RECOMMENDATION ITU-R F.758-1*

CONSIDERATIONS IN THE DEVELOPMENT OF CRITERIA FOR SHARING BETWEEN THE TERRESTRIAL FIXED SERVICE AND OTHER SERVICES

(Question ITU-R 127/9)

(1992-1997)

The ITU Radiocommunication Assembly,

considering

a) that it is necessary to establish sharing criteria between the fixed service (FS) and other services in frequency bands where both services have a primary allocation;

b) that sharing may be managed by determining allowable values of performance and availability degradations of analogue and digital radio-relay systems caused by interference from other radio services allocated in the same frequency bands as the FS on a primary basis;

c) that interference from other services sharing the same band on a non-primary basis, emissions from other services outside the shared band, and emissions from sources other than radio services must also be considered;

d) that principles for apportioning the performance and availability degradation over the length of the radio-relay system, and between each interference source, need to be established;

e) that the technical characteristics of each service need to be understood in order to derive interference criteria corresponding to the allowable degradation in performance and availability of the radio-relay system;

f) that performance and availability degradation may result from both long-term and short-term interference and hence both long-term and short-term interference criteria need to be established;

g) that availability of a basic methodology for the development of sharing criteria may be useful to other Study Groups when formulating criteria for sharing with the FS,

recommends

1 that the development of sharing criteria between the FS and other services should be carried out in accordance with the principles described in Annex 1;

2 that the information provided in Annex 2 should be used as guidance to the technical characteristics and sensitive sharing parameters of FS systems that need to be taken into account when developing criteria for sharing with other services;

3 that studies are required to further develop appropriate short-term interference criteria;

4 that further studies are required to derive interference criteria that are appropriate for specific types of new services.

NOTE 1 – Annex 3 describes additional technical characteristics of some FS systems specifically useful for sharing analysis in the 1-3 GHz band.

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* This Recommendation should be brought to the attention of Radiocommunication Study Groups 4 (Working Parties 4A and 4-9S), 7 (Working Party 7B), 8 (Working Party 8D) and 10 and 11 (Working Party 10-11S).

ANNEX 1

Basic considerations in the development of sharing criteria

1 Overall performance objective

One of the functions of a radiocommunications planner is to design and implement a transmission network which meets the performance objectives laid down by the ITU-T and ITU-R. It is important, therefore, that real systems can meet the appropriate design objectives, recognizing the increasing use of the radio spectrum. There are various ITU-R F Series Recommendations which relate to the overall performance objective for various types of circuit.

1.1 Error performance and availability objectives

Table 1 gives details of the error performance and availability objectives applicable for high-grade, medium-grade and local-grade portions of an integrated services digital network (ISDN) connection at bit rates below the primary rate utilizing digital radio-relay systems. In addition, the factors to be taken into account when determining error performance objectives for constant bit rate digital paths at or above the primary rate carried by digital radio-relay systems which may form part or all of the international or national portion of a hypothetical reference path are given in Recommendations ITU-R F.1092 and ITU-R F.1189 respectively.

TABLE 1

Digital performance and availability objectives

Objective	Hypothetical reference digital path (HRDP)	High grade	Medium grade	Local grade
Error performance	Rec. ITU-R F.594	Rec. ITU-R F.634	Rec. ITU-R F.696	Rec. ITU-R F.697
Availability	Rec. ITU-R F.557	Rec. ITU-R F.695	Rec. ITU-R F.696	Rec. ITU-R F.697

1.2 Analogue performance and availability objectives

Table 2 gives details of the noise limits and availability objectives applicable to analogue radio-relay systems.

TABLE 2

Analogue performance and availability objectives

Objective	Telephony	Television	Trans-horizon
Noise in hypothetical reference circuit (HRC)	Rec. ITU-R F.393	Rec. ITU-R F.555	Rec. ITU-R F.397
Noise in real links	Rec. ITU-R F.395	–	Rec. ITU-R F.593
Availability	Rec. ITU-R F.557	–	–

2 Sub-division of the performance and availability objectives

The previous section dealt with the overall performance objectives for digital and analogue reference connections. However, there are, in practice, a large number of potential sources of interference contributing to the degradation of performance of a radio-relay system. In order to move towards a practical method for planning, the overall performance objectives need to be sub-divided between individual sections of the overall HRC. Within a section, the performance objective is then apportioned between the various sources.

2.1 Apportionment of section performance objective

This is covered in Recommendation ITU-R F.1094. The allowable degradation is divided into an element of X% for the FS portion, Y% for frequency sharing on a primary basis, and Z% for all other sources of interference (It should be noted that $X\% + Y\% + Z\% = 100\%$). In the case of sharing with the fixed satellite service (FSS), typically, $Y = 10\%$ (e.g. Recommendation ITU-R SF.615).

There may be a further sub-division of the X% allowance to suit local requirements and this could be apportioned in such a way as to suit the grade of service.

A particular point to note is that an interference source (say a transmitter (Tx)) may affect more than one hop of a system.

3 Characteristics of interference

It is necessary to have information available on interference levels arising from other services, which would degrade system performance by specific amounts. This would be facilitated if, with the assistance from other Study Groups, a table were compiled giving information on the characteristics of emissions.

Two categories of interference are worth considering:

– the interference arising from services sharing on a primary basis that is likely to be within the receiver (Rx) bandwidth from analogue or digital modulations, in either carrier wave or burst emissions. Reference can be made to existing text where available in ITU-R F Series and SF Series Recommendations (e.g. Recommendation ITU-R SF.766);

– emissions from systems other than those sharing on a primary basis that could be numerous and diverse, and may be considered in a similar way to the spurious emissions.

Ultimately, another table could be prepared, again with the assistance of other Radiocommunication Study Groups, which compares levels of interference or Gaussian noise required to produce a specified degradation in the channel performance.

4 Limit values of interference

Following the considerations in the previous sections, one may now determine the limit values of interference allowable to a particular source. This has been done for the case of frequency sharing between the FSS and the FS in the joint workings of Radiocommunication Study Groups 4 and 9, where certain models have been established. These models may be appropriate for frequency sharing between radio-relay systems and other services in general.

Methods for characterizing interference levels into terrestrial radio-relay systems include power flux-density (pfd), power level at the input to the antenna or the power level at the receiver input. It is worth noting that both methods are in use in ITU-R SF Series Recommendations.

A single interference limit value is not adequate because of the time varying nature of the interference. Two limit values, corresponding to a long term (20% of time) and a short term (< 1% of time) have been identified in Recommendation ITU-R SF.1006. The exact value of the short-term time percentage is related to the performance objectives for the system under consideration. Radiocommunication Study Groups 4 and 9 have developed this method for the specific purpose of sharing between the FS and the FSS. Further study is needed to determine the extent to which the techniques developed in Radiocommunication Study Groups 4 and 9 are applicable to the other cases. Table 3 lists the references relating to sharing between the FS and the FSS, concerning interference into the FS.

TABLE 3

ITU-R Recommendations relating to frequency sharing between the FS and the FSS

Analogue	Digital	General
Rec. ITU-R SF.357		Rec. ITU-R SF.355
	Rec. ITU-R SF.615	Rec. ITU-R SF.1006

Recommendation ITU-R F.1094 lays the foundations for the apportionment of the performance and availability objectives, from which the long-term interference limit can be calculated. In the case of Rayleigh fading, it can be shown that if the aggregate level of interference is no higher than 10 dB below the receiver noise floor, the performance degradation will not exceed 10%.

Any temporal characteristics of exposure of the FS to interference will also need to be taken into account.

The derivation of permitted short-term interference levels, and associated time percentages, is a complex process which includes careful examination of performance/availability objectives, and assumptions about the fading characteristics and correlation of periods of wanted signal fading and interference enhancement. The procedures described in the ITU-R SF Series Recommendations texts and the principles described in this Annex 1 should be developed for this purpose and the tables expanded to include this important information.

5 Calculation of actual interference levels

To complete the analysis of sharing, the probability of interference arriving at the input to the antenna must be evaluated. This will take into account up-to-date propagation models and path factors, which are described in the ITU-R P Series Recommendations and Reports. It is unlikely that a single model will suffice for all possible applications. The transmission loss calculation will also include factors such as absorption losses, diffraction losses, scattering loss, polarization coupling loss, aperture-to-medium coupling loss and the effect of multipath. Also, both aggregate and single-entry interference levels may need to be considered.

ANNEX 2

FS system parameters for frequency sharing

1 Introduction

In order to calculate degradations in performance and availability, it is necessary to know the characteristics of the radio-relay system being degraded. There is a large variety of radio-relay systems in operation or being developed to meet future requirements. It would be unwise, therefore, to use a single "typical" radio-relay system as a general purpose model. This Annex provides details of the key radio system parameters required for interference evaluation and calculations for frequency sharing with other services.

2 Transmitter characterization

The basic transmitter parameters needed to assess interference potential to other services are:

– carrier frequency,

– spectral characteristics,

– equivalent isotropically radiated power (e.i.r.p.),

– antenna radiation pattern.

Operating frequencies normally correspond to standard ITU-R channel plans. The modulation type and system capacity will give a guide to the spectral characteristics of the emissions. However, detailed sharing calculations would require a template of the spectral characteristics to be specified so that any frequency offset rejection at a given wanted/interfering signal carrier frequency separation may be calculated.

The e.i.r.p. of the transmitter is calculated from the transmitter power, feeder/multiplexer losses and antenna gain. A maximum e.i.r.p. value would correspond to maximum antenna gain, minimum feeder/multiplexer losses and maximum transmitter output power, which represents the worst interference potential to other services.

Knowledge of antenna radiation patterns is essential to perform detailed sharing studies. Recommendation ITU-R F.699 should be used to obtain information on FS antenna radiation pattern envelopes in cases where measured patterns are not available.

3 Receiver characterization

3.1 Equipment parameters

Assessment of the effects of interference into the FS from other services requires knowledge of the performance characteristics of the radio receiver. The following receiver parameters are important for frequency sharing studies:

– noise figure,

– IF bandwidth,

– receiver thermal noise,

– received signal power for 1×10^{-3}, 1×10^{-6}, 1×10^{-10} BER (digital systems),

– nominal receiver input level.

The received signal levels and interference levels could be referenced to the LNA/mixer input of the receiver, so that they would be independent of receive antenna gain and feeder/multiplexer losses (assuming this to be the same for both transmitter/receiver).

It should also be noted that accurate sharing calculations require information on the frequency selectivity of the radio equipment.

The required signal levels for given BERs could be combined with the calculated receiver thermal noise level to obtain the required carrier-to-thermal noise ratio C/N for a given BER.

3.2 Permitted interference

It is necessary to specify maximum interference levels for both long- and short-term time percentages. For long-term interference, a time percentage of 20% is commonly used. Where aggregate long-term interference is specified, if interference from multiple sources can simultaneously occur, it should be noted that single entry interference criteria will be correspondingly lower. In the case of short-term interference, the time percentages of interest will be related to the system performance objectives.

The long- and short-term interference levels, and associated time percentages, must be individually derived for each system type in accordance with the principles described in Annex 1.

3.2.1 Digital systems

For digital receivers, it is the total interference power falling within the receiver bandwidth that is generally of most relevance. For convenience, the equivalent power spectral density (PSD) (dB(W/MHz)) can also be specified.

3.2.2 Analogue telephony (FM-FDM)

In analogue systems, the presence of long-term interference will lead to permanent increased noise levels in the demodulated baseband signal. The effect of RF interference on a given telephone channel in the FM-FDM multiplex after demodulation will depend on the nature of, and frequency separation between, the wanted and interfering carrier. This interference must be considered over a bandwidth similar to that of a single baseband channel. Thus, a reference bandwidth of 4 kHz is generally of interest when specifying maximum interference levels for analogue FM-FDM systems.

4 Tables of system parameters

A table can be constructed showing system parameters to be used when considering sharing between the FS and other services, and this should include the information discussed above.

Tables 4 to 15 show selected examples of some FS systems that are currently in use in some of the bands in which FSS operate. The various radio system types are identified in the tables by modulation type and system capacity.

The nominal long-term interference criteria specified in the tables provide some guidance to the results that would be obtained from detailed calculations and can be used for information for the time being. However, for detailed sharing studies accurate criteria must be derived in accordance with the information in Annex 1, and these may differ slightly from those in the table.

It is most important that the following Notes be taken into account when considering the example tables.

NOTE 1 – To simplify the tables, only the interfering carrier level corresponding to the 1×10^{-3} BER is included. Equally important are the 1×10^{-6} and 1×10^{-10} BER objectives, used in the evaluation of permissible performance degradation. Typically, the carrier level corresponding to 1×10^{-6} BER is around 4 dB lower than that for 1×10^{-3} BER; the carrier level difference between the 10^{-6} and 10^{-10} BER points is also about 4 dB.

NOTE 2 – In the example tables a straightforward, but conservative, approach to specifying maximum permitted long-term external interference is used. This was done because the characteristics and spatial distribution of the interference sources are undefined, and it is also impractical to attempt detailed performance and availability predictions for such a large number of systems at this stage.

By referencing interference to the receiver thermal noise level the problem is greatly simplified, since the permitted interference power spectral density so derived will be dependent solely on receiver noise figure and independent of the modulation scheme of the victim system. It may be shown that, independent of the normal received carrier level, the degradation in fade margin with interference set to a given level relative to receiver thermal noise level is as follows:

Interference level relative to receiver thermal noise (dB)	Resultant degradation in fade margin (dB)
–6	1
–10	0,5

Within the tables, the choice of an interference to thermal noise *I*/*N* value of –6 dB or –10 dB is selected to match the typical requirements of individual systems. For detailed sharing analyses, the interference criteria must be derived in accordance with Annex 1, to match the individual, specific, sharing scenario under consideration, and will need to be agreed between the parties concerned.

Another approach stated in Note (3) of Tables 4 to 15 can be applied, conforming to the method given in Recommendation ITU-R SF.615.

NOTE 3 – Short-term interference criteria have not been included in the example tables. This information must be derived in accordance with the principles derived in Annex 1. The tables may be updated when this information becomes available, as a result of future detailed studies of sharing with specific services.

NOTE 4 – In Tables 4 to 15, the antenna gain is expressed only in terms of maximum gain. However, in certain frequency sharing scenarios, the minimum gain or other parameters (such as side-lobe and back-lobe gain) of the antenna may be more relevant. Annex 4 gives information about typical minimum antenna gains.

TABLE 4

FS system parameters for FS frequency sharing below 3 GHz

Frequency band (GHz)	0.81-0.96									
Modulation	PSK	QAM	PSK	QAM	FSK	FSK	FM-FDM	FM-FDM	FM	FM-FDM
Capacity	1 channel	2 channels	24 channels	48 channels	Data	Data	52	52	Prog	1 channel
Channel spacing	25 kHz	25 kHz	600 kHz	12.5 kHz	12.5 kHz	2.5-200 kHz	2.5-200 kHz	500 kHz	25 kHz	2 MHz
			(P-MP)	(P-MP)		(P-MP)				
Antenna gain (maximum) (dBi)	10	10	0	0	10	0	27	27	18	27
Feeder/multiplexer loss (minimum) (dB)	0	0	0	0	0	0	0	0	0	0
Antenna type	Yagi	Yagi	Omni	Omni	Yagi	Omni	Rec. ITU-R F.699	Rec. ITU-R F.699	Rec. ITU-R F.699	Rec. ITU-R F.699
Maximum Tx output power (dBW)	7	7	30	30	7	20	13	13	10	13
e.i.r.p. (maximum) (dBW)	17	17	30	30	17	20	40	40	38	40
Receiver IF bandwidth (MHz)	–	–	–	–	–	–	–	–	–	–
Receiver noise figure (dB)	5	5	5	5	5	5	5	5	5	5
Receiver thermal noise (dBW)	–	–	–	–	–	–	–	–	–	–
Nominal Rx input level (dBW)	–	–	–	–	–	–	–	–	–	–
Rx input level for 1×10^{-3} BER (dBW)	–	–	–	–	–	–	–	–	–	–
Nominal short-term interference (dBW) (% time)	–	–	–	–	–	–	–	–	–	–
Nominal long-term interference (dBW)	–	–	–	–	–	–	–	–	–	–
Equivalent power (dB(W/4 kHz))	–	–	–	–	–	–	–	–	–	–
Spectral density (dB(W/MHz))	–	–	–	–	–	–	–	–	–	–
Refer to Notes	–	–	–	–	–	–	–	–	–	–

P-MP: point to multipoint

TABLE 5

FS system parameters for FS frequency sharing below 3 GHz

Frequency band (GHz)	1.45-1.53														1.67-1.69
Modulation	FDM-FM	PSK 4-PSK	FDM-FM	FDM-FM	4-PSK	4-PSK	16-QAM	4-PSK	PCM	MSK	4-PSK	4-PSK	4-PSK		FDM-FM
Capacity	36 channels	704 kbit/s 2 Mbit/s	8 channels	2 channels	9.6 kbit/s	64 kbit/s	64 kbit/s	144 kbit/s	–	2 Mbit/s	2 × 2 Mbit/s	2 × 2 Mbit/s			2 channels
Channel spacing (MHz)	0.5	1	0.2	0.05	0.025	0.075	0.0375	0.225	0.5	2	2	4	3.5		0.05
													CS	OS	
Antenna gain (maximum) (dBi)	33	33	33	33	33	33	33	33	33	16	16	16	17	27	33
Feeder/multiplexer loss (minimum) (dB)	1	1	1	1	1	1	1	1	1	5	5	5	0	0	1
Antenna type	Dish	Dish	Yagi	Yagi	Yagi/ dish	Yagi/ dish	Yagi/ dish	Yagi/ dish	Yagi/ dish		Yagi	Yagi	Omni/ section	Dish/ horn	Yagi
Maximum Tx output power (dBW)	7	7	7	10	7	7	7	7	10	7	7	7	7	7	10
e.i.r.p. (maximum) (dBW)	39	39	39	42	39	39	39	39	42	20	20	20	24	34	42
Receiver IF bandwidth (MHz)	0.4	0.7	0.3	0.04	0.005	0.032	0.016	0.072	0.35	1.2	1.2	3	3.5	3.5	0.04
Receiver noise figure (dB)	8	4.5	8	8	4	4	4	4	8	4	4	4	3.5	3.5	8
Receiver thermal noise (dBW)	–140	–141	–141	–149	–163	–155	–158	–151	–141	–139	–139	–145	–135	–135	–149
Nominal Rx input level (dBW)	–80	–90	–93	–105	–118	–112	–103.5	–106	–90	–126	–124	–123			–105
Rx input level for 1×10^{-3} BER (dBW)	N/A	–120	N/A	N/A	–143	–137	–128.5	–131	–	–86	–84	–83			N/A
Nominal short-term interference (dBW) (% time)															
Nominal long-term interference (dBW)	–150	–151	–151	–158	–173	–167	–168	–161	–151	–145	–145	–141	–145	–145	–159
Equivalent power (dB(W/4 kHz))	–170	–	–170	–169	–	–	–	–	–				–174	–174	
Spectral density (dB(W/MHz))	–	–149	–	–	–150	–152	–150	–150	–146	–146	–146	–146			–169
Refer to Notes	(2), (5)	(2), (4)	(2), (5)	(2), (5)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)		(1), (4)	(1), (4)			(2), (5)

CS: central station

OS: out station

N/A: not applicable

(1) Specified interference will reduce system *C/N* by 1 dB (interference 6 dB below receiver thermal noise floor)

(2) Specified interference will reduce system *C/N* by 0.5 dB (interference 10 dB below receiver thermal noise floor).

(3) Specified interference will have a relative contribution of no more than 10% of total noise.

(4) The specified interference level is total power within the receiver bandwidth.

(5) The specified interference level should be divided by the receiver bandwidth to obtain an average spectral density. The interference spectral density, averaged over any 4 kHz within the receiver bandwidth, must not exceed this value.

TABLE 6

FS system parameters for FS frequency sharing below 3 GHz

Frequency band GHz)	1.7-2.45																			
Modulation	FM-TVOB	FM-FDM	FM-MLT-PT		FM-TV	FM-FDM	FM-FDM tropos	4-PSK tropos	4-PSK	4-PSK	FM-FDM	4-PSK	4-PSK	FM-FDM	4-PSK	FM-QAM	9-QRP	0-QPSK	4-PSK	4-PSK
Capacity	625-line PAL	60-132 channels	94 channels		625-line PAL	960 channels	72-312 channels	2 Mbit/s	34 Mbit/s	8 Mbit/s	1-6 channels	48 channels	12.6 Mbit/s	600 channels	2 × 8 Mbit/s	1 TV + 2 Mbit/s	4 × 1.54 Mbit/s	45 Mbit/s	8 Mbit/s	2 × 8 Mbit/s
Channel spacing (MHz)	Variable	14/1	3.5		29	29	Special	Special	29	14	0.4	2.5	28	28	14	3.5	3.5	29	7	14
			CS	OS																
Antenna gain (maximum) (dBi)	25	31	10	19	34	34	49	45	31	30	25	29	30	35.7	28	32	32	33	28	28
Feeder/multiplexer loss (minimum) (dB)	0	5	3	3	5	3	2	2	1	3	3	6	3.5	3.5	4	6	3	3	5	5
Antenna type	1.2 m dish	2.4 m dish	Omni	Horn	3.7 m dish	3.7 m dish	12 m dish	9 m dish	1.8 m dish	1.2 m dish	Yagi	Dish	Dish	Dish	2.4 m dish	3 m dish	3 m dish	3 m dish	1.8 m dish	1.8 m dish
Maximum Tx output power (dBW)	7	7	4	4	10	7	28	30	3	0	10	–9	–10	–5.2	3	5	6	7	7	–3
e.i.r.p. (maximum) (dBW)	32	33	13	22	39	38	75	73	34	30	32	14	16.5	27	29	37	38	40	20	23
Receiver IF bandwidth (MHz)	30	2.8	2	2	40	40	6	1	20	4	0.15	1.5	6.5	20	8	3	3.5	29	3	4.6
Receiver noise figure (dB)	8	7	9	9	10	10	2	4	4	5	4	6	9	10	4	4	5	4	4	4
Receiver thermal noise (dBW)	–121	–133	–132	–132	–118	–118	–132	–140	–127	–133	–148	–	–	–	–131	–135	–133	–125	–135	–133
Nominal Rx input level (dBW)	–65	–79	–97	–97	–68	–64	–	–	–73	–78	–78	–78	–88.3	–78			–70	–75	–83	–83
Rx input level for 1×10^{-3} BER (dBW)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	–131	–113	–118	N/A	–	–	N/A			–117	–112	–123	–123
Nominal short-term interference (dBW) (% time)																				
Nominal long-term interference (dBW)	–127	–143	–142	–142	–128	–129	–138	–146	–137	–143	–158				–137	–141	–139	–135	–141	–139
Equivalent power (dB(W/4 kHz))	–	–172	–169	–169	–	–169	–172	–	–	–	–174				–170	–170	–168	–174	–	–
Spectral density (dB(W/MHz))	–142	–	–	–	–144	–	–	–146	–150	–149	–	–			–146	–			–146	–146
Refer to Notes	(1), (4)	(2), (5)	(2), (5)	(2), (5)	(2), (4)	(2), (5)	(1), (5)	(1), (4)	(2), (4)	(2), (4)	(2), (5)	(3), (4)	(3), (4)	(3), (5)	(1), (4)		(1)	(1)	(1)	(1)

TVOB: temporary TV outside broadcast (ENG) link OS: out station

CS: central station N/A: not applicable

(1) Specified interference will reduce system *C*/*N* by 1 dB (interference 6 dB below receiver thermal noise floor).

(2) Specified interference will reduce system *C*/*N* by 0.5 dB (interference 10 dB below receiver thermal noise floor).

(3) Specified interference will have a relative contribution of no more than 10% of total noise.

(4) The specified interference level is total power within the receiver bandwidth.

(5) The specified interference level should be divided by the receiver bandwidth to obtain an average spectral density. The interference spectral density, averaged over any 4 kHz within the receiver bandwidth, must not exceed this value.

TABLE 7

FS system parameters for FS frequency sharing below 3 GHz

Frequency band (GHz)	1.7-2.45				2.1-2.2						2.45-2.69				
Modulation	4-PSK		64-QAM	256-QAM	FDM-FM	FDM-FM	FDM-FM	32 TCM	64-QAM	256-QAM	FM-FDM tropos	MSK	4-PSK	4-PSK	FM-TVOB
Capacity			45 Mbit/s	18.5 Mbit/s	48 channels	96 channels	252 channels	3.1 Mbit/s	6.2 Mbit/s	18.5 Mbit/s	17-312 channels	2 × 2 Mbit/s	34 Mbit/s	2.3 Mbit/s	625-line PAL
Channel spacing (MHz)	3.5		10	3.5	0.8	1.6	3.5	0.8	1.6	3.5	Special	14			Variable
	CS	OS													
Antenna gain (maximum) (dBi)	17	27	33	33	38	38	38	38	38	38	49	25	35.4		18
Feeder/multiplexer loss (minimum) (dB)	0	0	2	2	0	0	0	0	0	0	2	4			1
Antenna type	Omni/ section	Dish/horn	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	12 m dish	1.2 m dish	3 m dish	Yagi	Dish
Maximum Tx output power (dBW)	7	7	1	–1	+8	+8	+8	+2	+5	+2	28	5	–2		7
e.i.r.p. (maximum) (dBW)	24	34	34	32	46	46	46	40	43	40	75	26	33		32
Receiver IF bandwidth (MHz)	3.5	3.5	10	3.5	2.5	6.0	12.0	0.8	1.6	3.5	6	3			30
Receiver noise figure (dB)	3.5	3.5	4	4	5	5	5	3	3	3	2	4			6
Receiver thermal noise (dBW)	–135	–135	–130	–134.5	–140	–137	–134	–142	–139	–136	–132	–135			–123
Nominal Rx input level (dBW)	–	–	–65	–65	–60	–60	–60	–60	–60	–60	–65	–			–55
Rx input level for 1×10^{-3} BER (dBW)	–	–	–106	–104.5	–121	–118	–114	–117	–115	–105	N/A	–			N/A
Nominal short-term interference (dBW) (% time)															
Nominal long-term interference (dBW)	–141	–141	–136	–140.5	–150	–147	–144	–152	–149	–146	–138	–141	–111.5		–123
Equivalent power (dB(W/4 kHz))	–170	–170	–170	–170	–173	–173	–173				–172	–170			–
Spectral density (dB(W/MHz))	–	–	–146	–146				–151	–151	–151	–	–162			–129
Refer to Notes	(1)	(1)			(2), (4), (5)	(2), (4), (5)	(2), (4), (5)	(2), (4)	(2), (4)	(2), (4)	(1), (5)				

CS: central station N/A: not applicable

OS: out station TVOB: temporary TV outside broadcast (ENG) link

(1) Specified interference will reduce system *C/N* by 1 dB (interference 6 dB below receiver thermal noise floor).

(2) Specified interference will reduce system *C/N* by 0.5 dB (interference 10 dB below receiver thermal noise floor).

(3) Specified interference will have a relative contribution of no more than 10% of total noise.

(4) The specified interference level is total power within the receiver bandwidth.

(5) The specified interference level should be divided by the receiver bandwidth to obtain an average spectral density. The interference spectral density, averaged over any 4 kHz within the receiver bandwidth, must not exceed this value.

TABLE 8

FS system parameters for FS frequency sharing between 3 and 10 GHz

Frequency band (GHz)	3.4-5.0		3.7-4.2			5.850-7.075		4.5-5.0			7.075-8.500		
Modulation	64-QAM	512-QAM	64-QAM			64-QAM		64-QAM			16-QAM	QPR	64-QAM
Capacity (Mbit/s)	90	311	45	90	135	45	135	45	90	135	45	90	135
Channel spacing (MHz)	20	40	10	20	30	10	30	10	20	30	20	40	30
Antenna gain (maximum) (dBi)	40	40	42	42	42	43	43	44	44	44	44	44	44
Feeder/multiplexer loss (minimum) (dB)	3	3	0	0	0	3	3	0	0	0	3	3	3
Antenna type	Horn/dish	Horn/dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish
Maximum Tx output power (dBW)	–1	+7[2]	–1	–1	–1	–1	+4	+2	+2	+2	+3	+10	+3
e.i.r.p. (maximum) (dBW)	36	44[2]	41	41	41	39	44	46	46	46	44	51	44
Receiver thermal noise (dBW)	–128	–126	–131	–128	–126	–130	–125	–131	–128	–126	–124	–120	–125
Rx input level for 1×10^{-3} BER (dBW)	–104	–93	–108	–105	–102	–103	–102	–108	–105	–102	–105	–101	–100
Nominal long-term interference (I/N = –13 dB[1]) (dBW)	–141	–139	–141	–138	–136	–143	–138	–141	–138	–136	–137	–133	–138
Spectral density (dB(W/MHz))	–154	–155	–151	–151	–151	–153	–153	–151	–151	–151	–150	–149	–153

(1) Objective for FS systems employing space diversity.

(2) –7 dBW transmit power and +30 dBW e.i.r.p. without APC.

TABLE 9

FS system parameters for FS frequency sharing between 3 and 10 GHz

Frequency Band (GHz)	3.7-4.2	3.6-4.2	3.7-4.2	5.9-6.4			5.925-6.425	5.85-6.425	5.925-6.425	6.425-7.11		
Modulation	FM/FDM	RBQPSK	QPSK	64-QAM			FM-FDM	RBQPSK	64-QAM	FM	QPSK	16-QAM
Capacity	1800 channels	140 Mbit/s	34 Mbit/s	45 Mbit/s	90 Mbit/s	135 Mbit/s	1800 channels	140 Mbit/s	140 Mbit/s	TV	34 Mbit/s	140 Mbit/s
Channel spacing (MHz)	29	90	29	10	20	30	29.65	90	29.65	20	20	40
Antenna gain (maximum) (dBi)	41	41	37	46	46	46	45	45	45	45	45	45
Feeder/multiplexer loss (minimum) (dB)	3	3	3	0	0	0	4	4	5.5	5	5	5
Antenna type	3.7m dish	3.7m dish	2.4m dish	Dish	Dish	Dish	3.7m dish	3.7m dish	3.7m dish	3.7m dish	3.7m dish	3.7m dish
Maximum Tx output power (dBW)	13	6	0	+3	+3	+3	13	6	2	10	0	0
e.i.r.p. (maximum) (dBW)	51	44	38	49	49	49	55	47	41.5	50	40	40
Receiver IF bandwidth (MHz)	46	56	26	10	20	30	40	56	29	28	26	44
Receiver noise figure (dB)	8.5	6	4	3	3	3	8	6	4	8.5	4	4
Receiver thermal noise (dBW)	–119	–122	–128	–131	–128	–126	–121	–122	–127	–122	–128	–126
Nominal Rx input level (dBW)	– 47	–65	–68	–60	–60	–60	–60	–65	–63	–60.5	–68	–65
Rx input level for 1×10^{-3} BER (dBW)	N/A	–105	–114.5	–109	–106	–104	N/A	–105	–103	N/A	–114.5	–105
Nominal short-term interference (dBW) (% time)												
Nominal long-term interference (dBW)	–129	–132	–138	–141	–138	–136	–131	–132	–137	–132	–138	–136
Equivalent power (dB(W/4 kHz))	–170	–	–				–171	–	–	–170	–	–
Spectral density (dB(W/MHz))	–	–149	–152	–151	–151	–151	–	–149	–152	–	–152	–152
Refer to Notes	(2), (5)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (5)	(2), (4)	(2), (4)	(2), (5)	(2), (4)	(2), (4)

N/A: not applicable

(1) Specified interference will reduce system *C*/*N* by 1 dB (interference 6 dB below receiver thermal noise floor).

(2) Specified interference will reduce system *C*/*N* by 0.5 dB (interference 10 dB below receiver thermal noise floor).

(3) Specified interference will have a relative contribution of no more than 10% of total noise.

(4) The specified interference level is total power within the receiver bandwidth.

(5) The specified interference level should be divided by the receiver bandwidth to obtain an average spectral density. The interference spectral density, averaged over any 4 kHz within the receiver bandwidth, must not exceed this value.

TABLE 10

FS system parameters for FS frequency sharing between 3 and 10 GHz

Frequency band (GHz)	3.400-3.456	3.4-3.6	3.6-4.2	4.4-5.0	5.850-5.925	5.925-6.425	6.425-6.570	6.4-7.1		6.570-6.870			6.5-6.9					6.870-7.125	7.425-7.750			7.1-8.5		
Modulation	4-PSK	AM	16-QAM	16-QAM	FM	16-QAM	FM	64-QAM		FM	4-PSK	16-QAM	128-TCM			FDM-FM		FM	FM	4-PSK	16-QAM	64-QAM		
Capacity	550 kbit/s	TV	52 Mbit/s	52 Mbit/s	TV	52 Mbit/s	TV	90 Mbit/s	135 Mbit/s	600 channels	10 Mbit/s	52 Mbit/s	3.1 Mbit/s	12.4 Mbit/s	24.7 Mbit/s	300 channels	600 channels	TV	960 channels	19 Mbit/s	52 Mbit/s	45 Mbit/s	90 Mbit/s	135 Mbit/s
Channel spacing (MHz)	0.5	6	20	20	18	20	18	20	40	10	20	20	0.8	2.5	5	5	10	25	20	20	20	10	20	30
Antenna gain (maximum) (dBi)	40	40	40.7	42.5	40	45.0	40	47	47	45	45	45	47	47	47	47	47	40	46	46	46	49	49	49
Feeder/multiplexer loss (minimum) (dB)	T:4.0 R:4.0	T:4.0 R:4.0	T:7.0 R:4.0	T:7.0 R:4.0	T:4.0 R:4.0	T:7.0 R:4.0	T:4.0 R:4.0	0	0	T:2.0 R:4.5	T:2.5 R:5.5	T:3.0 R:5.0	0	0	0	0	0	T:4.0 R:4.0	T:2.0 R:5.0	T:2.5 R:5.5	T:3.0 R:5.5	0	0	0
Antenna type	Dish	Dish	Horn	Horn	Dish	Horn	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish
Maximum Tx output power (dBW)	19	17.6	–5.2	–7.1	17.6	–9.8	17.6	+3	+3	10	3	3	+1	+1	+1	+3	+3	17.6	10	3	3	+3	+3	+3
e.i.r.p. (maximum) (dBW)	55	55	28.5	28.4	55	28.2	55	50	50	53	45.5	45	48	48	48	50	50	55	54	46.5	46	52	52	52
Receiver IF bandwidth (MHz)	0.35	5.0	16.65	16.65	17.0	16.65	17.0	20	30	20.0	12.5	17.5	0.8	2.5	5	15	28	25.0	27.0	12.5	17.5	10	20	30
Receiver noise figure (dB)	5	6	4.2	4.2	6	4.2	6	3	3	7	5	5	3	3	3	5	5	6	7	5	5	3	3	3
Receiver thermal noise (dBW)	–143.6	–132.0	–128.1	–128.1	–130.4	–128.1	–130.4	–128	–125	–124.0	–128.0	–126.6	–142	–137	–134	–127	–125	–129.1	–122.7	–128.0	–126.6	–131	–128	–126
Nominal Rx input level (dBW)	–87	–70	–73	–73	–70	–73	–70	–60	–60	–75	–92.5	–87.5	–60	–60	–60	–60	–60	–70	–70	–92.5	–87.5	–60	–60	–60

TABLE 11

Characteristics of an example code-division multiple access (CDMA) local access radio system operating in the 4 GHz band

Frequency band (GHz)	4	
System type	Fixed point-to-multipoint	(Direct sequence CDMA)
RF transmission rate (Mbit/s)	2	
Modulation	QPSK	
	Central station	Outstation
Transmit power (dBW)	2	2
Antenna polarization	Vertical	Vertical
Antenna maximum gain (dBi)	16	16
Feeder loss (dB)	8	18
Maximum e.i.r.p. (dBW)	10	0
Receiver IF bandwidth (MHz)	21	21
Receiver thermal noise (dBW)	–117	–117
Receiver threshold (1×10^{-6} BER) (dBW)	–118	–118
Maximum long term interference power (dB(W/MHz))	–140(1)	–140(1)
Availability target (% of time)	99.99	99.99
Typical fade margin (dB)	30	30
Path length (km)	3	3

(1) Measured at antenna port.

TABLE 12

FS system parameters for FS frequency sharing above 10 GHz

Frequency band (GHz)	10.6-10.7			10.7-11.7						12.2-12.44		13/14					14.4-15.35		
Modulation	128-TCM			4-PSK	FM-FDM	FM-TV	64-QAM	64-QAM	64-QAM	4-PSK	16-QAM	4-PSK	4-PSK	4-PSK	4-PSK	FM	64-QAM	FM-FDM	8-PSK
Capacity	3.1 Mbit/s	12.4 Mbit/s	24.7 Mbit/s	140 Mbit/s	960 channels	625-line PAL	45 Mbit/s	90 Mbit/s	135 Mbit/s	13.9 Mbit/s	50.4 Mbit/s	2 Mbit/s	8 Mbit/s	16 Mbit/s	34 Mbit/s	1 Video	140 Mbit/s	2 700 channels	156 Mbit/s
Channel spacing (MHz)	0.8	2.5	5	67	40	40	10	20	40	20	20	3.5	7	14	28	28	28	40	40
Antenna gain (maximum) (dBi)	51	51	51	49	47	47	51	51	51	50	50	49	49	49	49	49	49	52	52
Feeder/multiplexer loss (minimum) (dB)	0	0	0	5	5	5	0	0	0	1	1	0	0	0	0	0	2	5	5
Antenna type	Dish	Dish	Dish	3.7 m dish	2.5 m dish	2.5 m dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish
Maximum Tx output power (dBW)	–3	–3	–3	10	10	10	+3	+3	+3	–5	–5	10	10	10	10	10	5	3	0
e.i.r.p. (maximum) (dBW)	48	48	48	54	52	52	54	54	54	40	40	45	45	45	45	45	47	50	47
Receiver IF bandwidth (MHz)	0.8	2.5	5	68	29	29	10	20	30	12.3	17.2	1	2	4	17	24	40	56	50
Receiver noise figure (dB)	4	4	4	7	7	8	4	4	4	7	5	10	10	10	10	10	4	10	5
Receiver thermal noise (dBW)	–141	–136	–133	–119	–121	–121	–130	–127	–125	–		–134	–131	–128	–122	–120	–124		
Nominal Rx input level (dBW)	–60	–60	–60	–62	–65	–65	–60	–60	–60	–59 + M	–59 + M	–74	–71	–68	–65	–65	–66	–48	–44
Rx input level for 1×10^{-3} BER (dBW)	–110	–104	–101	–104	N/A	N/A	–109	–106	–103			–116	–113	–111	–109	N/A	–101		
Nominal short-term interference (dBW) (% time)																			
Nominal long-term interference (dBW)	–151	–146	–143	–129	–131	–131	–140	–137	–135			–144	–141	–138	–132	–130	–134		
Equivalent power (dB(W/4 kHz))				–	–170	–						–	–	–	–	–	–		
Spectral density (dB(W/MHz))	–150	–150	–150	–147	–	–146	–150	–150	–150			–144	–144	–144	–144	–144	–150		
Refer to Notes	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (5)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(3)	(3)	(1), (4)	(1), (4)	(1), (4)	(1), (4)	(1), (4)	(1), (4)		

M: fade margin

N/A: not applicable

(1) Specified interference will reduce system *C/N* by 1 dB (interference 6 dB below receiver thermal noise floor).

(2) Specified interference will reduce system *C/N* by 0.5 dB (interference 10 dB below receiver thermal noise floor).

(3) Specified interference will have a relative contribution of no more than 10% of total noise.

(4) The specified interference level is total power within the receiver bandwidth.

(5) The specified interference level should be divided by the receiver bandwidth to obtain an average spectral density. The interference spectral density, averaged over any 4 kHz within the receiver bandwidth, must not exceed this value.

TABLE 13

FS system parameters for FS frequency sharing above 10 GHz

Frequency band (GHz)	17.7-19.7															
Modulation	4-PSK	4-QAM	4-FSK	4-PSK	2-PSK	4-PSK	O-QPSK	64-QAM	4-QAM	4-PSK	4-FSK	4-QAM	4-QAM	4-QAM	4-QAM	4-QAM
Capacity	140 Mbit/s	140 Mbit/s	8 Mbit/s	8 Mbit/s	8 Mbit/s	34 Mbit/s	44.7 Mbit/s		8 Mbit/s	12.6 Mbit/s	400 Mbit/s	3.1 Mbit/s	6.2 Mbit/s	12.4 Mbit/s	24.7 Mbit/s	45 Mbit/s
Channel spacing (MHz)	110	55	20	20	20	27.5	40		10	10	300	2.5	5	10	20	40
Antenna gain (maximum) (dBi)	48	48	45	45	45	45	45	38	32-48	48	48	48	48	48	48	48
Feeder/multiplexer loss (minimum) (dB)	7	7	0	0	0	0	3	3	0	3	3	0	0	0	0	0
Antenna type	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish
Maximum Tx output power (dBW)	–10	–4	–16	–6	–9	–8	–9	–7	–5	–7	–8	–5	–5	–5	–5	–5
e.i.r.p. (maximum) (dBW)	31	37	29	39	27	37	33	31	27-43	38	40	43	43	43	43	43
Receiver IF bandwidth (MHz)	68	68	8	4	8	18	40	40	4	10	250	2.5	5	10	20	40
Receiver noise figure (dB)	7	8	13	7	7	7	5	5	7	7	8	6	6	6	6	6
Receiver thermal noise (dBW)	–119	–118	–122	–131	–128	–124	–125	–123	–131	–131		–134	–131	–128	–125	–122
Nominal Rx input level (dBW)	–63	–64	–65	–65	–65	–65	–70	–73	–65	–72		–60	–60	–60	–60	–60
Rx input level for 1×10^{-3} BER (dBW)	–103	–104	–106	–116	–116	–113	–106		–116	–113		–120	–117	–114	–111	–109
Nominal long-term interference (dBW)	–129	–131	–132	–141	–138	–143	–131		–141	–137		–144	–141	–138	–135	–132
Equivalent power (dB(W/4 kHz))	–	–	–	–	–		–171			–171						
Spectral density (dB(W/MHz))	–147	–149	–141	–147	–147				–147	–147		–148	–148	–148	–148	–148
Footnotes	(2), (3)	(2), (3)	(2), (3)	(2), (3)	(2), (3)	(2), (3)	(1)		(2), (3)	(1)		(2), (3)	(2), (3)	(2), (3)	(2), (3)	(2), (3)

(1) Specified interference will reduce system *C*/*N* by 1 dB (interference 6 dB below receiver thermal noise floor).

(2) Specified interference will reduce system *C*/*N* by 0.5 dB (interference 10 dB below receiver thermal noise floor).

(3) The specified interference level is total power within the receiver bandwidth.

TABLE 14

FS system parameters for FS frequency sharing fixed services above 10 GHz

Frequency band (GHz)	21.12-23.6											25.25-27		
Modulation	2-FSK	2-FSK	2-FSK	4-PSK	4-PSK	FM	4-PSK	ASK	ASK	2-FSK	64-QAM	FSK	DFSK	FSK
Capacity	2 Mbit/s	4 Mbit/s	8 Mbit/s	34 Mbit/s	140 Mbit/s	1 Video	34 Mbit/s	2 Mbit/s	4 × 2 Mbit/s	2 Mbit/s	140 Mbit/s	6 Mbit/s		8 Mbit/s
Channel spacing (MHz)	7	7	14	28	112	28	28	28	28	5	40	40		20
												CS	OS	CS
Antenna gain (maximum) (dBi)	47	47	47	47	47	47	47	35	50	47	38.5	20	47	47
Feeder/multiplexer loss (minimum) (dB)	0	0	0	0	0	0	0	4	4	0	3	0	0	0
Antenna type	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	90° Section	Dish	Dish
Maximum Tx output power (dBW)	0	0	0	0	0	0	0	–16	–14	–10	– 4	–8	–10	–10
e.i.r.p. (maximum) (dBW)	50	50	50	50	50	50	47	15	32	37	31.5	10	37	37
Receiver IF bandwidth (MHz)	2	4	8	17	70	24	18	5	14	2	40	16.4	16.4	16.4
Receiver noise figure (dB)	9	9	9	9	9	9	12	4	4	11	5	10	8	10
Receiver thermal noise (dBW)	–132	–129	–126	–123	–116	–121	–119	–133	–128		–123			
Nominal Rx input level (dBW)	–105 + M	–104 + M	–103 + M	–100 + M	–94 + M	–84 + M	–87	–108 + M	–109 + M	–115	–73	–99 + M	–123 + M	–99 + M
Rx input level for 1×10^{-3} BER (dBW)	–108	–	–106	–103	–97	N/A	–103	–112	–113		–96			
Nominal short-term interference (dBW) (% time)														
Nominal long-term interference (dBW)	–142	–139	–136	–133	–126	–131	–129	–139	–136		–131			
Equivalent power (dB(W/4 kHz))	–	–170	–	–	–	–	–	–	–		–171			
Spectral density (dB(W/MHz))	–143	–143	–143	–143	–143	–143	–141	–146	–148		–147			
Refer to Notes	(1), (4)	(1), (4)	(1), (4)	(1), (4)	(1), (4)	(1), (4)	(1), (4)	(1), (4)	(1), (4)	(3), (4)		(3), (4)		(3), (4)

CS: central station

OS: outstation

M: fade margin

N/A: not applicable

(1) Specified interference will reduce system *C/N* by 1 dB (interference 6 dB below receiver thermal noise floor).

(2) Specified interference will reduce system *C/N* by 0.5 dB (interference 10 dB below receiver thermal noise floor).

(3) Specified interference will have a relative contribution of no more than 10% of total noise.

(4) The specified interference level is total power within the receiver bandwidth.

(5) The specified interference level should be divided by the receiver bandwidth to obtain an average spectral density. The interference spectral density, averaged over any 4 kHz within the receiver bandwidth, must not exceed this value.

TABLE 15

FS system parameters for FS frequency sharing between 30 and 60 GHz

Frequency band (GHz)	37-39.5						38.6-40.0					47.2-50.2				54.25-57.2					
Modulation	2-FSK	2-FSK	4-FSK	4-FSK	FM	FM	2-FSK	OQPSK	4-QAM	16-QAM	256-QAM	2-FSK	4-QAM	16-QAM	256-QAM	2-FSK	2-FSK	4-PSK	4-PSK	FM	FM
Capacity	2 Mbit/s	8 Mbit/s	34 Mbit/s	140 Mbit/s	1 Video	1 Video	1.544 Mbit/s	44.736 Mbit/s	44.736 Mbit/s	90 Mbit/s	310 Mbit/s	1.544 Mbit/s	44.736 Mbit/s	90 Mbit/s	310 Mbit/s	2 Mbit/s	8 Mbit/s	34 Mbit/s	140 Mbit/s	1 Video	1 Video
Channel spacing (MHz)	7	14	28	140	28	56	5	40	50	50	50	5	50	50	50	14	14	28	140	28	56
Antenna gain (maximum) (dBi)	47	47	47	47	47	47	44	44	44	44	44	46	46	46	46	47	47	47	47	47	47
Feeder/multiplexer loss (minimum) (dB)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antenna type	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish
Maximum Tx output power (dBW)	0	0	0	0	0	0	–13	–15	–14	–4	–4	–11	–12	–2	–2	0	0	0	0	0	0
e.i.r.p. (maximum) (dBW)	50	50	50	50	50	50	31	29	30	40	40	35	34	44	44	50	50	50	50	50	50
Receiver IF bandwidth (MHz)	2	8	17	70	16	40	2	40	50	50	50	2	50	50	50	2	8	17	70	16	40
Receiver noise figure (dB)	11	11	11	11	12	12	11	8	13	5	5	11	13	5	5	11	11	11	11	12	12
Receiver thermal noise (dBW)	–130	–124	–121	–114	–120	–116	–130	–120	–114	–122	–122	–130	–114	–122	–122	–130	–124	–121	–114	–120	–116
Nominal Rx input level (dBW)	–108 + M	–102 + M	–99 + M	–93 + M	–98 + M	–85 + M	–114+M	–110+M	–101+M	–100+M	–88+M	–114+M	–101+M	–100+M	–88+M	–108 + M	–102 + M	–99 + M	–93 + M	–98 + M	–85 + M
Rx input level for 1×10^{-3} BER (dBW)	–111	–105	–102	–95	N/A	N/A	–122	–114.5	–105	–106	–94	–122	–105	–106	–94	–111	–105	–102	–95	N/A	N/A
Nominal short-term interference (dBW) (% time)							–	–	–	–	–	–	–	–	–						
Nominal long-term interference (dBW)	–140	–134	–131	–124	–130	–126	–140	–130	–124	–132	–132	–140	–124	–132	–132	–140	–134	–131	–124	–130	–126
Equivalent power (dB(W/4 kHz))	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–
Spectral density (dB(W/MHz))	–143	–143	–143	–143	–142	–142	–143	–146	–141	–149	–149	–143	–141	–149	–149	–143	–143	–143	–143	–142	–142
Refer to Notes	(1), (4)	(1), (4)	(1), (4)		(1), (4)	(1), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(1), (4)	(1), (4)	(1), (4)		(1), (4)	(1), (4)

M: fade margin

N/A: not applicable

(1) Specified interference will reduce system C/N by 1 dB (interference 6 dB below receiver thermal noise floor).

(2) Specified interference will reduce system C/N by 0.5 dB (interference 10 dB below receiver thermal noise floor).

(3) Specified interference will have a relative contribution of no more than 10% of total noise.

(4) The specified interference level is total power within the receiver bandwidth.

(5) The specified interference level should be divided by the receiver bandwidth to obtain an average spectral density. The interference spectral density, averaged over any 4 kHz within the receiver bandwidth, must not exceed this value.

TABLE 16

Representative characteristics of point-to-multipoint systems operating in the range 30-40 GHz

System No.	Hub No. 1	Remote No. 1	Hub No. 2	Remote No. 2	Hub No. 3	Remote No. 3
Capacity/data rate	DS-3 45 Mbit/s	DS-3 45 Mbit/s	OC-3 155 Mbit/s	OC-3 155 Mbit/s	OC-6 310 Mbit/s	OC-6 310 Mbit/s
Modulation type	OQPSK	OQPSK	16-QAM	16-QAM	256-QAM	256-QAM
Necessary bandwidth (MHz)	50	50	50	50	50	50
Tx power (dBW)	0	–13	5	–10	7	–4
Antenna gain (dBi)	16	29	18	33	28	39
Transmit e.i.r.p. (dBW)	16	16	23	23	35	35
Antenna beamwidth (degrees)	45 or 90	1.9	45 or 90	1.7	45 or 90	1.7
Antenna polarization	H/V	H/V	H/V	H/V	H/V	H/V
Rx noise figure (dB)	7	7	5	6	5	5
Rx noise temperature (K)	1 740	1 740	1 160	1 450	1 160	1 160
Rx sensitivity, (1×10^{-6} BER) (dBW)	–110	–110	–102	–101	–90	–90
Maximum interference (dB(W/MHz))	–146.2	–146.2	–148.0	–147.0	–148.0	–148.0

ANNEX 3

Additional technical characteristics of some FS systems useful for sharing analysis in the 1-3 GHz band

1 Introduction

This Annex provides the characteristics of FS systems, operating in the 1-3 GHz band, useful in performing analysis of sharing between stations in the FS and other services. Where applicable both typical and the most sensitive parameters are detailed:

– § 3 – Characteristics of digital point-to-point systems

– § 4 – Characteristics of analogue point-to-point systems

– § 5 – Characteristics of point-to-multipoint (P-MP) systems

It should be noted that digital FS systems are typically more sensitive to interference than analogue systems and that new installations of FS systems will primarily be digital. Sharing analysis should therefore concentrate on, but not be limited to, digital system characteristics and required protection levels.

2 Use of automatic power control (APC) in digital systems

APC has been implemented to facilitate intra-service sharing and coordination based on lower transmit power. During fade conditions the power level is increased for a short duration to overcome the effect of the fade condition. There are two problems associated with the use of APC to overcome interference. First, it does not appear likely that the potential total interference time from non-GSO networks would be considered a short-term event. Therefore, any intra-service coordination based upon lower power levels would be inappropriate. The higher power levels that would need to be used for coordination purposes between FS systems may impact sharing with other services. Additionally, the higher transmit power of the FS would make other inter-service sharing issues, including interference into non-GSO network uplinks, more difficult. The second and perhaps more significant problem is that there is currently no practical method for sensing interference that would cause APC to activate. An increase in a link margin beyond current engineering practices is not considered an appropriate method to improve resistance to interference and may make other inter-service sharing issues more difficult.

3 Characteristics of digital point-to-point systems

3.1 Typical characteristics

Three different digital systems are described in Table 17 which should be used for compatibility studies as they represent three different uses of FS systems:

– 64 kbit/s capacity used for example for outside-plant (individual subscriber connection);

– 2 Mbit/s capacity used for example for professional subscriber connection or local part of the inside-plant;

– 45 Mbit/s capacity used for example for trunk network.

These interference values (for long-term interference) correspond to a degradation in the receiver threshold of 1 dB or less.

As indicated in Note 1 of Annex 2, § 4, it must be noted that in order to simplify the table, only the interfering carrier level corresponding to the 1×10^{-3} BER is included. Equally important are the 1×10^{-6} and 1×10^{-10} BER objectives, used in the evaluation of permissible degradation. Typically, the carrier level corresponding to 1×10^{-6} BER is around 4 dB higher than that for 1×10^{-3} BER; the carrier level difference between 1×10^{-6} and 1×10^{-10} BER points is also about 4 dB.

TABLE 17

Capacity	64 kbit/s	2 Mbit/s	45 Mbit/s
Modulation	4-PSK	8-PSK	64-QAM
Antenna gain (dBi)	33	33	33
Transmit power (dBW)	7	7	1
Feeder/multiplexer loss (dB)	2	2	2
e.i.r.p. (dBW)	38	38	32
Receiver IF bandwidth (MHz)	0.032	0.7	10
Receiver noise figure (dB)	4	4.5	4
Receiver input level for a BER of 1×10^{-3}(dBW)	–137	–120	–106
Maximum long-term interference Total power (dBW)	–165	–151	–136
Maximum long-term interference Power spectral density (dB(W/4 kHz))	–174	–173	–170

It must be pointed out that when considering maximum power-spectral density for a long-term interference, the three values are about the same (only 4 dB difference).

3.2 FS antenna pattern

Recommendation ITU-R F.699 and Recommendation ITU-R F.1245 are appropriate.

4 Characteristics of analogue point-to-point radio-relay systems

The types of analogue point-to-point systems operating in the 1-3 GHz bands comprise of telephony, FM-TV and ENG links. A reference set of characteristics has been extracted from Tables 5, 6 and 7 of this Recommendation, Table 1 of Recommendation ITU-R F.759 and from Recommendation ITU-R SF.358 which details the analogue hypothetical reference circuit currently used within Radiocommunication WP 9D sharing studies.

4.1 Typical FS analogue characteristics operating in the 1-3 GHz bands

Antenna envelope characteristic: Recommendations ITU-R F.699 and ITU-R F.1245

Antenna gain: 33 dBi

e.i.r.p.: 36 dBW

Feeder/multiplexer loss: 3 dB

Receiver noise figure (referred to input of receiver): 8 dB

Long-term interference limit per link (20% of time): –170 dB(W/4 kHz).

4.2 ITU-R analogue HRC characteristics

Hop length: 50 km

Number of hops: 50

Antenna gain: 33 dBi

Feeder loss: 3 dB

Receiver noise figure (referred to input of receiver): 8 dB

Total route baseband noise power limit: 1 000 pW0p.

5 Characteristics of point-to-multipoint systems (P-MP)

The information presented below summarizes typical and worst-case basic parameters for use in sharing studies between P-MP systems and other systems, in the range 1-3 GHz.

TABLE 18

Typical characteristics

Parameter	Central station	Outstation
Antenna type	Omni/sectoral	Dish/horn
Antenna gain (dBi)	10/13	20 (analogue) 27 (digital)
e.i.r.p. (Maximum) (dBW): – analogue – digital	 12 24	 21 34
Noise figure (dB)	3.5	3.5
Feeder loss (dB)	2	2
IF bandwidth (MHz)	3.5	3,5
Maximum permissible long-term interference power (20% time): – total (dBW) – (dB (W/4 kHz)) – (dB (W/MHz))	 –142 –170 –147	 –142 –170 –147

TABLE 19

Worst-case characteristics

Parameter	Central station	Outstation
Antenna type	Omni/sector	Dish/horn
Antenna gain (dBi)	13/21 (1)	27/12
e.i.r.p. (maximum) (dBW) – analogue – digital	 23 24	 23 34
IF bandwidth (MHz)	6 (2)	6 (2)

(1) A 2 dBi antenna is used in some countries in the band 1 452-1 492 MHz.

(2) 6 MHz bandwidths used by AMDSB MVDS systems in the United States of America in the frequency bands 2 150-2 162 MHz and 2 500-2 690 MHz.

Basic sharing parameters for P-MP systems in the frequency range 1-3 GHz.

The characteristics of P-MP systems currently being deployed for local access use by at least one administration are summarized in Table 20. These systems are designed to operate in the 2 025-2 110 MHz and 2 200-2 290 MHz bands.

The characteristics of another example P-MP system are summarized in Table 21 and Fig. 1. These systems are designed to operate in the bands 2 076-2 111 MHz and 2 300-2 400 MHz.

For the central station is appropriate in the absence of further information regarding the outstation antenna pattern, the reference pattern of Recommendations ITU-R F.699 and ITU-R F.1245 should be assumed.

TABLE 20

Characteristics of an example CDMA local access radio system

Frequency band (GHz)	2	
System type	Fixed point-to-multipoint (CDMA)	
RF transmission rate (kbit/s)	2 048	
Modulation	4-PSK	
	Central station	Outstation
Transmit power (dBW)	–10.0 (per outstation)	–10.0
Antenna polarization	Vertical	Vertical
Antenna maximum gain (dBi)	10	9
Feeder loss (dB)	3.5	0
Maximum e.i.r.p. (dBW)	–3.5 per outstation(1)	–1.0(2)
Receiver IF bandwidth (MHz)	3.2	3.2
Receiver thermal noise (dBW)	–134.0	–134.0
Receiver threshold (BER 1×10^{-7})(3) (dBW)	–135.0	–135.0
Maximum long-term interference power (dB(W/MHz))	–150.0	–150.0
Availability target	99.99% of time	99.99% of time
Typical fade margin (dB)	< 20	< 20
Path length (km)	1-15	1-15

(1) Maximum e.i.r.p.: 8.5 dBW.

(2) Automatic power control is employed, therefore typical powers may be 0-20 dB less.

(3) Typical signal level for a system with 15 outstations.

TABLE 21

Characteristics of an example multipoint distribution system (MDS)

Frequency bands (MHz)		2 076-2 111 and 2 300-2 400	
System type		Fixed P-MP	
Modulation		Not specified – mainly AM-VSB	
Channel bandwidth (MHz)		7	
Emission mask		See Fig. 1	
	Main station	Repeater station	Outstation
e.i.r.p. (maximum) (dBW)(1)	30(1)	< 30(1)	Receive only
Antenna type	Omnidirectional in horizontal plane	Directional	Directional

(1) Transmission power at angles of elevation of 5° or more above the horizontal plane must not exceed the following e.i.r.p. limits:

– 100 W at 5°, decreasing linearly to 31.6 W at 10°;

– 31.6 W between 10° and 15°;

– 31.6 W at 15°, decreasing linearly to 10 W at 20°; and

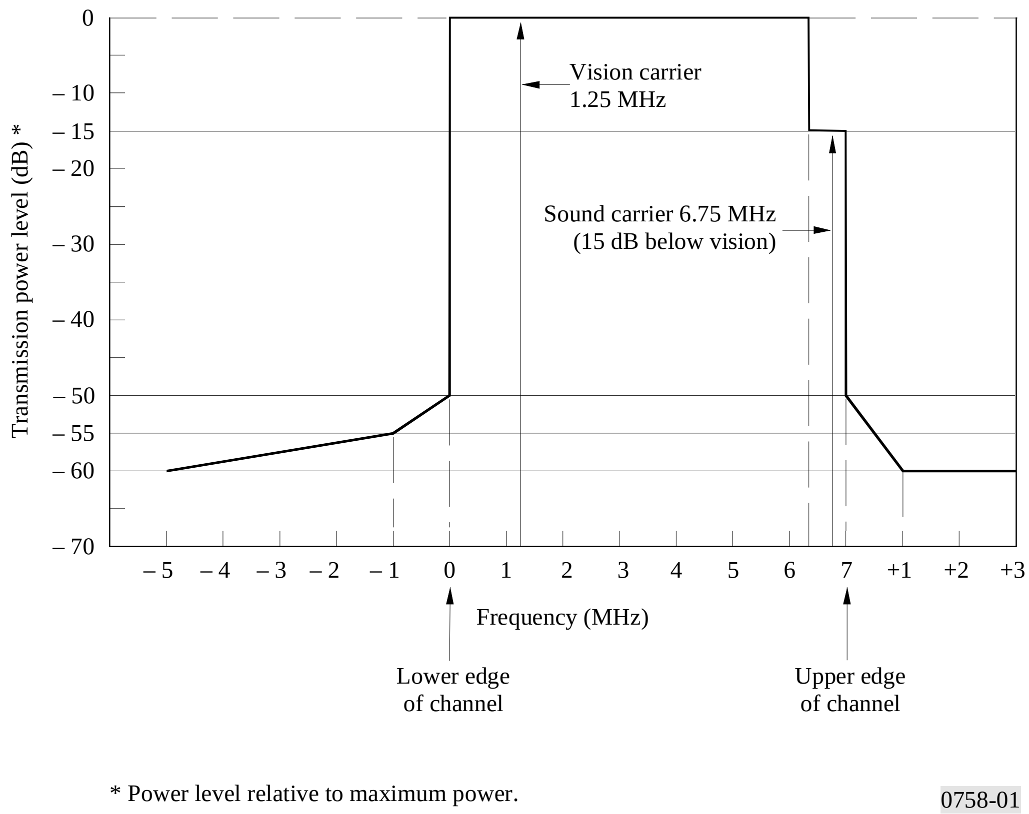
– 10 W between 20° and 90°.

NOTE 1 – Coordination level for protection of MDS receivers anywhere within service area is –146.2 dB(W/($m^2 \cdot 4$ kHz)).

Figure 1 shows the emission mask. The location shown for video and sound carriers applies when analogue PAL television signal is transmitted. Other signal formats are permitted, including video and data transmission using digital modulation, if they conform to this emission mask.

FIGURE 1

Transmission mask (emission limits)



ANNEX 4

FS antenna size in sharing studies

1 Interference considerations

Three cases for interference calculations are given below: coordination area around a satellite earth station, interference from GSO satellites and interference from non-GSO satellites. See Fig. 2.

2 Earth station coordination

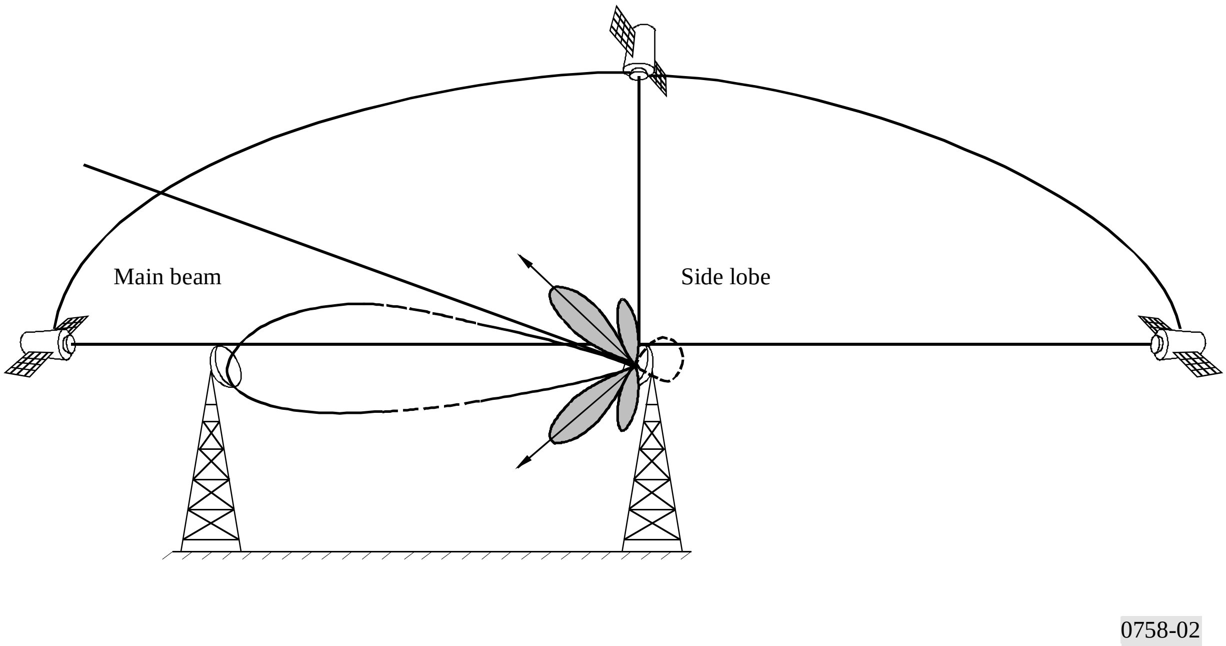
Calculation of the coordination area is done for the worst-case situation, which means that radio-relay link antenna pointing is taken to be towards the station of the other service. In such cases interference is then through the main beam and for the worst case the highest gain antennas are normally used.

3 GSO satellites

The visible part of the geostationary orbit is mainly several degrees over the horizon and satellites in that part of the orbit are not usually in the main beam of radio-relay link antennas. Only in the part of the orbit which is near the horizon could that be the case, if the geostationary orbit is not avoided. As the satellite is stationary, the interference is constant and long term. In most cases the interference from GSO satellites is through the side lobes of the antennas and low-gain antennas may be considered in studies.

FIGURE 2

Main beam and side-lobe interference



4 Non-GSO satellites

Non-GSO satellites are normally visible in large areas of the sky. Therefore satellites of a constellation are, for the main part of the time, at the side-lobe area of a radio-relay link antenna and only for a short time in the main beam of the antenna. If main beam or side-lobe interference is more important in studies, this depends on the satellite e.i.r.p. at low elevation angles compared to the e.i.r.p. at high elevation angles.

Main beam interference may be taken to be short-term interference. Normally there is at least one satellite at high elevation in the side-lobe region; its interference is long-term interference. Criteria for long-term interference level is much lower than for short-term interference and may be the decisive criteria. Both high- and low-gain antennas should be considered in studies.

5 Considering present and FS service antennas

If studies are made using only high-gain antennas and criteria for sharing is based on that, the interference to low-gain antennas may exceed the criterion. That would mean that new systems should be designed to use larger antennas than otherwise would be needed and more robust and more expensive masts have to be used. For existing shorter hops it would mean changing existing antennas to larger ones and probably new masts would be required.

The usage of smaller gain antennas than those in the technical parameter tables reduces the interference margin at antenna side lobes. In addition, the interference criteria is more stringent for long-term interference than for short-term interference. This may cause the long-term interference through the small size antenna side lobe to be decisive in sharing studies between the FS and other services.

6 FS technical parameters and antenna size

Typical radio-relay link parameters to be used in interference and sharing studies between the FS and other services are given in Tables 4 to 16. For antenna gain the value is for maximum antenna gain only. That is because the antenna gain is used, e.g. in calculations when determining if coordination is needed. The calculation for that purpose is done for the worst-case situation, which means that radio-relay link antenna pointing is taken to be towards the station of the other service. Interference is then through the main beam and for the worst case the highest gain antenna is used in the calculation.

However, for economical reasons small gain antennas are widely used in practice, especially for local area networks where hop lengths are short. Because of their wide deployment and the importance of side-lobe interference, small gain antennas should be included in the studies. Table 22 gives typical minimum antenna gains by frequency bands.

TABLE 22

Typical minimum antenna gains by frequency band

Frequency band (GHz)	Gain (minimum) (dBi)	(1)
1.35-1.53	11.2	Point-to-multipoint
1.67-1.69		
1.7-2.45	30	FM-FDM
1.7-2.45	13	2-8 Mbit/s
1.7-2.45	9	Point-to-multipoint
2.45-2.69	10	Point-to-multipoint
3.4-3.456		
3.4-3.6	27.5	AM-TV
3.6-4.2	16	Point-to-multipoint
3.6-4.2	30	
3.7-4.2	31	
3.8-4.2	31	
5.85-5.925		
5.85-6.425		
5.925-6.425	36	FM 1800 channels
6.425-7.11	43	140 Mbit/s
7.125-7.750	31	34-140 Mbit/s
7.425-7.900	37	8-155 Mbit/s, FM
8-8.5	38	
10.15-10.65	32	
10.2-10.68	32	2-8 Mbit/s
10.2-10.68	34	AM-TV
10.5-10.68	34	AM-TV
10.7-11.7	46.5	34-140 Mbit/s
12.2-12.44		
13-14	29	34 Mbit/s
14.25-14.5	35	2-155 Mbit/s
14.4-15.35	32	8-34 Mbit/s
17.7-19.7	45	4-16 Mbit/s
17.7-19.7	40	AM-TV for CATV
17.7-19.7	32	34 Mbit/s
17.7-19.7	35	140 Mbit/s
21.12-26.5	34	4-34 Mbit/s
21.2-26.5	6	Point-to-multipoint
30-40	16	Point-to-multipoint
31-31.3		
37-39.5	36	2-34 Mbit/s
37.0-40.5	38	1.544-310 Mbit/s
47.2-50.2	40	1.544-310 Mbit/s

(1) Different capacity or service may use different antennas.