Federal Telecommunications Recommendation 1050-1998

July 20, 1998

HIGH FREQUENCY RADIO BASELINE PARAMETERS

Federal Telecommunications Recommendations (FTR) are issued by the Technology and Standards Division, National Communications System (NCS), after approval by the Federal Telecommunications Standards Committee and the Deputy Manager, NCS, pursuant to Executive Order 12472[1], NCS Directive 4-1[2], and Public Law 104-113[3].

1. Name of Recommendation. High Frequency Radio Baseline Parameters.

2. Category. High Frequency Radio Automatic Link Establishment, Telecommunications Standards.

3. Explanation. This Federal Telecommunications Recommendation (FTR) is one of a series of standards and recommendations pertaining to automatic high frequency (HF) radio equipment and operation. Federal Standard (FED-STD) 1045A, "Telecommunications: HF Radio Automatic Link Establishment," October 18, 1993, provides Federal departments and agencies with a comprehensive description of the performance and interoperability criteria for automatic link establishment (ALE) in HF radio systems. Fed-Std-1045A provides the waveform, coding, and protocols to support ALE and is the foundation for the adaptive and automated radio features that are being defined in a family of Federal HF radio telecommunications standards and recommendations:

FED-STD 1046/1, "HF Radio Automatic Networking"
FTR 1047/3, "HF Radio Automatic Message Delivery"
FED-STD 1049/1, "HF Radio Automatic Operation in Stressed Environments"
FED-STD 1052, "HF Radio Modems"

This FTR establishes technical standards and design objectives (DOs) that are necessary to ensure interoperability and proper performance of the basic radio system parameters required for supporting ALE operations.

---

[1] Executive Order 12472, "Assignment of National Security and Emergency Preparedness Telecommunications Functions," April 3, 1984.

[2] NCS Directive 4-1, "Federal Telecommunication Standards Program," February 21, 1991.

[3] Public Law 104-113, "The National Technology Transfer and Advancement Act of 1995," February 27, 1996.

4. Approving Authority. Deputy Manager, National Communications System.

5. Maintenance Agency. Technology and Standards Division, National Communications System.

6. Related Documents.

a. FED-STD 1037C, "Telecommunications: Glossary of Telecommunication Terms."

b. FED-STD 1045A, "Telecommunications: HF Radio Automatic Link Establishment."

c. FED-STD 1049/1, "Telecommunications: HF Radio Automatic Operation in Stressed Environments, Section 1: Linking Protection."

d. FED-STD 1052, "Telecommunications: HF Radio Modems."

e. MIL-STD-188-114, "Electrical Characteristics of Digital Interface Circuits."

f. MIL-STD-188-141, "Interoperability and Performance Standards for Medium and High Frequency Radio Equipment."

g. MIL-STD-188-148, (S) "Interoperability Standard for Anti-Jam (AJ) Communications in the High Frequency Band (2-30 MHz) (U)."

h. NTIA, "Manual of Regulations and Procedures for Federal Radio Frequency Management."

i. ITU-R Recommendation F.455-2, "Improved Transmission System for HF Radiotelephone Circuits."

j. ITU-R Recommendation 475-1, "Improvements in the Performance of Radiotelephone."

k. ITU-R Recommendation F.1111, "Improved Lincompex System for HF Radiotelephone Circuits."

l. IEEE, "The New IEEE Dictionary of Electrical and Electronics Terms," 5^{th} Edition, January 15, 1993.

At the time of publication of this FTR, the editions indicated above were valid. All publications are subject to revision, and parties to agreements based on this FTR are encouraged to investigate the possibility of applying the most recent editions of these publications. You may obtain copies of the specifications and related documents from:

FED-STDS	- General Services Administration Federal Supply Service Specification Section 470 E. L'Enfant Plaza, S.W. Suite 8100 Washington, DC 20407
MIL-STDS	- Naval Publications and Forms Center Attn: NPODS 5801 Tabor Avenue Philadelphia, PA 19120-5099
ITU-T	- National Technical Information Service U.S. Department of Commerce Springfield, VA 22161 (703) 487-4650
NTIA Documents	- U.S. Department of Commerce NTIA Room 4890 14th and Constitution Ave., N.W. Washington, DC 20230
IEEE Documents	- The Institute of Electrical and Electronics Engineers, Inc. 345 East 47th Street New York, NY 10017

7. Objective. The objective of this FTR is to improve the Federal acquisition process by providing Federal departments and agencies a comprehensive, authoritative source of information on fully interoperable HF radio equipment to support automated operation. This FTR establishes technical parameters and design objectives that are considered necessary to ensure interoperability of new fixed, transportable, mobile, and man-portable radio equipment in the HF band. This document was developed in accordance with the "Statement of Requirements (SOR) for the Development of a Family of Federal Standards for Automated High Frequency Radio" to provide communications interoperability and to satisfy the requirements of Federal departments and agencies. It is also the purpose of this document to establish a level of performance of new radio equipment considered necessary to satisfy the requirements of a majority of users. These technical parameters represent minimum interoperability and performance standards.

8. Applicability. This FTR is recommended for use by all departments and agencies of the Federal Government in the procurement of HF radio equipment.

9. Specifications. High Frequency (HF) Radio Baseline Parameters.

9.1 General. This FTR establishes technical standards and design objectives that are necessary to ensure interoperability and to promote performance of HF radio equipment for automated operation and for operation in automatic link establishment (ALE) systems. The technical parameters of this document may be exceeded in order to satisfy certain specific requirements, provided that interoperability is maintained. For instance, the capability to incorporate features such as additional standard and nonstandard interfaces is permitted. The terms "system standard" and "design objective" are defined in Fed-Std-1037C. In this document, the word "shall" identifies mandatory system standards. The word "should" identifies DOs which are desirable but not mandatory.

9.2 Definitions.

9.2.1 Terms. Definitions needed for the technical understanding of this FTR are provided in annex A.

9.2.2 Abbreviations and acronyms. The abbreviations and acronyms used in this document are defined in annex B.

9.3 Reguirements. By convention, frequency band allocation for the medium frequency (MF) band is from 0.3 MegaHertz (MHz) to 3 MHz, and the HF band is from 3 MHz to 30 MHz. However, equipment designed for HF band use has historically been designed with frequency coverage extending down into the MF band. For new HF equipment, HF band standard parameters shall apply to any portion of the MF band included as extended coverage.

Equipment parameters will be categorized using functional use groups for radio assemblages/sets. For this FTR, group 1 is comprised of fixed and transportable radio sets and systems. Group 2 consists of both mobile and portable radio sets and systems. See annex A for definitions of these terms. The mobility of HF radio users dictates that a significant amount of long-haul requirements may be met with mobile or portable systems. When this second group of sets and systems is used to meet a long-haul requirement, the equipment shall meet long-haul minimum performance standards.

9.3.1 Equipment operation modes.

9.3.1.1 Baseline mode. Frequency control of all new HF equipment, except group 2, shall be capable of being stabilized by an external standard. As an option, 5 MHz with 1 MHz and 10 MHz as further options is recommended. Should multiple-frequency (channel) storage be incorporated, it shall be of the programmable-memory type and be capable of storing/initializing the operational mode associated with each particular channel. See paragraph 4.2, Fed-Std-1045A, and paragraphs 9.3.1.1 and 9.3.1.2 below.

9.3.1.1.1 Single-channel All new single-channel HF equipment shall provide, as a minimum, the capability for the following one-at-a-time selectable operational modes:

a. One nominal 3-kHz channel upper sideband (USB) or lower sideband (LSB) (selectable).

b. A narrowband frequency modulation (NBFM) channel capability should be included as a design objective.

9.3.1.1.2 Multichannel. All new multichannel HF equipment shall provide a single channel capability as set forth in paragraph 4.2.1.1 above, as a minimum, and one or more of the following modes, selectable one at a time:

a. Two nominal 3-kHz channels in the USB or LSB (two independent channels in the same sideband--sideband selectable).

b. One nominal 6-kHz channel in the USB or LSB (selectable).

c. Two nominal 3-kHz channels in the USB and two in the LSB (four independent 3-kHz channels--two in each sideband).

d. One nominal 6-kHz channel in the USB and one in the LSB (two independent 6-kHz channels--one in each sideband).

e. One nominal 3-kHz channel in the USB and one in the LSB (two independent 3-kHz channels--one in each sideband).

9.3.1.2 Automatic Link Establishment Mode. If an Automatic Link Establishment (ALE) capability is to be included, it shall be of the channel-scanning type and shall provide for contact initiation by either or both manual and automated control. See paragraph 4.5 for the list of features required to support this operational mode. Detailed requirements are in Fed-Std-1045A.

9.3.1.3 Antijam mode. If anti-jam (AJ) is to be implemented, the AJ capabilities and features for HF radios shall be in accordance with Mil-Std-188-148.

9.3.1.4 Linking protection. If Linking Protection (LP) is to be implemented, the LP capabilities and features for HF radios shall be in accordance with Fed-Std-1049/1.

9.3.2 Interface parameters.

9.3.2.1 Electrical characteristics of digital interfaces. As a minimum, any incorporated interfaces for serial binary data shall be in accordance with the provisions of Mil-Std-188-114. Such interfaces shall also include provisions for request-to-send (RTS) and clear-to-send (CTS) signaling. The capability to accept additional standard interfaces is permitted.

9.3.2.2 Electrical characteristics of analog interfaces. See sections 9.4.15 and 9.7.2.

9.3.2.3 Modulation and data signaling rates. The modulation rate (expressed in baud (Bd)) or the data signaling rate (expressed in bits per second (b/s)) at interface points A and AN on figure 1 shall include those contained in Fed-Std-1052.

9.3.3 Adaptive communications. Adaptive HF describes any HF communications system that has the ability to sense its communications environment and, if required, to automatically adjust operations to improve communications performance. Should the user elect to incorporate adaptive features, those features shall be in accordance with the requirements stated in this document.

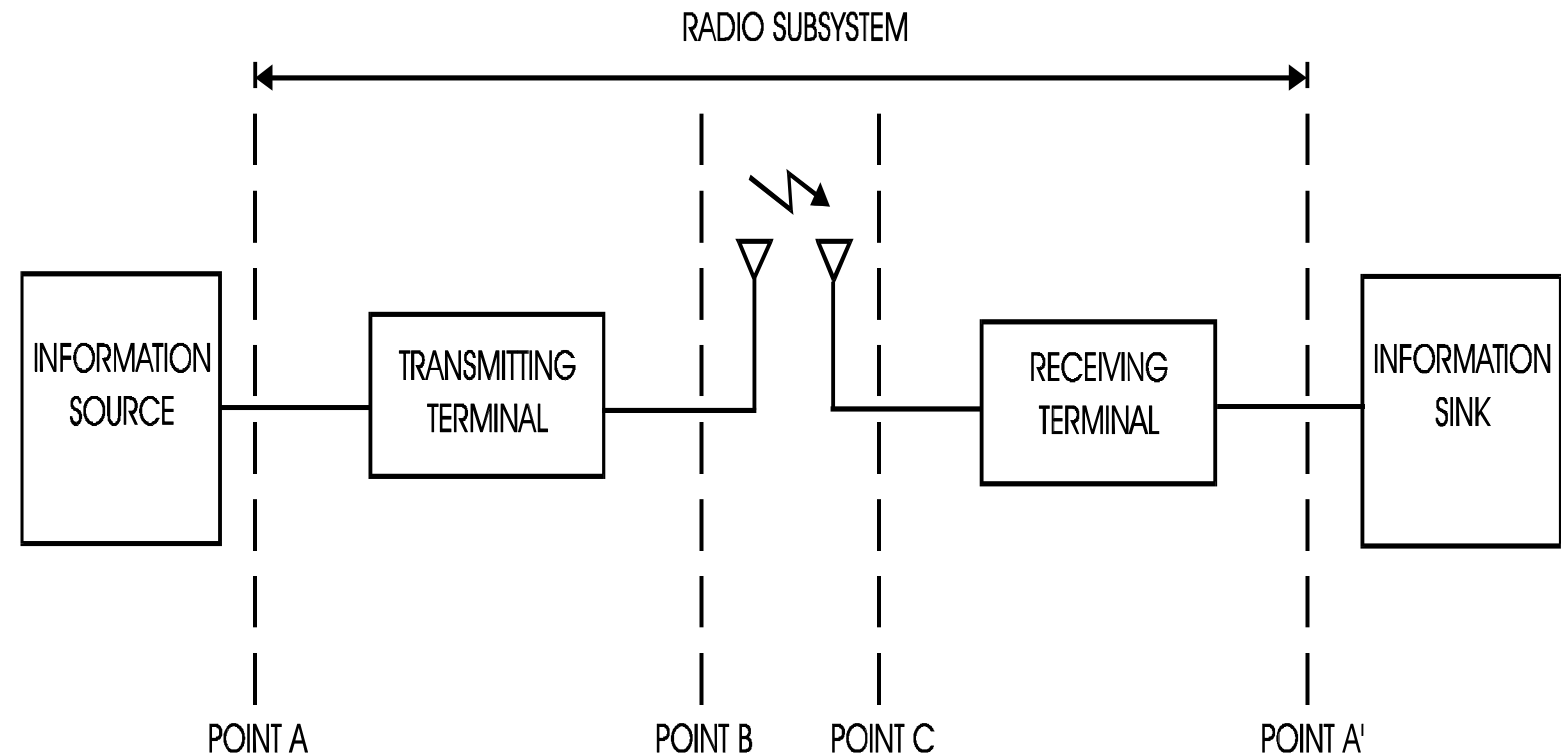


Figure 1. Radio subsystem interface points

Essential adaptive features:

a. Channel (frequency) scanning capability.

b. ALE, using an embedded selective calling capability. A disabling capability and an option to inhibit responses shall be included.

c. Automatic sounding (station identifiable transmissions). A capability to disable sounding and an option to inhibit responses shall be included.

d. Limited link quality analysis (LQA) for assisting the ALE function:

(1) Relative data error assessment.

(2) Relative SINAD (See section 9.4.2, below, for definition).

(3) Multipath/distortion assessment (DO)(not yet standardized).

9.4 Detailed Requirements.

9.4.1 Introduction. This section provides detailed performance standards for MF and HF radio equipment. These performance standards shall apply over the appropriate frequency range from 2.0 MHz to 29.9999 MHz (DO: 1.5 MHz to 29.9999 MHz).

9.4.2 Signal and noise relationships. The signal and noise relationships are expressed as signal-plus-noise-plus-distortion to noise-plus-distortion ratio (SINAD), unless otherwise identified. Unless otherwise specified, when the ratio is stated, the noise bandwidth is 3 kHz.

9.4.3 Common equipment characteristics. These characteristics shall apply to each transmitter and to each receiver unless otherwise specified.

9.4.4 Displayed frequency. The displayed frequency shall be that of the carrier, whether suppressed or not.

9.4.5 Frequency coverage. The radio equipment shall be capable of operation over the frequency range of 2.0 MHz to 29.9999 MHz in a maximum of 100-Hz frequency increments (DO: 10 Hz) for single-channel equipment and 10-Hz frequency increments (DO: 1 Hz) for multichannel equipment.

9.4.6 Frequency accuracy. The accuracy of the radio carrier frequency including tolerance and long-term stability, but not any variation due to doppler shift, shall be within ±20 Hz, measured during a period of not less than 30 days. See paragraph 9.3 for application statements on dual parameters.

9.4.7 Phase stability. The phase stability shall be such that the probability that the phase difference will exceed 5 degrees over any two successive 10-millisecond (ms) periods (13.33-ms periods may also be used) shall be less than 1 percent. Measurements shall be performed over a sufficient number of adjacent periods to establish the specified probability with a confidence of at least 95 percent.

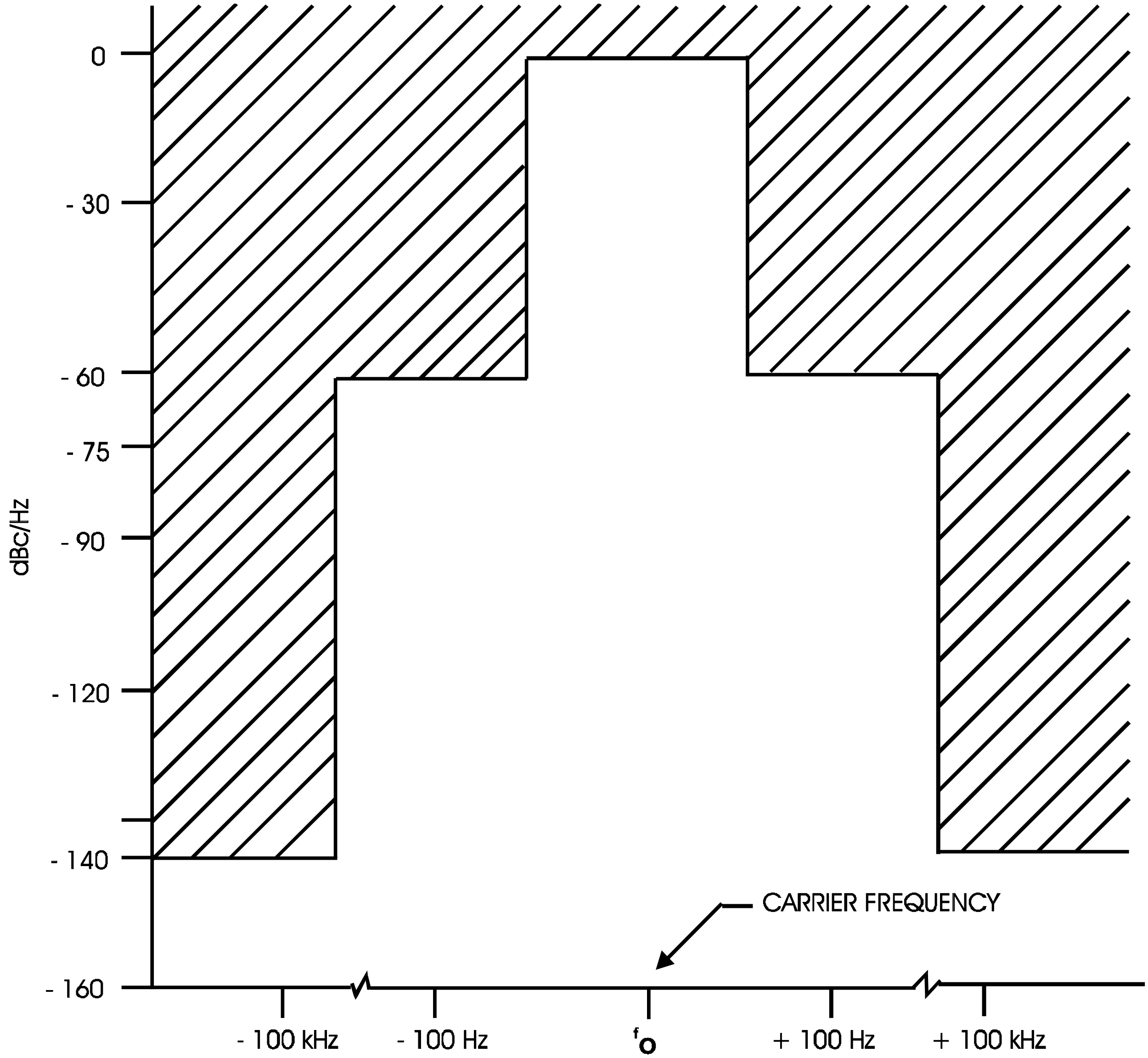
9.4.8 Phase noise. The synthesizer and mixer phase-noise spectrum at the transmitter output shall not exceed those limits as depicted on figures 2 and 3 under continuous carrier single-tone output conditions. Figure 2 depicts the limits of phase noise for group 1 radio transmitters and figure 3 depicts the limits for group 2 transmitters. See paragraph 9.3 for applicable statements on dual parameters.

9.4.9 Bandwidths. The bandwidths for high frequency band emissions shall be as shown in table 1. Other high frequency band emissions which may be required to satisfy specific user requirements may be found in the "NTIA Manual of Regulations and Procedures for Federal Radio Frequency Management."

9.4.10 Overall channel responses.

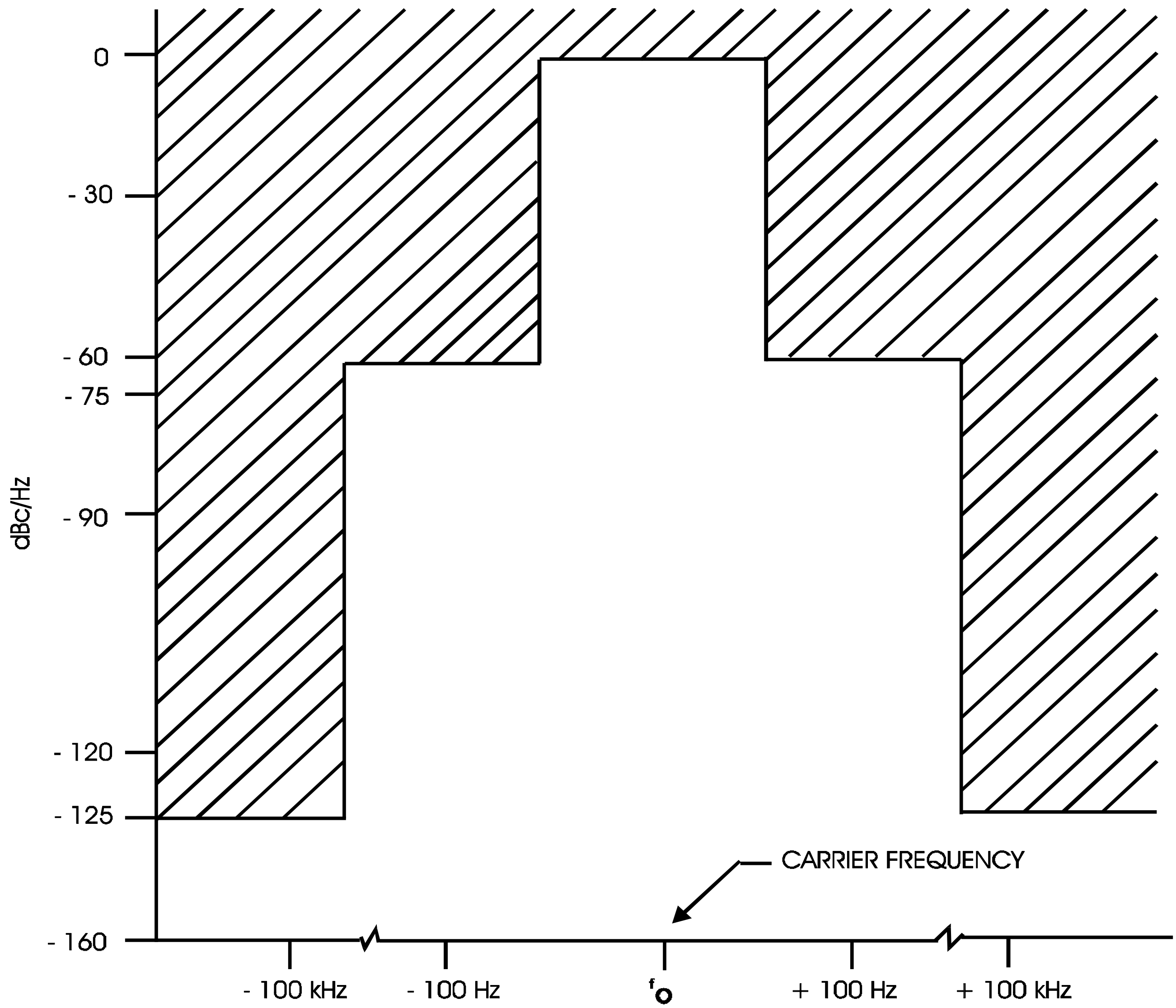
9.4.10.1 Single-channel or dual-channel operation. The amplitude vs. frequency response between (f_0 + 300 Hz) and (f_0 + 3050 Hz) shall be within 3 dB (total) where f_0 is the carrier frequency. The attenuation shall be at least 20 dB from f_0 to (f_0 - 415 Hz), at least 40 dB from (f_0 - 415 Hz) to (f_0 - 1000 Hz), and at least 60 dB below (f_0 - 1000 Hz). Attenuation shall be at least 30 dB from (f_0 + 4000 Hz) to (f_0 + 5000 Hz) and at least 60 dB above (f_0 + 5000 Hz). See figure 4. Group delay time shall not vary by more than 1.0 ms over the passband of 300 Hz to 3050 Hz. Group delay measurements shall be performed end-to-end (transmitter audio input to receiver audio output) with the radio equipment configured in a back-to-back test setup.

NOTE: Although the response values given are for single-channel USB operation, an identical shape, but inverted channel response, is required for LSB or the inverted channel of a dual-channel independent sideband operation.



NOTE:
dBc = Decibels referenced to a full-rated PEP carrier output.

Figure 2. Phase noise limit mask for group 1 radio transmitters



NOTE:
dBc = Decibels referenced to a full-rated PEP carrier output.

Figure 3. Phase noise limit mask for group 2 radio transmitters

Table 1. Bandwidths

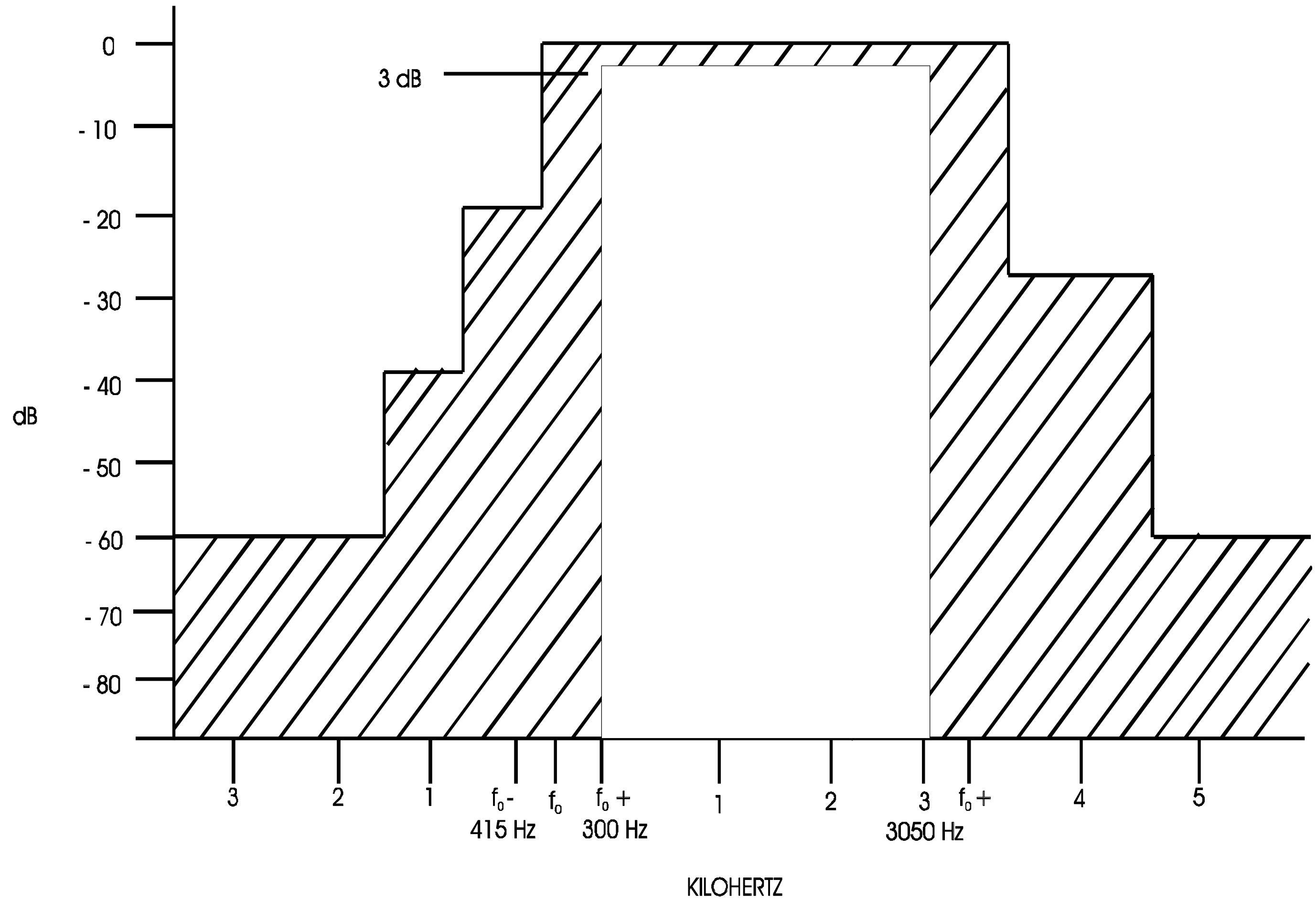
Emission type	Necessary bandwidth
Frequency-shift keying (FSK) (85-Hz shift)	$B_n = Bd + D_f K$ (see notes below)
Frequency-shift keying (FSK) (850-Hz shift)	$B_n = Bd + D_f K$ (see notes below)
Single-sideband modulation (SSB) single-channel	see par. 9.4.10.1
Independent sideband modulation (ISB)	
Two channels	see par. 9.4.10.1
Four channels	see par. 9.4.10.2

NOTES:

1. The simplified formula for calculation of necessary bandwidth is: $B_n = Bd + D_f K$ (The full formula is $B_n = 2M + 2DK$ with $M = Bd/2$) (2M reduces to Bd and 2D reduces to D_f)

Where: B_n = Necessary bandwidth
- Bd = Digital symbol rate for telegraphy (i.e., baud)
- D = Peak deviation, i.e., half the difference between the maximum and minimum values of the instantaneous frequency.
- D_f = Full deviation.
- K = An overall numerical factor which varies according to the emission and which depends upon the allowable signal distortion. Direct printing telegraphy using a frequency shifted modulating subcarrier, with error-correction, single-sideband, suppressed carrier (single channel) has a numerical factor of 1.2
- M = Maximum modulating frequency (Bd/2)

2. The baud rate for 60 wpm (words per minute) teletype is 45.5 Bd. The rate for 100 wpm is 74.2 Bd.



NOTES:

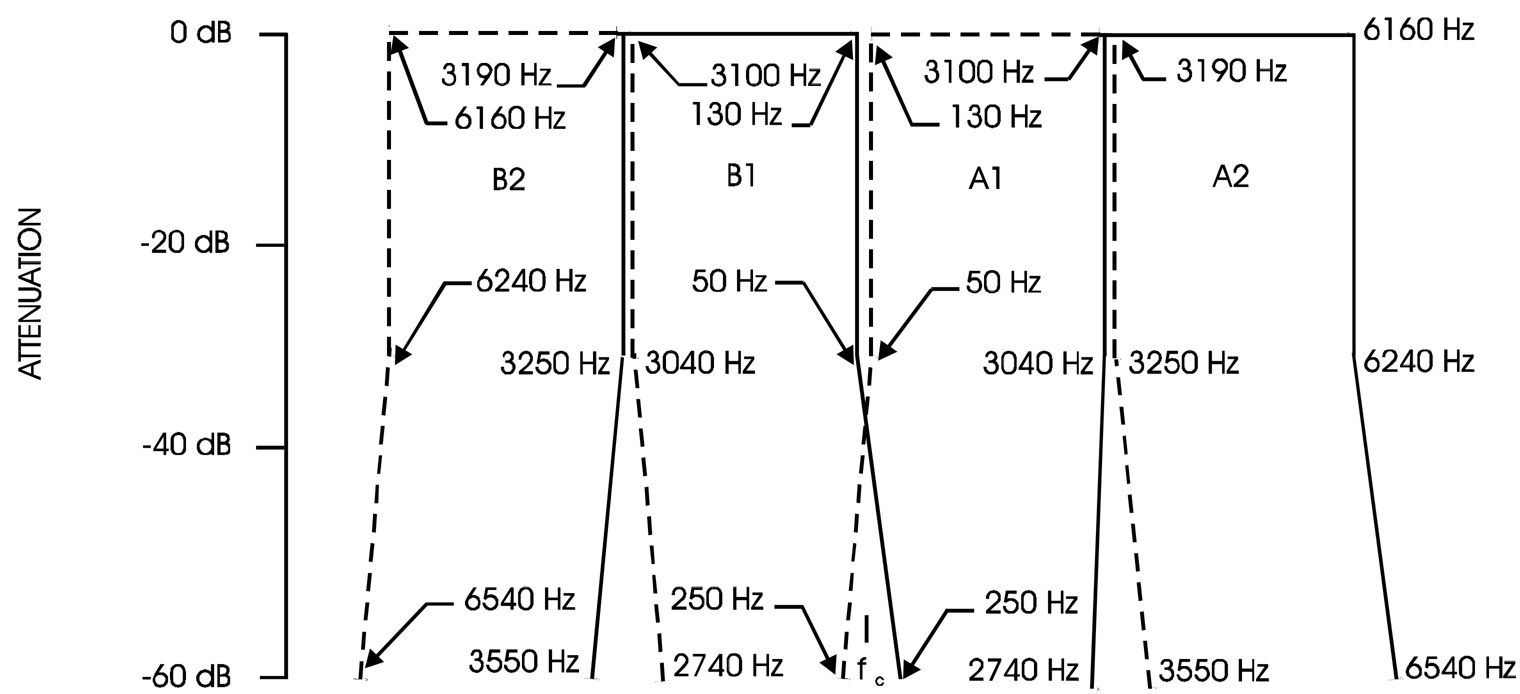
1. CHANNEL RESPONSE SHALL BE WITHIN SHADED PORTION OF CURVE (A 1 SHOWN).
2. f_0 FOR A SINGLE CHANNEL IS THE CARRIER FREQUENCY.
3. f_0 FOR 2-CHANNEL ISB IS THE CENTER FREQUENCY.

Figure 4. Overall channel response for single-channel or dual -channel equipment

9.4.10.2 Four-channel operation. When four-channel independent sideband operation is employed, the four individual 3-kHz channels shall be configured as shown on figure 5, which also shows amplitude response for these four channels. Channels A2 and B2 shall be inverted and displaced with respect to channels A1 and B1 as shown in the figure. This may be accomplished by using subcarrier frequencies of 6290 Hz above and below the center carrier frequency or by other suitable techniques which produce the required channel displacements and inversions. The suppression of any subcarriers used shall be at least 40 dB (DO: 50 dB) below the level of a single tone in the A2 or B2 channel modulating the transmitter to 25 percent of peak envelope power (PEP). Refer to figure 5. The following criteria apply equally to all four channels. The radio frequency (rf) amplitude versus frequency response for each individual ISB channel shall be within 2 dB (DO: 1 dB) between 250 Hz and 3100 Hz, referenced to each channel's carrier (either actual or virtual). Referenced from each channel's carrier, the channel attenuation shall be at least 40 dB at 50 Hz and 3250 Hz; and at least 60 dB at f_0 - 250 Hz and 3550 Hz. Group delay distortion shall not exceed 1500 microseconds over the ranges 370 Hz to 750 Hz and 3000 Hz to 3100 Hz. The distortion shall not exceed 1000 microseconds over the range 750 Hz to 3000 Hz. Group delay distortion shall not exceed 150 microseconds for any 100-Hz frequency increment between 750 Hz and 3000 Hz. Group delay measurements shall be performed end-to-end (transmitter audio input to receiver audio output) with the radio equipment configured in a back-to-back test setup.

9.4.10.3 Absolute delay. The absolute delay shall not exceed 10 ms (DO: 5 ms) over the frequency range of 300 Hz to 3050 Hz. Measurements shall be performed end-to-end and back-to-back as in paragraph 9.4.10.1.

9.4.10.4 Lincompex. Should a voice compression and expansion capability be included, it shall meet the Lincomplex requirements of ITU-R (formerly CCIR) Recommendation F.455-2, Recommendation 475-1, and Recommendation F.1111-1. In addition, such a device shall incorporate calibration techniques that automatically remove radio link frequency error from the control channel for the receiver expander function with the start of reception of each Lincompex transmission. As a design objective, frequency errors should also be removed from the speech channel. The calibration sequence is shown on figure 6.



NOTES:
1. THE VIRTUAL SUBCARRIER FOR THE A2 AND BE INVERTED CHANNELS SHALL BE f_c ±_6290 Hz.

2. FREQUENCIES SHOWN ARE AT THE FILTER dB (BREAK POINT) LEVELS NOTED.

Figure 5. Overall channel characteristics (four-channel equipment)

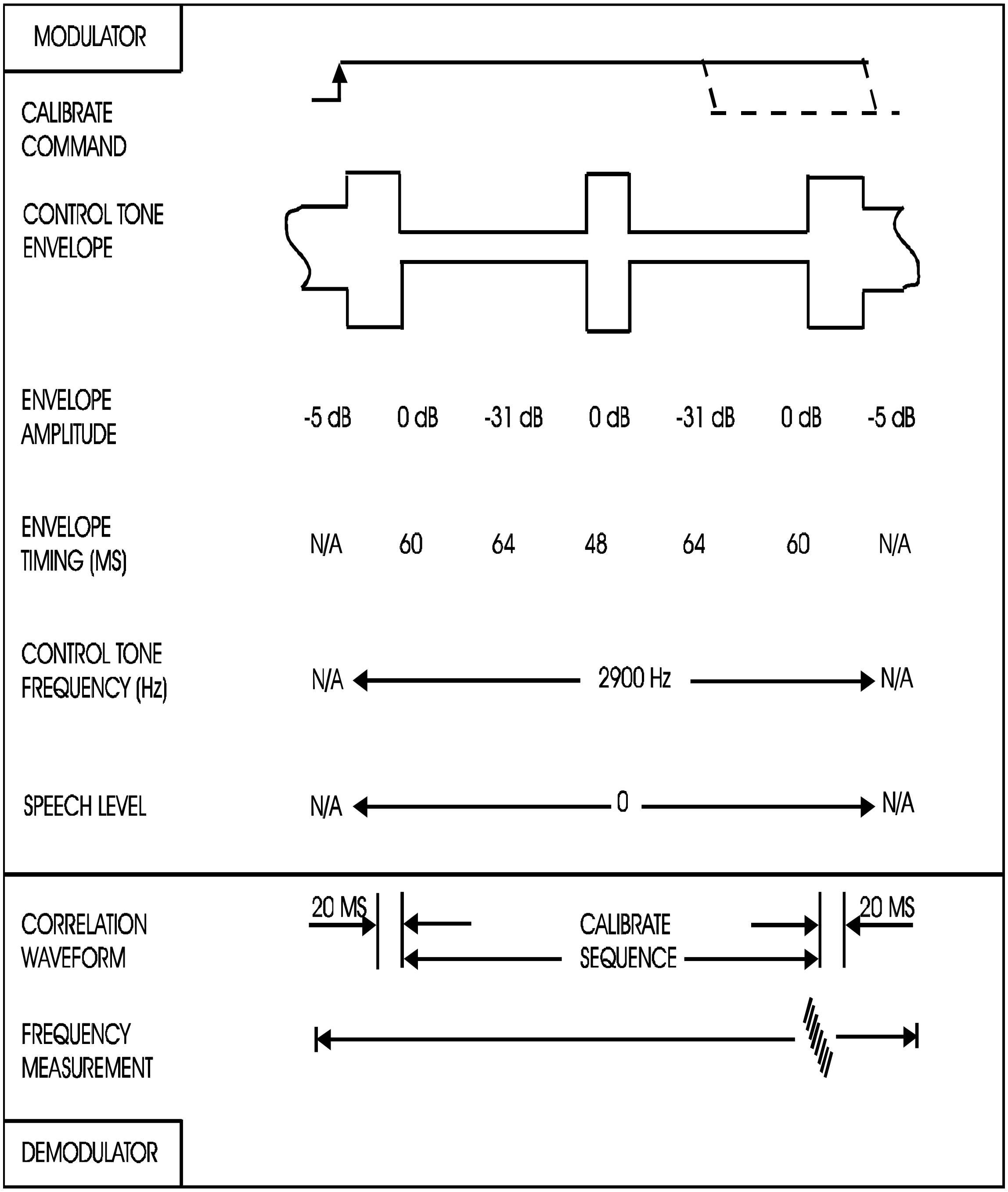


Figure 6. Digital Lincompex calibration sequence

There are four sets of specifications to accommodate the most common voice channel bandwidths found in user equipment. They are:

(A) Band 250-2500 Hz; control tone center frequency 2900 Hz (as shown on figure 6)

(B) Band 250-2380 Hz; control tone center frequency 2580 Hz

(C) Band 250-2000 Hz; control tone center frequency 2200 Hz

(D) Band 250-1575 Hz; control tone center frequency 1775 Hz.

9.4.11 Transmitter characteristics.

9.4.11.1 Noise and distortion.

9.4.11.1.1 In-band noise. Broadband noise in a 1-Hz band within the selected sideband shall be at least 85 dBc below the level of the HF transmitter's rated PEP.

9.4.11.1.2 Intermodulation distortion (IMD). The IMD products of HF transmitters produced by any two equal-level test signals within the 3-dB bandwidth (a single-frequency audio output) shall be at least 30 dB below either tone for group 1 station applications and 24 dB below either tone for group 2 applications when the transmitter is operating at rated PEP. The frequencies of the two audio test signals shall not be harmonically or subharmonically related and shall have a minimum separation of 300 Hz.

9.4.11.2 Spectral purity.

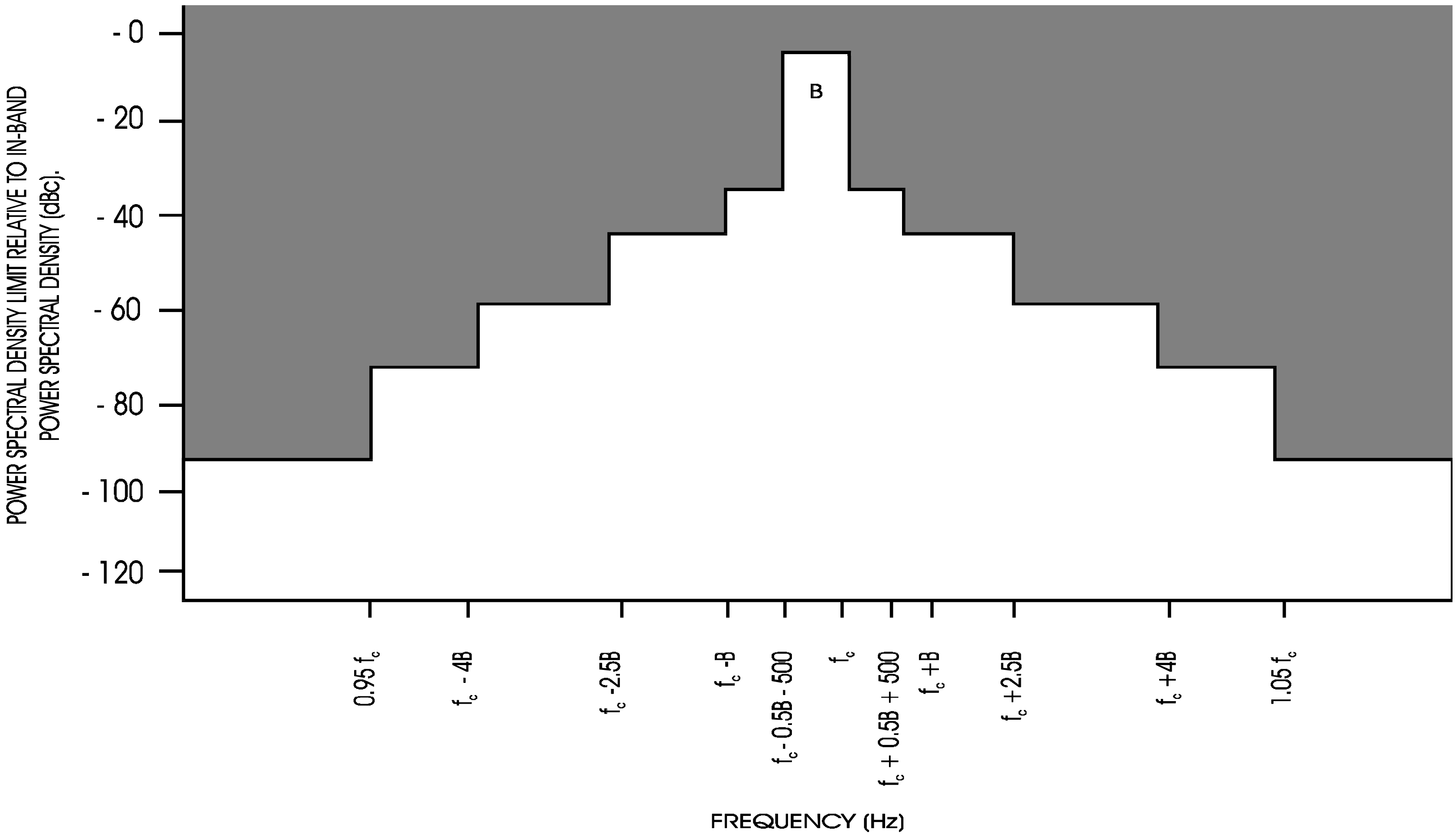
9.4.11.2.1 Broadband emissions. When the transmitter is driven with a single tone to rated PEP, the power spectral density of the transmitter broadband emission shall not exceed the level established in table 2 and as shown on figure 7. Discrete spurs shall be excluded from the measurement, and the measurement bandwidth shall be 1 Hz.

9.4.11.2.2 Discrete frequency spurious emissions. For HF transmitters, when driven with a single tone to produce an rf output of 25 percent rated PEP, all

Table 2. Out-of-band power spectral density limits for radio transmitters

Frequency (Hz)	Attenuation below in-band power density (dB)
$f_m = f_c \pm (0.5\ BW + 500)$	40 (DO: 43)
$f_m = f_c \pm 1.0\ BW$	45 (DO: 48)
$f_m = f_c \pm 2.5\ BW$	60 (DO: 80)
$(f_c + 4.0\ BW) \# f_m \# 1.05 f_c$ $0.95 f_c \# f_m \# (f_c - 4.0\ BW)$	70 (DO: 80)
$f_m \# 0.95 f_c$ $f_m \$ 1.05 f_c$	90 (DO: 120)

where: f_m = frequency of measurement (Hz)
f_c = center frequency of bandwidth (Hz)
BW = bandwidth (Hz)



NOTES:
1. B - NECESSARY BANDWIDTH (Hz).
2. f_c - CENTER FREQUENCY OF BANDWIDTH (Hz).
3. EMISSIONS SHALL FALL WITHIN THE UNSHADED PORTION OF THE CURVE.

Figure 7. Out-of-band power spectral density for HF transmitters

discrete frequency spurious emissions shall be suppressed as follows:

Group 1 application

a. Between the carrier frequency (f_c) and f_c ± 4B (where B = bandwidth), at least 40 dBc.

b. Between f_c ± 4B and ±5 percent of f_c removed from the carrier frequency, at least 60 dBc

c. Beyond ±5 percent of f_c removed from the carrier frequency, at least 80 dBc (see figure 8).

Group 2 application

a. Between f_c and f_c ± 4B, at least 40 dBc.

b. Beyond f_c ± 4B, at least 50 dBc.

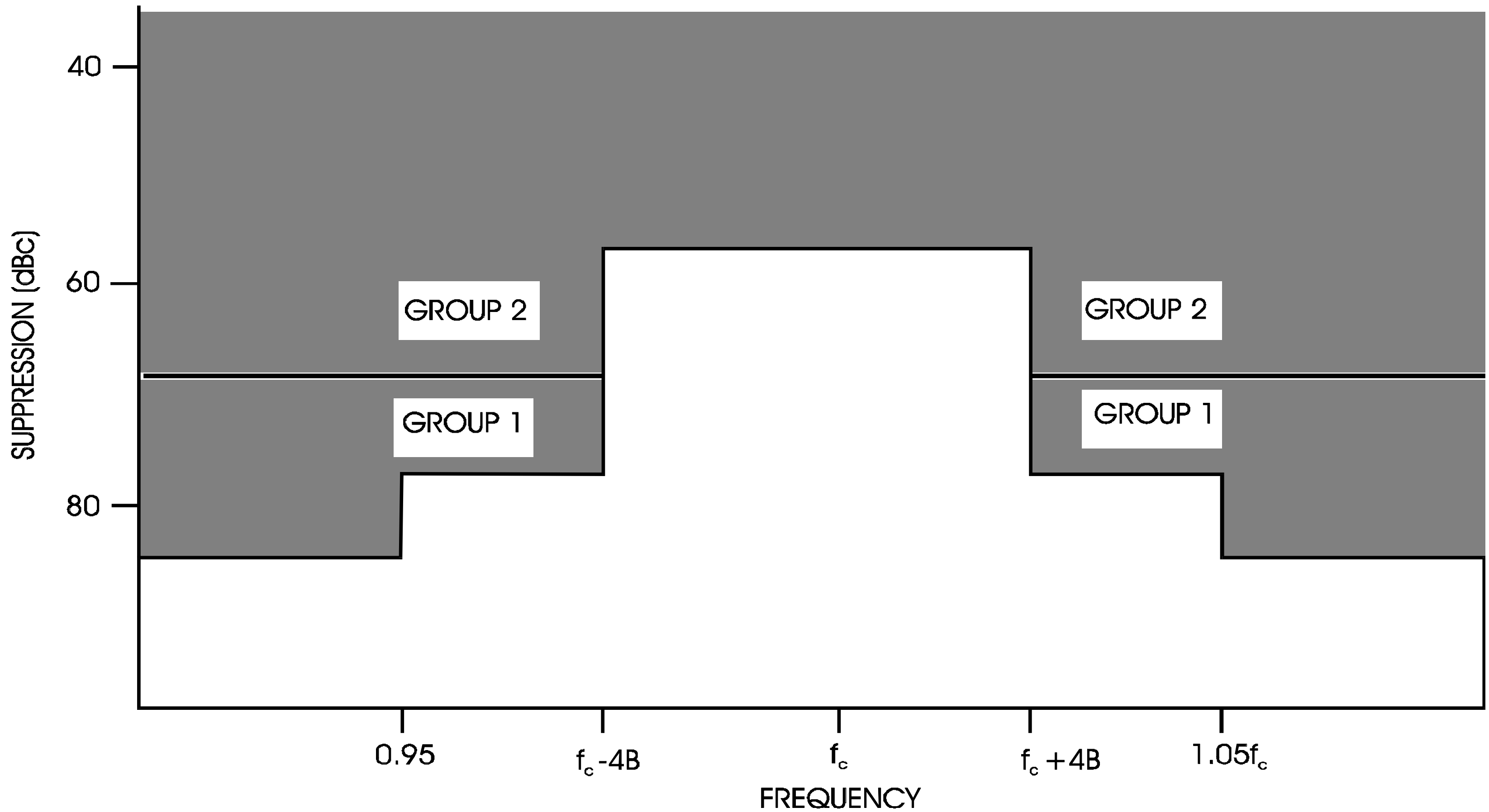
9.4.12 Carrier suppression. For group 1, the suppressed carrier shall be at least 50 dBc (DO: 60 dBc) below the output level of a single tone modulating the transmitter to rated PEP. For group 2 (not exceeding 100 watts output power), the suppressed carrier shall be at least 40 dBc (DO: 50 dBc) below the output level of a single tone modulating the transmitter to rated PEP.

9.4.13 Automatic level control (ALC). Starting at ALC threshold, an increase of 20 dB in audio input shall result in an increase of less than 1 dB in average rf power output.

9.4.14 Attack and release time delays.

9.4.14.1 Attack-time delay. The time interval, from keying-on a transmitter until the transmitted rf signal amplitude has increased to 90 percent of its steady-state value, shall not exceed 25 ms (DO: 10 ms). This delay excludes any necessary time for automatic antenna tuning.

9.4.14.2 Release-time delay. The time interval, from keying-off a transmitter until the transmitted rf signal amplitude has decreased to 10 percent of its key-on steady-state value, shall be 10 ms or less.



NOTE:
EMISSIONS SHALL FALL WITHIN THE UNSHADED PORTION OF THE CURVE.

Figure 8. Discrete spurious emissions limit for HF transmitters

9.4.15 Signal input interface characteristics.

9.4.15.1 Input signal power. Input signal power for microphone or handset input is not standardized. When a line-level input is provided (see paragraph. 5.3.6.2), rated transmitter PEP shall be obtainable for single-tone amplitudes from -17 dBm (dB referred to one milliwatt) to +6 dBm (manual adjustment permitted).

9.4.15.2 Input audio signal interface

9.4.15.2.1 Unbalanced interface. When an unbalanced interface is provided, it shall have an audio input impedance of a nominal 150 ohms, unbalanced with respect to ground, with a minimum return loss of 20 dB against a 150-ohm resistance over the nominal 3-kHz passband.

9.4.15.2.2 Balanced interface. When a balanced interface is provided, the audio input impedance shall be a nominal 600 ohms, balanced with respect to ground, with a minimum return loss of 26 dB against a 600-ohm resistance over the nominal 3-kHz passband. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB below the reference signal level.

9.4.16 Transmitter output load impedance. The nominal rf output load impedance at interface point B, on figure 1, shall be 50 ohms, unbalanced with respect to ground. Transmitters shall survive any VSWR (voltage standing wave ratio) at point B, while derating the output power as a function of increasing VSWR. However, the transmitter shall deliver full rated forward power into a 1.3:1 VSWR load. Figure 9 is a design objective for the derating curve. The VSWR between an exciter and an amplifier shall be less than 1.5:1. The VSWR between an amplifier and an antenna coupler shall be less than 1.5:1 for group 1 applications and less than 2.0:1 for group 2 applications.

NOTE: The full-rated output power of a transmitter, over the operating frequency range, is defined to be (a) the rated PEP when the transmitter is driven by a two-tone signal consisting of equal amplitude tones, and (b) the rated average power when driven by a single tone. The output rating shall be determined with the transmitter operating into a nominal 50-ohm load.

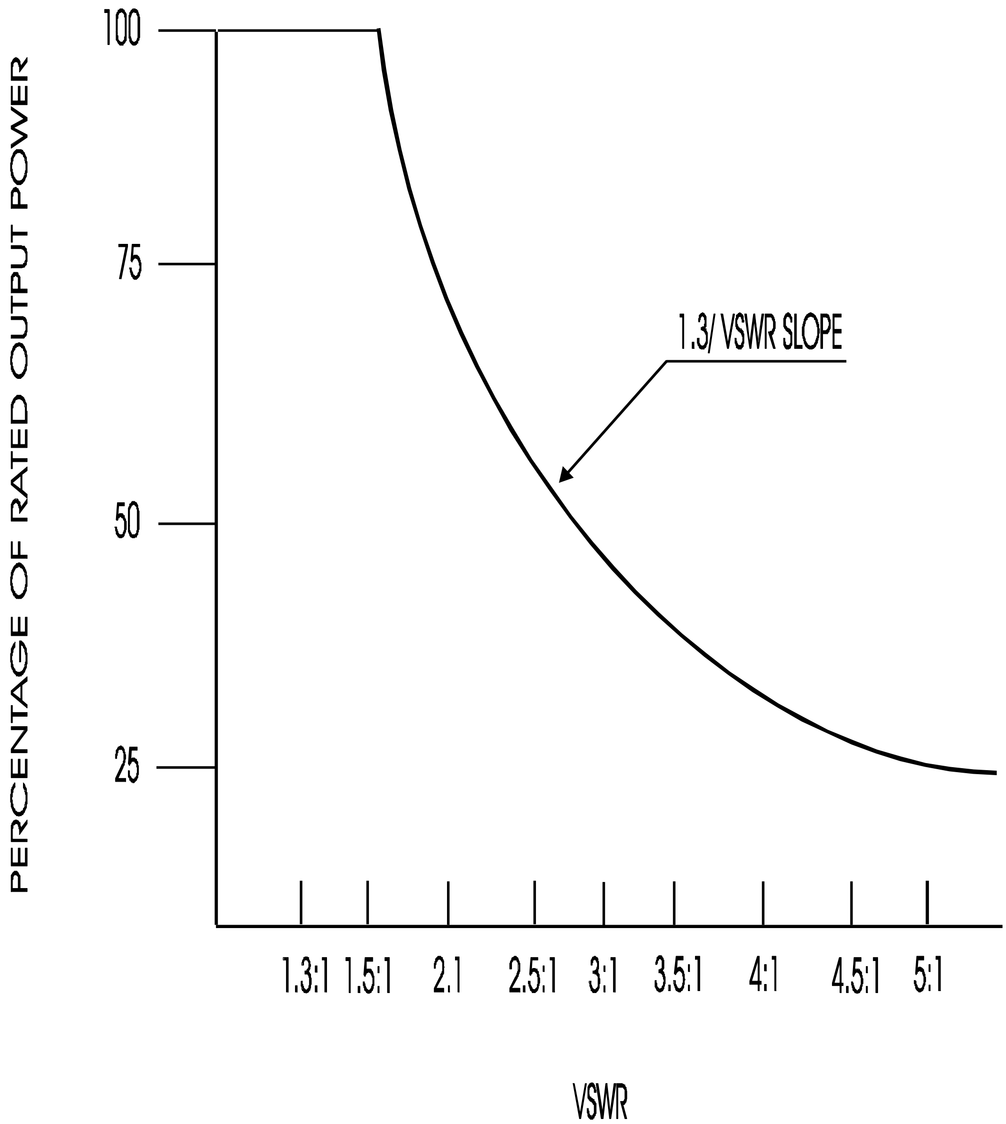


Figure 9. Output power vs. VSWR for transmitters with broadband output impedance networks

9.5 Receiver characteristics.

9.5.1 Receiver rf characteristics. NOTE: All receiver input amplitudes are in terms of available power in dBm from a 50-ohm source impedance signal generator.

9.5.1.1 Image rejection. The rejection of image signals shall be at least 70 dB for group 2 HF receivers and 80 dB for all other HF receivers (DO: 100 dB).

9.5.1.2 Intermediate frequency (IF) rejection. Spurious signals at the intermediate frequencies shall be rejected by at least 70 dB for group 2 HF receivers and 80 dB for all other HF receivers (DO: 100 dB).

9.5.1.3 Adjacent channel rejection. The receiver shall reject any signal in the undesired sideband and adjacent channel in accordance with figure 4.

9.5.1.4 Other single-frequency external spurious responses. Receiver rejection of spurious frequencies, other than IF and image, shall be at least 65 dB (55 dB for group 2) for frequencies from +2.5 percent to +30 percent, and from -2.5 percent to -30 percent, of the center frequency, and at least 80 dB (70 dB for group 2) for frequencies beyond ±30 percent of the center frequency.

9.5.1.5 Receiver protection. The receiver, with primary power on or off, shall be capable of survival without damage with applied signals of up to +43 dBm (DO: +53 dBm) available power delivered from a 50-ohm source for a duration of 5 minutes for group 1 applications and 1 minute for group 2 applications.

9.5.1.6 Desensitization dynamic range. The following requirement shall apply to the receiver in an SSB mode of operation with an IF passband setting providing at least 2750 Hz (nominal 3-kHz bandwidth) at the 3-dB points. With the receiver tuning centered on a sinusoidal input test signal and with the test signal level adjusted to produce an output SINAD of 10 dB, a single interfering sinusoidal signal, offset from the test signal by an amount equal to ±5 percent of the carrier frequency, is injected into the receiver input. The output SINAD shall not be degraded by more than 1 dB as follows:

a. For group 1 radios, the interfering signal is equal to or less than 100 dB above the test signal level.

b. For group 2 radios, the interfering signal is equal to or less than 90 dB above the test signal level.

9.5.1.7 Receiver sensitivity. The sensitivity of the receiver over the operating frequency range, in the sideband mode of operation (nominal 3-kHz bandwidth), shall be such that a -111 dBm (DO: -121 dBm) unmodulated signal at the antenna terminal, adjusted for a 1000-Hz audio output, produces an audio output with a SINAD of at least 12 dB over the operating frequency range.

9.5.1.8 Receiver out-of-band IMD. Second and higher order responses shall require a two-tone signal amplitude, with each tone at +80 dB or greater above that level required for a single tone input required to produce an output SINAD of 12 dB. This requirement is applicable for equal amplitude input signals with the closest signal spaced 30 kHz or more from the operating frequency.

9.5.1.9 Third-order intercept point. Using test signals within the first IF passband, the worst case third-order intercept point shall not be less than +10 dBm (+1 dBm for group 2 applications).

9.6.1 Receiver distortion and internally generated spurious outputs.

9.6.1.1 Overall Intermodulation Distortion (in-channel). The total of intermodulation distortion (IMD) products, with two equal-amplitude, in-channel tones spaced 110 Hz apart, present at the receiver rf input, shall meet the following requirements. For frequency-division multiplexing (FDM) service, the receiver shall meet the requirements for any tone spacing equal to or greater than the minimum between adjacent tones in any FDM library. The requirements shall be met for any rf input amplitude of 0 dBm PEP (-6 dBm/tone) at rated audio output. All IMD products shall be at least 35 dB (DO: 45 dB) below the output level of either of the two tones.

9.6.1.2 Adjacent-channel IMD. For multiple-channel equipment, the overall adjacent-channel IMD, in each 3-kHz channel being measured, shall not be greater than -35 dBm at the 3-kHz channel output with all other channels equally loaded with 0 dBm unweighted white noise.

9.6.1.3 Audio frequency total harmonic distortion. The total harmonic distortion produced by any single frequency rf test signal, which produces a frequency within the frequency bandwidth of 300 Hz to 3050 Hz, shall be at least 25 dB

(DO: 35 dB) below the reference tone level with the receiver at rated output level. The rf test signal shall be at least 35 dB above the receiver noise threshold.

9.6.1.4 Internally generated spurious outputs. Spurious signals at the output of the receiver, produced in the absence of rf signals by mixing of signals that are generated internally in the receiver, shall not exceed -112 dBm (DO: -122 dBm).

9.6.1.5 Automatic gain control characteristic. Automatic gain control (AGC) shall be such that the steady-state output level of the receiver (for a single tone) shall not vary by more than 3 dB over an rf input range from -103 dBm to +13 dBm for group 1 applications or -103 dBm to 0 dBm for group 2 applications.

9.6.1.6 AGC attack-time delay (nondata modes). The receiver AGC attack-time delay shall not exceed 30 ms.

9.6.1.7 AGC release time (nondata modes). The receiver AGC release time shall be between 800 and 1200 ms for SSB voice and intermittent continuous wave (ICW) operation. This shall be the time period from rf signal downward transition until audio output is within 3 dB of the steady-state output. The final steady-state audio output is simply receiver noise being amplified in the absence of any rf input signal.

9.6.1.8 AGC requirements for data service. In data service, the receiver AGC attack-time shall not exceed 13 ms. The AGC release-time shall not exceed 25 ms.

9.7.1 Receiver linearity. The following shall apply with the receiver operating at maximum sensitivity and with a reference input signal that produces a SINAD of 10 dB at the receiver output. The output SINAD shall increase monotonically and linearly within ± 1.5 dB for a linear increase in input signal level until the output SINAD is equal to at least 30 dB (DO: 40 dB). When saturation occurs, the output SINAD may vary ±3 dB for additional increases in signal level. This requirement shall apply over the operating frequency range of the receiver.

9.7.2 Interface characteristics.

9.7.2.1 Input impedance. The receiver rf input impedance shall be nominally 50 ohms, unbalanced with respect to ground. The input VSWR, with respect to 50 ohms, shall not exceed 2.5:1 over the operating frequency range.

9.7.2.2 Output impedance and power. When a balanced output is provided, the receiver output impedance shall be a nominal 600 ohms, balanced with respect to ground, capable of delivering 0 dBm to a 600-ohm load. Electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB below reference signal level. The receiver output signal power, for operation with a headset or handset, shall be adjustable at least over the range from -30 dBm to 0 dBm. For operation with a speaker, the output level shall be adjustable at least over the range from 0 dBm to +30 dBm. As a DO, an additional interface which can accommodate speakers ranging from 4 to 16 ohms impedance should be provided.

9.8 Automatic link establishment (ALE). If ALE is to be implemented, it shall be in accordance with Fed-Std-1045A. The ALE requirements include selective calling and handshake, link quality analysis and channel selection, scanning, and sounding. These requirements are organized in Fed-Std-1045A as follows:

a. Requirements for ALE implementation are given in sections 1 through 5.

b. Details on ALE waveform, signal structure protocols, and orderwire messages are contained in sections 5.1 through 5.5

10. Where to obtain Copies. Additional copies of this document can be obtained from the National Communications System, Technology and Standards Division (N6), 701 South Court House Road, Arlington, VA 22204-2198. When requesting copies, refer to Federal Telecommunications Recommendation 1050-1998, High Frequency Radio Baseline Parameters.

Definitions needed for the technical understanding of FTR 1050-1998 are provided below. Those that are common with Fed-Std-1037C have been included for convenience of the reader.

Automatic link establishment (ALE): The capability of an HF radio station to make contact, or initiate a circuit, between itself and another specified radio station, without human intervention and usually under processor control. *Note:* ALE techniques include automatic signaling, selective calling, and automatic handshaking. Other automatic techniques that are related to ALE are channel scanning and selection, link quality analysis (LQA), polling, sounding, message store-and-forward, address protection, and anti-spoofing (FED-STD 1037C).

Balanced to ground: Electrical symmetry with respect to a common ground.

Clear-to-send (CTS) signal: The control signal generated by the transmitting modem on the CTS connection to denote a state of readiness for transmission. The CTS signal is a response to the request-to-send (RTS) signal from the transmitting device.

Compatibility: Capability of two or more items or components of equipment or material to exist or function in the same system or environment without mutual interference (FED-STD 1037C).

Delay distortion: In a waveform consisting of two or more wave components at different frequencies, distortion caused by the difference in arrival times of the frequency components at the output of a transmission system (FED-STD 1037C).

Dynamic range: 1. In a system or device, the ratio of (a) a specified maximum level of a parameter, such as power, current, voltage, or frequency to (b) the minimum detectable value of that parameter. 2. In a transmission system, the ratio of (a) the overload level, i.e., the maximum signal power that the system can tolerate without distortion of the signal, to (b) the noise level of the system. 3. In digital systems or devices, the ratio of maximum and minimum signal levels required to maintain a specified bit error ratio. *Note:* The dynamic range is usually expressed in dB (FED-STD 1037C).

Fixed: A station intended to be used at a specified fixed point (NTIA).

Group delay: The rate of change of the total phase shift with respect to angular frequency, *d1/dT,* through a device or transmission medium, where *1* is the total phase shift, and *T* is the angular frequency equal to *2Bf,* where *f* is the frequency (FED-STD 1037C).

Image frequency: In radio reception using heterodyning in the tuning process, an undesired input frequency that is capable of producing the same intermediate frequency (IF) that the desired input frequency produces. *Note:* The term image arises from the mirror-like symmetry of signal and image frequencies about the beating-oscillator frequency (FED-STD 1037C).

Interoperability: The condition achieved among communications-electronics systems or items of communications-electronics equipment when information or services can be exchanged directly and satisfactorily between them and/or their users (FED-STD 1037C).

Linked compressor and expander (Lincompex): A speech processing system comprised of a compressor and expander linked by a control channel separate from the audio (speech) channel.

Mobile: A radio communication service between mobile and land stations, or betwee n mobile stations. A station in the mobile service intended to be used while in motion or during halts at unspecified points (NTIA).

Multipath (MP): The propagation phenomenon that results in radio signals reaching the receiving antenna by two or more paths (FED-STD 1037C).

Narrowband: At HF radio frequencies (1.5 - 30 MHz) the nominal voice frequency (VF) bandwidth allocated for single channel radio (i.e., 3 kHz).

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 (NTIA).

Nominal bandwidth: The widest band of frequencies, inclusive of guard bands, assigned to a channel (FED-STD 1037C).

Phase noise (dBc/Hz): The amount of single-sided phase noise, contained in a 1-Hertz (Hz) bandwidth, produced by a carrier (signal generation) source and referenced in decibels below the full (unsuppressed) carrier output power. *Note:* Phase noise is generally caused by minor fluctuations in the output frequency (phase) of an oscillator or frequency synthesizer. The effect of phase noise in a receiver is that as a receiver is tuned towards a strong near-by signal, there is an apparent rise in the receiver's noise floor, which can mask weak signals in the passband. Phase noise on a transmitter signal (from transmitter oscillator phase noise) will produce the same effect in a receiver.

Portable: A station designed to be carried by a person and capable of transmitting and/or receiving while in motion or during brief halts at unspecified locations (NTIA).

Request-to-send (RTS) signal: The control signal generated by the transmitting terminal on the RTS connection to denote a request for transmission.

Signal-plus-noise-plus-distortion to noise-plus-distortion ratio (SINAD): The ratio, expressed in decibels (dB), of (a) the recovered audio power (original modulating audio signal plus noise plus distortion) from a modulated radio frequency carrier, to (b) any residual audio power (noise plus distortion) remaining after the original modulating audio signal is removed (FED-STD 1037C).

Spurious emission: Emission on a frequency or frequencies which is outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information (FED-STD 1037C).

Third-order intercept point: A point (a) that is an extrapolated convergence--not directly measurable--of intermodulation distortion products in the desired output and (b) that indicates how well a receiver performs in the presence of strong nearby signals. *Note:* Determination of a third-order intercept point is accomplished by using two test frequencies that fall within the first intermediate frequency mixer passband. Usually, the test frequencies are about 20 to 30 kHz apart (FED-STD 1037C). Intermodulation products have an output-versus-input characteristic which, when graphically displayed, would theoretically intercept the plot of the desired output-versus-input if the nonlinear device continued to operate linearly without compression. The signal input level at which this theoretical point would occur is called the intercept point and is usually defined in dBm (IEEE).

Transportable: A station which is transferred to various fixed locations but is not intended to be used while in motion (NTIA).

Unbalanced to ground: Pertaining to electrical asymmetry with respect to a common ground. *Note:* Frequently, the term "unbalanced" describes a circuit, one side of which is grounded.

Wideband: At HF radio frequencies (1.5 - 30 MHz) a bandwidth larger than 3 kHz.

The abbreviations and acronyms used in FTR 1050-1998 are defined below. Those that are common with FED-STD 1037C have been included for the convenience of the reader.

AGC	automatic gain control
AJ	anti-jamming
ALC	automatic level control
ALE	automatic link establishment
Bd	baud
BER	bit error ratio
bit	acronym for <u>bi</u>nary digi<u>t</u>
b/s	bits per second
BW	bandwidth
CCIR	International Radio Consultative Committee
CTS	clear to send
dB	decibel
dBc	dB referred to the carrier
dBm	dB referred to one milliwatt
DO	design objective
FDM	frequency-division multiplexing
FED-STD	Federal Standard
f_0	carrier frequency
FSK	frequency-shift keying
FTSC	Federal Telecommunications Standards Committee
HF	high frequency
Hz	Hertz
IAW	in accordance with
IEEE	The Institute of Electrical and Electronics Engineers, Inc.
IF	intermediate frequency
IMD	intermodulation distortion
ISB	independent sideband
ITS	Institute for Telecommunication Sciences
ITU	International Telecommunication Union
ITU-R	International Telecommunication Union, Radiocommunication Assembly
kHz	kiloHertz (1,000 Hertz)
LP	linking protection
LQA	link quality analysis
LSB	lower sideband
MF	medium frequency
MHz	MegaHertz (1,000,000 Hertz)
MIL-STD	military standard
modem	modulator-demodulator
MP	multipath
ms	millisecond

NBFM	narrowband frequency modulation
NTIA	National Telecommunications and Information Administration
PEP	peak envelope power
rf	radio frequency
RTS	request-to-send
SINAD	signal-plus-noise-plus-distortion to noise-plus-distortion ratio
SOR	statement of requirements
SSB	single sideband
USB	upper sideband
VF	voice frequency
VSWR	voltage standing wave ratio
wpm	words per minute