

AMOS-Satellites System

Earth-Stations

Performance Requirements

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◇ **General Information**

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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:

- Recommended requirements - Related to the station characteristics affecting the quality of the AMOS customer service signals.
- Mandatory requirements – Related to the station characteristics affecting the AMOS network customers, as well as customers of other adjacent satellites (Mainly in terms of interferences and quality of transmission and reception. (Mandatory requirements are indicated by a dotted vertical line to the left side of the page).

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 and cross-polarized side-lobe peaks shall not exceed the envelope described by the following:

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

(*) 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:
 - * 12.75-13.25 GHz & 13.75-14.5 GHz (Ku-Band / FSS);
 - * 17.3 - 18.1 GHz (Ku-Band / BSS)
 - * 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:

- * 10.7-11.7 GHz (Ku-Band / FSS), 11.7-12.5 GHz (Ku-Band / BSS),
- * 12.5-12.75 GHz (Ku-Band / FSS)
- * 3.4-4.2 GHz (C-Band)

2.3. Polarization and Antenna Miss-Point at C-band, Ku-band and Ka-band (Mandatory)

- a) The earth stations shall transmit with linear polarization (Orthogonal V&H) at Ku-Band and with circular polarization (RHCP & LHCP) at C-Band.
- b) Antenna miss-point error shall be limited to 0.5 dB from the peak.
- c) Polarization related errors of the transmitting earth station shall comply with sub-paragraphs d through h.
- d) The Polarization Isolation of the transmit antenna in the direction of the satellite shall be as per sub-paragraphs e) and f) below.

Sub-paragraph e) is applicable everywhere within a cone centered on the main beam axis and whose angle is defined by the antenna tracking and/or pointing error. (Min. size of a cone is the -1dB contour of the main beam).

- e) Antenna polarization isolation for C-Band :
 Better than 25dB ($D \geq 2.4\text{m}$)
 Better than 18dB ($D < 2.4\text{m}$)
 Antenna polarization isolation for Ku-Band and Ka-Band:
 Better than 30dB ($D \geq 2.4\text{m}$)
 Better than 25dB ($D < 2.4\text{m}$)

- f) The off transmit cross-polarized gain of the earth-station shall be below the following envelope:

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

Where:

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

- g) It is highly recommended, for receive antennas, to comply with the specified polarization isolation performance of transmit antennas.



h) Earth stations may operate with a polarization discrimination which is less than specified in sub-paragraph d) 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)

The AMOS satellites are maintained at their designated orbital locations ("Station Keeping") within $\pm 0.1^\circ$ (N-S) & $\pm 0.08^\circ$ (E-W) for AMOS-2 and within $\pm 0.05^\circ$ (N-S) & $\pm 0.05^\circ$ (E-W) for AMOS-3/AMOS-4/AMOS-5 (worst case). Based on these limits and earth station antenna beam-width, auto-tracking is required for transmit antennas with reflector diameter larger than:

- 4m (AMOS-2/AMOS-3/AMOS-4/AMOS-5) at Ku-Band FSS
- 3.2m (AMOS-5) at Ku-Band BSS
- 9m (AMOS-5) at C-Band
- 1.8m (AMOS-4) at Ka-Band

The Beacon carriers, transmitted by the satellites, can be used for antenna tracking. The beacon carrier frequencies are detailed in Table-1.

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 (The -1.5dB requirement may be modified to a larger value for links having sufficient margin). These tolerances include all earth stations 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

- a) The capability to vary the frequency of each transmitted carrier shall be provided, in order to permit carriers to be radiated anywhere within the earth station operating RF band.
- b) It is highly recommended that the U/L frequency band of the station will cover the full U/L band available in the AMOS satellites network. The U/L frequency bands are listed in table 2.
- c) 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 2.5KHz.
- d) The frequency stability should be better than $\pm 0.015R$ but in no case exceeding $\pm 10KHz$.
(**R**= Transmission Rate in Bits per Second).

4. Emission Constraints

4.1. Carrier Spectral Sidelobes

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. The acceptable level of spectral side lobes falling within the users'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 not exceed the following U/L EIRP Density:

Satellite	U/L Frequency Band	Max. U/L Spurious Emission EIRP Density
AMOS-2/3	Ku (13.75-14.50 GHz)	2dB[W/40KHz] ¹
AMOS-2/3	Ku (12.75-13.25 GHz)	6dB[W/40KHz]
AMOS-4	Ku (13.00-14.50 GHz)	4dB[W/40KHz]
AMOS-5	Ku (14.0-14.5 GHz)	7dB[W/40KHz]
AMOS-5	Ku (17.3-18.1 GHz)	8dB[W/40KHz]
AMOS-5	C (5.8-6.6 GHz)	6dB[W/40KHz]

The above spurious EIRP results from spurious tones, bands of noise (i.e HPA’s N.F), or other undesirable products, including multi-carrier inter-modulation products and spectral spreading.

The above limit applies to U/L stations located within the satellite’s beam center (Maximum satellite's G/T). For any other U/L station located off beam center the following constraint shall apply:

Max Spurious Emission $\geq X + OBL$ [dBW/40KHz]

OBL = Off Beam Loss (absolute level in [dB] relative to beam center).

X= Max U/L Spurious emission EIRP density indicated in the above table (right column).

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.

Table-1: List of Beacons

	TM1	TM2
	Frequency (Polarization)	Frequency(Polarization)
AMOS-2	10,949.000 [MHz] (CP)	11,200.000 [MHz] (CP)
AMOS-3	11,449.000 [MHz] (CP)	11,700.000 [MHz] (CP)
AMOS-4	10703 [MHz] (CP)	11698.5 [MHz] (CP)
AMOS-5 (C-Band)	3,602.000 [MHz] (RHCP)	4,199.500 [MHz] (LHCP)
AMOS-5 (Ku Band)	11,442.500 [MHz] (CP)	11,692.500 [MHz] (CP)