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| **Radiocommunication Study Groups** |  |
| **INTERNATIONAL TELECOMMUNICATION UNION** |  |
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| Annex 4 to Working Party 5A Chairman’s Report |
| Working document towards a preliminary draft revision TO RECOMMENDATION ITU‑R M.1732‑1[[1]](#footnote-1)\* |
| Characteristics of systems operating in the amateurand 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 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;

*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;

– 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.

# 3 Technical characteristics

Tables 1 to 7 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 7 represent the current state of deployment of most amateur radio systems. As amateur usage of the 135.7–137.8 kHz and 472-kHz frequency bands is restricted to maximum radiated power of 1 W (e.i.r.p)[[2]](#footnote-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 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.

TABLE 1

Characteristics of amateur systems for Morse on-off keying

|  |  |
| --- | --- |
| Parameter | Value |
| Mode of operation | Continuous wave (CW) Morse10‑50 Bd  | Continuous wave (CW) Morse< 20 Bd (Earth-moon-Earth) |  |
| Frequency range(1) | 1.8-7.3 MHz | 10.1-29.7 MHz | 50-450 MHz | 902 MHz-250 GHz | 144 MHz | 432 MHz | 1 296 MHz |  |
| Necessary bandwidth and class of emission (emission designator) | 150HA1A 150HJ2A | 150HA1A 150HJ2A | 150HA1A 150HJ2A | 150HA1A 150HJ2A | 50H0A1A50H0J2A | 50H0A1A50H0J2A | 50H0A1A50H0J2A |  |
| 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 |  |
| Feeder loss (dB) | 0.2 | 0.3‑0.9 | 1‑2 | 0-10 | 1‑2 | 1‑2 | 1-4 |  |
| Transmitting antenna gain (dBi) | −20 to 6 | −10 to 12 | 0‑26 | 10-42 | 15‑26 | 20‑26 | 25-40 |  |
| Typical e.i.r.p. (dBW) | −17.2 to 37.5 | −7.3 to 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 |  |
| Receiver IF bandwidth (kHz) | 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 |  |
| (1) 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 polarizationRHCP: right-hand circular polarization |

TABLE 2

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

|  |  |
| --- | --- |
| Parameter | Value |
| Mode of operation(1) | PSK3131 Bd | NBDP50 Bd | PACTOR 2 | PACTOR 3 |  | MFSK16 |
| Frequency range(MHz)(2) | 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 |  | 316HJ2D 316HJ2B |
| Transmitter power (dBW)(3) | 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 |
| Transmitting antenna gain (dBi) | −20 to 12 | −20 to 12 | −20 to 12 | −20 to 12 |  | −20 to 12 |
| Typical e.i.r.p. (dBW) | −17.2 to 43.5 | −17.2 to 43.5 | −17.2 to 43.5 | −17.2 to 43.5 |  | −17.2 to 43.5 |
| Antenna polarization | Horizontal, vertical | Horizontal, vertical | Horizontal, vertical | Horizontal, vertical |  | Horizontal, vertical |
| Receiver IF bandwidth (kHz) | 0.5 | 0.5 | 0.5 | 2.7 |  | 0.5 |
| Receiver noise figure (dB)(4) | 7-13 | 7-13 | 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.* |

TABLE 3

Characteristics of amateur analogue voice systems

|  |  |
| --- | --- |
| Parameter | Value |
| Mode of operation | Single side-band (SSB) voice | FM voice |
| Frequency range(1) | 1.8‑7.3 MHz | 10.1‑29.7 MHz | 50‑450 MHz | 902 MHz‑250 GHz  | 28‑450 MHz | 902 MHz‑250 GHz |
| Necessary bandwidth and class of emission (emission designator) | 2K70J3E | 2K70J3E | 2K70J3E | 2K70J3E | 11K0F3E16K0F3E20K0F3E | 11K0F3E16K0F3E20K0F3E |
| 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 6 | −10 to 15 | 0‑23 | 0-42 | 0‑26 | 0-42 |
| Typical e.i.r.p. (dBW) | −16.8 to 37.5 | −7.3 to 46.5 | 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 | 915 | 915 |
| 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 |
| Mode of operation | Digital voice | Digital voice and multimedia |
| Frequency range(1) | 1.8‑7.3 MHz | 10.1-29.7MHz | 50-450 MHz | 1.240-1.300 GHz | 5.650-250 GHz |
| Necessary bandwidth and class of emission (emission designator) | 2K70J2E | 2K70J2E | 2K70J2E5k76G1E8K10F1E | 2K70G1D6K00F7D16K0D1D150KF1W | 2K70G1D6K00F7D16K0D1D150KF1W10M5F7W  |
| 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 6 | −10 to 15 | 0-26 | 30 | 36 |
| Typical e.i.r.p. (dBW) | −16.8 to 37.5 | −7.3 to 46.4 | 2-55 | 39 | 38 |
| Antenna polarization | Horizontal, vertical | Horizontal, vertical | Horizontal | Horizontal, vertical | Horizontal, vertical |
| Receiver IF bandwidth (kHz) | 2.7 | 2.7 | 2.75.768.1 | 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.

|  |  |
| --- | --- |
| Parameter | Value |
| Mode of operation | Continuous wave (CW)Morse 10‑50 Bd | Slow Morse≤ 1 Bd CW | Weak signal modes:[[3]](#footnote-3) |
| Necessary bandwidth and class of emission (emission designator) | 150H00A1A, 150H00J2A | 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[[4]](#footnote-5) |
| Antenna polarization | Vertical |
| Receiver IF bandwidth (kHz) | 0.4[[5]](#footnote-6) |
| Receiver noise figure (dB) | 13 |

TABLE 6

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 range(1) | 28-29.7 MHz | 144 MHz-5.670 GHz  | 10.450-250 GHz | 28-29.7 MHz | 144 MHz-5.670 GHz | 10.450-250 GHz |
| Necessary bandwidth and class of emission (emission designator) | 150HA1A150HJ2A | 150HA1A150HJ2A | 150HA1A150HJ2A | 2K70J3E2K70J2E16K0F3E | 2K70J3E16K0F3E44K2F1D88K3F1D | 2K70J3E16K0F3E44K2F1D88K3F1D |
| 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 | 2.716 | 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*." |

TABLE 7

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 range(1) | 28-29.7 MHz | 144 MHz-5.850 GHz | 10.450-250 GHz | 28-29.7 MHz | 144 MHz-5.850 GHz | 10.450-250 GHz |
| Necessary bandwidth and class of emission (emission designator) | 150HA1A150HJ2A | 150HA1A150HJ2A | 150HA1A150HJ2A | 2K70J3E2K70J2E16K0F3E | 2K70J3E16K0F3E44K2F1D88K3F1D | 2K70J3E16K0F3E44K2F1D88K3F1D |
| 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 dBW 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* |

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1. \* This Recommendation should be brought to the attention of Radiocommunication Study Group 1. [↑](#footnote-ref-1)
2. Administrations may increase this limit to 5 W e.i.r.p in accordance with RR No. **5.80A**. [↑](#footnote-ref-2)
3. 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. [↑](#footnote-ref-3)
4. *Editors note: check references for more recent information.* 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.** [↑](#footnote-ref-5)
5. Digital signal processing techniques can narrow the IF bandwidth to a fraction of a Hertz if needed. [↑](#footnote-ref-6)