RECOMMENDATION ITU-R M.478-5*

TECHNICAL CHARACTERISTICS OF EQUIPMENT AND PRINCIPLES GOVERNING THE ALLOCATION OF FREQUENCY CHANNELS BETWEEN 25 AND 3 000 MHz FOR THE FM LAND MOBILE SERVICE

(Question ITU-R 7/8)

(1970-1974-1978-1982-1990-1995)

Summary

The rapid development of the different applications of land mobile services in the frequency bands between 25 and 3 000 MHz requires the recommendation of technical characteristics of FM equipment and principles governing the allocation of frequency channels. The analogue and digitized voice transmissions may share the same frequency bands and channels with minimal interference between the systems. The Recommendation gives the preferred technical characteristics for VHF and UHF land mobile equipment using F3E class of emission, including the considerations of the necessary bandwidth, the transmitter, the receiver and the station characteristics.

The ITU Radiocommunication Assembly,

considering

a) that certain technical characteristics of equipment and stations in the land mobile service are of importance in connection with radio interference between the stations of different countries;

b) that agreement is desirable on certain technical characteristics of land mobile equipment, to minimize mutual interference and to facilitate the use of the same types of equipment in different countries in a geographical region;

c) that agreement is desirable on the practices governing the choice of station antenna height and effective radiated power taking into account geographical features, required communications range and system parameters;

d) that agreement is desirable on the practices governing the allocation of channels in the land mobile service, in order to minimize mutual interference and to obtain economy of use of the frequency spectrum;

e) that in some areas, different values for the technical characteristics of equipment are required, in order to minimize mutual interference;

f) that the values agreed upon should be based on circumstances that typify high-density radio usage areas and should be a compromise between optimum spectrum utilization and cost;

g) that under some circumstances, e.g. where channel assignments and/or types of system operation permit, not all recommended technical characteristics are required to minimize mutual interference;

h) that in the land mobile service, ultimate spectrum utilization is determined by assignment techniques, suppression and rejection of unwanted radiation, and other means additional to the actual characteristics of the equipment;

j) that there is a rapid development in methods of digitized voice and data transmission using various coding techniques;

k) that analogue and digitized voice transmissions may share the same frequency band and channels with minimal interference between these systems;

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

l) that, in Opinion ITU-R 42, the International Electrotechnical Commission (IEC) has been invited to advise the ITU-R (former CCIR) of any methods of measurement applicable to radio equipment used in land mobile services;

m) that Recommendation ITU-R SM.1045 provides advice on frequency stability requirements for future use,

recommends

1 that the preferred technical characteristics for VHF and UHF land mobile equipment using F3E class of emission should be indicated in Annex 1;

2 that Annex 2 should be taken into account, as appropriate, in the allocation of channels in the land mobile service between 25 and 1 000 MHz;

3 that reference should also be made to the IEC Publication 489 on methods of measurement (see Note 5 of § 3 of Annex 1);

4 that reference should be made to Annex 3 for information on some example values if the 1 500 MHz band is to be used.

ANNEX 1

Preferred technical characteristics for VHF and UHF land mobile equipment using F3E class of emission

1 Necessary bandwidth

The transmitter characteristics specified in § 2 are based on the following assumption regarding the necessary bandwidth (see Note 4).

1.1 For class F3E

30 and 25 kHz channel separations: 16 kHz

20 kHz channel separation:

Maximum permissible frequency deviation (kHz)	Necessary bandwidth (kHz)
± 4	14
± 5	16

12.5 and 15 kHz channel separation: 8.5 kHz or 11 kHz (see Note 5).

NOTE 1 – Subsequent Class A designations refer to alternative values and measurement methods which are specified in the United States of America telecommunications standard TIA/EIA-603.

NOTE 2 – Subsequent Class E designations refer to alternative values and measurement methods which are specified in European telecommunications standard ETS 300 086.

NOTE 3 – Where reference is not made to Classes A or E, the class(es) are in agreement with the preferred values.

NOTE 4 – Necessary bandwidth: For a given class of emission, the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions (from the Radio Regulations (RR)).

NOTE 5 – Another value may be used by some administrations. Class A specifies 11 kHz for 12.5 kHz.

2 Transmitter characteristics

2.1 Frequency tolerance

Within the temperature ranges specified by each administration according to the environment, and for specified ranges of primary supply voltages, the frequency error of any carrier emission should not exceed the values given in Tables 1 or 2 (Class E only).

Table 1 specifies the frequency tolerance in ppm.

TABLE 1

Preferred tolerances for each frequency band

	35 MHz		80 MHz		160 MHz		300 MHz		450 MHz		800 MHz		900 MHz	
Channel spacing (kHz)	kHz(1)	ppm	kHz(1)	ppm	kHz(1)	ppm	kHz(1)	ppm	kHz(1)	ppm	kHz(1)	ppm	kHz(1)	ppm
20, 25 and 30	0.43	12	0.96	12	0.8	5	1.5	5	2.25	5	–	2.5 (M)(B) 1.5 (B)	2.7	2.5
12.5	–	–	1.0	12	0.8	5	–	–	1.35	3	–	–	1.35	1.5 (M)(B) 0.1 (B)

(1) Approximate values.

B: base station.

M: mobile or handheld portable equipment.

ppm: parts per million (10^{-6}).

Table 2 applies to Class E equipment which specifies the frequency tolerance in units of kHz for the various frequency bands.

TABLE 2

Class E frequency tolerances

Channel separation (kHz)	Frequency error limit (kHz)				
	Below 47 MHz	47-137 MHz	Above 137 to 300 MHz	Above 300 to 500 MHz	Above 500 to 1 000 MHz
20 and 25	± 0.6	± 1.35	± 2.00	± 2.00	± 2.50(1)
12.5	± 0.6	± 1.00	± 1.00 (B) ± 1.50 (M)	± 1.00 (B) ± 1.50 (M)(1)	No value specified

(1) For handheld portable equipment having integral power supplies, the frequency error given shall not exceed over a temperature range of 0° to +30 °C. Under extreme temperature conditions, the frequency error shall not exceed:

– ± 2,50 kHz for a channel separation of 12.5 kHz between 300 and 500 MHz;
– ± 3,00 kHz for a channel separation of 20 and 25 kHz between 500 and 1 000 MHz.

2.2 Maximum permissible frequency deviation

The maximum permissible frequency deviation corresponding to the channel spacing should be the values given in Table 3.

TABLE 3

Deviation limits

Channel spacing (kHz)	Maximum permissible frequency deviation (kHz)
25 / 30	± 5.0
20	± 4.0 / ± 5.0
12.5 / 15	± 2.5

2.3 Adjacent channel power

2.3.1 25 and 30 kHz channel spacing

25-500 MHz: at least 70 dB below carrier power in a bandwidth of 16 kHz

500-1 000 MHz: at least 65 dB below carrier power in a bandwidth of 16 kHz. (Class A specifies 70 dB to 512 MHz, and 60 dB from 512 MHz to 940 MHz. Class E specifies 70 dB from 500 MHz to 1 000 MHz.)

2.3.2 20 kHz channel spacing

At least 70 dB below carrier power in a bandwidth of 14 kHz, $\Delta f = 4$ kHz (Δf: the maximum permissible frequency deviation).

At least 60 dB below carrier power in a bandwidth of 14 kHz, $\Delta f = 5$ kHz (Δf: the maximum permissible frequency deviation).

2.3.3 12.5 kHz channel spacing

At least 60 dB below carrier power in a bandwidth of 8.5 kHz. (Class A specifies 50 dB from 512 to 940 MHz.)

In each case, it is not necessary to reduce the adjacent channel power below 0.25 μW. (Class A specifies 50 μW rather than 0.25 μW.)

2.4 Conducted spurious emissions

Spurious emissions on discrete frequencies, when measured in a non-reactive load equal to the nominal output impedance of the transmitter, should not exceed 2.5 μW for transmitter carrier powers up to 25 W. For carrier powers in excess of 25 W, the level of any spurious emission should be at least 70 dB below the carrier power. (Class A specifies 50 μW rather than 2.5 μW. Class E specifies that any conducted spurious emissions should not exceed the values given in Table 4.)

TABLE 4

Class E conducted spurious emissions

Frequency range	9 kHz to 1 GHz	Above 1 to 4 GHz or above 1 to 12.75 GHz(1)
Tx operating (μW)	0.25	1.00
Tx standby (nW)	2.0	20.0

(1) The frequency range is equal to 1-4 GHz for equipment operating below 470 MHz and to 1-12.75 GHz for equipment operating above 470 MHz.

2.5 Cabinet radiation

The cabinet radiated power should not exceed 25 μW. The hand portable equipment should not exceed 2.5 μW. In some radio environments, a lower value may be required. (Class E specifies that cabinet radiation should not exceed the values given in Table 5.)

TABLE 5

Class E cabinet radiation

Frequency range	30 MHz to 1 GHz	Above 1 to 4 GHz
Tx operating (μW)	0.25	1.00
Tx standby (nW)	2.0	20.0

2.6 Attenuation of the intermodulation of base station transmitters

In the case of multiple transmitters operation at a base station site, the attenuation of intermodulation, due to the non-linearities of the output stage of the transmitter, should be at least 20 dB. In some conditions even higher values of attenuation might be necessary and may be obtained by means of appropriate protection devices. (Class A and Class E both specify 40 dB using a method of measurement different from IEC 489.)

3 Receiver characteristics

All parameters except the conducted spurious emissions and the cabinet radiation are not the subject of regulation in some countries (these specification may be mandatory for countries which regulate equipment using Class E standards). Measurements shall be performed using MUS (see Note 5).

3.1 Reference sensitivity

The reference sensitivity should be less than 2.0 μV, e.m.f., for a given reference signal-to-noise ratio at the output of the receiver (see Note 1).

3.2 Adjacent channel selectivity (see Notes 1 and 2)

3.2.1 20, 25 and 30 kHz channel spacing

The adjacent channel selectivity should not be less than 70 dB. (Some countries require not less than 65 dB for the frequency range 500-1 000 MHz. Also, Class A specifies 60 dB for portable handheld equipment.)

3.2.2 12.5 kHz channel spacing

The adjacent channel selectivity should not be less than 60 dB (see Note 3).

3.3 Radio-frequency intermodulation (see Note 2)

When measured using an interfering frequency combination of twice and four times the channel spacing separated from the receiving frequency, the intermodulation response rejection ratio should not be less than 70 dB (see Notes 3 and 4).

3.4 Co-channel rejection

When a wanted signal is applied in the presence of an interfering signal on the same frequency, the ratio of interference-to-signal is not less than –8 dB for 25 kHz channel spacing and not less than –12 dB for 12.5 kHz channel spacing.

3.5 Spurious responses (see Note 2)

At any frequency separated from the nominal frequency of the receiver by more than one channel spacing, the spurious response rejection ratio should not be less than 70 dB. (Class A specifies 60 dB for handheld portables.)

3.6 Conducted spurious emissions

The power of any spurious emission measured at the antenna terminals with matched termination, on any discrete frequency, should not exceed 2.0 nW. (Class A specifies 20 nW. Class E specifies that any conducted spurious emission should not exceed the values given in Table 6.)

TABLE 6

Class E conducted spurious emissions

Frequency range	9 kHz to 1 GHz	Above 1 to 4 GHz or above 1 to 12.75 GHz(1)
Limit (nW)	2.0	20.0

(1) The frequency range is equal to 1-4 GHz for equipment operating below 470 MHz and to 1-12.75 GHz for equipment operating above 470 MHz.

3.7 Cabinet radiation

The effective radiated power of any spurious emission on any frequency from 25 MHz to 1 000 MHz should not exceed 4.0 nW and from 1 000 MHz to 3 000 MHz should not exceed 20 nW. (Class A specifies this limitation as a field strength at a distance of 3 m as listed in Table 7. Class E specifies that any cabinet radiation should not exceed the values given in Table 8.)

TABLE 7

Class A cabinet radiation (3 m separation)

Frequency range	30-88 MHz	88-216 MHz	216-960 MHz	960 MHz to 1 GHz
Limit (μV/m)	100	150	200	500

TABLE 8

Class E cabinet radiation

Frequency range	30 MHz to 1 GHz	Above 1 to 4 GHz
Limit (nW)	2.0	20.0

NOTE 1 – Class E specifies a measurement method which uses 20 dB SINAD and 6 dB degradation, and a psophometric filter.

NOTE 2 – Class E specifies the measurement use SUS (see Note 5).

NOTE 3 – Some countries require at least 65 dB for the frequency range 500-1 000 MHz. Class A specifies 50 dB for handheld portable equipment, and Class E specifies 65 dB for mobile and handheld portable.

NOTE 4 – Class A and Class E both specify that measurement frequencies should be the combination of 50 and 100 kHz displaced from the reference frequency.

NOTE 5 – (Measured Usable Sensitivity) MUS and (Specified Usable Sensitivity) SUS are defined in IEC Doc. 12F(S) 216 which has been approved to be the draft international standard (DIS). Methods of measurement for the radiation at frequencies exceeding 1 GHz are in preparation for the revision of IEC Publication 489.

4 Station characteristics

4.1 Frequency characteristics

4.1.1 Radio-frequency band of operation

According to the Table of Frequency Allocations contained in RR Article 8; in particular the bands of 35, 80, 160, 300, 450, 800 and 900 MHz.

4.1.2 Separation of the transmit and receive frequencies for full duplex operation

35 MHz band: 4 MHz

80 MHz band: 3 MHz

160 MHz band: 3 MHz

300 MHz band: 4 MHz

450 MHz band: 5 MHz

The above are practical minimum values determined by cost and isolation required; smaller separations are possible using higher quality and more costly duplexers.

800 MHz band: 45 or 55 MHz

900 MHz band: 39 or 45 MHz

This preferred value is determined by the desirability to provide for high-capacity systems with a great number of channels. However, in some systems, greater transmit/receive frequency separation might be required.

In practice, the actual separations used may be other than the values given and may be determined by other factors than were used in this Recommendation. Frequencies should preferably be assigned with a constant separation between the transmit and receive frequencies over the whole of a band or the subbands within a band.

4.2 Effective radiated power and antenna height

It is recognized that the responsibility for limiting the effective radiated power and antenna height over the average level of the ground rests with administrations, taking into account:

– the general requirement not to radiate more power than is necessary and not to use larger antenna heights than necessary;

– the required range and communication quality;

– the frequency band of operation;

– the terrain over which service is required;

– special conditions, e.g. diversity reception at remote receiving stations;

– the potential intra-service or inter-service effects between the mobile service and other radio services.

4.3 Antenna system

Vertically polarized.

ANNEX 2

Assignment methods

1 Suggested principles

1.1 The following broad principles are suggested for use in the assignment of frequencies in the land mobile service:

– the choice of the most advantageous mode of operation, i.e. single-frequency or two-frequency operation, according to the type of service, bearing in mind the need for coordination between administrations in border areas;

– the gradual adoption, as opportunity occurs, of the same blocks of frequencies for base stations by all administrations, and similarly the same blocks of frequencies for mobile stations, in order to minimize interference between services of different administrations;

– the gradual adoption by all administrations, as opportunity occurs, of the same blocks of frequencies for the same types of service or at least for those services required to provide similar coverage;

– the adoption of compatible frequency plans, with the same channel spacing and the same centre frequencies of the channels and, when suitable, with centre frequencies off-set, e.g. by one half channel, especially in areas where mutual interference might occur between the services of different administrations;

– the use of common channel spacing, preferably 12.5 kHz (see Note 1) and the use of equipments which are readily adaptable for a reduction in channel separation without replacement of the whole equipment;

– the allocation of channels in such a way as to minimize the production of interference due to intermodulation products;

– the adoption of optimum sizes and shapes for service areas in relation to frequency economy;

– the use of the minimum effective radiated power compatible with the required service range;

– the use of the minimum height of base station antennas compatible with the required service range;

– the siting of co-channel stations with the minimum geographical separation compatible with the protection ratios and minimum field strengths to be protected which are appropriate to the service;

– the use by all administrations of common propagation data;

– the assignment of the same frequency channel to a number of users in the same area, in such a manner as to permit optimum use of the channel.

NOTE 1 – It is recognized that some administrations use other channel separations. Every opportunity should be taken to achieve the use of common channel separations.

1.2 These principles can be applied to full advantage when planning land mobile services, only if all are applied, since they are highly interdependent.

2 Abstract of channel spacing considerations and national practices

– 12.5 kHz channel separation is being used, which is a reduced separation of 25 kHz;

– 12.5 kHz interleave operation technique with 25 kHz separation equipment is also being used;

– other channel separations such as 10, 15, 20, 25, 30 and 40 kHz are being used.

ANNEX 3

Some example values to be used in 1 500 MHz band

Items not mentioned below adopt the same values as in the text for transmitter and receiver characteristics given in Annex 1.

1 Transmitter characteristics

1.1 Frequency tolerance

	Frequency band	
	1 500 MHz	
Channel spacing (kHz)	Approximate value (kHz)	ppm
25	2.7 (Mobile station) 0.7 (Base station)	2 0.5

1.2 Adjacent channel power

25 kHz channel spacing: at least 60 dB below carrier power in a bandwidth of 16 kHz.

1.3 Conducted spurious emissions

At least 60 dB below carrier power.

2 Receiver characteristics

All measurements utilize MUS (see Note 5 of § 3 of Annex 1).

2.1 Adjacent channel selectivity

25 kHz channel spacing: not less than 60 dB.

2.2 Radio-frequency intermodulation

Not less than 60 dB.

Measurement frequencies should be the combination of twice and four times channel spacing separated frequencies from the receiving frequency.

2.3 Spurious responses

Not less than 60 dB.

2.4 Conducted spurious emissions in receiver characteristics

20 nW in the frequencies from 1 000 to 3 000 MHz.

2.5 Cabinet radiation in receiver characteristics

The effective radiated power of any spurious emission on any frequency from 25 to 1 000 MHz should not exceed 4.0 nW and from 1 000 to 3 000 MHz should not exceed 20 nW.

3 Station characteristics

3.1 Separation of the transmit and receive frequencies for duplex operation: 48 MHz.

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