

ARINC

VHF DATA RADIO

ARINC CHARACTERISTIC 750

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Characteristic 750

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FOREWORD

Activities of AERONAUTICAL RADIO, INC. (ARINC)

and the

Purpose of ARINC Characteristics

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

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

An ARINC Equipment Characteristic is finalized after investigation and coordination with the airlines who have a requirement or anticipate a requirement, with other aircraft operators, with the Military services having similar requirements, and with the equipment manufacturers. It is released as an ARINC Equipment Characteristic only when the interested airline companies are in general agreement. Such a release does not commit any airline or ARINC to purchase equipment so described nor does it establish or indicate recognition of the existence of an operational requirement for such equipment, 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 describes one of the airborne components of the Aviation VHF Packet Communications (AVPAC) system, defined in ARINC Specification 631. 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 will cover the desired operational capability of the system and the standards necessary to achieve interchangeability of the hardware. The VHF Data Radio (VDR) has various modes of operation which are described more fully in Chapter 3.

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 Airborne Subsystem Configuration

This document assumes that the airborne components implementing AVPAC are arranged as shown in Attachment 1 and that they function within the system operating rules laid down in ARINC Specification 631, ARINC Specification 637, and ARINC Specification 638.

The VDR has two basic domains of operation as a standard double sideband AM analog voice transceiver and as a data-capable transceiver. Depending on the selected data mode, the VDR performs transceiver, modem, and/or link layer functionality. In AVPAC, the VDR is either a simple transceiver with an analog interface or a link layer bridge for the VHF subnetwork. In ACARS, the VDR is either a simple transceiver with an analog interface to the MU or a MSK modem.

As an AVPAC bridge, the VDR is an integral part of the AVPAC/ATN communications protocol suite. Detailed background of AVPAC/ATN can be found in ARINC Specifications 631, 637, and 638.

As an ACARS modem, the VDR (bidirectionally) converts digital data to RF output. Detailed background of ACARS can be found in ARINC Specifications 618, 619, and 620.

Depending on the selected mode, the VDR operates with a Communications Management Unit (CMU) (see ARINC Characteristic 748), a Management Unit (MU) (see ARINC Characteristic 597; ARINC Characteristic 724, ARINC Characteristic 724B, and ARINC Specification 618), a Central Fault Display Interface Unit (CFDIU) (see ARINC Report 604) or Onboard Maintenance System (see ARINC Report 624), and/or an antenna with vertical polarization and omnidirectional azimuth radiation pattern coverage.

1.3 Interchangeability

1.3.1 General

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

1.3.2 Interchangeability Required for the ARINC 750 VHF Data Radio

Unit interchangeability is required for the VDR regardless of manufacturing source. In defining the equipment described in this characteristic, the air transport industry has chosen to depart from its previous data link standards. In order to achieve the full benefit of the economies offered by these changes, the industry desires that any provisions for backwards compatibility with earlier generations of VHF Communications equipment described by ARINC 716 be provided as basic provisions. The ARINC 750 radio is pin- and function- compatible with the ARINC 716 radio.

1.4 Regulatory Approval

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 Section sets forth the specific form factor, mounting provisions, interwiring, input and output interfaces and power supply characteristics desired for the VHF Data Radio.

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

2.2 Form Factors, Connectors, and Index Pin Coding

2.2.1 VHF Data Radio (VDR)

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

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

The ATE interconnection insert (TP) will not be included in the mating half of the connector installed in the aircraft since ATE interconnections are employed in the bench testing of the receiver only, except as required for the expanded functionality identified in Attachment 3. This insert should be provided with a protective cover to prevent contamination of the contacts during the time the receiver is installed in the aircraft. Further guidance on the ATE interface will be found in Chapter 6 of this document.

2.2.2 Antennas

There are no specific form factors set forth herein for the antennas to be employed with this particular equipment as there are numerous designs presently on the market for 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 upon, of course, the particular aircraft type for which the antenna is intended and the need to minimize weight. It is recognized that for most air transport applications the antennas will be integrated into the airframe design and it is, therefore, only in special installations or retrofit installations where specific "antenna units" would be needed. The design

in this Characteristic is based on the use of a 0 dBi antenna. Airlines should realize that one of the factors limiting the potential throughput of the VHF communication system is the signal loss associated with the cabling between the VDR and the antenna.

2.3 Standard Interwiring

The standard interwiring to be installed for the VDR is set forth in Attachment 3. This interwiring is designed to provide the degree of interchangeability specified in Section 1.3. Manufacturers are cautioned not to rely upon special wires, cabling or shielding for use with particular units because they will not exist in the standard installation.

COMMENTARY

Why Standardize Interwiring?

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

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

The reader is also cautioned to give due consideration to the specific notes in Attachment 4 as they apply to the standard interwiring.

2.4 Power Circuitry

2.4.1 Primary Power Input

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

One 10A circuit breaker should be provided in the standard installation.

2.4.2 Power Control Circuitry

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

2.0 INTERCHANGEABILITY STANDARDS (cont'd)2.4.3 The Common Ground

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

2.4.4 Internal Circuit Protection

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

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

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

2.5 System Functions and Signal Characteristics

A list of the system functions and signal characteristics required to ensure the desired level of interchangeability for the VDR is set forth in Chapters 4 and 5 of this document.

2.6 Environmental Conditions

The VDR should be specified environmentally in terms of the requirements of RTCA Document DO-160C, "Environmental Conditions and Test Procedures for Airborne Equipment", dated December 1989 and Change 1 dated September 27, 1990. Attachment 5 to this characteristic tabulates the relevant environmental categories.

2.7 Cooling

The VDR should be designed to accept, and airframe manufacturers should configure the installation to provide forced air cooling as defined in ARINC Specification 600. The standard installation should provide an air flow rate of 13.6 kg/hr of 40°C air and the unit should not dissipate more than an average of 75 watts of energy. The coolant air pressure drop through the equipment should be 5 ± 3 mm at standard conditions of 1013.25 mbars. This pressure drop does not include the drop through a returning orifice when such orifice is located external to the equipment case. A loss of cooling should not cause total loss of functionality, although a partial reduction in duty cycle is acceptable.

COMMENTARY

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

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 VDR 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 and Appendix 1 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 subparagraphs 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.

2.0 INTERCHANGEABILITY STANDARDS (cont'd)**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 700-Series Characteristics, however, there are few exceptions for special conditions.

The logic sources for the Discrete Inputs to the VDR are expected to take the form of switches mounted on the airframe component (flap, landing 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 VDR will, in each case, be expected to provide the DC signal to be switched. Typically, this is done through a pull-up resistor. The VDR 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 "favorable" 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 VDR 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 at 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 VDR service connector 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,

2.0 INTERCHANGEABILITY STANDARDS (cont'd)

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 (MP10A).

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 MODES OF OPERATION

3.1 Introduction

There are three primary VDR modes of operation: 716 Voice compatibility mode, 716 Data compatibility mode, and 750 Data mode. The 716 Voice and 716 Data modes emulate the current ARINC 716 radio functions. While in 750 Data mode, the VDR may bridge ACARS traffic between the [C]MU/VDR digital bus and the internal 2.4 kbps MSK MODEM or bridge AVPAC traffic between the [C]MU/VDR digital bus and the 2.4 kbps MSK or high-speed MODEMs.

3.2 Description of the Modes

3.2.1 716 Voice Mode

716 Voice mode is the basic VHF COMM compatible voice mode defined in ARINC Characteristic 716, retained for backward compatibility. Voice signals are provided via normal audio I/O, with transmit and receive conditions initiated by the operator with the microphone. The RF signal in space will be double sideband AM. Tuning/frequency selection is made by low speed ARINC 429 data words from an associated radio control panel.

3.2.2 716 Data Mode

716 Data mode is the basic VHF COMM compatible data mode defined in ARINC Characteristic 716, retained for backward compatibility. Data will be transferred via analog discrete methods, using two conductor twisted pairs. Tuning data will be provided via a low speed ARINC 429 data bus, while transmit/receive commands are discrete digital signals from the [C]MU. Operating protocols may be per either ARINC Specification 618 (ACARS) or ARINC Specification 631 (AVPAC).

3.2.3 750 Data Mode

When in 750 Data mode, both tuning and digital data will be received over a high speed ARINC 429 port.

While in 750 Data mode, the [C]MU may command the VDR to operate as an ACARS MAC bridge by issuing the ACARS_ADDRESS.request primitive. Alternatively, if the [C]MU issues an AVPAC_ADDRESS.request primitive, the VDR should operate as an AVPAC link layer bridge. While in this mode, the data rate and modulation scheme is determined by the link management entity and controlled through the PH_DATARATE.request primitive.

3.2.4 Default Mode

This mode is the mode the radio should default to, either because of an inconsistent or lack of a command. The default operation of the VDR is to switch to the 716 Voice mode and to tune to 121.500 MHz.

3.3 Mode Logic

The VDR mode can be determined by a combination of the voice/data discrete, activity on either of the DFS busses, traffic on the VDR/[C]MU ARINC 429 bus, and the current operating mode. The voice/data discrete is open to indicate voice mode operation. If the voice/data discrete is grounded, the VDR should try to operate in either the 716 Data or 750 Data mode. The "Active" status of the selected DFS bus is determined by the continuous updates of the label 030 word by the [C]MU or radio control panel once every 200 milliseconds. Activity on the VDR/[C]MU busses is determined by continuous updates of the label 270 words by the [C]MU once per second as defined in Section 5.2.1. If updates of the listed words do not occur for two continuous seconds, the VDR should recognize this as an Inactive event for that bus.

Table 3.1 below describes the VDR mode switching logic. The first three columns indicate the possible inputs to the state machine as described above. The last four columns indicate the current mode (column headings) and next mode (column entries) of the VDR. The VDR initially enters the Default mode when it is powered on or reset.

Table 3.1 Mode Switching Logic

When the Input Status is:			And the Current Mode is:			
<u>V/D Disc</u>	<u>DFS Bus</u>	<u>[C]MU Buses</u>	<u>Default</u>	<u>716 Voice</u>	<u>716 Data</u>	<u>750 Data</u>
The next Mode will be:						
Data	Inactive	Inactive	Default	Default	716 Data	Default
Data	Inactive	Active	750 Data	750 Data	750 Data	750 Data
Data	Active	Inactive	716 Data	716 Data	716 Data	716 Data
Data	Active	Active	750 Data	750 Data	750 Data	750 Data
Voice	Inactive	Inactive	Default	716 Voice	Default	Default
Voice	Inactive	Active	Default	716 Voice ¹	Default	Default
Voice	Active	Inactive	716 Voice	716 Voice	716 Voice	716 Voice ²
Voice	Active	Active	716 Voice ¹	716 Voice ¹	716 Voice ¹	716 Voice ^{1,2}

①

This mode should be 750 Voice mode; however, since a digital voice system has not been defined yet, this selection should be treated as 716 Voice.

②

When the VDR is acting as an AVPAC bridge and is switched from 750 Data mode to 716 Voice mode, it should first attempt to disconnect from the ground station. The radio must be ready for voice operation within one second of opening the voice/data discrete.

4.0 INTERFACES AND PROTOCOLS TO THE GROUND SYSTEM

4.1 Introduction

When the VDR is operating in 716 Voice mode, it operates as a standard double sideband AM voice transceiver as described in ARINC Characteristic 716, "Airborne VHF Communication Transceiver".

When the VDR is operating in 716 Data mode, it operates as a standard double sideband AM data transceiver as described in ARINC Characteristic 716, "Airborne VHF Communication Transceiver".

When the VDR is operating in the ACARS submode of the 750 Data mode, it communicates to the ground, in a balanced mode, via protocols described in Section 4 of ARINC Specification 618, "Air-Ground Character-Oriented Protocol Specification" (or in Section 4 of ARINC Characteristic 724B, "Aircraft Communications Addressing and Reporting System (ACARS)").

COMMENTARY

Revisions are planned to ARINC Characteristics 597, 724, 724B so that reference will be made to ARINC Specification 618 for the definition of the interface between any VHF radio and the MU.

When the VDR is operating in the AVPAC submode of the 750 Data mode, it communicates to the ground, in a balanced mode, via protocols defined in Section 4 and 5, except for Section 5.5, of ARINC Specification 631, "Aviation VHF Packet Communications (AVPAC) Functional Description".

This chapter describes the direct interface to the VHF communications medium.

COMMENTARY

The parenthetical comment after some of the section titles limit the text to that particular emission.

4.2 Transmitter and Modulator Control

4.2.1 RF Power Output

The transmitter carrier power output measured into a 50 ohm resistive load should be 10 watts minimum and 20 watts maximum on any operating frequency when not in a 716-compatible mode.

COMMENTARY

The specification of 10 watts assumes a maximum cable loss to the antenna of 5.5 dB, thus providing 2.8 W into the antenna.

4.2.2 Radio Transmitter Duty Cycle

The VDR should be capable of a long-term duty cycle of 20%. Further, the transmitter should be capable of the following full-power sequence of operations:

ON- 30 seconds
OFF- 1 second
ON- 30 seconds
OFF-239 seconds

See ARINC Specification 631 for information about maximum data transmission duration.

COMMENTARY

The ON time values are chosen to be within the maximum continuous transmission times allowed by RTCA Document DO-207 (35 seconds), to a total transmit time of 1 minute. During a voice transmission, the OFF time is the approximate time required to release the transmitter key and re-key the transmitter following the time-out.

4.2.3 Transmitter RF Power Control

4.2.3.1 RF Output Power Level Regulation (OQAM)

In any 20 millisecond period after the transmitter attack time, the variation in the I- waveform, sampled at the baud center, of any one specific point in the constellation should be constant to within 0.5 dB. This section assumes that the transmitter operates into a load with a constant VSWR not to exceed 2:1.

COMMENTARY

Each I sample should be paired with a sample taken 1/2 of a baud period later.

4.2.3.2 RF Output Power Protection

The transmitter should not be damaged when operating into any passive load.

4.2.3.3 Radio Transmitter Keying Protection

Two maximum transmit timeout modes are required in order to be consistent with RTCA document DO-207. The first mode detects extended transmit keying while in voice mode. In this circumstance, an exceedance bit is reported in the BITE status word and the transmission is automatically terminated. Subsequent transmissions are enabled only after de-activation of the voice mode PTT discrete. The second mode detects extended transmit keying in data mode. In this circumstance, transmit keying is terminated unilaterally and permanently. Control electronics are assumed to be in a failure state and should be placed in a halted condition.

COMMENTARY

Manufacturers are reminded that maximum transmit time detection should be implemented as close as possible to circuitry delivering energy to the RF antenna and must be independent of digital control supporting modulation hardware. This may include any or all of the following components: VSWR detector, current to the PA, and temperature of the PA.

4.0 INTERFACES AND PROTOCOLS TO THE GROUND SYSTEM (cont'd)

4.2.3.3 Radio Transmitter Keying Protection (cont'd)

The voice mode maximum transmit timeout function may be inhibited through an analog discrete (MP2A) as described in Attachment 4.

COMMENTARY

This disabling function is consistent with a recommendation that has been made to the FAA to add the capability for enabling and disabling the time-out feature for aircraft on the ground being proposed by TSO-C128.

4.2.4 Tuning

The radio should be capable of tuning to any of the 760 25-kHz channels from 118.000 MHz through 136.975 MHz within 100 msec of the receipt of the last bit of the command on the appropriate ARINC 429 input.

The VDR must accept frequency information from two sources: a radio control panel and a MU/CMU. If the VDR is operating in 716 Voice or 716 Data mode, the VDR will accept tuning information over the low speed ARINC 429 bus from a frequency control source. This means of frequency tuning is identical to that of an ARINC Characteristic 716 VHF transceiver as defined in ARINC Characteristic 716, Section 3.2. When operating in 750 Data mode, the VDR will accept tuning information across the high speed ARINC 429 bus. The formats for the high speed 429 frequency data are defined in sections 5.3.1.

4.2.5 Modulation Definition for Analog Voice

Analog voice transmissions, compatible with ARINC Characteristic 716, is included in the VDR for backwards compatibility. Radio characteristics can be found in ARINC Characteristic 716.

4.2.6 Modulation Definition for MSK

This mode provides for analog and digital data transmissions using AM-MSK, as defined in ARINC Specification 618.

4.2.6.1 Training Sequence (MSK)

The training sequence comprising of Pre-Key and a bit ambiguity resolution segment, as defined in ARINC Specification 618, should be sent before each transmission on the VHF frequency. For an AVPAC transmission, a flag (7E_H) will follow the bit ambiguity. For an ACARS block, a SYN SYN (16_H 16_H) will follow the bit ambiguity. The transmitter ramp-up allowance for prekey is 2 msec.

4.2.7 Modulation Definition for OQAM

Basic provisions for the VDR include two physical layers which are both in a family of techniques called M-OQAM. M-OQAM is a class of pulse-shape filtered multilevel (one or more levels as determined by the constellation set) offset quadrature amplitude modulated techniques with M channel symbols in the constellation.

These are defined in the following table (where T is the Baud Period as defined below). The modulation scheme(s) supported by the ground system are specified in Ground Station Identification Frames (GSIFs), see ARINC Specification 631.

Description	Parameter	Values
4-OQAM	M = 4,	T = 1/10,500 second
16-OQAM	M = 16,	T = 1/10,500 second

COMMENTARY

Although this Characteristic only includes information for the 4-square and 16-square constellations, this Section may be amended in the future to include more complex constellations. Specific concern here is directed toward the transmission of digitized voice and operation in severe environments such as rotorcraft.

Phase 1 implementation may include only 4-OQAM.

4.2.7.1 Analog Signal Transmission (OQAM)

M-Offset uadrature Amplitude Modulation (M-OQAM) is used to encode the digital data on the RF frequencies. A synchronous data stream of "ones" and "zeros" will be presented to the input of the ideal transmitter described in Attachment 11, which is an ideal offset quadriphase modulator, at a bit rate of $\log_2 M / T$. The data encoder will vary depending on the data rate desired, and is described in Section 4.2.7.2. The synchronous samplers, S, operate at a rate of $1/T$ and generate ideal impulses of discrete amplitudes, which depend on the input data and the data rate. The delay in the quadrature channel has a value of $T/2$. The ideal frequency response, $H(f)$, of the pulse-shaping filters have the shape of a raised cosine function with alpha equal to 0.6.

$$\begin{aligned} H(f) &= (1 - \sin[\pi (2Tf - 1) / 1.2]) / 2 & f < 0.8/T \\ H(f) &= 0 & f \geq 0.8/T \end{aligned}$$

or

$$h(t) = \frac{\left[\sin\left(\pi \frac{t}{T}\right) \right] \left[\cos\left(0.6\pi \frac{t}{T}\right) \right]}{\left[\pi \frac{t}{T} \right] \left[1 - 4\left(0.6 \frac{t}{T}\right)^2 \right]}$$

where f is the frequency offset from the channel center, and T is the baud period (1 / baud rate). The I and modulators are ideal 4-quadrant multipliers, and the local oscillator produces only the desired frequency.

COMMENTARY

The encoding scheme demands that phase coherence be maintained through the transmission media for successful decoding to be possible. The establishment of correct phase relationships will be performed by the ground and airborne decoding hardware

4.0 INTERFACES AND PROTOCOLS TO THE GROUND SYSTEM (cont'd)

during the "Pre-key" periods of preamble transmissions.

The emission designator is TBD.

4.2.7.2 Data Encoder (OQAM)

The data stream to be transmitted is divided into groups of $\log_2 M$ consecutive data bits, low bit first. Since the number of bits to be transmitted does not necessarily need to be an exact number of channel symbols, any padding bits in the last channel symbol should be zeros. Note that 2 bits are sent per channel symbol with 4-OQAM and 4 bits are sent per channel symbol with 16-OQAM. See Attachment 8 for an example of an encoded message.

4-OQAM Data Encoder

Input 21	Output I Q	Training Sequence Code
00	3 3	A
01	3 -3	B
10	-3 3	D
11	-3 -3	C

16-OQAM Data Encoder

Input 4321	Output I Q	Training Sequence Code
0000	1 1	
0001	1 3	
0010	1 -1	
0011	1 -3	
0100	3 1	
0101	3 3	A
0110	3 -1	
0111	3 -3	B
1000	-1 1	
1001	-1 3	
1010	-1 -1	
1011	-1 -3	
1100	-3 1	
1101	-3 3	D
1110	-3 -1	
1111	-3 -3	C

4.2.7.3 Training Sequence (4-OQAM)

After the transmitter power stabilization, there will be a demodulator training sequence consisting of six segments: prekey, ambiguity resolution, reserved symbol, transmission length, header FEC, and equalizer training. The training sequence, or preamble, must achieve:

- receiver AGC settling
- receiver phase synchronization
- equalizer initialization (including transmitter frequency offset and any filter compensation)
- baud clock initialization

Following the training sequence, a single flag octet (01111110) is transmitted, using the specified constellation to establish octet synchronization and to signal the beginning of an AVPAC "frame".

COMMENTARY

Note that the flag will be the first octet to undergo Reed-Solomon FEC and interleaving and will also be the first symbol of the equalization period, as defined in Sections 4.2.7.5, 4.2.7.7, 4.2.7.8. The message length segment will be the first bit scrambled, as defined in Section 4.2.7.6. See Attachment 8 for an example.

4.2.7.3.1 Pre-Key (4-OQAM)

The first segment of the preamble will consist of a "Pre-key" transmission consisting of 21 repetitions of the symbol A ("AAAAA..."), for a total of 2 milliseconds of CW at 10.5 kbaud.

COMMENTARY

The transmitter stabilization should be completed prior to starting the prekey sequence.

4.2.7.3.2 Synchronization and Ambiguity Resolution (4-OQAM)

The second segment of the training sequence will consist of the unique word sequence "CACA CCAA CCCA ACAC AACC AAAC".

COMMENTARY

For further information about this unique word, see the INMARSAT Standard M channel SDM.

4.2.7.3.3 Reserved Symbol (4-OQAM)

The third segment of the training sequence will consist of a pair of zeroes (the symbol "A"). This symbol is reserved for future definition.

4.2.7.3.4 Transmission Length (4-OQAM)

In order to allow the receiver to determine the length of the last block, the transmitter will send a 17 bit transmission length word indicating the total length of the transmission as the fourth segment.

COMMENTARY

The total length of a transmission is the total amount of information entering the Reed-Solomon decoder, this includes the actual frames, the bits added for HDLC bit stuffing, the added flags, and the Reed-Solomon parity check bits.

The 17 bits of this segment of the training sequence will be transmitted from least significant bit to most significant bit.

4.0 INTERFACES AND PROTOCOLS TO THE GROUND SYSTEM (cont'd)**4.2.7.3.5 Header Error Correction Code (4-OQAM)**

In order to correct bit errors in the header, a (24, 19) block code is computed over the reserved symbol and the transmission length segments and transmitted as the fifth segment. The encoder will accept the header in the bit sequence that is being transmitted. The five parity bits which will be transmitted will be generated using the equation $p = iH$, where p is the parity word, i is the reserved symbol / transmission length sequence, and H is the parity matrix defined below. The five parity bits of the resultant vector product are transmitted from left bit first.

$$H = \begin{bmatrix} 0 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 1 & 1 \\ 1 & 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 1 \\ 1 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

COMMENTARY

This code is capable of correcting all 1 bit errors and detecting 75 of 276 possible two bit errors.

4.2.7.3.6 Equalizer Training Sequence (4-OQAM)

In order to simplify the equalizer training sequence and avoid blind training the equalizer, a variable length sequence of 0s will be transmitted.

COMMENTARY

The scrambler will ensure that a pseudo-random data pattern is actually transmitted.

The length of this segment (in bits), $L(b)$, is dependent on the transmission length (in bits):

$$\begin{aligned} L(b) &= 0 & b &< 512 \\ L(b) &= 2 \cdot \lfloor b / 32 \rfloor & 512 &\leq b \leq 1344 \\ L(b) &= 84 & b &> 1344 \end{aligned}$$

where $\lfloor \cdot \rfloor$ is the floor function.

4.2.7.4 Training Sequence (16-OQAM)

After the transmitter power stabilization, there will be a demodulator training sequence consisting of six segments: prekey, ambiguity resolution, reserved symbol, transmission length, header FEC, and equalizer training. The training sequence, or preamble, must achieve:

- receiver AGC settling
- receiver phase synchronization
- equalizer initialization (including transmitter frequency offset and any filter compensation)
- baud clock initialization

Following the training sequence, a single flag octet (01111110) is transmitted, using the specified constellation to establish octet synchronization and to signal the beginning of an AVPAC "frame".

COMMENTARY

Note that the flag will be the first octet to undergo Reed-Solomon FEC and interleaving and will also be the first symbol of the equalization period, as defined in Sections 4.2.7.5, 4.2.7.7, 4.2.7.8. The message length segment will be the first bit scrambled, as defined in Section 4.2.7.6. See Attachment 8 for an example.

4.2.7.4.1 Pre-Key (16-OQAM)

The first segment of the preamble will consist of a "Pre-key" transmission consisting of 21 repetitions of the symbol A ("AAAAA..."), for a total of 2 milliseconds of CW at 10.5 kbaud.

COMMENTARY

The transmitter stabilization should be completed prior to starting the prekey sequence.

4.2.7.4.2 Synchronization and Ambiguity Resolution (16-OQAM)

The second segment of the training sequence will consist of the unique word sequence "CACA CCAA CCCA ACAC AACC AAAC".

COMMENTARY

For further information about this unique word, see the INMARSAT Standard M channel SDM.

4.2.7.4.3 Reserved Symbol (16-OQAM)

The third segment of the training sequence will consist of a pair of zeroes (the symbol "A"). This symbol is reserved for future definition.

4.2.7.4.4 Transmission Length (16-OQAM)

In order to allow the receiver to determine the length of the last block, the transmitter will send a 17 bit transmission length word indicating the total length of the transmission as the fourth segment.

COMMENTARY

The total length of a transmission is the total amount of information entering the Reed-Solomon decoder, this includes the actual frames, the bits added for HDLC bit stuffing, the added flags, and the Reed-Solomon parity check bits.

The 17 bits of this segment of the training sequence will be transmitted from least significant bit to most significant bit.

4.0 INTERFACES AND PROTOCOLS TO THE GROUND SYSTEM (cont'd)

4.2.7.4.5 Header Error Correction Code (16-OQAM)

In order to correct bit errors in the header, a (TBD, 19) block code is computed over the reserved symbol and the transmission length segments and transmitted as the fifth segment. The encoder will accept the header in the bit sequence that is being transmitted. The five parity bits which will be transmitted will be generated using the equation $p = iH$, where p is the parity word, i is the reserved symbol / transmission length sequence, and H is the parity matrix defined below. The five parity bits of the resultant vector product are transmitted from left bit first.

$$H = \begin{bmatrix} 0 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 1 & 1 \\ 1 & 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 1 \\ 1 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

COMMENTARY

This code is capable of correcting all 1 bit errors and detecting 75 of 276 possible two bit errors.

4.2.7.4.6 Equalizer Training Sequence (16-OQAM)

In order to simplify the equalizer training sequence and avoid blind training the equalizer, a variable length sequence of 0s will be transmitted.

COMMENTARY

The scrambler will ensure that a pseudo-random data pattern is actually transmitted.

The length of this segment (in bits), $L(b)$, is dependent on the transmission length (in bits):

$$\begin{aligned} L(b) &= 0 & b < 1024 \\ L(b) &= 4 \cdot \lfloor b / 64 \rfloor & 1024 \leq b \leq 2688 \\ L(b) &= 168 & b > 2688 \end{aligned}$$

where $\lfloor \cdot \rfloor$ is the floor function.

4.2.7.5 Equalization (OQAM)

In order to allow for a reduced complexity equalizer in the receiver, the sixteenth channel symbol after the end of the training sequence and every sixteenth channel symbol thereafter will be the symbol A, defined in Section 4.2.7.2. This will enable easy amplitude and phase equalization every 1.5 msec for a 6% penalty in data throughput.

COMMENTARY

Equipment manufacturers are advised that equalization techniques which use the value of the most recent equalization channel symbol only could exhibit unacceptable error rates in heavy fading conditions.

4.2.7.6 Bit Scrambling (OQAM)

In order to aid clock recovery, a PN scrambler with a 15-stage generator register will be exclusive-ored with the transmitted data stream, starting with the message length segment of the training sequence. The concept of a PN scrambler is explained in CCIR Report 384-3, Annex III, Section 3, Method 1. The scrambler and descrambler configurations are exactly as shown in Attachment 10. The polynomial for the h-register of the scrambler and descrambler is $1 + X + X^{15}$. The scrambler and descrambler are clocked at the rate of one shift per bit, with the first scrambler bit in the frame unshifted. The initial status of the shift register, preset at the beginning of the transmission, is programmable to enable the scrambler to be used for encryption in the future. The default initial value of the h-register is 1101 0010 1011 001 with the leftmost bit in the first stage of the h-register as shown in Attachment 10.

4.2.7.7 Forward Error Correction (OQAM)

In order to improve the effective channel throughput by reducing the number of required retransmissions, Forward Error Correction (FEC) will be applied to the data stream. That is, error correction will be applied on the single transmission (that is, everything after the training sequence) as a whole, regardless of frame boundaries.

The FEC coding is accomplished by means of a systematic Reed-Solomon (255,249) 2^8 -ary code capable of correcting up to 3 code word symbol errors. The field defining primitive polynomial of the code is:

$$p(x) = (x^8 + x^7 + x^2 + x + 1)$$

The generator polynomial is given by:

$$\prod_{i=120}^{125} (x - \alpha^i)$$

COMMENTARY

For more information on Reed-Solomon codes, see Consultative Committee for Space Data Systems, "Recommendation for Space Data System Standards: Telemetry Channel Coding."

Transmissions longer than 1992 bits will be split up into 249 8-bit word blocks, with the last block being potentially less than 249 words. The six parity check octets are then appended to the 249 words of data to produce a 255 words block. These bits will be converted

4.0 INTERFACES AND PROTOCOLS TO THE GROUND SYSTEM (cont'd)**4.2.7.7 Forward Error Correction (OQAM) (cont'd)**

into 8-bit words low bit first, and the words will be converted into blocks low word first.

Blocks less than 1992 bits long will be coded according to the following code. Although the encoder and decoder will fill the block with zeros, these zeros will not actually be transmitted.

Block Length	Code
0-16 bits	none
17-240 bits	Reed-Solomon (251,249) 2 ⁸ -ary 1 error correcting*
241-536 bits	Reed-Solomon (253,249) 2 ⁸ -ary 2 error correcting**
537-1992 bits	Reed-Solomon (255,249) 2 ⁸ -ary 3 error correcting

* For blocks intended to correct only 1 word, all six parity code word symbols will be generated, but only the first two will be transmitted. The last four parity code word symbols will be treated as erasures at the decoder.

** For blocks intended to correct only 2 words, all six parity code word symbols will be generated, but only the first four will be transmitted. The last two parity code word symbols will be treated as erasures at the decoder.

4.2.7.8 Interleaving (OQAM)

In order to improve the performance of the FEC, a word-based table-driven interleaver will be used. The transmitter will write the message to be transmitted (on which the FEC has already been computed) into a table (with 255 cells per row, with each cell containing an 8-bit word) by row and read the transmission by column. The receiver should calculate the number of full rows and the size of the last row (which may be a partial row) and fill its table by column and read it out by rows, realizing that the number of rows per column may change while filling the table.

4.2.8 Permissible Transmitter Variations

Since modulator implementations may differ widely, modulator and transmitter requirements are specified against an ideal model. This section lists the permitted variations from ideal.

4.2.8.1 Frequency Accuracy

The transmitter carrier frequency accuracy should be within ± 5 ppm.

COMMENTARY

This specification assumes that the ground station transmitter frequency stability shall be ± 2 ppm.

4.2.8.2 Transmitter Occupied Spectrum Mask (OQAM)

The transmitted spectrum should not exceed the limits shown in Attachment 6 tables A6-1 (spectrum amplitude mask) and A6-2 (spectrum phase mask). In addition, the total power radiated into the filter shown in table A6-3

should be -60 dB lower when the filter is offset at every integer multiple (except zero) of 25 kHz from the channel center compared to when the filter is centered at the channel center.

COMMENTARY

Considerable discussion about the adjacent channel performance and the achievability of -60 dBc adjacent channel performance occurred while drafting this section. Some participants felt that present technology was not capable of building efficient practical power amplifiers which could exceed -40 dB; however, the committee decided that the -60 dB figure was a desirable objective.

4.2.8.3 Transmitter Quadrature Balance (OQAM)

For 4-OQAM, the relationship between the quadrature components (I and Q) in the transmitted signal should be $90^\circ \pm 3$ in phase, and equal in amplitude to within ± 1 dB. For 16-OQAM, the relationship between the quadrature components (I and Q) in the transmitted signal should be $90^\circ \pm 1$ in phase, and equal in amplitude to within ± 1 dB.

4.2.8.4 Transmitter Data Clock Stability

The VDR should be capable of transmitting within $\pm 0.02\%$ of its operating data rate.

4.2.8.5 Transmitter Phase Acceleration (OQAM)

During the transmitter attack, the acceleration of the phase of the transmitted signal is undefined. After the transmitter attack is completed as defined in Section 4.2.3.2, the phase acceleration should be less than 30 Hz/sec.

4.2.8.6 Transmitter Spurious Radiation

Any emissions on a harmonic of the transmit carrier frequency should be less than -16 dBm. Any other spurious emissions more than 25 kHz removed from the carrier frequency, but within the 108 to 137 MHz band, should be less than -45 dBm, and preferably -75 dBm. Any spurious within the band of 108 to 137 MHz, but more than 5 MHz removed from the carrier frequency, should be down to at least -75 dBm. Any other spurious emissions should be less than -35 dBm.

COMMENTARY

The specification for spurious radiation is stated in terms of absolute power level rather than amount of attenuation by virtue of several historical agreements reached as a result of interference on harmonics of aeronautical mobile frequencies. The absolute level of -16 dBm for harmonics is based on 60 dB attenuation of the harmonics in a 25 to 50 watt transmitter and is compatible with FCC requirements. This has been determined to be a maximum allowable level for operation.

In the context of this specification, "spurious signals" are understood to be discrete signals.

It should also be recognized that the Electromagnetic Compatibility Analysis Center (ECAC) recommended maximum level is -16 dBm for all spurious emissions except where 40 dB attenuation below the

4.0 INTERFACES AND PROTOCOLS TO THE GROUND SYSTEM (cont'd)

fundamental power output results in a lower power level. ECAC has also considered recommending -26 dBm as the maximum level for all spurious emissions in the band 108.0 to 137.0 MHz, regardless of the fundamental power output.

For this reason equipment manufacturers should regard the figures specified in this paragraph as "barely acceptable minima", and aim to do better in their LRUs.

4.3 Receiver and Demodulator Control**4.3.1 Sensitivity**

The VDR will be capable of demodulating individual blocks of 255 octets to within a BFR of 10^{-6} for a noise-free signal with a power level into a 50 ohm resistive load for 4-OQAM of -105 dBm to +7 dBm and a power level for 16-OQAM of -98 dBm to +7 dBm. For MSK, the VDR will be capable of demodulating data to within a BER of 10^{-6} for a noise-free signal with a power level into a 50 ohm resistive load of -105 dBm to +7 dBm.

COMMENTARY

The minimum receive power levels are specified assuming:

5.5 dB of aircraft antenna cable loss
2 dB of ground system antenna cable loss
14 dB of receiver implementation loss
2.5 dB of transmitter implementation loss
thermal noise 290 K, 10.5 kHz receive noise bandwidth

This gives a path loss of 138 dB for 4-OQAM, and 131 dB for 16-OQAM. Note that into a 50 ohm load, 2.5 hard microvolts is -105 dBm, 5.6 μ V is -98 dBm, and 500,000 μ V is +7 dBm.

4.3.2 Burnout Protection

The unit should not suffer permanent damage when subjected to a signal of [+20] dBm or less.

COMMENTARY

This section will be reviewed for compatibility with HIRF requirements.

4.3.3 Selectivity

The receiver selectivity mask should be designed to minimize the expected value of the BFR. Section 4.3.4 discusses this environment in greater detail.

COMMENTARY

The nominal mask should be a raised cosine filter with an alpha equal to 0.6.

4.3.4 Noise Immunity

The receiver/demodulator should be capable of successfully demodulating received signals in the noisy RF environment in which an aircraft normally operates. As such, this section provides design guidance to

manufacturers to enable them to meet the desires of their airline customers.

COMMENTARY

There is a problem in testing the performance requirements as specified in the following paragraphs. A BFR test expecting a value of 10^{-6} would take approximately 1 hour to complete. Consequently, the following sections have been written using BER expecting a value of 3.5×10^{-5} .

It should be noted that there is a potential for comm-to-comm interference using multiple radios assigned to neighboring channels.

4.3.4.1 Desensitization and Interference Rejection**COMMENTARY**

Circuitry should be included for the prevention, insofar as practicable, of receiver desensitization due to pulse-type interference. As the magnitude and character of the pulse interference levels expected in a typical installation in the future is not known, system performance specifications would be meaningless, and therefore this Section is included as commentary. However, RF pulses of the following characteristics are prototypical of what can be expected.

Width of Pulse	10 $\pm$ 2 microseconds
Repetition Rate	1000 $\pm$ 100 pps
Waveform	Rise and Decay time each less than 1 microsecond

4.3.4.1.1 Bit Error Rate Versus Pulse Interference**COMMENTARY**

With a pulse peak amplitude equal in magnitude to the desired signal level, the BER should not increase to more than 10^{-5} . With a pulse amplitude with a magnitude of 100 times the desired carrier signal, the BER should not increase to more than 10^{-3} .

4.3.4.2 Receiver Operation in the Presence of Interfering Transmissions

In the presence of any modulated signal tuned to a frequency 6 MHz or more removed from that to which the receiver is tuned, the IRR should be TBD dB or better. With a carrier frequency as close as 2 MHz to the receiver frequency, the IRR should be TBD dB or better.

COMMENTARY

This Section assumes that the transmitter meets the requirements specified in the appropriate ARINC Characteristics, such as ARINC Characteristic 716 and this document. These IRRs were derived assuming a 25W transmitter and either 35 dB or 45 dB of transmitter to receiver isolation.

This section is intended to cover both cross-modulation and inband signals. Since the digital modulation being used in this system has FM characteristics, the potential for inter-modulation problems is real, and text for this may need to be added.

4.0 INTERFACES AND PROTOCOLS TO THE GROUND SYSTEM (cont'd)

4.3.4.3 Undesired Response

Using a CW signal which is tuned outside the 118.000 to 136.975 MHz frequency band, T_q as defined in Section 4.3.6.1 should not increase by more than 3 dB when the signal is -25 dBm. When the signal is tuned within the frequency band of 118.000 to 136.975 MHz, but at least 1 MHz away from the desired frequency, the signal can be as great as -10 dBm, and preferably +10 dBm. When the signal is tuned more than 25 kHz from the desired frequency, the signal can be as great as 70 dB above an on-channel signal giving the same response.

4.3.4.4 Receiver Performance in the Presence of Out-of-Band FM Broadcast Interference

With one or more FM broadcast signals present across the VDR input terminals, the IRR should be at least 100 dB.

COMMENTARY

In other words, the effects of intermodulation, desensitization or any other cause should have a negligible effect on VDR performance when the received signal levels are less than -2 dBm for 4-OQAM and MSK and +5 dBm for 16-OQAM.

4.3.4.5 Adjacent Channel Interference

With an uncorrelated data signal present on any other in-band channel, the IRR should be at least TBD dB.

COMMENTARY

This Section assumes that the transmitter meets the requirements specified in the appropriate ARINC Characteristics, such as ARINC Characteristic 716 and this document.

4.3.5 Signal quality Analysis

The link management function requires knowledge of the stations the aircraft can receive and how well it can receive those stations. Accordingly, frames transmitted by ground stations should be evaluated for signal quality and the signal quality should be passed to the link management function along with the address of the ground station.

The VDR may perform analysis of both the transmitter, the receiver and the channel, measuring such properties as phase distortion, coherence, signal-to-noise measurements, and confidence of demodulation.

COMMENTARY

Manufacturers are advised against using the bit error rate as an SP metric, as the transition band is too small.

4.3.6 Channel Sense Algorithms

When running a CSMA algorithm prior to transmitting data or packetized voice, the VDR should determine if the channel is idle based on the following algorithm.

4.3.6.1 Channel Quiescent Value

Whenever the VDR is not transmitting or receiving a message, the VDR should calculate a channel quiescent value, T_q , according to the following algorithm:

If $L \leq T_{max}$, then

$$T_q(i+1) = T_q(i) + k(L, T_q(i)) * (L - T_q(i))$$

else

$$T_q(i+1) = T_{max}$$

where L is the rms received signal level (volts) calculated over the past 1 msec, and T_{max} is a value in the range of 15 to 30 hard microvolts, and $k(L, T_q)$ equals:

$$k(L, T_q) = \max[0.01^{(L/T_q)}, 1/16384]$$

4.3.6.2 Channel Busy Threshold

The channel busy threshold, T_b , is defined to be $1.4(T_q)$. Whenever L exceeds T_b , the channel will be declared busy. The channel sense algorithm will then be suspended while synchronization is attempted. The maximum time the VDR should try to synchronize is 20 msec for MSK signals and 5 msec for OQAM signals. If synchronization is not achieved, a new value is taken for L and processed to yield T_q and channel sense determination.

4.3.6.3 Channel Sense Reporting

The system should transition from "idle" to "busy" or "busy" to "idle" within 0.2 msec of when the incoming signal power level crosses the T_b threshold.

4.4 Transmitter - Receiver Interaction

The following paragraphs define turn-around time requirements for 750 Data mode. For the 716 compatible modes, the requirements are defined in ARINC Characteristic 716.

Commentary

Manufacturers should be advised that with the potential inclusion of digital voice through the implementation of undefined TDMA systems, it may be necessary to have synthesizer retuning and Transmit to Receive turn-around times significantly better than specified here.

4.4.1 Transmitter to Receiver Turnaround Time

The transmitter to receiver turnaround, beginning with the end of the last transmission of the last channel symbol and concluding when the receiver can successfully demodulate signals within the sensitivity limits of Section 4.3.1, should be less than 5 msec. Further, the transmitter output power should decay at least 20 dB below the steady output power level within 0.3 ms after beginning the turnaround. While the transmitter is decaying, the last channel symbol should be transmitted (i.e. no further modulation should occur).

4.4.2 Receiver to Transmitter Turnaround Time

The receiver to transmitter turnaround time is defined as the minimum time between when the channel is released

4.0 INTERFACES AND PROTOCOLS TO THE GROUND SYSTEM (cont'd)

by another station and when it is seized by this station. The channel is released when the received signal power level crosses the channel busy threshold level (see Section 4.3.6.2), this triggers the channel sense reporting algorithm (see Section 4.3.6.3) and the MAC layer then declares channel "idle". Using a 1-persistent MAC algorithm, the duration of time from when the received signal level crosses the busy threshold until the transmitter has ramped up to within 0.5 dB of the final steady state output power level should be less than 2 msec. During the transmitter attack phase, the modulator should be transmitting the symbol 'A'.

COMMENTARY

The channel busy threshold, which is computed internally, can be set to an externally known value by maintaining a constant signal level at the receiver input port for ten to fifteen seconds.

The maximum link throughput available to all users is highly sensitive to the RF channel sense to RF channel seizure time. Accordingly, it is imperative that all efforts are made to reduce this time as the state-of-the art advances.

5.0 INTERFACE AND PROTOCOLS TO THE CMU/MU

5.1 ARINC 429 Interface Definition

5.1.1 Layer 1 - The Physical Layer

The VDR will communicate with a MU/CMU across a high-speed physical link as defined in ARINC Specification 429, "Mark 33 Digital Information Transfer System (DITS)".

COMMENTARY

Manufacturers should note that the new protocols introduced in ARINC Specification 429, Supplement 14 should be used to meet the performance requirements of the high speed data link.

5.1.2 Layer 2 - The Link Layer

Both the ARINC 429 Bit Oriented Protocol (BOP) and conventional broadcast words will be used to facilitate the transfer of information between the VDR and the CMU/MU. The ARINC 429 BOP will be the predominate mechanism for data transfer. The BOP will be used for the transfer of command and control data, ACARS blocks, and AVPAC DLSDUs (Data Link Service Data Units). Conventional 429 broadcast words will be used for the transfer of periodic status data and data used in the implementation of the bit-oriented protocol.

5.1.2.1 ARINC 429 BOP

The ARINC 429 BOP is designed to accommodate data transfer between sending and receiving units in a form compatible with the Open Systems Interconnect (OSI) model developed by the International Organization for Standardization (ISO). The data file and associated protocol control information are encoded into 32 bit words and transmitted over an ARINC 429 physical interface. Data is transferred using a data transparent bit-oriented file transfer protocol designed to permit the units involved to send and receive information in multiple word frames. The bit-oriented protocol will support full duplex operations.

For a detailed explanation of the ARINC 429 BOP, as well as definitions of the ARINC 429 BOP word formats, refer to Section 2.5 of ARINC Characteristic 429-14, "Mark 33 Digital Information Transfer System (DITS)".

5.1.2.2 Generic Message Format

The GFI code (contained in the LDU's Start of Text (SOT) word) associated with all BOP data files should be set to "02h". This GFI will be used for primitives including command data, ACARS blocks, and AVPAC DLSDUs. The general format of all the primitives exchanged with this GFI code between the CMU and VDR is as follows:

<u>Octet</u>	<u>Definition</u>
1	ID Field
2	Data Field Length MSB
3	Data Field Length LSB
4	Data Field Byte #1
5	Data Field Byte #2
.	.
.	.
.	.
N+3	Data Field Byte #N

The first byte will contain the ID field. The ID field is a single byte in length, and will uniquely identify the primitive and its data field bytes. The second and third bytes will contain the length of the corresponding data field. The value of the data field length will be an unsigned integer, and will represent the number of bytes in the data field. The data field length will not include the ID field or the data field length bytes. The data field may be multiple bytes in length and will contain the parameters/data that pertain to the primitive.

5.1.2.3 Description of 429 Options

The CMU-VDR interface should use the following 429 options:

<u>Option</u>	<u>Description</u>	<u>Default</u>
01	Half or Full duplex	Half
02	High speed or Low speed	High
03	"Automatic CTS when ready"	No
04	"Accept Auto CTS"	No
05	"SYS priority to resolve RTS conflict"	No
06	spare	
07	spare	
08	use of the SOLO word	Yes
09	spare	No
010	"Destination code in RTS/CTS/NCTS/BUSY used"	Yes
011	"Bit Protocol Verification"	Yes

5.2 Initialization

5.2.1 Determination of Active MU/CMU

The VDR may be connected to two MU/CMUs with each MU/CMU on a separate high speed ARINC 429 bus. The VDR will accept frequency tuning information, mode data, command parameters, ACARS blocks, and AVPAC frames from the single MU/CMU it determines to be in the "active" state.

If the SSM code of the received ARINC label 270 word (as defined in Section 5.8.5) is set to "Normal" (00B) or "Functional Test" (10B), the VDR will examine the Active/Standby bit. If the active/standby bit is set to

5.0 INTERFACE AND PROTOCOLS TO THE CMU/MU (cont'd)

"active" for five seconds, the MU/CMU transmitting the ARINC 270 word will be defined as "active". If the SSM code of the receive ARINC label 270 word is set to "NCD" (01B) or "Failure Warning" (11B), then the 270 word will be ignored.

The VDR will monitor the two MU/CMU ports in its search for the active MU/CMU. During the interim time where the VDR is determining the active MU/CMU, the VDR will not forward received ACARS or AVPAC data. Similarly transmission requests, command parameters, and status requests transmitted by an MU/CMU prior to the confirmation of its active/standby status will be ignored.

The VDR will periodically notify both MU/CMUs which unit it considers to be active. The information will be conveyed within the ARINC label 270 word the VDR outputs over the high speed ARINC 429 bus. When the VDR has determined a MU/CMU as "active", the VDR will set the active MU/CMU field (bits 16 & 15) to the SDI of the active MU/CMU as defined in Section 5.8.2. During the period where the VDR has not declared either MU/CMU as active, the VDR will notify the MU/CMU of this condition by setting the MU/CMU active field to announce that neither MU/CMU is active as defined in Section 5.8.2.

Once an MU/CMU has been defined as "active", the VDR will continuously monitor the active/standby state of the unit. If the CMU/MU has failed to transmit and ARINC label 270 word with an SSM code of "Normal" or "Functional Test" within the past 5 seconds, or if an ARINC label 270 word is received which defines the MU/CMU as being in the standby state, the VDR will attempt to re-establish which MU/CMU is "active".

If both systems indicate active, then the VDR should select CMU-1 as active.

5.2.2 Initialization Notification

Upon an initialization or reset of the VDR, the VDR should inform the active MU/CMU of the condition by sending a 270 status word to inform the MU/CMU that the contents of the transmit queue, as well as all of the command parameters have been deleted by setting the Download Request bit.

5.3 Command Data

Command data is sent by the MU/CMU to the VDR. Command data is information which defines the operating characteristics of the VHF transceiver. Command data may be AVPAC primitives, tuning frequency, or other information used in the transmission or reception of air-ground protocol data.

The following table defines the different types of command data which the VDR will accept. The command parameter is defined along with its associated AVPAC primitive as defined in ARINC Specification 631 "Aviation VHF Packet Communications (AVPAC)".

Parameters	AVPAC Primitive
Frequency	PH_FREQUENCY.request
Data Mode Scheme	PH_DATARATE.request
MSK Pre-Key Length	PH_PREKEY.request
Transmitter Temperature Protection	N/A
ACARS Address Table	N/A
AVPAC Address Table	N/A
P-Persistence Value	N/A
N2 - Max number of retransmissions	DL_MAXTRANSMISSION.request
TM2 - MAC transmit timer	MA_TIMER2.request
k - Window size	N/A
Air/Ground Status	N/A

Command data parameters are received aperiodic, and typically will be transmitted by the CMU upon notification of a VDR initialization, or when the CMU desires to change specific command parameter settings. When new command parameters are received by the VDR, the new parameter setting should immediately replace the existing setting.

The command data parameters will reside in the data words of the ARINC 429 BOP. When the MU/CMU has several new command data parameters to download the VDR, it is recommended that the MU/CMU transmit the parameters to the VDR in a single ARINC 429 BOP LDU. This is simply accomplished by daisy-chaining the command data parameters together, where the last data field byte of one parameter is immediately followed by the ID field of the next parameter. The VDR will be able to separate the command parameters by recognition of the ID fields and data field lengths.

COMMENTARY

While not recommended, the CMU may send command data parameters in multiple LDUs.

5.3.1 Frequency Command Parameter

5.3.1.1 Frequency Command Format

The following table defines the frequency tuning command parameter data format:

Octet	Data	Units	Range
1	PH_FREQUENCY.request	ID Field	20h
2	00h	-	-
3	02h	Byte	-
4	Binary MHz Frequency	1 MHz	118-136 MHz
5	Binary kHz Frequency	12.5 kHz	000-987.5 kHz

In the future, provisions may be added for separate receive and transmit frequencies.

5.3.1.2 Frequency Command Use

When the VDR receives the Frequency Command it will tune to that frequency.

5.3.2 Data Mode Scheme Command Parameter

5.0 INTERFACE AND PROTOCOLS TO THE CMU/MU (cont'd)**5.3.2.1 Data Mode Scheme Command Format**

The following table defines the VDR's data mode scheme command format:

Octet	Data	Units	Range
1	PH_Datarate.request	ID Field	22h
2	00h	-	-
3	01h	Byte	-
4	Mode Scheme Code	Code	01h, 02h, 04h

The mode scheme code resides in a single octet. The mode scheme code should be set to one of the values in the following table:

Mode	Code
AM MSK	01h
4-OQAM	02h
16-OQAM	04h

5.3.2.2 Data Mode Scheme Command Use

When the VDR receives the Data Mode Scheme Command it will change to the mode given in the command.

5.3.3 MSK Pre-Key Length Command Parameter**5.3.3.1 MSK Pre-Key Length Command Format**

The following table defines the VDR's Pre-key length command format:

Octet	Data	Units	Range
1	PH_PREKEY.request	ID Field	23h
2	00h	-	-
3	01h	Byte	-
4	Pre-Key Length	1 msec	0-180 msec (0-B4h)

5.3.3.2 MSK Pre-Key Length Command Use

The VDR should prefix each ACARS block received from the MU/CMU for transmission to a ground station with the order dependent preamble consisting of the pre-key, bit synchronization character as defined in ARINC characteristic 618 "Air-Ground Character-Oriented Protocol Specification". The VDR will set the pre-key length to the prescribed value provided by the MU/CMU.

5.3.4 Transmitter Temperature Protection Command Parameter**5.3.4.1 Transmitter Temperature Protection Command Format**

The following table defines the transmit temperature command format:

Octet	Data	Units	Range
1	VDR_TX_TEMP.request	ID Field	03h
2	00h	-	-
3	01h	Byte	-
4	Trans.Temp Enable	Enable/ Disable	00h, 01h

5.3.4.2 Transmitter Temperature Protection Command Use

The Transmitter Temperature Protection Enable/Disable bit will reside in a single data field octet. If the LSB bit of the octet is set to "1" then the VDR will enable transmitter temperature protection by disabling the transmitter if it reaches a prescribed temperature. If the LSB bit of the nibble is set to "0", then the VDR will not provide transmitter temperature protection allowing the user to override the thermal protection.

The transmitter temperature is an optional command parameter. For installations which do not use this command parameter, the VDR should operate in a stable which provides transmitter temperature protection.

5.3.5 ACARS Address Table Command Parameter**5.3.5.1 ACARS Address Table Command Format**

The following tables define the ACARS address table command parameter data formats:

Octet	Data	Units	Range
1	ACARS_ADDRESS.request	ID Field	10h
2	Length	Byte	0, 7, 14, 21, 28, 35, 42, 49, 56
3-9	Address #1 ISO IA5	Character	
10-16	Address #2 ISO IA5	Character	
17-23	Address #3 ISO IA5	Character	
24-30	Address #4 ISO IA5	Character	
31-37	Address #5 ISO IA5	Character	
38-44	Address #6 ISO IA5	Character	
45-51	Address #7 ISO IA5	Character	
52-58	Address #8 ISO IA5	Character	

The VDR should accept a maximum of eight address fields for the purpose of address screening of ACARS uplink blocks. Each address field should reside in 7 bytes of space within the data field as defined in the following table:

Octet	Description
N	Address Character #1 (Most Significant Character)
N+1	Address Character #2
N+2	Address Character #3
N+3	Address Character #4
N+4	Address Character #5
N+5	Address Character #6
N+6	Address Character #7 (Least Significant Character)

The addresses will be encoded using ISO IA5 characters. This field is the same format as will appear in the address field of the ACARS uplink blocks.

5.0 INTERFACE AND PROTOCOLS TO THE CMU/MU (cont'd)

ISO IA5 characters are 8 bits in length, where the least seven significant bits are comprised of character data, and the most significant bit is the odd parity bit, which the VDR may not assume is correct.

The address data fields will be transferred most significant character first, least significant character last. For example given a seven character address of DEL2145 it will be transmitted in the data field of the address table in the following order: D, E, L, 2, 1, 4, 5.

If an address used for ACARS uplink screening is less than seven characters in length, the VDR will assume that the address is right justified and filled with leading period characters. For example given the five character address N2101, it should be transmitted in the address field of the configuration data information in the following order: ., ., N, 2, 1, 0, 1.

5.3.5.2 Undesired Transmission Filtering

The VDR receives not only ACARS uplinks but also ACARS downlinks and AVPAC frames (both uplinks and downlinks) originating from proximate aircraft. The VDR should identify each ACARS block as either an uplink or a downlink. If the block has been identified as a downlink (or it is an AVPAC frame), the VDR should discard the message. No quality of service parameters will be forwarded to the MU/CMU for received ACARS downlinks or AVPAC frames.

COMMENTARY

Identification of AVPAC frames can be accomplished by a flag instead of a SYN SYN beginning the frame. ACARS uplink/downlink identification can be accomplished by examining the mode character.

5.3.5.3 ACARS Uplink Address Screening

The MU/CMU will have explicit control of the address screening of ACARS uplinks. The VDR will use tables provided by the MU/CMU to screen for up to 8 addresses. Through the address uplink tables, the VDR will either pass every uplink, pass no uplinks, or pass selected uplinks. An address table containing no addresses will result in every ACARS uplink passed to the MU/CMU. A table containing 1 to 8 addresses will result in only ACARS uplinks which have an address which match one of the addresses in the table to be forwarded to the MU/CMU. In addition, the VDR should forward all traffic with a broadcast address (all DEL characters) to the MU for processing.

The configuration data may contain less than eight ACARS addresses. The VDR software should be adaptive such that it will only screen for the addresses supplied by the MU/CMU. The reception of an address table without screening addresses (Data Field Length of zero) should result in the VDR forwarding every ACARS uplink received to the MU/CMU.

When a new address table is received, the old address table should be completely deleted from the VDR. For

example if the VDR is presently screening addresses from a table of four addresses, and it receives a new table containing only two receiver addresses, the VDR should purge all four addresses from the table and continue receiver address screening with only the two new addresses.

COMMENTARY

The MU/CMU can have the VDR forward no ACARS blocks (except broadcast messages) by providing the VDR with an address table with an invalid address.

5.3.6 AVPAC Address Table Command Parameter

5.3.6.1 AVPAC Address Table Format

The following tables define the AVPAC receive address table command parameter data formats:

Octet	Data	Units	Range
1	AVPAC_ADDRESS.request	ID Field	11h
2	00h		
3	Length	Byte	04h
4-7	Address	Byte	0-FFh

The VDR should accept an address field to use as the local address for AVPAC frames. The address field should reside in the byte fields defined by the following table:

Octet	Bits	Description
4	8-6	Address bits 22-24
4	5-3	Address Type Field
4	2	Air/Ground bit (set to zero)
4	1	Address extension bit (set to zero)
5	8-2	Address bits 15-21
5	1	Address extension bit (set to zero)
6	8-2	Address bits 8-14
6	1	Address extension bit (set to zero)
7	8-2	Address bit 1-7
7	1	Address extension bit (set to one)

COMMENTARY

The format of the address in the address table is the same as an AVPAC frame. The lower order bit of each octet is reserved for address extension. When set to binary zero it indicates that the octet is an extension of the address field. The presence of binary one in the lower order bit signifies that the octet is the final octet of the address field. Note that an address of all ones is illegal for all stations, as well as the all zeros address for aircraft.

The VDR should always pass broadcast AVPAC traffic (either all station or all stations of the appropriate type) to the CMU for processing.

5.3.6.2 AVPAC Address Usage

The VDR should use the configured address as the local AVPAC station address.

5.3.7 P-Persistence Command Parameter

5.0 INTERFACE AND PROTOCOLS TO THE CMU/MU (cont'd)

5.3.7.1 P-Persistence Command Format

The following table defines the P-persistence command data parameter format:

Octet	Data	Units	Range
1	MA_P.request	ID Field	30h
2	00h	-	-
3	01h	Byte	-
4	P-Persistence	.003906251	-.996 (0-FFh)

5.3.7.2 P-Persistence Parameter Use

This parameter will be used as an input to the MAC layer's CSMA algorithm. This parameter can also be received via XID frame, thus the VDR will use the last P-Persistence value it receives. When this parameter is returned to the CMU as status data (Section 5.4) the value returned in this field will be the value received from the CMU.

5.3.8 N2 - Maximum Number of Retransmissions Parameter

5.3.8.1 N2 - Maximum Number of Retransmissions Format

The following table defines the maximum number of retransmissions configuration data format.

Octet	Data	Units	Range
1	DL_MAXTRANSMISSION.req	ID Field	40h
2	Length MSB	Byte	0
3	Length LSB	Byte	1
4	Max Number of re-xmt	Scalar	00-FFh

5.3.8.2 N2 - Maximum Number of Retransmissions Use

N2 will be used as an input to the VDR's AVPAC link layer protocol state machine to establish the limit on the number of retransmission attempts.

5.3.9 TM2 - MAC Transmit Timer

5.3.9.1 TM2 - MAC Transmit Timer Format

The following table defines the maximum frame transmit attempt time configuration data format.

Octet	Data	Units	Range
1	MA_TIMER2.request	ID Field	31h
2	Length MSB	Byte	0
3	Length LSB	Byte	1
4	Max Frame Transmit Attempt Time	Seconds	0-255

5.3.9.2 TM2 - MAC Transmit Timer Use

The VDR will use the TM2 value to establish the maximum length of time its MAC algorithm will attempt to access a transmission channel.

5.3.10 Window Size

5.3.10.1 Window Size Format

The following table defines the window size configuration data format.

Octet	Data	Units	Range
1	DL_K.request	ID Field	41h
2	Length MSB	Byte	0
3	Length LSB	Byte	1
4	K	Scalar	1-7

5.3.10.2 Window Size Use

The VDR will use the Window Size parameter, K, as an input to its AVPAC link layer protocol state machine. "K" will be used to define the maximum number of AVPAC frames which can be transmitted contiguously without an acknowledgement from the receiver.

5.3.11 Air/Ground Status

5.3.11.1 Air/Ground Status Parameter Format

The following table defines the format of the Air/Ground Status parameter.

Octet	Data	Units	Range
1	VDR_AG.request	ID Field	04h
2	Length MSB	Byte	0
3	Length LSB	Byte	1
4	Air/Ground Status	Scalar	0-1

5.3.11.2 Air/Ground Status Parameter Use

The Air/Ground Status parameter will be used by the VDR to set the Air/Ground bit in the AVPAC link layer header, the sense of this bit is defined in ARINC Specification 631.

5.4 Aperiodic Status Data

Upon request, or, whenever the CMU outputs a new command parameter to the VDR, the VDR will transmit aperiodic status information to the MU/CMU. The transmission of aperiodic status data is the means by which command data parameters are fed back to the MU/CMU. Aperiodic status data will be transmitted in a single ARINC 429 BOP file and will be comprised of all command data parameters which are passed across the VDR-MU/CMU interface. The format used for data transfer will be the same as that specified in Section 5.3.

The format of the status information request will be an ARINC 429 BOP SOLO word with the ID field set to VDR_STATUS.request.

5.5 Air-Ground Protocol Data

The VDR should communicate ACARS blocks and AVPAC DLSDUs with the active MU/CMU across a full duplex high speed ARINC 429 data bus. The ARINC 429 BOP data file will be used as the link-layer

5.0 INTERFACE AND PROTOCOLS TO THE CMU/MU (cont'd)

communication mechanism for the transfer of air-ground protocol data between the VDR and the MU/CMU.

Air-ground protocol data will be sent in an ARINC 429 BOP data files.

5.5.1 ACARS Data

The following table defines the ACARS data format for downlinks:

Octet	Data	Units	Range
1	ACARS_UNITDATA.request	ID Field	12h
2	Length Byte MSB	Byte	00h-FFh
3	Length Byte LSB	Byte	00h-FFh
4	00h	Fixed	-
5	SOH	Character	00h-FFh
.	.	.	.
.	.	.	.
.	.	.	.
N	ETX or ETB	Character	.
N+1	BCS_MSB	Byte	.
N+2	BCS_LSB	Byte	.

The following table defines the ACARS data format for uplinks:

Octet	Data	Units	Range
1	ACARS_UNITDATA.indication	ID Field	13h
2	Length Byte MSB	Byte	00h-FFh
3	Length Byte LSB	Byte	00h-FFh
4	SQP	Byte	-
5	SOH	Character	00h-FFh
.	.	.	.
.	.	.	.
.	.	.	.
N	ETX or ETB	Character	.
N+1	BCS_MSB	Byte	.
N+2	BCS_LSB	Byte	.

An ACARS block as it applies to the VDR-MU/CMU interface is that portion of the ACARS message from the Start of Header (SOH) character through Block Check Sequence (BCS) inclusively. The preamble portion of the ACARS message contains no information which is utilized by the MU/CMU; therefore the transportation of the preamble is not supported by the MU/CMU interface. For specifics on the formats of ACARS blocks refer to ARINC 618 "Air-Ground Character-Oriented Protocol Specification".

5.5.1.1 Block Check Sequence Testing

For each received ACARS uplink the VDR will perform the address screening first. If the block is to be forwarded to the MU/CMU the Block Check Sequence (BCS) is not required to be verified by the VDR. If there is no address match and the block is an uplink as defined in AEEC 618 then the VDR should determine the BCS status and forward this status in the ACARS SQP ARINC 429 word as defined by Section 5.7.1. The VDR should not screen from the MU/CMU, ACARS messages which have a bad BCS.

5.5.1.2 ACARS Transmit Operations

When the VDR receives an ACARS block from the active MU/CMU it should transmit it as soon as the MAC sublayer gives a clear-to-send. The transmission of the block should be preceded by a pre-key and preamble appropriate to the modulation scheme being used.

The VDR must also prefix the bit and character synchronization characters as defined in ARINC 618.

5.5.2 AVPAC Data

The AVPAC link layer state machine will reside in the VDR which will be responsible for executing all of the link layer functions defined in ARINC 631. To allow the CMU's network layer to transfer data through the VDR's link layer, and initiate, terminate, and reset link layer connections, the DATA, CONNECT, DISCONNECT, RESET, XID, and HANDOFF primitives will be used.

The following paragraphs describe the format and use of these primitives.

5.5.2.1 DL_CONNECT primitives

5.5.2.1.1 DL_CONNECT.request Format

The VDR will receive a DL_CONNECT.request primitive from the CMU in the following format:

Octet	Data	Units	Range
1	DL_CONNECT.request	ID Field	42h
2	Length Byte MSB	Byte	0
3	Length Byte LSB	Byte	8
4-7	Destination Address	(same as Section 5.3.6.1)	
8-11	Source Address	(same as Section 5.3.6.1)	

The Destination address is the address of the ground station which the VDR is attempting to establish a connection with.

The Source address is the VDR's address.

5.5.2.1.2 DL_CONNECT.request Use

When the VDR receives a DL_CONNECT.request it will attempt to establish a link layer connection to the Destination Address. The VDR will make the connection by negotiating link layer parameters with the Destination via XID frames. When the VDR successfully makes the connection it will output a DL_CONNECT.indication to the CMU. If the VDR cannot make the connection, a DL_DISCONNECT.request or DL_DISCONNECT.indication, will be sent to the CMU (see Sections 5.5.2.3.1 and 5.5.2.3.3).

5.0 INTERFACE AND PROTOCOLS TO THE CMU/MU (cont'd)

5.5.2.1.3 DL_CONNECT.indication Format

The VDR will send a DL_CONNECT.indication primitive to the CMU in the following format:

Octet	Data	Units	Range
1	DL_CONNECT.indication	ID Field	43h
2	Length Byte MSB	Byte	0
3	Length Byte LSB	Byte	9
4-7	Destination Address	(same as Section 5.3.6.1)	
8-11	Source Address	(same as Section 5.3.6.1)	

The Destination address, and Source address are the same as described in Section 5.5.2.1.1.

5.5.2.1.4 DL_CONNECT.indication Use

When the VDR successfully establishes a link layer connection to the Destination given by the DL_CONNECT.request it will output a DL_CONNECT.indication to the CMU.

5.5.2.2 DL_DATA primitives

5.5.2.2.1 DL_DATA.request Format

The VDR will receive a DL_DATA.request primitive from the CMU in the following format:

Octet	Data	Units	Range
1	DL_DATA.request	ID Field	44h
2	Length Byte MSB	Byte	0-3h
3	Length Byte LSB	Byte	0-FFh
4	Data (first information octet)		0-FFh
N	Data (last information octet)		0-FFh

5.5.2.2.2 DL_DATA.request Use

DATA.request will be used to transfer packets from the network layer in the CMU to the link layer in the VDR.

5.5.2.2.3 DL_DATA.indication Format

The VDR will send a DL_DATA.indication primitive to the CMU in the same format as the DL_DATA.request primitive with the ID Field set to 45h.

5.5.2.2.4 DL_DATA.indication Use

DATA.indication will be used to transfer packets from the link layer in the VDR to the packet layer in the CMU.

5.5.2.3 DL_DISCONNECT primitives

5.5.2.3.1 DL_DISCONNECT.request Format

The DL_DISCONNECT.request primitive will be in the following format:

Octet	Data	Units	Range
1	DL_DISCONNECT.request	ID Field	46h
2	Length Byte MSB	Byte	0
3	Length Byte LSB	Byte	1
4	Reason	Byte	0-9

The Reason field is defined as follows:

Field Value	Reason
0	Reason unspecified
1	Disconnection-normal condition
2	Disconnection-abnormal condition
3	Connection rejection-permanent condition
4	Connection rejection-transient condition
5 - 9	Used by DL_DISCONNECT.indication

5.5.2.3.2 DL_DISCONNECT.request Use

DL_DISCONNECT.request is used by the CMU's network layer (reasons 1 and 2) to disconnect a link layer connection. It is also used by the VDR to notify the CMU that a link layer connection cannot be made (reasons 3 and 4).

5.5.2.3.3 DL_DISCONNECT.indication Format

The VDR will send a DL_DISCONNECT.indication primitive to the CMU in the following format:

Octet	Data	Units	Range
1	DL_DISCONNECT.ind	ID Field	47h
2	Length Byte MSB	Byte	0
3	Length Byte LSB	Byte	5
4	Reason	Byte	0-9
5-8	Originator Address	(same as Section 5.3.6.1)	

The Originator address can be the VDR address, the ground station address, or "unknown". When the originator address indicates that the ground station initiated the disconnect the reason field should be in the range of 0 to 4. When the originator address indicates that the VDR is initiating the disconnect the reason field should be in the range of 5 to 9. When the originator address is "unknown" the reason field should be set to 0, reason-unspecified.

5.0 INTERFACE AND PROTOCOLS TO THE CMU/MU (cont'd)

The Reason field is defined as follows:

Field Value	Reason
0	Reason unspecified
1	Disconnection-normal condition
2	Disconnection-abnormal condition
3	Connection rejection-permanent condition
4	Connection rejection-transient condition
5	Disconnection-permanent condition
6	Disconnection-transient condition
7	Connection rejection- - destination address unknown.
8	Connection rejection- - destination unreachable/permanent
9	Connection rejection- - destination unreachable/transient

Octet	Data	Units	Range
1	DL_RESET.indication	ID Field	49h
2	Length Byte MSB	Byte	0
3	Length Byte LSB	Byte	5
4	Reason	Byte	0-3
5-8	Originator Address	(same as Section 5.3.6.1)	

The Reason field is defined as follows:

Field Value	Reason
0	Reason unspecified
1	User resynchronization
2	Data Link flow control congestion
3	Data Link error

5.5.2.3.4 DL_DISCONNECT.indication Use

DL DISCONNECT.indication is used by the VDR to notify the CMU that the link layer connection has been disconnected by the ground station (reasons 5 and 6). It is also used by the VDR to notify the CMU that a link layer connection cannot be made (reasons 7, 8, and 9).

5.5.2.4 DL_RESET primitives**5.5.2.4.1 DL_RESET.request Format**

The VDR will receive a DL_RESET.request primitive from the CMU in the following format:

Octet	Data	Units	Range
1	DL_RESET.request	ID Field	48h
2	Length Byte MSB	Byte	0
3	Length Byte LSB	Byte	1
4	Reason	Byte	0-3

The Reason field is defined as follows:

Field Value	Reason
0	Reason unspecified
1	User resynchronization
2 - 3	Used by DL_RESET.indication

5.5.2.4.2 DL_RESET.request Use

When the VDR receives a DL_RESET.request from the CMU it will reset its link layer state machine and its state variables.

5.5.2.4.3 DL_RESET.indication Format

The VDR will send a DL_RESET.indication primitive to the CMU in the following format:

5.5.2.4.4 DL_RESET.indication Use

The VDR will send the CMU a DL_RESET.indication for one of the four reasons given above. The Originator address can be the VDR address, the ground station address, or "unknown". When the originator address indicates that the ground station initiated the reset the reason field should be set to 1. When the originator address indicates that the VDR is initiating the reset the reason field should be set to 2 or 3. When the originator address is "unknown" the reason field should be set to 0, reason- unspecified.

5.5.2.5 DL_HANDOFF primitives

The DL_HANDOFF primitives will be used to coordinate handoff connections.

5.5.2.5.1 DL_HANDOFF.request Format

The VDR will receive a DL_HANDOFF.request primitive from the CMU in the following format:

Octet	Data	Units	Range
1	DL_HANDOFF.request	ID Field	48h
2	Length Byte MSB	Byte	0
3	Length Byte LSB	Byte	4
4-7	Destination Address	(same as Section 5.3.6.1)	

The Destination address is the address of the ground station which the VDR should attempt to hand off to.

5.5.2.5.2 DL_HANDOFF.request Use

When the VDR receives a DL_HANDOFF.request from the CMU it will attempt to establish a linklayerconnection with the Destination through the exchange of XID frames.

5.0 INTERFACE AND PROTOCOLS TO THE CMU/MU (cont'd)5.5.2.5.3 DL_HANDOFF.indication Format

The VDR will send a DL_HANDOFF.indication primitive to the CMU in the following format:

Octet	Data	Units	Range
1	DL_HANDOFF.indication	ID Field	4Ch
2	Length Byte MSB	Byte	0
3	Length Byte LSB	Byte	8
4-7	Source Address	(same as Section 5.3.6.1)	
8-11	Destination Address	(same as Section 5.3.6.1)	

The Source address is the address of the entity which is attempting to initiate a handoff.

The Destination address is the address of the entity to which the Source is attempting to hand off.

5.5.2.5.4 DL_HANDOFF.indication Use

The VDR will send a DL_HANDOFF.indication to the CMU when a ground station is attempting to initiate a handoff.

5.5.2.5.5 DL_HANDOFF.response Format

The VDR will receive a DL_HANDOFF.response primitive from the CMU in the following format:

Octet	Data	Units	Range
1	DL_HANDOFF.response	ID Field	4Dh
2	Length Byte MSB	Byte	0
3	Length Byte LSB	Byte	4
4-7	Responding address	(same as Section 5.3.6.1)	

The Responding address is the address of the ground station to which a handoff connection should be made.

5.5.2.5.6 DL_HANDOFF.response Use

The VDR will receive a DL_HANDOFF.response from the CMU once the LME determines which ground station to handoff to. The VDR should send an XID_RSP_HO to that ground station.

5.5.2.5.7 DL_HANDOFF.confirm Format

The VDR will send a DL_HANDOFF.confirm primitive to the CMU in the following format:

Octet	Data	Units	Range
1	DL_HANDOFF.confirm	ID Field	4Eh
2	Length Byte MSB	Byte	0
3	Length Byte LSB	Byte	1h
4	Success(1)/Failure(0)	Boolean	0-1

5.5.2.5.8 DL_HANDOFF.confirm Use

The VDR will send a DL_HANDOFF.confirm to the CMU when it has completed its hand off attempt.

5.5.2.6 DL_XID primitives

The DL_XID primitives will be used to facilitate the transfer of information between the CMU and its peer on the ground. The data provided in the primitives will be transferred as an XID frame during link establishment.

5.5.2.6.1 DL_XID.request Format

The following table defines the XID Frame information output to the VDR.

Octet	Data	Units	Range
1	DL_XID.request	ID Field	4Fh
2	Length MSB	Byte	3
3	Length LSB	Byte	FFh
4-n	XID Frame(s)	Byte	0-FFh

5.5.2.6.2 DL_XID.request Use

The VDR will send the XID frame contained in the DL_XID.request primitive as an XID frame. The VDR will retransmit the XID if it is a command frame with the P bit set.

5.5.2.6.3 DL_XID.indication Format

The following table defines the XID Parameters output to the CMU.

Octet	Data	Units	Range
1	DL_XID.indication	ID Field	50h
2	Length MSB	Byte	3
3	Length LSB	Byte	FFh
4-n	XID Frame(s)	Byte	0-FFh

5.5.2.6.4 DL_XID.indication Use

When the VDR receives an XID frame it will attempt to decode the received frame. With the exception of the XID parameters given below, the VDR will parse the following XID parameters: Autotune Frequency parameter and Replacement Ground Station address. Regardless of the success of the decoding process, the VDR will send the contents of the received XID frame to the CMU.

COMMENTARY

As noted in ARINC Specification 631, the VDR should only parse an XID from a ground station which matches after anding with the handoff mask of the ground station to which a connection is established.

5.5.2.7 DL_EVENT primitive

5.0 INTERFACE AND PROTOCOLS TO THE CMU/MU (cont'd)

5.5.2.7.1 DL_EVENT indication Format

The following table defines the DL_EVENT.indication format.

Octet	Data	Units	Range
1	DL_EVENT.indication	ID Field	51h
2	Length MSB	Byte	0
3	Length LSB	Byte	4h
4	N2 exceeded	Boolean	0-1
5	TM2 expired	Boolean	0-1
6	T4 expired	Boolean	0-1

5.5.2.7.2 DL_EVENT indication Use

Whenever one of the above events occur the VDR will output a DL_EVENT.indication to the CMU. Zero will be false, and one will be true.

5.6 BITE Data

Upon request, the VDR will convey a limited amount of BITE data to the MU/CMU. The purpose of sending BITE information to the MU/CMU is to report the relative health of the VDR for installations which do not include a Central Fault Display System (CFDS). The MU/CMU BITE information is meant to be a subset of the information made available to the CFDS. The VDR should only inform the MU/CMU of its present health state. There is no requirement for the VDR- MU/CMU interface to support fault recording and the variety of CFDS menu modes supported for the CFDS. It is not the intent of this function to be compatible to ARINC 604 or 624.

The following table defines the different types of BITE data parameters which are visible to the MU/CMU.

Parameters
BITE Boolean
VSWR
SW Part Numbers

All BITE data parameters will be comprised of multiple bytes arranged in a common format. The generic format is shown in the following table:

Octet	Definition
1	ID Field
2	Data Field Length
3	Data Field Length
4	Data Field Byte #1
5	Data Field Byte #2
.	.
.	.
.	.
N+2	Data Field Byte #N

The first byte of each BITE data parameter will contain the ID field. The ID field is a single byte in length, and will uniquely identify each parameter. The second byte of the BITE data parameter will contain the length of the corresponding data field. The value of the data field length will be an integer, and will represent the number

of bytes in the data field. The data field length will not include the ID field or the data field length. The data field may be multiple bytes in length and will contain the information related to the parameter. Each BITE data parameter will have a unique definition for the data field.

When the VDR receives a request for BITE data, it should send to the MU/CMU every visible BITE data parameter. The BITE data parameters will reside in the data words of the ARINC 429 BOP data file. The VDR should transmit every BITE parameter in a single LDU.

5.6.1 BITE Data Request

The format of the BITE data request will be an ARINC 429 BOP SOLO word with the ID field set to VDR_BITE.request.

5.6.2 BITE Boolean Data Format

The following table defines the BITE boolean data format:

Octet	Data	Units	Range
1	VDR_BITE_STATUS.indication	ID Field	08h
2	Length MSB	Byte	00h
3	Length LSB	Byte	03h
4	Bite Booleans	Bit Dis- cretes	(0-FFh)
5	Bite Booleans	Bit Dis- cretes	(0-FFh)
6	Bite Booleans	Bit Dis- cretes	(0-FFh)

The bit discrettes of the BITE Boolean data format should be defined as follows:

Octet	Bit	CFDS BITE Fault Summary word (Label 350)
4	8-7	padded with zeros
4	6	bit 11
4	5	bit 12
4	4	bit 13
4	3	bit 14
4	2	bit 15
4	1	bit 16
5	8	bit 17
5	7	bit 18
5	6	bit 19
5	5	bit 20
5	4	bit 21
5	3	bit 22
5	2	bit 23
5	1	bit 24
6	8	bit 25
6	7	bit 26
6	6	bit 27
6	5	bit 28
6	4	bit 29
6	3-1	padded with zeros

If the VDR detects a failure which will prohibit the transmission or reception of voice, or air-ground protocol data, it should set the "VDR Status" bit to "1". The VDR status bit should be set to "0" if the fault condition ceases to exist.

5.0 INTERFACE AND PROTOCOLS TO THE CMU/MU (cont'd)

5.6.1 BITE Boolean Data Format (cont'd)

If the VDR detects a failure with the antenna such that it will prohibit the transmission or reception of voice, or air-ground protocol data, it should set the "Antenna/Coax Status" bit to "1". The antenna fail bit should be set to "0" if the fault condition ceases to exist.

The VDR will report the status of the designated Digital Frequency Select (DFS) low speed ARINC 429 input bus. If frequency data has been received on the designated DFS bus in the past 5 seconds and utilized to tune the transceiver, the respective DFS bus BITE Boolean should be set to "0". Otherwise the DFS bus BITE Boolean should be set to "1". The DFS Bus Selection boolean reports which bus the VDR is respecting. This bit should be set to a "1" if Port A is selected by the Data Select Discrete (pin MP11D is grounded), "0" otherwise.

The VDR will maintain separate statuses for both high speed ARINC 429 CFDS busses. If the VDR has not received an ARINC 429 data word with a valid label (as defined in ARINC 604) over the respective CFDS bus in the past 5 seconds, the respective "CFDS Input Bus" bit should be set to "1". Otherwise the bit should be set to "0".

The VDR will maintain separate statuses for both high speed ARINC 429 MU/CMU busses. If the VDR has not received an ARINC 429 data word with a valid label (as defined in ARINC 604) over the respective MU/CMU bus in the past 5 seconds, the respective "MU/CMU Input Bus" bit should be set to "1". Otherwise the bit should be set to "0".

5.6.3 VSWR BITE Data Parameter

The following table defines the Voltage Standing Wave Ratio (VSWR) BITE data parameter format:

Octet	Data	Units	Range
1	VDR_BITE_VSWR.ind	ID Field	06h
2	Length MSB	Byte	00
3	Length LSB	Byte	01
4	VSWR	0.1	1.0-15 (10h- FFh)

If the VDR calculates a VSWR above the maximum setting, octet #3 should be set to "FFh".

5.6.4 Part Number BITE Data Parameter

The following table defines the software part number BITE data parameter format:

Octet	Data	Units	Range
1	VDR_BYTE_CONFIG.ind	ID Field	07h
2	Length MSB	Byte	00h
3	Length LSB	Byte	0N
4	Part No. Quantity (Q)	Integer	1-255 (01h- FFh)
5	Part No.#1, Char #1	ISO IA5	
.	.	.	.
.	.	.	.
.	.	.	.
N+3	Part No.#1, Char #N	ISO IA5	

Octet	Data	Units	Range
N+4	Part No.#2, Char #1	ISO IA5	
.	.	.	.
.	.	.	.
.	.	.	.
2N+3	Part No.#2, Char #N	ISO IA5	
.	.	.	.
.	.	.	.
.	.	.	.
(Q-1)*			
N+4	Part No.#Q, Char #1	ISO IA5	
.	.	.	.
.	.	.	.
.	.	.	.
QN+3	Part No.#Q, Char #N	ISO IA5	

The VDR should transmit "Q", "N" character software part numbers to the MU/CMU within the BITE data file transfer. "Q" is defined to be the quantity of part numbers, and "N" is defined to be the number of characters per part number.

The VDR's software part numbers should be encoded using ISO IA5 characters. The VDR should transmit the software part no. most significant digit first, least significant digit last with correct parity. For example, given a ten character software part no. of 653-9831-001, the number should be transmitted in the data field in the following order: 6, 5, 3, 9, 8, 3, 1, 0, 0, 1.

5.7 Signal Quality Parameter (SQP)

For every received ACARS message block or AVPAC frame, the VDR should determine the Signal Quality Parameter. The SQP is forwarded to the MU/CMU with the ACARS message block or AVPAC PH SQP primitive, or with a signal quality report which will be used by the MU/CMU to determine the ground station which will best meet the communication needs.

There are two mechanisms for transporting SQP information. The mechanism used is dependent upon the address of the air-ground protocol messages. For air-ground protocol messages which are not forwarded to the MU/CMU (due to address screening) conventional ARINC 429 words should be used to convey the information. For air-ground messages which are forwarded to the MU/CMU, the SQP will be set in the header of an ACARS block or passed as part of an AVPAC primitive.

The signal quality field occupies four bits. A signal quality field of "0Fh" is defined as the highest quality signal received. A signal quality is "0h-03h" is poor, "04h-0Ah" is adequate, and "0Bh- 0Fh" is considered excellent.

5.7.1 ACARS Signal Quality Parameter

SQP information for ACARS blocks which are not forwarded to the MU/CMU should be passed in an ARINC label 124 word. The ARINC label 124 word should be transmitted within 500 milliseconds of the reception of the discarded ACARS block. The format of the transmitted ARINC label 124 word should be in accordance with Table A8-4.

5.0 INTERFACE AND PROTOCOLS TO THE CMU/MU (cont'd)

The SDI codes (bits 10 and 9) should be set in accordance with the SDI strapping of the transceiver as defined in Table A8-12. The site ID field (bits 17- 24) should contain the 8 bit ISO IA5 mode character from the corresponding ACARS uplink block. Bit 17 should contain the least significant bit of the mode character. Bit 24 should contain the most significant bit (parity bit) of the mode character. The SQP field (bits 25-28) should be filled with the signal quality field associated with the ACARS uplink block. Bit 25 should contain the least significant bit of the SQP. Bit 28 should contain the most significant bit of the SQP. The BCS status (bit #29) should be set to "1" if the block check sequence of the corresponding ACARS uplink block is invalid and to "0" if valid. The pad fields should always be set to zero. The SSM Field (bits 31 and 30) should be set to "Normal" as defined in Table A8-11.

5.7.2 AVPAC Signal Quality Parameter, Mode, and Address

SQP information for AVPAC frames which are not forwarded to the MU/CMU (due to address screening) should be passed in ARINC label 125 and 126 data words. The ARINC label 125 and 126 words should be transmitted in tandem within 500 milliseconds of the reception of the discarded AVPAC frame. The format of the transmitted ARINC 429 label 125 and 126 data words should be in accordance with Table A8-5 and Table A8-6 respectively.

For the ARINC label 125 data word, the SDI codes (bits 10 and 9) should be set in accordance with the SDI strapping of the transceiver as defined in Table A8-12. Bits 11-12 should be set to the mode which the frame was received. Bits 13-16 and 18-24 should hold an AVPAC base station transmitting address bits 1-4 and 5-11 respectively. The pad field should be set to zero. The SSM Field (bits 31 and 30) should be set to "Normal" as defined in Table A8-11.

For the ARINC label 126 data word, the SDI codes (bits 10 & 9) should be set in accordance with the SDI strapping of the transceiver as defined in Table A8-12. Bits 11-16 and 18-24 should hold an AVPAC base station transmitting address bits 19-24 and 12- 18 respectively. The SQP field (bits 25-28) should be filled with the signal quality associated with the received AVPAC frame. Bit 25 should contain the least significant bit of the SQP. Bit 28 should contain the most significant bit of the SQP. The pad field should be set to zero. The SSM Field (bits 31 and 30) should be set to "Normal" as defined in Table A8-12.

5.7.3 PH_SQP.indication primitive

The following table defines the format of the PH_SQP.indication primitive.

Octet	Data	Units	Range
1	PH_SQP.indication	ID Field	54h
2	Length MSB	Byte	0
3	Length LSB	Byte	5
4	SQP	Byte	0-12
5-8	Source Address	Byte	(same as Section 5.3.6)

5.8 Periodic Data

The VDR and MU/CMU will each transmit a set of ARINC 429 data words in all modes to the other periodically. By definition periodic data is nondescript in nature, and includes information which is passed across the bus without request, independent of operating mode of the sending unit. The continuous reception of this data assures the sink that the source of the ARINC 429 words is in an on line state. Conversely the disappearance of periodic data informs the sink that the source has gone off line due to a reset, or failure.

Periodic data includes information used in the link layer processing of ARINC 429 BOP data, real-time status data, or data used to supplement BITE data processing.

Periodic data is communicated in conventional ARINC 429 words. The transmission and reception of conventional ARINC 429 word should not interfere with the transfer of ARINC 429 BOP files. If the VDR receives a conventional data word intermixed in an ARINC 429 BOP file, it should accept the conventional data word and resume processing the incoming ARINC 429 BOP information as if the conventional data word was never present.

The VDR should periodically transmit the following list of ARINC 429 words to the MU/CMU:

ARINC 429 Label	Nominal Output Rate	Description
172	1 sec	VDR System Address Label
270	1 sec	VDR real-time status
377	1 sec	VDR Equipment ID

The VDR should output ARINC label 172, 270, and 377 words in accordance with Tables A8-7, A8-8, and A8-9.

The VDR should expect to periodically receive the following list of ARINC 429 words from the MU/CMU:

ARINC 429 Label	Nominal Output Rate	Description
172	1 sec	(C)MU System Address Label
270	1 sec	(C)MU real-time status

5.8.1 Transmitted System Address Label (SAL) Word

The purpose of the transmitted ARINC label 172 word is to inform the MU/CMU of the VDR's SAL. The format of the 172 word is shown in Table A8-7. The SAL field (Bits 16-9) will be set as a function of the transceiver's SDI strapping and is defined in Table A8-10. The pad fields (bits 29-17) should always be set to zero. The SSM Field (bits 31 and 30) setting are defined in Table A8-11.

5.8.2 Transmitted Status Word

The transmitted ARINC label 270 word is used to inform the MU/CMU of real-time status data. The format of the 270 word is shown in Table A8-8. The SDI codes (bits 10 and 9) should be set in accordance with the SDI

5.0 INTERFACE AND PROTOCOLS TO THE CMU/MU (cont'd)

5.8.2 Transmitted Status Word (cont'd)

strapping of the transceiver as defined in Table A8-12. The Pad fields (Bits 14-16, 18-29) are reserved for future growth and should be set to zero. The SSM Field (bits 31 and 30) setting are defined in Table A8-11.

Individual status bits (bits 11, 12, 13, and 17) define the operating environment of the VDR. The Download Request Boolean (bit #11) should be set to "1" if the VDR has not received both frequency and mode scheme command information from the MU/CMU since the last power up or initialization. The VDR may also set the Download Request Boolean (bit #11) if it wishes to receive a periodic update or verification of the command information. When the Download Request Boolean is set to "1", the VDR is requesting a command data parameter file comprised of the elements defined in Section 5.3 from the active MU/CMU.

The Download Request Boolean should be set to "0" if the VDR has successfully received a complete command data parameter file from the MU/CMU and is operating in a 750 Data mode. The reception of partial command data will result in Download Request Boolean remaining set to the "1" state.

The Transmit/Receive bit (bit #12) should be set to a "1" whenever the VDR is transmitting (in any mode). Otherwise, this bit should be set to a "0". The Transmission Time-out Warning bit should be set to a "1" whenever the transmitter has been keyed continuously for more than 25 seconds (that is, there is less than 5 seconds remaining until the time-out function disables the transmitter or the time-out function has already disabled the transmitter), otherwise this bit should be set to a "0". These two bits can be used to inform the pilots when the radio is no disabled.

The Voice/Data status (bit #17) should be set to a "1" if the transceiver is operating in a 716 compatible mode. When set to "1", the VDR would be receiving frequency tuning information over the low speed ARINC 429 bus. The bit should be set to a "0" if the transceiver is operating in the 750 Data mode and would also be receiving frequency tuning information over the high speed ARINC 429 bus.

5.8.3 Transmitted Equipment Identification Word

The ARINC label 377 word is used to transmit the VDR's equipment identification code to the MU/CMU. The format of the 377 word is shown in Table A8-9. The SDI codes (bits 10 & 9) should be set in accordance with the SDI strapping of the transceiver as defined in Table A8-12. The Equipment Class field (bits 22-11) will be set to "016h" which identifies the LRU as a "VHF Transceiver". The pad field (bits 29-23) should be set to zero. The SSM code should be set to "Normal" as defined in Table A8-12.

5.8.4 Received System Address Label Word

The VDR should receive an ARINC label 172 data word from the MU/CMU over the high speed ARINC 429 interface. The ARINC label 172 data word will contain

the SAL of the MU/CMU. The format of the received ARINC label 172 word is defined in Table A8-7.

5.8.5 Received Status Word

The VDR should receive an ARINC label 270 word from the MU/CMU over the high speed ARINC 429 interface. The ARINC label 270 data word will contain information on whether the MU/CMU is "active" or in "standby" mode. Bit #20 is defined to be the MU/CMU active/standby bit. If the bit is set to "1", the MU/CMU is defined to be "active", and if "0" it is defined to be in "standby".

5.9 Error Messages

If the VDR or MU/CMU experiences an error in communication, the receiving unit should notify the sender of the communication problem. Error messages will be passed between the VDR and the MU/CMU in ARINC 429 BOP SOLO words. A SOLO word ID field of VDR_ERROR.indication will be reserved for error message transfers. The id field of the illegal frame will be passed in bits 16-9 of the VDR_ERROR.indication.

A frame should be considered illegal if it has an unknown id, the length is wrong, the format is not correct for the specified id, or the value(s) contained in the frame are out-of-bounds.

6.0 PROVISIONS FOR AUTOMATIC TEST EQUIPMENT (ATE)

6.1 General

To enable Automatic Test Equipment (ATE) to be used in the bench maintenance, internal circuit functions not available at the 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. This connector should be fitted with only that number of contacts needed to support the ATE functions. The connector should be provided with a protective cover suitable to protect these contacts from damage, contamination, etc. while the unit is installed in the aircraft. The manufacturer should observe ARINC Specification 600 standards for unit projections, etc., when choosing the location for this auxiliary connector.

6.1.1 ATE Testing

The VDR should be ATE testable and should have a test program written using the 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 626 ATLAS."

The ATLAS test procedure should be demonstrated to execute without modification on "SMART Automatic Test Systems" which are defined in ARINC Project Paper 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."

7.0 PROVISIONS FOR BUILT-IN TEST EQUIPMENT (BITE)

7.1 Introduction

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

COMMENTARY

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

The VDR BITE should be capable of detecting and annunciating a minimum of 95% of the faults or failures which can occur within the VDR and as many faults as possible associated with the VHF 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. The antenna cabling loss is specified as not more than 5.5 dB. 5.5 dB will yield a VSWR of not more than 1.9:1 regardless of the antenna VSWR. Therefore measuring the VSWR at the connector of the radio will 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 VDR 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.

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.

COMMENTARY

An example of this would be an internal loopback test which would demodulate and monitor each frame transmitted, in order to verify the correct operation of the transmitter and receiver.

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

COMMENTARY

Sufficient margins should be used in choosing BITE parameters to preclude nuisance warnings. Discrepancies in VDR operation caused by power

bus transients, received noise, EMI, servicing interference, abnormal accelerations, turbulence, etc. should not be recorded as faults.

7.2 BITE Interfaces

The VDR should facilitate control and annunciation of the BITE information via the following interfaces:

- OMS/CFDS Interfaces
- MU/CMU Interfaces
- VDR Front Panel

COMMENTARY

The VDR 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 VDR 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 VDR 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 VDR should provide an interactive, "user friendly" aid to maintenance.

7.2.1 OMS Interfaces

The VDR should facilitate BITE control and fault reporting capability, including interfaces with single or dual Central Maintenance Computer (CMC) units in accordance with ARINC Report 624. Attachment 9, Table 9-1 describes the list of BITE codes which should be used for VDR fault reporting.

7.2.2 Character-Oriented CFDS Interfaces

The VDR 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.

7.2.3 Bit-Oriented CFDS Interfaces

The VDR 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 9, Tables 9-2 and 9-3.

7.2.4 MU/CMU BITE Interfaces

The VDR 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

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

Fault summary words should be in accordance with Attachment 9, Tables 9-2 and 9-3.

for the OMS, CFDS, MU, or CMU.

7.3 BITE Presentation

BITE information provided on the data buses for the OMS/CFDS and CMU/MU will be presented to maintenance personnel on the display contained within the applicable system. Additionally, the VDR should present System/LRU fault status on its front panel 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.

COMMENTARY

Airlines desire that BITE information be presented to line maintenance personnel using easily understandable text - not coded! - and using an alpha-numeric display or equivalent technique. The airlines do not want the maintenance personnel to be burdened with carrying a library of code translations, and desire BITE fault analysis capability equal to or surpassing that realized with shop Automatic Test Equipment.

7.4 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 VDR 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.

7.5 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 VDR 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)

COMMENTARY

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

As an aid to shop maintenance and local trouble-shooting on the aircraft, a mechanism should be provided on the VDR front panel 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.

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.

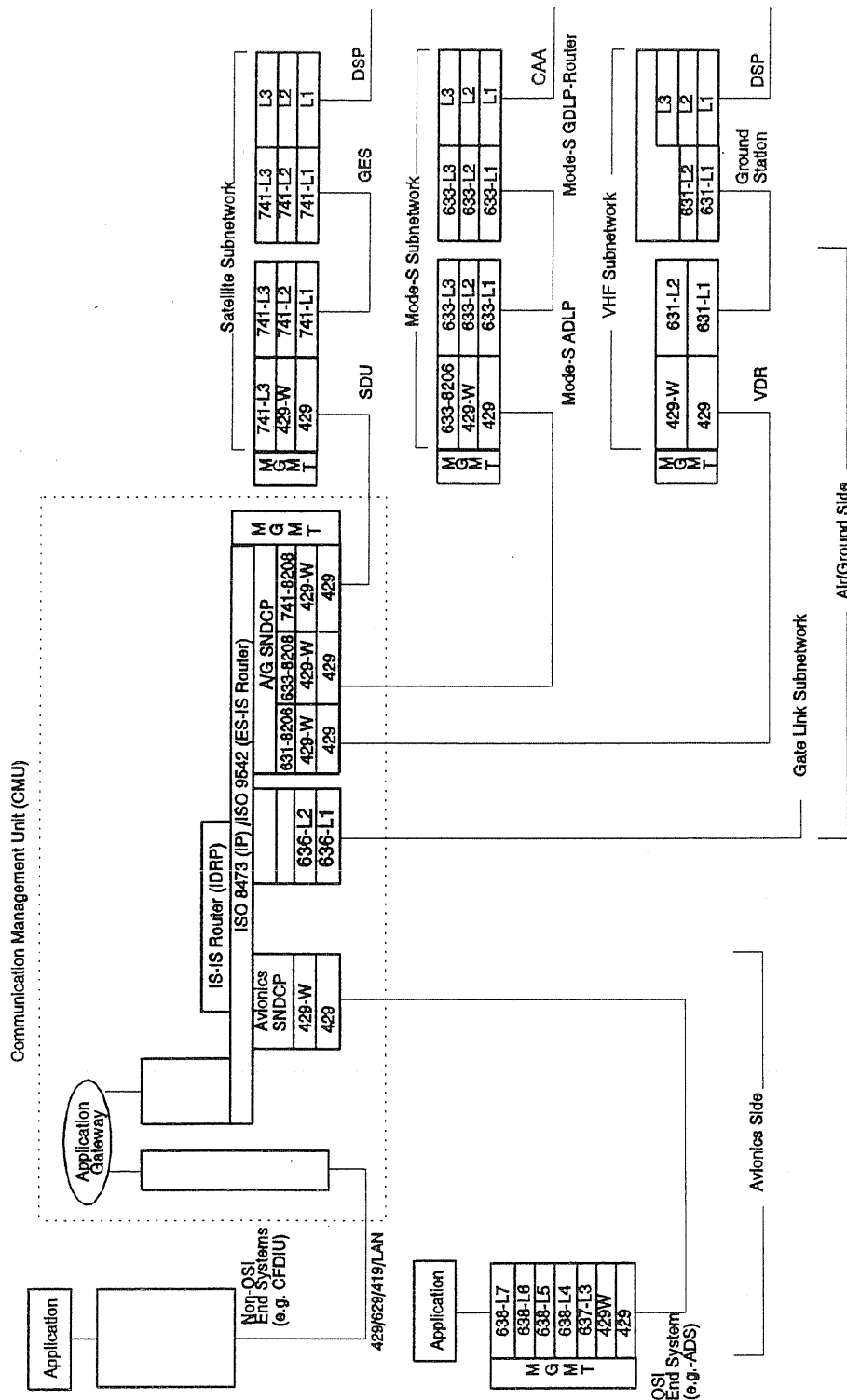
7.6 Monitor Memory Output

The BITE Monitor Memory output should consist of the following:

- (a) An output on the applicable ARINC 429 Data bus to the OMS/CFDS or MU/CMU when so requested, as described in ARINC Reports 624 and 604 using the format described therein.
- (b) An output to the VDR front panel annunciator, indicating the status of the VDR, antenna, coaxial cable, and interfaces. An English language presentation is preferred over coded messages.
- (c) An output of undefined format which should be made available for shop read-out at the ATE reserved pins of the upper connector located on the VDR.

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

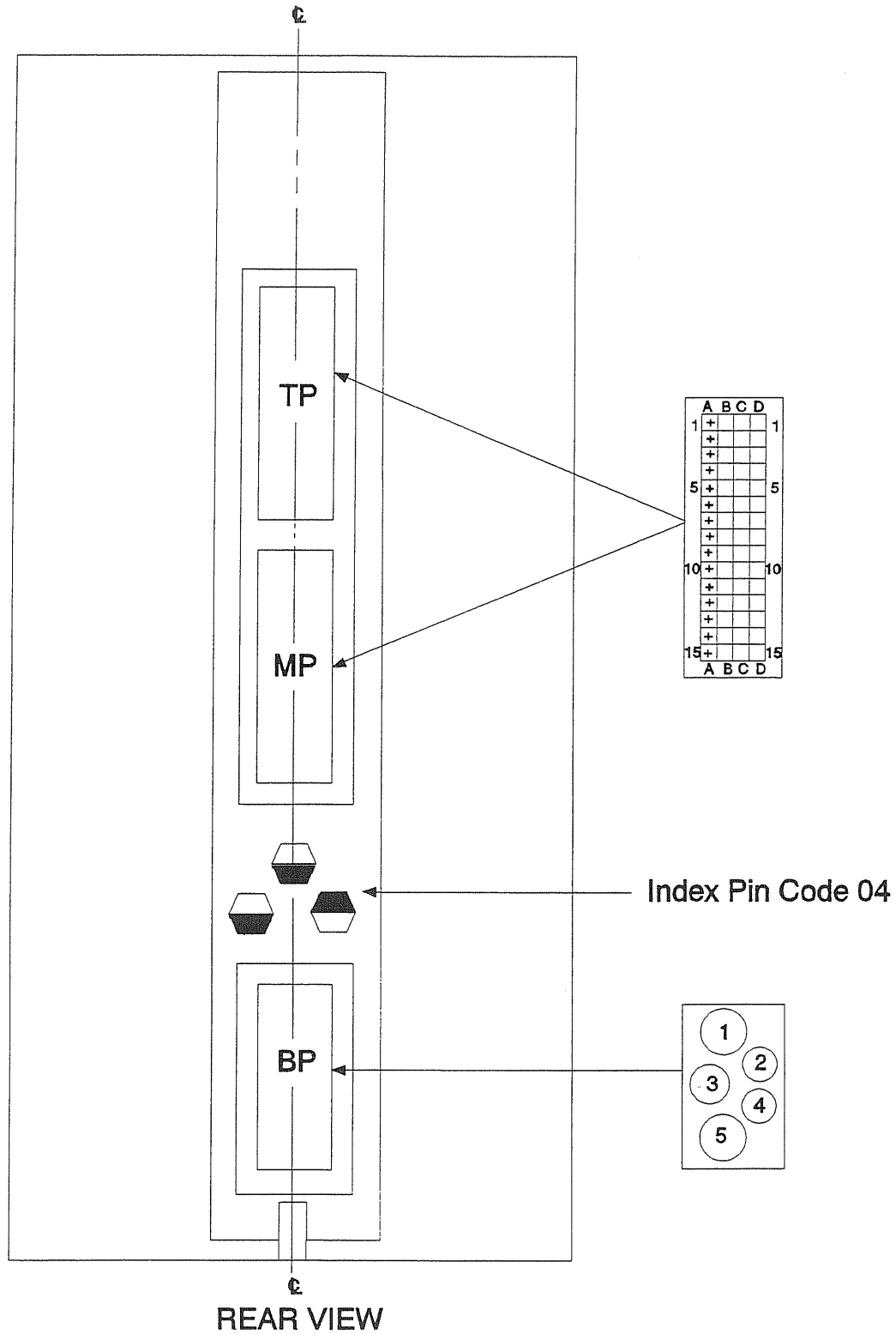
ATTACHMENT 1
AIRBORNE SUBSYSTEM BLOCK DIAGRAM



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
VDR CONNECTOR POSITIONING



ATTACHMENT 3
STANDARD INTERWIRING

<u>FUNCTION</u>	<u>VDR</u>	<u>CMU#1</u>	<u>CMU#2</u>	<u>OMS</u>	<u>DL</u>	<u>OTHER</u>	<u>NOTES</u>
Future Spare	TP1A						
Future Spare	TP1B						
Future Spare	TP1B						
Future Spare	TP1D						
Future Spare	TP2A						
Future Spare	TP2B						
Future Spare	TP2C						
Future Spare	TP2D						
Future Spare	TP3A						
Future Spare	TP3B						
Future Spare	TP3C						
Future Spare	TP3D						
Future Spare	TP4A						
Future Spare	TP4B						
Future Spare	TP4C						
Future Spare	TP4D						
Reserved for ATE	TP5A						
Reserved for ATE	TP5B						
Reserved for ATE	TP5C						
Reserved for ATE	TP5D						
Reserved for ATE	TP6A						
Reserved for ATE	TP6B						
Reserved for ATE	TP6C						
Reserved for ATE	TP6D						
Reserved for ATE	TP7A						
Reserved for ATE	TP7B						
Reserved for ATE	TP7C						
Reserved for ATE	TP7D						
Future Spare	TP8A						
Future Spare	TP8B						
Future Spare	TP8C						
Future Spare	TP8D						
Future Spare	TP9A						
Future Spare	TP9B						
Future Spare	TP9C						
Future Spare	TP9D						
Future Spare	TP10A						
Future Spare	TP10B						
Future Spare	TP10C						
Future Spare	TP10D						
Future Spare	TP11A						
Future Spare	TP11B						
Future Spare	TP11C						
Future Spare	TP11D						
Future Spare	TP12A						
Future Spare	TP12B						
Future Spare	TP12C						
Future Spare	TP12D						
Future Spare	TP13A						
Future Spare	TP13B						
Future Spare	TP13C						
Future Spare	TP13D						
Future Spare	TP14A						
Future Spare	TP14B						
Future Spare	TP14C						
Future Spare	TP14D						
Future Spare	TP15A						
Future Spare	TP15B						
Future Spare	TP15C						
Future Spare	TP15D						

ATTACHMENT 3 (cont'd)
STANDARD INTERWIRING

<u>FUNCTION</u>		<u>VDR</u>	<u>CMU#1</u>	<u>CMU#2</u>	<u>OMS</u>	<u>DL</u>	<u>OTHER</u>	<u>NOTES</u>
Mike Input	] Hi Lo PTT	MP1A	o-----o					1,A
		MP1B	o-----o					1,A
		MP1C	o-----o					1,A
Key Event		MP1D	o-----o					1,A
Max Trans Cutoff		MP2A	o-----o					4,K
Mike Input (Gnd)		MP2B	o-----o					1
Data Loader Input	] A B	MP2C						4,O
		MP2D						4
Optional (Remote Squelch)	] Hi ARM Lo	MP3A	o-----o					1,B
		MP3B	o-----o					1,B
		MP3C	o-----o					1,B
DC Ground		MP3D	o-----o					2
Self Test Discrete		MP4A	o-----o					1
Audio Ground		MP4B	o-----o					1
Data Loader Output	] A B	MP4C						4,O
		MP4D						4
Data Link	] Hi Lo	MP5A	o-----o					1,C
Data Input		MP5B	o-----o					1,C
Reserved for 716 Compatability		MP5C						
Reserved for 716 Compatability		MP5D						
Data from OMS/CFDS #1 Input Port A	] A B	MP6A	o-----o					2,P
		MP6B	o-----o					2
Data from OMS/CFDS #2 Input Port B	] A B	MP6C	o-----o					4,P
		MP6D	o-----o					4
Freq./Funct. Select	] A B	MP7A	o-----o					1,P
Data I/P Port B		MP7B	o-----o					1
Voice/Data Select		MP7C	o-----o					1,D
Data Key Line		MP7D	o-----o					1,E
Antenna Monitor Program		MP8A	o-----o					1
Data Loader Enable		MP8B						4,N
Reserved for 716 Compatability		MP8C	o-----o					1
Data Keyline Return		MP8D	o-----o					1
SDI Code Input		MP9A						2,F
SDI Code Input		MP9B						2,F
Ground		MP9C						2
Reserved for AGC		MP9D	o-----o					1
Program Common		MP10A	o-----o					1
Future Spare		MP10B						
Data to both CMUs Output Port	] A B	MP10C	o--o-----o					4,O
		MP10D	o--o-----o					4
Freq./Funct. Section	] A B	MP11A	o-----o					1,P
Input Data I/P Port A		MP11B	o-----o					1
Spare		MP11C						
Data Select Discrete		MP11D	o-----o					2,G
Data from CMU#1	] A B	MP12A	o--o					4,O
Input Port A		MP12B	o--o					4
Data from CMU#2 Input Port B	] A B	MP12C	o-----o					4,O
		MP12D	o-----o					4
SELCAL Audio and	] Hi Lo	MP13A	o-----o					1,I
Data Output		MP13B	o-----o					1,I
Squelch Disable		MP13C	o-----o					1,J
Squelch Disable Return		MP13D	o-----o					1,J
Future Spare		MP14A						
Ground/Air Discrete		MP14B	o-----o					2,H
Data to OMS or CFDS Output Port	] A B	MP14C	o-----o					2,P
		MP14D	o-----o					2

ATTACHMENT 3 (cont'd)
STANDARD INTERWIRING

<u>FUNCTION</u>		<u>VDR</u>	<u>CMU#1</u>	<u>CMU#2</u>	<u>OMS</u>	<u>DL</u>	<u>OTHER</u>	<u>NOTES</u>
Audio/Sidetone Output	Hi	MP15A	o-----	-----	-----	o		1,L
	Lo	MP15B	o-----	-----	-----	o		1,L
Muting		MP15C	o-----	-----	-----	o		1,M
Muting Return		MP15D	o-----	-----	-----	o		1,M
Antenna RF Input		BP1	o-----	-----	-----	o		2
Power Input +27.5VDC		BP2	o-----	-----	-----	o		2,N
Spare		BP3						
Power Input Ground		BP4	o-----	-----	-----	o		2
Not Used		BP5						

ATTACHMENT 4
NOTES APPLICABLE TO STANDARD INTERWIRING

1. Applicable to ARINC 716 VHF COM compatible operations only.
 2. Applicable to both ARINC 716 VHF COM and ARINC 750 VDR operations. Functions are identical.
 3. Applicable to both ARINC 716 VHF COM and ARINC 750 VDR operations. The new VDR functions are different from VHF modes.
 4. Applicable to ARINC 750 VDR operations only.
- A. Microphone Input (MP1A, B, C, D)
- Standard four wire microphone interwiring as described in Attachment 6 of ARINC Characteristic 716-7. The microphone should be keyed when MP1C is grounded.
- B. Optional Remote Squelch (MP3A, B, C)
- To accommodate an optional remote squelch adjustment if so required or provided.
- C. Data Link Input (MP5A, B)
- Analog 2400 bps ACARS data input to the VHF 716 COMM. The interface is defined in ARINC Specification 618.
- D. Voice/Data Select (MP7C)
- When in ARINC 716-compatible modes, then the VDR is in Mode 1A when pin MP7C is grounded and in Mode 0 when pin MP7C is open.
- E. Data Key Line (MP7D)
- When in Mode 1A, the transmitter should be keyed when pin MP7D is grounded and should be unkeyed when pin MP7D is open.
- F. SDI Code Input (MP9A, B)
- An analog discrete pair, prewired at the rear connector to identify specific VHF radio location in the aircraft.
- G. Data Select Discrete (MP11D)
- Used to enable either Frequency/Function Select Data I/P Port A or B. Port A should be selected when pin MP11D is grounded, and port B should be selected when pin MP11D is open.
- H. Ground/Air Discrete (MP14B)
- This discrete is used for BITE functionality. Pin MP14B is grounded to indicate the aircraft is airborne, and is open to indicate the aircraft is on the ground. Note that the air/ground digital command parameter should be used for AVPAC protocol functionality.
- I. SELCAL Audio & Data Output (MP13A, B)
- An analog out put to provide 2400 bps data to the ACARS MU. May also be used for SELCAL provisions.
- J. Squelch Disable/Return (MP13C, D)
- An analog discrete to provide squelch override or disable capability. The squelch should be disabled when pin MP13C is grounded, and enabled when pin MP13C is open.
- K. Maximum Transmission Cutoff Enable (MP2A)
- An analog discrete which determines whether the maximum transmission time cutoff feature is implemented. Discrete is open to enable the cutoff feature; if the discrete is grounded, then the cutoff feature is disabled.
- L. Audio/Sidetone Output (MP15A, B)

ATTACHMENT 4 (cont'd)
NOTES APPLICABLE TO STANDARD INTERWIRING

An analog output for either receiver audio during RCV, or sidetone audio during voice transmit modes.

M. Muting/Return (MP15C, D)

An optional two wire analog discrete to provide a switch closure internal to the VHF COMM for external system muting applications during transmit modes. Muting should be enabled when pin MP15C is grounded, and disabled when pin MP15C is open.

N. Power Input (BP2)

One 10 amp circuit breaker should be provided in the standard installation.

O. High Speed ARINC 429 Bus

P. Low Speed ARINC 429 Bus

ATTACHMENT 5
ENVIRONMENTAL CONDITIONS FOR AIRBORNE EQUIPMENT
RTCA/DO-160C

The following RTCA/DO-160C categories apply to the environmental specification of the ARINC 750 VHF Data Radio.

Environment	UNIT LOCATION			
	DO-160C Section	Rack Mounted	Internal Airframe Mounted	External Airframe Mounted
Temperature and Altitude	4	A1	A1	D2
Temperature Variation	5	C	C	A
Humidity	6	A	A	A
Operational Shocks and Crash Safety	7	Shock	Shock	Shock
Vibration	8	B	B	C
Explosion Proofness	9	X	X	E
Water Proofness	10	X	X	W
Fluids Susceptibility	11	X	X	H
Sand and Dust	12	X	X	D
Fungus Resistance	13	X	X	F
Salt Spray	14	X	X	S
Magnetic Effect	15	X	X	X
Power Input	16	A	A	A
Voltage Spike	17	A	A	A
Audio Frequency Conducted Susceptibility - Power Inputs	18	Z	Z	Z
Induced Signal Susceptibility	19	A	A	A
Radio Frequency Susceptibility (Radiated and Conducted)	20	U	V	W
Emission of Radio Frequency Energy	21	A	A	A
Lightning Induced Transient Susceptibility	22	A2C2	A3C3	A4C4
Lightning Direct Effects	23	-	-	-
Icing	24	X	X	A

ATTACHMENT 6
SIGNAL IN SPACE MASKS

Table A6-1 Spectral Mask of Transmitter for Modes 1 and 2

Lower Bound		Upper Bound	
Frequency	Attenuation	Frequency	Attenuation
0	-0.25	0	0.25
1700	-0.25	2500	0.25
3000	-1	3900	-1
3900	-3	4900	-3
4800	-6	5800	-6
5350	-10	6650	-10
6310	-20	7910	-20
6680	-30	8680	-30

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

Table A6-2 Tolerance on the Phase Mask of Transmitter for Modes 1 and 2

Lower Bound		Upper Bound	
Frequency	Phase	Frequency	Phase
0	-1.8	0	1.8
5250	-1.8	5250	1.8
5250	-2.8	5250	2.8
6000	-2.8	6000	2.8
6000	180	6000	180

Frequency is specified in Hz deviation from the channel center (on both sides), and the phase is specified in degrees deviation from linear.

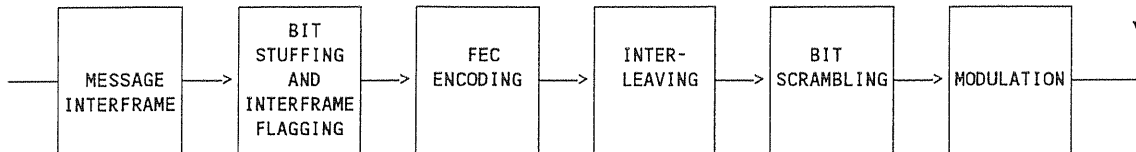
Table A6-3 Adjacent Channel Interference Measurement Filter

Label	Attenuation	Frequency	Tolerance Toward Carrier	Tolerance Away From Carrier
D1	-1	5	+3.1 to 0.0	+3.5 to -3.5
D2	-6	8	+0.1 to -0.1	+3.5 to -3.5
D3	-26	9.25	+1.35 to -0.0	+3.5 to -3.5
D4	-90	13.25	+0.0 to -5.35	+3.5 to -7.5

Attenuation is specified in dB, frequency is specified in kHz deviation from the channel center (in both directions), and the tolerances are specified in kHz deviation from the specified frequency, and the carrier is the signal under test.

The filter slope between point D3 and D4 must be greater than or equal to 20 dB / 1.25 kHz on the side towards the carrier. Beyond the 90 dB points, the suppression should be less than 90 dB.

ATTACHMENT 7
EXAMPLE SYMBOL ENCODING



Example Messages:

Messages to be sent in the transmission:

MSG1; MSG2

Bitstuff, add CRC, and Flag:

Message 1

01111110 10110010 11001010 11100010 10001100 00111110 10010100 1

Message 2

01111110 10110010 11001010 11100010 01001100 11100110 01100101 01111110

Compute FEC:

Block over which FEC is computed

01111110 10110010 11001010 11100010 10001100 00111110 10010100 01111110 10110010 11001010 11100010
01001100 11100110 01100101 01111110

(Uncomputed) FEC 2 words for this length message

00000000 00000000

Interleave:

Since interleaving is done across 255 word blocks, there is no effect for short transmissions such as

01111110 10110010 11001010 11100010 10001100 00111110 10010100 10111111 01011001 01100101 01110001
00100110 01110011 00110010 10111111 00000000 00000000 0

Insert Scrambled Portion of Training Sequence:

Note short transmission does not contain any equalization training symbols

Res	Message Length	Check
00	10010001 00000000 0	10001

Message

01111110 10110010 11001010 11100010 10001100 00111110 10010100 10111111 01011001 01100101 01110001
00100110 01110011 00110010 10111111 00000000 00000000 0

Scramble:

00110111 01011011 11010101 01011011 10111101 01000110 11110111 01100011 11110011 11111110 01010011
11000000 00001011 01010010 01001110 00001000 01010010 00011011 10000001 10001110 0

Into Modulation Symbols:

Added Unscrambled Portion of Training Sequence

Prekey

AAAAAAAAAAAAAAAAAAAAA

Unique Word

CACACCAA CCAACAC AACCAAAC

Message

ACDCDDBC CDDDDDBC A BCCDDADB CCDCDBAC A CCACCCCB DDACCAA A AABCDDAB DACBAABA A
DDABADBC BAADBACB A A

ATTACHMENT 8
VDR TABLES

Table A8-1 CFDS Fault Identification Codes

Fault Code ID	Nomenclature	Meanings
1	Power Interrupt Recovery	Power interrupt has occurred in last 3 seconds
2	Left CFDS Activity Fail	No data received from left CFDS.
3	Left CFDS Signal Fail	Left CFDS data is invalid.
4	Right CFDS Activity Fail	No data received from right CFDS.
5	Right CFDS Signal Fail	Right CFDS data is invalid.
6	BITE Test Inhibit	Initiated test is inhibited.
7	VDR Failure	VDR is in failure.
8	VHF Antenna/Coax Failure	VHF antenna or coax is in failure.
9	MU/CMU Input-1 Failure	No data received from MU/CMU Input-1.
10	MU/CMU Input-2 Failure	No data received from MU/CMU Input-2.

Note: Fault ID Codes 1 thru 5 are assigned to generic faults, and Code 6 is assigned to BITE Test Inhibit, based on guidance material in ARINC Report 624.

Staff Note: This table, derived from draft material in Avionics PUB 91-174/FCM-55, may require changes based on work in progress on Report 624 in the FCM Subcommittee.

ATTACHMENT 8 (cont'd)
VDR TABLES

Table A8-2 Bit-Oriented CFDS BITE Command Summary Word for VDR

Bit No.	Function	Bit Status	
		1	0
1	Label 227 (Octal)		
2			
3			
4			
5			
6			
7			
8			
9	SDI		
10			
11	Pad		
12			
13	Equipment ID (Hex) - TBD		
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25	(See Functional Select Table A7.1 in ARINC Report 604.)		
26			
27			
28			
29			
30			
31			
32			

Note: In the event of a conflict between the material in this Attachment and ARINC Report 604, "Guidance for Design and Use of Built-In Test Equipment (BITE)", this Attachment should take precedence.

ATTACHMENT 8 (cont'd)
VDR TABLES

Table A8-3 Bit-Oriented CFDS BITE Fault Summary Word for VDR

Bit No.	Function	Bit Status	
		1	0
1	Label (350) (Octal)		
2			
3			
4			
5			
6			
7			
8			
9	SDI		
10			
11	VDR Status	Failed	OK
12	Antenna/Coax Status	Failed	OK
13	CFDIU Input Bus 1	Inactive	Active
14	DFS Bus Selection	Port A	Port B
15	Selected DFS Input Bus	Inactive	Active
16	CFDIU Input Bus 2	Inactive	Active
17	CMU/MU Input Bus 1	Inactive	Active
18	CMU/MU Input Bus 2	Inactive	Active
19			
20			
21			
22			
23			
24			
25			
26			
27			
28	BITE Test Inhibit	Inhibit	Enable
29	Command Word Acknowledge	ACK	NAK
30	SSM		
31			
32	Parity (Odd)		

Note: In the event of a conflict between the material in this Attachment and ARINC Report 604, "Guidance for Design and Use of Built-In Test Equipment (BITE)", this Attachment should take precedence.

ATTACHMENT 8 (cont'd)VDR TABLESTable A8-4 ACARS SQP Word

Bit	Function	Comments
1-8	Label 124 (octal)	
9-10	SDI	
11-16	pad	set to zero
17-24	Site ID Field	bit 24 = parity bit
25-28	SQP	LSB = 25
29	BCS Status	invalid = 1, OK = 0
30-31	SSM Code	
31	Parity (odd)	

Table A8-5 AVPAC SQP Word

Bit	Function	Comments
1-8	Label 125 (octal)	
9-10	SDI	
11-12	Mode Scheme	00 = error 01 = MSK 10 = 4-OQAM 11 = 16-OQAM
13-16	AVPAC Address bits (1-4)	
17	pad	Always zero
18-24	AVPAC Address bits (5-11)	
25-29	pad	set to zero
30-31	SSM Code	
32	Parity (odd)	

Table A8-6 AVPAC SQP Word

Bit	Function	Comments
1-8	Label 126 (octal)	
9-10	SDI	
11-16	AVPAC Address bits (19-24)	
17	filler	Always zero
18-24	AVPAC Address bits (12-18)	
25-28	SQP	LSB = 25
29	FCS Status	Invalid = 1, OK = 0
30-31	SSM Code	
32	Parity (odd)	

Note: The fields have been rearranged for octet alignment. Modulation type should be added to SQP words.

ATTACHMENT 8 (cont'd)
VDR TABLES

Table A8-7 VDR SAL Word to MU/CMU

Bit	Function	Comments
1-8 9-16 17-29 30-31 32	Label 172 (octal) System address Label pad SSM Code Parity (odd)	set to zero

Table A8-8 VDR Status Word

Bit	Function	Comments
1-8 9-10 11	Label 270 (octal) SDI Download Request bit	Request = 1, Not Request = 0 Transmit = 1, Receive = 0 <5 seconds until transmit time out (or timed out) set to zero Voice = 1, Data = 0 set to zero
12 13	Transmit/Receive bit Transmission Time-out Warning bit	
14-16 17	pad Voice/Data Status bit	
18-29 30-31 32	pad SSM Code Parity (odd)	

Table A8-9 Equipment ID Word

Bit	Function	Comments
1-8 9-10 11-22 23-29 30-31 32	Label 377 (octal) SDI Equipment Class pad SSM Code Parity (odd)	set to zero

ATTACHMENT 8 (cont'd)
VDR TABLES

Table A8-10 System Address Label Field

SDI Strapping	SAL (octal)	Bit 16	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9
N/A	250 (TBD)	0	0	0	1	0	1	0	1
Left	251 (TBD)	1	0	0	1	0	1	0	1
Right	252 (TBD)	0	1	0	1	0	1	0	1
Center	253 (TBD)	1	1	0	1	0	1	0	1

Table A8-11 Sign Status Matrix Setting

SSM Setting	Bit 31	Bit 30
Normal	0	0
NCD	0	1
Functional Test	1	0
Failure Warning	1	1

Table A8-12 SDI Field

Installation Position	Bit 10	Bit 9
N/A	0	0
Left	0	1
Right	1	0
Center	1	1

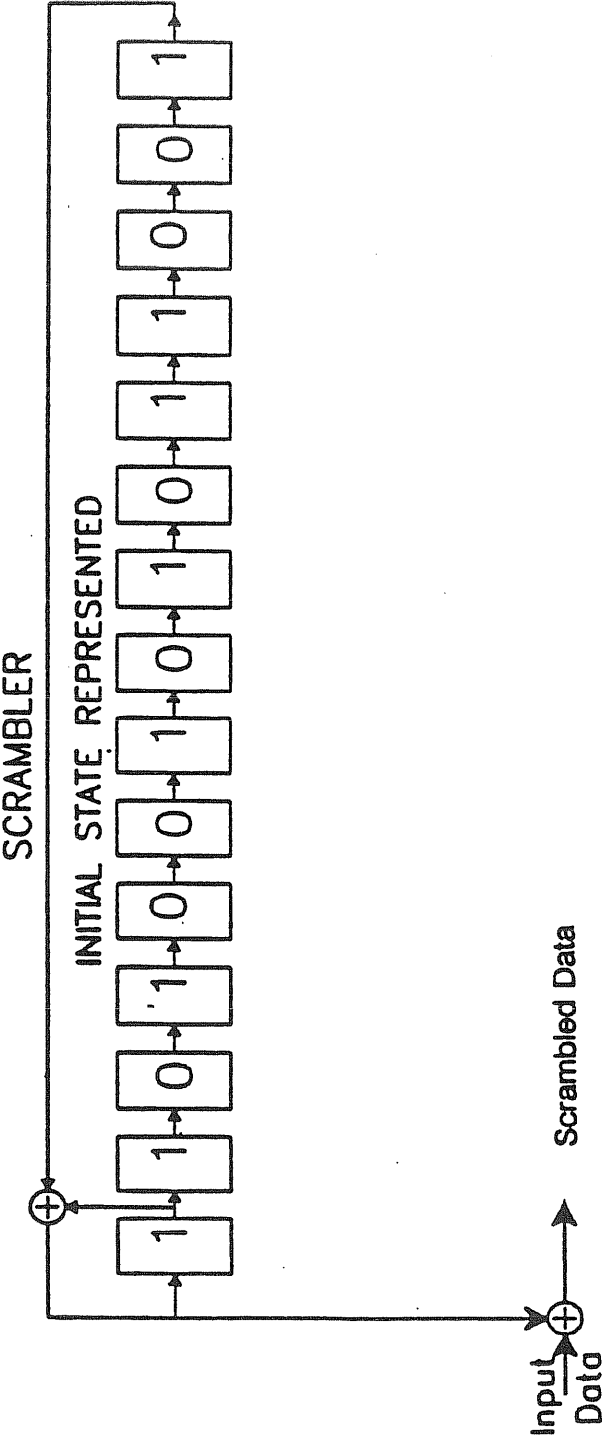
ATTACHMENT 8 (cont'd)
VDR TABLES

Table A8-13 ID Field Table

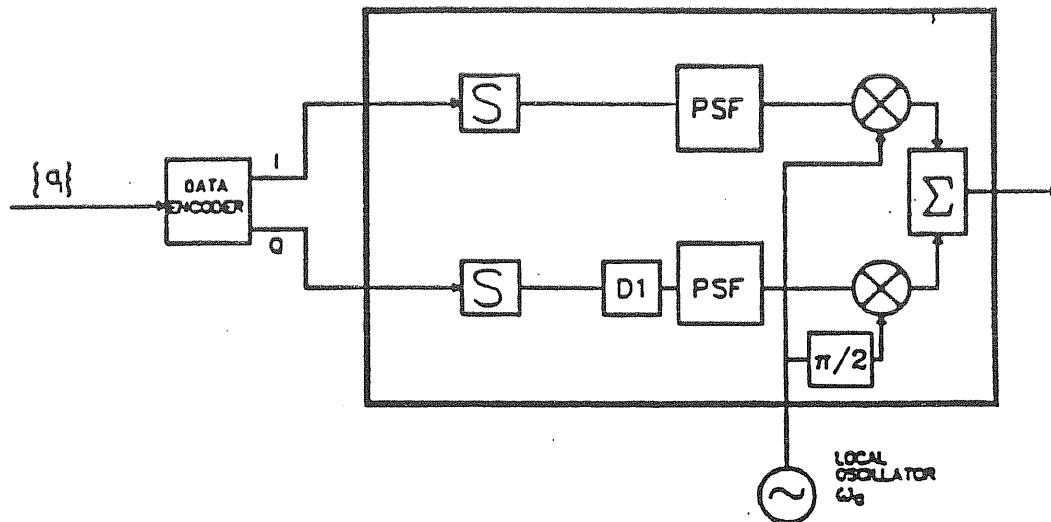
ID Field	Command Parameter/Primitive
03h	VDR_TRANSMIT.confirm
04h	VDR_PURGE_TX_QUEUE.confirm
06h	VDR_STATUS.REQUEST
09h	VDR_BYTE.request
0Ah	VDR_TRNASMIT.request
0Bh	VDR_PURGE_TX_QUEUE.request
0Fh	VDR_ERROR.indication
10h	ACARS_UNITDATA.indication
11h	AVPAC_UNITDATA.indication
12h	ACARS_UNITDATA.request
13h	AVPAC_UNITDATA.request
20h	PH_FREQUENCY.request / confirm / indication
22h	VDR_MODE.request / indication
23h	PH_PREKEY.request / indication
24h	MA_P.request / indication
25h	VDR_TX_TEMP.request / indication
26h	ACARS_ADDRESS.request / indication
27h	AVPAC_ADDRESS.request / indication
28h	VDR_BITE_STATUS.indication
29h	VDR_BITE_VSWR.indication
2Ah	VDR_BITE_CONFIG.indication

Note: Requests are from the MU/CMU to the VDR. Confirms are responses from the VDR to requests. Indications are from the VDR to the MU/CMU. If there is no confirm primitive then there is no response to a request primitive.

ATTACHMENT 9
SCRAMBLER FUNCTIONAL BLOCK



ATTACHMENT 10
IDEAL MODULATOR MODEL (4-OQAM - 16-OQAM)



$\{a_i\}$ is input data sequence. Bit rate $= 2/T$ for 4-OQAM
 $4/T$ for 16-OQAM

$\boxed{S}$ is an ideal sampling process:
For 4-OQAM:
input = "0", output = $3\delta(t)$
input = "1", output = $-3\delta(t)$
For 16-OQAM:
input = "01", output = $3\delta(t)$
input = "00", output = $\delta(t)$
input = "10", output = $-\delta(t)$
input = "11", output = $-3\delta(t)$

$\boxed{D1}$ is a delay of: $T/2$

$\boxed{PSF}$ are Impulse Shaping Filters (raised cosine with $\alpha = 0.6$)

$\otimes$ represents an ideal linear modulator

$\boxed{\Sigma}$ represents an ideal combiner

APPENDIX A TERMS

Balanced mode	A communications protocol using a peer-to-peer relation.
Baud rate	Signalling rate
BER	Uncorrected bit error rate. This is the probability that a given bit at the input to the Reed-Solomon decoder is in error.
BFR	Corrected block failure rate. This is the probability that a given block is valid after the Reed-Solomon decoder. Note that if the block is invalid, an arbitrary number of bits in the block may be decoded incorrectly.
Channel rate	Information rate on the channel (raw data rate).
Data rate	Information rate available to the user.
dBm	dB with respect to a milliwatt
dBr	dB with respect to the reference power level.
IRR	Interference Rejection Ratio. Given an on-channel, noise-free signal of 3 dBr, the IRR is the power ratio between the on-channel signal and an interfering signal, where the interfering signal causes a degradation of the uncorrected BER to the reference BER.
kbps	kilo bits per second
Reference BER	An uncorrected BER of $3.5 * 10^{-5}$. This yields a corrected block failure rate of 10^{-6} .
Reference power level	This is the sensitivity specified in section 4.2.2.2 for a given modulation scheme to achieve the reference BER.
Unbalanced mode	A communications protocol using a master-slave relation.
Uncorrected BER	The raw bit error rate at the input to the Reed-Solomon decoder.

CONVENTIONS

In this document bytes are called octets and are numbered, from right (least significant bit) to left (most significant bit), 1 to 8 (e.g., $_{MSB}8765\ 4321_{LSB}$).

APPENDIX B
ACRONYMS

ADL	Airborne Data Loader
AFC	Automatic Frequency Control
AGC	Automatic Gain Control
AIF	Alarm Identification Field
AM	Amplitude Modulation
ATE	Automatic Test Equipment
AVPAC	Aviation VHF Packet Communications
BER	Bit Error Rate
BFR	Block Failure Rate
BITE	Built-In Test Equipment
CFDS	Centralized Fault Display System
CMU	Communications Management Unit
DTS	Data Transfer State
ECAC	Electromagnetic Compatibility Analysis Center
EDAC	Error Detection and Correction
FEC	Forward Error Correction
FTD	Frame Type Designator
IRR	Interference Rejection Ratio
ISO	International Organization for Standardization
LLC	Logical Link Control (upper sub-layer of layer 2 of the standard ISO model)
MAC	Media Access Control (lower sub-layer of layer 2 of the standard ISO model)
MSK	Minimum Shift Keying
OMS	Onboard Maintenance System
OQAM	Offset Quadrature Amplitude Modulation
OSI	Open Systems Interconnection
PIF	PDU Identification Field
PDU	Protocol Data Unit
VDR	VHF Data Radio

APPENDIX C
BIBLIOGRAPHY

The following documents are referenced in this Characteristic. Designers should be aware that many of these documents are in the continuing process of being supplemented.

ARINC Specification 404A, "Air Transport Equipment Cases and Racking"

ARINC Report 413A, "Guidance for Aircraft Electrical Power Utilization and Transient Protection"

ARINC Report 414, "General Guidance for Equipment and Installation Designers"

ARINC Characteristic 429, "Mark 33 Digital Information Transfer System (DITS)"

ARINC Characteristic 597, "Mark 2 Aircraft Communications Addressing and Reporting System"

ARINC Specification 600, "Air Transport Avionics Equipment Interfaces (NIC Phase 1)"

ARINC Report 604, "Guidance for Design and Use of Built-In Test Equipment (BITE)"

ARINC Project Paper 608A, "Design Guidance for Avionics Test Equipment"

ARINC Specification 616, "Avionics Subset of ATLAS"

ARINC Specification 618, "Air-Ground Character-Oriented Protocol Specification"

ARINC Report 624, "Design Guidance for Onboard Maintenance System"

ARINC Specification 626, "Standard ATLAS Subset for Modular Test"

ARINC Specification 631, "Aviation VHF Packet Communication (AVPAC) Functional Description"

ARINC Specification 637, "Internetworking Specification"

ARINC Characteristic 716, "Airborne VHF Communication Transceiver"

ARINC Characteristic 724, "Mark 2 Aircraft Communications Addressing and Reporting System"

ARINC Characteristic 724B, "Aircraft Communications Addressing and Reporting System (ACARS)"

AEEC Project Paper 748, "Communications Management Unit (CMU)"

ISO DIS 8208, "X.25 Packet Level Protocol for Data Terminating Equipment"

RTCA Document DO-160C, "Environmental Conditions and Test Procedures for Airborne Electronic/Electrical Equipment and Instruments".

RTCA Document DO-207, "Minimum Operational Performance Standards for Devices that Prevent Blocked Channels used in Two-Way Radio Communications Due to Unintentional Transmissions".