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Commercial Satellite Receiving Terminal Antenna Performance by Measurement

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Antennas that are classed as commercial-off-the-shelf (COTS) comprise an antenna, usually a reflector type, which is highly integrated with a multi-purpose front-end often called a low-noise block (LNB). Operationally, these integrated terminals receive at the radio frequency (RF), and output the signal at an intermediate frequency (IF). This presentation will cover a procedure and results for the antenna pattern characterization, required for ITU Standards proposals for evaluating COTS performance.

In some COTS terminals, the reflector is fed from a waveguide-fed splash plate. In others, multiple, corrugated feedhorns feed an offset reflector to create multiple beams. Many satellite channels (RF bands and polarizations) can be thus obtained from the same design, fostering mass production. The channels are user-selected by injecting low-frequency tones and powering with different DC voltages via the same coax port that the IF signal exits from. The electronics is on one or several printed circuit boards that: separate the IF signal exiting the port from the input tone and DC power, condition the DC power, detect the input tone, and buffer the IF output signal. The receiving functionality includes: integrated dual-port feeds for each of the feed horn antennas for multiple polarizations, low-noise amplifiers and filter stages, several local oscillators (LOs) for the different RFs, frequency shifters, and IF filtering, buffering and automatic gain control (AGC) to maintain the IF at a constant level against changes in the RF link gain. The polarizations are left and right circular, and both linears (typically referred to as L, R, θ, ϕ). These are auto-selected by signal combination of the signals from the dual feeds of each feed horn.

The question arises as to how to measure the various aspects of the terminal performance, in particular the pattern which is the most critical parameter, dominantly governing the terminal performance. The terminal is an active three-port device with two input ports at RF and the output at IF, with an AGC, i.e., a non-linear relationship between inputs and output. This makes conventional multiport measurement somewhat meaningless, especially when trying to characterize the pattern which requires linearity. The front-end design and high level of integration means that the RF signals needed for pattern measurement cannot be extracted without changing the operating performance of the terminal. The kneejerk approach is to separate the LNB from the antenna, and measure each separately. But again the high level of integration means that destructive modification of the terminal is required to separate the antenna ports from the rest of the LNB, and then the feeds can be connectorized ready for pattern measurement. This allows the antenna pattern to be measured for its power pattern, but not rigorously for its polarized patterns as the terminal (antenna plus LNB) would operate, as will be discussed in the presentation. We investigated three different COTS terminals. Sample results of the antenna of one terminal are given below, and it is emphasized that the polarization purity (cross-polarization discrimination (XPD) at boresight) may not correspond accurately to that of the operating performance. Also, this XPD is very sensitive to the presence of a minimum in the cross-polar pattern near boresight, for example the case where the XPD is over 50 dB occurs exactly at a deep minima in the cross-polar pattern.

Table 1. Sample of Pattern Results at 12.2 GHz

Dual Feed Configuration	Port Configuration	Polarization	Directivity	XPD
Ports connectorized, power combined with splitter:	Two Ports	Linear ($\tau = -68°$)	30.7 dBi	11.6 dB
		LHCP	29.8 dBi	4.73 dB
Splitter connected to Port 1:	Port 2 open	LHCP	31.1 dBi	50.3 dB
	Port 2 load	LHCP	31.1 dBi	37.8 dB
	Port 2 short	LHCP	31.1 dBi	32.3 dB
Splitter connected to Port 2:	Port 1 open	RHCP	31.1 dBi	23.0 dB
	Port 1 load	RHCP	30.9 dBi	26.8 dB
	Port 1 short	RHCP	30.9 dBi	20.4 dB