OUTDOOR UNITS FOR Ka/Ku-BAND SATELLITE INTERACTIVE TERMINALS

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ABSTRACT

This paper describes the main features and components of a class of OutDoor Units (ODUs) for user terminals for interactive data communications as well as for TV reception via the new 12/30 GHz ASTRA satellite launched last year, and future satellites with similar parameters. The first prototypes of these units were first reported at the 5th Ka-band Utilisation Conference in Taormina, Italy (Ref. 1). Since then, the units underwent further re-design and are now in regular production.

The ODUs use block conversion from S-band (2.5 – 3 GHz) for the transmitter and to standard L-band (0.95-2.15 GHz) for the receiver, and interface with an Indoor Unit (IDU) with the the corresponding S/L –band modem. Their EIRP, G/T and spectral purity allow transmittting at maximum data rates from 144 kb/s to about 2 Mb/s using the above satellites, with sufficient margin, and reception of signals with high data rates (such as 40 Mb/s or even higher). Three ODUs with different Tx power levels and antenna sizes have been designed to cover the above range of data rates.

The configuration, main characteristics and technology of the ODUs are described and their performance data reported in this paper.

OVERALL DESCRIPTION

Each ODU is physically composed of an dual offset-fed (Gregorian) parabolic antenna and a transceiver. The antenna boom is equipped with a dual 12/30 GHz feed/diplexer. This assembly contains two waveguide flanges (C120 and WR28) to which a typical Ku-band LNB and the transmitter can be attached. The LNB attaches directly while the transmitter is attached by means of a flexible waveguide, with the transmitter mounted lower down on the boom. The three antennas feature the same f/d so that the same feed/diplexer can be used for all of them. The Tx input and Rx output (at S-band and L-band respectively) interface with the IDU via an Interfacility Link (IFL),

The main requirements on the two ODUs are summarised in Table 1 below:

Table 1: Main ODU Parameters

Parameter	ODU 1/2/3
Tx frequency range	29.5 – 30 GHz
Rx frequency range	10.7- 12.75 GHz
Tx polarization (set)	Linear, V or H,
Rx pol. (switched)	Linear, V or H,
EIRP, nominal	40/45/50 dBW
Max. antenna dia	76/92/122 cm
Min G/T	15 dB/°K
Tx IF freq. range Rx IF freq. range	2.5 – 3 GHz 0.95 – 2.15 GHz
DC power (max)	30/40/60W

Fig. 1 shows an assembled ODU.

The above requirements result in the following breakdown of the required antenna and transceiver performance:

Table 2: Antenna/transc. performance

Parameter	ODU 1/2/3
Antenna Tx gain	44/46/48dB
Min. Tx power	26/29/32 dBm
Antenna Rx gain	35/37/39 dB
Rx Noise Figure	1.3 dB max

Fig. 1: Complete ODU

BLOCK DIAGRAM

The functional block diagram of the ODU is shown in Fig. 2. The transceiver is interconnected with the corresponding IDU via an IFL consisting of one Rx coaxial cable and one Tx coaxial cable on which the following signals are multiplexed: Tx IF, reference signal, a 22 kHz tone for Monitor, Alarm & Control Functions (MAC) and the DC power for the transmitter. The Rx cable carries the Rx IF signal as wel as the DC voltage for the LNB and the 22 kHz tone for band switching. The block diagram shows a single output LNB but a Twin or Quad Universal LNB can also be used.

Note that electrically, the feed/diplexer is part of in the antenna subsystem.

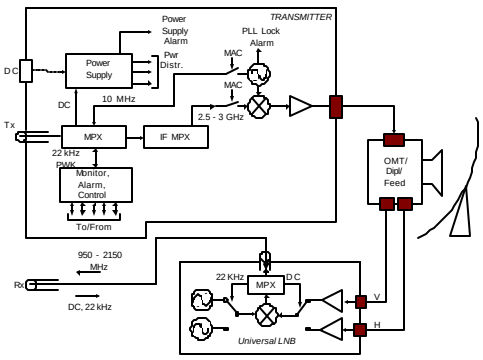

Fig. 2: RF Front End Block Diagram

TRANSMITTER

The input S-band (2.5 – 3 MHz) Tx signal from the IDU is transmitted to the ODU on the RF cable of the IFL. The Tx signal is separated in the multiplexer part of the transmitter from the other signals on the cable and upconverted in the UPC unit to the 29.5 – 30.0 GHz range. The signal then passes through a filter (not shown) to remove any residual LO signal as well as other unwanted signals. The filtered signal from the UPC is amplified in the SSPA to the desired level and connected to the feed/diplexer. The transmitter contains a 10 MHz reference oscillator used to lock the LO for the UPC. This signal is also sent back, through the multiplexer and IFL RF cable, to the IDU to be compared with a received beacon for the purpose of frequency corrections for the terminal by adjusting the Tx IF. In case of a PLL alarm, the connection to the IDU is interrupted as shown in the diagram.

The **MAC circuitry** is responsible for controlling and monitoring the transmitter from the IDU. As shown in the diagram, the MAC circuitry interfaces with the IDU through the multiplexer. This is done using a 22 kHz PWM signal. It monitors and/or controls the power supply alarm, reference disconnect switch and the PLL alarm and Tx enable/disable switch.

RECEIVER

The signal received by the feed is separated from the Tx signal in the diplexer part of the feed and brought to a standard flanged universal LNB which can then select between two orthogonally polarized signals. The two signals are fed to two input stages, the outputs of which can be switched to select the desired polarization by the DC supply voltage brought from the transmitter to the output connector. The selected signal is then applied to the mixer to downconvert to the 950 – 2150 MHz L-Band IF. This is done in two bands converting the Ku low band (10.7-11.7 GHz) to the range 950-1950 MHz and the high band (11.7-12.75 GHz)

to 1100 – 2150 MHz. The output is connected to the IDU via the Rx coaxial cable. A typical standard universal LNB has approximately 55 dB of gain. It can be a single, TWIN or QUAD LNB. Its outputs would be controlled from the IDU, via separate cables, in the same way as in standard Ku-band DTH receivers.

ANTENNA SUBSYSTEM

Reflector and Mount

The antennas for the three ODUs use upgraded Ku-band reflectors, with the dual-offset Gregorian geometry for the feed. using an f/d ratio of 0.6. The reflector diameters are 76 cm, 92 cm and 122 cm. A fine- adjust Az/El mount is attached to the dish and to a "canister assembly" which in turn rotates on the mast. The mast is attached to a non-penetrating roof mount. The 76 cm reflector can also be attached to a wall.

Feed Support (Boom)

The feed support system uses a rectangular cross-section boom further supported by two side struts to account for the weight of the transmitter and subreflector.

Feed/Diplexer & Transceiver Mounting

The Feed diplexer is a commercially available unit featuring a Ku-band horn with a polyrod radiator for 30 GHz, and with a built-in diplexer section featuring a C120 flange for the attachment of an LNB, and a WR28 flange to connect the transmitter to. Fig. 3 shows the detail of the feed, LNB and transmitter mounting.. The transmitter is connected to the feed by flexible waveguide.

TRANSCEIVER MECHANICS AND ELECTRONICS

The transceiver consists of two parts, a commercially available LNB, and the NORSAT-designed transmitter. These two parts are visible in Figure 3.

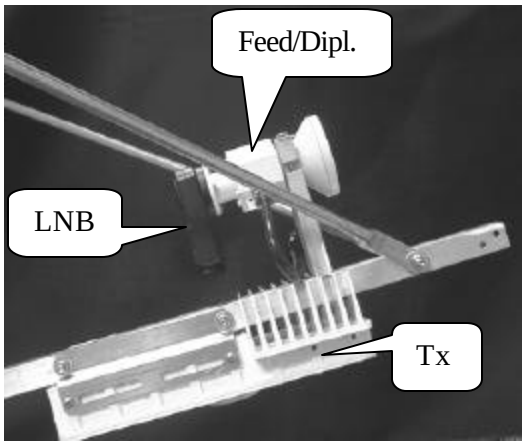

Fig. 3: ODU Transceiver and Feed

As for the electronics of the **transmitter**, the following are some of the characteristic aspects of the design approach taken and of the technology used:

a) In the LO for the UPC, an SPD (Sampling Phase Detector) is used in the the LO PLL circuit. This provides better phase performance as it does away with the synthesizer threshold noise typical for the "divide down and synthesize schemes.

b) The SSPA, which has a gain of approximately 55 dB, uses mostly internally matched MMICs, both for the low-level drivers and the final stage. The required output power for SIT 1 and 2 (29 dBm) is obtained from one MMIC chip. No off-chip combining was therefore necessary for ODU 1 and 2. However, combining is required for ODU 3.

   An electronically controlled variable attenuator was used in conjunction with a temperature sensing circuit to compensate for amplitude variations of the Tx chain caused by temperature changes.

c) The technology used in the realisation of the above circuits and units is SMT-packaged devices on softboard, except for the SSPA stages where alumina inserts are used in the packages into

which the MMIC chips are die-attached and wire-bonded.

PERFORMANCE

A summary of all relevant ODU parameters and the measured results is given in Table 3.

Table 3: ODU Performance

Parameter	Performance
RF Tx Band:	29.5 - 30 GHz
RF Rx Band:	10.7- 12.75 GHz
EIRP: Nominal **(-20 dBc regrowth)***	42/45/50 dBW
Antenna size	76 /92/122cm
Antenna Tx gain	44.5/46/48.5 dB
Tx Gain Pattern	ETSI Compliant
Cross-Pol. Isolation: Tx(in 1/10 dB cont.)	> 30 dB
Rx (in 1 dB contour)	> 20 dB
Nominal Tx power*	28/29/31.5 dBm
Tx IF Input freq. range	2.5-3.0 GHz
Tx IF level for nominal EIRP	-33 to –23 dBm
Antenna Rx gain	36/38/40 dB
G/T (equipment only)	16/18/20 dB/K
Rx noise temperature	100 K
Rx Output freq. range:	950- 2150 MHz
Receiver gain	56 dB
ODU Reference	10 MHz(+/- 20 ppm)
Temperature range	-30°C to + 50°C
CMF protocol/ link	SIMP, 22 kHz PWM

*** It is to be noted that the "nominal" Tx power is not defined at the 1 dB compression point as is customary, but rather at a specified level of spectral regrowth caused to the actual modulated signal.** Based on studies conducted by the author, operation at 1 dB compression point results in very different actual distortion, depending on whether the compressing device (typically the power stage) has a soft or hard compression characteristics (Ref. 2).

SUMMARY

Three 12/30 GHz ODUs (antenna and transceiver) for Satellite Interactive Terminals have been designed and prototyped, and their performance verified in bench testing as well as in antenna tests on an antenna range.. **The 76cm ODUs are now in regular production.**

The ODUs use dual-offset parabolic antennas with a special dual 12/30 GHz feed. The transmitter technology used is "classical" SMT except in the SSPA module where the thin film on alumina and "chip and wire" techniques are employed. In the receiver, commercially available Ku-band LNBs are used.

The ODUs are characterised by EIRPs of 42/45/50 dBW, G/T of 16 dB/°K and better, and by an L/S band Rx/Tx IF interface with the modem in the IDU.

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