Application Note

LTE Downlink Signal
Multi-Antenna Transmitter Measurement

Timing Difference Between Four Antennas and PDSCH EVM of Each Antenna

MS2690A/MS2691A/MS2692A/MS2830A
Signal Analyzer

MG3710A
Vector Signal Generator

Introduction

This document explains how to output an LTE FDD/TDD downlink signal in a 4-antenna configuration from the vector signal generator and how to measure the timing difference between the antennas and the PDSCH EVM of each antenna using a signal analyzer.

The aim of this guide is to provide an understanding of the following items:

- How to simulate and operate one MG3710A Vector Signal Generator outputting signals as a base station with four antennas
- How to measure the timing difference between the four antennas and the PDSCH EVM of each antenna using the MS269xA Signal Analyzer

The target readers for this guide are engineers developing and evaluating LTE base stations.

The following diagram shows a simple model of the base station simulated by this demonstration. The base station has four antennas and performs MIMO transmissions using Tx diversity and spatial multiplexing functions. The signal output from each antenna has slight relative differences in timing due to the base station design and other environmental factors.

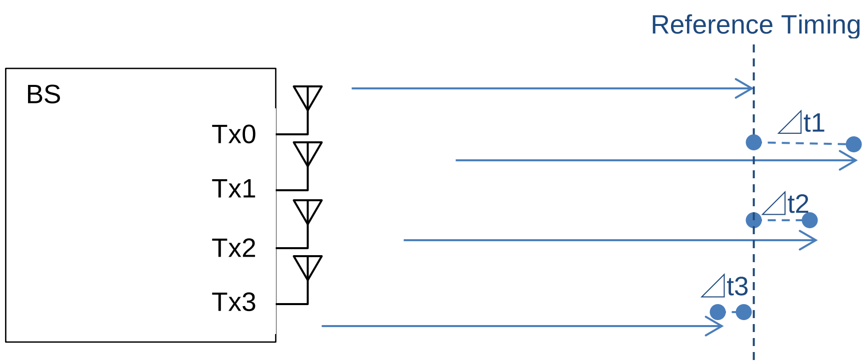

Fig. 1. Configuration of Base Station with Four Antennas

This demonstration outputs four simulated antenna signals from the MG3710A Vector Signal Generator with the baseband signal addition function installed for each of the two RF ports. The Tx0 and Tx1 signals are loaded into memory A and memory B, respectively, of the SG1 side and the Tx2 and Tx3 signals are loaded into memory A and memory B of the SG2 side.

The following figure shows the simple block diagram for the MG3710A Vector Signal Generator when simulating the base station in this demonstration. The Tx0 and Tx1, and Tx2 and Tx3 waveform patterns are added by digital processing. The baseband blocks and local signals are synchronized between SG1 and SG2 to output the Tx0, Tx1, Tx2, and Tx3 signals from the MG3710A Vector Signal Generator with fixed relative timings and timing offsets.

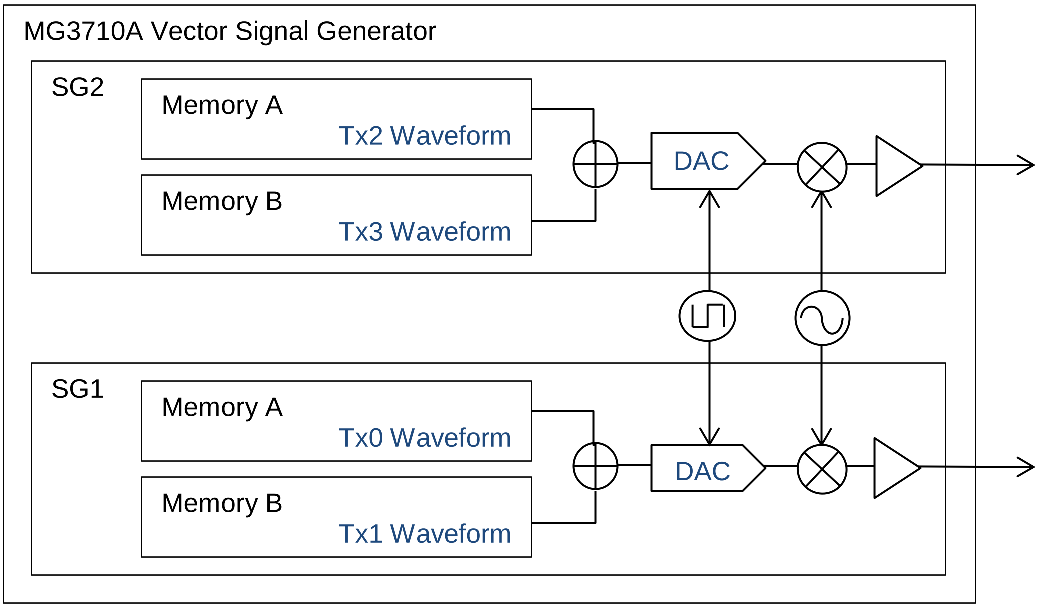

Fig. 2. Block Diagram of MG3710A Vector Signal Generator Simulating Base Station with Four Antennas

The MS269xA Signal Analyzer measures the timing offset between antennas by identifying different reference signals for each antenna. When performing this measurement, the signal outputs from the two RF ports of the MG3710A Vector Signal Generator are combined at a combiner and input to the RF port of the MS269xA Signal Analyzer.

When measuring the Data channel PDSCH EVM, the output from each antenna of the MG3710A is input directly to the RF port of the MS269xA Signal Analyzer. The number of the antenna to be measured is set at the MS269xA and the PDSCH EVM of that antenna is measured.

The timing offset measurement in this demonstration refers to the definition of item 6.5.3 Time alignment between transmitter branches in Rel. 8 and Rel. 9 of the 3GPP TS36.141 standard. Although PDSCH EVM measurement is defined in item 6.5.2 Error Vector Magnitude of the same standard as measurement for a single antenna, this demonstration measures the same signal configuration as the timing offset to monitor the modulation accuracy for multiple antennas.

Preparations

Prepare the following equipment and software for the demonstration.

- MG3710A Vector Signal Generator (Firmware Ver. 2.00.02 or newer)

Opt-032	1stRF 100 kHz to 2.7 GHz (Opt-034, -036 also OK)
Opt-048	1stRF Baseband Signal Addition
Opt-062	2ndRF 100 kHz to 2.7 GHz (Opt-064, -066 also OK)
Opt-078	2ndRF Baseband Signal Addition

  MX370108A LTE_IQproducer (for LTE FDD)
  Or
  MX370110A LTE TDD IQproducer (for LTE TDD)

- MS2690A/MS2691A/MS2692A/MS2830A Signal Analyzer (Firmware Ver. 5.04.00 or newer)
  MX269020A LTE Downlink Measurement Software (for LTE FDD)
  Or
  MX269022A LTE TDD Downlink Measurement Software (for LTE TDD)

- RF Cable 3 pcs
- 2 Signal Combiner 1 pc

Connect the instruments as shown in the following set-up diagram.

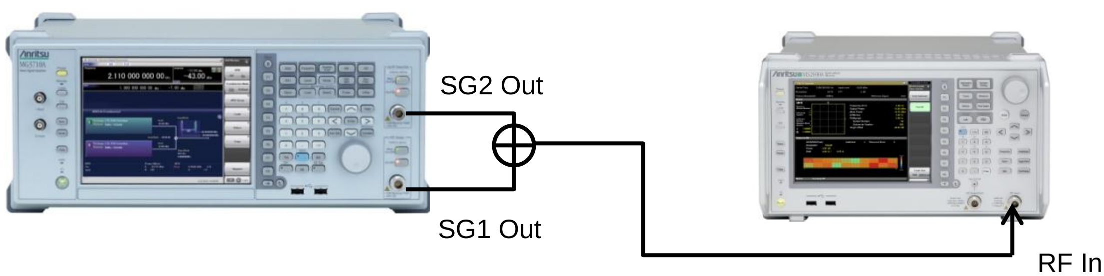

Fig. 3. Connection Set-up

To simplify the operations described in this application note, the cable attenuation settings and calibration procedures are omitted. To measure more accurately, refer to the operation manual and add the required procedures.

Unless otherwise noted, the description of following procedures and figures is for LTE FDD measurement. The procedures for LTE TDD measurement are similar as for LTE FDD measurement. This document complements the procedures especially for LTE TDD measurement.

Creating Waveform Patterns

The LTE FDD/TDD downlink signals are measured under the following conditions in this demonstration. To test the wireless characteristics using multiple antennas, several parameters differ according to the actual MIMO signal composition.

Table 1. Main Parameters of Created Waveform Patterns

Parameter	Value	Remarks
Cell ID	1	
Bandwidth	5 MHz	
No. of Antennas	4	In this demo, each antenna signal is Tx0, Tx1, Tx2, and Tx3.
Diversity Mode	Spatial Multiplexing	
No. of Layers	1	
Base Signal	E-TM1.1	Same as measurement conditions for 6.5.3 Time alignment between transmitter branches
Synchronization Signal	Only Tx0 enabled	

Use the following procedure to create the output signal waveform pattern using IQproducer built into the MG3710A Vector Signal Generator.

[Procedure]
1. Press [IQpro] to start IQproducer.
2. Press [LTE FDD] at the System (Cellular) tab to start LTE IQproducer
   (Press [LTE TDD] for TDD)
3. Press [Normal Setup].
4. Press [Easy Setup] → [BS Test] → [E-UTRA Test Models] → [E-TM1.1] to select BW = 5 MHz.
5. Select Common at the top of the tree on the left side of the window.
6. Set [Number of Antennas] in the Common column at the window center to 4.
   In the case of TDD, Set [Test Model] to [Off] before setting of [Number of Antennas].
7. Select [Synchronization of signals] in the center of the tree at the left side of the window.
8. Set [Data Status] of [Antenna Port 1] of [Primary Synchronization signals] at the right side of the window to [Disable].
9. Similarly, set [Data Status] of [Antenna Port 2] and [Antenna Port 3] to [Disable].
   (Set only Antenna Port 0 to Enable.)
10. Set [Data Status] of [Antenna Port 1] of [Secondary Synchronization signals] at the right side of the window to [Disable].
11. Similarly, set [Data Status] of [Antenna Port 2] and [Antenna Port 3] to [Disable].
    (Set only Antenna Port 0 to Enable.)
12. Press [Calculation].
13. Change the package name and output file (waveform pattern) as necessary.
    (Refer to the end of this procedure for the name used in this demo.)
14. Press [OK] to start waveform pattern generation.
15. Select [Yes] if the "Folder is not found' message is displayed.

The created waveform pattern setting file can be saved as necessary using [File] → [Save Parameter File]. The same settings can be recalled by reading this file using [Recall Parameter File].

The following four waveform patterns are created as examples in this demonstration.
Package: LTE_FDD
(“LTE_TDD” for TDD)
Tx0 Waveform Pattern: E-TM_1-1_05M_0
Tx1 Waveform Pattern: E-TM_1-1_05M_1
Tx2 Waveform Pattern: E-TM_1-1_05M_2
Tx3 Waveform Pattern: E-TM_1-1_05M_3

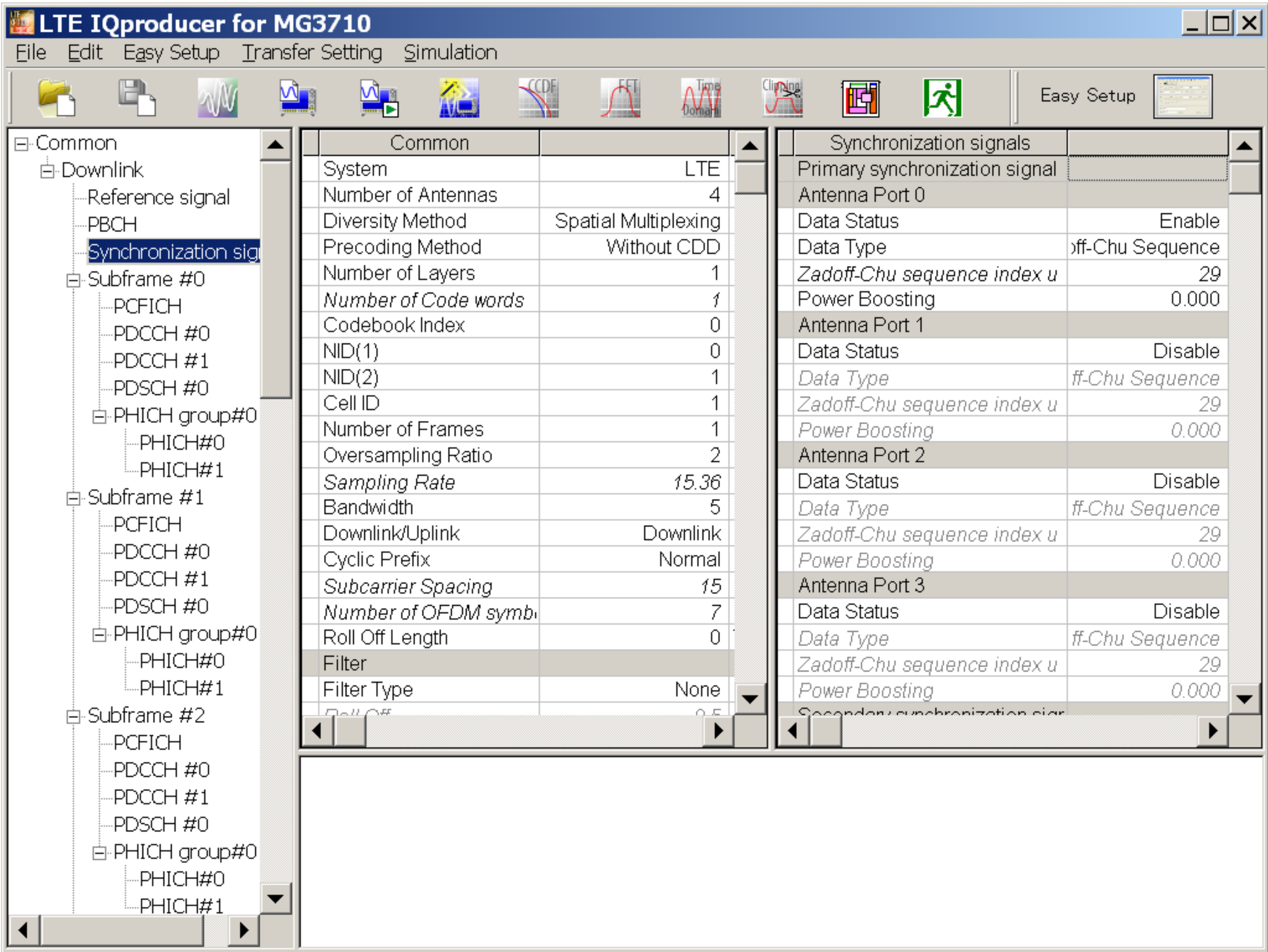

Fig. 4. LTE IQproducer Settings

The above procedure creates and saves four waveform patterns for each antenna to the HDD built-into the MG3710A Vector Signal Generator.

Setting Signal Generator

The signal created by IQproducer is output from the MG3710A Vector Signal Generator.

The Tx0 and Tx1 signals are output from the SG1 port of the MG3710A Vector Signal Generator after combining using the Baseband Signal Addition function. The Tx0 signal is loaded in memory A and the Tx1 signal is loaded in memory B. The Tx2 and Tx3 signals are output from the SG2 port of the MG3710A after combining using the Baseband Addition function. The Tx2 signal is loaded in memory A and the Tx3 signal is loaded in memory B.

Table 2. Waveform Pattern Arrangement and Output

Waveform Pattern	RF Port	Waveform Memory Save Destination
Tx0: E-TM_1-1_05M_0	SG1	A
Tx1: E-TM_1-1_05M_1	SG1	B
Tx2: E-TM_1-1_05M_2	SG2	A
Tx3: E-TM_1-1_05M_3	SG2	B

Additionally, the Local signal for generating the RF signal is synchronized between the two RF ports. This is to synchronize the signals between antennas when each antenna is connected to each RF port.

The MG3710A Vector Signal Generator operation procedure is explained below.

The operation flow is as follows:
(1) Select waveform at SG1.
(2) Select waveform at SG2.
(3) Synchronize SG1 and SG2 signals, set frequency, level, etc., and output signal.

[Procedure]
(1) Select the waveform at SG1.
1. Press [SG1].
2. Press [Preset] → [F1] Preset to initialize the instrument.
3. Press [Load] and select [LTE_FDD] from the Packages list on the left side of the window.
   (Press [LTE TDD] for TDD)
4. Press [F8] To Memory to set [A].
5. Select [E-TM_1-1_05M_0] from the Packages list on the right side of the window and press [F6] Load Pattern.
6. Press [F8] To Memory to set [B].
7. Select [E-TM_1-1_05M_1] from the Packages list on the right side of the window and press [F6] Load Pattern.
8. Press [Mode] → [F2] Combination Mode to set [Edit].
9. Press [Select] → [F8] On Memory to set [A].
10. Select [LTE_FDD] from the Packages list on the left side of the window.
    (Select [LTE TDD] for TDD)
11. Select [E-TM_1-1_05M_0] from the Packages list on the right side of the window and press [F6] Select.
12. Press [Select] → [F8] On Memory to set [B].
13. Select [E-TM_1-1_05M_1] from the Packages list on the right side of the window and press [F6] Select.
14. Press [Mode] → [F3] ARB Setup → [F3] Output B to set [On].

(2) Select the waveform at SG2.

15. Press [SG2].
16. Press [Load] and select [LTE_FDD] from the Packages list on the left side of the window.
    (Press [LTE TDD] for TDD)
17. Press [F8] To Memory to set [A].
18. Select [E-TM_1-1_05M_2] from the Packages list on the right side of the window and press [F6] Load Pattern.
19. Press [F8] To Memory to set [B].
20. Select [E-TM_1-1_05M_3] from the Packages list on the right side of the window and press [F6] Load Pattern.
21. Press [Mode] → [F2] Combination Mode to set [Edit].
22. Press [Select] → [F8] On Memory to set [A].
23. Select [LTE_FDD] from the Packages list on the left side of the window.
    (Select [LTE TDD] for TDD)
24. Select [E-TM_1-1_05M_2] from the Packages list on the right side of the window and press [F6] Select.
25. Press [Select] → [F8] On Memory to set [B].
26. Select [E-TM_1-1_05M_3] from the Packages list on the right side of the window and press [F6] Select.
27. Press [Mode] → [F3] ARB Setup → [F3] Output B to set [On].

(3) Synchronize the SG1 and SG2 signals, set the frequency, level, etc., and output the signal.

28. Press [Mode] → [→] → [F8] Sync Multi SG → [F1] Sync Type → [F4] SG1&2.
29. Press Back → [F4] LO Sync to set [On].
30. Press [SG1].
31. Press [Frequency] and set the frequency to 2110 MHz. The SG1 and SG2 frequencies become the same value because the Local signal is synchronized.
32. Press [Level] and set the output level to –15 dBm.
33. Press [RF Output] → [Mod On/Off] and [On/Off] to set each to [On].
34. Press [SG2].
35. Press [Level] and set the output level to –15 dBm.
36. Press [2nd RF Output] → [Mod On/Off] and [On/Off] to set each to [On].
37. Press [SG1].
38. Press [Mode] → [→] → [F2] Start/Frame Trigger → [F3] Source→ [F2] Trigger Key.
39. Press Back → [F8] Trigger Key.

The above procedure outputs the Tx0 and Tx1 added signal from SG1 and the Tx2 and Tx3 added signal from SG2.

Fig. 5. Example of Four Antenna Signal Outputs (SG1 Setting Display)

Measuring Timing Offset

The timing difference (offset) between the antenna signals is measured using the MS269xA Signal Analyzer. Measurement is performed using the MX269020A LTE Downlink Measurement Software modulation analysis function of the MS269xA Signal Analyzer measurement software.

Use the following MS269xA Signal Analyzer measurement procedure.

[Procedure]

1. Press [Application Switch] and select [3GLTE Downlink] ([LTE-TDD Downlink] for TDD).
2. Press [Frequency] and set the frequency to 2110 MHz.
3. Press [Amplitude] and set the level to –15 dBm.
4. Press [Measure] → [F2] MIMO Summary ([F3] MIMO Summary for TDD).
5. Press [F3] Channel Bandwidth → [F3] 5 MHz.
6. Press Back → [F7] Detail Settings.
7. Set [Number of Antenna Ports] to [4].
8. Press [Set] to display the Detail Settings log.
9. Press [Continuous] to start measurement and check the [RS Timing Offset] value.

The above procedure displays the timing offset for each antenna based on the Tx0 signal on the MS269xA Signal Analyzer screen. The reference antenna is specified at the [Antenna Port] setting of [Detail Settings] in step 6.

Fig. 6. Example of Timing Offset Measurement between Four Antennas

Measuring PDSCH EVM

The PDSCH EVM is measured using the timing offset measurement system. Measurement is performed using the modulation analysis function of the MX269020A LTE Downlink Measurement Software for the MS269xA Signal Analyzer. Additionally, each antenna signal is output from the MG3710A Vector Signal Generator.

The following measurement procedure follows on from the timing offset measurement using the MG3710A Vector Signal Generator and MS269xA Signal Analyzer. After outputting the target measurement antenna signals from the MG3710A Vector Signal Generator, measurement is performed by the signal analyzer.

Since the Synchronization Signal is embedded in the generated Tx1, Tx2, and Tx3 signals, the synchronization mode is set to Reference Signal at measurement.

NOTE*:*
MX269020A LTE Downlink Measurement Software does NOT support to analyze pre-coded signal. Please turn off the pre-coding when you measure signal from the base station.

Setting Signal Generator

[Procedure]
(1) Outputting Tx0
1. Press [SG1].
2. Press [Mode] → [→] → [F8] Sync Multi SG → [F1] Sync Type → [F1] Off.
3. Press [Mode] → [F3] ARB Setup → [F1] Output A to set [On].
4. Press [Mode] → [F3] ARB Setup → [F3] Output B to set [Off].
5. Set both of [RF Output] (SG1 side) [Mod On/Off] and [On/Off] to [On].
6. Set both of [2nd RF Output] (SG2 side) [Mod On/Off] and [On/Off] to [Off].
7. Use the signal analyzer to measure the PDSCH EVM of Tx0.

(2) Outputting Tx1
8. Press [SG1].
9. Press [Mode] → [F3] ARB Setup → [F1] Output A to set [Off].
10. Press [Mode] → [F3] ARB Setup → [F3] Output B to set [On].
11. Use the signal analyzer to measure the PDSCH EVM of Tx1.

(3) Outputting Tx2
12. Press [SG2].
13. Press [Mode] → [F3] ARB Setup → [F1] Output A to set [On].
14. Press [Mode] → [F3] ARB Setup → [F3] Output B to set [Off].
15. Set both of [RF Output] (SG1 side) [Mod On/Off] and [On/Off] to [Off].
16. Set both of [2nd RF Output] (SG2 side) [Mod On/Off] and [On/Off] to [On].
17. Use the signal analyzer to measure the PDSCH EVM of Tx2.

(4) Outputting Tx3
18. Press [SG2].
19. [Press [Mode] → [F3] ARB Setup → [F1] Output A to set [Off].
20. Press [Mode] → [F3] ARB Setup → [F3] Output B to set [On].
21. Use the signal analyzer to measure the PDSCH EVM of Tx3.

Fig. 7. Example of Tx0 Signal Output

Signal Analyzer Operation

[Procedure]
(1) Measuring Tx0

1. Press [Measure] → [F1] Modulation Analysis → [F7] Detail Settings.
2. Set [Synchronization Mode] to [Reference Signal].
3. Set [Cell ID] to 1.
4. Set [Number of Antenna Ports] to [4].
5. Set [Antenna Port] to [0].
6. Uncheck the [PDCCH] On/Off checkbox (set to [Off]).
7. Uncheck the [PHICH] On/Off checkbox (set to [Off]).
8. Press [Set] to close the [Detail Settings] dialog.
9. Press [Trace] → [F1] Trace Mode → [F6] Summary.
10. Press [Continuous] to start measurement and check the [PDSCH EVM (rms)] value.

(2) Measuring Tx1

11. Press [Measure] → [F1] Modulation Analysis → [F7] Detail Settings.
12. Set [Antenna Port] to [1].
13. Press [Set] to close the [Detail Settings] dialog.
14. Press [Continuous] to start measurement and check the [PDSCH EVM (rms)] value.

(3) Measuring Tx2

15. Press [Measure] → [F1] Modulation Analysis → [F7] Detail Settings.
16. Set [Antenna Port] to [2].
17. Press [Set] to close the [Detail Settings] dialog.
18. Press [Continuous] to start measurement and check the [PDSCH EVM (rms)] value.

(4) Measuring Tx3

19. Press [Measure] →F1] Modulation Analysis → [F7] Detail Settings.
20. Set [Antenna Port] to [3].
21. Press [Set] to close the [Detail Settings] dialog.

22. Press [Continuous] to start measurement and check the [PDSCH EVM (rms)] value.

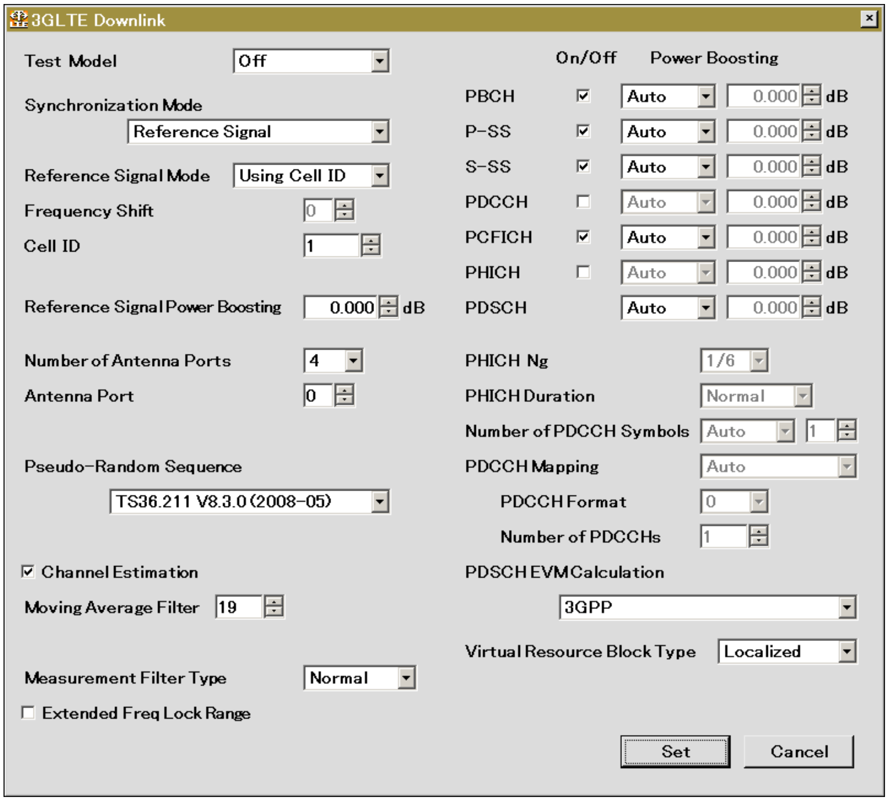

Fig. 8. Tx0 PDSCH EVM Settings

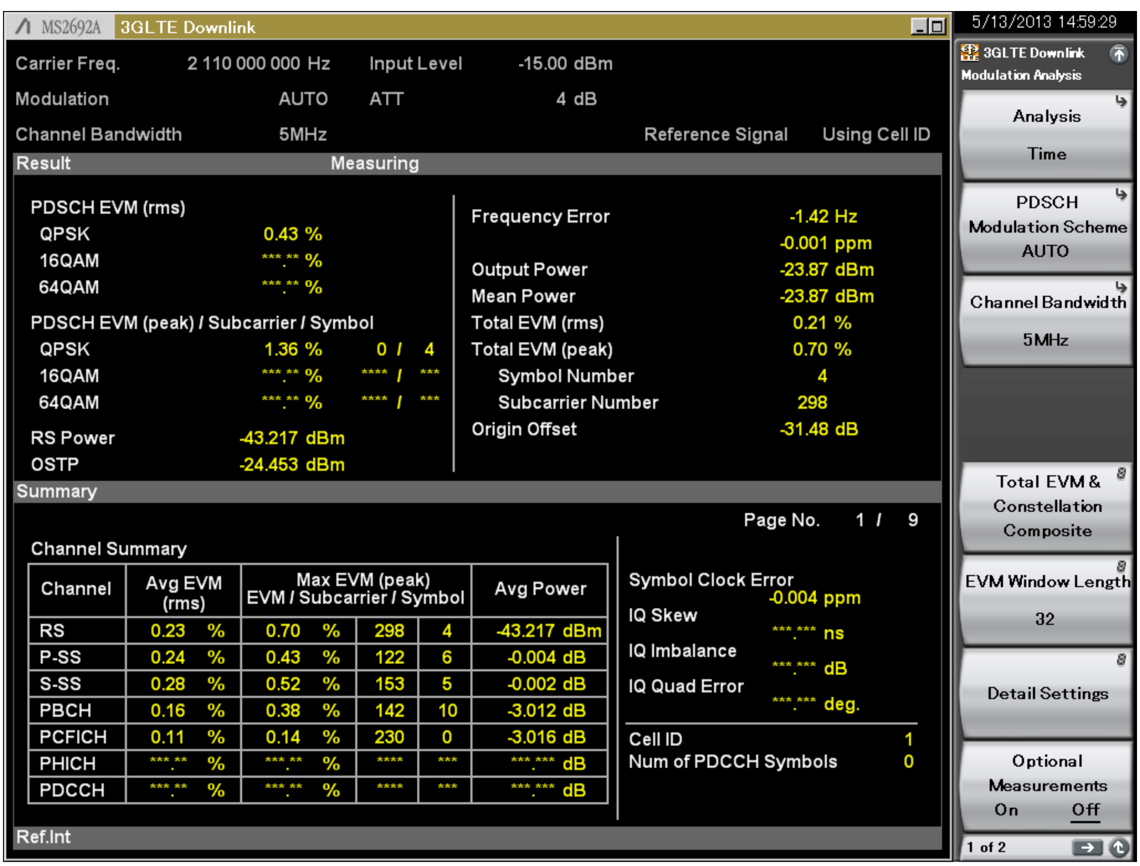

Fig. 9. Tx0 PDSCH EVM Measurement Results

Appendix

This demonstration uses the baseband addition function of a MG3710A Vector Signal Generator to output four antenna signals from one MG3710A. However, it is also possible to use two MG3710A units without the baseband addition function to allocate the four base station antenna signals in a 1:1 ratio to the four RF ports of the two vector signal generators. Refer to the following Table 3 and Figure 10 for the differences when simulating signal output from four antennas using the baseband signal addition function and one MG3710A, and when using two MG3710A units without the baseband signal addition function.

Table 3. Examples of MG3710A Vector Signal Generator Configuration (with Four Tx Antennas).

	Configuration 1 (Contents of this demonstration)	Configuration 2
No. of MG3710A Vector Signal Generators with 2ndRF option	1 unit	2 units
No. of RF Ports	2	4
Requires Baseband Signal Addition Option for Each RF Port	Yes	No
Extra Required Options	-	MG3710A-017 General I/O
Extra Instruments	-	Frame Trigger Source (Function Generator), Cables, etc., for Synchronizing Trigger, Baseband Clock, Local Signal, etc., between Each Vector Signal Generator
Timing Adjustment Function between Antennas	Yes	Yes
Phase Adjustment Function between Antennas	No (Baseband Signal Addition Function: No Phase Offset Adjustment Between Memory A and Memory B)	Yes
Fading Test Support for Each Antenna Signal	No	Yes

This demonstration tested a multi-antenna transmitter but it cannot be used for a test of multi-antenna/MIMO receivers with fading. The usual fading simulation calculates the MIMO matrix for the multiple antennas and outputs these values at the independent RF ports. However, since these signals for each RF port are the signals at the receiver antenna terminal, they contain a mixture of multiple channels. Consequently, attempting baseband signal addition for these types of signals does not capture the actual test target signal.

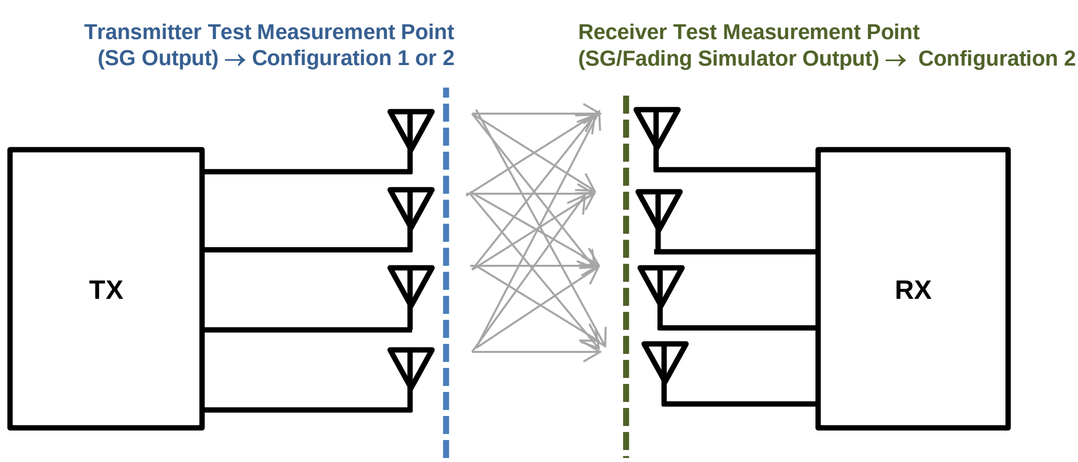

Fig. 10. Measurement points for multi-antenna testing

Refer to the application note MG3710A-J-F-3 MIMO Phase Coherence using Vector Signal Generator for the method for synchronizing between each RF port (Phase Coherence) using two MG3710A Vector Signal Generator units, and the method for minimizing the timing and phase offsets between each RF port.

Specifications are subject to change without notice.

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