XVII A.P.
DÜSSELDORF
21.5-1.6 1990
CCIR

XVIIth PLENARY ASSEMBLY
DÜSSELDORF, 1990

INTERNATIONAL TELECOMMUNICATION UNION

RECOMMENDATIONS OF THE CCIR, 1990

(ALSO RESOLUTIONS AND OPINIONS)

VOLUMES IV AND IX – PART 2

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

CCIR INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

Geneva, 1990

CCIR

1. The International Radio Consultative Committee (CCIR) is the permanent organ of the International Telecommunication Union responsible under the International Telecommunication Convention "... to study technical and operating questions relating specifically to radiocommunications without limit of frequency range, and to issue recommendations on them..." (International Telecommunication Convention, Nairobi 1982, First Part, Chapter I, Art. 11, No. 83).*

2. The objectives of the CCIR are in particular:

a) to provide the technical bases for use by administrative radio conferences and radiocommunication services for efficient utilization of the radio-frequency spectrum and the geostationary-satellite orbit, bearing in mind the needs of the various radio services;

b) to recommend performance standards for radio systems and technical arrangements which assure their effective and compatible interworking in international telecommunications;

c) to collect, exchange, analyze and disseminate technical information resulting from studies by the CCIR, and other information available, for the development, planning and operation of radio systems, including any necessary special measures required to facilitate the use of such information in developing countries.

* *See also the Constitution of the ITU, Nice, 1989, Chapter 1, Art. 11, No. 84.*

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92-61-04201-5

Geneva, 1990

PLAN OF VOLUMES I TO XV
XVIIth PLENARY ASSEMBLY OF THE CCIR

(Düsseldorf, 1990)

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VOLUME II (Recommendations) *Annex to Vol. II* (Reports)	Space research and radioastronomy services
VOLUME III (Recommendations) *Annex to Vol. III* (Reports)	Fixed service at frequencies below about 30 MHz
VOLUME IV-1 (Recommendations) *Annex to Vol. IV-1* (Reports)	Fixed-satellite service
VOLUMES IV/IX-2 (Recommendations) *Annex to Vols. IV/IX-2* (Reports)	Frequency sharing and coordination between systems in the fixed-satellite service and radio-relay system
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1990
Printed in Switzerland

VOLUMES IV AND IX, PART 2

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

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SECTION 4/9A: SHARING CONDITIONS

RECOMMENDATION 355-3

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

(Questions 32/4 and 17/9)

(1963-1966-1974-1982)

The CCIR,

CONSIDERING

(a) that systems in the fixed-satellite service and terrestrial radio services 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 terrestrial radio systems 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,

UNANIMOUSLY 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 356 and 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 558 (see Note);

3. 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 358 and 406;

4. that questions of sharing between systems in the fixed-satellite service and terrestrial radio systems, other than line-of-sight radio-relay systems, as well as the bases for such sharing, should receive further study;

5. 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 28 to Radio Regulations.

Note – See Report 877 concerning interference to digital radio-relay systems by fixed-satellite service systems.

RECOMMENDATION 356-4

MAXIMUM ALLOWABLE VALUES OF INTERFERENCE FROM LINE-OF-SIGHT RADIO-RELAY SYSTEMS IN A TELEPHONE CHANNEL OF A SYSTEM IN THE FIXED-SATELLITE SERVICE EMPLOYING FREQUENCY MODULATION, WHEN THE SAME FREQUENCY BANDS ARE SHARED BY BOTH SYSTEMS

(Questions 32/4 and 17/9)

(1963-1966-1970-1974-1978)

The CCIR,

CONSIDERING

(a) that systems in the fixed-satellite service and line-of-sight radio-relay systems share frequency bands in the range above 1 GHz;

(b) that mutual interference would increase the noise in both types of system beyond that which would exist in the absence of frequency sharing;

(c) that it is desirable that the noise due to interference in the telephone channels of systems in the fixed-satellite service because of the transmitters of radio-relay systems should, during most of the time, be a small fraction of the total noise in those systems, as set out in Recommendation 353;

(d) that it is necessary to specify the maximum allowable interference power in a telephone channel, to determine the maximum transmitter power and equivalent isotropically radiated power of line-of-sight radio-relay stations, and to determine whether specific locations for satellite-earth stations and terrestrial radio-relay stations would be satisfactory;

(e) that a distribution of one-minute mean power, as exemplified in Fig. 1 would allot to interference an appropriate fraction of the total noise power permitted in the hypothetical reference circuit;

(f) that systems in the fixed-satellite service may receive interference both through the satellite receiver and through the earth-station receiver, but will receive the higher levels of interference associated with small percentages of time primarily through the earth-station receivers,

UNANIMOUSLY RECOMMENDS

1. that systems in the fixed-satellite service and radio-relay systems sharing the same frequency bands, be designed in such a manner that the interference noise power, at a point of zero relative level in any telephone channel of a hypothetical reference circuit of a system in the fixed-satellite service, caused by the aggregate of the transmitters of radio-relay stations, conforming to Recommendation 406, should not exceed:

1.1 1000 pW0p psophometrically-weighted one-minute mean power for more than 20% of any month;

1.2 50 000 pW0p psophometrically-weighted one-minute mean power for more than 0.03% of any month.

2. that the following Note should be regarded as part of the Recommendation.

Note – The way in which the above values are to be taken into account in the general noise objective for systems in the fixed-satellite service is defined in Note 6 of Recommendation 353.

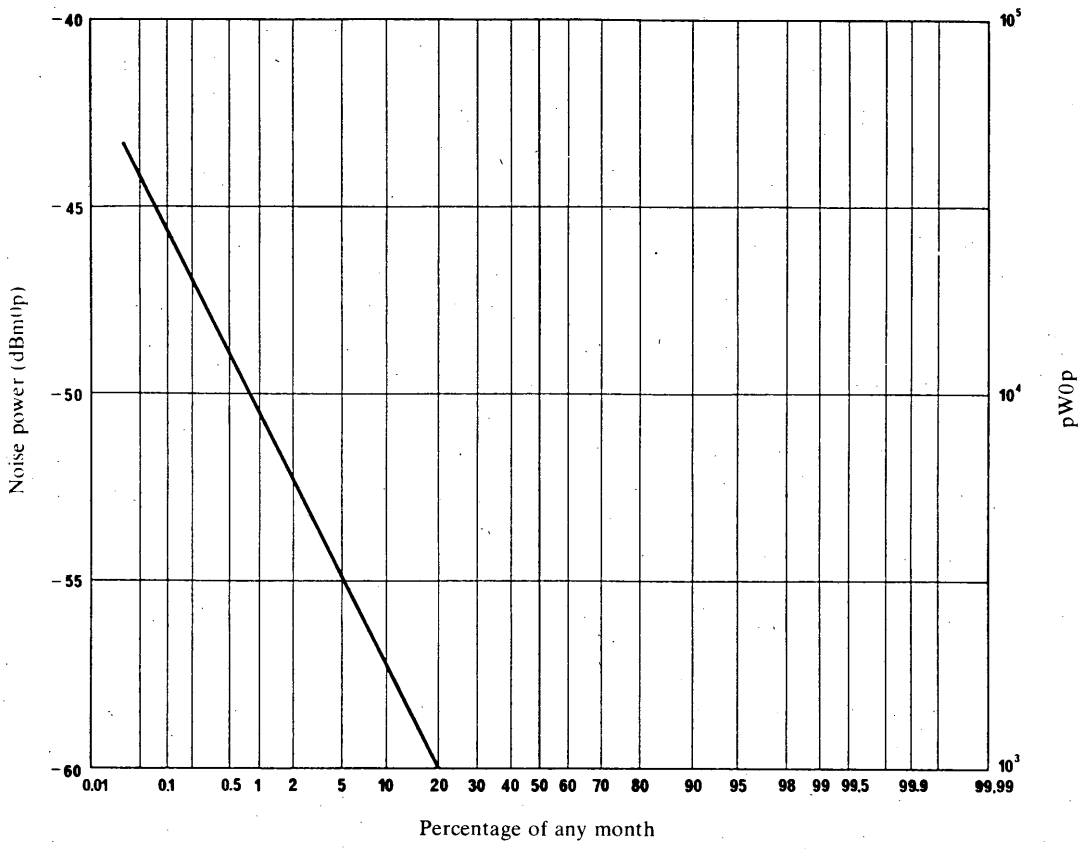

FIGURE 1 – *Example of possible interpolation*

RECOMMENDATION 357-3

MAXIMUM ALLOWABLE VALUES OF INTERFERENCE IN A TELEPHONE CHANNEL OF AN ANALOGUE ANGLE-MODULATED RADIO-RELAY SYSTEM SHARING THE SAME FREQUENCY BANDS AS SYSTEMS IN THE FIXED-SATELLITE SERVICE

(Questions 32/4 and 17/9)

(1963-1966-1974-1978)

The CCIR,

CONSIDERING

(a) that systems in the fixed-satellite service and line-of-sight radio-relay systems share certain frequency bands above 1 GHz;

(b) that mutual interference would increase the noise in both types of system beyond that which would exist in the absence of frequency sharing;

(c) that it is desirable that the noise, due to interference in the telephone channels of existing radio-relay systems, emanating from transmitters of satellites and earth stations, should be a fraction of the total noise in those systems, such that it would not be necessary to change the design objectives for radio-relay systems, as set out in Recommendation 393;

(d) that it is necessary to specify the maximum allowable interference power in a telephone channel, to determine the maximum power flux from communication satellites which can be allowed at the surface of the Earth and to determine whether specific locations for satellite-earth stations and terrestrial radio-relay stations would be satisfactory;

(e) that a distribution of one-minute mean power, as exemplified in Fig. 1, would allot to interference a reasonable fraction of the total noise power permitted in the hypothetical reference circuit,

UNANIMOUSLY RECOMMENDS

1. that systems in the fixed-satellite service and line-of-sight analogue angle-modulated radio-relay systems which share the same frequency bands, should be designed in such a manner, that in any telephone channel of a 2500 km channel hypothetical reference circuit for frequency-division multiplex, analogue angle-modulated radio-relay systems, the interference noise power at a point of zero relative level, caused by the aggregate of the emission of earth stations and space stations of the systems in the fixed-satellite service, including associated telemetering, telecommand and tracking transmitters, should not exceed:

1.1 1000 pW0p psophometrically-weighted one-minute mean power for more than 20% of any month;

1.2 50 000 pW0p psophometrically-weighted one-minute mean power for more than 0.01% of any month.

2. that the following Note should be regarded as part of the Recommendation.

Note – The way in which the above values are to be taken into account in the general noise objective for radio-relay systems is defined in Recommendation 393.

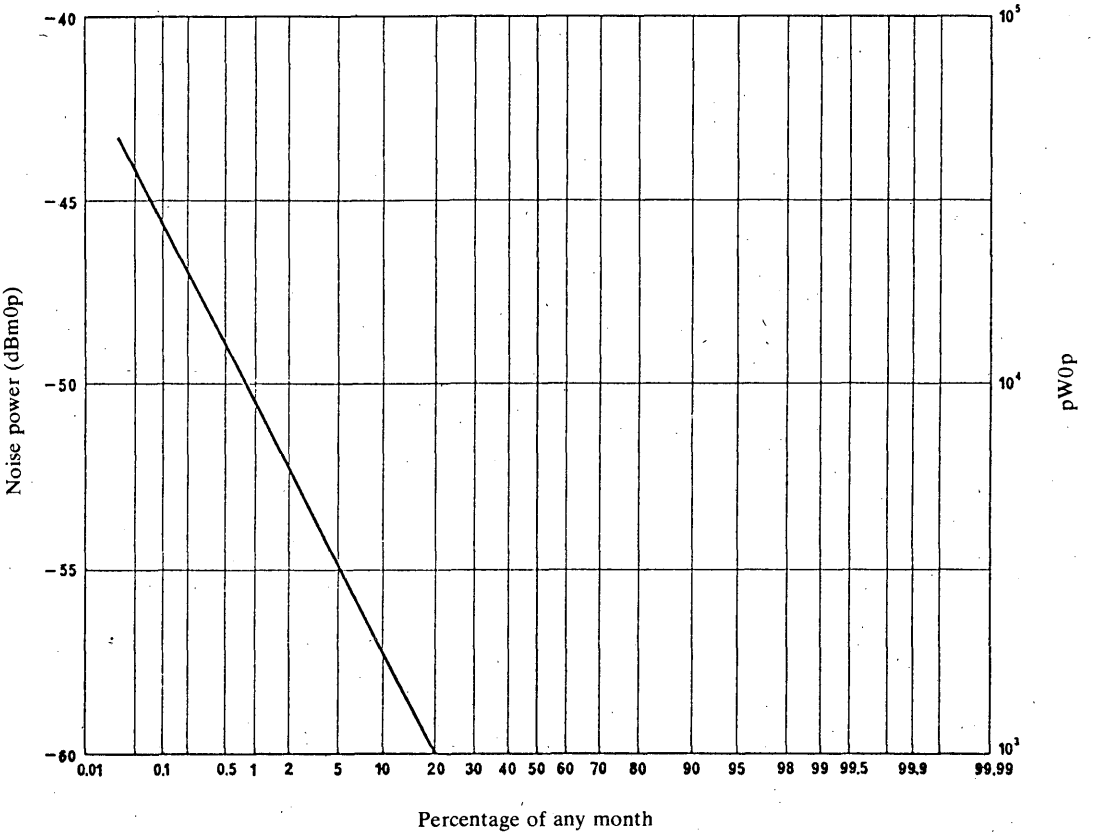

FIGURE 1 – *Example of possible interpolation*

RECOMMENDATION 558-2

MAXIMUM ALLOWABLE VALUES OF INTERFERENCE FROM TERRESTRIAL RADIO LINKS TO SYSTEMS IN THE FIXED-SATELLITE SERVICE EMPLOYING 8-BIT PCM ENCODED TELEPHONY AND SHARING THE SAME FREQUENCY BANDS

(Questions 32/4 and 17/9)

(1978-1982-1986)

The CCIR,

CONSIDERING

(a) that systems in the fixed-satellite service and line-of-sight radio-relay systems share frequency bands in the range above 1 GHz;

(b) that interference from radio-relay systems would degrade the bit error ratio performance of a satellite system relative to its performance in the absence of frequency sharing;

(c) that it is desirable that the bit error ratio in systems in the fixed-satellite service due to interference from transmitters of radio-relay systems should, during most of the time, be a controlled fraction of the total bit error ratio in those systems, as set out in Recommendation 522;

(d) that it is necessary to determine the maximum allowable interfering RF power in a satellite system to establish the maximum transmitter power and equivalent isotropically radiated power of line-of-sight radio-relay stations, and to determine whether specific locations for satellite-earth stations and terrestrial radio-relay stations would be satisfactory;

(e) that interference from radio-relay systems may vary with time due to the effect of varying propagation conditions;

(f) that systems in the fixed-satellite service may receive interference both through the satellite receiver and through the earth-station receiver but will receive the higher levels of interference associated with small percentages of time primarily through the earth-station receivers;

(g) that where propagation variations are small it is preferable to define the permissible interference limit as a fraction of the pre-demodulator noise power, as this allows multiple interference entries to be superimposed on each other on the basis of RF power addition,

UNANIMOUSLY RECOMMENDS

1. that systems in the fixed-satellite service and radio-relay systems sharing the same frequency bands be designed in such a manner that the interference to an 8-bit PCM telephony system in the fixed-satellite service caused by the aggregate of the transmitters of radio-relay stations operating in accordance with Recommendation 406, should conform to the following provisional* limit at the output of the hypothetical reference digital path as defined in Recommendation 521;

1.1 the interfering power**, averaged over any ten minutes, should not exceed, for more than 20% of any month, 10% of the total noise power at the input to the demodulator that would give rise to an error ratio of 1 in 10^6;

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* These criteria may need to be amended in the light of further studies.

** It is assumed in this Recommendation that the long-term interference from the terrestrial radio links is of a continuous nature. The situation relating to cases where interference is not of a continuous nature has not been considered.

1.2 the interfering RF power should not cause an increase of more than 0.03% of any month during which the bit error ratio exceeds 1×10^{-4} averaged over 1 min;

1.3 the interfering RF power should not cause an increase of more than 0.005% of any month during which the bit error ratio exceeds 1×10^{-3} averaged over 1 s.

Note 1 – To calculate the limit referred to in § 1.1, it must be assumed that the total noise power at the input to the demodulator is of a thermal nature.

Note 2 – The interference criterion of RECOMMENDS 1.1 is related to the maximum permissible levels of interference in a geostationary-satellite network in the fixed-satellite service using 8-bit PCM encoded telephony, caused by other networks of the fixed-satellite service, as defined in Recommendation 523. Note 7 of Recommendation 523 indicates that the limits of interference power for more than 20% of any month should normally be evaluated with the assumption that the total noise power level present is that which produces the specified bit error ratio under unfaded conditions of the received signal. This is discussed further in Report 793, § 2.

RECOMMENDATION 615

MAXIMUM ALLOWABLE VALUES OF INTERFERENCE FROM THE FIXED-SATELLITE SERVICE INTO TERRESTRIAL RADIO-RELAY SYSTEMS WHICH MAY FORM PART OF AN ISDN AND SHARE THE SAME FREQUENCY BAND BELOW 15 GHz

(Questions 32/4 and 17/9)

(1986)

The CCIR,

CONSIDERING

(a) that systems in the fixed-satellite service and the fixed service share many frequency bands below 15 GHz;

(b) that many radio-relay systems employing digital modulation for telephony are operational or are planned for operation in these shared bands;

(c) that it is necessary to specify the maximum allowable interference into the terrestrial service to determine whether specific locations for satellite earth stations and terrestrial radio-relay stations would be satisfactory;

(d) that the maximum allowable values of power flux-density at the surface of the Earth produced by space stations in the fixed-satellite service using the same bands above 1 GHz as the terrestrial service, are in accordance with Recommendation 358;

(e) that the allowable performance objectives and availability objectives are given respectively in Recommendation 594 and Recommendation 557 for digital radio-relay systems;

(f) that the allowable degradations in performance and availability of a terrestrial digital radio-relay system due to interference from satellite systems of the fixed-satellite service should be expressed as a permissible fraction of the total allowable degradation in performance and availability,

UNANIMOUSLY RECOMMENDS

1. that systems in the fixed-satellite service and terrestrial digital radio-relay systems should be designed in such a manner that, in the 2500 km HRDP defined in Recommendation 556, the permissible degradation in performance and availability resulting from the aggregate of the emissions of earth stations and space stations of the fixed-satellite service, including associated telemetering, telecommand and tracking transmitters operating in accordance with Recommendation 358 should not exceed the following provisional limits:

1.1 the interfering emissions should not degrade the performance by causing an increase of more than 0.04% of the period of time in any month during which the bit error ratio exceeds 1×10^{-6} (integration time, 1 min);

1.2 the interfering emissions should not degrade the performance by causing an increase of more than 0.0054% of the period of time in any month during which the bit error ratio exceeds 1×10^{-3} (integration time 1 s);

1.3 the interference emissions should not degrade the availability by causing an increase in the period of unavailability, as defined in Recommendation 557, of more than 0.03% of any year;

1.4 the interference emissions should not degrade the performance by causing an increase in the number of errored seconds measured at the 64 kbit/s interface by more than 0.032% in any month (see Note 2).

Note 1 – The limits on permissible interference apply to the cumulative sum of the effects of emissions from space stations, direct long-term emissions from earth stations and interference due to the anomalous propagation of emissions from earth stations.

Note 2 – The relationship between BER at the system bit rate and errored seconds of a 64 kbit/s channel is under study as a possible approach for ensuring compliance with RECOMMENDS 1.4 (see Report 930).

RECOMMENDATION 358-3

MAXIMUM PERMISSIBLE VALUES OF POWER FLUX-DENSITY AT THE SURFACE OF THE EARTH PRODUCED BY SATELLITES IN THE FIXED-SATELLITE SERVICE USING THE SAME FREQUENCY BANDS ABOVE 1 GHz AS LINE-OF-SIGHT RADIO-RELAY SYSTEMS

(Question 17/9 and Study Programme 32C/4)

(1963-1966-1974-1982)

The CCIR,

CONSIDERING

(a) that systems in the fixed-satellite service and line-of-sight radio-relay systems share frequency bands;

(b) that, because of such sharing, it is necessary to ensure that emissions from satellites do not cause harmful interference to line-of-sight radio-relay systems;

(c) that radio-relay systems can be satisfactorily protected from the emissions from satellites by placing suitable limits on the power flux-density, set up at the surface of the Earth, in a reference bandwidth;

(d) that, nevertheless, any limitations of the power flux-density set up at the surface of the Earth should not be such as to place undue restrictions on the design of systems in the fixed-satellite service;

(e) that for systems in the fixed-satellite service, methods of carrier-energy dispersal can be employed to reduce the radio-frequency spectral power density of satellite emissions;

(f) that calculations in recent studies demonstrate that power flux-density limits can generally be increased with increasing frequency and still provide adequate protection to line-of-sight radio-relay systems,

UNANIMOUSLY RECOMMENDS

1. that, in frequency bands in the range 2.5 to 23 GHz shared between systems in the fixed-satellite service and line-of-sight radio-relay systems, the maximum power flux-density produced at the surface of the Earth by emissions from a satellite, including those from a reflecting satellite, for all conditions and methods of modulation, should not exceed:

1.1 in the band 2.5 to 2.690 GHz, in any 4 kHz band:

-152	$dB(W/m^2)$ for	$\theta \leqslant 5°$
$-152 + 0.75(\theta - 5)$	$dB(W/m^2)$ for	$5° < \theta \leqslant 25°$
-137	$dB(W/m^2)$ for	$25° < \theta \leqslant 90°$

1.2 in the band 3.4 to 7.750 GHz, in any 4 kHz band:

-152	$dB(W/m^2)$ for	$\theta \leqslant 5°$
$-152 + 0.5(\theta - 5)$	$dB(W/m^2)$ for	$5° < \theta \leqslant 25°$
-142	$dB(W/m^2)$ for	$25° < \theta \leqslant 90°$

1.3 in the band 8.025 to 11.7 GHz, in any 4 kHz band:

-150	$dB(W/m^2)$ for	$\theta \leqslant 5°$
$-150 + 0.5(\theta - 5)$	$dB(W/m^2)$ for	$5° < \theta \leqslant 25°$
-140	$dB(W/m^2)$ for	$25° < \theta \leqslant 90°$

1.4 in the band 12.2 to 12.75 GHz, in any 4 kHz band:

-148	$dB(W/m^2)$ for	$\theta \leqslant 5°$
$-148 + 0.5(\theta - 5)$	$dB(W/m^2)$ for	$5° < \theta \leqslant 25°$
-138	$dB(W/m^2)$ for	$25° < \theta \leqslant 90°$

1.5 in the band 17.7 to 19.7 GHz, in any 1 MHz band:

-115	$dB(W/m^2)$ for	$\theta \leqslant 5°$
$-115 + 0.5\,(\theta - 5)$	$dB(W/m^2)$ for	$5° < \theta \leqslant 25°$
-105	$dB(W/m^2)$ for	$25° < \theta \leqslant 90°$

where θ is the angle of arrival of the radio-frequency wave (degrees above the horizontal);

2. that the aforementioned limits relate to the power flux-density and angles of arrival which would be obtained under free-space propagation conditions.

Note 1 – Definitive limits applicable in shared frequency bands are laid down in Nos. 2561 to 2580.1 of Article 28 of the Radio Regulations. The CCIR is continuing its study of these problems, which may lead to changes in the recommended limits.

Note 2 – Under Nos. 2581 to 2585 of the Radio Regulations, the power flux-density limits in the band 17.7 to 19.7 GHz shall apply provisionally to the band 31.0 to 40.5 GHz until such time as the CCIR has recommended definitive values, endorsed by a competent Administrative Conference (No. 2582.1 of the Radio Regulations).

RECOMMENDATION 674

POWER FLUX-DENSITY VALUES TO FACILITATE THE APPLICATION OF ARTICLE 14 FOR FSS IN RELATION TO THE FIXED-SATELLITE SERVICE IN THE 11.7-12.2 GHz BAND IN REGION 2

(Study Programme 32F/4)

(1990)

The CCIR,

CONSIDERING

(a) that systems in the fixed-satellite service and the fixed service share the band 11.7-12.2 GHz in Region 2;

(b) that the use of this band for the fixed-satellite service is subject to prior agreement with administrations with services that comply with the Table of Frequency Allocations of the Radio Regulations;

(c) that the identification of affected administrations using the fixed service in Region 2 will be facilitated by the use of appropriate power flux-density values;

(d) that the power flux-density (pfd) is one of the technical characteristics of space stations in the fixed-satellite service that have already been used for the determination of criteria which facilitate sharing with terrestrial services;

(e) that it was never intended to introduce any power flux-density limits in this band due to the nature of the fixed-satellite services that are to be provided in this band in Region 2,

UNANIMOUSLY RECOMMENDS

1. that in the frequency band 11.7-12.2 GHz shared between systems in the fixed-satellite service and line-of-sight radio-relay systems in Region 2, the values of power flux-density on the territory of the affected administrations using the fixed service which would be used to identify these administrations to facilitate the application of Article 14 of the Radio Regulations, should be, in any 4 kHz band:

-150 dB(W/m^2) in 4 kHz for $0° \leqslant \theta \leqslant 5°$

$-150 + 0.5\,(\theta - 5)$ dB(W/m^2) in 4 kHz for $5° < \theta < 25°$

-140 dB(W/m^2) in 4 kHz for $\theta \geqslant 25°$

where θ is the angle of arrival, in degrees, on the surface of the Earth of the radio-frequency wave;

2. that the above values relate to the power flux-density and angles of arrival which would be obtained under free-space propagation conditions;

3. that the technical criteria in this Recommendation do not apply to Regions 1 and 3;

4. that the following Note should be regarded as part of this Recommendation.

Note – Power flux-density limits where appropriate are contained in the Radio Regulations. The values in RECOMMENDS 1 are intended to facilitate the application of Article 14 and are not intended as pfd limits.

RECOMMENDATION 406-6

MAXIMUM EQUIVALENT ISOTROPICALLY RADIATED POWER OF LINE-OF-SIGHT RADIO-RELAY SYSTEM TRANSMITTERS OPERATING IN THE FREQUENCY BANDS SHARED WITH THE FIXED-SATELLITE SERVICE

(Questions 32/4 and 17/9, Study Programme 17E/9)

(1966-1970-1974-1978-1982-1990)

The CCIR,

CONSIDERING

(a) that systems in the fixed-satellite service and line-of-sight radio-relay systems share certain frequency bands in the range of 1 GHz to about 30 GHz;

(b) that, to avoid significant interference to reception in space station receivers, without excessive transmitter powers at the earth stations of systems in the fixed-satellite service or excessively large antennas, it is necessary to define maximum allowable values for the equivalent isotropically radiated power of line-of-sight radio-relay systems;

(c) that the maximum allowable values of radiated power should be such as not to place undue restriction on the design of line-of-sight radio-relay systems;

(d) that it is desirable that radio-relay systems should employ highly directional antennas;

(e) that it is necessary to avoid relatively constant excessive levels of interference from radio-relay emissions directed at satellites in the fixed-satellite service, and particularly those in the geostationary-satellite orbit;

(f) that the radio-relay system planner often has a choice in routing new systems without severe economic or other penalties being incurred,

UNANIMOUSLY RECOMMENDS

1. that in those frequency bands* between 1 and 10 GHz, shared between systems in the fixed-satellite service and line-of-sight radio-relay systems involving reception at the space station:

1.1 the power delivered to the antenna input of any such radio-relay system transmitter shall not exceed +13 dBW;

1.2 the maximum value of the equivalent isotropically radiated power of any such radio-relay system transmitter shall not, in any case, exceed +55 dBW;

1.3 as far as practicable, sites for new transmitting stations, employing maximum values of equivalent isotropically radiated power exceeding +35 dBW should be selected so that the direction of maximum radiation of any antenna will be at least 2° away from the geostationary-satellite orbit;

1.3.1 if, in a particular case, this should prove impracticable, the maximum values of equivalent isotropically radiated power for each transmitter shall not exceed:

1.3.1.1 +47 dBW for any antenna beam directed within 0.5° of the geostationary-satellite orbit;

1.3.1.2 +47 to +55 dBW, on a linear decibel scale (8 dB per angular degree), for any antenna beam directed between 0.5° and 1.5° of the geostationary-satellite orbit;

* The frequency bands concerned are given in the Radio Regulations.

1.4 in new radio-relay systems built on existing routes* the maximum values of equivalent isotropically radiated power for each transmitter should not, as far as possible, exceed:

1.4.1 +47 dBW for any antenna beam directed within 0.5° of any location in the geostationary-satellite orbit which has been internationally notified, or, if practicable, the geostationary orbit (see Note 4);

1.4.2 +47 to +55 dBW, on a linear decibel scale (8 dB per angular degree), for any antenna beam directed between 0.5° and 1.5° of any location in the geostationary-satellite orbit which has been internationally notified, or, if practicable, the geostationary orbit (see Note 4);

2. that in those frequency bands** between 10 and 15 GHz, shared between systems in the fixed-satellite service and line-of-sight radio-relay systems involving reception at the space station:

2.1 the power delivered to the antenna input of any such radio-relay system transmitter shall not exceed +10 dBW;

2.2 the maximum value of the equivalent isotropically radiated power of any such radio-relay system transmitter shall not, in any case, exceed +55 dBW;

2.3 as far as practicable, sites for transmitting stations, employing maximum values of equivalent isotropically radiated power exceeding +45 dBW should be selected so that the direction of maximum radiation of any antenna will be at least 1.5° away from the geostationary-satellite orbit;

3. that in those frequency bands** above 15 GHz, shared between systems in the fixed-satellite service and line-of-sight radio-relay systems involving reception at the space station:

3.1 the power delivered to the antenna input of any such radio-relay system transmitter shall not exceed +10 dBW;

3.2 the maximum value of the equivalent isotropically radiated power of any such radio-relay system transmitter shall, in all cases, not exceed +55 dBW;

3.3 there shall be no restriction as to the direction of maximum radiation (see Note 6).

Note 1 – The above RECOMMENDS 1.3 and 2.3 should be interpreted that, taking into account the effects of atmospheric refraction, any emission within 2 or 1.5° from the direction of maximum radiation of radio-relay antenna and going beyond the local horizon should not reach the geostationary-satellite orbit.

An alternative interpretation of RECOMMENDS 1.3 and 2.3 is that the angle between the direction of maximum radiation of a radio-relay antenna in outer space and the geostationary-satellite orbit, taking into account the effects of atmospheric refraction, should be at least 2 or 1.5° as appropriate where if the direction of maximum radiation is intercepted by the Earth, it is deemed that no intersection occurs.

Preference is given to the first interpretation. (See Report 393.)

Note 2 – Receiving stations in terrestrial systems operating in frequency bands between 1 and 15 GHz shared with space systems (space-to-Earth) may benefit from avoiding directing their antenna main beams towards the geostationary orbit, if their sensitivity is sufficiently high.

Note 3 – Definitive limits applicable in shared frequency bands are laid down in Article 27 of the Radio Regulations (Nos. 2502 to 2511.2). The CCIR is continuing to study the question, and these studies may lead in the future to a Recommendation, that the limits should be revised. At the present time, no changes are proposed to the limits as laid down in the Radio Regulations.

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* For the purpose of this Recommendation, an existing route is regarded as one already planned before the conclusion of the XIth CCIR Plenary Assembly, Oslo 1966, and brought into service before 1 January 1973.

** The frequency bands concerned are given in the Radio Regulations.

Note 4 – The operation of a radio-relay system established on an existing route and exceeding the limits given in § 1.4.1 and 1.4.2 may, in view of the characteristics of the terrestrial and space systems involved, result in objectionable levels of interference to a geostationary satellite whose position has been notified after the radio-relay system has been brought into service; in such a case the action to be taken with regard to both systems to reduce such interference to a level which can be agreed by the administrations concerned should be determined by consultation between those administrations.

Note 5 – The above limits for the bands above 10 GHz should normally afford adequate protection to digital satellite systems using 8-bit PCM encoded telephony (see Report 790).

Note 6 – No. 2504.1 of the Radio Regulations stipulates that the provisions of No. 2504, which correspond to § 3.3 above, shall apply until such time as the CCIR has made a Recommendation as to the need for restrictions in the frequency bands specified in No. 2511 (bands above 15 GHz); all systems introduced after 1 January 1982 should as far as practicable meet any such restriction.

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SECTION 4/9B: CO-ORDINATION AND INTERFERENCE CALCULATIONS

RECOMMENDATION 359-5

DETERMINATION OF THE CO-ORDINATION AREA OF EARTH STATIONS IN THE FIXED-SATELLITE SERVICE USING THE SAME FREQUENCY BANDS AS THE SYSTEMS IN THE FIXED TERRESTRIAL SERVICE

(Questions 32/4 and 17/9)

(1963-1966-1970-1974-1978-1982)

The CCIR,

CONSIDERING

(a) that, where earth stations and terrestrial stations share the same frequency bands, there is a possibility of interference, both as regards the earth-station transmission interfering with reception at terrestrial stations, and the terrestrial-station transmissions interfering with reception at earth stations;

(b) that, to avoid such interference, it will be desirable for the transmitting and receiving frequencies used by earth stations to be co-ordinated with the frequencies used by terrestrial services, which might be in a position either to receive interference from earth-station transmissions or to cause interference to reception at earth stations;

(c) that this co-ordination will need to be established within an area surrounding the earth station and extending to the limits beyond which the possibility of mutual interference may be considered negligible;

(d) that this area may sometimes involve more than one administration;

(e) that such mutual interference will depend upon several factors, including the transmitter powers, antenna gains in the direction of the unwanted signals, the permissible interference levels at the receivers, mechanisms of radio-wave propagation, radio-climatology, the distance between stations and the terrain profile;

(f) that the possibility of interference will need to be examined in detail in each case, taking all factors into account;

(g) that, as a preliminary to this detailed examination, it is desirable to establish a method of determining, on the basis of broad assumptions, a co-ordination area around an earth station, such that the possibility of mutual interference with terrestrial stations situated outside this area may be regarded as negligible; mutual co-ordination between administrations is required by the Radio Regulations if the co-ordination area of this station overlaps the territory under the jurisdiction of another administration;

(h) that the World Administrative Radio Conference, Geneva, 1979, adopted the method of determining the co-ordination area set out in Appendix 28 of the Radio Regulations and invited the CCIR to continue its studies on the subject (see Recommendation No. 711 of the WARC-79);

(j) that the Conference also adopted Resolution No. 60 inviting the CCIR to maintain the relevant texts as a result of these studies in a format which would permit direct insertion into Appendix 28 of the Radio Regulations in place of existing § 3, 4, 6 or Annex III when it is concluded by the CCIR Plenary Assembly that such an insertion is warranted,

UNANIMOUSLY RECOMMENDS

1. that account be taken of the international co-ordination and planning which will be involved, if earth stations in the fixed-satellite service are to share frequency bands with terrestrial stations in nearby countries without undue mutual interference;

2. that the co-ordination areas of transmitting and receiving earth stations be determined by the method described in Appendix 28 to the Radio Regulations and on the basis of the parameters indicated in that Appendix;

3. that Report 382, which gives the results of complementary studies for the determination of the co-ordination area, could be useful in future but includes for the time being provisional propagation data;

4. that § 3, 4, 6 and Annex II of Report 382 be updated, based on the latest propagation information adopted by Study Group 5, in a format suitable for direct insertion into Appendix 28 of the Radio Regulations;

5. that if such changes are sufficiently significant to warrant revision of Appendix 28, a proposal for such a revision be made to the Plenary Assembly of the CCIR in accordance with Resolution No. 60 of the World Administrative Radio Conference, Geneva, 1979.

RECOMMENDATION 675

CALCULATION OF THE MAXIMUM POWER DENSITY (AVERAGED OVER 4 kHz) OF A FREQUENCY-MODULATED FDM CARRIER

(Questions 32/4 and 28/9, Study Programme 28C/9)

(1990)

The CCIR,

CONSIDERING

(a) that administrations are requested to prepare the information listed in Appendices 3 and 4 to the Radio Regulations for coordination and notification purposes;

(b) that one item of the information listed in Appendices 3 and 4 to the Radio Regulations is the maximum power density per Hz at the input of the antenna averaged over the worst 4 kHz band;

(c) that generalized methods are necessary for the calculation of the maximum power density of a frequency-modulated FDM carrier,

UNANIMOUSLY RECOMMENDS

1. that the methods described in Annex I be used for the calculation of the maximum power density averaged over 4 kHz of a frequency-modulated FDM carrier;

2. that for the determination of the maximum spectral power density, with agreement of the other administrations concerned, administrations should make use of the most precise calculation method available to them.

ANNEX I

CALCULATION OF THE MAXIMUM POWER DENSITY (AVERAGED OVER 4 kHz) OF A FREQUENCY-MODULATED FDM CARRIER

Given below is the method of calculating the power level in the worst 4 kHz (W/4 kHz). The power density per Hz required by the Radio Regulations is obtained by dividing this value by 4000.

1. Maximum power density per 4 kHz of an FM carrier

1.1 *FM carrier modulated by a multi-channel telephony signal*

The maximum power spectral density at full baseband loading is determined either by the residual carrier or by the peaks of the continuous spectrum, depending upon the nature of the modulation.

The power of the residual carrier is given by the expression:

$$P_t \cdot e^{-\psi_0} \quad \text{(W)} \tag{1}$$

where:

$$\psi_0 = \frac{m^2}{\varepsilon}\left[C_0 + C_2 \cdot \varepsilon + \frac{C_4}{3}(\varepsilon + \varepsilon^2 + \varepsilon^3)\right] \tag{2}$$

In equation (2), m is the multi-channel r.m.s. modulation index and the constants C_0, C_2 and C_4 describe the prevailing pre-emphasis characteristic in the general expression for the pre-emphasis:

$$p(f/f_h) = C_0 + C_2(f/f_h)^2 + C_4(f/f_h)^4 \quad (3)$$

where f is the specific baseband frequency under consideration, to be given in the same units as f_h. In the range $\varepsilon \leqslant f/f_h \leqslant 1$, the CCIR pre-emphasis characteristic (Recommendation 275) is well approximated by:

$$p(f/f_h) = 0.4 + 1.35(f/f_h)^2 + 0.75(f/f_h)^4 \quad (4)$$

Thus, for a system with CCIR pre-emphasis:

$$\psi_0 \approx \frac{m^2}{\varepsilon}\,(0.4 + 1.6\,\varepsilon + 0.25\,\varepsilon^2 + 0.25\,\varepsilon^3) \quad (5)$$

wherein $m = f_\Delta/f_h$.

Note – Administrations should make details available of the spectrum shape and the value of the coefficients used in equations (2) and (3), for detailed coordination purposes.

The maximum power of the spectral density in the continuous part of the spectrum can be obtained approximately from Figs. 1 and 2.

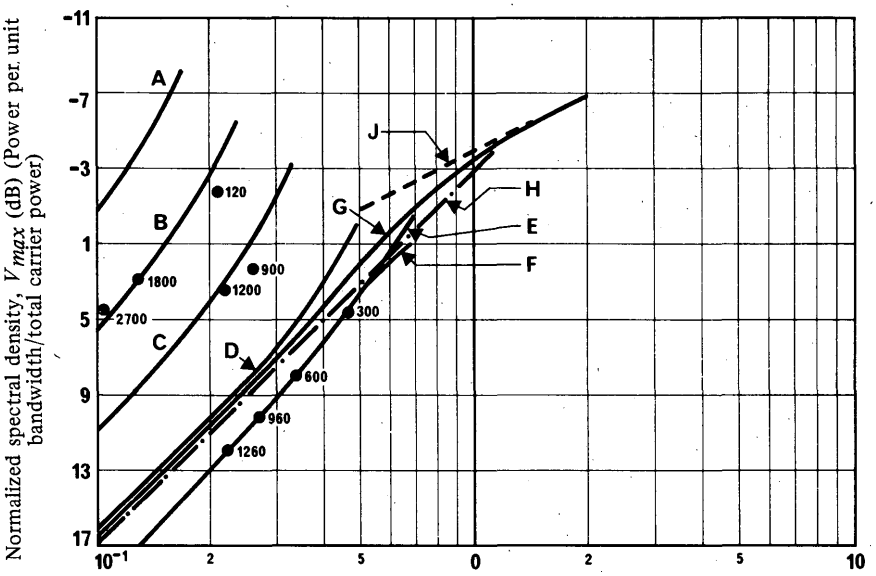

FIGURE 1 – *Maximum spectral density of signal (distributed component) frequency modulated by Gaussian noise*

(pre-emphasis of Recommendation 275)

Curves A: $\psi_0 = 0.1$
B: $\psi_0 = 0.2$
C: $\psi_0 = 0.4$
D: $\psi_0 = 1.0$
E: $\psi_0 = 2.0$
F: $\psi_0 = 4.0$
G: $\psi_0 = \infty$
H: small-deviation approximation (Report 792)
J: large-deviation approximation
●: values for standard radio-relay systems (as labelled) are for the following baseband limits:

120 channels	60-552 kHz
960 channels	60-4028 kHz
1260 channels	60-5636 kHz

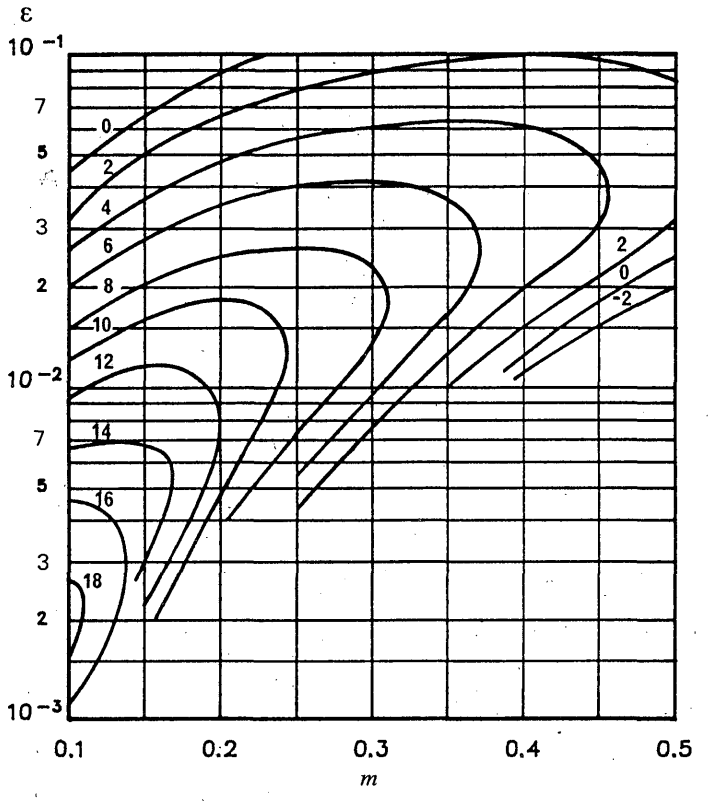

FIGURE 2 – *Equal contour of V_{max} (maximum spectral density) of the FDM-FM signal*
(pre-emphasis of Recommendation 275)

Parameters: V_{max} (dB)

In the equations and the figures, the symbols have the following meanings:

P_t: the total power of carrier (W),

f_Δ: multi-channel r.m.s. deviation (Hz).

$$f_\Delta \begin{cases} f_d \times 10^{(-15 + 10 \log N_c)/20} & \text{for } N_c \geqslant 240 \\ f_d \times 10^{(-1 + 4 \log N_c)/20} & \text{for } 240 > N_c \geqslant 60 \\ f_d \times 10^{(2.6 + 2 \log N_c)/20} & \text{for } 60 > N_c \geqslant 12 \end{cases} \quad \text{or} \quad \begin{cases} f_d \times 10^{(-15 + 10 \log N_c)/20} & \text{for } N_c \geqslant 240 \\ f_d \times 10^{(-1 + 4 \log N_c)/20} & \text{for } 12 \leqslant N_c < 240 \end{cases}$$

f_d: r.m.s. test tone deviation (Hz),

N_c: number of channels,

f_h: top frequency of the baseband (Hz),

f_1: bottom frequency of the baseband (Hz),

m: multi-channel modulation index ($= f_\Delta / f_h$),

$\varepsilon = f_1 / f_h$,

$V_{max} = W_{max} f_h / P_t$,

W_{max}: maximum spectral power per unit bandwidth (W/Hz).

For carriers for which $1 < N \leqslant 12$, the maximum power density per 4 kHz is approximated by the expression:

$$P_t \cos^2 \frac{m_b}{1.5} \qquad \text{(W/4 kHz for } m_b < 1\text{)} \tag{6}$$

where:

P_t: total power of the carrier (W),

m_b: the peak modulation index (radians) due to an 0 dBm test tone in the highest frequency baseband channel.

1.2 *FM carrier modulated by a multi-channel telephony signal and an energy dispersal signal of a triangular waveform with fixed amplitude*

Triangular wave dispersal systems are normally designed to ensure that the maximum power spectral density per 4 kHz centred on the carrier frequency is maintained within 3 dB of the fully loaded value.

The power spectral density centred on the carrier frequency is given by:

$$\frac{P_t}{\Delta F} \times 4000 \qquad \text{(W/4 kHz)} \tag{7}$$

where:

P_t: the total power of the carrier (W),

ΔF: peak-to-peak frequency deviation due to the energy dispersal signal (Hz).

Note 1 – Equation (7) assumes the use of perfectly linear triangular dispersal waveform.

Note 2 – The calculation methods of the maximum power spectral density averaged over 4 kHz of FM carrier modulated by a television video signal, and PSK carrier are not included in this Recommendation (see Report 792). All administrations are encouraged to carry out further studies into calculation methods relating to these modulation schemes.

[redacted]