

Recommendation ITU-R F.1762-1 (02/2026)

F Series: Fixed service

**Characteristics of enhanced
applications of High Frequency
radiocommunication systems in the
fixed and mobile service**



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RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management
SNG	Satellite news gathering
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V	Vocabulary and related subjects

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 F.1762-1

**Characteristics of enhanced applications of High Frequency*
radiocommunication systems in the fixed and mobile service**

(2006-2026)

Scope

This Recommendation describes the typical technical characteristics for radiocommunication systems operating in the frequency range 2-30 MHz to provide enhanced digital applications.

Keywords

Enhanced applications, channel bandwidth, video streams, file transfer, voice over IP

Abbreviations

BPSK	Binary phase shift keying
e.i.r.p.	Equivalent isotropically radiated power
FSK	Frequency shift keying
HF	High frequency
NVIS	Near vertical incidence skywave
OFDM	Orthogonal frequency division multiplexing
PSK	Phase shift keying
PX	Peak envelope power
PY	Mean power
QAM	Quadrature amplitude modulation
RF	Radio frequency
SINAD	Signal to interference ratio including noise and distortion
SSB	Single sideband modulation
<i>S/N</i>	Signal-to-noise ratio
VoIP	Voice over Internet protocol

Terms and definitions

Ground wave	A radio wave basically determined by the properties of the ground which propagates in the troposphere, and which is mainly due to diffraction around the Earth ¹
Seawave ²	Groundwaves over water
Skywave	The propagation of radio waves reflected or refracted back toward Earth from the ionosphere

* in the frequency range 2-30 MHz

¹ See Recommendation ITU-R V.573-4 (2000) reflected at the ITU Terms and Definitions database.

² See Recommendation ITU-R P.2146.

Related ITU-R Recommendations and Reports

Recommendation ITU-R BS.80 – Transmitting antennas in HF broadcasting

Recommendation ITU-R F.240 – Signal-to-interference protection ratios for various classes of emission in the fixed service below about 30 MHz

Recommendation ITU-R SM.326 – Determination and measurement of the power of amplitude-modulated radio transmitters

Recommendation ITU-R F.339 – Bandwidths, signal-to-noise ratios and fading allowances in complete systems

Recommendation ITU-R V.573 – Radiocommunication vocabulary

Recommendation ITU-R BS.705 – HF transmitting and receiving antennas characteristics and diagrams

Recommendation ITU-R F.1610 – Planning, design and implementation of HF fixed service radio systems

Recommendation ITU-R F.1611 – Prediction methods for adaptive HF system planning and operation

Recommendation ITU-R BS.1698 – Evaluating electromagnetic fields from terrestrial broadcasting transmitting systems to assess human exposure to non-ionizing emissions

Recommendation ITU-R F.1761 – Characteristics of HF fixed radiocommunication systems

Recommendation ITU-R F.1778 – Channel access requirements for HF adaptive systems in the fixed and land mobile services

Recommendation ITU-R F.1821 – Characteristics of advanced digital high frequency (HF) radiocommunication systems

Recommendation ITU-R P.2146 – Sea surface bistatic scattering

Report ITU-R BS.458 – Characteristics of systems in LF, MF and HF broadcasting

Report ITU-R F.2061 – HF fixed radiocommunications systems

Report ITU-R F.2062 – Enhanced high frequency digital radiocommunication systems capable of providing enhanced applications

Report ITU-R F.2087 – Requirements for high frequency (HF) radiocommunication systems in the fixed service

Report ITU-R F.2484 – Cooperative frequency competition model and the corresponding algorithms

The ITU Radiocommunication Assembly,

considering

- a) that some high frequency (HF)³ systems can be used to provide enhanced applications for electronic messaging systems (e-mail), digital voice, IP based applications and large file transfer providing a communications path to the Internet for exchanging information;
- b) that the increasing use of spectrum in the HF bands for enhanced applications such as electronic messaging systems, both with and without attachments, should be taken into account;
- c) that such HF systems are not standardized in use and may have different operational technical characteristics;
- d) that with electronic messaging, and other enhanced applications for HF systems, equipment interoperability is an important issue,

³ Some systems described in this Recommendation are operated from 2 MHz, noting that HF starts at 3 MHz.

recognizing

that the frequency range 2 to 30 MHz is also allocated to several other services on a primary basis,

noting

- a) that such HF systems are capable of providing routine and emergency public protection and disaster relief;
- b) that HF digital networks utilizing increased contiguous channel bandwidths or non-contiguous multichannel equipment can be used as a mechanism for providing enhanced applications;
- c) that additional information on such HF systems capable of providing enhanced applications can be found in Report ITU-R F.2062,

recommends

that the technical and operational characteristics of those systems providing enhanced applications, including electronic messaging and other Internet capability, described in the Annex should be considered representative of those systems operating in the frequency range between 2 and 30 MHz.

Annex

Characteristics of radio systems operating in the frequency range 2-30 MHz to provide enhanced applications

TABLE OF CONTENTS

		<i>Page</i>
1	Introduction	3
2	HF Transmitter/Receiver RF technical characteristics	4
3	Typical HF Antenna Patterns	7
4	Emission characteristics	8

1 Introduction

Enhanced applications that can be supported over HF include:

- a) messaging, also known as e-mail,
- b) voice over Internet protocol, also known as VoIP,
- c) interactive Internet applications;
- d) large file transfer; and
- e) real-time video streams over HF.

In the event of the collapse or overload of normal telecommunication operation due to natural disasters (e.g. earthquakes) and other emergencies, applications for enhanced HF systems using fixed,

transportable and mobile stations could provide emergency links during the first phase of the alarm or during the coordination of the relief operation.

2 HF transmitter/receiver RF technical characteristics

Tables 1 to 6 contain technical characteristics of representative HF systems capable of providing enhanced applications. Table 1 provides common technical characteristics for several parameters of the HF systems provided in Tables 2 to 6. These characteristics are sufficient for general calculation to assess the compatibility between these systems and systems operating in other services.

In Table 2, protection ratios are specified as the ratio of wanted-to-unwanted average powers (PY). This contrasts with Recommendation ITU-R F.240 where the ratios are expressed in peak envelope powers (PX). Conversion from PX to PY is waveform dependent for both wanted and unwanted signals. Conversion factors can be obtained from Recommendation ITU-R SM.326.

The parameters in Table 1 apply to the Groundwave, Seawave, Skywave and Near Vertical Incidence Skywave (NVIS) systems that are listed in Table 2.

Table 6 is dedicated to enhanced systems using non-contiguous multichannel equipment. These enhanced systems permit the simultaneous use of up to 16 non-contiguous traditional single-sideband modulation (SSB) channels arranged in an (non-overlapping) arbitrary way. The modulation of such an equipment consists in a set of elementary 3 kHz wide modulators, arranged in a frequency division multiplex. Any elementary modulation is processed and applied to a subcarrier whose frequency value is chosen according to the allocated channels. All channels shall be contained within a working bandwidth of up to a maximum of 200 kHz.

TABLE 1

Typical radio frequency characteristics for HF systems

Parameter	Value
Necessary bandwidth (kHz)	3
Feeder loss (dB)	1
Receiver bandwidth (kHz)	3
Receiver maximum RF bandwidth (kHz) (Contiguous channel bandwidth) (See Note)	3-48
Receiver maximum RF bandwidth (kHz) For n-number of non-contiguous channels	up to 200
Typical receiver noise figure (dB)	10-20

NOTE – This parameter describes the range of RF bandwidth for the case of systems aggregating multiple channels simultaneously, either in contiguous or non-contiguous manner.

TABLE 2

Typical radio frequency characteristics of HF systems (See Note)

Parameter	System		
	Groundwave/ Seawave	Skywave (oblique)	NVIS Near vertical
Mode of operation	Groundwave/ Seawave	Skywave (oblique)	NVIS Near vertical
Frequency range (MHz)	Groundwave 2-15 Seawave 3-30	3-30	2-15
Transmitter power PX (dBW)	10-30	0-26	10-26
Antenna directivity gain (dBi)	6	3	0
Maximum e.i.r.p. (dBW)	33	26	23
Antenna polarization	Vertical/ Horizontal	Vertical/ Horizontal	Vertical/ Horizontal
Protection ratio PY (dB)	21	28	10
S/N (Recommendation ITU-R F.339)	21	28	10

NOTE – The S/N in Table 2 are for a binary phase shift keying (BPSK) system with a 3 kHz channel bandwidth.

TABLE 3

Typical RF characteristic of enhanced HF systems for channel bandwidths of 3 to 48 kHz (transmitter for ISB and contiguous channels systems)

Enhanced HF transmitter parameters	Groundwave/ Seawave	Skywave/NVIS	Skywave/Oblique incidence
Frequency range (MHz)	2-30 Groundwave 2-15 Seawave 3-30	2-15	3-30
Channel bandwidth (kHz) (see Note)	Variable 3-48	Variable 3-48	Variable 3-48
Transmitter power (dBW)	30	22	40
Feeder loss (dB)	2.2	1.5	1.1
Antenna directivity gain (dBi)	0-3	0-6	0-15
Antenna height above ground level to the centre of the antenna (m)	20-60	1-60	1-4
Antenna polarization	Horizontal/Vertical	Horizontal/Vertical	Horizontal/Vertical
Antenna type	Broadband Omni	Narrowband Monopole	Narrowband Dipole Broadband Dual Fan-Wire
Maximum e.i.r.p. (dBW)	31	27	54
Modulation	AM/FM/PSK/FSK/ QAM/OFDM	AM/FM/PSK/FSK/ QAM/OFDM	FM/PSK/FSK/QAM/ OFDM

NOTE – Channel bandwidths of 24 kHz within the 3-30 MHz frequency range have been recognized and defined in Recommendation ITU-R F.339, existing Table 4a.

The parameters in Table 4 apply to Groundwave, Skywave and NVIS Systems operating within the 2-30 MHz frequency range. Additional parameters are listed in Table 5.

TABLE 4

**Typical receiver characteristics of enhanced HF systems for channel bandwidths of 3 to 48 kHz
(See Note) (ISB and contiguous channels systems)**

Enhanced HF receiver parameters	Values
Channel bandwidth (kHz)	from 3 to 48
Variable (3 kHz to 12 kHz)	12
Variable (3 kHz to 18 kHz)	18
Variable (3 kHz to 24 kHz)	24
Variable (3 kHz to 48 kHz)	48
Filter bandwidth (kHz)	48
Sensitivity (dBm)	
SSB for 10 dB SINAD	-110 to -130
ISB for 10 dB SINAD	-125 to -130
CW for 10 dB SINAD	-110 to -130

NOTE – Channel bandwidths of 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39, 42, 45 or 48 kHz can also be applicable, as a function of the application.

TABLE 5

**Typical RF characteristic of enhanced HF systems for channel bandwidths of 3 to 48 kHz
(receiver of ISB and contiguous channels systems)**

Enhanced HF receiver parameters	Groundwave/ Seawave	Skywave/ NVIS	Skywave/Oblique incidence
<i>S/N</i> (dB) (See Note)			
PSK	5	12	14
FSK	8	18	18
QAM	14	24	24
OFDM	16	26	30
Feeder loss (dB)	2.2	1.5	1.1
Antenna directivity gain (dBi)	0-3	0-6	0-15
Antenna height above ground level to the centre of the antenna (m)	20-60	1-4	1-4
Antenna polarization	Horizontal/Vertical	Horizontal/Vertical	Horizontal/Vertical
Antenna type	Broadband Omni	Narrowband Monopole	Broadband Dual Fan-Wire

NOTE – The *S/N* in Table 5 are given in a waveform's necessary bandwidth and are typical of systems that operate under the indicated propagation modes.

TABLE 6

Typical characteristics of enhanced HF systems (non-contiguous multichannel systems)

Parameter	Propagation mode		
	Groundwave/ Seawave	Skywave	
		NVIS	Oblique incidence
Frequency range (MHz)	Groundwave 2-15 Seawave 3-30	2-15	3-30
Approximate service area (km)	Up to 40 (ground) Up to 370 (sea)	Up to 300	Greater than 300
Antenna polarization	Vertical/Horizontal	Vertical/horizontal	Vertical/horizontal
Transmitting antenna gain (dBi)	0-3	0-6	0-15
Transmitter power PX (dBW)	10-30	10-22	10-40
S/N per channel (dB) (See Note 1)	17	25	25
Necessary bandwidth (kHz)	SSB: 3, ISB: 6		
Type of emission (See Note 2)	3K00J2D		
Sensitivity for 10 dB SINAD in 3 kHz (dBm)	-110 to -130		
Type of modulation	AM/FM/PSK/FSK/QAM/OFDM		
Receiver IF filter bandwidth (kHz)	> 200 kHz		

NOTE 1 – One second interleaver, 16 channels.

NOTE 2 – For emission type the last letter (D) refers to data transmissions. If emission is not data (D), substitute (E) for voice, (C) for facsimile, (W) combination or (X) for cases not otherwise covered.

3 Typical HF antenna patterns

HF Systems utilize a variety of antenna types as a function of operational range. For short range applications, conventional whip antennae are typically mounted on man-packs and vehicles. Medium range Skywave NVIS applications utilize loop, bent whips and dipoles. Long range use large vertical whip antennas, yagi and log-periodic antennas. Dipoles that are higher above ground are also used for long range applications.

Antenna patterns for typical HF antenna types; Whip, Loop, Bent Whip, Dipole and Log-Periodic, can be found in Recommendation ITU-R BS.705. Additional antenna patterns can be found in the Annex 1 to Recommendation ITU-R BS.705 and include curtain antennas with different feeding arrangements and reflector types, tropical antennas, horizontal and vertical log-periodic, rhombic, quadrant, cross dipole and vertical monopoles⁴. Attachments 1 and 2 to the Annex to Recommendation ITU-R BS.1698 compare calculated field strengths near broadcasting antennas and measurements. Additional information and data regarding HF Broadcasting antennas can be found in Recommendation ITU-R BS.80.

⁴ See Recommendation ITU-R BS.705.

4 Emission characteristics

Table 7 provides the emission masks for HF systems utilizing channel bandwidths of up to 48 kHz, where Type A applies to fixed transmitter installations on land-based sites, maritime and aircrafts (both fixed wing and rotary). The transmit power is typically greater than 150 W PX. Type B radio systems apply to transmitters that are mounted and/or dismounted on vehicles. The transmit power is typically up to 150 W PX. Requirements for unwanted emissions are defined to achieve reasonable non-interference conditions between receivers and distant transmitters. Figures 1 and 2 illustrate these spectrum masks that can be applicable to any system utilizing the channel bandwidths that are listed in Tables 1 to 5.

TABLE 7

Emission Mask for HF Systems with channel bandwidths of up to 48 kHz

Measurement frequency (Hz)	Spectral power density limit (dBc/Hz)	
	Type B transmitters	Type A transmitters
$f_c - 1.0B \leq f_m \leq f_c - 0.5B - 500 \text{ Hz}$ $f_c + 0.5B + 500 \text{ Hz} \leq f_m \leq f_c + 1.0B$	-65	-75
$f_c - 2.5B \leq f_m \leq f_c - 1.0B$ $f_c + 1.0B + 500 \text{ Hz} \leq f_m \leq f_c + 1.0B$	-70	-80
$f_c - 4.0B \leq f_m < f_c - 2.5B$ $f_c + 2.5B < f_m \leq f_c + 4.0B$	-85	-95
$MIN\{0.95f_c, f_c - 0.25 \text{ MHz}\} < f_m < (f_c - 4.0B)$ $(f_c + 4.0B) < f_m < MAX\{1.05f_c, f_c + 0.25 \text{ MHz}\}$	-95	-105
$f_m < MIN\{0.95f_c, f_c - 0.25 \text{ MHz}\}$ $f_m < MIN\{0.95f_c, f_c - 0.25 \text{ MHz}\}$	-125	-125

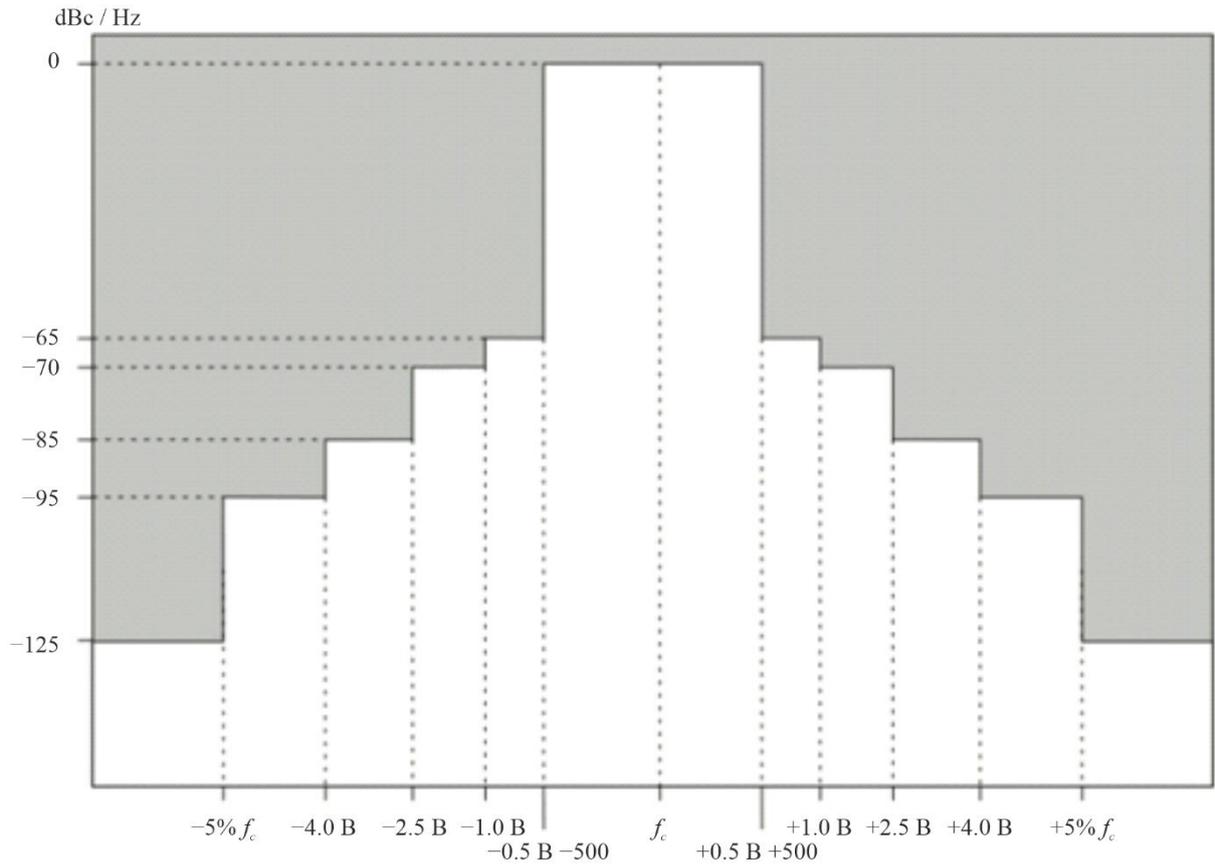
where:

f_m = frequency of measurements (Hz)

f_c = centre frequency of bandwidth (Hz)

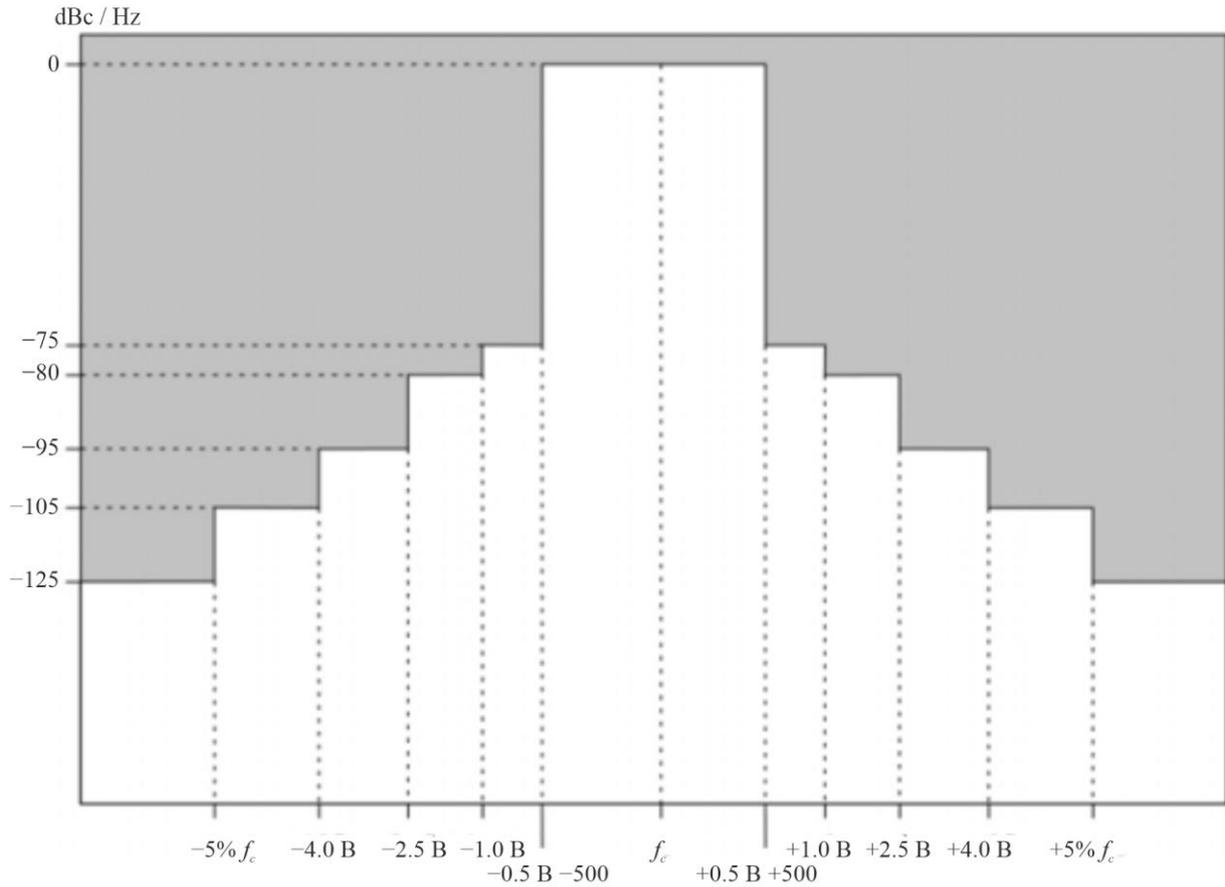
B = necessary bandwidth (Hz)

FIGURE 1
Type B transmitters



NOTES: B = necessary bandwidth (Hz)
 f_c = centre frequency of bandwidth (Hz)
 Emissions shall fall within the unshaded portion of the curve.

FIGURE 2
Type A transmitters



NOTES: B = necessary bandwidth (Hz)
 f_c = centre frequency of bandwidth (Hz)
 Emissions shall fall within the unshaded portion of the curve.

F.1762-02

Table 8 illustrates the spectrum mask that can be applicable to any enhanced system using non-contiguous multichannel equipment.

When the transmitter is driven to rated PX with a non-contiguous multichannel transmission waveform, the power spectral density of the transmitter broadband emission shall not exceed the levels given in the following spectrum mask table.

Spectral density is specified in dBc/Hz, with the reference representing the rated PX of the transmission of the total waveform (including all individual 3 kHz channels).

Type B and Type A transmitter typologies follow the above term in § 4.

TABLE 8

Emission mask for HF systems using non-contiguous multichannel equipment

Measurement frequency	Spectral power density limit [(dBc/Hz)]	
	Type B transmitters	Type A transmitters
$2\ 000\ \text{Hz} \leq f_d \leq 3\ 000\ \text{Hz}$	-65	-75
$3\ 000\ \text{Hz} < f_d \leq 4\ 500\ \text{Hz}$	-70	-80
$4\ 500\ \text{Hz} < f_d \leq 12\ \text{kHz}$	-85	-95
$12\ \text{kHz} < f_d < \text{Max}\{250\ \text{kHz}, 5\% f_c\ \text{kHz}\}$	-95	-105
$\text{Max}\{250\ \text{kHz}, 5\% f_c\ \text{kHz}\} < f_d$	-125	-125

where:

f_d = frequency difference to the closest carrier centre frequency

f_c = centre frequency of bandwidth.

For Type B radio systems, the power of any discrete frequency (non-harmonic) spurious emission shall be at least 40 dB below the peak envelope power within ± 12 kHz of each individual 3 kHz carrier frequency and at least 50 dB below the peak envelope power at any other frequency.

For Type A radio systems, the power of any such spurious emission shall be at least 40 dB below the peak envelope power within ± 12 kHz of each individual carrier frequency, at least 60 dB below the peak envelope power between ± 12 kHz and $\pm 5\%$ removed from each individual carrier frequency, and at least 80 dB below the peak envelope power at any other frequency. These shall be measured when the HF transmitter is transmitting modulated 3 kHz channels multicarrier signals at full rated PX power.

Figures 3 and 4 illustrate spectrum mask that can be applicable to any enhanced system using non-contiguous multichannel equipment.

FIGURE 3

Spectrum mask for enhanced systems using non-contiguous multichannel equipment

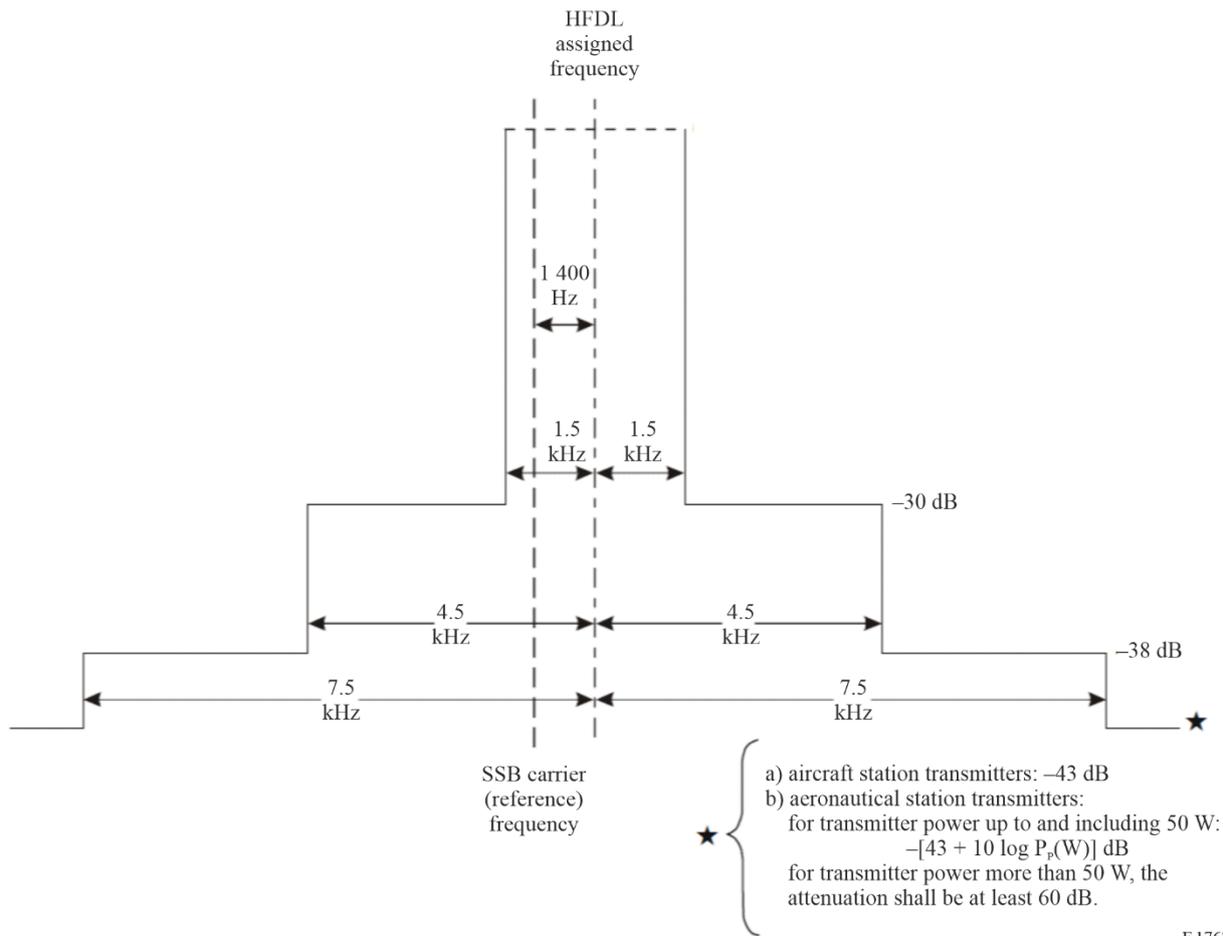
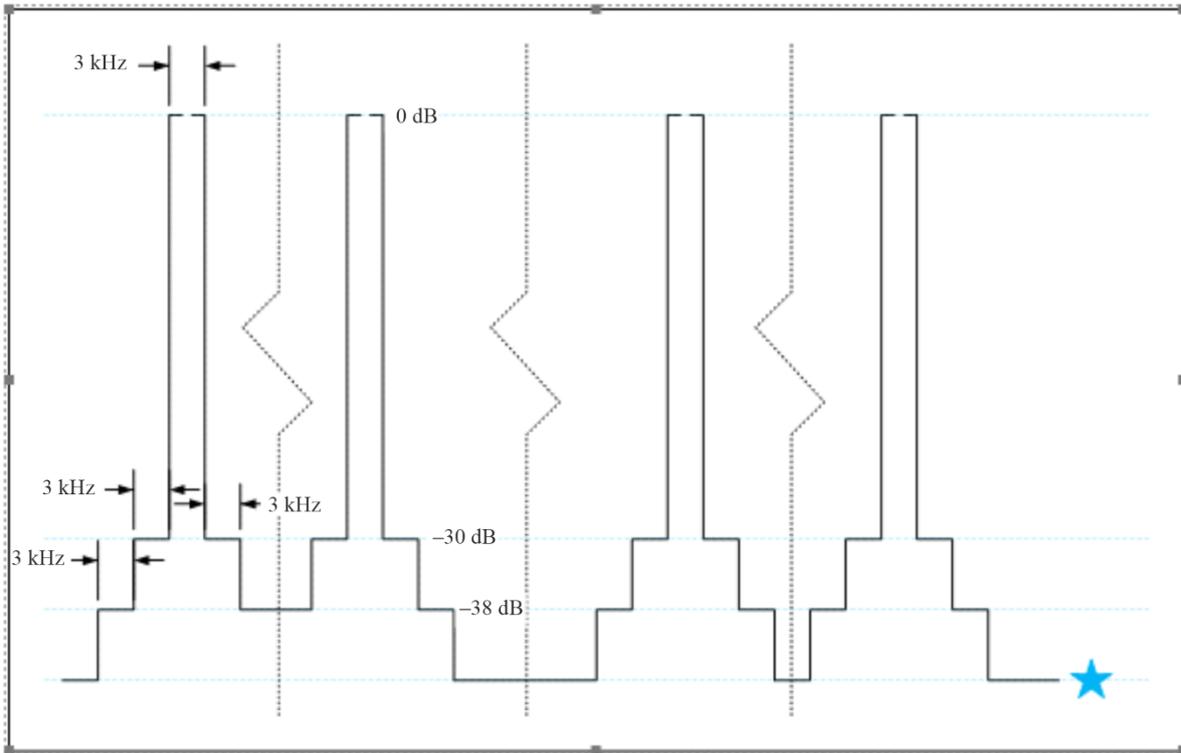


FIGURE 4

Spectrum mask for enhanced systems using non-contiguous multichannel equipment



- a) aircraft station transmitters: -43 dB
- b) aeronautical station transmitters:
 for transmitter power up to and including 50 W:
 $-[43 + 10 \log P_p(\text{W})]$ dB
 for transmitter power more than 50 W, the
 attenuation shall be at least 60 dB.