Technical Appendix

I. Executive Summary

In accordance with Section 24.114 of the FCC's rules, this Technical Appendix provides an overall description of Embratel's Star One C4 to operate in geostationary satellite orbit ("GSO"). including its facilities, operations, services provided, and spectrum resources to be utilized. This Technical Appendix also provides additional information required under Section 25.114 and other Part 25 rules.

II. Star One C4 - Service Description

The Star One C4 satellite will be able to support a wide variety of business/commercial, public and backbone applications.

These applications will be available anywhere in the United States (CONUS). The main objective is to support the transmission of digital data, providing services to users.

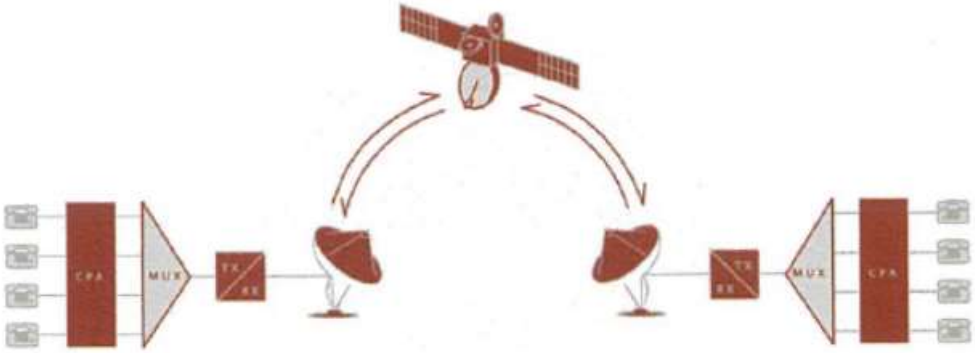
The range of applications supported by this satellite is described below.

1. Networking

The main characteristic of the Networking application is the use of relatively small diameter VSATs, transmitting data through a single carrier per terminal (inbound channel) to a central station (Hub) of large diameter. The central station transmits one or more carriers (outbound channels) to the entire corporate network of which it is a part.

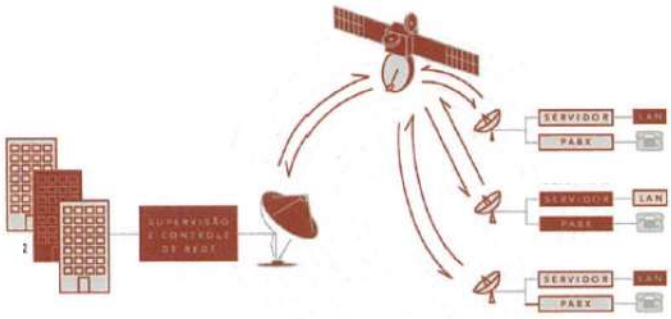
2. Trunking

It is a point-to-point application, using larger-diameter antennas for transmission and reception, interconnecting areas that are underserved by terrestrial means



3. Transponder Leasing to Service Providers

In this application, service providers rent space segment to implement communications networks via satellite to their customers with ubiquitous coverage

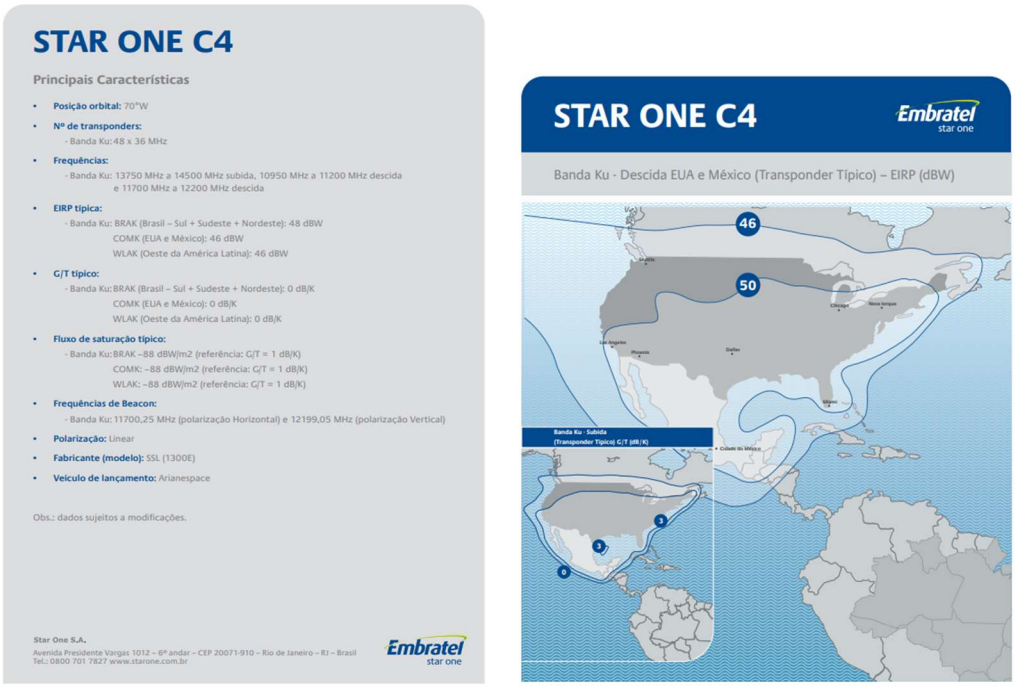


III. Star One C4 Description

The Star One C4 satellite was built by Space Systems Loral and launched in July 2015 from Kourou, French Guiana. The satellite currently operates in orbit at 70° W and consists of 28 36 MHz Ku Band transponders operating at 13750 MHz to 14500 MHz for uplink (ground to space) and downlink 10950 MHz to 11200 MHz and 11700 MHz to 12200 MHz (space to ground). The Star One C4 satellite operates in Ku Band using Brazil (BRAK beam), Continental North America – CONUS and Mexico (COMK beam) and West Latin America (WLAK beam) coverages.

An overview of the Ku Band coverage of the COMK beam and principle operating characteristics are shown in the figure 1 below.

Figure 1. Typical characteristics and D/L coverage of Star One C4 Operations[1]



[1] From Embratel.com.br website

TECHNICAL PARAMETERS:

1. Basic Characteristics of the Space Segment

The Star One C4 satellite is located at the orbital position of 70.0° W.

1.1. Frequency Range

Ku Band	Uplink (MHz)	Downlink (MHz)	Conversion (MHz)
Extended	13,750 to 14,000	10,950 to 11,200	2805
Standard	14,000 to 14,500	11,700 to 12,200	2300

Table 1. Star One C4 Ku Band frequencies[2]

1.1.1. Transponders

The Star One C4 satellite operates in Ku Band, in frequency ranges of 13,750.0 - 14,500.0 MHz on the uplink and 10,950 - 11,200 MHz and 11,700 - 12,200 MHz downlink, using 36.0 MHz bandwidth transponders in both horizontal (H) and vertical (V) polarizations. Star One C4 has the ability to interconnect uplink and downlink transponders between the North America, Western Latin America and Brazilian beams as dictated by customer demands in hemisphere and availability.

1.1.1.1 COMK beam Frequency Plan (source http://frequencyplansatellites.altervista.org/Embratel/Star_One_C4.pdf)

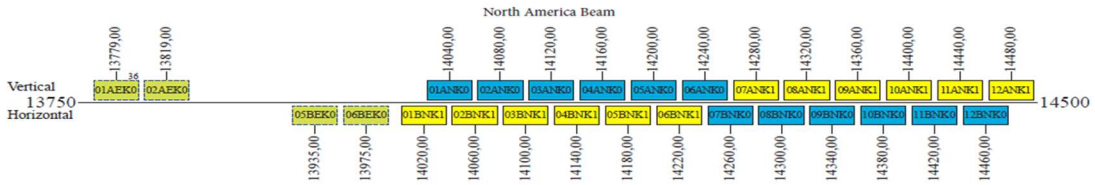


Figure 2 COMK Uplink Frequency Plan

[2] From Embratel.com.br website

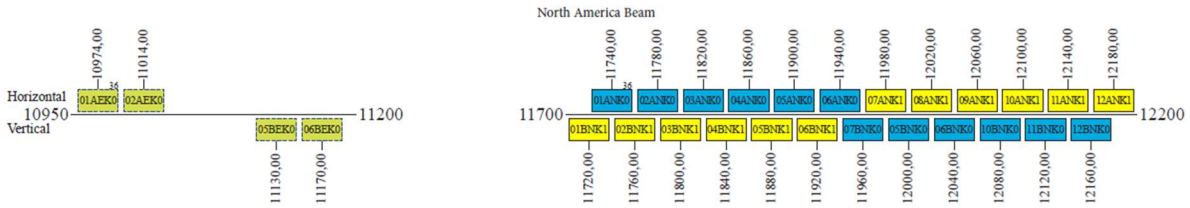


Figure 3 COMK Downlink Frequency Plan

1.1.2. Beacons

The Star One C4 satellite beacons in the Ku Band are unmodulated and are located at frequencies of 11,700.25 MHz (Horizontal polarization) and 12,199.05 MHz (Vertical polarization) with minimum EIRP of 13.0 dBW.

1.1.3. Tracking, Telemetry and Command (TT&C)

Operation of the Star One C4 satellite does not use TT&C facilities in North America and transponder assignments for TT&C are allocated in beams covering South America only.

1.2. Polarization

The Star One C4 operates with linear polarization. Since the Star One C4 reuses frequencies through the use of dual-polarization, the isolation of satellite antennas between the two orthogonal polarizations is in the order of 30.0 dB within the coverage area, both in the uplink and downlink.

1.3. Coverage Characteristics

The Star One C4 satellite operates in Ku Band in North America (COMK beam). Typical star one C4 COMK satellite coverage are shown in Figure 4 and 5:

1.3.1. COMK Beam - Typical Coverage

1.3.1.1 - Uplink

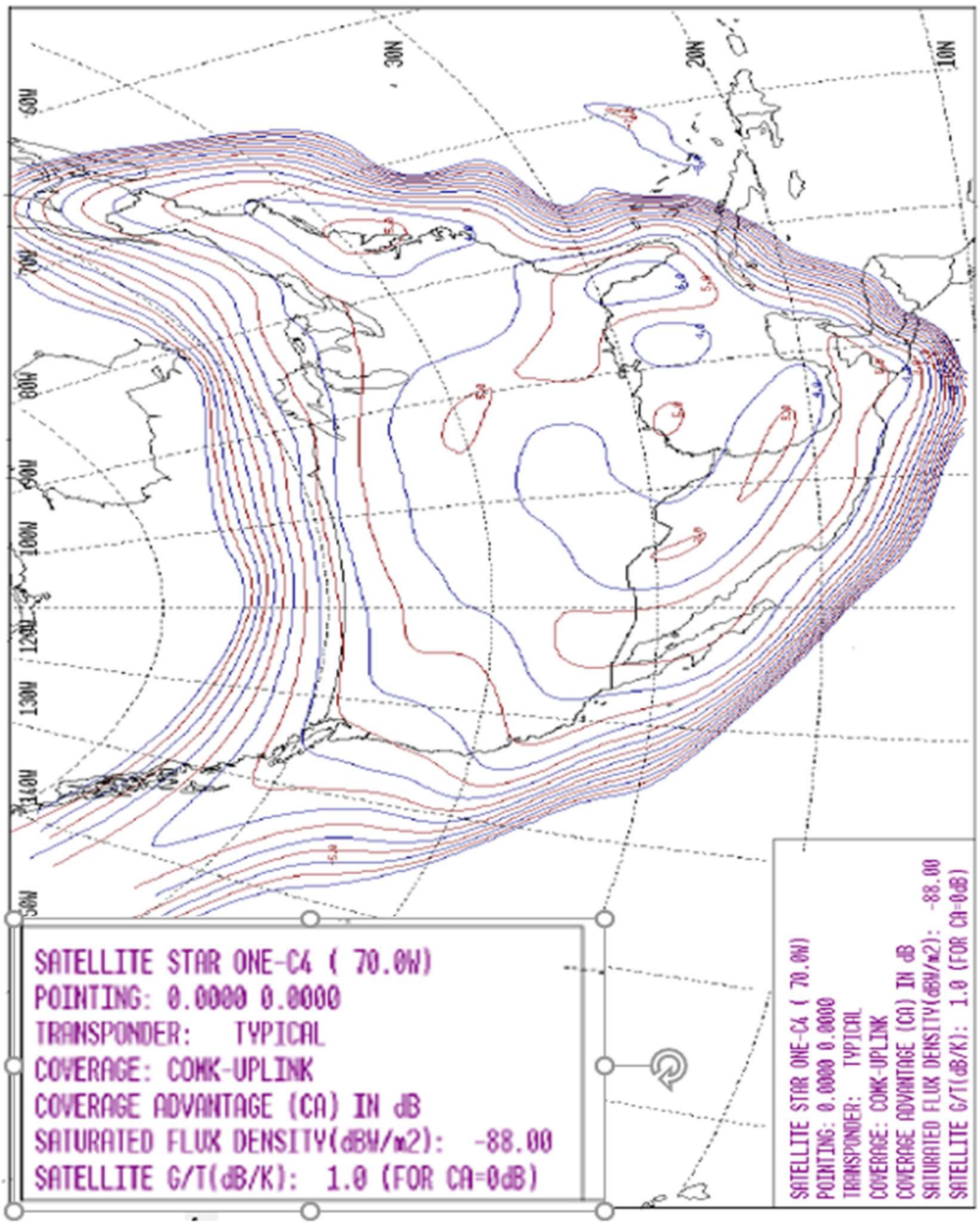


Figure 4 - Star One C4 (G/T) COMK Typical Uplink Coverage

1.3.1.2. Downlink

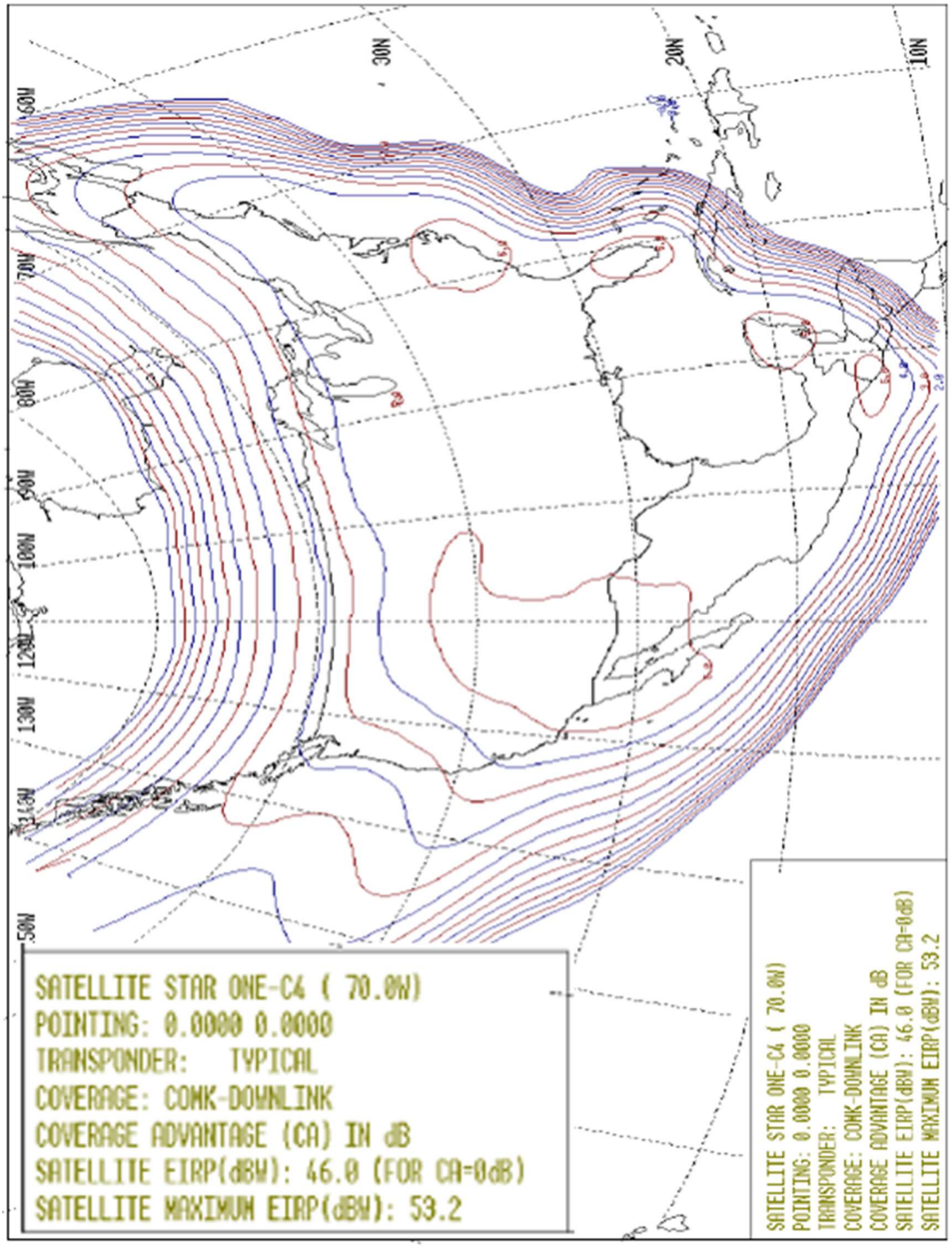


Figure 5 - Star One C4 (EIRP) COMK Typical Downlink Coverage

NOTE: We emphasize that actual coverage may show some differences depending on the specific transponder. We also point out that the reference contours for saturation flow, satellite G/T and satellite EIRP, mentioned throughout this document, correspond to the geographic gain of 0.0 dB.

1.4. EIRP

The Star One C4 satellite typical EIRP at the reference contour is 46.0 dBW in the Ku Band.

1.5. G/T

The typical Star One C4 satellite G/T at the reference contour is 1.0 dB/K in the Ku Band.

1.6. Saturation Flux Density

For Star One C4 satellite, in Ku Band, it should be considered a typical Saturation Flux Density of -88.0 dBW/m2 in the reference contour.

The Saturation Flux Density may be adjusted in a range of -4.0 dB to + 4.0 dB in steps of 1.0 dB from the reference below, to be assigned by Embratel Star One in light of service characteristics and the selected transponder.

1.7. Typical Input and Output Back-off and Intermodulation Noise Density

The typical Star One C4 satellite input and output back-off for transponders allocated to multi-carrier (multi-carrier mode) are 5.5 dB and 4.0 dB, respectively. The intermodulation noise density in this case is -97.0 dB/Hz, related to the saturation power output, corresponding to -15.0 dBW/4kHz, at the reference contour.

The typical Star One C4 satellite input and output back-off for transponders allocated to 2(two) carriers (dual-carrier mode) are 3.0 dB and 2.0 dB, respectively. The intermodulation noise density in this case can be disregarded because its major part will occur outside the frequency limits of the transponder.

The typical Star One C4 satellite input and output back-off for transponders allocated to 1 (one) carrier (single-carrier mode) are 1.0 dB and 0.5 dB, respectively. In the case of 16APSK carriers, the input and output back-off of -3.0 dB and -1.5 dB respectively must be used.

1.8. Operational Conditions

Carriers allocated in Star One C4 satellite transponders are subject to the following operational conditions:

1.8.1. Adjacent Satellites

Considering the ANATEL Resolution 288: "Operating Conditions of Geostationary Satellites, in Ku Band, with Coverage over Brazilian Territory", as well coordination agreements with operators of adjacent satellites sharing the same frequency band at the geostationary orbital arc, the carriers shall comply with the maximum densities levels listed below:

Note: the densities shall be calculated in a 1.0 Hz reference bandwidth, with the digital carrier bandwidth expressed in terms of its symbol rate.

1.8.0.1. Maximum Uplink Density

The maximum allowable uplink power density for carriers operating in Star One C4 satellite COMK beam coverage is -48.0 dBW/Hz, referred to the earth station antenna input. Density values greater than -48.0 dBW/Hz requires Embratel Star One prior written authorization.

1.8. Operating Conditions

Carriers on the Star One C4 satellite are subject to operating conditions described in the following sub-items.

1.8.1. Spatial Coordination

Considering Anatel Resolution 288: "Conditions of Operation of Satellites Geostationary in Ku Band with Coverage over the Brazilian Territory", as well as as spatial coordination agreements with neighbouring satellite operators sharing the same frequency range in the geostationary orbital arc, the carrier transmissions are subject to the maximum densities shown below.

NOTE: densities should be calculated in a 1.0 Hz reference band within the digital carrier's bandwidth equivalent to its symbol rate.

1.8.1.1. Maximum Uplink Power Density

The maximum uplink power density of carriers from a transmit antenna operating in the COMK beam of the Star One C4 satellite is -48.0 dBW/Hz. Higher densities may only be used with authorisation Embratel Star One.

1.8.1.2. Maximum Downlink Power Density

The maximum eirp density of a carrier operating of the Star One C4 satellite is -22.0 dBW/Hz (--58.02 dBW/4kHz). Higher densities may only be used with authorization by Embratel Star One.

Note: Star One C4 satellite maximum saturated EIRP is about 53.2 dBW for COMK coverage.

1.8.1.3. Minimum Diameter of Antennas

Antennas with diameters within conditions 1-3 described below only may be used with the written permission of Embratel Star One, after evaluation of its technical characteristics as well geographic location

1. receive only antennas less than 75.0 cm, operating in the standard Ku Band;

2. receive only antennas less than 60.0 cm, operating in the extended Ku Band;

3. Antennas less than 96.0 cm, operating in the standard Ku Band;

4. Antennas less than 1.2 m, operating in the extended Ku Band.

Note: Transmissions in the extended Ku Band with antennas less than 1.2 m are prohibited, pursuant to the resolution of the World Conference on Radio communications from 2003.

1.8.2. Link / System Margins

- An overall margin of 2.2 dB to cover adjacent satellites interference, terrestrial interference, co-transponder cross-polarization interference and earth station spurs shall be assumed;
- An additional margin of 0.5 dB in TX and 0.5 dB in RX shall be assumed to cover mispointing of earth station antennas with diameter larger than 4.5 m, equipped with tracking system. For antennas with diameter less than or equal to 4.5 m without tracking system, it is recommended to use the following margins to cover mispointing due to movement of the satellite in its orbital control box (+ / - 0.05 °):

Diameter (m)	Margin for TX (dB)	Margin for RX (dB)
D ≤ 1.8	0.3	0.2
2.4	0.4	0.3
3.6	1.0	0.7
4.5	1.5	1.1

Table 2 - Typical Margin of Antenna loss without Tracking

- An additional earth station HPA margin of 2.0 dB shall be assumed to cover: differences between the real coverages, switching from primary to redundant satellite units in case of failures and possible degradations during satellite lifetime.

2. Mandatory Characteristics of Earth Stations Transmitting Data via Satellite

2.1. Emission Characteristics

2.1.1. Frequency Stability

The RF frequency tolerance (maximum uncertainty of initial adjustment plus displacement over time) shall not exceed ±800.0 Hz in one day and ±3500.0 Hz in one month, for earth stations equipped with equipment installed in a controlled environment temperature or with equipment installed outdoors.

2.1.2. Off-Axis EIRP Density Limits

The maximum off-axis EIRP density emission for any angle equal or greater than 1.9° outside the earth station antenna main lobe, within the geostationary satellite orbital arc, must not exceed the values presented on Table 2 (reference document: ANATELResolution 288).

Out of Beam Emission (dBW/Hz)	Angle
- 48 + 29 - 25 log θ	1.9° ≤ θ < 36°
- 48 - 10	36° ≤ θ ≤ 180°

Table 3 - Off-Axis EIRP Density Limit

Notes:

1. densities should be calculated on a 1.0 Hz reference band within the digital carrier's bandwidth equivalent to its symbol rate;

2. Use of an antenna/ transmission configuration exceeding Table 3 values **requires Embratel Star One prior written authorization.**

2.1.3. Out of Band Emission

The EIRP density transmitted outside the allocated band of the carrier shall not exceed the value of 10.0 dBW/4 kHz for intermodulation and 0.0 dBW/4 kHz for spurious, resulting in an aggregate of 10.4 dBW/4 kHz.

The limits presented above must be lowered from the value corresponding to the receive gain increase of the satellite antenna relative to the reference contour.

In any case, when an emission outside the authorized band causes prejudicial interference an additional decrease may be requested from those limits established above.

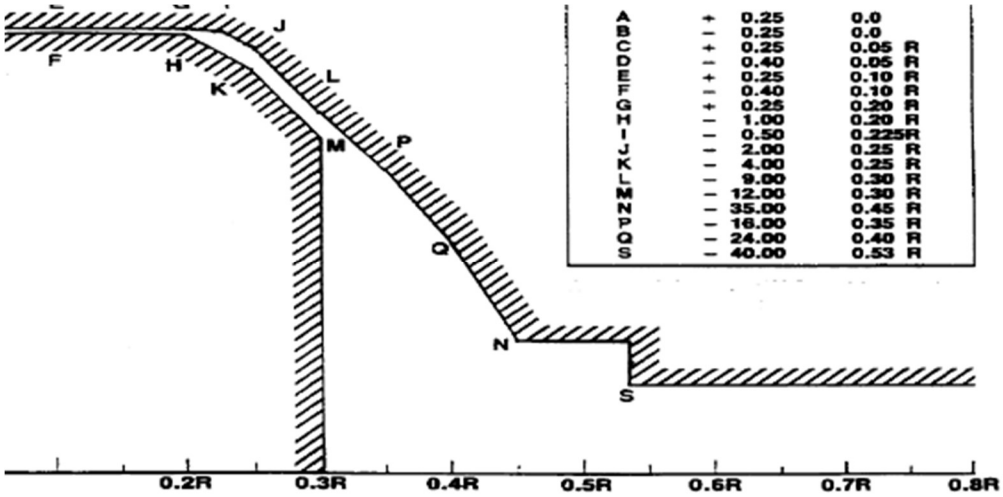
2.1.4. EIRP stability

The EIRP variation of the earth station over a day must be less than 2.0 dBpp, discounting the contributions of the variation in the satellite position and adverse weather conditions, for stations equipped with equipment installed in an environment with control of temperature or with equipment installed outdoors.

2.1.5. Power Spectral Density

The spectral power density of the modulated carrier at the modulator output and at the earth station transmitter output must conform to the masks shown in the two figures below.

2.1.5.1. Power Spectral Density Mask at the Modulator Output



NORMALIZED FREQUENCY IN RELATION TO THE CENTER (Hz)

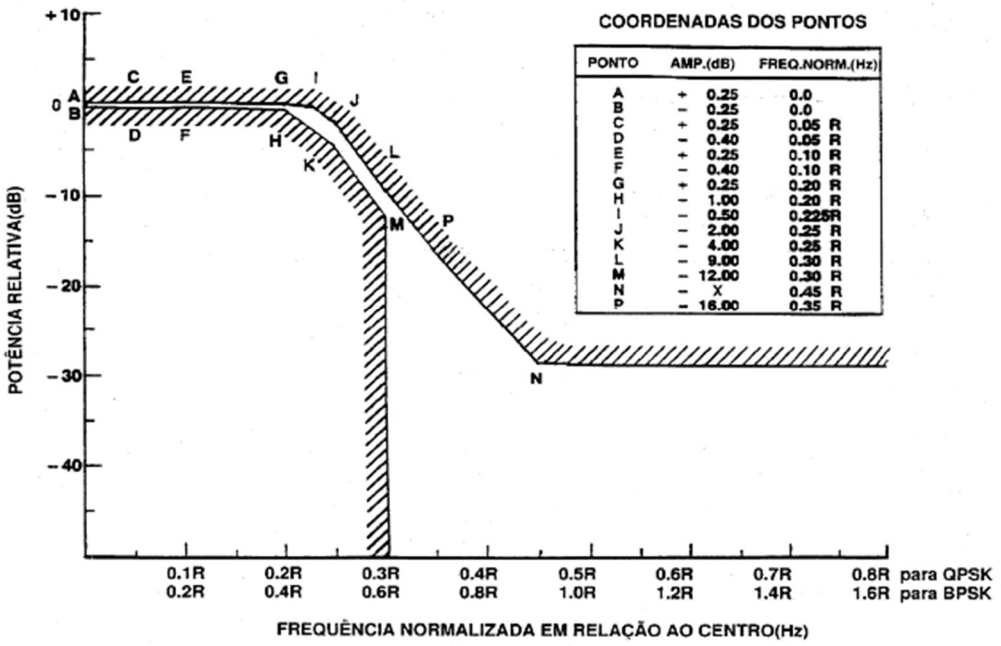
NOTES:

1. R = Bit rate per second

2. The normalized frequency of the abscissa axis corresponds to the QPSK modulation; to obtain the frequencies for the BPSK modulation, multiply the constant values of the abscissa by 2; to obtain the frequencies for the 8PSK modulation, divide the constant values of the abscissa by 1.5

3. The relative power of 0.0 dB, for QPSK modulation, corresponds to -10 log (R/2) dB/Hz in relation to the power of the carrier without modulation; to obtain the relative power for the BPSK modulation, use R instead of R/2; to obtain the relative power for 8PSK modulation, use 3R/2 instead of R/2

2.1.5.2. Power Spectral Density Mask at Transmitter Output



NORMALIZED FREQUENCY IN RELATION TO THE CENTER (Hz)

Notes:

1. R = Transmission Rate in BITS per second

2. NBPS = Number of BITS per symbol (1 for BPSK and 2 for QPSK)

3. The relative power of 0.0 dB corresponds to -10 log (R/NBPS) dB/Hz in relation to the unmodulated carrier power

4. X(dB) = EIRPTX(dBW) + GVUP(dB) + 25.6 dB - 10 log (R / NBPS)

5. The plotted X value refers to a BPSK carrier of 512KBPS+FEC1/2 with a typical EIRPTX = 56.0dBW on a 7.0dB rising contour

6. The secondary lobe cannot have a relative amplitude (X) greater than -26.0 dB at the normalized frequency in relation to the center of 0.75R for QPSK and 1.5R for BPSK

7. Note 6. can superimpose the note 5.

8. Independent spurs must meet the criterion of 0.0 dBW/4kHz

2.2. Antenna Characteristics

The main minimum technical characteristics of earth station antenna radiation, used in geostationary satellite communications links in the Brazilian territory, are indicated below:

- G = 29 – 25 log ϕ dBi for ϕ-between 1° or 100 λ/D (whichever is greater) and 20°
- G = – 3.5 dBi for 20° < ϕ ≤ 26.3°
- G = 32 – 25 log ϕ dBi for 26.3°< ϕ < 48°
- G = –10 dBi for 48° ≤ ≤ 180°

  Where G is the antenna gain, ϕ the angle between the considered direction and the antenna axis, D the largest diameter of its aperture area and λ the wavelength.

- Axis cross polarization isolation
  - 27 dB for D ≤ 2.4 m
  - 30 dB for 2.4 m < D ≤ 7m
  - 35 dB for 7 m < D

Note: Such as "Standard for Certification and Homologation of Antennas for Earth Stations Operating with Geostationary Satellites" (Annex to Resolution No. 572 of Anatel, of 28/09/2011) was revoked, Embratel Star One started to adopt as a reference the Recommendation ITU-R S.580-6 "Radiation Diagrams for Use as Design Objectives for Antennas of Earth Stations Operating with Geostationary Satellites" with emphasis on items 1 and 2.

3. Satellite in-orbit tolerances

3.1. East-west station-keeping range: +/-0.05°

3.2. North-south station-keeping range: +/-0.05°

3.3. Accuracy to which antenna axis attitude will be maintained:

Pointing accuracy (Attitude):

- 0.035° Roll;
- 0.025° Pitch;
- 0.05° Yaw.

4. Information

Questions, suggestions, or clarifications, please contact or send correspondence to:

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