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Radiocommunication Sector of ITU

Recommendation ITU-R M.1732-3
(02/2023)

Characteristics of systems operating in the amateur and amateur-satellite services for use in sharing studies

M Series

Mobile, radiodetermination, amateur and related satellite services

ITU International Telecommunication Union

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

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RECOMMENDATION ITU-R M.1732-3*

Characteristics of systems operating in the amateur and amateur-satellite services for use in sharing studies

(Question ITU-R 48-6/5)

(2005-2012-2017-2023)

Scope

This Recommendation documents the technical and operational characteristics of systems used in the amateur service and amateur-satellite services for the purposes of carrying out sharing studies. The systems and their characteristics described in this Recommendation are considered representative of those operating in the frequency bands available to these services ranging from 135.7 kHz through 250 GHz.

Keywords

Amateur, amateur-satellite, characteristics, sharing techniques

The ITU Radiocommunication Assembly,

considering

a) that the Radio Regulations (RR) defines an amateur service and an amateur-satellite service and allocates frequencies to them on an exclusive or shared basis;

b) that systems in the amateur and amateur-satellite services operate over a wide range of frequencies;

c) that the technical characteristics of systems operating in the amateur and amateur-satellite services may vary within a band;

d) that some ITU-R technical groups are considering the potential for the introduction of new types of systems or services in bands used by systems operating in the amateur and amateur-satellite services;

e) that representative technical and operational characteristics of systems operating in the amateur and amateur-satellite services are required to determine the feasibility of introducing new types of systems into frequency bands in which the amateur and amateur-satellite services operate;

f) that communications between amateur stations are generally achieved at a relatively low signal to noise ratios as any increase to the noise floor may cause interference,

recommends

1 that the technical and operational characteristics of systems operating in the amateur and amateur-satellite services described in Annex 1 may be considered representative of those operating in the frequency bands allocated to the amateur and amateur-satellite services;

2 that Recommendation ITU-R M.1044 should be used as a guide in studies of the compatibility between systems operating in the amateur and amateur-satellite services and systems operating in other services.

* This Recommendation should be brought to the attention of Radiocommunication Study Group 1.

Annex 1

Characteristics of systems operating in the amateur and amateur-satellite services for use in sharing studies

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1 Introduction

A number of frequency bands are allocated to the amateur and amateur-satellite services throughout the spectrum. These bands provide different propagation characteristics and allow experimentation using different technologies as applicable to the different operating frequencies.

Amateur and amateur-satellite stations perform a variety of functions, such as:

– training, intercommunication between amateur stations and technical investigations by duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest (RR Nos. **1.56** and **1.57**);

– disaster relief communications as elaborated in Recommendation ITU-R M.1042.

To achieve these aims, amateurs make use of existing mature and leading-edge technology to advance their self-education, technical interests and service to the wider community including providing communications for disaster relief as well as employing amateur radio as a tool for teaching young students in the field of radiocommunications. Amateur operators often apply communications technology in new and innovative ways to meet their needs in an increasingly crowded and noisy electromagnetic spectrum.

As new technology becomes available, it is applied by amateurs to extending the range and capability of their amateur stations, and this feeds back into new ideas and uses that might have application in the wider community through commercial non-amateur providers.

The bands and modes listed in this Recommendation are those currently used by the amateur and amateur-satellite services; as usage, band allocations and technology changes, this Recommendation will be updated to reflect the most recent developments and outcomes of the regular World Radiocommunication Conferences.

2 Operational characteristics

Amateur stations and amateur-satellite earth stations generally do not have assigned frequencies but dynamically select frequencies within an allocated band using listen-before-talk techniques. Terrestrial repeaters, digital relay stations and amateur-satellites use frequencies within these frequency bands selected on the basis of voluntary coordination.

Some amateur frequency allocations are exclusive to the amateur and amateur-satellite services, while other allocations are shared with other radio services. Amateur operators are aware of their obligations to not cause harmful interfere to, and the need to coexist with other users or services.

Communications may be initiated on prearranged schedule or by one station initiating a general or specific call. One or more stations may respond to the call. Weak signal radio contacts are highly dependent on natural phenomena that occur at unexpected moments. Formal and informal radio networks involving groups of operators may be initiated as needed. Contacts may last from about 1 minute to about 1 hour, depending on traffic to be transmitted. In specific applications including, e.g. emergency and disaster-relief, amateur radio networks may utilize automatic link establishment[1], IP or other mesh networks to maximize communications throughput.

Generally amateur stations will spend considerably more of their operating time receiving than transmitting.

Selection of frequency bands varies according to communication requirements and propagation:

– LF and MF bands typically use ground wave propagation and sky wave propagation over medium distance communication paths;

– HF bands are used for near-vertical-incidence-sky wave and low angle sky wave propagation for regional and global communications;

– VHF, UHF and SHF bands are generally used for short-range communications, however, there are times when suitable propagation conditions allow beyond line-of-sight communications, under such conditions it is not uncommon for VHF and UHF signals to span 600 to 2 500 km;

– Amateur satellites afford an opportunity for long-distance communications without the need for favourable ionospheric propagation conditions; and

– Signals bounced off the Moon offer worldwide communication paths. However, this technique is used by only a small number of amateur operators.

In many cases, because of restricted transmitter power, communications between amateur stations are achieved under a relatively low signal to noise ratio compared to commercial communication links and application in other services. Consequently, increases in the ambient radio frequency noise floor may severely limit the ability of amateur stations to successfully communicate. The criterion of interfering signal power to receiver noise power level I/N, of −6 dB should be considered as the protection trigger level for stations of the amateur and amateur-satellite service in sharing and compatibility studies with other services.

3 Technical characteristics

Tables 1 to 8 contain technical characteristics of representative systems operating in the amateur and amateur-satellite services. This information is provided for general calculations to assess the compatibility between these systems and systems operating in other services. The upper frequency boundaries shown in Tables 1 to 8 represent the current state of deployment of most amateur radio systems. As amateur usage of the 135.7-137.8 kHz and 472-479 kHz frequency bands is restricted to maximum radiated power of 1 W (e.i.r.p.)[2] and electrically short antennas in a high noise environment, operation on these bands is generally different to higher frequency bands. To establish communications with distant stations weak-signal techniques and operating protocols have been

[1] "Frequency-Adaptive Communications Systems and Networks in the MF/HF Bands", ITU Radiocommunication Bureau, 2002. https://www.itu.int/pub/R-HDB-40

[2] Administrations may increase this limit to 5 W e.i.r.p. in accordance with RR No. **5.80A**.

developed for use in this difficult environment and representative characteristics are shown in Table 4. These techniques utilize digital signal processing, forward error correction and bandwidth optimization to minimize the effects of high levels of natural and man-made noise.

Tables 1 through 8 contain data on receiver parameters, transmitter power, antenna gain and radiated power (e.i.r.p.) and it should be noted that the values shown are notional and operational characteristics and any given amateur service station may deviate from specific values given in the following Tables. This particularly applies to transmitter power which is often more likely to be determined by the licence conditions of individual countries, equipment availability and the need/interest of the individual amateur station, so the actual transmitter power used is very likely to be significantly less than the maximum values shown in the Tables.

Another factor to consider is that various transmission modes have significantly different duty cycles and this affects the average power that is actually radiated. For continuous-carrier modes, e.g. F3E (FM), the power shown is constant for the duration of the transmission. For intermittent transmission modes, e.g. A1A (CW), the power shown is during key-down and the average power during a transmission is approximately 45% of the value shown. For single-sideband (SSB) voice, Emission Class J3E, the power shown is expressed as peak envelope power (PEP). The average power per transmission depends upon the characteristics of the operator's voice and is typically 30 to 40% of the value shown. For emission class A3E (AM), the power shown is PEP and the average power per transmission is about 80% of the value shown. Narrowband digital modes (which require a bandwidth of less than 3 kHz) typically operate at far less than the maximum power authorized because high power is not needed for reliable communications.

Similarly for antenna gain and feeder loss, the maximum values shown are also notional and the actual antenna gain and feeder loss at any amateur station will be affected by near field effects, cost considerations, equipment availability, local planning regulations and individual operator needs.

For all Tables covering receiving modes, a typical receiver noise figure (NF) has been given for the various bandwidths. These figures are taken from either the specifications of commercially manufactured amateur equipment, or from measurements made on amateur home-built equipment for those frequency bands where commercial manufactured amateur equipment is not available.

To improve the usability of the data in Tables 1 through 8 the frequency ranges in the Tables have been arranged to group, as far as possible, frequency bands that use similar techniques and equipment, noting that the techniques used by the amateur service continues to evolve over time as technology, equipment availability and the regulatory environment changes, so individual characteristics for any particular band or mode of transmission may be different to the values in the Tables. The need for additional application information will depend upon the specific band sharing issues.

TABLE 1A

Characteristics of terrestrial amateur systems for Morse on-off keying, narrow-band digital modes and weak signal modes below 900 MHz

Parameter	Value				
Frequency range (MHz)[1]	1.8-7.3	10.1-29.7	50-54	144-225	420-450
Necessary bandwidth and class of emission (emission designator)	150HA1A 150HJ2A 60H0J2B 250HF1D 2K70A1D[2] 2K70F1D[2]	150HA1A 150HJ2A 60H0J2B 250HF1D 2K70A1D[2] 2K70F1D[2]	150HA1A 150HJ2A 60H0J2B 250HF1D 2K70A1D[2] 2K70F1D[2]	150HA1A 150HJ2A 60H0J2B 250HF1D 2K70A1D[2] 2K70F1D[2]	150HA1A 150HJ2A 60H0J2B 250HF1D 2K70A1D[2] 2K70F1D[2]
Transmitter power (dBW)[3]	3 to 31.7	3 to 31.7	3 to 31.7	3 to 31.7	3 to 31.7
Feeder loss (dB)	0.2	0.3 to 0.9	1 to 2	1 to 2	1 to 2
Transmitting antenna gain (dBi)	–20 to 6	–10 to 12	−6 to 12	−6 to 18	−3 to 23
Typical e.i.r.p. (dBW)[4]	–17 to 23	–7 to 26	2 to 26	2 to 34	2 to 36
Antenna polarization	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical
Receiver IF bandwidth (kHz)	0.5, 2.7	0.5, 2.7	0.5, 2.7	0.5, 2.7	0.5, 2.7
Receiver noise figure (dB)[5]	13	7 to 13	0.5 to 6	0.5 to 2	0.5 to 1

[1] Amateur bands within the frequency ranges shown conform to RR Article **5**.

[2] "Weak signal modes" are structured for very basic communications with low data rate and narrow bandwidth for best weak signal performance. Well known and commonly used weak signal modes include WSPR, FT8, JT65, Q65 and their derivatives. The listed bandwidths are the most used receiving bandwidth for these modes.

[3] Maximum powers are determined by each administration.

[4] Maximum e.i.r.p. may be limited by RR Article **5** in some cases, see for example No. **5.133B**.

[5] There are also high data rate modes such as FSK441, MSK144, ISCAT etc. which are used for meteor scatter or other experiments with an extremely short reflection duration and the required bandwidth is typically 2.7 kHz.

[6] Receiver noise figures for bands above 50 MHz assume the use of low-noise preamplifiers. Below 29.7 MHz the external noise level is the dominant factor and typically higher than the receiver noise level.

TABLE 1B

Characteristics of terrestrial amateur systems for Morse on-off keying, narrow-band digital modes above 900 MHz

Parameter	Value			
Frequency range (GHz)[1]	0.902-3.5	5.65-10.5	24-47.2	76-250
Necessary bandwidth and class of emission (emission designator)	150HA1A 150HJ2A 60H0J2B 250HF1B	150HA1A 150HJ2A 60H0J2B 250HF1B	150HA1A 150HJ2A 60H0J2B 250HF1B	150HA1A 150HJ2A 60H0J2B 250HF1B
Transmitter power (dBW)[2]	3 to 31.7	3 to 20	–10 to 10	–20 to 0
Feeder loss (dB)	1 to 6	1 to 6	0 to 6	0 to 6
Transmitting antenna gain (dBi)	10 to 42	10 to 42	10 to 42	10 to 52
Typical e.i.r.p. (dBW)	1 to 45	1 to 45	1 to 45	1 to 45
Antenna polarization	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical
Receiver IF bandwidth (kHz)	0.5	0.5	0.5	0.5
Receiver noise figure (dB)[3]	0.5 to 1	0.5 to 1	3 to 7	3 to 7

[1] Amateur bands within the frequency ranges shown conform to RR Article **5**.

[2] The maximum allowable power is determined by each administration. Maximum transmitter power for bands above 1 GHz is typically limited by available equipment and is much less than the administration authorizes.

[3] Receiver noise figures for bands above 50 MHz assume the use of low-noise preamplifiers.

TABLE 2A

Characteristics of terrestrial amateur analogue voice systems below 900 MHz

Parameter	Value				
Frequency range (MHz)[1]	1.8-7.3	10.1-29.7	50-54	144-225	420-450
Necessary bandwidth and class of emission (emission designator)	2K70J3E	2K70J3E 11K0F3E[2] 16K0F3E[2]	2K70J3E 11K0F3E 16K0F3E 20K0F3E	2K70J3E 11K0F3E 16K0F3E 20K0F3E	2K70J3E 11K0F3E 16K0F3E 20K0F3E
Transmitter power (dBW)[3]	3 to 31.7	3 to 31.7	3 to 31.7	3 to 31.7	3 to 31.7
Feeder loss (dB)	0.2	0.3 to 0.9	1 to 2	1 to 2	1 to 2
Transmitting antenna gain (dBi)	−20 to 6	−10 to 12	−6 to 12	−6 to 18	−3 to 23
Typical e.i.r.p. (dBW)[4]	−17 to 23	−7 to 26	2 to 26	2 to 34	2 to 36
Antenna polarization	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical
Receiver IF bandwidth (kHz)	2.7	2.7, 9, 12	2.7, 9, 12, 16	2.7, 9, 12, 16	2.7, 9, 12, 16
Receiver noise figure (dB)[5]	13	7 to 13	0.5 to 6	0.5 to 2	0.5 to 1

[1] Amateur bands within the frequency ranges shown conform to RR Article **5**.

[2] Typically only used above 29 MHz.

[3] The maximum allowable power is determined by each administration.

[4] Maximum e.i.r.p. may be limited by RR Article **5** in some cases, see for example RR No. **5.133B**.

[5] Receiver noise figures for bands above 50 MHz assume the use of low-noise preamplifiers. Below 29.7 MHz the external noise level is the dominant factor and typically higher than the receiver noise level.

TABLE 2B

Characteristics of terrestrial amateur analogue voice systems above 900 MHz

Parameter	Value			
Frequency range (GHz)[1]	0.902-3.5	5.65-10.5	24-47.2	76-250
Necessary bandwidth and class emission (emission designator)	2K70J3E 11K0F3E 16K0F3E 20K0F3E	2K70J3E 11K0F3E 16K0F3E 20K0F3E	2K70J3E 11K0F3E 16K0F3E 20K0F3E	2K70J3E 11K0F3E 16K0F3E 20K0F3E
Transmitter power (dBW)[2]	3 to 31.7	3 to 20	−10 to 10	−20 to 0
Feeder loss (dB)	1 to 6	1 to 6	0 to 6	0 to 6
Transmitting antenna gain (dBi)	10 to 42	10 to 42	10 to 42	10 to 52
Typical e.i.r.p. (dBW)	1 to 45	1 to 45	1 to 45	1 to 45
Antenna polarization	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical
Receiver IF bandwidth (kHz)	2.7, 9, 12, 16	2.7, 9, 12, 16	2.7, 9, 12, 16	2.7, 9, 12, 16
Receiver noise figure (dB)[3]	0.5 to 1	0.5 to 1	3 to 7	3 to 7

[1] Amateur bands within the frequency ranges shown conform to RR Article **5**.

[2] The maximum allowable power is determined by each administration. Maximum transmitter power for bands above 1 GHz is typically limited by available equipment and is much less than the administration authorizes.

[3] Receiver noise figures for bands above 50 MHz assume the use of low-noise preamplifiers.

TABLE 3A

Characteristics of terrestrial amateur data, digital voice and multimedia systems below 900 MHz

Parameter	Value				
Frequency range (MHz)[1]	1.8-7.3	10.1-29.7	50-54	144-225	420-450
Necessary bandwidth and class of emission (emission designator)	2K70J2E	2K70J2E	2K70J2E 5K76G1E 8K10F1E 500KG7W	2K70J2E 5K76G1E 8K10F1E 150KG7W	2K70G1D 6K00F7D 16K0D1D 150KF1W 2M00G7W
Transmitter power (dBW)[2]	3 to 31.7	3 to 31.7	3 to 31.7	3 to 31.7	3 to 31.7
Feeder loss (dB)	0.2	0.3 to 0.9	1 to 2	1 to 2	1 to 2
Transmitting antenna gain (dBi)	−20 to 6	−10 to 12	−6 to 12	−6 to 18	−3 to 23
Typical e.i.r.p. (dBW)[3]	−17 to 17	−7 to 20	2 to 20	2 to 28	2 to 30
Antenna polarization	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical
Receiver IF bandwidth (kHz)	2.7	2.7	2.7, 6, 9, 500	2.7, 6, 9, 150	2.7, 6, 16, 150, 2 000
Receiver noise figure (dB)[4]	13	7 to 13	0.5 to 6	0.5 to 2	0.5 to 1

[1] Amateur bands within the frequency ranges shown conform to RR Article **5**.

[2] The maximum allowable power is determined by each administration. Wideband multimedia applications are typically limited to less than 10 dBW because of transmitter linearity concerns.

[3] Maximum e.i.r.p. may be limited by RR Article **5** in some cases, see for example RR No. **5.133B**.

[4] Receiver noise figures for bands above 50 MHz assume the use of low-noise preamplifiers. Below 29.7 MHz the external noise level is the dominant factor and typically higher than the receiver noise level.

TABLE 3B

Characteristics of terrestrial amateur data, digital voice and multimedia systems above 900 MHz

Parameter	Value			
Frequency range (GHz)[1]	0.902-3.5	5.65-10.5	24-47.2	76-250
Necessary bandwidth and class of emission (emission designator)	2K70G1D 6K00F7D 16K0D1D 150KF1W 2M50G7W	2K70G1D 6K00F7D 16K0D1D 150KF1W 10M5G7W	2K70G1D 6K00F7D 16K0D1D 150KF1W 10M5G7W	2K70G1D 6K00F7D 16K0D1D 150KF1W 10M5G7W
Transmitter power (dBW)[2]	3 to 31.7	3 to 20	−10 to 10	−20 to 0
Feeder loss (dB)	1 to 6	1 to 6	0 to 6	0 to 6
Transmitting antenna gain (dBi)	10 to 42	10 to 42	10 to 42	10 to 52
Typical e.i.r.p. (dBW)	1 to 45	1 to 45	1 to 45	1 to 45
Antenna polarization	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical
Receiver IF bandwidth (kHz)	2.7, 6, 16, 150, 2 500	2.7, 6, 16, 150, 10 500	2.7, 6, 16, 150, 10 500	2.7, 6, 16, 150, 10 500
Receiver noise figure (dB)[3]	0.5 to 1	0.5 to 1	3 to 7	3 to 7

[1] Amateur bands within the frequency ranges shown conform to RR Article **5**.

[2] The maximum allowable power is determined by each administration. Maximum transmitter power for bands above 1 GHz is typically limited by available equipment and is much less than the administration authorizes. Wideband multimedia applications are typically limited to less than 10 dBW because of transmitter linearity concerns.

[3] Receiver noise figures for bands above 50 MHz assume the use of low-noise preamplifiers.

TABLE 4

Characteristics of amateur operation in the 135.7-137.8 kHz and 472–479 kHz frequency bands

Parameter	Value		
Mode of operation	Continuous wave (CW) Morse 10 to 50 Bd	Slow Morse ≤ 1 Bd CW	Weak signal modes:[1]
Necessary bandwidth and class of emission (emission designator)	150HA1A, 150HJ2A	1H00A1B, 1H00J2B	2K10A1D, 2K10F1D 2K10J2D[4]
Typical transmitter power (dBW)	20		
Feeder loss (dB)	Negligible		
Transmitting antenna gain (dBi)	−40 to −10		
Maximum e.i.r.p. (dBW)	0[2]		
Antenna polarization	Vertical		
Receiver IF bandwidth (kHz)	0.4[3]		
Receiver noise figure (dB)	13		

[1] These modes are highly structured for weak signal performance and only send enough information to confirm a radio contact. Further information about these modes of operation can be obtained from the ARRL 2021 Handbook for Radio Communications, 68th edition, American Radio Relay League, ISBN: 978-1-62595-139-7 Well known and commonly used weak signal modes include WSPR, JT65, Q65 and their derivatives.

[2] In the frequency range 472-479 kHz, administrations may increase this limit to 5 W e.i.r.p. in accordance with RR No. **5.80A**.

[3] Digital signal processing techniques can reduce the IF bandwidth to a fraction of a Hertz if needed.

[4] The 2.1 kHz bandwidth is for the 135.7-137.8 kHz band. For the 472-479 kHz band the standard 2.7 kHz bandwidth will be used.

TABLE 5

Characteristics of Earth-Moon-Earth (EME) systems

Parameter	Value				
Frequency range[1]	144-438 MHz	1.24-3.5 GHz	5.65-10.5 GHz	24-47.2 GHz	76-250 GHz
Necessary bandwidth and class of emission (emission designator)	50H0A1A 50H0J2A 1K80F1B	50H0A1A 50H0J2A 1K80F1B	50H0A1A 50H0J2A 1K80F1B 1K50J2D	50H0A1A 50H0J2A 1K80F1B 2K00J2D	50H0A1A 50H0J2A 1K80F1B 2K40J2D
Transmitter power (dBW)[2]	17 to 31.7	17 to 31.7	13 to 20	7 to 13	0 to 10
Feeder loss (dB)	1 to 2	1 to 4	1 to 4	1 to 4	1 to 4
Transmitting antenna gain (dBi)	15 to 24	25 to 40	25 to 46	25 to 53	35 to 65
Typical e.i.r.p. (dBW)	30 to 40	40 to 68	50 to 65	55 to 70	60 to 75
Antenna polarization	Horizontal, vertical, LHCP, RHCP	Horizontal, vertical, LHCP, RHCP	Horizontal, vertical, LHCP, RHCP	Horizontal, vertical, LHCP, RHCP	Horizontal, vertical, LHCP, RHCP
Receiver IF bandwidth (kHz)	0.4	1	1.5	2	2.4
Receiver noise figure (dB)[3]	0.5	0.5	1	3 to 7	3 to 7

[1] Amateur bands within the frequency ranges shown conform to RR Article **5**.

[2] The maximum allowable power is determined by each administration. Maximum transmitter power for bands above 1 GHz is typically limited by available equipment and is much less than the administration authorises.

[3] Receiver noise figures for bands above 50 MHz assume the use of low-noise preamplifiers.

Usage note: Main antenna beam direction can be assumed to be pointing above the horizon.

Emission note: EME increasingly employs digital “Weak Signal Modes” which are structured for very basic communications with relatively low transmitter power, using low data rates and narrow bandwidth for best weak signal performance.

TABLE 6

Characteristics of amateur-satellite systems in the Earth-to-space direction

Parameter	Value					
Frequency range[1]	7–29.7 MHz	144-438 MHz	1.24-3.5 GHz	5.65-10.5 GHz	24-47.2 GHz	76-250 GHz
Necessary bandwidth and class of emission (emission designator)	150HA1A 150HJ2A	150HA1A 150HJ2A	150HA1A 150HJ2A	150HA1A 150HJ2A	150HA1A 150HJ2A	150HA1A 150HJ2A
Necessary bandwidth and class of emission (emission designator)[2]	2K70J3E 2K70J2E 8K00F3E[3]	2K70J3E 2K70J2E 5K76G1E 8K10F1E 16K0F3E	2K70J3E 2K70J2E 16K0F3E 44K2F1D 88K3F1D 350KF1D 2M50G7W	2K70J3E 2K70J2E 16K0F3E 44K2F1D 88K3F1D 350KF1D 10M0G7W	2K70J3E 2K70J2E 16K0F3E 44K2F1D 88K3F1D 350KF1D 10M0G7W	2K70J3E 2K70J2E 16K0F3E 44K2F1D 88K3F1D 350KF1D 10M0G7W
Transmitter power (dBW)[4]	3 to 31.7	3 to 23	3 to 23	3 to 20	−10 to 10	−10 to 0
Feeder loss (dB)	0.3 to 0.9	1 to 2	1 to 2	1 to 10	1 to 10	1 to 10
Transmitting antenna gain (dBi)	−10 to 12	0 to 26	10 to 42	10 to 42	10 to 42	10 to 52
Typical e.i.r.p. (dBW)	7 to 43	2 to 40	3 to 45	3 to 45	3 to 45	3 to 45
Antenna polarization	Horizontal, vertical, RHCP, LHCP	Horizontal, vertical, RHCP, LHCP	Horizontal, vertical, RHCP, LHCP	Horizontal, vertical, RHCP, LHCP	Horizontal, vertical, RHCP, LHCP	Horizontal, vertical, RHCP, LHCP
Satellite receiver noise figure (dB)[5]	3 to 10	1 to 3	1 to 3	1 to 3	3 to 7	3 to 7

[1] Amateur bands within the frequency ranges shown conform to RR Article **5**.

[2] Any mode with a necessary bandwidth greater than 44 kHz may require higher e.i.r.p. values than shown in the table to achieve a satisfactory link budget.

[3] Typically only used above 29 MHz.

[4] The maximum allowable power is determined by each administration. Maximum transmitter power for bands above 1 GHz is typically limited by available equipment and is much less than the administration authorises.

[5] Receiver noise figures for bands above 50 MHz assume the use of low-noise preamplifiers. Below 29.7 MHz the external noise level is the dominant factor and typically higher than the receiver noise level.

TABLE 7

Characteristics of amateur-satellite systems in the space-to-Earth direction for low earth orbit (LEO) satellites

Parameter	Value					
Frequency range[1]	7-29.7 MHz	144-438 MHz	1.24-3.5 GHz	5.65-10.5 GHz	24-47.2 GHz	76-250 GHz
Necessary bandwidth and class of emission (emission designator)	150HA1A 150HJ2A	150HA1A 150HJ2A	150HA1A 150HJ2A	150HA1A 150HJ2A	150HA1A 150HJ2A	150HA1A 150HJ2A
Necessary bandwidth and class of emission (emission designator)[2]	2K70J3E 2K70J2E 8K00F3E[3]	2K70J3E 2K70J2E 16K0F3E	2K70J3E 2K70J2E 16K0F3E 44K2F1D 88K3F1D 350KF1D 2M50G7W	2K70J3E 2K70J2E 16K0F3E 44K2F1D 88K3F1D 350KF1D 10M0G7W	2K70J3E 2K70J2E 16K0F3E 44K2F1D 88K3F1D 350KF1D 10M0G7W	2K70J3E 2K70J2E 16K0F3E 44K2F1D 88K3F1D 350KF1D 10M0G7W
Transmitter power (dBW)[4]	−10 to 10	−20 to 17[5]	−20 to 3	−20 to 3	−20 to 0	−20 to 0
Feeder loss (dB)	0.2 to 1	0.2 to 1	0.2 to 1	0.2 to 1	0.2 to 2	0.2 to 2
Transmitting antenna gain (dBi)	0 to 3	0 to 6	0 to 10	0 to 23	0 to 23	0 to 23
Typical e.i.r.p. (dBW)	−7 to 9	−7 to 15	−7 to 15	0 to 15	0 to 15	0 to 15
Antenna polarization	Horizontal, vertical, RHCP, LHCP	Horizontal, vertical, RHCP, LHCP	Horizontal, vertical, RHCP, LHCP	Horizontal, vertical, RHCP, LHCP	Horizontal, vertical, RHCP, LHCP	Horizontal, vertical, RHCP, LHCP
Receiver IF bandwidth (kHz)	0.4, 2.7 8	0.4, 2.7 16	0.4, 2.7, 16 50, 100 400 2 500	0.4, 2.7, 16 50, 100 400 10 000	0.4, 2.7, 16 50, 100 400 10 000	0.4, 2.7, 16 50, 100 400 10 000
Receiver noise figure (dB)[6]	3 to 10	1 to 3	1 to 7	1 to 7	3 to 7	3 to 7

Notes to Table 7

(1) Amateur bands within the frequency ranges shown conform to RR Article **5**.

(2) Any mode with a necessary bandwidth greater than 44 kHz may require higher e.i.r.p. values than shown in the table to achieve a satisfactory link budget.

(3) Typically only used above 29 MHz.

(4) The maximum allowable power is determined by each administration. Maximum transmitter power for bands above 1 GHz is typically limited by available equipment and is much less than the administration authorizes.

(5) 17 dBW is the maximum power used aboard manned spacecraft e.g. the International Space Station, small satellites use much less transmitter power, typically 10 dBW or less.

(6) Receiver noise figures for bands above 50 MHz assume the use of low-noise preamplifiers. Below 29.7 MHz the external noise level is the dominant factor and typically higher than the receiver noise level.

TABLE 8

Characteristics of amateur-satellite systems in the space-to-Earth direction for geostationary (GEO) and high earth orbit (HEO) satellites

Parameter	**Value**					
Frequency range(1)	7-29.7 MHz	144-438 MHz	1.24-3.5 GHz	5.65-10.5 GHz	24-47.2 GHz	76-250 GHz
Necessary bandwidth and class of emission (emission designator)	150HA1A 150HJ2A	150HA1A 150HJ2A	150HA1A 150HJ2A	150HA1A 150HJ2A	150HA1A 150HJ2A	150HA1A 150HJ2A
Necessary bandwidth and class of emission (emission designator)(2)	2K70J3E 2K70J2E 8K00F3E(3)	2K70J3E 2K70J2E 16K0F3E	2K70J3E 2K70J2E 16K0F3E 44K2F1D 88K3F1D 350KF1D 2M50G7W	2K70J3E 2K70J2E 16K0F3E 44K2F1D 88K3F1D 350KF1D 10M0G7W	2K70J3E 2K70J2E 16K0F3E 44K2F1D 88K3F1D 350KF1D 10M0G7W	2K70J3E 2K70J2E 16K0F3E 44K2F1D 88K3F1D 350KF1D 10M0G7W
Transmitter power (dBW)(4)	0 to 10	0 to 20	0 to 20	0 to 20	−10 to 0	−10 to 0
Feeder loss (dB)	0.2 to 1	0.2 to 1	0.2 to 1	0.2 to 1	0.2 to 2	0.2 to 2
Transmitting antenna gain (dBi)	0 to 3	0 to 6	0 to 20	0 to 20	0 to 30	0 to 30

TABLE 8 (*end*)

Parameter	Value					
Typical e.i.r.p. (dBW)	9	9 to 15	9 to 25	9 to 30	6 to 30	3 to 30
Antenna polarization	Horizontal, vertical, RHCP, LHCP	Horizontal, vertical, RHCP, LHCP	Horizontal, vertical, RHCP, LHCP	Horizontal, vertical, RHCP, LHCP	Horizontal, vertical, RHCP, LHCP	Horizontal, vertical, RHCP, LHCP
Receiver IF bandwidth (kHz):	0.4, 2.7 8	0.4, 2.7 16	0.4, 2.7, 16 50, 100 400 2 500	0.4, 2.7, 16 50, 100 400 10 000	0.4, 2.7, 16 50, 100 400 10 000	0.4, 2.7, 16 50, 100 400 10 000
Receiver noise figure (dB)[5]	3 to 10	1 to 3	1 to 7	1 to 7	3 to 7	3 to 7

[1] Amateur bands within the frequency ranges shown conform to RR Article **5**.

[2] Any mode with a necessary bandwidth greater than 44 kHz may require higher e.i.r.p. values than shown in the table to achieve a satisfactory link budget.

[3] Typically only used above 29 MHz.

[4] The maximum allowable power is determined by each administration. Maximum transmitter power for bands above 1 GHz is typically limited by available equipment and is much less than the administration authorizes.

[5] Receiver noise figures for bands above 50 MHz assume the use of low-noise preamplifiers. Below 29.7 MHz the external noise level is the dominant factor and typically higher than the receiver noise level.