CHIEF OF NAVAL OPERATIONS

Functional Requirements Document
For
8.33 kHz CHANNEL SEPARATION

(FRD for 8.33 kHz Channel Separation)

Revision A

1 August 2005

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FUNCTIONAL REQUIREMENTS DOCUMENT FOR 8.33 kHz CHANNEL SEPARATION (FRD for 8.33 kHz Channel Separation)

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CHANGE SUMMARY PAGE

This change summary page is provided to maintain a record of change to the last issue of the FRD. Upon receipt of a change or revision, the holder of the FRD should incorporate the change(s)/revision(s) into the original and make an appropriate entry on the Record of Change listing below:

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		intermodulation requirements. Page 12, Paragraph 3.9, renumbered paragraph from 3.6 to 3.9. Page 12, Paragraph 3.9.1 (Former 3.6.1) Modified Power Output Requirement Page 16, Paragraph 3.9.13 (Former 3.6.13) Deleted requirement concerning unintentional or continuous transmissions Page 16, Paragraph 3.9.14 (Former 3.6.13) Deleted requirement concerning simultaneous transmissions	

COMMENT INFORMATION

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EXECUTIVE SUMMARY

During the 1990's, Europe's Air Traffic Services (ATS) realized that the current 25 kHz frequency channel spacing availability in the Very High Frequency (VHF) radio band could no longer accommodate the growing demand for channels. A recommendation was made to divide the existing 25 kHz bandwidth channels into 8.33 kHz channels thereby increasing the available channels for future use.

The "Plan for the 8.33 kHz Channel Spacing Implementation in Europe" was developed at the special European Organization for Safety of Air Navigation (EUROCONTROL) Regional Air Navigation Meeting in Vienna, Austria in September of 1994 and expanded at the International Civil Aviation Organization (ICAO) Special Communications/Operations Divisional Meeting, in Montreal, Canada in March of 1995. This plan was endorsed by the 38th meeting of the European Air Navigation Planning Group (EPANG) in November of 1996. The equipage and operation of radios capable of VHF 8.33 kHz channel spacing became mandatory as stated in the European Regional Supplementary Procedures ICAO Doc. 7030/4 for flights above Flight Level (FL) 245. The ICAO Doc. 7030/4 specified the Mandatory Equipage date as 1 January 1999, but due to the slow rate of aircraft equipping, EUROCONTROL, in coordination with ICAO, decided to delay the requirement to 7 October 1999. EUROCONTROL is the overarching European Organization agency for the Safety of Air Navigation, currently having 32 European country member states.

Presently State aircraft, which includes military aircraft, flying as General Air Traffic (GAT) 30 hours or less on an annual basis are given an exemption to operate in the same Very High Frequency (VHF) 8.33 kHz airspace if the same en route airspace is supported by Ultra High Frequency (UHF) ground infrastructure. Because not all of the European airspace is supported by UHF communications ground infrastructure, military aircraft without VHF 8.33 kHz capability can fly as GAT but can incur long delays and non-direct routes around those areas.

This Functional Requirements Document (FRD) establishes the minimum functional requirements needed for Naval Aviation to conform to civil EUROCONTROL VHF 8.33 kHz channel separation requirements. It should be understood that this FRD does not usurp any international agreements or treaties that pertain to "State Owned Aircraft" being operated in accordance with rules governing Operational Air Traffic (OAT).

PMA209 is designated as the Navy Lead Program Office to coordinate Communication, Navigation, Surveillance/Air Traffic Management (CNS/ATM) efforts as recommended by the Deputy Chief of Naval Operations for Air Warfare (N78) Letter (CNO Ser 7U660859 dated 14 October 1997). In accordance with this tasking, PMA209 has developed this 8.33 kHz Channel Separation FRD for Naval Aviation.

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1.0 INTRODUCTION

1.1 PURPOSE

This FRD specifies VHF communications system characteristics that will be useful to the designer as well as the Navy/Marine Corps integrator and operator of the aircraft. This document is designed to insure that Navy and Marine Corps equipment that meets these requirements will also be compliant with international standards for interoperability, flight safety requirements for use in a VHF 8.33 kHz channel separation environment, and standards for military tactical communications equipment.

1.2 SCOPE

This document specifically addresses the minimum requirements for U.S. Naval aircraft, which are required to conform to communications channel spacing of 8.33 kHz in civil airspace for VHF communications in the frequency band of 117.975 to 137.000 MHz. Compliance with these minimum requirements will result in safe communications, conformance with civilian airspace requirements and prevention of a civil communications violation. Aircraft that comply with these requirements will be considered airworthy by the U.S. Navy for operations in sovereign civil airspace where the requirement for 8.33 kHz channel separation exists.

The term “shall” is used in this document to define mandatory minimum requirements. An approved design should comply with every requirement, which can be assured by inspection, test, analysis or demonstration. The term “must” is to identify items which are important but are either duplicated somewhere else in the document as a “shall” or are considered outside the scope of this document. The term “should” is used to denote a recommendation that would improve the equipment, but that does not constitute a requirement. Requirements in this document may or may not be quoted verbatim from the European Organization for Civil Aviation Electronics (EUROCAE) reference. They have been phrased as necessary to meet minimum Navy/Marine Corps needs.

1.3 BACKGROUND

In order to alleviate the growing frequency congestion problem in Europe, EUROCONTROL has imposed regulations to increase communications capacity by reducing VHF channel separation from 25 kHz to 8.33 kHz. This separation is now required in Europe and air traffic control sectors in the Atlantic Ocean, North Sea, and parts of the Mediterranean Sea controlled by European nations. U.S. military aircraft operating routinely in the controlled airspace of these sovereign nations must now be equipped with radios that can communicate in the 117.975 to 137.000 MHz band with 8.33 kHz channel separation.

ICAO has imposed additional requirements for 8.33 kHz separation:

(a). The carriage of dual VHF communications equipment approved for 8.33 kHz separation is mandatory above FL 245 in the ICAO European Region.
(b). Equipment must meet the requirements for Frequency Modulation (FM) Broadcast immunity.
(c). The ICAO EANPG 44 meeting, held in Paris on 2-5 December 2002, made a decision to proceed with 8.33 kHz Vertical Expansion below FL245.

- Above FL-195 in the ICAO European Region from 2006;
- In certain busy Terminal Control Areas (TMAs) and Control Zones (CTRs) where individual States have determined this to be a practical measure for alleviating VHF congestion (no date specified);
- In Designated Controlled Airspace in the ICAO European Region from 2009 onwards.

1.4 DESCRIPTION OF SYSTEM

The civil/military air-ground system is based on the use of Continuous Wave (CW), amplitude-modulated carriers in the 117.975 to 137.000 MHz frequency band. The lowest selectable channel is centered on 118.000 MHz and the highest selectable channel is centered on 136.975 MHz. The emissions are vertically polarized.

1.4.1 ATC Application

The air-ground VHF communication system is used world wide for Air Traffic Control (ATC) communications with civilian air traffic. An exception would be in a war zone when military tactical communications requirements are expected to supersede civil ATC requirements and revert to military UHF ATC.

1.4.2 Operational Frequency Range

This document applies to all classes of VHF communications equipment operating in a 25 kHz or 8.33 kHz channel separation environment over the frequency range of 117.975 to 137.000 MHz. The lowest selectable channel is 118.000 MHz and the highest selectable channel is 136.975 MHz. For the purposes of this document, 50 kHz channel separation is not considered because it is not be acceptable for ATC activity in European sovereign airspace.

1.4.3 Equipment Classes

1.4.3.1 Receivers

Two receiver classes, currently used by Naval Aviation, are defined as follows:

Class C: Receivers used in a 25 kHz channel separation environment having offset carrier operation.
Class E: Receivers used in an 8.33 kHz channel separation environment not having off-set carrier operation.

Ref: EUROCAE ED-23B paragraph 2.6.1

1.4.3.2 Transmitters

The transmitter classes currently used are defined as in Table 1 below:

Table 1: Transmitter Class Information

Class	Distance (nm)	Minimum Output Power (Watts)	Channel Separation
3	200	16	25 kHz
4	100	4	25 kHz
5	200	16	8.33 kHz
6	100	4	8.33 kHz

Ref: EUROCAE ED-23B paragraphs 2.6.2 and 3.21

2.0 REFERENCE DOCUMENTS

2.1 EUROCAE

(a). ED-18	Audio Systems Characteristics and Minimum Performance Specifications Covering Microphones (Except Carbon), Headsets, Handset	Jul 1985
(b). ED-23B	Minimum Operational Performance Specification for Airborne VHF Receiver-Transmitter Operating in the Frequency Range 117.975-136.975 MHz	Mar 1995 with Amendments 1-3 through 28 November 1997

2.2 RTCA

(e). DO-178B	Software Considerations in Airborne Systems and Equipment Certification	Dec 1992
(f). DO-186A, Change 1 Change 2	Minimum Operational Performance Specification for Airborne Radio Communications Equipment Operating in the Frequency Range 117.975 -137.000 MHz	Aug 1998 Sept 1998 Mar 2002

2.3 EUROCONTROL

(g). Avionics MIL Requirements V06231204	Avionics Requirements in Terms of Applicability to State Aircraft	23 Dec 2004

2.4 JOINT AVIATION AUTHORITY

(h). Temporary Guidance Leaflet (TGL) 7 Revision 1	Operations With 8.33 kHz Channel Spacing VHF Communication Radios	1 Jun 1999

2.5 U.S. MILTARY DOCUMENTS

(i). Military Standard (MIL-STD)-810F	Environmental Engineering Considerations and Laboratory Test	5 May 03

3.0 REQUIREMENTS

(Former Paragraph 3.0 REQUIREMENTS was deleted. This paragraph was formerly paragraph 3.2.) Naval Aviation radio equipment operating over the VHF frequency range of 117.975 to 136.975 MHz shall comply with civil aviation requirements for 8.33 kHz channel separation as documented herein.

3.1 DUAL EQUIPAGE

(Formerly Paragraph 3.0 Deleted. This paragraph is new.) In airspace where 8.33 kHz Channel Separation is mandatory, at least two such systems shall be carried (as opposed to one 8.33 kHz system and one 25 kHz system).

Note: No 25 kHz back-up will be available in the 8.33 kHz sectors.

Ref: JAA Temporary Guidance Leaflet No. 7, Revision 1, para. 5.3 dated 1 June 1999 and EUROCONTROL Military Business Division AvionicsMILReqsV06231204 dated 23 December 2004.

3.2 FM IMMUNITY

(Formerly Paragraph 3.2 was moved to Paragraph 3.0. This paragraph is new.) Provisions shall be made for Frequency Modulation Immunity (FMI) in the VHF FM Band to the extent feasible without negatively impacting military communication functionality. For those aircraft type/model/series unable to meet the FMI requirements, a conditional certification may be pursued. Note: Intermodulation testing is performed in accordance with paragraph 3.8.10 to verify FM Immunity.

Ref: JAA Temporary Guidance Leaflet No. 7, Revision 1 Dated 1 June 1999, amended for Navy unique requirements.

3.3 RECEIVER CLASSES

Aircraft operating where 8.33 kHz Channel Separation is mandatory shall use a combination Class C/Class E receiver. (This is a receiver capable of 25 kHz and 8.33 kHz channel separation operation as selected by the aircrew.) Class C receivers are designed for use in a 25 kHz channel separation environment and intended for offset carrier operation. Class E receivers are designed for use in an 8.33 kHz channel separation environment and not intended for offset carrier operation.

Ref: EUROCAE ED-23B, Para. 2.6.1 Receiver Classes, amended and RTCA DO-186A, Para. 2.1.8 a Receiver Classes, amended.

3.4 TRANSMITTER CLASSES

In the European Region of ICAO, aircraft shall use Class 3 or 4 transmitters for 25 kHz channel separation operations and Class 5 or 6 transmitters for 8.33 kHz channel separation operations.

Ref: EUROCAE ED-23B, Para. 2.6.2 Transmitter Classes and RTCA DO-186A, Para. 2.1.8 a Receiver Classes, amended to allow Class 4 and Class 6 (nominal 100 nm) transmitters.

3.5 SAFETY

Note: Paragraph 3.5 was formerly Paragraph 3.4.1.

3.5.1 Operation of the installed radio equipment shall not impair the airworthiness of the aircraft under normal or fault conditions.

3.5.2 The conduct of specified radio operation shall not result in a condition that would be detrimental to the continued performance of the equipment.

3.5.3 To the maximum practical extent and consistent with the planned operational scenario, design of the installed radio equipment and its operational and support processes will avoid hazards to people and material, whether by failure of hardware or software, variation in task or process, or by any man-machine interaction; where hazards to people or equipment are operationally or economically unavoidable, design will provide cost-effective mitigation of such risks throughout manufacture, operation, training, maintenance and disposal of the system and its components.

Ref: EUROCAE ED-23B, Para. 2.1 AIRWORTHINESS.

3.6 HUMAN ENGINEERING

Note: Paragraph 3.6 was formerly Paragraph 3.4.2.

(a). The radio equipment controls shall be able to be operated as intended under all flight conditions including the ability to use the controls in all required positions, combinations, and sequences. The aircraft must have continuous normal performance during this test.
(b). All radio related controls shall be usable from the operator's normal harnessed seated position.
(c). Radio controls shall be designed to prevent inadvertent actuation, e.g., changing frequency or turning off the radio.
(d). The aircraft integration shall provide an indication or annunciation of transmitter operation to the pilot.
(e). The radio related displays, including aural if employed, shall be usable under all flight conditions in the manner intended.
(f). Operators shall have an unobstructed view of displayed data from their normal harnessed seated position.
(g). Visual display and control lighting intensity shall be manually adjustable to levels suitable for readability under all cockpit ambient light conditions ranging from total darkness to direct sunlight.
(h). In cockpits that employ Night Vision Imaging Systems (NVIS), the visual display and control lighting shall not degrade NVIS performance.

(i). Radio related controls and displays shall not interfere with the use of other controls and displays in the aircraft.
(j). Radio controls shall be designed to be compatible with standard aircrew flight gear.
(k). Channels shall be labeled in accordance with the frequency-channel nomenclature pairing plan detailed in Table 2 to allow unique identification of the 8.33 kHz channels.

Ref: EUROCAE ED-23B, Para. 2.3 OPERATION OF CONTROLS.

Table 2: Frequency-Channel Pairing Plan

Frequency (MHz)	Channel Separation (kHz)	Channel Name
118.0000	25	118.000
118.0000	8.33	118.005
118.0083	8.33	118.010
118.0167	8.33	118.015
118.0250	25	118.025
118.0250	8.33	118.030
118.0333	8.33	118.035
118.0417	8.33	118.040
118.0500	25	118.050
118.0500	8.33	118.055
118.0583	8.33	118.060
118.0667	8.33	118.065
118.0750	25	118.075
118.0750	8.33	118.080
118.0833	8.33	118.085
118.0917	8.33	118.090
118.1000	25	118.100
Etc.		Etc.

Ref: EUROCAE ED-23B, Para. 1.3.2 Operational Frequency Range.

3.7 SOFTWARE ENGINEERING

Note: Paragraph 3.7 was formerly Paragraph 3.4.3.

Deleted.

3.8 RECEIVER REQUIREMENTS

Note: Paragraph 3.8 was formerly 3.5. Tests in Section 3.8 are test bench requirements.

3.8.1 Audio Frequency Response

(a). Receiver audio output shall not vary more than 6 dB when the level of a Radio Frequency (RF) signal modulated 30% is held constant at 1 millivolt (-53 dBm) and the modulation frequency is varied over the audio frequency range of 350-2500 Hz.

(b). For Class C and Class E receivers, the audio frequency response above 2500 Hz shall decrease, and at all frequencies above 4000 Hz, it shall be at least 18 dB below the output obtained at 1000 Hz.

Ref: EUROCAE ED-23B, Para. 3.1.1 (a) and (b) Audio Frequency Response, amended.

3.8.2 Automatic Gain Control (AGC)

Audio output power shall not vary by more than 6 dB when the level of an RF signal modulated 30% at 1000 Hz is varied over the range of 10 microvolts (-93 dBm) to 10 millivolts (-33 dBm). When the level of an RF signal modulated 30% at 1000 Hz, at the selected channel frequency, is reduced from 200 millivolts (-7 dBm) to 10 microvolts
(-93 dBm), the receiver shall recover within 0.25 seconds. The receiver shall also recover from a transmit-to-receive transfer operation within 0.25 seconds.

Recovery is the time taken for the receiver audio output level to return to and remain within 3 dB of the steady output obtained with an input signal of 10 microvolts
(-93 dBm) modulated 30% at 1000 Hz.

Ref: EUROCAE ED-23B, Para. 3.1.2(a)-(c) Automatic Gain Control.

3.8.3 Sensitivity

The level of an RF input signal, modulated 30% at 1000 Hz, required to produce a signal-plus-noise to noise ratio of 6 dB shall not exceed 10 microvolts (-93 dBm) with an audio output power not lower than 10 db below the declared audio output power.

Ref: EUROCAE ED-23B, Para. 3.1.3 Sensitivity (Signal –Plus-Noise to Noise Ratio).

3.8.4 Output Level Control

If an output level control is provided, it shall be capable of reducing the output to at least 40 dB below the manufacturer's rated output.

Ref: EUROCAE ED-23B, Para. 3.1.4 Output Level Control.

3.8.5 Distortion

The distortion in the receiver output shall not exceed 25% at rated power output when the receiver input signal is modulated 85% at a level of 10 millivolts (-33 dBm). The distortion in the receiver output shall not exceed 15% at a level 10 dB below the rated power output when the receiver input signal is modulated 30% at an input signal level of 10 millivolts (-33 dBm). These distortion requirements shall be met over the audio frequency range of 350-2500 Hz.

Ref: EUROCAE ED-23B, Para. 3.1.5 Distortion.

3.8.6 Audio Noise Level

The signal-plus-noise to noise ratio of the receiver audio output shall be at least 25 dB over the RF input signal range of 200 microvolts (-67 dBm) to 10 millivolts (-33 dBm) when the signal is modulated 30% at 1000 Hz.

Ref: EUROCAE ED-23B, Para. 3.1.6 Audio Noise Level.

3.8.7 Effective Bandwidth

The effective bandwidth relative to the selected channel frequency with 8.33 KHz channel separation shall be:

(a). Not less than ± 2.78 kHz at the 6 dB points.

(b). Not greater than ± 7.37 kHz at the 60 dB points.

Ref: EUROCAE ED-23B, Para. 3.1.7 (5) Effective Bandwidth for Class E Equipment.

3.8.8 Spurious Responses

When an undesired signal is within the 108-156 MHz band and is on any frequency within ± 8 kHz of any assigned channel other than the desired channel and its upper and lower adjacent channels, the level of an input signal on an undesired frequency required to produce a detector carrier level equal to that required for a 6 dB signal-plus-noise to noise ratio (specified in 3.5.3) shall not be less than 10 millivolts (-33 dBm). When the undesired signal is between 50 kHz and 1215 MHz, excluding the 108-156 MHz frequency range, the level of an input signal on an undesired frequency required to produce a detector carrier level equal to that required for a 6 dB signal-plus-noise to noise ratio (specified in 3.5.3) shall also not be less than 10 millivolts (-33 dBm).

Ref: EUROCAE ED-23B, Para. 3.1.8 (a), (b) Spurious Responses.

3.8.9 Cross Modulation

When modulated 30% at 1000 Hz, the audio output power due to cross modulation, resulting from the simultaneous application to the receiver input of desired and undesired signals, shall be at least 10 dB below that value obtained on application of the desired signal only. The desired signal shall be the selected frequency with no modulation, at levels from 20-500 microvolts (-87 dBm to –59 dBm). The undesired signal shall be at a level of 10 millivolts (-33 dBm), modulated 30% at 1000 Hz. The frequency of the undesired signal shall be 108-156 MHz including the frequencies equivalent to the second higher and second lower channels to which the receiver can be tuned, but excluding the frequency range between these two channels.

Ref: EUROCAE ED-23B, Para. 3.1.9 Cross Modulation.

3.8.10 Intermodulation

The receiver shall provide the required performance in the presence of two-signal, third order, intermodulation products caused by VHF FM broadcast signals having a level of –5 dBm at the receiver input. With squelch and audio compressor disabled, the simultaneous application of two undesired signals within the 87.5-107.9 MHz frequency range shall result in an audio quieting of less than 6 dB. The undesired signals shall be at a level of 250 millivolts (-5 dBm) with no modulation at the receiver input terminals.

For aircraft type/model/series which require an external filter to meet this requirement, the receiver shall be tested with the external filter in the transmission line of the system. For those aircraft type/model/series unable to meet the intermodulation requirements, a conditional certification may be pursued.

Ref: EUROCAE ED-23B, Para. 3.1.10 Intermodulation, amended.

3.8.11 Desensitization

The signal-plus-noise to noise ratio of the receiver shall not decrease to less than 6 dB when the undesired signals specified below are applied in addition to the desired signal. The desired signal shall be the selected frequency, modulated 30% at 1000 Hz, at a level of 20 microvolts (-87 dBm). The undesired signals shall be:

3.8.11.1 10 millivolts (-33 dBm) with no modulation in the frequency range of 108-156 MHz. This includes the frequencies equivalent to the second higher and second lower channels to which the receiver can be tuned, but excludes the frequency range between these two channels.

3.8.11.2 200 millivolts (-7 dBm) with no modulation in the frequency range of 50 kHz to 1215 MHz, excluding the range of 87.5-156 MHz.

3.8.11.3 250 millivolts (-5 dBm) with no modulation in the frequency range of 87.5-107.9 MHz.

Ref: EUROCAE ED-23B, Para. 3.1.11 Desensitization.

3.8.12 Spurious Emissions

When the receiver input is terminated in a resistive load equal to the nominal receiver input impedance, the level of any spurious emission appearing across the load shall not exceed 2000 picowatts over the frequency range of 50 kHz to 1215 MHz. This excludes the range of 108-137 MHz, where it shall not exceed 400 picowatts.

Ref: EUROCAE ED-23B, Para. 3.1.12(a) Spurious Emissions.

3.8.13 Channel Selection Time

When a channel is selected, the time required for the equipment audio output to reach and remain within 3 dB of the steady state output shall not exceed one second.

Ref: EUROCAE ED-23B, Para. 3.1.13 Channel Selection Time.

3.8.14 Receiver Muting

When used in an offset carrier environment, the receiver muting circuits (if provided) shall operate and meet their specified performance in the presence of audio heterodynes resulting from the reception of two or more frequencies in a multi-carrier system. Under these conditions, the receiver sensitivity specified in 3.8.3 shall not be worse than 24 microvolts (-85 dBm).

Ref: EUROCAE ED-23B, Para. 3.1.14 Receiver Muting.

3.8.15 Adjacent Channel Rejection

Adjacent channel rejection shall be at least 45 dB when the specified desired and interfering signals are applied to the receiver. The desired signal shall be the selected frequency modulated 60% at 1000 Hz, at a level adjusted to produce a signal-plus-noise over noise ratio of 20 dB. The frequencies of the interfering signals shall be the first upper and first lower adjacent channels, applied separately. The interfering signal shall be modulated 60% at 400 Hz, at a level adjusted to degrade the signal-plus-noise over noise ratio of the desired signal from 20 dB to 14 dB.

Ref: EUROCAE ED-23B, Para. 3.1.15 Adjacent channel Rejection.

3.9 TRANSMITTER REQUIREMENTS

Note: Paragraph 3.9 was formerly Paragraph 3.6. Tests in Section 3.9 are test bench requirements except for transmitter range.

3.9.1 Power Output

The transmitter output power on all channels within the 118.000-136.975 MHz frequency range shall be sufficient for an aircraft at or above FL 195 to establish a voice line-of-sight communication with a fifty-foot high sea level ground station antenna at a nominal range consistent with the class of transmitter in use. See paragraph 1.4.3.2 for nominal transmitter class ranges.

Note: The operational range of each integrated communications system will be documented.

Ref: EUROCAE ED-23B, Para. 3.2.1, amended.

3.9.2 Residual Radiation

When all sources of primary power are connected to the transmitter and the microphone switch is in the open position, the RF power output at the selected frequency shall not exceed 0.02 picowatts.

Ref: EUROCAE ED-23B, Para. 3.2.2 Residual Radiation.

3.9.3 Modulation Capability

The transmitter output carrier shall be amplitude-modulated not less than 70% by an audio frequency input signal of 1000 Hz over the audio input voltage range for which the transmitter is designed.

Ref: EUROCAE ED-23B, Para. 3.2.3 Modulation Capability.

3.9.4 Audio Frequency Distortion

The combined distortion and noise in the modulated output of the transmitter shall not be greater than 25% of the total demodulated output. This requirement shall be met when the audio input signal is held constant at a level just below where clipping or limiting action occurs, at the frequency of maximum response. The distortion shall be consistent with the required transmitter occupied spectrum of paragraph 3.9.8.

Ref: EUROCAE ED-23B, Para. 3.2.4 Audio Frequency Distortion.

3.9.5 Audio Frequency Response

The output carrier percentage modulation shall not vary more than 6 dB when the frequency of the input audio signal is varied over the range of 350-2500 Hz. In this situation the level of the input audio signal is held constant at that value which produces 70% modulation at the frequency of maximum response, or more than 70% modulation at the frequency of maximum response when the input audio signal level is immediately below where clipping or limiting action occurs. There shall be a cutoff in response for frequencies above 2500 Hz, and frequencies above 3200 Hz shall be attenuated at least 45 dB. The transmitter shall also provide audio frequency sidetone varying by not more than 10 dB with the frequency response and conditions above, and at a level sufficient to operate one headset of standard sensitivity (90 ± 5 dB at 1000 Hz).

Ref: EUROCAE ED-23B, Para.3.2.5 Audio Frequency Response and EUROCAE ED-18, Part II, Section 4,3.

3.9.6 Carrier Noise Level

The demodulated noise output obtained from the un-modulated RF carrier shall be at least 35 db below the demodulated output obtained from the RF carrier modulated 70% by a 1000 Hz audio input signal. When the equipment operates using an alternating current power source, this requirement shall be met over the range of specified power source frequencies.

Ref: EUROCAE ED-23B, Para. 3.2.6 Carrier Noise Level.

3.9.7 Emission of Spurious Radio Frequency Energy

When the transmitter is modulated 30% at 1000 Hz and is terminated in a resistive load equal to the nominal output impedance, the power of any spurious emission at the output of the transmitter shall not exceed:

(a). 2.5 microwatts at frequencies within the 108-112 MHz range.

(b). 25 microwatts or a level 40 dB below the power at the selected frequency, whichever is more stringent, at frequencies within the range of 50 kHz to 1215 MHz excluding frequencies within the 108-112 MHz range, ± 25 kHz of the selected frequency, and ± 8.33 kHz of the selected frequency. The power of the emission shall not be reduced below 10 microwatts.

Ref: EUROCAE ED-23B, Para. 3.2.7.1(b) Emission of Radio Frequency Energy.

3.9.8 Transmitter Occupied Spectrum for 8.33 kHz Channels

For the 8.33 kHz channels, the transmitter spectrum shall not exceed the limits shown in Figure 1 when the transmitter is modulated by any frequency between 300 Hz and 10 kHz, and:

(a). The audio input level is adjusted to produce 70% modulation at 1000 Hz.

(b). Then the frequency of the audio input level is varied between 300 Hz and 10 kHz at the constant level in subparagraph (a) above between 300 and 800 Hz, and following a slope of –10 dB/octave between 800 Hz and 10 kHz.

Under the conditions specified in (a). and (b)., the power of each spectral tone shall not exceed the spectrum mask shown in Figure 1.

Ref: EUROCAE ED-23B, Para. 3.2.7.2 Transmitter Occupied Spectrum for 8.33 kHz Mode.

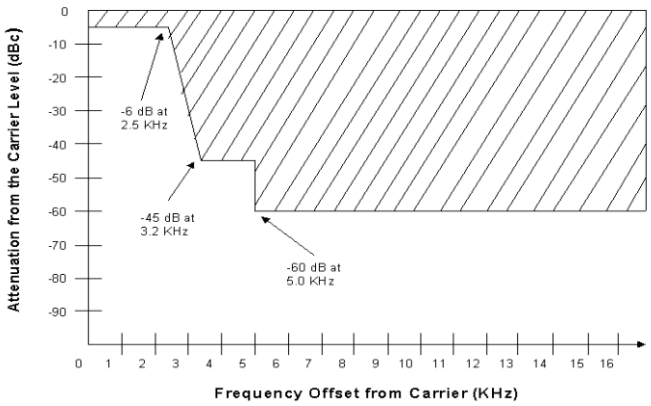

Figure 1 - Spectral Mask

Ref: EUROCAE ED-23B, Figure 3-1: Spectral Mask

3.9.9 Channel Selection Time

The time required for the transmitter to change correctly from any channel to another shall not exceed one second.

Ref: EUROCAE ED-23B, Para. 3.2.8 Channel Selection Time.

3.9.10 Frequency Tolerance

The frequency of the RF carrier shall be within 0.0005% of the selected channel frequency over the entire range of the 117.975 to 137.000 MHz band.

Ref: EUROCAE ED-23B, Para. 3.2.9 (3) Frequency Tolerance for Class 5 and 6 Transmitters.

3.9.11 Unwanted Frequency Modulation

The unwanted frequency modulation shall comply with the spectrum mask defined in Figure 1.

Ref: EUROCAE ED-23B, Para. 3.2.10 Unwanted Frequency Modulation for Class 5 Transmitters.

3.9.12 Effects of Antenna Mismatch

When a 3:1 mismatch is applied to the transmitter output terminals by a feeder that is varied in length by as much as a half wavelength, the requirements shall be met as follows:

(a). The combined distortion and noise in the modulated output of the transmitter shall not be greater than 25% of the total demodulated output. This requirement shall be met when the audio input signal is held constant at a level just below where clipping or limiting action occurs, at the frequency of maximum response. The distortion shall be consistent with the requirements of Paragraph 3.9.4.

(b). When the transmitter is modulated 30% at 1000 Hz and is terminated in a resistive load equal to the nominal output impedance, the power of any spurious emission at the output of the transmitter shall be consistent with Paragraph 3.9.7 and not exceed:

1. 2.5 microwatts at frequencies within the 108-112 MHz range.

2. 25 microwatts or a level 40 dB below the power at the selected frequency, whichever is more stringent, at frequencies within the range of 50 kHz to 1215 MHz. This excludes frequencies within the 108-112 MHz range, ± 25 kHz of the selected frequency, and ± 8.33 kHz of the selected frequency. The power of the emission need not be reduced below 10 microwatts.

(c). For the 8.33 kHz channels, the transmitter spectrum shall be consistent with Paragraph 3.6.8 and not exceed the limits shown in Figure 1 when the transmitter is modulated by any frequency between 300 Hz and 10 kHz, and:

1. The audio input level is adjusted to produce 70% modulation at 1000 Hz.

2. The frequency of the audio input level is then varied between 300 Hz and 10 kHz at the constant level in (a) above, between 300 and 800 Hz, and following a slope of -10 dB/octave between 800 Hz and 10 kHz.

3. Under the conditions specified in 1. and 2., the power of each spectral tone shall not exceed the spectrum mask shown in Figure 1.

(d). The frequency of the RF carrier shall be consistent with Paragraph 3.9.10 and within 0.0005% of the selected channel frequency over the entire range of the 117.975 to 137.000 MHz band.

(e). In addition, the power output shall be at least 40% of the value established by paragraph 3.9.1.

Ref: EUROCAE ED-23B, Para. 3.2.11 Effects of Antenna Mismatch.

3. 9.13 Unintentional or Continuous Transmissions

Deleted.

Note: With respect to unintentional or continuous transmissions, the recommendation of ED-23B was omitted from this document in order to provide military operational flexibility.

3.9.14 Simultaneous Transmissions

Deleted.

Note: With respect to simultaneous transmissions, the recommendation of ED-23B was omitted from this document in order to provide military operational flexibility.

4.0 Minimum Performance – Standard Bench Conditions

The standard conditions in Table 3 shall be used for establishing normal performance characteristics when conducting laboratory bench tests, unless otherwise specified in this document:

Table 3: Standard Bench Test Conditions

Temperature	25°C ± 10°C
Altitude	-200 to +5000 feet with respect to mean sea level
Vibration	MIL-STD-810F
Humidity	Room ambient up to 90% relative humidity (non-condensing)
Input power voltage	+28 ± 0.5 vdc

Ref: EUROCAE ED-23B, Para. 5.1.1. Test Conditions.

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APPENDIX A - ACRONYMS

AC	Alternating Current
AF	Audio Frequency
AGC	Automatic Gain Control
ATC	Air Traffic Control
ATS	Air Traffic Services
CNS/ATM	Communications Navigation Surveillance/Air Traffic Management
CNO	Chief of Naval Operations
CTR	Control Zone
CW	Continuous Wave
dB	Decibel
dBm	Decibels (referenced to milliwatts)
EPANG	European Air Navigation Planning Group
EUROCAE	European Organization for Civil Aviation Electronics
EUROCONTROL	European Organization for Safety of Air Navigation
FL	Flight Level
FM	Frequency Modulation
FMI	Frequency Modulation Immunity
FRD	Functional Requirements Document
GAT	General Air Traffic
Hz	Hertz
ICAO	International Civil Aviation Organization
kHz	kilohertz
MHz	Megahertz
NAVAIR	Naval Air Systems Command
NVIS	Night Vision Imaging Systems
OAT	Operational Air Traffic
PMA	Program/Project Manager, Air (NAVAIR)
PTT	Push-To-Talk
RF	Radio Frequency
RTCA	Radio Technical Commission for Aeronautics
TMA	Terminal Control Area
UHF	Ultra High Frequency
VHF	Very High Frequency
vdc	Volts Direct Current

APPENDIX B - GLOSSARY

8.33 kHz Channel Assignments – Defined in this document as 25 kHz divided by three which is 8.3333 kHz.

Airworthiness – Defined as the ability for an aircraft to perform normal flight operations in civilian or military airspace.

ATC – Air Traffic Control is a civil organization which is state supported for the purpose of maintaining proper control of aircraft within a specified region of airspace.

Class 1 Transmitter – Transmitters that provide for a minimum of 200 nm range of operation for use within a 50 kHz channel separation environment.

Class 2 Transmitter – Transmitters that provide for a minimum of 100 nm range of operation for use within a 50 kHz channel separation environment.

Class 3 Transmitter – Transmitters that provide for a minimum of 200 nm range of operation for use within a 25 kHz channel separation environment.

Class 4 Transmitter – Transmitters that provide for a minimum of 100 nm range of operation for use within a 25 kHz channel separation environment.

Class 5 Transmitter – Transmitters that provide for a minimum of 200 nm range of operation for use within an 8.33 kHz channel separation environment.

Class 6 Transmitter – Transmitters that provide for a minimum of 100 nm range of operation for use within an 8.33 kHz channel separation environment.

Class A Receiver – Receivers that are to be used in a 50 kHz channel separation environment and intended for offset carrier operation.

Class B receiver – Receivers that are to be used in a 50 kHz channel separation environment but not intended for offset carrier operation.

Class C Receiver – Receivers that are to be used in a 25 kHz channel separation environment and intended for an offset carrier operation.

Class D Receiver – Receivers that are to be used in a 25 kHz channel separation environment but not intended for offset carrier operation.

Class E Receiver – Receivers that are to be used in an 8.33 kHz channel separation environment but not intended for offset carrier operation.

EUROCONTROL **–** This is a European organization headquartered in Belgium whose purpose is to assure the safety of air navigation and to control and assure European aviation standards.

UHF - The frequency band covering 225.000 to 399.975 MHz used by U.S. Military for aircraft communications and military air traffic control.

VHF – The frequency band covering 117.975 to 137.000 MHz used by civil Air Traffic Control to maintain aircraft communications.