

ARINC

AIRBORNE HF/ SSB SYSTEM

ARINC CHARACTERISTIC 719-5

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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 foreign flag 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, nor 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.

TABLE OF CONTENTSARINC CHARACTERISTIC 719

<u>ITEM</u>	<u>SUBJECT</u>	<u>PAGE</u>
1.0	<u>INTRODUCTION AND DESCRIPTION</u>	1
1.1	Purpose of this Document	1
1.2	Function of Equipment	1
1.3	Unit Description	1
1.3.1	HF Transceiver Unit	1
1.3.2	Frequency Control	1
1.3.3	Antenna Tuner (With Self-Contained or Separate Antenna Tuner Control)	1
1.4	Interchangeability	1
1.4.1	General	1
1.4.2	Interchangeability Desired for the ARINC 719 HF Transceiver	1
1.4.3	"General Interchangeability" Considerations	1
1.5	Regulatory Approval	2
1.6	System Parameters	2
1.7	Additional Needs of Military Customers	2
2.0	<u>INTERCHANGEABILITY STANDARDS</u>	3
2.1	Introduction	3
2.2	Form Factors, Connectors & Index Pin Coding	3
2.2.1	Transceiver Unit	3
2.2.2	"Standard Control Panel"	3
2.2.3	Antennas and Antenna Tuners	3
2.3	Interwiring	3
2.4	Power Circuitry	4
2.4.1	Primary Power Input	4
2.4.2	Power Control Circuitry	4
2.4.3	The Common Ground	4
2.4.4	Internal Circuit Protection	4
2.4.5	Abnormal Power	4
2.5	Environmental Conditions	4
2.6	Cooling	4-5
2.7	Grounding and Bonding	5
3.0	<u>TRANSCEIVER UNIT DESIGN</u>	6
3.1	Frequency Range and Channeling	6
3.2	Frequency Selection	6
3.3	Transmit to Receive Recovery	6
3.4	Choice of Sideband	6
3.5	Transceiver Operation	6
3.5.1	Mode of Operation	6
3.5.2	Interlocks on Dual Systems	6
3.5.2.1	Tuning Interlock	6
3.5.2.2	Specific Provisions for Interlocking	6-7
3.6	Receiver Design	7
3.6.1	Sensitivity	7
3.6.2	Selectivity	7
3.6.2.1	AM-SSB Full Carrier	7
3.6.2.2	Suppressed Carrier SSB	7
3.6.3	Receiver Frequency Stability	7
3.6.4	Undesired Responses	7
3.6.5	Audio Output	7
3.6.5.1	Audio Source Impedance	7
3.6.5.2	Output Regulation	7
3.6.5.3	Gain	7
3.6.5.4	Hum Level	7
3.6.5.5	Frequency Response	7
3.6.5.6	Distortion	7A
3.6.5.7	Voice Phase Shift Limit	7A
3.6.6	Automatic Gain Control	8
3.6.7	RF Sensitivity Control and/or Squelch Control	8
3.6.8	Receiver SSB-Mode Linearity	8
3.6.8.1	Desired Signal Linearity	8
3.6.8.2	Interfering Signal Linearity	8
3.6.9	Tone Tuning Signal	8
3.6.10	SELCAL/Data Output	8
3.6.10.1	Frequency Response	8
3.6.10.2	Distortion	9
3.6.10.3	Phase Shift	9
3.6.10.3.1	SELCAL/Data Phase Shift	9
3.6.10.3.2	Differential Phase Delay	9

TABLE OF CONTENTS (cont'd)ARINC CHARACTERISTIC 719

<u>ITEM</u>	<u>SUBJECT</u>	<u>PAGE</u>
3.7	Transmitter Design	9
3.7.1	Power Output	9
3.7.1.1	Minimum Power Output with SSB Suppressed Carrier Operation	9
3.7.1.2	Minimum Power Output Full Carrier SSB Operation	9
3.7.1.3	Minimum Power Output with FSK or Data Transmission	9-10
3.7.1.4	Maximum Power Output Limit	10
3.7.2	Transmitter Frequency Stability	10
3.7.3	Sidetone	10
3.7.4	Microphone Input	11
3.7.4.1	Speech Processing and Automatic Modulation Limiting	11
3.7.4.2	Frequency Response and Spectrum Limits	11
3.7.4.3	Transmitter Distortion	12
3.8	Data Transmission and Reception	12
3.8.1	Background of Data Link	12
3.8.2	Data Link Audio Input to the Transmitter	12
3.8.3	Data Link Audio Input Frequency Response	12
3.8.4	Data Link Output from HF Receiver	12-13
3.8.4.1	Special "SELCAL Output" Circuit From HF AM Receiver Detector	13
3.9	Keyline	13
4.0	<u>ANTENNAS</u>	14
4.1	Antenna Tuner	14
4.2	Radio Frequency Input Characteristics	14
4.3	Automatic Control of SSB R/T Power Output	14
4.4	Antenna Impedance Characteristics and Frequency Coverage	14
4.5	Band Information	14
4.6	Power Handling Capability	14
4.7	Tuner Pressure Fault Line	14
5.0	<u>AUTOMATIC TEST EQUIPMENT PROVISIONS</u>	15
5.1	General	15
5.2	Unit Identification	15
5.3	Pin Allocation	15
5.4	Use of ATLAS Language	15
6.0	<u>BUILT-IN TEST EQUIPMENT (BITE)</u>	15A
6.1	Built-In Test Equipment (BITE)	15A
6.2	BITE Display	15A
6.3	Fault Monitor	15A
6.4	Self-Test Initiation	15A-15B
6.5	Monitor Memory Output	15B
<u>ATTACHMENTS</u>		
0	Notes Pertaining to Attachments	16-17
1	Standard Interwiring	18-19
2	Transceiver Unit Connector Positioning	20
3	Schematic of Audio Grounds and Use of 4-Wire Microphone (with system interlock relays)	21
4	Control Panel Wiring Using ARINC 429 Serial Digital Tuning	22
5	Antenna Tuner Pin Connections	23
6	SSB Receiver Selectivity	24
7	Environmental Test Categories	25
8	Control Panel Guidelines	26-27
9	Typical Test Procedures	27A
<u>APPENDICES</u>		
0	Guidelines for HF Antenna System Designers and Installers	28-57
1	Original "Assumed" Essential System Characteristics	58-63
2	Ground Equipment Requirements	64-67
3	Chronology and Bibliography of the AEEC SSB Project and Membership of The AEEC SSB Subcommittee	68-73
4	FCC Rule Making Related to SSB Equipment and the Type Acceptance of that Equipment	74-84
5	Reference Background Material on Spectrum Limitations and the Relation to the Implementation of SSB	85-94
6	Reference Background Material on the Effect of Frequency Translation Error on an SSB System Conforming with the Systems Standards of Appendix 1 and Utilizing Airborne Equipment Conforming to ARINC Characteristics 533 or 533A	95-121
7	Background and Analysis—Frequency Planning vs. Equipment Planning --1955-1971	122-125
8	Extracts from ICAO Annex 10	126-131
9	Bibliography	132

1.0 INTRODUCTION AND DESCRIPTION

1.1 Purpose of this Document

This document sets forth the desired characteristics of a new generation HF/SSB 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 HF Transceiver primarily for airline use. It will describe the desired operation capability of the equipment and the standard necessary to ensure interchangeability.

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. Their airline customers are interested primarily in the end result rather than the means employed to achieve it.

1.2 Function of Equipment

This Characteristic covers the requirements for an airborne transmitter-receiver equipment capable of transmitting and receiving HF radio intelligence in the following forms:

- (a) SSB-full carrier transmission of voice and tone signals and AM-double sideband reception.
- (b) SSB-suppressed carrier transmission and SSB-suppressed carrier reception of voice and other signals not critical of exact frequency synchronism.
- (c) Transmission and reception capabilities (using external coding and keying equipment which is not made a part of this Characteristic) for special data applications.

Although the HF/SSB System should contain the capabilities under (c) above, the external coding and keying equipment to operate with those capabilities is not detailed in this Equipment Characteristic, nor is it likely to be purchased by the customer at this time. The user desires the capabilities in the HF/SSB System to accommodate data transmission at a later date without subsequent modification.

Eventually this equipment will be used exclusively in a 3 kHz channel spaced HF/SSB frequency plan. However, full compatibility with the present International Telecommunications Union (ITU) and International Civil Aviation Organization (ICAO) AM frequency plan will be needed until the HF/SSB plan is implemented. Further the capability of transmitting and receiving full carrier transmission of tones (A2H) will continue to be needed with the future 3 kHz HF/SSB plan for the ICAO SELCAL service.

1.3 Unit Description

1.3.1 HF Transceiver Unit

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

1.3.2 Frequency Control

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

1.3.3 Antenna Tuner (With Self-Contained or Separate Antenna Tuner Control)

Although a suitable antenna Tuner and Tuner Control should be provided by the manufacturers supplying equipment to this Characteristic, the equipment manufacturer should also design his SSB equipment to work with existing automatic antenna tuner units of the type designed for SSB operation, and presently installed in many aircraft.

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 interchange-ability. 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 719 HF Transceiver

Unit interchangeability 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 should 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 HF 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 earlier generations of HF Communication equipment.

Unchanged, however, is the industry's traditional 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 interchangeability" (as best can be predicated) are included in this document to guide manufacturers in future developments.

1.0 INTRODUCTION AND DESCRIPTION (cont'd)**1.5 Regulatory Approval**

The equipment must meet all applicable FAA and GCC regulatory requirements. Manufacturers are urged to obtain all necessary information from the FAA and the FCC or 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 HF communications may be found in the Appendices to this Characteristic.

1.7 Additional Needs of Military Customers

Military users of airborne HF/SSB traditionally have had some additional needs that dictate features not desired by civil users. The most significant of these features are: extended frequency coverage, tenth-kHz channel selection and wide band transmitter/ receiver audio baseband.

Some military people confirmed these same features would continue to be needed in future equipment and designers might wish to include provisions in the equipment to satisfy a future military market. The civil users approved the addition of guidance material concerning these military needs for consideration by the equipment designers provided it is clearly understood the civil users are NOT prepared to accept increased costs (either initial or continuing ownership costs) simply to provide such features. Designers should note the marketplace will determine the extent to which provisions should be incorporated for these features.

Any consideration of Appendices 1 and 4 should take into account the planned use of such equipment by the military when operating in the Aeronautical Mobile R Service for an indefinite period of time after the planned 3 kHz spaced frequency plan is implemented.

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 HF 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 6 MCU form factor. The Transceiver should also comply with ARINC 600 standards in respect of weight, racking attachments, front and rear projections and cooling.

The Transceiver should be provided with a low insertion force, size 2 shell ARINC 600 service connector. This connector, 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 10 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 HF Transceiver unit only. This insert should be provided with a protective cover to prevent contamination of the contacts during the time the Transceiver is installed in the aircraft. Further guidance on the ATE interface will be found in Chapter 5 of this document.

2.2.2 "Standard Control Panel"

Frequency control of the ARINC 719 HF Transceiver is effected by means of facilities provided on a HF COMM control panel or 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 HF COMM control panel suitable for use with the ARINC 719 HF Transceiver may be found in Attachment 8 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.

2.2.2 "Standard Control Panel" (cont'd)

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 8 of this Characteristic and having form factor and connector functions as set forth therein. The standard interwiring is included in Attachment 1.

2.2.3 Antennas and Antenna Tuners

There are no specific form factors set forth herein for antennas or antenna tuners to be employed with this particular equipment as there are numerous designs presently on the market for the purpose. 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, the 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 and antenna tuners may be found in Section 4.0.

2.3 Interwiring

The standard interwiring to be installed for the HF COMM Transceiver is set forth in Attachment 1. 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.

The reader is also cautioned to give due consideration to the specific notes in Attachment 1 as they apply to the standard interwiring.

2.0 INTERCHANGEABILITY STANDARDS (cont'd)**2.4 Power Circuitry****2.4.1 Primary Power Input**

The HF Transceiver should be designed to use 115 VAC 400 Hz 3-phase 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 3- gang circuit breaker of the size shown in Attachment 1 should be provided in the standard installation.

2.4.2 Power Control Circuitry

The primary power to the HF transceiver should not normally be controlled by a master on/off switch. It should be noted that no on/off switches will be needed in most installations. A master on/off power switching capability should be provided as an option. When this option is selected, power input to the transceiver should be accomplished using the pins reserved for switched power.

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 the 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.

2.4.5 Abnormal Power

The SSB Equipment should accept power variations (refer to ARINC 413) without adverse effects upon equipment performance. The equipment should be of such design that it will not be damaged by power supply frequencies and/or voltages below the minimum specified operating voltage and frequency, and if operation is interrupted under these conditions, the equipment shall automatically resume normal operation when the frequency and/or voltage returns within limits. Set manufacturers should provide their own protection, wholly within the equipment against

2.4.5 Abnormal Power (cont'd)

the possibility of one of the three AC line circuits being interrupted by an aircraft electrical system power phase failure in the aircraft. The equipment should not be damaged in any way if one phase lead is opened and it is desirable that the equipment:

- (a) continue to operate at reduced power, or,
- (b) cease operating entirely, or,
- (c) malfunction in such a manner as to make it evident to the crew that such a failure has occurred, in order to guard against attempted continued operation which is not providing satisfactory communications.

2.5 Environmental Conditions

The HF 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 7 to this Characteristic tabulates the relevant environmental categories.

2.6 Cooling

The HF 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 57.2 Kg/hr of 40°C air and the unit should not dissipate more than 260 watts of energy during continuous transmission. The coolant air pressure drop through the equipment should be 25 ± 5 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 -3

The HF Transceiver should provide for blower control by use of pin MP3K. Grounding of this pin should disable the normal continuous operation of the blower.

NOTE: Manufacturers have stated that a 400W PEP output is within the "state-of-the-art" and may be implemented at the option of the user. Cooling provisions should be increased for the higher power radio. Based on a 540W power dissipation, the air flow rate should be increased to 120 Kg/hr. -C -3

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 HF Transceivers and aircraft installations. -C -3

2.0 INTERCHANGEABILITY STANDARDS (cont'd)**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**

- ④- 1- The transceiver should operate on frequencies spaced 1 kHz apart in the band 2.8 to 24 MHz. Channel changing time should not exceed 1 second.

COMMENTARY

Currently there is no airline requirement for the equipment to operate at 100 Hz channel spacing as does the military HF equipment for ease of modification to provide for the 100 Hz spacing if it were requested in the future by the airlines. The manufacturer, though, should take care in keeping the additional cost for the convertibility down to an absolute minimum in order not to lose marketability of a radio which selects frequencies in 1 kHz increments only. The same applies to the frequency range of the equipment. Some users may desire a range of 2.0 to 30 MHz. If the equipment were to operate over this range, then response, interference rejection, etc. specified for 2.8 to 24 MHz would also be applicable to the increased frequency range.

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 1 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 1. 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 (+36 VDC maximum) at this pin or a resistance to DC ground from this pin of greater than 100,000 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)", defined the format of the serial digital tuning signal delivered to the receiver and

3.2 Frequency Selection (cont'd)

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 indicate an invalid condition, or the word parity fail to be odd, the receiver should flag its own data outputs as invalid and remain tuned to the last valid frequency received.

NOTE: The re-entrant tuning capability should be provided as a option. Refer to ARINC 559A for details of implementation.

3.3 Transmit to Receive Recovery

With the receiver squelch set to operate at 3 uV, the receiver should recover after transmission to provide 90% of its output at an input level of 10 uV modulated 30% at 1000 Hz in less than 250 mS.

3.4 Choice of Sideband

As specified in further detail elsewhere in this Characteristic, this equipment should employ only the upper sideband for SSB operation and there is no requirement specified or implied herein for either transmission or reception of the lower sideband in either of the SSB modes. The frequency channel corresponding to the unused AM sideband will, in the due course of time, be utilized as a discrete SSB channel and with the carrier frequency so chosen as to permit upper sideband operation on that frequency channel.

3.5 Transceiver Operation**3.5.1 Mode of Operation**

The transceiver will not be required to operate in a double-channel mode. Operation in the simplex mode (receive and transmit on the same channel) should prove adequate for all anticipated uses.

3.5.2 Interlocks on Dual Systems**3.5.2.1 Tuning Interlock**

Each system should contain interlocking circuitry tailored to ensure satisfactory automatic tune-up when two systems are installed on the same airplane. The interlocking should be effective for all combinations and manipulations of the pilot's controls regardless of whether a common antenna or dual antennas are employed. When dual installations are used with automatic antenna tuning units, interlocking circuitry should be provided to prevent one system from being tuned or operated while the other system is in the self-tuning process. When one system is kept from tuning after channeling because the other unit is retuning, the system should be designed so that the one unit will automatically be retuned after the other has completed its retuning.

When one unit is removed or its power is shut off, the interlock system should not prevent the other system from operating or tuning. However, the design of interlocks should be such as to assure no simultaneous operations of two transmitters.

3.0 TRANSCEIVER UNIT DESIGN (cont'd)**3.5.2.2 Specific Provisions for Interlocking**

The typical interlock consists of bringing out both sides of the keying relay for use with an external interlock relay as shown in Attachment 3. With these provisions the installation designer can provide a dual system interlock as he may choose, utilizing external relays to provide the necessary interlock contacts that may be required. Such external relays as may be required to operate simultaneously with the R/T keying relay should not draw a total current of more than 0.25 amps at 27.5 VDC and they should be connected in parallel with the "keyline interlock" leads from the R/T Unit with due regard for the potential noise problems.

3.6 Receiver Design**3.6.1 Sensitivity**

With a 1 microvolt (hard) signal, the signal plus-noise-to-noise ratio should be 10 dB for SSB operation. With a 4 microvolt (hard) signal, amplitude modulated 30% at 1000 Hz, the signal-plus- noise-to-noise ratio should be 10 dB.

3.6.2 Selectivity**3.6.2.1 AM-SSB Full Carrier**

The bandwidth at the 6 dB down should be at least 5.5 kHz and the skirt bandwidth at 60 dB down should not exceed 12 kHz.

3.6.2.2 Suppressed Carrier SSB

Receiver selectivity should conform with Attachment 6.

3.6.3 Receiver Frequency Stability

The basic frequency stability of the receiver should not be more than 20 Hz difference between the actual transmitted and the receiver frequency, without regard to Doppler effects. This maximum frequency error of 20 Hz should be held under all environmental conditions for which the equipment is designed and should apply immediately after turn on.

Adjustments of the frequency to correct for slow random or non-random drifts should be required no more often than approximately every year (equivalent to a maximum of about 4,000 hours operating time).

The frequency reference means should be so designed as to facilitate shop adjustments of the frequency when required, and the set manufacturers should provide whatever facilities or special test equipment or procedural instructions are required to facilitate this checking as a routine shop operation.

There is no requirement, nor is it acceptable to include any pilot-operated or front panel adjustments of the frequency standard, or of any corrector circuits, to allow either pilot adjustment or line service adjustment of the basic frequencies using either WWV transmissions or other test facilities. All frequency adjustments are to be accomplished exclusively in the overhaul shop, and the design of the equipment should be such as to assure reliable and accurate frequency control in the equipment for the period between shop overhauls. It is acceptable, however, for means to be provided whereby qualified personnel may check the frequency accuracy of the equipment in the aircraft or in flight using WWV

transmissions, if the manufacturer so desires, however, no means are to be provided for correcting this error in flight or during line maintenance.

3.6.4 Undesired Responses

All spurious responses, including image, should be down at least 60 dB. All spurious responses within the frequency band of 2.8 to 24 MHz should be down at least 60 dB and preferably 80 dB.

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 5mW to 40mW into a $600 \pm 20\%$ ohm resistance load. The nominal setting should be 10mW 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 ohms 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 ohms 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

With the output signal adjusted to 10mW into 600 ohms at 1000 Hz, the output voltage should not change more than 2dBV when the load is varied between 450 ohms and 2,400 ohms and by not more than 6 dBV when the load is varied between 200 ohms and 20,000 ohms. 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 microvolt signal modulated 30% at 1000 Hz will produce at least 40 mW of output into a $600 \pm 20\%$ ohm resistive level.

3.6.5.4 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.

3.6.5.5 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.

3.0 TRANSCEIVER UNIT DESIGN (cont'd)**3.6.5.6 Distortion**

With an input signal of 1000 microvolts modulated with 1000 Hz and the receiver gain adjusted to produce 40 milliwatts into a 500 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.

3.6.5.7 Voice Phase Shift Limit

c- 5-

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.

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3.0 TRANSCEIVER UNIT DESIGN (cont'd)**3.6.6 Automatic Gain Control**

The receiver output should not vary more than 6 dB with input signals from 5 microvolts to 100,000 microvolts, and should not increase by more than 2 dB up to a 1 volt input level. 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. Recovery time should be approximately 0.5 seconds.

3.6.7 RF Sensitivity Control and/ or Squelch Control

Inasmuch as some customers will desire to use an RF Sensitivity Control while other customers will desire to use a squelch control instead of an RF sensitivity control, the receiver should be designed to operate with either one or the other as the external control. Both functions should be controlled by the R/T Control Data Bus provided as shown in the standard interwiring. Note that although the standard R/T Control Data Bus might permit both a squelch control and an RF sensitivity control to be employed at the panel, the set design need not permit operation of the receiver with both controls as it is not expected that both controls will be used in a particular aircraft installation. The user will determine which he wishes to employ in a particular aircraft, depending upon the mode of operation employed with the SSB equipment, and therefore, will decide whether a control panel containing a squelch control, or a control panel containing an RF sensitivity control will be utilized. The control panel should be so designed that a given R/T Unit will be capable of operation in one group of aircraft in an airline equipped with RF sensitivity controls and in another group of aircraft in that same airline equipped with squelch controls.

NOTE: When HF operation is employed under conditions where SELCAL is utilized it is generally deemed advisable to operate the HF equipment with the RF sensitivity at maximum so that SELCAL transmissions will always be received. Under these conditions, it is usually impractical for an aural monitor to be maintained on the circuit by the crew members because of the heavy noise level on the HF receiver. Thus, if this mode of operation is employed, it is extremely important that a highly satisfactory squelch system be incorporated in the HF equipment with provisions for manual control of the squelch threshold. In this case, the squelch threshold adjustment would apply only to the headphone output circuits and not the output circuits so that SELCAL reception will be at full sensitivity at all times, irrespective of the threshold sensitivity of the squelch circuit employed for the aural monitoring. Manufacturers should recognize the operational desire for a satisfactory squelch system and endeavor to meet customer's requirements.

The range of the RF sensitivity control, when utilized should be approximately 50 dB and should be essentially linear in dB per unit of angular rotation of the linear control. The range of the squelch control should be the minimum required to effect complete quieting of the receiver under the worst conditions

3.6.7 RF Sensitivity Control and/ or Squelch Control (cont'd)

of noise. The range of control provided for both RF sensitivity and squelch should be divided into a minimum of 16 increments by the R/T Control Data Bus Circuitry.

COMMENTARY

No word structure is currently defined for implementation of sensitivity or squelch control. It is envisaged that when the word(s) is defined, it will be available on the frequency selection bus, precluding the need for a separate input port.

3.6.8 Receiver SSB- Mode Linearity**3.6.8.1 Desired Signal Linearity**

With the Receiver in the SSB mode with any two-tone test signal corresponding to any signal level from threshold sensitivity to 20,000 microvolts, the intermodulation product (difference frequency of the two test tones) should be at least 40 and preferably 50 dB below the output of the two desired tones.

Furthermore, at signal levels up to 100,000 microvolts, the intermodulation product should be at least 30 dB below the output of the two desired tones.

3.6.8.2 Interfering Signal Linearity

With a 1200 Hz single tone SSB signal applied, having any level from threshold sensitivity level to 100,000 microvolts, and with an interfering carrier applied three kHz higher in frequency than the desired signal carrier frequency, it should be possible to increase the level of this interfering carrier to a level corresponding to at least 10,000 and preferably 100,000 microvolts before the 1800 Hz intermodulation product equals the level of the 1200 Hz desired signal output.

3.6.9 Tone Tuning Signal

A tuning tone signal should be generated within the R/T unit and should be mixed into the sidetone output channel at the appropriate level required. A service adjustment of this level is desirable within the R/T Unit. Within the R/T Unit the tone signal should be generated whenever tuning is in progress.

3.6.10 SELCAL/ Data Output

An output isolated from ground having a source impedance of 300 ohm 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.

3.6.10.1 Frequency Response

The total receiver frequency response should be such that no more than a 3 dB difference in levels occurs for any two SELCAL tones between 300 and 1500 Hz.

3.0 TRANSCEIVER UNIT DESIGN (cont'd)**3.6.10.2 Distortion**

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

3.6.10.3 Phase Shift

There should be no phase inversion through the receiver.

3.6.10.3.1 SELCAL/ Data Phase Shift

With 1000 uV modulated with 1000 Hz and the output level adjusted to 0.5V into 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 -90°.

COMMENTARY

The phase shifts 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.

3.6.10.3.2 Differential Phase Delay

The differential delay through the receiver to audio frequencies (f) from 300 Hz to 1.5 kHz should be less than 1/10f seconds.

3.7 Transmitter Design**3.7.1 Power Output**

Power output should be measured in terms of peak envelope power and measured directly in accordance with permissible distortion and spectrum limits with the two tones applied to the transmitter (rather than utilizing the method recommended by CCIR). Power output should be measured at nominal line voltage working into a 52 ohm resistive load at the end of a 5-foot RG-8U transmission line. A proportionate reduction of power output at the same distortion is permitted with reduced line voltage below the nominal down to the minus 10% line voltage limits.

The transmitter should be rated for continuous operation at 50% duty cycle of 5 minutes on (except as otherwise specified in the following subparagraphs) at 55 degrees C ambient temperature.

NOTE: Optional Minimum Output- Users recognize the power limitations of the solid-state RF amplifiers (at HF frequencies) available. Thus, the users will reluctantly accept, as a temporary expedient, the reduction in RF power output, as a manufacturers option, provided:

- A. The power output is not less than 200 Watts PEP, and
- B. The power output regulation with respect to the input power, environmental conditions and aging (maintenance run-down) will keep the output power up to 200 Watts PEP throughout the normal service life of the transmitter.

3.7.1 Power Output (cont'd)

Readers should note the need to recognize this option in interpreting other Sections of this Characteristic where it will be necessary to substitute "200 Watts PEP" for "400 Watts PEP" in applicable conditions.

COMMENTARY

During the development of ARINC 559A, 400W PEP could not be achieved using solid-state devices, therefore, a 200W PEP output was suggested in the spec. Many users have found the 200 watts of power to be adequate and now have no interest in the higher power. Current technology in solid-state final output stages will now permit a 400W PEP output. Some users are interested in the higher power and may elect to have the capability in their new radios. Manufacturers are urged to provide the 400W PEP output power as an option and should make known to the user the additional cooling required for that radio. (See Section 2.6).

Users recognize the need to use two or more solid-state devices in the transmitter final power amplifier due to limitations in the present state-of-the-art. They urge the designers to provide fully adequate protection from "ripple effect" failure modes where a failure of one component induces failures in other devices or components.

3.7.1.1 Minimum Power Output with SSB Suppressed Carrier Operation

The transmitter output should be 400 Watts PEP tested as specified above.

3.7.1.2 Minimum Power Output Full Carrier SSB Operation

The transmitter output should be at least 100 Watts carrier power with peak envelope power measured directly and without exceeding the distortion limits. If AM operations is provided by the manufacturer (instead of full carrier SSB), the transmitter should be capable of 100% modulation without exceeding the distortion limits or the spurious radiation limits. If full carrier SSB is provided by the manufacturer the transmitter should be capable of the equivalent of 100% modulation (sideband amplitude equal to carrier amplitude on peaks) without exceeding the distortion limits or the spurious radiation limits. The design of the transmitter should be such that 100% modulation or equivalent may be applied continuously at the duty cycle specified in this Characteristic.

NOTE: Full carrier single-sideband operation is some-times referred to as "AM Equivalent" or "AME".

3.7.1.3 Minimum Power Output with FSK or Data Transmission

When the input to the SSB equipment is in the form of an audio tone to provide the necessary single-sideband FSK transmission, or what would be the equivalent of CW operation on an offset frequency, the transmitter should provide a CW output power in accordance with the definitions and

3.0 TRANSCEIVER UNIT DESIGN (cont'd)**3.7.1.3 Minimum Power Output with FSK or Data Transmission (cont'd)**

methods specified above at a PEP of 400 Watts based on a duty cycle of one minute on and four minutes off, but with continuous operation at this duty cycle.

NOTE: It is recognized that with some designs of SSB transmitters it may not be possible to obtain 400 Watts PEP on a single frequency for data transmission even with the lowered duty cycle specified herein. Manufacturers should note, however, the desire of the user for the maximum practical CW power rating at this reduced duty cycle for data transmission and should endeavor to provide the above rating. If this is not practical, the manufacturer should provide the highest CW power rating that is practical for the circuit and devices employed, and should ensure that when the system is operated with the standard interwiring and control functions and with signal inputs on the data link audio input and with the pre-trigger signal applied, the transmitter configuration proper for the maximum CW power output should be established automatically. It is particularly important that there be no need for external adjustments or gain settings in the aircraft because of the lower CW power rating of such a transmitter.

3.7.1.4 Maximum Power Output Limit

The maximum power output of the transmitter under any of the modes of operation described above, should not, under any circumstances, exceed 650 watts PEP as an all-out maximum.

COMMENTARY

The purpose of this maximum power limitation is to provide guidance to antenna tuner unit manufacturers and airframe manufacturers so that they can be assured of the maximum limit on power which they will ever have to accommodate on an antenna tuner on a particular aircraft. For this purpose they are only interested in the maximum level that can ever occur under the worst possible combination of circumstances.

With the original Characteristic No. 533, no power maximum limit was established based on a previous decision by the airline industry that all antenna tuners should be designed with at least 1 kw PEP rating in the knowledge that this was the power level employed by earlier military SSB airborne equipment. With the advent of higher flying transport aircraft and with much greater problems of high voltage insulation on the antenna and in the antenna tuner, the airframe manufacturers asked the industry to determine the maximum power rating which would need to be accommodated in a transport aircraft and establish such a limit as an all-out maximum. Thus, based on a 400-watt transmitter which would never normally

3.7.1.4 Maximum Power Output Limit (cont'd)

exceed 450 watts under the usual operating conditions, a figure of 650 watts as set forth above has now been agreed to be the all-out maximum which must be accommodated for safety. The reason for choosing this value is that set manufacturers have pointed out that it is not economically practicable to critically control the power level of transmitters against line voltage changes and other circumstances and thus, a reasonable margin between the nominal power rating and the maximum all-out rating must be accepted.

3.7.2 Transmitter Frequency Stability

The basic frequency stability of the transmitter should not be more than 20 Hz difference between the actual transmitted and the carrier frequency, without regard to Doppler effects. This maximum frequency error of 20 Hz should be held under all environmental conditions for which the equipment is designed and should apply immediately after turn on.

Adjustments of the frequency to correct for slow random or non-random drifts should be required no more often than approximately every year (equivalent to a maximum of about 4,000 hours operating time).

The frequency reference means should be so designed as to facilitate shop adjustments of the frequency when required, and the set manufacturers should provide whatever facilities or special test equipment or procedural instructions are required to facilitate this checking as a routine shop operation.

There is no requirement, nor is it acceptable to include any pilot-operated or front panel adjustments of the frequency standard, or of any corrector circuits, to allow either pilot adjustment or line service adjustment of the line service adjustment of the basic frequencies using either WWV transmissions or other test facilities. All frequency adjustments are to be accomplished exclusively in the overhaul shop, and the design of the equipment should be such as to assure reliable and accurate frequency control in the equipment for the period between shop overhauls. It is acceptable, however, for a means to be provided whereby qualified personnel may check the frequency accuracy of the equipment in the aircraft or in flight using WWV transmissions, if the manufacturer so desires, however, no means are to be provided for correcting this error in flight or during line maintenance.

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 40mW into a $600 \pm 20\%$ 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 40 mW. The nominal setting should be 10mW RMS to 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.

3.0 TRANSCEIVER UNIT DESIGN (cont'd)

3.7.4 Microphone Input

The system should work with microphones designed as per ARINC 538A and ARINC 559A. Equipment manufacturers are encouraged to design microphone input-circuits in future equipment according to the following standards:

- (a) Excitation voltage: 16 VDC.
- (b) Filter-network resistance: 200 Ohms.
- (c) Load resistance: 150 Ohms.

3.7.4.1 Speech Processing and Automatic Modulation Limiting

It is desirable that some form of speech processing be included with sufficient extra gain, still meeting the microphone input level requirements of Section 3.7.4. Service adjustment provisions are to be included to allow setting the speech processing to the desired amount.

Whether or not speech processing is included, automatic modulation limiting should be provided such that when adjusted for proper input level as in Section 3.7.4, and with full rated PEP output as in Section 3.7.1, an increase of 10 dB in the steady-state input signal level should not result in spectrum output extending beyond the limits.

COMMENTARY

As explained in the note under Section 3.7.4 above, the foregoing specification requirements are for design purposes and have no relation to the adjustment procedures that will be employed in an actual operating environment.

Users stress the importance of speech processing especially in transmitters where the RF power output is limited to 200 Watts PEP as described in Section 3.7.1. In such equipment the designer should optimize the speech processing to compensate for the loss of communications effectiveness due to the reduction in RF power output. Hopefully, the new 200 Watt PEP transmitters will equal or exceed existing 400 Watt PEP (ARINC 533A) transmitters in providing effective communications.

3.7.4.2 Frequency Response and Spectrum Limits

NOTE: Notwithstanding the FCC, ITU, and ICAO regulatory standards for bandwidth, spectrum control and channel spacings, those standards were deliberately minimized because those Agencies knew the airborne hardware performance was controlled by the airline specification process to ensure future system compatibility as the evolutionary introduction of SSB makes more channels available.

The single most important performance feature to provide for the future and to ensure satisfactory operation when the other halves of the AM channels are employed for SSB is the transmitter spectrum control specified in this Section. The experts point out that (for HF operation) it is not receiver selectivity that sets the limitation on how

3.7.4.2 Frequency Response and Spectrum Limits (cont'd)

well a receiver rejects an adjacent channel: it is transmitter spectrum control (particularly the control of the third-order distortion) that determines how satisfactory the operation adjacent channels will be. But to make the spectrum control even more difficult (and more important!) the equipment must ensure satisfactory spectrum control with future channels spaced 3 kHz and with carriers (either transmitted or suppressed) spaced 3 kHz apart. The background of why this is necessary, and of extreme importance, is explained in Appendix 7, with additional technical detail in Appendix 5.

The overall frequency response measured from the microphone audio input should not vary more than ± 6 dB from the 1000 Hz reference level through the range of 350 Hz to 2500 Hz.

Suitable transmitter circuit filtering should be employed, and the linearity of the transmitter should be such, as to assure the following spectrum limits, when checked with a two-tone test on SSB-suppressed carrier or SSB-floating carrier transmission:

- (a) All spectrum components at a frequency lower in frequency than 100 Hz below the carrier frequency and higher in frequency than 2900 Hz above the carrier frequency should be attenuated by at least 30 dB.
- (b) All emissions lower in frequency than 3.1 kHz below the carrier frequency and higher in frequency than 5.9 kHz above the carrier frequency should be attenuated by at least 40 dB.
- (c) With the exception of emissions on a harmonic of the desired frequency all other spectrum components lower in frequency than 6.1kHz below the carrier frequency and higher in frequency than 8.9 kHz above the carrier frequency should be attenuated by at least 54 dB and preferably 60 dB or more.
- (d) Any emissions on a harmonic of the desired frequency should be down at least 43 dB below PEP (as measured in a 52 ohm load at the end of a 5-foot transmission line and connected to the output of the receiver-transmitter unit). All intermodulation distortion and spurious radiation should be at least 60 dB below PEP.

These requirements should be met with the introduction of any modulating tone or tones either inside or outside the transmitter frequency response bandwidth.

3.0 TRANSCEIVER UNIT DESIGN (cont'd)

3.7.4.3 Transmitter Distortion

With transmitter power output on single-sideband of 400 watts PEP and with sinusoidal modulating inputs the distortion as indicated on an external monitor detector should not exceed 10%.

With the sideband peak level equal to carrier level while employing sine wave input on SSB-full carrier transmission, the distortion as read on a linear monitor detector on the RF signal should not exceed 25% at the 400 watt PEP output level.

It is recognized that the spectrum performance characteristics of the transmitter set forth in Section 3.7.4.2 are far more stringent on the design of the transmitter and its linearity than is this requirement for distortion of the audio signal.

NOTE: In the event that a manufacturer chooses to exceed the specified power output specified under Section 3.7.1 or wishes to design an SSB System complying with ARINC Characteristic 719 in all respects except with a lesser rated power output than specified in Section 3.7.1, it should be understood that the transmitter distortion be within the limits as specified above and with spectrum limitations as set forth in Section 3.7.4.2 and with the automatic modulation limiting of Section 3.7.4.1, but with each of these test requirements modified watt figure specified under Section 3.7.1 of this Characteristic. In other words, it is not considered acceptable for a set manufacturer to rate his SSB equipment at a power rating based on a dummy load test of the equipment and then meet the requirements of spectrum and distortion at an entirely different power rating level. For purposes of this ARINC Characteristic, the power output rating of the equipment is considered to be than output at which the distortion and spectrum limitations specified herein can be met or exceeded.

Distortion should be measured at the 200 Watts PEP (rather than 400 Watts) level where the manufacturer has exercised his option to provide a reduced power output as described in Section 3.7.1.1.

3.8 Data Transmission and Reception

3.8.1 Background of Data Link

The users considered proposals to discontinue the long established industry practice of including actual circuitry and other hardware provisions for a future automatic data transmission system. They found sufficient industry interest in these features to justify the small increases in equipment complexity and cost due to these provisions. A detailed account of the background may be found in Section 6.1 of ARINC Characteristics 559A.

3.8.2 Data Link Audio Input to the Transmitter

A separate pair of transmitter audio input leads, labeled “data in-hot” and “data in-cold” should be provided, isolated from ground and from other internal circuitry for DC and having an input impedance preferably of 600 ohms, but acceptably of 100 ohms, and with sufficient gain provided to allow full modulation of the transmitter over the audio frequency range with not more than 1.6 volts RMS input at any frequency (1.0 volts RMS if a 100 ohm input is employed). A service adjustment should be provided independently of the microphone audio input to the transmitter to control the input level. No wave form processing should be provided on this input circuit, however, modulation limiting (similar to that for voice operation but with no clipping) should be provided so that with the service adjustment properly set initially, the input signal can be increased to a level of at least 10 dB and preferably 20 dB above the preset value without the transmitter exceeding the spectrum limits and without distortion of the tone data signals.

COMMENTARY

When operating in the suppressed carrier single-sideband mode (as would be normal for most applications with data transmission), it is expected that the actual keying of the transmitter will be effectively accomplished by the presence or absence of the data input tone signals. As explained in a subsequent Section of this Characteristic a “pre-trigger” signal, which will probably be an absolute necessity on VHF equipment, can be dispensed with by using the keying capabilities of the SSB transmitter from the introduction of tone signals, and which is a very practicable means of keying the transmitter quickly and easily for data transmission purposes. The only alternative to providing automatic keying operation of the transmitter by form of electronic keying in the “keyline” circuit as was provided in the earlier HF SSB equipment.

Obviously when full carrier single-sideband operation is employed, keying of the transmitter by turning on and off the data tone signal is not satisfactory, however, the industry has agreed that it is very unlikely that this equipment covered by ARINC Characteristic No. 719 would be used extensively in the full carrier SSB mode for data communication purposes.

3.8.3 Data Link Audio Input Frequency Response

The overall frequency response (as measured in Section 3.8.2 from the data link audio input) should not vary by more than ± 6 dB from the 1 kHz reference level over the frequency range of 350 to 2500 Hz.

3.8.4 Data Link Output from HF Receiver

An output circuit isolated from DC ground and having a source impedance of 100 ohms should be provided, which should supply an open circuit voltage output of 0.5 volts RMS with a receiver input signal either AME or SSB selected by the function and mode selector switch and at a level as specified in this Characteristic and should have a frequency response within ± 6 dB of the 1 kHz reference from 350 Hz to 2500 Hz.

3.0 TRANSCEIVER UNIT DESIGN (cont'd)**3.8.4 Data Link Output from HF Receiver (cont'd)**

Furthermore, for SELCAL tones over the frequency range of 300 Hz to 1500 Hz there should be no more than 6 dB difference between the responses at any two frequencies within this range.

This data link output should not pass through the noise limiter nor should it be affected by the squelch circuits (operation of the squelch to shut off the aural output of the receiver should not shut off the data link output circuit) and this output should be taken from which ever detector is being employed in accordance with the position of the mode switch at the time. Separate service adjustments to adjust the level of this output on each of the two modes should be provided, however, the setting of the control(s) should not affect the impedance or frequency characteristics of this output circuit.

3.8.4.1 Special "SELCAL Output" Circuit From HF AM Receiver Detector

SELCAL operation is an absolute necessity on HF communications circuits and yet SELCAL cannot operate effectively in the suppressed carrier single-sideband mode where reception is by means of locally inserted carrier (the frequency translation error is too great and would have to be reduced to less than one cycle to ensure reliable operation of SELCAL), and thus, SELCAL operation ground to air will always be conducted by means of a full carrier transmission from the ground and with reception in the air by means of an AM detector rather than by the SSB suppressed carrier means usually employing a product detector. Therefore, to ensure satisfactory SELCAL operation at all times regardless of the position of the function and mode selector switch the receiver should be designed in such a way that the AM detector with its associated carrier passband will always be operative regardless of the position of the mode selector switch and with this AM detector fed into a "SELCAL" output circuit having electrical characteristics identical with that of Section 3.8.4 except that it should not be switched from one detector to the other with the function selector switch, and with the output brought out on separate pins of the rear connector, and with its own service adjustment for setting the output level.

3.9 Keyline

c- 1- The transmitter PTT keyline (MPIC) should be enabled only when the transceiver is in the Voice mode, i.e., Voice/ Data Select Pin MP2D is open circuit. The transmitter data keyline (MP1K) should be enabled only when the transmitter is in the Data mode, i.e., Voice/ Data Select Pin MP2D is externally grounded.

4.0 ANTENNAS

4.1 Antenna Tuner

The Standard SSB interwiring in Attachment 1 shows connections to the "symbolic" antenna tuner leads designated by the letters (A) through (P), however, these do not represent any particular antenna tuner but merely the generic functions of essentially all tuners. Attachment 5 tabulates these symbolic function leads in terms of specific pin connections and connector types for various antenna tuners which are presently designed or implemented. Further guidance for antenna installations is provided in Appendix O.

4.2 Radio Frequency Input Characteristics

The antenna tuners should provide, in the order to be compatible with the SSB equipment covered by this Characteristic, a match from the antenna system to the 52 ohm (or 50 ohm) transmission line corresponding to a standing wave ratio of 1.3:1 or less.

NOTE: Some older antenna tuners which may be encountered in retrofit installations are reported to have a standing wave ratio as high as 1.6:1.

COMMENTARY

As the SSB equipment can only provide full power output capability when the antenna tuner SWR is kept low, it is naturally important from the user's standpoint to obtain the best possible SWR in the antenna tuner. Furthermore, with SSB equipment the set designer finds difficulty in automatically limiting the power output satisfactorily in all cases (as is necessary to keep the distortion and spurious transmitter output to the required figure) when the SWR is not held to the 1.3:1 figure. Thus, although in the practical case with long transmission lines, the SWR at the SSB transmitter may be somewhat lower than the SWR at the antenna tuner, the user cannot depend on this and he does not desire this, because this implies a lossy transmission line, which in turn represents a power loss which is equally unacceptable to the user. Accordingly, antenna tuner unit designers are strongly encouraged to provide the lowest possible standing wave ratio (even below 1.3:1 where practical) and new designs on to develop a suitable modification on existing designs to make them most effective with SSB equipment corresponding to this Characteristic.

4.3 Automatic Control of SSB R/T Power Output

Because of the practical problem of compatibility with existing tuners providing only 1.5:1 SWR, set designers are encouraged to provide automatic control of SSB power output through a sensing of the change in SWR or other parameter, to keep the spurious signal generation always within the specified limits.

4.4 Antenna Impedance Characteristics and Frequency Coverage

Inasmuch as the antenna tuner will usually be designed to operate specifically with a general class of antenna

4.4 Antenna Impedance Characteristics and Frequency Coverage (cont'd)

types covering a specific frequency range, this Characteristic will not set forth any specific antenna impedance characteristics for new antenna tuners. In general there is a need for both the universal type of antenna tuners suitable for many different aircraft, and the special purpose type designed for most efficient and effective operation in a particular aircraft having a specific antenna characteristic, and it is, therefore, the economics of the airframe design which will dictate the antenna tuner design.

4.5 Band Information

It has been the practice in the past for some antenna tuners to utilize band information from the control panel or directly from the transmitter to simplify the antenna tuner design and eliminate the need for specialized sequential operations of the tuner, or in some units the band information has been employed merely to speed up the operation of the tuner when the band information is available, yet the band information would not be required for actual operation of the tuner.

4.6 Power Handling Capability

Although previous industry discussion of many years ago had led to the conclusion that antenna tuners should be designed with adequate power handling capacity to accommodate at least a 1 kw PEP, it has subsequently been determined (Spring of 1965) that such a power handling capacity on civil aircraft is not necessary. The figure of 650 (maximum, maximum!) watts PEP now set forth is deemed to be more realistic for the guidance of antenna tuner manufacturers.

4.7 Tuner Pressure Fault Line

Inasmuch as a pressurized antenna tuner is probably a necessity for many jet aircraft, it is important to assure that the pressurization is satisfactory within the antenna tuner before the transmitter is allowed to operate. Some manufacturers choose to provide a purely mechanical means of checking the pressurization as a maintenance check on the ground while other antenna tuner designers prefer to utilize some form of pressure switch within the antenna tuner unit which can be optionally used by the customer in several ways. Either the leads from the pressure switch could be extended to a point in the aircraft where ohm-meter checks could be accomplished or, if the customer so desires, the pressure switch line could be connected in series with the keyline of the particular transmitter involved so that the transmitter will automatically be kept from operation when pressurization is not adequate in the tuner. Whether or not the customer feels that the pressure switch reliability is sufficient to allow its connection in series with the keyline is the airframe manufacturers and the customers decision, however, when such a pressure fault line is provided in the antenna tuner it is preferable that for interchangeability reasons, this be in the form of a pair of contacts within the tuner, completely isolated from ground or power sources and which will be closed whenever the pressurization within the tuner is adequate.

The pressure fault line pin connections are not set forth in Attachment 5, nor are any interconnections of these pressure fault lines shown in the standard interwiring of Attachment 2 as this will be a customer option.

5.0 AUTOMATIC TEST EQUIPMENT PROVISIONS

5.1 General

To enable Automatic Test Equipment to be used in the bench maintenance of the ARINC 719 HF/SSB 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.

5.2 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.

5.3 Pins 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.

5.3 Pin Allocation (cont'd)

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.

5.4 Use of ATLAS Language

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

6.0 BUILT-IN TEST EQUIPMENT (BITE)**6.1 Built-In Test Equipment (BITE)**

The HF/SSB System 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 HF Transceiver and as many faults as possible associated with the antenna, frequency controllers and their interfaces with the HF/SSB 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 6.4. 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 HF/SSB Transceiver.

COMMENTARY

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

6.2 BITE Display

The HF/SSB System 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 failures in 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.

6.3 Fault Monitor

The results of in-flight or ground operations of BITE should be stored in a non-volatile monitor memory.

6.3 Fault Monitor (cont'd)

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 Replaceable 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.

6.4 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 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 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 trouble-shooting 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 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

6.0 BUILT- IN EQUIPMENT (BITE) (cont'd)**6.4 Self-Test Initiation (cont'd)**

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.

6.5 Monitor Memory Output

The BITE Monitor Memory output should consist of the following:

- (a) An output to the display located on the LRU, 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.

6- 5- 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.

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 ZERONOTES PERTAINING TO ATTACHMENTS

NOTE 1: Wire Types should be shielded, twisted or twisted and shielded as indicated where protection from electromagnetic interference (EMI) is deemed appropriate in Attachment 1. All shielded wires should have an insulating jacket over the shield to prevent intermittent grounds. All shields for analog circuits are to be grounded at one end only and to the same ground stud. Shields for digital circuits should be grounded at every break point.

NOTE 2: Wire “Type” and “I-R” needs are set forth in this Characteristic to more accurately define the standard installation. The maximum current each circuit should accommodate is set forth as amperes in column I. The designation “D” refers to a “Dry” circuit where the current is less than 10 milliamperes. The maximum circuit resistance in ohms is set forth in column “R”.

These specific needs supersede the general guidance set forth in ARINC Report 414. Details on the “Type” of wire which should be used to provide the degree of noise protection needed in the Standard Interwiring is described in Note 1.

NOTE 3: The “115 volt AC out” power circuits from the SSB R/T Unit provided on pin BP9, may be employed for various functions within the antenna tuner. However, the maximum drain from the R/T Unit is not expected to exceed the value set forth in Attachment 1.

NOTE 4: A three-phrase ganged circuit breaker of the size shown in Attachment 1 should be provided in the standard installation. Equipment designers should, however, observe the guidance set forth concerning primary power failures in any one of the three- phrases that may not be protected by the circuit breaker.

NOTE 5: Inasmuch as audio and sidetone outputs from the receiver are fairly low impedance, the mixing circuit for the audio and sidetone should take into consideration any possible interaction due to squelch operation and audio volume control adjustment.

As pointed out in Note 6, below, any external relays required for sidetone or muting operation should be connected as explained in Note 6.

NOTE 6: The Attachment 2 interwiring does not show the interconnections of the interlock with any other HF equipment in the aircraft. It should be noted that the keying relay in the R/T Unit cannot operate unless the “keyline” lead is energized external to the R/T Unit with 27 VDC. The “keyline” lead is connected to ground through the usual push-to-talk switch on the microphone as detailed in Attachment 3, or this lead may be grounded automatically by the antenna tuner, using functional lead (F) as a means of providing automatic tune-up. With most sophisticated antenna tuners, the 27 volt DC power for the keyline interlock lead is provided through the connection of the functional lead (G) on the usual antenna tuner. The tuner either supplies its own 27 VDC to this lead through appropriate control circuitry or it may employ function lead (P) to obtain 27 VDC from the R/T provided on pin BP11. When the SSB equipment is employed with an antenna tuner not providing such a keyline interlock, the user must run a jumper (in the junction box) between pins BP1 and MP5H on the R/T Unit to energize the keyline interlock lead and hence the keying relay.

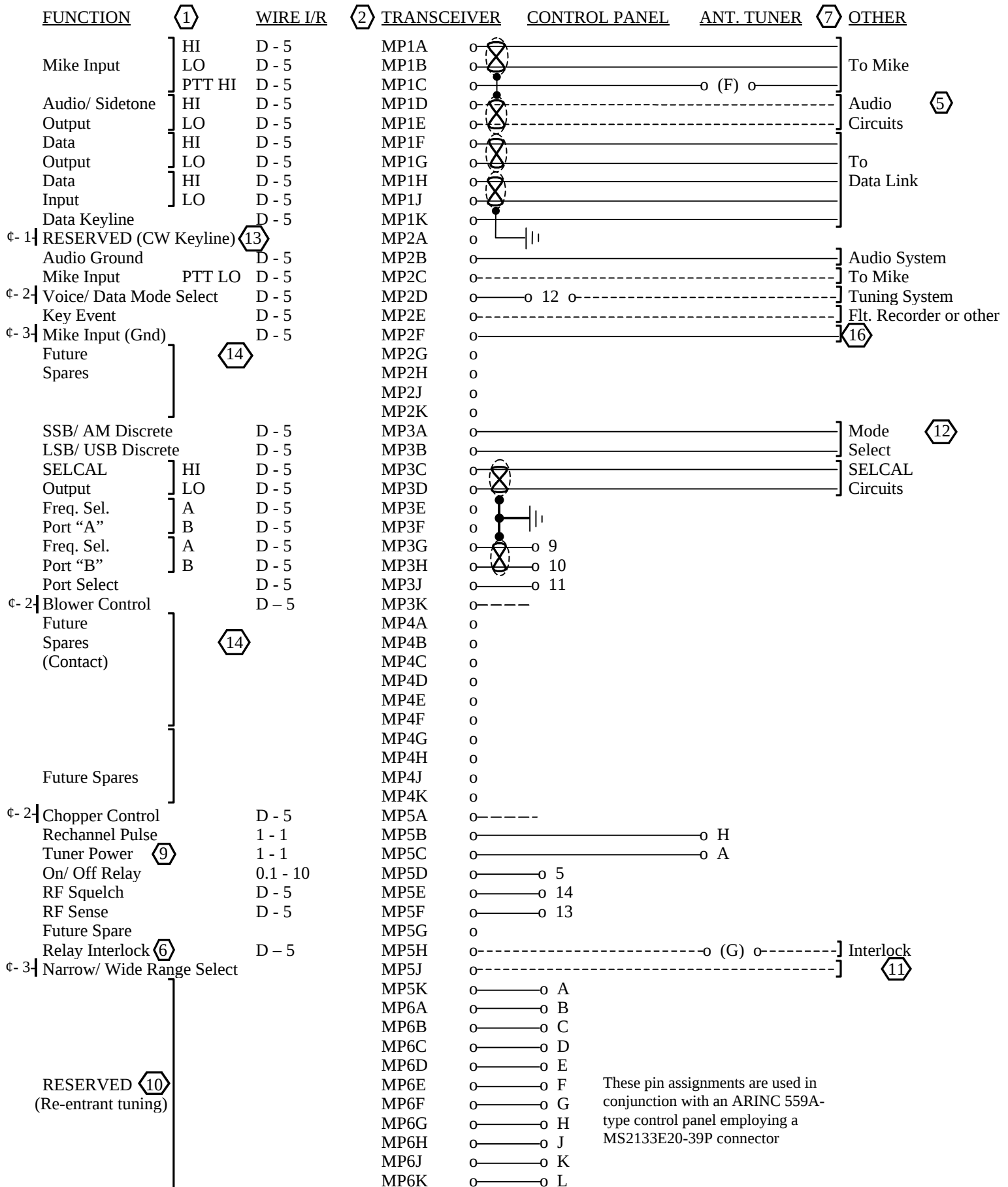
When external relays are employed to provide special interlock functions or to supply sidetone or audio muting in accordance with Note 5, all such relays in a particular installation should be designed to operate on a total current drain less than 0.25 amperes at 27 VDC and the coils of all such relays should be paralleled with the “keyline” lead MP1K and the “keyline interlock” lead MP5H, noting the special case of some tuners explained in Note 9 which draw a pulse current.

NOTE 7: The letters in parentheses under the column “antenna tuner” are not specific pin connections on any specific connector but are symbolic connections which are interpreted in terms of specific antenna tuners in the table of Attachment 5. No attempt is made in the interwiring of Attachment 1 to show other circuitry and wiring to the antenna tuners other than the standardized interconnections with the SSB System which are specifically shown for symbolic connections (A) through (P). The installer should refer to the antenna tuner manufacturers’ manuals and instructions for further information on the various applications of the specific antenna tuners.

In Attachment 5 the 400 VDC to symbolic pin (M) on the Antenna Tuner has been reduced to 250 VDC. Since none of the Antenna Tuners referenced in Attachment 5 need 250 VDC, no pin is assigned for this function on ARINC 719 equipment.

ATTACHMENT ZERO (cont'd)NOTES PERTAINING TO ATTACHMENTS

- NOTE 8: The 27 VDC output on pin BP 11 should supply an impulse relay in some models of antenna tuners. The average current drawn by the antenna tuner should not exceed ½ amp. However, the peak current may be as high as 8 amps for a maximum duration of 20 milliseconds. The aircraft interwiring should take this peak load condition into consideration.
- NOTE 9: A tune power provision has been deemed necessary on this equipment. Pin MP5C on the R/T Unit should be connected to functional lead A on the antenna tuner. A ground on this line while the antenna tuner is tuning should reduce the RF output power of the R/T Unit, operate the AM relay, and activate a tune tone circuit to supply a tuning tone to the aircraft audio system.
- NOTE 10: Pin assignments shown are for ARINC 559A-compatible control panels. Details on pin functions for the optional re-entrant tuning system may be found in ARINC Characteristic 559A.
- NOTE 11: Some certifying authorities may require that the transmitter be disabled and a warning tone generated in the audio system when the receiver is tuned to a radio frequency on which the transmitter is unable to transmit because of limitations to the aircraft antenna tuning unit. Pin MP5J is reserved for selection of either a narrow (2.8 to 23.9999 MHz) range or a wide (2.0 to 29.9999 MHz) range of operation. An “open” pin selects the narrow range and a grounded pin selects the wide range. If the narrow range is selected and an attempt is made to operate the transceiver outside the 2.8 to 23.9999 MHz range, a warning tone is produced in the audio output and the transmitter is disabled.
- NOTE 12: An “open” on pin MP3A selects SSB operation and a “ground” selects AM operation. An “open” on MP3B selects USB operation and a “ground” selects LSB operation. These pins select modes only when re-entrant tuning is selected on MP5J.
- NOTE 13: Some specialized radios use Pin MP2A as a CW keyline. However none of these radios are expected to be used by the airlines. Pin MP2A has been reserved to promote interchangeability.
- NOTE 14: Future Spare (Contact) Contact 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.
- NOTE 15: When three-phase power is supplied through these pins, the “state” of power control relay is controlled by Pin MP5D. A “ground” on pin MP5D should turn the radio “on”. An “open” on pin “MP5D” should turn the radio “off”.
- NOTE 16: Pin MP2F is connected internally to pin MP1B. Pin MP2F can be jumpered to pin MP2B to obtain internal grounding or it may be connected to an external ground.
- NOTE 17: For control panels utilizing liquid crystal displays, a “ground” on pin 6 initiates a test of static displays.

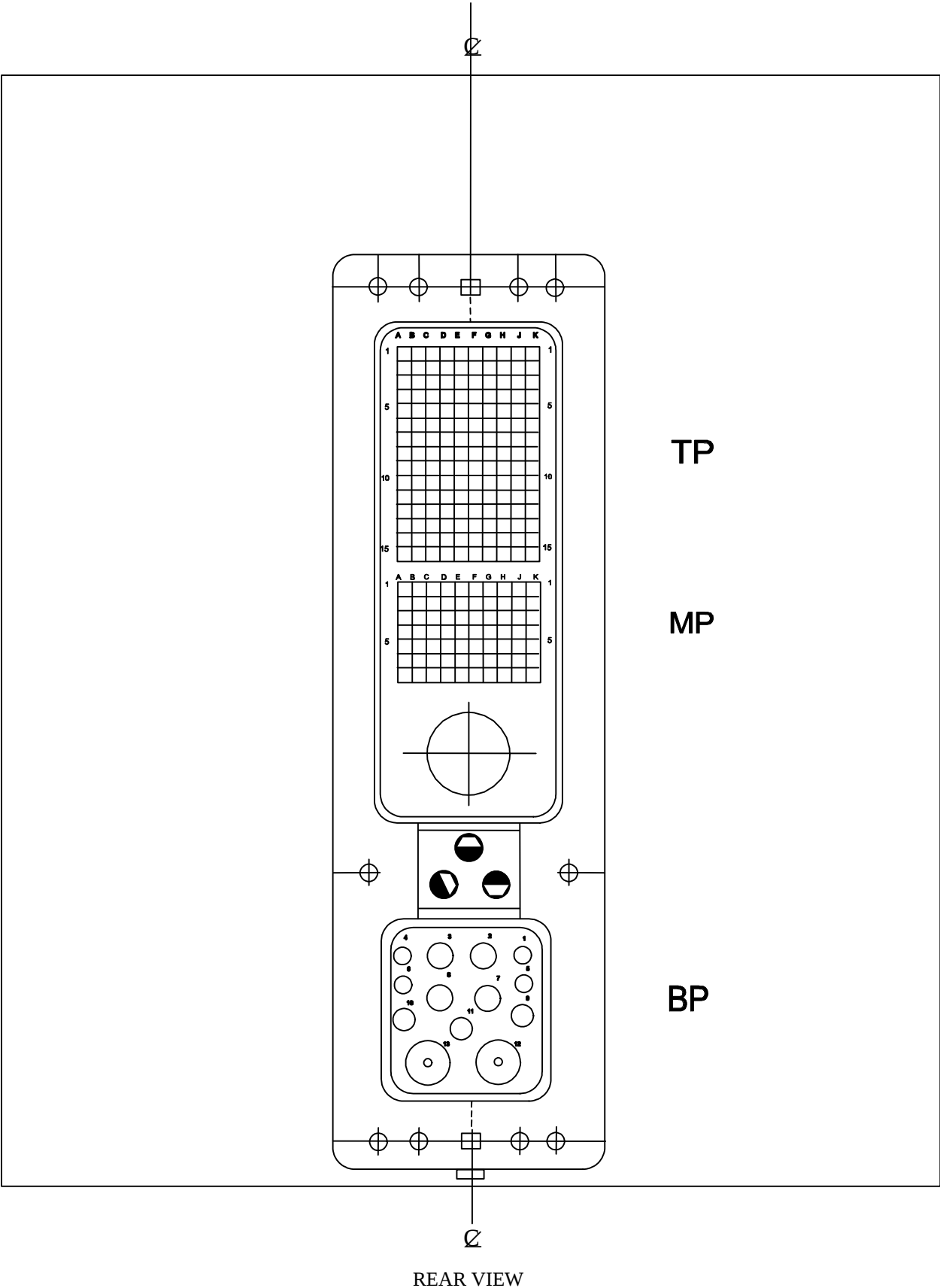
ATTACHMENT 1
STANDARD INTERWIRING

<u>FUNCTION</u>	<u>1</u>	<u>WIRE I/R</u>	<u>2</u>	<u>TRANSCIVER</u>	<u>CONTROL PANEL</u>	<u>ANT. TUNER</u>	<u>7</u>	<u>OTHER</u>
RESERVED (Re-entrant tuning)	10			MP7A	o — o	M		
				MP7B	o — o	N		
				MP7C	o — o	P		
				MP7D	o — o	R		
				MP7E	o — o	S	These pin assignments are used in conjunction with an ARINC 559A-type control panel employing a MS3122E20- 39P connector	
				MP7F	o — o	T		
				MP7G	o — o	W		
				MP7H	o — o	X		
				MP7J	o — o	r		
				MP7K	o — o	j		

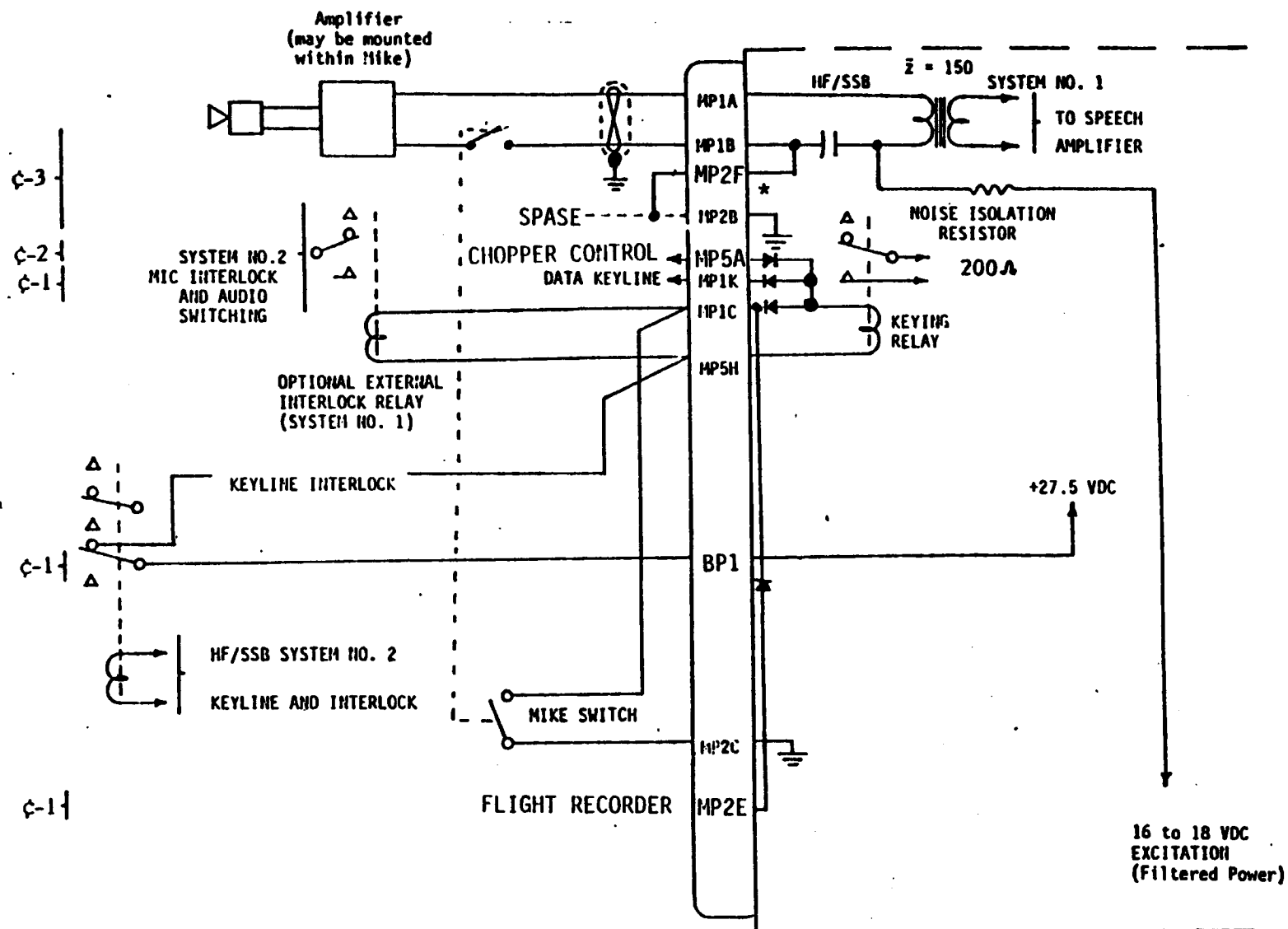
Pin	Signal	Notes	Pin	Signal	Notes
C-2	Interlock Exc.		BP1		Interlock
	RESERVED (Switched Phase A)	15	BP2	0	
	RESERVED (Switched Phase B)		BP3	0	
	115 VAC	Unswitched Phase A	BP4	0	3-Phase Source
	115 VAC	Unswitched Phase B	BP5	0	
	115 VAC	Unswitched Phase C	BP6	0	
	RESERVED (Switched Phase C)	15	BP7	0	
	AC Cold		BP8	0	3
	115 VAC Out		BP9	0 (O) 0 (N)	
	Chassis Ground		BP10	0	
+ 27.5 VDC	8-07	BP11	0 (P)		
Spare		BP12	0		
		BP13	0		
C-4	5 VAC Lighting	H		0 1	Lighting
		L		0 2	
	115 VAC In	H		0 3	115 VAC Source
		L		0 4	
	RESERVED (Static Display Test)	17		0 6	
RESERVED (Coupler Tune Ind.)			0 7		
RESERVED (Coupler Tune Ind. Ret.)			0 8		
Chassis Ground			0 15	0	

ATTACHMENT 2

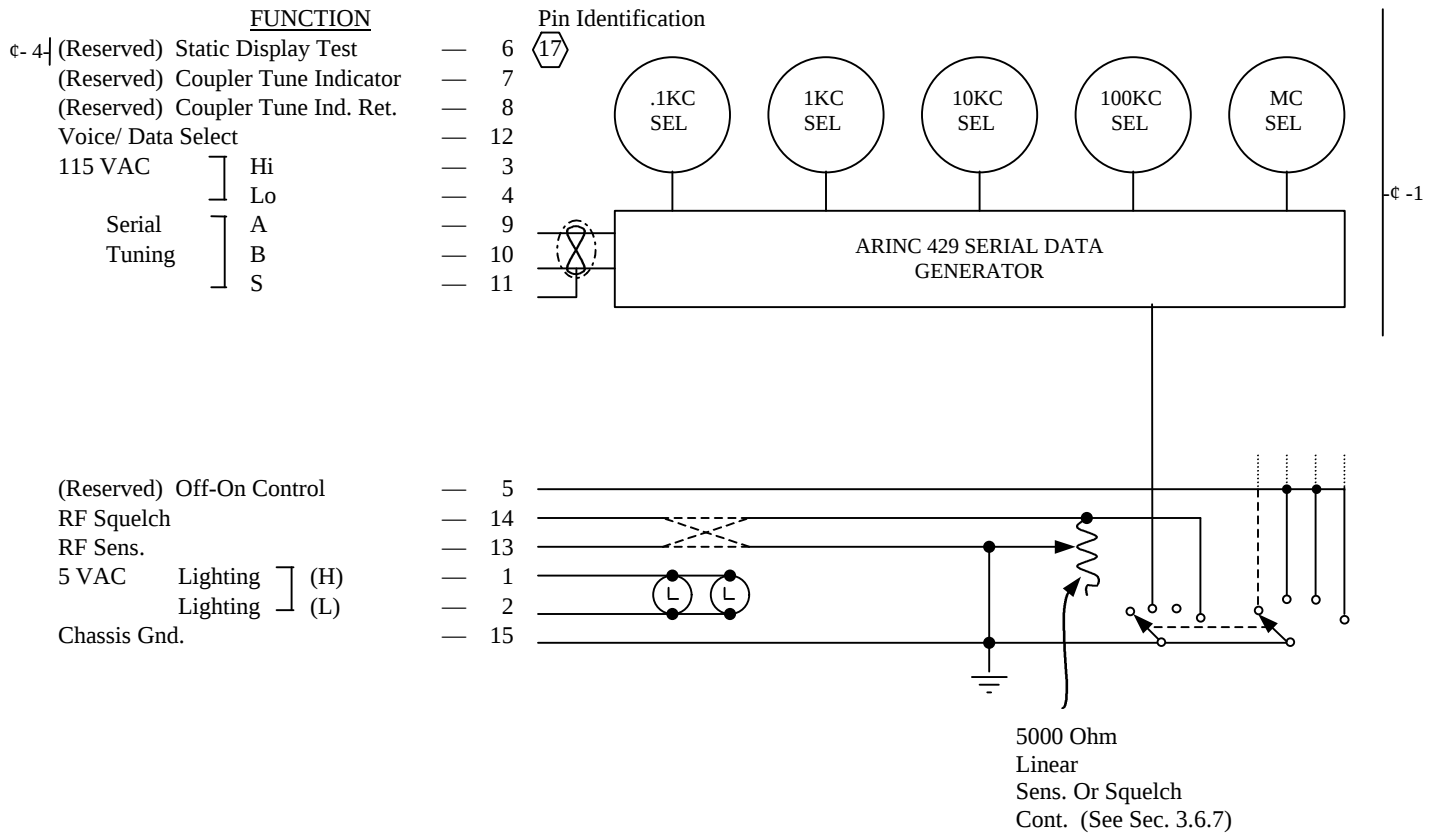
TRANSCEIVER UNIT CONNECTOR POSITIONING



ATTACHMENT 1
SCHEMATIC OF AUDIO GROUNDS
AND USE OF 4-WIRE MICROPHONE
(WITH SYSTEM INTERLOCK RELAYS)

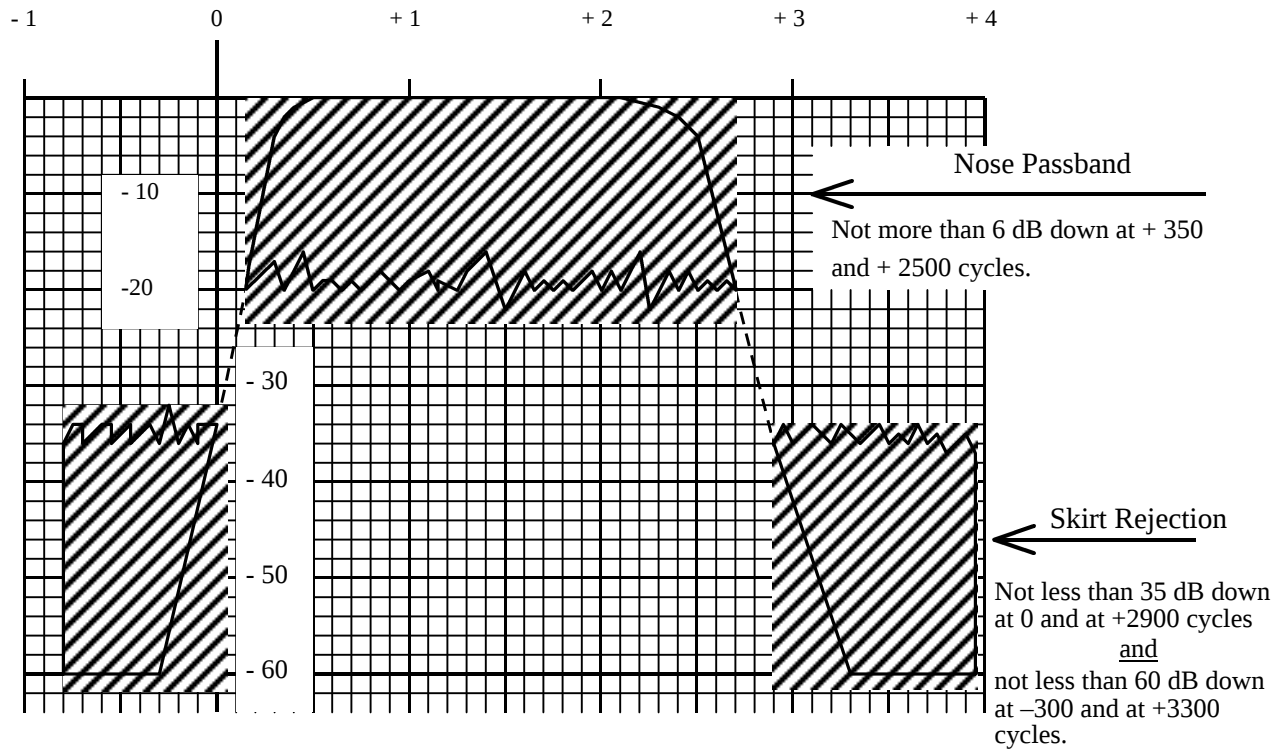


*See Note 16 of Attachment 0.

ATTACHMENT 4CONTROL PANEL WIRINGUSING ARINC 429 SERIAL DIGITAL TUNING

ATTACHMENT 5ANTENNA TUNER PIN CONNECTIONS

			COLLINS 309A-1 180R-4	UNIVAC 3250/ 3255	COLLINS 309A-9 (180R-12)	COLLINS 309A-9A (180R-12)	MARCONI AD7400 or AD7400A	COLLINS 180R-17 309A-17	COLLINS 490S-1	COLLINS 490T-1/1A	COLLINS 309A-2D (180R-6)
FUNCTION			INTERWIRING DIAGRAM SYSTEM	P-5	2J6	P1-B	P1-B	Deutsch DM9702 27-35	J1	J1	J5
1/	Tune Power	(A)	7	26	25	26	2	25	H	H	H
	(Not Used)	(B)					2				
2/	Band Info X	(C)	23		6	29					C
2/	Band Info Y	(D)	24		7	15					B
2/	Band Info Z	(E)	25		14	14					D
	Keyline	(F)	2 & 12	19	45	19	3	19	K	K	R
3/	Keyline Interlock	(G)	27	4	35	4	10	4	S	S	E
4/	Ground Pulse	(H)	10 & 6	3	33	3	1	3	F	F	T
5/	Chopper Control	(I)									
	Normally Open Contacts	(J)	15								
		(K)	14								
	Chassis Gnd.	(L)	20	2			9		G	G	G
6/	250 VDC	(M)									
	115 VAC	(N)	1 & 3	28			11				
	AC Ground	(O)		20			12		D	D	
	+27 VDC	(P)	7/	25 & 27	24	25	14 & 8	24	L	L	L
9/	Others				10/	11/	12/				

ATTACHMENT 6 – SSB RECEIVER SELECTIVITY**NOTE:**

This selectivity applies to the SSB Audio output and additional bandpass requirements apply to the SELCAL output.

ENVIRONMENTAL TEST CATEGORIES

The following RTCA Document No. DO-160 categories apply to the environmental specification of the equipment described in this Characteristic.

ENVIRONMENT	DO- 160 Section	UNIT LOCATION		
		Electronics Rack	Cockpit	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			
Vibration 	8	CAT 0 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 A or B	CAT A	CAT A or B
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

ATTACHMENT 8CONTROL GUIDELINES1.1 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 HF Comm frequency display, essentially in the center with four selector knobs.

1.2 Frequency Selection & Display

The frequency selector should extend through the range 2.0 through 30 MHz. Suitable switch wafers, conforming to the requirements of ARINC Specification No. 410, to cover this frequency range in 1 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 ¼" numerals and would prefer the largest numerals practical.

1.3 Connector Types

- ¢- 1- The "Standard Control Panel" should utilize an MIL-C-83723-72R14159 connector (or equivalent) positioned on the vertical center line of the unit.

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- A master off-on control should be offered as an option. When this option is selected the control panel should supply a "ground" to tune on the transceiver and an "open" to turn it off.

1.6 Integral Lighting

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.

1.8 Mode Control

A switch should be provided to select the AM, SSB or SSB-Data mode.

1.9 Sensitivity/ Squelch Control

A sensitivity or squelch control should be provided as required. Guidance for this control may be found in Section 3.6.7.

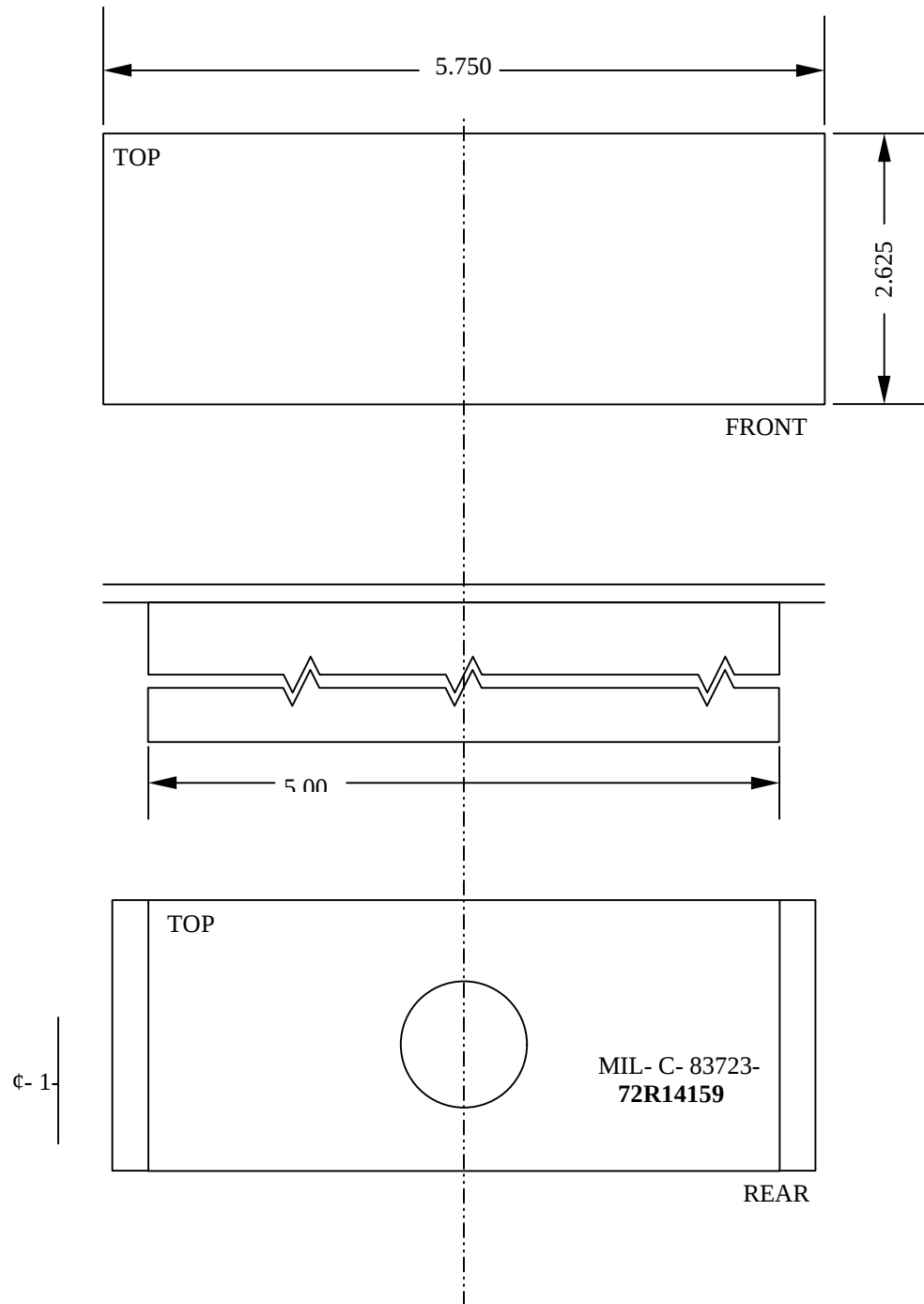
ATTACHMENT 8 (cont'd)CONTROL PANEL GUIDELINES

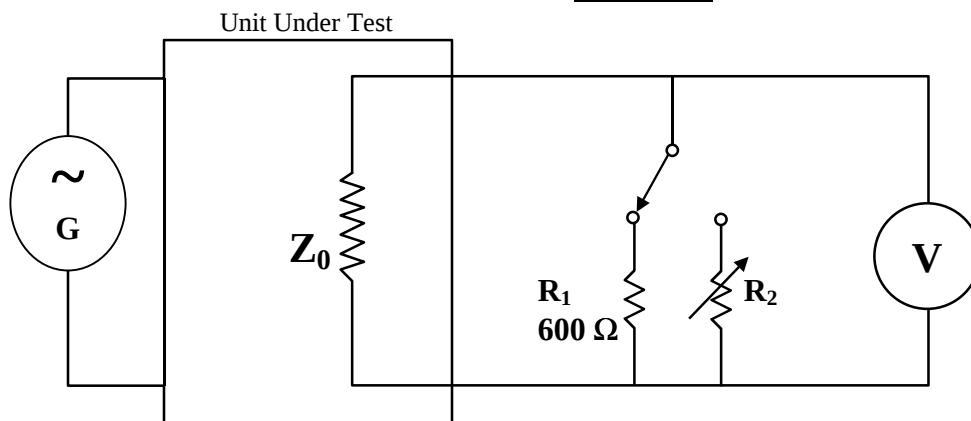
FIGURE 1

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

ATTACHMENT 9
TYPICAL TEST PROCEDURES
AUDIO OUTPUT

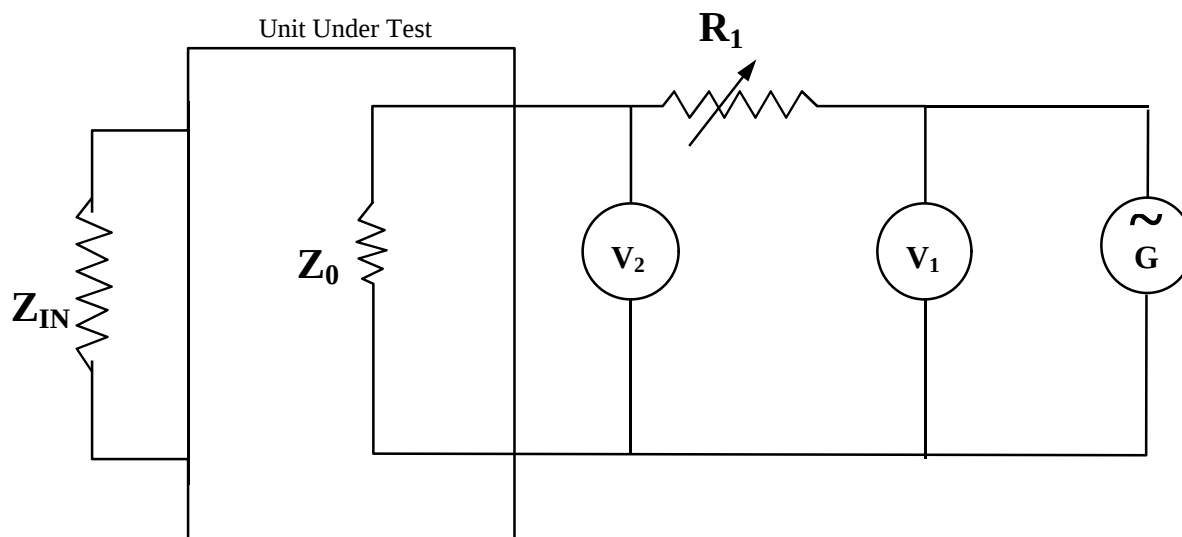
¢-5

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) $Z_0 = \frac{60 R_2}{540 - R_2}$

FIGURE 2



- a) adjust and maintain signal source (G) at $V_1 = 30 \text{ mV}$
- b) adjust R_1 until $V_2 = \frac{1}{2} V_1$
- c) $Z_0 = R_1$

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APPENDIX 0

GUIDELINES FOR HF ANTENNA SYSTEM DESIGNERS AND INSTALLERS

1. GENERAL

The intention of this supplement is to provide HF antenna system designers and installers with some general guidelines, to be used as an aid in establishing a satisfactory HF antenna installation. Although a good electrical design can be established by means of academic knowledge, a successful HF antenna installation must be integrated into the airframe with full consideration for airplane operation. Components of the antenna system that are not easily accessible, or require special handling equipment to gain access, must be designed for the highest reliability possible. For example, past experience has shown that mechanical moving parts, such as relays, should be kept to an absolute minimum. Also, non rigid electrical joints that carry RF current, such as quick disconnect interfaces, should be designed to reliably accommodate or avoid relative movement of the contact area, due to conditions such as aircraft vibration.

Other considerations should include ease of trouble shooting. For example, the HF communications system comprises several units which may be separated by long distances. Therefore, changing units to eliminate a fault can become a time consuming process, unless the number of line replaceable units is kept to a minimum.

Impedance data has been included for various airplane installations, and is intended as a general reference. The data presented is in no way intended to establish bounds on the values of resistance and reactance.

2. HF ANTENNA TYPES

HF antenna installations in commercial air transport aircraft to date can be categorized in four basic types: fixed wire, probe, cap, and shunt/notch antennas. A brief description of each is presented below.

Fixed Wire Antennas-These antennas usually consist of a wire connected to a feed-through mast located on top of and near the front of the fuselage, with the other end either secured to an insulator or grounded directly to the upper portion of the vertical stabilizer leading edge. If it becomes necessary to use a wire shorter than about 20 feet, the wire at the vertical stabilizer is usually grounded. The use of wire antennas is usually limited in their application to slower turboprop and piston driven aircraft. However, if wires are used on high performance airplanes, the angle of the wire to the fuselage should be kept to a minimum and suitable wire type and tension incorporated. On airplanes with rear mounted engines, the safety aspects of wire being ingested into an engine must be considered.

Since any wire antenna is a possible lightning attach point, properly designed lightning protection should be provided. To prevent unwanted RF radiation within the airplane the feedline between the coupler and the antenna mast should be suitably shielded, and RF bonded at both ends of the shield. Zero tension wire release systems must be provided in wire antenna installations to eject the remaining wire if a break occurs. This prevents the wire slapping on the skin and prevents possible interference to aircraft control surfaces.

Fixed wire antennas provide a low cost approach that is usually suitable for retrofit installations. The antenna coupler is usually inside the fuselage, which should provide easy access. The radiation patterns are satisfactory and the antenna coupler efficiency varies considerably over the frequency band. Installing a wire antenna is a skilled operation requiring careful attention to details. The antenna system reliability can not be considered high for all applications and conditions, and fixed wires should be used only after a design study shows it to be the optimum design

for a particular airplane. Often there is considerable opposition to the use of fixed wire antennas for aesthetic reasons, particularly on the higher speed airplanes. An impedance plot of a wire antenna installed on a Boeing 737 is presented in Figure 1.

Probe Antennas - This antenna type usually consists of a rigid isolated probe about eight feet long which is generally installed on an airplane extremity such as the top of the vertical stabilizer or wing tip. This type of antenna is a probable lightning attach point and therefore a lightning arrester is required. Additionally, the antenna coupler and lightning arrester must be located near the antenna, where vibration and temperature conditions can be sufficient to degrade reliability of the electronic equipment, if adequate precautions are not taken in the coupler design and in the installation. In installations of this type, the antenna coupler and lightning arrester must be mounted as rigidly as possible. The installer must insure that the RF interface between the coupler and the lightning arrester is secure and that the arrester's breakdown characteristics will in fact protect the coupler from lightning damage. The antenna coupler must include internal protection design features for lightning effects which are below the high transmit voltage breakdown characteristic of the lightning arrester.

Providing that adequate structural provisions have been made, the probe antenna is suitable for retrofit installations, especially where more than two HF systems are required on an airplane. The probe antenna provides a moderate, cost, reliability, and performance installation. A disadvantage of the probe antenna is that it does not provide for easy access to the antenna coupler and lightning arrester. Figures 2, 3, and 4 give an impedance plot for the probe antenna mounted on the Boeing 707, 727, and 747 airplanes. The series equivalent impedance is capacitively reactive at the lower frequencies, and goes through resonance and becomes inductively reactive at the high end of the HF spectrum. The increase of resistance with frequency is not monotonic but indicates aircraft resonance effects which are inherent in the airframe.

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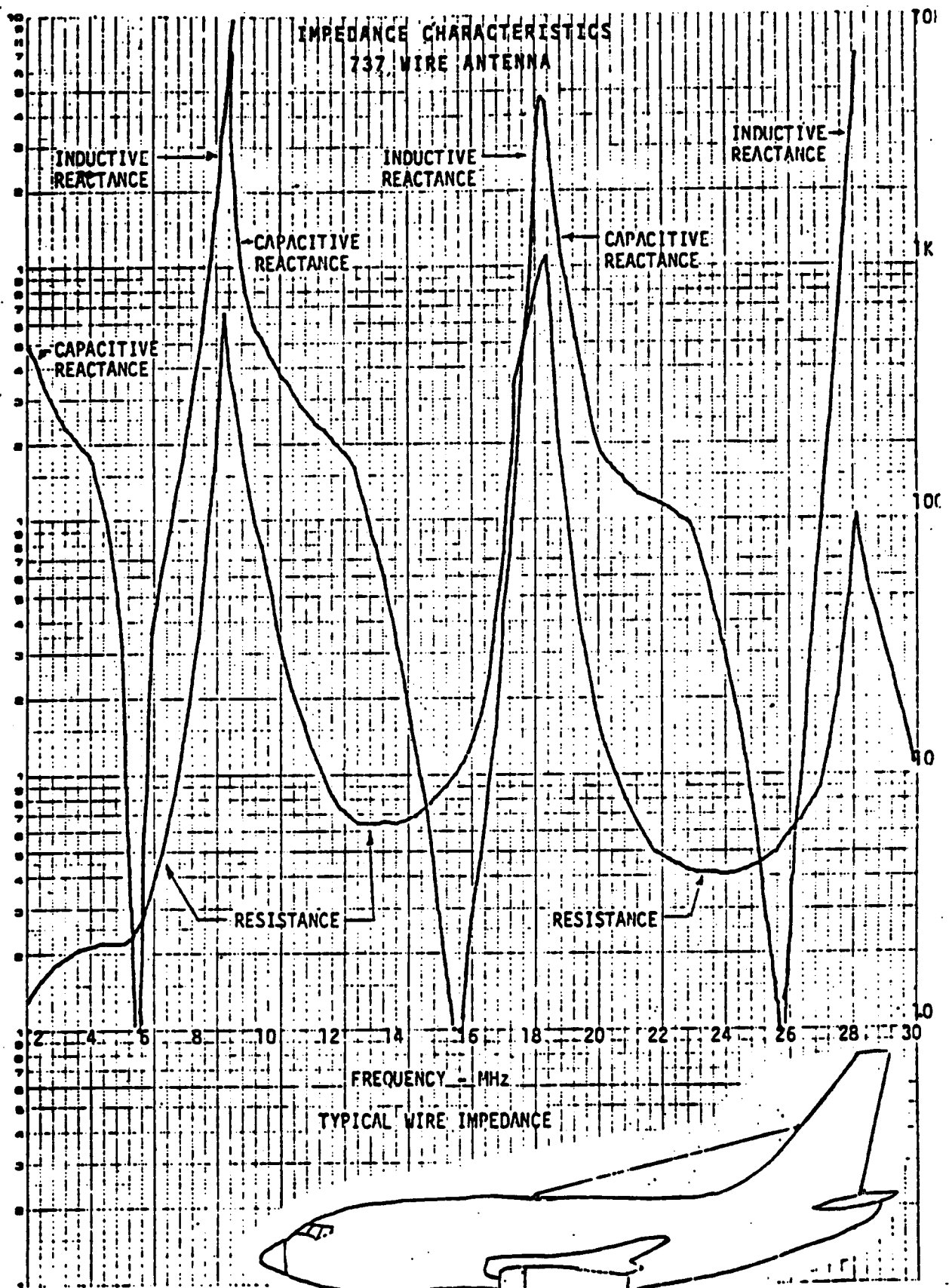
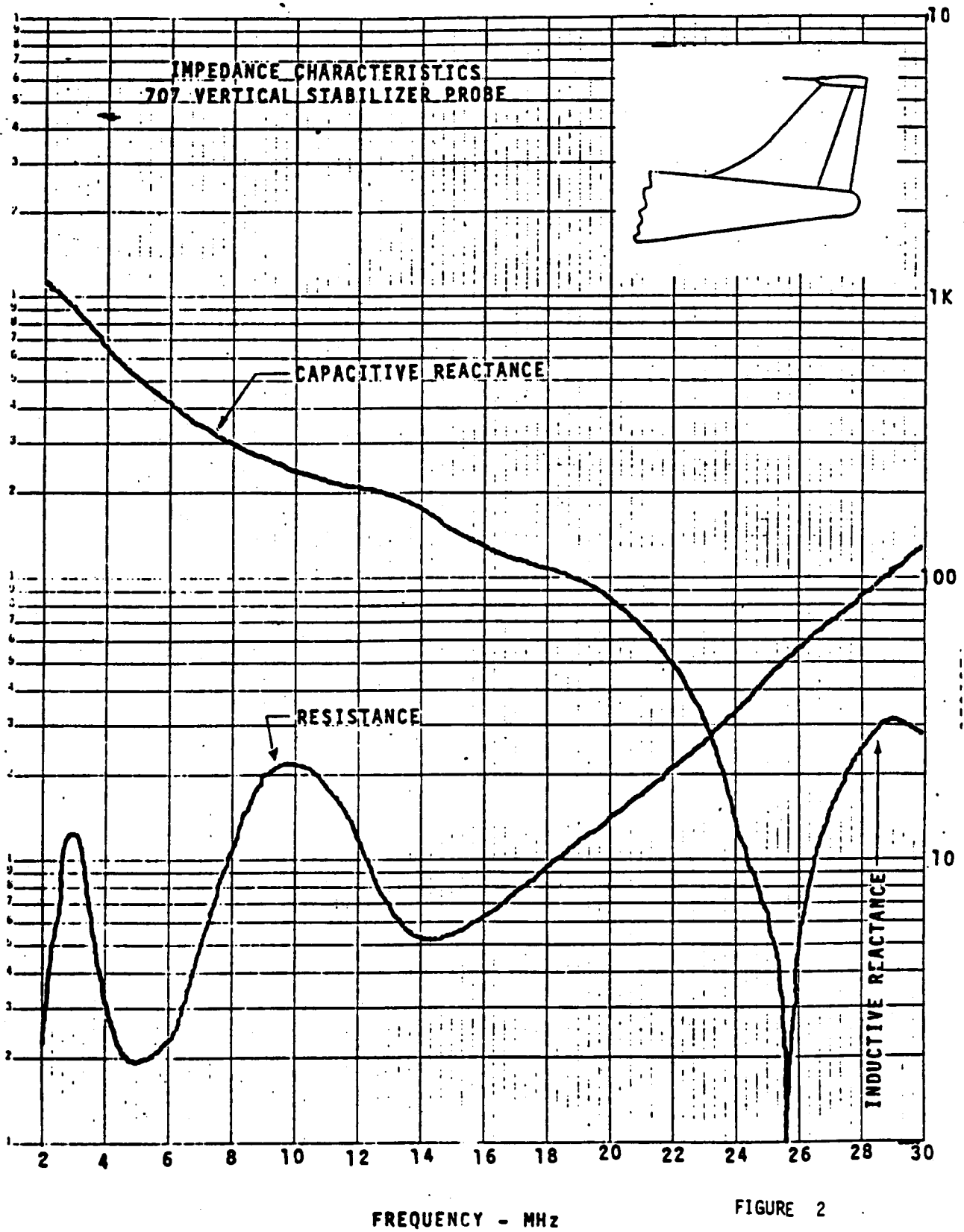
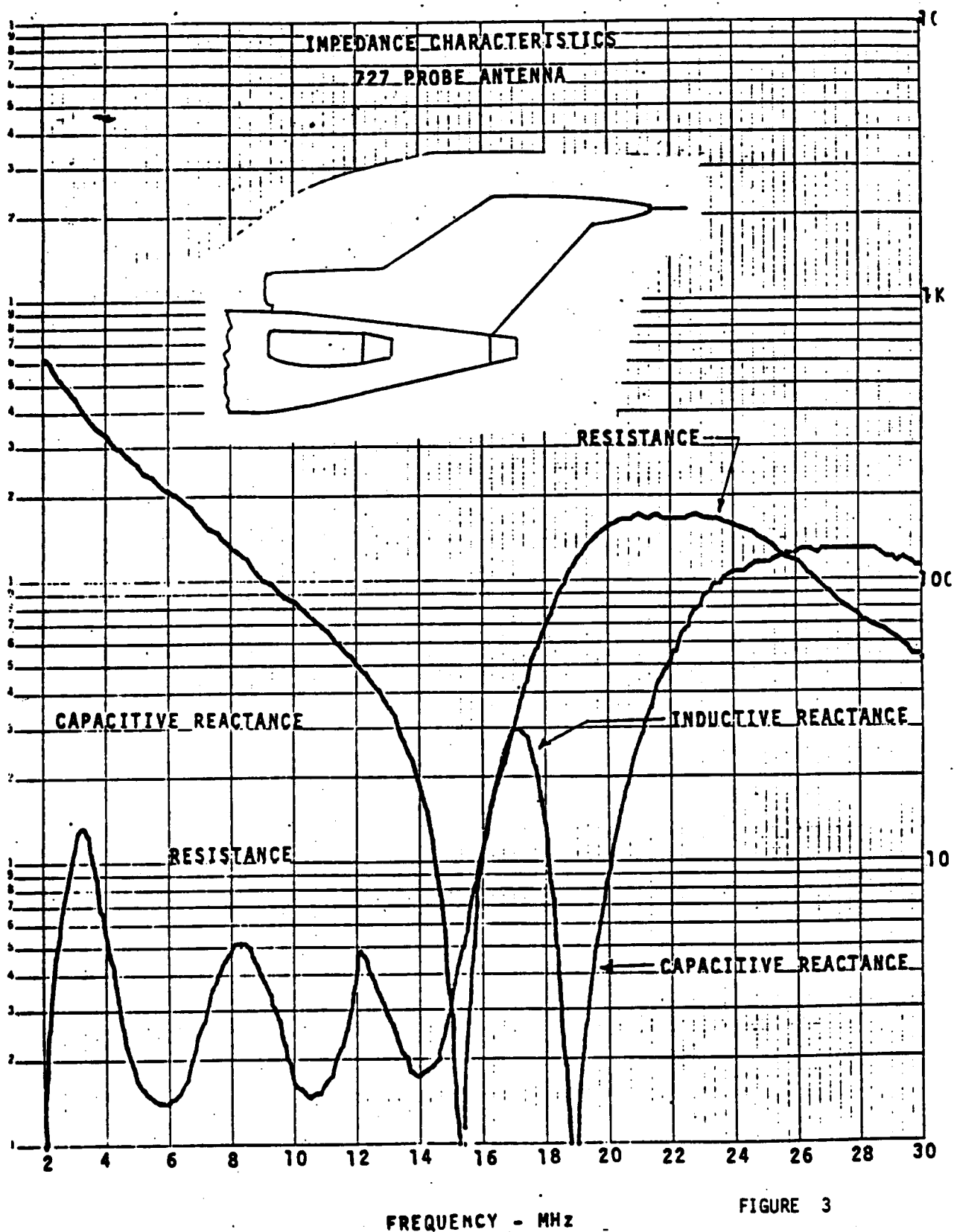


FIGURE 1



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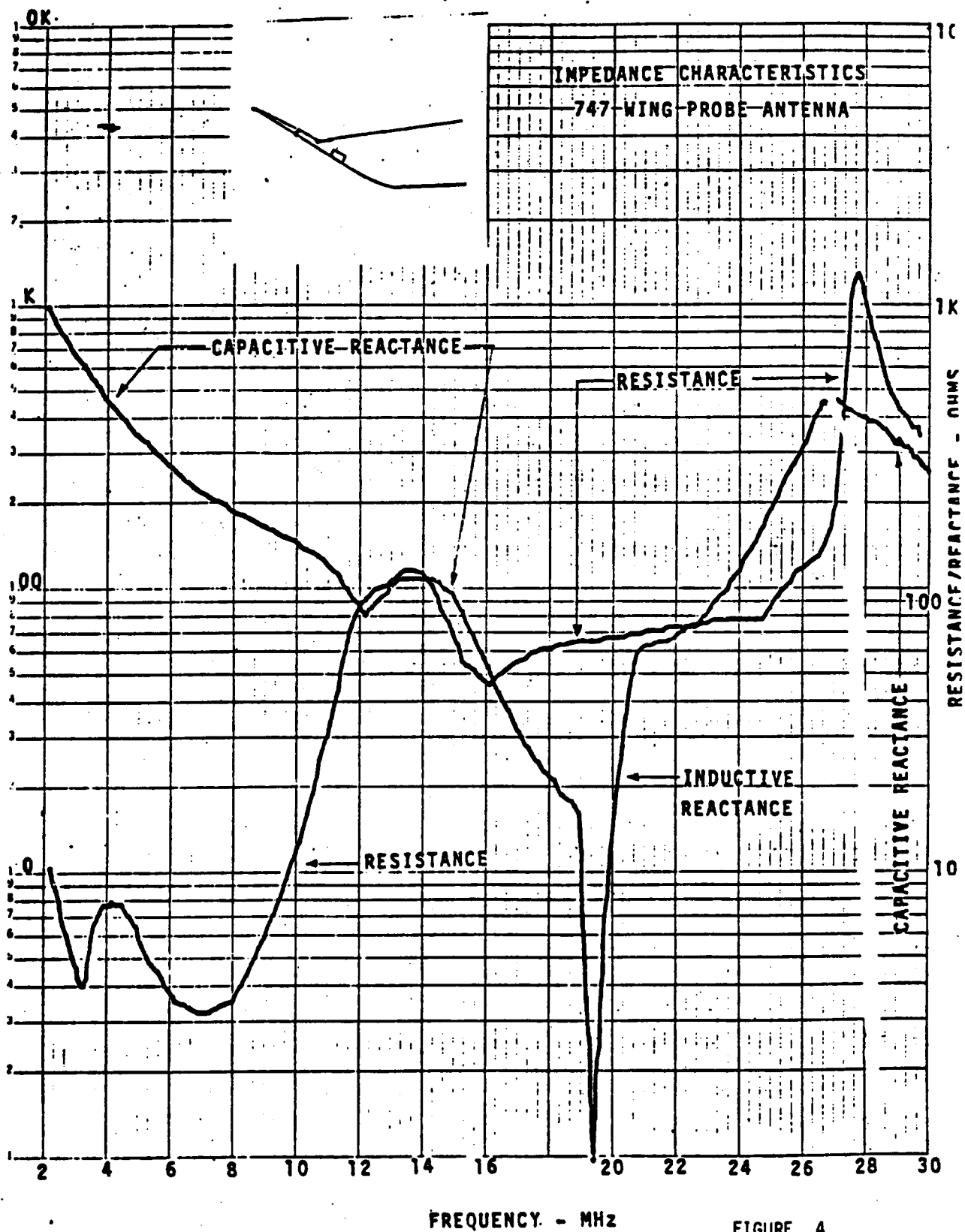


FIGURE 4

Cap Antennas - Cap antennas consist of an electrically isolated section of structure, such as a wing tip, top section of the vertical stabilizer, or the end of the fuselage. The cap antenna can be considered a flush mounted probe, with similar electrical characteristics to the probe.

The cap antennas requires a lightning arrester, the environmental conditions are less severe than for the probe antenna, and the reliability is moderate to good. However, due to the structural impact, a high fleet usage of HF communications is often required to make the cap cost effective. And, for similar reasons, the cap antenna is not suitable for most retrofit installations. Ease of access to the antenna coupler and lightning arrester varies for the various possible locations. The impedance plot of the cap antennas on the DC-8 and DC-9 are presented in Figures 5 and 6.

Shunt/Notch Antennas - The shunt or notch type HF antenna is formed by replacing metallic structural sections of the airframe with insulating material, such as fiberglass. The insulated section is usually in the shape of a slot or notch. The notch is cut into a section of the airframe that has a high RF current density, such as the lower leading edge of the vertical stabilizer, or the leading or trailing edge of the wing roots.

The notch antenna is cut as deep as practical into the airframe, but its effective electrical length should be less than a quarter wavelength at the highest operating frequency. The shunt antenna often consists of a long slot running along the leading edge of the vertical stabilizer or wing. It is longer than a notch but should be less than a half wavelength at its highest operating frequency. As the notch antenna is more commonly used for commercial applications, the following discussion relates principally to the notch type antenna, but is generally applicable to both the notch and shunt antennas.

The antenna couplers are installed inside, or in close proximity to the notch. The accessibility to the couplers is usually better than that for the wing or fin tip locations, and the environment is less severe.

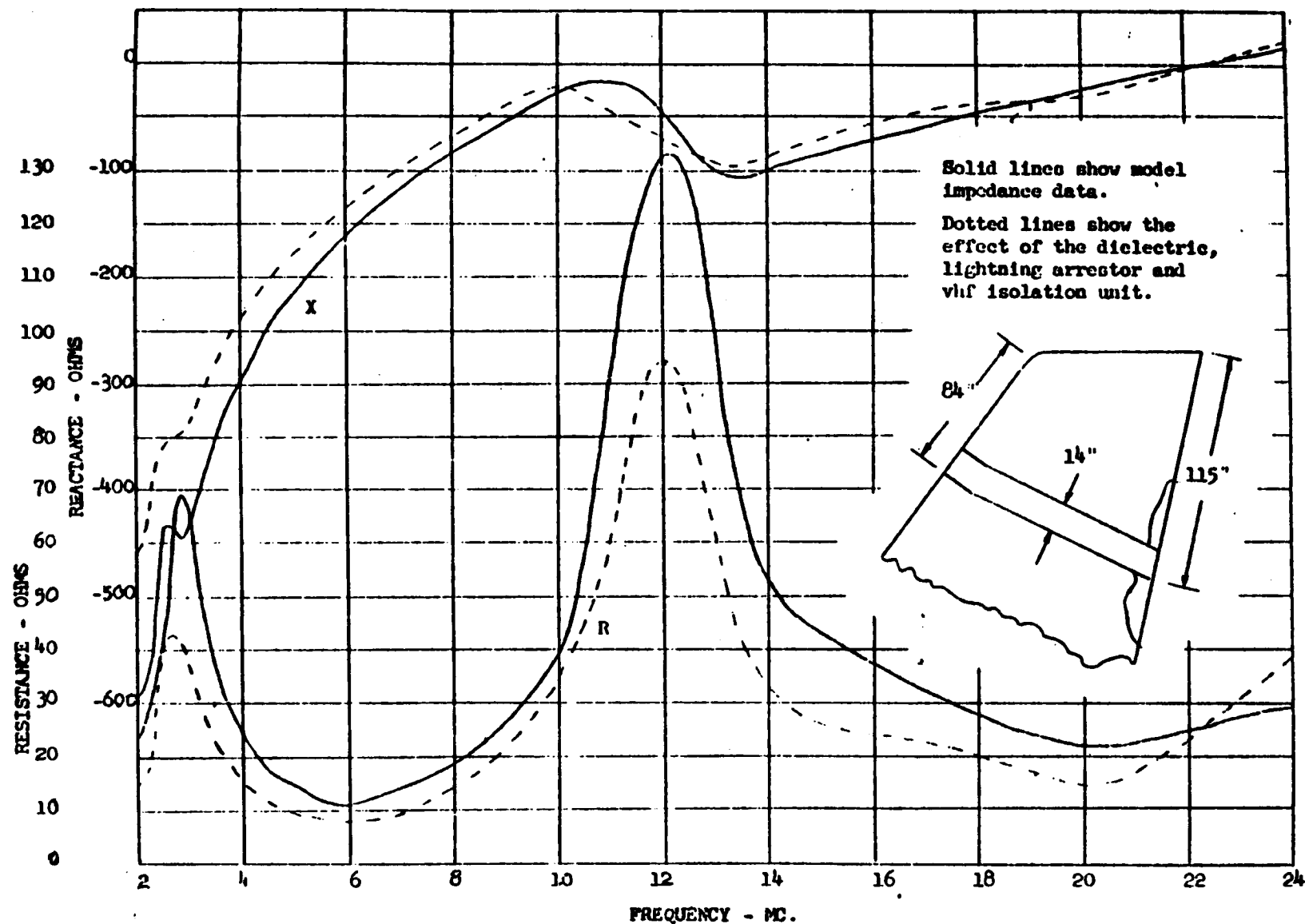


FIGURE 5 - IMPEDANCE DATA FOR THE DC-8 TAIL CAP ANTENNA

REACTANCE- OHMS
RESISTANCE- OHMS
FREQUENCY

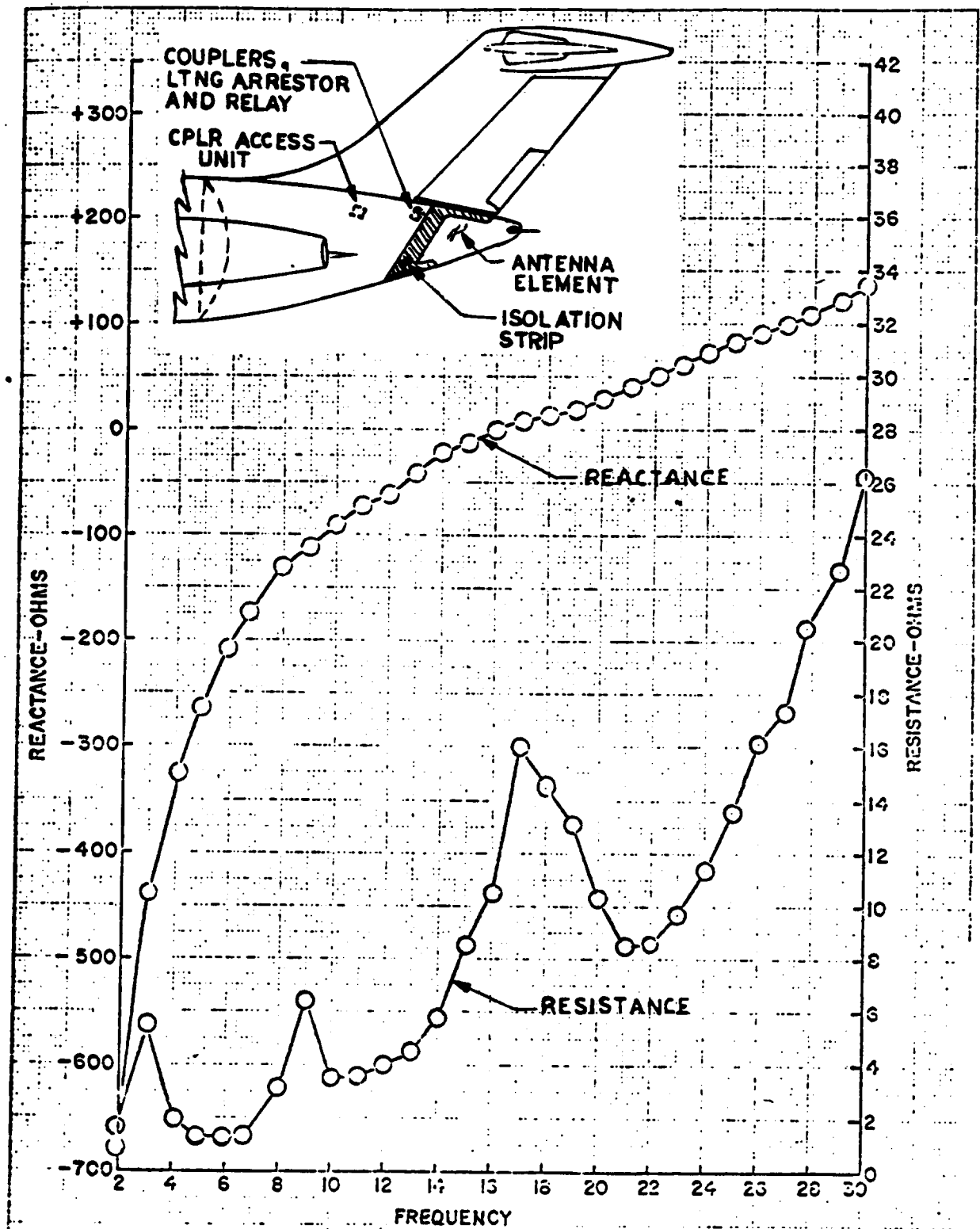


FIGURE 6

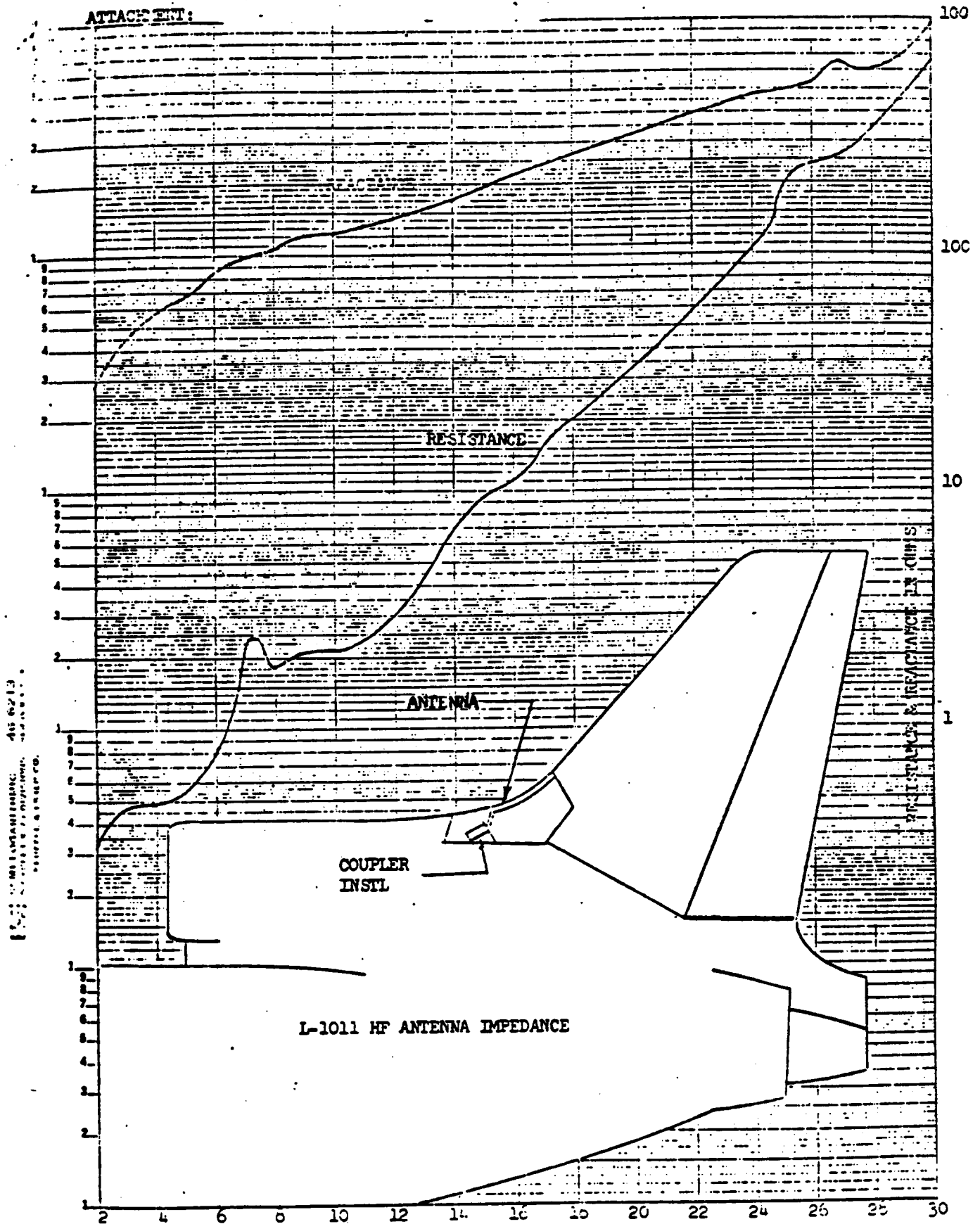
DC-9, SERIES 30, HF ANTENNA IMPEDANCE

High voltages are generated in wire, probe, and cap antennas, which become the principal design constraint. However, due to the low impedances encountered in notch antennas, low voltages and high RF currents are encountered. Therefore, notch antennas must be made of rugged high current metallic parts.

Notch antenna couplers can be very efficient, as the notch is tuned principally with high Q variable vacuum capacitors while the other types of antennas use variable inductors in their couplers, which have a lower Q (less efficient). However, great care must be taken in the design of the current path in notch antennas and feed line from the antenna to the coupler, since at low frequencies the radiation resistance will be in the region of 0.1 ohms. Therefore, the dc resistance of the antenna and feed system should be kept as low as possible to maintain system efficiency. A typical design value is less than 10 milliohms for a notch antenna with a short feed line, and 30 milliohms for a shunt antenna and feed line.

Due to their location, notch antennas are unlikely to be subjected to direct lightning strikes. Also, the design provides a low impedance by-pass for lightning current. Therefore, high voltage lightning arresters are not usually required. However, electrical impulse protection should be provided for the antenna coupler, as lightning strikes to the airplane can produce a pulse with a high rate of rise at the antenna terminals.

Notch antenna systems have good electrical efficiency and reliability. The coupler can often be located inside or close to the cabin which provides for good access. If provisions have not been made for a notch antenna in the basic airplane design, it is probable that a shunt antenna will be more suitable for retrofit installations. The low resistance values encountered at the lower frequencies are difficult to measure, therefore three useful techniques using readily available equipment are described in Section 10. Impedance plots for the L-1011 and DC-10 are presented in Figures 7 and 8.



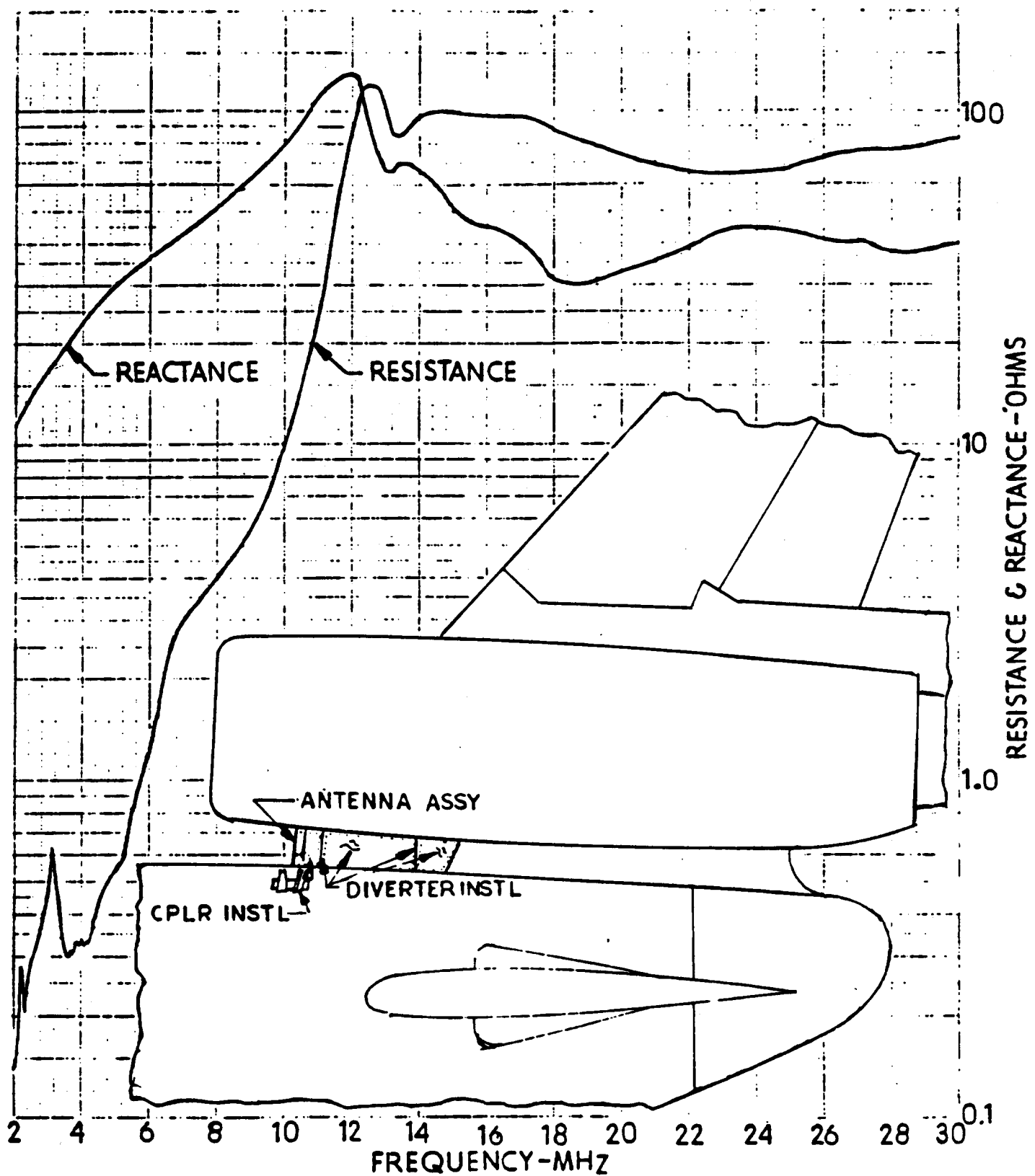


FIGURE 8 DC-10 HF ANTENNA IMPEDANCE

3. COUPLER LOCATION AND ACCESS

Perhaps the most important long-term aspect of HF antenna system design is to provide for low maintenance. Antenna system failures at remote line stations can cause time and money-consuming aircraft delays if unit replacement is frequent, or if special equipment must be brought to the aircraft to reach the coupler, lightning arrester, etc. Every effort should be made to eliminate potential maintenance actions and to make access to the antenna system as easy as possible.

The antenna coupler should be rack mounted if feasible, but installations may be encountered where there is insufficient space for rack mounting. In these cases, provisions should be made for an alternative securing system using quick disconnect type fasteners that require no tools for installation or removal. If the antenna coupler is bolted in place, a few large bolts are more desirable than a large number of a smaller size. Access to the coupler should be as easy as possible and removal straightforward. The feedline should maintain a low resistance quick disconnect capability as well as provide fatigue-free performance throughout the life of the aircraft.

4. TRANSCEIVER INTERFACE

The electrical interface between the antenna coupler and the transceiver should be compatible with both the ARINC 533A and 559 types of radio. This interface contains the minimum information required for universal coupler compatibility and has been proven with all current designs. All control lines must contain RFI filtering and transient suppression provisions.

Frequency octave band information is presently available from the radio set control. Other paragraphs of ARINC 559A describe an optional serial interface between the radio set control and radio. To avoid the necessity for a serial control interface in the coupler, new coupler designs should not require frequency band signals.

The coupler should provide a means to detect tuning faults, or loss of coupler pressurization and provide remote signals that can be used to troubleshoot the system at the radio rack. The coupler should maintain pressure for a period of one year without maintenance. The pressure fault line pin should be made available for monitoring.

It is desirable that the radio primary power contactor also switch on power to the coupler when the radio is turned ON. The coupler should be designed to use ac primary power per ARINC Specification 413 (MIL-STD-704).

During coupler tuning, the impedance presented to the radio (power amplifier) will vary from near open to near short circuit. The radio must be capable of self protection and still deliver power to the coupler to allow tuning (approximately 75 watts at end of tune). Harmonics from the radio must be at least 20 dB down from the carrier during tuning.

5. DUAL SYSTEM CONSIDERATIONS

In dual installations where two couplers use a common antenna to provide simultaneous reception on both systems, and transmission from one system at a time, provisions such as interlocks must be made to prevent damage to one system when transmitting from the other system.

For simultaneous reception there must be no interaction between the systems that will cause loss of operational performance. Isolation amplifiers or other networks may be used to prevent one coupler degrading the performance of the other. When one coupler is transmitting power to the antenna, the receive isolation amplifiers or networks must be adequately protected from damage due to the high power signal. The interlock system must permit only one system to transmit at any time.

Dual systems must be completely independent from each other except for the interlock circuits and the common antenna connection. Interlocks must be as simple and reliable as possible. The primary requirement is to prevent any single failure from disabling both systems. The basic interlock (two wires between couplers) allows the first system keyed to transmit and locks out the other system through the coupler interlocks. Some installations also provide additional interlocking of the key lines (to one system or the other).

In a dual system both couplers are identical, so positive provisions are required to insure connecting the RF coax and control cables, as a set, from one radio to one coupler. Intermixing may defeat the interlocks and damage one (or both) systems.

6. ANTENNA COUPLER

The coupler must match the antenna impedance to a VSWR of less than 1.3:1 as measured at the terminals on the transceiver. The coupler must be capable of handling 650 watts PEP over the frequency range from 2 to 30 MHz at the maximum altitude capability of the aircraft.

The single unit coupler (no separate control unit) simplifies system fault isolation and lowers system costs. Sensors in the coupler that remotely signal a coupler tune fault, low tune power from the radio, low coupler pressure, etc., can greatly simplify system troubleshooting, and should be available.

Mechanically, the coupler should be designed to be easily and quickly removed for maintenance. A mount which is bolted to the airframe structure should provide quick disconnect mechanical hold-downs for the coupler unit without need for special tools. Insertion of the coupler into the mount should also complete the electrical connection to the antenna feedline (including the all-important RF ground current connection) without need for special tools.

The coupler should be pressurized for maximum reliability and have an easily removable cover which provides good access to all inside modules. A minimum number of cover bolts (8-32 size or larger) should be used to simplify maintenance. The inside of the unit should be constructed to isolate the RF tuning network from the control type circuits.

The RF interfaces of the coupler to the coupler mount, and the coupler mount to the antenna feed point must be designed and installed to prevent RF currents or voltages inside the fuselage. This basically requires a coaxial connection between the coupler and antenna.

7. GROUNDING, BONDING, CORROSION AND LIGHTNING PROTECTION

HF antennas can involve very high RF currents. For example, a shunt/notch type of HF antennas has approximately 50 amps, at 2 MHz, flowing between the coupler and antenna circuit. A reliable, low resistance path from the coupler, through the mount and feedline, and around the antenna dielectric slot is most important for satisfactory performance. The DC resistance of this path should be on the order of 10 milliohms for a notch, a higher value is considered acceptable for antennas with a higher radiation resistance, such as a shunt. All connections in this path (except for the "coupler to mount" quick disconnect interface) must be secured using high current type connections. Do not use wires or braid for those connections; use wide metal straps or large metal tubes. Mounting instructions must always require the coupler to be firmly seated in the coupler mount (for electrical as well as mechanical reasons).

Provisions must be made to insure that there is no paint, insulating material, sealing compound, epoxy, plastic, etc., in any of the high current metal to metal connections. Do not use dissimilar metals in connections and protect all connections from corrosion. Two clean aluminum mating surfaces (with an electrically conductive chemically plated finish) which are tightly held together make good joints. Additional protective sealing may be required in very corrosive environments. Poor joints or corroded joints have caused performance problems with some shunt/notch antennas.

The probe antenna requires high voltage consideration since high reactance is present at the low frequencies. The lightning arrester must be able to sustain the high voltage present without nuisance triggering. Likewise, coupler components must be able to sustain the high operating voltages.

The lightning arrester (required for the probe or cap antenna) must effectively bypass the full charge for each of 12 lightning strokes having the following successive current components:

- (a) An initial component rising from zero to a crest value of $100,000 \pm 5,000$ amperes in 5 ± 2 microseconds and decaying to

50,000 $\pm$ 10,000 amperes in 10 $\pm$ 3 microseconds from the beginning of the current waveform with a voltage rise rate of not less than 1 kilovolt per microsecond.

- (b) Immediately following, a second component of the same polarity, rising to 2,000 $\pm$ 100 amperes within 5 milliseconds from the beginning of the first component and with a total charge transfer in excess of 20 coulombs.
- (c) Immediately following, a third component of the same polarity consisting of a continuous discharge transferring at least 300 coulombs having a duration of not less than 1 second or more than 2 seconds.

The arrester must bypass six lightning strokes as specified in (a), (b), and (c) above, and the spark gap breakdown voltage should not vary more than +8% or -20% of the specified breakdown voltage after each stroke.

The gap breakdown voltage should be monitored following each stroke and should be equal to the highest of three individual breakdown voltages occurring after a steadily increasing voltage.

The arrester should successfully bypass six additional strokes without failure of arrester or its component parts except that the gap breakdown voltage need not remain within the +8% or -20% tolerance.

Arresters for commercial applications are generally designed to conform to the requirements of specification MIL-A-9094D(ASD) 16 March 1969. This Military Specification can be used as an additional source of information on high coulomb capability lightning arresters.

A bleed-off resistor should be included in the lightning arrester for probe/cap type antennas, and for ungrounded wire antennas, to reduce p-static problems.

Antenna coupler manufacturers are warned that voltage spikes containing very little energy may pass through the lightning arrester with a high rate of rise and components in the coupler, particularly of the solid state variety, must be protected. This is particularly applicable to the transceiver side of the coupler where the voltages are normally low because of the 50-ohm characteristic impedance.

8. VIBRATION

The coupler should be designed to withstand the vibration envelope specified by the airframe manufacturers for the specific airplanes and locations, for which the coupler will be installed.

The vibration level requirement for a fuselage located shunt/notch type antenna coupler is usually less severe than required for a wing or fin tip coupler. Two test levels should be used to test vibration characteristics of a coupler. One is a functional test based on coupler operational performance being demonstrated at a real time (actual) environment. The second is a structural endurance test, based on an accelerated time input test level which is used to establish structural integrity. The coupler must be tested in the mounting provisions for which it is designed.

9. TEMPERATURE / ALTITUDE

A pressurized coupler case allows the coupler to be used either inside or outside of the pressurized cabin area. The pressurized case design helps eliminate the problems associated with moisture, frost, and high altitude voltage breakdown, thus greatly increasing reliability.

The case and cover seals should be designed for a one year (minimum) leak-down rate. The cover seals must be capable of performance at maximum altitude and minimum temperature. Seals must be reusable over the normal life of the equipment. The coupler should normally be pressurized with dry nitrogen at 5 to 7 pounds gauge pressure and it should maintain this pressure for a period of one year without servicing.

10. LOW RESISTANCE RF MEASUREMENT

Method No. 1

At the lower HF frequencies, the impedance of notch antennas is comprised of low reactance and very low resistance. The reactance can usually be measured without difficulty, but the resistive value is too low to be measured directly with most instruments. The following is a description of a possible measuring technique using a General Radio GR 1606B Impedance Bridge. The technique consists of synthetically increasing the value of the resistive component of the impedance by placing a low loss capacitor across the antenna terminals. This impedance value is measured and used to compute the true resistive value. The procedure is given below.

- (1) Set up the bridge at the appropriate frequency and then measure the impedance of the antenna, obtaining the value X_s , the reactance of the antenna. The resistive component will be too small to accurately measure.
- (2) Place a low loss capacitor of suitable value across the antenna to obtain a resistance value between 30 and 70 ohms. Accurately measure the impedance value $R_m + jX_m$ of the capacitor and antenna combination.
- (3) Using the following equation, calculate R_p of the combination

$$R_p = \frac{R_m^2 + X_m^2}{R_m} \quad (R_m \text{ and } X_m \text{ are in ohms}).$$

Since the loss in the capacitor is small, for all practical purposes, R_p is the equivalent parallel circuit resistance of the antenna.

- (4) Since the Q of the antenna is relatively high, about 80, the series resistance component of the antenna impedance may be calculated from:

$$R_s = \frac{X_s^2}{R_p}$$

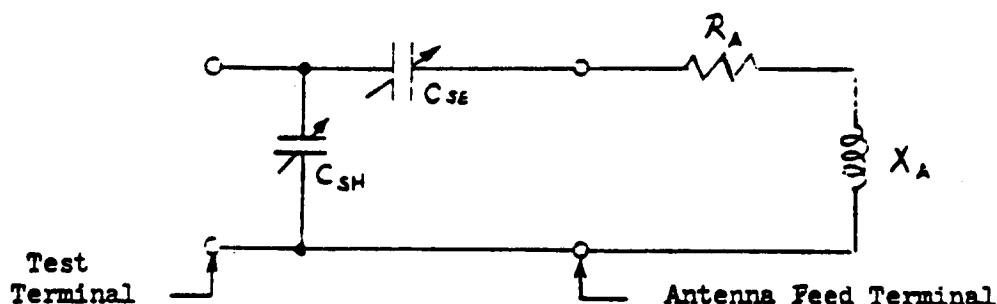
This method has the advantages that all resistance values are easily measured and the value of the capacitor used need not be known. Also, the addition of the capacitor reduces the load VSWR, which in turn reduces the probability of error introduced in rotating the measured impedance down the cable from the bridge to the antenna input.

A variation of the above measurement technique is to use a low loss variable capacitor across the antenna. The capacitor is adjusted to resonate the antenna so that R_p can be measured directly.

Method No. 2

A second possible measuring technique to determine low values of resistance for notch type antennas uses the Hewlett-Packard 4815A Vector Impedance meter. This method is useful in scale model applications where the antenna feed point is limited in space available for instrumentation. In this method, the antenna impedance is transformed to $50 + j0$ by the addition of two small high Q variable capacitors which form an L-network in the same configuration as a standard HF coupler. The R and the X values are obtained as follows:

- (a) Connect high Q, variable series and shunt capacitors at the antenna feed point to form an L-network.



- (b) Connect the Vector Impedance Meter to the test terminal and adjust the series and shunt capacitors to read 50 ohms impedance and 0 degrees phase angle.
- (c) Accurately measure the capacity of the series capacitor and the shunt capacitor.
- (d) Because the losses in a high Q (> 1000) air dielectric variable capacitor are low, the antenna resistance can be computed as:

$$R_A = \frac{50 (C_{se})^2}{(C_{sh} + C_{se})^2}$$

and antenna reactance can be computed as:

$$X_A = \frac{10^6}{W_o (C_{sh} + C_{se})}$$

where W_o is at the test frequency in MHz.

Method No. 3

A Method to Extend the Tuning Range of the HP4815A To Measure the Impedance of Aircraft HF Antennas

The HP4815A vector impedance meter is not accurate enough to directly measure impedance (Z_A) if the angle (θ) is greater than approximate 84 degrees. If θ is large, antenna reactance (X_S) can be measured directly, but resistance (R_S) can only be determined by a measurement procedure which involves using additional inductors and/or capacitors which are shown in the form of an L-C Box. For best accuracy, Z_3 should be as large as possible.

This measurement procedure consists of four steps:

1. Measure antenna impedance (Z_1 , θ_1)
2. Measure antenna and coil/capacitor resonant impedance (Z_2)
3. Measure coil and capacitor resonant impedance (Z_3)
4. Calculate antenna impedance $Z_A = R_S \pm jX_S$

To get good accurate data, one must securely bond (ground) all measurement equipment to the aircraft skin in the same manner that the antenna coupler must be bonded (see figure 1). The bonding point must be as close as possible to the antenna feed through.

The aircraft should be located away from large metal structures such as buildings, power lines, and steel reinforced concrete to minimize changes to antenna impedance. Power cords and wires which connect to the aircraft should be arranged to have a minimum effect on antenna data. If touching or moving the power wires causes changes to meter readings, add isolating choke inductors or ferrite cores to the wires (at entry to aircraft) to isolate the aircraft from the power system.

The HP-4815A model with OPTN H-01 is recommended for measurements near areas of strong RF signals (such as near an airport or near transmitting antennas). The version of the meter has high level internal injection signals to reduce interference from antenna conducted RF noise.

Measurement Procedure

Step

1. Measure Z_1 Antenna Impedance

Connect the HP4815A to the antenna feedline in place of the antenna coupler (see figure 1). If the L-C Box is used, C1 and L1 are not

connected to the antenna for this measurement. The antenna and rf ground connections must be securely fastened. At each desired frequency, record impedance magnitude and phase angle as Z_1 and θ_1 .

- a. For θ_1 readings of approximately 84 degrees or less, antenna series impedance $R_s \pm jX_s$ can be calculated directly from the Z_1 and θ_1 readings. Proceed directly to step 4(a).
- b. For θ_1 greater than approximately 84 degrees, use steps, 2, 3, 4(b), and 4(c) to determine R_s and X_s .

2. Measure Z_2 (Antenna Impedance Parallel Resonated with Capacitor and/or Coil).

Connect the capacitor and/or coil to the equipment setup of step 1.

See the attached diagram for details of L1 and C1. The connecting lead or straps must be kept as short as possible to avoid adding effective length to antenna. A metal box around L1 and C1 is suggested to provide shielding (one side may be left open - the open end of L1 should face the open side of the box).

a. Capacitive θ_1 Greater than 84 Degrees (Use Test Coil and Capacitor)

Adjust the inductance of L1 to be just large enough to allow C1 to resonate the coil and antenna. Start with C1 at minimum capacity and Z_2 reading inductive. Increase capacity just enough to reach the first parallel resonance. At parallel resonance, $\theta_2 = 0$ degrees and Z_2 indicates the parallel resistance of L1 and the antenna. Vacuum capacitor losses can be neglected except for very short antennas. Record Z_2 and proceed to step 3.

b. Inductive θ_1 Greater than 84 Degrees (Use Test Capacitor)

Repeat step 2(a), using only C1 to resonate the antenna.

For shunt or notch antennas, connecting straps must have very low loss and inductance (use short, heavy aluminum or copper straps which are bolted in place).

Record Z2 and proceed to step 4(c).

3. Measure Z3 Coil/Capacitor Impedance

Carefully disconnect the antenna lead without moving the HP4815A probe or the L-C box.

Adjust C1 to again get parallel resonance as in step 2(a). This results in Z3 equal to the parallel resistance of the test coil.

Record Z3 and proceed to step 4(b).

4. Calculate ZA Antenna Impedance $Z_A = R_s + jX_s$

a. For θ_1 approximately 84 degrees or less

$$R_s = Z_1 \cos \theta_1$$

$$X_s = Z_1 \sin \theta_1$$

b. For θ_1 capacitive and greater than 84 degrees

$$X_s = Z_1 \sin \theta_1 = X_p = -jZ_1$$

$$R_p = \frac{Z_3 (Z_2)}{Z_3 - Z_2}$$

$$R_s = \frac{(Z_1)^2}{R_p} \quad \text{Note exact solution is: } R_s = \frac{X_s(X_p)}{R_p}$$

c. For θ inductive and greater than 84 degrees

$$X_S = Z_1 \sin \theta = +jZ_1$$

$$R_P = Z_2$$

d. Examples

Capacitive Antenna

Measure: $Z_1 = 600, \theta_1 = -90$ degrees at 2 MHz.

$$Z_2 = 72,000 \text{ ohms}, \theta_2 = 0$$

$$Z_3 = 90,000 \text{ ohms}, \theta_3 = 0$$

$$\text{Calculate } X_S = 600 \sin (-90^\circ) = -j600$$

$$R_P = \frac{90,000 (72,000)}{90,000 - 72,000} = 360,000 \text{ ohms}$$

$$R_S = \frac{(600)^2}{360,000} = 1 \text{ ohm}$$

$$Z_A = 1 - j600 \text{ ohms at 2 MHz}$$

Inductive Antenna

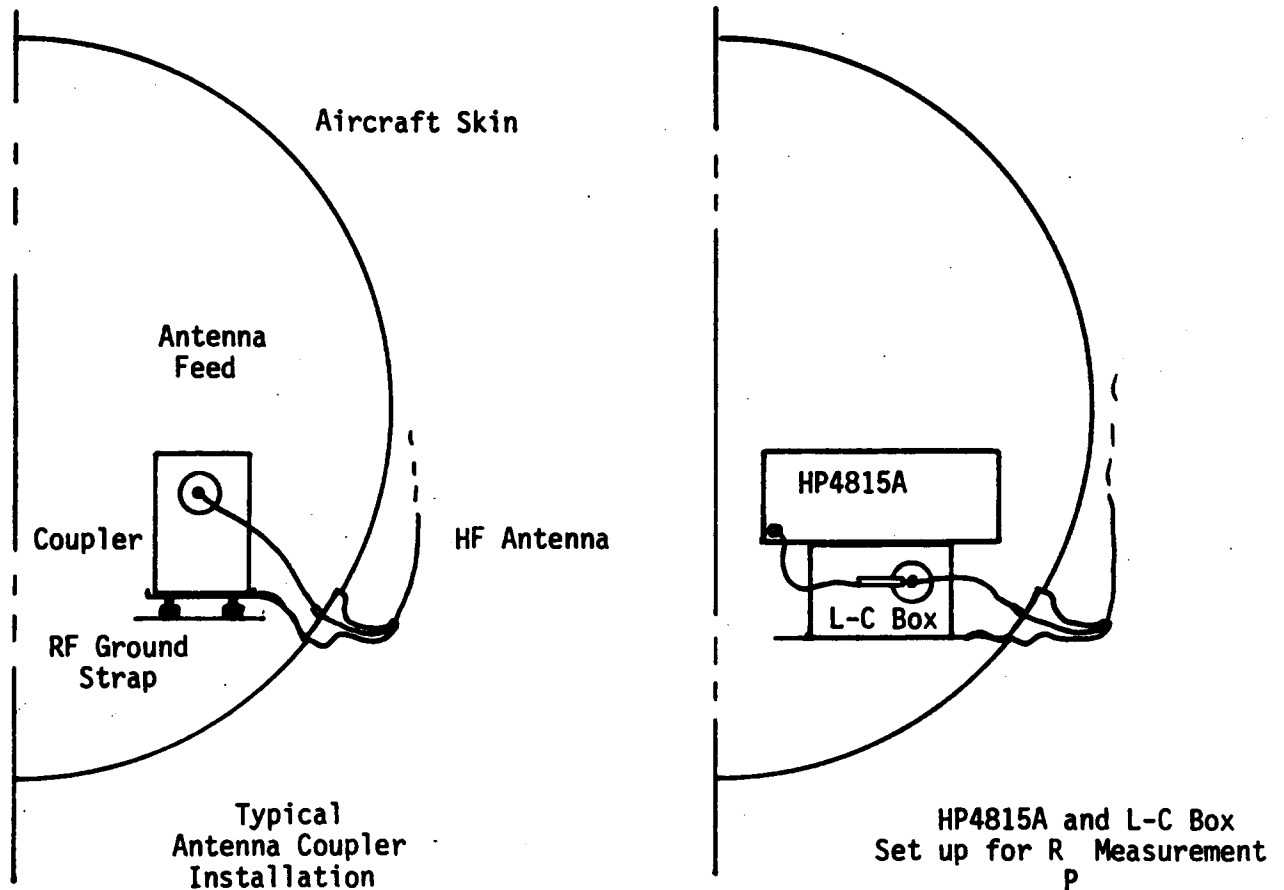
Measure: $Z_1 = 30, \theta_1 = 89$ degrees at 2.5 MHz

$$Z_2 = 3200 \text{ ohms}, \theta_2 = 0 \text{ degrees}$$

$$\text{Calculate: } X_S = Z_1 \sin \theta_1 = jZ_1 = j30 \text{ ohms}$$

$$R_S = \frac{(30)^2}{3200} = 0.282 \text{ ohms}$$

$$Z_A = 0.282 + j30 \text{ at 2.5 MHz}$$



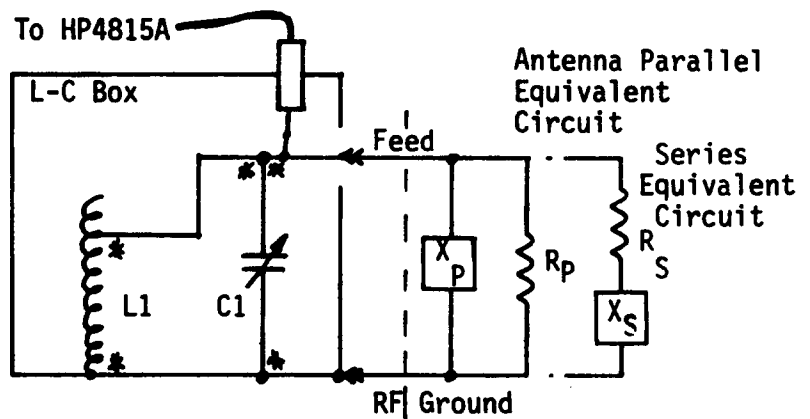
L-C Box should be aluminum enclosure for good shielding

L1 is a high Q coil which can be adjusted (with a low loss tap) to approximately equal (resonant) capacitive antenna reactance X_p .

C1 is a variable vacuum or air dielectric capacitor. C1 must cover a capacity range to resonate X_L or X_L in parallel with X_p . C1 is 5 to 500 Pf for

most antennas (to around 4500 Pf for shunt antennas).

*Low loss connection (bolt or solder)



L-C Box Schematic

Figure 1

APPENDIX 1

ORIGINAL "ASSUMED" ESSENTIAL SYSTEM CHARACTERISTICS

(See Section 1.7 of this Characteristic for significance of this material.)

NEW NOTE: The implementation of HF/SSB will have required three decades before it is completed. Since there still remains some actions to be taken by various regulatory bodies throughout the world, these original "assumed" Essential System Characteristics are reproduced herein. Appendix 9 provides information needed to update the "Assumed" Essential System Characteristics to reflect the final stages of HF/SSB implementation.

OLD NOTE: The "Assumed Essential System Characteristics" set forth in this Appendix 1 were developed in the late 1950's by the first AEEC HF/SSB Subcommittee based on the IATA principles adopted and published in 1955, which were given international stature by ICAO in 1957 (see next page). These "assumed" parameters have served as the basis for airborne equipment planning and design as reflected in ARINC Characteristic 533 in 1959. Most all aspects of these "Assumed Characteristics" were subsequently (ICAO-1966) given the status of International Standards except for the matter of half-kHz vs unit kHz-channels as explained in detail in Appendix 7. Thus, because all decisions had not yet been properly settled at the time ARINC 559 was published, this material has considerable historical significance, even though, officially, it has been superseded by the ITU and ICAO standards (see Appendix 8 for latest [1966] ICAO standards and Recommended Practices).

APPENDIX 1
(CONTINUED)

ORIGINAL "ASSUMED" ESSENTIAL SYSTEM CHARACTERISTICS

As explained in the introduction note on the previous page of this Appendix 1, this is old ICAO material, included here for historical record purposes. The new ICAO material is contained in Appendix 8.

Annex 10 — Aeronautical Telecommunications

Attachment D to Part I

4.—Single Sideband (SSB) HF Radiotelephone Communication System Characteristics

4.1 States wishing to utilize a Single Sideband system for HF radiotelephone communications in the International Aeronautical Mobile Service should be guided by the following characteristics, noting the fact that any future data transmission system would have to operate within the frequency characteristics and tolerances of the radiotelephone Single Sideband system being proposed, or that an alternative system to be applied to the IIF radiotelephone International Aeronautical Mobile Service would have to be adapted, capable of accommodating both voice and certain types of coded intelligence.

i) *Mode of operation.* Single channel simplex mode of operation should be employed.

ii) *Frequency range.* The radio frequencies used should be selected from the band 2 to 24 Mc/s. The assigned carrier frequency assignments should be on integral multiples of 1 kc/s.

iii) *Frequency accuracy.* For radiotelephone operation the frequency accuracy and stability should be such that the difference between any two elements of the system working on the same channel would not be more than 45 c/s.

Note 1.—In the case of a suppressed carrier system, this difference does not include Doppler effects.

Note 2.—In the case of a controlled carrier system, this is the difference after AFC operation, which will, by its nature, include correction for the error introduced by the Doppler effect.

iv) *Sideband selection.* The upper sideband only shall be employed.

v) *Bandwidth.* The necessary bandwidth should not exceed 4000 c/s. However, in initial implementation planning for the system, 3000 c/s virtual carrier separation is necessary in the lower frequency bands for effective utilization of the existing ITU frequency allotment plan.

Note.—The maximum modulating frequency is not expected to exceed 3000 c/s.

vi) *Suppression of undesired sideband and spurious output (Transmitter).* All out-of-band radiations resulting

from incomplete sideband suppressions, intermodulation distortion, harmonics or other spurious outputs should be limited in accordance with the appropriate ITU Radio Regulations and note should be taken of the relevant ITU/CCIR recommendations.

4.2 *Steps to be taken to ensure a smooth transition to SSB from DSB systems in use.* The transition to SSB will require careful planning of the steps to be taken in the development, evaluation and implementation of SSB.

4.2.1 Planning.

4.2.1.1 There appears to be little possibility of a sudden and discrete change from present DSB aeromobile HF/RTF to an "ultimate" system of SSB. Therefore, one of the major requirements of an SSB system should be ease of implementation on a step-by-step basis without degrading existing services during any phase of the transition.

4.2.1.2 To facilitate development and operational evaluation, certain channels should be re-assigned to SSB and should be substantially free of interference from other types of emission.

4.2.1.3 Initial frequency allocation for the SSB HF/RTF service should be on a basis that will permit progressive expansion and optimum spectrum utilization within the frequency allotment plan in Appendix 26 to the ITU Radio Regulations (Geneva, 1959), avoiding the need for a complete frequency rearrangement during later stages.

4.2.2 Evaluation and development.

4.2.2.1 It is essential that system performance, as affected by co-channel and adjacent-channel interference, Doppler shift, propagation conditions and network operations, should be evaluated by users under strictly operational conditions.

4.2.2.2 In order to avoid unnecessary complications during the evaluation trials, the mixing of SSB with other modes of operation should be avoided as was done in the case of amateur frequency bands.

4.2.2.3 Following operational evaluation, system characteristics can be developed in more detail than the basic characteristics presently suggested.

4.2.2.4 With operational experience, there should be progressive evolutionary development to ensure the optimum relation between the practical technical possibilities and the operational conditions experienced. For this reason, the system specifications should be no more rigid than necessary.

APPENDIX 1 (Contd)

ORIGINAL "ASSUMED" ESSENTIAL SYSTEM CHARACTERISTICS FOR HF/SSB

APPENDIX 1 (CONTINUED)

ORIGINAL "ASSUMED" ESSENTIAL SYSTEM CHARACTERISTICS FOR HF/SSB

1.0 INTRODUCTION

As explained in Section 1.7 of this ARINC Equipment Characteristic, the International Civil Aviation Organisation will, at the appropriate time, adopt an internationally acceptable set of Standards and Recommended Practices (SARPS) to properly define the necessary HF Single Sideband parameters for international use. The present Section 4. of Attachment D to Part 1 of Annex 10 to the Convention of International Civil Aviation (7th Edition - August, 1963) provides the very basic SSB System Characteristics in the form of "guidance material", as they were developed at the ICAO Sixth COM Division Meeting of September, 1957. As explained in Section 4.2.2.4 of that Attachment there should, with operational experience, be progressive evolutionary development to ensure the optimum relation between the practical, the technical possibilities and the operational conditions experienced. For this reason, the Essential System Characteristics should be no more rigid than necessary. Section 4.2.2.3 of that Attachment emphasizes the Essential System Characteristics can be developed in more detail than the basic material contained in the present Section 4.1 of Attachment D to Part 1 after operational evaluation has been completed.

Although the Sixth COM Division Meeting of ICAO fully expected developmental programs on HF Single Sideband in the following years, the implementation, even on a test basis, did not materialize --- probably for the specific reason that a firm and final decision could not be reached at the ICAO Sixth COM Division Meeting on the specific type of single sideband system which would be needed to accommodate future data transmissions and future voice communications using supersonic aircraft. It was not until many years later that the questions implied in Section 4.1 of the original ICAO Attachment D to Part 1, relative to the future type of SSB system to be needed for data and voice transmissions on supersonic transports, could be satisfactorily answered, thereby allowing a more definitive set of Essential System Characteristics to be adopted. Once an international agreement has been reached that a suppressed carrier system of Single Sideband will be acceptable for voice and future data systems on HF, the material originally contained in Section 4. of the Attachment D to Part 1 can be supplemented and perhaps raised in status from "green page" Guidance Material to "white pages" for incorporation in Chapter 4 of Annex 10 as "SARPS". The material contained herein is predicated on such a decision, endorsing suppressed carrier SSB as suitable for voice and data, being made at the next ICAO COM Division Meeting.

Such international agreement on HF SSB SARPS cannot take place until the ICAO Eighth COM Division Meeting (or alternative ICAO Conference, probably in the Fall of 1966); however, specific proposals can be developed at the technical working level prior to that time with at least some degree of assurance that States will (later) adopt a system which will be in all practical respects identical to that agreed upon now. While such "assumed Essential System Characteristics for HF/SSB" cannot have any international status as of now, the system and equipment planners must go through this exercise at the working level in order that the hardware, both ground and air, can have the features and performance capabilities which are most likely to be stated as necessary in the ICAO SARPS when finally adopted several years from now. It is, therefore, the purpose of this Appendix 1 of this ARINC Equipment Characteristic to set forth certain suggested HF/SSB communication Essential System Characteristics which can serve as a basis for the airborne equipment covered by this ARINC Equipment Characteristic.

It must be assumed that these Essential System Characteristics will be the ones eventually to be adopted by ICAO, and it is upon these Essential System Characteristics that the equipment covered by this ARINC Equipment Characteristic is based.

In the following tabulation of Essential System Characteristics, those items which are presently in Attachment D to Part 1 of ICAO Annex 10 are referenced in the pertinent section number in parenthesis:

NOTE: At this early stage of editing material for possible consideration by a future ICAO COM Division meeting, the wording in the following proposal has been made to fit as precisely as possible in the original wording and the original format of the "green page" material developed by the Sixth ICAO COM Division meeting in the belief that this will facilitate the study and consideration of the following proposal by ICAO. Undoubtedly a complete re-editing of this material at a later date (possibly just prior to, or during, the Eighth COM Division meeting of ICAO) would be proper in the interest of providing a more effective format for the "white page" SARPS which might eventually result; yet, at this early stage of development of these "words", the advantage of maintaining the original ICAO format and organization of the material would seem to be quite important.

Furthermore, no attempt has been made to include in the following proposal any material relating to the operational use of the HF/SSB system but instead the following proposal has been confined to the technical items which are of major import in allowing work to proceed on the airborne hardware equipment development.

2.0 IMPLEMENTATION

(Same as Section 4.1, first paragraph but modified in view of the decision to accept suppressed carrier single sideband for data transmission as well as for voice.)

APPENDIX 1 (contd)

ORIGINAL "ASSUMED" ESSENTIAL SYSTEM CHARACTERISTICS FOR HF/SSB

States wishing to utilise a Single Sideband System for Radiotelephone Communications in the International Aeronautical Mobile Service should be guided by the following characteristic noting that any future data transmission must operate within the frequency characteristics and tolerances of the Single Sideband System, which must, therefore, be capable of accommodating both voice and certain types of coded intelligence.

2.1. Mode of Operation

(Same as Section 4.1 i) of Attachment D to Part 1) but with a more specific statement of intent.)

Only the single channel simplex mode of operation should be employed.

2.2. Frequency Range

(Same as Section 4.1 ii) of Attachment D to Part 1 but add "Note".) The radio frequencies used should be selected from the band 2 to 24 Mc/s. The assigned carrier frequency assignments should be on integral multiples of 1 Kc/s.

NOTE: During the interim period of transition from AM to SSB operation where a mixture of SSB and AM communications might exist on AM frequency channels, and where the AM assigned carrier frequency assignments presently end in half-kilocycles, and where it is desired that such AM transmissions be receivable by stations employing suppressed carrier SSB receivers, ground AM transmitters should be moved to the assigned carrier frequency assignments (on integral multiples of 1 kc/s) of the SSB stations using that channel and held to the frequency accuracy established in Section 2.3 herein, in order that reception by these suppressed carrier single sideband-equipped receiving stations will be ensured.

2.3. Frequency Accuracy

(Same as Section 4.1 iii) of Attachment D to Part 1 except new Sections 2.3.1 and 2.3.2 have been added and the text has been clarified as a result of the decision on the SSB suppressed carrier system.)

For radiotelephone operation or for data link application the frequency accuracy and stability should be such that the difference between any two elements of the system working on the same channel would not be more than 45 c/s.

NOTE: The foregoing frequency difference is inclusive of Doppler effects for air-ground-air SSB communications with subsonic aircraft; however, for supersonic aircraft, an additional frequency difference must be tolerated due to Doppler effects (the Doppler frequency shift between an aircraft and the ground station is approximately one cycle per second, per megacycle, per Mach number) such

Appendix 1 (contd)

"ASSUMED" ESSENTIAL SYSTEM CHARACTERISTICS FOR HF/SSB

that a Mach 3 aircraft operating on 15 megacycles will produce a Doppler shift of 45 cycles per second which, when added arithmetically to the sum of the frequency tolerances of the air and ground portions of the system, gives a total "worst case" difference frequency of approximately 75 cycles per second and which is considered an acceptable total difference including Doppler effects for either voice or data transmission, considering all of the rather improbable circumstances which must add up the wrong way to produce this "worst case" condition.

2.3.1 Frequency Accuracy of Ground-to-Air Transmissions

The frequency of any ground-to-air transmission intended for reception by suppressed carrier SSB means should be held to an accuracy of ± 10 cycles per second, expressed in terms of the actual carrier frequency, whether or not transmitted, with respect to the assigned carrier frequency.

2.3.2 Frequency Accuracy of Air-to-Ground Transmissions

The frequency of any air-to-ground transmission intended for reception by suppressed carrier SSB means, should be held to within ± 20 cycles per second, expressed in terms of the actual carrier frequency, whether or not transmitted, with respect to the assigned carrier frequency.

2.4. Sideband Selection

(Same as that of Section 4.1 iv) of Attachment D to Part 1 but add Note.) The upper sideband only shall be employed.

NOTE: This does not imply that the frequency spectrum previously taken up by the lower sideband of the AM transmission would not be employed; the important significance of the foregoing requirement is that only the upper sideband on a particular transmission will be employed on the ICAO frequencies for air-ground-air communications. (For certain point-to-point communications, the "independent sideband system" of Section 5 of Attachment D to Part 1 of Annex 10 applies; however, the independent sideband system is not authorized for air-ground-air use on ICAO circuits.)

***2.5. Bandwidth**

(Essentially same as Section 4.1 v) of Attachment D to Part 1 - modified for Clarity.)

The authorized emission bandwidth, should not exceed 4000 c/s. However, in initial implementation planning for the system, 3000 c/s virtual carrier separation is necessary in the lower frequency bands for effective utilisation of the existing ITU/IAARC frequency allotment plan.

NOTE: The maximum modulating frequency is not expected to exceed 3000 c/s.

*See Appendix 9

APPENDIX 1 (contd)

ORIGINAL "ASSUMED" ESSENTIAL SYSTEM CHARACTERISTICS FOR HF/SSB

*2.6. Suppression of Undesired Sideband and Spurious Output (Transmitter)

(Same as Section 4.1 vi) of Attachment D to Part 1 except new Sections 2.6.1 and 2.6.2 have been added.)

All out-of-band radiations resulting from incomplete sideband suppression, intermodulation distortion, harmonics or other spurious output should be limited in accordance with the appropriate ITU Radio Regulations and note should be taken of the relevant ITU/CCIR recommendations.

2.6.1 Spectrum Limits of Airborne Transmissions (New Material to be Added)

The power of any emission outside the authorized frequency band of emission should be suppressed below the peak envelope power in accordance with the following schedule:

- On any frequency removed from the center of the authorized frequency band of emission by more than 50% up to and including 150% of the authorized emission bandwidth, at least 25 decibels.
- On any frequency removed from the center of the authorized frequency band of emission by more than 150% up to and including 250% of the authorized emission bandwidth, at least 35 decibels.
- On any frequency removed from the center of the authorized frequency band of emission by more than 250% of the authorized emission bandwidth, at least 40 decibels.

2.6.2 Spectrum Limits of Ground Transmissions (New Material to be Added)

The power of any emission outside the authorized frequency band of emission should be suppressed below the peak envelope power in accordance with the following schedule:

- On any frequency removed from the center of the authorized frequency band of emission by more than 50% up to and including 150% of the authorized emission bandwidth, at least 25 decibels.
- On any frequency removed from the center of the authorized frequency band of emission by more than 150% up to and including 250% of the authorized emission bandwidth, at least 35 decibels.
- On any frequency removed from the center of the authorized frequency band of emission by more than 250% of the authorized emission bandwidth, at least to a power level of 50 microwatts, defined by formula as:

$$43 + 10 \log_{10} (\text{mean output power in watts}) \text{ Decibels.}$$

*See Appendix 9

APPENDIX 1 (contd)

ORIGINAL "ASSUMED" ESSENTIAL SYSTEM CHARACTERISTIC FOR HF/SSB

NOTE: The significance of the different wording in the sub-paragraphs "c" for aircraft and ground transmitters is that aircraft transmitters cannot, in a practical operating environment provide more than 40 db of attenuation, while with ground transmitters the attenuation is not as difficult to provide as in an airborne transmitter. Higher attenuation is necessary when the power is higher than in an aircraft transmitter, and it is mandatory that the power be reduced to 50 microwatts.

2.7. Transmitter/Carrier Provisions

The form of carrier transmission shall be selected from one of the following modes depending upon the mode of reception for which the transmission is intended:

2.7.1 Transmission Intended for AM Reception

When the transmission is intended for AM reception (using an AM detector), a constant level carrier should be transmitted at a level which is reduced not more than 6 db below peak envelope power.

2.7.2 Transmission Intended for Suppressed Carrier SSB Reception

When the transmission is intended for reception by detection means using a locally generated carrier rather than a received carrier, the carrier to be transmitted shall be selected from one of the following (in order of preference).

a) Suppressed Carrier

The carrier to be at a constant level which is reduced 20 db or more below peak envelope power.

b) Reduced Carrier

The carrier to be transmitted at a level which is reduced more than 6 db and less than 26 db below peak envelope power.

c) Controlled Carrier

The carrier to be made to vary inversely, or in an indirect manner, as the average level of the sideband amplitude varies so that the power radiated will remain roughly constant during modulation.

NOTE: With controlled carrier operation the power transmitted in the carrier does not appreciably reduce the effective radiated power in the

APPENDIX 1 (contd)

ORIGINAL "ASSUMED" ESSENTIAL SYSTEM CHARACTERISTICS FOR HF/SSB

sidebands during full modulation inasmuch as the transmitter is usually adjusted to radiate a reduced level of carrier when no modulation is present but with a reduction to 26 db or more below peak envelope power when full modulation is present. This type of carrier operation is well suited to high power ground station transmitters for practical and economic design reasons associated with the circuitry of the transmitter and the power supply system.

d) Full Carrier

The carrier to be transmitted at a constant level which is reduced not more than 6 db below peak envelope power.

NOTE: The use of full carrier transmissions during the early phases of implementation where SSB and DSB users (A2, A2H, A2A, and A2J) are intermixed on the same frequency channels can aid the discipline on the communications network by allowing users which are equipped with receivers and transmitters of several types to monitor the circuit. It is particularly desirable that full carrier operation be continued by ground stations operating on such networks until such time as AM users of that network would no longer be inconvenienced by their inability to monitor the circuit prior to making a call.

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- 2-1 -

APPENDIX 2

GROUND EQUIPMENT REQUIREMENTS

NOTE: The "Ground Equipment Requirements" set forth in this appendix were developed as part of the original HF/SSB activities in the late 1950's and published as part of the ARINC 533 Spec. This information is again reproduced in this Characteristic for historical or REFERENCE USE ONLY since this material has not been updated since 1960.

APPENDIX 2 (Cont'd)

GROUND EQUIPMENT REQUIREMENTS

1.0 Applicability

It is not the intent of this ARINC Characteristic to establish detailed design requirements for ground equipment used either by government or non-government operators as this will always be the specific prerogative of the individual customer as there is little, if any, justification for ground equipment standardization.

Yet the concept of a System Specification for SSB, such as set forth as an assumption in Appendix 1 of this Characteristic, implies certain performance requirements which should be followed as a minimum by all operators who provide SSB communications service to aircraft. These minimum requirements for ground equipment are certainly not intended as mandatory requirements but, as a part of this ARINC Characteristic, have the same significance and status as does the portion of this Characteristic pertaining to airborne equipments, namely, this material serves as a guide to prospective manufacturers on the probable industry requirements and further provides a guide to customers in specifying their requirements directly with the manufacturers.

2.0 Physical Characteristics and Environmental Conditions

There is no intent to standardize any of the physical characteristics of ground equipment in this Characteristic nor is there any intent to establish environmental conditions such as temperature, humidity, electrical power characteristics, audio input and output levels and impedances or even antenna characteristics or performance. These will be subject to the usual customer's desires or the manufacturer's standard practices.

3.0 Modes of SSB Transmission and Reception Required

Although this Characteristic specifies very specific modes of operation for the airborne equipment for obvious reasons, it is not the intent of this Appendix II to establish specific modes of operation as a requirement for any and all ground station equipments. The decision as to whether a particular mode of operation is required at a particular station is the prerogative of the equipment purchaser and is dictated by the operations requirement of the user at that station. It is not the prerogative of this Appendix to specify which mode shall be used at which station.

APPENDIX 2 (Cont'd)

GROUND EQUIPMENT REQUIREMENTS

3.0 Modes of SSB Transmission and Reception Required (Continued)

Neither is it the prerogative of this Appendix to specify that if two modes of single sideband are required at a particular station, these two modes should be accommodated in a single transmitter. Obviously, the user has the choice of providing two separate transmitters and two separate receivers or a single transmitter and a single receiver or, in fact any combination desired, depending upon his operating requirements at that station. It is possible that in some ground stations an existing AM transmitter could be retained for AM operation and a new transmitter would provide for SSB operation. However, at most stations it is likely that a single transmitter will normally provide the single sideband and the AM-compatible operation by simply providing a full carrier with single sideband and with sufficient stability to meet the needs of suppressed carrier SSB operation and with sufficient excess power in the transmitter that the service range will not be degraded by "wasting" some of the power in carrier transmission. Economics and other factors such as flexibility of operation would dictate the specific configuration of transmitters and receivers at a particular site. It is, therefore, the intent of this Appendix only to set forth the requirements which are deemed important for a particular mode of operation rather than specify which specific modes shall be provided in a particular station or set of equipment.

4.0 Ground Equipment Performance Characteristics which are Identical to those for Airborne Equipments

The following Sections of ARINC Characteristic No. 559 apply equally to ground equipment and to airborne equipment and are, therefore, made a part of this Appendix II:

NOTE: In the following tabulation those sections preceded by an asterisk (*) are included for completeness but compliance with these sections is obviously not required in all cases and should be subject to customer specification. They are, however, suitable as general guidance to manufacturers.

Section 2.0	Definitions for Purposes of this Characteristic (Including all Subparagraphs)
*Section 4.1	Frequency Coverage
Section 4.5	Mode of Operation
Section 4.6	Choice of Sideband
Section 4.14	Transmitter Distortion
Section 4.15	Transmitter Frequency Response and Spectrum Limitations
Section 4.19	SSB Transmitter Carrier Characteristics (Including all Subparagraphs)
*Section 4.23	Receiver Sensitivity
*Section 4.25	Automatic Gain Control
Section 4.26	Receiver Recovery after Transmission
Section 4.28	Receiver Selectivity in Suppressed Carrier SSB Reception Mode
Section 4.29	Receiver Selectivity in SSB-AFC Reception Mode
Section 4.30	Receiver AFC Characteristics (Including all Subparagraphs)
Section 4.31	Receiver Spurious Responses
Section 4.32	Receiver Overall Frequency Response
*Section 4.33	Hum and Noise in Receiver Output
*Section 4.35	Receiver Automatic Noise Limiter
Section 4.36	Receiver SSB-Mode Linearity (Including all Subparagraphs)

APPENDIX 2 (Cont'd)

GROUND EQUIPMENT REQUIREMENTS

5.0 Other Performance Requirements

5.1 Undesired Radiation: Any emissions on a harmonic of the desired frequency and any distortion products are to conform with the spectrum limits of the following Section 5.2.

5.2 Transmitter Frequency Response and Spectrum Limitations: The overall frequency response measured from the microphone audio input should not vary by more than ± 3 db from the 1000 cycle per second reference level, throughout the range of 312 cycles per second to:

- (1) With Customer's Option No. 1 - 3 Kc: (See explanation of significance of this filter in Note in Section 4.15) To an upper limit of 2500 cycles per second.
- (2) With Customer's Option No. 2 - 4 Kc: To an upper limit of 3000 cycles per second.

Further for compatibility with SELCAL operations there should be no more than 3 db difference in response for any two frequencies in the range of 312 cps to 1200 cps.

Suitable transmitter circuit filtering should be employed, and the linearity of the transmitter should be such as to assure the following spectrum limits, when checked with rated power output using a two-tone test on SSB-suppressed carrier or SSB floating carrier transmission, and with a single-tone test with SSB-full carrier transmission.

- (a) All spectrum components at a frequency lower in frequency than the assigned carrier frequency and higher in frequency than the following upper limit with respect to the assigned carrier frequency will be attenuated by at least 30 db.
 - (1) With Customer's Option No. 1 - 3 Kc: An upper limit of 3 Kc.
 - (2) With Customer's Option No. 2 - 4 Kc: An upper limit of 3.5 Kc.
- (b) All transmission lower in frequency than the following lower limit with respect to the assigned carrier frequency and higher in frequency than the following upper limits above the assigned carrier frequency will be attenuated by $40 + 10$ times the log of the mean power (in watts) db, or 60 db whichever is less:

APPENDIX 2 (Cont'd)

GROUND EQUIPMENT REQUIREMENTS

5.0 Other Performance Requirements (Continued)

5.2 Transmitter Frequency Response and Spectrum Limitations (Continued)

- (1) With Customer's Option No. 1 - 3 Kc: The lower limit will be 3 Kc below the assigned carrier frequency and the upper limit will be 6 Kc above the assigned carrier frequency.
- (2) With Customer's Option No. 2 - 4 Kc: The lower limit will be 3.5 Kc below the assigned carrier frequency and the upper limit will be 7 Kc above the assigned carrier frequency.

NOTE: As these limits (for FCC purposes) are based on mean power it may be assumed that mean power is $1/4$ of the rated PEP of the transmitter.

These requirements are to be met with the introduction of any modulating tone or tones either inside or outside the transmitter frequency response bandwidth and having amplitudes up to at least 10 db and preferably 20 db greater than that which generates rated PEP.

- 5.3 Transmitter and Receiver Frequency Stability: The basic frequency stability of the transmitter and of the receiver shall be identical and such that there is never more than 10 cycles difference between the actual transmitted or received frequency and the assigned carrier frequency, without regard to Doppler effects. This maximum frequency error of 10 cycles should be held under all environmental conditions for which the equipment is designed and intended to operate.
- 5.4 Power Output: This Appendix will not specify the power output for ground transmitters in the knowledge that a number of different power ratings of transmitters will be needed and the customer and the manufacturer will jointly agree on the power requirements. Power rating will be in accordance with the definition of Section 2.2.
- 5.5 Provisions for Data Transmission and Reception by Ground Equipment: Inasmuch as the system considerations pertaining to data transmission have not yet been established and inasmuch as there is presently no operational requirement for data transmission or reception (other than SELCAL) from stations operated by civil users (as traffic control data link systems will be provided as a part of traffic control communications, generally operated by Government facilities), there will be nothing included in this Appendix to cover this mode of operation.

APPENDIX 2 (Cont'd)

GROUND EQUIPMENT REQUIREMENTS

5.0 Other Performance Requirements (Continued)

- 5.6 Provisions for Compatibility with SELCAL Operations: Although the major emphasis in terms of automatic data transmission for Air Traffic Control purposes has been placed on future data link it is expected that wide use will continue to be made of the ICAO SELCAL System (ARINC Characteristic No. 531) for many years to come and operation of SELCAL from privately owned and operated ground stations will be necessary. SELCAL operation can be accomplished either through AM transmissions from the ground, or full carrier single sideband transmission from the ground. Suppressed carrier transmission cannot be employed because of inadequate frequency stability.

The audio response characteristics for the ground transmitter are so specified in Section 5.2 that not more than 3 db difference will be obtained in the response over the frequency range of 312 or 1200 cps.

This Appendix does not provide any performance requirements catering to CALSEL or similar signalling techniques utilizing frequencies below 350 cycles per second or above 2500 cycles ground-to-air and air-to-ground.

- 5.7 Regulatory Approval: Manufacturers are cautioned that all transmitting equipment, to be licensed in the U. S., must be suitable for FCC Type Acceptance approval and such Type Acceptance should be obtained by the manufacturer before offering the equipment for sale commercially.

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APPENDIX 3

CHRONOLOGY AND BIBLIOGRAPHY
OF THE
AEEC SSB PROJECT
AND MEMBERSHIP OF
THE AEEC SSB SUBCOMMITTEE

(See Section 3.8.1 for related background material on the "Data Link" System.)

APPENDIX 3 (Cont'd)

CHRONOLOGY AND BIBLIOGRAPHY
OF THE
AEEC SSB PROJECT
AND MEMBERSHIP OF
THE AEEC SSB SUBCOMMITTEE

CHRONOLOGY:

Although AEEC gave its first consideration to SSB for HF communications as a result of a paper submitted by Trans-Canada Airlines on October 10, 1950, the first AEEC HF Subcommittee chaired by Mr. B. F. McLeod of PAA recommended that the first Industry ARINC Characteristics No. 522 through 527 be released (in 1952) without SSB provisions.

The real spark for the program came from the Military development of a satisfactory bi-mode equipment capable of both SSB and AM compatible operation and airline interest developed as a result of the November 14, 1955 IATA Symposium on Single Sideband Systems planning held in Montreal. Immediately thereafter AEEC established an SSB Subcommittee chaired by Mr. B. F. McLeod of PAA and this Subcommittee met on February 20, 1956 to review draft No. 1 of ARINC Characteristic No. 533 which had been prepared by the Subcommittee Chairman.

Then followed a series of complications; the FCC proposed rule making to require single sideband operation, resulting from Commission action of April 11, 1956; then a difference of opinion on equipment design developed, and particularly there was evident a difference of opinion on system compatibility between various segments of aviation, with Drafts Nos. 2, 3 and 4 of Char. No. 533 each serving as a proposal for resolution of these knotty problems; and finally with several competing systems such as the Kahn Compatible Full-Carrier SSB (proposed as a specific system at that time) and the General Electric Synchronous Detection technique being offered as a replacement for suppressed carrier SSB. This obvious difference of opinion culminated in an ARINC Symposium held on February 1, 1957 at which the merits and demerits of the various competing systems were threshed out and documented in a series of papers subsequently circulated by ARINC. By this time, Draft No. 5 of Characteristic No. 533 had been circulated, however, because of the many competing systems, the Airline Industry concluded they should await the outcome of U.S. Government policy determinations on systems standards as this was now making the rounds of the U. S. Air Coordinating Committee in preparation for the ICAO Sixth COM Division Meeting in the Fall, 1957. Although AEEC had now developed Draft No. 6, the Characteristics split with questions which had not been resolved on a systems basis, thus, the Airline Industry completely disowned this draft! By this time, the other competing systems were no longer a problem to the Airlines, however, the controversy now was between suppressed carrier SSB and an AFC system, with the Airlines still asking

APPENDIX 3 (Cont'd)

CHRONOLOGY AND BIBLIOGRAPHY
OF THE
AEEC SSB PROJECT AND MEMBERSHIP OF
THE AEEC SSB SUBCOMMITTEE

CHRONOLOGY: (Continued)

for AFC capability and the Military claiming it wasn't necessary. ICAO, over the objections of the U.S. Delegation, adopted in the Sixth COM Division Meeting, some very basic system standards which were sufficiently broad to encompass either AFC or suppressed carrier, at the U.S. Delegation request, and this controversy continued in RTCA Special Committee 84 through the next year in an attempt to get an agreed system proposal.

The major airlines of the world had missed implementation in their first round of airline jet aircraft in 1956, and the subsequent government-military-airline-manufacturer controversy on the basic system requirements served to make the airlines again miss their chance for the second go-around, and it was not until the Spring of 1959 that it again became apparent that another deadline date was approaching for new fleets of aircraft, thus, Drafts No. 7 and 8 of Characteristic No. 533 were developed in May, 1959. In July, 1959, AEEC endorsed a system of suppressed carrier SSB with AFC capability and directed the Subcommittee to work out all the remaining details, which they did in their meeting of September 22nd and 23rd, 1959, resulting in Draft No. 9. By this time, there was no further disagreement on the basic system as it was quite evident that provisions for AFC would be a requirement for the future. AEEC approved Draft No. 9 with only minor changes on November 17, 1959 and the "final draft"—No. 10 was then circulated in January, 1960 for approval as an Industry document by the Airlines Communication Administrative Council.

The following years produced very little implementation of ARINC Characteristic No. 533 SSB equipment in the airline industry although there was widespread implementation in the Military in several countries. The subsequent years were marked with many discussions of data link systems and the background of this is covered in Section 6.1 of this document under the data link "past history".

The important next step was a proposal by the U. S. Government about mid-1964 to introduce HF Single Sideband Suppressed Carrier to the Aviation Service by means of certain stations which FAA presently operates for traffic control communications purposes. Advance documentation prepared by the U. S. for discussion during the ICAO North Atlantic Regional Air Navigation Meeting of February, 1965 emphasized the plan of the U. S. Government to implement more and more ground facilities equipped for SSB capability. The airlines chose to work with the FAA on developing uniform international system standards and this required an industry consideration of the pros and cons of keeping the automatic frequency control capability in the system or taking it out.

The industry gave careful consideration to this matter during the October, 1964 AEEC General Session in Brussels, Belgium and recommended deleting all requirements for AFC in the ARINC HF SSB airborne equipment. This was again reaffirmed at a subsequent SSB Subcommittee meeting held on January 5-7, 1965 and "Proposed System Standards" describing the agreed SSB System were tentatively drafted. Based on these tentative System Standards, the AEEC SSB Subcommittee reviewed the ARINC Characteristic No. 533 Equipment Characteristic document and concluded

APPENDIX 2 (Continued)

CHRONOLOGY AND BIBLIOGRAPHY OF THE AEEC SSB PROJECT AND MEMBERSHIP OF THE AEEC SSB SUBCOMMITTEE

CHRONOLOGY (continued)

that the state of the art had moved along to the extent that an updated equipment would probably be justified in the near future and that a departure should be made from the original connector and interwiring standards of that original ARINC Characteristic 533 equipment. Accordingly, a new draft document was prepared by the ARINC staff based on the conclusions of this Subcommittee meeting and circulated for industry review in the Spring of 1965 on the assumption that the industry would desire to issue this document after its approval, as an entirely new Equipment Characteristic No. 559. However, as more and more users became committed to equipment designed to Char. 533, the industry asked that AEEC explore the possibilities open for a modernized equipment keeping interchangeability with the older Char. 533 equipment.

Thus, an additional subcommittee meeting was held on June 29-30, 1965. One of the principle reasons underlying development of the Draft 559 Spec. was the airlines' desire for a completely updated equipment designed to employ solid state tuning techniques in order to eliminate the maintenance and reliability problems associated with the complex mechanical devices presently employed for frequency selection and tuning controls. At the June Subcommittee meeting manufacturers agreed that techniques for solid state frequency selection and tuning were now available which could use either the existing HF re-entrant control techniques or the more recent "two-out-of-five" frequency selection system. Now that the "electricity" problems involved in utilizing the re-entrant control system seemed to have been solved, the June Subcommittee meeting agreed to retain the frequency selection pin assignments and interwiring provisions contained in Char. No. 533 and to add additional pin assignments and aircraft jumper wires to accommodate 0.1 Kc channel selection capability for possible military application if so desired by that customer. This "break-thru" made it practical to use the ARINC 533 Char. for a full updated equipment design, including full use of solid state techniques. The Subcommittee also refined the Draft 559 Project Paper for AEEC final consideration.

At the September 1965 AEEC General Session in New Orleans, AEEC agreed that an industry need for Char. 533A existed and thus, AEEC approved this Char. 533A. However, although several airlines favored AEEC approval of Project Paper 559 to be issued as ARINC Char. 559, as an alternative piece of hardware, there was insufficient support for such approval at that meeting.

After it was evident that the Industry did not need Char. No. 559 at this time, AEEC noted the considerable amount of work expended and possible future customer-manufacturer interest in the advantages offered by that Char. Several airlines urged that the Draft Project Paper 559 not be completely abandoned at this time, but preserved in its present draft form for possible future consideration if and when there may be sufficient industry interest in repackaging the new HF equipment. This agreement was recorded for posterity in the following motions:

Mr. White (TMA) moved, Mr. Donbaugh (NAL) seconded and AEEC approved without dissent or abstention the motion that consideration of the Draft Project Paper No. 559 be delayed to some future date and that the draft is to be held in abeyance pending such possible future action.

NOTE: It was also agreed any future consideration of the Draft Project Paper 559 would not be undertaken unless it appeared in the meeting Agenda to give everyone an opportunity to prepare for the discussion.

APPENDIX 3 (Continued)

CHRONOLOGY AND BIBLIOGRAPHY OF THE AEEC SSB PROJECT AND MEMBERSHIP OF THE AEEC SSB SUBCOMMITTEE

But work on the 559 remained dormant until resumed in 1969 upon the recommendation of EAEC. Although there was a well defined interest on the part of some airlines, this interest was not universal and AEEC agreed to proceed deliberately, not hastily, to develop a new draft of Project Paper 559 with Vic Persson of SAS serving as rapporteur of a working group. This approach was selected in order to minimize both the need for meetings and the possibility of misunderstandings concerning the significance of work on an updated HF SSB Spec.

Vic prepared Draft 101 of Project Paper 559 which was circulated for industry coordination. The subsequent Ad Hoc meeting held during September 1969 in Stockholm resulted in an updated draft. Review of the draft at the subsequent Fall 1969 AEEC General Session revealed two significant problem areas involving the type of power supply and box size which could not be resolved at that time. Further work on these and other problems throughout the following year resulted in Draft 103 which was approved at the Fall 1970 AEEC General Session in London, subject to a few minor details being worked out with manufacturers. That coordination was completed in the Spring of 1971 however further publishing delay was occasioned by the staff conclusion that some of the Appendix material must be updated before publishing. With this rewriting completed, the Gray cover Characteristic was published in the Summer of 1971.

The HF/SSB subject and all hardware development remained dormant for several years following approval of ARINC 559. At the Spring 1975 AEEC General Session in Washington EAEC, a number of airlines and some manufacturers expressed interest in new hardware. Vic Persson also reported ARINC 559 should be reviewed in the light of current user needs and design limitations for such equipment. AEEC approved this undertaking, with Vic as Chairman, noting the industry considered the Subcommittee should be free to revise ARINC 559 in ANY way since little or no hardware or installations had been produced.

This decision by AEEC reflects, in part, a growing acquiescence by the airlines for somewhat more restrictive regulatory requirements on FUTURE equipment. Preliminary coordination of the proposed new ICAO/ITU regulatory requirements progressed throughout the early part of 1975.

The ARINC staff prepared Draft 1 of Project Paper 559A to reflect both the users' needs and the anticipated changes in the "Assumed Essential System Characteristics" (ESC's). That Draft was circulated in August 1975 by AEEC Letter 75-063/HFC-01. In September the Subcommittee met at SAS headquarters in Stockholm and reviewed both the hardware description and ESC's as set forth in the Appendices to that Draft. The questions concerning differences between user needs and manufacturers capabilities were resolved. The proposed changes in the ESC's were approved by the Subcommittee. The Reports of this meeting and updated Draft were circulated in October 1975. AEEC reviewed Draft 2 of 559A at the General Session in Miami during December 1975. Draft 2 was approved subject to a change in the amount of cooling air and a number of editorial corrections. The question of cooling was again raised by the airframe people prior to ARINC 559A publication in Gray Covers and final resolution appeared, at that time, destined to be the subject of a future change by Supplement.

APPENDIX 3 (Continued)

CHRONOLOGY AND BIBLIOGRAPHY OF THE AEEC SSB PROJECT AND MEMBERSHIP OF THE AEEC SSB SUBCOMMITTEE

Committee Membership and Participation in SSB Project

Due to the long history of Subcommittee meetings, symposia, and extensive correspondence on this project from its inception in 1955 until publication of the ARINC Characteristic No. 533 in February 15, 1960, we shall list herein, as a part of this first phase of the project only the participants and the official members of the SSB Subcommittee as of the date of the September, 1959 SSB Subcommittee meeting which was the major effort leading to the original ARINC Characteristic No. 533:

AEEC SSB OFFICIAL SUBCOMMITTEE MEMBERS

B. F. McLeod, PAA, Chairman
R. Weihe, Northwest Air Lines
R. M. White, Trans World Airlines
H. A. Ferris, Trans Canada Airlines
R. O. Smith, Hq., USAF

PARTICIPANTS IN SEPTEMBER 22-23, 1959 MEETING

H. D. Shamblin	Aero. Communications Equipment, Inc., Miami
A. J. Edwards	British Embassy, Washington, D. C.
W. E. Brunt	British Overseas Airways Corp., London, England
E. W. Pappenfus	Collins Radio Co., Cedar Rapids, Iowa
A. M. Gluck	General Precision Labs., Pleasantville, N.Y.
K. B. Boothe	Kahn Research Labs., Freeport, N.Y.
L. R. Kahn	Kahn Research Labs., Freeport, N.Y.
P. J. Cahen	Kaiser Aircraft and Elec., Washington, D. C.
Mr. Sorani	KLM, Schiphol, Holland
E. J. Hird	Marconi's Wireless Telegraph Co., New York
D. H. Dowding	Mullard Equipment Ltd., London, England
R. F. Brown	Remington Rand Univac, St. Paul, Minn.
R. P. Doherty	Remington Rand Univac, St. Paul, Minn.
W. R. Lewis	Wilcox Electric Co., Kansas City, Mo.
E. Lazar	Wright Air Development Center, WPAFB, Ohio
W. T. Carnes	ARINC, Washington, D. C.
W. S. Smoot	ARINC, Washington, D. C.

Committee Membership and Participation in SSB Project (Continued)

For the second phase of this project where the ARINC Characteristic No. 533 document was reviewed and updated to produce the ARINC Characteristic No. 559 document, the Official Subcommittee was revised as follows and the following participants took place in the January 5-7, 1965 meeting:

AEEC SSB OFFICIAL SUBCOMMITTEE MEMBERS (February, 1965)

B. F. McLeod, PAA, Chairman
Gordon Bickel, MWA
Nick Kolen, TWA
Vern Hoey, Air Canada
F. Bennet, Flying Tiger Lines
D. Clark, UAL
Les Sebald, UAL

APPENDIX 3 (continued)

CHRONOLOGY AND BIBLIOGRAPHY OF THE AEEC SSB PROJECT AND MEMBERSHIP OF THE AEEC SSB SUBCOMMITTEE

PARTICIPANTS IN JANUARY 5-7, 1965 AEEC SSB SUBCOMMITTEE MEETING

F. C. White	Air Transport Association	Washington, D. C.
L. E. Sorenson	Continental Air Lines, Inc.	Los Angeles, California
J. Verekamp	KLM	Amsterdam, Holland
R. Bohannon	Pan American World Airways	Miami, Florida
J. Olds	Pan American World Airways	Miami, Florida
W. Gasper	Trans World Airlines	Kansas City, Mo.
F. W. Ungry	United Air Lines	Chicago, Illinois
R. O. Smith	U. S. Air Force	Washington, D. C.
T. Kouchnerkavich	U. S. Army	Washington, D. C.
W. T. Carnes	ARINC	Washington, D. C.
B. R. Climie	ARINC	Washington, D. C.
C. A. Petry	ARINC	Washington, D. C.
W. S. Smoot	ARINC	Washington, D. C.
T. H. Taylor	ARINC	Washington, D. C.
W. Weaver	ARINC	Washington, D. C.
H. D. Shamblin	AEROCOM	Miami, Florida
D. E. Busse	AVCO ELECTRONICS	Cincinnati, Ohio
I. T. Pope	AVCO CORP.	Cincinnati, Ohio
J. L. Whittaker	BENDIX RADIO	Baltimore, Maryland
T. J. McWiggin	BRITISH EMBASSY	Washington, D. C.
C. Williams	BRITISH EMBASSY	Washington, D. C.
F. W. Bonnyman, F/L	CANADIAN DEPT. OF NATIONAL DEFENCE	Ottawa, Canada
C. M. Madson, F/L	CANADIAN JOINT STAFF	Washington, D. C.
R. C. Christie	COLLINS RADIO COMPANY	Cedar Rapids, Iowa
L. R. Duncan	COLLINS RADIO COMPANY	Cedar Rapids, Iowa
D. J. Medley	COLLINS RADIO COMPANY	Richardson, Texas
O. L. Miller	COLLINS RADIO COMPANY	Cedar Rapids, Iowa
P. H. Weinheimer	COLLINS RADIO COMPANY	Cedar Rapids, Iowa
J. A. Davis	FAA	Oklahoma City, Oklahoma
W. W. Felton	FAA	Washington, D. C.
F. B. Holsclaw	FAA	Washington, D. C.
W. M. Honea	FAA	Washington, D. C.
D. K. Child	FCC	Washington, D. C.
J. T. Dixon	FCC	Washington, D. C.
J. B. Lewis	FCC	Washington, D. C.
S. M. Myers	FCC	Washington, D. C.
E. W. Spurway	GENERAL DYNAMICS CORP.	Washington, D. C.
H. C. Baasch	ITT FEDERAL LABS	Hutley, New Jersey
J. S. Brodovics	MCDONNELL AIRCRAFT	St. Louis, Mo.
L. R. Mullin	THE MARCONI CO. LTD.	Basilton, Essex, England
R. S. Robson	THE MARCONI CO. LTD.	Basilton, Essex, England
R. Ely	SUN OIL CO.	Philadelphia, Pa.
J. Caputo	TECHNICAL MATERIEL CORP.	Manamoneck, New York
N. J. Geist	TECHNICAL MATERIEL CORP.	Manamoneck, New York
F. I. Lambert	TECHNICAL MATERIEL CORP.	Alexandria, Va.
J. R. Andras	U. S. AIR FORCE	Wright-Patterson AFB, Ohio
J. C. Kerns	U. S. AIR FORCE	Wright-Patterson AFB, Ohio
H. R. Ware	U. S. AIR FORCE	Wright-Patterson AFB, Ohio
P. B. Peterson	U. S. Army	Fort Monmouth, New Jersey
A. R. Rasmussen	U. S. Army	Washington, D. C.
D. B. Whittemore	U. S. Army	Bronxville, New York

APPENDIX 1 (continued)

ORGANOLOGY AND SIGNIFICANCE OF THE AIREC AND PROJECT AND MEMBERSHIP OF THE AIREC SUB COMMITTEE

PARTICIPANTS IN JUNE 22-23, 1964 AIREC SUB COMMITTEE MEETING

F. C. White	Air Transport Association	Washington, D. C.
Robert Robinson	Pan American World Airways	Miami, Florida
B. F. Nelson	Pan American World Airways	Miami, Florida
Nicholas Kelen	Trans World Airlines	Chicago, Illinois
D. L. Clark	United Air Lines	San Francisco, California
L. E. Sebold	United Air Lines	San Francisco, California
T. A. Petry	ARIHC	Washington, D. C.
T. H. Taylor	ARIHC	Washington, D. C.
W. T. Carnes	ARIHC	Washington, D. C.
W. S. Smart	ARIHC	Washington, D. C.
W. E. Clinie	ARIHC	Washington, D. C.
H. D. Shamblin	AEROCOM	Miami, Florida
C. E. Keeler	U. S. Air Force	Wright Air Force Base, Ohio
R. O. Smith	U. S. Air Force	Washington, D. C.
J. R. Neigh	AMP, Inc.	Alamogordo, Virginia
B. J. Helman, Jr.	AVCO Corp.	Cincinnati, Ohio
J. P. Braun	The Boeing Company	Seattle, Washington
E. E. Erdosson	The Boeing Company	Seattle, Washington
J. E. Callaway	The Boeing Company	Seattle, Washington
R. C. Christie	Collins Radio Company	Cedar Rapids, Iowa
L. Duncan	Collins Radio Company	Cedar Rapids, Iowa
N. J. Marston	Collins Radio Company	Cedar Rapids, Iowa
J. F. McCaddon	Collins Radio Company	Cedar Rapids, Iowa
D. L. Miller	Collins Radio Company	Cedar Rapids, Iowa
W. D. Rodes	Collins Radio Company	Cedar Rapids, Iowa
M. Vandeville	Collins Radio Company	Cedar Rapids, Iowa
J. A. Davis	Federal Aviation Agency	Oklahoma City, Oklahoma
W. B. Hawthorne	Federal Aviation Agency	Washington, D. C.
U. E. Child	Federal Communications Comm.	Washington, D. C.
J. T. Robinson	Federal Communications Comm.	Washington, D. C.
R. A. Lowy	Radio Corp. of America	Camden, New Jersey
R. Trachtenberg	Radio Corp. of America	Camden, New Jersey

PARTICIPANTS IN SEPTEMBER 2-3, 1964 AD HOC MEETING

ON THE SUB MEETING IN STOCKHOLM

V. Persson, Chairman	SAS	Stockholm, Sweden
U. Ghessi	Alitalia	Rome, Italy
D. Meredith	BOAC	Huddersfield, England
S. Gomis	Deutsche Lufthansa	Munich, Germany
J. Jurisch	Deutsche Lufthansa	Munich, Germany
J. Mohr	KLM	Amsterdam, Holland
S. I. Levy	Pan American World Airways	Miami, Florida
Ph. Nutereau	SABENA	Brussels, Belgium
O. Rommagen	SAS	Stockholm, Sweden
H. D. Shamblin	AEROCOM	Miami, Florida
W. J. Hess	Collins Radio Company	Cedar Rapids, Iowa
N. J. Marston	Collins Radio Company	Cedar Rapids, Iowa
D. Sloan	Collins Radio Company	Cedar Rapids, Iowa

PARTICIPANTS IN SEPTEMBER 12-13, 1975

SUBCOMMITTEE MEETING IN STOCKHOLM

Vic Persson, Chairman	SCANDINAVIAN AIRLINES SYSTEM	Stockholm-Bromma Sweden
D. Meredith	BRITISH AIRWAYS	London, England
Jose M. Escucha	IBERIA SPANISH AIRLINES	Madrid, (Madrid) Spain
John Mohr	KLM ROYAL DUTCH AIRLINES	Amsterdam, The Netherlands
Wolfgang Godek	LUFTHANSA	Munich, Germany
Stegmar Gouille	LUFTHANSA	Munich, Germany
Ed Cressel	PAN AMERICAN WORLD AIRWAYS	New York, New York
Philip Nutereau	SABENA	Brussels, Belgium
Bertil Jacobsson	SCANDINAVIAN AIRLINES SYSTEM	Stockholm-Bromma, Sweden
Ottar M. Rommagen	SCANDINAVIAN AIRLINES SYSTEM	Stockholm-Bromma, Sweden
Chuck Schild	UNITED AIRLINES	Chicago, Illinois
Dennis Tansley	UNITED AIRLINES	San Francisco, California
B. E. Clinie	AERONAUTICAL RADIO, INC.	Annapolis, Maryland

H. D. Shamblin	AEROCOM	Miami, Florida
William C. Thompson	REDFIN AVIONICS	Ft. Lauderdale, Florida
Wesley Follembae	COLLINS RADIO	Cedar Rapids, Iowa
E. H. Hamford	COLLINS RADIO	Cedar Rapids, Iowa
Vlad J. Adam	IATA	Montreal, Que, Canada
Ken Berg	KING RADIO CORP.	Olathe, Kansas

APPENDIX 1 (Continued)

ORGANOLOGY AND SIGNIFICANCE OF THE AIREC AND PROJECT AND MEMBERSHIP OF THE AIREC SUB COMMITTEE

Recorded herewith for posterity is the index of reference AIREC letters and other documents pertaining to the AIREC project. (Naturally, AIREC does not stock entire copies of all of the AIREC letters referenced herein. Very few are available, however, we can get copies made if the need arises).

The most important reference for basic background is: The Status of Single Sideband Communications System, International Air Transport Association document 001/1414, dated November 14-16, 1958 (This document is obtainable from the International Air Transport Association, Terminal Centre Building, 1000 University Street, Montreal 3, Quebec).

Ltr. No.	Date	Subject
36-1-47	12/30/56	Single Sideband HF Communications Equipment Planning
36-3-8	2/1/56	Announcement of Steering Committee, AIREC Subcommittee and AIREC Subcommittee Meetings during week of 2/21/56
36-3-4	2/1/56	Single Sideband Subcommittee Meeting Announcement and Draft AIREC Characteristic No. 533
36-3-9	2/20/56	Comments of Collins Radio on Draft AIREC Characteristic
36-3-13	2/23/56	Comments of Northwest Airlines on Draft AIREC Characteristic
36-3-26	6/1/56	Status Report on the AIREC Project and Draft No. 2 of AIREC Char. No. 533
36-3-60	6/20/56	Supplementary Data for Draft No. 2 of AIREC Char. No. 533
36-3-16	8/2/56	Announcement of Single Sideband Subcommittee Meeting and Draft No. 3 of Char. No. 533
36-3-26	9/10/56	Status Report on Single Sideband Project and Draft No. 4 of AIREC Char. No. 533
36-3-44	10/10/56	Paper by L. R. Kahn on Compatible Full Carrier SSB
37-1-3	11/5/56	Further Information on the Compatible SSB System
37-1-13	12/5/56	Comparison of Synchronous Detection, SSB and CSB for Aeronautical Communications
37-1-22	1/7/57	AIREC Symposium Detection-Single Sideband Symposium
37-1-23	1/11/57	Draft No. 5 of Proposed AIREC Char. No. 533
37-1-41	1/28/57	Carton Letter to SSB on SSB
37-3-1	2/8/57	Papers presented by Kahn and Pappas at AIREC SSB-SSB Symposium
37-3-3	2/10/57	AIREC Single Sideband-Dual Sideband Symposium
37-3-21	4/16/57	"Electronic Industries" Article on Single Sideband Communications
37-3-23	4/23/57	Draft U. S. Position Paper on Single Sideband prepared by Single Sideband Ad Hoc Group to the AEC/CCS Subcommittee
37-3-36	6/20/57	AIREC Proposal for an RAO Developmental System Characteristic for SSB
37-3-40	6/13/57	Birth Draft of Char. No. 533 SSB/AM SSB Equipment
37-3-4	7/8/57	AIREC Decisions on SSB Developmental Program
38-1-14	12/31/57	Announcement of AIREC AIREC Subcommittee on Single Sideband
38-1-15	1/9/58	Status Report on SSB Project
38-1-24	2/4/58	SSB Project Status Report - Conclusions and Recommendations as a Result of January 23, 1958 Subcommittee Meeting
38-3-64	7/22/58	RTCA EC-84 Report "Characteristics of Aeronautical Single Sideband Systems"
38-3-10	8/25/58	Approval of RTCA EC-84 Report
38-3-21	11/24/58	Single Sideband Status Report
39-1-12	1/9/59	Termination of Kahn SSB Tests at AIREC New York Station On February 1, 1959
39-1-23	4/28/59	Status Report on AIREC SSB Program
39-1-26	4/28/59	SSB System Considerations Affecting Choice of SSB Mode of Operation
39-1-66	6/17/59	Draft No. 8 of AIREC Char. No. 533 SSB System
39-3-11	8/28/59	SSB Subcommittee Meeting Announcement
39-3-12	9/21/59	A Selection of Papers and Reports Pertaining to SSB
39-3-21	11/2/59	Transmittal of Draft No. 9 of AIREC Char. No. 533, SSB
39-3-20	11/2/59	Report of September, 1959 SSB Subcommittee Meeting and Status of Draft No. 9 of Char. No. 533
60-1-10	12/22/59	Pre-Approval Copies of AIREC Char. No. 533 "Airborne HF SSB/AM System"
60-1-22	2/18/60	Release of AIREC Characteristic No. 533, Airborne HF SSB/AM System
60-1-23	2/11/60	Information from Rommagen Road UNIVAC on Boeing 707 Antenna Coupler Standing Wave Ratio

APPENDIX 3 (continued)

CHRONOLOGY AND BIBLIOGRAPHY OF THE AECC SSB PROJECT AND MEMBERSHIP OF THE AECC
SSB SUBCOMMITTEE

BIBLIOGRAPHY: (continued)

Ltr. No.	Date	Subject
61-1-16	11/4/60	Proposed Changes to the Interwiring of the ARINC SSB Characteristic No. 533
61-2-10	3/22/61	Release of ARINC Characteristic No. 532C and Supplement No. 1 to ARINC Characteristic No. 533
61-2-28	4/25/61	FCC Rule Making - Voluntary Single Sideband Operation in Aviation Services (Dockets 11513, 11678 and 11654)
64-2-57	9/23/64	HF SSB System Standards and the Updating of ARINC Characteristic No. 533 - SST Newsletter No. 19
65-1-16	11/19/64	Announcement of AECC HF Single Sideband Meeting on January 5-7, 1965 in Washington, D. C. - SST Newsletter No. 22
65-1-19	11/30/64	More Information on HF SSB System Standards and Their Relationship to ARINC Characteristic 533 - SST Newsletter No. 23
65-1-20	11/30/64	Changes Required in ARINC Characteristic No. 533, "Airborne HF SSB/AM System"
65-1-32	1/25/65	HF SSB System Standards Proposal Resulting from January 5-7, 1965 SSB Subcommittee Meeting - SST Newsletter No. 26
65-1-33	3/17/65	Distribution of Draft No. 1 of ARINC Project Paper No. 559, "Mark 2 Airborne HF SSB/AM System", Resulting from the January 5-7, 1965 SSB Subcommittee Meeting - SST Newsletter No. 28
65-1-43	3/15/65	Further Report on the January 5-7, 1965 SSB Subcommittee Meeting and the Decisions Reached on the New Equipment Characteristics for SSB.
65-2-2	4/20/65	Report of the April 7, 8, and 9, AECC General Session held in Miami Beach, Florida
65-2-7	5/19/65	Announcement of "Final" SSB Subcommittee meeting to resolve remaining industry problems on Specs. (SST Newsletter No. 31)
65-2-9	6/2/65	The Problems of Updating the old Characteristic No. 533 by New Characteristic No. 533A to permit Modernized HF SSB/AM Equipment within the physical design and Interchangeability Limitations of the old Characteristic No. 533. (SST Newsletter No. 32)
65-2-10	6/3/65	Distribution of Draft No. 1 of ARINC Characteristic No. 533A, "Airborne HF SSB/AM System" for consideration in the June 29-30, 1965 SSB Subcommittee Meeting (SST Newsletter No. 33)
65-2-11	6/3/65	Changes to Draft No. 1 of ARINC Project Paper No. 559, "Mark 2 - Airborne HF SSB/AM System" Resulting from the April 1965 AECC General Session in Miami Beach. (SST Newsletter No. 34)
65-2-15	6/8/65	Marconi Company Limited comments on Characteristic No. 559, "Mark 2 - Airborne HF SSB/AM System". (SST Newsletter No. 35)
65-2-19	6/18/65	HF SSB System Standards - FAA Proposal for Reconsideration of Tenth-Kilocycle Channel Spacing (SST Newsletter No. 36)
65-2-23	7/16/65	Report of the June 29-30 AECC SSB Subcommittee Meeting in Washington, D. C. (SST Newsletter No. 37)
65-2-23A	8/16/65	Correction to June 1965 SSB Meeting Report -- FAA Clarification of Tenth KC Discussion
65-2-24	7/16/65	Distribution of Draft No. 2 of Project Paper No. 533A, "Airborne HF SSB/AM System". (SST Newsletter No. 38)
65-2-24A	7/26/65	Corrections to Control Panel of Draft No. 2 of Char. No. 533A
65-2-25	7/16/65	Distribution of Draft No. 2 of Project Paper No. 559, "Mark 2 - Airborne HF SSB/AM System". (SST Newsletter No. 39)
65-2-25A	3/11/66	Corrections to Draft No. 2 of Project Paper No. 559, "Mark 2 - Airborne HF SSB/AM System"
66-1-53	3/11/66	Issue of ARINC Char. No. 533A, "Airborne HF SSB/AM System" -- in grey covers.

APPENDIX 3 (continued)

CHRONOLOGY AND BIBLIOGRAPHY OF THE AECC SSB PROJECT AND MEMBERSHIP OF THE AECC
SSB SUBCOMMITTEE

BIBLIOGRAPHY: (continued)

Ltr. No.	Date	Subject
69-1-56	4/23/69	Report of AECC meeting of March 2-5, 1969 and updated "Electronic Installation Characteristic" (The section on HF Communication included in strong recommendation to set up an HF Subcommittee to prepare a new project paper.)
69-2-2	5/27/69	Report of the May 14-16 AECC General Session Held in Los Angeles, California. (Vic Persson of SAS was designated rapporteur of a working group to draft a new HF/SSB project paper.)
69-2-27	7/8/69	Distribution of proposed Draft 101 of ARINC Project Paper 559, "Mark 2 Airborne HF/SSB AM System"
69-2-53	9/18/69	Circulation of Draft 102 of ARINC Project Paper 559, "Mark 2 Airborne HF/SSB/AM System"
69-2-53A	10/7/69	Circulation of Draft 102 of ARINC Project Paper 559, "Mark 2 Airborne HF/SSB/AM System" (Corrected cover letter)
69-2-64	10/6/69	Minutes of 43rd AECC Meeting Held in Brussels September 9-11, 1969. (This report summarizes the changes in/and status of Project Paper 559.)
69-2-71	10/10/69	Report of the HF/SSB Ad Hoc Meeting in Stockholm on September 2-3, 1969.
70-2-71	9/23/70	Circulation of Draft 103 of ARINC Project Paper 559, "Mark 2 Airborne HF/SSB/AM System"
70-2-84	10/13/70	Circulation of Minutes of the 45th AECC Meeting Held in Brussels September 29, 30 and October 1, 1970. (This report summarizes the AECC review of Draft 103.)
70-1-2	11/18/69	Report of the October 29-31 AECC General Session Held in Atlanta, Georgia. (This report summarizes the status of the HF/SSB project.)
70-2-2	5/11/70	Report of the April 21-23 AECC General Session Held in Denver, Colorado. (This report describes the equipment improvements and changes introduced by the draft project paper.)
71-1-2	12/31/70	Report of the November 4-6 AECC General Session Held in London, England. (This report documents the last minute changes in the project paper and the subsequent approval by AECC.)
N75-042/AGS-22	6/27/75	Report of May 21-22 AECC General Session held in Washington, D.C. (This report documents industry decision to update ARINC 559.)
75-063/HFC-01	8/15/75	Circulation of Draft No. 1 of Project Paper 559A "Mark 2 Airborne HF/SSB System"
75-064/SMA-61	8/15/75	Announcement of AECC Subcommittee Meeting on HF/SSB
75-065/HFC-02	8/15/75	Circulation of Correspondence, Technical Proposals and Background Info for New HF/SSB Spec.
75-088/HFC-03	10/14/75	Report of HF/SSB Subcommittee Meeting in Stockholm September 15-17, 1975
75-095/HFC-04	10/28/75	Circulation of Draft 2 of Project Paper 559A "Mark 2 Airborne HF/SSB System"
76-006/HFC-05	1/7/76	Industry Approval of Project Paper 559A, "Mark 2 Airborne HF/SSB System"

APPENDIX 4

FCC RULE MAKING RELATED TO SSB EQUIPMENT AND THE TYPE ACCEPTANCE OF THAT EQUIPMENT

Current FCC Rules and Regulations

FCC Rules and Regulations currently (February 1976) applicable to HF/SSB for use in the Aviation Service, as set forth in Part 87, are reproduced on the next several pages of this Appendix.

FCC Order Deleting Limitations on Use of A3J

The 1971 FCC Rule Making information in this Appendix reflects the other historical material deleting the limitations in the use of A3A and A3J emission under Part 87.67 (b). It has been retained in this Appendix for reference use.

Original FCC "Report and Order" on HF/SSB

Early FCC material relating to the Single Sideband subject was published as a part of an FCC "Report and Order" which was adopted by the FCC on April 24, 1961. As this material contains much of the historical foundation for the current FCC Rules relating to single sideband, it is retained as a part of this ARINC Equipment Characteristic for reference use.

TECHNICAL SPECIFICATIONS

§ 87.61 Frequencies.

(a) Specific information concerning the assignment of frequencies to stations operating in any of the Aviation Services is set forth in the applicable subparts of this part. Applicants for, and licensees of, stations in these services shall cooperate in the selection and use of frequencies in order to minimize interference and obtain the most effective use of authorized facilities. Frequencies are available for assignment to stations in these services on a shared basis only and will not be assigned for the exclusive use of any applicant. The use of any assigned frequency may be restricted to one or more geographical areas.

(b) Frequencies assigned to government radio stations under Executive order of the President may be authorized for use by stations in these services upon a satisfactory showing by the applicant that such assignment is required for inter-communication with government stations or required for coordination with activities of the Federal Government, and where the Commission finds, after consultation with the appropriate government agency or agencies, that such assignment is necessary.

(c) The frequency coinciding with the center of an authorized bandwidth of emission shall be specified as the assigned frequency; for single sideband emission the carrier frequency shall also be specified.

§ 87.63. Power.

(a) The power which may be authorized for use at any station in the Aviation Services shall not be greater than the minimum required for satisfactory technical operation.

(b) Except as indicated in paragraph (c) of this section, the power authorized for use at any station shall be specified in terms of peak envelope power at the transmitter output terminals. Peak envelope power is defined as the mean power during one radio frequency cycle at the highest crest of the modulation envelope.

(c) For stations using amplitude modulated emission and transmitting both sidebands and a full carrier, authorized power will be specified in terms of unmodulated radio frequency carrier power at the transmitter output terminals.

(d) Power may be determined either by direct measurement or by multiplying the plate input power to the final amplifier by an appropriate factor.

§ 87.65 Frequency stability.

(a) Except as provided in paragraphs (c), (d), and (f) of this section, and § 87.81, the carrier frequency of each station in the Aviation Services shall be main-

tained within the applicable following percentage of the assigned frequency:

<i>Frequency bands (lower limit exclusive, upper limit inclusive) and categories of stations</i>	<i>Tolerances</i>
(1) Band—10 to 535 kHz:	
Land stations.....	0.01
Mobile stations.....	.02
Radionavigation stations.....	.01
(2) Band—1605 to 4000 kHz:	
Fixed stations:	
Power 200 w or less.....	.01
Power above 200 w.....	.005
Land stations:	
Power 200 w or less.....	.01
Power above 200 w.....	.005
Mobile stations.....	.01
(3) Band—4 to 29.7 MHz:	
Fixed stations:	
Power 500 w or less.....	.005
Power above 500 w.....	.0015
Land stations:	
Power 500 w or less.....	.01
Power above 500 w.....	.005
Mobile stations.....	.01
(4) Band—29.7–100 MHz:	
Fixed stations, except operational fixed:	
Power 200 w or less.....	.005
Power above 200 w.....	.003
Operational fixed stations:	
73.0–74.6 MHz.....	.005
72.0–73.0 MHz and 75.4–76.0 MHz.....	.0005
Land stations:	
Power 15 w or less.....	.005
Power above 15 w.....	.002
Mobile stations:	
Power 5 w or less.....	.01
Power above 5 w.....	.005
Radionavigation stations.....	.01
(5) Band—100 to 136 MHz:	
Land stations.....	¹ 0.002
Emergency locator transmitter test stations.....	0.005
Mobile stations:	
Survival craft stations.....	0.005
Emergency locator stations.....	0.005
Aircraft and all other mobile stations.....	¹ 0.003
Radionavigation stations.....	0.005
(6) Band—136 to 470 MHz:	
Fixed stations:	
Power 50 w or less.....	.005
Power above 50 w.....	.002
Land stations.....	.005
Mobile stations:	
Survival craft stations.....	.01
Land mobile stations with power above 5 w.....	.002
Aircraft and all other mobile stations.....	.005
Radionavigation stations.....	.005
(7) Band—470 to 960 MHz: All stations.....	.01
(8) Band—960 to 1215 MHz:	
Land stations.....	.002
Aircraft stations.....	.01
(9) All stations on frequencies above 1215 MHz.....	.01

¹ The tolerance shown is applicable to all types of transmitters first authorized after January 1, 1974. Those types of transmitters meeting a tolerance of 0.005 percent which were licensed before January 1, 1966 and those types of transmitters meeting a tolerance of 0.003 percent first authorized during the period January 1, 1966 to January 1, 1974 may continue to operate, *Provided, however*; That sta-

(b) The power set forth in paragraph (a) of this section is mean power, which is defined as the power supplied to the antenna transmission line by a transmitter during normal operation, averaged over a time sufficiently long compared with the period of the lowest frequency encountered in the modulation. A time of $\frac{1}{10}$ second during which the mean power is greatest will be selected normally.

(c) When transmitting single side-band emission, the carrier frequency shall be maintained within the applicable following number of hertz of the specified carrier frequency:

(1) For other than Civil Air Patrol Stations:

	Hertz
(i) All ground stations.....	10
(ii) All aircraft stations.....	20

(2) For Civil Air Patrol Stations:

	Hertz
(i) All land stations.....	50
(ii) All mobile stations.....	50

* Mobile CAP stations, either on aircraft or in vehicles, authorized prior to January 1, 1978, with equipment having a frequency stability of 100 Hz, may continue to use such equipment until January 1, 1983.

(d) Radar transmitters shall meet the following requirements in lieu of a frequency tolerance: The frequency at which maximum emission occurs shall be within the authorized frequency band and shall not be closer than $1.5/T$ MHz to the upper and lower limits of the authorized bandwidth, where T is the pulse duration in microseconds.

(e) Tolerances other than those specified in this section may be authorized upon a satisfactory showing of need therefor. In such cases, the tolerance authorized may be specified on the instrument of authorization.

(f) The carrier frequency of each telemetry transmitter operating in the band between 1435 MHz and 1535 MHz shall remain within 0.003 percent of the assigned frequency.

§ 87.67 Types of emission.

(a) Each authorization issued pursuant to these rules shall show as the emission designator a symbol representing the classification of emission and the bandwidth.

(b) (1) The emissions normally available for assignment in the Aviation Services and the corresponding

emission designators and authorized bandwidths are as follows:

Class of emission	Emission designator	Authorized bandwidth		
		Below 50 MHz	Above 50 MHz	Frequency deviation
		kilohertz	kilohertz	kilohertz
A1.....	81A1.....	0.25		
A2.....	21A2.....	2.724	50	
A3.....	8A3.....	8.0	50	
A3A ¹	3A3A ¹	4.0		
A3H ²	3A3H ²	4.0		
A3J ³	3A3J ³	4.0		
A9.....	12A9 ⁴		25	
A9.....	22A9 ⁴		25	
F1.....	17F1.....	1.7		
F1.....	24F1.....	2.5		
F3 ⁵	36F3.....		40	15
F3 ⁶	16F3.....		20	8
P.....	(7).....	(7)		

¹ To be specified on authorization.

² Each aeronautical en route station authorized to use 3A3A and/or 3A3J emission shall render service to those aircraft stations which are equipped for double sideband (DSB) operation as well as those equipped for single sideband (SSB). Aircraft stations equipped for SSB operation shall use full carrier except when it is known that the receiving station is capable of receiving reduced or suppressed carrier emissions, and shall use full carrier upon request of any station using the same frequency. 3A3A, 3A3H, and 3A3J emissions will be authorized only below 25,000 kHz.

³ Applicable to operational fixed stations presently authorized in the band 73.0-74.6 MHz.

⁴ Applicable to operational fixed stations in the bands 72.0-73.0 MHz and 73.4-76.0 MHz and to CAP stations using class F3 emissions on 143.9 MHz and 148.15 MHz.

⁵ In the band 117.975-136 MHz, wherever footnote N667 applies, the authorized bandwidth is 25 kHz after January 1, 1974, for all transmitters type accepted after that date.

⁶ This emission may be authorized only for audio phase and frequency shift keying and carrier phase and frequency shift keying for digital data link purposes in the band 117.975-136 MHz when the channel on which the signal is transmitted is not used for voice communications, or if the channel is used for voice communication the emission is authorized as specified herein, provided it is multiplexed on the voice carrier without derogation to voice signals. Use of this emission by ground stations must be approved by the Commission prior to operation.

⁷ Applicable only to Survival Craft stations and to the emergency locator transmitters and emergency locator transmitter test stations employing modulation in accordance with that specified in § 87.73(h) of the rules. The specified bandwidth and modulation requirements shall apply to emergency locator transmitters and survival craft transmitters for which type acceptance is granted after October 21, 1973.

(2) The maximum bandwidth for stations operating in the frequency band 10.350 to 10.680 MHz is 25 MHz.

(c) For other emissions, the emission designator may be determined from Part 2 of this chapter and the authorized bandwidth may be specified on the authorization. The authorization of 50 kHz bandwidth for A3 emission on frequencies above 50 MHz is temporary and this fact should be considered in the design of VHF radio equipment for future use.

(d) An authorization to use radiotelephone emission will be construed to include use of tone signals or signaling devices whose sole function is to establish or maintain voice communications.

(e) Emissions other than, or bandwidths in excess of, those listed in paragraph (b) of this section, may be authorized upon a satisfactory showing of need therefor. An application requesting such special authorization shall fully describe the emission desired and the required bandwidth and state the purpose for which such operation is proposed.

[§ 87.67(b)(2) amended eff. 8-1-75; V(74)-1]

tions using offset carrier techniques must comply with 0.002 tolerance after January 1, 1974.

* The tolerance shown in the Table is applicable to all types of transmitters first authorized after January 1, 1974. No applications for type acceptance of transmitters which fail to meet this requirement will be accepted after January 1, 1974. Transmitters with 0.005 percent tolerance authorized before January 1, 1974, may continue to be used until further notice.

§ 87.69 Bandwidth of emission.

(a) Occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission.

(b) The authorized bandwidth is the maximum occupied bandwidth authorized to be used by a station.

§ 87.71 Emission limitations.

(a) The mean power of emission shall be attenuated below the mean output power of the transmitter in accordance with the following schedule:

(1) When using transmissions other than single sideband (3A3A, 3A3H, 3A3J):

(i) On any frequency removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: at least 25 decibels;

(ii) On any frequency removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: at least 35 decibels.

(2) When using single sideband (3A3A, 3A3H or 3A3J) transmission:

(i) On any frequency removed from the assigned frequency by more than 50 percent up to and including 150 percent of the authorized bandwidth: at least 25 decibels.

(ii) On any frequency removed from the assigned frequency by more than 150 percent up to and including 250 percent of the authorized bandwidth: at least 35 decibels.

(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth:

(i) Aircraft stations below 30 MHz: 40 decibels,

(ii) Aircraft stations above 30 MHz and all ground stations: 43 plus 10 Log₁₀ (mean output power in watts) decibels.

(b) When an emission outside of the authorized bandwidth results in harmful interference, the Commission may require appropriate technical changes in equipment to alleviate the interference.

§ 87.73 Modulation requirements.

(a) When double sideband full carrier amplitude modulation is used for telephony, the modulation percentage shall be sufficient to provide efficient communication and shall normally be maintained above 70 percent on peaks but shall not exceed 100 percent: *Provided, however*, That this requirement does not apply to transmitters carried aboard aircraft in such a manner as to be available for use only under emergency and distress conditions for survival purposes.

(b) When special types of emission are employed, the modulation requirements may be specified.

(c) In order to meet the requirements for type acceptance in the Aviation Services, a double sideband full carrier amplitude modulated radiotelephone transmitter with rated carrier power output exceeding 10 watts shall be capable of automatically preventing modulation in excess of 100 percent. In the event that operation of any licensed radiotelephone transmitter causes harmful interference to any authorized radio service because of excessive modulation, the Commission may require that the use of such transmitter be discontinued until it is rendered capable of automatically preventing modulation in excess of 100 percent.

(d) In order to meet the requirements for type acceptance in the Aviation Services, a single sideband transmitter shall be capable of operation in both of the following modes:

(1) With the carrier suppressed at least 26 db below peak envelope power.

(2) With the carrier transmitted at a level between 3 and 6 db below peak envelope power.

(e) In single sideband operation, the sideband on the higher frequency side of the carrier frequency shall be transmitted.

(f) Each frequency modulated transmitter operating in the band 72.0-76.0 MHz shall be provided with a device which automatically will prevent modulation in excess of that specified in § 87.67: *Provided, however*, That this requirement shall not apply to transmitters first authorized prior to July 1, 1960, for operation in the band 73.0-74.6 MHz.

(g) Each frequency modulated transmitter equipped with a modulation limiter in accordance with paragraph (f) of this section shall also be equipped with a low pass filter between the modulation limiter and the modulated stage and, at audio frequencies between 3 kHz and 15 kHz shall have an attenuation greater than the attenuation at 1 kHz by at least

$$40 \log_{10} (f/1) \text{ decibels}$$

where "f" is the frequency in kilohertz. At audio frequencies above 15 kHz, the attenuation shall be at least 28 decibels greater than the attenuation at 1 kHz.

(h) Emergency locator transmitters, and emergency locator transmitter test stations shall employ amplitude modulation of the carrier with an audio frequency sweeping downward over a range of not less than 700 Hz, within the range 1600 to 300 Hz, with a sweep rate between two and four times per second. The modulation applied to the carrier shall be in accordance with that specified in the Radio Technical Commission for Aeronautics (RTCA) Documents Nos. DO-145 or DO-146 (available from Radio Technical Commission for Aeronautics, Room 655, 1717 H Street, NW., Washington, DC 20006).

§ 87.75 Transmitter control requirements.

(a) Each transmitter shall be so installed and protected that it is not accessible to, or capable of operation by, persons other than those duly authorized by the licensee.

(b) Unless otherwise specifically authorized, each station shall be provided with a control point at the location of the transmitting equipment. Applications for additional control points shall specify the location of each proposed control point and any authorization which may be issued shall show the location of each such control point.

(c) A control point is a position which meets all of the following conditions:

(1) Such position must be under the control and supervision of the licensee:

(2) It is a position at which the monitoring facilities required by this section are installed and at which the transmitter can, without delay, be rendered inoperative;

(3) It is a position at which the required licensed radio operator, responsible for the actual operation of the transmitter, is stationed.

(6) At each control point the following facilities shall be installed:

(1) A device which will provide continuous visual indication when the transmitter is radiating or when the transmitter control circuits have been placed in a condition to produce radiation: *Provided, however,* That this requirement shall not apply to aircraft stations;

(2) Equipment to permit the operator to monitor, aurally, all transmissions originating at dispatch points under his supervision;

(3) Facilities which will permit the operator to disconnect any or all dispatch point circuits from the transmitter.

(e) A dispatch point is an operating position from which messages may be transmitted under the direct supervision of the licensed control point operator. Dispatch points may be installed without authorization from the Commission, and persons authorized by the station licensee to initiate messages from these points are not required to be licensed by the Commission.

§ 87.77 Acceptability of transmitters for licensing.

(a) From time to time the Commission publishes a revised list of type approved and type accepted equipment entitled, "Radio Equipment List—Equipment Acceptable for Licensing". Copies of this list are available for inspection at the Commission's offices in Washington, D.C., and at each of its field offices.

(b) Except as provided in paragraph (d) of this section, each transmitter used in the Aviation Services must be of a type which has been type accepted by the Commission for use in these services.

(c) Some radio equipment which is to be installed aboard air carrier aircraft must meet requirements of the Federal Communications Commission, and those requirements of the Federal Aviation Regulations which are applicable. The applicable Federal Aviation Administration requirements may be obtained from the Federal Aviation Administration, Washington, D.C. 20553.

(d) The following exceptions to the provisions of paragraph (b) of this section are provided on the express condition that the operation of stations using transmitting equipment not type accepted by the Commission shall not result in harmful interference due to the failure of such equipment to comply with the current technical standards of Subpart A of this part.

(1) Type accepted equipment is not required at developmental stations.

(2) Type accepted equipment is not required at Civil Air Patrol stations.

(3) Equipment which has not been type accepted may be used at flight test stations for limited periods where justified on the basis of good cause shown.

(4) Equipment which is to be used exclusively under emergency and distress conditions for survival purposes and which is carried aboard aircraft in such a manner as to only be available under these conditions need not be type accepted by the Commission if

it is a type which was in use prior to January 1, 1965.

(5) [Reserved]

(6) All equipment sought to be utilized under a license authorizing the use of frequencies in the band 10,550 to 10,680 MHz shall be type accepted if specified in an application filed after July 20, 1962, except that equipment authorized to be used prior thereto is permitted to continue to be used provided such operation does not result in harmful interference to other stations or systems which are conforming to the technical standards contained in §§ 87.63, 87.65, and 87.67.

(7) All transmitters for use in radionavigation land test stations after October 1, 1966, must be of a type which has been type accepted by the Commission for use in these services: *Provided, however,* That nontype accepted equipment authorized for use in a radionavigation land test station before October 1, 1966, may continue to be used until October 1, 1976.

(8) Type acceptance is not required for U.S. Government furnished transmitters in the performance of a U.S. Government contract if the use of type accepted equipment would increase the cost of the contract or if the transmitter will be incorporated in the finished product: *Provided, however,* That such equipment shall comply with all the technical specifications contained in this subpart.

§ 87.77(d)(6) amended eff. 8-1-75; V(74)-1

§ 87.79 Type acceptance of equipment.

(a) A manufacturer of a type of transmitter intended for use in these services may request type acceptance for such transmitter by following the type acceptance procedure set forth in Part 2, Subpart J, of this chapter. (Airborne transmitters intended for use in these services shall be tested with ambient temperature variation from -20° to $+50^{\circ}$ centigrade.)

(b) Type acceptance for an individual transmitter may also be requested by an applicant for station authorization, in accordance with the type acceptance procedure set forth in Part 2, Subpart J, of this chapter. Such transmitter, if accepted, will not normally be included on the Commission's "Radio Equipment List—Equipment Acceptable for Licensing," but will be individually enumerated on the station authorization.

(c) Additional rules with respect to type acceptance are set forth in Part 2, Subpart J, of this chapter. These rules include information with respect to withdrawal of type acceptance, modification of type accepted equipment and limitations on the findings upon which type acceptance is based.

(d) In the case of applications for type acceptance of equipment (ground and airborne) intended for transmission in any of the frequency bands listed below, the applicant shall, on a date no later than the date of filing of the application with the Commission, transmit to the Federal Aviation Administration (FAA) a letter of notification advising that agency of the intent to file, or the filing, as appropriate, of the type acceptance application. (Manufacturers and inventors are encouraged to contact the FAA in the early conceptual or developmental stages to reduce the possibilities of acceptance delays and economic loss.) The letter of notification shall be transmitted to: Federal Aviation Administration, Systems Research and Development Service, Spectrum Analysis Branch, 800 Independence Avenue SW., Washington, DC 20591. It shall describe the equipment, giving the identification by manufacturer and type number and including statements of the antenna characteristics, rated output power, type and characteristics of emission, the frequency or frequencies of operation, statement of essential receiver characteristics if protection is required, and the purpose for which the equipment is to be used. The type acceptance application shall include a copy of the letter of notification and shall attest to its transmittal, and date thereof, to the FAA. Action will be withheld for a period of 21 days following the date of receipt of the type acceptance application in order to afford the FAA an opportunity to comment. If the Commission receives from FAA an objection to issuance of type acceptance which includes a showing of noncompatibility of the equipment with the National Airspace System, the Commission will consider this showing together with all other information in its possession concerning the equipment before taking final action on the application. The frequency bands are as follows:

105 MHz to 117.975 MHz.	14.0 GHz to 14.4 GHz.
328.6 MHz to 335.4 MHz.	15.40 GHz to 15.70 GHz.
960 MHz to 1215 MHz.	24.25 GHz to 25.25 GHz.
1535 MHz to 1680 MHz.	31.80 GHz to 33.40 GHz.
5000 MHz to 5250 MHz.	

§ 87.81 [Reserved]

[§ 87.81 deleted and [Reserve] eff. 8-1-75; V(74)-1]

APPENDIX 4FCC ORDER DELETING LIMITATIONS IN USE OF A3A AND A3J**FEDERAL COMMUNICATIONS
COMMISSION**

[FCC 71-164]

SINGLE SIDEBAND EMISSIONS**Order Deleting Limitations on Certain
Aircraft Radio Station Licenses**

1. The Commission on June 26, 1968, adopted a report and order in Docket 17858 which, among other things, amended § 87.67(b)(1) of the Commission's rules to provide for the regular use of suppressed carrier single sideband emissions in aircraft stations when it is known that the receiving station is capable of receiving such emissions.

2. Prior to the above amendment of the rules, aircraft stations, when using single sideband equipment, were not authorized to use suppressed carrier emissions except under a developmental authorization. Aircraft radio station licenses which were issued prior to the rule amendment contained special provisions limiting the single sideband operation to the transmission of full carrier (A3H) emission. These provisions were

included in order to protect stations using double sideband equipment.

3. In a letter to the Commission, Aeronautical Radio, Inc. directs attention to an operational evaluation of 3A3J emission on a family of high frequencies used on the North Atlantic air routes. ARINC suggests that license restrictions may prevent some U.S. aircraft from participating in the program; and in light of the amended rule, recommends that the Commission lift the restriction on current aircraft licenses in order that single sideband suppressed carrier operations may be conducted in accordance with the present rule. ARINC suggests that the license restrictions be lifted without the administrative need for license modification.

4. The use of single sideband suppressed carrier operations continues to increase in the aeronautical mobile service. The remaining double sideband operation is protected by the present provisions of the rules. Suppressed carrier emissions may be used when it is known that the receiving station is capable of handling that kind of emission, and full carrier must be used at the request of any other user of the same frequency. Accordingly, it appears that the license restrictions are no longer necessary and should be removed.

5. In view of the above: *It is ordered*, That effective immediately, the licensee of any aircraft radio station authorized to use frequencies below 30 MHz as set forth in Part 87 of the Commission's rules and an appropriate transmitter may employ A3A and A3J emission in accordance with § 87.67(b) of the Commission's rules notwithstanding license provisions to the contrary.

Adopted: February 18, 1971.

Released: February 24, 1971.

FEDERAL COMMUNICATIONS
COMMISSION,

[SEAL] BEN F. WAPLE,

Secretary.

[FR Doc. 71-2913 Filed 3-2-71; 8:51 am]

APPENDIX 4 (Cont'd)
FCC RULE MAKING RELATED TO SSB EQUIPMENT
AND THE TYPE ACCEPTANCE OF THAT EQUIPMENT

Before the
 FEDERAL COMMUNICATIONS COMMISSION
 Washington 25, D. C.

G
 FCC 61-511
 3140

In the Matter of

Amendment of Parts 6 and 9 of the Commission's Rules and Regulations to require the use of single sideband transmissions in fixed radio-telephone service below 25,000 kc, except Alaskan and maritime fixed.

DOCKET NO. 11513

and

In the Matter of

Amendment of Part 9 of the Commission's Rules to require the use of single sideband transmission in the aeronautical mobile service for radiotelephony on frequencies below 25,000 kc.

DOCKET NO. 11678

and

In the Matter of

Amendment of Parts 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 16, and 19 of the Commission's Rules concerning type acceptance of transmitters, bandwidth and spurious emissions.

DOCKET NO. 11654

Report and Order

By the Commission:

1. On October 16, 1957, the Commission adopted a Further Notice of Proposed Rule Making in the above-entitled matter insofar as Part 9 of the Rules is concerned, which Notice was published in the Federal Register on October 24, 1957 (22 F.R. 8386). Comments were to be filed by February 3, 1958, and replies within ten days thereafter. The Commission subsequently granted petitions for additional time to file comments. The time was extended finally to October 15, 1958 and replies within twenty days thereafter.

2. This Report and Order completes rule-making with regard to the Commission's proposals to specify the applicable technical standards for voluntary single sideband operation below 25,000 kc in the Aviation Services (Part 9). The attached Appendix contains appropriate amendments to Part 9 of the Commission's Rules.

APPENDIX 4 (Cont'd)
FCC RULE MAKING RELATED TO SSB EQUIPMENT
AND THE TYPE ACCEPTANCE OF THAT EQUIPMENT

-2-

3. Comments in response to this Further Notice of Proposed Rule Making were submitted by Aeronautical Radio, Inc., (ARINC), Barker & Williamson, Inc., Collins Radio Co. and Motorola, Inc. ARINC comments incorporate, by reference, the conclusions of RTCA SC-34 contained in "Characteristics of Aeronautical Single Sideband Systems." Reply comments were filed by Collins Radio Co.

4. In general, the comments favored the principle of Single Sideband (SSB) operation and none opposed it. Motorola, Inc., however, proposed a technical approach to SSB operation different from the suppressed and full carrier modes of operation proposed by the Commission.

5. Motorola, Inc. advocates synchronous single sideband, pilot carrier, operation instead of suppressed carrier operation, citing, among other reasons, that no doppler shift will be experienced regardless of aircraft speed and the frequency stability requirements can be materially relaxed, thus enabling the use of techniques which are technically and economically feasible.

6. In regard to the Motorola proposal of synchronous single sideband operation, it should be noted that the Commission's proposal requires both full carrier and suppressed carrier operation to insure compatibility with double sideband equipment. This Report and Order is not intended to prohibit operation in other modes of single sideband; it is intended only to preclude the use of large amounts of equipment which may eventually prove unsuitable for integration into an ultimate single sideband system. Therefore, in this respect, the single sideband transmitter specifications will be as proposed.

7. Concerning the frequency stability requirements of Docket No. 11654, Motorola, Inc. has expressed concern that the requirements are extreme and may not be technically and economically feasible. Collins Radio Company in its reply comments indicated that they had found, as a matter of fact, that the requirements are technically feasible and economically feasible. The Commission finds that these requirements are technically and economically feasible.

8. Comments have been submitted which are not considered to be within the scope of the issues as proposed, and they are accordingly rejected. This includes proposals as to the techniques of making power measurements and the question of supplemental use of the lower sideband.

9. Collins Radio Company proposed that the frequency tolerance be changed from the proposed 5 cycles per second for ground based equipment and 20 cycles per second for airborne equipment to 15 and 25 cycles respectively. The present tolerance has been relaxed from that originally proposed to 10 and 20 cycles respectively. This revision is in accordance with the recommendation by RTCA SC-34, however, it does not reach the accuracy proposed by Collins.

APPENDIX 4 (Cont'd)
FCC RULE MAKING RELATED TO SSF EQUIPMENT
AND THE TYPE ACCEPTANCE OF THAT EQUIPMENT

-3-

10. Concerning spurious emissions, the Commission has followed the recommendations of the RTCA which is considered by the Commission as an expert body representing government and industry.

11. Some parties have recommended that the carrier be suppressed by at least 40 db in single sideband suppressed carrier operations. In the suppressed carrier mode, it is desirable that the carrier be attenuated as much as is practicable. For regulatory purposes, however, it is found necessary to require only a minimum attenuation of 26 db below peak envelope power.

12. In connection with the assignment of a "carrier frequency" as set forth in Section 9.178(c), it was noted that the term "carrier frequency" loses meaning with many types of multiplexing and data signaling. It should suffice to say that this proceeding relates only to radiotelephony and it is so entitled.

13. While this rule-making adopts technical standards to allow single sideband operation, it is important to note the requirement for compatibility of operation with existing double sideband equipment. In view of this, requests for air ground operation using SSF emission with carrier suppressed more than 6 db will not be granted on a regular basis nor will the fact that a station may have only capability of 6A3 emission be in itself sufficient grounds for authorizing an additional station to serve the same area utilizing single sideband emission. Potential users of HF single sideband are not urged by this Report and Order to increase the use of high frequencies domestically and, in fact, are cautioned that there is no present reliable estimate as to how long HF air/ground communications will be justified domestically in the United States. The trend in the United States has been for domestic aviation operations to be conducted on VHF frequencies. In this connection, the Geneva Radio Regulations (1959), presently before Congress for ratification, provides, among other things, in Resolution No. 14 that administrations take the necessary steps "to make as great a use as possible of very high frequencies in order to lessen the load on the high frequency (R) bands."

14. The matter of a possible conversion program to compulsory single sideband may be considered again at a later date when development and implementation have progressed sufficiently to enable the Commission to accumulate more detailed data on equipment and systems performance under normal operating conditions.

APPENDIX 4 (Cont'd)
FCC RULE MAKING RELATED TO SSF EQUIPMENT
AND THE TYPE ACCEPTANCE OF THAT EQUIPMENT

-4-

15. In view of the foregoing, IT IS ORDERED, pursuant to the authority contained in Section 303(e), (f) and (r) of the Communications Act of 1934, as amended, that effective May 26, 1961, Part 9 of the Commission's Rules is amended as set forth in the attached Appendix.

16. IT IS FURTHER ORDERED, that the proceeding in Docket No. 11678 is terminated and the proceedings in Dockets No. 11513 and 11654 are terminated insofar as they relate to Part 9 of the Commission's Rules.

FEDERAL COMMUNICATIONS COMMISSION

Ben F. Waple
Acting Secretary

Attachment

Adopted: April 19, 1961
Released: April 24, 1961

NOTE: Rules changes herein will be covered by T. S. V(61)-1.

APPENDIX 4 (Cont'd)
FCC RULE MAKING RELATED TO SSB EQUIPMENT
AND THE TYPE ACCEPTANCE OF THAT EQUIPMENT

A P P E N D I X

1. Section 9.178 is amended by adding new paragraph (c) as follows:

§ 9.173 Frequencies.

* * * * *

(c) The frequency coinciding with the center of an authorized bandwidth of emission shall be specified as the assigned frequency; for single sideband emission, the carrier frequency shall also be specified.

2. In § 9.179, paragraphs (b) and (c) are deleted and new paragraphs (b), (c), and (d) are added, as follows:

§ 9.179 Power.

* * * * *

(b) Except as indicated in paragraph (c) of this section, the power authorized for use at any station shall be specified in terms of peak envelope power at the transmitter output terminals. Peak envelope power is defined as the mean power during one radio frequency cycle at the highest crest of the modulation envelope.

(c) For stations using amplitude modulated emission and transmitting both sidebands and a full carrier, authorized power will be specified in terms of unmodulated radio frequency carrier power at the transmitter output terminals.

(d) Power may be determined either by direct measurement or by multiplying the plate input power to the final amplifier by an appropriate factor.

3. In § 9.180, the introductory text of paragraph (a) is amended, paragraphs (c) and (d) are redesignated (d) and (e), and new paragraph (c) is added, as follows:

§ 9.180 Frequency stability.

(a) Except for microwave stations, for which the frequency stability is specified in § 9.190 and when transmitting single sideband emissions, the carrier frequency of each station in the Aviation Services shall be maintained within the applicable following percentage of the assigned frequency:

* * * * *

(c) When transmitting single sideband emissions, the carrier frequency shall be maintained within the applicable following number of cycles per second of the specified carrier frequency.

APPENDIX 4 (Cont'd)
FCC RULE MAKING RELATED TO SSB EQUIPMENT
AND THE TYPE ACCEPTANCE OF THAT EQUIPMENT

- 2 -

(1) All ground stations 10 cps

(2) All aircraft stations 20 cps

(d) Radar transmitters operated on frequencies above 2400 Mc shall meet the following requirements in lieu of a frequency tolerance: The frequency at which maximum emission occurs shall be within the authorized frequency band and shall not be closer than 1.5/T Mc to the upper and lower limits of the authorized bandwidth, where T is the pulse duration in microseconds.

(e) Tolerances other than those specified in this section may be authorized upon a satisfactory showing of need therefore. In such cases, the tolerance authorized may be specified on the instrument of authorization.

In § 9.181, the table in paragraph (b) and paragraph (d) are amended to read as follows:

§ 9.181 Types of emission.

(b) * * *

Class of Emission	Emission Designator	Authorized	
		Below 50 Mc	Above 50 Mc
A1	0.1A1	0.25 kc	
A2	2.1A2	2.724 kc	
A3	6A3	3.0 kc	50 kc
A3a 2/	3A3a 2/	4.0 kc	
F1	1.7F1	1.7 kc	
F1	2.5F1	2.5 kc	
P	1/	1/	

1/ To be specified on the authorization
2/ For the purposes of this Part A3a includes single sideband full carrier and single sideband with carrier suppressed; however, operation with carrier suppressed more than 6 db below peak envelope power will be authorized only on a developmental basis except for stations operating in the aeronautical fixed service. A3a emission will be authorized only below 25,000 kc.

APPENDIX 4 (Cont'd)
FCC RULE MAKING RELATED TO SSB EQUIPMENT
AND THE TYPE ACCEPTANCE OF THAT EQUIPMENT

- 3 -

(d) An authorization to use radiotelephone emission will be construed to include use of tone signals or signaling devices whose sole function is to establish or maintain voice communications.

5. Section 9.183 (a)(1) and (2) is amended to read:

§ 9.183 Emission limitations.

(a) * * *

- (1) When using transmissions other than single sideband (A3a):

(i) On any frequency removed from the assigned frequency by more than 50 per cent up to and including 100 per cent of the authorized bandwidth: at least 25 decibels;

(ii) On any frequency removed from the assigned frequency by more than 100 per cent up to and including 250 per cent of the authorized bandwidth: at least 35 decibels.

- (2) When using single sideband (A3a) transmission:

(i) On any frequency removed from the assigned frequency by more than 50 per cent up to and including 150 per cent of the authorized bandwidth: at least 25 decibels.

(ii) On any frequency removed from the assigned frequency by more than 150 per cent up to and including 250 per cent of the authorized bandwidth: at least 35 decibels.

APPENDIX 4 (Cont'd)
FCC RULE MAKING RELATED TO SSB EQUIPMENT
AND THE TYPE ACCEPTANCE OF THAT EQUIPMENT

- 4 -

6. Section 9.184 is revised to read as follows:

§ 9.184 Modulation requirements.

(a) When double sideband full carrier amplitude modulation is used for telephony, the modulation percentage shall be sufficient to provide efficient communication and shall normally be maintained above 70 per cent on peaks but shall not exceed 100 per cent.

(b) When special types of emission are employed, the modulation requirements may be specified.

(c) In order to meet the requirements for type acceptance in the Aviation Services, a double sideband full carrier amplitude modulated radiotelephone transmitter with rated carrier power output exceeding 10 watts shall be capable of automatically preventing modulation in excess of 100 per cent. In the event that operation of any licensed radiotelephone transmitter causes harmful interference to any authorized radio service because of excessive modulation, the Commission may require that the use of such transmitter be discontinued until it is rendered capable of automatically preventing modulation in excess of 100 per cent.

(d) In order to meet the requirements for type acceptance in the Aviation Services, a single sideband transmitter shall be capable of operation in both of the following modes:

(1) With the carrier suppressed at least 26 db below peak envelope power.

(2) With the carrier transmitted at a level between 3 and 6 db below peak envelope power.

(e) In single sideband operation, the sideband on the higher frequency side of the carrier frequency shall be transmitted.

APPENDIX 5REFERENCE BACKGROUND MATERIAL ON SPECTRUM LIMITATIONS AND
THE RELATION TO THE IMPLEMENTATION OF SSBNOTE 1: Origin of This Material

The following material was prepared by the ARINC staff (based on an earlier (1957) technical paper by Ernie Papenfuss of Collins Radio) for reference purposes during SSB meetings and was originally published in AEEC Letter 65-1-19 on November 30, 1964. Because of an apparent wide misunderstanding of the spectrum characteristics of SSB transmitters, and the allowance which must be made in frequency planning, this material was included in the ARINC Characteristic 533A when published in 1966 and was carried forward into this Appendix in Characteristic 559 in 1971.

NOTE 2: Relationship to ITU Regulations In 1971

ITU and ICAO do not now (1971) reflect the basic industry planning set forth in this appendix for the reasons noted in Section 4.2 and 4.14 and explained in somewhat greater detail in Appendix 7, but it is anticipated that the international standards will be revised to be compatible with the existing and planned airborne hardware, probably through the course of action outlined in Appendix 7.

NOTE 3: Relationship to Future ITU Regulations

The following material has been updated with the publication of ARINC 559A to reflect the changes in the "Original 'Assumed' Essential Signal Characteristics" set forth in Appendix 9. Most of the original text of Appendix 5 from ARINC 533 and 559 has been included herein because of its historical significance. The text following the "Fall 1975 NOTE" and indicated by the "ç-Bar" (vertical line) has been changed as described in that note. This guidance on spectrum limitations and its relationship to 3kHz HF/SSB channel implementation is intended for use by both equipment and frequency planners. It applies to the interim use of 3kHz HF/SSB within the existing (1975) AM frequency plan and the anticipated future 3kHz HF/SSB frequency plan.

APPENDIX 5 (cont'd)THE ORIGIN OF THE "SPECTRUM LIMIT AND SPURIOUS RESPONSE" MATERIAL ON SSB TRANSMITTERS IN THE APPENDIX 1 OF THIS CHARACTERISTIC 559.

The detailed material contained in Sections 2.6.1 and 2.6.2 of Appendix 1 "Assumed Essential System Characteristics for SSB" will be found to be very similar in format to RTCA Paper 146-58/DO 86 prepared by RTCA Special Committee SC-84 on August 12, 1958, but the RTCA work was not the origin of that particular material. The manner in which transmitter spectrum characteristics are specified by "frequency people" has always caused a lot of confusion to the uninitiated; however, it has been the practice for a great many years for the U.S. FCC to specify emission limitations in terms of "percentage-of-the-authorized-bandwidth-plus-or-minus-with-respect-to-the-center--of-that-authorized-bandwidth". The actual numbers which are prescribed in Section 87.71 of the FCC Rules and Regulations (See Appendix 4 of ARINC 559A) have undergone many changes through the years but the current wording for transmissions other than "single sideband" reads as follows:

- (i) On any frequency removed from the assigned frequency by more than 50 per cent up to and including 100 per cent of the authorized bandwidth: at least 25 decibels;
- (ii) On any frequency removed from the assigned frequency by more than 100 per cent up to and including 250 per cent of the authorized bandwidth: at least 35 decibels.

Beyond this 250 per cent point the emission is limited by other parts of the FCC Rules and Regulations relating to the harmonic generation, etc. and thus (for airborne transmitters) the spectrum limit drops to 40 db beyond 250 per cent of the authorized emission bandwidth and remains at that point on out to infinity. The solid line in the figure 1A shows how this spectrum looks when plotted in terms of the AEB (authorized emission bandwidth), and which for purposes of discussion is assumed to be 8 kilocycles for AM and which is exactly twice the original authorized emission bandwidth of 4 kHz for single sideband transmission. (See the FCC Rules in Appendix 4). You will note in the Fig. 1A that the first plateau at the minus 25 dB level on both sides of the AM transmission represents the spectrum produced by second harmonic distortion in the modulation process and the next plateau which is set -35 dB in the solid line sketch of Figure 1A represents third, fourth and fifth harmonic distortion. The regulation of spectrum characteristics by the FCC in quantitative terms developed with the advent of the FCC Type Acceptance and Type Approval program in recent years and it is common knowledge that there could be many transmitters in existence which won't meet the FCC Rules --- simply because spectrum analyzers were not too generally available in past years when many of the older AM transmitters were designed and most transmitter designers had no actual knowledge of the spectrum characteristics of their own transmitters!

The FCC rule making on single sideband use originally started in 1957 and the FCC first proposed making the same spectrum characteristics for AM transmitters applicable to SSB transmitters, in the belief that when expressed in terms of "percentage-of-authorized-emission-bandwidth" both types of transmitters should be describable in the same set of "words and numbers". This was proven to be impracticable and the 1961 FCC rule making established the following requirement under paragraph 87.71 with respect to single sideband transmission: (See also the complete text of the FAA rule making in Appendix 4.)

- (i) On any frequency removed from the assigned frequency by more than 50 per cent up to and including 150 per cent of the authorized bandwidth: at least 25 decibels.
- (ii) on any frequency removed from the assigned frequency by more than 150 per cent up to and including 250 per cent of the authorized bandwidth: at least 35 db.

Obviously, for the reasons given previously herein the rejection beyond the 250 per cent point must be 40 db on out through the harmonics and on to infinity for airborne transmitters.

If these figures are plotted in terms of "authorized emission bandwidth" as in Figure 1B it will be seen that the AM and SSB spectrums have a specific difference in that the minus 25 db plateau extends out further in the SSB case than in the AM case. The reason for this is sometimes missed by the technical people who are so accustomed to dealing with AM transmission where all of the harmonic products are extraneous spectrum emission while with single sideband the position of the carrier has been shifted to near one edge of the authorized emission bandwidth such that the high order distortion products appear in an entirely different place in the spectrum than the AM transmitter expert is used to seeing --- and yet this has to be taken into consideration in the wording of the system standards for FCC or for ICAO purposes.

MODERN AIRBORNE TRANSMITTER SPECTRUM LIMITS

It is quite practicable to better the FCC limits with very, very careful control of transmitter design and construction; however, it will take a lot of careful maintenance to keep the spectrum

APPENDIX 5 (cont'd)

REFERENCE BACKGROUND MATERIAL ON SPECTRUM LIMITATIONS AND
THE RELATION TO THE IMPLEMENTATION OF SSB

limits at a consistent level better than the FCC Rule Making. It is difficult to state just what performance can be accomplished by existing AM transmitters; however, the dashed lines of Figure 1A show the spectrum limits established in this Characteristic (under Section 4.14) for the spectrum characteristics to be met on AM in the event a manufacturer chooses to offer an SSB transmitter with double sideband AM capability. Thus, these limits of Fig. 1A are based on a modern, carefully designed, airborne AM transmitter developed to SSB standards but used for AM transmission.

HOW MUCH BETTER THAN THE FCC SSB SPECTRUM CHARACTERISTICS CAN AN AIRLINE SSB TRANSMITTER BE?

When the ARINC Characteristic 533 was written in 1960 considerable study was given to the spectrum capabilities of equipment and the figures given in Section 4.15 (specified in Section 4.14 of Characteristic 559A) were very carefully developed, based on two different customer options of frequency response. Using the lesser of two bandwidths, and plotting the ARINC-required performance of the airborne equipment on Figure 1-B (dashed lines), and assuming that the transmitter actual bandwidth figure (approximately 3 kHz is just three-fourths of the "authorized emission bandwidth" (4 kHz) used for plotting the solid line spectrum characteristics of Figure 1-B, a direct comparison can be made between the expected performance of a modern airborne equipment and the spectrum conditions which will probably appear as system requirements (They actually did appear in the 1961 FCC Rules and Regulations.).

Similarly, a comparison can be made with the dashed lines of figure 1-A which gives the corresponding transmitter spectrum from a modern AM transmitter of equivalent quality.

JULY 1975 NOTE

Further information on the additional margin of performance, above the regulatory "minimum", recommended in ARINC 559 is presented near the end of this Appendix and in Figure 3B.

WHY ARE THE SPECTRUM LIMITS SHOWN WITH SQUARE CORNERS RATHER THAN IN THE ROUNDED-OFF FORM WHICH SPECTRUM DISTRIBUTIONS OF VOICE TRANSMITTERS ACTUALLY PRODUCE?

Certainly everyone knows that for either AM or SSB, the spectrum is rounded off not only at the low frequency end but at the high frequency end as well and that the spectrum characteristics of a voice frequency transmitter could never be as bad as Figure 1-A or B. But this is only true with voice frequency transmission!

The knowledgeable manufacturer and systems planner must certainly have been impressed that the airline industry has long given very careful and hopeful consideration to the use of data systems on any and all communication circuits provided between air and ground. Initially the airline industry was not prepared to state with any certainty what limitations might or might not in the future be applied to transmissions of data and hopefully felt that a transmitter should be designed which would not have any limitations of any kind (other than duty cycle) thus some rather stringent test requirements were established in Characteristic 533 and reaffirmed in Section 4.14, 4.15 and 4.17 of this Characteristic 559A. Thus, if tested in accordance with the requirements in Section 4.14 the spectrum characteristics of the SSB transmitter (or an AM transmitter if that is tested also) will resemble the general square shape characteristic modified only to the degree that the passband filters cannot have perfectly straight sides. However, it was made abundantly clear in the wording of the ARINC Characteristic, Section 4.14, that the spectrum characteristics of the transmitter must be within the boundaries set forth by the square lines (shown dashed) in the Figure 1B. Certainly present day voice transmission does not utilize the available spectrum very efficiently but the hope is that in the future whatever systems of transmission are used (whether voice or data) will effectively utilize the whole 2.5 kHz spectrum and thus equipment ought to be predicated on this future possibility.

HF AM CHANNEL SPLITTING TO PROVIDE TWO SSB SIGNAL CHANNELS?

Figure 2 shows a composite of the "best AM airborne equipment" spectrum characteristics (taken from the dashed curve of Figure 1-A) plotted as a solid line in Figure 2 and with the "best SSB airborne equipment" (taken from the dashed curve of Figure 1B) and plotted in the dashed curve of Figure 2, to show how a single sideband signal operating in the upper half of a particular channel will produce a spectrum characteristic which is almost identical to that of an AM transmitter. (The AM signal extends approximately 3 kHz further out on the lower frequency side.) When plotted in this manner it should be evident that the single sideband signal does take up just one-half the space of the AM signal (even though both signals are symmetrical on both sides and radiate spurious signals following the step-functions as shown) because its spectrum extending on the low

APPENDIX 5 (cont'd)

REFERENCE BACKGROUND MATERIAL ON SPECTRUM LIMITATIONS AND
THE RELATION TO THE IMPLEMENTATION OF SSB

frequency side is no worse than the spectrum of a corresponding AM transmitter would have been if its desired frequency spectrum was positioned exactly where the edge of the SSB desired frequency spectrum was!

The whole key to the success of the eventual channel splitting using integral kHz increments is contained in the rather innocuous-looking statement under the original sub-paragraph 5b of Section 4.1 of the Attachment D to Part 1 of the ICAO Annex 10 document (see Appendix 1) which states: "However, in initial implementation planning for the system, 3,000 Hz virtual carrier separation is necessary in the lower frequency bands for effective utilization of the existing ITU frequency allotment plan" ----- then still rather innocuously under this paragraph the user is urged by means of a Note to "not transmit more than 3,000 Hertz of signal", EVEN THOUGH THE "NECESSARY BANDWIDTH" IS PERMITTED TO BE 4,000 HERTZ. Thus, it is of utmost importance that the ARINC Characteristic SSB Transmitter produce sufficiently low adjacent channel and second adjacent channel spurious signals to minimize interference after channel splitting has been accomplished with a 3 kHz carrier spacing. (Of course, it is equally important that the receiver rejection characteristic be sufficiently good to reject adjacent channel signals, however, the spectrum characteristics of the transmitter are usually the limiting factor on HF rather than receiver I. F. design, with the present state of the art in receiver design.)

Following the concept of a technical paper by Ernie Papenfuss of Collins Radio (circulated in AEEC Letter No. 57-2-1, dated February 5, 1957) it can be shown graphically the channel relationship with DSB stations as compared with SSB stations, and the basic intermodulation distortion relationships with modern SSB equipment and how operation is limited by the spectrum characteristics of the transmitter rather than by other factors.

Fall 1975 Note Regarding Figure 3

Figure 3 was originally prepared to illustrate exactly how 3 kHz HF/SSB channels should be implemented within the then existing AM channel plan. At that time the AM channels varied in spacing from 7 to 10 kHz (including 7.5 kHz spacing). The original Figure 3 showed the 7.5 kHz situation since that was the most difficult to envision.

The updated version, Figure 3A, provided herein shows the regulatory aspects of how 3 kHz HF/SSB channels will now be implemented in the present 7 kHz and 8 kHz AM channels. The frequency spacing considerations are shown in the horizontal axis of Figure 3A.

Figure 3A also shows the signal amplitude relationships which must be observed by frequency planners. These amplitude relationships, shown in the vertical axis of Figure 3A, are the direct result of the physical parameters of the TRANSMITTER! These amplitude limits are not in any way related to receiver characteristics.

Figure 3B shows the extended range of signal amplitudes that should be accommodated by ARINC 559 transmitters. The difference between Figures 3A and 3B are the "PERFORMANCE MARGINS" described below.

Although not illustrated in either Figures 3A or 3B, earlier ARINC 533/533A having the wide (option 2) audio baseband characteristics, and the consequent spectrum characteristics, will provide an acceptable level of service in actual operations. Any apparent compromise in quality of service has been determined by both the airlines and military aircraft operators to be acceptably small since it involves only a limited portion of the highest frequencies in audio baseband. The difference in single-to-noise ratio has been estimated by the civil and military users to be about 1 to 2dB. This difference may in fact, be even less depending upon the audio baseband limits imposed by other elements of the system, such as microphone frequency range.

Figure 3A shows how 559A equipment should operate in an adjacent channel environment where present (Fall, 1975) ITU/IAARC AM channels are 7 kHz wide and have their centers (and thus the presently assigned AM frequencies) on integral kHz. Figure 3A shows the regulatory requirements for spectrum characteristics from an SSB transmitter in the center as "A-Upper Half AM Channel" with the carrier of that particular transmitter exactly coinciding with the "assigned carrier frequency" of the AM signal which ordinarily would have operated in that channel. The signal level appearing at the receiving site is assumed to be "some-number-of-microvolts" established as a reference value for "zero dB" on the amplitude curve of Figure 3A. This transmitted signal is flanked on the lower frequency side by signal "A-Lower Half AM Channel" and on the higher frequency side by signal "B1-Lower Half AM Channel". The bottom line of the signals "A-Lower Half AM Channel" and "B1-Lower Half AM Channel" extend down to the minus 20 dB levels to indicate that signal appearing in these channels at the hypothetical receiving site (where the desired signal "A-Upper Half AM Channel" produces a level of zero dB) must be stronger than minus 20dB level in order to be at least 10dB above noise and interference generated by the spectrum radiation (minus 30dB third order distortion) from the signal "A-Upper Half AM Channel". Therefore, the bottom line of each "rectangle" represents the minimum signal level that can be laid down by that particular transmission to still be intelligible at the hypothetical receiving site insofar as interference is concerned from the original signal (A Upper Half AM Channel). The top line of each "rectangle" represents the maximum signal that can be laid down without that signal producing third order distortion on the channel occupied by the original signal "A-Upper Half AM Channel". Similarly, the signals in further-removed channels "B1-Upper Half AM Channel" can be permitted to have greater ranges of signal intensity at the hypothetical receiving station without producing interfering spectrum troubles and the further-removed channels all have a lesser degree of signal limita-

APPENDIX 5 (cont'd)REFERENCE BACKGROUND MATERIAL ON SPECTRUM LIMITATIONS AND
THE RELATION TO THE IMPLEMENTATION OF SSB

tions on them. These latter signals have their lower limits established by receiver noise level in the ultimate case rather than by spectrum difficulties although spectrum interference could be the limiting case under certain circumstances.

Even though certain limitations are established on the amplitude ranges of adjacent channel signals for SSB operation these limitations are no worse than would have been necessary if AM signals were being employed (of half-the-band-width) as previously explained in Figure 2.

In Figure 3A two SSB signals are shown in channel A. The carrier position of the "A-Upper Half AM Channel" signal has been positioned exactly on the center of the AM channel (which is an integral kHz point) and then the carrier of the "A-Lower Half AM Channel" signal in that same AM channel has been positioned on an integral kHz point exactly 3 kHz below the carrier of the "A-Upper signal". This procedure is repeated in each channel starting with the presently "assigned AM frequency" in the middle of channel, each of which is an integral kHz point.

Once again, the lower SSB signals in each of these two channels ("B1-Lower Half AM Channel and "B2-Lower Half AM Channel") will have their carriers positioned exactly 3 kHz below the carriers of signals "B1-Upper Half AM Channel" and "B2-Upper Half AM Channel", respectively. With frequency channels C1 and C2 the carriers in the upper and lower halves of the AM channels are positioned exactly as with the original desired signal in channel A and are repeated like this through that frequency band.

NOTE -

This implementation is based upon use of the 3 kHz capability of all existing air-borne equipment, rather than the 3.5 kHz channel spacing recommended by ITU in 1966, for the reasons stated in Appendix 7.

In other frequency bands where the spacings are 8 kHz, instead of 7 kHz, the situation is very much the same as in Figure 3A except there will be a 1 kHz gap in the spectrum between the pair of HF/SSB "Upper" and "Lower" channels within each 8 kHz AM channel. This results from the spacing between carriers being four 4 kHz as now specified by ICAO Annex 10, instead of 3 kHz as shown in Figure 3A. Thus, for the higher ITU AM channels having spacings of 8 kHz, there will always be 4 kHz between adjacent carriers, but in other respects the arrangement of carriers within each channel will follow the same rules as illustrated in Figure 3.

SPECTRUM GAPS DISAPPEAR IN 3 kHz PLAN

The spectrum gaps shown in Figure 3A (for example, between "A-Upper" and "B1-Lower Half AM Channels) will disappear completely after the 3 kHz frequency plan is fully implemented. At that time the carrier frequencies can be located every 3 kHz throughout the HF spectrum exactly as the pairs of HF/SSB channels are shown within the present 7kHz AM channels.

PERFORMANCE MARGINS GOBBLED UP BY REGULATIONS

Airline operators have consistently demanded of the equipment designers additional margins of performance beyond those specified in the regulations. The amount of these margins is discussed above (How Much Better Than The FCC ...) and illustrated in Figure 1B.

The changes in the "Assumed" Essential System Characteristics described in Appendix 9, if in fact adopted by ICAO and ITU, will usurp a great amount of these margins. In the case of first adjacent channels the entire margin is consumed by the changes in regulatory requirements. In second adjacent channels and beyond only portions of the original margins are preserved.

Unfortunately, limitations in technology preclude any significant improvement in equipment performance for the foreseeable future. Thus, the airlines and planners should not blithely assume a continued flow of hidden benefits to the system and frequency planning as in the past.

The extent to which the users may expect "better-than-minimum" performance is illustrated in Figure 3B. This shows, particularly after the frequency gaps disappear with the full implementation of 3 kHz, there is NO margin in the frequency domain. The remaining margins in the range of signal amplitudes may be derived by comparison with the regulatory limits shown in Figure 3A.

These losses of performance margins will force the operators into more demanding and costly maintenance practices. Further compromises must be avoided.

APPENDIX 5 (Cont'd)

Fig. 1-A Spectrum Limits for AM Transmitters

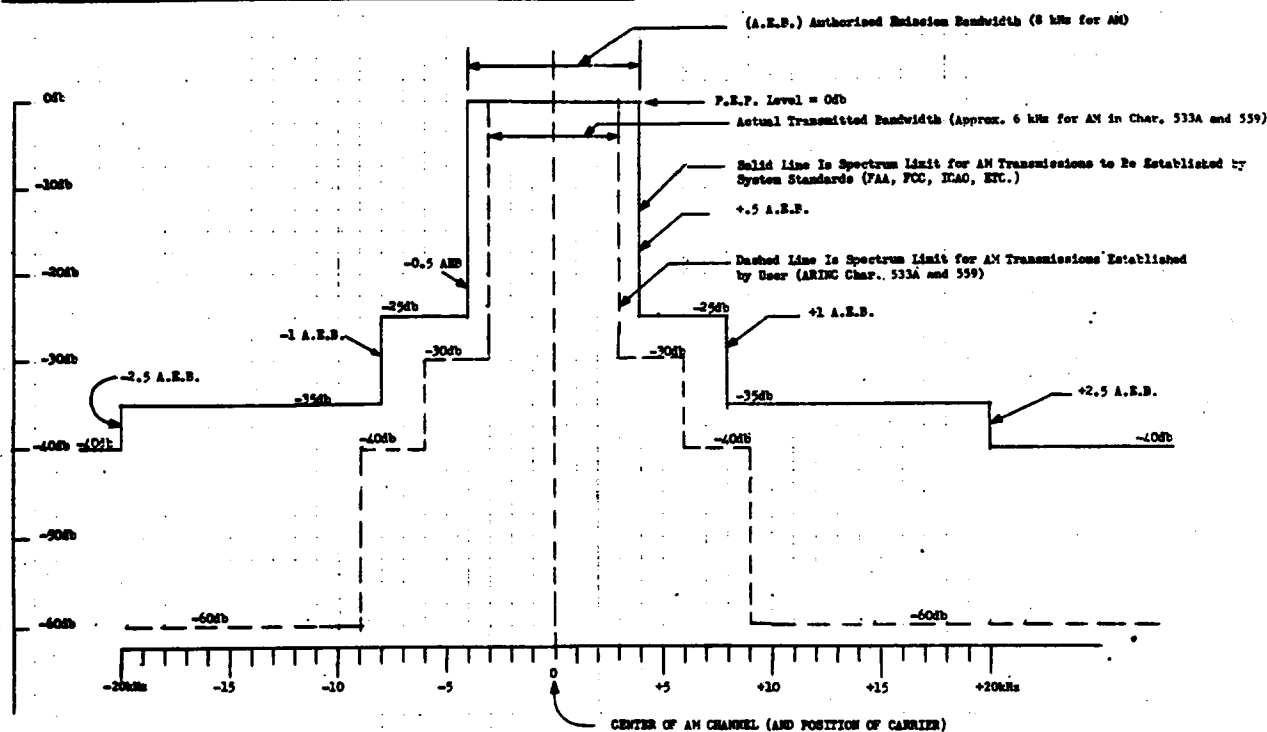
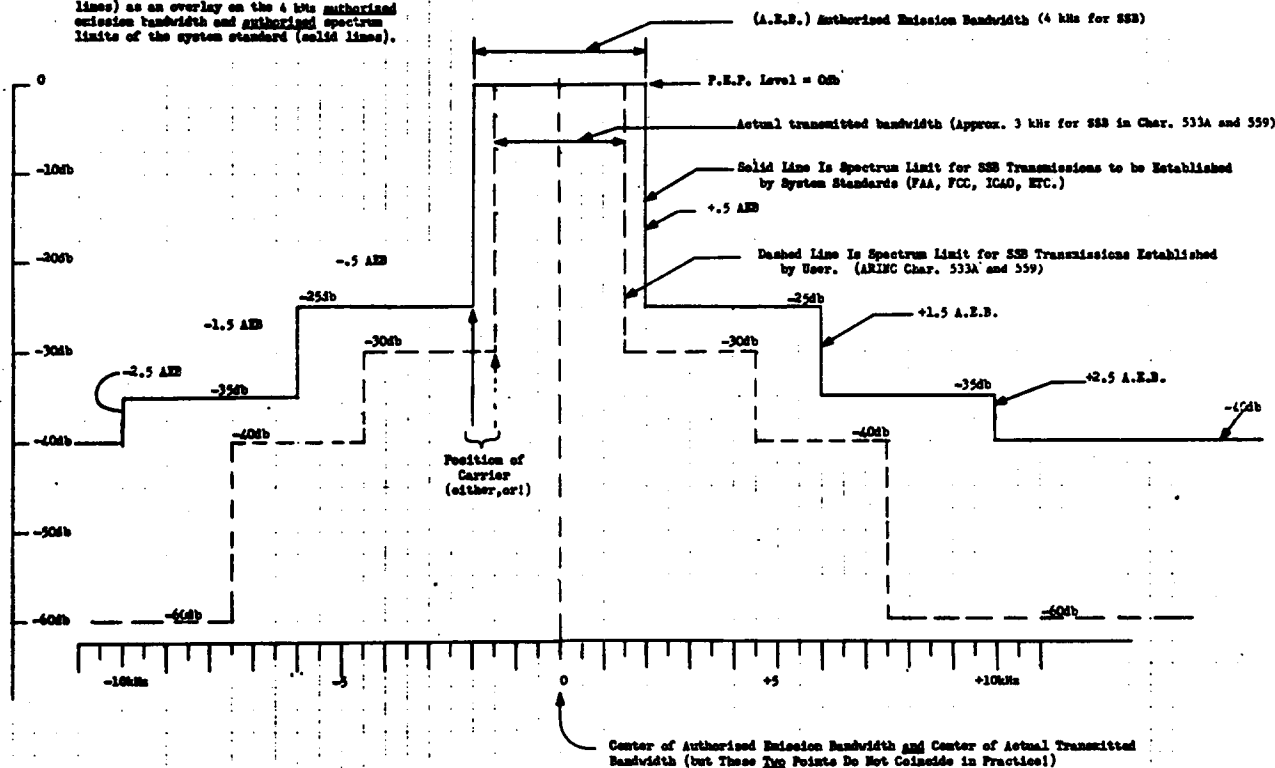


Fig. 1-B Spectrum Limits for SSB Transmitters

NOTE: SSB Transmitters should not be positioned in freq. as shown here. This is an illustrative example to show spectrum distribution & symmetry of a 3 kHz SSB Transmission (dashed lines) as an overlay on the 4 kHz authorized emission bandwidth and authorized spectrum limits of the system standard (solid lines).



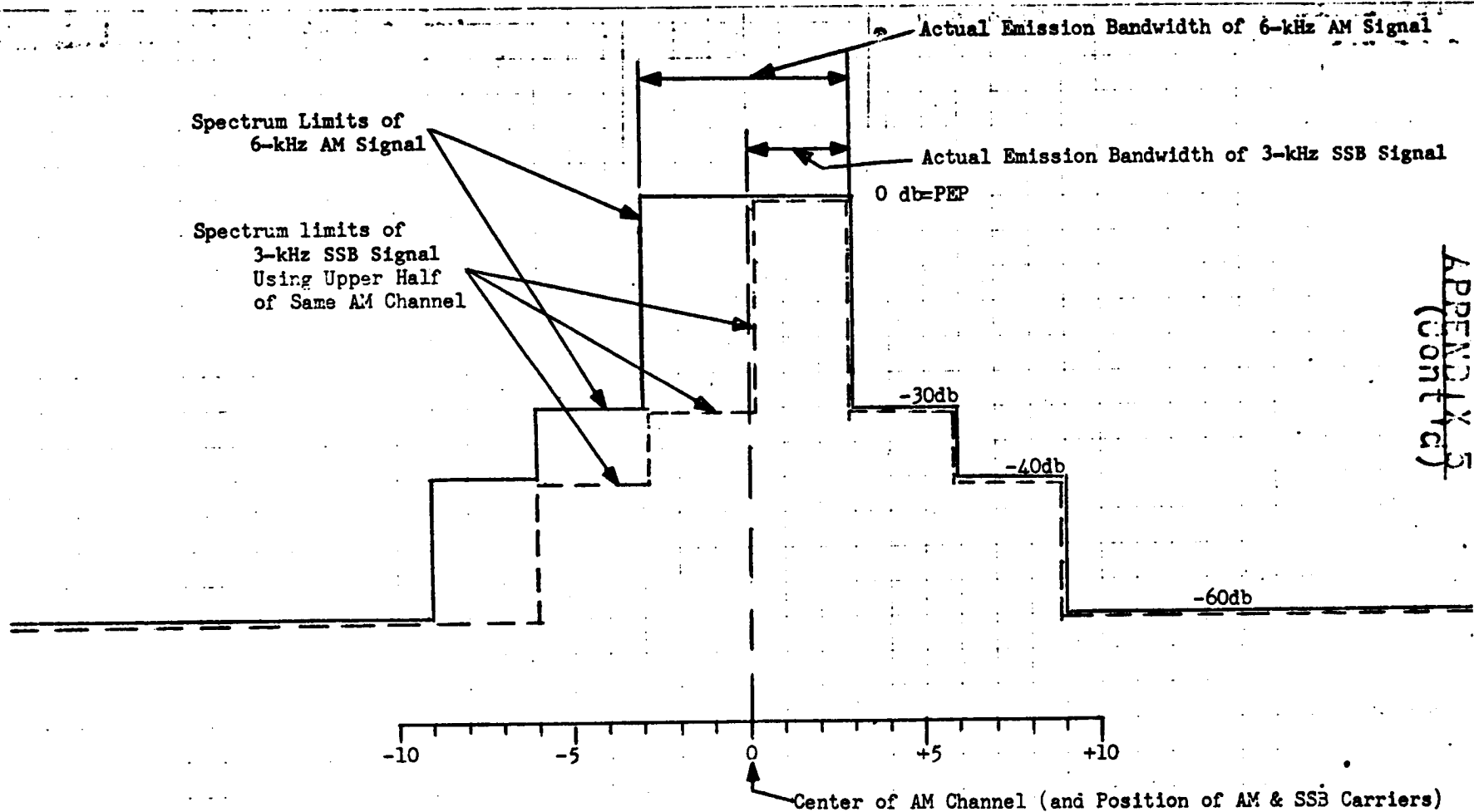
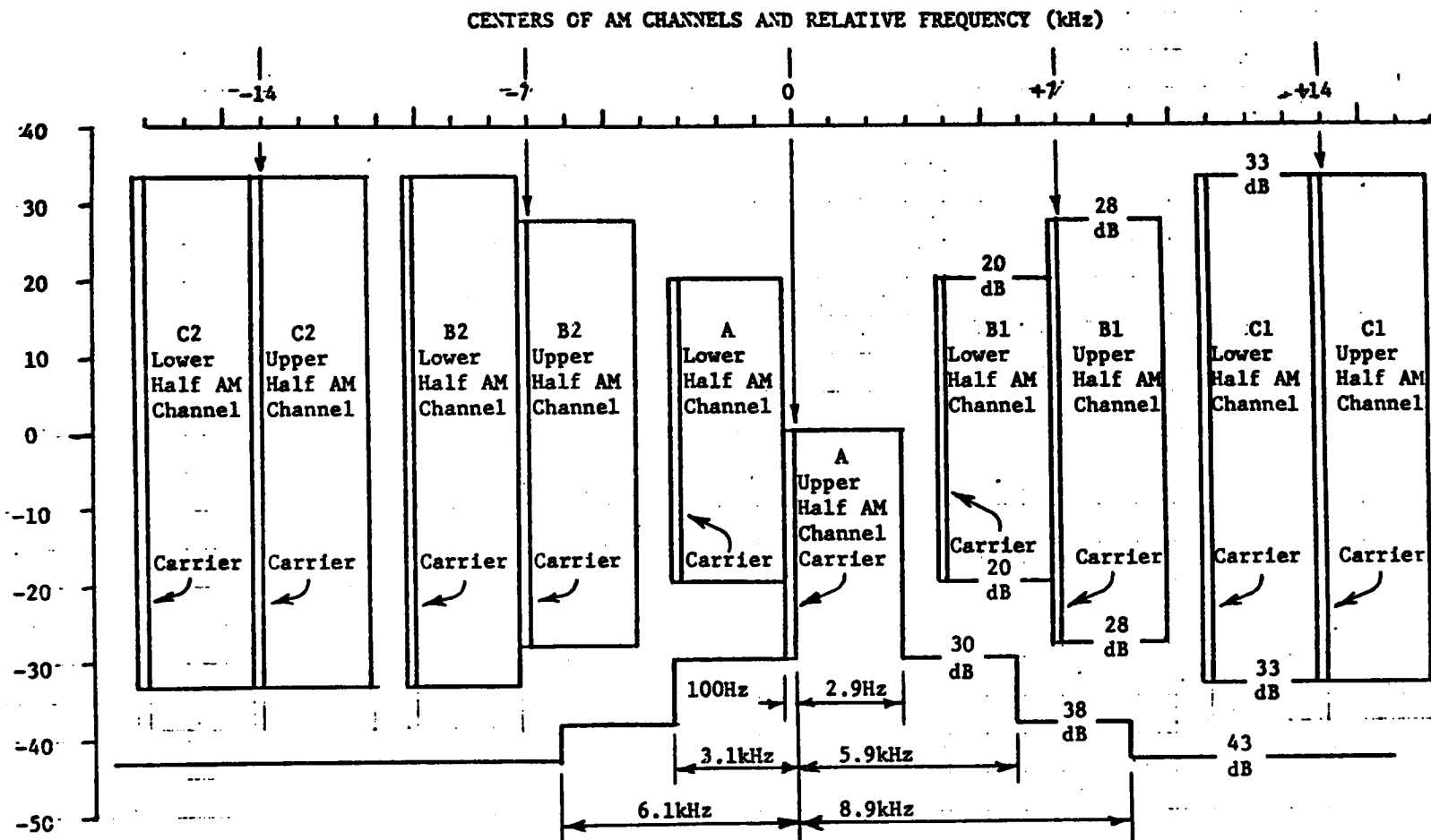


Fig. 2 Comparison of Spectrum Characteristics of AM & SSB Signals Operating on Same Assigned Carrier Frequency Based on Specification Requirements of ARINC Char.

APPENDIX 5
(cont'd)



- NOTES:
1. Amplitudes shown provide "Desired" to Undesired" (interference) signal rates of 10dB.
 2. Specific amplitude levels shown for higher frequency channels also apply to the lower frequency channels.
 3. Upper sideband modulation is used in ALL cases.

FIG. 3A - AM CHANNEL SPLITTING TO ACCOMMODATE 3kHz HF/SSB

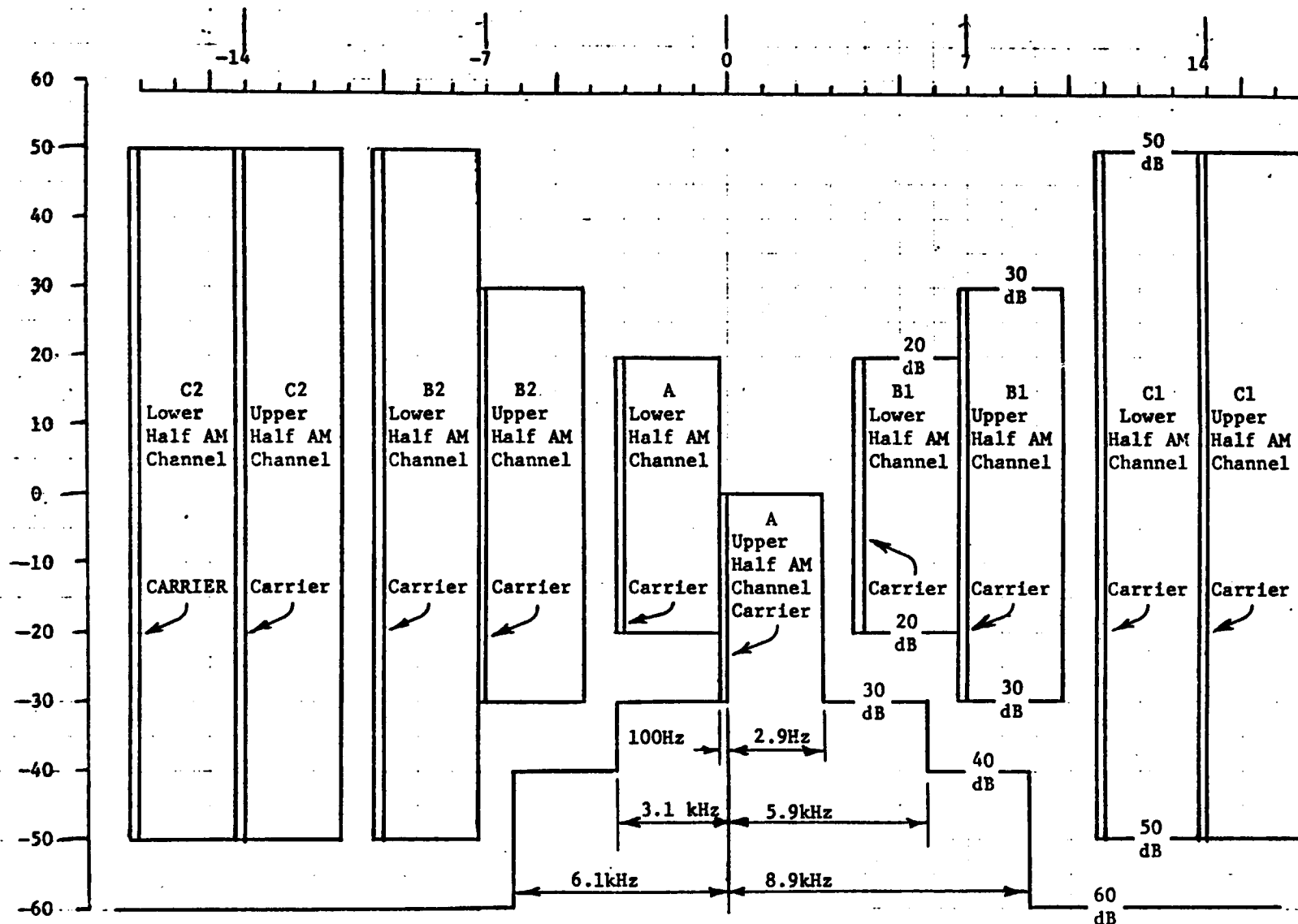


FIGURE 3B - EXTENDED RANGE OF SIGNAL AMPLITUDES ACCOMMODATED
BY ARINC 3KHz HF/SSB TRANSMITTERS

- NOTES:
1. Amplitudes shown provide "Desired" to "Undesired" (interference) signal rates of 10dB.
 2. Specific amplitude levels shown for higher frequency channels also apply to the lower frequency channels.
 3. Upper sideband modulation is used in ALL cases.

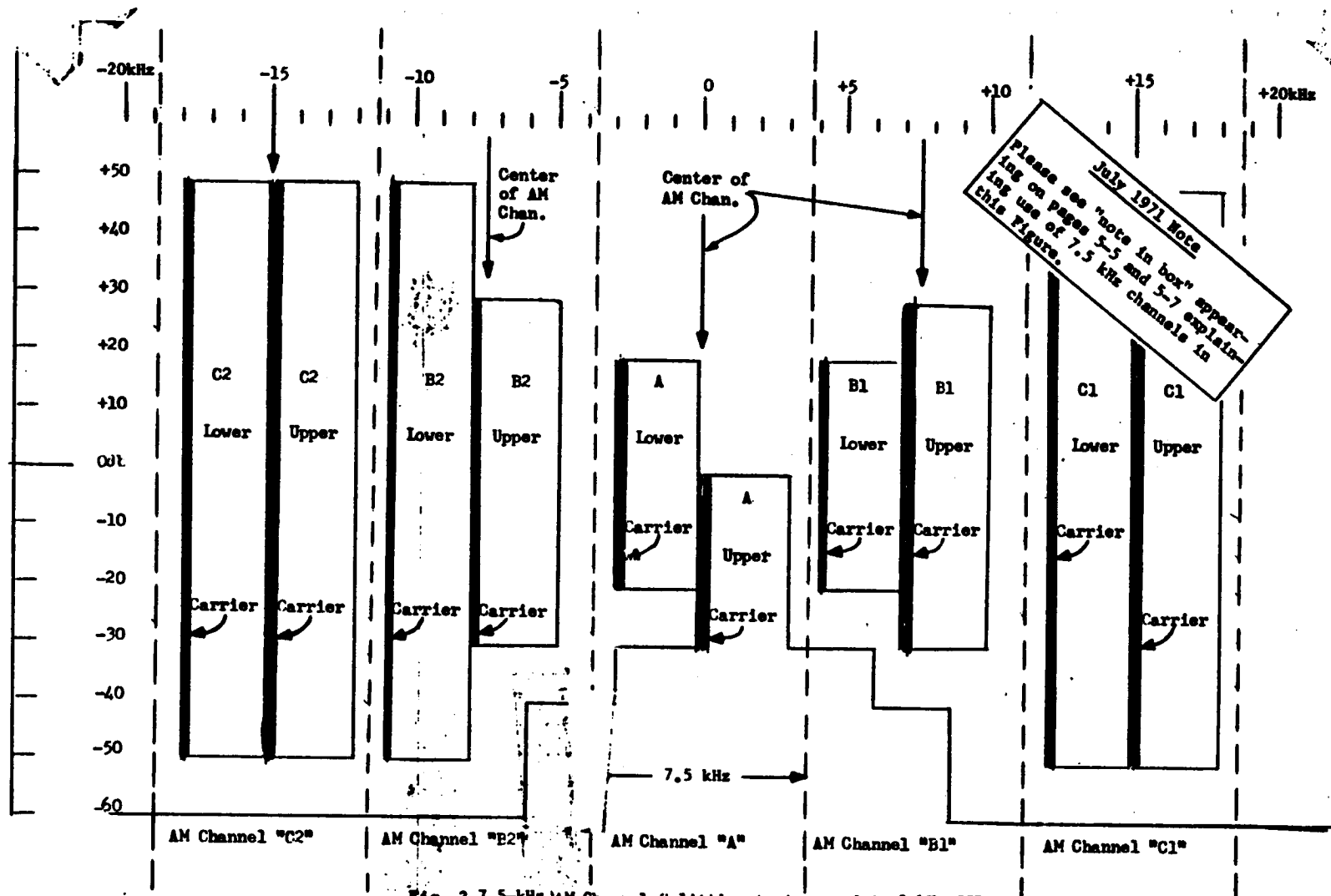


Fig. 3 7.5-kHz AM Channel Splitting to Accommodate 3-kHz SSB Signals Operating with Carriers on Integral Multiples of 1 kHz

NOTE: The carriers of the SSB signals in the upper halves of the AM channels "A" & "C" are positioned on the AM-Channel Assigned Carrier frequencies as these are integral multiples of 1 kHz. The carriers of the SSB signals in the upper halves of the AM Channels "B" are positioned on the next lower integral multiples of 1 kHz below the AM-Channel Assigned Carrier frequencies.

APPENDIX 6

REFERENCE BACKGROUND MATERIAL ON THE EFFECT OF FREQUENCY
TRANSLATION ERROR ON AN SSB SYSTEM CONFORMING WITH THE
SYSTEMS STANDARDS OF APPENDIX 1 AND UTILIZING AIRBORNE
EQUIPMENT CONFORMING TO ARINC CHARACTERISTIC 533 OR 533A

The following material contains important reference material developed under a program of the U. S. Air Force, Rome Air Development Center, relating to the frequency translation error on voice communications, and reported to AEEC during the development of the ARINC Equipment Characteristic No. 533 and circulated in AEEC Letter No. 59-2-12 dated August 31, 1959.

July, 1971 Note:

Although the foregoing assessment of this material was prepared in 1966 for the publication of Characteristic 533A, we believe it is still true in 1971 that no other data is available as authoritative as this Montana University study. CCIR is reported to be studying the question (as every organization likes to make its own analysis of every problem before drawing conclusions); yet the papers that we have seen circulated by CCIR seem to have been based on the same Montana State University study and, in fact, quote the conclusions of the "ARINC Commentary" (page 6-3) and the ARINC Figure Q (page 6-4) as the authority for concluding we can all talk on SSB while flying fast!

The following material has not been changed (kilocycles are prevalent instead of the more fashionable kilohertz) since publication of Characteristic 533A.

July, 1975 Note:

Still no change!

- 6-3 -

APPENDIX 6ARINC COMMENTARY ON FREQUENCY TRANSLATION ERROR

A controversy has raged for many, many years over the effect of translation error on SSB performance. The literature is full of data, and pseudo data, but most researchers were more concerned with qualitative than with quantitative tests. For example, one test that has been widely reported involved the flying of two B-52 aircraft toward each other while communicating together (Yes! they missed!). The communication was "good" and this test was reported by some to "prove" that supersonic flight would not produce intolerable Doppler shift!

It was to answer some of the many questions quantitatively that the U.S.A.F. contracted for tests under controlled conditions to determine the relation between the parameters a) noise, b) signal level, c) intelligibility, --- as well as the effect of bandwidth, practice of the communicators, and many other factors which were believed to bear on the results.

Since the publication of the Montana State University report in 1959, there have been only three basic arguments which still are heard against using the SSB System without AFC at supersonic speeds up to Mach 3:

- 1) "It will produce serious intelligibility problems!"

(mostly by people who have either not heard of, or not studied the Montana University Report --- and which we hope to remedy by making it widely available herewith).

- 2) "The Montana State University tests were conducted with white noise instead of the burst noise which HF circuits encounter and thus, the results show far less intelligibility loss than would actually occur."

(This criticism was levied against the Report in 1959 but, to the best of our knowledge it has neither been proven nor disproven, and thus, we are inclined to discount it).

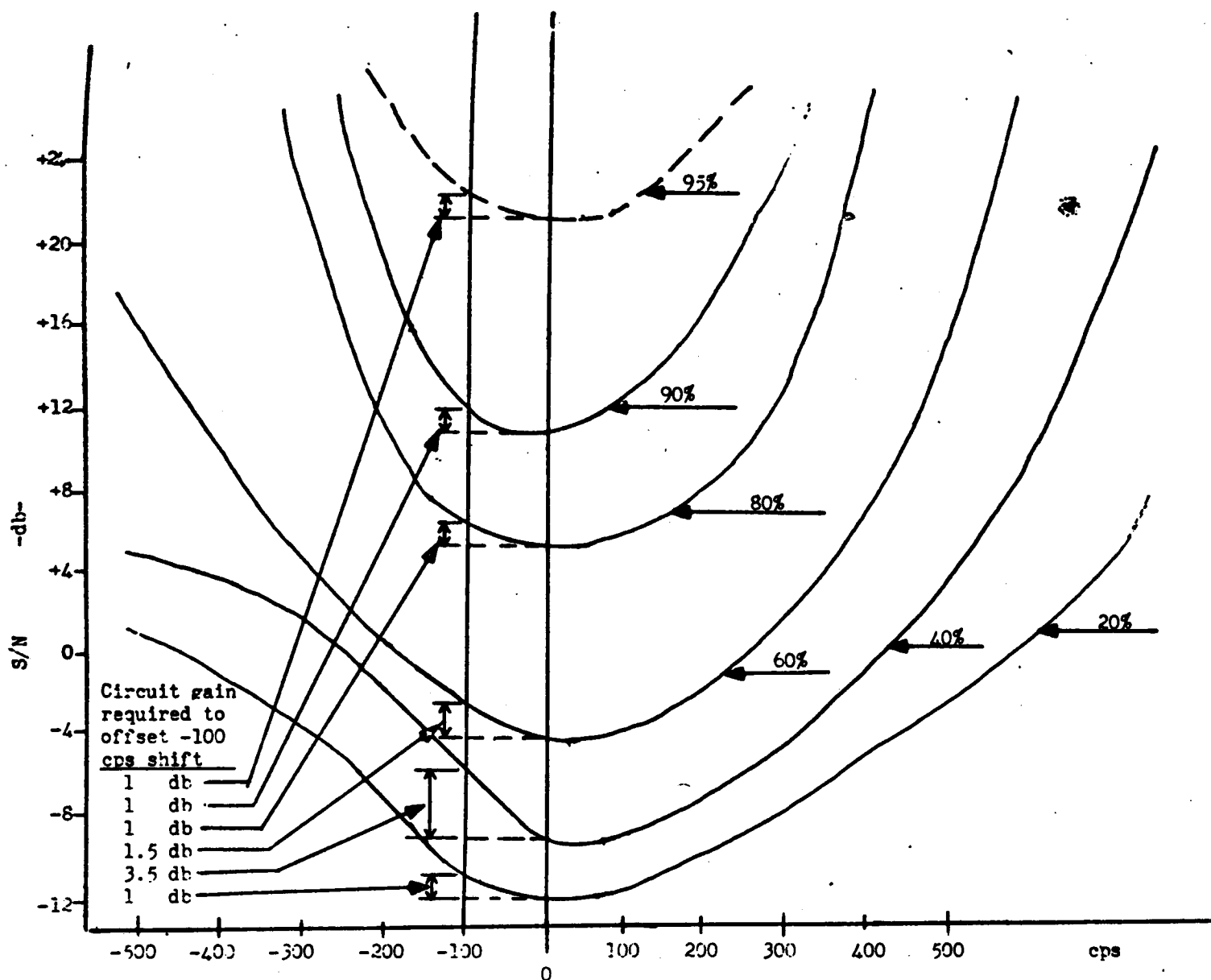
- 3) "The curves given in Figure 33 of the Montana University Report show that a 100 cycle downward shift reduces the intelligibility, and this means translation error is unacceptable."

(This latter point is the most common criticism and we believe it results from a failure of the individual to carefully review all aspects of the Montana University Report.

The reader should remember that Figure 33 "Selected Intelligibility Contours" expresses a relationship between Three Parameters, SNR, frequency error, and intelligibility.

Reference to the "ARINC Figure Q" on a following page illustrates, by additions to the original "Figure 33", the trade-off that is possible between frequency error and signal level, keeping the intelligibility constant. This "ARINC Figure Q" shows that (within the accuracy limitations of the original data) the effect on intelligibility of a 100-cycle downward frequency shift can be completely corrected for by simply increasing the received signal level, necessitating an approximate one-db power increase at the transmitter. For shifts of thirty or fifty cycles, which are more probable, the power increase needed is negligible for good signals and still quite reasonable for poor signal conditions. Frequency shifts of 100 cycles in the upward direction are of no concern whatsoever.

The Report of the Montana State University study for the USAF has served as the basis for SSB System Standards (Appendix 1) and Equipment requirements (Chrs. 533 and 533A), and was the basis on which the Brussels decision (October 1964) by AEEC eliminated all further consideration of any need for Automatic Frequency Control for Mach 3 operation of Suppressed Carrier SSB on voice. (The recent developments by RTCA Special Committees SC-100 and SC-110 served as the justification for eliminating AFC provisions for Data operation).



ARINC FIG. Q - Additions to Original Fig. 33 "Selected Intelligibility Contours"

APPENDIX 6

- 6-4 -

- 6-5 -
APPENDIX 6

The ARINC Extract of this USAF Report deletes the abstract, the table of contents, the list of illustrations, the list of tables, and the list of Appendices which appeared in the original USAF Report on the following pages.

Instead, starting on the next page, is the main body of the report, original pages 1-16, after which the Appendices, I, II, III, and IV are deleted, however, Appendix V is retained in this extract.

**A STUDY OF THE EFFECT OF FREQUENCY
TRANSLATIONAL ERROR ON INTELLIGIBILITY
OF SPEECH IN THE PRESENCE OF NOISE**

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Contract AF 30(602)-1818

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Prepared
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Air Research and Development Command
United States Air Force

Griffiss Air Force Base
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- 6-6 -

APPENDIX 6ERL-MSC ARINC EXTRACT OF USAF-MONTANA STATE COLLEGE REPORTI. INTRODUCTIONTHE PROBLEM

Interest has turned recently to the frequency translational error experienced in single-sideband radio transmission of speech and in radio transmission between high speed jet aircraft or between aircraft and ground. The frequency translational errors thus introduced produce a serious distortion in speech communication which affects in part some of the gain resulting from the use of single-sideband systems. The distortion introduced by frequency translation is an unusual type (of distortion) in that a constant error is added to all component frequencies thus destroying the harmonic relationship between components of a given signal. Previous study of the effect of frequency shift on speech is apparently quite limited. Only two studies were found which bear directly on the problem. Fletcher¹, in 1929, reported an idealized curve of the function showing a differential effect of upward and downward shift upon articulation scores (intelligibility) with losses of less than 10% for shifts of not more than ± 100 cps. The findings were based on nonsense syllables heard without noise. A study recently released by RCA² presents four curves showing variation of intelligibility according to S/N ratio within a frequency shift range of ± 150 cps. These data were based on field conditions and are therefore not directly comparable to other studies either as to signal and noise levels or resultant intelligibility levels.

¹Fletcher, H. Speech and Hearing. New York: Van Nostrand, 1929.

²Radio Corporation of America, Tactical Single-Sideband Transmission Study. Signal Corps Contract: DA-36-039-EC-64683, June, 1956.

- 6-7 -

APPENDIX 6ARINC EXTRACT OF USAF-MONTANA STATE COLLEGE REPORT

ERL-MSC

2

Data are needed to show the detailed relationship between intelligibility and frequency translational error of speech in the presence of noise in order to suggest operational limits where frequency shift is introduced and likewise to explore the effect of selective filtering upon frequency-shifted speech.

II. DISCUSSION

THE STUDY

The purpose of the present study is to explore the effect of frequency translational error upon the intelligibility of speech in the presence of noise. A second part of the study is to explore the effect of selective filtering upon the intelligibility of frequency-shifted speech heard in noise.

EQUIPMENT.

The equipment design employed in the study is shown in Figures 1 through 5 (Appendix I.). A detailed description of the equipment design and test facility are to be found in the Report submitted July 13, 1958, to Rome Air Development Center, Contract AF 30(602)-1818, by Leslie E. McCoy entitled "Articulation Testing Facility at Montana State College".

EXPERIMENTAL DESIGN.

PART I.

Eight subjects with normal hearing were given articulation tests for each of the combinations of frequency shift and S/N ratios shown in Figure 6 (Appendix II.). All subjects received at least 5 hours of training under representative test conditions prior to the beginning of the experiment. The 103 test conditions shown in Figure 6 were presented by means of tape-recording a series of W-22 tests, one for each of the frequency shifts to be used. S/N ratios were varied according to demand

- 6-8 -

APPENDIX 6ARINC EXTRACT OF USAF-MONTANA STATE COLLEGE REPORT

ERL-MS

3

by means of attenuators. The 103 test conditions were then presented in a random order. A replication of the experiment was carried out with a new recording of W-22 tests and frequency shifts and a second randomization of the order of presentation of the 103 test conditions. This procedure afforded 16 test scores for each test condition and made reasonable provision for the effects of order of presentation, possible variation in W-22 lists, and practice.

Subjects. All subjects were of college age, either students, or student wives and included 3 men and 5 women. Selection was made following two practice periods of 2½ hours each during which the subject showed acceptable ability to "hear" the test material under a wide range of test conditions. Subjects were paid on an hourly basis for their work.

Test Materials. The Central Institute for the Deaf (C.I.D.) W-22 word lists³ were used for test material. These tests were adapted from the phonetically-balanced word lists (PAL-PB) developed by the Psycho-Acoustic Laboratory, Harvard University during World War II. The items of this test are 200 one-syllable words, divided into four lists of 50 words each. The words are heard often and are familiar words. Each of the four 50-word lists has been "phonetically-balanced". There are six different word orders for each of the four lists making 24 tests in all. A 1000-cycle calibration tone at the average level of the carrier phrases is recorded on each record to permit easy

³Hirsh, I.J., et al. Development of materials for speech audiometry. Journal of Speech and Hearing Disorders, 1952, Vol. 17, No. 3, 328-337. Central Institute for the Deaf, (St. Louis, Mo.) Auditory test W-22: Phonetic-Balanced Word Lists. (ONR-Contract N6onr-272, Project No. NR 142-170, Task Order III).

- 6-9 -

APPENDIX 6ARINC EXTRACT OF USAF-MONTANA STATE COLLEGE REPORT

ERL-MSC

4

calibration of speech level. Intelligibility scores represent the percentage heard correctly, obtained by counting up the number of words correct and multiplying by two.

All speech materials (W-22 tests) were passed through a 0.3-5 kc band-pass filter as re-recorded from disk to tape. Random thermal noise was passed through the same band-pass filter and mixed with the filtered speech at the levels required by each test condition. In each case noise was fed to the earphone at 80 db (re 1 microbar) while the speech signal was attenuated as necessary to produce the required S/N ratio.⁴

Test Conditions. The 103 test conditions shown in Figure 6 (Appendix II.) were selected on the basis of extensive preliminary trials on two subjects and data obtained from eight subjects during preliminary practice sessions. In these early trials an attempt was made to estimate the range of conditions (combinations of frequency shift and S/N ratio) which would produce intelligibility scores ranging between 20% and 95%.

Recording Details. Twelve W-22 tests assigned serially (2d, 1d, 4c, 3c, 2c, ...) were recorded one at each of the desired frequency shifts (-500, -400, ..., +400, +500, +750) with a 1000-cycle calibration

⁴Attention is called to the fact that all noise readings were made on a VTVM which indicated the average value of the noise signal. The meter is calibrated to indicate the rms value of a sine wave. Noise measurements should be increased by 1 db to give the true rms value. Speech levels are based on readings made on the recorded 1000 cps sine wave reference tone and no correction is required. (See footnote 3, page 3, for further discussions on speech level data.)

- 6-10 -

APPENDIX 6ARINC EXTRACT OF USAF-MONTANA STATE COLLEGE REPORT

ERL-MS

5

tone at the beginning of the tape.⁵ By this method of recording, the 103 test conditions could be readily presented by playing any of the 12 frequency-shifted tests and varying the S/N ratio by attenuator.

Order of Presentation. The 103 test conditions were then presented to the subjects in a random order.⁶ Six sessions of 2½ hours each were required.

Replication. To increase the stability of the intelligibility score estimate for each test condition and to make allowance for practice effect a replication of the experiment was made. After assigning a different series of W-22 tests to the 12 frequency shifts a second tape was cut. The 103 test conditions were then given a new random order and presented in the same manner as before.

Data Presentation and Analysis. The complete raw score data by test condition and by subject are presented (Appendix III). Means and standard deviations of test score distributions are presented in Figures 7 through 17 (Appendix V). Smoothed curves for mean values and ± 1 standard deviation were drawn to estimate each function under study and the range of intelligibility to be expected for 68% of

⁵While this has the disadvantage of employing the same W-22 test for each of the S/N ratios for a given frequency shift it was much easier to administer. On the basis of the data on the development of the W-22 tests it was assumed that this procedure would not influence the results as the 24 variations of the W-22 tests were all equated.

⁶An exception to the random order of presentation of test conditions occurred in the presentation of "no-noise" conditions. The latter were inadvertently omitted from the original test plan but the 10 "no-noise" conditions were later assigned a random order and inserted between the 50th and 51st test presentation and following each fourth presentation thereafter. In the replication which followed, the "no-noise" conditions were incorporated within the random order set up for all 103 conditions.

- 6-11 -

APPENDIX 6ARINC EXTRACT OF USAF-MONTANA STATE COLLEGE REPORT

ERL-MSC

6

measures taken. Data for each frequency shift and for each S/N ratio were grouped for study and plotted. Several "intelligibility contours" were then drawn against the intelligibility scores as indicated for each of the 103 test conditions shown in Figure 6 (Appendix II.). Points for each of the intelligibility levels (20%, 40%, 60%, 80%, 90%) were interpolated along the ordinates for each of the frequency shifts and a smoothed curve sketched to suggest the probable contour.

To establish the significance of differences to be observed between the curves presented in Figures 7 through 17 an analysis of variance was made of the distribution of data common to the curves for $S/N = 0, 4, 8, 12$, and 16 (See Table 4, Appendix IV). The analysis yielded an F value of 6.58 which was significant at the $P = .01$ level.

Since significance of difference was established by the analysis of variance described above, a series of "t"-tests was made on the differences between mean scores for four sets of adjacent curves ($S/N = 20$ and $S/N = 16$; $S/N = 16$ and $S/N = 12$; $S/N = 12$ and $S/N = 8$; $S/N = 8$ and $S/N = 4$) Table 5, Appendix IV contains the data of differences and the resultant "t" values. Significance levels for the four comparisons ranged as follows: $P < .05 > .02$, $P < .001$, $P < .01$, $P < .001$. These sample tests were considered representative of the differences to be observed among the data and no further tests were attempted.

Only a limited attempt was made to examine the data further with regard to individual subject differences, mean gains (practice effect) from replication, and score variance as compared to selected intelligibility levels. The latter analysis was not considered of prime importance to the present study and is therefore not reported.

- 6-12 -

APPENDIX 6ARINC EXTRACT OF USAF-MONTANA STATE COLLEGE REPORT

ERL-MSC

7

Interpretation. The functions as revealed by the smoothed curves of Figures 7 through 17 appear to be consistent with expectation as based on the earlier work of Fletcher⁷ and on the four curves contained in the RCA report.⁸ The curves for S/N = 0 and S/N = +4 reasonably approximate that of Fletcher in his 1929 report with maximum intelligibility ranging from 70% - 80%. However, the Fletcher maximum intelligibility levels are inconsistent with other published studies. Had his system and method been optimum in terms of studies made in later years (Hudgins, et.al., 1947),⁹ (Miller, 1947),¹⁰ (Miller and Licklider, 1950),¹¹ and (French and Steinberg, 1947),¹² his maximum articulation scores should have approached the 95% - 98% range for non-frequency-shifted speech. Apparently the lower levels of intelligibility yielded in Fletcher's original study were a function of the equipment used or the nature of his test materials (nonsense syllables).

Similarly it should be noted that the data of the present study confirm and extend those of the RCA study though intelligibility levels of the present study tend to run from 6 - 20 db above those reported in the RCA study. As inferred above, although the intelligibility levels of the present study run higher than either the Fletcher or RCA levels,

⁷Loc. cit. (See p. 1, footnote 1).

⁸Loc. cit. (See p. 1., footnote 2).

⁹Hudgins, C.V., J.E. Hawkins, J.E. Karlin, and S.S. Stevens. The development of recorded auditory tests for measuring hearing loss for speech. Laryngoscope, 1947, 57, 57-89.

¹⁰Miller, G.A. The masking of speech. Psychol. Bull., 1947, 44, 105-129.

¹¹Miller, G.A., and J.C.R. Licklider. The intelligibility of interrupted speech. J. Acoust. Soc. Amer., 1950, 22, 167-173.

¹²French, N.R., and J.C. Steinberg. Factors governing the intelligibility of speech sounds. J. Acoust. Soc. Amer., 1947, 19, 90-119.

- 6-13 -

APPENDIX 6ARINC EXTRACT OF USAF-MONTANA STATE COLLEGE REPORT

ERL-MSC

8

they are consistent with various other studies cited above. For example, the work of French and Steinberg¹³ is illustrative of studies during and following the war which show consistently that non-frequency-shifted speech when presented under otherwise optimum conditions of filtering, equipment specification, and S/N ratio will yield intelligibility levels of 95% and upward. Apparently the lower intelligibility levels yielded in both the Fletcher and RCA studies were a function of the equipment or test materials employed. The Fletcher study was performed some 30 years ago on equipment long since superseded and with specially prepared test materials not well described in the report. Speech and noise levels specified in the RCA study were based on field-recorded material and were arrived at by an unusual and atypical method of estimate. Therefore, such inconsistencies as observed between present data and the two most closely related studies are to be expected.

Upon examination of the standard deviations of the score distributions it is interesting to see the expected widening of "error" among individuals as intelligibility deteriorates and to see the decrease of "error" under optimum conditions.

The non-symmetrical nature of the curves when one compares upward and downward frequency shift, particularly in the mid-range of S/N ratios could probably have been anticipated in terms of the concept of "pitch-distance". For example, an octave upward from a given reference tone represents twice the frequency of the octave downward, yet the "pitch-distance" is still an octave. From this fact one would anticipate that when the function of intelligibility of frequency-shifted speech in the presence of noise is plotted with frequency shift indicated on a

¹³Loc. cit. (See p. 7, footnote 12).

- 6-14 -

APPENDIX 6ARINC EXTRACT OF USAF-MONTANA STATE COLLEGE REPORT

ERL-MSC

9

linear scale, the curve for the downward shift would have a much sharper deflection than for upward shift, perhaps twice the rate of change.

The "intelligibility contour" estimates, while admittedly only approximations, do yield useful estimates of tolerance of both frequency shift and S/N ratio for communication tasks requiring certain minimum levels of intelligibility. For example, a communication net requiring a minimum of 60% intelligibility (based on monosyllabic words such as used in the W-22's) could, for example, describe its tolerance limits from -200 to +300 frequency-shift with S/N ratios of 0 or more. Or similarly, one could state that frequency errors of ± 400 would demand S/N ratios of +8 or more. If S/N ratios were +12 or better frequency shifts of ± 500 would be satisfactory.

Lastly the raw data deserve some comment. Unusual variations between subjects and among performances of the same subject are to be noted. Marked individual differences and individual variance are evident.

It should be mentioned again that these subjects were not highly trained for this skill and could, in fact, be classed as "naive" subjects relative to this skill. Practice sessions were in most cases limited to two 2½-hour sessions, admittedly not enough to negate practice effect.

Part of the variations can be attributed to weaknesses in the W-22 test materials. The original records are not well recorded, the tests are tedious and time consuming, and motivation is difficult to maintain at best. When intelligibility levels are low it is readily possible for "blocks" to be set up or for a listener to lose his "act" to hear.

- 6-15 -

APPENDIX 6ARINC EXTRACT OF USAF-MONTANA STATE COLLEGE REPORT

ERL-MSC

10

These and other factors can account for the marked variations to be observed.

However, in spite of the marked individual variance the data of means show quite sharp contrasts from condition to condition. Had these contrasts not emerged it would have necessitated rejection of the data of individuals showing too marked variance in repeated performance or in comparisons to the rest of the group. All of this suggests that we may have even firmer confidence in the smoothed curves which have been drawn to indicate the functions under test.

PART II.

The application of selective filtering to frequency-shifted speech in the presence of noise is designed to explore the influence upon intelligibility of band-passing both the noise and the signal. Since little is to be gained from varying bandwidth when intelligibility is already high, sample conditions to be explored in Part II were chosen from among test conditions which in Part I of this study yielded intelligibility scores ranging from 75% downward to 35-30%, e.g. in the mid and lower range of intelligibility.

Nine subjects were given articulation tests for each of four frequency shifts, four S/N ratios, and four band-pass filter conditions making 64 test conditions in all. The 64 test conditions were presented in random order each with a different W-22 word list which was assigned in serial order prior to randomizing. A replication of the experiment was carried out by re-recording the speech materials with another serial order of W-22 word lists and presenting the test conditions in reverse order to that of the first presentation. This

- 6-16 -

APPENDIX 6ARINC EXTRACT OF USAF-MONTANA STATE COLLEGE REPORT

ERL-MSO

11

afforded 18 test scores for each test condition and made allowance for the effects of order of presentation, possible variation of W-22 word lists, and practice.

Subjects. The subjects were chosen as in Part I on the basis of performance in a two-session practice period. The subjects included 3 men and 6 women all but two of which were of college age. The two exceptions were upper-class high school students both of whom are radio "hams". Only three of the 9 subjects were subjects in Part I.

Test Materials. (See Part I above)

Test Conditions. The combinations of frequency shift and S/N ratio were selected from the data of intelligibility contours of Part I, Figure 33, (Appendix V.). Four representative frequency shifts were selected (-400, -200, +300, +500) and four S/N ratios were chosen for each frequency shift to cover an intelligibility range from approximately 75% downward to 25%. (See Figure 33, Appendix V.)

Each of these 16 combinations was presented under four different filter conditions (0.3-3 kc, 0.3-5 kc, 0.5-3 kc, and 0.5-5 kc). These conditions were chosen to represent normal band-pass operational procedure (0.3-3 kc), the same as was employed in Part I of the study, and three other combinations which either reduced the lower portion of the spectrum by 0.2 kc or extended the upper portion by 2 kc, thus permitting comparisons of the influence of these portions of the spectrum on frequency-shifted speech.

Recording Detail. Sixteen different W-22 tests, one for each of the combinations of frequency shift and filter factor, were recorded on a single tape with a 1000-cycle calibration tone. Care was taken that no word list or word order was repeated for any of the 16 conditions.

- 6-17 -

APPENDIX 6ARINC EXTRACT OF USAF-MONTANA STATE COLLEGE REPORT

ERL-MSc

12

S/N ratio was altered by attenuator as each test condition was presented in its random sequence. The thermal noise was given the appropriate band-pass filtering to conform to the recorded test condition in the final presentation. Table 1, (Appendix II), shows the test combinations and W-22 word lists as assigned for the first presentation as well as the replication which followed.

Order of Presentation. The 64 test conditions were assigned a random order and presented to the subjects in three 2½ hour sessions.

Replication. As in Part I the experiment was replicated by preparing a new tape using the same frequency shifts but a new serial order of W-22 tests (See Table 1, Column II, Appendix II). The 64 conditions were then presented in reverse order to that used in the first presentation thus making an appropriate allowance for practice effect when averaged with the scores of the first presentation.

Data Presentation and Analysis. Raw score data and means are presented by test condition (Appendix III). Means of test score distributions for each test condition are presented in Figures 34 - 37, (Appendix V). Smoothed curves for mean values are presented to show comparative effects of filtering upon intelligibility for each of the four frequency shifts.

No further analysis of the data was attempted since the data of Part II were gathered primarily to offer suggestive clues concerning the effects of filter factors on frequency shifted speech.

Interpretations. A series of comparisons of the intelligibility curves yielded by the four band-pass filters yield the following possibilities:

- 6-18 -

APPENDIX 6ARINC EXTRACT OF USAF-MONTANA STATE COLLEGE REPORT

ERL-MS C

13

The commonly used 0.3-3 kc band-pass filter affords consistently higher intelligibility scores than any of the others used in this study for frequency-shifted speech in the presence of noise. Intelligibility levels were up to 10% better at the more favorable S/N ratios and as much as 40% better when S/N ratios were marginal.

Limiting the lower edge of the "speech spectrum",¹⁴ (using 0.5 kc high-pass filter), consistently reduces intelligibility. If, as the data suggest, 0.3-3 kc is an optimum band-pass then comparisons of the several filter variations against the 0.3-3 kc band-pass can be useful. Use of the 0.5 kc high-pass consistently reduced intelligibility whether one compares 0.5-3 kc with 0.3-3 kc or both 0.5 kc high-pass systems with both 0.3 kc high-pass systems.

Similarly, extending the upper edge of the "speech spectrum" (using the 5 kc low-pass filter) reduces intelligibility in all cases whether one compares 0.3-5 kc with 0.3-3 kc or both 5 kc low-pass systems with both 3 kc low-pass systems.

The combination of the two above conditions, limiting the lower edge of the "speech spectrum" (using 0.5 kc high-pass) and extending the upper edge (using 5 kc low-pass) consistently yielded the lowest intelligibility of the four filter combinations under comparison.

Extending the upper edge of the spectrum to 5 kc appears to be more deleterious to speech than limiting the lower edge to 0.5 kc only where speech is frequency-shifted downward 400 cps. At all other shifts there

¹⁴See discussions in Miller, G.A., Loc. cit. (See p. 7, footnote 10). 0.3-3 kc contains roughly 90% of all speech information.

- 6-19 -

APPENDIX 6ARINC EXTRACT OF USAF-MONTANA STATE COLLEGE REPORT

ERL-MSC

14

is little or no difference between these two variations of the spectrum.

Conversely on speech frequency-shifted downward 400 cps, limiting the spectrum at the lower end with an 0.5 kc high-pass appears to reduce intelligibility less than does the upward extension of the spectrum to 5 kc.

None of the above interpretations can be made firm from these data. They are offered only as clues to the use of filters in communication nets subject to frequency translational error and are suggestive for further study.

III. CONCLUSIONS

PART I.

Frequency-shifting of speech in the presence of noise produces marked deterioration of intelligibility dependent upon direction and extent of the frequency shift.

Downward frequency shifts produce greater deterioration in intelligibility than do upward shifts.

As listening conditions deteriorate the tolerable amount of frequency-shifting is reduced.

For optimum listening conditions (S/N ratio = 16 or more) frequency-shifting upward 400 cps or downward 300 cps appear tolerable for most communication requirements (intelligibility levels of 85% or more).

For average listening conditions (S/N ratio = 0 to 8) frequency shifts of +200 or -100 appear to be the tolerable maxima for normal communication requirements (intelligibility levels of 70% or more).

For poor listening conditions (S/N ratio = 0 or less) shifts of more than 100 cps are unsatisfactory for normal communication (intelligibility levels < 60%).

- 6-20 -

APPENDIX 6ARINC EXTRACT OF USAF-MONTANA STATE COLLEGE REPORT

ERL-MSC

15

PART II.

The 0.3-3 kc band-pass filter appears optimum for frequency-shifted speech.

Removing the lower portion of the 0.3-3 kc spectrum by means of a 0.5 kc hi-pass filter reduces intelligibility of frequency-shifted speech.

Extending the 0.3-3 kc spectrum by use of a 5 kc low-pass filter reduces intelligibility of frequency-shifted speech.

Both removing the lower portion of the 0.3-3 kc spectrum and extending it upward to 5 kc produces the maximum deterioration in intelligibility of the filter conditions under study.

ERL-MSC

16

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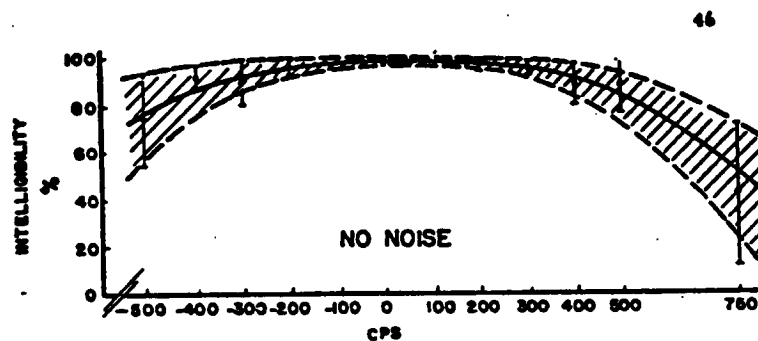


FIG.7- INTELLIGIBILITY OF FREQUENCY-SHIFTED SPEECH: NO NOISE

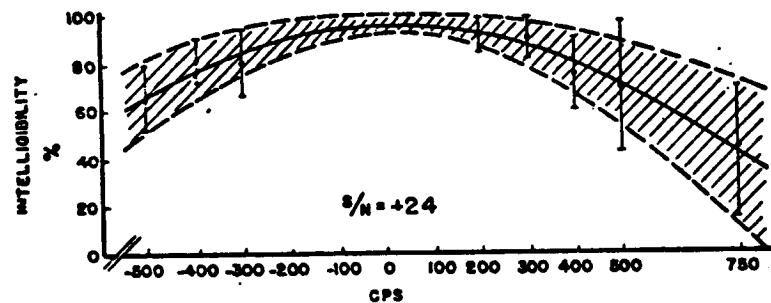


FIG.8- INTELLIGIBILITY OF FREQUENCY-SHIFTED SPEECH: $S/N = 24$

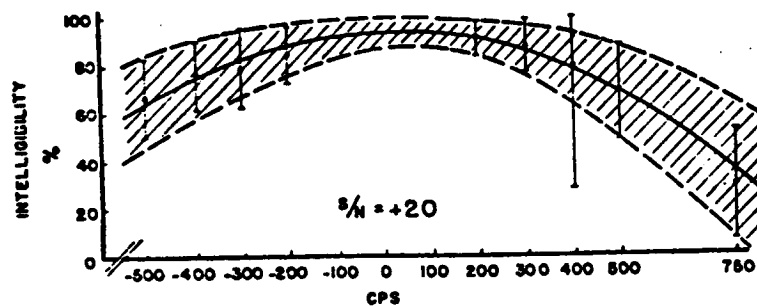


FIG.9- INTELLIGIBILITY OF FREQUENCY-SHIFTED SPEECH: $S/N = 20$

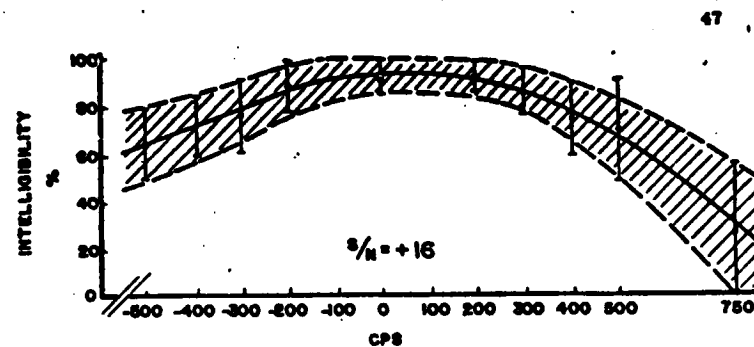


FIG.10- INTELLIGIBILITY OF FREQUENCY-SHIFTED SPEECH: $S/N = 16$

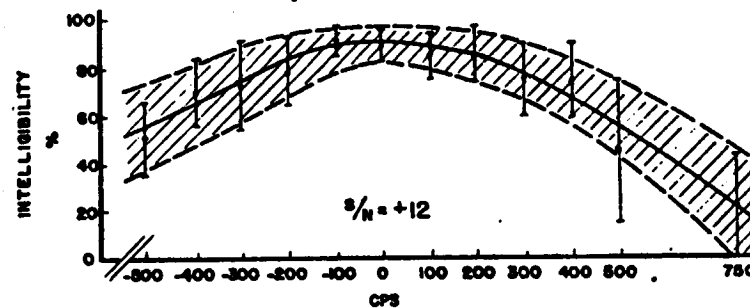


FIG.11- INTELLIGIBILITY OF FREQUENCY-SHIFTED SPEECH: $S/N = 12$

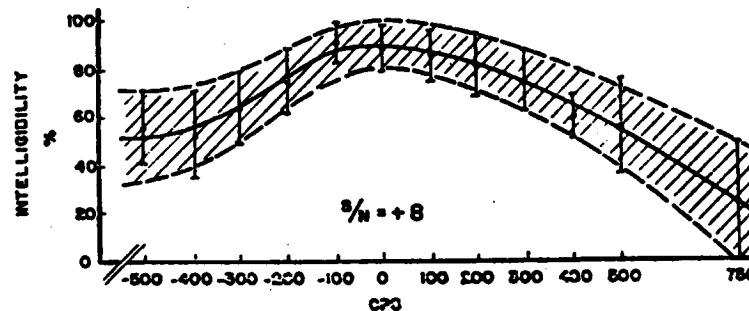


FIG.12- INTELLIGIBILITY OF FREQUENCY-SHIFTED SPEECH: $S/N = 8$

- 6-21 -
 APPENDIX 6
 AIRINC EXTRACT OF USAF AIRCRAFT STATE COLLECT REPORT

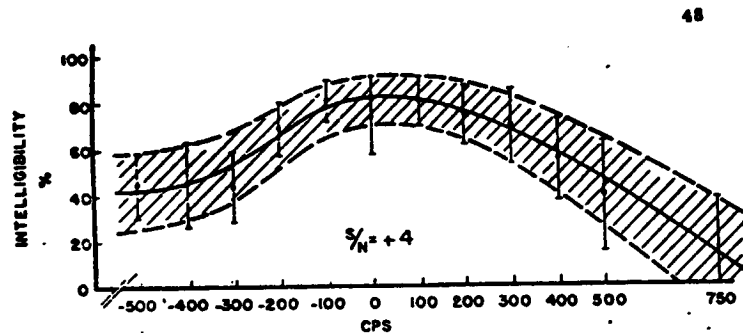


FIG.13- INTELLIGIBILITY OF FREQUENCY-SHIFTED SPEECH: $S/N = +4$

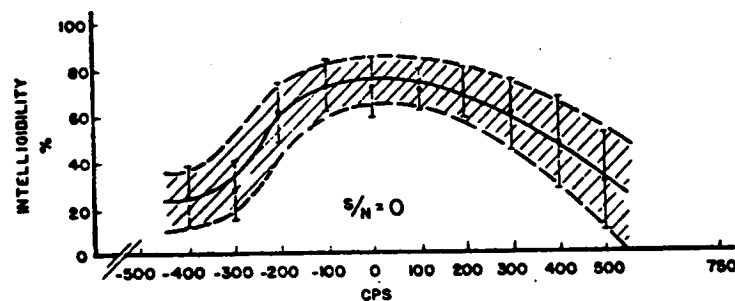


FIG.14- INTELLIGIBILITY OF FREQUENCY-SHIFTED SPEECH: $S/N = 0$

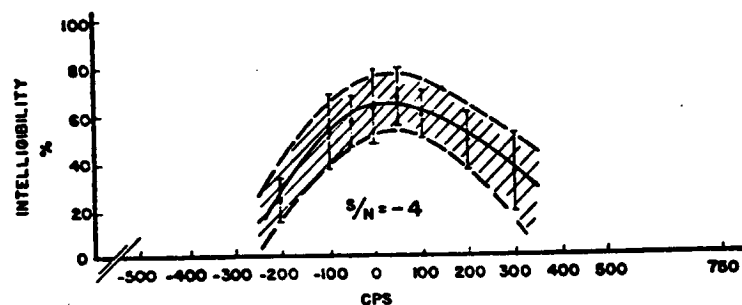


FIG.15- INTELLIGIBILITY OF FREQUENCY-SHIFTED SPEECH: $S/N = -4$

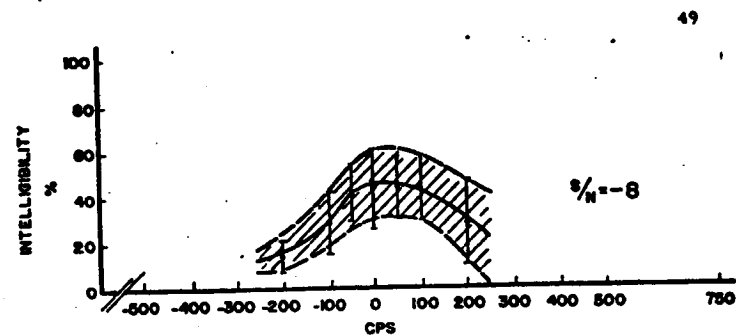


FIG.16- INTELLIGIBILITY OF FREQUENCY-SHIFTED SPEECH: $S/N = -8$

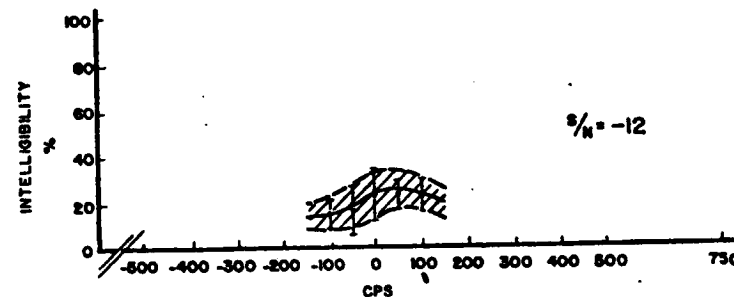


FIG.17- INTELLIGIBILITY OF FREQUENCY-SHIFTED SPEECH: $S/N = -12$

ARINC EXTRACT OF USAF WRIGHT STATE COLLEGE REPORT
 APRIL 64
 - 6-22 -

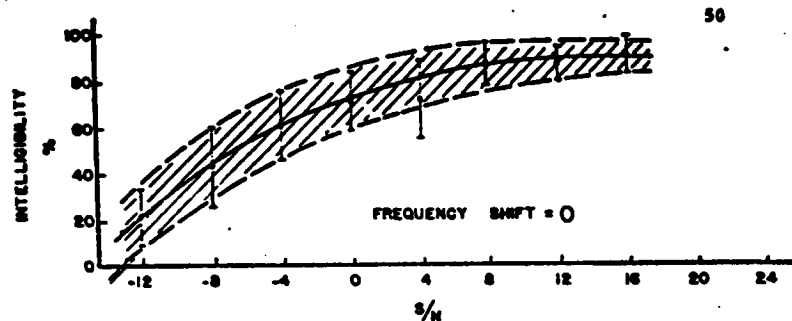


FIG. 18 - INTELLIGIBILITY OF SPEECH IN NOISE: FREQUENCY SHIFT = 0

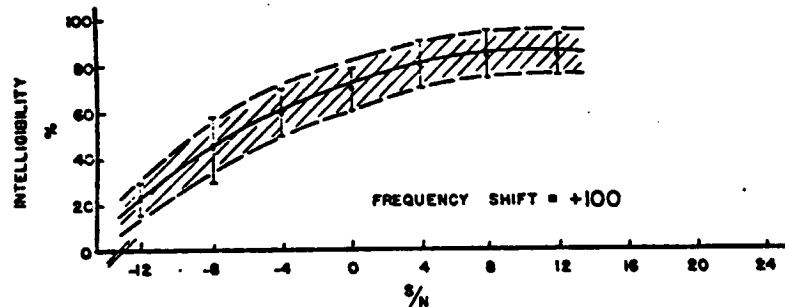


FIG. 19 - INTELLIGIBILITY OF SPEECH IN NOISE: FREQUENCY SHIFT = 100

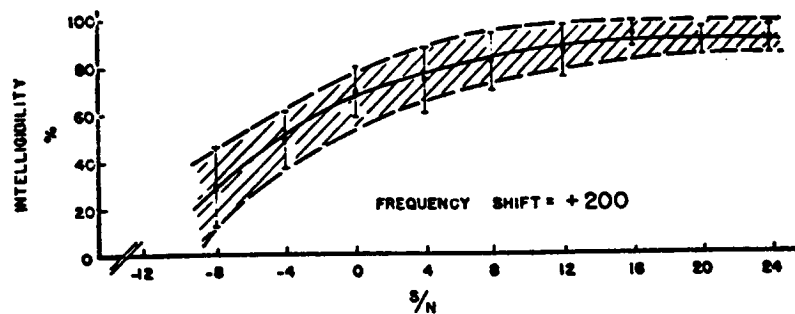


FIG. 20 - INTELLIGIBILITY OF SPEECH IN NOISE: FREQUENCY SHIFT = 200

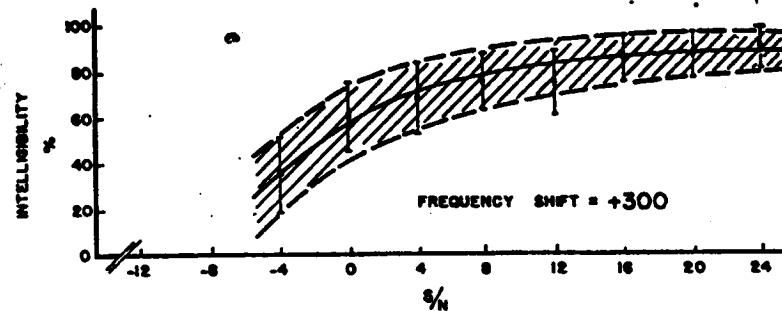


FIG. 21 - INTELLIGIBILITY OF SPEECH IN NOISE: FREQUENCY SHIFT = 300

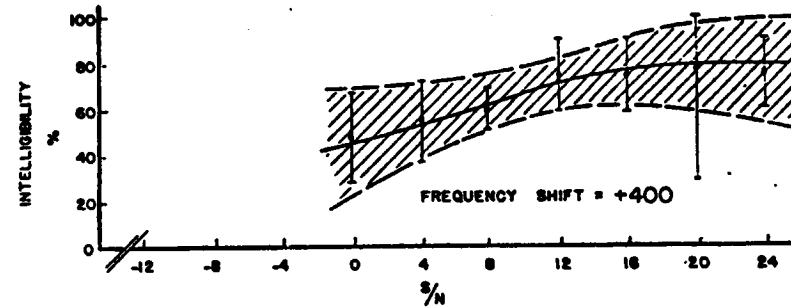


FIG. 22 - INTELLIGIBILITY OF SPEECH IN NOISE: FREQUENCY SHIFT = 400

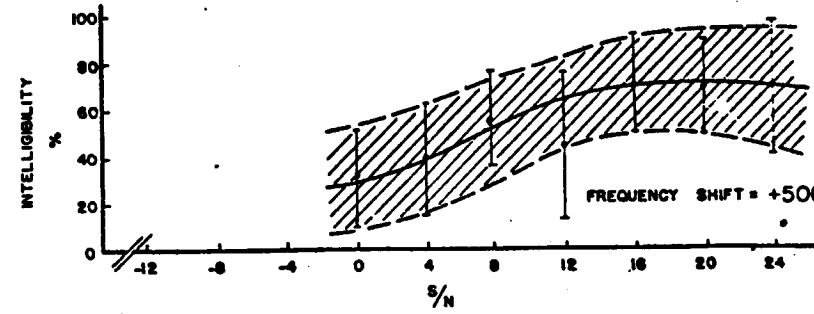


FIG. 23 - INTELLIGIBILITY OF SPEECH IN NOISE: FREQUENCY SHIFT = 500

-6-23-
 APPENDIX 6
 AIRINC EXTRACT OF USAF AIRCRAFT STATE COLLEGE REPORT

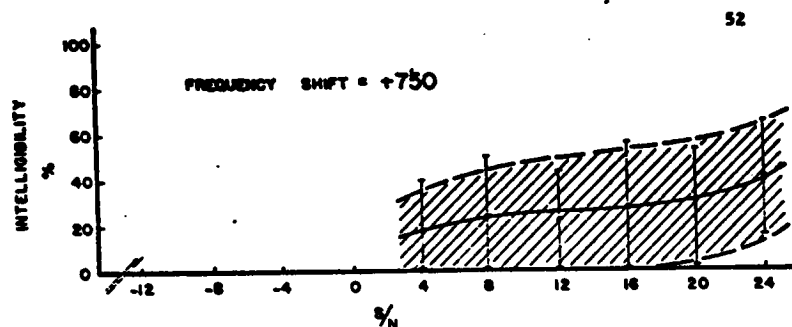


FIG. 24 - INTELLIGIBILITY OF SPEECH IN NOISE - FREQUENCY SHIFT = 750

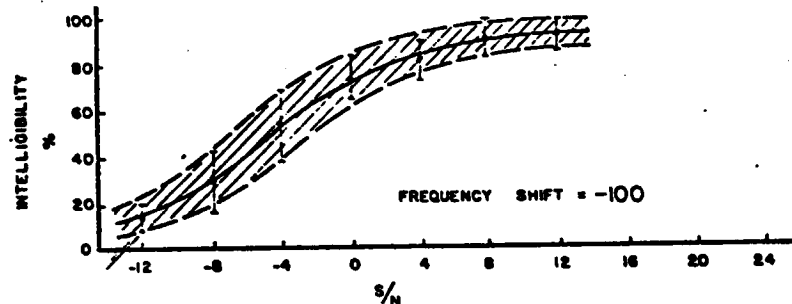


FIG. 25 - INTELLIGIBILITY OF SPEECH IN NOISE - FREQUENCY SHIFT = -100

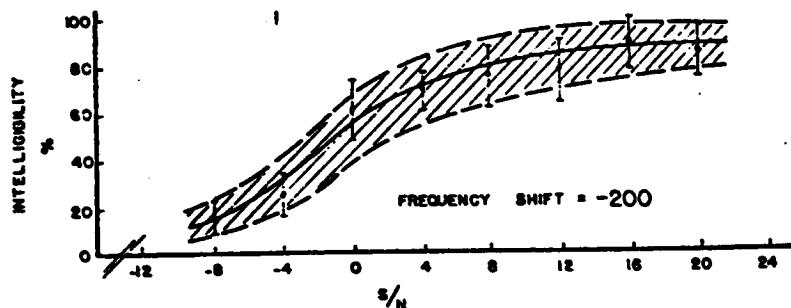


FIG. 26 - INTELLIGIBILITY OF SPEECH IN NOISE - FREQUENCY SHIFT = -200

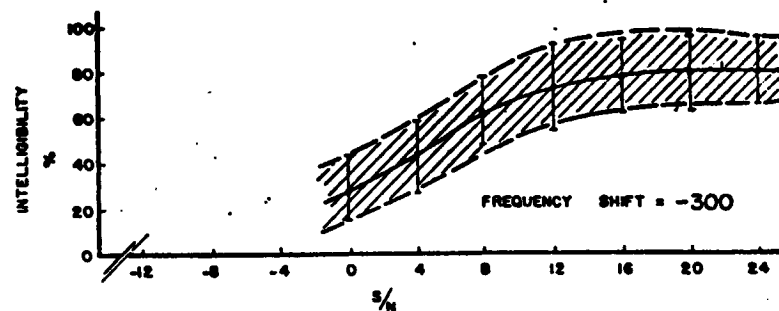


FIG. 27 - INTELLIGIBILITY OF SPEECH IN NOISE - FREQUENCY SHIFT = -300

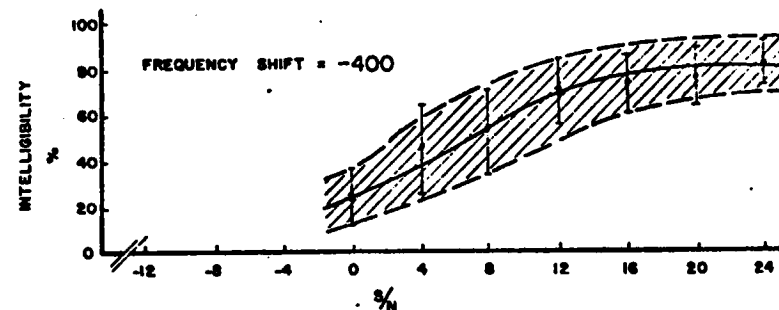


FIG. 28 - INTELLIGIBILITY OF SPEECH IN NOISE - FREQUENCY SHIFT = -400

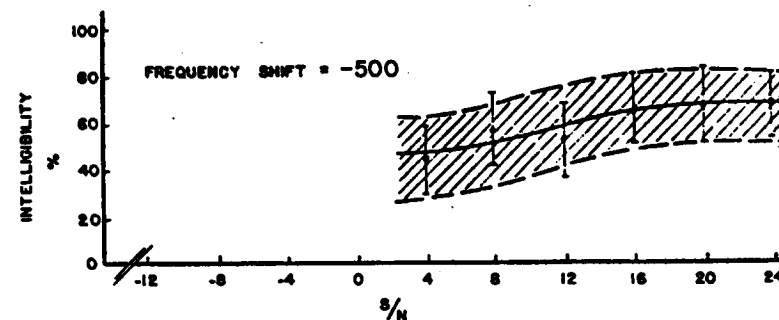


FIG. 29 - INTELLIGIBILITY OF SPEECH IN NOISE - FREQUENCY SHIFT = -500

ARINC EFFECT OF NOISE ON STATE COLLEGE REPORT
 APPENDIX C
 - (C-24) -

- 6-25 -

APPENDIX 6

ARINC EXTRACT OF USAF-MONTANA STATE COLLEGE REPORT

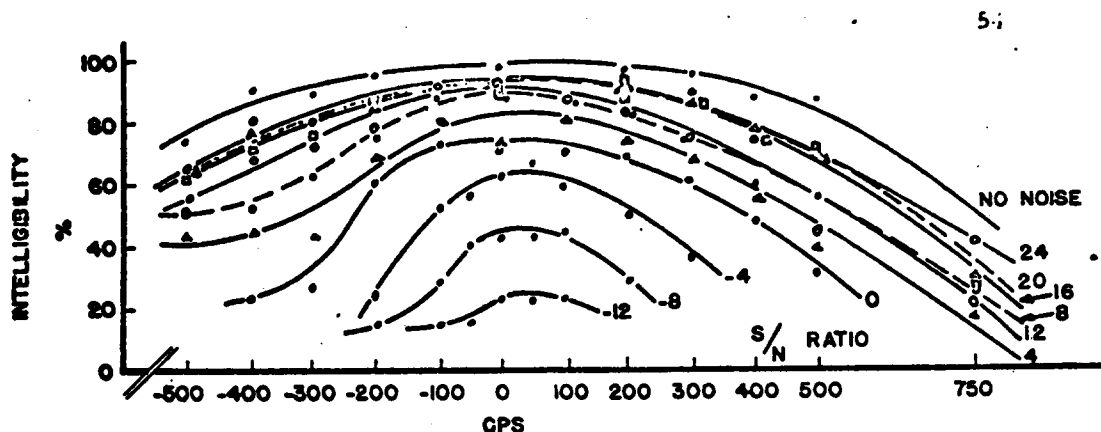


FIG.30- INTELLIBILITY OF FREQUENCY-SHIFTED SPEECH (FIGURES 7-17).

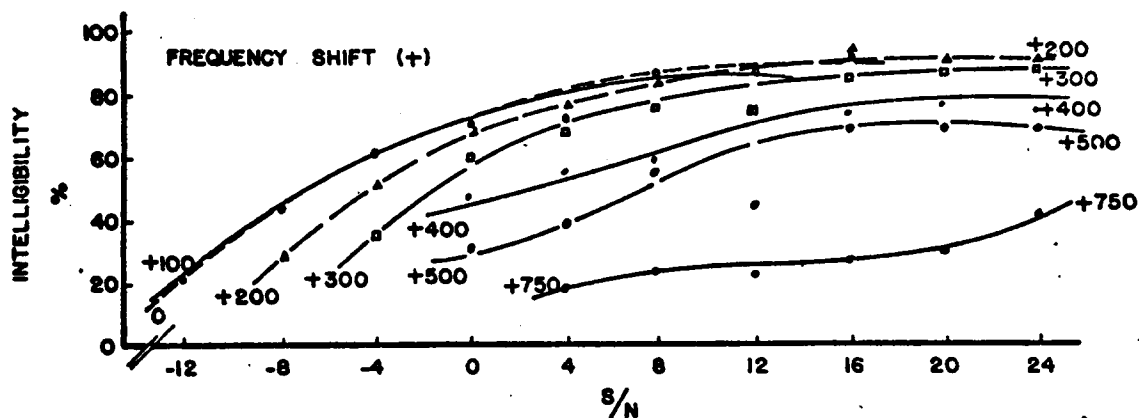


FIG.31- INTELLIBILITY CURVES OF FREQUENCY-SHIFTED SPEECH (FIGURES 18-24).

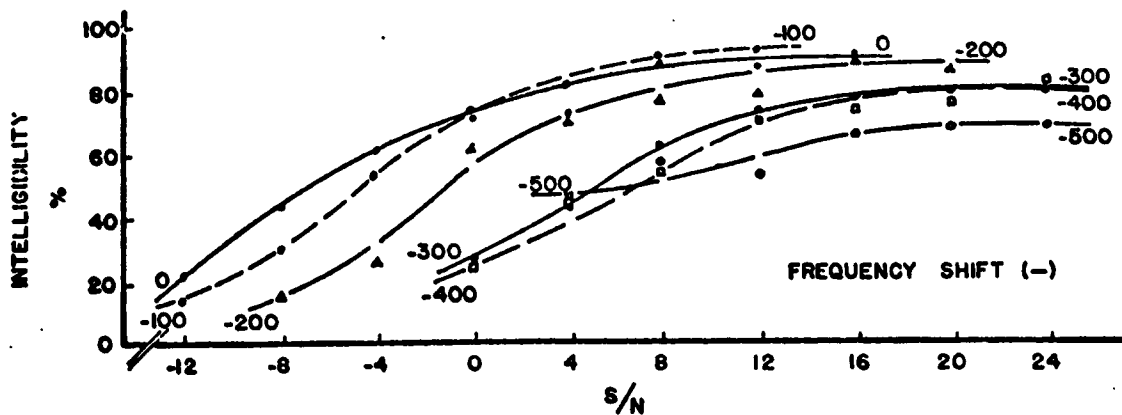


FIG.32- INTELLIBILITY CURVES OF FREQUENCY-SHIFTED SPEECH (FIGURES 25-30),

- 6-26 -

APPENDIX 6

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ARINC EXTRACT OF USAF MONTANA STATE COLLEGE REPORT

55

S/N - dB -

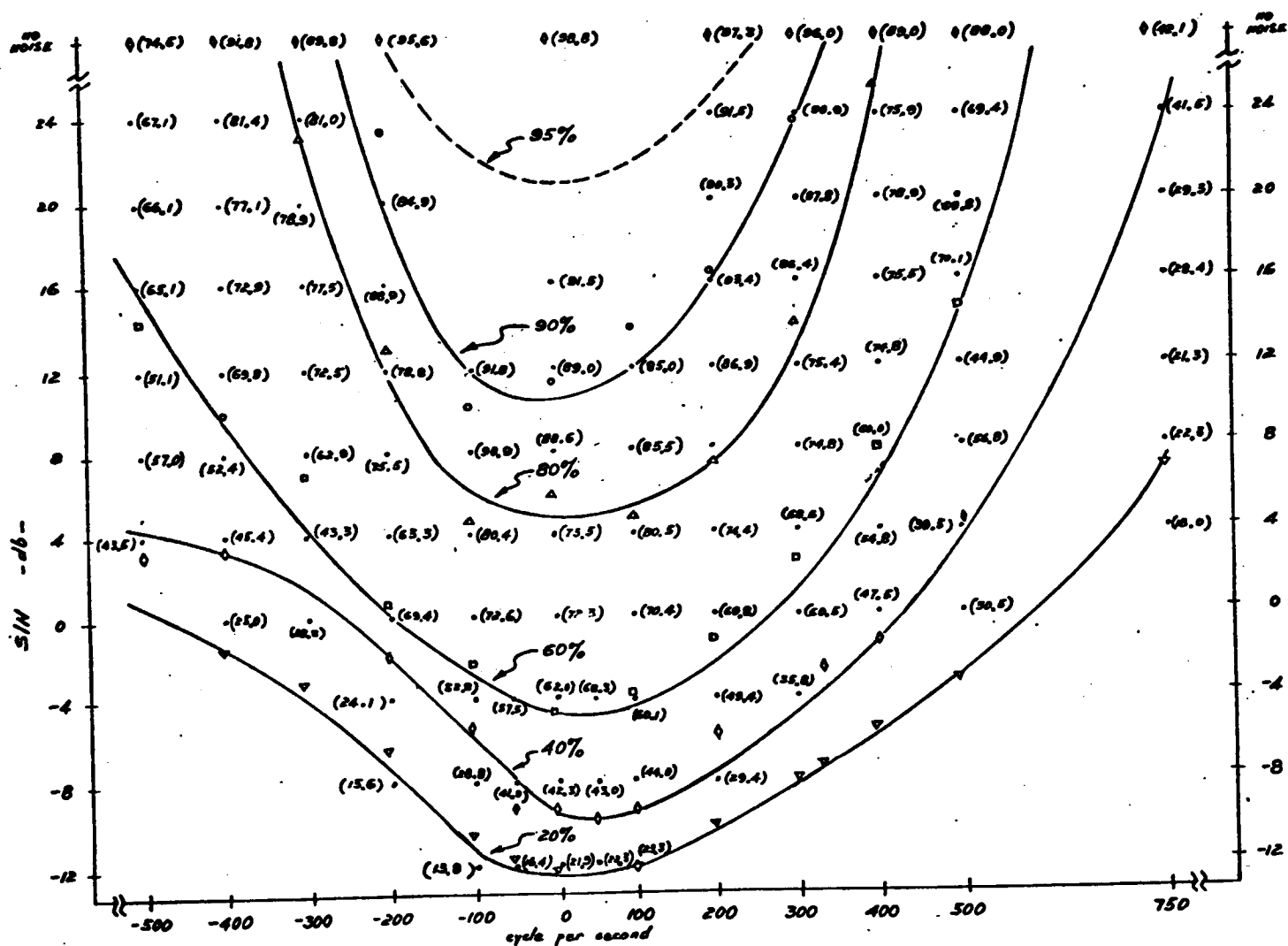


FIGURE 33. SELECTED INTELLIGIBILITY CONTOURS

- 6-27 -

APPENDIX 6

ARINC EXTRACT OF USAF-MONTANA STATE COLLEGE REPORT

ERL-MSC

56

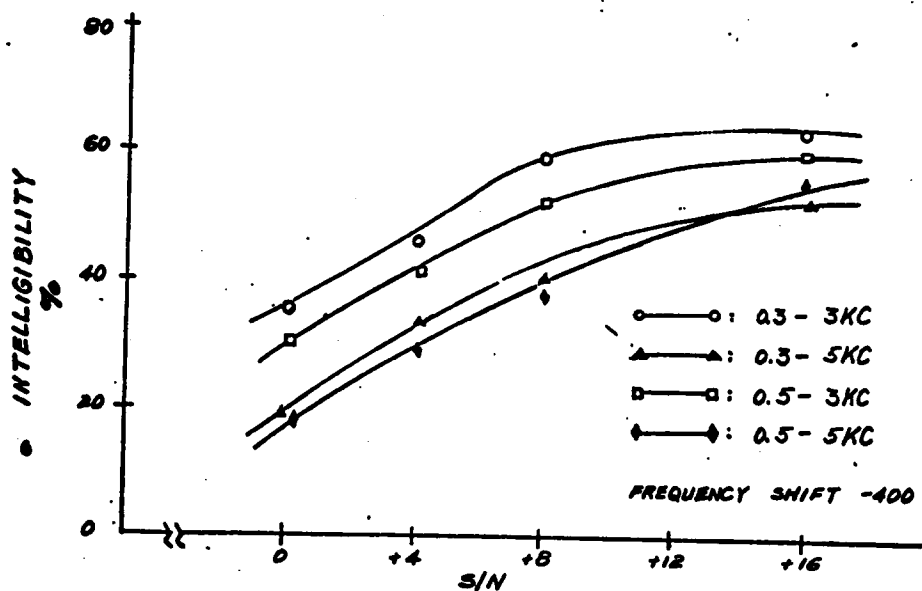


FIGURE 34. INTELLIGIBILITY OF FILTERED SPEECH
FREQUENCY SHIFT -400.

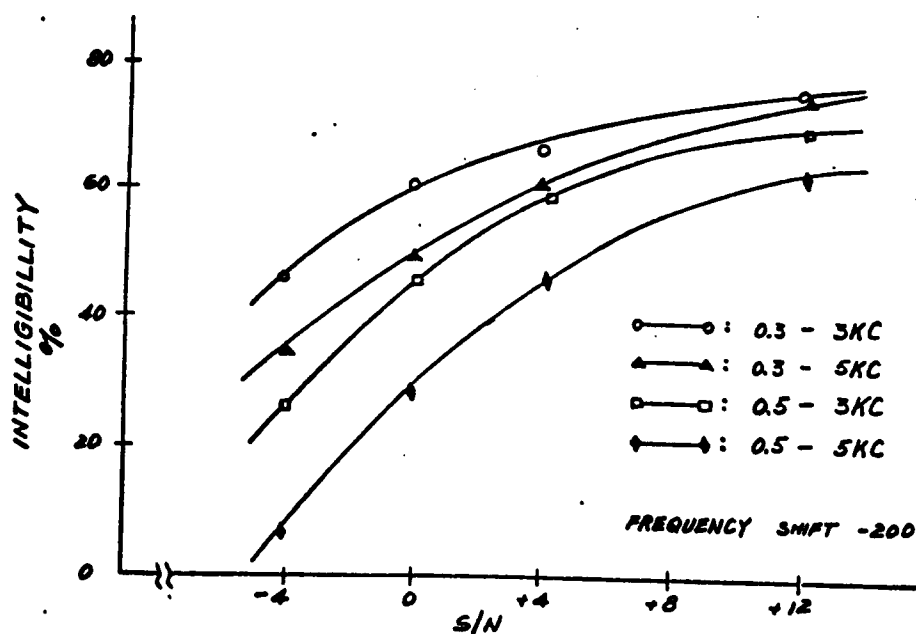


FIGURE 35. INTELLIGIBILITY OF FILTERED SPEECH
FREQUENCY SHIFT -200.

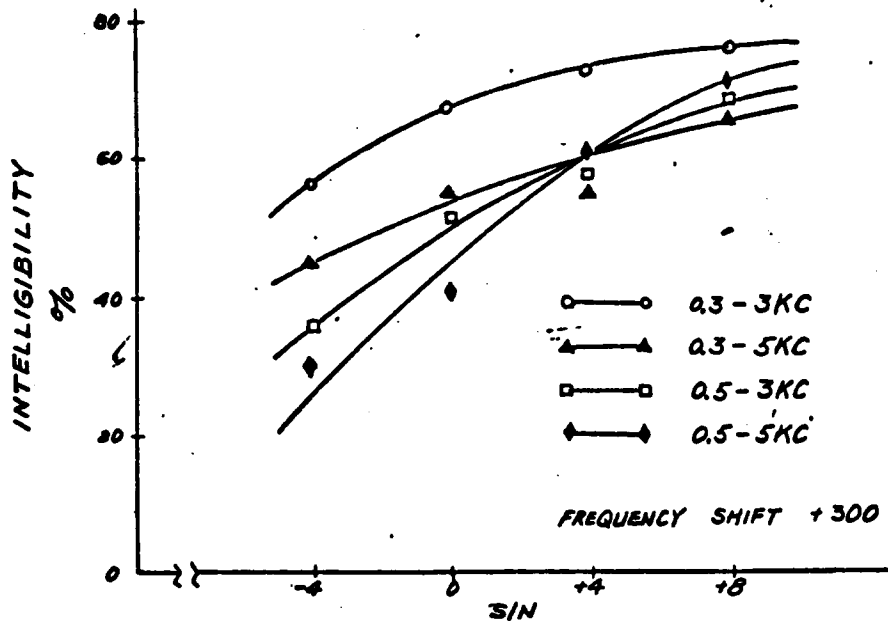
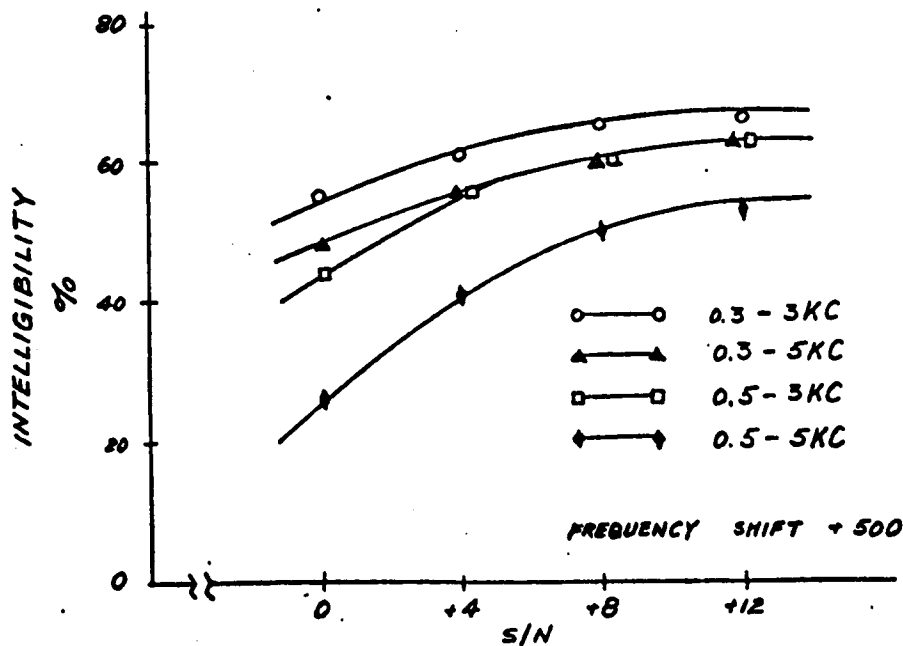
- 6-28 -

APPENDIX 6

ARINC EXTRACT OF USAF-MONTANA STATE COLLEGE REPORT

ERL-MS

57

FIGURE 36. INTELLIGIBILITY OF FILTERED SPEECH
FREQUENCY SHIFT +300.FIGURE 37. INTELLIGIBILITY OF FILTERED SPEECH
FREQUENCY SHIFT +500

APPENDIX 7

BACKGROUND AND ANALYSIS --- FREQUENCY PLANNING
vs. EQUIPMENT PLANNING -- 1955-1971

ORIGINAL NOTE:

This Appendix was prepared by the ARINC staff in July, 1971 when publishing ARINC Characteristic 559 in Gray Covers. The motivation was the renewed evidence of continuing "unawareness" by some systems planners and frequency planners, concerning the historical background which so firmly had shaped the early airline industry planning for SSB operation. This seemed to have been forgotten in the ITU Conference of 1966, in which the airline industry's carefully worked out plan for evolving into an exceedingly efficient and effective future use of the Aeronautical HF Spectrum was lost in the rush to solve some interim problem.

It is the purpose of this Appendix to again point out the right direction for the planning to go and how it can best be redirected toward that end.

JULY, 1975 NOTE:

Appendix 7 has been retained, with only a few minor editorial changes, from ARINC 559 to complete the historical perspective of equipment and frequency planning. The basic transition process suggested in this Appendix is still applicable. Although the growth in communications has temporarily slowed in recent years (due to the introduction of wide-body aircraft and other factors), the increasing need for HF communications is expected to continue for many years into the future. Thus, the frequency and equipment planners must work in concert to fulfill their mutual obligations in meeting the industry's needs.

APPENDIX 7SPECIAL NOTE REGARDING THE APPARENT DISPARITY BETWEEN THE
ARINC CHARACTERISTIC AND THE INTERNATIONAL REGULATIONS

The knowledgeable airline operators and airborne equipment designers are well aware of the insistence by the airline industry on certain design features for Characteristic 333 airborne HF/SSB equipment which have been carried over into this Characteristic 339 which would seem to conflict with frequency planning principles implied by the 1966 ITU Conference. Specifically, as explained in Section 4.2, the airline industry has refused to accept any other than unit-kHz frequency increments despite the implications in ITU Regulations that half-kHz increments would be appropriate in the future. Secondly, the airline industry has consistently insisted on tighter spectrum control of transmitters (Section 4.14) and better receiver adjacent channel rejection (Section 4.24 and 4.30), than required by ITU, due to operational and economic advantages. The basis of the AEEC decisions of the late 1950s, which have been carried forward in all hardware designs, despite some temporary disparities with ITU planning principles, has been the airline belief that spectrum needs of the future will dictate, sooner or later, a demand for the minimum HF channel widths and closest practicable spacings. The airlines predicted in the mid-1950s (and have seen no reason to revise today) that channel widths (and spacings) will end up at 6 kHz for AM and 3 kHz for SSB. The airlines were convinced a decade-and-a-half ago (IATA SSB Compatibility Meeting, Montreal, November, 1955) that the most important technical parameters in SSB equipment design were those that must be specified to ensure compatible operation on any and all of the existing (ITU Appendix 26) channels, and most particularly, the 7 kHz-spaced channels. The airlines, therefore, (in that IATA Meeting) acknowledged, and stated their insistence upon, a hardware capability for operating two SSB channels within that 7 kHz bandwidth and using only unit-kHz frequency increments. The means of accomplishing this objective by the use of alternate 3-kHz and 4-kHz SSB channels in those 7-kHz AM channels was internationally accepted and documented by the ICAO 5th Comm. Div. meeting of 1957 as Attachment D to Part 1-Section 4.1 of Annex 10 to the Convention on International Civil Aviation. This became the basis for the ARINC Characteristic 333 and was accepted by set manufacturers as the basic design premise from that date on.

But although the 1966 ITU Conference should have been aware of these factors, and the prior ICAO planning, that ITU Conference took a different route—for reasons that remain obscure even today (1971). The ITU Conference attached considerable importance to the "unitizing" of their new HF frequency plan (ITU Appendix 27 channels) and succeeded in eliminating all half-kHz frequency channels. Although the then-existing (Appendix 26) frequency plan had employed channel spacings of 7, 7.5, 8.5, 9, 9.5 and 10-kHz, ITU established only two spacings for the new Appendix 27 plan: 7 kHz below 10 MHz and 8 kHz above 10MHz. The 7-kHz AM channels don't divide evenly into unit-kHz SSB channels as they would have if 8 kHz had been selected (this would have wasted channels) or if 6 kHz had been selected (not all present AM equipment could accommodate this close spacing). But after "unitizing" all of the AM channels, ITU prescribed a future subdivision of each 7-kHz AM channel into two 3.5-kHz SSB channels in the naive belief all airborne equipment could undoubtedly accommodate half-kHz increments. Apparently the frequency planners were unaware of the users' reason for rejecting the half-kHz increments: it was to avoid the cockpit confusion of an extra (unnecessary) frequency selector digit—not the extra cost and complexity of the hardware. (Note that an HF set must be capable of selecting over 20,000 discrete frequencies—with four knobs—in order to accommodate the relatively few operating channels. The industry is unwilling to double that 20,000 number when no technical reason exists.) The users were well aware of the military procurement of some airborne equipment (for special applications) having half-kHz, quarter-kHz, or even tenth-kHz frequency increments. But, even after the 1966 ITU Conference decisions, the airlines were unwilling to acquiesce to an improper and unsound ITU decision predicated on improper technical planning; thus, in planning for the ICAO Meeting later that year (Fall 1966), a number of State delegations were briefed by their National airlines in the hope of reversing, or at least "re-interpreting," the ITU decision then only a few months old. But it became evident, notwithstanding strong technical arguments presented by the U.S. and other delegations, that it was not in ICAO's province to reverse, in October, 1966, a 1966 ITU decision.

As stated under Section 4.2, AEEC endorsed, in November 1966, following the ICAO and ITU Meetings, their earlier decision on unit-kHz increments. In 1970 at the time of approval of Characteristic 339, AEEC again endorsed the same unit-kHz increments.

But that 1966 ICAO Conference, itself, suggested the solution to the problem. Although ICAO was unwilling to suggest reversing an ITU decision (that problem should be left to ITU), a possible course of action, by aviation (although not recorded in the official report of the meeting) was, presented to the ICAO Conference by a member of the ITU Secretariat, Mr. J. Gracie, and seconded by numerous States' Delegates. The course of action outlined was rather general, but one that made proper use of an established procedure traditionally used for accommodating special problems of this nature. We believe the general solution proposed would embrace the following steps, to be taken when, and as required:

- 1) Noting that the users have no problem with introducing SSB on the upper halves of either the (then existing) Appendix 26 channels or the future (effective 1970) Appendix 27 channels in the manner prescribed by ITU (ITU. No. 27/71 G), the earliest that a problem could exist would be the first date on which lower-halves of Appendix 27 AM channels were desired to be used for SSB. It was noted that there might even be another ITU Conference which could reconsider the matter before the airline implementation had proceeded. But in the meantime (probably for many years) there was no ITU (or ICAO) problem.

APPENDIX 7 (cont'd)

- 2) If and when certain AM channels had been converted to exclusive SSB operation over a sufficiently large portion of the globe, aviation might, only then, consider introducing SSB operations into the lower halves of those AM channels. As such a step must be coordinated throughout aviation (through ICAO Divisional and/or Regional agreements) to avoid disruptions of (or interference to, or from) existing AM operation by aviation services on these channels, that same agreement might, logically, establish, under the long-standing authority granted by ITU Article 3 Nos. 113, 114 and 115, (See last page in this Appendix 7) the exact frequencies to be used for the lower-half channel SSB operation when implemented. As this abridgement of ITU conclusions would be necessary only for frequencies below 10 MHz (above 10 MHz the channel widths are 8 kHz), and as the frequencies in question would be few in number, and exclusively assigned to aviation, and as the overriding provisions of ITU Nos. 27/67 3.4.1 and 27/68 3.4.2 will have been properly complied with, the only abridgement of ITU Rules would concern Nos. 27/70 b), 27/71 c), and the included table and Note 3 (See Appendix 1-B of this Characteristic 539), which aviation has the option to do in conformity with the ITU General Rules cited.
- 3) Assuming that Step 2 has been satisfactorily implemented by aviation with ICAO acceptance, the subsequent bringing into line of the ITU regulations would follow as a logical extension of the (prior) acceptance by States' aviation officials of the principle.
- 4) But yet an even more significant step, long envisaged by the airborne equipment planners could, conceivably, be taken before, if not simultaneously with, or at least subsequent to, the action of Step 3: If and when the expanding use of SSB equipment will have generated sufficient momentum, in the retirement of obsolescent AM equipment, either ICAO or ITU could decide to introduce universal 6-kHz Am channel widths throughout most if not all of the HF aviation bands. This would not only gain more channels but would provide a better match between the capabilities of carefully designed modern airborne hardware (in accordance with design precepts established in the IATA Meeting of 1955) and the vanishing radio spectrum.

Thus can be seen the importance of careful attention by users and manufacturers to the design factors established many years ago by the users and systems planners. These are necessary to ensure proper and satisfactory operation in an environment in which 3 kHz-spaced channels are inevitably to become standard, throughout the aeronautical HF bands, rather than being simply the temporary expedient it had appeared to be when ARINC Characteristic 533 had specified this capability in 1960 to facilitate what was envisaged to be a complex and lengthy transition from AM to SSB operation.

- 7-4 -
APPENDIX 7

NOTE:

This page from Annex 10 has been marked-up to reflect the HF/SSB implementation plans discussed in the staff analysis presented in Attachment 7.

Annex 10 — Aeronautical Telecommunications

Volume I

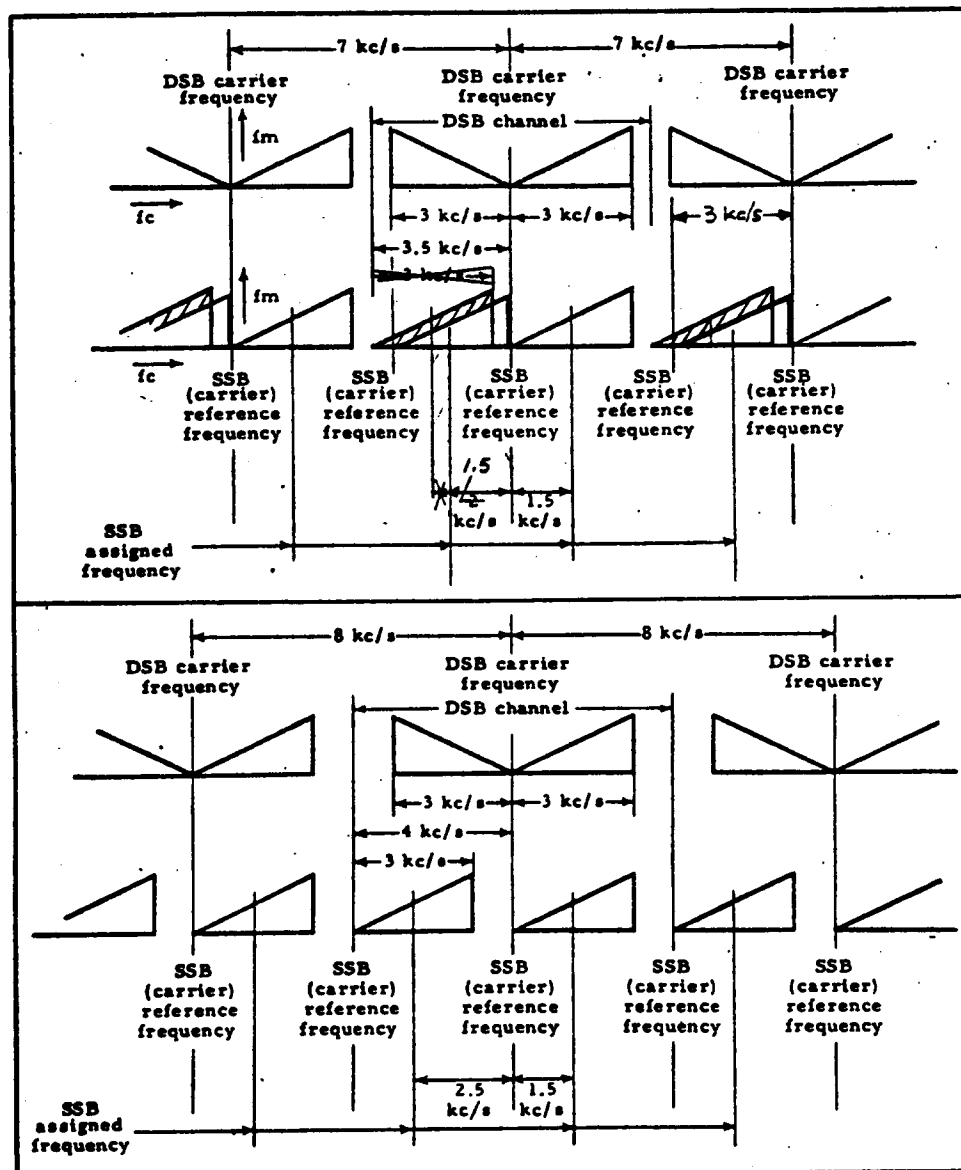


Fig. D-1.—DSB and SSB channelling with 7 kc/s and 8 kc/s DSB channel spacings, as defined in the Final Acts of the ITU EARC

APPENDIX 8

EXTRACTS FROM ICAO ANNEX 10

(See Sections 1.7, 4.2 and 4.14 of this Characteristic for significance of this material.)

The attached ICAO standards and Recommended Practices (SARPS) followed as a natural consequence of the 1966 ITU decision to plan for eventual half-kHz channel increments, but neither the ITU nor ICAO standards reflect actual aviation industry planning and equipment implementation as noted in this Characteristic, Sections 4.2 and 4.14. A detailed staff analysis and explanation of why the airline industry does not find these ITU and ICAO planning principles acceptable is given in Appendix 7, along with a probable course of action to redirect the ICAO and ITU planning.

NOTE: Original ICAO Annex 10 Material on SSB

The original "green page" guidance material on SSB developed by an ICAO Comm. Div. meeting of 1957, based on airline industry planning principles developed in the 1955 IATA SSB Compatibility meeting has considerable historical significance (in view of the controversy still brewing over the planning principles!) and is reproduced on the second page of Appendix 1.

JULY, 1975 NOTE: FUTURE CHANGES

The extracts from ICAO Annex 10 reproduced herein remain in effect as of December, 1975, but changes will be needed to properly reflect 3kHz Frequency Spacing. Needed changes in the "assumed" Essential System Characteristics (Appendix 1) are set forth in Appendix 9.

Annex 10 — Aeronautical Telecommunications

tions over the group may be made by mutual agreement between the group control station and the stations of the group concerned.

Note.—The designation of the group control station is normally made by regional meetings when drawing up plans for the AFTN.

4.9.1.2 *Group control station — Functions.* An AFTN group control station shall endeavour to ensure:

a) the expeditious passing of communications between stations of the group;

b) that there is efficient operation and good radio discipline in the group, and that communications between stations are not restricted, except when intervention by the group control station is necessary to regulate or stop transmissions which might affect the efficient operation and discipline of the group;

c) the application of current ICAO procedures by all stations within the group;

d) that the times of change of actual frequencies for the group are determined and co-ordinated (taking into account propagation data, operating conditions, and frequencies authorized for the use of stations in the group), e.g. changes from day to night frequencies;

e) that arrangements are made for such of the following as may become necessary:

i) the answering of calls,

ii) the acceptance, and forwarding of communications,

iii) the notification of communications,

addressed to stations experiencing difficulties in communication or absent from group watch.

4.9.1.3 *Duties of stations other than the group control station.*

4.9.1.3.1 **RECOMMENDATION.**—Stations of an AFTN group that are not able to change frequencies at the time indicated should notify the group control station of the time at which they expect to be able to effect the change.

4.9.1.3.2 **RECOMMENDATION.**—Stations of an AFTN group that are unable to continue guarding the working frequency of the group should notify the group control station accordingly stating, if possible, the time of return to watch.

4.10—Technical Provisions Relating to ATS Message Transmission

4.10.1 *Interconnexion by direct or omnibus channels—low modulation rates—5-unit code.*

Note.—See 4.12 for medium modulation rates.

4.10.1.1 **RECOMMENDATION.**—AFTN techniques (cf. 4.2) should be used.

4.11—Single Side-Band (SSB) HF Radiotelephone Communication System Characteristics for Use in the Aeronautical Mobile Service

4.11.1 The characteristics of the air-ground HF SSB system, where used in the Aeronautical Mobile Service, shall be in conformity with the following specification:

4.11.1.1 *Frequency range.*

4.11.1.1.1 HF SSB installations shall be capable of operation at any SSB reference frequency available to the Aeronautical Mobile (R) Service in the band 2 MHz to 22 MHz and necessary to meet the approved assignment plan for the Region(s) in which the system is intended to operate, and in compliance with the relevant provisions of the ITU Radio Regulations.

Note 1.—See Introduction to Chapter 3, Part II and Fig. 4-1.

Note 2.—The Extraordinary Administrative Radio-Conference (EARC), Geneva, 1966, established a new Allotment Plan (Appendix 27 to the ITU Radio Regulations) which provides for the following channel utilization:

3.4 Channel utilization.

27/67 3.4.1 A station using single side-band emissions shall be considered to be operating in accordance with the Allotment Plan if the necessary bandwidth is confined within either the upper or the lower half of the channel provided for double side-band emissions;

27/68 3.4.2 Subject to the provisions of No. 27/12* and to the following conditions, a station using single side-band emissions may operate either in the upper half or in the lower half of a double side-band channel designated by its centre frequency in the Allotment Plan;

27/69 a) when operating in the upper half of the channel, the station shall use upper side-band emissions with the carrier at the channel centre frequency listed in the Allotment Plan;

27/70 b) equipment capable of operating only on integral multiples of 1 kHz shall be restricted to the upper halves of the channels listed in the Allotment Plan, when operated in channels having a width of 7 kHz;

27/71 c) when operating in the lower half of the channel, the station shall use upper side-band emissions with the carrier at the following value below the channel centre frequency listed in the Allotment Plan:

Band	Carrier (reference) frequency relative to centre frequency of channel
2, 3, 4, 5, 6 and 8 MHz	3 500 Hz below
10, 11, 13 and 17 MHz	4 000 Hz below

Note 3.—It is recognized that Regions may assign the lower half of the channels allowed by the ITU Allotment Plan (Appendix 27 to the ITU Radio Regulations). Accordingly, ground and airborne installations operating in such a Region would be required to have 500 Hz channelling capability below 10 MHz. However, those ground and airborne installations which had no requirement to operate in such a Region, or no requirement to operate below 10 MHz, would require only a 1 000 Hz channelling capability.

Note 4.—It is also recognized that, during the currency of the HF Allotment Plan contained in Appendix 26 to the ITU Radio Regulations, and pending the bringing into force of the revised Plan contained in Appendix 27, equipment having only a 1 000 Hz channelling capability may operate on frequencies 0.5 kHz below the channel frequencies when these end in half kilohertz.

* Provision 27/12 stipulates that the use of channels for the various authorized classes of emission will be subject to specific arrangements by the Administrations concerned.

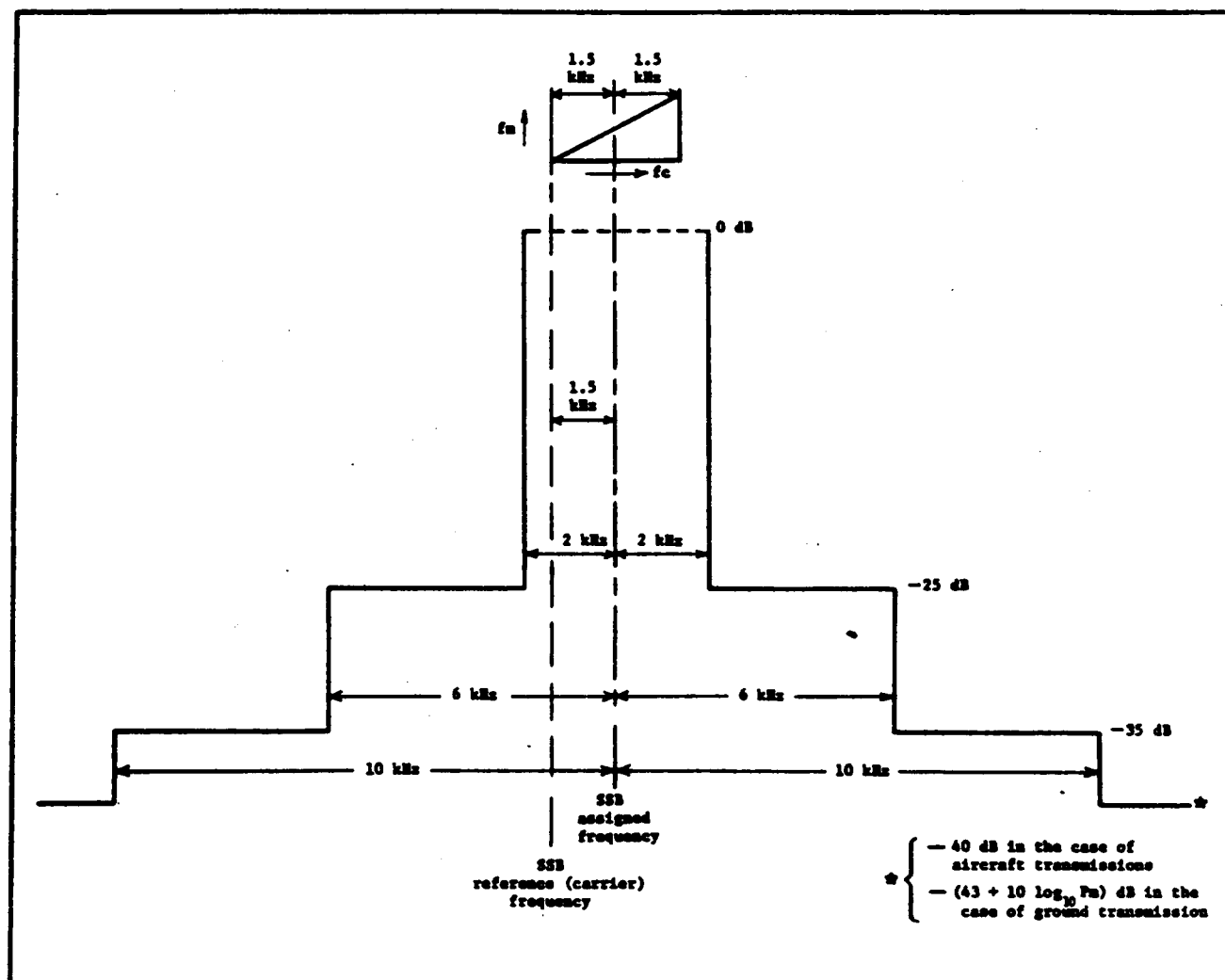


Fig. 4-1. — Required side-band attenuation characteristic

4.11.1.2 Side-band selection.

4.11.1.2.1 The side-band transmitted shall be that on the higher frequency side of its reference frequency.

4.11.1.3 Reference frequency.

4.11.1.3.1 The SSB reference frequency:

a) in the higher frequency half of a DSB channel, shall be that of the DSB carrier;

b) in the lower frequency half of a DSB channel, shall be:

i) 3.5 kHz lower than the DSB carrier where the latter are spaced at 7 kHz;

ii) 4 kHz lower than the DSB carrier where the latter are spaced at 8 kHz.

Note.—See also Attachment D to Part I.

4.11.1.4 Carrier mode.

4.11.1.4.1 The system shall operate in the suppressed carrier mode (A3J). Where communication is necessary with installations designed only for DSB reception, or where SELCAL is employed as specified in 4.8 of Part I, and when DSB emission is not provided, the instal-

lation shall be capable of operation in the full carrier mode (A3H) in addition to A3J.

Note.—Current ITU Radio Regulations require a minimum of 26 dB carrier suppression with respect to peak envelope power in Mode A3J.

4.11.1.4.2 RECOMMENDATION.—Ground installations should be capable of 40 dB carrier suppression with respect to peak envelope power.

4.11.1.5 Frequency tolerance.

4.11.1.5.1 The basic frequency stability of the transmitting function in the A3J mode shall be such that the

Annex 10 — Aeronautical Telecommunications

Volume I

difference between the virtual carrier of the transmission and the SSB reference frequency shall not exceed:

- 20 Hz for airborne installations;
- 10 Hz for ground installations.

4.11.5.2 The basic frequency stability of the receiving function shall be such that, with the transmitting function stabilities specified in 4.11.5.1, the overall frequency difference between ground and airborne functions achieved in service and including Doppler shift, does not exceed 45 Hz. However, a greater frequency difference shall be permitted in the case of supersonic aircraft.

4.11.6 Spectrum limits. In a single side-band A3H or A3J transmission, the mean power of any emission on any discrete frequency shall be less than the mean power (P_m) of the transmitter in accordance with the following:

- on any frequency removed by 2 kHz or more up to 6 kHz from the assigned frequency: at least 25 dB;
- on any frequency removed by 6 kHz or more up to 10 kHz from the assigned frequency: at least 35 dB;
- on any frequency removed from the assigned frequency by 10 kHz or more:

- a) aircraft stations: 40 dB;
- b) aeronautical stations:
43 + 10 log₁₀ P_m (watts) dB.

Note 1.—See Fig. 4-1.

Note 2.—For promulgation purposes and entries in appropriate Regional Plans, the frequency to be used and published shall be the SSB reference frequency. For specific purposes related to IFRB registration which, according to ITU regulations, must be stated in terms of the "assigned frequency", this must be a frequency equal to the SSB reference frequency plus 1 500 Hz. For further guidance, see Fig. D-1 of Attachment D to Part I.

4.11.1.7 Power.

4.11.1.7.1 Ground installations. Except as permitted by the relevant provisions of Appendix 27 to the Radio Regulations of the ITU, the peak envelope power (PEP) supplied to the antenna transmission line of a ground installation for A3H and A3J emissions shall not exceed a maximum value of 6 kilowatts.

4.11.1.7.2 Airborne installations. The peak envelope power, supplied to the antenna transmission line of an airborne installation for A3H and A3J emissions, shall be limited to a value that will not cause harmful interference to other stations using frequencies in accordance with the technical principles on which the ITU Allotment Plan (Appendix 27 to the ITU Radio Regulations) is based.

Note.—It is intended that, in the application of 4.11.1.7.2, the maximum peak envelope power of an airborne installation would not exceed a nominal figure of twice the value of 300 watts specified in Appendix 27 to the ITU Radio Regulations.

4.11.1.8 Method of operation. Single channel simplex shall be employed.

4.12.—Technical Provisions Relating to International Ground-Ground Data Interchange at Medium and Higher Signalling Rates

Note 1.—Throughout this paragraph in the context of coded character sets, the term "unit" means the unit of selective information, and is essentially equivalent to the term "bit".

Note 2.—See Attachment G to Part I for guidance material on ground-ground data interchange over data links at medium and higher signalling rates.

4.12.1.—GENERAL

4.12.1.1 RECOMMENDATION.—In international data interchange of characters, a 7-unit coded character set providing a repertoire of 128 characters should be used. Compatibility with the 5-unit coded character set of International Telegraph Alphabet No. 2 should be ensured where applicable.

4.12.1.2 When the provisions of 4.12.1.1 are applied, the 7-unit coded character set contained in the accompanying table (page 71) shall be used.

4.12.1.2.1 The serial transmission of units comprising an individual character of the 7-unit coded character set shall be with the low order unit (b_1) transmitted first.

4.12.1.2.2 RECOMMENDATION.—When the 7-unit coded character set is used, each character should in general include an additional unit for parity in the eighth level position.

4.12.1.2.3 When the provisions of 4.12.1.2.2 are applied, the sense of the

character parity bit shall produce even parity in links which operate on the start-stop principle, and odd parity in links using end-to-end synchronous operations.

4.12.2.—DATA TRANSMISSION CHARACTERISTICS

4.12.2.1 RECOMMENDATION.—The data signalling rate should be chosen from among the following:

600 bits/s
1 200 bits/s
2 400 bits/s
4 800 bits/s
9 600 bits/s

4.12.2.2 RECOMMENDATION.—The type of transmission for each data signalling rate should be chosen as follows:

Data Signalling Rate	Type of Transmission
600 bits/s	Synchronous or asynchronous serial transmission
1 200 bits/s	Synchronous or asynchronous serial transmission
2 400 bits/s	Synchronous serial transmission
4 800 bits/s	Not specified yet
9 600 bits/s	Not specified yet

4.12.2.3 RECOMMENDATION.—The type of modulation for each data signalling rate should be chosen as follows:

Data Signalling Rate	Type of Modulation
600 bits/s	Frequency
1 200 bits/s	Frequency
2 400 bits/s	Phase
4 800 bits/s	Not specified yet
9 600 bits/s	Not specified yet

Note.—This recommendation does not necessarily apply to ground-ground extensions of air-ground links used exclusively for the transfer of air-ground data, inasmuch as such circuits may be considered as part of the air-ground link.

4.12.3.—DATA LINK APPLICATION

4.12.3.1 The following descriptions shall apply to the data link application:

- a) A data link is a single means of direct communication between two points, including the functions to control the two-

Annex 10 — Aeronautical Telecommunications

Volume I

ments of the user and may consist of a lamp, a bell, a chime or any combination of such indicating devices.

4.—Single Side-Band (SSB) HF Radiotelephone Communication

4.1 When reviewing the HF en-route communication element of ICAO Regional Plans, careful consideration should be given to ensuring that the

standard of the existing service is not degraded during the transition period, during which the two types of modulation, DSB and SSB, will coexist.

4.2. It is recognized that a sudden universal change to SSB from DSB HF/RTF is impracticable and that uniform progress towards SSB operation is as unlikely between Regions and within Regions as between international and national HF/RTF systems. However,

because all HF operations in the Aeronautical Mobile (R) Service must be contained within the one frequency allotment plan in the current Appendix to the ITU Radio Regulations, the coexistence of both DSB and SSB systems must be accepted for some time. As, in practice, this will result in stations equipped for SSB being required to operate in an environment of stations equipped for DSB, or vice versa, a problem of compatibility arises.

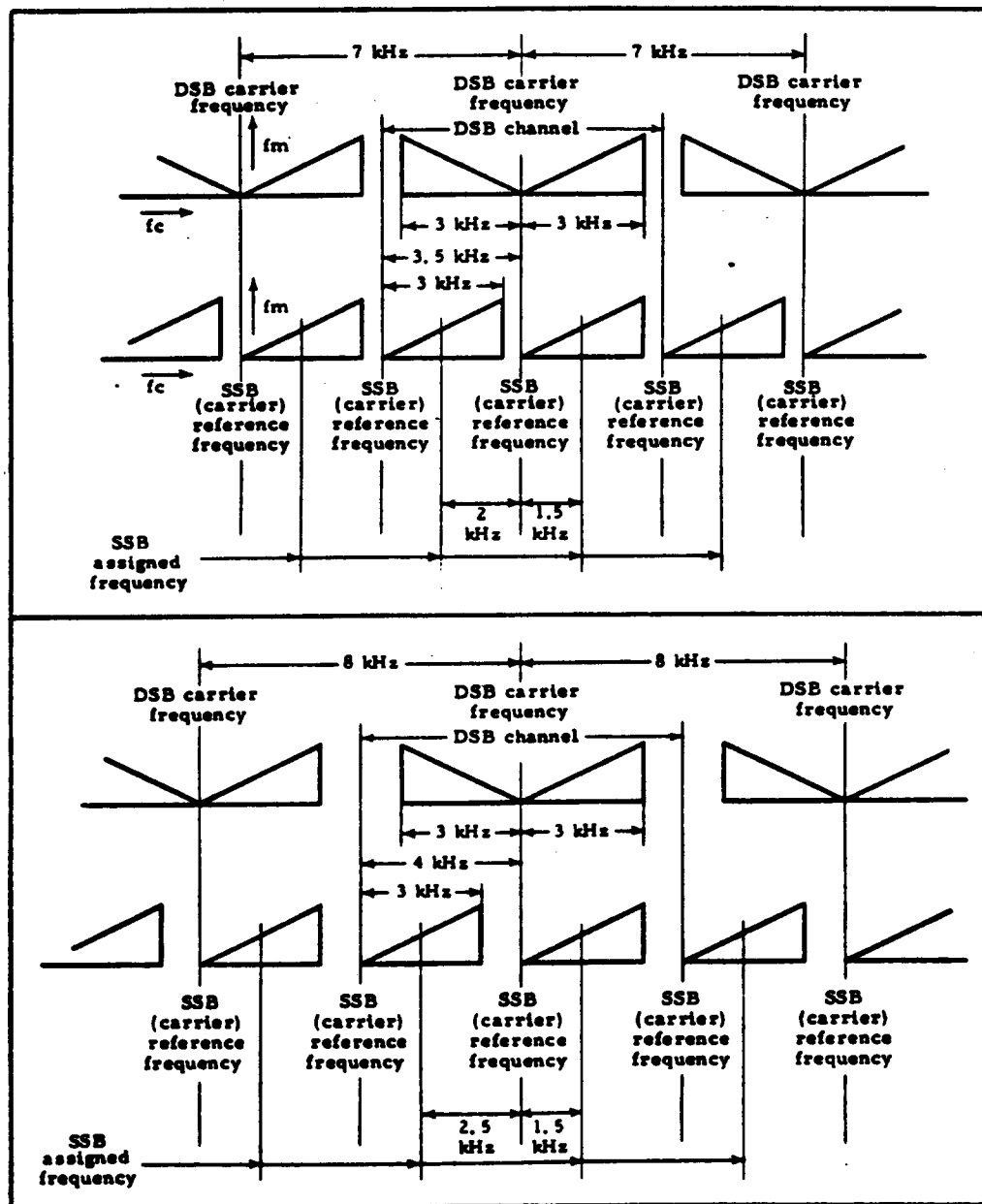


Fig. D-1.—DSB and SSB channelling with 7 kHz and 8 kHz DSB channel spacings, as defined in the Final Acts of the ITU EARC

Attachment D to Part I

4.3 The compatibility problem can be overcome, in any particular Region, by at least two methods. The first, which amounts to its avoidance, consists of segregating the systems by frequency planning and, wherever possible, specific channels should be reassigned to SSB. Alternatively, and recognizing that aircraft can seldom be restricted in their operations to any specific area or route, full carrier SSB (A3H) could be used as an interim arrangement capable of affording compatibility. The second sentence of 4.11.1.4.1 of Part I is included for this purpose only, as it is recognized that the full advantages of SSB operation will not accrue until conversion to the Standard mode (A3J) is completed.

4.4 The following considerations are intended to assist planning for the introduction of SSB:

a) To comply with the regulatory requirements to avoid interference, the necessary bandwidth of a SSB emission has to be confined within either the upper or lower half of the channel provided for DSB.

b) A station using single side-band may operate either in the upper half or in the lower half of a DSB channel designated by the centre frequency listed in the ITU Allotment Plan.

c) The simultaneous use of channels in the Aeronautical Mobile (R) Service for SSB and DSB has to be the subject of regional agreement.

d) When operating in the upper half of a DSB channel, the SSB station has to use as its reference frequency the DSB channel centre frequency listed in the Allotment Plan, except as set forth in Note 4 to 4.11.1.1.1 of Part I.

e) All stations using 3023.5 kHz and 5680 kHz for search and rescue purposes and equipped for SSB, have also to radiate a signal capable of reception on a DSB receiver and be able to receive DSB transmissions.

f) As an exception to the provisions in Part I, 4.11.1.7, relating to power, aeronautical stations serving MVARAs or VOLMET areas may exceed the limits specified, subject to compliance with the relevant clauses of Appendix 27 to the ITU Regulations.

g) Airborne installations should, as far as possible, incorporate equipment providing more than 26 dB carrier suppression in the A3J mode.

h) So as to permit aircraft having A3J receiving capability to benefit from the improved signal-to-noise and intelligibility attainable thereby, ground stations transmitting DSB should, already in the interim period, have the improved frequency stability required for SSB transmission.

i) The spectrum limits defined in Part I, 4.11.1.6, which are attainable in the present conditions, may not be sufficiently stringent to permit the use of both upper and lower halves of a DSB channel in the same air route area.

5.—Independent Side-Band (ISB) System

5.1 The independent side-band system provides a convenient method of providing, within the same circuit:

- a) one or more voice channels; and
- b) one or more teletypewriter channels.

5.1.1 The use of the double side-band system for ground-to-ground radio-telephony is rapidly being superseded by the single side-band system which, by suppressing one of the side-bands and reducing the power in the carrier, ensures that the radiated power is more effectively used.

5.1.2 ISB systems may be considered as a logical development of the single side-band system. Beginning from the low level carrier and the single side-band carrying intelligence, it is logical to use the second side-band for the transmission of independent intelligence. For example, one side-band could carry speech and the other could carry teletypewriter channels.

5.1.3 For commercial purposes ISB systems with two speech channels and the order of 24 teletypewriter channels are common.

5.1.4 An ISB transmission can be provided by any suitable transmitter with a linear output but special modulation equipment is necessary. Two balanced modulators are required, one for each side-band. The carrier frequency itself is removed by filtering and is replaced by a steady pilot carrier at a typical level of 28 dB below the peak side-band power.

5.1.5 Special receivers are necessary. The early stages follow standard design practice adjusted as necessary to provide the necessary bandwidth. Filters separate the pilot carrier and the two side-bands; the first is used to control the receiver gain and thus ensure a controlled output of the intelligence derived by demodulation of the latter.

6.—HF Radioteletypewriter Circuits Using Four-Frequency Shift (F6 Modulation)

6.1 Multi-channel operation of radioteletypewriter circuits can be provided in the following ways:

a) By time division (F1 modulation):

i) by using electronic techniques so that the content of two (or four) modulations at 50 bauds, for example, is transformed by interleaving into a single 100 bauds modulation (or 200 bauds modulation for four channels);

ii) by the addition of an Automatic Error Correction (ARQ) system to the circuit.

b) By frequency division (F6 modulation) using four frequencies f_1 to f_4 corresponding to the following characteristics:

CODING SYSTEM

Frequency of emission	Channel 1	Channel 2
f_4 (highest frequency)	A	A
f_3	A	Z
f_2	Z	A
f_1 (lowest frequency)	Z	Z

Spacing between adjacent frequencies (kHz)	Nominal modulation rate of each channel (bauds)
1 000	over 300
500	200 to 300
400	100 to 200
200 or 250	below 100

APPENDIX 9

BIBLIOGRAPHY

1.0 Bibliography

The following AEEC Letters relating to the Airborne HF/SSB System Project have been circulated.

<u>AEEC LETTER NO.</u>	<u>DATE</u>	<u>SUBJECT</u>
79-088/HFC-10	JUNE 18, 1979	Circulation of Draft 1 of Project Paper 719 "Airborne HF/SSB System"
79-143/HFC-11	OCTOBER 3, 1979	Adoption of Draft 1 of Project Paper 719 "Airborne HF/SSB System"

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SUPPLEMENT 1

TO

ARINC CHARACTERISTIC 719

AIRBORNE HF/ SSB SYSTEM

Published: September 5, 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 new control panel connector, a modified 4-wire microphone interface, commentary on expansion of the frequency range, revised microphone grounding, switched power (optional), modified audio output, and additional pin assignments for CW keying modes, key event and primary power.

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 "C-1" symbols in the margins. Existing copies of Characteristic 719 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 719-1 already contain this Supplement and thus do not require revisions by the reader.

C. CHANGES TO CHARACTERISTIC 719 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.

2.4.2 Power Control Circuitry

Text added describing on/off control and optional relay.

ORIGINAL TEXT FOLLOWS:

2.4.2 Power Control Circuitry

There should be no master on/off power switching within the HF Transceiver. Any user desiring power on/off control for the unit should provide, through 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 to the on/off switches for the HF Transceiver will not be needed in most installations, and power will be wired directly to the equipment from the circuit breaker panel.

3.1 Frequency Range and Channeling

Commentary expanded to include desirability of 2-30 MHz range.

Text change reflect 1 kHz frequency spacing.

ORIGINAL TEXT FOLLOWS:

3.1 Frequency Range and Channeling

The transceiver should operate on channels spaced 3 kHz apart in the band 2.8 to 24 MHz. Channel changing time should not exceed 1 second.

COMMENTARY

Currently there is no airline requirement for the equipment to operate at 100 Hz channel spacing as does the military HF equipment. However, it would be wise of HF equipment manufacturers to design the equipment for ease of modification to provide for the 100 Hz spacing if it were requested in the future by the airlines. The manufacturer, though, should take care in keeping the additional cost for the convertibility down to an absolute minimum in order not to lose marketability of a radio which selects frequencies in 1 kHz increments only.

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 ohms 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.

3.6.5.3 Voice Phase Shift Unit

Audio output reference changed from 50mW to 40mW.

ORIGINAL TEXT FOLLOWS:

3.6.5.3 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 phrase 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 $\pm$ 20% ohm resistive load when the transmitter is amplitude modulated 90% at 1000 Hz. A service adjustment independent of the receiver audio output 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.

3.9 Keyline

New Section inserted.

5.4 Use of ATLAS Language

Reference changed to ARINC Specification 616.

ORIGINAL TEXT FOLLOWS:

5.4 Use of ATLAS Language

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

ATTACHMENT ZERO – NOTES PERTAINING TO ATTACHMENTS

Note 6 – Pin MP5B changed to BP11 and Pin MP5G changed to BP1.

Note 10 – Direct reference to ARINC 559A control panel added.

Note 13 – Replaced with new description of use for Pin MP2A.

Note 14 – Replace with new description of future spares.

ATTACHMENT 1 – STANDARD INTERWIRING

Pin MP2A – Note number changed to 13.

Pin MP2D – Reserved status removed from “Voice/ Data Mode Select”.

Pin MP2E – Assigned to “Key Event”.

Pins BP2, BP3, and BP7 have been given reserved status.

Pins BP4, BP5 and BP6 have been assigned as the primary power input.

Control panel pin assignments changed.

“Future Spare” and “Future Spare (Contact)” assignments added.

ATTACHMENT 3 – SCHEMATIC OF AUDIO GROUNDS AND USE OF 4-WIRE MICROPHONE (WITH SYSTEM INTERLOCK RELAYS)

Pin MP2E added to schematic.

Pin MP5G changed to BP1.

Ground connections revised.

ATTACHMENT 4 – CONTROL PANEL WIRING

Pins assignments revised for new connector.

ATTACHMENT 8 – CONTROL PANEL GUIDELINES

Connector type changed from MIL-C-83723-72R2255N to MIL-C-83723-77R14159.

Text added to describe optional master off-on control.

ORIGINAL TEXT FOLLOWS:

1.3 Connector Types

The “Standard Control Panel” should utilize an MIL-C-83723-72R2255N connector (or equivalent) positioned on the vertical center line of the unit.

1.5 Master Off-On Control

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.

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SUPPLEMENT 2

TO

ARINC CHARACTERISTIC 719

AIRBORNE HF/SSB SYSTEM

Published: May 29, 1981

Prepared by the Airlines Electronic Engineering Committee

Adopted by the Airlines Electronic Engineering Committee: March 12, 1981

A. PURPOSE OF THIS SUPPLEMENT

This Supplement introduces a modified 4-wire microphone interface, commentary on reduced cooling provisions, a blower control pin, and more guidance on the switched and unswitched power inputs.

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 "C-2" symbols in the margins. Existing copies of Characteristic 719 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 719-2 already contain this Supplement and thus do not require revisions by the reader.

C. CHANGES TO CHARACTERISTIC 719 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

Text added describing blower control feature.

Commentary expanded to summarize test results for a radio operated at less than specified air flow rate.

ORIGINAL TEXT FOLLOWS:

2.6 Cooling

The HF 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 110 Kg/hr of 40°C air and the unit should not dissipate more than 500 watts of energy during continuous transmission. The coolant air pressure drop through the equipment should be 25 ± 5 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)

NOTE: Manufacturers have stated that a 400W PEP output is within the "state-of-the-art" and may be implemented at the option of the user. Cooling provisions should be increased for the higher power radio. Based on a 700W power dissipation, the air flow rate should be increased to 154 Kg/hr.

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 HF Transceivers and aircraft installations.

ATTACHMENT ZERO – NOTES PERTAINING TO ATTACHMENTS

Note 15 added to describe switched and unswitched power inputs.

ATTACHMENT 1 – STANDARD INTERWIRING

Pin MP3K assigned to blower control.

Pin MP5A assigned to chopper control.

Pins BP4, BP5 and BP6 descriptions expanded to designate unswitched power.

Note 15 designator added to pins BP2, BP3 and BP7.

ATTACHMENT 3 – SCHEMATIC OF 4-WIRE MICROPHONE

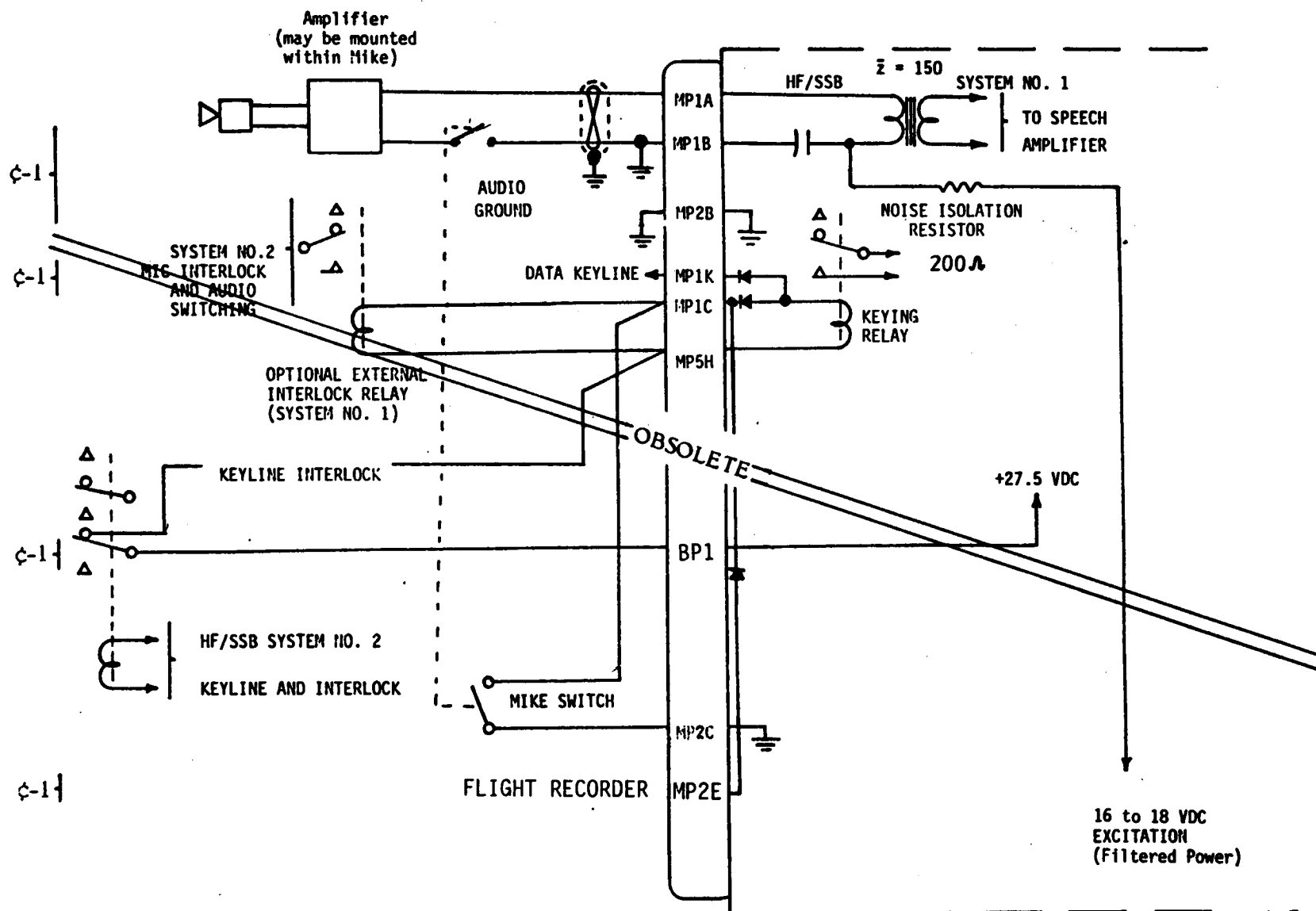
Pin MP5A (Chopper Control) added to schematic.

ORIGINAL FOLLOWS:

See Page 3 for Attachment 3.

ATTACHMENT 3

SCHEMATIC OF AUDIO GROUNDS
AND USE OF 4-WIRE MICROPHONE
(WITH SYSTEM INTERLOCK RELAYS)



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SUPPLEMENT 3

TO

ARINC CHARACTERISTIC 719

AIRBORNE HF/ SSB SYSTEM

Published: March 4, 1982

Prepared by the Airlines Electronic Engineering Committee

Adopted by the Airlines Electronic Engineering Committee: December 10, 1981

A. PURPOSE OF THIS SUPPLEMENT

This Supplement introduces a revised 4-wire microphone schematic, a new pin assignment to provide for varying audio grounding techniques, and a program pin to provide for narrow/wide frequency tuning selection.

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 "C-3" symbols in the margins. Existing copies of Characteristic 719 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 719-3 already contain this Supplement and thus do not require revisions by the reader.

C. CHANGES TO CHARACTERISTIC 719 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

Cooling air and power dissipation revised. First paragraph of Commentary deleted.

ORIGINAL TEXT FOLLOWS:

2.6 Cooling

The HF 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 110 Kg/hr of 40°C air and the unit should not dissipate more than 500 watts of energy during continuous transmission. The coolant air pressure drop through the equipment should be 25 ± 5 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)

The HF Transceiver should provide for blower control by use of pin MP3K. Grounding of this pin should disable the normal continuous operation of the blower.

NOTE: Manufacturers have stated that a 400W PEP output is within the "state-of-the-art" and may be implemented at the option of the user. Cooling provisions should be increased for the higher power radio. Based on a 700W power dissipation, the air flow rate should be increased to 154 Kg/hr.

COMMENTARY

Equipment racks in some aircraft cannot supply the air flow rate specified for the HF system. In light of the problem, tests have revealed that reliability should not be significantly degraded when the radio is operated with 125 pounds (57 kilograms) per hour of 40°C, provided that the radio's maximum transmit time is limited to one minute AM modulation with five minute receive periods and the internal blower is operated continuously.

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 HF Transceivers and aircraft installations.

ATTACHMENT ZERO – NOTES PERTAINING TO ATTACHMENTS

Note 11 changed to describe use of pin MP5J.

Note 16 added to describe use of pin MP2F.

ATTACHMENT 1 – STANDARD INTERWIRING

Pin MP2F changed to "Mike Input (Gnd)."

Pin MP5J changed to "Narrow/ Wide Range select."

ATTACHMENT 3 – SCHEMATIC OF 4-WIRE MICROPHONE

Pin MP2F added for alternate grounding methods.

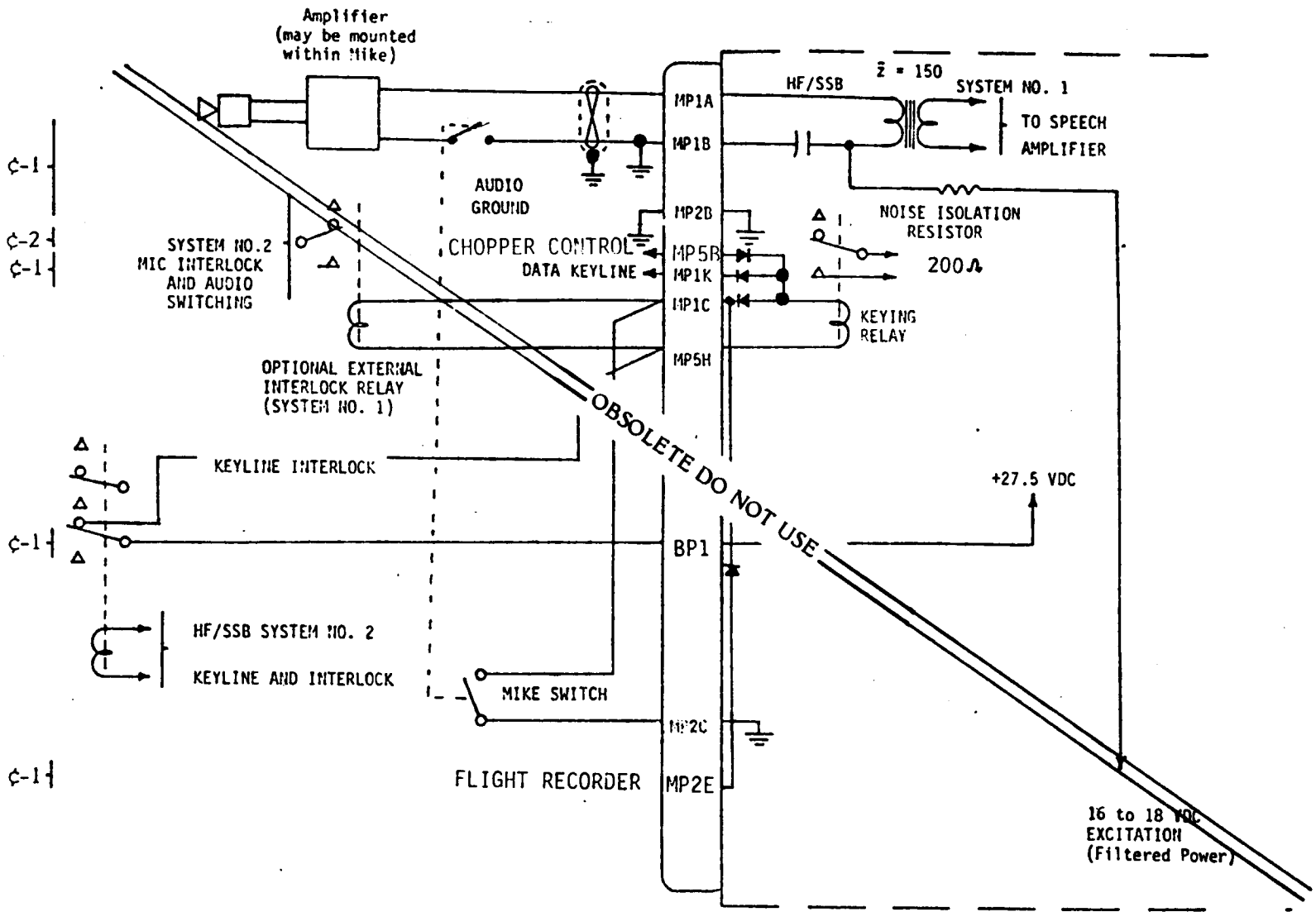
"Chopper Control" pin changed to MP5A (typographical error)

ORIGINAL ON NEXT PAGE:

ATTACHMENT 1

ORIGINAL

SCHEMATIC OF AUDIO GROUNDS
AND USE OF 4-WIRE MICROPHONE
(WITH SYSTEM INTERLOCK RELAYS)



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AMENDMENT

TO

SUPPLEMENT 3

TO

ARINC CHARACTERISTIC 719

AIRBORNE HF/ SSB SYSTEM

Published: May 25, 1982

Prepared by the Airlines Electronic Engineering Committee

Adopted by the Airlines Electronic Engineering Committee: December 10, 1981

A. Purpose of the Amendment

This amendment reinstates into the Characteristic material originally incorporated by Supplement No. 1, inadvertently omitted by Supplement No. 3.

B. Organization of this Amendment

This amendment to Supplement No. 3 contains only white replacement pages 21- 22. A description of changes introduced on page 21 is found in the buff-colored pages of Supplement No. 3, while the description of changes introduced on page 22 is found in Supplement No. 1.

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SUPPLEMENT 4

TO

ARINC CHARACTERISTIC 719

AIRBORNE HF/ SSB SYSTEM

Published: December 23, 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 a pin on the HF/SSB control panel for discrete test of static displays.

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 “C-4” symbols in the margins. Existing copies of Characteristic 719 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 719 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 ZERO – NOTES PERTAINING TO ATTACHMENTS

Note 17 added - explains use of control panel pin 6 for discrete input for static displays test on those control panels utilizing liquid crystal displays.

ATTACHMENT 1 – STANDARD INTERWIRING AND ATTACHMENT 4 – CONTROL PANEL WIRING

Change control panel pin 6 from “SPARE” to “RESERVED, Discrete Input for Static Displays Test”

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SUPPLEMENT 5

TO

ARINC CHARACTERISTIC 719

AIRBORNE HF/ SSB SYSTEM

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Prepared by the Airlines Electronic Engineering Committee

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A. PURPOSE OF THIS SUPPLEMENT

This Supplement introduces a detailed description of Built-In Test Equipment (BITE) and revises portions of the audio output characteristics.

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 "C-5" symbols in the margins. Existing copies of Characteristic 719 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 719-5 already contain this Supplement and thus do not require revisions by the reader.

C. CHANGES TO CHARACTERISTIC 719 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.

3.6.5 Audio Output

Section revised completely.

ORIGINAL TEXT FOLLOWS:

3.6.5 Audio Output

An output isolated from ground having a source impedance of 20 ohms 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 40mW. The nominal setting should be 10mW at 1000 Hz.

3.6.5.1 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.

3.6.5.2 Frequency Response

For SSB the response in the passband of 350-2500 Hz should not vary by more than 6 dB. For AM 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 2900 Hz is desirable. Frequencies above 2900 Hz should be attenuated at least 35 dB and frequencies above 3300 Hz should be attenuated at least 60 dB.

3.6.5.3 Voce 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.

6.0 BUILT-IN TEST EQUIPMENT (BITE)

New section added.

ATTACHMENT 9 - TYPICAL TEST PROCEDURES-AUDIO OUTPUT

New section added.