HF DATA LINK SYSTEM

ARINC CHARACTERISTIC 753

PUBLISHED: DECEMBER 30, 1994

AN ARINC DOCUMENT
Prepared by
AIRLINES ELECTRONIC ENGINEERING COMMITTEE
Published by
AERONAUTICAL RADIO, INC.
2551 RIVA ROAD, ANNAPOLIS, MARYLAND 21401

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Published: December 30, 1994

Prepared by the Airlines Electronic Engineering Committee

Characteristic 753 Adopted by the Airlines Electronic Engineering Committee: October 20, 1994

Adopted by the Industry: December 9, 1994

FOREWORD

Activities of AERONAUTICAL RADIO, INC. (ARINC)

and the

Purpose of ARINC Characteristics

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

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

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

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1.0 INTRODUCTION

1.1 Purpose of This Document

This document contains the physical form and fit dimensions, the electrical interface definition and a description of the functional operation of the airborne components of the High Frequency Data Link (HFDL) communications system. An overview of the associated ground system is also provided. The protocols used in the HFDL system are defined in ARINC Specification 635 "HF Data Link Protocols".

The intent of this document is to provide general and specific design guidance for the development and installation of the airborne equipment. As such, this guidance covers the desired operational capability of the HFDL system and the standards necessary to achieve interchangeability of the airborne hardware. The HF Data Link system has various modes of operation which are described more fully in Chapters 3, 4 and 5.

COMMENTARY

Equipment manufacturers should note that this document aims to encourage them to produce maintenance-free, high performance equipment. They are at liberty to accomplish this by the use of design techniques they consider to be the most appropriate. Their airline customers are more interested in the end result than in the means to achieve it.

1.2 Relationship to Other Documents

This Characteristic introduces functionality into the components of the HFDL by way of reference. Many of these references are to other Airline Electronic Engineering Committee (AEEC) documents. The designer should use the most current version of the referenced document unless a specific version is given. A list of referenced documents is provided in Appendix D for the readers convenience.

1.3 System Overview

The HFDL System consists of the Airborne HFDL System Configuration described in Section 1.3.1 and the Ground System Configuration described in Section 1.3.2.

1.3.1 Airborne HFDL System Configuration

The HFDL avionics system hardware consists of an HF Data Unit (HFDU) or an integrated voice/data HF Data Radio (HFDR). The HFDR provides either voice or data communications services in a simplex mode on demand. The HFDU interfaces with a conventional analog Single Side Band (SSB) HF transceiver already installed in the aircraft to provide voice or data communications services in a simplex mode on demand also. This document assumes that the airborne components implementing HF Data Link are arranged as shown in Attachments 2 through 4 and that they function within the system operating rules specified in ARINC Specification 635, ARINC Specification 637, and ARINC Specification 638.

The HFDL system should have two main modes:

- the Data Mode for digital data transmission as described throughout this document and ARINC Specification 635,

- the Voice Mode, which is identical in function and control as the existing HF Voice Radios, according to ARINC Characteristic 719.

As an HF Packet Communications (HFPAC) bridge, the High Frequency Data Link (HFDL) system is an integral part of the HFPAC/Aeronautical Telecommunication Network (ATN) communications protocol suite. Detailed background of HFPAC/ATN can be found in ARINC Specifications 635, 637 and 638.

COMMENTARY

The use of the HFDL system (Attachments 2 through 4), for sole means of ATN operation depends on the integrity and availability requirements set forth by world wide agencies. Aeronautical operators planning to implement ATN capability may need to install additional equipment.

Depending on the selected mode, the HFDL avionics system operates with a Communications Management Unit (CMU) (see ARINC Characteristic 748), a Management Unit (MU) (see ARINC Characteristics 597, 724 and 724B, and ARINC Specification 618), a Centralized Fault Display Interface Unit (CFDIU) (see ARINC Report 604) or Onboard Maintenance System (OMS) (see ARINC Report 624).

The Aircraft Communications Addressing and Reporting System (ACARS) Management Unit (MU) or Communications Management Unit (CMU) is the onboard router for the Aeronautical Telecommunications Network (ATN). As such, all application messages intended for transmission to the ground are sent onboard to the MU or CMU, which in-turn has the responsibility to determine the most efficient subnetwork over which to transmit the packet, and to route the packet accordingly. The MU or CMU also implements any management protocols required to ensure the continued and correct operation of the various bridges located onboard the aircraft.

1.3.2 Ground System Configuration

The aeronautical HF subnetwork provides air/ground data and voice communications capability. Ground service is provided by a network of HF ground stations strategically located to cover major oceanic air routes as well as continental areas.

The HFDL air/ground subnetwork provides primarily Airline Operational Control (AOC) and Air Traffic Control (ATC) data and voice communications services. Optional services, FAX and voice patch, may also be available at some ground stations.

1.0 INTRODUCTION (cont'd)

1.4 Terms

Antenna: Built-In Antenna; not considered as part of the HFDR

CFDS: Central Fault Display System

Coupler: Antenna tuning device to match the antenna impedance to the 50 ohm coaxial transmission line.

HFDL: High Frequency Data Link; HF Data/Voice Communication Subnetwork Air/Ground.

HFDR: High Frequency Data Radio; used for the airborne HF Transceiver.

HFDU: High Frequency Data Unit. The HFDU contains the Modem for the system when the Modem is a separate LRU.

OMS: On-Board Maintenance System

1.5 Interchangeability

System interchangeability, as defined in Section 2.0 of ARINC Report 607, "Guidance for Designers of Airborne Electronic Equipment", is desired for the HFDR and HFDU. The standards necessary to ensure this level of interchangeability are set forth in Chapter 2 of this document.

1.6 Regulatory Approvals

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

2.0 INTERCHANGEABILITY STANDARDS

2.1 Introduction

This chapter sets forth the specific form factor, mounting provisions, interwiring, input and output interfaces and power supply characteristics desired for the HF Data Radio and HF Data Unit. These standards will permit the parallel, but independent design of compatible equipment and airframe installations.

Unit interchangeability is required for the HF Data Radio, HF Data Unit, and Antenna Coupler, regardless of manufacturing source.

COMMENTARY

In order to achieve the full benefit of the economics offered by these changes, the industry desires that any provisions for backwards compatibility with earlier generations of HF Communications equipment described by ARINC 719 be provided as basic provisions.

The ARINC 753 transceiver (HFDR) is pin- and function-compatible with the ARINC 719 transceiver. When an HF Data Radio is installed in an ARINC 719 slot, (replacing an ARINC 719 transceiver) it should operate with ARINC 719 radio functionality. An HF Data Unit attached to this array would be required to obtain HF Data Link functionality.

2.2 Form Factor, Connector, and Index Pin Coding

The HFDR and HFDU should comply with the dimensional standards in ARINC Specification 600, "Air Transport Avionics Equipment Interfaces (NIC Phase 1)", for the 6 MCU and 4 MCU form factors respectively. The HFDR and HFDU should also comply with ARINC Specification 600 standards with respect to weight, racking attachments, front and rear projections and cooling.

COMMENTARY

The only form factor defined in this Characteristic is the Modular Concept Unit (MCU) defined in ARINC Specification 600. Packaging of the HFDR in accordance with ARINC Specification 404A was not considered desirable. However, some retrofit installations into aircraft racking for ARINC 404A equipment are expected.

The HFDR and HFDU should each be provided with a low insertion force, Size 2 Shell ARINC Specification 600 service connector. This connector, which should accommodate service interconnections in its middle plug (MP) and top plug (TP) inserts and power interconnections in its bottom plug (BP) insert, should be located on the center grid of the HFDR and HFDU rear panel. Index pin code 10 should be used for the HFDR. Index pin code 20 should be used for the HFDU. The pin coding for the HFDR and HFDU are depicted in Attachments 2-3D and 3-3D respectively.

If bench testing of the HFDR and HFDU with Automatic Test Equipment (ATE) necessitates interconnect capabilities that are not covered by the pin assignments on the service connector set forth in Attachments 2-3A through 2-3C and 3-3A through 3-3C (including pins TP4A through TP4D which are designated for unspecified ATE function use) an auxiliary connector should be provided whose type and location are selected by the equipment manufacturer. As this auxiliary connector will not be used while the HFDR or HFDU is installed in the aircraft, it should be provided with a cover to ensure protection from damage, contamination, etc., during that time. The manufacturer should observe the standards of ARINC Specification 600 when choosing the location for the connector. Also, other than accommodating the needs for equipment identification by the ATE described in Section 8 of this document, the manufacturer is free to make whatever use of both the service connector ATE pins and the auxiliary connector pins he wishes.

COMMENTARY

The auxiliary connector is specified to permit completion of the interface without recourse to the use of individual "test leads" from the ATE, each of which has to be clipped, or otherwise secured, to a test point on the equipment.

2.3 Standard Interwiring

The standard interwiring to be installed for the HFDR and HFDU are set forth in Attachments 2-2 and 3-2 respectively. This interwiring is designed to provide the degree of interchangeability specified in Section 1.5 of this Characteristic.

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.

COMMENTARY

The reader is cautioned to give due consideration to the specific notes in Attachment 5 as they apply to the standard interwiring. Manufacturers are cautioned not to rely on special wires, cabling or shielding for use with particular units because they will not exist in a standard installation. Furthermore, manufactures are encouraged to utilize, for ATE purposes, only those pins designated for ATE, and not make use of pins not currently defined or left for customer definition.

2.0 INTERCHANGEABILITY STANDARDS (cont'd)

2.4 Power Circuitry

2.4.1 Primary Power Input

The HFDR should be designed to accept 115 Vac, 400 Hz, three phase power. The HFDR should be protected by a 5 ampere circuit breaker in each phase. The HFDU, if installed, should be designed to accept 115 Vac, 400 Hz, single phase power. The HFDU should be protected by a single 2 ampere circuit breaker. See ARINC Characteristic 413A, "Guidance for Aircraft Electrical Power Utilization and Transient Protection".

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

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

If such subdistribution circuit protection is by means of circuit breakers, the majority of airlines 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 HFDL equipment should accept power variations without adverse effects upon equipment performance. Refer to ARINC Report 413A, "Guidance for Aircraft Electrical Power Utilization and Transient Protection" or ARINC Report 609, "Design Guidance for Aircraft Electrical Power Systems". The equipment should be of such design that it will not be damaged by power supply frequencies and/or voltages below the minimum or exceeding the maximum specified operating voltage and frequency, and if operation is interrupted under these conditions, the equipment should 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 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 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 System Functions and Signal Characteristics

A list of the system functions and signal characteristics required to ensure the desired level of interchangeability for the HFDR and HFDU are set forth in Chapters 4, 5 and 6 of this document and ARINC Specification 635.

2.6 Environmental Conditions

The HFDL Line Replaceable Units (LRUs) should be specified environmentally in terms of the requirements of RTCA Document DO-160C, "Environmental Conditions and Test Procedures for Airborne Electronic and Electrical Equipment and Instruments". Attachment 6 to this document tabulates the relevant environmental categories.

2.7 Cooling

The HFDR and HFDU 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 HFDR installation should provide an air flow rate of 57.2 kg/hr of 40 °C (max.) air and the unit should not dissipate more than an average of 260 watts of power. The standard HFDU installation should provide an air flow rate of 22 kg/hr of 40 °C (max.) air and the unit should not dissipate more than an average of 100 watts of power. The coolant air pressure drop through the HFDR should be 25 $\pm$ 5 mm of water and 5 $\pm$ 5 mm of water through the HFDU at standard conditions. The HFDR and HFDU should be designed to expend this pressure drop to maximize the cooling effect. Adherence to the pressure drop standard is needed to allow interchangeability of the equipment. Continuous transmitter operation without ARINC cooling is permissible as long as the internal blower operates continuously and the ambient air temperature does not exceed 55°C.

COMMENTARY

Although the HFDR and HFDU are packaged in accordance with ARINC Specification 600, some retrofit installations will be made into aircraft racking designed in accordance with ARINC Specification 404A. The cooling provisions of these racking standards were intentionally established such that ARINC 600 equipment would be compatible with ARINC 404A racking. Thus, the HFDR and HFDU cooling provisions are compatible with ARINC 404A aircraft racking.

The HFDR and/or HFDU designer should consider that the HFDR and HFDU will be expected to operate without substantially lower reliability in an aircraft installation in which cooling is not available. A loss of cooling should not cause total loss of functionality, although a partial reduction in output power is acceptable.

COMMENTARY

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

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 HFDR/HFDU and aircraft installation.

2.8 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 as well as Section 6 and Appendix 2 of ARINC Specification 404A on the subject of equipment and radio rack grounding and bonding.

2.9 Standardized Signalling

The standard electrical inputs and outputs from the systems should be in the form of a digital format or switch contact. Standards should be established exactly to assure the desired interchangeability of equipment.

Certain basic standards established herein are applicable to all signals. Unless otherwise specified the signals should conform with the standards set forth in the subsections below.

2.9.1 ARINC 429 DITS Data Bus

ARINC Specification 429 "Mark 33 Digital Information Transfer System (DITS)" is the controlling document for data word formats, refresh rates, resolutions, etc. Material in this document on these topics is included for reference purposes only. In the event of conflict between this document and ARINC Specification 429, the latter should be assumed to be correct.

2.9.2 Standard "Open"

The standard "open" signal is characterized by a resistance of 100,000 ohms or more with respect to signal common.

COMMENTARY

In many installations, a single switch is used to supply a logic input to several LRUs. One or more of these LRUs may utilize a pull-up resistor in its input circuitry. The result is that an "open" may be accompanied by the presence of +27.5 Vdc nominal. The signal could range from 12 to 36 Vdc.

2.9.3 Standard "Ground"

A standard "ground" signal may be generated by either a solid state or mechanical type switch. For mechanical switch-type circuitry a resistance of 10 ohms or less to signal common would represent the "ground" condition. Semiconductor circuitry should exhibit a voltage of 3.5 Vdc or less with respect to signal common in the "ground" condition.

2.9.4 Standard "Applied Voltage" Output

The standard "applied voltage" is defined as having a nominal value of +27.5 Vdc. This voltage should be considered to be "applied" when the actual voltage under the specified load conditions exceeds 18.5 volts (+36 Vdc maximum) and should be considered to be "not applied" when the equivalent impedance to the voltage source exceeds 100,000 ohms.

2.9.5 Standard Discrete Input

A standard Discrete Input should recognize incoming signals having two possible states, "open" and "ground". The characteristics of these two states are defined in Sections 2.9.2 and 2.9.3 of this Characteristic. The maximum current flow in the "ground" state should not exceed 20 milliamperes.

The "true" condition may be represented by either of the two states (ground or open) depending on the aircraft configuration.

COMMENTARY

In the past installations there have been a number of voltage levels and resistances for Discrete states. In addition the assignments of "Valid" and "Invalid" states for the various voltage levels and resistances were sometimes interchanged, which caused additional complications. In this Characteristic a single definition of Discrete levels is being used in an attempt to "standardize" conditions for Discrete signals.

The voltage levels and resistances used are, in general, acceptable to hardware manufacturers and airlines. This definition of Discretes is also being used in the other ARINC 700-Series Characteristics,

2.0 INTERCHANGEABILITY STANDARDS (cont'd)

2.9.5 Standard Discrete Input (cont'd)

COMMENTARY (cont'd)

however, there are a few exceptions for special conditions. The logic sources for the Discrete Inputs to the HFDL system are expected to take the form of switches mounted on the airframe component (flap, including gear, etc.) from which the input is desired. These switches will either connect the Discrete Input pins on the connector to airframe DC ground or leave them open circuit as necessary to reflect the physical condition of the related components. The HFDR and/or HFDU will, in each case, be expected to provide the DC signal to be switched. Typically, this is done through a pull-up resistor. The HFDL system input should sense the voltage on each input to determine the state (open or closed) of each associated switch.

The selection of the values of voltages (and resistances) which define the state of an input is based on the assumption that the Discrete Input will utilize a ground-seeking circuit. When the circuit senses a low resistance or a voltage of less than 3.5 Vdc, the current flow from the input will signify a "ground" state. When a voltage level between 18.5 and 36 Vdc is present or a resistance of 100,000 ohms or greater is presented at the input, little or no current should flow. The input may utilize an internal pull-up to provide for better noise immunity when a true "open" is present at the input. This type of input circuit seems to be the "favorite" among both manufacturers and users.

Because the probability is quite high that the sensors (switches) will be providing similar information to a number of users, the probability is also high that unwanted signals may be impressed on the inputs to the HFDL system from other equipment, especially when the switches are in the open condition. For this reason, equipment manufacturers are advised to base their logic sensing on the "ground" state of each input. Also, both equipment and airframe suppliers are cautioned concerning the need for isolation to prevent sneak circuits from "fouling up" the logic. Typically diode isolation is used to prevent this from happening.

2.9.6 Standard Discrete Output

A standard Discrete output should exhibit two states, "open" and "ground" as defined in Sections 2.9.2 and 2.9.3. In the "open" state, provision should be made to present an output resistance of a least 100,000 ohms. In the "ground" state provision should be made to sink at least 20 milliamperes of current. Non-Standard current sinking capability may be defined.

COMMENTARY

Not all Discrete output needs can be met by the Standard Discrete output defined above. Some Discrete outputs may need to sink more current than the standard value specified above.

A Discrete output may need to source current. Discrete outputs which are to source current should utilize the standard "Applied Voltage" output defined in Section 2.9.4. These special cases will be noted in the text describing each applicable Discrete output function and in the notes to interwiring.

COMMENTARY

Although defined here, Discrete outputs which provide a current output rather than a current sink are not "Standard Discrete outputs".

2.9.7 Standard Program Pin Input

Program pins may be assigned on the HFDR and/or HFDU service connectors for the purpose of identifying a specific aircraft configuration or to select (enable) optional performance. The optional operational function may be in effect at all times or only under certain conditions, such as when the aircraft is on the ground (identified by the enabling of the Air/Ground Discrete input).

COMMENTARY

Program pins may be used for a variety of purposes. Program pins enable a piece of equipment to be used over a greater number of airframe types. One way this is done is by identifying the unique characteristics of the airframe in which the unit is installed. Another is to identify the location (left, right, center) of the unit. Often program pins are used to enable (turn on) options for alternate or extended performance characteristics.

The encoding logic of the Program pin relies upon two possible states of the designated input pin. One state is an "open" as defined in Section 2.9.2 of this Characteristic. The other state is a connection (short circuit i.e., 10 ohms or less) to the pin designated as the "Program Common" pin.

COMMENTARY

Normally, the "primary" location or "usual", "common" or "standard" function is defined by the "open" logic and the optional response is programmed (encoded) by connection to Program Common.

3.0 SYSTEM DESIGN

3.1 Introduction

This section provides background information for the design of the HFDL airborne equipment. The HFDL airborne equipment consists of the HF Data Radio or an HF Data Unit combined with an HF Transceiver. Detailed specifications for the HFDR and HFDU are given in Sections 4 and 5 respectively.

3.2 System Design

HF Data Link provides the capability to send Airline Operational Control (AOC) and Air Traffic Control (ATC) data to and from aircraft equipped with either an ACARS Management Unit (MU) or a Communications Management Unit (CMU also referred to as ATN Router). HF Data Link capability on the aircraft side should be provided by means of the standard configurations A shown in Attachment 2-1A and configurations B shown in Attachments 3-1A, 3-1B and Attachment 3-1C respectively.

In configuration A, all HFDL functions are implemented in an HF Data Radio (HFDR) which interfaces directly to a MU or CMU via a pair of ARINC 429 busses.

In configuration B, all HFDL functions except for transmission/reception via HF radio are implemented in an HF Data Unit (HFDU) which interfaces to a MU or CMU via a pair of ARINC 429 buses and to a HF transceiver. The HF transceiver may be a transceiver which complies with ARINC 719 or an older generation HF transceiver which complies with ARINC 559A.

Standard configurations A and B specify that the MU or CMU have two ARINC 429 ports dedicated to transmission and reception of HFDL downlink and uplink data. In addition, all decision making regarding the use of HF versus VHF or Satellite Communications (SATCOM) resides in the MU or CMU.

3.2.1 AOC and ATS

AOC services and Air Traffic Services (ATS) are provided using frequencies that are dedicated to these services. HFDL ground stations which provide overlapping or adjacent AOC/ATS service coverage in a given area operate on different frequencies in order to avoid mutual interference.

COMMENTARY

AOC/ATS frequencies may be re-used in sufficiently separated coverage areas. AOC/ATS services are provided to ground and air users equipped with ACARS and ATN data communications equipments on the same AOC/ATS frequencies. Thus, in some aircraft the HFDU or HFDR will interface with an ACARS Management Unit while in others they will interface with a Communications Management Unit.

The air/ground protocols used to provide AOC/ATS packet data communication services are defined in ARINC Specification 635.

3.2.2 Other Services

Other services may be available at some ground stations.

COMMENTARY

The HF Data Link Subcommittee recognized that the primary use of HF Data Link should be for ATC and AOC purposes. At some future date if excess capacity is available then other services such as AAC and APC may be added.

3.3 HFDL Avionics Components

Along with the Satellite Data Unit (SDU), the Mode S Airborne Data Link Processor (ADLP), and the VHF Data Radio (VDR), the HF Data Link avionics is a bridge to the ground. The HFDL components implement layers one and two as well as functions of layer three of the ACARS/Aeronautical Telecommunications Network (reference ARINC Specification 635), and as such is responsible for all functionality associated with those layers. See Attachment 1.

COMMENTARY

HF Data Link can support ATN air-ground data transmissions. The integrity and availability of the various transmission media may not be similar. Full ATN capability may have to be realized by integrating multiple systems.

3.3.1 HF Data Radio

The HF Data Radio (HFDR) provides the means to process, transmit and receive data as well as analog voice. The HFDR Transceiver should operate on frequencies spaced 100 Hz apart in the 2-30 MHz band. Simultaneous analog voice and data transmission is not required. Voice transmission should be compatible with current Single Side Band (SSB) HF transceivers. Data transmission should also be compatible with ground HF transmitting and receiving systems which may use conventional SSB HF transceivers.

The HFDR system performs the following functions:

a. Single Side Band simplex transmission and reception of analog voice or digital data (selectable, but not simultaneous) in a standard channel in the aeronautical HF bands as defined in Section 4 and subsections.

b. Encoding and modulation of digital data, and demodulation and decoding of digital data as defined in ARINC Specification 635.

c. HF frequency search and link acquisition per the protocols defined in ARINC Specification 635.

d. Error-free air/ground data exchange in an environment where multiple aircraft share the same communications channel using the protocols defined in ARINC Specification 635.

3.0 SYSTEM DESIGN (cont'd)

3.3.1 HF Data Radio (cont'd)

e. Exchange of downlink and uplink data with the MU or CMU per the protocols defined in ARINC Specification 635.

f. SELCAL output lines to a selective calling decoder elsewhere in the aircraft for the purpose of alerting the pilot of an incoming voice call.

g. Analog Data Input and Output for compatibility with ARINC 719 retrofit installations. These connections are used with external modem equipment where an HFDR transceiver is being used as a spare with an external HFDU or where some other type of modem waveform is desired (non-HFDL type).

COMMENTARY

Simplex operation (antennas)(radio transmitters) is a method of operation in which communication between two stations takes place in one direction at a time. Note: This includes ordinary transmit-receive operation, press-to-talk operation, voice operated carrier and other forms of manual or automatic switching from transmit to receive.

3.3.2 HF Data Unit

The HFDU provides the means to process, transmit and receive data via a standard ARINC 719 or ARINC 559A conventional SSB HF transceiver tunable over the HF band (2-30 MHz).

The HFDU interfaces with the MU or CMU as shown in Attachment 3-1A, 3-1B and 3-1C.

The HFDU system performs the following functions:

a. HF transceiver tuning and control as defined in Section 5.5 and subsections.

b. Encoding and modulation of digital data and demodulation and decoding of digital data as defined in ARINC Specification 635.

c. HF frequency search and link acquisition per the protocols defined in ARINC Specification 635.

d. Error-free air/ground data exchange in an environment where multiple aircraft share the same communications channel using the protocols defined in ARINC Specification 635.

e. Exchange of downlink and uplink data with the MU or CMU per the protocols defined in Section 5.8 of this document and ARINC Specification 635.

3.3.3 HF Data Link Control Functions

The switching of the HFDR or the HFDU/HF transceiver combination between voice and data modes is accomplished by means of an HF Data Control Function (HFDCF) defined in Section 6. This function may be integrated into a Radio Control Panel (RCP), a centralized radio management system or it may be provided in a separate HF Data Control Panel (HFDCP) at the discretion of the airline and/or the airframe manufacturer.

When the HFDR or the HFDU/HF transceiver combination are in the voice mode, frequency tuning is controlled by the crew from the centralized radio management system or Radio Control Panel. When the HFDR or the HFDU/HF transceiver combination are in the data mode, frequency tuning is controlled by the HFDL functions implemented in the HFDR or the HFDU respectively.

3.4 Optional Additional Components

The provisions explained in the following sections should not be included in the basic provision for the airborne HFDL system, but can be provided additionally by suppliers.

3.4.1 Central Maintenance System

The HFDR communicates with the Central Maintenance System (CMS)/Centralized Fault Display Interface Unit (CFDIU), according to ARINC Report 604, "Guidance for Design and Use of Built-In Test Equipment (BITE)", which will be the repository for maintenance information; otherwise the CMU should maintain this database. Reference Section 9.2 of this document.

3.4.2 Analog Data Operation

The HFDR contains an analog data system interface as defined in ARINC Characteristic 719; pinouts have been reserved for this option. Reference Attachment 2-2.

If the optional analog data system component interface is provided, the HFDR may be used as an ARINC 719 HF communication radio for both voice and data. The data mode would be provided by an external modem which would provide either ARINC Specification 635 type data functionality or some other user desired protocol. This is provided so that HFDR transceivers can be used as universal spares in that they can be used in either an ARINC 719 or ARINC 753 slot.

3.5 Interlocks on Dual HFDR Systems

Each system should contain interlocking circuitry tailored to ensure satisfactory automatic tune-up when two systems are installed on the same aircraft.

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 re-tuning, the system should be designed so that the one unit will automatically be re-tuned after the other has completed its re-tuning.

3.0 SYSTEM DESIGN (cont'd)

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.

3.6 HFDR and HFDU Modes of Operation

The HFDR and HFDU/HF Transceiver combination operate in voice or data modes. The switching between these modes is controlled by the crew from an HF Data Control Function (HFDCF) in the cockpit. When the HFDR or HFDU/HF Transceiver combination is in the voice mode, the Multifunction Control Display Unit (MCDU) should display HF Data Link-In-Voice to alert the crew. The information needed to display this warning is sent by the HFDR/HFDU to the MU/CMU via an ARINC 429 interface.

3.6.1 HFDR Mode Select

An HFDL mode enable discrete input, TP7G, from the HFDCF to the HFDR is used to place the system in the voice or data mode. The details are defined in Section 4.6.1.

In the voice mode, the HFDR operates as an ARINC 719 HF transceiver. The cockpit audio input modulates the SSB carrier when the PTT is keyed. The frequency is selected from a dedicated HF Radio Control Panel or a Radio Management Panel in the cockpit connected to the serial ARINC 429 or to the parallel tuning ports on the HFDR.

In the data mode, the HFDR performs all HF Data Link functions defined in ARINC Specification 635. Downlink/uplink data is exchanged with the MU/CMU via a pair of ARINC 429 ports. The cockpit audio, PTT, and frequency control and tuning signals should be ignored.

The HFDR sends a status word to the MU/CMU periodically to inform it whether the HFDR is in the voice or data mode.

3.6.2 HFDU/HF Transceiver Combination Mode Select

A Voice/Data mode Discrete input, MP12D, from the HFDCF to the HFDU is used to place the HFDU in the voice or data mode. The details are defined in Section 5.2.

When in the data mode, the HFDU controls the tuning of the HF transceiver and performs the HF Data Link functions defined in ARINC Specification 635. Downlink/uplink data is exchanged with the HF transceiver via transmit and receive audio lines, and with the MU/CMU via a pair of ARINC 429 ports. In the voice mode, the HFDU stops data transmission and reception functions.

The HFDU sends a status word to the MU/CMU periodically to inform it whether the HFDU/HF transceiver combination is in the voice or data mode.

Switching of the HF transceiver between voice and data modes depends on the type of HF transceiver. Three different cases need to be considered.

3.6.2.1 ARINC 719 HF Transceiver Controlled By Discretes

In these installations (Frequency Source Select, pin MP2K, open), the ARINC 719 transceiver has separate audio ports for voice and data communications, and separate voice PTT and data keylines. A Voice/Data Mode Select Discrete input, MP2D, from the HFDCF to the HF transceiver is used to select between the voice and data audio and keyline ports.

In addition, the tuning of the transceiver to voice frequencies is controlled from a dedicated HF Radio Control Panel in the cockpit connected to one of the transceiver serial ARINC 429 frequency tuning ports, generally Port B, MP3G and MP3H. ARINC 429 words with Label 037 are used to tune the HF transceiver to the appropriate voice frequency. The second serial ARINC 429 frequency tuning port, generally Port A, MP3E and MP3F, is connected to the HFDU (See Attachment 3-1A). The HFDU should also use ARINC 429 words with Label 037 to tune the HF transceiver to the appropriate data frequency. A Frequency Port Select Discrete input, MP3J, from the HFDCF to the HF transceiver is used to select between Frequency Tuning Ports A and B. The state of the Frequency Port Select Discrete should be tied to the state of the Voice/Data Mode Select Discrete, MP2D.

3.6.2.2 ARINC 719 HF Transceiver Controlled By ARINC 429 Words

In these installations, (Frequency Source Select, pin MP2K, grounded), the ARINC 719 transceiver also has separate audio ports for voice and data communications, and separate voice PTT and data keylines. However the Voice/Data Mode Select Discrete input, MP2D, to the HF transceiver is ignored by the radio. Instead, an ARINC 429 word with Label 207 should be used to place the HF transceiver in the voice or data mode. In addition, the tuning of the transceiver to voice frequencies is controlled from the Radio Management System in the cockpit which is normally connected to both serial ARINC 429 frequency tuning Ports A and B. ARINC 429 words with Label 205 are used to tune the HF transceiver to the appropriate voice frequency.

In order to provide HDFL capability in these installations with the addition of an HFDU and an HFDCF, the Radio Management System should be disconnected from the ARINC 429 Frequency Tuning Port A and connected only to the ARINC 429 Frequency Tuning Port B MP3G/H as shown in Attachment 3-1B. The capability to tune the HF transceiver to a voice frequency from either of the two Radio Management Panels which comprise the Radio Management System should still be retained.

The Voice/Data Mode Select discrete input, MP2D, to the HF transceiver from the HFDCF need not be connected. The data frequency tuning ARINC 429 serial output from the HFDU should be connected to the serial ARINC 429

3.6.2.2 ARINC 719 HF Transceiver Controlled By ARINC 429 Words (cont'd)

Frequency Tuning Port A, MP3E/F, of the HF transceiver as shown in Attachment 3-1B. The HFDU should also use ARINC 429 words with label 207/205 to place the transceiver in data mode and to tune the HF transceiver to the appropriate data frequency. A Frequency Port Select discrete input, MP3J, from the HFDCF to the HF transceiver should be used to select between Frequency Tuning Ports A and B.

3.6.2.3 ARINC 559A HF Transceiver

In these installations, the ARINC 559A HF transceiver audio ports and keyline (PTT) should be shared between the cockpit audio and HFDU data audio and Data Keyline. In addition, the ARINC 559A HF transceiver has a single parallel discrete tuning input which should also be shared between the Radio Control Panel and the HFDU to tune the radio to the voice or data frequency, respectively.

A function which switches between cockpit and HFDL audio, keying, and tuning signals based on the state of the Voice/Data Mode Discrete input, MP12D, from the HFDCF should be implemented either in the Radio Control Panel, or the HFDU, as shown in Attachment 3-1C, at the discretion of the aircraft operator.

4.0 HF DATA RADIO DESIGN

4.1 Introduction

This section sets forth the specifications for the HF Data Radio transmitter and receiver parameters. The HF Data Radio (HFDR) provides the primary functions of voice and data link. For compatibility with existing ARINC 719 installations the HFDR also provides Amplitude Modulated Equivalent (AME), Continuous Wave (CW), Selective Calling (SELCAL) and Analog Data functions. In addition to providing traditional HF radio functionality the HFDR contains an internal data modem and controller. The data communications protocols to be implemented in the HFDR are defined in ARINC Specification 635.

4.2 Transceiver

4.2.1 Tuning

The HFDR transceiver can be tuned by either parallel Re-Entrant type tuning or by ARINC 429 Serial type tuning. The HFDR unit should be able to automatically determine which type of tuning is being provided to it. When operating in the HFDL "data" mode the HFDR transceiver should disregard external frequency tuning controls as the frequency will be internally controlled by the data link processor.

4.2.1.1 Frequency Switching Time

The transmitter channel/frequency change time (power amplifier tuning) should not exceed 1 second (excluding coupler tune time) when changing from one transmit channel/frequency to another transmit channel/frequency. Tuning should be initiated by the operation of the Push-to-Talk (PTT) or keyline.

COMMENTARY

Designers of the HFDL system should realize that the existing ARINC 719 equipment can take as long as 400 ms to change bands. As the protocol evolves, this timing should be kept in mind in order that the HFDL system should retrofit into existing ARINC 719 installations. The following sections detail new timing characteristics that should be met by newer ARINC 753 Equipment.

COMMENTARY

The HFDL controller should scan frequencies from highest to lowest as this minimizes the number of rotations of the bandswitch assembly in existing 719 transceivers. This should result in faster switching of frequencies.

Voice Mode

The HFDR transmitter should be tunable to any frequency in the HF range within 250 ms, excluding power amplifier and coupler tune time.

The HFDR receiver should be tunable to any frequency in the HF range within 250 ms.

Data Mode

When controlled by the link processor in the HFDR Transceiver, the transmitter should be tuned to the appropriate frequency. The HF transceiver should be tunable to any frequency in the HF range within 250 ms, excluding power amplifier and coupler tune time.

When listening for a squitter, the receiver scans over the systems HF frequency pool and listens to each of the frequencies for approximately 35 seconds. The receiver should be tunable to any frequency in the HF range within 250 ms.

4.2.2 Transmitter - Receiver Interaction

The HFDR should operate in a simplex mode with transmit/receive switching times no worse than with those of ARINC 719 and ARINC 559A HF transceivers.

4.2.2.1 Transmit to Receive Turnaround Time

Voice Mode

With the receiver squelch set to operate at 3 μV, the receiver should recover after transmission to provide 90% of its output at an input level of 10 μV modulated 30% at 1 kHz in less than 100 ms.

Data Mode

The receiver should recover after transmission to provide 90% of its output at an input level of 10 μV modulated 30% at 1 kHz in less than 100 msec.

4.2.2.2 Receive to Transmit Turnaround Time

Voice Mode

The Transmitter power output should reach 90% of its rated output power within 250 ms from the time the Microphone Key (MP1C) line is grounded.

Data Mode

The Transmitter power output should reach 90% of its rated output power within 250 ms from the time the Analog Data Key (MP1K) line is grounded.

COMMENTARY

When the HFDR transceiver is operated with the ARINC 719 type coupler attached, the coupler inserts a delay of 125 ms between the time the keyline is activated and the time the coupler returns "Key Interlock" back to the transceiver. This creates a delay in the transmitter coming on the air. For the data function this delay, in addition to other delays, necessitates the prekey as described in the ARINC 635 Specification.

HFDR transceivers should exceed the above specifications. However, the HFDL system is capable of withstanding the specified delay to allow compatibility with older ARINC 719 transceivers.

4.0 HF DATA RADIO DESIGN (cont'd)

4.2.2.2 Receive to Transmit Turnaround Time (cont'd)

COMMENTARY

HFDR Transceivers do not have an HFDL data keyline external to the unit so these delays should be accounted for internal to the unit hardware and software.

4.3 Transmitter

4.3.1 Power Output

Power output should be measured in terms of peak envelope power (PEP) and measured directly in accordance with permissible distortion and spectrum limits with two tones applied to the transmitter (rather than utilizing the method recommended by the International Radio Consultative Committee (CCIR)). Power output should be measured at nominal line voltage working into a 50 ohm resistive load. A proportional 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.

COMMENTARY

R.F. Power amplifiers typically have average power limiters that are set to 125 W average power. When running the tests specified below that require 400 W PEP power output using a two tone test, the average power ALC circuit may be defeated. Normal duty cycle and cooling requirements should be observed during testing to avoid overheating.

4.3.1.1 SSB Suppressed Carrier

The transmitter output should be 400 watts PEP, +1 dB, -1.5 dB when measured per Section 4.3.1.

4.3.1.2 SSB Full Carrier (AME)

The transmitter output should be 125 watts average, +1 dB, -1.5 dB into a 50 ohm load. The output should be measured with the sideband amplitude equal to the carrier amplitude.

4.3.1.3 Tune Power

In the tune mode, the HF transmitter should output a power level of 70 to 100 watts into a 50 ohm load.

4.3.1.4 VSWR Tolerance

The HF transmitter should be able to operate with a load VSWR of 2.0:1. The transmitter should not be damaged when the load is either an open or a short circuit at the transceiver antenna connector.

4.3.1.5 Transmit Duty Cycle

The transmitter should be rated for continuous Amplitude Modulated Equivalent (AME) transmit when supplied with continuous 360 lbs/hr cooling air and the ambient temperature does not exceed 55 °C. The transmitter should be duty cycle rated for 1-minute AME transmit, 4-minute receive, when supplied with 125 lbs cooling air at 55 °C ambient temperature.

The transmitter should be rated for continuous operation at 55 °C ambient temperature as long as the internal blower operates continuously by ungrounding pin MP3K of the aircraft rear connector.

4.3.2 Frequency Stability

The maximum frequency error of 20 Hz between actual and selected frequency should be held under all environmental conditions for which the equipment is designed.

Adjustments of the frequency to correct for slow random or non-random drifts should be required no more often than every year (approximately 4000 hours operating time).

The frequency reference means should be designed so 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 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.

4.3.3 Phase Stability

The phase jitter caused by the transmitting path between the (analog) input from the modem and the power output should not exceed 3 degrees rms measured in a 500 microsecond sampled interval.

4.3.4 Audio Input

Microphone Input

The HFDR should work with microphones designed as per ARINC Characteristic 538A and ARINC Characteristic 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 ohm

c) Load resistance: 150 ohm

4.0 HF DATA RADIO DESIGN (cont'd)

Analog Data Ports

A separate pair of transmitter audio input leads, labelled "Analog Data In Hi" and "Analog Data In Lo" should be provided, isolated from ground and from other internal circuitry for DC and having an input impedance of 600 ohms. A service adjustment should be provided independently of the audio input to the transmitter to control the input level.

4.3.4.1 Input Level

Microphone Input

Nominal audio input level should be 0.25 Vrms and should provide for adjustment of input levels from 0.1 Vrms to 5.5 Vrms.

Analog Data Ports

The data audio input level should be 0.5 Vrms nominal with provision for adjustment for levels of 0.1 to 5.5 Vrms into 600 ohms.

4.3.4.2 Audio Processing and Modulation Limiting

Microphone Input

It is desirable that some form of speech processing be included with sufficient extra gain, still meeting the microphone input level specifications of Section 4.3.4.1. 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 4.3.4, and with full rated PEP output as in Section 4.3.1, an increase of 10 dB in the steady-state input signal level should not result in spectrum output extending beyond the limits.

COMMENTARY

The foregoing specifications are for design purpose and have no relation to the adjustment procedures that are employed in an actual operating environment.

Analog Data Ports

No waveform 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 data signals.

4.3.4.3 Frequency Response

Microphone Input

The overall frequency response measured from the microphone audio input should not vary more than from +2 to -6 dB with respect to the 1 kHz reference level through the range of 350 Hz to 2.5 kHz.

Analog Data Ports

The overall frequency response should not vary by more than ± 4 dB from a 1 kHz reference level over the frequency range of 350 to 2500 Hz.

4.3.4.4 Transmit Audio Distortion

With transmitter power output on single-sideband of 400 W 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 W PEP output level.

It is recognized that the spectrum performance characteristics of the transmitter set forth in Sections 4.3.6 and 4.3.6.1 are far more stringent on the design of the transmitter and its linearity than is this specification for distortion of the audio signal.

COMMENTARY

In the event that a manufacturer chooses to exceed the specified power output specified under Section 4.3.1 or wishes to design a SSB System complying with ARINC Characteristic 719 in all respects except with a lesser rated power output than specified in Section 4.3.1, it should be understood that the transmitter distortion be within the limits as specified above and with spectrum limitations as set forth in Section 4.3.4.3 and with the automatic modulation limiting of Section 4.3.4.2, but with each of these test specifications modified watt figure specified under Section 4.3.1 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 specifications 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 that output at which the distortion and spectrum limitations specified herein can be met or exceeded.

4.3.5 Transmitter Keying

Operation of the PTT or data keyline should cause the transmitter to operate in the transmit mode. When operating in the Data Mode the HF Data Link Modem should control the keyline functions. When powered "off", the HFDR should not cause a "key event" to occur.

4.3.6 Occupied Spectrum

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

4.0 HF DATA RADIO DESIGN (cont'd)

4.3.6 Occupied Spectrum (cont'd)

a two-tone test on SSB-suppressed carrier transmission or with a single-tone test with SSB-full carrier transmission:

a) All spectrum components at a frequency lower in frequency than 100 Hz below the carrier frequency and higher in frequency than 2.9 kHz above the carrier frequency should be attenuated at least 30 dB below PEP.

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 at least 38 dB below PEP.

c) With the exception of emissions on a harmonic of the desired frequency, all other spectrum components lower in frequency than 6.1 kHz below the carrier frequency and higher in frequency than 8.9 kHz above the carrier frequency should be attenuated at least 54 dB and preferably 60 dB or more below PEP.

d) Any emissions on a harmonic of the desired frequency should be down at least 43 dB below PEP as measured in a 50 ohm load. All intermodulation distortion and spurious radiation should be at least 43 dB below PEP.

The above specifications should be met with the introduction of any modulation tone or tones either inside or outside the transmitter frequency response bandwidth.

4.3.6.1 Intermodulation Distortion

Whether or not speech processing is included, automatic modulation limiting should be provided such that when adjusted for proper input level, with full rated PEP output, an increase of 10 dB in the steady-state input signal level should not result in spectrum output extending beyond the limits. Intermodulation distortion products of the 3rd and 5th order should be at least 24 dB below either tone of a two tone test signal at full rated output power. The 7th order products should be at least 34 dB below either tone.

4.3.6.2 Harmonics

All harmonically related spurious emissions should be not less than 43 dB below full rated output when measured into a 50 ohm resistive load at full rated output power.

4.3.6.3 Non-Harmonics

All non-harmonically related spurious emissions should be less than 25 microwatts when measured into a 50 ohm resistive load at full rated output power and more than 20 kHz frequency offset.

4.3.7 Tone Tuning Signal

A tuning tone signal should be generated within the HFDR Transceiver and should be mixed into the sidetone output channel at the appropriate level specified. A service adjustment of this level is desirable within the HFDR Transceiver. Within the HFDR Transceiver the tone signal should be generated whenever tuning is in progress.

4.4 Receiver

4.4.1 Sensitivity

With a 1 μV (hard) signal, the signal plus-noise-to-noise ratio should be $\leq$ 10 dB for SSB operation. With a 4 μV (hard) signal, amplitude modulated 30% at 1 kHz, the signal plus-noise-to-noise ratio should be 10 dB for AM operation.

4.4.2 Selectivity

COMMENTARY

The users of this document should be aware that the receiver selectivity characteristics, in this document, have been improved over those in ARINC Characteristic 719 to improve the performance in the data mode.

4.4.2.1 SSB Suppressed Carrier

The receiver passband should be defined such that the amplitude should not vary more than 2 dB for input frequencies between f_c + 350 Hz and f_c + 2500 Hz, where f_c is the carrier frequency. The attenuation of the signal should be at least 35 dB from f_c to f_c - 300 Hz, and from f_c + 2900 Hz to f_c + 3300 Hz. The attenuation should be at least 60 dB for frequencies less than f_c - 300 Hz or greater than f_c + 3300 Hz. See Attachment 8 for a graphical depiction.

4.4.2.2 Amplitude Modulated Equivalent (AME)

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

4.4.2.3 Group Delay

The group delay of the HFDR should not vary by more than 0.5 ms over the passband of 350 Hz to 2500 Hz between the antenna port and the Analog Data Output, MP1F and MP1G.

COMMENTARY

The users of this document should be aware that the receiver group delay characteristics were not included in ARINC Characteristic 719. Group delay has been included in this document to improve the performance in the data mode.

4.4.3 Frequency Stability

The receiver frequency stability should conform to Section 4.3.2 of this document.

4.4.4 Spurious Responses

All spurious responses, including images, should be down at least 60 dB. All spurious responses within the HF frequency band should be down at least 60 dB and preferably 80 dB.

4.4.5 Audio Output

Audio/Sidetone Output

An audio output should be provided which is isolated from ground. A service control should be provided within the transceiver for adjustment of the output level. The adjustment should vary the output from 5 mW to 50 mW into a 600 ± 20% ohm resistive load. The nominal setting should be 10 mW at 1 kHz. 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.

Analog Data 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 -10 dBm to +10 dBm into a 600 ± 20% ohm resistive load. The nominal setting should be 0 dBm at 1 kHz. The output should be able to endure a short circuit (zero ohms) and open circuit, and should operate normally after removal of the short or open. The output level should be independent of the effects of the squelch and noise limiter circuits.

4.4.5.1 Source Impedance

Audio/Sidetone Output

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 1000 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 kHz.

Analog Data Output

The data output should have a source impedance of 100 ohms or less.

4.4.5.2 Gain

The receiver gain should be such that a 2 μV signal modulated 30% at 1 kHz will produce at least 10 mW of output into a 600 ohm ± 20 % resistive level.

4.4.5.3 Frequency Response

Audio/Sidetone Output

The audio power output level should not vary more than 4 dB over the frequency range 300 Hz to 2.5 kHz with respect to a reference level of up to 10 mW established at 1 kHz with a constant input carrier level modulated 30%. A sharp cut-off in response below 300 Hz and above 2.5 kHz is desirable. Frequencies above 3.75 kHz should be attenuated at least 20 dB and preferably 40 dB.

Analog Data Output

The audio power output level should not vary more than 4 dB over the frequency range 300 Hz to 2.5 kHz with respect to a reference level of 1 mW established at 1 kHz with a constant input carrier level modulated 30%. A sharp cut-off in response below 300 Hz and above 2.5 kHz is desirable. Frequencies above 3.75 kHz should be attenuated at least 20 dB and preferably 40 dB.

4.4.5.4 Distortion

Audio/Sidetone Output

With an input signal of 1 mV modulated with 1 kHz and the receiver gain adjusted to produce 10 mW into a 600 ohm resistive load, the total harmonic distortion should not exceed 5% with 30% modulation or 10% with 90% modulation (with the gain control reset to maintain the output at 10 mW), including any effects of the noise limiter.

Analog Data Output

With an input signal of 1 millivolt modulated with 1 kHz and the receiver gain adjusted to provide 0 dBm into a 600 ohm resistive load, the total distortion should not exceed 5 percent in SSB.

4.4.5.5 Hum Level

Hum and noise in the receiver output should be at least 40 dB below 10 mW output with a reference input of 1 mV modulated with 1 kHz and 30% AM.

4.4.5.6 Phase Shift

Audio/Sidetone Output

With 1 mV modulated with 1 kHz and the output level adjusted for 10 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 Selective Calling (SELCAL) output due to the number of stages required for the processing of each signal.

Analog Data Output

With 1 mV modulated with 1 kHz and the output level adjusted for 10 mW into a 600 ohm resistive load, the analog data 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.

4.0 HF DATA RADIO DESIGN (cont'd)

4.4.5.7 Phase Stability

Analog Data Output

The phase jitter caused by the receiving path between the antenna input and the (analog) output to the modem should not exceed 3 degrees rms measured in a 500 microsecond sampled interval.

4.4.6 Automatic Gain Control

Variation of percentage modulation should have negligible effect on the automatic gain control.

The receiver output should not vary more than 6 dB with input signals between 5 μV and 100 mV. The output should not increase by more than 2 dB from 100 mV to 1 V input level. The receiver should not overload with 1 V (hard) RF energy applied to the antenna terminals. The receiver should not be damaged with 20 volts of RF energy (hard) applied to the antenna terminals. Recovery time of the protection circuit should be less than 0.5 seconds.

COMMENTARY

> The test procedure for measuring AGC time constant is described in RTCA DO-163 Appendix B, Test Procedure T-1. A method similar to step C can be used to test the protection circuit recovery. Input 20 V and switch to a 1 V signal. Measure the recovery time.

4.4.6.1 Voice Mode

Voice Mode Time Constants

The attack time for a 60 dB increase in RF signal (step function) should be less than 50 ms.

The decay time for a 60 dB decrease in RF signal (step function) should be between 1 and 2 s.

4.4.6.2 Data Mode

Data Mode Time Constants

The attack time for a 60 dB increase in RF signal (step function) should be less than 10 ms.

The decay time for a 60 dB decrease in RF signal (step function) should be typically 25 ms, including a hold time.

4.4.6.3 Settling Time

The automatic gain control of the receiver should be capable to control slow level variations of the input signal of $\pm$ 5 dB with a loop settling time of typically 20 dB/sec.

4.4.7 RF Sensitivity Control and/or Squelch Control

Inasmuch as some customers may desire to use an RF Sensitivity Control while other customers may 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 Receive/Transmit (R/T) Control Data Bus provided as shown in the standard interwiring. Note that although the standard R/T Control Data Bus might provide for both a squelch control and an RF sensitivity control to be employed at the panel, the set design need not provide for operation of the receiver with both controls as it is not expected that both controls should be used in a particular aircraft installation. The user should determine which he wishes to employ in a particular aircraft, depending upon the mode of operation employed with the SSB equipment, and therefore, should decide whether a control panel containing a squelch control, or a control panel containing an RF sensitivity control should be utilized. The control panel should be so designed that a given R/T Unit is 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.

COMMENTARY

> 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 should 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, so that SELCAL reception should 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 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.

The RF sensitivity and squelch can also be controlled via the Label 207 word on the ARINC 429 control bus input. Bit 22 of the Label 207 word defines if the next 7 bits represent the magnitude of the squelch control or the RF sensitivity control. A binary one represents RF sensitivity and a binary zero represents squelch. Bits 23 through 29 are defined for the magnitude of the resistance. Bit 29 is the most significant bit and bit 23 is the least significant bit. A binary 0000000 represents 0 ohms and a binary 1111111 represents a resistance of 5000 ohms. The HFDR transceiver should automatically determine if

4.0 HF DATA RADIO DESIGN (cont'd)

analog or digital squelch/RF sensitivity is being used. In the event both analog and digital is provided, the digital ARINC 429 should prevail. When the HFDR transceiver is operated in the data mode, squelch should be set to squelched and the sensitivity should be set to max.

COMMENTARY

Existing ARINC 719 radios do not support ARINC 429 type control of RF sensitivity and squelch. These bits were allocated by the ARINC 429 Specification, but not very well defined. This Characteristic is now defining them for implementation in new ARINC 753 type HFDRs.

4.4.8 SSB Mode Linearity

With the HFDR in the SSB mode with any two-tone test signal corresponding to any signal level from threshold sensitivity to 20 mV, the intermodulation product (difference frequency of the two test tones) should be at least 40 dB and preferably 50 dB below the output of the two desired tones. Furthermore, at signal levels up to 100 mV, the intermodulation product should be at least 30 dB below the output of the two desired tones.

Interfering Signal Linearity

With a 1.2 kHz single tone SSB signal applied, having any level from threshold sensitivity level to 100 mV, and with an interfering carrier applied 3 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 mV and preferably 100 mV before the 1.8 kHz intermodulation product equals the level of the 1.2 kHz desired signal output.

4.5 SELCAL 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.

4.5.1 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 Hz and 1.5 kHz.

4.5.2 Distortion

With an input signal of 1 mV modulated 30% at 1 kHz and the level adjusted to provide 0.5 V output into 600 ohms, the total distortion should not exceed 5.0%.

4.5.3 Phase Shift

With 1 mV modulated with 1 kHz and the output level adjusted to 0.5 V 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 +225° or less than +135°.

COMMENTARY

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

4.5.4 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 sec.

4.6 HFDR - System Interface

4.6.1 HF Voice/Data Mode Switching

The HFDR should monitor a discrete input, TP7G, from an HF Data Control Function (HFDCF) to determine whether to go into voice or data mode. See Section 6 for a definition of the HFDCF functions. If the discrete input is "high", the HFDR should operate in the voice mode, and if it is "low" it should be in the data mode. The HFDR transceiver should "pull up" the HFDL Mode Enable input so that if the HFDR is installed in an ARINC 719 type tray (no HFDCF installed) it will automatically default to "voice mode".

In the voice mode, the HFDR should inhibit all data transmission and reception functions and periodically send notifications of its status to the MU/CMU using an ARINC 429 Label 270 status word. To prevent possible corruption of the voice mode, the transmitter data keyline, MP1K, and data input, MP4A & MP4B, should be inhibited.

In the data mode, the HFDR should perform the air/ground data transfer protocols defined in ARINC Specification 635 including the specific functions defined in the following sections. Likewise, when in the data mode the voice keyline, MP1C, and input, MP1A & MP1B, should be inhibited.

4.6.2 HFDR Voice Transceiver Tuning

The HFDR transceiver can be frequency tuned by Serial ARINC 429 or Re-entrant methods. The HFDR should automatically determine which tuning method is being provided.

COMMENTARY

A "Frequency Program" pin on MP2J was originally provided for this purpose, but was not connected in aircraft installations. The line can be used to definitively determine that ARINC 429 serial control is in use by grounding this pin. The HFDR software can monitor this line for direct quick determination of tuning method.

In existing aircraft, the HFDR software should determine the tuning method by monitoring the inputs and determining which tuning method is present on its inputs.

4.6.2 HFDR Voice Transceiver Tuning (cont'd)

COMMENTARY

Older aircraft use re-entrant tuning and newer aircraft use ARINC 429 serial control. The HFDR transceiver should be designed to be retrofitable into all types of aircraft in order to minimize airline spare inventory.

4.6.2.1 ARINC 719 Style HF Transceiver Tuning

Tuning of the HFDR transceiver should be accomplished by sending a tuning command via a low-speed ARINC 429 bus connected to Port A or B of the HFDR transceiver. The tuning command consists of one 32-bit word or optionally two 32-bit words encoded as specified in Section 3.1 of ARINC Specification 429.

The "Frequency Source Select" discrete input line on MP2K should determine if the HFDR should respond to a Label 037 word or Label 205/207 words. When MP2K is grounded the HFDR should respond to Label 205/207 words. The HFDR should consider the input control invalid if both the "205" and "207" label words are not provided. The "205" Label can optionally contain 2 words with the second containing the 100 Hz frequency information. Reference Appendix C for the ARINC 429 word formats for the HFDR.

The Port A/B Select Discrete on MP3J determines if the HFDR responds to Port A or Port B. Port A is selected when the Port A/B Select discrete is grounded.

Two additional inputs are provided to the HFDR. These inputs are designated as the Source/Destination Identifiers (SDI). These discrete inputs on Pins MP4H and MP4J are used to distinguish between two different HFDR destination addresses such as "left" and "right" HFDR's.

COMMENTARY

The SDI inputs are used in aircraft that have Radio Management Panels (RMP's) which control several HF and VHF radios.

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 "Frequency Select Port A", MP3E & MP3F, and the other "Frequency Select Port B", MP3G & MP3H. The transceiver should determine which of these ports should be open to admit data by reference to the binary state of the Port Select Discrete, MP3J.

The HFDR 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. The HFDR 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.

4.6.2.2 ARINC 559A Style HF Transceiver Tuning

Tuning of ARINC 559A HF transceivers should be accomplished by the grounding/opening of 21 parallel discrete lines using a re-entrant code defined in ARINC Characteristic 559A, Attachment 6. The mode of the HFDR is also controlled by MP3A and MP3B which select the SSB/AM or LSB/USB modes respectively.

4.6.3 HF Voice Transceiver Keying

The HFDR should be capable of going into the transmit mode by grounding a PTT Hi line input. The PTT Hi line, MP1C, is a bi-directional line to the HFDR. The PTT Hi-line is used in the voice mode to "key" the transmitter for voice operation the same as in all ARINC 719 transceivers. When the HFDL mode is enabled, the HFDR should ground the PTT Hi-line so as to place the Antenna Tuner Unit (ATU) in the transmit mode whenever the HFDR transmits data.

COMMENTARY

The HFDR transceiver should respond to the key line for voice mode transmissions.

The "DATA KEY" input is retained for compatibility with other ARINC 719 transceivers and is used in conjunction with the "Analog Data Inputs". This line has no function in the HFDL system when used with a self contained HFDU. The transmitter keying is done internal to the unit by the control processor in the HFDR.

4.6.4 HF Antenna Coupler Tuning Initiation

The HFDR should initiate and complete the tuning of the HF antenna coupler prior to the first transmission after a frequency change.

Antenna tuning should be initiated by grounding the keyline briefly. The HFDR should monitor the Tune Power Ground line from the coupler to determine when antenna tuning is completed. The HFDR should also monitor the Tune Fail line from the coupler to determine whether tuning has failed or was successfully completed.

4.6.5 ACARS MU/CMU Interface Functions

The interface between the HFDR and the ACARS MUs or the CMUs should be via a transmit/receive pair of ARINC 429 ports. This pair of ports should be used to interface to ACARS MU's or CMU's which have HF Data Link provisions. The ACARS MU/CMU - HFDL interface protocols are defined in Section 6.4 of ARINC Specification 635. The System Address Label (SAL) for HF #1 is 340. The SAL for HF #2 is 344. The SAL for the MU/CMU is 304.

4.6.6 Voice/Data Mode Switching Function

The HFDR should monitor the HFDL Data Mode Enable, TP7G, input from the HFDCF and default to the voice mode when the discrete input is "high". When the discrete input is "low" the HFDR should operate in the data mode.

4.0 HF DATA RADIO DESIGN (cont'd)

4.6.7 Other Interfaces

The HFDR should also interface to other equipments on the aircraft to obtain position information, Universal Coordinated Time information, ICAO address, to upload/download maintenance data, and to a Data Loader.

4.6.7.1 Aircraft Position Data

Current latitude, longitude and altitude data may be used by the HFDR to optimize its search of HF ground stations and frequencies. The HFDR should obtain latitude, longitude and altitude data by interfacing to the appropriate sources on the aircraft.

In aircraft installations where the latitude and longitude is available on an ARINC 429 bus, this data may be encoded in Binary Coded Decimal (BCD) or Binary (BNR) form. The 32-bit BCD and BNR word formats for latitude and longitude are defined in ARINC Specification 429.

In aircraft installations where altitude is available on ARINC 429 buses, this data should be encoded in BNR form. The 32-bit BNR word format is defined in ARINC Specification 429.

4.6.7.2 Universal Coordinated Time (UTC) Data

Current UTC data may also be used by the HFDR, along with the aircraft position, to optimize its search for a working frequency. The HFDR should obtain UTC data by interfacing to an appropriate source on the aircraft.

In aircraft installations where the UTC is available on ARINC 429 buses, this data may be encoded in BCD or BNR form. The label determines the format used. The 32-bit word formats are defined in Attachment 6 of ARINC Specification 429.

4.6.7.3 ICAO Address Data

The HFDR should provide one or more of the following means of receiving ICAO address information:

a) from an MU/CMU with HF Data Link provisions for a data exchange during initialization via an ARINC 429 interface;

b) from 25 discrete pins (24 pins for the ICAO address and 1 pin for address even parity); and/or

c) via an ARINC 429 bus interface to a source of International Civil Aviation Organization (ICAO) address on the aircraft.

When the ICAO address is obtained from the MU/CMU, it should be stored in non-volatile memory.

4.6.7.4 Maintenance Data

The HFDR should provide a pair of ARINC 429 low-speed transmit/receive ports to interface to the Onboard Maintenance System on aircraft installations so equipped. See Section 9 of this document.

4.6.7.4.1 Maintenance System Identification

The HFDR should determine the presence and type of maintenance system on board the aircraft from the state of three programming pins CFDS Mode A, TP3D, CFDS Mode B, TP3E, and CFDS Mode C, TP3F, according to the definitions in Table 7.5 of Attachment 7. However, if the three discrete pins are open then another means to determine if a CMC is present must be used.

4.6.7.5 Data Loader

The HFDR should provide a low speed transmit and a high speed receive pair of ARINC 429 ports to interface to a Portable and/or Airborne Data Loader. The Data Loader is described in ARINC Report 615. The HFDR should be capable of distinguishing its own unique address (System Address Label) as several LRU's may share a single high speed ARINC 429 bus. As an additional precaution the HFDR should not data load unless the "Load Discrete" line (TP11E) is grounded.

4.6.8 Status Indication Discretes

The HFDR should provide an HF Data Link DATA LINK LOST Output indication, TP9J, and an HFDR Fault Output indication, TP7H, to the HFDCF via two separate discrete outputs and on the ARINC 429 output bus to the MU/CMU.

4.6.8.1 HF DATA LINK LOST Indication Discrete

A discrete "high" should indicate DATA LINK LOST, while a discrete "low" should indicate that the HFDR is in a Logged On state with an HF Data Link ground station. The HFDR status should also be indicated in the ARINC 429 Label 270 word. If the HFDL system has been in a frequency search mode longer than 3 minutes, or if the HFDL system is in the voice mode, the DATA LINK LOST condition should be indicated while the system continues to attempt establishment of a connection.

4.6.8.2 HFDR FAULT Indication Discrete

A discrete "high" should indicate FAULT, while a discrete "low" should indicate that the HFDR is operating normally. The HFDR status should also be included in an ARINC 429 Label 270 word sent to the CMU/MU as defined in Section 6 of ARINC Specification 635.

4.6.9 Built-In Tests

The HFDR should perform Built-In Test Equipment (BITE) diagnostics in accordance with Section 9.0 of this document.

4.6.10 Air/Ground Discrete Input

The HFDR makes use of Air/Ground Discrete Input, MP4G, to determine the flight status of the aircraft. Pin TP5B is the Air/Ground Logic discrete that is used to reverse the sense of the Air/Ground Discrete Input. With TP5B "open" or "1", MP4G "short" or "0", indicates airborne, and "open" or "1", indicates the aircraft is on the ground. A "short" or "0", on TP5B reverses the sense of MP4G.

4.0 HF DATA RADIO DESIGN (cont'd)

4.6.11 Transmit Inhibit Discrete Input

The HFDR makes use of Transmit Inhibit Discrete Input, TP3G, to determine if the data radio should be allowed to transmit. This is to prevent automatic data transmissions from occurring while the aircraft is in certain ground operations. The source of this discrete can be from various sources such as strut, parking brake, oil pressure, doors, etc. The source selection would be according to air carrier choice. An additional strap, TP3H, is provided to change the polarity of the Transmit Discrete Input. With TP3H "open" or "1", TP3G "short" or "0" indicates the transmitter is inhibited, and "open" or "1" indicates the transmitter is enabled. A "short" or "0" on TP3H reverses the sense of TP3G.

4.6.12 Key Event Output

The HFDR transceiver provides a "Key Event" output, MP2E, which provides a "short" or "0" logic output when the transceiver is "keyed" in the voice mode. This output is not active in the CW, Analog Data, or HFDL modes. This output is intended to be connected to the cockpit voice recorder.

4.6.13 SDI Input Pin Definition

When the HFDR is used in aircraft that have Radio Management Panels the HFDR is tuned using ARINC 429 "205", "206" or "207" words, reference Appendix C. These words contain bits for SDI. The SDI input pins MP4J, SDI 0, and MP4H, SDI 1, are used to identify the installation position number. Connect SDI 0 and SDI 1 to ground (SDI common MP4K) per the following table to configure the installation number of the HFDR. Note that inverted logic is used, in that grounds are logical "1".

INSTALLATION NUMBER	SDI 1	SDI 0
Not Used	open	open
1	open	ground
2	ground	open
3	ground	ground

4.6.14 HF Test Enable Discrete Definition

The HFDR includes a test pin to allow service personnel to test the HFDR while on the ground. The "HF Test Enable" pin, TP7J is pulled to "ground" or "0" by the control panel when the HFDL enable button is held in. The test mode is selected when the input is held at "ground" or "0" state for at least 10 seconds.

4.6.15 Chopper Control

The HFDR should provide a Chopper Control output on pin MP5A. This pin provides a "short" or "0" whenever the transmitter in the HFDR is transmitting regardless of modulation mode.

COMMENTARY

The chopper control output is provided for retrofit compatibility. This output was used in older aircraft that were outfitted with couplers using chopper stabilized control systems, such as models 180L2, 180L3, 180L3A, and possibly others.

4.6.16 Strap Even Parity

The HFDR should use the Strap Even Parity input discrete, TP3A, to detect single failures in the wiring of the following discrete inputs:

DISCRETE INPUT NAME	PIN #
SDI 0	MP4J
SDI 1	MP4H
CFDS Mode A	TP3D
CFDS Mode B	TP3E
CFDS Mode C	TP3F
TX Inhibit Program Input	TP3H
Air/Ground Program Discrete	TP5B
Frequency Source Select	MP2K
Narrow/Wide Range	MP5J
CMU #1/#2 Speed Select	TP5A

TP3A should be wired "open" when the number of discretes wired "open" in the table above is odd. Otherwise TP3A should be wired "short". In the event the Strap Even Parity discrete does not match the parity calculated from the discrete inputs, the HFDR should set bit 24 in the 350 CFDS word.

4.6.17 ICAO Strap Even Parity

The HFDR should use the ICAO Strap Even Parity input discrete, TP15K, to detect single failures in the wiring of the 24 discrete ICAO address pins TP11F to TP11K, TP13A to TP13K, and TP15A to TP15J.

TP15K should be wired "open" when the number of discretes wired "open" in the ICAO address is odd. Otherwise TP15K should be wired "short"

In the event the ICAO Strap Even Parity discrete does not match the parity calculated from the discrete ICAO Address pins, the HFDR should declare a "DATA LINK LOST" fault.

5.0 HF DATA UNIT DESIGN

5.1 Introduction

The HFDU should provide the means to transmit and receive data via a standard ARINC 719 or ARINC 559A SSB HF transceiver tunable over the HF band (2-30 MHz).

The HFDU functions are as follows:

a. HF voice/data mode enable switching,

b. air/ground data transmit functions,

c. air/ground data receive functions,

d. HF transceiver tuning,

e. HF transceiver keying,

f. antenna coupler tuning,

g. ACARS MU/CMU interface functions, and,

h. built-in-test functions.

The following sections define the HFDU functions.

5.2 HF Voice/Data Mode Enable Switching

The HFDU should monitor Voice/Data mode discrete input, MP12D, from an HF Data Link Control Function (HFDCF) in the cockpit to determine when to enable voice or data mode. See Section 6 for a definition of the HFDCF. If the discrete input is "high", the HFDU should disable the data mode.

When the data mode is disabled the HFDU should inhibit all data transmission functions and periodically send notifications of its status to the MU/CMU.

In the data mode the HFDU should perform the air/ground data transfer protocols defined in ARINC Specification 635 including the specific functions defined in the following sections.

5.3 Air/Ground Data Transmission Functions

5.3.1 HF Transceiver Audio Interface

The HFDU data transmit output should be an audio signal with -6 dB spectrum points between 440 Hz and 2440 Hz and -20 dB points between 300 Hz and 2580 Hz. The audio output level delivered to a 600 ohm load should be adjustable between 0.1 mW and 1 mW. The audio output impedance should be 600 ohms balanced.

COMMENTARY

In installations where the HFDU interfaces to ARINC 719 HF transceivers, the HFDU transmit audio output should be connected to the dedicated data audio input on the transceiver. Hence, no special precautions need to be taken. However, in installations where the HFDU interfaces to ARINC 559A HF transceivers, the HFDU transmit audio output should be connected to a transceiver audio input which is to be shared with voice audio from the Audio Control Panel. Hence, a means to switch between the two audio inputs to the transceiver should be provided. The switching should be done according to whether the HF transceiver is to be used for voice or data.

5.3.2 Transmit Audio Waveform

The output audio waveform should consist of a nominal 249 ms prekey, followed by a 295 ms preamble, and data. The prekey, preamble and data segments should be encoded as specified in Section 4 of ARINC Specification 635.

5.3.3 HF Transceiver Keying

The HFDU should be capable of keying ARINC 719 HF transceivers and ARINC 559A HF transceivers by grounding a discrete line output.

COMMENTARY

In installations where the HFDU interfaces to ARINC 719 HF transceivers, the HFDU keyline should be connected to the dedicated Data Keyline input on the transceiver. Hence, no special precautions need to be taken. However, in installations where the HFDU interfaces to ARINC 559A HF transceivers, the HFDU keyline should be connected to a transceiver keyline input which is to be shared with the push-to-talk line from the Audio Control Panel (ACP). Hence, a means to switch between the two keylines to the HF transceiver should be provided. The switching should be done according to whether the HF transceiver is being used for voice or data.

5.4 Air/Ground Data Receive Functions

5.4.1 HF Transceiver Audio Interface

The HFDU should function properly with audio from an ARINC 719 transceiver with a frequency response of ± 6 dB from 350 Hz and 2500 Hz. The input level should be from a source impedance of less than 100 ohms at less than 0.5 Vrms. The HFDU should operate normally with an input signal variation of ± 10 dB. The HFDU should have an input impedance of 600 ohms balanced.

5.4.2 Receive Audio Waveform

The received audio waveform should consist of the waveform defined in Section 4 of ARINC Specification 635 subject to the distortions defined in Section 4 of ARINC Specification 635.

5.5 HF Transceiver Tuning

The HFDU should use the Serial/Parallel input discrete, MP11C, to determine the frequency tuning interface to the HF transceiver. When MP11C is "open", the HF transceiver is an ARINC 719 transceiver. When MP11C is "short", the HF transceiver is an ARINC 559A transceiver. In addition, if the HF transceiver tuning is

5.0 HF DATA UNIT DESIGN (cont'd)

5.5 HF Transceiver Tuning (cont'd)

per ARINC 719, the HFDU should use the Serial Tune Label Select discrete input, MP15A, to determine the type ARINC 429 words to use to tune the HF transceiver. With MP15A "open", the HFDU should use Label 037 words, and with MP15A "short", it should use Label 205/207 words as defined below.

5.5.1 ARINC 719 HF Transceiver Tuning

Tuning of ARINC 719 HF transceivers should be accomplished by sending a tuning command via a low-speed ARINC 429 bus connected to Port A of the HF transceiver.

When the ARINC 719 HF Transceiver is configured for voice/data switching via a discrete input (MP2K discrete on the HF transceiver set "high"), the tuning command should consist of one Label 037 32-bit word encoded as specified in Section 3 of ARINC Specification 429.

When the ARINC 719 HF transceiver is configured for voice/data switching via a Label 207 ARINC 429 word command (MP2K discrete on the HF transceiver set "low"), the tuning command should consist of one Label 205 32-bit word encoded as specified in Section 3.0 of ARINC Specification 429.

The average channel tuning time is less than 1 second from the time the command is received by the HF transceiver.

5.5.2 ARINC 559A HF Transceiver Tuning

Tuning of ARINC 559A HF transceivers should be accomplished by the grounding/opening of 21 parallel discrete lines using a re-entrant code defined in ARINC Characteristic 559A, Attachment 5.

COMMENTARY

> ARINC 559A HF transceivers provide for only one set of 21 parallel discrete inputs for tuning. Hence these inputs should be shared between the Radio Control Panel and the HFDU. A means to control the switching between the two sets of parallel lines should be provided. The switching should be done according to whether the HF transceiver is being used for voice or data.

The average tuning time is less than 8 seconds from the time the command is received by the HF transceiver.

5.6 HF Antenna Coupler Tuning Initiation

The HFDU should initiate the tuning of the HF antenna coupler prior to the first transmission after a frequency change. Antenna tuning should be initiated by momentarily grounding the data keyline. The HFDU should monitor the Tune Power Ground line from the coupler to determine when antenna tuning is completed. The HFDU should also monitor the Tune Fail line from the coupler to determine whether tuning has failed or was successfully completed.

5.7 Air/Ground Data Transfer Protocol

The HFDU should control the transmission and reception of air/ground data packets using the protocols defined in ARINC Specification 635.

5.8 ACARS MU/CMU Interface Functions

The HFDU should interface to one ACARS MU or one or two CMUs which have HF Data Link provisions via one transmit and two receive ARINC 429 ports. The speed of the ARINC 429 ports should be set as defined in Section 5.9.7. An optional pair of transmit and receive MSK audio ports may also be provided to interface to ACARS MUs which do not have HF Data Link provisions. Refer to Section 4.6.5 for the System Address Labels (SALs).

When the ARINC 429/MSK Interface Select discrete input, MP13C, is "open", the HFDU should use the ARINC 429 ports to communicate with the MU/CMU. With MP13C "short", the HFDU should use the MSK audio ports to communicate with the ACARS MU. The ACARS MU/CMU - HFDL interface protocols are defined in Section 6 of ARINC Specification 635.

5.9 Other Interfaces

The HFDU should provide for the interfaces defined in Section 4.6.7 of this document.

5.9.1 Aircraft Position Data

The HFDU may use the position data available on pins TP12C and TP12D as defined in Section 4.6.7.1 of this document.

5.9.2 Universal Coordinated Time (UTC) Data

The HFDU may use UTC data available on pins TP10C and TP10D as defined in Section 4.6.7.2 of this document.

5.9.3 ICAO Address Data

The HFDU should acquire the ICAO address according to Section 4.6.7.3 of this document.

5.9.4 Maintenance Data

The HFDU should provide maintenance data according to Section 4.6.7.4 of this document.

5.9.4.1 Maintenance System Identification

The HFDU should determine the presence and type of maintenance system on board the aircraft from the state of three programming pins CFDS Mode A, MP5H, CFDS Mode B, MP5J, and CFDS Mode C, MP5K, according to the definitions in Table 7.5 of Attachement 7. However, if the three discrete pins are open then another means to determine if a CMC is present must be used.

5.0 HF DATA UNIT DESIGN

5.9.5 Data Loader

The HFDU should provide a low speed transmit and a high speed receive pair of ARINC 429 ports on pins TP4A and TP4B to interface to a Portable and/or Airborne Data Loader. The Data Loader Discrete, MP14C should be used to determine the presence of a data loader.

5.9.6 Air/Ground Discrete Input

The HFDU should monitor the Air/Ground Input discrete, MP11D, to determine the flight status of the aircraft and the Air/Ground Polarity Select discrete, MP13A, to determine the sense of the Air/Ground Input discrete. With MP13A "open", MP11D "short" indicates airborne, and MP11D "open" indicates the aircraft is on the ground. With MP13A "short" the logic of MP11D is reversed.

5.9.7 MU/CMU Interface Speed Select

The HFDU should monitor the CMU/MU Speed Select discrete input, MP14A, to select the ARINC 429 bus speed "High" or "Low" to the MU/CMU. A discrete open implies low speed and a short implies high speed.

5.9.8 Transmit Inhibit Discrete Input

The HFDU should make use of Transmit Inhibit discrete input, MP15B, to determine whether the HFDL transmit function should be enabled or not. An additional programming pin Transmit Inhibit Polarity, MP14B, should be used to determine the sense of MP15B. With MP14B "open", MP15B "short" indicates the HFDL transmit function should be inhibited, and "open" should indicate the HFDL transmit function is enabled. With MP14B "short", the sense of MP15B is reversed.

5.9.9 SDI Inputs

The HFDU should make use of the SDI 0 and SDI 1 input discretes, MP11B and MP13D respectively, in the encoding of the Label 205/207 ARINC 429 words used to tune the HF transceiver in aircraft installations where the Serial Tune Label Select discrete input, MP15A, is "short". The SDI 0 and SDI 1 input discretes should therefore be wired the same way as the SDI discrete inputs to the HF transceiver to which the HFDU interfaces. The HFDU should also use the SDI 0 and SDI 1 input discretes in the encoding of the Label 270 words sent to the MU/CMU, Label 350 words sent to the CMC, and in the decoding of Label 227 words received from the CMC. The logic of the SDI 0 and SDI 1 inputs is as defined in Section 4.6.13. In the event the Strap Even Parity discrete does not match the parity calculated from the discrete inputs, the HFDU should set bit 24 in the 350 CFDS word.

5.9.10 Strap Even Parity

The HFDU should use the Strap Even Parity input discrete, MP13B, to detect single failures in the wiring of the following discrete inputs:

DISCRETE INPUT NAME	PIN #
SDI 0	MP11B
SDI 1	MP13D
CFDS Mode A	MP5H
CFDS Mode B	MP5B
CFDS Mode C	MP5K
Air/Ground Polarity Select	MP13A
Serial/Parallel Tune Select	MP11C
Serial Tune Label Select	MP15A
CMU/MU Bus Select	MP14A
ARINC 429/MSK Interface Select	MP13C
TX Inhibit Polarity	MP14B

MP13B should be wired "open" when the number of discretes wired "open" in the table above is odd. Otherwise, MP13B should be wired "short". In the event the Strap Even Parity discrete does not match the parity calculated from the discrete inputs, the HFDR should set bit 24 in the 350 CFDS word.

5.10 Status Indications

The HFDU should provide an HF DATA LINK LOST indication discrete, MP10D, and an HFDU FAULT indication, MP10C, to the HFDCF.

5.10.1 HF DATA LINK LOST Indication Discrete

The HFDU should provide a DATA LINK LOST indication in accordance with Section 4.6.8.1 of this document.

5.10.2 HFDU FAULT Indication Discrete

The HFDU should provide a FAULT indication in accordance with Section 4.6.8.2 of this document.

5.11 Built-In Tests

The HFDU should perform Built-In Test Equipment (BITE) diagnostics in accordance with Section 9.0 of this document.

6.0 DATALINK CONTROL FUNCTIONS

6.1 Introduction

An HF Data Control Function (HFDCF) should provide the crew in the cockpit with the means to control the shared use of the HF transceiver or HFDR for HF Data Link and voice communications. The HFDCF also should display HF Data Link status information.

The HFDCF may be integrated into a Radio Control Panel, or a centralized radio management system, or in retrofit installations, the HFDCF may be incorporated in a separate HF Data Control Panel (HFDCP) at the discretion of the airline operator of the aircraft and/or the airframe manufacturer.

6.2 HFDCF Functions

The HFDCF functions for aircraft equipped with an HFDR or an HFDU should consist of:

a. HF voice/data mode selection,

b. programmable automatic voice-to-data return and programmable default to voice or data,

c. HF Data Link enabling,

d. monitoring of HFDL equipment for DATA LINK LOST and Fault conditions, and

e. HF Data Link status display.

The HFDCF should provide the following additional functions in aircraft equipped with an HFDU:

f. HFDU mode selection,

g. ARINC 719 frequency tuning port selection, and

h. RF sensitivity or squelch control.

6.2.1 HF Voice/Data Select

Both the HFDR and ARINC 719 HF transceivers have a voice/data discrete input that is used to select the mode of operation. ARINC 719 HF transceivers also have separate audio ports for data and voice as well as separate data and voice (PTT) keylines. The voice/data select discrete input controls the selection of the appropriate audio and keyline ports.

The HFDCF should provide an HF Data Link (HFDL) Mode Enable discrete output (Pin 15) to the HFDR or ARINC 719 HF transceiver voice/data select port. The discrete output level should be controlled by the crew by means of an HF Voice/Data toggle switch or equivalent.

When the HF Voice/Data "switch" is in the voice position, the HFDL Mode enable, discrete output should be "high", and the crew should have complete control of the tuning of the HF transceiver.

When the HF Voice/Data switch is in the data position, the HFDL Mode Enable discrete output should be "low" and the HFDR/HFDU should control the tuning of the HFDR/HF radio.

6.2.2 Programmable Functions

The HFDCF should provide the capability to be programmed via a configuration discrete input (Pin 14) to default to data mode (discrete input "low") or voice mode (discrete input "high") on power on and in the event of an HFDU, HFDR, HFDCF fault.

The HFDCF should also provide the capability to be programmed to automatically return to data mode from voice mode via a second configuration discrete (Pin 13).

When programmed for automatic voice-to-data return (discrete input "high"), the HFDCF (via Pin 10) should monitor the push-to-talk input to the HF transceiver or HFDR to return them automatically to the data mode from the voice mode if no voice activity has been detected for a user specified time, ranging from 0-6 minutes.

6.2.3 HF Datalink ON/OFF Switch

An ON/OFF switch on the HFDCF should provide the crew with the means to enable or disable HF Data Link operation.

When the switch is in the OFF position, the HFDCF should disable HF datalink operation by setting the HFDL mode Enable (Pin 15), HF frequency port select (Pin 16), and RF sensitivity (Pin 17) discretes to "high". The HF transceiver/HFDU combination or the HFDR should be in the voice mode and the HFDCF Status display should indicate Voice. The crew in the cockpit should then have complete control of the tuning of the HF transceiver or HFDR.

When the switch is in the ON position, HF Datalink operation should be enabled and the HF Voice/Data switch described in Section 6.2.1 should be used by the crew to control the HF transceiver/HFDU combination or the HFDR mode of operation.

6.2.4 HF DATA LINK LOST Indication

The HFDCF should monitor a discrete input (Pin 12) from the HFDU/HFDR which indicates when an HF DATA LINK LOST condition occurs. See Section 4.6.8.1 for a definition of the discrete states.

6.2.5 HFDU/HFDR FAULT Indication

The HFDCF should monitor a discrete input (Pin 4) from the HFDU/HFDR which indicates when an HFDU/HFDR Fault condition occurs. See Section 4.6.8.2 for a definition of the discrete states.

6.2.6 HF Datalink Status Display

These HFDCF functions should consist of:

a. displaying whether the HFDL function has been enabled,

b. displaying whether the HF transceiver-HFDU or HFDR is in voice or data mode,

c. displaying HF Datalink DATA LINK LOST condition, and

d. displaying HFDR/HFDU and HFDCF FAULT condition.

COMMENTARY

If a single lamp is used in the HFDCF to display a fault in the HFDR/HFDU or the HFDCF, a separate discrete output (Pin 3) can be used to indicate an HFDCF fault. This discrete output should be "high" when there are no faults in the HFDCF, and it should be "low" when an internal HFDCF fault has been detected.

6.2.7 HFDU Mode Select

The HFDCF should provide a separate discrete output (Pin 18) to place the HFDU in voice or data mode. The discrete output should be "high" when in the voice mode, and it should be "low" when in the data mode.

6.2.8 HF Frequency Port Select

ARINC 719 and ARINC 753 HF transceivers have two ARINC 429 bus input Ports, A and B, that may be used to control the transceiver operating frequency. In most aircraft installations, the Radio Control Panel in the cockpit is connected to Port B while Port A is not used. The HFDU should be connected to Port A. A Frequency Port Select discrete input controls the selection of Port A or B.
In HF Datalink installations consisting of an ARINC 719 or 753 HF transceiver/HFDU combination, the HFDCF should provide a discrete output (Pin 16) to the HF transceiver Frequency Port Select input. The discrete output should be "high" when in the voice mode, and it should be "low" when the in the data mode.

6.2.9 RF Sensitivity or Squelch Control

An analog signal from the Radio Control Panel to the HF transceiver is used to control the RF sensitivity of the HF transceiver with maximum sensitivity achieved when the analog input is grounded.

In order to override any RF sensitivity setting in the Radio Control Panel, other than maximum sensitivity during data operation in HF Datalink installations consisting of an HF transceiver/HFDU combination, the HFDCF should provide a discrete output (Pin 17) to the RF sensitivity or squelch control input to the HF transceiver. This discrete should be grounded ("low") in the HF data mode, and open ("high") in the HF voice mode.

COMMENTARY

If the HFDCF is integrated into the Radio Control Panel, then the RF sensitivity analog signal should be grounded in data mode operation and set to any level desired by the crew in voice mode operation.

7.0 ANTENNA SYSTEMS

7.1 Introduction

The standard HFDR interwiring in Attachment 2-2 shows connections to the "symbolic" antenna coupler leads that are designated by the letters (A) through (P). However, these do not represent any particular antenna coupler, but merely the generic functions of essentially all couplers. Attachment 5 of ARINC Characteristic 719 tabulates these symbolic function connections in terms of specific pin connections and connector types for various antenna couplers. For optimized overall efficiency, shunt/notch antennas are recommended. Additional guidance for antenna installations is provided in Appendix 0 of ARINC Characteristic 719.

7.2 Antenna

Various kinds of antennas are installed in the various types of airframes; for details refer to Appendix 0 of ARINC 719.

COMMENTARY

The user should realize that one of the factors limiting the potential throughput of the HF communication system is the signal loss associated with the cabling between the HFDR and the antenna.

There are no specific form factors set forth herein for the antennas to be employed with this particular equipment as there are numerous designs presently on the market for this 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 on the particular aircraft type for which the antenna is intended and the need to minimize weight.

Dual HF installations sharing a common antenna do not allow simultaneous transmissions.

7.3 HF Antenna Coupler

The Antenna Coupler should be form, fit, and function compatible with ARINC Characteristic 719 installations. The HF Antenna Coupler may be connected to the HFDR Transceiver via a single 50 ohm coaxial RF cable. RF transmission, exchange of control information between HFDR Transceiver and Antenna Coupler, and the power supply for the Antenna Coupler may be transferred via the single cable.

COMMENTARY

The HFDL Antenna Coupler should be backward compatible with existing installations. The existing transceiver interface and interwiring should be retained to allow for ease of retrofit. Many of the parameters in ARINC Characteristic 719 pertaining to the antenna coupler are applicable to newer generation antenna couplers.

7.3.1 Matching

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

COMMENTARY

As the SSB equipment can only provide full power output capability when the antenna coupler VSWR is kept low, it is naturally important from the user's standpoint to obtain the best possible VSWR in the antenna coupler.

7.3.2 Frequency Coverage

The coupler should be designed to cover the "wide frequency range" of 2.0 to 29.9999 MHz. Inasmuch as the Antenna Coupler should usually be designed to operate specifically with a general class of antenna types covering a specific frequency range, this Characteristic does not set forth any specific antenna impedance characteristics for new Antenna Couplers.

7.3.3 Power Handling Capability

The Antenna Coupler should be designed to safely operate at a maximum power level of 650 watts PEP and at an average power level of 160 watts. During tuning the coupler should be capable of handling up to 100 watts of forward power (characteristic impedance of 50 ohms).

COMMENTARY

Although previous industry discussion many years ago led to the conclusion that Antenna Couplers should be designed with adequate power handling capacity to accommodate at least a 1 kW PEP, it has subsequently been determined that such a power handling capacity on civil aircraft is not necessary. The figure of 650 watts PEP is deemed to be more realistic for the guidance of antenna coupler manufacturers.

7.3.4 Tune Mode

After the first tuning to a specified frequency, the tuning values may be stored and be available for future use.

7.3.5 Interwiring

The new generation of HF Antenna Couplers should be capable of communicating serial data over existing aircraft wiring. In addition, the ability to operate with older ARINC 719 interface units should be supported. The new generation transceiver and coupler should be capable of detecting whether they are connected to new or old generation equipment and automatically select the appropriate control interface. To allow usage of old generation couplers, the wiring according to ARINC Characteristic 719 should be maintained.

7.0 ANTENNA SYSTEMS (cont'd)

7.4 Multiwire Serial Interface (MSI)

Current HF transceivers and antenna couplers communicate over parallel wires carrying discrete signals. The additional functionality and flexibility of the new HFDR system indicates a need for greater communications flexibility, implying the need for a serial data bus. In addition, it is considered important that each unit should have the ability to operate with their older ARINC 719 interface counterparts.

Because of the cost and inconvenience of rewiring aircraft already in service, it is considered imperative that the new HFDR transceiver and antenna coupler should be capable of communicating using the existing aircraft wiring.

The following paragraphs describe an interface which uses the existing aircraft wiring to communicate using both discrete signals and a serial bus, depending on the capabilities of the transceiver and coupler in the system. This interface approach allows complete backwards compatibility with older HF radio systems, allows older aircraft to be easily upgraded, and allows ARINC 719 equipment to serve as spares for new radios.

7.4.1 Physical Layer

The Physical Layer comprises the physical medium and the circuitry required to send information between the transceiver and the antenna coupler.

7.4.1.1 Physical Medium

ARINC 719 SIGNAL DESCRIPTION	ARINC 753 SIGNAL USAGE
Rechannel pulse (Ground Pulse)	Transceiver RTS/CTS signal
Tune Power	Coupler RTS/CTS signal
+27.5 Vdc (Interlock Excitation)	Balanced serial data high, non-inverting
Keyline Interlock	Balanced serial data low, inverting
Keyline	not used
115 Vac	115 Vac
Transceiver Fault (optional)	not used
Coupler Fault (optional)	not used

7.4.1.1.1 Serial vs. Parallel Interface Selection

In order to support intermixing of old generation units with new generation units, a means must be provided such that an ARINC 753 capable unit can accurately detect whether it is connected to a new or old generation unit. This enables new ARINC 753 interface units to automatically switch interface characteristics depending on whether they are connected to new ARINC 753 serial or old ARINC 719 parallel interface units.

7.4.1.1.1.1 Detection Scheme

The basis of the detection scheme is that the transceiver first attempts to communicate with the antenna coupler over the ARINC 753 interface, reference Section 7.4.1.1.1.3. If the coupler responds to this request the MSI interface can be selected. If the coupler does not respond, the transceiver switches to the ARINC 719 interface, reference Section 7.4.1.1.1.2. To prevent misinterpretation by couplers, which are not switched on due to different power supply connections, this procedure is repeated each time a new frequency is selected. A rechannel pulse should be sent to the antenna coupler when the transceiver is in the ARINC 719 mode.

Once communication is established over the ARINC 753 interface, further detection tests can be omitted. If the communication link malfunctions, the transceiver should fall back to the detection procedure.

The detection procedure is as follows:

- After power up, the transceiver attempts to send an Initialize Coupler command (10h) to the coupler by switching its RTS/CTS (Rechannel Pulse) line to medium level (RTS function).

- If an ARINC 753 coupler is connected, the coupler responds with its RTS/CTS (Tune Power) line to low level (CTS function). The transceiver perceives the capability of the coupler to respond to ARINC 753 control and responds by sending the serial data associated with the Initialize Coupler command (10h). Upon receipt of Initialize Coupler command data, the coupler responds with a command Acknowledge. The system now operates using the ARINC 753 interface.

- If an ARINC 719 coupler is connected, the coupler does not recognize the medium level RTS/CTS (Rechannel Pulse) line of the transceiver and does not respond. The transceiver switches to the ARINC 719 interface if the coupler fails to respond to the Initialize Coupler command (10h) after three attempts.

- In order to achieve proper interface determination in the event that transceiver and coupler are powered up at different times, the transceiver precedes each ARINC 719 rechannel operation by switching its RTS/CTS (Rechannel pulse) line to medium level (RTS function). If the coupler does not respond with a CTS function, the transceiver assumes the coupler is not capable of data communications and proceeds with a normal ARINC 719 rechannel operation.

- Upon power up, the antenna coupler monitors the transceiver RTS/CTS (Rechannel pulse) line to determine which interface is used. If the coupler detects a medium level RTS/CTS line it responds according to ARINC 753 protocol, reference Section

7.0 ANTENNA SYSTEMS (cont'd)

7.4.1.1.1.1 Detection Scheme (cont'd)

7.4.2. If it detects alow level RTS/CTS line without a preceding RTS function (medium level) it responds as an ARINC 719 coupler and recognizes the Rechannel Function.

7.4.1.1.1.2 Parallel Interface (ARINC 719) Definition

The parallel interface signals and their use are as described in ARINC Characteristic 719. This section provides some additional characterization of the indicated ARINC 719 signals in order to ensure interchangablility with the currently installed HF radio equipment.

Rechannel Pulse (Ground Pulse)

Rechannel pulse is a logic signal used by the transceiver to cause the antenna coupler to enter an untuned state with the tuning network bypassed. This is necessary in order to tune to another frequency. This signal should also cause the antenna coupler to clear its fault status.

The transceiver should present a high impedance if rechannel is not asserted.

The transceiver should present a low impedance to ground (0.5 Vdc max at 100 mA minimum sink current) for at least 90 ms in order to assert Rechannel.

Tune Power

Tune Power is a logic signal used by the antenna coupler to cause the transmitter to output tuning power with CW at F_0 when the transmitter is keyed.

The coupler should present a high impedance if Tune Power is not asserted.

The coupler should present a low impedance to ground (1.5 Vdc max at 150 mA minimum sink current) to assert Tune Power.

+27.5 Vdc (Interlock Excitation)

Interlock Excitation of +27.5 Vdc is supplied by the transceiver for use in the coupler for the Keyline Interlock circuitry. The transceiver should be capable of supplying 0.5 A continuous and 8 A peak for 20 ms (per ARINC Characteristic 719).

Keyline Interlock

The Keyline Interlock signal is provided by the antenna coupler as an interlock on RF transmission to the transceiver.

The coupler should present +27.5 Vdc nominal with a minimum 50 mA source in order to allow RF transmission for tuning or system operation.

The coupler should present a high impedance (0 Vdc from the coupler) in order to inhibit all RF transmission from the transceiver.

7.4.1.1.1.3 Multiwire Serial Interface (ARINC 753 or MSI) Definition

When the MSI is selected then the indicated interconnect signals take on the following characteristics:

Transceiver RTS/CTS

Transceiver RTS/CTS is a tri-level logic signal used by the transceiver to indicate to the coupler either a Request-To-Send (RTS), Clear-To-Send (CTS), or neither RTS nor CTS.

The transceiver should present a high impedance if neither RTS nor CTS are being asserted.

The transceiver should present 7.5 Vdc ± 1 Vdc at 10 mA minimum sink current in order to assert RTS.

The transceiver should present a low impedance to ground (0.5 Vdc max at 50 mA minimum sink current) in order to assert CTS.

Coupler RTS/CTS

Coupler RTS/CTS is a tri-level logic signal used by the antenna coupler to indicate to the transceiver either a Request-To-Send (RTS), Clear-To-Send (CTS), or neither RTS nor CTS.

The coupler should present a high impedance if neither RTS nor CTS are being asserted.

The coupler should present 7.5 Vdc ± 1 Vdc at 10 mA minimum sink current in order to assert RTS.

The coupler should present a low impedance to ground (0.5 Vdc max at 50 mA minimum sink current) in order to assert CTS.

Balanced Serial Data High and Balanced Serial Data Low

This pair of signals is a differential pair used for bi-directional serial data transfers between the transceiver and the antenna coupler. The RTS/CTS signal described in the Link Layer Protocol Section 7.4.2 determines when the transceiver or coupler may transmit data on the bus.

Bus Transmitter Characteristics (Defined at LRU Connector)

The differential output voltage across the balanced pair at the bus transmitter should be as follows when the bus transmitter is open circuit:

	Logic "1"	Logic "0"
Serial Data High referenced to Serial Data Low	-6.0V to -1.5V	+1.5V to +6V

The bus transmitter should have an output impedance of 100 ± 50 ohms divided evenly between each line of the pair.

Bus Receiver Characteristics (Defined at LRU Connector)

The differential input voltages across the balanced pair at the bus receiver should be associated with the following logic levels:

	Logic "1"	Logic "0"
Serial Data High referenced to Serial Data Low	<-0.2V	>+0.2V

The bus receiver should exhibit input characteristics as follows:

Differential Input Resistance 100 ohms minimum
Differential Input Capacitance 100 nF maximum
Resistance to Ground 1000 ohms minimum
Capacitance to Ground 100 nF maximum

The format of the serial data should be:

Symbols: Start bits are represented by "logic 0", stop bits and the marking state of the bus are indicated by "logic 1".

Word Format: Serial words should be 8 bits of data (LSB transmitted first), preceded by one start bit, and followed by one parity bit and then 1 stop bit.

Parity: Parity should be even.

Data Rate: Data transmission should be at 9600 bits per second, asynchronous.

COMMENTARY

Note that these specifications are essentially the same as EIA RS-485 with the addition of some transmitter wave shaping capacitance to reduce EMI effects.

7.4.2 Link Layer Protocol

The link layer protocol is the protocol used, on the physical interface, when a device (hereafter called the source device) desires to transmit data to another device (hereafter called the sink device). The actual meaning of the specific data is not relevant at this layer.

7.4.2.1 Link Protocol Sequencing

The general sequence of events for the link layer protocol is given as follows:

1. A source device should first verify that the sink device is indicating neither CTS or RTS.

2. The source should assert RTS.

3. The sink, upon receiving an RTS from the source should prepare to receive a message and then assert CTS. Note that if both the Transceiver and the coupler assert RTS, then the coupler should deassert its RTS and then become the sink device (and assert CTS when it is ready to receive).

4. The source should then transmit its message, comprised of a length byte followed by the data and concluding with a check byte.

5. The source should relinquish the bus and prepare to receive an acknowledge word. When the source is prepared to receive this word the source should assert CTS.

6. The sink, upon receiving a CTS from the source, should assume message transmission is complete. The sink should check the validity of the message. The sink should then transmit to the source an Acknowledge word, if the transfer is deemed valid, or a Not Acknowledge word, if the transfer is invalid.

7. The source should then deassert CTS.

8. The sink should then deassert CTS.

9. If the source received a Not Acknowledged word, then it should try to re-send the message by repeating the above process.

7.4.2.2 Link Protocol Message Description

The Link protocol message is a variable length packet of 8 bit data words (bytes).

- The first word of a message is the length of the message in bytes. This length includes the length byte itself and all other protocol words. The length byte can represent values from 3 to 255.

- Following the length byte is one or more data word(s) with up to 253 bytes in number.

- The last word of a message is the checksum byte. It is used as a check on the integrity of the message transfer. The checksum is a modulo 256 sum of all preceding message bytes, including the length byte, but not the checksum byte itself.

Message integrity is checked by several means:

- First, each of the serial data words must be individually valid, i.e. the framing and parity must both be correct. If any individual word is invalid then the entire message should be deemed invalid.

- Second, the received message must be of the exact length given by the length byte or the entire message should be deemed invalid.

- In addition, the modulo 256 sum of all bytes (except the checksum byte) should equal the checksum byte of the message or the entire message should be deemed invalid.

The Acknowledge (ACK) and Not Acknowledge (NACK) words are dependent upon the direction of the message transfer.

The transceiver indicates ACK by sending the byte: 17h

7.0 ANTENNA SYSTEMS (cont'd)

7.4.2.2 Link Protocol Message Description (cont'd)

The transceiver indicates NACK by sending the byte: 2Bh
The coupler indicates ACK by sending the byte: 4Dh
The coupler indicates NACK by sending the byte: 8Eh

The source device should attempt to repeat the message if it receives a Not Acknowledged word. It should attempt to send the message at least 3 times before declaring a communication fault.

There is no provision at the link layer for multiple packet messages. If this feature is desired, then it should be implemented in a higher protocol layer.

7.4.2.3 Link Protocol Timings

The diagram in Attachment 10 shows a typical transfer using the Link Protocol. Shown is the scenario where both the transceiver and the coupler attempt to send a message at the same time. The coupler yields the bus to the transceiver and the transceiver then transfers a message to the coupler. The coupler is shown acknowledging the transfer, which is then completed.

The following times are considered absolute maximum (minimum) for correct operation. If a timing is violated then the message transfer should be deemed invalid.

TIMES	DESCRIPTION OF TIMING FUNCTION	VALUE
t1	RTS asserted to CTS asserted	50 ms max
t2	CTS asserted to Data Bus driven.	0 ms min
t3	CTS asserted to 1st data word completed	10 ms max
t4	Data word completed to subsequent data word completed	10 ms max
t5	Last data word completed to CTS asserted.	1-10 ms max
t6	CTS asserted to Acknowledge word completed.	90 ms max
t7	Acknowledge word completed to CTS not asserted.	10 ms max
t8	CTS not asserted to CTS not asserted.	10 ms max

Note that times are the same regardless of the direction of communication.

7.4.3 Control Protocol

The control protocol provides the commands and responses used to control the interface between the transceiver and the antenna coupler. The commands and responses described in this section are transported between the transceiver and the antenna coupler using the Multiwire Serial Interface (see Section 7.4.1 for the Physical Layer and Section 7.4.2 for the Link Layer Protocol).

The control protocol uses, as its basis, a Command - Complete sequence. When a command (or request) is issued by one unit the other unit should indicate when the command is completed as well as providing any related information or status. The commands, responses, and their codes are listed in Section 7.4.3.4, along with a description of the purpose, effects, and limitations of each.

COMMENTARY

The "Command/Complete" protocol was chosen because operations between transceivers and antenna couplers tend to be essentially sequential control, dependent on one operation completing before another begins.

7.4.3.1 Sequencing

No command should be considered completed until the complete message has been received. The state of the sink device cannot be assumed before the sink has indicated command completion. As an example, the transceiver should not assume the coupler is ready for transmit until the antenna coupler has indicated that the Key command has been completed.

Queuing of commands is not permitted. Both the antenna coupler and the transceiver are allowed to have only one command pending completion. If another command is received before the previous is completed, the previous command should be aborted and the new command begun.

COMMENTARY

The limit on pending commands, which significantly simplifies the protocol, is permitted by the nature of antenna coupler operations, i.e. the sequential nature of tuning. As a benefit, this also allows an easy method of aborting pending commands in the case of operator input or fault conditions.

7.4.3.2 Aborting Commands

If the sink device receives a command that it is unable to complete, either because of fault conditions or because the command is inappropriate, then the sink should abort the command and send that information to the command source. The command source should "close" the command in question and, if necessary, take appropriate action. The aborting device should indicate the reason for its action in the abort message according to the following table:

REASON FOR ABORTING COMMAND	CODE
Fault Status Prevents Completion	00h
Mode/Configuration Prevents Completion	01h
Antenna Interlocked	02h
Capability Not Implemented	03h
Duplicate Command	04h
Subsequent Command Overrode	05h
Unrecognized Command	06h
Unrecognized Parameter(s)	07h
Invalid Parameter(s)	08h
spare	09h
. . .	. . .
spare	FEh
Other/Indeterminate	FFh

If a device receives a command which duplicates the command it is presently operating upon, it should abort the initial command by issuing a Duplicate Command Abort code (04h) and begin operation on the new instance of that command. The Duplicate Command Abort code (04h) enables the commanding device to determine that the abort is for the first instance of the command and that a command is still pending.

Note that if a device aborts a command with the reasons Unrecognized Command, Unrecognized Parameters, Invalid Parameters and/or the command being aborted is not a command the commanding device considers pending, then it is possible that the message transfer was somehow corrupted. Any currently pending command should be considered aborted, and the commanding device may reissue the command. The commanding device should ensure that the receiving device is compatible with the protocol version being used for commands (see Request Coupler Version and Request Transceiver Version messages).

7.4.3.3 RF Operations

The transceiver should only transmit RF in response to a request by the antenna coupler or after it receives a Key Command/Complete sequence. Once RF is OFF, either by command of the antenna coupler, fault conditions, or the Unkey sequence, the transceiver must once again request permission in order to transmit.

7.4.3.4 Control Protocol Command and Request Messages

The result of the MSI Link Layer transfer is one or more 8 bit words which are used to form a transceiver-coupler control protocol message. The general format of this control protocol message is one byte coded to indicate the particular command or request, with zero or more subsequent words indicating any data or parameters associated with the command or request. Command completed and command aborted messages follow the same general format.

The following table describes the messages comprising the control protocol. The *Dir.* field indicates the direction of the transfer. The *Code or Data* field contains a command code (in hexadecimal format) along with identifiers for the data parameters and a number to indicate the data field width, in bits. Words of 16, 32, or 64 bits are broken into bytes (octets) with the least significant byte sent first. Single bit and 4 bit fields (nibbles or semi-octets) should be packed into bytes with the first field listed being in the lowest order bits. If the 1 bit and 4 bit fields do not evenly pack into a byte, then the byte should be filled with 0's in the upper order bits.

COMMENTARY

As an example, if there was data comprising a field of 8 bits (a), followed by a field of 4 bits (b), a field of 1 bit (c), another field of 1 bit (d), and followed by a field of 16 bits (low order = e, high order = g) they would be transmitted as follows:

1st byte transmitted:	MSB	aaaaaaaa	LSB
2nd byte transmitted:		00dcbbbb	
3rd byte transmitted:		eeeeeeee	
4th byte transmitted:		gggggggg	

{Note that in the following table, all hexadecimal values end in "h" and all binary values end in "b".}

7.0 ANTENNA SYSTEMS (cont'd)

COMMAND/REQUEST DESCRIPTION	DIR.	CODE OR DATA
Initialize Coupler - This command causes the antenna coupler to return to its initial state. The initial state is: Receive (Unkeyed), Untuned, Not tuning, Antenna interlock released, History Storage enabled, Quick Tunes enabled, and in Dual System Receive mode (unless external discretes indicate otherwise). During this initialization all antenna coupler faults should be cleared. The coupler should also adapt it's operation according to the following configuration words: Ignore Freq OOR: Ignore Frequency Out Of Range. If this bit is 1b then the coupler should not declare a fault for frequencies which are beyond its ability to tune. A 0b indicates a fault should be declared. Silent Quick Tune: If this bit is a 1b, then when a Quick Tune is used for a tune operation, there is no VSWR check before the tune operation is completed. If either FaultThr or RetunrThr is exceeded during operation, then the Quick Tune used should be marked invalid. A 0b indicates that the Quick Tune should be checked before the tune operation is completed. ContThr: Contingency Tune VSWR Threshold. This value, when divided by 100, gives a VSWR (i.e. the value 235 means a VSWR of 2.35:1). The coupler should attempt to tune to a VSWR of 1.3:1 as normal. If a tune is not possible, however, the best tune point yet encountered during the tune operation should be utilized if it results in a VSWR of the threshold or better. When the coupler cannot tune to within 1.3:1 and the VSWR is greater than the threshold, then the coupler should indicate a failure to tune. The default value should be 200 which corresponds to a VSWR of 2.0:1. FaultThr: Fault VSWR Threshold. If the value is non-zero, the coupler should monitor the VSWR during operation (i.e. while tuned and in transmit) and declare a VSWR fault if the observed VSWR is greater than the Fault threshold divided by 100. If the value is zero, the coupler should not indicate a fault based upon VSWR during operation. The default value should be 0 which means the function is disabled. RetuneThr: Retune VSWR Threshold. If the value is non-zero, the coupler should monitor the VSWR during operation (i.e. while tuned and in transmit) and issue a Retune Request message if the observed VSWR is greater than the Retune threshold divided by 100. If the value is zero, the coupler should not request a retune based upon VSWR during operation. The default value should be 0 which means the function is disabled. KeyStkTO: Key Stuck Time-Out. This value represents the maximum time, in seconds, for which the coupler may remain continuously keyed. When the value is non-zero, the coupler should declare a Key Stuck fault if the coupler is continuously keyed for longer than the Key Stuck threshold. When the value is zero, the coupler should not declare a fault based upon the duration of key. The default value should be 0 which means the function is disabled.	XCVR → CPLR	10h Ignore Freq OOR (1) Silent Quick Tunes (1) ContThr (16) FaultThr (16) RetuneThr (16) KeyStkTO (16)

7.0 ANTENNA SYSTEMS (cont'd)

COMMAND/REQUEST DESCRIPTION	DIR.	CODE OR DATA
Commentary The use of configuration words allows for desirable operational characteristics to be selected while also allowing for backwards compatibility with current ARINC 719 parallel controlled couplers (all values default to 0). Care should be taken to not indicate inappropriate configuration combinations (i.e. FaultThr less than either RetuneThr or ContThr, etc.) or confusing operation may result.		
Initialize Coupler Completed - This message informs the transceiver that the initialize coupler command has been completed. The antenna coupler should now be in its initialization state. The status information shown should be the same format as the coupler status message.	XCVR ← CPLR	11h Frequency (32) Op Mode Code (4) Tune Status (4) Power Requested (4) Dual Sys Status (4) Key Status (1) Quick Tune Status (1) History Status (1) Ignore Freq OOR (1) Silent Quick Tunes (1) ContThr Status (16) FaultThr Status (16) RetuneThr Status (16) KeyStkTO Status (16) Fault Status (8) (Vendor Codes)
Initialize Coupler Aborted - This message informs the transceiver that the initialize coupler command has been aborted. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	12h Abort Code (8)
Coupler Key - This command instructs the antenna coupler to enter the transmit state. In particular, this causes the antenna interlock (to the other antenna coupler) to be asserted, the coupler switched into the RF path, and a tune sequence to begin if the frequency has changed since the last key. This is the *only* method by which the transceiver is able to request permission to transmit RF.	XCVR → CPLR	20h
Coupler Key Completed - This message informs the transceiver that the coupler key command has been completed and the antenna coupler is now in the transmit state. This message constitutes permission for the transceiver to transmit RF.	XCVR ← CPLR	21h
Coupler Key Aborted - This message informs the transceiver that the coupler key command has been aborted and the antenna coupler is *not* in the transmit state. If the antenna coupler aborts the key command because it cannot comply with the key command (if the antenna is interlocked, for example), then an advisory message should be sent to the transceiver prior to the key abort. This message inhibits RF transmission from the transceiver. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	22h Abort Code (8)
Coupler Unkey - This command instructs the antenna coupler to enter the receive state. The particular actions caused by this command depend upon the current operating mode as determined by the Operating Mode Select command.	XCVR → CPLR	24h

7.0 ANTENNA SYSTEMS (cont'd)

COMMAND/REQUEST DESCRIPTION	DIR.	CODE OR DATA
Coupler Unkey Completed - This message informs the transceiver that the coupler unkey command has been completed and the antenna coupler is now in the receive state.	XCVR ← CPLR	25h
Coupler Unkey Aborted - This message is to inform the transceiver that the coupler unkey command has been aborted. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	26h Abort Code (8)
New Frequency - This command instructs the antenna coupler to operate on a new frequency. Frequency is a 32 bit integer indicating frequency in Hz. The action taken upon receipt of a New Frequency command depends upon the current state of the Key. If the coupler is Unkeyed, then the antenna coupler should clear its faults (if any). If the coupler is Keyed, then RF will be disabled, faults cleared, and the antenna coupler untuned. A tune will be initiated on a subsequent coupler Key command.	XCVR → CPLR	30h Frequency (32)
New Frequency Completed - This message informs the transceiver that the New Frequency command has been completed. The antenna coupler is now ready to tune the new frequency. Note that at this time the antenna coupler is effectively unkeyed (even if it was keyed prior to the New Frequency command) and it will be necessary for the transceiver to re-key the coupler in order to tune the coupler and receive permission to transmit.	XCVR ← CPLR	31h
New Frequency Aborted - This message informs the transceiver that the new frequency command has been aborted. The antenna coupler should now be bypassed. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	32h Abort Code (8)
RF OFF - This command instructs the transceiver to turn off the RF. This message constitutes denial of permission for the transceiver to transmit RF	CPLR → XCVR	50h
RF OFF Completed - This message informs the antenna coupler that the RF OFF command has been completed and RF has been turned off. COMMENTARY The antenna coupler should verify the RF OFF condition before it takes action that might damage the coupler.	CPLR ← XCVR	51h
RF OFF Aborted - This message informs the antenna coupler that the RF OFF command has been aborted. The abort code is as described in Section 7.4.3.2.	CPLR ← XCVR	52h Abort Code (8)
Request Tune RF - This command instructs the transceiver to supply RF at the operating frequency. This RF should be at the tune power level and have a CW signal present.	CPLR → XCVR	54h
Request Tune RF Completed - This message informs the antenna coupler that the Tune RF request has been completed and RF at the operating frequency is available. COMMENTARY The antenna coupler should verify the presence of RF before RF related measurements are taken.	CPLR ← XCVR	55h

7.0 ANTENNA SYSTEMS (cont'd)

COMMAND/REQUEST DESCRIPTION	DIR.	CODE OR DATA
Request Tune RF Aborted - This message informs the antenna coupler that the Tune RF request has been aborted. The transceiver should turn RF OFF if this should occur. The abort code is as described in Section 7.4.3.2.	CPLR ← XCVR	56h Abort Code (8)
Request Test RF - This command instructs the transceiver to supply RF at the frequency specified by Test Frequency. The RF should be at the tune power level and have the characteristics described in the Request Tune RF command above. Commentary It is anticipated that the test frequency identified here is the one sent to the antenna coupler in the Perform Coupler Transmit BIT command. The transceiver should not rely on the Perform Coupler Transmit command, however, and be able to respond to any frequency in its capability.	CPLR → XCVR	58h Test Freq (32)
Request Test RF Completed - This message informs the antenna coupler that the Test RF request has been completed and RF at the specified frequency is available. COMMENTARY The antenna coupler should verify the presence of RF before RF related measurements are taken.	CPLR ← XCVR	59h
Request Test RF Aborted - This message informs the antenna coupler that the Test RF request has been aborted. The transceiver should turn RF OFF if this should occur. The abort code is as described in Section 7.4.3.2.	CPLR ← XCVR	5Ah Abort Code (8)
Operate at Reduced Power - This command instructs the transceiver to operate at a reduced power level. Implementation of this command is optional. COMMENTARY This command is usually performed in order to cause a graceful degradation in the case of the antenna coupler overheating.	CPLR → XCVR	60h
Operate at Reduced Power Completed - This message informs the antenna coupler that the Operate at Reduced Power command has been completed. The transceiver has accepted the command and should operate at significantly lower power.	CPLR ← XCVR	61h
Operate at Reduced Power Aborted - This message informs the antenna coupler that the Operate at Reduced Power command has been aborted (essentially, the request has been denied). The abort code is as described in Section 7.4.3.2.	CPLR ← XCVR	62h Abort Code (8)
Enable Operate at Full Power - This command informs the transceiver that it may once again operate at full power. This command is optional, though it should be recognized even if no action is taken.	CPLR → XCVR	64h
Enable Operate at Full Power Completed - This message informs the antenna coupler that the request for operation at full power has been completed.	CPLR ← XCVR	65h

7.0 ANTENNA SYSTEMS (cont'd)

COMMAND/REQUEST DESCRIPTION	DIR.	CODE OR DATA
Enable Operate at Full Power Aborted - This message informs the antenna coupler that the request for operation at full power has been aborted. The abort code is as described in Section 7.4.3.2.	CPLR ← XCVR	66h Abort Code (8)
Retune Request - This command informs the transceiver that the coupler has observed VSWR in excess of the configured Retune Request VSWR Threshold. This command requires no action, but it is anticipated that the transceiver will eventually cause another tune operation by re-issuing a New Frequency command and Key command. Even if no action is taken this command should be recognized and completed.	CPLR → XCVR	68h
Retune Request Completed - This message informs the antenna coupler that the retune request has been completed.	CPLR ← XCVR	69h
Retune Request Aborted - This message informs the antenna coupler that the retune request has been aborted. The abort code is as described in Section 7.4.3.2.	CPLR ← XCVR	6Ah Abort Code (8)
Request Coupler Status - This command instructs the antenna coupler to provide its status information to the transceiver.	XCVR → CPLR	70h

7.0 ANTENNA SYSTEMS (cont'd)

COMMAND/REQUEST DESCRIPTION	DIR.	CODE OR DATA
Request Coupler Status Completed - This message informs the transceiver that the request for coupler status has been completed and also supplies the status to the transceiver. Each of the identified words is described as follows: Frequency: A 32 bit integer indicating the operating frequency in Hertz. Op Mode Code: 1h = Dual System Receive, 2h = Tuned Simplex. Tune Status: 1h = Tuned, 2h = Tuning, 3h = Not Tuned. Power Requested: 1h = Operating Power, 2h = Reduced Power, 3h = Tune Power. Dual Sys Status: 1h = This coupler controls the antenna, 2h = Antenna available for dual receive operation, 3h = This coupler interlocked. Key Status: 0b = Not Keyed, 1b = Keyed. Quick Tune Status: 0b = Quick Tunes Enabled, 1b = Quick Tunes Disabled. History Status: 0b = History Storage Enabled, 1b = History Storage Disabled. Ignore Freq OOR: 0b = Report fault, 1b = Do not report fault if frequency is out of range of the coupler. Silent Quick Tunes: 0b = Check VSWR before tune complete. 1b = Do not check VSWR during tune operation - mark quick tune invalid if FaultThr or RetuneThr are exceeded during operation. ContThr: n/100 = Contingency Tune VSWR Threshold (i.e. the value 235 means a VSWR of 2.35:1). FaultThr: 0 = VSWR Fault Disabled, otherwise n/100 = Fault VSWR Threshold (i.e. the value 235 means a VSWR of 2.35:1). RetuneThr: 0 = Retune Request Disabled, otherwise n/100 = Retune Request VSWR Threshold (i.e. the value 235 means a VSWR of 2.35:1). KeyStkTO: 0 = Key Stuck Timer Disabled, otherwise n = Key Stuck Time-Out limit, in Seconds. Fault Status: This value represents the number of faults declared. It is the number of subsequent words that are to be interpreted as Vendor specific fault codes.	XCVR ← CPLR	71h Frequency (32) Op Mode Code (4) Tune Status (4) Power Requested (4) Dual Sys Status (4) Key Status (1) Quick Tune Status (1) History Status (1) Ignore Freq OOR (1) Silent Quick Tunes (1) ContThr Status (16) FaultThr Status (16) RetuneThr Status (16) KeyStkTO Status (16) Fault Status (8) (Vendor Codes)
Request Coupler Status Aborted - This message informs the transceiver that the coupler status request has been aborted. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	72h Abort Code (8)
Request Coupler Version - This command instructs the antenna coupler to provide its version data to the transceiver.	XCVR → CPLR	74h

7.0 ANTENNA SYSTEMS (cont'd)

COMMAND/REQUEST DESCRIPTION	DIR.	CODE OR DATA
Request Coupler Version Completed - This message informs the Transceiver that the coupler version request has been completed. The second field indicates the latest version of this protocol that the transceiver recognizes. The third field should indicate the particular Vendor ID of the antenna coupler. Specific Vendor IDs are as follows: 01h = Rockwell International 02h = Rohde & Schwarz The fourth field indicates the hardware version ID of the antenna coupler. The fifth field indicates the current software version of the antenna coupler. Formats for the HW and SW Version IDs are vendor specific.	XCVR ← CPLR	75h Protocol Version (8) Vendor ID (8) HW Version (64) SW Version (64)
Request Coupler Version Aborted - This message informs the transceiver that the coupler version request has been aborted. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	76h Abort Code (8)
Request Transceiver Version - This command instructs the transceiver to provide its version data to the coupler.	CPLR → XCVR	78h
Request Transceiver Version Completed - This message informs the coupler that the Transceiver version request has been completed. The second field indicates the latest version of this protocol that the transceiver recognizes. The third field should indicate the particular Vendor ID of the transceiver. Specific Vendor IDs are as follows: 01h = Rockwell International 02h = Rohde & Schwarz The fourth field indicates the hardware version ID of the transceiver. The fifth field indicates the current software version of the transceiver. Formats for the HW and SW Version IDs are vendor specific.	CPLR ← XCVR	79h Protocol Version (8) Vendor ID (8) HW Version (64) SW Version (64)
Request Transceiver Version Aborted - This message informs the coupler that the transceiver version request has been aborted. The abort code is as described in Section 7.4.3.2.	CPLR ← XCVR	7Ah Abort Code (8)

7.0 ANTENNA SYSTEMS (cont'd)

COMMAND/REQUEST DESCRIPTION	DIR.	CODE OR DATA
Coupler Fault Declaration - This message informs the transceiver that the coupler is declaring a fault condition. The fault class is a general classification of the type of fault the antenna coupler may have detected. 1h - Coupler Fault. This implies that the coupler may have determined that the fault is internal to itself. 2h - RF Fault. This declares that the fault is related to RF operations. 3h - System Fault. This is a fault that the coupler has detected that applies to the radio system as a whole, or to an element external to itself. Upon reception of a fault, the transceiver should disable RF and then take any appropriate action. The particular fault(s) can be identified by a request for coupler status.	CPLR → XCVR	80h Fault Class (4)
Coupler Fault Declaration Completed - This message informs the antenna coupler that the coupler fault declaration has been completed.	CPLR ← XCVR	81h
Coupler Fault Declaration Aborted - This message informs the antenna coupler that the coupler fault declaration has been aborted. The abort code is as described in Section 7.4.3.2.	CPLR ← XCVR	82h Abort Code (8)
Clear Coupler Faults - This command instructs the antenna coupler to clear its fault status and return to normal operation. Faults are also cleared each time an Initialize Coupler command is received.	XCVR → CPLR	84h
Clear Coupler Faults Completed - This message informs the transceiver that the clear coupler faults command has been successfully completed. The antenna coupler fault status should now be clear.	XCVR ← CPLR	85h
Clear Coupler Faults Aborted - This message informs the transceiver that the clear coupler faults command has been aborted. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	86h Abort Code (8)
Enable History Storage - This command instructs the antenna coupler to record and store history information in its internal memory for later examination by the Central & Maintenance Computer (through the radio) or ground based test equipment. This information includes the CMC data received from the radio upon request, the reason the history is being updated, and any other relevant information. History updates should occur on every fault condition and, optionally, upon other notable events.	XCVR → CPLR	A0h
Enable History Storage Completed - This message informs the transceiver that the history storage enable command is completed and the antenna coupler's history data storage is enabled.	XCVR ← CPLR	A1h
Enable History Storage Aborted - This message informs the transceiver that the history storage enable command has been aborted and the antenna coupler's history data storage status has reverted to that prior to the command. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	A2h Abort Code (8)

Command codes A0h through AAh, C0h through CAh, and D0h through D6h are intended for maintenance use only.

7.0 ANTENNA SYSTEMS (cont'd)

COMMAND/REQUEST DESCRIPTION	DIR.	CODE OR DATA
Inhibit History Storage - This command instructs the antenna coupler *not* to record and store history information. It is intended mainly for use in a testing or maintenance environment as a means for preserving the memories where this information is stored.	XCVR → CPLR	A4h
Inhibit History Storage Completed - This message informs the transceiver that the history storage inhibit command is completed and the antenna coupler's history data storage is disabled.	XCVR ← CPLR	A5h
Inhibit History Storage Aborted - This message informs the transceiver that the history storage inhibit command has been aborted and the antenna coupler's history data storage status has reverted to that prior to the command. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	A6h Abort Code (8)
Clear History Storage - This command instructs the antenna coupler to erase and reinitialize the internal memory where coupler history data is stored. This is intended for use in a testing or maintenance environment and the radio should not send this command while the aircraft is airborne.	XCVR → CPLR	A8h
Clear History Storage Completed - This message informs the transceiver that the Clear Coupler History Storage command has been completed and the coupler history data has been erased.	XCVR ← CPLR	A9h
Clear History Storage Aborted - This message informs the transceiver that the Clear History Data Storage command has been aborted. The status of the history data storage is indeterminate at this time - some may have already been erased, some may be invalid, and some may be usable. The antenna coupler should be able to continue to operate and correctly store and retrieve history data acquired after this time. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	AAh Abort Code (8)
Request History Data - This command instructs the antenna coupler to supply history data which it has stored in its history data memory. The second word of the command (described as Last "n" Events) represents the number of history events to be transferred (a value of 0 indicates that all stored history events are to be provided). Events are ordered in reverse order of occurrence, i.e. 1 = the most recent event (the last one stored). This message is intended for use in a testing or maintenance environment.	XCVR → CPLR	B0h Last "n" Events (8)
Request History Data Completed - This message informs the transceiver that the request for history data has been completed. All requested history data should have been made available to the transceiver in history data messages prior to this time.	XCVR ← CPLR	B1h
Request History Data Aborted - This message informs the transceiver that the request for history data has been aborted. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	B2h Abort Code (8)

Command codes A0h through AAh, C0h through CAh, and D0h through D6h are intended for maintenance use only.

7.0 ANTENNA SYSTEMS (cont'd)

COMMAND/REQUEST DESCRIPTION	DIR.	CODE OR DATA
History Data - This message contains coupler history data which has been in its history data memory. The second word of the command (Event no. "n") is an integer and represents the index of the event. Events are ordered in reverse order of occurrence, i.e. 1 = the most recent event (the last one stored). The series of words referred to as CMC Flight Data is the data received from the transceiver (originally the CMC) when the event was logged. At present this data and its format is described in Attachment 11 . The series of data words referred to as Event Data is vendor specific event data. This message is intended for use in a testing or maintenance environment.	CPLR → XCVR	B4h Event no. "n" (8) CMC Flight Data Vendor Data
History Data Completed - This message informs the antenna coupler that the last history data packet has been completed.	CPLR ← XCVR	B5h
History Data Aborted - This message informs the antenna coupler that the last history data packet has been aborted. The abort code is as described in Section 7.4.3.2.	CPLR ← XCVR	B6h Abort Code (8)
Request CMC Flight Data - This command instructs the transceiver to supply CMC flight data which it has received via the aircraft maintenance bus. The coupler should issue this request each time it desires to log an event into its history data storage. If the transceiver has no flight data available, then it should abort this command.	CPLR → XCVR	B8h
Request CMC Flight Data Completed - This message informs the antenna coupler that the request for CMC flight data has been completed. The second and subsequent words are the CMC flight data. This data and format are described in Attachment 11.	CPLR ← XCVR	B9h CMC Flight Data
Request CMC Flight Data Aborted - This message informs the antenna coupler that the request for CMC flight data has been aborted. The antenna coupler should log the history event with null data. The abort code is as described in Section 7.4.3.2.	CPLR ← XCVR	BAh Abort Code (8)
Enable Coupler Quick Tunes - This command instructs the antenna coupler to search its non-volatile memory for Quick Tune data whenever a tune cycle is initiated, and to store tune data in a Quick Tune whenever a tune sequence is successfully completed.	XCVR → CPLR	C0h
Enable Coupler Quick Tunes Completed - This message informs the transceiver that the Enable Coupler Quick Tunes command is completed and the antenna coupler should both search for and store Quick Tune data during tune operations.	XCVR ← CPLR	C1h
Enable Coupler Quick Tunes Aborted - This message informs the transceiver that the Enable coupler Quick Tunes command has been aborted and the antenna coupler's Quick Tune status has reverted to that prior to the command. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	C2h Abort Code (8)
Inhibit Coupler Quick Tunes - This command instructs the antenna coupler *not* to search for or store Quick Tune data during tunes. It is intended mainly for use in a testing or maintenance environment as a means for preserving the memories where this information is stored.	XCVR → CPLR	C4h

Command codes A0h through AAh, C0h through CAh, and D0h through D6h are intended for maintenance use only.

7.0 ANTENNA SYSTEMS (cont'd)

COMMAND/REQUEST DESCRIPTION	DIR.	CODE OR DATA
Inhibit Coupler Quick Tunes Completed - This message informs the transceiver that the Inhibit coupler Quick Tunes command is completed and the antenna coupler should *not* search for nor store Quick Tune data during tune operations.	XCVR ← CPLR	C5h
Inhibit Coupler Quick Tunes Aborted - This message informs the transceiver that the Inhibit coupler Quick Tunes command has been aborted and the antenna coupler's Quick Tune status has reverted to that prior to the command. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	C6h Abort Code (8)
Clear Coupler Quick Tune - This command instructs the antenna coupler to erase and reinitialize the internal memory where coupler Quick Tune data is stored. Because of the extensive time delays in the erase procedure, the operational advantages of Quick Tune acquired over time, and the self-updating nature of the Quick Tune data, it is not anticipated that this command will be needed outside of the factory environment and the radio should not send this command while the aircraft is airborne.	XCVR → CPLR	C8h
Clear Coupler Quick Tune Completed - This message informs the transceiver that the Clear coupler Quick Tunes command has been completed and the coupler Quick Tune data has been cleared.	XCVR ← CPLR	C9h
Clear Coupler Quick Tune Aborted - This message informs the transceiver that the Clear coupler Quick Tune command has been aborted. The status of the Quick Tune tables is indeterminate at this time - some Quick Tune commands may have already been erased, some may be invalid, and some others may be usable. The antenna coupler should be able to continue to operate and correctly store newly acquired Quick Tunes and use those determined to be valid. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	CAh Abort Code (8)
Request Quick Tune Data - This command instructs the antenna coupler to supply the Quick Tune data associated with the frequency indicated by the second word of this message. This message is intended for use in a testing or maintenance environment.	XCVR → CPLR	D0h Quick Tune Freq (32)
Request Quick Tune Data Completed - This message informs the transceiver that the request for Quick Tune data has been completed. Quick Tune Freq indicates the frequency of the Quick Tune data being supplied and should be the same as that in the original request. The third and subsequent words are vendor specific preset data.	XCVR ← CPLR	D1h Quick Tune Freq (32) Vendor Data
Request Quick Tune Data Aborted - This message informs the transceiver that the request for Quick Tune data has been aborted. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	D2h Abort Code (8)
Request Tune Data - This command instructs the antenna coupler to supply the tune data associated with the last tuned frequency. This message is intended for use in a testing or maintenance environment.	XCVR → CPLR	D4h
Request Tune Data Completed - This message informs the transceiver that the request for tune data has been completed. Tune Freq indicates the frequency of the tune data being supplied. The third and subsequent words are vendor specific tune data.	XCVR ← CPLR	D5h Tune Freq (32) Vendor Data

Command codes A0h through AAh, C0h through CAh, and D0h through D6h are intended for maintenance use only.

7.0 ANTENNA SYSTEMS (cont'd)

COMMAND/REQUEST DESCRIPTION	DIR.	CODE OR DATA
Request Tune Data Aborted - This message informs the transceiver that the request for tune data has been aborted. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	D6h Abort Code (8)
Perform Coupler Local BIT - This command instructs the antenna coupler to perform any BIT functions that are possible without external intervention or response.	XCVR → CPLR	E0h
Perform Coupler Local BIT Completed - This message informs the transceiver that the coupler Local BIT has been completed. The second word indicates whether the coupler Passed (00h) or Failed (FFh) the BIT. The third and subsequent words are vendor specific fault data or BIT status.	XCVR ← CPLR2	E1h Passed/Failed (8) Vendor Data
Perform Coupler Local BIT Aborted - This message informs the transceiver that the coupler Local BIT has been aborted. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	E2h Abort Code (8)
Perform Coupler System BIT - This command instructs the antenna coupler to perform the coupler Local BIT functions and, additionally, those BIT functions that require the services of or response from the transceiver, *except* those which require RF transmission.	XCVR → CPLR	E4h
Perform Coupler System BIT Completed - This message informs the transceiver that the coupler System BIT has been completed. The second word indicates whether the coupler Passed (00h) or Failed (FFh) the BIT. The third and subsequent words are vendor specific fault data or BIT status.	XCVR ← CPLR	E5h Passed/Failed (8) Vendor Data
Perform Coupler System BIT Aborted - This message informs the transceiver that the coupler System BIT has been aborted. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	E6h Abort Code (8)
Perform Coupler Transmit BIT - This command instructs the antenna coupler to perform the Local and System BIT functions as well as any BIT functions that may require RF transmission. Test Frequency indicates a frequency the antenna coupler may utilize for transmission (this frequency uses the same format as the New Frequency Command).	XCVR → CPLR	E8h Test Frequency (32)
Perform Coupler Transmit BIT Completed - This message informs the transceiver that the coupler Transmit BIT has been completed. The second word indicates whether the coupler Passed (00h) or Failed (FFh) the BIT. The third and subsequent words are vendor specific fault data or BIT status.	XCVR ← CPLR	E9h Passed/Failed (8) Vendor Data
Perform Coupler Transmit BIT Aborted - This message informs the transceiver that the coupler Transmit BIT has been aborted. The transceiver should turn RF OFF if it is presently ON. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	EAh Abort Code (8)
Coupler Loop Test Message - This message is used to test the communications path between the transceiver and the coupler.	CPLR → XCVR	F0h Loop Test Data (16)
Coupler Loop Test Message Completed - With this message the transceiver completes the coupler Loop Test Message. The Test Data field should be an exact duplicate of the Loop Test Data field in the coupler Loop Test Message sent to the transceiver.	CPLR ← XCVR	F1h Loop Test Data (16)

Command codes A0h through AAh, C0h through CAh, and D0h through D6h are intended for maintenance use only.

7.0 ANTENNA SYSTEMS (cont'd)

COMMAND/REQUEST DESCRIPTION	DIR.	CODE OR DATA
Coupler Loop Test Message Aborted - This message informs the antenna coupler that the coupler Loop Test Message has been aborted. The abort code is as described in Section 7.4.3.2.	CPLR ← XCVR	F2h Abort Code (8)
Transceiver Loop Test Message - This message is used to test the communications path between the transceiver and the coupler.	XCVR → CPLR	F4h Loop Test Data (16)
Transceiver Loop Test Message Completed - With this message the coupler completes the Transceiver Loop Test Message. The Test Data field should be an exact duplicate of the Loop Test Data field in the Transceiver Loop Test Message sent to the coupler.	XCVR ← CPLR	F5h Loop Test Data (16)
Coupler Loop Test Message Aborted - This message informs the transceiver that the Transceiver Loop Test Message has been aborted. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	F6h Abort Code (8)
Coupler Free Form Message - This message is a free form data message intended for use in a testing or maintenance environment. Other than acknowledge and completion, this message should be ignored by the transceiver.	CPLR → XCVR	F8h Vendor Data
Coupler Free Form Message Completed - This message informs the antenna coupler that the coupler Free Form Message has been completed.	CPLR ← XCVR	F9h
Coupler Free Form Message Aborted - This message informs the antenna coupler that the coupler Free Form Message has been aborted. The abort code is as described in Section 7.4.3.2.	CPLR ← XCVR	FAh Abort Code (8)
Transceiver Free Form Message - This message is a free form data message intended for use in a testing or maintenance environment. Other than acknowledge and completion, this message should be ignored by the coupler.	XCVR → CPLR	FCh Vendor Data
Transceiver Free Form Message Completed - This message informs the transceiver that the Transceiver Free Form Message has been completed.	XCVR ← CPLR	FDh
Transceiver Free Form Message Aborted - This message informs the transceiver that the Transceiver Free Form Message has been aborted. The abort code is as described in Section 7.4.3.2.	XCVR ← CPLR	FEh Abort Code (8)

7.0 ANTENNA SYSTEMS (cont'd)

7.4.3.5 Example Communication Sequence

The following message sequence is an illustrative example of the link layer and control protocols in action. The example shows a typical tune operation.

Initial situation: The radio system is in receive (Dual System Receive mode for the coupler). The current operating frequency is 6.789 MHz. The operator changes the operating frequency to 12.345 MHz.

The transceiver is commanded to change to a new frequency. The transceiver sends a New Frequency Message for 12.345 MHz to the Antenna Coupler.

TRANSCEIVER SENDS/ASSERTS THE FOLLOWING		SERIAL DATA & DIRECTION	COUPLER SENDS/ASSERTS THE FOLLOWING	
Interpretation of Serial Word	RTS CTS		RTS CTS	Interpretation of Serial Word
	Off		Off	
	RTS		Off	
	RTS		CTS	
Length Word	RTS	0000 0111 →	CTS	
New Frequency	RTS	0011 0000 →	CTS	
Freq (12.345 MHz) - LSW.LSB	RTS	1010 1000 →	CTS	
Freq (12.345 MHz) - LSW.MSB	RTS	0101 1110 →	CTS	
Freq (12.345 MHz) - MSW.LSB	RTS	1011 1100 →	CTS	
Freq (12.345 MHz)-MSW.MSB	RTS	0000 0000 →	CTS	
Checksum Word	RTS	0100 0011 →	CTS	
	CTS		CTS	
	CTS	← 0100 1101	CTS	Acknowledge Word
	Off		CTS	
	Off		Off	

The coupler receives the New Frequency command and begins the frequency changing process. The HF system is in receive, so it is not necessary to turn the RF off. Likewise, there are no faults, so it is not necessary to clear them. The coupler sends an acknowledge word to the transceiver indicating that all coupler operations necessary for a frequency change are complete.

TRANSCEIVER SENDS/ASSERTS THE FOLLOWING		SERIAL DATA & DIRECTION	COUPLER SENDS/ASSERTS THE FOLLOWING	
Interpretation of Serial Word	RTS CTS		RTS CTS	Interpretation of Serial Word
	Off		Off	
	Off		RTS	
	CTS		RTS	
	CTS	← 0000 0011	RTS	Length Word
	CTS	← 0011 0001	RTS	New Frequency Completed
	CTS	← 0011 0100	RTS	Checksum Word
	CTS		CTS	
Acknowledge Word	CTS	0001 0111 →	CTS	
	CTS		Off	
	Off		Off	

7.0 ANTENNA SYSTEMS (cont'd)

The transceiver can now complete any steps left in the frequency change operation. Since the transceiver is not yet in transmit, a Coupler Key command is sent to the coupler.

TRANSCEIVER SENDS/ASSERTS THE FOLLOWING		SERIAL DATA & DIRECTION	COUPLER SENDS/ASSERTS THE FOLLOWING	
Interpretation of Serial Word	RTS CTS		RTS CTS	Interpretation of Serial Word
	Off		Off	
	RTS		Off	
	RTS		CTS	
Length Word	RTS	0000 0011 →	CTS	
Coupler Key	RTS	0010 0000 →	CTS	
Checksum Word	RTS	0010 0011 →	CTS	
	CTS		CTS	
	CTS	← 0100 1101	CTS	Acknowledge Word
	Off		CTS	
	Off		Off	

The coupler receives the Coupler Key command. The antenna coupler checks the dual system lines and determines that the antenna is available for transmit. The coupler then asserts its antenna interlock line to command the other coupler to disconnect from the antenna. The coupler should wait enough time to insure that the other unit has had time to disengage from the antenna before RF is allowed to be put on the antenna.

Since the operating frequency has changed since the last tune, a tuning operation is necessary.

The antenna coupler first checks to see if the frequency (12.345 MHz) has a Quick Tune available. In this example a Quick Tune is available so the coupler switches the network to the Quick Tune settings.

The coupler now requires tune RF in order to verify that the Quick Tune is still good. Note that if Silent Quick Tunes were selected then the next several steps ↓ would not be implemented. The coupler requests RF from the transceiver.

7.0 ANTENNA SYSTEMS (cont'd)

TRANSCEIVER SENDS/ASSERTS THE FOLLOWING		SERIAL DATA & DIRECTION	COUPLER SENDS/ASSERTS THE FOLLOWING	
Interpretation of Serial Word	RTS CTS		RTS CTS	Interpretation of Serial Word
	Off		Off	
	Off		RTS	
	CTS		RTS	
	CTS	← 0000 0011	RTS	Length Word
	CTS	← 0101 0100	RTS	Request Tune RF
	CTS	← 0101 0111	RTS	Checksum Word
	CTS		CTS	
Acknowledge Word	CTS	0001 0111 →	CTS	
	CTS		Off	
	Off		Off	

The transceiver has receives the Tune RF Request. Unless the transceiver is inhibited by fault or other conditions (not in this case) the transceiver should turn on RF. The RF should be at the operating frequency (12.345 MHz), at tune power level, and with a CW signal. The transceiver should allow sufficient time for the RF to stabilize before indicating command completed.

TRANSCEIVER SENDS/ASSERTS THE FOLLOWING		SERIAL DATA & DIRECTION	COUPLER SENDS/ASSERTS THE FOLLOWING	
Interpretation of Serial Word	RTS CTS		RTS CTS	Interpretation of Serial Word
	Off		Off	
	RTS		Off	
	RTS		CTS	
Length Word	RTS	0000 0011 →	CTS	
Request Tune RF Completed	RTS	0101 0101 →	CTS	
Checksum Word	RTS	0101 1000 →	CTS	
	CTS		CTS	
	CTS	← 0100 1101	CTS	Acknowledge Word
	Off		CTS	
	Off		Off	

The antenna coupler should verify RF is available and take any readings required to determine if the Quick Tune is "good".

After the readings are taken the coupler requests the transceiver to shut the RF off. The RF should be shut off as soon as possible to avoid keeping the PA transmitting into a potentially high VSWR for extended periods of time as well as to minimize interference on the operating frequency.

7.0 ANTENNA SYSTEMS (cont'd)

TRANSCEIVER SENDS/ASSERTS THE FOLLOWING		SERIAL DATA & DIRECTION	COUPLER SENDS/ASSERTS THE FOLLOWING	
Interpretation of Serial Word	RTS CTS		RTS CTS	Interpretation of Serial Word
	Off		Off	
	Off		RTS	
	CTS		RTS	
	CTS	← 0000 0011	RTS	Length Word
	CTS	← 0101 0000	RTS	RF OFF
	CTS	← 0101 0011	RTS	Checksum Word
	CTS		CTS	
Acknowledge Word	CTS	0001 0111 →	CTS	
	CTS		Off	
	Off		Off	

The transceiver receives the RF OFF command. The transceiver should immediately turn the RF off and should allow sufficient time for the RF to actually go off before indicating command completed.

TRANSCEIVER SENDS/ASSERTS THE FOLLOWING		SERIAL DATA & DIRECTION	COUPLER SENDS/ASSERTS THE FOLLOWING	
Interpretation of Serial Word	RTS CTS		RTS CTS	Interpretation of Serial Word
	Off		Off	
	RTS		Off	
	RTS		CTS	
Length Word	RTS	0000 0011 →	CTS	
RF OFF Completed	RTS	0101 0001 →	CTS	
Checksum Word	RTS	0101 0100 →	CTS	
	CTS		CTS	
	CTS	← 0100 1101	CTS	Acknowledge Word
	Off		CTS	
	Off		Off	

The antenna coupler should verify that RF is off.

In this example the Quick Tune has been determined to be valid (the VSWR is less than 1.3:1), thus the tune is now complete. The previous several steps ↑ would not have occurred had Silent Quick Tunes been selected.

The antenna coupler indicates that tuning is complete by sending a Coupler Key Acknowledge.

7.0 ANTENNA SYSTEMS (cont'd)

TRANSCEIVER SENDS/ASSERTS THE FOLLOWING		SERIAL DATA & DIRECTION	COUPLER SENDS/ASSERTS THE FOLLOWING	
Interpretation of Serial Word	RTS CTS		RTS CTS	Interpretation of Serial Word
	Off		Off	
	Off		RTS	
	CTS		RTS	
	CTS	← 0000 0011	RTS	Length Word
	CTS	← 0010 0001	RTS	Coupler Key Complete
	CTS	← 0010 0100	RTS	Checksum Word
	CTS		CTS	
Acknowledge Word	CTS	0001 0111 →	CTS	
	CTS		Off	
	Off		Off	

The transceiver is now able to transmit. The transceiver turns on the RF and the radio system is now set to transmit at 12.345 MHz.

7.5 Tuning Time

The average tuning time should not exceed 5 seconds. The maximum tuning time should not exceed 7 seconds. Future protocols could require a frequency switching time mentioned in Section 4.2.1.1 without the exception for the coupler.

8.0 PROVISIONS FOR AUTOMATIC TEST EQUIPMENT

8.1 General

To enable Automatic Test Equipment (ATE) to be used in the bench maintenance of the HFDL equipment, internal circuit functions not available at the ARINC 600 unit service connector and considered by the equipment manufacturer necessary for automatic test purposes may be brought to pins on an auxiliary connector of a type selected by the equipment manufacturer. The manufacturer should observe ARINC Specification 600 standards for unit projections, etc., when choosing the location for this auxiliary connector.

8.2 ATE Testing

The HFDL LRUs should be ATE testable and should have a test program written using the Abbreviated Test Language for All Systems (ATLAS) language elements of ARINC Specification 626, "Standard ATLAS Subset for Modular Test" developed in accordance with ARINC Report 627, "Programmers Guide for SMART™ Systems Using ARINC Specification 626 ATLAS."

The ATLAS test procedure should be demonstrated to execute without modification on "SMART Automatic Test Systems" which are defined in ARINC Specification 608A as "avionics test systems ... in conformance with ARINC Specification 608A, contain the hosted SMART™ software offered by Aeronautical Radio, Inc. and other licensed vendors."

9.0 PROVISIONS FOR BUILT-IN TEST EQUIPMENT

9.1 Introduction

The HFDL LRUs should contain BITE capabilities in accordance with ARINC Report 624, "Design Guidance for Onboard Maintenance System (OMS)", and ARINC Report 604, "Guidance for Design and Use of Built-In Test Equipment."

COMMENTARY

> The guidance in ARINC Report 624 regarding the BITE capability for detection and isolation of internal and external HFDL system faults or failures generally supersedes that in ARINC Report 604. Also, the general philosophy, basic guidance, and certain specific recommendations are described for the OMS in ARINC Report 624, and for the Centralized Fault Display System (CFDS) in ARINC Report 604.

The HFDL LRU's BITE should be capable of detecting and annunciating a minimum of 95% of the faults or failures which can occur within the HFDL LRU's and as many faults as possible associated with the HF antenna, coaxial cable, and interfaces with the CMU or MU.

COMMENTARY

> Whether the VSWR of the antenna and its associated cabling should be measured and judged "GOOD" has been a subject of considerable discussion in the past. It should be noted that the antenna cabling loss of 5.5 dB will yield a VSWR of not more than 1.9:1 regardless of the antenna system VSWR. Therefore, measuring the VSWR at the connector of the radio should at best only determine whether or not the antenna feed line is connected and not severely damaged near the transceiver. Under no circumstances should an antenna and its associated cabling be judged "BAD" if acceptable communications can be performed.

The HFDL LRU's BITE should operate continuously during flight. Monitoring of the results should be automatic. The BITE should automatically test, detect, isolate, and record both intermittent and steady state faults.

COMMENTARY

> It is not the intent that BITE operation interfere with the normal operation of the LRUs. The use of full BITE during initialization may not be practical during normal operation.
>
> Discussion - Users realize that 95% coverage may not be possible in operational environments except during very unique conditions. For example, the testing of RAM is not reasonable during operation, except at power-up.

The BITE should indicate its condition and any faulty inputs upon activation of the self-test routine. In addition, BITE should display faults which have been detected during in-flight monitoring. No failure occurring within the BITE system should interfere with the normal operation of the HFDL system.

COMMENTARY

> Sufficient margins should be used in choosing BITE parameters to preclude nuisance warnings. Discrepancies in HFDL operation caused by power bus transients, received noise, Electromagnetic Interference (EMI), servicing interference, abnormal accelerations, turbulence, etc. should not be recorded as faults.

9.2 BITE Interfaces

The HFDL LRUs should facilitate control and annunciation of the BITE information via one or more of the following:

- OMS/CFDS Interfaces
- MU/CMU Interfaces
- HFDR Front Panel
- HFDU Front Panel
- HFDCF
- CMS/CFDIU Interfaces

The CMS/CFDIU should communicate via one input and one output ARINC 429 port, both operating low speed. For data format and protocol ARINC Report 604 should apply.

COMMENTARY

> The HFDL system is intended to be compatible with newer aircraft which have either an OMS or CFDS, as well as older aircraft which have no centralized maintenance system. In order to ensure interchangeability of the HFDL system across the entire range of installations, it should be capable of supporting BITE on the various interfaces.

On the OMS/CFDS interfaces and the MU/CMU interfaces, the HFDL system should provide a listing of BITE options in menu format for operator selection. By menu selection, the operator should be capable of requesting fault status (current and previous), initiating self tests and requesting detailed failure information for diagnostics. The philosophy expressed in ARINC Reports 604 and 624 is that avionic units such as the HFDL LRUs should provide an interactive, "user friendly" aid to maintenance.

COMMENTARY

> The interactive BITE capability which provides detailed failure information and fault isolation data is meant to be used by trained maintenance personnel while the aircraft is on the ground.

9.2.1 OMS Interfaces

The HFDL system should facilitate BITE control and fault reporting capability, including an interface with a Central Maintenance Computer (CMC) in accordance

9.0 PROVISIONS FOR BUILT-IN TEST EQUIPMENT (cont'd)

9.2.1 OMS Interfaces (cont'd)

with ARINC Report 624. Attachment 7, Table 7-1 describes the list of BITE codes which should be used for HFDL fault reporting.

9.2.2 Character-Oriented CFDS Interfaces

The HFDL system should facilitate BITE control and readout, including interfaces with single or dual Centralized Fault Display Interface units (CFDIUs), in accordance with the character oriented fault reporting protocol described in ARINC Report 604. Attachment 7, Table 7-4 contains the list of BITE fault messages which should be used for ARINC 753 HFDR fault reporting.

9.2.3 Bit-Oriented CFDS Interfaces

The HFDL system should facilitate BITE control and readout, including interfaces with single or dual CFDIUs, in accordance with the bit-oriented fault reporting protocol described in ARINC Report 604. Command and Fault summary words should be in accordance with Attachment 7, Tables 7-2 and 7-3.

9.2.4 MU/CMU BITE Interfaces

The HFDL system should facilitate BITE control and readout via the single or dual interfaces with the MU or CMU. Protocols for exchange of BITE data on these interfaces should be in accordance with the bit-oriented CFDIU protocol described in ARINC Report 604. Command and Fault summary words should be in accordance with Attachment 7, Tables 7-2 and 7-3.

9.2.5 HFDR/HFDU Equipment Identification Word

The ARINC Label 377 word is issued to transmit the HFDR equipment identification code to the MU/CMU and A/C monitoring tools. The format of the Label 377 word is defined in ARINC Specification 429. The equipment ID for the HFDR should be set to "019" which identifies the LRU as a "HF transceiver".

COMMENTARY

To be compatible with current OMS installations, the equipment code should be the same in ARINC 719 and 753 radios, i.e. "019". This will provide an interface with the OMC without modifying the HFDR installation in the event of retrofit.

The equipment ID for the HFDU should be set to 053.

9.3 BITE Presentation

BITE information provided on the data buses for the OMS/CFDS and CMU/MU should be presented to maintenance personnel on the display contained within the applicable system. Additionally, the HFDL system should present System/LRU fault status on its front panels in order to facilitate the use of BITE for local troubleshooting in the electronics equipment bay and for installations without a compatible OMS/CFDS or MU/CMU.

9.4 Fault Monitor

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

The contents of the monitor memory should be retrievable by BITE operation or by shop maintenance equipment. Refer to ARINC Report 624 for further guidance on fault recording.

The HFDL system should send BITE fault data to the OMS/CFDS and MU/CMU on the applicable Data Bus.

COMMENTARY

The airlines have expressed an interest in having BITE data from as many as 64 previous flight legs available in memory.

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 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.

9.5 Self-Test Initiation

At the time of equipment turn-on, a power-up self-test should be initiated automatically as described in ARINC Reports 604 and 624. In addition, the HFDL system should provide self-test capability for troubleshooting and installation verification. The initiation of the applicable test sequences should be possible from the control point(s) for the OMS, CFDS, MU, or CMU.

COMMENTARY

It is desirable that the power-up self-test be completed in less than 15 seconds.

As an aid to shop maintenance and trouble-shooting on the aircraft, a mechanism should be provided on the HFDR and HFDU front panels for initiation and annunciation of a unit/system self-test results. The self-test routine should start with a test which verifies the correct operation of all elements of the annunciating mechanism. If the self-test routine detects a fault, the appropriate fault should be annunciated. If no fault is found, the contents of the intermittent fault memory should be reviewed; if an occurrence of a fault on one of the four earlier flight legs is detected, the appropriate fault should be annunciated. If no faults are detected, and none were recorded during the four earlier flight legs, a "normal" status should be annunciated. Fault annunciations should continue until the self-test control is activated a second time or a "time-out" period of approximately ten minutes expires.

9.0 PROVISIONS FOR BUILT-IN TEST EQUIPMENT (BITE) (cont'd)

COMMENTARY

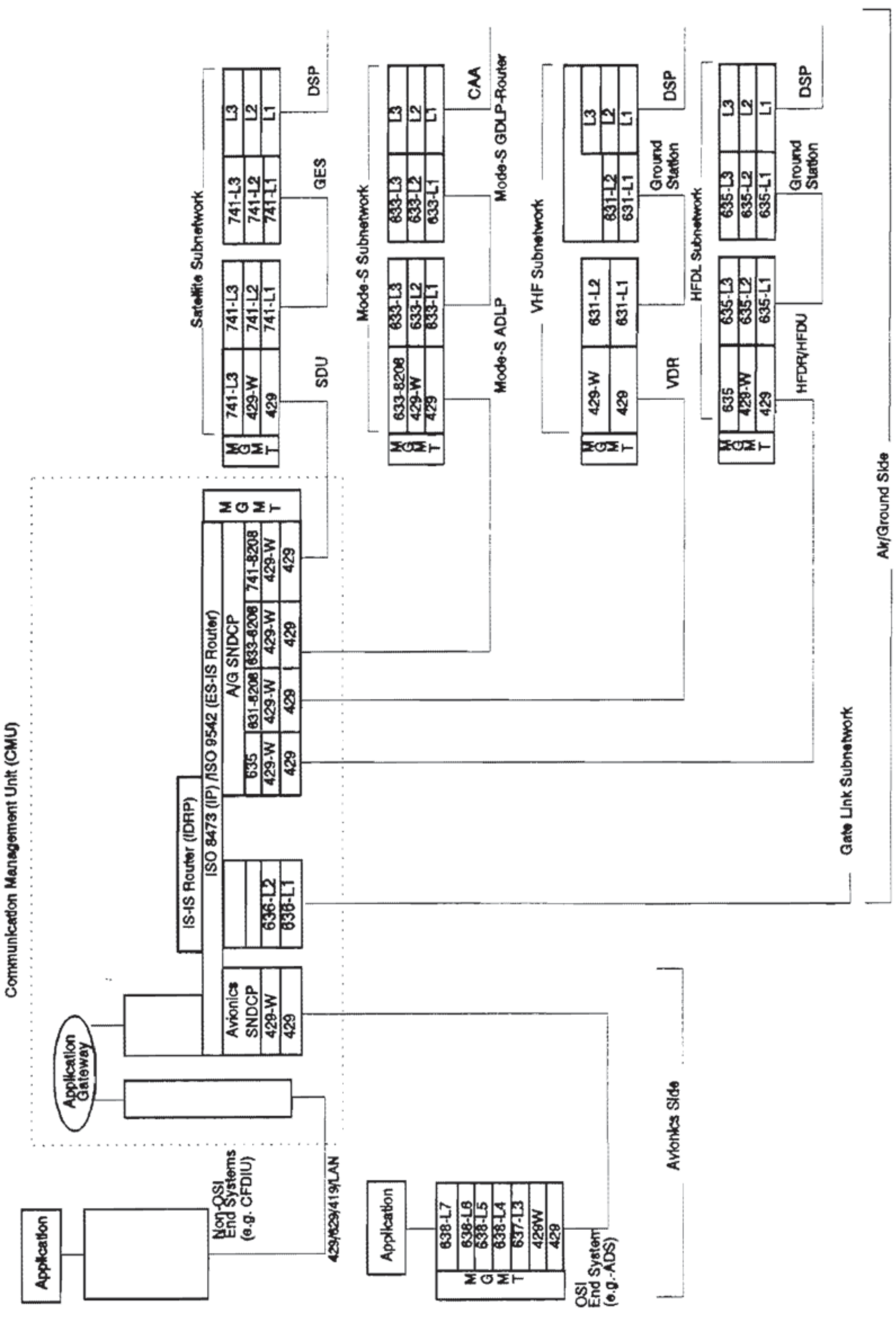
Selection of four as the number of flight legs (for which intermittent fault memory should be examined for the line maintenance BITE function) was made in the belief that it could be reduced as confidence in the BITE was built up. Manufacturers are urged to make this number easily alterable in their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

9.6 Monitor Memory Output

The BITE Monitor Memory should provide an output of undefined format for shop read-out at the ATE reserved pins of the upper connector located on the HFDL LRUs.

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

ATTACHMENT 1-1
AIRBORNE SUBSYSTEM BLOCK DIAGRAM



Note: This figure also appears in other ARINC standards. Due to non-synchronous update of ARINC standards, differences in this figure between standards may arise. In all cases, the figure with the most recent date (see lower left-hand corner) should have precedence.

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ATTACHMENT 2-1A
HFDR AVIONICS CONFIGURATION A