ARINC

AIRBORNE VHF COMMUNICATIONS TRANSCEIVER

ARINC CHARACTERISTIC 716-9

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FOREWORD

Activities of AERONAUTICAL RADIO, INC. (ARINC)

and the

Purpose of ARINC Characteristics

Aeronautical Radio, Inc. is a corporation in which the United States scheduled airlines are the principal stockholders. Other stockholders include a variety of other air transport companies, aircraft manufacturers and non-U.S. airlines.

Activities of ARINC include the operation of an extensive system of domestic and overseas aeronautical land radio stations, the fulfillment of systems requirements to accomplish ground and airborne compatibility, the allocation and assignment of frequencies to meet those needs, the coordination incident to standard airborne communications and electronics systems and the exchange of technical information. ARINC sponsors the Airlines Electronic Engineering Committee (AEEC), composed of airline technical personnel. The AEEC formulates standards for electronic equipment and systems for the airlines. The establishment of Equipment Characteristics is a principal function of this Committee.

An ARINC Equipment Characteristic is finalized after investigation and coordination with the airlines who have a requirement or anticipate a requirement, with other aircraft operators, with the Military services having similar requirements, and with the equipment manufacturers. It is released as an ARINC Equipment Characteristic only when the interested airline companies are in general agreement. Such a release does not commit any airline or ARINC to purchase equipment so described nor does it establish or indicate recognition of the existence of an operational requirement for such equipment, not does it constitute endorsement of any manufacturer's product designed or built to meet the Characteristic. An ARINC Characteristic has a twofold purpose, which is:

(1) To indicate to the prospective manufacturers of airline electronic equipment the considered opinion of the airline technical people, coordinated on an industry basis, concerning requisites of new equipment, and

(2) To channel new equipment designs in a direction which can result in the maximum possible standardization of those physical and electrical characteristics which influence interchangeability of equipment without seriously hampering engineering initiative.

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1.0 INTRODUCTION AND DESCRIPTION

1.1 Purpose of This Document

This document sets forth the desired characteristics of a new generation VHF Communications Transceiver System intended for installation in all types of commercial transport aircraft. The intent of this document is to provide general and specific design guidance for the development and installation of a VHF Transceiver primarily for airline use. It will describe the desired operation capability of the equipment and the standards necessary to ensure interchanageability.

Section 3.0 is applicable to the 25 kHz channel-spaced voice and data modes of operation. Section 4.0 is applicable to an optional 8.33 kHz channel-spaced voice mode of operation and defines only the characteristics specific to the 8.33 kHz channel-spaced mode of operation, such as the channeling, the frequency selection, the selectivity, the frequency stability, the frequency response, and the transmitter occupied spectrum. The characteristics in Section 3.0 are also applicable to the optional 8.33 kHz channel-spaced voice mode of operation unless otherwise specified in Section 4.0.

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COMMENTARY

The 8.33 kHz channel-spaced mode of operation for voice communications, if implemented concurrently with the 25 kHz channel-spaced modes of operation, would require dual-bandwidth receivers to ensure inter-operability of the airborne transceivers with the current (25 kHz) and proposed European narrowband (8.33 kHz) VHF voice communications systems. The narrowband mode of operation is limited to voice communications.

Equipment manufacturers should note that this document encourages them to produce maintenance-free, high performance equipment rather than that of minimum weight and size. They are at liberty to accomplish this objective by means of the techniques they consider to be the most appropriate. The airline customers are interested primarily in the end result rather than the means employed to achieve it.

1.2 Function of Equipment

The function of the VHF Communication Transceiver is to provide the aircraft with a voice or data communications capability with the ground via conventional VHF circuits.

1.3 Unit Description

1.3.1 VHF Transceiver Unit

The VHF Transceiver unit should house all the components, electronics circuitry, etc., incident to channel selection, receiving and transmitting functions of VHF air-ground-air communications.

1.3.2 Frequency Control

Manual frequency control of the VHF Transceiver should be accomplished from a VHF frequency control unit or the equivalent data input from a centralized radio management system. The VHF Transceiver control should utilize the 2-wire serial digital frequency/function selection system defined in ARINC Specification 429.

1.3.3 Antenna

The VHF Comm. antenna should be vertically polarized and provide omnidirectional azimuth radiation pattern coverage.

1.4 Interchangeability

1.4.1 General

One of the primary functions of an ARINC Equipment Characteristic is to designate, in addition to certain performance parameters, the interchangeability in an aircraft of equipment produced by various manufacturers. The manufacturer is referred to Section 1.6 of ARINC Report 414 for definitions of terms and general requirements for the airline industry for interchangeability. As explained in that report, the degree of interchangeability considered necessary and attainable for each particular system is specified in the pertinent ARINC Equipment Characteristic for that system.

1.4.2 Interchangeability Desired for the ARINC 716 VHF Transceiver

Unit interchangeabilty is required for the transceiver regardless of manufacturing source. In recognition of the widely varying control unit designs expected in the future, unit interchangeability is not sought in the control unit except, however, that electrical interface of controls shall conform to the digital signal standards set forth in this characteristic.

1.4.3 "Generation Interchangeability" Considerations

In defining the equipment described in this characteristic, the air transport industry has chosen to depart from several of its previous VHF transceiver standards. In order to achieve the full benefit of the economics offered by these changes, the industry desires that no provisions be made in the equipment for backward compatibility with with earlier generations of VHF Communication equipment described by ARINC 520, ARINC 546, ARINC 566 and ARINC 566A.

Unchanged, however, is the industry's tradititional desire that future evolutionary equipment improvements and the inclusion of additional functions in new equipments during the next few years, do not violate the interwiring and form factor standards set forth in this document. Provisions to ensure forward-looking "generation

1.0 INTRODUCTION AND DESCRIPTION (cont'd)

1.4.3 "Generation Interchangeability" Considerations (cont'd)

interchangeability" (as best can be predicated) are included in this document to guide manufacturers in future developments.

1.5 Regulatory Approval

The equipment must meet all applicable FAA and FCC regulatory requirements. Manufacturers are urged to obtain all necessary information from the FAA and the FCC for such regulatory approval. This information is not contained in this characteristic, nor is it available from ARINC.

1.6 System Parameters

System parameters applicable to air-ground-air VHF communications may be found in Appendix 1 to this Characteristic. They have been excerpted from ICAO Annex 10, "International Standards and Recommended Practices, Aeronautical Telecommunications", and from the report of the ICAO's 7th Air Navigation Conference.

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2.0 INTERCHANGEABILITY STANDARDS

2.1 Introduction

This Section of this Characteristic sets forth the specific form factor, mounting provisions, interwiring, input and output interfaces and power supply characteristics desired for this VHF Communications Transceiver.

Manufacturers should note that although this Characteristic does not preclude the use of different form factors and interwiring features, the practical problem of redesigning what will then be a standard aircraft installation to accommodate some special system could very well make the use of that other design prohibitively expensive for the customer. They should recognize, therefore, the practical advantages of developing equipment in accordance with the standards set forth in this document.

2.2 Form Factors, Connectors & Index Pin Coding

2.2.1 Transceiver Unit

The Transceiver should comply with the dimensional standards in ARINC Specification 600, "Air Transport Avionics Equipment Interfaces (NIC Phase 1)", for the 3 MCU form factor. The Transceiver should also comply with ARINC 600 standards in respect of weight, racking
¢-1 attachments, front and rear projections and cooling.

The Transceiver should be provided with a low insertion force, size 1 shell ARINC 600 service connector. This connection, which should accommodate service interconnections in its middle insert (MP), automatic test equipment interconnections in its top insert (TP) and coaxial and power interconnections in its bottom insert (BP), should be located on the center grid of the receiver's rear panel. Index pin code 04 should be used.

The ATE interconnection insert (TP) will not be included in the mating half of the connector installed in the aircraft since ATE interconnections are employed in the bench testing of the receiver only. This insert should be
¢-1 provided with a protective cover to prevent contamination of the contacts during the time the receiver is installed in the aircraft. Further guidance on the ATE interface will
¢-8 be found in Chapter 6 of this document.

2.2.2 "Standard Control Panel"

Frequency control of the ARINC 716 VHF Transceiver is effected by means of facilities provided on a VHF NAV/COMM control panel, a dedicated control panel on the data entry panel of a centralized radio management system. The approach used in a given airframe will be the choice of the airline and/or the airframe manufacturer. Guidance on the design of a VHF COMM control panel suitable for use with the ARINC 716 VHF Transceiver may be found in Attachment 7 to this document, in accordance with the tradition in ARINC Equipment Characteristics of setting forth certain standardized provisions for a "Standard Control Panel" which should be made available by equipment manufacturers for those customers having "standard" needs.

COMMENTARY

The Mythical "Standard Control Panel"

The term "Standard Control Panel" as used in this Characteristic applies to a control panel conforming to the functional specification in Attachment 7 of this Characteristic and having form factor and connector functions as set forth therein. The standard interwiring is included in Attachment 2.

2.2.3 Antennas

There are no specific form factors set forth herein for the antennas to be employed with this particular equipment as there are numerous designs presently on the market for the purpose. Attachment 5 shows a typical antenna. Designers of new antennas are encouraged to survey the present antenna mounting provisions and maintain compatibility insofar as is practicable with the present standard mountings, depending upon, of course, on the particular aircraft type for which the antenna is intended and the need to minimize weight. It is recognized that for most air transport applications the antennas will be integrated into the airframe design and it is, therefore, only in special installations or retrofit installations where specific "antenna units" would be needed.

Further general information on antennas may be found in ¢
Section 5.0.

2.3 Interwiring

The standard interwiring to be installed for the VHF COMM Transceiver is set forth in Attachment 2. This interwiring is designed to provide the degree of interchangeability specified in Section 1.4, and manufacturers are cautioned not to rely upon special wires, cabling or shielding for use with particular units because they will not exist in the standard installation.

COMMENTARY

Why Standardize Interwiring?

The standardized interwiring is perhaps the heart of all ARINC Characteristics. It is this feature which allows the airline customer to complete his negotiation with the airframe manufacturer so that the latter can proceed with engineering and initial fabrication prior to airline commitment on a specific source of equipment. This provides the equipment manufacturer with many valuable months in which to put the final "polish" on his equipment in development.

The reader's attention is directed to the interwiring guidance in ARINC Report No. 414, Section 5.0. This material defines all of the basic standards utilized in airframe wiring installations and all equipment manufacturers should make themselves familiar with it.

2.0 INTERCHANGEABILITY STANDARDS (cont'd)

The reader is also cautioned to give consideration to the specific notes in Attachment 2 as they apply to the standard interwiring.

2.4 Power Circuitry

2.4.1 Primary Power Input

The VHF Transceiver and Control Panel should be designed to use 27.5 volts DC primary power. The aircraft power supply characteristics, utilization, equipment design limitations, and general guidance material are set forth in ARINC Report No. 413A, "Guidance for Aircraft Electrical Power Utilization and Transient Protection."

One circuit breaker of the size shown in Attachment 2 should be provided in the standard installation.

2.4.2 Power Control Circuitry

There should be no master on/off power switching within the VHF Transceiver. Any user desiring power on/off control for the unit should provide, through the medium of a switching function installed in the airframe, means of interrupting the primary power to the equipment. It should be noted that primary power on/off switches for the VHF Transceiver will not be needed in most installations, and power will be wired directly to the equipment from the circuit breaker panel.

2.4.3 The Common Ground

The wires designated as "Common Ground" (or as chassis ground) are used for the DC ground return to the aircraft structure and may be grounded to the chassis of the equipment if the manufacturer so desires. In any event, they will be grounded to the ship's structure. They should not be used as common returns for any circuits carrying AC currents.

2.4.4. Internal Circuit Protection

The basic master power protection means for the transceiver will be external to the unit and utilize a standard circuit breaker rating. Within the equipment, no master power protection means is to be provided, although subdistribution circuit protection is acceptable where the set manufacturer feels this would improve the overall reliability of the equipment.

If internal protection by fuses is employed, these fuses should not be accessible when the set is installed in the aircraft radio rack, but should be replaceable only when the equipment goes through the service shop.

If such subdistribution circuit protection is by means of circuit breakers, the majority prefer that these be accessible on the front panel of the equipment so that they can be reset in service.

2.5 Environmental Conditions

The VHF Transceiver should be specified environmentally in terms of the requirements of RTCA Document DO-160, "Environmental Conditions and Test Procedures for Airborne Electronic/Electrical Equipment and Instruments", dated February 28, 1975. Attachment 4 to this Characteristic tabulates the relevant environmental categories.

2.6 Cooling

The VHF Transceiver should be designed to accept, and airframe manufacturers should configure the installation to provide forced air cooling as defined in ARINC Specification 600. The standard installation should provide an air flow rate of 13.6 kg/hr of 40°C air and the unit should not dissipate more than an average of 62 watts of energy. The coolant air pressure drop through the equipment should be 5 ± 3 mm at standard conditions of 1013.25 mbars. This pressure drop does not include the drop through a returning orifice when such orifice is located external to the equipment case. c-4

COMMENTARY

The specified cooling air flow rate is based on an estimated average power dissipation. However, it should be noted that power dissipation during transmission will be higher than the estimated average. Thus, the specified air flow rate will be less than the rate recommended in ARINC Specification 600 (NIC) for the maximum dissipation. c-4

COMMENTARY

Equipment failures in aircraft due to inadequate thermal management have plagued the airlines for many years. In Section 3.5 of ARINC Specification 600 they have written down everything they believe airframe and equipment suppliers need to know to prevent such problems in the future. They regard this material as "required reading" for all potential suppliers of VHF Transceivers and aircraft installations.

2.7 Grounding and Bonding

The attention of equipment and airframe manufacturers is drawn to the guidance material in Section 3.2.4 of ARINC Specification 600 and Appendix 1 of ARINC Specification 404A on the subject of equipment and radio rack grounding and bonding.

3.0 TRANSCEIVER UNIT DESIGN

3.1 Frequency Range and Channeling

The transceiver should operate on a total of 760 channels spaced 25 kHz apart in the band 118.000 to 137.000 MHz. Channel changing time should not exceed 60 ms.

COMMENTARY

¢-5 Prior to the publication of Supplement 5 of this Characteristic, the upper frequency limit was 136 MHz, with the ability to operate in the band 136-138 MHz when needed. The 1979 World Administrative Radio Conference of the ITU allocated an additional 1 MHz of spectrum to the Aeronautical Mobile (R) Service, resulting in the new allocation 118 to 137 MHz. While operational requirements have not yet been fully identified, the users desire that all ARINC 716 radios operate over that frequency band.

3.2 Frequency Selection

The transceiver should be designed to utilize the serial digital frequency/function selection system described in ARINC Specification 720. Two serial digital data input ports should be provided, one labeled "Freq./Funct. Select Data Input Port A" and the other "Freq./Funct. Select Data Input Port B". (See Attachment 2 to this document for the connector pin assignments.) The receiver should determine which of these ports should be open to admit data by reference to the binary state of the tuning data source selection discrete. It should respond to data delivered to the "A" port and ignore data delivered to the "B" port when the source selection discrete is in the "ground" state. It should respond to data delivered to the "B" port and ignore data delivered to the "A" port when the discrete is in the "open circuit" state. The "ground" state of the discrete is defined as a voltage between 0 and +3.5 VDC at the connector pin assigned to the discrete in Attachment 2. The maximum current flow in the discrete wire in this condition should not exceed 20 mA. The "open circuit" state is defined as a voltage greater than +18.5 VDC (+30 VDC maximum) at this pin or a resistance to DC ground from this pin of greater than 500,000 Ωs.

When the transceiver is installed in an aircraft in which a dedicated control panel supplies tuning information, the data bus from that panel should be connected to the "B" port on the receiver. The "A" port and the source selection discrete are unused. When the receiver is installed in an aircraft in which a centralized radio management system is employed, its normal control source should be connected to the "A" port, its back-up source to the "B" port and the source selection discrete wired in the manner described in the radio management specification.

ARINC Specification 429, "Mark 33 Digital Information Transfer System (DITS)", defines the format of the serial digital tuning signal delivered to the transceiver and the word repetition rate (5 per second minimum). Should this rate fall below 5 per second (word removal from the bus signifies tuning information source failure), the word sign/status matrix indicates an invalid condition, or the word parity fail to be odd, the transceiver should remain tuned to and operate on the last valid frequency received.

The VHF transceiver should recognize frequency/function words with Source/Destination Identifier (SDI) bits 9 and 10 encoded with its own installation number or encoded with "00", the "all-call" code as defined in ARINC Specification 429. See Note 1 to Attachment 2 for pin encoding of the installation numbers. ¢-6

3.3 Residual FM Specification

A modulation index of 1 or better should be achieved across the entire range of the transceiver.

3.4 Transmitter Frequency Offset

The transceiver should be capable of double-channel operation, i.e., transmitting on a frequency higher by some whole number of megahertz than that on which its receiver is tuned. Sufficient flexibility should be provided to permit the same or a different value for this offset to be selected for each whole megahertz of receiving frequency.

Double-channel operation should be effected by the grounding of the "Frequency Offset Enable" wire, either by the control panel or other source.

COMMENTARY

The amount of separation of transmit and receive frequencies that might be employed in communications systems of the future has not yet been determined. It is assumed that once they are established, however, offset values will be subject to no more than very infrequent change. It is anticipated, therefore, that offset selection for each receive frequency will be made within the transceiver by reference to a hard-wired program.

3.5 Transmit to Receive Recovery

With the receiver squelch set to operate at 3 μV, the receiver should recover after transmission to provide 90% of its output at an input level of 10 μV modulated 30% at 1000 Hz in less than 50 ms.

3.6 Receiver Design

3.6.1 Sensitivity

With a 2 μV (hard) signal, amplitude modulated 30% at 1000 Hz, the signal-plus-noise-to-noise ratio should be 6 dB.

3.6.2 Selectivity

The nose pass band and the stability of the receiver should be such that when a carrier modulated 30% at 1000 Hz is applied on any assigned carrier frequency there is no more than 6 dB attenuation when it is moved to ±8 kHz from its assigned frequency.

The skirt selectivity should be such that at least 60 dB of attenuation results when the modulated carrier departs ±17 kHz or more from its assigned frequency.

3.0 TRANSCEIVER UNIT DESIGN (cont'd)

Note: Although the airlines have not chosen to specify bandwidths for attenuations greater than 60 dB, they do expect rejection to increase (to at least 100 dB) as the modulated carrier departs more than ±17 kHz from its assigned value.

COMMENTARY

It is the equipment manufacturer's option to choose the stability figure for the receiver, even though it may to some extent be dictated by the stability specified for the transmitter elsewhere in this Characteristic. It should be evident that the foregoing specification sets forth the minimum nose bandwidth and the maximum 60 dB skirt bandwidth for the receiver. Obviously, a wider-than-minimum nose bandwidth and/or a narrower-than-maximum skirt bandwidth are acceptable to the airlines in actual practice. The manufacturer is free to trade these numbers with stability as he sees fit.

In making his decisions, the manufacturer might note that early utilization of offset carrier (CLIMAX) networks in the 25 kHz channel-spaced environment may well be facilitated if a wider-than-specified nose bandwidth is provided. Later on, as 25 kHz channel deployment increases, receivers having enchanced adjacent channel rejection, i.e., 60 dB skirt bandwidths of ±15 kHz or less, may well find favor in the market place. Despite the fact that by that time, all offset carriers should be reliably constrained within ±8 kHz of their assigned channel frequencies, the prudent manufacturer will still provide a wider-than-specified nose bandwidth. In addition to ensuring optimal utility of the equipment, this approach will also provide the airlines with an inservice maintenance run-down margin on these important characteristics.

For purposes of illustration, Attachment 3 shows a typical receiver's selectivity characteristics based on an assumed receiver stability that is believed to be reasonable. It must be realized, however, that the stability figure suggested for the receiver in that Attachment is not part of the specification material contained in this Characteristic. Note further that no allowances are included in Section 3.4.2 for a non-symmetrical pass-band or other design problems. These deficiencies in actual receivers must be considered within the limits set forth in Section 3.4.2.

3.6.3 Undesired Responses

All spurious responses, including image, should be down at least 80 dB. All spurious responses within the frequency band of 118 to 136 MHz should be down at least 100 dB and preferably 120 dB.

3.6.4 Cross Modulation

The undesired cross modulation product should be down at least 10 dB with respect to the audio output when the desired signal is modulated 50% under the following conditions:

Undesired Signal Frequency	Minimum Undesired Signal Level Modulated 50% (Hard μV)	Desired Signal Level-Unmodulated (Hard μV)
±25 kHz	10,000	10
±50 kHz	20,000	10
±100 kHz	60,000	10
±500 kHz	100,000	10
±1 MHz	200,000	10

With the simultaneous application to the input of the receiver of a 30% modulated off-resonance signal with an unmodulated desired signal, the audio output produced by the undesired signal should not exceed -10 dB with reference to the output produced by the desired signal only (when modulated 30%) under the conditions specified below. With the desired signal level varied from 3 μV to 0.1 volt, and the audio gain adjusted in each case for 100 mW output, the receiver should meet the above specification with the following undesired signals:

Undesired Signal Level	Off Resonance
0.06 volts	0.1 MHz
0.3 volts	0.5 MHz
0.6 volts	1.0 MHz
1.2 volts	2.0 MHz

COMMENTARY

No-one reading this section should believe that reflects the airlines true requirements for receiver cross modulation performance and interference rejection. They really want very much better performance than this, but found difficulty in trying to write a meaningful specification of "just how much better". A short historical note will explain why.

At the time ARINC Characteristic 546 was being prepared, the "all-transistor" receiver was just about to become a commercial reality. Despite its many advantages over its tubed predecessor, there were some areas in which it could not match the performance of the older radio, of which cross modulation performance and interference rejection was one. The reasons for this were bound up in the limitations of semi-conductor state-of-the-art at the time.

Fortunately in this respect, the requirement for double channel duplex operation, foreseen when ARINC Characteristic 520A was written, had not materialized, nor was it necessary to specify more than the very minimum provisions for it in ARINC Characteristic 546. This enabled the airlines to accept the contemporary transistor receiver capabilities without submitting to too many operational problems.

3.0 TRANSCEIVER UNIT DESIGN (cont'd)

3.6.4 Cross Modulation (cont'd)

COMMENTARY (cont'd)

With the advent of the need for the re-introduction of crossband operation into the airborne transceiver, the requirement for good cross modulation and interference rejection capabilities has returned. The airlines require latest-state-of-the-art capability in first generation ARINC 716 equipment and even better than this in subsequent designs. Equipment manufacturers should recognize that the airlines regard this area as one in which considerable design effort should be expended, involving in all probability the semi-conductor device industry in some basic R&D.

3.6.5 Audio Output

An audio output should be provided which is isolated from ground. A service control should be provided within the transceiver for adjustment of the output level. The adjustment should vary the output from 5 mW to 40 mW into a 600 ±20% Ω resistive load. The nominal setting should be 10 mW at 1,000 Hz. The output circuit should be able to endure a short circuit (zero ohms) and open circuit, and should operate normally after removal of the short or open.

3.6.5.1 Audio Source Impedance

The audio output circuit should present less than 20 Ω impedance to the load circuit under all power-on conditions (signal and no-signal) when measured using the Figure 1 and Figure 2 methods of Attachment 9. The audio output circuit should present less than 50 Ω impedance to the load circuit (measured using the Figure 2 method of Attachment 9) when no power is applied to the unit. The source impedance limits should apply over the frequency range of 100 Hz to 6,000 Hz.

3.6.5.2 Output Regulation

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With the output signal adjusted to 10 mW into 600 Ω at 1000 Hz, the output voltage should not change more than 2 dBV when the load is varied between 450 Ω and 2,400 Ω and by not more than 6 dBV when the load is varied between 200 Ω and 20,000 Ω. The above described output regulation should also be true when tested using 350 and 2,500 Hz signals.

3.6.5.3 Gain

The receiver gain should be such that a 2 μV signal modulated 30% at 1000 Hz will produce at least 40 mW of output into 600 ±20% Ω resistive load.

3.6.5.4 Hum Level

Hum and noise in the receiver output should be at least 40 dB below 10 mW output with a 1000 μV 30% 1000 Hz modulated reference input.

3.6.5.5 Voice Phase Shift Limit

The audio power output level should not vary more than 6 dB over the frequency range 300 Hz to 2500 Hz with respect to a reference level of up to 10 mW established at 1000 Hz with a constant input carrier level modulated 30%. A sharp cut-off in response below 300 Hz and above 2500 Hz is desirable. Frequencies above 3750 Hz should be attenuated at least 20 dB and preferably 40 dB.

3.6.5.6 Distortion

With an input signal of 1000 μV modulated with 1000 Hz and the receiver gain adjusted to produce 40 mW into a 500 Ω resistive load, the total harmonic distortion should not exceed 7.5% with 30% modulation or 20% with 90% modulation (with the gain control reset to maintain the output at 40 mW), including any effects of the voice limiter.

3.6.5.7 Voice Phase Shift Limit c-6

With 1000 μV modulated with 1000 Hz and the output level adjusted for 40 mW into a 600 Ω resistive load, the audio output phase should not depart from that of the positive going modulation envelope at the receiver input by more than -30 degrees or +120 degrees.

COMMENTARY

The phase shift limits of the audio output are different from those of data/SELCAL output due to the number of stages required for the processing of each signal type.

3.6.6 Automatic Gain Control

The receiver amplitude modulation output should not vary more than 3 dB with input signals from 5 μV to 100,000 μV, and not more than 6 dB with input signals from 5 μV to 500,000 μV. Variation of percentage modulation should have negligible effect on the automatic gain control. The receiver should not overload with one volt of rf energy (hard) applied to antenna terminals.

3.6.7 Desensitization and Interference Rejection

Circuitry should be included for the prevention, insofar as practicable, of receiver desensitization due to pulse-type interference. As the magnitude and character of the pulse interference levels expected in a typical installation in the future is not known, system performance specifications would be meaningless. The following specification paragraphs 3.6.7.1, 3.6.7.2, and 3.6.7.3 are not made a requirement of this Characteristic, but are included as being typical of the type and degree of protection that is likely to be needed. The content of 3.6.7.1, 3.6.7.2 and 3.6.7.3 apply when rf pulses having the following characteristics are introduced into the receiver through a 52-Ω dummy antenna:

Width of Pulse	10 ±2 μs
Repetition Rate	1000 ±100 pps
Waveform	Rise and decay time each less than 1 μs

3.6.7.1 AGC Versus Pulse Interference

With the receiver sensitivity set to maximum and with a test signal of 3 to 1000 μV, modulated 30% at 1000 Hz, the resulting 1000 Hz output, should not decrease more

3.0 TRANSCEIVER UNIT DESIGN (cont'd)

than 2 dB for pulses having the same carrier level, or more than 10 dB for pulses with amplitudes 100 times the carrier level, introduced simultaneously with the standard test voltages.

3.6.7.2 Squelch Versus Pulse Interference

The squelch should not open when pulses and unmodulated carrier on the same frequency are introduced, having the following levels in microvolts:

Squelch Threshold	Carrier Level	Pulse Peak Amplitude
5	0	3000
5	3	1000

3.6.7.3 Pulse Noise Output

With the receiver gain adjusted so that a test signal of 100 μV, modulated 30% at 1000 Hz, produces 10 mW output in a 600-Ω resistive load, substitution of pulse-type interference superimposed upon the 100 μV carrier in lieu of the 1000 Hz modulation should not produce more than 5 mW audio output with pulse peak amplitudes up to one volt.

3.6.7.4 Receiver Operation in the Presence of Inband Transmission

The receiver design should be the best that the state-of-the-art can provide with respect to freedom from interference from transmitters operating in the 118.000 to 137.000 MHz band on the same aircraft. There should be no squelch tripping or degradation of receivers performance when a 25 watt transmitter tuned to a frequency 6 MHz or more removed from that to which the receiver is tuned is operated into an antenna space-isolated from the receiver's antenna by 35 dB. If 45 dB of space isolation is provided between the two antennas, there should be no interference or squelch tripping when the transmission frequency is as close as 2 MHz to the receive frequency.

3.6.7.5 Out-of-Band FM Broadcast Intermodulation Interference

No degradation of performance should occur when third order intermodulation products in the VHF communications band of 118.000 to 137.000 MHz result from two or more FM broadcast signals of -5 dBm or less mixing within the receiver. See Attachment 8 of this document.

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3.6.7.6 Out-of-Band FM Broadcast Desensitization Interference

No degradation in performance should occur if the aggregate level of one or more FM broadcast signals across the VHF communications transceiver input terminals is less than -5 dBm. See Attachment 8 of this document.

3.6.8 Squelch Provision

Manufacturers are encouraged to provide the best possible squelch system: one that can distinguish between communications signals and the usual types of interference and receiver background noise which can obscure such signals. Sophisticated squelch systems which automatically adjust the squelch threshold to match the masking level of the noise are highly desirable so that the user can take full advantage of the highest possible sensitivity capability in the receiver when the aircraft is away from ground generated noise conditions, but will also automatically adjust the sensitivity level of the receiver when flying over industrial areas where heavy noise levels exist. The desire is that the squelch be capable of tripping open whenever a readable signal is present, yet remain closed whenever a signal is below the noise level.

The receiver squelch should open when signals are received from multiple stations in an offset carrier network. Up to five such stations may transmit simultaneously on frequencies falling within the receiver passband.

COMMENTARY c-7

A carrier-to-noise type of squelch may see the multiple ground station signal complex as noise and refuse to open. Thus, a carrier-override squelch sensor may also be needed to enable the receiver audio circuits when the received signal level is 20 μV or greater.

Irrespective of how stable and reliable the squelch system may be, it should also be possible to disable the squelch by command of a test function as part of the serial frequency control format.

3.6.9 SELCAL/Data Output

An output isolated from ground having a source impedance of 300 Ω or less and independent of the voice output and its associated squelch, noise limiters, audio compressors, etc., should be provided. A service adjustment independent of the voice or sidetone outputs should be provided within the transceiver for output level adjustment.

3.6.9.1 Gain

The receiver gain should be such that a 2 μV signal modulated 30% at 1000 Hz will produce at least 0.5 VAC of output into a 600 $\pm$20% Ω load.

3.6.9.2 Frequency Response

The total receiver frequency response should be within 3 dB from 312 Hz to 1200 Hz and the post detection response with respect to 1000 Hz should be within $\pm$6 dB from 300 Hz to 6.6 kHz.

3.6.9.3 Distortion

With an input signal of 1000 μV modulated with 30% mod 1000 Hz and the level adjusted to provide 0.5 V output into 600 Ω, the total distortion should not exceed 5.0%.

3.0 TRANSCEIVER UNIT DESIGN (cont'd)

3.6.9.4 Phase Shift

There should be no phase inversion through the receiver.

3.6.9.4.1 SELCAL/Data Phase Shift

With 1000 μV modulated with 1000 Hz and the output level adjusted to 0.5 V into a 600 Ω resistive load, the audio output phase should not depart from that of the positive going modulation envelope at the receiver input by more than -90°.

COMMENTARY

> The phase shift limits of the data/SELCAL output are different from those of the audio output due to the number of stages required for the processing of each signal type.

3.6.9.4.2 Differential Phase Delay

The differential delay through the receiver to audio frequencies (f) from 600 Hz to 6.6 kHz should be less than 1/10f seconds.

3.6.9.5 AGC Attack Time

The data link audio output should reach 90% of its steady state value within 40 ms after the step application of a 1000 μV 30% 1000 Hz modulated rf signal to the receiver input.

3.6.9.6 AGC Decay Time

The data link audio output should reach 90% of its steady state value within 50 ms after the receiver rf input of 1000 μV, modulated 30% with 1000 Hz is step reduced to 10 μV.

3.7 Transmitter Design

3.7.1 Power Output

When operated at rated input power, the transceiver carrier power output measured into a 52 Ω resistive load at the end of a 5 ft. transmission line should be 25 to 40 watts on any operating frequency. The transmitter should be capable of continuous operation with ARINC 600 cooling air. The transmitter should be designed to operate with a 52 Ω transmission line terminated in its characteristic impedance. ¢-1

3.7.2 Frequency Stability

The transceiver carrier frequency should not deviate from the assigned carrier frequency of any selected channel by more than $\pm$0.002% under the following conditions taken one at a time.

(a) the DC input voltages vary from 22 volts to 29 volts.

(b) the ambient temperature is varied from -55°C to +71°C and internal warm up (not to exceed 5 minutes) has been attained.

(c) the humidity is varied from 10% to 95% at 50°C.

(d) The pressure is varied from sea level to that equivalent of an altitude of 40,000 feet (the equipment should not require pressurization).

The transmitter output carrier frequency should not deviate from the assigned carrier frequency on any channel by more than $\pm$0.003% when the ambient temperature is varied from -50°C to 71°C and without internal warm up. This applies to all operational conditions.

The transmitter frequency should not deviate from the assigned carrier frequency by more than $\pm$0.003% when any other environmental characteristic or other situation shall develop which might, in the opinion of the manufacturer or the airline customer, exist in actual service.

3.7.3 Sidetone

The sidetone output (shared with the audio output) should have a source of impedance of less than 20 Ω, and should provide an output level of 40 mW into a 600 $\pm$20% Ω resistive load when the transmitter is amplitude modulation 90% at 1000 Hz. A service adjustment independent of the receiver audio output service adjustment shall be provided to adjust the output level. The adjustment shall provide for a variation from 5 mW to 40 mW. The nominal setting should be 10 mW at 1000 Hz. The rf power required to operate the sidetone should be obtained from a source as close as practical to the transmitter power output connection. ¢-2

3.7.4 Transmitter Spurious Radiation

Any emissions on a harmonic of a desired frequency should be less than -46 dBW (dB below one watt). Any other emissions should be less than -65 dBW, and any emissions within the band 108 to 136 MHz should be down to at least -75 dBW and preferable to -105 dBW. Any spurious within the band 108 to 136 MHz, but more than 5 MHz from the carrier frequency, should be down to at least -105 dBW. This attenuation should be accomplish within the transmitter without the aid of external circuits.

NOTE: The specification for spurious radiation is stated in terms of absolute power level rather than amount of attenuation by virtue of several historical agreements reached as a result of interference on harmonics of aeronautical mobile frequencies. The absolute level of -45 dBW for harmonics is based on 60 dB attenuation of the harmonics in a 25 to 50 watt transmitter and is compatible with FCC requirements. This has been determined to be a maximum allowable level for operation.

It should also be recognized that the ECAC* recommended maximum level is -46 dBW for all spurious emissions except where 40 dB attenuation below the fundamental power output results in a lower power level. ECAC has also considered recommending -56 dBW as the maximum level for all spurious emissions in the band 108.0 to 136.0 MHz, regardless of the fundamental power output.

For this reason equipment manufactures should regard the figures specified in this paragraph as "barley acceptable minima", and aim to do rather better in their boxes.

3.0 TRANSCEIVER UNIT DESIGN (cont'd)

3.7.5 Microphone Input

The transmitter voice communication input should be designed to work with microphone meeting ARINC 535A and 538A. The input circuit should provide the following characteristics:

(a) Microphone excitation voltage: 16 VDC open circuit.
(b) Excitation voltage source impedance: 400 Ω.
(c) Input impedance: 150 Ω.

3.7.5.1 Modulation Level

An input level of 0.25 V rms at 1000 Hz applied to the microphone input should provide at least 90% modulation of the transmitter. This modulation level may be accomplished through use of a dynamic or carbon microphone. A service adjustment should be provided to allow accommodation of input levels up to 20 dB higher.

3.7.5.2 Speech Processing

It is desirable that some form of clipping or speech processing be included in the microphone input circuits. It should provide sufficient extra gain to allow at least 10 dB (preferable 20 dB) of such speech processing, still meeting the microphone input level requirements. Service adjustment provisions should be included to allow setting the speech processing or clipping to the desired amount.

3.7.5.3 Frequency Response

The transmitter modulation response should be flat within 6 dB from 300 Hz to 2500 Hz. Attenuation beyond this range is desirable.

3.7.5.4 Distortion

With the speech processing circuits de-energized or the speech processing service adjustment of Section 3.5.5.2 set to "minimum", the transmitter distortion indicated on an external monitor detector should not exceed 10% with full 90% sinusoidal modulation at any frequency in the range 300 to 2500 Hz. The noise level should be at least 45 dB below the level of a carrier modulated 90% at 1000 Hz.

3.7.6 Leakage

The transmitter output shall not exceed .02 picowatts at the selected frequency or more than 400 picowatts at any other frequency in the key up condition when terminated into a 50 Ω resistive load.

3.7.7 Key Line

The transmitter PTT keyline (MPC1) should be enabled only when the transceiver is in the Voice mode, i.e., Voice/Data Select pin MPC7 is open circuit (50 kΩ or
¢-1 greater). The transmitter data keyline (MPD7) should be enabled only when in the Data mode, i.e., Voice/Data Select pin MPC7 is externally grounded (±3V).

The transmitter should be keyed (key down) when a resistance of 60 Ω or less to ground or a positive voltage of between 0 and 3 VDC from an external source is applied to the key line PTT pin MPC1 (in Voice mode), or to the data key line pin MPD7 (in Data mode).

The transmitter should not be keyed (key up) when 50 kΩ or more to ground or a positive voltage of 20 to 31 VDC from an external source is applied to the key line PTT pin ¢-2
MPC1 and data key line pin MPD7.

The transmitter should not be damaged by inadvertent application of up to -35 VDC from an external source to the key line.

3.7.8 Data Input

A balanced 600 ±20% Ω input should be provided for data modulation of the transmitter.

3.7.8.1 Modulation Level

A minus 10 dBm input at 1000 Hz should provide 70% modulation. A service adjustment independent of the microphone input adjustment should be provided to accommodate input levels up to +10 dBm.

3.7.8.2 Level Control

Adequate compression should be provided to control the modulation level to less than 100% when input signals of 10 and preferably +20 dBm above that producing 70% ¢-1
modulation, reference pp 3.7.8.1, are applied.

3.7.8.3 Frequency Response

The frequency response from the data input to the modulated carrier output should be flat within 6 dB from 600 Hz to 6.6 kHz.

3.7.8.4 Distortion

The distortion at modulation levels up to 90% should not exceed 10% over the frequency range of 45 dB below the level of 90% modulation at 1000 Hz.

3.7.8.5 Phase Shift

There should be no phase inversion through the transmitter. The transmitter modulated envelope peak should be 60 degrees of the positive peak of the audio applied as the high data input connector pin MPA5 as 1000 Hz.

3.7.8.6 Differential Delay

The differential delay to audio frequencies (f) from 600 Hz to 6.6 kHz should be less than 1/10f seconds through the transmitter.

3.7.9 Muting

Provisions should be included within the transmitter to provide a switch closure actuated by the microphone key line or the data key line. In the key up condition the switch shall present at least 50 kΩ between pins MPC15 and MPD15 (ground) and be able to withstand +50 VDC. In the key down condition (switch closure) the "ground" provided may have a potential of up to 3.5 VDC, but should be capable of sinking 2 amperes at 27.5 VDC.

3.7.10 Receive to Transmit Turn Around

The modulated rf output should be at least 90% of the steady state output within 50 ms after a key down condition is applied.

4.0 TRANSCEIVER UNIT DESIGN FOR THE 8.33 kHz CHANNEL-SPACED MODE OF OPERATION

4.1 Frequency Range and Channeling

The transceiver should operate on 2,280 channels spaced 8.33 kHz apart in the band 117.975 to 137.000 MHz. The lowest assignable channel is centered on 118.000 MHz for 25 kHz channel spacing, and on 117.9916 MHz for 8.33 kHz channel spacing. Channel changing time should not exceed 60 ms. A table of the Frequency-Channel Pairing Plan is provided in Appendix 3 for the reader's convenience.

COMMENTARY

The channel naming used is based on the frequency-channel pairing plan defined in ICAO Annex 10 to the convention on International Civil Aviation "International Standards and Recommended Practices, Aeronautical Telecommunications" which
¢-8 allows unique identification of the 8.33 kHz channels. ICAO Annex 10 has precedence over Appendix 3 in this Characteristic.

The emergency frequency (121.50 MHz), the auxiliary SAR frequency (123.10 MHz), and the datalink channels (at least the four upper channels) will be used with a 25 kHz channel spacing.

4.2 Frequency Selection

The ARINC 429 tuning-word format for the 8.33 kHz channels is the same as that for the 25 kHz channels except for the label. The VHF COM label is 030 (octal) for 25 kHz channel spacing and 047 (octal) for 8.33 kHz channel spacing, see ARINC Specification 429, "Mark 33 Digital Information Transfer System (DITS)".

COMMENTARY

The tuning control panel should be able to control and display the channel name with at least six digits. When the control panel is operating in a mode which is capable of displaying 8.33 kHz channels, like 118.005, it should also display the 25 kHz channels, like 118.000, by scrolling through both the 8.33 and 25 kHz spaced channels as shown in the Frequency-Channel Pairing Plan in Appendix 3.

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4.2.1 Control Panel Programming

When MPD5 is internally grounded the transceiver is capable of operating in either of the 8.33 kHz or 25 kHz modes.

COMMENTARY

The control panel programming feature is optional.

4.3 Receiver Design

4.3.1 Selectivity

The nose passband and the stability of the receiver should be such that when a carrier modulated 30% at 1,000 Hz is applied on any assigned carrier frequency there is no more than 6 dB attenuation when it is moved to ± 2.780 kHz from its assigned frequency.

The skirt selectivity should be such that at least 60 dB of attenuation results when the modulated carrier departs ± 7.365 kHz or more from its assigned frequency.

Note: The nose passband is defined in order to receive the full speech bandwidth (± 2.5 kHz). This value is increased by the ground frequency tolerance (± 1 ppm) plus the Doppler effect (± 140 Hz).

COMMENTARY

Skirt selectivity is defined at the minimum separation between the adjacent and wanted channel, i.e., at the maximum airborne transmitter frequency tolerance (± 5 ppm as defined in paragraph 3.7.2) plus the Doppler effect (air/air communication being the worst operational case for Adjacent Channel ¢
Interference). The equipment manufacturer may choose the stability figure for the receiver. However, the stability figure may be dictated by the stability specified for the transmitter elsewhere in this Characteristic. It should be evident that the preceding specification sets forth the minimum nose bandwidth and the maximum 60 dB skirt bandwidth for the receiver. Obviously, a wider-than-minimum nose bandwidth and/or a narrower-than-maximum skirt bandwidth are acceptable to the airlines in actual practice. The manufacturer is free to trade these numbers with stability as he sees fit.

For purposes of illustration, Attachment 10 depicts the selectivity characteristics of a typical receiver based on an assumed receiver stability of ± 5 ppm. However, the stability figure suggested for the receiver in Attachment 10 is not part of the specification material contained in this Characteristic. Also, Section 3.6.2 does not include allowances for a non-symmetrical pass-band or other design problems. These deficiencies in actual receivers must be considered within the limits set forth in Section 3.6.2.

It should also be noted that the receiver local oscillator phase noise should be sufficiently low to avoid any

4.0 TRANSCEIVER UNIT DESIGN FOR THE 8.33 kHz CHANNEL-SPACED MODE OF OPERATION (cont'd)

degradation of the receiver capability to reject off-channel signals. A phase noise level better than -114 dBc/Hz is necessary to comply with a 60 dB adjacent channel rejection.

4.3.2 Cross Modulation

The undesired cross modulation product should be down at least 10 dB with respect to the audio output when the desired signal is modulated 50% under the following conditions:

Undesired Signal Frequency		Minimum Undesired Signal Level Modulated 50% (Hard μV)	Desired Signal Level-Unmodulated (Hard μV)
± 8.33	kHz	10,000	10
± 25	kHz	10,000	10
± 50	kHz	20,000	10
± 100	kHz	60,000	10
± 500	kHz	100,000	10
± 1	MHz	200,000	10

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With the simultaneous application to the input of the receiver of a 30% modulated off-resonance signal with an unmodulated desired signal, the audio output produced by the undesired signal should not exceed -10 dB with reference to the output produced by the desired signal only (when modulated 30%) under the conditions specified below. With the desired signal level varied from 3 μV to 0.1 V, and the audio gain adjusted in each case for 100 mW output, the receiver should meet the above specification with the following undesired signals:

Undesired Signal Level	Off Resonance
0.06 volts	0.1 MHz
0.3 volts	0.5 MHz
0.6 volts	1.0 MHz
1.2 volts	2.0 MHz

4.3.3 Squelch Provision

Manufacturers are encouraged to provide the best possible squelch system; i.e., one that can distinguish between communications signals and the usual types of interference and receiver background noise which can obscure such signals. Sophisticated squelch systems which automatically adjust the squelch threshold to match the masking level of the noise are highly desirable so that the user can take full advantage of the highest possible sensitivity capability in the receiver when the aircraft is away from ground generated noise conditions, but which will also automatically adjust the sensitivity level of the receiver when flying over industrial areas where heavy noise levels exist. The desire is that the squelch be capable of tripping open whenever a readable signal is present, yet remain closed whenever a signal is below the noise level. The receiver squelch should open when signals are received from multiple stations.

COMMENTARY

No offset carrier network is foreseen to be used in the 8.33 kHz environment.

4.3.4 SELCAL/Data Output

The only data output allowed when using the 8.33 kHz mode is the SELCAL output. An output that is isolated from ground, with a source impedance of 300 Ω or less, and independent of the voice output and its associated squelch, noise limiters, audio compressors, etc., should be provided. A service adjustment independent of the voice or sidetone outputs should be provided within the transceiver for output level adjustment.

4.3.4.1 Gain

The receiver gain should be such that a 2 μV signal modulated 30% at 1,000 Hz will produce at least 0.5 VAC of output into a 600 ± 20% Ω load. ¢-8

4.3.4.2 Frequency Response

The total receiver frequency response should be within 3 dB from 312 Hz to 1,200 Hz. The post detection response with respect to 1,000 Hz should be within ± 6 dB from 300 Hz to 2.5 kHz.

4.3.4.3 Distortion

With an input signal of 1,000 μV modulated 30% at 1,000 Hz and with the level adjusted to provide a 0.5 V output into 600 Ω, the total distortion should not exceed 5.0%.

4.3.4.4 Phase Shift

There should be no phase inversion through the receiver.

4.3.4.4.1 SELCAL Phase Shift

With 1,000 μV modulated with 1,000 Hz and the output level adjusted to 0.5 V into 600 Ω resistive load, the audio output phase should not depart from that of the positive going modulation envelope at the receiver input by more than -90°.

COMMENTARY

The phase shift limits of the SELCAL output are different from those of the audio output due to the number of stages required for the processing of each signal type.

4.0 TRANSCEIVER UNIT DESIGN FOR THE 8.33 kHz CHANNEL-SPACED MODE OF OPERATION (cont'd)

4.3.4.4.2 Differential Phase Delay

The differential delay through the receiver to audio frequencies (f) from 600 Hz to 2.5 kHz should be less than 1/10f seconds.

4.3.4.5 AGC Attack Time

The audio output should reach 90% of its steady state value within 40 ms after the step application of a 1,000 μV 30% 1,000 Hz modulated rf signal to the receiver input.

4.3.4.6 AGC Decay Time

The audio output should reach 90% of its steady state value within 50 ms after the receiver rf input of 1,000 μV, modulated 30% with 1,000 Hz is step reduced to 10 μV.

4.4 Transmitter Design

4.4.1 Frequency Stability

The transmitter carrier frequency should not deviate from the assigned carrier frequency of any selected channel by more than ± 0.0005% under the following conditions taken one at a time.

¢-8

(a) the DC input voltages vary from 22 V to 29 V.

(b) the ambient temperature is varied from -55°C to +71°C and internal warm up (not to exceed 5 minutes) has been attained.

(c) the humidity is varied from 10% to 95% at 50°C.

(d) the pressure is varied from sea level to that equivalent of an altitude of 40,000 feet (the equipment should not require pressurization).

The transmitter output carrier frequency should not deviate from the assigned carrier frequency on any channel by more than ±0.0005% when the ambient temperature is varied from -50°C to +71°C and without internal warm up. This applies to all operational conditions.

The transmitter frequency should not deviate from the assigned carrier frequency by more than ±0.0005% when any other environmental characteristic or other situations develop which might, in the opinion of the manufacturer or other airline customer, exist in actual service.

4.4.2 Microphone Input

The transmitter voice communication input should be designed to work with microphones meeting ARINC Characteristics 535A and 538A. The input circuit should provide the following characteristics:

(a) Microphone excitation voltage: 16 VDC open circuit.

(b) Excitation voltage source impedance: 400 Ω.

(c) Input impedance : 150 Ω.

4.4.2.1 Modulation Level

An input level of 0.25 V rms at 1,000 Hz applied to the microphone input should provide at least 90% modulation of the transmitter. This modulation level may be achieved through use of a dynamic or carbon microphone. A service adjustment should be provided to allow accommodation of input levels up to 20 dB higher.

4.4.2.2 Speech Processing

It is desirable that some form of clipping or speech processing be included in the microphone input circuits. The microphone input circuits should provide sufficient extra gain to allow at least 10 dB (preferably 20 dB) of speech processing, still meeting the microphone input level requirements. Service adjustment provisions should be included to allow setting the speech processing or clipping to the desired amount. ¢-8

4.4.2.3 Frequency Response

The transmitter modulation response should be flat within 6 dB from 300 Hz to 2,500 Hz. A sharp cut-off in response below 300 Hz and above 2,500 Hz is required. Frequencies above 3,200 Hz should be attenuated at least 50 dB

4.4.2.4 Distortion

The transmitter distortion should be consistent with the required transmitter occupied spectrum.

4.4.2.5 Transmitter Occupied Spectrum

The transmitted spectrum should not exceed the limits shown in Attachment 11 when the transmitter is modulated by any frequency between 300 Hz and 10 kHz, the input level being adjusted to provide 90 % modulation at 1,000 Hz.

4.4.3 Data Input

Data inputs are not allowed when using the 8.33 kHz mode.

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5.0 ANTENNAS

¢-8 | 5.1 General

This document does not specify a "standard" antenna for the VHF communications transceiver. For reference purposes, however, Attachment 5 shows a typical non-flush antenna and its mounting details. Whether an antenna of this type is used, or one of the flush-mounted, "airframe integrated" types frequently offered by airframe manufacturers is employed instead, it should be designed to match 52 Ω and exhibit a standing wave ratio of less than 2.0:1 over the operating frequency range of the transceiver. The antenna should be essentially vertically polarized and omnidirectional to the maximum degree practicable.

¢-8 | 5.2 Antenna Considerations for Multiple Systems Operations

The installation designer should note that, to permit multiple VHF transceivers to be used simultaneously on the same aircraft, it is necessary to provide adequate space isolation between the antennas of each unit to ensure that the use of one transmitter does not interfere with reception on another receiver. A minimum of 50 dB of space isolation should be provided between antennas mounted on opposite sides (top and bottom) of the fuselage. A minimum of 35 dB of space isolation should be provided between antennas mounted on the same side of the fuselage. Any steps which can be taken to provide further isolation in new aircraft and antenna designs is encouraged.

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6.0 AUTOMATIC TEST EQUIPMENT PROVISIONS

¢-8 | 6.1 General

To enable Automatic Test Equipment to be used in the bench maintenance of the ARINC 716 Communications Transceiver, an ATE connector insert (TP) has been provided. The connector and its cover should be totally contained within the form factor prescribed in Section 2.2.1 and the related NIC 600 racking standards.

This connector should be fitted with a suitable cover to prevent damage to the contacts and entry of contaminants into the connector while the equipment is installed or being moved between the shop and aircraft. This cover should be secured to the T-R unit by a suitable means so as to prevent loss.

The circuits made available on this connector may also be used in shop maintenance with manual test equipment.

¢-8 | 6.2 Unit Identification

Six pins on the ATE connector insert should be reserved for the implementation of a "resistor coding" scheme for unit identification by the ATE, in which a 1% tolerance resistor is connected from each pin to a common ground in a "star" formation. Values selected should correspond to the standard 10% increments in resistance in order to prevent ambiguities resulting from tolerance build-up and aging. The power handling capability of each resistor need not exceed 0.1 watt.

¢-8 | 6.3 Pin Allocation

Two pins should be allocated to each of the following functions and one pin to the "star formation common" (i.e., DC chassis ground).

TP1A-TP1B	Manufacturers Identification (Resistor values to be registered with ARINC when selected)
TP1C-TP1D	Part No. or Type No. of the Equipment
TP2A-TP2B	Modification Status of the Equipment
TP2C	Network Common (Resistor "Star" Points)

IMPORTANT NOTE: Resistor codes for manufacturers identification will be recorded by ARINC in order to prevent duplication. Such registration, however, should not be confused with assignment. It is the responsibility of each manufacturer to select a code and inform ARINC of his choice. Code assignments for equipment part number and modification status are entirely the province of the manufacturer and do not require registration with ARINC.

COMMENTARY

Equipment designers may wish to note that it is probable that the equivalent of an open-circuit relay contact will be present at each connector pin used in the automatic test sequence during the time the test is in progress. In practice this is the equivalent of connecting a 100 pF capacitor from each pin to ground.

6.4 Use of ATLAS Language | ¢-8

Equipment of manufacturers should note that the airlines desire to have VHF Transceiver test procedures intended for execution by automatic test equipment written in the ATLAS language described in ARINC Specification 616. | ¢-2

7.0 BUILT-IN TEST EQUIPMENT (BITE)

7.1 Built-In Test Equipment (BITE)

The VHF Transceiver described in this Characteristic should contain Built-In Test Equipment (BITE) capable of detecting and annunciating a minimum of 95% of the faults or failures which can occur within the VHF Transceiver and as many faults as possible associated with the antenna, frequency controllers and their interfaces with the VHF Transceiver.

BITE should operate continuously during flight. Monitoring of the results should be automatic and the BITE should automatically test, detect, isolate and record intermittent and steady state failures. The BITE should display system condition and indicate any faulty LRU's upon activation of the self-test routine described in Section 7.4. In addition BITE should display faults which have been detected during in-flight monitoring.

No failure occurring within the BITE subsystem should interfere with the normal operation of the VHF Transceiver.

COMMENTARY

Sufficient margins should be used in choosing BITE parameters to preclude nuisance warnings. Discrepancies in VHF Transceiver operation caused by power bus transients, EMI, ground-handling, servicing interference, abnormal accelerations or turbulence should not be recorded as faults.

7.2 BITE Display

The VHF Transceiver should have a System/LRU status display on the front panel.

The display, as a minimum should be composed of one red and one green LED. Green should indicate "good" and red should indicate detection of a fault. The display should be energized only when BITE is activated locally by the control located on the front panel or a remote activation signal. Multiple red LEDs should be used to indicate subsystems when appropriate.

COMMENTARY

Most users desire an alpha-numeric display to present fault information to line maintenance personnel. The desire includes presentation of the information in the form of easily understandable text --- not coded! The airlines do not want the maintenance personnel to be burdened with carrying a library of code translations. The airlines would like to have the fault analysis capability of BITE using the alpha-numeric display equal to or surpassing the capability currently realized with shop Automatic Test Equipment.

The use of LEDs on equipment, even though considered inadequate, is described in this section to provide guidance to manufacturers currently using LEDs for BITE. The guidelines are intended to aid in achieving consistency in BITE operation between units supplied by different manufacturers.

7.3 Fault Monitor

The results of in-flight or ground operations of BITE should be stored in a non-volatile monitor memory. The size of the memory should be sufficient to retain detected faults during the previous ten flight legs. The data in the monitor memory should include flight-leg identification, fault description, and faulty LRU.

The contents of the monitor memory should be retrievable by BITE operation or by shop maintenance equipment.

COMMENTARY

A question which must be considered by the equipment designer is "What is the scope/purpose of BITE?" It appears from the unconfirmed failure data that is available from repair shop operations, that there is a good deal of merit in considering storage of data which will identify the Shop Replacement Unit (SRU). BITE should be used to detect and isolate faults to the LRU level and it should also provide fault isolation information at the SRU level.

7.4 Self-Test Initiation

The momentary depression of the push-button on the front panel of the LRU should initiate a unit/system self-test. The self-test routine should start with an indicator test in which all indicator elements are activated simultaneously. If the self-test routine detects a fault, the "all on" indication should be deactivated leaving the appropriate "fault" indication activated. If no fault is found, the contents of the intermittent fault memory should be reviewed. Only the four most recent flight legs should be considered. If no fault is recorded, the "all on" indication should be deactivated leaving the "normal" indication visible. If an occurrence of a fault on one of the four earlier flight legs is detected, the appropriate "fault" indication should be activated. The activated indications should remain visible until the line maintenance mechanic presses the self-test button a second time or a "time-out" period of approximately ten minutes expires.

COMMENTARY

Selection of four of the number of flight legs for which intermittent fault memory should be examined for the line maintenance BITE function was made in the belief that it could be reduced as confidence in the BITE was built up. Manufacturers are urged to make this number easily alterable in their BITE implementations.

Currently there are no display provisions for differentiation of stored faults from faults detected during the self-test routine. Discussions in the past have not uncovered any significant benefits of such differentiation for maintenance personnel in the troubleshooting mode. However, depending on how BITE is implemented, problems with lack of differentiation between display of stored faults and self-test faults may be realized. If faults in units external to the central LRU were stored in the LRU fault memory and the maintenance personnel

¢-8 | 7.0 BUILT-IN TEST EQUIPMENT (BITE) (cont'd)

¢-8 | 7.4 Self-Test Initiation (cont'd)

COMMENTARY (cont'd)

¢-6 replaced the external LRU, the central LRU fault memory would retain the fault. A post-maintenance self-test initiation would display a (stored) fault regardless of the self-test results. Due to the lack of differentiation, maintenance personnel will be uncertain of the success of the maintenance action. Where BITE does store faults of external units, differentiation between stored and self-test faults may have merit.

¢-8 | 7.5 Monitor Memory Output

The BITE Monitor Memory output should consist of the following:

(a) An output to the display located on the transceiver, indicating system and LRU status.

(b) An output of undefined format which should be made available at the ATE segment of the connector located on the Interrogator Unit.

The monitor memory should be capable of being reset in order that stored faults will not be carried over once an LRU replacement or repair has been effected. The reset should be initiated only by shop maintenance.

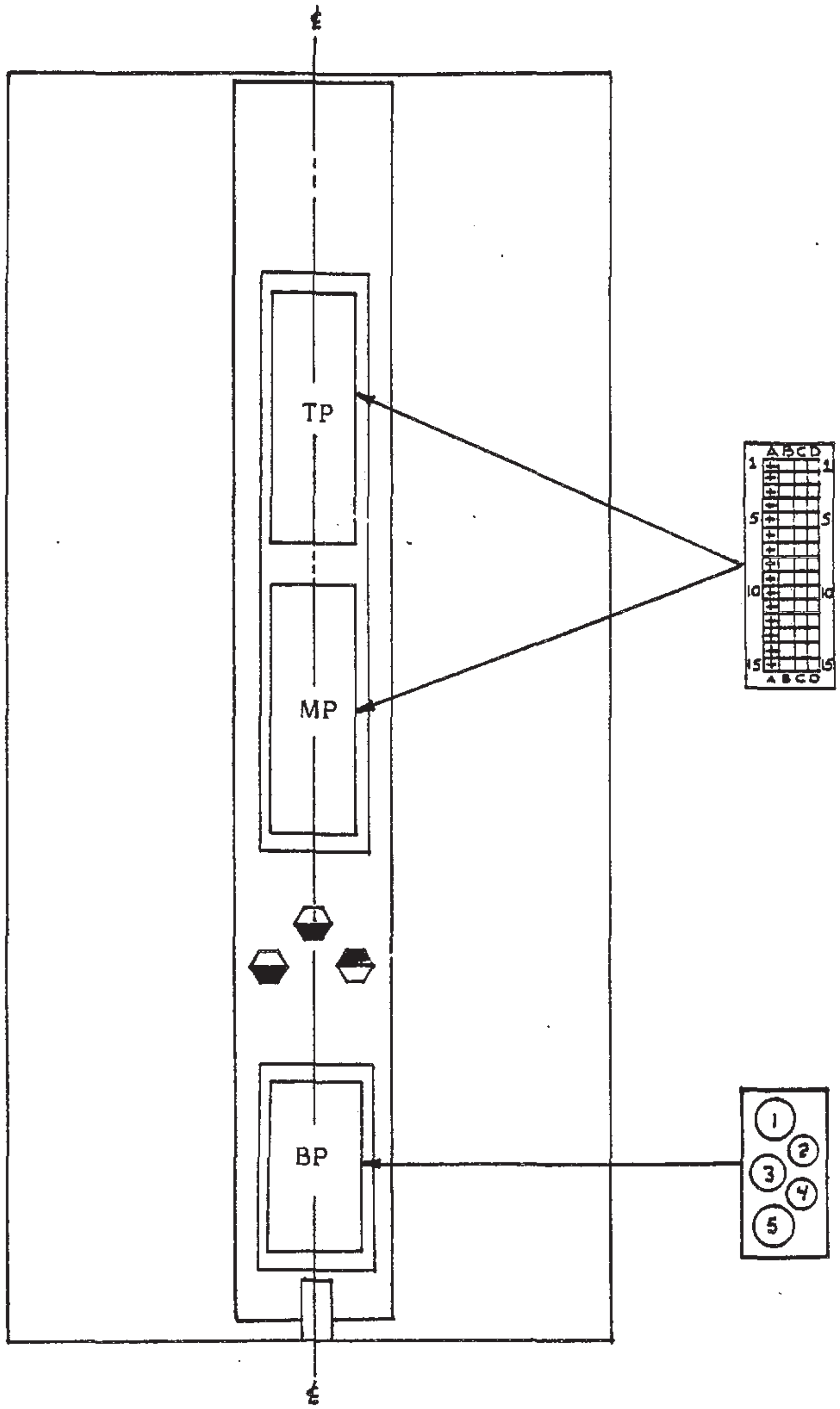
¢-6

COMMENTARY

Many users have expressed interest in transferring and storing fault information in a central unit. The unit would be the heart of a Fault Isolation and Detection System (FIDS). The FIDS Unit could be internal to a central unit of a large avionics system or could be a stand-alone unit. A FIDS Unit in order to act as a collector of fault information would be fed fault data from external LRUs. It is envisaged that fault data words will be transmitted via the normal DITS output ports of the external LRUs. The FIDS input ports would monitor the DITS buses and extract the word(s) assigned for transmission of the fault data. If such a system were to be implemented, the LRU BITE memory could be the source of the fault data.

ATTACHMENT 1

TRANSCEIVER UNIT CONNECTOR POSITIONING



REAR VIEW

ATTACHMENT 2
STANDARD INTERWIRING

c-1	FUNCTION		WIRE I-R (6)	TRANSCEIVER	CONTROL PANEL	
	Mike Input	Hi	D-5	MPA1		
		Lo	D-5	MPB1	(5)	To Mike
		PTT	D-5	MPC1		
	Key Event		D-5	MPD1		To Flight Recorder
c-2	Future Spare			MPA2		
c-4	Mike Input (Gnd)		D-5	MPB2	(9)	
c-2	Future Spare			MPC2		
	Future Spare			MPD2		
c-1	Optional	Hi	D-5	MPA3	5	
	(Remote Squelch)	ARM	D-5	MPB3	6	
		Lo	D-5	MPC3	7	
	DC Ground		D-0.1	MPD3	14	D.C. Ground
c-2	Future Spare			MPA4		
c-4	Audio Ground		D-5	MPB4	(9)	
c-2	Future Spare			MPC4		
	Future Spare			MPD4		
	Data Input	Hi	D-5	MPA5		To Data Link
	Data Input	Lo	D-5	MPB5	(2)	
c-5	Reserved		(11)	MPC5	3	
c-9	8.33 kHz Program		(12)	MPD5	4	
c-2	Future Spare			MPA6		
	Future Spare (Contact)		(7)	MPB6		
	Future Spare			MPC6		
	Future Spare			MPD6		
c-1	Freq./Funct	A	D-5	MPA7	17	
	Sel.Data I/P PortB	B	D-5	MPB7	18	
	Voice/Data Select		D-5	MPC7	16	
	Data Key Line		D-5	MPD7		To Data Link
c-2	Future Spare			MPA8		
	Future Spare (Contact)			MPB8		
	Freq. Offset Enable		D-5	MPC8		
c-1	Data Keyline Return		D-5	MPD8		To Data Link
c-6	SDI Code Input		D-0.1	MPA9	(1)	
			D-0.1	MPB9		
	Ground		D-0.1	MPC9		
	Reserved for AGC		D-0.1	MPD9		
c-2	Future Spare			MPA10		
	Future Spare (Contact)			MPB10		
	Future Spare			MPC10		
	Future Spare			MPD10		
c-1	Freq./Funct.	A	D-5	MPA11	21	
	Sel.Data I/P PortA	B	D-5	MPB11	22	To Frequency Control
	Suggested Spare #3		D-5	MPC11	19	
	Data Select Discrete		D-5	MPD11	24	To Frequency Control
c-2	Future Spare			MPA12		
	Future Spare (Contact)			MPB12		
	Future Spare			MPC12		
	Future Spare			MPD12		
	SELCAL Audio &	Hi	D-5	MPA13		To SELCAL &
	Data Output	Lo	D-5	MPB13		Data Link
	Squelch Disable		D-5	MPC13	8	
	Squelch Disable Return		D-5	MPD13	9	
c-2	Future Spare			MPA14		
c-3	Ground/Air Discrete		D-5	MPB14	(8)	
c-2	Future Spare			MPC14		
	Future Spare			MPD14		
	Audio/Sidetone Output	Hi	D-5	MPA15		
	Audio/Sidetone Output	Lo	D-5	MPB15		
	Muting		D-5	MPC15		Customer Option
	Muting Return			MPD15		
	Antenna RF Input			BP1		To Aircraft Antenna
	Power Input +27.5 VDC		10-0.1	BP2	10A (4)	27.5 VDC
	Spare			BP3		
	Power Input Ground		10-0.1	BP4		
	Not Used			BP5		
c-1	Volume	Lo	D-5		10	Customer Optional
		ARM	D-5		11	
		Hi	D-5		12	
	28 VDC Power In		2.5		13	
	Voice/Data Mode Annun.		D-5		15	
	5 VAC Panel Lights	Hi	0.2-1		1	Panel Light
	5 VAC Panel Lights	Lo	0.2-1		2	Supplies
c-5	Reserved					
	Transfer Light 28 VDC dimmable				20	
	Reserved					
	Test - Transfer Light and Static Displays				23	(10)

ATTACHMENT 2 (cont'd)
NOTES APPLICABLE TO THE STANDARD INTERWIRING

⟨1⟩ Source/Destination Identifier (SDI) Encoding

¢-6

These pins should be used for encoding the location of the COMM receiver in the aircraft, (i.e., "system number") per Section 2.1.4 of ARINC Specification 429. The following encoding scheme should be employed, the pins designated being either left open circuit or connected, on the aircraft-mounted half of the connector, to pin MPC9. The wiring of these pins should cause the COMM Transceiver to recognize the binary states of bits 9 and 10 defined in Specification 429. When the SDI function is not used, both pins MPA9 and MPB9 should be left open circuit. See Section 3.2.

Unit No.	Connector Pin	
	MPA9	MPB9
1/2/3	Open	Open
1	Open	To MPC9
2	To MPC9	Open
3	To MPC9	To MPC9

⟨2⟩ Shield Grounds

Digital data bus shields should be grounded to the aircraft structure at both ends and on both sides of all breaks. Equipment manufacturers should not count on shield grounds being carried through the connector into the COMM Transceiver, despite the assignment pins for the purpose.

Airframe manufacturer practice is to ground the shields on the aircraft of the connector rather than to terminate them individually on their own pins.

The audio cable shield should be grounded at one end (the audio system end) only.

⟨3⟩ ATE Functions

The assignment of pins on the upper insert (TP) of the equipment connection to functions required specifically to support automatic testing in the workshop is the responsibility of the equipment manufacturer. These pins are not part of the equipment/aircraft interface. Suitable protection, such as a cover for open TP aperture of the aircraft-mounted half of the connector, should be provided to ensure freedom from damage, contamination, etc., for the box-mounted TP contacts during the time the equipment is installed in the aircraft.

⟨4⟩ Transceiver Unit Master Power Circuits

A standard 10 amp circuit breaker is to be employed in the main power lead to the Transceiver Unit. If the user so desires, the primary power may be interrupted by an airframe-mounted relay. Section 2.4.2 of this Characteristic refers.

⟨5⟩ Four Wire Microphone

Pin MPB1 provides the return pin for microphones having separate PTT function to achieve PTT function isolated from audio voice input. (See Attachment 6). ¢-1

⟨6⟩ Wire Types and Sizes

The "I-R" values define the maximum current (I) in amperes and effective resistance (R) in ohms for which the installation and equipment should be designed. It is anticipated that installation designers will use these figures, together with the lengths of the cable runs in a given airframe, to calculate the gauge of each wire in the installation. Where their calculations reveal the possibility of using higher gauge numbers than #22 AWG, they are asked to stop and consider whether the mechanical strength of this wire is adequate for the installation before deciding to use it. The airlines report recent sad experiences with such wire, and although they are, of course, interested in the weight saving its use affords, they will quickly point out that these savings are rapidly nullified by maintenance costs if frequent breakage occurs. ¢-1

NOTE: Wires for which a "D" symbol is shown in place of a current rating may be used for any function ranging from "Dry Circuits" (hence "D") to 5 ampere applications.

Both installation and equipment designers should give due regard to special cases wherein parallel or series-parallel connected circuits may result in higher currents or voltage drop (effective resistance) than in simple circuits. Unless otherwise noted, the current limit set forth applies to all elements of parallel or series-parallel circuits.

⟨7⟩ Future Spare (Contact)

Contract positions in equipment-mounted service connectors labelled "Future Spare (Contact)" should be furnished with contact hardware (pin or socket as appropriate) and provisions made within the equipment for their easy use. Contact positions labelled "Future Spare" may or may not be furnished with connector hardware at the equipment manufacturer's discretion. Contact hardware need not be provided in either type of contact position in aircraft-mounted rack connectors. The "Future Spare (Contact)" positions will be the first to be used if and when additional contact assignments are needed. ¢-2

⟨8⟩ Air/Ground Logic Input

This pin is assigned to an air/ground logic input to the VHF Transceiver for application therein as the user sees fit. It should be wired to a logic source in the aircraft that presents a standard open circuit ¢

ATTACHMENT 2 (cont'd)
NOTES APPLICABLE TO THE STANDARD INTERWIRING

(100,000 ohms or more resistance from this pin to airframe DC ground or a voltage between +18.5 and +36 VDC) while the aircraft is on the ground and a
¢-3 standard ground (less than 10 ohms resistance from the pin to airframe DC ground or a voltage between 0 and +3.5 VDC) when the aircraft is airborne. Airframe and equipment manufacturers are cautioned to provide sneak circuit protection for this input so that malfunctions of other equipment connected to the same logic source do not affect the VHF transceiver's operation.

⟨9⟩ 4-Wire Mike Grounding

Pin MPB2 is connected internally to pin MPB1. The
¢-6 microphone circuit can be grounded by either of the three following methods:

a. Pin MPB2 can be jumpered to pin MPB4 to obtain internal grounding, or
b. Pin MPB2 can be connected to SPASE, or
c. Pin MPB1 can be connected to SPASE.

Only one of the three ground alternatives should be implemented in any given installation (MPB2 to SPASE, MPB1 to SPASE, or MPB2 to MPB4).

⟨10⟩ Control Panel Lamps

For Control Panels utilizing liquid crystal displays,
¢-5 a "ground" on Pin 23 initiates a test of static displays.

⟨11⟩ Reserved Control Panel Pins

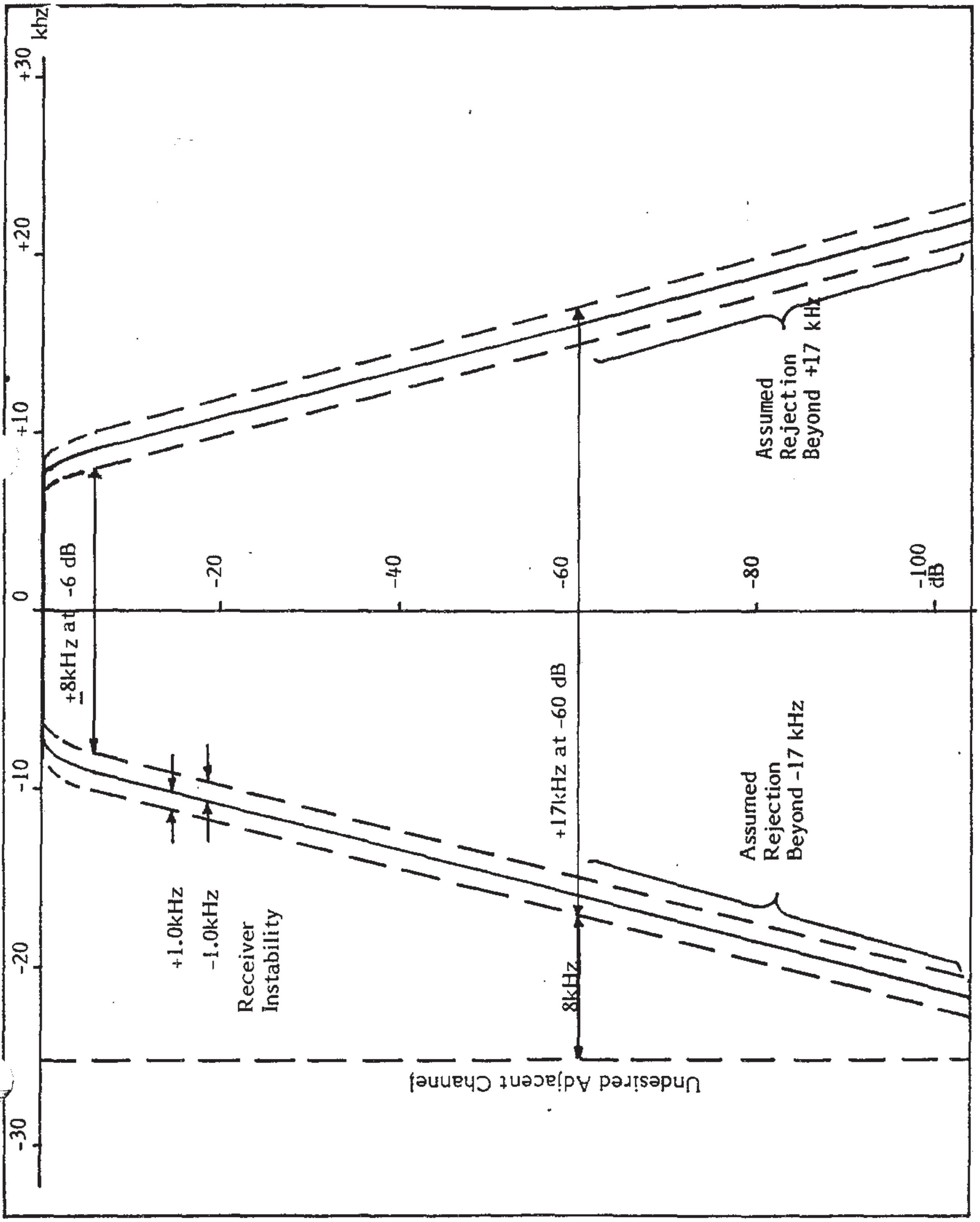
Control panel pins 3 and 4 have been reserved to protect against possible future non-interchangeability problems resulting from their reported non-coordinated use in some aircraft.

⟨12⟩ 8.33 kHz Program

¢-9 See Section 4.2.1 Control Panel Programming.

ATTACHMENT 3

RECEIVER SELECTIVITY



ATTACHMENT 4

ENVIRONMENTAL TEST CATEGORIES

The following RTCA DO-160 categories apply to the environmental specification of the ARINC 716 Comm Transceiver:

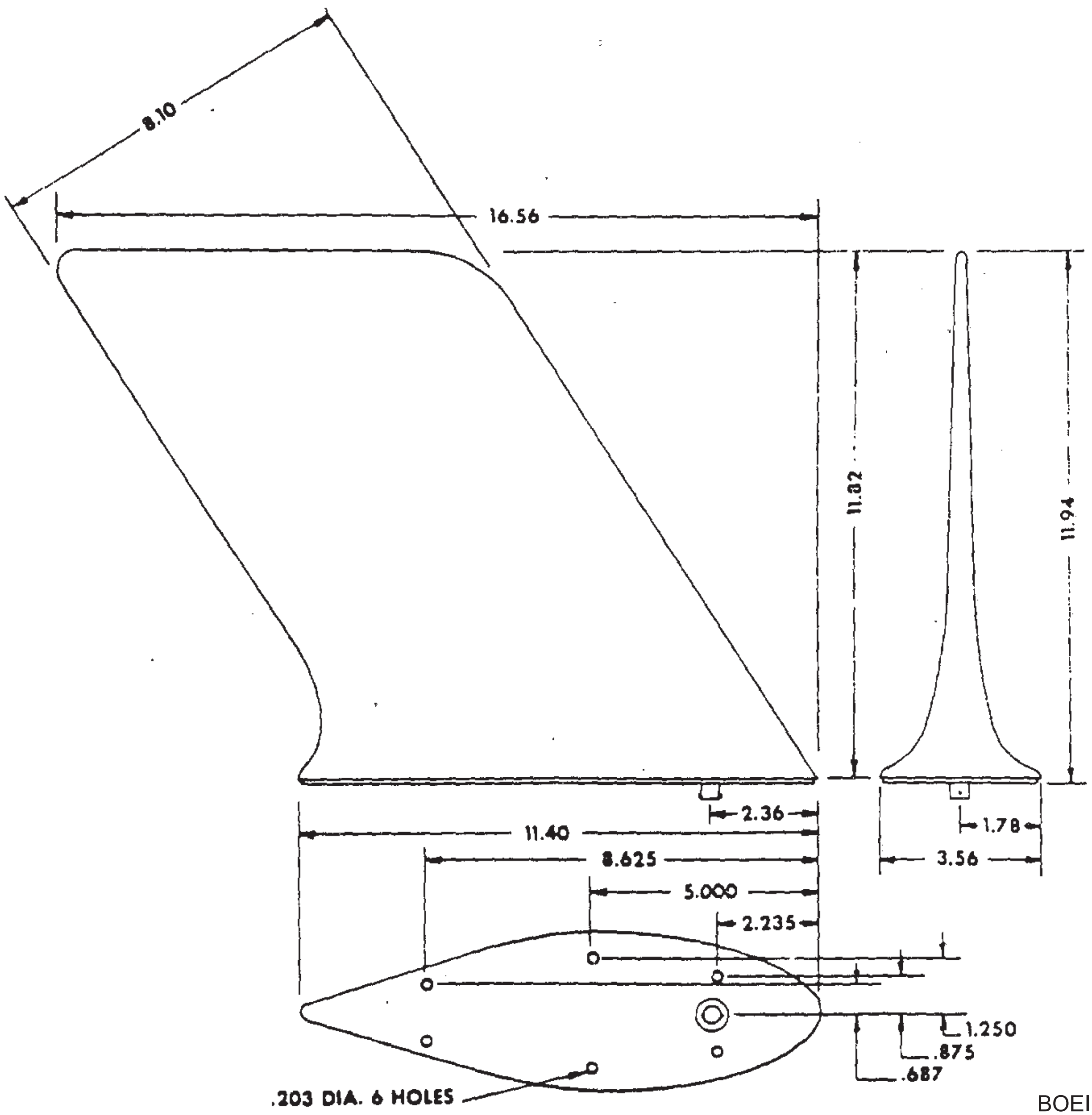
Environment	DO-160 Section	UNIT LOCATION Electronics Rack	Cockpit	External To Skin of A/C
Temperature & Altitude	4	CAT A1	CAT A1	CAT D2
Temperature Variation	5	CAT C	CAT C	CAT A
Humidity	6	CAT A	CAT A	CAT B
Shock	7	CAT A	CAT A	CAT B
Vibration	8	CAT O or B*	CAT K or A*	CAT J or C*
Explosion	9	CAT X	CAT X	CAT E
Waterproofness	10	CAT X	CAT X	CAT W
Hydraulic Fluid	11	CAT X	CAT X	CAT H
Sand & Dust	12	CAT X	CAT X	CAT D
Fungus	13	CAT X	CAT X	CAT F
Salt Spray	14	CAT X	CAT X	CAT S
Magnetic Effect	15	CAT X	CAT X	CAT X
Power Input	16	CAT A	CAT A	CAT A
Conducted Voltage Transient	17	CAT A	CAT A	CAT A
Audio Frequency Conducted Susceptibility	18			
Induced Signal Susceptibility	19	CAT A	CAT A	CAT A
Radio Frequency Susceptibility (Radiated & Conducted)	20	CAT A	CAT A	----
Spurious Radio Frequency Emission	21	CAT A	CAT A	CAT A

* The use of alternative categories may be necessary if the installation is to be made in other turbine-powered fixed-wing aircraft. Refer to RTCA DO-160 directly.

REPLACEMENT PAGE

ATTACHMENT 5

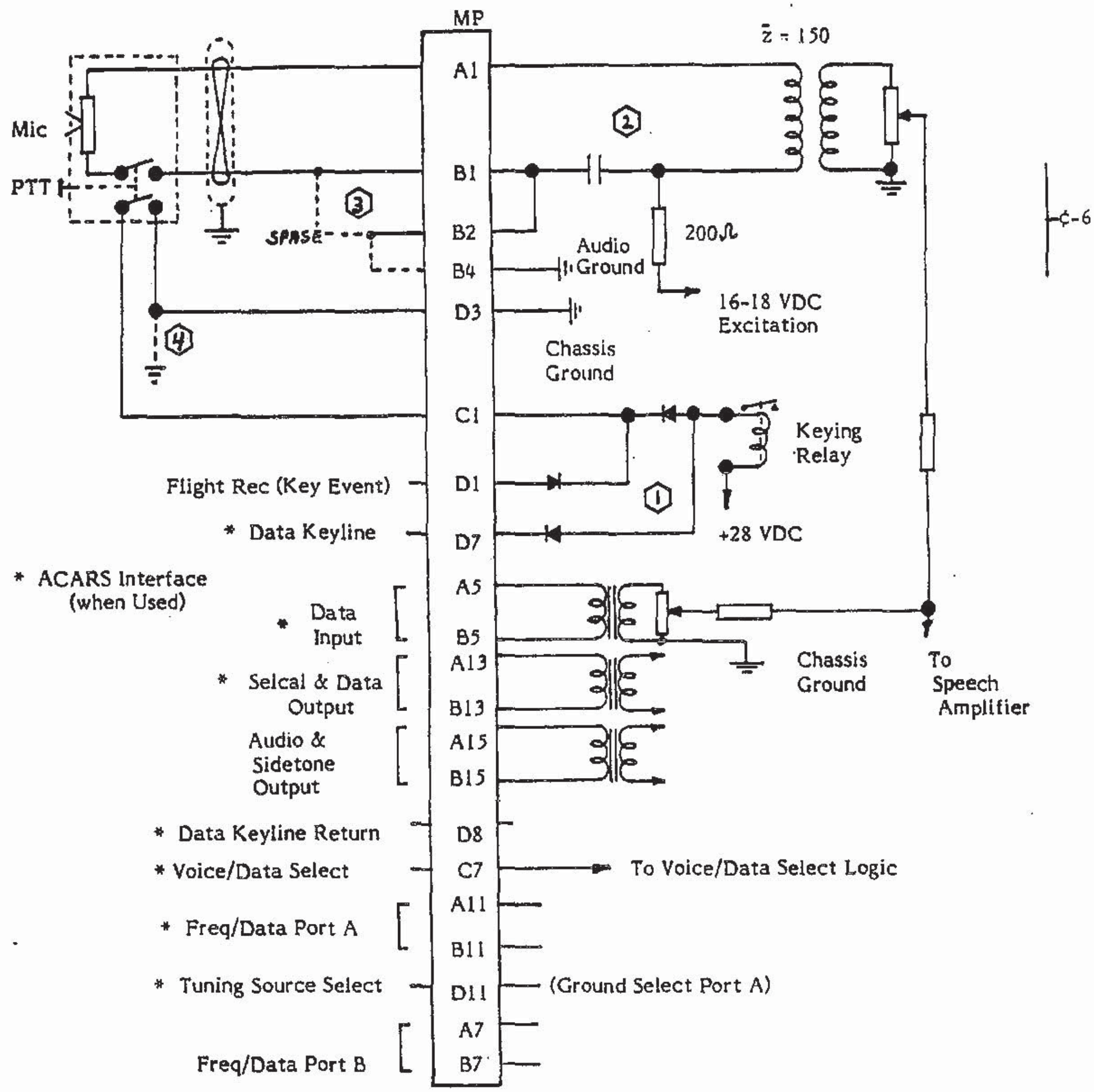
TYPICAL VHF COMMUNICATIONS ANTENNA



ATTACHMENT 6

STANDARD "FOUR-WIRE"

MICROPHONE INTERFACE



(1) A diode is used in series with keying relay to prevent sneak current from the data link (also required in the data link).

(2) A single-ended audio input may be used provided that the input impedence between pins MPA1 and MPB1 is 150 ohms.

(3) Pin MPB2 is connected internally to pin MPB1. The microphone circuit can be grounded by either of the three following methods:

a. Pin MPB2 can be jumpered to pin MPB4 to obtain internal grounding, or
b. Pin MPB2 can be connected to SPASE, or
c. Pin MPB1 can be connected to SPASE.

¢-6

Only one of the three ground alternatives should be implemented in any given installation (MPB2 to SPASE, MPB1 to SPASE, or MPB2 to MPB4).

(4) Pin MPD3 can be wired directly to the microphone PTT switch - Lo or, both the microphone PTT switch - Lo and pin MPD3 can be wired to a common ground.

ATTACHMENT 7

Control Panel Guidelines

1.1 General Configuration

Although individual customers will desire various knob and switch configurations on their panels, the "Standard Control Panel", for purposes of this Characteristic will conform to the form factor of Section 2.2.2 and this Attachment. It comprises a single VHF Comm frequency display, essentially in the center, with two selector knobs, one on each side.

1.2 Frequency Selection & Display

The frequency selector should extend through the range 118.0 through 135.975 MHz. Suitable switch wafers, conforming to the requirements of ARINC Specification No. 410, to cover this frequency range in 25 kHz increments should be provided.

Most users have stated a preference for a horizontal frequency display, rather than a vertical display. All users desire nothing smaller than 1/4" numerals and would prefer the largest numerals practical. Normally, the 0.005 MHz digit will not be displayed.

The frequency displayed in dual-channel mode should be the receive frequency. Frequency offset occurs within the R/T only.

1.3 Connector Types

¢-1 The "Standard Control Panel" should utilize a MIL-C-83723, Series 3-type connector (M83723-72R1624N) positioned at the center of the unit. The connector ¢-2 mounting panel should be 5.000 inches from the rear face of the front panel as shown in Figure 1.

1.4 Volume Control

An audio volume control may or may not be desired by the individual customer. Provisions should be included in the "standard control panel", utilizing a 500 ohm potentiometer connected to the audio output prior to feeding the audio distribution system in the aircraft.

1.5 Master Off-On Control

¢-1 In accordance with Section 2.4.2 of this Characteristic there should be no provision in the "Standard Control Panel" for a master Off-On control.

1.6 Integral Lighting

¢-1 Integral control panel lighting should be provided utilizing 5 VAC power.

1.7 Control Function Transfer Switch

Although some customers may require means for transferring control functions from one receiver to another or for handling pre-set frequency selections, no such provisions are stated herein for the "Standard Control Panel". Such functions should be custom designed in accordance with the standards of ARINC Specification No. 410, to meet the specific requirement of the customer.

ATTACHMENT 7 (cont'd)

STANDARD CONTROL PANEL OUTLINE DRAWING

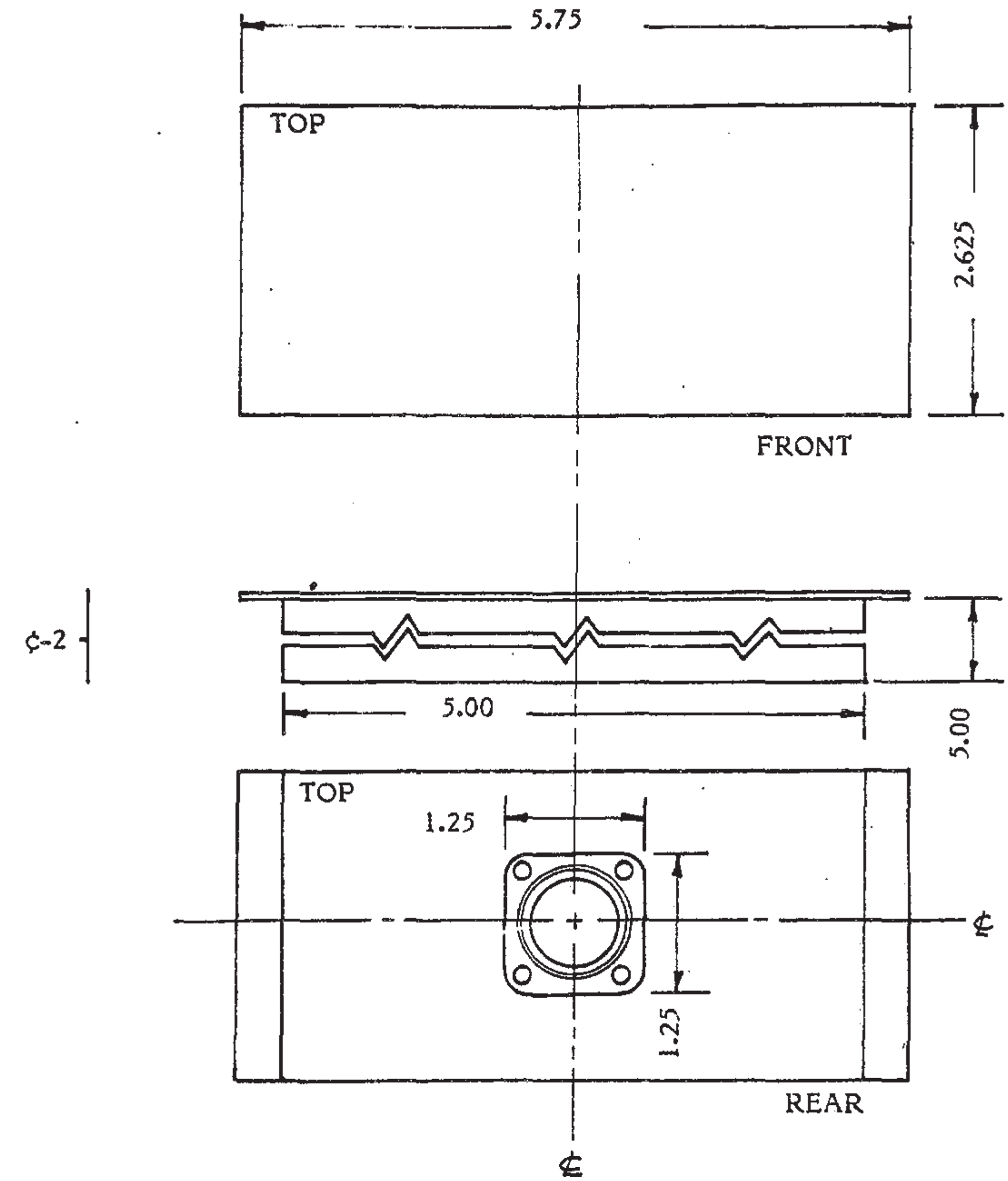


FIGURE 1

NOTE: The positions of the controls and display are not shown in order to allow design flexibility.

ATTACHMENT 8

ASSUMED TEST PROCEDURES FOR

DESENSITIZATION AND INTERFERENCE REJECTION

For bench measurement purposes, the application to VHF COM receivers of simulated FM sound broadcasting signals with levels corresponding to the criteria in paragraphs 3.6.7.5 and 3.6.7.6, should not cause:

a) a reduction in the audio signal plus noise-to-noise ratio (s+n)/n of 6 dB or less with a wanted signal of 40 microvolts per meter across the VHF COM receiver input. (It should be noted that Annex 10 specifies a wanted signal strength of 75 microvolts per meter for VHF COM, and this value should be satisfied "on a high percentage of occasions" (Annex 10, Volume I, Part I, paragraph 4.7.2.1). In practice there are a significant number of occasions when VHF communications need to take place when the field strength is below 75 microvolts per meter, and therefore 40 microvolts per meter is considered appropriate); and

b) more than 5 dB (equivalent RF) increase in AGC voltage or an audio interference plus noise-to-noise ratio (i+n)/n of greater than 6 dB, with no wanted signal present.

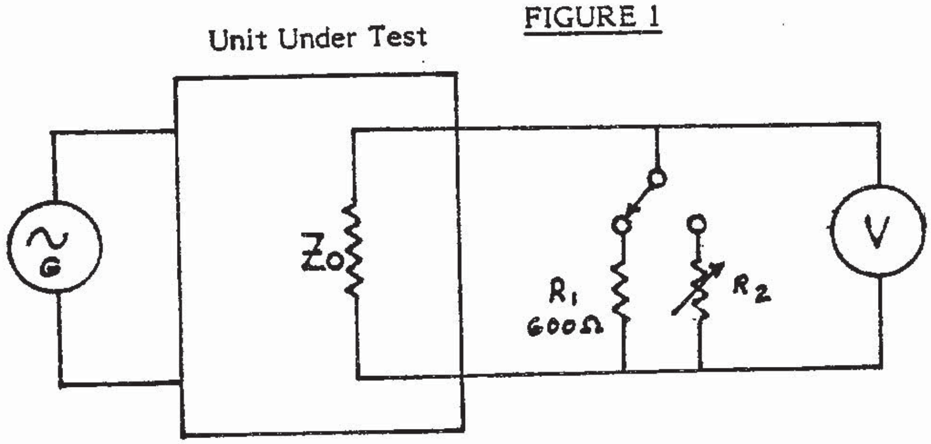
¢-6

ATTACHMENT 9

TYPICAL TEST PROCEDURES

AUDIO OUTPUT

FIGURE 1

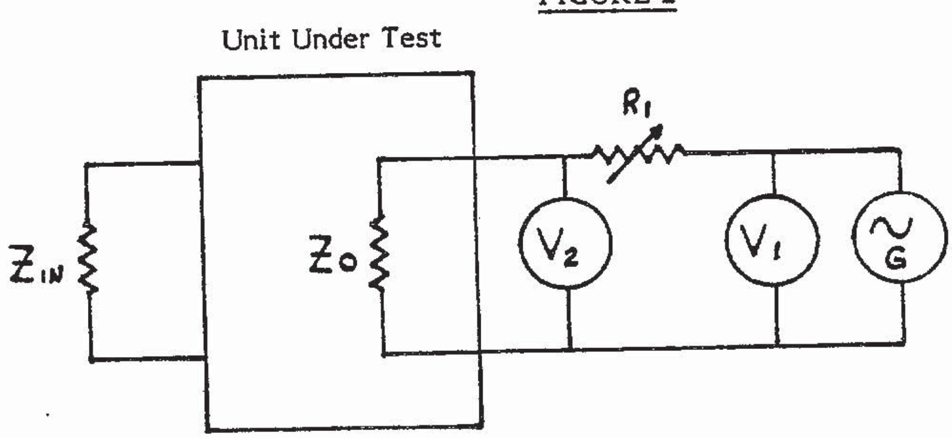


a) select R_1, adjust input and unit under test for desired output level V_1 (up to rated output)

b) select R_2, adjust R_2 for $V_2 = .9\ V_1$

c) $Z_o = \frac{60\ R_2}{540 - R_2}$

FIGURE 2



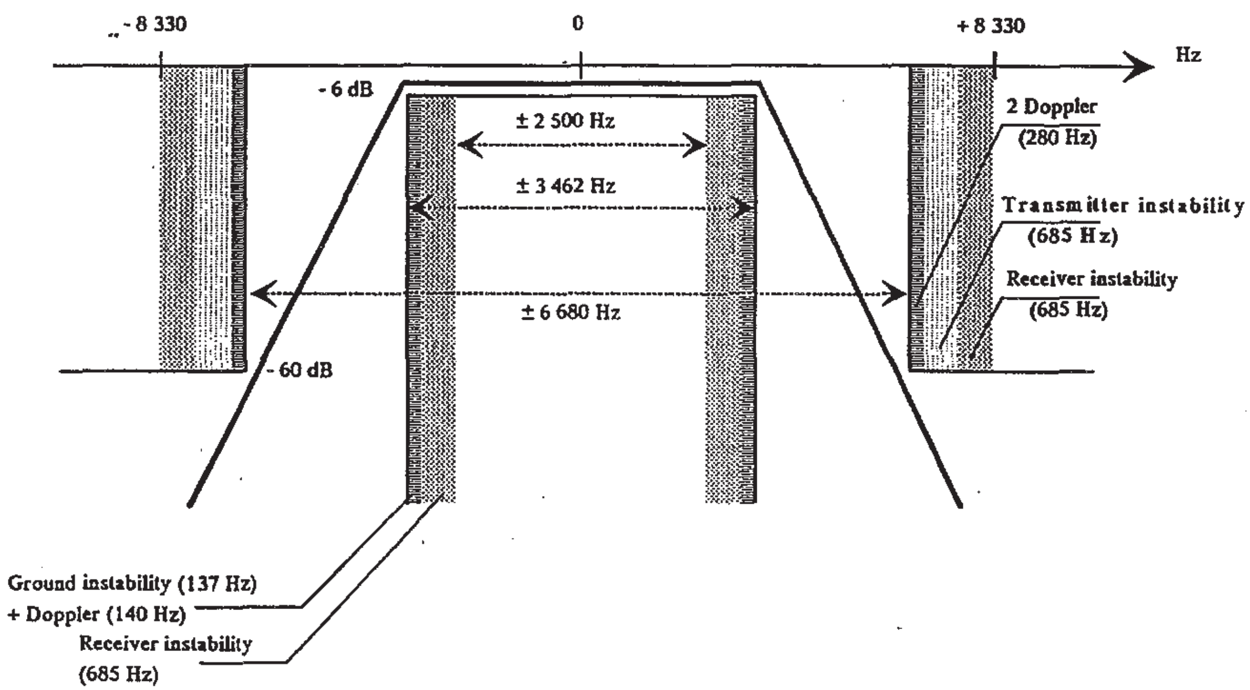
a) adjust and maintain signal source (G) at $V_1 = 30$ mV

b) adjust R_1 until $V_2 = ½\ V_1$

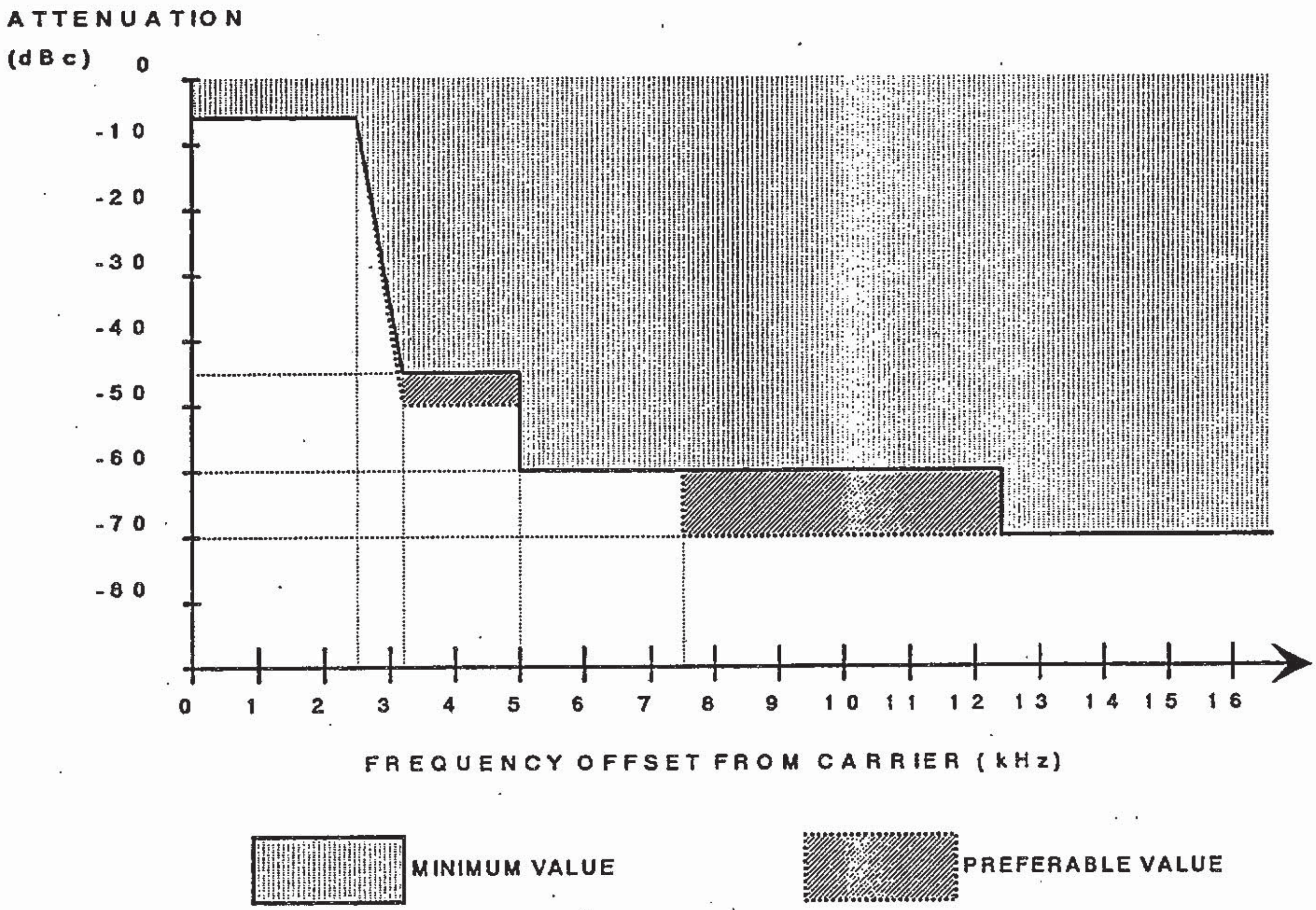
c) $Z_o = R_1$

ATTACHMENT 10
RECEIVER SELECTIVITY

The following filtering mask is an example of selectivity curve, for a receiver stability of ± 5 ppm.



ATTACHMENT 11
TRANSMITTER SPECTRUM MASK



Upper bound :

Freq	Attenuation value (Required)	Attenuation value (Preferable)
0	0	0
2500	-6	-6
3200	-45	-50
5000	-60	-60
7500	-60	-70
12500	-70	-70

Frequency is specified in Hz deviation from the channel center (on both sides), and the attenuation is specified in dBc.

Appendix I PART I
EXCERPTS FROM

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES

AERONAUTICAL TELECOMMUNICATIONS

ANNEX 10

TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME I

(PART I — EQUIPMENT AND SYSTEMS; PART II — RADIO FREQUENCIES)

THIRD EDITION OF VOLUME I — JULY 1972

4.5.—Air-Ground VHF Communication System Characteristics

4.5.1 The characteristics of the air-ground VHF communication system used in the International Aeronautical Mobile Service shall be in conformity with the following specifications:

4.5.1.1 Radiotelephone emissions shall be continuous wave (CW) amplitude modulated carriers (A3).

4.5.1.2 Spurious emissions shall be kept at the lowest value which the state of technique and the nature of the service permit.

Note.—Appendix 4 to the Radio Regulations contains the tolerances for the levels of spurious emissions to which transmitters must conform in accordance with RR 3247/672.

4.5.1.3 * The radio frequencies used shall be selected from the radio frequencies in the band 117.975 MHz to 136 MHz. The separation between assignable frequencies (channel spacing) and frequency tolerances applicable to elements of the system shall be as specified in Part II, 4.1.2. and 4.1.6.

Note.—The band 117.975-132 MHz was allocated to the Aeronautical Mobile (R) Service in the Radio Regulations (1947). By subsequent revisions of the Regulations at ITU World Administrative Conferences the band 132-136 MHz was added to the (R) allocation under conditions which differ for ITU Regions, or for specified countries or combinations of countries.

4.5.1.4 The design polarization of emissions shall be vertical.

4.7.—System Characteristics of the Airborne Installation

4.7.1.—TRANSMITTING FUNCTION

4.7.1.1 *Frequency stability.* The radio frequency of operation shall not vary more than plus or minus 0.005 per cent from the assigned frequency. Where 25 kHz channel spacing is introduced, the radio frequency of operation shall not vary more than plus or minus 0.003 per cent from the assigned frequency for new transmitters installed after 1 January 1974 and for all transmitters after 1 January 1981.

4.7.1.2 *Power.* On a high percentage of occasions, the effective radiated power shall be such as to provide a field strength of at least 20 microvolts per metre (minus 120 dBW/m^2) on the basis of free space propagation, at ranges and altitudes appropriate to the operational conditions pertaining to the areas over which the aircraft is operated.

4.7.1.3 *Modulation.* A peak modulation factor of at least 0.85 shall be achievable.

4.7.1.4 RECOMMENDATION.—*Means should be provided to maintain the average modulation factor at the highest practicable value without overmodulation.*

4.7.2.—RECEIVING FUNCTION

4.7.2.1 * *Sensivity.*

RECOMMENDATION.—*After due allowance has been made for aircraft feeder mismatch, attenuation loss and antenna polar diagram variation, the sensitivity of the receiving function should be such as to provide on a high percentage of occasions an audio output signal with a wanted/unwanted ratio of 15 dB, with a 50 per cent amplitude modulated (A3) radio signal having a field strength of 75 microvolts per metre (minus 109 dBW/m^2).*

Note.—For planning extended range VHF facilities, an airborne receiving function sensitivity of 30 microvolts per metre may be assumed.

4.7.2.2 *Effective acceptance bandwidth for 100 kHz, 50 kHz and 25 kHz*

* ARINC STAFF NOTE

See Amendment 63, page 42 of this document

Part I — Equipment and Systems

channel spacing receiving installations. The receiving function shall ensure an effective acceptance bandwidth as follows:

a) Until 1 January 1974 and in areas where off-set carrier systems are employed, the receiving function shall provide an adequate audio output when the signal specified at 4.7.2.1 has a carrier frequency within 15 kHz of the assigned frequency.

b) After 1 January 1974 and in areas where off-set carrier systems are employed, the receiving function shall provide an adequate audio output when the signal specified at 4.7.2.1 has a carrier frequency within 8 kHz of the assigned frequency.

c) In areas where off-set carrier systems are not employed, the receiving function shall provide an adequate audio output when the signal specified at 4.7.2.1 has a carrier frequency within plus or minus 0.005 per cent of the assigned frequency.

4.7.2.3 *Adjacent channel rejection.* The receiving function shall ensure an effective adjacent channel rejection as follows:

a) *25 kHz channel spacing environment*: 50 dB or more at plus or minus 25 kHz with respect to the assigned frequency and 40 dB or more at plus or minus 17 kHz;

b) *50 kHz channel spacing environment*: 50 dB or more at plus or minus 50 kHz with respect to the assigned frequency and 40 dB or more at plus or minus 35 kHz;

c) *100 kHz channel spacing environment*: 50 dB or more at plus or minus 100 kHz with respect to the assigned frequency.

4.7.2.4 RECOMMENDATION.— *Whenever practicable, the receiving system should ensure an effective adjacent channel rejection characteristic of 60 dB or more at plus or minus 25 kHz, 50 kHz and 100 kHz from the assigned frequency for receiving systems intended to operate in channel spacing environments of 25 kHz, 50 kHz and 100 kHz respectively.*

Note.–Frequency planning is normally based on an assumption of 60 dB effective adjacent channel rejection at plus or minus 25 kHz, 50 kHz or 100 kHz from the assigned frequency as appropriate to the channel spacing environment.

4.7.2.5 RECOMMENDATION.— *In the case of receivers complying with 4.7.2.2 used in areas where off-set carrier systems are in force, the characteristics of the receiver should be such that:*

a) the audio frequency response precludes harmful levels of audio heterodynes resulting from the reception of two or more off-set carrier frequencies;

b) the receiver muting circuits, if provided, operate satisfactorily in the presence of audio heterodynes resulting from the reception of two or more off-set carrier frequencies.

4.8.—SELCAL System *

4.8.1 RECOMMENDATION.— *Where a SELCAL system is installed, the following system characteristics should be applied:*

a) Transmitted code. *Each transmitted code should be made up of two consecutive tone pulses, with each pulse containing two simultaneously transmitted tones. The pulses should be of 1.0 plus or minus 0.25 seconds duration, separated by an interval of 0.2 plus or minus 0.1 second.*

b) Stability. *The frequency of transmitted tones should be held to plus or minus 0.15 per cent tolerance to ensure proper operation of the airborne decoder.*

c) Distortion. *The overall audio distorsion present on the transmitted r-f signal should not exceed 15 per cent.*

d) Per cent modulation. *The r-f signal transmitted by the ground radio station should contain, within 3 dB, equal amounts of the two modulating tones. The combination of tones should result in a modulation envelope having a nominal modulation percentage as high as possible and in no case less than 60 per cent.*

e) Transmitted tones. *Tone codes should be made up of various combinations of the tones listed in the following table and designated by colour and letter as indicated:*

TABLE OF TONE FREQUENCIES

Designation	*Frequency (Hz)*
Red A	312.6
Red B	346.7
Red C	384.6
Red D	426.6
Red E	473.2
Red F	524.8
Red G	582.1
Red H	645.7
Red J	716.1
Red K	794.3
Red L	881.0
Red M *	977.2
Blue A	323.6
Blue B	358.9
Blue C	398.1
Blue D	441.6
Blue E	489.8
Blue F	543.3
Blue G	602.6
Blue H	668.3
Blue J	741.3
Blue K	822.2
Blue L	912.0
Blue M	1 011.6
Yellow A	335.0
Yellow B	371.5
Yellow C	412.1
Yellow D	457.1
Yellow E	507.0
Yellow F	562.3
Yellow G	623.7
Yellow H	691.8
Yellow J	767.4
Yellow K	851.1
Yellow L	944.1
Yellow M	1.047.1

Note 1.—It should be noted that the tones in any one colour group are spaced by Log^{-1} *0.045 to avoid the possibility of harmonic combinations.*

Note 2.—In accordance with the application principles developed by the Sixth Session of the Communications Division, the only codes at present used internationally are selected from the red group.

Note 3.—Guidance material on the use of SELCAL systems is contained in Attachment D to Part I.

*ARINC STAFF NOTE

See Amendment 63, page 42 of this document

Chapter 4.—Utilization of Frequencies above 30 MHz

4.1.—Utilization * in the Band 117.975 - 136 MHz

Introduction

The band 118 - 132 MHz was allocated in 1947 by the Atlantic City ITU Radio Conference, and again in 1959 by the Geneva Conference, but with extension downwards to 117.975 MHz, for the exclusive use by the Aeronautical Mobile (R) Service. This Chapter of Annex 10 deals with Standards and Recommended Practices relating to this band and includes matters pertaining to the selection of particular frequencies for various aeronautical purposes. These Standards are introduced by the following preface, which sets out the principles upon which the utilization of VHF on a world-wide basis with due regard to economy has been planned.

ITU Radio Conferences subsequent to 1947 also made provisions for the use of the band 132 - 136 MHz for the Aeronautical Mobile (R) Service under conditions which vary for the different ITU Regions, countries or combination of countries. The utilization of this band has been included in the Allotment Table in this Chapter; however, it should be kept in mind that the use of frequencies of the band 132 - 136 MHz must take account of the conditions contained in the notes against this band in the ITU Allocation Table.

Preface

The utilization of VHF on a world-wide basis with due regard to economy and practicability requires a plan that will take into account:

a) *the need for an orderly evolution towards improved operation and the required degree of world-wide standardization;*

b) *the desirability of providing for an economic transition from present utilization to optimum utilization of the frequencies available, taking into account the maximum possible utilization of existing equipment;*

c) *the need to provide for co-ordination between international and national utilization so as to ensure mutual protection from interference;*

d) *the need for providing a framework for the integrated development of Regional Plans;*

e) *the desirability of incorporating in any group of frequencies to be used those now in use for international air services;*

f) *the need for keeping the total number of frequencies and their grouping in appropriate relation to the airborne equipment known to be widely used by international air services;*

g) *a requirement for the provision of a single frequency that may be used for emergency purposes on a world-wide basis and, also, in certain regions, for another frequency that may be used as a common frequency for special purposes;*

h) *the need for providing sufficient flexibility to allow for the differences in application necessitated by regional conditions.*

4.1.1.—General Allotment * of Frequency Band 117.975 - 136 MHz

Note.—The plan includes a general Allotment Table that subdivides the complete band 117.975 - 136 MHz, the chief subdivisions being the bands of frequencies allocated to both national and international services, and the bands allocated to national services. Observance of this general subdivision should keep to a minimum the problem of co-ordinating national and international application.

The block allotment of the frequency band 117.975 - 136 MHz shall be as shown in the following table (*see* box on page 78).

4.1.2.—Frequency Separation and Limits of Assignable Frequencies

4.1.2.1 Until 1 July 1976, the minimum separation between assignable frequencies used in the International Aeronautical Mobile Service shall be 50 kHz, except that a minimum channel spacing of 25 kHz may be used prior to that date provided that the deployment of frequencies at 25 kHz channel spacing does not cause harmful interference to users of equipment designed for 50 kHz channel spacing and provided that operational requirements so dictate, for facilities providing primary means of communication.

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ALLOTMENT TABLE (*see* 4.1.1)

Block allotment of frequencies (MHz)	*World-wide utilization*	*Remarks*
a) 118 to 121.4 inclusive	International and National Aeronautical Mobile Services	Specific international allotments will be determined in the light of regional agreement. National assignments are covered by the provisions in 4.1.5.10.
b) 121.5	Emergency frequency	In order to provide a guard band for the protection of the aeronautical emergency frequency, the nearest assignable frequencies on either side of 121.5 MHz are 121.4 MHz and 121.6 MHz, except that by regional agreement it may be decided that the nearest assignable frequencies are 121.3 MHz and 121.7 MHz.
c) 121.6 to 121.975 inclusive	International and National aerodrome surface communications	Reserved for ground movement, pre-flight checking, air traffic services clearances, and associated operations.
d) 122 to 123.05 inclusive	National Aeronautical Mobile Services	Reserved for national allotments.
e) 123.1	Auxiliary frequency SAR	*See* 4.1.4.1
f) 123.15 to 123.675	National Aeronautical Mobile Service	Reserved for national allotments.
g) 123.7 to 129.675 inclusive	International and National Aeronautical Mobile Services	Specific international allotments will be determined in the light of regional agreement. National assignments are covered by the provisions in 4.1.5.10.
h) 129.7 to 130.875 inclusive	National Aeronautical Mobile Services	Reserved for national allotments but may be used in whole or in part, subject to regional agreement, to meet the requirements mentioned in 4.1.8.1.3.
i) * 130.9 to 135.975 inclusive	International and National Aeronautical Mobile Services	Specific international allotments will be determined in the light of regional agreement. National assignments are covered by the provisions in 4.1.5.10. (*See* remark in the Introduction to Chapter 4 regarding the band 132 – 136 MHz.)

4.1.2.2 After 1 July 1976 and until 1 January 1977, the minimum separation between assignable frequencies in the International Aeronautical Mobile Service shall be 25 kHz in those areas where such channel spacing has been introduced by regional agreement, and the minimum separation between assignable frequencies shall be 50 kHz in all other areas. After 1 January 1977, the minimum separation between assignable frequencies in the International Aeronautical Mobile Service shall be 25 kHz.

Note 1.—The intent of this paragraph is to allow those aircraft engaged in operations in areas where 25 kHz channel spacing will not be introduced prior to 1 January 1977, an additional period of time in which to effect the required airborne equipment modifications necessary to operate in a 25 kHz channel spacing environment.

Note 2.—It is recognized that, after 1 July 1976 and even after 1 January 1977 in some regions or areas, 100 kHz or 50 kHz channel spacing may provide an adequate number of frequencies suitably related to international and national air services and that equipment designed specifically for 100 kHz or 50 kHz channel spacing will remain adequate for services operating within such regions or areas.

4.1.2.3 Until at least 1 January 1985, equipment specifically designed for 25 kHz channel spacing shall be safeguarded with respect to its suitability for the International Aeronautical Mobile Service.

4.1.2.4 * In the band 117.975 – 136 MHz, the lowest assignable frequency shall be 118 MHz and the highest 135.975 MHz.

4.1.3.—FREQUENCIES USED FOR PARTICULAR FUNCTIONS

4.1.3.1 *Emergency channel.*

4.1.3.1.1 The emergency channel (121.5 MHz) shall be used only for genuine emergency purposes, as broadly outlined in the following:

a) to provide a clear channel between aircraft in distress or emergency and a ground station when the normal channels are being utilized for other aircraft;

b) to provide a VHF communication channel between aircraft and aerodromes, not normally used by international air services, in case of an emergency condition arising;

c) to provide a common VHF communication channel between aircraft, either civil or military, and between such aircraft, and surface services, involved in common search and rescue

*ARINC STAFF NOTE

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operations, prior to changing when necessary to the appropriate frequency;

d) to provide air-ground communication with aircraft when airborne equipment failure prevents the use of the regular channels;

e) to provide a frequency channel for the operation of survival radio equipment or emergency location beacon – aircraft (ELBA), and for communication between survival craft and aircraft engaged in search and rescue operations;

f) to provide a common VHF channel for communication between civil aircraft and military aircraft or intercept control units in the event of interception of the civil aircraft.

Note 1.—The use of the frequency 121.5 MHz for the purpose outlined in c) above is to be avoided if it interferes in any way with the efficient handling of distress traffic.

Note 2.—The current Radio Regulations make provisions that the aeronautical emergency frequency 121.5 MHz may also be used by mobile stations of the Maritime Mobile Service, using A3 emission to communicate on this frequency for safety purposes with stations of the Aeronautical Mobile Service (RR 3572/273, 6651A/968 and 6652/969).

4.1.3.1.2 The frequency of 121.5 MHz shall be provided at:

a) all area control centres and flight information centres, and

b) aerodrome control towers and approach control offices serving international aerodromes and international alternate aerodromes.

where the provision of that frequency is considered necessary to ensure immediate reception of distress calls or to serve the purposes specified in 4.1.3.1.1.

4.1.3.1.3 RECOMMENDATION.—*The frequency of 121.5 MHz should be provided at any additional locations where such provision is considered necessary to ensure immediate reception of distress calls or to serve the purposes specified in 4.1.3.1.1.*

4.1.3.1.4 The emergency channel shall be guarded continuously during the hours of service of the units at which it is installed.

4.1.3.1.5 The emergency channel shall be guarded on a single channel simplex operation basis.

4.1.4.—Auxiliary Frequencies for Search and Rescue Operations

4.1.4.1 Where a requirement is established for the use of a frequency auxiliary to 121.5 MHz, as described in 4.1.3.1.1 *c*), the frequency 123.1 MHz shall be used.

4.1.5.—Provisions Concerning the Deployment of VHF Frequencies and the Avoidance of Harmful Interference

4.1.5.1 In the case of those VHF facilities providing service up to the radio horizon, the geographical separation between facilities working on the same frequency shall, except where there is an operational requirement for the use of common frequencies for groups of facilities, be such that points at the protection heights and at the limit of the functional service range of each facility are separated by distances not less than the sum of distances from each of the points to its associated radio horizon.

4.1.5.2 In the case of those VHF facilities providing service beyond the radio horizon, except where there is an operational requirement for the use of common frequencies for groups of facilities, planning for co-channel operations shall be such that points at the protection heights and at the limits of the functional service area of each facility are separated by distances not less than the sum of distances from each point to its associated radio horizon.

Note 1.—The distance to the radio horizon from a station in an aircraft is normally given by the formula:

$$D = K\sqrt{h}$$

where D = *distance in nautical miles;*

h = *height of the aircraft station above earth;*

K = *(corresponding to an effective earth's radius of 4/3 of the actual radius)*

= *2.22 when* h *is expressed in metres; and*

= *1.23 when* h *is expressed in feet.*

Note 2.—In calculating the radio line-of-sight distance between a ground station and an aircraft station, the distance from the radio horizon of the aircraft station computed from Note 1 above must be added to the distance from the radio horizon of the ground station. In calculating the latter the same formula is employed, taking for h *the height of the ground station transmitting antenna.*

Note 3.—The criterion contained in 4.1.5.2 is applicable in establishing minimum geographical separation between VHF facilities, with the object of avoiding co-channel air-to-air interference. Guidance material relating to the establishment of separation distances between ground stations and between aircraft and ground stations for co-channel operations is contained in Section 3 of Attachment A to Part II. Guidance material relating to adjacent channel frequency deployment is contained in Section 2 of Attachment A to Part II.

Note 4.—Guidance material on the interpretation of 4.1.5.1 and 4.1.5.2 is contained in Attachment A to Part II.

4.1.5.3 The geographical separation between facilities working on adjacent channels shall be such that points at the protection heights and at the limit of the functional service range of each facility are separated by a distance sufficient to ensure operations free from harmful interference.

Note.—Guidance material covering separation distances and related system characteristics is contained in Attachment A to Part II.

4.1.5.4 The protection height shall be a height above a specified datum associated with a particular facility, such that below it harmful interference is improbable.

4.1.5.5 The protection height to be applied to functions or to specific facilities shall be determined regionally, taking into consideration the following factors:

a) the nature of the service to be provided;

b) the air traffic pattern involved;

c) the distribution of communication traffic;

d) the availability of frequency channels in airborne equipment;

e) probable future developments.

4.1.5.6 RECOMMENDATION.—*Where the protection heights determined are less than those operationally desirable, separation between facilities operating on the same frequency should not be less than that necessary to ensure that an aircraft at the limit of the functional service range and the operationally desirable protection height of one facility does not come above the radio horizon with respect to adjacent facilities.*

Note.—The effect of this recommendation is to establish a geographical separation distance below which harmful interference is probable.

4.1.5.7 The geographical separation between VHF VOLMET stations shall be determined regionally and, generally, shall be such that operations free from harmful interference are secured at the highest altitude flown by aircraft in the area concerned.

Note.—Guidance material on the interpretation of 4.1.5.7 is contained in Attachment A to Part II.

4.1.5.8 When utilizing 25 kHz channel spacing prior to 1 July 1976, along international air routes and at locations serving international air services, selectivity characteristics of airborne equipment designed for 50 kHz channel spacing shall be taken into account in frequency deployment in order to avoid harmful interference caused by 25 kHz channel spacing.

4.1.5.9 Frequencies in the aeronautical mobile VHF band used for national services, unless world-wide or regionally allotted to this specific purpose, shall be so deployed that minimum interference is caused to facilities for the international air services in this band.

4.1.5.10 RECOMMENDATION.— *The problem of inter-State interference on frequencies allotted world-wide or on a regional basis to national services, should be resolved by consultation between the Administrations concerned.*

4.1.5.11 The communication coverage provided by a VHF ground transmitter shall, in order to avoid harmful interference to other stations, be kept to the minimum consistent with the operational requirement for the function.

4.1.5.12 RECOMMENDATION.— *For ground VHF facilities which provide service beyond the radio horizon, any spurious or harmonic radiation outside the band plus or minus 250 kHz from the assigned carrier frequency should not exceed an effective radiated power of 1 milliwatt in any azimuth.*

4.1.6.—EQUIPMENT REQUIREMENTS

Note 1.—Frequency tolerances to which stations operating in the aeronautical mobile band (117.975-136 MHz) must conform are contained in Appendix 3 to the Radio Regulations. Tolerances for transmitters used for aeronautical services are not mentioned in Annex 10, except in those cases where tighter tolerances than those contained in the Radio Regulations are required (e.g. the equipment specifications in Part I contain several such instances).

Note 2.—The frequency tolerance applicable to individual components of a multi-carrier or similar system will be determined by the characteristics of the specific system.

4.1.6.1 RECOMMENDATION.— *The antenna gain of an extended range VHF facility should preferably be such as to ensure that, beyond the limits of plus or minus 2 ϕ about the centre line of the angular width ϕ of the area to be served, it does not exceed 3 dB above that of a dipole. But, in any case, it should be such as to ensure freedom from harmful interference with other radio services.*

Note 1.—The actual azimuth, the angular width of the service area, and the effective radiated power would have to be taken into account in each individual case.

Note 2.—Guidance material on the interpretation of 4.1.6.1 is contained in Attachment A to Part II.

4.1.7.—METHOD OF OPERATION

4.1.7.1 Single channel simplex operation shall be used in the VHF band 117.975 MHz to 136 MHz at all stations providing for aircraft engaged in international air navigation.

4.1.7.2 In addition to the above, the ground-to-air voice channel associated with an ICAO standard radio navigational aid may be used, subject to regional agreement, for broadcast or communication purposes or both.

* 4.1.8.—PLAN FOR THE ALLOTMENT OF SPECIFIC VHF RADIO FREQUENCIES FOR USE IN THE INTERNATIONAL AERONAUTICAL MOBILE SERVICE

Introduction

This plan designates the list of frequencies available for assignment, together with provision for the use by the International Aeronautical Mobile Service of all frequencies with a channel spacing of 25 kHz, with the frequencies in Group A continuing to be used wherever they provide a sufficient number to meet the operational requirements.

The plan provides that the total number of frequencies required in any region would be determined regionally. The effect of this will be that frequencies assignable in a particular region may be restricted to a limited number of the frequencies in the list, the actual number being selected as outlined herein.

In order that the assignable frequencies may be co-ordinated between regions as far as practicable, the plan requires that, whenever the number of frequencies contained in Group A of 4.1.8.1.2 is sufficient to meet the requirements in a region, the frequencies of this group be used in the sequence commencing with 118 MHz. This ensures that all regions will have in common the frequencies used in the region requiring the least number of frequencies and, in respect to any two regions, the region with the greater number will have in use all the frequencies used by the other. Group A provides for frequency planning based on 100 kHz channel spacing.

Group B of the list at 4.1.8.1.2 contains the frequencies in the band 117.975 – 132 MHz ending in 50 kHz. Together with the frequencies in Group A, they provide for frequency planning based on 50 kHz channel spacing. In Group C are listed the frequency channels in the band 132 – 136 MHz based upon 50 kHz channel spacing. Group D contains the frequency channels in the band 132 – 136 MHz ending in 25 kHz, and Group E similarly lists the frequency channels in the band 117.975 – 132 MHz. The utilization of the channels in Groups B, C, D and E is explained below.

Whenever the number of frequencies required in a particular region exceeds the number in Group A, frequencies may be selected from the other Groups taking into account the provisions of 4.1.8.1 with respect to the use of channels based on 25 kHz channel spacing and, with regard to the band 132 – 136 MHz, the provisions of the Radio Regulations (see Introduction to 4.1.). Although for Groups B, C, D and E a preferred order of selection is not indicated, regional planning may require a particular selection of frequencies from these Groups in order to cater for specific regional circumstances. This may apply particularly to the utilization of frequencies from the band 132 – 136 MHz for reasons of available airborne equipment and/or availability of particular frequency channels for the Aeronautical Mobile (R) Service. It may also be found that, in a particular region, it is desirable to select frequencies from Group B first, before selecting frequencies from Groups C, D or E.

In many regions particular frequencies have already been assigned for particular functions as, for instance, aerodrome or approach control. The plan does not make such assignments (except in respect to the emergency channel and ground service frequencies), such action being taken regionally if considered desirable.

4.1.8.1 The frequencies in the band 117.975 MHz to 136 MHz for use in the International Aeronautical Mobile Service shall be selected from the list in 4.1.8.1.2.

4.1.8.1.1 When the number of frequencies required in a particular region does not exceed the number of frequencies contained in Group A of 4.1.8.1.2, the frequencies to be used shall be selected in sequence, in so far as practicable, from those of Group A of 4.1.8.1.2.

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4.1.8.1.2 *List of assignable frequencies.*

Frequency (MHz)	*Annotations*
121.5	Emergency frequency
123.1	Auxiliary frequency SAR
121.60	Reserved for aerodrome surface communications [*see* 4.1.1, Allotment Table, Item *c*]
121.65	
121.70	
121.75	
121.80	
121.85	
121.90	
121.95	
121.625	
121.675	
121.725	
121.775	
121.825	
121.875	
121.925	
121.975	

GROUP A

Frequency (MHz)	*Frequency (MHz)*	*Frequency (MHz)*
118.00	123.80	127.40
118.10	123.90	127.50
118.20	124.00	127.60
118.30	124.10	127.70
118.40	124.20	127.80
118.50	124.30	127.90
118.60	124.40	128.00
118.70	124.50	128.10
118.80	124.60	128.20
118.90	124.70	128.30
119.00	124.80	128.40
119.10	124.90	128.50
119.20	125.00	128.60
119.30	125.10	128.70
119.40	125.20	128.80
119.50	125.30	128.90
119.60	125.40	129.00
119.70	125.50	129.10
119.80	125.60	129.20
119.90	125.70	129.30
120.00	125.80	129.40
120.10	125.90	129.50
120.20	126.00	129.60
120.30	126.10	130.90
120.40	126.20	131.00
120.50	126.30	131.10
120.60	126.40	131.20
120.70	126.50	131.30
120.80	126.60	131.40
120.90	126.70	131.50
121.00	126.80	131.60
121.10	126.90	131.70
121.20	127.00	131.80
121.30	127.10	131.90
121.40	127.20	
123.70	127.30	

GROUP B

Frequency (MHz)	*Frequency (MHz)*	*Frequency (MHz)*
118.05	123.85	127.35
118.15	123.95	127.45
118.25	124.05	127.55
118.35	124.15	127.65
118.45	124.25	127.75
118.55	124.35	127.85
118.65	124.45	127.95
118.75	124.55	128.05
118.85	124.65	128.15
118.95	124.75	128.25
119.05	124.85	128.35
119.15	124.95	128.45
119.25	125.05	128.55
119.35	125.15	128.65
119.45	125.25	128.75
119.55	125.35	128.85
119.65	125.45	128.95
119.75	125.55	129.05
119.85	125.65	129.15
119.95	125.75	129.25
120.05	125.85	129.35
120.15	125.95	129.45
120.25	126.05	129.55
120.35	126.15	129.65
120.45	126.25	130.95
120.55	126.35	131.05
120.65	126.45	131.15
120.75	126.55	131.25
120.85	126.65	131.35
120.95	126.75	131.45
121.05	126.85	131.55
121.15	126.95	131.65
121.25	127.05	131.75
121.35	127.15	131.85
123.75	127.25	131.95

GROUP C

Frequency (MHz)	*Frequency (MHz)*	*Frequency (MHz)*
132.00	132.90	133.80
132.05	132.95	133.85
132.10	133.00	133.90
132.15	133.05	133.95
132.20	133.10	134.00
132.25	133.15	134.05
132.30	133.20	134.10
132.35	133.25	134.15
132.40	133.30	134.20
132.45	133.35	134.25
132.50	133.40	134.30
132.55	133.45	134.35
132.60	133.50	134.40
132.65	133.55	134.45
132.70	133.60	134.50
132.75	133.65	134.55
132.80	133.70	134.60
132.85	133.75	134.65

Group C (*Contd*)

Frequency (MHz)	*Frequency (MHz)*	*Frequency (MHz)*
134.70	135.15	135.60
134.75	135.20	135.65
134.80	135.25	135.70
134.85	135.30	135.75
134.90	135.35	135.80
134.95	135.40	135.85
135.00	135.45	135.90
135.05	135.50	135.95
135.10	135.55	

GROUP D

Frequency (MHz)	*Frequency (MHz)*	*Frequency (MHz)*
132.025	133.375	134.725
132.075	133.425	134.775
132.125	133.475	134.825
132.175	133.525	134.875
132.225	133.575	134.925
132.275	133.625	134.975
132.325	133.675	135.025
132.375	133.725	135.075
132.425	133.775	135.125
132.475	133.825	135.175
132.525	133.875	135.225
132.575	133.925	135.275
132.625	133.975	135.325
132.675	134.025	135.375
132.725	134.075	135.425
132.775	134.125	135.475
132.825	134.175	135.525
132.875	134.225	135.575
132.925	134.275	135.625
132.975	134.325	135.675
133.025	134.375	135.725
133.075	134.425	135.775
133.125	134.475	135.825
133.175	134.525	135.875
133.225	134.575	135.925
133.275	134.625	135.975
133.325	134.675	*

GROUP E

Frequency (MHz)	*Frequency (MHz)*	*Frequency (MHz)*
118.025	118.575	119.125
118.075	118.625	119.175
118.125	118.675	119.225
118.175	118.725	119.275
118.225	118.775	119.325
118.275	118.825	119.375
118.325	118.875	119.425
118.375	118.925	119.475
118.425	118.975	119.525
118.475	119.025	119.575
118.525	119.075	119.625

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Group E (*Contd*)

Frequency (MHz)	*Frequency (MHz)*	*Frequency (MHz)*
119.675	124.925	127.875
119.725	124.975	127.925
119.775	125.025	127.975
119.825	125.075	128.025
119.875	125.125	128.075
119.925	125.175	128.125
119.975	125.225	128.175
120.025	125.275	128.225
120.075	125.325	128.275
120.125	125.375	128.325
120.175	125.425	128.375
120.225	125.475	128.425
120.275	125.525	128.475
120.325	125.575	128.525
120.375	125.625	128.575
120.425	125.675	128.625
120.475	125.725	128.675
120.525	125.775	128.725
120.575	125.825	128.775
120.625	125.875	128.825
120.675	125.925	128.875
120.725	125.975	128.925
120.775	126.025	128.975
120.825	126.075	129.025
120.875	126.125	129.075
120.925	126.175	129.125
120.975	126.225	129.175
121.025	126.275	129.225
121.075	126.325	129.275
121.125	126.375	129.325
121.175	126.425	129.375
121.225	126.475	129.425
121.275	126.525	129.475
121.325	126.575	129.525
121.375	126.625	129.575
123.725	126.675	129.625
123.775	126.725	129.675
123.825	126.775	130.925
123.875	126.825	130.975
123.925	126.875	131.025
123.975	126.925	131.075
124.025	126.975	131.125
124.075	127.025	131.175
124.125	127.075	131.225
124.175	127.125	131.275
124.225	127.175	131.325
124.275	127.225	131.375
124.325	127.275	131.425
124.375	127.325	131.475
124.425	127.375	131.525
124.475	127.425	131.575
124.525	127.475	131.625
124.575	127.525	131.675
124.625	127.575	131.725
124.675	127.625	131.775
124.725	127.675	131.825
124.775	127.725	131.875
124.825	127.775	131.925
124.875	127.825	131.975

4.1.8.1.3 **RECOMMENDATION.**— *Frequencies for operational control communications may be required to enable aircraft operating agencies to meet the obligations prescribed in Annex 6, Part I, in which case they should be selected from the bands 128.825 – 132.025 MHz. These frequencies should be chosen, in so far as practicable, from the upper end of the band and in sequential order.*

Note.—It is recognized that the assignment of such frequencies and the licensing of the operation of the related facilities are matters for national determination. However, in regions where a problem exists with respect to the provision of frequencies for operational control purposes, it may be advantageous if States endeavour to co-ordinate the requirements of aircraft operating agencies for such channels prior to regional meetings.

4.1.8.2 The frequencies that may be allotted for use in the International Aeronautical Mobile Service in a particular region shall be limited to the number determined as being necessary for operational needs in the region.

Note.—The number of frequencies required in a particular region is normally determined by the Council on the recommendations of Regional Air Navigation Meetings. The capabilities of VHF airborne equipment known to be widely used in the region will be taken into account in this determination.

ATTACHMENT D TO PART I. — GUIDANCE MATERIAL FOR COMMUNICATION SYSTEMS

2.—VHF Communications

2.1.—Audio Characteristics of VHF Communication Equipment

The aeronautical radiotelephony services represent a special case of the application of radiotelephony, in that the requirement is for the transmission of messages in such a way that fidelity of wave form is of secondary importance, emphasis being upon fidelity of basic intelligence. This means that it is not necessary to transmit those parts of the wave form which are solely concerned with individuality, accent and emphasis.

2.2.—Off-Set Carrier System

The following are examples of off-set carrier systems which meet the requirements of Part I, 4.6.1.1.2:

a) *2-carrier system.* Carriers should be spaced at plus and minus 5 kHz. This requires a frequency stability of plus or minus 2 kHz (15.3 parts per million at 130 MHz).

b) *3-carrier system.* Carriers should be spaced at zero and plus and minus 7.3 kHz. This requires a frequency stability of plus or minus 0.65 kHz (5 parts per million at 130 MHz).

The following are examples of 4- and 5-carrier systems which meet the requirements of Part I, 4.6.1.1.3:

a) *4-carrier system.* Carriers should be spaced at plus and minus 2.5 kHz and plus and minus 7.5 kHz. This requires a frequency stability of plus or minus 0.5 kHz (3.8 parts per million at 130 MHz).

b) 5-carrier system. Carriers should be spaced at zero, plus and minus 4 kHz and plus and minus 8 kHz. A frequency stability in the order of plus or minus 40 Hz (0.3 parts per million at 130 MHz) is an achievable and practicable interpretation of the requirement in this case.

Note.— The carrier frequency spacings referred to above are with respect to the assigned channel frequency.

3.—SELCAL System

3.1 This material is intended to provide information and guidance relating to the operation of the SELCAL system. It is associated with the Recommended Practices contained in Part I, 4.8.

i) Function. The purpose of the SELCAL system is to permit the selective calling of individual aircraft over radiotelephone channels linking the ground station with the aircraft, and is intended to operate on en-route frequencies with existing HF and VHF ground-to-air communications transmitters and receivers with a minimum of electrical and mechanical modification. The normal functioning of the ground-to-air communications link should be unaffected, except at such time as the selective calling function is being formed.

ii) Principles of operation. Selective calling is accomplished by the coder of the ground transmitter sending a single group of coded tone pulses to the aircraft receiver and decoder. The airborne receiver and decoder equipment is capable of receiving and interpreting, by means of an indicator, the correct code and rejecting all other codes in the presence of random noise and interference. The ground portion of the coding device (ground selective calling unit) supplies coded information to the ground-to-air transmitter. The airborne selective calling unit is the special airborne equipment which operates with existing communications receivers on the aircraft to permit decoding of the ground-to-air signals for display on the signal indicator. The type of signal indicator can be chosen to suit operational requirements of the user and may consist of a lamp, a bell, a chime or any combination of such indicating devices.

ATTACHMENT A TO PART II. — CONSIDERATIONS AFFECTING THE DEPLOYMENT OF VHF COMMUNICATION FREQUENCIES

Introduction

Paragraphs 4.1.5.2 and 4.1.5.3 of Part II specify the geographical separation required for co-channel operation of VHF facilities in the Aeronautical Mobile Service. In Fig. A-1 the distance AB indicates the separation required in order that aircraft *a* and *b* operating at the protection heights and at the limits of the functional service range of stations A and B respectively, will not experience harmful interference.

Paragraph 4.1.6.1 of Part II recommends the maximum antenna gain outside the main beam of facilities which provide service beyond the radio horizon. Figure A-2 illustrates the azimuthal angle to be protected and the method of derivation. Smaller beam widths than 30 degrees are not considered practical at present.

Note.—The term "main beam" includes all azimuths where antenna gain exceeds 3 dB above that of a dipole.

1.—Criteria Employed in Establishing Adjacent Channel Frequency Deployment with Respect to Receiver Rejection and Other System Characteristics

1.1 For aircraft receivers designed for operation in a 50 kHz channel spacing environment and a ground station frequency tolerance of 50 parts in 10^6 ($\pm$ 0.005 per cent), an effective adjacent channel rejection characteristic of 60 dB or better is assumed. This assumption will result in a geographical separation distance between the nearest limits of the functional service ranges of the two facilities of at least 3 nautical miles.

1.2 For aircraft receivers designed for operation in a 25 kHz channel spacing environment and a ground station frequency tolerance of plus or minus 0.002 per cent, an effective adjacent channel rejection characteristic of 60 dB or better is assumed. This assumption will result in a geographical separation distance between the nearest limits of the functional service ranges of the two facilities of at least 3 nautical miles.

1.3 The above criteria are based on the concept of protection by receiver muting, except in the case of area control and FIR channels where a minimum field strength is specified in order to secure the desired wanted-to-unwanted signal ratio.

1.4 The following additional assumptions were made in establishing the criteria:

i) Propagation: free space propagation between aircraft. The CCIR curves for 100 MHz vertical polarization over land in conjunction with an assumed ground antenna height of 20 metres (65 feet) were used in computing ground-air field strengths.

ii) Minimum field strength at limit of functional service range: 45 dB above 1 microvolt per metre at 3 000 metres (10 000 feet) in the case of area control and FIR channels.

Note.—To meet this requirement, a station radiating 100 watts from an antenna 20 metres (65 feet) high should be not more than 100 nautical miles from the limit of its functional service range.

iii) Effective radiated power (ERP): a maximum ERP of 20 watts from ground and airborne stations with the exception that, in case of ground stations providing flight information or area control service communications, it was necessary to assume a minimum ERP of 100 watts.

iv) Airborne antenna polar patterns: total variations not exceeding 10 db. Since a maximum ERP was assumed (and therefore all variations are downwards from this figure), no allowance was necessary in respect of airborne transmitter polar diagrams.

v) Wanted-to-unwanted signal ratio: 20 dB at the receiver output.

vi) Receiver muting characteristics: a muting threshold corresponding to a received field strength of 5 microvolts per metre.

2.—Criteria to be Employed in Establishing Adjacent Channel Frequency Deployment of VHF Facilities that have a Service Range beyond the Radio Horizon

For the most economical use of frequencies and to ensure freedom from interference, planning must be based on an accurate knowledge of equipment used. When the equipment characteristics and field strength (or attenuation) curves are on hand for the troposcatter regions, it is relatively easy to determine the required geographical separation. When these are not known, the maximum permitted antenna gain stipulated in Part II, 4.1.6.1 will be assumed. There are several conditions that must be calculated and compared to determine the appropriate separation to be used. The conditions to be compared are:

1) ground facility-to-aircraft;

2) aircraft-to-ground facility;

3) aircraft-to-aircraft;

4) ground facility-to-ground facility.

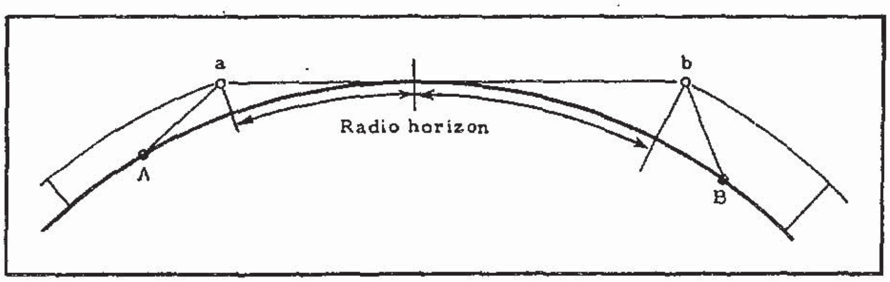


Fig. A-1.—Geographical separation required for co-channel operation of VHF facilities

Case 1.—For the case of protection of aircraft A from a ground facility (*see* Fig. A-3):

A. Determine the signal level S (db rel. 1 μV/m) received from the desired station at the limit of the service radius at the protection altitude.

B. Assign the desired protection ratio P (dB) required at the aircraft receiver.

C. Let receiver adjacent channel rejection be represented by A (dB). Then the level L (dB rel. 1 μV/m) that can be tolerated at the the receiver antenna can be determined by:

$$L = S - P + A$$

D. Distance d (km) from protection point to undesired facility to provide protection established by "C" above, is found by application of L to the appropriate curves.*

E. The facility-to-facility separation D is d (km) plus service radius (km).

**Note 1.*—*Figures A-7 to A-14 are field strength curves appropriate for the average temperate climate over land or sea, which may be used to determine geographical separation for situations where these field strengths will not normally be exceeded more than 5 per cent of the time. These curves were established by the Institute for Telecommunications Sciences and Aeronomy of the Environmental Science Services Administration of the United States of America.*

Note 2.—For power levels other than 1 kilowatt the necessary corrections under "C" above would have to be made. For example, 5 kilowatts ERP requires a minus 7 dB correction.

Case 2.—Aircraft (A)-to-ground facility (*see* Fig. A-3).

A. Determine signal level Sg at the ground facility receiving antenna for proper system operation.

B. Proceed as in Case 1, where

$$L = Sg - P + A$$

C. Ground facility-to-ground facility separation will also be determined as in Case 1 (D = d + service radius).

Note.—Where ground facility receivers have sensitivities of less than 1 microvolt across 50 ohms, Case 2 is most likely to yield the separation to be used.

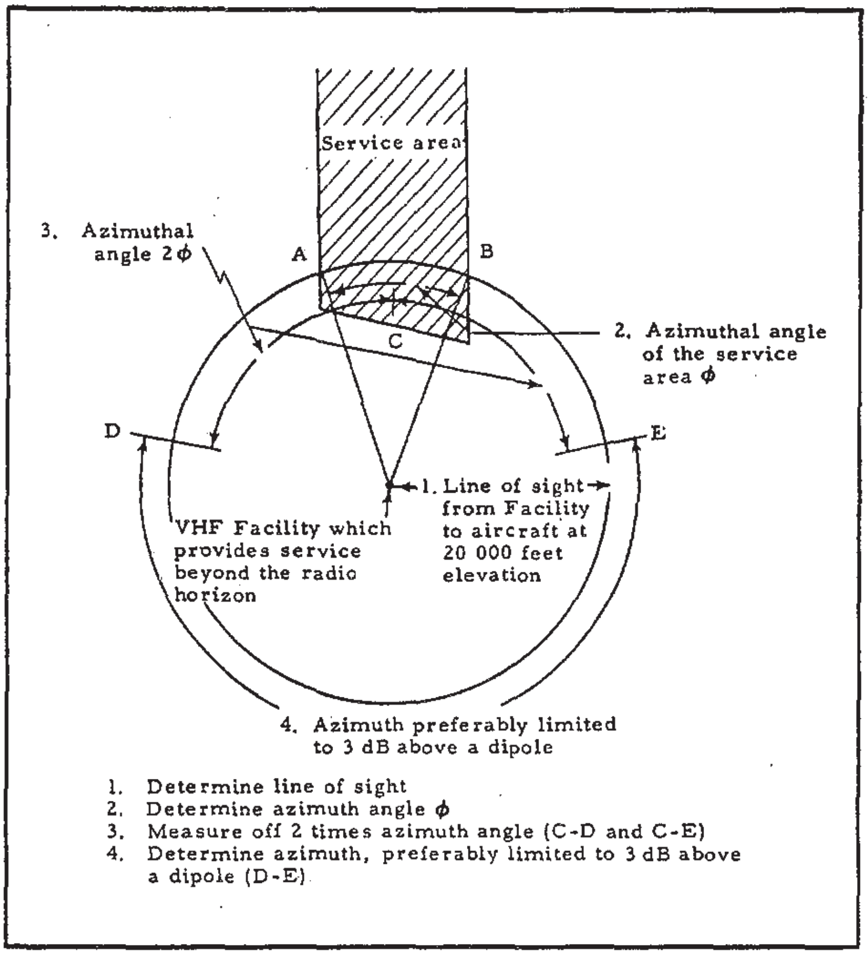


Fig. A-2.—Limit of azimuth protection for VHF facilities which provide a service beyond the radio horizon

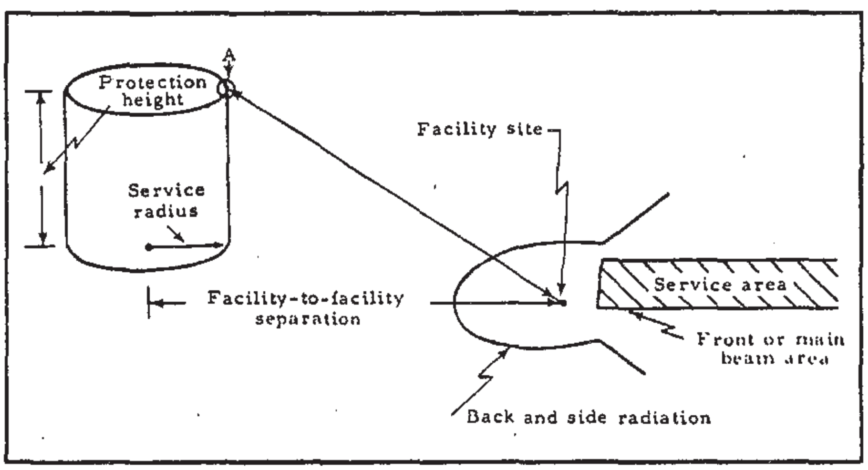


Fig. A-3.—Air-to-ground (facility from A) and ground-to-air (A from facility)

Case 3.—Aircraft (A)-to-aircraft (B) (*see* Fig. A-4):

A. Establish service radius and protection altitude for facility to be protected (*see* aircraft A in Fig. A-4).

B. Determine closest point to aircraft A that aircraft B will be transmitting to the ground facility site and the altitude where this will take place.

C. Proceed as in Case 1, using the aircraft (B) contacting ground facilities as the undesired signal.

D. Then L = S − P + A

E. The distance d to aircraft B (undesired) obtained from the curves, plus the service radius of the facility to be protected, will determine the separation between aircraft B and the ground facility protected.

F. Facility-to-facility separation may then be determined graphically or by trigonometric means.

Case 4.—Ground facility-to-ground facility (*see* Fig. A-4).

A. Determine signal level that can be tolerated at the receiver antenna at one facility by L = Sg − P + A (*see* Case 1)

B. Then facility-to-facility separation for these conditions is read directly from the curves (after correcting for transmitter power of other facilities if different from 1 kilowatt).

C. Should equipments at the two facilities have different characteristics, repeat procedure in "A" and "B" above for the other combination of equipments.

D. Of the two distances derived, use the greater to compare with other cases (*see* below).

Note.—In most instances, it will be found that the facility-to-facility consideration will not be the controlling factor in determining geographical separation.

Facility separation will then be the greatest distance derived for Cases 1 to 4.

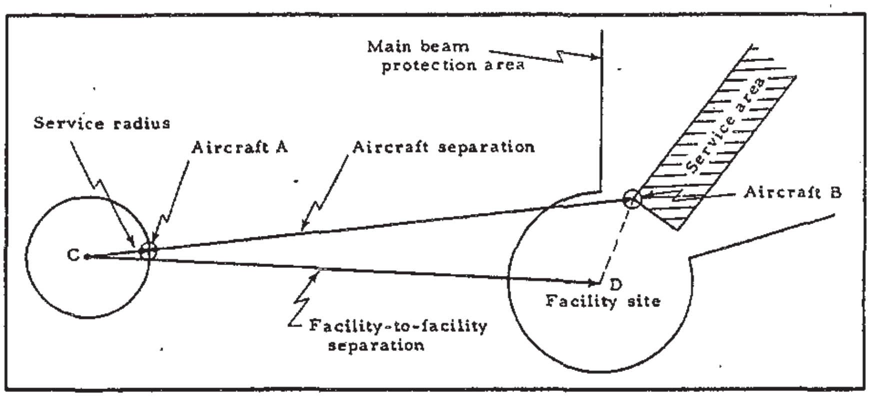


Fig. A-4.—Facility-to-facility separation based on air-to-air (A from B) and ground-to-ground (C from D).

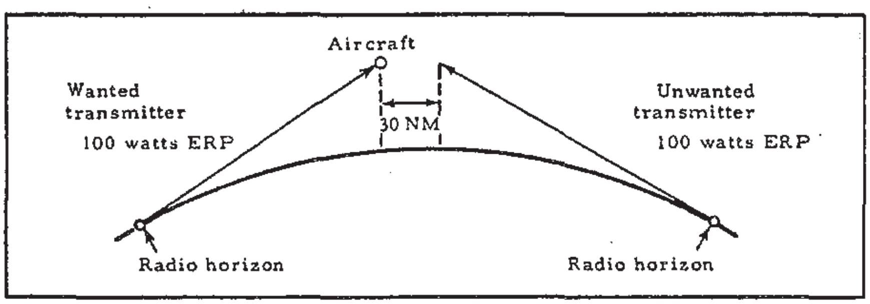


Fig. A-5.—VOLMET planning (illustrating co-channel protection)

3.—Criteria to be Employed in Establishing Geographical Separation between Ground Stations and between Aircraft and Ground Stations for Co-Channel Operation of VHF Facilities that have a Service Area beyond the Radio Horizon

Geographical separation of co-channel facilities can be calculated by using the method given in 2 above except that the adjacent channel rejection (A) is omitted from consideration.

4.—Criteria Employed in Establishing Co-Channel Frequency Deployment of VHF VOLMET Facilities

In the case of VHF VOLMET services, the geographical separation between co-channel stations should be 30 nautical miles plus twice the distance to the radio horizon from an aircraft at the highest altitude flown by aircraft in the area concerned.

Note.—At 15 nautical miles beyond the radio horizon, the field strength at 13 500 metres (45 000 feet), from a transmitter of 100 watts ERP, will be approximately at the receiver muting level of 5 microvolts per metre.

5.—Criteria Employed in Establishing Adjacent Channel Frequency Deployment of VHF VOLMET Facilities

5.1 For aircraft receivers designed for operation in a 25 kHz channel spacing environment, an effective adjacent channel rejection characteristic of 60 dB or better is assumed. This assumption will result in a geographical separation distance (D) between VHF VOLMET ground transmitters derived as follows:

$$D = (d_1 + d_2) \text{ NM}$$

where

d_1 = distance between aircraft and wanted ground station

= radio horizon + 15 NM

and

d_2 = distance between aircraft and unwanted ground station

= 13 NM.

5.2 Where it is necessary to take account, on a regional basis, of receivers not specifically designed for 25 kHz channel spacing and used in a 25 kHz channel spacing environment, an effective adjacent channel rejection characteristic of the receiver of the order of 40 dB is assumed. This assumption will result in a minimum geographical separation distance (D) between VHF VOLMET ground transmitters derived as follows:

$$D = (d_1 + d_2) \text{ NM}$$

where

d_1 = distance between aircraft and wanted ground station
= radio horizon + 15 NM

d_2 = distance between aircraft and unwanted ground station
= 130 NM.

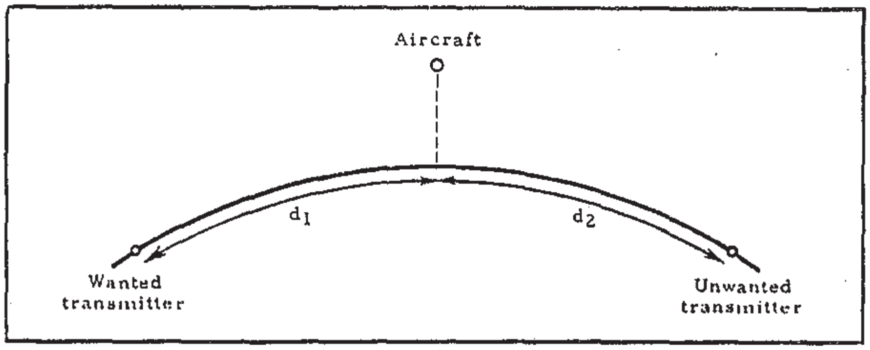


Fig. A-6.—VOLMET planning (illustrating adjacent channel protection)

5.3 Application of the above criteria in the case of aircraft altitudes of 13 500 metres (45 000 feet) and 20 000 metres (66 000 feet) results in the following separation distances:

Altitude	*Receiver rejection characteristic*	d_1 *(NM)*	d_2 *(NM)*	D *(NM)*
13 500 m (45 000 ft)	60 dB	265	13	278
13 500 m (45 000 ft)	40 dB	265	130	395
20 000 m (66 000 ft)	60 dB	334	13	347
20 000 m (66 000 ft)	40 dB	334	130	464

5.4 The above criteria are based on the following additional assumptions:

i) Effective radiated power: an ERP of 100 watts for the ground stations.

Note.—If an ERP of 20 watts is assumed, this would result in separation distances for 13 500 metres (45 000 feet) of 255 nautical miles for 60 dB receiver adjacent channel rejection and 309 nautical miles for 40 dB receiver adjacent channel rejection.

ii) Interfering signal strength: if the received signal strength is in excess of the free space propagation value, then the maximum value will not exceed the free space value by more than 5 dB over average earth. This condition is satisfied when transmitters of 20 watts ERP or more are used in conjunction with a receiver adjacent channel rejection of not less than 35 dB. Thus, the minimum distance for d_2 can be derived from a consideration of receiver muting level, receiver adjacent channel rejection and transmitter ERP.

FIGS. A-7 to A-14.—PROPAGATION CURVES FOR STANDARD ATMOSPHERE (301) FOR FREQUENCY OF 127 MHz

(ESSA/I.T.S.A. — 1966 Propagation Model)

These curves labelled "5 per cent time availability" represent only a statistically expected value; *i.e.*, a probability of 0.05 that a particular situation will result in the specified field strength or greater during 5 per cent of the time.

The parameters used to develop these curves include:

1) frequency of 127 MHz;

2) horizontal or vertical polarization;

3) smooth earth with land or sea surface;

4) reflection coefficient of unity magnitude;

5) standard atmosphere with a 301 surface refractivity;

6) continental temperate climate;

7) Nakagami-Rice statistics for within-the-horizon fading;

8) An effective radiated power (ERP) corresponding to 1 kilowatt input power into a lossless half-wave dipole.

BOEING
Ex. 1041, p. 58

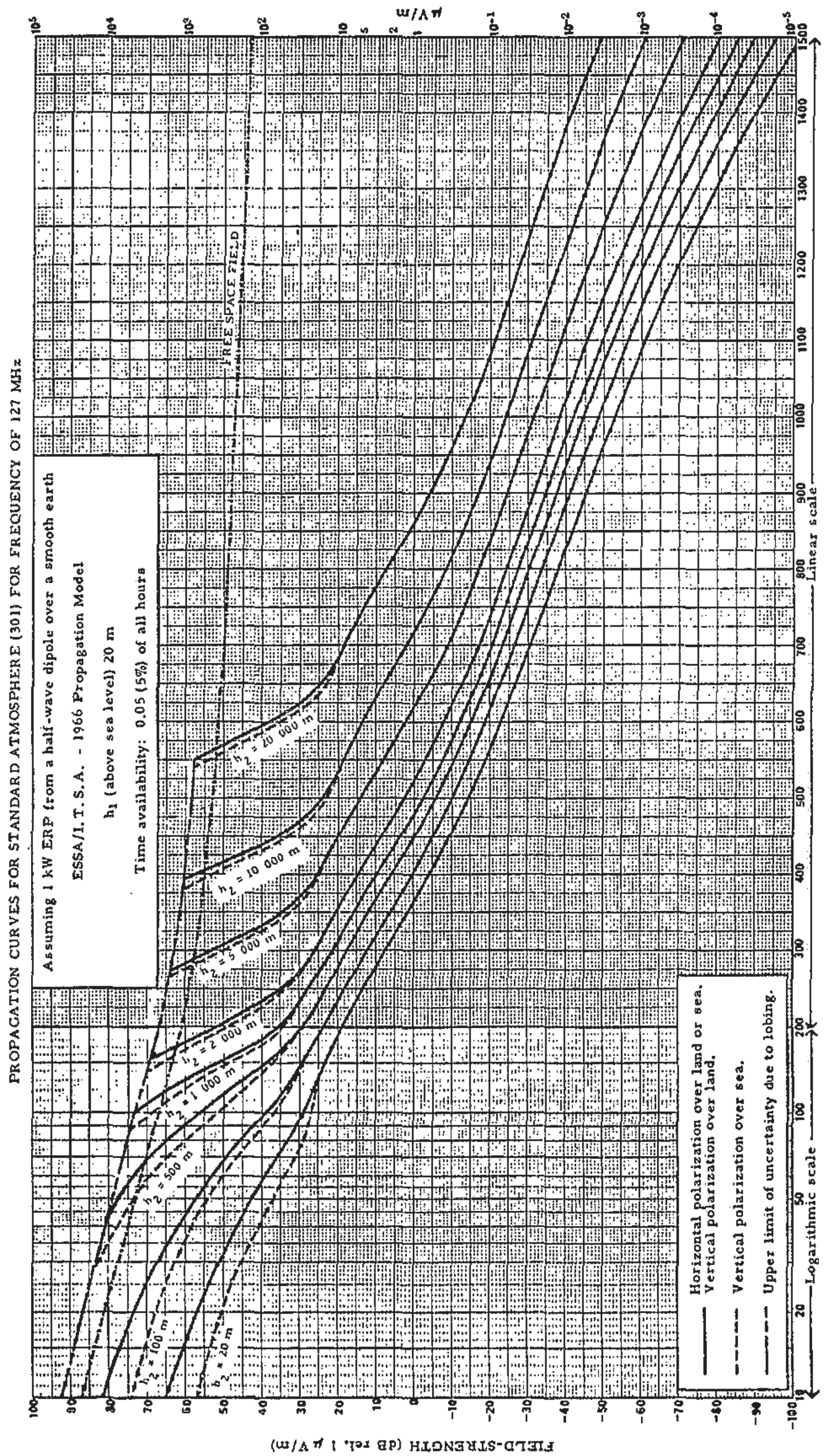


Fig. A-7

Appendix 1 Part I (cont'd)

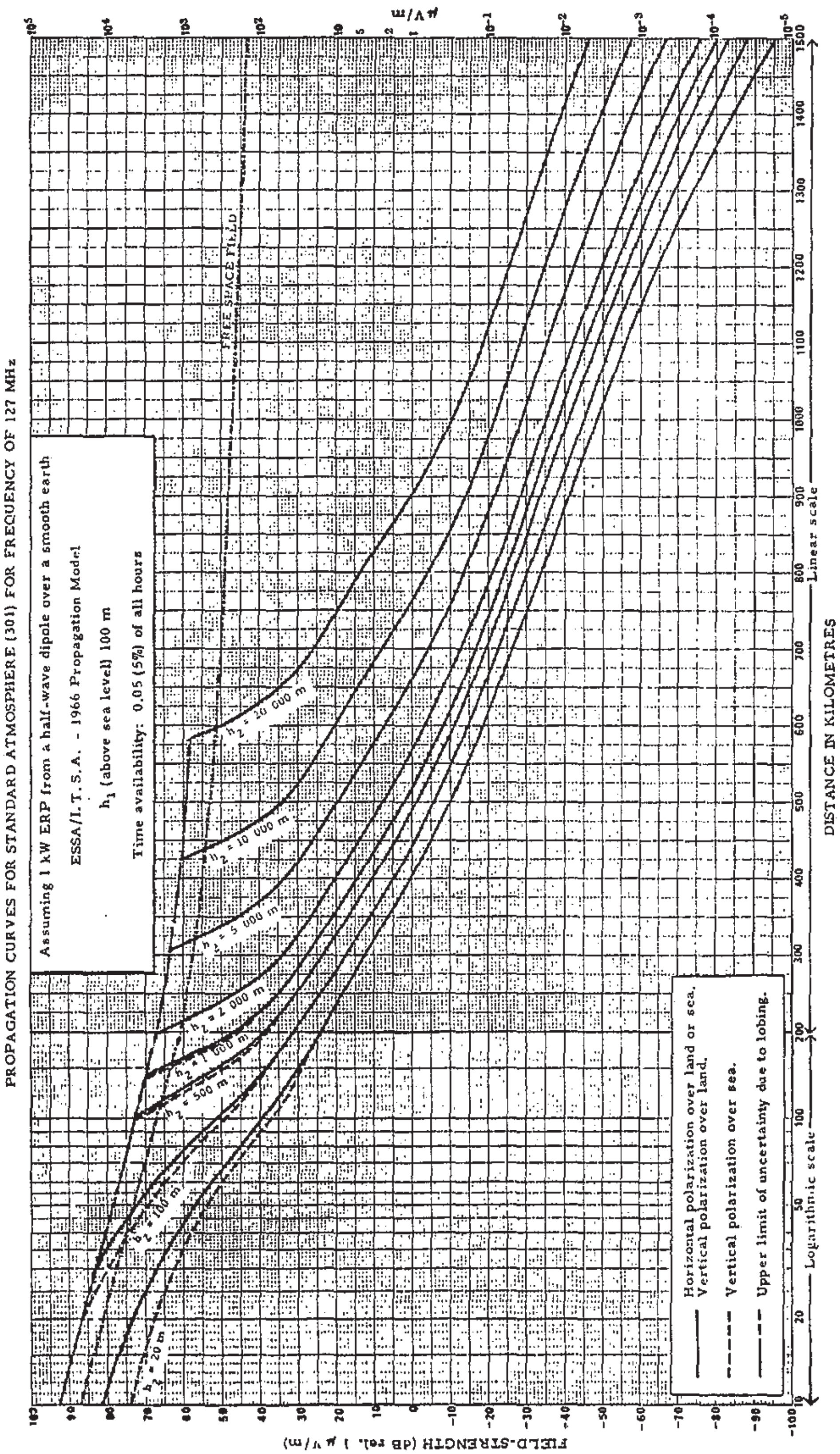


Fig. A-8

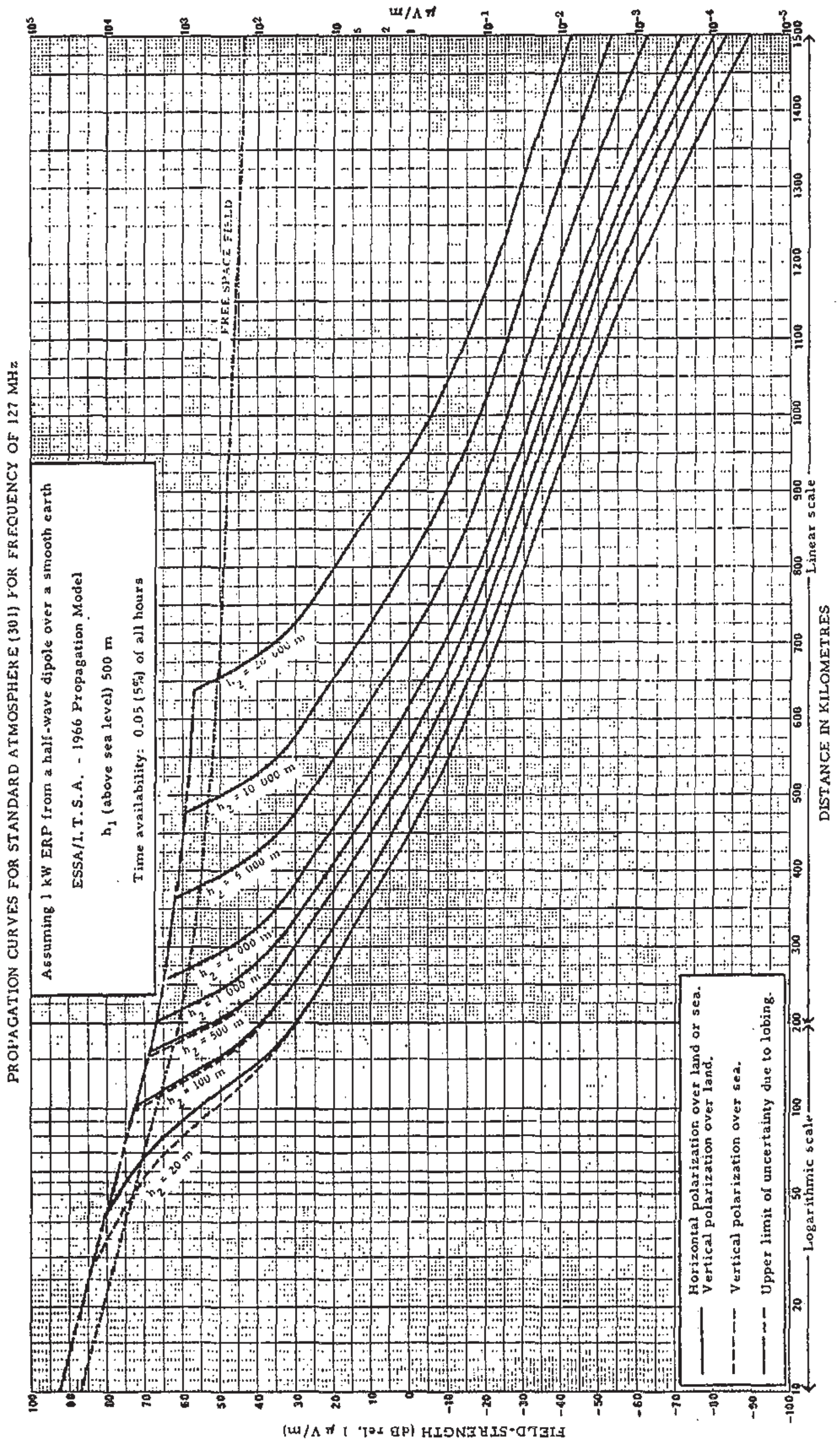

PROPAGATION CURVES FOR STANDARD ATMOSPHERE (301) FOR FREQUENCY OF 127 MHz
Assuming 1 kW ERP from a half-wave dipole over a smooth earth
ESSA/I.T.S.A. - 1966 Propagation Model
h1 (above sea level) 500 m
Time availability: 0.05 (5%) of all hours
FREE SPACE FIELD
h2 = 20 000 m
h2 = 10 000 m
h2 = 5 000 m
h2 = 2 000 m
h2 = 1 000 m
h2 = 500 m
h2 = 100 m
h2 = 20 m
Horizontal polarization over land or sea.
Vertical polarization over land.
Vertical polarization over sea.
Upper limit of uncertainty due to lobing.
DISTANCE IN KILOMETRES
Logarithmic scale
Linear scale
FIELD-STRENGTH (dB rel. 1 μ V/m)
μ V/m

Fig. A-9

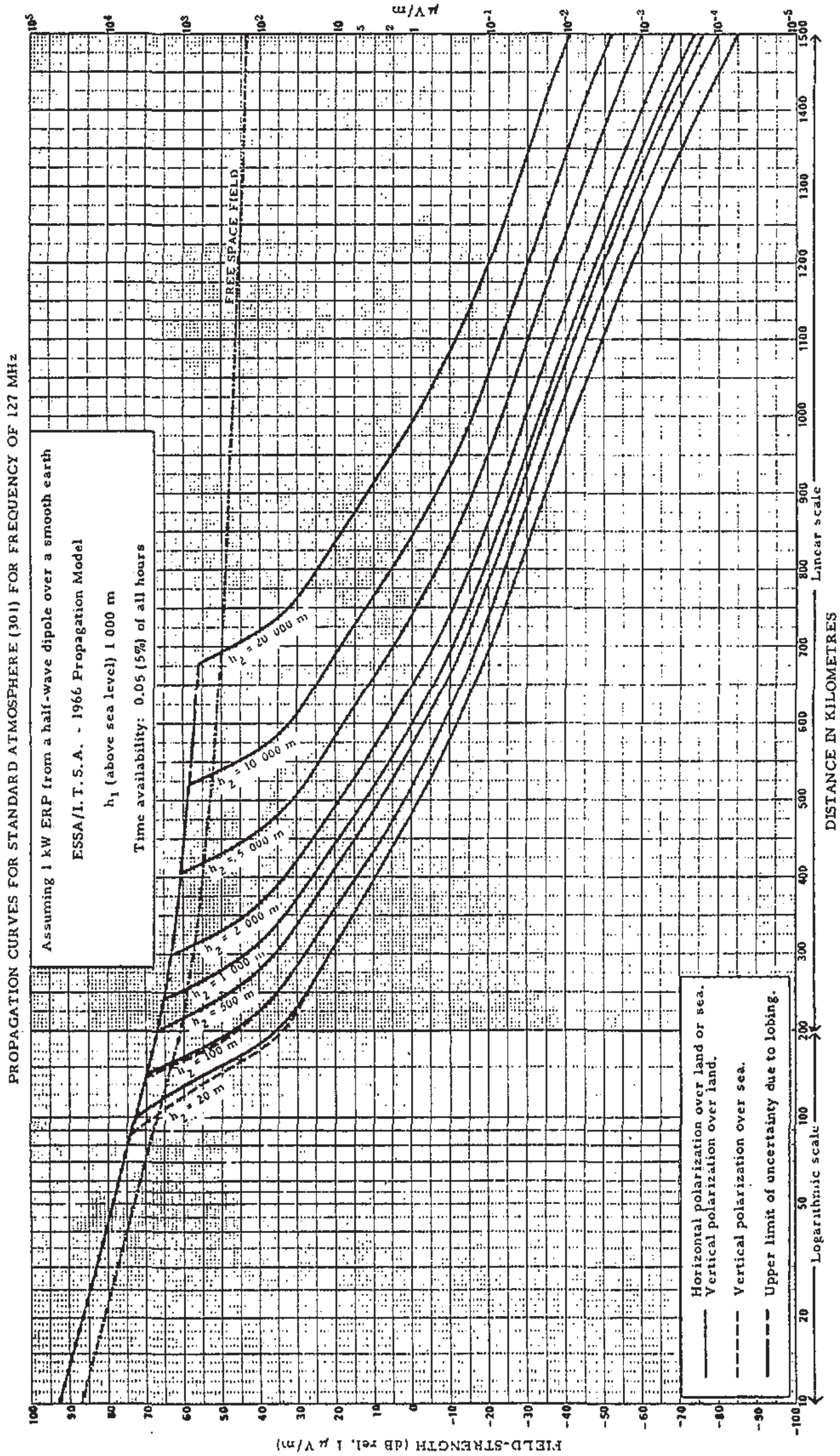

PROPAGATION CURVES FOR STANDARD ATMOSPHERE (301) FOR FREQUENCY OF 127 MHz
Assuming 1 kW ERP from a half-wave dipole over a smooth earth
ESSA/I. T. S. A. - 1966 Propagation Model
h1 (above sea level) 1 000 m
Time availability: 0.05 (5%) of all hours
FREE SPACE FIELD
h2 = 20 000 m
h2 = 10 000 m
h2 = 5 000 m
h2 = 2 000 m
h2 = 1 000 m
h2 = 500 m
h2 = 100 m
h2 = 20 m
Horizontal polarization over land or sea.
Vertical polarization over land.
Vertical polarization over sea.
Upper limit of uncertainty due to lobing.
DISTANCE IN KILOMETRES
Logarithmic scale
Linear scale
FIELD-STRENGTH (dB rel. 1 μV/m)
μV/m

Fig. A-10

BOEING
Ex. 1041, p. 62

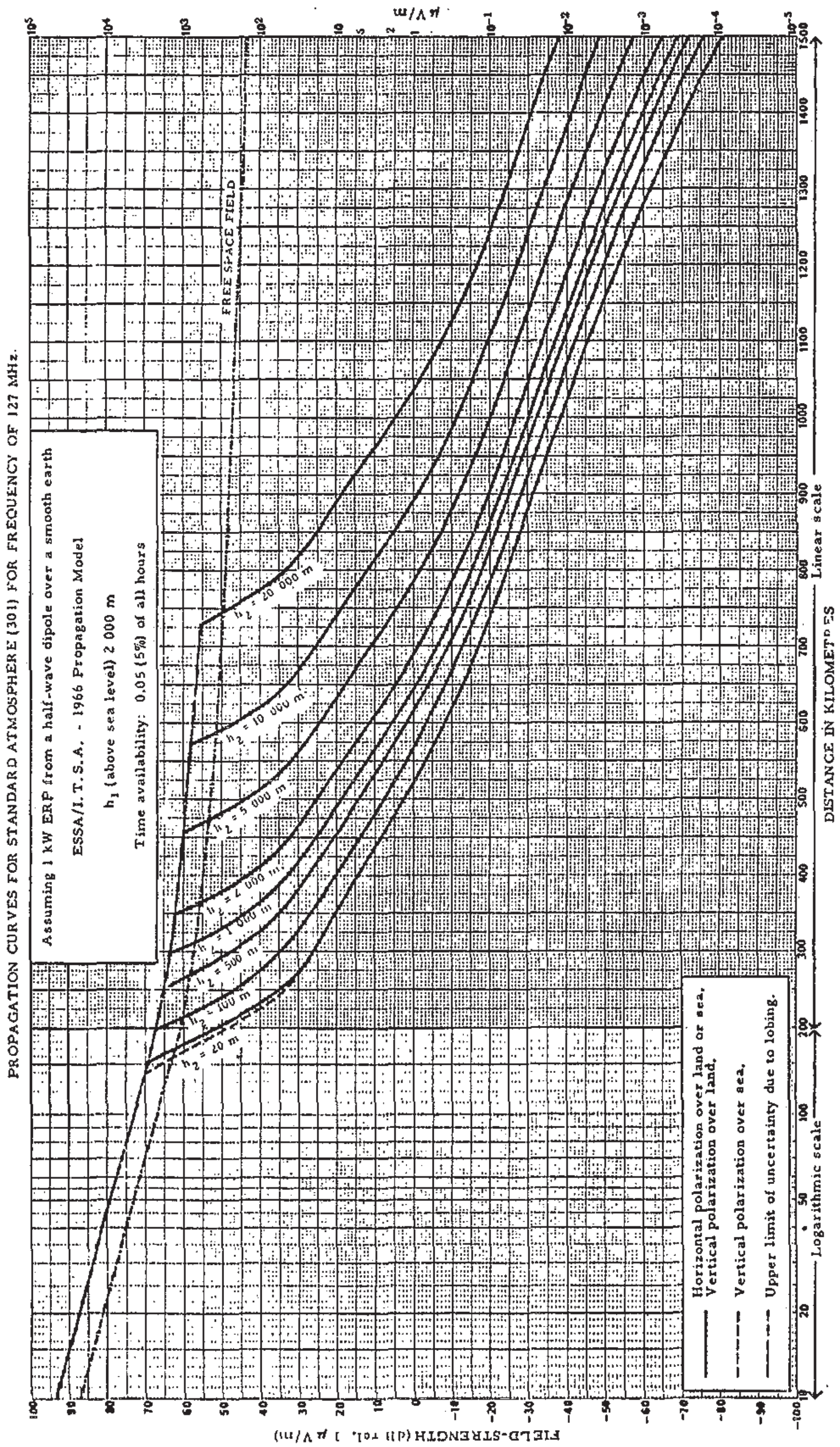


Fig. A-11

BOEING
Ex. 1041, p. 63

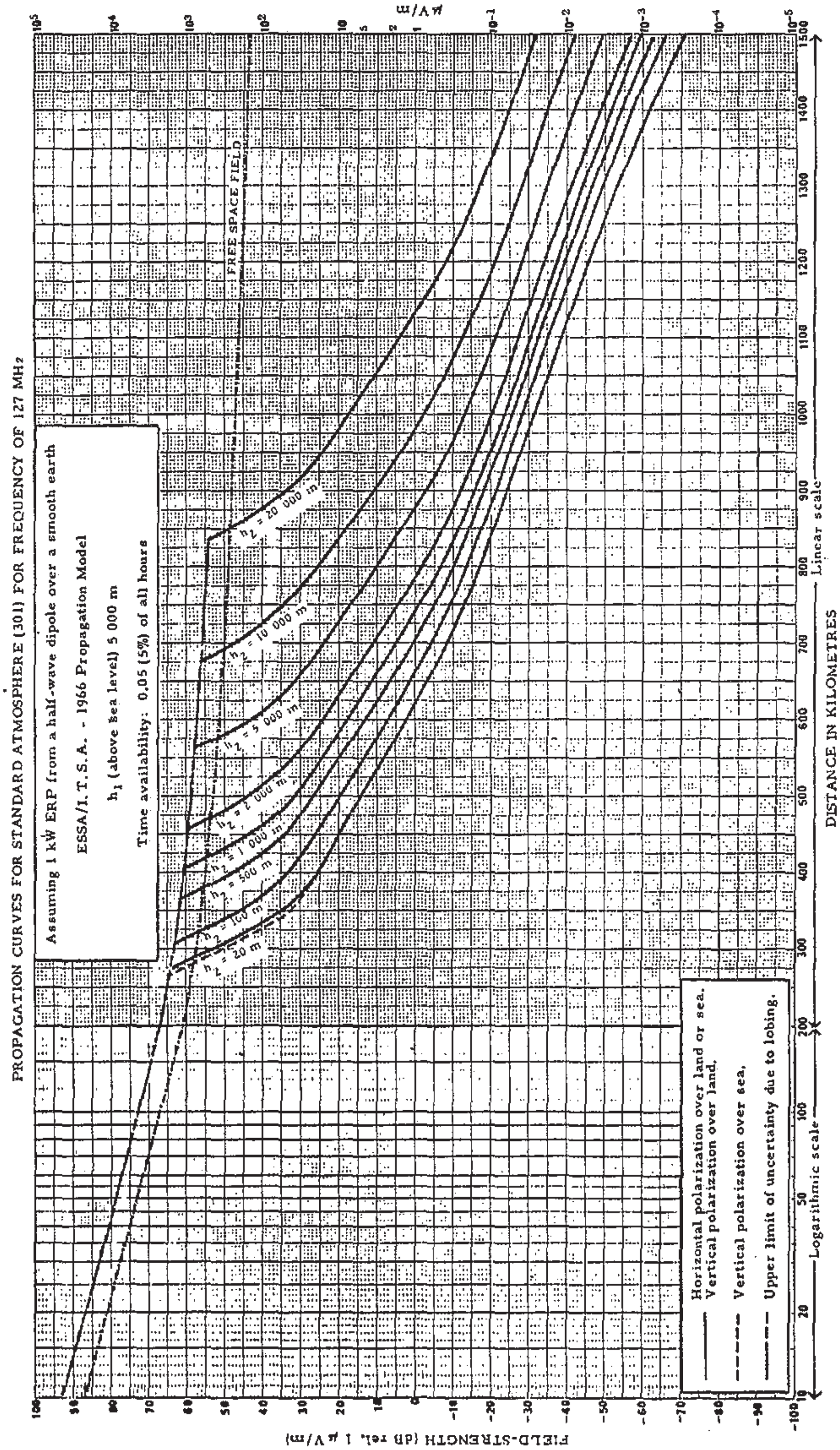


Fig. A-12

Appendix 1 Part I (cont'd)

Attachment A to Part II ***Annex 10 — Aeronautical Telecommunications***

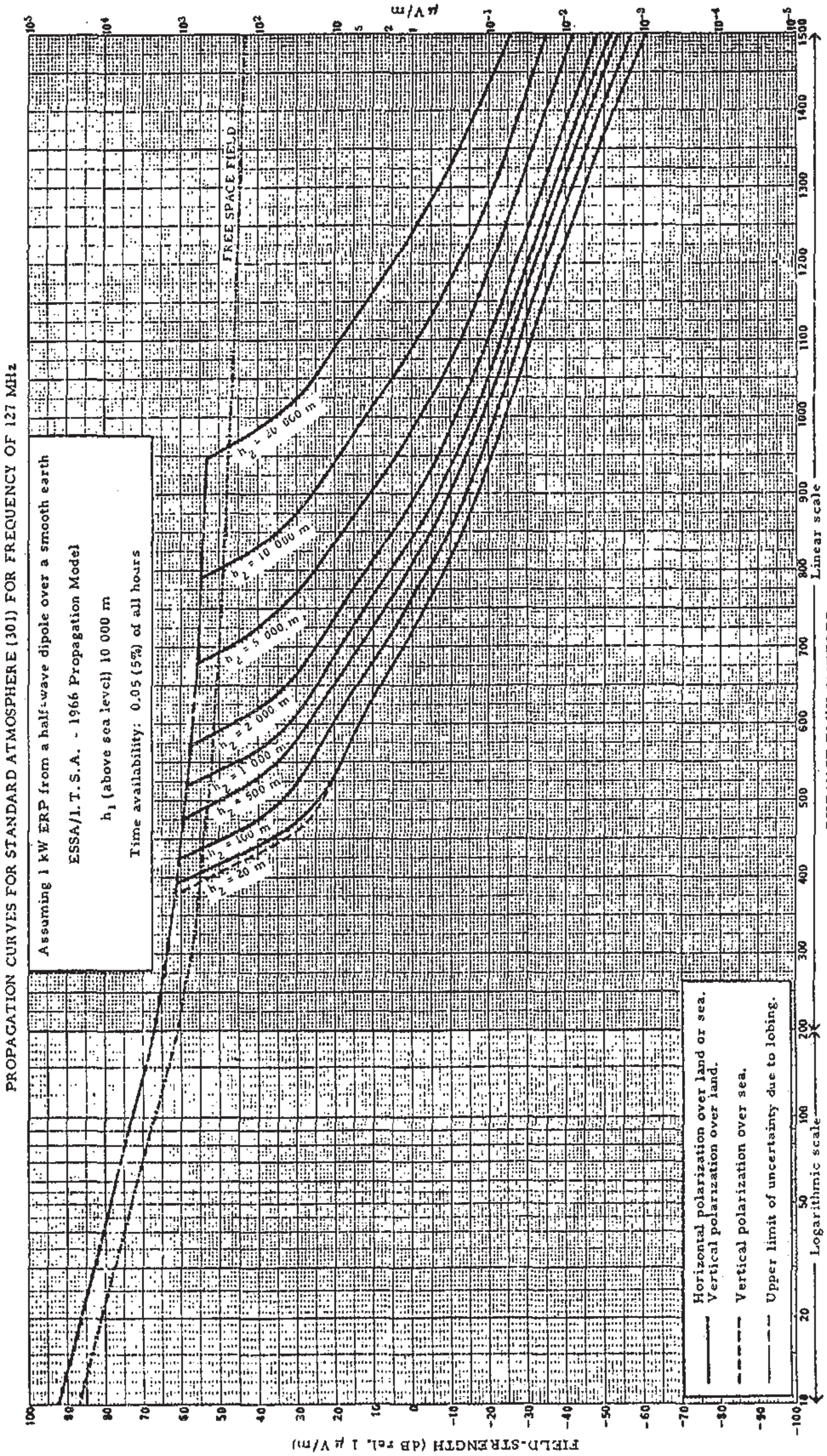
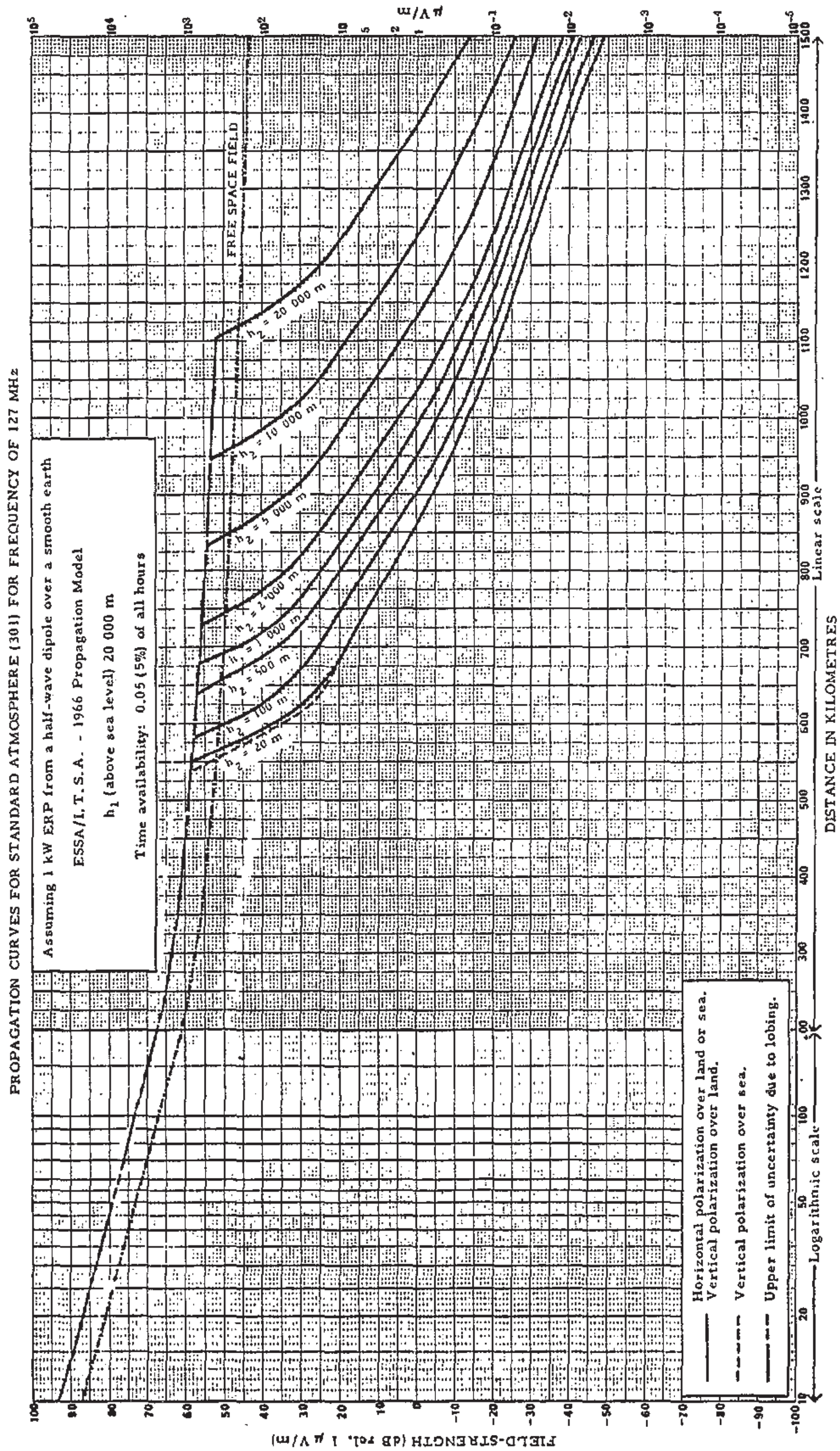


Fig. A-13


PROPAGATION CURVES FOR STANDARD ATMOSPHERE (301) FOR FREQUENCY OF 127 MHz
Assuming 1 kW ERP from a half-wave dipole over a smooth earth
ESSA/I.T.S.A. - 1966 Propagation Model
h1 (above sea level) 20 000 m
Time availability: 0.05 (5%) of all hours
FREE SPACE FIELD
h2 = 20 000 m
h2 = 10 000 m
h2 = 5 000 m
h2 = 2 000 m
h2 = 1 000 m
h2 = 500 m
h2 = 100 m
h2 = 20 m
μV/m
FIELD-STRENGTH (dB rel. 1 μV/m)
DISTANCE IN KILOMETRES
Linear scale
Logarithmic scale
Horizontal polarization over land or sea.
Vertical polarization over land.
Vertical polarization over sea.
Upper limit of uncertainty due to lobing.

AMENDMENT No. 63

TO THE

INTERNATIONAL STANDARDS,
RECOMMENDED PRACTICES AND
PROCEDURES FOR AIR NAVIGATION SERVICES

AERONAUTICAL TELECOMMUNICATIONS

ANNEX 10

TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME II

The amendment to Annex 10 contained in this document was adopted by the Council of ICAO on 13 December 1982. Such parts of this amendment as have not been disapproved by more than half of the total number of Contracting States on or before 13 April 1983, will become effective on that date and will become applicable on 24 November 1983 as specified in the Resolution of Adoption.

DECEMBER 1982

INTERNATIONAL CIVIL AVIATION ORGANIZATION

Relevant existing text of Annex 10 Volume I as amended by Amendment No. 62 (1)	Action Recommended (2)
4.5.1.3 The radio frequencies used shall be selected from the radio frequencies in the band 117.975 MHz to 136 MHz. The separation between assignable frequencies (channel spacing) and frequency tolerances applicable to elements of the system shall be as specified in Part II, 4.1.2. and 4.1.6.	and the band 136 MHz to 137 MHZ subject to the conditions of Radio Regulation 595.
Note.—The band 117.975-132 MHz was allocated to the Aeronautical Mobile (R) Service in the Radio Regulations (1947). By subsequent revisions of the Regulations at ITU World Administrative Conferences the band 132-136 MHz was added to the (R) allocation under conditions which differ for ITU Regions, or for specified countries or combinations of countries.	the bands 132 - 136 MHz and 136 - 137 MHz were
4.6.2.—RECEIVING FUNCTION	
4.6.2.1 *Sensitivity.* After due allowance has been made for feeder loss and antenna polar diagram variation, the sensitivity of the receiving function shall be such as to provide on a high percentage of occasions an audio output signal with a wanted/unwanted ratio of 15 dB, with a 50 per cent amplitude modulated (A3) radio signal having a field strength of 20 microvolts per metre (minus 120 dBW/m²) or more.	(A3E)
4.7.2.—RECEIVING FUNCTION	
4.7.2.1 *Sensivity.*	
RECOMMENDATION.—*After due allowance has been made for aircraft feeder mismatch, attenuation loss and antenna polar diagram variation, the sensitivity of the receiving function should be such as to provide on a high percentage of occasions an audio output signal with a wanted/unwanted ratio of 15 dB, with a 50 per cent amplitude modulated (A3) radio signal having a field strength of 75 microvolts per metre (minus 109 dBW/m²).*	(A3E)

Relevant existing text of Annex 10, Vol. I, Part I, as amended by Amendment No. 62	Action Recommended (2)

4.8.—SELCAL System

4.8.1 RECOMMENDATION.— *Where a SELCAL system is installed, the following system characteristics should be applied:*

a) Transmitted code. *Each transmitted code should be made up of two consecutive tone pulses, with each pulse containing two simultaneously transmitted tones. The pulses should be of 1.0 plus or minus 0.25 seconds duration, separated by an interval of 0.2 plus or minus 0.1 second.*

b) Stability. *The frequency of transmitted tones should be held to plus or minus 0.15 per cent tolerance to ensure proper operation of the airborne decoder.*

c) Distortion. *The overall audio distorsion present on the transmitted r-f signal should not exceed 15 per cent.*

d) Per cent modulation. *The r-f signal transmitted by the ground radio station should contain, within 3 dB, equal amounts of the two modulating tones. The combination of tones should result in a modulation envelope having a nominal modulation percentage as high as possible and in no case less than 60 per cent.*

e) Transmitted tones. *Tone codes should be made up of various combinations of the tones listed in the following table and designated by colour and letter as indicated:*

TABLE OF TONE FREQUENCIES

Designation	*Frequency (Hz)*
Red A	312.6
Red B	346.7
Red C	384.6
Red D	426.6
Red E	473.2
Red F	524.8
Red G	582.1
Red H	645.7
Red J	716.1
Red K	794.3
Red L	881.0
Red M	977.2

X

Action recommended (insert at X):

Red P	1083.9
Red Q	1202.3
Red R	1333.5
Red S	1479.1

Relevant existing text of Annex 10, Vol. I, Part I, as amended by Amendment No. 62	Action Recommended (2)

Blue A	323.6
Blue B	358.9
Blue C	398.1
Blue D	441.6
Blue E	489.8
Blue F	543.3
Blue G	602.6
Blue H	668.3
Blue J	741.3
Blue K	822.2
Blue L	912.0
Blue M	1 011.6
Yellow A	335.0
Yellow B	371.5
Yellow C	412.1
Yellow D	457.1
Yellow E	507.0
Yellow F	562.3
Yellow G	623.7
Yellow H	691.8
Yellow J	767.4
Yellow K	851.1
Yellow L	944.1
Yellow M	1.047.1

delete

Note 1.—It should be noted that the tones in any one colour group are spaced by Log⁻¹ 0.045 to avoid the possibility of harmonic combinations.

delete

Note 2.—In accordance with the application principles developed by the Sixth Session of the Communications Division, the only codes at present used internationally are selected from the red group.

Note 3.—Guidance material on the use of SELCAL systems is contained in Attachment D to Part I.

X — Note 4.—The tones Red P, Red Q, Red R, and Red S, are applicable after 1 September 1985, in accordance with 4.8.2.

X — 4.8.2 As from 1 September 1985, aeronautical stations which are required to communicate with SELCAL-equipped aircraft shall have SELCAL encoders in accordance with the red group in the Table of Tone Frequencies of 4.8.1. After 1 September 1985, SELCAL codes using the tones RED P, RED Q, RED R, and RED S may be assigned.

Relevant existing text of Annex 10 Volume I as amended by Amendment No. 62 (1)	Action Recommended (2)
3.1.2.5 The use of classes of emission [A7J and A9J] shall be subject to the following provisions of Appendix 27 Aer2:	J7B and J9B
27/11 For radiotelephone emissions the audio frequencies will be limited to between 300 and 2 700 Hz and the occupied bandwidth of other authorized emissions will not exceed the upper limit of [A3J] emissions. In specifying these limits, however, no restriction in their extension is implied in so far as emissions other than [A3J] are concerned, provided that the limits of unwanted emissions are met (see Nos. 27/66B and 27/66C).	J3E J3E
27/11B On account of the possibility of interference, a given channel should not be used in the same allotment area for radiotelephony and data transmissions.	
27/12 The use of channels derived from the frequencies indicated in 27/16 for the various classes of emissions other than [A3J and A2H] will be subject to special arrangements by the administrations concerned and affected in order to avoid harmful interference which may result from the simultaneous use of the same channel for several classes of emission.	J3E and H2B
Chapter 4.—Utilization of Frequencies above 30 MHz	
4.1.—Utilization in the Band 117.975 - 136 MHz	4.1 Utilization in the Band 117.975 - 137 MHz
Introduction	
ITU Radio Conferences subsequent to 1947 also made provisions for the use of the band 132 - 136 MHz for the Aeronautical Mobile (R) Service under conditions which vary for the different ITU Regions, countries or combination of countries. The utilization of this band has been included in the Allotment Table in this Chapter; however, it should be kept in mind that the use of frequencies of the band 132 - 136 MHz must take account of the conditions contained in the notes against this band in the ITU Allocation Table. X	The ITU Radio Conference (1979) made provisions for the use of the band 136-137 MHz by the aeronautical mobile (R) service, subject to conditions of No. 595 of the Radio Regulations.
X	In the utilization of these bands, States' attention is drawn to the possibility of harmful radio interference from non-aeronautical sources of radio frequency energy and the need to take appropriate measures to minimize its effects.
Preface	

Relevant existing text of Annex 10 Volume I as amended by Amendment No. 62 (1)	Action Recommended (2)
4.1.1.—GENERAL ALLOTMENT OF FREQUENCY BAND 117.975-136 MHz	4.1.1 - General allotment of Frequency Band 117.975 - 137 MHz
Note.—The plan includes a general Allotment Table that subdivides the complete band 117.975-136 MHz, the chief subdivisions being the bands of frequencies allocated to both national and international services, and the bands allocated to national services. Observance of this general subdivision should keep to a minimum the problem of co-ordinating national and international application.	137 MHz,
The block allotment of the frequency band 117.975-136 MHz shall be as shown in the following table (*see* box on page 78).	137 MHz
×	In the case of the new band 136 - 137 MHz, international applications have not yet been agreed, and these frequencies should be brought into use on a regional basis where and in the manner required.

Relevant existing text of Annex 10 Volume I as amended by Amendment No. 62 (1)	Action Recommended (2)

ALLOTMENT TABLE (see 4.1.1)

Block allotment of frequencies (MHz)	World-wide utilization	Remarks
a) 118 to 121.4 inclusive	International and National Aeronautical Mobile Services	Specific international allotments will be determined in the light of regional agreement. National assignments are covered by the provisions in 4.1.5.10.
b) 121.5	Emergency frequency	In order to provide a guard band for the protection of the aeronautical emergency frequency, the nearest assignable frequencies on either side of 121.5 MHz are 121.4 MHz and 121.6 MHz, except that by regional agreement it may be decided that the nearest assignable frequencies are 121.3 MHz and 121.7 MHz.
c) 121.6 to 121.975 inclusive	International and National aerodrome surface communications	Reserved for ground movement, pre-flight checking, air traffic services clearances, and associated operations.
d) 122 to 123.05 inclusive	National Aeronautical Mobile Services	Reserved for national allotments.
e) 123.1	Auxiliary frequency SAR	See 4.1.4.1
f) 123.15 to 123.675	National Aeronautical Mobile Service	Reserved for national allotments.
g) 123.7 to 129.675 inclusive	International and National Aeronautical Mobile Services	Specific international allotments will be determined in the light of regional agreement. National assignments are covered by the provisions in 4.1.5.10.
h) 129.7 to 130.875 inclusive	National Aeronautical Mobile Services	Reserved for national allotments but may be used in whole or in part, subject to regional agreement, to meet the requirements mentioned in 4.1.8.1.3.
i) 130.9 to 135.975 inclusive	International and National Aeronautical Mobile Services	Specific international allotments will be determined in the light of regional agreement. National assignments are covered by the provisions in 4.1.5.10. (See remark in the Introduction to Chapter 4 regarding the band 132 – 136 MHz.)

Action Recommended for i):

i) 130.9-136.975 inclusive	no change	Specific international allotments will be determined in the light of regional agreement. National assignments are covered by the provisions in 4.1.5.10. (See remark in the Introduction to Chapter 4 regarding the band 132-137 MHz.)

Relevant existing text of Annex 10, Vol. I as amended by Amendment 62 (1)	Action Recommended (2)

ANNEX 10 - VOLUME I

PART II. - RADIO FREQUENCIES

Chapter 4.—Utilization of Frequencies above 30 MHz

....

4.1.2.4 In the band 117.975 - [136] MHz, the lowest assignable frequency shall be 118 MHz and the highest [135.975] MHz.	137 136.975
4.1.3.—FREQUENCIES USED FOR PARTICULAR FUNCTIONS	
4.1.3.1 *Emergency channel.*	
4.1.3.1.1 The emergency channel (121.5 MHz) shall be used only for genuine emergency purposes, as broadly outlined in the following:	
....	
f) to provide a frequency channel for use in the event of interception of aircraft.	
Note 1.—The use of the frequency 121.5 MHz for the purpose outlined in c) above is to be avoided if it interferes in any way with the efficient handling of distress traffic.	
Note 2.—The current Radio Regulations make provisions that the aeronautical emergency frequency 121.5 MHz may also be used by mobile stations of the Maritime Mobile Service, using [A3] emission to communicate on this frequency for safety purposes with stations of the Aeronautical Mobile Service [(RR 3572/273, 6651A/968 and 6652/969).]	A3E (RR593, 2990, and 2991).

Relevant existing text of Annex 10, Vol. I as amended by Amendment 62 (1)	Action Recommended (2)
....	
4.1.3.1.4 The emergency channel shall be guarded continuously during the hours of service of the units at which it is installed.	
4.1.3.1.5 The emergency channel shall be guarded on a single channel simplex operation basis.	
X	4.1.3.2 <u>Air-to-air communications channel</u> 4.1.3.2.1 Subject to regional air navigation agreement, an air-to-air VHF communications channel shall be designated to enable aircraft engaged in flights over remote and oceanic areas out of range of VHF ground stations to exchange necessary operational information and to facilitate the resolution of operational problems. <u>Note</u>: The assignment of the frequency to be used for the VHF air-to-air communications channel is intended to be co-ordinated whenever necessary between adjacent regions to ensure the most efficient and safe utilization of VHF frequencies.
....	
4.1.6.—EQUIPMENT REQUIREMENTS *Note 1.—Frequency tolerances to which stations operating in the aeronautical mobile band (117.975-136 MHz) must conform are contained in Appendix 3 to the Radio Regulations. Tolerances for transmitters used for aeronautical services are not mentioned in Annex 10, except in those cases where tighter tolerances than those contained in the Radio Regulations are required (e.g. the equipment specifications in Part I contain several such instances).*	137
....	
4.1.8.—PLAN FOR THE ALLOTMENT OF SPECIFIC VHF RADIO FREQUENCIES FOR USE IN THE INTERNATIONAL AERONAUTICAL MOBILE SERVICE	Plan of Assignable VHF Radio Frequencies for Use in the International Aeronautical Mobile Service
Introduction ***This plan designates the list of frequencies available for assignment, together with provision for the use by the International Aeronautical Mobile Service of all frequencies with a channel spacing of 25 kHz, with the frequencies in Group A continuing to be used wherever they provide a sufficient number to meet the operational requirements.*** ***The plan provides that the total number of frequencies required in any region would be determined regionally: The effect of this will be that frequencies assignable in a particular region may be restricted to a limited number of the frequencies in the list, the actual number being selected as outlined herein.***	

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Relevant existing text of Annex 10 Volume I as amended by Amendment No. 62 (1)	Action Recommended (2)
. . . .	
Group B of the list at 4.1.8.1.2 contains the frequencies in the band 117.975 – 132 MHz ending in 50 kHz. Together with the frequencies in Group A, they provide for frequency planning based on 50 kHz channel spacing. In Group C are listed the frequency channels in the band 132 – 136 MHz based upon 50 kHz channel spacing. Group D contains the frequency channels in the band 132 – 136 MHz ending in 25 kHz, and Group E similarly lists the frequency channels in the band 117.975 – 132 MHz. The utilization of the channels in Groups B, C, D and E is explained below.	137 (for "136" in the band 132 – 136 MHz, Group C); 137 (for "136" in the band 132 – 136 MHz, Group D)
Whenever the number of frequencies required in a particular region exceeds the number in Group A, frequencies may be selected from the other Groups taking into account the provisions of 4.1.8.1 with respect to the use of channels based on 25 kHz channel spacing and, with regard to the band 132 – 136 MHz, the provisions of the Radio Regulations (see Introduction to 4.1.). Although for Groups B, C, D and E a preferred order of selection is not indicated, regional planning may require a particular selection of frequencies from these Groups in order to cater for specific regional circumstances. This may apply particularly to the utilization of frequencies from the band 132 – 136 MHz for reasons of available airborne equipment and/or availability of particular frequency channels for the Aeronautical Mobile (R) Service. It may also be found that, in a particular region, it is desirable to select frequencies from Group B first, before selecting frequencies from Groups C, D or E.	137 (for "136" in the band 132 – 136 MHz, provisions of the Radio Regulations); 137 (for "136" in the band 132 – 136 MHz, available airborne equipment)
In many regions particular frequencies have already been assigned for particular functions as, for instance, aerodrome or approach control. The plan does not make such assignments (except in respect to the emergency channel and ground service frequencies), such action being taken regionally if considered desirable.	
4.1.8.1 The frequencies in the band 117.975 MHz to 136 MHz for use in the International Aeronautical Mobile Service shall be selected from the list in 4.1.8.1.2.	
X	Note.-Frequencies between 136 and 136.975 MHz are not available for international use before 1990. (insert at X)

Relevant existing text of Annex 10 Volume I as amended by Amendment No. 62 (1)	Action Recommended (2)

GROUP D

Frequency (MHz)	Frequency (MHz)	Frequency (MHz)
132.025	133.375	134.725
132.075	133.425	134.775
132.125	133.475	134.825
132.175	133.525	134.875
132.225	133.575	134.925
132.275	133.625	134.975
132.325	133.675	135.025
132.375	133.725	135.075
132.425	133.775	135.125
132.475	133.825	135.175
132.525	133.875	135.225
132.575	133.925	135.275
132.625	133.975	135.325
132.675	134.025	135.375
132.725	134.075	135.425
132.775	134.125	135.475
132.825	134.175	135.525
132.875	134.225	135.575
132.925	134.275	135.625
132.975	134.325	135.675
133.025	134.375	135.725
133.075	134.425	135.775
133.125	134.475	135.825
133.175	134.525	135.875
133.225	134.575	135.925
133.275	134.625	135.975
133.325	134.675	

X

GROUP D (Continued)

136.000	136.325	136.650
136.025	136.350	136.675
136.050	136.375	136.700
136.075	136.400	136.725
136.100	136.425	136.750
136.125	136.450	136.775
136.150	136.475	136.800
136.175	136.500	136.825
136.200	136.525	136.850
136.225	136.550	136.875
136.250	136.575	136.900
136.275	136.600	136.925
136.300	136.625	136.950
		136.975

Note.-Frequencies between 136 and 136.975 MHz are not available for international use before 1990.

GROUP E

Frequency (MHz)	Frequency (MHz)	Frequency (MHz)
118.025	118.575	119.125
118.075	118.625	119.175
118.125	118.675	119.225
118.175	118.725	119.275
118.225	118.775	119.325
118.275	118.825	119.375
118.325	118.875	119.425
118.375	118.925	119.475
118.425	118.975	119.525
118.475	119.025	119.575
118.525	119.075	119.625

APPENDIX 2
BIBLIOGRAPHY

2.1 Bibliography

The following is a list of AEEC Letters associated with the preparation of ARINC Characteristic 716.

AEEC Letter No.	Date	Subject
78-041/VHFC-10	April 3, 1978	Circulation of Collins Strawman Spec for a new VHF Com Transceiver
78-089/VHFC-11	August 8, 1978	Circulation of Draft 1 of Project Paper 716 VHF Communications Transceiver
78-107/VHFC-12	August 29, 1978	Circulation of Letters from Douglas Aircraft and Dorne & Margolin, Inc., concerning VHF COMM Project Paper Draft
78-157/VHFC-13	November 16, 1978	Circulation of Comments on Draft 1 of VHF COMM Project Paper 716
79-001/VHFC-14	January 2, 1979	VHF COMM Transceiver Audio Output Phase Shift
79-008/VHFC-15	January 23, 1979	Adoption of Draft 1 of Project Paper 716, "VHF Communications Transceiver"
80-015/VHFC-16	January 18, 1980	Circulation of Draft 1 of Supplement 2 to ARINC Characteristic 716 "Airborne VHF Communications Receiver"
80-040/VHFC-17	March 18, 1980	Circulation of Draft 2 to ARINC Characteristic 716 "Airborne VHF Communications Receiver"
80-083/VHFC-18	July 2, 1980	Adoption of Draft 2 of Supplement 2 to ARINC Characteristic 716, "Airborne VHF Communications Receiver
81-048/VHFC-19	June 8, 1981	Circulation of Draft 1 of Supplement 3 to ARINC 716
81-065/VHFC-20	July 17, 1981	Circulation of Draft 1 of Supplement 4 to ARINC Characteristic 716, "Airborne VHF Communications Receiver"
82-028/VHFC-21	May 3, 1982	Circulation of Draft 1 of Supplement 5 to ARINC Characteristic 566A, "Mark 3 VHF Communications Transceiver"

APPENDIX 3
FREQUENCY-CHANNEL PAIRING PLAN

ç-9

Frequency (MHz)	Channel Spacing (kHz)	Channel Name	Labels Transmitted	ARINC 429 Word Content
118.0000	25	118.000	030	18.000
118.0000	8.33	118.005	047	18.000
118.0083	8.33	118.010	047	18.008
118.0166	8.33	118.015	047	18.017
118.0250	25	118.020	030	18.025
118.0250	8.33	118.030	047	18.025
118.0333	8.33	118.035	047	18.033
118.0416	8.33	118.040	047	18.042
118.0500	25	118.050	030	18.050
118.0500	8.33	118.055	047	18.050
118.0583	8.33	118.060	047	18.058
118.0666	8.33	118.065	047	18.067
118.0750	25	118.070	030	18.075
118.0750	8.33	118.080	047	18.075
118.0833	8.33	118.085	047	18.083
118.0916	8.33	118.090	047	18.092
118.1000	25	118.100	030	18.100
e.t.c				

NOTE: This table is provided for the reader's convenience. ICAO Annex 10 to the convention on International Civil Aviation "International Standards and Recommended Practices, Aeronautical Telecommunications" has precedence.

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Supplement 1

to

ARINC CHARACTERISTIC 716

AIRBORNE VHF COMMUNICATIONS TRANSCEIVER

Published: December 31, 1979

Prepared by the Airlines Electronic Engineering Committee

Adopted by the Airlines Electronic Engineering Committee: August 30, 1979

A. PURPOSE OF THIS SUPPLEMENT

This Supplement modifies Characteristic 716 material on the subjects of remote squelch, master off-on control and integral lighting power. Additionally, typographical errors are corrected and minor editorial changes are made to improve clarity.

B. ORGANIZATION OF THIS SUPPLEMENT

The first part of this document, printed on buff-colored paper, contains descriptions of the changes introduced into the Characteristic by this Supplement, and, where appropriate, extracts from the original text for comparison purposes. The second part consists of replacement white pages for the Characteristic, modified to reflect these changes. The modified and added material on each replacement page is identified with "¢-1" symbols in the margins. Existing copies of Characteristic 716 may be updated by simply inserting the replacement white pages where necessary and destroying the pages they replace. The buff-colored pages should be inserted inside the rear cover of the Characteristic.

Copies of the Characteristic bearing the number 716-1 already contain this Supplement and thus do not require revision by the reader.

C. CHANGES TO CHARACTERISTIC 716 INTRODUCED BY THIS SUPPLEMENT

This section presents a complete tabulation of the changes and additions to the Characteristic introduced by this Supplement. Each change or addition is identified by the section number and title that will be employed when the Supplement is eventually incorporated. In each case there is included a brief description of the addition or change and, for other than very minor revisions, any text originally contained in the Characteristic is reproduced for reference.

TABLE OF CONTENTS

Typographical error corrected.

2.2.1 TRANSCEIVER UNIT

The word "mass" changed to "weight".

Text revised in third paragraph to redefine provision for protective cover.

ORIGINAL TEXT FOLLOWS

2.2.1 Transceiver Unit

The Transceiver should comply with the dimensional standards in ARINC Specification 600, "Air Transport Avionics Equipment Interfaces (NIC Phase 1)", for the 3 MCU form factor. The Transceiver should also comply with ARINC 600 standards in respect of mass, racking attachments, front and rear projections and cooling.

The Transceiver should be provided with a low insertion force, size 1 shell ARINC 600 service connector. This connection, which should accomodate service interconnections in its middle insert (MP), automatic test equipment interconnections in its top insert (TP) and coaxial and power interconnections in its bottom insert (BP), should be located on the center grid of the receiver's rear panel. Index pin code 04 should be used.

The ATE interconnection insert (TP) will not be included in the mating half of the connector installed in the aircraft since ATE interconnections are employed in the bench testing of the receiver only. The aperture for this insert in the aircraft-mounted connector half should be provided with a protective cover to prevent contamination of the contacts in the equipment half during the time the receiver is installed in the aircraft. Further guidance on the ATE interface will be found in Chapter 5 of this document.

3.2 FREQUENCY SELECTION

Typographical error corrected and reference to data output deleted.

Text added to describe continued operation of receiver with a failure of the tuning source.

3.6.5.4 DISTORTION

Output signal level changed from 200 milliwatts to 50 milliwatts.

ORIGINAL TEXT FOLLOWS

3.6.5.4 Distortion

With an input signal of 1000 microvolts modulated with 1000 Hz and the receiver gain adjusted to produce 200 milliwatts into a 600 ohm resistive load, the total harmonic distortion should not exceed 7.5% with 30% modulation or 20% with 90% modulation (with the gain control reset to maintain the output at 50 milliwatts), including any effects of the noise limiter.

3.6.5.6 Short Circuit Protection

New section added.

3.6.7.1 AGC VERSUS PLUS INTERFERENCE

Typographical error corrected in title.

3.7.1 POWER OUTPUT

Power of 25 watts nominal changed to cover a range of 25 to 40 watts.

ORIGINAL TEXT FOLLOWS

3.7.1 Power Output

When operated at rated input power, the Transceiver carrier power output measured into a 52 ohm resistive load at the end of a 5 ft. transmission line should be 25 Watts (nominal) on any operating frequency. The transmitter should be capable of continuous operation with ARINC 600 cooling air. The transmitter should be designed to operate with a 52 ohm transmission line terminated in its characteristic impedance. The rf power output should be within the range of 25 to 40 watts.

3.7.7 KEY LINE

Voice/Data Select pin MPB8 changed to MPC7.

3.7.8.2 LEVEL CONTROL

Paragraph reference changed from 3.5.8.1 to 3.7.8.1.

ATTACHMENT 2 - STANDARD INTERWIRING

Pin assignments changed for control panel connector.

Pins MPA3, MPB3 and MPC3 change to "Optional" status for remote squelch.

Pin MPD8 assigned to "Data Keyline Return".

In Note 1: pin MPC1 change to MPA9
pin MPC2 changed to MPB9
pin MPC3 changed to MPC9

In Note 4: reference to On/Off control deleted.

In Note 5: pin MPD1 changed to MPB1.

Note 6 added to describe Wire I-R.

ATTACHMENT 6 - STANDARD "FOUR-WIRE" MICROPHONE INTERFACE

Interface revised.

ATTACHMENT 7 - CONTROL PANEL GUIDELINES

Standard connector used.

Master off/on control deleted.

Integral control panel lighting power changed from 26 volts to 5 VAC.

ORIGINAL TEXT FOLLOWS

1.3 Connector Types

The "Standard Control Panel" should utilize two Cannon type DC 37P connectors (or equivalent) positioned on the vertical center line of the unit. The connector mounting panel should be 4.000 inches from the rear face of the fron panes as shown in Attachment 8.

1.5 Master Off-On Control

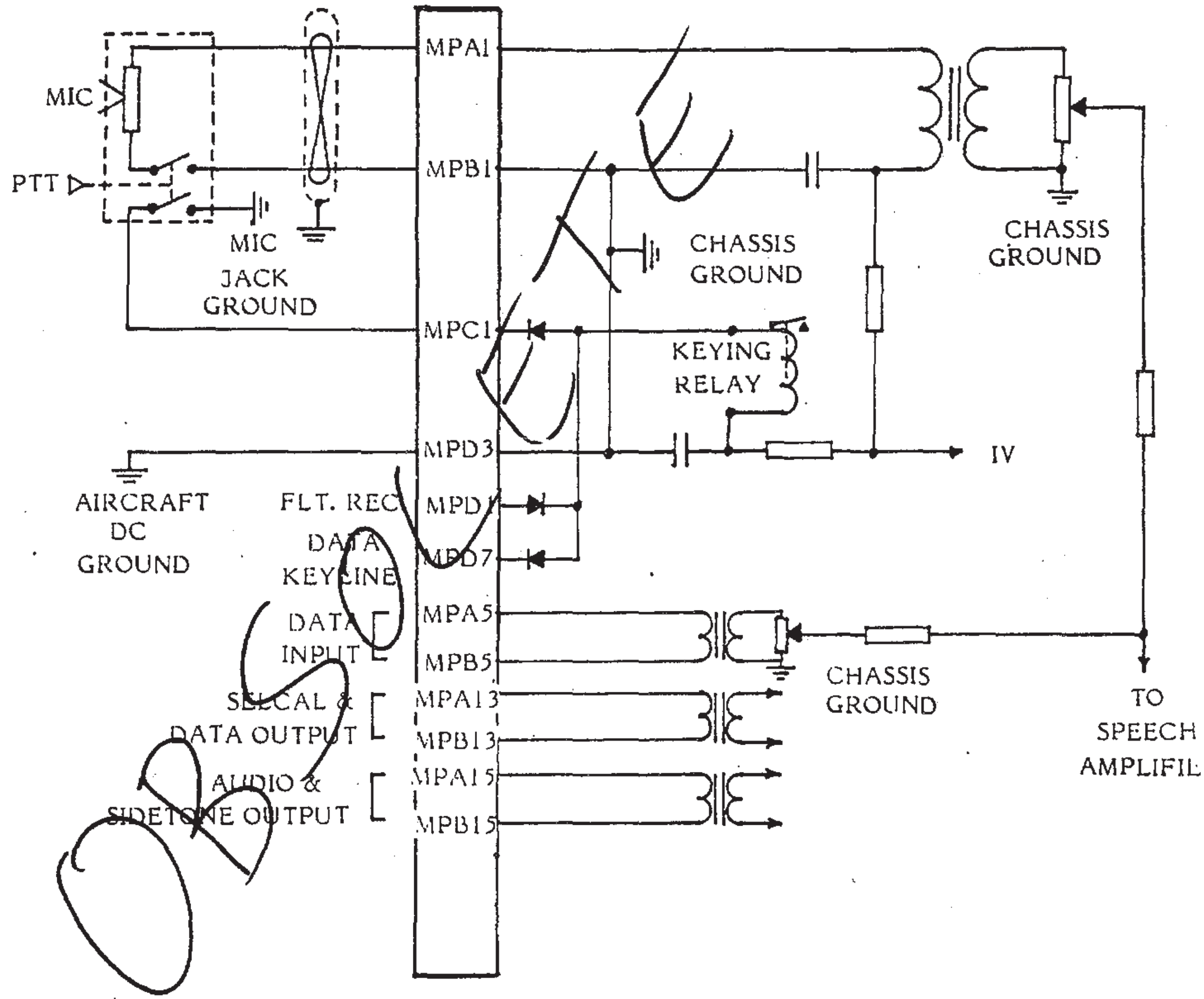
Some customers will desire a master off-on switch for controlling primary power to the VHF transceiver. This should consist of a single pair of contacts, arranged either as a separate switch or ganged with the audio volume control, as the customer may choose, to energize the airframe-mounted switching function described in Section 2.4.2 of this Characteristic.

1.6 Integral Lighting

Integral control panel lighting should be provided utilizing 26 VAC power, of 26 VDC power if special circumstances should dictate a customer's choice of this power. The control panel lighting circuit should be isolated from ground and other circuitry within the control panel. The control of these lights will be dictated by the user's requirements and the controlling power circuits will be external, in most cases, from the radio control panel. Tha lighting should properly illuminate the control marking and the positions of all controls. Provisions should be made for either red or white lighting at the user's option. The airline customers prefer internal lighting of the frequency selector drums or discs instead of surface lighting.

ORIGINAL SCHEMATIC

ATTACHMENT 6
STANDARD "FOUR-WIRE" MICROPHONE INTERFACE



NOTE: A diode is used in series with keying relay to prevent sneak current from the data link (also required in the data link)

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SUPPLEMENT 2

TO

ARINC CHARACTERISTIC 716

AIRBORNE VHF COMMUNICATIONS RECEIVER

Published: August 15, 1980

Prepared by the Airlines Electronic Engineering Committee

Adopted by the Airlines Electronic Engineering Committee: June 19, 1980

A. PURPOSE OF THIS SUPPLEMENT

This Supplement introduces a change to frequency response, a modification to the key event, an increase in control panel depth, a revision of the four-wire microphone schematic and change of the audio output levels.

B. ORGANIZATION OF THIS SUPPLEMENT

The first part of this document, printed on buff-colored paper, contains descriptions of the changes introduced into the Characteristic by this Supplement, and, where appropriate, extracts from the original text for comparison purposes. The second part consists of replacement white pages for the Characteristic, modified to reflect these changes. The modified and added material on each replacement page is identified with "¢-2" symbols in the margins. Existing copies of Characteristic 716 may be updated by simply inserting the replacement white pages where necessary and destroying the pages they replace. The buff-colored pages should be inserted inside the rear cover of the Characteristic.

Copies of the Characteristic bearing the number 716-2 already contain this Supplement and thus do not require revisions by the reader.

C. CHANGES TO CHARACTERISTIC 716 INTRODUCED BY THIS SUPPLEMENT

This section presents a complete tabulation of the changes and additions to the Characteristic introduced by this Supplement. Each change or addition is entitled by the section number and title currently employed in the Characteristic, or by the section number and title that will be employed when the Supplement is eventually incorporated. In each case there is included a brief description of the addition or change and, for other than very minor revisions, any text originally contained in the Characteristic is reproduced for reference.

3.4 TRANSMITTER FREQUENCY OFFSET

Text modified.

ORIGINAL TEXT FOLLOWS:

3.4 Transmitter Frequency Offset

The transceiver should be capable of double-channel operation, i.e., transmitting on a frequency higher by some whole number of megahertz than that on which it is receiving. Sufficient flexibility should be provided to permit the same or a different value for this offset to be selected for each whole megahertz of receiving frequency.

Double-channel operation should be effected by the grounding of the "Transmitter Frequency Offset" wire, either at the control panel or elsewhere.

3.4 Transmitter Frequency Offset (cont'd)

COMMENTARY

The amount of separation of transmit and receive frequencies that might be employed in communications systems of the future has not yet been determined. It is assumed that once they are established, however, offset values will be subject to no more than very infrequent change. It is anticipated, therefore, that offset selection for each receive frequency will be made within the transceiver by reference to a hard-wired program.

3.6.5 AUDIO OUTPUT

Text changed to incorporate RTCA SC-132 values.

ARINC STAFF NOTE deleted.

ORIGINAL TEXT FOLLOWS:

3.6.5 Audio Output

An output isolated from ground having a source impedance of 50 ohm or less shall be provided for voice communication output. A service control should be provided within the transceiver for adjustment of the output level. The adjustment should vary the output from 5mW to 50mW.

ARINC STAFF NOTE: During the discussion of the items incorporated into this Characteristic, AEEC called for the audio output standards specified herein to be in consonance with the audio system minimum operational standards being developed by RTCA Special Committee 132. This RTCA work was not complete as of the publication date of this document. Accordingly, manufacturers and users should expect a Supplement to this Characteristic at some time in the future to amend the numbers specified in the sub-parts of this Section.

3.6.5.1 GAIN

Audio output reference changed for 50mW to 40mW.

ORIGINAL TEXT FOLLOWS:

3.6.5.1 Gain

The receiver gain should be such that a 2 microvolt signal modulated 30% at 1000 Hz will produce at least 50 mW of output into a 600 ± 20% ohm resistive load.

3.6.5.3 FREQUENCY RESPONSE

Output level variation limit modified.

ORIGINAL TEXT FOLLOWS:

3.6.5.3 Frequency Response

The audio power output level should not vary more than 2 dB over the frequency range 300 Hz to 2500 Hz with respect to a reference level of up to 10 milliwatts established at 1000 Hz with a constant input carrier level modulated 30%. A sharp cut-off in response below 300 Hz and above 2500 Hz is desirable. Frequencies above 3750 Hz should be attenuated at least 20 dB and preferably 40 dB.

3.6.5.4 DISTORTION

Audio output reference changed from 50mW to 40mW.

ORIGINAL TEXT FOLLOWS:

3.6.5.4 Distortion

With an input signal of 1000 microvolts modulated with 1000 Hz and the receiver gain adjusted to produce 50 milliwatts into a 600 ohm resistive load, the total harmonic distortion should not exceed 7.5% with 30% modulation or 20% with 90% modulation (with the gain control reset to maintain the output at 50 milliwatts), including any effects of the noise limiter.

3.6.5.5 VOICE PHASE SHIFT UNIT

Audio output reference changed from 50mW to 40mW.

ORIGINAL TEXT FOLLOWS:

3.6.5.5 Voice Phase Shift Limit

With 1000 uV modulated with 1000 Hz and the output level adjusted for 50 mW into a 600 ohm resistive load, the audio output phase should not depart from that of the positive going modulation envelope at the receiver input by more than -30 degrees or +120 degrees.

COMMENTARY

The phase shift limits of the audio output are different from those of data/SELCAL output due to the number of stages required for the processing of each signal type.

3.7.3 SIDETONE

Audio output reference changed from 50mW to 40mW.

A nominal setting of 10mW inserted.

ORIGINAL TEXT FOLLOWS:

3.7.3 Sidetone

The sidetone output (shared with the audio output) should have a source impedance of less than 50 ohms, and should provide an output level of 50 mW into a 600 ±20% ohm resistive load when the transmitter is amplitude modulated 90% at 1000 Hz. A service adjustment independent of the receiver audio output service adjustment shall be provided to adjust the output level. The adjustment shall provide for a variation from 5 mW to 50 mW. The RF power required to operate the sidetone should be obtained from a source as close as practical to the transmitter power output connection.

3.7.7 KEYLINE

Typographical error omitting a line corrected.

ORIGINAL TEXT FOLLOWS:

3.7.7 Key Line

The transmitter PTT keyline (MPC1) should be enabled only when the transceiver is in the Voice mode, i.e., Voice/Data Select pin MPC7 is open circuit (50K ohms or greater). The transmitter data keyline (MPD7) should be enabled only when in the Data mode, i.e., Voice/Data Select pin MPC7 is externally grounded (± 3V).

The transmitter should be keyed (key down) when a resistance of 60 ohms or less to ground or a positive voltage of between 0 and 3 VDC from an external source is applied to the key line PTT pin MPC1 (in Voice mode), or to the data key line pin MPD7 (in Data mode).

The transmitter should not be keyed (key up) when 50K to 31 VDC from an external source is applied to the key line PTT pin MPC1 and data key line pin MPD7.

The transmitter should not be damaged by inadvertent application of up to -35 VDC from an external source to the key line.

5.4 USE OF ATLAS LANGUAGE

Reference changed to ARINC Specification 616.

ORIGINAL TEXT FOLLOWS:

5.4 Use of ATLAS Language

Equipment of manufacturers should note that the airlines desire to have VHF Transceiver test procedures intended for execution by automatic test equipment written in the ATLAS Language described in IEEE Standard 416-1976.

ATTACHMENT 2 - STANDARD INTERWIRING

Pin MPC8 assigned to "Frequency Offset Enable".

"Not Assigned" spares assigned.

Note ⟨7⟩ added.

ATTACHMENT 6 - STANDARD "FOUR-WIRE" MICROPHONE INTERFACE

Diode arrangement changed for flight recorder discrete (key event).

"VOICE/DATA SELECT" connection shown.

Ground connection added.

Note on single-ended input added.

ACARS interface added.

ATTACHMENT 7 - CONTROL PANEL GUIDELINES

1.3 CONNECTOR TYPES

Panel depth increased to five inches.

ORIGINAL TEXT FOLLOWS:

1.3 Connector Types

The "Standard Control Panel" should utilize a MIL-C-83723, Series 3-type connector (M83723-72R1624N) positioned at the center of the unit. The connector mounting panel should be 4.000 inches from the rear face of the front panel as shown in Figure 1.

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SUPPLEMENT 3

TO

ARINC CHARACTERISTIC 716

AIRBORNE VHF COMMUNICATIONS TRANSCEIVER

Published: September 25, 1981

Prepared by the Airlines Electronic Engineering Committee

Adopted by the Airlines Electronic Engineering Committee: September 1, 1981

A. PURPOSE OF THIS SUPPLEMENT

This Supplement introduces a new pin assignment of an air/ground discrete.

B. ORGANIZATION OF THIS SUPPLEMENT

The first part of this document, printed on buff-colored paper, contains descriptions of the changes introduced into the Characteristic by this Supplement, and, where appropriate, extracts from the original text for comparison purposes. The second part consists of replacement white pages for the Characteristic, modified to reflect these changes. The modified and added material on each replacement page is identified with "¢-3" symbols in the margins. Existing copies of Characteristic 716 may be updated by simply inserting the replacement white pages where necessary and destroying the pages they replace. The buff-colored pages should be inserted inside the rear cover of the Characteristic.

Copies of the Characteristic bearing the number 716-3 already contain this Supplement and thus do not require revisions by the reader.

C. CHANGES TO CHARACTERISTIC 716 INTRODUCED BY THIS SUPPLEMENT

This section presents a complete tabulation of the changes and additions to the Characteristic introduced by this Supplement. Each change or addition is entitled by the section number and title currently employed in the Characteristic, or by the section number and title that will be employed when the Supplement is eventually incorporated. In each case there is included a brief description of the addition or change and, for other than very minor revisions, any text originally contained in the Characteristic is reproduced for reference.

ATTACHMENT 2 - STANDARD INTERWIRING

Pin MPB14 changed from "Future Spare (Contact)" to "Ground/Air Discrete".

Note ⟨8⟩ added.

AERONAUTICAL RADIO, INC.
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SUPPLEMENT 4

TO

ARINC CHARACTERISTIC 716

AIRBORNE VHF COMMUNICATIONS RECEIVER

Published: January 15, 1982

Prepared by the Airlines Electronic Engineering Committee

Adopted by the Airlines Electronic Engineering Committee: December 9, 1981

A. PURPOSE OF THIS SUPPLEMENT

This Supplement introduces pin assignments for microphone grounding provisions and revised cooling.

B. ORGANIZATION OF THIS SUPPLEMENT

The first part of this document, printed on buff-colored paper, contains descriptions of the changes introduced into the Characteristic by this Supplement, and, where appropriate, extracts from the original text for comparison purposes. The second part consists of replacement white pages for the Characteristic, modified to reflect these changes. The modified and added material on each replacement page is identified with "¢-4" symbols in the margins. Existing copies of Characteristic 716 may be updated by simply inserting the replacement white pages where necessary and destroying the pages they replace. The buff-colored pages should be inserted inside the rear cover of the Characteristic.

Copies of the Characteristic bearing the number 716-4 already contain this Supplement and thus do not require revisions by the reader.

C. CHANGES TO CHARACTERISTIC 716 INTRODUCED BY THIS SUPPLEMENT

This section presents a complete tabulation of the changes and additions to the Characteristic introduced by this Supplement. Each change or addition is entitled by the section number and title currently employed in the Characteristic, or by the section number and title that will be employed when the Supplement is eventually incorporated. In each case there is included a brief description of the addition or change and, for other than very minor revisions, any text originally contained in the Characteristic is reproduced for reference.

2.6 Cooling

Maximum power dissipation and cooling reduced.

ORIGINAL TEXT FOLLOWS:

2.6 Cooling

The VHF Transceiver should be designed to accept, and airframe manufacturers should configure the installation to provide forced air cooling as defined in ARINC Specification 600. The standard installation should provide an air flow rate of 33.0 Kg/hr of 40°C air and the unit should not dissipate more than 150 watts of energy during continuous transmission. The coolant air pressure drop through the equipment should be 5 ± 3 mm at standard conditions of 1013.25 mbars. This pressure drop does not include the drop through a returning orifice when such orifice is located external to the equipment case.

2.6 Cooling (cont'd)

COMMENTARY

Equipment failures in aircraft due to inadequate thermal management have plagued the airlines for many years. In Section 3.5 of ARINC Specification 600 they have written down everything they believe airframe and equipment suppliers need to know to prevent such problems in the future. They regard this material as "required reading" for all potential suppliers of VHF Transceivers and aircraft installations.

ATTACHMENT 2 - STANDARD INTERWIRING

Pin MPB2 assigned to "Mike Input (Gnd)."

Pin MPB4 assigned to "Audio Ground."

Note ⟨8⟩ added to describe use of pins MPB2 and MPB4.

ATTACHMENT 6 - STANDARD "FOUR-WIRE" MICROPHONE INTERFACE

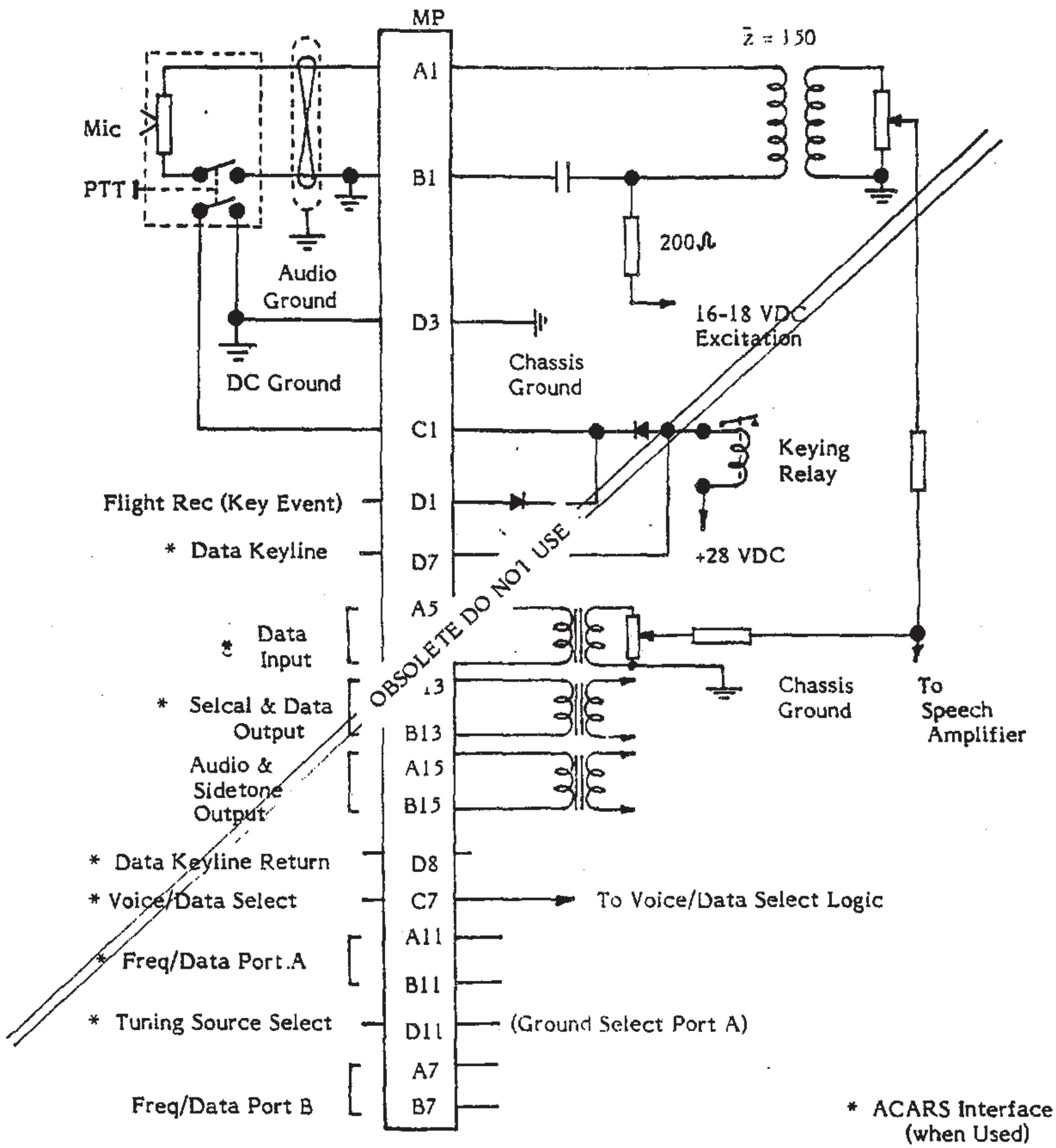
Pins MPB2 and MPB4 added.

Ground removed from pin MPB1.

ORIGINAL

ATTACHMENT 6

STANDARD "FOUR-WIRE" MICROPHONE INTERFACE



NOTES:

1. A diode is used in series with keying relay to prevent sneak current from the data link (also required in the data link).
2. A single-ended audio input may be used provided that the input impedance between pins MPA1 and MPB1 is 150 Ω.

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AERONAUTICAL RADIO, INC.
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AMENDMENT TO

SUPPLEMENT 4

TO

ARINC CHARACTERISTIC 716

AIRBORNE VHF COMMUNICATIONS RECEIVER

Published: March 26, 1982

Prepared by the Airlines Electronic Engineering Committee

Adopted by the Airlines Electronic Engineering Committee: December 9, 1981

A. PURPOSE OF THIS SUPPLEMENT

This Supplement re-introduces into the Characteristic material originally incorporated by Supplement No. 3 that was inadvertently omitted from the replacement white pages furnished with Supplement No. 4.

B. ORGANIZATION OF THIS SUPPLEMENT

The first part of this document, printed on buff-colored paper, contains descriptions of the changes introduced into the Characteristic by this Supplement, and, where appropriate, extracts from the original text for comparison purposes. The second part consists of replacement white pages for the Characteristic, modified to reflect these changes. The modified and added material on each replacement page is identified with "¢-4" symbols in the margins. Existing copies of Characteristic 716 may be updated by simply inserting the replacement white pages where necessary and destroying the pages they replace. The buff-colored pages should be inserted inside the rear cover of the Characteristic.

Copies of the Characteristic bearing the number 716-4 already contain this Supplement and thus do not require revisions by the reader.

C. CHANGES TO CHARACTERISTIC 716 INTRODUCED BY THIS SUPPLEMENT

This section presents a complete tabulation of the changes and additions to the Characteristic introduced by this Supplement. Each change or addition is entitled by the section number and title currently employed in the Characteristic, or by the section number and title that will be employed when the Supplement is eventually incorporated. In each case there is included a brief description of the addition or change and, for other than very minor revisions, any text originally contained in the Characteristic is reproduced for reference.

ATTACHMENT 2 - STANDARD INTERWIRING

Note ⟨8⟩ of Supplement 3 added.

Note ⟨8⟩ of Supplement 4 changed to Note ⟨9⟩.

Assigment of pin MPB14 to "Ground/Air Discrete" added (from Supplement 3).

AERONAUTICAL RADIO, INC.
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SUPPLEMENT 5

TO

ARINC CHARACTERISTIC 716

AIRBORNE VHF COMMUNICATIONS RECEIVER

Published: December 22, 1982

Prepared by the Airlines Electronic Engineering Committee

Adopted by the Airlines Electronic Engineering Committee: November 4, 1982

A. PURPOSE OF THIS SUPPLEMENT

This Supplement reserves pins on the VHF Communications Control Panel to control tests of static displays and transfer light annunciation. In addition, the frequency coverage has been changed to 118.000 to 137.000 MHz.

B. ORGANIZATION OF THIS SUPPLEMENT

The first part of this document, printed on buff-colored paper, contains descriptions of the changes introduced into the Characteristic by this Supplement, and, where appropriate, extracts from the original text for comparison purposes. The second part consists of replacement white pages for the Characteristic, modified to reflect these changes. The modified and added material on each replacement page is identified with "¢-5" symbols in the margins. Existing copies of Characteristic 716 may be updated by simply inserting the replacement white pages where necessary and destroying the pages they replace. The buff-colored pages should be inserted inside the rear cover of the Characteristic.

Copies of the Characteristic bearing the number 716-5 already contain this Supplement and thus do not require revisions by the reader.

C. CHANGES TO CHARACTERISTIC 716 INTRODUCED BY THIS SUPPLEMENT

This section presents a complete tabulation of the changes and additions to the Characteristic introduced by this Supplement. Each change or addition is entitled by the section number and title currently employed in the Characteristic, or by the section number and title that will be employed when the Supplement is eventually incorporated. In each case there is included a brief description of the addition or change and, for other than very minor revisions, any text originally contained in the Characteristic is reproduced for reference.

3.1 Frequency Range and Channeling

Revise to increase coverage to 137.000 MHz, delete reference to potential use of 137-138 MHz, and revise Commentary.

ORIGINAL TEXT FOLLOWS:

3.1 Frequency Range and Channeling

The transceiver should operate on a total of 720 channels spaced 25 KHz apart in the band 118.000 to 135.975 MHz. Channel changing time should not exceed 60 milliseconds.

The transceiver should also be capable of operating in the band 136 to 138 MHz when needed.

COMMENTARY

The capability for easy adaptation of the transceiver to operate in the band 136 to 138 MHz is desired as insurance for the future. Current U.S. aviation community thinking is that increased spectrum may be needed to accommodate future air-ground communications needs.

Attachment 2 - Standard Interwiring

Revise assignment of pins.

Pin	Old Assignment	New Assignment
20	Spare	Reserved - Transfer light annunciation -28 V. dimmable
23	Spare	Reserved - Test transfer light and static displays
3	Spare	Reserved
4	Spare	Reserved

Attachment 2 Notes Applicable to the Standard Interwiring

Add Note 10 on use of control panel pins reserved for transfer light annunciation and lamp tests.

Add Note 11 to reserve control panel pins 3 and 4 to protect against possible future non-interchangeability problems resulting from their reported non-coordinated use in some aircraft.

AERONAUTICAL RADIO, INC.
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AMENDMENT TO

SUPPLEMENT 5

TO

ARINC CHARACTERISTIC 716

AIRBORNE VHF COMMUNICATIONS RECEIVER

Published: February 16, 1983

Prepared by the Airlines Electronic Engineering Committee

Adopted by the Airlines Electronic Engineering Committee: November 4, 1982

A. PURPOSE OF THIS SUPPLEMENT

This Amendment corrects the erroneous duplication of assignments for control panel pins 3 and 4 in Supplement 5. These pins were correctly assigned "Reserved" status in Supplement 5 but their previous assignments as "Suggested Spares" were not deleted.

B. ORGANIZATION OF THIS SUPPLEMENT

The first part of this document, printed on buff-colored paper, contains descriptions of the changes introduced into the Characteristic by this Supplement, and, where appropriate, extracts from the original text for comparison purposes. The second part consists of replacement white pages for the Characteristic, modified to reflect these changes. The modified and added material on each replacement page is identified with "¢-5" symbols in the margins. Existing copies of Characteristic 716 may be updated by simply inserting the replacement white pages where necessary and destroying the pages they replace. The buff-colored pages should be inserted inside the rear cover of the Characteristic.

C. CHANGES TO CHARACTERISTIC 716 INTRODUCED BY THIS SUPPLEMENT

This section presents a complete tabulation of the changes and additions to the Characteristic introduced by this Supplement. Each change or addition is entitled by the section number and title currently employed in the Characteristic, or by the section number and title that will be employed when the Supplement is eventually incorporated. In each case there is included a brief description of the addition or change and, for other than very minor revisions, any text originally contained in the Characteristic is reproduced for reference.

Attachment 2 - Standard Interwiring

Delete references to assignment of control panel pins 3 and 4 as "Suggested Spares". Pins are now assigned "Reserved" status.

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SUPPLEMENT 6

TO

ARINC CHARACTERISTIC 716

AIRBORNE VHF COMMUNICATIONS RECEIVER

Published: December 7, 1983

Prepared by the Airlines Electronic Engineering Committee

Adopted by the Airlines Electronic Engineering Committee: October 12, 1983

A. PURPOSE OF THIS SUPPLEMENT

This Supplement introduces a detailed description of Built-In Test Equipment (BITE) and text addressing recognition of the SDI bits on ARINC 429 inputs. It also revises the desensitization and interference rejection characteristics of the VHF Communications receiver, and adds an attachment with "Assumed Test Procedures", providing guidelines for the bench testing of those parameters. In addition, it revises portions of the audio output characteristics to bring them in line with RTCA Document DO-170, Audio System Characteristics and Minimum Performance Standards and revises the standard "four-wire" microphone interface to incorporate the provisions for Single Point Audio System Earth (SPASE) concept. It also revises the status of the SDI bits from "reserved" to "standard".

B. ORGANIZATION OF THIS SUPPLEMENT

The first part of this document, printed on buff-colored paper, contains descriptions of the changes introduced into the Characteristic by this Supplement, and, where appropriate, extracts from the original text for comparison purposes. The second part consists of replacement white pages for the Characteristic, modified to reflect these changes. The modified and added material on each replacement page is identified with "¢-6" symbols in the margins. Existing copies of Characteristic 716 may be updated by simply inserting the replacement white pages where necessary and destroying the pages they replace. The buff-colored pages should be inserted inside the rear cover of the Characteristic.

Copies of the Characteristic bearing the number 716-6 already contain this Supplement and thus do not require revisions by the reader.

C. CHANGES TO CHARACTERISTIC 716 INTRODUCED BY THIS SUPPLEMENT

This section presents a complete tabulation of the changes and additions to the Characteristic introduced by this Supplement. Each change or addition is entitled by the section number and title currently employed in the Characteristic, or by the section number and title that will be employed when the Supplement is eventually incorporated. In each case there is included a brief description of the addition or change and, for other than very minor revisions, any text originally contained in the Characteristic is reproduced for reference.

3.2 FREQUENCY SELECTION

Description of SDI code added.

ORIGINAL TEXT FOLLOWS:

3.2 Frequency Selection

The transceiver should be designed to utilize the serial digital frequency/function selection system described in ARINC Specification 720. Two serial digital data input ports should be provided, one labeled "Freq./Funct. Select Data Input Port A" and the other "Freq./Funct. Select Data Input Port B". (See Attachment 2 to this

3.2 Frequency Selection (cont'd)

ORIGINAL TEXT FOLLOWS:

document for the connector pin assignments.) The receiver should determine which of these ports should be open to admit data by reference to the binary state of the tuning data source selection discrete. It should respond to data delivered to the "A" port and ignore data delivered to the "B" port when the source selection discrete is in the "ground" state. It should respond to data delivered to the "B" port and ignore data delivered to the "A" port when the discrete is in the "open circuit" state. The "ground" state of the discrete is defined as a voltage between 0 and +3.5 VDC at the connector pin assigned to the discrete in Attachment 2. The maximum current flow in the discrete wire in this condition should not exceed 20 mA. The "open circuit" state is defined as a voltage greater than +18.5 VDC (+30 VDC maximum) at this pin or a resistance to DC ground from this pin of greater than 500,000 ohms.

When the transceiver is installed in an aircraft in which a dedicated control panel supplies tuning information, the data bus from that panel should be connected to the "B" port on the receiver. The "A" port and the source selection discrete are unused. When the receiver is installed in an aircraft in which a centralized radio management system is employed, its normal control source should be connected to the "A" port, its back-up source to the "B" port and the source selection discrete wired in the manner described in the radio management specification.

ARINC Specification 429, "Mark 33 Digital Information Transfer System (DITS)", defines the format of the serial digital tuning signal delivered to the transceiver and the word repetition rate (5 per second minimum). Should this rate fall below 5 per second (word removal from the bus signifies tuning information source failure), the word sign/status matrix indicates an invalid condition, or the word parity fail to be odd, the transceiver should remain tuned to and operate on the last valid frequency received.

3.6.5 Audio Output

Section revised to conform with RTCA DO-170, Audio System Characteristics and Minimum Performance Standards. Paragraphs renumbered.

ORIGINAL TEXT FOLLOWS:

3.6.5 Audio Output

An output isolated from ground having a source impedance of 20 ohms or less should be provided for voice communication output. A service control should be provided within the transceiver for adjustment of the output level. The adjustment should vary the output from 5mW to 40mW. The nominal setting should be 10mW at 1000 Hz.

3.6.5.1 Gain

The receiver gain should be such that a 2 microvolt signal modulated 30% at 1000 Hz will produce at least 40 mW of output into a 600 ± 20% ohm resistive load.

3.6.5.2 Hum Level

Hum and noise in the receiver output should be at least 40 dB below 10 milliwatts output with a 1000 microvolt 30% 1000 Hz modulated reference input.

3.6.5.3 Frequency Response

The audio power output level should not vary more than 6 dB over the frequency range 300 Hz to 2500 Hz with respect to a reference level of up to 10 milliwatts established at 1000 Hz with a constant input carrier level modulated 30%. A sharp cut-off in response below 300 Hz and above 2500 Hz is desirable. Frequencies above 3750 Hz should be attenuated at least 20 dB and preferably 40 dB.

3.6.5.4 Distortion

With an input signal of 1000 microvolts modulated with 1000 Hz and the receiver gain adjusted to produce 40 milliwatts into a 600 ohm resistive load, the total harmonic distortion should not exceed 7.5% with 30% modulation or 20% with 90% modulation (with the gain control reset to maintain the output at 40 milliwatts), including any effects of the noise limiter.

3.6.5.5 Voice Phase Shift Limit

With 1000 uV modulated with 1000 Hz and the output level adjusted for 40 mW into a 600 ohm resistive load, the audio output phase should not depart from that of the positive going modulation envelope at the receiver input by more than -30 degrees or +120 degrees.

COMMENTARY

The phase shift limits of the audio output are different from those of data/SELCAL output due to the number of stages required for the processing of each signal type.

3.6.5.6 Short Circuit Protection

The transceiver should be able to endure an output short circuit and should operate normally after the removal of the short circuit.

3.6.7 Desensitization and Interference Rejection

Sections added to improve receiver performance in the presence of high power FM broadcast transmissions.

6.0 BUILT-IN TEST EQUIPMENT (BITE)

New section added.

ATTACHMENT 2 - NOTES APPLICABLE TO THE STANDARD INTERWIRING

SDI pin assignment revised from "reserved" to "assigned". Note 1 revised.

ORIGINAL TEXT FOLLOWS:

(1) Source/Destination Identifier (SDI) Encoding

These pins are reserved for encoding the location of the Comm receiver in the aircraft, (i.e., "system number") per Section 2.1.4 of ARINC Specification 429. If the SDI function is used, the following encoding scheme should be employed, the pins designated being either left open circuit or connected, on the aircraft-mounted half of the connector, to pin MPC9. The wiring of these pins should cause bit Nos. 9 and 10 of each digital word transmitted to the Comm Transceiver to take on the binary states defined in Specification 429. When the SDI function is not used, both pins

ATTACHMENT 2 - NOTES APPLICABLE TO THE STANDARD INTERWIRING (cont'd)

ORIGINAL TEXT FOLLOWS:

MPA9 and MPB9 should be left open circuit with the result that Bit Nos. 9 and 10 are binary "zeros."

Unit No.	Connector Pin MPA9	Connector Pin MPB9
1/2/3	Open	Open
1	Open	To MPC9
2	To MPC9	Open
3	To MPC9	To MPC9

Note 9 revised.

ORIGINAL TEXT AS FOLLOWS:

(9) 4-Wire Mike Grounding

Pin MPB2 is connected internally to pin MPB1. Pin MPB2 can be jumpered to pin MPB4 to obtain internal grounding of the microphone circuit or it may be connected to an external ground.

ATTACHMENT 6 - STANDARD "FOUR-WIRE" MICROPHONE INTERFACE

Drawing revised to make provisions for Single Point Audio System Earth (SPASE) concept.

ATTACHMENT 8 - ASSUMED TEST PROCEDURES, DESENSITIZATION AND INTERFERENCE REJECTION

Attachment added to reflect recommendations of the ICAO HIRSG.

ATTACHMENT 9 - TYPICAL TEST PROCEDURES, AUDIO OUTPUT

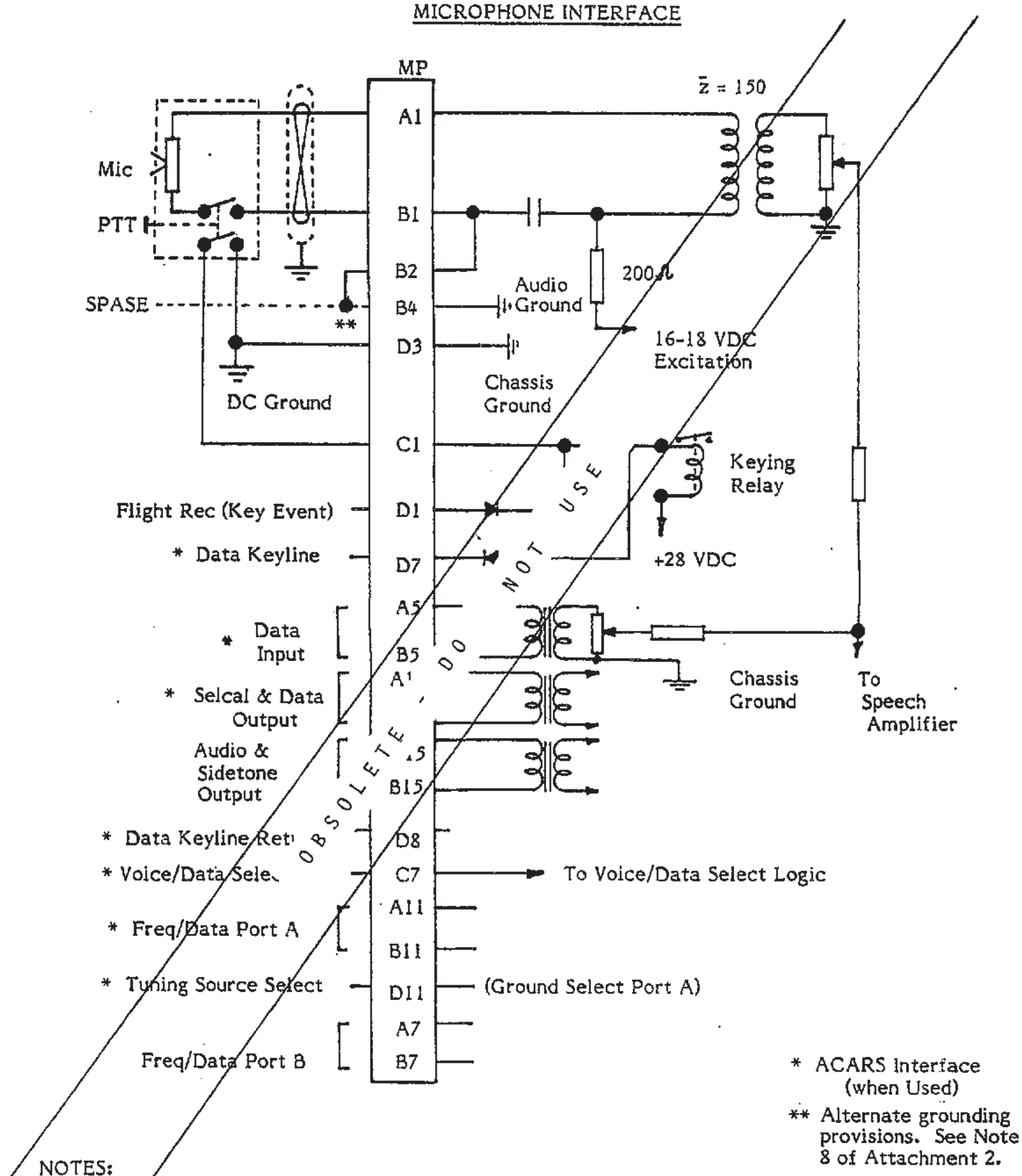
Attachment added to reflect revised audio output characteristics.

ORIGINAL FOLLOWS:

ATTACHMENT 6

STANDARD "FOUR-WIRE"

MICROPHONE INTERFACE



* ACARS Interface (when Used)

** Alternate grounding provisions. See Note 8 of Attachment 2.

NOTES:

1. A diode is used in series with keying relay to prevent sneak current from the data link (also required in the data link).
2. A single-ended audio input may be used provided that the input impedance between pins MPA1 and MPB1 is 150Ω.

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SUPPLEMENT 7

TO

ARINC CHARACTERISTIC 716

AIRBORNE VHF COMMUNICATIONS RECEIVER

Published: May 31, 1985

Prepared by the Airlines Electronic Engineering Committee

Adopted by the Airlines Electronic Engineering Committee: May 24, 1985

A. PURPOSE OF THIS SUPPLEMENT

This Supplement introduces a description of squelch operation in offset carrier environment.

B. ORGANIZATION OF THIS SUPPLEMENT

The first part of this document, printed on buff-colored paper, contains descriptions of the changes introduced into the Characteristic by this Supplement, and, where appropriate, extracts from the original text for comparison purposes. The second part consists of replacement white pages for the Characteristic, modified to reflect these changes. The modified and added material on each replacement page is identified with "¢-7" symbols in the margins. Existing copies of Characteristic 716 may be updated by simply inserting the replacement white pages where necessary and destroying the pages they replace. The buff-colored pages should be inserted inside the rear cover of the Characteristic.

Copies of the Characteristic bearing the number 716-7 already contain this Supplement and thus do not require revisions by the reader.

C. CHANGES TO CHARACTERISTIC 716 INTRODUCED BY THIS SUPPLEMENT

This section presents a complete tabulation of the changes and additions to the Characteristic introduced by this Supplement. Each change or addition is entitled by the section number and title currently employed in the Characteristic, or by the section number and title that will be employed when the Supplement is eventually incorporated. In each case there is included a brief description of the addition or change and, for other than very minor revisions, any text originally contained in the Characteristic is reproduced for reference.

3.6.8 Squelch Provisions

This addition describes proper squelch operation during reception of multiple signals from an offset carrier network.

SUPPLEMENT 8
ARINC CHARACTERISTIC 716©
AIRBORNE VHF COMMUNICATIONS TRANSCEIVER

Published: December 30, 1994

Prepared by the Airlines Electronic Engineering Committee

Specification 716 Adopted by the Airlines Electronic Engineering Committee: October 20, 1994

A. PURPOSE OF THIS SUPPLEMENT

This Supplement primarily introduces a new Section 4.0 for the description of an optional 8.33 kHz channel spaced DSB-AM VHF voice communications system. The 8.33 kHz channel-spaced mode of operation for voice communications, if implemented concurrently with the 25 kHz channel-spaced modes of operation, would require dual-bandwidth receivers to ensure inter-operability of the airborne transceivers with the current (25 kHz) and proposed European narrowband (8.33 kHz) VHF voice communications systems. The narrowband mode of operation is limited to voice communications.

B. ORGANIZATION OF THIS SUPPLEMENT

The first part of this document, printed on buff-colored paper, contains a list of changes being introduced into ARINC Characteristic 716 by Supplement 8. These pages should be inserted inside the rear cover of the Characteristic. The second part of this document, printed on white paper, consists of the replacement pages for Supplement 8. Changes introduced as a result of Supplement 8 are identified by a ¢-8 symbol in the margin. Existing copies of ARINC Characteristic 716 may be updated by simply replacing all of the Table of Contents and text pages for Sections 1 through 6 preceding Attachment 1 with Supplement 8 which includes all of the text for Sections 1 through 7. New Attachments 10, 11 and Appendix 3 should be inserted where appropriate.

C. CHANGES TO ARINC CHARACTERISTIC 716 INTRODUCED BY THIS SUPPLEMENT

This section presents a complete tabulation of the changes and additions to the Characteristic to be introduced by this Supplement. Each change or addition is defined by the section number and the title that will be employed when the Supplement is eventually incorporated. In each case a brief description of the change or addition is included.

1.1 Purpose of This Document

Text and commentary was added to indicate that Section 3.0 applies to the 25 kHz channel-spaced voice and data modes of operation and that Section 4.0 applies to an optional 8.33 kHz channel-spaced voice mode of operation.

2.2.1 Transceiver Unit

A reference to Chapter 5 was changed to Chapter 6.

2.2.3 Antennas

A reference to Section 4.0 was changed to Section 5.0.

4.0 TRANSCEIVER UNIT DESIGN FOR THE 8.33 KHZ CHANNEL-SPACED MODE OF OPERATION

A new section was added to define the transceiver characteristics of an optional 8.33 kHz channel-spaced voice mode of operation. The 8.33 kHz channel-spaced mode of operation for voice communications, if implemented concurrently with the 25 kHz channel-spaced modes of operation, would require dual-bandwidth receivers to ensure inter-operability of the airborne transceivers with the current (25 kHz) and proposed European narrowband (8.33 kHz) VHF voice communications systems. The narrowband mode of operation is limited to voice communications. The characteristics specified for the 8.33 kHz channel-spaced mode of operation are mainly the channeling, the frequency selection, the selectivity, the frequency stability, the frequency response, and the transmitter occupied spectrum.

5.0 ANTENNAS

This Section was formerly Section 4.0 and was re-numbered when the new Section 4.0 Transceiver Unit Design for the 8.33 kHz Channel-Spaced Mode of Operation was introduced.

6.0 AUTOMATIC TEST EQUIPMENT PROVISIONS

This Section was formerly Section 5.0 and was re-numbered when the new Section 4.0 Transceiver Unit Design for the 8.33 kHz Channel-Spaced Mode of Operation was introduced.

7.0 BUILT-IN-TEST EQUIPMENT (BITE)

This Section was formerly Section 6.0 and was re-numbered when the new Section 4.0 Transceiver Unit Design for the 8.33 kHz Channel-Spaced Mode of Operation was introduced.

ATTACHMENT 10 - RECEIVER SELECTIVITY

This is a new attachment containing the receiver selectivity for the 8.33 kHz channel-spaced mode of operation referenced in Section 4.0.

ATTACHMENT 11 - TRANSMITTER SPECTRUM MASK

This is a new attachment containing the Transmitter occupied spectrum for the 8.33 kHz channel-spaced mode of operation referenced in Section 4.0.

APPENDIX 3 - FREQUENCY CHANNEL PAIRING PLAN

This is a new appendix containing the frequency-channel pairing plan for 8.33 and 25 kHz spaced channels referenced in Section 4.1.

SUPPLEMENT 9
TO
ARINC CHARACTERISTIC 716©
AIRBORNE VHF COMMUNICATIONS TRANSCEIVER

Published: December 20, 1995

Adopted by the Airlines Electronic Engineering Committee: October 31, 1995

A. PURPOSE OF THIS SUPPLEMENT

This Supplement introduces clarification of the Tuning Control Panel operation with 8.33 kHz and 25 kHz channel spacing.

B. ORGANIZATION OF THIS SUPPLEMENT

The first part of this document, printed on buff-colored paper contains a list of changes introduced into Characteristic 716 by Supplement 9. The second part consists of replacement white pages for Characteristic 716, modified to reflect the changes. The modified and added material on each page is identified by a ¢-9 in the margins. Existing copies of ARINC Characteristic 716 may be updated by simply inserting the replacement white pages where necessary and discarding the pages they replace. The buff-colored pages are inserted inside the rear cover of the Characteristic.

C. CHANGES TO ARINC CHARACTERISTIC 716 INTRODUCED BY THIS SUPPLEMENT

This section presents a complete tabulation of the changes and additions to Characteristic 716 introduced by Supplement 9. Each change or addition is defined by the section number and the title currently employed in Characteristic 716. In each case a brief description of the change or addition is included.

4.2 Frequency Selection

Commentary was changed to clarify that the tuning control panel should scroll through both the 25 kHz and 8.33 kHz spaced channels.

4.2.1 Control Panel Programming

MPD5 was designated to be internally grounded to indicate if the transceiver is capable of operating in either of the 8.33 kHz or 25 kHz modes.

ATTACHMENT 2 - STANDARD INTERWIRING

MPD5 was changed from "reserved" to "8.33 kHz Program" and a new note 12 was added to refer to Section 4.2.1.

APPENDIX 3 - FREQUENCY-CHANNEL PAIRING PLAN

Replaced table. The new table contains two additional columns for "Labels Transmitted" and "ARINC 429 Word Content".