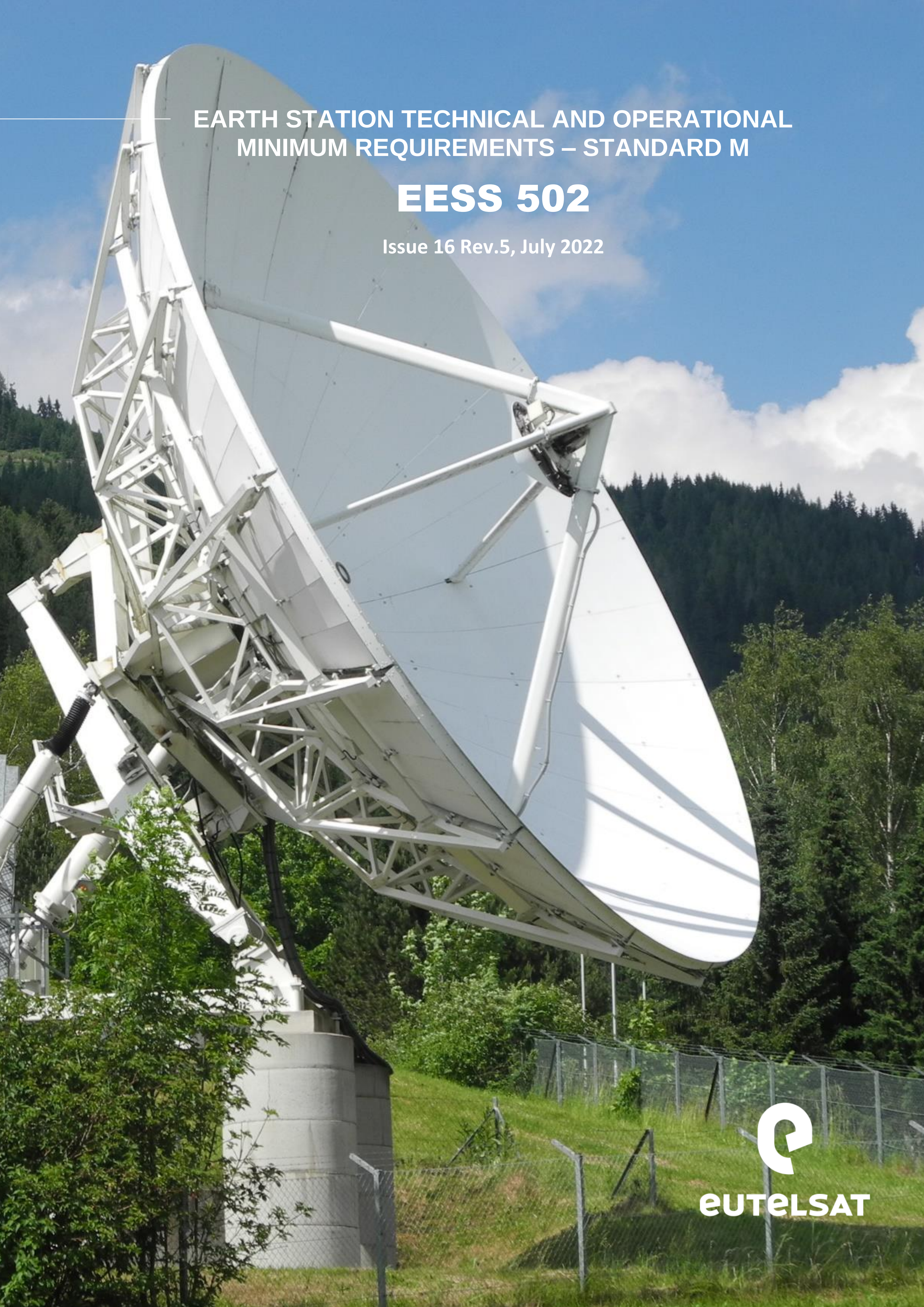

EARTH STATION TECHNICAL AND OPERATIONAL MINIMUM REQUIREMENTS – STANDARD M

EESS 502

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eutelsat

Earth Station Technical and Operational Requirements Standard M

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16/2	May 2021	14, 16, 17, 18, 19, 20
16/3	February 2022	4.1.2, addition section 4.1.3 & 6.4
16/4	February 2022	Modified sections 4.1.3 and 4.1.4. Added references to Table 4.1 in related sections
16/5	July 2022	Modified Table 6-1

Reference Documents

[RD1] “ESOG 120, Type Approval and Characterization Procedures”, Module 120, Issue 7.1, 19 November 2019, Eutelsat S.A. System Operations Guide

[RD2] “Earth Station Verification and Assistance”, Volume I, ESOG 130, Issue 2.0, 25 July 2000, Eutelsat S.A. System Operations Guide

1 Introduction

1.1 General

Under Eutelsat procedures, approval of earth stations for access to the Eutelsat space segment is required (See ESOG Module 110).

Eutelsat recognises that it is the Allottee's responsibility to establish compatibility between all earth stations within their network and to comply with Eutelsat criteria for minimising interference between earth stations and Eutelsat satellites on which space segment capacity is provided.

The Allottee is also responsible to take all the necessary actions to obtain all relevant authorisations to operate earth stations, as required by the appropriate National Regulatory Agencies.

The scope of this document is to define the minimum conditions under which approval may be given for an earth station to access the capacity in the Eutelsat Space Segment.

Earth station approval procedures are defined in the Eutelsat Systems Operations Guide (ESOG).

In addition, an earth station shall meet the conditions given in the Technical Annex A to the relevant capacity allotment agreement.

1.2 The Eutelsat satellites

All Eutelsat satellites have a three-axis stabilized configuration with deployable solar arrays and batteries to power the satellite in sunlight and eclipse.

Eutelsat satellites are normally maintained within ±0.1°, both in longitude and in latitude, of their respective nominal positions in geosynchronous orbit. However, at the end of their nominal station-keeping lifetime, they may be operated in inclined orbit whilst still being maintained within ±0.1° in longitude.

2 General conditions

The technical and operating characteristics described in the following sections are mainly those which are necessary to ensure an adequate level of protection to the other services carried via the Eutelsat Space Segment, as well as to services carried by adjacent satellite systems.

For this reason, no mention is made of characteristics such as modulation methods, G/T, quality objectives, etc., that are left to the Allottee to define as part of the design of the transmission system that meets his particular requirements. However, Eutelsat may require to review and agree on these parameters.

Transmissions in the 13.75 GHz to 14.00 GHz frequency band are subject to additional constraints imposed by the Radio Regulations. Earth stations operating in the band 13.75 - 14.00 GHz shall have minimum antenna diameter of 1.2 m.

For earth stations within the fixed-satellite service having an antenna diameter greater than or equal to 4.5 m, the EIRP of any emission should be at least 68 dBW and should not exceed 85 dBW.

Earth station owners should be aware of the need for flexibility in the design and operation of the earth station to accommodate any changes in the overall configuration of the Eutelsat Space Segment.

In addition to fulfilling the requirements outlined below, the earth station owner shall provide Eutelsat with information on the shape of the transmit signal spectrum so that the necessary frequency separation of adjacent carriers can be assessed.

2.1 Frequency band designations

The following table reports the frequency band designations used in the Eutelsat satellites. They include both the bands adopted for the feeder links and for the end user stations in transmission as well as in reception.

Band Reference	Transmit Frequency Band (GHz)	Receive Frequency Band (GHz)
C	5.850 – 6.725 6.725 – 7.025	3.400 – 4.200 4.500 – 7.025
Ku	12.750 – 13.250 (AP30B) 13.750 – 14.500 14.500 – 14.800	10.700 – 11.700 (AP30B incl.) 11.700 – 12.750
K (DBS up-link)	17.300 – 18.100 18.100 – 18.400	10.700 – 11.700 11.700 – 12.750
Ka	27.500 – 30.000 30.000 – 31.000	17.300 – 20.200 20.200 – 21.200
Q/V	47.200 – 50.200 50.400 – 51.400	37.500 – 40.400

Table 2-1: frequency bands designations

3 General radio frequency requirements

3.1 General

The earth station design shall be such that changes of transmitted and received carrier frequencies and levels are possible in order to conform to overall system planning needs and ensure flexibility in intersystem coordination.

3.2 System Bandwidth

Whichever satellite transponder is to be accessed by the earth station, it may be necessary to reallocate the corresponding satellite capacity from one frequency to another. For this reason the earth station should be capable of transmitting carriers at any frequency over the full extent of at least one of the frequency bands of the Eutelsat satellites.

3.3 Amplitude and group delay response

Each carrier shall be filtered on the transmit chain, according to its bandwidth requirement.

The recommended amplitude and group delay response of digital carriers is given in Figure 8-1 in Annex 1.

In the case of fractional transponder lease, the in-band amplitude and group delay response of the transmit station path are mandatory requirements.

3.4 Gain-to-Noise Temperature (G/T) ratio

The earth station gain-to-noise temperature ratio (G/T) is not specified and it is left to the Allottee to define the earth station G/T that meets his particular requirement.

The Allottee should be aware that the lower the earth station G/T, the higher the power required from the satellite for a given transmission.

The Allottee shall also provide Eutelsat with information on the minimum G/T under clear sky conditions for each of the earth station receive bands and for any elevation angle of the antenna greater than or equal to 10°.

3.5 Common wideband receiving amplifier linearity requirements

The linearity requirements will be determined by the earth station owner for his specific applications, taking into consideration that the maximum total power flux density at the surface of the earth could be -87 dBW/m^2 in Ku and Ka-Band and -101 dBW/m^2 in C-Band. This figure refers to the aggregate power flux density from all the transponders on one plane of polarization.

4 Antenna performance characteristics

4.1 Passive antenna side-lobe patterns

In the following of this document, a passive antenna is defined as any antenna which radio-electronic components, i.e. LNA and HPA, can be dismounted enabling the access to the transmission and reception radio ports for the measurement of the transmit and receive gain on the main and the cross polarizations.

4.1.1 Specified Envelope for Transmit and Receive Gains

For all the apertures allowing the direct measurement of the gain with a test range, and over the full extent of the antenna transmit and receive frequency bands, the gain of the antenna side-lobe peaks at any steering angle should not exceed:

$$\begin{cases} 29 - 25 \cdot log_{10}\theta & dBi \quad for \quad \alpha \leq \theta \leq 7^{\circ} \\ +8 & dBi \quad for \quad 7^{\circ} < \theta \leq 9.2^{\circ} \\ 32 - 25 \cdot log_{10}\theta & dBi \quad for \quad 9.2^{\circ} < \theta \leq 48^{\circ} \\ -10 & dBi \quad for \quad 48^{\circ} < \theta \end{cases}$$

Equation 4-1

where $\alpha = 1^{\circ}$ or $100 \cdot \lambda / D$ whichever is the greater, where D is the antenna diameter and λ is the carrier wavelength. In case of non-circular apertures, D is the dimension of the antenna aperture in the plane of the geostationary orbit, as seen from the earth station location. For example, in elliptical satellite on the move (SOTM) antennas, the value of D depends on the antenna skew and can be variable.

In addition, in the cross-polarization plane, the gain of the antenna side-lobe peaks should not exceed:

$$\begin{cases} 19 - 25 \cdot log_{10}\theta & dBi \quad for \quad 1.8^{\circ} \leq \theta \leq 7^{\circ} \\ -2 & dBi \quad for \quad 7^{\circ} < \theta \leq 9.2^{\circ} \end{cases}$$

Equation 4-2

where θ is the angle, in degrees, between the main beam axis and any direction towards the geostationary satellite orbit (within the bounds between 5° North and 5° South of this orbit, as seen from the centre of the earth).

4.1.2 Requirements for very small VSATs

For antennas with a $D/\lambda \leq 30$, where D is defined in section 4.1.1, over the full extent of the antenna transmit and receive frequency bands, the gain of the antenna side-lobe peaks should not exceed:

$$\begin{cases} 32 + 10\left(1 - \frac{1}{0.3\alpha}\right) - 25log_{10}\theta & dBi\ for \quad \alpha \leq \theta \leq 48^\circ \\ -\frac{10}{0.3\alpha} & dBi\ for \quad \theta > 48^\circ \end{cases}$$

Equation 4-3

In addition, in the cross-polarization plane, the gain of the antenna side-lobe peaks should not exceed:

$$\begin{cases} 19 - 25 \cdot log_{10}\theta & dBi \quad for \quad 1.8^\circ \leq \theta \leq 7^\circ \\ -2 & dBi \quad for \quad 7^\circ < \theta \leq 9.2^\circ \end{cases}$$

Equation 4-4

4.1.3 Tolerances on the overshoot amplitude

Some tolerances with reference to the masks described in Equation 4-1 and Equation 4-3 are accepted with the following modalities.

For D/λ > 30, over the full extent of the antennas transmit frequency bands any individual co-polarization peak shall not exceed the masks described by Table 4-1 by more than 3dB for angles θ between α and 9.2° and by more than 6 dB for angles θ between 9.2° and 180°.

For D/λ ≤ 30, any individual peak shall not exceed those envelopes for more than the limits described by Equation 4-5.

$$\begin{cases} 32 + 10\left(1 - \frac{1}{0.3\alpha}\right) - 25log_{10}\theta + 3dB & dBi\ for \quad \alpha \leq \theta \leq 9.2° \\ max\begin{Bmatrix} 32 + 10\left(1 - \frac{1}{0.3\alpha}\right) - 25log_{10}\theta + 3dB, \dots \\ 32 - 25log_{10}\theta + 6\ dB \end{Bmatrix} & dBi\ for \quad 9.2° < \theta \leq 48° \\ max\left\{-\frac{10}{0.3\alpha} + 3dB\ , \quad -10 + 6\ dB\right\} & dBi\ for \quad \theta > 48° \end{cases}$$

Equation 4-5

In addition, the transmit sidelobe pattern of the antenna shall be such that the off-axis EIRP density limits specified in chapter 6 can be met for any given operating conditions as may be required in practical situations.

4.1.4 Tolerances on the overshoot angular width

For angles θ between α° and 9.2° the cumulated peaks angular width shall respect the Table 4-1.

Antenna size w.r.t. wavelength	Maximum allowed cumulative angular width (°)
D/λ ≤ 30	30 λ/D
30 < D/λ ≤ 80	60 λ/D
D/λ > 80	10% of angles θ between α and 9.2°

Table 4-1: maximum cumulative angular width of the peaks exceeding the masks

For angles θ between 9.2° and 180°, the cumulated peaks angular width shall not exceed the 10% of this interval.

The angular width tolerances apply to the next chapter when indicated.

4.1.5 Receive capability

To ensure compliance of beam pointing accuracy with the Standard as specified in paragraph 4.4.2, transmit earth stations must be equipped with a receive chain which allows pointing optimization and tracking prior to and during transmissions.

4.2 Active apertures side-lobe patterns

Active apertures are defined as the set of antennas where the radio-electronic components (HPA and LNA) are integrated directly in the radiating surface and cannot be disassembled for the measurement of the antenna gain. It is the case, for example, of electronic steering phased array where each element (or group of elements) integrates also the LNA and the SSPA. In these antennas the transmit gain pattern can be evaluated only indirectly from the measurement of the EIRP and the receive gain pattern can be evaluated only indirectly from the measurement of a reference signal level.

4.2.1 Specified Envelope of the Transmission antenna pattern ($\mathbf{30 < D/\lambda \leq 110}$)

For $30 < D/\lambda \leq 110$, with D defined in section 4.1.1, over the full extent of the antenna transmit frequency bands, the side-lobes EIRP peaks of the antenna emitting a modulated signal or a continuous waveform with a fix power, at any steering angle shall respect the following margins given by the following formula:

$$\begin{cases} X|^{3dB} - 25 \cdot \log_{10}\theta & dBm^* \quad for \quad \alpha \leq \theta \leq 7^\circ \\ X|^{3dB} - 21 & dBm^* \quad for \quad 7^\circ < \theta \leq 9.2^\circ \\ X|^{6dB} + 3 - 25 \cdot \log_{10}\theta & dBm^* \quad for \quad 9.2^\circ < \theta \leq 48^\circ \\ X|^{6dB} - 39 & dBm^* \quad for \quad 48^\circ < \theta \end{cases} \qquad \text{Equation 4-6}$$

* *values in dBm could be in dBW depending on the test range performances and on the antenna characteristics*

where $\alpha = 1^\circ$ or $100 \cdot \lambda/D$ whichever is the greater, where λ is the carrier wavelength and D is the dimension of the antenna projected in the geo-stationary arc.

The nominal value of X shall be chosen in order to keep the mask tangent to one of the two first side-lobes.

The symbol $X|^{MdB}$ indicates the accepted upper tolerance M over the mask computed with the nominal value X.

Over the full extent of the antennas transmit frequency bands, the angular width tolerances in section 4.1.4 are applicable.

The value X shall be evaluated, for any steering position, as the minimum value allowing the pattern to respect the conditions described above. The value of X shall be chosen in order to allow the measurement range to exploit at best its dynamic range with the output EIRP of the antenna under test.

In addition, in the cross-polarization plane, the gain of the antenna side-lobe peaks shall not exceed:

$$\begin{cases} X - 10 - 25 \cdot log_{10}\theta & dBi \quad for \quad 1.8^\circ \leq \theta \leq 7^\circ \\ X - 31 & dBi \quad for \quad 7^\circ < \theta \leq 9.2^\circ \end{cases}$$ Equation 4-7

Where θ is the angle, in degrees, between the main beam axis and any direction towards the geostationary satellite orbit (within the bounds between 5° North and 5° South of this orbit, as seen from the centre of the earth).

4.2.2 Specified Envelope of the Transmission antenna pattern for very small apertures ($D/\lambda \leq 30$)

For antennas with a $D/\lambda \leq 30$, where D is defined in section 4.1.1, over the full extent of the antenna transmit frequency bands, the side-lobes EIRP peaks of the antenna emitting a modulated signal or a continuous waveform, at any steering angle shall respect the margins given by the following formula:

$$\begin{cases} X|^{3dB} - \frac{10}{0.3\alpha} - 25log_{10}\theta \quad dBm^* \quad for \quad \alpha \leq \theta \leq 48^\circ \\ \mathrm{X}|^{3\mathrm{dB}} - 42 - \frac{10}{0.3\alpha} \quad dBm^* \quad \mathrm{for} \quad \theta > 48^\circ \end{cases}$$ Equation 4-8

* *values in dBm could be in dBW depending on the test range performances and on the antenna characteristics*

The symbol $X|^{MdB}$ indicates the accepted upper margin M over the mask computed with the nominal value X.

Over the full extent of the antennas transmit frequency bands, the angular width tolerances in section 4.1.4 are applicable.

In addition, in the cross-polarization plane, the gain of the antenna side-lobe peaks shall not exceed:

$$\begin{cases} X - 23 - 25 \cdot log_{10}\theta & dBi \quad for \quad 1.8^\circ \leq \theta \leq 7^\circ \\ X - 44 & dBi \quad for \quad 7^\circ < \theta \leq 9.2^\circ \end{cases} \qquad \text{Equation 4-9}$$

4.2.3 Specified Envelope of the Receive Antenna Pattern ($\mathbf{30 < D/\lambda \leq 110}$)

Over the full extent of the antenna receive frequency bands, the side-lobe peaks of the antenna gain pattern derived from the measurement of a reference signal shall respect, at any steering angle, the margins given by the following formula:

$$\begin{cases} X|^{3dB} - 25 \cdot \log_{10}\theta \quad dBm^* \quad for \quad 1^\circ \leq \theta \leq 7^\circ \\ X|^{3dB} - 21 \quad dBm^* \quad for \quad 7^\circ < \theta \leq 9.2^\circ \\ X|^{6dB} + 3 - 25 \cdot \log_{10}\theta \quad dBm^* \quad for \quad 9.2^\circ < \theta \leq 48^\circ \\ X|^{6dB} - 39 \quad dBm^* \quad for \quad 48^\circ < \theta \end{cases}$$

Equation 4-10

* *Values in dBm are received at the receive port of the antenna. The signal could be translated into intermediate frequencies or in the original band depending on the antenna configuration*

The nominal value of X shall be chosen in order to keep the mask tangent to one of the two first side-lobes.

The symbol $X|^{MdB}$ indicates the accepted upper margin M above the mask computed with the nominal value X.

4.2.4 Specified Envelope of the Receive Antenna Pattern for very small VSATs ($\mathbf{D/\lambda \leq 30}$)

For antennas with a $D/\lambda \leq 30$, where D is defined above in chapter, over the full extent of the antenna receive frequency bands, the side-lobe peaks of the antenna gain pattern derived from the measurement of a reference signal shall respect, at any steering angle, the margins given by the following formula:

$$\begin{cases} X|^{3dB} - \dfrac{10}{0.3\alpha} - 25log_{10}\theta \quad dBm^* \quad for \quad \alpha \leq \theta \leq 48^\circ \\ X|^{3dB} - 42 - \dfrac{10}{0.3\alpha} \quad dBm^* \quad \text{for} \quad \theta > 48^\circ \end{cases}$$

Equation 4-11

* *Values in dBm are received at the receive port of the antenna. The signal could be translated into intermediate frequencies or in the original band depending on the antenna configuration*

The nominal value of X shall be chosen in order to keep the mask tangent to one of the two first side-lobes.

The symbol $X|^{MdB}$ indicates the accepted upper margin M above the mask computed with the nominal value X. If no margin is indicated means that any value is accepted.

4.3 Polarizations

4.3.1 Polarization capability

For transmit/receive stations, it is recommended that the antenna feed be equipped for dual polarization operations on both transmission and reception.

Transmit/receive stations having antennas equipped only with single polarization capability shall be able to transmit and receive orthogonal polarizations (e.g. transmit on horizontal and receive on vertical for linear polarization and transmit on RHCP and receive on LHCP for circular polarization).

All antennas shall be provided with the means to change the polarization in which they operate (as seen from the earth station location).

4.3.2 Polarization Alignment Capability (Linear Polarization)

The polarization alignment shall be adjusted, and in case of moving earth station shall be continuously maintained, within 1° of the nominal satellite receive antenna polarization plane as seen from the earth station location.

4.3.3 Polarization discrimination

The corresponding values of the reference cross-polarization discrimination (transmit and receive) are the following:

- 35 dB for linear polarization in all frequency bands,
- 30 dB for circular polarization in Ku and Ka frequency bands,
- 27 dB for circular polarization in C-Band.

Over the full extent of the antenna transmit frequency bands, the antenna polarization discrimination in the direction of the satellite shall correspond to the applicable reference value everywhere within a cone centred on the main beam axis, with the cone angle defined by the pointing error or the -1 dB contour of the mean beam axis, whichever is greater.

Provided that the spectral EIRP density of the transmitted carrier does not exceed the Associated Maximum Permissible Spectral EIRP Density as defined in Table 6-3. Earth Stations may operate with a polarization discrimination down to:

- 25 dB for linear polarization in all frequency bands and circular polarization in Ku-Band (30 dB for a total operational RF power superior to 50 Watt at the antenna input),
- 20 dB in circular polarization in Ka-Band (25 dB for a total operational RF power superior to 50 Watt at the antenna input),
- 18 dB for circular polarization in C-Band (22 dB for a total operational RF power superior to 50 Watt at the antenna input).

The term "operational" used in the three points above indicates the maximum power that the HPA provides at the input of the antenna taking into account its operational back-off (for example typically 1dB for SSPAs) and the insertion losses.

4.4 Antenna steering

4.4.1 Capability of the antenna beam to be steered

All transmit earth stations shall be equipped with precise adjustment capabilities in both azimuth and elevation.

For operational reasons, it should be possible to point the antenna in the direction of any geostationary satellite visible from the earth station location.

Sufficient steering capability is also desirable to permit demonstration of compliance with the mandatory transmit side-lobe envelope specification.

Transmissions with low elevation angles (below 10°) can be affected by tropospheric scintillations, under both adverse weather and clear weather conditions. Scintillation can impair the quality of the transmitted services and be a source of interference to other services.

Operation at such low elevation angles is considered to be critical and is therefore not recommended for permanent services.

In cases where such transmissions take place, either occasional, or permanent, additional restrictions may need to be applied on a case-by-case basis. In particular, in case of proven interference related to tropospheric scintillation, the earth station generating the interference must immediately reduce the transmit EIRP or immediately stop transmissions as directed by the Eutelsat Communication Systems Control Centre (CSC).

4.4.2 Satcom On The Pose (SOTP) terminals pointing accuracy

In order to protect transmissions on other satellites, the antenna main beam axis shall not deviate by more than ±0.4° from the nominal direction of the satellite along the geostationary orbit, under the operating conditions and taking into account all relevant contributions including wind speeds of 72 km/h (45mph) and at higher speeds at which the earth station may have to operate.

If a satcom antenna is mounted on a vehicle (van, car, trailer …) it is mandatory that the vehicle be equipped with suitable jacks to comply with the beam pointing accuracy requirement during the course of all transmissions.

The maximum pointing error of the antenna main beam axis from the actual position of the satellite shall be such that, under all operating conditions and taking into account all relevant factors, the requirements of chapter 6. are met, as well as any other requirements (such as those given in the related transmission plan(s), imposed by the National Regulatory Authorities and by the International Telecommunication Union).

4.4.3 Fix stations and SOTP tracking

The need for tracking will be determined by the earth station owner. In the receive side, the de-pointing losses will need to be compensated for by increasing the EIRP of the transmitted carrier and the allotted resources. For transmit antennas the need for tracking is determined by taking into consideration the requirement of the EIRP stability, paragraph 5.4.2, the necessary increase in the on-axis EIRP to compensate for antenna de-pointing losses, as well as the requirements of chapter 6.

For tracking purposes, the satellite beacon may be used. The frequencies and the characteristics of the satellite beacons are available on request.

4.4.4 Satcom On The Move (SOTM) Terminals: satellite tracking

Satcom-on-the-Move (SOTM) terminals must meet all the following pointing requirements:

a) The antenna control unit shall be able to evaluate in any instant the angular direction of the main beam axis.
b) The antenna main beam pointing error shall not deviate by more than ±0.2° from the nominal direction of the satellite along the geostationary orbit, under the operating conditions and taking into account all the relevant contributions
c) Whereas the pointing error exceed the maximum pointing error indicated in the previous point b) the terminal[1] shall inhibit any transmission within the period of time T = 100ms. Such a period of time should include the period required for the pointing error evaluation.
d) The terminal must be authorised to enable the transmission only once its pointing error becomes lower than ±0.2° during a period of time greater than 500ms
e) If the pointing accuracy requirement under b) above is not met, the SOTM manufacturer shall provide a comprehensive declaration of the applicable maximum antenna beam misalignment under the operating conditions and taking into account all relevant contributions. The related maximum permissible spectral EIRP density shall be set under consideration of both antenna characteristics and beam pointing error such that the resulting maximum permissible spectral EIRP density complies with the requirements of paragraphs 6.2.1 and 0.

4.4.5 SOTM: polarization alignment tracking (Linear Polarization Only)

The cross-polarization pattern specified in 4.1.1 shall take into account also the alignment error during the polarization tracking. The SOTM antenna shall be able to automatically compensate the polarization misalignment due to the motion of the antenna w.r.t. an inertial reference, by means of a procedure of polarization alignment tracking.

[1] The inhibit can be piloted directly by the antenna control unit or indirectly through the modem depending on the terminal architecture. In any case the manufacturer will be able to measure the inhibit delay

The polarization alignment tracking should be done by adjusting the OMT angle w.r.t. the azimuth plane, in case of optics with reflectors, or by following a procedure similar to the skew compensation reported in 6.2.3 for optics based on radiating panels.

5 Carrier characteristics

5.1 General

Due to the fact that large networks exist for certain applications, Eutelsat makes its best efforts to avoid changes of frequency of transmitted and received carriers of an approved transmission plan. However, Eutelsat, in full consultation with the Allottee, may have to change power level and frequency of the carriers of an approved transmission plan whenever overall system planning so requires.

5.2 Carrier frequency tolerance

5.2.1 Transmit frequency

The frequency tolerance (maximum uncertainty of initial frequency adjustment plus long-term drift) of each digital carrier transmitted by the earth station shall be at least as shown below:

±1.5 kHz	for TSR < 30 kSymbols/s	
±0.05 x TSR (kHz)	for 30 kSymbols/s ≤ TSR < 200 kSymbols/s	Equation 5-1
±10 kHz	for 200 kSymbols/s ≤ TSR	

where TSR is the transmission symbol rate in kSymbols/s.

The above frequency tolerance shall include the maximum uncertainty of initial frequency adjustment plus long-term drift, long-term being assumed to be at least one month.

5.2.2 Receive frequency

The earth station receive chain frequency stability will be determined by the earth station owner, taking into account the frequency acquisition and tracking capabilities of the demodulator and the frequency drift of the earth station transmit chain and the satellite transponder translation tolerance.

However, it is recommended that the frequency inaccuracy due to earth station down conversion should not be greater than ±1.5 kHz over any 6 months period.

5.3 Phase noise

The level of the phase noise induced on any carrier by the transmit and receive earth stations is the responsibility of the earth station owner, since this affects only the quality of the transmitted carrier.

5.4 Equivalent isotropic radiated power (EIRP)

5.4.1 Level

The maximum permissible operating EIRP levels for transmitting to a Eutelsat satellite will be constrained by the requirements of Chapter 6.

For earth stations which do not comply with the reference cross-polarization discrimination, the operating EIRP levels are also constrained by the maximum allowed EIRP density given in Table 6-3.

The operating EIRP for transmission from any given location shall be agreed with Eutelsat prior to the starting of operation from the location and shall comply with the transmission plan approved by Eutelsat.

In case of operation of Uplink Power Control (UPC) or Uplink Power Density Control (UPDC) Systems, the earth station concerned will be required to provide means to increase the EIRP or the EIRP density above the value assigned by Eutelsat. Such an increase shall be applied in case of uplink atmospheric fading variations only. Its application to compensate other anomalies such as misbehaviour in the tracking, but not only, is not admitted. In this respect,

- the power increase shall in any case comply with the out-of-band emission regulations (see subsection 6.3);
- the power or power density increase (in dB) shall be limited to half of the actual fade level (in dB) with a maximum value of 10 dB;
- the EIRP stability in short periods of time and the antenna tracking shall not be affected by the power increase in any way.

5.4.2 Stability

The EIRP of any carrier in the direction of the satellite shall be maintained to within ±0.5 dB of the assigned operating value as defined in the relevant transmission plan.

In certain operational modes of the transmission, on a case-by-case basis for small carriers (uplink EIRP < 55 dBW), the EIRP in the direction of the satellite shall be maintained at between -1.5 dB and +0.5 dB from the assigned operating value as defined in the transmission plan. In this case, the allottee will be responsible for allowing for a sufficient margin for such operations.

5.4.3 Adjustment capability

Adequate means shall be provided to allow adjustment and permanent measurement of the carrier EIRP.

The level of each carrier should be adjustable over a range of 20 dB below the assigned operating value.

5.4.4 Superimposed carriers

If several carriers fall simultaneously in the same frequency band, the sum of their EIRP spectral densities shall be employed when determining compliance with the requirements of chapter 6.

6 Emission constraints

6.1 General

The satellite G/T reference, designated as SG/T_{ref}, is defined for each satellite in the Table 6-1 below for the purpose of this specification. For all satellites and frequency bands, the EIRP spectral density levels indicated in this section apply for transmissions and from locations where the Satellite G/T is equal or lower than SG/T_{ref} as specified below. For locations where the satellite G/T is higher than SG/T_{ref}, these EIRP spectral density levels shall be decreased by the difference (in dB) between the satellite G/T in the direction of the earth station and the SG/T_{ref}.

Frequency Band	Satellite G/T Reference (SG/T_{ref}) [dB/K]	Satellite
C-Band	0	All Satellites
Ku-Band	0	All Satellites
Ka Band	0	EUTELSAT 7B, EUTELSAT 7A, EUTELSAT 16A, EUTELSAT 25B
	4	EUTELSAT 172B
	7	EUTELSAT 3B
	10	EUTELSAT 33D
	11	EUTELSAT 70D
	12	EUTELSAT 65WA, KONNECT (Africa)
	14	KONNECT (Europe)
	16	EUTELSAT 36C
	18	EUTELSAT KA-SAT 9A, KONNECT VHTS

Table 6-1: reference G/T per satellite

If several carriers fall simultaneously in the same frequency band, the sum of their EIRP spectral densities shall not exceed the limits given in Paragraph 6.2 and 6.3.

6.2 EIRP spectral density

The maximum permissible spectral EIRP density will be evaluated taking into account the antenna side-lobe performance starting at 1°.

For particular situations and restricted to well-identified specific space segment capacity, the maximum permitted EIRP spectral density (at satellite beam edge) may be increased, on request from the Allottee concerned, considering the applicable starting angle. In particular 1° corresponding to 1.5° orbital separation, 2.5° for 3° orbital separation. Those angles take into account the earth station beam pointing stability and the station keeping.

6.2.1 Off-axis EIRP density

The off-axis EIRP in any 40 kHz band in the direction of the geostationary satellite orbit (within the bounds between 5° North and 5° South of this orbit, as seen from the centre of the earth) shall not exceed the following values:

$$\begin{cases} F - 25 \cdot log_{10}\theta & dBW & for & 1^\circ \leq \theta \leq 7^\circ \\ F - 21 & dBW & for & 7^\circ < \theta \leq 9.2^\circ \\ F + 3 - 25 \cdot log_{10}\theta & dBW & for & 9.2^\circ < \theta \leq 48^\circ \\ F - 39 & dBW & for & 48^\circ < \theta \end{cases} \qquad \text{Equation 6-1}$$

In the case of linear polarized transmissions, the orthogonally polarized component of the off-axis EIRP in any 40 kHz band in the direction of the geostationary satellite orbit (within the bounds between 5° North and 5° South of this orbit, as seen from the centre of the earth) shall not exceed the following values:

$$\begin{cases} F - 10 - 25 \cdot log_{10}\theta & dBW & for & 1^\circ \leq \theta \leq 7^\circ \\ F - 31 & dBW & for & 7^\circ < \theta \leq 9.2^\circ \end{cases} \qquad \text{Equation 6-2}$$

where:

- θ is the angle, is the angle, in degrees, between the main beam axis and the direction considered.
- $F = F_0 - SG/T_{ref}$
- SG/T_{ref} is the satellite G/T reference, in dB/K, defined in Table 6-1

F_0 is defined in Table 6-2 below:

Frequency Band	F_0 [dBW/40kHz]	Satellite
C-Band	31	All Satellites
Ku-and K (DBS) Band	31	All Satellites for entire band except below
	29	All Satellites for 13.75-14.00 GHz frequency band with antenna diameters < 4.5m*
Ka Band	33	All Satellites for entire band except those below
	31	EUTELSAT 7B, EUTELSAT 7A, EUTELSAT 16A, EUTELSAT 25B
	29	EUTELSAT 3B
	30	EUTELSAT 70D

*According to constraints imposed by the Radio Regulations, antennas with diameters <1.2m are not supposed to operate in this frequency band.

Table 6-2 : F_0 definitions for the different satellites

The above maximum off-axis EIRP density limitations shall be met for any value of azimuth and elevation pointing angles of the antenna.

6.2.2 Polarization discrimination

(Grey shading) Total operational RF Power ≤ 50 Watt at the antenna input (see 4.3.3)

			Cross Polarization Discrimination [dB] as defined in 4.3.3							
			35	30	27	25	24	22	20	18
			Associated Maximum Permissible Spectral EIRP Density [dBW/4 kHz]							
Linear Polarization	CF	C-Band Ku & K-Band (DBS) Ka-Band	0	2	3.8	5	Non Standard			
Linear Polarization	A	C-Band	36				Non Standard			
Linear Polarization	A	Ku-Band & Ka-Band	39				Non Standard			
Linear Polarization	A	K-Band (DBS)	42				Non Standard			
Circular Polarization	CF	C-Band			0	1	1.5	3	5	7
Circular Polarization	CF	Ku & K-Band (DBS)		0	1.8	3	Non Standard			
Circular Polarization	CF	Ka-Band		0	1.8	3	3.6	4.8	6	
Circular Polarization	A	C-Band			33					
Circular Polarization	A	Ku-Band		37			Non Standard			
Circular Polarization	A	K-Band (DBS)		42			Non Standard			
Circular Polarization	A	Ka-Band		44						

Table 6-3: polarization discrimination parameters CF and A

Linear interpolation shall be applied between the above values.

The values here declared shall take into account the constraints reported in 4.3.3

The EIRP in any 4 KHz band in the direction of the satellite shall not exceed the following Associated Maximum Permissible Spectral EIRP Density, PSD_{max}, defined as follows:

$$PSD_{max} = A - CF - SG/T_{ref} \quad \text{[dBW/4kHz]} \qquad \text{Equation 6-3}$$

where:

- SG/T_{ref} is the satellite G/T reference, in dB/K, defined in Table 6-1.
  - CF is the correction factor due to the reduction of the cross-polarization discrimination.
  - A is the reference spectral EIRP density, applicable to the chosen frequency band and polarization (circular or linear).
  - The values A and CF are defined in the Table 6-3.

Stations compliant with the Reference cross-polarization discrimination (4.3.3) can be allowed to transmit higher EIRP values (than those specified in this table) in the transmission plan.

6.2.3 SOTM: skew compensation

In this document the skew is intended as the angle between the antennas horizontal plane and the tangent to the geostationary arc corresponding to the satellite position.

The motion of the terminal with reference to the satellite orbital position and with reference to an inertial reference (roll, pitch, yaw) introduces skew variations. For linear polarization these variations follow the polarization misalignment (see 4.4.4)[2].

Low profile antennas (elliptic, rectangular or flat optics) have a main lobe beam-width and off-axis gain dependent on the with the cut planes inclination. The plane tangent to the GSO arc depends on the skew which variation can cause a variable interference to/from the adjacent satellites.

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[2] In general Eutelsat satellites apply a polarization skew offset of 3.535° clockwise when looking at the satellite from the earth station. See https://www.eutelsat.com/files/contributed/support/pdf/azimuth-elevation-polarisation.pdf

A SOTM terminal should be capable to mitigate the effects of the skew variations, independently on the polarization alignment tracking, in order to guarantee in any operating conditions, the compliance with the off-axis EIRP density requirements. The methods are:

- Compensation of the skew variation by rotating the antenna radiation pattern around the main lobe axis; in such a way also the polarization alignment is partially maintained.
- Reduction of the PSD.
- Ceasing any transmission as soon as the skew effects cannot be mitigated (inertial constraints, mechanical limitation). The transmission should be disabled 100 ms from the detection of an additional skew error greater than 3.2°.

For linear polarization, if there is not the possibility to compensate the skew effects by rotation of the radiating surface, in any case the SOTM must be capable to track the polarization in order to maintain the alignment accuracy as specified in 4.3.2.

6.3 Out of band radiation

The maximum EIRP spectral density outside the allocated bandwidth but within any of the frequency band segments of Eutelsat satellites shall not exceed both EIRP density levels integrated in 4kHz and integrated in 12.5 MHz as defined below:

for 4 kHz Integration Bandwidth (peak value):

$$PSD_{max} = A_1 - SG/T_{ref} \quad \text{[dBW/4 kHz]}$$ Equation 6-4

for 12.5 MHz Integration Bandwidth (average value):

$$PSD_{max} = A_2 - SG/T_{ref} \quad \text{[dBW/12.5 MHz]}$$ Equation 6-5

where:

- SG/T_{ref} is the satellite G/T reference, in dB/K, defined in Table 6-1
- A_1 and A_2 are the reference out-of-band EIRP density values. They depend on the frequency band and are defined in Table 6-4 below.

Frequency Band	Space Segment	Integration Bandwidth	
		Peak A_1 (dBW/4 kHz)	Peak A_2 (dBW/12.5MHz)
C-Band	All Satellites (except EUTELSAT 5 WEST A)	1	31
	EUTELSAT 5 WEST A	4	34
Ku-Band	All Satellites	12	42
K-Band (DBS)	All Satellites	15	45
Ka-Band (user term.)	All Satellites	16	46
Ka-Band (gateways)	All Satellites	18	48

Table 6-4: out of band spurius emissions parameters A_1 and A_2

The values above (Table 6-4) refer to the cumulative effect of all out-of-band emissions including in particular intermodulation products, carrier spectral side-lobes and spurious radiation.

It may be permissible in some cases to exceed this limit if it can be shown that, for the particular frequency plan, this will not cause the overall noise performance objectives of the interfered-with carriers to be exceeded.

6.4 Mask for digital carriers

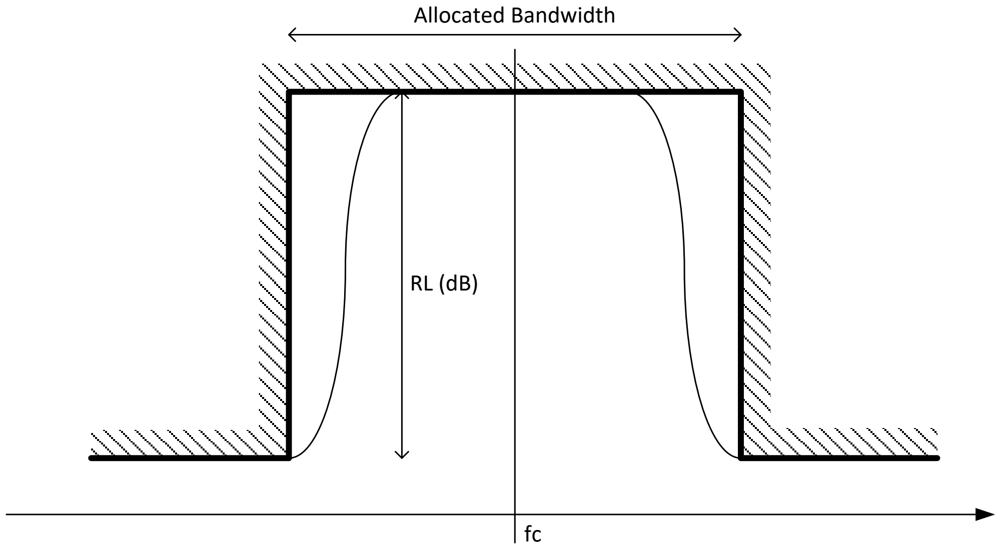

Figure 6-1: the mask for digital carriers

Both values, TSR and $EIRP_0$ are stated in the Eutelsat S.A. Transmission Plans.

The value for Allocated Bandwidth is normally stated in the Eutelsat S.A. Transmission Plans, as being generally Transmit Symbol Rate (TSR) multiplied by the (1+ROF), ROF being the roll-off factor, for the linear digital modulations.

The value for RL (Relative Level) depends on the TSR and on the allocated Reference Carrier $EIRP_0$. The beam edge is defined as the satellite receive G/T contour as indicated Table 6-1.

The formula for the computation of RL is

$$RL = \begin{cases} EIRP_0 - 10\log_{10}(TSR) - 24 - A_1 + \frac{SG}{T_{ref}} & for \quad TSR \leq 4.0 \\ EIRP_0 - A_2 + \frac{SG}{T_{ref}} & for \quad 4.0 < TSR \leq 12.5 \\ EIRP_0 - 10\log_{10}(TSR) + 11 - A_2 + \frac{SG}{T_{ref}} & for \quad TSR > 12.5 \end{cases}$$

Equation 6-6

where the TSR is in Mbauds and RL is always a positive value.

Typical RL values are reported in the following tables.

Transmit Symbol Rate (Mbaud)	Carrier $EIRP_0$ (dBW)	RL (dB)
45.00	77.0	29.5
30.00	77.0	31.2
8.45	68.0	26.0
2.05	64.0	25.0

Table 6-5: Typical RL values in Ku band band

Satellite (coverage)	Transmit Symbol Rate (Mbaud)	Carrier $EIRP_0$ (dBW)	RL (dB)
Europe	2.00	47.0	18.0
	1.00	47.0	21.0
Africa	1.00	47.0	19.0
	0.512	47.0	22.0

Table 6-6: Typical RL values for user terminals transmitting in Ka band

6.5 Spectral spreading of the carrier energy

Scrambling shall be provided to ensure that uniform spectral spreading is applied to the transmitted carrier at all times.

7 Operational Requirements

The operational requirements to be met by earth stations accessing allotted capacity are documented in the Eutelsat Systems Operation Guide (ESOG).

The ESOG is available on the Eutelsat website at www.eutelsat.com.

8 Annex 1

Digital carriers shall be generated using shaping filters respecting the masks provided in Figure 8-1.

For information, the random phase noise and the periodic phase noise profiles defined for the Eutelsat satellites can be provided on requires.

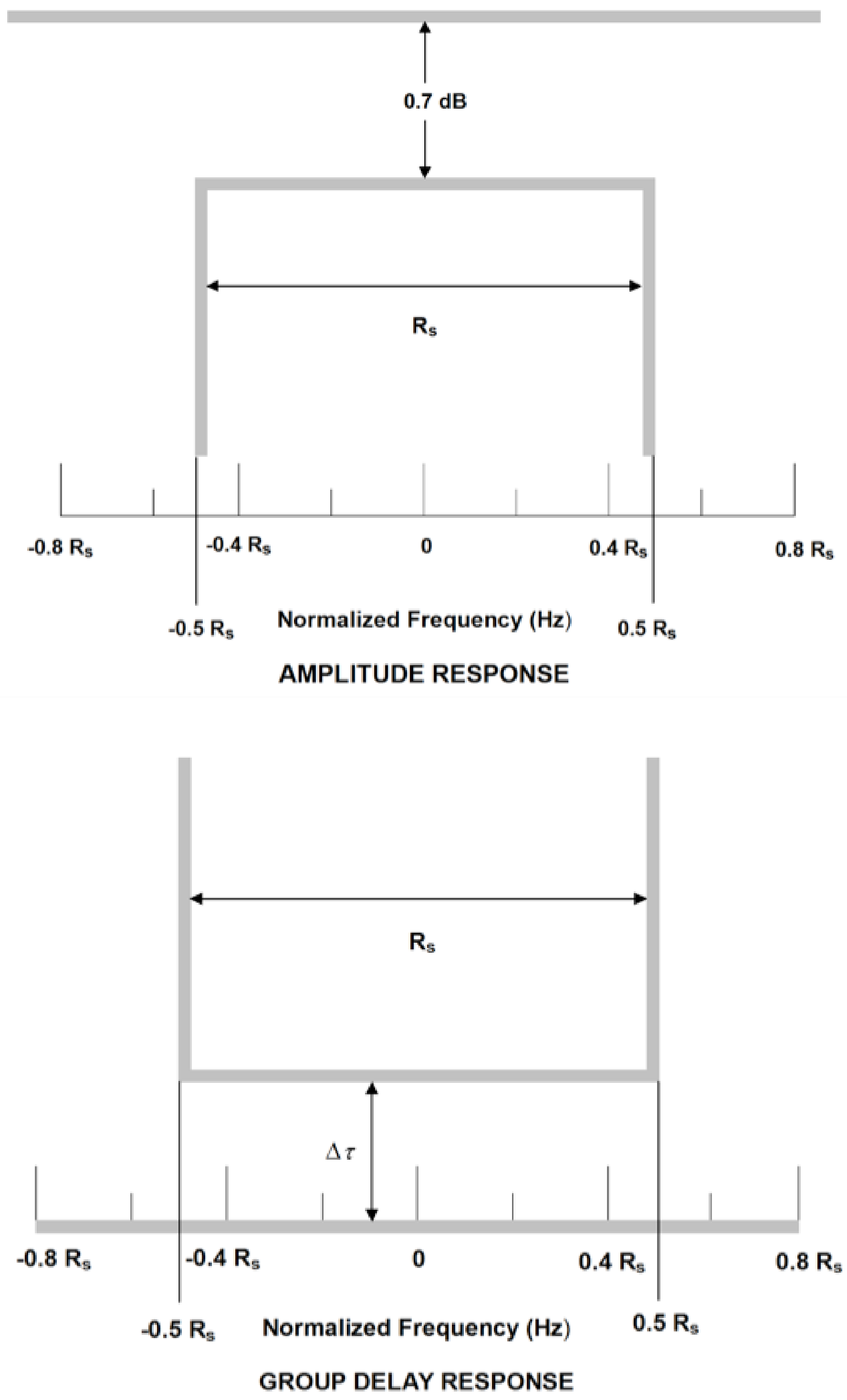

Figure 8-1: digital carriers amplitude and group delay characteristics

NOTES: R_s is the transmission symbol rate in Baud

$$\Delta\tau\ [nsec] = \frac{0.15 \times 10^9}{R_S}$$

Eutelsat is one of the world's leading and most experienced operators of communications satellites.

Our extensive network of high-performance satellites, located between 133° West and 174° East, provides capacity to clients that include broadcasters and broadcasting associations, pay-TV operators, video, data and Internet service providers, enterprises and government agencies.

Eutelsat's satellites provide ubiquitous coverage of Europe, the Middle East, Africa, Asia-Pacific and the Americas, enabling video, data, broadband and government communications to be established irrespective of a user's location.

Headquartered in Paris, with offices and teleports around the globe, Eutelsat represents a workforce of 1,200 men and women from 46 countries who are experts in their fields and work with clients to deliver the highest quality of service.
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