EUTELSAT S.A.

Systems Operations Guide

ESOG
Volume II

TELEVISION HANDBOOK

Issue 1.1, 01-09-2005
Annex E modified on 01-02-2013

Module 210

EUTELSAT S.A.

SYSTEMS OPERATIONS GUIDE

ESOG	Module 210
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FOREWORD

The Eutelsat S.A. Systems Operations Guide (ESOG) is published to provide all Eutelsat S.A. space segment users with information that is necessary for successful operation of earth stations within the Eutelsat S.A. satellite system.

The ESOG consists of 2 Volumes. They contain, in modularised form, all the necessary details, which are considered important for the operations of earth stations.

Volume I concentrates on System Management and Policy aspects and is therefore primarily of interest to personnel engaged in these matters.

Volume II is of direct concern to earth station staff who are directly involved in systems operations, i.e. the initial line-up of satellite links between earth stations and the commissioning of earth stations for Eutelsat S.A. services. The modules that are contained in this Volume relate to the services provided via Eutelsat S.A. satellites.

The ESOG can be obtained either by requesting a printed version to Eutelsat S.A. **or** in Acrobat format from the Eutelsat S.A. Web:

http://www.eutelsat.com

Paris, 01-09-2005

OVERVIEW ESOG MODULES

VOLUME I

EUTELSAT S.A. SYSTEM MANAGEMENT AND POLICIES

VOLUME II

EUTELSAT S.A. SYSTEMS OPERATIONS AND PROCEDURES

1. INTRODUCTION

This module contains all the necessary information relating to earth stations which intend to provide Analogue and/or Digital Television Services via the Eutelsat S.A. Space Segment, and is structured in four major parts:

Chapter 2: Mandatory Pre-Transmission Line-Up Tests

Chapter 3: Analogue Transmission Line-Up Tests

Chapter 4: Digital Transmission Line-Up Tests

Chapter 5: Supplementary Tests

The Pre-Transmission Line-Up (PTLU) is mandatory and upon its successful completion the earth station will be granted **Authorisation to Operate** in the Eutelsat S.A. Space Segment as described in the ESOG Module 110, Paragraph 3.2.

The Analogue and Digital Transmission Line Up (TLU) are a series of tests which Eutelsat S.A. regards as very essential to provide a more complete assessment of earth station performance, but have been highly automated and simplified to reduce the time taken to complete these tests. The tests focus on service quality, but are minimised to provide a more realistic and commercially sensitive process by saving valuable time during the testing phase.

Supplementary Tests is a more in detailed step-by-step description of the TLU and also contains additional information to allow more complex problems to be resolved.

Eutelsat S.A. or the Earth Station Operator may request to perform Transmission Line-up Tests (TLU) for the verification of transmit/receive transmission parameters before commercial operation. The TLU can be used for the purpose of initial line-up, maintenance, location of problems etc.

Prior to conducting the TLU the SUT must perform the mandatory PTLU

The designated Eutelsat S.A. TVCSM or receive earth station will be responsible for conducting the recommended TLU tests, if necessary, with the assistance of the Eutelsat S.A. CSC in Paris.

2. MANDATORY PRE-TRANSMISSION LINE-UP TESTS (PTLU)

Before commencing PTLU tests via the satellite, the Earth Station Operator shall ensure that all in-station preparations, adjustments and testing on the transmission equipment[1] that will be in-service for the particular transmission, have been carried out in accordance with the Eutelsat S.A. approved transmission configuration(s) and parameter(s); i.e. as described in the Transmission Plan or Test Plan.

The Eutelsat S.A. CSC in Paris will be responsible for conducting the mandatory PTLU tests.

2.1. Satellite Acquisition

Prior to the transmission of any signal, the transmit earth station shall identify and acquire the desired Eutelsat S.A. satellite. To achieve this, the following steps are to be undertaken:

Step 1: Check azimuth, elevation and polarisation angle calculations.

Step 2: Check magnetic variation figure for earth station site to give correct magnetic azimuth bearing.

Step 3: Accurately set antenna pointing and feed polarisation offset.

Step 4: Verify the frequency of the on-board satellite beacon or another existing or temporary RF carrier. Calculate the down converted frequency accurately that you will be viewing on the spectrum analyser. Remember that many LNB's (Low Noise Block down-converters) have fairly inaccurate DRO local oscillators (+/- 2 MHz is common) and this must be taken into account when setting the spectrum analyser span/division and resolution bandwidth.

Step 5: If using the on-board satellite beacon, its level is very low and is linearly polarised. Hence, the position of the feed will affect the beacon level. Also, ensure that the spectrum analysers sweep bandwidth and resolution bandwidth is optimised or the beacon will be impossible to see.

NOTE: The on-board beacon is visible from any point within Eutelsat S.A. satellite beam coverage.

Step 6: Once all these values are determined and the antenna is pre-pointed, begin a slow antenna sweep in azimuth each side of the calculated azimuth and repeat in small (0.5°) elevation increments. Carefully peak antenna pointing once the beacon is detected.

Step 7: If a temporary RF carrier is being used, it can also be used to peak the polariser. Because of the response of the feed, it is better to "null out" the marker and then rotate back 90° trying to peak directly. If a temporary marker had been used, it is valuable to use the spectrum analyser to find the satellites on-board beacon to double-check, that you are pointed to the desired Eutelsat S.A. satellite.

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[1] A recommended procedure for adjusting modulator deviation and demodulator sensitivity is given in Annex A, Bessel Zero Method.

2.2. Polarisation Alignment

Prior to any transmission to the satellite, the earth station shall optimise its polarisation plane alignment by means of the satellite on-board beacon. The procedures for this test is as follows:

Step 1 Connect the spectrum analyser to the X-polarisation output port of the antenna feed system.

Step 2 Adjust the spectrum analyser to receive the satellites beacon frequency.

Step 3 Gauge carefully the antenna in azimuth (AZ) and elevation (EL) to achieve maximum satellite beacon level on the spectrum analysers screen.

Step 4 When the satellite beacon is shown on the spectrum analysers screen ensure that the instruments sweep bandwidth and resolution bandwidth is optimised.

Step 5 Gauge carefully the polariser (or feed) in clockwise and counter clockwise direction until maximum receive beacon level is optimised. Mark the antenna and polariser (or feed) positions and note the beacon level value.

NOTE: Observe the moderate changes in beacon receive level while gauging the antenna and polariser (or feed) around the maximum beacon level readings.

Step 6 Remove the spectrum analyser from the X-polarisation port and connect the instrument to the Y-polarisation output port of the feed system without changing the previous frequency, sweep bandwidth and resolution bandwidth settings.

Step 7 Re-adjust the instruments sweep bandwidth and resolution bandwidth until the cross-polar component of the beacon level can be clearly measured on the spectrum analysers screen.

NOTE: Observe the very low receive level of the satellite beacon which is to be used for gauging the polariser (or feed) to achieve minimum overall cross-polarisation discrimination.

Step 8 Gauge very carefully the polariser (or feed) in clockwise and counter clockwise direction until minimum beacon level has been reached. Mark position and this beacon level value.

NOTE: Observe the very fast changes in receive beacon level when gauging very slowly the polariser (or feed), in counter clockwise direction, through the minimum beacon level reading on the spectrum analyser screen.

Feed system cross-polarisation optimisation (also called "Nulling") has been achieved when the polariser (or feed) has been adjusted and set to minimum satellite beacon receive level in Y-polarisation.

Minimum receive beacon level in Y-polarisation should normally correspond to maximum receive beacon level in X-polarisation at the same setting of the polariser (or feed).

Step 9 Compare the polariser (or feed) setting in X-polarisation with the polariser setting achieved in Y-polarisation (Step 8). It should be the same.

Step 10 Polarisation discrimination has now been optimised on-site.

2.3. Space Segment Access

Before start of transmission, the Eutelsat S.A. CSC will ascertain by means of the spectrum monitoring facilities that the space segment is free of any activated carrier in the bandwidth and polarisation as assigned by Eutelsat S.A.

The Station Under Test (SUT), under the control of the Eutelsat S.A. CSC, will illuminate the satellite at the allocated frequencies with the reduced EIRP (typically 10 - 20 dB below nominal). The carriers shall be dispersed with the nominal EDF/scrambling signal in accordance with the approved Transmission Plan and with the baseband/channel inputs terminated.

The Eutelsat S.A. CSC will check the Satellite down-link carrier frequency, which shall be in compliance with the approved Transmission Plan and the reduced EIRP.

2.4. Final EIRP Adjustment

The SUT will, under the control of the Eutelsat S.A. CSC, gradually increase the EIRP of the dispersed/scrambled carrier(s), up to the nominal level as given in the approved Transmission Plan, and confirm the final settings.

The Eutelsat S.A. CSC will verify and confirm the main carrier characteristics with the following objectives:

a)	RF Carrier EIRP:	nominal, ± 0.5 dB
b)	RF Carrier Frequency :	nominal, ± 250 kHz
c)	Main sound subcarrier:	6.60/6.65 MHz ± 5 kHz
d)	Additional sound subcarriers:	7.02/8.04 MHz ± 5 kHz
e)	Overall Link Polarisation Isolation :	optimised, at least 28 dB

2.5. Subjective Performance Assessment

NOTE: IfTransmission Line-up (TLU) tests are to be performed, the subjective performance assessment should be performed on the completion of the TLU.

The Eutelsat S.A. CSC and the user should observe the quality of the sound/video in accordance with the Performance Assessment Scale indicated in the table below:

Video Grade	Sound Program	Assessment	Definition of Impairment
V 5	P5	Excellent	Imperceptible
V 4	P4	Good	Perceptible but not annoying
V 3	P3	Fair	Slightly annoying
V 2	P2	Poor	Annoying
V 1	P1	Bad	Very annoying

NOTE: Use of the colour bar test pattern for assessment of the picture quality is not recommended. A 100% colour bar or electronically inserted captions used in conjunction with the 75 % colour bar may cause interference to adjacent carriers.

If any of the above tests produces results which are unsatisfactory, Eutelsat S.A. recommends that the (TLU) tests as detailed in Chapter 3 or 4 are effected to localise and identify the problem.

If on the other hand, the above tests are satisfactorily completed, the earth station can assume that it has now been granted **Authorisation to Operate** in the Eutelsat S.A. Space Segment as described in ESOG Module 110, Paragraph 3.2.

3. ANALOGUE TRANSMISSION LINE-UP TESTS (TLU)

The following tests are considered as most essential for all new stations which will operate analogue television in the Eutelsat S.A. system.

All video tests will be performed with the aid of an automatic video measuring device. An overview of all instruments needed for both Transmit and Receive Chain line-up tests are given in Annex I, together with some example models.

For each test the following conditions will apply unless indicated otherwise:

- The SUT will terminate the sound program carriers baseband/channel input(s) with its characteristic impedance (if combined with the video carrier).
- A nominal video baseband level will be used.
- The SUT will transmit its dispersed RF carrier at nominal EIRP.
- All baseband equipment shall be included at both ends.
- The TVCSM/(Receive E/S) will measure the received test signal at video baseband output.

An overview of key video and sound parameters is given in Annex B for the most commonly used analogue TV modulation schemes on Eutelsat S.A. satellites.

Upon completion, the test results shall be made available to Eutelsat S.A. by mail, fax, telex or any other commercially available data system when requested. Annex G to this Module includes the format for the test report.

3.1. Video Tests

Prior to performing the following tests, the SUT shall ensure that the sensitivity of the video modulator is properly adjusted, using the Bessel Zero Method, as described in Annex A.

3.1.1. FM Video Test Tone Deviation and Insertion Gain

The SUT test will transmit a full field test signal **Line 17**.

The TVCSM or Receive E/S will measure signal **element B2** of the received test signal and under the direction of the TVCSM or Receive E/S, the SUT will adjust, if necessary, the video deviation.

Objective: The insertion gain shall not exceed ±0.5 dB.

3.1.2. Video Amplitude Frequency Response

The SUT will transmit a full field test signal **Line 18**.

The TVCSM or Receive E/S will measure signal **elements C1 and C2** of the received test signal and plot the resultant frequency response.

3.1.3. Line-Time Waveform Distortion (Pulse/Bar Ratio)

The SUT will transmit a full field test signal **Line 17 or 330**.

The TVCSM or Receive E/S will measure signal **element B2** of the received test signal and plot the results.

Objective: The Pulse/Bar Ratio shall not exceed 3%.

3.1.4. Short-Time Waveform Distortion (2T Pulse/Bar Ratio and 2T Pulse Lobes)

The SUT will transmit a full field test signal **Line 17 or 330**.

The TVCSM or Receive E/S will measure 2T pulse/bar ratio **element B2-B1/B2** and 2T pulse lobes of the received test signal and plot the results.

Objectives: 2T pulse/bar ratio shall not exceed 12% (Step Response)
2T pulse lobes should be in accordance with CCIR Rec 567-1 (Pulse Response).

3.1.5. Chrominance-Luminance Gain Inequality

The SUT test will transmit a full field test signal **Line 17**.

The TVCSM or Receive E/S will measure signal **element F** of the received test signal.

Objectives: Chrominance-Luminance gain inequality shall not exceed ±10%.

3.1.6. Chrominance-Luminance Delay Inequality

The SUT test will transmit a full field test signal **Line 17**.

The TVCSM or Receive E/S will measure signal **element F** of the received test signal.

Objectives: Chrominance-Luminance delay inequality will not exceed ±50 nanoseconds.

3.1.7. Differential Gain and Differential Phase

The SUT will transmit a full field test signal **Line 330** with variable APL (Average Picture Level, 12,5% low and 87.5% high).

The TVCSM or Receive E/S will measure signal **element D2** of the received test signal.

Objectives: The differential phase measured at lower APL and higher APL shall not exceed 3 degrees.

The differential gain measured at low APL and at Higher APL shall not exceed 10%.

3.1.8. Luminance Non-Linear Distortion

The SUT will transmit a full field test signal **Line 17**.

The TVCSM or Receive E/S will measure signal **element D1** of the received test signal.

Objectives: The luminance non-linear distortion shall not exceed 10%.

3.1.9. Chrominance-Luminance Intermodulation

The SUT will transmit a full field test signal **Line 331** and variable APL (Average Picture Level, 12,5% and 87.5%).

The TVCSM or Receive E/S will measure signal **elements G1 and G2** of the received test signal.

Objectives: Chrominance-luminance intermodulation at low and high APL shall not exceed +/-4.5%.

3.1.10. Continuous Random Noise

The SUT will terminate with its characteristic impedance the input to the video modulator.

The TVCSM or Receive E/S will measure, using a video analyser with noise measuring capability, and equipped with low and band pass filters (referred to in Supplementary Test 5.7.) The measured RMS value of the unweighted and weighted random noise should be used to determine the signal to noise ratio.

Objectives: The S/N value should comply with the operational transmission or test plan.

3.1.11. Periodic Noise

The SUT will transmit blank level with **EDF** set to **OFF**.

The TVCSM or Receive E/S using an oscilloscope, (set to field mode) will check for any periodic noise while ensuring that no clamping is present.

Objectives: Periodic noise shall not exceed 2.2mV p-p
Signal to noise ratio: below 1 kHz $\geq$ 50 dB
1 kHz → 5 kHz $\geq$ 55 dB

See Supplementary Tests (Chapter 5) for more detailed measuring method.

3.1.12. Impulse Noise

The SUT will terminate with characteristic impedance the input to the video modulator.

The TVCSM or Receive E/S will measure using an oscilloscope (set to field mode) any impulse noise while ensuring that no clamping is present.

Objectives: Impulse noise of sporadic or of frequently occurring nature shall not exceed 39.4mV p-p
Signal to Impulsive Noise Ratio > 25 dB

See Supplementary Tests (Chapter 5) for more detailed measuring method.

3.2. Sound Sub-Carrier Tests

Prior to performing the following tests, the SUT shall ensure that the sensitivity of the Main and Companded sound sub-carrier modulator's are properly adjusted.

3.2.1. Video to Sound Sub-carrier Relative IF Level

This test requires an IF in-station adjustment, which is followed by a satellite IF test verification by the TVCSM. During this test, video and sound inputs are terminated (video pre-emphasis inserted, no video modulation, energy dispersal (EDF) disabled).

The SUT will connect a spectrum analyser to the IF point of the video modulator. The resultant spectrum will show the 1st Side Frequencies due to the deviation caused by the Sound Sub-carriers. A relative level measurement should be made between the 70 MHz carrier and the Main and Companded Sound Sub-carriers 1st side frequency components. A plot should be taken (See Annex F for typical plot).

Next, the SUT will transmit a residual video carrier to the satellite with the video and sound input/s terminated and all FM Sound Sub-Carriers including any companded channels. The TVCSM will verify that the performance objectives are met.

Objectives: The IF Level of the 1st Side Frequency component(s) for:

- Main Sound Sub-Carrier shall be -17.7 dBc relative to the residual video carrier loaded with all sound sub-carriers.
- Companded Sound Sub-Carriers relative to the residual video carrier should be -23.1 dBc.

3.2.2. Test Tone Deviation of the Main and Companded Sound Sub-carriers

The SUT will transmit a composite full field video carrier with test signal Line 330. The SUT will in turn apply at the input to each sound sub-carrier channel a -12 dBm0 test tone of 800 Hz for the main sound channel and 400 Hz for any companded sound channel.

The TVCSM or Receive E/S will measure the incoming test tone for each channel and record the level. If the objective is not met then the modulator at the SUT requires adjustment.

Objectives: The test tone shall be -12 dBm0 $\pm$ 0.5 db.

3.2.3. Sound Channel S/N (Weighted)

The SUT will transmit a composite full field video carrier. The SUT will in turn terminate each sound channel, with its characteristic impedance.

The TVCSM will in turn measure the S/N using psophometric noise measuring set.

Objectives: As per Transmission or Test Plan.

4. DIGITAL TRANSMISSION LINE-UP TESTS (TLU)

The following tests are considered as most essential for all new stations which will operate digital television in the Eutelsat S.A. system.

Upon completion, the test results shall be made available to Eutelsat S.A. by mail, fax, telex or any other commercially available data system when requested. Annex H to this Module includes the format for the test report.

4.1. Measurement of Carrier to Noise Power Density Ratio (Co/No)

The SUT will transmit a carrier modulated with a scrambled signal.

The TVCSM or Receive E/S will display the receive IF carrier spectrum with a spectrum analyser.

The TVCSM will measure the Carrier plus Noise, then the Noise. These two measurements should be used to determine the required C/N. Refer to Test 5.2 for detailed procedures.

The SUT will record its EIRP in dBW.

The TVCSM or Receive E/S will measure occupied bandwidth by the carrier within the 10 dB points of its spectrum.

Objective: The C/N and Occupied bandwidth will be as per the Transmission or Test Plan.

4.2. HPA Output Spectrum of Transmit Station at Nominal EIRP

The SUT, will adjust the spectrum analyser setting according to the bit rate such that the span width and resolution filter bandwidth are correct.

Measure the actual signal bandwidth at the -10 dB points at the HPA output test point, after all filtering, plot and record the spectrum.
Measure the level at the $\pm$ 0.5 points of the ABW (see: Mask for Digital Carriers, Annex E) and record.

The TVCSM or Receive E/S is not required to participate in this test.

Objective: The actual transmitted RF spectrum shall be within the limits of the mask given in Annex E.

NOTE: For further digital tests, see: Supplementary Tests.

5. SUPPLEMENTARY TESTS

5.1. Carrier-to-Noise (C/N) Ratio (Analogue)

Test Objectives:

1. To measure the C/N ratio of analogue carriers by means of a spectrum analyser at the TVCSM (or receive earth station).
2. The calculated C/N ratio will be as expected in the Eutelsat S.A. Transmission or Test Plan.

Test Equipment:

- Spectrum Analyser, with capability to measure noise power density.
- Printer/Plotter/Camera

Test Procedure:

Step 1: The SUT will radiate a dispersed carrier at nominal transmit frequency and EIRP. The satellite transponder will be set to the gain as indicated in the approved Eutelsat S.A. Transmission Plan.

Step 2: At the receive earth station, connect the spectrum analyser to the IF stage or, where this is not possible, via an additional pre-amplifier to the RF stage (*NOTE:* the AGC will be switched off when measuring at IF level!).

Step 3: At the receive earth station, record the value of the carrier level (C) in dBm. A typical spectrum analyser display for this measurement is shown in figure 5.1.a, together with the spectrum analyser settings to be used (NB: Noise Level **disabled**, Max Hold **enabled**).

Step 4: At the receive earth station, measure the value of the noise power density (N_o) in dBm/Hz. A typical spectrum analyser display for this measurement is shown in figure 5.1.b, together with the spectrum analyser settings to be used. (NB: Noise Level **enabled**, Max Hold **disabled**).

Step 5: Calculate the carrier to noise ratio (C/N) as follows:

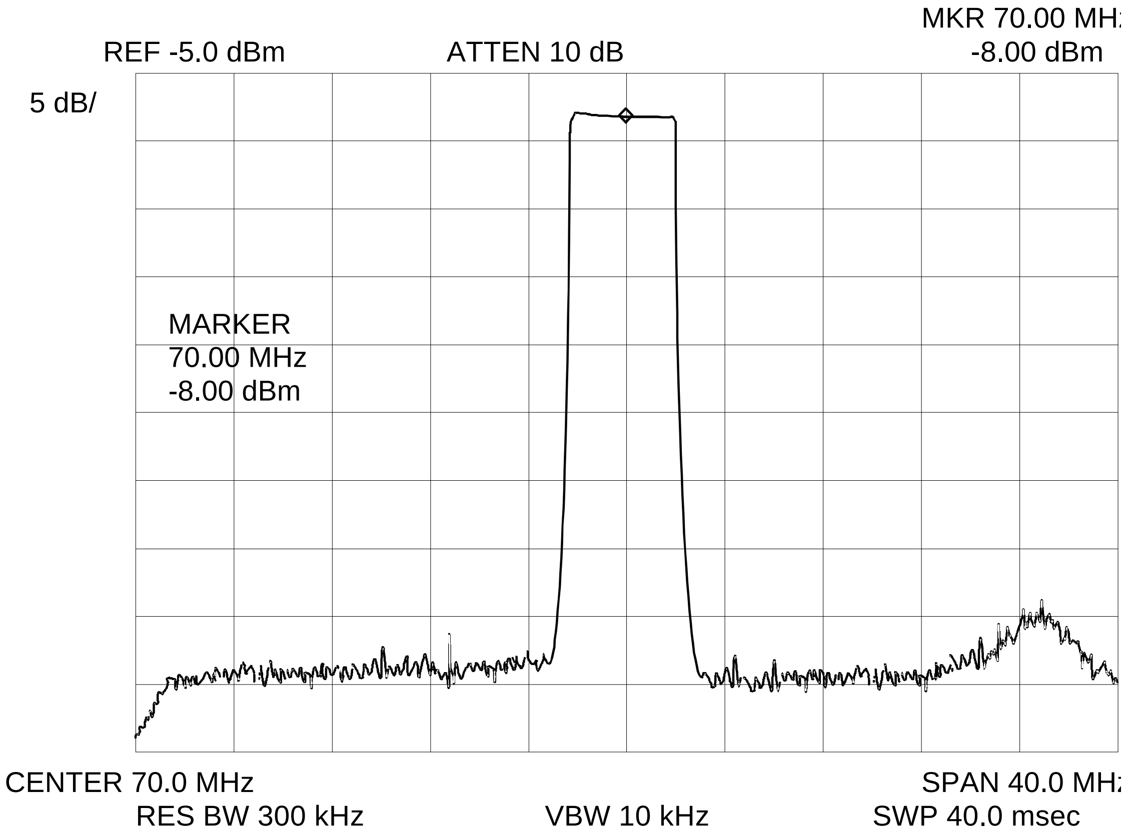
$$C/N = C - N_o - 10 \log_{10} (NBW) \qquad dB$$

where NBW = noisebandwidth (Hz), which may be obtained from the applicable IF-filer calibration record.

C/N ratio calculation example (based on Figures5.1.a and 5.1.b):

1. Figure 5.1.a: Carrier level C: -8.00 dBm
2. Figure 5.1.b: Noise power density N_o: -106.45 dBm/Hz
3. From If-filter calibration: noise power bandwidth: 38.408 MHz
4. C/N = -8.00 + 106.45 - 75.84 = 22.61 dB

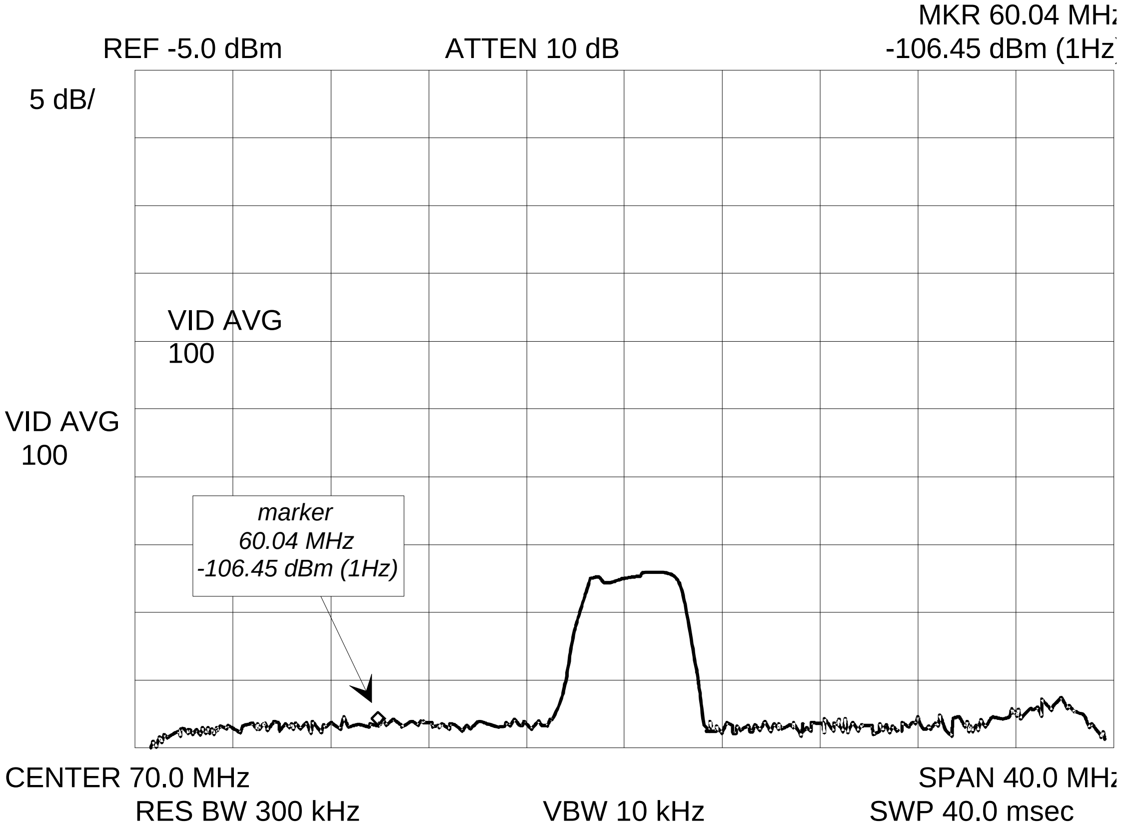
Figure 5.1.a, Measurement of Carrier Power



<u>Spectrum Analyser Settings:</u>

CENTRE FREQUENCY:	70 MHz (or applicable IF frequency)
RESOLUTION BANDWIDTH:	300 kHz
VIDEO BANDWIDTH:	10 kHz
SPAN:	40 MHz
SWEEP-TIME:	40 msec
SCALE:	5 dB/division
REFERENCE LEVEL:	as applicable
VIDEO AVERAGING:	disabled
MARKER POSITION:	centre frequency
NOISE LEVEL:	disabled
MAX. HOLD:	enabled

Figure 5.1.b, Measurement of Noise Power Density



Spectrum Analyser Settings

CENTRE FREQUENCY:	70 MHz (or applicable IF frequency)
RESOLUTION BANDWIDTH:	300 kHz
VIDEO BANDWIDTH:	10 kHz
SPAN:	40 MHz
SWEEP-TIME:	40 msec
SCALE:	5 dB/division
REFERENCE LEVEL:	same as in figure
VIDEO AVERAGING:	disabled
MARKER POSITION:	centre frequency + 5...10MHz
NOISE LEVEL:	enabled
MAX. HOLD:	disabled

5.2. Carrier-to-Noise Density (C_o/N_o) Ratio (Digital)

(Spectrum Analyser Method)

Test Objectives: 1. To measure the C_o/N_o ratio of digital carriers by means of a spectrum analyser at the TVCSM (or receive earth station).

2. The calculated C_o/N_o ratio will be as expected in the Eutelsat S.A. Transmission or Test Plan.

NOTE 1: A sample measurement for 2 MHz digital carriers is described below. The respective typical spectrum analyser measurement display including instrument settings are shown in Figure 5.2.a.

NOTE 2: The necessary data conversions are described in Annex D together with theoretical considerations.

NOTE 3: Explanations about definitions of C/N, (C_o/N_o) and E_b/N_o are shown in Annex D.

Test Principle: The $(C_o + N_o)/N_o$ ratio is measured directly by means of the Spectrum Analyzer "delta marker" function, after which a conversion is made to C_o/N_o and C/N_o

Test Equipment: - Spectrum Analyser, with capability to measure noise power density.
- Printer/Plotter/Camera

Test Procedure:

Step 1: The SUT will radiate a dispersed carrier at nominal transmit frequency and EIRP. The satellite transponder will be set to the gain as indicated in the approved Eutelsat S.A. Transmission Plan.

Step 2: The TVCSM will:

a) Connect the spectrum analyser to the appropriate test point and ensure that the display spectrum is at least 20 dB above the spectrum analysers noise floor (*NOTE:* the AGC will be switched off when measuring at IF level!).

b) Adjust the carriers sweep bandwidth to be 20 to 30 percent of the horizontal display.

c) Ensure that the spectrum analysers resolution filter bandwidth in use is less than 20% of the signal bandwidth (*NOTE:* A 100 kHz filter would be suitable for a 2.048 MBit/s carrier or within 1.7 MHz occupied bandwidth).

d) Adjust the spectrum analysers IF step attenuator to place the peak of the digital carrier as shown in Figure 5.2.a on some convenient horizontal reference line with the vertical scale set to 1 dB or 2 dB per division.

e) Use as much video filtering as practical to limit the uncertainty in the average level.

f) Use the delta marker function to take the difference between marker M2 and M1 as shown in Figure 5.2.a to read directly from the spectrum analyser the $(C_o + N_o)/N_o$ ratio; i.e. 1.855 MHz/- 14.30 dB (1 Hz).

g) Calculate the carrier-to-noise density ratio $(C_o + N_o)$ as described thereafter.

NOTE: This method provides meaningful results only if no inband spurious are present.

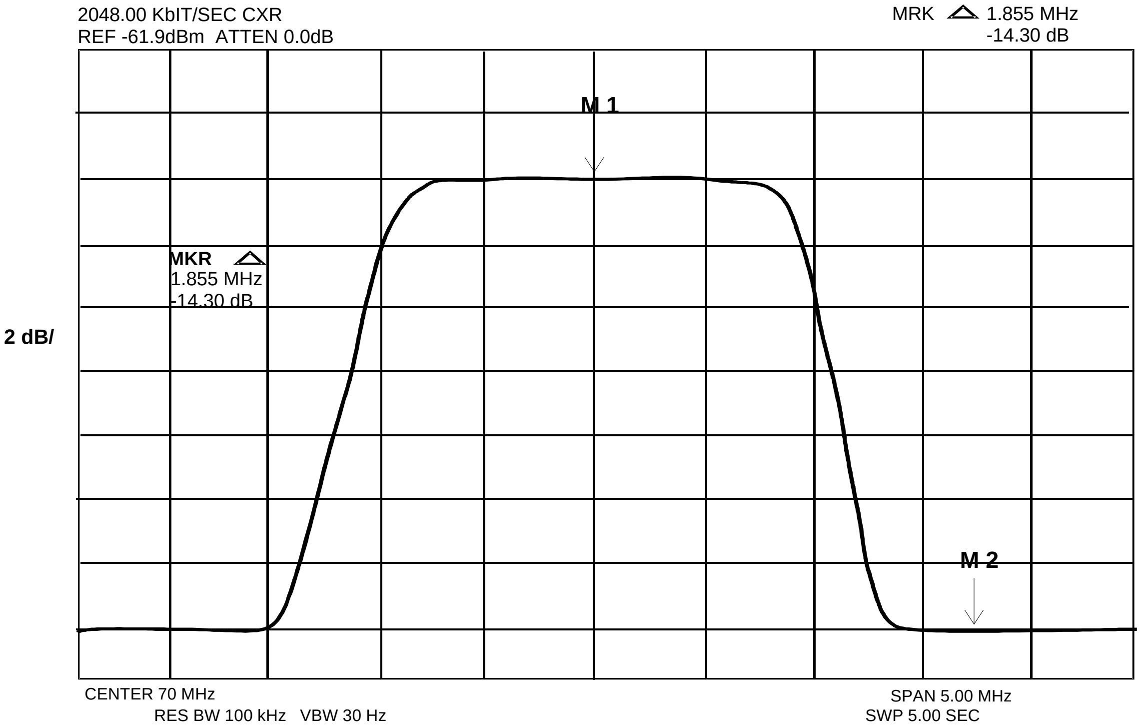
Digital Carrier C_o/N_o Ratio Calculations Example (based on Figure 5.2.a):

1. Take the reading as recorded from the spectrum analyser measurement as indicated in the test procedure above. This is the $(C_o + N_o)/N_o$ ratio.
2. Correct the $(C_o + N_o)/N_o$ by using a correction factor obtained by linear interpolation in the conversion table given in Annex C,

Conversion factor: -0.18 + 0.30 x (-0.14 + 0.18) = -0.168 dB

C_o/N_o = 14.3 - 0.168 = 14.13 dB

Figure 5.2.a, Digital $(C_o+N_o)/N_o$ Ratio Measurement



Spectrum Analyser Settings

CENTRE FREQUENCY:	70 MHz (or applicable IF frequency)
RESOLUTION BANDWIDTH:	100 kHz
VIDEO BANDWIDTH:	30 Hz
SPAN:	5 MHz
SWEEP-TIME:	automatic; 5 sec
SCALE:	2 dB/division
REFERENCE LEVEL:	as applicable
VIDEO AVERAGING:	disabled
MARKER POSITION:	centre frequency (C_o) and $\pm$ x MHz (N_o)
NOISE LEVEL:	disabled
MAX. HOLD:	disabled

5.3. IF to IF Response

Test Purpose: 1. To measure transmit-filter to receive-filter IF amplitude/frequency and group-delay/ frequency response.

2. To measure the characteristics of the transmit IF filter only.

Performance Objective:

1a. The transmit/receive IF-filter amplitude/ frequency response will be within the limits as shown in Figure 5.3.a. (*NOTE:* The minimum total swept IF bandwidth for FM carriers will be in conformance with the bandwidths as given by B/b and C/c in Figure 5.3.a).

1b. The transmit/receive IF filter group- delay/frequency response will be within the limits as shown in Figure . (*NOTE:* The minimum total swept IF bandwidth for FM carriers will be in conformance with the bandwidth given by C/c in Figure)

2. The amplitude/frequency and group-delay/frequency response of the Transmit IF filter **only** will be half the values indicated in the figures.

Test Equipment: **-** IF Measuring Instrument
- Printer/Plotter/Camera

NOTE: It is important that the test equipment at both ends is compatible for the performance of measurements.

Test Procedure Amplitude Frequency Response:

Step 1: The SUT will connect the test instruments IF generator and IF receiver back- to-back and arrange IF test instrument calibration as follows:

- Adjust the IF generators output level to the nominal IF input level of the up-link transmission equipment.
- Adjust the IF generators sweep bandwidth in accordance with the carriers allocated IF bandwidth as listed in the Eutelsat S.A. Transmission or Test Plan (normally corresponding to one of the lines in the tables of figures 5.3.a and b).
- After calibration connect the IF generator output to the IF input of the transmit IF filter of the up-link equipment.

NOTE: Ensure that the IF test instruments 18 Hz sweep frequency is always applied during testing.

Step 2: On request of the TVCSM the SUT will transmit the carrier at an EIRP such that the satellite TWT is operating in the linear region and not in saturation.

Step 3: The TVCSM will disable the receive AGC, connect the IF test equipment receiver at IF level in front of (respectively after) the receive IF filter and proceed as follows:

- Ensure the carriers IF swept bandwidth does not exceed B/b of figure 5.3.a
- Request the SUT to increase the carriers IF swept bandwidth to check the transmit IF filters out-of-band performance (normally C/c of figure 5.3.a) and conduct another measurement.

Test Procedure Group Delay Characteristics:

Step 1: The SUT will connect the test instruments IF generator and IF receiver back-to-back and arrange IF test instrument calibration as follows:

- Adjust the IF generators output level to the nominal IF input level of the up-link transmission equipment.
- Select the IF generators 277,778 kHz baseband modulation frequency and remove the 18 Hz sweep signal.
- Adjust the IF generators baseband modulation frequency level for a RMS deviation of 200 kHz. Other settings will be advised if necessary.

NOTE: The RMS deviation of 200 kHz can be achieved by adjusting the level of the 277,778 kHz baseband modulation frequency for first carrier drop-out and then reducing this level by 7.5 dB.

Step 2: Re-apply the 18 Hz sweep frequency, and adjust the IF test instruments IF output level to give a combined sweep plus baseband modulation signal in accordance with the RF carriers allocated IF bandwidth as listed in the Eutelsat S.A. Transmission Plan (normally corresponding to one of the lines in the tables of figures 5.3.a and b). After calibration connect the IF generator output to the IF input of the transmit IF filter of the up-link equipment.

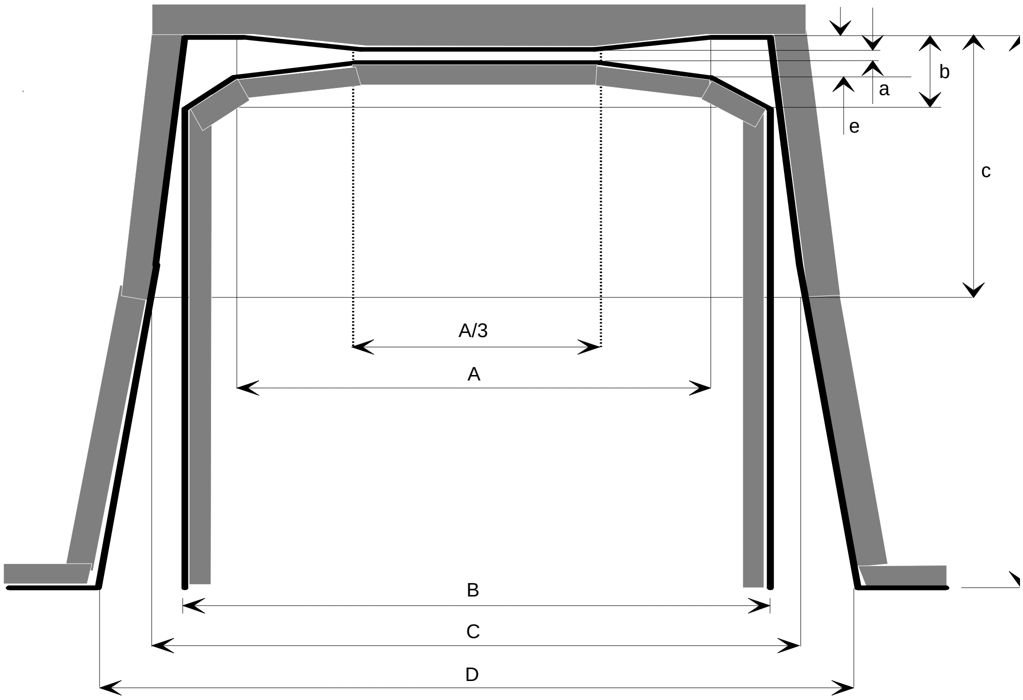
Step 3: On request of the TVCSM the SUT will transmit the RF carrier at nominal EIRP.

NOTE: Ensure that the IF test instruments 18 Hz sweep frequency is always applied during testing.

Step 4: The TVCSM will disable the receive AGC, connect the IF test instruments receiver at IF level in front of (respectively after) the receive IF filter and proceed as follows:

Step 5: Adjust the sensitivity of the IF test equipment receiver. Calibrate the display in accordance with the carriers allocated IF bandwidth as listed in the Eutelsat S.A. Transmission Plan (normally corresponding to one of the lines in the tables of figures 5.3.a and b).

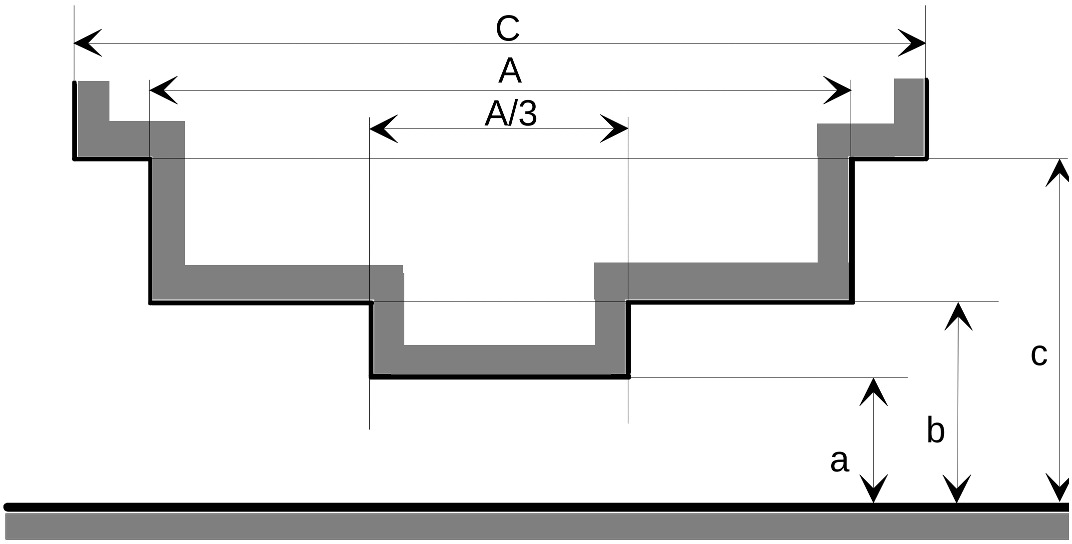
Figure 5.3.a Amplitude Frequency Response Mask



TV B/W (MHz)	Deviation (MHz/V)	A (MHz)	B (MHz)	C (MHz)	D (MHz)	a[1] (dB)	b[1] (dB)	c[1] (dB)	d[1] (dB)	e[1] (dB)
17.5	15	12.6	15.75	18.0	26.5	0.6	5.0	13.0	50.0	0.2
20.0	16	14.4	18.0	20.5	28.0	0.6	5.0	15.0	50.0	0.2
25.0	18	18.0	22.5	25.75	34.0	0.6	5.0	16.0	50.0	0.4
27.0	16/19	19.4	24.3	27.8	36.0	0.6	5.0	16.0	50.0	0.4
30.0	22	24.0	30.0	35.0	50.0	0.6	5.0	14.0	50.0	0.6
36.0	25	28.8	36.0	45.25	60.0	1.2	5.0	20.0	50.0	0.6

NOTE [1]: For transmit IF Filter characteristics only the value in columns a to e must be divided by 2.

Figure 5.3.b Group delay response Mask



Signal Bandwidth(MHz)	A (MHz)	C (MHz)	a[1] (ns)	b[1] (ns)	c[1] (ns)
17.5	12.6	14.2	12.0	12.0	30.0
20.0	14.4	16.6	8.0	10.0	30.0
25.0	18.0	20.7	6.0	10.0	30.0
27.0	19.4	22.4	6.0	10.0	30.0
30.0	24.0	30.0	10.0	10.0	30.0
36.0	28.8	33.1	6.0	10.0	30.0

NOTE [1]: For transmit IF Filter characteristics only the value in columns a to c must be divided by 2.

5.4. RF Carrier Energy Dispersal Waveform and Frequency (EDF)

Performance Objective:

1. EDF Waveform: Triangular.
2. EDF Frequency: 25 Hz, ± 2 Hz (625/50).
3. EDF Spreading: 2 MHz pp with modulating signal present, 4 MHz pp without video signal present.

Test Procedure:

Step 1: The SUT will at first transmit a full field test signal Line 17 with the sound channel input/s terminated (if combined with the video carrier).

Step 2: The test signal will be removed upon request of the TVCSM and the video baseband input terminated.

Step 3: The TVCSM will measure the functioning of the EDF in both conditions on the spectrum analyser.

NOTE: For demonstration of the correct EDF generator settings it is recommended to request transmission of blank level signal by the SUT.

5.5. Steady State Synchronising Signal Non-Linear Distortion

Performance Objective: At low and high APL +5 % / -10 %

Test Procedure:

Step 1: The SUT will transmit CCITT test signal No. 3 with intermediate lines black at variable APL (Average Picture Level, 12,5% low and 87,5% high) and the sound channel input/s terminated (if combined with the video carrier).

Step 2: The TVCSM will measure the amplitude of the line synchronising pulses during the vertical-interval.

NOTE 1: Synchronising pulse re-generating equipment shall not be used on the transmit or receive side of the satellite radio link.

NOTE 2: To conduct a measurement in the presence of sound-in-sync signals, the sync amplitude must be measured in the vertical interval between the midpoint of the last broad pulse of each field.

5.6. Main Sound Channel Non-Linear Distortion

Performance Objective:

Between 40 - 125 Hz:	0.70% or 43 dB
125 - 7500 Hz:	0.35% or 49 dB

Test Procedure:

Step 1: The SUT will terminate the video baseband input (if combined with the video carrier) and transmit the 60, 90, 533 and 800 Hz/+ 9 dBm test tone applied in turn to each sound channel input.

NOTE: The audio signal generator should have a spectral purity better 0.25%

Step 2: The TVCSM will measure, in turn, the corresponding 2nd/3rd harmonics of the test tones (180 Hz and 1600 Hz) in each of the sound channels, as applicable.

NOTE: For the companded sound channels the appropriate test frequencies should be selected.

5.7. Video Transmit Baseband Low-Pass Filter Characteristics

Performance Objective:	Between: 5.0 - 5.5 MHz	Attenuation:	-3 dB
	> 6.2 MHz		-30 dB
	> 6.5 MHz		-40 dB
	> 7.0 MHz		> -40 dB

Test Procedure:

Step 1: The SUT will terminate the sound program channel input/s (if combined with the video carrier) and transmit the test tones in the video baseband.

NOTE: Test tones should be bilaterally agreed to allow demonstration of the video/sound separation filter curve between 5.0 MHz and 7.0 MHz.

Step 2: The TVCSM will measure with the selective measuring instrument this video baseband sections amplitude frequency response.

5.8. Mutual Interference

Performance Objective:	Weighted Noise:	≥ – 47 dBm0p RMS
	or	≥ – 42 dBq0p Quasi-Peak Noise
	Unweighted Noise:	≥ – 41 dBm0 RMS
	or	≥ – 36 dBq0 Quasi-Peak Noise

Test Procedure:

Step 1: The SUT will terminate the sound program channel input/s (if combined with the video carrier) and transmit a full field test signal Line 17.

Step 2: The TVCSM will measure the weighted and unweighted interference noise levels with the RMS noise measuring instrument (ITU-R Rec. 567-3) in the sound channel output/s.

NOTE: Although sound to video channel interference is not expected the reversed test may be performed.

5.9. C/N versus BER Performance at the Receive E/S (Digital Carriers)

Test Purpose: To record the C_o/N_o and BER performance curve at the receiving earth station by varying the transmit up-link EIRP, in order to reduce the C_o/N_o from nominal in defined steps until sufficient reliable non- zero BER data points are measured to characterise the carrier performance taking into account actual transmission parameters, actual earth station G/T and the demodulation threshold performance.

NOTE: This test should only be conducted under clear sky conditions.

Test Equipment:
- Spectrum Analyser
- BER Test Set

Test Procedure:

Step 1: The carrier under test shall be radiated with the nominal EIRP as established during PTLU Test 2.4, with the Eutelsat S.A. CSC and/or the receive station confirming the corresponding down-link level and C_o/N_o, before proceeding with the test.

Step 2: At the transmit earth station, connect the BER generator to the modulator input or, if FEC is used, to the FEC encoder input. At the receive earth station, connect the BER receiver to the demodulator output or to the FEC decoder output, if FEC is used. At both earth stations, set the pattern mode switch on the BER test set to a Pseudo Random Bit Sequence (PRBS) for a pattern conforming to the bit rate of the carrier under test.

Step 3: At the transmit and receive earth station set the BER test set according to the manufacturers instructions. The receive earth station records the number of errors over the appropriate test period depending on the bit rate.

Step 4: At the transmit earth station, decrease the EIRP in defined steps (e.g. nominal EIRP -3 dB; -4 dB etc.), at the receive station measure the BER as prescribed in Step 3. Repeat this process until the receive earth stations modem continuously loses synchronisation. Record for each step, the C_o/N_o, the corresponding up-link EIRP, test period, BER and weather conditions for inclusion in the test report.

Step 5: Increase the transmit earth station's EIRP in increments of 0.3 to 0.5 dB until the receive modem regains sync.

Step 6: Measure and record the C_o/N_o up-link EIRP and BER.

Step 7: Repeat Step 5 through 6 until at least three non-zero BER readings are obtained. Record the BER, EIRP and C_o/N_o. Repeat Step 5 and 6 until a BER reading better than 10^{-6} is obtained.

Step 8: Upon completion of Step 7 above, the transmit earth station shall restore the nominal EIRP as established under PTLU Test 2.4.

5.10. BER Continuity Test (Digital Carriers)

Test Purpose: To validate the BER performance of the satellite link between the transmit and the receive earth stations over a 24 hour test period. The test will be conducted under nominal link conditions.

Test Equipment: BER Test Set

Test Procedure:

Step 1: The carrier under test should be radiated with the nominal EIRP as established during PTLU Test 2.4.

Step 2: At the transmit earth station, connect the BER generator to the modulator input or, if FEC is used, to the FEC encoder input. At the receive earth station, connect the BER receiver to the demodulator output or to the FEC decoder output, if FEC is used. At both earth stations, set the pattern mode switch on the BER test set to a Pseudo Random Bit Sequence (PRBS) for a pattern conforming to the bit rate of the carrier under test.

Step 3: At the transmit and receive earth station, set the BER test set according to the manufacturers instructions and record, at the receive earth station, the number of errors over convenient test intervals throughout the next 24 hours, and compute the BER.

Annex A - Bessel Zero Method

Test Objectives:

a. To confirm video modulator deviation and video demodulator sensitivity setting prior to access the satellite.

b. To achieve the performance objective: the video insertion gain shall be 0 db $\pm$ 0.1 dB.

Test Equipment:

- Video Signal Generator
- Frequency Counter
- Baseband Signal Generator
- Spectrum Analyser
- Waveform Monitor

Test Procedure:

Step 1: Connect the baseband signal generator to the baseband input of the video modulator and the spectrum analyser to the modulators IF output. Switch EDF "OFF". Terminate the sound program channel(s) with its characteristic impedance when combined with the video carrier.

Step 2: Use the frequency counter to set on the signal generator the crossover frequency (1.512 MHz) and apply the appropriate first carrier drop-out level according to Table 1 to the video baseband input of the video modulator including all baseband equipment.

Step 3: Observe the output of the modulator with the spectrum analyser and adjust the video modulator deviation sensitivity to achieve "First Carrier Drop-Out". As the modulators deviation adjustment is now correct, do not change the setting of the modulator sensitivity control.

Step 4: Establish a modulator-demodulator loop at IF level. Connect the video signal generator to the video baseband input and the waveform monitor to the video baseband output. Apply a full field video signal Element B2 Signal Line 17 at a level of 1 V_{pp} (0 dBV) to the video baseband input. Determine the video insertion gain and adjust, if necessary, the video baseband output level of the video demodulator to obtain the nominal value of 1 V_{pp}.

Bessel Theory:

The following lines briefly describe the underlaying theory for the procedure given before.

In general, the result of frequency modulation may be expressed as:

$$Y = a \sin (\omega_o t + m \sin(\omega_m t)) \quad (1)$$

where m is the ratio of peak excursion to the modulating frequency and ω_o is the carrier frequency.

Expanding equation (1) results in a component at the carrier frequency of $\omega = 0$; and the sideband at $\omega_o+\omega$, $\omega_o+2\omega_m$, etc.

The amplitude of the carrier frequency component is:

$$J_o (m) \quad (2)$$

where J_o (m) is the zero-order Bessel function of m.

A table of Bessel functions will show that $J_o(m)$ becomes zero when m = 2.405 and at other higher values of m. The condition described above of the carrier component becoming zero when m = 2.405 is known as the "First Carrier Drop-Out". In general, the relation between the peak deviation and the modulating frequency when the First Carrier Drop-Out occurs is:

$$\text{Peak Deviation} = 2.405 \times \text{modulating frequency} \qquad (3)$$

It is common practice for fm modulators with pre-emphasis to set deviation at the neutral frequency of the pre-emphasis network, the so called "Crossover Frequency". This because we know that the Peak Deviation at Crossover Frequency with nominal input signal applied should be ΔF [1].

Hence, assuming a nominal input level of 1.0 Volt_{pp}, we find for the signal level at which First Carrier Drop-Out should occur:

$$L = 20 \, \text{Log}_{10} \left[\frac{2.405 \times \text{Crossover Frequency}}{\Delta F} \right] \qquad (4)$$

where L is the level at the video input in dBV.

If "First Carrier Drop-Out" does not occur at this level, the modulator sensitivity should be adjusted.

The following table gives the values of L for the most commonly used modulation standards in the Eutelsat S.A. system.

IF Bandwidth (MHz)	Deviation if 0 dBV Applied		ΔF (MHz)	L 1st Carrier Drop Out Level (dBV)
	At Crossover Frequency (MHz p-p)	At 15 kHz (MHz p-p)		
36	25	7.04	12.5	-10.72
30	22	5.35	11.0	-9.61
27	19	5.35	9.5	-8.34
27	16	4.50	8.0	-6.84
25	18	5.07	9.0	-7.87
20	16	4.50	8.0	-6.84
17.5	15	4.22	7.5	-6.28

[1] ΔF defined here corresponds to half the peak-to-peak deviation normally mentioned as TV signal modulation parameter.

Annex B - Commonly Used Transmission Parameters

VIDEO

IF Bandwidth (MHz)	P-P Deviation if 0 dBV Applied (MHz)		P-P Energy Dispersal Waveform (mV)	
	At Crossover Frequency [1]	At 15 kHz	With Video [2]	Without Video [3]
36	25	7.04	284	568
30	22	5.35	373	746
27	19	5.35	373	746
27	16	4.50	443	886
25	18	5.07	394	788
20	16	4.50	443	886
17.5	15	4.22	473	946

NOTE [1]: Crossover frequency 1.512 MHz.
NOTE [2]: Peak to Peak Deviation with video 2 MHz.
NOTE [3]: Peak to peak deviation without video 4 MHz.

AUDIO

Audio Baseband Peak to peak Amplitude:

As a typical example, the following table gives the values of the baseband peak to peak amplitude of subcarrier before pre-emphasis for a video frequency deviation of 16 MHz/V and 25 MHz/V.

Subcarrier Type	number	frequency (MHz)	modulation index	C 16 MHz/V (mV)	C 25 MHz/V (mV)
Uncompanded	a	6.60	0.26	155.43	99.48
Uncompanded	b	6.65	0.26	156.61	100.23
Companded	1	7.02	0.14	89.02	56.97
Companded	2	7.20	0.14	91.30	58.43
Companded	3	7.38	0.14	93.59	59.90
Companded	4	7.56	0.14	95.87	61.36
Companded	5	7.74	0.14	98.15	62.82
Companded	6	7.92	0.14	100.43	64.28
Companded	7	8.10	0.14	102.72	65.74
Companded	8	8.28	0.14	105.00	67.20
C =baseband peak to peak amplitude of the subcarrier before pre-emphasis. **Values given are for 16 MHz/V and 25 MHz/V video deviation.**					

The peak to peak test tone deviations at the pre-emphasis cross-over frequency are:

- uncompanded: 170 kHz (typical, depending upon the application)
- companded: 100 kHz

The levels of the sound sub-carriers can be derived for other values of the video frequency deviation by using the following formulae:

$$C_{before\ p.e.} = C_{after\ p.e.} / 1.38$$

$$C_{after\ p.e.} = \frac{2 \times f_{sub} \times m \times 1000}{\Delta f} \qquad [mV]$$

where:

m : subcarrier modulation index (0.26 for main and 0.14 for companded subcarriers, see table previous page)

f_{sub}: subcarrier frequency in MHz

Δf: video frequency deviation in MHz/V

Annex C - Theory of C/N Spectrum Analyser Measurement

A convenient method of measuring carrier-to-noise density ratio (C/N_o) uses a spectrum analyser. Good results can be obtained if care is taken in operation of the instrument. The spectrum analyser measurement can be converted to a carrier-to-noise density ratio (C/N_o) by the method described below. A modulated QPSK transmission that uses a scrambler has a spectral density (C_o) at its centre frequency that is a function of the total carrier power and the transmission rate. This can be expressed as:

$$C_o = C - 10 \log (R/2) \quad \text{dBW/Hz} \quad (1)$$

where : C_o = Spectral Density dBW/Hz

C = Carrier Power dBW

R = Transmission Rate bit/s

An alternate form of the same expression is:

$$C_o = C + 3 - 10 \log (R) \quad \text{dBW/Hz} \quad (2)$$

A spectrum analyser using a resolution bandwidth that is less than the signal bandwidth will measure the carrier power spectral density. When a PSK signal is measured in the presence of noise, the spectrum analyser will display the ratio of the carrier spectral density and the noise spectral density. Since the ratio is of two spectral densities, the value will be independent of the actual noise bandwidth of the spectrum analyser resolution filter. Therefore, it is not necessary to know either the noise bandwidth or the log converter RMS correction factor to correctly measure the ratio of two spectral densities.

The ratio of the carrier spectral density and the noise spectral density (which the spectrum analyser measures) is actually a $(C_o+N_o)/N_o$ ratio. The correction factors given in the table on the next page must be used to give the actual C_o/N_o ratio.

$\frac{(C_o + N_o)}{N_o}$ (dB)	Correction Factor (dB)	$\frac{C_o}{N_o}$ (dB)
3.0	- 3.02	0.0
3.5	- 2.57	0.9
4.0	- 2.20	1.8
4.5	- 1.90	2.6
5.0	- 1.65	3.3
5.5	- 1.44	4.1
6.0	- 1.26	4.7
6.5	- 1.10	5.4
7.0	- 0.97	6.0
7.5	- 0.85	6.6
8.0	- 0.75	7.2
8.5	- 0.66	7.8
9.0	- 0.58	8.4
9.5	- 0.52	9.0
10.0	- 0.46	9.5
11.0	- 0.36	10.6
12.0	- 0.28	11.7
13.0	- 0.22	12.8
14.0	- 0.18	13.8
15.0	- 0.14	14.9
16.0	- 0.11	15.9
17.0	- 0.09	16.9
18.0	- 0.07	17.9
19.0	- 0.06	18.9
20.0	- 0.04	20.0

C_o/N_o Conversion Table

The C_o/N_o ratio thus obtained can easily be converted into the common units used to measure signal-to-noise ratios through the following derivation:

$C_o = C + 3 - 10 \log (R)$	dBW/Hz	(2)
$C = C_o - 3 + 10 \log (R)$	dBW	(3)
$C/N_o = C - N_o$	dB/Hz	(4)
$C/N_o = C_o - 3 + 10 \log (R) - N_o$	dB/Hz	(5)
$C/N_o = C_o/N_o - 3 + 10 \log (R)$	dB/Hz	(6)

Annex D - Relationship between C/N, $(C_o+N_o)/N_o$ and E_b/N_o

1- C/N_o: Carrier-To-Noise Spectral Density Ratio

The carrier-to-noise spectral density ratio is an "artificial" measure of signal-to-noise ratio. It is artificial in the sense that it implies that it is possible to measure noise power in a filter having a noise bandwidth of 1 Hertz. Real measurements made with actual filters of wider bandwidth must be converted to express the C/N_o. The carrier-to-noise spectral density is a useful measure, as it expresses satellite link performance in terms that are independent of the measuring method. The "artificial" measure can be related to a realisable measurement as:

$$C/N_o = C/N + 10 \log (B) \quad \text{dB/Hz} \quad (1)$$

Where: C/N is the measured ratio using a filter of bandwidth B Hertz.

It has been assumed that the QPSK signal will occupy a bandwidth equal to 0.6R, where R is the actual transmission rate. This bandwidth, (0.6R), is used to calculate the signal's C/N:

$$C/N_o = C/N + 10 \log (0.6R) \quad \text{dB/Hz} \quad (2)$$

$$C/N = C/N_o - 10 \log (0.6\ R) \quad \text{dB} \quad (3)$$

$$C/N = C/N_o + 2.2 - 10 \log (R) \quad \text{dB} \quad (4)$$

This relation for C/N is only valid for a filter bandwidth equal to the occupied bandwidth of the QPSK signal. It is important to use the actual transmission rate for R.

2- E_b/N_o: Energy Per Bit/Noise Power Per Hertz

The E_b/N_o is commonly used to evaluate the performance of digital modems. It is defined by the general formula as:

$$E_b/N_o = C/N_o - 10 \log (\text{data rate}) \quad \text{dB} \quad (5)$$

where: E_b = Energy Per Bit (referred to the data rate) dBW/Hz

N_o = Noise Spectral Density dBW/Hz

C = Carrier Power dBW

The data rate in bits per second could be the symbol rate, transmission rate, composite rate or information rate. The E_b/N_o is then referred to the chosen data rate, and it is important to bear that in mind when using the E_b/N_o in any calculations.

Just as a C/N measurement has no real significance without a definition of the measurement bandwidth, E_b/N_o must be carefully specified in terms of the data rate associated with the value. Modems having built-in codecs are typically specified by the manufacturer in terms of the uncoded or input composite data rate E_b/N_o.

The composite data rate is the sum of the information rate and the overhead (OH) bit rate and does not include any bits for forward error correction (FEC).

The composite rate E_b/N_o is defined as follows :

$$E_{bc}/N_o = C/N_o - 10 \log (IR + OH) \quad (6)$$

where : IR= information rate (bits/sec)

OH= overhead (bits/sec)

When FEC is used, the "Transmission Rate (R)" is generated by the addition of forward error correction (FEC) information to the uncoded composite rate. The transmission rate is the product of the composite rate and the inverse of the FEC coding rate.

The transmission rate E_b/N_o is defined as follows:

$$E_{bt}/N_o = C/N_o - 10 \log (R) \quad (7)$$

where: R = transmission ratebits/sec

Thus, the transmission rate of a Rate 3/4 system will be 1.333 (i.e. 4/3) times the composite rate and the transmission rate E_b/N_o will be 1.25 dB (10 log 4/3) less than the composite rate E_b/N_o, for Rate 3/4 FEC.

The transmission rate of a Rate 1/2 system will be 2 times the composite rate. Therefore, the transmission rate E_b/N_o will be 3 dB (10 log 2) less than the composite rate E_b/N_o for Rate 1/2 FEC.

The transmission rate E_b/N_o has particular relevance to spectrum analyser C_o/N_o measurements. For QPSK, the transmission rate E_b/N_o is 3 dB less than the spectrum analysers C_o/N_o. The relationship between C/N_o, C_o/N_o, E_b/N_o and C/N is shown in the following.

3- C_o/N_o, C/N_o, E_b/N_o and C/N

$C/N_o = C - N_o$	dB/Hz	(8)
$C_o = C + 3 - 10 \log (R)$	dBW/Hz	(8a)
$C = C_o - 3 + 10 \log (R)$	dBW	(9)
$C - N_o = C_o - 3 + 10 \log (R) - N_o$	dB/Hz	(10)
$\boxed{C/N_o = C_o/N_o - 3 + 10 \log (R)}$	dB/Hz	(11)
E_{bt}/N_o [1] $= C/N_o - 10 \log (R)$	dB	(7)
Ebt/N_o [1] $= C/N_o - 3 + 10 \log (R) - 10 \log (R)$	dB	(12)
$\boxed{E_{bt}/N_o\ [1] = C/N_o - 3}$	dB	(13)
$\boxed{E_{bc}/N_o\ [2] = C/N_o - 1.75 \text{ (for rate 3/4 FEC)}}$	dB	(14)
$\boxed{E_{bc}/N_o\ [2] = C/N_o \text{ (for rate 1/2 FEC)}}$	dB	(15)

Finally, for the C/N in the QPSK occupied bandwidth:

$C/N = C/N_o + 2.2 - 10 \log (R)$	dB	(4)
$C/N = C_o/N_o - 3 + 10 \log (R) + 2.2 - 10 \log (R)$	dB	(16)
$\boxed{C/N = C_o/N_o - 0.8}$	dB	(17)

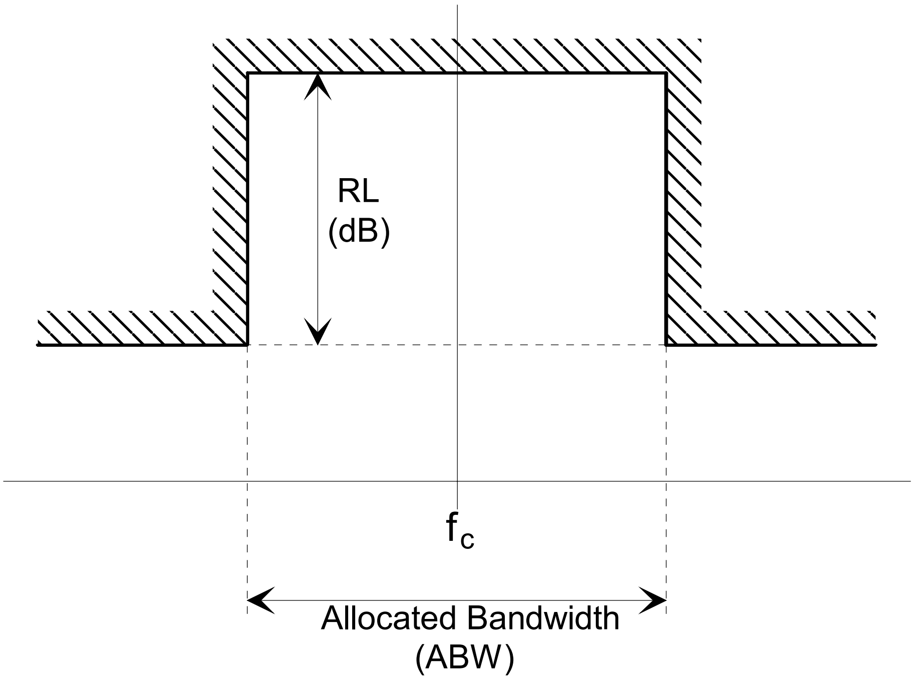
To reiterate, C_o/N_o is the ratio of carrier to noise spectral density obtained from the spectrum analyser measurement after correction for the $(C_o + N_o)/N_o$ difference. In all cases, R is the actual transmission rate.

$C_o/N_o =$	$C/N_o + 3 - 10 \log (R)$	dB	(11)
$C_o/N_o =$	$E_{bt}/N_o + 3$	dB	(14)
$C_o/N_o =$	$E_{bc}/N_o + 1.75$ for Rate 3/4 FEC	dB	(13)
$C_o/N_o =$	E_{bc}/N_o for Rate 1/2 FEC	dB	(15)
$C_o/N_o =$	$C/N + 0.8$	dB	(18)

[1] *E_{bt}/N_o relates to the transmission rate R.*

[2] *E_{bc}/N_o relates to the composite data rate.*

Annex E - Mask for Digital Carriers



The value for ABW is stated in the Eutelsat S.A. Transmission Plans, being typically 1.4 times the Transmit Symbol Rate (TSR).

The value for RL (Relative Level) depends on the TSR and on the allocated Reference Carrier EIRPo. The beam edge is defined as the satellite receive G/T contour of 0 dB/K for all satellites and frequency bands, except for :

- Ka-Band transmissions on Eutelsat Hot Bird 13A (previously HB6) for which the beam edge is defined as the satellite G/T contour of 10 dB/K.

- Ka-Band transmissions on KA-SAT for which the beam edge is defined as the satellite G/T contour of 18 dB/K.

Both values, TSR and $EIRP_o$ are stated in the Eutelsat S.A. Transmission Plans.

The formulae to calculate RL are:

1- Case of 14.0 GHz Uplink Frequency Band:

$RL = EIRP_o - 10 \log_{10}(TSR) - 36$ dBW for: $TSR \leq 4$
$RL = EIRP_o - 42$ dBW for: $4 < TSR \leq 12.5$
$RL = EIRP_o - 10 \log_{10}(TSR) - 31$ dBW for: $TSR > 12.5$

with TSR expressed in **Mbaud**.

2- Case of 18.0 GHz Uplink Frequency Band:

$RL = EIRP_o - 10 \log_{10}(TSR) - 39$ dBW for: $TSR \leq 4$
$RL = EIRP_o - 45$ dBW for: $4 < TSR \leq 12.5$
$RL = EIRP_o - 10 \log_{10}(TSR) - 34$ dBW for: $TSR > 12.5$

with TSR expressed in **Mbaud**.

Some typical values for RL are given in the following tables:

Table 5.a: Typical values for RL for 14.0 GHz Uplink Frequecy Band

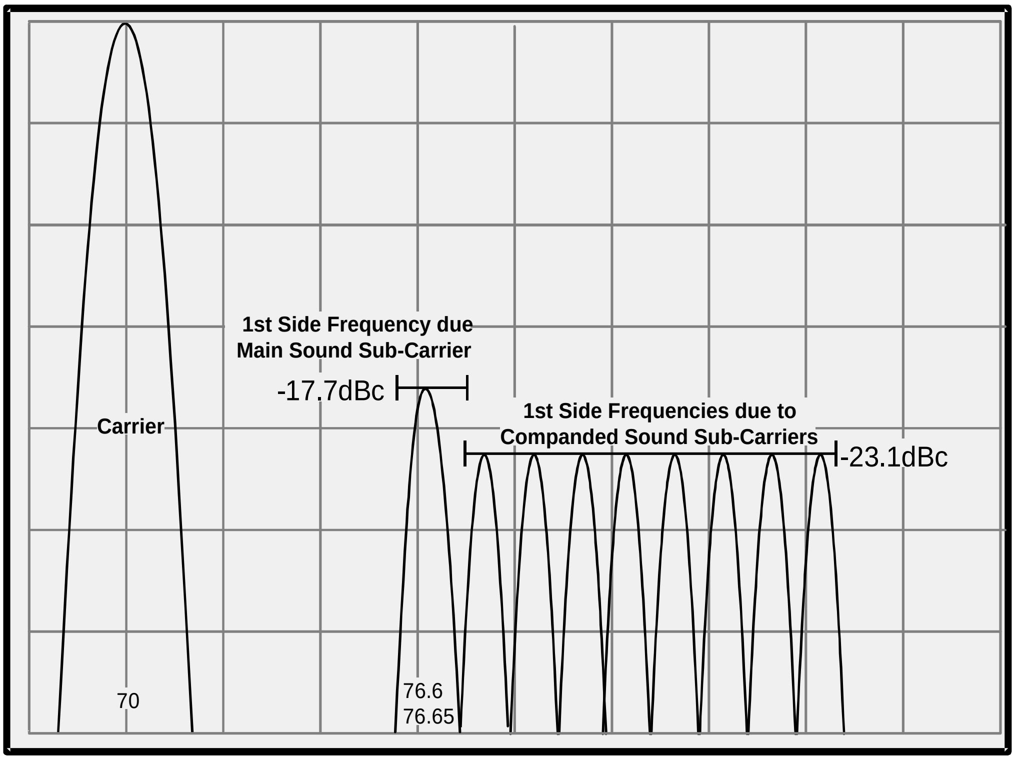
Bit Rate (MBit/s)	Modulation	FEC	Transmit Symbol Rate (Mbaud)	Carrier EIRPo[1] (dBW)	RL (dB)
45.0	QPSK	3/4	30.0	77.0	**31.2**
45.25	QPSK	3/4	27.5	77.0	**31.6**
36.67	QPSK	2/3	27.5	77.0	**31.6**
8.448	QPSK	3/4	5.632	68.0	**26.0**
2.048	QPSK	1/2	2.048	64.0	**25.0**

Table 5.b:Typical value for RL for 18.0 Ghz Uplink Frequency Band

Bit Rate (MBit/s)	Modulation	FEC	Transmit Symbol Rate (Mbaud)	Carrier EIRPo[1] (dBW)	RL (dB)
45.0	QPSK	3/4	30.0	80.0	**31.2**
41.25	QPSK	3/4	27.5	80.0	**31.6**
36.67	QPSK	2/3	27.5	80.0	**31.6**

Annex F - Sound Sub-Carrier Relative IF Level Measurement

IF SPECTRUM



MHz

The relative IF levels of the sound subcarriers are derived using the following formula:

$$RL = 20 \log \left[\frac{m}{4} \quad \frac{(8 - m^2)}{(4 - m^2)} \right] \quad \text{dBc}$$

where m is the modulation index (0.26 for main subcarriers and 0.14 for companded subcarriers, see also table page 28).

Annex G - Format for Analogue TLU Test Results Report

The next pages give the format of the Test Result Report, to be sent to the CSC upon completion of the line-up testing.

Facsimile and telex addresses of the CSC are given in the list of Operational Contact Points in the back of every ESOG Module.

Analogue TLU Test Result Report

From: .... Date: ....

Reference: ....

SUT: .... Eutelsat S.A. Ref: ....

VIDEO TESTS

		In Spec Y	In Spec N	Value [1]
3.1.1	FM Video Test Tone Deviation & Insertion Gain	?	?	.... dB
3.1.2	Video Amplitude Frequency Response	?	?	
3.1.3	Line-Time Waveform Distortion	?	?	.... %
3.1.4	Short-Time Waveform Distortion	?	?	.... %
3.1.5	Chrominance-Luminance Gain Inequality	?	?	.... %
3.1.6	Chrominance-Luminance Delay Inequality	?	?	.... nS
3.1.7	Differential Gain	?	?	.... %
	Differential Phase	?	?	.... °
3.1.8	Luminance Non-Linear Distortion	?	?	.... %
3.1.9	Chrominance-Luminance Intermodulation	?	?	.... %
3.1.10	Continuous Random Noise [2] unweighted:			.... dB
	weighted:			.... dB
3.1.11	Periodic Noise	?	?	
3.1.12	Impulse Noise	?	?	

NOTE [1]: Give value when measured out of specification only

NOTE [2]: Give measured values

SOUND SUB-CARRIER TESTS

Test 3.2.1: Video to Sound Sub-carrier Relative IF Level

Test 3.2.2: Test Tone Deviation of the Main and Companded Sound Sub-carriers

Test 3.2.3: Sound Channel S/N (Weighted)

	test 3.2.1			test 3.2.2.			test 3.2.3.		
Sub Carrier frequency	spec.		s/c level[1]	spec.		tone[1]	spec.		S/N[1]
	Y	N	(dBc)	Y	N	(dBm0)	Y	N	(dB)
6.60 MHz	?	?	....	?	?	....	?	?	....
6.65 MHz	?	?	....	?	?	....	?	?	....
7.02 MHz	?	?	....	?	?	....	?	?	....
7.20 MHz	?	?	....	?	?	....	?	?	....
7.38 MHz	?	?	....	?	?	....	?	?	....
7.56 MHz	?	?	....	?	?	....	?	?	....
7.74 MHz	?	?	....	?	?	....	?	?	....
7.92 MHz	?	?	....	?	?	....	?	?	....
8.10 MHz	?	?	....	?	?	....	?	?	....
8.28 MHz	?	?	....	?	?	....	?	?	....
.... MHz	?	?	....	?	?	....	?	?	....
.... MHz	?	?	....	?	?	....	?	?	....

Note [1]: Give value when measured out of specification only.

Annex H - Format for Digital TLU Test Results Report

The next pages give the format of the Test Result Report, to be send to the CSC upon completion of the line-up testing.

Facsimile and telex addresses of the CSC are given in the list of Operational Contact Points in the back of every ESOG Module.

Digital TLU Test Result Report

From: .... Date: ....

Reference: ....

SUT: .... Eutelsat S.A. Ref: ....

Test 4.1:Measurement of Carrier to Noise Power Density Ratio (C_o/N_o)

Measured N_o	: ....dBW/Hz
Measured C_o	: .... dBW/Hz
Correction Factor	: .... dB
Resulting C_o/N_o	: .... dB
Corresponding C/N	: .... dB
Expected [1] C/N	: .... dB

Test 4.2:HPA Output Spectrum of Transmit Station at Nominal EIRP

	Yes	No
Spectrum inside mask:	?	?

NOTE [1]: according to Eutelsat S.A. Transmission Plan.

Annex I - Test Equipment List

TRANSMIT CHAIN LINE-UP		
Test Number	**Instrument**	**Example**
3.1.1 to 3.1.10	PAL Television Generator Line 17-18-330-331. Selectable low-high APL	Tektronix TSG-271 or equivalent
3.2.1	Spectrum Analyzer	Hewlett Packard 8562A or equivalent
3.2.2	Audio Generator	Rohde & Schwarz UPA-3 or equivalent

RECEIVE CHAIN LINE-UP		
Test Number	**Instrument**	**Example**
3.1.1 to 3.1.10	Video Measurement Set	Tektronix VM700A or equivalent
3.1.11	Selective Level Meter	Wandel & Goltermann SPM-15 or equivalent
3.1.12	Oscilloscope	Hewlett Packard 54600A or equivalent
3.2.1	Spectrum Analyzer	Hewlett Packard 8562A or equivalent
3.2.2 & 3.2.3	Audio Analyzer	Rohde & Schwarz UPA-3 or equivalent

EUTELSAT S.A. OPERATIONS CONTACT POINTS

Eutelsat S.A. CSC e-mail: csc@eutelsat.fr	Voice: +33-1-45.57.06.66 Fax: +33-1-45.75.07.07
Systems Operations Earth Station Approval and Line-up Office e-mail: esapproval@eutelsat.fr ESVA	Voice: +33-1-53.98.48.12 Fax: +33-1-53.98.37.41 Voice: +33-1-53.98.39.25 +33-1-53.98.46.13 Voice: +33-1-53.98.48.25 +33-1-53.98.49.76
Operational Planning e-mail (SMS Section): dsvplan@eutelsat.fr e-mail (LT Section): ltplan@eutelsat.fr	Voice: +33-1-53.98.42.50 Fax: +33-1-53.98.30.00
Eutelsat S.A. Booking Office e-mail: booking@eutelsat.fr	Voice: +33-1-53.98.47.48 +33-1-53.98.47.45 +33-1-53.98.39.48 Fax: +33-1-53.98.37.37
Mailing Address	Eutelsat S.A. 70, rue Balard F-75502 PARIS Cedex 15 FRANCE
Eutelsat S.A. Web	http://www.eutelsat.com