RECOMMENDATION ITU-R SF.355-4*

FREQUENCY SHARING BETWEEN SYSTEMS IN THE FIXED-SATELLITE SERVICE AND RADIO-RELAY SYSTEMS IN THE SAME FREQUENCY BANDS

(1963-1966-1974-1982-1992)

The ITU Radiocommunication Assembly,

considering

a) that systems in the fixed-satellite service and the fixed service share certain bands above 1 GHz;

b) that control of mutual interference between stations of the two services is necessary;

c) that the continued development of both services is desirable;

d) that it is necessary to restrict the noise contribution, in a telephone channel of either service, caused by interference from stations of the other, to permissibly small amounts;

e) that among the means for reducing, to permissible levels, interference between systems in the fixed-satellite service and the fixed service sharing the same frequency bands are:

– on the part of satellite space stations, limitation of the power flux per unit area in unit bandwidth produced at the surface of the Earth;

– on the part of communication-satellite earth stations, limitation of the minimum distance to terrestrial transmitters, appropriate to the technical characteristics concerned and to propagation factors, together with limitation of the maximum power radiated at low angles of elevation;

– on the part of stations in the terrestrial services, limitation of the distance to earth stations, appropriate to the technical characteristics concerned and to propagation factors, together with limitation of the total emitted power and the equivalent isotropically radiated power;

f) that the application of reasonable constraints on the design of both line-of-sight radio-relay systems and systems in the fixed-satellite service can permit the sharing of frequency bands, but that considerable difficulties may arise in sharing frequency bands with other terrestrial services which involve high power transmitters, highly sensitive receivers, and changing areas of coverage,

recommends

1. that, in sharing between line-of-sight analogue angle-modulated radio-relay systems and systems in the fixed-satellite service, the noise in a telephone channel arising from mutual interference should be limited to a permissibly small amount, compared to the total allowable noise in the appropriate hypothetical reference circuit, as set out at present in Recommendations ITU-R SF.356 and ITU-R SF.357;

2. that, in sharing between line-of-sight radio-relay systems and digital systems in the fixed-satellite service, the interfering power should be limited to a permissibly small amount, as at present indicated in Recommendation ITU-R SF.558;

3. that, in sharing between digital radio-relay systems and systems in the fixed-satellite service, the interfering power from the latter should be limited to a permissibly small amount, as at present indicated in Recommendation ITU-R SF.615;

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* Radiocommunication Study Groups 4 and 9 made editorial amendments to this Recommendation in 2000 in accordance with Resolution ITU-R 44.

4. that the control of mutual interference between space stations in the fixed-satellite service and line-of-sight radio-relay systems should be through constraints applicable to the use of both, so as to avoid the need for specific coordination procedures between the administrations operating radio-relay stations and those operating space stations; these constraints are set out at present in Recommendations ITU-R SF.358 and ITU-R SF.406;

5. that questions of sharing between systems in the fixed-satellite service and trans-horizon radio-relay systems, as well as the bases for such sharing, should receive further study;

6. that the control of mutual interference between each earth station of a system in the fixed-satellite service and terrestrial radio stations sharing the same frequency bands should be by the application of specific coordination procedures between the administrations concerned. Recommended procedures are set out in Appendix S7 to the Radio Regulations.

Note 1 – Additional guidance relating to this Recommendation is given in Annex 1.

ANNEX 1

Frequency sharing between systems in the fixed-satellite service and the fixed service

1. Introduction

In considering frequency sharing between systems in the fixed-satellite service and the fixed service there are four conditions which must be satisfied:

– the signals from the satellites must not cause unacceptable interference to the receivers of the terrestrial service, as in A in Fig. 1;

– the signals from satellite earth-stations must not cause unacceptable interference to the receivers of the terrestrial service, as in B in Fig. 1;

– the signals from terrestrial stations must not cause unacceptable interference to the receivers of satellite-system earth stations, as in C in Fig. 1;

– the signals from terrestrial stations must not cause unacceptable interference in the satellite receivers, as in D in Fig. 1.

2. Sharing factors

A determination of whether sharing between two systems is possible depends on the following factors:

– the maximum allowable value of interference either in a telephone, television or sound channel, at the output of the system subject to this interference;

– the number of specific interference paths between which the total allowable interference must be divided;

– the ratio of the powers, or the ratio of the power spectral-densities, of the wanted signal and the unwanted signal, at the input to the receiver, which would just result in the allowable value of interference at the output of the receiver, taking account of the types of modulation involved;

– the power, or the power spectral-density, of the interfering transmitter;

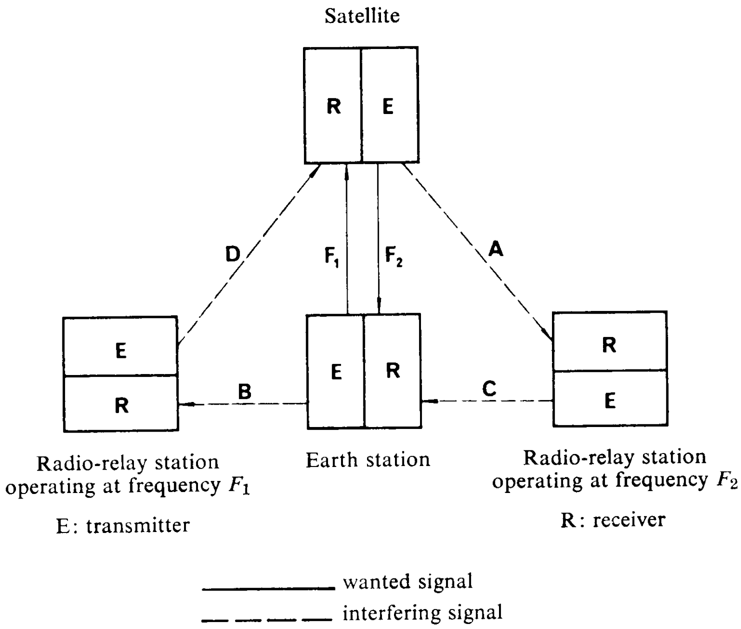
– the transmission loss along the unwanted signal propagation path, including effective antenna gain, basic transmission loss, and the effect of the polarizations concerned;

– the power, or the power spectral-density, of the wanted transmitter;

– the transmission loss along the wanted signal propagation path, including the effective antenna gains, and basic transmission loss.

FIGURE 1

Interference paths between systems in the fixed-satellite service and the fixed service



Note – The frequencies shown are in the bands shared between the fixed service and fixed-satellite service, allocated to Earth-to-space transmission (F_1) and space-to-Earth transmission (F_2).

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The maximum permissible values of interference in the hypothetical reference circuit or digital path are given in Recommendations ITU-R SF.356 and ITU-R SF.558 in the case of systems in the fixed-satellite service and in Recommendations ITU-R SF.357 and ITU-R SF.615 in the case of line-of-sight radio-relay systems.

3. Sharing methods

The specific methods for achieving sharing between systems in the fixed-satellite service and terrestrial systems include the following:

– a limitation of the power radiated by the radio-relay transmitters (see Recommendations ITU-R SF.406 and ITU-R SF.765). (Appendix 1 gives some details on this matter);

– a limitation of the power spectral density at the surface of the Earth produced by satellites of the fixed-satellite service (see Recommendation ITU-R SF.358);

– a specified method of computing the distance within which earth station transmitters or terrestrial transmitters may produce unacceptable interference respectively to terrestrial receivers or earth station receivers sharing the same bands (see Recommendation ITU-R SM.1448).

Specific limits and computation methods are given in Article S21 and Appendix S7 to the Radio Regulations.

Some details on the possibilities of frequency band sharing between the fixed-satellite service and trans-horizon radio-relay systems are given in Appendix 2.

4. System trade-offs for sharing between fixed-satellite systems and radio-relay systems

The design performance objectives of radio-relay systems and fixed-satellite services are specified by CCIR Recommendations ITU-R F.393 and ITU-R S.353 respectively for FDM-FM systems and by Recommendations ITU-R F.594 and ITU-R S.522 for systems using PCM.

These Recommendations represent a compromise between the preferred standards to be attained for a telephony circuit and the increase in cost with performance of communication systems. For this reason they constitute primary bases for the overall design of terrestrial radio and satellite systems.

The total permitted degradation of any system must be shared among:

– thermal noise,

– interference within the system, and

– interference from other systems sharing the same frequency band.

Consistency in the allocation of interference can be achieved if the relevant Recommendations are based on the effect of interference on the total cost of the mutually interfering systems. While a consistent technique for allocation of interference may not be readily applicable where more than one administration is concerned, the potential total cost savings may justify consideration of its use.

APPENDIX 1

TO ANNEX 1

Protection of space stations in the fixed-satellite service against interference from the fixed service in shared frequency bands above 1 GHz

When limitation of terrestrial transmitter power is considered, there are two possibilities:

– interference to a satellite in the main beam of a terrestrial radio-relay transmitter;

– interference to a satellite from side-lobe radiation of a large number of terrestrial stations within the satellite coverage area.

The first leads to a limit for the maximum e.i.r.p. of terrestrial stations whose antennas are directed close to the geostationary orbit. The second leads to a limit for the maximum power supplied to the antennas of terrestrial stations.

1. Limitation of e.i.r.p.

For the satellite to be in the main beam the interfering terrestrial station will be located at the horizon visible from the satellite. The permissible e.i.r.p. will depend upon, *inter alia*, the gain of the satellite antenna towards the horizon, which in general will be appreciably less than the main beam gain.

Other parameters of the satellite which enter into the calculation are: the receiver noise temperature, the number of telephone channels and the degree of energy dispersal used.

2. Limitation of power into the antenna

Outside its main beam the gain of a terrestrial-station antenna is largely independent of the in-beam gain. Consequently, when the satellite is not in the main beam the interference may be controlled by limiting the total power fed to the antenna rather than by limiting the e.i.r.p.

The total interference entering the main beam of the satellite antenna therefore depends upon the number of terrestrial stations within the coverage area and the average of their antenna gains in the direction of the satellite. Other parameters of the satellite which are relevant to the calculation are mentioned in the previous section.

APPENDIX 2

TO ANNEX 1

Sharing of frequency bands between systems in the fixed-satellite service and trans-horizon terrestrial radio-relay systems

1. Introduction

This Appendix examines the conditions under which the systems in the fixed-satellite service and trans-horizon systems can share the same frequency band, without causing undue mutual interference.

2. Trans-horizon radio-relay systems

Trans-horizon systems have wide differences in system parameters – for example, transmitter powers from a few hundred watts to 50 kW, antenna diameters from 3 to 35 m, baseband capacities from 1 telephone channel to 1 television channel, receiver noise figures from 1 to 12 dB. It is usually necessary, economically, to choose the system parameters that best suit each specific system and sometimes each specific link. The operating margins that would permit standardization tend to be either not available technically or not feasible economically.

It seems unlikely that trans-horizon radio-relay systems will make any extensive use of parallel radio-frequency channels as in line-of-sight systems.

3. Geometric considerations

The geometric relations of exposure of satellites to the antenna beams of terrestrial radio-relay stations are outlined in Annex 1 of Recommendation ITU-R SF.765. Although the narrower beamwidths of trans-horizon antennas tend to reduce the exposure probabilities to various satellite orbit systems, the greater transmitter power, receiver sensitivity and antenna gain all increase the probability of significant interference from such beam exposures and even from exposures to major side lobes.

Additionally, trans-horizon links are frequently used between small and greatly separated islands, and in other similar circumstances which limit the choice of possible path directions and which thus preclude this means of avoiding orbit exposures.

4. Interference considerations

4.1 Interference to and from satellites

The equivalent isotropically radiated power from the terminal of a trans-horizon system may be of the order of 85 to 90 dBW, i.e., not greatly dissimilar from that of typical earth stations. A satellite in the main lobe of a trans-horizon antenna would therefore receive unwanted and wanted signals of the same order of power, if a frequency were shared in the up-path. If a frequency were shared in the down-path, the unwanted signal in the trans-horizon receiver would be about –110 dBW, which is of the same order as the median value of the wanted signal, and would therefore cause a virtual circuit outage.

4.2 Interference to and from earth stations

The problem of coordination distance between earth stations and trans-horizon stations is essentially similar to that of coordination distance between earth stations and line-of-sight stations, except for the larger path basic transmission loss. The loss required to make interference negligible ranges from about 190 dB, when neither terminal looks at the other, to about 300 dB when both stations look at each other (complementary directions in azimuth but beyond line-of-sight).

It should be noted that much more is known about downward fading in trans-horizon propagation than about the upward fading that is significant in estimating coordination distance. The usual statistics of trans-horizon loss can be seriously distorted above the median value by ducting due to temperature inversions, which have been known to increase the signals received over trans-horizon paths by as much as 60 to 70 dB above the median values for substantial periods of time. Local topographic features below the scattering region can create ducting on particular paths with a much higher prevalence than the average for the region or type of region.

It is advisable to measure the propagation loss in a path likely to suffer interference during a time when temperature inversions along the path are most likely to occur. Basic transmission losses greater than 250 dB are difficult to measure with transportable equipment.

For geostationary satellites, the problem of coordination is eased somewhat by the fact that the antenna of the earth station will always point in one direction, rather than in various directions, as when it is tracking a moving satellite.

5. Conclusions

5.1 It appears likely that the problem of coordination can be solved in most actual situations. It would be eased in a particularly difficult situation, if an unshared frequency band were available, to which the frequencies of the offending link could be transferred.

5.2 Sharing with a system of geostationary satellites would require a restriction over a small part of the surface of the Earth on the range of permissible azimuth directions for trans-horizon links. This restriction will probably not be considered so limiting as to prevent sharing.

5.3 Systems of random satellites in inclined orbits appear at present to require such large restrictions on permissible azimuth directions for trans-horizon links over so much of the world that sharing does not appear to be feasible.