ASTRA Reception Equipment Recommendations

Technical Recommendations for Single Cable LNBs

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Acronyms

AGC	Automatic Gain Control
CENELEC	Comité Européen de Normalisation Electrotechnique
C/N	Carrier-to-Noise ratio
C/(N+I)	Carrier-to-Noise and Interference ratio
CTB	Composite Triple Beat
DTH	Direct-To-Home
DRO	Dielectric Resonator Oscillator
EMC	Electromagnetic Compatibility
IEC	International Electrotechnical Commission
IF	Intermediate Frequency
IM2	2nd order Intermodulation products
IM3	3rd order intermodulation products
ODU	Outdoor Unit
LNB	Low Noise Block converter
ISO	International Standardization Organization
RF	Radio Frequency
RMS	Root Mean Square
SMATV	Satellite Master Antenna Television

1 INTRODUCTION

This document details SES ASTRA's technical recommendations for the RF and IF parameters of Single Cable LNBs for DTH and SMATV satellite reception.

For the single cable functionality the LNB shall be compliant with the CENELEC EN 50494 industry standard.

2 Single-Cable LNB Characteristics[1]

2.1 Common

No.	Parameter		Value Min.	Value Typ.	Value Max.	Unit
1	Input Frequency			10.70 to 12.75		GHz
2	Output Frequency			950 to 2150		MHz
3	Local Oscillator Uncertainty[12]		-5		+5	MHz
4	Phase Noise[2]	Over 3kHz – 15MHz		1.6	2.5	°rms
5	Image Rejection		40			dB
6	In-Band Spurious[3]	950-1690MHz, 1710-2150MHz		-30	-28	dBc
		1690-1710MHz			-20	dBc
7	Cross-Satellite & Cross-Band Isolation[4]	Equal level inputs, Cross-Satellite for ≥2 Satellites	32.5			dBc
8	Cross-Polar Rejection		22			dB
9	Output Return Loss	Output Impedance 75Ω	8			dB
10	LNB Supply Voltage		11		19	V
11	Current Consumption				350	mA
12	Communication Protocol	CENELEC EN50494				
13	EMC Emissions and Susceptibility	IEC 60728 - 2				
14	Safety	IEC 60728 - 11				
15	External ODU Operating Temperature		-40		60	°C

Table 1: Common Characteristics for Single-Cable LNBs

2.2 Single-Cable Output

No.	Parameter		Value Min.	Value Typ.	Value Max.	Unit
16	Gain Ripple	Over 30MHz bandwidth			3	dBpp
17	Phase Error (relative to linear phase)[5]	Over 30MHz bandwidth			3.5	°rms
18	Aggregate Off-Channel Leakage[6]	Equal Input Levels			-37	dBc
19	Input to Output IF Leakage[7]	Equal Input Levels			-32	dBc
20	Noise Figure	Outside of AGC		1.1	1.3	dB
21	CTB[8]				-22.5	dBc
22	IM2[9]				-28	dBc
23	Fixed Conversion Gain[10]	4 or Less User Transponders	53		63	dB
		5 or more User Transponders	60		73	dB
24	Minimum Gain outside of AGC[10]	4 or Less User Transponders	53			dB
		5 or more User Transponders	60			dB
25	Output AGC Setpoint[10]	Transponder power	-32		-17	dBm
26	Output Magnitude Glitch[11]			0.75	1	dB

Table 2: Unique Characteristics for Single-Cable LNBs Single-Cable Output

2.3 Legacy Output

No.	Parameter		Value Min.	Value Typ.	Value Max.	Unit
27	Gain Ripple	Over 950-1950MHz, 1100-2150MHz			7	dBpp
		Over 30MHz bandwidth			2	dBpp
28	Fixed Conversion Gain[10]		50		60	dB
29	Minimum Gain outside of AGC[10]		50			dB
30	Output Gain Difference (between legacy outputs)	Over 30MHz bandwidth			6	dB
31	Output AGC Setpoint[10]	Aggregate power	-22		-13	dBm
32	Noise Figure	Outside of AGC		1.1	1.3	dB
33	CTB[8]				-20.5	dBc
34	IM2[9]				-28	dBc
35	Input Frequency	Low Band		10.70 to 11.70		GHz
		High Band		11.70 to 12.75		GHz
36	Local Oscillator Frequency	Low Band		9.75		GHz
		High Band		10.60		GHz

Table 3: Unique Characteristics for Single-Cable LNBs Legacy Outputs

Parameter notes:

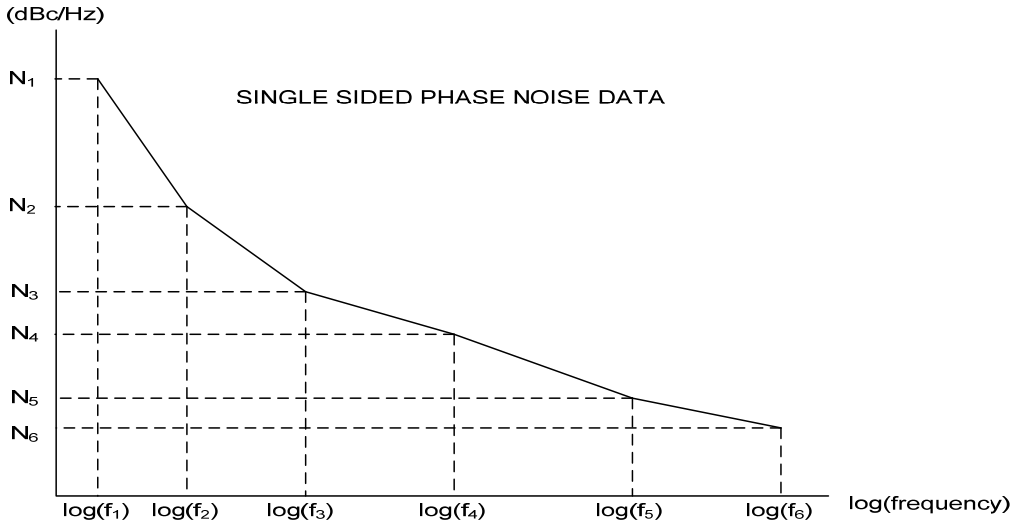
1. These parameter recommendations are for Single-Cable LNBs with optional Legacy outputs. They are applicable for an input transponder power range of -100dBm to -85dBm, with an associated aggregate power range, per polarisation, of -82dBm to -67dBm. It is also recommended the LNB can still function with a maximum aggregate power of -63dBm per polarisation.

   These parameter recommendations are applicable to systems operating with both DVB-S and DVB-S2 for QPSK with code-rates ≤9/10 and 8PSK with code-rates ≤3/4. The maximum operating symbol rate assumed is 30Msymbol/s (Rs) and the C/N measurement bandwidth is equal to Rs, as recommended in DVB-S2.

   The C/N range applicable is 2.30dB to 9.30dB and is the C/N at the RF input to the Set-Top Box and has margin for the satellite-link degradation (≤ -16dBc) and STB implementation-loss (≤ 0.5dB) as recommended within DVB-S2.

   These parameter recommendations when combined, limit the additional C/(N+I) degradation due to the Single-Cable function, over the recommended signal operating range, to ≤ 0.3dB for QPSK code-rate ≤3/4 and ≤ 0.6dB for 8PSK code-rate ≤3/4.

2. Integrated Phase-Noise can be calculated from a series of spot phase-noise measurements at 3kHz, 10kHz, 100kHz, 1MHz, 10MHz and 15MHz using the method below:



As well as meeting the Integrated Phase-Noise specification, it is required that each Spot Phase-Noise point meets the maximum levels as specified in the table below.

Index n	Offset Frequency (Hz)	Suggested Offset Frequency	Single Sided Spot Phase Noise @ Offset Freq (dBc/Hz)	Maximum Single Sided Spot Phase Noise (dBc/Hz)
		1 kHz		-55
1	f_1	3 kHz	N_1	
2	f_2	10 kHz	N_2	-75
3	f_3	100 kHz	N_3	-80
4	f_4	1 MHz	N_4	-100
5	f_5	10 MHz	N_5	-115
n/a	f_6	15 MHz	N_6	-115

If the 10MHz & 15MHz points cannot be measured reliably then they can be extrapolated from the 1MHz measurement point using: $N_5 = N_4 - 20$, where $N_5 \geq -120$
$N_6 = N_4 - 23.5$, where $N_6 \geq -120$

$$m_n = \text{slope} = \frac{N_{n+1} - N_n}{\text{Log}_{10}(f_{n+1}) - \text{Log}_{10}(f_n)}$$

b_n = y intercept $= N_n - m_n[\text{Log}_{10}(f_n)]$

Where:

- m_n = slope at index n
- b_n = y intercept at index n
- f_n = Offset Frequency in Hz at index n
- N_n = Single sided spot phase noise in dBc/Hz at f_n

Double Sided Integrated Phase Noise (dBc) =

$$3+10\text{Log}_{10}\sum_{n=1}^{5}\frac{10^{b_n/10}}{(m_n/10)+1}(f_{n+1}^{[(m_n/10)+1]} - f_n^{[(m_n/10)+1]})$$

3. In-Band Spurious (dBc) is specified relative to an output transponder power level. In-Band Spurious is specified over an input transponder power range of -95dBm to -85dBm.

4. For an LNB with two (or more) satellite feed-horns (monoblock) Cross-Satellite Isolation specifies how much of the signals received in one feed-horn leaks into a signal received in another feed-horn as measured at the output of the LNB. This is specified relative to the wanted transponder power signal level and assumes the input RF signal levels are equal.

   For an LNB that internally splits the RF input bandwidth of 2050MHz into two bands (High and Low, of ~1000MHz) then Cross-Band Isolation specifies how much of the signals emanating from one band leaks into a signal from the other band as measured at the output of the LNB. This is specified relative to the wanted transponder power signal level and assumes the input RF signal levels are equal.

5. Phase Error is specified as the RMS error of the phase function relative to a linear-phase straight line function over the 30MHz bandwidth. The straight line function is a curve fit using linear regression (Least-Mean-Squared-Error). As the transponder channel filters in the Single-Cable sub-system dominant the Phase Error, then the Phase Error of each filter can be measured directly, as an alternative to measuring the overall LNB Phase Error.

6. Aggregate Off-Channel Leakage specifies the total unwanted signal power leaking into the wanted signal output bandwidth from other transponders, due to the finite stop-band attenuation characteristics of the channel filters that precede the output summing function. This is specified relative to the wanted output signal.

7. Input to Output IF Leakage specifies the unwanted leakage of signals at IF frequencies at the input of the Single-Cable sub-system to the wanted output signal bandwidth without frequency translation. This is specified relative to the wanted output signal.

8. Composite Triple Beat (CTB) is a measure of third order distortion for systems with a large number of carriers. This is the most appropriate specification but is difficult to measure in practice. To simplify this we recommend measuring IM3 (dBc) for six tone pairs spread across the input bandwidth (or Low-Band or High-Band referred to the input) and feeding the results into the equation below to calculate CTB:

$$\mathrm{CTB}\left(\mathrm{dBc}\right) = 50\mathrm{Log}_{10}\left[\sum_{j=1}^{6}\left(10^{\left[\frac{\mathrm{IM3}_j}{50}\right]}\right)\right] - 31.5$$

   The tone pairs consist of two tones of -70dBm each at the RF input with the following RF frequency pairs:

   For Low-Band (DRO1 = 9750MHz typically) → DRO1+950/1000, DRO1+1140/1190, DRO1+1330/1380, DRO1+1520/1570, DRO1+1710/1760, DRO1+1900/1950

   For High-Band (DRO2 = 10600MHz typically) → DRO2+1100/1150, DRO2+1300/1350, DRO2+1500/1550, DRO2+1700/1750, DRO2+1900/1950, DRO2+2100/2150

   IM3 products are measured relative to the reference tones at the output.

9. IM2 is measured with tone pairs that consist of two tones of -70dBm each at the RF input with the following RF frequencies pairs:

   For Low-Band (DRO1 = 9750MHz typ) → DRO1+950/1000, DRO1+1000/1950

   For High-Band (DRO2 = 10600MHz typ) → DRO2+1050/1100, DRO2+1050/2150

   The IM2 products are measured relative to the reference tones at the output.
10. For a Single-cable LNB with fixed gain, minimum and maximum gain recommendations are provided.

    For a Single-cable LNB with an AGC function, the output signal's level will be controlled by an AGC once the input signal is large enough to force the AGC to regulate the output. To specify a system with an output-referred AGC two parameters are required, 'minimum gain' for when the signal is small enough for the AGC to be inactive and 'output AGC setpoint' to specify the output power when the AGC is active. For the Single-Cable output each AGC would typically regulate each output transponder independently, so the setpoint is specified for output transponder power level. For the Legacy output the AGC would typically regulate the aggregate output power.

11. When a switch matrix changes state due to one user requesting a channel change, the paths through the matrix supplying signals to the users who are not presently changing channels, can have their signals disturbed by this channel change. Output Magnitude Glitch specifies the maximum amplitude change experienced by the wanted static signal.

12. Local Oscillator Uncertainty does not include the known synthesizer step size error in the Single-Cable sub-system.

3 Industry Standards

[1] EN 50494
"Satellite signal distribution over a single coaxial cable in single dwelling installations", Cenelec, 2007

[2] EN 61319-1/A11:
"Interconnections of satellite receiving equipment; Part 1: Europe", Cenelec, 1999

[3] EN 50083
"Cable Networks for Television Signals, Sound Signals and Interactive Services", Cenelec

[4] ISO 60169-24:
"Radio-frequency connectors – Part 24: Radio-frequency connectors with screw coupling, typically for use in 75 Ohm cable distribution systems (Type F)", ISO

[5] IEC 60728
"Cable Networks for Television Signals, Sound Signals and Interactive Services", IEC

4 Publications by SES ASTRA

[5] ASTRA Reception Equipment Recommendations for DTH and SMATV Systems"
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