RECOMMENDATION ITU-R F.758-4*

Considerations in the development of criteria for sharing between the fixed service and other services

(Questions ITU-R 225/9 and ITU-R 127/9)

(1992-1997-2000-2003-2005)

Scope

This Recommendation contains principles for the development of sharing criteria of digital systems in the fixed service. It also contains information on the technical characteristics and sharing parameters of digital systems in the fixed service. Information relating to analogue systems is contained in prior versions of this Recommendation.

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;

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* This Recommendation should be brought to the attention of Radiocommunication Study Groups 4, 6, 7 and 8.

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.

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

Error performance objectives for real digital fixed wireless links used in 27 500 km hypothetical reference paths and connections are given in Recommendation ITU-R F.1668, based on ITU-T Recommendations G.826, G.828 and G.829. It is the only Recommendation defining error performance objectives for all real digital fixed wireless links. The applicability of Recommendations ITU-R F.594, ITU-R F.634, ITU-R F.696, ITU-R F.697, ITU-R F.1092, ITU-R F.1189, ITU-R F.1397 and ITU-R F.1491 is limited to systems designed prior to the approval of Recommendation ITU-R F.1668.

Availability objectives for real digital fixed wireless links used in 27 500 km hypothetical reference paths and connections are given in Recommendation ITU-R F.1703, based on ITU-T Recommendation G.827. It is the only Recommendation defining availability objectives for all real digital fixed wireless links. Recommendations ITU-R F.1492 and ITU-R F.1493 are superseded by this Recommendation. The applicability of Recommendations ITU-R F.557, ITU-R F.695, ITU-R F.696 and ITU-R F.697 is limited to systems designed prior to the approval of Recommendation ITU-R F.1703.

2 Sub-division of the performance and availability objectives

The previous section dealt with the overall performance objectives for digital 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 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 1 lists the references relating to sharing between the FS and the FSS, concerning interference into the FS.

TABLE 1

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

Digital	General
Rec. ITU-R SF.615	Rec. ITU-R SF.355
	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 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, ITU-R F.1245 and ITU-R F.1336 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 low noise amplifier (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.

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 2 to 21 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 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 1×10^{-6} and 1×10^{-10} BER points is also about 4 dB. For radio equipment using forward error correction (FEC), the carrier level corresponding to 1×10^{-6} BER is 1 to 2 dB higher than that for 1×10^{-3} BER; the carrier difference between 1×10^{-6} and 1×10^{-10} is also 1 to 2 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 PSD 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 8 and 17 can be applied, conforming to the method given in Recommendation ITU-R F.1565, such that the specified interference have a relative contribution of no more than 10% of total noise.

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 2 to 18, 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 2

FS system parameters for FS frequency sharing below 1 GHz

Frequency band (MHz)	340-470			406.1-450						610-960
Modulation	GMSK	GMSK	GMSK	DQPSK	DQPSK	16-QAM	16-QAM	32-QAM	32-QAM	2-FSK and others
Capacity (Mbit/s)	5 × 32 kbit/s	5 × 32 kbit/s	5 × 32 kbit/s	0.32	4	2	8	0.768	8	1.024; 30 channels (it can use lower data rates)
Channel spacing (MHz)	0.6	0.6	0.6	0.25	3.5	1.75	3.5	0.20	1.75	0.75
	Base station	Base station	Out station							
Antenna gain (maximum) (dBi)	7	12	6	25	25	25	25	25	25	16
Feeder/multiplexer loss (minimum) (dB)	4.4	4.4	2.2	2	2	2	2	2	2	1
Antenna type	Omni	Sectoral	Panel	Yagi	Yagi	Yagi	Yagi	Yagi	Yagi	Square reflector
Maximum Tx output power (dBW)	6	6	6	7	7	10	10	0	0	7 dBW (typical: 0 dBW)
e.i.r.p. (maximum) (dBW)	8.6	13.6	9.8	30	30	33	33	23	23	22 dBW (typical: 15 dBW)
Receiver IF bandwidth (MHz)	0.6	0.6	0.6	0.3	3.14	3.5	3.5	0.15	1.67	0.75
Receiver noise figure (dB)	4	4	4	5	5	3	3	3.5	3.5	7
Receiver thermal noise (dBW)	−146.5	−146.5	−146.5	−144	−134	−143	−137	−148.7	−138.3	−138
Nominal Rx input level (dBW)	−100	−100	−100							−100
Rx input level for 1×10^{-3} BER (dBW)	−117	−117	−117	−131	−121	−122	−116	−127	−117	−124
Nominal long-term interference (dBW)	−152.5	−152.5	−152.5	−154	−144	−153	−147	−157	−147	
Spectral density (dB(W/MHz))	−150.3	−150.3	−150.3	−149	−149	−151	−151	−149	−149	

DQPSK: differentially coherent quaternary phase shift keying

GMSK: gaussian minimum shift keying

TABLE 3

FS system parameters for FS frequency sharing below 1 GHz

Frequency band (GHz)	0.81-0.96					
Modulation	7-FSK	4-QAM	16-QAM	7-FSK	4-QAM	16-QAM
Capacity (Mbit/s)	64 kbit/s	64 kbit/s	128 kbit/s	256 kbit/s	256 kbit/s	512 kbit/s
Channel spacing (kHz)	50	50	50	200	200	200
Antenna gain (maximum) (dBi)	24	24	24	24	24	24
Feeder/multiplexer loss (minimum) (dB)	3	3	3	3	3	3
Antenna type	Grid	Grid	Grid	Grid	Grid	Grid
Maximum Tx output power (dBW)	7	7	7	7	7	7
e.i.r.p. (maximum) (dBW)	31	31	31	31	31	31
Receiver IF bandwidth (kHz)	50	50	50	200	200	200
Receiver noise figure (dB)	5	5	5	5	5	5
Receiver thermal noise (dBW)	–152	–152	–152	–146	–146	–146
Nominal Rx input level (dBW)	–90	–90	–90	–90	–90	–90
Rx input level for 1×10^{-3} BER (dBW)	–123	–135	–130	–117	–129	–124
Nominal long-term interference (dBW)	–153	–165	–160	–147	–159	–154
Spectral density (dB(W/MHz))	–140	–152	–147	–140	–152	–147

TABLE 4

FS system parameters for FS frequency sharing below 3 GHz

Frequency band (GHz)	0.81-0.96						1.4
Modulation	PSK	QAM	PSK	QAM	FSK	FSK	4-PSK
Capacity	1 channel	2 channels	24 channels	48 channels	Data	Data	2
Channel spacing	25 kHz	25 kHz	600 kHz	12.5 kHz	12.5 kHz	25-200 kHz	2
			(P-MP)	(P-MP)		(P-MP)	
Antenna gain (maximum) (dBi)	10	10	0 (BS)	0 (BS)	10	0	8-26
Feeder/multiplexer loss (minimum) (dB)	0	0	0	0	0	0	5
Antenna type	Yagi	Yagi	Omni (BS)	Omni (BS)	Yagi	Omni (BS)	Yagi/Dish
Maximum Tx output power (dBW)	7	7	30	30	7	20	0
e.i.r.p. (maximum) (dBW)	17	17	30	30	17	20	21
Receiver IF bandwidth (kHz)	25	25	600	12.5	12.5	25-200	1.5
Receiver noise figure (dB)	5	5	5	5	5	5	7
Receiver thermal noise (dBW)	–155	–155	–158	–141	–158	–155 to –146	–135
Nominal Rx input level (dBW)	–	–	–	–	–		–79
Rx input level for 1×10^{-3} BER (dBW)	–	–	–	–	–	–	–119
Nominal long-term interference (dBW)	–	–	–	–	–	–	
Spectral density (dB(W/MHz))	–	–	–	–	–	–	

BS: base station

P-MP: point-to-multipoint

TABLE 5

FS system parameters for FS frequency sharing below 3 GHz

Frequency band (GHz)	1.45-1.531.45-1.53														
Modulation	PSK 4-PSK	4-PSK	4-PSK	16-QAM	4-PSK	PCM	MSK	4-PSK	4-PSK	4-PSK	4-PSK	4-PSK		4-PSK	
Capacity	704 kbit/s 2 Mbit/s	9.6 kbit/s	64 kbit/s	64 kbit/s	144 kbit/s	–	2 Mbit/s	2 × 2 Mbit/s	2 × 2 Mbit/s	4 × 2 Mbit/s	2 × 2 Mbit/s			2 Mbit/s	
Channel spacing (MHz)	1	0.025	0.075	0.0375	0.225	0.5	2	2	3.5	7	4	3.5		2	
												CS	OS	CS	OS
Antenna gain (maximum) (dBi)	33	33	33	33	33	33	16	16	28	28	16	17	27	13	17.5
Feeder/multiplexer loss (minimum) (dB)	1	1	1	1	1	1	5	3	T:3/R:6	T:3/R:6	5	0	0	4	4
Antenna type	Dish	Yagi/ dish	Yagi/ dish	Yagi/ dish	Yagi/ dish	Yagi/ dish		Yagi	Dish	Dish	Yagi	Omni/ section	Dish/ horn	Omni/ sectoral	Yagi/ horn
Maximum Tx output power (dBW)	7	7	7	7	7	10	7	7	6	6	7	7	7	0	0
e.i.r.p. (maximum) (dBW)	39	39	39	39	39	42	20	20	31	31	20	24	34	6	16
Receiver IF bandwidth (MHz)	0.7	0.005	0.032	0.016	0.072	0.35	1.2	1.2	3.5	7	3	3.5	3.5	1.3	1.3
Receiver noise figure (dB)	4.5	4	4	4	4	8	4	4	4	4	4	3.5	3.5	4	4
Receiver thermal noise (dBW)	–141	–163	–155	–158	–151	–141	–139	–139	–135	–132	–135	–135	–135	–139	–139
Nominal Rx input level (dBW)	–90	–118	–112	–103.5	–106	–90	–86	–84	–136	–133	–83				
Rx input level for 1×10^{-3} BER (dBW)	–120	–143	–137	–128.5	–131	–	–126	–124	–124.3	–121.3	–123			–124	–124
Nominal long-term interference (dBW)	–151	–173	–167	–168	–161	–151	–145	–145	–146	–143	–141	–145	–145	–145	–145
Spectral density (dB(W/MHz))	–149	–150	–152	–150	–150	–146	–146	–146	–149.7	–155.4	–146				
Refer to Notes	(2), (3)	(2), (3)	(2), (3)	(2), (3)	(2), (3)	(2), (3)		(2), (3)			(2), (3)				

CS: central station

OS: out station

(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 6

FS system parameters for FS frequency sharing below 3 GHz

System	150, 450, 800 MHz	890 to 960 MHz	1.5, 2.4 and 2.6 GHz		1.5 and 2.4 GHz	1.5 to 2.6 GHz	2 GHz
Channel capacity (typical) (kbit/s)	2 × 32 or 4 × 16	64 × 1.2	10 × 64	30 × 64	30 × 64	60 × 64	48 × 64
Aggregate bit rate (kbit/s)	26 × 64	240	832	2 304	2 432	4 864	3 088
Modulation method	16-DPSK	Offset 4-PSK	2-FSK	4-PSK	4-PSK	Offset 4-PSK	4-PSK
Central station (CS) antenna	Omnidirectional: gains up to 10 dBi or Yagi	Omni or wide beam: gain 10 dBi	Omnidirectional: gain 10 dBi Yagi: gain 16-21 dBi Horn: gain 13 dBi		Omni or wide beam: gain 10 dBi	Omni or wide beam: gain 10 dBi	(45°) wide beam: gain: see Fig. 4 of Report 1057 (Düsseldorf, 1990)
Out-station (OS) antenna	Yagi: gain 10 dBi	Loop Yagi: gain 20 dBi	Yagi: gain 16-21 dBi Horn: gain 13 dBi		Yagi: gain 17 dBi at 1.5 GHz Parabolic: gain 22 dBi at 1.5 GHz gain 27 dBi at 2.4 GHz	Conical: gain 17 dBi	Parabolic ($\varphi \geq 1.2$ m)
Customer data rates (kbit/s)	Up to 1.2	1.2-64	64	1.2-19.2 64 144 (ISDN)	a) Up to 9.6 b) Standard: 64	2.4-64	64-1 544
Customer assignment	Fixed or demand assignment	Fixed assignment	Fixed or demand assignment		Fixed or demand assignment	Fixed or demand assignment	Fixed assignment

NOTE – These parameters are from Recommendation ITU-R F.755 for TDMA systems below 3 GHz.

TABLE 7

FS system parameters for FS frequency sharing below 3 GHz

Frequency band (GHz)	1.427-1.452/1.492-1.517				
Modulation	O-QPSK				
Capacity	60 × 64 kbit/s				
Channel spacing (MHz)	3.5				
	Central station/repeater			Out station	
Antenna gain (maximum) (dBi)	13	16	31	23.5	17
Feeder/multiplexer loss (dB)	4.4			2.5	
Antenna type	Omni	Sectoral 180°	Dish (3 m)	Dish (1.2 m)	Panel
Maximum Tx output power (dBW)	5			5	
e.i.r.p. (maximum) (dBW)	13.6	16.6	31.6	26	19.5
Receiver IF bandwidth (MHz)	3.5			3.5	
Receiver thermal noise (dBW)	−134			−134	
Nominal Rx input level (dBW)					
Rx input level for 1×10^{-3} BER (dBW)	−121			−121	
Nominal long-term interference (dBW)	−140			−140	
Spectral density (dB(W/MHz))	−145.4			−145.4	

TABLE 8

FS system parameters for FS frequency sharing below 3 GHz

Frequency band (GHz)	1.7-1.9		1.7-2.45									
Modulation	4-PSK	4-PSK	4-PSK tropos.	4-PSK	4-PSK	4-PSK	4-PSK	4-PSK	9-QPR	O-QPSK	4-PSK	4-PSK
Capacity	2 × 2 Mbit/s	4 × 2 Mbit/s	2 Mbit/s	34 Mbit/s	8 Mbit/s	48 channels	12.6 Mbit/s	2 × 8 Mbit/s	4 × 1.54 Mbit/s	45 Mbit/s	8 Mbit/s	2 × 8 Mbit/s
Channel spacing (MHz)	14	14	Special	29	14	2.5	28	14	3.5	29	7	14
Antenna gain (maximum) (dBi)	28	28	45	31	30	29	30	28	32	33	28	28
Feeder/multiplexer loss (minimum) (dB)	T:3/R:6	T:3/R:6	2	1	3	6	3.5	4	3	3	5	5
Antenna type	2.4 m dish	2.4 m dish	9 m dish	1.8 m dish	1.2 m dish	Dish	Dish	2.4 m dish	3 m dish	3 m dish	1.8 m dish	1.8 m dish
Maximum Tx output power (dBW)	0	0	30	3	0	–9	–10	3	6	7	7	–3
e.i.r.p. (maximum) (dBW)	25	25	73	34	30	14	16.5	29	38	40	20	23
Receiver IF bandwidth (MHz)	3.5	7	1	20	4	1.5	6.5	8	3.5	29	3	4.6
Receiver noise figure (dB)	4	4	4	4	5	6	9	4	5	4	4	4
Receiver thermal noise (dBW)	–136	–133	–140	–127	–133	–	–	–131	–133	–125	–135	–133
Nominal Rx input level (dBW)			–	–73	–78	–78	–88.3		–70	–75	–83	–83
Rx input level for 1×10^{-3} BER (dBW)	–124.3	–121.3	–131	–113	–118	–	–		–117	–112	–123	–123
Nominal long-term interference (dBW)	–146	–143	–146	–137	–143			–137	–139	–135	–141	–139
Spectral density (dB(W/MHz))	–149.7	–155.4	–146	–150	–149	–		–146			–146	–146
Refer to Notes			(1), (4)	(2), (4)	(2), (4)	(3), (4)	(3), (4)	(1), (4)	(1)	(1)	(1)	(1)

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

CS: central station

(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.

TABLE 9

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	32 TCM	64-QAM	256-QAM	MSK	4-PSK	4-PSK	FM-TVOB
Capacity			45 Mbit/s	18.5 Mbit/s	3.1 Mbit/s	6.2 Mbit/s	18.5 Mbit/s	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	14			Variable
	CS	OS									
Antenna gain (maximum) (dBi)	17	27	33	33	38	38	38	25	35.4		18
Feeder/multiplexer loss (minimum) (dB)	0	0	2	2	0	0	0	4			1
Antenna type	Omni/ section	Dish/ horn	Dish	Dish	Dish	Dish	Dish	1.2 m dish	3 m dish	Yagi	Dish
Maximum Tx output power (dBW)	7	7	1	–1	+2	+5	+2	5	–2		7
e.i.r.p. (maximum) (dBW)	24	34	34	32	40	43	40	26	33		32
Receiver IF bandwidth (MHz)	3.5	3.5	10	3.5	0.8	1.6	3.5	3			30
Receiver noise figure (dB)	3.5	3.5	4	4	3	3	3	4			6
Receiver thermal noise (dBW)	–135	–135	–130	–134.5	–142	–139	–136	–135			–123
Nominal Rx input level (dBW)	–	–	–65	–65	–60	–60	–60	–			–55
Rx input level for 1×10^{-3} BER (dBW)	–	–	–106	–104.5	–117	–115	–105	–			N/A
Nominal short-term interference (dBW) (% time)											
Nominal long-term interference (dBW)	–141	–141	–136	–140.5	–152	–149	–146	–141	–111.5		–123
Spectral density (dB(W/MHz))	–	–	–146	–146	–151	–151	–151	–162			–129
Refer to Notes	(1)	(1)			(2), (3)	(2), (3)	(2), (3)				

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

TABLE 10

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

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

QPR: quadrature partial response

(1) Objective for FS systems employing space diversity.

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

TABLE 11

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

Frequency Band (GHz)	3.7-4.2	3.7-4.2	4.4-5.0	4.4-5.0	5.9-6.4			5.925-6.425	5.925-6.425	6.425-7.11	
Modulation	RBQPSK	QPSK	16-QAM	64-QAM	64-QAM			RBQPSK	64-QAM	QPSK	16-QAM
Capacity	140 Mbit/s	34 Mbit/s	140 Mbit/s	155 Mbit/s	45 Mbit/s	90 Mbit/s	135 Mbit/s	140 Mbit/s	140 Mbit/s	34 Mbit/s	140 Mbit/s
Channel spacing (MHz)	90	29	40	40	10	20	30	90	29.65	20	40
Antenna gain (maximum) (dBi)	41	37	42.5	42.5	46	46	46	45	45	45	45
Feeder/multiplexer loss (minimum) (dB)	3	3	2	3.5	0	0	0	4	5.5	5	5
Antenna type	3.7 m dish	2.4 m dish	Dish	Dish	Dish	Dish	Dish	3.7 m dish	3.7 m dish	3.7 m dish	3.7 m dish
Maximum Tx output power (dBW)	6	0	3	3	+3	+3	+3	6	2	0	0
e.i.r.p. (maximum) (dBW)	44	38	43.5	42	49	49	49	47	41.5	40	40
Receiver IF bandwidth (MHz)	56	26			10	20	30	56	29	26	44
Receiver noise figure (dB)	6	4			3	3	3	6	4	4	4
Receiver thermal noise (dBW)	–122	–128	–125.3	–127.5	–131	–128	–126	–122	–127	–128	–126
Nominal Rx input level (dBW)	–65	–68			–60	–60	–60	–65	–63	–68	–65
Rx input level for 1×10^{-3} BER (dBW)	–105	–114.5	–106	–106	–109	–106	–104	–105	–103	–114.5	–105
Nominal long-term interference (dBW)	–132	–138	–138.3	–140.5	–141	–138	–136	–132	–137	–138	–136
Spectral density (dB(W/MHz))	–149	–152	–154	–155.3	–151	–151	–151	–149	–152	–152	–152
Refer to Notes	(1), (3)	(1), (2)			(1), (2)	(1), (2)	(1), (2)	(1), (3)	(1), (2)	(1), (2)	(1), (2)

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

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

(3) 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 12

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

Frequency band (GHz)	3.400-3.456	3.6-4.2	4.4-5.0	5.925-6.425	6.4-7.1		6.570-6.870		6.5-6.9			7.425-7.750		7.1-8.5		
Modulation	4-PSK	16-QAM	16-QAM	16-QAM	64-QAM		4-PSK	16-QAM	128-TCM			4-PSK	16-QAM	64-QAM		
Capacity	550 kbit/s	52 Mbit/s	52 Mbit/s	52 Mbit/s	90 Mbit/s	135 Mbit/s	10 Mbit/s	52 Mbit/s	3.1 Mbit/s	12.4 Mbit/s	24.7 Mbit/s	19 Mbit/s	52 Mbit/s	45 Mbit/s	90 Mbit/s	135 Mbit/s
Channel spacing (MHz)	0.5	20	20	20	20	40	20	20	0.8	2.5	5	20	20	10	20	30
Antenna gain (maximum) (dBi)	40	40.7	42.5	45.0	47	47	45	45	47	47	47	46	46	49	49	49
Feeder/multiplexer loss (minimum) (dB)	T:4.0 R:4.0	T:7.0 R:4.0	T:7.0 R:4.0	T:7.0 R:4.0	0	0	T:2.5 R:5.5	T:3.0 R:5.0	0	0	0	T:2.5 R:5.5	T:3.0 R:5.5	0	0	0
Antenna type	Dish	Horn	Horn	Horn	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish
Maximum Tx output power (dBW)	19	–5.2	–7.1	–9.8	+3	+3	3	3	+1	+1	+1	3	3	+3	+3	+3
e.i.r.p. (maximum) (dBW)	55	28.5	28.4	28.2	50	50	45.5	45	48	48	48	46.5	46	52	52	52
Receiver IF bandwidth (MHz)	0.35	16.65	16.65	16.65	20	30	12.5	17.5	0.8	2.5	5	12.5	17.5	10	20	30
Receiver noise figure (dB)	5	4.2	4.2	4.2	3	3	5	5	3	3	3	5	5	3	3	3
Receiver thermal noise (dBW)	–143.6	–128.1	–128.1	–128.1	–128	–125	–128.0	–126.6	–142	–137	–134	–128.0	–126.6	–131	–128	–126
Nominal Rx input level (dBW)	–87	–73	–73	–73	–60	–60	–92.5	–87.5	–60	–60	–60	–92.5	–87.5	–60	–60	–60

TABLE 13

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

Frequency Band (GHz)	6.425-7.11	6.425-7.11	7.425-7.750	7.725-8.275	8.275-8.500	8.275-8.500
Modulation	16-QAM	16-QAM	16-QAM	128-QAM	4-PSK	16-QAM
Capacity (Mbit/s)	34	2×34	34	155	34	34
Channel spacing (MHz)	20	20	14	29.65	28	14
Antenna gain (maximum) (dBi)	45	45	45	45	45	45
Feeder/multiplexer loss (minimum) (dB)	Tx:1.5 Rx:2	Tx:1.5 Rx:2	Tx:1.5 Rx:2	Tx:4.6 Rx:4.8	Tx:3.0 Rx:6.5	Tx:3.0 Rx:6.5
Antenna type	Dish	Dish	Dish	Dish	Dish	Dish
Maximum Tx output power (dBW)	0	0	0	3	0	0
e.i.r.p. (maximum) (dBW)	43.5	43.5	43.5	43.4	42	42
Receiver IF bandwidth (MHz)	24	24	14	28	26	14
Receiver noise figure (dB)	4	4	4	2	4	4
Receiver thermal noise (dBW)	–130	–127	–130	–128	–127	–130
Nominal Rx input level (dBW)						
Rx input level for 1×10^{-3} BER (dBW)	–111.5	–108.5				
Nominal long-term interference (dBW)	–140	–137				
Spectral density (dB(W/MHz))	–149.8	–149.7				

TABLE 14

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

Frequency band (GHz)	3.4-3.6 (TDMA)[1]		4 (DS-CDMA)	
Modulation	π/4-DQPSK		QPSK	
RF transmission rate (Mbit/s)	54 channels		2	
Channel spacing (MHz)	0.30	0.30		
System type	Base station	Remote station	Remote station	Base station
Antenna maximum gain (dBi)	10	15	16 (Vertical)	16 (Vertical)
Transmit power (dBW)	–1	–3	2	2
Feeder loss (dB)	1.5	0	18	8
Antenna type				
Maximum e.i.r.p. (dBW)	9	12	0	10
Receiver IF bandwidth (MHz)	0.256	0.256	21	21
Receiver thermal noise (dBW)	–145	–145	–117	–117
Receiver threshold (10^{-6} BER) (dBW)	–72.5 (10^{-3})	–72.5 (10^{-3})	–118	–118
Maximum long-term interference power (dB(W/MHz))			–140[2]	–140[2]
Availability target (% time)			99.99	99.99
Typical fade margin (dB)			30	30
Path length (km)			3	3

[1] Time slot length (ms) 0.5; Frame length (ms) 5.0; Time slots per frame 10.

[2] Measured at antenna port.

TABLE 15

FS system parameters for FS frequency sharing between 10 and 30 GHz

System (GHz)	10.5	19	23	26	26
Channel capacity (typical) (kbit/s)	30 × 64	90 × 64 47 × 144 (2B+D)	10 × 64	192 × 64	96 × 64
Aggregate bit rate (kbit/s)	2 100	8 192	832	14 300	4 × 2 048
Modulation method	QPSK	2-FSK	2-ASK	FSK (CS-RT) DFSK (RT-CS)	2-FSK
Central station (CS) antenna	90° or 120° wide beam: gain 13 dBi	90° or 120° wide beam: gain 18 dBi	90° or 120° wide beam: gain 10 to 15 dBi	90° wide beam: gain 20 dBi	90° wide beam: gain 20 dBi
Out-station (OS) antenna (dBi)	Parabolic: gain 34	Parabolic: gain 35	Parabolic: gain 35	Cassegrain: gain 35 to 47	Parabolic: gain 30
Customer data rates (kbit/s)	64 Others available	12.8 and 64 initially, expandable to include ISDN rates of 80 or 144	64	64 to 6 144	64
Customer assignment	Fixed or demand assignment	Fixed or demand assignment	Fixed or demand assignment	Fixed assignment	Demand assignment

NOTE 1 – These parameters are from Recommendation ITU-R F.755.

TABLE 16

FS system parameters for FS frequency sharing above 10 GHz

Frequency band (GHz)	10.50- 10.68	10.55-10.68		10.6-10.7			10.7-11.7			
Modulation	4-PSK	FSK, QPSK	FSK, QPSK	128-TCM			4-PSK	64-QAM	64-QAM	64-QAM
Capacity	34 Mbit/s	8 Mbit/s	16 Mbit/s	3.1 Mbit/s	12.4 Mbit/s	24.7 Mbit/s	140 Mbit/s	45 Mbit/s	90 Mbit/s	135 Mbit/s
Channel spacing (MHz)	14	7	14	0.8	2.5	5	67	10	20	40
Antenna gain (maximum) (dBi)	36-45	49	49	51	51	51	49	51	51	51
Feeder/multiplexer loss (minimum) (dB)	0	0	0	0	0	0	5	0	0	0
Antenna type	Dish	Dish	Dish	Dish	Dish	Dish	3.7 m dish	Dish	Dish	Dish
Maximum Tx output power (dBW)	−7	–2	–2	–3	–3	–3	10	+3	+3	+3
e.i.r.p. (maximum) (dBW)	34	47	47	48	48	48	54	54	54	54
Receiver IF bandwidth (MHz)	20.4	7	14	0.8	2.5	5	68	10	20	30
Receiver noise figure (dB)	8	3	3	4	4	4	7	4	4	4
Receiver thermal noise (dBW)	−123	−135.5	−129.5	–141	–136	–133	–119	–130	–127	–125
Nominal Rx input level (dBW)	−68	−60	−60	–60	–60	–60	–62	–60	–60	–60
Rx input level for 1×10^{-3} BER (dBW)	−108	−117	−114	–110	–104	–101	–104	–109	–106	–103
Nominal long-term interference (dBW)		−142.5	−139.5	–151	–146	–143	–129	–140	–137	–135
Spectral density (dB(W/MHz))		−151	−148	–150	–150	–150	–147	–150	–150	–150
Refer to Notes				(1), (2)	(1), (2)	(1), (2)	(1), (2)	(1), (2)	(1), (2)	(1), (2)

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

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

TABLE 17

FS system parameters for FS frequency sharing above 10 GHz

Frequency band (GHz)	12.2-12.44		13/14					14.4-15.35	
Modulation	4-PSK	16-QAM	4-PSK	4-PSK	4-PSK	4-PSK	FM	64-QAM	8-PSK
Capacity	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	156 Mbit/s
Channel spacing (MHz)	20	20	3.5	7	14	28	28	28	40
Antenna gain (maximum) (dBi)	50	50	49	49	49	49	49	49	52
Feeder/multiplexer loss (minimum) (dB)	1	1	0	0	0	0	0	2	5
Antenna type	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish
Maximum Tx output power (dBW)	–5	–5	10	10	10	10	10	5	0
e.i.r.p. (maximum) (dBW)	40	40	45	45	45	45	45	47	47
Receiver IF bandwidth (MHz)	12.3	17.2	1	2	4	17	24	40	50
Receiver noise figure (dB)	7	5	10	10	10	10	10	4	5
Receiver thermal noise (dBW)	–		–134	–131	–128	–122	–120	–124	
Nominal Rx input level (dBW)	–59 + M	–59 + M	–74	–71	–68	–65	–65	–66	–44
Rx input level for 1×10^{-3} BER (dBW)			–116	–113	–111	–109	N/A	–101	
Nominal long-term interference (dBW)			–144	–141	–138	–132	–130	–134	
Spectral density (dB(W/MHz))			–144	–144	–144	–144	–144	–150	
Refer to Notes	(3)	(3)	(1), (4)	(1), (4)	(1), (4)	(1), (4)	(1), (4)	(1), (4)	

M: fade margin

(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.

TABLE 18

FS system parameters for FS frequency sharing above 10 GHz

Frequency band (GHz)	17.7-19.7														
Modulation	4-PSK	4-QAM	2-PSK	4-PSK	4-PSK	O-QPSK	64-QAM	4-QAM	4-PSK	4-FSK	4-QAM	4-QAM	4-QAM	4-QAM	4-QAM
Capacity (Mbit/s)	140	140			8	44.7		8	12.6	400	3.1	6.2	12.4	24.7	45
Channel spacing (MHz)	110	55			13.75	40		10	10	300	2.5	5	10	20	40
Antenna gain (maximum) (dBi)	48	48			49	45	38	32-48	48	48	48	48	48	48	48
Feeder/multiplexer loss (minimum) (dB)	7	7			1	3	3	0	3	3	0	0	0	0	0
Antenna type	Dish	Dish	Dish	Dish	1.8 m dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish
Maximum Tx output power (dBW)	–10	–4			–5	–9	–7	–5	–7	–8	–5	–5	–5	–5	–5
e.i.r.p. (maximum) (dBW)	31	37			43	33	31	27-43	38	40	43	43	43	43	43
Receiver IF bandwidth (MHz)	68	68			25	40	40	4	10	250	2.5	5	10	20	40
Receiver noise figure (dB)	7	8			9	5	5	7	7	8	6	6	6	6	6
Receiver thermal noise (dBW)	–119	–118			–121	–125	–123	–131	–131		–134	–131	–128	–125	–122
Nominal Rx input level (dBW)	–63	–64			–60	–70	–73	–65	–72		–60	–60	–60	–60	–60
Rx input level for 1×10^{-3} BER (dBW)	–103	–104			–111	–106		–116	–113		–120	–117	–114	–111	–109
Nominal long-term interference (dBW)	–129	–131			–134	–131		–141	–137		–144	–141	–138	–135	–132
Spectral density (dB(W/MHz))	–147	–149						–147	–147		–148	–148	–148	–148	–148
Refer to Notes	(2), (3)	(2), (3)	(2), (3)	(2), (3)	(4)	(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.

(4) Occupied bandwidth = 6 MHz.

TABLE 19

FS system parameters for FS frequency sharing above 10 GHz

Frequency band (GHz)	10.7-11.7				14.4-15.35		17.7-19.7			21.8-23.6				22.0-23.0, 25.25-27.0			
Modulation	64-QAM	32-QAM	16-QAM	64-QAM	4-PSK	4-PSK	4-PSK	4-PSK	16-QAM	4-PSK	4-PSK	4-PSK	16-QAM	4-PSK	4-FSK	16-QAM	16-QAM
Capacity	155 STM-1	155 STM-1	140 Mbit/s	155 Mbit/s	2 × 2 Mbit/s	4 × 2 Mbit/s	2 × 2 Mbit/s	4 × 2 Mbit/s	155 Mbit/s	2 × 2 Mbit/s	4 × 2 Mbit/s	34 Mbit/s	155 Mbit/s	6 Mbit/s	45 Mbit/s	52 Mbit/s	156 Mbit/s
Channel spacing (MHz)	40	40	40	40	10.5	10.5	5	10	55	7	10.5	28	56	10	50	20	60
Antenna gain (maximum) (dBi)	49	49	45	45	45	45	45	45	45	47	47	47	45	46	46	46	46
Feeder/multiplexer loss (minimum) (dB)[5]	3	3	5	4	0	0	0	0	Tx:4.5 Rx:3.5	0	0	0	Tx:6 Rx:4	0	0	0	0
Antenna type	3m dish	3m dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish, plate	Dish, plate	Dish, plate	Dish, plate
Maximum Tx output power (dBW)	0	–3.5	3	3	–7	–7	–7	–7	–5	–7	–7	0	–10	–3.0	–3.0	–3.0	–3.0
e.i.r.p. (maximum) (dBW)	46	42.5	43	44	38	38	38	38	35.5	40	40	47	29	43.0	43.0	43.0	43.0
Receiver IF bandwidth (MHz)	27	39	50	40	3.5	7	3.5	7	55	3.5	7	18	56	5.3	33.1	18.6	55.6
Receiver noise figure (dB)	5	3.5	4	2	4	4	5	5	4.5	6.5	6.5	7	5	8	8	8	8
Receiver thermal noise (dBW)	–125	–126	–124	–127	–136	–133	–135	–132	–123	–133.5	–130.5	–124	–122.6	–128.9	–121.2	–123.5	–118.7
Nominal Rx input level (dBW)	–60 80[4]	–60 75[4]												–112.1 + M	–100.6 + M	–100.0 + M	–95.2 + M
Rx input level for 1×10^{-3} BER (dBW)	–101	–107	–106	–105.6	–123.5	–120.5	–122.5	–119.5	–105.4	–120.5	–117.5	–113	–104.9	–116.2	–108.8	–103.3	–98.5
Nominal long-term interference (dBW)	–138	–140	–134	–137	–146	–143	–145	–142	–133	–143.5	–140.5	–134	–132.6	–138.9	–131.2	–133.5	–128.7
Spectral density (dB(W/MHz))	–152	–156	–149.6	–151.8	–149.8	–149.7	–148.8	–148.7	–149.2	–147.3	–147.2	–146.9	–148.8	–146.0	–146.0	–146.0	–146.0
Refer to Notes	[3], [4]	[3], [4]												[1], [2]	[1], [2]	[1], [2]	[1], [2]

M: fade margin

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

[2] Specified interference level is total power within the receiver bandwidth.

[3] For these systems using space diversity an $I/N = -13$ dB (corresponding to a threshold degradation of 0.2 db) is necessary.

[4] With automatic transmit power control (ATPC).

[5] For bands above 20 GHz, current FS installations have outdoor applications: indoor applications are possibly found as custom arrangement. Feeder losses, whenever mentioned, are considered as ranging from 0 dB to the value mentioned in the Table.

TABLE 20

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	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	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	5	40	40		20
											CS	OS	CS
Antenna gain (maximum) (dBi)	47	47	47	47	47	47	35	50	47	38.5	20	47	47
Feeder/multiplexer loss (minimum) (dB) (4)	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	90° section	Dish	Dish
Maximum Tx output power (dBW)	0	0	0	0	0	0	–16	–14	–10	– 4	–8	–10	–10
e.i.r.p. (maximum) (dBW)	50	50	50	50	50	47	15	32	37	31.5	10	37	37
Receiver IF bandwidth (MHz)	2	4	8	17	70	18	5	14	2	40	16.4	16.4	16.4
Receiver noise figure (dB)	9	9	9	9	9	12	4	4	11	5	10	8	10
Receiver thermal noise (dBW)	–132	–129	–126	–123	–116	–119	–133	–128		–123			
Nominal Rx input level (dBW)	–105 + M	–104 + M	–103 + M	–100 + M	–94 + 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	–103	–112	–113		–96			
Nominal long-term interference (dBW)	–142	–139	–136	–133	–126	–129	–139	–136		–131			
Spectral density (dB(W/MHz))	–143	–143	–143	–143	–143	–141	–146	–148		–147			
Refer to Notes	(1), (3)	(1), (3)	(1), (3)	(1), (3)	(1), (3)	(1), (3)	(1), (3)	(1), (3)	(2), (3)		(2), (3)		(2), (3)

CS: central station

OS: out station

M: fade margin

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

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

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

(4) For bands above 20 GHz, current FS installations have outdoor applications: indoor applications are possibly found as custom arrangement. Feeder losses, whenever mentioned, are considered as ranging from 0 dB to the value mentioned in the Table.

TABLE 21

FS system parameters for FS frequency sharing above 10 GHz

Frequency band (GHz)	25.25-27.5, 27.5-28.35, 29.1-29.25, 31.0-31.3					
Service type	2-way asymmetric – FDD		2-way asymmetric – FDD		2-way asymmetric – TDD	
Modulation	16-QAM	4-PSK	64-QAM	16-QAM	64-QAM	64-QAM
Direction of transmission	Hub to RT	RT to Hub	Hub to RT	RT to Hub	Hub to RT	RT to Hub
Capacity (Mbit/s)	24	11	35	20	180	180
Channel spacing (MHz)	7	7	7	7	50	50
Antenna gain (dBi)	21	36	21	36	21	36
Antenna diameter (m)	–	0.30	–	0.30	–	0.30
3 dB beamwidth (degrees)	90° sector 2.7° vertical	2.7°	90° sector 2.7° vertical	2.7°	90° sector 2.7° vertical	2.7°
Antenna type	Sector	Dish	Sector	Dish	Sector	Dish
Feeder loss (dB)	0	0	0	0	0	0
Maximum Tx power (dBW)	–3	–13.5	–6	–16.5	–14	–14
e.i.r.p. (maximum) (dBW)	18	22.5	15	19.5	7	22
Receiver noise figure (dB)	7	6.5	7	6.5	7	7
Receiver thermal noise (dBW)	–129	–129	–129	–129	–120	–120
Nominal long-term interference (dBW)	–139	–139	–139	–139	–130	–130
Spectral density (dB(W/MHz))	–147	–147	–147	–147	–147	–147

TABLE 22

FS system parameters for FS frequency sharing above 10 GHz

Frequency band (GHz)	25.25-27.5, 27.5-28.35, 29.1-29.25, 31.0-31.3[8], [9]						
Service type	1-way	2-way symmetric			2-way asymmetric – TDMA		
Modulation	4-PSK FDM/TDM	4-PSK FDM/TDM	4-PSK FDM/TDM	4-PSK FDM/TDM	4-PSK FDM/TDM	4-PSK FDM/TDMA	4-PSK FDM/TDMA
Capacity	1 ch/40 MHz BW	20 ch/30 MHz BW	20 ch/30 MHz BW	20 ch/30 MHz BW	1 ch/50 MHz BW	20 ch/50 MHz BW	20 ch/50 MHz BW
Channel spacing (code rate 3/4) (MHz)	40	1.36	1.36	1.36	50	2.5	2.5
Direction of transmission	Hub to RT	Hub to RT	RT to hub	RT to hub	Hub to RT	RT to hub	RT to hub
Condition	Clear-air	Clear-air	Clear-air	Rain-faded	Clear-air	Clear-air	Rain-faded
Antenna Gain (maximum) (dBi)	15	15	36	36	15	36	36
Feeder/multiplexer loss (minimum) (dB)	0	0	0	0	0	0	0
Antenna type (El × Az)	15° × 90° horn	15° × 90° horn	2° × 2° dish	2° × 2° dish	15° × 90° horn	2° × 2° dish	2° × 2° dish
Maximum Tx output power (dBW)	9.0[7]	–5.7[7]	–40.0	–4.2[7]	10.0[7]	–32.7	4.0[7]
Maximum Tx P.S.D. (dB(W/MHz))	–7.0[7]	–7.0[7]	–41.3	–5.5[7]	–7.0[7]	–36.7	0.0[7]
e.i.r.p. (maximum) (dBW)	24.0[7]	9.3[7]	–4.0	31.8[7]	25.0[7]	3.3	40.0[7]
Receiver IF bandwidth (MHz)[6]	40.0	1.36	1.36	1.36	50.0	2.5	2.5
Receiver noise figure (Typ.) (dB)	7.0	7.0	7.5	7.5	7.0	7.5	7.5
Receiver thermal noise (dBW)[5]	–121.0	–135.6	–135.1	–135.1	–120.0	–132.6	–132.6
Rx input level for 1×10^{-3} BER (dBW)							
Nominal Rx input level (dBW) for 1×10^{-6} BER at 5 km	–77.0	–91.7	–126.0	–125.9	–76.0	–118.7	–118.6
Rx E_b/N_0 for 1×10^{-6} BER (dB)	7.2	7.6	8.6	8.6	7.2	14.0	14.0
Nominal long-term interference (dBW)[1], [2]	–130.1	–144.8	–144.3	–144.3	–129.1	–141.6	–141.6
Spectral density (dB(W/MHz))	–146	–146	–146	–146	–146	–146	–146
Refer to Notes		[4]	[3], [4]	[3], [4]		[3]	[3]

See notes on the next page.

Notes relating to Table 22:

Hub: Hub station

RT: remote terminal (subscriber station)

TDM: time division multiplexed (continuous transmission when in service)

FDM: frequency division multiplexed

TDMA: time-division multiple access (burst transmission)

(1) Specified interference will reduce system C/N by 0.5 dB.

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

(3) Remote terminal power control (RTPC) is used to transmit the minimum power necessary to meet the hub receiver threshold (E_b/N_0). In order to limit system self-interference to less than 10 dB, an interference mitigation algorithm detects interference and restricts transmit e.i.r.p. escalation.

(4) Code rates typically range from rate 1/2 to rate 7/8.

(5) Receiver thermal noise is based on Nyquist bandwidth of detection process.

(6) Total occupied bandwidth per carrier.

(7) Operating points are typically set to meet fade margin requirements while minimizing self-interference. Systems with these values will typically be operated in locations where fade margins at 5 km are from 20 to 40 dB. Interference studies should take into account fade margin requirements and related operating points for a given location and hub-to-RT separation.

(8) Typical parameters for a point-to-multipoint system operating at 8 dB(W/MHz) hub e.i.r.p. and requiring 37 dB of fade margin at 5 km hub-to-RT separation.

(9) ITU-R is studying sharing in the band 25.25 to 27.5 GHz.

TABLE 23

FS system parameters for FS frequency sharing above 10 GHz

Frequency band (GHz)	27.5-28.35, 29.1-29.25, 31.0-31.3[8]						
Service type	1-way	2-way symmetric			2-way asymmetric – TDMA		
Modulation	4-PSK FDM/TDM	4-PSK FDM/TDM	4-PSK FDM/TDM	4-PSK FDM/TDM	4-PSK FDM/TDM	4-PSK FDM/TDMA	4-PSK FDM/TDMA
Capacity	1 ch/40 MHz BW	20 ch/30 MHz BW	20 ch/30 MHz BW	20 ch/30 MHz BW	1 ch/50 MHz BW	20 ch/50 MHz BW	20 ch/50 MHz BW
Channel spacing (code rate ¾) (MHz)	40	1.36	1.36	1.36	50	2.5	2.5
Direction of transmission	Hub to RT	Hub to RT	RT to hub	RT to hub	Hub to RT	RT to hub	RT to hub
Condition	Clear-air	Clear-air	Clear-air	Rain-faded	Clear-air	Clear-air	Rain-faded
Antenna Gain (maximum) (dBi)	24	24	36	36	24	36	36
Feeder/multiplexer loss (minimum) (dB)	0	0	0	0	0	0	0
Antenna type (El × Az)	3° × 45° horn	3° × 45° horn	2° × 2° dish	2° × 2° dish	3° × 45° horn	2° × 2° dish	2° × 2° dish
Maximum Tx output power (dBW)	22.0[7]	7.3[7]	–49.0	7.3[7]	23.0[7]	–41.7	10.0[7]
Maximum Tx P.S.D. (dB(W/MHz))	6.0[7]	6.0[7]	–50.3	6.0[7]	6.0[7]	–45.7	6.0[7]
e.i.r.p. (maximum) (dBW)	46.0[7]	31.3[7]	–13.0	43.3[7]	47.0[7]	–5.7	46.0[7]
Receiver IF bandwidth (MHz)[6]	40.0	1.36	1.36	1.36	50.0	2.5	2.5
Receiver noise figure (Typ.) (dB)	7.0	7.0	7.5	7.5	7.0	7.5	7.5
Receiver thermal noise (dBW)[5]	–121.0	–135.6	–135.1	–135.1	–120.0	–132.5	–132.5
Rx input level for 1×10^{-3} BER (dBW)							
Nominal Rx input level (dBW) for 1×10^{-6} BER at 5 km	–55.0	–69.7	–126.0	–125.9	–54.0	–118.7	–118.6
Rx E_b/N_0 for 1×10^{-6} BER (dB)	7.2	7.6	8.6	8.6	7.2	14.0	14.0
Nominal long-term interference (dBW)[1, 2]	–130.1	–144.8	–144.3	–144.3	–129.1	–141.6	–141.6
Spectral density (dB(W/MHz))	–146	–146	–146	–146	–146	–146	–146
Refer to Notes		[4]	[3], [4]	[3], [4]		[3]	[3]

[1] Specified interference will reduce system C/N by 0.5 dB.

[2] The specified interference level is total power within the receiver bandwidth.

[3] Remote terminal power control (RTPC) is used to transmit the minimum power necessary to meet the hub receiver threshold (E_b/N_0). In order to limit system self-interference to less than 10 dB, an interference mitigation algorithm detects interference and restricts transmit e.i.r.p. escalation.

[4] Code rates typically range from rate 1/2 to rate 7/8.

[5] Receiver thermal noise is based on Nyquist bandwidth of detection process.

[6] Total occupied bandwidth per carrier.

[7] Operating points are typically set to meet fade margin requirements while minimizing self-interference. Systems with these values will typically be operated in locations where fade margins at 5 km are from 40 to 60 dB. Interference studies should take into account fade margin requirements and related operating points for a given location and hub-to-RT separation.

[8] Typical parameters for a point-to-multipoint system operating at 30 dB(W/MHz) hub e.i.r.p., up to 42 dB(W/MHz) RT e.i.r.p., and requiring 57 dB of fade margin at 5 km hub-to-RT separation.

TABLE 24

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

Frequency band (GHz)	31.8-33.4											
Modulation	4-FSK	4-FSK	4-FSK	16-QAM	16-QAM	32-QAM	128-QAM	4-FSK	O-QPSK	4-FSK	16-QAM	16-QAM
Capacity (Mbit/s)	2 × 2	2 × 8	34	STM-1 155	STM-0 52	STM-0 52	STM-1 155	6.2	45	45	45	155
Channel spacing (MHz)	3.5	14	28	56	28	14	28	5	40	40	20	50
Antenna gain (maximum) (dBi)	46*	46*	46*	46*	46*	46*	46*	43**	43**	43**	43**	43**
Feeder/multiplexer loss (minimum) (dB)	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
Maximum Tx output power (dBW)	–3	–3	–3	–3	–3	–3	–3	–15	–13	–13	–7	–4
e.i.r.p. (maximum) (dBW)	43	43	43	43	43	43	43	28	30	30	36	39
Receiver IF bandwidth (MHz)	2	8	17	40	15	12	30	5	40	40	20	50
Receiver noise figure (dB)	9	9	9	7	7	7	7	8	8	8	8	8
Receiver thermal noise (dBW)	–132	–126	–123	–121	–125	–126	–123	–129	–120	–120	–122	–119
Nominal Rx input level (dBW)	–113 + M	–107 + M	–104 + M	–100 + M	–99 + M	–96 + M						
Rx input level for 1×10^{-3} BER (dBW)	–116	–110	–107	–103	–107	–104	–95	–118	–113	–109.5	–108.5	–103
Nominal long-term interference (dBW)	–142	–136	–133	–131	–135	–136	–133	–139	–130	–130	–132	–129
Spectral density (dB(W/MHz))	–145	–145	–145	–147	–147	–147	–147	–146	–146	–146	–145	–146
Refer to Notes	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)

* 0.9 m dish assumed.

** 0.6 m dish assumed.

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

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

TABLE 25

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

Frequency band (GHz)	37.0-39.5					38.6-40.0				
Modulation	4-FSK	4-FSK	4-FSK	4-FSK	16-QAM	2-FSK	OQPSK	4-QAM	16-QAM	256-QAM
Capacity (Mbit/s)	2×2	8	2×8	34	155	1.544	44.736	44.736	90	310
Channel spacing (MHz)	3.5	7	14	28	56	5	40	50	50	50
Antenna gain (maximum) (dBi)	47*	47*	47*	47*	47*	44**	44**	44**	44**	44**
Feeder/multiplexer loss (minimum) (dB)	0	0	0	0	0	0	0	0	0	0
Antenna type	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish
Maximum Tx output power (dBW)	0	0	0	0	0	–13	–15	–14	–4	–4
e.i.r.p. (maximum) (dBW)	47	47	47	47	47	31	29	30	40	40
Receiver IF bandwidth (MHz)	2	4	8	17	40	2	40	50	50	50
Receiver noise figure (dB)	11	11	11	11	8	11	8	13	5	5
Receiver thermal noise (dBW)	–130	–127	–124	–121	–120	–130	–120	–114	–122	–122
Nominal Rx input level (dBW)	–112 + M	–109 + M	–106 + M	–103 + M	–99 + M	–114 + M	–110 + M	–101 + M	–100 + M	–88 + M
Rx input level for 1×10^{-3} BER (dBW)	–115	–112	–109	–106	–102	–122	–114.5	–105	–106	–94
Nominal long-term interference (dBW)	–140	–137	–134	–131	–130	–140	–130	–124	–132	–132
Spectral density (dB(W/MHz))	–143	–143	–143	–143	–146	–143	–146	–141	–149	–149
Refer to Notes	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)

* 0.9 m dish assumed.

** 0.6 m dish assumed.

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

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

TABLE 26

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

Frequency band (GHz)	37.0-39.5											
Modulation	4-PSK	4-PSK	4-PSK	CPM	CPM	CPM	4-FSK	4-FSK	4-FSK	C-QPSK	C-QPSK	C-QPSK
Capacity (Mbit/s)	2 × 2	4 × 2	16 × 2	2 × 2	4 × 2	8 × 2	2 × 2	4 × 2	8 × 2	2 × 2	4 × 2	8 × 2
Channel spacing (MHz)	3.5	7	28	3.5	7	14	3.5	7	14	3.5	7	14
Antenna gain (maximum) (dBi)	47	47	47	44.3	44.3	44.3	44.3	44.3	44.3	44	44	44
Feeder/multiplexer loss (minimum) (dB) (5)	0	0	0	1.0	1.0	1.0				0	0	0
Antenna type	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish	Dish
Maximum Tx output power (dBW)	–15	–15	–15	–13	–13	–13	–14	–14	–14	–13.7	–13.7	–13.7
e.i.r.p. (maximum) (dBW)	32	32	32	30.34	30.34	30.34	30.3	30.3	30.3	30.5	30.5	30.5
Receiver IF bandwidth (MHz)	3.5	7	28	3.5	7.5	14	3.5	7	14	3.5	7	14
Receiver noise figure (dB)	7.5	7.5	7.5	10	10	10	8	8	8	12	12	12
Receiver thermal noise (dBW)	–132.5	–129.5	–123.5	–133.4	–130.1	–127.4	–130.5	–127.5	–124.5	–128	–125	–122
Nominal Rx input level (dBW)												
Rx input level for 1×10^{-3} BER (dBW)	–119	–116	–110	–117.5	–114.5	–111.5	–112	–110	–106	–115	–112	–109
Nominal long-term interference (dBW)	–142.5	–139.5	–133.5	–143.4	–140.1	–137.4	–140.5	–137.5	–134.5	–138	–135	–132
Spectral density (dB(W/MHz))	–146.3	–146.2	–146.2	–148.9	–148.9	–148.9	–143.5	–143.5	–143.5	–143.4	–143.4	–143.4
Refer to Notes	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)

CPM: continuous phase modulation

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

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

(5) For bands above 20 GHz, current FS installations have outdoor applications: indoor applications are possibly found as custom arrangement. Feeder losses, whenever mentioned, are considered as ranging from 0 dB to the value mentioned in the Table.

TABLE 27

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

requency 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	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
Capacity	2 Mbit/s	8 Mbit/s	34 Mbit/s	140 Mbit/s	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
Channel spacing (MHz)	7	14	28	140	5	40	50	50	50	5	50	50	50	14	14	28	140
Antenna gain (maximum) (dBi)	47	47	47	47	44	44	44	44	44	46	46	46	46	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
Antenna type	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	–13	–15	–14	–4	–4	–11	–12	–2	–2	–10	–10	–10	–10
e.i.r.p. (maximum) (dBW)	47	47	47	47	31	29	30	40	40	35	34	44	44	37	37	37	37
Receiver IF bandwidth (MHz)	2	8	17	70	2	40	50	50	50	2	50	50	50	2	8	17	70
Receiver noise figure (dB)	11	11	11	11	11	8	13	5	5	11	13	5	5	11	11	11	11
Receiver thermal noise (dBW)	–130	–124	–121	–114	–130	–120	–114	–122	–122	–130	–114	–122	–122	–130	–124	–121	–114
Nominal Rx input level (dBW)	–108 + M	–102 + M	–99 + M	–93 + 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
Rx input level for 1×10^{-3} BER (dBW)	–111	–105	–102	–95	–122	–114.5	–105	–106	–94	–122	–105	–106	–94	–111	–105	–102	–95
Nominal long-term interference (dBW)	–140	–134	–131	–124	–140	–130	–124	–132	–132	–140	–124	–132	–132	–140	–134	–131	–124
Spectral density (dB(W/MHz))	–143	–143	–143	–143	–143	–146	–141	–149	–149	–143	–141	–149	–149	–143	–143	–143	–143
Refer to Notes	(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) 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).

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

TABLE 28

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

Frequency band (GHz)	51.4-52.6									
Modulation	4-FSK	4-FSK	4-FSK	4-FSK	16-QAM	16-QAM	32-QAM	4-FSK	4-FSK	4-FSK
Capacity (Mbit/s)	2 × 2	8	2 × 8	34	STM-0 52	STM-1 155	STM-0 52	1.544	6.2	45
Channel spacing (MHz)	3.5	7	14	28	28	56	14			
Antenna gain (maximum) (dBi)	50	50	50	50	50	50	50	37*	37*	37*
Feeder/multiplexer loss (minimum) (dB)	0	0	0	0	0	0	0	0	0	0
Antenna type	Dish/horn	Dish/horn	Dish/horn	Dish/horn	Dish/horn	Dish/horn	Dish/horn	Dish	Dish	Dish
Maximum Tx output power (dBW)	–20	–20	–20	–20	–20	–20	–20	–10	–10	0
e.i.r.p. (maximum) (dBW)	30	30	30	30	30	30	30	27	27	37
Receiver IF bandwidth (MHz)	2	4	8	17	15	40	12	2.5	5	40
Receiver noise figure (dB)	11	11	11	11	7	8	7	10	10	10
Receiver thermal noise (dBW)	–130	–127	–124	–121	–125	–120	–126	–130	–127	–118
Nominal Rx input level (dBW)	–111 + M	–108 + M	–105 + M	–102 + M	–99 + M	–99 + M	–96 + M			
Rx input level for 1×10^{-3} BER (dBW)	–114	–111	–108	–105	–107	–102	–104	–122	–116	–107.5
Nominal long-term interference (dBW)	–140	–137	–134	–131	–135	–130	–136	–140	–137	–128
Spectral density (dB(W/MHz))	–143	–143	–143	–143	–147	–146	–147	–144	–144	–144
Refer to Notes	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)

* 0.3 m dish assumed.

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

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

TABLE 29

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

Frequency band (GHz)	55.78-57 (TDD)		55.78-57 (FDD)	57-59 (TDD)		57-59 (FDD)		
Modulation	4-FSK	4-FSK	4-FSK	2-FSK	2-FSK	4-FSK	4-FSK	4-FSK
Capacity (Mbit/s)	2×8	4×8	45	$> 2 \times 2$	> 8	1.544	6.2	45
Channel spacing (MHz)	14	28	40	50	100	2.5	5	40
Antenna gain (maximum) (dBi)	45*	45*	37**	32	32	37**	37**	37**
Feeder/multiplexer loss (minimum) (dB)	0	0	0	0	0	0	0	0
Antenna type	Dish, horn	Dish, horn	Dish	Flat panel	Flat panel	Dish	Dish	Dish
Maximum Tx output power (dBW)	–10	–10	–10	–20	–20	–10	–10	0
e.i.r.p. (maximum) (dBW)	35	35	27	15	15	27	27	37
Receiver IF bandwidth (MHz)				10	20			
Receiver noise figure (dB)				20	20			
Receiver thermal noise (dBW)				–114	–111			
Nominal Rx input level (dBW)								
Rx input level for 1×10^{-3} BER (dBW)				–100	–97			
Nominal long-term interference (dBW)				–140	–137			
Spectral density (dB(W/MHz))				–143	–143			
Refer to Notes	(6)	(6)		(2), (4), (5)	(2), (4), (5)			

* 0.45 m dish assumed.

** 0.3 m dish assumed.

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

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

(5) 57-59 (TDD), channel spacings should be more than twice that of FDD systems (turn over time).

(6) Sum of capacity for both directions.

TABLE 30

Representative characteristics of P-MP 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	Hub No. 4	Remote No. 4
Capacity/data rate (Mbit/s)	DS-3 45	DS-3 45	OC-3 155	OC-3 155	250	250	OC-6 310	OC-6 310
Modulation type	OQPSK	OQPSK	16-QAM	16-QAM	64-QAM	64-QAM	256-QAM	256-QAM
Necessary bandwidth (MHz)	50	50	50	50	50	50	50	50
Tx power (dBW)	0	–13	5	–10	7	7	7	–4
Antenna gain (dBi)	16	29	18	33	9 to 23	39 to 48	28	39
Transmit e.i.r.p. (dBW)	16	16	23	23	16 to 30	46 to 55	35	35
Antenna beamwidth (degrees)	45 or 90	1.9	45 or 90	1.7	15 to 120	0.5 to 1	45 or 90	1.7
Antenna polarization	H/V	H/V	H/V	H/V	H/V	H/V	H/V	H/V
Rx noise figure (dB)	7	7	5	6	5	5	5	5
Rx noise temperature (K)	1 740	1 740	1 160	1 450	1 160	1 160	1 160	1 160
Rx sensitivity, (1×10^{-6} BER) (dBW)	–110	–110	–102	–101	–102.9	–102.9	–90	–90
Maximum interference (dB(W/MHz))	–146.2	–146.2	–148.0	–147.0	–148.8	–148.8	–148.0	–148.0

TABLE 31

System characteristics of P-MP systems operating in the range 30-40 GHz

Frequency band (GHz)	31.8-33.4											
Multiple access method	TDMA						FDMA					
Modulation	2-level		4-level		16-level		4-level		8-level		16-level	
Station type	CS	TS	CS	TS	CS	TS	CS	TS	CS	TS	CS	TS
Capacity/transmission rate (Mbit/s)/per sector	8 × 2 or equivalent	8 × 2 or equivalent	16 × 2 or equivalent	16 × 2 or equivalent	32 × 2 or equivalent	32 × 2 or equivalent	32	2	48	2	64	2
Channel spacing (MHz)	28	28	28	28	28	28	28	28	28	28	28	28
Tx necessary bandwidth (MHz)	28	28	28	28	28	28	28	1.5	28	1.1	28	0.8
Antenna gain (maximum) (dBi) Terminal dish/planar 90°/45°/15° sector planar	14/17/20	41/28	14/17/20	41/28	14/17/20	41/28	14/17/20	41/28	14/17/20	41/28	14/17/20	41/28
Feeder/multiplexer loss (minimum) (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Antenna type	Sector	Dish	Sector	Dish	Sector	Dish	Sector	Dish	Sector	Dish	Sector	Dish
Antenna polarization	V/H	V/H	V/H	V/H	V/H	V/H	V/H	V/H	V/H	V/H	V/H	V/H
Antenna beamwidth (3 dB) azimuth/elevation (degrees)	> 15	1.2/1.2	1 > 15	1.2/1.2	> 15	1.2/1.2	> 15	1.2/1.2	1 > 15	1.2/1.2	> 15	1.2/1.2
Maximum Tx output power (dBW)	–5	–10	–5	–10	–5	–10	–5	–20	–5	–20	–5	–20
e.i.r.p (maximum with/without ATPC) (dBW)	15	31/18	15	31/18	15	31/18	15	21/8	15	21/8	15	21/8
ATPC – range (dB)	10	> 20	10	> 20	10	> 20	15	15	15	15	15	15
Receiver IF bandwidth (MHz)	28	28	28	28	28	28	28/1.3	1.3	28/1.3	1.1	28/0.75	0.75
Receiver noise figure (dB)	7	7	7	7	7	7	7	7	7	7	7	7
Receiver thermal noise (dBW)	–122.5	–122.5	–122.5	–122.5	–122.5	–122.5	–135	–135	–137	–137	–138	–138
Nominal Rx input level (dBW)												
Rx input level for 1×10^{-3} BER (dBW)	–116.5	–116.5	–114.5	–114.5	–105.5	–105.5	–127	–127	–126	–126	–121	–121
Range of cell radius (km)	7	7	5	5	2-3	2-3	5-6	5-6	4	4	2-3	2-3
Typical fade margin (dB)							23	23	20	20	18	18
Availability target (% time)	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
Nominal long-term interference[4, 5] (dBW)	–132.5	–132.5	–132.5	–132.5	–132.5	–132.5	–147	–147	–147	–147	–147	–147
Spectral density (dB(W/MHz))							–137	–137	–137	–137	–137	–137
Refer to Notes							(1), (2)	(1), (2)	(1), (2)	(1), (2)	(1), (2)	(1), (2)

TS: terminal station

(1) For a 2 Mbit/s signal, maximum Tx. Output CS refers to total output.

(2) Code rate 3/4.

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

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

TABLE 32

System characteristics of P-MP systems operating in the range 30-40 GHz

Frequency band (GHz)	37.0-40.0											
Multiple access method	TDMA						FDMA					
Modulation	2-level		4-level		16-level		4-level		8-level		16-level	
Station type	CS	TS	CS	TS	CS	TS	CS	TS	CS	TS	CS	TS
Capacity/transmission rate (Mbit/s)/ per sector	8 × 2 or equivalent	8 × 2 or equivalent	16 × 2 or equivalent	16 × 2 or equivalent	32 × 2 or equivalent	32 × 2 or equivalent	32	2	48	2	64	2
Channel spacing (MHz)	28	28	28	28	28	28	28	28	28	28	28	28
Tx necessary bandwidth (MHz)	28	28	28	28	28	28	28	1.5	28	1.1	28	0.8
Antenna gain (maximum) (dBi) Terminal dish/planar 90°/45°/15° sector planar	14/17/20	41/28	14/17/20	41/28	14/17/20	41/28	14/17/20	41/28	14/17/20	41/28	14/17/20	41/28
Feeder/multiplexer loss (minimum) (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Antenna type	Sector	Dish	Sector	Dish	Sector	Dish	Sector	Dish	Sector	Dish	Sector	Dish
Antenna polarization	V/H	V/H	V/H	V/H	V/H	V/H	V/H	V/H	V/H	V/H	V/H	V/H
Antenna beamwidth (3 dB) azimuth/elevation (degrees)	> 15	1.2/1.2	1 > 15	1.2/1.2	> 15	1.2/1.2	> 15	1.2/1.2	1 > 15	1.2/1.2	> 15	1.2/1.2
Maximum Tx output power (dBW)	–5	–10	–5	–10	–5	–10	–5	–20	–5	–20	–5	–20
e.i.r.p (maximum with/without ATPC) (dBW)	15	31/18	15	31/18	15	31/18	15	21/8	15	21/8	15	21/8
ATPC – range (dB)	10	> 20	10	> 20	10	> 20	15	15	15	15	15	15
Receiver IF bandwidth (MHz)	28	28	28	28	28	28	28/1.3	1.3	28/1.3	1.1	28/0.75	0.75
Receiver noise figure (dB)	8	8	8	8	8	8	7	7	7	7	7	7
Receiver thermal noise (dBW)	–121.5	–121.5	–121.5	–121.5	–121.5	–121.5	–135	–135	–137	–137	–138	–138
Nominal Rx input level (dBW)												
Rx input level for 1×10^{-3} BER (dBW)	–115.5	–115.5	–113.5	–113.5	–104.5	–104.5	–127	–127	–126	–126	–121	–121
Range of cell radius (km)	5-6	5-6	4	4	2	2	4	4	3	3	1-2	1-2
Typical fade margin (dB)							23	23	20	20	18	18
Availability target (% time)	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
Nominal long-term interference[4, 5] (dBW)	–131.5	–131.5	–131.5	–131.5	–131.5	–131.5	–147	–147	–147	–147	–147	–147
Spectral density (dB(W/MHz))							–137	–137	–137	–137	–137	–137
Refer to Notes							(1), (2)	(1), (2)	(1), (2)	(1), (2)	(1), (2)	(1), (2)

(1) For a 2 Mbit/s signal, maximum Tx. Output CS refers to total output.

(2) Code rate 3/4.

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

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

TABLE 33

FS system parameters for FS frequency sharing between 60 and 70 GHz

Frequency band (GHz)	64-66 (FDD)					64-66 (TDD)				64-66 (FDD)		
Modulation	4-FSK	4-FSK	4-FSK	4-FSK	16-QAM	4-FSK	4-FSK	4-FSK	4-FSK	4-FSK	4-FSK	4-FSK
Capacity (Mbit/s)	2×2	8	2×8	34	155	$2 \times 2^{(x)}$	$4 \times 2^{(x)}$	$2 \times 8^{(x)}$	$4 \times 8^{(x)}$	1.544	6.2	45
Channel spacing (MHz)	3.5	7	14	28	56	3.5	7	14	28	2.5	5	40
Antenna gain (maximum) (dBi)	46*	46*	46*	46*	46*	46*	46*	46*	46*	37**	37**	37**
Feeder/multiplexer loss (minimum) (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Antenna type	Dish, horn	Dish, horn	Dish, horn	Dish, horn	Dish, horn	Dish, horn	Dish, horn	Dish, horn	Dish, horn	Dish, horn	Dish	Dish
Maximum Tx output power (dBW)	–20	–20	–20	–20	–20	–20	–20	–20	–20	–10	–10	0
e.i.r.p. (maximum) (dBW)	25	25	25	25	25	25	25	25	25	27	27	37
Receiver IF bandwidth (MHz)	2	4	8	17	40					2.5	5	40
Receiver noise figure (dB)	12	12	12	12	9					10	10	10
Receiver thermal noise (dBW)	–129	–126	–123	–120	–119					–130	–127	–118
Nominal Rx input level (dBW)	–109 + M	–106 + M	–103 + M	–100 + M	–98 + M							
Rx input level for 1×10^{-3} BER (dBW)	–112	–109	–106	–103	–101					–122	–116	–107.5
Nominal long-term interference (dBW)	–139	–136	–133	–130	–129					–140	–137	–128
Spectral density (dB(W/MHz))	–142	–142	–142	–142	–145					–144	–144	–144
Refer to Notes	(2), (4)	(2), (4)	(2), (4)	(2), (4)	(2), (4)					(2), (4)	(2), (4)	(2), (4)

(x) sum of capacity for both directions

* 0.45 m dish assumed.

** 0.3 m dish assumed.

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

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

TABLE 34

System characteristics of FS P-MP systems in the range 25-27 GHz

	Type 1 (TDD)			Type 2 (FDD)		
Service type	P-MP			P-MP		
Frequency band (GHz)	25.25-27.0	25.25-27.0	25.25-27.0	25.25-27.0	25.25-27.0	25.25-27.0
Multiple access	TDMA/TDD	TDMA/TDD	TDMA/TDD	TDMA/FDD	TDMA/FDD	TDMA/FDD
Modulation	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK
Capacity (Mbit/s)	50	50	50	52	13	13
Channel spacing (MHz)	40	40	40	40	10	10
	CS-OS	OS-CS	OS-CS	CS-OS	OS-CS	OS-CS
Condition	Clear-air	Clear-air	Rain-faded	Clear-air	Clear-air	Rain-faded
Antenna gain (maximum) (dBi)	12	35	35	15	32	32
Feeder/multiplexer loss (minimum) (dB) (5)	6	0	0	0	0	0
Antenna type	60° sector	Plate	Plate	90° sector	Plate	Plate
Maximum Tx output power (dBW)	–11.3	–21.3	–11.3	–4	–20	–10
Maximum Tx P.S.D. (dB(W/MHz))	–25.3	–35.3	–25.3	–18.1	–28.1	–18.1
e.i.r.p. (maximum) (dBW)	–5.3	13.7	23.7	11	12	22
e.i.r.p spectral density (dB(W/MHz))	–19.3	–0.3	9.7	–3.1	3.9	13.9
Receiver IF bandwidth (MHz)	32.2	32.2	32.2	33.4	8.4	8.4
Receiver noise figure (dB)	7	7	7	6	6	6
Receiver thermal noise (dBW)	–122.9	–122.9	–122.9	–122.8	–128.8	–128.8
Rx input level for 1×10^{-6} BER (dBW)	–108.9	–108.9	–108.9	–106.8	–112.8	–112.8
Rx E_b/N_0 for 1×10^{-6} BER (dB)	7.9	7.9	7.9	13	13	13
Nominal long-term interference (dBW)	–132.9	–132.9	–132.9	–132.8	–138.8	–138.8
Spectral density (dB(W/MHz))	–146.8	–146.8	–146.8	–146.9	–146.9	–146.9
Refer to Notes	(1), (2)	(1), (2)	(1), (2)	(1), (2)	(1), (2)	(1), (2)

OS: out station (subscriber station)

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

(2) Specified interference level is total power within the receiver bandwidth.

(5) For bands above 20 GHz, current FS installations have outdoor applications: indoor applications are possibly found as custom arrangement. Feeder losses, whenever mentioned, are considered as ranging from 0 dB to the value mentioned in the Table.

TABLE 35

System characteristics of FS P-MP systems operating in the range 30-60 GHz

Frequency band (GHz)	51.4-52.6											
Multiple access method	TDMA						FDMA					
Modulation	2-level		4-level		16-level		4-level		8-level		16-level	
Station type	CS	TS	CS	TS	CS	TS	CS	TS	CS	TS	CS	TS
Capacity/transmission rate (Mbit/s)/ per sector	8 × 2 or equivalent	8 × 2 or equivalent	16 × 2 or equivalent	16 × 2 or equivalent	32 × 2 or equivalent	32 × 2 or equivalent	32	2	48	2	64	2
Channel spacing (MHz)	28	28	28	28	28	28	28	28	28	28	28	28
Tx necessary bandwidth (MHz)	28	28	28	28	28	28	28	1.5	28	1.1	28	0.8
Antenna gain (maximum) (dBi) Terminal dish/planar 90°/45°/15° sector planar	14/17/20	41/28	14/17/20	41/28	14/17/20	41/28	14/17/20	41/28	14/17/20	41/28	14/17/20	41/28
Feeder/multiplexer loss (minimum) (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Antenna type	Sector	Dish	Sector	Dish	Sector	Dish	Sector	Dish	Sector	Dish	Sector	Dish
Antenna polarization	V/H	V/H	V/H	V/H	V/H	V/H	V/H	V/H	V/H	V/H	V/H	V/H
Antenna beamwidth (3 dB) azimuth/elevation (degrees)	> 15	1.2/1.2	1 > 15	1.2/1.2	> 15	1.2/1.2	> 15	1.2/1.2	> 15	1.2/1.2	> 15	1.2/1.2
Maximum Tx output power (dBW)	–10	–15	–10	–15	–10	–15	–5	–20	–5	–20	–5	–20
e.i.r.p (maximum with/without ATPC) (dBW)	10	26/13	10	26/13	10	26/13	15	21/8	15	21/8	15	21/8
ATPC – range (dB)	10	> 15	10	> 15	10	> 15	15	15	15	15	15	15
Receiver IF bandwidth (MHz)	28	28	28	28	28	28	28/1.3	1.3	28/1.3	1.1	28/0.75	0.75
Receiver noise figure (dB)	10	10	10	10	10	10	7	7	7	7	7	7
Receiver thermal noise (dBW)	–119.5	–119.5	–119.5	–119.5	–119.5	–119.5	–135	–135	–137	–137	–138	–138
Nominal Rx input level (dBW)												
Rx input level for 1×10^{-3} BER (dBW)	–113.5	–113.5	–111.5	–111.5	–102.5	–102.5	–127	–127	–126	–126	–121	–121
Range of cell radius (km)	4	4	2-3	2-3	< 1	< 1	2-3	2-3	1-2	1-2	< 1	< 1
Typical fade margin (dB)							23	23	15-20	15-20	15-20	15-20
Availability target (% time)	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
Nominal long-term interference (dBW)[4, 5]	–129.5	–129.5	–129.5	–129.5	–129.5	–129.5	–147	–147	–147	–147	–147	–147
Spectral density (dB(W/MHz))							–137	–137	–137	–137	–137	–137
Refer to Notes							(1), (2)	(1), (2)	(1), (2)	(1), (2)	(1), (2)	(1), (2)

(1) For a 2 Mbit/s signal, maximum Tx. Output CS refers to total output.

(2) Code rate 3/4.

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

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

TABLE 36

Examples and representative characteristics of multimedia wireless systems in the range 40.5 to 43.5 GHz

Parameter	Uplink/downlink
Frequency band (GHz)	40.5-43.5
System type	Mesh
RF Tx rate (Mbit/s)(1)	100 maximum
Modulation scheme(2)	QPSK
Tx power (dBW)	–10
Antenna polarization(3)	Circular
Antenna gain (dBi)	22-35
Feeder/antenna system loss (dB)(4)	2-6
Max e.i.r.p. (dBW)	6-23
Rx bandwidth (MHz)(5)	10-75
Rx thermal noise (dBW)(6)	–120
Rx threshold (dBW)	–107
Maximum interference (dB(W/MHz))(7)	–149
Availability targets (%)(8)	99.9-99.999
Fade margin (dB)	10-30
Path length (km)	1-5
User capacity	64 kbit/s-40 Mbit/s, full duplex

(1) Could be lower depending on the traffic requirements.

(2) Higher order schemes are under study.

(3) Vertical under study.

(4) For bands above 20 GHz, current FS installations have outdoor applications: indoor applications are possibly found as custom arrangement. Feeder losses, whenever mentioned, are considered as ranging from 0 dB to the value mentioned in the Table.

(5) Dependant on the delivered bit rate.

(6) For a 75 MHz bandwidth.

(7) At the receiver input and based on a 0.5 dB degradation in C/N. Therefore the maximum interferer is assumed to be 10 dB below receiver thermal noise ($I/N = -10$ dB).

(8) Dependant on the market sector addressed.

TABLE 37

Representative characteristics of microwave video distribution systems (MVDS) and associated multi-user access systems operating in the range 40.5-43.5 GHz

System type	Digital MVDS	Multi-access (downlink)	Multi-access (uplink)
Data rate (Mbit/s)	34	≤ 11 (adaptive)	≤ 11 (adaptive)
Modulation type	QPSK	Multi-symbol QPSK	Multi-symbol QPSK
Channel width (MHz)	39	19.5	19.5
Transmit power (dBW)	–3	–6	–12
Transmit antenna gain (dBi)	15	15	38
Transmit e.i.r.p. (dBW)	12	9	26
Transmit antenna azimuth beamwidth (degrees)	64	64	2
Antenna polarization	H/V	H/V	H/V
Receive antenna gain (dBi)	32	38	15
Receiver noise figure (dB)	7	8	7
Receiver noise temperature (K)	1 163	1 540	1 163
Receiver sensitivity for 1×10^{-6} BER (dBW)	–109	–114	–115
Maximum interference (dB(W/MHz))	–148	–147	–148

NOTE 1 – The data for the representative digital MVDS system conforms to that used in some national standards.

NOTE 2 – Channel width indicates the bandwidth that needs to be allocated for transmissions of the stated type; the effective receiver bandwidth will be adaptive and appropriate to the delivered bit rate.

NOTE 3 – Receive antenna gain is the peak value (with no derating for pointing inaccuracy); this is the relevant figure for assessing the effect of external interference.

NOTE 4 – The maximum interference level has been set for a maximum $I/N = -10$ dB where N is the receiver thermal noise floor.

TABLE 38

Representative characteristics of a 42 GHz interactive MVDS system

	Hub	**Remote**
Modulation	QPSK/16-QAM	DQPSK
Bandwidth (MHz)	8/36	2/10
Tx power maximum (dBW)	0	–10
Antenna gain[(1)] (dBi)	15	34
Antenna beamwidth[(1)] (degrees)	64	2
Polarization	H/V	H/V
Rx noise figure (dB)	5	6
Rx sensitivity (BER 1×10^{-6})	–118	–124
Maximum interference (dB(W/MHz))	–150.5	–149

(1) Omnidirectional antennas or further sectorization may also be used.

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 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 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 39 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 39

Capacity	64 kbit/s	2 Mbit/s	45 Mbit/s
Modulation	QPSK	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 electronic news gathering (ENG) links. A reference set of characteristics has been extracted from Tables 5, 8 and 9 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 ITU-R SF-Series 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 P-MP systems

The information presented in Tables 40 and 41 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 40

Typical characteristics

Parameter	Central station	Out station
Antenna type	Omni/sector	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 41

Worst-case characteristics

Parameter	Central station	Out station
Antenna type	Omni/sector	Dish/horn
Antenna gain (dBi)	13/21[1]	27/12
e.i.r.p. (maximum) (dBW):		
– analogue	23	23
– digital	24	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 AM-DSB MVDS applications in the United States of America in the frequency bands 2 150-2 162 MHz and 2 500-2 690 MHz.

6 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 42. These systems are designed to operate in the 2 025-2 110 MHz and 2 200-2 290 MHz bands.

TABLE 42

Characteristics of an example CDMA local access radio system

Frequency band (GHz)	2	
System type	Fixed P-MP (CDMA)	
RF transmission rate (kbit/s)	2 048	
Modulation	4-PSK	
	Central station	Out station
Transmit power (dBW)	–10.0 (per out station)	–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 out station[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 (% of time)	99.99	99.99
Typical fade margin (dB)	< 20	< 20
Path length (km)	1-15	1-15

[1] Maximum e.i.r.p.: 8.5 dBW.

[2] APC is employed, therefore typical powers may be 0-20 dB less.

[3] Typical signal level for a system with 15 out stations.

The characteristics of another example P-MP system are summarized in Table 43 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 out-station antenna pattern, the reference pattern of Recommendations ITU-R F.699 and ITU-R F.1245 should be assumed.

TABLE 43

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:

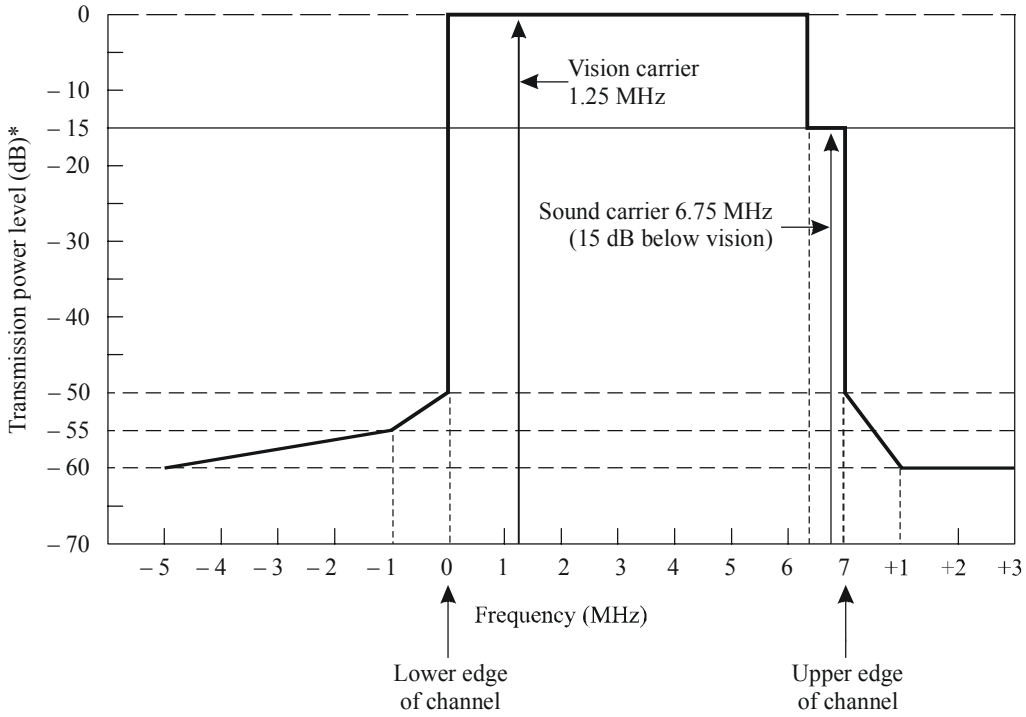
- 100 W at 5°, decreasing linearly to 31.6 W at 10°;
- 31.6 W between 10° and 15°;
- 31.6 W at 15°, decreasing linearly to 10 W at 20°; and
- 10 W between 20° and 90°.

NOTE 1 – Coordination level for protection of MDS receivers anywhere within service area is –146.2 dB(W/(m^2 · 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)



* Power level relative to maximum power.

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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

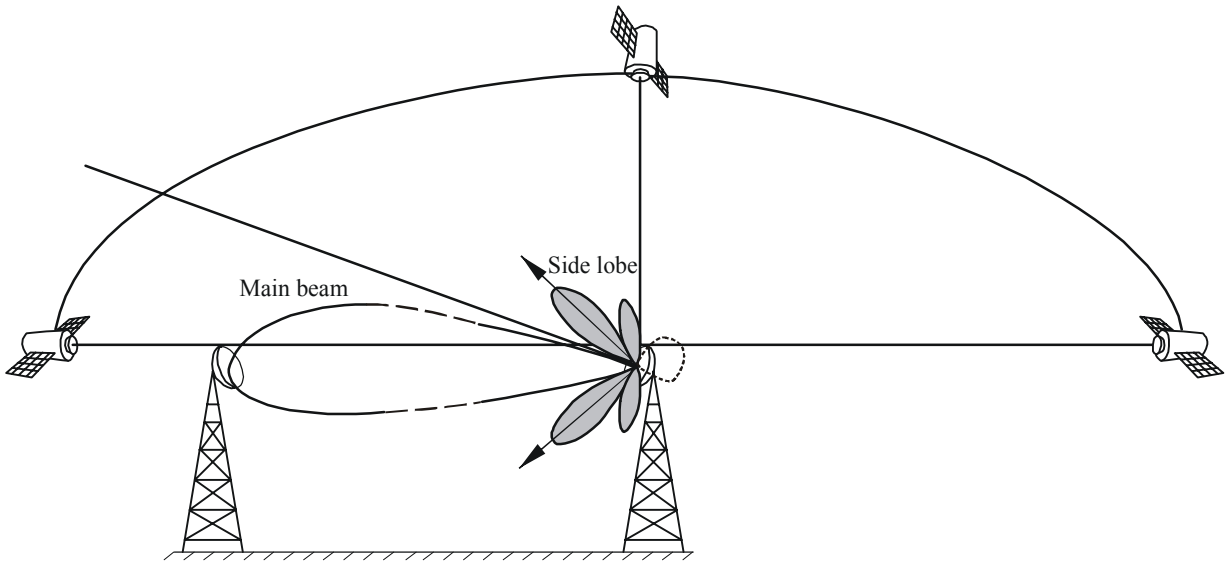
Calculation of the coordination area is done for the worst-case situation, which means that radio-relay link antenna pointing is taken to be towards the station of the other service. In such cases interference is then through the main beam and for the worst case the highest gain antennas are normally 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 geostationary, 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 2 to 35. 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 44 gives typical minimum antenna gains by frequency bands.

TABLE 44

Typical minimum antenna gains by frequency band

Frequency band (GHz)	Gain (minimum) (dBi)	(1)
1.35-1.53	11.2	P-MP
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	P-MP
2.45-2.69	10	P-MP
3.4-3.456		
3.4-3.6	27.5	AM-TV
3.6-4.2	16	P-MP
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 1 800 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	41	34-155 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	33	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	P-MP
30-40	16	P-MP
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.