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# INTELSAT EARTH STATION STANDARDS (IESS)

## Document IESS–208 (Rev. 6)*

STANDARDS C, E and K

ANTENNA AND WIDEBAND RF PERFORMANCE CHARACTERISTICS OF
Ku–BAND EARTH STATIONS ACCESSING THE INTELSAT SPACE SEGMENT
FOR STANDARD SERVICES

(14 and 11/12 GHz Frequency Bands)

Approval Date: 23 February 2006

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* Prior to the adoption of IESS–208, the requirements for Standard C and E earth stations were contained in IESS–203 (Rev. 3) and IESS–205 (Rev. 2) respectively.

# INTELSAT Ku–BAND EARTH STATION STANDARDS (IESS)

## STANDARDS C, E and K
(14 and 11/12 GHz Frequency Bands)

## 1.0 ANTENNA SYSTEM

For the purposes of this IESS module the term RFP (request for proposal) is considered to include any document specifying contractual performance characteristics.

### 1.1 Gain–to–Noise Temperature Ratio

INTELSAT has developed this IESS module for earth stations that would meet one of six minimum G/T values. The selection of a Standard K–2, K–3*, E–1, E–2, E–3 or C earth station will depend upon User requirements with respect to site location, traffic volume, and channel performance.

Approval of an earth station in the category of Standard C, E or K will only be obtained if the following condition is met for operation in the direction of the satellite under clear–sky, light wind loading, and for the frequency bands defined in paragraph 2.2.

| Standard | G/T Requirement |
|---|---|
| C | $\geq 37.0 + 20 \log_{10} f/11.2$, dB/K |
| E–3 | $\geq 34.0 + 20 \log_{10} f/11.0$, dB/K |
| E–2 | $\geq 29.0$ (but $< 34.0$) $+ 20 \log_{10} f/11.0$, dB/K |
| E–1 | $\geq 25.0$ (but $< 29.0$) $+ 20 \log_{10} f/11.0$, dB/K |
| K–3 | $\geq 23.3 + 20 \log_{10} f/11.0$, dB/K |
| K–2 | $\geq 19.8 + 20 \log_{10} f/11.0$, dB/K |

Where: G is the receiving antenna gain referred to the input of the low–noise amplifier relative to an isotropic radiator; T is the receiving system noise

* The designation Standard K–1 has been reserved for future use.

temperature referred to the input of the low–noise amplifier relative to 1 kelvin; and f is the frequency in GHz.

Clear–sky is taken to be the condition of intrinsic atmospheric attenuation due to gases and water vapor (Rec. ITU–R PN.676–1) without excess attenuation due to tropospheric precipitation such as rain and snow.

To ensure the best utilization of the space segment, the aim is to achieve for the receiving system a gain–to–noise temperature ratio (G/T) that is sufficient to ensure that applicable performance criteria are met. In designing earth stations to achieve these performance criteria, consideration should be given to the local environmental conditions. During adverse climatic conditions, such as rain, snow, strong winds, etc., the nominal performance will not necessarily be met. The percentage of time during which these values will be exceeded will depend, *inter alia*, upon the statistics of the local weather, upon antenna performance characteristics, and upon the relationship between the weather parameters and the channel performance.

This requires a consideration of long–term rainfall data and the associated attenuation and sky noise temperature data at each earth station. Considering the form in which propagation information is available, it is more convenient to express the monthly channel performance criteria in terms of percentage–of–a–year relationships which are chosen to be equivalent to the ITU–R values.

Users are cautioned that the above G/T values do not ensure that all INTELSAT standard service (e.g., IDR or IBS) performance objectives can be met at all geographic locations. In planning earth station facilities for supporting INTELSAT standard services, Users shall take into consideration the excess of the downlink degradation[*] predicted by local rain statistics over the reference degradation margins provided in the applicable IESS 300 series module for the same percentage of time. Users are referred to the applicable IESS 300 series module for the requirements of operation with these services.

The preferred method of determining the G/T of an earth station is by radiostar measurement at a high elevation angle, whenever possible. Correction for the operating elevation angle can then be performed through the system noise temperature (T) profile. Due to the low flux densities radiated by the radiostars (Cassiopeia A, Taurus A, and Cygnus A) at 11 GHz, the use of radiometric techniques is required. Alternatively, the G/T can be determined by separate

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* Downlink degradation is defined as the sum of the precipitation attenuation (in dB) and the increase in the receiving system noise temperature (in dB) for the given percentage of time.

measurements of the antenna gain (G), using a satellite carrier or a boresight facility, and of the system noise temperature (T). Information on measurement methods, source characteristics, correction factors and parameters associated with the radiostar method and the antenna gain method can be found in Rec. ITU–R S.733–1 and the INTELSAT SSOG.

## 1.2 Earth Station Approval

Approval of an earth station will be limited to angles of operation for which the condition of paragraph 1.1 is satisfied. Therefore, the User may need to modify the earth station before permission is given to operate it with satellites seen at elevation angles other than those for which the above values are satisfied. Earth stations operating with elevation angles between 5° and 10° will qualify as Standard C, E and K only if improved RF characteristics are provided to overcome the adverse propagation conditions experienced locally. These cases will be reviewed by INTELSAT on a case–by–case basis.

Due to the technical difficulties associated with the testing of small aperture antennas and the costs associated with the testing of large numbers of such antennas, all Standard K earth for which an RFP is issued after 1 January 1999 and Standard E–1* earth stations for which an RFP is issued after 1 January 2002 are required to utilize type–approved antennas. Prior to these dates, it is highly recommended that Standard K and E–1 antennas be tested using the antenna manufacturer's facilities. The G/T performance of such antennas may be demonstrated by computation using type–approved values of antenna receive gain and noise temperature and LNA noise temperature data supplied by the LNA manufacturer.

## 1.3 Antenna Sidelobe Pattern

Sidelobe levels are referred to the gain of an isotropic antenna and shall meet the criteria in the following subsections. These requirements shall be met within any frequency defined in paragraph 2.2 and for any direction which is within 3° of the geostationary arc.

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* Users of other INTELSAT standard earth stations are also urged to consider the benefits of using type–approved antennas.

The following definitions apply to these requirements:

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

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

90 percent = the total number of peaks within the orbital boundaries defined by Rec. ITU–R S.580–5.

1.3.1 Transmit Sidelobe Mandatory Requirements for Standard K

Antennas With an RFP Issued Prior To 1996

At angles greater than 100 λ/D° 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, $100\ \lambda/D° \leq \theta < 48°$
$G = -10$ dBi $48° \leq \theta$

Antennas Having an RFP Issued After 1995

At angles greater than 100 λ/D° 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:

D/λ < 50

$G = 32 - 25 \log \theta$ dBi, $100\ \lambda/D° \leq \theta < 48°$
$G = -10$ dBi, $48° \leq \theta$

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

$G = 29 - 25 \log \theta$ dBi, $100\ \lambda/D° \leq \theta \leq 20°$
$G = -3.5$ dBi, $20° < \theta \leq 26.3°$
$G = 32 - 25 \log \theta$ dBi, $26.3° < \theta < 48°$
$G = -10$ dBi, $48° < \theta$

1.3.2 Transmit Sidelobe Design Objectives For Standard E Antennas with an RFP Issued Before 1996

The design objective for antennas with $D/\lambda \geq 100$ should be such that the gain of 90 percent of the copolarized and crosspolarized sidelobe peaks not exceed an envelope described by:

| | | | | | |
|---|---|---|---|---|---|
| $G = 29 - 25 \log \theta$ 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, | | | $\theta$ | $>$ | $48^{\circ}$ |

1.3.3 Transmit Sidelobe Mandatory Requirements

a) Standard C Antennas with an RFP Issued Before 1989 and Standard E Antennas with an RFP Issued Before 1996.

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, | $1^{\circ*}$ | $\leq$ | $\theta$ | $\leq$ | $48^{\circ}$ |
| $G = -10$ dBi | | | $\theta$ | $>$ | $48^{\circ}$ |

b) Standard C Antennas with an RFP Issued After 1988 and Standard E Antennas with an RFP Issued After 1995. (Rec. ITU–R S.465–5 and Rec. ITU–R S.580–5) It is required that the gain of 90 percent of the copolarized and crosspolarized sidelobe peaks not exceed an envelope described by:

| | | | | | |
|---|---|---|---|---|---|
| $G = 29 - 25 \log \theta$ 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, | | | $\theta$ | $>$ | $48^{\circ}$ |

1.3.4 Receive Sidelobes

In order to protect receive signals from interference arising elsewhere, restrictions should also be placed on the receive sidelobe characteristics. Therefore, while not

* For $D/\lambda$ below 100, this angle becomes 100 $\lambda/D$ degrees. However, it is expected that Standard C and E antennas will always have $D/\lambda$ greater than 100.

mandatory, it is recommended that the transmit sidelobe characteristics apply to the receive band as well.

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

<u>Standard C Antennas with an RFP Issued Prior To 1989 and Standard E Antennas With an RFP Issued Prior to 1996</u>

| | |
|---|---|
| $G = 32 - 25 \log \theta$ dBi, | $1° \leq \theta \leq 48°$ |
| $G = -10.0$ dBi, | $\theta > 48°$ |

<u>Standard C Antennas with an RFP Issued After 1988 and Standard E Antennas with an RFP Issued After 1995</u>

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

<u>Standard K Antennas with an RFP Issued Prior to 1996</u>

| | |
|---|---|
| $G = 32 - 25 \log \theta$ dBi, | $100\ \lambda/D° \leq \theta < 48°$ |
| $G = -10.0$ dBi, | $48° \leq \theta$ |

<u>Standard K Antennas with an RFP Issued After 1995</u>

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

| | |
|---|---|
| $G = 32 - 25 \log \theta$ dBi, | $100\ \lambda/D° \leq \theta < 48°$ |
| $G = -10$ dBi, | $48° \leq \theta$ |

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

| | |
|---|---|
| $G = 29 - 25 \log \theta$ dBi, | $100\ \lambda/D° \leq \theta \leq 20°$ |
| $G = -3.5$ dBi, | $20° < \theta \leq 26.3°$ |
| $G = 32 - 25 \log \theta$ dBi, | $26.3° < \theta < 48°$ |
| $G = -10$ dBi, | $48° \leq \theta$ |

For $\theta < 100\ \lambda/D°$ off–axis gain will be computed based on the antenna model contained in Annex III to Appendix 29 of the Radio Regulations.

1.3.5 Wide–Angle Sidelobe Data

It is requested that the User submit wide–angle sidelobe data to INTELSAT in advance of earth station verification tests via the satellite. These data might include, for instance, measurements on the antenna obtained on–site using a boresight, or measurements made on an antenna of the same design on a test range at another location. Such data will be used to substantiate antenna performance beyond the off–beam angles which can be measured using INTELSAT facilities.

1.4 Polarization

1.4.1 Transmit and Receive Polarization Senses

a) Polarization Requirements For Operation with INTELSAT VA, VI, VII, VIII, VIIIA and IX**.**

Earth station polarization requirements for operation with INTELSAT VA, VI, VII, VIII ,VIIIA and IX in the 14/11 and 14/12 frequency bands are shown in Table 1. Earth stations are required to operate with the appropriate polarization for each spot beam.

Although overlapping spot beam operation from the same spacecraft for international traffic is not anticipated on INTELSAT VII, contingencies or User requirements may necessitate such a mode of operation. INTELSAT VIII and IX spot beams may be used in an overlapping configuration. INTELSAT VIIIA has only one spot beam.

b) Polarization Requirements for Operation with INTELSAT VIIA.

With INTELSAT VIIA, orthogonal dual linear polarization is used with the 14/11 GHz and 14/12 GHz bands.

Earth stations located in Spot 1 or Spot 2 of INTELSAT VIIA shall be capable of operating in any designated transponder in any polarization sense, as shown in Table 1. Users planning to operate with Spot 3 should take into consideration that the polarization of this spot is switchable by ground command. For additional information on INTELSAT VIIA, refer to IESS–415.

### 1.4.2 Polarization Orientation

The orientation of the satellite transmit and receive beams is defined in the IESS–400 series modules. Earth stations are required to operate with the appropriate linear polarization for each beam.

Under clear–weather conditions, it is required that Standard C and E earth stations have the capability for aligning the earth station polarization relative to that of the spacecraft to achieve the following objectives:

a) Standard C Antennas

It is required that the earth station feed be able to match the spacecraft polarization angle to within 1 degree under clear–weather conditions.

b) Standard E and K Antennas With An RFP Issued Prior to 2 January 1993 (INTELSAT VA, VI, VII, VIII, VIIIA and IX)

It is recommended that the earth station feed be able to match the spacecraft polarization angle to within 1 degree under clear–weather conditions.

c) Standard E and K Antennas with an RFP Issued After 1 January 1993 (INTELSAT VA, VI, VII, VIII, VIIIA and IX)

It is required that the earth station feed be able to match the spacecraft polarization angle to within 1 degree under clear–weather conditions.

d) Standard E and K Antennas Operating With INTELSAT VIIA*

With INTELSAT VIIA, orthogonal dual linear polarization is used with the 14/11 GHz and 14/12 GHz frequency bands. It is required that the earth station feed be able to match the spacecraft polarization angle to within 1 degree under clear–weather conditions.

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* Standard E earth stations having an RFP prior to 2 January 1993 which do not have the capability to match the polarization angle of the spacecraft to within 1° will be considered for operation on INTELSAT VIIA on a case–by–case basis.

1.5 Transmit and Receive Axial Ratio

a) Standard C Antennas

The voltage axial ratio of transmission in the direction of the satellite shall exceed 31.6 (30.0 dB polarization discrimination) over at least one of the minimum bandwidths defined in paragraph 2.2 everywhere within a cone centered on the main beam axis and defined by the antenna tracking and/or pointing errors. It is recommended that this axial ratio also be exceeded for reception.

b) Standard E Antennas with an RFP Issued Prior to 2 January 1993 (INTELSAT VA, VI, VII, VIII, VIIIA and IX)

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) over at least one of the minimum bandwidths defined in paragraph 2.2 everywhere within a cone centered on the main beam axis and defined by the antenna tracking and/or pointing errors. It is recommended that this axial ratio also be exceeded for reception.

c) Standard E Antennas with an RFP Issued After 1 January 1993 (INTELSAT VA, VI, VII, VIII, VIIIA and IX)

The voltage axial ratio of transmission in the direction of the satellite shall exceed 31.6 (30.0 dB polarization discrimination) over at least one of the minimum bandwidths defined in paragraph 2.2 everywhere within a cone centered on the main beam axis and defined by the antenna tracking and/or pointing errors. It is recommended that this axial ratio also be exceeded for reception.

d) Standard E Antennas Operating with INTELSAT VIIA*

The voltage axial ratio of transmission in the direction of the satellite shall exceed 31.6 (30.0 dB polarization discrimination) over at least one of the minimum bandwidths defined in paragraph 2.2 everywhere within a cone centered on the main beam axis and defined by the antenna tracking and/or

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* Standard E earth stations having an RFP prior to 1993 which do not meet a 30 dB polarization discrimination will be considered for operation on INTELSAT VIIA on a case–by–case basis.

pointing errors. It is recommended that this axial ratio also be exceeded for reception.

e) Standard K Antennas

The voltage axial ratio of transmission in the direction of the satellite shall exceed 20 (26 dB polarization discrimination) over at least one of the minimum bandwidths defined in paragraph 2.2 everywhere within a cone centered on the main beam axis and defined by the antenna tracking and/or pointing errors. It is recommended that this axial ratio also be exceeded for reception.

1.6 Antenna Steering or Beam Positioning

1.6.1 Antenna or Beam Steerability

Automatic or manual steering shall be capable of changing the antenna pointing to be compatible with geostationary satellites at orbital locations within the intended ocean region of operation and for which the earth station elevation angle is not less than 10°. Operation below 10° will be reviewed on a case–by–case basis.

INTELSAT satellites are planned for locations within the nominal orbital arcs indicated below:

AOR = 304.5° to 359° E
IOR = 33° to 66° E
APR = 83° to 157° E
POR = 174° to 180° E

Operational considerations indicate the desirability of full steering capability. Such capability would permit on–site demonstration of compliance with mandatory sidelobe levels and would, in addition, allow future operation with satellites at other locations. Users are strongly encouraged to consider antenna designs which permit the easy reconfiguration of their antenna to operate in all visible regions in order to ensure compatibility with future operational plans.

If a natural obstruction prevents full compliance with the above paragraphs, INTELSAT should be contacted by the User during the earth station design stage.

1.6.2 Tracking Requirements

Standard C, E and K earth stations shall be equipped with the minimum tracking requirements shown in Table 2. These minimum requirements apply to those earth stations which either transmit or transmit and receive.

Users need to consider the EIRP stability requirements contained in the IESS–300 series when selecting an antenna tracking system. Tropospheric scintillation can occur in Ku–band under both adverse weather and clear weather conditions. The effects of scintillation may be significant on links having elevation angles less than 20°. On links having elevation angles near 10° 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 near 10°.

Standard E receive–only stations should be designed with a tracking capability consistent with the overall objectives of the User's business network, bearing in mind the stationkeeping tolerances INTELSAT intends to employ.

1.6.2.1 Satellite Stationkeeping Limits

Under nominal conditions, INTELSAT intends to maintain the orbital movements of its satellites to the limits indicated in Table 3.

1.6.2.2 Satellite Beacon Characteristics

(a) 11 GHz Beacons

The characteristics of the 11 GHz beacons are defined in Table 4(a).

(b) 12 GHz Beacons

The characteristics of the 12 GHz beacons are defined in Table 4(b).

(c) Additional Beacon Information.

Those earth stations which use beacons for tracking should be capable of operating satisfactorily under degraded conditions such as may occur during heavy rain periods or under contingency beacon EIRP operation.

Additional 11 and 12 GHz beacon information is available in the IESS–400 series spacecraft description modules.

1.6.2.3 Antenna Steering Data

Beginning in 1992, INTELSAT discontinued routinely providing the pointing angles appropriate to a given satellite for each station. Instead, INTELSAT now provides the parameters necessary for an earth station to compute its own pointing angles. INTELSAT will, on an exceptional basis, continue to provide pointing data when difficulties would be experienced by current stations with the revised approach, pending resolution of the difficulty. The User is referred to IESS–412 for details of the computational method.

1.7 Diversity

Where weather statistics indicate the use of space diversity, it will be necessary to duplicate the 14/11 GHz or 14/12 GHz antenna and RF system at a suitable distance from the main site and provide interconnection via an appropriate link. In some cases, an economic tradeoff may show it is less expensive to duplicate only the receiving facilities and provide an additional power control range for the transmitter at the main site. In either case, it will be necessary for the diversity earth station to meet the mandatory performance characteristics.

It should be noted that the ITU–R hypothetical reference circuits contained in Rec. ITU–R S.352–4 and Rec. ITU–R S.521–2 includes the diversity interconnection links to the diversity switching point and any additional modulation/demodulation equipment required. This means that system noise budgets must include this additional link. It is also necessary to account for weather effects when a microwave interconnection link is employed.

Another element of importance is associated with the differential time delay between the diversity signals as they arrive at the switching point. Minimizing this time delay before switching or combining will reduce the requirements for built–in memory to avoid loss of data. The circuit interruption during switching should be such that errors are not introduced into telephone signalling circuits.

## 2.0 GENERAL RADIO FREQUENCY REQUIREMENTS

### 2.1 Satellite RF Bandwidth and Beam Switching Capabilities

Information on the INTELSAT satellites RF bandwidth and beam switching capabilities is provided in separate modules of the IESS–400 series which describe each satellite series.

### 2.2 Transmit and Receive Bandwidth

#### 2.2.1 Minimum Earth Station Bandwidth Requirements

(a) 14/11 GHz Bands (Standards C, E–3 and E–2) and 14/12 GHz Bands (Standards C, E–3, E–2, E–1, K–3 and K–2).

Earth stations are required to be able to operate over one of the full 14/11 or 14/12 GHz frequency bands indicated in Table 5. The instantaneous bandwidth of the antenna feed elements and low–noise amplifier shall cover the full band.

For those earth stations operating with satellites capable of operation in several bands, the required earth station frequency band of operation is dependant on the satellite configuration.

(b) Standard E–1, K–3 and K–2 Earth Stations Utilizing the 14/11 GHz Bands.

In order to achieve some reduction in the cost of Standard E–1, K–3 and K–2 earth stations, the RF electronics (this includes frequency translators, local oscillators, HPAs, and transceivers*) need only be capable of operation, with tuning if necessary, across one of the following transmit and receive band segments:

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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.

| 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 |

The earth station antenna feed elements shall have an instantaneous bandwidth covering 10.95 – 11.7 GHz and 14.0 – 14.5 GHz.

Users are strongly urged to consider earth stations 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 station, 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.

2.2.2 Frequency Conversion Equipment

It is recommended that earth stations be equipped with frequency conversion equipment capable of operating anywhere within at least one of the bandwidth segments indicated in paragraph 2.2.1 above, in order to allow operational flexibility during frequency plan transitions and contingency circumstances.

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.

2.2.3 Simultaneous Transmission Of the Same Carrier at Two Different Frequencies During Frequency Plan Transitioning

To avoid a prolonged service disruption during frequency plan transitioning, it may be necessary to "dual feed" the same carrier at two different transmit frequencies simultaneously. Accordingly, Users are strongly urged to consider a means of simultaneous transmission of the same carrier at two different frequencies anywhere within at least one of the frequency band segments in Table 5.

2.3 Common Wideband Receiving Amplifier Linearity Requirements

2.3.1 General

It is expected that adequate intermodulation performance will be obtained if the common wideband receiving amplifier meets a two–carrier intermodulation specification as follows:

(a) Input power of each carrier equals 3 dB below total receiving power level.

(b) Level of each third–order intermodulation product equals to 51 dB below the level of each carrier.

2.3.2 Total Receive Power Flux Density

The maximum receive power flux density that may be expected at an earth station is given in Table 6.

2.4 Amplitude, Group Delay and Electrical Path Length Equalization

In designing the RF subsystem, consideration should be given to specific amplitude, group delay and electric path length equalization requirements addressed in the applicable modulation/access modules which are intended to be used with the earth station.

3.0 TESTING REQUIREMENTS

3.1 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 such a way that the performance requirements described in this document can be measured and assured.

Certain of the tests and measurements required between cooperating pairs of earth stations require compatibility of test equipment.

Specific test equipment requirements which may apply to the various modulation/access techniques are described in the appropriate modules of the IESS.

## 3.2 Earth Station Control and Monitoring

Earth stations should be equipped with the means for measuring the power of their own transmitted carriers at some point after the HPA. In addition, a means should be provided for observing the spectrum of carriers transmitted and received by the earth station, e.g., by means of a spectrum analyzer. In this way, Users will be able to detect malfunctions in their transmitting and receiving equipment.

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. 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.

For those earth stations being controlled remotely, the full functionality of the Engineering Service Circuits (ESC) must be extended to the control point.

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. In addition, it is desirable that unattended earth stations use automatic fail–safe features to cease transmission in the event that the power at the feed input exceeds the nominal value by more than 1.5 dB.

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[*] Users are strongly encouraged to consider the advantages of 24–hour per day staffing in their operational planning.

[†] Available is defined as meaning that a point of contact is available to the IOC, whenever the earth station is operational.

3.3 Engineering Service Circuits (ESC)

The engineering service circuit communication requirements related to Standard C and E earth stations are provided in IESS–403.

TABLE 1

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

| | | Linear Polarization (1) | |
|---|---|---|---|
| Satellite | Coverage | Earth Station Transmit | Earth Station Receive |
| VA and VI | East Spot<br>West Spot | Horizontal<br>Vertical | Vertical<br>Horizontal |
| VII | Spot 1 &<br>Spot 3 (2)<br><br>Spot 2 | Horizontal<br><br><br>Vertical | Vertical<br><br><br>Horizontal |
| VIIA | S1, S2X, & S3 (2)<br>S1X, S2 | Vertical<br>Horizontal | Vertical<br>Horizontal |
| VIII and IX (3) | Spot 1<br>Spot 2 | Horizontal<br>Vertical | Vertical<br>Horizontal |
| VIIIA (805) | Spot 1 | Horizontal | Vertical |

NOTES: See Notes on following page.

NOTES TO TABLE 1

(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) The polarization sense of both INTELSAT VIII and IX 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 2

MINIMUM TRACKING REQUIREMENTS FOR STANDARD C, E and K EARTH STATIONS

| Earth Station | INTELSAT VA | INTELSAT VI, VII, VIIA, VIII, VIIIA & IX (± 0.05° N/S and ± 0.05° E/W) |
|---|---|---|
| C | Auto Track (1) | Auto Track (1) |
| E–1 | Manual, E/W Only (Weekly Peaking) | Fixed Antenna (2) |
| E–2 | Manual, E/W and N/S (Peaking every 3 to 4 hours) | Fixed Antenna (2) |
| E–3 | Auto Track (1) | Auto Track (1) |
| K–2 | N/A (4) | Fixed Antenna (2) |
| K–3 | N/A (4) | Fixed Antenna (2) |

NOTES:

(1) Step–track operation can experience difficulties in a Ku–Band environment due to severe fading or scintillations. Users may wish to consider systems which utilize step–tracking in conjunction with program tracking during periods of adverse atmospheric conditions.

(2) "Fixed" antenna mounts will still require the capability to be steered from one satellite position to another, as dictated by operational requirements (typically once or twice every 2 to 3 years). These antennas should also be capable of being steered at least over a range of ± 5 degrees from beam center for the purpose of verifying that the antenna pointing is correctly set toward the satellite and for providing a means of verifying the sidelobe characteristics in this range.

(3) Users are referred to the Notes on Table 3.

(4) Standard K antennas are designed for use in the VSAT IBS service. The VSAT IBS service is not planned for INTELSAT VA.

TABLE 3

INTELSAT SATELLITE STATIONKEEPING LIMITS

| Satellite | Nominal Stationkeeping North–South (degrees) | Nominal Stationkeeping East–West (degrees) |
|---|---|---|
| VA | ± 0.1 (1)(2) | ± 0.1 |
| VI, VII, VIIA, VIII, VIIIA & IX | ± 0.05 | ± 0.05 |

Notes:

(1) The INTELSAT VA satellite (flight model 511) is presently operating in inclined orbit.

(2) Users are referred to IESS–411 for a discussion of additional operational considerations when operating with satellites in inclined orbit.

TABLE 4(a)

11 GHz BEACON CHARACTERISTICS

| Satellite | Beacon Frequencies (GHz) | Coverage, Polarization, Modulation | Voltage Axial Ratio |
|---|---|---|---|
| VA | 11.198 & 11.452 | Global,RHCP, Unmodulated | < 1.12 |
| VI, VII, VIIA, VIII and IX | 11.198 & 11.452 | Global,RHCP, Unmodulated | ≤ 1.03 |

TABLE 4(b)

12 GHz BEACON CHARACTERISTICS

| Satellite | Beacon Frequencies (GHz) | Coverage, Polarization, Modulation | Voltage Axial Ratio |
|---|---|---|---|
| VII, VIIA, VIII and VIIIA | 11.701† & 12.501 | Spot,Linear*, Unmodulated | * |

* Beacons are transmitted through the communications antennas.

† 11.701 GHz beacon is associated with the 11.7 to 11.95 GHz band and the 12.501 GHz beacon with the 12.5 to 12.75 GHz band.

TABLE 5

MINIMUM BANDWIDTH REQUIREMENTS FOR STANDARD C, E and K EARTH STATIONS (1) (2)

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

NOTES: See Notes on following page.

NOTES TO TABLE 5

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

(2) For Standard C, E–2 and E–3 earth stations, the minimum bandwidth requirements apply to the antenna feed elements and RF electronics utilizing the 14/11 GHz and 14/12 GHz bands. These requirements also apply to the RF electronics and antenna feed elements of Standard E–1 and K earth stations using the 14/12 GHz band. For Standard E–1 and K earth stations using the 14/11 GHz band, these requirements apply to the antenna feed elements only (for the minimum bandwidth requirements of the RF electronics of Standard E–1 and K earth stations, see paragraph 2.2.1(b)).

(3) 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 that these spacecraft series can be operated in any Ocean region.

(4) 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.

(5) 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.

TABLE 6

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* |
|---|---|---|---|
| VA | 11 GHz | – 118.7 | – 112.3 |
| 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 | 12 GHz | – 117.1 | – 108.9 |
| IX | 11 GHz | –115.6 | –104.6 |

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

# APPENDIX A

## ITU REFERENCES

Radiocommunication Sector Recommendations:

| | |
|---|---|
| Rec. ITU–R S.352–4 | Previously CCIR Recommendation 352–4 |
| Rec. ITU–R S.465–5 | Published 1993 |
| Rec. ITU–R S.521–2 | Previously CCIR Recommendation 521–2 |
| Rec. ITU–R S.524–5 | Published 1994 |
| Rec. ITU–R S.580–5 | Published 1994 |
| Rec. ITU–R PN.676–1 | Published 1992 |
| Rec. ITU–R S.733–1 | Published 1993 |

# APPENDIX B

## REVISION HISTORY

| Revision No. | Approval Date | Major Purpose |
|---|---|---|
| Original* | 19 May 1994 | • New module |
| 1 | 09 Nov 1994 | • Include INTELSAT VIII and VIIIA |
| 2 | 16 May 1996 | • Incorporate requirements for Standard K. |
| 3 | 13 Feb 1997 | • Eliminate local rain statistics factor in definition of minimum G/T (paragraph 1.1 and delete Tables 1–7). This requirement has been included in the appropriate IESS–300 series module. |
| 4 | 30 Nov 1998 | • Delete references to INTELSAT VA(IBS) and satellites transferred to New Skies Satellite. |
| 5 | 10 Feb 2000 | • Include INTELSAT IX.<br>• Delete INTELSAT V. |
| 6 | 23 Feb 2006 | • Changed “20 log 10” to “20 $\log_{10}$” in six places in Section 1.1. |

* Prior to the adoption of IESS–208, the requirements for Standard C and E earth stations were contained in IESS–203 (Rev. 3) and IESS–205 (Rev. 2) respectively.