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INTELSAT EARTH STATION STANDARDS (IESS)

Document IESS–601 (Rev. 12)

STANDARD G

PERFORMANCE CHARACTERISTICS FOR EARTH STATIONS
ACCESSING THE INTELSAT SPACE SEGMENT FOR INTERNATIONAL AND
DOMESTIC SERVICES NOT COVERED BY OTHER EARTH STATION STANDARDS

(6/4, 14/11 and 14/12 GHz)

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1. INTRODUCTION

Standard G earth stations can access the Intelsat space segment through the use of transponder resources which are defined in Intelsat's Leased Transponder Definitions Module (IESS–410) or through the use of other space segment facilities for which utilization charges have been approved by Intelsat, excluding stations used in experiments and those used for a limited period of time to support other stations being retrofitted.

Standard G earth stations may be used to access leased transponder resources supporting domestic or international services. Services which are provided through earth stations which are approved under the Standard G category are reviewed periodically to determine if more detailed specifications should be developed for a given application.

The Standard G earth station performance characteristics do not specify particular values for the following parameters:

- Maximum EIRP per carrier,
- Modulation method,
- G/T,
- Transmit gain and,
- Channel quality

These parameters are left to the user in deciding the best transmission design for a particular requirement.

However, the actual values selected for these parameters still require Intelsat's review as part of the transmission plan that must be approved by Intelsat.

1.1 Standard Gx and GE

In response to user requirements for services to small antennas, Intelsat has developed two sub-categories of Standard G known as Standard Gx and Standard GE.

1.1.1 Standard Gx

Standard Gx is intended for those applications which by virtue of their low transmit EIRP density have little potential for causing interference to other users. Such antennas can access the space segment without submitting measured antenna performance data subject to a constraint on transmit EIRP density as described in Appendix A.

1.1.2 Standard GE

Standard GE is intended for those applications, such as, satellite news gathering, requiring increased uplink EIRP capability and/or improved protection from adjacent satellite interference. Standard GE earth stations are required to meet the requirements contained in the main body of this specification as well as the supplementary requirements contained in Appendix A.

If the requirements for Standard G performance are met, a wide range of earth station sizes, modulation techniques and performance quality can be selected and applied to domestic and international services (for which more comprehensive standards do not already apply). These performance requirements specify minimum earth station capabilities and maximum levels of interference.

The transmission plan for Standard G earth stations will be coordinated and agreed with Intelsat for the purpose of ensuring that levels of interference are kept within acceptable limits. The implementation of the transmission plan rests with the user where it should be noted that departures from the agreed transmission plan may result in degradation in the quality of service, due to interference and other causes such as a lower value of earth station G/T. In view of the importance of G/T, substantiating data is required to be submitted to Intelsat. Substantiating data may be either a measured G/T value or a value calculated from measured antenna gain and measured receiver noise temperature. This measured data can be taken either from in–plant tests or taken on–site.

Earth stations making applications as Standard G will be classified at the highest Standard possible, i.e., Standard A, B, C, E, F, H or K, based on G/T data presented as part of the earth station verification process. Earth stations entering the system under the Standard Gx restriction are not classified based on G/T. Earth stations approved in categories of Standard A, B, C, E, H–4, H-3, H–2, K–3 and K–2 which are qualified to access space segment capacity appropriate to Standard G, will retain their original classification as well as automatically assume the Standard G classification. Standard F terminals having a transmit voltage axial ratio of 1.09 across the frequency band 5.925 to 6.425 GHz may also automatically assume the Standard G classification. In such cases, it is not necessary to subject the station to additional verification testing nor is the submission of a new application form required.

Earth stations accessing Intelsat transponders which do not conform to the Standard G performance characteristics specified in this document (or which cannot automatically assume the Standard G classification as discussed in paragraph 1.4) will be treated on a case–by–case basis as non–standard earth stations.

2. GENERAL EARTH STATION GUIDELINES/REQUIREMENTS

The detailed design of the Standard G earth station has been left to the user, including considerations regarding channel performance. For this reason the “General Guidelines for Intelsat Earth Stations” discussed in IESS–101 do not apply to Standard G earth stations. However, the following general guidelines/requirements are provided.

Users of Standard G earth stations should be conscious of the need for flexibility in the design and operation of the earth station to accommodate changes in the configuration of the Intelsat space segment.

It is required that the earth station design be such that changes in the transmitted and received RF carrier frequencies can be made in order that frequency plans can be properly coordinated for the purposes of limiting mutual interference and for flexibility in intersystem coordination.

Due to the probability that very large networks will exist for some applications, Intelsat will make its best efforts to minimize changes in RF carrier frequency.

The reliability of earth station equipment should be such that the space segment cannot be jeopardized by emissions that are in error due to carrier level, frequency, or polarization state.

3. GENERAL PERFORMANCE CHARACTERISTICS REQUIRED FOR STANDARD G EARTH STATIONS ACCESSING THE INTELSAT SPACE SEGMENT

3.1 Antenna System

3.1.1 Antenna Sidelobe Pattern (6/4 GHz, 14/11 GHz and 14/12 GHz)

New antennas, for the purpose of this paragraph, are considered to be those which have an RFP (or similar document specifying contractual performance characteristics) issued after 1995.

(a) Transmit Sidelobe Design Objective

The design objective should be such that the gain of 90 percent of the copolarized and crosspolarized sidelobe peaks does not exceed an envelope described by:

$G = 29 - 25 \log \theta$ dBi,	$1°$*	$\leq$	θ	$\leq$	$20°$
$G = -3.5$ dBi,	$20°$	$<$	θ	$\leq$	$26.3°$
$G = 32 - 25 \log \theta$ dBi,	$26.3°$	$<$	θ	$\leq$	$48°$
$G = -10$ dBi,			θ	$>$	$48°$

where: G is the gain of the sidelobe envelope relative to an isotropic antenna in the direction of the geostationary orbit, in dBi.

θ is the angle in degrees between the main beam axis and the direction considered.

This requirement should be met within any frequency defined in paragraph 3.2.2 for any direction which is within 3° of the geostationary arc (Rec. ITU-R S.580-5).

(b) Transmit Sidelobe Mandatory Requirements (Existing Antennas)

At angles greater than 1°* away from the main beam axis, it is required that the gain of 90 percent of the copolarized and crosspolarized sidelobe peaks not exceed an envelope described by:

$G = 32 - 25 \log \theta$ dBi,	$1°$*	$\leq$	θ	$\leq$	$48°$
$G = -10$ dBi			θ	$>$	$48°$

Where G and θ are defined in paragraph 3.1.1(a).

This requirement should be met within any frequency defined in paragraph 3.2.2 in any direction within 3° of the geostationary arc (Rec. ITU–R S.580–5).

(c) Transmit Sidelobe Mandatory Requirements (New Antennas)

It is required that the gain of 90 percent of the copolarized and crosspolarized sidelobe peaks not exceed an envelope described by the following:

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* For D/λ below 100, this angle becomes $100\ \lambda/D$ degrees.

D/λ < 50

$G = 32 - 25 \log \theta$ dBi,	$100\ \lambda/D$ °*	≤ θ	≤	48°
$G = -10$ dBi,		θ	>	48°

D/λ ≥ 50 (Rec. ITU–R S.580–5 and Rec. ITU–R S.465–5)

$G = 29 - 25 \log \theta$ dBi,	1°*	≤	θ	≤	20°
$G = -3.5$ dBi,	20°	<	θ	≤	26.3°
$G = 32 - 25 \log \theta$ dBi,	26.3°	<	θ	≤	48°
$G = -10$ dBi,			θ	>	48°

where G and θ are defined in Paragraph 3.1.1(a).

This requirement should be met within any frequency defined in paragraph 3.2.2 in any direction within 3° of the geostationary arc.

(d) Receive Sidelobes

In order to protect receive signals from interference arising elsewhere, restrictions must also be placed on the receive sidelobe characteristics. Therefore, while not mandatory, it is recommended that the transmit sidelobe characteristics apply to the receive band as well.

Existing Antennas

Unless other agreements have been negotiated interference protection will be afforded to the following sidelobe envelope:

$G = 32 - 25 \log \theta$ dBi,	1°*	≤	θ	≤	48°
$G = -10.0$ dBi,			θ	>	48°

New Antennas

Interference protection will be afforded only to the following sidelobe envelope:

D/λ < 50

$G = 32 - 25 \log \theta$ dBi,	$100\ \lambda/D$°	≤ θ	≤	48°
$G = -10$ dBi,		θ	>	48°

* For D/λ below 100, this angle becomes 100 λ/D degrees.

<u>$D/\lambda \geq 50$</u>

$G = 29 - 25 \log \theta$ dBi,	$1^{*\circ} \leq \theta \leq 20^\circ$
$G = -3.5$ dBi,	$20^\circ < \theta \leq 26.3^\circ$
$G = 32 - 25 \log \theta$ dBi,	$26.3^\circ < \theta \leq 48^\circ$
$G = -10$ dBi,	$\theta > 48^\circ$

Where G and θ are defined in paragraph 3.1.1(a).

3.1.2 Polarization Sense, Orientation and Switchability

3.1.2.1 C–Band Antennas

(a) Transmit and Receive Polarization Senses

Intelsat VI, VII, VIIA, VIII, IX and X (1002) satellites utilize dual circular polarization at 6/4 GHz in the hemispheric, zone, and global transponders. Additionally, Intelsat VII, and VIIA are equipped with two 4 GHz spot beams, each operating at a different polarization (RHCP or LHCP)*.

Intelsat VIIIA (805) provides dual polarization coverage by overlapping two Hemispheric coverages (Hemi A or Hemi B), each operating with a different linear polarization.

The polarization requirements to operate in the 6/4 GHz band are shown in Table 1 and Table 2. Earth stations shall be capable of operating in any designated transponder in any polarization sense. However, simultaneous operation in both senses of polarization will not normally be required for either the uplink or for the downlink.

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* For D/λ below 100, this angle becomes $100\ \lambda/D$ degrees.

† Senses of polarization are defined in ITU Radio Regulations Article 1, Nos. 148 and 149.

(b) Faraday Rotational Effects [Linearly Polarized Antennas Operating with Intelsat VIIIA (805)]

Faraday rotation affects linearly polarized waves passing through the ionosphere. The effect of Faraday rotation is a decrease in the cross polarization discrimination. Because the magnitude of Faraday rotation varies as $1/f^2$, the effect is not as significant a consideration at Ku-Band. At C–Band, however, the $1/f^2$ dependence makes Faraday rotation an important consideration, particularly on the downlink.

The magnitude of the Faraday rotation depends on frequency, latitude, elevation angle, direction of propagation, the position of the sun relative to the earth station and solar flare activity. Faraday rotation has a distinct diurnal variation pattern which can lead to a diurnal variation in crosspolarization isolation. The diurnal variations become larger in years of high sunspot activity and during the equinox periods of any year.

Automated techniques to compensate for or to minimize the effect of Faraday rotation do exist and are similar to those used to compensate for rain depolarization. Faraday rotation effects can, also, be minimized by applying a fixed feed rotation equal to one half the expected diurnal variation. It is not possible, however, to select a fixed, pre–set rotational compensation that is adequate for all sunspot activity periods. Rather, the rotational compensation must be set on a yearly or seasonal basis.

Users using linear polarization in C–Band are urged to consider feed designs which would permit, if necessary, feed rotational compensation. Users of large earth stations should also consider feed designs which can accommodate an automated compensation network. As the direction of Faraday rotation is opposite on the uplink and downlink, feed designs which permit independent adjustment of the uplink and downlink are highly desirable.

(c) Polarization Orientation Of Linearly Polarized Antennas Operating With Intelsat VIIIA (805)

It is required that the earth station feed be optimized to match the spacecraft polarization angle under clear–weather conditions. This requirement does not apply to earth stations employing Faraday rotation compensation.

As explained in paragraph (b) above, Faraday rotation is diurnal in nature with the peak–to–peak diurnal variation increasing during the equinox periods of any year and in years of high sunspot activity. Because Faraday rotation effects are at a minimum just prior to sunrise, it is recommended that the antenna feed be aligned during the time period immediately preceding local sunrise. If possible, feeds should be aligned during the time period within one month of a solstice. Alignment of feeds during the period within one month of a equinox should be avoided whenever possible. It is recommended that the orientation of feeds aligned during periods other than the solstice be realigned during the next solstice period.

3.1.2.2 Ku–Band Antennas

(a) Transmit and Receive Polarization Senses

The polarization requirements to operate in the 14/11 and 14/12 GHz bands are shown in Table 3. Earth stations are required to operate with the appropriate polarization for each spot beam.

(b) Polarization Orientation

Although collocated spot beam operation from different spacecraft is not anticipated on Intelsat VII, VIII, VIIIA (805), IX or X (1002), contingencies or user requirements may necessitate such a mode of operation. The polarization alignment requirements of new antennas operating with these spacecraft have, accordingly, been developed in order to permit such collocated spot beam operation.

<u>Existing Antennas Operating with Intelsat VI, VII, VIII, VIIIA (805), IX and X (1002) (Built prior to 2 January 1993)</u>

It is recommended that the earth station feed be optimized match the spacecraft polarization angle under clear–weather conditions.

<u>New Antennas Operating with Intelsat VI , VII, VIII, VIIIA (805), IX and X (1002) (Built after 1 January 1993)</u>

It is required that the earth station feed be optimized to match the spacecraft polarization angle under clear–weather conditions.

<u>Antennas Operating with Intelsat VIIA</u>

With Intelsat VIIA, orthogonal dual linear polarization is used at 14/11 GHz and 14/12 GHz frequency bands. Earth stations shall be capable of operating in any designated transponder in any polarization sense. For additional information on Intelsat VIIA polarization, refer to IESS–415. It is required that the earth station feed be optimized to match the spacecraft polarization angle under clear–weather conditions.

3.1.2.3 Transmit and Receive Axial Ratio

The following voltage axial ratio requirements apply to the full bandwidth specified in paragraph 3.2.2:

(a) Circularly Polarized Antennas Operating in the 5.925 – 6.425 GHz and 3.700 - 4.200 GHz Bands (500 MHz)*

Antennas With Diameter Larger Than 2.5 m

The voltage axial ratio of transmission in the direction of the satellite shall not exceed 1.09 (27.3 dB polarization discrimination) everywhere within a cone centered on the main beam axis and whose angle is defined by the antenna tracking and/or pointing errors. The design goal, however, is 1.06 (30.7 dB polarization discrimination). It is recommended that this axial ratio not be exceeded for reception.

It is a mandatory requirement for earth station users to provide Intelsat with proof or certification of the antenna's receive axial ratio performance from their antenna manufacturer.

a) Antennas with Diameter 2.5 m or Smaller

The voltage axial ratio of transmission in the direction of the satellite shall not exceed 1.3 (17.7 dB polarization discrimination) everywhere within a cone centered on the main beam axis and whose angle is defined by the antenna tracking and/or pointing errors. It is recommended that this axial ratio not be exceeded for reception.

It is a mandatory requirement for earth station users to provide Intelsat with proof or certification of the antenna's receive axial ratio performance from their antenna manufacturer.

b) Special Conditions

The following exceptional relaxations apply to specific categories of antennas and will be evaluated on their merits by Intelsat on a case–by–case basis.

For certain specific applications, it may be possible to reduce the frequency bandwidth specified in paragraph 3.2.2 over which the mandatory axial ratio requirements are to be met in order to achieve some reduction in the feed costs.

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* These requirements also apply to earth stations operating in the 5.850 – 6.425 GHz and 3.625 – 4.200 GHz (575 MHz) bands on Intelsat VI, VIII, IX and X (1002).

For 6/4 GHz antennas, there may be special circumstances which would permit stations operating with particular modulation techniques to have an antenna voltage axial ratio greater than 1.09, even when a dual polarized spacecraft is being accessed. This may occur when frequency plans in oppositely polarized transponders can be interleaved, or when it can be demonstrated that no harmful co–channel interference will be produced, such as may occur when spectrum spreading techniques are used. In particular, if it is shown in the transmission plan that the on–axis crosspolarized aggregate EIRP density of all antennas at any uplink frequency does not exceed 20 dBW/4 kHz, then antennas with reduced axial ratio performance will be considered on a case–by–case basis.

(b) Antennas Operating in the 5.850 – 6.650 GHz and 3.400 – 4.200 GHz (800 MHz) Bands of Intelsat VIIIA (805)

Linearly Polarized Antennas* With Diameter Larger Than 4.5 Meters

The voltage axial ratio of transmission in the direction of the satellite shall exceed 31.6 (30.0 dB polarization discrimination) everywhere within a cone centered on the main beam axis and whose angle is defined by the antenna tracking and/or pointing errors. It is recommended that this axial ratio be exceeded for reception.

It is a mandatory requirement for earth station users to provide Intelsat with proof or certification of the antenna's receive axial ratio performance from their antenna manufacturer.

Linearly Polarized Antennas* With Diameter 4.5 Meters or Smaller

The voltage axial ratio of transmission in the direction of the satellite shall exceed 22.4 (27.0 dB polarization discrimination) everywhere within a cone centered on the main beam axis and whose angle is defined by the antenna tracking and/or pointing errors. The design goal, however, is 31.6 (30.0 dB polarization discrimination). It is recommended that this axial ratio be exceeded for reception.

It is a mandatory requirement for earth station users to provide Intelsat with proof or certification of the antenna's receive axial ratio performance from their antenna manufacturer.

(c) Existing Antennas Operating in the 14/11 or 12 GHz Bands with Intelsat VI, VII, VIIA, VIII, VIIIA (805), IX and X (1002)

As a design objective, the voltage axial ratio of transmission in the direction of the satellite should exceed 31.6 (30.0 dB polarization discrimination)

* The Intelsat VIIIA (805) spacecraft utilizes linear polarization in the 6 and 4 GHz bands.

everywhere within a cone centered on the main beam axis and whose angle is defined by the antenna tracking and/or pointing errors. It is recommended that this axial ratio be exceeded for reception.

It is a mandatory requirement for earth station users to provide Intelsat with proof or certification of the antenna's receive axial ratio performance from their antenna manufacturer.

To assist the frequency planning process, earth stations operating with Intelsat VIIA or with satellites having overlapping spot beam coverages may be required to submit measured data of the voltage axial ratio of transmission everywhere within a cone centered on the main beam axis and whose angle is defined by the antenna tracking and/or pointing errors.

(d) New Antennas Operating in the 14/11 or 12 GHz Bands with Intelsat VI, VII, VIIA, VIII, VIIIA (805), IX and X (1002) (Built after 1 January 1993).

Antennas with Diameter Larger Than 2.5 Meters

The voltage axial ratio of transmission in the direction of the satellite shall exceed 31.6 (30.0 dB polarization discrimination) everywhere within a cone centered on the main beam axis and whose angle is defined by the antenna tracking and/or pointing errors. It is recommended that this axial ratio be exceeded for reception.

It is a mandatory requirement for earth station users to provide Intelsat with proof or certification of the antenna's receive axial ratio performance from their antenna manufacturer.

Antennas With Diameter 2.5 Meters or Smaller

The voltage axial ratio of transmission in the direction of the satellites shall exceed 20.0 (26.0 dB polarization isolation) everywhere within a cone centered on the main beam axis and whose angle is defined by the antenna tracking and/or pointing errors. It is recommended that this axial ratio be exceeded for reception.

It is a mandatory requirement for earth station users to provide Intelsat with proof or certification of the antenna's receive axial ratio performance from their antenna manufacturer.

Transmit earth stations which do not comply with this 26 dB polarization discrimination requirement may operate, provided the polarization discrimination is 20 dB or greater everywhere within a cone centered on the main beam axis and whose angle is defined by the antenna tracking and/or pointing errors and the power density of the transmitted carrier does not exceed the following:

$$\text{Maximum EIRP Density} = 52.0 - (26.0 - \text{XPD})\ \text{dBW / 40 kHz}$$

Where: XPD is defined as the worse case polarization discrimination (≥ 20 dB) everywhere within a cone centered on the main beam axis and whose angle is defined by the antenna tracking and/or pointing errors.

Notes:

(1) The above computed EIRP density may not exceed that permitted by the off–axis emission limitations of Rec. ITU–R S.524–7.

(2) Type–approved antennas are required to meet a 26 dB polarization isolation everywhere within a cone centered on the main beam axis and whose angle is defined by the antenna tracking and/or pointing errors.

3.1.3 Antenna Steering or Beam Positioning

3.1.3.1 Antenna or Beam Steerability

Automatic or manual steering should be compatible with geostationary satellites at orbital locations for which the earth station elevation angle is not less than 5°.

Intelsat satellites are planned for locations within the nominal orbital arcs indicated below (subject to change with time). Intelsat should be contacted during the earth station design stage to determine if a reduction in the limits of these orbital arcs may apply:

AOR = 304.5° to 359° E

IOR = 33° to 66° E*

APR = 83° to 157° E*

POR = 174° to 180° E

If steering systems meeting these requirements are not provided, considerable outages may occur during transition to another satellite or during periods of service restoration through satellites at different orbit locations. Sufficient steering capability is also desirable to permit on–site demonstration of compliance with mandatory sidelobe levels.

* To provide the maximum flexibility for contingency operation, users in the APR and IOR should consider antenna steering systems capable of covering both regions to the extent possible from their geographic location.

3.1.3.2 Tracking Modes and Capability

Under nominal conditions, Intelsat intends to maintain the orbital movements of its satellites to the limits indicated below:

Satellite	Nominal Stationkeeping North–South (degrees)	Nominal Stationkeeping East–West (degrees)
VI, VII, VIIA, VIII, VIIIA, IX & X	± 0.05	± 0.05

Based on the above nominal stationkeeping limits and the earth station antenna beamwidth, the user should determine whether autotrack is required, taking into account the EIRP stability required in paragraph 3.1.3.4, the axial ratio requirement of paragraph 3.1.2.3 and performance objectives. As a minimum, manual tracking capability with the facility to peak up the receive signal is recommended, since the intended stationkeeping limits may be exceeded under certain special circumstances.

(a) 4 GHz Beacons

4 GHz beacon transmit frequencies for the Intelsat satellites are shown below:

Satellites	Beacon Frequencies (MHz)
VI	3,947.5, 3,948.0, 3,952.0 and 3,952.5
VII, VIIA, VIII, VIIIA (805), IX & X (1002)	Same 4 frequencies above used for telemetry, plus an unmodulated tracking–only beacon at 3,950.0

Only two of the four beacons on each Intelsat VII, VIIA, VIII, VIIIA (805), IX and X (1002) satellite can be operated simultaneously, one at the low frequency (3,947.5 or 3,948.0 MHz) and the other at the high frequency (3,952.0 or 3,952.5 MHz).

Standard G stations equipped with autotrack should note that in order to autotrack the Intelsat VI series of satellites by means of the beacon signals transmitted by these satellites, it is necessary to be able to receive and adequately differentiate between the following beacon frequencies: 3,947.5, 3,948.0, 3,952.0 and 3,952.5 MHz. It should be noted that a pair of beacon frequencies will normally be used at any given time, the choice of which will be determined by Intelsat.

Alternative means for tracking these satellites may be utilized.

Standard G stations accessing Intelsat VII, VIIA, VIII, VIIIA (805), IX and X (1002) satellites should, preferably, utilize the unmodulated 3,950 MHz beacon for tracking purposes. However, under contingency circumstances, the earth stations may be required to track using any of the four telemetry beacon frequencies. In which case, the provisions of the above paragraph shall apply.

(b) 11 GHz Beacons (Unmodulated)

The 11 GHz beacon transmit frequencies for the Intelsat VI, VII, VIIA, VIII, IX and X (1002) series are as follows:

- 11.198 GHz
- 11.452 GHz

Depending on the tracking requirements of users operating in the 14/11 GHz bands with antennas smaller than 3.8 meters on Intelsat VII, VIIA, VIII, IX and X (1002), Intelsat may operate the 11.198 GHz and 11.452 GHz beacons simultaneously. On Intelsat VI, only one beacon will be operated at a time. In case of a beacon failure on Intelsat VI, Intelsat may, at its discretion, operate the other beacon transmitter or provide an artificial beacon at the original frequency. In case of a beacon failure, some period of time may elapse before such an artificial beacon can be implemented. Users on Intelsat VI requiring a beacon for tracking purposes should confirm with Intelsat the operational frequency of the beacon on the satellite of interest and any contingency beacon plans. Users are urged to consider tracking system designs capable of operation with either beacon frequency.

(c) 12 GHz Beacons (Unmodulated)

12 GHz beacon transmit frequencies for the Intelsat VII, VIIA, VIII, and VIIIA (805) series are as follows:

– 11.701 GHz associated with the 11.7 to 11.95 GHz band, and

– 12.501 GHz associated with the 12.5 to 12.75 GHz band

Additional information regarding beacons is provided in the IESS 400 series spacecraft description modules.

3.1.3.3 Antenna Steering Data

IESS–412 describes a method by which earth station operators may compute the pointing direction from any earth station to any selected Intelsat–owned or operated spacecraft. The method may be implemented on a variety of computers ranging from a hand–held scientific calculator to personal computers. A Microsoft Windows–based software program (*Earth Station Pointing Data)* that performs all of the necessary computations described in IESS–412 has been developed by Intelsat and is available for downloading from the Intelsat Business Network (IBN) (https://ibn.intelsat.com/).

3.1.3.4 EIRP Stability

Tropospheric scintillation can occur in C–Band or Ku–Band under both adverse weather and clear–weather conditions and affects both linearly and circularly polarized signals. The effects of scintillation may be significant on links having elevation angles less than 20° and on links having elevation angles near 5°, scintillation effects can be severe. As a consequence of scintillation, antennas employing active tracking on low elevation paths may experience antenna mispointing or may transmit excessive EIRP levels when uplink power control is employed. The use of program track is, therefore, highly recommended on links operating with elevation angles less than 20° for those periods when tropospheric scintillation is severe and is recommended as the primary tracking method for antennas with elevation angles below 10°.

(a) Clear Weather

Carrier levels will be agreed upon in the coordinated transmission plan described in Section 1.0.

For tracking earth stations, the EIRP in the direction of the satellite shall, except under adverse weather conditions, be maintained to within +1.0 dB, -1.5 dB from the level assigned by Intelsat. For non-tracking earth stations, the EIRP in the direction of the satellite shall, except under adverse weather conditions, be maintained to within ± 0.75 dB from the level assigned by Intelsat. These tolerances include all earth station factors contributing to EIRP variation, antenna beam pointing and/or tracking error and fluctuations in the output RF power developed by the earth station transmit equipment, added on a root–sum–square basis.

In allocating a portion of the permitted EIRP instability to antenna beam pointing and/or tracking, users are cautioned that the crosspolarization isolation requirements of paragraph 3.1.2.3 must be met everywhere within a cone centered on the main beam axis and whose angle is defined by the antenna tracking and/or pointing errors.

The –1.5 dB requirement may be modified to a larger value for applications having sufficient margin. A request for a specific relaxation must be submitted at the time an earth station application is made and must be accompanied by a detailed transmission plan, as described in Section 1.0. Any relaxation will be evaluated on its merits by Intelsat on a case–by–case basis taking into account the immunity of the link to co–channel interference.

(b) Adverse Weather Conditions (Ku–Band)

If open–loop* uplink power control is used, it is recommended that when the up–path excess attenuation is greater than 1.5 dB, control of transmitter power be applied to restore the power flux density at the satellite to –1.5 dB, ± 1.5 dB of nominal, to the extent that it is possible with the total power control range available. The flux density level obtained for clear–sky EIRP shall not be exceeded by more than 1.5 dB prior to or following cessation of precipitation, except for a brief interval following recovery from propagation conditions.

3.2 General Radio Frequency Requirements

3.2.1 Satellite Bandwidth and Transponder Frequency Allocations

Transponder frequency details are provided in the IESS 400 series spacecraft description modules. Services can be assigned to any available transponder and to any satellite series as may be necessary for contingency operation or resource management.

3.2.2 Minimum Earth Station Bandwidth Requirements

(a) 6/4 GHz Bands (All Earth Stations), 14/12 GHz Bands (All Earth Stations) and 14/11 GHz Bands Having Antennas Larger Than 3.8 Meters

The instantaneous bandwidth of the earth station antenna feed elements and LNA shall include one of the full 6/4 GHz, 14/11 or 14/12 GHz frequency bands indicated in Table 4 and Table 5. The RF electronics of the earth station (this includes the frequency translators, local oscillators and HPA) shall be capable of operating (with tuning if necessary) across the full extent of the indicated transmit and receive bands.

As referred to in paragraph 3.1.2.3, for certain specific applications, it may be possible to allow a reduction in the frequency bandwidth

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* The term “open–loop” refers to uplink power control systems which derive the excess uplink path attenuation experienced by a given carrier by measurement of the downlink power of another carrier (such as the spacecraft beacon).

described in Table 4 and Table 5 in order to achieve some reduction in the earth terminal costs while meeting the axial ratio requirements. Any relaxation will be evaluated on its merits by Intelsat on a case–by–case basis.

(b) Earth Stations Utilizing the 14/11 GHz Bands Having Antennas with Diameters 3.8 Meters or Smaller

In order to achieve some reduction in the cost of earth terminals, the RF electronics (this includes the frequency translators, local oscillators, HPA, and transceivers*, if applicable) need only be capable of operation, with tuning if necessary, across one of the following transmit and receive band segments:

Receive		Transmit
10.95 to 11.2 GHz	and	14.0 to 14.25 GHz
	or	
11.45 to 11.7 GHz	and	14.25 to 14.5 GHz
	or	
12.50 to 12.75 GHz	and	13.75 to 14.0 GHz (Intelsat 1002 Spot 3 only)

Users are strongly urged to consider terminal designs capable of operation across the 10.95 to 11.7 GHz and 14.0 to 14.5 GHz bands. While Intelsat will make every effort to maintain frequency assignments within the capabilities of an earth terminal, reassignments may occur as a consequence of satellite transitions or traffic requirements. Frequency reassignments may also occur as a result of unforeseen circumstances such as may arise during contingency operation. In such contingency circumstances, advanced notification of frequency assignments may not be possible. Users of the 11 GHz band operating with reduced bandwidth terminals and utilizing the spacecraft beacon for tracking purposes should consider in their designs that, in the event of a failure of the spacecraft beacon, some period of time may elapse before the beacon can be restored (see para. 3.1.3.2(b)). This will, generally, be a serious consideration only for earth stations operating with inclined orbit satellites.

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* The term transceiver is used to denote integrated units generally containing an LNA, SSPA or TWTA, frequency translators and local oscillators.

3.2.3 Ability to Vary Frequency of Carriers

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 bandwidth.

Although two 70 MHz frequency converters can be used for multicarrier operation with 72 MHz transponders, users should consider the use of 140 MHz IF conversion equipment.

3.2.4 Carrier RF Frequency Tolerance

The frequency tolerance (maximum uncertainty of initial frequency adjustment plus long–term drift) on all earth station carriers shall be as shown below:

(a) Digital Carriers: ± 0.015 R Hz (± 2.0 kHz minimum, ± 10 kHz maximum), where R is the transmission rate in bits per second.

c) Analog Carriers
b) Carrier Type

Carrier Type	Carrier Bandwidth (B, MHz)					Freq. Tolerance (kHz)
SCPC/FM			-----------			± 1
FDM/FM and			B	≤	1.25	± 40
TV/FM	1.25	<	B	≤	5.0	± 80
	5.0	<	B	<	17.5	± 150
			B	≥	17.5	± 250

3.2.5 Satellite Transponder Translation Frequency Tolerance

The translation frequency tolerance (for all bands) due to the satellite should be assumed to be no worse than ± 25 kHz for Intelsat VI, VII, VIIA, VIII, VIIIA (805), IX and X (1002) satellites over their lifetime. The tolerance over any one month is typically ± 2.5 kHz.

3.2.6 Transmission Time Delay Variations Due to Satellite Motion

If digital carriers are to be interfaced with synchronous data networks, it may be necessary to provide the receive station with elastic buffer storage facilities or equivalent to allow for time delay variations caused by satellite motion. The amount of storage necessary is affected by the maximum diurnal satellite motion and the longitudinal drift.

Under nominal stationkeeping conditions, it may be assumed that the maximum time delay variation parameters to be expected from Intelsat satellites will be as follows:

Satellite	Max. Time Delay Variations (1) (Milliseconds)	Max. Rate of Time Delay Variations (2) (Nanoseconds/ second)
VI	0.32	10.0
VII, VIIA, VIII, VIIIA (805) and IX	0.43	15.4
X (1002)	0.23	8.2
NOTES: (1) Maximum = peak–to–peak, uplink plus downlink. (2) Maximum = uplink plus downlink.		

3.3 Emission Constraints

3.3.1 Off–Beam Emission EIRP Density (6 and 14 GHz)

The off–beam emission limits given in Rec. ITU–R S.524–7 shall not be exceeded.

3.3.2 Spurious Emissions Within The Satellite Band (5,850 to 6,425 MHz and 13,750 to 14,500 MHz)

3.3.2.1 Spurious Emissions (Except Intermodulation Products)

The EIRP resulting from spurious tones, bands of noise or other undesirable products, but excluding multicarrier intermodulation products and spectral spreading due to earth station non–linearities, that would be present when carriers are not activated (carrier “off”) shall not exceed 4 dBW/4 kHz anywhere within the following frequency ranges:

Operating Satellite	Frequency Range
Intelsat VII & VIIA	5,925 to 6,425 MHz 14,000 to 14,500 MHz
Intelsat VI, VIII & IX	5,850 to 6,425 MHz 14,000 to 14,500 MHz
Intelsat VIIIA (805)	5,850 to 6,650 MHz 14,000 to 14,500 MHz

Intelsat X (1002)	5,850 to 6,425 MHz 13,750 to 14,000 MHz 14,000 to 14,500 MHz

a) Spurious Products Associated With Transmissions To Standard E-1, F-1, G, H or K Earth Stations:

Spurious products falling in any 4 kHz band, which lies within the frequency range described in the above table, shall be at least 50 dB below the level of an unmodulated carrier (i.e., – 50 dBc)

b) Spurious Products Associated With Transmissions To Standard A, B, C, E–3, E–2, F–3 or F–2 Earth Stations

Spurious products falling in any 4 kHz band, which lies within the frequency range described in the above table, shall be:

1) at least 40 dB below the level of an unmodulated carrier (i.e., – 40 dBc) for carriers having information rates up to and including 2.048 Mbit/s.

2) at least 50 dB below the level of an unmodulated carrier (i.e., – 50 dBc) for carriers with information rates greater than 2.048 Mbit/s.

d)

3.3.2.2 Spurious Emission – Intermodulation Products

(a) 6 GHz Band

The EIRP density resulting from the buildup of intermodulation products transmitted from the earth station shall not exceed the levels shown in Table 6. This requirement applies outside the user's bandwidth. The level of earth station intermodulation which is acceptable within the user's bandwidth is determined by the user.

(b) 14 GHz Band

The EIRP density resulting from the buildup of intermodulation products transmitted from the earth station shall not exceed the limits shown in Table 7 under clear–sky conditions. When uplink power control is used, the limit given in Table 7 may be exceeded during rain events when the control is active, but under no circumstance shall it be exceeded by more than 9 dB. This specification applies outside the user's bandwidth. The level of earth station intermodulation which is acceptable within the user's bandwidth is determined by the user.

It may be permissible in some cases for the limits given in para. 3.3.2.2 (a) and (b) to be exceeded by some intermodulation products 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. Aggregate Earth Station HPA Intermodulation Products and HPA Output Noise.

3.3.2.3 Aggregate Earth Station HPA Intermodulation Products and HPA Output noise

The EIRP density limits specified in this module apply to intermodulation products resulting from the operation of a single HPA. For the recommended levels of aggregate earth station HPA IM and noise EIRP density levels to use in link budget calculations, refer to IESS–410.

3.3.2.4 Carrier Spectral Sidelobes

The spectral sidelobe of each transmitted digital carrier shall be more than 26 dB down from the spectral mainlobe peak when it falls outside the user's bandwidth. The acceptable level of spectral sidelobes falling within the user's bandwidth is determined by the user.

3.3.3 Unwanted Emissions Outside The Satellite Band

The definition of unwanted emissions (out–of–band and spurious) from both earth stations and spacecraft operating in the Fixed Satellite Service (FSS) are defined in Article 1 of the Radio Regulations, Nos. 1.144 and 1.145, respectively.

The out–of–band (OOB) domain comprises the region extending from the edge of the earth station amplifier's passband to the boundary between the OOB domain and the spurious domain. This boundary is normally located at a frequency offset from the edge of earth station high power amplifier's passband that is equal to twice the amplifier's bandwidth. The spurious emissions domain extends from the boundary with the OOB domain outwards. (Refer to Recommendations ITU–R SM.329, SM.1539 and SM.1541.)

Users should note that national regulators may impose additional domestic constraints on earth stations beyond those listed in this section. Users should, therefore, consult with their domestic regulatory authority to determine if such limits exist and to comply with them.

3.3.3.1 Out–Of–Band (OOB) Emissions

The Radio Regulations provide some general guidance on the need to limit OOB emissions to protect those services operating in the adjacent frequency bands (see RR No. 4.5).

The level of undesirable emissions in the out–of–band (OOB) domain should conform with the requirements of Annex 5 of ITU–R Recommendation SM.1541.

3.3.3.2 Spurious Emissions in the Spurious Domain – For Earth Stations Brought Into Service After 1 January 2003

All earth stations brought into service after 1 January 2003 shall ensure that spurious emissions in the spurious domain meet the mandatory requirements of Section 2 of Appendix 3 of the Radio Regulations.

3.3.3.3 Spurious Emissions in the Spurious Domain – For All Earth Stations After 1 January 2012

After 1 January 2012, all earth stations must meet the mandatory requirement of Section 3.3.3.2.

3.4 Ability to Vary EIRP of Carriers

It is recommended that means be provided whereby the level of each transmitted carrier can be adjusted over a range of 15 dB to meet changes that may occur in the agreed transmission plan.

3.5 Total Receive Power Flux Density at the Earth's Surface

The maximum expected total receive power flux densities for C–Band and Ku-Band earth stations are shown in Table 8 and Table 9 respectively.

3.6 Amplitude, Group Delay, and Electrical Path Length Equalization

In designing the RF subsystem, consideration should be given to amplitude, group delay and electric path length equalization requirements necessary to achieve user performance objectives.

3.7 Communications Between Intelsat and Standard G Earth Station

The user responsible for the control of each Standard G network shall ensure that a communications link can be established between Intelsat and a single point of contact for the purpose of relaying emergency and routine operational information and data. The user shall arrange in cooperation with, and to the satisfaction of, Intelsat for communication of the appropriate information to all Standard G earth stations in that particular network.

In order to facilitate the achievement of the communication requirement outlined above, collocation of transmitting Standard G stations and other Intelsat earth stations (e.g., A, B, C, etc.) is encouraged.

3.8 Testing Requirements

3.8.1 Test Equipment

The quantity and type of test and measuring equipment provided at an earth station will depend largely upon the wishes of the user and upon the quantities and types of equipment used. It should be such that all apparatus can be tested and maintained in a way that the performance requirements described in this document can be measured and verified. Certain of the tests and measurements required between cooperating pairs of earth stations require compatibility of test equipment.

3.8.2 Carrier Line–up and In–Service Monitoring

Standard G earth stations shall be equipped with facilities to measure the link parameters during the initial line–up.

Facilities to monitor the in–service communications performance are recommended.

It is the responsibility of the Standard G user to establish line–up procedures which are suitable for the modulation/access techniques employed in the user's network. When practicable, Intelsat may provide measuring facilities of some link parameters through its monitoring stations.

Users should consider the use of station fault indicators and automatic status reporting. Remote diagnostics should also be considered such that unmanned stations can be remotely controlled and test routines exercised.

3.9 Earth Station Control

In view of the numerous earth stations accessing the space segment on a multiple access (simultaneous) basis, any variation in transmit RF frequency, transmit EIRP and antenna tracking could cause interference with other services or cause hazardous conditions in the space segment. Accordingly, it is mandatory that earth stations be controlled at all times to avoid such interference.

In addition, bearing in mind that earth stations may be operated on a part–time or reservation basis, the station control facility should be compatible with such operation.

This requirement is considered to be satisfied when earth stations are attended 24–hours per day by operating personnel capable of adjusting frequency, EIRP and tracking, as required. In the event stations are not manned on a 24–hour per day basis, this requirement is considered to be satisfied when a positive means is available (remotely or otherwise) for immediately turning off RF carriers which are interfering with services or creating hazardous conditions in the space segment.

Table 1

STANDARD G EARTH STATION POLARIZATION REQUIREMENTS
TO OPERATE WITH INTELSAT VI, VII AND VIIA SATELLITES (6/4 GHz)

Coverage	Intelsat VI		Intelsat VII/VIIA	
	Earth Station Transmit	Earth Station Receive	Earth Station Transmit	Earth Station Receive
1. Global A	LHCP	RHCP	LHCP	RHCP
2. Global B	RHCP	LHCP	RHCP	LHCP
3. West Hemisphere (Hemi 1)* †	LHCP	RHCP	LHCP	RHCP
4. East Hemisphere (Hemi 2)* †	LHCP	RHCP	LHCP	RHCP
5. NW Zone (Z1)** (ZA)†	RHCP	LHCP	RHCP	LHCP
6. NE Zone (Z3)** (ZB)†	RHCP	LHCP	RHCP	LHCP
7. SW Zone (Z2)** (ZC)†	RHCP	LHCP	RHCP	LHCP
8. SE Zone (Z4)** (ZD)†	RHCP	LHCP	RHCP	LHCP
9. C–Spot A	N/A	N/A	LHCP	RHCP
10. C–Spot B	N/A	N/A	RHCP	LHCP

* Hemi 1, Hemi 2, ZA, ZB, ZC, ZD nomenclature applies to Intelsat VII and VIIA only.

** Z1, Z2, Z3, Z4 nomenclature applies to Intelsat VI only.

† This indicates the normal mode of operation for Intelsat VII and VIIA; the inverted mode implies different beams in the East and West, as illustrated in IESS–409.

Notes: LHCP = Left–Hand Circularly Polarized. N/A = Not applicable to this spacecraft

RHCP = Right–Hand Circularly Polarized.

Table 2

EARTH STATION POLARIZATION REQUIREMENTS TO OPERATE WITH INTELSAT VIII, VIIIA (805), IX and X (1002) SATELLITES (6/4 GHz) (1)

COVERAGE	Intelsat VIII & IX		Intelsat VIIIA (805)		Intelsat X (1002)	
	Earth Station Transmit	Earth Station Receive	Earth Station Transmit	Earth Station Receive	Earth Station Transmit	Earth Station Receive
1. Global A	LHCP	RHCP	N/A	N/A	LHCP	RHCP
2. Global B	RHCP	LHCP	N/A	N/A	RHCP	LHCP
3. Hemi 1 (2) (3)	LHCP	RHCP	N/A	N/A	LHCP	RHCP
4. Hemi 2 (2) (3)	LHCP	RHCP	N/A	N/A	LHCP	RHCP
5. Zone 1	RHCP	LHCP	N/A	N/A	RHCP	LHCP
Zone 2	RHCP	LHCP	N/A	N/A	RHCP	LHCP
Zone 3	RHCP	LHCP	N/A	N/A	N/A	N/A
Zone 4	RHCP	LHCP	N/A	N/A	N/A	N/A
Zone 5 (5)	RHCP	LHCP	N/A	N/A	N/A	N/A
6. Hemi A (4)	N/A	N/A	HPOL	VPOL	N/A	N/A
7. Hemi B (4)	N/A	N/A	VPOL	HPOL	N/A	N/A

NOTES:

(1) N/A = Not applicable to this spacecraft.

RHCP = Right–Hand Circularly Polarized LHCP = Left–Hand Circularly Polarized

VPOL = Vertically Linearly Polarized HPOL = Horizontal Linearly Polarized

(2) The Intelsat VIII may be operated in the normal or inverted attitude. In the AOR and IOR Hemi 1 corresponds to the West Hemi and Hemi 2 to the East Hemi. In the POR the Intelsat VIII will be operated in the inverted mode and, therefore, Hemi 1 corresponds to the East Hemi and Hemi 2 to the West Hemi.

(3) The Intelsat X (1002) Hemi 1A & Hemi 2A receive/transmit in LHCP/RHCP while Hemi 1B receives/transmits in RHCP/LHCP (there is no Hemi 2B).

(4) The Intelsat VIIIA Hemi A and Hemi B coverages are coincident.

(5) Only for Intelsat IX with 5–Zone mode.

Table 3

EARTH STATION POLARIZATION REQUIREMENTS TO OPERATE
WITH INTELSAT VI, VII, VIIA, VIII, VIIIA (805), IX and X (1002) SATELLITES
(14/11 GHz and 14/12 GHz)

		Linear Polarization (1)	
Satellite	Coverage	Earth Station Transmit	Earth Station Receive
VI	East Spot	Horizontal	Vertical
	West Spot	Vertical	Horizontal
VII	Spot 1 & Spot 3 (2)	Horizontal	Vertical
	Spot 2	Vertical	Horizontal
VIIA	S1, S2X, & S3 (2)	Horizontal	Vertical
	S1X, S2	Vertical	Horizontal
VIII, IX (4)	Spot 1	Horizontal	Vertical
	Spot 2	Vertical	Horizontal
VIIIA (805)	Spot 1	Horizontal	Vertical
X (1002)	Spot 1 (4) & Spot 3A	Vertical	Horizontal
	Spot 2 (4) & Spot 3B	Horizontal	Vertical

(1) Users are referred to the IESS–400 series modules for the definition of horizontal and vertical linear polarization and the dependence of the polarization orientation on the geographic location of the earth station.

(2) On Intelsat VII (F–4, F–5, and F–9) and Intelsat VIIA (F–6 and F–7), Spot 3 receive and transmit antenna polarization senses can be switched in orbit by ground command.

(3) Earth stations located in the South American beam are only required to receive in the vertical polarization.

(4) The polarization sense of either Intelsat VIII, IX or X (Spot 1 and Spot 2) Spot beams can be changed independently by ground command. Users are urged to confirm with Intelsat the polarization sense of the Spot beam that will be utilized.

Table 4

MINIMUM BANDWIDTH REQUIREMENTS FOR STANDARD G
C–BAND EARTH STATIONS

Satellite (1)	ITU Region	Earth Station Transmit Freq. (GHz)	Earth Station Receive Freq. (GHz)	Transmit and Receive Bandwidth (MHz)
VI, VII, VIIA, VIII, IX & X (1002)	All	5.925 – 6.425 (2)	3.700 – 4.200 (2)	500
VIIIA (805)	All			
Tx/Rx Antennas:				
Band 1		5.925 – 6.425 (2)	3.700 – 4.200 (2)	500
Band 2		5.850 – 6.650 (3)	3.400 – 4.200 (3)	800
Rx–Only Antennas:				
Band 1		N/A	3.700 – 4.200 (2)	500
Band 2		N/A	3.400 – 4.200 (3)	800

NOTES:

(1) Users are referred to the IESS–400 series modules for details of the channelization of the various Intelsat spacecraft.

(2) At 6/4 GHz, users should consider in their design the possibility of extending their usable bandwidth down to 3.625 GHz for receive and down to 5.850 GHz for transmit, in order to include transponder (1' – 2') of Intelsat VI, VIII, VIIIA (805), IX and X (1002).

(3) Some Administrations do not permit operation within the entire 5.850 – 6.650 GHz and 3.400 – 4.200 GHz Bands. Users in such Administrations may equip for those portions of the bands that are permitted.

Table 5

MINIMUM BANDWIDTH REQUIREMENTS FOR STANDARD G
Ku–BAND EARTH STATIONS

Satellite (1)	ITU Region	Earth Station Transmit Freq. (GHz)	Earth Station Receive Freq. (GHz)
VI, IX	All	14.00 – 14.50	10.95 – 11.20 & 11.45 – 11.70
VII, VIIA, VIII, X (1002) (4) (5)	All	14.00 – 14.50	10.95 – 11.20 & 11.45 – 11.70
	2 (2) (3)	14.00 – 14.25	11.70 – 11.95
	1 & 3 (2)	14.00 – 14.25	12.50 – 12.75
VIIIA (805)	2	14.00 – 14.25	11.70 – 11.95
	1 & 3	14.00 – 14.25	12.50 – 12.75

NOTES:

(1) Users are referred to the IESS–400 series modules for details of the channelization of the various Intelsat spacecraft.

(2) On Intelsat VII, the receive band segments of 11.70 – 11.95 GHz and 12.50 - 12.75 GHz are interchangeable between the East and West Spot beams, so this spacecraft series can be operated in any Ocean region.

(3) Earth station users should consider in their design the possibility of extending their usable bandwidth to 14.35 GHz in the transmit band and to 11.45 GHz in the receive band.

(4) For Ku–Band earth stations, consideration should be given to designing the RF system with a receive bandwidth of 10.95–12.75 GHz and a transmit bandwidth of 14.0 - 14.5 GHz. This will simplify conversion from the 11 GHz band to the 12 GHz band and provide maximum flexibility for operation with any spacecraft series.

(5) The Intelsat X (1002) Spot 3 beam receives in the 14.00 – 14.25 GHz band and transmits in the 12.50 – 12.75 GHz (Band D).

Table 6

EIRP DENSITY LIMITS FOR INTERMODULATION PRODUCTS
(6 GHz)

Uplink Transponder Impacted By Intermodulation Product	Limit* at 10 degree Elevation Angle and Beam Edge (dBW/4 kHz) (1)	Correction Factor (dB)
1. Hemi and Zone (2)	21	$-K_1$
2. Global & C–Spot (2)	24	$-K_2$

Where: K_1 and K_2 are the correction factors defined in IESS–402 for elevation angles other than 10° and earth station locations other than at beam edge.

NOTES:

(1) Obtaining these levels involves the suitable choice of operating conditions for all common amplifiers.

(2) Intelsat VIIIA (805) has hemispheric coverage only.

* See Section 3.3.2.3 for aggregate HPA IMP and output noise EIRP density levels recommended for use in link budget calculations.

Table 7

EIRP DENSITY LIMITS FOR INTERMODULATION PRODUCTS
(14 GHz)

Uplink Transponder Impacted By Intermodulation Product	Limit at 10 degree Elevation Angle and Beam Edge (dBW/4 kHz) (1)		Correction Factor (dB)
	VI	VII, VIIA, VIII, VIIIA (805), IX & X (1002)	
Spot	10	16	– K_1

Where: K_1 is the correction factor defined in IESS–402 for elevation angles other than 10° and earth station locations other than at beam edge.

NOTES:

(1) Obtaining these levels involves the suitable choice of operating conditions for all common amplifiers.

Table 8

MAXIMUM POWER FLUX DENSITY (PFD) AT THE EARTH'S SURFACE
(C–Band Downlinks, dBW/m^2)

Satellite	Typical PFD Per Transponder			Maximum Total PFD*	
	(Global)	(Hemi/Zone)	(C–Spot)	(A–Pol)**	(B–Pol)**
VI	– 137.1	– 132.1	N/A	– 123.5	– 124.0
VII	– 134.6	– 131.1	– 125.1	– 117.9	–117.9
VIIA	–134.1	–131.1	–124.5	–117.4	–117.7
VIII	–133.1	–130.1	N/A	–118.8	–118.8
IIIA (805)	N/A	–128.6	N/A	–113.4	–113.4
IX	–130.6	–124.4	N/A	–116.0	–116.0
X (1002)	TBD	TBD	N/A	TBD	TBD

NOTES:

* Maximum total PFD is the PFD resulting from all transponders in a given beam.

** Circularly Polarized Spacecraft

A–pol = A polarization (RHCP), which includes global, hemispheric, and 4 GHz spot beams.

B–pol = B polarization (LHCP), which includes global, zone, and 4 GHz spot beams.

Linearly Polarized Spacecraft [Intelsat VIIIA (805)]

A–pol = Hemi A, which is vertically polarized on the downlink.

B–pol = Hemi B, which is horizontally polarized on the downlink.

Table 9

MAXIMUM POWER FLUX DENSITY AT THE EARTH'S SURFACE
(Ku–Band Downlinks, dBW/m^2)

Satellite	Downlink Spot Beams	Typical PFD Per Transponder	Maximum Total PFD*
VI	11 GHz	– 118.3	– 110.4
VII	11 GHz	– 115.4	– 107.4
	12 GHz	– 115.4	– 109.1
VIIA	11 GHz	– 112.6	– 106.2
	12 GHz	– 113.6	– 108.8
VIII	11 GHz	– 113.5	– 106.2
	12 GHz	– 113.5	– 108.7
VIIIA (805)	12 GHz	– 117.1	– 108.9
IX	11 GHz	–115.6	–104.6
X (1002)	11 GHz	TBD	TBD
	12 GHz		

* Maximum total PFD is the PFD resulting from all transponders in a given beam.

Appendix A

REQUIREMENTS FOR EARTH STATIONS ACCESSING INTELSAT SPACE SEGMENT WITHOUT SUBMITTING ANTENNA PERFORMANCE DATA

(STANDARD Gx)

STANDARD Gx

A.1 INTRODUCTION

Standard Gx is a sub–classification of Standard G antennas having diameters 4.5 meters or less at C–Band and 3.5 meters or less at Ku–Band which are permitted to access the Intelsat space segment without submitting measured antenna performance data, subject to the constraints on transmit EIRP density identified below.

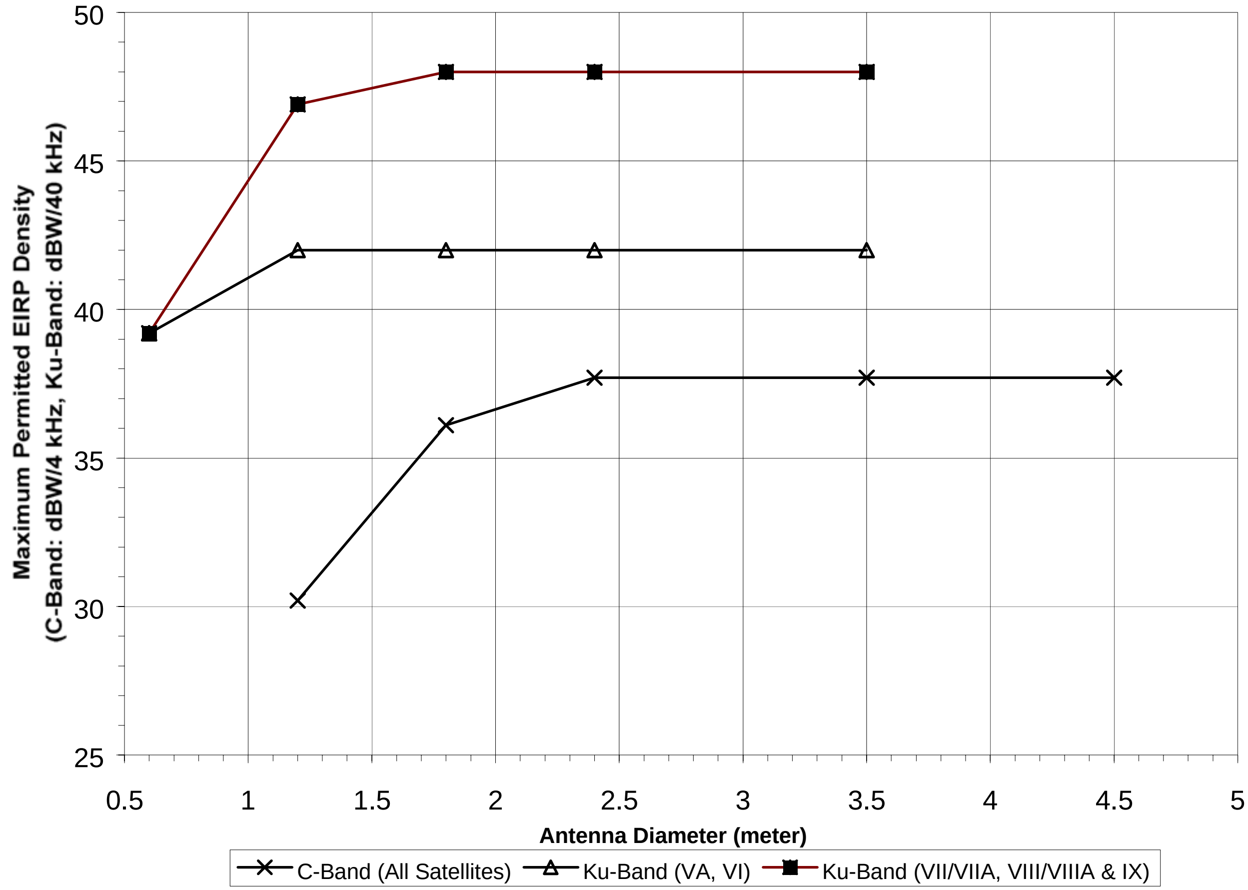
A.2 Maximum Transmit EIRP

C–Band earth stations utilizing antennas with diameters of 4.5 meter or less and Ku–Band earth stations with diameters of 3.5 m or less which have not undergone the standard antenna verification testing process or are not type-approved may access the space segment provided the maximum aggregate transmit EIRP density of all antennas at any uplink frequency, as documented in the approved transmission plan, does not exceed the values shown in Figure A.1. Such antennas will be classified as Standard Gx.

Note:

The above computed EIRP density may not exceed that permitted by the off–axis emission limitations of Rec. ITU–R S.524–7.

Figure A.1
Maximum Permitted EIRP Density Versus Antenna Diameter



Appendix B

REQUIREMENTS FOR EARTH STATIONS EMPLOYING ENHANCED PERFORMANCE OFFSET-FED ANTENNAS

(STANDARD GE)

STANDARD GE

B.1 INTRODUCTION

Standard GE is a sub-classification of Standard G earth stations which is used for applications requiring increased uplink EIRP capability or increased protection from adjacent satellite interference. This Appendix provides supplementary RF required requirements for Standard GE earth stations. Standard GE earth stations shall comply with the Standard G requirements contained in the main body of this IESS module.

B.2 GENERAL ANTENNA PERFORMANCE CHARACTERISTICS REQUIRED FOR STANDARD GE EARTH STATIONS ACCESSING THE INTELSAT SPACE SEGMENT

B.2.1 Antenna Sidelobe Pattern (6/4 GHz)

(a) Transmit Sidelobe Design Objective

The design objective should be such that the gain of 90 percent of the copolarized and crosspolarized sidelobe peaks does not exceed an envelope described by:

First Sidelobe Gain: $G = 15 \log (D/\lambda) - 6$ dBi, $2.4 \leq D \leq 2.8$ meter.

$D \geq 2.4$ meter

Region Beyond The First Sidelobe:

$G = 22 - 25 \log \theta$ dBi,	1°*	$\leq$	$\theta \leq$	10.5°
$G = -3.5$ dBi,	10.5°	$<$	$\theta \leq$	26.3°
$G = 32 - 25 \log \theta$ dBi,	26.3°	$<$	$\theta \leq$	48°
$G = -10$ dBi,			$\theta >$	48°

where: G is the gain of the sidelobe envelope relative to an isotropic antenna in the direction of the geostationary orbit, in dBi.

θ is the angle in degrees between the main beam axis and the direction considered.

* For D/λ below 100, this angle becomes $100\ \lambda/D$ degrees.

This requirement should be met within any frequency defined in paragraph 3.2.2 of the main text and for any direction which is within 3° of the geostationary arc (Rec. ITU-R S.580–4).

(b) Transmit Sidelobe Mandatory Requirements

It is required that the gain of 90 percent of the copolarized and crosspolarized sidelobe peaks not exceed an envelope described by the following:

First Sidelobe Gain: $G = 15 \log (D/\lambda) - 6$ dBi, $2.4 \leq D \leq 2.8$ meter.

<u>D ≥ 2.4 meter</u>

Region Beyond The First Sidelobe:

$G = 25 - 25 \log \theta$ dBi,	$1°$*	$\leq$	θ	$\leq$	$13.8°$
$G = -3.5$ dBi,	$13.8°$	$<$	θ	$\leq$	$26.3°$
$G = 32 - 25 \log \theta$ dBi,	$26.3°$	$<$	θ	$\leq$	$48°$
$G = -10$ dBi,			θ	$>$	$48°$

Where G and θ are as defined above.

B.2.2 Antenna Sidelobe Pattern (14/11 GHz and 14/12 GHz)

(a) Transmit Sidelobe Design Objective

The design objective should be such that the gain of 90 percent of the copolarized and crosspolarized sidelobe peaks does not exceed an envelope described by:

First Sidelobe Gain: $G = 15 \log (D/\lambda) - 6$ dBi, $1.0 \leq D \leq 1.2$ meter.

<u>D ≥ 1.0 meter</u>

Region Beyond The First Sidelobe:

$G = 22 - 25 \log \theta$ dBi,	$1°$*	$\leq$	θ	$\leq$	$10.5°$
$G = -3.5$ dBi,	$10.5°$	$<$	θ	$\leq$	$26.3°$
$G = 32 - 25 \log \theta$ dBi,	$26.3°$	$<$	θ	$\leq$	$48°$
$G = -10$ dBi,	$\theta >$	$48°$			

where G and θ are as defined above.

* For D/λ below 100, this angle becomes $100\ \lambda/D$ degrees.

This requirement should be met within any frequency defined in paragraph 3.2.2 of the main text in any direction within 3° of the geostationary arc.

(b) Transmit Sidelobe Mandatory Requirements

It is required that the gain of 90 percent of the copolarized and crosspolarized sidelobe peaks not exceed an envelope described by the following:

First Sidelobe Gain: $G = 15 \log (D/\lambda) - 6$ dBi, $1.0 \leq D \leq 1.2$ meter.

<u>$D \geq 1.0$ meter</u>

Region Beyond The First Sidelobe:

$G = 25 - 25 \log \theta$ dBi,	$1°^* \leq \theta \leq 13.8°$
$G = -3.5$ dBi,	$13.8° < \theta \leq 26.3°$
$G = 32 - 25 \log \theta$ dBi,	$26.3° < \theta \leq 48°$
$G = -10$ dBi,	$\theta > 48°$

where G and θ are as defined above.

This requirement should be met within any frequency defined in paragraph 3.2.2 of the main text in any direction within 3° of the geostationary arc.

B.2.3 Receive Sidelobes

In order to protect receive signals from interference arising elsewhere, restrictions must also be placed on the receive sidelobe characteristics. Therefore, while not mandatory, it is recommended that the transmit sidelobe characteristics apply to the receive band as well.

Interference protection will be afforded only to the following sidelobe envelope:

First Sidelobe Gain: $G = 15 \log (D/\lambda) - 6$ dBi,

$2.4 \leq D \leq 2.8$ meter, C–Band

$1.0 \leq D \leq 1.2$ meter, Ku–Band

<u>$D \geq 2.4$ meter in C–Band and $D \geq 1.0$ meter in Ku–Band</u>

Region Beyond The First Sidelobe:

$G = 25 - 25 \log \theta$ dBi,	$1° \leq \theta \leq 13.8°$
$G = -3.5$ dBi,	$13.8° < \theta \leq 26.3°$

e)

$G = 32 - 25 \log \theta$ dBi,	26.3°	<	θ	≤ 48°
$G = -10$ dBi,			θ	> 48°

where G and θ are as defined above.

B.2.4 Transmit and Receive Axial Ratio

The following voltage axial ratio requirements apply to the full bandwidth specified in paragraph 3.2.2 of the main text.

(a) Circularly Polarized Antennas Operating in the 5.925 – 6.425 GHz and 3.700 – 4.200 GHz Bands (500 MHz)*

The voltage axial ratio of transmission in the direction of the satellite shall not exceed the following values everywhere within a cone centered on the main beam axis and whose angle is defined by the antenna tracking and/or pointing errors.

Antenna Diameter (m)	2.4	> 2.4
Voltage Axial Ratio	1.18	1.056
Polarization Discrimination (dB)	21.7	31.3

(b) Antennas Operating in the 5.850 – 6.650 GHz and 3.400 – 4.200 GHz (800 MHz) Bands of Intelsat VIIIA (805) and APR1

Linearly Polarized Antennas* With Diameter 4.5 Meters or Smaller

The voltage axial ratio of transmission in the direction of the satellite shall exceed 35.5 (31.0 dB polarization discrimination) everywhere within a cone centered on the main beam axis and whose angle is defined by the antenna tracking and/or pointing errors.

(c) Antennas Operating in the 14/11 or 12 GHz Bands with Intelsat VI, VII/VIIA, VIII/VIIIA (805), IX and X (1002).

Antennas with Diameter 2.5 Meters or Larger

The voltage axial ratio of transmission in the direction of the satellite shall exceed 50.1 (34.0 dB polarization discrimination) everywhere within a cone centered on the main beam axis and whose angle is defined by the antenna tracking and/or pointing errors. It is recommended that this axial ratio be exceeded for reception.

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* These requirements also apply to earth stations operating in the 5.850 – 6.425 GHz and 3.625 – 4.200 GHz (575 MHz) bands on Intelsat VI, VIII and X (1002), and for antennas accessing Intelsat VIIIA (805) which do not equip for operation with the full 800 MHz extended C–Band.

Antennas With Diameter Larger Than 0.9 Meter and Less Than 2.5 Meter

The voltage axial ratio of transmission in the direction of the satellites all exceed 31.6 (30.0 dB polarization isolation) everywhere within a cone centered on the main beam axis and whose angle is defined by the antenna tracking and/or pointing errors. It is recommended that this axial ratio be exceeded for reception.

Appendix C

ITU REFERENCES

Radiocommunication Sector Recommendations:

Rec. ITU–R S.465–5	Reference Earth Station Radiation Pattern For Use In Coordination And Interference Assessment In The Frequency Range From 2 to about 30 GHz.
Rec. ITU–R S.524–7	Maximum Permissible Levels Of Off–Axis EIRP Density From Earth Stations In The Fixed–Satellite Service Transmitting In The 6 and 14 GHz Frequency Bands
Rec. ITU–R S.580–5	Radiation Diagrams For Use As Design Objectives For Antennas Of Earth Stations Operating With Geostationary Satellites.
Rec. ITU–R SM.329	Spurious Emissions
Rec. ITU–R SM.1539	Variation Of The Boundary Between The Out–Of–Band And Spurious Domains Required For The Application Of Recommendations ITU–R SM.1541 and ITU–R SM.329
Rec. ITU–R SM.1541	Unwanted Emissions In The Out–Of–Band Domain

ITU Radio Regulations:

Appendix 3: Table Of Maximum Permitted Spurious Emission Levels
Radio Regulation Article 1, Numbers 148 and 149
Radio Regulation Article 1, Numbers 1.144 and 1.145

Appendix D

REVISION HISTORY

Revision No.	Approval Date	Major Purpose
Original	10 Dec 1987	• New module.
1	21 Jun 1989	• Relax voltage axial ratio to 1.3 for small C-Band antennas. • Add CCIR/CCITT references
2	13 Jun 1990	• Incorporate Intelsat VII and K, delete Intelsat IVA. • Add revision history.
3	09 Dec 1991	• Unify terminology by replacing terms such as applicants, earth station operating entities, owners, etc., with users. • Update CCIR references. • Clarify the requirement for the allowable energy density of intermodulation products at 6 GHz (Table 3). • Make the polarization requirements of Table 1 mandatory (para. 3.1.2.1). • Add a mandatory Ku–Band polarization requirement to para. 3.1.2.1. Added Table 2. • Add mandatory requirement for 1 degree Ku–Band antenna polarization adjustment accuracy (para. 3.1.2.2). • Add mandatory requirement for Ku–Band antenna transmit axial ratio (para. 3.1.2.3). • Clarify how antenna steering data will be provided (para. 3.1.3.3). • Add requirement for uplink power control (para. 3.1.3.4).

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Revision No.	Approval Date	Major Purpose
		• Clarify the transponder translation frequency tolerance for Intelsat VA (IBS) and K (para. 3.2.3). • Update the 14 GHz band off–beam emission limits to be consistent with CCIR Recommendation 524–3 (para. 3.3.1).
4	09 Feb 1994	• Incorporate Intelsat VIIA. • Extend Standard G definition to include earth stations supporting both domestic and international lease services. (Standard Z designation will no longer be used for new earth stations accessing the leased space segment) (para. 1.1) • Clarify that all Standard A, B, C, D–2, E earth stations may operate as a Standard G. Standard F and D–1 terminals meeting a 1.09 axial ratio over the 5.925 – 6.425 GHz band may also operate as a Standard G. (para. 1.4) • Update transmit and receive antenna sidelobe requirement to be consistent with Rec. ITU-R S.580.4 (para. 3.1.1) • Update recommended antenna steerability limits. Add APR region (para. 3.1.3.1). • Update source of antenna steering data (para. 3.1.3.3). • Relax clear–weather EIRP stability requirement to permit larger decrease of EIRP under special conditions. Clarify that ULPC systems should restore EIRP to -1.5 dB of nominal value under adverse weather conditions (para. 3.1.3.4).

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REVISION HISTORY

Revision No.	Approval Date	Major Purpose
		• Clarify that minimum operational bandwidth requirement of terminals operating in the 14/11 GHz bands with antennas smaller than 3.8 meters applies only to the antenna feed elements. • Relax RF frequency tolerance for low rate digital carriers (para. 3.2.4). • Update ITU nomenclature and references to reflect Radio Communications Sector recommendations (Appendix A).
5	25 Aug. 1994	• Incorporate Intelsat VIII and VIIIA, including bandwidth requirements for operation in the extended C–Bands of Intelsat VIIIA. • Add paragraph concerning Faraday rotation and detailing recommended time periods for aligning linearly polarized C–Band antenna feeds (para. 3.1.2.1). • Add special condition for antennas with diameters in the range of 4.5 to 7 meters which utilize meanderline polarizers (para. 3.1.2.3). • Add section 3.5 and associated Tables 6(a) and 6(b) giving maximum and typical earth station receive PFD levels.
6	15 Aug. 1995	• Add requirement that Ku–Band earth stations built prior to 1993 may be required to supply measured data of transmit polarization isolation (para. 3.1.2.3 (c)).

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REVISION HISTORY

Revision No.	Approval Date	Major Purpose
		• Relax requirement for transmit polarization isolation of Ku–Band earth stations with antenna diameters 2.5 m or smaller (para. 3.1.2.3 (d)).
7	15 May 1997	• Clarify earth station classification procedure (para. 1.1). • Incorporate Standard Gx requirements (para. 3.1.2.3). • Clarify necessity for considering cross-polar isolation in the process of allocating EIRP instability allowance between tracking/pointing and RF equipment level fluctuation (para. 3.1.3.4). • Align clear–weather spurious emission requirements with those in other IESS modules (para. 3.3.2).
8	5 Nov 1997	• Add EIRP stability requirements for non-tracking earth stations (para. 3.1.3.4(a)) • Move Standard Gx requirements to Appendix A. • Incorporate Standard GE requirements (Appendix B).
9	30 Nov 1998	• Delete reference to Intelsat VA (IBS) and satellites transferred to New Skies Satellites.
10	10 Feb 2000	• Include Intelsat IX. • Delete Intelsat V.

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REVISION HISTORY

Revision No.	Approval Date	Major Purpose
10A	20 Nov 2000	• Add recommendation for the aggregate level of earth station HPA IM and noise to use in link budget calculations.
11	07 Oct 2002	• Editorial updates: change INTELSAT to Intelsat and font from Times New Roman to Arial. • Add Radio Regulations requirements for unwanted emissions outside the satellite band.
12	10 March 2005	• Slightly revise the wording for the Radio Regulations requirements for unwanted emissions outside the satellite band. • Delete Intelsat VA. • Include Intelsat X (1002).