

Radiocommunication Study Groups



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Working Party 5A (WG 5A-1)

WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT REVISION TO RECOMMENDATION ITU-R M.1732-1*

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

(Question ITU-R 48-6/5)

(2005-2012)

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 ~~81.5~~250 GHz.

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;

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

Attention: The information contained in this document is temporary in nature and does not necessarily represent material that has been agreed by the group concerned. Since the material may be subject to revision during the meeting, caution should be exercised in using the document for the development of any further contribution on the subject.

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 should 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.

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 band allocations and technology changes, this recommendation will be updated to reflect the most recent developments.

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 min to about 1 h, depending on traffic to be transmitted.

Operating protocols vary according to communication requirements and propagation:-

- [LF and MF bands typically use ground wave propagation and sky wave propagation over medium distance paths;](#)
- [MF and HF bands are used for near-vertical-incidence-sky wave and low angle sky wave propagation paths for regional and global paths;](#)
- [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-;](#)

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3 Technical characteristics

Tables 1 to 76 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 76 represent the current state of deployment of most amateur radio systems. ~~The characteristics are expected to be extended to higher frequencies (up to 250 GHz) over time.~~

[As amateur usage of the 135.7–137.8 kHz and 472-kHz frequency bands is restricted to maximum radiated power of 1W \(e.i.r.p\)¹ 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 5. 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.](#)

¹ Administrations may increase this limit to 5 W e.i.r.p in accordance with RR No. 5.80A.

TABLE 1
Characteristics of amateur systems for Morse on-off keying

Parameter	Value							
	Continuous wave (CW) Morse 10-50 Bd				Continuous wave (CW) Morse < 20 Bd (Earth-moon-Earth)			Slow Morse ≤ 1 Bd CW
Frequency band range (MHz) ⁽¹⁾	1.8-7.3 MHz	10.1-29.7 MHz	50-450 MHz	902 MHz- 81-500 250 GHz	144 MHz	432 MHz	1 296 MHz	0-136
Necessary bandwidth and class of emission (emission designator)	150HA1A 150HJ2A	150HA1A 150HJ2A	150HA1A 150HJ2A	150HA1A 150HJ2A	50H0A1A 50H0J2A	50H0A1A 50H0J2A	50H0A1A 50H0J2A	1H00A1B 1H00J2B
Transmitter power (dBW) ⁽²⁾	3-31.7	3-31.7	3-31.7	3-31.7	3-31.7	3-31.7	17-31.7	23
Transmitter line Feeder loss (dB)	0.2	0.3-0.9	1-2	0-10	1-2	1-2	1-4	0.0
Transmitting antenna gain (dBi)	-20 to 15 6	-10 to 21 12	0-26	10-42	20 15-26	20-26	25-40	-22
Typical e.i.r.p. (dBW)	-17.2 to 37.5 46.5	-7.3 to 52.4 43.4	2-55	1-45	38-55	38-55	68	+
Antenna polarization	Horizontal, vertical	Horizontal, vertical	Horizontal	Horizontal, vertical	Horizontal	Horizontal, vertical, LHCP, RHCP	Horizontal, vertical, LHCP, RHCP	Vertical
Receiver IF bandwidth (kHz)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Receiver noise figure (dB) ⁽³⁾	13	7-13	0.5-2	1-7	0.5	0.5	0.5	13

(1) With the exception of the band around 0.136 MHz, the amateur bands within the frequency ranges shown conform to RR Article 5.

(2) Maximum powers are determined by each administration.

(3) 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 equipment noise level."

LHCP: left-hand circular polarization

RHCP: right-hand circular polarization

TABLE 2
Characteristics of amateur systems for narrow-band direct printing telegraphy and data

Parameter	Value					
Mode of operation ⁽¹⁾	PSK31 31 Bd	NBDP 50 Bd	PACTOR 2	PACTOR 3	CLOVER 2000	MFSK16
Frequency <u>band-range</u> (MHz) ⁽²⁾	1.8-29.7	1.8-29.7	1.8-29.7	1.8-29.7	1.8-29.7	1.8-29.7
Necessary bandwidth and class of emission (emission designator)	60H0J2B	250HF1B	375HJ2D	2K20J2D	2K00J2D 2K00J2B	316HJ2D 316HJ2B
Transmitter power (dBW) ⁽³⁾	3-31.7	3-31.7	3-31.7	3-31.7	3-31.7	3-31.7
Feeder loss (dB)	0.2-0.9	0.2-0.9	0.2-0.9	0.2-0.9	0.2-0.9	0.2-0.9
Transmitting antenna gain (dBi)	-20 to <u>2+12</u>	-20 to <u>2+12</u>	-20 to <u>2+12</u>	-20 to <u>2+12</u>	-20 to 2+12	-20 to <u>2+12</u>
Typical e.i.r.p. (dBW)	-17.2 to <u>52.543.5</u>	-17.2 to <u>52.543.5</u>	-17.2 to <u>52.543.5</u>	-17.2 to <u>52.543.5</u>	-17.2 to 52.543.5	-17.2 to <u>52.543.5</u>
Antenna polarization	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical
Receiver IF bandwidth (kHz)	0.5	0.5	0.5	2.7	2.4	0.5
Receiver noise figure (dB) ⁽⁴⁾	7-13	7-13	<u>7-13</u>	7-13	7-13	7-13

⁽¹⁾ PSK31 is a data system using phase shift keying (PSK) at 31.1 bauds. PACTOR 2 is a data system using differential PSK (DPSK) modulation with rates varying according to conditions. PACTOR 3 is a data system with a potential throughput of up to 5.2 kbit/s. CLOVER 200 is a digital data system capable of rates up to 5.2 kbit/s. MFSK16 is a data system using 16-tone frequency shift keying (FSK) and forward error correction (FEC). [As the technology of digital signal processing and software defined radio advances new digital modes are likely to be developed and brought into use.](#)

Further information about these modes of operation can be obtained from the ARRL HF Digital Handbook (4th Ed.), American Radio Relay League, ISBN: 0-87259-103-4, published 2008.

⁽²⁾ Amateur bands within the frequency ranges shown conform to RR Article 5.

⁽³⁾ Maximum powers are determined by each administration.

⁽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 equipment noise level.*

Editor's note: This table needs further work to add modes or be generalised to cover existing and potential new modes.

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TABLE 3
Characteristics of amateur analogue voice systems

Parameter	Value					
	Single side-band (SSB) voice				FM voice	
Frequency band-range (MHz) ⁽¹⁾	1.8-7.3 MHz	10.1-29.7 MHz	50-450 MHz	902 MHz-81500250 GHz	2850-450 MHz	902 MHz-81500250 GHz
Necessary bandwidth and class of emission (emission designator)	2K70J3E	2K70J3E	2K70J3E	2K70J3E	11K0F3E 16K0F3E 20K0F3E	11K0F3E 16K0F3E 20K0F3E
Transmitter power (dBW) ⁽²⁾	3-31.7	3-31.7	3-31.7	3-31.7	3-31.7	3-31.7
Feeder loss (dB)	0.2	0.3-0.9	1-2	0-10	1-2	0-10
Transmitting antenna gain (dBi)	-20 to 45 6	-10 to 21 21.5	0-23	0-42	0-26	0-42
Typical e.i.r.p. (dBW)	-16.8 to 46.5 37.5	-7.3 to 52.44 63.5	2-53.7	1-45	2-55	1-45
Antenna polarization	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical
Receiver IF bandwidth (kHz)	2.7	2.7	2.7	2.7	9 15	9 15
Receiver noise figure (dB) ⁽³⁾	13	7-13	0.5-2	1-7	0.5-2	1-7

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

⁽²⁾ Maximum powers are determined by each administration.

⁽³⁾ 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 equipment noise level.

TABLE 4
Characteristics of amateur digital voice and multimedia systems

Parameter	Value				
	Digital voice			Digital voice and multimedia	
Mode of operation	Digital voice			Digital voice and multimedia	
Frequency band-range (MHz) ⁽¹⁾	1.8-7.3 MHz	10.1-29.7 MHz	50-450 MHz	1,240-1,300 GHz	5,650- 40,500 250 GHz
Necessary bandwidth and class of emission (emission designator)	2K70J2E	2K70J2E	2K70J2E 5K76G1E 8K10F1E	2K70G1D 6K00F7D 16K0D1D 150KF1W	2K70G1D 6K00F7D 16K0D1D 150KF1W 10M5F7W
Transmitter power (dBW) ⁽²⁾	3-31.7	3-31.7	3-31.7	1-10	3
Feeder loss (dB)	0.2	0.3-0.9	1-2	1-3	1-6
Transmitting antenna gain (dBi)	-20 to 15 6	-10 to 21 25	0-26	30	36
Typical e.i.r.p. (dBW)	-16.8 to 46.5 37.5	-7.3 to 52.4 36.4	2-55	39	38
Antenna polarization	Horizontal, vertical	Horizontal, vertical	Horizontal	Horizontal, vertical	Horizontal, vertical
Receiver IF bandwidth (kHz)	2.7	2.7	2.7 5.76 8.1	2.7, 6, 16, 130	2.7, 6, 16, 130, 10 500
Receiver noise figure (dB) ⁽³⁾	13	7-13	1	2	2

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

(2) Maximum powers are determined by each administration.

(3) 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 equipment noise level.*

TABLE 5
Characteristics of amateur operation in the 135.7-137.8 kHz and 472-479 KHz frequency bands.

<u>Parameter</u>	<u>Value</u>		
<u>Mode of operation</u>	<u>Continuous wave (CW)</u> <u>Morse 10-50 Bd</u>	<u>Slow Morse</u> <u>< 1 Bd CW</u>	<u>Weak signal modes:²</u>
<u>Necessary bandwidth and class of emission (emission designator)</u>	<u>150H00A1A, 150H00J2A</u>	<u>1H00A1B, 1H00J2B</u>	<u>2H00A1D, 2H00F1D</u> <u>2H00J2D</u>
<u>Typical F transmitter power (dBW)</u>	<u>20³</u>		
<u>Feeder loss (dB)</u>	<u>Negligible</u>		
<u>Transmitting antenna gain (dBi)</u>	<u>-40 to -10</u>		
<u>Maximum e.i.r.p (dBW)</u>	<u>0⁴</u>		
<u>Antenna polaization polarization</u>	<u>Vertical</u>		
<u>Receiver IF bandwidth (kHz)</u>	<u>0.4⁵</u>		
<u>Receiver noise figure (dB)</u>	<u>13</u>		

² 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. Well known and commonly used weak modes include WSPR, JT65 and Opera.

Editors note: check references for more recent information

⁴ In the frequency range 472-479 kHz, administrations may increase this limit to 5 W e.i.r.p in accordance with footnote RR No. 5.80A.

⁵ Digital signal processing techniques can narrow the IF bandwidth to a fraction of a Hertz if needed.

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TABLE 56

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

Mode of operation	CW Morse, 10-50 Bd			SSB voice, digital voice, FM voice, data		
Frequency <u>range</u> ⁽¹⁾	28-29.7 MHz	144 MHz-5.670 GHz	10,450-250 GHz 24 050	28-29.7 MHz	144 MHz-5.670 GHz	10,450-24,050 250 GHz
Necessary bandwidth and class of emission (emission designator)	150HA1A 150HJ2A	150HA1A 150HJ2A	150HA1A 150HJ2A	2K70J3E 2K70J2E 16K0F3E	2K70J3E 16K0F3E 44K2F1D 88K3F1D	2K70J3E 16K0F3E 44K2F1D 88K3F1D
Transmitter power (dBW) ⁽²⁾	0-20	0-20	0-13	0-20	0-20	0-13
Feeder loss (dB)	0.2-1.5	0.2-3	0.2-3	0.2-1.5	0.2-3	0.2-3
Transmitting antenna gain (dBi)	-2 to 10	-2 to 27	-2 to 31	-2 to 10	-2 to 27	-2 to 31
Typical e.i.r.p. (dBW)	10-29	10-45	10-42	10-29	10-45	10-42
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	2.7 16	2.7, 16, 50, 100	2.7, 16, 50, 100
Receiver noise figure (dB) ⁽³⁾	3-10	1-3	1-7	3-10	1-3	1-7

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

⁽²⁾ Maximum powers are determined by each administration.

⁽³⁾ 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 equipment noise level.*

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TABLE 67

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

Mode of operation	CW Morse, 10-50 Bd			SSB voice, digital voice, FM voice, data		
Frequency band range(MHz) ⁽¹⁾	28-29.7 MHz	144 MHz-5.850 GHz	10.450-24.050 GHz	28-29.7 MHz	144 MHz-5.850 GHz	10.450-24.050 GHz
Necessary bandwidth and class of emission (emission designator)	150HA1A 150HJ2A	150HA1A 150HJ2A	150HA1A 150HJ2A	2K70J3E 2K70J2E 16K0F3E	2K70J3E 16K0F3E 44K2F1D 88K3F1D	2K70J3E 16K0F3E 44K2F1D 88K3F1D
Transmitter power (dBW) ⁽²⁾	10	10	10	10	10	0-10
Feeder loss (dB)	0.2-1	0.2-1	0.2-1	0.2-1	0.2-1	0.2-1
Transmitting antenna gain (dBi)	0	0-6	0-6	0	0-6	0-6
Typical e.i.r.p. (dBW)	9	9-15	9-15	9	9-15	9-15
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	2.7, 16	2.7, 16, 50, 100	2.7, 16, 50, 100
Receiver noise figure (dB) ⁽³⁾	3-10	1-3	1-7	3-10	1-3	1-7

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

(2) While total transmitter power of 20 dB is assumed, 10 dB is used as power is shared among signals in passband.

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

Editor's note: check for additional amateur satellite allocations e.g. 7 MHz