

**Recommendation ITU-R M.1732-2**  
(01/2017)

**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**

## Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

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

Electronic Publication  
Geneva, 2017

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## RECOMMENDATION ITU-R M.1732-2\*

**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)

**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,

*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.

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\* 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

#### 1 Introduction

A number of frequency bands are allocated to the amateur and amateur-satellite services throughout the spectrum. These bands have been selected to provide different propagation conditions.

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. 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 selected on the basis of voluntary coordination within the amateur services.

Some amateur frequency allocations are exclusive to the amateur and amateur-satellite services. Many of the allocations are shared with other radio services and amateur operators are aware of the sharing limitations.

Communications may be initiated on prearranged schedule or by one station initiating a general or specific call. One or more stations may respond. Formal and informal nets 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 voice networks may utilize automatic link establishment<sup>1</sup> employing a variation of the 2G ALE protocol (sometimes referred to as 2.5G ALE) typically utilizing an external device.

Operating protocols vary according to communication requirements and propagation:

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<sup>1</sup> “Frequency-Adaptive Communications Systems and Networks in the MF/HF Bands”, ITU Radiocommunication Bureau, 2002. <https://www.itu.int/pub/R-HDB-40>

- 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;
- Amateur satellites afford an opportunity to use frequencies above HF for long-distance communications; and
- Signals bounced off the moon offer worldwide communication paths.

### 3 Technical characteristics

Tables 1 to 8 contain technical characteristics of representative systems operating in the amateur and amateur-satellite services. This information is sufficient for general calculation 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.)<sup>2</sup> 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 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 limitation 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 transmissions 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 duty-cycle 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. Narrow-bandwidth digital modes, e.g. J2B (PSK31), typically operate at far less than the maximum power authorized.

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 and individual operator needs.

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<sup>2</sup> Administrations may increase this limit to 5 W e.i.r.p. in accordance with RR No. **5.80A**.

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.

Following Tables of the amateur service when using the data contained in Tables 1 through 8 when undertaking sharing and compatibility studies.

**TABLE 1A**  
**Characteristics of amateur systems for Morse on-off keying, PSK31, NBDP**  
**and weak signal modes below 900 MHz**

Parameter	Value				
	1.8-7.3 MHz	10.1-29.7 MHz	50-54 MHz	144-225 MHz	420-450 MHz
Frequency range <sup>(1)</sup>	1.8-7.3 MHz	10.1-29.7 MHz	50-54 MHz	144-225 MHz	420-450 MHz
Necessary bandwidth and class of emission (emission designator)	150HA1A 150HJ2A 60HOJ2B 250HF1D 1H00A1D <sup>(2)</sup> 1H00F1D <sup>(2)</sup>	150HA1A 150HJ2A 60HOJ2B 250HF1D 1H00A1D 1H00F1D	150HA1A 150HJ2A 60HOJ2B 250HF1D 1H00A1D 1H00F1D	150HA1A 150HJ2A 60HOJ2B 250HF1D 1H00A1D 1H00F1D	150HA1A 150HJ2A 60HOJ2B 250HF1D 1H00A1D 1H00F1D
Transmitter power (dBW) <sup>(3)</sup>	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) <sup>(4)</sup>	-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	0.5	0.5	0.5	0.5
Receiver noise figure (dB) <sup>(5)</sup>	13	7 to 13	0.5 to 6	0.5 to 2	0.5 to 1

<sup>(1)</sup> Amateur bands within the frequency ranges shown conform to RR Article 5.

<sup>(2)</sup> "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, JT65 and Opera.

<sup>(3)</sup> Maximum powers are determined by each administration.

<sup>(4)</sup> May be limited by RR Article 5 in some cases.

<sup>(5)</sup> 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 amateur systems for Morse on-off keying, PSK31 and  
 NBDP above 900 MHz**

Parameter	Value			
Frequency range <sup>(1)</sup>	0.902-3.5 GHz	5.65-10.5 GHz	24-47.2 GHz	76-250 GHz
Necessary bandwidth and class of emission (emission designator)	150HA1A 150HJ2A 60H0J2B 250HF1B	150HA1A 150HJ2A 60H0J2B 250HF1B	150HA1A 150HJ2A 60H0J2B 250HF1B	150HA1A 150HJ2A 60H0J2B 250HF1B
Transmitter power (dBW) <sup>(2)</sup>	3 to 31.7	3 to 20	-10 to 10	-10 to 10
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) <sup>(3)</sup>	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) <sup>(4)</sup>	0.5 to 1	0.5 to 1	3 to 7	3 to 7

<sup>(1)</sup> Amateur bands within the frequency ranges shown conform to RR Article 5.

<sup>(2)</sup> Maximum powers are determined by each administration. Maximum powers at 24-250 GHz are typically limited by available equipment and less than the administration authorises.

<sup>(3)</sup> May be limited by RR Article 5 in some cases.

<sup>(4)</sup> Receiver noise figures for bands above 50 MHz assume the use of low-noise preamplifiers.

TABLE 2A

## Characteristics of amateur analogue voice systems below 900 MHz

Parameter	Value				
	1.8-7.3 MHz	10.1-29.7 MHz	50-54 MHz	144-225 MHz	420-450 MHz
Frequency range <sup>(1)</sup>	1.8-7.3 MHz	10.1-29.7 MHz	50-54 MHz	144-225 MHz	420-450 MHz
Necessary bandwidth and class of emission (emission designator)	2K70J3E	2K70J3E 11K0F3E <sup>(2)</sup> 16K0F3E <sup>(2)</sup>	2K70J3E 11K0F3E 16K0F3E 20K0F3E	2K70J3E 11K0F3E 16K0F3E 20K0F3E	2K70J3E 11K0F3E 16K0F3E 20K0F3E
Transmitter power (dBW) <sup>(3)</sup>	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) <sup>(4)</sup>	-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) <sup>(5)</sup>	13	7 to 13	0.5 to 6	0.5 to 2	0.5 to 1

<sup>(1)</sup> Amateur bands within the frequency ranges shown conform to RR Article 5.

<sup>(2)</sup> Typically only used above 29 MHz

<sup>(3)</sup> Maximum powers are determined by each administration.

<sup>(4)</sup> May be limited by RR Article 5 in some cases.

<sup>(5)</sup> 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 amateur analogue voice systems above 900 MHz**

Parameter	Value			
	0.902-3.5 GHz	5.65-10.5 GHz	24-47.2 GHz	76-250 GHz
Frequency range <sup>(1)</sup>				
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) <sup>(2)</sup>	3 to 31.7	3 to 20	-10 to 10	-10 to 10
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 2	10 to 52
Typical e.i.r.p. (dBW) <sup>(3)</sup>	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) <sup>(4)</sup>	0.5 to 1	0.5 to 1	3 to 7	3 to 7

<sup>(1)</sup> Amateur bands within the frequency ranges shown conform to RR Article 5.

<sup>(2)</sup> Maximum powers are determined by each administration. Maximum powers at 24-250 GHz are typically limited by available equipment and less than the administration authorises.

<sup>(3)</sup> May be limited by RR Article 5 in some cases.

<sup>(4)</sup> Receiver noise figures for bands above 50 MHz assume the use of low-noise preamplifiers.

TABLE 3A

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

Parameter	Value				
	1.8-7.3 MHz	10.1-29.7 MHz	50-54 MHz	144-225 MHz	420-450 MHz
Frequency range <sup>(1)</sup>	1.8-7.3 MHz	10.1-29.7 MHz	50-54 MHz	144-225 MHz	420-450 MHz
Necessary bandwidth and class of emission (emission designator)	2K70J2E	2K70J2E	2K70J2E 5K76G1E 8K10F1E	2K70J2E 5K76G1E 8K10F1E	2K70G1D 6K00F7D 16K0D1D 150KF1W 2M00G7W
Transmitter power (dBW) <sup>(2)</sup>	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) <sup>(3)</sup>	-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	2.7, 6, 9	2.7, 6, 16, 150 2000
Receiver noise figure (dB) <sup>(4)</sup>	13	7 to 13	0.5 to 6	0.5 to 2	0.5 to 1

<sup>(1)</sup> Amateur bands within the frequency ranges shown conform to RR Article 5.

<sup>(2)</sup> Maximum powers are determined by each administration. Duty cycle limitations may affect the transmitter power used.

<sup>(3)</sup> May be limited by RR Article 5 in some cases.

<sup>(4)</sup> 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 amateur data, digital voice and multimedia systems above 900 MHz

Parameter	Value			
	0.902-3.5 GHz	5.65-10.5 GHz	24-47.2 GHz	76-250 GHz
Frequency range <sup>(1)</sup>	0.902-3.5 GHz	5.65-10.5 GHz	24-47.2 GHz	76-250 GHz
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) <sup>(2)</sup>	3 to 31.7	3 to 20	-10 to 10	-10 to 10
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) <sup>(3)</sup>	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 2500	2.7, 6, 16, 150, 10500	2.7, 6, 16, 150, 10500	2.7, 6, 16, 150, 10500
Receiver noise figure (dB) <sup>(4)</sup>	0.5 to 1	0.5 to 1	3 to 7	3 to 7

<sup>(1)</sup> Amateur bands within the frequency ranges shown conform to RR Article 5.

<sup>(2)</sup> Maximum powers are determined by each administration. Maximum powers at 24-250 GHz are usually limited by available equipment and less than the administration maximum. Duty cycle limitations may affect the transmitter power used.

<sup>(3)</sup> May be limited by RR Article 5 in some cases.

<sup>(4)</sup> 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 $\leq 1$ Bd CW	Weak signal modes: <sup>(1)</sup>
Necessary bandwidth and class of emission (emission designator)	150HA1A, 150HJ2A	1H00A1B, 1H00J2B	2H00A1D, 2H00F1D 2H00J2D
Typical transmitter power (dBW)	20		
Feeder loss (dB)	Negligible		
Transmitting antenna gain (dBi)	-40 to -10		
Maximum e.i.r.p (dBW)	0 <sup>(2)</sup>		
Antenna polarization	Vertical		
Receiver IF bandwidth (kHz)	0.4 <sup>(3)</sup>		
Receiver noise figure (dB)	13		

<sup>(1)</sup> 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 Handbook for Radio Communications (2012 Ed.), American Radio Relay League, ISBN: 978-0-87259-677-1, published 2011 and from the ARRL HF Digital Handbook (4th Ed.), American Radio Relay League, ISBN: 0-87259-103-4, published 2008. Well known and commonly used weak signal modes include WSPR, JT65 and Opera.

<sup>(2)</sup> 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**.

<sup>(3)</sup> Digital signal processing techniques can narrow the IF bandwidth to a fraction of a Hertz if needed.

TABLE 5  
**Characteristics of Earth-Moon-Earth (EME) systems**

Parameter	Value				
	144-438 MHz	1.24-3.5 GHz	5.65-10.5 GHz	24-47.2 GHz	76-250 GHz
Frequency range <sup>(1)</sup>	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) <sup>(2)</sup>	17 to 31.7	17 to 31.7	13 to 20	13 to 20	10 to 20
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) <sup>(3)</sup>	0.5	0.5	1	3 to 7	3 to 7

<sup>(1)</sup> Amateur bands within the frequency ranges shown conform to RR Article 5.

<sup>(2)</sup> Maximum powers are determined by each administration. Maximum powers at 24-250 GHz are typically limited by available equipment and less than the administration authorises.

<sup>(3)</sup> 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 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					
	7–29.7 MHz	144–438 MHz	1.24–3.5 GHz	5.65–10.5 GHz	24–47.2 GHz	76–250 GHz
Frequency range <sup>(1)</sup>	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) <sup>(2)</sup>	2K70J3E 2K70J2E 8K00F3E <sup>(3)</sup>	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) <sup>(4)</sup>	3 to 31.7	3 to 31.7	3 to 31.7	3 to 20	–10 to 10	–10 to 10
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) <sup>(5)</sup>	3 to 10	1 to 3	1 to 3	1 to 3	3 to 7	3 to 7

<sup>(1)</sup> Amateur bands within the frequency ranges shown conform to RR Article 5.

<sup>(2)</sup> 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.

<sup>(3)</sup> Typically only used above 29 MHz.

<sup>(4)</sup> Maximum powers are determined by each administration. Maximum powers at 24–250 GHz are typically limited by available equipment and less than the administration authorises.

<sup>(5)</sup> 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					
	7 - 29.7 MHz	144-438 MHz	1.24-3.5 GHz	5.65-10.5 GHz	24-47.2 GHz	76-250 GHz
Frequency range <sup>(1)</sup>	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) <sup>(2)</sup>	2K70J3E 2K70J2E 8K00F3E <sup>(3)</sup>	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) <sup>(4)</sup>	-10 to 10	-20 to 17 <sup>(5)</sup>	-20 to 10	-10 to 10	-10 to 10	-10 to 10
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	0.4	0.4	0.4	0.4	0.4
Receiver IF bandwidth (kHz):	2.7 8	2.7 16	2.7, 16 50, 100 400 2 500	2.7, 16 50, 100 400 10 000	2.7, 16 50, 100 400 10 000	2.7, 16 50, 100 400 10 000
Receiver noise figure (dB) <sup>(6)</sup>	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) Maximum powers are determined by each administration. Maximum powers at 24-250 GHz are typically limited by available equipment and less than the administration authorises.
- (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					
	7-29.7 MHz	144-438 MHz	1.24-3.5 GHz	5.65-10.5 GHz	24-47.2 GHz	76-250 GHz
Frequency range <sup>(1)</sup>	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) <sup>(2)</sup>	2K70J3E 2K70J2E 8K00F3E <sup>(3)</sup>	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) <sup>(4)</sup>	0 to 10	0 to 20	0 to 20	0 to 20	0 to 17	-3 to 10
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	0.4	0.4	0.4	0.4	0.4
Receiver IF bandwidth (kHz):	2.7 8	2.7 16	2.7, 16 50, 100 400 2 500	2.7, 16 50, 100 400 10 000	2.7, 16 50, 100 400 10 000	2.7, 16 50, 100 400 10 000
Receiver noise figure (dB) <sup>(5)</sup>	3 to 10	1 to 3	1 to 7	1 to 7	3 to 7	3 to 7

<sup>(1)</sup> Amateur bands within the frequency ranges shown conform to RR Article 5.

<sup>(2)</sup> 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.

<sup>(3)</sup> Typically only used above 29 MHz.

<sup>(4)</sup> Maximum powers are determined by each administration. Maximum powers at 24-250 GHz are typically limited by available equipment and less than the administration authorises.

<sup>(5)</sup> 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.