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S-Band Comm/Inst Workbook

S-BD COMM/IN 21002

**Mission Operations Directorate
Space Flight Training Division**

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**This document has been reviewed and updated.
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S-BD COMM/IN 21002

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FOREWORD

The content of this document was provided by the Shuttle Communications/Payloads section, Shuttle Training Branch, United Space Alliance (USA), Mission Operations Directorate (MOD), Lyndon B. Johnson Space Center (JSC), National Aeronautics and Space Administration (NASA). This document was produced through the MOD Training Resource Center, Space Flight Training and Facility Operations Branch, Space Flight Training Division, MOD, JSC, with the assistance of the Integrated Documentation Services. This material is for training purposes only and should not be used as a source of operational data. All numerical data, displays, and checklist references are intended only as examples. Consult the applicable Certification Plan outlined in your Flight Operations Support Personnel Training Guide (Blue Book) or the Crew Training Catalog to determine any prerequisites before using this document. This training package should be studied before attending any classroom session or lesson for which this is a prerequisite.

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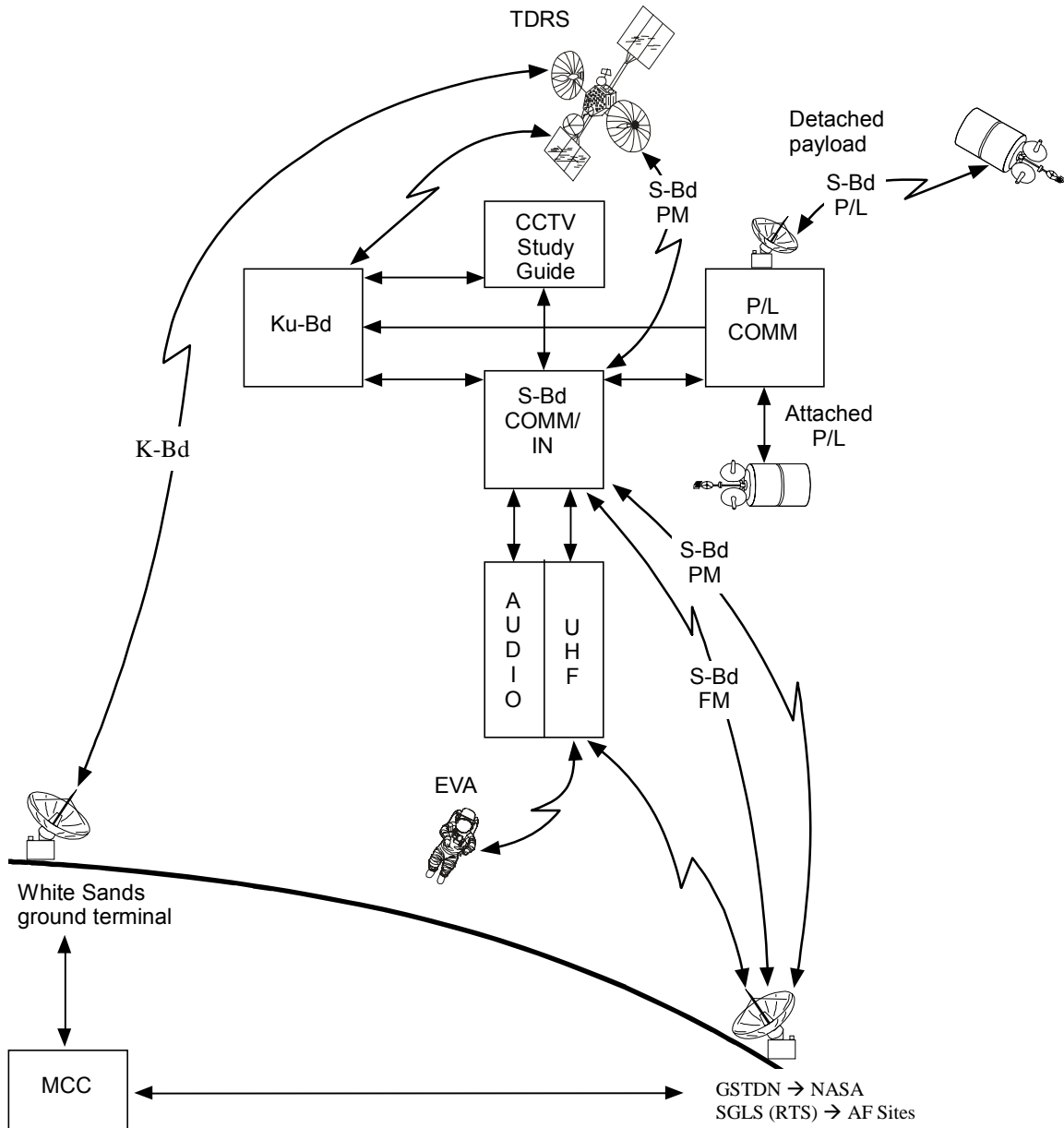
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1.0 INTRODUCTION

The goal of the Shuttle Communications (COMM) series of training manuals is to prepare the reader to analyze communication cockpit indications (cues) and to perform onboard procedures associated with the shuttle communication system. Figure 1-1 is a simplified diagram of the various communication subsystems and interfaces of the orbiter. Each block in the figure represents a workbook, or study guide, that is dedicated to that particular subsystem.



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Figure 1-1. Space shuttle communication subsystems

The space shuttle communication system provides a link for the transfer of voice, telemetry, commands, and file/info transfer, through Radio Frequency (RF) links. RF allows the transfer of information by a radio signal. More specifically, these RF link use a carrier wave signal to transfer the information (called data, using modulation techniques) between MCC and the orbiter by various RF networks. The five RF links/systems on the orbiter are the S-band (S-Bd) PM (Phase Modulation), S-Bd FM (Frequency Modulation), Ku-band, UHF (Ultra-High-Frequency) and S-Bd PL (also referred to as S-Bd Payload Comm System).

The RF, or communication (Comm) networks for the orbiter, consists of three RF bands defined in the frequency spectrum: S-band (1.55-5.2 GHz); Ku-band (10.9-36.0 GHz); and UHF (300-3000 MHz), specific orbiter usage within these bands are discussed in Section 2. The RF networks include the Space Tracking and Data Network (STDN), Space Ground Link System (SGLS), and Tracking and Data Relay Satellite System (TDRSS). Figure 1-2 illustrates the RF networks and the RF systems associated with them.

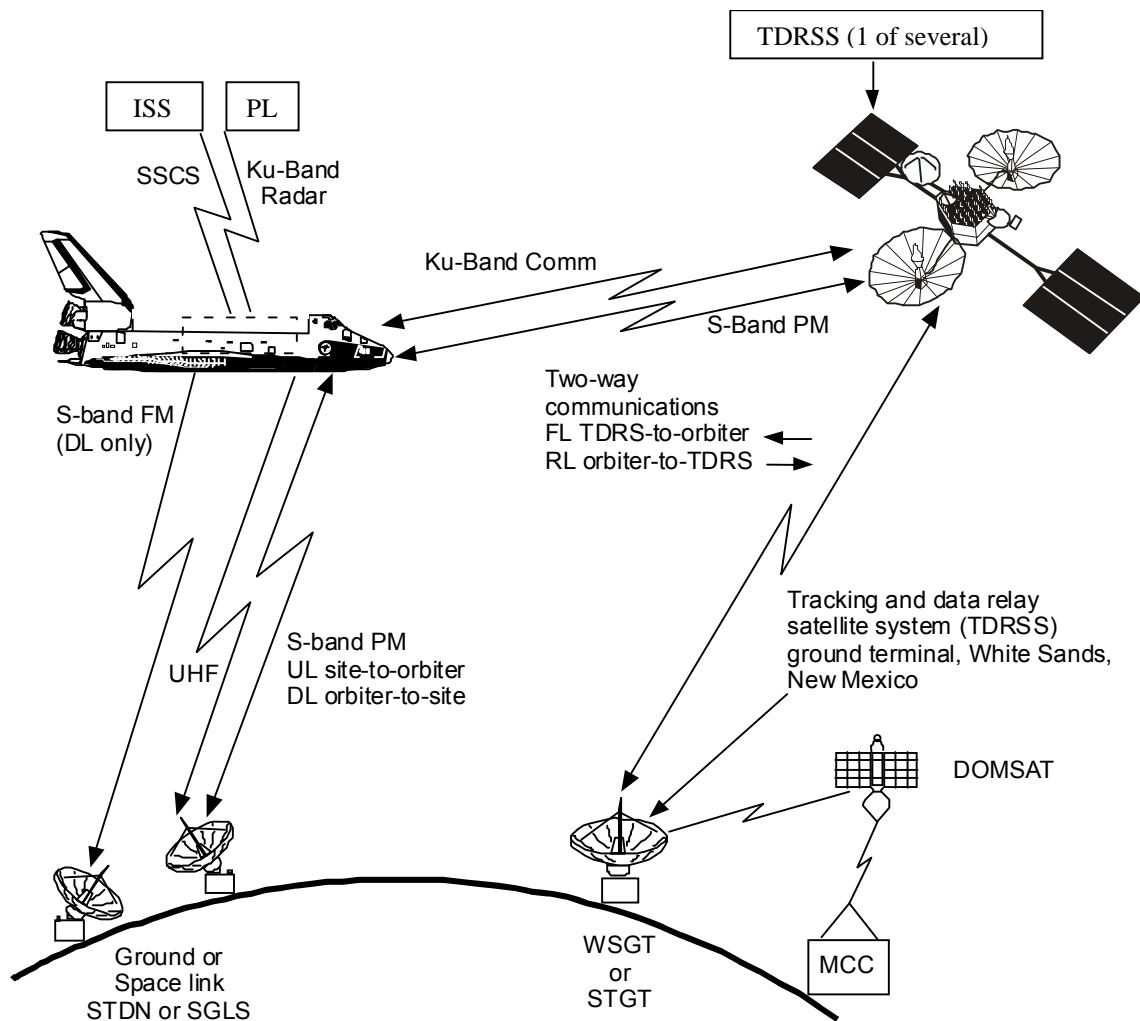
The S-band Communications & Instrumentation (COMM/IN) block from Figure 1-1 represents the S-Bd PM; the Network Signal Processor (NSP); NSP interfacing Line Replaceable Units (LRUs) for Uplink/Downlink (UL/DL) processing; recorders; and S-Bd FM systems. The operations of these systems are discussed in this workbook.

S-Bd PM is the primary RF system for all phases of flight. Operationally it will be set-up to communicate via STDN for pre-launch and most of powered flight. At a Mission-Elapsed-Time (MET) of 7:30 the S-band PM system and associated NSP are changed (or configured) by a pre-stored command into TDRS mode, using the TDRSS network. TDRS will be used for the rest of the mission until landing phase, roughly 150-170K feet (or about MACH 10-12), where again a pre-stored command configures back to STDN Mode, through the landing site STDN Site [usually MIL (Merritt island), for KSC, or DRY (Dryden) for Edwards]. SGLS mode is used for special uses or contingency operations.

S-Bd FM is used for downlink activities only, through the STDN or SGLS networks. On ascent it provides a real-time downlink of main engine (ME) data and on landing can provide video from the pilot-point-of-view (PPOV) camera(s) via the STDN landing site. On orbit S-band FM can provide a back-up downlinks such as payload, TV, recorder playbacks should the Ku-band system not be available, or fail in its downlink capabilities.

The Ku-Bd system is another path through which the orbiter can achieve two-way Comm with MCC, only via the TDRSS. The Ku-Bd system has three channels to downlink, and two channels available for uplink, where the S-Bd PM supports just NSP uplink (voice and commands) and downlink (voice and data). The Ku-Bd can be set-up to support the NSP links that S-Bd PM does plus up to two additional sources such as: closed circuit television (CCTV), recorder dumps (MMU1 or 2), digital or analog payload data streams. Channel 3 even can support up to 50M of science or video data. With several pluses to the Ku-Bd system, it has limits as well. For one it can only be used on orbit since the Antenna is deployed in the payload bay when the doors are open. It also

blockage areas and can have from usage restrictions with certain payloads or in proximity to the ISS. More details on the Ku-band system is found in the KU OPS 21002 Workbook.



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Figure 1-2. Orbiter RF links

The UHF-Simplex (SPLX) system is used to provide a back-up voice system during powered flight and landing phases of flight. In this mode it routes analog voice to/from orbiter via STDN sites that support the orbiter UHF frequencies, like Merritt Island station (called MIL), near Kennedy Space Center (KSC). The UHF system on orbit can be changed to support voice with other space vehicle, like the International Space Station (ISS), and/or with Extravehicular Activity (EVA) crewmembers. This system, for ISS and/or EVA support, is called the space-to-space communication system (SSCS). The orbiter portion of this system is called the Space-to-Space Orbiter Radio (SSOR). The UHF-SPLX and the SSCS are two completely different UHF systems, which share a common crew control panel (on O6). The SSCS can support up to 5 users using a TDM modulation scheme. The audio system is the main source for the transfer of voice

and caution and warning tones/alarms. The audio and UHF systems (including SSCS) are explained in the AUDIO/UHF 21002 Workbook.

The CCTV system is used by the crew-members to support payload operation, EVA operations, record on-board crew activities, and downlink TV (recorded or live) to the ground through either the Ku-Bd or S-Bd FM systems. The system is explained in the CCTV OPS study guide and Shuttle Crew Operations Manual (SCOM).

The fifth and final RF system is the S-Bd PL (also called PL Comm system), which operates ancillary to the S-Bd PM or Ku-Bd systems, for hardline or RF interfacing to payloads or ISS. The PL Comm system includes connectivity to the Orbiter Interface Unit (OIU) that provides MS-1553 interface with the ISS, and other 1553 compatible devices such as SSCS to allow voice, commands and/or telemetry between shuttle and other space vehicles. Additional details about the PL Comm system is found in the PL COM 21002 Workbook.

2.0 S-BAND COMM/IN OVERVIEW

After completing this workbook, including the review material in Section 7, the student will be able to

- Identify the RF modes used to support S-Bd PM Comm system
- Identify the LRUs used for S-Bd PM high power and low power modes
- Identify the S-Bd PM transponder modes used to communicate through TDRSS, STDN, and SGLS [a.k.a., United States Air Force (USAF) Remote Tracking Station (RTS)]
- Trace the signal flow using the S-Bd PM Comm drawing (Figure 2-1, note this can also be found in Malfunction Procedures, Comm Section, called 'COMM S-Bd PM SCHEMATIC'), given appropriate S-Bd PM Display and Control (D&C) information, specifically:
 - Trace the uplink (voice and commands) from the received antenna to the Audio Control Central Unit (ACCU) and General Purpose Computer (GPC) for high power and low power modes
 - Trace the downlink (voice and telemetry) from the ACCU and Pulse Code Modulation Master Unit (PCMMU) to transmitting antenna for high power and low power modes
- Identify crew displays and controls used for monitoring and controlling S-Bd Comm systems

The purpose of this S-band Comm/In Workbook is to discuss functions and operations of the S-Bd PM, NSP, NSP interfacing LRUs, instrumentation, orbiter recorders, and S-Bd FM systems.

The S-Bd PM section focuses on the S-Bd PM LRUs; namely, the quad antennas, antenna electronics, pre and power amplifiers, and transponders. It also, explains the basic uses, functions, and interface of the S-Bd PM system. S-Bd antenna management is also reviewed in this section.

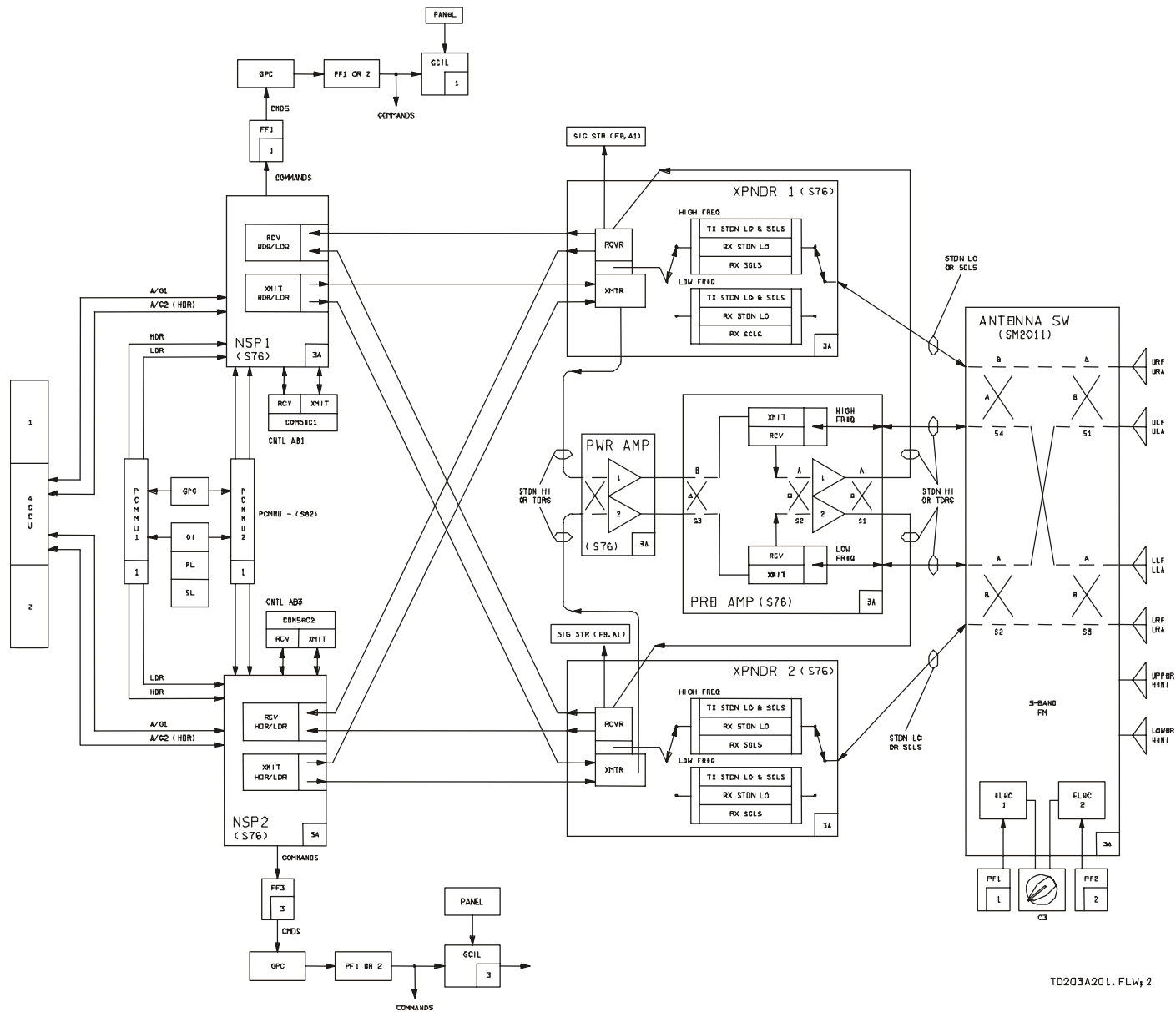
The next section reviews the NSP, plus LRUs interfacing with the NSP for uplink (commands and voice) and downlink (telemetry and voice). This section will also briefly cover the Ku-Bd interface with the NSP, since both S-Bd PM and Ku-Bd are routinely used for uplink communications. Since Ku-Bd is preferred due to its extra capabilities, it is not always available (also supports RADAR operations or gets blocked from good line-of-sight (los) with TDRS) and has no redundancy, the S-Bd PM system is considered the prime communications system.

The recorders section explains the different recorders used on the orbiter, including, Modular Auxiliary Data System (MADS), and the Solid State Recorders (SSRs), which are contained within the Mass Memory Units (MMUs). These recorders are used for the following two purposes:

- The SSRs can record data or data and voice as a back-up to real-time data, especially useful for cases of Loss of Signal (LOS) situations. These LOS situations can be expected, like in the zone of exclusion and no TDRS Z support scheduled, or unexpected due to network or orbiter problems or failures. The SSRs can be played back through either the Ku-Bd or the S-Bd FM systems.
- MADS is to collect data, such as pressure, temperature, strain, vibration and event data during all phases of flight for later analysis on the ground.

The S-Bd FM section explains the use, function, and interfaces of the systems LRUs and interfaces.

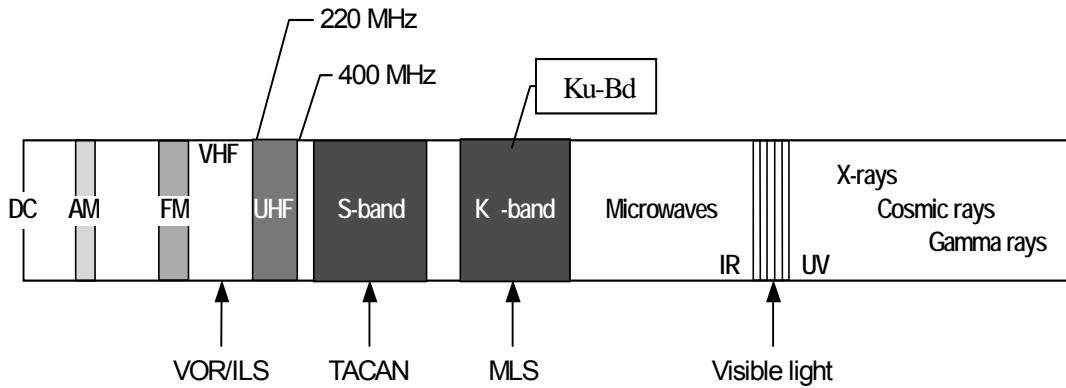
After explaining the S-Bd PM, NSP and its interfacing LRUs, recorders and S-band FM the final section ties together the systems from an operations, cockpit cue (displays and controls) and procedures viewpoint. Using the cockpit cue (displays and controls) and procedures we trace the data flows for command and telemetry from an operational perspective, keeping in mind that voice is interleaved into both signals. Data flow begins and ends at the S-Bd PM antenna in this workbook.



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Figure 2-1. S-Bd PM Comm drawing shell

The S-Bd PM is the primary system used to transfer commands and voice (uplink) and telemetry and voice (downlink) between the Mission Control Center (MCC) and the orbiter for all phases of flight. The S-band is one of several frequency ranges within the radio frequency spectrum that is used for orbiter communications (see Figure 2-2). The specific orbiter S-band frequencies for Transmit (XMIT) and Receive (RCV) are also provided in the table with Figure 2-2.



Orbiter frequencies			
UHF XMIT/RCV	243.0	MHz	
	259.7	MHz	
	296.8	MHz	
UHF – SSOR	414.2	MHz	
	417.1	MHz	
S-band PM XMIT	2217.5	MHz	
	2287.5	MHz	
	RCV	2041.9	MHz
	2106.4	MHz	
S-band PL XMIT	1759.7 - 2120.1	MHz	
	RCV	1197.5 - 2302.4	MHz
S-band FM	2250.0	MHz	
Ku-band XMIT	13.775	GHz	
	RCV	15.0034	GHz

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Figure 2-2. Radio frequency spectrum chart

During “Powered” ascent, Merritt Island (MIL) is the main STDN sites used to relay uplink and downlink signals to and from the orbiter with MCC. The onboard S-Bd PM and NSP (also referred to as the S-Bd Comm system) are configured to support the STDN mode, in high power. At Mission Elapsed Time (MET) of 7:30, the onboard S-Bd Comm system is commanded into Tracking and Data Relay Satellite (TDRS) mode for communication relay through the TDRSS. The orbiter remains in TDRS mode for orbit operations and deorbit phases of flight. Once acquisition of signal of the supporting

End Of Mission (EOM) entry site is obtained, the S-Bd Comm system is commanded back into STDN for approach and landing phases. Normally, both the ascent and entry S-Bd Comm system mode changes are accomplished by a Stored Program Command (SPC), which is stored in the Backup Flight Software (BFS) computer and activated at a defined Greenwich Mean Time (GMT).

Note: An SPC is a set of command instructions, sent by Instrumentation and Communications Officer (INCO) that executes at the specified time word (in GMT), equivalent to the desired MET, to change configurations and functions of the S-Bd Comm system.

If the SPC is unable to configure the S-Bd Comm system, the INCO may be able to send a Real-Time Command (RTC) or the crewmembers could configure the S-Bd PM Comm system via on-board displays or switches.

The NSP processes both uplink and downlink information (called data). The uplink data are verified, processed, and routed to the audio system for voice or a GPC for commands. The NSP routes the uplink data to/from the Communications Security (COMSEC) LRU if encrypted. The NSP converts the voice from digital-to-analog (changes computer ones and zeros into signals the ear can understand) and routes commands to a GPC through the appropriate Flight-Critical (FC) Multiplexer/Demultiplexer (MDM). The GPC processes or routes commands to an end item LRU through a Flight Critical (FC) or Payload Forward (PF) MDM. Other commands (referred to as Loads) are processed internal to a GPC or sent to another GPC through Intercomputer Communication (ICC) buses.

For downlink, the telemetry is combined with voice (that has been digitized) and sent to the S-Bd PM and/or Ku-Bd system for transmission to MCC. MCC may then route orbiter data to flight controllers, and science or payload data to the appropriate Payload Operations Control Center (POCC). The NSP also routes downlink signals to the Recorders (SSRs) for playback to MCC after a loss of signal or need occurs.

Telemetry is composed of Operational Instrumentation (OI), payload (which may include ISS data), and GPC downlist (d/l) data. The OI data are gathered via seven OI MDMs: four Operational Forward (OF) MDMs and three Operational Aft (OA) MDMs. Payload data are gathered by the Payload Data Interleaver (PDI). The OI, and Payload, data are fetched by the active Pulse Code Modulation Master Unit (PCMMU) for formatting and routing to the NSP, with the GPC downlist (d/l) data. GPC d/l data from Guidance, Navigation, and Control (GNC), Systems Management (SM), and BFS are routed to PCMMU toggle buffers. The PCMMU combines this OI, payload, and downlink data into two, formatted data signals: High Bit Rate (HBR) and Low Bit Rate (LBR). Both telemetry streams are then sent to the NSP where it is combined (interleaved) with the voice, in high or low data rates, for transmission to MCC. Some of the data gathered by a PCMMU are also available for crew displays or on-board Portable General Support Computer (PGSC) applications.

The instrumentation system includes LRUs used to combine telemetry, recorded or downlinked, for MCC. The PCMMUs and OI MDMs are part of the instrumentation system. The instrumentation system also includes several Dedicated Signal Conditioners (DSCs) used to convert signals for acceptance by the MDMs and/or crew meters. The DSCs receive their data from the thousands of data points (sensors) around the orbiter. There are 14 DSCs for the orbiter and up to 4 additional DSCs for the Extended Duration Orbiter (EDO) pallet, for EDO missions. To date, only 2 DSCs have been used on EDO missions, called OPI and OP2.

Two types of recorders are used to gather data for orbiter and payload data during a flight. Two Solid State Recorders (SSRs) are used as a backup to the real-time telemetry (and sometimes voice) for scheduled loss of signals, such as the zone of exclusion, or unexpected loss of Comm situations. The recorded data can be downlinked, or dumped, through S-Bd FM or Ku-Bd. To dump through the S-Bd FM requires a STDN or SGLS site for relay to MCC. Ku-band uses a TDRS to relay the dump to MCC. The SSRs have no dedicated displays or controls. The SSRs are internal to the Mass Memory Units (MMUs), which are powered through switches on overhead Panels 14 and 15, O14 and O15, respectively.

The MADS is used to measure and record selected pressures, temperatures, strain, vibration, and event data during a flight. Data collected by the MADS are recorded and are not available until after landing. All recorder operations are normally controlled through commands by MCC. Crew controls for the MADS will be mentioned primarily so crew can see the location of the control switches in case MCC is unable to command MADS from the ground.

The S-Bd FM is used to downlink selected sources, one of seven, to MCC. These sources include main engine data, Mass Memory Unit (MMU)/Solid State Recorders (SSRs), TV, and payload sources (digital or analog). The S-Bd FM system uses ground sites, Ground Spacecraft Tracking and Data Network (GSTDN), or RTS/SGLS to relay the source to MCC. The S-Bd FM system provides real-time space shuttle main engine data from the Engine Interface Units (EIUs), through Merritt Island (MIL), during ascent. The EIU data are also available through downlink and recorded (on SSR 2) for later playback.

The S-band Comm/In Operation Review Section will help with awareness and trouble shooting of S-band Comm systems. The final section reviews the overall training objectives and prepares the student for Comm/In Single System Trainer (SST) lessons.

The appendixes include a collection of displays and controls, locations, facts and information, and an acronym list.

Technical notes in certain sections provide additional detailed information, but may be skipped while still maintaining the basic workbook objectives.

3.0 S-BAND PM

3.1 OBJECTIVES

After completing this section, the student will be able to

- Identify the five LRUs of the S-Bd PM system
- Identify S-Bd PM Power Amp warm-up time, if not already in the stand-by state
- Identify the LRU differences between high and low power modes
- Identify why high power mode is required for S-Bd TDRS operations
- Identify some single-point-failure components within the S-Bd PM system
- Identify a key Comm management function that does NOT use the Ground Command Interface Logic Controller (GCILC) in its command path

3.2 SYSTEM OVERVIEW

To facilitate the information in this and subsequent sections the reader should refer to Figure 3-1 [this is also located in on-board FDF, Malfunction Procedures, COMM Section, called COMM S-BD PM SCHEMATIC]. Explanations of schematic will be discussed as the reader proceeds through the workbook.

There are five "black boxes," or LRUs, plus four antennas for the S-band PM system.

The five LRUs are:

- the Antenna Switch Electronics Assembly – [ANTENNA SW: ELEC1 and ELEC2]
- the Preamplifier Assembly [PRE AMP]
- the Power Amplifier Assembly [PWR AMP]
- and two Transponders – [XPNDR 1 and XPNDR 2]

Notice that the ANTENNA SW, PRE AMP and PWR AMP are internally redundant, whereas there are two separate XPNDRs.

SCHEMATIC OVERVIEW

Operationally speaking, the S-Bd Comm system consists of an S-Bd PM set of LRUs and an NSP, which is commonly called an S-Bd PM string.

There are four QUAD antennas that can be pointed forward or aft, thus providing eight antenna coverage zones (Figure 3-2), under control of one of the two ANTENNA SW ELECs.

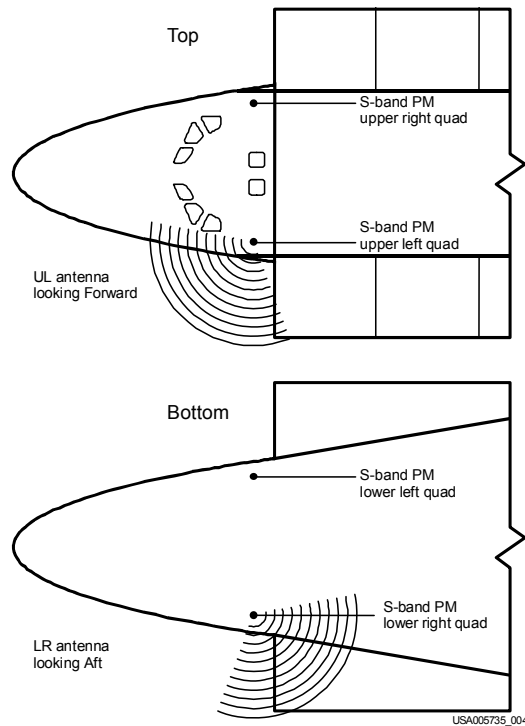


Figure 3-2. S-Bd PM system antenna locations

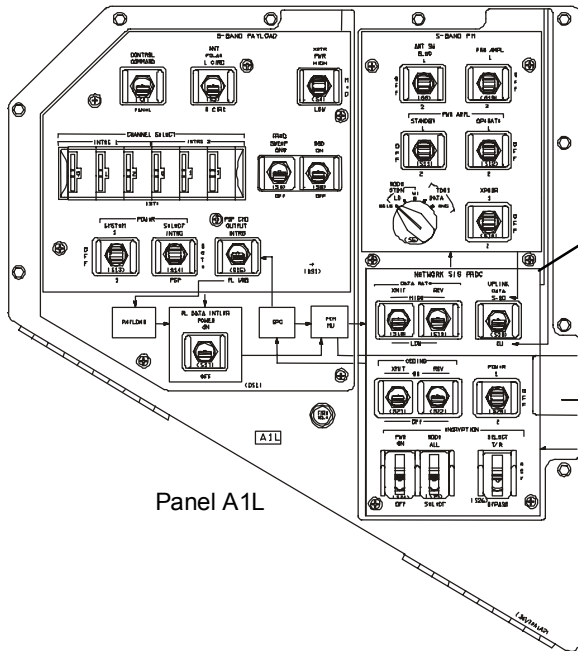
The PRE AMPs and PWR AMPs are used in the High Power Modes: STDN HI and TDRS. For Low Power the signal is routed from the active ANTENNA SW ELEC to/from the XPNDR for UL and DL, respectively. The two LRUs may be interconnected (or cross-strapped) for redundancy. For example, you could operate with ELEC 2, PREAMP 2, XPNDR 1, and PWR AMP 1. BUT, normally System (or String) 2 is operating with System (String) 1 as the backup. The backup configuration is what the crew will configure on their aft control panel, whereas the operating system can be seen on orbit using SM SPEC 76 (Figure 3-3). When SM SPEC 76 is unavailable, the normal configuration (System 2) is assumed or the MCC, specifically the INCO, should advise the crew of any changes to the normal configuration.

XXXX/XXX/076		COMMUNICATIONS		XX X	DDD/HH:MM:SS	DDD/HH:MM:SS
S-BAND PM		XXXXXS		KU-BAND		
FREQ	XXS	1	2	PA TEMP		±XXXXS
ANT ELEC	XXS	XXS	XXS	GIMBAL TEMP A		±XXXXS
XPNDR	XXS	XXS	XXS	GIMBAL TEMP B		±XXXXS
PREAMP	XXS	XXS	XXS	GYRO TEMP		±XXXXS
PWR AMPL				PWR OUT		XXS
OPER	XXS	XXS	XXS	FRM SYNC		XXXXS
STBY	XXXXXS	XXXXXS	XXXXXS	MODE		XXXXXS
PWR OUT	XXXXS	XXXXS	XXXXS	FAIL SAFE		XXXXS
TEMP	XXXXS	XXXXS	XXXXS	AUTO K TO S		XXX
				AUTO S TO K		XXX
NSP		1	2	SSOR	PRI	B/U
BIT SYNC	XXXXS	XXXXS	XXXXS	FRM SYNC	XXXXS	XXXXS
FRM SYNC	XXXXS	XXXXS	XXXXS	PROC STAT	XXXXS	XXXXS
BITE	XXXXXS	XXXXXS	XXXXXS	PWR LEVEL		±XX.XS
COMSEC BITE	XXXXXS	XXXXXS	XXXXXS	STATUS		X.XS
UL DATA SOURCE		XXS		GCIL CONFIG		XXXXS
DATA RATE XMIT		XXS		CCTV CAMR OVRTMP		XXXXS
		XXS				
CODING		XXXXS				
		XXXXS				

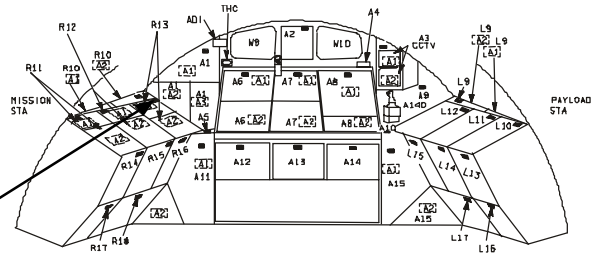
Figure 3-3. SM SPEC 76

Control of the S-Bd Comm system is generally handled through command by INCO, with crew panels available as backup or to recover from Loss of Comm situations. Crew controls are on the aft one left (A1L) Panel, with the S-Bd PM CONTROL and ANTENNA selection switches located on the center three (C3) Panel, for easy reach during powered flight and entry/landing phases. Figure 3-4 shows the general location of the Panels A1L and C3, specific details will be show in later figures, or can also be found in Space Shuttle Systems Handbook, Displays and Control Section. In the COMMAND position the S-Bd PM CONTROL switch allows commands from INCO, or keyboard entries from crew, to select the required LRU or function. In the PANEL position, the crew switches select the required LRU or function.

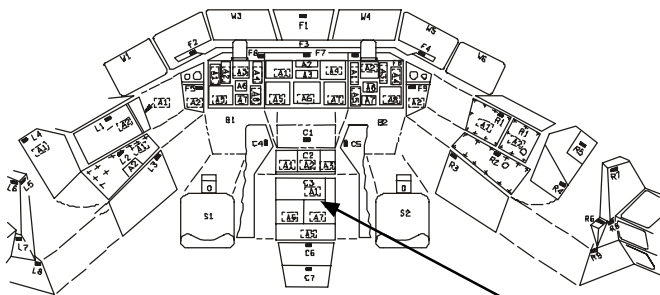
Command control is through an LRU called the GCILC. The GCILC allows the configuration of multiple LRU functions at the same time, using multiple real time commands (MRTCs). When MRTCs are given a time-tag they are called a Stored Program Command (SPC). For example, when the S-Bd string is changed from ascent configurations (STDN HI) to the orbit configuration TDRS, the GCILC responds to a command that changes the XPNDR mode and the NSP configurations. The GCILC also frees the crew from having to configure the five systems that the GCILC commands, namely: the S-Bd Comm, S-Bd FM, PL Comm, Ku-band, and the CCTV system. Details about GCILC operation are covered in the NSP interfacing LRU (GCILC) Section. As mentioned earlier, one of the five GCILC controls, also called the panel/command switch, for the S-Bd Comm system is located on Panel C3. The remaining four GCILC control switches are located on the related systems panel; i.e., S-Bd FM, S-Bd payload, Ku, and CCTV.



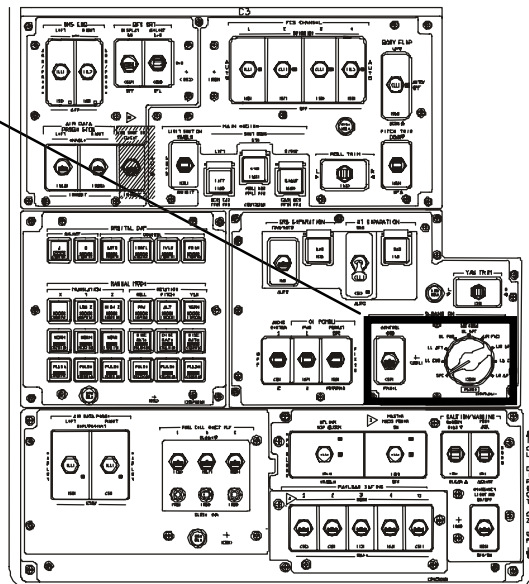
Panel A1L



AFT STATION



FLIGHT STATION



Panel C3

Figure 3-4. Crew controls

ANTENNAS and ANTENNA ELECTRONICS

The S-Bd PM antenna selection rotary switch, on C3, Figure 3-5, allows the GPC or crew to select one of the eight S-Bd PM antennas. S-Bd PM antenna selection, for antenna management, is NOT done through the GCILC, but directly from the associated PL MDM. Normally the switch is in the GPC position to allow the GPC with the PL MDMs to send the commands to the ANTENNA SW ELEC for antenna selection.

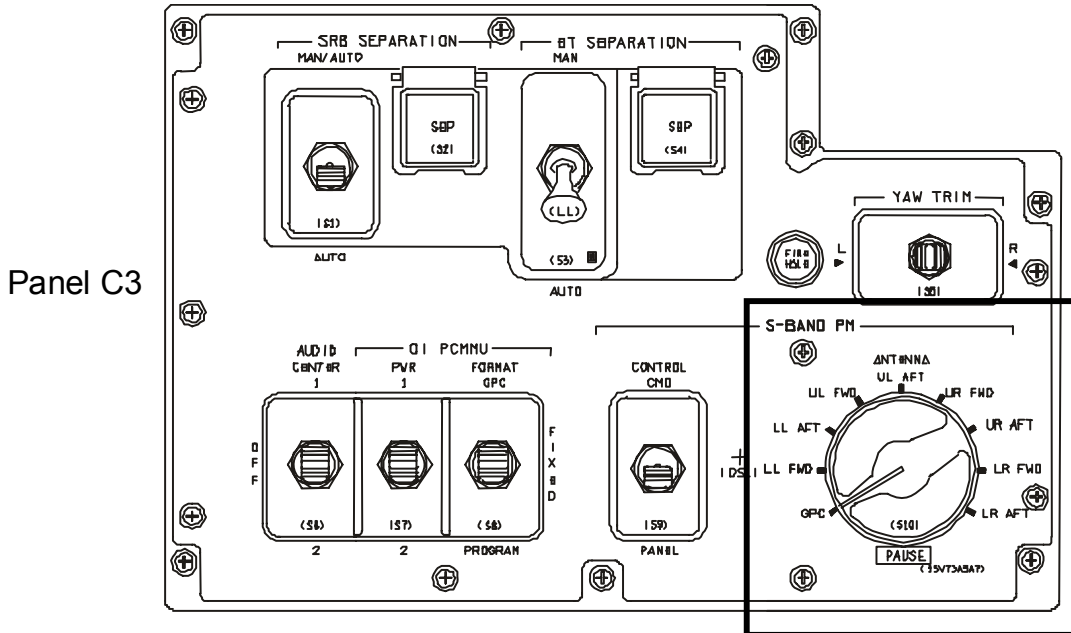
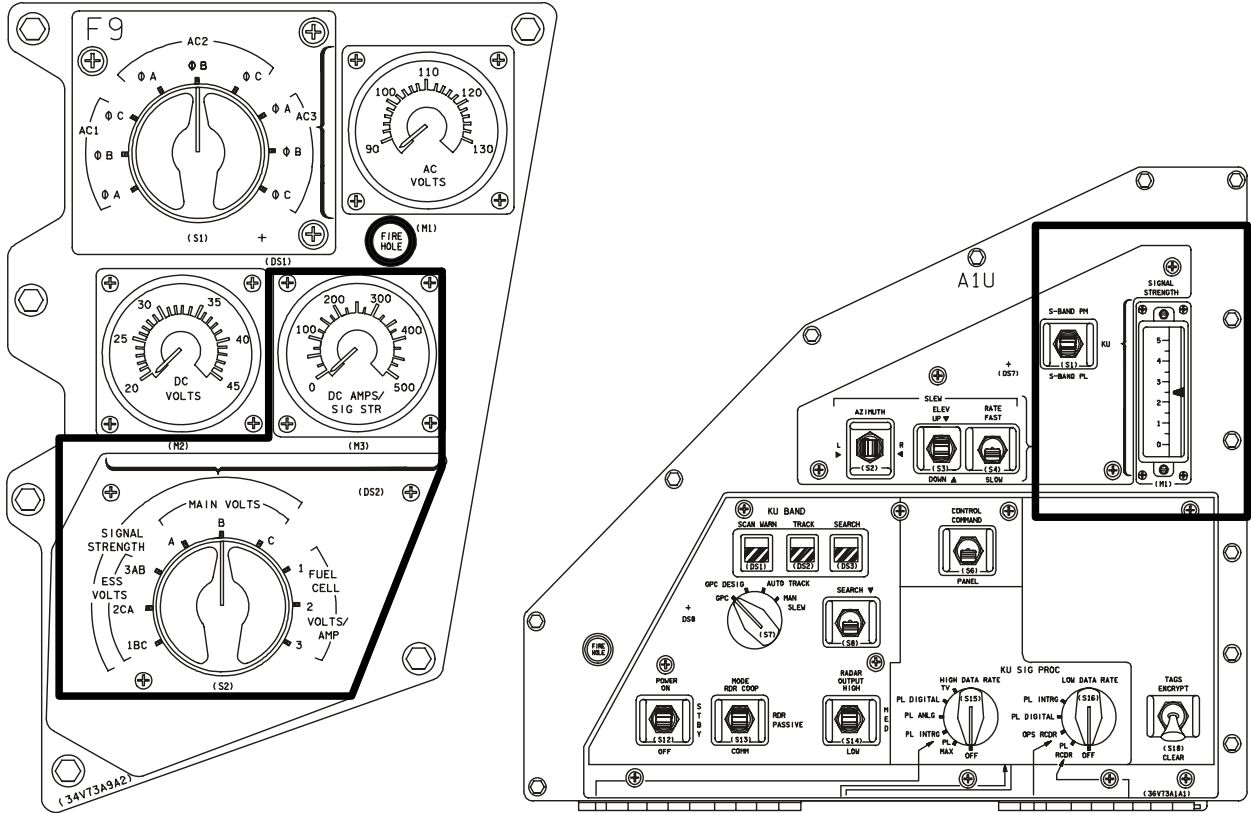


Figure 3-5. Panel C3

More details on antenna management are discussed in the Antenna Management subsection. When the “Best Antenna” is commanded/selected the receive signal strength for the S-Bd PM system can be seen on forward nine (F9) Panel and/or aft one upper (A1U) Panel, when their respective control switches are set correctly. (Figure 3-6) During orbit operations, the receive signal strength can also be seen on the OPS 2011 ANTENNA display. (Figure 3-7) Also on the Antenna display one can see the active ANT ELEC unit (1 or 2) handling antenna selections, based on antenna management processes. When manual antenna selection is required, the crew member should PAUSE ~ 2 sec to allow switches within the ANTENNA ELEC LRU to change AND to give time to check uplink signal strength.

Note: The default/low signal strength reading on OPS 2011/ANTENNA display is 2.50, use F9 or A1U to cross-check this Comm cockpit cue.

Note: Occasionally when manually switching antennas, the F9 meter may fluctuate before settling to new signal value.



Note: Ensure selector switch is within "signal strength" position (1 of 6) for reading S-Bd PM signal strength.

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Figure 3-6. S-band PM signal strength meters

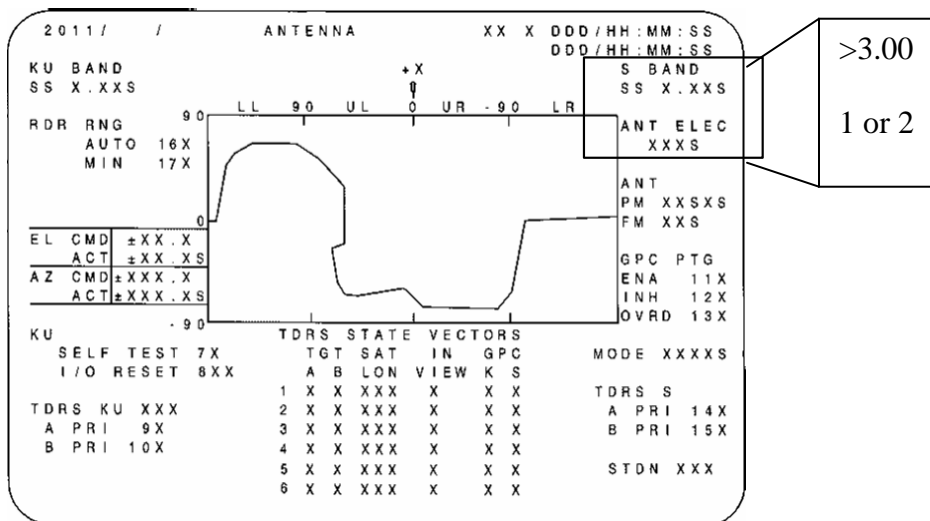
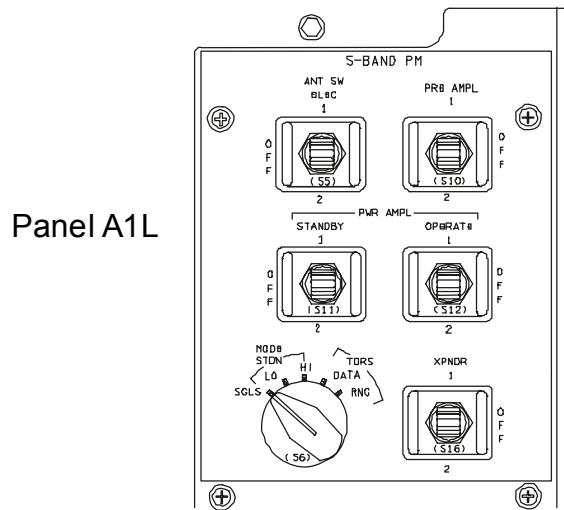


Figure 3-7. S-band PM signal strength display

The S-Bd PM crew controls located on Panel A1L (Figure 3-8) are three-position switches (sys1, off, and sys2), except for the XPNDR mode switch. The three-position switches are for powering/selecting the S-Bd PM ANT SW ELEC, PRE AMP, PWR AMPL (STANDBY and OPERATE) and XPNDR, when the panel/command control switch is in the PANEL position. The XPNDR rotary switch allows selection of the four transponder modes: SGLS, STDN LO, STDN HI or TDRS (Data). All six switches are under control of the C3 GCILC CONTROL (panel/command) switch.

The low power modes (that bypass the PREAMP and PWR AMP assemblies) are SGLS and STDN LO, which are used when communicating through a remote tracking site (RTS) or an STDN site, respectively. An RTS is also referred to as a SGLS site. The high power modes are STDN HI and TDRS are used to communicate through an STDN site or TDRS. High power mode is required for S-Bd PM TDRS mode to compensate for the distance between the orbiter (~160 n. mi.) and the TDRS (at geo-synchronous orbit ~22,300 miles) in RF relay to/from MCC.



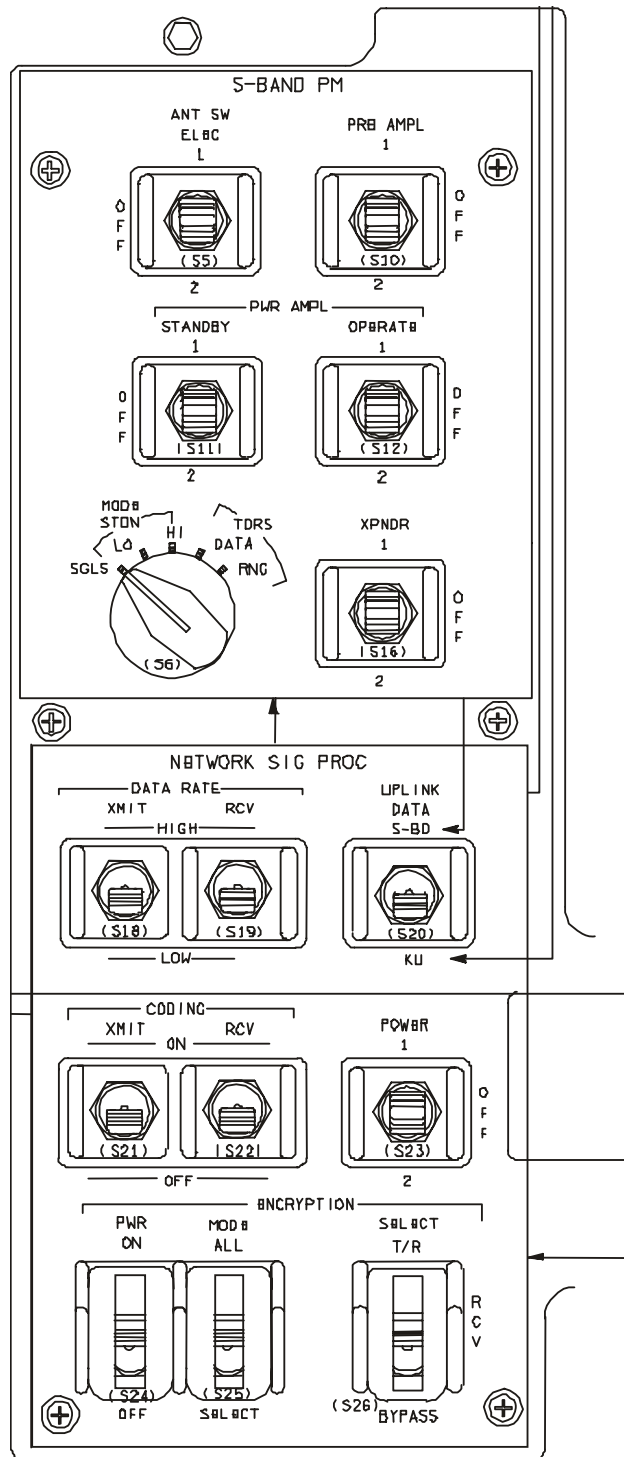
USA005735_009

Figure 3-8. S-Bd PM crew controls

The S-Bd PM system interfaces to the orbiter through the NSP (Figure 3-9 adds the NSP with the previous S-Bd PM switches). The received signal, which is referred to as the uplink (UL) signal, contains commands and up to two voice channels. The transmitting signal, which is called the downlink (DL) signal, contains data at 64 kilobits per second (kbps) or 128 kbps and up to two voice channels. For TDRS communication, the UL is sometimes referred to as The Forward Link (FL) and the DL is sometimes called the Return Link (RL).

The S-Bd Comm system gets its operating power from two of the three orbiter Main Busses: Forward Power Controller (FPC) and Forward Load Controller (FLC), busses. String 1 from MNB FPC2 and FLC2, and string 2 from MNC FPC3 and FLC3. The control power for string 1 is control bus BC1, whereas the control power for string 2 is control bus BC2. A sample of the S-band Comm Systems drawing is shown in Figure 3-10, with power information (circled) also the avionics bay locations referenced

in the lower right corner of each LRU (example circled for XPNDR 2). Power information can also be found in the Reference Data (REF DATA) Book, Critical Equipment Lost tables.



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Figure 3-9. S-Bd PM - NSP

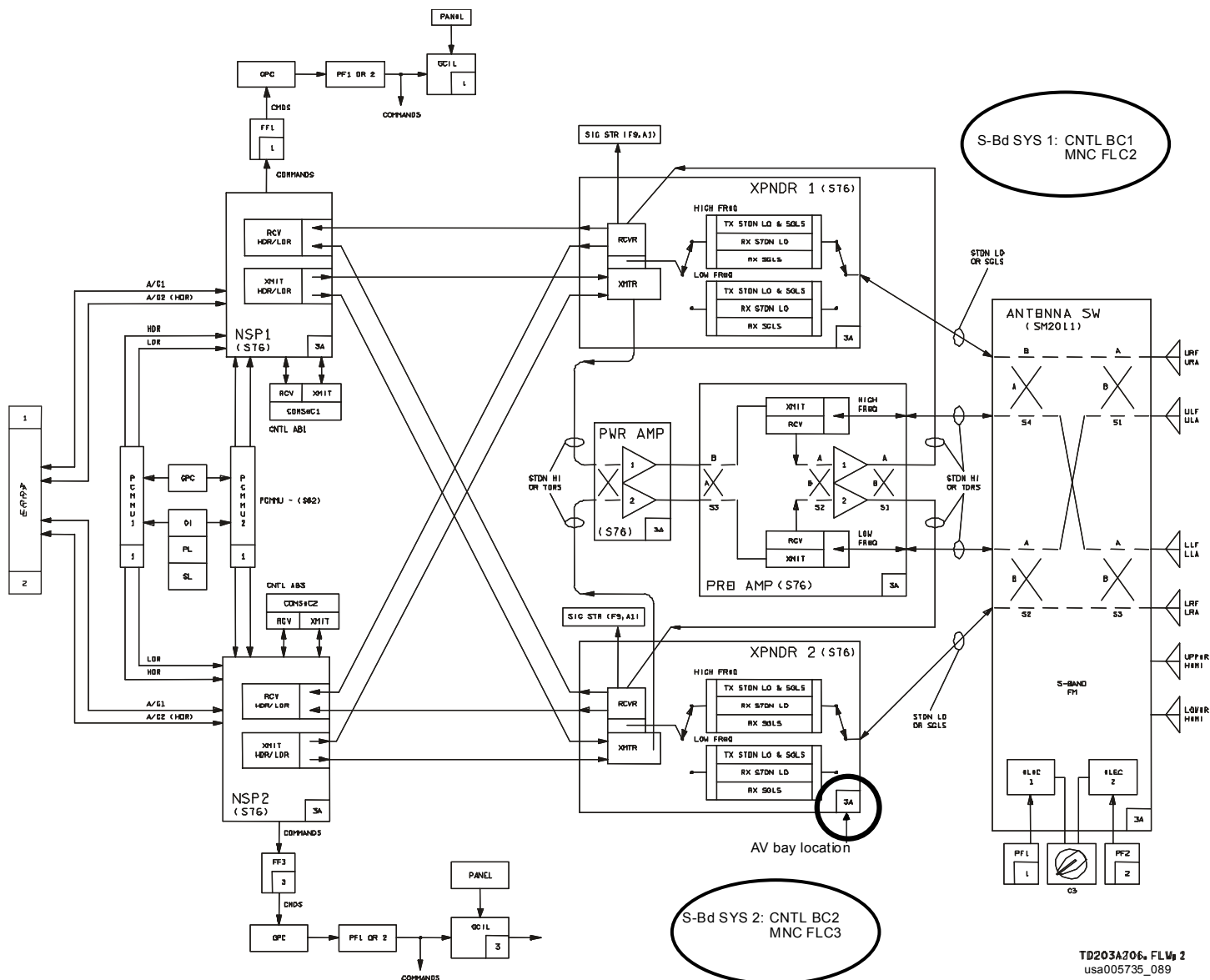


Figure 3-10. S-band Comm system

3.3 OPERATIONAL DESCRIPTION

To assist in our discussion of the antennas and five S-Bd PM LRUs, we will use the S-band portions of the comm drawing (Figure 3-11). This drawing, or its FDF equivalent, can be used in flight to help analyze or troubleshoot the Comm System, along with Comm cockpit cues like: audio (Voice), signal strength, caution & warning, and display indications (Specifically the ANTENNA and SM Spec 76, on orbit; or BFS/GNC Spec 51 for ascent/entry).

The system is discussed in the order of a received signal at an antenna through uplink LRUs, then back through the remaining downlink LRU. Specifically, the following LRUs are covered: quad antennas, the ANTENNA SW Assy, PREAMP Assy, XPNDRs, and the PWR AMP Assy.

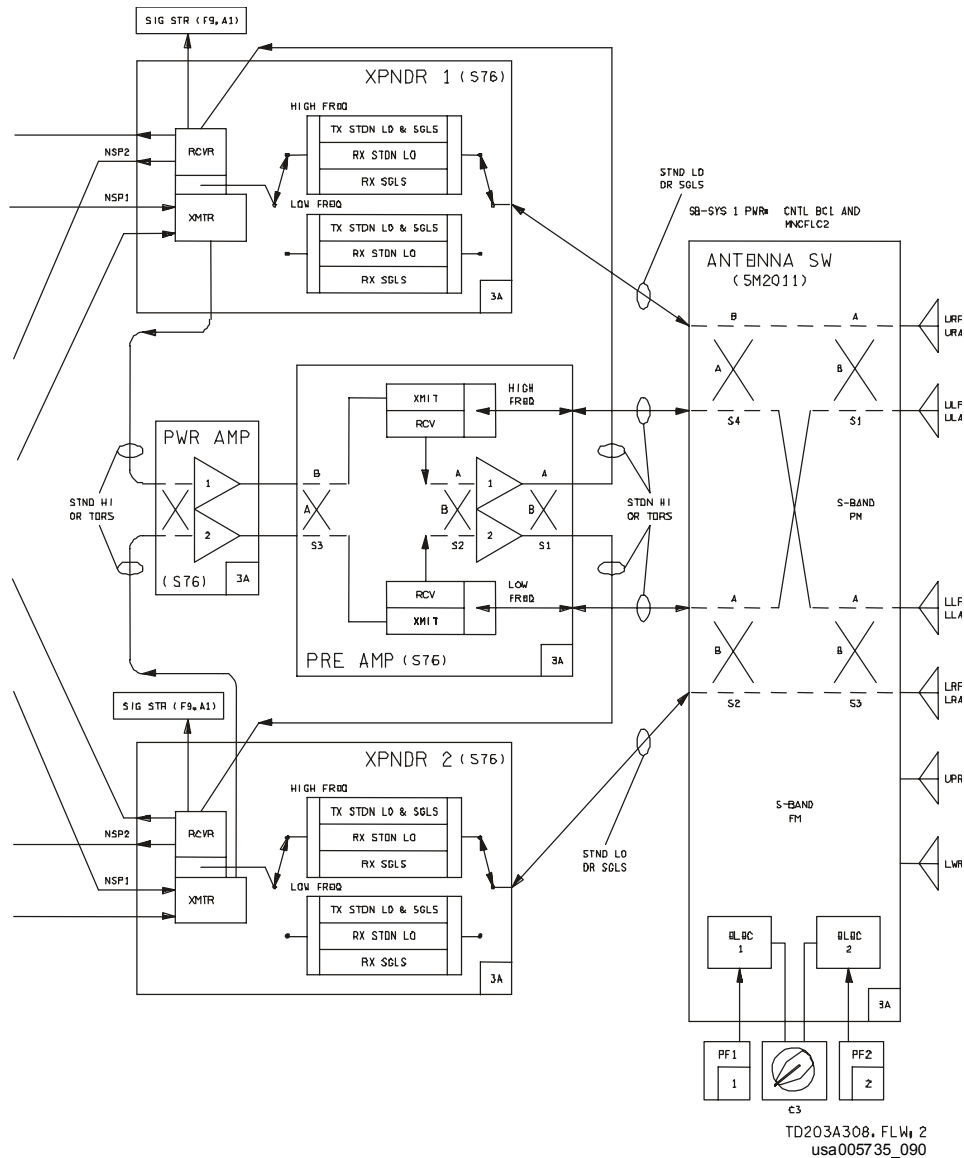


Figure 3-11. S-Bd PM Comm drawing

3.3.1 Antennas and Antenna Electronics

The four S-Bd PM quad antennas are located in the lower left (LL), upper left (UL), upper right (UR), and lower right (LR) quadrants (thus the designation quad antennas) or the forward fuselage, about 90° apart (Figure 3-12). Each quad antenna has the capability of directing its coverage zone forward (FWD) or AFT, therefore providing eight areas of coverage. Two S-Bd FM hemispherical (hemi) antennas are located on the lower and upper fuselage. The S-Bd FM hemi antenna locations are also shown in Figure 3-12.

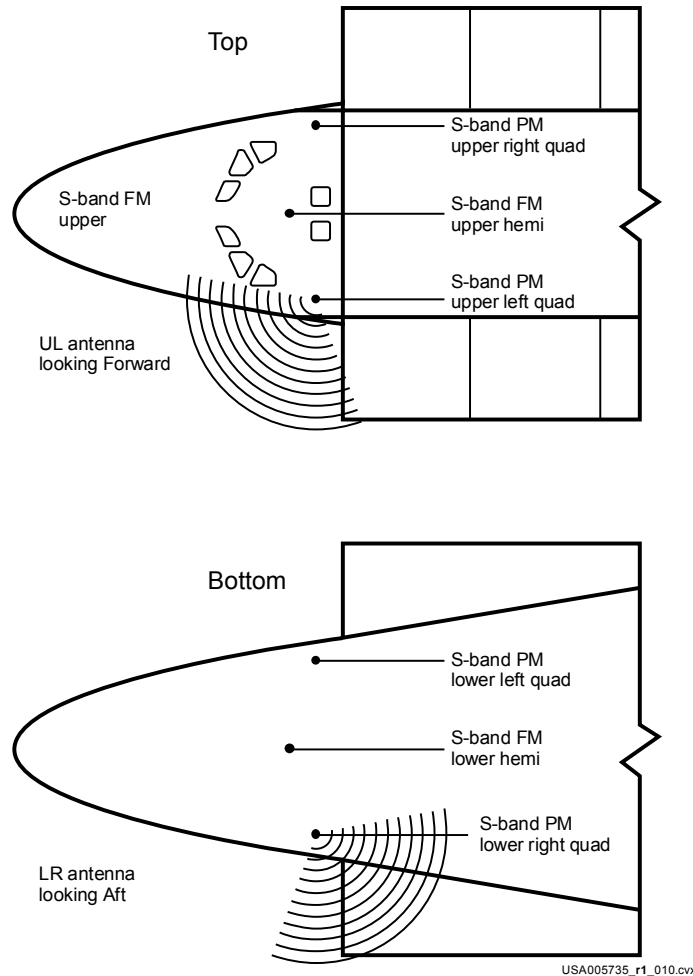


Figure 3-12. Quad and hemi antenna locations

Antenna selections are made by the logic within the ANTENNA SW. The ANTENNA SW contains the S-band Antenna Switch Electronics (ASE), Switch Beam Control Electronics (SBCE), these are contained (shown) as ELEC 1 or 2 on the drawing; also switches for routing the RF signal to and from the S-Bd PM quad antennas. The switches are depicted as S1, S2, S3, and S4 and are used for routing the RF signal to and from an S-Bd PM antenna. These switches respond to either ELEC 1 or 2, so they are NOT redundant, just redundantly controlled. See Figure 3-13. The ANTENNA SW also contains two ASEs and an RF switch for the S-band FM hemi antennas.

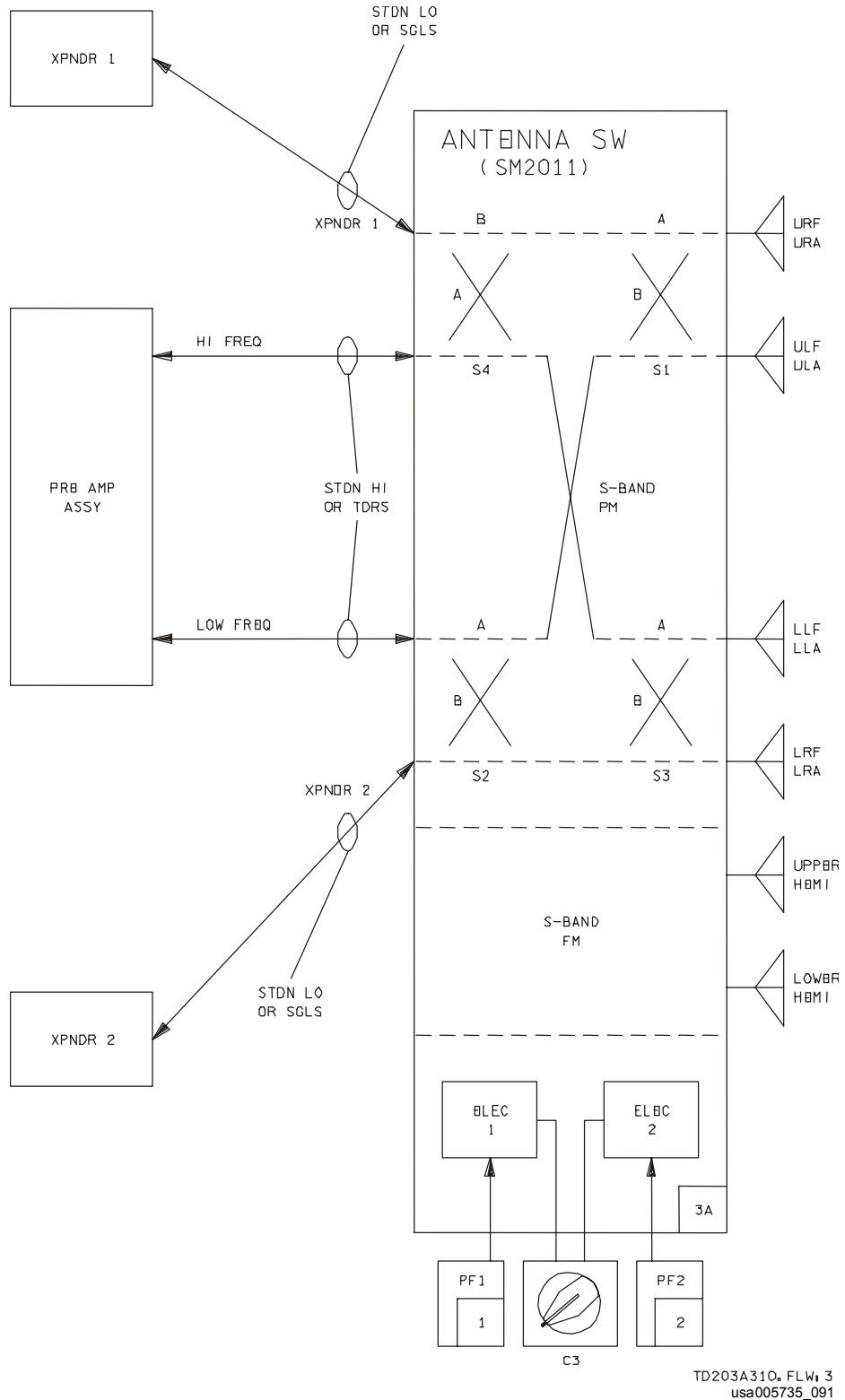


Figure 3-13. Antenna electronics assembly

Switches S1 and S3 route the RF signal to/from the upper and lower quad antennas, respectively. Switches S2 and S4 interface the RF signal to/from a XPNDR or the PRE

AMP Assy. The ANT SW ELEC-to-XPNDR interface is used for the low power modes, STDN LO or SGLS. The ANT SW ELEC -to-PRE AMP interface is used for the high power modes, STDN HI or TDRS. Switch S4 interfaces to XPNDR 1 or the high frequency selector (also called a diplexer) in the PRE AMP. A diplexer is used to separate two frequencies; in this case, the diplexer separates the XMIT from the RCV frequency. This capability allows the same QUAD antenna to be used for UL and DL. Switch S2, therefore, interfaces to XPNDR 2 or the low frequency diplexer in the PRE AMP. The FM RF switch routes the FM signal and information to either FM antenna.

Because switches S1-S4 are mechanical switches used by both antenna ELEC units, they are potential single-point-failure locations and could limit/prevent S-Bd PM Comm.

Loss or problems with S1 or S3 would prevent certain antenna(s) from being selected. Recovering Comm in this case may require MANual ANTenna via C3 Switch, or maneuvering the orbiter, to “select a good antenna.”

Loss or problems with S2 or S4 would prevent certain interfaces from working. Recovery would require using different interfaces, such as low instead of high frequency. These "single-point failure" situations can be resolved using a crew procedure in the Malfunction Procedure Book (also called Long-form Malfunctions), Comm section.

Crew controls for S-Bd PM antenna electronics and Antenna Management (AM) are found on Panels A1L and C3, while the controls for S-Bd FM are found on Panels A1L and A1R. Panel A1L contains the antenna switch electronics (ANT SW ELEC) for both S-Bd PM and FM. Panel C3 has the ANTENNA rotary switch for S-Bd PM antenna selection. Panel A1R has the three-position switch for S-Bd FM antenna selection (Figure 3-14). The AM controls, C3 and A1R, allow a GPC (usually BFS or SM) or the crew to Manually (MAN) select the required antenna for S-Bd PM and FM, respectively.

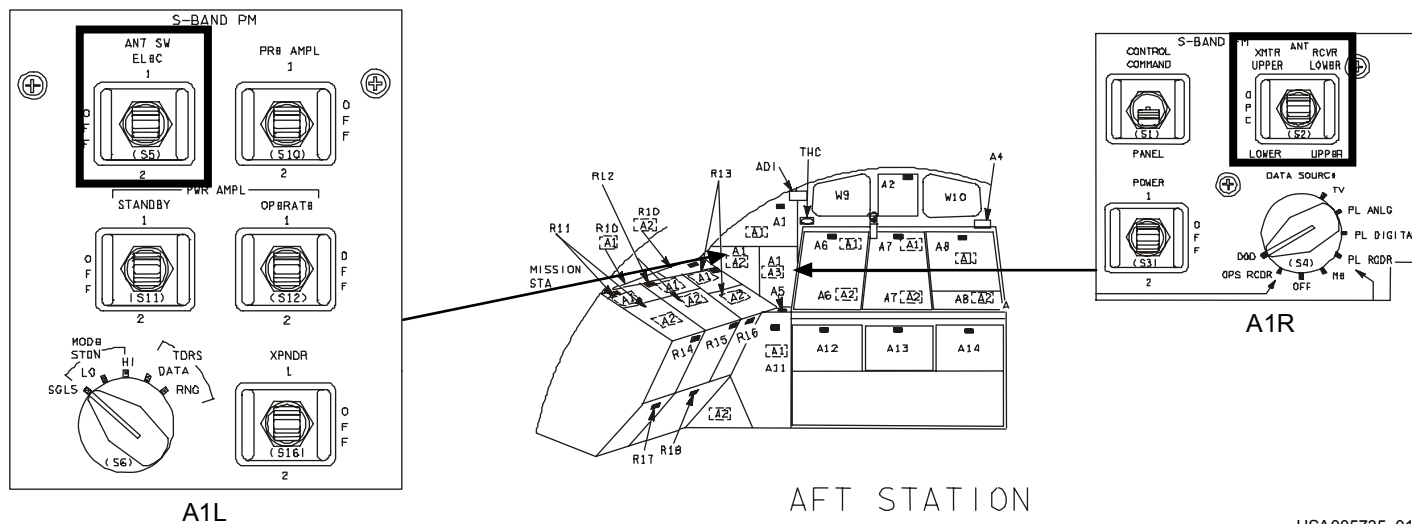
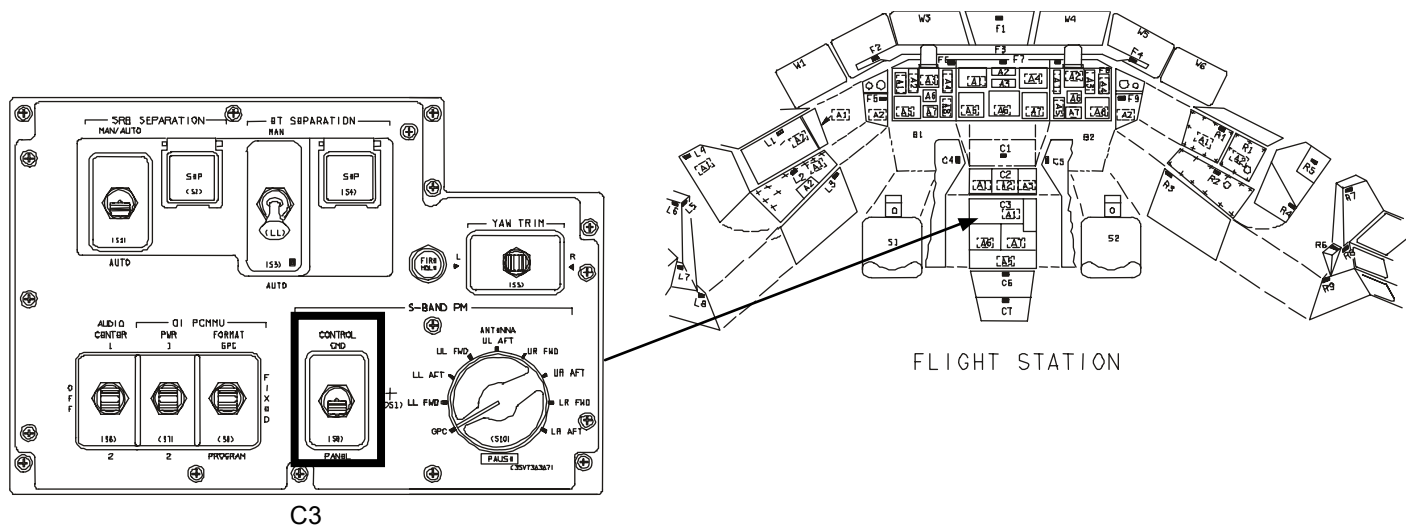


Figure 3-14. S-band PM and FM antenna controls

3.3.2 Antenna Management

AM is a function performed in a GPC that automatically performs antenna selection for S-Bd PM and FM antennas. The selection is based on the orbiter position and the position on the Comm site (example: TDRS). The AM function calculates the optimum antenna, based on “current” orbiter and TDRS State Vectors, commands the switching to that antenna if it is not already selected, and verifies the commanded antenna with the selected antenna.

During ascent and entry, the BFS GPC handles the S-Bd AM, while on orbit the SM GPC provides the S-Bd AM functions. The AM GPC commands through PL 1 or 2 MDM for selecting S-Bd PM or FM antennas. PF1 MDM commands through ANT ELEC 1, and PF2 MDM via ANT ELEC 2. The active ANT ELEC, usually ANT ELEC 2, will select an S-Bd PM or FM based on this AM GPC command. In the event that the AM GPC fails, or cannot control antennas properly, INCO or the crew can command or select antennas. INCO can command antennas through a GPC as long as INCO can command through the PF MDM with the active ANT ELEC. The crew can select antennas with the C3 or A1R antenna select switch for S-Bd PM or FM, respectively.

The crew ANTENNA switch overrides the GPC selection.

Note: If the crew has manually selected an antenna from Panel C3, ANTENNA messages will not occur. Also the ANTENNA message is only issued for S-Bd PM, not for S-Bd FM antenna selection.

TECHNICAL NOTE

Figure 3-15 shows a simplified data flow for SM AM. The GNC computer uses the ICC bus to provide orbiter position and attitude to the SM GPC. The SM GPC then selects the proper antenna using the previously loaded value for site position (example TDRS) along with the GNC values for the orbiter position and attitude. Commands are issued once every 2 seconds based on the SM calculation through the PF MDMs. The active antenna electronics unit will then switch to the antenna as commanded. Once the antenna commands have been sent to ELEC 1 or 2 the SM GPC attempts to verify that the selection has occurred via the OI system, specifically OI MDM OF3 through the PCMMU. If the antenna status (telemetry) is not the same as the SM commanded antenna, the SM GPC will issue an ANTENNA message.

The main difference between SM and BFS AM is that BFS always uses its own navigation information to determine antenna pointing, rather than relying on the GNC GPC. The BFS does Navigation (NAV) as part of the entire BFS task, to be ready to take control of the vehicle in a BFS engage situation. In a pre-engage scenario, the BFS acquires NAV data, such as Inertial Measurement Unit (IMU) rates, by listening to the GNC GPC transactions on the FC buses. If BFS loses track on flight critical (FC) buses 1-3, it will no longer have any IMU data. With no IMU data, the BFS NAV state will go bad and ANTENNA selection will not be accurate. Unlike the SM, the BFS does not give an ANTENNA message if the ‘Commanded’ and ‘Actual’ antennas do not agree

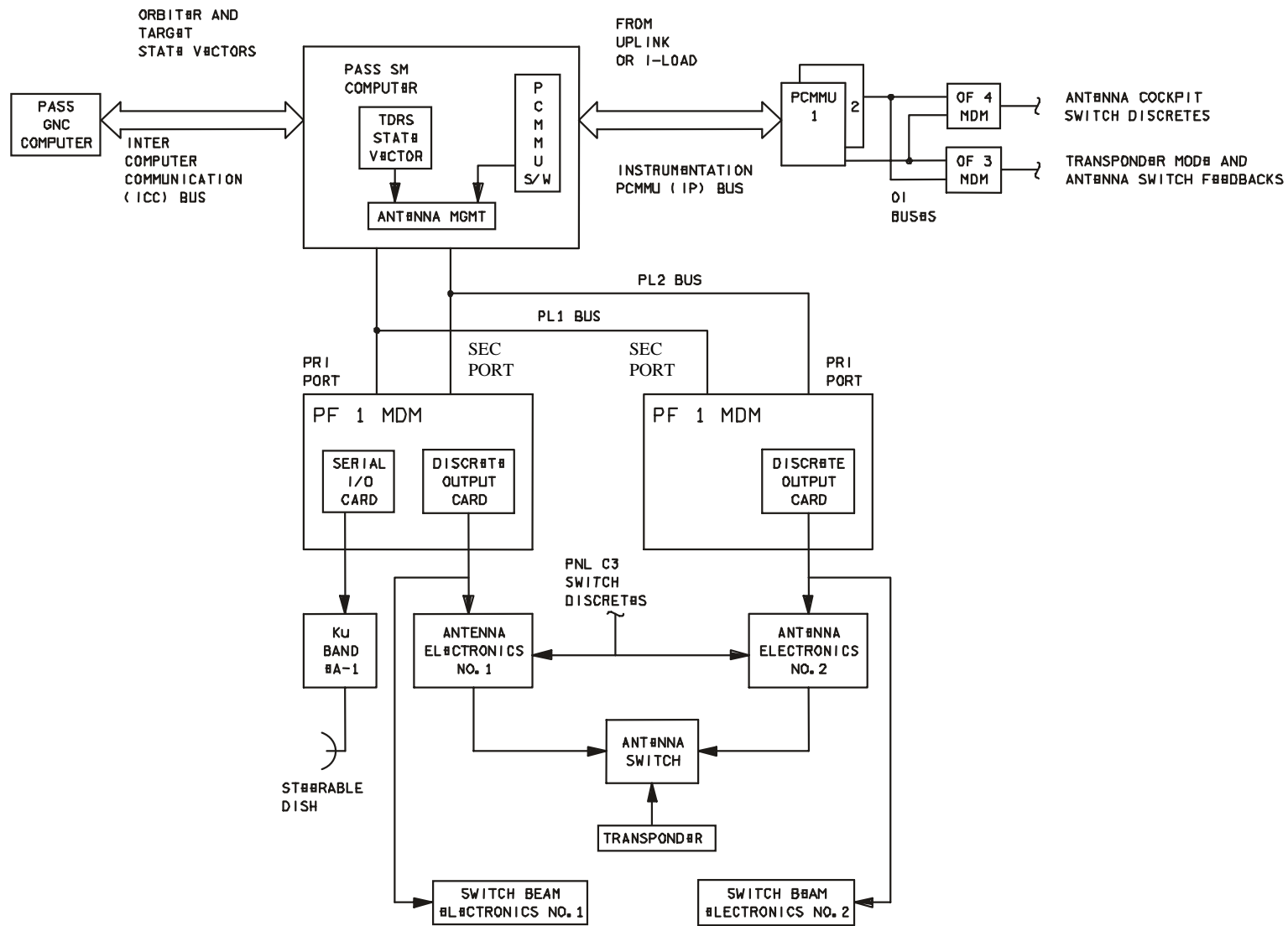


Figure 3-15. SM antenna management

3.3.3 Preamplifier Assembly

The Preamplifier Assembly (PRE AMP Assy) is used in high power modes STDN HI or TDRS to filter, amplify, and route the received signal into the transponder. It also routes the transmit signal from the PWR AMP Assy to ANTENNA SW ELEC (selected Quad antenna). The PRE AMP Assy contains two frequency diplexers (high and low), two amplifiers (preamp 1 and preamp 2), two preamp control logic units, and three switches (S1, S2 and S3) for routing the RF signal. Figure 3-16 shows the Comm drawing PRE AMP (Assy).

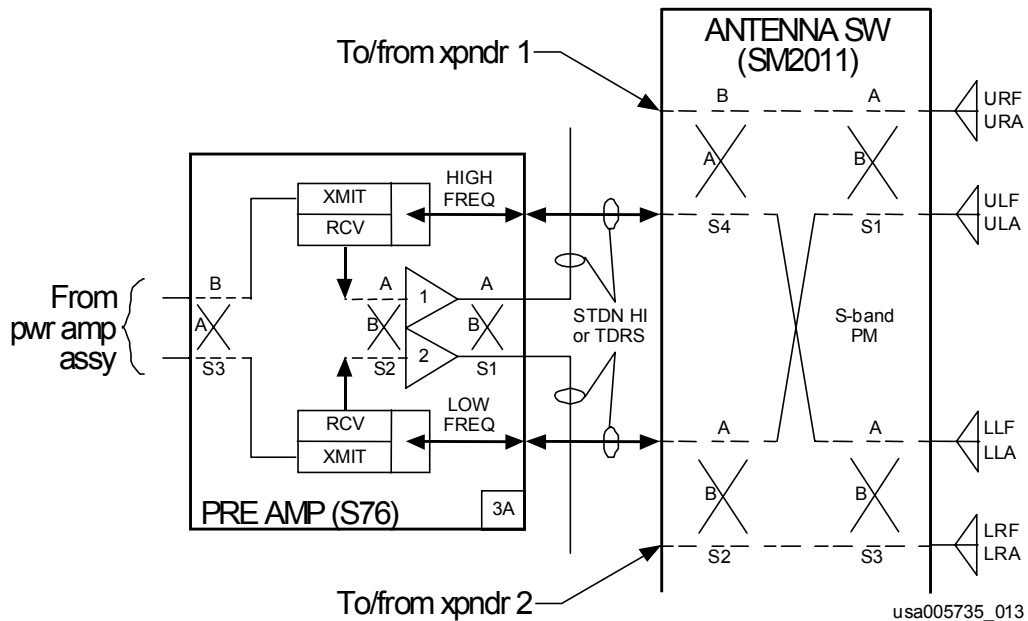


Figure 3-16. Preamp Assy RF switches

One of the preamps increase (amplify) the received signal so that a transponder can lock onto it. The preamp gain is 23 to 25 dB. The preamp requires a warm-up time of 4 to 18 minutes from an off state to allow full gain through the amplifier. Preamps 1 and 2 are represented on drawing by triangles 1 and 2.

The PRE AMP Assy has two preamp control logic units that select the configuration of the three RF switches: S1, S2, and S3. Switch S1 is used to transfer the RF signal from a PRE AMP to a XPNDR. Switch S2 is used to interface the RCV signal to a PRE AMP through a diplexer (HIGH or LOW). Switch S3 is the interface for the XMIT signal from the PWR AMP Assy to the ANTENNA SW ELEC through the active diplexer. The diplexers are shown as the XMIT/RCV boxes. It can be seen in ANTENNA SW that switch S2 connects the LOW frequency diplexers, whereas switch S4 connects the HIGH frequency diplexers. For the crew to change frequencies, an RTC through SM SPEC 1 is required as called out in the Malfunction procedure.

Note: The active frequency diplexer could be a single-point failure point for S-Bd PM Comm, requiring the selection of the alternate Freq to regain RCV, XMIT or both. Again, the Long-form Malfunction book covers this situation.

```

XXXX/001/          DPS UTILITY          XX X DDD/HH: MM: SS
                  DDD/HH: MM: SS

MMU ASSIGN        PORT ASSIGN
  1 2
GNC 1X 2X        STRING 1 15X 16X  UL CNTL
SM 3X 4X          2 17X 18X   AUTO 35X
PL 5X 6X          3 19X 20X   BNA 36X
OPS 0 7X 8X      4 21X 22X   INH 37X
                  PL 1/2 23X 24X  IPL SOURCE SW
                  MASK 38X

MMU STATUS
  1 XXX
  2 XXX

MMU SOURCE/BUS   VAR PARAM ID LIST
GPC/MMU 9X       25 XXXX
MMU/MMU 10X      26 XXXX
GPC/LDB 11X      27 XXXX
                  28 XXXX
                  29 XXXX
                  30 XXXX
                  31 XXXX
                  32 XXXX
                  33 XXXX
                  34 XXXX

CKPT RETRY       G3 ARCHIVE
  BNA 12X        LOAD 48X
                  RBTRIEVB 49X

RTC              GROUND OPS
  13 XXXX XXXX  GSE POLL BNA 50X
  CMD 14         SM GSE INH 51X
                  SM C/O INH 52X
                  GNC C/O BNA 53X
                  BFC C/O BNA 54X
                  ALT PL9 TB 55X

( XX)
    
```

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Figure 3-17. DPS UTILITY, RTC page

TECHNICAL NOTE

Table 3-1 shows high and low XMIT and RCV frequencies for high power modes.

Table 3-1. High power frequency allocations

STDN HI/ TDRS	XMIT (MHz)	RCV (MHz)
High	2287.5	2106.4
Low	2217.5	2041.9

3.3.4 Transponder

The Transponder (XPNDR) is for transmitting and receiving the S-Bd PM RF signal with ground sites (STDN or RTS) or the TDRSS. Comm with ground sites uses STDN HI or LO mode for NASA STDN; SGLS mode for military RTS/SGLS; and TDRS mode for the TDRSS. Figure 3-18 shows a portion of the Comm Schematic for a XPNDR and its key interfaces. This XPNDR can also be related back to our comm drawing. The XPNDR can also provide S-Bd PM ranging of the orbiter, if enabled. Ranging is a method for tracking the orbiter.

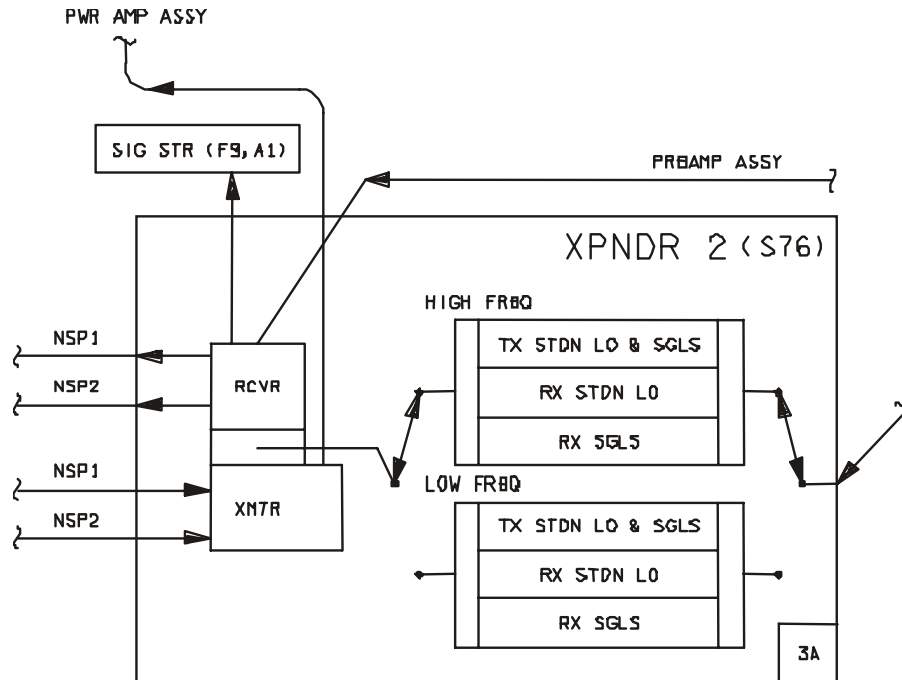


Figure 3-18. Sample XPNDR from Comm drawing

Each XPNDR has two frequency triplexers (high and low); receiving circuitry, which includes an output to the crew meters to read received signal strength; transmitting circuitry; frequency source circuitry (Voltage Control Oscillator (VCXO)); control logic; and a power supply. In short, it is the “radio” portion of the S-band system, for transmit and receive of communications between MCC/POCC and crew.

The received signal strength is the one of the cockpit cues for troubleshooting Loss of Comm from MCC. Recall, signal strength can be seen of F9 or A1U meter, if properly selected. When an SM GPC is available, the crew can also see signal strength on the OPS 2011 ANTENNA display (Figure 3-19). [NOTE: The ANTENNA display has a default low signal strength reading of about 2.50]. A Spread Spectrum Processor (SSP) is used in the receive processing for the TDRS mode, mostly due to FCC regulations. The SSP is used to recover the orbiter signal sent through TDRS in a “spread-out” beam versus a narrow beam. On a standard ascent, the crew gets a call about MET 18 minutes that MCC will “be unable to talk to the crew do to spreading”; this typically takes 20-60 seconds. Basically another SPC is on-board to enable SSP processing.

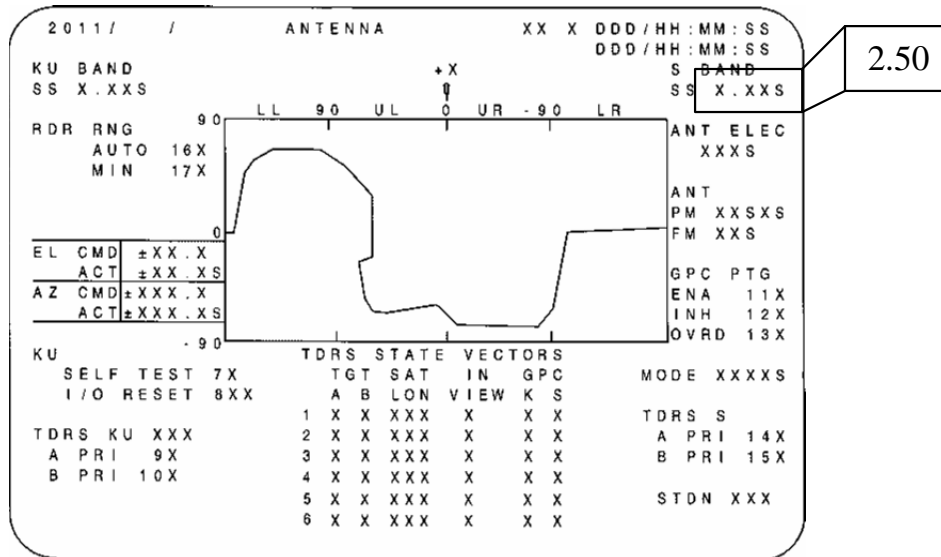


Figure 3-19. OPS 2011 antenna

The two triplexers are similar to the diplexers in the Preamp Assy in that they allow two frequency modes, high or low, to communicate with MCC. They are different in that there are three (tri-) instead of two (di-) frequencies being separated or filtered. The triplexers are used in the Direct Comm mode with ground sites in STDN or SGLS. The three filters separate STDN LO & SGLS XMIT, STDN LO RCV, and SGLS RCV frequencies. The triplexers interface between the ANTENNA SW ELEC and the receiver for UL, and the transmitter and ANTENNA SW ELEC for DL.

The receiving circuitry processes the incoming signal for the receive detector and phase lock logic. The receive detector detects the incoming signal sent through STDN, TDRS, or SGLS modes. The detector also removes the ranging signal, if present, and routes it to the transmitter for combining with the DL carrier. This ranging signal can be processed by MCC to track the orbiter. The modulation (command and voice data) is removed (demodulated) from the incoming signal at the detector and sent to the active NSP for further processing.

The transmitter circuitry combines the DL (telemetry and voice) data from an NSP with the S-Bd PM carrier. Combining (or multiplexing) is done using modulation techniques. Basically, modulation places the data on a carrier to transfer the information to its destination, which in this case is the MCC. The transmitter will also combine the ranging tone signal, if active.

The frequency source circuitry provides inputs to the receiver and transmitter circuits for processing the required data. The control logic responds to GCILC inputs to set the transponders internal processes and functions for STDN, TDRS, or SGLS modes. The power supply provides regulated power to the internal circuits as needed.

TECHNICAL NOTE

The frequency allocations for low power mode are shown in Table 3-2.

Table 3-2. Low power frequency allocations

Low PWR modes	XMIT (MHz) STDN LO/SGLS	RCV (MHz) STDN LO	RCV (MHz) SGLS
High	2287.5	2106.4	1831.8
Low	2217.5	2041.9	1775.7

Lock, lock error, and signal strength are telemetry indications that show uplink signal status. Lock shows that the transponder is locked on the carrier signal. Lock error indicates how far from center frequency the receiver is locked, which is also referred to as Static Phase Error (SPE). Finally, signal strength indicates how strong the received signal is using a 0 to 5 scale. Typically for TDRS, the receive signal is around 3.0, whereas ground sites should be higher.

3.3.5 Power Amplifier Assembly

The Power Amplifier Assembly (PWR AMP Assy) is used in high power modes STDN HI or TDRS to amplify the transmit (XMIT) signal from a transponder to the "ANTENNA," routed through the PRE AMP Assy Diplexer for XMIT. Logic and an RF switch route the RF signal from the transponder to a PWR AMP. Additional circuitry provides the standby and operate mode controls interface with the GCILC. The STANDBY (STBY) mode provides for "instant-on" operation by maintaining the 140 sec timer, used in critical phases of a flight. Normally, PWR AMP 2 is operating. PWR AMP 1 is kept in STBY for critical phases of a flight, such as ascent, entry, and high payload activities. Figure 3-20 shows the PWR AMP Assy with several key interfaces and a block diagram, similar to the Comm drawing. As with the rest of the S-Bd PM system (Figure 3-21), the STANDBY and OPERATE modes are selected by command or by Panel A1L through the GCILC switch on C3

Note: If a power amp is not in standby and is commanded/selected to operate, there will be NO downlink in TDRS or STDN HI mode for 140 sec.

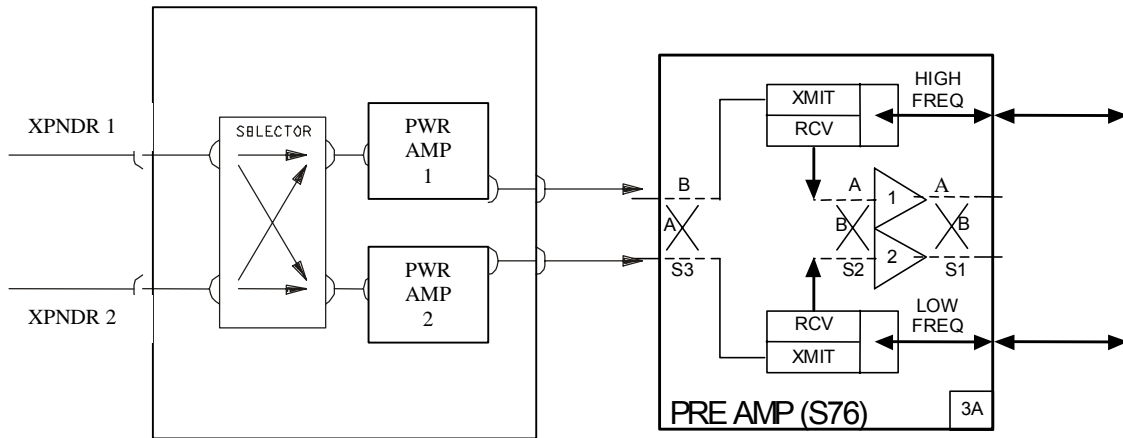


Figure 3-20. PWR AMP interface diagram

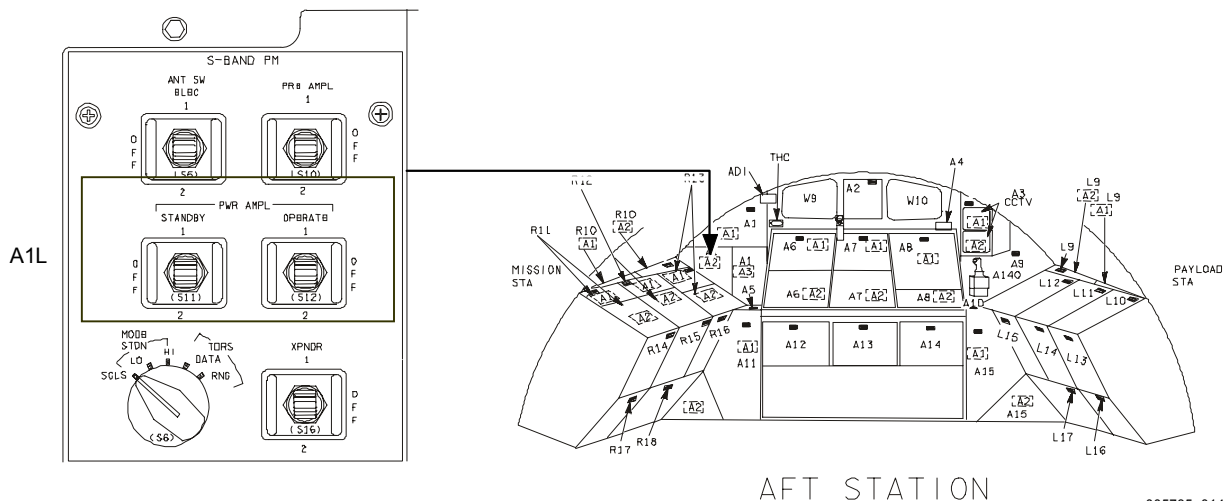
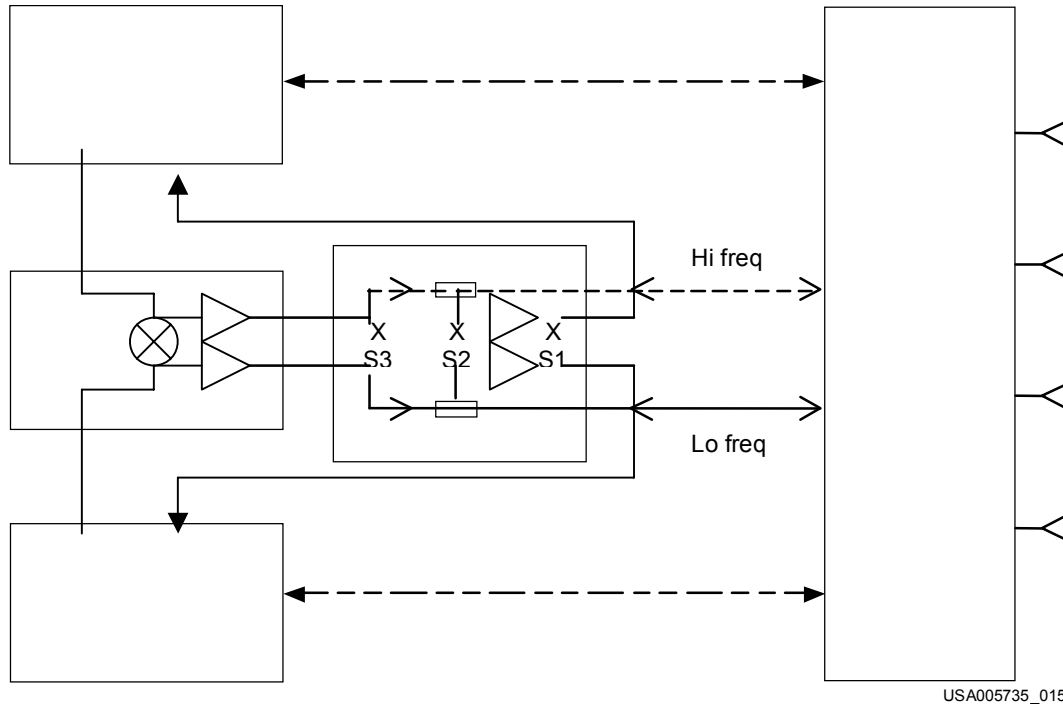


Figure 3-21. S-Bd PM panel controls

QUESTIONS

- Using the block (comm) diagram below, identify (fill in) the names of the S-Bd PM LRUs and identify low power versus high power paths. Use the quad antennas: LL, UL, UR, LR; Preamp Assy (PRE AMP), ant ELEC Assy (ANTENNA SW), XPNDR 1, PWR AMP Assy (PWR AMP), and XPNDR 2 to identify LRUs. Some internal switches are given for reference.



- True/False. The switches S1 to S4, in the ANTENNA SW (Antenna Electronics Assembly (AEA)) and the diplexers/triplexers in the PRE AMP/XPNDRs are considered as single-point-failure locations for the S-Bd PM Comm system.
- What is the warm-up time for the power amp, if not previously placed in STANDBY mode?
- The power amp is NOT used for the following XPNDR modes (circle all that apply):
 - STDN HI
 - STDN LO
 - TDRS
 - SGLS

5. High power mode is required for _____ mode to compensate for the distance between the orbiter and the satellite to/from MCC.
6. The following commands for Comm or Antenna management do not use the GCILC in their command path:
 - (a) Frequency Selection
 - (b) Antenna Selection
 - (c) Transponder Mode
 - (d) Antenna Electronic 1 or 2 selection
7. The PRE AMP 1 or 2 in the Pre Amp Assembly is used for:
 - (a) uplink only in high power mode
 - (b) uplink and downlink in high power modes
 - (c) uplink and downlink in low power modes
 - (d) uplink only in low power modes

4.0 NSP AND INTERFACING LRUs

4.1 OBJECTIVES

After completing this section, the student will be able to

- Identify the two primary functions of the NSP
- Identify key LRUs that interface to the NSP for
 - Uplink
 - Downlink (real-time or recorded)
- Complete an Uplink path drawing for Comm system, including key voice and command LRUs
- State the operational versus panel configuration for the S-band PM and NSP system for
 - Ascent
 - Post Insertion; Orbit; Deorbit Prep
 - Entry
- Identify the normal configuration for the COMSEC
- List the five Comm systems under control of the GCILC for selecting required functions and configurations
- Locate the S-Bd PM and NSP GCILC control switch
- Complete a Downlink path drawing for Comm system, including key voice and telemetry LRUs.
- Complete basic drawing of key input sources for a PCMMU, including GPC, OI, and PL data.
- Identify the status indication visible on SM SYS SUMMs for OI DSC failure, OI MDM failures, and total MDM-to-PCMMU interface failure
- Identify the two data rates and three basic types of data processed by a PCMMU.
- Identify the configuration required to load TFLs, and conditions for an automatic load of the LBR/64k TFL.
- Identify how the OI PCMMU FORMAT switch affects the SM software (SPEC 62)

4.2 NSP AND INTERFACING LRU OVERVIEW

This section examines the Network Signal Processor (NSP) and LRUs that interface to the NSP for uplink and downlink communication, specifically through the S-Bd PM system.

There are two NSPs to support the two S-Bd PM strings. The active NSP processes the UL and DL data signals between the orbiter and MCC. Uplink includes voice (up to two channels) and commands; the Downlink includes voice (up to two channels) and telemetry. The NSP normally receives and transmits data through the active S-Bd PM transponder, during all phases of a mission. However, after the payload bay doors are open, and Ku-Bd antenna is deployed and activated, then the NSP can also receive and transmit through the Ku-Bd system. Basically, the NSP uses the S-Bd PM or Ku-Bd system as the RF (radio) interface between MCC and the orbiter. The NSP can transmit through either RF system, but it can only receive through one at any given time. Figure 4-1 is a simplified portion of the MALF Comm drawing with key interfaces, and Figure 4-2 a detailed schematic of the internal NSP circuitry.

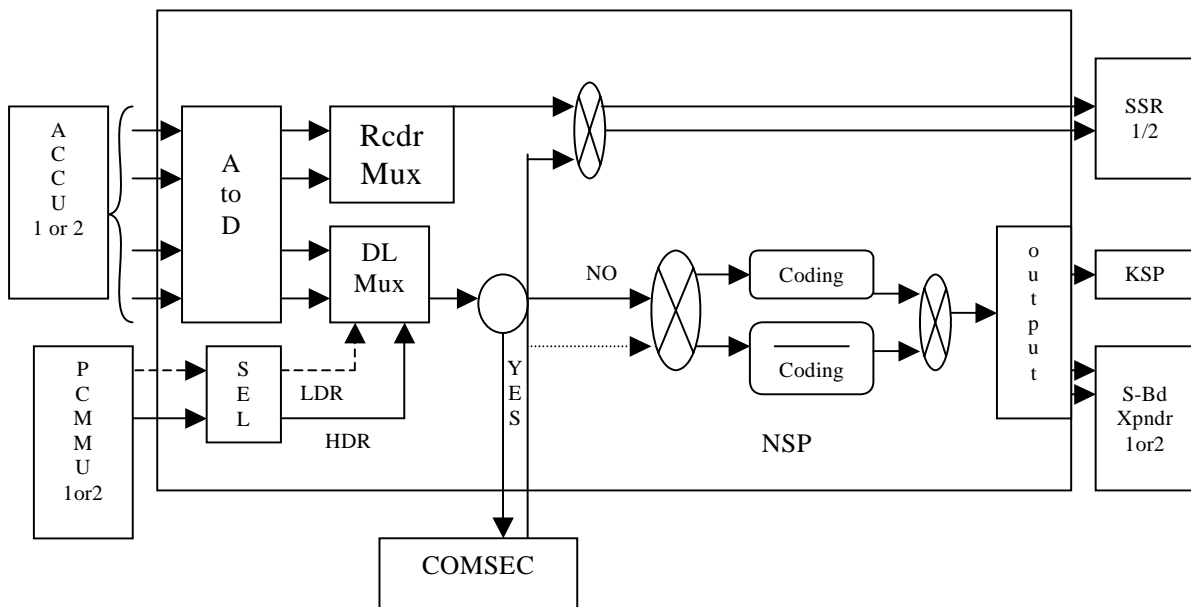


Figure 4-1. Simplified NSP & I/O LRUs

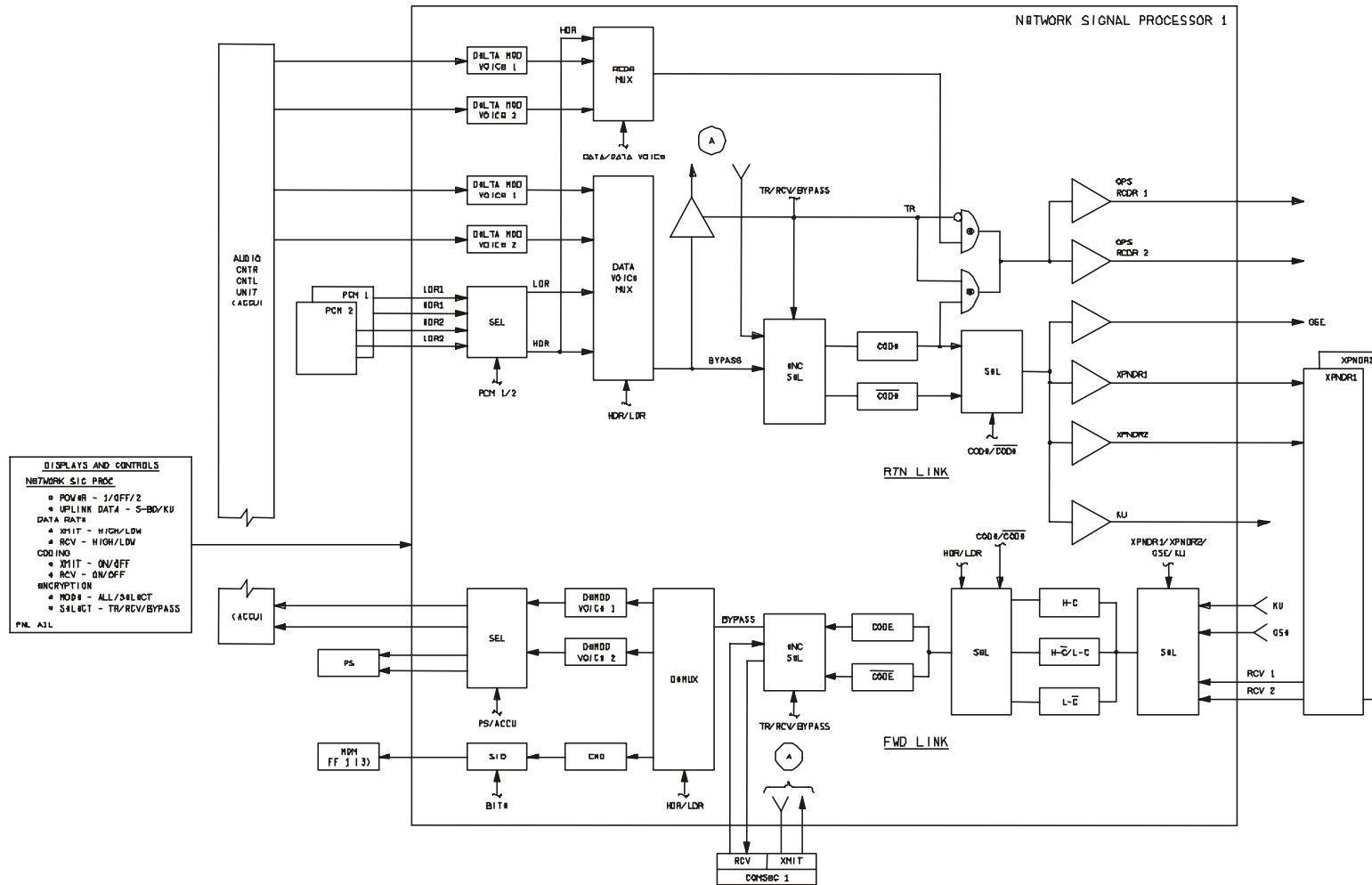
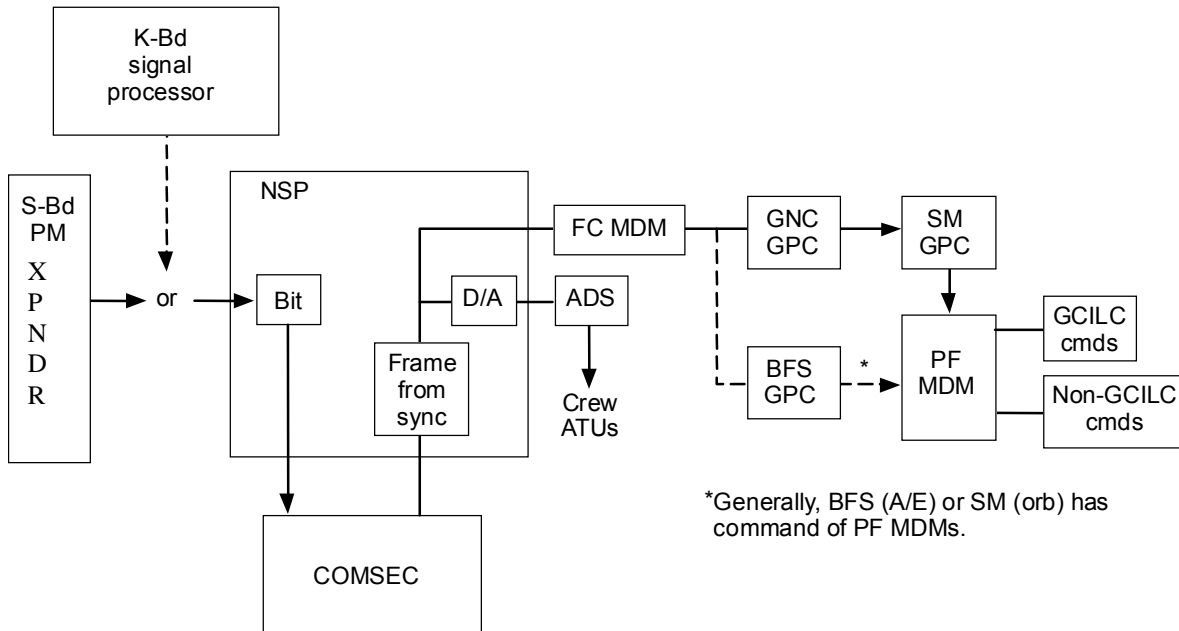


Figure 4-2. Internal NSP circuitry schematic (simplified)

4.2.1 Uplink Path Overview

The active NSP receives the UL signal (commands and digitized voice) from the RF system; for our purpose, let us assume the S-Bd PM system. The NSP locks on the data signal from the active XPNDR, decodes the data signal if coding is ON, routes the data signal to its related COMSEC unit when uplink is encrypted. Finally, the NSP processes and routes analog voice to the active ACCU and verified commands to the GPCs. NSP1 interfaces to the GPCs through Flight Forward 1 MDM (FF1 MDM), and NSP2 through FF3 MDM. Figure 4-3 shows a simplified drawing of the command path, from NSP to end item(s).



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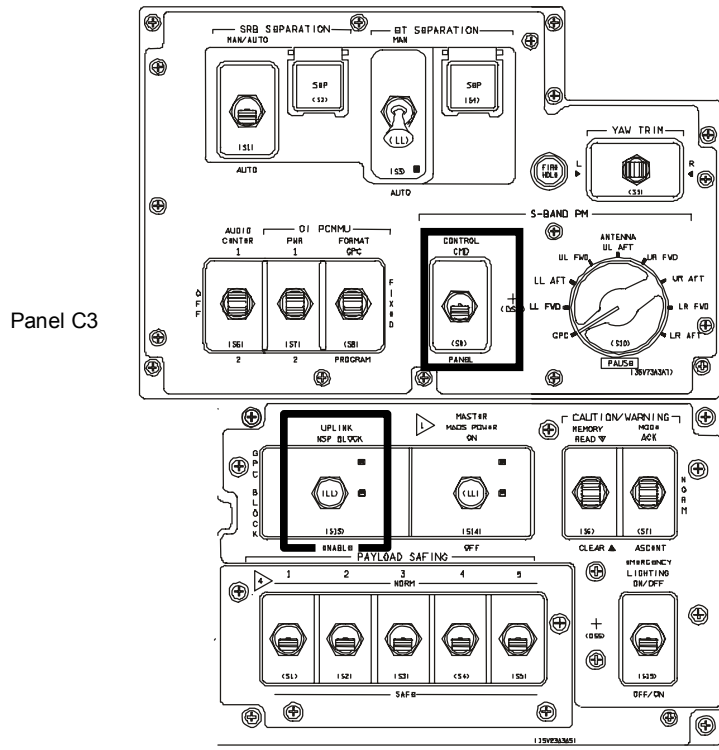
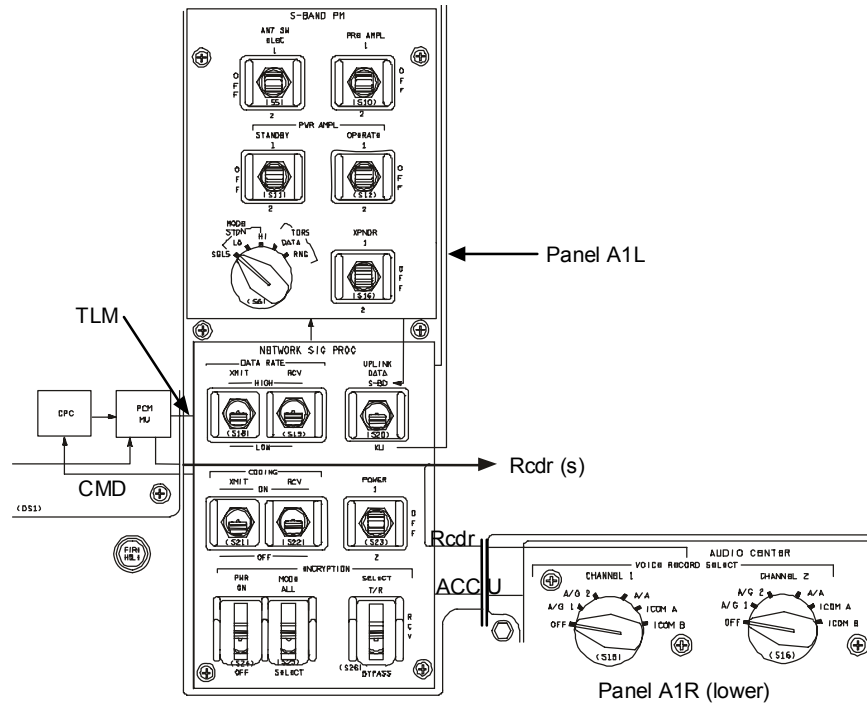
Figure 4-3. Command path (simplified)

The NSP verifies the UL commands (shown as NSP Frame Sync) and routes them to the GNC GPC(s) assigned to FF1 or FF3; that is, from NSP1 or NSP2, respectively. During ascent and entry phases of a mission, the BFS will listen over the flight-critical bus assigned to the active NSP for PF MDM commands, which allows command of Comm systems by INCO at MCC. On orbit, the PF MDMs are usually assigned to the SM GPC. The GNC GPC will route commands through an ICC bus to the SM GPC, which processes and routes the commands to Comm systems through the PF MDMs. The PF MDMs provide the interface to the GCILC, which allows INCO to control 5 Comm system functions by command. The GCILC will be covered in greater detail in an upcoming section.

The two ACCUs are part of the Audio Distribution System (ADS). A more thorough explanation of the orbiter ADS is found in the AUDIO/UHF Workbook. Basically, once the voice changes from digital to analog in the NSP, the active ACCU routes the voice to crew audio stations, including speakers and other loose Comm equipment, like the Battery Powered Speaker Microphone Unit (BPSMU).

GPCs process and route commands received from an NSP for internal use, for another GPC, or to control an orbiter system or LRU. For a more thorough understanding of commanding, please refer to the COMMANDING 21002 Workbook.

The NSP switches are found on Panel A1L and A1R, Figure 4-4, under the S-Bd PM switches, discussed in the previous section. The GCILC control switch for these switches is on C3, the same switch used for the S-band PM system. Panel C3 also has an uplink switch the ENABLE or “Block” commands to the orbiter GPC or NSP. The function of this switch will be described later.



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Figure 4-4. NSP/GCILC controls

4.2.2 Downlink Path Overview

The active NSP combines (or multiplexes) the telemetry (also referred to as Data), from 1 of 2 pulse code modulation master units (PCMMUs) and voice, and from 1 of 2 ACCUs, into a downlink (DL) signal. The NSP digitizes the voice (up to 2 channels) prior to combining it with the Data. The multiplexed Data and Voice can be routed to the COMSEC encryptor, if required, then back to the NSP for convolutional coding (called Coding for following overview), if enabled, before being routed to the S-Bd PM XPNDR and/ or Ku-Bd Signal Processor for Downlink to MCC. Normally the Downlink IS NOT encrypted, but Coding is used for TDRS mode. The DL signal is also routed to on-board recorders, called solid state recorders (SSRs), for playback after expected (or unexpected) loss of signal/comm situations occur. See Figure 4-5.

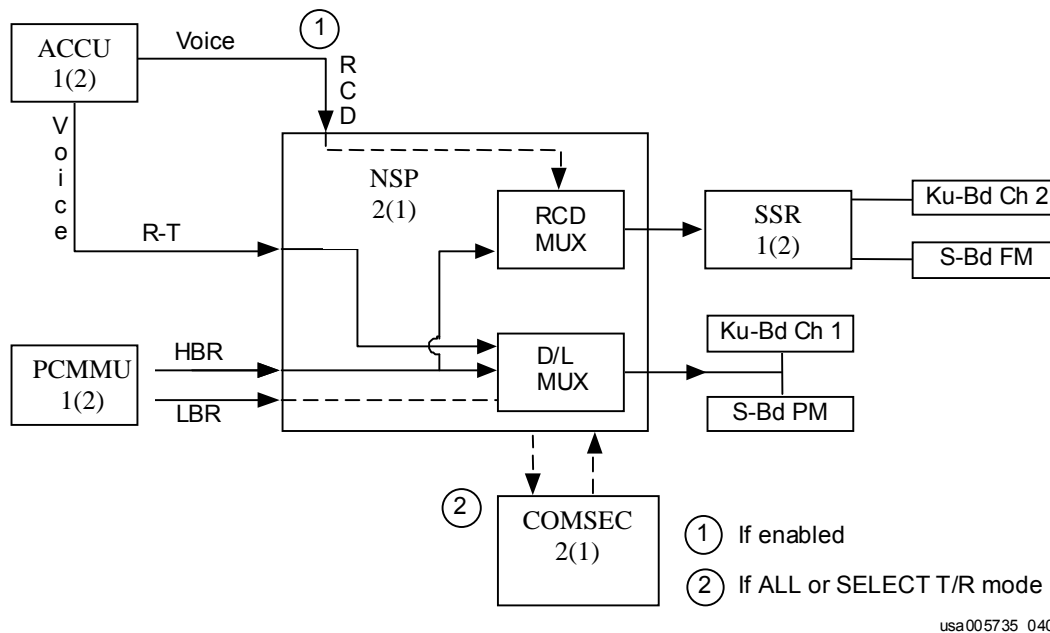


Figure 4-5. Downlink path (simplified)

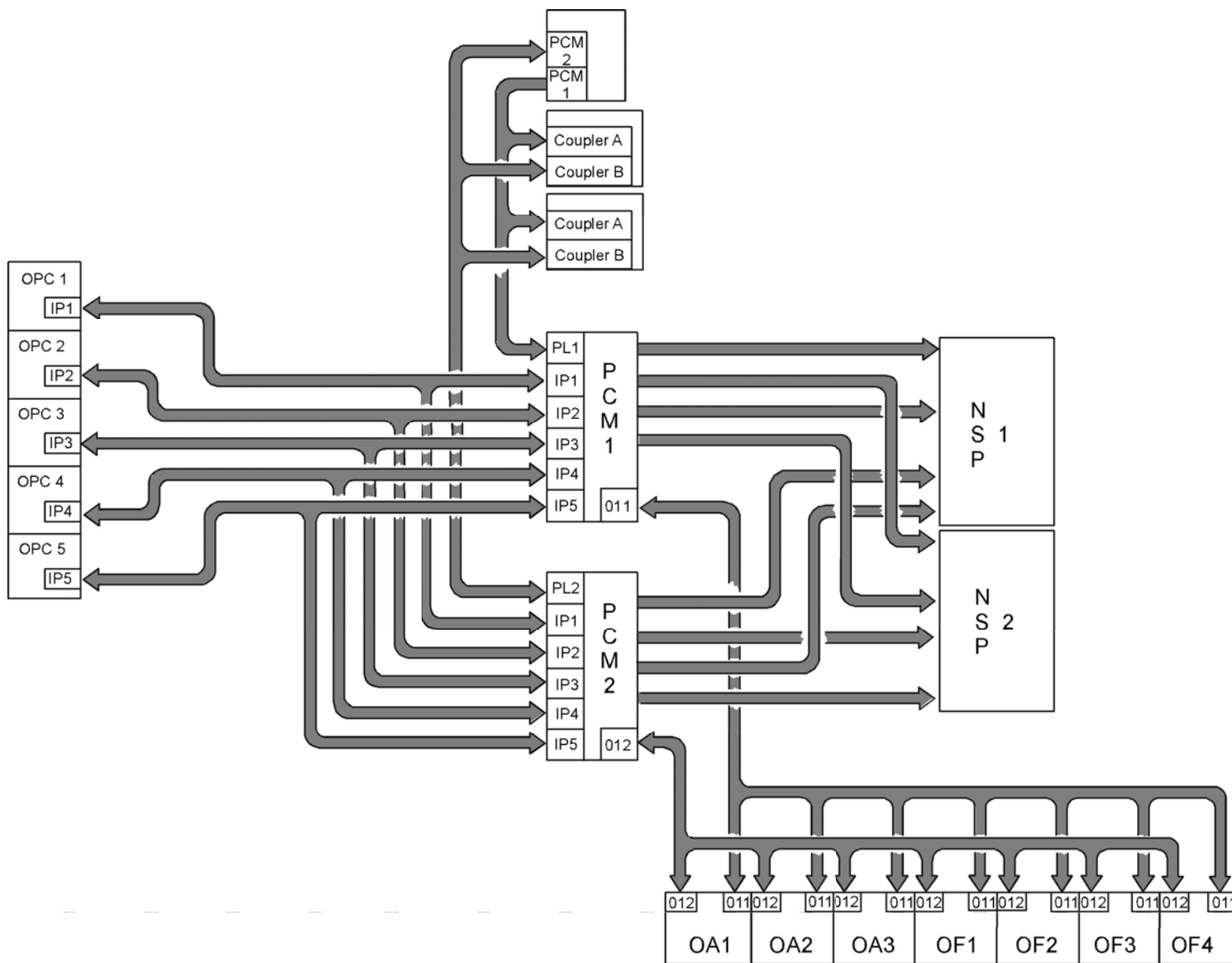
The active PCMMU (one of two) formats GPC downlist, OI data and Payload Data Interleaver (PDI) data into HBR (128kbps) and LBR (64kbps), based on the internal Telemetry Format Loads (TFLs). The NSP selects the HBR or LBR data (telemetry) based on the NSP configuration, combines it with voice, and routes it to S-Bd PM and Ku-Bd for DL. If XMIT encryption is enabled, the combined data and voice are sent to the COMSEC and returned to the NSP for downlink. INCO, or the crew, configures the NSP data rates through GCILC command or crew panels, respectively.

The crew selects the active PCMMU, 1 or 2, on Panel C3. The active PCMMU, usually PCMMU1, receives GPC downlist data from a GNC and the BFS GPC during ascent and entry, and from a GNC and the SM GPC on orbit. The active PCMMU fetches OI data from the seven OI MDMs and cargo/payload data from the PDI (Payload Data Interleaver). Figure 4-6 shows a PCMMU operational interface drawing.

There are seven Operational Instrumentation (OI) Multiplexer/DeMultiplexers (MDMs): four OF (Operational Forward) and three OA (Operational Aft). These 7 MDMs gather their data from 14 OI Dedicated Signal Conditioners (DSCs), plus sensor data not requiring signal processing prior to MDM.

The OI DSCs provide conditioning of analog sensor data into levels the MDMs, crew meters, and the Caution and Warning (C&W) system can accept. This includes data such as: RF power outputs, RF signal strength, temperatures, pressures, and rates.

The PDI combines payload data from four Decommutators (DECOMs), stores the payload data in a toggle buffer or Random Access Memory (RAM), and routes the data to the PCMMU. The PCMMU fetches the OI and PDI data based on a fetch Programmable Read-Only Memory (PROM) that is loaded pre-mission. The PCMMU stores the data in an OI/PL data RAM for requests by the telemetry formatter or crew displays.



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Figure 4-6. PCMMU operational interface diagram

The active NSP also routes telemetry and voice, if enabled, to RCDRS for later playback to MCC. The recorded telemetry is the high rate data from the active PCMMU. The crew selects the voice loops to be recorded on Panel A1R (Figure 4-7). INCO configures the Solid State Recorders (SSRs) for recording voice plus data or data only depending on the phase or crew activities. Each SSRs is housed within the associated Solid State Mass Memory Units (MMUs).

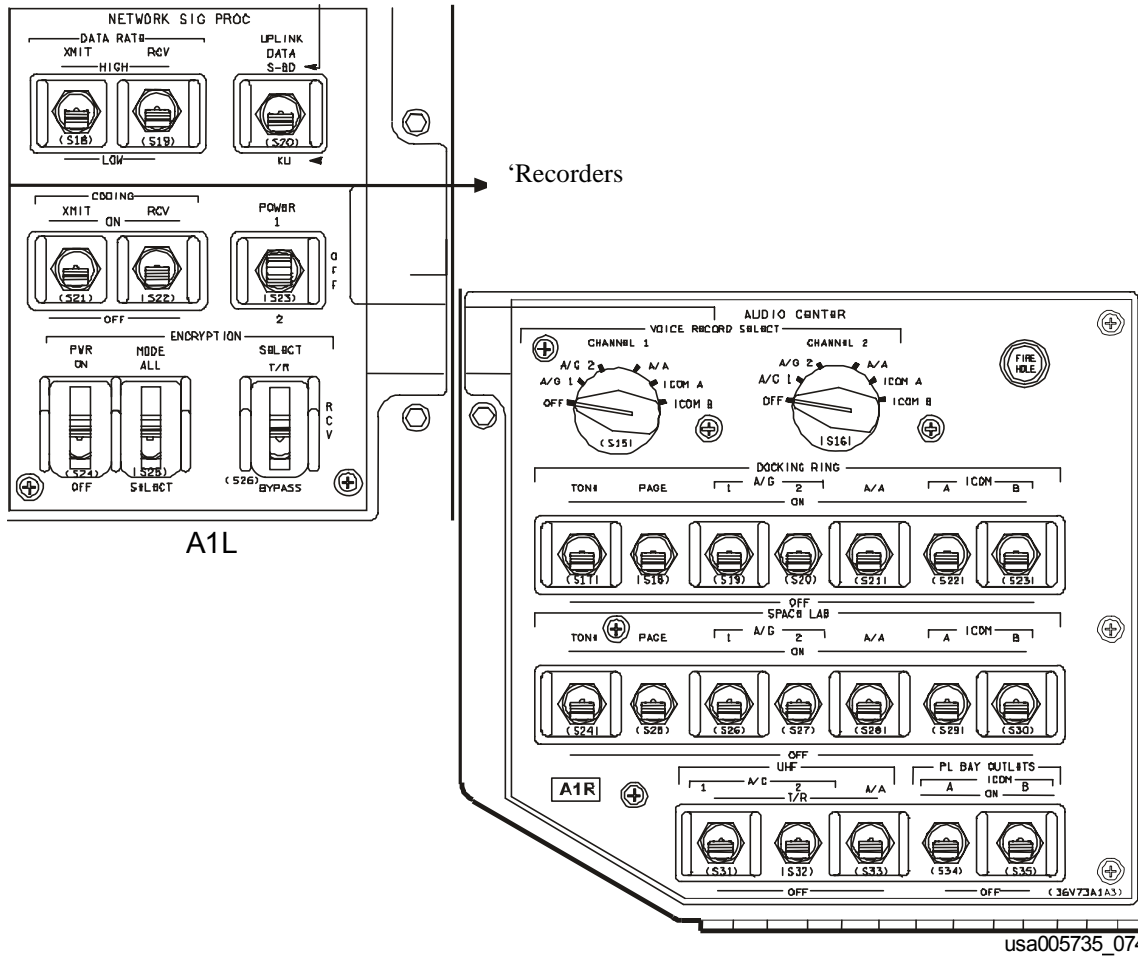


Figure 4-7. Panel A1R (lower)

4.2.3 NSP Operational Description

The two NSPs, located in avionics bay 3A, process digitized voice and commands on the UL and analog voice and telemetry for the DL. The NSP operates in coding ON or OFF, and data rates HIGH or LOW for RCV and XMIT. The INCO or the crew configures the NSP through the GCILC, based on the receiving and transmitting RF system. Normally, the NSP uses the S-Bd PM system for its RCV and XMIT RF system; therefore, the S-Bd PM XPNDR mode determines the coding and data rates configurations. Table 4-1 lists standard S-band/Ku-band PNL CONFIG, as found in the Orbit Operations Checklist. The crew configures these functions on Panel A1L and activates or selects the configuration with the S-Bd PM control switch on Panel C3.

Table 4-1. STD S-BD/KU-BD PNL CONFIG (PNL A1L)

Standard configuration	STDN(SGLS) S-BD	TDRS S-BD	TDRS KU-BD
NSP data rate XMIT	HI	HI	HI
RCV	HI	HI	HI
UPLK DATA	S-BD	S-BD	KU
Coding XMIT	OFF	ON	ON
RCV	OFF	ON	OFF
S-BD PM MODE (Rot)	STDN LO (SGLS)	TDRS DATA	—

Normally, NSP 2 (therefore S-Bd PM string 2) is the operating system for most of the mission. Currently engineering has requested a minimum 24 hour checkout of String 1 each mission and will be scheduled in the Flight Plan accordingly. The back panel switches should always be configured to the alternate string, unless told otherwise by MCC. Assuming the normal string 2 is operating, then NSP 1 (and S-Bd PM String 1) is the backup or panel configuration.

Typically, at a Mission Elapsed Time (MET) of 7:30, the S-Bd PM and NSP changes to TDRS mode configuration by an on-board Stored Program Command (SPC). The SPC is sent before launch, by INCO into the BFS GPC.

The back Panel (A1L) remains in the ascent STDN HI panel configuration until the crew performs the “AFT STATION CONFIG” block during post-insertion, approximately 1 hour MET. The S-Bd PM and NSP remain in TDRS mode for the entire orbit phase of a mission. During deorbit, the operational mode stays in the TDRS mode until Acquisition Of Signal (AOS) landing support site, plus a few minutes, and then changes to a STDN configuration, again by an SPC loaded into the BFS GPC.

Table 4-2 shows the crew A1L configuration, for the different Mission Phases, which assumes the S-Bd PM and NSP LRU switches are set to String 1:

ASCENT (essentially lift-off until the on-board SPC commands to 'orbit' configuration),
ORBIT (which includes most of Post Insertion and Deorbit Preparation), and
ENTRY

Table 4-2. S-Bd PM NSP Back-Panel configuration

Standard configuration	ASCENT	ORBIT	ENTRY
XPNDR Mode	STDN HI	TDRS Data	STDN LO
NSP – UPLK DATA	S-BD	S-BD	S-BD
NSP data rate XMIT -	HI	HI	HI
RCV -	HI	HI	HI
Coding XMIT -	OFF	ON	OFF
RCV -	ON**	ON	OFF

Note: ** RCV coding is enabled (ON) during ascent to allow greater reliability on the uplink through the plume; otherwise, coding is OFF for STDN modes.

Generally, STDN HI is the operational configuration for landing at Edwards (EDW), whereas STDN LO is preferred for KSC landings, to avoid saturating STDN site (MIL) system. During deorbit prep, the crew configures the back panel into a STDN LO configuration, in the "ENT AFT FLT DECK CONFIG" block. STDN LO is chosen over STDN HI for entry in case of a high power mode problem. Recall that low power modes bypass the preamp and power amp assemblies.

In summary, the NSP provides UL processing and routing of commands and voice and DL processing and routing of telemetry and voice to RF systems and SSRs. In the next section, we examine the NSPs interfacing LRUs for uplink and downlink processing for commands, voice, and telemetry.

The Crew Cockpit Cues: BIT SYNC and FRAME SYNC indications are shown for the crew on SM SPEC 76 (Figure 4-8), or NSP COMM status (LOCK or NOLK) on BFS GNC SPEC 51 (Figure 4-9). The COMM status indication is equivalent to the NSP Frame Sync from the NSP.

XXXX/XXX/076		COMMUNICATIONS		XX X	DDD/HH:MM:SS	DDD/HH:MM:SS
S-BAND PM	XXXXS			KU-BAND		
FREQ	XXS	1	2	PA TEMP		±XXXXS
ANT ELEC	XXS	XXS	XXS	GIMBAL TEMP A		±XXXXS
XPNDR	XXS	XXS	XXS	GIMBAL TEMP B		±XXXXS
PREAMP	XXS	XXS	XXS	GYRO TEMP		±XXXXS
PWR AMPL				PWR OUT		XXS
OPER	XXS	XXS	XXS	FRM SYNC		XXXXS
STBY	XXXXS	XXXXS	XXXXS	MODE		XXXXS
PWR OUT	XXS	XXS	XXS	FAIL SAFE		XXXXS
TEMP	XXXXS	XXXXS	XXXXS	AUTO K TO S		XXX
				AUTO S TO K		XXX
NSP		1	2	SSOR	PRI	B/U
BIT SYNC	XXXXS	XXXXS	XXXXS	FRM SYNC	XXXXS	XXXXS
FRM SYNC	XXXXS	XXXXS	XXXXS	PROC STAT	XXXXS	XXXXS
BITE	XXXXS	XXXXS	XXXXS	PWR LEVEL		±XX.XS
COMSEC BITE	XXXXS	XXXXS	XXXXS	STATUS		X.XS
UL DATA SOURCE			XXS	GCIL CONFIG		XXXXS
DATA RATE XMIT			XXS	CCTV CAMR OVRTMP		XXXXS
RCV			XXS			
CODING XMIT			XXXXS			
RCV			XXXXS			

YES or NO for Act. NSP

(XX)

Figure 4-8. SM SPEC 76

XXXX/051/		OVERRIDE		XX X	DDD/HH:MM:SS	BFS	DDD/HH:MM:SS
ABORT MODE				ENTRY	FCS		
TAL	1X	ELEVON		FILTER		ATMOSPHERE	
ATO	2X	AUTO	17X	NOM	20X	NOM	22X
ABORT	3X	FIXED	18X	ALT	21X	N POLE	23X
THROT MAX	4X	SSME REPOS	19	XXX		S POLE	24X
ABT	50X						
NOM	51X						
PRPLT DUMP		IMU DES	ATT	AA	RGA	SURF	
XXX ICNCT	5 XXXX	1	25X	X	LRU	DES	DES
OMS DUMP		2	26X		1	31X	35X
ARM	6X	3	27X		2	32X	36X
START	7X				3	33X	37X
STOP	8X	ET SEP			4	34X	38X
9 QUAN/SIDE	XXX	AUTO	28X				
OMS DUMP TTG	XXX	SEP	29X				
AFT RCS	13 XXX	ET UMB DR					
14 TIME	XXX	CLOSE	30X				
FWD RCS	15 XXX	VENT DOOR CNTL					
16 TIME	XXX	OPEN	43X	XX			
		CLOSE	44X	XX			
					ROLL MODE		
					WRAP MODE	45	XXX
					COMM	XXXX	
					TDRS	46X	
					STDN-HI	47X	
					STDN-LO	48X	
					SGLS	49X	

LOCK or NOLK

Figure 4-9. BFS/GNC SPEC 51

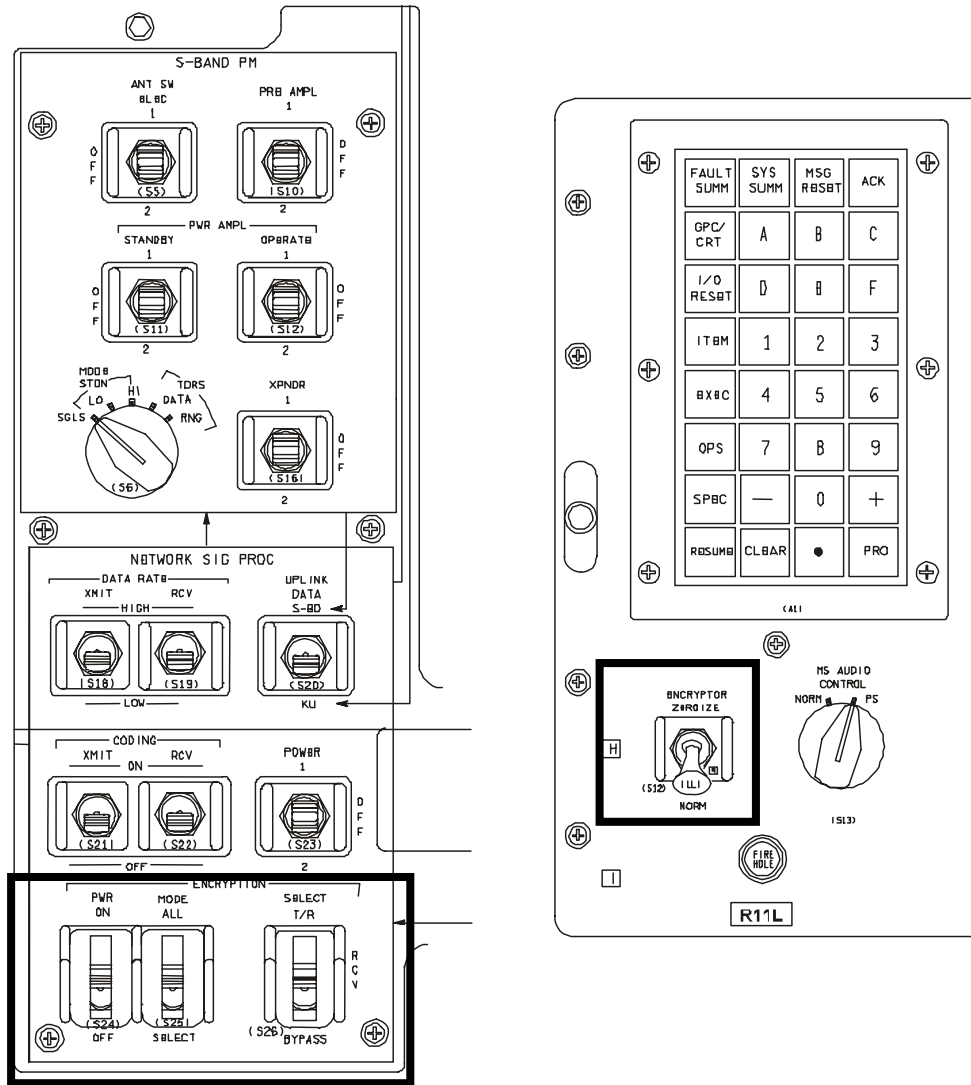
4.3 NSP INTERFACING LRU DESCRIPTION

This section discusses the basic functions and operations of the LRUs which interface with the NSP for Uplink/Command and Downlink/Data Flow: Uplink LRUs include: COMSECs and GCILC. Command Displays and Controls will also be covered. Downlink LRUs include: OI DSCs, OI MDMs, and PCMMU. These LRUs are the primary communications and instrumentation LRUs for voice, commands, or telemetry between MCC and the orbiter.

NSP UPLINK LRUs

4.3.1 Communications Security

There are two COMSEC unit interfaces, one with each NSP to decrypt receiving and to encrypt transmitting data signals as required. Normally, the COMSEC receives the UL/FL data signal from its NSP (i.e., COMSEC1 from NSP1 and COMSEC2 from NSP2), decrypts the signal, and routes the signal back to the NSP. The COMSEC units cannot be cross-connected (or cross-strapped) like the rest of the S-band PM/NSP LRUs. Failure of a COMSEC requires selection of the alternate COMSEC/NSP to recover. Controls for the COMSEC are crew only and found on Panel A1L under the NSP switches, with protective guards over them. See Figure 4-10.



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Figure 4-10. Encryption - COMSEC controls

The POWER (PWR) switch provides the power interface to all COMSEC units being flown, normally COMSECs 1 and 2. This PWR switch is always ON. The MODE switch positions are ALL and SELECT, for Department of Defense (DOD) and NASA modes, respectively. The ALL mode provides encryption and decryption of DL and UL data signals and also routes the encrypted downlink to the recorders. The SELECT mode activates the third COMSEC switch that sets-up the COMSEC for transmit/ receive (T/R), receive only (RCV), or bypasses (BYP) mode of operation.

Normally the MODE switch is in SELECT and the SELECT switch is in RCV. One other switch for the COMSECs, on Panel R11L, is for zeroizing (erasing) the COMSEC keys. If this switch is moved to the zeroize position, all COMSECs are inoperative until after landing. Likewise, if the power switch fails, or is turned to OFF for more than 8 seconds, the COMSECs are unusable for the rest of a flight.

4.3.2 Ground Command Interface Logic Controller

The GCILC provides the INCO with a method of controlling and configuring multiple functions within the Comm systems at the same time, from the MCC. It also allows crew control of the functions through manual switches or keyboard command through DPS Utility/ SPEC 1.

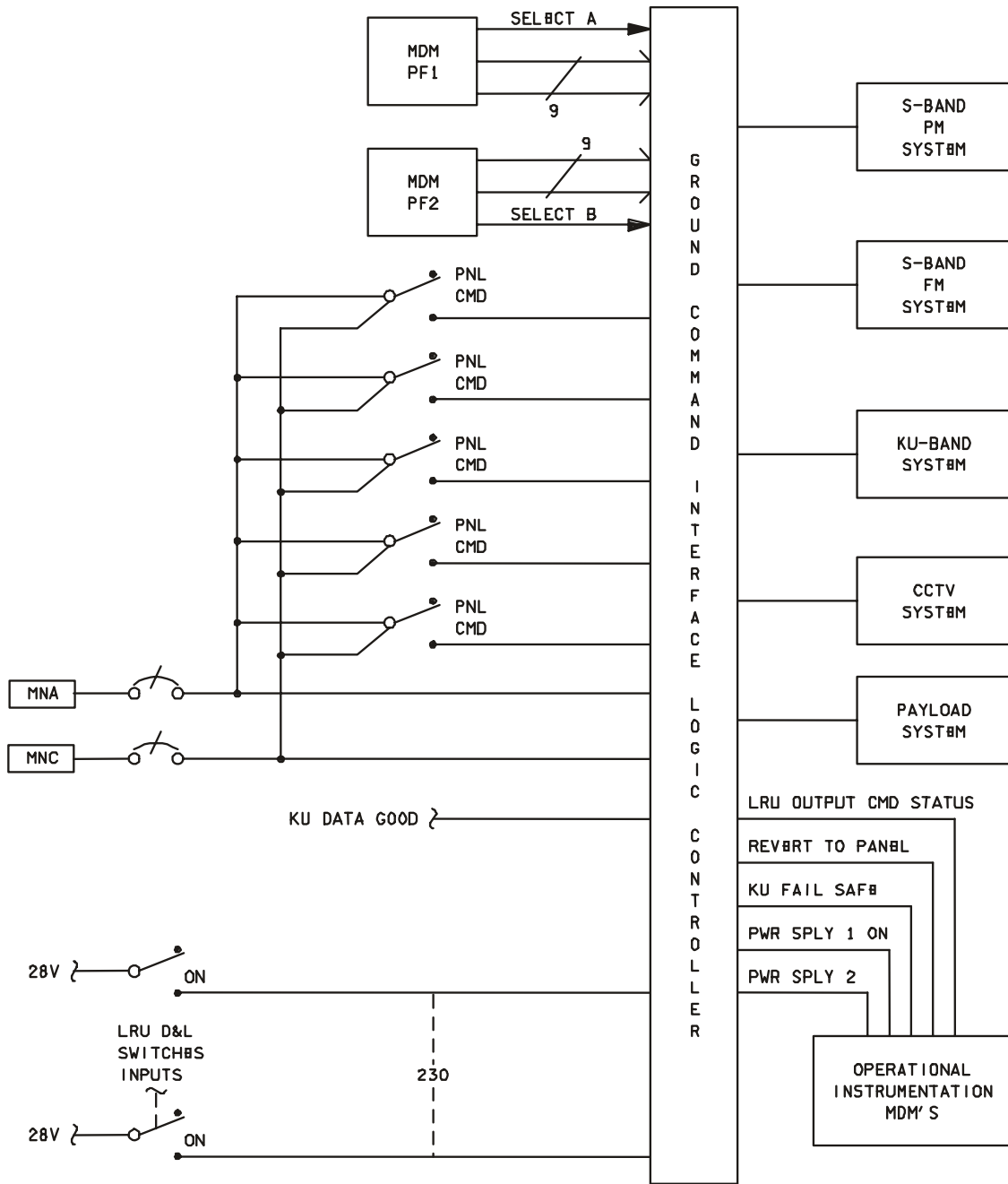
The GCILC CONTROL switches provide the COMMAND or PANEL operation of the associated Comm system namely: S-Bd PM, S-Bd FM, Ku-Bd, S-Bd PL, and CCTV functions. In the COMMAND position, commands may be sent real time (now), stored within a GPC to activate at a future GMT/MET, or input into a keyboard by the crew. The PANEL position prevents control of the associated system by command. The GCILC CONTROL switches are on the panel with their associated function switches, except the S-Bd PM/NSP CONTROL switch, which is located on C3. The position of the S-Bd PM/NSP CONTROL switch allows it to be reached during ascent and entry. The other CONTROL switches are on A1R for S-Bd FM, A1L for S-Bd PL (PL Comm), A1U for Ku-Bd, and A7U for CCTV. If the GCIL is failed, or if control switch is in panel, no commands (MCC or SPEC 1) will work for the associated system.

The GCILC is internally redundant, providing two decoders (A and B) to control GCILC systems by commands or crew switches. Most commands for the S-Bd PM, S-Bd FM, Ku-Bd, S-Bd PL, and CCTV can go through either decoder, GCILC-A or GCILC-B. The GCILC decoders receive commands from the GPC in command of the PF MDMs, usually BFS or SM. GCILC-A receives commands through PF1, while GCILC-B receives commands from PF2.

Figure 4-11 shows the GCILC and its interfaces. It also shows the two power sources [MNA/R14 and MNC/R14] for the GCILC. Should both power sources be lost for greater than 10 sec. the GCILC will default to the PNL positions, and remain in those settings until changed by PNL switches. Should power recover COMMAND capability is restored but systems will stay in their last know state.

Note: Since there is **no switch** to select the S-band PM frequency: the GCILC was designed to default to the HIGH frequency mode should the GCILC fail to PNL mode.

A mismatch in frequency between orbiter and Network (TDRS or Ground Site) will result in Loss of Comm until frequency match is restored. INCO and Ground Controllers (GCs) will coordinate/configure the Network to agree (match) the orbiter.



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Figure 4-11. GCILC interface diagram

4.3.3 CMD Display and Controls

The crew has a display, DPS Utility (SPEC1), and an uplink switch on Panel C3 for enabling or inhibiting commands. SM SPEC 1 (Figure 4-12) allows software to determine UL CNTL automatically (AUTO), force UL CNTL ON in enable (ENA), force UL CNTL OFF in inhibit (INH) using items 35, 36 and 37, respectively. The AUTO selection enables or inhibits commanding based on SM S-Bd AM, acquisition of signal (AOS) (in view), or loss of signal (LOS) (out of view) flags being set for Comm sites. ANTENNA Display (Figure 4-13) has GPC PTG ENA and INH selections, which MCC configures as needed. Here ENA allows antenna management/GPC to point/select antenna, INH allows MCC/INCO to command an ANTENNA other than the "GPC" choice of Antenna, for certain failure conditions.

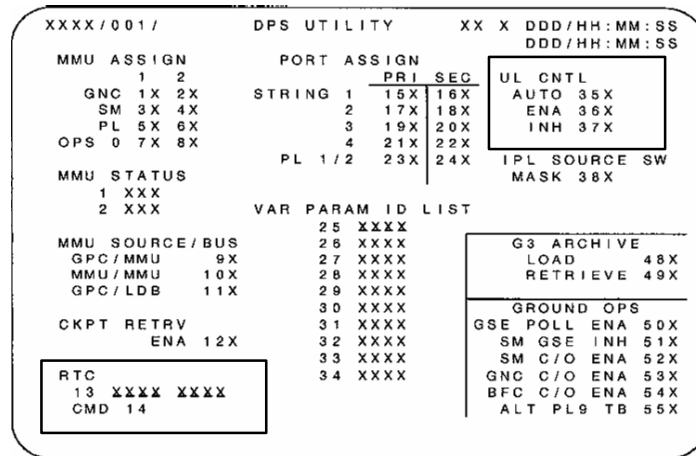


Figure 4-12. DPS utility (SPEC 1)

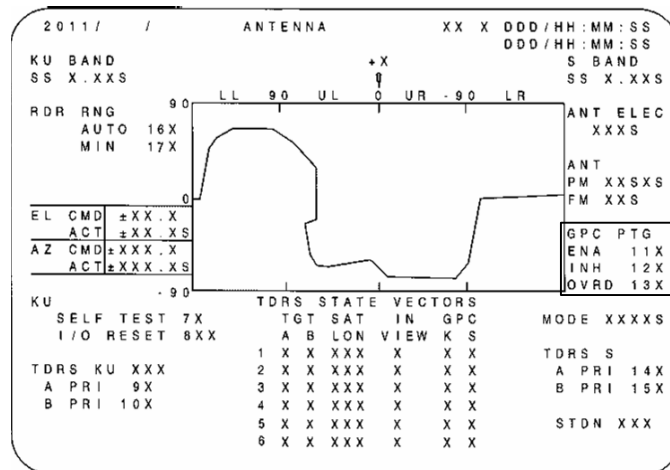
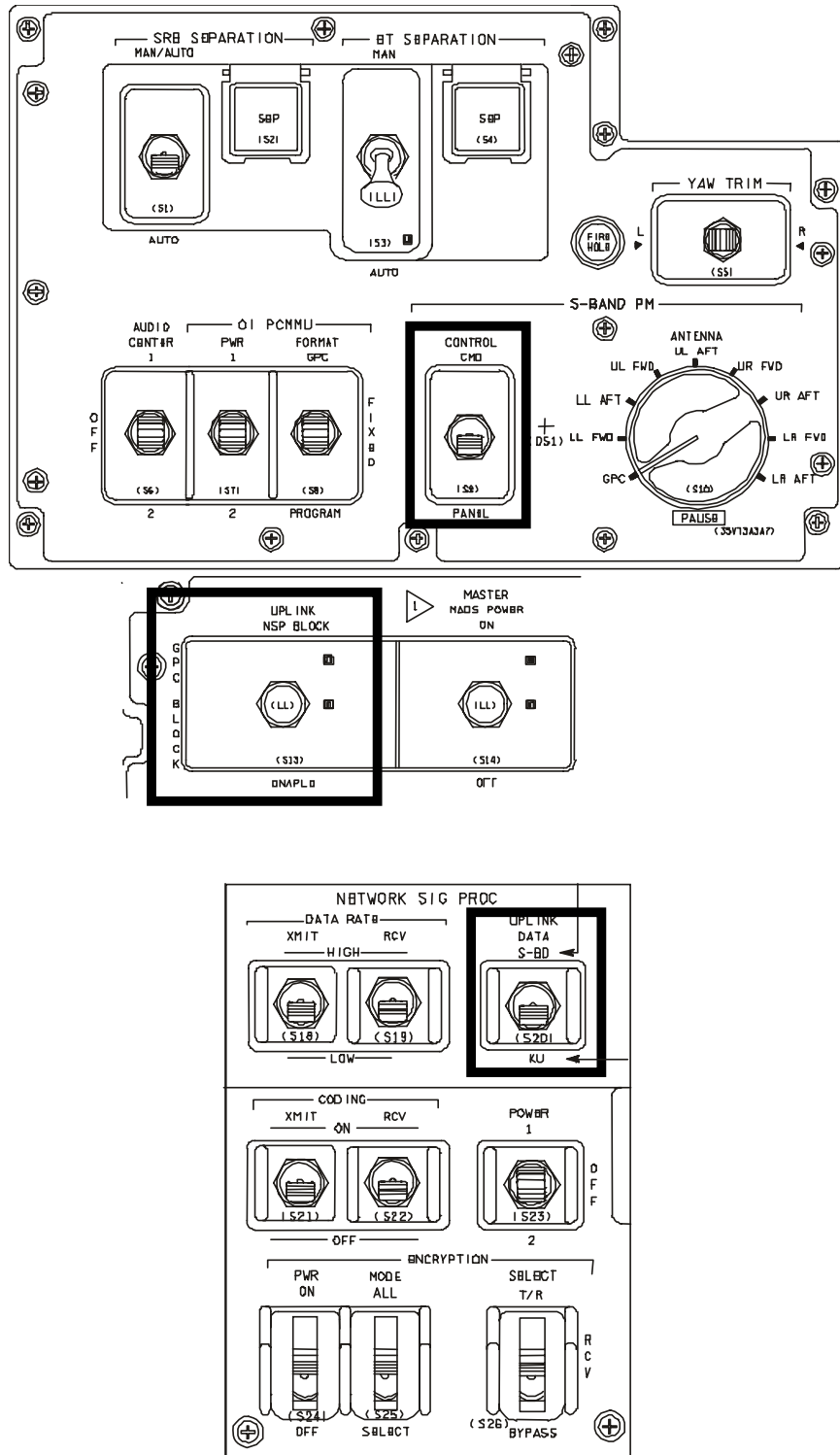


Figure 4-13. Antenna (OPS 2011)

A crew will select AUTO during the post-insertion and select ENA during deorbit preparation (DPS) reconfiguration. The uplink switch on Panel C3 is a hardware method for enabling or inhibiting commands at the GPC or NSP. The switch provides inhibiting of commands when the uplink is NOT encrypted and the SM antenna

management is unavailable, such as during ascent or entry phases. If not encrypted and using BFS, the uplink switch is used to inhibit commands into the orbiter during loss of signal (LOS) periods. Since we normally operate in RCV encrypt mode or have the SM SPEC 1 available, the uplink switch is usually left in the ENA position.

Figure 4-14 shows the command system crew controls. The other switch associated with the Uplink command path is the NSP UPLK DATA switch on A1L. This switch is normally set to S-Bd on-board. The Uplink Data Source is a GCILC function therefore MCC can command it to Ku when appropriate. With OI-29 they added the capability to have the SM trigger the GCILC to configure for Ku TDRS or S-Bd PM TDRS mode through enabling (ENA) and inhibiting (INH) the AUTO S to K and AUTO K to S fields on SM SPEC 76. When both these fields are ENA the SM will trigger the NSP into KU UL mode when the KU has signal strength greater than 1.0 and DATA GOOD flag is set (associated with the KU FRM Sync seen on SM SPEC 76) the SM waits 15 sec then issues the commands to configure NSP for KU UL. When using Ku UL and the KU goes into blockage or loses UL signal, after 5 seconds the SM will issue commands to return to S-band PM TDRS mode and config. [per Table 4-1, seen earlier]. Figure 4-15 is the NSP portion of the Malfunction Procedures, providing a good reference in flight (and during Training) for Data Flow troubleshooting.



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Figure 4-14. Command system crew switches

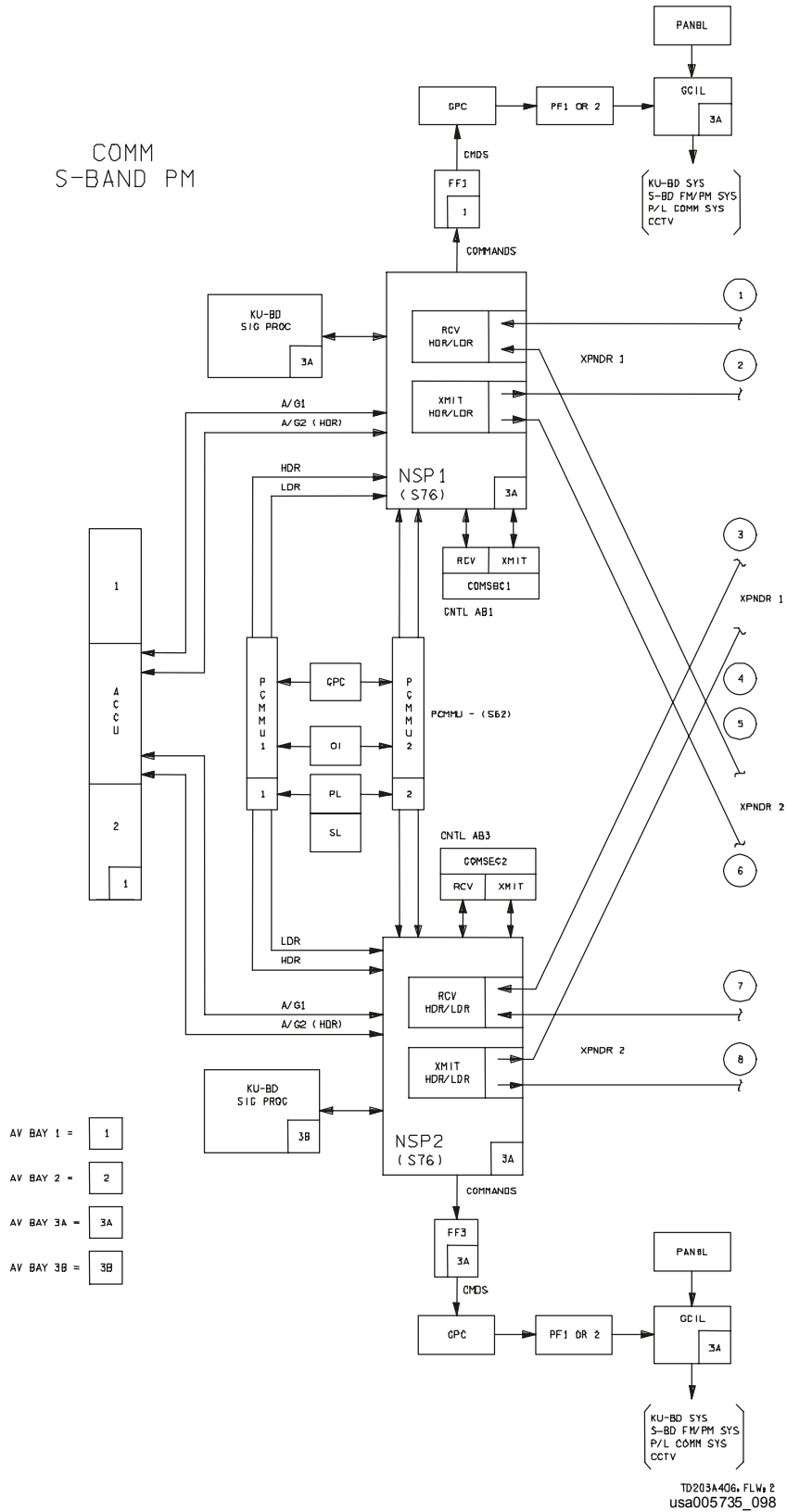


Figure 4-15. NSP interfaces

4.3.4 Downlink LRUs

The Operational Instrumentation (OI) system consists of the orbiter equipment necessary to condition, scale, digitize, and multiplex telemetry data before they are downlinked. Sensors and transducers provide data to the OI system from orbiter and payload systems throughout the orbiter. Figure 4-16 shows a function interface drawing of the OI system, which includes OI DSCs, OI MDMs, PCMMUs, and PDI interface to PCMMUs.

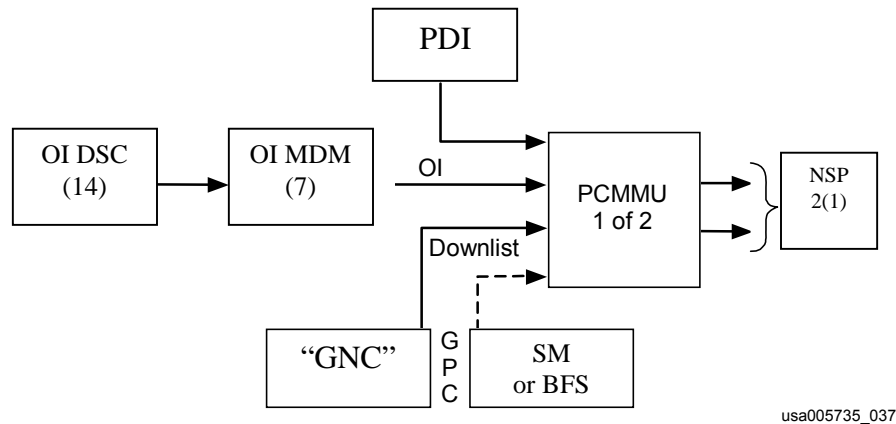


Figure 4-16. OI system interfaces

4.3.5 OI DSCs

Fourteen DSCs located throughout the orbiter provide acquisition and conditioning of vehicle data to FC MDMs, OI MDMs, crew meters, and the C&W systems. DSCs scale the sensor data to a 0 to 5 V dc signal, which is proportional to the input signal. Figure 4-17 shows the relative location of each DSC. Each DSC routes its data to one or more locations, such as to the MDMs, crew meters, and C&W system for the purpose of monitoring equipment and systems by crew and flight controllers.

Figures 4-18 to 4-20 shows the circuit breakers (cb's), or switches for the OI DSCs:

- Figure 4-18 and Figure 3-4 shows the cb's for the OF (Operational Forward) and OM (Operational Mid) DSCs. The four OF and three Operational Mid (OM) DSCs receive power from two main overhead sub-buses in pairs, except DSC OM3. For example, DSCs OF2 and 3 get power from MNB/015 and MNC/016.
- Figure 4-19 shows the OA (Operational Aft), OL (Operational Left), and OR (Operational Right) DSCs. The three OA, two Operational Left (OL), and two Operational Right (OR) DSCs receive power from two main Aft Power Control (APC) buses and two control buses.

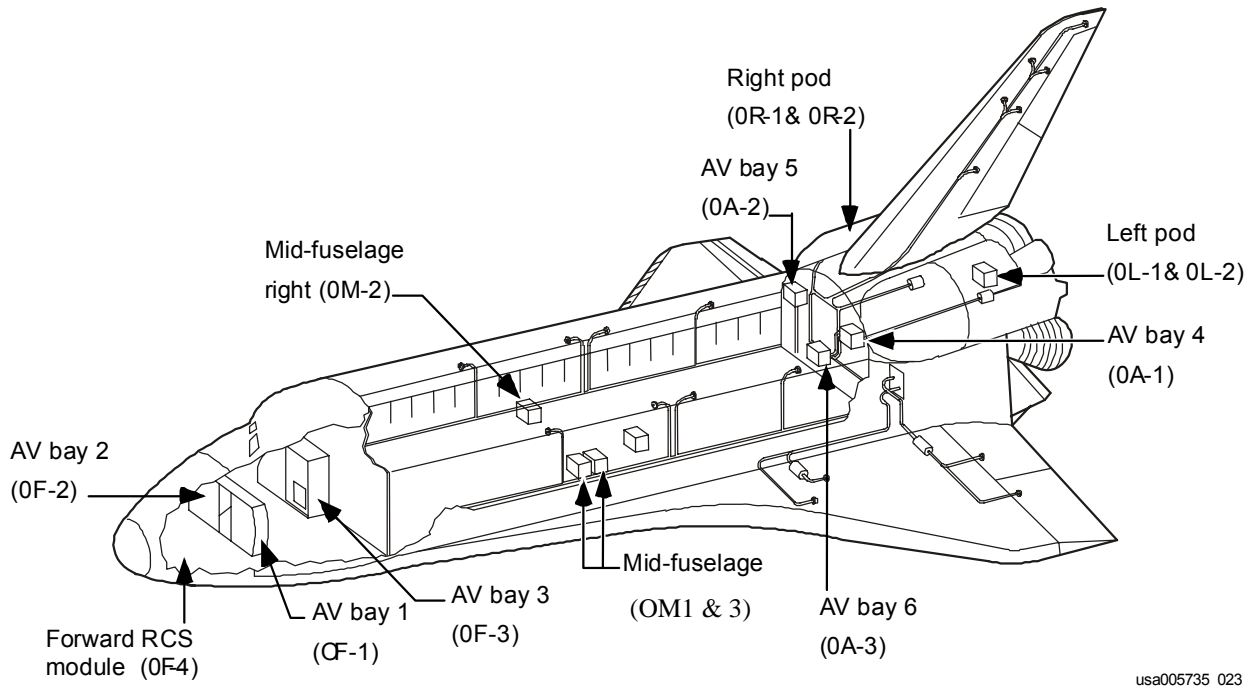
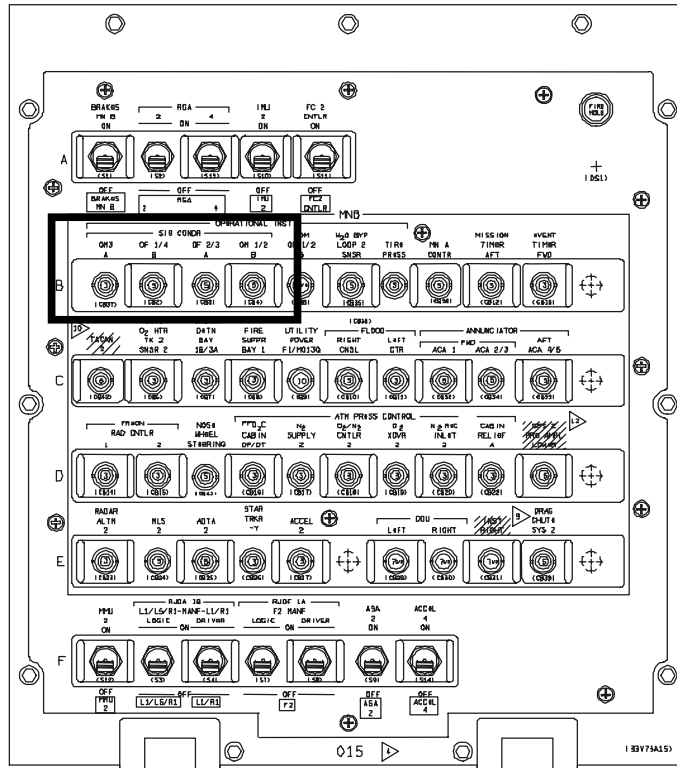
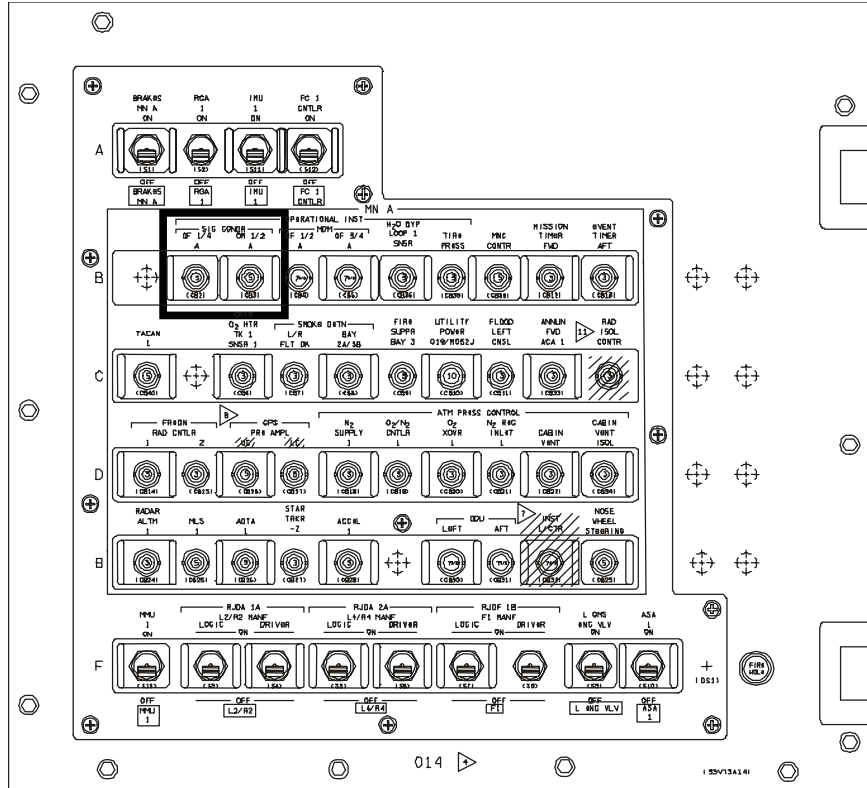


Figure 4-17. DSC location



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Figure 4-18. OF and OM DSC cb's

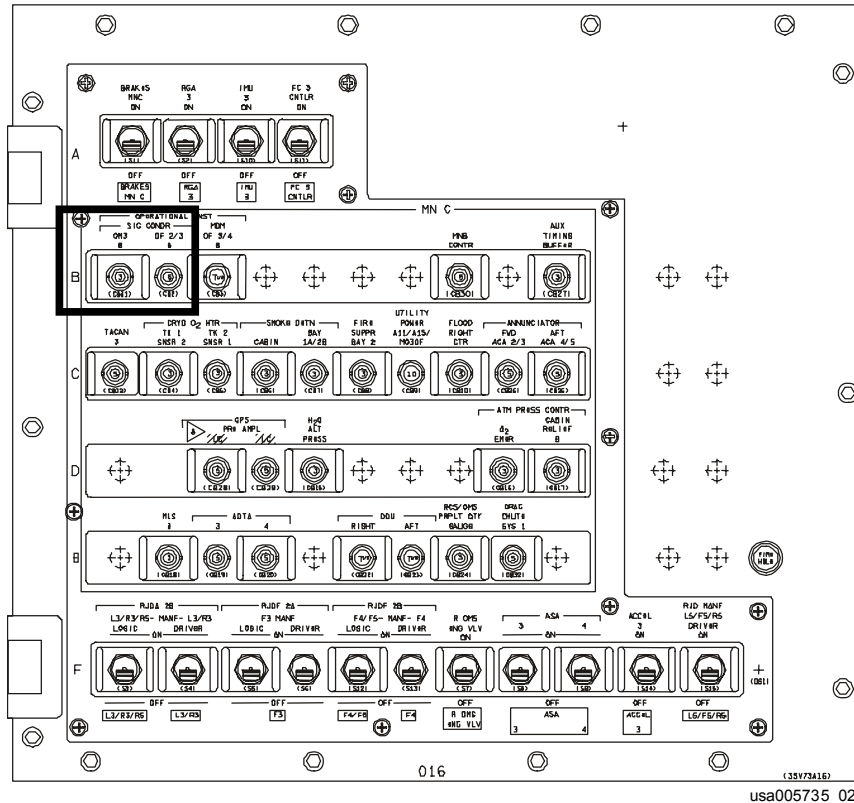


Figure 4-18. OF and OM DSC cb's (concluded)

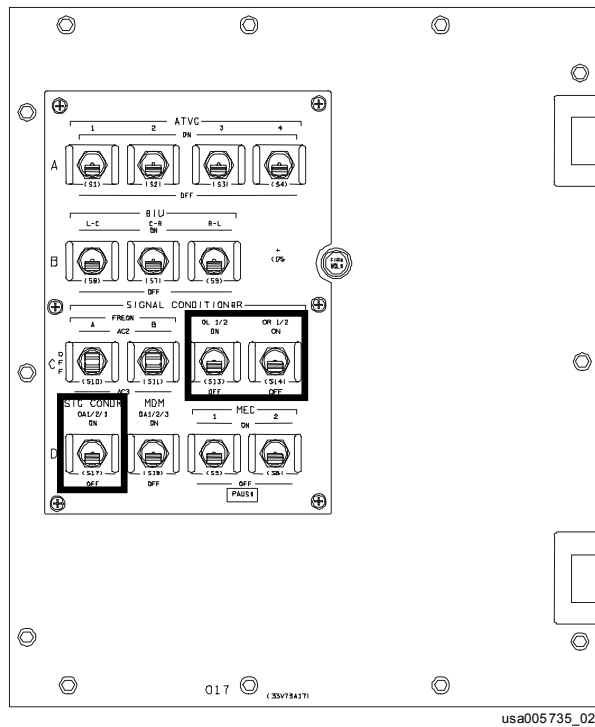


Figure 4-19. OA, OL, and OR DSC switches

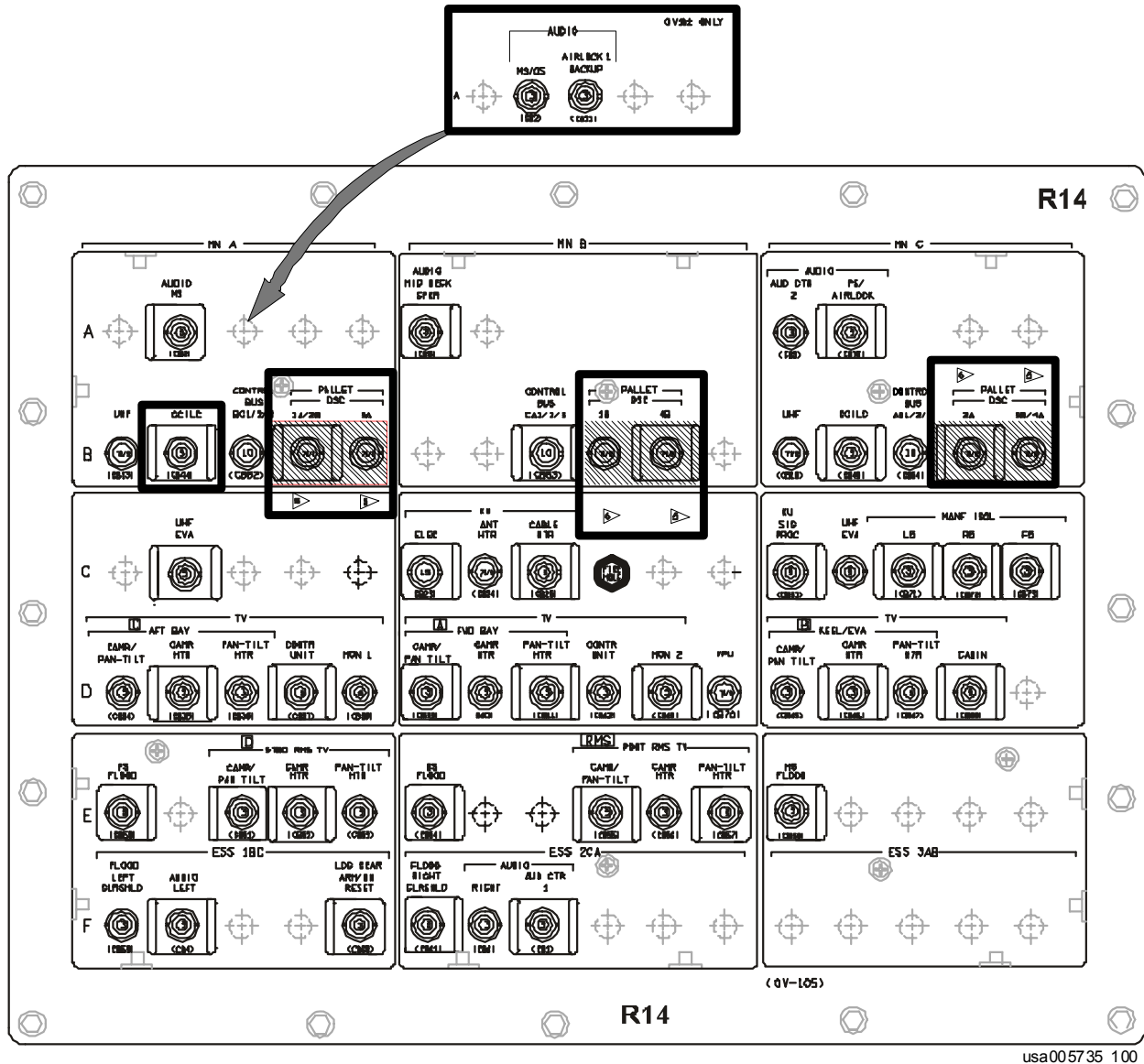
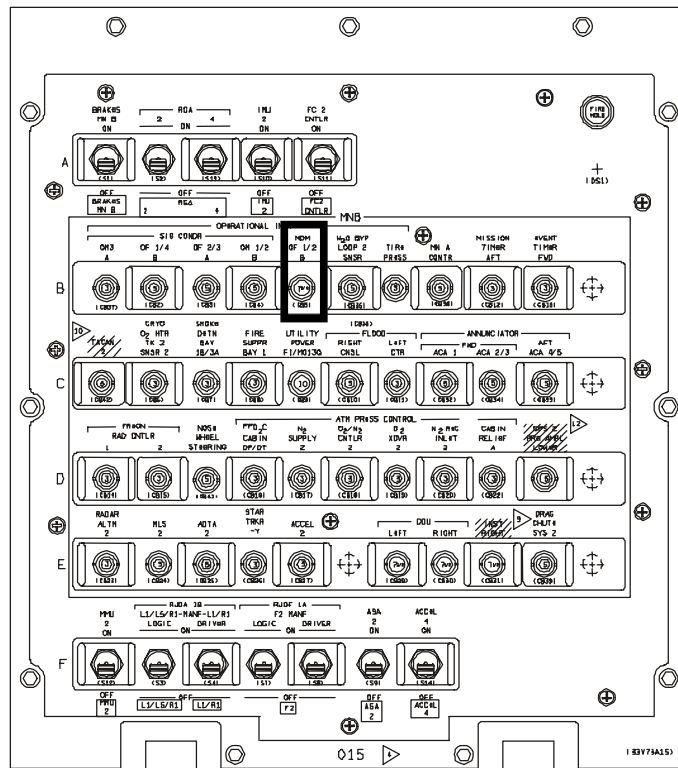
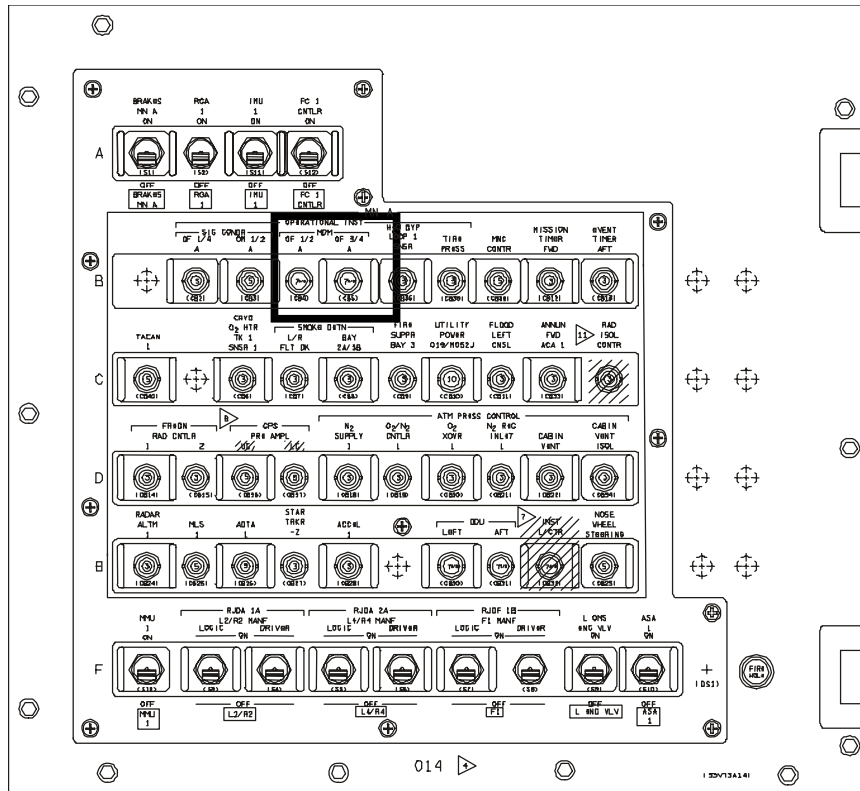


Figure 4-20. Circuit breakers for extended duration orbiter DSCs

4.3.6 OI MDMS

Seven OI MDMs receive data from several DSCs plus inputs directly from sensors, switches or transducers. These MDMs also change analog signals to digital signals; combine the data into a single, multiplexed data stream; and route the data stream to the active PCMMU, upon its request.

The OF MDMs receive power from two main overhead sub-buses, like the OI DSCs, in pairs. The OA MDMs receive power from two APC buses and two control buses. The cb's and switch for the OI MDMs are also on Panels MNA/014, MNB/015, MNC/016 and 017, near the OI DSCs. See Figure 4-21.



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Figure 4-21. OI MDMs

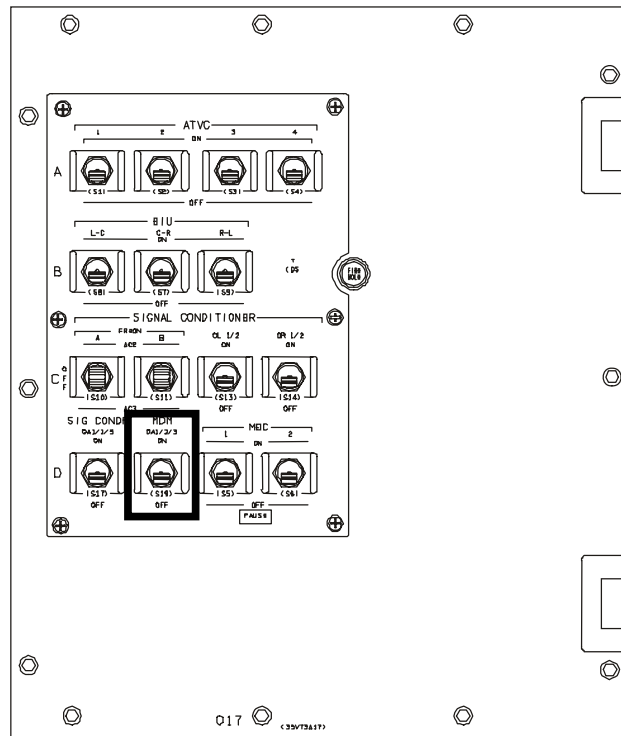
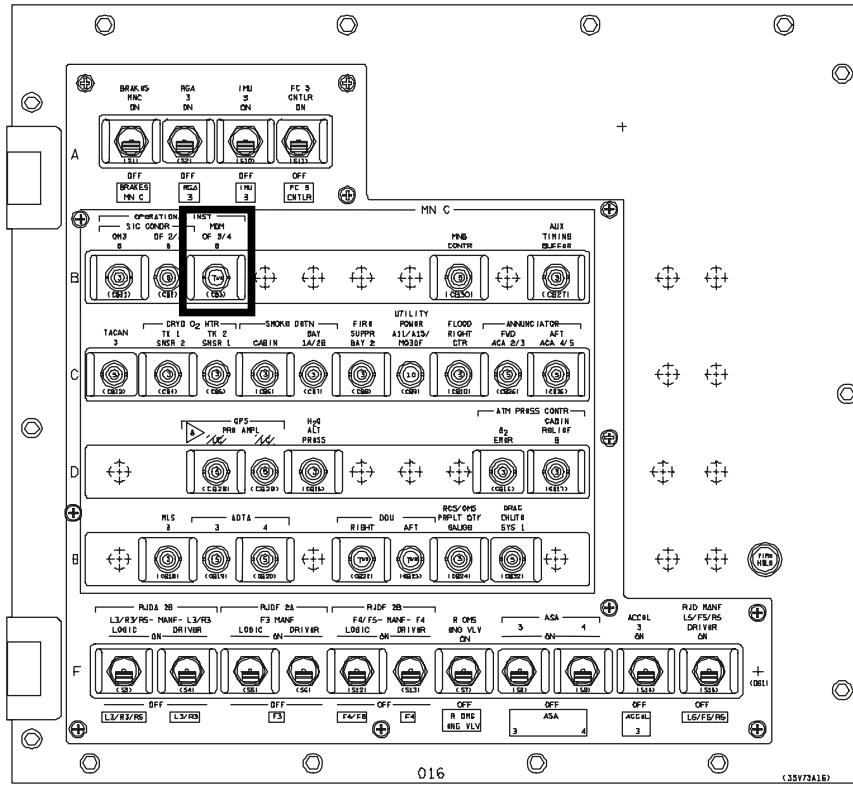


Figure 4-21. OI MDMs (concluded)

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4.3.7 OI Failure Recognition

OI DSCs and MDMs give C&W messages and status indications on crew displays for the parameters lost by a failed DSC or MDM. Loss of a DSC usually causes “off-scale low” (L or ↓) indications, and sometimes gives a message for the parameters lost through the failed DSC. Using the SYS SUMMs in the Reference Data Book or Malfunction Procedures Book, crews can use on-board displays to isolate a failed DSC, when LOS. INCO can identify failed DSCs through telemetry Built-In Test Equipment (BITE) indications, when AOS and provide failure information to the crew.

Note: Care should be taken if crews try to use the Reference Data or Malfunction Book pages to identify failed MDMs. There is NOT a one-to-one correlation between OI DSCs and MDMs. For example, there are only 7 MDMs for up to 14 DSCs.

Loss of an MDM gives “missing” (M) indications on crew displays. A message will also flag the failure that is dependent on whether the BFS or SM is doing SM C/W. The BFS GPC (ascent/entry) provides a generic “I/O ERROR PCMMU” message for any PCMMU interface problem. A quick check of BFS/ SM SYS SUMMs provides insight into whether the problem is a partial or total PCMMU problem:

- All Ms indicate a total PCMMU problem. A total PCMMU problem is usually cleared with the alternate PCMMU.
- A few Ms indicate a partial PCMMU problem, such as a single MDM port failure with the active PCMMU. A partial PCMMU problem may or may not be recovered on the alternate PCMMU. An MDM port (or MIA) failure is considered a partial PCMMU problem.

The SM GPC (on orbit) provides “S62 BCE BYP xxx” message(s) for PCMMU problems with MDMs, where xxx equals OFA for MDM OF1 and OF2, OFB for MDM OF3 and OF4, and OA for MDM OA1, OA2, or OA3. The identifier in the message refers to the MDM pairs that share the same power sources, from the overhead Panels O14, O15, O16, and O17. Getting all three messages simo, namely, “S62 BCE BYP OFA,” “S62 BCE BYP OFB,” and “S62 BCE BYP OA,” indicate a total interface problem between the active PCMMU and all seven OI MDM ports.

4.3.8 Pulse Code Modulation Master Unit

There are two PCMMUs to format and route telemetry to the active NSP. Only one PCMMU is active at a time, only selectable by the C3 OI PCMMU Pwr switch. A PCMMU, usually PCMMU 1, receives GPC downlist (d/l) data, OI MDM data, and PDI data for formatting into an HBR (128 kbps) and LBR (64) kbps telemetry stream. Figure 4-22 shows a PCMMU with interfacing LRUs. The PCMMU then routes the telemetry stream, in both rates, to the active NSP for combining with voice before downlinking to MCC.

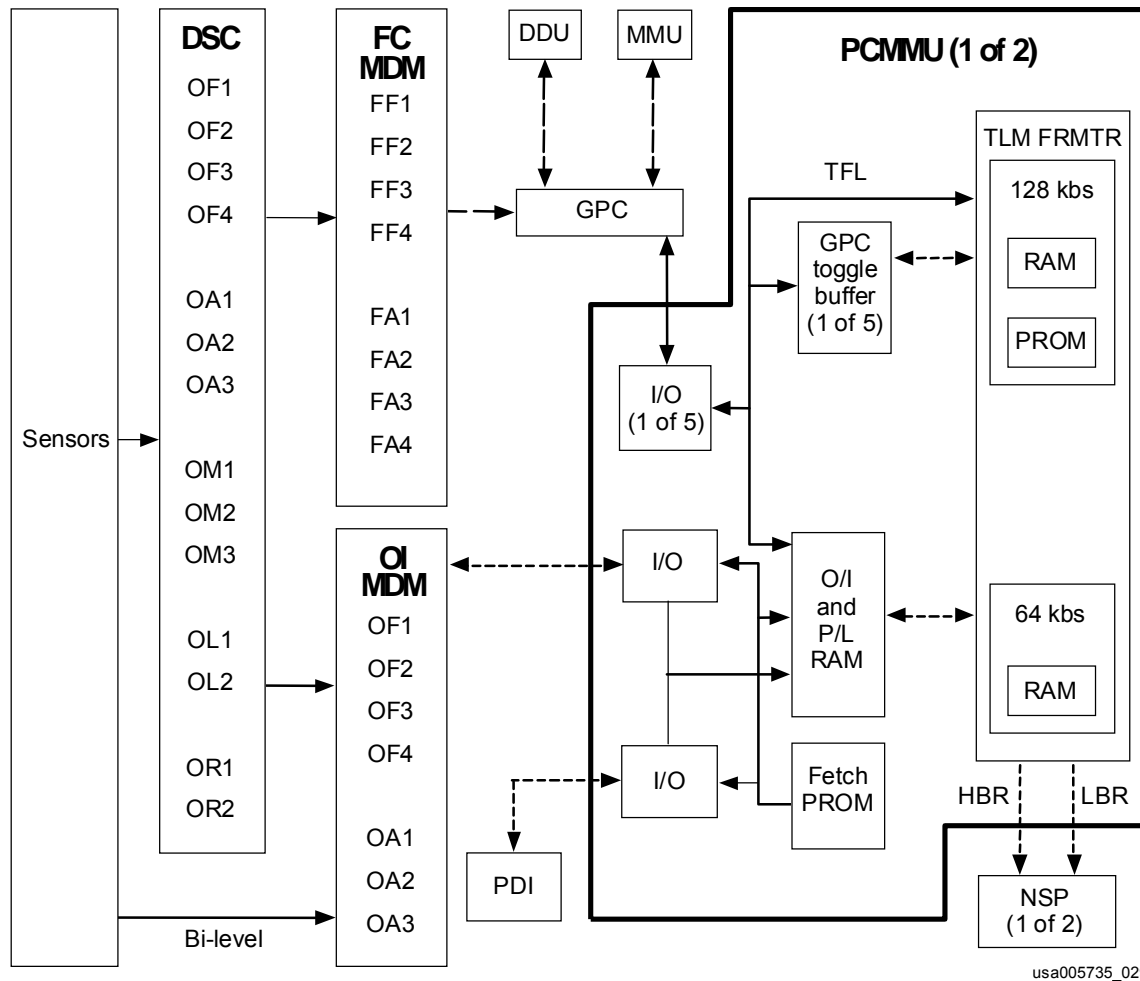


Figure 4-22. PCMMU with interfacing LRUs

During ascent or entry, the PCMMU receives the GPC d/I data from the Primary Avionics Software System (PASS) GNC and Backup Flight Software (BFS) GPCs. On orbit, the GPC d/I comes from PASS GNC and SM. PCMMU toggle buffers receive the GPC d/I and route it to the Telemetry Formatter (TLM FMTR). The PCMMU fetches the Payload Data from the Payload Data Interleaver (PDI) and the OI Data from the 7 OI MDMs into the PCMMU OI/PL Data Ram. The TLM FMTR combines the GPC d/I with OI and PDI data, for downlink to MCC, and on-board computers. The OI/PL data RAM also stores the OI and PL for crew displays.

The TLM FMTR uses a programmed (PGM), or fixed (FXD), Telemetry Format Load (TFL) to process the High and Low Data Rates. The FXD is a programmable read-only memory (PROM), as part of the PCMMU design. The PGM TFLs are loaded into a high and low random access memory (RAM) storage device, by Command (INCO), or the crew, via SM SPEC 62 (Figure 4-23).

Each PCMMU contains five toggle buffers that can interface to any of the five GPCs. Operationally, however, only TBs 1, 2, and 5 are used to receive PASS/GNC, PASS/SM, and BFS DL, respectively, and then route the downlist data to the TLM

FMTR, based on the TFL. If a problem occurs with the GPC sending the d/I to the PCMMU, an alternate GPC can be selected on GPC MEMORY (SPEC 0), as available. If a problem occurs with the GPC/PCMMU Interface Port (IP), or within the TB itself, the alternate PCMMU must be selected to restore d/I to the TLM FMTR. Most likely, a PCMMU d/I problem will require a call from MCC to the crew, because the crew has little or no insight into MCC/downlisted telemetry.

```

      XXXX/062/      PCMMU/PL COMM      XX X DDD/HH: MM: SS
SM COM BUFF XXX   PCMMU              DDD/HH: MM: SS
PCMMU              PDI
BITE WORD XXXX   I/O RESET 8XX
FMT              BITB WORD XXXX
SBL FXD          1XS          9 SBL DECOM X
PGM              2XS          10 SBL FMT XXX
PGM ID 64 XXX   LOAD 11 XXXX
                128 XXX      12 SBL INPUT X
3 SBL ID XXX    LOAD 13
LOAD 4 XXXX    DECOM INPUT FMT
                1 X      XXS
                2 X      XXS
                3 X      XXS
                4 X      XXS
                5-FPM    XXX
I/O RBSBT       PCM 5XX      DECOM ENA
                                FDA 1 14X
                                2 15X
                                3 16X
                                4 17X
PSP              PL INTRG
I/O RBSBT        1 CHANNBL XXXS
PSP1 6XX        2 CHANNBL XXXS
PSP2 7XX        PHASE LOCK XXXS
SYNC            BIT XXXS      BRR ±XXS
FRAMB XXXS      XMIT PWR XX.XXS
LOAD XXXX XXXX  PL SIG STR X.XXS 18 TFL GPC SBL X
                                                    ( XX)

```

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Figure 4-23. SM SPEC 62

A power interrupt, or cycle, of PCMMUs erases the PGM TFLs, which reside in the HBR (128) and LBR (64) RAM buffers, respectively. The fixed TFL, format number 129, is hard-coded into the FXD PROM before launch. The FXD TFL is not lost during a PCMMU power interrupt or cycle. In fact, a PCMMU activates with the FXD TFL selected. This allows telemetry to be processed while the PGM TFLs are loaded. The crew/or MCC selects the FXD TFL (129), Item 1 on SPEC 62, to change or load PGM TFLs for two reasons: 1) selecting fixed allows telemetry to be processed while loading PGM TFLs, and selecting FXD enables the 128 RAM Format to be changed. 128 RAM (PGM) TFLs can only be loaded or changed when PASS SM is available, such as during Ops 9 or Ops 2. During ascent or entry, the BFS provides an AUTO load function of the 64 TFL if the crew changes PCMMUs. The AUTO load may not occur if MDM OF1 is bypassed. During orbit, the AUTO load function is not provided, therefore MCC or crew must reload the PGM TFLs when the alternate PCMMU is selected. If the MCC has NO SM downlist data the crew is required to Load the new 128 PGM format.

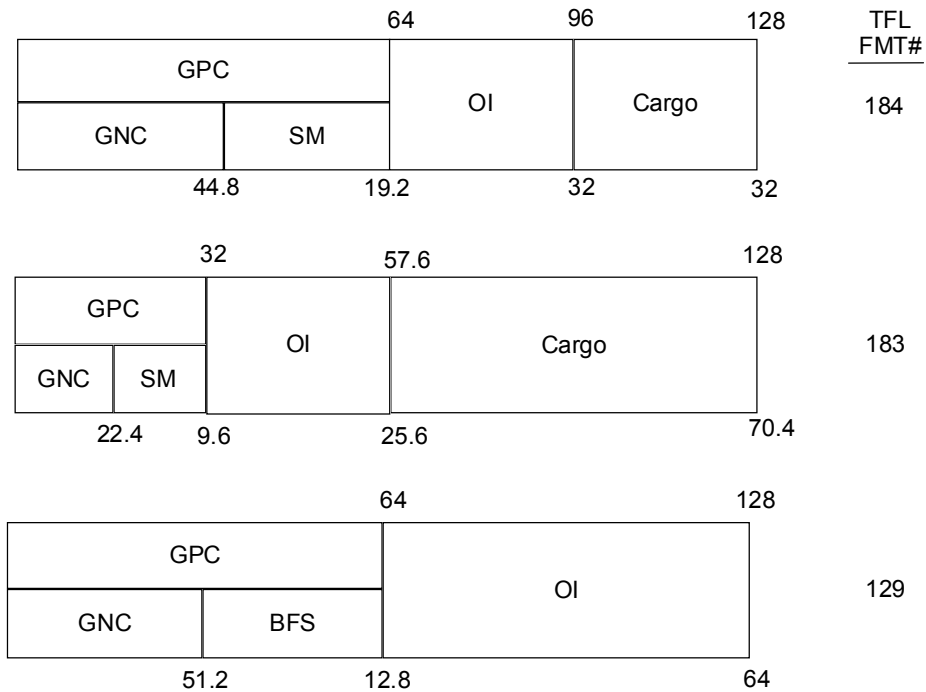
The PGM TFLs determine the amount of GPC d/I, OI, and PDI data being formatted relative to mission phase and requirements. Generally, ascent and entry will have minimal, if any, PDI data; whereas on orbit, the PDI data window will be larger relative to the GPC and OI data in the overall telemetry data stream.

TECHNICAL NOTE

The following information uses the Space Shuttle Telemetered and Recorded Data Format Requirements, (JSC-10784), for window sizes, etc.

Note: The data window order shown is not necessarily the actual order in downlinked telemetry.

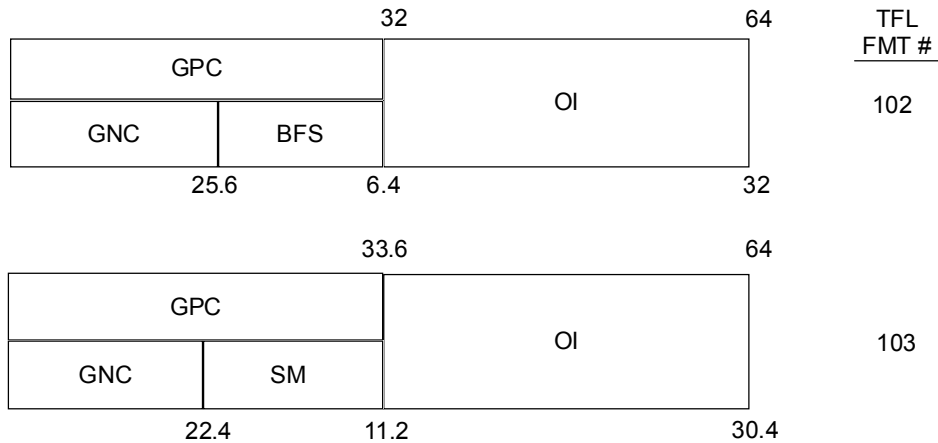
Basically the TFL breaks the telemetry into windows or segments for the different sources of data: GPC downlist (PASS GNC, PASS SM, and/or BFS); OI (MDM); and cargo/payload (PDI). The total HBR telemetry stream is 128 kbps (or 128,000 bits second (bps)). Figure 4-24 shows some sample breakdowns in kbps for three common 128 RAM TFLs.



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Figure 4-24. Common HBR TFLs

The total LDR telemetry stream is 64 kbps (or 64,000 bps). Figure 4-25 shows the breakdown for the two “prime” 64 RAM TFLs.



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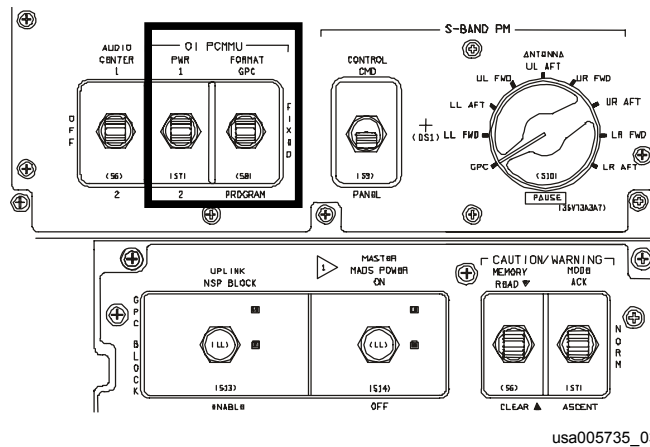
Figure 4-25. Prime LBR TFLs

4.3.9 TLM Display and Controls

The OI PCMMU PWR and FORMAT switches, are on Panel C3, see Figure 4-26. The OI PCMMU:

- PWR switch selects PCMMU 1, OFF (neither) or PCMMU 2.
- The FORMAT switch positions are: PROGRAM, for the 128 RAM formatter; FIXED for the 129/Fixed PROM formatter; or GPC for selecting FXD or PGM via SM SPEC 62.

It is important to know that the C3 switch overrides the SM software selections on SM SPEC 62. Normally, the PWR switch is set to 1, and the FORMAT switch to GPC.



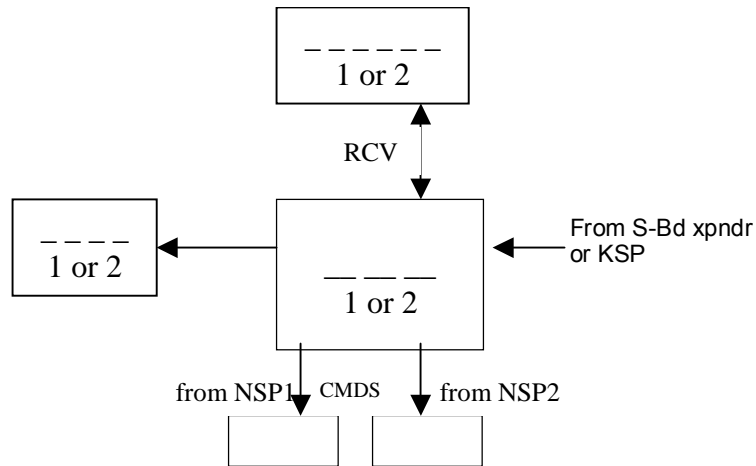
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Figure 4-26. OI PCMMU switches (Panel C3)

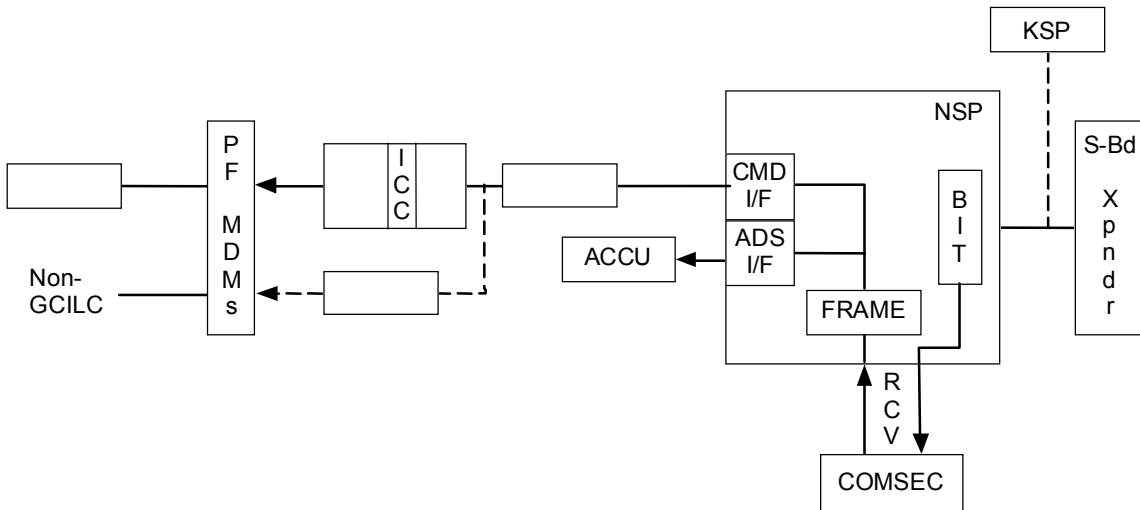
QUESTIONS

1. Identify the two primary functions of the NSP:
 - (a) Combining data from PDI, OI and GPCs for downlink and on-board laptops
 - (b) Separating Command and Voice on the uplink and combining Data and Voice on the downlink with MCC
 - (c) Routing Data to recorders and downlink RF systems

2. Fill in the interfacing LRU systems for uplink with the NSP.



3. Complete the command path LRU for commanding Comm systems from the NSP shown.



td203a_002aq.cnv

- 4a. [circle] Normally the NSP and S-Bd PM is operating on String: 1 2
- 4b. According to the standard S-band/Ku-band PNL CONFIG, as found in the Orbit Operations Checklist, fill in the INFORMATION for each configuration:

Standard configuration	STDN(SGLS) S-BD	TDRS S-BD	TDRS KU-BD
NSP data rate XMIT	HI	HI	HI
RCV	HI	HI	HI
UPLK DATA			
Coding XMIT	OFF	ON	ON
RCV	OFF	ON	OFF
S-BD PM MODE (Rot)	(SGLS)		—

- 5a. [circle] The normal 'back-up' configuration for the A1L (Back Panel) is String:
1 2
- 5b. Complete the table for the Back Panel/A1L configuration for the given flight phases:

	ASCENT	ORBIT	ENTRY
S-Bd PM mode			
NSP – UPLK DATA	S-BD		S-BD
Data rate XMIT -	HI	HI	HI
RCV -	HI	HI	HI
Coding XMIT -	OFF	ON	OFF
RCV -		ON	

6. The COMSEC is normally powered and configured as follows, using panel?

POWER: _____

PANEL: (circle)

MODE: _____

A1U A1L A1R C3

SELECT: _____

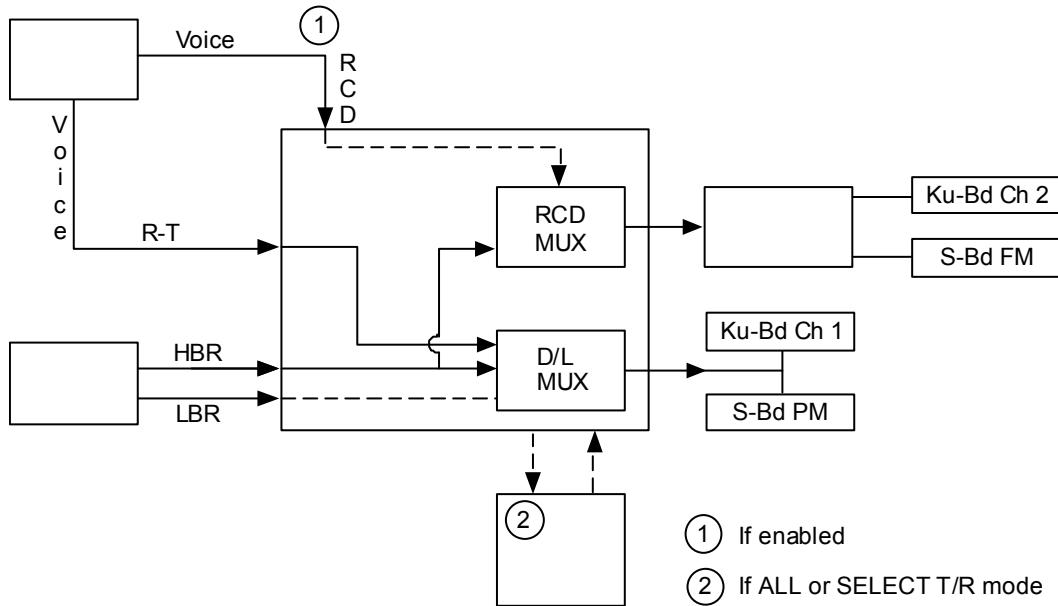
7. List the five Comm systems under control of the GCILC for selecting required functions and configurations via command or panel.

1) _____ 2) _____ 3) _____

4) _____ 5) _____

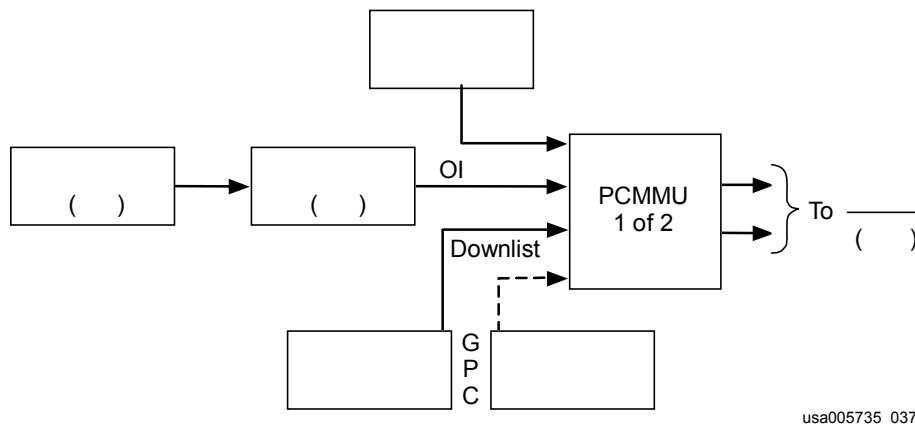
8. The GCILC control switch for the S-Bd PM and NSP functions is located on which panel?

9. Fill in the interfacing LRU systems for downlink with the NSP.



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10. Complete the telemetry path for OI, GPC d/I [PASS & BFS], and PDI data into the PCMMU shown.



11. Match the status indications that will be seen on SYS SUMM displays for the listed OI instrumentation failures?

- | | |
|-----------------------------|-----------------------------------|
| 1. An OI DSC failure fields | a. all Ms in SYS SUMM status |
| 2. An OI MDM failure fields | b. off scale low or Ls in status |
| 3. Total MDM-to-PCMMU | c. pattern of Ms in status fields |

12. A PCMMU formats the telemetry data into _____ and _____ data rates.
13. The TLM FMTR combines _____, _____, and _____, data based on the TFLs.
14. True/False. A power interrupt or selecting a new PCMMU will cause the formatter to default to the HBR/128kbps program TFL.
15. True/False. The OI PCMMU FORMAT switch overrides the SM SPEC 62 item selections for FXD and PGM TFLs.
16. True/False. The PCMMU must be in FIXED format for loading both the High and Low program TFLs.
17. True/False. Only the BFS provides an automatic load of the Low Rate TFL after changing PCMMUs.

5.0 RECORDERS

5.1 OBJECTIVES

After completing this section, the student will be able to

- Identify the LRU, and Avionics Bay, each Solid State Recorders (SSRs) is located
- Identify when SSRs record Data and Voice (versus Data only)
- Identify the system(s) used to playback (or dump) the SSRs during a flight
- State the primary purpose for the MADS
- Identify the crew panel for MADS recorders

5.2 OVERVIEW

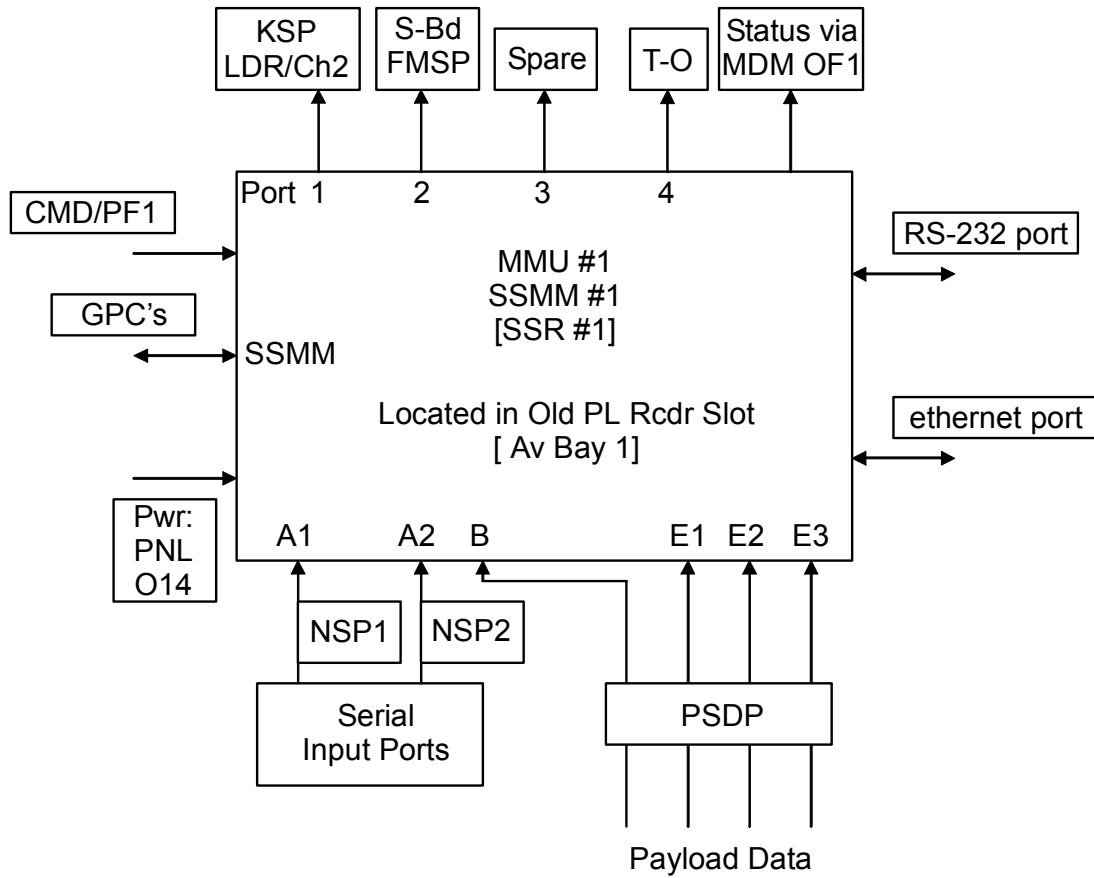
This section discusses the SSRs and MADS that provide backup or post flight information for the orbiter and payloads. Two SSRs provide recording and playback (dump) of PCMMU telemetry, or PCMMU telemetry plus voice, in the event of real-time downlink problems or during loss of signal periods. An NSP, as mentioned in Section 4, combines and routes the PCMMU telemetry plus voice or routes the PCMMU telemetry to the active SSRs.

MADS measures and records selected pressures, temperatures, strains, vibrations, and events data for dynamic flight activity, such as ascent, orbit maneuvers, and entry. MADS data is only retrieved after the shuttle returns after a mission.

Normally, the SSRs and MADS are operated from the MCC (command mode) by the INCO. MADS provides some crew interface panels for ground support personnel or in the event that MCC cannot control the recorders by command. This section reviews the basic purpose of the recorders and discusses the crew displays and controls.

5.2.1 Mass Memory Unit/Solid State Recorders

Figure 5-1 and Figure 5-2 show a block diagram of the MMU/SSR1 and 2, respectively with key interfaces for control, input sources, and output destinations.



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Figure 5-1. MMU/SSR1

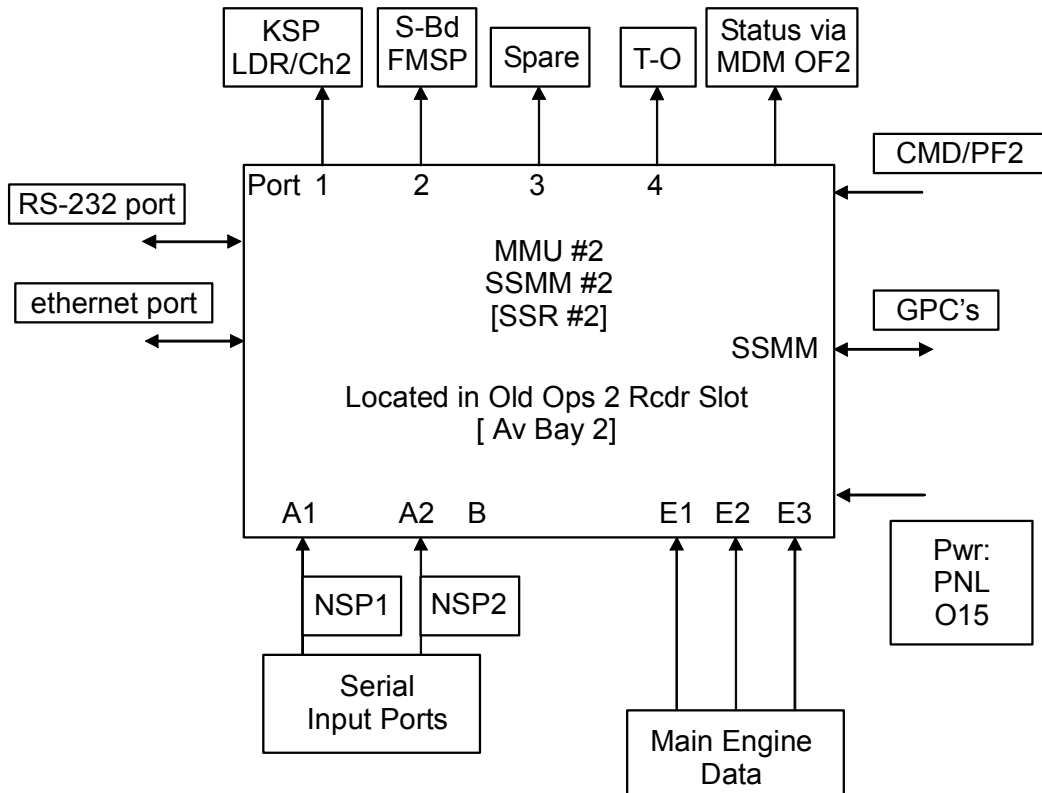


Figure 5-2. MMU/SSR2

The main reason for the SSRs is to record DATA and Voice, or DATA only to 'back-up' real time data. During high activity periods, such as ascent, payload deploys or rendezvous, and entry, SSRs usually record DATA (essentially the same as the real-time data) plus voice. Most other times they will record data only. Recorded data can be dumped to MCC through the S-band FM or Ku-band system.

- On ascent, SSR2 records the main engine data to back up the real-time data downlinked through the S-band FM system. This recorded main engine data is later dumped for comparison and information on main engine performance. After powered flight, at about Main Engine Cutoff (MECO) plus 6 minutes, the SSRs are configured by INCO to support orbit, then entry operations.
- On orbit the SSRs will be managed/commanded to record data, or data with voice, depending on flight or missions requirements. Also on some missions do to cryo or power savings only one SSR will be active at a time. Recall for voice recording, the voice channel selections are made from the crew's Audio Center Panel, A1R (lower), Figure 5-3.

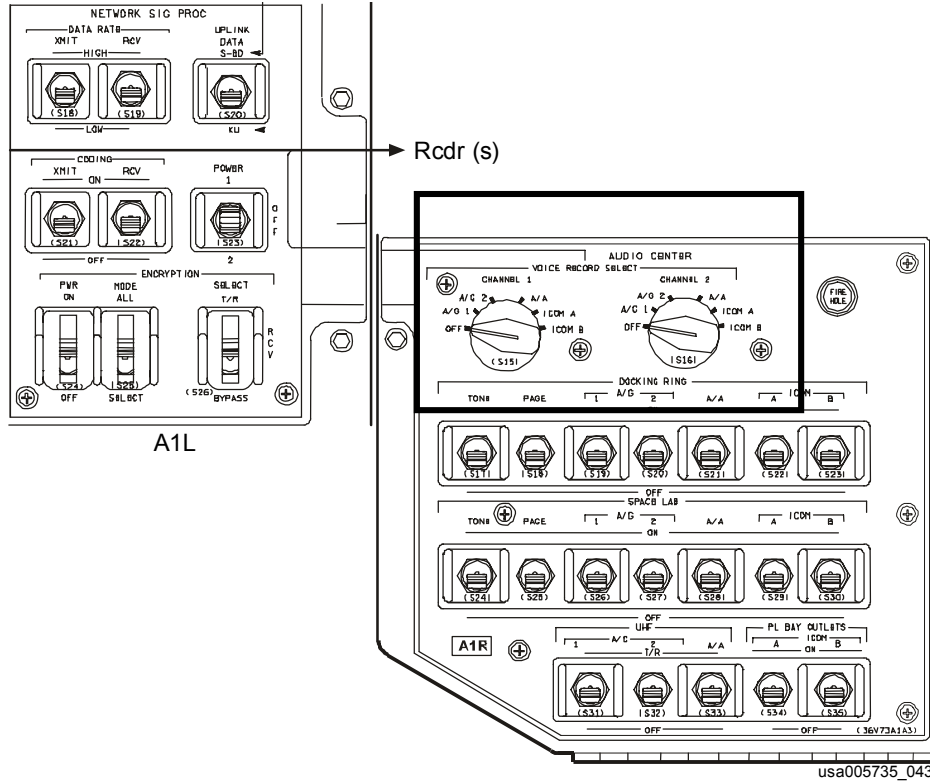


Figure 5-3. A1R (lower)

The command interface for SSR1 or 2, through the Payload MDMs (1 or 2, respectively), is the only means to configure and control the functions of the SSRs. Status/Telemetry for the configuration and operation of SSR1 and SSR2 is through the OI MDM OF1 and OF2.

Power is provided to the SSR when the associated MMU power switch is ON, and powered as shown in Table 5-1.

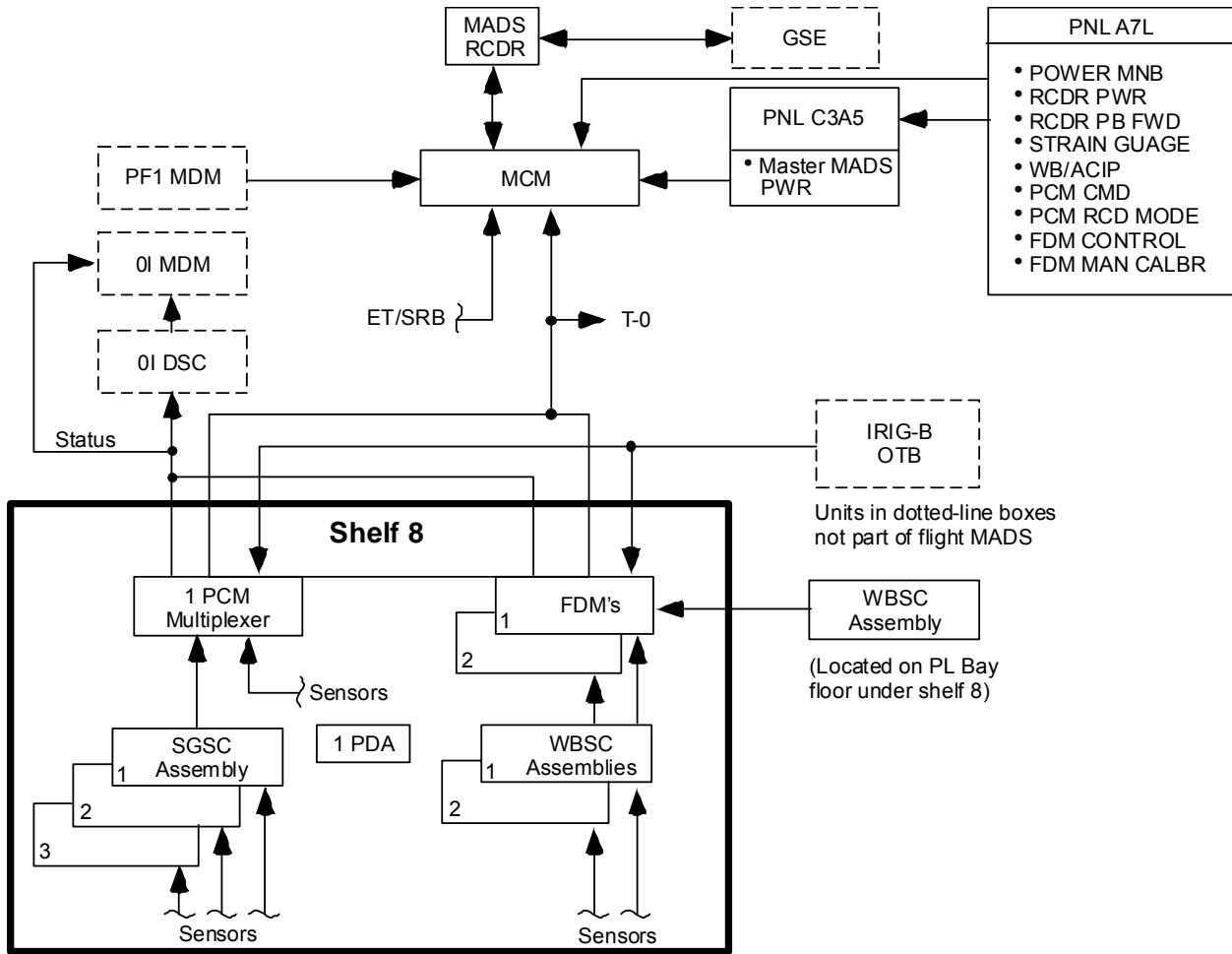
Table 5-1. MMU/SSR Switch and Power

MMU/SSR #	PANEL SW Location	MAIN /sub bus	Control Bus
1	O14	MNA/FPC1	AB1
2	O15	MNB/FPC2	AB2

5.2.2 Modular Auxiliary Data System

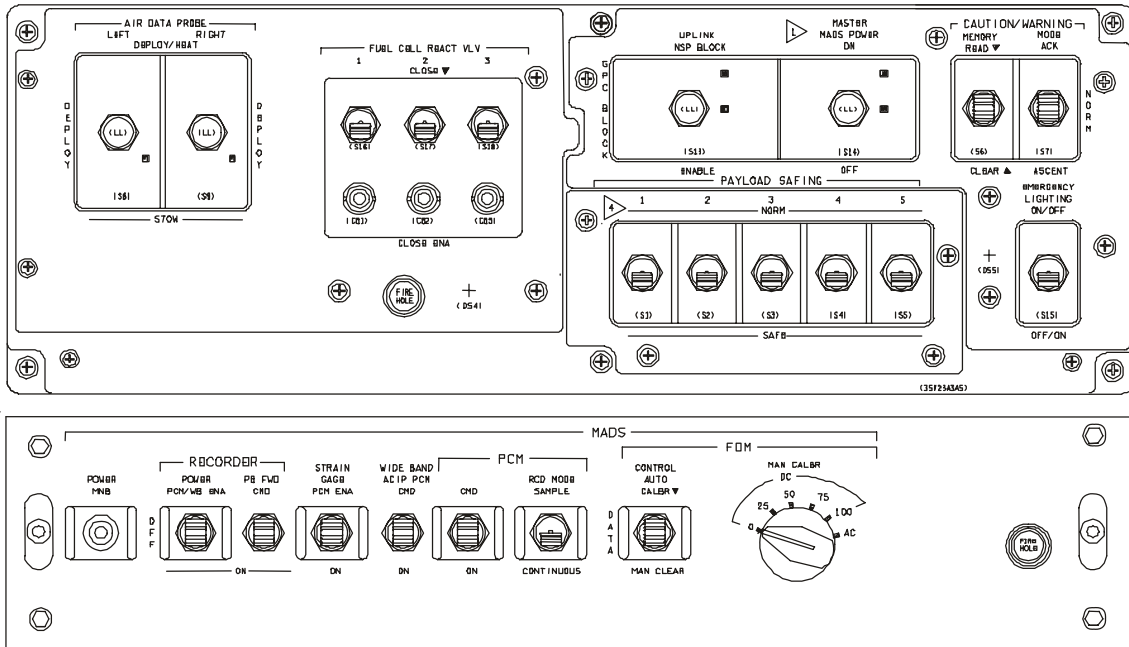
MADS provides data measuring and recording on orbiter equipment and structure points. Data collection includes pressures, temperatures, strains, vibrations, and events throughout the orbiter during a flight. Figure 5-4 a sample overview of the MADS system, Figure 5-5 shows crew panel, normally on A6 or A7.

The figures include the interfaces for control, command, and status of the respective recorder systems and the location of the crew panels. Basically, INCO configures the MADS throughout a mission. Crew switches are primarily for prelaunch and postlanding activities; however, crews should at least be familiar with the location of the control panels in case INCO cannot command. The master power switch for MADS is on Panel C3. Many powerdown procedures will have the crew turn the MADS OFF, because in full operation they use about 150 watts.



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Figure 5-4. Sample MADS overview



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Figure 5-5. Sample MADS control panels

QUESTIONS

1. The Solid State Recorders 1 and 2 are located in:
 - (a) Av Bay 1 and 2
 - (b) The Mass Memory Units 1 and 2, respectively
 - (c) The PCMMU1 or 2, respectively
 - (d) a and b
 - (e) a and c
2. True/False. SSRs can only be played back (or dumped) through the S-Bd FM system.
3. True/False. During high activity periods, such as ascent, payload deploys or rendezvous, and entry, SSRs usually record DATA plus voice. Most other times they will record data only.
4. Crew controls for the MADS are on panels _____ or _____, with the Master Power switch located on _____.
5. (Fill in) The primary purpose for MADS is to _____ and _____ selected orbiter data for dynamic event during ascent, critical orbit burns, and entry.

6.0 S-BAND FM

6.1 OBJECTIVES

After completing this section, the student will be able to

- State the primary purpose of the S-Bd FM system
- Identify the crew display and controls for the S-Bd FM system
- List the seven possible data sources for the FM signal processor
- Identify the antenna switch electronics control switch for the S-Bd FM hemi antennas

6.2 OVERVIEW

The S-Bd FM system provides wideband downlink of seven selectable data sources, including real-time sources or recorder dump data. The real-time data sources include TV, payload (PL ANLG, DOD, or PL DIGITAL), or Main Engine (ME) and the recorder sources identified on the rotary as MMU1 and MMU2, for SSR1 and SSR2. An eighth selection is OFF. Normal control of the S-Bd FM system is by command; however, crew display and controls provide some insight and control of the system. Recall that the S-Bd FM system is one of the five Comm systems under control of the GCILC. The crew controls are found on Panel A1R (Figure 6-1) including the GCILC switch.

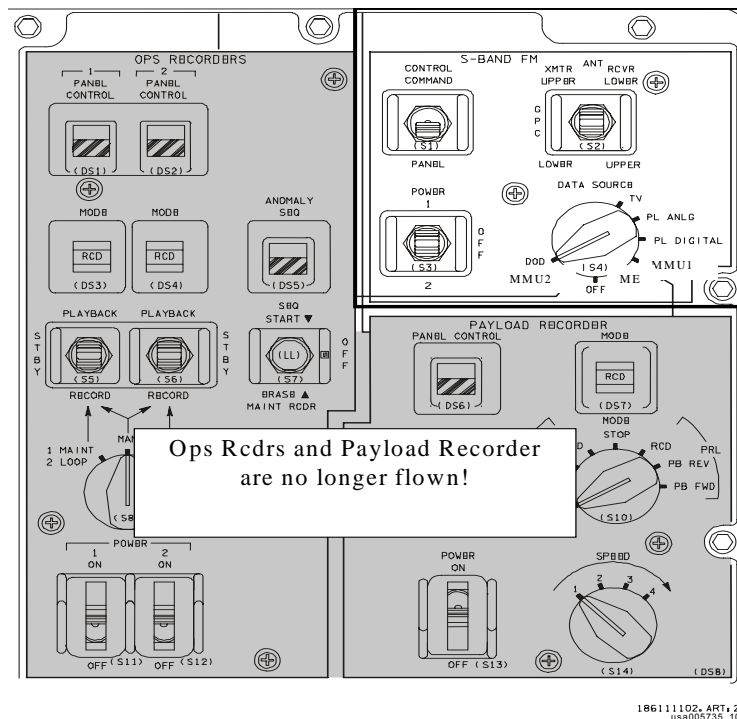


Figure 6-1. Panel A1R

In command, the functions are controlled by INCO at MCC. In panel, the POWER and DATA SOURCE switch provides crew control of the FM system (1, OFF, or 2), and the FM signal processor input source (one of eight options). The antenna switch is non-GCILC, like the S-Bd PM antenna system. In fact, the same antenna electronics unit controller provides PM and FM antenna management selections through either command or the manual crew switches. Recall, the crew switch for selecting S-Bd PM and FM antenna electronics is on Panel A1L which is under control of the S-band PM CONTROL switch on Panel C3. Figure 6-2 shows the FM associated Panels A1R, A1L, and C3.

The S-Bd FM has two hemi antennas that are located on the top and bottom of the forward fuselage, Figure 6-3.

The hemis can be selected such that one antenna transmits its source data to MCC, while the opposite antenna can receive a signal from a camera, such as an extravehicular mobility unit (EMU) camera. Note that the S-Bd FM system does NOT process any received camera signal. The FM hemi receives the camera signal and routes it to a separate receiver, usually in the middeck. Hence, the nomenclature for the S-Bd FM ANT switch is transmit (XMTR) upper/receive (RCVR) lower, or XMTR lower/RCVR upper. The crew can view which S-Bd FM antenna (ANT) hemi is chosen on the SM 2011 Antenna display (Figure 6-4).

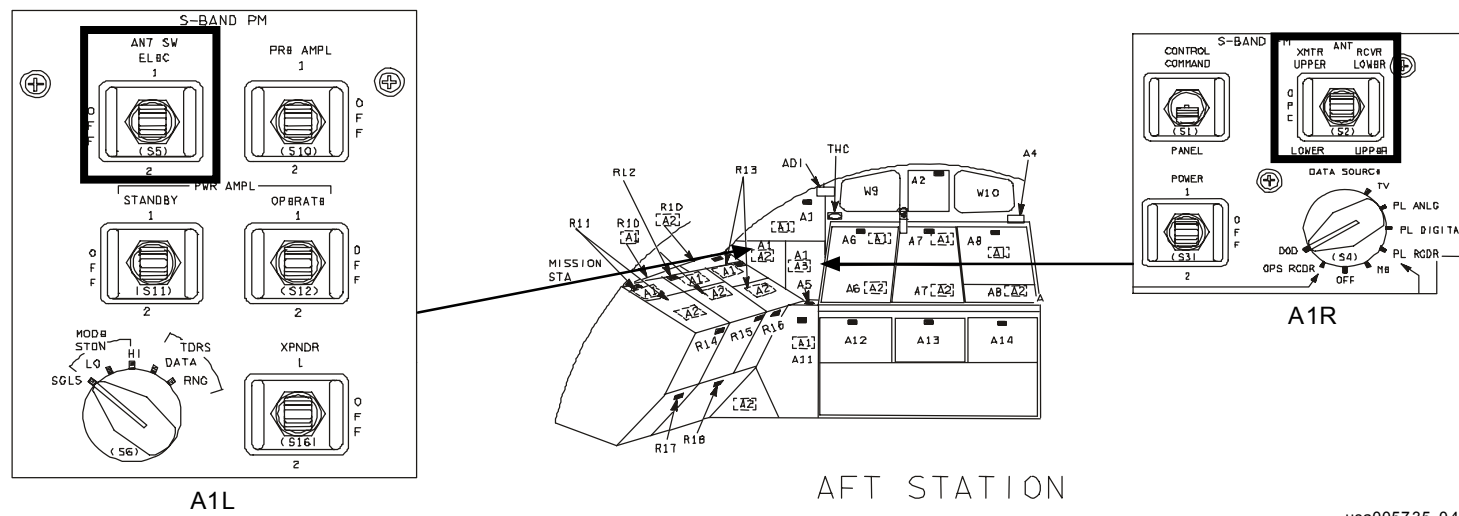
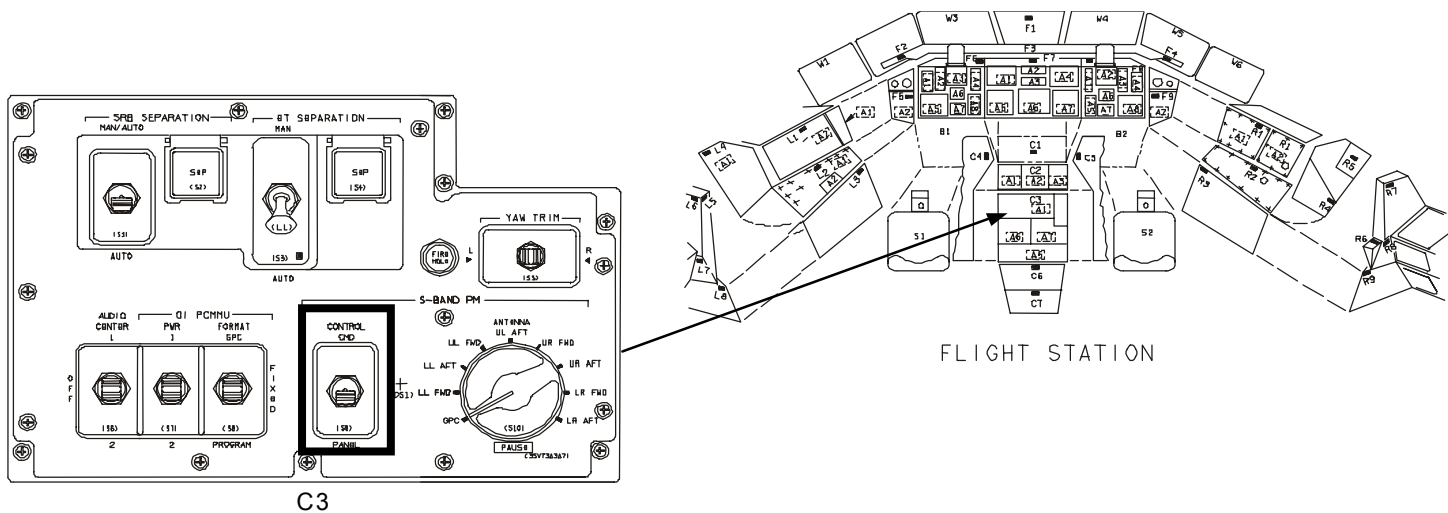


Figure 6-2. S-Bd FM antenna controls

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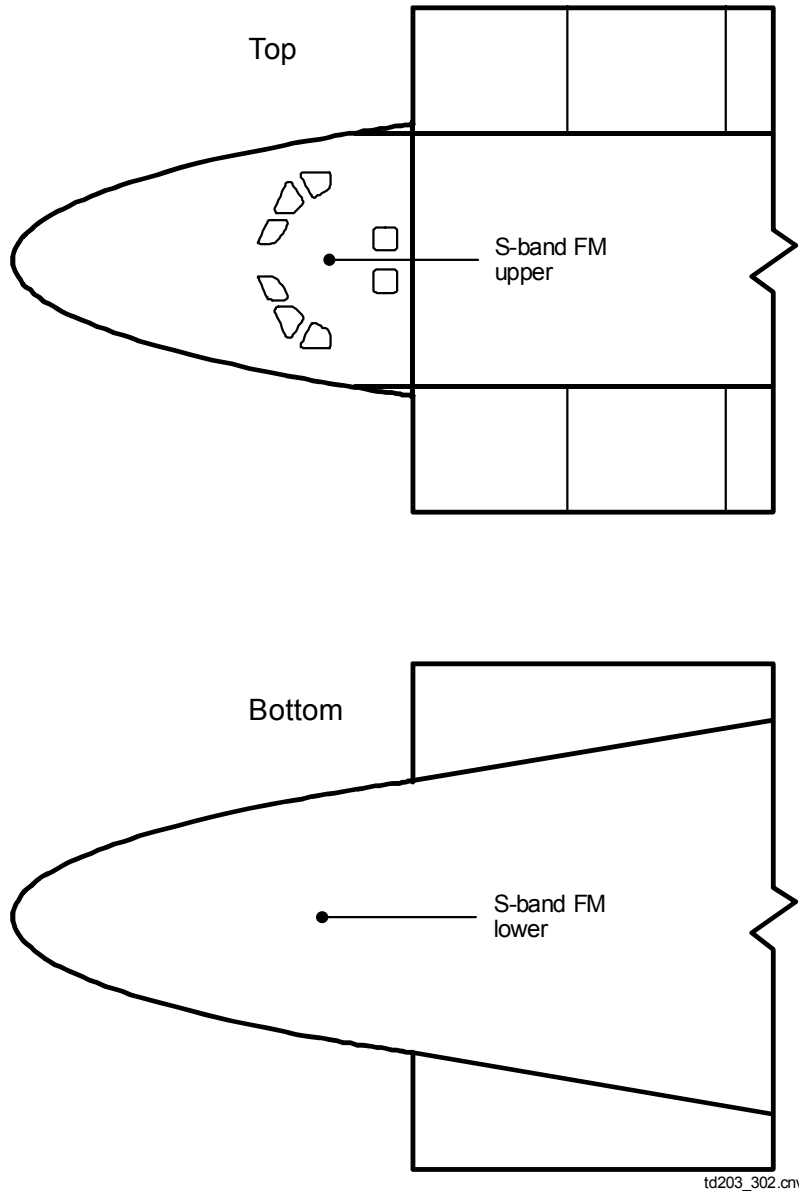


Figure 6-3. S-Bd FM system antenna locations

As for S-Bd PM antenna information, the ANTENNA display also provides the operating antenna electronics unit (ANT ELEC) and shows if a STDN/SGLS site is in view. The STDN/SGLS site identifier is displayed under the STDN field, when SITE is enabled in the flight software, by INCO. Also an "S" will appear on the map for the relative position of the orbiter-to-ground site.

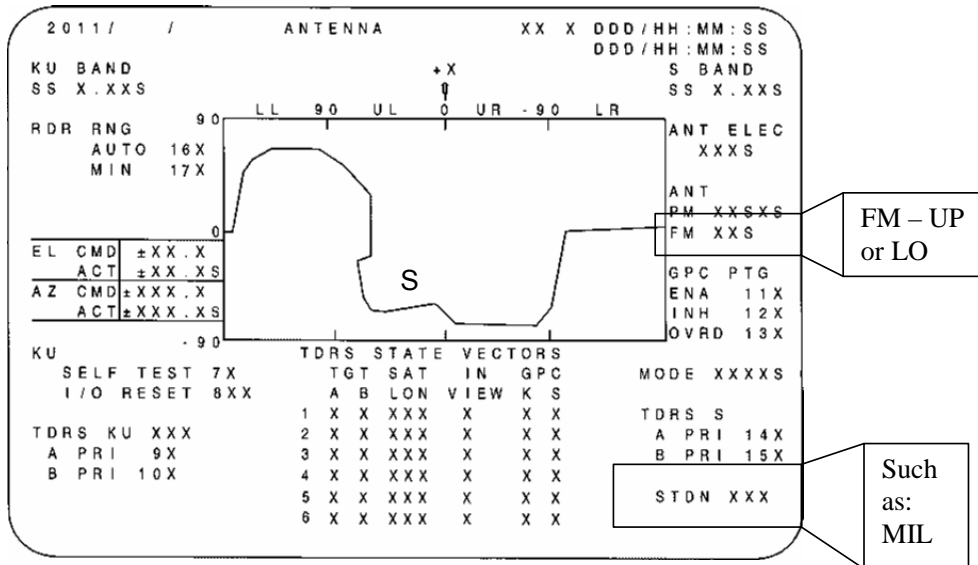


Figure 6-4. SM 2011 ANTENNA display

The S-Bd FM system provides real-time main engine data during ascent to various ground control centers, including MCC. After MECO plus several minutes, the S-Bd FM source is commanded to dump the SSRs. INCO will select other sources, throughout orbit, based on mission requirements. On orbit, the S-Bd FM system is considered as a backup to Ku-band for sources that can be sent or dumped through either system. Redundant downlink capability of S-Bd FM and Ku-band includes TV, PL ANLG, PL DIGITAL, MMU/SSR1 and MMU/SSR2. Ku-band has a higher transmit data rate but can have blockage problems because of orbiter attitude. S-Bd FM does not have a big problem with orbiter attitude but must be over a STDN or SGLS site that supports orbiter S-Bd FM and relays it to MCC. After landing, the FM system is used to complete any remaining SSR dumps, particularly deorbit and entry data.

QUESTIONS

1. What does the S-Bd FM system provide?

2. What SM display allows a crew to view S-Bd FM antenna and site information?

3. The S-Bd FM crew controls are on which three panels?

4. List the seven data sources, other than OFF, for the S-Bd FM system:
 1. _____
 2. _____
 3. _____
 4. _____
 5. _____
 6. _____
 7. _____

5. True/False. The Antenna Electronic unit for selecting the S-band PM Quad Antennas also contains the logic to select the FM Hemi antennas.

7.0 S-BAND COMM/INST OPERATIONS REVIEW

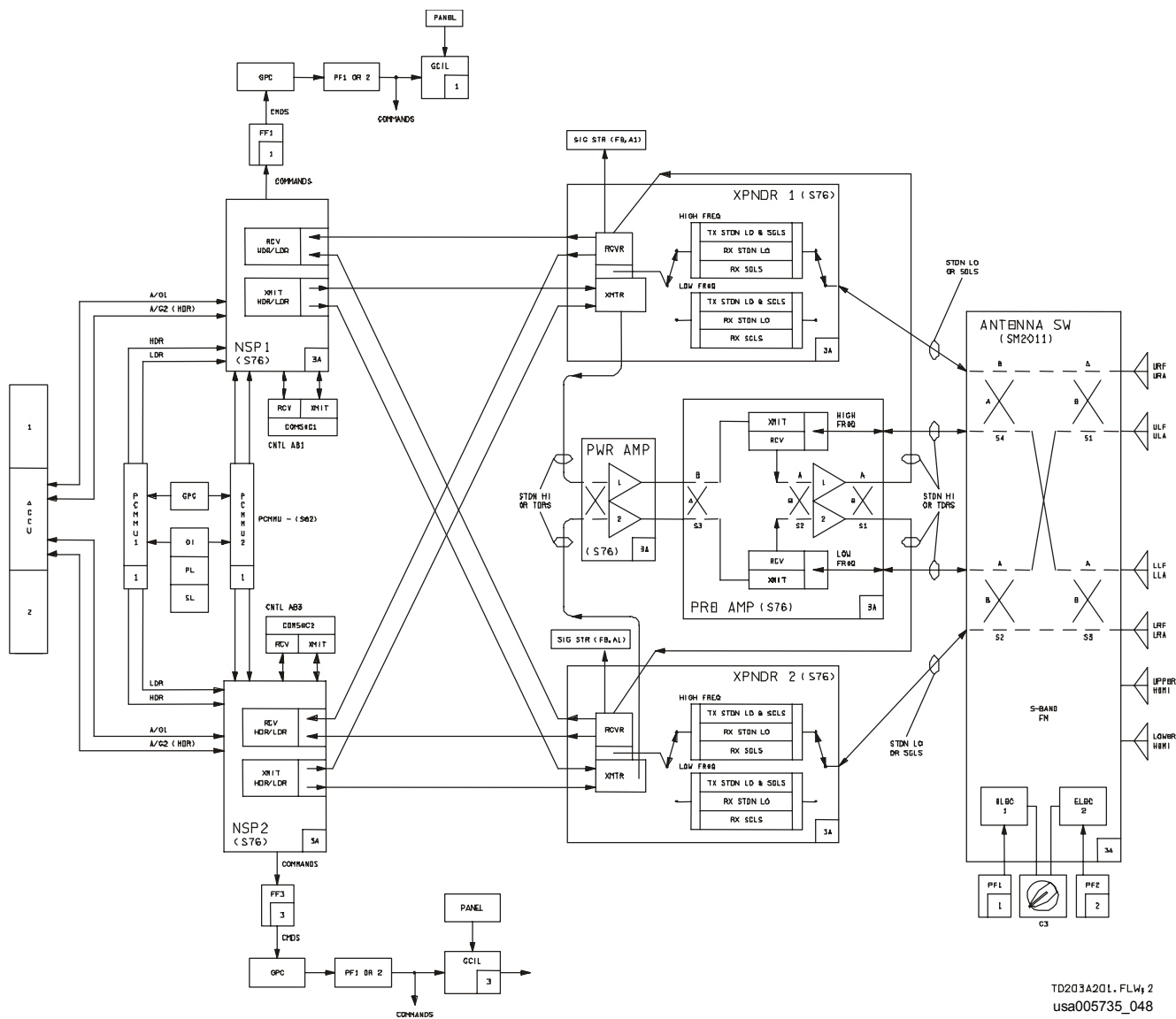
7.1 OBJECTIVES

Recall that the overall objectives for this training manual are to

- Identify the LRUs used for S-band PM high power and low power modes
- Identify the S-band PM transponder modes used to communicate through TDRSS, STDN, and RTS
- Trace the UL (voice and commands) from the received antenna to the ACCU and GPC for high power and low power modes (see Figure 7-1), given appropriate S-Bd PM D&C information
- Trace the DL (voice and telemetry) from the ACCU and PCMMU to the transmitting antenna for high power and low power modes (Figure 7-1), using the S-Bd PM D&C information
- Identify crew displays, controls and other cockpit cues used for monitoring and controlling S-band Comm systems
- Identify OI INST failures, such as an OI DSC failure, OI MDM failure, and total MDM-to-PCMMU interface problem, from failure information given

7.2 UPLINK AND DOWNLINK OPERATIONS

This section ties together the discussion in the previous six sections on how to operate, status, and troubleshoot S-band Communications and Instrumentation systems and their LRUs. It should also prepare you for the COMM/IN SSTs.



TD203A201.FLW_y 2
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Figure 7-1. Comm flow

7.2.1 S-band Review

The S-Bd PM is the primary RF Comm link between MCC and an orbiter. The S-Bd PM system 1, or 2, interfaces to NSP 1, or 2, to provide UL (commands and voice) and DL (telemetry and voice) support for all phases of shuttle flights.

The S-Bd PM LRUs (ANT ELEC, PRE AMP, PWR AMPS, and XPNDRs) and NSP/COMSEC LRU pair can operate as System 1 (String 1), System 2 (String 2), or cross-strap between LRUs 1 and 2 for failures. Normally, String 2 (i.e., ANT ELEC 2, PREAMP 2, XPNDR2, NSP/COMSEC 2, and PWR AMP 2) is the operating Comm string, with String 1 set up on the Crew Panel (A1L) to activate using the C3 S-band PM CONTROL (PNL/CMD) switch.

The S-Bd Comm system can communicate through STDN or the TDRSS sites operated by NASA. For contingency or special operations the SGLS/RTSs operated by the USAF, can also be used.

- The S-BD PM XPNDR uses STDN HI or LO mode to communicate through STDN
- SGLS to communicate through RTS
- and TDRS Data to communicate through TDRSS

S-band PM XPNDR modes STDN HI and TDRS are considered S-Bd PM high power modes because they use the PREAMP for UL and DL and the PWR AMP for DL operations. S-band PM XPNDR modes STDN LO and SGLS are low power modes that bypass the PRE AMP and PWR AMP for UL and DL.

Crew displays: A complete review of communication (and other) displays can be found in the Orbiter Display Reference Guide, for the appropriate OI Software.

The specific displays for Comm status or troubleshooting are: The SM OPS 2011 (ANTENNA) and SM SPEC 76 (COMMUNICATIONS).

Additional displays for command or instrumentation analysis are: SM SPEC 62 (PCMMU/PL COMM); SM SPEC 1 (DPS UTILITY); and SM SYS SUMMs provide insight and troubleshooting into S-band Comm and INST systems. GNC SYS SUMM 2 provides additional insight into some OI DSC parameters when BFS is available.

Using the ANTENNA and COMMUNICATIONS display, Figure 7-2, the crew has status about the operating S-Bd PM Comm system. Since the S-band PM system is controlled by the GCILC, the display versus panel configuration will not be the same unless a total failure of the GCILC occurs. Usually the system, hence displays, should show string 2 operating while the panel is in the backup string 1 configuration.

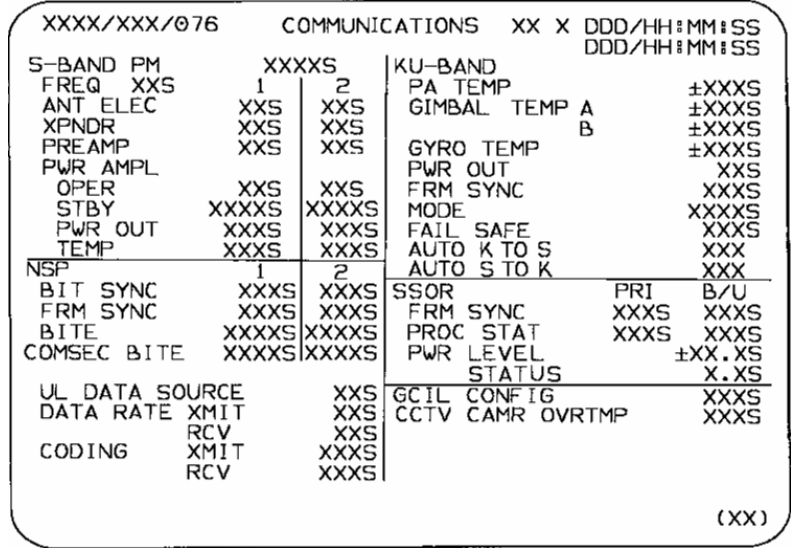
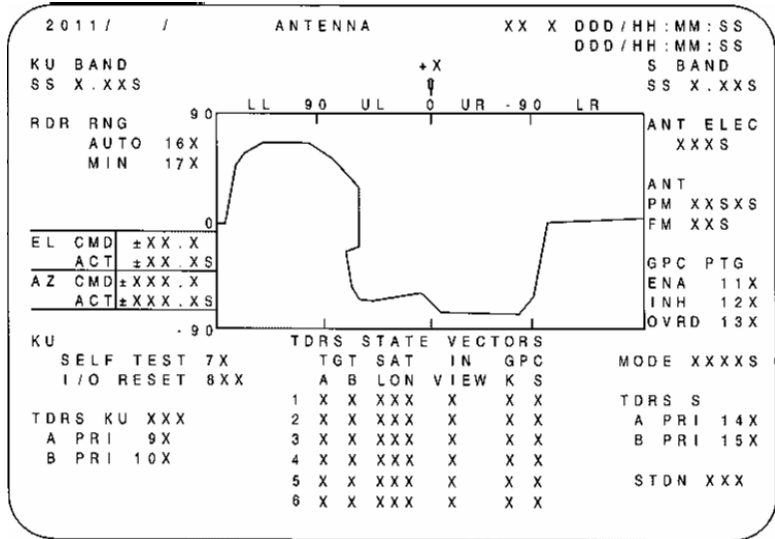
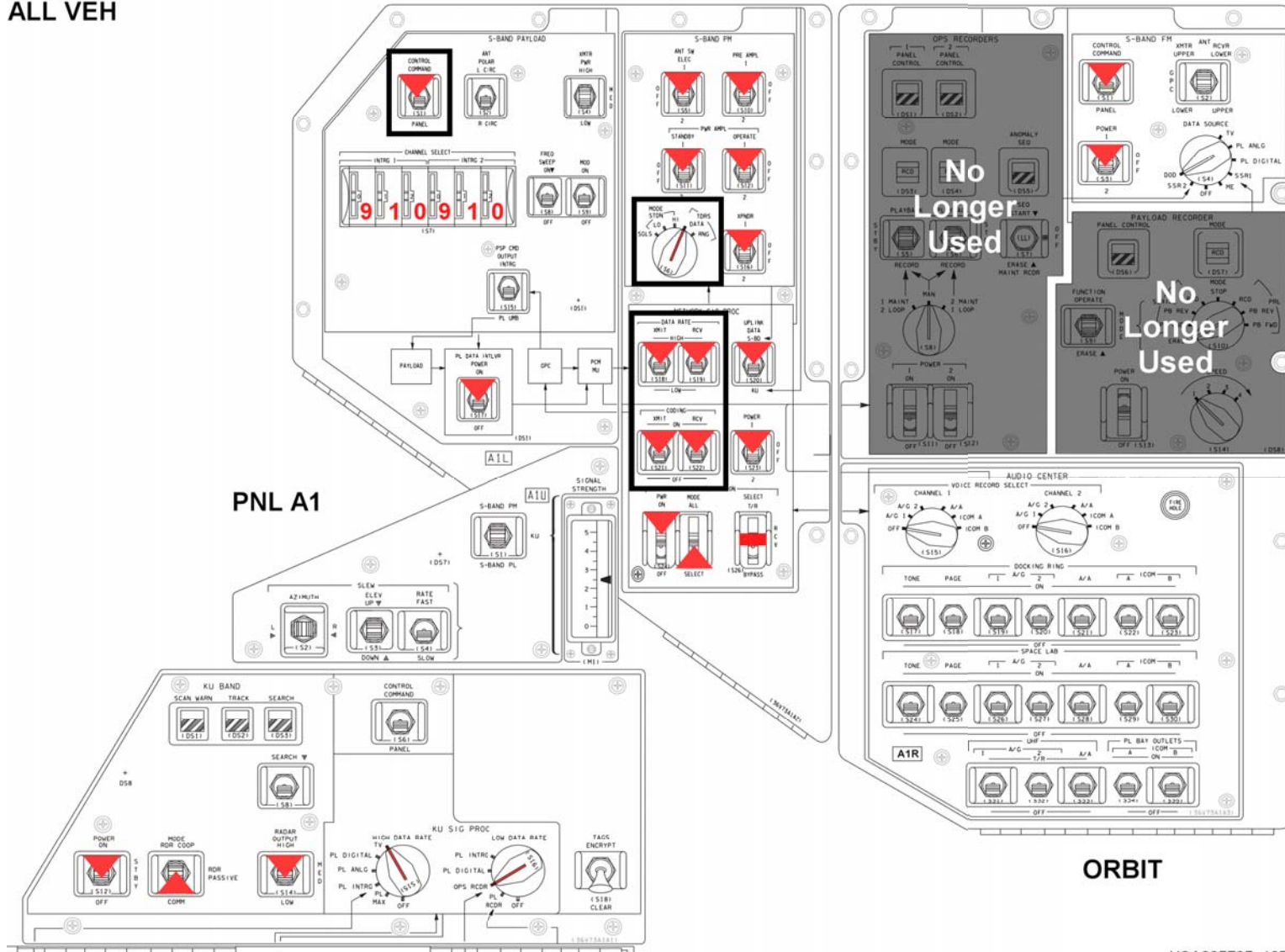


Figure 7-2. ANTENNA and COMMUNICATIONS displays

Crew panels and meters on Panels A1U, A1R, A1R lower (audio center), A1L, A7L, C3, F9, 014-017, and R14 provide the crew with manual control and signal strength indications for S-band Comm and Inst systems. You may also find these panels in Space Shuttle Systems Handbook (SSSH, Section 20).

ALL VEH



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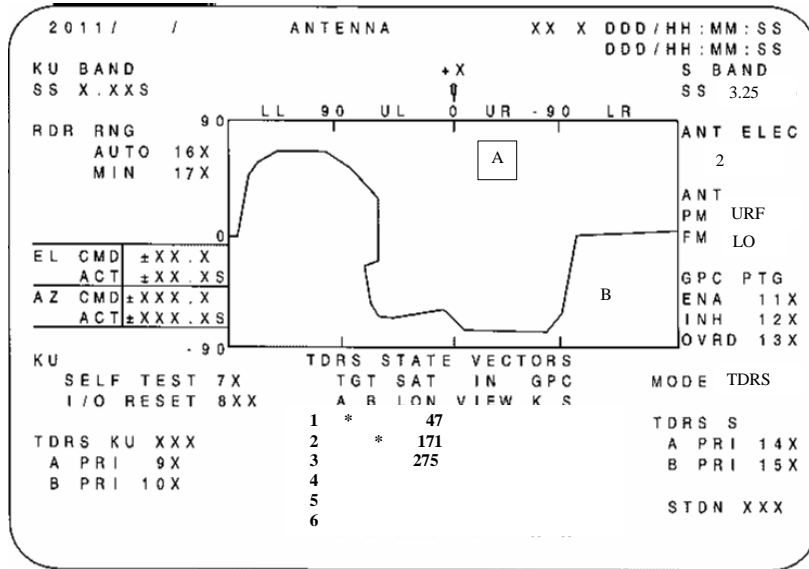
Figure 7-3. A1 Communications panels

The COMMUNICATIONS and ANTENNA display may be used to trace through the S-band PM Comm UL and DL. An example follows, using Figure 7-4 and Figure 7-5 Crew display information: Assume: ACCU 1, PCMMU1 and COMSEC in SELECT/RCV

- Figure 7-6 shows the UL from the S-Bd PM receiving antenna to the output of the NSP, which ends at the active ACCU or GPC path.
- Figure 7-7 shows the DL from the ACCU and PCMMU to the S-Bd PM transmitting antenna.

S-BAND PM		TDRS		XXXX/XXX/076 COMMUNICATIONS XX X DDD/HH:MM:SS DDD/HH:MM:SS				
FREQ LO	1	2		S-BAND PM	TDRS	?	KU-BAND	
ANT ELEC		ON		FREQ LO	1	ON	PA TEMP	±XXXX
XPNDR		ON		ANT ELEC		ON	GIMBAL TEMP A	±XXXX
PREAMP	ON			XPNDR		ON	GIMBAL TEMP B	±XXXX
PWR AMPL				PREAMP	ON		GYRO TEMP	±XXXX
OPER		ON		PWR AMPL		ON	PWR OUT	XXS
STBY		STBY		OPER		STBY	FRM SYNC	XXXX
PWR OUT		132		STBY		133	MODE	XXXXXS
TEMP		168		PWR OUT		165	FAIL SAFE	XXXX
				TEMP		?	AUTO K TO S	XXX
				NSP	1	?	AUTO S TO K	XXX
NSP	1	2		BIT SYNC		YES	SSOR	PRI B/U
BIT SYNC		YES		FRM SYNC		YES	FRM SYNC	XXXX XXXS
FRM SYNC		YES		BITE		GOOD	PROC STAT	XXXX XXXS
BITE	GOOD	GOOD		COMSEC BITE	FAIL	GOOD	PWR LEVEL	±XX.XS
COMSEC BITE	FAIL	GOOD					STATUS	X.XS
UL DATA SOURCE		S		UL DATA SOURCE		S	GCIL CONFIG	XXXX
DATA RATE XMIT		HI		DATA RATE XMIT		HI	CCTV CAMR OVRTMP	XXXX
		HI		RCV		HI		
		ON		CODING XMIT		ON		
		ON		RCV		ON		
		ON						

Figure 7-4. SM/Spec 76 Communications



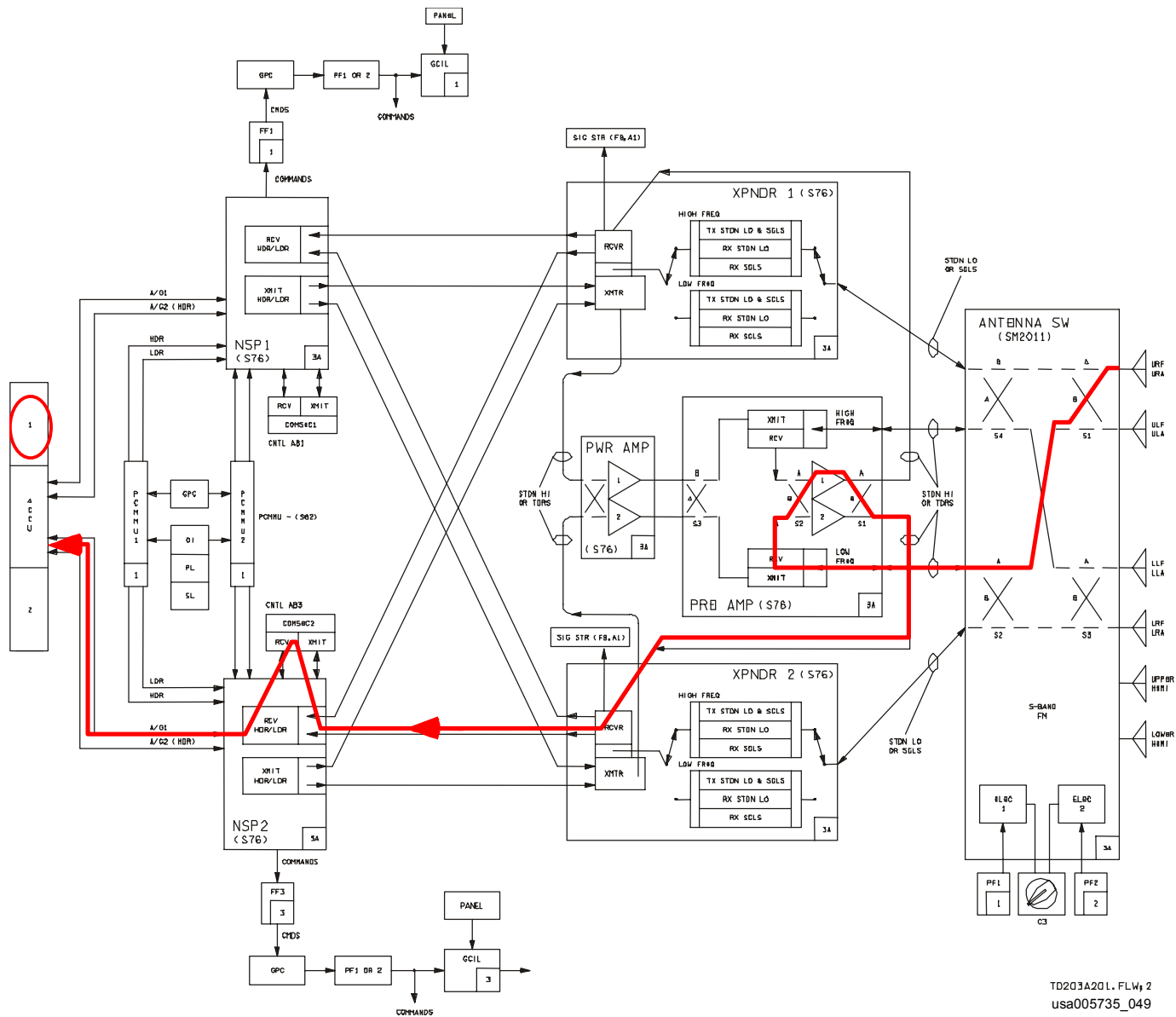
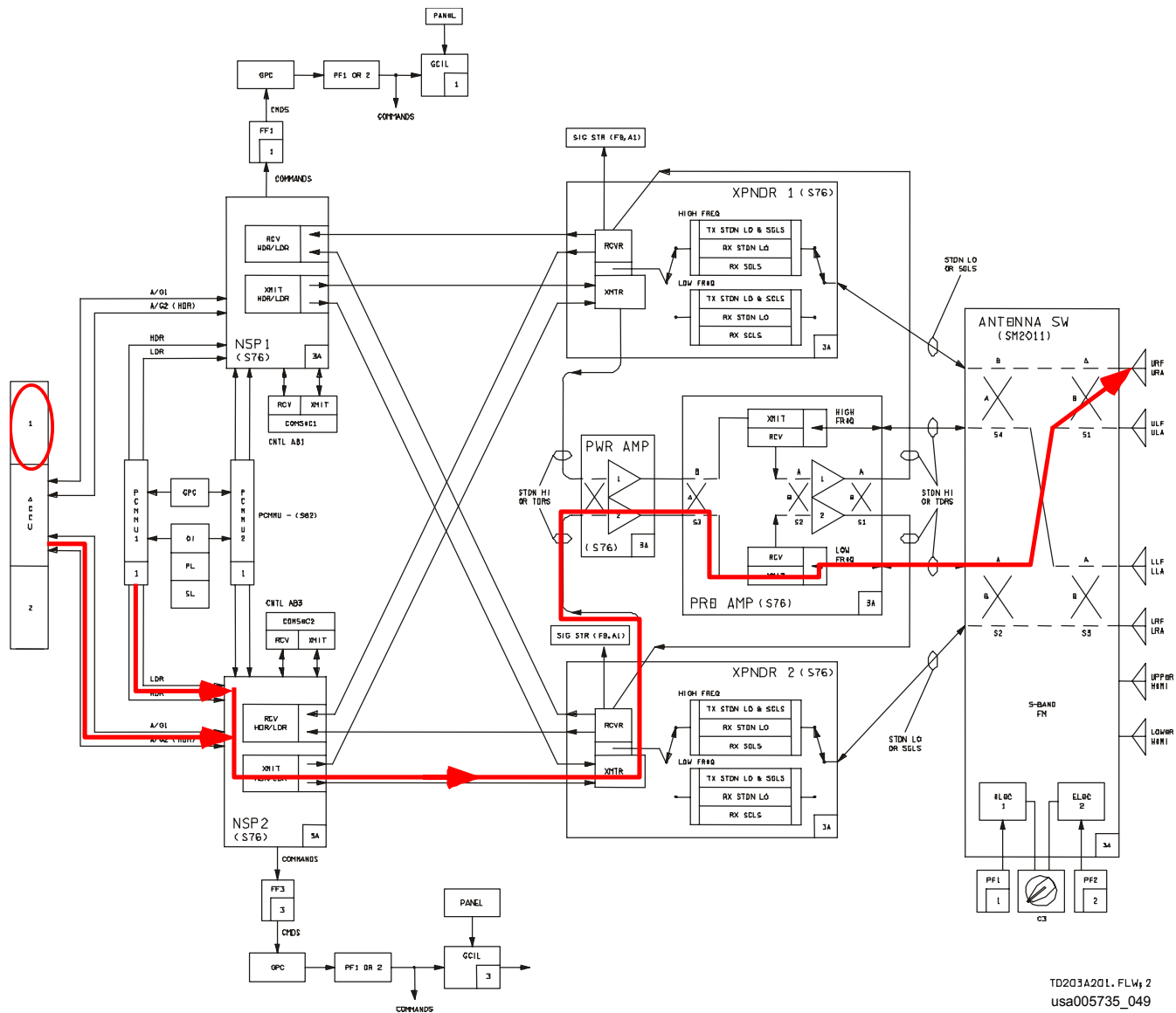


Figure 7-6. S-Bd PM Comm UL trace

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TD203A201.FLV4.2
usa005735_049

Figure 7-7. S-Bd PM Comm DL trace

Recall also that the F9 and A1U Panels have meters to display S-Bd PM receive signal strength. Data for the meters come directly out of the XPNDR receiver when a receive lock is present. Not that the S-Bd PM signal strength seen on the ANTENNA display comes from the PCMMU OI/PL DATA RAM via OI MDM OF3.

There are several Cockpit Cues that the crew should be aware of in trouble shooting the S-Bd PM Comm system; these include the following:

- Current location of Comm site (Acquisition Of Signal (AOS) vs. Loss Of Signal (LOS)) relative to orbiter and S-Bd PM transponder mode (ANTENNA or S76 COMMUNICATIONS display). Comm sites may include the TDRS, STDN or SGLS network when using the TDRS Data, STDN HI or LO, or SGLS modes, respectively.
- Attitude of orbiter relative to Comm site
- Presence or absence of S-Bd PM signal strength (meters and ANTENNA display)
- Presence or absence of NSP BIT and/or FRAME sync (SPEC 76) or NSP Lock on (BFS/GNC SPEC 51)
- Presence or absence of Air-to-Ground (A/G) voice (audio)

Note: S-band PM Comm, specifically in TDRS mode, can be affected, even lost, in tail-to-TDRS or nose-to-TDRS attitudes; see Figure 7-8. The shaded areas shown are somewhat oversimplified to show the regions where comm could be affected.

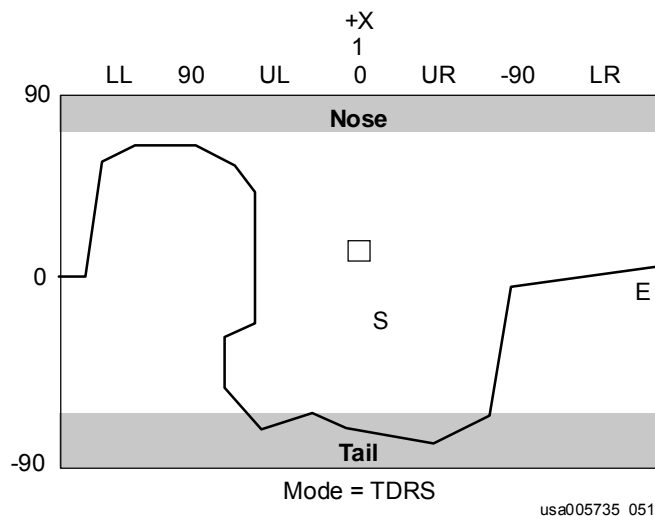


Figure 7-8. S-Bd PM nose-tail LOS regions

The Reference Data Book or “orbit” Malfunction Produced (MALF PROC) gives tables to help identify OI DSC failures only. The OI DSC failures show “off-scale low” (L) indications in the status field for lost parameters, through the failed DSC. Note that multiple messages will occur relating to parameters lost that go through the failed DSC. Figure 7-9 shows the OI DSC failure signature SYS SUMMs from the Reference Data Book.

CAUTION

Care must be taken in using OI DSC MALF ID displays to determine MDM problems, although certain patterns of Ms on these displays can help isolate an MDM failure. This process is used in the S62 BCE BYP XXX procedures.

The AESP/APCL or EPCL (Ascent/Entry Systems Procedures or Ascent or Entry Pocket Checklist) or MALF PROC provides procedures to handle and identify single OI MDM or total OI MDM-to-PCMMU problems. OI MDM and OI MDM-to-PCMMU problems show missing (M) indications on the SM SYS SUMMs display.

During Ascent Entry Systems Procedure (AESP), Ascent Pocket Checklist (APCL), or Entry Pocket Checklist (EPCL) phases, a generic I/O ERROR PCMMU message occurs for partial or total OI MDM-to-PCMMU failures. It is best, if the time permits, to check the BFS SYS SUMMs for partial or total Ms when an I/O ERROR PCMMU occurs, then call MCC prior to selecting the new PCMMU (PCMMU 2/1).

On orbit, the SM GPC will give an S62 BCE BYP OFA, OFB, and/or OA message for partial or total MDM-to-PCMMU failures. The MALF PROC provides procedures for identifying the OI MDM related problem as OI MDM OF1 or OF2 failures with the OFA; OI MDM OF3 or OF4 with the OFB; and OI MDM OA1, OA2, or OA3, with the OA message (see Figure 7-10). A total failure of all MDMs to PCMMU gives all three messages, and all Ms on the SYS SUMMs.

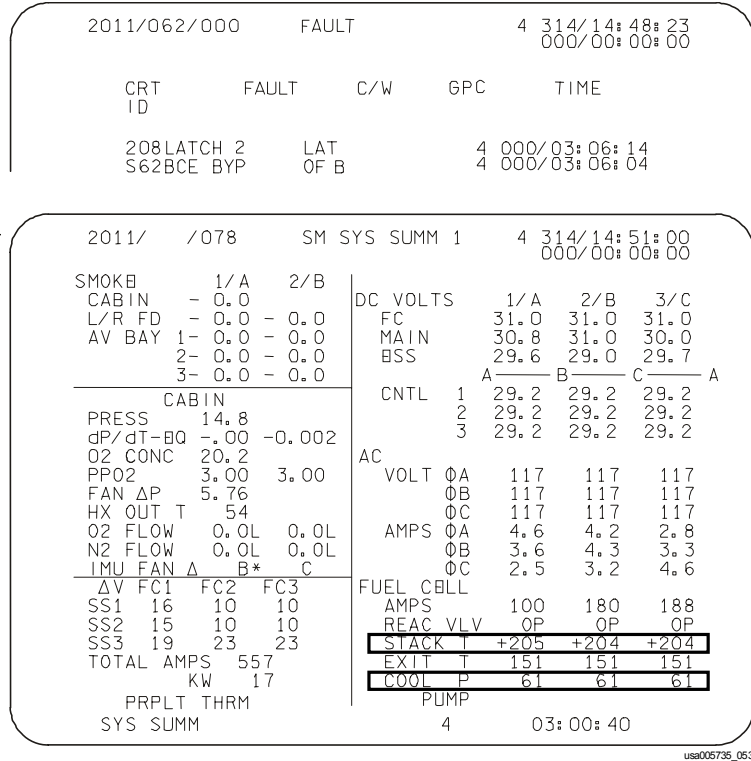
2011/ /078 SM SYS SUMM 1			4 314/14:51:00		
SMOKB 1/A 2/B			DC VOLTS 1/A 2/B 3/C		
CABIN - 0.0 - 0.0			FC 31.0 31.0 31.0		
L/R FD - 0.0 - 0.0			MAIN 30.8 31.0 30.0		
AV BAY 1- 0.0 - 0.0			BSS 29.6 29.0 29.7		
2- 0.0 - 0.0			A B C A		
3- 0.0 - 0.0			CNTL 1 29.2 29.2 29.2		
CABIN			2 29.2 29.2 29.2		
PRESS 14.8			3 29.2 29.2 29.2		
dP/dT-BQ -0.00 -0.002			AC		
O2 CONC 20.2			VOLT 0A 117 117 117		
PP02 3.00 3.00			0B 117 117 117		
FAN ΔP 5.76			0C 117 117 117		
HX OUT T 54			AMPS 0A 4.6 4.2 2.8		
O2 FLOW 0.0L 0.0L			0B 3.6 4.3 3.3		
N2 FLOW 0.0L 0.0L			0C 2.5 3.2 4.6		
IMU FAN Δ B* C			FUEL CELL		
ΔV FC1 FC2 FC3			AMPS 100 180 188		
SS1 16 10 10			RBAC VLV OP OP OP		
SS2 15 10 10			STACK T +205 +204 +204		
SS3 19 23 23			EXIT T 151 151 151		
TOTAL AMPS 557			COOL P 61 61 61		
KW 17			PUMP		
PRPLT THRM			4 03:00:40		
SYS SUMM					

2011/ /079 SM SYS SUMM 2					4 314/14:50:47	
CRYO TK 1 2 3 4 5					000/00:00:00	
H2 PRESS 224 219 236 236 145L					MANF1 235	MANF2 235
O2 PRESS 850 850 860 860 515L					860	860
HTR T1 -240 -240 -210 -210 -417L						
T2 -240 -240 -210 -210 -417L						
APU 1 2 3			HYD 1 2 3			
TBMP EGT 0L 280 277			PRBSS 56L 0L 56L			
B/U EGT 280 280 0L			RSVR T - 77L 169 195			
OIL IN - 0L 67 67			P 0L 63 62			
OUT 67 67 - 2L			QTY - 0L 56 53			
SPBED % 0L 0L 0L			W/B			
FUJL QTY 0L 75 75			H2O QTY 98 98 100			
PMP LK P 14 14 14			BYP VLV BYP BYP BYP			
OIL OUT P- 0L 26 26			THRM CNTL 1 2			
AV BAY			H2O PUMP P 24 65			
TBMP 89 89 77			FRBON FLOW 2100 2100			
FAN ΔP 3.82 3.79 3.94			EVAP OUT T 39 39			
S85XX2PLT THRM OM					4 03:08:40(15)	
SYS SUMM						

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Figure 7-9. OI DSC failure example (sample)

Note: Refer to Reference Data, OI DSC Loss, PASS displays, or Malfunction Procedure for OI DSC Loss. Circled parameters correspond to DSC OA 1-detected problem. Malfunction procedure provides power/cb locations and SSRs for further troubleshooting for lost comm or for use by MCC.



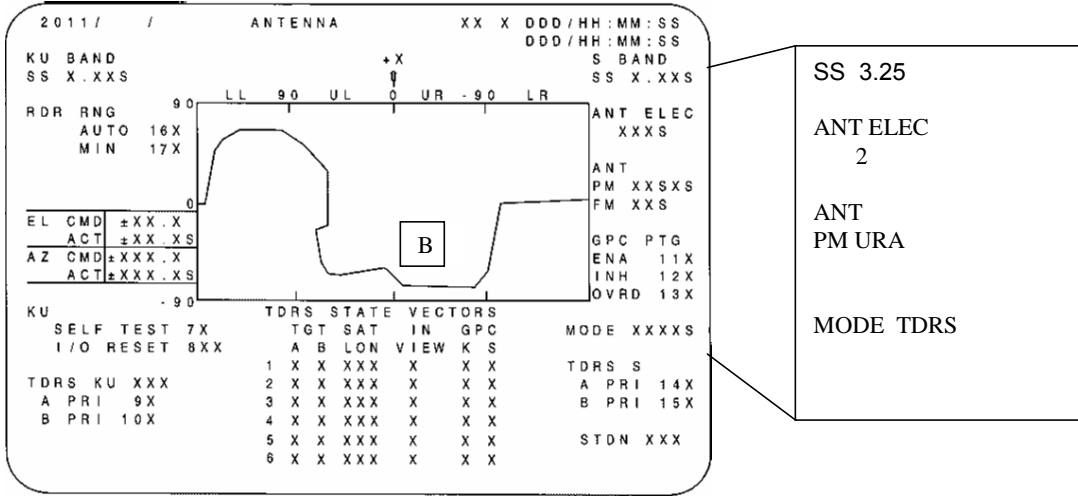
usa005735_063

Figure 7-10. OI MDM failure example (sample)

Note: Refer to Malfunction Procedure 2.5b: S62 BCE BYP OFB with M in the status field for fuel cell 3 stack T and cool P. This indicates an MDM OF3-detected problem and Malf would lead you to corrective action or bypass failure actions.

QUESTIONS

1. The two S-band PM high power modes are: _____ & _____
2. Given the information in Figure 7-11 (assume ACCU1, PCMMU1, and COMSEC in SELECT/RCV mode);
 - (a) On Figure 7-12, circle the operating S-Bd PM LRUs for high power mode and NSP. Circle the operating XPNDR FREQ (within PREAMP ASSY), NSP RCV and XMIT rates, ACCU, and PCMMU.
 - (b) Trace the UL signal from the received antenna to the ACCU and GPC, through the S-Bd PM high power LRUs and NSP.
 - (c) Trace the DL signal from the ACCU and PCMMU, combined at the NSP, through the S-Bd PM high power LRUs to the transmitting antenna.
3. The two S-band PM high low modes are: _____ & _____
4. Given the information in Figure 7-13 (assume ACCU2, PCMMU1, and COMSEC in SELECT/BYP mode):
 - (a) On Figure 7-14, circle the operating S-Bd PM LRUs for low power mode and NSP. Circle the operating XPNDR FREQ, NSP RCV and XMIT rates, ACCU, and PCMMU.
 - (b) Trace the UL signal from the received antenna to the ACCU and GPC through the S-Bd PM low power LRUs and NSP.
 - (c) Trace the DL signal from the ACCU and PCMMU, combined at the NSP, through the S-Bd PM low power LRUs to the transmitting antenna.



SS 3.25
 ANT ELEC 2
 ANT PM URA
 MODE TDRS

S-BAND PM	TDRS	
FREQ LO	1	2
ANT ELEC		ON
XPNDR		ON
PREAMP		ON
PWR AMPL		
OPER		ON
STBY		STBY
PWR OUT		132
TEMP		168
<hr/>		
NSP	1	2
BIT SYNC		YES
FRM SYNC		YES
BITE	GOOD	GOOD
COMSEC BITE	FAIL	GOOD
<hr/>		
UL DATA SOURCE		S
DATA RATE	XMIT	HI
	RCV	HI
CODING	XMIT	ON
	RCV	ON

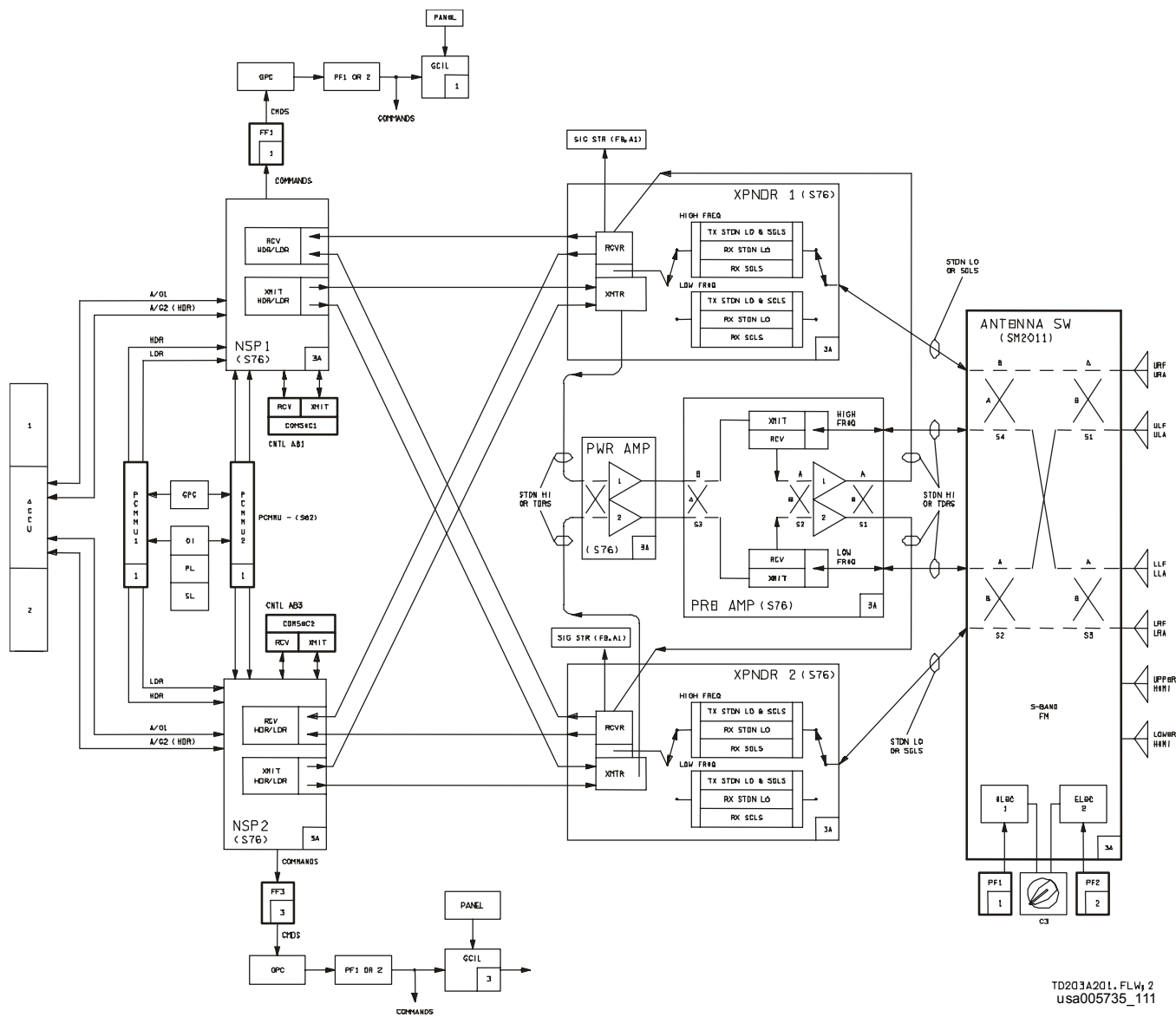
XXXX/XXX/076 COMMUNICATIONS XX X DDD/HH:MM:SS
 ODD/HH:MM:SS

S-BAND PM	XXXXX		KU-BAND		±XXXX
FREQ	1	2	PA TEMP		±XXXX
ANT ELEC	XXS	XXS	GIMBAL TEMP A		±XXXX
XPNDR	XXS	XXS	GIMBAL TEMP B		±XXXX
PREAMP	XXS	XXS	GYRO TEMP		±XXXX
PWR AMPL			PWR OUT		XXS
OPER	XXS	XXS	FRM SYNC		XXXX
STBY	XXXXX	XXXXX	MODE		XXXX
PWR OUT	XXXX	XXXX	FAIL SAFE		XXXX
TEMP	XXXX	XXXX	AUTO K TO S		XX
<hr/>			AUTO S TO K		XX
NSP	1	2	SSOR	PRI	B/U
BIT SYNC	XXXX	XXXX	FRM SYNC	XXXX	XXXX
FRM SYNC	XXXX	XXXX	PROC STAT	XXXX	XXXX
BITE	XXXX	XXXX	PWR LEVEL		±XX.XS
COMSEC BITE	XXXX	XXXX	STATUS		X.XS
<hr/>			GCIL CONFIG		XXXX
UL DATA SOURCE		XXS	CCTV CAMR OVRTMP		XXXX
DATA RATE	XMIT	XXS			
	RCV	XXS			
CODING	XMIT	XXXX			
	RCV	XXXX			

(XX)

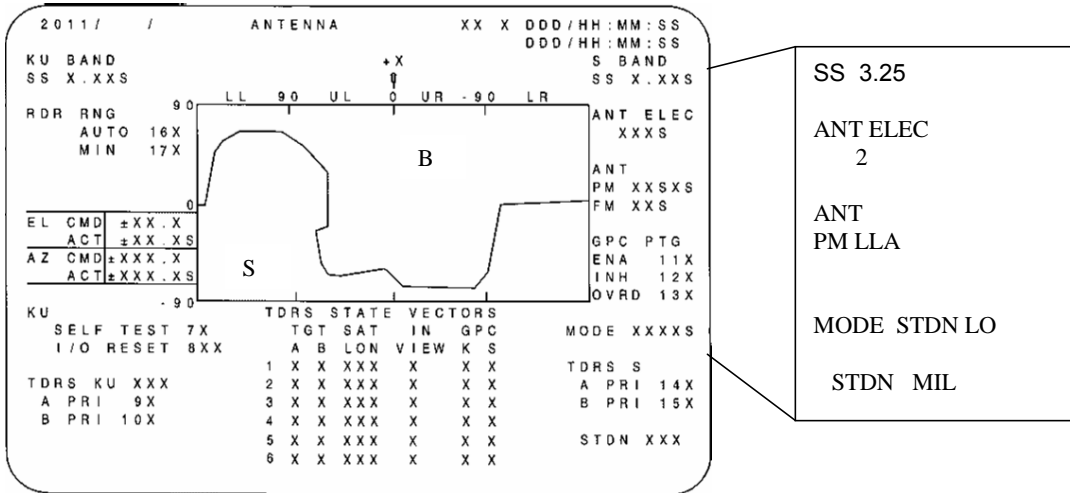
C3 → ACCU 1, PCMMU1
 A1L → COMSEC PWR ON
 MODE – SELECT
 SELECT - RCV

Figure 7-11. Information for question 2



TD203A201.FLWj 2
usa005735_111

Figure 7-12. Comm figure for question 2



SS 3.25
 ANT ELEC 2
 ANT PM LLA
 MODE STDN LO
 STDN MIL

S-BAND PM	STDN LO
FREQ LO	1 2
ANT ELEC	ON
XPNDR	ON
PREAMP	ON
PWR AMPL	
OPER	ON
STBY	STBY STBY
PWR OUT	132
TEMP	168
NSP	1 2
BIT SYNC	YES
FRM SYNC	YES
BITE	GOOD GOOD
COMSEC BITE	FAIL GOOD
UL DATA SOURCE	S
DATA RATE XMIT	HI
	RCV LO
CODING XMIT	ON
	RCV ON

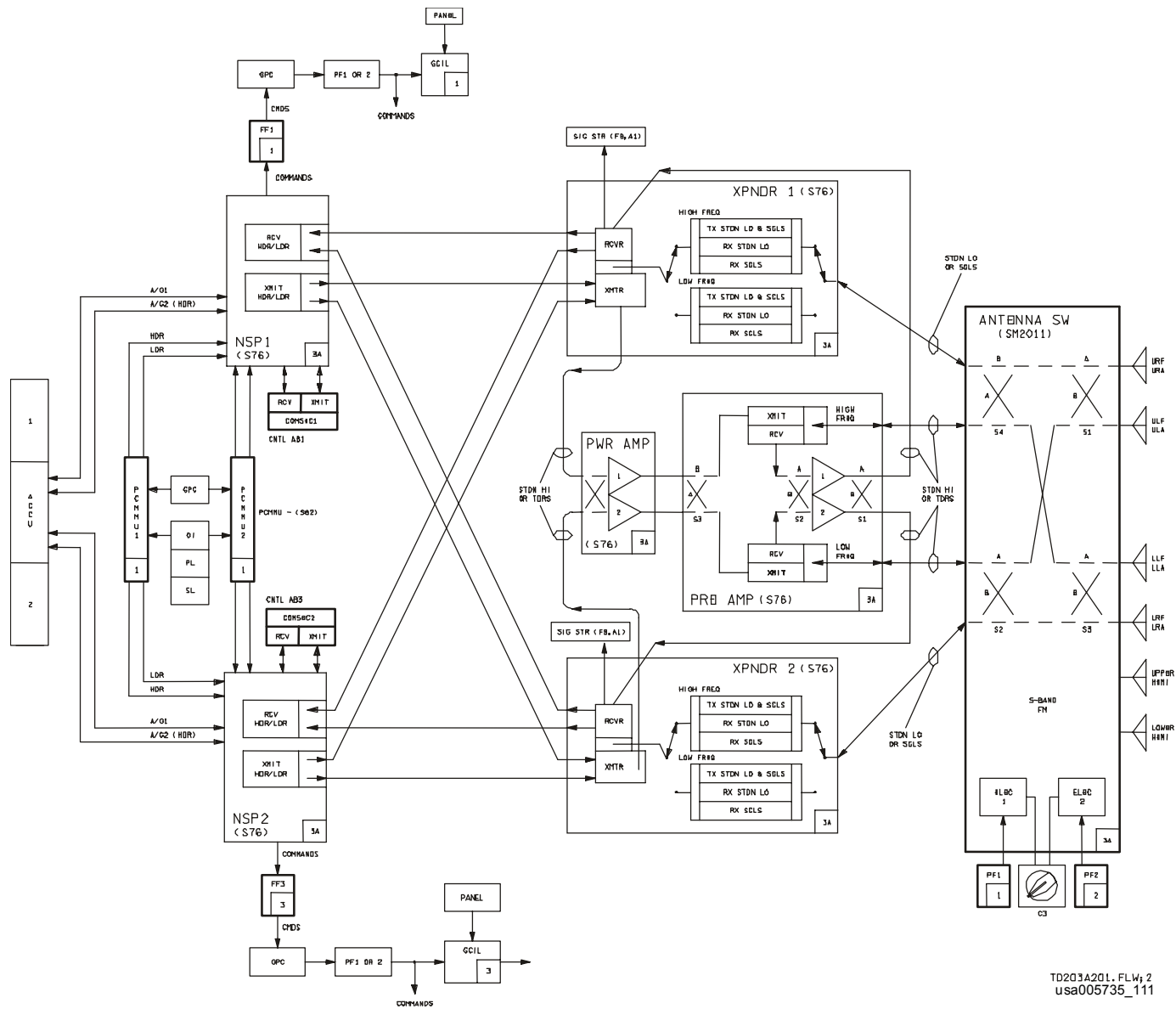
XXXX/XXX/076 COMMUNICATIONS XX X DDD/HH:MM:SS
 DDD/HH:MM:SS

S-BAND PM	XXXXS	KU-BAND	
FREQ XXS	1 2	PA TEMP	±XXXX
ANT ELEC	XXS XXS	GIMBAL TEMP A	±XXXX
XPNDR	XXS XXS	GIMBAL TEMP B	±XXXX
PREAMP	XXS XXS	GYRO TEMP	±XXXX
PWR AMPL		PWR OUT	XXS
OPER	XXS XXS	FRM SYNC	XXXXS
STBY	XXXXS XXXXS	MODE	XXXXS
PWR OUT	XXXXS XXXXS	FAIL SAFE	XXXXS
TEMP	XXXXS XXXXS	AUTO K TO S	XXX
		AUTO S TO K	XXX
NSP	1 2	SSOR	PRI B/U
BIT SYNC	XXXXS XXXXS	FRM SYNC	XXXXS XXXXS
FRM SYNC	XXXXS XXXXS	PROC STAT	XXXXS XXXXS
BITE	XXXXS XXXXS	PWR LEVEL	±XX.XS
COMSEC BITE	XXXXS XXXXS	STATUS	X.XS
UL DATA SOURCE	XXS	GCIL CONFIG	XXXXS
DATA RATE XMIT	XXS	CCTV CAMR OVRTMP	XXXXS
	RCV XXS		
CODING XMIT	XXXXS		
	RCV XXXXS		

(XX)

C3 → ACCU 2, PCMMU1
 A1L → COMSEC PWR ON
 MODE – SELECT
 SELECT - BYP

Figure 7-13. Information for question 4



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usa005735_111

Figure 7-14. Comm figure for question 4

5. Select SGLS, STDN LO, STDN HI, or TDRS to identify the transponder modes used to communicate through

Modes

- (a) Remote tracking sites _____
- (b) Space tracking data network _____
- or _____
- (c) Tracking data relay satellites system _____

6. Identify the crew displays for the following information or actions. Choices are SM SPEC 76, OPS 2011 ANTENNA, SM SPEC 62, and PASS SPEC 1.

- Allowing GPC-to-AUTO enable or inhibit uplink commanding
- Forcing S-Bd PM SM antenna management to point at TDRS B
- Loading telemetry format loads into the PCMMU
- Determine operating S-Bd PM LRUs (two displays)
- Performing RTCs
- GCILC configuration status

7. Identify the crew panel, switch, or method for changing, controlling, or monitoring the following: (Options: Panels A1U, A1R lower, A1L, A7L, C3, F9, 06, O14, O15, O16, O17, R14, and RTC) Note each option may be used once, more than once, or not at all.

- Changing the S-Bd PM frequency
- Bypassing COMSEC/encryption
- S-Bd PM manual antenna selection
- S-Bd FM manual antenna selection
- Master power for the MADS
- Selecting F9 meter to read signal strength versus fuel cell amps
- Monitoring S-Bd PM signal strength on an aft meter
- Selecting voice channels for recording on SSRs
- Configuring NSP data rates and coding switches for selected S-Bd PM mode

8. Determine the failed OI LRUs from the information provided.
 - During ascent, OI ERROR PCMMU message occurs. Upon calling up SM SYS SUMMs, you see all status fields showing Ms. This indicates a partial or total OI MDM/PCMMU failure.
 - During entry multiple messages occur simultaneously. Upon calling up GNC SYS SUMMs, Ls are showing for many of the parameter status fields. This indicates an OI MDM or DSC failure.
 - On orbit, you get an S62 BCE BYP OFB message. Upon calling up SYS SUMM1, you see a few parameters with Ms in their status fields. This indicates OI MDM (a) OF1 or 2, (b) OF3 or 4, or (c) OA1, 2, or 3 has failed.

APPENDIX A ACRONYMS AND DEFINITIONS

A/G	Air-to-Ground
ACCU	Audio Control Central Unit
ACIP	Aerodynamic Coefficient Identification Package
ADS	Audio Distribution System
AEA	Antenna Electronics Assembly
AESP	Ascent/Entry Systems Procedures
AIP	Aerothermal Instrumentation Package
AM	Antenna Management
ANT	Antenna
AOS	Acquisition Of Signal
APC	Aft Power Control
APCL	Ascent Pocket Checklist
ASE	Antenna Switch Electronics
ASSY	Assembly
AUTO	Automatic
BFS	Backup Flight Software
BITE	Built-In Test Equipment
BOT	Beginning Of Tape
bp	barberpole
bps	bits per second
C&W	Caution and Warning
C3	Center Three
cb	circuit breaker
CCTV	Closed Circuit Television
COMM	Communications
COMSEC	Communications Security
CRT	Cathode Ray Tube
D&C	Display and Control
dB	decibel
DECOM	Decommutators
DFI	Developmental Flight Instrumentation
DIR	Direction
DKR	Dakar
DL	Downlink
DoD	Department of Defense
DPS	Data Processing System
DSC	Dedicated Signal Conditioner
DSN	Deep Space Network
EDO	Extended Duration Orbiter
EDW	Edwards Air Force Base
EIU	Engine Interface Unit

ELEC	Electrical
EMU	Extravehicular Mobility Unit
ENA	Enabling
EOM	End Of Mission
EOT	End Of Tape
EPCL	Entry Pocket Checklist
EVA	Extravehicular Activity
FC MDM	Flight Critical
FCOS	Flight Control Operating System
FF	Flight Forward
FL	Forward Link
FM	Frequency Modulation
GCILC	Ground Command Interface Logic Controller
GMT	Greenwich Mean Time
GNC	Guidance, Navigation, and Control
GPC	General Purpose Computer
GSE	Ground Support Equipment
GSTDN	Ground Spacecraft Tracking and Data Network
HDR	High Data Rate
HEMI	Hemispherical
ICC	Intercomputer Communication
ILS	Instrument Landing System
IMU	Inertial Measurement Unit
INCO	Instrumentation and Communications Officer
INH	Inhibiting
INST	Instrumentation
IP	Interface Port
IPL	Initial Program Load
kbps	kilobits per second
KSC	Kennedy Space Center
KSP	Ku-Bd Signal Processor
Ku-Bd	Ku-band
L	(off-scale) low
LDB	Launch Data Bus
LDR	Low Data Rate
los	Line-Of-Sight
LOS	Loss Of Signal
LRU	Line Replaceable Unit

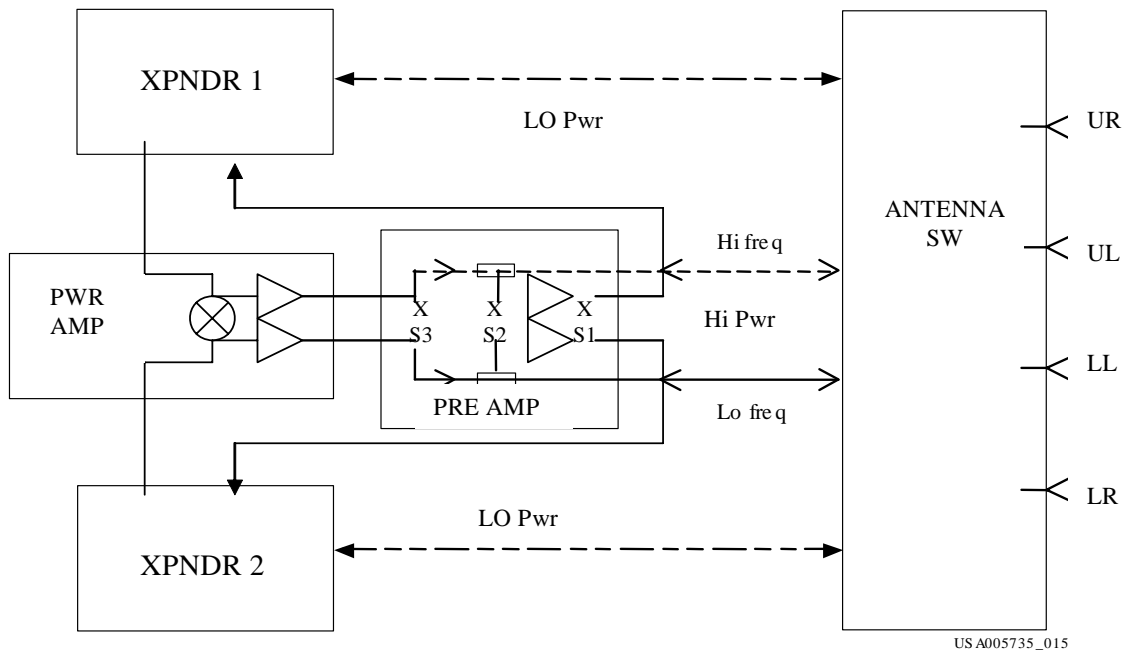
M	Missing
MAD	Madrid
MADS	Modular Auxiliary Data System
MAN	Manual
MCC	Mission Control Center
MDM	Multiplexer/Demultiplexer
ME	Main Engine
MECO	Main Engine Cutoff
MET	Mission Elapsed Time
MIL	Merritt Island
MLS	Microwave Landing System
NASA	National Aeronautics and Space Administration
NAV	Navigation
NSP	Network Signal Processor
OA	Operational Aft
OF	Operational Forward
OI	Operational Instrumentation
OL	Operational Left
OM	Operational Mid
Ops RCDR	Operational Recorder
OR	Operational Right
OV	Orbiter Vehicle
PASS	Primary Avionics Software System
PB	Playback
PCLU	Preamp Control Logic Unit
PCM	Pulse Code Modulation
PCMMU	Pulse Code Modulation Master Unit
PDI	Payload Data Interleaver
PF	Payload Forward
PGM	Program
PL	Payload
PL RCDR	Payload Recorder
PM	Phase Modulation
POCC	Payload Operations Control Center
PRL	Parallel
PROM	Programmable Read-Only Memory
PSK	Phase Shift Keyed
RAM	Random Access Memory
RCD	Record
RCDR	Recorder
RCV	Receive
RF	Radio Frequency

RL	Return Link
rot	Rotary
RTC	Real-Time Command
RTS	Remote Tracking Station
SBCE	Switch Beam Control Electronics
S-Bd	S-band
SEADS	Shuttle Entry Air Data System
SEQ	Sequence
SGLS	Space Ground Link System
SILTS	Shuttle Infrared Leaside Temperature Sensing
SM	Systems Management
SPC	Stored Program Command
SPE	Static Phase Error
SSME	Space Shuttle Main Engine
SSO	Space Shuttle Orbiter
SSP	Spread Spectrum Processor
SSR	Solid State Recorder
SST	Single System Trainer
STBY	Standby
STDN	Space Tracking and Data Network
SUMS	Shuttle Upper Atmosphere Mass Spectrometer
T/R	Transmit/Receive
tb	talkback
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TFL	Telemetry Format Load
TLM FMTR	Telemetry Formatter
TV	Television
TWT	Traveling Wave Tube
UHF	Ultrahigh Frequency
UL	Uplink
USAF	United States Air Force
VCXO	Voltage Control Oscillator
VOR	VHF Omni Range Directional
WB	Wideband
XMIT	Transmit
XPNDR	Transponder

APPENDIX B ANSWERS

Section 3

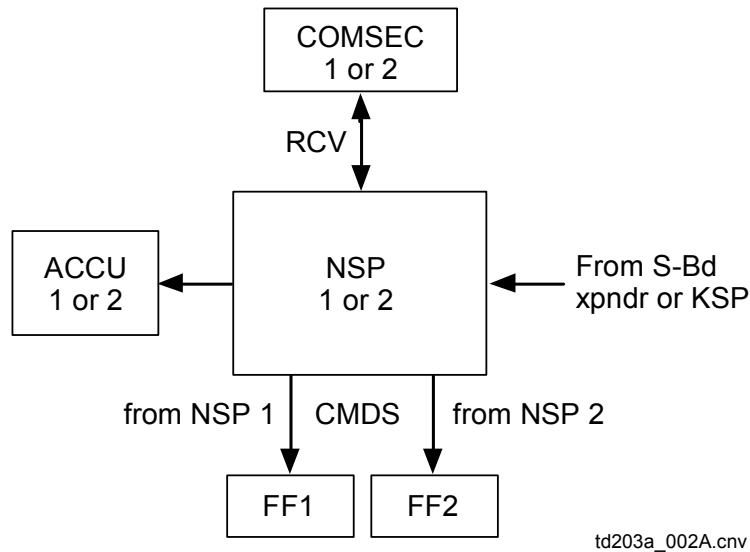
1.



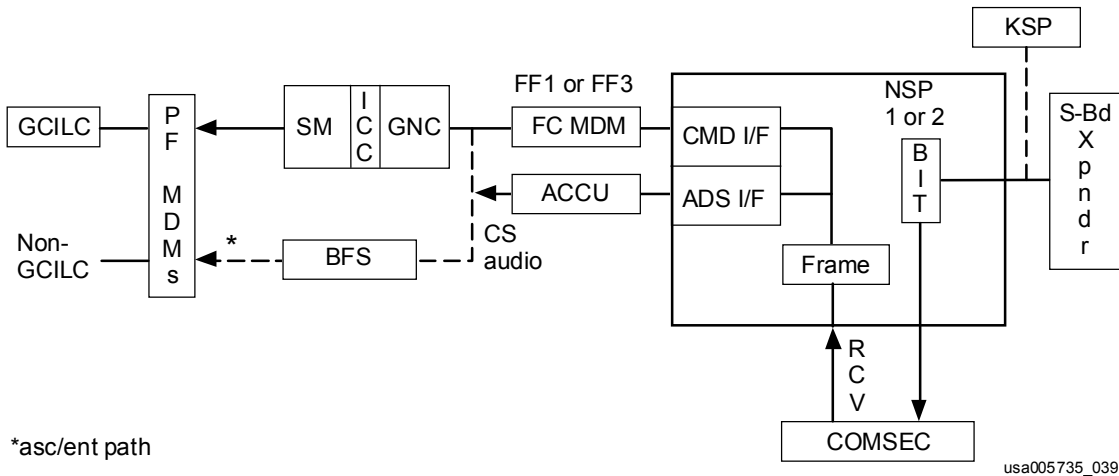
2. True: The switches S1 to S4, in the ANTENNA SW (Antenna Electronics Assembly (AEA)) and the diplexers/triplexers in the PRE AMP/XPNDRs are considered as single-point-failure locations for the S-Bd PM Comm system.
3. What is the warm-up time for the power amp, if not previously placed in STANDBY mode? 140 sec (2 min 20 sec)
4. The power amp is NOT used for the following XPNDR modes (circle all that apply):
 - b and d
5. High power mode is required for TDRS mode to compensate for the distance between the orbiter and the satellite to/from MCC.
6. The following commands for Comm or Antenna management do not use the GCILC in their command path:
 - (a) Frequency Selection
7. The PRE AMP 1 or 2 in the Pre Amp Assembly is used for:
 - (a) uplink only in high power mode

Section 4

1. Identify the two primary functions of the NSP:
 - (b) Separating Command and Voice on the uplink and combining Data and Voice on the downlink with MCC and
 - (c) Routing Data to recorders and downlink RF systems
2. NSP uplink LRUs are



3. Command path for Comm systems



- 4a. Normally the NSP and S-Bd PM is operating on string: 2
- 4b. According to the standard S-band/Ku-band PNL CONFIG, as found in the Orbit Operations Checklist, fill in the INFORMATION for each configuration:

Standard configuration	STDN(SGLS) S-BD	TDRS S-BD	TDRS KU-BD
NSP data rate XMIT	HI	HI	HI
RCV	HI	HI	HI
UPLK DATA	S	S	KU
Coding XMIT	OFF	ON	ON
RCV	OFF	ON	OFF
S-BD PM MODE (Rot)	STDN LO (SGLS)	TDRS DATA	—

- 5a. The normal 'back-up' configuration for the A1L (Back Panel) is string: 1
- 5b. Complete the table for the Back Panel/A1L configuration for the given flight phases:

	ASCENT	ORBIT	ENTRY
S-Bd PM mode	STDN HI	TDRS DATA	STDN LO
NSP – UPLK DATA	S-BD	S	S-BD
Data rate XMIT -	HI	HI	HI
RCV -	HI	HI	HI
Coding XMIT -	OFF	ON	OFF
RCV -	ON	ON	OFF

6. The COMSEC is normally powered and configured as follows, using panel?

POWER: ON

PANEL: A1L

MODE: SELECT

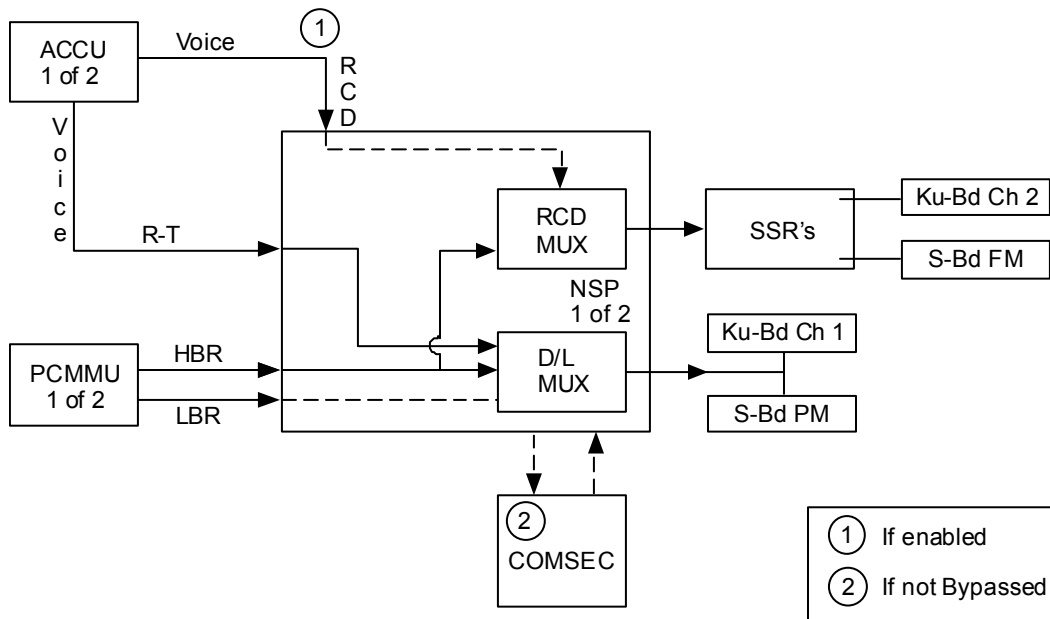
SELECT: RCV

7. List the five comm systems under control of the GCILC for selecting required functions and configurations via command or panel.

- 1) S-BD PM 2) S-BD FM 3) S-BD PL 4) K-BD
- 5) CCTV

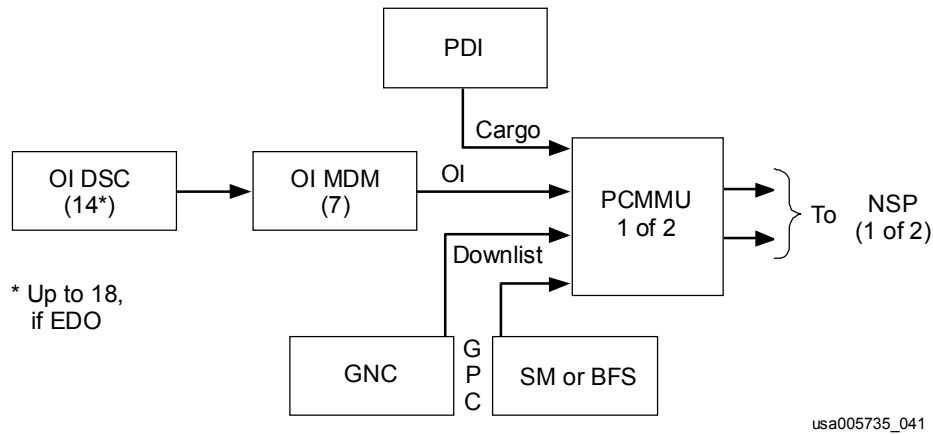
8. The GCILC control switch for the S-Bd PM and NSP functions is located on which panel? C3

9. NSP downlink LRUs are shown below



USA005735_203

10. Data source paths into PCMMU:



11. Match the status indications that will be seen on SYS SUMM displays for the listed OI instrumentation failures?
 1. b. off scale low or Ls in status fields
 2. c. pattern of Ms in status fields
 3. a. all Ms in SYS SUMM status fields
12. A PCMMU formats the telemetry data into HBR/128kbps and LBR/64kbps data rates.
13. The TLM FMTR combines GPC downlist, OI MDM, and Payload/PDI data based on the TFLs.
14. False: A power interrupt or selecting a new PCMMU will cause the formatter to default to the **HBR/FIXED** TFL.
15. True: The OI PCMMU FORMAT switch overrides the SM SPEC 62 item selections for FXD and PGM TFLs.
16. False: The PCMMU must be in FIXED format for loading the High Program TFL only. FIXED is not required for loading LBR, but for convenience when crew loads TFLs FIXED is used to load both, THEN Program (Item 2) is performed.
17. True: Only the BFS provides an automatic load of the Low Rate TFL after changing PCMMUs. NOTE: SM requires the crew or MCC to load the LBR after a PCMMU swap/power interrupt.

Section 5

1. The Solid State Recorders 1 and 2 are located in:
(d) a (Av Bay 1 and 2) and b (the Mass Memory Units 1 and 2, respectively)
2. False: SSRs can only be played back (or dumped) through the S-Bd FM **or Ku-Bd** system.
3. True: During high activity periods, such as ascent, payload deploys or rendezvous, and entry, SSRs usually record DATA plus voice. Most other times they will record data only.
4. Crew controls for the MADS are on Panels **A6 or A7**, with the Master Power switch located on **C3**.
5. The primary purpose for MADS is to **measure** and **record** selected orbiter data for dynamic event during ascent, critical orbit burns, and entry.

Section 6

1. What does the S-Bd FM system provide?

The S-Bd FM system provides wideband downlink of seven selectable data sources, including real-time sources or recorder dump data.

2. What SM display allows a crew to view S-Bd FM antenna and site information?

OPS 2011 ANTENNA display

3. The S-Bd FM crew controls are on which three panels?

A1L, C3, and A1R

4. List the seven data sources, other than OFF, for the S-Bd FM system:

DOD, MMU2, ME, MMU1, PL DIGITAL, PL ANLG, and TV

5. True: The Antenna Electronic unit for selecting the S-Band PM Quad Antennas also contains the logic to select the FM Hemi antennas.

Section 7

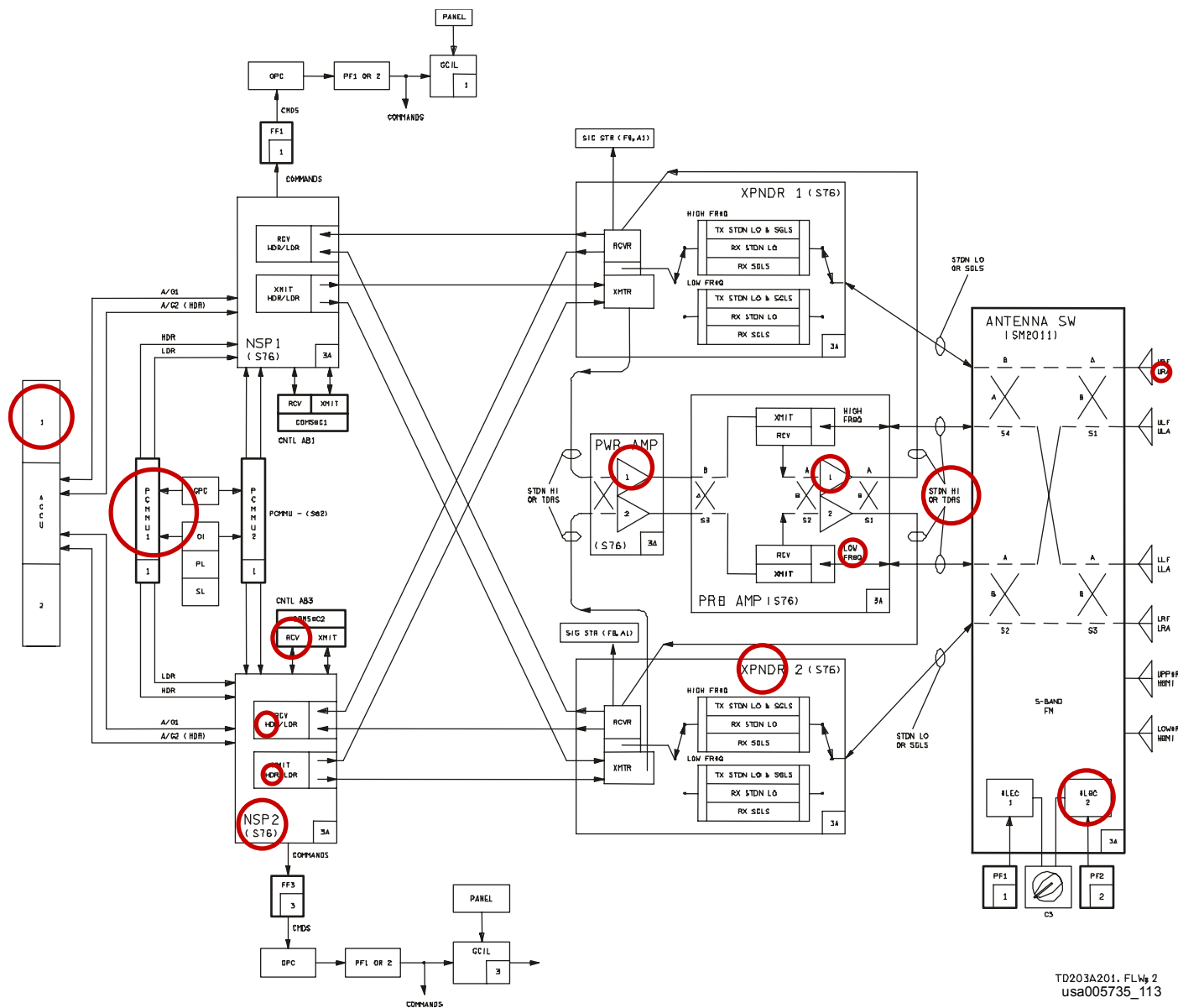
1. The two S-band PM high power modes are STDN HI and TDRS.
2. The information requested in Figure 7-11 is shown in Figures 7-15a, 7-15b, and 7-15c.
3. The two S-band PM low power modes are STDN LO and SGLS.
4. The information requested in Figure 7-12 is shown in Figures 7-16a, 7-16b, and 7-16c.
5. Select SGLS, STDN LO, STDN HI, or TDRS to identify the transponder modes used to communicate through

Modes

- | | |
|--|-------------------|
| (a) Remote tracking sites | <u>SGLS</u> |
| (b) Space tracking data network | <u>STDN HI</u> |
| | or <u>STDN LO</u> |
| (c) Tracking data relay satellite system | <u>TDRS</u> |

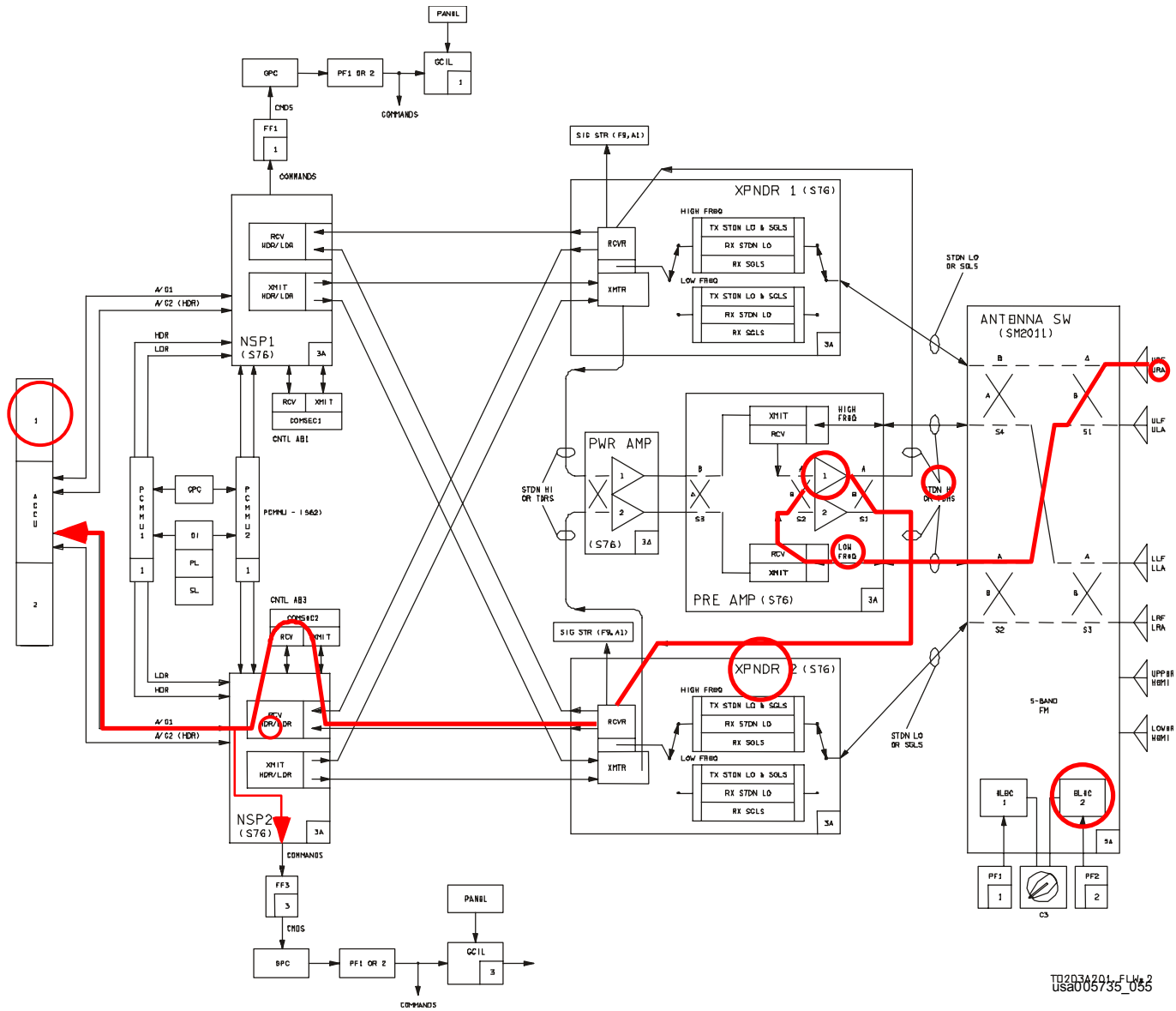
6. The crew displays for the following information or actions are as follows
 - SM SPEC 1: Allowing GPC-to-AUTO enable or inhibit uplink commanding
 - OPS 2011 ANTENNA: Forcing S-Bd PM SM antenna management to point at B vs. A TDRS
 - SM SPEC 62: Loading telemetry format loads into the PCMMU
 - SM SPEC 76 and OPS 2011 Antenna: Determine operating S-Bd PM LRUs (two displays)
 - PASS SPEC 1: Performing RTCs
 - SM SPEC 76: GCILC configuration status

7. Identify the crew panel, switch, or method for changing, controlling, or monitoring the following: (Options: Panels A1U, A1R lower, A1L, A7L, C3, F9, 06, O14, O15, O16, O17, R14, and RTC)
 - RTC: Changing the S-Bd PM frequency
 - A1L: Bypassing COMSEC/encryption
 - A1L: S-Bd PM manual antenna selection
 - A1R: S-Bd FM manual antenna selection
 - C3: Master power for the MADS
 - F9: Selecting F9 meter to read signal strength versus fuel cell amps
 - A1U: Monitoring S-Bd PM signal strength on an aft meter
 - A1R Lower: Selecting voice channels for recording on SSRs
 - A1L: Configuring NSP data rates and coding switches for selected S-Bd PM mode



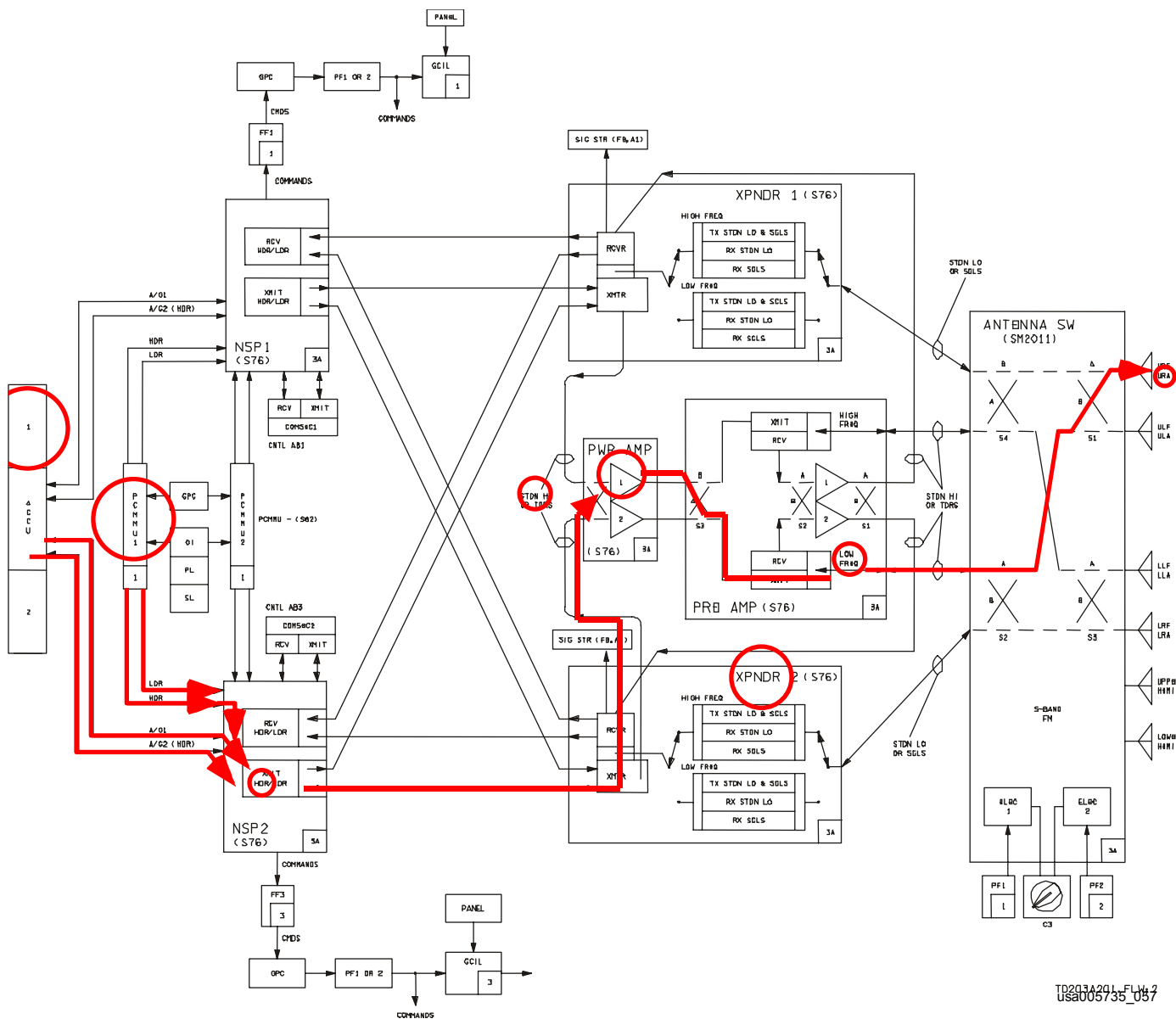
TD203A201, FLW 2
usa005735_113

Figure 7-15a. Answer for question 2



T0203A201_FLW_2
usa005735_055

Figure 7-15b. Answer for question 2



T0203A201_F10_2
USA005735_087

Figure 7-15c. Answer for question 2

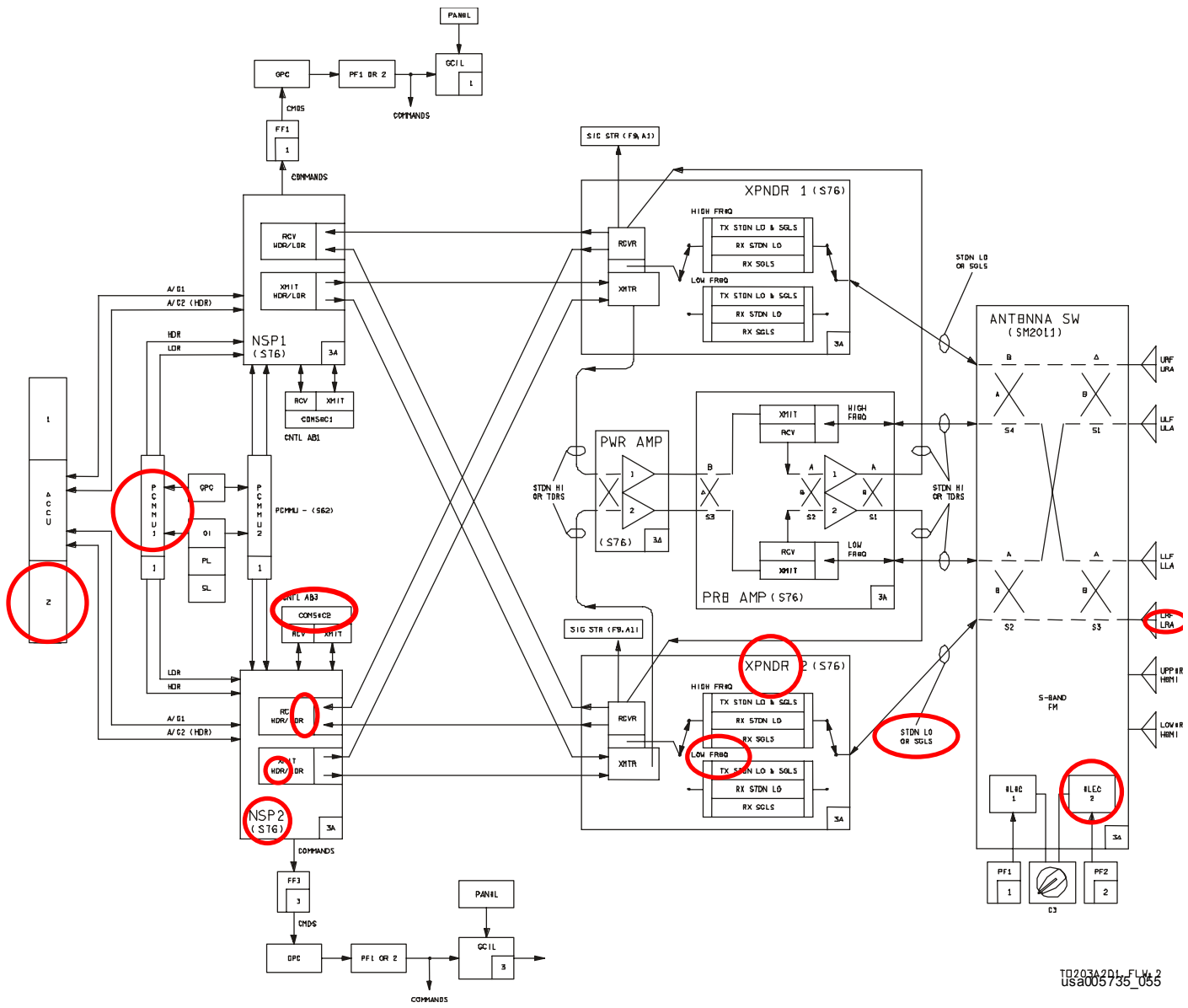
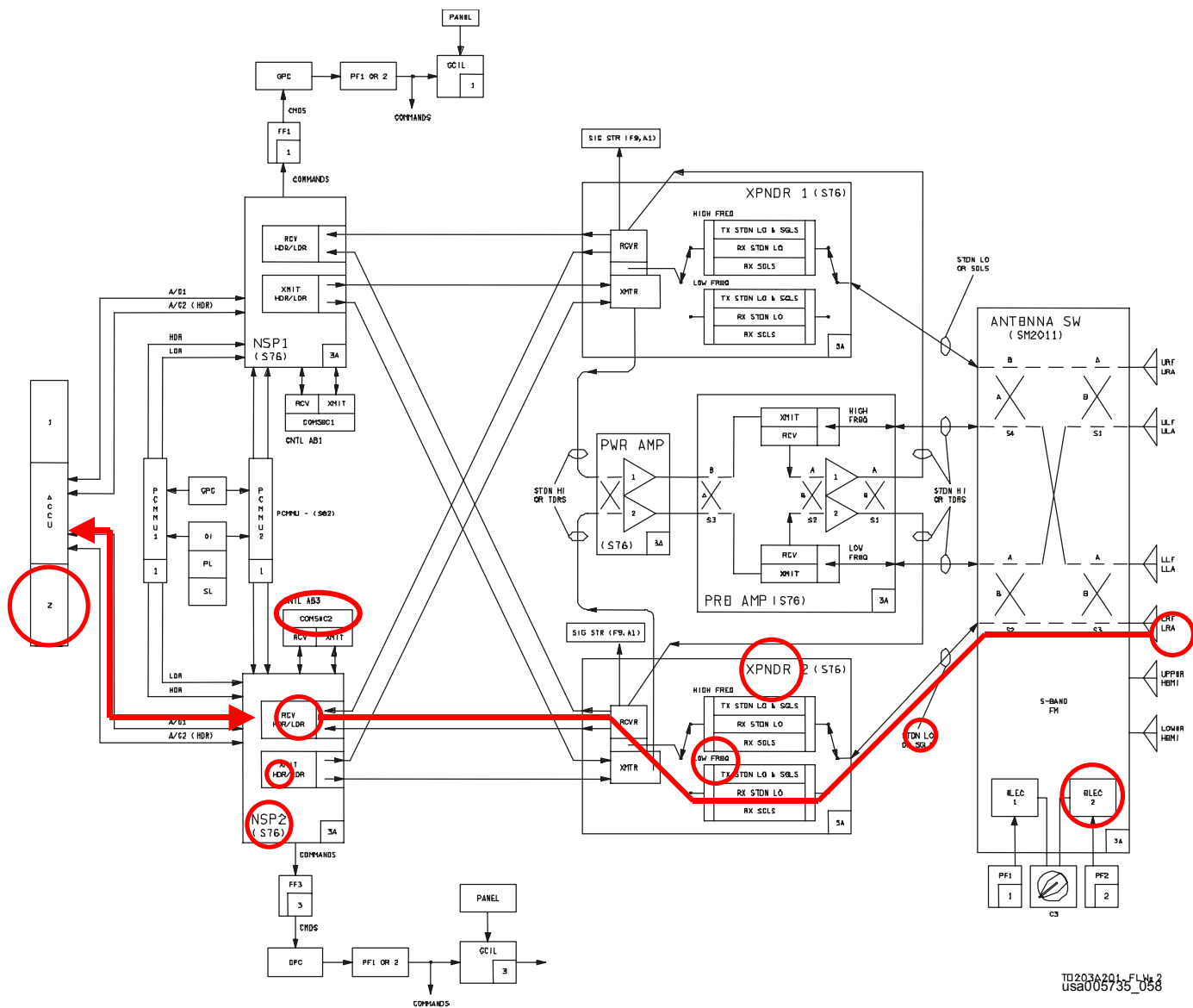


Figure 7-16a. Answer for question 4



T0203A201-FLW-2
USA005735_058

Figure 7-16b. Answer for question 4

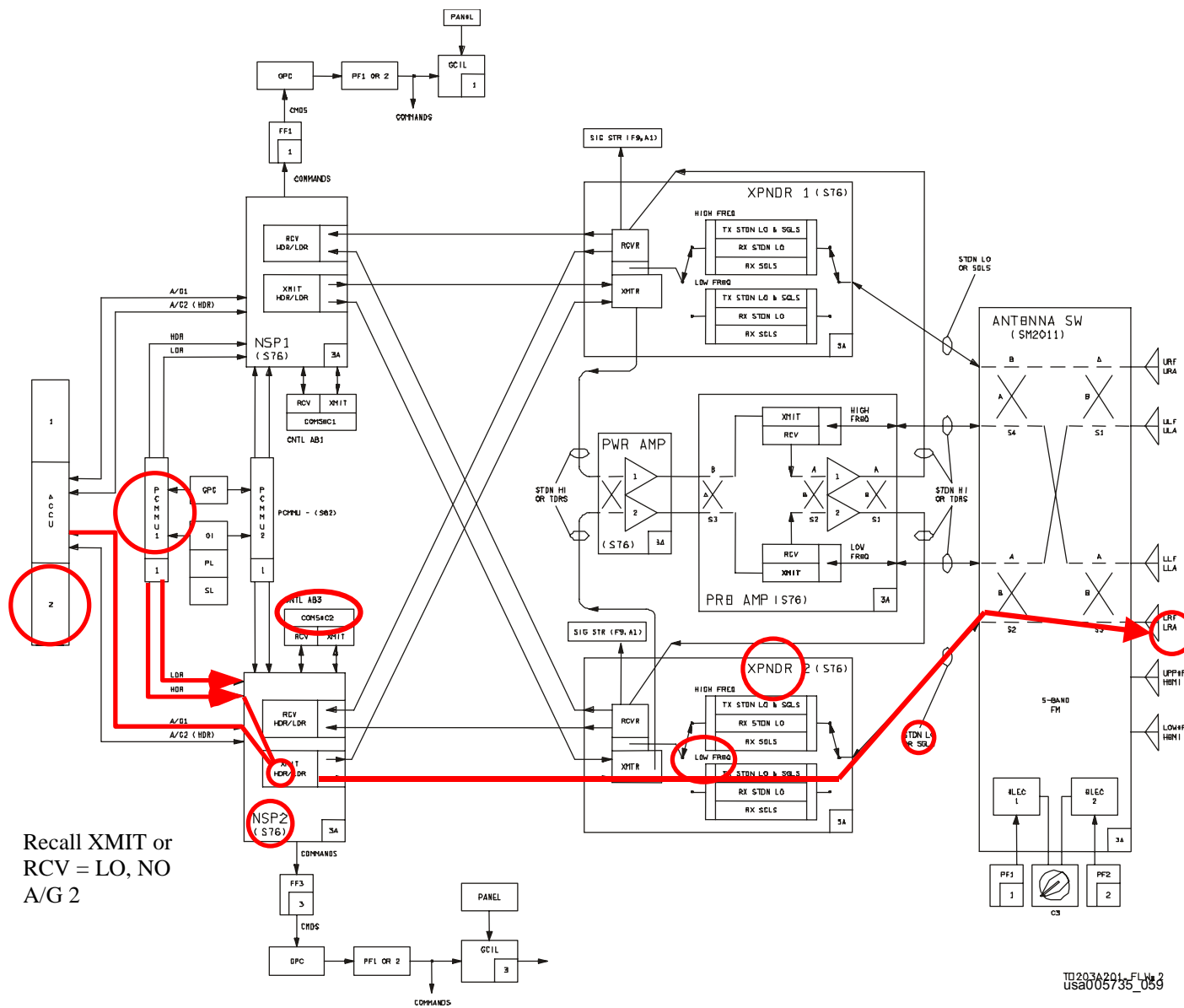


Figure 7-16c. Answer for question 4

APPENDIX C FACTS AND INFORMATION

(Information is summarized from the Shuttle Operational Data Book.)

PART A: OPERATIONAL DATA ON S-BD PM, FM, NSP, AND COMSEC LRUs

Operational RF Transmitters and Receivers

S-Band Transmitter Assembly

a. Redundancy	2 units
b. Transmit frequencies	Table B-1
c. Receive frequencies	Table B-1
d. Turnaround ratio	
1. STDN	240/221
2. AFSCF	256/205
e. Power output – low power mode	2 W minimum
f. Duty cycle	Continuous
g. Warm-up time to stability	30 sec
h. Receiver bandwidth	±2.5 MHz at 0.3 dB down
i. Received signal sensitivity	-128 dBm minimum -30 dBm minimum
j. Transmitter bandwidth	±2.5 MHz at 0.3 dB down
k. Frequency stability	0.001 percent
l. DL sources	Table B-2
UL sources	Table B-3

S-Band Preamplifier Assembly

a. Redundancy	One internally redundant unit
b. Receive frequencies	Table B-1
c. Receive bandwidth	± 2.5 MHz – 0.3 dB flat ± 12 MHz at 3 dB
d. Receive signal sensitivity	-130 dBm minimum -55 dBm maximum
e. Gain	20 dB minimum
f. Preamplifier noise temperature	240 K
g. Duty cycle	Continuous
h. Warm-up time	18 minutes from off (10 sec from standby mode)

S-Band Power Amplifier Assembly

a. Redundancy	One internally redundant unit
b. Frequency	Table 1
c. Power output at amplifier	100W minimum 175 W maximum
d. Bandwidth	5.0 MHz at 1.0 dB down for each of two frequencies
e. Duty cycle	Continuous
f. Warm-up time	3 minutes (from standby mode, less than 10 sec)

S-Band FM Transmitter

a. Redundancy	2 units
b. OI carrier frequency	225 MHz ± 0.004 percent
c. Power output	10 W minimum
d. Warm-up time	30 sec

- | | |
|------------------------|------------------|
| e. Frequency stability | ±0.005 percent |
| f. RF bandwidth | ±12 MHz at -3 dB |
| g. DL sources | Table B-4 |

Signal Processing Equipment

Network Signal Processor

- | | |
|---|--|
| a. Redundancy | 2 units |
| b. Inputs | |
| 1. OI data | 64 or 128 kbps |
| 2. Ground/orbiter uplink serial bit streams | |
| (a) Direct S-band | 32 or 72 kbps |
| (b) Relay S-band encoded | 96 or 216 kbps |
| (c) Relay Ku-band | 72 or 216 kbps |
| 3. Launch umbilical | 32/72/96/216 kbps |
| 4. Voice | |
| (a) Analog | 300 to 3000 Hz from ACCU |
| (b) Digital | One or two 32 kbps from PS |
| c. Outputs | |
| 1. Commands | 2 kbps |
| 2. Voice | |
| (a) Analog | One or two analog voice channels to ACCU |
| (b) Digital | 24 or two 32 kbps to PS |
| 3. Orbiter/ground downlink serial bit | 96/192/288/516 kbps streams |
| (a) Direct S-band | 96 or 192 kbps |
| (b) Relay S-band encoded | 288 or 516 kbps |
| (c) Relay Ku-band | 192 kbps |

Communications Security Equipment (COMSEC) KGC-60

Each NSP operates with a COMSEC LRU KGX-60 unit. The NSP and its XOMSEC unit operate as a pair and cannot operate in a cross-strap mode (i.e., NSP 1 must operate with COMSEC 1 and NSP 2 must operate with COMSEC 2). Each pair provides DoD and NASA encrypted and decrypted data processing.

- a. Switchable Modes Transmit, receive, and record in either Hi or Low data rate

- b. Zeroize Control The COMSEC LRU Crypto Variable Memory (CVM) can be zeroized by the zeroize control switch or by removing power from the LRU. The zeroize function causes the LRU to be functionally inoperable in both transmit and receive until the memory can be restored postflight by the key load device.

Table C-1. Orbiter radio frequencies

Function/System	Orbiter transmit	Orbiter receive
STDN PM-1(HI freq)	2287.5 MHz	2106.406 MHz
STDN PM-2 (LO freq)	2217.5 MHz	2041.947 MHz
AFSCF PM-1 (SGLS HI freq)	2287.5 MHz	1831.787 MHz
AFSCF PM-2 (SGLS LO freq)	2217.5 MHz	1775.733 MHz
STDN/AFSCF FM	2250.0 MHz	None

Table C-2. Direct downlink radio frequency configurations

(a) NASA (STDN) PM and AFSCF (SGLS) PM

Simultaneous channels	Data rate or subcarrier frequency	Multiplexing	Modulation	Carrier frequency
NASA - PM				
Voice 1	32 kbps – High 32 kbps – Low		PM, Index = 0.55 rad.	High 2287.5 MHz or Low 2217.5 MHz
Voice 2	32 kbps – High Off – Low		PM, Index = 0.55 rad.	Same as above
Telemetry	128 kbps – High 64 kbps – Low		PM, Index = 0.55 rad.	Same as above
Ranging channel	1.7 MHz	N/A	PM, Index = 1.0 rad	Same as above
AFSCF - PM				
Voice 1	32 kbps – High 32 kbps – Low		PM, Index = 0.55 rad.	High 2287.5 MHz or Low 2217.5 MHz
Voice 2	32 kbps – High Off – Low		PM, Index = 0.55 rad.	Same as above
Telemetry	128 kbps – High 64 kbps – Low			

(b) TDRSS DL FR CONFIG.

Link	Mode	Channel	Rate	Multiplexing	Channel encoding/decoding	Modulation	Carrier frequency
S-band	–	Voice 2	32 kbps – high 32 kbps – low	192 kbps or 96 kbps time division multiplexed in a biphase level format	Decoding algorithm: viterbi (maximum likelihood)	Technique: PM or PSK Index – 1.1 rad	PM 1 2287.5 MHz
	–	Voice 2	32 kbps – high 0 kbps – low				PM 2 2217.5 MHz
	–	Telemetry	128 kbps – high 64 kbps - low				Constraint length (K) = 7 Quantiza- tion level (Q) = 8

Table C-3. Uplink RF configurations
(a) Direct uplink

NASA (STDN)				
Simultaneous channels	Data or subcarrier frequency rate	Multiplexing	Modulation	Carrier frequency
Voice 1	32 kbps – high 24 kbps – low	72 kbps or 32 kbps time division multiplexed in a biphas level format	PM, Index = 1.1 rad. PSK	High 2106.406 MHz or Low 2041.947 MHz
Voice 2	32 kbps – high	with ranging “on”		
Command and synchronization	Off – low 8 kbps ^a – high 8 kbps – low	with ranging “off”		
Ranging subcarrier	1.7 MHz or Off	N/a	PM, Index = 1.0	
AIR FORCE (SGLS)				
Voice 1	32 kbps – high 24 kbps – low	72 kbps or 32 kbps time division multiplexed in a biphas level format (secured)	PSK	High 1831.787 MHz or Low 1775.733 MHz
Voice 2	32 kbps – high Off – low			
Command and synchronization	8 kbps ^a – high 8kbps – low			

^a The 2.4-kbps command information is encoded into a 6.4-kbps bit stream and formatted with 1.6 kbps of frame synchronization to yield a total of 8.0 kbps.

(b) TDRSS uplink

Link	Mode	Channel	Rate	Multiplexing	Channel encoding/decoding	Modulation	Carrier frequency
S-band	–	Voice 1	32 kbps – high 24 kbps – low	Technique: time division multiplex (TDM) Multiplexed rate = 72 kbps or 32 kbps Format: Biphase level	Decoding algorithm: Viterbi (maximum likelihood) Number of sub-bit (V) = 3 Constraint length (K) = 7 Quantization level (Q) = 8	Technique: PSK	PM1 2106.4 MHz
		Voice 2	32 kbps – high 0 kbps – low				or PM2 2041.0 MHz
		Command and synchronization	8 kbps ^a – high 64 kbps – low				

^a The 2.4-kbps command information is encoded into a 6.4-kbps bit stream and formatted with 1.6 kbps of frame synchronization to yield a total of 8.0 kbps.

Table C-4. Direct DL RF configuration
(a) NASA (STDN) PM and Air Force (SGLS) FM

Data source (Selector switch position 1-7)	Data rate or bandwidth	Multiplexing	Modulation	Carrier frequency
Main engine data	3 channels at 60 kbps	PSK on 3 sub- carriers at 576, 768, and 124 kHz	Each subcarrier frequency devi- ation ± 635 kHz	2250.0 MHz
CCTV	4.5 MHz		Frequency devi- ation ± 4.5 MHz	Same as above
AF payload	250 bps to 256 kbps (encrypted)		Frequency devi- ation ± 635 kHz	Same as above
NASA payload digital	200 bps to 5 Mbps (NRZ)		Frequency devi- ation ± 2 MHz	Same as above
Analog	200 bps to 2 Mbps (Bi ϕ -L) 300 Hz to 4 MHz		Frequency devi- ation ± 2 MHz	Same as above

Table C-5. Communications Equipment: Power and coolant summary

LRU	Quantity	Power consumption, W	Power bus	Coolant source	LRU location	Circuit protection	Control signal	Minimum temp.	Maximum temp. Long term	Maximum temp. Short term	Notes
Network signal processor	2	28.8	(1) MNB FLC2 (2) MNC FLC3	Water loop	Bay 3A	(1) LCA-2, F(3A) (2) LCA-3, F(3A)	(1) CNTL BC-1 (2) CNTL BC-2 CNTL AB2,(GPC BLOCK SW TLM)	Air temperature Minimum: -20° F Maximum: 120° F Baseplate temperature Minimum: 35° F Maximum: 120° F			
S-BD transponder Mode - DIRECT	2	58.5 41.0 30.0	(1) MNB FLC2 (2) MNC FLC3	Water loop	Bay 3A	(1) LCA-2, F(10A) (2) LCA-3, F(10A)	(1) CNTL BC-1 (2) CNTL BC-2		(a)	(a)	
TDRS - RCV ONLY											
S-BD power amp Mode - OPERATE	2	(1) 373.6 (1) 387.2 11.2	(1) MNB FPC2 (1) MNB FLC2 (2) MNC FPC3 (2) MNC FLC3	Water loop	Bay 3A	OPERATE: (1) LCA-2, F(3A) (2) LCA-3, F(3A) OPERATE/STBY: (1) PCA-2, RPC(20A) (2) PCA-3, RPC(20A)	(1) CNTL BC-1 (2) CNTL BC-2	35° F	212° F	225° F	The S-BD power amp has temperature telemetry. (212↑)
STBY											
S-BD pre amp Mode - OPERATE S/U	2	39.9 28.7 29.6 14.8	(1) MNB FLC2 (2) MNC FLC3	Water loop	Bay 3A	OPERATE/STBY (1) LCA-2, F(10A) (2) LCA-3, F(10A)	(1) CNTL BC-1 (2) CNTL BC-2		(a)		Start up (S/U) approx 10 min. STBY equals 2 heaters on.
OPERATE											
STBY S/U											
STBY											
S-BD FM XMTR	2	(1) 75.7 (2) 74.2	(1) MNB FLC2 (2) MNC FLC3	Water loop	Bay 3A	(1) LCA-2, F(3A) (2) LCA-3, F(3A) Fusable line	(1) CNTL BC-1 (2) CNTL BC-2		(a)		
S-BD FM signal processor	1	3.8	(1) MNB FLC2 (2) MNC FLC3	Air	Bay 3A	LCA-2, F(3A) LCA-3, F(3A)	(1) CNTL BC-1 (2) CNTL BC-2				The LRU is internally redundant.
S-BD FM RF switch Mode - QUES	1	0 11.2*	MNB FLC2 MNC FLC3	Air	Bay 3A	LCA-2, F(3A) LCA-3, F(3A)	N/A				*Switching peak.
SWITCH											
S-BD ANT switch assy Mode - QUES - PM* - FM*	1	0.6 19.6* 10.0*	(1) MNB FLC2 (2) MNC FLC3	Air	Bay 3A	LCA-2, F(3A) LCA-3, F(3A)	(1) CNTL BC-1 (2) CNTL BC-2	-20° F	120° F	120° F	The LRU is internally redundant. *Switching peak.

(a) The baseplate temperature is assumed to be the same as the coldplate temperature. (The baseplate temperature limits take into account thermal rise caused by LRU heat

Table C-5. Communications Equipment: Power and coolant summary (continued)

LRU	Quantity	Power consumption, W	Power bus	Coolant source	LRU location	Circuit protection	Control signal	Maximum temp.			Notes
								Minimum temp.	Long term	Short term	
S-BD switch beam electronics	1	3.0	(1) MNB FLC2 (2) MNC FLC3	Air	Bay 3A	LCA-2, F(3A) LCA-3, F(3A)	(1) CNTL BC-1 (2) CNTL BC-2	-20° F	120° F	120° F	OV099
S-BD quad antenna	4							-160° F	180° F	500° F	Thermal limits for pattern degradation.
S-BD quad switched beam antenna	4							-160° F	180° F	500° F	Thermal limits for pattern degradation.
S-BD hemi antenna	2							-160° F	180° F	500° F	Thermal limits for pattern degradation.
dissipation.) COMSEC unit Mode - OPERATE	2	25.0 2.5	MNA FPC1 MNB FPC2	Water loop	Bay 3A	PCA-1&2					OV099 COMSEC units powered by MAIN A and/or MAIN B.
STBY GCIL	1	50.9	MNA R15 MNC R15	Water loop	Bay 3A	CB-44, 3A CB-49, 3A	N/A	0° F	140° F	140° F	The GCIL is powered by Main A and/or Main C.
ACCU	2	36.3	(1) ESS 2 CA (2) MNC R15	Water loop	Bay 1	(1) CB-1, 3A (2) CB-9, 3A	N/A	-20° F	100° F	120° F	The LRU is internally redundant.

Table C-5. Communications Equipment: Power and coolant summary (continued)

LRU	Quantity	Power consumption, W	Power bus	Coolant source	LRU location	Circuit protection	Control signal	Minimum temp.	Maximum temp. Long term	Maximum temp. Short term	Notes
ATU MODE – No sig -	8	4.3 11.8		Cabin air (convection)	Cabin		N/A	-20° F	100° F	120° F	
Signal PILOT CDR MSS MIDDECK SPEAKER MIDDECK CCU PS OS AL			ESS 2 CA ESS 1 BC MNA R15 MNB R15 MNB R15 MNC R15 MNA R15 MNC R15			CB-6, 3 ^a CB-4, 3 ^a CB-2, 3 ^a CB-5, 3 ^a CB-3, 3 ^a CB-10, 3 ^a CB-2, 3 ^a CB-10, 3 ^a					OS ATU and middeck CCT ATU not on OV-099.
Speaker/mike unit Mode – No sig -	2	3.0 14.9		Cabin air (convection)	Cabin		N/A	-20° F	100° F	120° F	
Signal OS Middeck			MNA R15 MNB R15			CB-2, 3A CB-5, 3A					
HIU Mode – No sig -	2	0.5 0.76			Cabin			-20° F	100° F	120° F	Powered via CCU PWR switch; same source, circuit protection as associated ATU power.
Signal											
IFU Mode – No sig -	2	0.73 1.21		Cabin air	Cabin			-20° F	100° F	120° F	Powered via RIGHT (LEFT) COMM power switch in SUIT position.
Signal PLT CDR			ESS2CA ESS1BC			CB-6, 3A CB-4, 3A					
KU-BD signal processor assembly	1	87	MNC R15	Water loop	Bay 3B	CB31, 5A	EA-1	0° F	140° F	140° F	
KU-BD electronics assembly 1	1	150	MNC FPCA3	Water loop	Bay 3A	RPC53, 10A	MNB R15	0° F	140° F	140° F	
KU-BD electronics assembly 2	1	48	MNB R15	Water loop	Bay 3A	CB23, 15A	EA-1	0° F	140° F	140° F	
KU-BD digital display and X-PNTR	1	15	MNB R15	Cabin air	Cabin	CB23, 15A Fuse, 3A					

Table C-5. Communications Equipment: Power and coolant summary (continued)

LRU	Quantity	Power consumption, W	Power bus	Coolant source	LRU location	Circuit protection	Control signal	Maximum temp.			Notes
								Minimum temp.	Long term	Short term	
KU-BD deployed electronics assembly Mode – COMM ON - COMM STBY - RADAR ON - RADAR STBY	1	290 112 244 112	MNB MPC2	Not actively cooled	PLB	Fuse, 20A	MNB R15	0° F	156° F	156° F	
KU-BD deployed mechanical assembly (ANT GIMBAL MOTORS)	1	2@ 83W PEA 4.5W AVG	MNC FPCA3	Not actively cooled	PLB	RPC53, 10A	MNB R15	0° F	180° F	180° F	Temp limits for lubricant
KU-BD deployed mechanical assembly HEATER	1	115.5	MNB MPC2	Not actively cooled	PLB	Fuse, 20A	MNB R15				For gyro assembly gimbal motors A and B and antenna feed SPEC 76 COMM ALERT temp on TLM
KU-BD deployed electronics assembly HEATER	2	134	(1) MNB MPC2 (2) MNB MPC2	Not actively cooled	PLB	(1) Fuse, 20A (2) Fuse, 20A	MNB R15				Temp on TLM
Text and graphics (HARDCOPIER) Mode – OPERATE - STBY - WARMUP (15 min)	1	100 70 135	MNC FPC	Water loop	Bay 3B	PCA-3 (10A)	CNTL CA1				
EBIA (Encryption By-pass Isolation Assb.)	1	5	MNC FPC3	11	Bay 3A	PCA-3 (10A)	CNTL CA1				
Payload signal processor	2	32.0	(1) MNB FLC2 (2) MNC FLC3	Water loop	Bay 2	(1) Fuse, 3A LCA2 (2) Fuse, 3A LCA3	(1) CNTL BC1 (2) CNTL BC2	-20° F	120° F	120°	

Table C-5. Communications Equipment: Power and coolant summary (continued)

LRU	Quantity	Power consumption, W	Power bus	Coolant source	LRU location	Circuit protection	Control signal	Minimum temp.	Maximum temp.		Notes
									Long term	Short term	
Payload interrogator	2	97.9	(1) MNB FLC2 (2) MNC FLC3	Water loop	Bay 2	(1) LCA2 (2) LCA3	(1) CNTL BC1 (2) CNTL BC2	-20° F	120° F	120°	
Payload interrogator RF switch	1	0	MNB FLC2 MNC FLC3	Water loop	Bay 2	Fuse, 10A LCA2 Fuse, 10A LCA3	CNTL BC1 (TLM only)				
Payload data inter-leaver	1	27	MNA FPC1 MNC FPC3	Water loop	Bay 1	RPC (5A) RPC (5A)	CNTL BC1 CNTL BC2	35° F	120° F	120° F	
MADS strain gauges	85	112 (all)	MNA MPC2	Not actively cooled	PLB	RPC (15A)	MNB A14	+20° F	165° F	165° F	
MADS wideband system	1	56	MNA MPC1	Not actively cooled	PLB	RPC (15A)	MNB A14	-65° F	165° F	165° F	
- FDM		115						+20° F	165° F	165° F	
- Wideband equip:	1										
PCM ACIP	2										
FASCO pressure sensors	10										
WBSC	12										
MADS PCMMU	1	60	MNB MPC2	Not actively cooled	PLB	RPC (15A)	MNB A14	-45° F	150° F	150° F	
MADS RCDR	1		MNB FPC2	Cabin air (forced)	Vol. D of crew comp. (under middeck floor)	RPC (10A)	MNB A14	35° F	120° F	120° F	Temp on TLM
- STBY		58									
- RCD 3.75		103									
IPS		106									
- RCD 15 IPS		109									
- PB 60 IPS											

Table C-5. Communications Equipment: Power and coolant summary (continued)

LRU	Quantity	Power consumption, W	Power bus	Coolant source	LRU location	Circuit protection	Control signal	Minimum temp.	Maximum temp.		Notes
									Long term	Short term	
MADS control module	1	16-25	MNB FPC2	Cabin air (forced)	Vol. D of crew comp. (under middeck floor)	CB-1, 5A	MNB A14	° F	125° F	125° F	Power depends on MADS RCDR direction
Dedicated signal conditioner OI OA1	1	36.2	MNA APC4 MNB APC5	Cold-plate Freon	Aft bay 4	RPC 5A RPC 5A	CNTL AB2 CNTL BC2 017 S17	-65° F	160° F	160° F	Redundant power
Dedicated signal conditioner OI OA2	1	29.1	MNB APC5 MNC APC6	Cold-plate Freon	Aft bay 5	RPC 5A RPC 5A	CNTL BC2 CNTL CA1 017 S17	-65° F	160° F	160° F	Redundant power
Dedicated signal conditioner OI OA3	1	29.1	MNA APC4 MNC APC6	Cold-plate Freon	Aft bay 6	RPC 5A RPC 5A	CNTL AB2 CNTL CA1 017 S17	-65° F	160° F	160° F	Redundant power
Dedicated signal conditioner OI OF1	1	22.8	MNA 014 MNB 015	Cold-plate Freon	Middeck bay 1	014 CB2 015 CB	None	-65° F	160° F	160° F	Redundant power
Dedicated signal conditioner OI OF2	1	32.6	MNB 015 MNC 016	Cold-plate Freon	Middeck bay 2	015 CB3 016 CB2	None	-65° F	160° F	160° F	Redundant power
Dedicated signal conditioner OI OF3	1	26.8	MNC 016 MNB 015	Cold-plate Freon	Avionics bay 3	016 CB2 015 CB3	None	-65° F	160° F	160° F	Redundant power
Dedicated signal conditioner OI OF4	1	26.9	MNB 015 MNA 014	Not actively cooled	FWD RCS Module	015 CB2 014 CB2	None	-65° F	160° F	160° F	Redundant power
Dedicated signal conditioner OI OL1	1	23.3	MNB APC2 MNA APC1	Not actively cooled	Left-hand OMS pod	RPC 5A RPC 5A	CNTL BC2 CNTL AB2 017 S13	-65° F	160° F	160° F	Redundant power
Dedicated signal conditioner OI OL2	1	21.4	MNA APC1 MNC APC3	Not actively cooled	Left-hand OMS pod	RPC 5A RPC 5A	CNTL AB2 CNTL CA2 017 S13	-65° F	160° F	160° F	Redundant power
Dedicated signal conditioner OI OM1	1	13.9	MNB 015 MNA 015	Not actively cooled	Mid-fuselage	015 CB4 015 CB3	None	-65° F	160° F	160° F	Redundant power
Dedicated signal conditioner OI OM2	1	22.1	MNB 015 MNA 014	Not actively cooled	Mid-fuselage	015 CB4 014 CB3	None	-65° F	160° F	160° F	Redundant power
Dedicated signal conditioner OI OM3	1	13.4	MNB 015 MNC 016	Not actively cooled	Mid-fuselage	015 CB 37 016 CB 31	None	-65° F	160° F	160° F	Redundant power

Table C-5. Communications Equipment: Power and coolant summary (concluded)

LRU	Quantity	Power consumption, W	Power bus	Coolant source	LRU location	Circuit protection	Control signal	Minimum temp.	Maximum temp.		Notes
									Long term	Short term	
Dedicated signal conditioner OI OR1	1	23.3	MNB APC2 MNA APC1	Not actively cooled	Right-hand OMS pod	RPC 5A RPC 5A	CNTL BC3 CNTL AB3 017 S14	-65° F	160° F	160° F	Redundant power
Dedicated signal conditioner OI OR2	1	21.4	MNB APC2 MNC APC3	Not actively cooled	Right-hand OMS pod	RPC 5A RPC 5A	CNTL BC3 CNTL CA3	-65° F	160° F	160° F	Redundant power
Multiplexer demultiplexer OI OA1	1	41.3	MNB APC5 MNA APC4	Cold-plate Freon	Aft bay 4	RPC 5A RPC 5A 017 S19	CNTL BC1 CNTL AB1	-65° F	160° F	160° F	Redundant power
Multiplexer demultiplexer OI OA2	1	42.1	MNC APC6 MNB APC5	Cold-plate Freon	Aft bay 4	RPC 5A RPC 5A 017 S19	CNTL CA2 CNTL BC1	-65° F	160° F	160° F	Redundant power
Multiplexer demultiplexer OI OA3	1	42.7	MNC APC6 MNA APC4	Cold-plate Freon	Aft bay 6	RPC 5A RPC 5A 017 S19	CNTL CA2 CNTL AB1	-65° F	160° F	160° F	Redundant power
Multiplexer demultiplexer OI OF1	1	46.8	MNA 014&A8 MNB 015&A8	Cold-plate Freon	Bay 1	014 CB4 015 CB5	None	-65° F	160° F	160° F	Redundant power
Multiplexer demultiplexer OI OF2	1	46.8	MNA 014&A8 MNB 015&A8	Cold-plate Freon	Bay 2	014 CB4 015 CB5	None	-65° F	160° F	160° F	Redundant power
Multiplexer demultiplexer OI OF3	1	47.4	MNA 014&A8 MNC 016	Cold-plate Freon	Bay 3	014 CB5 016 CB3	None	-65° F	160° F	160° F	Redundant power
Multiplexer demultiplexer OI OF4	1	40.4	MNA 014&A8 MNC 016	Cold-plate Freon	Flight deck	014 CB5 016 CB3	None	-65° F	160° F	160° F	Redundant power
PCMMU OI1	1	55	MNC FPC3 MNA FPC1	Cold-plate Freon	Bay 1	RPC 5A RPC 5A C3 S7	CNTL CA1 CNTL AB1	35° F	120° F	120° F	
PCMMU OI2	1	55	MNA FPC1 MNB FPC2	Cold-plate Freon	Bay 2	RPC 5A RPC 5A C3 S7	CNTL AB1 CNTL BC1	35° F	120° F	120° F	
Payload data interleaver	1	40	MNA FPC1 MNC FPC3	Cold-plate Freon	Bay 1	RPC 5A RPC 5A A1 S17	CNTL AB1 CNTL CA1	35° F	120° F	120° F	