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Radiocommunication Sector of ITU

Recommendation ITU-R F.1249-5
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**Technical and operational requirements that
facilitate sharing between point-to-point
systems in the fixed service and
the inter-satellite service in the
band 25.25-27.5 GHz**

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Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

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RECOMMENDATION ITU-R F.1249-5*

**Technical and operational requirements that facilitate sharing
between point-to-point systems in the fixed service and the
inter-satellite service in the band 25.25-27.5 GHz**

(Question ITU-R 118/7)

(1997-2000-2009-2013-2015-2018)

Scope

This Recommendation provides maximum e.i.r.p. density of transmitting point-to-point fixed service (FS) stations towards the direction of the geostationary-satellite orbit to enable sharing with the inter-satellite service in the band 25.25-27.5 GHz. The reference e.i.r.p. density in this Recommendation takes into account the need for transmission at the minimum necessary level while taking into account use of automatic transmitter power control (ATPC) at the FS stations for precipitation events.

Keywords

Data relay satellites, orbital locations, e.i.r.p., spectral density

Abbreviations

ATPC Automatic transmitter power control

DRS Data relay satellite

e.i.r.p. equivalent isotropically radiated power

FS Fixed service

GSO Geostationary-satellite orbit

Related ITU Recommendations and Reports

Recommendation ITU-R F.758	System parameters and considerations in the development of criteria for sharing or compatibility between digital fixed wireless systems in the fixed service and systems in other services and other sources of interference
Recommendation ITU-R F.1333	Estimation of the actual elevation angle from a station in the fixed service towards a space station taking into account atmospheric refraction
Recommendation ITU-R F.1404	Minimum propagation attenuation due to atmospheric gases for use in frequency sharing studies between systems in the fixed service and systems in the broadcasting-satellite, mobile-satellite and space science services
Recommendation ITU-R F.1509	Technical and operational requirements that facilitate sharing between point-to-multipoint systems in the fixed service and the inter-satellite service in the band 25.25-27.5 GHz

* This Recommendation was jointly developed by Radiocommunication Study Groups 7 and 5, and future revisions should be undertaken jointly.

Recommendation ITU-R P.526	Propagation by diffraction
Recommendation ITU-R P.676	Attenuation by atmospheric gases
Recommendation ITU-R SA.1155	Protection criteria related to the operation of data relay satellite systems
Recommendation ITU-R SA.1276	Orbital locations of data relay satellites to be protected from the emissions of fixed service systems operating in the band 25.25-27.5 GHz
Recommendation ITU-R SF.765	Intersection of radio-relay antenna beams with orbits used by space stations in the fixed-satellite service

The ITU Radiocommunication Assembly,

considering

- a) that the frequency band 25.25-27.5 GHz is allocated to the inter-satellite service and the fixed service on a primary basis;
- b) that this frequency band is used for space research and Earth exploration applications for return inter-satellite links to data relay satellites (DRSs) in the geostationary-satellite orbit (GSO);
- c) that some transmitting stations in the fixed service (FS) may be able to use automatic transmit-power control (ATPC) to reduce their equivalent isotropically radiated power (e.i.r.p.) during clear-weather conditions;
- d) that aggregate interference from the side lobes of the antennas of a large number of transmitting stations in the FS which do not point towards a DRS has been shown to be tolerable, but that main beam coupling from a single transmitting station in the FS service which does point towards a DRS is considered to represent a potentially severe interference situation (see Annex 1);
- e) that, whereas exceptionally long FS links require operation at elevated e.i.r.p. densities, these usually operate near or at zero elevation angles where atmospheric attenuation substantially reduces the potential interference;
- f) that, under certain circumstances, topography and man-made structures obstruct FS radiation into space, or introduce substantial attenuation into the potential interference path;
- g) that interference mitigation techniques can be used by both services to minimize the interference from the emissions of FS systems into DRS systems,

recognizing

- a) that Recommendation ITU-R SA.1155 recommends that the maximum aggregate interference power spectral density levels received in the 25.25-27.5 GHz band by geostationary DRSs in the inter-satellite service should not exceed -178 dB(W/kHz) for more than 0.1% of the time;
- b) that a limited number of DRS networks are used in the GSO as listed in Recommendation ITU-R SA.1276 (see Note 1);
- c) that Recommendation ITU-R F.758 provides a large variety of fixed wireless system parameters generalized by representative systems for specific frequency ranges,

recommends

- 1 that the maximum e.i.r.p. within the channel bandwidth of such an FS station should, where practicable, be the lowest necessary for satisfactory operation;
- 2 that, for the GSO locations specified in Recommendation ITU-R SA.1276 (see Note 1):
 - 2.1 as far as practicable, the e.i.r.p. density of such an FS station in the direction of the above locations should not exceed +24 dBW in any 1 MHz band (see Note 2);
 - 2.2 during conditions when precipitation attenuation is experienced between the FS transmitting and receiving stations, the transmitting station may use ATPC to increase its transmitted power, by an amount not exceeding the precipitation attenuation, such that its e.i.r.p. density in the direction of the GSO locations referenced above does not exceed +33 dBW in any 1 MHz band;
 - 2.3 when the atmospheric attenuation towards the GSO locations referenced above, calculated using the procedures in Annex 1 of Recommendation ITU-R P.676, taking into account the elevation angle towards these orbit locations, the altitude of the FS transmitting antenna and local information of average water vapour content in the driest month and of other meteorological parameters (see Note 3), exceeds 3 dB, this excess may be applied as an increase of the e.i.r.p. density of the FS station;
 - 2.4 when the Fresnel zones on the path from such a transmitting FS station in the direction of the above orbit locations are completely or partially blocked, the e.i.r.p. density in this direction may be increased by an amount calculated using the methods of Recommendation ITU-R P.526, taking due account of atmospheric refraction on this path (see Recommendation ITU-R F.1333);
 - 2.5 Annex 2 is a method which may be used to calculate separation angles from the specific locations on the GSO;
- 3 that, for all other locations on the GSO:
 - 3.1 the e.i.r.p. density of such an FS station in the direction of the GSO should not exceed +33 dBW in any 1 MHz band;
 - 3.2 Annex 2 to Recommendation ITU-R SF.765 is a method which may be used to calculate separation angles from the GSO (see Note 4);
- 4 the four following Notes 1, 2, 3 and 4 are part of this Recommendation:

NOTE 1 – Recommendation ITU-R SA.1276-5 identifies the following geostationary orbital positions:

9° E, 10.6° E, 16.4° E, 16.8° E, 20.4° E, 21.5° E, 47° E, 59° E, 77° E, 80° E, 85° E, 89° E, 90.75° E, 95° E, 113° E, 121° E, 133° E, 160° E, 167° E, 171° E, 176.8° E, 177.5° E, 12° W, 16° W, 32° W, 41° W, 44° W, 46° W, 49° W, 62° W, 139° W, 160° W, 164.2° W, 167.5° W, 170° W, 171° W, 174° W.

When Recommendation ITU-R SA.1276 is revised so that new DRS orbital locations are added, the protection of the space stations in these new orbital slots in revision to this Recommendation applies only to FS stations installed after the enforcement date of the revised Recommendation ITU-R SA.1276.

NOTE 2 – The interference potential to DRSs from point-to-point fixed wireless systems which exceed the e.i.r.p. density limits outlined in *recommends* 2.1, may be reduced by avoiding the use of the DRS centre frequencies, where practical. Further study of this mitigation technique is required.

NOTE 3 – Recommendation ITU-R F.1404 proposes the estimation of atmospheric attenuation using detailed information of local meteorological parameters for the band 25.5-27.5 GHz. Where

this is not available a simple procedure, which assumes simplified climate models, is proposed on a provisional basis. This method requires further study. Administrations which have obtained local meteorological parameters for use in estimation of gaseous attenuation are requested to make those data available for the ITU-R (particularly Radiocommunication Study Groups 3 and 5).

NOTE 4 – Recommendation ITU-R SF.765 was originally developed to give precise separations up to 2 degrees. It is to be noted that the algorithm used in this Recommendation is equally valid to be expanded up to 10 degrees by using $B = 10^\circ$ in § 1 of Annex 2 to Recommendation ITU-R SF.765.

Annex 1

Maximum e.i.r.p. density of point-to-point fixed wireless system transmitters operating in the band 25.25-27.5 GHz shared with the inter-satellite service

1 Introduction

This Annex summarizes analyses that demonstrate that the protection criteria of Recommendation ITU-R SA.1155 for DRSs can be satisfied except in the case of main beam-to-main beam coupling by the emissions of point-to-point fixed wireless stations.

2 System models

2.1 Point-to-point FS deployment in the band 25.25-27.5 GHz

The following assumptions concerning the technical and operational characteristics of point-to-point FS stations are extrapolated from existing 23 GHz systems:

- 100 000 transmitters assumed worldwide in the band 25.25-27.5 GHz (the 26 GHz band).
- Estimated distribution of transmitter e.i.r.p. density levels:
 - more than 70% of all FS links in the 25.25-27.5 GHz band are estimated to operate below +24 dB(W/MHz);
 - less than 25% are estimated to operate in the range of +24 dB(W/MHz) to +33 dB(W/MHz);
 - less than 5% are estimated to operate above +33 dB(W/MHz).
- Single frequency per transmitter. Half transmitters are “go”, half “return”.
- Frequency channelization in accordance with Recommendation ITU-R F.748 (the recommended channel bandwidths range from 112 MHz to 3.5 MHz and 2.5 MHz, there is a possibility of adding 1.75 MHz and 1.25 MHz bandwidths in the future).
- Operating channels are distributed across the band.
- Elevation angles are typically in the 0° to 5° range.
- Path length is typically in the 2 to 5 km range.
- Large rain fade margins are required in the 26 GHz band to achieve 99.999% availability.
- Large-scale point-to-point FS providers increasingly use the lowest possible transmitter power options in order to reduce frequency reuse distances.

- Only a minor number of equipment types are currently available with automatic power control.

2.2 Deployment of DRSs that use space-to-space links in the inter-satellite service

The technical and operational characteristics of DRSs to be operated by NASA of the United States of America, the European Space Agency (ESA), the Russian Space Agency, and the Japan Aerospace Exploration Agency of Japan (JAXA) that will use space-to-space links in the 26 GHz band are summarized below:

- Orbital locations are given in Recommendation ITU-R SA.1276.
- Typical DRS characteristics:
 - has two high gain single access antennas with a peak gain of 58 dBi;
 - receiving antenna 3 dB beamwidth is less than 0.2 degrees;
 - receiving antenna can support one 20/30 GHz band return signal at a time;
 - DRS receiver noise temperature, $T = 703$ K (-140.13 dB(W/MHz) noise density);
 - return data rates: 1 kbit/s-300 Mbit/s in a 225 MHz bandwidth;
 - return data rates: 1 kbit/s-800 Mbit/s in a 650 MHz bandwidth;
 - receiving centre frequency is tunable in 25 MHz (or smaller) steps.
- DRS centre frequencies selected in conformance with Space Network Interoperability Panel (SNIP) recommendations for common DRS return channels will have centre frequencies at: 25.60 GHz, 25.85 GHz, 26.10 GHz, 26.35 GHz, 26.60 GHz, 26.85 GHz, 27.10 GHz or 27.35 GHz.

Interference mitigation techniques have neither been studied nor implemented on the current generation of 26 GHz DRS.

3 Interference assessment

3.1 DRS protection criteria

Recommendation ITU-R SA.1155 – Protection criteria related to the operation of data relay satellite systems, recommends that the maximum aggregate interference power spectral density level from all sources to be exceeded for no more than 0.1% of the time be -178 dB(W/kHz) in the 25.25-27.5 GHz band (this is equivalent to -148 dB(W/MHz)). This level is based on an $I/N = -10$ dB and a link margin degradation of 0.4 dB. The recommended maximum reference bandwidth is 1 kHz. The protection criteria translates to a maximum FS interference e.i.r.p. density of 13.5 dB(W/MHz) in the direction of the DRS when there is main beam coupling as shown in Table 1.

TABLE 1

**Maximum FS e.i.r.p. density in the direction of a
DRS for main beam coupling**

FS e.i.r.p. density (dB(W/MHz))	13.5
Atmospheric loss (dB)	3
Polarization loss (dB)	3
Free space loss (dB)	213.5
DRS peak receive antenna gain (dBi)	58
Maximum interference density (dB(W/MHz))	-148

3.2 Main beam interference

The main beam interference criteria include:

- the tolerable FS e.i.r.p. density limit that satisfies the DRS protection criteria of Recommendation ITU-R SA.1155;
- the probability of main beam interference occurrence. The tolerable FS e.i.r.p. density limit is calculated under the assumptions of co-channel interference into a non-inclined DRS orbit. The assessment of the probability of main beam interference occurrence is based on the operating conditions of the two systems.

The case of a FS radio-relay radiating towards a DRS and coupling into the main beam of the DRS high gain antenna is considered for a range of e.i.r.p. density levels. The results are given in Table 2. The Table shows that an e.i.r.p. spectral density in excess of 13.5 dB(W/MHz), assuming 3 dB loss due to atmospheric absorption and 3 dB polarization loss, will result in an interference level greater than the value specified in Recommendation ITU-R SA.1155 when there is direct alignment.

TABLE 2

**Amount interference criteria is exceeded versus FS e.i.r.p.
density radiated towards the DRS**

FS e.i.r.p. density (dB(W/MHz))	13.5	24	33
DRS spacecraft Rx antenna gain (dBi)	58	58	58
Free space loss (dB)	213.5	213.5	213.5
Atmospheric loss (dB)	3	3	3
Polarization loss (dB)	3	3	3
Interference power, I (dB(W/MHz))	-148	-137.5	-128.5
Maximum interference criteria (dB(W/MHz))	-148	-148	-148
<i>Criteria exceeded by (dB)</i>	<i>0</i>	<i>10.5</i>	<i>19.5</i>

It should be noted that atmospheric loss may be less than 3 dB under some climatic conditions for higher elevation angles.

Simulations were performed to evaluate the interference as a percentage of time as the DRS tracks a low-Earth orbiting (LEO) satellite. To analyse the interference versus percentage of time, it is necessary to simulate the orbital flight of the LEO satellite. A range of inclination angles for

the LEO satellites was used. In each case, the terrestrial station longitude was set so that the DRS would be in the terrestrial station antenna main beam, which is directed in the horizontal plane.

Three different simulations were performed. Each simulation was run for 100 days at a time increment of 0.1 min and the level of the received interference relative to the level received for boresight coupling at the receiver of the DRS was calculated at each increment. The simulations were run for three cases, with the results plotted in Fig. 1. The cases are:

Case 1: low-orbiting user satellite orbital altitude of 300 km, an inclination of 85° and an FS station latitude of 50° ;

Case 2: low-orbiting user satellite orbital altitude of 300 km, an inclination of 65° and an FS station latitude of 60° ;

Case 3: low-orbiting user satellite orbital altitude of 300 km, an inclination of 28.5° and an FS station latitude of 28.5° .

The curves given in Fig. 1 may be used to determine the e.i.r.p. spectral density obtained under free space propagation conditions that will ensure that the interference power received by the DRS does not exceed -148 dB(W/MHz) for more than 0.1% of the time. The calculations are summarized in Table 3. The table shows that the e.i.r.p. spectral density required to satisfy the criteria is a function of the orbital parameters of the LEO satellite that the DRS is tracking and the location of the FS transmitting station. The acceptable level of e.i.r.p. spectral density ranges from 31.5 dB(W/MHz) for case 1, down to 17.5 dB(W/MHz) for case 3. For the purpose of this Recommendation, a single value of 24 dB(W/MHz) is acceptable. The e.i.r.p. spectral density is obtained under free space propagation conditions.

Several operating conditions substantially reduce the probability and effects of FS-to-DRS interference, such as:

- the distribution of FS e.i.r.p. density levels (see § 2.1), which indicates that less than 30% of FS systems are likely to operate above the $+24$ dB(W/MHz) limit;
- the different frequency band usage of the FS and DRS systems (see Table 5), which indicates that only about 4% of direct beam coupling occurrences are likely to result in interference;
- the pointing of the FS transmitter antenna both at a random azimuth angle that is uniformly distributed between 0° and 360° , and at a uniformly distributed random elevation angle between 0° and 5° (see § 3.1 and 3.3 of this annex), which further reduces the probability of direct beam coupling by at least three orders of magnitude.

The resulting order-of-magnitude probability of direct beam coupling occurrence is lower than 10^{-5} .