

Earth-Stations
Performance Requirements

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1. General

This document specifies the required performance-characteristics of earth stations, approved for access to the AMOS space segment. All requirements must be guaranteed by compliant stations accessing the AMOS network.

The document defines two requirement types:

- a) Recommended requirements - Related to the station characteristics affecting the quality of the customer's service.
- b) Mandatory requirements – Related to the station characteristics affecting the AMOS network customers, as well as customers of other adjacent satellites (Mainly in terms of interference and quality of transmission and reception (Mandatory requirements are marked in **bold**)).

Mandatory requirements must be assured and are part of the required "Earth-Station" registration and approval process, prior to any access to the AMOS space segment.

2. Antenna

2.1. Transmit side-lobes (Mandatory)

The gain of 90% of the co-polarized side-lobe peaks shall not exceed the envelope described by the following:

Antenna Gain [dBi]	Off-Axis Angle [degrees]
$G=29-25 \log \theta$	$\text{Max}(1^\circ, 100 \lambda / D^\circ) \leq \theta \leq 20^\circ$
$G= -3.5$	$20^\circ < \theta \leq 26.3^\circ$
$G=32-25 \log \theta$	$26.3^\circ < \theta \leq 48^\circ$
$G= -10$	$48^\circ \leq \theta$

(*) Earth stations operating in the 13.75-14.0GHz band shall incorporate antennas of min. 1.2m reflector diameter.

Where:

G = the side-lobe gain envelope relative to an isotropic antenna, in the direction of GEO arc (in dBi).

θ = The angle between the main beam axis to the direction considered (in degrees).

- The above requirement is based on Rec. ITU-R S.580-6 and Rec. ITU-R S.465-6.
- The above requirements should be met within the following frequency bands:
 - 27.0-31.0 GHz (Ka-Band)
 - 14.5-14.8 GHz & 17.3 - 18.1 GHz (Ku-Band)
 - 12.75-13.25 GHz & 13.75-14.5 GHz (Ku-Band)
 - 5.725- 6.725 GHz (C-Band)

2.2. Receive side-lobes (Recommendation)

It is recommended that the transmit side-lobe characteristics shall apply also to the receive side-lobe characteristics as well in the following frequency bands:

- 17.3-22.0 GHz (Ka-Band)
- 13.4-13.65 GHz (Ku-Band)
- 10.7-12.75 GHz (Ku-Band)
- 3.4-4.2 GHz (C-Band)

2.3. Polarization and Antenna Miss-Pointing at C-band, Ku-band and Ka-band (Mandatory) - For transmit earth station

2.3.1. Antenna miss-pointing error shall be limited to 0.5 dB from the peak.

2.3.2. The Polarization Isolation of the transmit antenna in the direction of the satellite shall be as per sub-paragraphs 2.3.3 and 2.3.4 below.

Sub-paragraph 2.3.3 is applicable within a –1 dB contour of the main beam.

2.3.3. Antenna polarization isolation for circular polarization and the corresponding maximum VAR value:

Antenna diameter (D) [m]	Cross Polarization Discrimination (XPD) [dB]	Voltage Axial Ratio (VAR)
$D \leq 2.4\text{m}$	$XPD > 17.7$	$VAR < 1.3$
$D > 2.4\text{m}$	$XPD > 25$	$VAR < 1.12$

Antenna polarization isolation for linear polarization:

Antenna diameter (D) [m]	Cross Polarization Discrimination (XPD) [dB]
$D \leq 2.4\text{m}$	$XPD > 25$
$D > 2.4\text{m}$	$XPD > 30$

2.3.4. The off transmit cross-polarized gain of the earth-station shall be below the envelope shown in the following table:

Antenna Gain [dBi]	Off-Axis Angle [degrees]
$G = 20 - 20 \log \theta$	$\text{Max}(1^\circ, 100 \lambda / D^\circ) \leq \theta \leq 7^\circ$
$G = 17.2 - 16.7 \log \theta$	$7^\circ < \theta \leq 26.3^\circ$
$G = 29 - 25 \log \theta$	$26.3^\circ < \theta \leq 36.4^\circ$
$G = -10$	$36.4^\circ < \theta \leq 180^\circ$

Where:

θ = The angle between the main beam axis to the direction considered (in degrees).

2.3.5. It is recommended, for receive antennas, to comply with the specified polarization isolation performance of transmit antennas.

2.3.6. Earth stations may operate with a polarization discrimination which is less than specified in sub-paragraph e) above, depending on their U/L EIRP density, subject to a formal approval by SPACECOM, on a case by case basis.

2.4. **Tracking (Mandatory)**

Auto-tracking is mandatory for transmit antennas with reflector diameter larger than:

- 9m at C-Band
- 4.5m at Ku-Band
- 2.0m at Ka-Band

3. General RF Requirements

3.1. U/L EIRP control (Mandatory)

The earth station shall be capable of changing the transmitted power in a range of at least 15dB.

The power-step resolution shall be at least 0.5dB.

3.2. EIRP Stability (Mandatory)

The EIRP in the direction of the satellite shall, except under adverse weather conditions, be maintained within +1/-1.5 dB from the level assigned by SPACECOM. These tolerances include all earth station factors contributing to EIRP variations, antenna beam pointing and/or tracking error and fluctuations in the output RF power due to the earth-station transmit equipment.

For Ku-Band transponders it is highly recommended to use an Automatic Uplink Power Control (AUPC) system based on a beacon receiver. AUPC allows continuity of service during periods of heavy rainfall, but it must be carefully maintained to guarantee proper operation. It is mandatory that the AUPC be performed in an automated fashion, to guarantee that the power flux density at the input to the satellite never exceeds the nominal level by more than 1dB.

3.3. Frequency Agility and Stability

3.3.1. It is recommended that earth stations should have transmit and receive equipment that allows the carrier frequency to be set with a precision of at least 2.5 KHz.

3.3.2. The frequency stability should be better than $\pm 0.015R$ but in no case exceeding ± 10 KHz (R= Transmission Rate in Bits per Second).

4. Emission Constraints

4.1. Carrier Spectral Side-lobes

- 4.1.1. The spectral side lobe of each transmitted digital carrier shall be more than 26dB down from the spectral main lobe peak when it falls outside the user's bandwidth.
- 4.1.2. The acceptable level of spectral side lobes falling within the user's bandwidth is determined by the user.

4.2. Spurious Emission

4.2.1. Spurious Emission in the Out of Band Domain

The spurious emission, within the U/L frequency bands which fall at frequencies outside the allocated bandwidth up to a frequency separated from the edge of the transponder by 200% of the transponder bandwidth transmitted from the U/L station shall meet the limitations of ITU-R SM.1541 Annex 5.

4.2.2. Spurious Emission in the Spurious Domain

The spurious emission, within the U/L frequency bands outside the allocated bandwidth which fall at frequencies separated from the edge of the transponder frequency by 200% of the transponder bandwidth shall be at least $43+10\text{Log}(P)$ or 60dBc, whichever is less stringent.

dBc: Decibels relative to the unmodulated carrier power of the emission.

P: Transmitted Power from the U/L earth station measured in Watts.

5. Earth Stations on the move (ESOMPs/ESVs)

On the move earth station shall be approved on a case by case basis.

The following parameters shall be provided:

- Antenna type (phase array\ reflector, etc.
- Tracking scheme (number of axis, tracking error, etc.)
- Radiation patterns (Az, El)
- Transmission plan (max on-axis EIRP density)