC and AMC.
   - ZoneNumOfSym specifies the symbol number for the zone. The value must be a multiple of two for DL_PUSC, and be a multiple of one for DL_FUSC, DL_OFUSC. For AMC, the value must be multiple of six, three and two for mode 1x6, 2x3 and 3x2 respectively.
   - GroupBitmask specifies which groups of subchannel are used on the PUSC zone. This parameter uses 1 for assigned groups and 0 for unassigned groups.
   - NumberOfBurst specifies the number of active downlink bursts.
   - BurstWithFEC specifies the downlink burst FEC.
   - BurstSymOffset, BurstSubchOffset, BurstNumOfSym and BurstNumOfSubch specify the position and range for each rectangular burst, seen in the following figure.



Downlink Rectangular Burst Structure

   - DataLength specifies MAC PDU payload byte length for each burst.
   - Rate_ID specifies the rate ID for each burst. Rate_ID, along with CodingType, determines the modulation

and coding rate, shown in the following table.

Coding type	Rate ID	<th
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in the following table.

Repetition Coding	Meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4used on the burst
3	Repetition coding of 6used on the burst

- PowerBoosting specifies the power boosting for each burst. Each value is defined in units of dB.
- DecoderType specifiers the Viterbi decoder type chosen from CSI, Soft and Hard. CSI (Channel State Information) is a channel estimate profile. This decision is neither hard or soft; it is adaptive based on where you are in the channel profile.
- SNR specifies the signal noise ratio at receiver antenna in dB. This parameter is useful for the channel estimator in DL PUSC.
- Tmax specifies the maximum echo delay in multi-path channel. This parameter is useful for the channel estimator in DL PUSC.
- Fmax specifies the maximum Doppler frequency. This parameter is useful for the channel estimator in DL PUSC.
- BurstFEC_CodingType specifies the coding type for the burst with FEC-encoding. CC means convolutional coding while CTC means convolutional turbo coding.
- IterationNumber specifies the number of iterations for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).
- CycleNumber specifies the number of decoding cycles in order to get circulation states for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).

4. Samples per frame
The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-10-06-050.gif!) as follows,
$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$
The sampling factors are listed in the following table.

Sampling Factor n	Bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval (!wman_m-10-06-052.gif!) is calculated as follows:
$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$
So, the total samples of one downlink frame $Samples_{Frame}$ is
$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

5. Output Pin Delay Adjustment
This model works frame by fame. Each firing, $Samples_{Frame}$ tokens are consumed at Pin FrameData.

Constellation has one frame delay. This pin outputs all the number OFDM symbols except preambles. Each firing, pin Constellation produces

$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 / N_{SymPerSlot}$$

tokens, where $N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC. Moreover, the first

$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 / N_{SymPerSlot}$$

output signals at the Constellation pin are zeros.
PSDUFCS has one frame delay.
This pin outputs demodulated PSDU and FCS information bits after decoding.
So, the delay of PSDUFCS is $8 \times DataLength[BurstWithFEC] + 80$.
The first $8 \times DataLength[BurstWithFEC] + 80$ bits at the PSDUFCS pin are zeros.
PSDU also has one frame delay. This pin outputs demodulated PSDU information bits after decoding.
So, the delay of PSDUFCS is $8 \times DataLength[BurstWithFEC]$.
The first $8 \times DataLength[BurstWithFEC]$ bits at the PSDU pin are zero.
CIR output pin also has one frame delay. Each firing, pin CIR produces $UsedCarriers \times N_{Sym}$ tokens.
The first $UsedCarriers \times N_{Sym}$ output signals at the CIR pin are zeros.
UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in the following table. Nsym is (ZoneNumOfSym-2) for PUSC and ZoneNumOfSym for FUSC and OFUSC.

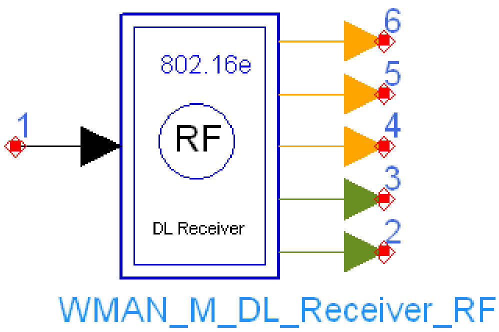
Zone Type	FFT Size	UsedCarriers
DL_PUSC	2048	1680
DL_PUSC	1024	840
DL_PUSC	512	420
DL_FUSC	2048	1702
DL_FUSC	1024	850
DL_FUSC	512	426
DL_OFUSC	2048	1728
DL_OFUSC	1024	864
DL_OFUSC	512	432

Pin DLFP also has one frame delay. Each firing, pin DLFP produces 192 tokens. One frame delay at pin DLFP is 192.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_Receiver_RF (802.16e OFDMA Downlink RF Receiver)



Description: Downlink RF receiver
Library: WMAN 16e, Receiver

Parameters

Name	Description	Default	Unit	Type	Range
RIn	Input resistance	DefaultRIn	Ohm	int	(0,∞)
RTemp	Temperature, in degrees C	DefaultRTemp	Celsius	real	[-273.15,∞]
FCarrier	Carrier frequency	3407 MHz	Hz	real	(0,∞)
Sensitivity	voltage output sensitivity, Vout/Vin	1		real	(-∞,∞)
Phase	Reference phase in degrees	0.0	deg	real	(-∞,∞)
GainImbalance	Gain imbalance in dB, Q channel relative to I channel	0.0		real	(-∞,∞)
PhaseImbalance	Phase imbalance in degrees, Q channel relative to I channel	0.0		real	(-∞,∞)
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
DLMAP_Enable	DLMAP is inserted or not: NO, YES	NO		enum	
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
PreambleIndex	Preamble index	3		int	[0,113]
DL_PermBase	Downlink permutation base	9		int	[0,31]
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00, 0X00, 0X01}		int array	[0,255]
PRBS_ID	PRBS ID	0		int	[0,3]
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	22		int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array	[0,1]
NumberOfBurst	Number of Bursts	2		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}		int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,12}		int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}		int array	[1,60]
DataLength	MAC PDU payload byte length of each burst	{200,300}		int array	[1,∞)
Rate_ID	Rate ID of each burst	{5,5}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0,0}		int array	[0,3]
PowerBoosting	Power boosting of each burst in dB	{0,0}		real array	[-∞,∞]
DecoderType	Soft decision viterbi decoding type: Hard, Soft, CSI	Soft		enum	
SNR	SNR in dB.	15		real	[-∞,∞]
Tmax	The maximum delay of multi-path channel.	1e-6		real	[0,∞]
Fmax	The maximum doppler frequency.	100 Hz	Hz	real	[0,∞]
BurstFEC_CodingType	Coding type for the burst with FEC-encoding: CC, CTC	CC		enum	
IterationNumber	The number of iterations (only for CTC decoder)	8		int	[1,16]
CycleNumber	The number of decoding cycles to get circulation states (only for CTC decoder)	1		int	[1,16]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	

Pin Inputs

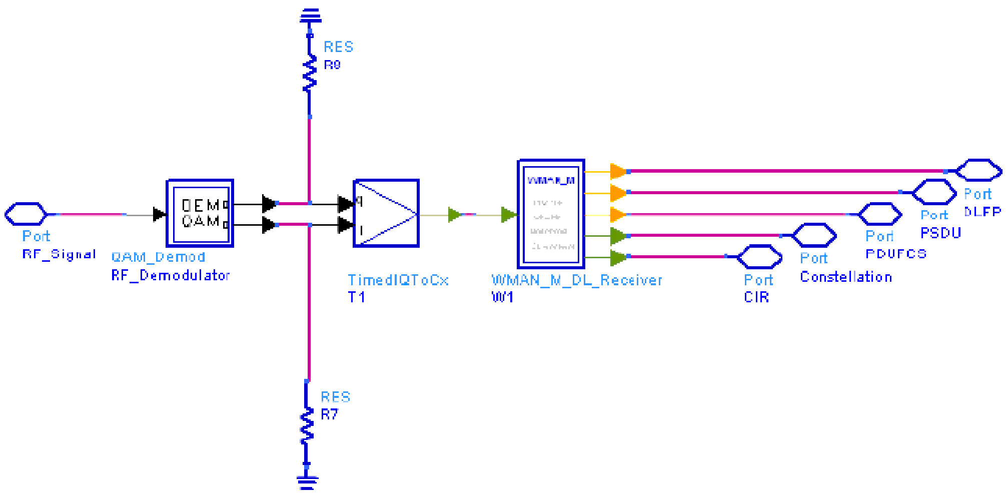
Pin	Name	Description	Signal Type
1	RF_Signal	input of RF signal	timed

Pin Outputs

Pin	Name	Description	Signal Type
2	CIR	output of channel estimation of all bursts	complex
3	Constellation	output of Modulated data of all bursts	complex
4	PDUFCS	output of MAC PDU data of burst with FEC	int
5	PSDU	output of PSDU bits	int
6	DLFP	output of DLFP bits	int

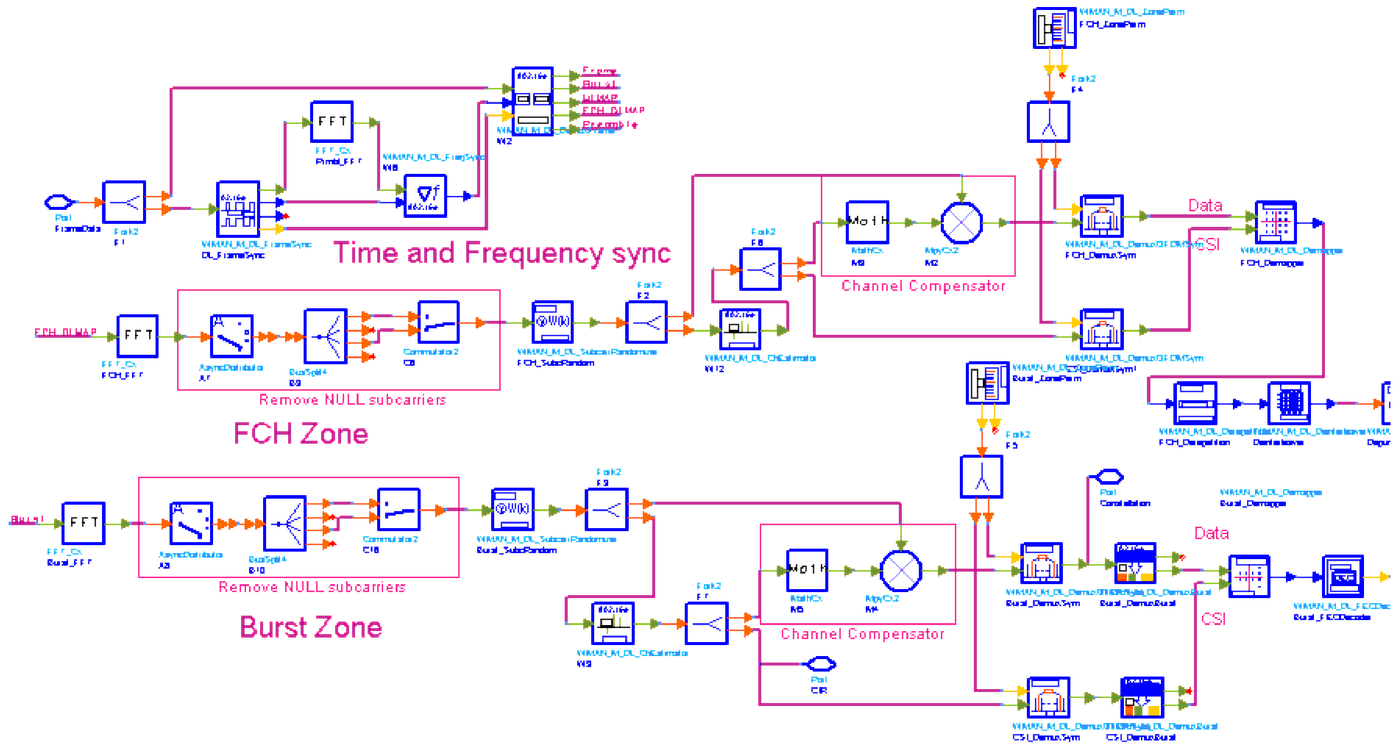
Notes/Equations

1. This subnetwork acts as WMAN OFDMA downlink RF receiver. The schematic for this subnetwork is shown in WMAN_M_DL_Receiver_RF Schermatic. The RF_Demodulator inverts the input RF signal to baseband signal and delivers it to WMAN_M_DL_Receiver.



WMAN_M_DL_Receiver_RF Schermatic

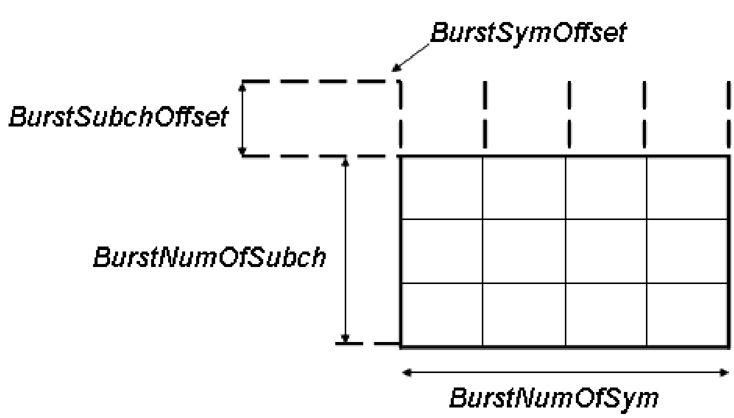
2. The WMAN_M_DL_Receiver generates an 802.16e OFDMA downlink subsystem baseband receiver. The schematic for this subnetwork is shown in WMAN_M_DL_Receiver Schematic.



WMAN_M_DL_Receiver Schematic

3. Receiver functions are implemented as follows:
   Start of frame is detected. WMAN_M_DL_FrameSync calculates the correlation between the received signal, and selects the index with the maximum correlation value as the start of frame.
   Frequency offset is estimated. WMAN_M_DL_FreqSync calculates the frequency offset and makes frequency synchronization using the preamble.
   The packet is de-rotated according to the estimated frequency offsets (frequency synchronization) which is compensated by WMAN_M_DL_DemuxFrame. WMAN_M_DL_DemuxFrame outputs the preamble, FCH (including DL-MAP), UL-MAP and data bursts. The WMAN_M_DL_DemuxFrame component introduces one frame delay.
   The FCH and data bursts are sent to perform FFT transformation respectively.
   The factors of randomzier appended to the subcarries are removed in WMAN_M_DL_SubcarrRandomizer. Then the complex channel impulse responses (CIR) are estimated and interpolated for each subcarrier (channel estimation). First, WMAN_M_DL_ChEstimator gets CIRs for the pilot subcarriers. Then, WMAN_M_DL_ChEstimator gets CIRs for the data subcarriers by interpolation. These CIRs are output at pin CIR.
   Each value in the subcarrier is divided by a complex estimated channel response coefficient. The simple one-tap frequency domain channel response compensation is implemented in the receiver.
   After equalization, WMAN_M_DL_DemuxOFDMSym transfers the physical subcarriers to logical data sequences and pilot sequences for each burst where the physical indices of data subcarriers and pilot subcarriers for each burst are calculated by WMAN_M_DL_ZonePerm. The data sequences after WMAN_M_DL_DemuxOFDMSym are output at pin Constellation. The signal can be used to show the demodulated constellation and to calculate the RCE (relative constellation error) or EVM.
   The burst with FEC-encoded is separated from the multi-bursts in WMAN_M_DL_DemuxBurst. The demodulated OFDM symbols of burst with FEC are then de-mapped by WMAN_M_Demapper. Three demapper types (CSI, Soft and Hard) are supported in WMAN_M_Demaper.
   After WMAN_M_FECDecoder, the MAC PDU data are achieved, which are divided into MAC header, MAC PDU payloads and CRC. The MAC PDU and its payloads are output at pin PDUFCS and PSDU respectively. The de-repetition, de-interleaving, CC decoding, de-randomizing are performed in WMAN_M_FECDecoder.
   For FCH and DL-MAP, the de-mapped data are only passed through the de-repetition, de-interleaving, CC decoding, and only the decoded DLFP (FCH) is output at pin DLFP.
4. Parameter Details
   - RIn is the RF input resistance.
   - RTemp is the RF output resistance temperature in Celsius and sets the noise density in the RF output signal to (k(RTemp+273.15)) Watts/Hz, where k is Boltzmann's constant.

- FCarrier is the RF output signal frequency.
- Sensitivity is the voltage output sensitivity (Vout/Vin) of the internal oscillator that generates the reference carrier signal used to demodulate the RF signal.
- Phase is the reference phase in degrees of the reference carrier signal.
- GainImbalance and PhaseImbalance add certain impairments to the ideal output RF signal. Impairments are added as described here.
  The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:
  $$V_3(t) = A\left(V_1(t)\cos(\omega_c t) - gV_2(t)\sin\left(\omega_c t + \frac{\Phi\pi}{180}\right)\right)$$
  where V1(t) is the in-phase RF envelope, V2(t) is the quadrature phase RF envelope, g is the gain imbalance:
  $$g = 10^{\frac{GainImbalance}{20}}$$
  and, ϕ (in degrees) is the phase imbalance.
- Bandwidth determines the nominal channel bandwidth.
- OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
- FFTSize specifies the size of FFT. Sizes 2048, 1024 and 512 are supported.
- CyclicPrefix specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
- FrameMode specifies the duplexing method which should be FDD or TDD. In FDD transmission, the downlink occupies the entire frame and the respective gaps (zeros) are automatically adjusted to fill the frame
- DL_Ratio specifies the percentage (1 to 99) of the frame time to be used for the downlink subframe. The parameter is only active when the FrameMode is TDD.
- FrameDuration determines the frame durations (ms) of the generated waveform. There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
- DLMAP_Enable specifies whether the DL-MAP burst is inserted in the downlink subframe.
- ULMAP_Enable specifies whether the UL-MAP burst is inserted in the downlink subframe.
- IdleInterval specifies the time of idle interval between the two continuous frames. The default value is 0.
- PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to the standard.
- DL_PermBase specifies the basis of downlink permutation to be used in initialization vector of the PRBS generator for subchannel randomization in the zone and in STC_DL_Zone_IE() in DL-MAP message.
- BSID specifies the base station ID which is used in DL-MAP message.
- PRBS_ID specifies the PRBS ID which may be used in initialization vector of the PRBS generator for subchannel randomization and in STC_DL_Zone_IE() in DL-MAP message.
- ZoneType specifies the zone type which can be set to PUSC, FUSC, OFUSC and AMC.
- ZoneNumOfSym specifies the symbol number for the zone. The value must be a multiple of two for DL_PUSC, and be a multiple of one for DL_FUSC, DL_OFUSC. For AMC, the value must be multiple of six, three and two for mode 1x6, 2x3 and 3x2 respectively.
- GroupBitmask specifies which groups of subchannel are used on the PUSC zone. This parameter uses 1 for assigned groups and 0 for unassigned groups.
- NumberOfBurst specifies the number of active downlink bursts.
- BurstWithFEC specifies the downlink burst FEC.
- BurstSymOffset, BurstSubchOffset, BurstNumOfSym and BurstNumOfSubch specify the position and range for each rectangular burst, seen Downlink Rectangular Burst Structure.



Downlink Rectangular Burst Structure

- DataLength specifies MAC PDU payload byte length for each burst.
- Rate_ID specifies the rate ID for each burst. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in the following table.

Coding type	Rate ID	<th
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in the following table.

Repetition Coding	Meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4used on the burst
3	Repetition coding of 6used on the burst

- PowerBoosting specifies the power boosting for each burst. Each value is defined in units of dB.
- DecoderType specifiers the Viterbi decoder type chosen from CSI, Soft and Hard. CSI (Channel State Information) is a channel estimate profile. This decision is neither hard or soft; it is adaptive based on where you are in the channel profile.
- SNR specifies the signal noise ratio at receiver antenna in dB. This parameter is useful for the channel estimator in DL PUSC.
- Tmax specifies the maximum echo delay in multi-path channel. This parameter is useful for the channel estimator in DL PUSC.
- Fmax specifies the maximum Doppler frequency. This parameter is useful for the channel estimator in DL PUSC.
- BurstFEC_CodingType specifies the coding type for the burst with FEC-encoding. CC means convolutional coding while CTC means convolutional turbo coding.
- IterationNumber specifies the number of iterations for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).
- CycleNumber specifies the number of decoding cycles in order to get circulation states for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).

5. Samples per frame
The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-10-07-073.gif!) as follows,
$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$
The sampling factors are listed in the following table.

Sampling Factor n	Bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval(!wman_m-10-07-075.gif!) is calculated as follows:
$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$
So, the total samples of one downlink frame $Samples_{Frame}$ is

$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$

6. Output Pin Delay Adjustment

This model works frame by fame. Each firing, $Samples_{Frame}$ tokens are consumed at Pin FrameData. Constellation has one frame delay. This pin outputs all the number OFDM symbols except preambles. Each firing, pin Constellation produces $\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48/N_{SymPerSlot}$ tokens, where $N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC. Moreover, the first $\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48/N_{SymPerSlot}$ output signals at the Constellation pin are zeros.
PSDUFCS has one frame delay. This pin outputs demodulated PSDU and FCS information bits after decoding. So, the delay of PSDUFCS is $8 \times DataLength[BurstWithFEC] + 80$. The first $8 \times DataLength[BurstWithFEC] + 80$ bits at the PSDUFCS pin are zeros.
PSDU also has one frame delay. This pin outputs demodulated PSDU information bits after decoding. So, the delay of PSDUFCS is $8 \times DataLength[BurstWithFEC]$. The first $8 \times DataLength[BurstWithFEC]$ bits at the PSDU pin are zero.
CIR output pin also has one frame delay. Each firing, pin CIR produces $UsedCarriers \times N_{Sym}$ tokens. The first $UsedCarriers \times N_{Sym}$ output signals at the CIR pin are zeros. UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in the following table. Nsym is (ZoneNumOfSym-2) for PUSC and ZoneNumOfSym for FUSC and OFUSC.

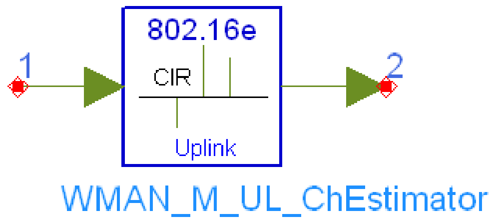
Zone type	FFT size	UsedCarriers
DL_PUSC	2048	1680
DL_PUSC	1024	840
DL_PUSC	512	420
DL_FUSC	2048	1702
DL_FUSC	1024	850
DL_FUSC	512	426
DL_OFUSC	2048	1728
DL_OFUSC	1024	864
DL_OFUSC	512	432

Pin DLFP also has one frame delay. Each firing, pin DLFP produces 192 tokens. One frame delay at pin DLFP is 192.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_ChEstimator (802.16e OFDMA Uplink Channel Estimator)



Description: Uplink channel estimator
Library: WMAN 16e, Receiver

Parameters

Name	Description	Default	Unit	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC		enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
ZoneNumOfSym	Number of symbols in ZONE	16		int	[1,1024]
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
SNR	SNR in dB. (used by Wiener filter in PUSC)	15		real	(-∞,∞)
Tmax	The maximum delay of multi-path channel. (used by Wiener filter in PUSC)	1e-6		real	[0,∞)
Fmax	The maximum doppler frequency. (used by Wiener filter in PUSC)	100 Hz	Hz	real	[0,∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	Input	output signals from FFT	complex

Pin Outputs

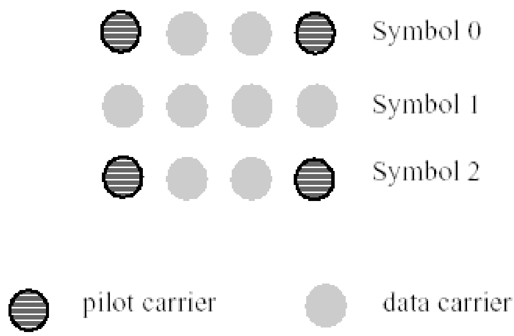
Pin	Name	Description	Signal Type
2	Coef	channel coefficient in subcarriers	complex

Notes/Equations

1. This model is used to calculate uplink channel estimation based on the pilot channels and output the active subcarriers estimated channel impulse response (CIR).
2. Each firing,
   $3 \times UsedCarriers$ tokens are consumed at pin Input;
   $3 \times UsedCarriers$ tokens are produced at pin Coef, where UsedCarriers is dependent on the zone type and FFT size according to the specification, shown in *The Calculation of UsedCarriers*.

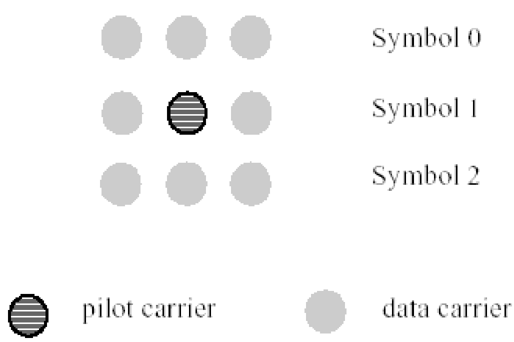
Zone type	FFT size	UsedCarriers
UL_PUSC	2048	1680
UL_PUSC	1024	840
UL_PUSC	512	408
UL_OPUSC	2048	1728
UL_OPUSC	1024	864
UL_OPUSC	512	432
UL_AMC	2048	1728
UL_AMC	1024	864
UL_AMC	512	432

3. For PUSC and OPUSC, the channel estimator is performed on the tile one by one.
   For PUSC, each tile has four pilot subcarriers and eight data subcarriers whose configuration is illustrated in Tile structure for UL_PUSC. The channel estimator for PUSC is performed in the following manner:
   - The Wiener filter coefficients (!wman_m-10-08-092.gif!) are calculated by employing the well-known two-dimensional MMSE estimator (Reference [1]) which is based on maximum Doppler frequency (Fmax), maximum echo delay (Tmax) and SNR.
   - The CIRs in the pilot subcarriers are obtained by the LS (Least Squares) algorithm.
   - The CIRs in all the subcarriers are the product of Wiener filter W and the CIRs in the pilot subcarriers.



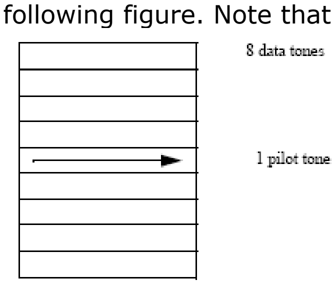
Tile structure for UL_PUSC

   For OPUSC, each tile has one pilot subcarriers and eight data subcarriers whose configuration is illustrated in Tile structure for UL_OPUSC. The CIRs in all the data subcarrier are just the repetitions of that in the pilot subcarrier.



Tile structure for UL_OPUSC

4. For DL AMC, symbol data within a subchannel is assigned to adjacent subcarriers and the pilot and data subcarriers are assigned fixed positions in the frequency domain within an OFDMA symbol. This permutation is the same for both UL and DL. To define adjacent subcarrier permutation, a bin, which is a set of nine contiguous subcarriers within an OFDMA symbol, is a basic allocation unit both in DL and UL, as shown in the following figure. Note that the pilot location in the bin varies along with OFDMA symbol index.



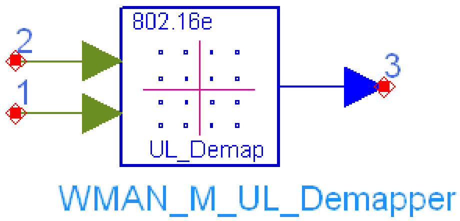
   An AMC slot consists of N bins by M symbols where N x M =6. Three AMC modes are supported: 1 bins by 6 symbols (1x6), 2 bins by 3 symbols (2x3) and 3 bins by 2 symbols (3x2).
   For DL AMC, the channel estimator is performed on N bins by M symbols where N and M could be 1x6, 2x3

and 3x2 according to AMC mode. The well-known two-dimensional MMSE estimator (Reference [3]\ is employed, the same as UL PUSC.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. P. Hoeher, S. Kaiser, and P. Robertson. "Two-Dimensional Pilot-Symbol-Aided Channel Estimation by Wiener Filtering". Proc. IEEE ICASSP '97, Munich, Germany, pp. 1845-1848, Apr. 1997.

WMAN_M_UL_Demapper (802.16e OFDMA Uplink Soft Demapper)



Description: 16e uplink soft demapper
Library: WMAN 16e, Receiver

Parameters

Name	Description	Default	Type	Range
Rate_ID	Rate ID of each burst	1	int	[0,7]
DecoderType	Demapping type: Hard, Soft, CSI	CSI	enum	
BurstAssignedSlot	Assigned slot in each burst	4	int	[1,6868]

Pin Inputs

Pin	Name	Description	Signal Type
1	input	signal to be demodulated	complex
2	CSIBits	channel state information	complex

Pin Outputs

Pin	Name	Description	Signal Type
3	output	decision bits	real

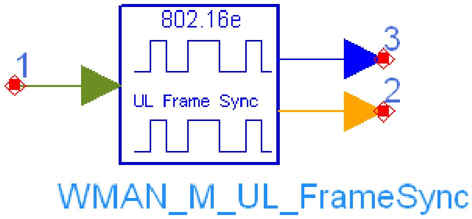
Notes/Equations

1. This model de-maps uniform QPSK, 16-QAM and 64-QAM to determine the soft-bit information that is used by Viterbi decoding on uplink. When Rate_ID equals to 0 or 1, QPSK demapper is used. When Rate_ID equals to 2 or 3, 16-QAM demapper is used. When Rate_ID equals to 4, 5 or 6, 64-QAM demapper is used.
2. Each firing
   - The CSIBits and input pins consume Ndemodulation tokens each;
   - $2 \times N_{demodulation}$ tokens for QPSK, $4 \times N_{demodulation}$ tokens for 16-QAM, or $6 \times N_{demodulation}$ tokens for 64-QAM are generated at pin output.
     $N_{demodulation} = BurstAssignedSlot \times 48$
3. Decision equations:
   - If input is multiplied by sqrt(42) and I is the real part of product and Q is the imaginary part, the decision equations for 64-QAM are:
     b0 = 2.0-|b1|; b1 = 4 - |Q|; b2 = -Q; b3 = 2.0-|b4|; b4 = 4 - |I|; b5 = -I.
   - If input is multiplied by sqrt(10) and I is the real part of product and Q is the imaginary part, the decision equations for 16-QAM are:
     b0 = 2.0-|b1|; b1 = -Q; b2 = 2.0-|b3|; b3 = -I.
   - If input is multiplied by sqrt(2) and I is the real part of product and Q is the imaginary part, the decision equations for QPSK are:
     b0 = -Q; b1 = -I.
4. Based on the above calculations, let any one of decision bits equal b:
   - when DecoderType is set to Hard, if b < 0, -1.0 is output, otherwise 1.0 is output.
   - when DecoderType is set to Soft, if b < -1.0, -1.0 is output; if b > 1.0, 1.0 is output, otherwise, b is output directly.
   - when DecoderType is set to CSI, b is multiplied by CSI (normalized channel response estimation) and output. Different bits which form one constellation have the same CSI.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_FrameSync (802.16e OFDMA Uplink Frame Synchronization)



Description: Uplink frame sync
Library: WMAN 16e, Receiver

Parameters

Name	Description	Default	Unit	Type	Range
Bandwidth	Bandwidth	1.75 MHz	Hz	int	[1,1e9]
CyclicPrefix	Cyclic prefix	0.25		real	[0,1]
IdleInterval	Idle Interval	10 usec	sec	real	[0,0.02]
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration (ms): time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_2048		enum	
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 1		enum	
ZoneNumOfSym	Number of symbol in zone	3		int	[3,1212]

Pin Inputs

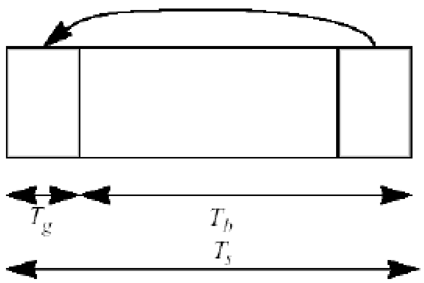
Pin	Name	Description	Signal Type
1	DataIn	input data	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	Index	frame start index	int
3	Corr	correlation results	real

Notes/Equations

1. This model is used to perform uplink frame synchronization.
2. Each firing,
   - SampleNumFrame tokens are consumed at DataIn, where SampleNumFrame is the number of samples within one frame.
   - One token is generated at pin Index, which indicates the value of synchronization index; and $SampleNumSym \times (ZoneNumSym - 1)$ tokens are generated at pin Corr, which indicate the autocorrelation values, where SampleNumSym is the number of samples within one symbol, and ZoneNumSym is the number of symbols within the zone. $SampleNumSym \times (ZoneNumSym - 1)$ is the width of search window.
3. Inverse-Fourier-transforming creates the OFDMA waveform, as shown in OFDMA symbol time structure; this time duration is referred to as the useful symbol time Tb. A copy of the last Tg of the useful symbol period , termed CP, is used to collect multipath, while maintaining the orthogonality of the tones. This provides multipath immunity as well as a tolerance for symbol time synchronization errors. OFDMA symbol time structure illustrates this structure.



OFDMA symbol time structure

4. The synchronization algorithm is based on autocorrelation of the repetitive fragments of the symbol time structure, i.e CP and the last Tg of the useful symbol period. Autocorrelation is calculated as follows:

$$Correlation_i = \sum_{j=0}^{ZoneNumSym-1} |C_j|$$

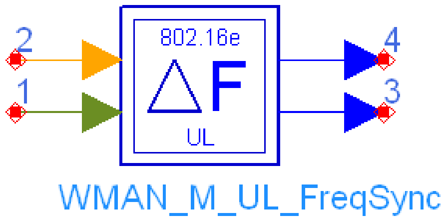
$$Cj = \sum_{k=0}^{SampleNumCP-1} Sample_{i+j \bullet SampleNumSym+k}(Sample_{i+j \bullet SampleNumSym+k+SampleNumData})^*$$

where
SampleNumCP is the number of samples within Tg,
SampleNumData is the number of samples within Tb
i = 0, 1, ..., $SampleNumSym \times (ZoneNumSym-1)$
The value of i, which makes autocorrelation Correlationi largest, corresponds to the beginning position of the frame, and is output at Index, and Correlationi is output at Corr.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_FreqSync (802.16e OFDMA UpLink Frequency Synchronization)



Description: Uplink frequency sync
Library: WMAN 16e, Receiver

Parameters

Name	Description	Default	Unit	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_2048		enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC	UL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	6		int	[3,1212]
UL_PermBase	UL PermBase	0		int	[0 , 69]
NumberOfBurst	Number of Bursts	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots in each burst	{4}		int array	[1,6868]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 1		enum	
Bandwidth	Nominal bandwidth	3.5 MHz	Hz	int	[1,1e9]
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
CyclicPrefix	Cyclic prefix	0.25		real	[0,1]
IdleInterval	Idle Interval	10 usec	sec	real	[0,0.02]
ZoneSymOffset	Symbol offset in zone	0		int	[0,1212]
PreambleIndex	Preamble index	16		int	[0,113]
FrameNumber	Frame number	0		int	[1,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
FreqOffsetRange	Frequency offset range	5		int	[0,10]

Pin Inputs

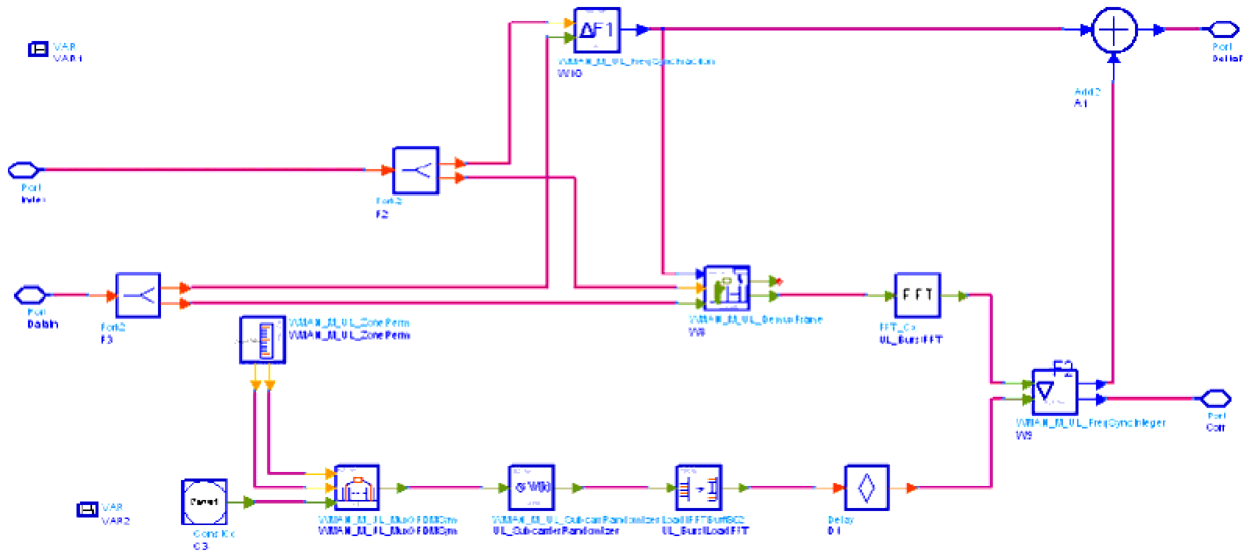
Pin	Name	Description	Signal Type
1	DataIn	input data	complex
2	Index	frame start index	int

Pin Outputs

Pin	Name	Description	Signal Type
3	Corr	correlation result	real
4	DeltaF	frequency offset	real

Notes/Equations

1. This subnetwork is used to estimate uplink frequency offset.
2. The schematic of the subnetwork is shown in WMAN_M_UL_FreqSync Schematic.



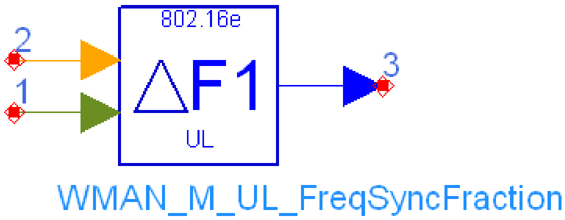
WMAN_M_UL_FreqSync Schematic

The WMAN_M_UL_FreqSyncFraction is used to estimate frequency offset less than subcarrier, and WMAN_M_UL_FreqSyncInteger is used to estimate frequency offset which is multiple times of subcarrier spacing. The frequncy offsets from the above two models are added together and output at pin DeltaF.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_FreqSyncFraction (802.16e OFDMA Uplink Fractional Frequency Synchronization)



Description: Uplink fraction frequency sync
Library: WMAN 16e, Receiver

Parameters

Name	Description	Default	Unit	Type	Range
Bandwidth	Bandwidth	1.75 MHz	Hz	int	[1,1e9]
CyclicPrefix	Cyclic prefix	0.25		real	[0,1]
IdleInterval	Idle Interval	10 usec	sec	real	[0,0.02]
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration (ms): time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_2048		enum	
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 1		enum	
ZoneNumOfSym	Number of symbol in zone	3		int	[3,1212]

Pin Inputs

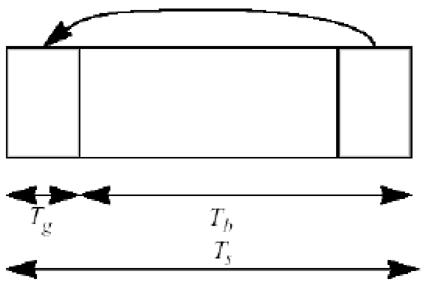
Pin	Name	Description	Signal Type
1	DataIn	input data	complex
2	Index	frame start index	int

Pin Outputs

Pin	Name	Description	Signal Type
3	DeltaF	frame start index	real

Notes/Equations

1. This model is used to estiamte uplink fractional frequency offset, i.e frequency offset which is less than subcarrier spacing.
2. Each firing,
   - SampleNumFrame tokens are consumed at DataIn, where SampleNumFrame is the number of samples within one frame, and one token is consumed at pin Index, which indicates the beginning of the frame.
   - One token is generated at pin DeltaF, which indicates the estiamted frequency offset.
3. Inverse-Fourier-transforming creates the OFDMA waveform, as shown in OFDMA Symbol Time Structure; this time duration is referred to as the useful symbol time Tb. A copy of the last Tg of the useful symbol period , termed CP, is used to collect multipath, while maintaining the orthogonality of the tones. This provides multipath immunity as well as a tolerance for symbol time synchronization errors.



OFDMA Symbol Time Structure

4. The fractional frequency offset estimation algorithm is based on autocorrelation of the repetitive fragments of the symbol time structure, i.e CP and the last Tg of the useful symbol period, and is calculated as follow:

$$DeltaF = \arg\left(\sum_{j=0}^{ZoneNumSym-1} C_j\right) / (2\pi T_b)$$

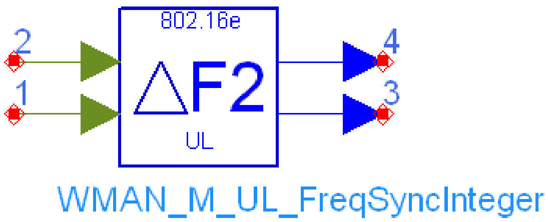
$$Cj = \sum_{k=0}^{SampleNumCP-1} Sample_{Index+jSampleNumSym+k+SampleNumData}(Sample_{Index+jSampleNumSym+k})^*$$

where
SampleNumCP is the number of samples within Tg,
SampleNumData is the number of samples within Tb

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_FreqSyncInteger (802.16e OFDMA Uplink Integer Frequency Synchronization)



Description: Uplink integer frequency sync
Library: WMAN 16e, Receiver

Parameters

Name	Description	Default	Unit	Type	Range
Bandwidth	Bandwidth	1.75 MHz	Hz	int	[1,1e9]
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_2048		enum	
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 1		enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC	UL_PUSC		enum	
ZoneNumOfSym	Number of symbol in zone	3		int	[3,1212]
FreqOffsetRange	Frequency offset range	5		int	[0,10]

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	complex
2	PilotIn	input pilot	complex

Pin Outputs

Pin	Name	Description	Signal Type
3	DeltaF	integer freqoffset	real
4	Corr	correlation result	real

Notes/Equations

1. This model is used to estimate integer frequency offset, i.e frequency offset which is multiple times of subcarrier spacing.
2. Each firing,
   - $SCNUmSym \times SymNumZone$ tokens are consumed at DataIn and PilotIn respectively, where SCNumOf Sym is the number of subcarriers within one symbols, and SymNumZone is the number of symbols within the zone.
   - One token is generated at DeltaF, which indicates the estimated integer frequency offset, and $2 \times FrequencyOffset + 1$ tokens are generated at Corr, where FrequncyOffset is the maximum frequency offset in unit of subcarrier spacing, and $2 \times FrequencyOffset + 1$ is the width of searching window.
3. The integer frequency offset estimation algorithm is based on slide correlation of the input data sequence and local pilot sequence in frequency domain as follows:

   $$Corr_{offset} = \sum_{j=0}^{SymNumZone-1} \left| \sum_{i=0}^{SCNumSym-1} P_{jSymNumZone+i+offset} D_{jSymNumZone+i} \right|^2$$

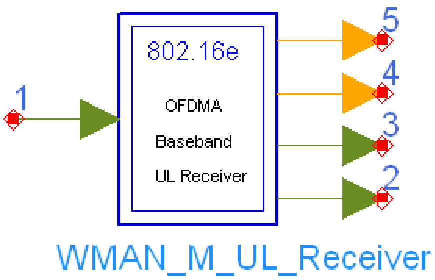
   where
   offset is frequncy offset in unit of subcarrier spacing, and ranges from -FrequncyOffset to +FrequncyOffset;
   D is input data sequence; and
   P is local pilot sequence.

The value of offset which makes Corroffset maximum is the frequncy offset in number of subcarrier spacing and is ouput at DeltaF. Corroffset is output at Corr.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_Receiver (802.16e OFDMA UL Receiver)



Description: Uplink receiver
Library: WMAN 16e, Receiver

Parameters

Name	Description	Default	Unit	Type	Range
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01 , 0.99]
FrameDuration	Frame duration: time 2ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[0,20000]
PreambleIndex	Preamble index	3		int	[0,113]
FrameNumber	Frame number	0		int	[1,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
UL_PermBase	Uplink permutation base	0		int	[0 , 69]
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24		int	[3,1212]
ZoneSymOffset	Symbol offset in zone	0		int	[0,1211]
NumberOfBurst	Number of Bursts	1		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}		int array	[1,6868]
DataLength	MAC PDU payload byte length of each burst	{300}		int array	[1,∞)
Rate_ID	Rate ID of each burst	{3}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0}		int array	[0,3]
DecoderType	Demapping type: Hard, Soft, CSI	CSI		enum	
FreqOffsetRange	Frequency offset range	5		int	[0,10]
SNR	SNR in dB.	15		real	[-∞,∞]
Tmax	The maximum delay of multi-path channel.	1e-6		real	[0,∞]
Fmax	The maximum doppler frequency.	100 Hz	Hz	real	[0,∞]
BurstFEC_CodingType	Coding type for the burst with FEC-encoding: CC, CTC	CC		enum	
IterationNumber	The number of iterations (only for CTC decoder)	8		int	[1,16]
CycleNumber	The number of decoding cycles to get circulation states (only for CTC decoder)	1		int	[1,16]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	

Pin Inputs

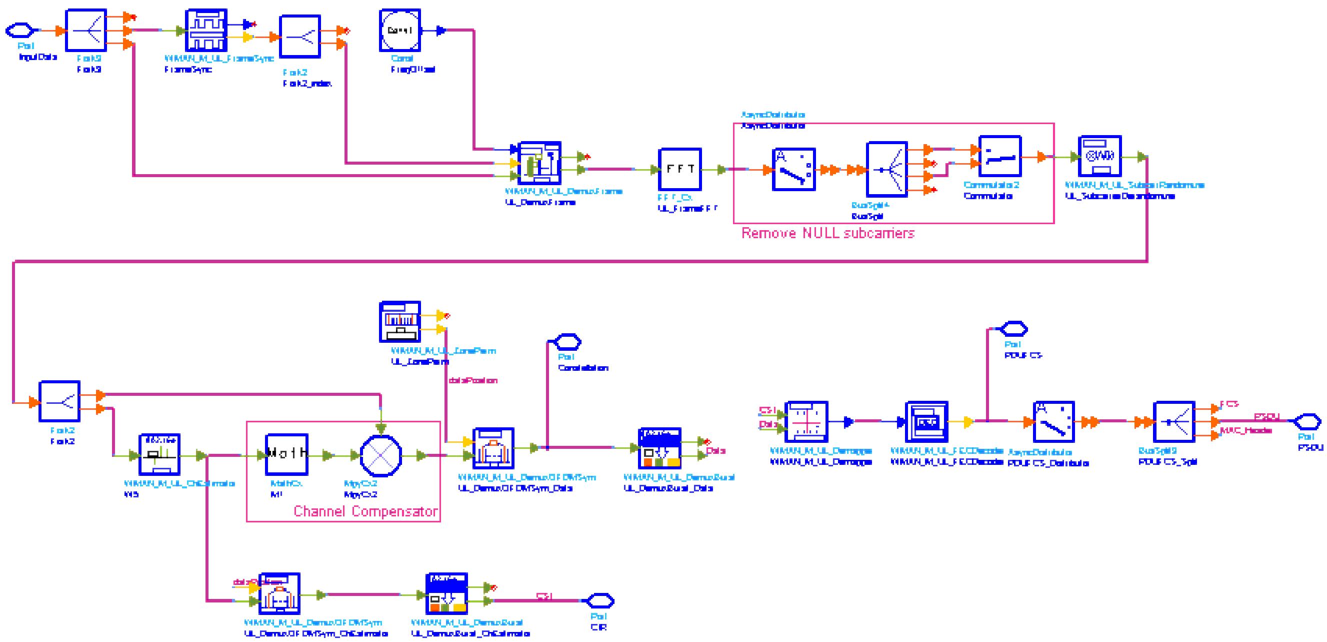
Pin	Name	Description	Signal Type
1	InputData	input of uplink Subframe	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	CIR	output of channel pulse response	complex
3	Constellation	output of Modulated data of all bursts	complex
4	PDUFCS	output of MAC data of burst with FEC	int
5	PSDU	output of MAC PDU data of burst with FEC	int

Notes/Equations

1. This subnetwork model implements 802.16e OFDMA uplink baseband receiver following IEEE 802.16-2004 specification. The uplink baseband receiver schematic is shown in WMAN_M_UL_Receiver Schematic.



WMAN_M_UL_Receiver Schematic

2. Receiver functions are implemented as follows:
Start of frame is detected. WMAN_M_UL_FrameSync calculates the correlation between the received OFDMA symbols and the CyclicPrefix, and selects the index with the maximum correlation value as the start of frame.
Frequency offset is estimated. WMAN_M_UL_FreqSyncFraction calculates the fraction part of the frequency offset using CyclicPrefix. WMAN_M_UL_FreqSyncInteger calculates the correlation between the ideal pilots and the received signal which has been synchronized and frequency compensated of fraction part, and get the integer part of frequency offset. WMAN_M_UL_FreqSync outputs the frequency offset.
The packet is de-rotated according to the estimated frequency offsets (frequency synchronization). The phase effect caused by the frequency offset is compensated by WMAN_M_UL_DemuxFrame.
WMAN_M_UL_DemuxFrame outputs OFDMA symbols for multi-bursts and non frequency compensated uplink frame with useful data for CCDF calculation. This WMAN_M_UL_DemuxFrame component introduces one frame delay.
After FFT and subcarrier derandomizer, complex channel impulse responses (CIR) are estimated and interpolated for each subcarrier (channel estimation). First, in each tile WMAN_M_UL_ChEstimator gets CIRs for the pilot subcarriers. Then, WMAN_M_UL_ChEstimator gets CIRs for the data subcarriers by interpolating in both frequency and time domain.
Each subcarrier value is divided by a complex estimated channel response coefficient. This simple one-tap frequency domain channel response compensation is implemented in the receiver.
After equalization, WMAN_M_UL_DemuxOFDMSym extracted the data sequences of multi-bursts according to the physical indices of data subcarriers calculated by WMAN_M_UL_ZonePerm. The data sequences of multi-bursts are output at pin Constellation. The signal can be used to show the demodulated constellation and to calculate the RCE (relative constellation error) or EVM.
The CIRs is separated by WMAN_M_UL_DemuxOFDMSym and WMAN_M_UL_DemuxBurst to get CIR for the burst FEC-encoded and output at pin CIR.
The burst with FEC-encoded is separated from the multi-bursts in WMAN_M_UL_DemuxBurst.
The data sequences of burst with FEC are then de-mapped by WMAN_M_Demapper. Three demapper types (CSI, Soft and Hard) are supported in WMAN_M_Demaper.
After de-repetition, de-interleaving, FEC-decoding, de-randomizer by WMAN_M_UL_FECDecoder, the MAC PDU data are achieved, which are divided into MAC header, MAC PDU payloads and CRC. The MAC Header and MAC PDU payloads are output at pin PDUFCS and PSDU respectively. CTC decoding is not supported currently.
3. Parameter Details
    - Bandwidth determines the nominal channel bandwidth.
    - OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
    - FFTSize indicates the FFT point size (512, 1024, or 2048). The FFT size is independent on the selected bandwidth.

- CyclicPrefix (G) specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
- FrameMode determines what will actually be included in the generated waveform. FDD Mode means the entire frame is used for the uplink and the uplink starts at the beginning of the frame. TDD Mode means only the uplink is included in the generated waveform and it starts at some delay from the frame start time based on the Downlink Ratio setting.
- DL_Ratio set the percentage (1 to 99) of the frame time to be used for the downlink and also set the start time for the uplink. The parameter is only active when the frame mode is TDD.
- FrameDuration determines the frame durations (ms) of the generated waveform. There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
- IdleInterval specifies the time of idle interval between two consecutive frames.
- PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to Table 309 in the standard.
- FrameNumber specifies the frame number (0 to 0xffffff) of the uplink frame.
- FrameIncreased indicates whether the frame number of the generated waveform is increased one by one.
- UL_PermBase specifies the permutation base that will be used in this uplink zone. Accepted values are 0 to 69.
- ZoneType specifies the zone type which can be set to PUSC, OPUSC or AMC.
- ZoneNumOfSym specifies the number of symbols in the zone. The value must be a multiple of three because the uplink zone is divided into slots of 3 symbols x 1 subchannel for PUSC, OPUSC and AMC with 2x3. For AMC with 1x6, the value should be a integer multiple of six. For AMC with 3x2, the value should be a integer multiple of two. The maximum number of symbols available depends on the Bandwidth, frame length, DL_Ratio, FFTSize, and CyclicPrefix.
- NumberOfBurst specifies the number of active uplink bursts.
- BurstWithFEC specifies the uplink burst FEC.
- BurstSymOffset positions each burst on the horizontal axis (x), if necessary, to avoid any burst overlap. The parameter is an array element .
- BurstSubchOffset positions each burst on the vertical axis (y), if necessary, to avoid any burst overlap. The parameter is an array element.
- BurstAssignedSlot specifies the total available slots in each burst. The parameter is an array element.
- DataLength is the array of each burst's MAC PDU payload data length in bytes.
- Rate_ID is the array of each burst's Rate ID, whose range is from 0 to 6 for CC encoding. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in *The Relation of Coding Type and Rate ID*.

Coding type	**Rate ID**	**<th**
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. The parameter is an array element and only available when QPSK 1/2 or QPSK 3/4 is selected as the burst profile (Rate_ID). Each repetition coding can be selected from 0 to 3, whose meaning is shown in *The Meaning of Repetition Coding*.

Repetition coding	**Meaning**
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4used on the burst
3	Repetition coding of 6used on the burst

- DecoderType specifiers the Viterbi decoder type chosen from CSI, Soft and Hard.CSI (Channel State

Information) is a channel estimate profile. This decision is neither hard or soft; it is adaptive based on where you are in the channel profile.

- FreqOffsetRange determines frequency offset in unit of subcarrier spacing, and ranges from -FrequencyOffset to +FrequencyOffset used by WMAN_M_UL_FreqSyncInteger.
- SNR specifies the signal noise ratio at receiver antenna in dB. This parameter is useful for the channel estimator in UL PUSC.
- Tmax specifies the maximum echo delay in multi-path channel. This parameter is useful for the channel estimator in UL PUSC.
- Fmax specifies the maximum Doppler frequency. This parameter is useful for the channel estimator in UL PUSC.
- BurstFEC_CodingType specifies the coding type for the burst with FEC-encoding. CC means convolutional coding while CTC means convolutional turbo coding.
- IterationNumber specifies the number of iterations for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).
- CycleNumber specifies the number of decoding cycles in order to get circulation states for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).

4. Output Pin Delay Adjustment
The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-10-14-121.gif!) as follows,
$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$
The sampling factors are listed in *Sampling Factor Requirement*.

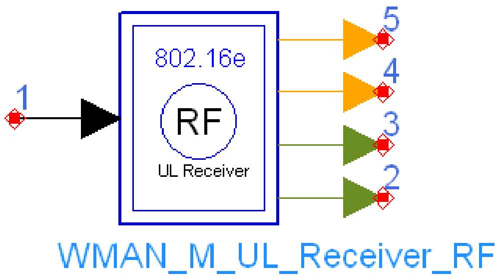
Sampling factor n	Bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval (!wman_m-10-14-123.gif!) is calculated as follows:
$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$
So, the total samples of one uplink frame $Samples_{Frame}$ is
$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$
This model works frame by fame. Each firing, $Samples_{Frame}$ tokens are consumed at Pin FrameData. CIR pin outputs channel pulse response for burst FEC-encoded. Each firing, pin CIR produces $BurstAssignedSlot[BurstWithFEC] \times 48$ tokens. The first $BurstAssignedSlot[BurstWithFEC] \times 48$ signals at the CIR pin are zeros. Constellation pin has one WMAN OFDMA UL frame delay. This pin outputs constellations for all bursts. Each firing, pin Constellation produces $\sum_{i=1}^{NumberOfBurst} BurstAssignedSlot[i] \times 48$ tokens. The first $\sum_{i=1}^{NumberOfBurst} BurstAssignedSlot[i] \times 48$ signals at the Constellation pin are zeros. PSDUFCS has one frame delay. This pin outputs demodulated PSDU and FCS information bits after fully decoding (de-interleaving, Viterbi decoding and de-randomizer). So, the delay of PDUFCS is $8 \times DataLength[BurstWithFEC] + 80$. The first $8 \times DataLength[BurstWithFEC] + 80$ bits at the PSDUFCS pin are zeros.
PSDU also has one frame delay. This pin outputs demodulated PSDU information bits after fully decoding (de-interleaving, Viterbi decoding and de-randomizer). So, the delay of PSDU is $8 \times DataLength[BurstWithFEC]$. The first $8 \times DataLength[BurstWithFEC]$ bits at the PSDU pin are zeros.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_Receiver_RF (802.16e OFDMA Uplink Receiver RF)



Description: Uplink RF receiver
Library: WMAN 16e, Receiver

Parameters

Name	Description	Default	Unit	Type	Range
RIn	input resistance	DefaultRIn	Ohm	int	(0,∞)
RTemp	TEMPERATURE	DefaultRTemp	Celsius	real	[-273.15,∞]
FCarrier	Carrier frequency	3407 MHz	Hz	real	(0,∞)
Sensitivity	voltage output sensitivity, Vout/Vin	1		real	(-∞,∞)
Phase	Reference phase in degrees	0.0	deg	real	(-∞,∞)
GainImbalance	Gain imbalance in dB Q channel relative to I channel	0.0		real	(-∞,∞)
PhaseImbalance	Phase imbalance in dB Q channel relative to I channel	0.0		real	(-∞,∞)
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	([0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
PreambleIndex	Preamble index	0		int	[0,113]
FrameNumber	Frame number	0		int	[1,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
UL_PermBase	Uplink permutation base	0		int	[0 , 69]
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24		int	[3,1212]
NumberOfBurst	Number of Bursts	1		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}		int array	[1,6868]
DataLength	MAC PDU payload byte length of each burst	{300}		int array	[1,∞)
Rate_ID	Rate ID of each burst	{3}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0}		int array	[0,3]
DecoderType	Demapping type: Hard, Soft, CSI	CSI		enum	
FreqOffsetRange	Frequency offset range	5		int	[0,10]
SNR	SNR in dB.	15		real	[-∞,∞]
Tmax	The maximum delay of multi-path channel.	1e-6		real	[0,∞]
Fmax	The maximum doppler frequency.	100 Hz	Hz	real	[0,∞]
BurstFEC_CodingType	Coding type for the burst with FEC-encoding: CC, CTC	CC		enum	
IterationNumber	The number of iterations (only for CTC decoder)	8		int	[1,16]
CycleNumber	The number of decoding cycles to get circulation states (only for CTC decoder)	1		int	[1,16]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	

Pin Inputs

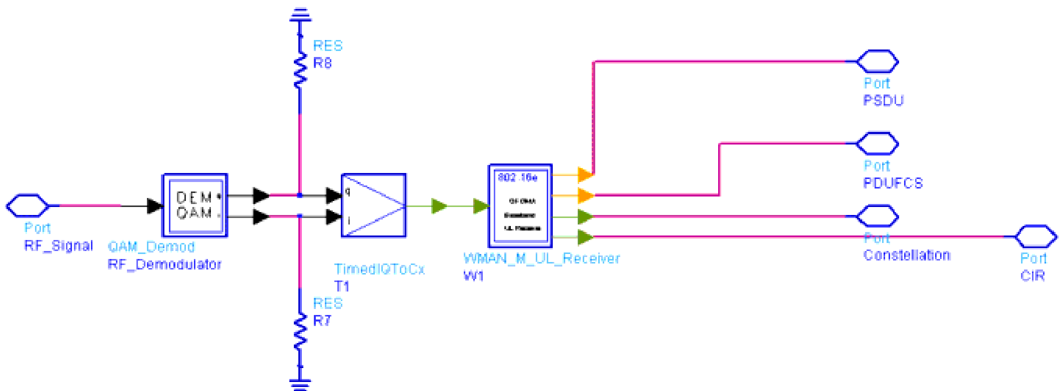
Pin	Name	Description	Signal Type
1	RF_Signal	input of RF signal	timed

Pin Outputs

Pin	Name	Description	Signal Type
2	CIR	output of channel pulse response	complex
3	Constellation	output of Modulated data of all bursts	complex
4	PDUFCS	output of MAC data of burst with FEC	int
5	PSDU	output of MAC PDU data of burst with FEC	int

Notes/Equations

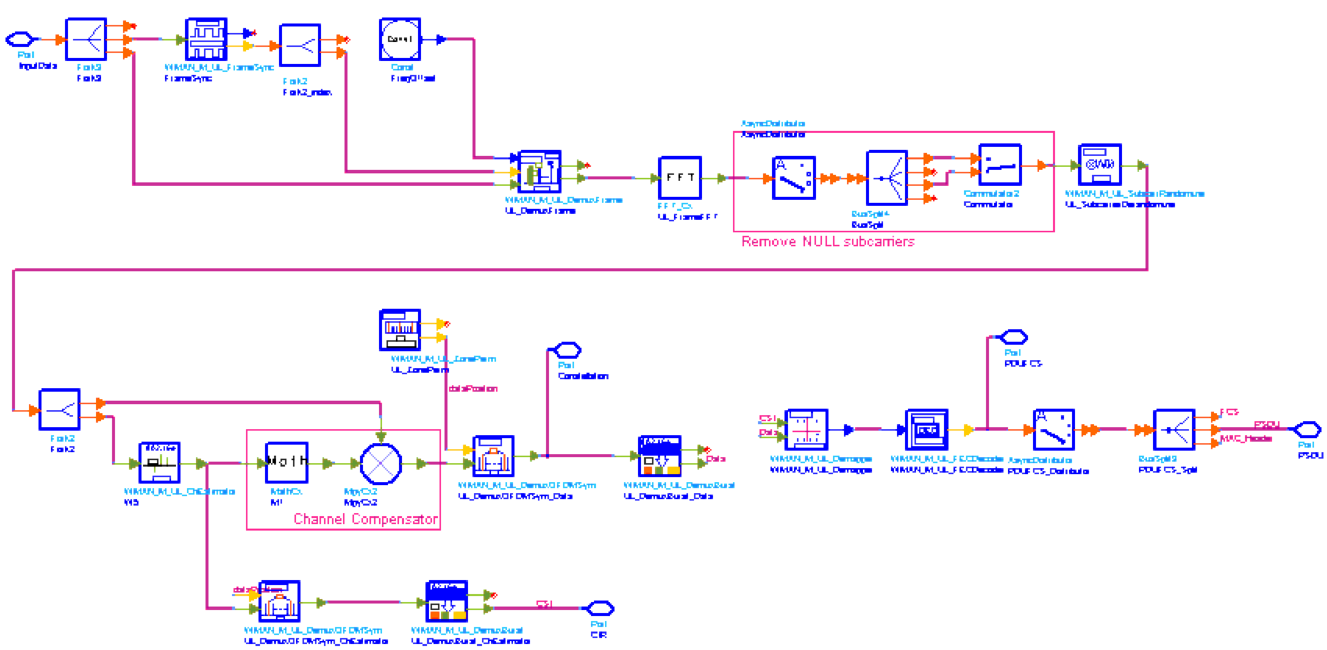
1. This subnetwork is used to demodulate and decode 802.16e OFDMA uplink RF signals. The schematic for this subnetwork is shown in WMAN_M_UL_Receiver_RF Schematic.



WMAN_M_UL_Receiver_RF Schematic

The received RF signal is demodulated by QAM_Demod, the demodulated signal is then fed to the baseband receiver for baseband processing.

2. The WMAN_M_UL_Receiver acts as 802.16e OFDMA uplink baseband receiver. The schematic for this subnetwork is shown in WMAN_M_UL_Receiver Schematic.



WMAN_M_UL_Receiver Schematic

3. Receiver functions are implemented as follows:
   Start of frame is detected. WMAN_M_UL_FrameSync calculates the correlation between the received OFDMA symbols and the CyclicPrefix, and selects the index with the maximum correlation value as the start of frame.
   Frequency offset is estimated. WMAN_M_UL_FreqSyncFraction calculates the fraction part of the frequency offset using CP. WMAN_M_UL_FreqSyncInteger calculates the correlation between the received signal which has been synchronized and frequency compensated of fraction part and the pilots, and get the integer part of frequency offset. WMAN_M_UL_FreqSync outputs the frequency offset.
   The packet is de-rotated according to the estimated frequency offsets (frequency synchronization). The phase effect caused by the frequency offset is compensated by WMAN_M_UL_DemuxFrame.
   WMAN_M_UL_DemuxFrame outputs OFDMA symbols for multi-bursts and non frequency compensated uplink frame with useful data for CCDF calculation. This WMAN_M_UL_DemuxFrame component introduces one frame delay.
   After FFT and subcarrier derandomizer, complex channel impulse responses (CIR) are estimated and interpolated for each subcarrier (channel estimation). First, in each tile WMAN_M_UL_ChEstimator gets CIRs for the pilot subcarriers . Then, WMAN_M_UL_ChEstimator gets CIRs for the data subcarriers by interpolating in both frequency and time domain.
   Each subcarrier value is divided by a complex estimated channel response coefficient . This simple one-tap frequency domain channel response compensation is implemented in the receiver.
   After equalization, WMAN_M_UL_DemuxOFDMSym extracted the data sequences of multi-bursts according to the physical indices of data subcarriers calculated by WMAN_M_UL_ZonePerm. The data sequences of multi-bursts are output at pin Constellation. The signal can be used to show the demodulated constellation and to calculate the RCE (relative constellation error) or EVM.
   The CIRs is separated by WMAN_M_UL_DemuxOFDMSym and WMAN_M_UL_DemuxBurst to get CIR for the burst FEC-encoded and output at pin CIR.
   The burst with FEC-encoded is separated from the multi-bursts in WMAN_M_UL_DemuxBurst.
   The data sequences of burst with FEC are then de-mapped by WMAN_M_Demapper. Three demapper types (CSI, Soft and Hard) are supported in WMAN_M_Demaper.
   After de-repetition, de-interleaving, FEC-decoding, de-randomizer by WMAN_M_UL_FECDecoder, the MAC PDU data are achieved, which are divided into MAC header, MAC PDU payloads and CRC. The MAC Header and MAC PDU payloads are output at pin PDUFCS and PSDU respectively. CTC decoding is not supported currently.
4. Parameter Details
   - RIn is the RF input resistance.
   - RTemp is the RF output resistance temperature in Celsius and sets the noise density in the RF output signal to (k(RTemp+273.15)) Watts/Hz, where k is Boltzmann's constant.
   - FCarrier is the RF output signal frequency.
   - Sensitivity is the voltage output sensitivity (Vout/Vin) of the internal oscillator that generates the reference carrier signal used to demodulate the RF signal.
   - Phase is the reference phase in degrees of the reference carrier signal.
   - GainImbalance and PhaseImbalance add certain impairments to the ideal output RF signal. Impairments are added as described here.
     The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:
     $$V_3(t) = A\left(V_1(t)\cos(\omega_c t) - gV_2(t)\sin\left(\omega_c t + \frac{\Phi\pi}{180}\right)\right)$$
     where V1(t) is the in-phase RF envelope, V2(t) is the quadrature phase RF envelope, g is the gain imbalance:
     $$g = 10^{\frac{GainImbalance}{20}}$$
     and, !wman_m-10-15-141.gif!(in degrees) is the phase imbalance.
   - Bandwidth determines the nominal channel bandwidth.
   - OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
   - FFTSize indicates the FFT point size (512, 1024, or 2048). The FFT size is independent of the selected bandwidth.
   - CyclicPrefix (G) specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
   - FrameMode determines what will actually be included in the generated waveform. FDD Mode means the entire frame is used for the uplink and the uplink starts at the beginning of the frame. TDD Mode means only the uplink is included in the generated waveform and it starts at some delay from the frame start time based on the Downlink Ratio setting.
   - DL_Ratio set the % (1 to 99) of the frame time to be used for the downlink and also set the start time for the uplink. This parameter is only active when the frame mode is TDD.
   - FrameDuration determines the frame durations (ms) of the generated waveform. There are eight frame

durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.

- IdleInterval specifies the time of idle interval between two consecutive frames.
- PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to Table 309 in the standard.
- FrameNumber specifies the frame number (0 to 0xffffff) of the uplink frame.
- FrameIncreased indicates whether the frame number of the generated waveform is increased one by one.
- UL_PermBase specifies the permutation base that will be used in this uplink zone. Accepted values are 0 to 69.
- ZoneType specifies the zone type which can be set to PUSC, OPUSC or AMC.
- ZoneNumOfSym specifies the number of symbols in the zone. The value must be a multiple of three because the uplink zone is divided into slots of 3 symbols x 1 subchannel for PUSC, OPUSC and AMC with 2x3. For AMC with 1x6, the value should be a integer multiple of six. For AMC with 3x2, the value should be a integer multiple of two. The maximum number of symbols available depends on the Bandwidth, frame length, DL_Ratio, FFTSize, and CyclicPrefix.
- NumberOfBurst specifies the number of active uplink bursts.
- BurstWithFEC specifies the uplink burst FEC.
- BurstSymOffset positions each burst on the horizontal axis (x), if necessary, to avoid any burst overlap. This parameter is an array element.
- BurstSubchOffset positions each burst on the vertical axis (y), if necessary, to avoid any burst overlap. This parameter is an array element.
- BurstAssignedSlot specifies the total available slots in each burst. This parameter is an array element.
- DataLength is the array of each burst's MAC PDU payload data length in bytes.
- Rate_ID is the array of each burst's Rate ID, whose range is from 0 to 6 for CC encoding. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in *The Relation of Coding Type and Rate ID*.

Coding type	Rate ID	<th
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. The parameter is an array element and only available when QPSK 1/2 or QPSK 3/4 is selected as the burst profile (Rate ID). Each repetition coding can be selected from 0 to 3, whose meaning is shown in *The Meaning of Repetition Coding*.

Repetition Coding	Meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4used on the burst
3	Repetition coding of 6used on the burst

- DecoderType specifiers the Viterbi decoder type chosen from CSI, Soft and Hard. CSI (Channel State Information) is a channel estimate profile. This decision is neither hard or soft; it is adaptive based on where you are in the channel profile.
- FreqOffsetRange determines frequency offset in unit of subcarrier spacing, and ranges from -FrequencyOffset to +FrequencyOffset used by WMAN_M_UL_FreqSyncInteger.
- SNR specifies the signal noise ratio at receiver antenna in dB. This parameter is useful for the channel estimator in UL PUSC.
- Tmax specifies the maximum echo delay in multi-path channel. This parameter is useful for the channel estimator in UL PUSC.

- Fmax specifies the maximum Doppler frequency. This parameter is useful for the channel estimator in UL PUSC.
- BurstFEC_CodingType specifies the coding type for the burst with FEC-encoding. CC means convolutional coding while CTC means convolutional turbo coding.
- IterationNumber specifies the number of iterations for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).
- CycleNumber specifies the number of decoding cycles in order to get circulation states for CTC decoder. This parameter is only valid when the coding type for the burst with FEC encoding is CTC (i.e. CodingType[BurstWithFEC]=1).

5. Output Pin Delay Adjustment
The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-10-15-142.gif!) as follows,
$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$
The sampling factors are listed in *Sampling Factor Requirement*.

Sampling factor n	Bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval(!wman_m-10-15-144.gif!) is calculated as follows:
$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$
So, the total samples of one uplink frame $Samples_{Frame}$ is
$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$
This model works frame by fame. Each firing, $Samples_{Frame}$ tokens are consumed at Pin FrameData. CIR pin outputs channel pulse response for burst FEC-encoded. Each firing, pin CIR produces $BurstAssignedSlot[BurstWithFEC] \times 48$ tokens. The first $BurstAssignedSlot[BurstWithFEC] \times 48$ signals at the CIR pin are zeros. Constellation pin has one WMAN OFDMA UL frame delay. This pin output constellations for all bursts.Each firing, pin Constellation produces $\sum_{i=1}^{NumberOfBurst} BurstAssignedSlot[i] \times 48$ tokens.
The first $\sum_{i=1}^{NumberOfBurst} BurstAssignedSlot[i] \times 48$ signals at the Constellation pin are zeros. PSDUFCS has one frame delay. This pin outputs demodulated PSDU and FCS information bits after fully decoding (de-interleaving, Viterbi decoding and De-randomizer). So, the delay of PDUFCS is $8 \times DataLength[BurstWithFEC] + 80$. The first $8 \times DataLength[BurstWithFEC] + 80$ bits at the PSDUFCS pin are zeros.
PSDU also has one frame delay. This pin outputs demodulated PSDU information bits after fully decoding (de-interleaving, Viterbi decoding and de-randomizer). So, the delay of PSDU is $8 \times DataLength[BurstWithFEC]$. The first $8 \times DataLength[BurstWithFEC]$ bits at the PSDU pin are zeros.

References

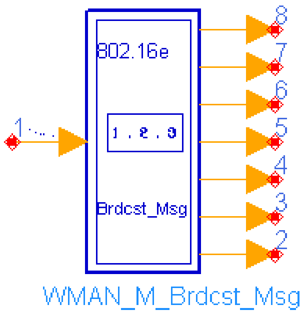
1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

802.16e OFDMA Signal Source Components

The 16e signal source models provide models to generate downlink and uplink signal sources.

- *WMAN M Brdcst Msg (802.16e OFDMA Broadcast Message)* (wman_m)
- *WMAN M CDD (802.16e OFDMA CDD Implementation)* (wman_m)
- *WMAN M Compressed DL UL MAP (802.16e OFDMA Compressed DL and UL MAP)* (wman_m)
- *WMAN M DataPattern (802.16e OFDMA Data Pattern)* (wman_m)
- *WMAN M DCD (802.16e OFDMA DCD)* (wman_m)
- *WMAN M DLFP (802.16e OFDMA Downlink Frame Prefix)* (wman_m)
- *WMAN M DL MAP (802.16e OFDMA DLMAP)* (wman_m)
- *WMAN M DL PowerAdjust (802.16e OFDMA Downlink Power Adjust)* (wman_m)
- *WMAN M DL SignalSrc (802.16e OFDMA Downlink Signal Source)* (wman_m)
- *WMAN M DL SignalSrc RF (802.16e OFDMA Downlink RF Signal Source)* (wman_m)
- *WMAN M DL Src AllCoded (802.16e OFDMA Downlink Source with All Coded Bursts)* (wman_m)
- *WMAN M DL Src AllCoded RF(802.16e OFDMA Downlink RF Source with All Coded Bursts)* (wman_m)
- *WMAN M DL Src FDD (802.16e OFDMA Downlink FDD Signal Source)* (wman_m)
- *WMAN M DL Src FDD RF (802.16e OFDMA Downlink FDD RF Signal Source)* (wman_m)
- *WMAN M DL Src Ranging (802.16e OFDMA Downlink Src Ranging)* (wman_m)
- *WMAN M DL Src Ranging RF (802.16e OFDMA Downlink Ranging RF Src)* (wman_m)
- *WMAN M DL ZonePerm (802.16e OFDMA DL Zone Permutation)* (wman_m)
- *WMAN M MACHeader (802.16e OFDMA MAC Header)* (wman_m)
- *WMAN M MACPDU (802.16e OFDMA MAC PDU)* (wman_m)
- *WMAN M OFDM Modulator (802.16e OFDMA OFDM Modulator)* (wman_m)
- *WMAN M OFDM Modulator CDD (802.16e OFDMA OFDM Symbol Modulator With CDD)* (wman_m)
- *WMAN M Preamble (802.16e OFDMA Preamble)* (wman_m)
- *WMAN M SymWindow (802.16e OFDMA Symbol Window)* (wman_m)
- *WMAN M UCD (802.16e OFDMA UCD)* (wman_m)
- *WMAN M UL ACK (802.16e OFDMA Uplink Acknowledgement)* (wman_m)
- *WMAN M UL FFB (802.16e OFDMA UL FFB)* (wman_m)
- *WMAN M UL MAP (802.16e OFDMA ULMAP)* (wman_m)
- *WMAN M ULMAP Full (802.16e OFDMA ULMAP Full)* (wman_m)
- *WMAN M UL PowerAdjust (802.16e OFDMA Uplink Power Adjust)* (wman_m)
- *WMAN M UL Ranging (802.16e OFDMA Uplink Ranging)* (wman_m)
- *WMAN M UL RangingGuard (802.16e OFDMA Uplink Ranging Guard)* (wman_m)
- *WMAN M UL SignalSrc (802.16e OFDMA Uplink Signal Source)* (wman_m)
- *WMAN M UL SignalSrc RF (802.16e OFDMA Uplink RF Signal Source)* (wman_m)
- *WMAN M UL Src Ranging (802.16e OFDMA Uplink Source Ranging)* (wman_m)
- *WMAN M UL Src Ranging RF (802.16e OFDMA Uplink RF Source Ranging)* (wman_m)
- *WMAN M UL ZonePerm (802.16e OFDMA UL Zone Permutation)* (wman_m)
- *WMAN M UL ZonePerm Rect (802.16e OFDMA UL ZonePerm with Rect)* (wman_m)

WMAN_M_Brdcst_Msg (802.16e OFDMA Broadcast Message)



Description: Broadcast message
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Unit	Type	Ra
DLMAP_Enable	DLMAP is enabled or not: NO, YES	NO		enum	
Compressed_DLMap	Compressed DL_MAP or not if enabled: NO, YES	NO		enum	
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
Compressed_ULMap	Compressed UL_MAP or not if appended: NO, YES	NO		enum	
AutoMACHeaderSetting	Auto MAC_Header Setting: NO, YES	NO		enum	
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.
FrameDuration	Frame duration: time 2ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
Bandwidth	Bandwidth	10 MHz	Hz	int	[1,
CyclicPrefix	Cyclic prefix	0.125		real	[0,
DL_FFTSize	Downlink FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
DL_ZoneType	Downlink zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC		enum	
DL_AMC_Mode	Downlink AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
DL_ZoneNumOfSym	Number of OFDM symbols in downlink zone	24		int	[1,
DL_GroupBitmask	Used subchannel bitmaps in downlink zone	{1, 1, 1, 1, 1, 1}		int array	[0,
DL_NumberOfBurst	Number of Bursts in downlink zone	2		int	[1,
DL_BurstSymOffset	Symbol offset of each burst in downlink zone	{4,10}		int array	[0,
DL_BurstSubchOffset	Subchannel offset of each burst in downlink zone	{5,1}		int array	[0,
DL_BurstNumOfSym	Number of symbols of each burst in downlink zone	{6,14}		int array	[1,
DL_BurstNumOfSubch	Number of subchannels of each burst in downlink zone	{15,18}		int array	[1,
DL_CodingType	Coding type of each burst in downlink zone	{0,0}		int array	[0,
DL_Rate_ID	Rate ID of each burst in downlink zone	{5,5}		int array	[0,
DL_RepetitionCoding	Repetition coding of each burst in downlink zone	{0,0}		int array	[0,
DL_PowerBoosting	Power boosting of each burst in dB in downlink zone	{0,0}		real array	[-c
DL_STC_Encoder	STC encoder or not in downlink zone: NO, YES	NO		enum	
DL_STC_Matrix	STC matrix in downlink zone: Matrix_A, Matrix_B	Matrix_A		enum	
DL_FrameNumber	Frame number in downlink zone	0		int	[1,
DL_FrameIncreased	Frame number increasing or not in downlink zone: NO, YES	NO		enum	

DL_ZoneSymOffset	Symbol offset in downlink zone	3		int	[2,
DL_PermBase	DL permutation base	9		int	[0,
DL_PRBS_ID	PRBS initialization vector in downlink zone	0		int	[0,
ULMAP_CodingType	Coding type of ULMAP	0		int	[0,
ULMAP_Rate_ID	Rate ID of ULMAP	0		int	[0,
ULMAP_RepetitionCoding	Repetition coding of UL_MAP	0		int	[0,
ULMAP_PowerBoosting	Power boosting of UL_MAP	0		real	[-c
DCD_Count	DCD count	0		int	[0,
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00, 0X00, 0X01}		int array	[0,
DL_MidamblePresence	Midamble presence or not in downlink zone: NO, YES	NO		enum	
DL_MidambleBoosting	Midamble boosting or not in downlink zone: NO, YES	NO		enum	
DL_DedicatedPilots	Pilot symbols are broadcast or not in downlink zone: NO, YES	NO		enum	
UL_ZoneType	UL zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC		enum	
UL_AMC_Mode	Uplink AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
UL_ZoneSymOffset	Symbol offset in UL zone	0		int	[0,
UL_ZoneNumOfSym	Number of OFDMA symbols in the UL subframe	24		int	[0,
UL_PermBase	Uplink permutation base	0		int	[0,
UL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum	
UCD_Count	UCD count	1		int	[0,
UL_NumberOfBurst	Number of Bursts in uplink	1		int	[1,
UL_CID	Uplink CID	{1}		int array	[0,
UL_CodingType	Uplink coding type of each burst	{0}		int array	[0,
UL_Rate_ID	Uplink rate ID	{0}		int array	[0,
UL_BurstAssignedSlot	Assigned slots of each burst in uplink	{96}		int array	[1,
UL_RepetitionCoding	Repetition coding of each burst in uplink	{0}		int array	[0,
HARQ_ACK_Enable	HARQ ACK channel enabled or not: NO, YES	NO		enum	
HARQ_ACK_Allocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 12, 3, 6}		int array	[0,
RangingEnable	Ranging channel enabled or not: NO, YES	NO		enum	
RangingAllocation	Rectangular allocation: (SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 0, 3, 6}		int array	[0,
RangingMethod	Ranging mode: Initial/Handover_2 symbols, Initial/Handover_4 symbols, BW Request/Periodic_1 symbol, BW Request/Periodic_3 symbol	Initial/Handover_2 symbols		enum	
FastFeedBackEnable	Fast feedback channel enabled or not: NO, YES	NO		enum	
FastFeedBackAllocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 6, 3, 6}		int array	[0,
CQICH_Enable	CQICH channel enabled or not: NO, YES	NO		enum	
CQICH_ID	CQICH ID, set to fixed 6 bits	0		int	[0,
CQICH_AllocationOffset	CQICH channel allocation offset	0		int	[0,
CQICH_Period	CQICH channel period	0		int	[0,
CQICH_FrameOffset	CQICH channel frame offset	0		int	[0,
CQICH_Duration	CQICH channel duration	0		int	[0,
CQICH_FeedbackType	CQICH channel feedback type: physical CINR feedback, effective CINR feedback	physical CINR feedback		enum	
CQICH_CINR_Type	CQICH channel CINR preamble report type: Frequency reuse factor = 1 config, Frequency reuse factor = 3 config	Frequency reuse factor = 1 config		enum	
CQICH_AvgParamIncluded	CQICH channel average parameter included for physical CINR feedback: NO, YES	NO		enum	
CQICH_AvgParam	CQICH channel average parameter for physical CINR feedback	0		int	[0,
CQICH_MIMO_FeedbackCycle	CQICH channel MIMO permutation feedback cycle	0		int	[0,
UL_MIMO_Enable	MIMO enabled IE or not in uplink zone: NO, YES	NO		enum	
UL_Collaborative_SM_Indicator	Uplink collaborative SM indicator: non collaborative SM, collaborative SM	non collaborative		enum	

		SM			
UL_MIMO_Control	Uplink MIMO mode, effective when collaborative_SM_Indicator = non: STTD, SM	STTD		enum	
UL_CID_B	Uplink CID that shall use pilot pattern B	{1}		int array	[0,
UL_CodingType_B	Uplink coding type of each burst that shall use pilot pattern B	{0}		int array	[0,
UL_Rate_ID_B	Uplink rate ID that shall use pilot pattern B	{0}		int array	[0,
DLMAP_CodingType	Coding type of DLMAP	0		int	[0,
DLMAP_RepetitionCoding	Repetition coding of DL_MAP	0		int	[0,
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum	
DL_PreambleIndex	Downlink preamble index	3		int	[0,
DL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum	
DIUC_RateID	Mapping from DIUC (0-12) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}, {1,3}, {1,4}, {1,5		int array	[0,
UIUC_RateID	Mapping from UIUC (1-10) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2		int array	[0,

Pin Inputs

Pin	Name	Description	Signal Type
1	Cmps_MAP_MAC_Header	MAC header for compressed map	int

Pin Outputs

Pin	Name	Description	Signal Type
2	Coded_DLMAP	Coded and multiplexed DL_MAP and FCH	int
3	Coded_ULMAP	Coded and multiplexed normal UL_MAP	int
4	DLMAP_DCD	DL_MAP and DCD message	int
5	ULMAP_UCD	UL_MAP and UCD message	int
6	Cmps_MAP	Compressed DL_MAP and compressed UL_MAP message if appended	int
7	DLFP	output of DLFP data	int
8	DLMAP	output of DLMAP data	int

Notes/Equations

1. This subnetwork is used to generate coded broadcast messages for 802.16e OFDMA system.
2. Each firing
   6 bytes tokens are consumed at Pin Cmps_MAP_MAC_Header. When parameter AutoMACHeaderSetting is set to "Yes", this port is useless.
   $2 \times PUSC - UsedCarriers$ tokens are produced at Pin Coded_DLMAP and Pin Coded_ULMAP.

FFT size	UsedCarriers
2048	1680
1024	840
512	420

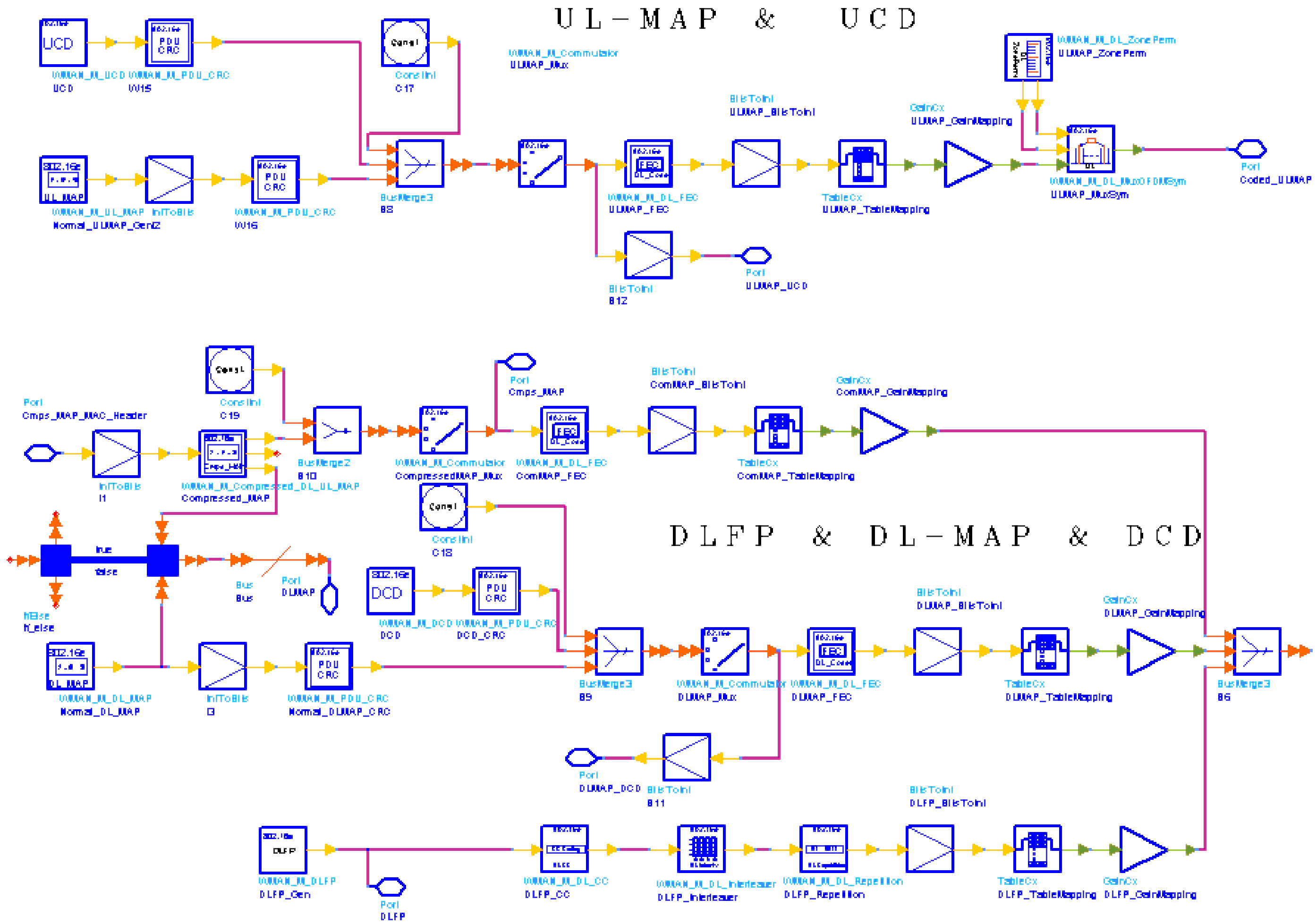
   $DLMAP - Len + 91$ tokens are produced at Pin DLMAP_DCD, where 91 stands for the number of bytes of DCD messages and DLMAP_Len is the number of bytes of DL_MAP and calculated as follows:

   - If the parameter ZoneType is set to "PUSC" and the parameter STCEncoder is set to "No":
     when the parameter ULMAP_Enable is set to "Yes"
     $DLMAP - Len = 6 + ceil(13 + (1 + NumberOfBurst) \times DL - IEBytes) + 4$
     when the parameter ULMAP_Enable is set to "No"

$DLMAP-Len = 6 + ceil(13 + (NumberOfBurst) \times DL-IEBytes) + 4$

- If the parameter ZoneType is set to "FUSC" or "OFUSC" or the parameter STCEncoder is set to "Yes": when the parameter ULMAP_Enable is set to "Yes"
  $DLMAP-Len = 6 + ceil(13 + (NumberOfBurst + 1) \times DL-IEBytes + ZoneBytes) + 4$
  when the parameter ULMAP_Enable is set to "No"
  $DLMAP-Len = 6 + ceil(13 + (NumberOfBurst) \times DL-IEBytes + ZoneBytes) + 4$
  where 6 stands for the number of bytes of MAC_Header, 13 stands for the number of bytes of DL_MAP Header, 4 stands for the number of bytes of crc, DL_IE_Bytes stands for the number of bytes of DL_MAP_IE and ZoneBytes stands for the number of bytes of DL_Zone_IE.DL_IEBytes equals to 4.5 and ZoneBytes equals to 5.5.
  $ULMAP-Len + 76$ tokens are prodecud at Pin ULMAP_UCD, where 76 stands for the number of bytes of UCD message and ULMAP_Bytes is the number of bytes of UL_MAP message and calculated as follows:
- If the parameter UL_MIMO_Enable is set to "No"
  ULMAP_Len = 10 +
  $ceil(8 + 6.5 + RangingBytes + FFB-Bytes + ACK-Bytes + CQICH-Bytes + UL-NumOfBurst \times 4)$
- If the parameter UL_MIMO_Enable is set to "Yes"
  $ULMAP-Len = ceil(8 + 6.5 + MIMO-Bytes) + 10$
  where 8 stands for the number of bytes of UL_MAP Header, 6.5 stands for the number of bytes of UL_Zone_IE.
  $6 + Com-DLMAP-Bytes + Com-ULMAP-Bytes + 4$ bytes tokens are produced at Pin Cmps_MAP.
  where 6 stands for the number of bytes of MAC Header, 4 stands for the number of bytes of CRC, Com_DLMAP_Bytes is the number of bytes of compressed DL_MAP message, and calculated as follows:
- If the parameter ZoneType is set to "PUSC" and the parameter STCEncoder is set to "No".
  When parameter ULMAP_Enable and Compressed_ULMap are both set to "Yes"
  $Com-DLMAP-Bytes = ceil(11 + (DL-NumberOfBurst + 1) \times DL-IEBytes)$
  When either parameter ULMAP_Enable or Compressed_ULMap is set to "No"
  $Com-DLMAP-Bytes = ceil(11 + DL-NumberOfBurst \times DL-IEBytes)$
- If the parameter ZoneType is set to "FUSC" or "OFUSC" or the parameter STCEncoder is set to "Yes".
  When parameter ULMAP_Enable and Compressed_ULMap are both set to "Yes"
  $Com-DLMAP-Bytes = ceil(11 + (DL-NumberOfBurst + 1) \times DL-IEBytes + ZoneBytes)$
  When either parameter ULMAP_Enable or Compressed_ULMap is set to "No"
  $Com-DLMAP-Bytes = ceil(11 + DL-NumberOfBurst \times DL-IEBytes + ZoneBytes)$
  where 11 stands for the number of bytes of compressed DL_MAP Header.
  Com_ULMAP_Bytes is the number of bytes of compressed UL_MAP message. When either parameter ULMAP_Enable or Compressed_ULMap is set to "No", Com_ULMAP_Bytes equals to 0; otherwise, is calculated as follows:
- If the parameter UL_MIMO_Enable is set to "No"
  Com_ULMAP_Bytes =
  $ceil(6 + 6.5 + RangingBytes + FFB-Bytes + ACK-Bytes + CQICH-Bytes + UL-NumOfBurst \times 4)$
- If the parameter UL_MIMO_Enable is set to "Yes"
  $Com-ULMAP-Bytes = ceil(6 + 6.5 + MIMO-Bytes)$
  where 6 stands for the number of bytes of compressed UL_MAP Header, 6.5 stands for the number of bytes of UL Zone IE, RangingBytes stands for the number of bytes of Ranging_IE, FFB_Bytes stands for the number of bytes of FAST-FEEDBACK Channel IE, ACK_Bytes stands for the number of bytes of HARQ ACKCH Region Allocation IE and CQICH_Bytes stands for the number of bytes of CQICH_Alloc_IE.
  MIMO_Bytes is calculated as follows:
  $(MIMO-Bytes) = ((32 + UL-NumberOfBurst \times variableBits + 7)/8)$
  where 32 equals to fixed bits length,
  variableBits equals to 51 when parameter UL_Collaborative_SM_Indicator is set to "Collaborative SM" and equals to 32 when parameter UL_Collaborative_SM_Indicator is set to "non Collaborative SM".
- If the parameter RangingEnable is set to "Yes", then RangingBytes equals to 6.5; otherwise, RangingBytes equals to 0.
- If the parameter FastFeedBackEnable is set to "Yes", then FFB_Bytes equals to 6.5; otherwise, FFB_Bytes equals to 0.
- If the parameter HARQ_ACK_Enable is set to "Yes", then ACK_Bytes equals to 7; otherwise, ACK_Bytes equals to 0.
- If the parameter CQICH_Enable is set to "Yes", then CQICH_Bytes equals to 7.5; otherwise, CQICH_Bytes equals to 0.
- 24 bits tokens are produced at Pin DLFP.
  If the parameter Compressed_DLMap is set to "Yes", Com_DLMAP_Bytes tokens in bytes are produced at Pin DLMAP, otherwise, $DLMAP-Len-4$ tokens in bytes are produced at Pin DLMAP.

3. The schematic of this subnetwork is shown in *WMAN_M_MACPDU Schematic* (wman_m).



WMAN_M_Brdcst_Msg schematic

- The FCH is coded in the following manner:
  - WMAN_M_DLFP generates the message for DLFP and output at Pin DLFP.
  - CC encoded by WMAN_M_DL_CC.
  - Interleaved by WMAN_M_DL_Interleaver
  - Repeated four times by WMAN_M_DL_Repetition.
  - Mapped to QPSK constellation by TableCx.
- The burst for DL-MAP and DCD is coded in the following manner:
  - WMAN_M_DL_MAP generates the message for normal DL-MAP. WMAN_M_DCD generates the message for DCD.
  - MAC CRCs are added to DL-MAP and DCD by WMA_M_PDU_CRC respectively.
  - DL-MAP and DCD are combined by WMAN_M_Commutator and output at Pin DLMAP_DCD.
  - The combined data are encoded by WMAN_M_DL_FEC.
  - Repeated by WMAN_M_DL_Repetition in WMAN_M_DL_FEC.
  - Mapped to constellation by TableCx.
- The burst for UL-MAP and UCD is coded in the following manner:
  - WMAN_M_UL_MAP generates the normal message for UL-MAP. WMAN_M_UCD generates the message for UCD.
  - MAC CRCs are added to UL-MAP and UCD by WMA_M_PDU_CRC respectively.
  - DL-MAP and UCD are combined by WMAN_M_Commutator and output at Pin ULMAP_UCD.
  - The combined data are encoded by WMAN_M_DL_FEC.
  - Repeated by WMAN_M_DL_Repetition in WMAN_M_DL_FEC.

- Mapped to constellation by TableCx.
- The burst for Compressed_MAP is coded in the following manner:
    - WMAN_M_Compressed_DL_UL_MAP generates the compressed MAP message for Compressed_DL_MAP or Compressed_DL_MAP + Compressed_UL_MAP.
    - MAC CRCs are added to the compressed MAP in WMAN_M_Compressed_DL_UL_MAP.
    - The data are encoded by WMAN_M_DL_FEC.
    - Repeated by WMAN_M_DL_Repetition in WMAN_M_DL_FEC.
    - Mapped to constellation by TableCx.
- The FCH and DLMAP_DCD are combined by WMAN_M_Commutator if parameter Compressed_DLMap is set to "No", otherwise the FCH and Compressed_MAP are combined by WMAN_M_Commutator.The physical indices of data subcarriers and pilot subcarriers for the combined are calculated by WMAN_M_DL_ZonePerm. The data sequences and pilot sequences are placed to their physical subcarrier location by WMAN_M_DL_MuxOFDMSym and output at pin Coded_DLMAP. As the combined data sequences, the same action are performed to ULMAP_UCD and output at Pin Coded_ULMAP.
- When Compressed_DLMap is set to "No", the normal DL_MAP is generated by WMAN_M_DL_MAP and output at Pin DLMAP, otherwise the compressed DL_MAP is generated by WMAN_M_Compressed_DL_UL_MAP and output at Pin DLMAP.

Note
The compressed UL_MAP shall only appear after a compressed DL_MAP. With default settings of parameters, the DL-MAP occupies 26 subchannels, and the UL-MAP occupies 27 subchannels. The compressed DL_MAP occupies 12 subchannels and the compressed DL_MAP and compressed UL_MAP occupies 24 subchannels. Sometimes the occupied subchannels by DL-MAP or UL-MAP or compressed MAP may exceed the available subchannels when the settings of paramters are changed. It may be caused by one of the following reasons:

1. The parameters of channel coding (such as coding type, rate ID and repetition coding) for the DL-MAP, UL-MAP and compressed MAP are changed.
2. The FFTSize is too small. For example, if FFTSize is set to FFT_512 and GroupBitmask are all set to 1, the maximum number of subchannels is 15. However the number of subchannels needed by FCH and DL-MAP is 30.
3. The number of selected subchannel groups indicated by GroupBitmask is too small.

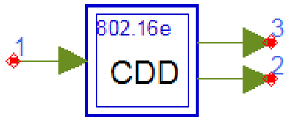
   It is recommended to properly change the corresponding parameters or to turn DL-MAP and UL-MAP off.

4. Please refer to WMAN_M_DL_MAP, WMAN_M_UL_MAP, WMAN_M_DLFP, WMAN_M_DCD, WMAN_M_UCD and WMAN_M_Compressed_DL_UL_MAP documents for map messages in detail.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_CDD (802.16e OFDMA CDD Implementation)



WMAN_M_CDD

Description: CDD (cyclic delay diversity) implementation with one logical antenna in and two physical antennas out
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Type	Range
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2	enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
CDD_Enable	Whether CDD is applied on preamble and the first PUSC zone: NO, YES	NO	enum	
CDD_NumTaps	The number of delay taps that are used on one each physical antenna, valid only when CDD_Enable=YES	1	int	[1,2]
CDD_PowerRatio	The ratio of the power on first tap relative to the power on the second tap in dB, valid only when CDD_Enable=YES and CDD_NumTaps=2	0	real	(-∞,∞)
CDD_Tap1Delay	The delay in samples in the first tap for the two physical antennas, valid only when CDD_Enable=YES	{0, 16}	int array	[0,64]
CDD_Tap2Delay	The delay in samples in the second tap for the two physical antennas, valid only when CDD_Enable=YES and CDD_NumTaps=2	{16, 32}	int array	[0,64]
CDD_Tap2Phase	The phase in degrees in the second tap for the two physical antennas, valid only when CDD_Enable=YES and CDD_NumTaps=2	{0, 90}	real array	[-∞,∞]

Pin Inputs

Pin	Name	Description	Signal Type
1	in	input data	complex

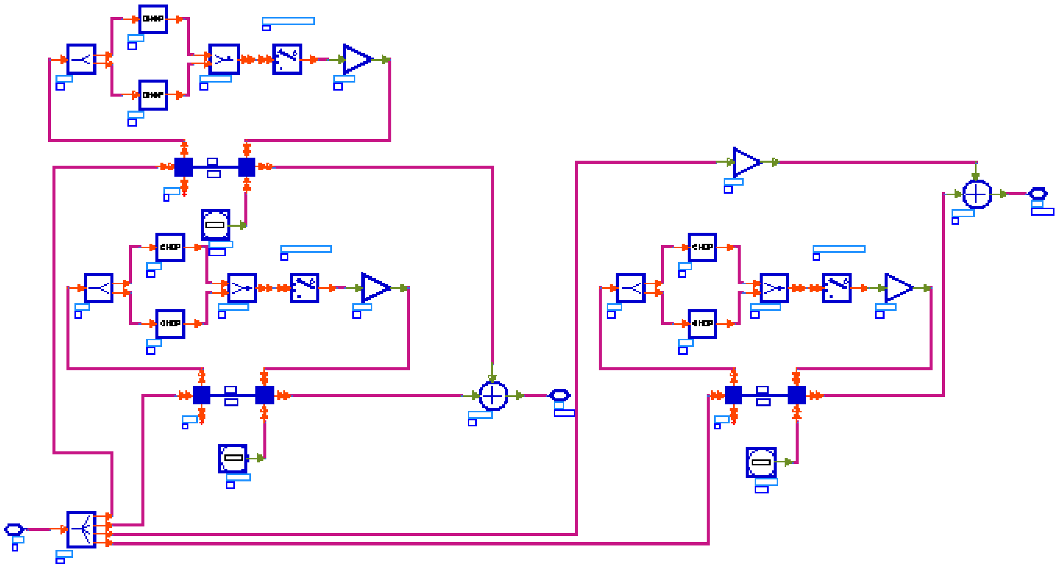
Pin Outputs

Pin	Name	Description	Signal Type
2	Ant1Out	output data at Ant1	complex
3	Ant2Out	output data at Ant2	complex

Notes/Equations

1. This subnetwork is used to implement the CDD (cyclic delay diversity) on the non-STC zone (including Preamble) assuming the number of transmit antennas is two. See the Reference below on Definitions for transparent transmit diversity.
2. The schematic of this subnetwork is shown in the following figure.

WMAN_M_CDD schematic

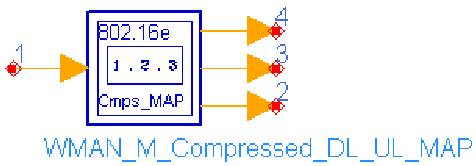


3. Cyclic Delay Diversity (CDD, also known as Cyclic Shift Transmit Diversity- CSTD) is an adaptation of the idea of delay diversity to OFDM systems. With CDD, each antenna element in transmit array sends a circularly shifted version of the same OFDM time domain symbol (for symbol b), x(n, b) (0<=n<N, where N is the system FFT size). For example if there are M transmit antennas at the base station and if antenna 1 sends an unshifted version of the OFDM symbol, then antenna m transmits the same OFDM symbol, but circularly shifted by (m-1)D time-domain samples.
4. In this subnetwork, the input signal is time domain symbol in which the CP (cyclic prefix) is not added while the oversampling is applied. Note that the delay samples defined in *CDD_Tap1Delay* and *CDD_Tap2Delay* assume that the time domain OFDM symbol is not oversampled (i.e. *OversamplingOption* = Ratio 1).
   - When CDD_Enable = NO, *Ant1Out* outputs the input signal; *Ant2Out* outputs zeros.
   - When CDD_Enable = YES, CDD is applied on the two output signals.
     - When CDD_NumTaps = 1
       - One delay tap is used on each transmit antenna. The delay in samples on Ant1 (*Ant1Out*) is CDD_Tap1Delay[1] (fixed to 0); The delay in samples on Ant2 (*Ant2Out*) is CDD_Tap1Delay[2]. Note that the phase of the tap on each transmit antenna is 0.
     - When CDD_NumTaps = 2
       - Two delay taps are used on each transmit antenna. The ratio of the power on first tap relative to the power on the second tap is *CDD_PowerRatio* in dB while the total power on the two taps is fixed to 1.
       - For the first tap, the delay in samples on Ant1 (*Ant1Out*) is CDD_Tap1Delay[1] (fixed to 0); The delay in samples on Ant2 (*Ant2Out*) is CDD_Tap1Delay[2]. Note that the phase of the first tap on each transmit antenna is 0.
       - For the second tap, the delay in samples on Ant1 (*Ant1Out*) is CDD_Tap2Delay[1]; The delay in samples on Ant2 (*Ant2Out*) is CDD_Tap2Delay[2]. The phase in degrees on Ant1 (*Ant1Out*) is CDD_Tap2Phase[1]; The phase in degrees on Ant2 (*Ant2Out*) is CDD_Tap2Phase[2];

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. C80216maint-08_006r8, Definitions for transparent transmit diversity, April 18, 2008.

WMAN_M_Compressed_DL_UL_MAP (802.16e OFDMA Compressed DL & UL MAP)



Description: Compressed downlink and uplink map
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Unit	Type	Ra
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
Compressed_ULMap	Compressed UL_MAP or not if appended: NO, YES	NO		enum	
AutoMACHeaderSetting	Auto MAC_Header Setting: NO, YES	NO		enum	
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.
FrameDuration	Frame duration: time 2ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
Bandwidth	Bandwidth	10 MHz	Hz	int	[1,
CyclicPrefix	Cyclic prefix	0.125		real	[0,
DL_FFTSize	Downlink FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
DL_ZoneType	Downlink zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC		enum	
DL_AMC_Mode	Downlink AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
DL_ZoneNumOfSym	Number of OFDM symbols in downlink zone	24		int	[1,
DL_GroupBitmask	Used subchannel bitmaps in downlink zone	{1, 1, 1, 1, 1, 1}		int array	[0,
DL_NumberOfBurst	Number of Bursts in downlink zone	2		int	[1,
DL_BurstWithFEC	The number of burst with FEC in downlink zone	1		int	[1,
DL_BurstSymOffset	Symbol offset of each burst in downlink zone	{4,10}		int array	[0,
DL_BurstSubchOffset	Subchannel offset of each burst in downlink zone	{5,1}		int array	[0,
DL_BurstNumOfSym	Number of symbols of each burst in downlink zone	{6,14}		int array	[1,
DL_BurstNumOfSubch	Number of subchannels of each burst in downlink zone	{15,18}		int array	[1,
DL_CodingType	Coding type of each burst in downlink zone	0 0		int array	[0,
DL_Rate_ID	Rate ID of each burst in downlink zone	5 5		int array	[0,
DL_RepetitionCoding	Repetition coding of each burst in downlink zone	0 0		int array	[0,
DL_PowerBoosting	Power boosting of each burst in dB in downlink zone	0 0		real array	[-c
DL_STC_Encoder	STC encoder or not in downlink zone: NO, YES	NO		enum	
DL_STC_Matrix	STC matrix in downlink zone: Matrix_A, Matrix_B	Matrix_A		enum	
DL_FrameNumber	Frame number in downlink zone	0		int	[1,
DL_FrameIncreased	Frame number increasing or not in downlink zone: NO, YES	NO		enum	
DL_ZoneSymOffset	Symbol offset in downlink zone	3		int	[2,
DL_PermBase	DL permutation base	9		int	[0,
DL_PRBS_ID	PRBS initialization vector in downlink zone	0		int	[0,
ULMAP_SymOffset	symbol offset in UL_MAP	2		int	[2,
ULMAP_SubchOffset	Subchannel offset of UL_MAP	0		int	[0,

ULMAP_NumOfSym	Number of symbol in UL_MAP	2		int	[1,
ULMAP_NumOfSubch	Number of subchannel in UL_MAP	1		int	[1,
ULMAP_CodingType	Coding type of ULMAP	0		int	[0,
ULMAP_Rate_ID	Rate ID of ULMAP	0		int	[0,
ULMAP_RepetitionCoding	Repetition coding of UL_MAP	0		int	[0,
ULMAP_PowerBoosting	Power boosting of UL_MAP	0		real	[-c
DCD_Count	DCD count	0		int	[0,
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00, 0X00, 0X01}		int array	[0,
DL_MidamblePresence	Midamble presence or not in downlink zone: NO, YES	NO		enum	
DL_MidambleBoosting	MIMO midamble boosting in dB	0		real	[-c
DL_DedicatedPilots	Pilot symbols are broadcast or not in downlink zone: NO, YES	NO		enum	
UL_ZoneType	UL zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC		enum	
UL_AMC_Mode	Uplink AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
UL_ZoneSymOffset	Symbol offset in UL zone	0		int	[0,
UL_ZoneNumOfSym	Number of OFDMA symbols in the UL subframe	24		int	[0,
UL_PermBase	Uplink permutation base	0		int	[0,
UL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum	
UCD_Count	UCD count	1		int	[0,
UL_NumberOfBurst	Number of Bursts in uplink	1		int	[1,
UL_CID	Uplink CID	{1}		int array	[0,
UL_CodingType	Uplink coding type of each burst	0		int array	[0,
UL_Rate_ID	Uplink rate ID	{0}		int array	[0,
UL_BurstAssignedSlot	Assigned slots of each burst in uplink	{96}		int array	[1,
UL_RepetitionCoding	Repetition coding of each burst in uplink	{0}		int array	[0,
HARQ_ACK_Enable	HARQ ACK channel enabled or not: NO, YES	NO		enum	
HARQ_ACK_Allocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 12, 3, 6}		int array	[0,
RangingEnable	Ranging channel enabled or not: NO, YES	NO		enum	
RangingAllocation	Rectangular allocation: (SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 0, 3, 6}		int array	[0,
RangingMethod	Ranging mode: Initial/Handover_2 symbols, Initial/Handover_4 symbols, BW Request/Periodic_1 symbol, BW Request/Periodic_3 symbol	Initial/Handover_2 symbols		enum	
FastFeedBackEnable	Fast feedback channel enabled or not: NO, YES	NO		enum	
FastFeedBackAllocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 6, 3, 6}		int array	[0,
CQICH_Enable	CQICH channel enabled or not: NO, YES	NO		enum	
CQICH_ID	Index to uniquely identify the CQICH resource assigned to the SS	0		int	[0,
CQICH_AllocationOffset	CQICH channel allocation offset	0		int	[0,
CQICH_Period	CQICH channel period	0		int	[0,
CQICH_FrameOffset	CQICH channel frame offset	0		int	[0,
CQICH_Duration	CQICH channel duration	0		int	[0,
CQICH_FeedbackType	CQICH channel feedback type: physical CINR feedback, effective CINR feedback	physical CINR feedback		enum	
CQICH_CINR_Type	CQICH channel CINR preamble report type: Frequency reuse factor = 1 config, Frequency reuse factor = 3 config	Frequency reuse factor = 1 config		enum	
CQICH_AvgParamIncluded	CQICH channel average parameter included for physical CINR feedback: NO, YES	NO		enum	
CQICH_AvgParam	CQICH channel average parameter for physical CINR feedback	0		int	[0,
CQICH_MIMO_FeedbackCycle	CQICH channel MIMO permutation feedback cycle	0		int	[0,
UL_MIMO_Enable	MIMO enabled IE or not in uplink zone: NO, YES	NO		enum	
UL_Collaborative_SM_Indicator	Uplink collaborative SM indicator: non collaborative SM, collaborative SM	non collaborative SM		enum	

UL_MIMO_Control	Uplink MIMO mode, effective when collaborative_SM_Indicator = non: STTD, SM	STTD		enum	
UL_CID_B	Uplink CID that shall use pilot pattern B	{1}		int array	[0,
UL_CodingType_B	Uplink coding type of each burst that shall use pilot pattern B	0		int array	[0,
UL_Rate_ID_B	Uplink rate ID that shall use pilot pattern B	{0}		int array	[0,
DL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum	
DIUC_RateID	Mapping from DIUC (0-12) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}, {1,3}, {1,4}, {1,5		int array	[0,
UIUC_RateID	Mapping from UIUC (1-10) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2		int array	[0,

Pin Inputs

Pin	Name	Description	Signal Type
1	MAC_Header	MAC header	int

Pin Outputs

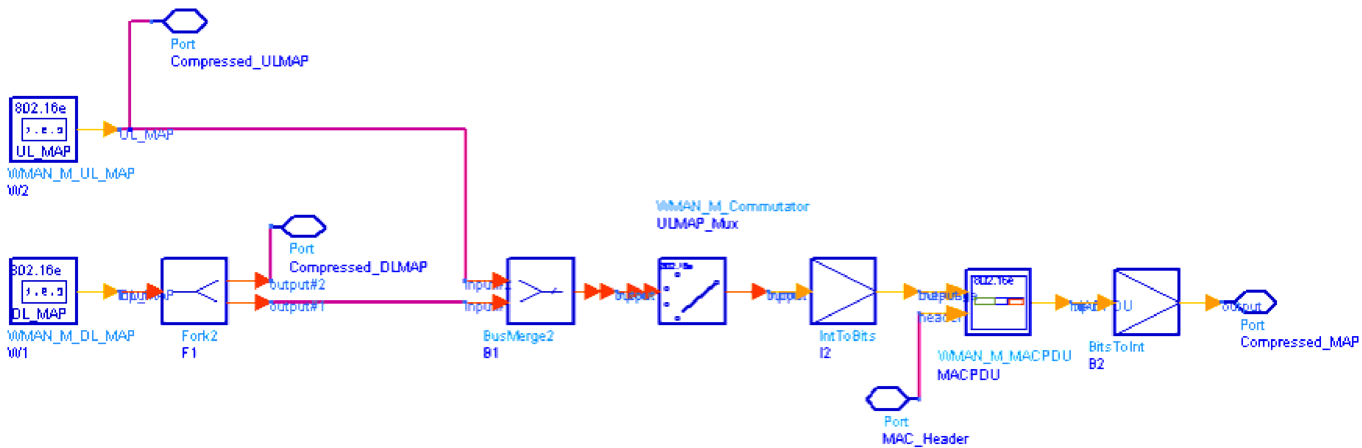
Pin	Name	Description	Signal Type
2	Compressed_DLMAP	Compressed DL_MAP message	int
3	Compressed_ULMAP	Compressed UL_MAP message	int
4	Compressed_MAP	Compressed DL_MAP and compressed UL_MAP message if appended	int

Notes/Equations

1. This subnetwork is used to generate compressed MAP messages for 802.16e OFDMA system.
2. Each firing,
   6 bytes tokens are consumed at Pin MAC_Header. When parameter AutoMACHeaderSetting is set to "Yes", this port is useless.
   $6 + Com-DLMAP-Bytes + Com-ULMAP-Bytes + 4$ bytes tokens are produced at Pin Compressed_MAP.
   Com_DLMAP_Bytes bytes tokens are produced at Pin Compressed_DL_MAP.
   Com_ULMAP_Bytes bytes tokens are produced at Pin Compressed_UL_MAP. When either parameter ULMAP_Enable or Compressed_ULMap is set to "No", this port is useless.
   where 6 stands for the number of bytes of MAC Header, 4 stands for the number of bytes of CRC, Com_DLMAP_Bytes is the number of bytes of compressed DL_MAP message, and calculated as follows:
   - If the parameter ZoneType is set to "PUSC" and the parameter STCEncoder is set to "No":
     When parameter ULMAP_Enable and Compressed_ULMap are both set to "Yes"
     $Com-DLMAP-Bytes = ceil(11 + (DL-NumberOfBurst + 1) \times DL-IEBytes)$
     When either parameter ULMAP_Enable or Compressed_ULMap is set to "No"
     $Com-DLMAP-Bytes = ceil(11 + DL-NumberOfBurst \times DL-IEBytes)$
   - If the parameter ZoneType is set to "FUSC" or "OFUSC" or the parameter STCEncoder is set to "Yes":
     When parameter ULMAP_Enable and Compressed_ULMap are both set to "Yes"
     $Com-DLMAP-Bytes = ceil(11 + (DL-NumberOfBurst + 1) \times DL-IEBytes + ZoneBytes)$
     When either parameter ULMAP_Enable or Compressed_ULMap is set to "No"
     $Com-DLMAP-Bytes = ceil(11 + DL-NumberOfBurst \times DL-IEBytes + ZoneBytes)$
     where 11 stands for the number of bytes of compressed DL_MAP Header, DL_IEBytes equals to 4.5 and ZoneBytes equals to 5.5.
     Com_ULMAP_Bytes is the number of bytes of compressed UL_MAP message. When either parameter ULMAP_Enable or Compressed_ULMap is set to "No", Com_ULMAP_Bytes equals to 0; otherwise, is calculated as follows:
   - If the parameter UL_MIMO_Enable is set to "No":
     Com_ULMAP_Bytes =
     $ceil(6 + 6.5 + RangingBytes + FFB-Bytes + ACK-Bytes + CQICH-Bytes + UL-NumOfBurst \times 4)$

- If the parameter UL_MIMO_Enable is set to "Yes"
  $Com-ULMAP-Bytes = ceil(6+6.5+MIMO-Bytes)$
  where 6 stands for the number of bytes of compressed UL_MAP Header, 6.5 stands for the number of bytes of UL Zone IE, RangingBytes stands for the number of bytes of Ranging_IE, FFB_Bytes stands for the number of bytes of FAST-FEEDBACK Channel IE, ACK_Bytes stands for the number of bytes of HARQ ACKCH Region Allocation IE and CQICH_Bytes stands for the number of bytes of CQICH_Alloc_IE.
- If the parameter RangingEnable is set to "Yes", then RangingBytes equals to 6.5; otherwise, RangingBytes equals to 0.
- If the parameter FastFeedBackEnable is set to "Yes", then FFB_Bytes equals to 6.5; otherwise, FFB_Bytes equals to 0.
- If the parameter HARQ_ACK_Enable is set to "Yes", then ACK_Bytes equals to 7; otherwise, ACK_Bytes equals to 0.
- If the parameter CQICH_Enable is set to "Yes", then CQICH_Bytes equals to 7.5; otherwise, CQICH_Bytes equals to 0.
- MIMO_Bytes is calculated as follows:
  $(32+UL-NumberOfBurst \times variableBits+7)/8$
  where 32 equals to fixed bits length,
  variableBits equals to 51 when parameter UL_Collaborative_SM_Indicator is set to "Collaborative SM" and equals to 32 when parameter UL_Collaborative_SM_Indicator is set to "non Collaborative SM".

3. The schematic of this subnetwork is shown in *WMAN_M_MACPDU Schematic* (wman_m).



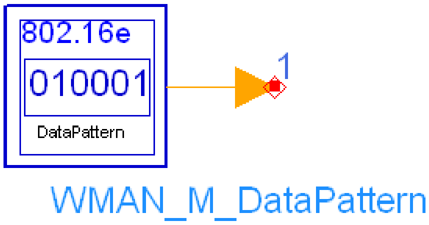
WMAN_M_Compressed_DL_UL_MAP schematic

4. The compressed UL_MAP message is generated by WMAN_M_UL_MAP, and the compressed DL_MAP message is generated by WMAN_M_DL_MAP. The compressed UL_MAP shall only appear after a compressed DL_MAP. The compressed UL_MAP is appended to the compressed DL_MAP by WMAN_M_Commutator if enabled. Then MAC Header and crc are added by WMAN_M_MACPDU. The compressed MAP is outputed by pin Compressed_MAP. Please refer to WMAN_M_DL_MAP and WMAN_M_UL_MAP documents for map messages in detail.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DataPattern (802.16e OFDMA Data Pattern)



Description: Data pattern
Library: WMAN 16e, Signal Source

Parameters

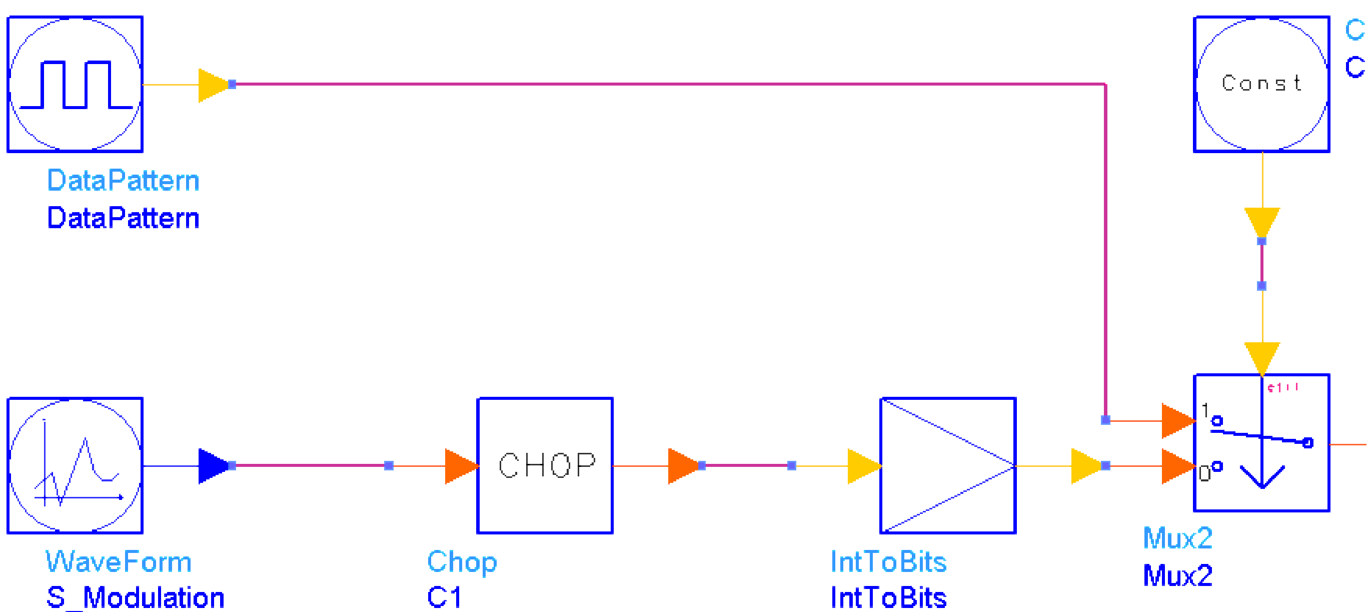
Name	Description	Default	Type	Range
Pattern	WMAN data pattern: PN9, PN15, FIX4, _4_1_4_0, _8_1_8_0, _16_1_16_0, _32_1_32_0, _64_1_64_0, S_QPSK, S_16-QAM, S_64-QAM	PN9	enum	
DataLength	payload byte length	100	int	[1,∞)

Pin Outputs

Pin	Name	Description	Signal Type
1	pattern	data pattern	int

Notes/Equations

1. This subnetwork is used to generate Data Pattern.
2. The schematic of this subnetwork is shown in WMAN_DataPattern Schematic



WMAN_DataPattern Schematic

3. DataLength is the MAC PDU payload length in bytes of burst with forward error coding
4. For the Pattern parameter:

    if PN9 is selected, a 511-bit pseudo-random test pattern is generated according to CCITT Recommendation O.153

    if PN15 is selected, a 32767-bit pseudo-random test pattern is generated according to CCITT Recommendation O.151

    if FIX4 is selected, a zero-stream is generated

    if x_1_x_0 is selected, where x equals 4, 8, 16, 32, or 64, a periodic bit stream is generated, with the period being 2 x. In one period, the first x bits are 1s and the second x bits are 0s.

    if S_QPSK, S_16-QAM or S_64-QAM is selected, sequences below are generated. These are test messages for receiver sensitivity measurement.

    S_QPSK = [0xE4, 0xB1, 0xE1, 0xB4]

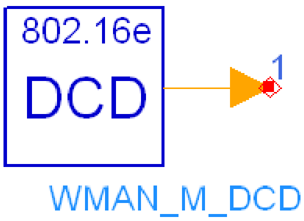
    S_16-QAM = [0xA8, 0x20, 0xB9, 0x31, 0xEC, 0x64, 0xFD, 0x75]

    S_64-QAM = [0xB6, 0x93, 0x49, 0xB2, 0x83, 0x08, 0x96, 0x11, 0x41, 0x92, 0x01, 0x00, 0xBA, 0xA3, 0x8A, 0x9A, 0x21, 0x82, 0xD7, 0x15, 0x51, 0xD3, 0x05, 0x10, 0xDB, 0x25, 0x92, 0xF7, 0x97, 0x59, 0xF3, 0x87, 0x18, 0xBE, 0xB3, 0xCB, 0x9E, 0x31, 0xC3, 0xDF, 0x35, 0xD3, 0xFB, 0xA7, 0x9A, 0xFF, 0xB7, 0xDB]

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.

WMAN_M_DCD (802.16e OFDMA DCD)



Description: DCD
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Type	Range
DL_ChannelID	Downlink channel ID	0	int	[0,255]
DCD_Count	DCD	0	int	[0,255]
NumberOfBurst	Number of Bursts	2	int	[1,8]
CodingType	Coding type of each burst	0 0	int array	[0,1]
Rate_ID	Rate ID of each burst	5 5	int array	[0,7]
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO	enum	
ULMAP_CodingType	ULMAP coding type	0	int	[0,1]
ULMAP_Rate_ID	Uplink rate ID	0	int	[0,7]
AutoMACHeaderSetting	Auto MAC_Header Setting: NO, YES	NO	enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}	int array	[0,255]
DIUC_RateID	Mapping from DIUC (0-12) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}, {1,3}, {1,4}, {1,5	int array	[0,255]

Pin Outputs

Pin	Name	Description	Signal Type
1	out	DCD	int

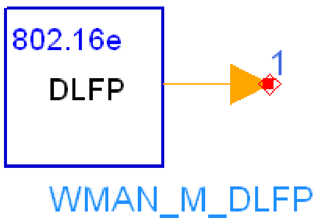
Notes/Equations

1. This model is used to generate Downlink Channel Descriptor (DCD) message for 802.16e OFDMA system. A DCD shall be transmitted by the BS at a periodic interval to define the characteristics of a downlink physical channel.
2. The DCD message format is defined in Table 15 of Reference [1].

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October 1, 2004.

WMAN_M_DLFP (802.16e OFDMA Downlink Frame Prefix)



Description: Downlink frame prefix generator
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Type	Range
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}	int array	[0,1]
CodingType	Coding type of each burst: CC, CTC	CC	enum	
RepetitionCoding	Repetition coding of each burst	0	int	[0,3]
DLMapLength	length of DL_MAP	0	int	[0, 255]

Pin Outputs

Pin	Name	Description	Signal Type
1	out	downlink frame prefix	int

Notes/Equations

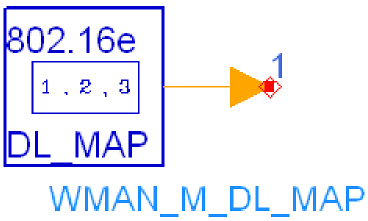
1. This model is used to generate Downlink Frame Prefix (DLFP).
2. Each firing 3×8 bit tokens are produced at Pin out.
3. Each firing 24 tokens are produced at Pin out. The content in DLFP is specified in *OFDMA Downlink Frame Prefix Format*.

Syntax	Size	Notes
DL_Frame_Prefix_Format(){		
Used subchannel bitmap	6 bits	Bit #0: Subchannels 0-11 are used
reserved	1 bit	Shall be set to zero
Repetition_Coding_Indication	2 bits	00 - No repetition coding on DL-MAP
Coding Indication	3 bits	0b000 - CC encoding used on DL-MAP
DL-Map_Length	8 bits	
reserved	4 bits	Shall be set to zero

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_MAP (802.16e OFDMA DLMAP)



Description: Downlink map
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Unit	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	24		int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array	[0,1]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
NumberOfBurst	Number of Bursts	2		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4, 10}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5, 1}		int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6, 14}		int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15, 18}		int array	[1,60]
CodingType	Coding type of each burst	{0, 0}		int array	[0,1]
Rate_ID	Rate ID of each burst	{0, 1}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0, 0}		int array	[0,3]
PowerBoosting	Power boosting of each burst in dB	{0, 0}		real array	(-∞,∞)
STC_Encoder	STC encoder or not: NO, YES	NO		enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A		enum	
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink Ratio in TDD mode	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 10 ms		enum	
FrameNumber	Frame number	0		int	[1,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
ZoneSymOffset	Symbol offset in zone	3		int	[2,16]
DL_PermBase	DL permutation base	9		int	[0,31]
PRBS_ID	PRBS initialization vector	0		int	[0,3]
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
ULMAP_SymOffset	symbol offset in UL_MAP	2		int	[2,1211]
ULMAP_SubchOffset	Subchannel offset of UL_MAP	0		int	[0,59]
ULMAP_NumOfSym	Number of symbol in UL_MAP	2		int	[1,1210]
ULMAP_NumOfSubch	Number of subchannel in UL_MAP	1		int	[1,60]
ULMAP_CodingType	Coding type of ULMAP	0		int	[0,1]

ULMAP_Rate_ID	Rate ID of ULMAP	0		int	[0,7]
ULMAP_RepetitionCoding	Repetition coding of UL_MAP	0		int	[0,3]
ULMAP_PowerBoosting	Power boosting of UL_MAP	0		real	(-∞,∞)
DCD_Count	DCD count	0		int	[0,255]
Bandwidth	Bandwidth	3.5 MHz	Hz	int	[1,1e9]
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00, 0X00, 0X01}		int array	[0,255]
AutoMACHeaderSetting	Auto MAC_Header Setting: NO, YES	NO		enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array	[0,255]
Compressed_DLMap	Compressed DL_MAP or not: NO, YES	NO		enum	
Compressed_ULMap	Compressed UL_MAP or not if appended: NO, YES	NO		enum	
MidamblePresence	Midamble presence or not: NO, YES	NO		enum	
MidambleBoosting	MIMO midamble boosting in dB	0		real	(-∞,∞)
DedicatedPilots	Pilot symbols are broadcast or not: NO, YES	NO		enum	
DL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum	
DIUC_RateID	Mapping from DIUC (0-12) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}, {1,3}, {1,4}, {1,5		int array	[0,255]

Pin Outputs

Pin	Name	Description	Signal Type
1	DL_MAP	output DL_MAP	int

Notes/Equations

1. This model is used to generate normal DL_MAP and compressed DL_MAP messages for 802.16e OFDMA system. DL_MAP is a MAC Layer Message that tells a subscriber station (SS) about the construction of the downlink OFDMA signal. This allows the SS to decode the DL transmission and extract any messages that are either specifically designated for a particular SS or any broadcast messages that the BTS is sending to all SS's.
2. Each firing,
   - If the parameter Compressed_DLMap is set to "No"
     - If the parameter ZoneType is set to "PUSC" and the parameter STCEncoder is set to "No":
       when the parameter ULMAP_Enable is set to "Yes" $6 + ceil(13 + (1 + NumberOfBurst) \times DL-IEBytes)$ tokens in bytes are produced at Pin DL_MAP.
       when the parameter ULMAP_Enable is set to "No" $6 + ceil(13 + (NumberOfBurst) \times DL-IEBytes)$ tokens in bytes are produced at Pin DL_MAP.
     - If the parameter ZoneType is set to "FUSC", "OFUSC", "AMC" or the parameter STCEncoder is set to "Yes":
       when the parameter ULMAP_Enable is set to "Yes" $6 + ceil(13 + (NumberOfBurst + 1) \times DL-IEBytes + ZoneBytes)$ tokens in bytes are produced at Pin DL_MAP.
       when the parameter ULMAP_Enable is set to "No" $6 + ceil(13 + (NumberOfBurst) \times DL-IEBytes + ZoneBytes)$ tokens in bytes are produced at Pin DL_MAP.
       where 6 stands for the number of bytes of MAC_Header, 13 stands for the number of bytes of DL_MAP Header, 4 stands for the number of bytes of crc, DL_IE_Bytes stands for the number of bytes of DL_MAP_IE and ZoneBytes stands for the number of bytes of DL_Zone_IE.DL_IEBytes equals to 4.5 and ZoneBytes equals to 5.5.
   - If the parameter Compressed_DLMap is set to "Yes"
     - If the parameter ZoneType is set to "PUSC" and the parameter STCEncoder is set to "No":
       When parameter ULMAP_Enable and Compressed_ULMap are both set to "Yes" $ceil(11 + (DL-NumberOfBurst + 1) \times DL-IEBytes)$ tokens in bytes are produced at Pin DL_MAP.
       When either parameter ULMAP_Enable or Compressed_ULMap is set to "No" $ceil(11 + DL-NumberOfBurst \times DL-IEBytes)$ tokens in bytes are produced at Pin DL_MAP.
     - If the parameter ZoneType is set to "FUSC", "OFUSC", "AMC" or the parameter STCEncoder is set to "Yes".

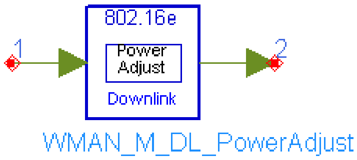
When parameter ULMAP_Enable and Compressed_ULMap are both set to "Yes"
$ceil(11 + (DL - NumberOfBurst + 1) \times DL - IEBytes + ZoneBytes)$ tokens in bytes are produced at Pin DL_MAP.
When either parameter ULMAP_Enable or Compressed_ULMap is set to "No"
$ceil(11 + DL - NumberOfBurst \times DL - IEBytes + ZoneBytes)$ tokens in bytes are produced at Pin DL_MAP.
where 11 stands for the number of bytes of compressed DL_MAP Header.

3. The DL_MAP Message format, OFDMA DL_MAP IE format, STC_DL_Zone_IE format and Compressed DL_MAP message format are defined in Table 16, Table 275, Table 279 and Table 305 of IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006. The OFDMA MAC header formate is defined in Table 4 of Reference [1]. Note that normal DL_MAP of the model generated does not include HCS, which will be added later, and compressed DL_MAP of the model generated does not include MAC Header and HCS.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_PowerAdjust (802.16e OFDMA Downlink Power Adjust)



Description: Downlink power adjustment
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbols in zone	24	int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}	int array	[0,1]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
NumberOfBurst	Number of Bursts	2	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}	int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,14}	int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}	int array	[1,60]
PowerBoosting	Power boosting of each burst in dB	{0,0}	real array	(-∞,∞)
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
DLMAP_Enable	DLMAP is inserted or not: NO, YES	NO	enum	
DLMAP_Allocation	DLMAP allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0,4,2,26}	int array	[0,∞)
DLMAP_PowerBoosting	Power boosting of DLMAP in dB	0	real	(-∞,∞)
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO	enum	
ULMAP_Allocation	ULMAP allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{2,0,2,24}	int array	[0,∞)
ULMAP_PowerBoosting	Power boosting of ULMAP in dB	0	real	(-∞,∞)
FrameLength	Frame length	56000	int	[1,∞)
DedicatedPilot	Is the dedicated pilot mode employed for DL PUSC or AMC zone: NO, YES	NO	enum	
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupied, Burst power with allocated subchs): Peak power, Burst power when all subchs occupied, Burst power with allocated subchs	Burst power when all subchs occupied	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	input	input data before power adjustment	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	output	output data after power adjustment	complex

Notes/Equations

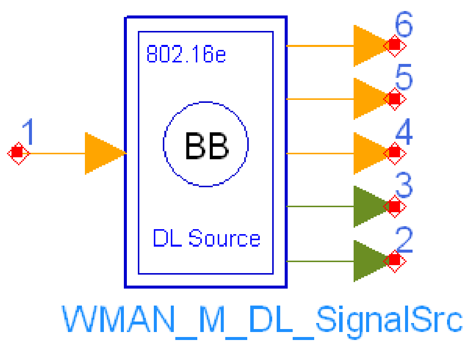
1. This model is used to adjust the downlink output power according to the parameter PowerType.
2. Each firing:
   - $Samples_{Frame}$ tokens are consumed at pin input,

     where $Samples_{Frame}$ is the frame length defined by the parameter FrameLength.
   - $Samples_{Frame}$ tokens are produced at pin output.
3. In Mobile WiMAX, currently there is no unified method on the definition of transmit power. Three different downlink power definitions are provided in Mobile WiMAX wireless design library to meet with different requirements.
4. For more information, refer to *Transmit Power Definition".* (wman_m)

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_SignalSrc (802.16e OFDMA Downlink Signal Source)



Description Downlink signal src
Library WMAN 16e, Signal Source
Class SDFWMAN_M_DL_SignalSrc

Name	Description	Default	Unit	Type	Range
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1, 1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0, 1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01, 0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
DLMAP_Enable	DLMAP is inserted or not: NO, YES	NO		enum	
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[0, 0.02]
PreambleIndex	Preamble index	3		int	[0, 113]
FrameNumber	Frame number	0		int	[0, 0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
DL_PermBase	DL permutation base	9		int	[0, 31]
DCD_Count	DCD count	1		int	[0, 255]
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00, 0X00, 0X01}		int array	[0, 255]
PRBS_ID	PRBS ID	0		int	[0, 3]
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	YES		enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array	[0, 255]
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	22		int	[1, 1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array	[0, 1]
NumberOfBurst	Number of Bursts	2		int	[1, 8]
BurstWithFEC	The number of burst with FEC	1		int	[1, 8]
BurstSymOffset	Symbol offset of each burst	{4,10}		int array	[0, 1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}		int	[0, 59]

				array	
BurstNumOfSym	Number of symbols of each burst	{6,12}		int array	[1, 1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}		int array	[1, 60]
DataLength	MAC PDU payload byte length of each burst	{200,300}		int array	[1, ∞)
CodingType	Coding type of each burst	{0,0}		int array	[0, 1]
Rate_ID	Rate ID of each burst	{5,5}		int array	[0, 7]
RepetitionCoding	Repetition coding of each burst	{0,0}		int array	[0, 3]
PowerBoosting	Power boosting of each burst in dB	{0,0}		real array	[-∞, ∞]
DLMAP_CodingType	Coding type of DLMAP	0		int	[0, 1]
DLMAP_RepetitionCoding	Repetition coding of DLMAP	0		int	[0, 3]
ULMAP_CodingType	Coding type of ULMAP	0		int	[0, 1]
ULMAP_Rate_ID	Rate ID of ULMAP	0		int	[0, 7]
ULMAP_RepetitionCoding	Repetition coding of ULMAP	0		int	[0, 3]
ULMAP_PowerBoosting	Power boosting of ULMAP in dB	0		real	[-∞, ∞]
UL_ZoneType	UL zone type: UL_PUSC, UL_OPUSC	UL_PUSC		enum	
UL_ZoneSymOffset	Symbol offset in UL zone	0		int	[0, 127]
UL_ZoneNumOfSym	Number of OFDMA symbols in the UL subframe	24		int	[3, 255]
UL_PermBase	UL permutation base	0		int	[0, 69]
UL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum	
UCD_Count	UCD count	1		int	[0, 255]
UL_NumberOfBurst	Number of Bursts in uplink	1		int	[1, 8]
UL_CID	Uplink CID	{1}		int array	[0, 65535]
UL_CodingType	Uplink coding type of each burst	{0}		int array	[0, 1]
UL_Rate_ID	Uplink rate ID	{0}		int array	[0, 7]
UL_BurstAssignedSlot	Assigned slots of each burst in uplink	{96}		int array	[1, 6868]
UL_RepetitionCoding	Repetition coding of each burst in uplink	{0}		int array	[0, 3]
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupied, Burst power with allocated subchs): Peak power, Burst power when all subchs occupied, Burst power with allocated subchs	Burst power when all subchs occupied		enum	
DIUC_RateID	Mapping from DIUC (0-12) to RateID {CodingType,Modulation/Rate}	{{0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}, {1,3}, {1,4}, {1,5}}		int array	[0, 255]
UIUC_RateID	Mapping from UIUC (1-10) to RateID {CodingType,Modulation/Rate}	{{0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}}		int array	[0, 255]

Pin Inputs

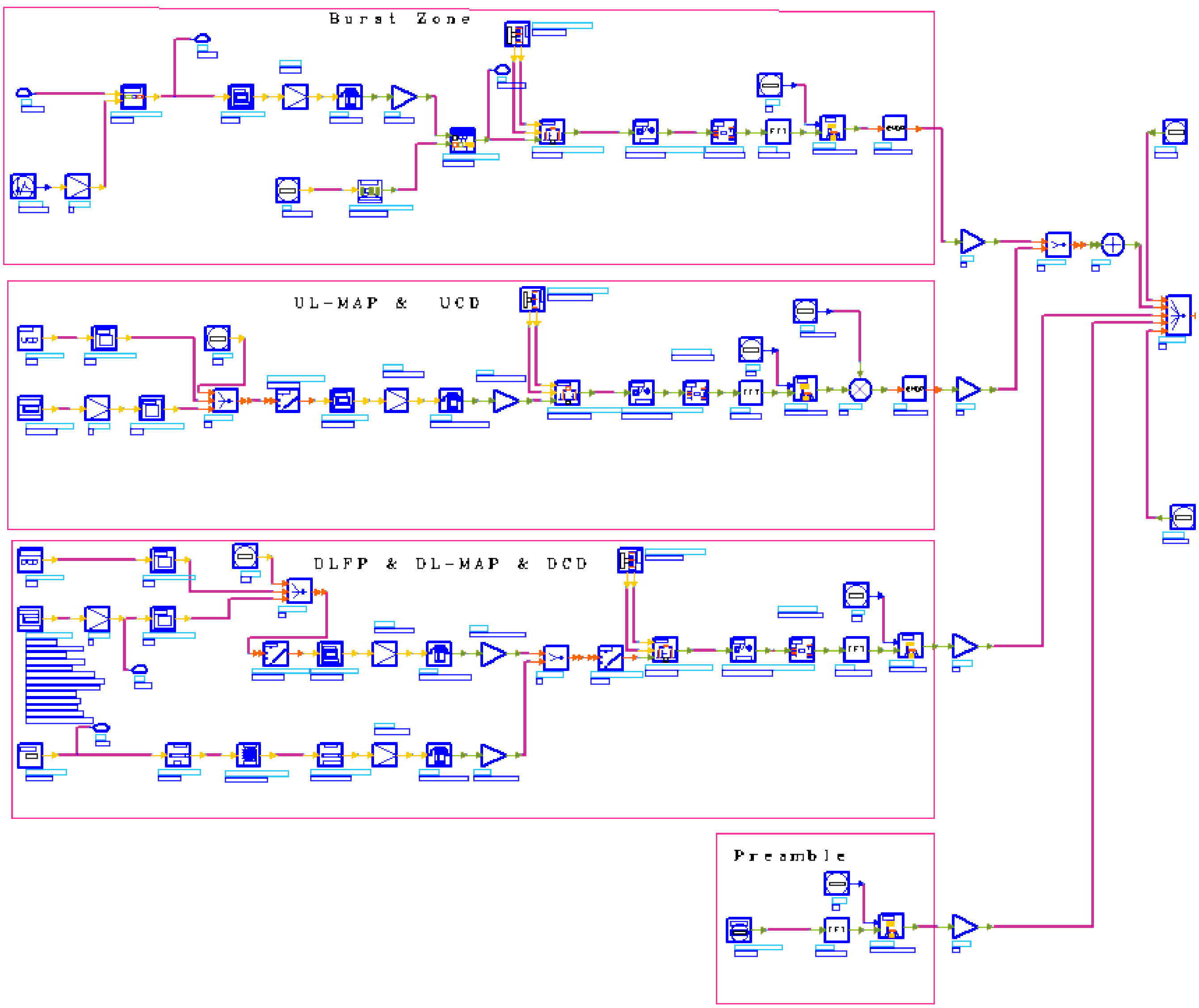
Pin	Name	Description	Signal Type
1	InputData	input of raw data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	FrameData	output of uplink Subframe	complex
3	Constellation	output of Modulated data of all bursts for EVM	complex
4	PDUFCS	output of MAC PDU data of burst with FEC	int
5	DLFP	output of DLFP data	int
6	DLMAP	output of DLMAP data	int

Notes/Equations

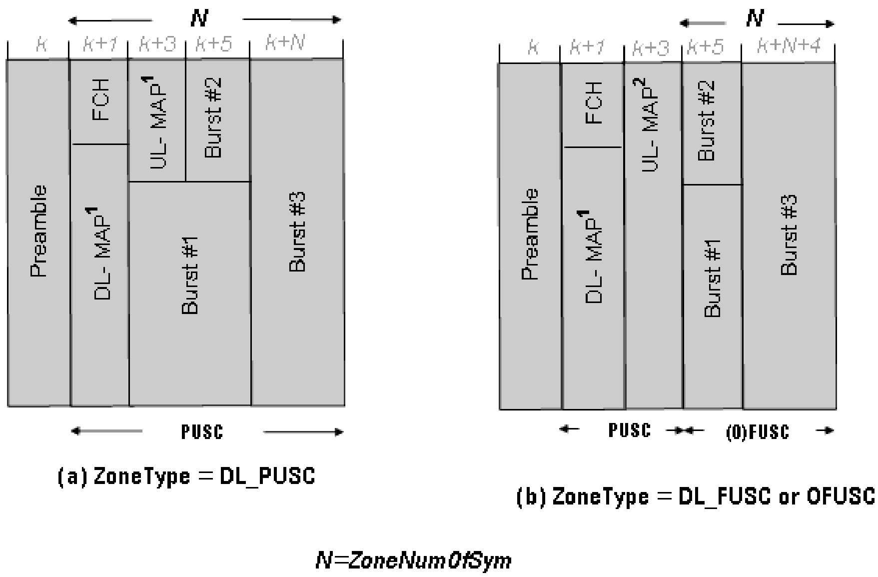
1. This subnetwork generates an 802.16e OFDMA downlink subsystem baseband signal. The schematic for this subnetwork is shown in WMAN_M_DL_SignalSrc Schematic.



WMAN_M_DL_SignalSrc Schematic

2. The input of this subnetwork is MAC PDU data of the FEC-encoded burst; MAC header data is specified by MAC_Header.
3. WMAN_M_DL_SignalSrc is implemented according to the specification. 802.16e OFDMA Downlink Subframe

Structure shows the downlink frame format.



802.16e OFDMA Downlink Subframe Structure

Note that DL_AMC is also supported in this source.
The downlink subframe starts with one preamble which consists of a OFDM symbol. Then the PUSC zone where FCH, DL-MAP and UL-MAP are allocated. The FCH information will be sent on the first four adjacent subchannels with successive logical subchannel numbers in the PUSC zone. The DL-MAP message immediately follows FCH. The UL-MAP message is always allocated on the third and fourth OFDM symbols if ULMAP_Enable is set to YES.
If ZoneType is DL_PUSC, then a single PUSC zone is defined (as in 802.16e OFDMA Downlink Subframe Structure). If ZoneType is DL_FUSC DL_OFUSC or DL_AMC, then two zones are defined: one is the PUSC zone where FCH is allocated, the other is the FUSC, OFUSC or AMC zone for allocating data bursts (b in 802.16e OFDMA Downlink Subframe Structure). ZoneNumOfSym is defined as the number of OFDM symbols for the zone which is allocated data bursts. One downlink frame contains maximum 8 data bursts except FCH, DL-MAP and UL-MAP, and each burst contains only one MAC PDU. Among these bursts, only one burst is CC-encoded which is randomized, CC coded and interleaved. Other bursts will be provided PN sequences as their coded source respectively.
For DL_PUSC, the total number of symbols in the downlink subframe is (1+ZoneNumOfSym); For DL_FUSC, DL_OFUSC or DL_AMC, the total number of symbols in the downlink subframe is (1+2+ULMAP_Enable*2+ZoneNumOfSym), where 1 is for the preamble, the first 2 is for the FCH and DL-MAP, the second 2 is for the UL-MAP, ULMAP_Enable is 1 when set to YES and 0 when set to NO.

Zone type	ULMAP_Eanble	NPreamble	NFCH DL-MAP	NUL-MAP	NData	NFrame
DL_PUSC	YES	1	2	2	ZoneNumOfSym-2	1+ZoneNumOfSym
DL_PUSC	NO	1	2	0	ZoneNumOfSym-2	1+ZoneNumOfSym
DL_FUSC	YES	1	2	2	ZoneNumOfSym	5+ZoneNumOfSym
DL_FUSC	NO	1	2	0	ZoneNumOfSym-2	3+ZoneNumOfSym
DL_OFUSC	YES	1	2	2	ZoneNumOfSym	5+ZoneNumOfSym
DL_OFUSC	NO	1	2	0	ZoneNumOfSym	3+ZoneNumOfSym
DL_AMC	YES	1	2	2	ZoneNumOfSym	5+ZoneNumOfSym
DL_AMC	NO	1	2	0	ZoneNumOfSym	3+ZoneNumOfSym

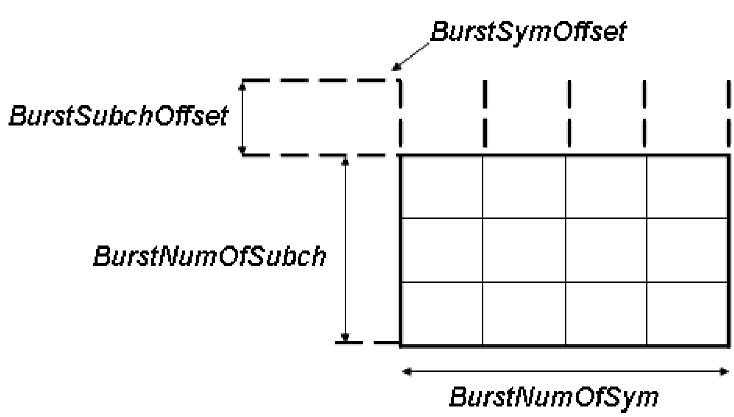
- The FCH is coded in the following manner:
  - WMAN_M_DLFP generates the message for DLFP.
  - CC encoded by WMAN_M_DL_CC.
  - Interleaved by WMAN_M_DL_Interleaver
  - Repeated four times by WMAN_M_DL_Repetition.
- The burst for DL-MAP and DCD is coded in the following manner:
  - WMAN_M_DL_MAP generates the message for DL-MAP. WMAN_M_DCD generates the message for DCD.

    - MAC CRCs are added to DL-MAP and DCD by WMA_M_PDU_CRC respectively.
    - DL-MAP and DCD are combined by WMAN_M_Commutator.
    - The combined data are encoded by WMAN_M_DL_FEC.
    - Repeated by WMAN_M_DL_Repetition in WMAN_M_DL_FEC.
- The burst for UL-MAP and UCD is coded in the following manner:
    - WMAN_M_UL_MAP generates the message for UL-MAP. WMAN_M_UCD generates the message for UCD.
    - MAC CRCs are added to UL-MAP and UCD by WMA_M_PDU_CRC respectively.
    - DL-MAP and UCD are combined by WMAN_M_Commutator.
    - The combined data are encoded by WMAN_M_DL_FEC.
    - Repeated by WMAN_M_DL_Repetition in WMAN_M_DL_FEC.
- The FEC-encoded burst is coded in the following manner:
    - Add MAC header with parameter MAC_Header or generate MAC header automatically by WMAN_M_MACPDU.
    - Randomized by WMAN_M_DL_Randomizer.
    - If the coding type is CC, then CC encoded, punctured and interleaved by WMAN_M_DL_FEC; If the coding type is CTC, then CTC encoded by WMAN_M_DL_FEC.
    - Repeated by WMAN_M_DL_Repetition in WMAN_M_DL_FEC.
- After encoding, the encoded burst is mapped to the constellation. Other bursts without FEC, are provided PN sequence as their coded bits and mapped to the constellation according to their Rate_ID by WMAN_M_DL_BurstWoFEC. The FEC-encoded burst is concatenated with non-coded bursts by WMAN_M_DL_MuxBurst. The FCH and DL-MAP are combined, and also are mapped to the constellations. The same actions are performed on UL-MAP.
- The physical indices of data subcarriers and pilot subcarriers for each burst are calculated by WMAN_M_DL_ZonePerm. The data sequences and pilot sequences are placed to their physical subcarrier location by WMAN_M_DL_MuxOFDMSym. Then the useful subcarriers are randomized by WMAN_M_DL_SubcarrRandomizer. The same actions are performed on FCH & DL-MAP and UL-MAP. After IFFT and cyclic prefix insertion, the idle interval and downlink payloads (Bursts, FCH & DL-MAP, UL-MAP) are combined with zero padding bits if needed by WMAN_M_Commutator. In addition, uplink position will be preserved and filled with zeros after downlink payload if FrameMode is TDD.
- The zone boosting is performed according to the parameter of GroupBitmask. At last, a symbol windowing is implemented to smooth the transitions between the consecutive OFDM symbols in the subframe.

> **Note**
> With default settings of parameters, the DL-MAP occupies 26 subchannels, and the UL-MAP occupies 23 subchannels. Sometimes the occupied subchannels by DL-MAP or UL-MAP may exceed the available subchannels when the settings of paramters are changed. It may be caused by one of the following reasons:
> 1. The parameters of channel coding (such as coding type, rate ID and repetition coding) for the DL-MAP and UL-MAP are changed.
> 2. The FFTSize is too small. For example, if FFTSize is set to FFT_512 and GroupBitmask are all set to 1, the maximum number of subchannels is 15. Howerer the number of subchannels needed by FCH and DL-MAP is 30.
> 3. The number of selected subchannel groups indicated by GroupBitmask is too small.
>
> When the DL-MAP and UL-MAP are requried, but they cannot be allocated in WMAN_M_DL_SignalSrc_RF, it is recommended to use WMAN_M_DL_Src_AllCoded_RF where the allocation of DL-MAP and UL-MAP is flexible, and, DCD and UCD can be turned on or off respectively.

4. Parameter Details
    - Bandwidth determines the nominal channel bandwidth.
    - OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
    - FFTSize specifies the size of FFT. Sizes 2048, 1024 and 512 are supported.
    - CyclicPrefix specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
    - FrameMode specifies the duplexing method which should be FDD or TDD. In FDD transmission, the downlink occupies the entire frame and the respective gaps (zeros) are automatically adjusted to fill the frame
    - DL_Ratio specifies the percentage (1 to 99) of the frame time to be used for the downlink subframe. The parameter is only active when the FrameMode is TDD.
    - FrameDuration determines the frame durations (ms) of the generated waveform.There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
    - DLMAP_Enable specifies whether the DL-MAP burst is inserted in the downlink subframe.
    - ULMAP_Enable specifies whether the UL-MAP burst is inserted in the downlink subframe.
    - IdleInterval specifies the time of idle interval between the two continuous frames. the default value is 0.
    - PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to the standard.

- FrameNumber specifies the starting frame number in the downlink subframe.
- FrameIncreased specifies whether the frame number for the downlink subframe is increased. When FrameIncreased is set to YES, then the frame numbers in Frame#0, Frame#1, Frame#2, Frame#3 will be FrameNumber, FrameNumber+1, FrameNumber+2, FrameNumber+3. When FrameIncreased is set to NO, then the frame numbers in Frame#0, Frame#1, Frame#2, Frame#3 will be FrameNumber, FrameNumber, FrameNumber, FrameNumber.
- DL_PermBase specifies the basis of downlink permutation to be used in initialization vector of the PRBS generator for subchannel randomization in the zone and in STC_DL_Zone_IE() in DL-MAP message.
- DCD_Count specifies the DCD count which is used in DL-MAP and DCD messages. This is increased by one (modulo 256) whenever there is a downlink configuration change.
- BSID specifies the base station ID which is used in DL-MAP message.
- PRBS_ID specifies the PRBS ID which may be used in initialization vector of the PRBS generator for subchannel randomization and in STC_DL_Zone_IE() in DL-MAP message.
- AutoMACHeaderSetting specifies whether the MAC header is automatically generated or input by users. If it is set to NO, data sequences in parameter MAC_Header will be used before data content, otherwise MAC_Header content will be calculated with parameter DataLength and CID and be used before data content.
- MAC_Header specifies 6 bytes of MAC header before the data contents. The cell is only active when the AutoMACHeaderSetting is set to NO.
- CRC32_Mode specifies the method for CRC32 calculation appended to MAC PDU. For consistency with 802.16e-2005, it shall be set to MSB first while shall be set to LSB first for consistency with 802.16-2004 Cor1/D3.
- ZoneType specifies the zone type which can be set to PUSC, FUSC, OFUSC and AMC.
- ZoneNumOfSym specifies the symbol number for the zone. The value must be a multiple of two for DL_PUSC, and be a multiple of one for DL_FUSC, DL_OFUSC. For AMC, the value must be multiple of six, three and two for mode 1x6, 2x3 and 3x2 respectively.
- GroupBitmask specifies which groups of subchannel are used in the PUSC zone. This parameter uses 1 for assigned groups and 0 for unassigned groups.
- NumberOfBurst specifies the number of active downlink bursts.
- BurstWithFEC specifies the downlink burst FEC.
- BurstSymOffset, BurstSubchOffset, BurstNumOfSym and BurstNumOfSubch specify the position and range for each rectangular burst, seen Downlink Rectangular Burst Structure.



Downlink Rectangular Burst Structure

- DataLength specifies MAC PDU payload byte length for each burst.
- CodingType specifies the coding type for each burst. Each coding type can be selected from 0 to 1, whose meaning is shown in *The Meaning of Coding Type*.

Coding Type	Meaning
0	Convolutional coding (CC)
1	Convolutional turbo coding (CTC)

- Rate_ID specifies the rate ID for each burst. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in *The Relation of Coding Type and Rate ID246*.

Coding type	Rate ID	Modulation/Coding rate
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in *The Meaning of Repetition Coding*.

Repetition coding	Meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4used on the burst
3	Repetition coding of 6used on the burst

- PowerBoosting specifies the power boosting for each burst. Each value is defined in units of dB.
- DLMAP_CodingType specifies the rate ID for the burst carrying DL-MAP and DCD messages.
- DLMAP_RepetitionCoding specifies the repetition coding for the burst carrying DL-MAP and DCD messages. This parameter can be selected from 0 to 3, whose meaning is shown in *The Meaning of Repetition Coding*.
- ULMAP_CodingType specifies the rate ID for the burst carrying UL-MAP and UCD messages.
- ULMAP_Rate_ID specifies the rate ID for the burst carrying UL-MAP and UCD messages.
- ULMAP_RepetitionCoding specifies the repetition coding for the burst carrying UL-MAP and UCD messages. This parameter can be selected from 0 to 3, whose meaning is shown in *The Meaning of Repetition Coding*.
- ULMAP_PowerBoosting specifies the power boosting for the burst carrying UL-MAP and UCD messages. This parameter is defined in units of dB.
- UL_ZoneType specifies the uplink zone permutation. This parameter is used in the UL_Zone_IE () IE.
- UL_ZoneSymOffset specifies the offset of the OFDMA symbol in which the uplink zone starts, the offset value is defined in units of OFDMA symbols and is relevant to the Allocation Start Time field given in the UL-MAP message. This parameter is used in the UL_Zone_IE() IE.
- UL_ZoneNumOfSym specifies the number of OFDM symbols in the uplink subframe. This parameter is used in the OFDMA UL_MAP IE.
- UL_PermBase specifies the basis of uplink permutation. This parameter is used in the UL_Zone_IE() IE.
- UL_AllSCIndicator specifies whether all subchannel shall be used. When the UL_AllSCIndicator is set to 0, subchannels indicated by allocated subchannel bitmap in UCD shall be used. Otherwise all subchannels shall be used. This parameter is used in the UL_Zone_IE() IE.
- UCD_Count specifies the UCD count which is used in the UL_MAP and UCD messages. It is increased by one (modulo 256) whenever there is an uplink configuration change.
- UL_NumberOfBurst specifies the number of the uplink bursts. This parameter is used to determine the number of OFDMA UL-MAP IE in UL-MAP message.
- UL_CID specifies the Connection Identifier (CID) for each uplink burst. This parameter is used in the OFDMA UL-MAP IE.
- UL_CodingType specifies the coding type for each uplink burst. Each coding type can be selected from 0 to 1, where 0 is CC and 1 is CTC. This parameter is used in the OFDMA UL-MAP IE.
- UL_Rate_ID specifies the rate ID for each uplink burst. UL_Rate_ID, along with UL_CodingType, determines the modulation, coding rate. This parameter is used in the OFDMA UL-MAP IE.
- UL_BurstAssignedSlot specifies the duration for each uplink burst in units of OFDMA slots. This parameter is used in the OFDMA UL-MAP IE.
- UL_RepetitionCoding specifies the repetition coding for each uplink burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in *The Meaning of Repetition Coding*. This parameter is used in the OFDMA UL-MAP IE.

- PowerType specifies the exact meaning of the parameter Power in RF source. Three types are defined in downlink (Type I: Peak power; Type II: Burst power when all subchs occupied; Type III: Burst power with allocated subchs). Type I is recommended for transmitter measurement; Type II is recommended for receiver measurement; Type III is recommended for hardware measurement. For more information, please refer to *Transmit Power Definition* (wman_m).
- DIUC_RateID specifies the mapping from DIUC (0-12) to coding type and modulation/rate. The default value is

- `{{0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}, {1,3}, {1,4}, {1,5}} .`
  The first element (i.e. array {0,0}) is mapped to DIUC 0, and the second (i.e. array {0,1}) is mapped to DIUC 1, and so on. Each element represents {coding type, modulation and rate (Rate ID)}. For example, {1,2} means coding type is CTC (here 0: CC, 1:CTC) and Rate ID is 2 (16QAM rate 1/2). This parameter is used in DCD and DL-MAP IE. Note that if the coding type and modulation/rate for an allocated downlink burst is not mapped to a DIUC in this parameter, the DIUC field in DL-MAP IE will be filled with 0.
- UIUC_RateID specifies the mapping from UIUC (1-10) to coding type and modulation/rate. The default value is

  `{{0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}} .`

  The first element (i.e. array {0,0}) is mapped to UIUC 1, and the second (i.e. array {0,1}) is mapped to UIUC 2, and so on. Each element represents {coding type, modulation and rate (Rate ID)}. For example, {1,2} means coding type is CTC (here 0: CC, 1:CTC) and Rate ID is 2 (16QAM rate 1/2). This parameter is used in UCD and UL-MAP IE. Note that if the coding type and modulation/rate for an allocated uplink burst is not mapped to a UIUC in this parameter, the UIUC field in UL-MAP IE will be filled with 0.
- UM_AMC_Mode specifies the AMC mode which could be 1x6 (1 bin by 6 symbols), 2x3 (2 bins by 3 symbols) or 3x2 (3 bins by 2 symbols) for the uplink bursts when the UL_ZoneType = UL_AMC.
- UL_BurstSlotOffset specifies the slot offset for each burst in uplink.
- HARQ_Enable specifies whether all the bursts allocated are HARQ-enabled. When HARQ_Enable = YES, see *HARQ transmission* (wman_m) for more information.
- AMC_Mode specifies the AMC mode which could be 1x6 (1 bin by 6 symbols), 2x3 (2 bins by 3 symbols) or 3x2 (3 bins by 2 symbols) for the downlink bursts when the ZoneType = DL_AMC.
- DedicatedPilot specifies whether the pilots are dedicated. When DedicatedPilot = NO, all the pilots are transmitted; when DedicatedPilot = YES, only the pilots bleonging to the bursts allocated are transmitted. Note that this parameter is valid only when ZoneType = DL_AMC.

Samples per frame
The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-11-08-074.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in Sampling Factor Requirement.

Sampling Factor n	Bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval (!wman_m-11-08-076.gif!) is calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

So, the total samples of one downlink frame $Samples_{Frame}$ is

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

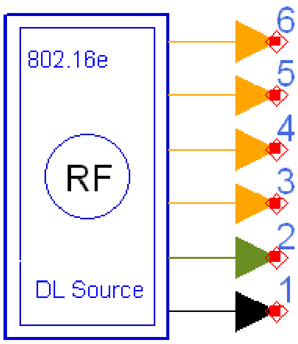
This model works frame by frame. Each firing,
$8 \times DataLength[BurstWithFEC]$ tokens are consumed at pin InputData,
$Samples_{Frame}$ tokens are produced at pin FrameData,
$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48/N_{SymPerSlot}$ tokens are produced at pin Constellation,
$8 \times DataLength[BurstWithFEC]] + 80$ tokens are produced at pin PDUFCS,

where $N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC.
Output delay
No delay is introduced by WMAN_M_SymWindow in this design.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_SignalSrc_RF (802.16e OFDMA Downlink RF Signal Source)



Description: Downlink RF signal source
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Unit	Type	Range
ROut	Output resistance	DefaultROut	Ohm	int	(0,∞)
RTemp	Temperature, in degrees C	DefaultRTemp	Celsius	real	[-273.15,∞]
FCarrier	Carrier frequency	3407 MHz	Hz	real	(0,∞)
Power	Transmit power (the meaning of Power is defined in Parameter PowerType)	0.01 W	W	real	(0,∞)
MirrorSpectrum	Mirror spectrum about carrier?: NO, YES	NO		enum	
GainImbalance	Gain imbalance in dB, Q channel relative to I channel	0.0		real	(-∞,∞)
PhaseImbalance	Phase imbalance in degrees, Q channel relative to I channel	0.0		real	(-∞,∞)
I_OriginOffset	I origin offset in percent with repect to output rms voltage	0.0		real	(-∞,∞)
Q_OriginOffset	q origin offset in percent with repect to output rms voltage	0.0		real	(-∞,∞)
IQ_Rotation	IQ rotation in degrees	0.0		real	(-∞,∞)
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
DLMAP_Enable	DLMAP is inserted or not: NO, YES	NO		enum	
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
PreambleIndex	Preamble index	3		int	[0,113]
FrameNumber	Frame number	0		int	[0,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
DL_PermBase	Downlink permutation base	9		int	[0,31]
DCD_Count	DCD count	1		int	[0,255]
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00, 0X00, 0X01}		int array	[0,255]
PRBS_ID	PRBS ID	0		int	[0,3]
DataPattern	WMAN data pattern: PN9, PN15, FIX4, _4_1_4_0, _8_1_8_0, _16_1_16_0, _32_1_32_0, _64_1_64_0,	PN9		enum	

	S_QPSK, S_16-QAM, S_64-QAM				
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	YES		enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array	[0,255]
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	22		int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array	[0,1]
NumberOfBurst	Number of bursts	2		int	[1,8]
BurstWithFEC	Number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}		int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,12}		int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}		int array	[1,60]
DataLength	MAC PDU payload byte length of each burst	{200,300}		int array	[1,∞)
CodingType	Coding type of each burst	{0,0}		int array	[0,1]
Rate_ID	Rate ID of each burst	{5,5}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0,0}		int array	[0,3]
PowerBoosting	Power boosting of each burst in dB	{0,0}		real array	(-∞,∞)
DLMAP_CodingType	Coding type of DLMAP	0		int	[0,1]
DLMAP_RepetitionCoding	Repetition coding of DLMAP	0		int	[0,3]
ULMAP_CodingType	Coding type of ULMAP	0		int	[0,1]
ULMAP_Rate_ID	Rate ID of ULMAP	0		int	[0,7]
ULMAP_RepetitionCoding	Repetition coding of ULMAP	0		int	[0,3]
ULMAP_PowerBoosting	Power boosting of ULMAP in dB	0		real	[-∞,∞]
UL_ZoneType	UL zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC		enum	
UL_ZoneSymOffset	Symbol offset in UL zone	0		int	[0,127]
UL_ZoneNumOfSym	Number of OFDMA symbols in the UL subframe	24		int	[3,255]
UL_PermBase	UL permutation base	0		int	[0, 69]
UL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum	
UCD_Count	UCD count	1		int	[0,255]
UL_NumberOfBurst	Number of bursts in uplink	1		int	[1,8]
UL_CID	Uplink CID	{1}		int array	[0,65535]
UL_CodingType	Uplink coding type of each burst	{0}		int array	[0,1]
UL_Rate_ID	Uplink rate ID	{0}		int array	[0,7]
UL_BurstAssignedSlot	Assigned slots of each burst in uplink	{96}		int array	[1,6868]
UL_RepetitionCoding	Repetition coding of each burst in uplink	{0}		int array	[0,3]
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupied, Burst power with allocated subchs): Peak power, Burst power when all subchs occupied, Burst power with allocated subchs	Burst power when all subchs occupied		enum	
DIUC_RateID	Mapping from DIUC (0-12) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}, {1,3}, {1,4}, {1,5		int array	[0,255]
		0,0}, {0,1}, {0,2},			

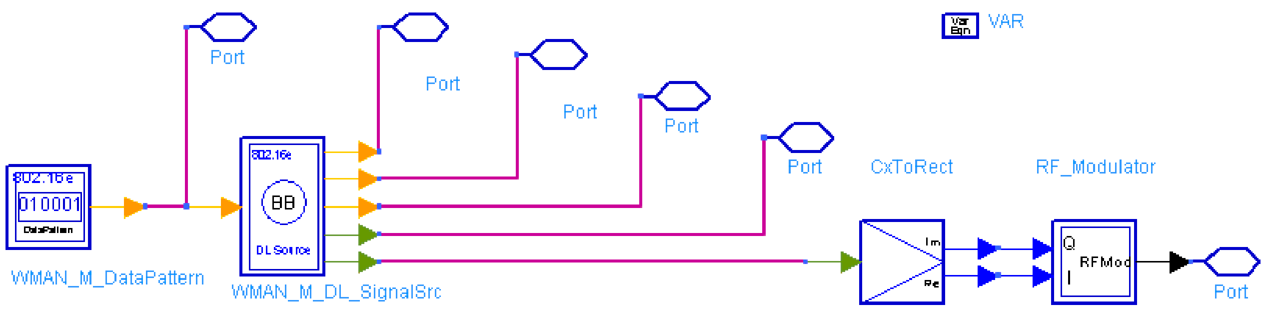
UIUC_RateID	Mapping from UIUC (1-10) to RateID {CodingType,Modulation/Rate}	{0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2		int array	[0,255]
UL_AMC_Mode	Uplink AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
UL_BurstSlotOffset	slot offsets of each burst in uplink	{0}		int array	[1,6868]
HARQ_Enable	Whether bursts are HARQ-enabled: NO, YES	NO		enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
DedicatedPilot	Is the dedicated pilot mode employed for DL PUSC or AMC zone: NO, YES	NO		enum	

Pin Outputs

Pin	Name	Description	Signal Type
1	RF	output of RF signal	timed
2	Constellation	output of Modulated data of all bursts for EVM	complex
3	PDUFCS	output of MAC PDU data of burst with FEC	int
4	DLFP	output of DLFP data	int
5	DLMAP	output of DLMAP data	int
6	PSDU	output of PSDU bits	int

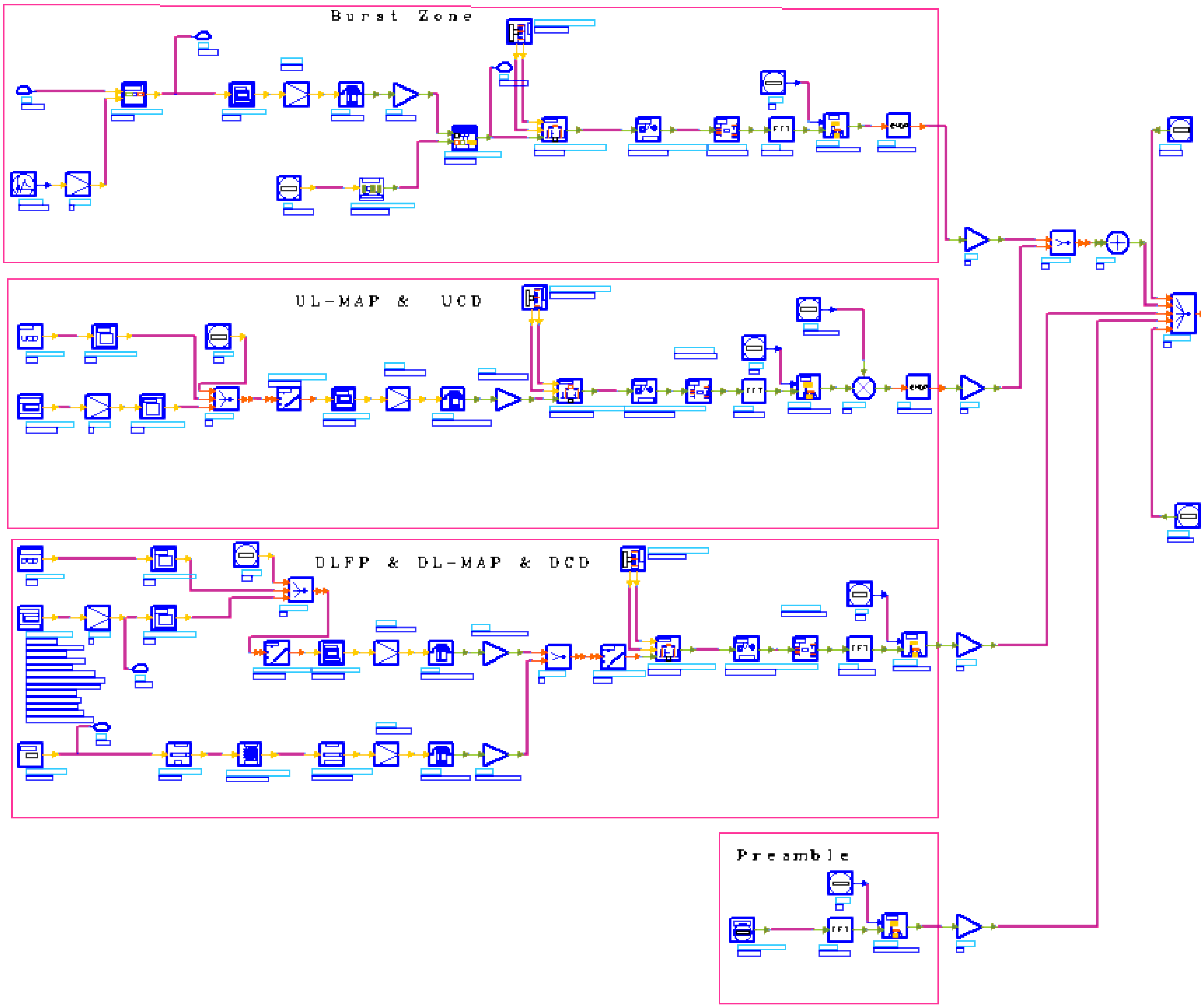
Notes/Equations

1. This subnetwork generates an 802.16e OFDMA downlink subsystem RF signal. The subnetwork includes WMAN_M_DL_SignalSrc, which generates the downlink baseband signal of 802.16e downlink subsystem, and the RF_Modulator. The schematic for this subnetwork is shown in WMAN_M_DL_SignalSrc_RF schematic.



WMAN_M_DL_SignalSrc_RF schematic

2. The WMAN OFDM downlink baseband signal source format follows the specification. The schematic is shown in WMAN_M_DL_SignalSrc schematic.



WMAN_M_DL_SignalSrc schematic

The implementation of WMAN_M_DL_SignalSrc is described in *Downlink baseband signal source* (wman_m).

3. Parameter Details
    - ROut is the RF output resistance.
    - RTemp is the RF output resistance temperature in Celsius and sets the noise density in the RF output signal to (k(RTemp+273.15)) Watts/Hz, where k is Boltzmann's constant.
    - FCarrier is the RF output signal frequency.
    - Power is used to set the modulator output RF power. This is true for an ideal transmitted signal (no impairments added) or when small impairments are added. If large impairments are added to the signal (using GainImbalance, I_OriginOffset, and Q_OriginOffset parameters) the output RF power may be different from the value of the Power parameter.
    - MirrorSpectrum is used to mirror the RF_out signal spectrum about the carrier. This is equivalent to conjugating the complex RF envelope voltage. Depending on the configuration and number of mixers in an RF transmitter, the RF output signal from hardware RF generators can be inverted. If such an RF signal is desired, set this parameter to YES.
    - GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation are used to add certain impairments to the ideal output RF signal. Impairments are added in the order described here.
      The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given

$$V_{RF}(t) = A\left(V_I(t)\cos(\omega_c t) - gV_Q(t)\sin\left(\omega_c t + \frac{\Phi\pi}{180}\right)\right)$$

by:
where A is a scaling factor based on the Power and ROut parameters specified by the user, VI(t) is the in-phase RF envelope, VQ(t) is the quadrature phase RF envelope, g is the gain imbalance

$$g = 10^{\frac{GainImbalance}{20}}$$

and, !wman_m-11-09-091.gif!(in degrees) is the phase imbalance.
Next, the signal VRF(t) is rotated by IQ_Rotation degrees. The I_OriginOffset and Q_OriginOffset are then applied to the rotated signal. Note that the amounts specified are percentages with respect to the output rms voltage. The output rms voltage is given by sqrt(2×ROut×Power).

- For the other baseband parameters, refer to *Baseband parameters* (wman_m).

4. Samples per frame
The sampling frequency (Fs) implemented in the design is decided by Bandwidth, OversamplingOption and related sampling factor (!wman_m-11-09-093.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in Sampling Factor Requirement.

Sampling Factor n	Bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval (!wman_m-11-09-095.gif!) are calculated as follows:
$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$

So, the total samples of one downlink frame $Samples_{Frame}$ are
$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$

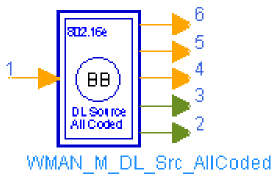
This model works frame by frame. Each firing,
$8 \times DataLength[BurstWithFEC]$ tokens are produced at pin PSDU,
$Samples_{Frame}$ tokens are produced at pin RF,
$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48/N_{SymPerSlot}$ tokens are produced at pin Constellation,
$8 \times DataLength[BurstWithFEC]] + 80$ tokens are produced at pin PDUFCS,
where $N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC.

5. Output delay
No delay is introduced by WMAN_M_SymWindow in this design.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_Src_AllCoded (802.16e OFDMA Downlink Source with All Coded Bursts)



Description: Downlink signal src with all coded bursts
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Unit	Type	Range
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01, 0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
DLMAP_Enable	DLMAP is inserted or not: NO, YES	NO		enum	
DCD_Enable	DCD is inserted or not: NO, YES	NO		enum	
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
UCD_Enable	UCD is inserted or not: NO, YES	NO		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[0,0.02]
PreambleIndex	Preamble index	3		int	[0,113]
FrameNumber	Frame number	0		int	[0,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
DL_PermBase	DL permutation base	9		int	[0,31]
DCD_Count	DCD count	1		int	[0,255]
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00, 0X00, 0X01}		int array	[0,255]
PRBS_ID	PRBS ID	0		int	[0,3]
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	YES		enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array	[0,255]
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	22		int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array	[0,1]
NumberOfBurst	Number of Bursts	2		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}		int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,12}		int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}		int array	[1,60]
DataLength	MAC PDU payload byte length of each burst	{200,300}		int array	[1,∞)

CodingType	Coding type of each burst	{0,0}		int array	[0,1]
Rate_ID	Rate ID of each burst	{5,5}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0,0}		int array	[0,3]
PowerBoosting	Power boosting of each burst in dB	{0,0}		real array	[-∞,∞]
DLMAP_CodingType	Coding type of DLMAP	0		int	[0,1]
DLMAP_RepetitionCoding	Repetition coding of DLMAP	0		int	[0,3]
ULMAP_CodingType	Coding type of ULMAP	0		int	[0,1]
ULMAP_Rate_ID	Rate ID of ULMAP	0		int	[0,7]
ULMAP_RepetitionCoding	Repetition coding of ULMAP	0		int	[0,3]
ULMAP_PowerBoosting	Power boosting of ULMAP in dB	0		real	[-∞,∞]
UL_ZoneType	UL zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC		enum	
UL_ZoneSymOffset	Symbol offset in UL zone	0		int	[0,127]
UL_ZoneNumOfSym	Number of OFDMA symbols in the UL subframe	24		int	[3,255]
UL_PermBase	UL permutation base	0		int	[0, 69]
UL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum	
UCD_Count	UCD count	1		int	[0,255]
UL_NumberOfBurst	Number of Bursts in uplink	1		int	[1,8]
UL_CID	Uplink CID	{1}		int array	[0,65535]
UL_CodingType	Uplink coding type of each burst	{0}		int array	[0,1]
UL_Rate_ID	Uplink rate ID	{0}		int array	[0,7]
UL_BurstAssignedSlot	Assigned slots of each burst in uplink	{96}		int array	[1,6868]
UL_RepetitionCoding	Repetition coding of each burst in uplink	{0}		int array	[0,3]
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupied, Burst power with allocated subchs): Peak power, Burst power when all subchs occupied, Burst power with allocated subchs	Burst power when all subchs occupied		enum	
DIUC_RateID	Mapping from DIUC (0-12) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}, {1,3}, {1,4}, {1,5		int array	[0,255]
UIUC_RateID	Mapping from UIUC (1-10) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2		int array	[0,255]
UL_AMC_Mode	Uplink AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
UL_BurstSlotOffset	slot offsets of each burst in uplink	{0}		int array	[1,6868]
HARQ_Enable	Whether bursts are HARQ-enabled: NO, YES	NO		enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
DedicatedPilot	Is the dedicated pilot mode employed for DL PUSC or AMC zone: NO, YES	NO		enum	

Pin Inputs

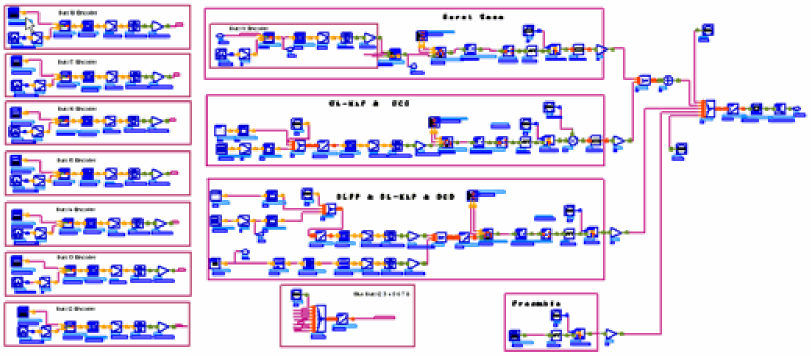
Pin	Name	Description	Signal Type
1	InputData	input of raw data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	FrameData	output of uplink Subframe	complex
3	Constellation	output of Modulated data of all bursts for EVM	complex
4	PDUFCS	output of MAC PDU data of burst with FEC	int
5	DLFP	output of DLFP data	int
6	DLMAP	output of DLMAP data	int

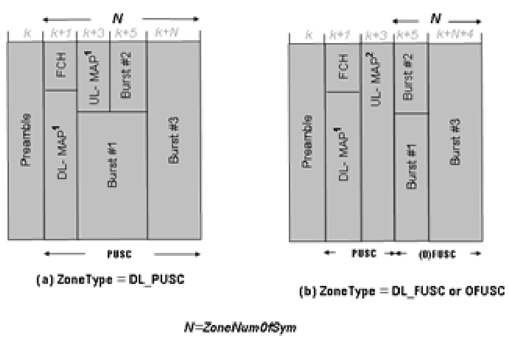
Notes/Equations

1. This subnetwork generates an 802.16e OFDMA downlink subsystem baseband signal with all encoded bursts. The schematic for this subnetwork is shown in the following illustration.



WMAN_M_DL_Src_AllCoded Schematic

2. WMAN_M_DL_Src_AllCoded is implemented according to the specification. The following figure shows the downlink frame format.

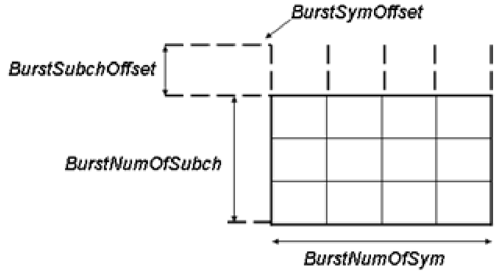


802.16e OFDMA Downlink Subframe Structure

3. This signal source performs the same functionality as WMAN_M_DL_SignalSrc with the following exceptions:
   - All the bursts are encoded with CC or CTC. Hence the parameter BurstWithFEC doesn't exist in this source. Up to 8 bursts are supported. The input of this subnetwork is the MAC PDU data for the first burst; MAC header data is specified by MAC_Header. The input MAC PDU data for other bursts are generated by WMAN_M_DataPattern in this source respectively. To change the input MAC PDU data for these bursts, please change the settings in WMAN_M_DataPattern respectively.
   - The MAC messages (DL-MAP, UL-MAP, DCD and UCD) are supported more flexibly compared to WMAN_M_DL_SignalSrc. The allocated subchannels for DL-MAP or UL-MAP bursts are variable with the actual size of DL-MAP (including DCD) or UL-MAP (including UCD). The variable DLMAP_NumOfSubch in this source determine the actual allocated subchannels for DL-MAP burst; The variable ULMAP_NumOfSubch in this source determine the actual allocated subchannels for UL-MAP burst; Meanwhile the DCD message in DL-MAP burst can be disabled with the parameter DCD_Enable; the UCD message in UL-MAP burst can be disabled with the parameter UCD_Enable. With the settings above, it is possible to allocate DL-MAP and UL-MAP bursts even when FFT size is 512.
   - Overall, this signal source is an ideal one to generate all kinds of mobile WiMAX downlink waveforms. For other functionality of this source, please refer to the documentation of WMAN_M_DL_SignalSrc.

4. Parameter Details

- Bandwidth determines the nominal channel bandwidth.
- OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
- FFTSize specifies the size of FFT. Sizes 2048, 1024 and 512 are supported.
- CyclicPrefix specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
- FrameMode specifies the duplexing method which should be FDD or TDD. In FDD transmission, the downlink occupies the entire frame and the respective gaps (zeros) are automatically adjusted to fill the frame.
- DL_Ratio specifies the percentage (1 to 99) of the frame time to be used for the downlink subframe. The parameter is only active when the *FrameMode* is TDD.
- FrameDuration determines the frame durations (ms) of the generated waveform.There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
- DLMAP_Enable specifies whether the DL-MAP burst is inserted in the downlink subframe.
- ULMAP_Enable specifies whether the UL-MAP burst is inserted in the downlink subframe.
- DCD_Enable specifies whether the DCD message is inserted in the DL-MAP burst.
- UCD_Enable specifies whether the UCD message is inserted in the UL-MAP burst.
- IdleInterval specifies the time of idle interval between the two continuous frames. the default value is 0.
- PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to the standard.
- FrameNumber specifies the starting frame number in the downlink subframe.
- FrameIncreased specifies whether the frame number for the downlink subframe is increased. When *FrameIncreased* is set to YES, then the frame numbers in Frame#0, Frame#1, Frame#2, Frame#3 will be *FrameNumber*, *FrameNumber*+1, *FrameNumber*+2, *FrameNumber*+3. When *FrameIncreased* is set to NO, then the frame numbers in Frame#0, Frame#1, Frame#2, Frame#3 will be *FrameNumber*, *FrameNumber*, *FrameNumber*, *FrameNumber*.
- DL_PermBase specifies the basis of downlink permutation to be used in initialization vector of the PRBS generator for subchannel randomization in the zone and in STC_DL_Zone_IE() in DL-MAP message.
- DCD_Count specifies the DCD count which is used in DL-MAP and DCD messages. This is increased by one (modulo 256) whenever there is a downlink configuration change.
- BSID specifies the base station ID which is used in DL-MAP message.
- PRBS_ID specifies the PRBS ID which may be used in initialization vector of the PRBS generator for subchannel randomization and in STC_DL_Zone_IE() in DL-MAP message.
- AutoMACHeaderSetting specifies whether the MAC header is automatically generated or input by users. If it is set to NO, data sequences in parameter MAC_Header will be used before data content, otherwise MAC_Header content will be calculated with parameter DataLength and CID and be used before data content.
- MAC_Header specifies 6 bytes of MAC header before the data contents. The cell is only active when the AutoMACHeaderSetting is set to NO.
- CRC32_Mode specifies the method for CRC32 calculation appended to MAC PDU. For consistency with 802.16e-2005, it shall be set to *MSB first* while shall be set to *LSB first* for consistency with 802.16-2004 Cor1/D3.
- ZoneType specifies the zone type which can be set to PUSC, FUSC, OFUSC or AMC.
- ZoneNumOfSym specifies the symbol number for the zone. The value must be a multiple of two for DL_PUSC, and be a multiple of one for DL_FUSC, DL_OFUSC and DL_AMC.
- GroupBitmask specifies which groups of subchannel are used in the PUSC zone. This parameter uses 1 for assigned groups and 0 for unassigned groups.
- NumberOfBurst specifies the number of active downlink bursts.
- BurstSymOffset, BurstSubchOffset, BurstNumOfSym and BurstNumOfSubch specify the position and range for each rectangular burst, seen in the following figure.



Downlink Rectangular Burst Structure

- DataLength specifies MAC PDU payload byte length for each burst.
- CodingType specifies the coding type for each burst. Each coding type can be selected from 0 to 1, whose

meaning is shown in the following table.

The Meaning of Coding Type

Coding Type	Meaning
0	Convolutional coding (CC)
1	Convolutional turbo coding (CTC)

- Rate_ID specifies the rate ID for each burst. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in the next table.

The Relation of Coding Type and Rate ID9

Coding type	Rate ID	Modulation/Coding rate
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in the following table.

The Meaning of Repetition Coding

Repetition coding	Meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4used on the burst
3	Repetition coding of 6used on the burst

- PowerBoosting specifies the power boosting for each burst. Each value is defined in units of dB.
- DLMAP_CodingType specifies the coding type for the burst carrying DL-MAP and DCD messages.The rate ID for the burst carrying DL-MAP and DCD messages is fixed to 0.
- DLMAP_RepetitionCoding specifies the repetition coding for the burst carrying DL-MAP and DCD messages. This parameter can be selected from 0 to 3, whose meaning is shown in in preceding table, "The Meaning of Repetition Coding".
- ULMAP_CodingType specifies the coding type for the burst carrying UL-MAP and UCD messages.
- ULMAP_Rate_ID specifies the rate ID for the burst carrying UL-MAP and UCD messages.
- ULMAP_RepetitionCoding specifies the repetition coding for the burst carrying UL-MAP and UCD messages. This parameter can be selected from 0 to 3, whose meaning is shown in preceding table, "The Meaning of Repetition Coding".
- ULMAP_PowerBoosting specifies the power boosting for the burst carrying UL-MAP and UCD messages. This parameter is defined in units of dB.
- UL_ZoneType specifies the uplink zone permutation. This parameter is used in the UL_Zone_IE () IE.
- UL_ZoneSymOffset specifies the offset of the OFDMA symbol in which the uplink zone starts, the offset value is defined in units of OFDMA symbols and is relevant to the Allocation Start Time field given in the UL-MAP message. This parameter is used in the UL_Zone_IE() IE.
- UL_ZoneNumOfSym specifies the number of OFDM symbols in the uplink subframe. This parameter is used in the OFDMA UL_MAP IE.

- UL_PermBase specifies the basis of uplink permutation. This parameter is used in the UL_Zone_IE() IE.
- UL_AllSCIndicator specifies whether all subchannel shall be used. When the UL_AllSCIndicator is set to 0, subchannels indicated by allocated subchannel bitmap in UCD shall be used. Otherwise all subchannels shall be used. This parameter is used in the UL_Zone_IE() IE.
- UCD_Count specifies the UCD count which is used in the UL_MAP and UCD messages. It is increased by one (modulo 256) whenever there is an uplink configuration change.
- UL_NumberOfBurst specifies the number of the uplink bursts. This parameter is used to determine the number of OFDMA UL-MAP IE in UL-MAP message.
- UL_CID specifies the Connection Identifier (CID) for each uplink burst. This parameter is used in the OFDMA UL-MAP IE.
- UL_CodingType specifies the coding type for each uplink burst. Each coding type can be selected from 0 to 1, where 0 is CC and 1 is CTC. This parameter is used in the OFDMA UL-MAP IE.
- UL_Rate_ID specifies the rate ID for each uplink burst. UL_Rate_ID, along with UL_CodingType, determines the modulation, coding rate. This parameter is used in the OFDMA UL-MAP IE.
- UL_BurstAssignedSlot specifies the duration for each uplink burst in units of OFDMA slots. This parameter is used in the OFDMA UL-MAP IE.
- UL_RepetitionCoding specifies the repetition coding for each uplink burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in preceding table, "The Meaning of Repetition Coding". This parameter is used in the OFDMA UL-MAP IE.
- PowerType specifies the exact meaning of the parameter Power in RF source. Three types are defined in downlink (Type I: Peak power; Type II: Burst power when all subchs occupied; Type III: Burst power with allocated subchs). Type I is recommended for transmitter measurement; Type II is recommended for receiver measurement; Type III is recommended for hardware measurement. For more information, please refer to Transmit Power Definition.
- DIUC_RateID specifies the mapping from DIUC (0-12) to coding type and modulation/rate. The default value is { {0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}, {1,3}, {1,4}, {1,5} }. The first element (i.e., array {0,0}) is mapped to DIUC 0, and the second (i.e., array {0,1}) is mapped to DIUC 1, and so on. Each element represents {coding type, modulation and rate (Rate ID)}. For example, {1,2} means coding type is CTC (here 0: CC, 1:CTC) and Rate ID is 2 (16QAM rate 1/2). This parameter is used in DCD and DL-MAP IE. Note that if the coding type and modulation/rate for an allocated downlink burst is not mapped to a DIUC in this parameter, the DIUC field in DL-MAP IE will be filled with 0.
- UIUC_RateID specifies the mapping from UIUC (1-10) to coding type and modulation/rate. The default value is { {0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2} }. The first element (i.e., array {0,0}) is mapped to UIUC 1, and the second (i.e., array {0,1}) is mapped to UIUC 2, and so on. Each element represents {coding type, modulation and rate (Rate ID)}. For example, {1,2} means coding type is CTC (here 0: CC, 1:CTC) and Rate ID is 2 (16QAM rate 1/2). This parameter is used in UCD and UL-MAP IE. Note that if the coding type and modulation/rate for an allocated uplink burst is not mapped to a UIUC in this parameter, the UIUC field in UL-MAP IE will be filled with 0.
- UM_AMC_Mode specifies the AMC mode which could be 1x6 (1 bin by 6 symbols), 2x3 (2 bins by 3 symbols) or 3x2 (3 bins by 2 symbols) for the uplink bursts when the UL_ZoneType = UL_AMC.
- UL_BurstSlotOffset specifies the slot offset for each burst in uplink.
- HARQ_Enable specifies whether all the bursts allocated are HARQ-enabled. When HARQ_Enable = YES, see *HARQ transmission* (wman_m) for more information.
- AMC_Mode specifies the AMC mode which could be 1x6 (1 bin by 6 symbols), 2x3 (2 bins by 3 symbols) or 3x2 (3 bins by 2 symbols) for the downlink bursts when the ZoneType = DL_AMC.
- DedicatedPilot specifies whether the pilots are dedicated. When DedicatedPilot = NO, all the pilots are transmitted; when DedicatedPilot = YES, only the pilots bleonging to the bursts allocated are transmitted. Note that this parameter is valid only when ZoneType = DL_AMC.

5. Samples per frame
   The sampling frequency (Fs) implemented in the design is decided by *Bandwidth* and related sampling factor N_{factor} as follows:
   $F_s = \text{floor}((N_{factor} \times \text{Bandwidth}) / 8000) \times 8000$
   The sampling factors are listed in the following table:

Sampling Factor Requirement

Sampling Factor *n*	**Bandwidth**
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval($Samples_{idle}$) is calculated as follows:

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

So, the total samples of one downlink frame $Samples_{Frame}$ is:

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

This model works frame by frame. Each firing, $8 \times DataLength[1]$ tokens are consumed at pin InputData, $Samples_{Frame}$ tokens are produced at pin FrameData,

$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 / N_{SymPerSlot}$$

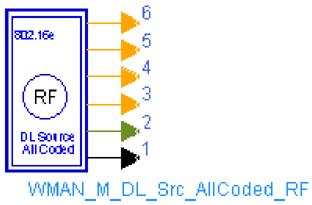
tokens are produced at pin Constellation, $8 \times DataLength[1] + 80$ tokens are produced at pin PDUFCS, where $N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC.

6. Output delay
   No delay is introduced by WMAN_M_SymWindow in this design.

References

1. IEEE Std 802.16-2004, *Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY*, October 1, 2004.
2. IEEE Std 802.16e-2005, *Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY*, February 2006.

WMAN_M_DL_Src_AllCoded_RF (802.16e OFDMA Downlink RF Source with All Coded Bursts)



Description: Downlink RF signal source with all coded bursts
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Unit	Type	Range
ROut	Output resistance	DefaultROut	Ohm	int	(0,∞)
RTemp	Temperature, in degrees C	DefaultRTemp	Celsius	real	[-273.15,∞]
FCarrier	Carrier frequency	3407 MHz	Hz	real	(0,∞)
Power	Transmit power (the meaning of Power is defined in Parameter PowerType)	0.01 W	W	real	(0,∞)
MirrorSpectrum	Mirror spectrum about carrier?: NO, YES	NO		enum	
GainImbalance	Gain imbalance in dB, Q channel relative to I channel	0.0		real	(-∞,∞)
PhaseImbalance	Phase imbalance in degrees, Q channel relative to I channel	0.0		real	(-∞,∞)
I_OriginOffset	I origin offset in percent with repect to output rms voltage	0.0		real	(-∞,∞)
Q_OriginOffset	q origin offset in percent with repect to output rms voltage	0.0		real	(-∞,∞)
IQ_Rotation	IQ rotation in degrees	0.0		real	(-∞,∞)
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
DLMAP_Enable	DLMAP is inserted or not: NO, YES	NO		enum	
DCD_Enable	DCD is inserted or not: NO, YES	NO		enum	
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
UCD_Enable	UCD is inserted or not: NO, YES	NO		enum	
PreambleIndex	Preamble index	3		int	[0,113]
FrameNumber	Frame number	0		int	[0,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
DL_PermBase	Downlink permutation base	9		int	[0,31]
DCD_Count	DCD count	1		int	[0,255]
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00, 0X00, 0X01}		int array	[0,255]
PRBS_ID	PRBS ID	0		int	[0,3]
DataPattern	WMAN data pattern: PN9, PN15, FIX4, _4_1_4_0, _8_1_8_0, _16_1_16_0, _32_1_32_0, _64_1_64_0, S_QPSK, S_16-QAM, S_64-QAM	PN9		enum	
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	YES		enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array	[0,255]
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum	

ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	22		int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array	[0,1]
NumberOfBurst	Number of bursts	2		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}		int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,12}		int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}		int array	[1,60]
DataLength	MAC PDU payload byte length of each burst	{200,300}		int array	[1,∞)
CodingType	Coding type of each burst	{0,0}		int array	[0,1]
Rate_ID	Rate ID of each burst	{5,5}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0,0}		int array	[0,3]
PowerBoosting	Power boosting of each burst in dB	{0,0}		real array	(-∞,∞)
DLMAP_CodingType	Coding type of DLMAP	0		int	[0,1]
DLMAP_RepetitionCoding	Repetition coding of DLMAP	0		int	[0,3]
ULMAP_CodingType	Coding type of ULMAP	0		int	[0,1]
ULMAP_Rate_ID	Rate ID of ULMAP	0		int	[0,7]
ULMAP_RepetitionCoding	Repetition coding of ULMAP	0		int	[0,3]
ULMAP_PowerBoosting	Power boosting of ULMAP in dB	0		real	[-∞,∞]
UL_ZoneType	UL zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC		enum	
UL_ZoneSymOffset	Symbol offset in UL zone	0		int	[0,127]
UL_ZoneNumOfSym	Number of OFDMA symbols in the UL subframe	24		int	[3,255]
UL_PermBase	UL permutation base	0		int	[0, 69]
UL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum	
UCD_Count	UCD count	1		int	[0,255]
UL_NumberOfBurst	Number of bursts in uplink	1		int	[1,8]
UL_CID	Uplink CID	{1}		int array	[0,65535]
UL_CodingType	Uplink coding type of each burst	{0}		int array	[0,1]
UL_Rate_ID	Uplink rate ID	{0}		int array	[0,7]
UL_BurstAssignedSlot	Assigned slots of each burst in uplink	{96}		int array	[1,6868]
UL_RepetitionCoding	Repetition coding of each burst in uplink	{0}		int array	[0,3]
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupied, Burst power with allocated subchs): Peak power, Burst power when all subchs occupied, Burst power with allocated subchs	Burst power when all subchs occupied		enum	
DIUC_RateID	Mapping from DIUC (0-12) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}, {1,3}, {1,4}, {1,5		int array	[0,255]
UIUC_RateID	Mapping from UIUC (1-10) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2		int array	[0,255]
UL_AMC_Mode	Uplink AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
UL_BurstSlotOffset	slot offsets of each burst in uplink	{0}		int array	[1,6868]

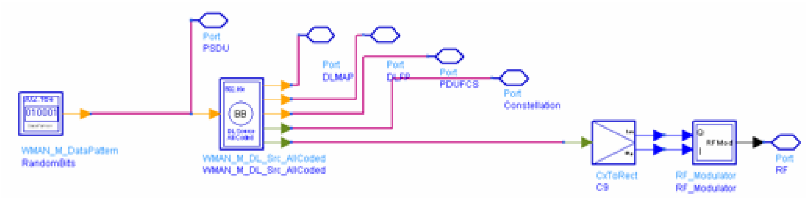
HARQ_Enable	Whether bursts are HARQ-enabled: NO, YES	NO		enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
DedicatedPilot	Is the dedicated pilot mode employed for DL PUSC or AMC zone: NO, YES	NO		enum	

Pin Outputs

Pin	Name	Description	Signal Type
1	RF	output of RF signal	timed
2	Constellation	output of Modulated data of all bursts for EVM	complex
3	PDUFCS	output of MAC PDU data of burst with FEC	int
4	DLFP	output of DLFP data	int
5	DLMAP	output of DLMAP data	int
6	PSDU	output of PSDU bits	int

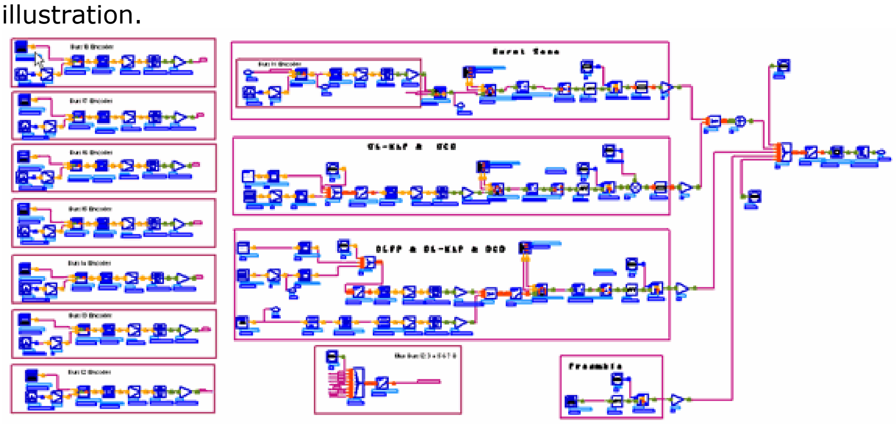
Notes/Equations

1. This subnetwork generates an 802.16e OFDMA downlink subsystem RF signal with all coded bursts. The subnetwork includes WMAN_M_DL_Src_AllCoded, which generates the downlink baseband signal of 802.16e downlink subsystem, and the RF_Modulator. The schematic for this subnetwork is shown in the following illustration.



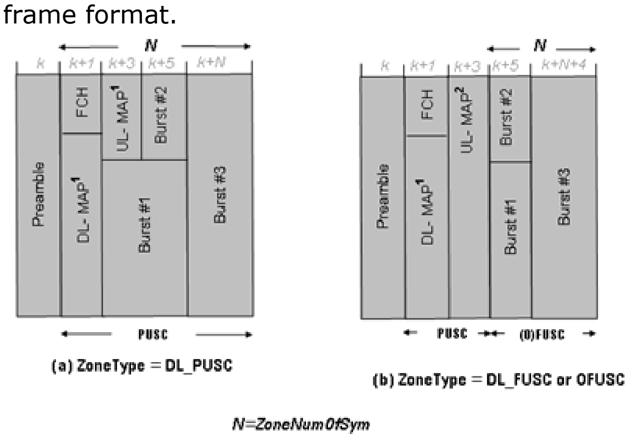
WMAN_M_DL_Src_AllCoded_RF schematic

2. WMAN_M_DL_Src_AllCoded is implemented according to the specification. The schematic is shown in the next illustration.



WMAN_M_DL_Src_AllCoded schematic

3. WMAN_M_DL_Src_AllCoded is implemented according to specification. The next figure shows the downlink frame format.



802.16e OFDMA downlink subframe structure

4. This baseband signal source performs the same functionality as WMAN_M_DL_SignalSrc with the following exceptions:
   - All the bursts are encoded with CC or CTC. Hence the parameter BurstWithFEC doesn't exist in this source. Up to 8 bursts are supported. The input of this subnetwork is the MAC PDU data for the first burst; MAC header data is specified by MAC_Header. The input MAC PDU data for other bursts are generated by WMAN_M_DataPattern in this source respectively. To change the input MAC PDU data for these bursts, please change the settings in WMAN_M_DataPattern respectively.
   - The MAC messages (DL-MAP, UL-MAP, DCD and UCD) are supported more flexibly compared to WMAN_M_DL_SignalSrc. The allocated subchannels for DL-MAP or UL-MAP bursts are variable with the actual size of DL-MAP (including DCD) or UL-MAP (including UCD). The variable DLMAP_NumOfSubch in this source determine the actual allocated subchannels for DL-MAP burst; The variable ULMAP_NumOfSubch in this source determine the actual allocated subchannels for UL-MAP burst; Meanwhile the DCD message in DL-MAP burst can be disabled with the parameter DCD_Enable; the UCD message in UL-MAP burst can be disabled with the parameter UCD_Enable. With the settings above, it is possible to allocate DL-MAP and UL-MAP bursts even when FFT size is 512.
   - Overall, this signal source is an ideal one to generate all kinds of mobile WiMAX downlink waveforms. For other functionality of this baseband source, please refer to the documentation of WMAN_M_DL_SignalSrc.
5. Parameter Details
   - ROut is the RF output resistance.
   - RTemp is the RF output resistance temperature in Celsius and sets the noise density in the RF output signal to (k(RTemp+273.15)) Watts/Hz, where k is Boltzmann's constant.
   - FCarrier is the RF output signal frequency.
   - Power is used to set the modulator output RF power. This is true for an ideal transmitted signal (no impairments added) or when small impairments are added. If large impairments are added to the signal (using GainImbalance, I_OriginOffset, and Q_OriginOffset parameters) the output RF power may be different from the value of the Power parameter.
   - MirrorSpectrum is used to mirror the RF_out signal spectrum about the carrier. This is equivalent to conjugating the complex RF envelope voltage. Depending on the configuration and number of mixers in an RF transmitter, the RF output signal from hardware RF generators can be inverted. If such an RF signal is desired, set this parameter to YES.
   - GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation are used to add certain impairments to the ideal output RF signal. Impairments are added in the order described here.
     The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:
     $V_{RF}(t) = A\left(V_I(t)\cos(\omega_c t) - gV_Q(t)\sin\left(\omega_c t + \frac{\Phi\pi}{180}\right)\right)$
     where A is a scaling factor based on the Power and ROut parameters specified by the user, *VI(t)* is the in-phase RF envelope, *VQ(t)* is the quadrature phase RF envelope, g is the gain imbalance,
     $g = 10^{\frac{GainImbalance}{20}}$
     and, (in degrees) is the phase imbalance.
     Next, the signal *VRF(t)* is rotated by *IQ_Rotation* degrees. The I_OriginOffset and Q_OriginOffset are then applied to the rotated signal. Note that the amounts specified are percentages with respect to the output rms voltage. The output rms voltage is given by sqrt_(2ROut;Power)_.
   - For the other baseband parameters, refer to *Baseband parameters* (wman_m).
6. Samples per frame
   The sampling frequency (Fs) implemented in the design is decided by Bandwidth, OversamplingOption and related sampling factor N_{factor}() as follows,
   $F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$
   The sampling factors are listed in the following table:

Sampling Factor Requirement

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval $Samples_{idle}$ () are calculated as follows:
$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$
So, the total samples of one downlink frame $Samples_{Frame}$ are:

$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$

This model works frame by frame. Each firing, $8 \times DataLength[1]$ tokens are produced at pin PSDU, $Samples_{Frame}$ tokens are produced at pin FrameData,

$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48 / N_{SymPerSlot}$$

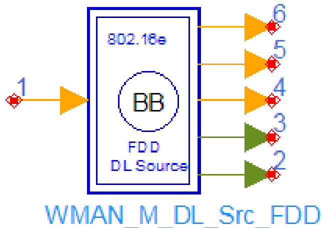
tokens are produced at pin Constellation, $8 \times DataLength[1] + 80$ tokens are produced at pin PDUFCS, where $N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC.

7. Output delay
   No delay is introduced by WMAN_M_SymWindow in this design.

References

1. IEEE Std 802.16-2004, *Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY*, October 1, 2004.
2. IEEE Std 802.16e-2005, *Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY*, February 2006.

WMAN_M_DL_Src_FDD (802.16e OFDMA Downlink FDD Signal Source)



Description: Downlink FDD signal src
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Unit	Type	Range
ActiveDLSubframe	Which DL subframe is set by this source (the first (DL1) or the second DL subframe (DL2)): DL1, DL2	DL1		enum	
DL1_NumOfSyms	The total number of symbols in the first DL subframe (DL1) including Preamble and MAP1	23		int	[3,60]
DL2_NumOfSyms	The total number of symbols in the second DL subframe (DL2) including MAP2	22		int	[2,60]
Gap_DL1_DL2	The integer number of symbols in the gap between DL1 and DL2 excluding the optional unused time	1		int	[0,60]
UnusedTimePosition	The position for the unused time of the frame: After DL2, Between DL1 and DL2	After DL2		enum	
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
DLMAP_Enable	DLMAP is inserted or not: NO, YES	NO		enum	
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[0,0.02]
PreambleIndex	Preamble index	3		int	[0,113]
FrameNumber	Frame number	0		int	[0,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
DL_PermBase	DL permutation base	9		int	[0,31]
DCD_Count	DCD count	1		int	[0,255]
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00, 0X00, 0X01}		int array	[0,255]
PRBS_ID	PRBS ID	0		int	[0,3]
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	YES		enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array	[0,255]
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	22		int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array	[0,1]
NumberOfBurst	Number of Bursts	2		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}		int	[0,59]

				array	
BurstNumOfSym	Number of symbols of each burst	{6,12}		int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}		int array	[1,60]
DataLength	MAC PDU payload byte length of each burst	{200,300}		int array	[1,∞)
CodingType	Coding type of each burst	{0,0}		int array	[0,1]
Rate_ID	Rate ID of each burst	{5,5}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0,0}		int array	[0,3]
PowerBoosting	Power boosting of each burst in dB	{0,0}		real array	[-∞,∞]
DLMAP_CodingType	Coding type of DLMAP	0		int	[0,1]
DLMAP_RepetitionCoding	Repetition coding of DLMAP	0		int	[0,3]
ULMAP_CodingType	Coding type of ULMAP	0		int	[0,1]
ULMAP_Rate_ID	Rate ID of ULMAP	0		int	[0,7]
ULMAP_RepetitionCoding	Repetition coding of ULMAP	0		int	[0,3]
ULMAP_PowerBoosting	Power boosting of ULMAP in dB	0		real	[-∞,∞]
UL_ZoneType	UL zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC		enum	
UL_ZoneSymOffset	Symbol offset in UL zone	0		int	[0,127]
UL_ZoneNumOfSym	Number of OFDMA symbols in the UL subframe	24		int	[3,255]
UL_PermBase	UL permutation base	0		int	[0, 69]
UL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum	
UCD_Count	UCD count	1		int	[0,255]
UL_NumberOfBurst	Number of Bursts in uplink	1		int	[1,8]
UL_CID	Uplink CID	{1}		int array	[0,65535]
UL_CodingType	Uplink coding type of each burst	{0}		int array	[0,1]
UL_Rate_ID	Uplink rate ID	{0}		int array	[0,7]
UL_BurstAssignedSlot	Assigned slots of each burst in uplink	{96}		int array	[1,6868]
UL_RepetitionCoding	Repetition coding of each burst in uplink	{0}		int array	[0,3]
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupied, Burst power with allocated subchs): Peak power, Burst power when all subchs occupied, Burst power with allocated subchs	Burst power when all subchs occupied		enum	
DIUC_RateID	Mapping from DIUC (0-12) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}, {1,3}, {1,4}, {1,5		int array	[0,255]
UIUC_RateID	Mapping from UIUC (1-10) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2		int array	[0,255]
UL_AMC_Mode	Uplink AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
UL_BurstSlotOffset	slot offsets of each burst in uplink	{0}		int array	[1,6868]
HARQ_Enable	Whether bursts are HARQ-enabled: NO, YES	NO		enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
DedicatedPilot	Is the dedicated pilot mode employed for DL PUSC or AMC zone: NO, YES	NO		enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	InputData	input of raw data	int

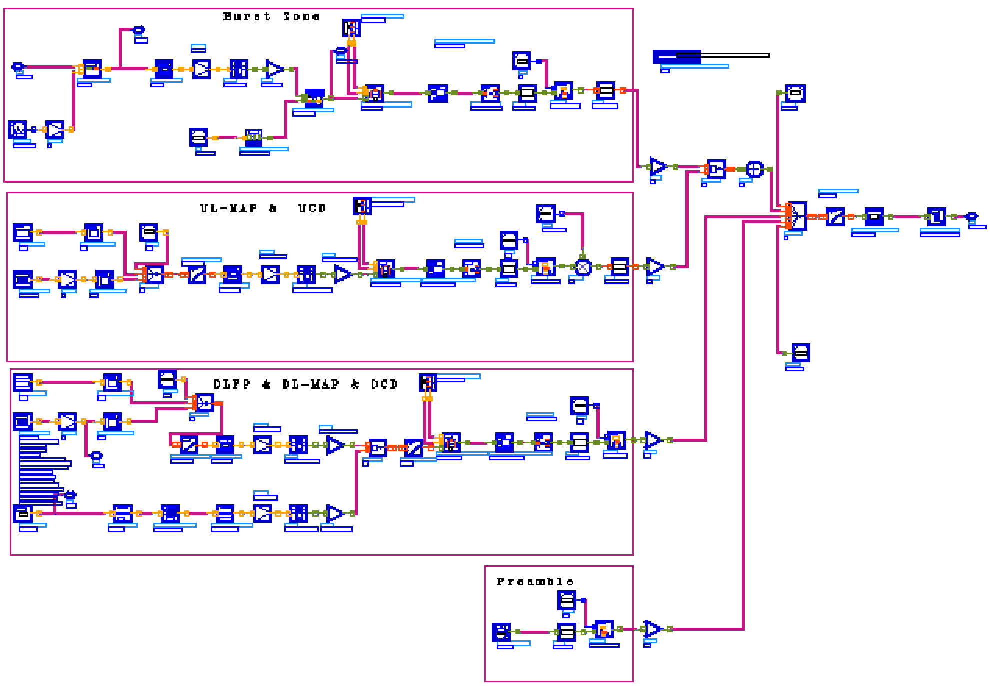
Pin Outputs

Pin	Name	Description	Signal Type
2	FrameData	output of uplink Subframe	complex
3	Constellation	output of Modulated data of all bursts for EVM	complex
4	PDUFCS	output of MAC PDU data of burst with FEC	int
5	DLFP	output of DLFP data	int
6	DLMAP	output of DLMAP data	int

Notes/Equations

1. This subnetwork is used to generate an 802.16e OFDMA downlink FDD subsystem baseband signal.
2. The schematic of this subnetwork is shown in the following figure.

WMAN_M_DL_Src_FDD schematic



3. The downlink frame structure of an OFDMA FDD system is partitioned into two subframes. The first DL subframe (DL1) begins with a preamble symbol followed by a MAP1 and data symbols for group-1 users. The second DL subframe (DL2) starts with MAP2 and is followed by data symbols for group-2 users. The unused time of the frame (the frame duration minus the total time occupied by the frame symbols) may be placed either immediately after the last symbol of DL2, or in a temporal gap between DL1 and DL2 which is specified by *UnusedTimePosition*. The duration of this optional DL1-DL2 gap shall be an integer number of symbols (0, 1, 2 etc') plus, optionally, the unused frame time. The number of symbols in the DL intersubframes gap is specified by *Gap_DL1_DL2*.
4. This source implements one of two DL subframes in the downlink FDD frame. When *ActiveDLSubframe* = DL1, the first DL subframe (DL1) is generated in this source; when *ActiveDLSubframe* = DL2, the second DL subframe (DL2) is generated. A typical downlink FDD frame should be the combination of two sources (one with *ActiveDLSubframe* = DL1, the other with *ActiveDLSubframe* = DL2). Refer to *WMAN_OFDMA_DL_FDD_TxWaveform* (wman_m) for more information.
5. The processing for the DL1 (or DL2) in this source is similar to *WMAN_M_DL_SignalSrc*. See *Downlink signal source* (wman_m) for more information.

6. This source will check whether the actual number of symbos in the active subframe (DL1 or DL2) and the value in DL1_NumOfSyms for DL1 or in DL2_NumOfSyms for DL2 are the same.
   - *ActiveDLSubframe* = DL1
     For *ZoneType* = DL PUSC, the actual number of symbos in DL1 is *(1+ZoneNumOfSym)* where 1 refers to the preamble; For *ZoneType* = DL FUSC, OFUSC or AMC, the actual number of symbos in DL1 *(1+2+ULMAP_Syms+ZoneNumOfSym)* where 1 refers to the preamble, 2 refers to FCH. When

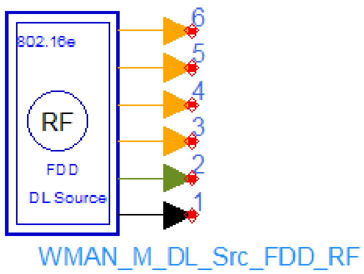
ULMAP_Enable = YES, ULMAP_Syms is 2 for carrying UL-MAP; When *ULMAP_Enable* = NO, ULMAP_Syms is 0.
- *ActiveDLSubframe* = DL2
  For *ZoneType* = DL PUSC, the actual number of symbos in DL2 is *ZoneNumOfSym*; For *ZoneType* = DL FUSC, OFUSC or AMC, the actual number of symbos in DL2 *(2+2*(ULMAP_Enable)+ZoneNumOfSym)* where 2 refers to FCH. When *ULMAP_Enable* = YES, ULMAP_Syms is 2 for carrying UL-MAP; When *ULMAP_Enable* = NO, ULMAP_Syms is 0. Note that no preamble exsits in DL2.

7. Parameter Details
   - ActiveDLSubframe is used to specify which DL subframe is active for this source (DL1 or DL2).
   - DL1_NumOfSyms, DL2_NumOfSyms specify the total number of symbols in DL1 and DL2 respetively.
   - Gap_DL1_DL2 specifies the number of symbols in the DL intersubframes gap (i.e. between DL1 and DL2).
   - UnusedTimePosition specifies the loacation of the unused time of the frame (the frame duration minus the total time occupied by the frame symbols) which can be placed immediately after the last symbol of DL2, or in a temporal gap between DL1 and DL2.
   - For the other parameters, refer to *Downlink signal parameters* (wman_m).

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. P802.16 Rev2/D4, April, 2008.

WMAN_M_DL_Src_FDD_RF (802.16e OFDMA Downlink FDD RF Signal Source)



Description: Downlink FDD RF signal source
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Unit	Type	Range
ROut	Output resistance	DefaultROut	Ohm	int	(0,∞)
RTemp	Temperature, in degrees C	DefaultRTemp	Celsius	real	[-273.15,∞]
FCarrier	Carrier frequency	3407 MHz	Hz	real	(0,∞)
Power	Transmit power (the meaning of Power is defined in Parameter PowerType)	0.01 W	W	real	(0,∞)
MirrorSpectrum	Mirror spectrum about carrier?: NO, YES	NO		enum	
GainImbalance	Gain imbalance in dB, Q channel relative to I channel	0.0		real	(-∞,∞)
PhaseImbalance	Phase imbalance in degrees, Q channel relative to I channel	0.0		real	(-∞,∞)
I_OriginOffset	I origin offset in percent with repect to output rms voltage	0.0		real	(-∞,∞)
Q_OriginOffset	q origin offset in percent with repect to output rms voltage	0.0		real	(-∞,∞)
IQ_Rotation	IQ rotation in degrees	0.0		real	(-∞,∞)
ActiveDLSubframe	Which DL subframe is set by this source (the first (DL1) or the second DL subframe (DL2)): DL1, DL2	DL1		enum	
DL1_NumOfSyms	The total number of symbols in the first DL subframe (DL1) including Preamble and MAP1	23		int	[3,60]
DL2_NumOfSyms	The total number of symbols in the second DL subframe (DL2) including MAP2	22		int	[2,60]
Gap_DL1_DL2	The integer number of symbols in the gap between DL1 and DL2 excluding the optional unused time	1		int	[0,60]
UnusedTimePosition	The position for the unused time of the frame: After DL2, Between DL1 and DL2	After DL2		enum	
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
DLMAP_Enable	DLMAP is inserted or not: NO, YES	NO		enum	
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
PreambleIndex	Preamble index	3		int	[0,113]
FrameNumber	Frame number	0		int	[0,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
DL_PermBase	DL permutation base	9		int	[0,31]
DCD_Count	DCD count	1		int	[0,255]
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00, 0X00, 0X01}		int array	[0,255]
PRBS_ID	PRBS ID	0		int	[0,3]

DataPattern	WMAN data pattern: PN9, PN15, FIX4, _4_1_4_0, _8_1_8_0, _16_1_16_0, _32_1_32_0, _64_1_64_0, S_QPSK, S_16-QAM, S_64-QAM	PN9		enum	
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	YES		enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array	[0,255]
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	22		int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array	[0,1]
NumberOfBurst	Number of Bursts	2		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}		int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,12}		int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}		int array	[1,60]
DataLength	MAC PDU payload byte length of each burst	{200,300}		int array	[1,∞)
CodingType	Coding type of each burst	{0,0}		int array	[0,1]
Rate_ID	Rate ID of each burst	{5,5}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0,0}		int array	[0,3]
PowerBoosting	Power boosting of each burst in dB	{0,0}		real array	[-∞,∞]
DLMAP_CodingType	Coding type of DLMAP	0		int	[0,1]
DLMAP_RepetitionCoding	Repetition coding of DLMAP	0		int	[0,3]
ULMAP_CodingType	Coding type of ULMAP	0		int	[0,1]
ULMAP_Rate_ID	Rate ID of ULMAP	0		int	[0,7]
ULMAP_RepetitionCoding	Repetition coding of ULMAP	0		int	[0,3]
ULMAP_PowerBoosting	Power boosting of ULMAP in dB	0		real	[-∞,∞]
UL_ZoneType	UL zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC		enum	
UL_ZoneSymOffset	Symbol offset in UL zone	0		int	[0,127]
UL_ZoneNumOfSym	Number of OFDMA symbols in the UL subframe	24		int	[3,255]
UL_PermBase	UL permutation base	0		int	[0, 69]
UL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum	
UCD_Count	UCD count	1		int	[0,255]
UL_NumberOfBurst	Number of Bursts in uplink	1		int	[1,8]
UL_CID	Uplink CID	{1}		int array	[0,65535]
UL_CodingType	Uplink coding type of each burst	{0}		int array	[0,1]
UL_Rate_ID	Uplink rate ID	{0}		int array	[0,7]
UL_BurstAssignedSlot	Assigned slots of each burst in uplink	{96}		int array	[1,6868]
UL_RepetitionCoding	Repetition coding of each burst in uplink	{0}		int array	[0,3]
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupied, Burst power with allocated subchs): Peak power, Burst power when all subchs occupied, Burst power with allocated subchs	Burst power when all subchs occupied		enum	
DIUC_RateID	Mapping from DIUC (0-12) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}, {1,3}, {1,4},		int array	[0,255]

		{1,5			
UIUC_RateID	Mapping from UIUC (1-10) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2		int array	[0,255]
UL_AMC_Mode	Uplink AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
UL_BurstSlotOffset	slot offsets of each burst in uplink	{0}		int array	[1,6868]
HARQ_Enable	Whether bursts are HARQ-enabled: NO, YES	NO		enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
DedicatedPilot	Is the dedicated pilot mode employed for DL PUSC or AMC zone: NO, YES	NO		enum	

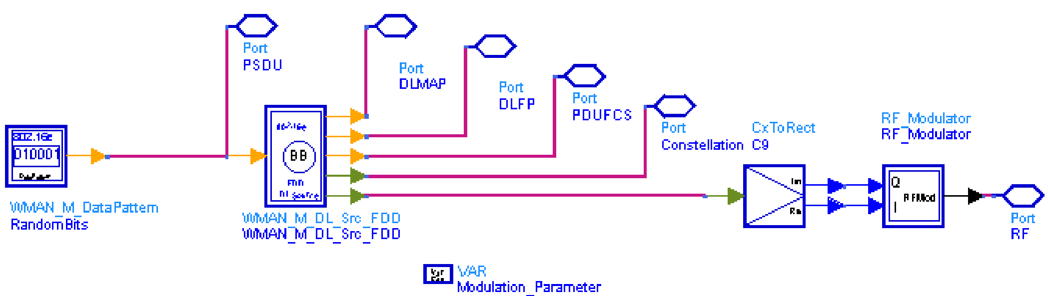
Pin Outputs

Pin	Name	Description	Signal Type
1	RF	output of RF signal	timed
2	Constellation	output of Modulated data of all bursts for EVM	complex
3	PDUFCS	output of MAC PDU data of burst with FEC	int
4	DLFP	output of DLFP data	int
5	DLMAP	output of DLMAP data	int
6	PSDU	output of PSDU bits	int

Notes/Equations

1. This subnetwork generates an 802.16e OFDMA downlink FDD subsystem RF signal. The subnetwork includes WMAN_M_DL_Src_FDD, which generates the downlink baseband signal of 802.16e downlink FDD subsystem, and the RF_Modulator.
2. The schematic of this subnetwork is shown in the following figure.

WMAN_M_DL_Src_FDD_RF schematic

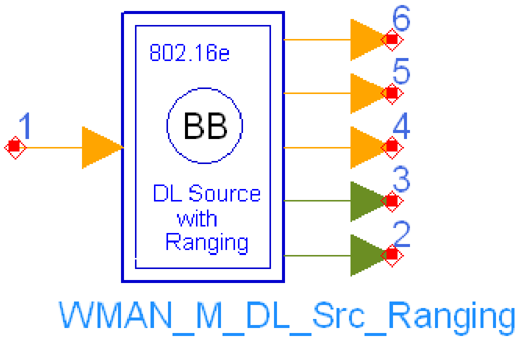


3. Parameter Details
   - For RF parameters, refer to *Downlink FDD RF parameters* (wman_m).
   - For baseband parameters, refer to *Downlink FDD baseband parameters* (wman_m).

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. P802.16 Rev2/D4, April, 2008.

WMAN_M_DL_Src_Ranging (802.16e OFDMA Downlink Src Ranging)



Description: Downlink baseband signal source with Ranging
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Unit	Type	Range
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01, 0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
DLMAP_Enable	DLMAP is inserted or not: NO, YES	NO		enum	
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[0,0.02
PreambleIndex	Preamble index	3		int	[0,113
FrameNumber	Frame number	0		int	[0,0xff
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
DL_PermBase	DL permutation base	9		int	[0,31]
DCD_Count	DCD count	1		int	[0,255
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00, 0X00, 0X01}		int array	[0,255
PRBS_ID	PRBS ID	0		int	[0,3]
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	YES		enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array	[0,255
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	22		int	[1,121
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array	[0,1]
NumberOfBurst	Number of Bursts	2		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}		int array	[0,121
BurstSubchOffset	Subchannel offset of each burst	{5,1}		int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,12}		int	[1,121

				array	
BurstNumOfSubch	Number of subchannels of each burst	{15,18}		int array	[1,60]
DataLength	MAC PDU payload byte length of each burst	{200,300}		int array	[1,∞)
CodingType	Coding type of each burst	{0,0}		int array	[0,1]
Rate_ID	Rate ID of each burst	{5,5}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0,0}		int array	[0,3]
PowerBoosting	Power boosting of each burst in dB	{0,0}		real array	[-∞,∞
DLMAP_CodingType	Coding type of DLMAP	0		int	[0,1]
DLMAP_RepetitionCoding	Repetition coding of DLMAP	0		int	[0,3]
ULMAP_CodingType	Coding type of ULMAP	0		int	[0,1]
ULMAP_Rate_ID	Rate ID of ULMAP	0		int	[0,7]
ULMAP_RepetitionCoding	Repetition coding of ULMAP	0		int	[0,3]
ULMAP_PowerBoosting	Power boosting of ULMAP in dB	0		real	[-∞,∞
UL_ZoneType	UL zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC		enum	
UL_ZoneSymOffset	Symbol offset in UL zone	0		int	[0,127
UL_ZoneNumOfSym	Number of OFDMA symbols in the UL subframe	24		int	[3,255
UL_PermBase	UL permutation base	0		int	[0, 69]
UL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum	
UCD_Count	UCD count	1		int	[0,255
UL_NumberOfBurst	Number of Bursts in uplink	1		int	[1,8]
UL_CID	Uplink CID	{1}		int array	[0,655
UL_CodingType	Uplink coding type of each burst	{0}		int array	[0,1]
UL_Rate_ID	Uplink rate ID	{0}		int array	[0,7]
UL_BurstAssignedSlot	Assigned slots of each burst in uplink	{96}		int array	[1,686
UL_RepetitionCoding	Repetition coding of each burst in uplink	{0}		int array	[0,3]
UL_HARQ_ACK_Enable	Uplink HARQ ACK channel enabled or not: NO, YES	NO		enum	
UL_HARQ_ACK_Allocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 12, 3, 6}		int array	[0,255
UL_RangingEnable	Uplink ranging channel enabled or not: NO, YES	NO		enum	
UL_RangingAllocation	Rectangular allocation: (SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 0, 3, 6}		int array	[0,255
UL_RangingMethod	Uplink ranging mode: Initial/Handover_2 symbols, Initial/Handover_4 symbols, BW Request/Periodic_1 symbol, BW Request/Periodic_3 symbol	Initial/Handover_2 symbols		enum	
UL_FastFeedBackEnable	Uplink fast feedback channel enabled or not: NO, YES	NO		enum	
UL_FastFeedBackAllocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 6, 3, 6}		int array	[0,255
Compressed_DLMap	Compressed DL_MAP or not if enabled: NO, YES	NO		enum	
Compressed_ULMap	Compressed UL_MAP or not if appended: NO, YES	NO		enum	
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupied, Burst power with allocated subchs): Peak power, Burst power when all subchs occupied, Burst power with allocated subchs	Burst power when all subchs occupied		enum	
DIUC_RateID	Mapping from DIUC (0-12) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}, {1,3}, {1,4}, {1,5		int array	[0,255
UIUC_RateID	Mapping from UIUC (1-10) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5},		int array	[0,255

		{0,6}, {1,0}, {1,1}, {1,2			
UL_AMC_Mode	Uplink AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
UL_BurstSlotOffset	slot offsets of each burst in uplink	{0}		int array	[1,686
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
DedicatedPilot	Is the dedicated pilot mode employed for DL PUSC or AMC zone: NO, YES	NO		enum	

Pin Inputs

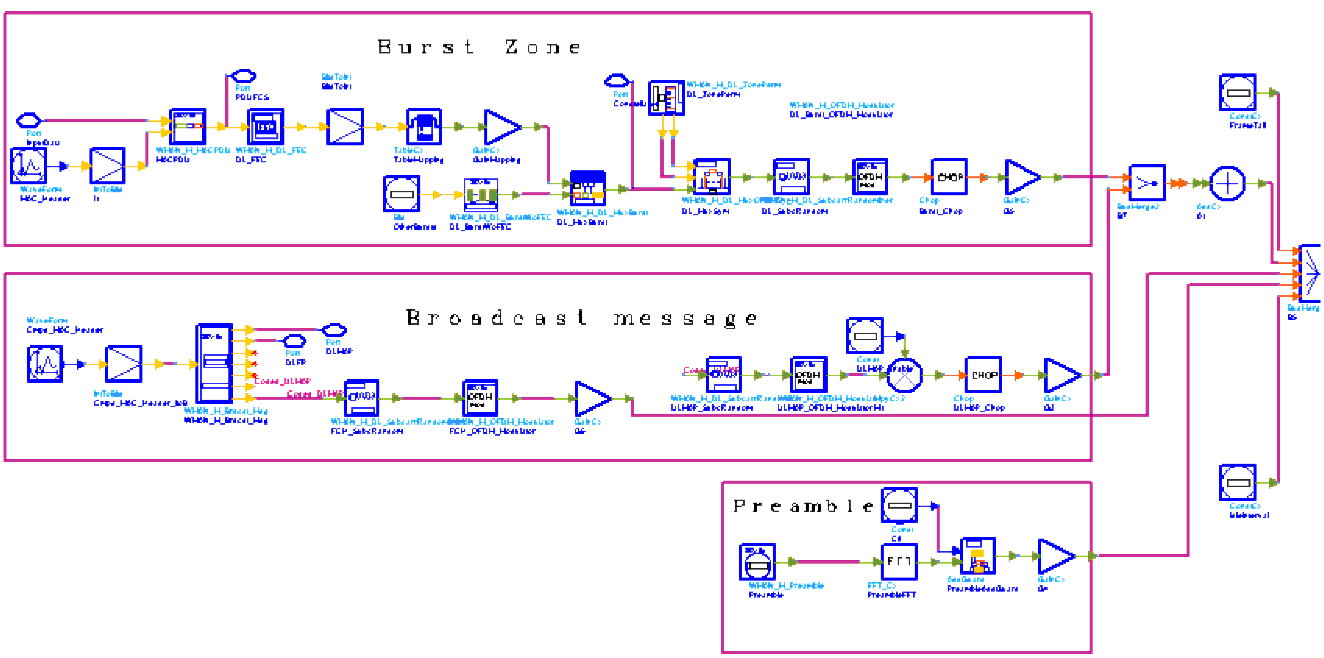
Pin	Name	Description	Signal Type
1	InputData	input of raw data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	FrameData	output of uplink Subframe	complex
3	Constellation	output of Modulated data of all bursts for EVM	complex
4	PDUFCS	output of MAC PDU data of burst with FEC	int
5	DLFP	output of DLFP data	int
6	DLMAP	output of DLMAP data	int

Notes/Equations

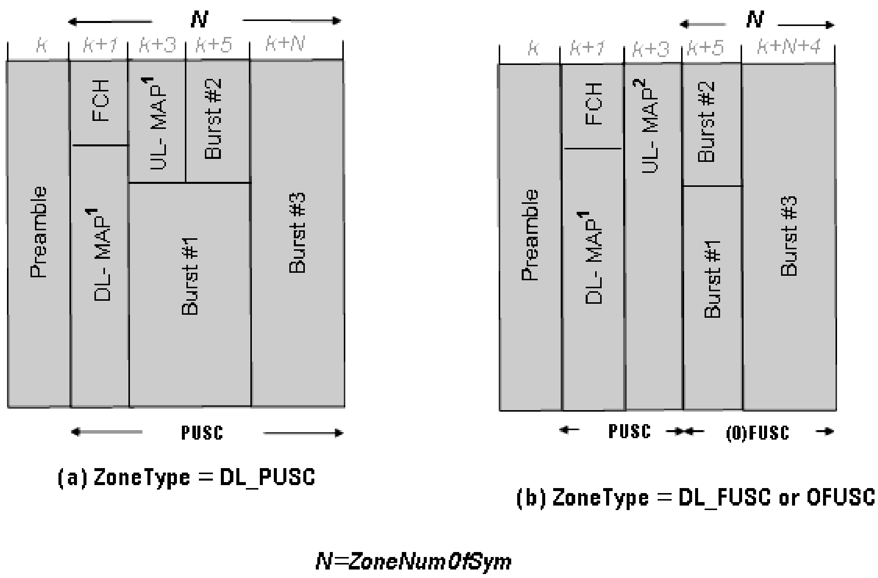
1. This subnetwork generates an 802.16e OFDMA downlink subsystem baseband signal with ranging IE. The schematic for this subnetwork is shown in WMAN_M_DL_Src_Ranging Schematic.



WMAN_M_DL_Src_Ranging Schematic

2. The input of this subnetwork is MAC PDU data of the FEC-encoded burst; MAC header data is specified by MAC_Header.

3. WMAN_M_DL_Src_Ranging is implemented according to the specification. 802.16e OFDMA Downlink Subframe Structure shows the downlink frame format.



802.16e OFDMA Downlink Subframe Structure

Note that DL_AMC is also supported in this source.
The downlink subframe starts with one preamble which consists of a OFDM symbol. Then the PUSC zone where FCH, DL-MAP and UL-MAP(contains ranging IE) are allocated. The FCH information will be sent on the first four adjacent subchannels with successive logical subchannel numbers in the PUSC zone. The DL-MAP message (or compressed map message) immediately follows FCH. The UL-MAP message is always allocated on the third and fourth OFDM symbols if ULMAP_Enable is set to YES and Compressed_ULMap is set to No.
If ZoneType is DL_PUSC, then a single PUSC zone is defined (as in 802.16e OFDMA Downlink Subframe Structure). If ZoneType is DL_FUSC, DL_OFUSC or DL_AMC, then two zones are defined: one is the PUSC zone where FCH is allocated, the other is the FUSC or OFUSC zone for allocating data bursts (b in 802.16e OFDMA Downlink Subframe Structure). ZoneNumOfSym is defined as the number of OFDM symbols for the zone which is allocated data bursts. One downlink frame contains maximum 8 data bursts except FCH, DL-MAP and UL-MAP, and each burst contains only one MAC PDU. Among these bursts, only one burst is CC-encoded which is randomized, CC coded and interleaved. Other bursts will be provided PN sequences as their coded source respectively.
For DL_PUSC, the total number of symbols in the downlink subframe is (1+ZoneNumOfSym); For DL_FUSC or DL_OFUSC, the total number of symbols in the downlink subframe is (1+2+UL_MAP_Pst*2+ZoneNumOfSym), where 1 is for the preamble, the first 2 is for the FCH and DL-MAP, the second 2 is for the normal UL-MAP; UL_MAP_Pst equals to 1 when ULMAP_Enable is set to YES and Compressed_ULMap is set to No, otherwise, UL_MAP_Pst equals to 0.

The Calculation of Number of OFDM Symbols in Downlink Subframe

Zone type	ULMAP_Pst	NPreamble	NFCH DL-MAP	NUL-MAP	NData	NFrame
DL_PUSC	YES	1	2	2 Overlapped with Data	ZoneNumOfSym-2	1+ZoneNumOfSym
DL_PUSC	NO	1	2	0	ZoneNumOfSym-2	1+ZoneNumOfSym
DL_FUSC	YES	1	2	2	ZoneNumOfSym	5+ZoneNumOfSym
DL_FUSC	NO	1	2	0	ZoneNumOfSym-2	3+ZoneNumOfSym
DL_OFUSC	YES	1	2	2	ZoneNumOfSym	5+ZoneNumOfSym
DL_OFUSC	NO	1	2	0	ZoneNumOfSym	3+ZoneNumOfSym
DL_AMC	YES	1	2	2	ZoneNumOfSym	5+ZoneNumOfSym
DL_AMC	NO	1	2	0	ZoneNumOfSym	3+ZoneNumOfSym

Both standard map messages and compressed map messages can be generated by the WMAN_M_Brdcst_Msg. As the standard defined, a compressed UL-MAP is appended to the current compressed DL-MAP data structure. The map message format and parameter settings are listed in *Broadcast message format*.

Broadcast message format

DLMAP_Enable	Compressed_DLMap	ULMAP_Enable	Compressed_ULMap	MAP Msg Format	Occupied slots
No	No	No	No	None	0
No	No	No	Yes	None	0
No	No	Yes	No	Normal UL-MAP	27
No	No	Yes	Yes	Error	0
No	Yes	No	No	None	0
No	Yes	No	Yes	None	0
No	Yes	Yes	No	Normal UL-MAP	27
No	Yes	Yes	Yes	Error	0
Yes	No	No	No	Normal DL-MAP	26
Yes	No	No	Yes	Normal DL-MAP	26
Yes	No	Yes	No	Normal DL-MAP+ Normal UL-MAP	DL:26 UL:27
Yes	No	Yes	Yes	Error	DL:26 UL:0
Yes	Yes	No	No	Cmps DL-MAP	12
Yes	Yes	No	Yes	Cmps DL-MAP	12
Yes	Yes	Yes	No	Cmps DL-MAP+ Normal UL-MAP	DL:12 UL:27
Yes	Yes	Yes	Yes	Cmps MAP	24

The FEC-encoded burst is coded in the following manner:

Add MAC header with parameter MAC_Header or generate MAC header automatically by WMAN_M_MACPDU.

Randomized by WMAN_M_DL_Randomizer.

If the coding type is CC, then CC encoded, punctured and interleaved by WMAN_M_DL_FEC; If the coding type is CTC, then CTC encoded by WMAN_M_DL_FEC.

Repeated by WMAN_M_DL_Repetition in WMAN_M_DL_FEC.

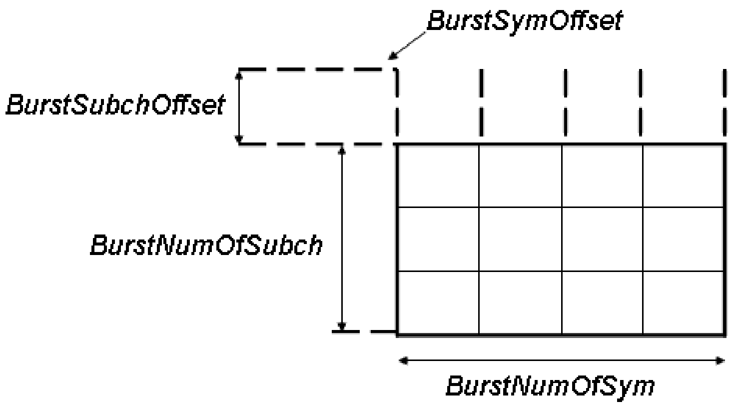
After encoding, the encoded burst is mapped to the constellation. Other bursts without FEC, are provided PN sequence as their coded bits and mapped to the constellation according to their Rate_ID by WMAN_M_DL_BurstWoFEC. The FEC-encoded burst is concatenated with non-coded bursts by WMAN_M_DL_MuxBurst.
The physical indices of data subcarriers and pilot subcarriers for each burst are calculated by WMAN_M_DL_ZonePerm. The data sequences and pilot sequences are placed to their physical subcarrier location by WMAN_M_DL_MuxOFDMSym. The same actions are performed on FCH & DL-MAP and UL-MAP by WMAN_M_Brdcst_Msg.
Then the useful subcarriers are randomized by WMAN_M_DL_SubcarrRandomizer. The oversampling is implemented by IFFT. After IFFT and cyclic prefix insertion, the idle interval and downlink payloads (Bursts, FCH & DL-MAP, UL-MAP) are combined with zero padding bits if needed by WMAN_M_Commutator. In addition, uplink position will be preserved and filled with zeros after downlink payload if FrameMode is TDD. The zone boosting is performed according to the parameter of GroupBitmask. Then power adjustment are implemented by WMAN_M_DL_PowerAdjust. At last, a symbol windowing is implemented to smooth the transitions between the consecutive OFDM symbols in the subframe.

Note
With default settings of parameters, the DL-MAP occupies 26 subchannels, and the UL-MAP occupies 27 subchannels. Sometimes the occupied subchannels by DL-MAP or UL-MAP may exceed the available subchannels when the settings of paramters are changed. It may be caused by one of the following reasons:

1. The parameters of channel coding (such as coding type, rate ID and repetition coding) for the DL-MAP and UL-MAP are changed.
2. The FFTSize is too small. For example, if FFTSize is set to FFT_512 and GroupBitmask are all set to 1, the maximum number of subchannels is 15. However the number of subchannels needed by FCH and DL-MAP is 30.
3. The number of selected subchannel groups indicated by GroupBitmask is too small.

When the DL-MAP and UL-MAP are requried, but they cannot be allocated in WMAN_M_DL_SignalSrc_RF, it is recommended to use WMAN_M_DL_Src_AllCoded_RF where the allocation of DL-MAP and UL-MAP is flexible, and, DCD and UCD can be turned on or off respectively.

4. Parameter Details
    - Bandwidth determines the nominal channel bandwidth.
    - OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
    - FFTSize specifies the size of FFT. Sizes 2048, 1024 and 512 are supported.
    - CyclicPrefix specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
    - FrameMode specifies the duplexing method which should be FDD or TDD. In FDD transmission, the downlink occupies the entire frame and the respective gaps (zeros) are automatically adjusted to fill the frame
    - DL_Ratio specifies the percentage (1 to 99) of the frame time to be used for the downlink subframe. The parameter is only active when the FrameMode is TDD.
    - FrameDuration determines the frame durations (ms) of the generated waveform.There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
    - DLMAP_Enable specifies whether the DL-MAP burst is inserted in the downlink subframe.
    - ULMAP_Enable specifies whether the UL-MAP burst is inserted in the downlink subframe.
    - IdleInterval specifies the time of idle interval between the two continuous frames. the default value is 0.
    - PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to the standard.
    - FrameNumber specifies the starting frame number in the downlink subframe.
    - FrameIncreased specifies whether the frame number for the downlink subframe is increased. When FrameIncreased is set to YES, then the frame numbers in Frame#0, Frame#1, Frame#2, Frame#3 will be FrameNumber, FrameNumber+1, FrameNumber+2, FrameNumber+3. When FrameIncreased is set to NO, then the frame numbers in Frame#0, Frame#1, Frame#2, Frame#3 will be FrameNumber, FrameNumber, FrameNumber, FrameNumber.
    - DL_PermBase specifies the basis of downlink permutation to be used in initialization vector of the PRBS generator for subchannel randomization in the zone and in STC_DL_Zone_IE() in DL-MAP message.
    - DCD_Count specifies the DCD count which is used in DL-MAP and DCD messages. This is increased by one (modulo 256) whenever there is a downlink configuration change.
    - BSID specifies the base station ID which is used in DL-MAP message.
    - PRBS_ID specifies the PRBS ID which may be used in initialization vector of the PRBS generator for subchannel randomization and in STC_DL_Zone_IE() in DL-MAP message.
    - AutoMACHeaderSetting specifies whether the MAC header is automatically generated or input by users. If it is set to NO, data sequences in parameter MAC_Header will be used before data content, otherwise MAC_Header content will be calculated with parameter DataLength and CID and be used before data content.
    - MAC_Header specifies 6 bytes of MAC header before the data contents. The cell is only active when the AutoMACHeaderSetting is set to NO.
    - CRC32_Mode specifies the method for CRC32 calculation appended to MAC PDU. For consistency with 802.16-2004 Cor1/D5, it shall be set to MSB first while shall be set to LSB first for consistency with 802.16-2004 Cor1/D3.
    - ZoneType specifies the zone type which can be set to PUSC, FUSC, OFUSC or AMC.
    - ZoneNumOfSym specifies the symbol number for the zone. The value must be a multiple of two for DL_PUSC, and be a multiple of one for DL_FUSC and DL_OFUSC, and be a multiple of six, three and two for DL_AMC with 1x6, 2x3 and 3x2 respectively.
    - GroupBitmask specifies which groups of subchannel are used in the PUSC zone. This parameter uses 1 for assigned groups and 0 for unassigned groups.
    - NumberOfBurst specifies the number of active downlink bursts.
    - BurstWithFEC specifies the downlink burst FEC.
    - BurstSymOffset, BurstSubchOffset, BurstNumOfSym and BurstNumOfSubch specify the position and range for each rectangular burst, seen Downlink Rectangular Burst Structure.



Downlink Rectangular Burst Structure

- DataLength specifies MAC PDU payload byte length for each burst.
- CodingType specifies the coding type for each burst. Each coding type can be selected from 0 to 1, whose meaning is shown in The Meaning of Coding Type.

The Meaning of Coding Type

Coding Type	Meaning
0	Convolutional coding (CC)
1	Convolutional turbo coding (CTC)

- Rate_ID specifies the rate ID for each burst. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in The Relation of Coding Type and Rate ID.

The Relation of Coding Type and Rate ID

Coding Type	Rate ID	Modulation/Coding Rate
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in The Meaning of Repetition Coding.

Repetition Coding	Meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4used on the burst
3	Repetition coding of 6used on the burst

- PowerBoosting specifies the power boosting for each burst. Each value is defined in units of dB.
- DLMAP_CodingType specifies the rate ID for the burst carrying DL-MAP and DCD messages.
- DLMAP_RepetitionCoding specifies the repetition coding for the burst carrying DL-MAP and DCD messages. This parameter can be selected from 0 to 3, whose meaning is shown in The Meaning of Repetition Coding.
- ULMAP_CodingType specifies the rate ID for the burst carrying UL-MAP and UCD messages.
- ULMAP_Rate_ID specifies the rate ID for the burst carrying UL-MAP and UCD messages.
- ULMAP_RepetitionCoding specifies the repetition coding for the burst carrying UL-MAP and UCD messages. This parameter can be selected from 0 to 3, whose meaning is shown in The Meaning of Repetition Coding.
- ULMAP_PowerBoosting specifies the power boosting for the burst carrying UL-MAP and UCD messages. This parameter is defined in units of dB.
- UL_ZoneType specifies the uplink zone permutation. This parameter is used in the UL_Zone_IE () IE.
- UL_ZoneSymOffset specifies the offset of the OFDMA symbol in which the uplink zone starts, the offset value is defined in units of OFDMA symbols and is relevant to the Allocation Start Time field given in the UL-MAP message. This parameter is used in the UL_Zone_IE() IE.
- UL_ZoneNumOfSym specifies the number of OFDM symbols in the uplink subframe. This parameter is used in the OFDMA UL_MAP IE.
- UL_PermBase specifies the basis of uplink permutation. This parameter is used in the UL_Zone_IE() IE.
- UL_AllSCIndicator specifies whether all subchannel shall be used. When the UL_AllSCIndicator is set to 0, subchannels indicated by allocated subchannel bitmap in UCD shall be used. Otherwise all subchannels shall be used. This parameter is used in the UL_Zone_IE() IE.
- UCD_Count specifies the UCD count which is used in the UL_MAP and UCD messages. It is increased by one (modulo 256) whenever there is an uplink configuration change.
- UL_NumberOfBurst specifies the number of the uplink bursts. This parameter is used to determine the number of OFDMA UL-MAP IE in UL-MAP message.
- UL_CID specifies the Connection Identifier (CID) for each uplink burst. This parameter is used in the OFDMA UL-MAP IE.
- UL_CodingType specifies the coding type for each uplink burst. Each coding type can be selected from 0 to 1, where 0 is CC and 1 is CTC. This parameter is used in the OFDMA UL-MAP IE.
- UL_Rate_ID specifies the rate ID for each uplink burst. UL_Rate_ID, along with UL_CodingType, determines the modulation, coding rate. This parameter is used in the OFDMA UL-MAP IE.
- UL_BurstAssignedSlot specifies the duration for each uplink burst in units of OFDMA slots. This parameter is used in the OFDMA UL-MAP IE.
- UL_RepetitionCoding specifies the repetition coding for each uplink burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in The Meaning of Repetition Coding. This parameter is used in the OFDMA UL-MAP IE.
- UL_HARQ_ACK_Enable specifies whether the UL HARQ_ACK allocation IE is inserted in the UL_MAP IE.
- UL_HARQ_ACK_Allocation specifies the rectangular allocation:(symbol offset, subchannel offset,number of symbols, number of subchannels) for the uplink HARQ ACK channel.
- UL_RangingEnable specifies whether the ranging allocation information is inserted in the UL_MAP IE.
- UL_RangingAllocation specifies the rectangular allocation:(symbol offset, subchannel offset,number of symbols, number of subchannels) for the uplink ranging channel.
- UL_RangingMethod specifies uplink ranging mode.
- UL_FastFeedBackEnable specifies whether the FAST-FEEDBACK allocation IE is inserted in the UL_MAP IE.
- UL_FastFeedBackAllocation specifies the rectangular allocation:(symbol offset, subchannel offset,number of symbols, number of subchannels) for the uplink fast feedback channel.
- Compressed_DLMap specifies the message format of the DL-MAP.
- Compressed_ULMap specifies the message format of the UL-MAP.
- PowerType specifies the exact meaning of the parameter Power in RF source. Three types are defined in downlink (Type I: Peak power; Type II: Burst power when all subchs occupied; Type III: Burst power with allocated subchs). Type I is recommended for transmitter measurement; Type II is recommended for receiver measurement; Type III is recommended for hardware measurement. For more information, please refer to *Transmit Power Definition* (wman_m).
- DIUC_RateID specifies the mapping from DIUC (0-12) to coding type and modulation/rate. The default value is

- `{{0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}, {1,3}, {1,4}, {1,5}}.`
  The first element (i.e. array {0,0}) is mapped to DIUC 0, and the second (i.e. array {0,1}) is mapped to DIUC 1, and so on. Each element represents {coding type, modulation and rate (Rate ID)}. For example, {1,2} means coding type is CTC (here 0: CC, 1:CTC) and Rate ID is 2 (16QAM rate 1/2). This parameter is used in DCD and DL-MAP IE. Note that if the coding type and modulation/rate for an allocated downlink burst is not mapped to a DIUC in this parameter, the DIUC field in DL-MAP IE will be filled with 0.

- UIUC_RateID specifies the mapping from UIUC (1-10) to coding type and modulation/rate. The default value is

```
{{0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}}.
```

  The first element (i.e. array {0,0}) is mapped to UIUC 1, and the second (i.e. array {0,1}) is mapped to UIUC 2, and so on. Each element represents {coding type, modulation and rate (Rate ID)}. For example, {1,2} means coding type is CTC (here 0: CC, 1:CTC) and Rate ID is 2 (16QAM rate 1/2). This parameter is used in UCD and UL-MAP IE. Note that if the coding type and modulation/rate for an allocated uplink burst is not mapped to a UIUC in this parameter, the UIUC field in UL-MAP IE will be filled with 0.
- AMC_Mode specifies the AMC mode which could be 1x6 (1 bin by 6 symbols), 2x3 (2 bins by 3 symbols) or 3x2 (3 bins by 2 symbols) for the downlink bursts when the ZoneType = DL_AMC.
- DedicatedPilot specifies whether the pilots are dedicated. When DedicatedPilot = NO, all the pilots are transmitted; when DedicatedPilot = YES, only the pilots bleonging to the bursts allocated are transmitted. Note that this parameter is valid only when ZoneType = DL_AMC.

Samples per frame
The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (N_{factor}) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in Sampling Factor Requirement.

Sampling Factor n	Bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval ($Samples_{idle}$) is calculated as follows:
$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$

So, the total samples of one downlink frame $Samples_{Frame}$ is
$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$
This model works frame by frame. Each firing,
$8 \times DataLength[BurstWithFEC]$ tokens are consumed at pin InputData,

$Samples_{Frame}$ tokens are produced at pin FrameData,

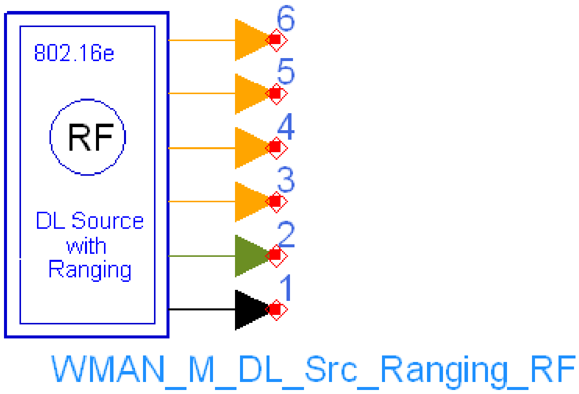
$$\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48/N_{SymPerSlot}$$

tokens are produced at pin Constellation,
$8 \times DataLength[BurstWithFEC]] + 80$ tokens are produced at pin PDUFCS,
where $N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC.
Output delay
No delay is introduced by WMAN_M_SymWindow in the design WMAN_M_DL_Src_Ranging.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_Src_Ranging_RF (802.16e OFDMA Downlink Ranging RF Src)



Description: Downlink RF signal source with ranging
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Unit	Type	Rang
ROut	Output resistance	DefaultROut	Ohm	int	(0,∞
RTemp	Temperature, in degrees C	DefaultRTemp	Celsius	real	[- 273.
FCarrier	Carrier frequency	3407 MHz	Hz	real	(0,∞
Power	Transmit power (the meaning of Power is defined in Parameter PowerType)	0.01 W	W	real	(0,∞
MirrorSpectrum	Mirror spectrum about carrier?: NO, YES	NO		enum	
GainImbalance	Gain imbalance in dB, Q channel relative to I channel	0.0		real	(-∞,
PhaseImbalance	Phase imbalance in degrees, Q channel relative to I channel	0.0		real	(-∞,
I_OriginOffset	I origin offset in percent with repect to output rms voltage	0.0		real	(-∞,
Q_OriginOffset	q origin offset in percent with repect to output rms voltage	0.0		real	(-∞,
IQ_Rotation	IQ rotation in degrees	0.0		real	(-∞,
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
DLMAP_Enable	DLMAP is inserted or not: NO, YES	NO		enum	
ULMAP_Enable	ULMAP is inserted or not: NO, YES	NO		enum	
PreambleIndex	Preamble index	3		int	[0,11
FrameNumber	Frame number	0		int	[0,0x
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
DL_PermBase	Downlink permutation base	9		int	[0,31
DCD_Count	DCD count	1		int	[0,25
BSID	Base station ID	{0X00, 0X00, 0X00, 0X00, 0X00, 0X01}		int array	[0,25
PRBS_ID	PRBS ID	0		int	[0,3]
DataPattern	WMAN data pattern: PN9, PN15, FIX4, _4_1_4_0, _8_1_8_0, _16_1_16_0, _32_1_32_0, _64_1_64_0, S_QPSK, S_16-QAM, S_64-QAM	PN9		enum	
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	YES		enum	

MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array	[0,25
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	22		int	[1,12
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}		int array	[0,1]
NumberOfBurst	Number of bursts	2		int	[1,8]
BurstWithFEC	Number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}		int array	[0,12
BurstSubchOffset	Subchannel offset of each burst	{5,1}		int array	[0,59
BurstNumOfSym	Number of symbols of each burst	{6,12}		int array	[1,12
BurstNumOfSubch	Number of subchannels of each burst	{15,18}		int array	[1,60
DataLength	MAC PDU payload byte length of each burst	{200,300}		int array	[1,∞
CodingType	Coding type of each burst	{0,0}		int array	[0,1]
Rate_ID	Rate ID of each burst	{5,5}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0,0}		int array	[0,3]
PowerBoosting	Power boosting of each burst in dB	{0,0}		real array	(-∞,
DLMAP_CodingType	Coding type of DLMAP	0		int	[0,1]
DLMAP_RepetitionCoding	Repetition coding of DLMAP	0		int	[0,3]
ULMAP_CodingType	Coding type of ULMAP	0		int	[0,1]
ULMAP_Rate_ID	Rate ID of ULMAP	0		int	[0,7]
ULMAP_RepetitionCoding	Repetition coding of ULMAP	0		int	[0,3]
ULMAP_PowerBoosting	Power boosting of ULMAP in dB	0		real	[-∞,
UL_ZoneType	UL zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC		enum	
UL_ZoneSymOffset	Symbol offset in UL zone	0		int	[0,12
UL_ZoneNumOfSym	Number of OFDMA symbols in the UL subframe	24		int	[3,25
UL_PermBase	UL permutation base	0		int	[0, 6
UL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum	
UCD_Count	UCD count	1		int	[0,25
UL_NumberOfBurst	Number of bursts in uplink	1		int	[1,8]
UL_CID	Uplink CID	{1}		int array	[0,65
UL_CodingType	Uplink coding type of each burst	{0}		int array	[0,1]
UL_Rate_ID	Uplink rate ID	{0}		int array	[0,7]
UL_BurstAssignedSlot	Assigned slots of each burst in uplink	{96}		int array	[1,68
UL_RepetitionCoding	Repetition coding of each burst in uplink	{0}		int array	[0,3]
UL_HARQ_ACK_Enable	Uplink HARQ ACK channel enabled or not: NO, YES	NO		enum	
UL_HARQ_ACK_Allocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 12, 3, 6}		int array	[0,25
UL_RangingEnable	Uplink ranging channel enabled or not: NO, YES	NO		enum	
UL_RangingAllocation	Rectangular allocation: (SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 0, 3, 6}		int array	[0,25
UL_RangingMethod	Uplink ranging mode: Initial/Handover_2 symbols, Initial/Handover_4 symbols, BW Request/Periodic_1 symbol, BW Request/Periodic_3 symbol	Initial/Handover_2 symbols		enum	
UL_FastFeedBackEnable	Uplink fast feedback channel enabled or not: NO, YES	NO		enum	
UL_FastFeedBackAllocation	Rectangular	{0, 6, 3, 6}		int	[0,25

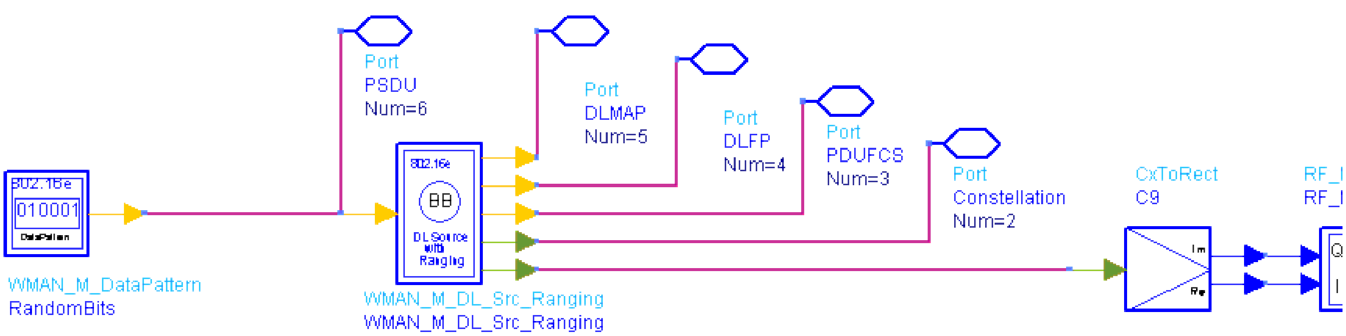
	allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)			array	
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupied, Burst power with allocated subchs): Peak power, Burst power when all subchs occupied, Burst power with allocated subchs	Burst power when all subchs occupied		enum	
DIUC_RateID	Mapping from DIUC (0-12) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2}, {1,3}, {1,4}, {1,5		int array	[0,25
UIUC_RateID	Mapping from UIUC (1-10) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2		int array	[0,25
UL_AMC_Mode	Uplink AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
UL_BurstSlotOffset	slot offsets of each burst in uplink	{0}		int array	[1,68
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
DedicatedPilot	Is the dedicated pilot mode employed for DL PUSC or AMC zone: NO, YES	NO		enum	

Pin Outputs

Pin	Name	Description	Signal Type
1	RF	output of RF signal	timed
2	Constellation	output of Modulated data of all bursts for EVM	complex
3	PDUFCS	output of MAC PDU data of burst with FEC	int
4	DLFP	output of DLFP data	int
5	DLMAP	output of DLMAP data	int
6	PSDU	output of PSDU bits	int

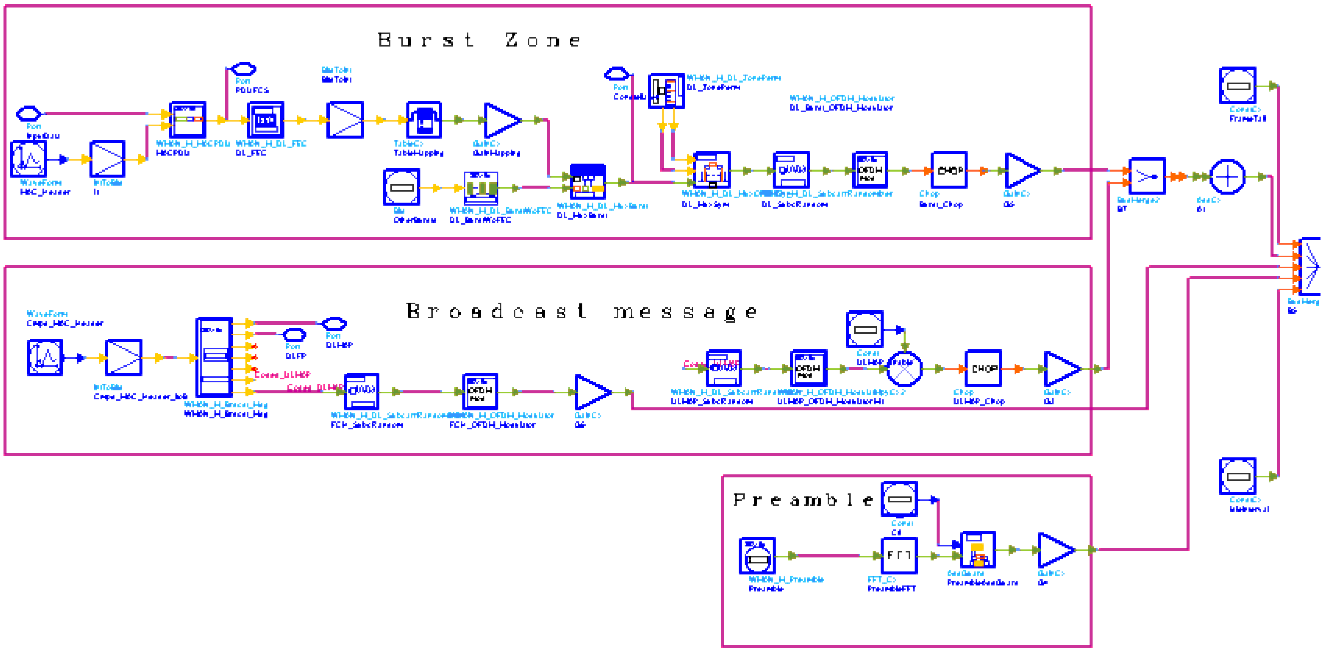
Notes/Equations

1. This subnetwork generates an 802.16e OFDMA downlink subsystem RF signal with ranging IE. The subnetwork includes WMAN_M_DL_Src_Ranging, which generates the downlink baseband signal with ranging IE of 802.16e downlink subsystem, and the RF_Modulator. The schematic for this subnetwork is shown in WMAN_M_DL_Src_Ranging_RF Schematic.



WMAN_M_DL_Src_Ranging_RF Schematic

2. The WMAN OFDM downlink baseband signal source with ranging format follows the specification. The schematic is shown in WMAN_M_DL_Src_Ranging Schematic.



WMAN_M_DL_Src_Ranging Schematic

The implementation of WMAN_M_DL_SignalSrc is described in *Downlink baseband signal source* (wman_m).

3. Parameter Details
   - ROut is the RF output resistance.
   - RTemp is the RF output resistance temperature in Celsius and sets the noise density in the RF output signal to (k(RTemp+273.15)) Watts/Hz, where k is Boltzmann's constant.
   - FCarrier is the RF output signal frequency.
   - Power is used to set the modulator output RF power. This is true for an ideal transmitted signal (no impairments added) or when small impairments are added. If large impairments are added to the signal (using GainImbalance, I_OriginOffset, and Q_OriginOffset parameters) the output RF power may be different from the value of the Power parameter.
   - MirrorSpectrum is used to mirror the RF_out signal spectrum about the carrier. This is equivalent to conjugating the complex RF envelope voltage. Depending on the configuration and number of mixers in an RF transmitter, the RF output signal from hardware RF generators can be inverted. If such an RF signal is desired, set this parameter to YES.
   - GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation are used to add certain impairments to the ideal output RF signal. Impairments are added in the order described here.
     The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:
     $$V_{RF}(t) = A\left(V_I(t)\cos(\omega_c t) - gV_Q(t)\sin\left(\omega_c t + \frac{\Phi\pi}{180}\right)\right)$$
     where A is a scaling factor based on the Power and ROut parameters specified by the user, VI(t) is the in-phase RF envelope, VQ(t) is the quadrature phase RF envelope, g is the gain imbalance
     $$g = 10^{\frac{GainImbalance}{20}}$$
     and, ϕ (in degrees) is the phase imbalance.
     Next, the signal VRF(t) is rotated by IQ_Rotation degrees. The I_OriginOffset and Q_OriginOffset are then applied to the rotated signal. Note that the amounts specified are percentages with respect to the output rms voltage. The output rms voltage is given by sqrt(2ROutPower).
   - For the other baseband parameters, refer to *Baseband parameters* (wman_m).

4. Samples per frame
   The sampling frequency (Fs) implemented in the design is decided by Bandwidth, OversamplingOption and related sampling factor (N_{factor}) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

   The sampling factors are listed in *Sampling Factor Requirement*.

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

   The samples of IdleInterval ($Samples_{idle}$) are calculated as follows:
   $Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$

   So, the total samples of one downlink frame $Samples_{Frame}$ are
   $Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$

   This model works frame by frame. Each firing,
   $8 \times DataLength[BurstWithFEC]$ tokens are produced at pin PSDU,

   $Samples_{Frame}$ tokens are produced at pin RF,

   $\sum_{i=1}^{NumberOfBurst} BurstNumOfSym[i] \times BurstNumOfSubch[i] \times 48/N_{SymPerSlot}$ tokens are produced at pin Constellation,

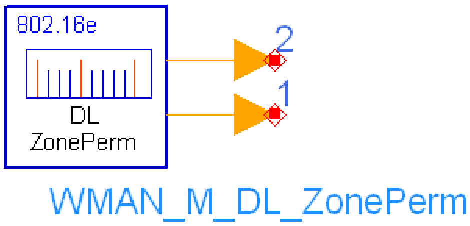
   $8 \times DataLength[BurstWithFEC]] + 80$ tokens are produced at pin PDUFCS,

   where $N_{SymPerSlot}$ is 2 for PUSC and is 1 for FUSC and OFUSC.
5. Output delay
   No delay is introduced by WMAN_M_SymWindow in the design WMAN_M_DL_Src_Ranging_RF.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_DL_ZonePerm (802.16e OFDMA DL Zone Permutation)



Description: Downlink subchannel subcarrier allocator
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbols in zone	24	int	[1,1212]
GroupBitmask	Used subchannel bitmaps	{1, 1, 1, 1, 1, 1}	int array	[0,1]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
NumberOfBurst	Number of Bursts	2	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{4,10}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{5,1}	int array	[0,59]
BurstNumOfSym	Number of symbols of each burst	{6,14}	int array	[1,1212]
BurstNumOfSubch	Number of subchannels of each burst	{15,18}	int array	[1,60]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	
DL_PermBase	DL permutation base	0	int	[0, 31]
PreambleIndex	Preamble index	16	int	[0,113]
FirstZone	Is the first zone or not: NO, YES	NO	enum	
DedicatedPilot	Is the dedicated pilot mode employed for DL PUSC or AMC zone: NO, YES	NO	enum	

Pin Outputs

Pin	Name	Description	Signal Type
1	Data_Pos	output of the symbol and subcarrier position of each burst	int
2	Pilot_Pos	output of the symbol and subcarrier position of pilot	int

Notes/Equations

1. This model is used to calculate the location of data subcarriers for each downlink bursts and the location of pilot subcarriers in the zone. Subchannel allocation in the downlink can be performed by PUSC, FUSC and OFUSC with FFT size 2048, 1024 and 512.
2. Each firing
   - $\sum_{i=1}^{NumberOfBurst} (N_{BurstAssignedSlot}[i]) \times 48$ tokens are produced at pin Data_Pos,
   where $N_{BurstAssignedSlot}[i]$ specifies the number of assigned slots for the i-th downlink burst which is decided by ZoneType, BurstNumberOfSym, and BurstNumberOfSubch as follows:
   $N_{BurstAssignedSlot}[i] = floor((BurstNumOfSym[i])/N_{SymbolsPerSlot}) \times BurstNumOfSubch[i]$

$N_{SymbolsPerSlot}$ specifies the number of OFDMA symbols per slot which is decided by the parameter ZoneType. When the parameter ZoneType is set to "PUSC" then $N_{SymbolsPerSlot}$ equals to 2, else $N_{SymbolsPerSlot}$ equals to 1.

- $N_{PilotsPerSymbol} \times ZoneNumOfSym$ tokens are produced at pin Pilot_Pos

where $N_{PilotsPerSymbol}$ specifies the number of pilot subcarriers per OFDMA symbol. For PUSC mode, $N_{PilotsPerSymbol}$ is decided by FFTSize and GroupBitmask as follows:

$$N_{PilotsPerSymbol} = \sum_{i=0}^{5} N_{SubchannelsPerGroup}[i] \times GroupBitmask[i] \times 4$$

$N_{SubchannelsPerGroup}[i]$ indicates the number of subchannels for the i-th group which is decided by the parameter FFTSize as shown in Subchannel Index of the six Subchannel Groups for PUSC.

Subchannel Index of the six Subchannel Groups for PUSC

FFTSize	Subchannel group	#Subchannel Range	FFTSize	Subchannel group	#Subchannel Range
2048	0	0-11	512	0	0-4
	1	12-19		1	N/A
	2	20-31		2	5-9
	3	32-39		3	N/A
	4	40-51		4	10-14
	5	52-59		5	N/A
1024	0	0-5	128	0	0
	1	6-9		1	N/A
	2	10-15		2	1
	3	16-19		3	N/A
	4	20-25		4	2
	5	26-29		5	N/A

For FUSC and OFUSC mode, $N_{PilotsPerSymbol}$ is decided by FFTSize as shown in *Number of Pilot Subcarrier per OFDMA Symbol*.

ZoneType	FFT 2048	FFT 1024	FFT 512	FFT 128
FUSC	166	82	42	10
OFUSC	192	96	48	12

3. The symbol structure is constructed using pilots, data and zero subcarriers.
For PUSC mode, the symbol is first divided into basic clusters and zero carriers are allocated. Pilots and data carriers are allocated within each cluster. The parameters of the symbol structure are summarized in *2048-FFT OFDMA Downlink Subcarrier Allocations--PUSC*, *1024-FFT OFDMA Downlink Subcarrier Allocations--PUSC* and *512-FFT OFDMA Downlink Subcarrier Allocations--PUSC*. The cluster structure is shown in Figure 1 Cluster structure for PUSC.

2048-FFT OFDMA Downlink Subcarrier Allocations--PUSC

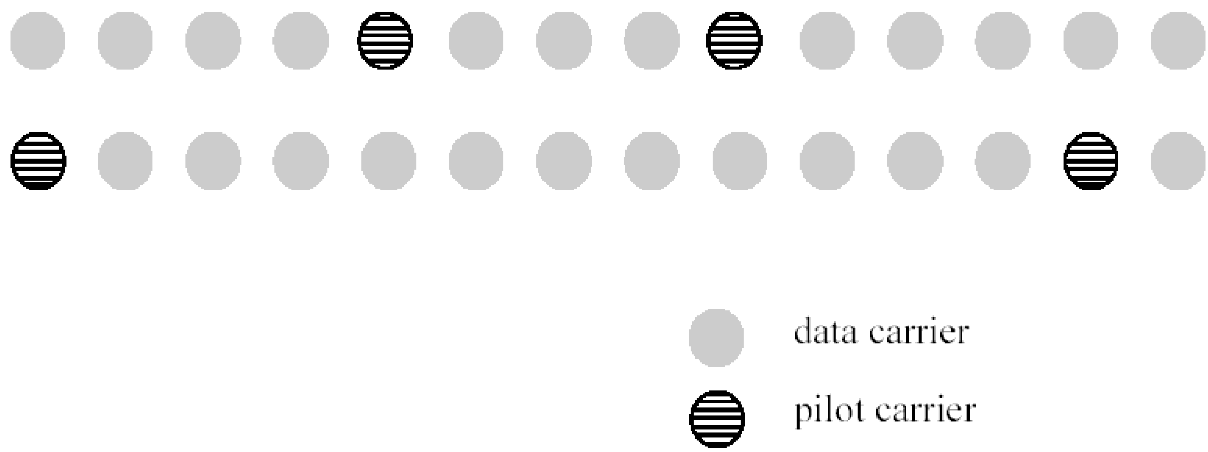
Parameter	Value	Comments
Number of DC subcarriers	1	Index 1024(counting from 0)
Number of Guard subcarriers, Left	184	
Number of Guard subcarriers, Right	183	
Number of used subcarriers	1681	Number of all subcarriers used within a symbol, including all possible allocated pilots and the DC carrier.
Number of subcarriers per cluster	14	
Number of clusters	120	
Renumbering sequence	1	6, 108, 37, 81, 31, 100, 42, 116, 32, 107, 30, 93, 54, 78, 10, 75, 50, 111, 58, 106, 23, 105, 16, 117, 39, 95, 7, 115, 25, 119, 53, 71, 22, 98, 28, 79, 17, 63, 27, 72, 29, 86, 5, 101, 49, 104, 9, 68, 1, 73, 36, 74, 43, 62, 20, 84, 52, 64, 34, 60, 66, 48, 97, 21, 91, 40, 102, 56, 92, 47, 90, 33, 114, 18, 70, 15, 110, 51, 118, 46, 83, 45, 76, 57, 99, 35, 67, 55, 85, 59, 113, 11, 82, 38, 88, 19, 77, 3, 87, 12, 89, 26, 65, 41, 109, 44, 69, 8, 61, 13, 96, 14, 103, 2, 80, 24, 112, 4, 94, 0
Number of data subcarrier in each symbol per subchannel	24	
Number of subchannel	60	
Basic permutation sequence 12 (for 12 subchannels)		6,9,4,8,10,11,5,2,7,3,1,0
Basic permutation sequence 8 (for 8 subchannels)	4	7,4,0,2,1,5,3,6

1024-FFT OFDMA Downlink Subcarrier Allocations--PUSC

Parameter	Value	Comments
Number of DC subcarriers	1	Index 512(counting from 0)
Number of Guard subcarriers, Left	92	
Number of Guard subcarriers, Right	91	
Number of used subcarriers	841	Number of all subcarriers used within a symbol, including all possible allocated pilots and the DC carrier.
Number of subcarriers per cluster	14	
Number of clusters	60	
Renumbering sequence	1	Used to renumber clusters before allocation to subchannels: 6, 48, 37, 21, 31, 40, 42, 56, 32, 47, 30, 33, 54, 18, 10, 15, 50, 51, 58, 46, 23, 45, 16, 57, 39, 35, 7, 55, 25, 59, 53, 11, 22, 38, 28, 19, 17, 3, 27, 12, 29, 26, 5, 41, 49, 44, 9, 8, 1, 13, 36, 14, 43, 2, 20, 24, 52, 4, 34, 0
Number of data subcarrier in each symbol per subchannel	24	
Number of subchannel	30	
Basic permutation sequence 6 (for 6 subchannels)		3,2,0,4,5,1
Basic permutation sequence 4 (for 4 subchannels)		3,0,2,1

512-FFT OFDMA Downlink Subcarrier Allocations--PUSC

Parameter	Value	Comments
Number of DC subcarriers	1	Index 256(counting from 0)
Number of Guard subcarriers, Left	46	
Number of Guard subcarriers, Right	45	
Number of used subcarriers	421	Number of all subcarriers used within a symbol, including all possible allocated pilots and the DC carrier.
Number of subcarriers per cluster	14	
Number of clusters	30	
Renumbering sequence	1	Used to renumber clusters before allocation to subchannels: 12, 13, 26, 9, 5, 15, 21, 6, 28, 4, 2, 7, 10, 18, 29, 17, 16, 3, 20, 24, 14, 8, 23, 1, 25, 27, 22, 19, 11, 0
Number of data subcarrier in each symbol per subchannel	24	
Number of subchannel	15	
Basic permutation sequence 5 (for 5 subchannels)		4,2,3,1,0



Cluster structure for PUSC

- For FUSC mode, the symbol is first allocated with the appropriate pilots and with zero subcarriers, and then all the remaining subcarriers are used as data subcarriers (these will be divided into subchannels). There are two variable pilot-sets and two constant pilot-sets. Each segment uses both sets of variable/constant pilot-sets. The parameters of the symbol structure are summarized in *2048-FFT OFDMA Downlink Subcarrier Allocations-- FUSC*, *1024-FFT OFDMA Downlink Subcarrier Allocations--FUSC* and *512-FFT OFDMA Downlink Subcarrier Allocations--FUSC*. Downlink symbol structure for segment 0 on symbol number 1 using FUSC depicts an example of the symbol allocation for segment 0 on symbol number 1.

2048-FFT OFDMA Downlink Subcarrier Allocations-- FUSC

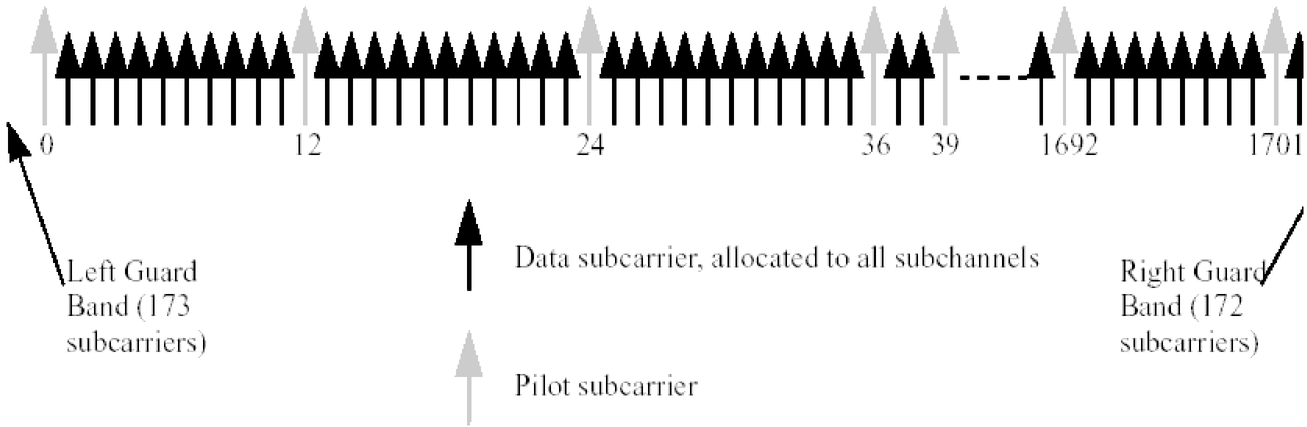
Parameter	Value	Comments
Number of DC subcarriers	1	Index 1024(counting from 0)
Number of Guard subcarriers, Left	173	
Number of Guard subcarriers, Right	172	
Number of used subcarriers	1703	Number of all subcarriers used within a symbol, including all possible allocated pilots and the DC carrier.
Pilots		
VariableSet # 0	71	0,72,144,216,288,360,432,504,576,648,720,792,864,936,1008,1080,1152,1224,1296,1368,1440,1512,1584 1656,48,120,192,264,336,408,480,552,624,696,768, 840,912,984,1056,1128,1200,1272,1344,1416,1488, 1560,1632,24,96,168,240,312,384,456,528,600,672, 744,816,888,960,1032,1104,1176,1248,1320,1392, 1464,1536,1608,1680
ConstantSet # 0	12	9,153,297,441,585,729,873,1017,1161,1305,1449,1593
VariableSet # 1	71	36,108,180,252,324,396,468,540,612,684,756,828,900,972,1044,1116,1188,1260,1332,1404,1476,1548, 1620,1692,12,84,156,228,300,372,444,516,588,660, 732,804,876,948,1020,1092,1164,1236,1308,1380, 1452,1524,1596,1668,60,132,204,276,348,420,492, 564,636,,708,780,852,924,996,1068,1140,1212,1284, 1356,1428,1500,1572,1644
ConstantSet # 1	12	81,225,369,513,657,801,945,1089,1233,1377,1521,1665
Number of data subcarriers	1536	
Number of data subcarriers per subchannel	48	
Number of Subchannels	32	
Base permutation sequence		3, 18, 2, 8, 16, 10, 11, 15, 26, 22, 6, 9, 27, 20, 25, 1, 29, 7, 21, 5, 28, 31, 23, 17, 4, 24, 0, 13, 12, 19, 14, 30

1024-FFT OFDMA Downlink Subcarrier Allocations--FUSC

Parameter	Value	Comments
Number of DC subcarriers	1	Index 512
Number of Guard subcarriers, Left	87	
Number of Guard subcarriers, Right	86	
Number of used subcarriers	851	Number of all subcarriers used within a symbol, including all possible allocated pilots and the DC carrier.
Pilots		
VariableSet # 0	36	0,24,48,72,96,120,144,168,192,216,240,264,288,312,336,360,384,408,432,456,480,504,528,552,576,600,6 6,840
ConstantSet # 0	6	72*(2*n + k) + 9 when k=0 and n=0..5
VariableSet # 1	35	36,108,180,252,324,396,468,540,612,684,756,828,12,84,156,228,300,372,444,516,588,660,732,804,60,13 780
ConstantSet # 1	5	72*(2*n + k) + 9 when k=1 and n=0..4
Number of data subcarriers	768	
Number of data subcarriers per subchannel	48	
Number of Subchannels	16	
Base permutation sequence		6, 14, 2, 3, 10, 8, 11, 15, 9, 1, 13, 12, 5, 7, 4, 0

512-FFT OFDMA Downlink Subcarrier Allocations--FUSC

Parameter	Value	Comments
Number of DC subcarriers	1	Index 256
Number of Guard subcarriers, Left	42	
Number of Guard subcarriers, Right	43	
Number of used subcarriers	427	Number of all subcarriers used within a symbol, including all possible allocated pilots and the DC carrier.
Pilots		
VariableSet # 0	18	0,24,48,72,96,120,144,168,192,216,240,264,288,312,336,360,384,408
ConstantSet # 0	3	72*(2*n + k) + 9 when k=0 and n=0..2
VariableSet # 1	18	12,36,60,84,108,132,156,180,204,228,252,276,300,324,348,372,396,420
ConstantSet # 1	3	72*(2*n + k) + 9 when k=1 and n=0..2
Number of data subcarriers		
Number of data subcarriers per subchannel		
Number of Subchannels		
Base permutation sequence		2,0,1,6,4,3,5,7



Downlink symbol structure for segment 0 on symbol number 1 using FUSC

- For OPUSC mode, all the pilots carriers are allocated first, and then the remaining carriers are used exclusively for data transmission. The used subcarriers are divided into nine contiguous subcarriers in which one pilot carrier is allocated. The position of the pilot carrier in nine contiguous subcarriers varies according to the index of OFDMA symbol which contains the subcarriers. If the nine contiguous subcarriers indexed as 0...8, the index of the pilot carrier shall be $3l + 1$ where $l = m mod 3$ (m is the symbol index). The parameters of the symbol structure are summarized in *2048-FFT OFDMA Downlink Subcarrier Allocations--OFUSC*, *1024-FFT OFDMA Downlink Subcarrier Allocations--OFUSC* and *512-FFT OFDMA Downlink Subcarrier Allocations--OFUSC*.

2048-FFT OFDMA Downlink Subcarrier Allocations--OFUSC

Parameter	**Value**	**Comments**
Number of DC subcarriers	1	
Number of Guard subcarriers, Left	160	
Number of Guard subcarriers, Right	159	
Number of used subcarriers	1729	Number of all subcarriers used within a symbol, including all possible allocated pilots and the DC carrier.
Number of Pilot Subcarriers	192	
Pilot subcarrier index	`9k + 3m + 1,for k = 0,...,191 and m = [symbol index] mod 3`	Symbol of index 0 in pilot subcarrier index is shall be the first symbol of the current zone
Number of data subcarriers	1536	
Number of data subcarriers per subchannel	48	
Number of Subchannels	32	

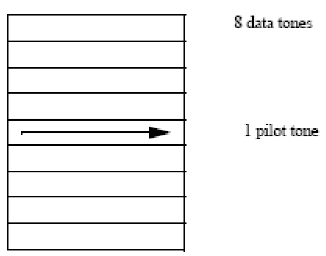
1024-FFT OFDMA Downlink Subcarrier Allocations--OFUSC

Parameter	Value	Comments
Number of DC subcarriers	1	
Number of Guard subcarriers, Left	80	
Number of Guard subcarriers, Right	79	
Number of used subcarriers	865	Number of all subcarriers used within a symbol, including all possible allocated pilots and the DC carrier.
Number of Pilot Subcarriers	96	
Pilot subcarrier index	9k + 3m + 1, for k = 0,1,...,95 and m = [symbol index] mod 3	Symbol of index 0 in pilot subcarrier index is shall be the first symbol of the current zone
Number of data subcarriers	768	
Number of data subcarriers per subchannel	48	
Number of Subchannels	16	

512-FFT OFDMA Downlink Subcarrier Allocations--OFUSC

Parameter	Value	Comments
Number of DC subcarriers	1	
Number of Guard subcarriers, Left	40	
Number of Guard subcarriers, Right	39	
Number of used subcarriers	433	Number of all subcarriers used within a symbol, including all possible allocated pilots and the DC carrier.
Number of Pilot Subcarriers	48	
Pilot subcarrier index	9k + 3m + 1, for k = 0,1,...,47 and m = [symbol index] mod 3	Symbol of index 0 in pilot subcarrier index is shall be the first symbol of the current zone
Number of data subcarriers	384	
Number of data subcarriers per subchannel	48	
Number of Subchannels	8	

- For AMC mode, symbol data within a subchannel is assigned to adjacent subcarriers and the pilot and data subcarriers are assigned fixed positions in the frequency domain within an OFDMA symbol. This permutation is the same for both UL and DL. A bin structure is shown in the following figure. ADS supports the mechanism by subchannel index reference in UL-MAP and DLMAP. An AMC subchannel of type NxM (where NxM=6) is defined as six contiguous bins (a slot consists of N bins by M symbols). Three AMC modes are supported by the parameter AMC_Mode: 1 bins by 6 symbols (1x6), 2 bins by 3 symbols (2x3) and 3 bins by 2 symbols (3x2). The subchannels are numbered from the lowest (0) to the highest frequency so that subchannel k (k = 0 - 192/N for FFT2048) consists of bins Nxk to Nxk+N-1.



The following tables summarize the parameters of the AMC subcarrier for FFT 2048, 1024 and 512.

Parameter	Value
Number of DC Subcarriers	1 (Index 1024, counting from 0)
Number of Guard Subcarriers, left	160
Number of Guard Subcarriers, right	159
Nused, Number of Used Subcarriers (which includes the DC subcarrier)	1729
Total Number of Subcarriers	2048
Number of Pilots	192
Number of Data Subcarriers	1536
Number of Physical Bands	48
Number of Bins per Physical Band	4
Number of Data Subcarriers per Slot	48

2048-FFT OFDMA AMC subcarrier allocations--AMC

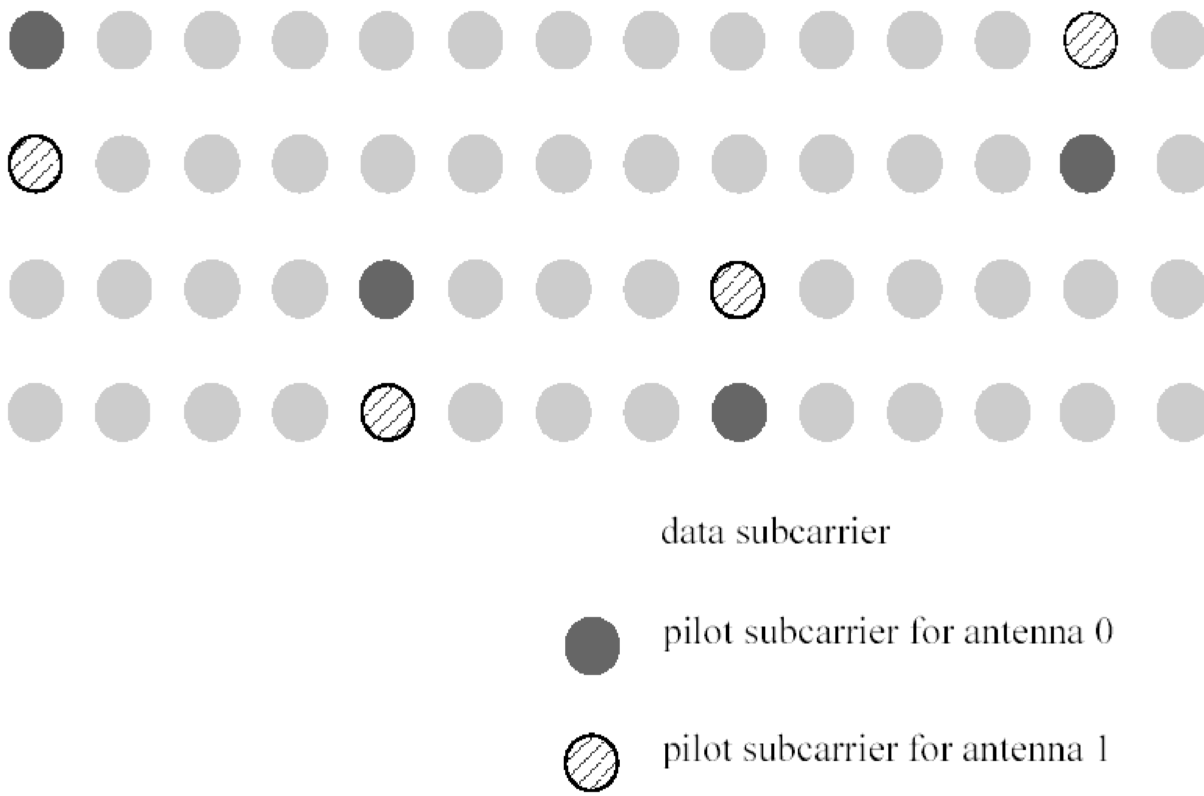
Parameter	Value
Number of DC Subcarriers	1 (Index 512, counting from 0)
Number of Guard Subcarriers, left	80
Number of Guard Subcarriers, right	79
Nused, Number of Used Subcarriers (which includes the DC subcarrier)	865
Total Number of Subcarriers	1024
Number of Pilots	96
Pilot Subcarrier Index	9k+3m+1, for k = 0,1...95, m = [symbol index] mod 3
Number of Data Subcarriers	768
Number of Physical Bands	24
Number of Bins per Physical Band	4
Number of Data Subcarriers per Slot	48

1024-FFT OFDMA AMC subcarrier allocations--AMC

Parameter	Value
Number of DC Subcarriers	1 (Index 256, counting from 0)
Number of Guard Subcarriers, left	40
Number of Guard Subcarriers, right	39
Nused, Number of Used Subcarriers (which includes the DC subcarrier)	433
Total Number of Subcarriers	512
Number of Pilots	48
Pilot Subcarrier Index	9k+3m+1, for k = 0,1...47, m = [symbol index] mod 3
Number of Data Subcarriers	384
Number of Physical Bands	12
Number of Bins per Physical Band	4
Number of Data Subcarriers per Slot	48

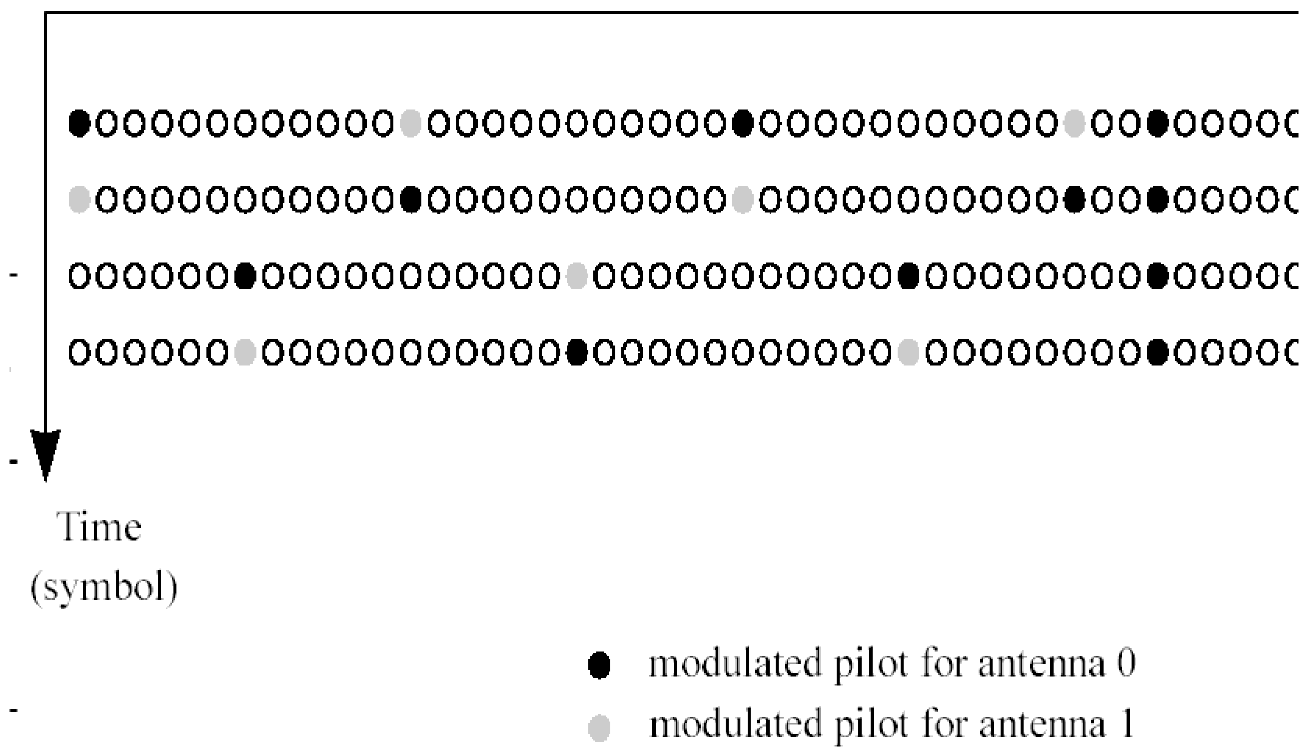
512-FFT OFDMA AMC subcarrier allocations--AMC

1. For STC Encoder, PUSC, FUSC and AMC modes with 2 antennas are supported.
    - The cluster structure for PUSC is shown in Cluster structure for STC PUSC using 2 Antennas. The pilot locations change in period of 4 symbols. The pilot locations for antenna 0 and antenna 1 are both output.



Cluster structure for STC PUSC using 2 Antennas

- In FUSC, the pilot within the symbols shall be divided between the antennas - antenna 0 uses VariableSet#0 and ConstantSet#0 for even symbols while antenna 1 uses VariableSet#1 and ConstantSet#1 for even symbols, antenna 0 uses VariableSet#1 and ConstantSet#0 for odd symbols while antenna 1 uses VariableSet#0 and ConstantSet#1 for even symbols. The pilot locations for antenna 0 and antenna 1 are both output. The transmission of the data shall be performed in pairs of symbols as illustrated in STC usage with FUSC using 2 antenna.



STC usage with FUSC using 2 antenna

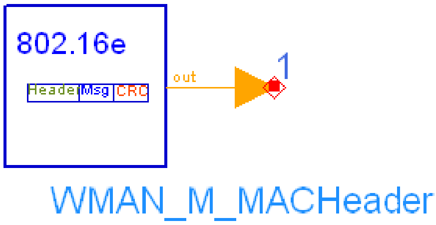
- AMC STC zone is described in *AMC STC permutation* (wman_m).

2. This model outputs the locations of the data subcarriers for each burst in order. The output sequences at pin *Data_Pos* indicates symbol location and subcarrier location for data subcarrier. The output sequences at pin *Pilot_Pos* indicates symbol location and subcarrier location for each pilot subcarrier. Let OutIndex be the output, SubcarrierLocation be the used subcarrier excluding left and right guard subcarriers and DC subcarrier and counting from 0 continuously, and SymbolLocation be the symbol number in the zone counting from 0. The OutIndex is calculated as follows:
$$OutIndex = SubcarrierLocation + SymbolLocation \times 2048$$

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_MACHeader (802.16e OFDMA MAC Header)



Description: MACHeader
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Type	Range
DataLength	MAC PDU payload byte length	100	int	[1,∞)
CID	connection identifier	0	int	[0,65535]
HT	Header type field	0	int	[0,1]
EC	Encryption control field	0	int	[0,1]

Pin Outputs

Pin	Name	Description	Signal Type
1	out	MACHeader	int

Notes/Equations

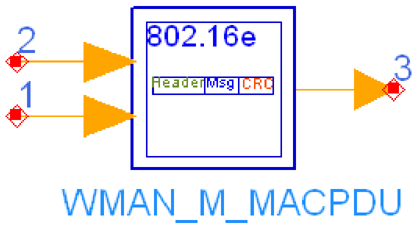
1. This subnetwork is used to generate MAC Header.
2. Each firing 6!wman_m-11-14-161.gif!
   8 bit tokens are produced at Pin MACHeader.
3. Two MAC Header formats are defined. The first is the generic MAC header that begins each MAC PDU containing either MAC management messages or CS data. The second is the bandwidth request header used to request additional bandwidth. The single-bit Header Type (HT) field distinguishes the generic MAC header and bandwidth request header formats. The HT field shall be set to zero for the Generic Header and to one for a bandwidth request header. In this module, HT is set to zero.

Syntax	Size	Notes
HT	1 bit	Header Type. Shall be set to zero in Generic MAC header.
EC	1 bit	Encryption Control 0 = Payload is not encrypted
Type	6 bit	This field indicates the subheaders and special payload types present in the message payload. Set zero here.
reserved	1 bit	0
CI	1 bit	CRC Indicator 1 = CRC is included in the PDU by appending it to the PDU Payload
EKS	2 bit	Encryption Key Sequence The index of the Traffic Encryption Key (TEK) and Initialization Vector used to encrypt the payload. This field is only meaningful if the EC field is set to 1. Set zero here.
reserved	1 bit	0
LEN	11 bit	Length. The length in bytes of the MAC PDU including the MAC header and the CRC if present
CID	16 bit	Connection identifier
HCS	8 bit	Header Check Sequence An 8-bit field used to detect errors in the header. The transmitter shall calculate the HCS value for the first five bytes of the cell header, and insert the result into the HCS field (the last byte of the MAC header). It shall be the remainder of the division (Modulo 2) by the Generator polynomial g(D)=D8+D2+D+1 of the polynomial D8 multiplied by content of the header excluding the HCS field. (Example: [HT EC Type]=0x80, BR=0xAAAA, CID=0x0F0F; HCS should then be set to 0xD5) .

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.

WMAN_M_MACPDU (802.16e OFDMA MAC PDU)



Description: MAC PDU generator
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Type	Range
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first	enum	
DataLength	MAC message payload byte length	100	int	[1,∞)
CID	connection identifier	0	int	[0,65535]
AutoMACHeaderSetting	Auto MAC_Header Setting: NO, YES	NO	enum	
HT	Header type field	0	int	[0,1]
EC	Encryption control field	0	int	[0,1]

Pin Inputs

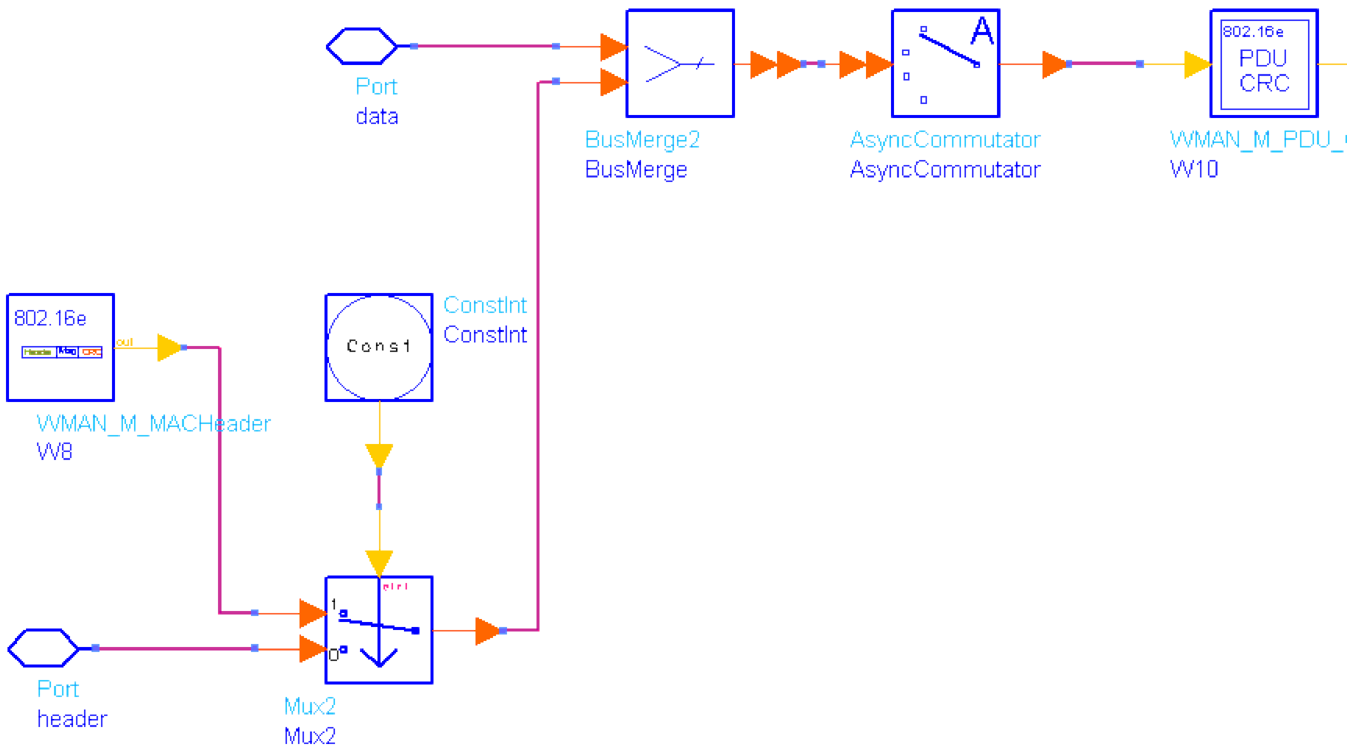
Pin	Name	Description	Signal Type
1	header	MAC header	int
2	message	MAC message payload	int

Pin Outputs

Pin	Name	Description	Signal Type
3	MACPDU	MAC PDU	int

Notes/Equations

1. This subnetwork is used to generate MAC PDU.
2. Each firing 6×8 bit tokens are consumed at Pin header; DataLength×8 bit tokens are consumed at Pin data; (DataLength+10)×8 bit tokens are produced at Pin out.
3. The schematic of this subnetwork is shown in WMAN_M_MACPDU Schematic.



WMAN_M_MACPDU Schematic

4. The structure of MAC PDU is shown in MAC PDU. Each MAC PDU contains 6 bytes MAC Header, DataLength[SSWithFEC] bytes MAC PDU payload and 4 bytes CRC.

MAC Header (6 Bytes)	MAC PDU Payload (DataLength bytes)	CRC (4 Bytes)

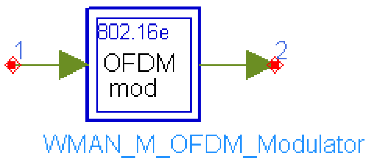
MAC PDU

5. MAC Header can be generated automaticly by WMAN_M_MACHeader or read from input port, decided by the value of AutoMACHeaderSetting.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.

WMAN_M_OFDM_Modulator (802.16e OFDMA OFDM Modulator)



Description: OFDM symbol modulator
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Type	Range
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2	enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
UsedCarriers	Number of used subcarriers	840	int	[1,2048]
CyclicPrefix	Cyclic prefix	0.125	real	[0,1]

Pin Inputs

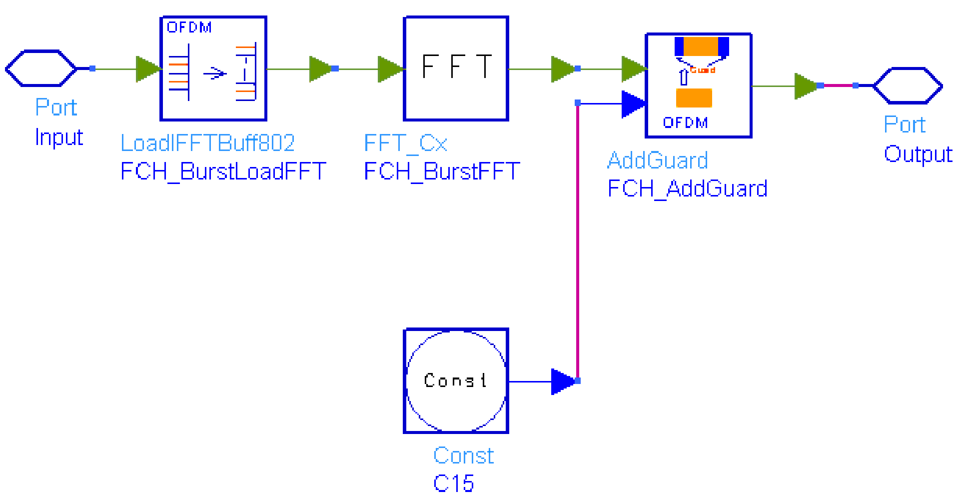
Pin	Name	Description	Signal Type
1	Input	input data	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	Output	output data	complex

Notes/Equations

1. This subnetwork is used to do IFFT and add guard intervals to the transmission data.
2. Each firing,
   UsedCarriers tokens are consumed at Pin Input;
   $(1+CyclicPrefix)\times 2^{11-FFTSize+OversamplingOption}$ tokens are produced at Pin Output.
3. The schematic of this subnetwork is shown in WMAN_M_OFDM_Modulator Schematic.



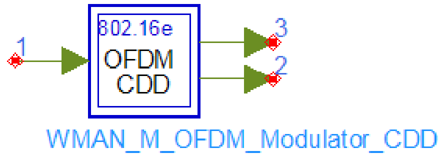
WMAN_M_OFDM_Modulator Schematic

4. The transmission data at Pin Input is loaded into the IFFT buffer by LoadIFFTBuff802, then do IFFT transformation by FFT_Cx, and at last added guard interval by AddGurad.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.

WMAN_M_OFDM_Modulator_CDD (802.16e OFDMA OFDM Symbol Modulator With CDD)



Description: OFDM symbol modulator with CDD (cyclic delay diversity) implementation
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Type	Range
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2	enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
UsedCarriers	Number of used subcarriers	840	int	[1,2048]
CyclicPrefix	Cyclic prefix	0.125	real	[0,1]
CDD_Enable	Whether CDD is applied on preamble and the first PUSC zone: NO, YES	NO	enum	
CDD_NumTaps	The number of delay taps that are used on one each physical antenna, valid only when CDD_Enable=YES	1	int	[1,2]
CDD_PowerRatio	The ratio of the power on first tap relative to the power on the second tap in dB, valid only when CDD_Enable=YES and CDD_NumTaps=2	0	real	(-∞,∞)
CDD_Tap1Delay	The delay in samples in the first tap for the two physical antennas, valid only when CDD_Enable=YES	{0, 16}	int array	[0,64]
CDD_Tap2Delay	The delay in samples in the second tap for the two physical antennas, valid only when CDD_Enable=YES and CDD_NumTaps=2	{16, 32}	int array	[0,64]
CDD_Tap2Phase	The phase in degrees in the second tap for the two physical antennas, valid only when CDD_Enable=YES and CDD_NumTaps=2	{0, 90}	real array	[-∞,∞]

Pin Inputs

Pin	Name	Description	Signal Type
1	In	input data	complex

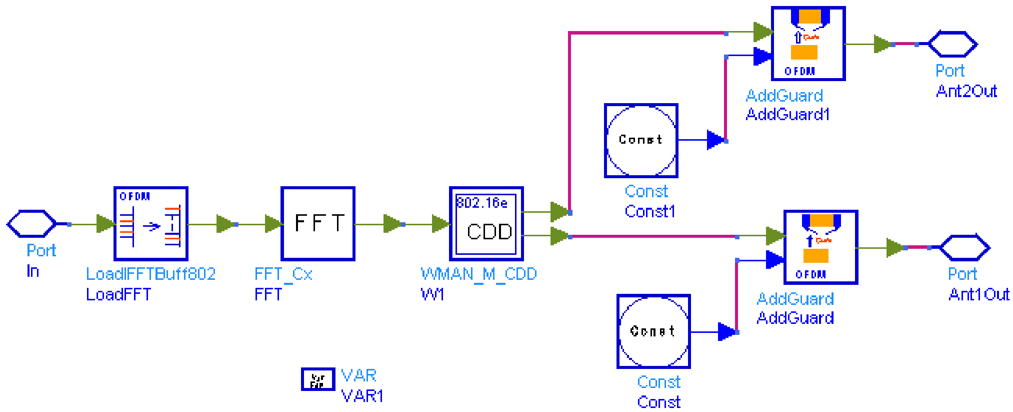
Pin Outputs

Pin	Name	Description	Signal Type
2	Ant1Out	output data at Ant1	complex
3	Ant2Out	output data at Ant2	complex

Notes/Equations

1. This subnetwork is used to do IFFT, implement CDD (cyclic delay diversity) (defined in Definitions for transparent transmit diversity), and add guard intervals to the time domain OFDM symbol assuming the number of transmit antennas is two.
2. The schematic of this subnetwork is shown in the following figure.

WMAN_M_OFDM_Modulator_CDD schematic

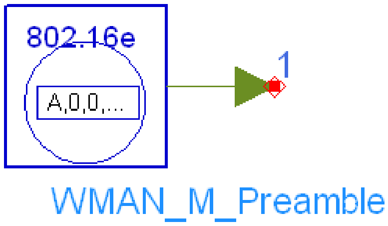


3. The frequency data at Pin Input is loaded into the IFFT buffer by LoadIFFTBuff802, then do IFFT transformation by FFT_Cx. The time domain signal is splitted into two signals for two transmit antennas with CDD feature. See *CDD implementation* (wman_m) for more infomation about CDD. At last the guard interval (i.e. cyclic prefix (CP)) is added on both two signals by AddGurad.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. C80216maint-08_006r8, Definitions for transparent transmit diversity, April 18, 2008.

WMAN_M_Preamble (802.16e OFDMA Preamble)



Description: Preamble generator
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Type	Range
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2	enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_2048	enum	
PreambleIndex	Preamble index	0	int	[0,113]

Pin Outputs

Pin	Name	Description	Signal Type
1	output	Preamble sequences	complex

Notes/Equations

1. This model is used to generate the 802.16e OFDMA Preamble sequence.
2. The first symbol of the downlink transmission is the preamble. There are 3 types of preamble carrier-sets, those are defined as follow: $PreambleCarrierSet_n = n + 3 \cdot k$
   where:

   PreambleCarrierSetn specifies all subcarriers allocated to the specific preamble,

   n is the number of the preamble carrier-set indexed 0...2,

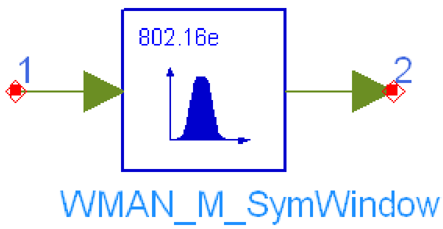
   k is a running index 0...567.

   Those subcarriers are modulated using a boosted BPSK modulation with a specific Pseudo-Noise(PN) code. The preamble modulation series per segment are defined in 8.4.6.1.1, and the modulation used on the preamble is defined in 8.4.9.4.3.1.
3. Each segment uses a preamble composed of a carrier-set out of the three available carrier-sets in the following manner:
   - Segment 0 uses preamble carrier-set 0
   - Segment 1 uses preamble carrier-set 1
   - Segment 2 uses preamble carrier-set 2

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_SymWindow (802.16e OFDMA Symbol Window)



Description: Symbol transition windowing
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Unit	Type	Range
Direction	Direcion (Downlink, Uplink): Downlink, Uplink	Downlink		enum	
Bandwidth	Nominal bandwidth	3.5 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
IdleInterval	Idle interval	0 usec	sec	real	[0,0.02]
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 10 ms		enum	
ZoneType	Zone type: DL_PUSC or UL_PUSC, DL_FUSC or UL_OPUSC, DL_OFUSC or UL_AMC, DL_AMC	DL_PUSC or UL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbols in zone	24		int	[1,1212]
ULMAP_Enable	ULMAP is inserted or not (only valid in Downlink): NO, YES	NO		enum	
WindowLength	The length for the window in unit of chips (without oversampling)	16		int	[0,96]
FDD_Enable	Whether the frame structure is FDD (only for Downlink): NO, YES	NO		enum	
ActiveDLSubframe	Which DL subframe is set by this source (the first (DL1) or the second DL subframe (DL2)), only valid when FDD_Enable=YES: DL1, DL2	DL1		enum	
DL1_NumOfSyms	The total number of symbols in the first DL subframe (DL1) including Preamble and MAP1, only valid when FDD_Enable=YES	23		int	[3,60]
DL2_NumOfSyms	The total number of symbols in the second DL subframe (DL2) including MAP2, only valid when FDD_Enable=YES	22		int	[2,60]
Gap_DL1_DL2	The integer number of symbols in the gap between DL1 and DL2 excluding the optional unused time, only valid when FDD_Enable=YES	1		int	[0,60]
UnusedTimePosition	The position for the unused time of the frame, only valid when FDD_Enable=YES: After DL2, Between DL1 and DL2	After DL2		enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	complex

Notes/Equations

1. This model is used to perform the symbol windowing on the 802.16e frame.
2. Each firing,
   $Samples_{Frame}$ tokens are consumed at pin DataIn;

$Samples_{Frame}$ tokens are consumed at pin DataOut;
where
$Samples_{Frame}$ denotes the total samples of one frame (uplink or downlink subframe in FDD, or the combination of the uplink and downlink subframes in TDD).

$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$

where $Samples_{idle}$ is

$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$

The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-11-18-180.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in *Sampling Factor Requirement*.

Sampling Factor n	Bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

3. The symbol windowing is employed in order to smooth the transitions between the consecutive OFDM symbols. This creates a small overlap between them, of duration TTR (see Illustration of OFDM Symbol Windowing). Here the time duration of TTR is determined by the parameter WindowLengh,

$$T_{TR} = \frac{WindowLength}{F_S}$$

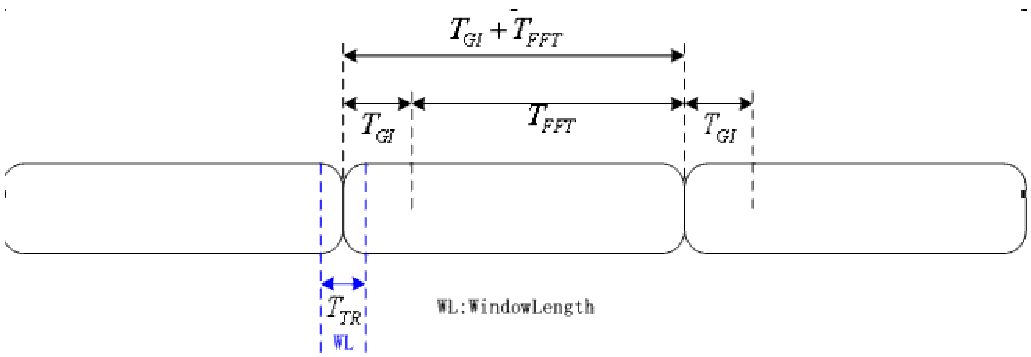


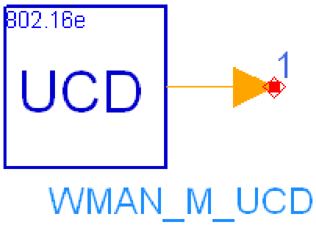
Illustration of OFDM Symbol Windowing

The symbol windowing function is defined in Equation (4), Page 10, in Reference [3].
The parameter Direction is used to determine on which part (Downlink or Uplink subframe) the symbol windowing function is employed.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. IEEE Std 802.11a-1999, Part 11: Wireless LAN Medium Access Control (MAC) and hysical Layer (PHY) specifications: High-speed Physical Layer in the 5 GHZ Band, 16 September 1999.

WMAN_M_UCD (802.16e OFDMA UCD)



Description: UCD
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Type	Range
UL_CodingType	Uplink coding type of each burst	{0}	int array	[0,1]
UL_Rate_ID	Uplink rate ID of each burst	{0}	int array	[0,7]
UCD_Count	UCD count	1	int	[0,255]
RangingBackoffStart	Ranging backoff start	1	int	[0,255]
RangingBackoffEnd	Ranging backoff end	7	int	[0,255]
RequestBackoffStart	Request backoff start	1	int	[0,255]
RequestBackoffEnd	Request backoff end	7	int	[0,255]
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	NO	enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}	int array	[0,255]
UIUC_RateID	Mapping from UIUC (1-10) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2	int array	[0,255]

Pin Outputs

Pin	Name	Description	Signal Type
1	out	UCD	int

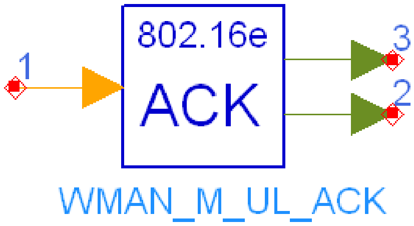
Notes/Equations

1. This model is used to generate Uplink Channel Descriptor (UCD) message for 802.16e OFDMA system. A UCD shall be transmitted after UL-MAP by the BS to define the characteristics of a downlink physical channel.
2. The UCD message format is defined in Table 15 of Reference [1] below.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_ACK (802.16e OFDMA Uplink Acknowledgement)



Description: Uplink ACK channel generator
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Type	Range
ACK_Allocation	Rectangular allocation: (SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 0, 6, 2}	int array	[0,1211]
ACK_SlotChosen	The index of slot for carrying the ACK code.	0	int	[0,6867]

Pin Inputs

Pin	Name	Description	Signal Type
1	input	input bits	int

Pin Outputs

Pin	Name	Description	Signal Type
2	ACK_Slots	data sequence for FFB slots	complex
3	ACK_Msg	data sequence for FFB message	complex

Notes/Equations

1. This model is used to generate Uplink ACK.
2. Each firing, $(48 \times (ACK-Allocation[2] \times ACK-Allocation[3]))/3$ tokens are produced at pin ACK_Slot.
   24 tokens are produced at pin ACK_Msg.
   1 token is used at pin Input.
3. The input 1 bit is encoded into a length 3 codeword over 8-ary alphabet for the error protection as shown in *ACK Channel Subcarrier Modulation* and output at pin ACK_Msg.

ACK 1-bit Symbol	Vector Indices per Tile Tile(0), Tile(1), Tile(2)
0	0,0,0
1	4,7,2

   The UL ACK channel is orthogonally modulated with QPSK symbols. Let $M_{n,8m+k}(0 \le k \le 7)$ be the modulation symbol index of the k-th modulation symbol in the m-th uplink tile of the n-th UL ACK channel. The possible modulation patterns composed of $M_{n,8m}$, $M_{n,8m+1}$, ... $M_{n,8m+7}$ in the m-th tile of the n-th UL ACK channel are defined in *Orthogonal Modulation Index in UL ACK Channel*.

Vector index	<th
0	P0,P1,P2,P3,P0,P1,P2,P3
1	P0,P3,P2,P1,P0,P3,P2,P1
2	P0,P0,P1,P1,P2,P2,P3,P3
3	P0,P0,P3,P3,P2,P2,P1,P1
4	P0,P0,P0,P0,P0,P0,P0,P0
5	P0,P2,P0,P2,P0,P2,P0,P2
6	P0,P2,P0,P2,P2,P0,P2,P0
7	P0,P2,P2,P0,P2,P0,P0,P2

where

$P0 = \exp\left(j \cdot \frac{\pi}{4}\right)$,

$P1 = \exp\left(j \cdot \frac{3\pi}{4}\right)$,

$P2 = \exp\left(-j \cdot \frac{3\pi}{4}\right)$,

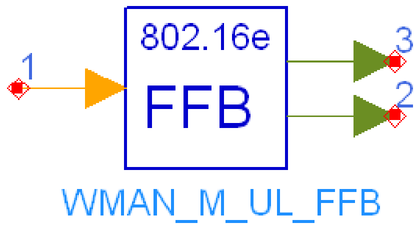
$P3 = \exp\left(-j \cdot \frac{\pi}{4}\right)$.

4. One ACK channel occupies a half subchannel.The number of assigned subchannel may large than 1, and ACK channel can be allocated any half of the assigned subchannels which is decided by parameter ACK_SlotChosen. For the assigned subchannels, chosen half subchannel is filled with modulated ACK data, and others filled with zeros. Data for the assigned subchannels is output at pin ACK_Slot.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_FFB (802.16e OFDMA UL FFB)



Description: Uplink fast feedback generator
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Type	Range
FFB_ChannelType	FFB channel type: FFB_NORMAL, FFB_ENHANCED, FFB_3MIMO	FFB_NORMAL	enum	
FFB_Allocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 0, 6, 2}	int array	[0,1211]
FFB_SlotChosen	The index of slot for carrying the Fast FeedBack code.	0	int	[0,6867]

Pin Inputs

Pin	Name	Description	Signal Type
1	input	input bits	int

Pin Outputs

Pin	Name	Description	Signal Type
2	FFB_Slots	data sequence for FFB slots	complex
3	FFB_Msg	data sequence for FFB message	complex

Notes/Equations

1. This model is used to generate one uplink fast-feedback channel for 802.16e OFDMA system. Fast-feedback channel is a set of information that requires fast response from the SS. Three types of fast-feedback channel can be supported :fast-feedback channel(normal), enhanced fast-feedback channel and MIMO mode feedback for enhanced fast-feedback channel.
2. Each firing, $(48 \times (FFB - Allocation[2] \times FFB - Allocation[3]))/3$ tokens are produced at pin FFB_Slots. 1 token is used by pin input. If the parameter FFB_ChannelType is set to FFB_3MIMO, 24 tokens are produced at pin FFB_Msg, otherwise, 48 tokens are produced at pin FFB_Msg.
3. The fast-feedback slot consists of 1 OFDMA slots and can carry a data payload of 4 bits. The mapping between the payload bit sequences and the subcarriers modulation is defined in Table 296 in item 1 in References. The fast-feedback code words used in Table 296 in Reference [1] belong to a set of orthogonal vectors and are mapped directly to the subcarriers. The vectors are defined in Table 297 in item 1 in References.
The enhanced fast-feedback slot consists of 1 OFDMA slots and can carry a data payload of 6 bits. The mapping between the payload bit sequences and the subcarriers modulation is defined in Table 298d in item 2 in References. The vectors used in Table 298d in Reference [2] is defined in Table 298e in item 2 in References.
The 3-bit MIMO fast-feedback slot consists of 1/2 OFDMA slots which contains 24 data subcarriers and can carry a data payload of 3 bits. The mapping between the payload bit sequences and the subcarriers modulation is defined in Table 298c in Reference [2]. The vectors used in Table 298c in Reference [2] is defined in Table 298e in Reference [2].
The QPSK modulation is defined as
$$P0 = \exp\left(j \cdot \frac{\pi}{4}\right),$$
$$P1 = \exp\left(j \cdot \frac{3\pi}{4}\right),$$

$$P2 = \exp\left(-j \cdot \frac{3\pi}{4}\right)$$,

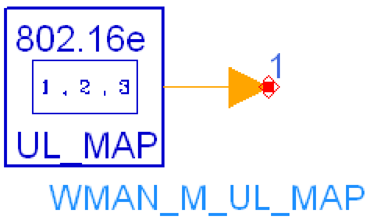
$$P3 = \exp\left(-j \cdot \frac{\pi}{4}\right)$$.

4. The modulated FFB data occupies one or a half slot and output at pin FFB_Msg. The number of assigned subchannel may large than 1, and FFB channel can be allocated anywhere of the assigned subchannels which is decided by parameter FFB_SlotChosen. For the assigned subchannels, chosen one or a half subchannel is filled with modulated FFB data, and others filled with zeros. Data for the assigned subchannels is output at pin FFB_Slot.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_MAP (802.16e OFDMA ULMAP)



Description: Uplink map
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Unit	Type	Ran
UL_ZoneType	UL zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC		enum	
UL_AMC_Mode	Uplink AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	
UL_ZoneSymOffset	Symbol offset in UL zone	0		int	[0,1
UL_ZoneNumOfSym	Number of OFDMA symbols in the UL subframe	24		int	[0,2
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
Bandwidth	Bandwidth	3.5 MHz	Hz	int	[1,1
UL_PermBase	Uplink permutation base	0		int	[0, 6
UL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum	
UCD_Count	UCD count	1		int	[0,2
UL_NumberOfBurst	Number of Bursts in uplink	1		int	[1,8
UL_CID	Uplink CID	{1}		int array	[0,6
UL_CodingType	Uplink coding type of each burst	{0}		int array	[0,1
UL_Rate_ID	Uplink rate ID	{0}		int array	[0,7
UL_BurstSlotOffset	slot offsets of each burst in uplink	{0}		int array	[1,6
UL_BurstAssignedSlot	Assigned slots of each burst in uplink	{96}		int array	[1,6
UL_RepetitionCoding	Repetition coding of each burst in uplink	{0}		int array	[0,3
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.0
AutoMACHeaderSetting	Auto MAC_Header Setting: NO, YES	NO		enum	
MAC_Header	MAC header data	{0X03, 0X40, 0X1D, 0XFF, 0XFF, 0X2A}		int array	[0,2
HARQ_ACK_Enable	HARQ ACK channel enabled or not: NO, YES	NO		enum	
HARQ_ACK_Allocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 12, 3, 6}		int array	[0,2
RangingEnable	Ranging channel enabled or not: NO, YES	NO		enum	
RangingAllocation	Rectangular allocation: (SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 0, 3, 6}		int array	[0,2
RangingMethod	Ranging mode: Initial/Handover_2 symbols, Initial/Handover_4 symbols, BW Request/Periodic_1 symbol, BW Request/Periodic_3 symbol	Initial/Handover_2 symbols		enum	
FastFeedBackEnable	Fast feedback channel enabled or not: NO, YES	NO		enum	
FastFeedBackAllocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 6, 3, 6}		int array	[0,2
CQICH_Enable	CQICH channel enabled or not: NO, YES	NO		enum	
CQICH_ID	CQICH ID, set it to fixed 6 bits	0		int	[0,6

CQICH_AllocationOffset	CQICH channel allocation offset	0		int	[0,6
CQICH_Period	CQICH channel period	0		int	[0,3
CQICH_FrameOffset	CQICH channel frame offset	0		int	[0,7
CQICH_Duration	CQICH channel duration	0		int	[0,7
CQICH_FeedbackType	CQICH channel feedback type: physical CINR feedback, effective CINR feedback	physical CINR feedback		enum	
CQICH_CINR_Type	CQICH channel CINR preamble report type: Frequency reuse factor = 1 config, Frequency reuse factor = 3 config	Frequency reuse factor = 1 config		enum	
CQICH_AvgParamIncluded	CQICH channel average parameter included for physical CINR feedback: NO, YES	NO		enum	
CQICH_AvgParam	CQICH channel average parameter for physical CINR feedback	0		int	[0,1
CQICH_MIMO_FeedbackCycle	CQICH channel MIMO permutation feedback cycle	0		int	[0,3
MIMO_Enable	MIMO enabled IE or not: NO, YES	NO		enum	
Collaborative_SM_Indicator	collaborative SM indicator, 0:non collaborative SM, 1:collaborative SM	{0}		int array	[0,1
MIMO_Control	MIMO mode, 0: STTD, 1:SM, effective when collaborative_SM_Indicator = 0	{0}		int array	[0,1
UL_CID_B	Uplink CID that shall use pilot pattern B	{1}		int array	[0,6
UL_CodingType_B	Uplink coding type of each burst that shall use pilot pattern B	{0}		int array	[0,1
UL_Rate_ID_B	Uplink rate ID that shall use pilot pattern B	{0}		int array	[0,7
Compressed_ULMap	Compressed UL_MAP or not: NO, YES	NO		enum	
UIUC_RateID	Mapping from UIUC (1-10) to RateID {CodingType,Modulation/Rate}	0,0}, {0,1}, {0,2}, {0,3}, {0,4}, {0,5}, {0,6}, {1,0}, {1,1}, {1,2		int array	[0,2

Pin Outputs

Pin	Name	Description	Signal Type
1	UL_MAP	output UL_MAP	int

Notes/Equations

1. This model is used to generate normal and compressed UpLink MAP message (UL_MAP) for 802.16e OFDMA system. UL_MAP is a set of information that defines the entire access for a scheduling interval.
2. Each firing,
   - If the parameter Compressed_ULMap is set to "No"
     - If the parameter UL_MIMO_Enable is set to "No"
       $6 + ceil(8 + 6.5 + RangingBytes + FFB - Bytes + ACK - Bytes + CQICH - Bytes + UL - NumOfBurst \times 4)$
       tokens in bytes are produced at Pin UL_MAP.
     - If the parameter UL_MIMO_Enable is set to "Yes"
       $6 + ceil(8 + 6.5 + MIMO - Bytes)$ tokens in bytes are produced at Pin UL_MAP.
       where 6 stands for the number of bytes of MAC_Header, 8 stands for the number of bytes of normal UL_MAP Header, 4 stands for the number of bytes of UL_MAP_IE.
   - If the parameter Compressed_ULMap is set to "Yes"
     - If the parameter UL_MIMO_Enable is set to "No"
       $ceil(6 + 6.5 + RangingBytes + FFB - Bytes + ACK - Bytes + CQICH - Bytes + UL - NumOfBurst \times 4)$
       tokens in bytes are produced at Pin UL_MAP.
     - If the parameter UL_MIMO_Enable is set to "Yes"
       $ceil(6 + 6.5 + MIMO - Bytes)$ tokens in bytes are produced at Pin UL_MAP.
       where 6 stands for the number of bytes of compressed UL_MAP Header, 6.5 stands for the number of bytes of UL Zone IE, 4 stands for the number of bytes of UL_MAP_IE.
       MIMO_Bytes is calculated as follows:
       $$(MIMO - Bytes) = \left(\left(\left(32 + \left(\sum_{i=1}^{NumberOfBurst} variableBits[i]\right)\right) + 7\right) / 8\right)$$
       where 32 equals to fixed bits length, variableBits[i] equals to 51 when parameter

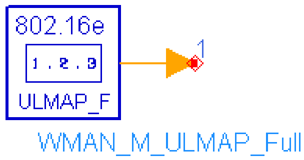
UL_Collaborative_SM_Indicator[i] is set to "1" and equals to 32 when parameter UL_Collaborative_SM_Indicator[i] is set to "0".
RangingBytes stands for the number of bytes of Ranging_IE, FFB_Bytes stands for the number of bytes of FAST-FEEDBACK Channel IE, ACK_Bytes stands for the number of bytes of HARQ ACKCH Region Allocation IE and CQICH_Bytes stands for the number of bytes of CQICH_Alloc_IE.
If the parameter RangingEnable is set to "Yes", then RangingBytes equals to 6.5; otherwise, RangingBytes equals to 0.
If the parameter FastFeedBackEnable is set to "Yes", then FFB_Bytes equals to 6.5; otherwise, FFB_Bytes equals to 0.
If the parameter HARQ_ACK_Enable is set to "Yes", then ACK_Bytes equals to 7; otherwise, ACK_Bytes equals to 0.
If the parameter CQICH_Enable is set to "Yes", then CQICH_Bytes equals to 7.5; otherwise, CQICH_Bytes equals to 0.

3. The OFDMA UL_MAP message, UL_MAP IE format, HARQ ACKCH region allocation IE, FAST-FEEDBACK allocation IE format, UL ZONE IE format, CIQCH_Alloc_IE format and MIMO_UL_Basic_IE format are defined in Table 18, Table 287, Table302t, Table 295a, Table 294, Table 300 and Table 299 respectively, in Reference [2]. The Compressed UL_MAP format is defined in Table 306 of IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October 1, 2004 and IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006. The OFDMA MAC header formate is defined in Table 4 of Reference [2].

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_ULMAP_Full (802.16e OFDMA ULMAP Full)



Description: Uplink map full
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Unit	Type	R
Compressed_ULMap	Compressed UL_MAP or not: NO, YES	NO		enum	
MAC_Header_Enable	6 bytes MAC_Header is inserted or not: NO, YES	NO		enum	
MAPHeader_Enable	UL_MAP Header Ie is inserted or not: NO, YES	NO		enum	
MAP_CID	CID for this message	0xffff		int	[0
UCD_Count	UCD count	1		int	[0
UL_ZoneNumOfSym	Number of OFDMA symbols in the UL subframe	24		int	[0
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
Bandwidth	Bandwidth	3.5 MHz	Hz	int	[1
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0
FastFeedBackEnable	UIUC0 IE enabled or not: NO, YES	NO		enum	
FastFeedBackAllocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 6, 3, 6}		int array	[0
UL_BurstPrfl_Enable	UIUC_1-UIUC_10(different burst profiles) is inserted or not: NO, YES	NO		enum	
UL_NumberOfBurst	Number of Bursts in uplink	1		int	[1
UL_CID	Uplink CID	{1}		int array	[0
UL_Burst_UIUC	Uplink different burst profiles	{1}		int array	[1
UL_BurstAssignedSlot	Assigned slots of each burst in uplink	{96}		int array	[1
UL_RepetitionCoding	Repetition coding of each burst in uplink	{0}		int array	[0
CQI_Enhanced_Enable	CQICH Enhanced Enable: NO, YES	NO		enum	
CQI_Enhncd_CQI_ID	CQICH Enhanced CQICH ID	0		int	[0
CQI_Enhncd_Period	CQICH Enhanced Period	0		int	[0
CQI_Enhncd_FrmOffset	CQICH Enhanced FrameOffset	0		int	[0
CQI_Enhncd_Duration	CQICH Enhanced Duration	0		int	[0
CQI_Enhncd_CQI_Num	CQICH Enhanced CQICH Number	0		int	[0
CQI_Enhncd_FBType	CQICH Enhanced Feedback Type	{0}		int array	[0
CQI_Enhncd_AllocIdx	CQICH Enhanced Allocation Index	{0}		int array	[0
CQI_Enhncd_CQI_Type	CQICH Enhanced CQICH Type	{0}		int array	[0
CQI_Enhncd_STTD_Idt	CQICH Enhanced STTD Indication	{0}		int array	[0
CQI_Enhncd_BndAMC_PrMD	CQICH Enhanced BandAMC Precoding Mode: Common, Distinct	Common		enum	
CQI_Enhncd_NrPrecodFB	CQICH Enhanced Nr Precoders feedback	0		int	[0
HO_AchAtv_Enalbe	UIUC11_Ext01 IE is inserted or not: NO, YES	NO		enum	
HO_AchAtv_NumOfBurst	HO Anchor Active Number Of Burst	1		int	[1
HO_AchAtv_AnchorPrml	HO Anchor Active Anchor Preamble	{0}		int	[0

				array	
HO_AchAtv_Anchor_CID	HO Anchor Active Anchor CID	{0}		int array	[0
HO_AchAtv_StrtSubOffst	HO Anchor Active Start Subchannel Offset	{0}		int array	[0
HO_AchAtv_UIUC	HO Anchor Active UIUC	{0}		int array	[0
HO_AchAtv_Duration	HO Anchor Active Duration	{0}		int array	[0
HO_AchAtv_RptCoding	HO Anchor Active Repeatition Coding Indication	{0}		int array	[0
HO_AtvAch_Enable	UIUC11_Ext02 IE is inserted or not: NO, YES	NO		enum	
HO_AtvAch_NumOfBurst	HO Active Anchor Number Of Burst	1		int	[1
HO_AtvAch_ActivePrml	HO Active Anchor Active Preamble	{0}		int array	[0
HO_AtvAch_Anchor_CID	HO Active Anchor Anchor CID	{0}		int array	[0
HO_AtvAch_StrtSubOffst	HO Active Anchor Start Subchannel Offset	{0}		int array	[0
HO_AtvAch_UIUC	HO Active Anchor UIUC	{0}		int array	[0
HO_AtvAch_Duration	HO Active Anchor Duration	{0}		int array	[0
HO_AtvAch_RptCoding	HO Active Anchor Repeatition Coding Indication	{0}		int array	[0
Achr_BS_SW_Enable	UIUC11_Ext03 IE is inserted or not: NO, YES	NO		enum	
Achr_BS_SW_Number	Anchor BS Switch Number	1		int	[1
Achr_BS_SW_Rducd_CID	Anchor BSSwitch Reduced CID	{0}		int array	[0
Achr_BS_SW_ActCode	Anchor BSSwitch Active Code	{0}		int array	[0
Achr_BS_SW_ActTime	Anchor BSSwitch Active Time	{0}		int array	[0
Achr_BS_SW_TMP_BS_ID	Anchor BSSwitch Temp BS ID	{0}		int array	[0
Achr_BS_SW_CQI_AllocIdt	Anchor BSSwitch CQI Allocation Indiction	{0}		int array	[0
Achr_BS_SW_CQI_ID	Anchor BSSwitch CQI ID	{0}		int array	[0
Achr_BS_SW_CQI_FdkChOffst	Anchor BSSwitch CQI Feedback Channel Offset	{0}		int array	[0
Achr_BS_SW_CQI_Period	Anchor BSSwitch CQI Period	{0}		int array	[0
Achr_BS_SW_CQI_FrmOffst	Anchor BSSwitch CQ Frame Offset	{0}		int array	[0
Achr_BS_SW_CQI_Duration	Anchor BSSwitch CQI Duration	{0}		int array	[0
Achr_BS_SW_MIMO_PrmFdkCyc	Anchor BSSwitch MIMO Permutation Feedback Cycle	{0}		int array	[0
UL_Snd_Cmd_Enable	UIUC11_Ext06 IE is inserted or not: NO, YES	NO		enum	
UL_Snd_SndType	UL Sounding Sounding Type: Type A, Type B	Type A		enum	
UL_Snd_Sd_Snd_RptFlg	UL Sounding Send Sounding Report Flag: NO, YES	NO		enum	
UL_Snd_Rlv_Flg	UL Sounding Relevance Flag: Same, Specified	Same		enum	
UL_Snd_Rlv	UL Sounding Relevance: in carrying frame, in next frame	in carrying frame		enum	
UL_Snd_Incld_Add_FB	UL Sounding Include Addtional Feedback: No Add FB, Incld Ch Coef, Incld Rx Pilot Cf, Incld FB Msg	No Add FB		enum	
UL_Snd_Num_Snd_Sym	UL Sounding Number of Sounding Symbols	1		int	[1
UL_Snd_Spt_Type	UL Sounding Separability Type: All, Decimated	All		enum	
UL_Snd_Max_Cyc_Shft_Idx_P	UL Sounding Max Cyclic Shift Index P	0		int	[0
UL_Snd_Decm_Val_D	UL Sounding Decimation Value D	0		int	[0
UL_Snd_Decm_Offset_Rnd	UL Sounding Decimation Value D: No Rnd, PN Rnd	No Rnd		enum	
UL_Snd_Snd_Sym_Idx	UL Sounding Souding Symbol Index	{0}		int	[0

				array	
UL_Snd_Num_CID	UL Sounding Number of CIDs	1		int	[1
UL_Snd_Shtd_Basic_CID	UL Sounding Shorted Basic CID	0		int array	[0
UL_Snd_Power_Assign_Mthd	UL Sounding Power Assignment Method	0		int array	[0
UL_Snd_Power_Boost	UL Sounding Power Boost	0		int array	[0
UL_Snd_MulAnt_Flg	UL Sounding Multi-Antenna Flag	0		int array	[0
UL_Snd_Alloc_Mode	UL Sounding Allocation Mode	0		int array	[0
UL_Snd_Band_BMP	UL Sounding Band Bit Map	0		int array	[0
UL_Snd_Strt_Freq_Band	UL Sounding Starting Frequency Band	0		int array	[0
UL_Snd_Num_FreqBands	UL Sounding Number of Frequency Bands	0		int array	[0
UL_Snd_Cyclic_TShft_Idx_m	UL Sounding Cyclic Time Shift Index m	0		int array	[0
UL_Snd_Decm_Offset_d	UL Sounding Decimation Offset d	0		int array	[0
UL_Snd_Us_Same_Sym_AddFB	UL Sounding Use Same Symbol for Additional Feedback	0		int array	[0
UL_Snd_Periodicity	UL Sounding Periodicity	0		int array	[0
UL_Snd_Perm	UL Sounding Permutation: PUSC, FUSC, OFUSC, PUSC_ASCA, TUSC1, TUSC2, AMC(2X3)	PUSC		enum	
UL_Snd_DL_PermBase	UL Sounding DL PermBase	0		int	[0
UL_Snd_SubChOffset	UL Sounding Subchannel Offset	0		int array	[0
UL_Snd_Num_SubCh	UL Sounding	0		int array	[0
MIMO_Enhanced_Enable	UIUC11_Ext06 is inserted or not: NO, YES	NO		enum	
MIMO_Enhanced_NumAssign	MIMO UL Enhanced Number Assign	1		int	[1
MIMO_Enhanced_NumCID	MIMO UL Enhanced CID number	1		int	[1
MIMO_Enhanced_CID	MIMO UL Enhanced CID	0		int array	[0
MIMO_Enhanced_UIUC	MIMO Enhanced UIUC	1		int array	[0
MIMO_Enhanced_MatrixIdt	MIMO UL Enhanced Matrix Idication	0		int array	[0
MIMO_Enhanced_PilotPattern	MIMO UL Enhanced Pilot Pattern	{0}		int array	[0
MIMO_Enhanced_Duration	MIMO UL Enhanced Duration	{0}		int array	[0
HARQ_ACK_Enable	UIUC11_Ext08 IE enabled or not: NO, YES	NO		enum	
HARQ_ACK_Allocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 12, 3, 6}		int array	[0
AAS_SDMA_Enable	UIUC11_Ext0e IE enabled or not: NO, YES	NO		enum	
AAS_SDMA_RCID_Tp	AAS_SDMA RCID type: Normal CID, RCID11, RCID7, RCID3	Normal CID		enum	
AAS_SDMA_NumBstRgn	AAS_SDMA num burst region	1		int	[1
AAS_SDMA_SlotOffst	AAS_SDMA slot offset	{0}		int array	[0
AAS_SDMA_SlotDrt	AAS_SDMA slot duration	{0}		int array	[0
AAS_SDMA_NumOfUser	AAS_SDMA number of users	1		int	[1
AAS_SDMA_RCID_CID	AAS_SDMA CID in RCID_IE	0		int array	[0
AAS_SDMA_RCID_Prefix	AAS_SDMA prefix in RCID_IE	0		int array	[0
AAS_SDMA_EncodingMode	AAS_SDMA encoding mode	0		int	[0

				array	
AAS_SDMA_PwrAdjust	AAS_SDMA power adjust is included or not	0		int array	[0
AAS_SDMA_PilotPtnMdf	AAS_SDMA pilot pattern modifier	0		int array	[0
AAS_SDMA_PrmlUsed	AAS SDMA preamble used or not:0:not used, 1:used	0		int array	[0
AAS_SDMA_PrmlMdfIdx	AAS SDMA preamble modifier index	0		int array	[0
AAS_SDMA_PilotPattern	AAS_SDMA pilot pattern	0		int array	[0
AAS_SDMA_DIUC	AAS_SDMA DIUC of each user	1		int array	[0
AAS_SDMA_RptCodingIdt	AAS_SDMA repetition coding indication	0		int array	[0
AAS_SDMA_ACID	AAS_SDMA ACID	0		int array	[0
AAS_SDMA_AI_SN	AAS_SDMA AI_SN	0		int array	[0
AAS_SDMA_Nep	AAS_SDMA Nep	0		int array	[0
AAS_SDMA_Nsch	AAS_SDMA Nsch	0		int array	[0
AAS_SDMA_SPID	AAS_SDMA SPID	0		int array	[0
AAS_SDMA_PwrAdjustment	AAS_SDMA ACID	0		int array	[0
FB_Polling_Enable	UIUC11_Ext0F ie is inserted or not: NO, YES	NO		enum	
FB_Polling_NumAlloc	Feedback polling number of allocations	1		int	[1
FB_Polling_DdtULAllocIncluded	Feedback polling dedicated UL allocation included or not: NO, YES	NO		enum	
FB_Polling_BCID	Feedback polling basic CID of each allocation	{1}		int array	[0
FB_Polling_AllocDuration	Feedback polling allocation duration of each allocation	{0}		int array	[0
FB_Polling_FBType	Feedback polling feedback type of each allocation	{0}		int array	[0
FB_Polling_FrmOffset	Feedback polling frame offset of each allocation	{0}		int array	[0
FB_Polling_Period	Feedback polling period of each allocation	{0}		int array	[0
FB_Polling_UIUC	Feedback polling UIUC of each dedicated UL allocation	{1}		int array	[0
FB_Polling_SymOffset	Feedback polling OFDMA symbol offset of each dedicated UL allocation	{0}		int array	[0
FB_Polling_SubOffset	Feedback polling subchannel offset of each dedicated UL allocation	{0}		int array	[0
FB_Polling_Duration	Feedback polling duration in OFDMA slots of each dedicated UL allocation	{1}		int array	[1
FB_Polling_RptCoding	Feedback polling repetition coding indication of each dedicated UL allocation	{0}		int array	[0
RangingEnable	UIUC12 enabled or not: NO, YES	NO		enum	
RangingAllocation	Rectangular allocation: (SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0, 0, 3, 6}		int array	[0
RangingMethod	Ranging mode: Initial/Handover_2 symbols, Initial/Handover_4 symbols, BW Request/Periodic_1 symbol, BW Request/Periodic_3 symbol	Initial/Handover_2 symbols		enum	
PAPR_Enable	UIUC13 IE is inserted or not: NO, YES	NO		enum	
PAPR_Allocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0,0,4,4}		int array	
PAPR_Type	Allocation type: PAPR reduction, Safety zone, Sounding zone	PAPR reduction		enum	
CDMA_Alloc_Enable	UIUC14 IE is inserted or not: NO, YES	NO		enum	
CDMA_Duration	CDMA allocation duration	0		int	[0
CDMA_UIUC	UIUC for transmission	0		int	[0

CDMA_RepetitionCoding	Repetition coding indicator: No_rpt, Rpt2, Rpt4, Rpt6	No_rpt		enum	
CDMA_FrameNumIdx	LSBs of relevant frame number	0		int	[0
CDMA_RangingCode	Ranging code for CDMA allocaion	0		int	[0
CDMA_RangingSymbol	Ranging symbol for CDMA allocaion	0		int	[0
CDMA_RangingSubch	Ranging subchannel for CDMA allocaion	0		int	[0
CDMA_BW_ReqMandatory	BW request mandatory: NO, YES	NO		enum	
PwrControl_Enable	UIUC15_Ext00 IE is inserted or not: NO, YES	NO		enum	
PwrControl	Power control	0		int	[0
PwrMeasFrame	Power measurement frame	0		int	[0
MiniSubch_Enable	UIUC15_Ext01 ie enabled or not: NO, YES	NO		enum	
MiniSubch_CType	Mini subchannel CType	0		int	[0
MiniSubch_Duration	Mini subchannel duration	0		int	[0
MiniSubch_CID	Mini subchannel CID for each allocation	{0,3}		int array	[0
MiniSubch_UIUC	Mini subchannel UIUC for each allocation	{1,2}		int array	[0
MiniSubch_RptCoding	Mini subchannel repetition coding for each allocation	{0,0}		int array	[0
AAS_UL_Enable	UIUC15_Ext02 IE is inserted or not: NO, YES	NO		enum	
AAS_ZoneType	AAS zone permutation type: AAS_PUSC, AAS_OPUSC	AAS_PUSC		enum	
AAS_UL_PermBase	AAS UL_PermBase	0		int	[0
AAS_ZoneSymOffset	AAS zone symbol offset	0		int	[0
AAS_ZoneNumOfSym	Number of symbols in AAS zone	0		int	[0
AAS_UL_PrmlConfig	AAS preamble config: sym_0, sym_1, sym_2, sym_3	sym_0		enum	
AAS_PrmlType	AAS preamble type: Freq_shft, Time_shft	Freq_shft		enum	
CQICH_Enable	UIUC15_Ext03 enabled or not: NO, YES	NO		enum	
CQICH_ID	CQICH ID, set to fixed 6 bits	0		int	[0
CQICH_AllocationOffset	CQICH channel allocation offset	0		int	[0
CQICH_Period	CQICH channel period	0		int	[0
CQICH_FrameOffset	CQICH channel frame offset	0		int	[0
CQICH_Duration	CQICH channel duration	0		int	[0
CQICH_FeedbackType	CQICH channel feedback type: physical CINR feedback, effective CINR feedback	physical CINR feedback		enum	
CQICH_CINR_Type	CQICH channel CINR preamble report type: Frequency reuse factor = 1 config, Frequency reuse factor = 3 config	Frequency reuse factor = 1 config		enum	
CQICH_AvgParamIncluded	CQICH channel average parameter included for physical CINR feedback: NO, YES	NO		enum	
CQICH_AvgParam	CQICH channel average parameter for physical CINR feedback	0		int	[0
CQICH_MIMO_FBCycle	CQICH channel MIMO permutation feedback cycle	0		int	[0
UL_ZoneIE_Enable	UIUC15_Ext04 is inserted or not: NO, YES	NO		enum	
UL_ZoneSymOffset	Symbol offset in UL zone	0		int	[0
UL_ZoneType	UL zone type: UL_PUSC, UL_OPUSC	UL_PUSC		enum	
UL_PermBase	Uplink permutation base	0		int	[0
UL_AllSCIndicator	Use all subchannels or not: NO, YES	NO		enum	
PHYMOD_UL_Enable	UIUC15_Ext05 IE is inserted or not: NO, YES	NO		enum	
PHYMOD_PrmlModType	Preamble modifier type: Frequency shifted, Time shifted	Frequency shifted		enum	
PHYMOD_PrmlShiftIdx	Preamble frequency or time shift index	0		int	[0
PHYMOD_PilotPatternMod	Pilot pattern modified or not: NO, YES	NO		enum	
PHYMOD_PilotPatternIdx	Pilot pattern index: Pattern A, Pattern B, Pattern C, Pattern D	Pattern A		enum	
MIMO_Basic_Enable	UIUC15_Ext06 IE is inserted or not: NO, YES	NO		enum	
MIMO_Basic_NumAssign	Number of Bursts assignment	1		int	[1
MIMO_Basic_Clt_SM_Idt	collaborative SM indicator, 0:non collaborative SM, 1:collaborative SM	{0}		int array	[0
MIMO_Basic_MIMO_Ctl	MIMO mode, 0: STTD, 1:SM, effective when MIMO_Basic_Clt_SM_Idt = 0	{0}		int array	[0
MIMO_Basic_CID_A	Uplink CID that shall use pilot pattern A	{1}		int array	[0
MIMO_Basic_UIUC_A	UIUC used for allocations that shall use pilot pattern A	{0}		int	[0

				array	
MIMO_Basic_CID_B	Uplink CID that shall use pilot pattern B	{1}		int array	[0
MIMO_Basic_UIUC_B	UIUC used for allocations that shall use pilot pattern B	{0}		int array	[0
MIMO_Basic_Duration	Assigned slots of each allocation	{6}		int array	[1
FstTracking_Enable	UIUC15_Ext07 IE is inserted or not: NO, YES	NO		enum	
FstTracking_Len	Fast indication bytes length	1		int	[1
FstTracking_PowCorr	Power correction indication: 0:no change,1:+2dB,2:-1dB,3:-2dB,4:-4dB,5:-6dB,6:4dB,7:6dB	{0}		int array	[0
FstTracking_FreqCorr	Frequency correction indication	{0}		int array	[0
FstTracking_TimeCorr	Time correction indication:0:0, 1:1, 2:-1	{0}		int array	[0
AllcInOthSeg_Enable	UIUC15_Ext08 IE is inserted or not: NO, YES	NO		enum	
AllcInOthSeg_UIUC	UIUC for other BS' sector	0		int	[0
AllcInOthSeg_SegNum	Segment number for other BS' sector	0		int	[0
AllcInOthSeg_Prmbase	UL Permbase for other BS' sector	0		int	[0
AllcInOthSeg_SymOffst	OFDMA symbol offset for other BS' sector	0		int	[0
AllcInOthSeg_SubOffst	Subchannel offset for other BS' sector	0		int	[0
AllcInOthSeg_Duration	Duration for other BS' sector	1		int	[1
AllcInOthSeg_RptCoding	Repetition coding indicator for other BS' sector: no repetition, Repetition 2, Repetition 4, Repetition 6	no repetition		enum	
FstRnging_Enable	UIUC15_Ext09 IE is inserted or not: NO, YES	NO		enum	
FstRnging_HOID_Id	HO ID indicator: MAC Address present, HO ID present	MAC Address present		enum	
FstRnging_HO_ID	HO ID	0		int	[0
FstRnging_MAC_Address	MAC Header for fast ranging ie	{0,0,0,0,0,6}		int array	[0
FstRnging_UIUC	UIUC for fast ranging ie	0		int	[0
FstRnging_Duration	Duration for fast ranging ie	1		int	[1
FstRnging_RptCoding	Repetition coding for fast ranging ie: no_rpt, Rpt_2, Rpt_4, Rpt_6	no_rpt		enum	

Pin Outputs

Pin	Name	Description	Signal Type
1	UL_MAP	output UL_MAP	int

Notes/Equations

1. This model is used to generate most of the UpLink MAP message (UL_MAP) for 802.16e OFDMA system. UL_MAP is a set of information that defines the entire access for a scheduling interval. Both normal UL_MAP message and compressed UL_MAP message can be generated by this model. If parameter XXX_Enable is set to "Yes", the XXX element will be included in the UL_MAP message.
2. The UIUC in UL_MAP message is used to define the type of uplink access and the burst type associated with that access. The supported UIUC and message format are provided in *OFDMA UIUC Values and IE Format*.

UIUC	IE format	Usage
0	Table 295a in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	FAST-FEEDBACK Channel
1-10	Table 15 in *IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October 1, 2004.*	Different burst profiles(Data Grant Burst Type)
11	Table 290b in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	Extended UIUC 2 IE
11-00	Table 302b in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in*	CQICH_Enhanced_Allocation_IE

	Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.	
11-01	Table 302d in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	HO_Anchor_Active_UL-MAP_IE
11-02	Table 302e in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	HO_Active_Anchor UL MAP
11-03	Table 302i in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	Anchor_BS_switch_IE
11-04	Table 316a in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	UL_sounding_command_IE
11-06	Table 302f in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	MIMO UL Enhanced IE
11-08	Table 302t in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	HARQ ACKCH Region Allocation IE
11-0E	Table 302u in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	AAS_SDMA_UL_IE
11-0F	Table 302v in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	Feedback_polling_IE
12	Table 287 in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	CDMA Bandwidth Request, CDMA Ranging
13	Table 289 in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	PAPR reduction allocation, Safety zone
14	Table 290 in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	CDMA Allocation IE
15	Table 291 in *IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October 1, 2004.*	Extended UIUC
15-00	Table 292 in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	Power_control_IE
15-01	Table 295 in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	Mini-subchannel_allocation_IE

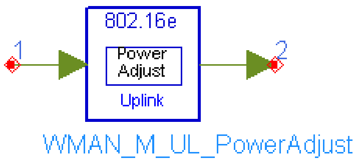
15-02	Table 293 in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	AAS_UL_IE
15-03	Table 300 in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	CQICH_Alloc_IE
15-04	Table 294 in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	UL Zone IE
15-05	Table 302 in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	PHYMOD_UL_IE
15-06	Table 299 in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	MIMO_UL_Basic_IE
15-07	Table 302h in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	UL-MAP_Fast_Tracking_IE
15-08	Table 302c in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	UL_PUSC_Burst_Allocation_in_Other_Segment_IE
15-09	Table 302g in *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.*	Fast_Ranging_IE

3. The OFDMA UL_MAP message and UL_MAP IE format are defined in Table 18, Table 287, respectively, in Reference [2]. The OFDMA MAC header formate is defined in Table 4 of Reference [1].The compressed UL_MAP message format is defined in Table 306 of *IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.* and *IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October 1, 2004.*.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_PowerAdjust (802.16e OFDMA Uplink Power Adjust)



Description: Uplink power adjustment
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24	int	[3,1212]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
NumberOfBurst	Number of Bursts	1	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}	int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}	int array	[1,6868]
BurstPowerOffset	Power offset of each burst in dB	{0}	real array	(-∞,∞)
RangingEnable	Ranging channel enabled or not: NO, YES	NO	enum	
RangingAllocation	Ranging allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0,0,3,6}	int array	[0,∞)
RangingPowerOffset	Ranging power offset in dB	0	real	(0,∞)
FastFeedBackEnable	Fast feedback channel enabled or not: NO, YES	NO	enum	
FastFeedBackAllocation	FastFeedBack allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0,6,3,6}	int array	[0,∞)
FastFeedBackPowerOffset	Fast FeedBack power offset in dB	0	real	(0,∞)
HARQ_ACK_Enable	HARQ ACK channel enabled or not: NO, YES	NO	enum	
HARQ_ACK_Allocation	HARQ ACK allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0,12,3,6}	int array	[0,∞)
HARQ_ACK_PowerOffset	HARQ-ACK power offset in dB	0	real	(0,∞)
FrameLength	Frame length	56000	int	[1,∞)
PowerType	Power definition (Peak power in frame, Average power for data zone when all subchs occupied): Peak power, Average power when all subchs occupied	Average power when all subchs occupied	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	input	input data before power adjustment	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	output	output data after power adjustment	complex

Notes/Equations

1. This model is used to adjust the uplink output power according to the parameter PowerType.

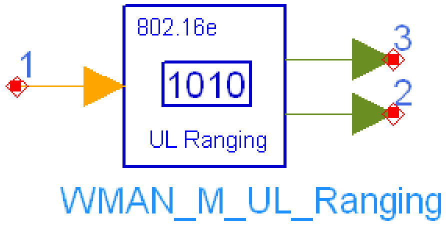
2. Each firing,
   - $Samples_{Frame}$ tokens are consumed at pin input,

     where $Samples_{Frame}$ is the frame length defined by the parameter FrameLength.
   - $Samples_{Frame}$ tokens are produced at pin output.
3. In Mobile WiMAX, currently there is no unified method on the definition of transmit power. Two different uplink power definitions are provided in Mobile WiMAX wireless design library to meet with different requirements.
4. For more information, refer to *Transmit Power Definition* (wman_m).

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_Ranging (802.16e OFDMA Uplink Ranging)



Description: Uplink ranging codes generator
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Type	Range
ZoneType	Zone type: UL_PUSC, UL_OPUSC	UL_PUSC	enum	
UL_PermBase	Uplink permutation base	0	int	[0, 69]
RangingMethod	Ranging method: Initial Ranging over 2 symbols, Initial Ranging over 4 symbols, Periodic Ranging over 1 symbol, Periodic Ranging over 3 symbols, BW Request over 1 symbol, BW Request over 3 symbols, Handover Ranging over 2 symbols, Handover Ranging over 4 symbols	Initial Ranging over 2 symbols	enum	
RangingAllocation	Rectangular allocation: (SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0,0,3,6}	int array	[0,1211]
RangingSlotChosen	The index of slot for carrying the ranging code.	0	int	[0,∞)

Pin Inputs

Pin	Name	Description	Signal Type
1	RangingCodeChosen	input of code chosen	int

Pin Outputs

Pin	Name	Description	Signal Type
2	ModulatedData	output of all the modulated data in the Ranging burst	complex
3	Ranging_Msg	output of modulated data for the ranging code chosen	complex

Notes/Equations

1. This model is used to generate uplink ranging codes and modulated QAM data.
2. Each firing,
   One token is consumed at pin RangingCodeChosen;
   $NumberOfSlots \times 72$ tokens are produced at pin ModulatedData, where NumberOfSlots specifies the total number of slots allocated to the Ranging burst which is calculated from RangingAllocation. RangingAllocation specifies the allocation of Ranging burst in the form of {SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs}; 72 is the total number of subcarriers in one slot including data subcarriers (48) and pilot subcarriers (24).
   $144 \times NumberOfCodesUsed$ tokens are produced at pin Ranging_Msg, where NumberOfCodesUsed is dependent on the RangingMethod selected according to the specification, shown in *The Calculation of NumberOfCodesUsed*.

Ranging Method	NumberOfCodesUsed
Initial Ranging over 2 symbols	1
Initial Ranging over 4 symbols	2
Periodic Ranging over 1 symbol	1
Periodic Ranging over 3 symbols	3
BW Request over 1 symbol	1
BW Request over 3 symbols	3
Handover Ranging over 2 symbols	1
Handover Ranging over 4 symbols	2

3. Each firing, one token is read from pin RangingCodeChosen. This token is taken as the starting index of Ranging code (N) whose range is [0, 255]. Then according to the RangingMethod selected, the number of Raning codes (NumberOfCodesUsed) is determined. For example, the starting index (N) is 20, and RangingMethod is Periodic Ranging over 3 symbols, then the number of Ranging codes is 3; The array of Ranging codes is {20, 21, 22}, and Raning code 20 is transmitted on the first symbol and Ranging code 21 is on the sencod symbol, etc.
4. Each Ranging code has 144 bits generated by the following PRBS generator.

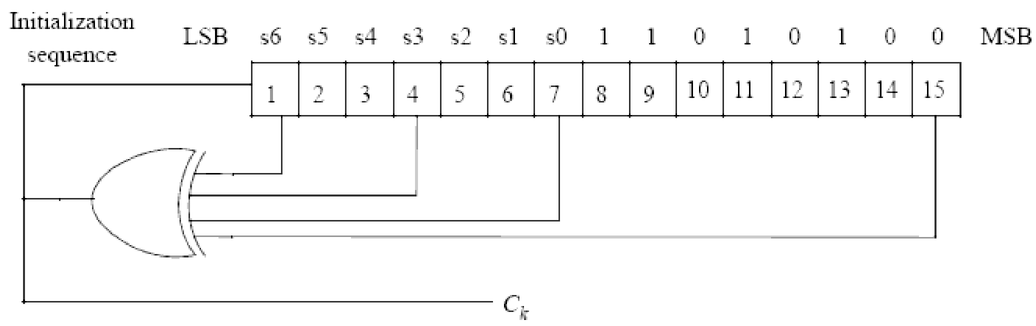


Figure 243—PRBS generator for ranging code generation

PRBS Generator for Ranging Code Generation

The PRBS generator shall be initialized by the seed
b0...b15 = 0,0,1,0,1,0,1,1,s0,s1,s2,s3,s4,s5,s6 where s6 is the LSB of the PRBS seed, and s6:s0 = UL_PermBase, where s6 is the MSB of UL_PermBase.
The first 144 bits output is allocated to Ranging code 0, and the next ranging code is produced by taking the output of the 145th to 288th clock of the PRBS generator, etc.
These 144 bits are used to modulate the subcarriers (BPSK) in a group of six adjacent subchannels, where subchannels are considered adjacent if they have successive logical subchannel numbers. The bits are mapped to the subcarriers in increasing frequency order of the subcarriers, such that the lowest indexed bit modulates the subcarrier with the lowest frequency index and the highest indexed bit modulates the subcarrier with the highest frequency index. The six subchannels are called a ranging subchannel. The ranging subchannel is referenced in the ranging and Bandwidth Request messages by the index of lowest numbered subchannel.
For CDMA ranging and BW request, the ranging opportunity size is the number of symbols required to transmit the appropriate ranging/BW request code (1,2,3 or 4 symbols), and is denoted N1. N2 denotes the number of subchannels required to transmit a ranging code (6 for UL PUSC). Then the ranging allocation is subdivided into slots of N1 OFDMA symbols by N2 subchannels, shown in Ranging/BW Request Opportunities.
The RangingSlotChosen specifies the index of the ranging opportunity where the Ranging code(s) are allocated.

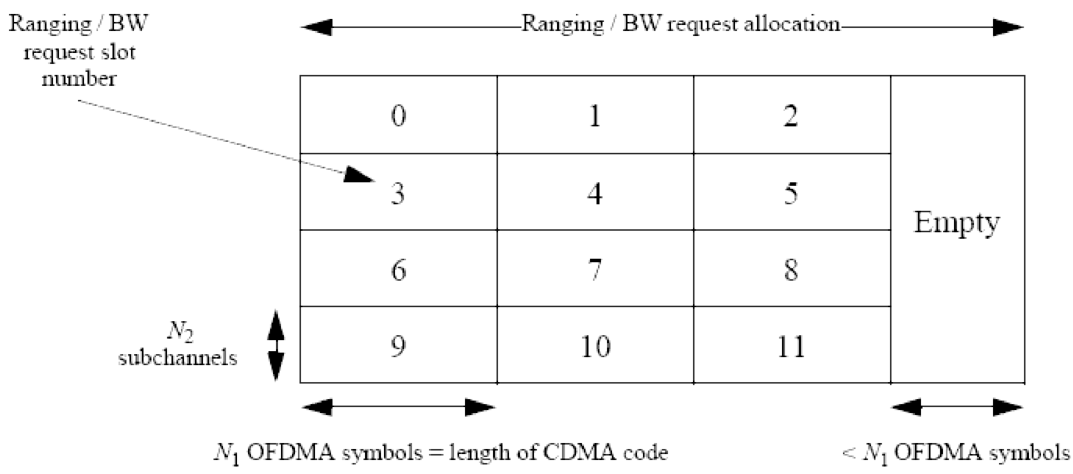


Figure 243a—Ranging/BW request opportunities

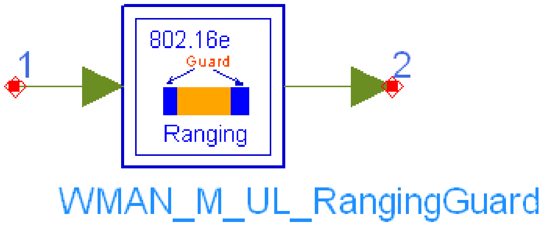
Ranging/BW Request Opportunities

The allocation of ranging burst is allowed only in uplink PUSC.
For more information about uplink ranging, please refer to 8.4.7 in Reference [2].

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_RangingGuard (802.16e OFDMA Uplink Ranging Guard)



Description: Uplink ranging guard insertor
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Unit	Type	Range
Bandwidth	Nominal bandwidth	3.5 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	FDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01 , 0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 10 ms		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[0,20000]
ZoneNumOfSym	Number of OFDM symbol in zone	24		int	[3,1212]
RangingMethod	Ranging method: Initial Ranging over 2 symbols, Initial Ranging over 4 symbols, Periodic Ranging over 1 symbol, Periodic Ranging over 3 symbols, BW Request over 1 symbol, BW Request over 3 symbols, Handover Ranging over 2 symbols, Handover Ranging over 4 symbols	Initial Ranging over 2 symbols		enum	
RangingAllocation	Ranging allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0,0,3,6}		int array	[0,∞]
RangingTimingOffset	Ranging timing offset (Negative:transmit ahead of schedule; Positive:transmit behind schedule	0 usec	sec	real	(-∞,∞)

Pin Inputs

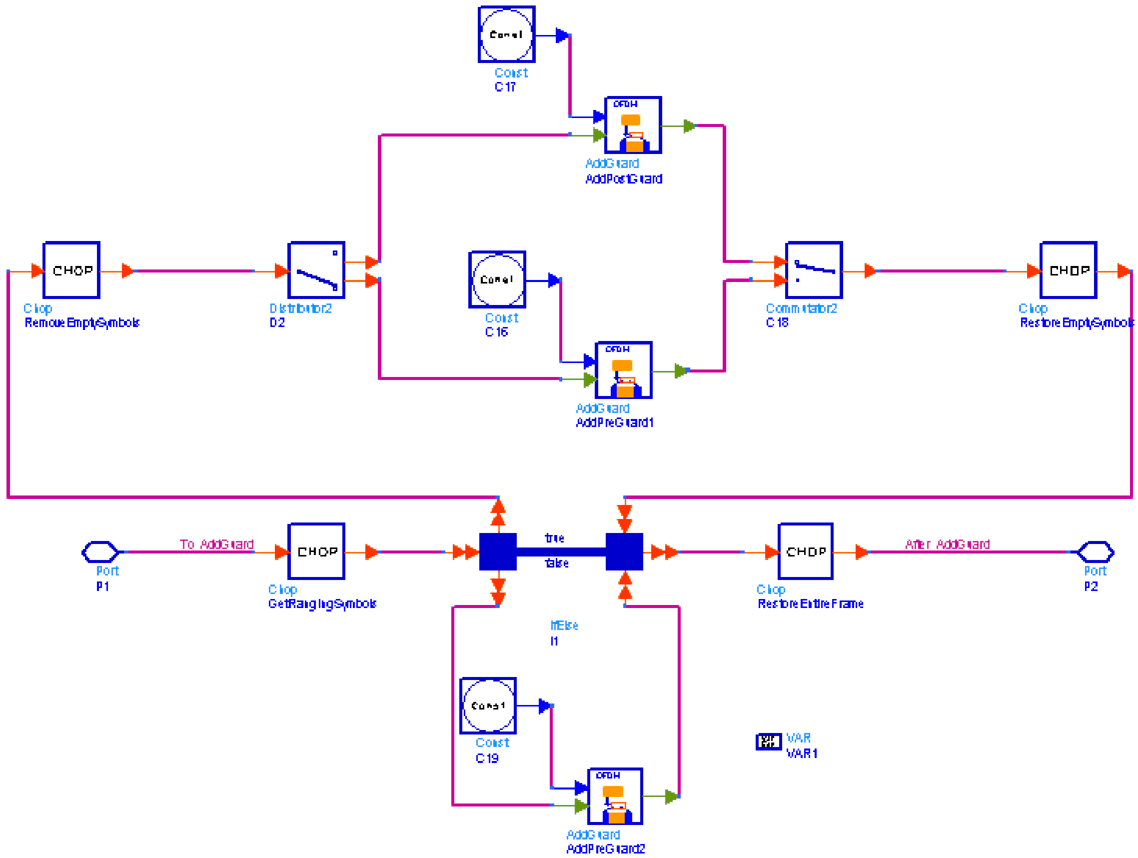
Pin	Name	Description	Signal Type
1	input	input data	complex

Pin Outputs

Pin	Name	Description	Signal Type
2	output	output data	complex

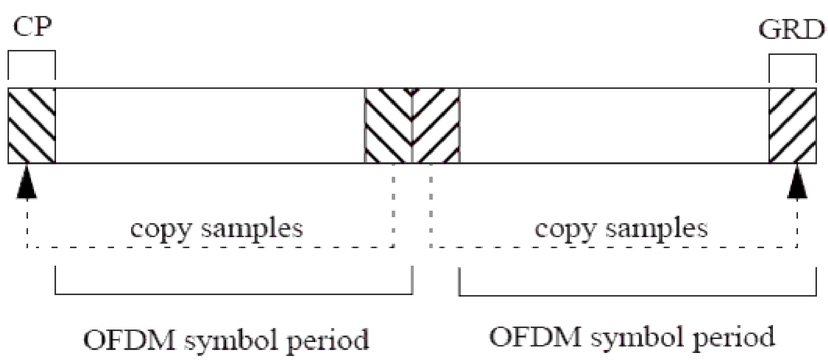
Notes/Equations

1. This subnetwork is used to add guard to the ranging burst.
2. The schematic of this subnetwork is shown in WMAN_M_UL_RangingGurad Schematic.



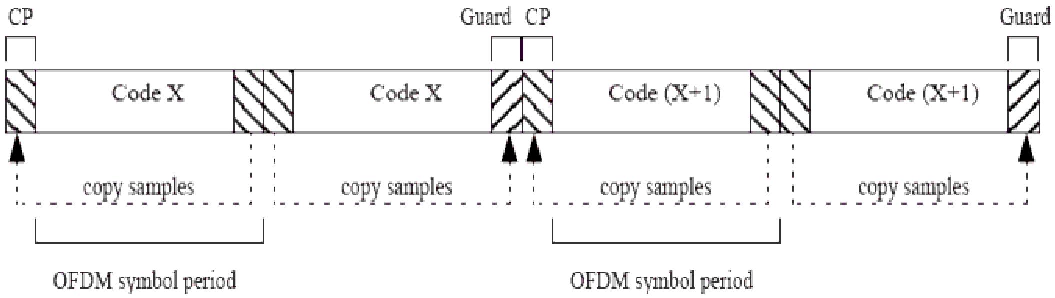
WMAN_M_UL_RangingGurad Schematic

3. For initial-ranging/handover-ranging over 2 symbols, the transmissions shall be performed during two or four consecutive symbols. The same ranging code is transmitted on the ranging channel during each symbol, with no phase discontinuity between the two symbols. A time-domain illustration of the initial-ranging/handover-ranging transmission is shown in Initial-Ranging/handover-ranging Over 2 Symbols.



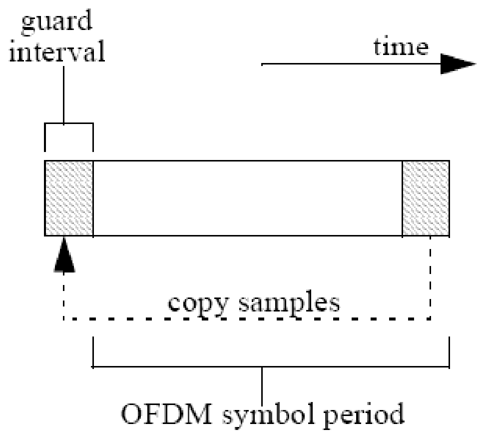
Initial-Ranging/handover-ranging Over 2 Symbols

4. For initial-ranging/handover-ranging over 4 symbols, the BS can allocate two consecutive initial-ranging/handover-ranging slots, onto those the MS shall transmit the two consecutive initial-ranging/handover-ranging codes. A time-domain illustration of the initial-ranging/handover-ranging transmission is shown in Initial-Ranging/handover-ranging Over 4 Symbols.



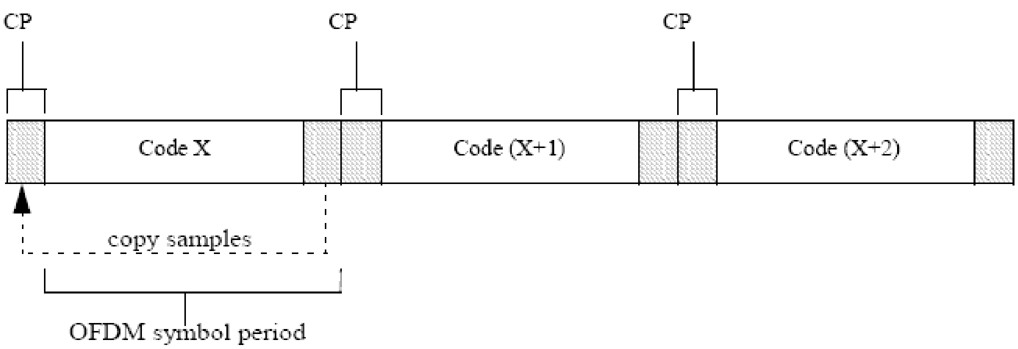
Initial-Ranging/handover-ranging Over 4 Symbols

5. For periodic-ranging/bandwidth-request over 1 symbol, the transmissions shall be in a period of one OFDMA symbol. A timedomain illustration of the periodic-ranging or bandwidth-request transmission is shown in Periodic-Ranging/bandwidth-request Over 1 Symbol.



Periodic-Ranging/bandwidth-request Over 1 Symbol

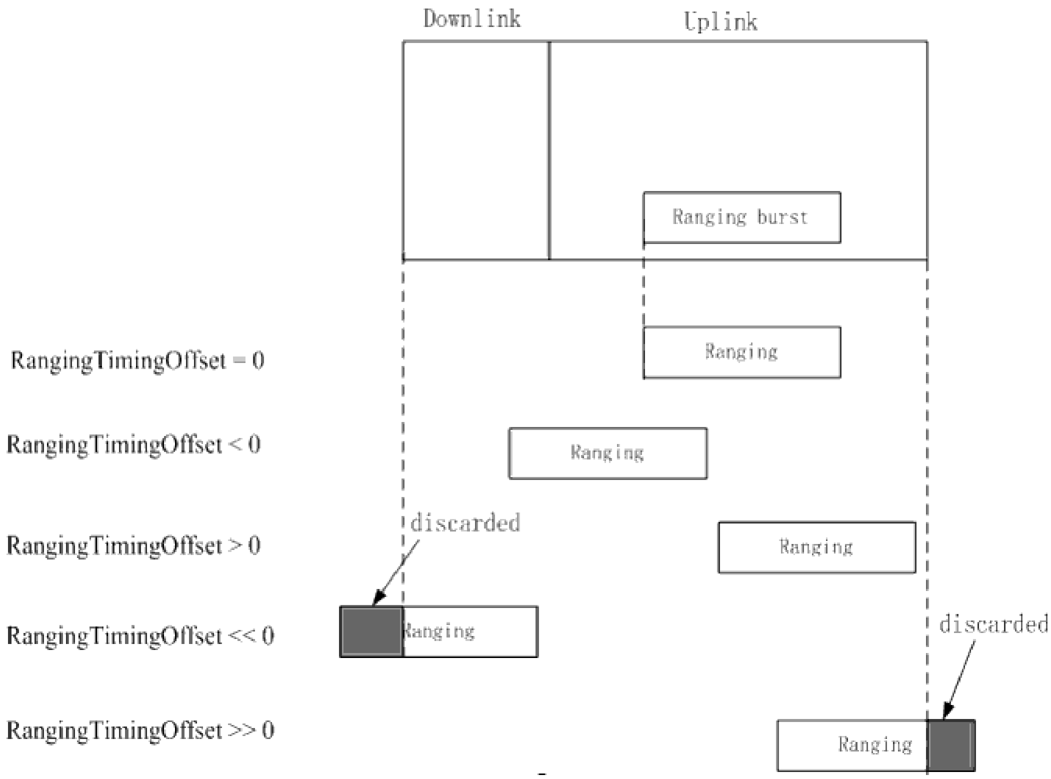
6. For periodic-ranging/bandwidth-request over 3 symbols, the transmissions shall be in a period of three OFDMA symbol (one code per symbol). A timedomain illustration of the periodic-ranging or bandwidth-request transmission is shown in Periodic-ranging/bandwidth-request Over 3 Symbols.



Periodic-ranging/bandwidth-request Over 3 Symbols

7. In this subnetwork, the timing offset (defined by RangingTimingOffset) of the ranging burst related to the uplink subframe is implemented. The limitation for the timing offset is,
   - when the transmission of the ranging burst is ahead of the start of the entire frame, the portion (the gray portion when RangingTimingOffset<< 0 in Ranging Timing Offset) ahead of the start of the entire frame will be discarded.
   - when the transmission of the ranging burst is behind the end of the uplink subframe, the portion (the gray portion when RangingTimingOffset>> 0 in Ranging Timing Offset) behind the end of the uplink

subframe will be discarded.

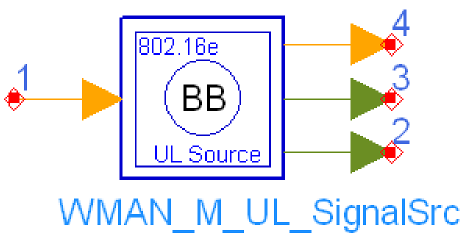


Ranging Timing Offset

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_SignalSrc (802.16e OFDMA Uplink Signal Source)



Description: Uplink signal src
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Unit	Type	Range
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01 , 0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[0,20000]
PreambleIndex	Preamble index	3		int	[0,113]
FrameNumber	Frame number	0		int	[1,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
UL_PermBase	Uplink permutation base	0		int	[0 , 69]
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	YES		enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array	[0,255]
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24		int	[3,1212]
ZoneSymOffset	Symbol offset in zone	0		int	[0,1211]
NumberOfBurst	Number of Bursts	1		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}		int array	[1,6868]
DataLength	MAC PDU payload byte length of each burst	{300}		int array	[1,∞)
CodingType	Coding type of each burst	{0}		int array	[0,1]
Rate_ID	Rate ID of each burst	{3}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0}		int array	[0,3]
BurstPowerOffset	Power offset of each burst in dB	{0}		real array	[-∞,∞]
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupiedd): Peak power, Burst power when all subchs occupied	Burst power when all subchs occupied		enum	
HARQ_Enable	Whether bursts are HARQ-enabled: NO, YES	NO		enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	

Pin Inputs

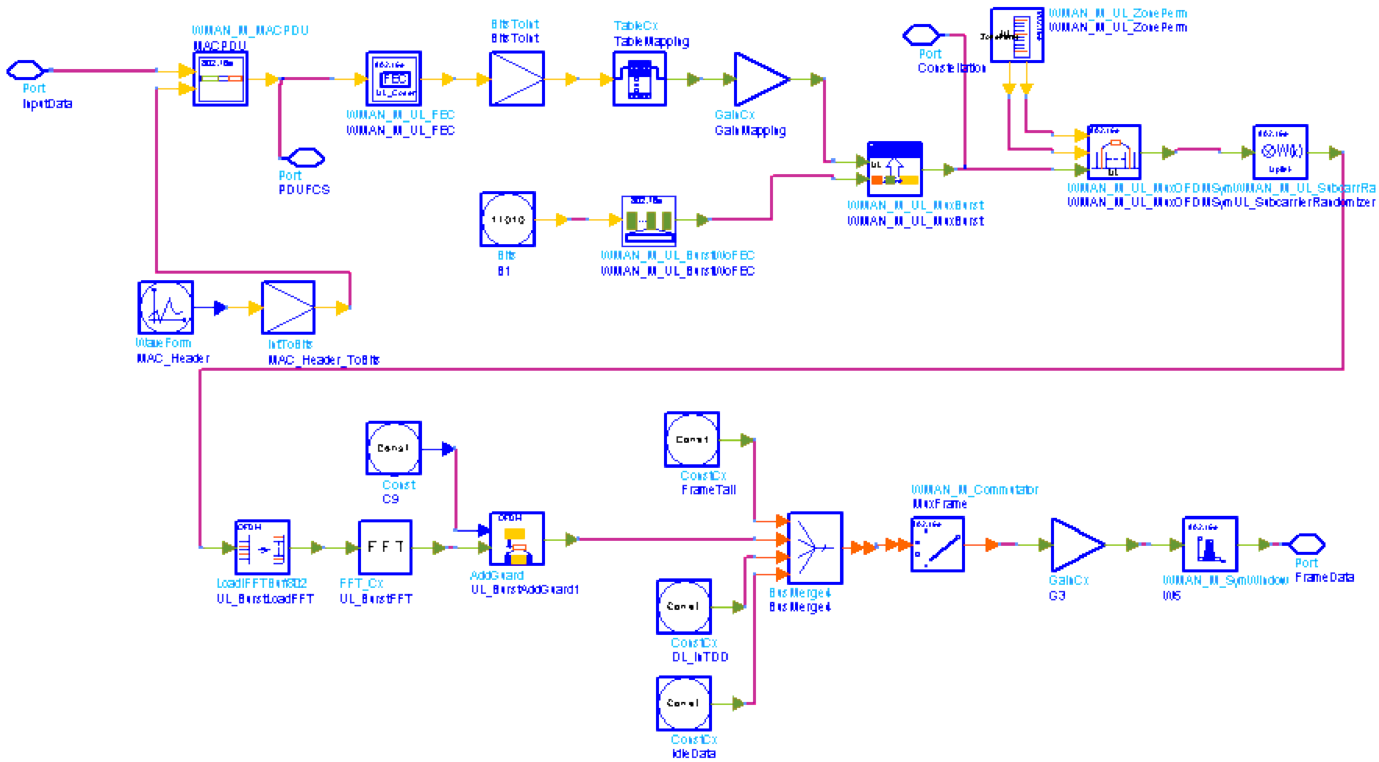
Pin	Name	Description	Signal Type
1	InputData	input of raw data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	FrameData	output of uplink Subframe	complex
3	Constellation	output of Modulated data of all bursts	complex
4	PDUFCS	output of MAC PDU data of burst with FEC	int

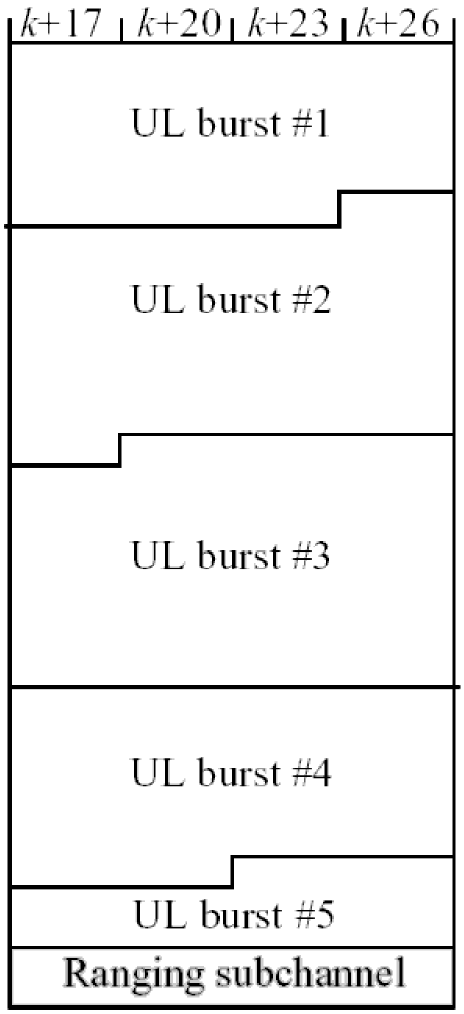
Notes/Equations

1. This subnetwork generates an 802.16e OFDMA Uplink subsystem baseband signal. The schematic for this subnetwork is shown in WMAN_M_UL_SignalSrc Schematic.



WMAN_M_UL_SignalSrc Schematic

2. The input of this subnetwork is MAC PDU data of the FEC-encoded burst; MAC header data can be either specified by MAC_Header or generated automatically.
3. WMAN_M_UL_SignalSrc is implemented according to specification. WMAN OFDMA UL Frame Structure shows the uplink frame format. It includes only one zone (alternative PUSC, OPUSC or AMC) which contains maximum 8 bursts carrying one MAC PDU each. Among these bursts, only one burst is FEC-encoded whose coding type can be set to CC or CTC. Other bursts are provided PN sequences as their coded source respectively. Both TDD mode and FDD mode can be supported for the uplink source.



WMAN OFDMA UL Frame Structure

Note that the allocation of Ranging, Fast FeedBack, HARQ ACK bursts is only available in WMAN_M_UL_Src_Ranging.

- The CC-encoded burst is coded in the following manner:
  - Add MAC header with parameter MAC_Header or generate MAC header automatically by WMAN_M_MACPDU.
- Randomized by WMAN_M_UL_Randomizer.
  - CC encoded and punctured by WMAN_M_UL_CC.
  - Interleaved by WMAN_M_UL_Interleaver.
  - Repeated by WMAN_M_UL_Repetition.
- The CTC-encoded burst is coded in the following manner:
  - Add MAC header with parameter MAC_Header or generate MAC header automatically by WMAN_M_MACPDU.
  - Randomized by WMAN_M_UL_Randomizer.
  - CTC encoded by WMAN_M_UL_CTC.
  - Repeated by WMAN_M_UL_Repetition.
- After encoding, the encoded burst is mapped to the constellation. Other bursts without FEC, are provided PN sequence as their coded bits and mapped to the constellation according to their Rate_ID by WMAN_M_UL_BurstWoFEC. The FEC-encoded burst is concatenated with non-coded bursts by WMAN_M_UL_MuxBurst.
- The physical indices of data subcarriers and pilot subcarriers for each burst are calculated by WMAN_M_UL_ZonePerm. The data sequences and pilot sequences are placed to their physical subcarrier location by WMAN_M_UL_MuxOFDMSym. Then the useful subcarriers are randomized by

WMAN_M_UL_SubcarrRandomizer. After IFFT and cyclic prefix insertion, the idle interval and uplink payload are combined with zero padding bits if needed by WMAN_M_Commutator. In addition, downlink position will be preserved and filled with zeros before uplink payload if FrameMode is TDD.
At last, oversampling is implemented by a transmitter filter.

4. Parameter Details.
   - Bandwidth determines the nominal channel bandwidth.
   - OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
   - FFTSize indicates the FFT point size (512, 1024, or 2048). The FFT size is independent of the selected bandwidth.
   - CyclicPrefix (G) specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
   - FrameMode determines what will actually be included in the generated waveform. FDD Mode means the entire frame is used for the uplink and the uplink starts at the beginning of the frame. TDD Mode means only the uplink is included in the generated waveform and it starts at some delay from the frame start time based on the Downlink Ratio setting.
   - DL_Ratio set the percentage (1 to 99) of the frame time to be used for the downlink and also set the start time for the uplink. The parameter is only active when the frame mode is TDD.
   - FrameDuration determines the frame durations (ms) of the generated waveform. There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
   - IdleInterval specifies the time of idle interval between two consecutive frames.
   - PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to Table 309 in the standard.
   - FrameNumber specifies the frame number(0 to 0xffffff) of the uplink frame.
   - FrameIncreased indicates whether the frame number of the generated waveform is increased one by one.
   - UL_PermBase specifies the permutation base that will be used in this uplink zone. Accepted values are 0 to 69.
   - AutoMACHeaderSetting indicates whether the MAC Header is calculated automatically. If it is set to NO, data sequences in parameter MAC_Header will be used before data content, otherwise MAC_Header content will be calculated with parameter DataLength and CID and be used before data content.
   - MAC_Header specifies 6 bytes of MAC header before the data contents. The parameter is only active when the AutoMACHeaderSetting is set to NO.
   - CRC32_Mode specifies the method for CRC32 calculation appended to MAC PDU. For consistency with 802.16e-2005, it shall be set to MSB first while shall be set to LSB first for consistency with 802.16-2004 Cor1/D3.
   - ZoneType specifies the zone type which can be set to PUSC, OPUSC or AMC.
   - ZoneNumOfSym specifies the number of symbols in the zone. The value must be a multiple of three because the uplink zone is divided into slots of 3 symbols x 1 subchannel for PUSC, OPUSC and AMC with 2x3. For AMC with 1x6, the value should be a integer multiple of six. For AMC with 3x2, the value should be a integer multiple of two. The maximum number of symbols available depends on the Bandwidth, frame length, DL_Ratio, FFTSize, and CyclicPrefix.
   - NumberOfBurst specifies the number of active uplink bursts.
   - BurstWithFEC specifies the uplink burst FEC.
   - BurstSymOffset positions each burst on the horizontal axis (x), if necessary, to avoid any burst overlap. The parameter is an array element .
   - BurstSubchOffset positions each burst on the vertical axis (y), if necessary, to avoid any burst overlap. The parameter is an array element.
   - BurstAssignedSlot specifies the total available slots in each burst. The parameter is an array element.
   - DataLength is the array of each burst's MAC PDU payload data length in bytes.
   - CodingType is the array of each burst's coding type which can be set to CC or CTC.
   - Rate_ID is the array of each burst's Rate ID, whose range is from 0 to 6 for CC encoding and from 0 to 7 for CTC encoding. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in *The Relation of Coding Type and Rate ID*.

Coding type	Rate ID	<th
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. The parameter is an array element and only available when QPSK 1/2 or QPSK 3/4 is selected as the burst profile (Rate_ID). Each repetition coding can be selected from 0 to 3, whose meaning is shown in *The Meaning of Repetition Coding*.

Repetition coding	Meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4used on the burst
3	Repetition coding of 6used on the burst

- BurstPowerOffset determines the power offset of each burst in dB. The parameter is an array element.
- PowerType specifies the exact meaning of the parameter Power in RF source. Two types are defined in uplink (Type I: Peak power; Type II: Burst power when all subchs occupied). Type I is recommended for transmitter measurement; Type II is recommended for receiver measurement. For more information, please refer to *Transmit Power Definition* (wman_m).
- HARQ_Enable specifies whether all the bursts allocated are HARQ-enabled. When HARQ_Enable = YES, see *HARQ transmission* (wman_m) for more information.
- AMC_Mode specifies the AMC mode which could be 1x6 (1 bin by 6 symbols), 2x3 (2 bins by 3 symbols) or 3x2 (3 bins by 2 symbols) for the downlink bursts when the ZoneType = UL_AMC.

5. Samples per frame
The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-11-26-226.gif!) as follows,
$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$
The sampling factors are listed in *Sampling Factor Requirement*.

Sampling factor n	Bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

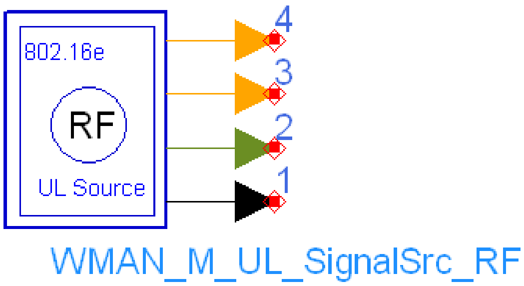
The samples of IdleInterval ($Samples_{idle}$) is calculated as follows:
$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$
So, the total samples of one uplink frame $Samples_{Frame}$ is
$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$
This model works frame by frame. Each firing,
$8 \times DataLength[BurstWithFEC]$ tokens are consumed at pin MAC_PDU,
$Samples_{Frame}$ tokens are produced at pin FrameData,
$\sum_{i=1}^{NumberOfBurst} BurstAssignedSlot[i] \times 48$ tokens are produced at pin Constellation,
$8 \times DataLength[BurstWithFEC] + 80$ tokens are produced at pin PDUFCS.

6. Output delay
No delay is introduced by WMAN_M_SymWindow in this design.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_SignalSrc_RF (802.16e OFDMA Uplink RF Signal Source)



Description: Uplink RF signal source
Library: WMAN 16e, Signal Source

Parameters

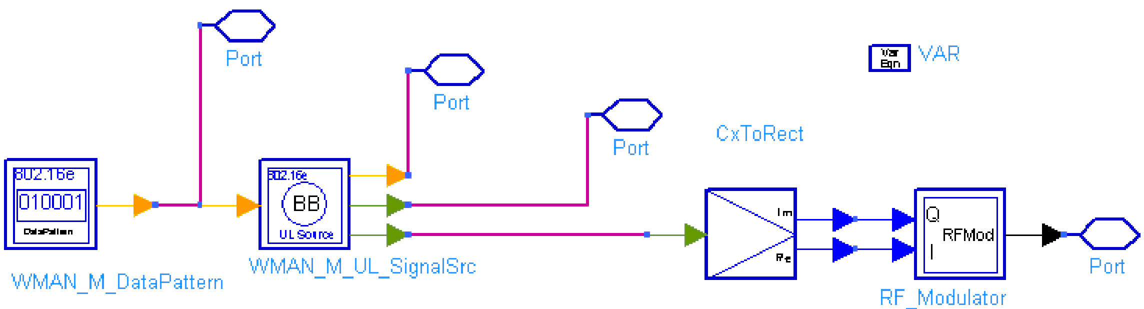
Name	Description	Default	Unit	Type	Range
ROut	Output resistance	DefaultROut	Ohm	int	(0,∞)
RTemp	Temperature, in degrees C	DefaultRTemp	Celsius	real	[-273.15,∞]
FCarrier	Carrier frequency	3407 MHz	Hz	real	(0,∞)
Power	Transmit power (the meaning of Power is defined in Parameter PowerType)	0.01 W	W	real	(0,∞)
MirrorSpectrum	Mirror spectrum about carrier?: NO, YES	NO		enum	
GainImbalance	Gain imbalance in dB, Q channel relative to I channel	0.0		real	(-∞,∞)
PhaseImbalance	Phase imbalance in degrees, Q channel relative to I channel	0.0		real	(-∞,∞)
I_OriginOffset	I origin offset in percent with repect to output rms voltage	0.0		real	(-∞,∞)
Q_OriginOffset	Q origin offset in percent with repect to output rms voltage	0.0		real	(-∞,∞)
IQ_Rotation	IQ rotation in degrees	0.0		real	(-∞,∞)
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01,0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
PreambleIndex	Preamble index	3		int	[0,113]
FrameNumber	Frame number	0		int	[0,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
UL_PermBase	Uplink permutation base	0		int	[0 , 69]
DataPattern	WMAN data pattern: PN9, PN15, FIX4, _4_1_4_0, _8_1_8_0, _16_1_16_0, _32_1_32_0, _64_1_64_0, S_QPSK, S_16-QAM, S_64-QAM	PN9		enum	
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	YES		enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array	[0,255]
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24		int	[3,1212]
NumberOfBurst	Number of bursts	1		int	[1,8]
BurstWithFEC	Number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}		int array	[1,6868]
DataLength	MAC PDU payload byte length of each burst	{300}		int array	[1,∞)
CodingType	Coding type of each burst	{0}		int array	[0,1]
Rate_ID	Rate ID of each burst	{3}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0}		int array	[0,3]
BurstPowerOffset	Power offset of each burst in dB	{0}		real array	(-∞,∞)
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupiedd): Peak power, Burst power when all subchs occupied	Burst power when all subchs occupied		enum	
HARQ_Enable	Whether bursts are HARQ-enabled: NO, YES	NO		enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3		enum	

Pin Outputs

Pin	Name	Description	Signal Type
1	RF	output of RF signal	timed
2	Constellation	output of modulated data of all bursts	complex
3	PDUFCS	output of MAC PDU data of burst with FEC	int
4	PSDU	output of PSDU bits	int

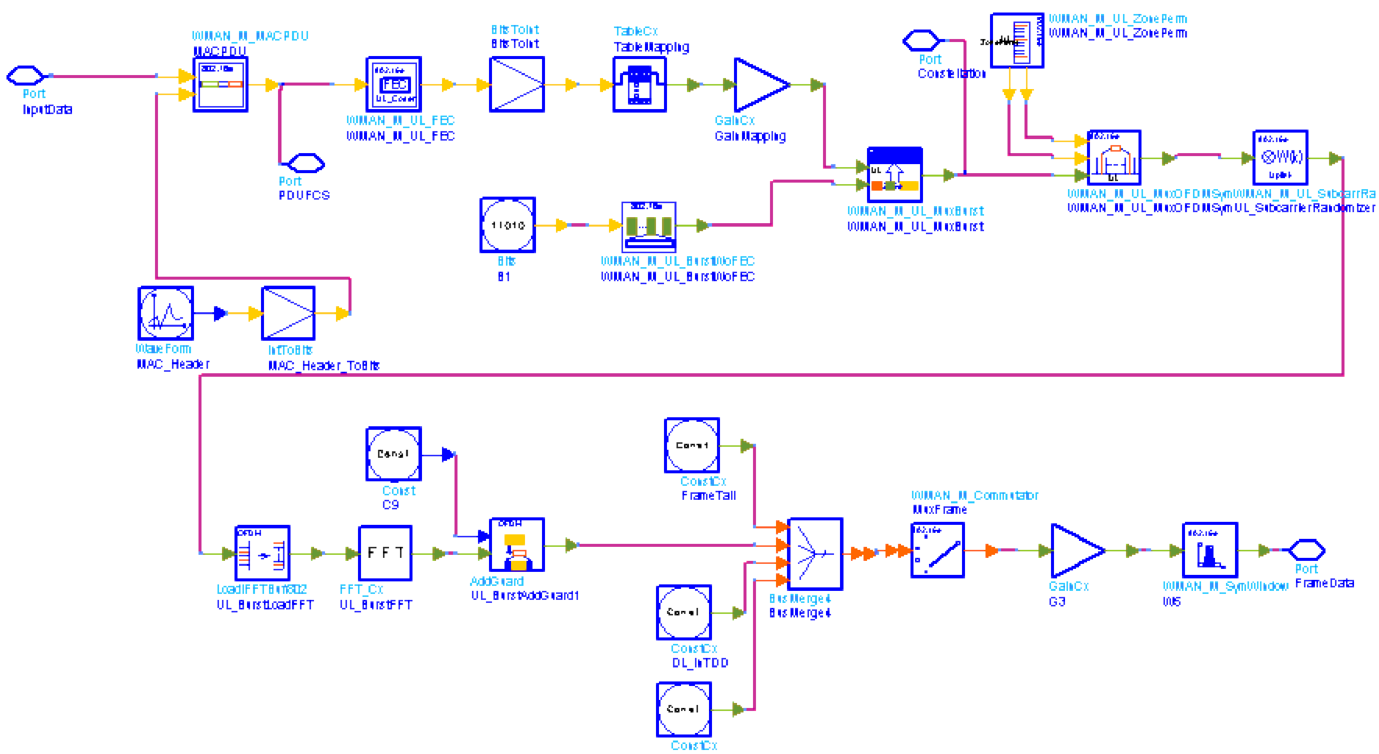
Notes/Equations

1. This subnetwork generates an 802.16e OFDMA uplink subsystem RF signal. The subnetwork includes WMAN_M_UL_SignalSrc, which generates the uplink baseband signal of 802.16e uplink subsystem, and the RF_Modulator. The schematic for this subnetwork is shown in WMAN_M_UL_SignalSrc_RF Schematic.



WMAN_M_UL_SignalSrc_RF Schematic

2. The WMAN OFDM downlink baseband signal source format follows the specification. The schematic is shown in WMAN_M_UL_SignalSrc Schematic.



WMAN_M_UL_SignalSrc Schematic

The implementation of WMAN_M_UL_SignalSrc is described in *Uplink baseband signal source* (wman_m).

3. Parameter Details
    - ROut is the RF output resistance.
    - RTemp is the RF output resistance temperature in Celsius and sets the noise density in the RF output signal to (k(RTemp+273.15)) Watts/Hz, where k is Boltzmann's constant.
    - FCarrier is the RF output signal frequency.
    - Power is used to set the modulator output RF power. This is true for an ideal transmitted signal (no impairments added) or when small impairments are added. If large impairments are added to the signal (using GainImbalance, I_OriginOffset, and Q_OriginOffset parameters) the output RF power may be different from the value of the Power parameter.
    - MirrorSpectrum is used to mirror the RF_out signal spectrum about the carrier. This is equivalent to conjugating the complex RF envelope voltage. Depending on the configuration and number of mixers in an RF transmitter, the RF output signal from hardware RF generators can be inverted. If such an RF signal is desired, set this parameter to YES.
    - GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation are used to add certain impairments to the ideal output RF signal. Impairments are added in the order described here.
      The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:
      $$V_{RF}(t) = A\left(V_I(t)\cos(\omega_c t) - gV_Q(t)\sin\left(\omega_c t + \frac{\Phi\pi}{180}\right)\right)$$
      where A is a scaling factor based on the Power and ROut parameters specified by the user, VI(t) is the in-phase RF envelope, VQ(t) is the quadrature phase RF envelope, g is the gain imbalance
      $$g = 10^{\frac{GainImbalance}{20}}$$
      and, ϕ (in degrees) is the phase imbalance.
      Next, the signal VRF(t) is rotated by IQ_Rotation degrees. The I_OriginOffset and Q_OriginOffset are then applied to the rotated signal. Note that the amounts specified are percentages with respect to the output rms voltage. The output rms voltage is given by sqrt(2×ROut×Power).
    - For the other baseband parameters, refer to *Baseband parameters* (wman_m).
4. Samples per frame
   The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-11-27-243.gif!) as follows,
   $$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$
   The sampling factors are listed in Sampling Factor Requirement.

Sampling Factor n	Bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

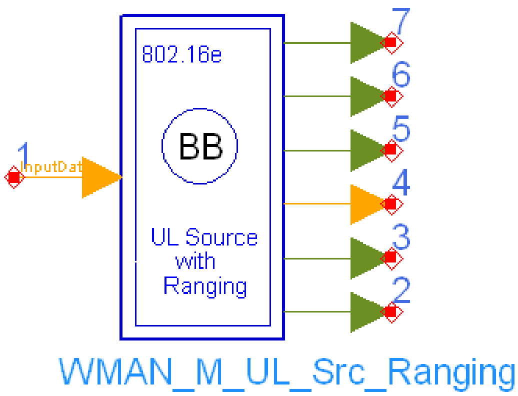
   The samples of IdleInterval (!wman_m-11-27-245.gif!) are calculated as follows:
   $$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$
   So, the total samples of one uplink frame $Samples_{Frame}$ are
   $$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$
   This model works frame by frame. Each firing,
   $8 \times DataLength[BurstWithFEC]$ tokens are produced at pin PSDU,
   $Samples_{Frame}$ tokens are produced at pin RF,
   $\sum_{i=1}^{NumberOfBurst} BurstAssignedSlot[i] \times 48$ tokens are produced at pin Constellation,
   $8 \times DataLength[BurstWithFEC]] + 80$ tokens are produced at pin PDUFCS.
5. Output delay
   No delay is introduced by WMAN_M_SymWindow in this design.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.

2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_Src_Ranging (802.16e OFDMA Uplink Source Ranging)



Description: Uplink baseband signal source with ranging
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Unit	Type	Range
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01 , 0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
IdleInterval	Idle Interval	0 usec	sec	real	[0,20000]
PreambleIndex	Preamble index	3		int	[0,113]
FrameNumber	Frame number	0		int	[1,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
UL_PermBase	Uplink permutation base	0		int	[0 , 69]
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	YES		enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array	[0,255]
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC	UL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24		int	[3,1212]
ZoneSymOffset	Symbol offset in zone	0		int	[0,1211]
SubchannelRotation	Subchannel rotation for UL PUSC enabled or not: NO, YES	YES		enum	
NumberOfBurst	Number of Bursts	1		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{3}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}		int array	[1,6868]
DataLength	MAC PDU payload byte length of each burst	{300}		int array	[1,∞)

CodingType	Coding type of each burst	{0}		int array	[0,1]
Rate_ID	Rate ID of each burst	{3}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0}		int array	[0,3]
BurstPowerOffset	Power offset of each burst in dB	{0}		real array	[-∞,∞]
RangingEnable	Ranging channel enabled or not: NO, YES	NO		enum	
RangingMethod	Ranging method: Initial Ranging over 2 symbols, Initial Ranging over 4 symbols, Periodic Ranging over 1 symbol, Periodic Ranging over 3 symbols, BW Request over 1 symbol, BW Request over 3 symbols, Handover Ranging over 2 symbols, Handover Ranging over 4 symbols	Initial Ranging over 2 symbols		enum	
RangingAllocation	Rectangular allocation: (SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0,29,3,6}		int array	[0,1211]
RangingCodeChosen	The number of ranging code for RangingMethod. The range is [0,255].	{0}		int array	[0,255]
RangingSlotChosen	The number of slot for carrying the ranging code.	0		int	[1,∞]
RangingPowerOffset	Ranging power offset in dB	0		real	(0,∞)
RangingTimingOffset	Ranging timing offset (Negative:transmit ahead of schedule; Positive:transmit behind schedule	0 usec	sec	real	(-∞,∞)
FastFeedBackEnable	Fast feedback channel enabled or not: NO, YES	NO		enum	
FastFeedBackType	FastFeedBack type: FFB_NORMAL, FFB_ENHANCED, FFB_3MIMO	FFB_NORMAL		enum	
FastFeedBackAllocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{3,28,12,7}		int array	[0,∞]
FastFeedBackCodeChosen	The number of Fast FeedBack code for FastFeedBackType. The range is [0,15].	{0}		int array	[0,∞]
FastFeedBackSlotChosen	The number of slot for carrying the Fast FeedBack code.	0		int	[1,∞]
FastFeedBackPowerOffset	Fast FeedBack power offset in dB	0		real	(0,∞)
HARQ_ACK_Enable	HARQ ACK channel enabled or not: NO, YES	NO		enum	
HARQ_ACK_Allocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0,25,3,4}		int array	[0,∞]
HARQ_ACK_CodeChosen	The number of HARQ_ACK code. The range is [0,1].	{1}		int array	[0,∞]
HARQ_ACK_SlotChosen	The number of slot for carrying the HARQ-ACK code.	0		int	[1,∞]
HARQ_ACK_PowerOffset	HARQ-ACK power offset in dB	0		real	(0,∞)
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupiedd): Peak power, Burst power when all subchs occupied	Burst power when all subchs occupied		enum	
HARQ_Enable	Whether bursts are HARQ-enabled: NO, YES	NO		enum	

Pin Inputs

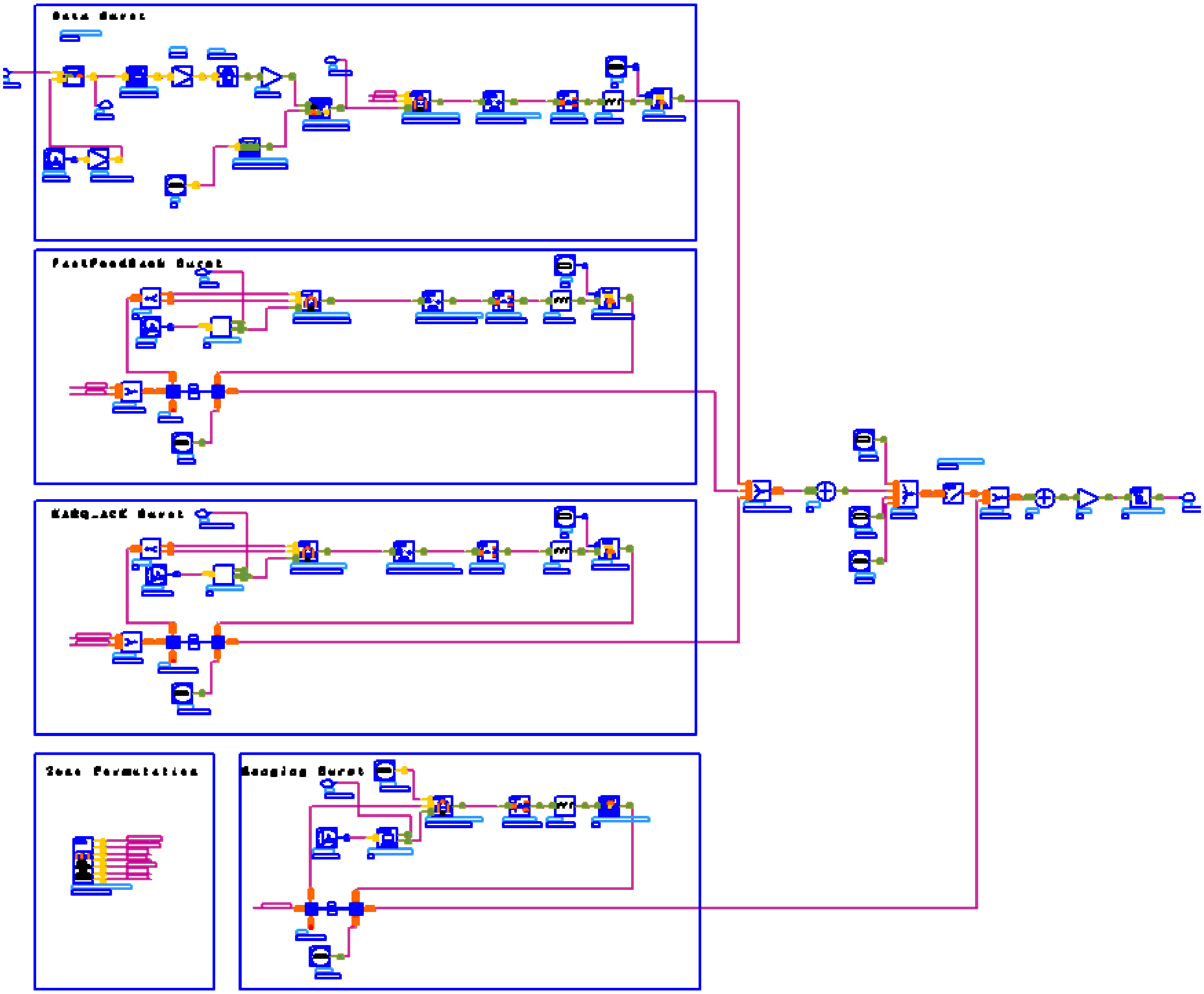
Pin	Name	Description	Signal Type
1	InputData	input of raw data	int

Pin Outputs

Pin	Name	Description	Signal Type
2	FrameData	output of uplink Subframe	complex
3	Constellation	output of Modulated data of all bursts	complex
4	PDUFCS	output of MAC PDU data of burst with FEC	int
5	Ranging_Msg	output of modulated data for the ranging code chosen	complex
6	FFB_Msg	output of modulated data for the FastFeedBack code chosen	complex
7	HARQ_ACK_Msg	output of modulated data for the HARQ-ACK code chosen	complex

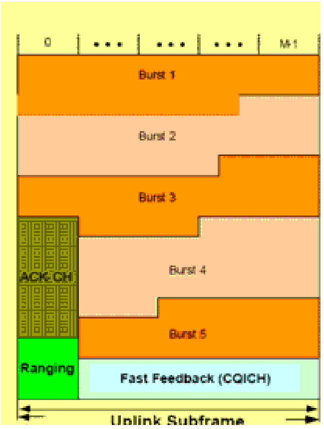
Notes/Equations

1. This subnetwork generates an 802.16e OFDMA Uplink subsystem baseband signal with Ranging, Fast-FeedBack and HARQ-ACK bursts. The schematic for this subnetwork is shown in WMAN_M_UL_Src_Ranging Schematic.



WMAN_M_UL_Src_Ranging Schematic

2. The input of this subnetwork is MAC PDU data of the FEC-encoded burst; MAC header data can be either specified by MAC_Header or generated automatically.
3. WMAN_M_UL_Src_Ranging is implemented according to specification. [WMAN OFDMA UL Frame Structure](#) shows the uplink frame format. It includes only one zone (alternative PUSC or OPUSC) which contains maximum 8 bursts carrying one MAC PDU each. Among these bursts, only one burst is FEC-encoded whose coding type can be set to CC or CTC. Other bursts are provided PN sequences as their coded source respectively. Also three rectangular bursts (Ranging, Fast-FeedBack and HARQ-ACK) are defined in the uplink subframe. Both TDD mode and FDD mode can be supported for the uplink source.



WMAN OFDMA UL Frame Structure

- The CC-encoded burst is coded in the following manner:
    - Add MAC header with parameter MAC_Header or generate MAC header automatically by WMAN_M_MACPDU.
    - Randomized by WMAN_M_UL_Randomizer.
    - CC encoded and punctured by WMAN_M_UL_CC.
    - Interleaved by WMAN_M_UL_Interleaver.
    - Repeated by WMAN_M_UL_Repetition.
- The CTC-encoded burst is coded in the following manner:
    - Add MAC header with parameter MAC_Header or generate MAC header automatically by WMAN_M_MACPDU.
    - Randomized by WMAN_M_UL_Randomizer.
    - CTC encoded by WMAN_M_UL_CTC.
    - Repeated by WMAN_M_UL_Repetition.
- After encoding, the encoded burst is mapped to the constellation. Other bursts without FEC, are provided PN sequence as their coded bits and mapped to the constellation according to their Rate_ID by WMAN_M_UL_BurstWoFEC. The FEC-encoded burst is concatenated with non-coded bursts by WMAN_M_UL_MuxBurst.
- The physical indices of data subcarriers and pilot subcarriers for all the bursts (including normal data bursts, Ranging, Fast-FeedBack and HARQ-ACK bursts) are calculated by WMAN_M_UL_ZonePerm_Rect. The data sequences and pilot sequences are placed to their physical subcarrier location by WMAN_M_UL_MuxOFDMSym. Then the useful subcarriers are randomized by WMAN_M_UL_SubcarrRandomizer. After IFFT and cyclic prefix insertion, the idle interval and uplink payload are combined with zero padding bits if needed by WMAN_M_Commutator. In addition, downlink position will be preserved and filled with zeros before uplink payload if FrameMode is TDD.
- Meanwhile, the Ranging, Fast-FeedBack and HARQ-ACK bursts are inserted into the uplink subframe.
- At last, a symbol windowing is implemented to smooth the transitions between the consecutive OFDM symbols in the subframe.

4. Parameter Details.
    - Bandwidth determines the nominal channel bandwidth.
    - OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
    - FFTSize indicates the FFT point size (512, 1024, or 2048). The FFT size is independent of the selected bandwidth.
    - CyclicPrefix (G) specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
    - FrameMode determines what will actually be included in the generated waveform. FDD Mode means the entire frame is used for the uplink and the uplink starts at the beginning of the frame. TDD Mode means only the uplink is included in the generated waveform and it starts at some delay from the frame start time based on the Downlink Ratio setting.
    - DL_Ratio set the percentage (1 to 99) of the frame time to be used for the downlink and also set the start time for the uplink. The parameter is only active when the frame mode is TDD.
    - FrameDuration determines the frame durations (ms) of the generated waveform. There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
    - IdleInterval specifies the time of idle interval between two consecutive frames.

- PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to Table 309 in the standard.
- FrameNumber specifies the frame number(0 to 0xffffff) of the uplink frame.
- FrameIncreased indicates whether the frame number of the generated waveform is increased one by one.
- UL_PermBase specifies the permutation base that will be used in this uplink zone. Accepted values are 0 to 69.
- AutoMACHeaderSetting indicates whether the MAC Header is calculated automatically. If it is set to NO, data sequences in parameter MAC_Header will be used before data content, otherwise MAC_Header content will be calculated with parameter DataLength and CID and be used before data content.
- MAC_Header specifies 6 bytes of MAC header before the data contents. The parameter is only active when the AutoMACHeaderSetting is set to NO.
- CRC32_Mode specifies the method for CRC32 calculation appended to MAC PDU. For consistency with Reference [2], it shall be set to MSB first while shall be set to LSB first for consistency with 802.16-2004 Cor1/D3.
- ZoneType specifies the zone type which can be set to PUSC or OPUSC.
- ZoneNumOfSym specifies the number of symbols in the zone. The value must be a multiple of three because the uplink zone is divided into slots of 3 symbols x 1 subchannel (section 8.4.3.1 of Reference [2]). The maximum number of symbols available depends on the Bandwidth, frame length, DL_Ratio, FFTSize, and CyclicPrefix.
- SubchannelRotation specifies whether the data subchannel rotation scheme (defined in 8.4.6.2.6 of Reference [2]) is applied. The specification requires SubchannelRotation = Yes.
- NumberOfBurst specifies the number of active uplink bursts.
- BurstWithFEC specifies the uplink burst FEC.
- BurstSymOffset positions each burst on the horizontal axis (x), if necessary, to avoid any burst overlap. The parameter is an array element.
- BurstSubchOffset positions each burst on the vertical axis (y), if necessary, to avoid any burst overlap. The parameter is an array element.
- BurstAssignedSlot specifies the total available slots in each burst. The parameter is an array element.
- DataLength is the array of each burst's MAC PDU payload data length in bytes.
- CodingType is the array of each burst's coding type which can be set to CC or CTC.
- Rate_ID is the array of each burst's Rate ID, whose range is from 0 to 6 for CC encoding and from 0 to 7 for CTC encoding. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in *The Relation of Coding Type and Rate ID*.

Coding type	Rate ID	<th
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. The parameter is an array element and only available when QPSK 1/2 or QPSK 3/4 is selected as the burst profile (Rate_ID). Each repetition coding can be selected from 0 to 3, whose meaning is shown in *The Meaning of Repetition Coding*.

Repetition Coding	Meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4used on the burst
3	Repetition coding of 6used on the burst

- BurstPowerOffset determines the power offset of each burst in dB. The parameter is an array element.
- RangingEnable specifies whether the ranging burst is enabled or not. If RangingEnable = No, the

following parameters whose prefix are `Ranging' will be inactive; Otherwise they will be active.

- RangingMethod specifies the method employed in the ranging burst. Eight methods are defined according to the specification.
- RangingAllocation specifies the allocation for the ranging burst in the form of {SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs}.
- RangingCodeChosen specifies the index of ranging codes selected to transmit in the ranging burst. Note that this parameter is an array element. The indices of ranging codes in this parameter will be employed the uplink subframes periodically. For example, if RangingCodeChosen = {1,8}, then the indices of ranging codes transmitted on from Subframe#0 to Subframe#4 will be {1,8,1,8,1}.
- RangingSlotChosen specifies the index of ranging slot selected on which the ranging code is transmitted. This value should not exceed the number of slots allocated in the ranging burst.
- RangingPowerOffset specifies the power offset for the ranging burst in dB.
- RangingTimingOffset specifies the timing offset for the ranging burst.
- FastFeedBackEnable specifies whether the Fast-FeedBack burst is enabled or not. If FastFeedBackEnable = No, the following parameters whose prefix are `FastFeedBack' will be inactive; Otherwise they will be active.
- FastFeedBackType specifies the type employed in the Fast-FeedBack burst. Three types (FFB_NORMAL, FFB_ENHANCED, FFB_3MIMO) are supported.
- FastFeedBackAllocation specifies the allocation for the Fast-FeedBack burst in the form of {SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs}.
- FastFeedBackCodeChosen specifies the index of Fast-FeedBack codes selected to transmit in the Fast-FeedBack burst. Note that this parameter is also an array element. For more usage, please refer to the description of RangingCodeChosen.
- FastFeedBackSlotChosen specifies the index of Fast-FeedBack slot selected on which the Fast-FeedBack code is transmitted. This value should not exceed the number of slots allocated in the Fast-FeedBack burst.
- FastFeedBackPowerOffset specifies the power offset for the Fast-FeedBack burst in dB.
- HARQ_ACK_Enable specifies whether the HARQ ACK burst is enabled or not. If HARQ_ACK_Enable = No, the following parameters whose prefix are `HARQ_ACK_' will be inactive; Otherwise they will be active.
- HARQ_ACK_Allocation specifies the allocation for the HARQ ACK burst in the form of {SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs}.
- HARQ_ACK_CodeChosen specifies the index of HARQ ACK codes selected to transmit in the HARQ ACK burst. Note that this parameter is also an array element. For more usage, please refer to the description of RangingCodeChosen.
- HARQ_ACK_SlotChosen specifies the index of HARQ ACK slot selected on which the HARQ ACK code is transmitted. This value should not exceed the number of slots allocated in the HARQ ACK burst.
- HARQ_ACK_PowerOffset specifies the power offset for the HARQ ACK burst in dB.
- PowerType specifies the exact meaning of the parameter Power in RF source. Two types are defined in uplink (Type I: Peak power; Type II: Burst power when all subchs occupied). Type I is recommended for transmitter measurement; Type II is recommended for receiver measurement. For more information, please refer to *Transmit Power Definition* (wman_m).
- HARQ_Enable specifies whether all the bursts allocated are HARQ-enabled. When HARQ_Enable = YES, see *HARQ transmission* (wman_m) for more information.

5. Samples per frame
The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-11-28-256.gif!) as follows,
$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$
The sampling factors are listed in *Sampling Factor Requirement*.

Sampling Factor n	Bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

The samples of IdleInterval (!wman_m-11-28-258.gif!) is calculated as follows:
$$Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$$
So, the total samples of one uplink frame $Samples_{Frame}$ is
$$Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$$
This model works frame by frame. Each firing,
$8 \times DataLength[BurstWithFEC]$ tokens are consumed at pin MAC_PDU,
$Samples_{Frame}$ tokens are produced at pin FrameData,

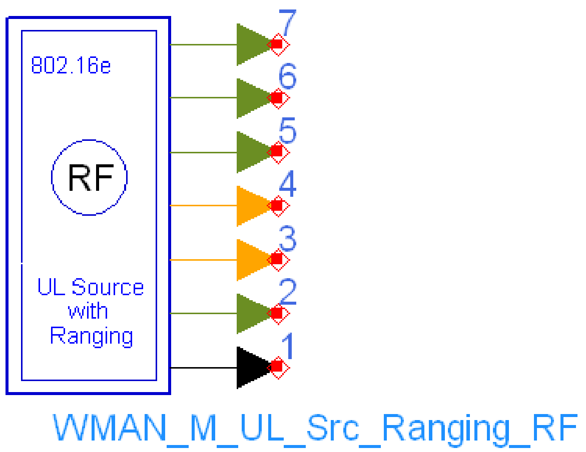
$\sum_{i=1}^{NumberOfBurst} BurstAssignedSlot[i] \times 48$ tokens are produced at pin Constellation,
$8 \times DataLength[BurstWithFEC] + 80$ tokens are produced at pin PDUFCS.
$144 \times NumOfCodesUsed$ tokens are produced at pin Ranging_Msg, where NumOfCodesUsed is dependent on the RangingMethod chosen (i.e. NumOfCodesUsed is 1 when RangingMethod is Initial Ranging over 2 symbols).
24 (FFB_ChannelType=FFB_3MIMO) or 48 (FFB_ChannelType=FFB_NORMAL, FFB_ENHANCED) tokens are produced at pin FFB_Msg.
24 tokens are produced at pin HARQ_ACK_Msg.

6. Output delay
   No delay is introduced by WMAN_M_SymWindow in this design.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_Src_Ranging_RF (802.16e OFDMA Uplink RF Source Ranging)



Description: Uplink RF signal source with ranging
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Unit	Type	Range
ROut	Output resistance	DefaultROut	Ohm	int	(0,∞)
RTemp	Temperature, in degrees C	DefaultRTemp	Celsius	real	[-273.15,∞]
FCarrier	Carrier frequency	3407 MHz	Hz	real	(0,∞)
Power	Transmit power (the meaning of Power is defined in Parameter PowerType)	0.01 W	W	real	(0,∞)
MirrorSpectrum	Mirror spectrum about carrier?: NO, YES	NO		enum	
GainImbalance	Gain imbalance in dB, Q channel relative to I channel	0.0		real	(-∞,∞)
PhaseImbalance	Phase imbalance in degrees, Q channel relative to I channel	0.0		real	(-∞,∞)
I_OriginOffset	I origin offset in percent with repect to output rms voltage	0.0		real	(-∞,∞)
Q_OriginOffset	Q origin offset in percent with repect to output rms voltage	0.0		real	(-∞,∞)
IQ_Rotation	IQ rotation in degrees	0.0		real	(-∞,∞)
Bandwidth	Nominal bandwidth	10 MHz	Hz	int	[1,1e9]
OversamplingOption	Oversampling ratio option: Ratio 1, Ratio 2, Ratio 4, Ratio 8, Ratio 16, Ratio 32	Ratio 2		enum	
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024		enum	
CyclicPrefix	Cyclic prefix	0.125		real	[0,1]
FrameMode	Frame mode: FDD, TDD	TDD		enum	
DL_Ratio	Downlink ratio	0.5		real	[0.01 , 0.99]
FrameDuration	Frame duration: time 2 ms, time 2.5 ms, time 4 ms, time 5 ms, time 8 ms, time 10 ms, time 12.5 ms, time 20 ms	time 5 ms		enum	
PreambleIndex	Preamble index	3		int	[0,113]
FrameNumber	Frame number	0		int	[1,0xffffff]
FrameIncreased	Frame number increasing or not: NO, YES	NO		enum	
UL_PermBase	Uplink permutation base	0		int	[0 , 69]
DataPattern	WMAN data pattern: PN9, PN15, FIX4, _4_1_4_0, _8_1_8_0, _16_1_16_0, _32_1_32_0, _64_1_64_0, S_QPSK, S_16-QAM, S_64-QAM	PN9		enum	
AutoMACHeaderSetting	Auto MAC header setting or not: NO, YES	YES		enum	
MAC_Header	MAC header data	{0XA2, 0X48, 0X22, 0X4F, 0X93, 0X0E}		int array	[0,255]
CRC32_Mode	CRC32 mode: MSB first, LSB first	MSB first		enum	

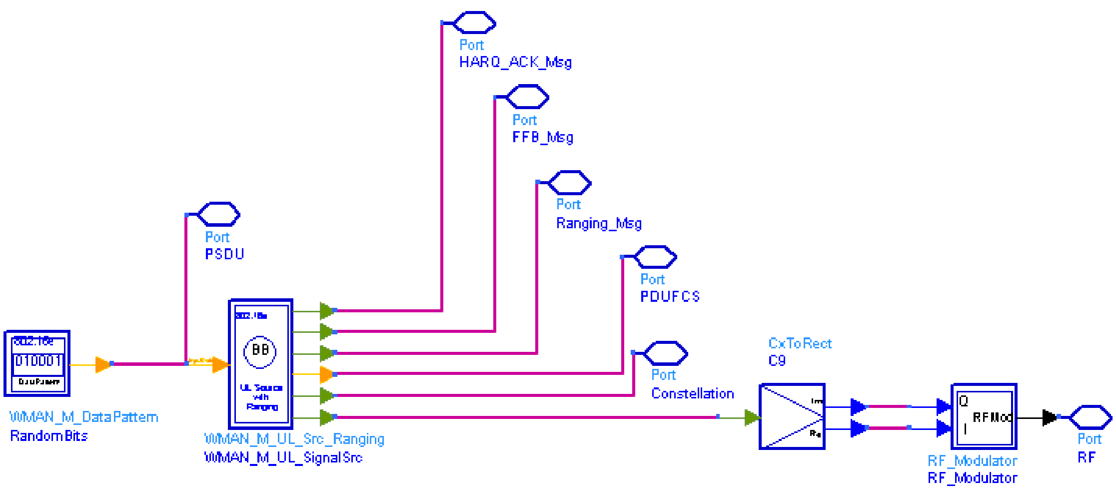
ZoneType	Zone type: UL_PUSC, UL_OPUSC	UL_PUSC		enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24		int	[3,1212]
SubchannelRotation	Subchannel rotation for UL PUSC enabled or not: NO, YES	YES		enum	
NumberOfBurst	Number of Bursts	1		int	[1,8]
BurstWithFEC	The number of burst with FEC	1		int	[1,8]
BurstSymOffset	Symbol offset of each burst	{3}		int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}		int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}		int array	[1,6868]
DataLength	MAC PDU payload byte length of each burst	{300}		int array	[1,∞)
CodingType	Coding type of each burst	{0}		int array	[0,1]
Rate_ID	Rate ID of each burst	{3}		int array	[0,7]
RepetitionCoding	Repetition coding of each burst	{0}		int array	[0,3]
BurstPowerOffset	Power offset of each burst in dB	{0}		real array	[-∞,∞]
RangingEnable	Ranging channel enabled or not: NO, YES	NO		enum	
RangingMethod	Ranging method: Initial Ranging over 2 symbols, Initial Ranging over 4 symbols, Periodic Ranging over 1 symbol, Periodic Ranging over 3 symbols, BW Request over 1 symbol, BW Request over 3 symbols, Handover Ranging over 2 symbols, Handover Ranging over 4 symbols	Initial Ranging over 2 symbols		enum	
RangingAllocation	Rectangular allocation: (SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0,29,3,6}		int array	[0,1211]
RangingCodeChosen	The number of ranging code for RangingMethod. The range is [0,255].	{0}		int array	[0,255]
RangingSlotChosen	The number of slot for carrying the ranging code.	0		int	[1,∞]
RangingPowerOffset	Ranging power offset in dB	0		real	(0,∞)
RangingTimingOffset	Ranging timing offset (Negative:transmit ahead of schedule; Positive:transmit behind schedule	0 usec	sec	real	(-∞,∞)
FastFeedBackEnable	Fast feedback channel enabled or not: NO, YES	NO		enum	
FastFeedBackType	FastFeedBack type: FFB_NORMAL, FFB_ENHANCED, FFB_3MIMO	FFB_NORMAL		enum	
FastFeedBackAllocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{3,28,12,7}		int array	[0,∞]
FastFeedBackCodeChosen	The number of Fast FeedBack code for FastFeedBackType. The range is [0,15].	{0}		int array	[0,∞]
FastFeedBackSlotChosen	The number of slot for carrying the Fast FeedBack code.	0		int	[1,∞]
FastFeedBackPowerOffset	Fast FeedBack power offset in dB	0		real	(0,∞)
HARQ_ACK_Enable	HARQ ACK channel enabled or not: NO, YES	NO		enum	
HARQ_ACK_Allocation	Rectangular allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0,25,3,4}		int array	[0,∞]
HARQ_ACK_CodeChosen	The number of HARQ_ACK code. The range is [0,1].	{1}		int array	[0,∞]
HARQ_ACK_SlotChosen	The number of slot for carrying the HARQ-ACK code.	0		int	[1,∞]
HARQ_ACK_PowerOffset	HARQ-ACK power offset in dB	0		real	(0,∞)
PowerType	Power definition (Peak power in frame, Burst power when all subchs occupiedd): Peak power, Burst power when all subchs occupied	Burst power when all subchs occupied		enum	
HARQ_Enable	Whether bursts are HARQ-enabled: NO, YES	NO		enum	

Pin Outputs

Pin	Name	Description	Signal Type
1	RF	output of RF signal	timed
2	Constellation	output of modulated data of all bursts	complex
3	PDUFCS	output of MAC PDU data of burst with FEC	int
4	PSDU	output of PSDU bits	int
5	Ranging_Msg	output of modulated data for the ranging code chosen	complex
6	FFB_Msg	output of modulated data for the FastFeedBack code chosen	complex
7	HARQ_ACK_Msg	output of modulated data for the HARQ-ACK code chosen	complex

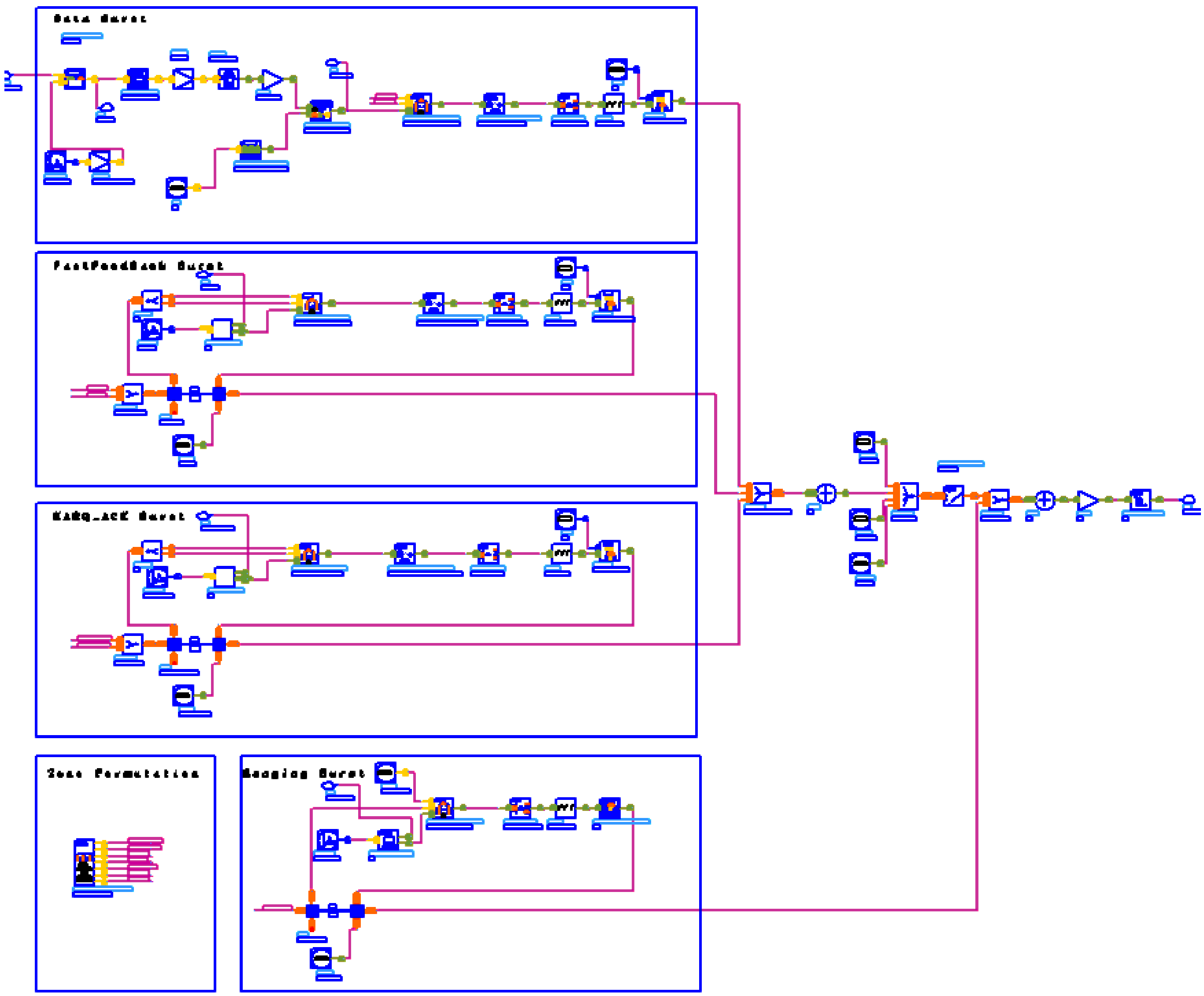
Notes/Equations

1. This subnetwork generates an 802.16e OFDMA uplink subsystem RF signal with Ranging, Fast-FeedBack and HARQ-ACK bursts. The subnetwork includes WMAN_M_UL_Src_Ranging, which generates the uplink baseband signal of 802.16e uplink subsystem, and the RF_Modulator. The schematic for this subnetwork is shown in WMAN_M_UL_Src_Ranging_RF Schematic.



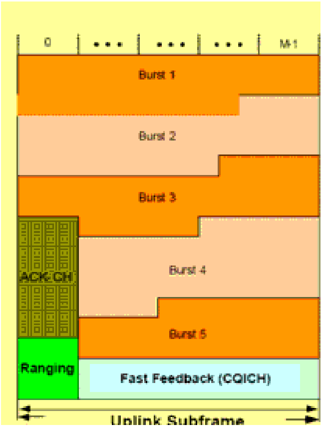
WMAN_M_UL_Src_Ranging_RF Schematic

2. The WMAN OFDM downlink baseband signal source format follows the specification. The schematic is shown in WMAN_M_UL_Src_Ranging Schematic.



WMAN_M_UL_Src_Ranging Schematic

3. The input of this subnetwork is MAC PDU data of the FEC-encoded burst; MAC header data can be either specified by MAC_Header or generated automatically.
4. WMAN_M_UL_Src_Ranging is implemented according to specification. WMAN OFDMA UL Frame Structure shows the uplink frame format. It includes only one zone (alternative PUSC or OPUSC) which contains maximum 8 bursts carrying one MAC PDU each. Among these bursts, only one burst is FEC-encoded whose coding type can be set to CC or CTC. Other bursts are provided PN sequences as their coded source respectively. Also three rectangular bursts (Ranging, Fast-FeedBack and HARQ-ACK) are defined in the uplink subframe. Both TDD mode and FDD mode can be supported for the uplink source.



WMAN OFDMA UL Frame Structure

- The CC-encoded burst is coded in the following manner:
    - Add MAC header with parameter MAC_Header or generate MAC header automatically by WMAN_M_MACPDU.
    - Randomized by WMAN_M_UL_Randomizer.
    - CC encoded and punctured by WMAN_M_UL_CC.
    - Interleaved by WMAN_M_UL_Interleaver.
    - Repeated by WMAN_M_UL_Repetition.
- The CTC-encoded burst is coded in the following manner:
    - Add MAC header with parameter MAC_Header or generate MAC header automatically by WMAN_M_MACPDU.
    - Randomized by WMAN_M_UL_Randomizer.
    - CTC encoded by WMAN_M_UL_CTC.
    - Repeated by WMAN_M_UL_Repetition.
- After encoding, the encoded burst is mapped to the constellation. Other bursts without FEC, are provided PN sequence as their coded bits and mapped to the constellation according to their Rate_ID by WMAN_M_UL_BurstWoFEC. The FEC-encoded burst is concatenated with non-coded bursts by WMAN_M_UL_MuxBurst.
- The physical indices of data subcarriers and pilot subcarriers for all the bursts (including normal data bursts, Ranging, Fast-FeedBack and HARQ-ACK bursts) are calculated by WMAN_M_UL_ZonePerm_Rect. The data sequences and pilot sequences are placed to their physical subcarrier location by WMAN_M_UL_MuxOFDMSym. Then the useful subcarriers are randomized by WMAN_M_UL_SubcarrRandomizer. After IFFT and cyclic prefix insertion, the idle interval and uplink payload are combined with zero padding bits if needed by WMAN_M_Commutator. In addition, downlink position will be preserved and filled with zeros before uplink payload if FrameMode is TDD.
- Meanwhile, the Ranging, Fast-FeedBack and HARQ-ACK bursts are inserted into the uplink subframe.
- At last, The uplink subframe is filtered by a transmitter filter (WMAN_M_SymWindow).

5. Parameter Details
    - ROut is the RF output resistance.
    - RTemp is the RF output resistance temperature in Celsius and sets the noise density in the RF output signal to (k(RTemp+273.15)) Watts/Hz, where k is Boltzmann's constant.
    - FCarrier is the RF output signal frequency.
    - Power is used to set the modulator output RF power. This is true for an ideal transmitted signal (no impairments added) or when small impairments are added. If large impairments are added to the signal (using GainImbalance, I_OriginOffset, and Q_OriginOffset parameters) the output RF power may be different from the value of the Power parameter.
    - MirrorSpectrum is used to mirror the RF_out signal spectrum about the carrier. This is equivalent to conjugating the complex RF envelope voltage. Depending on the configuration and number of mixers in an RF transmitter, the RF output signal from hardware RF generators can be inverted. If such an RF signal is desired, set this parameter to YES.
    - GainImbalance, PhaseImbalance, I_OriginOffset, Q_OriginOffset, and IQ_Rotation are used to add certain impairments to the ideal output RF signal. Impairments are added in the order described here.
      The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:

$$V_{RF}(t) = A\left(V_I(t)\cos(\omega_c t) - gV_Q(t)\sin\left(\omega_c t + \frac{\Phi\pi}{180}\right)\right)$$

where A is a scaling factor based on the Power and ROut parameters specified by the user, VI(t) is the in-phase RF envelope, VQ(t) is the quadrature phase RF envelope, g is the gain imbalance

$$g = 10^{\frac{GainImbalance}{20}}$$

and, ϕ (in degrees) is the phase imbalance.
Next, the signal VRF(t) is rotated by IQ_Rotation degrees. The I_OriginOffset and Q_OriginOffset are then applied to the rotated signal. Note that the amounts specified are percentages with respect to the output rms voltage. The output rms voltage is given by sqrt(2×ROut×Power).

- Bandwidth determines the nominal channel bandwidth.
- OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
- FFTSize indicates the FFT point size (512, 1024, or 2048). The FFT size is independent of the selected bandwidth.
- CyclicPrefix (G) specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
- FrameMode determines what will actually be included in the generated waveform. FDD Mode means the entire frame is used for the uplink and the uplink starts at the beginning of the frame. TDD Mode means only the uplink is included in the generated waveform and it starts at some delay from the frame start time based on the Downlink Ratio setting.
- DL_Ratio set the percentage (1 to 99) of the frame time to be used for the downlink and also set the start time for the uplink. The parameter is only active when the frame mode is TDD.
- FrameDuration determines the frame durations (ms) of the generated waveform. There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the standard.
- IdleInterval specifies the time of idle interval between two consecutive frames.
- PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to Table 309 in the standard.
- FrameNumber specifies the frame number(0 to 0xffffff) of the uplink frame.
- FrameIncreased indicates whether the frame number of the generated waveform is increased one by one.
- UL_PermBase specifies the permutation base that will be used in this uplink zone. Accepted values are 0 to 69.
- AutoMACHeaderSetting indicates whether the MAC Header is calculated automatically. If it is set to NO, data sequences in parameter MAC_Header will be used before data content, otherwise MAC_Header content will be calculated with parameter DataLength and CID and be used before data content.
- MAC_Header specifies 6 bytes of MAC header before the data contents. The parameter is only active when the AutoMACHeaderSetting is set to NO.
- CRC32_Mode specifies the method for CRC32 calculation appended to MAC PDU. For consistency with Reference [2], it shall be set to MSB first while shall be set to LSB first for consistency with 802.16-2004 Cor1/D3.
- ZoneType specifies the zone type which can be set to PUSC or OPUSC.
- ZoneNumOfSym specifies the number of symbols in the zone. The value must be a multiple of three because the uplink zone is divided into slots of 3 symbols x 1 subchannel (section 8.4.3.1 of Reference [2]). The maximum number of symbols available depends on the Bandwidth, frame length, DL_Ratio, FFTSize, and CyclicPrefix.
- SubchannelRotation specifies whether the data subchannel rotation scheme (defined in 8.4.6.2.6 of Reference [2]) is applied. The specification requires SubchannelRotation = Yes.
- NumberOfBurst specifies the number of active uplink bursts.
- BurstWithFEC specifies the uplink burst FEC.
- BurstSymOffset positions each burst on the horizontal axis (x), if necessary, to avoid any burst overlap. The parameter is an array element.
- BurstSubchOffset positions each burst on the vertical axis (y), if necessary, to avoid any burst overlap. The parameter is an array element.
- BurstAssignedSlot specifies the total available slots in each burst. The parameter is an array element.
- DataLength is the array of each burst's MAC PDU payload data length in bytes.
- CodingType is the array of each burst's coding type which can be set to CC or CTC.
- Rate_ID is the array of each burst's Rate ID, whose range is from 0 to 6 for CC encoding and from 0 to 7 for CTC encoding. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in *The Relation of Coding Type and Rate ID*.

Coding type	Rate ID	<th
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

- RepetitionCoding specifies the repetition coding for each burst. The parameter is an array element and only available when QPSK 1/2 or QPSK 3/4 is selected as the burst profile (Rate_ID). Each repetition coding can be selected from 0 to 3, whose meaning is shown in *The Meaning of Repetition Coding*.

Repetition Coding	Meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4used on the burst
3	Repetition coding of 6used on the burst

- BurstPowerOffset determines the power offset of each burst in dB. The parameter is an array element.
- RangingEnable specifies whether the ranging burst is enabled or not. If RangingEnable = No, the following parameters whose prefix are `Ranging' will be inactive; Otherwise they will be active.
- RangingMethod specifies the method employed in the ranging burst. Eight methods are defined according to the specification.
- RangingAllocation specifies the allocation for the ranging burst in the form of {SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs}.
- RangingCodeChosen specifies the index of ranging codes selected to transmit in the ranging burst. Note that this parameter is an array element. The indices of ranging codes in this parameter will be employed the uplink subframes periodically. For example, if RangingCodeChosen = {1,8}, then the indices of ranging codes transmitted on from Subframe#0 to Subframe#4 will be {1,8,1,8,1}.
- RangingSlotChosen specifies the index of ranging slot selected on which the ranging code is transmitted. This value should not exceed the number of slots allocated in the ranging burst.
- RangingPowerOffset specifies the power offset for the ranging burst in dB.
- RangingTimingOffset specifies the timing offset for the ranging burst.
- FastFeedBackEnable specifies whether the Fast-FeedBack burst is enabled or not. If FastFeedBackEnable = No, the following parameters whose prefix are `FastFeedBack' will be inactive; Otherwise they will be active.
- FastFeedBackType specifies the type employed in the Fast-FeedBack burst. Three types (FFB_NORMAL, FFB_ENHANCED, FFB_3MIMO) are supported.
- FastFeedBackAllocation specifies the allocation for the Fast-FeedBack burst in the form of {SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs}.
- FastFeedBackCodeChosen specifies the index of Fast-FeedBack codes selected to transmit in the Fast-FeedBack burst. Note that this parameter is also an array element. For more usage, please refer to the description of RangingCodeChosen.
- FastFeedBackSlotChosen specifies the index of Fast-FeedBack slot selected on which the Fast-FeedBack code is transmitted. This value should not exceed the number of slots allocated in the Fast-FeedBack burst.
- FastFeedBackPowerOffset specifies the power offset for the Fast-FeedBack burst in dB.
- HARQ_ACK_Enable specifies whether the HARQ ACK burst is enabled or not. If HARQ_ACK_Enable = No, the following parameters whose prefix are `HARQ_ACK_' will be inactive; Otherwise they will be active.
- HARQ_ACK_Allocation specifies the allocation for the HARQ ACK burst in the form of {SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs}.
- HARQ_ACK_CodeChosen specifies the index of HARQ ACK codes selected to transmit in the HARQ ACK burst. Note that this parameter is also an array element. For more usage, please refer to the description of RangingCodeChosen.

- HARQ_ACK_SlotChosen specifies the index of HARQ ACK slot selected on which the HARQ ACK code is transmitted. This value should not exceed the number of slots allocated in the HARQ ACK burst.
- HARQ_ACK_PowerOffset specifies the power offset for the HARQ ACK burst in dB.
- PowerType specifies the exact meaning of the parameter Power in RF source. Two types are defined in uplink (Type I: Peak power; Type II: Burst power when all subchs occupied). Type I is recommended for transmitter measurement; Type II is recommended for receiver measurement. For more information, please refer to *Transmit Power Definition* (wman_m).
- HARQ_Enable specifies whether all the bursts allocated are HARQ-enabled. When HARQ_Enable = YES, see *HARQ transmission* (wman_m) for more information.

6. Samples per frame
   The sampling frequency (Fs) implemented in the design is decided by Bandwidth and related sampling factor (!wman_m-11-29-274.gif!) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

   The sampling factors are listed in *Sampling Factor Requirement*.

Sampling Factor n	Bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

   The samples of IdleInterval (!wman_m-11-29-276.gif!) are calculated as follows:
   $Samples_{idle} = IdleInterval \times 2^{OversamplingOption} \times F_s$

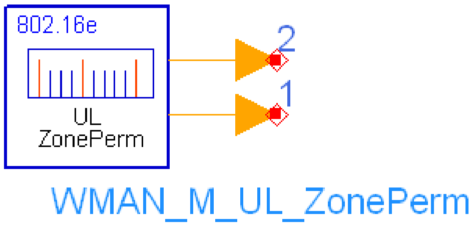
   So, the total samples of one uplink frame $Samples_{Frame}$ are
   $Samples_{Frame} = Samples_{idle} + FrameDuration \times F_s \times 2^{OversamplingOption}$

   This model works frame by frame. Each firing,
   $8 \times DataLength[BurstWithFEC]$ tokens are produced at pin PSDU,
   $Samples_{Frame}$ tokens are produced at pin RF,
   $\sum_{i=1}^{NumberOfBurst} BurstAssignedSlot[i] \times 48$ tokens are produced at pin Constellation,
   $8 \times DataLength[BurstWithFEC]] + 80$ tokens are produced at pin PDUFCS.
   $144 \times NumOfCodesUsed$ tokens are produced at pin Ranging_Msg, where NumOfCodesUsed is dependent on the RangingMethod chosen (i.e. NumOfCodesUsed is 1 when RangingMethod is Initial Ranging over 2 symbols).
   24 (FFB_ChannelType=FFB_3MIMO) or 48 (FFB_ChannelType=FFB_NORMAL, FFB_ENHANCED) tokens are produced at pin FFB_Msg.
   24 tokens are produced at pin HARQ_ACK_Msg.
7. Output delay
   No delay is introduced by WMAN_M_SymWindow in this design.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_ZonePerm (802.16e OFDMA UL Zone Permutation)



Description: Uplink subchannel subcarrier allocator
Library: WMAN 16e, Signal Source

Parameters

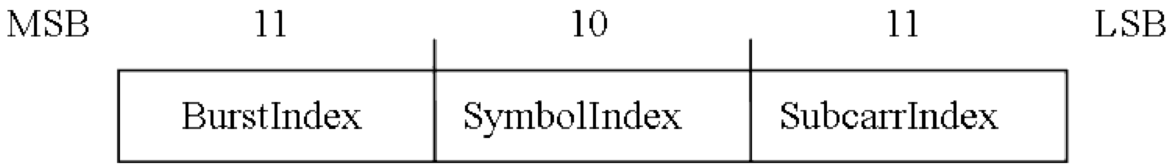
Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24	int	[3,1212]
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
NumberOfBurst	Number of Bursts	1	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}	int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}	int array	[1,6868]
UL_PermBase	Uplink permutation base	0	int	[0, 69]

Pin Outputs

Pin	Name	Description	Signal Type
1	Data_Pos	Data Position	int
2	Pilot_Pos	Pilot Position	int

Notes/Equations

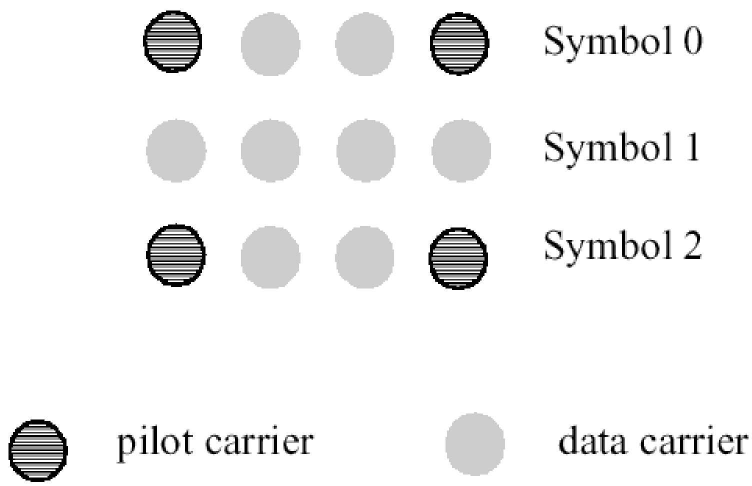
1. This model is used to calculate the location of data subcarriers for each uplink burst and the location of pilot subcarriers in the zone. Subchannel allocation in the uplink can be performed by PUSC and OPUSC with FFT size 2048, 1024 and 512.
2. Each firing
   - $\sum_{i=1}^{NumberOfBurst} (N_{BurstAssignedSlot}[i]) \times 48$ tokens are produced at pin Data_Pos, where $N_{BurstAssignedSlot}[i]$ specifies the number of assigned slots for the ith uplink burst.
   - $\sum_{i=1}^{NumberOfBurst} (N_{BurstAssignedSlot}[i]) \times 24$ tokens are produced at pin Pilot_Pos in case of PUSC and $\sum_{i=1}^{NumberOfBurst} (N_{BurstAssignedSlot}[i]) \times 6$ tokens are produced at pin Pilot_Pos in case of OPUSC.
3. The format of position is defined in The Format of BurstPos and PilotPos.



The Format of BurstPos and PilotPos

4. In uplink PUSC, one tile composes 4 adjacent subcarriers by 3 adjacent symbols, so there are 12 subcarriers in one tile, 4 are used to carry pilots and 8 are used to carry data. One slot is combination of 6 tiles and the index of these 6 tiles are calculated from a equation, dependent on slot index, UL_PermBase, TilePermutation and Total subchannel number (One slot equals one subchannel by 3 symbols).

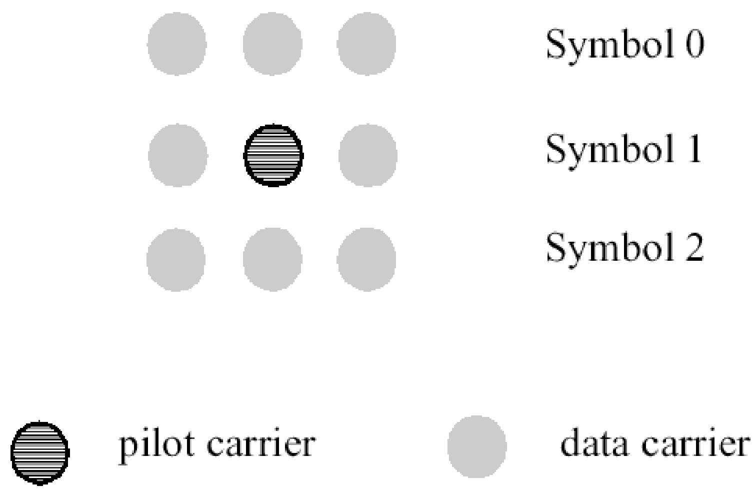
Parameter	**2048**	**1024**	**512**
Number of DC subcarriers	1	1	1
N_{used}	1681	841	409
Guard subcarriers Left.Right	184,183	92,91	52,51
TilePermutation	6, 48, 58, 57, 50, 1, 13, 26, 46, 44,30, 3, 27, 53, 22, 18, 61, 7, 55, 36, 45, 37, 52, 15, 40, 2, 20, 4, 34, 31,10, 5, 41, 9, 69, 63, 21, 11, 12, 19,68, 56, 43, 23, 25, 39, 66, 42, 16,47, 51, 8, 62, 14, 33, 24, 32, 17,54, 29, 67, 49, 65, 35, 38, 59, 64, 28, 60, 0	11,19,12,32,33,9,30,7,4,2,13,8,17,23,27,5,15,34,22,14,21,1,0,24,3,26,29,31,20,25,16,10,6,28,18	11,15,1
$N_{subchannels}$	70	35	17
$N_{Datasubcarriers}$	48	48	48
$N_{Pilotsubcarriers}$	24	24	24
N_{tiles}	420	210	102
Tiles per subchannel	6	6	6



Description of an uplink PUSC tile

- In uplink OPUSC, one tile composes 3 adjacent subcarriers by 3 adjacent symbols, so there are 9 subcarriers in one tile, one is used to carry pilots and 8 are used to carry data. One slot is combination of 6 tiles and the index of these 6 tiles are calculated from a equation, dependent on slot index, UL_PermBase, P1, P2 and Total subchannel number (One slot equals one subchannel by 3 symbols).

Parameter	**2048**	**1024**	**512**
Number of DC subcarriers	1	1	1
N_{used}	1729	865	409
Guard subcarriers Left.Right	160,159	80,79	40,39
$N_{subchannels}$	96	48	24
$N_{Datasubcarriers}$	48	48	48
$N_{Pilotsubcarriers}$	6	6	6
N_{tiles}	576	288	144
Tiles per subchannel	6	6	6



Description of an Uplink OPUSC Tile

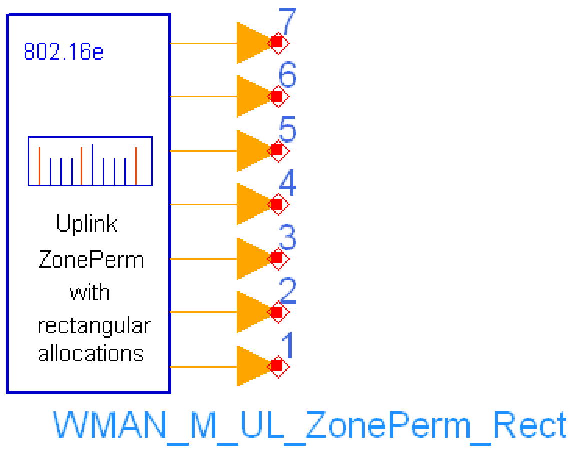
FFT size		Basic permutation sequences
512	P1	1, 2, 4, 3, 6, 7, 5
	P2	1, 4, 6, 5, 2, 3, 7
1024	P1	1, 2, 4, 8, 3, 6, 12, 11, 5, 10, 7, 14, 15, 13, 9
	P2	1, 4, 3, 12, 5, 7, 15, 9, 2, 8, 6, 11, 10, 14, 13
2048	P1	1, 2, 4, 8, 16, 5, 10, 20, 13, 26, 17, 7, 14, 28, 29, 31, 27,19, 3, 6, 12, 24, 21, 15, 30, 25, 23, 11, 22, 9, 18
	P2	1, 4, 16, 10, 13, 17, 14, 29, 27, 3, 12, 21, 30, 23, 22, 18,2, 8, 5, 20, 26, 7, 28, 31, 19, 6, 24, 15, 25, 11, 9

5. UL AMC zone is the same as DL AMC zone. Refer to *AMC zone* (wman_m).
6. The UL mapping consist of two steps. In the first the OFDMA slots allocated to each burst are selected. In the second steps the allocated slots are mapped.
    - Step1 – allocate OFDMA slots to bursts
      Map the slots such that the lowest numbered slot occupies the lowestnumbered subchannel in the lowest numbered OFDMA symbol. Continue the mapping such that the OFDMA symbol index is increased. When the edge of the UL zone is reached, continue the mapping from the lowest numbered OFDMA symbol in the next available subchannel.
    - Step2 – Map OFDMA slots within the UL allocation
      Map the slots such that the lowest numbered slot occupies the lowest numbered subchannel in the lowest numbered OFDMA symbol. Continue the mapping such that the Subchannel index is increased. When the last subchannel is reached, continue the mapping from the lowest numbered subchannel in the next OFDMA symbol that belongs to the UL allocation.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

WMAN_M_UL_ZonePerm_Rect (802.16e OFDMA UL ZonePerm with Rect)



Description: Uplink subchannel subcarrier allocator with rectangular allocation
Library: WMAN 16e, Signal Source

Parameters

Name	Description	Default	Type	Range
FFTSize	FFT size: FFT_2048, FFT_1024, FFT_512	FFT_1024	enum	
ZoneType	Zone type: UL_PUSC, UL_OPUSC, UL_AMC	UL_PUSC	enum	
ZoneNumOfSym	Number of OFDM symbol in zone	24	int	[3,1212]
NumberOfBurst	Number of Bursts	1	int	[1,8]
BurstSymOffset	Symbol offset of each burst	{0}	int array	[0,1211]
BurstSubchOffset	Subchannel offset of each burst	{0}	int array	[0,95]
BurstAssignedSlot	Assigned slots of each burst	{96}	int array	[1,6868]
SubchannelRotation	Subchannel rotating or not in UL PUSC: NO, YES	YES	enum	
UL_PermBase	Uplink permutation base	0	int	[0, 69]
RangingEnable	Ranging channel enabled or not: NO, YES	NO	enum	
RangingAllocation	Ranging allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0,0,3,6}	int array	[0,∞]
FastFeedBackEnable	Fast feedback channel enabled or not: NO, YES	NO	enum	
FastFeedBackAllocation	FastFeedBack allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0,6,3,6}	int array	[0,∞]
HARQ_ACK_Enable	HARQ ACK channel enabled or not: NO, YES	NO	enum	
HARQ_ACK_Allocation	HARQ ACK allocation:(SymbolOffset,SubchOffset,NumberOfSymbols,NumberOfSubchs)	{0,12,3,6}	int array	[0,∞]

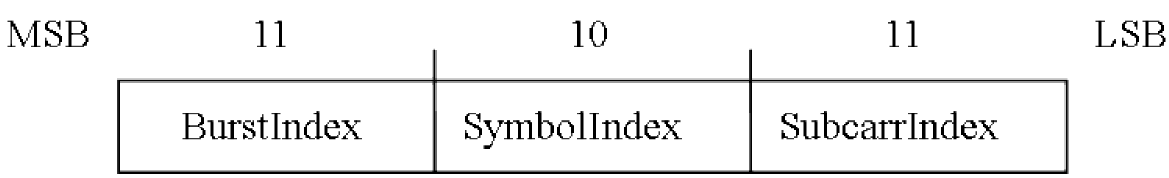
Pin Outputs

Pin	Name	Description	Signal Type
1	Data_Pos	Data Position	int
2	Pilot_Pos	Pilot Position	int
3	Ranging_Pos	Ranging channel Position	int
4	FFB_Pos	Fast feedback channel Position	int
5	FFB_Pilot	Fast feedback channel Pilot Position	int
6	HARQ_ACK_Pos	HARQ ACK channel Position	int
7	HARQ_ACK_Pilot	HARQ ACK channel Pilot Position	int

Notes/Equations

1. This model is used to calculate the location of data subcarriers for each uplink burst (including normal data bursts, Ranging, Fast-FeedBack and HARQ-ACK bursts) and the location of pilot subcarriers in the zone. When the three rectangular bursts (Ranging, Fast-FeedBack and HARQ-ACK) are turned off, the subchannel allocation in the uplink can be performed by both PUSC and OPUSC with FFT size 2048, 1024 and 512; Otherwise the subchannel allocation can be performed only by PUSC with FFT size 2048, 1024 and 512.
2. Each firing
   - $\sum_{i=1}^{NumberOfBurst} (N_{BurstAssignedSlot}[i]) \times 48$ tokens are produced at pin Data_Pos,
     where $N_{BurstAssignedSlot}[i]$ specifies the number of assigned slots for the ith uplink burst.
   - $\sum_{i=1}^{NumberOfBurst} (N_{BurstAssignedSlot}[i]) \times 24$ tokens are produced at pin Pilot_Pos in case of PUSC and
     $\sum_{i=1}^{NumberOfBurst} (N_{BurstAssignedSlot}[i]) \times 6$ tokens are produced at pin Pilot_Pos in case of OPUSC

   $N_{RangingAssignedSlot} \times 72$ tokens are produced at pin Ranging_Pos in case of PUSC, and one token is produced at pin Ranging_Pos in case of OPUSC,
   where $N_{RangingAssignedSlot}$ specifies the number of assigned slots for Ranging burst, derived from,
   $N_{RangingAssignedSlot} = (RangingAllocation[3] \times RangingAllocation[4])/3$
   Note that in Ranging burst, no pilot is inserted.
   $N_{FFBAssignedSlot} \times 48$ tokens are produced at pin FFB_Pos in case of PUSC and one token produced in case of OPUSC.
   $N_{FFBAssignedSlot} \times 24$ tokens are produced at pin FFB_Pilot in case of PUSC and one token produced in case of OPUSC,
   where $N_{FFBAssignedSlot}$ specifies the number of assigned slots for FFB burst, derived from,
   $N_{FFBAssignedSlot} = (FastFeedBackAllocation[3] \times FastFeedBackAllocation[4])/3$
   $N_{ACKAssignedSlot} \times 48$ tokens are produced at pin HARQ_ACK_Pos in case of PUSC and one token produced in case of OPUSC,
   $N_{ACKAssignedSlot} \times 24$ tokens are produced at pin HARQ_ACK_Pilot in case of PUSC and one token produced in case of OPUSC,
   where $N_{ACKAssignedSlot}$ specifies the number of assigned slots for HARQ-ACK burst, derived from,
   $N_{ACKAssignedSlot} = (HARQACKAllocation[3] \times HARQACKAllocation[4])/3$
3. The format of position is defined in The Format of BurstPos and PilotPos.



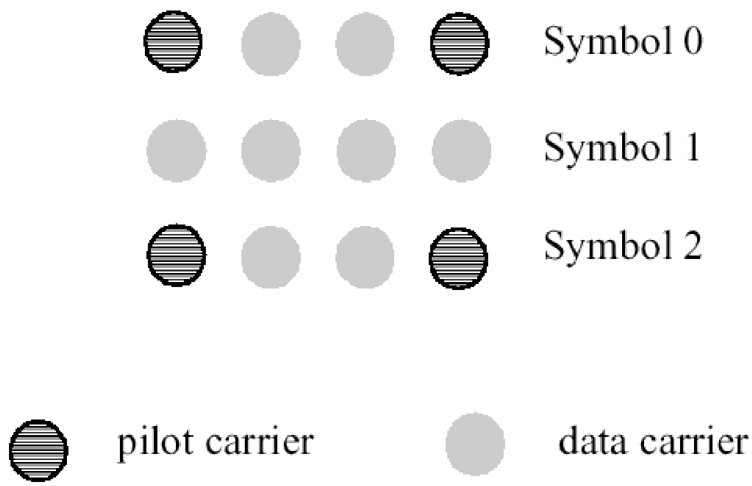
The Format of BurstPos and PilotPos

4. The allocations for Ranging (UIUC=12), Fast-FeedBack (UIUC=0), HARQ-ACK (UIUC=11) bursts are supported only in uplink PUSC. Each rectangular burst can be turned on or off separately. These rectangular allocations shall not break the UL tile structure, shall not span over multiple zones and conform to the following rules:
   1. In each subchannel, the size of each continuous group of OFDMA symbols remaining after allocation of UIUC = 0,12,13 regions shall be a multiple of 3 OFDMA symbols.
   2. The slot boundaries in all subchannels shall be aligned, i.e., if a slot starts in symbol k in any subchannel, then no slots are allowed to start at symbols k + 1, k + 2 at any other subchannel.

3. The number of UL symbols per zone shall be an integer multiple of slot duration. Data symbols shall always start on a slot boundary.

- In uplink PUSC, one tile composes 4 adjacent subcarriers by 3 adjacent symbols, so there are 12 subcarriers in one tile, 4 are used to carry pilots and 8 are used to carry data. One slot is combination of 6 tiles and the index of these 6 tiles are calculated from a equation, dependent on slot index, UL_PermBase, TilePermutation and Total subchannel number (One slot equals one subchannel by 3 symbols).

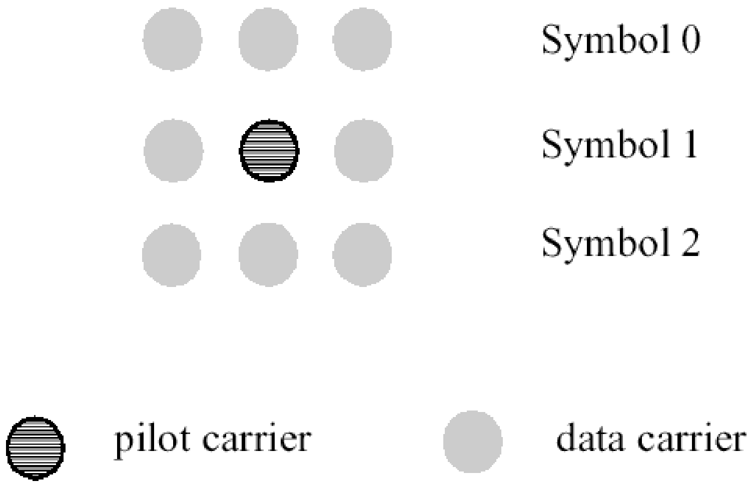
Parameter	**2048**	**1024**	**51**
Number of DC subcarriers	1	1	1
N_{used}	1681	841	40
Guard subcarriers Left.Right	184,183	92,91	52
TilePermutation	6, 48, 58, 57, 50, 1, 13, 26, 46, 44,30, 3, 27, 53, 22, 18, 61, 7, 55, 36, 45, 37, 52, 15, 40, 2, 20, 4, 34, 31,10, 5, 41, 9, 69, 63, 21, 11, 12, 19,68, 56, 43, 23, 25, 39, 66, 42, 16,47, 51, 8, 62, 14, 33, 24, 32, 17,54, 29, 67, 49, 65, 35, 38, 59, 64, 28, 60, 0	11,19,12,32,33,9,30,7,4,2,13,8,17,23,27,5,15,34,22,14,21,1,0,24,3,26,29,31,20,25,16,10,6,28,18	11
$N_{subchannels}$	70	35	17
$N_{Datasubcarriers}$	48	48	48
$N_{Pilotsubcarriers}$	24	24	24
N_{tiles}	420	210	10
Tiles per subchannel	6	6	6



Description of an Uplink PUSC Tile

- In uplink OPUSC, one tile composes 3 adjacent subcarriers by 3 adjacent symbols, so there are 9 subcarriers in one tile, one is used to carry pilots and 8 are used to carry data. One slot is combination of 6 tiles and the index of these 6 tiles are calculated from a equation, dependent on slot index, UL_PermBase, P1, P2 and Total subchannel number (One slot equals one subchannel by 3 symbols).

Parameter	**2048**	**1024**	**512**
Number of DC subcarriers	1	1	1
N_{usea}	1729	865	409
Guard subcarriers Left.Right	160,159	80,79	40,39
$N_{subchannels}$	96	48	24
$N_{Datasubcarriers}$	48	48	48
$N_{Pilotsubcarriers}$	6	6	6
N_{tiles}	576	288	144
Tiles per subchannel	6	6	6



Description of an Uplink OPUSC Tile

FFT size		Basic permutation sequences
512	P1	1, 2, 4, 3, 6, 7, 5
	P2	1, 4, 6, 5, 2, 3, 7
1024	P1	1, 2, 4, 8, 3, 6, 12, 11, 5, 10, 7, 14, 15, 13, 9
	P2	1, 4, 3, 12, 5, 7, 15, 9, 2, 8, 6, 11, 10, 14, 13
2048	P1	1, 2, 4, 8, 16, 5, 10, 20, 13, 26, 17, 7, 14, 28, 29, 31, 27,19, 3, 6, 12, 24, 21, 15, 30, 25, 23, 11, 22, 9, 18
	P2	1, 4, 16, 10, 13, 17, 14, 29, 27, 3, 12, 21, 30, 23, 22, 18,2, 8, 5, 20, 26, 7, 28, 31, 19, 6, 24, 15, 25, 11, 9

5. The UL mapping consist of two steps. In the first the OFDMA slots allocated to each burst are selected. In the second steps the allocated slots are mapped.
   - Step1 – allocate OFDMA slots to bursts
     Map the slots such that the lowest numbered slot occupies the lowest numbered subchannel in the lowest numbered OFDMA symbol. Continue the mapping such that the OFDMA symbol index is increased. When the edge of the UL zone is reached, continue the mapping from the lowest numbered OFDMA symbol in the next available subchannel. When the slot has been allocated to a rectangular burst (such as Ranging, Fast-FeedBack or HARQ-ACK bursts), the mapping shall ignore this slot and look for the next slot according to the above rule.
   - Step2 – Map OFDMA slots within the UL allocation
     Map the slots such that the lowest numbered slot occupies the lowest numbered subchannel in the lowest numbered OFDMA symbol. Continue the mapping such that the Subchannel index is increased. When the last subchannel is reached, continue the mapping from the lowest numbered subchannel in the next OFDMA symbol that belongs to the UL allocation.
6. A rotation scheme shall be applied per each OFDMA slot-duration in PUSC zone. On each slot-duration, the rotation scheme shall be applied to all UL subchannels that belong to the segment, except those subchannels indicated in the UL-MAP by UIUC = 0, UIUC = 13 or UIUC = 12. The rotation scheme is defined in 8.4.6.2.6 of Reference [2].
7. The output of positions for normal data bursts start from the first slot at the lowest indexed subcarrier and continuing in an ascending manner through the subcarriers in the same slot, then going to the next slot at the lowest indexed subcarrier, and so on.
   The output of positions for Ranging burst start from the first symbol at the lowest indexed subcarrier of the lowest indexed subchannel and continuing in an ascending manner through the subcarriers in the same subchannel in the first symbol, then going to the next subchannel in the first symbol at the lowest indexed subcarrier, and so on. When all the subchannels in the first symbol are output, then go to the second symbol at lowest indexed subcarrier of the lowest indexed subchannel.
   The output of positions for Fast-FeedBack burst start from the first slot at the lowest indexed subcarrier of the lowest indexed tile and continuing in an ascending manner through the subcarriers in the same tile in the first slot, then going to the next tile in the first slot at the lowest indexed subcarrier, and so on.

The output of positions for HARQ-ACK burst start from the first slot at the lowest indexed subcarrier of the lowest indexed tile and continuing in an ascending manner through the subcarriers in the same tile in the first slot, then going to the next tile in the first slot at the lowest indexed subcarrier, and so on.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

802.16e OFDM Design Examples

This section includes the 802.16e OFDM transmitter, receiver, and WiBro design examples.

Mobile WiMAX Transmitter Design Examples

The WMAN_16e_OFDMA_Tx_wrk workspace shows Mobile WiMAX transmitter measurement characteristics. The frequency is set to 2305 MHz.

Designs for these measurements include:

- DL EVM and constellation measurements: WMAN_OFDMA_DL_TxEVM
- DL EVM and constellation measurements with Phase Noise: WMAN_OFDMA_DL_TxEVM_PhaseNoise
- DL spectrum flatness measurement: WMAN_OFDMA_DL_TxSpecFlat
- DL spectrum measurement: WMAN_OFDMA_DL_TxSpectrum
- DL CCDF and waveform measurements: WMAN_OFDMA_DL_TxWaveform
- DL transmitter connect with VSA 89600 software: WMAN_OFDMA_DL_VSA
- DL FDD CCDF, waveform and spectrum measurements: WMAN_OFDMA_DL_FDD_TxWaveform
- UL Ranging transmitter connect with VSA 89600 software: WMAN_OFDMA_UL_Ranging_VSA
- UL EVM and constellation measurements: WMAN_OFDMA_UL_TxEVM
- UL spectrum measurement: WMAN_OFDMA_UL_TxSpectrum
- UL transmitter connect with VSA 89600 software: WMAN_OFDMA_UL_VSA
- UL spectrum flatness measurement: WMAN_OFDMA_UL_TxSpecFlat

Variables used in these designs are listed inthe following table.

VAR Parameters

Parameter Name	Description	Default Value
FCarrier	RF frequency	2305 (MHz)
Bandwidth	Nominal bandwidth	10 (MHz)
SignalPower	Signal power	10 (dBm)
FFTSize	FFT size	1024
ZoneType	Zone type	PUSC
FrameDuration	Frame duration	5 (ms)
CyclicPrefix	Cyclic prefix	1/8
PowerType	Power in frame	Peak power
CodingType	Coding type	CTC

Downlink Transmitter EVM and Constellation Measurements

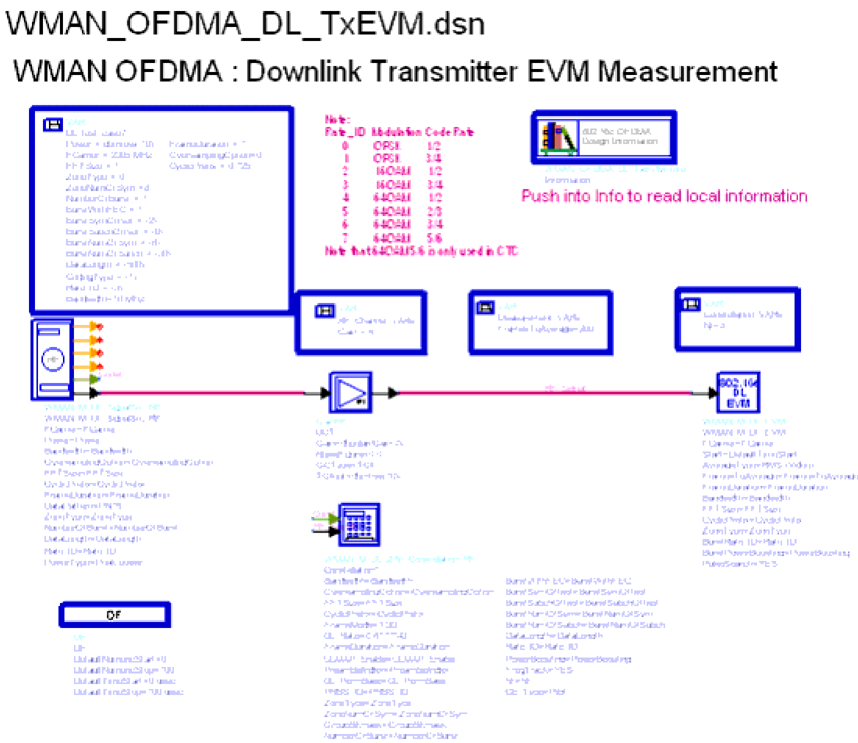
WMAN_OFDMA_DL_TxEVM Design

Features

- Mobile WiMAX downlink transmitter EVM and constellation measurements

Description

WMAN_OFDMA_DL_TxEVM measures the downlink transmitter EVM and constellation. The schematic is shown in The following illustration.



anchor:1019949}

WMAN_OFDMA_DL_TxEVM Schematic

In DL signal source, the *PowerType* is set to *Peak power* which is recommended for transmitter measurement. For more information, refer to *Transmit Power Definition.* (wman_m)

Users can change *Rate_ID* from 0 to 7 and get results for different modulations and code rates.

If *AverageType* is set to *OFF* , only one frame is analyzed. If *AverageType* is set to *RMS* (*Video*), after the first frame is analyzed the signal segment corresponding to it is discarded and new signal samples are collected from the input to fill in the signal buffer of length 2 × *FrameDuration*. The *SymbolTimingAdjust* parameter sets the percentage of symbol time by which we back away from the symbol end before we perform the FFT. The *TrackAmplitude*, *TrackPhase*, *TrackTiming*, and *EqualizerTraining* parameters determine the EVM measurement result. For more information, refer to *WMAN_M_DL_EVM (EVM Measurement for 802.16e Downlink Signals).* (wman_m)

Simulation Results

In this example, The performances of downlink PUSC for 16QAM 3/4 (*Rate_ID=3*) are given. *Parameter Settings* shows the simulation conditions.

Parameter Settings

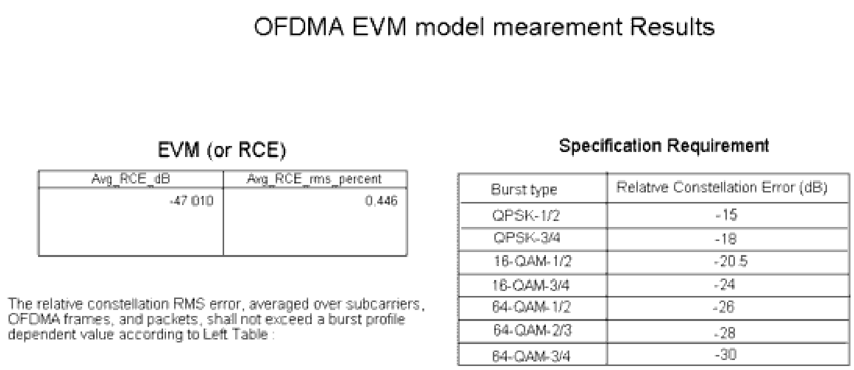
Parameter	Value
FCarrier	2305 MHz
Zone Type	DL PUSC
FFT Size	1024
Bandwidth	10 MHz
Frame Duration	2.5 msec
Oversampling Option	Ratio 1
Cyclic Prefix	0.125
Packet Length in One Frame (Data Length)	100 Bytes
Rate ID	16QAM 3/4

The relative constellation RMS error, averaged over subcarriers, OFDMA frames, and packets, shall not exceed a burst profile dependent value according to the allowed relative constellation error versus data rate as found in the following table, and defined in section 8.4.12.3, IEEE Std 802.16e-2005.

Allowed Relative Constellation Error versus Data Rate

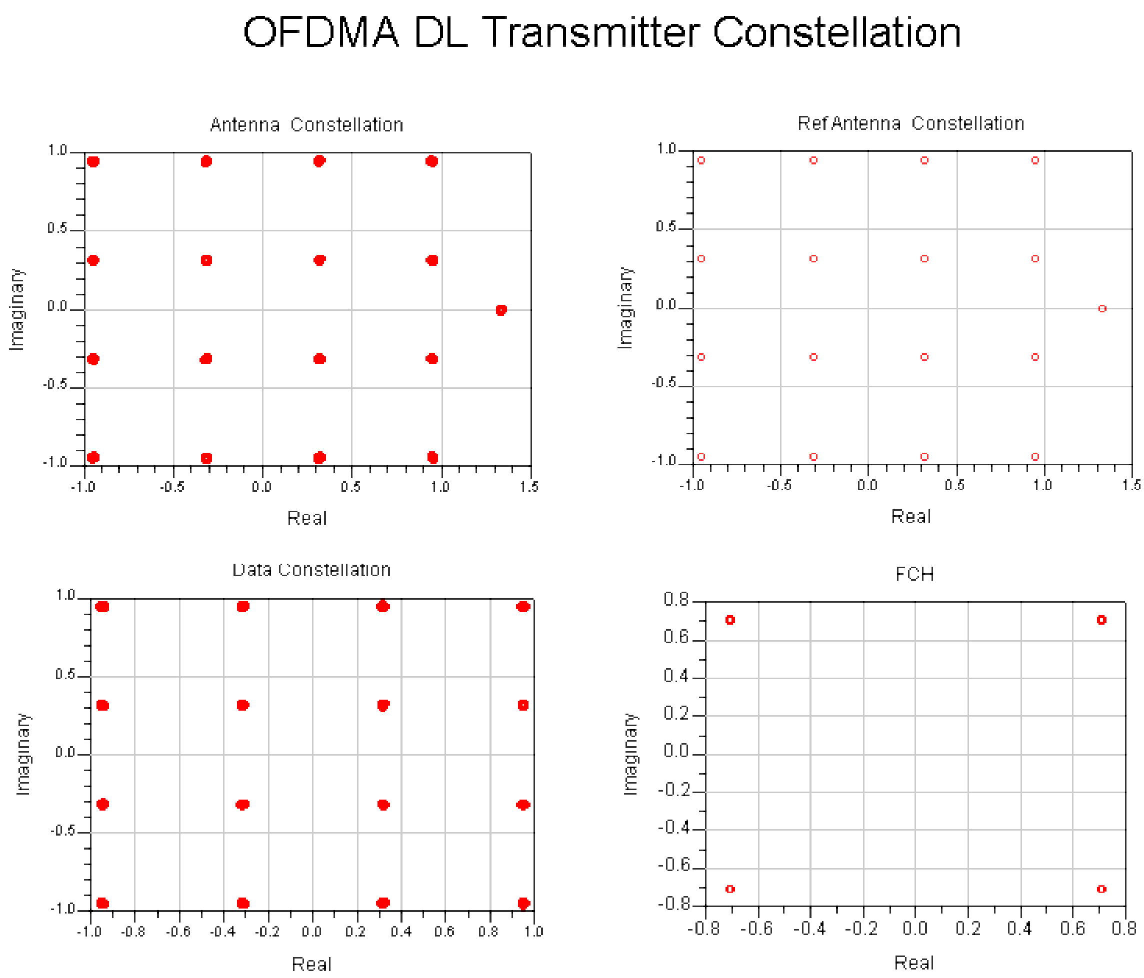
Burst type	Relative Constellation Error (dB)
QPSK-1/2	-15
QPSK-3/4	-18
16-QAM-1/2	-20.5
16-QAM-3/4	-24
64-QAM-1/2	-26
64-QAM-2/3	-28
64-QAM-3/4	-30

The following illustration shows the simulation results for EVM measurement.



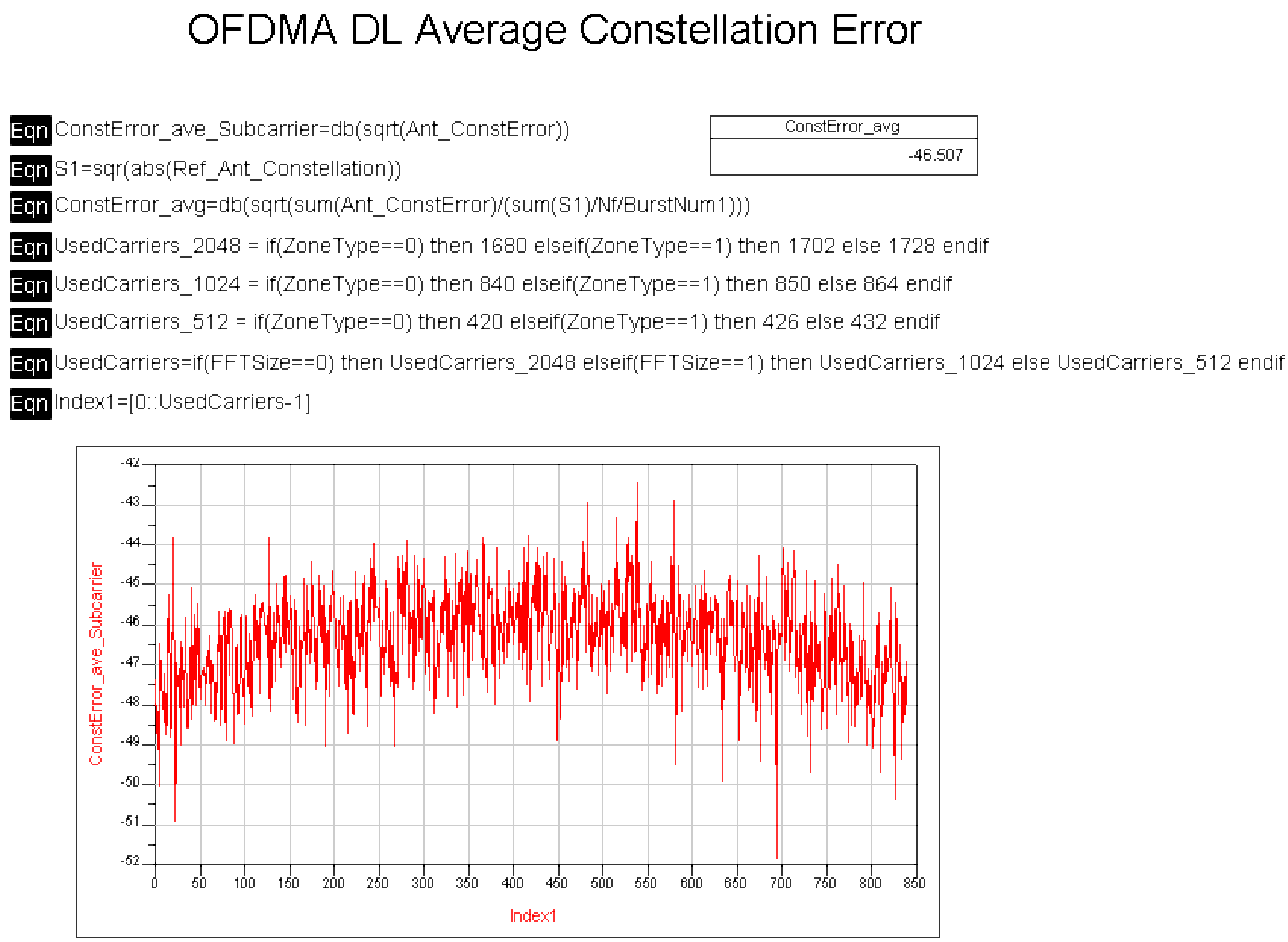
EVM Measurement Results

The next illustration shows the constellation diagrams.



OFDMA DL Transmitter Constellation

While the next figure shows the average constellation error versus subcarriers.



OFDMA DL Average Constellation Error

RCE (Relative Constellation Error) is the RMS level of the Error Vector Magnitude, averaged over all subcarriers and all detected OFDMA symbols. RCE (EVM) is computed in dB. The average RCE is shown in the following illustration.

OFDMA Data RMS Constellation Error

Eqn Err=Ref_Data_Constellation-Data_Constellation

Eqn ErrvsSubcarr=db(abs(Err))

Eqn RMSerr=sqr(abs(Err))

Eqn S1_Data=sqr(abs(Ref_Data_Constellation))

Eqn RCE=db(sqrt(sum(RMSerr)/sum(S1_Data)))

Eqn eye_sc=eye(ErrvsSubcarr,1/DataCarriers)

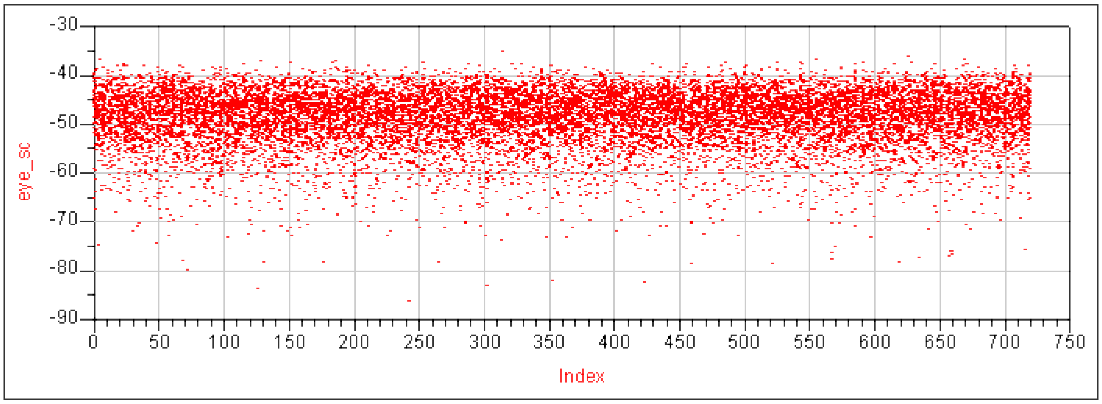
RCE
-45.789

Eqn DataCarriers_2048=if(ZoneType==0) then 60*24 else 32*48 endif

Eqn DataCarriers_1024=if(ZoneType==0) then 30*24 else 16*48 endif

Eqn DataCarriers_512=if(ZoneType==0) then 15*24 else 8*48 endif

Eqn DataCarriers=if(FFTSize==0) then DataCarriers_2048 elseif(FFTSize==1) then DataCarriers_1024 else DataCarriers_512 endif



OFDMA DL RMS Constellation Error

Benchmark

- Hardware Platform: Centrino Duo 2.0GHz, 2 GB memory
- Software Platform: Windows XP, ADS 2005A
- Simulation Time: about 10 hours for QPSK 1/2 (Rate_ID=0)

Downlink Transmitter EVM and Constellation Measurements with Phase Noise

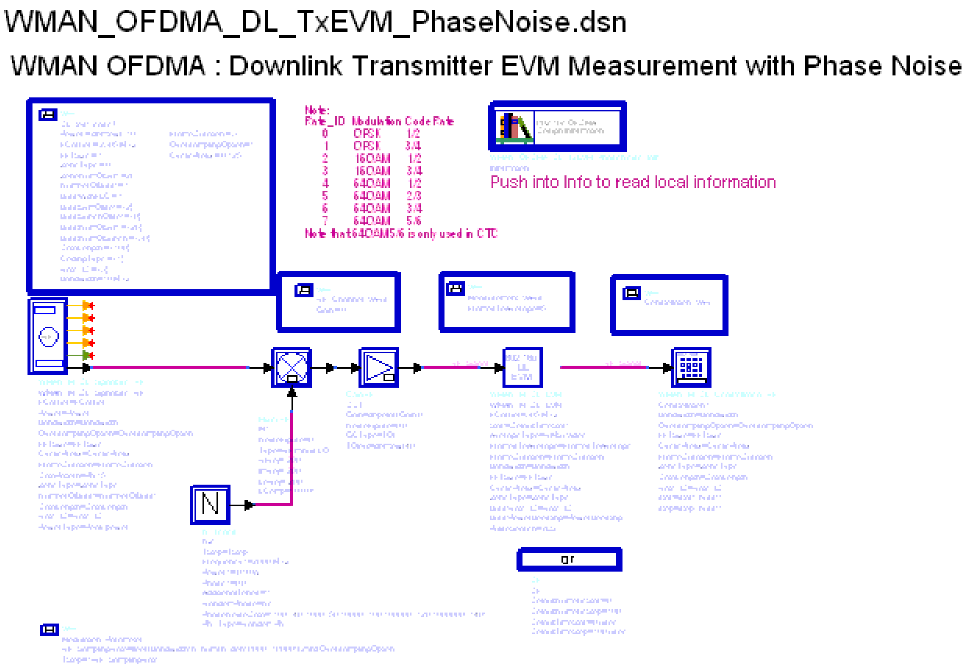
WMAN_OFDMA_DL_TxEVM_PhaseNoise Design

Features

- Mobile WiMAX downlink transmitter EVM and constellation measurements with phase noise present.

Description

WMAN_OFDMA_DL_TxEVM_PhaseNoise measures the downlink transmitter EVM and constellation with the presence of phase noise. The schematic is shown below.



WMAN_OFDMA_DL_TxEVM_PhaseNoise Schematic

In DL signal source, the *PowerType* is set to *Peak power* which is recommended for transmitter measurement. For more information, refer to *Transmit Power Definition.* (wman_m)

Users can change *Rate_ID* from 0 to 7 and get results for different modulations and code rates.

If *AverageType* is set to *OFF*, only one frame is analyzed. If *AverageType* is set to *RMS* (*Video*), after the first frame is analyzed the signal segment corresponding to it is discarded and new signal samples are collected from the input to fill in the signal buffer of length 2 x *FrameDuration* . The *SymbolTimingAdjust* parameter sets the percentage of symbol time by which we back away from the symbol end before we perform the FFT. The *TrackAmplitude* , *TrackPhase* , *TrackTiming* , and *EqualizerTraining* parameters determine the EVM measurement result. For more information, refer to WMAN_M_DL_EVM.

Simulation Results

In this example, The performances of downlink PUSC for 16QAM 3/4 (*Rate_ID=3*) are given. The following table shows the simulation conditions.

Parameter Settings

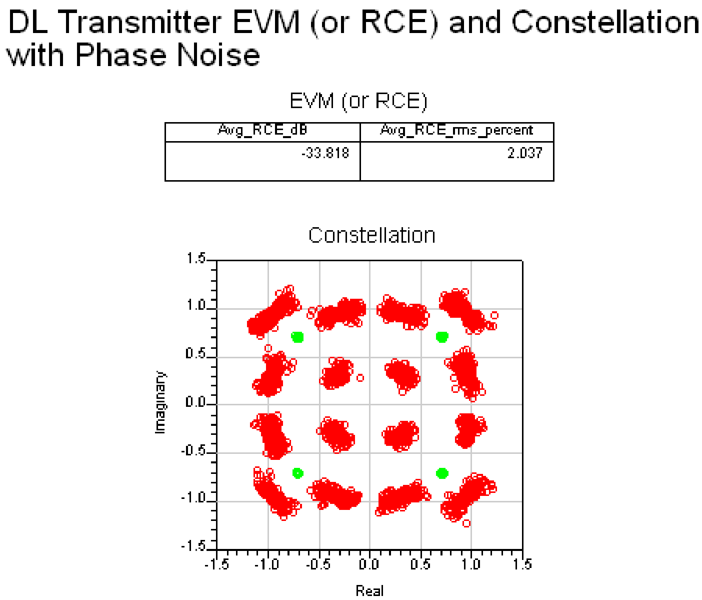
Parameter	**Value**
FCarrier	2305 MHz
Zone Type	DL PUSC
FFT Size	1024
Bandwidth	10 MHz
Frame Duration	5 msec
Oversampling Option	Ratio 2
Cyclic Prefix	0.125
Packet Length in One Frame (Data Length)	100 Bytes
Rate ID	16QAM 3/4

The relative constellation RMS error, averaged over subcarriers, OFDMA frames, and packets, shall not exceed a burst profile dependent value shown in the following table as defined in section 8.4.12.3, IEEE Std 802.16e-2005.

Allowed Relative Constellation Error versus Data Rate

Burst type	**Relative Constellation Error (dB)**
QPSK-1/2	-15
QPSK-3/4	-18
16-QAM-1/2	-20.5
16-QAM-3/4	-24
64-QAM-1/2	-26
64-QAM-2/3	-28
64-QAM-3/4	-30

The simulation results are shown below.



DL EVM and Constellation with Phase Noise

Benchmark

- Hardware Platform: Pentium IV 2.26GHz, 1 GB memory
- Software Platform: Window 2000, ADS 2005A
- Simulation Time: about 30 seconds

Downlink Transmitter Spectrum Flatness Measurements

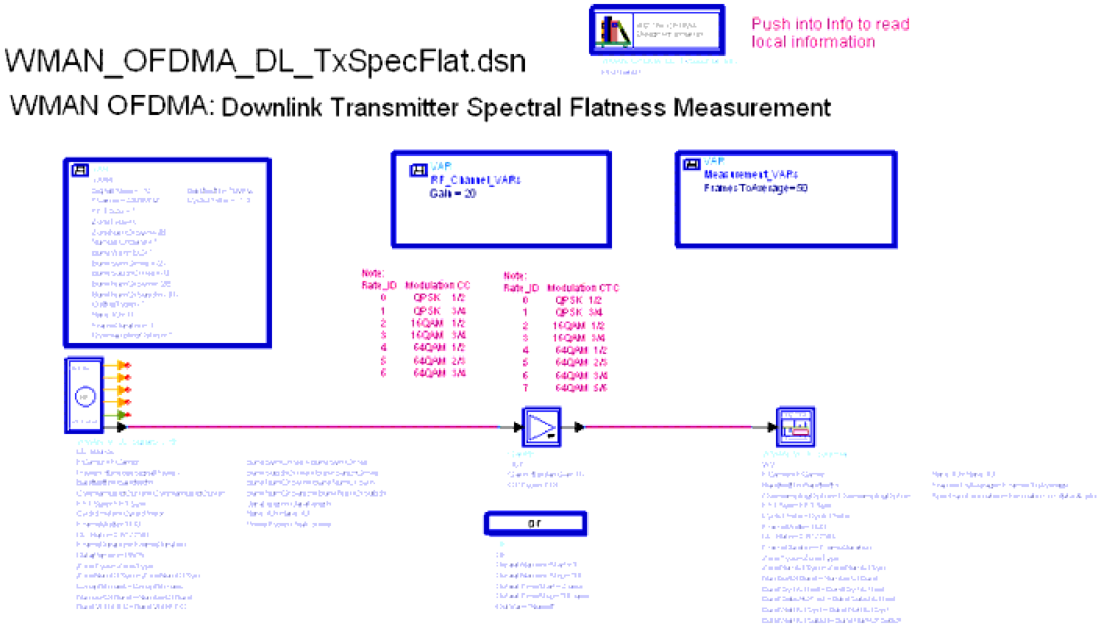
WMAN_OFDMA_DL_TxSpecFlat Design

Features

- Spectrum flatness measurement
- WMAN OFDMA downlink signal is used as the signal source
- DL PUSC supported

Description

WMAN_OFDMA_DL_TxSpecFlat measures the spectrum flatness of downlink signal. The schematic is shown below.



WMAN_OFDMA_DL_TxSpecFlat Schematic

The average energy of the constellations in each of the *n* spectral lines shall deviate no more than indicated in the following table, as defined in Section 8.4.12.2, Std 802.16-2004 and 802.16e-2005.

Spectral Flatness

Spectral Lines	Spectral Flatness
Spectral lines from -Nused to -1 and +1 to +Nused/4	+2/-2 dB from the measured energy averaged over all Nused active tones
Spectral lines from -Nused /2 to	+2/-4 dB from the measured energy averaged over all Nused active tones

The absolute difference between adjacent subcarriers shall not exceed 0.1 dB.

According the standard, the data for measuring spectral flatness shall be taken from the channel estimation step. In RCT (Ref[3]), more specifications are listed by observing the amplitude deviations from the constellation points. This function estimates the flatness as a function of frequency from ordinary data transmission signals.

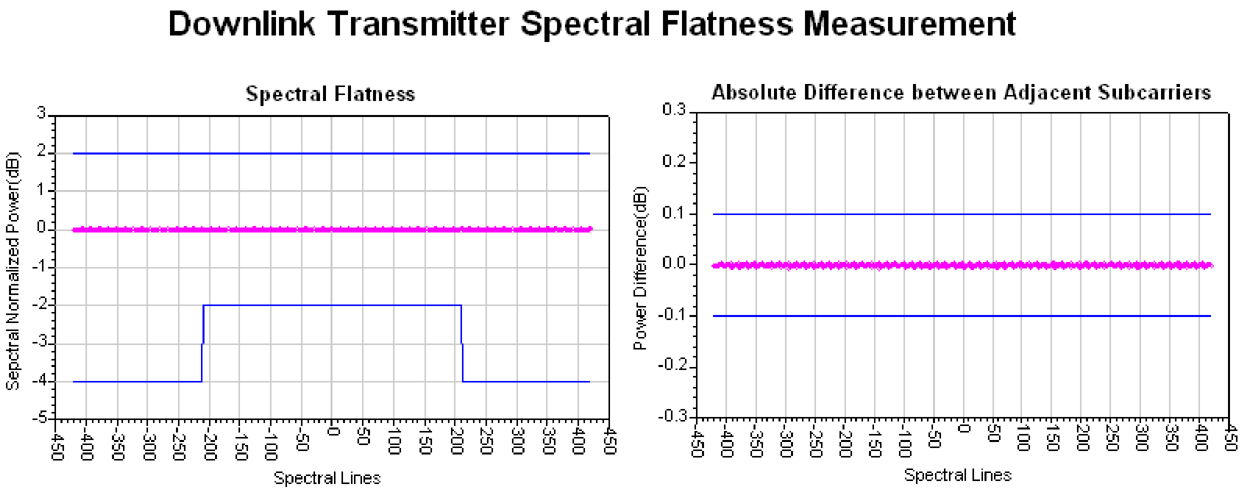
Two methods are provided to get the data for measuring spectral flatness.

1. *SpectrumEstimation is Estimation on pilots*
   In this method, the CIRs are estimated only on pilot subcarriers. The CIRs on data subcarriers are interpolated by the CIRs on pilot subcarriers.
   Note that this method is only applied for DL PUSC currently.
2. *SpectrumEstimation is Estimation on data & pilots*
   This method follows the requirement by RCT (Ref[3]). By observing the received amplitude deviations from the nearest constellation points in data and pilot subcarriers, this method estimates the flatness as a function of frequency from ordinary data transmission signals. The spectral flatness for each subcarrier across the whole data zone is averaged to remove spectral fluctuation due to modulation. The difference energy is obtained by comparing amplitudes within the CIRs obtained in the above measurement for all subcarriers with neighboring subcarriers excluding all non-allocated subcarriers.
   Note that this method is only applied for DL PUSC.

The results shall be the average of *FramesToAverage* downlink subframes, where *FramesToAverage* is set by users.

Simulation Results

The simulation result is shown in below. In DDS, the power at spectral line 0 in the two figures is not real (always set to 0 dB). The ratio of the real power at spectral line 0 to the total power is shown in the table with the title of "Ratio of power at Spectral line 0 to total power (in dB)".



Spectrum Flatness Measurement Result

Benchmark

- Hardware Platform: Centrino Duo 2.0GHz, 2GB memory
- Software Platform: Windows XP, ADS 2005A
- Simulation Time: 70 seconds

Downlink Transmitter Spectrum Measurement

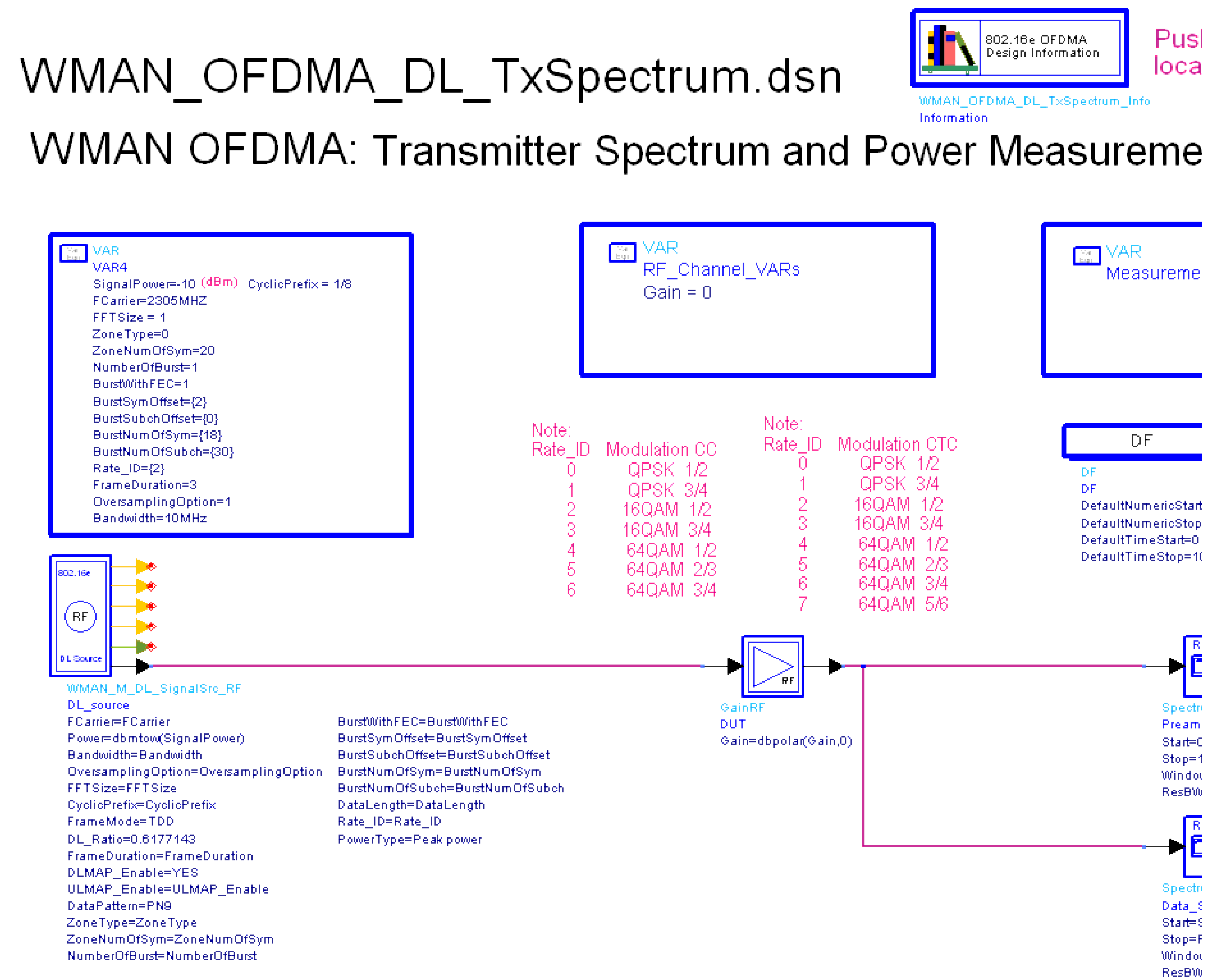
WMAN_OFDMA_DL_TxSpectrum Design

Features

- Transmitter Spectrum Measurement

Description

WMAN_OFDMA_DL_TxSpectrum measures the transmitter spectrum of downlink signal. The schematic is shown below.



WMAN_OFDMA_DL_TxSpectrum Schematic

In DL signal source, the *PowerType* is set to *Peak power* which is recommended for transmitter measurement. For more information, refer to *Transmit Power Definition.* (wman_m)

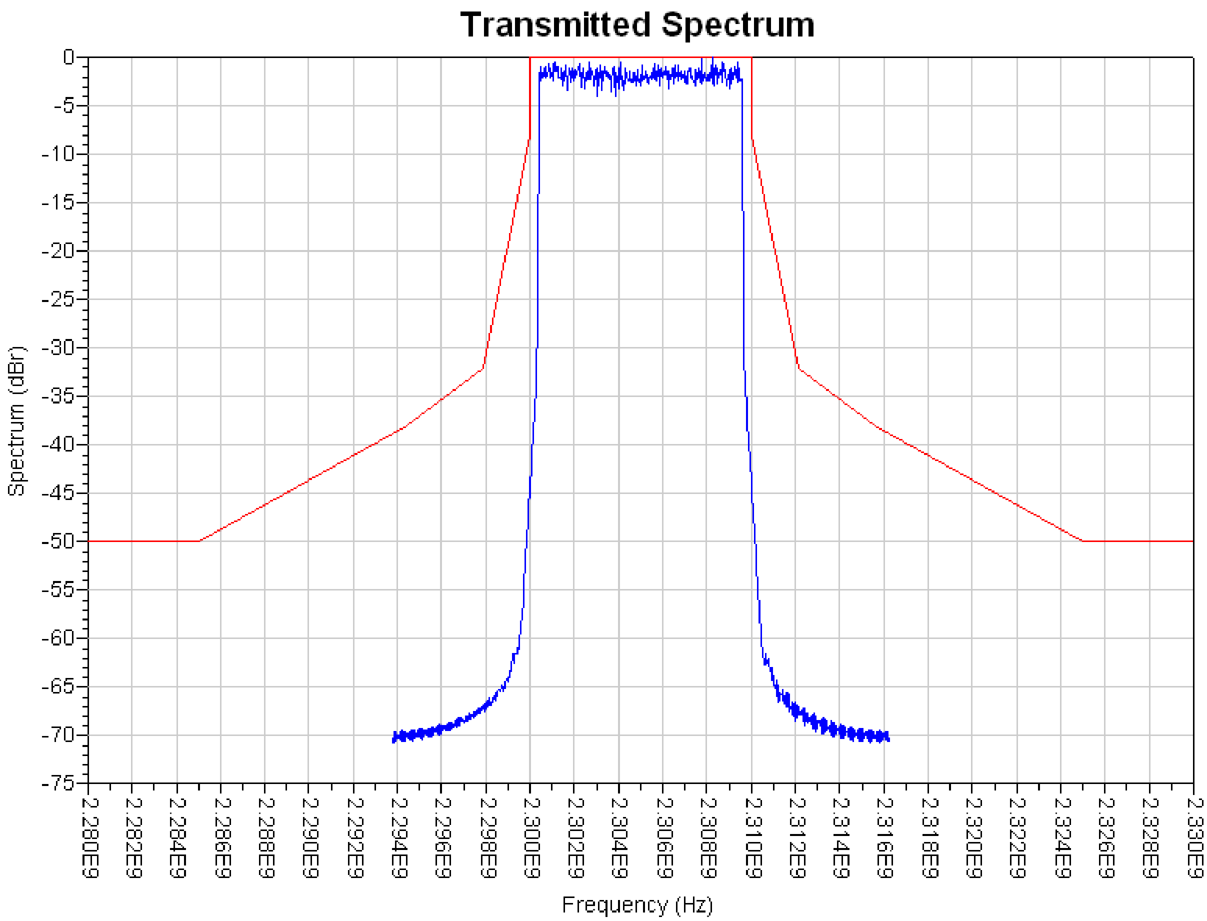
Simulation Results

The signal power density spectrum is obtained using the spectrum analyzer. The following table shows the simulation conditions.

Parameter Settings

Parameter	**Value**
FCarrier	2305 MHz
Zone Type	DL PUSC
FFT Size	1024
Bandwidth	10 MHz
Frame Duration	5 msec
Oversampling Option	Ratio 2
Cyclic Prefix	1/8
Packet Length in One Frame (Data Length)	3230 Bytes
Rate ID	16QAM 1/2
Coding Type	CTC

The signal power density spectrum is shown below. The transmitted spectral density shall fall within the spectral mask. From the results users can read the power of preamble is the *Peak Power*.



spec_power(dBm(Preamble_Spectrum))	spec_power(dBm(Data_Spectrum))
-10.018	-13.980

DL Transmitter Spectrum

Benchmark

- Hardware Platform: Pentium IV 2.26GHz, 1 GB memory
- Software Platform: Window 2000, ADS 2005A
- Simulation Time: 2 seconds

Downlink Transmitter Waveform Measurement

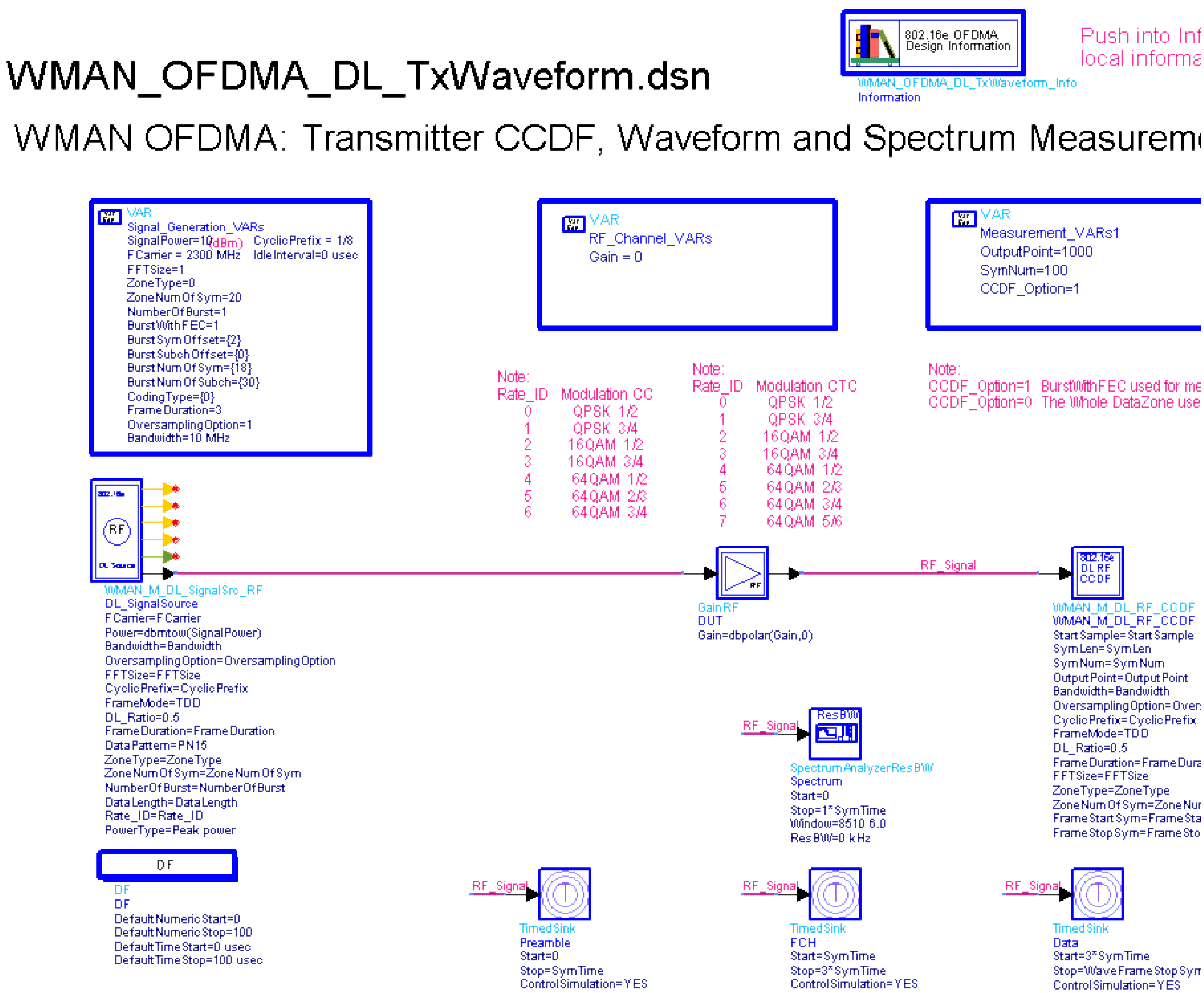
WMAN_OFDMA_DL_TxWaveform Design

Features

- Transmitter CCDF
- Preamble Power, Mean Power and Peak Power
- Transmitter Waveform

Description

This example measures CCDF and Power of WMAN OFDMA Downlink transmitter. The schematic is shown below.



WMAN_OFDMA_DL_TxWaveform Schematic

CCDF_Option decides which part of the Data Zone is used for measurement. When *CCDF_Option* =1, BurstWithFEC is measured. When *CCDF_Option* =0, the whole Data Zone is measured. *OutputPoint* means how many parts will X-axis be divided into in the CCDF figure. The larger *OutputPoint* is, the closer measured curve is to reference curve. *SymNum* means the number of symbol measured. *StartSample* in the WMAN_M_DL_RF_CCDF model is used to discard the first frame delay caused by receiver model. In WMAN_M_DL_SignalSrc_RF *PowerType* is set to *Peak Power*. For more information, refer to *Transmit Power Definition.* (wman_m)

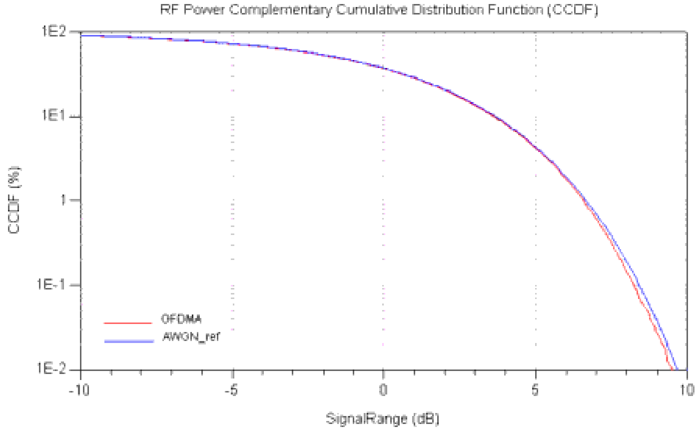
Simulation Results

The following table lists some key parameters. Transmitter CCDF and Power Measurement shows transmitter CCDF and power measurement. Transmitter Waveform shows transmitter waveform.

Parameter Settings

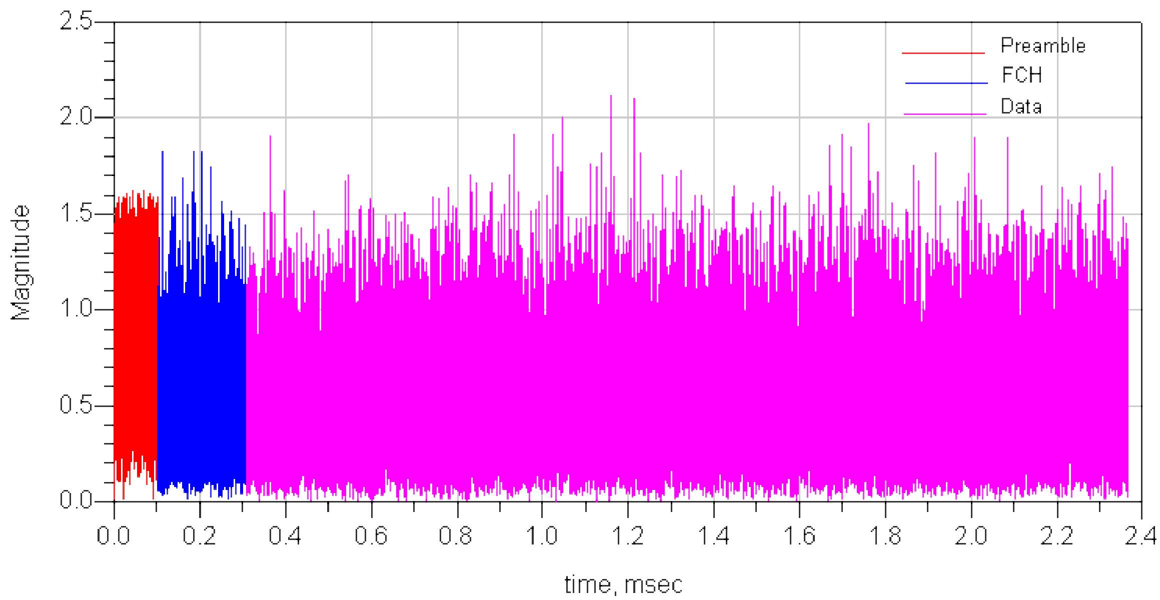
Parameter	Value
Signal Power	10 (dBm)
Zone Type	DL PUSC
FFT Size	1024
Bandwidth	10 MHz
Frame Duration	5 msec
Frame Mode	TDD
DL Ratio	0.6177
Oversampling Option	Ratio 1
PowerType	Peak Power
Gain	0 (in dB)
Output Point	1000
SymNum	100
CCDF Option	1

Transmitter CCDF and Power Measurement



MeanPower_dBm	PeakPower_dBm	..._Peak_to_Avg_dB	Preamble_Power
6.116	14.333	8.217	9.973

Transmitter Waveform



Benchmark

- Hardware Platform: Pentium IV 2.66GHz, 1 GB memory
- Software Platform: Window 2000, ADS 2005A
- Simulation Time: 20 seconds

Downlink Transmitter Connected with 89600 Trans

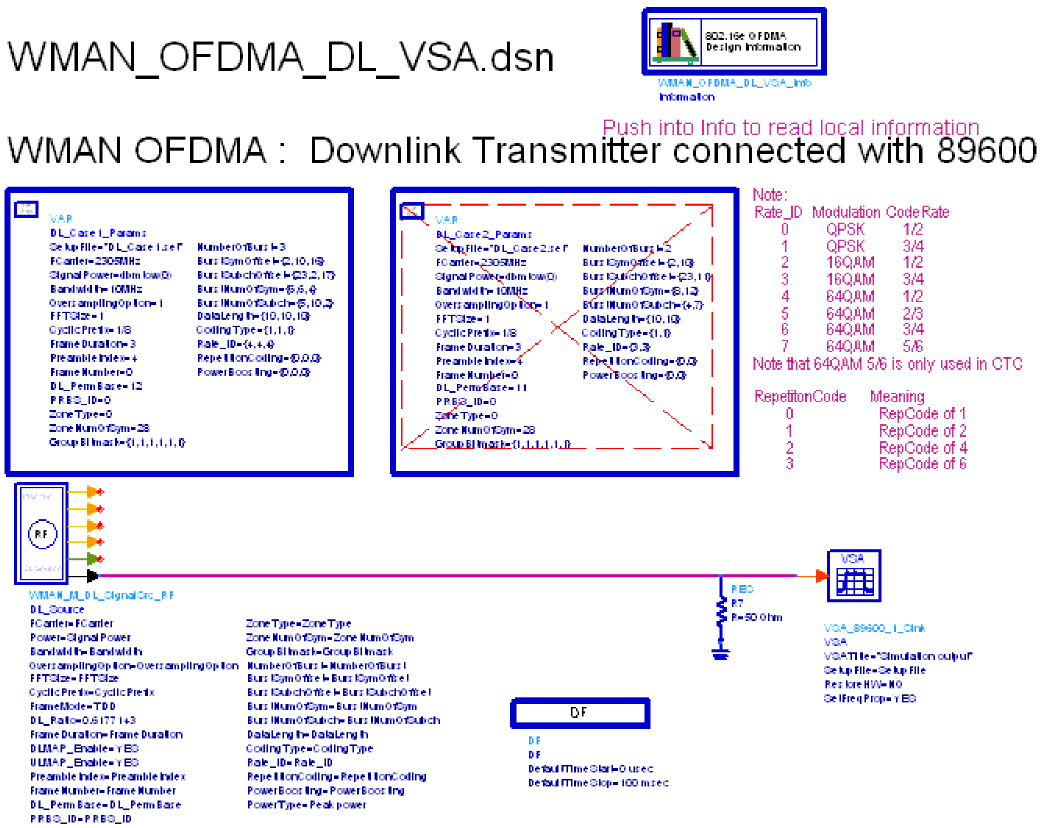
WMAN_OFDMA_DL_VSA Design

Features

- WMAN OFDMA downlink demodulation result using Agilent 89600 VSA software.

Description

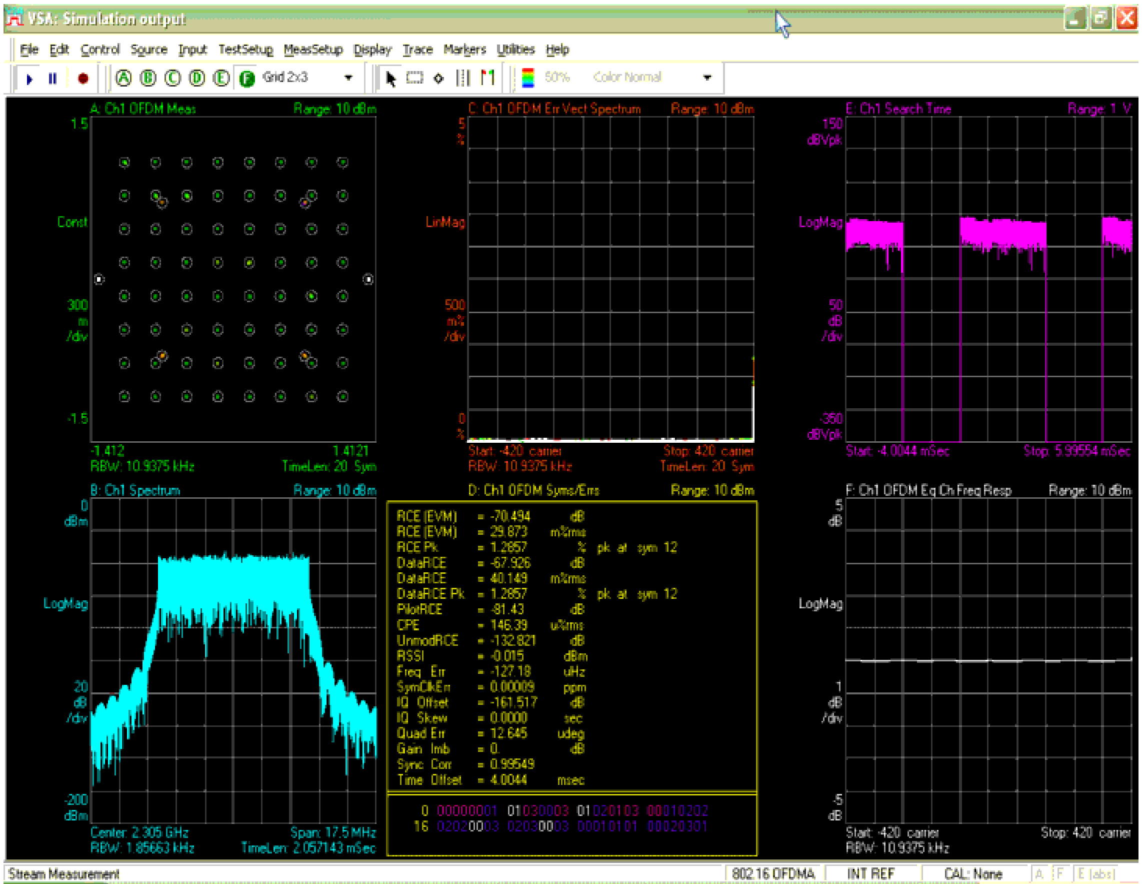
WMAN_OFDMA_DL_VSA shows WMAN OFDMA downlink demodulation results connecting with Agilent 89600 VSA. The schematic is shown below.



WMAN_OFDMA_DL_VSA Schematic

Simulation Results

The following illustration shows the demodulation result given by an Agilent 89600 VSA.



89600 VSA Software Demodulation Results

Benchmark

- Hardware Platform: Centrino Duo 2.0GHz, 2GB memory
- Software Platform: Windows XP, ADS 2005A

DL FDD Transmitter CCDF, Waveform and Spectrum Measurements

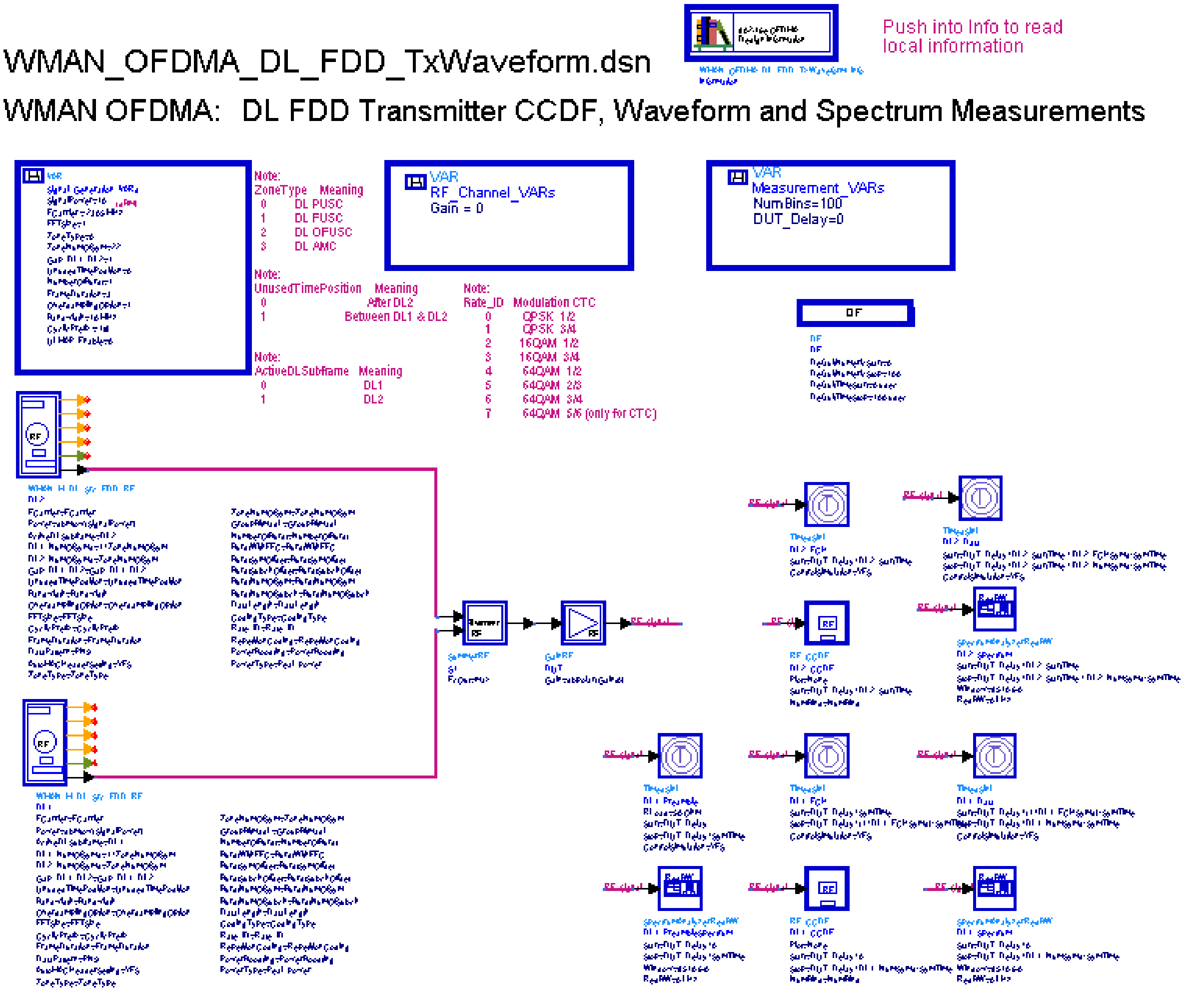
WMAN_OFDMA_DL_FDD_TxWaveform Design

Features

- Downlink FDD transmitter measurements with CCDF, waveform and spectrum.

Description

WMAN_OFDMA_DL_FDD_TxWaveform shows WMAN OFDMA FDD downlink measurement results with CCDF, waveform and spectrum. The schematic is shown below.



WMAN_OFDMA_DL_FDD_TxWaveform Schematic

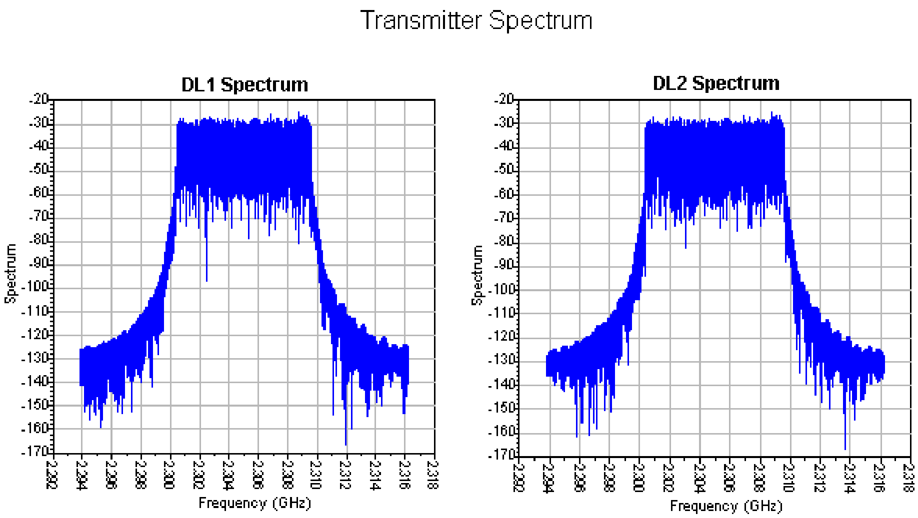
One complete downlink FDD RF source consists of two WMAN_M_DL_Src_FDD_RF. One WMAN_M_DL_Src_FDD_RF is assigned to the first DL subframe (DL1) by setting *ActiveDLSubframe* = DL1; the other is assigned to the second DL subframe (DL2) by setting *ActiveDLSubframe* = DL2. The following parameters related to downlink FDD frame structure should be the same in the two sources:

- ActiveDLSubframe
- DL1_NumOfSyms
- DL2_NumOfSyms
- Gap_DL1_DL2
- UnusedTimePosition

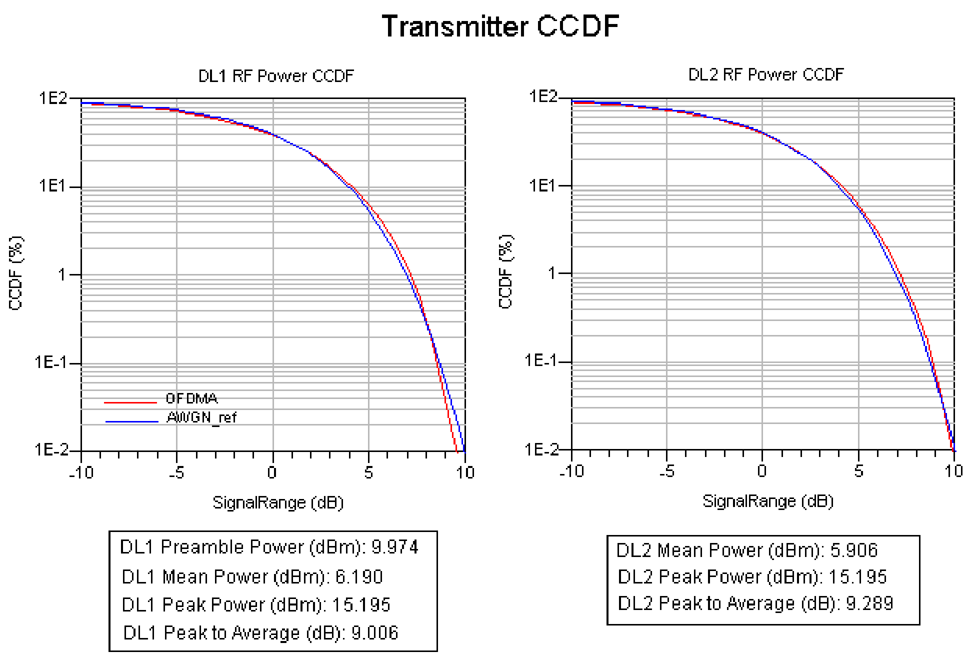
Make sure that DL1_NumOfSyms is equal to the actual number of symbols in DL1, and DL2_NumOfSyms is equal to the actual number of symbols in DL2. see *OFDM symbol calculation* (wman_m).
If the DUT has a specific time delay, please set variable DUT_Delay to this known delay.

Simulation Results

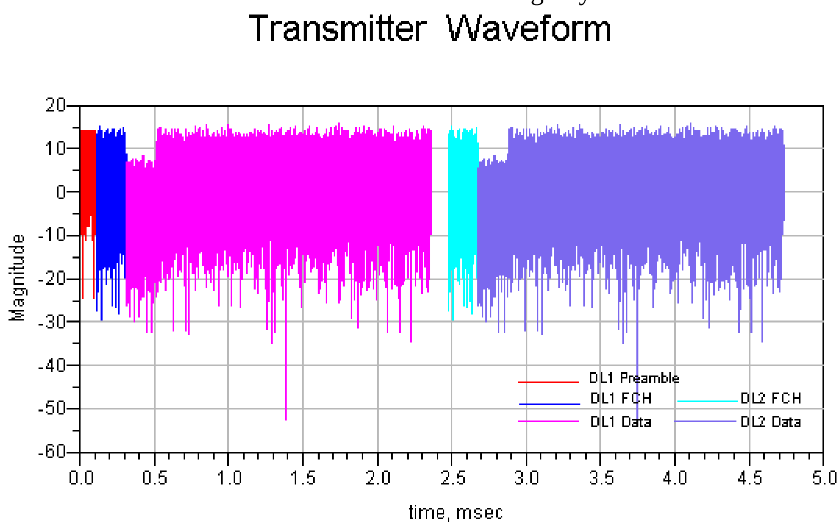
The following illustration shows the measurement results.



Downlink FDD transmitter spectrum results



Downlink FDD transmitter CCDF results



Downlink FDD transmitter waveform results

Benchmark

- Hardware Platform: Centrino Duo 2.0GHz, 2GB memory
- Software Platform: Windows XP, ADS 2008A
- Simulation Time: about 6 seconds

Uplink Ranging Transmitter Connected with 89600 Trans

WMAN_OFDMA_UL_Ranging_VSA Design

Features

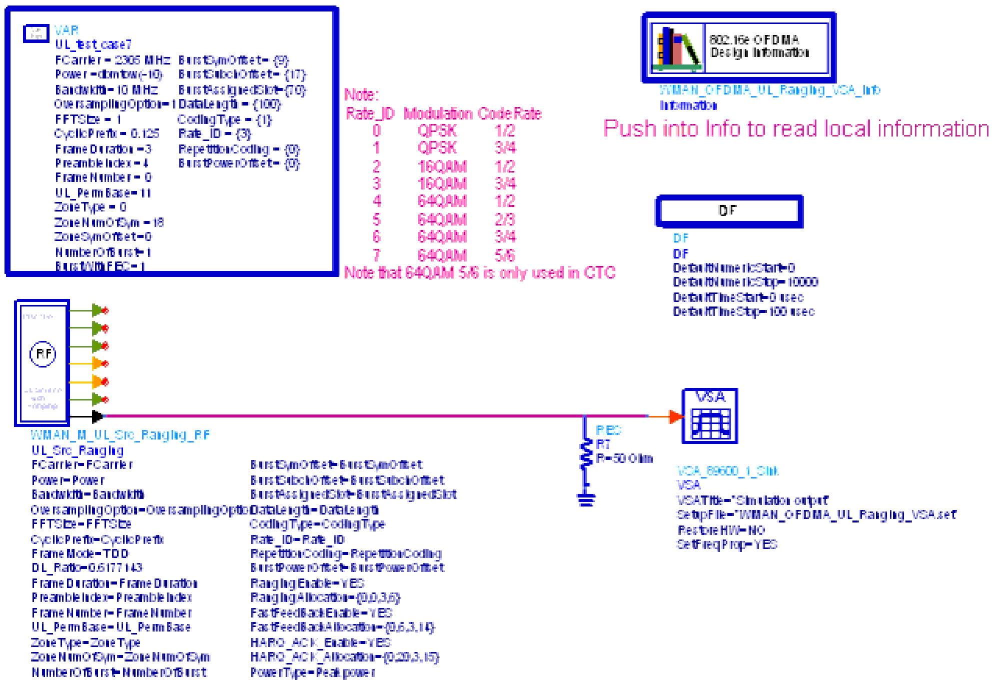
- WMAN OFDMA uplink ranging demodulation result using Agilent 89600 VSA software.

Description

WMAN_OFDMA_UL_Ranging_VSA shows WMAN OFDMA uplink ranging demodulation results connecting with Agilent 89600 VSA. The schematic is shown below.

WMAN_OFDMA_UL_Ranging_VSA.dsn

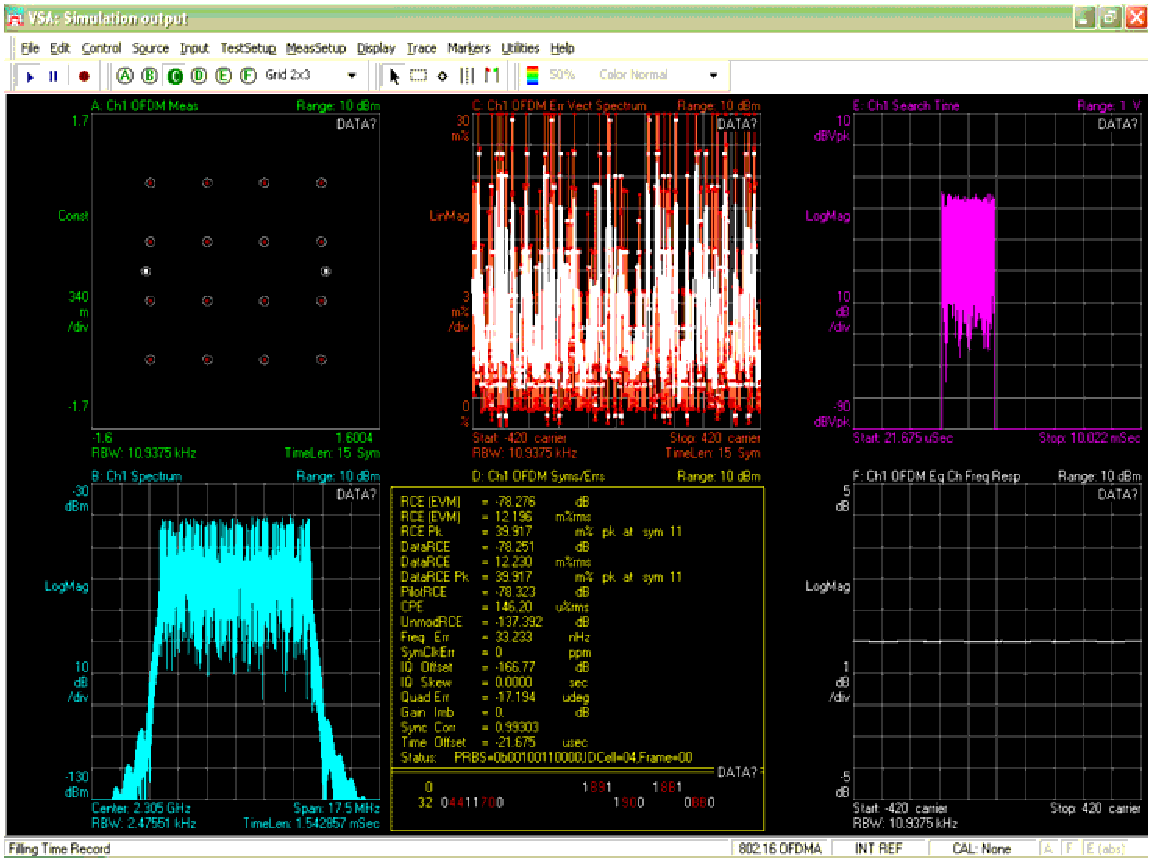
WMAN OFDMA Ranging: Uplink Transmitter Connected with 89600



WMAN_OFDMA_UL_VSA Schematic

Simulation Results

The demodulation result given by an Agilent 89600 VSA is shown below.



89600 VSA Software Demodulation Results

Benchmark

- Hardware Platform: Centrino Duo 2.0GHz, 2GB memory
- Software Platform: Windows XP, ADS 2005A

Uplink Transmitter EVM and Constellation Measurements

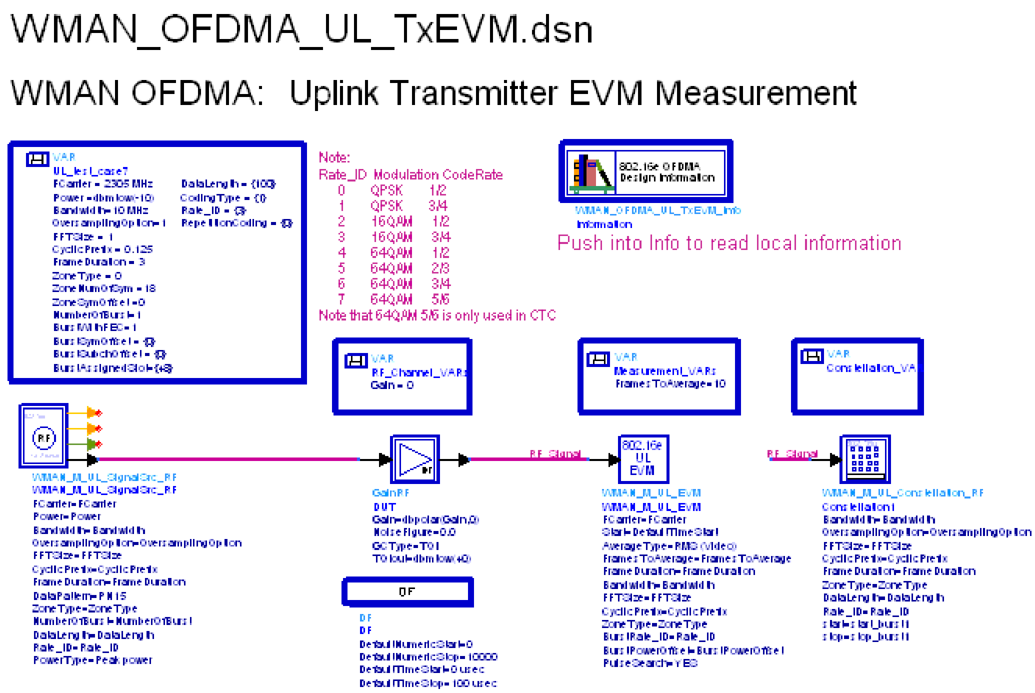
WMAN_OFDMA_UL_TxEVM Design

Features

- Mobile WiMAX uplink transmitter EVM and constellation measurements.

Description

WMAN_OFDMA_UL_TxEVM measures the uplink transmitter EVM and constellation. The schematic is shown below.



WMAN_OFDMA_UL_TxEVM Schematic

In UL signal source, the *PowerType* is set to *Peak power* which is recommended for transmitter measurement. For more information, refer to *Transmit Power Definition.* (wman_m)

Users can change *Rate_ID* from 0 to 7 and get results for different modulations and code rates.

If *AverageType* is set to *OFF*, only one frame is analyzed. If *AverageType* is set to *RMS* (*Video*), after the first frame is analyzed the signal segment corresponding to it is discarded and new signal samples are collected from the input to fill in the signal buffer of length 2 x *FrameDuration*. The *SymbolTimingAdjust* parameter sets the percentage of symbol time by which we back away from the symbol end before we perform the FFT. The *TrackAmplitude*, *TrackPhase*, *TrackTiming*, and *EqualizerTraining* parameters determine the EVM measurement result. For more information, refer to WMAN_M_UL_EVM.

Simulation Results

In this example, the performances of uplink PUSC for 16QAM 3/4 (*Rate_ID=3*) are given. The following table shows the simulation conditions.

Parameter Settings

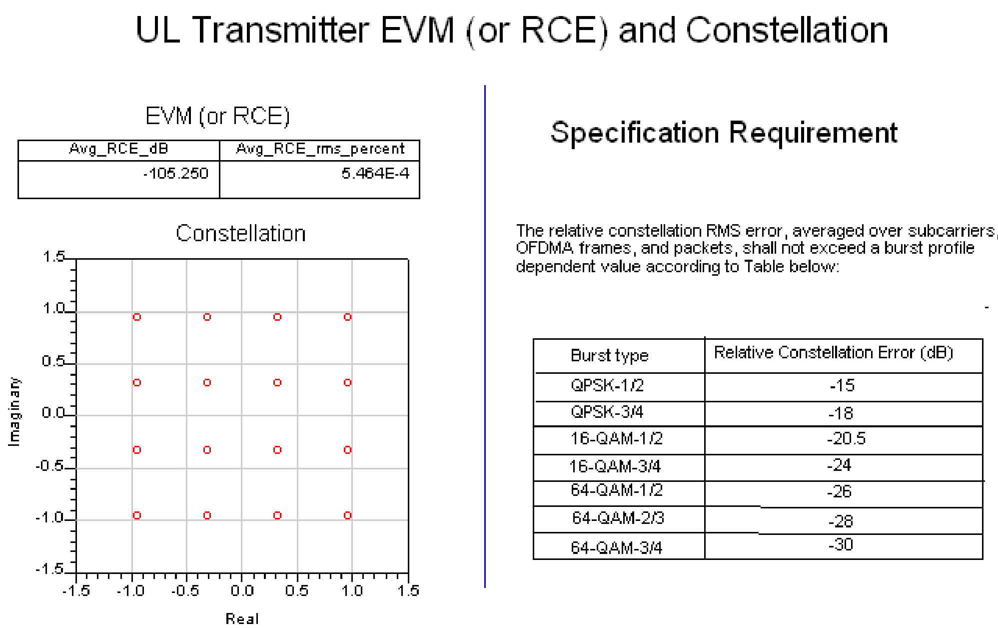
Parameter	Value
FCarrier	2305 MHz
Zone Type	UL PUSC
FFT Size	1024
Bandwidth	10 MHz
Frame Duration	5 msec
Oversampling Option	Ratio 2
Cyclic Prefix	0.125
Packet Length in One Frame (Data Length)	100 Bytes
Rate ID	16QAM 3/4

The relative constellation RMS error, averaged over subcarriers, OFDMA frames, and packets, shall not exceed a burst profile dependent value according to the valus shown in the following table, as defined in section 8.4.12.3, IEEE Std 802.16e-2005.

Allowed Relative Constellation Error versus Data Rate

Burst type	Relative Constellation Error (dB)
QPSK-1/2	-15
QPSK-3/4	-18
16-QAM-1/2	-20.5
16-QAM-3/4	-24
64-QAM-1/2	-26
64-QAM-2/3	-28
64-QAM-3/4	-30

The following illustration shows the simulation results.



Uplink EVM and Constellation

Benchmark

- Hardware Platform: Pentium IV 2.26GHz, 1 GB memory
- Software Platform: Window 2000, ADS 2005A
- Simulation Time: about 30 seconds

Uplink Transmitter Spectrum Measurement

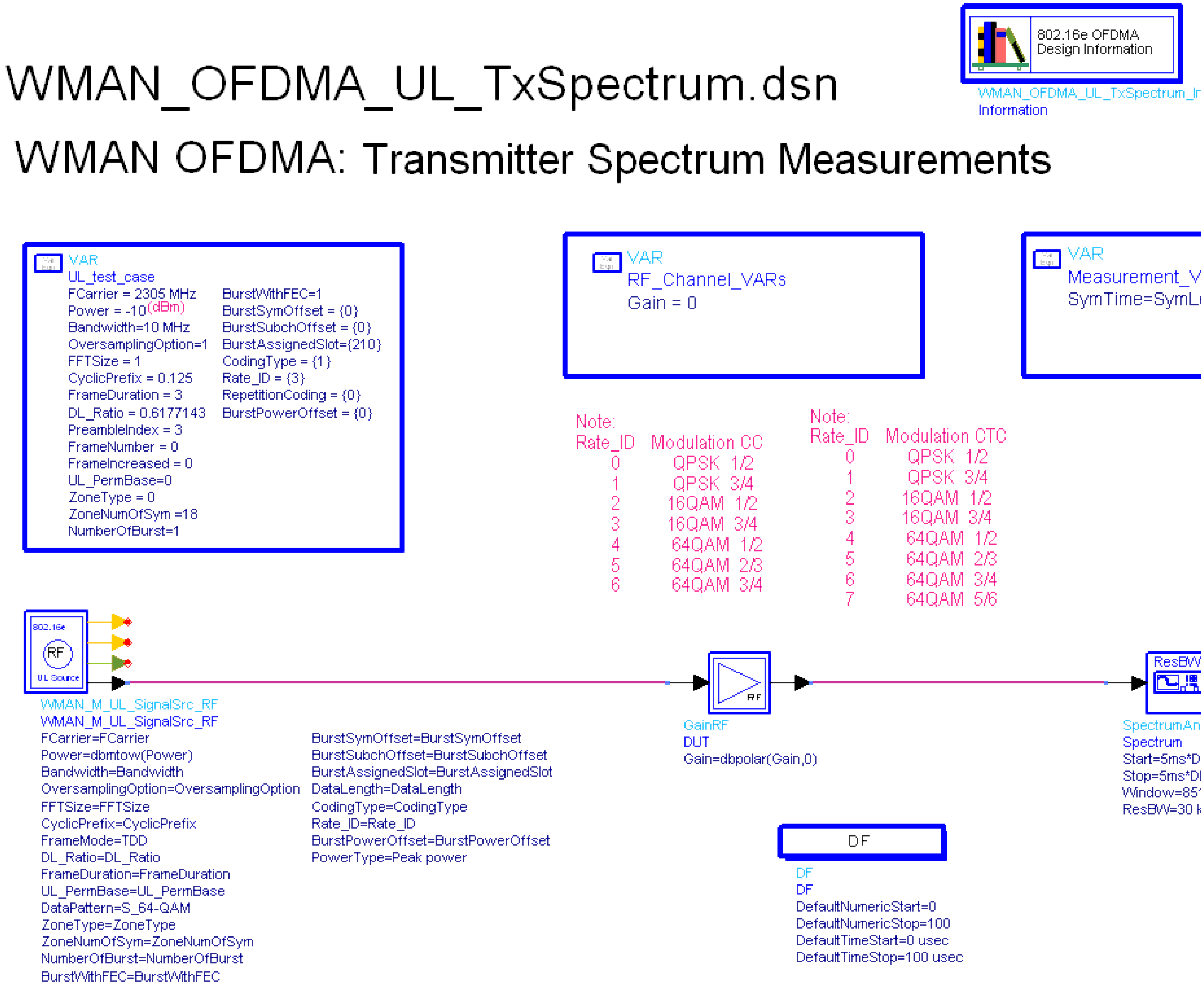
WMAN_OFDMA_UL_TxSpectrum Design

Features

- Transmitter Spectrum Measurement

Description

WMAN_OFDMA_UL_TxSpectrum measures the transmitter spectrum of uplink signal. The schematic is shown below.



WMAN_OFDMA_UL_TxSpectrum Schematic

In UL signal source, the *PowerType* is set to *Peak power* which is recommended for transmitter measurement. For more information, refer to *Transmit Power Definition.* (wman_m)

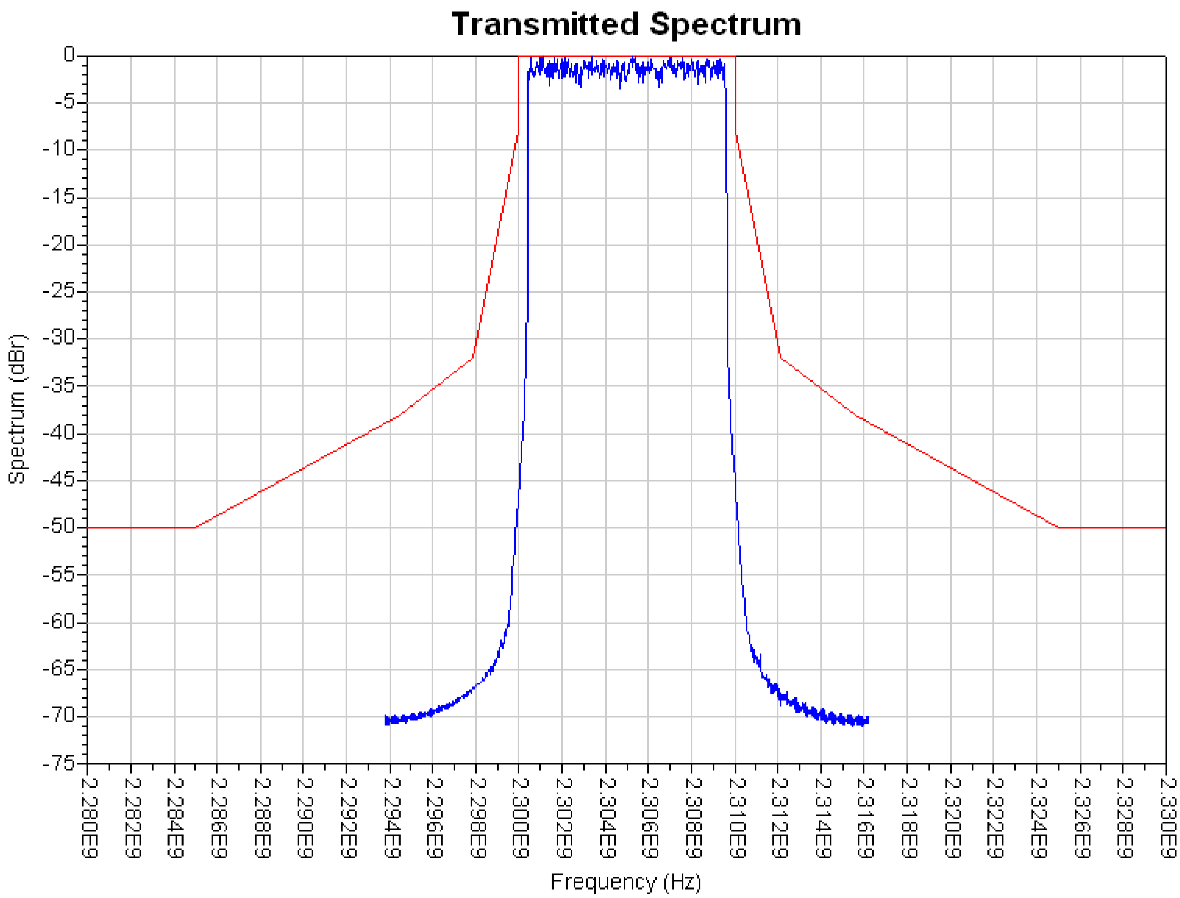
Simulation Results

The signal power density spectrum is obtained using the spectrum analyzer. The following table shows the simulation conditions.

Parameter Settings

Parameter	**Value**
FCarrier	2305 MHz
Zone Type	UL PUSC
FFT Size	1024
Bandwidth	10 MHz
Frame Duration	5 msec
Oversampling Option	Ratio 2
Cyclic Prefix	1/8
Packet Length in One Frame (Data Length)	3770 Bytes
Rate ID	16QAM 3/4
Coding Type	CTC

The following illustration shows the signal power density spectrum. The transmitted spectral density shall fall within the spectral mask.



spec_power(dBm(Spectrum))
-10.035

UL Transmitter Spectrum

Benchmark

- Hardware Platform: Pentium IV 2.26GHz, 1 GB memory
- Software Platform: Window 2000, ADS 2005A
- Simulation Time: 2 seconds

Uplink Transmitter Connected with 89600 Trans

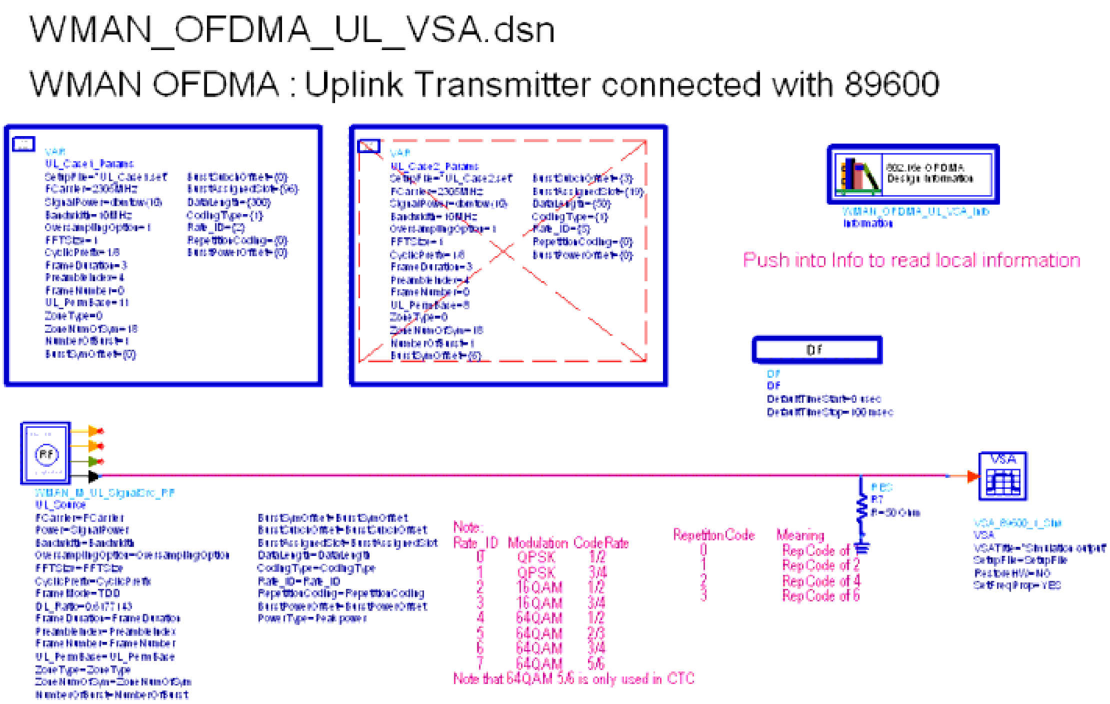
WMAN_OFDMA_UL_VSA Design

Features

- WMAN OFDMA uplink demodulation result using Agilent 89600 VSA software.

Description

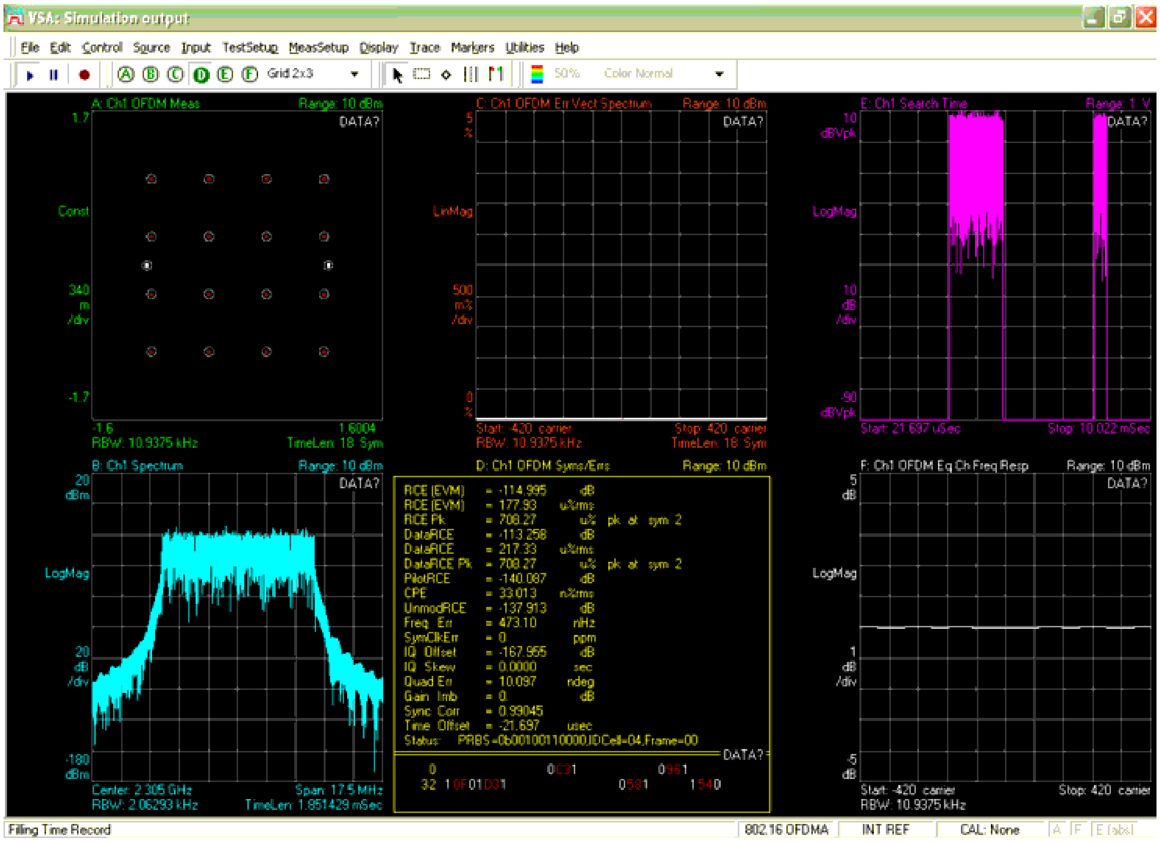
WMAN_OFDMA_UL_VSA shows WMAN OFDMA uplink demodulation results connecting with Agilent 89600 VSA. The schematic is shown below.



WMAN_OFDMA_UL_VSA Schematic

Simulation Results

The demodulation result given by an Agilent 89600 VSA is shown below.



89600 VSA Software Demodulation Results

Benchmark

- Hardware Platform: Centrino Duo 2.0GHz, 2GB memory
- Software Platform: Windows XP, ADS 2005A

Uplink Transmitter Spectral Flatness Measurement

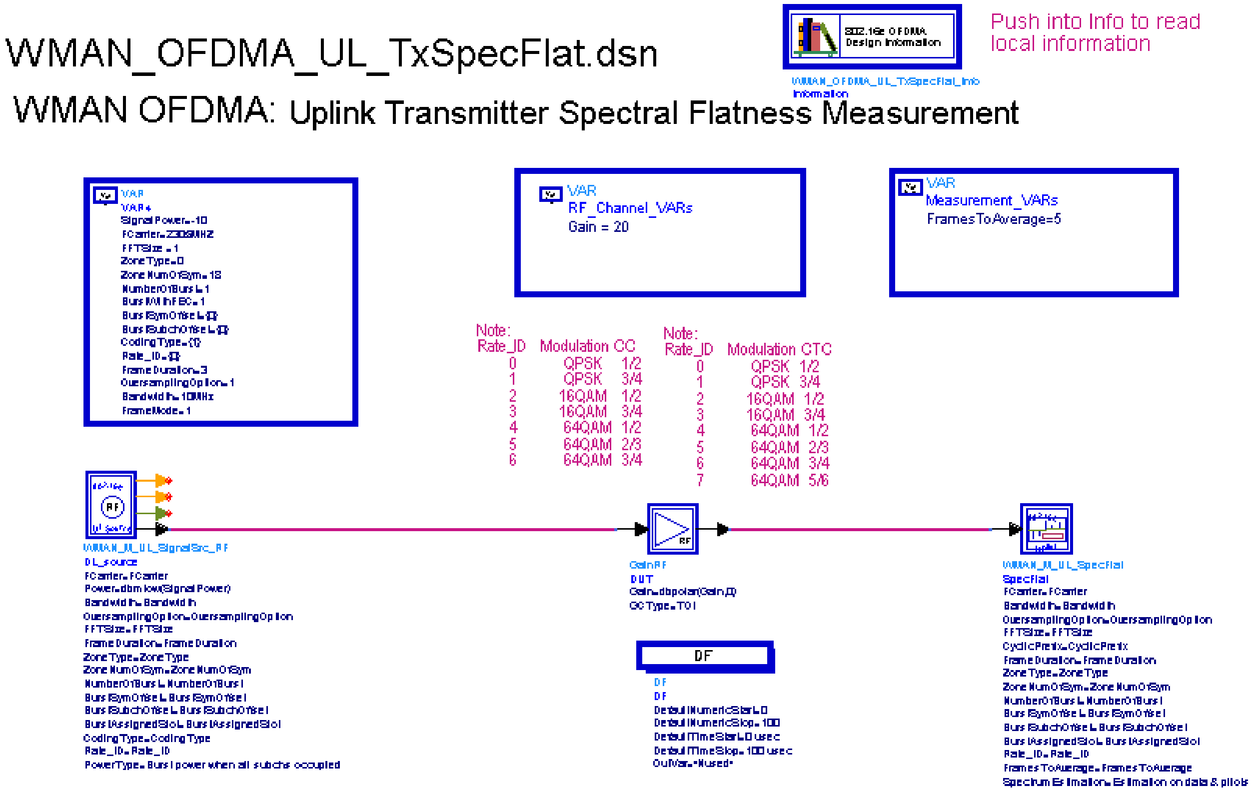
WMAN_OFDMA_UL_TxSpecFlat Design

Features

- Uplink transmitter spectral flatness measurement.

Description

WMAN_OFDMA_UL_TxSpecFlat shows WMAN OFDMA uplink spectral flatness measurement results. The schematic is shown below.

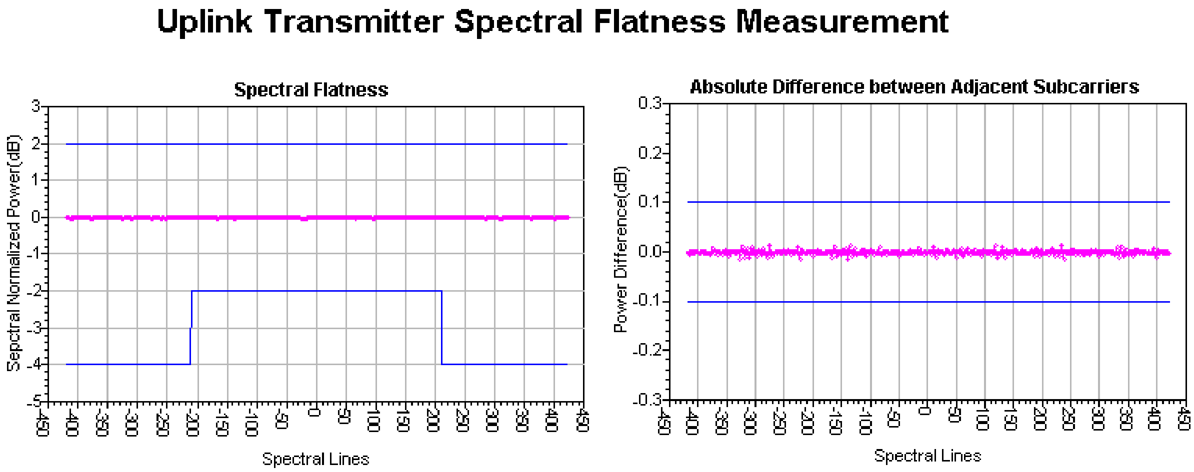


WMAN_OFDMA_UL_TxSpecFlat Schematic

1. Two methods are provided to get the data for measuring spectral flatness.
   1. *SpectrumEstimation is Estimation on pilots*
      In this method, the CIRs are estimated only on pilot subcarriers. The CIRs on data subcarriers are interpolated by the CIRs on pilot subcarriers. Note that this method can be applied for UL PUSC, OPUSC and AMC.
   2. *SpectrumEstimation is Estimation on data & pilots*
      This method follows the requirement by RCT. By observing the received amplitude deviations from the nearest constellation points in data and pilot subcarriers, this method estimates the flatness as a function of frequency from ordinary data transmission signals. The spectral flatness for each subcarrier across the whole data zone is averaged to remove spectral fluctuation due to modulation. Above measurement is applied only for the active subcarriers. When one subcarrier is non-allocated across the whole data zone, a fixed value (0) is output for this subcarrier (spectral line) to Sink SpecEnergy. The difference energy output to Sink SpecDiff is obtained by comparing amplitudes within the CIRs obtained in above measurement for all subcarriers with neighboring subcarriers excluding all non-allocated subcarriers. Note that this method can be applied for UL PUSC, OPUSC and AMC.
2. The results shall be the average of FramesToAverage uplink subframes, where FramesToAverage is set by users. The measurement results are output to Sink SpecEnergy. Meanwhile the difference energy between adjacent subcarriers from -Nused/2 to Nused/2 are output to Sink SpecDiff, and spectral lines from -Nused/2 to Nused/2 are output to Sink SpecLines. The ratio of the power at spectral line 0 to the total power is output to Sink DCPwrToTranPwr.
3. Unlike Mobile WiMAX downlink subframe, the pilots will not transmit in the uplink subframe if the tile for PUSC and OPUSC (or the bin for AMC) that the pilots belong to is not assigned to any of bursts. In this case, The CIRs for this tile (or bin) cannot be obtained even when SpectrumEstimation = Estimation on pilots. It is suggested that all the tiles in the whole data zone are assigned to the bursts.

Simulation Results

The following illustration shows the measurement results.



Uplink transmitter spectral flatness measurement results

Benchmark

- Hardware Platform: Centrino Duo 2.0GHz, 2GB memory
- Software Platform: Windows XP, ADS 2008A
- Simulation Time: about 5 minutes

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. WiMAX Forum, Mobile Radio Conformance Tests (MRCT), October 2006.

Mobile WiMAX Receiver Design Examples

The WMAN_16e_OFDMA_Rx_wrk workspace shows mobile WiMAX (802.16e OFDMA) receiver measurement characteristics including uplink AWGN BER, downlink sensitivity, downlink fading BER and downlink adjacent channel rejection measurements. The downlink frequency is set at 2305 MHz.
Designs for these measurements include:

- Uplink AWGN BER measurements: WMAN_OFDMA_UL_AWGN_BER
- Downlink sensitivity measurements: WMAN_OFDMA_DL_RxSensitivity
- Downlink fading BER measurements: WMAN_OFDMA_DL_Fading_BER
- Downlink adjacent channel rejection measurements: WMAN_OFDMA_DL_RxAdjCh
  Variables used in these designs are listed in the following table.

VAR Parameters

Parameter Name	Description	Default Value
FCarrier	Frequency carrier	2305 MHz
ZoneType	Zone type	PUSC
FFTSize	FFT size	1024
Bandwidth	Bandwidth	10 MHz
FrameDuration	Frame duration	5 msec (or 2 msec)
OversamplingOption	Oversampling option	Ratio 2
CyclicPrefix	Cyclic prefix	1/8
DecoderType	Decoder type	CSI

Uplink BER and PER Measurement under AWGN

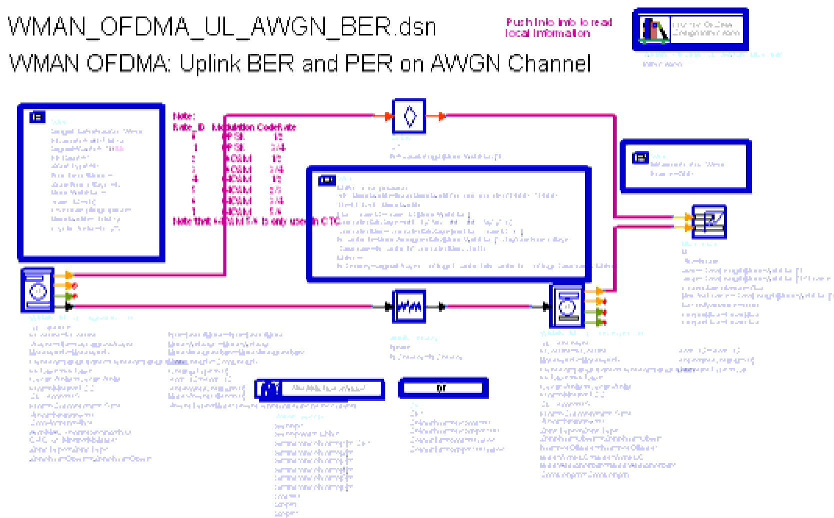
WMAN_OFDMA_UL_AWGN_BER Design

Features

- BER and PER measurement under AWGN
- Three decoder types supported in uplink receiver: Hard, Soft or CSI
- Multiple E_b/N_0 measurement points

Description

WMAN_OFDMA_UL_AWGN_BER performs uplink BER and PER measurements under AWGN. The schematic is shown in the following illustration.



WMAN_OFDMA_UL_AWGN_BER Schematic

In UL signal source, the *PowerType* is set to *Burst power when all subchs occupied* which is recommended for receiver measurement. For more information, refer to *Transmit Power Definition.* (wman_m)

In UL receiver, *DecoderType* can be selected with Hard, Soft or CSI. For UL PUSC and AMC, an advanced two-dimensional MMSE estimator are employed which is based on three input parameters: maximum Doppler frequency (*Fmax*), maximum echo delay (*Tmax*) and *SNR*. In order to get best performance, these parameters should be set according to the fading channel and noise conditions.
Users can change *Rate_ID* from 0 to 7 in *Signal_Generation_VARs* and get BER and PER results for different modulations and code rates. In *EbNo_Computation*, the E_b/N_0 and corresponding SNR is calculated. In *Measurement_Vars*, the number of frames for simulating BER/FER is defined which may be varied for different E_b/N_0 .

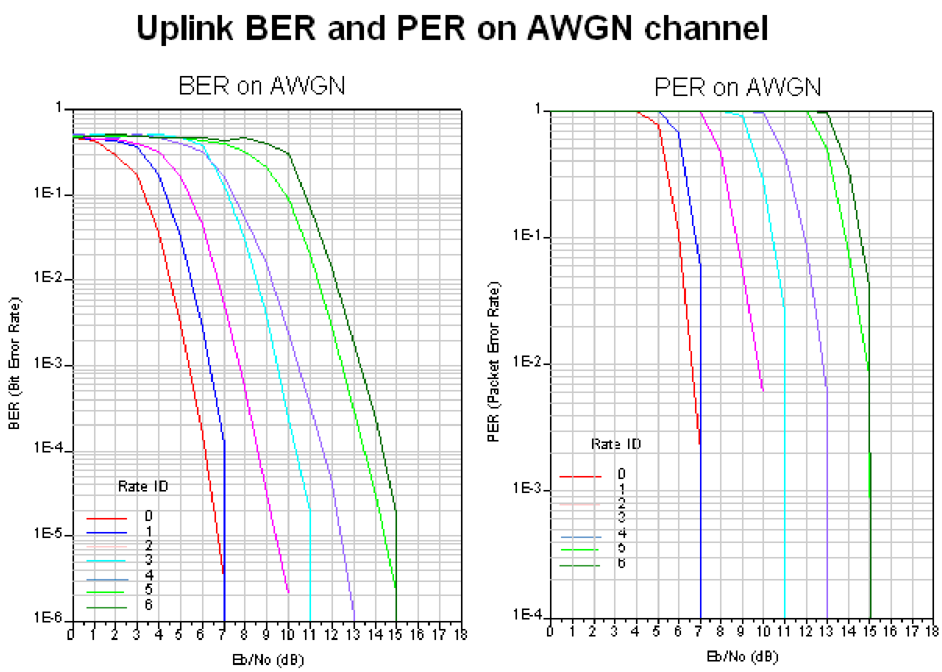
Simulation Results

In this example, The performances of uplink PUSC under AWGN for QPSK 1/2 (*Rate_ID=0*) are given. The following table shows the simulation conditions.

Parameter Settings

Parameter	Value
FCarrier	3407 MHz
Zone Type	UL PUSC
FFT Size	1024
Bandwidth	10 MHz
Frame Duration	5 msec
Oversampling Option	Ratio 2
Cyclic Prefix	1/8
Packet Length in One Frame (Data Length)	410 Bytes
Rate ID	QPSK 1/2
Decoder Type	CSI

The curves have been generated averaging over 500 frames under AWGN. The simulation results are shown in the following illustration.



Uplink BER and FER Simulation Curve

Benchmark

- Hardware Platform: Pentium IV 2.26GHz, 1 GB memory
- Software Platform: Windows 2000, ADS 2005A
- Simulation Time: 5 hours for QPSK 1/2 (Rate_ID=0)

Downlink Receiver Sensitivity Measurement

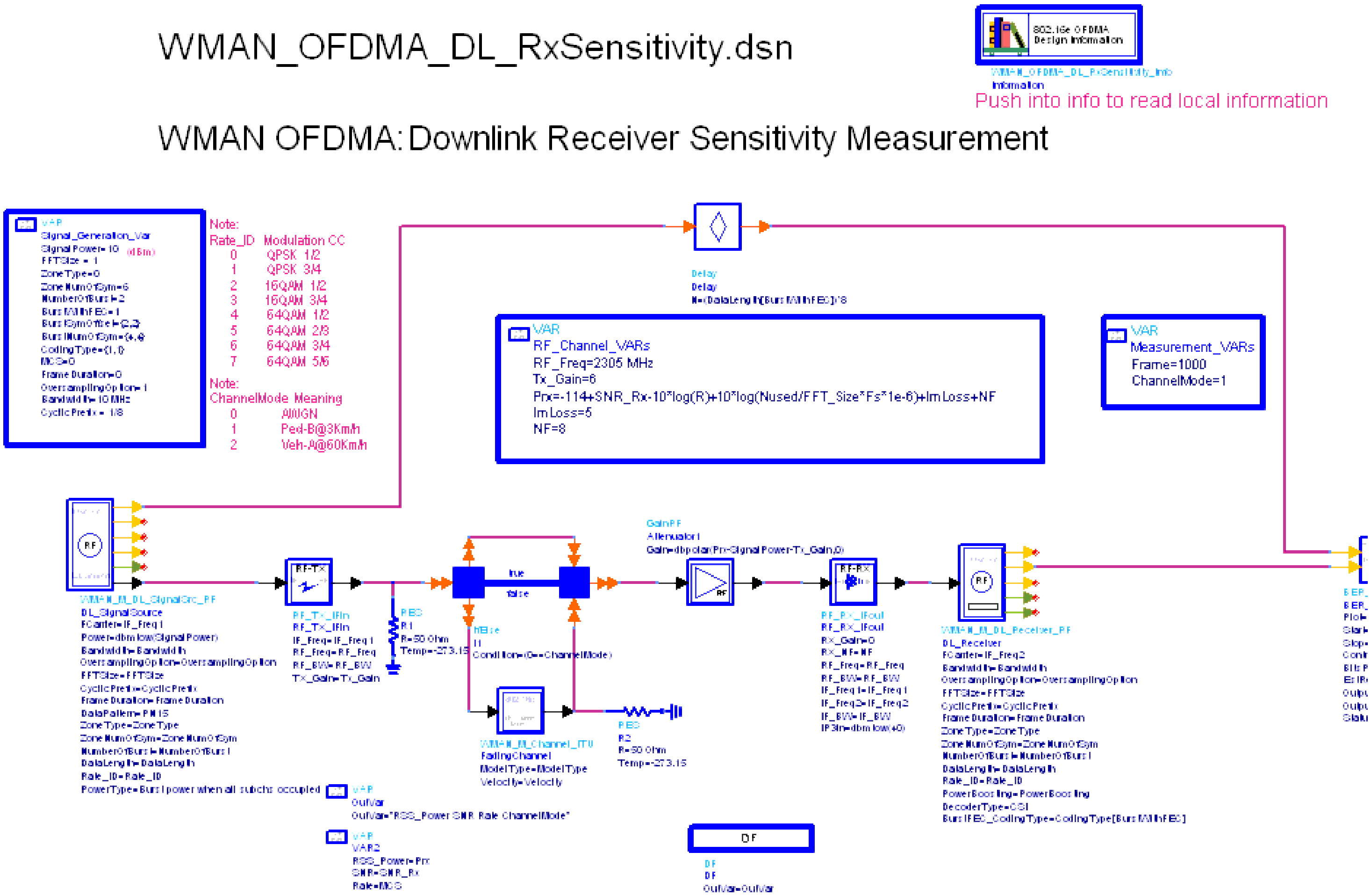
WMAN_OFDMA_DL_RxSensitivity Design

Features

- Receiver minimum input level sensitivity measurement
- AWGN, Peb-B 3Km/h and Veh-A 60Km/h supported

Description

WMAN_OFDMA_DL_RxSensitivity measures the PER results. The PER, rather than the BER, is measured over a larger number of frames to verify that the performance is better than or equal to the target at the power levels RSS defined in equation (149b) of section 8.4.13.1 of *IEEE Std 802.16e-2005* and 9.1.9 MS-09.1: MS receiver sensitivity of WiMAX Forum Mobile Radio Conformance Tests (MRCT). The schematic is shown in the following illustration.



WMAN_OFDMA_DL_RxSensitivity Schematic

In DL receiver, DecoderType can be selected with Hard, Soft or CSI. For DL PUSC, an advanced two-dimensional MMSE estimator is employed which is based on three input parameters: maximum Doppler frequency (Fmax), maximum echo delay (Tmax) and SNR. In order to get best performance, these parameters should be set according to the channel and noise conditions.

The receiver minimum sensitivity level, RSS, is shown according to Equation (149b) of *IEEE Std 802.16e-2005* :

$$R_{SS} = -144 + SNR_{Rx} - 10 \times \log(R) + 10 \times \log(F_s \times N_{Used}/N_{FFT}) + ImpLoss + NF$$

ImpLoss is the implementation loss including non-ideal receiver effects. The assumed value is 5 dB. The actual implementation loss in ADS receiver is addressed in the following sections. Note that the power level gotten from the above equation is to set the transmitter power (the parameter of Power) with *PowerType = Burst power when all subchs occupied* . In this power type, power offset due to pilot boosting is assumed to be 0 dB for the parameter of *Power* , which means the *Power* refers to the power level over all the data and non-boosted pilot subcarriers. But actually the pilots are boosted in the source and the power level measured over the output data zone is (*Power* + *Offset_pilot_boosting*). That is why in the equation (1-1) the pilot offset for the pilot boosting is missing compared with the equation in the Mobile WiMAX RCT.

Downlink Subframe Configurations

For DL PUSC zone, the downlink subframe structure is assumed with a preamble and a PUSC zone in which the first two (2) symbols are FCH and DL-MAP IE, followed by four (4) data symbols. In these four (4) symbols, two bursts are allocated; The first burst is for the PER measurement and the second is for maintaining the per-subcarrier

transmit power density level across the entire band for the test. The first burst occupies the region which is from the first symbol in these four (4) symbols and the first subchannel, and spans four symbols in time direction and wman_m-12-1-29.gif! subchannels in frequency direction. N_{Slots}
is the number of slots occupied for each packet depending on the MCS (Rate ID). The following table lists the packet length for each MCS. Note that only one packet (burst) is allocated for measuring PER in each subframe. For DL other zones, the downlink subframe structure is assumed with a preamble and a PUSC zone in which the two (2) symbols are FCH and DL-MAP IE, followed by a new zone with the permutation of DL FUSC, OFUSC or AMC. The two bursts, similar to PUSC zone, are allocated onto the new zone.

MCS	Payload (bytes)	PDUSize (bytes)	Slots per PDU (NSlots)	Packets (PDUs) per frame
QPSK rate-1/2	50	60	10	1
QPSK rate-3/4	44	54	6	1
16QAM rate-1/2	50	60	5	1
16QAM rate-3/4	44	54	3	1
64QAM rate-1/2	44	54	3	1
64QAM rate-2/3	38	48	2	1
64QAM rate-3/4	44	54	2	1
64QAM rate-5/6	50	60	2	1

The rest of the slots in the data symbols are allocated with the second burst with QPSK rate-1/2 (Rate ID 0).

Receiver Sensitivity in AWGN for PUSC

For AWGN channels, the target PER is converted from the packet size and the standard requirement of BER=1e-6, assuming independent error event after decoding. The required SNR and implementation loss in ADS for each MCS are shown in the following table.

MCS	Target PER	Min. Required SNR in RCT	Required SNR in ADS	Implementation loss in ADS
QPSK rate-1/2	0.048%	2.9 dB	3.2 dB	0.3 dB
QPSK rate-3/4	0.0432%	6.3 dB	6.3 dB	0.0 dB
16QAM rate-1/2	0.048%	8.6 dB	9.0 dB	0.4 dB
16QAM rate-3/4	0.0432%	12.7 dB	13.0 dB	0.3 dB
64QAM rate-1/2	0.0432%	13.8 dB	14.2 dB	0.4 dB
64QAM rate-2/3	0.0384%	16.9 dB	17.2 dB	0.3 dB
64QAM rate-3/4	0.0432%	18 dB	18.2 dB	0.2 dB
64QAM rate-5/6	0.048%	19.9 dB	20.1 dB	0.2 dB

Note that:

1. The number of frames for simulation in AWGN is 150,000.
2. The implementation loss in ADS only includes the loss in the baseband receiver.

Receiver Sensitivity in Peb-B@3Km/h for PUSC

For fading channels, the target PER is 10%, which is assumed to be near the target PER of a first HARQ transmission. The required SNR and implementation loss in ADS for each MCS are shown in the following table.

MCS	Target PER	Min. Required SNR in RCT	Required SNR in ADS	Implementation loss in ADS
QPSK rate-1/2	10%	7.0 dB	8.0 dB	1.0 dB
QPSK rate-3/4	10%	12.0 dB	13.1 dB	1.1 dB
16QAM rate-1/2	10%	12.5 dB	13.7 dB	1.2 dB
16QAM rate-3/4	10%	17.5 dB	19.1 dB	1.6 dB
64QAM rate-1/2	10%	17.0 dB	18.6 dB	1.6 dB
64QAM rate-2/3	10%	21.0 dB	22.2 dB	1.2 dB
64QAM rate-3/4	10%	23.0 dB	24.1 dB	1.1 dB
64QAM rate-5/6	10%	25.0 dB	26.6 dB	1.6dB

Note that:

1. The number of frames for simulation in Peb-B@3Km/h is 1,000.
2. The implementation loss in ADS includes the loss in the baseband receiver and the impairment introduced by the three RF modules (RF_TX_IFin, Attenuator1 and RF_RX_IFout) in this example.

Receiver Sensitivity in Veh-A@60Km/h for PUSC

For fading channels, the target PER is 10%, which is assumed to be near the target PER of a first HARQ transmission. The required SNR and implementation loss in ADS for each MCS are shown in the following table.

MCS	Target PER	Min. Required SNR in RCT	Required SNR in ADS	Implementation loss in ADS
QPSK rate-1/2	10%	8.0 dB	8.3 dB	0.3 dB
QPSK rate-3/4	10%	13.0 dB	13.1 dB	0.1 dB
16QAM rate-1/2	10%	13.5 dB	13.9 dB	0.4 dB
16QAM rate-3/4	10%	18.5 dB	19.5 dB	1.0 dB
64QAM rate-1/2	10%	18.0 dB	19.4 dB	1.4 dB
64QAM rate-2/3	10%	22.0 dB	23.1 dB	1.1 dB
64QAM rate-3/4	10%	NA	25.4 dB	NA
64QAM rate-5/6	10%	NA	NA	NA

Note that:

1. The number of frames for simulation in Veh-A@60Km/h is 1,000.
2. The implementation loss in ADS includes the loss in the baseband receiver and the impairment introduced by the three RF modules (RF_TX_IFin, Attenuator1 and RF_RX_IFout) in this example.

Receiver Sensitivity in Peb-B@3Km/h and Veh-A@60Km/h for AMC

For fading channels, the target PER is 10%, which is assumed to be near the target PER of a first HARQ transmission. The required SNR and implementation loss in AMC for each MCS are shown in the following table.

MCS	Target PER	Required SNR in Peb-B@3Km/h	Required SNR in Veh-A@60Km/h
QPSK rate-1/2	10%	8.8 dB	9.8 dB
QPSK rate-3/4	10%	14.5 dB	15.6 dB
16QAM rate-1/2	10%	15.5 dB	16.5 dB
16QAM rate-3/4	10%	21.9 dB	23.3 dB
64QAM rate-1/2	10%	21.6 dB	22.8 dB
64QAM rate-2/3	10%	26.5 dB	27.8 dB
64QAM rate-3/4	10%	28.0 dB	29.4 dB
64QAM rate-5/6	10%	30.5	32.0 dB

Note that:

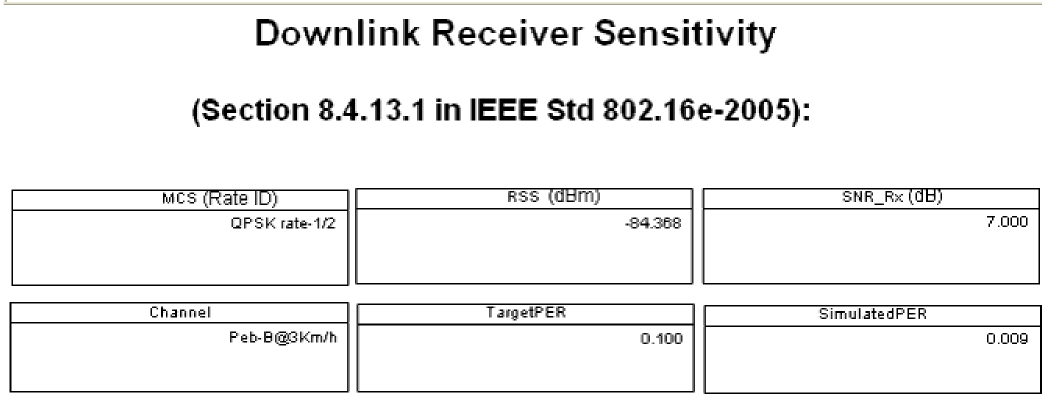
1. The number of frames for simulation in Veh-A@60Km/h is 2,000.
2. The packet in AMC zone for each MCS (Rate ID) is similar to that in PUSC zone.
3. The value in the table above is the required SNR for the target PER (10%).
4. The implementation loss in ADS includes the loss in the baseband receiver and the impairment introduced by the three RF modules (RF_TX_IFin, Attenuator1 and RF_RX_IFout) in this example.

Simulation Results

In this example, the performance of downlink PUSC for QPSK 1/2 (*Rate_ID=0*) is given. The following table shows the simulation conditions and DL Transmitter Spectrum shows the simulation results averaging over 1000 frames.

Parameter Settings

Parameter	Value
Zone Type	DL PUSC
FFT Size	1024
Bandwidth	10 MHz
Frame Duration	2 msec†
Oversampling Option	Ratio 4
Cyclic Prefix	1/8
Packet Length in One Frame (Data Length)	170 Bytes
Rate ID	CTC QPSK 1/2
Decoder Type	CSI
Channel Mode	Ped-B 3Km/h
† Here, in order to reduce the simulation time, the frame duarion is set to 2 msec instead of the required 5 msec.	



Downlink Receiver Sensitivity

Benchmark

- Hardware Platform: Centrino Duo 2.0GHz, 2 GB memory
- Software Platform: Windows XP, ADS 2006A
- Simulation Time: about 6 hours

Downlink BER and PER Measurement on Fading Channel

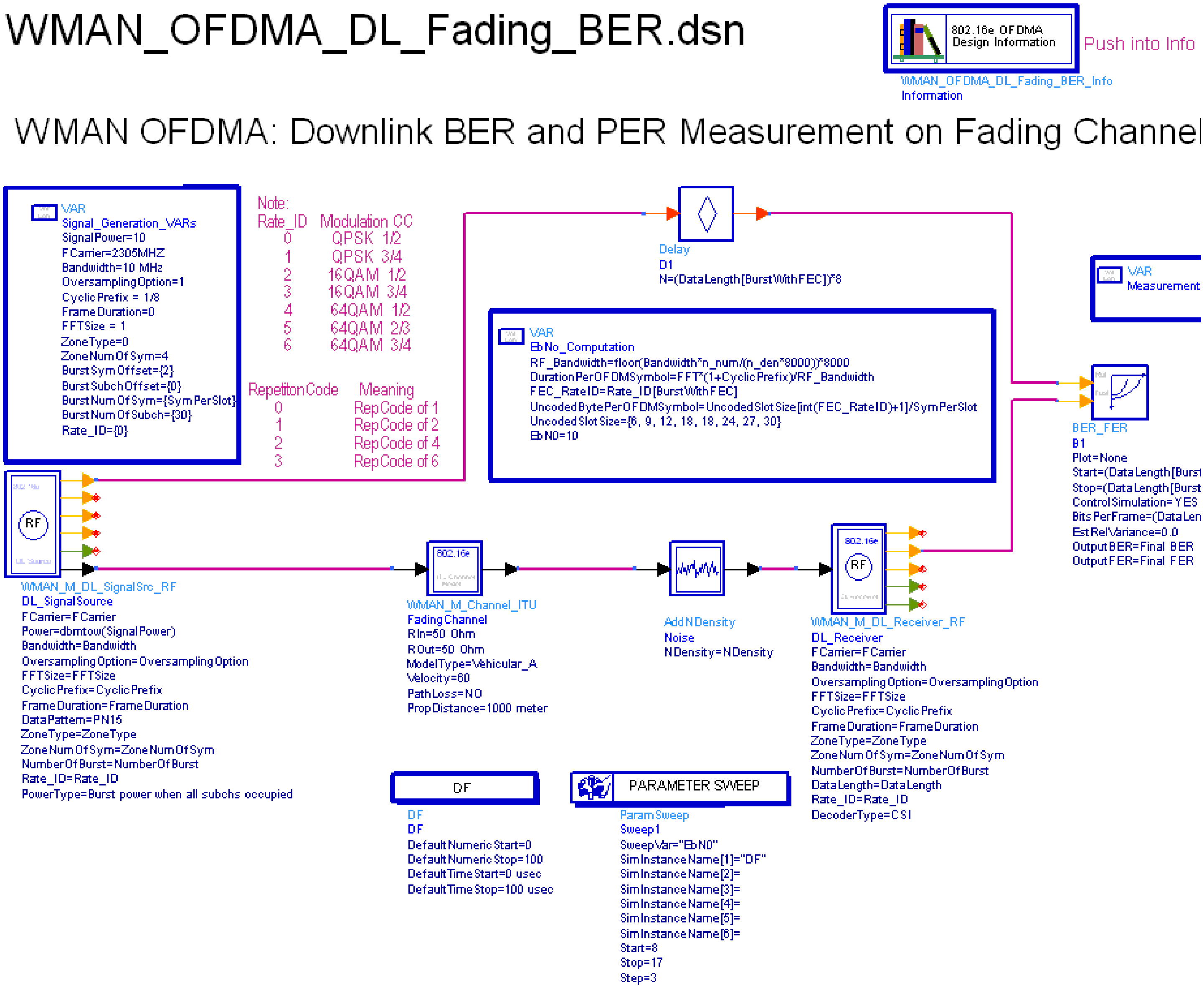
WMAN_OFDMA_DL_Fading_BER Design

Features

- BER and PER measurement on ITU fading channel
- Three decoder types supported in downlink receiver: Hard, Soft or CSI
- Multiple E_b/N_0 measurement points
- ITU fading channel conditions

Description

WMAN_OFDMA_DL_Fading_BER measures downlink BER and PER Measurement on ITU fading channel. The schematic is shown in the following illustration.



WMAN_OFDMA_DL_Fading_BER Schematic

In DL signal source, the *PowerType* is set to *Burst power when all subchs occupied* which is recommended for receiver measurement. For more information, refer to *Transmit Power Definition.* (wman_m)

In DL receiver *DecoderType* can be selected with Hard, Soft or CSI. For DL PUSC, an advanced two-dimensional MMSE estimator are employed which is based on three input parameters: maximum Doppler frequency (*Fmax*), maximum echo delay (*Tmax*) and *SNR* . In order to get best performance, these parameters should be set according to the fading channel and noise conditions.

The fading channel is based on ITU-R M.1225 supporting both pedestrian and vehicular environments. Also users can define specific fading channel mode by defining the parameters of *Delay* , *Power* and *Ricean_factor* .
Users can change *Rate_ID* from 0 to 6 in *Signal_Generation_VARs* and get BER and PER results for different modulations and code rates. In *EbNo_Computation* , the E_b/N_0 and corresponding SNR is calculated. In *Measurement_Vars* , the number of frames for simulating BER/FER is defined which may be varied for different E_b/N_0.

Simulation Results

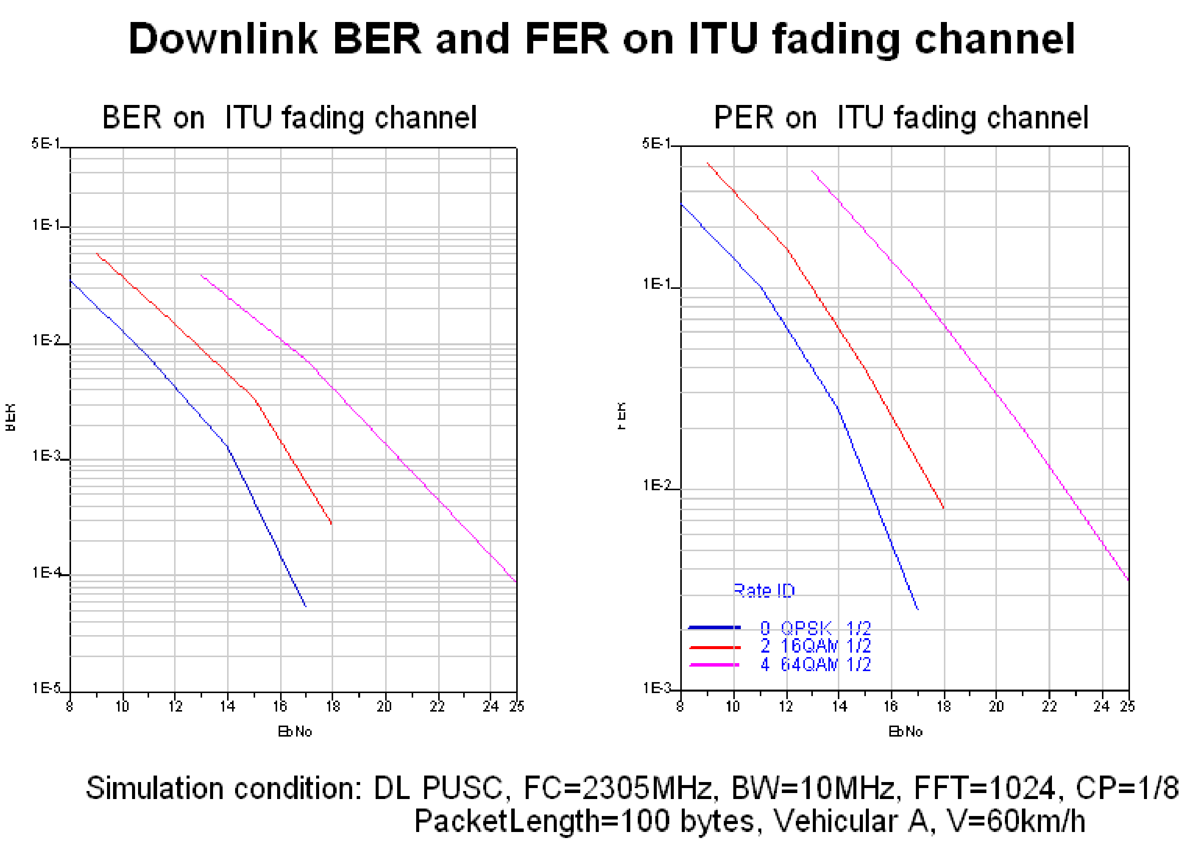
In this example, The performances of downlink PUSC under the velocity of 60Km/h for QPSK 1/2 (*Rate_ID=0*), 16QAM 1/2 (*Rate_ID=2*) and 64QAM 1/2 (*Rate_ID=4*) are given. The following table shows the simulation conditions.

Parameter Settings

Parameter	Value
FCarrier	2305 MHz
Zone Type	DL PUSC
FFT Size	1024
Bandwidth	10 MHz
Frame Duration	2 msec †
Oversampling Option	Ratio 2
Cyclic Prefix	1/8
Packet Length in One Frame (Data Length)	100 Bytes
Rate ID	QPSK 1/2, 16QAM1/2, 64QAM1/2
ITU Model Type	Vehicular A
Velocity	60 Km/h
Decoder Type	CSI

† Here, in order to reduce the simulation time, the frame duarion is set to 2 msec instead of required 5 msec.

The curves have been generated averaging over 1000 or 2000 frames on ITU fading channel. The simulation results are shown in the following illustration.



Downlink BER and FER Simulation Curve

Benchmark

- Hardware Platform: Centrino Duo 2.0GHz, 2 GB memory
- Software Platform: Windows XP, ADS 2005A
- Simulation Time: about 10 hours for QPSK 1/2 (*Rate_ID=0*)

WMAN OFDMA Downlink Receiver Adjacent and Alternate Channel Rejection

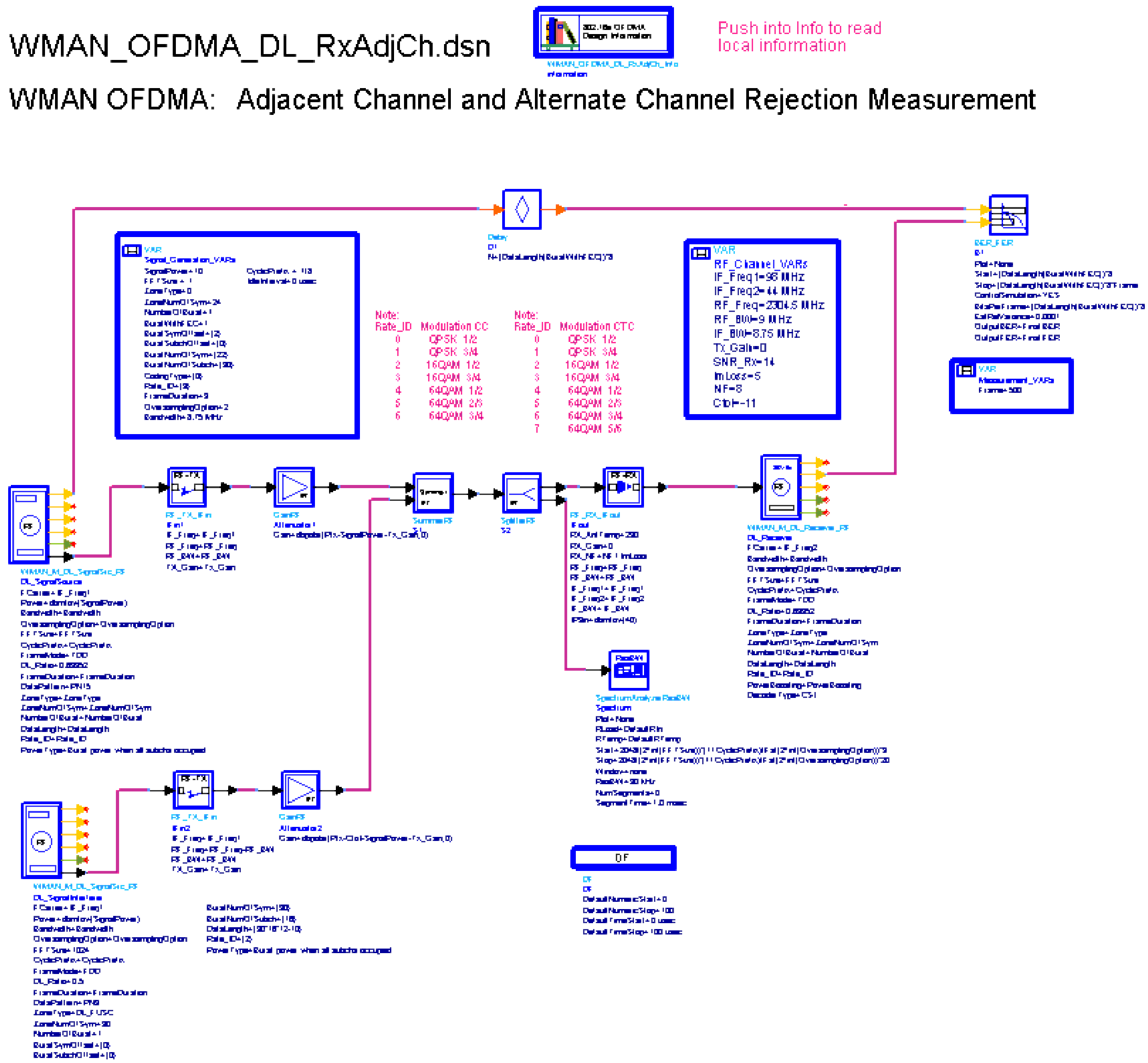
WMAN_OFDMA_DL_RxAdjCh Design

Features

- Spectrum of desired signal and interference
- BER and FER measurement of desired signal

Description

This example measures the adjacent and alternate channel rejection defined in section 8.4.13.2 IEEE Std 802.16-2004 and IEEE Std 802.16e-2005. The schematic is shown in the following illustration.



WMAN_OFDMA_DL_RxAdjCh Schematic

The channel spacing (CS) is determined as the same as channel bandwidth of the desired system, except for systems with a bandwidth of 8.75MHz. For 8.75MHz channel BW, CS is defined as 9MHz. Adjacent channel Interference frequency offset is CS and Alternate channel Interference frequency offset is 2!wman_m-12-1-35.gif! CS.

The desired signal's strength is set 3 dB above the rate dependent receiver sensitivity. When the interference signal's strength is set the value according to *Specification Requirements* the BER should be less than 1e-6. For the BER_FER model 500 frame is to be measured and *EstRelVariance* =0.0001.

Because the desired signal and interference use different transmit format, their frame structure , modulate type, frame length may be different. When measuring the spectrum of both signal, the *Start* and *Stop* should be set carefully to include both signal.

Modulation	<th	<th
16-QAM-3/4	-11	-30
64-QAM-2/3	-4	-23

Simulation Results

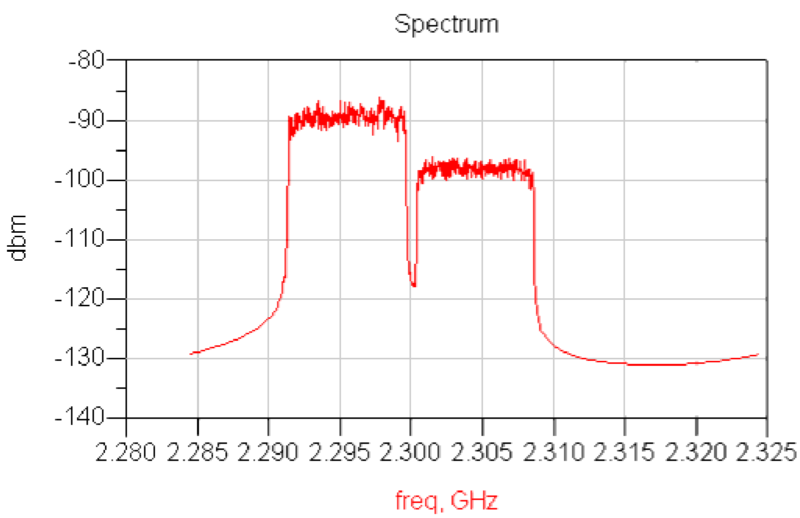
The following table lists some key parameters.

Parameter Settings

Parameter	Value
RF_Freq	2304.5 MHz
RF_BW	9 MHz
IF_BW	8.75 MHz
CtoI	-11
Frame	500
EstRelVariance	0.0001

The following illustration shows the spectrum of desired signal and interference as well as BER and FER of desired signal.

Spectrum and BER_FER



BER	FER
0.000	0.000

Benchmark

- Hardware Platform: Pentium IV 2.66GHz, 1 GB memory
- Software Platform: Window 2000, ADS 2005A
- Simulation Time: 300 minutes

References

1. EEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. WiMAX Forum, Mobile Radio Conformance Tests (MRCT), October 2006.

Mobile WiMAX MIMO Transmitter Design Examples

The Mobile_WiMAX_MIMO_Tx_wrk workspace shows MIMO transmitter measurement characteristics including downlink transmitter constellation measurement for MIMO system; downlink transmitter complementary cumulative distribution function (CCDF), waveform and spectrum measurement for MIMO system; uplink transmitter complementary cumulative distribution function (CCDF), waveform and spectrum measurement for MIMO system. The frequency is set to 2305 MHz.
Designs for these measurements include:

- DL constellation measurements for MIMO system: WMAN_OFDMA_DL_MIMO_TxConstellation
- DL MIMO CCDF, waveform and spectrum measurements: WMAN_OFDMA_DL_MIMO_Waveform
- UL MIMO CCDF, waveform and spectrum measurements: WMAN_OFDMA_UL_MIMO_Waveform

Variables used in these designs are listed in the following table.

Var Parameters

Parameter Name	Description	Default Value
FCarrier	RF frequency	2305 (MHz)
Bandwidth	Normimal bandwidth	10 (MHz)
SignalPower	Signal power	10 (dBm)
FFTSize	FFT size	1024
ZoneType	Zone type	PUSC
FrameDuration	Frame duration	5 (ms)
CyclicPrefix	Cyclic prefix	1/8
STC_Matrix	STC matrix	B
PowerType	Power in frame	Peak power
CodingType	Coding type	CTC

Downlink Constellation Measurement for MIMO System

WMAN_OFDMA_DL_MIMO_TxConstellation Design

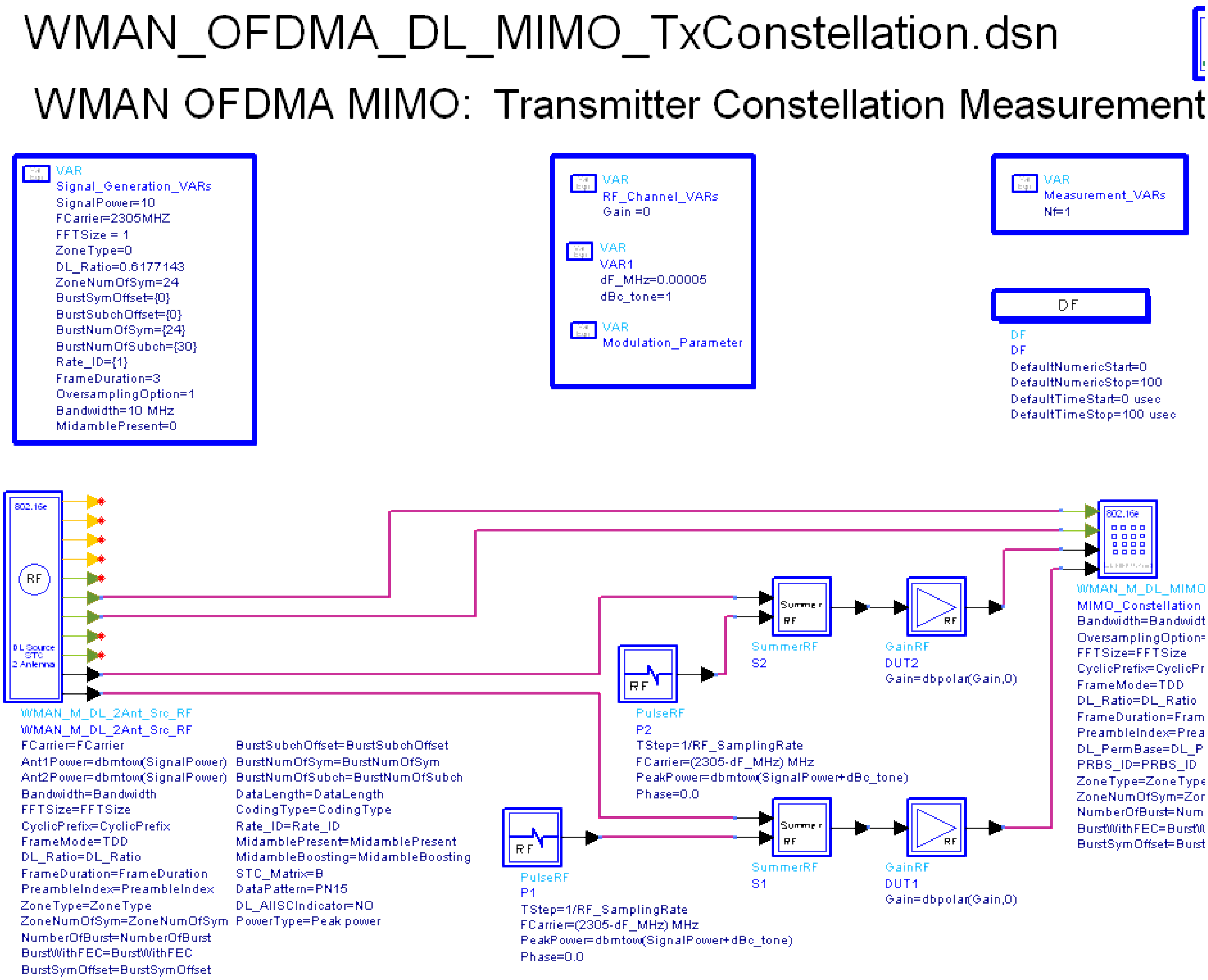
Features

- Mobile WiMAX 2x2 MIMO system configuration
- Three decoder types supported in downlink receiver: Hard, Soft or CSI
- Two STC/MIMO decoder types supported in downlink receiver: MMSE or ZF
- DC offset interference

Description

WMAN_OFDMA_DL_MIMO_TxConstellation measures the downlink constellation and constellation error under DC offset interference. The schematic is shown in the following illustration.

WMAN_OFDMA_DL_MIMO_TxConstellation Schematic



DC offset interference is a key issue in the zero IF system. PulseRF can simulate the DC offset in ADS. Both P1 and P2 (PulseRF) are added to I and Q branches. The peak power and frequency position of RF pulse can be set to parameters *PeakPower* and *FCarrier* in PulseRF, respectively. As the peak power of DC offset is increased, constellation error is also increased.

In DL signal source, the *PowerType* is set to *Peak power* which is recommended for transmitter measurement. For more information, refer to *Transmit Power Definition.* (wman_m)

In subnetwork WMAN_M_DL_MIMO_Constellation_RF,

- The *FreqSync* is set to YES with DC interference. In this case, the frequency offset is calculated by synchronization mode. If the FreqSync is set to NO, the frequency offset is zero.
- When *FrameSync* is set to *YES* that the synchronization frame start position is calculated by synchronization model. If the *FrameSync* is set to *NO*, the *FrameIndex* value is used as the synchronization frame start position.
- When *CheEstmator* = YES, the normal MIMO decoding procedure is applied which is the same as that in *WMAN_M_DL_MIMO_Ant2_Rx_RF*. In this mode, the signals after channel equalization in the cross-antenna path (i.e. the path from TX Ant1 to Rx Ant2 and the path from Tx Ant2 to Rx Ant1) are input to the MIMO decoding procedure.
  When *CheEstmator* = NO, the channel estimation results in the cross-antenna path (i.e. the path from TX Ant1 to Rx Ant2 and the path from Tx Ant2 to Rx Ant1) are set to zeros in the MIMO decoding procedure. The

mode is usful when you want to test the cross-antenna interference at transmitter side. In this mode, the interference is treated as a useless signal, and is measured precisely. When *CheEstmator* = YES, the interference is treated as a useful signal, and is completely compensated in the MIMO decoder.

When CDD is applied in the source, the frame (timing) synchronization in the model WMAN_M_DL_MIMO_Constellation_RF may introduce some mismatch. A workaround is to disable frame (timing) synchronization by setting FrameSync to NO, and to set FrameIndex to the actual index of the frame (the default value is 0).

Simulation Results

The following table shows the simulation conditions.

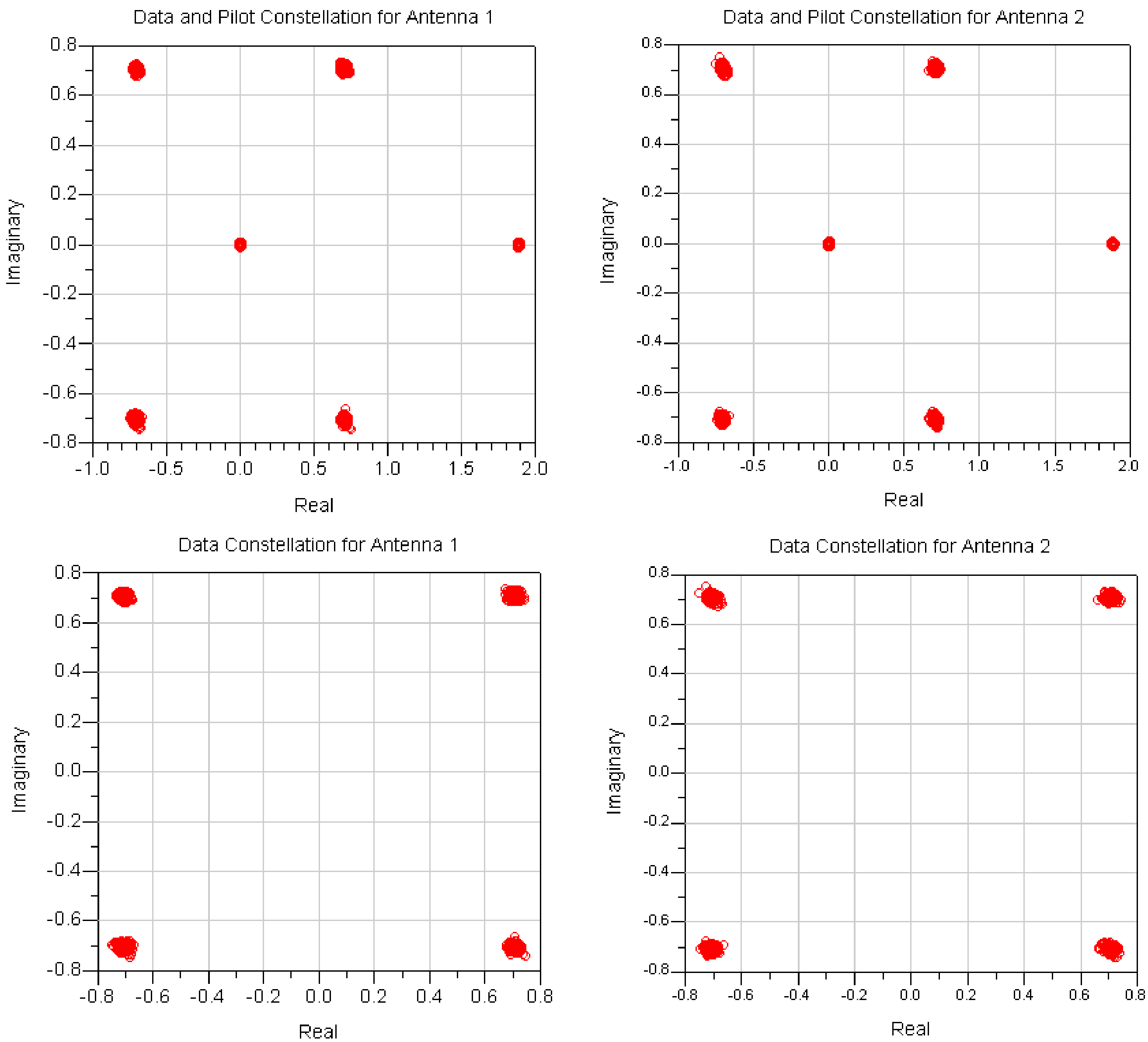
Parameter Settings

Parameter	**Value**
FCarrier	2305 MHz
Zone Type	DL PUSC
FFT Size	1024
Bandwidth	10 MHz
Frame Duration	5 msec
Oversampling Option	Ratio 2
Cyclic Prefix	1/8
Packet Length in One Frame (Data Length)	6470 Bytes
Rate ID	QPSK 3/4
Coding Type	CTC

The following illustration shows the constellation diagrams with RF pulse.

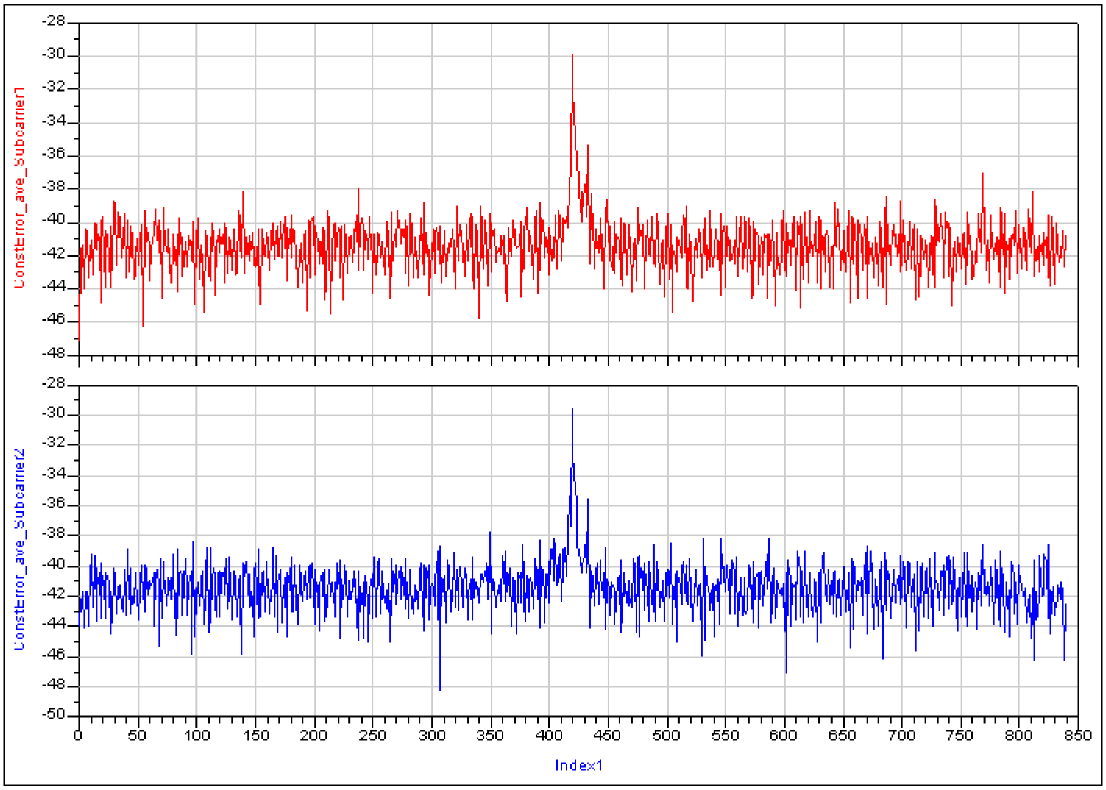
h6. DL MIMO Constellation

DL MIMO Constellation



The following illustration shows the average constellation error versus subcarriers. From the curves of average constellation error versus subcarriers, the DC offset interference just effects some subcarriers near to the DC carriers. Please note the number of subcarriers is 840 in PUSC, the DC subcarrier index is 419.

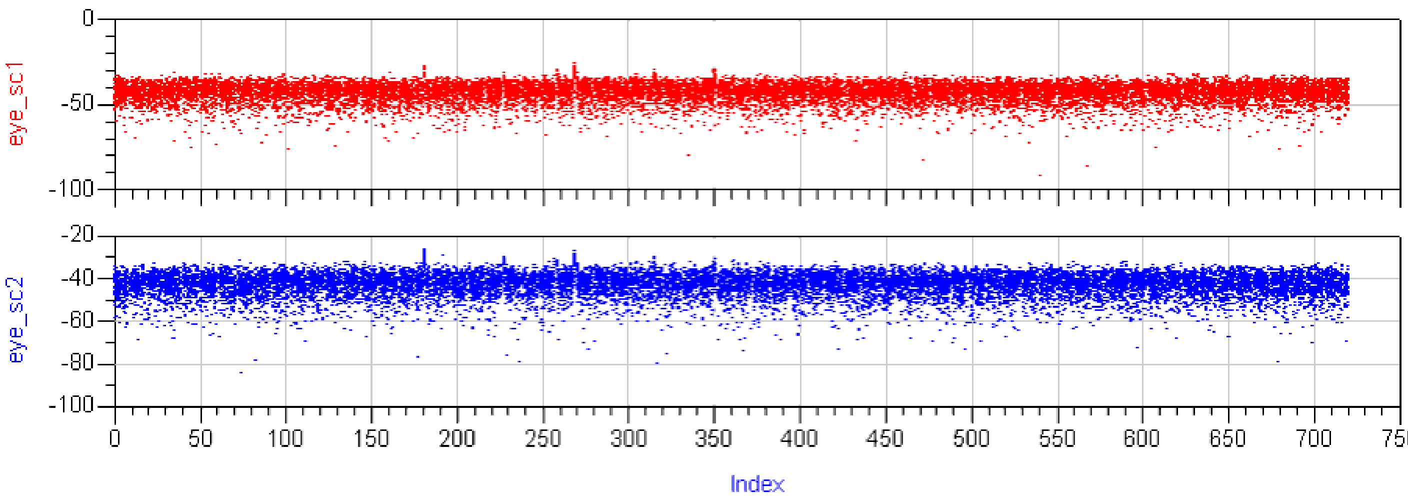
h6. DL MIMO Average Constellation Error versus Subcarrier



ConstError_avg1	ConstError_avg2
-41.430	-41.423

RCE (Relative Constellation Error) is the RMS level of the Error Vector Magnitude, averaged over all subcarriers and all detected OFDMA symbols. RCE (EVM) is computed in dB.The following illustration shows the average RCE.

h6. DL MIMO Average RMS Constellation Error



RCE1	RCE2
-40.435	-40.425

Benchmark

- Hardware Platform: Pentium IV 2.26GHz, 1 GB memory
- Software Platform: Window 2000, ADS 2005A
- Simulation Time: 30 seconds

Downlink MIMO CCDF, Waveform and Spectrum Measurements

WMAN_OFDMA_DL_MIMO_Waveform Design

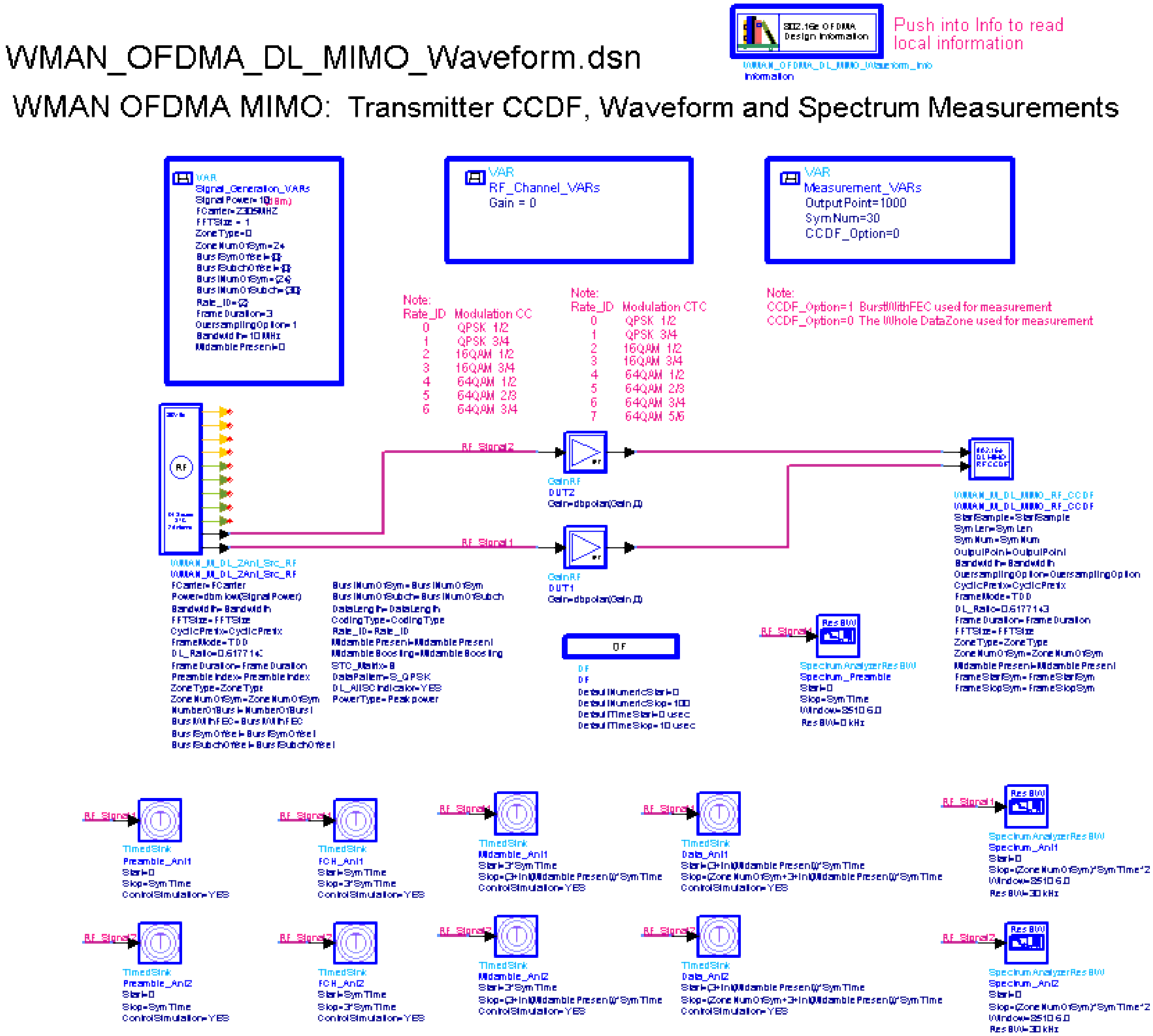
Features

- CCDF for each antenna
- Preamble Power, Mean Power and Peak Power for each antenna
- Waveform for each antenna
- Spectrum for each antenna

Description

This example measures CCDF, Power, Spectrum and Waveform of WMAN OFDMA Downlink MIMO Transmitter. The schematic is shown in the following illustration.

h6. WMAN_OFDMA_DL_MIMO_TxWaveform Schematic



CCDF_Option decides which part of the Data Zone is used for measurement. When *CCDF_Option* =1, BurstWithFEC is measured. When *CCDF_Option* =0, the whole Data Zone is measured. *OutputPoint* means how many parts will X-axis be divied into in the CCDF figure. The larger *OutputPoint* is, the closer measured curve is to reference curve. *SymNum* means the number of symbol measured. *StartSample* in the WMAN_M_DL_MIMO_RF_CCDF model is used to discard the first frame delay caused by receiver model. In WMAN_M_DL_2Ant_Src_RF *PowerType* is set to *Peak Power*. For more information, refer to *Transmit Power Definition.* (wman_m)

Simulation Results

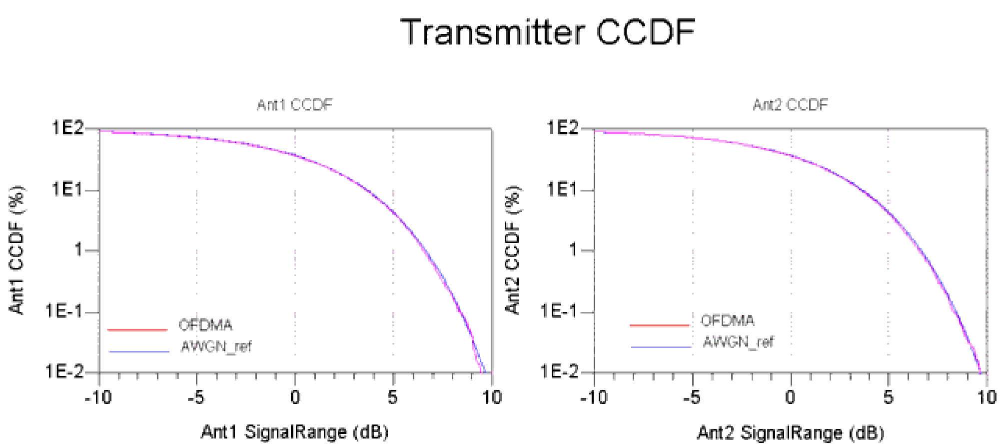
The following table lists some key parameters.

Parameter Settings

Parameter	**Value**
Signal Power	10 (dBm)
Zone Type	DL PUSC
FFT Size	1024
Bandwidth	10 MHz
Frame Duration	5 msec
Frame Mode	TDD
DL Ratio	0.6177
Oversampling Option	Ratio 1
PowerType	Peak Power
Gain	0 (in dB)
Output Point	1000
SymNum	100
CCDF Option	1

The following illustrations shows the transmitter CCDF and power measurement and transmitter waveform.

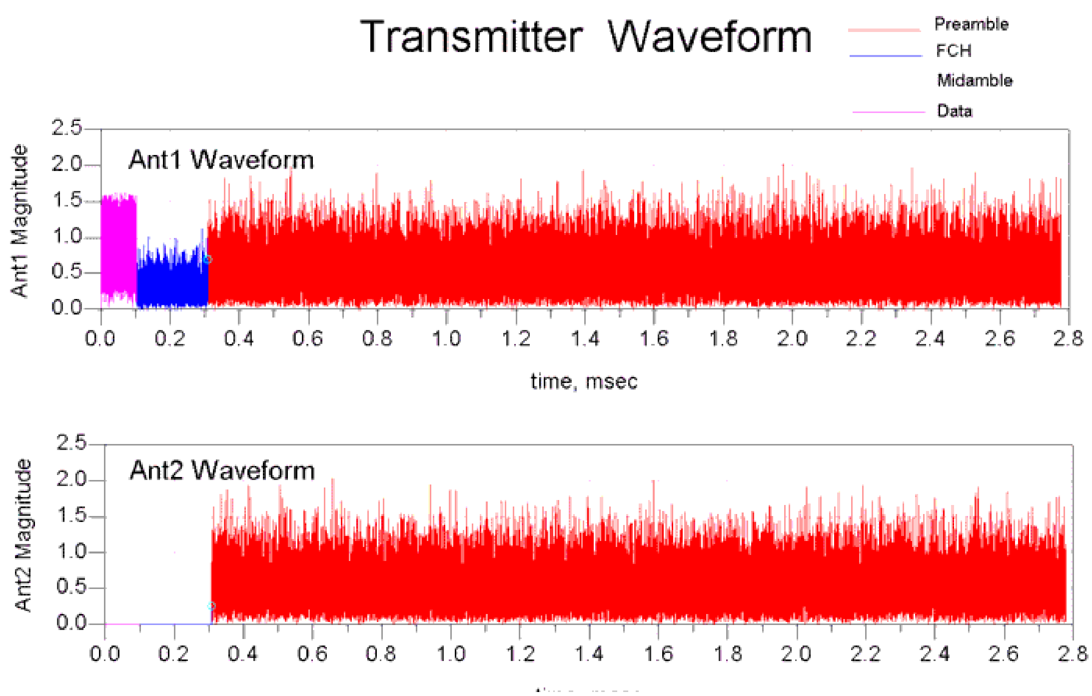
h6. Transmitter CCDF and Power Measurement



MeanPower_dBm_Ant1	PeakPower_dBm_Ant1	RF_Peak_to_Avg_dB_Ant1	PreamblePower_dBm
6.128	14.591	8.463	9.971

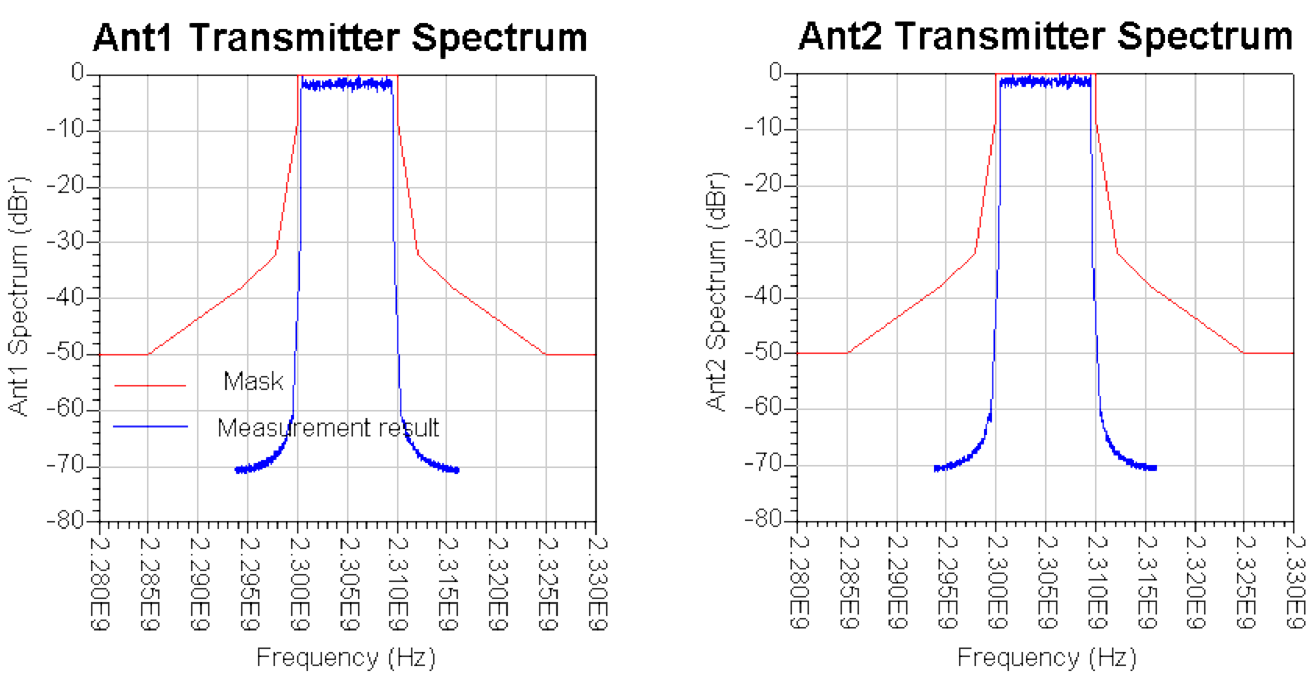
MeanPower_dBm_Ant2	PeakPower_dBm_Ant2	RF_Peak_to_Avg_dB_Ant2
6.119	14.470	8.351

Transmitter Waveform



The next illustration shows spectrum measurement. Spectral density of the transmitter signal shall fall within the spectral mask. More information about transmitted Spectrum Mask is defined in 5.3.3 ETSI EN 301 021 V1.6.1(2003-07).

Spectrum



Benchmark

- Hardware Platform: Pentium IV 2.66GHz, 1 GB memory
- Software Platform: Window 2000, ADS 2005A
- Simulation Time: 30 seconds

Uplink MIMO CCDF, Waveform and Specturm Measurements

WMAN_OFDMA_UL_MIMO_Waveform Design

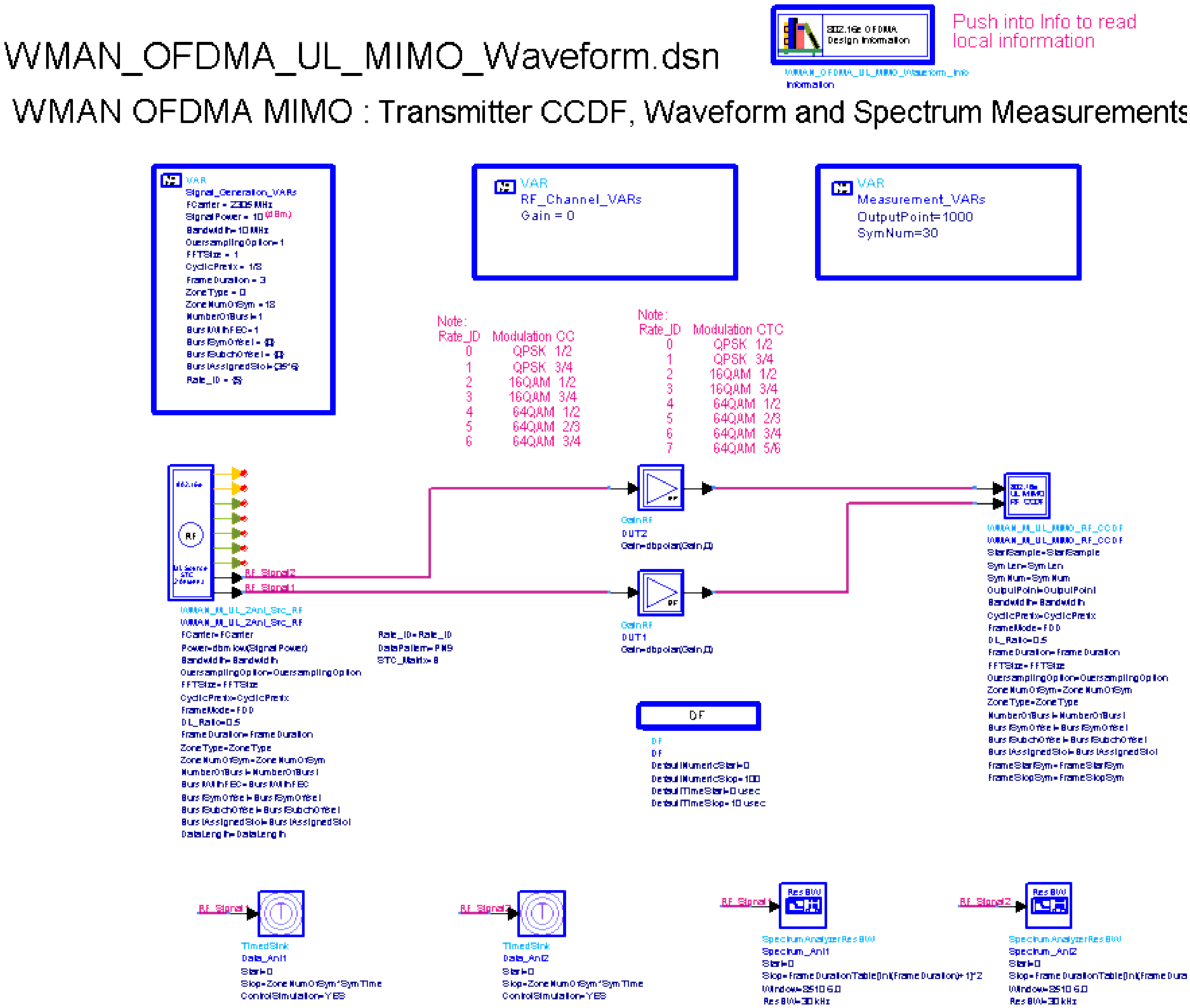
Features

- CCDF for each antenna
- Preamble Power, Mean Power and Peak Power for each antenna
- Waveform for each antenna
- Spectrum for each antenna

Description

This example measures CCDF, power, spectrum and waveform of WMAN OFDMA Uplink MIMO transmitter. The schematic is shown in the following illustration.

WMAN_OFDMA_UL_MIMO_TxWaveform Schematic



CCDF_Option decides which part of the Data Zone is used for measurement. When *CCDF_Option* =1, BurstWithFEC is measured. When *CCDF_Option* =0, the whole Data Zone is measured. *OutputPoint* means how many parts will X-axis be divied into in the CCDF figure. The larger *OutputPoint* is, the closer measured curve is to reference curve. *SymNum* means the number of symbol measured. *StartSample* in the WMAN_M_UL_MIMO_RF_CCDF model is used to discard the first frame delay caused by receiver model. In WMAN_M_UL_2Ant_Src_RF *PowerType* is set to *Peak Power* . For more information, refer to *Transmit Power Definition.* (wman_m)

Simulation Results

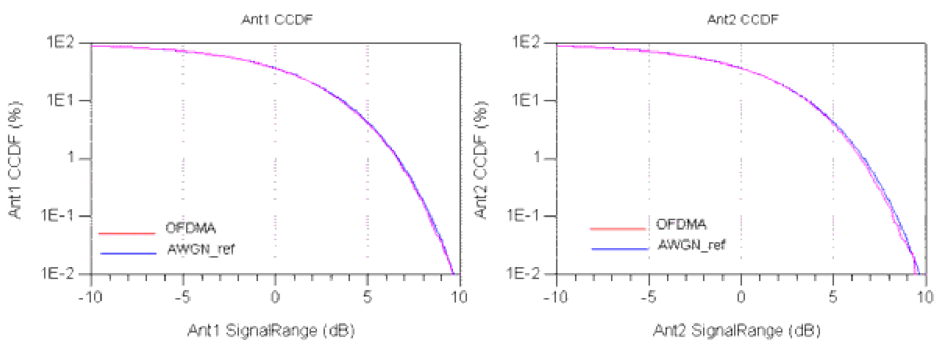
The following table lists some key parameters.

Parameter Settings

Parameter	Value
Signal Power	10 (dBm)
Zone Type	UL PUSC
FFT Size	1024
Bandwidth	10 MHz
Frame Duration	5 msec
Frame Mode	FDD
Oversampling Option	Ratio 1
PowerType	Peak Power
Gain	0 (in dB)
Output Point	1000
SymNum	100
CCDF Option	1

The following illustration show transmitter CCDF and power measurement and transmitter waveform.

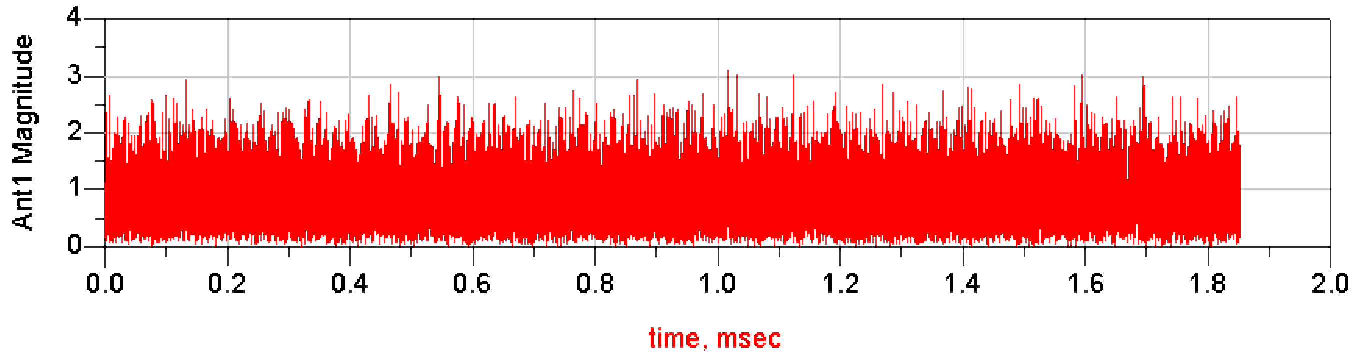
Transmitter CCDF and Power Measurement

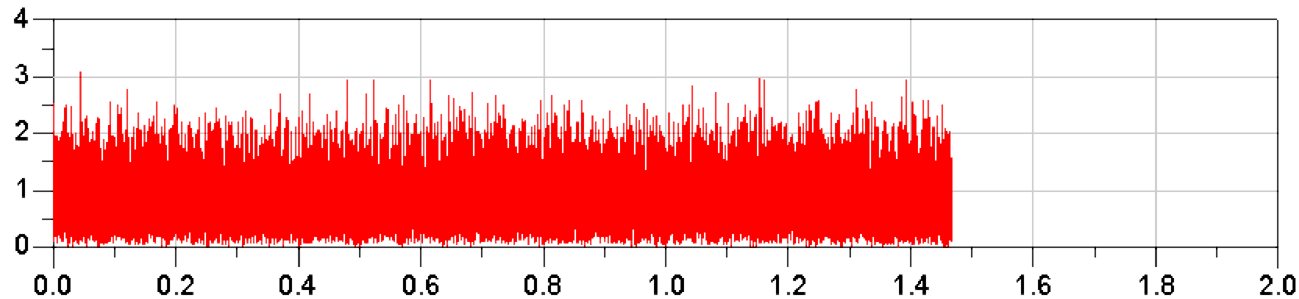


MeanPower_dBm_Ant1	PeakPower_dBm_Ant1	RF_Peak_to_Avg_dB_Ant1
9.997	18.330	8.333

MeanPower_dBm_Ant2	PeakPower_dBm_Ant2	RF_Peak_to_Avg_dB_Ant2
9.977	18.215	8.238

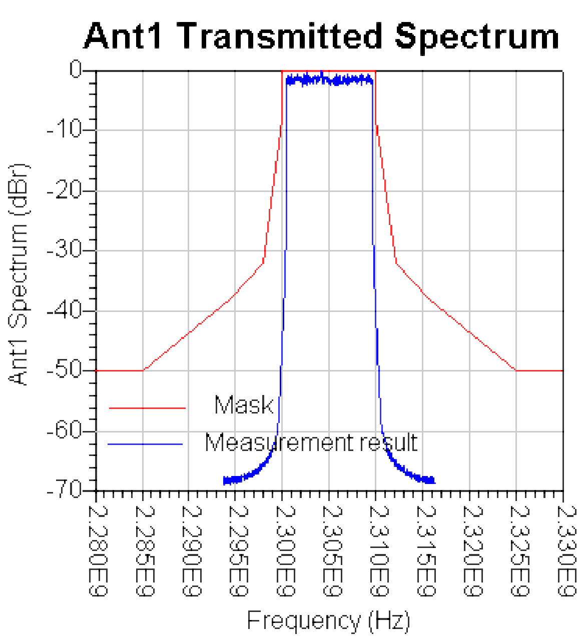
Transmitter Waveform

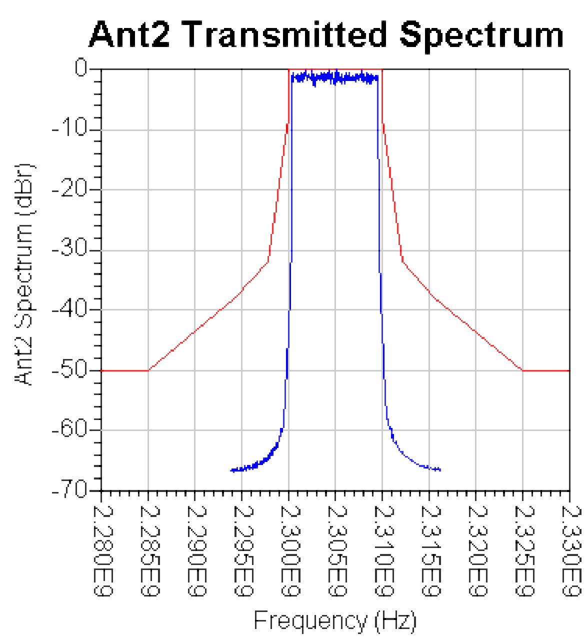




The next shows the spectrum measurement. Spectral density of the transmitter signal shall fall within the spectral mask. More information about transmitted Spectrum Mask is defined in 5.3.3 ETSI EN 301 021 V1.6.1(2003-07).

Spectrum





Benchmark

- Hardware Platform: Pentium IV 2.66GHz, 1 GB memory
- Software Platform: Window 2000, ADS 2005A
- Simulation Time: 110 seconds

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. WiMAX Forum, Mobile Radio Conformance Tests (MRCT), October 2006.

Mobile WiMAX MIMO Receiver Design Examples

The Mobile_WiMAX_MIMO_Rx workspace shows Mobile WiMAX (802.16e OFDMA) MIMO receiver measurement characteristics including zownlink MIMO fading BER and sensitivity, downlink STC fading BER and sensitivity, and uplink MIMO fading BER measurements. The downlink frequency is set at 2305 MHz.
Designs for these measurements include:

- Downlink MIMO fading measurements: WMAN_OFDMA_DL_MIMO_Fading_BER
- Downlink STC fading measurements: WMAN_OFDMA_DL_STC_Fading_BER
- Downlink MIMO Receiver Sensitivity Measurement: WMAN_OFDMA_DL_MIMO_RxSensitivity
- Downlink STC Receiver Sensitivity Measurement: WMAN_OFDMA_DL_STC_RxSensitivity
- Uplink MIMO fading measurements: WMAN_OFDMA_UL_MIMO_Fading_BER
  Variables used in these designs are listed in the following table.

Var Parameters

Parameter Name	Description	Default Value
FCarrier	Frequency carrier	2305 MHz
ZoneType	Zone type	PUSC
FFTSize	FFT size	1024
Bandwidth	Bandwidth	10 MHz
FrameDuration	Frame duration	5 msec (or 2 msec)
OversamplingOption	Oversampling option	Ratio 2
CyclicPrefix	Cyclic prefix	1/8
DecoderType	Decoder type	CSI

Downlink BER and PER Measurement on Fading Channel for MIMO system

WMAN_OFDMA_DL_MIMO_Fading_BER Design

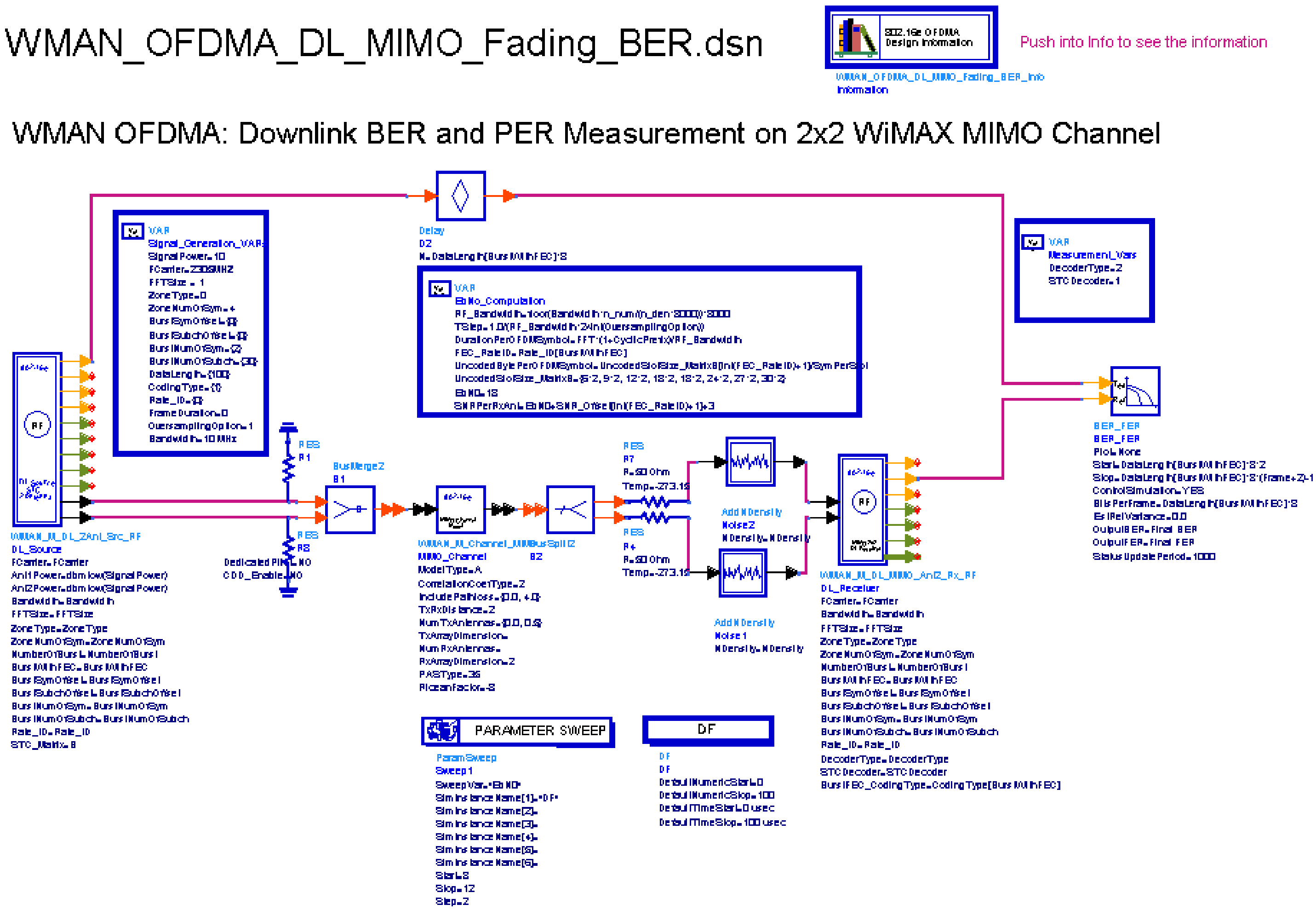
Features

- Mobile WiMAX 2x2 MIMO system configuration
- BER and PER measurement on 2x2 ITU channels
- Three decoder types supported in downlink receiver: Hard, Soft or CSI
- Two STC/MIMO decoder types supported in downlink receiver: MMSE or ZF
- Multiple E_b/N_0 measurement points

Description

WMAN_OFDMA_DL_MIMO_Fading_BER measures downlink BER and PER Measurement on ITU channels for 2x2 MIMO system. The schematic is shown in the following graphic.

WMAN_OFDMA_DL_MIMO_Fading_BER Schematic



In DL signal source, *PowerType* is set to *Burst power when all subchs occupied* which is recommended for receiver measurement. For more information, refer to *Transmit Power Definition.* (wman_m) *STC_Matirx* is set to *Matrix_B* for 2x2 MIMO system. MIMO Midamble can be inserted to get robust channel information.

In DL receiver, *DecoderType* can be selected with Hard, Soft or CSI and *STCDecoder* can be selected with MMSE or ZF. For DL PUSC and AMC, an advanced two-dimensional MMSE estimator are employed which is based on three input parameters: maximum Doppler frequency (*Fmax*), maximum echo delay (*Tmax*) and *SNR* . In order to get best performance, these parameters should be set according to the fading channel and noise conditions.

The MIMO channel is extended from ITU models (Ped-B & Veh-A) by adding the definition of a per-tap spatial correlation. Three levels of channel correlation (high, medium and low) have been defined to serve as three options for the RCTs.

Users can change *Rate_ID* from 0 to 6 in *Signal_Generation_VARs* and get BER and PER results for different modulations and code rates. In *EbNo_Computation*, the E_b/N_0 and corresponding SNR is calculated. In *Measurement_Vars*, the number of frames for simulating BER/FER is defined which may be varied for different E_b/N_0 .

Simulation Results

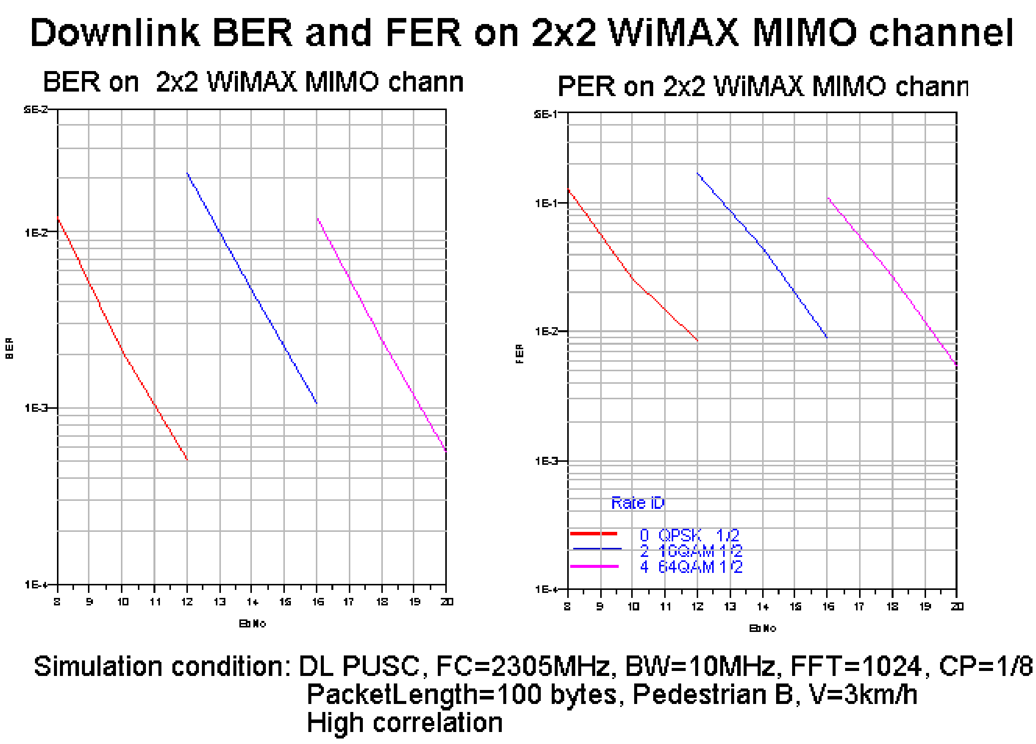
In this example, the performances of downlink PUSC under the ITU PB3 channels for QPSK 1/2 (*Rate_ID=0*), 16QAM 1/2 (*Rate_ID=2*) and 64QAM 1/2 (*Rate_ID=4*) are given. The following table shows the simulation conditions.

Parameter Settings

Parameter	Value
FCarrier	2305 MHz
Zone Type	DL PUSC
FFT Size	1024
Bandwidth	10 MHz
Frame Duration	2 msec †
Oversampling Option	Ratio 2
Cyclic Prefix	1/8
Packet Length in One Frame (Data Length)	100 Bytes
Rate ID	0, 2, 4
Channel	Ped-B 3Km/h, High correlation
STC Decoder	MMSE
Decoder Type	CSI
† Here, in order to reduce the simulation time, the frame duarion is set to 2 msec instead of required 5 msec.	

The curves have been generated averaging over 1000 or 2000 frames on 2x2 ITU fading channels. The following illustration shows the simulation results.

Downlink MIMO BER and FER Simulation Curve



Benchmark

- Hardware Platform: Centrino Duo 2.0GHz, 2 GB memory
- Software Platform: Windows XP, ADS 2005A
- Simulation Time: about 6 hours for QPSK 1/2 (*Rate_ID=0*)

Downlink BER and PER Measurement on Fading Channel for STC system

WMAN_OFDMA_DL_STC_Fading_BER Design

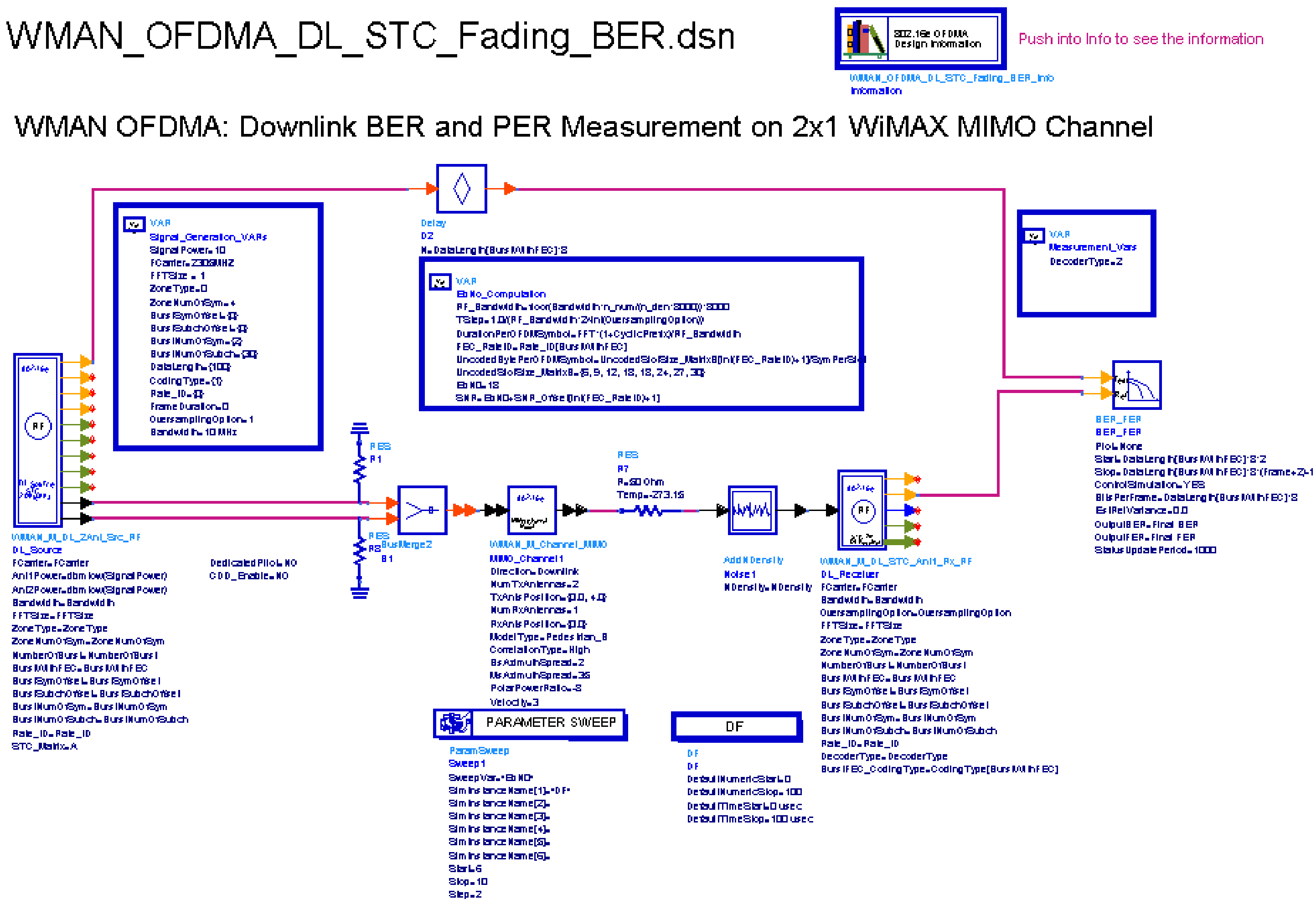
Features

- Mobile WiMAX 2x1 STC system configuration
- BER and PER measurement on 2x1 ITU channels
- Three decoder types supported in downlink receiver: Hard, Soft or CSI
- Multiple E_b/N_0 measurement points
- ITU fading channel conditions

Description

WMAN_OFDMA_DL_STC_Fading_BER measures downlink BER and PER Measurement on ITU channels for 2x1 STC system. The schematic is shown in the following illustration.

WMAN_OFDMA_DL_STC_Fading_BER Schematic



In DL signal source, *PowerType* is set to *Burst power when all subchs occupied* which is recommended for receiver measurement. For more information, refer to *Transmit Power Definition.* (wman_m) *STC_Matirx* is set to *Matrix_A* for 2x1 STC system. MIMO Midamble can be inserted to get robust channel information.

In DL receiver, *DecoderType* can be selected with Hard, Soft or CSI. For DL PUSC and AMC, an advanced two-dimensional MMSE estimator are employed which is based on three input parameters: maximum Doppler frequency (*Fmax*), maximum echo delay (*Tmax*) and *SNR*. In order to get best performance, these parameters should be set according to the fading channel and noise conditions.

The STC/MIMO channel is extended from ITU models (Ped-B & Veh-A) by adding the definition of a per-tap spatial correlation. Three levels of channel correlation (high, medium and low) have been defined to serve as three options for the RCTs.

Users can change *Rate_ID* from 0 to 6 in *Signal_Generation_VARs* and get BER and PER results for different modulations and code rates. In *EbNo_Computation*, the E_b/N_0 and corresponding SNR is calculated. In *Measurement_Vars*, the number of frames for simulating BER/FER is defined which may be varied for different E_b/N_0.

Simulation Results

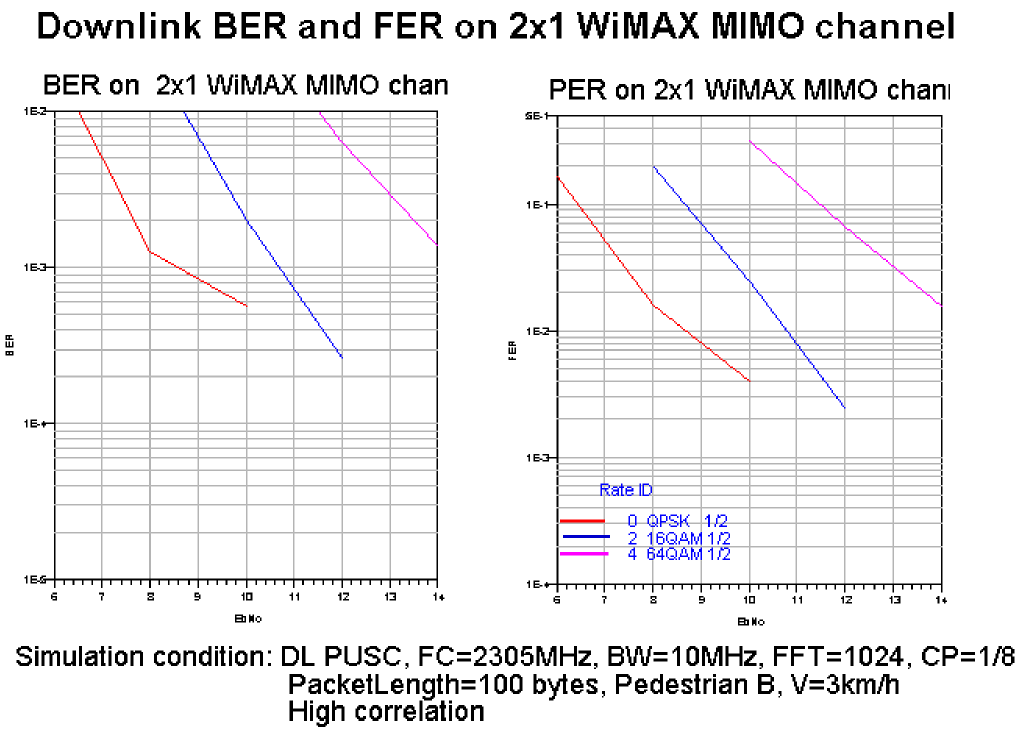
In this example, The performances of downlink PUSC under the ITU PB3 channels for QPSK 1/2 (*Rate_ID=0*), 16QAM 1/2 (*Rate_ID=2*) and 64QAM 1/2 (*Rate_ID=4*) are given. The following table shows the simulation conditions.

Parameter Settings

Parameter	Value
FCarrier	2305 MHz
Zone Type	DL PUSC
FFT Size	1024
Bandwidth	10 MHz
Frame Duration	2 msec †
Oversampling Option	Ratio 2
Cyclic Prefix	1/8
Packet Length in One Frame (Data Length)	100 Bytes
Rate ID	0, 2, 4
Channel	Ped-B 3Km/h, High correlation
Decoder Type	CSI
† Here, in order to reduce the simulation time, the frame duarion is set to 2 msec instead of the required 5 msec.	

The curves have been generated averaging over 1000 or 2000 frames on 2x1 ITU fading channels. The following illustration shows the simulation results.

Downlink STC BER and FER Simulation Curve



Benchmark

- Hardware Platform: Centrino Duo 2.0GHz, 2048M memory
- Software Platform: Windows 2000, ADS 2005A
- Simulation Time: about 6 hours for QPSK 1/2 (*Rate_ID=0*)

Downlink MIMO Receiver Sensitivity Measurement

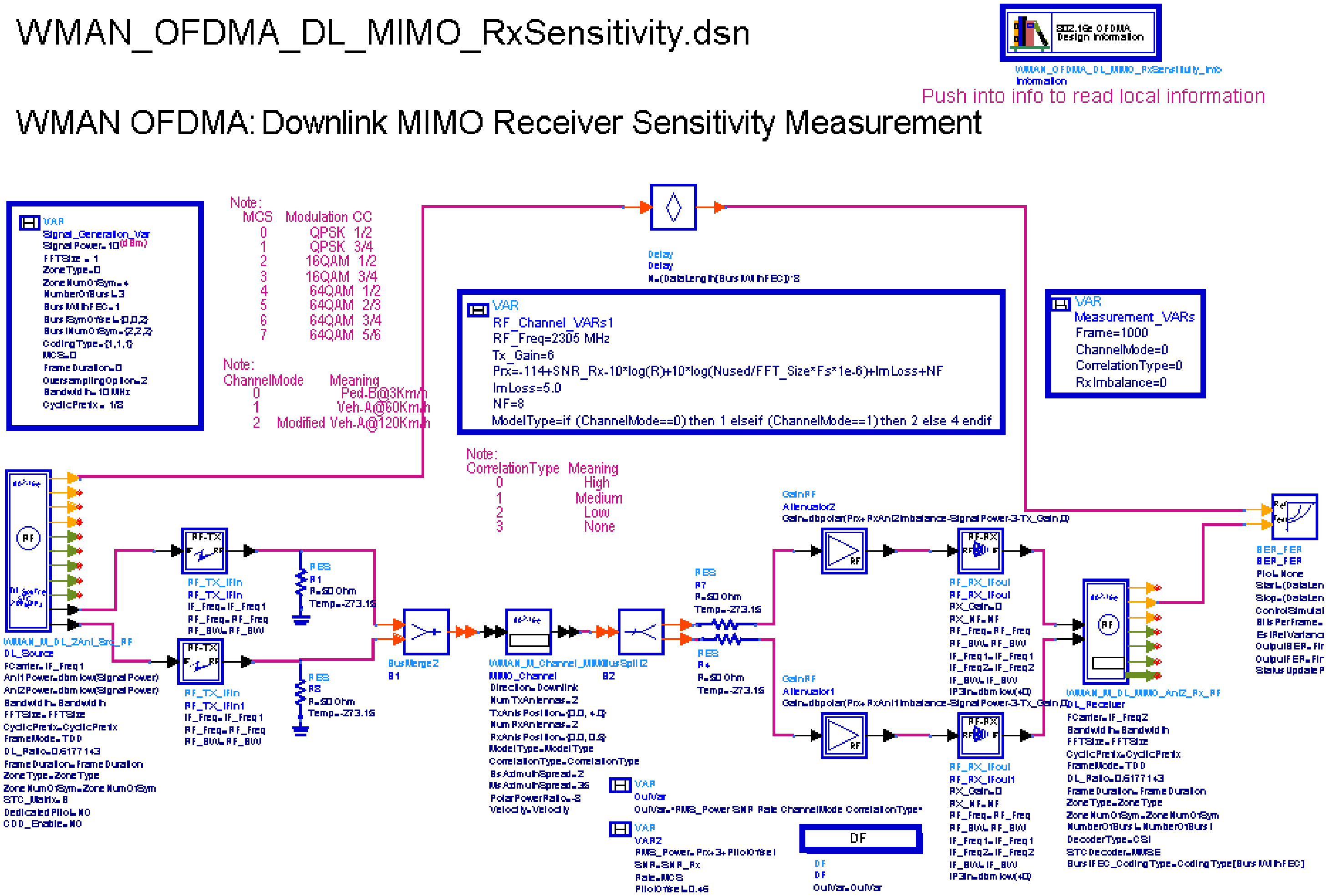
WMAN_OFDMA_DL_MIMO_RxSensitivity Design

Features

- Downlink MIMO receiver minimum input level sensitivity measurement
- Peb-B 3Km/h, Veh-A 60Km/h and modified Veh-A 120Km/h supported

Description

WMAN_OFDMA_DL_MIMO_RxSensitivity measures the PER results. The PER, rather than the BER, is measured over a larger number of frames to verify that the performance is better than or equal to the target at the power levels RMS defined in 9.1.22 MS-22.2: MS receiver MIMO processing of WiMAX Forum Mobile Radio Conformance Tests (MRCT). The schematic is shown in the following figure.



In DL signal source, the PowerType is set to Burst power when all subchs occupied which is recommended for receiver measurement. For more information, please refer to *Power definition* (wman_m).
In DL receiver, DecoderType can be selected with Hard, Soft or CSI. For DL PUSC, an advanced two-dimensional MMSE estimator is employed which is based on three input parameters: maximum Doppler frequency (Fmax), maximum echo delay (Tmax) and SNR. In order to get best performance, these parameters should be set according to the channel and noise level.

The total signal level at the two antenna port of the MS UUT, RMS, is shown according to the equation of MS receiver MIMO processing of WiMAX Forum Mobile Radio Conformance Tests (MRCT):

$$R_{MS} = -144 + 3 + SNR_{ideal} + 10 \times \log(F_s \times N_{Used}/N_{FFT}) + ImpLoss + NF + 0.46$$

where Fs is the sampling rate in MHz, Nused is the number of used subcarriers, NF is the maximal noise figure allowed (8dB), and ImpLoss is the implementation loss including non-ideal receiver effects. The assumed value is 5 dB. The actual implementation loss in ADS receiver is addressed in the following chapters. SNRideal is the average data subcarrier power to the noise power ratio in frequency domain, and it is also the average SNR across two receive antennas. The equation above defines the total received power at the MS UUT.

Downlink Subframe Configurations

The downlink subframe structure is assumed with a preamble, a non-STC zone with PUSC permutation for MAP/DCD/UCD payload, and a STC PUSC (or AMC) zone starting from the symbol right after the MAP traffic to the end of the DL subframe in which four (4) symbols are allocated. In these four (4) symbols, three bursts are allocated; The first burst is for the PER measurement and the others are for maintaining the per-subcarrier transmit power density level across the entire band for the test. The first burst occupies the region which is from the first symbol in the first two (2) symbols and the first subchannel, and spans two symbols in time direction and N_{Slots} subchannels in frequency direction. N_{Slots} is the number of slots occupied for each packet depending on the MCS (Rate ID). The following table lists the packet length for each MCS. Note that only one packet (burst) is allocated for measuring PER in each subframe.

MCS	Payload (bytes)	PDU Size (bytes)	Slots per PDU (N_{Slots}	Packtes(PDUs) per frame
QPSK rate-1/2	110	60x2	10x2	1
QPSK rate-3/4	98	54x2	6x2	1
16QAM rate-1/2	110	60x2	5x2	1
16QAM rate-3/4	98	54x2	3x2	1
64QAM rate-1/2	98	54x2	3x2	1
64QAM rate-2/3	86	48x2	2x2	1
64QAM rate-3/4	98	54x2	2x2	1
64QAM rate-5/6	110	60x2	2x2	1

Parameters for MIMO Receiver Sensitivity

The rest of the slots in the first two data symbols are allocated with the second burst with QPSK rate-1/2 (Rate ID 0). The entire slots in the last two data symbols are allocated with the third burst with QPSK rate-1/2 (Rate ID 0).

Receiver Sensitivity in Peb-B@3Km/h

For fading channels, the target PER is 19%, which is assumed to be near the target PER of a first HARQ transmission. The required SNR and implementation loss in ADS for each MCS are shown in the following table.

MCS	Target PER	MIMO Channel	Min. Required SNR in RCT	Required SNR in ADS	Impl. loss in ADS
QPSK rate-1/2	19%	Low	6.3 dB	7.8 dB	1.5 dB
		High	7.48 dB	10.18 dB	2.7 dB
QPSK rate-3/4	19%	Low	11.45 dB	13.75 dB	2.3 dB
		High	13.3 dB	16.7 dB	3.4 dB
16QAM rate-1/2	19%	Low	13.73 dB	16.23 dB	2.5 dB
		High	14.7 dB	17.7 dB	3.0 dB
16QAM rate-3/4	19%	Low	19.0 dB	21.3 dB	2.3 dB
		High	20.95 dB	23.95 dB	3.0 dB
64QAM rate-1/2	19%	Low	18.6 dB	20.6 dB	2.0 dB
		High	20.58 dB	22.78 dB	2.2 dB
64QAM rate-2/3	19%	Low	22.7 dB	25.0 dB	2.3 dB
		High	No test		
64QAM rate-3/4	19%	Low	No test		
		High	No test		
64QAM rate-5/6	19%	Low	No test		
		High	No test		

Required SNR for MIMO Receiver Sensitivity (Matrix-B, CTC, PUSC, Ped-B@3Km/h)

Note that:

- The number of frames for simulation in Peb-B@3Km/h is 2,000.
- The implementation loss in ADS only includes the loss in the baseband receiver.

Receiver Sensitivity in Veh-A@60Km/h

For fading channels, the target PER is 19%, which is assumed to be near the target PER of a first HARQ transmission. The required SNR and implementation loss in ADS for each MCS are shown in the following table.

MCS	Target PER	MIMO Channel	Min. Required SNR in RCT	Required SNR in ADS	Impl. loss in ADS
QPSK rate-1/2	19%	Low	6.59 dB	8.69 dB	2.1 dB
		High	7.82 dB	10.02 dB	2.2 dB
QPSK rate-3/4	19%	Low	11.8 dB	14.3 dB	2.5 dB
		High	13.2 dB	16.7 dB	3.5 dB
16QAM rate-1/2	19%	Low	14.23 dB	15.83 dB	1.6 dB
		High	14.94 dB	17.94 dB	3.0 dB
16QAM rate-3/4	19%	Low	19.83 dB	23.13 dB	3.3 dB
		High	22 dB	26.3 dB	4.3 dB
64QAM rate-1/2	19%	Low	19.16 dB	21.96 dB	2.8 dB
		High	21.35 dB	24.45 dB	3.1 dB
64QAM rate-2/3	19%	Low	No test		
		High	No test		
64QAM rate-3/4	19%	Low	No test		
		High	No test		
64QAM rate-5/6	19%	Low	No test		
		High	No test		

Required SNR for MIMO Receiver Sensitivity (Matrix-B, CTC, PUSC, Veh-A@60Km/h)

Note that:

- The number of frames for simulation in Veh-A@60Km/h is 2,000.
- The implementation loss in ADS only includes the loss in the baseband receiver.

Receiver Sensitivity in modified Veh-A@120Km/h

For fading channels, the target PER is 19%, which is assumed to be near the target PER of a first HARQ transmission. The required SNR and implementation loss in ADS for each MCS are shown in the following table.

MCS	Target PER	MIMO Channel	Min. Required SNR in RCT	Required SNR in ADS	Impl. loss in ADS
QPSK rate-1/2	19%	Low	6.8 dB	8.6 dB	1.8 dB
		High	7.44 dB	10.6 dB	3.16 dB
QPSK rate-3/4	19%	Low	12.4 dB	15.4 dB	3.0 dB
		High	13.5 dB	18.3 dB	4.8 dB
16QAM rate-1/2	19%	Low	14.6 dB	17.0 dB	2.4 dB
		High	16.79 dB	19.19 dB	2.4 dB
16QAM rate-3/4	19%	Low	No test		
		High	No test		
64QAM rate-1/2	19%	Low	No test		
		High	No test		
64QAM rate-2/3	19%	Low	No test		
		High	No test		
64QAM rate-3/4	19%	Low	No test		
		High	No test		
64QAM rate-5/6	19%	Low	No test		
		High	No test		

Required SNR for MIMO Receiver Sensitivity (Matrix-B, CTC, PUSC, Veh-A@120Km/h)

Note that:

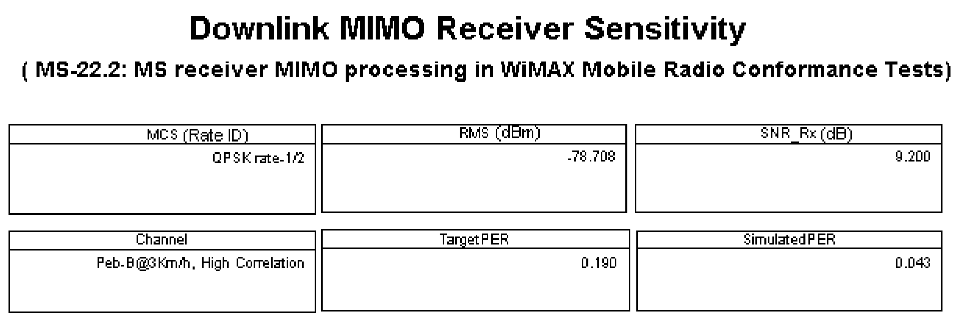
- The number of frames for simulation in modified Veh-A@120Km/h is 2,000.
- The implementation loss in ADS only includes the loss in the baseband receiver.

Simulation Results

In this example, the performance of downlink MIMO PUSC for QPSK 1/2 (Rate_ID=0) is given. The following figures show the simulation conditions and the simulation results averaging over 1000 frames.

Parameter Settings

Parameter	**Value**
FCarrier	2305 MHz
Zone Type	DL PUSC
FFT Size	1024
Bandwidth	10 MHz
Frame Duration	2 msec †
Oversampling Option	Ratio 4
Cyclic Prefix	1/8
Packet Length in One Frame (Data Length)	100 Bytes
Rate ID	0
Channel	Ped-B 3Km/h, High correlation
STC Decoder	MMSE
Decoder Type	CSI
† Here, in order to reduce the simulation time, the frame duarion is set to 2 msec instead of required 5 msec.	



DownLink MIMO Receiver Sensitivity Simulation Resutls

Benchmark

- Hardware Platform: Centrino Duo 2.0GHz, 2 GB memory
- Software Platform: Windows XP, ADS 2006A
- Simulation Time: about 6 hours

Downlink STC Receiver Sensitivity Measurement

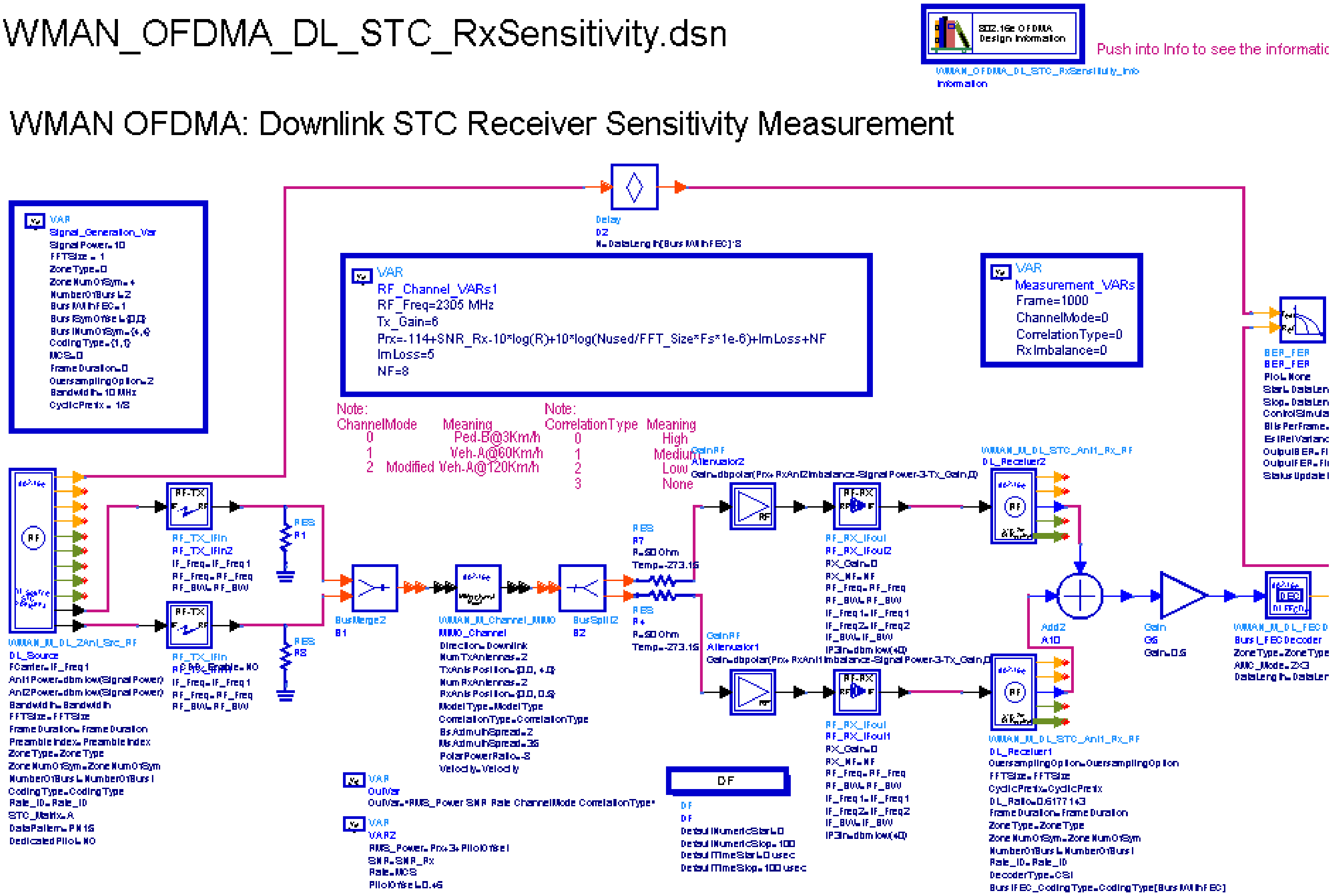
WMAN_OFDMA_DL_STC_RxSensitivity Design

Features

- Downlink STC receiver minimum input level sensitivity measurement
- Peb-B 3Km/h, Veh-A 60Km/h and modified Veh-A 120Km/h supported

Description

WMAN_OFDMA_DL_STC_RxSensitivity measures the PER results. The PER, rather than the BER, is measured over a larger number of frames to verify that the performance is better than or equal to the target at the power levels RMS defined in 9.1.22 MS-22.2: MS receiver MIMO processing of WiMAX Forum Mobile Radio Conformance Tests (MRCT). The schematic is shown in the following figure.



In DL signal source, the PowerType is set to Burst power when all subchs occupied which is recommended for receiver measurement. For more information, please refer to *Power definition* (wman_m).
In DL receiver, DecoderType can be selected with Hard, Soft or CSI. For DL PUSC, an advanced two-dimensional MMSE estimator is employed which is based on three input parameters: maximum Doppler frequency (Fmax), maximum echo delay (Tmax) and SNR. In order to get best performance, these parameters should be set according to the channel and noise level.

The total signal level at the two antenna port of the MS UUT, RMS, is shown according to the equation of MS receiver MIMO processing of WiMAX Forum Mobile Radio Conformance Tests (MRCT):

$$R_{MS} = -144 + 3 + SNR_{ideal} + 10 \times \log(F_s \times N_{Used}/N_{FFT}) + ImpLoss + NF + 0.46$$

where Fs is the sampling rate in MHz, Nused is the number of used subcarriers, NF is the maximal noise figure allowed (8dB), and ImpLoss is the implementation loss including non-ideal receiver effects. The assumed value is 5 dB. The actual implementation loss in ADS receiver is addressed in the following chapters. SNRideal is the average data subcarrier power to the noise power ratio in frequency domain, and it is also the average SNR across two receive antennas. The equation above defines the total received power at the MS UUT.

Downlink Subframe Configurations

The downlink subframe structure is assumed with a preamble, a non-STC zone with PUSC permutation for MAP/DCD/UCD payload, and a STC PUSC (or AMC) zone starting from the symbol right after the MAP traffic to the end of the DL subframe in which four (4) symbols are allocated. In these four (4) symbols, three bursts are allocated; The first burst is for the PER measurement and the others are for maintaining the per-subcarrier transmit power density level across the entire band for the test. The first burst occupies the region which is from the first symbol in the first two (2) symbols and the first subchannel, and spans two symbols in time direction and N_{Slots} subchannels in frequency direction. N_{Slots} is the number of slots occupied for each packet depending on the MCS (Rate ID). The following table lists the packet length for each MCS. Note that only one packet (burst) is allocated for measuring PER in each subframe.

MCS	Payload (bytes)	PDU Size (bytes)	Slots per PDU (N_{Slots}	Packtes(PDUs) per frame
QPSK rate-1/2	50	60x1	10x1	1
QPSK rate-3/4	44	54x1	6x1	1
16QAM rate-1/2	50	60x1	5x1	1
16QAM rate-3/4	44	54x1	3x1	1
64QAM rate-1/2	44	54x1	3x1	1
64QAM rate-2/3	38	48x1	2x1	1
64QAM rate-3/4	44	54x1	2x1	1
64QAM rate-5/6	50	60x1	2x1	1

Parameters for STC Receiver Sensitivity

The rest of the slots in the first two data symbols are allocated with the second burst with QPSK rate-1/2 (Rate ID 0). The entire slots in the last two data symbols are allocated with the third burst with QPSK rate-1/2 (Rate ID 0).

Receiver Sensitivity in Peb-B@3Km/h

For fading channels, the target PER is 19%, which is assumed to be near the target PER of a first HARQ transmission. The required SNR and implementation loss in ADS for each MCS are shown in the following table.

MCS	Target PER	MIMO Channel	Min. Required SNR in RCT	Required SNR in ADS	Impl. loss in ADS
QPSK rate-1/2	19%	High	0.75 dB	2.85 dB	2.1 dB
QPSK rate-3/4	19%	High	4.38 dB	6.38 dB	2.0 dB
16QAM rate-1/2	19%	High	6.23 dB	8.23 dB	2.0 dB
16QAM rate-3/4	19%	High	10.4 dB	12.2 dB	1.8 dB
64QAM rate-1/2	19%	High	10.9 dB	13.0 dB	2.1 dB
64QAM rate-2/3	19%	High	14.16 dB	16.46 dB	2.3 dB
64QAM rate-3/4	19%	High	15.58 dB	17.58 dB	2.0 dB
64QAM rate-5/6	19%	High	17.49 dB	19.39 dB	1.9 dB

Required SNR for STC Receiver Sensitivity (Matrix-A, CTC, PUSC, Ped-B@3Km/h)

Note that:

- The number of frames for simulation in Peb-B@3Km/h is 2,000.
- The implementation loss in ADS only includes the loss in the baseband receiver.

Receiver Sensitivity in Veh-A@60Km/h

For fading channels, the target PER is 19%, which is assumed to be near the target PER of a first HARQ transmission. The required SNR and implementation loss in ADS for each MCS are shown in the following table.

MCS	Target PER	MIMO Channel	Min. Required SNR in RCT	Required SNR in ADS	Impl. loss in ADS
QPSK rate-1/2	19%	High	0.9 dB	2.6 dB	1.7 dB
QPSK rate-3/4	19%	High	4.52 dB	5.92 dB	1.4 dB
16QAM rate-1/2	19%	High	6.58 dB	8.18 dB	1.6 dB
16QAM rate-3/4	19%	High	10.69 dB	11.99 dB	1.3 dB
64QAM rate-1/2	19%	High	11.15 dB	12.95 dB	1.8 dB
64QAM rate-2/3	19%	High	14.74 dB	16.84 dB	2.1 dB
64QAM rate-3/4	19%	High	16.09 dB	18.09 dB	2.0 dB
64QAM rate-5/6	19%	High	18.36 dB	20.86 dB	2.5 dB

Required SNR for STC Receiver Sensitivity (Matrix-A, CTC, PUSC, Veh-A@60Km/h)

Note that:

- The number of frames for simulation in Veh-A@60Km/h is 2,000.
- The implementation loss in ADS only includes the loss in the baseband receiver.

Receiver Sensitivity in modified Veh-A@120Km/h

For fading channels, the target PER is 19%, which is assumed to be near the target PER of a first HARQ transmission. The required SNR and implementation loss in ADS for each MCS are shown in the following table.

MCS	Target PER	MIMO Channel	Min. Required SNR in RCT	Required SNR in ADS	Impl. loss in ADS
QPSK rate-1/2	19%	High	1.2 dB	3.2 dB	2.0 dB
QPSK rate-3/4	19%	High	5.0 dB	6.3 dB	1.3 dB
16QAM rate-1/2	19%	High	7.31 dB	8.91 dB	1.6 dB
16QAM rate-3/4	19%	High	11.3 dB	13.2 dB	1.9 dB
64QAM rate-1/2	19%	High	11.81 dB	14.71 dB	2.9 dB
64QAM rate-2/3	19%	High	No test		
64QAM rate-3/4	19%	High	No test		
64QAM rate-5/6	19%	High	No test		

Required SNR for STC Receiver Sensitivity (Matrix-A, CTC, PUSC, Veh-A@120Km/h)

Note that:

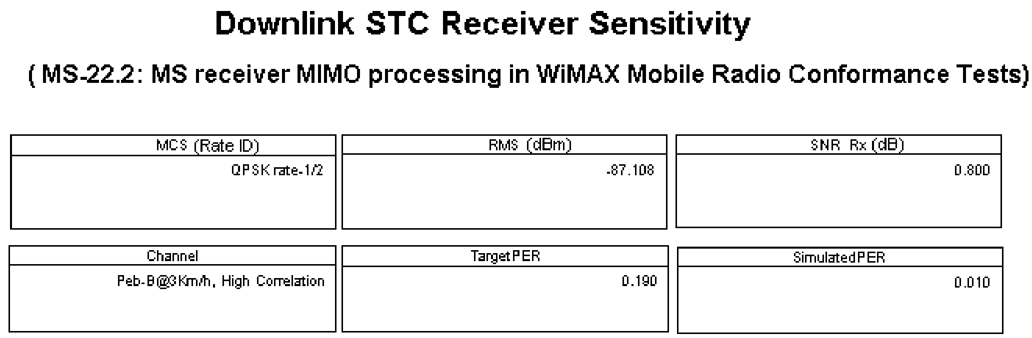
- The number of frames for simulation in modified Veh-A@120Km/h is 2,000.
- The implementation loss in ADS only includes the loss in the baseband receiver.

Simulation Results

In this example, the performance of downlink STC PUSC for QPSK 1/2 (Rate_ID=0) is given. The following figures show the simulation conditions and the simulation results averaging over 1000 frames.

Parameter Settings

Parameter	Value
FCarrier	2305 MHz
Zone Type	DL PUSC
FFT Size	1024
Bandwidth	10 MHz
Frame Duration	2 msec [†]
Oversampling Option	Ratio 4
Cyclic Prefix	1/8
Packet Length in One Frame (Data Length)	100 Bytes
Rate ID	0
Channel	Ped-B 3Km/h, High correlation
STC Decoder	MMSE
Decoder Type	CSI
[†] Here, in order to reduce the simulation time, the frame duarion is set to 2 msec instead of required 5 msec.	



DownLink MIMO Receiver Sensitivity Simulation Resutls

Benchmark

- Hardware Platform: Centrino Duo 2.0GHz, 2 GB memory
- Software Platform: Windows XP, ADS 2006A
- Simulation Time: about 6 hours

Uplink BER and PER Measurement on Fading Channel for MIMO system

WMAN_OFDMA_UL_MIMO_Fading_BER Design

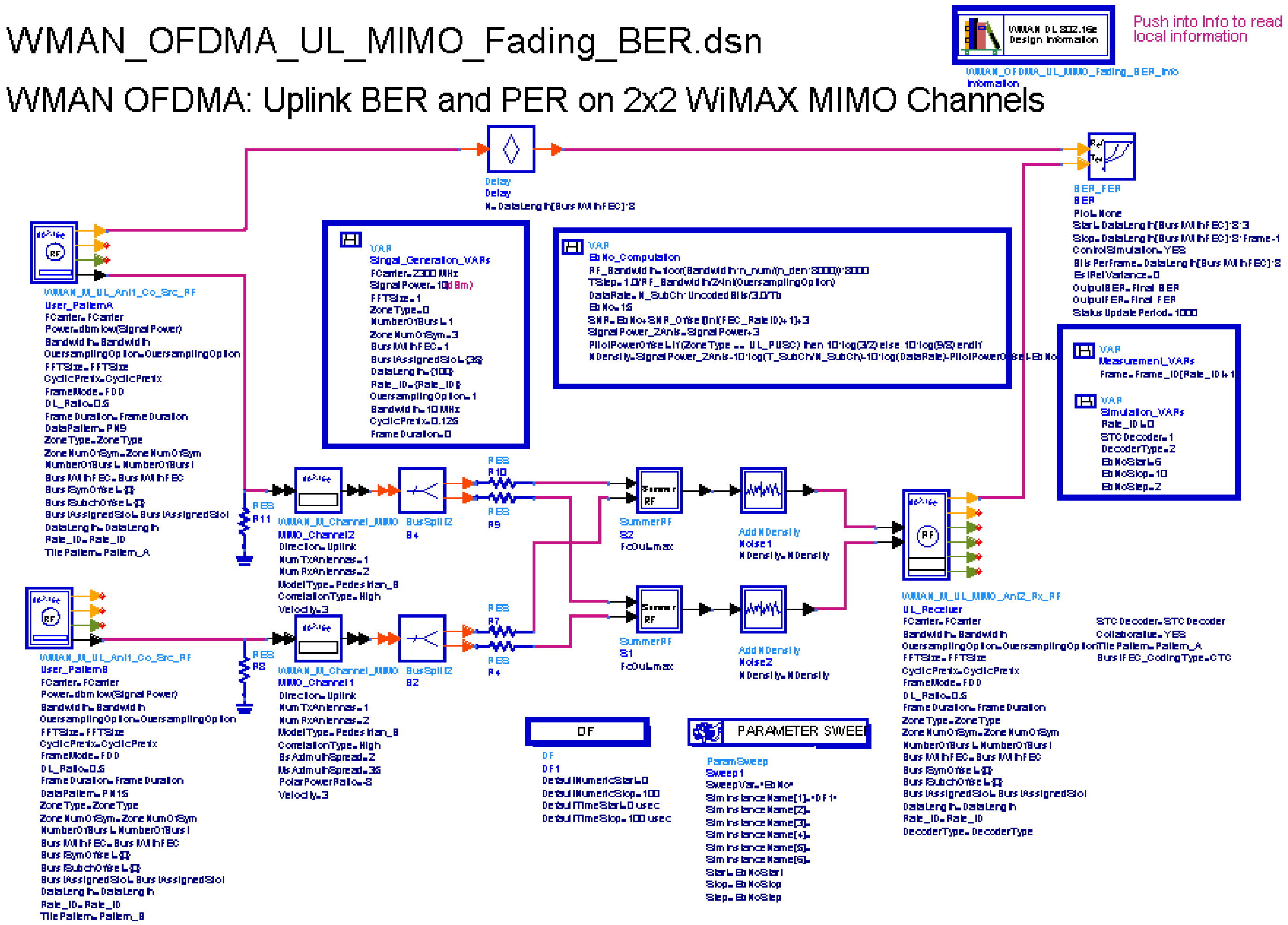
Features

- Mobile WiMAX 2x2 MIMO system configuration
- BER and PER measurement on 2x2 ITU channels
- Three decoder types supported in uplink receiver: Hard, Soft or CSI
- Two STC/MIMO decoder types supported in uplink receiver: MMSE or ZF
- Multiple E_b/N_0 measurement points

Description

WMAN_OFDMA_UL_MIMO_Fading_BER measures uplink BER and PER measurement on ITU channels for 2x2 MIMO system. The schematic is shown in the following illustration.

WMAN_OFDMA_UL_MIMO_Fading_BER Schematic



In UL signal source, *PowerType* is set to *Burst power when all subchs occupied* which is recommended for receiver measurement. For more information, refer to *Transmit Power Definition.* (wman_m) There is not signal power estimation model in UL receiver as in DL receiver. When choosing *STCDecoder* set MMSE, *SignalPower* should be set 10dBm. *STC_Matirx* is set to *Matrix_B* for 2x2 MIMO system. MIMO Midamble can be inserted to get robust channel information.

In UL receiver, *DecoderType* can be selected with Hard, Soft or CSI and *STCDecoder* can be selected with MMSE or ZF. For UL PUSC, an advanced two-dimensional MMSE estimator are employed which is based on three input parameters: maximum Doppler frequency (*Fmax*), maximum echo delay (*Tmax*) and *SNR*. In order to get best performance, these parameters should be set according to the fading channel and noise conditions.

The STC/MIMO channel is extended from ITU models (Ped-B & Veh-A) by adding the definition of a per-tap spatial correlation. Three levels of channel correlation (high, medium and low) have been defined to serve as three options for the RCTs.

Users can change *Rate_ID* from 0 to 6 in *Signal_Generation_VARs* and get BER and PER results for different modulations and code rates. In *EbNo_Computation*, the E_b/N_0 and corresponding SNR is calculated. In *Measurement_Vars*, the number of frames for simulating BER/FER is defined which may be varied for different E_b/N_0.

Simulation Results

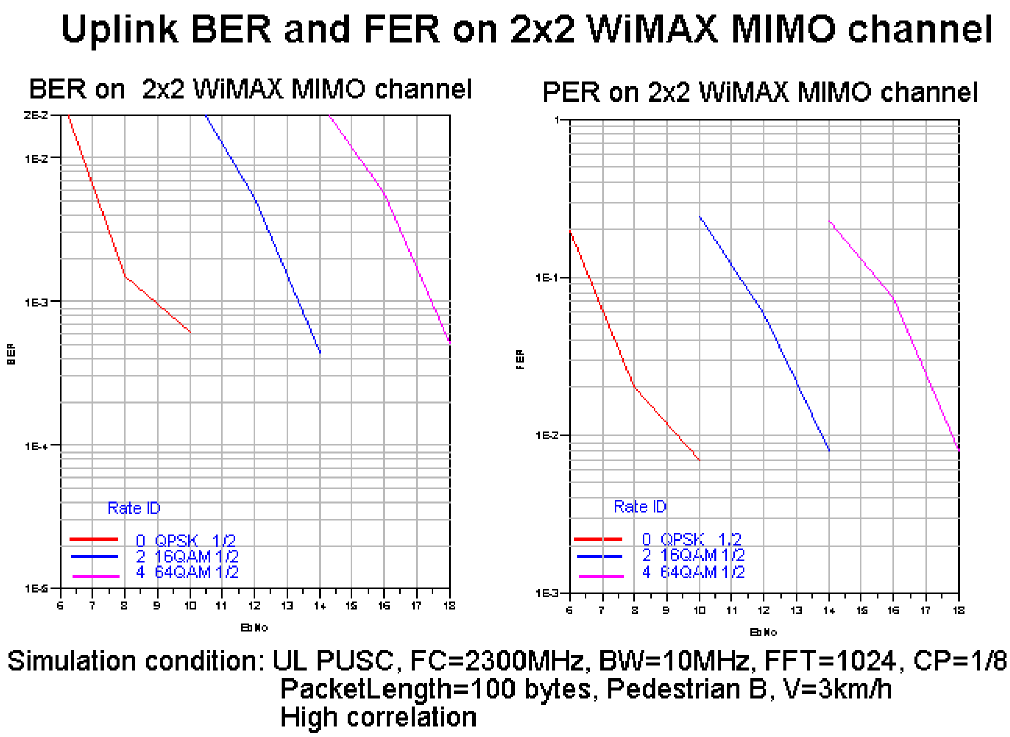
In this example, the performances of uplink PUSC under the ITU PB3 channels for QPSK 1/2 (*Rate_ID=0*), 16QAM 1/2 (*Rate_ID=2*) and 64QAM 1/2 (*Rate_ID=4*) are given. The following table shows the simulation conditions.

Parameter Settings

Parameter	Value
FCarrier	2305 MHz
Zone Type	UL PUSC
FFT Size	1024
Bandwidth	10 MHz
Frame Duration	2 msec
Oversampling Option	Ratio 1
Cyclic Prefix	1/8
Packet Length in One Frame (Data Length)	100 Bytes
Rate ID	0, 2, 4
Channel	Ped-B 3Km/h, High correlation
STC Decoder	MMSE
Decoder Type	CSI
† Here, in order to reduce the simulation time, the frame duarion is set to 2 msec instead of the required 5 msec.	

The curves have been generated averaging over 500 or 1000 frames on 2x2 ITU fading channels. The following illustrationshows the simulation results.

Uplink MIMO BER and FER Simulation Curve



Benchmark

- Hardware Platform: Centrino Duo 2.0GHz, 2048M memory
- Software Platform: Windows XP, ADS 2006A
- Simulation Time: about 4 hours for QPSK 1/2 (*Rate_ID=0*)

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. WiMAX Forum, Mobile Radio Conformance Tests (MRCT), October 2006.

WiBro Design Examples

The WMAN_WiBro_wrk workspace shows WiBro transmitter and receiver measurement characteristics including downlink BER and PER measurement on AWGN channel, downlink transmitter EVM and constellation; uplink transmitter EVM and constellation and uplink transmitter connected with 89600 VSA software measurements. The frequency is set to 2304.5 MHz.

Designs for these measurements include:

- DL BER and PER measurement on AWGN Channel: WiBro_DL_AWGN_BER
- DL transmitter EVM and constellation measurements: WiBro_DL_TxEVM
- UL transmitter EVM and constellation measurements: WiBro_UL_TxEVM
- UL transmitter connected with VSA software measurements: WiBro_UL_VSA

Variables used in these designs are listed in the following table.

Var Parameters

Parameter Name	Description	Default Value
FCarrier	Frequency carrier	2304.5 (MHz)
Bandwidth	Nominal bandwidth	8.75 (MHz)
SignalPower	Signal power	10 (dBm) for Rx and -10(dBm) for Tx
FFTSize	FFT size	1024
ZoneType	Zone type	PUSC
FrameDuration	Frame duration	5 (ms)
CyclicPrefix	Cyclic prefix	1/8
FrameMode	Frame mode	TDD
DL_Ratio	Downlink ratio	0.63952

Downlink BER and PER Measurements on AWGN Channel

WiBro_DL_AWGN_BER design

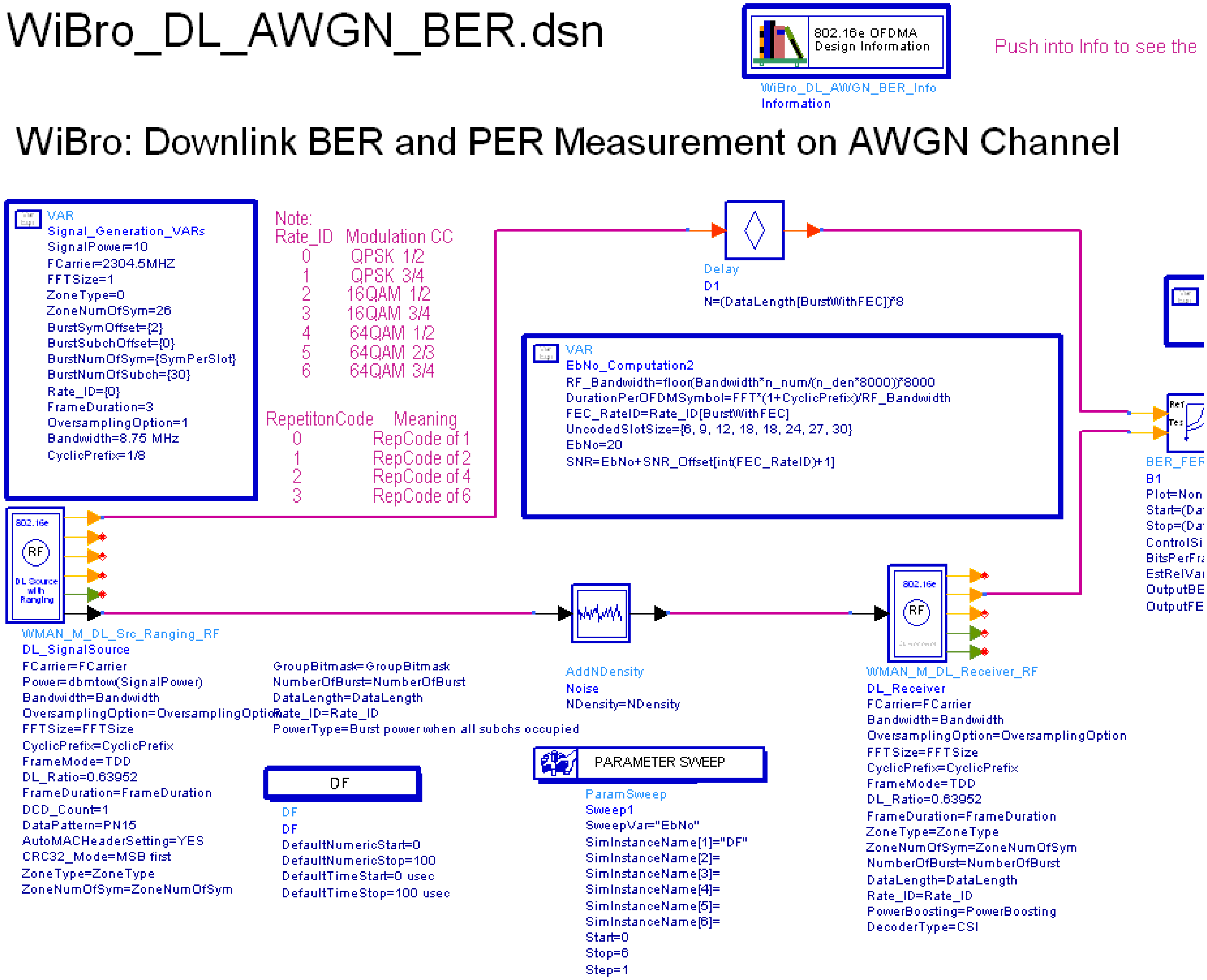
Features

- WiBro system configuration
- BER and PER measurement on AWGN channel
- Three decoder types supported in downlink receiver: Hard, Soft or CSI
- Multiple Eb/N0 measurement points

Description

WiBro_DL_AWGN_BER measures downlink BER and PER Measurement on AWGN channel for WiBro system. The schematic is shown in the following illustration.

WiBro_DL_AWGN_BER Schematic



In WiBro DL signal source, the *PowerType* is set to *Burst power when all subchs occupied* which is recommended for receiver measurement. For more information, please refer to *Transmit Power Definition.* (wman_m)

In WiBro DL receiver, *DecoderType* can be selected with Hard, Soft or CSI. For DL PUSC, an advanced two-dimensional MMSE estimator are employed which is based on three input paramters: maximum Doppler frequency (*Fmax*), maximum echo delay (*Tmax*) and *SNR*. In order to get best performance, these paramters should be set according to the fading channel and noise conditions.

Users can change *Rate_ID* from 0 to 6 in *Signal_Generation_VARs* and get BER and PER results for different modulations and code rates. In *EbNo_Computation*, the E_b/N_0 and corresponding SNR is calculated. In *Measurement_Vars*, the number of frames for simulating BER/FER is defined.

Simulation Results

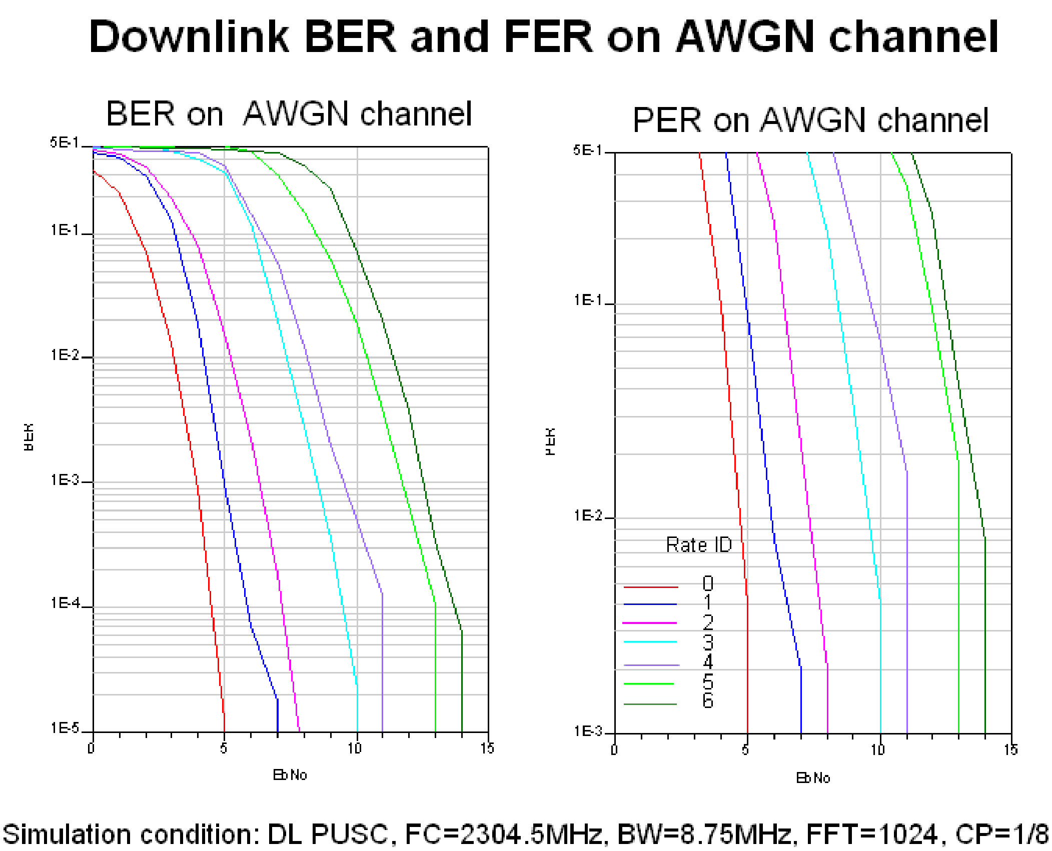
In this example, The performances of downlink PUSC under AWGN channel for QPSK 1/2 (*Rate_ID=0*) to 64QAM 3/4 (*Rate_ID=6*) are given. The following table shows WiBro system and simulation conditions.

Parameter Settings

Parameter	Value
FCarrier	2304.5 MHz
Zone Type	DL PUSC
FFT Size	1024
Bandwidth	8.75 MHz
Frame Duration	5 msec
Oversampling Option	Ratio 2
Cyclic Prefix	1/8
Packet Length in One Frame (Data Length)	100 Bytes
Rate ID	0, 1, 2, 3, 4, 5, 6
Channel	AWGN
Decoder Type	CSI

The curves have been generated averaging over 500 frames on AGWN fading channel. The following illustration shows the simulation results.

WiBro Downlink BER and FER Simulation Curve



Benchmark

- Hardware Platform: Pentium IV 2.66GHz, 1 GB memory
- Software Platform: Windows 2000, ADS 2005A
- Simulation Time: about 2 hours for QPSK 1/2 (*Rate_ID=0*)

Downlink Transmitter EVM and Constellation Measurements

WiBro_DL_TxEVM Design

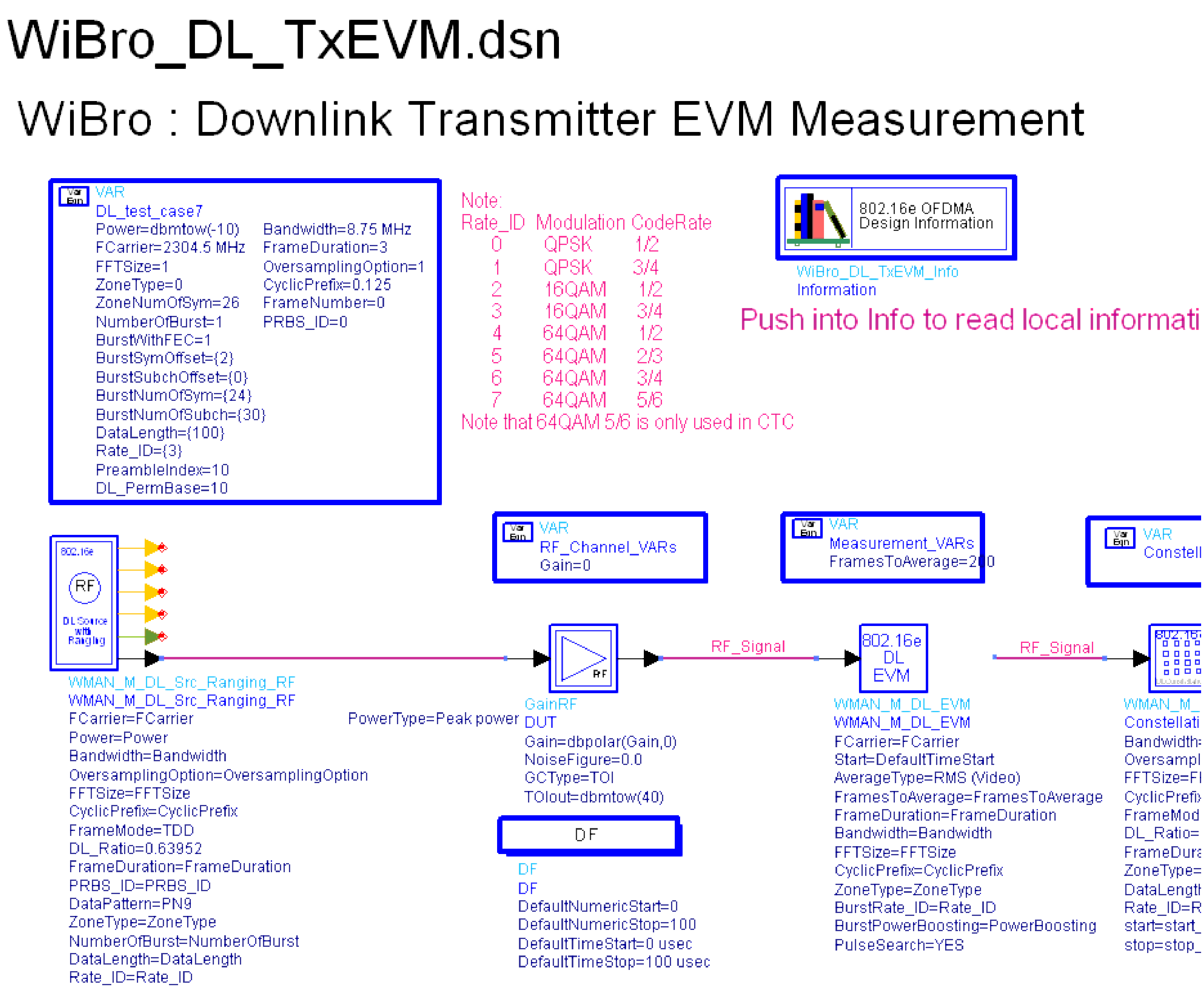
Features

- WiBro downlink transmitter EVM and constellation measurements.

Description

WiBro_DL_TxEVM measures the downlink transmitter EVM and constellation. The schematic is shown in the following illustration.

WiBro_DL_TxEVM Schematic



In DL signal source, the *PowerType* is set to *Peak power* which is recommended for transmitter measurement. For more information, please refer to *Transmit Power Definition.* (wman_m)

Users can change *Rate_ID* from 0 to 7 and get results for different modulations and code rates.

If *AverageType* is set to *OFF* , only one frame is analyzed. If *AverageType* is set to *RMS* (*Video*), after the first frame is analyzed the signal segment corresponding to it is discarded and new signal samples are collected from the input to fill in the signal buffer of length 2 x *FrameDuration* . The *SymbolTimingAdjust* parameter sets the percentage of symbol time by which we back away from the symbol end before we perform the FFT. The *TrackAmplitude* , *TrackPhase* , *TrackTiming* , and *EqualizerTraining* parameters determine the EVM measurement result. For more information, refer to WMAN_M_DL_EVM.

Simulation Results

In this example, The performances of downlink PUSC for 16QAM 3/4 (*Rate_ID=3*) are given. The following table shows the simulation conditions.

Parameter	**Value**
FCarrier	2304.5 MHz
Zone Type	DL PUSC
FFT Size	1024
Bandwidth	8.75 MHz
Frame Duration	5 msec
Oversampling Option	Ratio 2
Cyclic Prefix	1/8
Packet Length in One Frame (Data Length)	100 Bytes
Rate ID	16QAM 3/4

The relative constellation RMS error, averaged over subcarriers, OFDMA frames, and packets, shall not exceed a burst profile dependent value according to the Allowed Relative Constellation Error versus Data Rate, shown below and as defined in section 8.4.12.3, IEEE Std 802.16e-2005.

Allowed Relative Constellation Error versus Data Rate

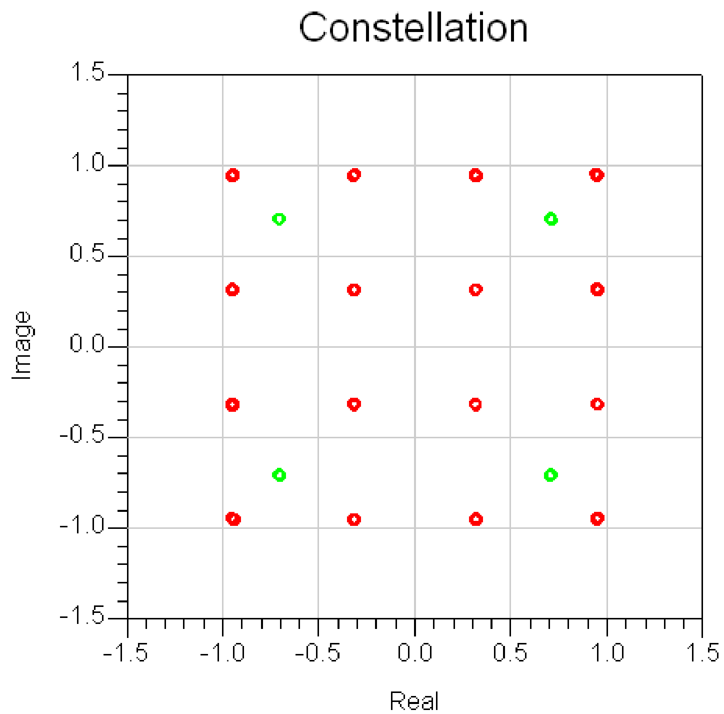
Burst type	**Relative Constellation Error (dB)**
QPSK-1/2	-15
QPSK-3/4	-18
16-QAM-1/2	-20.5
16-QAM-3/4	-24
64-QAM-1/2	-26
64-QAM-2/3	-28
64-QAM-3/4	-30

The following illustration shows the simulation results.

Downlink EVM and Constellation

EVM (or RCE)

Avg_RCE_dB	Avg_RCE_rms_percent
-80.906	0.009



Benchmark

- Hardware Platform: Pentium IV 2.26GHz, 1 GB memory
- Software Platform: Window 2000, ADS 2005A
- Simulation Time: about 4 minutes

Uplink Transmitter EVM and Constellation Measurements

WiBro_UL_TxEVM Design

Features

- WiBro uplink transmitter EVM and constellation measurements.

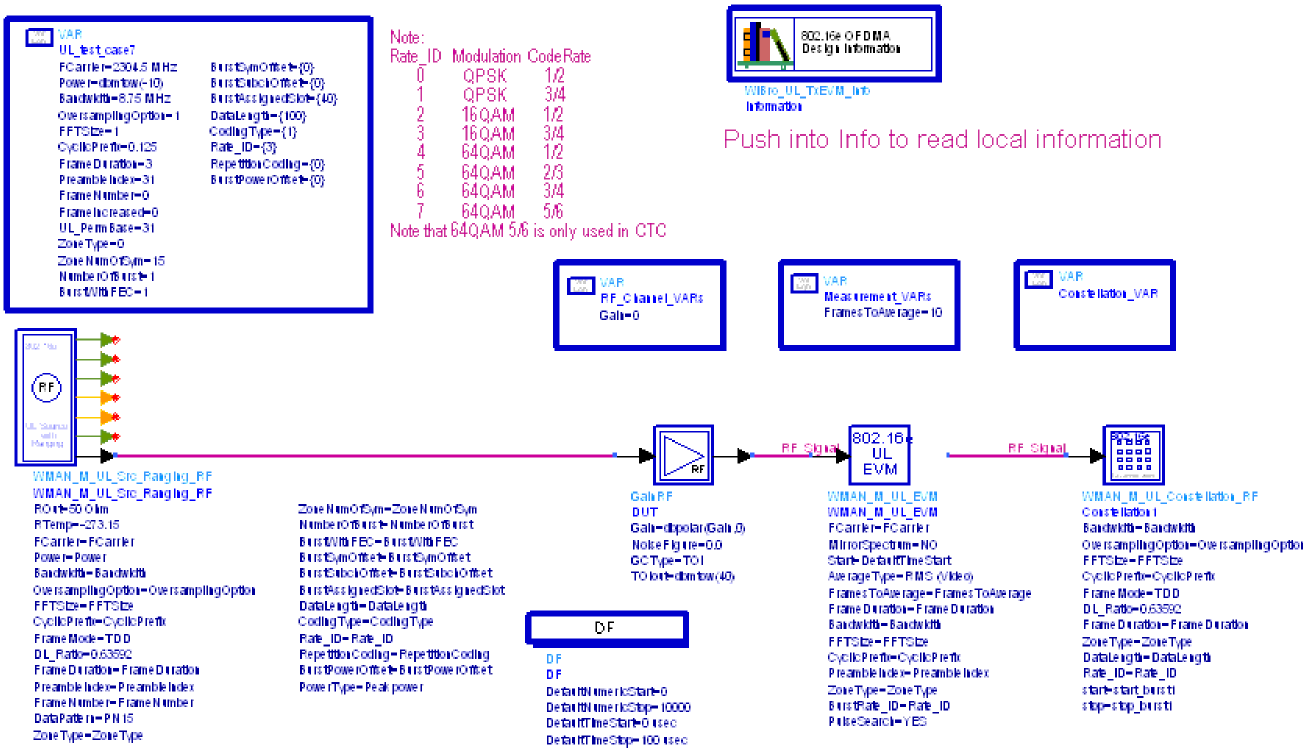
Description

WiBro_UL_TxEVM measures the uplink transmitter EVM and constellation. The schematic is shown in the following illustration.

WiBro_UL_TxEVM Schematic

WiBro_UL_TxEVM.dsn

WiBro: Uplink Transmitter EVM Measurement



In UL signal source, the *PowerType* is set to *Peak power* which is recommended for transmitter measurement. For more information, please refer to *Transmit Power Definition.* (wman_m)

Users can change *Rate_ID* from 0 to 7 and get results for different modulations and code rates.

If *AverageType* is set to *OFF* , only one frame is analyzed. If *AverageType* is set to *RMS* (*Video*), after the first frame is analyzed the signal segment corresponding to it is discarded and new signal samples are collected from the input to fill in the signal buffer of length 2 x *FrameDuration* . The *SymbolTimingAdjust* parameter sets the percentage of symbol time by which we back away from the symbol end before we perform the FFT. The *TrackAmplitude* , *TrackPhase* , *TrackTiming* , and *EqualizerTraining* parameters determine the EVM measurement result. For more information, refer to WMAN_M_UL_EVM.

Simulation Results

In this example, The performances of uplink PUSC for 16QAM 3/4 (*Rate_ID=3*) are given. The following table shows the simulation conditions.

Parameter Settings

Parameter	Value
FCarrier	2304.5 MHz
Zone Type	UL PUSC
FFT Size	1024
Bandwidth	8.75 MHz
Frame Duration	5 msec
Oversampling Option	Ratio 2
Cyclic Prefix	1/8
Packet Length in One Frame (Data Length)	100 Bytes
Rate ID	16QAM 3/4

The relative constellation RMS error, averaged over subcarriers, OFDMA frames, and packets, shall not exceed a burst profile dependent value according to the Allowed Relative Constellation Error versus Data Rate, shown below and as defined in section 8.4.12.3, IEEE Std 802.16e-2005.

Allowed Relative Constellation Error versus Data Rate

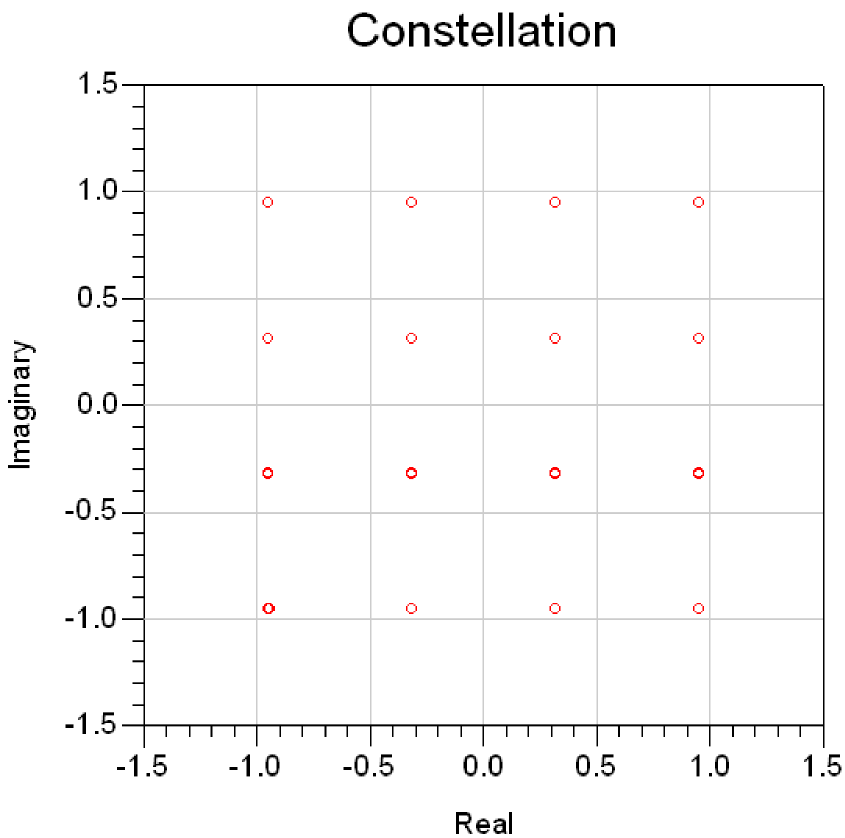
Burst type	Relative Constellation Error (dB)
QPSK-1/2	-15
QPSK-3/4	-18
16-QAM-1/2	-20.5
16-QAM-3/4	-24
64-QAM-1/2	-26
64-QAM-2/3	-28
64-QAM-3/4	-30

The following illustration shows the simulation results.

Uplink EVM and Constellation

EVM (or RCE)

Avg_RCE_dB	Avg_RCE_rms_percent
-105.374	5.386E-4



Benchmark

- Hardware Platform: Pentium IV 2.26GHz, 1 GB memory
- Software Platform: Window 2000, ADS 2005A
- Simulation Time: about 30 seconds

Uplink Transmitter Connected with 89600 VSA software

WiBro_UL_VSA Design

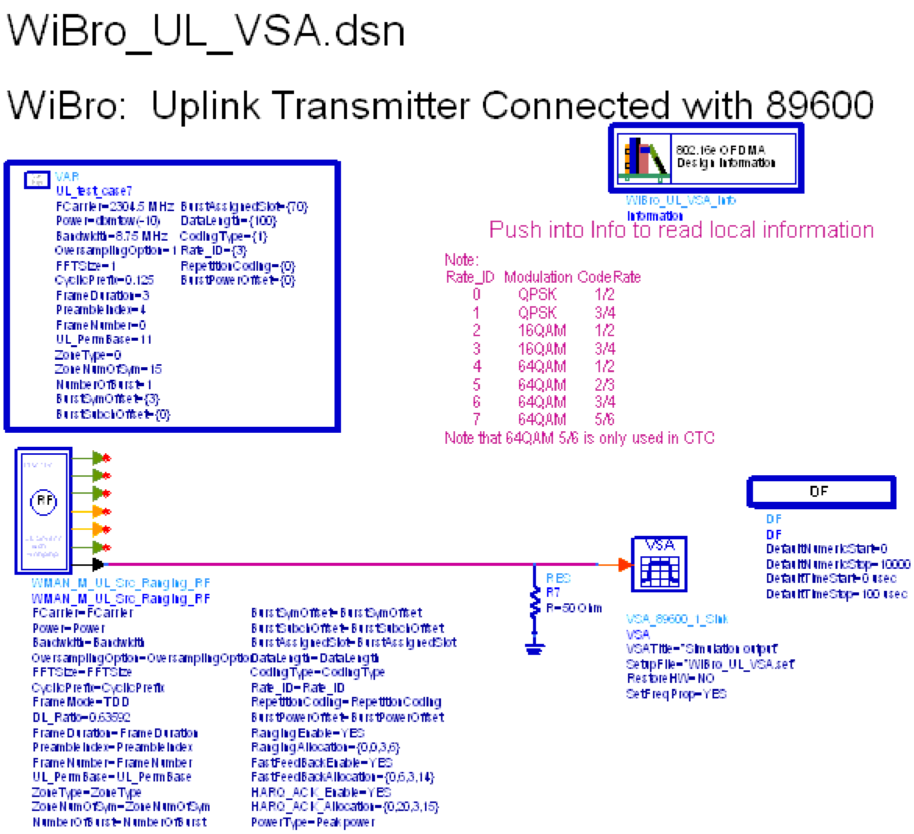
Features

- WiBro uplink demodulation result using Agilent 89600 VSA software.

Description

WiBro_UL_VSA shows WiBro uplink demodulation results connecting with Agilent 89600 VSA. The schematic is shown in the following illustration.

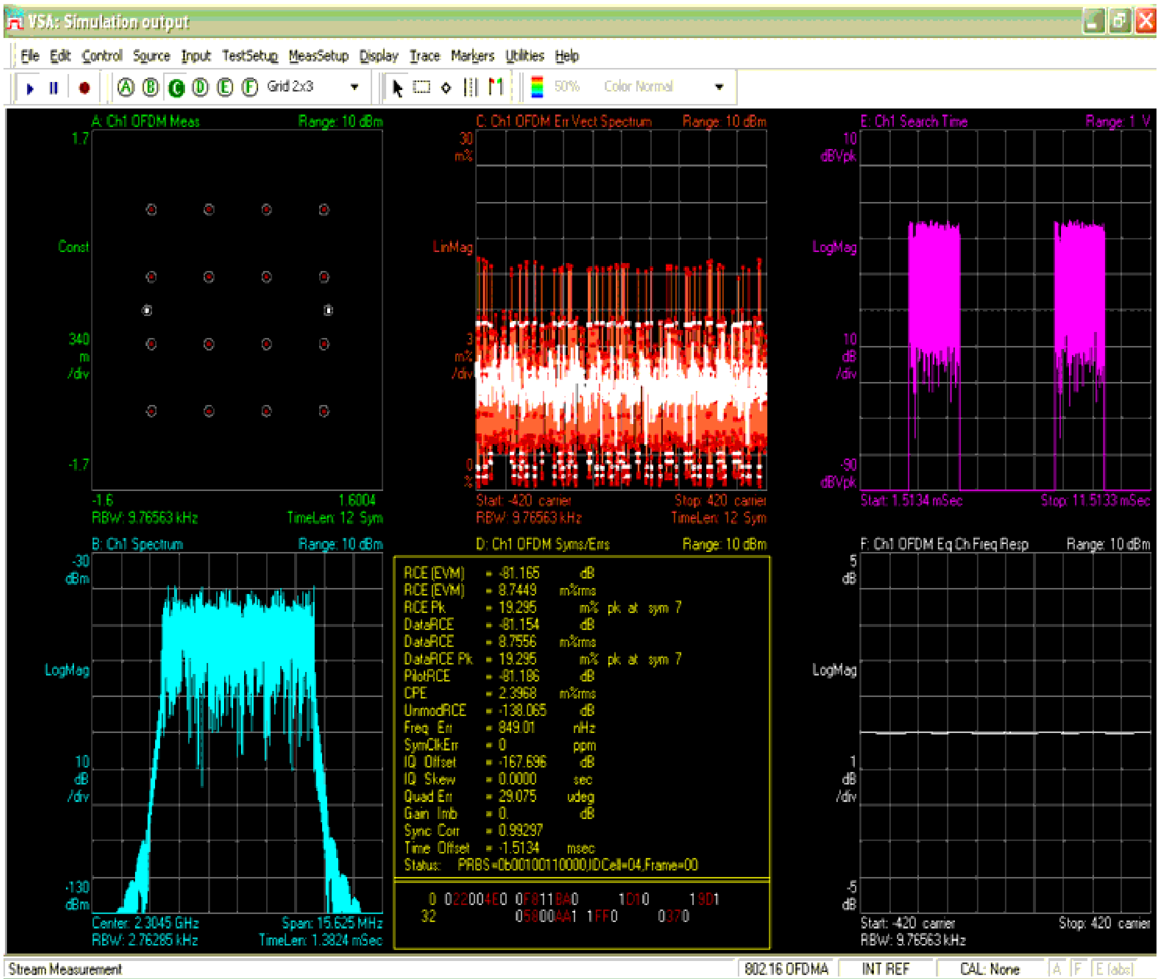
WiBro_UL_VSA Schematic



Simulation Results

Spectrum Flatness Measurement Result shows the demodulation result given by an Agilent 89600 VSA.

89600 VSA Software Demodulation Results



Benchmark

- Hardware Platform: Centrino Duo 2.0GHz, 2GB memory
- Software Platform: Windows XP, ADS 2005A

References

1. EEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. WiMAX Forum, Mobile Radio Conformance Tests (MRCT), October 2006.

About Mobile WiMAX Design Library

The Agilent EEsof 802.16e OFDMA wireless design library (WDL) is for the Mobile WiMAX OFDMA (802.16e) market. This wireless design library follows section 8.4 WirelessMAN-OFDMA PHY in both IEEE Std 802.16-2004 and IEEE Std 802.16e-2005. This design library is intended to be a baseline system for designers to get an idea of what a nominal or ideal system performance would be. Evaluations can be made regarding degraded system performance due to system impairments that may include non-ideal component performance.

Mobile WiMAX Systems

While wireless connectivity options have expanded rapidly in recent years, wireless network access is available now only in limited physical areas. Interned and entrant users need broadband access that extends over longer distances to more locations. The industry solution is the Worldwide Interoperability for Microwave Access (WiMAX) standard, developed to create certified standards-based products from a wide range of vendors.

WiMAX, a data-on-the-go alternative to cable and DSL, is a standards-based broadband wireless access technology for enabling the last-mile delivery of information. WiMAX will provide fixed, nomadic, portable and, eventually, mobile wireless broadband connectivity without the need for direct line-of-sight connection between a base station and a subscriber station. In a typical cell radius deployment of 3 to 10 Km, WiMAX-certified systems can be expected to support capacity of up to 40 Mbps per channel, for fixed and portable access applications. This is enough bandwidth to simultaneously support hundreds of businesses with T-1 speed connectivity and thousands of residences with DSL speed connectivity. Mobile network deployments are expected to provide up to 15 Mbps of capacity within a typical cell-radius deployment of up to 3 Km. It is expected that WiMAX technology will be incorporated in notebook computers and PDAs starting as early as the end of 2006, enabling urban areas and cities to become MetroZones for portable outdoor broadband wireless access. WiMAX technology has the potential to enable service carriers to converge the all-IP-based network for triple-play services such as data, voice, and video.

The IEEE 802.16 standard originally specified an operating frequency band from 10 to 66 GHz. The 802.16-2004 supports fixed broadband wireless access for both licensed and unlicensed spectra in the 2-to-11-GHz range. The 802.16e-2005 addresses mobile broadband wireless access.

In addition to supporting the 2-to-11-GHz frequency range, the 802.16-2004 standard supports three physical layers (PHYs). The mandatory PHY mode is 256-point FFT Orthogonal Frequency Division Multiplexing (OFDM). The other two PHY modes are Single Carrier (SC) and 2048 Orthogonal Frequency Division Multiple Access (OFDMA) modes. The corresponding European standard, the ETSI HiperMAN standard, defines a single PHY mode identical to the 256 OFDM mode in the 802.16-2004 standard.

Because the goal of WiMAX is to promote the interoperability of equipment based on either the 802.16-2004 or HiperMAN standards, the forum has chosen to support the 256 OFDM mode exclusively. To ensure worldwide interoperability, the WiMAX Forum will only certify equipment supporting that particular PHY mode.

WiFi 802.11a and 802.11g also use OFDM and have established an excellent performance record for robust wireless networking. However, WiFi uses 64 OFDM. The number before OFDM refers to the number of carriers that can be used in the overall modulation scheme. The much greater number of carriers for WiMAX helps achieve greater range because a receiver using 256 OFDM can tolerate delay spreads up to 10 times greater than systems using 64 OFDM. Also, 256 OFDM provides good non-line-of-sight capability.

This Mobile WiMAX WDL supports WirelessMAN-OFDMA PHY in both IEEE Std 802.16-2004 and IEEE Std 802.16e-2005.

Major specifications for the WirelessMAN-OFDMA PHY physical layer are listed in the following table.

WirelessMAN-OFDMA PHY Physical Layer Major Specifications

Specification	**Settings**
Information data rate	up to 70 Mbps at 20 MHz bandwidth
Modulation	BPSK, QPSK, 16-QAM, 64-QAM
Error correcting code	CC, CTC, BTC
Coding rate	1/2, 2/3, 3/4
N_{FFT}	2048, 1024, 512
Number of data subcarriers	variable
Number of pilot subcarriers	variable
Number of total subcarriers used	variable
Number of lower frequency guard subcarriers	variable
Number of higher frequency guard subcarriers	variable
n:Sampling factor	For channel bandwidths that are a multiple of 1.75 MHz, then n = 8/7 then n = 8/7 else for channel bandwidths that are a multiple of 1.5 MHz, then n = 28/25 else for channel bandwidths that are a multiple of 1.25 MHz, then n = 28/25 else for channel bandwidths that are a multiple of 2.75 MHz, then n = 28/25 else for channel bandwidths that are a multiple of 2.0 MHz, then n = 28/25 else for channel bandwidths not otherwise specified, then n = 8/7
G: Ratio of CP time to "useful" time	1/4, 1/8, 1/16, 1/32
BW: Nominal channel bandwidth	From 1.5 MHz to 28 MHz
F_s	$floor((n \cdot BW)/8000) \times 8000$
Δf	F_s/N_{FFT}
Tb: Useful symbol time	$1/(\Delta f)$
Tg: CP time	$G \cdot T_b$
Ts: OFDM symbol time	$T_b + T_g$

Mobile WiMAX Signal Sources Overview

In the ADS Mobile WiMAX wireless design library, four downlink and four uplink RF sources are developed. In downlink, two are for SISO (Single Input Single Output) with single transmit antenna and one for STC/MIMO with two transmit antennas. In uplink, two are for SISO (Single Input Single Output) with single transmit antenna, one for STC/MIMO with two transmit antennas and one for collaborative MIMO (SM) with one transmit antenna. The following table lists the features and the recommendation of usage for each source.

Feature and Recommendation for RF Sources

	RF Sources	**Features and Recommendations**
Downlink		
	WMAN_M_DL_SignalSrc_RF	**Feature:** 1. Basic DL/UL MAP for single antenna supported 2. DL PUSC, FUSC, OFUSC and AMC supported **Recommendation:** This source is recommended for general Tx and Rx measurements
	WMAN_M_DL_Src_Ranging_RF	**Feature:** 1. Advanced DL/UL MAP supported with full IEs (excluding IEs for STC/MIMO) 2. Compressed DL/UL MAP supported 3. DL PUSC, FUSC, OFUSC and AMC supported **Recommendation:** This source can be used for generating downlink signals with full broadcast messages (DL MAP, UL MAP, Compressed DL/UL MAP, etc.)
	WMAN_M_DL_Src_AllCoded_RF	**Feature:** 1. All the bursts are encoded with CC or CTC 2. DL/UL MAP supported with full IEs (excluding IEs for STC/MIMO) 3. The allocations for DL-MAP and UL-MAP bursts are flexible; DCD and UCD messages in DL-MAP burst can be enabled or disabled respectively. 4. DL PUSC, FUSC, OFUSC and AMC supported **Recommendation:** This source is highly recommended for generating downlink signals with flexible broadcast messages (DL MAP, UL MAP, etc.)
	WMAN_M_DL_Src_FDD_RF	**Feature:** 1. Downlink FDD frame structure with two subframes (DL1 and DL2) 2. Basic DL/UL MAP for single antenna supported 3. DL PUSC, FUSC, OFUSC and AMC supported 4. Two RF sources are needed for one complete downlink FDD frame **Recommendation:** This source is for generating downlink FDD frame signals
	WMAN_M_DL_2Ant_Src_RF	**Feature:** 1. STC 2x1 and MIMO 2x2 supported with two transmit antennas 2. Advanced DL/UL MAP supported with full IEs (including IEs for STC/MIMO) 3. Compressed DL/UL MAP supported 4. DL STC zone with PUSC, FUSC and AMC supported 5. Midamble supported. **Recommendation:** This source is recommended for general STC/MIMO Tx and Rx measurements and for generating downlink STC/MIMO signals with full broadcast messages (DL MAP, UL MAP, Compressed DL/UL MAP, etc.)
Uplink		
	WMAN_M_UL_SignalSrc_RF	**Feature:** 1. Basic UL signal source 2. UL PUSC, OPUSC and AMC supported **Recommendation:** This source is recommended for general Tx and Rx measurements
	WMAN_M_UL_Src_Ranging_RF	**Feature:** 1. Advanced UL signal source supported with three rectangular bursts: ranging, fast feedback (FFB), HARQ-ACK 2. Flexible configurations for these bursts 3. UL PUSC and OPUSC supported **Recommendation:** This source is recommended for generating uplink signals with rectangular allocations
	WMAN_M_UL_2Ant_Src_RF	**Feature:** 1. STC 2x1 and MIMO 2x2 supported with two transmit antennas 2. UL PUSC supported **Recommendation:** This source is recommended for general STC/MIMO Tx and Rx measurements and for generating uplink STC/MIMO signals.
	WMAN_M_UL_Ant1_Co_Src_RF	**Feature:** 1. Two-user collaborative MIMO (SM) 1x2 supported with one transmit antenna 2. UL PUSC supported **Recommendation:** This source is recommended for general collaborative MIMO (SM) Tx and Rx measurements and for generating uplink collaborative MIMO (SM) signals.

Mobile WiMAX MIMO Overview

ADS Mobile WiMAX wireless design library supports a full range of smart antenna technologies to enhance system performance. The smart antenna technologies supported include:

- Space-Time Code (STC): Transmit diversity such as Alamouti code is supported to provide spatial diversity and reduce fade margin.
- Spatial Multiplexing (SM, also known as MIMO): With spatial multiplexing, multiple streams are transmitted over multiple antennas. With 2x2 MIMO, SM increases the peak data rate two-fold by transmitting two data streams. Two data stream multiplexing method are addressed in 802.16e-2005: horizontal encoding and vertical encoding. Only vertical encoding is supported in ADS Mobile WiMAX wireless design library following WiMAX Forum Mobile System Profile Release-1. In UL, each user has only one transmit antenna, two users can transmit collaboratively in the same slot as if two streams are spatially multiplexed from two antennas of the same user. This is called UL collaborative SM.

ADS Mobile WiMAX MIMO systems fully support MIMO options (IO-MIMO) defined in Mobile System Profile Release-1, and support more features, such as UL MIMO 2x2 and etc. (see *ADS Supportability for MIMO Options* (wman_m)).

ADS Supportability for MIMO Options

Options	Operation Modes	Reference in 802.16e-2005	WiMAX Forum Status	ADS Library Supported
1	DL MIMO (SM) 2x2 for DL PUSC	8.4.8.1.4	BS:IO-MIMO MS:M	Y
2	DL MIMO (SM) 2x2 for DL FUSC	8.4.8.1.4	O	Y
3	DL STC 2x1 for DL PUSC	8.4.8.1.2.1.1 8.4.8.1.4	BS:IO-MIMO MS:M	Y
4	DL STC 2x1 for DL FUSC	8.4.8.1.2.1.2 8.4.8.1.4	O	Y
5	UL Collaborative SM 1X2 for UL PUSC	8.4.8.1.5	BS:IO-MIMO MS:M	Y
6	UL MIMO (SM) 2x2 for UL PUSC	8.4.8.1.5	O	Y
7	UL STC 2x1 for UL PUSC	8.4.8.1.5	O	Y (src only)
IO-MIMO: Group of Inter-operable Option features related to MIMO operation. O: optional. M: mandatory				

The following table lists all kinds of combinations of signal sources and receivers for supported operation modes in the library.

ADS MIMO Operation Modes

Operation modes	RF Source	RF Receiver
DL MIMO (SM) 2x2 for DL PUSC, FUSC	RF Source: WMAN_M_DL_2Ant_Src_RF Key Parameters: ZoneType = PUSC/FUSC STC_Matrix = Matrix_B	RF Receiver: WMAN_M_DL_MIMO_Ant2_Rx_RF Key Parameters: ZoneType = PUSC/FUSC DecoderType = Hard/Soft/CSI STCDecoder = ZF/MMSE
DL STC 2x1 for DL PUSC, FUSC	RF Source: WMAN_M_DL_2Ant_Src_RF Key Parameters: ZoneType = PUSC/FUSC STC_Matrix = Matrix_A	RF Receiver: WMAN_M_DL_STC_Ant1_Rx_RF Key Parameters: ZoneType = PUSC/FUSC DecoderType = Hard/Soft/CSI
UL Collaborative SM 1X2 for UL PUSC (Two users with single transmit antenna)	RF Source: WMAN_M_UL_Ant1_Co_Src_RF Key Parameters: ZoneType = PUSC TilePattern = Pattern_A/Pattern_B	RF Receiver: WMAN_M_UL_MIMO_Ant2_Rx_RF Key Parameters: ZoneType = PUSC DecoderType = Hard/Soft/CSI STCDecoder = ZF/MMSE Collaborative = YES TilePattern = Pattern_A/Pattern_B
UL MIMO (SM) 2x2 for UL PUSC	RF Source: WMAN_M_UL_2Ant_Src_RF Key Parameters: ZoneType = PUSC STC_Matrix = Matrix_B	RF Receiver: WMAN_M_UL_MIMO_Ant2_Rx_RF Key Parameters: ZoneType = PUSC DecoderType = Hard/Soft/CSI STCDecoder = ZF/MMSE Collaborative = NO
UL STC 2x1 for UL PUSC	RF Source: WMAN_M_UL_2Ant_Src_RF Key Parameters: ZoneType = PUSC STC_Matrix = Matrix_A	N/A N/A

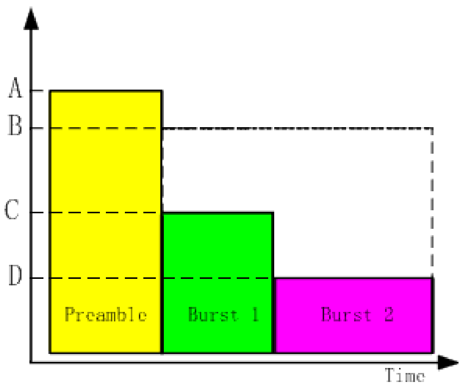
Transmit Power Definition

In Mobile WiMAX, currently there is no unified method for the definition of transmit power. Several transmit power definitions are provided in downlink and uplink.

Downlink

Three different downlink power definitions are provided in Mobile WiMAX wireless design library to meet with different requirements:

- Type I: Peak power.
- Type II: Burst power when all subchs occupied.
- Type III: Burst power with allocated subchs.



Downlink power definitions

The previous figure shows a simple downlink subframe example where the first verticle bar on the left is the preamble, and the second is Burst#1, followed by Burst#2. Three types of power points can be obtained from this figure:

- Power A: the preamble power.
- Power B: the burst power when all of the subchannels are allocated to the burst, ignoring data and pilot boosting. The power is about 4.2dB less than Power A.
- Power C/D: the burst power with the allocated subchannels, including data and pilot boosting.

Note that the power mentioned here is the average power measured in the preamble or in one OFDM data symbol.

In all downlink RF sources, a parameter Power defines transmit signal power. The exact meaning of the parameter Power is determined by the parameter PowerType.

- PowerType is Peak power.
  The Power refers to the maximum power measured in the preamble and in each OFDM data symbol. In *Downlink power definitions* (wman_m), the Power refers to Power A (preamble power). Sometimes when the data is boosted by a large scale, the OFDM data symbol power may be greater than the preamble power, then the Power refers to that OFDM data symbol power.
  This power definition is recommended for transmitter measurement.

- PowerType is Burst power when all subchs are occupied.
  The Power refers to Power B. In this power definition, it is convenient to calculate the transmit power per each subcarrier. For the ith subcarrier, the transmit power is:
  $$PowerPerSubcarr[i] = \frac{Power \times BoostingOffset[i]}{N_{used}}$$
  Where,

N_{used}
is the used subcarriers (e.g. 840 for FFT1024, PUSC).
BoostingOffset[i] is the data or pilot boosting offset. For pilot boosting, the offset is 2.5 dB (16/9) in downlink. For data boosting, the offset is defined in the parameter PowerBoosting.
The actual output power is

$$OutputPower = \sum_{i=1}^{N_{used}} \frac{Power \times BoostingOffset[i] \times Active[i]}{N_{used}}$$

Active[i] is the indication whether this subcarrier is active (1 for active and 0 for inactive).
For example, assuming FFT1024, PUSC, Power=10dBm, two bursts are allocated as shown in the figure above. Burst#1 occupies 20 subchannels, Burst#2 occupies 10 suchannels, no data boosting, then the output power at Burst#1 and Burst#2 are:

P1 = 10*log10(0.01*(20*24+120*16/9)/840) = 9.16dBm

P2 = 10*log10(0.01*(10*24+120*16/9)/840) = 7.32dBm

Where,

0.01 is the power set in the source (10dBm)

840 is the number of useful subcarriers when FFT size is 1024

*20*24 (10*24)* : 24 is the number of data subcarriers in one symbol for one subchannel in DL PUSC

120 is the number of pilot subcarriers in one symbol. These pilot subcarriers always transmit regardless of the number of subchannels allocated.

16/9 is the power boosting in pilot subcarriers comparing with the non-boosting data subcarriers

Note that the two bursts in the example above are not overlapped in the time domain, and the pilots always transmit regardless of burst allocation, so the power of pilots are counted in P1 and P2 respectively. If the bursts are allocated in the same OFDM symbols, the power of pilots should be counted only one time.
This power definition is recommended for receiver measurement.

- PowerType is Burst power with allocated subchs
  The Power refers to Power C/D. The Power is the actual burst output power considering data and pilot boosting. Note that in this power type, only one burst is allowed to allocate in the downlink subframe.
  This power definition is recommended for hardware measurement.

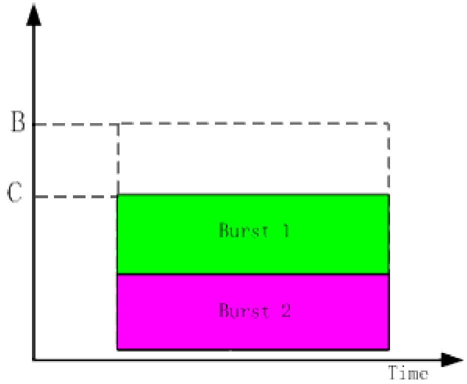
In the workspace of WMAN_16e_OFDMA_Tx_wrk, WMAN_OFDMA_DL_TxWaveform is provided to measure transmit power level for different power types.

Uplink

Two different uplink power definitions are provided in Mobile WiMAX wireless design library to meet with different requirements:

- Type I: Peak power.
- Type II: Burst power when all subchs occupied.

Compared with the downlink power definitions, there are only two types defined in the uplink subframe. Type I and Type III defined in downlink subframe is identical for uplink subframe which are merged into Type I (Peak power) in uplink subframe.



Uplink power definitions

The previous figure shows a simple uplink subframe example where the first is Burst#1, and Burst#2 follows Burst#1 concurrently. Two types of power points can be obtained from this figure:

- Power B: the burst power when all the subchannels are allocated to the burst, ignoring data and pilot boosting.
- Power C: the burst power with the allocated subchannels, including data and pilot boosting.

Note that the power mentioned here is the average power measured in one OFDM data symbol.
In all uplink RF sources, a parameter Power defines transmit signal power. The exact meaning of the parameter Power is determined by the parameter PowerType.

- PowerType is Peak power.
  The Power refers to the maximum power measured in each OFDM data symbol. In the figure above, the Power refers to Power C.
  This power definition is recommended for transmitter measurement.

- PowerType is Burst power when all subchs are occupied.
  The Power refers to Power B. In this power definition, it is convenient to calculate the transmit power per each subcarrier. For the ith subcarrier, the transmit power is:
  $$PowerPerSubcarr[i] = \frac{Power \times BoostingOffset[i]}{N_{used}}$$
  Where,
  N_{used}
  is the used subcarriers (e.g. 840 for FFT1024, UL PUSC).
  BoostingOffset[i] is the data or pilot boosting offset. For pilot boosting, the offset is 0 dB for UL PUSC; For data boosting, the offset is defined in the parameter PowerOffset.
  The actual output power is
  $$OutputPower = \sum_{i=1}^{N_{used}} \frac{Power \times BoostingOffset[i] \times Active[i]}{N_{used}}$$
  Active[i] is the indication whether this subcarrier is active (1 for active and 0 for inactive).
  For example, assuming FFT1024, UL PUSC, Power=10dBm, two bursts are allocated as shown in the figure above. Burst#1 occupies 12 subchannels, Burst#2 occupies 13 suchannels, no data boosting, then the output power at data zone (including Burst#1 and Burst#2) is:

  P = 10*log10(0.01*(12*6*4+13*6*4)/840) = 8.54dBm

  0.01 is the power set in the source (10dBm)

  840 is the number of useful subcarriers when FFT size is 1024

  *12*6*4 (13*6*4)* : 6 is the number of tile in each subchannel; 4 is the number of data and pilot subcarriers per OFDM symbol per tile for UL PUSC.

This power definition is recommended for receiver measurement.

HARQ Transmissions

HARQ (Hybrid ARQ), a fast retransmission scheme, uses Chase Combining (CC) or Incremental Redundancy (IR) for transmitting the coded data packets. In this version, only the chase combining scheme is implemented.
In both downlink and uplink, the bursts can be assigend as HARQ bursts. Bursts transmitted using Chase HARQ shall include CRC of 16 bits which is used for error detection and for ACK/NACK transmission. The CRC is appended to MAC data
after padding (before partitioning to FEC blocks and encoding). Padding is done so that the total length after CRC concatenation matches the size of the burst indicated by the map. The CRC shall be CRC16-CCITT, as defined in ITU-T Recommendation X.25, and it is calculated over all
the bits in the burst, including data and padding. The concatenation of HARQ packets in ADS Mobile WiMAX library is shown in the following figure.

MAC Header (6 Bytes)	MAC PDU (*DataLength* Bytes)	MAC CRC (4 Bytes)	Padding (Optional) (0xFF)	HARQ CRC (2 Bytes)

HARQ packet CRC encoding

Note the following restriction is applied in ADS on HARQ bursts:

- Only the downlink and uplink sources which have the parameter HARQ_Enable can support HARQ bursts; all receivers cannot support HARQ decoding currently
- Each HARQ burst contains only one sub-burst.
- In DL-MAP, the MAP IE for HARQ bursts is the same as normal downlink bursts, instead of HARQ DL MAP IE.
- In UL-MAP, the MAP IE for HARQ bursts is the same as normal uplink bursts, instead of HARQ UL MAP IE.

Component Libraries Overview

The mobile WiMAX (802.16e OFDMA) wireless design library is organized by library according to the types of behavioral models and subnetworks.

Channel Coding Components

The 16e channel coding models provide channel coding and scrambling in the transmitter end, and channel decoding in the receiving end.

- WMAN_M_CRC_Coder: CRC generator
- WMAN_M_DL_CC: Downlink CC encoder
- WMAN_M_DL_CC_Decoder: Downlink CC decoder
- WMAN_M_DL_CTC: Downlink CTC encoder
- WMAN_M_DL_CTC_Decoder: Downlink CTC decoder
- WMAN_M_DL_Deinterleaver: Downlink de-interleaver
- WMAN_M_DL_Derandomizer: Downlink de-randomizer
- WMAN_M_DL_Derepetition: Downlink de-repetiter
- WMAN_M_DL_FEC: Downlink FEC encoder
- WMAN_M_DL_FECDecoder: Downlink FEC decoder
- WMAN_M_DL_Interleaver: Downlink interleaver
- WMAN_M_DL_Randomizer: Downlink randomizer
- WMAN_M_DL_Repetition: Downlink repetiter
- WMAN_M_DL_SubcarrRandomizer: Downlink subcarrier randomizer
- WMAN_M_Puncturer: Puncturer and de-puncturer
- WMAN_M_UL_CC: Uplink CC encoder
- WMAN_M_UL_CC_Decoder: Uplink CC decoder
- WMAN_M_UL_CTC: Uplink CTC encoder
- WMAN_M_UL_CTC_Decoder: Uplink CTC decoder
- WMAN_M_UL_Deinterleaver: Uplink de-interleaver
- WMAN_M_UL_Derandomizer: Uplink de-randomizer
- WMAN_M_UL_Derepetition: Uplink de-repetiter
- WMAN_M_UL_FEC: Uplink FEC encoder
- WMAN_M_UL_FECDecoder: Uplink FEC decoder
- WMAN_M_UL_Interleaver: Uplink interleaver
- WMAN_M_UL_Randomizer: Uplink randomizer
- WMAN_M_UL_Repetition: Uplink repetiter
- WMAN_M_UL_SubcarrRandomizer: Uplink subcarrier randomizer
- WMAN_M_ViterbiDecoder: Viterbi decoder

Channel Model Components

The 16e channel models provide fixed WiMAX channel model (SUI channel model), ITU 1225 model and WiMAX MIMO model.

- WMAN_M_Channel_ITU: ITU channel model
- WMAN_M_Channel_MIMO: WiMAX MIMO channel model
- WMAN_M_Channel_SUI: FWA Channel model

Measurement Components

The 16e measurement models provide basic measurements (such as EVM, CCDF and etc.).

- WMAN_M_DL_Constellation_RF: Downlink constellation measurement
- WMAN_M_DL_EVM: Downlink EVM (RCE) measurement
- WMAN_M_DL_RF_CCDF: Downlink CCDF measurement

- WMAN_M_DL_SpecFlat: Downlink spectral flatness measurement
- WMAN_M_UL_Constellation_RF: Uplink constellation measurement
- WMAN_M_UL_EVM: Uplink EVM (RCE) measurement
- WMAN_M_UL_RF_CCDF: Uplink CCDF measurement
- WMAN_M_UL_SpecFlat: Uplink spectral flatness measurement

MIMO Measurement Components

The 16e MIMO measurement models provide basic MIMO measurements (such as CCDF and etc.).

- WMAN_M_DL_MIMO_RF_CCDF: Downlink MIMO CCDF measurement
- WMAN_M_UL_MIMO_RF_CCDF: Uplink MIMO CCDF measurement

MIMO Receiver Components

The 16e MIMO receiver models provide channel estimator, frame synchronization and frequency synchronization, top level baseband receivers and top level RF receivers.

- WMAN_M_DL_DemuxOFDMSym_M: Downlink OFDM symbol demultiplexer with matrix
- WMAN_M_DL_MIMO_Ant2_Rx: Downlink baseband receiver for 2x2 MIMO
- WMAN_M_DL_MIMO_Ant2_Rx_RF: Downlink RF receiver for 2x2 MIMO
- WMAN_M_DL_MIMO_Ant2_Sync: Downlink timing and frequency synchronization for STC and MIMO
- WMAN_M_DL_MIMO_ChEstimator: Downlink channel estimator for STC and MIMO
- WMAN_M_DL_MIMO_DemuxFrame: Downlink frame demultiplexer for STC and MIMO
- WMAN_M_DL_STC_Ant1_Rx: Downlink baseband receiver for 2x1 STC
- WMAN_M_DL_STC_Ant1_Rx_RF: Downlink RF receiver for 2x1 STC
- WMAN_M_DL_STCDecoder: Downlink STC decoder
- WMAN_M_MIMO_CSI_Gen: CSI generator for STC and MIMO
- WMAN_M_OFDM_Demodulator: OFDM symbols demodulator
- WMAN_M_UL_DemuxOFDMSym_M: Uplink OFDM symbol demultiplexer with matrix
- WMAN_M_UL_MIMO_Ant2_Rx: Uplink baseband receiver for 2x2 MIMO
- WMAN_M_UL_MIMO_Ant2_Rx_RF: Uplink RF receiver for 2x2 MIMO
- WMAN_M_UL_MIMO_ChEstimator: Uplink channel estimator for STC and MIMO
- WMAN_M_UL_MIMO_DemuxFrame: Uplink frame demultiplexer for STC and MIMO
- WMAN_M_UL_STCDecoder: Uplink STC decoder

MIMO Source Components

The 16e MIMO signal source models provide models to generate downlink and uplink signal sources.

- WMAN_M_DL_2Ant_Src: Downlink baseband signal source with 2 antennas
- WMAN_M_DL_2Ant_Src_RF: Downlink RF signal source with 2 antennas
- WMAN_M_DL_MuxOFDMSym_M: Downlink OFDM symbol multiplexer with Matrix
- WMAN_M_DL_STCEncoder: Downlink STC encoder
- WMAN_M_MidambleGen: MIMO Midamble generator
- WMAN_M_UL_2Ant_Src: Uplink baseband signal source with 2 antennas
- WMAN_M_UL_2Ant_Src_RF: Uplink RF signal source with 2 antennas
- WMAN_M_UL_Ant1_Co_Src: Uplink collaborative baseband signal source
- WMAN_M_UL_Ant1_Co_Src_RF: Uplink collaborative RF signal source
- WMAN_M_UL_MuxOFDMSym_M: Uplink OFDM symbol multiplexer with matrix
- WMAN_M_UL_STCEncoder: Uplink STC encoder

Multiplex Components

The 16e multiplex models provide framing and de-framing in 802.16e OFDMA transceiver.

- WMAN_M_Commutator: Data commutator
- WMAN_M_Distributor: Data distributor
- WMAN_M_DL_BurstWoFEC: Downlink bursts generator without FEC
- WMAN_M_DL_DemuxBurst: Downlink bursts demultiplexer
- WMAN_M_DL_DemuxFrame: Downlink frame demultiplexer
- WMAN_M_DL_DemuxOFDMSym: Downlink OFDM symbol demultiplexer
- WMAN_M_DL_MuxBurst: Downlink bursts multiplexer
- WMAN_M_DL_MuxOFDMSym: Downlink OFDM symbol multiplexer
- WMAN_M_UL_BurstWoFEC: Uplink bursts generator without FEC
- WMAN_M_UL_DemuxBurst: Uplink bursts demultiplexer
- WMAN_M_UL_DemuxFrame: Uplink frame demultiplexer
- WMAN_M_UL_DemuxOFDMSym: Uplink OFDM symbol demultiplexer
- WMAN_M_UL_MuxBurst: Uplink bursts multiplexer
- WMAN_M_UL_MuxOFDMSym: Uplink OFDM symbol multiplexer

Receiver Components

The 16e receiver models provide channel estimator, frame synchronization and frequency synchronization, top level baseband receivers and top level RF receivers.

- WMAN_M_DL_ChEstimator: Downlink channel estimator
- WMAN_M_DL_Demapper: Downlink soft demapper
- WMAN_M_DL_FrameSync: Downlink frame synchronizer
- WMAN_M_DL_FreqSync: Downlink frequency synchronizer
- WMAN_M_DL_Receiver: Downlink baseband receiver
- WMAN_M_DL_Receiver_RF: Downlink RF receiver
- WMAN_M_UL_ChEstimator: Uplink channel estimator
- WMAN_M_UL_Demapper: Uplink soft demapper
- WMAN_M_UL_FrameSync: Uplink frame synchronizer
- WMAN_M_UL_FreqSync: Uplink frequency synchronizer
- WMAN_M_UL_FreqSyncFraction: Uplink fraction frequency synchronizer
- WMAN_M_UL_FreqSyncInteger: Uplink integer frequency synchronizer
- WMAN_M_UL_Receiver: Uplink baseband receiver
- WMAN_M_UL_Receiver_RF: Uplink RF receiver

Signal Source Components

The 16e signal source models provide models to generate downlink and uplink signal sources.

- WMAN_M_Brdcst_Msg: Broadcast messages
- WMAN_M_CDD: CDD (cyclic delay diversity) implementation with one logical antenna in and two physical antennas out
- WMAN_M_Compressed_DL_UL_MAP: Compressed downlink and uplink MAP
- WMAN_M_DCD: DCD generator
- WMAN_M_DLFP: Downlink frame prefix generator
- WMAN_M_DL_MAP: DL-MAP generator
- WMAN_M_DL_PowerAdjust: Downlink power adjustment
- WMAN_M_DL_SignalSrc: Downlink baseband signal source
- WMAN_M_DL_SignalSrc_RF: Downlink RF signal source
- WMAN_M_DL_Src_AllCoded: Downlink signal src with all coded bursts
- WMAN_M_DL_Src_AllCoded_RF: Downlink RF signal source with all coded bursts
- WMAN_M_DL_Src_FDD: Downlink FDD signal src
- WMAN_M_DL_Src_FDD_RF: Downlink FDD RF signal source
- WMAN_M_DL_Src_Ranging: Downlink baseband signal source with ranging
- WMAN_M_DL_Src_Ranging_RF: Downlink RF signal source with ranging
- WMAN_M_DL_ZonePerm: Downlink subchannel subcarrier allocator
- WMAN_M_DataPattern: Data pattern
- WMAN_M_MACHeader: MAC header generator
- WMAN_M_MACPDU: MAC PDU generator

- WMAN_M_OFDM_Modulator: OFDM symbols modulator
- WMAN_M_OFDM_Modulator_CDD: OFDM symbol modulator with CDD (cyclic delay diversity) implementation
- WMAN_M_Preamble: Preamble generator
- WMAN_M_SymWindow: Symbol transition windowing
- WMAN_M_UCD: UCD generator
- WMAN_M_UL_ACK: Uplink ACK channel generator
- WMAN_M_UL_FFB: Uplink fast feedback generator
- WMAN_M_UL_MAP: UL-MAP generator
- WMAN_M_UL_PowerAdjust: Uplink power adjustment
- WMAN_M_UL_Ranging: Uplink ranging codes generator
- WMAN_M_UL_RangingGuard: Uplink ranging guard insertor
- WMAN_M_UL_SignalSrc: Uplink baseband signal source
- WMAN_M_UL_SignalSrc_RF: Uplink RF signal source
- WMAN_M_UL_Src_Ranging: Uplink baseband signal source with ranging
- WMAN_M_UL_Src_Ranging_RF: Uplink RF signal source with ranging
- WMAN_M_UL_ZonePerm: Uplink subchannel subcarrier allocator
- WMAN_M_UL_ZonePerm_Rect: Uplink subchannel subcarrier allocator with rectangular allocation
- WMAN_M_ULMAP_Full: Uplink map with full information elements (IEs)

Design Examples and Test Benches

The Mobile WiMAX wireless design library provides design examples and test benches of WirelessMAN-OFDMA PHY transmitter and receiver. Six workspaces are provided in this mobile WiMAX wireless design library,

- WMAN_16e_OFDMA_Tx_wrk
- WMAN_16e_OFDMA_Rx_wrk
- Mobile_WiMAX_MIMO_Tx_wrk
- Mobile_WiMAX_MIMO_Rx_wrk
- WMAN_WiBro_wrk
- WMAN_16e_OFDMA_RF_Verification_wrk

WMAN_16e_OFDMA_Tx_wrk

This library provides transmitter test benches of 802.16e OFDMA WirelessMAN-OFDMA PHY system. The transmitter measurements are EVM, constellation, spectrum mask and CCDF and etc.

- WMAN_OFDMA_DL_VSA: connect with VSA 89600 software and show the results of VSA 89600 software
- WMAN_OFDMA_DL_TxEVM: measure downlink EVM (or RCE) and show the demodulated constellation
- WMAN_OFDMA_DL_TxEVM_PhaseNoise: measure downlink EVM (or RCE) and show the demodulated constellation in phase noise environment
- WMAN_OFDMA_DL_TxWaveform: measure downlink transmitter CCDF and waveform
- WMAN_OFDMA_DL_TxSpectrum: measure downlink transmitter spectrum
- WMAN_OFDMA_DL_TxSpecFlat: measure downlink transmitter spectral flatness
- WMAN_OFDMA_DL_FDD_TxWaveform: measure downlink FDD transmitter CCDF, waveform and spectrum
- WMAN_OFDMA_UL_VSA: connect with VSA 89600 software and show the results of VSA 89600 software
- WMAN_OFDMA_UL_TxEVM: measure uplink EVM (or RCE) and show the demodulated constellation
- WMAN_OFDMA_UL_TxSpectrum: measure spectrum mask
- WMAN_OFDMA_UL_Ranging_VSA:connect with VSA 89600 software and show the results of VSA 89600 software when uplink ranging is present
- WMAN_OFDMA_UL_TxSpecFlat: measure uplink transmitter spectral flatness

For more information, refer to *Mobile WiMAX Transmitter Design Examples* (wman_m).

WMAN_16e_OFDMA_Rx_wrk

This library provides receiver test benches of 802.16e OFDMA WirelessMAN-OFDMA PHY system. The receiver measurements are sensitivity, PER on fading channel and etc.

- WMAN_OFDMA_DL_Fading_BER: measure downlink BER/PER in ITU fading environment
- WMAN_OFDMA_DL_RxSensitivity: measure downlink receiver minimum input level sensitivity
- WMAN_OFDMA_DL_RxAdjCh: measure downlink adjacent and alternate channel rejection
- WMAN_OFDMA_UL_AWGN_BER: measure uplink BER/PER in AWGN channel
  For more information, refer to *Mobile WiMAX Receiver Design Examples* (wman_m).

Mobile_WiMAX_MIMO_Tx_wrk

This library provides transmitter test benches of Mobile WiMAX MIMO system. The measurements are EVM, constellation and etc.

- WMAN_M_DL_TxConstellation: measure downlink MIMO EVM (or RCE) and show the demodulated constellation
- WMAN_OFDMA_DL_MIMO_Waveform: measure downlink MIMO transmitter CCDF and waveform
- WMAN_OFDMA_UL_MIMO_Waveform: measure uplink MIMO transmitter CCDF and waveform

For more information, refer to *Mobile WiMAX MIMO Transmitter Design Examples* (wman_m).

Mobile_WiMAX_MIMO_Rx_wrk

This library provides receiver test benches of Mobile WiMAX MIMO systems. The receiver measurements are BER/PER on fading channel and etc.

- WMAN_OFDMA_DL_MIMO_Fading_BER: measure downlink MIMO 2x2 BER/PER in 2x2 ITU fading environment
- WMAN_OFDMA_DL_STC_Fading_BER: measure downlink STC 2x1 BER/PER in 2x1 ITU fading environment
- WMAN_OFDMA_UL_MIMO_Fading_BER: measure uplink two-user collaborative SM BER/PER in 2x2 ITU fading environment

For more information, refer to *Mobile WiMAX MIMO Receiver Design Examples* (wman_m).

WMAN_WiBro_Tx_wrk

This library provides transmitter and receiver test benches for the Korean WiBro system. The measurements are EVM, constellation and BER and etc.

- WiBro_DL_AWGN_BER: measure downlink BER/PER in AWGN channel
- WiBro_DL_TxEVM: measure downlink EVM (or RCE) and show the demodulated constellation
- WiBro_UL_TxEVM: measure uplink EVM (or RCE) and show the demodulated constellation
- WiBro_UL_VSA: connect with VSA 89600 software to analyze uplink transmitter and show the results of VSA 89600 software

For more information, refer to *WiBro Design Examples* (wman_m).

WMAN_16e_OFDMA_RF_Verification_wrk

This library provides transmitter and receiver WTB of 802.16e OFDMA WirelessMAN-OFDMA PHY system. The measurements are EVM, constellation, BER and etc.

- WMAN_DL_802_16e_TX_test: measure downlink transmitter performances, such as EVM (or RCE), constellation, waveform and etc.
- WMAN_UL_802_16e_TX_test: measure uplink transmitter performances, such as EVM (or RCE), constellation, waveform and etc.
- WMAN_DL_802_16e_RX_Sensitivity_test: measure downlink receiver sensitivity
- WMAN_UL_802_16e_RX_Sensitivity_test: measure uplink receiver sensitivity
- WMAN_DL_802_16e_RF_PAE_test: measure downlink transmitter power added efficiency (PAE)
- WMAN_UL_802_16e_RF_PAE_test: measure uplink transmitter power added efficiency (PAE)

For more information, refer to the ADS *Mobile WiMAX Wireless Test Benches* documentation.

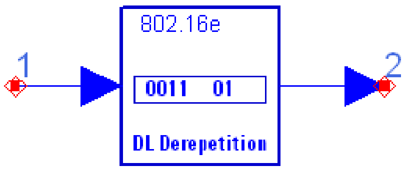
Glossary of Terms

AWGN	addition white Gaussian noise
CCDF	complementary cumulative distribution function
CP	cyclic prefix
CSMA/CA	carrier sense multiple access/collision avoidance
DL	downlink
EVM	error vector magnitude
FEC	forward error correction
FFT	fast fourier transform
IEEE	Institute of Electrical and Electronic Engineering
IFFT	inverse fast fourier transform
MAC	medium access control
MIMO	multiple input multiple output (Antenna)
OFDM	orthogonal frequency division multiplexing
OFDMA	orthogonal frequency division multiplexing access
PA	power amplifier
PER	packet error rate
PHY	physical layer
PLCP	physical layer convergence protocol
PSDU	PLCP service data unit
QPSK	quadrature phase shift keying
RCE	relative constellation error
RF	radio frequency
RX	receive or receiver
SDU	service data unit
SM	spatial multiplexing
STC	space time coding
TX	transmit or transmitter
UL	uplink
WiBro	wireless broadband (service)
WiMAX	worldwide interoperability for microwave access
WMAN	wireless metropolitan area networks
WDL	wireless design library

References

1. IEEE Std 802.16-2004, *Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY* , October 1, 2004.
2. IEEE Std 802.16e-2005, *Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY* , February 2006.
3. P802.16 Rev2/D4, April, 2008.

WMAN_M_DL_Derepetition (802.16e OFDMA DL Repeater Removal)



WMAN_M_DL_Derepetition

Description: Downlink repeater removal
Library: WMAN 16e, Channel Coding

Parameters

Name	Description	Default	Type	Range
ZoneType	Zone type: DL_PUSC, DL_FUSC, DL_OFUSC, DL_AMC	DL_PUSC	enum	
AMC_Mode	AMC mode: Mode_1X6, Mode_2X3, Mode_3X2	Mode_2X3	enum	
BurstNumOfSym	Number of symbols within burst	4	int	[1,1212]
BurstNumOfSubch	Number of subchannels within burst	1	int	[1,60]
CodingType	Coding type	0	int	[0,1]
Rate_ID	Rate ID	1	int	[0,7]
RepetitionCoding	Repetition coding	0	int	[0,3]
STC_Encoder	STC encoder or not: NO, YES	NO	enum	
STC_Matrix	STC matrix: Matrix_A, Matrix_B	Matrix_A	enum	

Pin Inputs

Pin	Name	Description	Signal Type
1	DataIn	input data	real

Pin Outputs

Pin	Name	Description	Signal Type
2	DataOut	output data	real

Notes/Equations

1. This model performs the reverse process of repetition on downlink burst.
2. Each firing,
   - $AssignedSlots \times STCRate \times UncodedSlotSize \times 8 / CodingRate$ tokens are consumed at pin DataIn, where

     AssignedSlots is the number of slots assigned to the burst,

     STCRate is the multiple due to STC encoding, which is dependent on STC_Encoder and STC_Matrix,

     UncodedSlotSize is the number of bytes within one slot before channel coding,

     CodingRate is coding rate.
   - $EffectiveSlots \times STCRate \times UncodedSlotSize \times 8 / CodingRate$ tokens are generated at pin DataOut, where

     EffectiveSlots is the number of slots actually used to transmit data before repetition coding, i.e. EffectiveSlots = floor (AssignedSlots / R), where

     R is repetition factor, which is 1, 2, 4 or 6 for QPSK and 1 for other modulation schemes.
3. In the case of repetition coding, R = 2, 4, or 6, AssignedSlots shall be in the range of $R \times EffectiveSlots$,

$R \times EffectiveSlots + (R-1)$. The output data are the average of the input data, which are repeated R times. This repetition scheme applies only to QPSK modulation; it can be applied in all coding schemes except H-ARQ with CTC.

References

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.