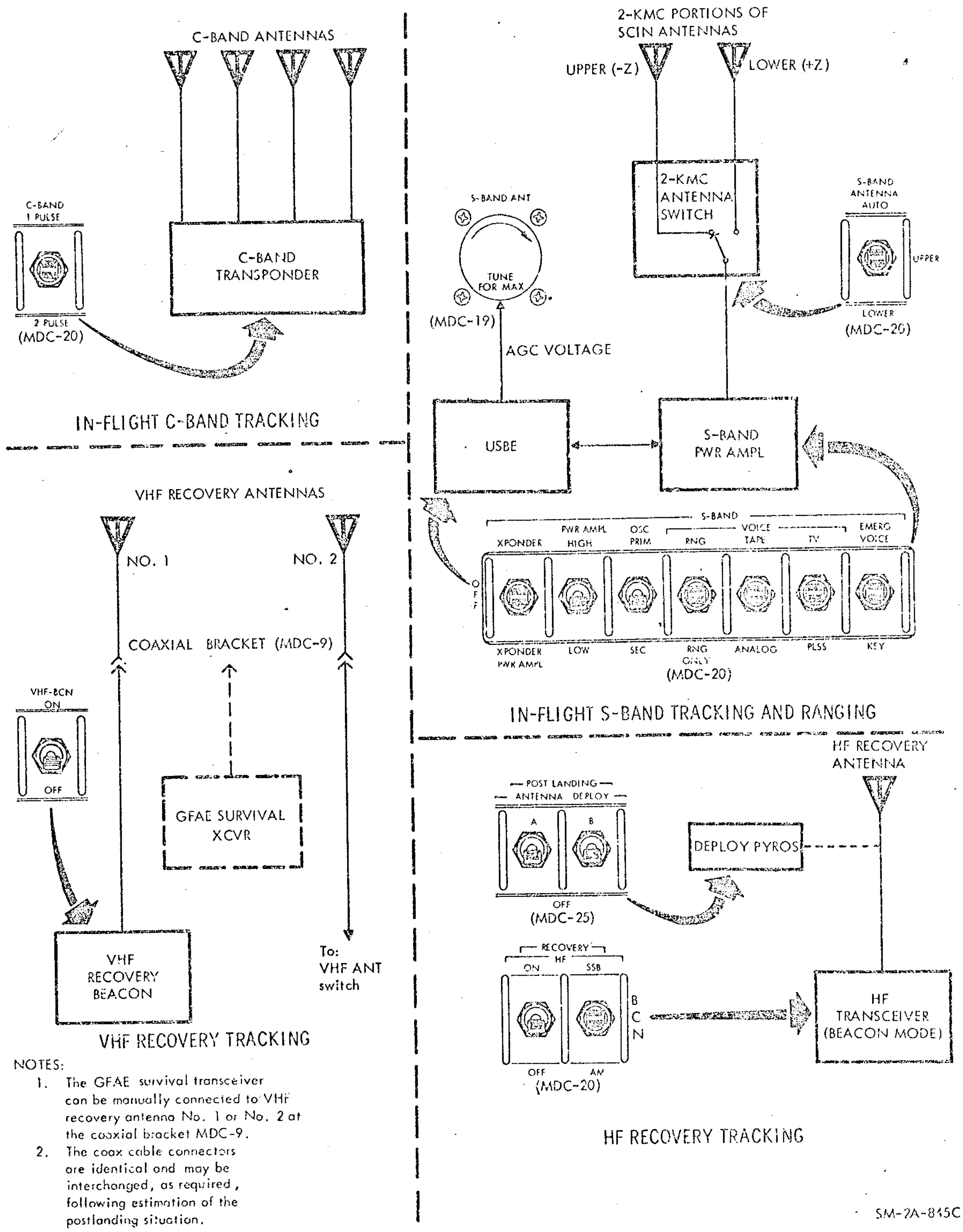


NOTES:

1. The GFAE survival transceiver can be manually connected to VHF recovery antenna No. 1 or No. 2 at the coaxial bracket MDC-9.
2. The coax cable connectors are identical and may be interchanged, as required, following estimation of the postlanding situation.

Figure 2.8-3. Tracking and Ranging

After touchdown, the HF recovery antenna must be deployed by setting the POSTLANDING – ANTENNA switches (MDC-25) to DEPLOY A and B while the MASTER EVENT SEQ CONT switches (MDC-24) are at PYRO ARM 1 and 2. HF beacon transmission at a preassigned frequency of 10.006 mc is accomplished by placing the RECOVERY – HF switch (MDC-20) to ON and the RECOVERY – HF-SSB/BCN/AM switch to BCN.

The GFAE survival transceiver (part of the crew's personal equipment) can also be operated in a beacon mode. If used inside the S/C, one of the VHF recovery antennas (No. 1 or No. 2) can be used by manually connecting it to the applicable coax connector on MDC-9.

The VHF antennas and communications equipment condition, as determined by the crew during the postlanding pre-recovery period, will decide the utilization of the coaxial cable connectors located on MDC-9. The connectors are identical and the recovery equipment coaxial cables may be interchanged to provide the most beneficial tracking configuration.

2.8.2.4 Unified S-Band Operations.

2.8.2.4.1 General.

The USBS is primarily designed to be used as a deep-space communications link between the S/C and the MSFN. Nevertheless, on mission 205 some of its capabilities will be tested and it may be called upon for use as backup equipment for voice communications, PCM data transmission, up-data reception, or S/C tracking and ranging when the S/C is within range of a MSFN station equipped for S-band operations. In addition, only the USBS is capable of transmitting TV.

The USBS consists of the S-band transmitter and receiver combined in a single electronic package called the unified S-band equipment (USBE) and the S-band power amplifier (PA). The function of the S-band PA is to provide additional power amplification of the USBE transmitter output. Two levels of amplification (high and low) are possible. A bypass mode is also possible wherein the S-band PA is turned off and the output of the USBE transmitter is sent to the S-band antenna equipment "as is." The 2-kmc portions of the upper and lower SCIN antennas are used for transmission and reception of S-band signals. Antenna selection is made by placing the S-BAND ANTENNA switch (MDC-20) to UPPER, LOWER, or AUTO. In the AUTO position, the antenna will be automatically switched if the signal falls below a minimum threshold.

The PMP is controlled in conjunction with the USBE by the S-BAND switches to provide the proper voice and data inputs to the USBE in accordance with the S-band mode selected.

When operating in a ranging mode, the MSFN can transmit a "coded" pseudo-random noise (PRN) pulse to the S/C via the S-band carrier. The S/C USBE will respond by transmitting an identical pulse to the MSFN. By measuring the time lapse between transmission of the signal and reception of the response signal the MSFN can accurately determine the S/C range. Once established, this value can then be continually updated by measuring the doppler shift in the S-band carrier. A ranging mode can be selected again at later times, to verify or up-date the doppler data.

2.8.3 MAJOR COMPONENT/SUBSYSTEM DESCRIPTION.

To facilitate this presentation, the equipment comprising the T/C system (figure 2.8-4) has been divided into four groups designated as instrumentation equipment, voice and data equipment, RF electronics equipment, and antenna equipment. Specifically, these equipment groups contain the following:

Instrumentation equipment group

- Operational instrumentation
- Flight qualification instrumentation

Voice and data equipment group

- Audio center (A/C) equipment
- Signal conditioning equipment (SCE)
- Pulse-code modulation-telemetry (PCM TLM) equipment
- Television (TV) equipment
- Premodulation processor (PMP) equipment
- Data storage equipment (DSE)
- Flight qualification recorder (FQR) equipment
- Up-data link (UDL) equipment
- Central timing equipment (CTE)
- Voice recorder

RF electronics equipment group

- VHF/AM transmitter-receiver equipment
- HF transceiver equipment
- VHF/FM transmitter equipment
- Unified S-band equipment (USBE)
- S-band power amplifier equipment
- C-band transponder equipment
- VHF recovery beacon equipment

Antenna equipment group

- VHF/2-KMC omni-antenna equipment
- HF antenna equipment
- VHF recovery antenna equipment
- C-band beacon antenna equipment

2.8.3.1 Instrumentation Equipment Group.

The S/C instrumentation equipment consists of various types of sensors and transducers for providing environmental, operational status, and performance measurements of the S/C structure, operational systems, and experimental equipment. The outputs from these sensors and transducers are conditioned to signals suitable for utilization by the S/C displays, presentation to the PCM TLM equipment, or both. In addition, various digital signals are presented to the PCM TLM equipment, including event information, guidance and navigation data, and a time signal from the CTE.

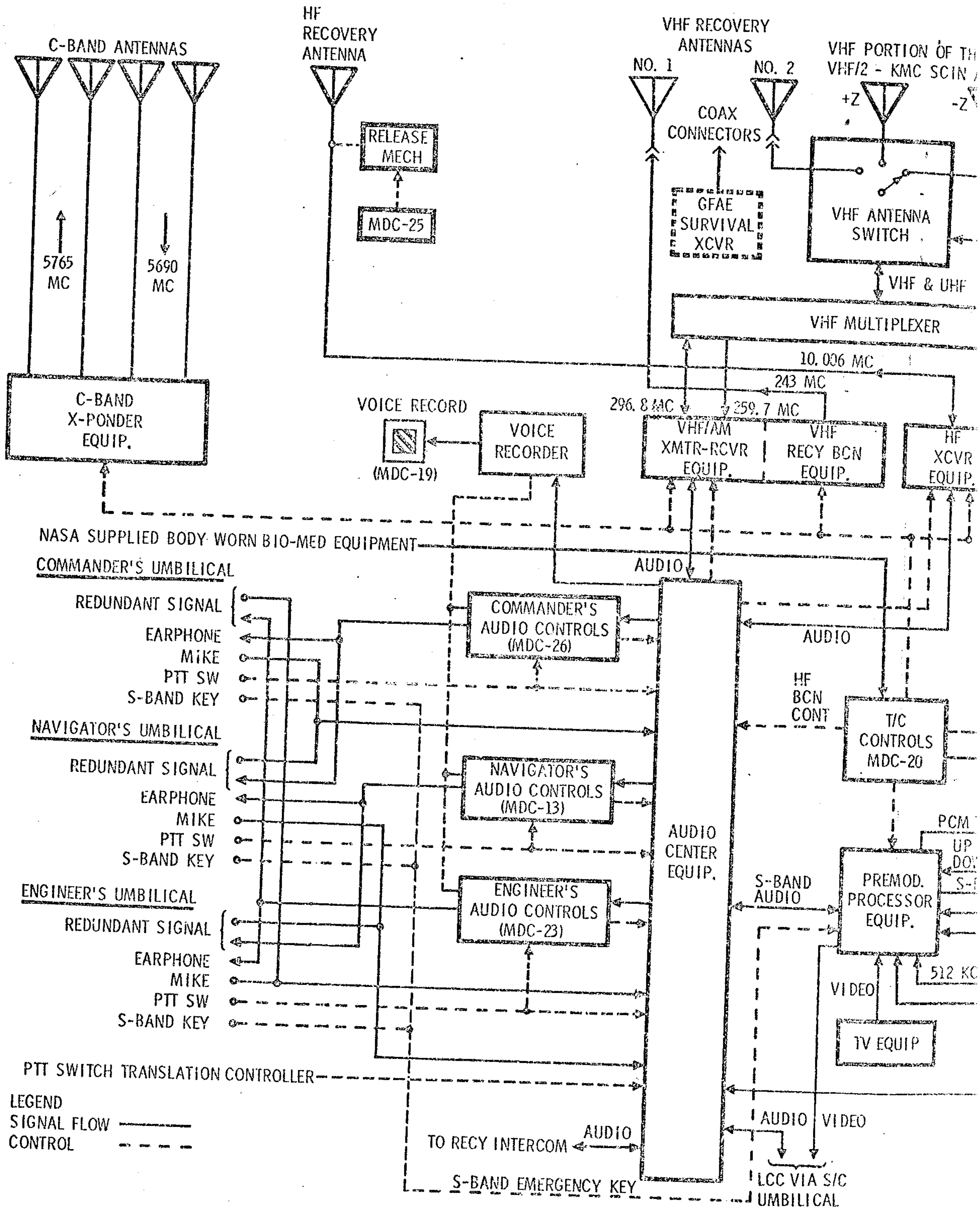
Many of the signals emanating from the instrumentation sensors are of forms or levels which are unsuitable for use by the S/C displays or PCM TLM equipment. Signal conditioners are used to convert these signals to forms and levels which can be utilized. Some signals are conditioned at or near the sensor by individual conditioners located throughout the S/C. Other signals are fed to the signal conditioning equipment (SCE), a single electronics package located in the lower equipment bay. (Refer to signal conditioning equipment in the Voice and Data Equipment Group.) In addition to conditioning many of the signals, the SCE also supplies 5-vdc excitation power to some sensors. The SCE can be turned on or off with the POWER-SCE switch on MDC-20. This is the only control that the crew can exercise over instrumentation equipment for operational and flight qualification measurements. These two instrumentation groups are discussed in the following two paragraphs. Information on scientific and special instrumentation can be found in section 4 of this manual, Experiments and Scientific Equipment.

2.8.3.1.1 Operational Instrumentation.

Operational measurements are those which are normally required for a routine mission and include three categories: in-flight management of the S/C, mission evaluation and system performance, and preflight checkout of the S/C. The operational instrumentation sensors and transducers are capable of making the following types of measurements: pressure, temperature, flow attitude, rate, quantity, angular position, current, voltage, frequency, RF power, and "on-off" type events.

2.8.3.1.2 Flight Qualification Instrumentation.

Flight qualification measurements are those which will vary on different S/C, depending on mission objectives and state of hardware development. Most of them will be pulse-code modulated along with the operational measurements and transmitted to the MSFN. Other flight qualification measurements will be stored in the FQR for postflight analysis only.


C-BAND ANTENNAS
HF RECOVERY ANTENNA
VHF RECOVERY ANTENNAS
NO. 1
NO. 2
VHF PORTION OF TH
VHF/2 - KMC SCIN
+Z
-Z
COAX CONNECTORS
RELEASE MECH
MDC-25
GFAE SURVIVAL XCVR
VHF ANTENNA SWITCH
VHF & UHF
VHF MULTIPLEXER
5765 MC
5690 MC
10.006 MC
243 MC
296.8 MC
259.7 MC
C-BAND X-PONDER EQUIP.
VOICE RECORD
(MDC-19)
VOICE RECORDER
VHF/AM XMTR-RCVR EQUIP.
VHF RECY BCN EQUIP.
HF XCVR EQUIP.
NASA SUPPLIED BODY WORN BIO-MED EQUIPMENT
COMMANDER'S UMBILICAL
REDUNDANT SIGNAL
EARPHONE
MIKE
PTT SW
S-BAND KEY
AUDIO
COMMANDER'S AUDIO CONTROLS (MDC-26)
AUDIO
HF BCN CONT
T/C CONTROLS MDC-20
NAVIGATOR'S UMBILICAL
REDUNDANT SIGNAL
EARPHONE
MIKE
PTT SW
S-BAND KEY
NAVIGATOR'S AUDIO CONTROLS (MDC-13)
AUDIO CENTER EQUIP.
PCM
UP
DO
S-
ENGINEER'S UMBILICAL
REDUNDANT SIGNAL
EARPHONE
MIKE
PTT SW
S-BAND KEY
ENGINEER'S AUDIO CONTROLS (MDC-23)
S-BAND AUDIO
PREMOD. PROCESSOR EQUIP.
512 KC
VIDEO
TV EQUIP
PTT SWITCH TRANSLATION CONTROLLER
LEGEND
SIGNAL FLOW
CONTROL
TO RECY INTERCOM
AUDIO
AUDIO
VIDEO
S-BAND EMERGENCY KEY
LCC VIA S/C UMBILICAL

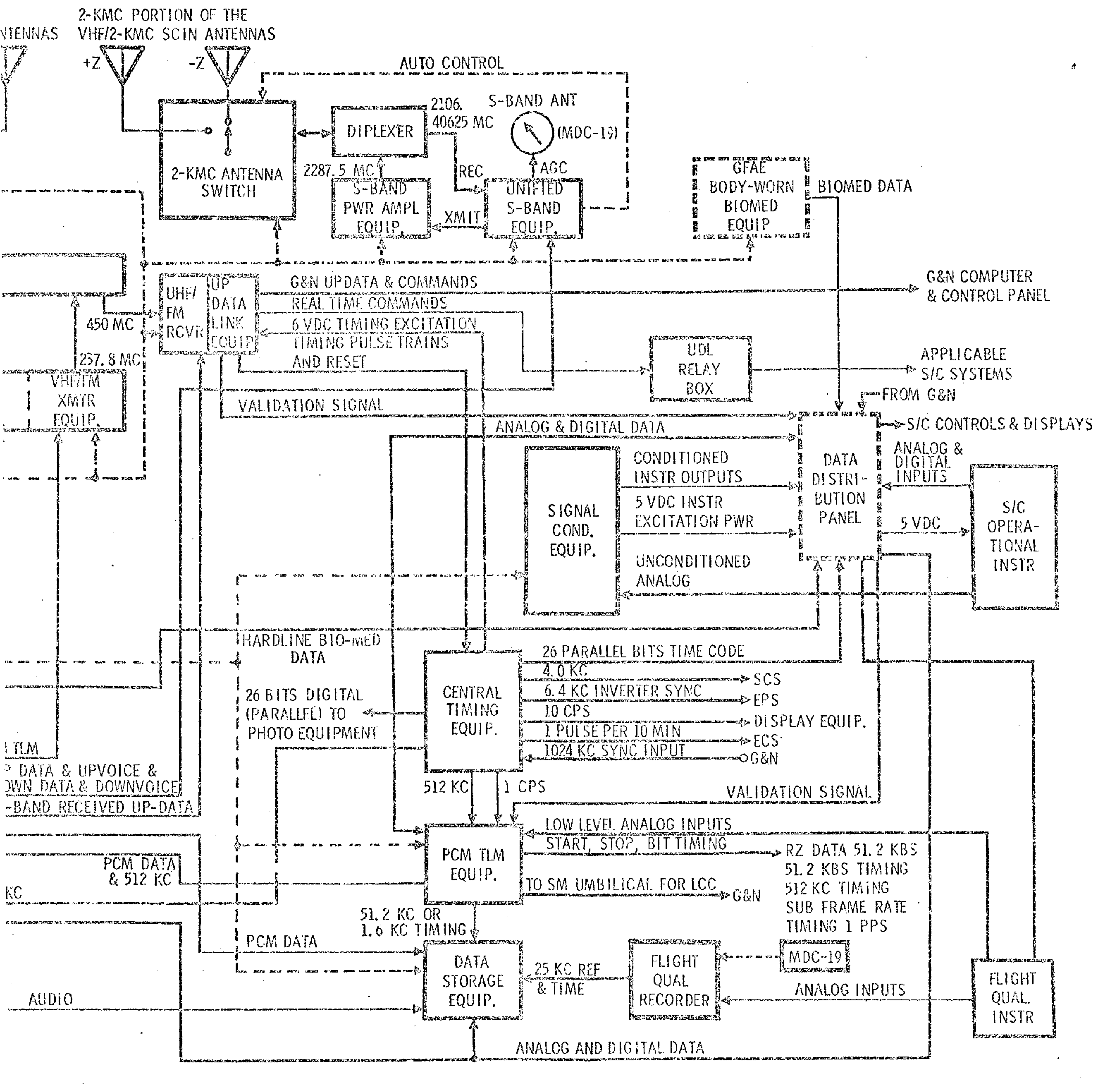


Figure 2. 8-4. Telecommunications System

2.8.3.2 Voice and Data Equipment Group.

2.8.3.2.1 Audio Center (A/C) Equipment.

The A/C equipment (figure 2.8-5) consists of three separate identical modules located in a single electronics package in the lower equipment bay. Each module is controlled independently by its own control panel and supplied with 28-vdc power through separate circuit breakers. The three control panels, MDC-26, -13, and -23, are located in stations 1, 2, and 3, respectively. Each of the astronaut's headsets, containing two microphones and two microphone amplifiers, and two independently operating earphones, is connected to one of the A/C modules by a cobra cable. Thus each astronaut has a separate headset, audio center module, and audio control panel to provide him with individual control of voice transmission and reception.

Each A/C module contains a microphone amplifier, VOX circuitry, an earphone amplifier, and various signal attenuation, switching, and isolation circuits. The earphone and microphone amplifiers amplify the voice signals to and from the headset. The VOX circuitry is a voice-operated keying circuit that supplies a ground return path necessary for activating the microphone amplifier and the transmitter keying relays in the HF transceiver, intercommunication system, and the power control relay in the operating voice recorder.

Audio signals are provided to and from the HF transceiver equipment, VHF/AM transmitter-receiver equipment, USBE (via the PMP), and the intercom bus. The intercom bus is common to all three modules and provides for the hardline communications between crewmen and with the LCC and recovery forces.

Inputs and outputs are controlled by the RCDR/HF, VHF/AM, S-BAND, and INTERCOM switches on the audio control panels. Each of these switches has three positions: T/R, OFF, and REC. Setting any of the switches to T/R (except S-BAND) permits transmission and reception of voice signals over its respective equipment. REC permits reception only, and OFF disables the input and the output. The operation of the microphone amplifier in each module is controlled by the VOX keying circuit or the PTT pushbutton on the cobra cable or the translation controller. The VOX circuit is energized by the position of the POWER – PTT/OFF/VOX switch on each audio control panel. The PTT position permits monitoring and activation of the microphone amplifier, voice recorder HF, VHF/AM and S-band voice transmission circuits by the PTT key. The VOX position permits all the functions of the PTT position plus VOX activation of the microphone amplifier, voice recorder and HF transmitter.

Three potentiometer controls are also provided on each audio control panel: VOX SENS, INTERCOM BALANCE, and VOLUME. The VOX SENS control is used to adjust the sensitivity of the VOX circuitry, determining the amplitude of the voice signal necessary to trigger the VOX keying

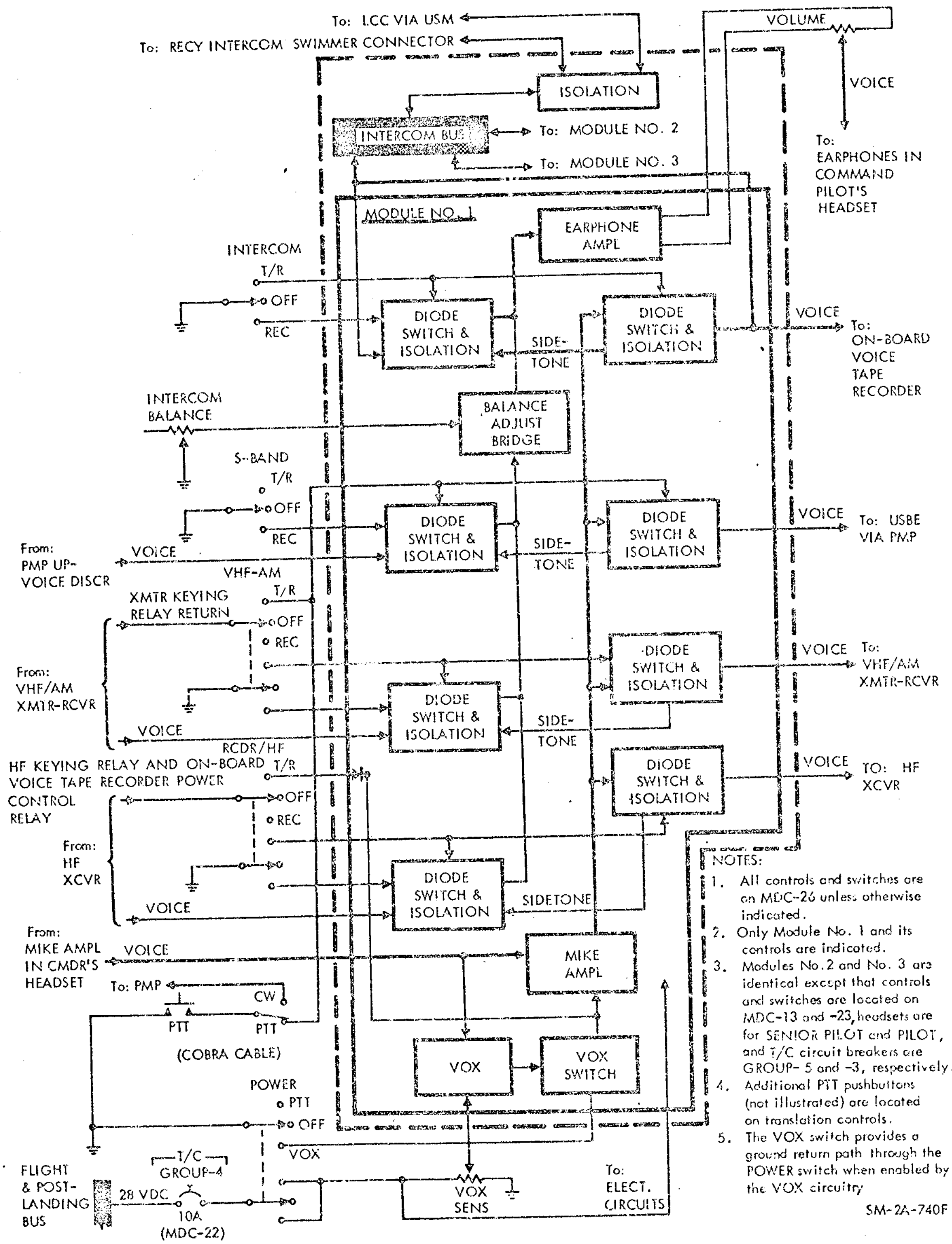


Figure 2.8-5. Audio Center Equipment

circuit. The INTERCOM BALANCE control adjusts the level of voice signal inputs from the RF equipment relative to the level of voice signal inputs from the intercom bus. The VOLUME control adjusts the output of the earphone amplifier.

2.8.3.2.2 Signal-Conditioning Equipment (SCE).

The signal-conditioning equipment (SCE) is contained in a single electronics package located in the LEB. (See figure 2.8-6.) Its functions are to convert various kinds of unconditioned signals from the instrumentation equipment into compatible, 0- to 5-volt d-c analog signals, and to provide excitation voltages to some of the instrumentation sensors and transducers.

The SCE uses the following module types: The active attenuator, to attenuate high-signal voltages; the ac-(am) to-dc converter, to detect the amplitude variations of an a-c signal; the dc differential amplifier, to amplify small signals; the dc differential bridge amplifier, to detect resistance changes; the bi-phase demodulator, to convert S/C position resolver outputs; the frequency demodulator, to detect frequency changes in an a-c signal; and the power supply, to provide +20 volts and -20 volts to the SCE circuitry, 10 volts as bridge excitation, and 5 volts to excite other S/C sensors.

The conditioned output signals from the SCE are routed to the data distribution panel (DDP). The DDP provides parallel outputs, where necessary, and routes the signals to the PCM telemetry equipment, S/C displays, and GSE connections.

The only external control for the SCE is the two-position POWER—SCE toggle switch on MDC-20. Placing this switch to ON applies 28 volts dc to the latch winding of the latching relay, which closes contacts applying 3-phase a-c power to the power supply module. In the OFF position, the relay is unlatched, removing a-c power from the power supply.

2.8.3.2.3 Pulse-Code Modulation Telemetry (PCM TLM) Equipment.

The function of the PCM TLM equipment (figure 2.8-7) is to convert TLM data inputs from various sources into one serial digital output signal. This single output signal is routed to the PMP for transmission to the MSFN or to the DSE for storage. The PCM TLM equipment is contained in two separate units located in the lower equipment bay: PCM unit 1 and PCM unit 2.

Input signals to the PCM TLM equipment are of four general types: low-level analog, high-level analog, parallel digital, and serial digital. Some of the low-level analog inputs are supplied directly from the instrumentation sensors; other data inputs are routed through the data distribution panel (DDP).

Two modes of operation are possible: the high- (normal) bit-rate mode of 51.2 kilobits per second (KBS) and the low- (reduced) bit-rate mode of 1.6 KBS. Operational mode is selected by placing the TLM INPUTS—PCM switch on MDC-20 to HIGH or LOW, as applicable. When the switch is in the LOW position, the high PCM bit-rate can be commanded by the MSFN via the UDL equipment.

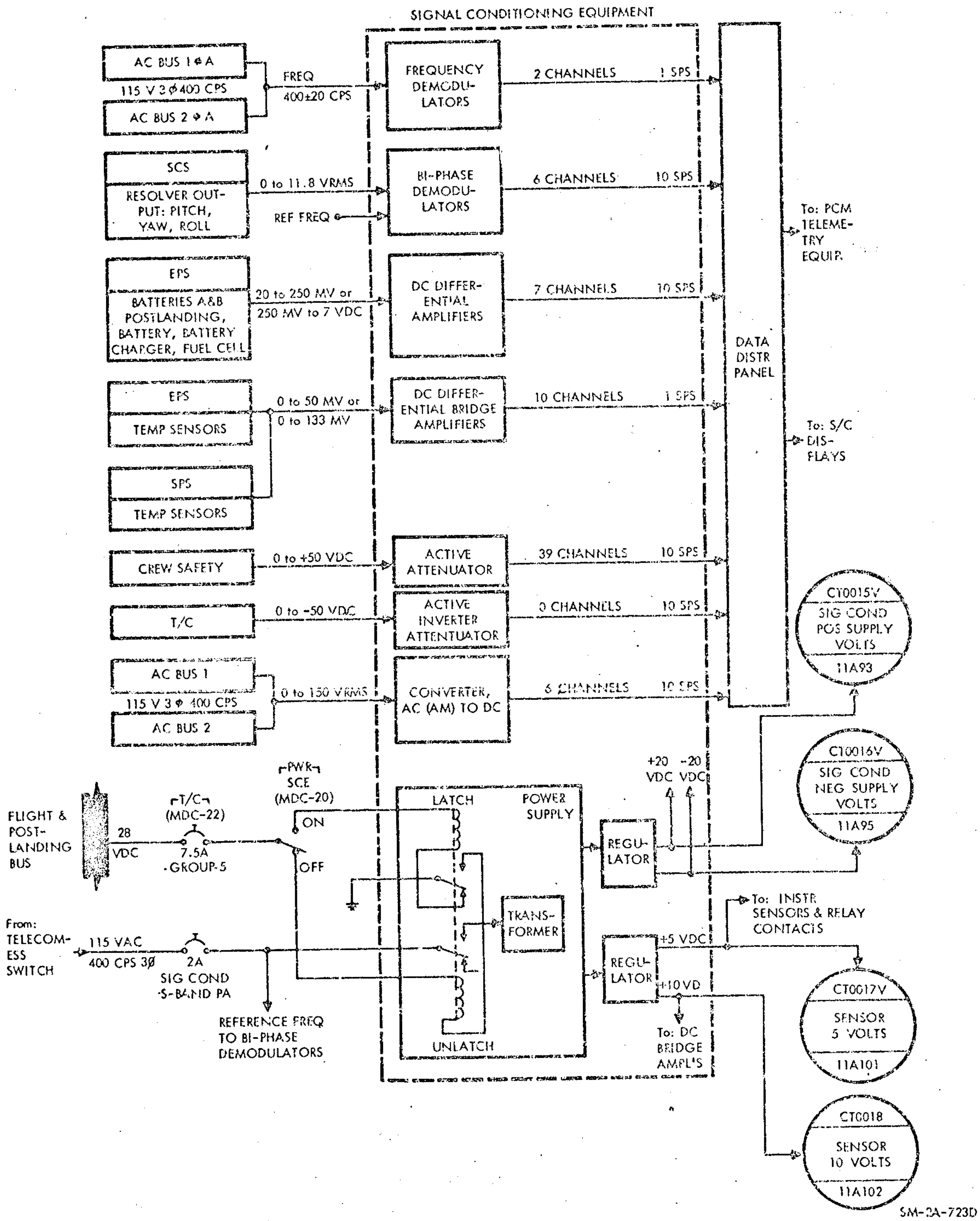


Figure 2.8-6. Signal Conditioning Equipment

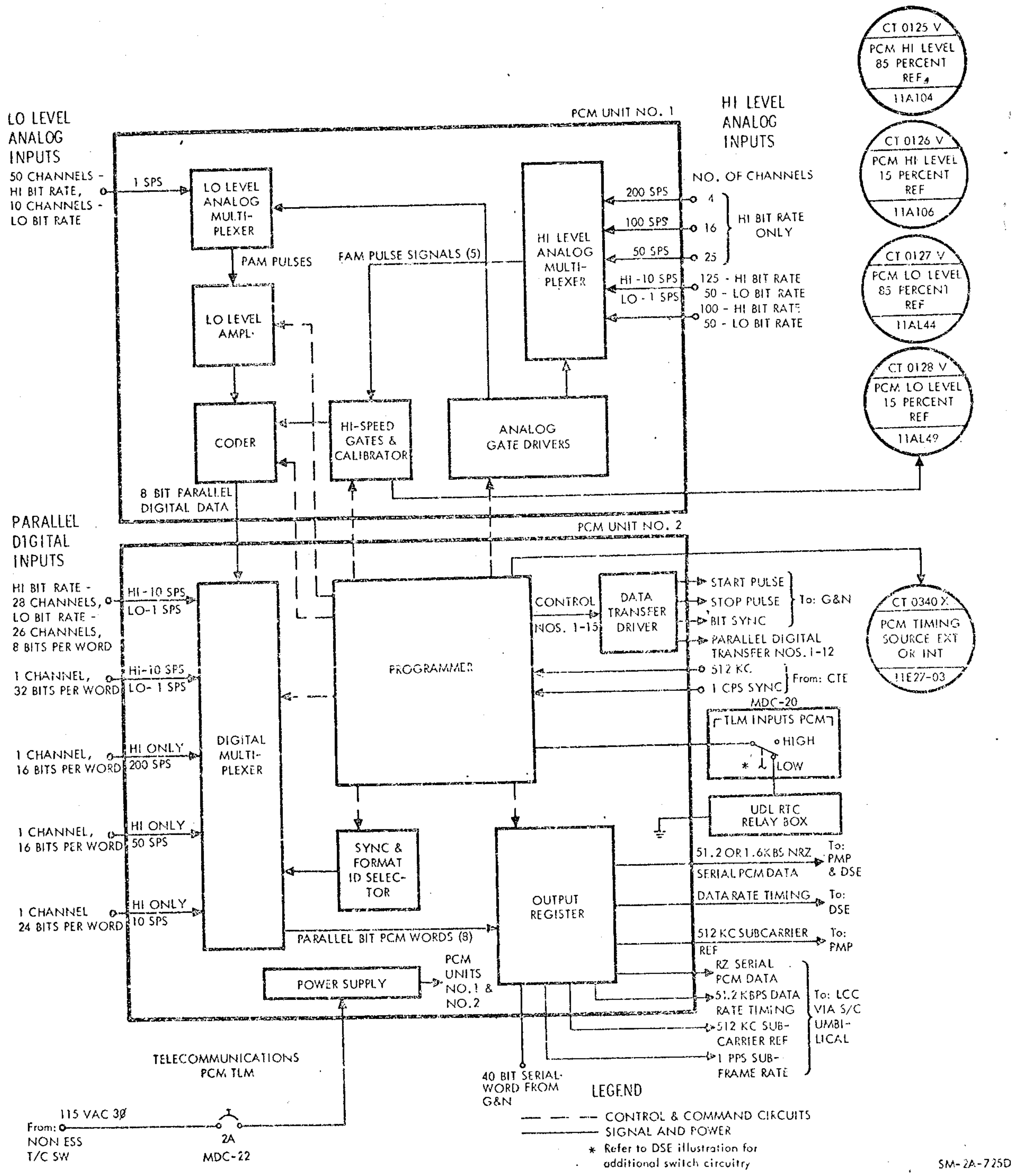


Figure 2.8-7. Pulse Code Modulation Telemetry

2.8.3.2.4 Television (TV) Equipment.

The TV equipment consists of a small, portable, TV camera (figure 2.8-8) that can be hand-held or mounted in one of four locations in the command module. Its function is to acquire real-time video information for transmission to the MSFN during S-band testing.

The first camera mounting position is located below the main display console, and will permit a front view of the crew lying in their couches. The second position is located behind the head of the center seat, and will permit viewing of crew activities in the middle of the command module. The second position is also provided with a five-foot stretch cable to permit hand-held use of the camera for coverage of any desirable target inside or outside the S/C. The third position is located in the right-hand equipment bay, and permits viewing of astronauts at work in that area. The final position utilizes a special bracket which allows the TV camera to look out the right-hand docking window.

The TV camera is connected directly to the PWR cable at the first mounting position. If the TV camera is to be used in the mounting position behind the center couch, the PWR cable must be connected to the connector marked "TV Cam to Hatch J107," and the camera, in turn, should be connected to the connector at that position (J191), by the stretch cable. If the TV camera is to be mounted by the right-hand equipment bay, the PWR cable must be connected to the connector marked "TV Cam to RHEB," and the TV camera connected to the connector at that location (J195) by the stretch cable.

The TV camera is constructed with a pistol-grip type of handle on the bottom, which can be extended to facilitate portable use. The TV camera is fitted with a fixed-focus wide-angle lens for picture taking within the command module. For taking pictures of the earth or moon through the C/M window, an interchangeable zoom lens is provided. The zoom lens has a look angle of from 9 degrees through 30 degrees. It is fitted with a through-the-lens type viewer that will enable the operator to see the change in field of view and relative size of the scene while the lens is adjusted. The electronic circuitry in the camera is equipped with an automatic gain control to allow for differences in target illumination.

The TV camera is activated by a slide switch in the pistol-grip handle, which applies 28 volts dc to the camera power supply when set to on. This energizes the entire camera and results in a video output signal that is fed to the PMP. In the PMP, the video signal is frequency multiplexed with the telemetry data and voice, which is transmitted to earth via the USBE. The USBE must be operating in a TV mode to permit this transmission. An AUTO LIGHT CONTROL switch has been added to the camera, permitting it to compensate for either peak or average scene illuminations from 0.1 to 30 foot candles.

2.8.3.2.5 Premodulation Processor (PMP) Equipment.

The PMP equipment (figure 2.8-9) functions as a data processing and distribution center providing necessary interface, where required, between the voice, data, and RF equipment. The PMP consists of ten modules mounted in a single electronics package located in the lower equipment bay. These modules contain filters, oscillators, modulators, demodulators, detectors, switching circuits, discriminators, mixing and keying networks, and a power supply.

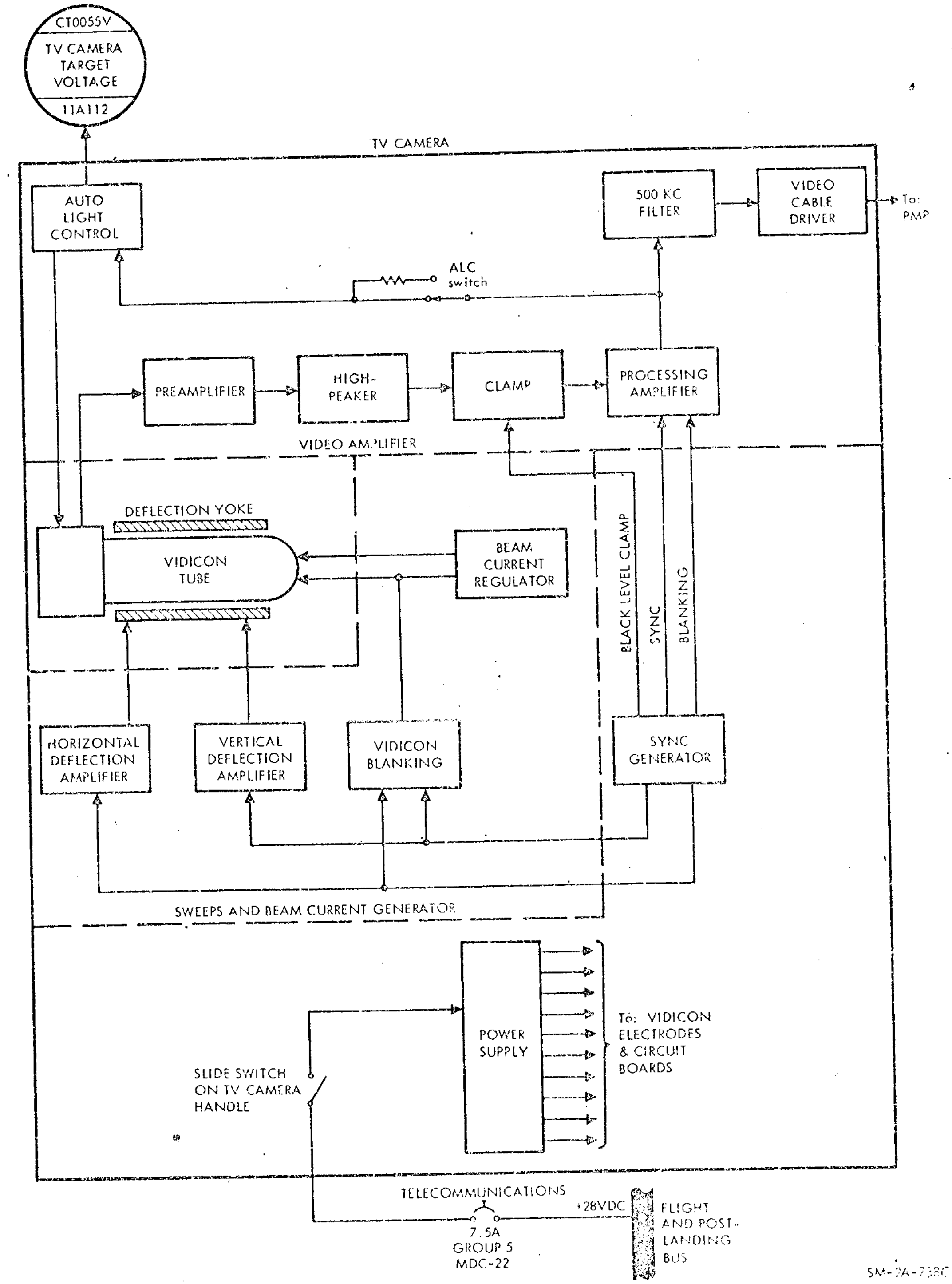


Figure 2.8-8. Television Equipment

The PMP can operate in many possible modes. All of the external controls for the PMP are switches located on MDC-20. The switches which affect the PMP consist of the POWER – PMP switch, the S-BAND – VOICE group of switches, the S-BAND – EMERG switch, and the TAPE RECORDER – PLAY and – RECORD/PLAY switches. Also, during emergency key operation, the PTT keys on the cobra cables and translation controls, control the PMP emergency key network. All of the signal inputs available to the PMP are listed in the PMP INPUTS table at the end of this paragraph. PMP outputs are dependent upon switch configuration. The PMP OUTPUTS table, also at the end of this paragraph, shows the various composite output signal possibilities along with their destinations and the switch positions required for any mode of operation. It should be noted that the S-BAND and TAPE RECORDER switches also affect the operational mode of the USBE and DSE.

One function of the PMP is to process the PCM TLM signal obtained from the PCM TLM equipment or DSE and route it to the VHF/FM transmitter equipment for transmission to the MSFN. This output will be provided whenever a PCM input is available, regardless of mode and simultaneously with other PMP outputs.

All remaining PMP functions involve interface with the USBE. Inputs to the PMP from the USBE are the 70-kc up-data and 30-kc up-voice subcarriers. These are fed into the up-data and up-voice discriminator circuits. These two circuits (as well as circuitry needed for emergency S-band modes) do not require the PWR-PMP switch to be on. They are supplied with power independently whenever the USBE is in operation. Outputs from the up-data and up-voice discriminators are fed to the UDL and A/C equipment, respectively.

The PMP supplies an output to one of the three USBE inputs, depending on S-band mode as selected by the S-BAND – VOICE group of switches and the S-BAND – EMERG switch. The USBE inputs are designated PM, FM-1, and FM-2. During normal S-band modes, the PMP supplies either a PM or FM-1 output to the USBE. The PM output supplies real-time PCM TLM and voice to the USBE when the USBE is operating in a normal voice or a ranging mode. If the USBE ranging only mode is selected, the PCM TLM portion of the output is eliminated, leaving only voice signals in the PM-1 output. When recorded data or TV data is to be transmitted along with PCM TLM and voice data, the FM-1 output is supplied to the USBE. This mode permits the greater bandwidth which is required for transmission of this data.

There are two emergency modes; emergency voice and emergency key, selected by the S-BAND – EMERG switch and used to permit emergency transmission of voice or code over the USBE with the PMP shutdown. With the S-BAND – EMERG switch in the center (OFF) position, the PWR — PMP switch controls the application of power to the PMP. However, with the S-BAND – EMERG switch set to either VOICE or KEY, a-c power is removed from the PMP. In the KEY position, a separate 28-volt d-c

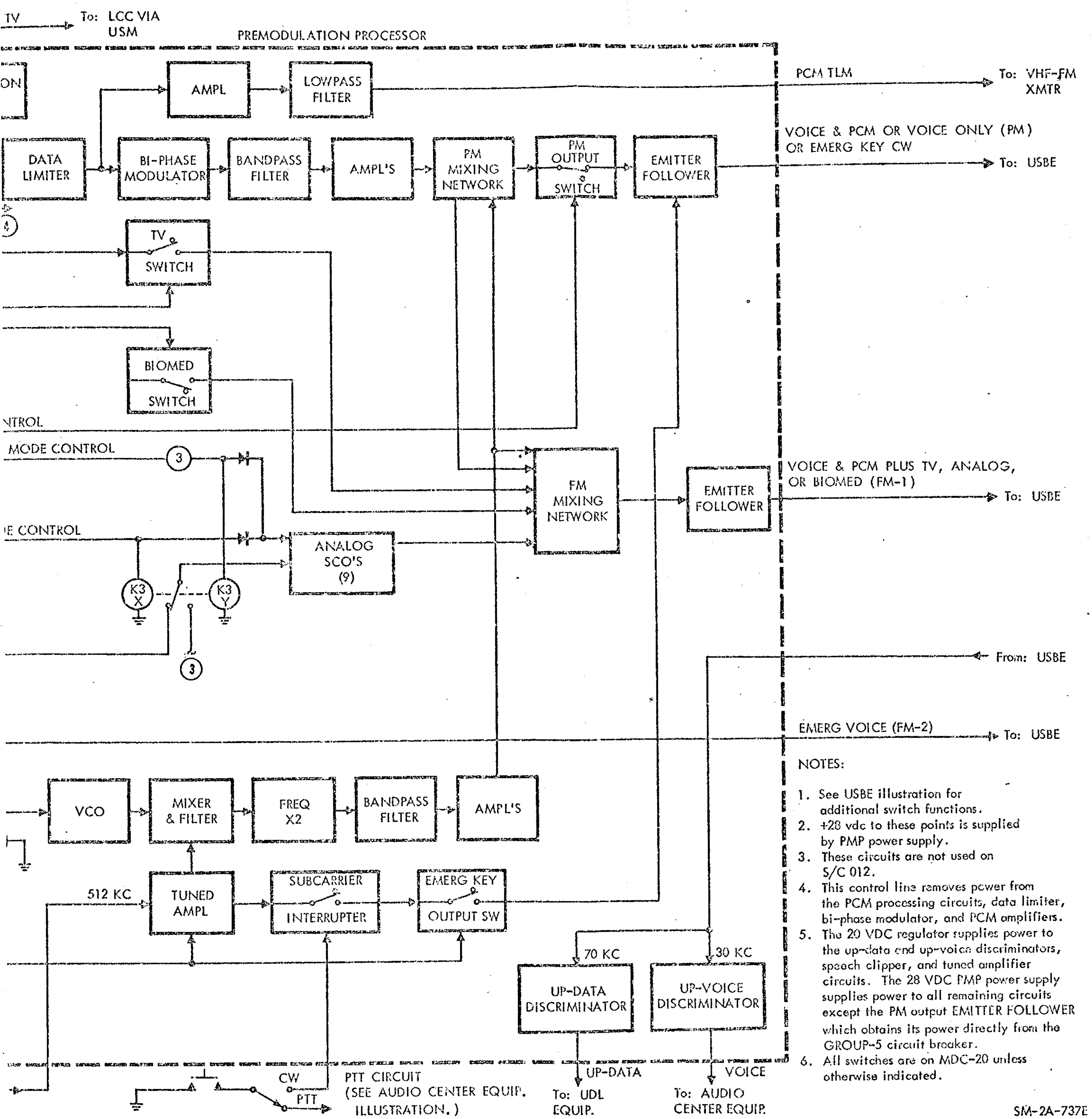
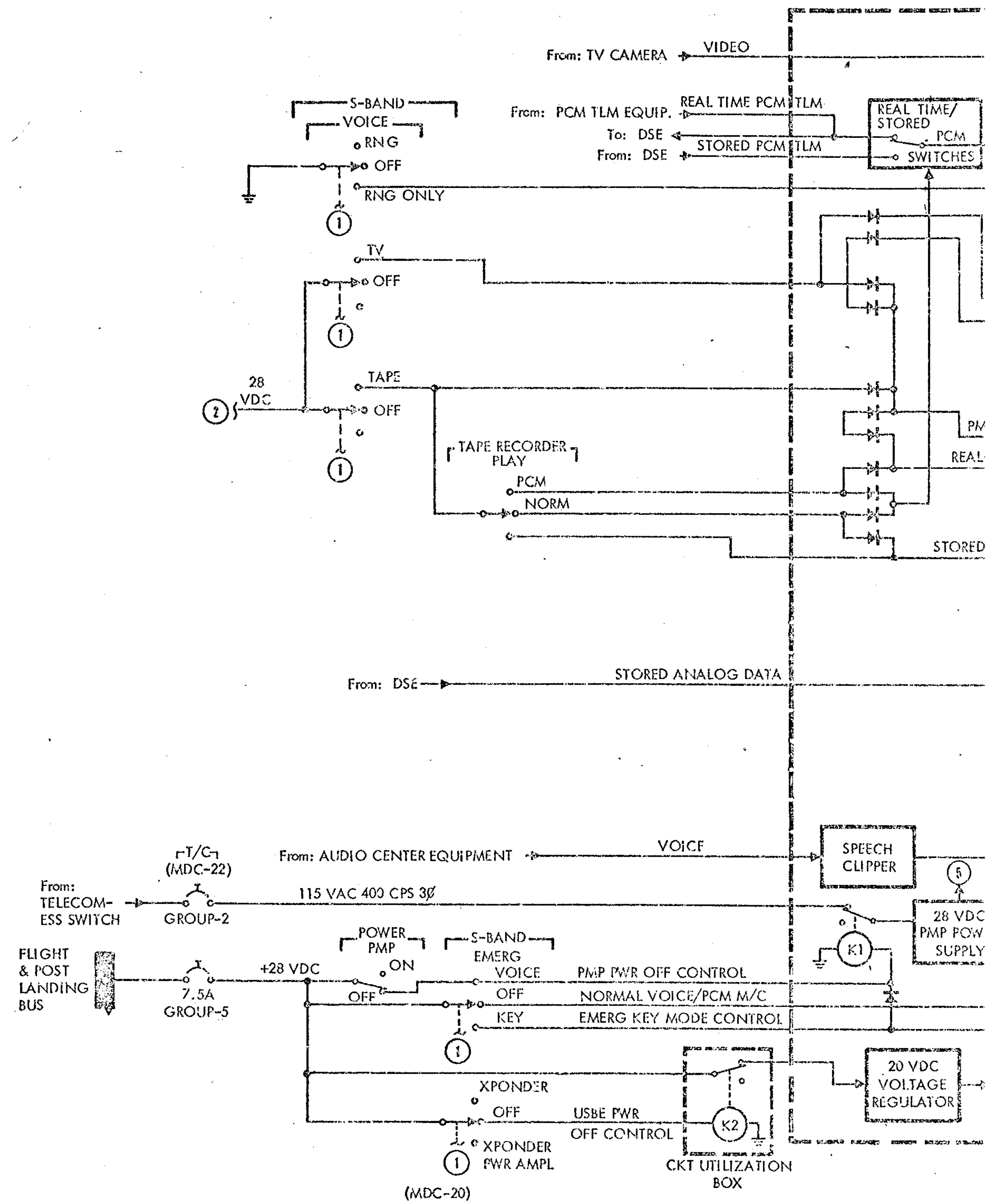


Figure 2.8-9. Premodulation Processor Equipment



From: TV CAMERA
VIDEO
S-BAND
VOICE
RNG
OFF
RNG ONLY
From: PCM TLM EQUIP.
REAL TIME PCM TLM
To: DSE
STORED PCM TLM
From: DSE
REAL TIME/ STORED
PCM
SWITCHES
TV
OFF
28 VDC
TAPE
OFF
TAPE RECORDER PLAY
PCM
NORM
REAL
STORED
From: DSE
STORED ANALOG DATA
T/C
(MDC-22)
From: AUDIO CENTER EQUIPMENT
VOICE
SPEECH CLIPPER
From: TELECOM- ESS SWITCH
GROUP-2
115 VAC 400 CPS 3Ø
28 VDC PMP POW SUPPLY
K1
FLIGHT & POST LANDING BUS
7.5A
GROUP-5
+28 VDC
POWER PMP
ON
OFF
S-BAND EMERG
VOICE
OFF
KEY
PMP PWR OFF CONTROL
NORMAL VOICE/PCM M/C
EMERG KEY MODE CONTROL
20 VDC VOLTAGE REGULATOR
XPONDER
OFF
XPONDER PWR AMPL
USBE PWR OFF CONTROL
K2
CKT UTILIZATION BOX
(MDC-20)

source is used to enable the emergency key network only, which permits a 512-kc signal from the CTE to be keyed by the PTT key in the cobra cable. This signal is applied to the PM input of the USBE. In the VOICE position, voice signals from the audio center equipment are routed directly through the PMP and supplied to the FM-2 (emergency voice) input of the USBE.

The following matrix shows the switching configurations of the S-band system in several operational modes.

PMP Inputs

Signal Type	Source	Application
Real-time PCM TLM	PCM TLM equipment	Transmission to MSFN via USBE or VHF/FM transmitter
Video	TV equipment	Transmission to MSFN via USBE
Voice	Audio center equipment	Transmission to MSFN via USBE
Recorded PCM TLM	DSE	Transmission to MSFN via USBE or VHF/FM transmitter
512-kc square wave	CTE	CW transmission to MSFN during emergency key mode
512-kc square wave	PCM TLM equipment	Subcarrier for transmission of PCM TLM to MSFN via USBE
70-kc up-data subcarrier	USBE	Detection of up-data received from MSFN via USBE
30-kc up-voice subcarrier	USBE	Detection of up-voice received from MSFN via USBE

TELECOMMUNICATION DATA

PMP Outputs

Output		Switch Positions (MDC-20)						
		PWR	S-BAND — VOICE Group			S-BAND	TAPE RECORDER	
Types of Data	Destination	PMP	RNG-Off-RNG ONLY	TAPE-Off	TV-Off	EMERG	PLAY	RECORD-Off-PLAY
Real-time voice	USBE (FM-2)	*	*	*	*	VOICE	*	*
Interrupted 512-kc carrier (keyed by PTT switch)	USBE (PM)					KEY		
Real-time PCM TLM	VHF/FM Transmitter	ON		Off (center)		Off (center)		
Recorded PCM TLM				TAPE			PCM or NORM	PLAY
Real-time PCM TLM and voice	USBE (PM)		RING or Off (center)	Off (center)	Off (center)		*	RECORD or OFF (center)
Real-time voice			RNG ONLY					
Recorded PCM and real-time voice	USBE (FM-1)		*	TAPE			NORM	PLAY

*This switch does not affect this output mode.

PMP Outputs

Output		Switch Positions (MDC-20)						
		PWR	S-BAND — VOICE Group			S-BAND	TAPE RECORDER	
Types of Data	Destination	PMP	RNG-Off-RNG ONLY	TAPE-Off	TV-Off	EMERG	PLAY	RECORD-Off-PLAY
Recorded PCM TLM and real-time voice	USBE (FM-1)	ON	*	TAPE	Off (center)	Off (center)	PCM	Play
Real-time PCM TLM and voice								
Real-time PCM TLM, voice, and TV				Off (center)	TV		*	*
Real-time PCM TLM and voice								
Up-data commands	UDL			*	*			
Up-voice	Audio Center Equipment							

*This switch does affect this output mode.

2.8.3.2.6 Data Storage Equipment (DSE).

The DSE (figure 2.8-10)is a three-speed, 14-track magnetic tape recorder and reproducer located in the LEB. It is used to store data during phases of the mission which inhibit or prevent the successful transmission of this data to the MSFN. Data can be recorded in parallel on five digital channels, and played back during a later phase of the mission for transmission to the MSFN. Each reel contains 2250 feet of one-inch-wide, magnetic, Mylar tape.

The PCM TLM data is obtained from the PCM TLM equipment as a single serial pulse train at a high bit-rate of 51.2 KBPS or a low bit-rate of 1.6 KBPS, depending on the PCM TLM mode. In the DSE, a serial-to-parallel converter circuit converts this signal into four parallel digital channels, each of which as a resulting pulse repetition rate (PRR) of only 12.8 KBPS or 0.4 KBPS (one-fourth of the original PRR). The PCM TLM equipment also furnishes a 51.2-kc or 1.6-kc square wave timing signal to the DSE, which is also divided by four. These five signals, the four channels of PCM TLM and the clock signal, are amplified by the five digital record amplifiers and fed to the digital record heads. Only one analog channel, the 25-kc reference and timing signal from the FQR, is scheduled for use on SC012.

During playback, the playback heads pick up the recorded data and present it to the digital playback amplifiers. The four parallel channels of recorded digital data and the clock signal divided by four are picked up by the five digital playback heads and presented to the five digital playback amplifiers. The amplified signals are then routed to the parallel-to-serial converter and the reproduce module. The four digital signals are converted back to a single serial pulse train which is fed to the PMP equipment. The bit-rate of this output will always be 51.2 KBPS, even if the recorded data was originally 1.6 KBPS. This is due to different speeds used in recording and reproducing. The 51.2 KBPS high bit-rate PCM signal is recorded at 15 inches per second (ips) and played back at the same speed. The low bit-rate signal of 1.6 KBPS is recorded at 3.75 ips, however, and played back at 120 ips, an increase of 32 times. This increases the 1.6 KBPS PRR to 51.2 KBPS.

The DSE is a bidirectional machine with a tape transport mechanism capable of forward or reverse operation at any of three speeds: 3.75 ips (low speed), 15 ips (normal speed), and 120 ips (high speed). The low speed of 3.75 ips is used only to record low bit-rate PCM TLM data. The DSE playback electronics is automatically disabled whenever this speed is selected. The normal speed of 15 ips is used to record and play back high bit-rate PCM TLM data. The high speed of 120 ips is used for fast dump of the low bit-rate PCM TLM data which was recorded at 3.75 ips. The high speed is also used for fast forward or reverse rewinding. Maximum operating times, to record or play back the entire 2250 feet of tape, are as follows: 2 hours at the low speed of 3.75 ips, 30 minutes at the normal speed of 15 ips, and 3.75 minutes at the high speed of 120 ips.

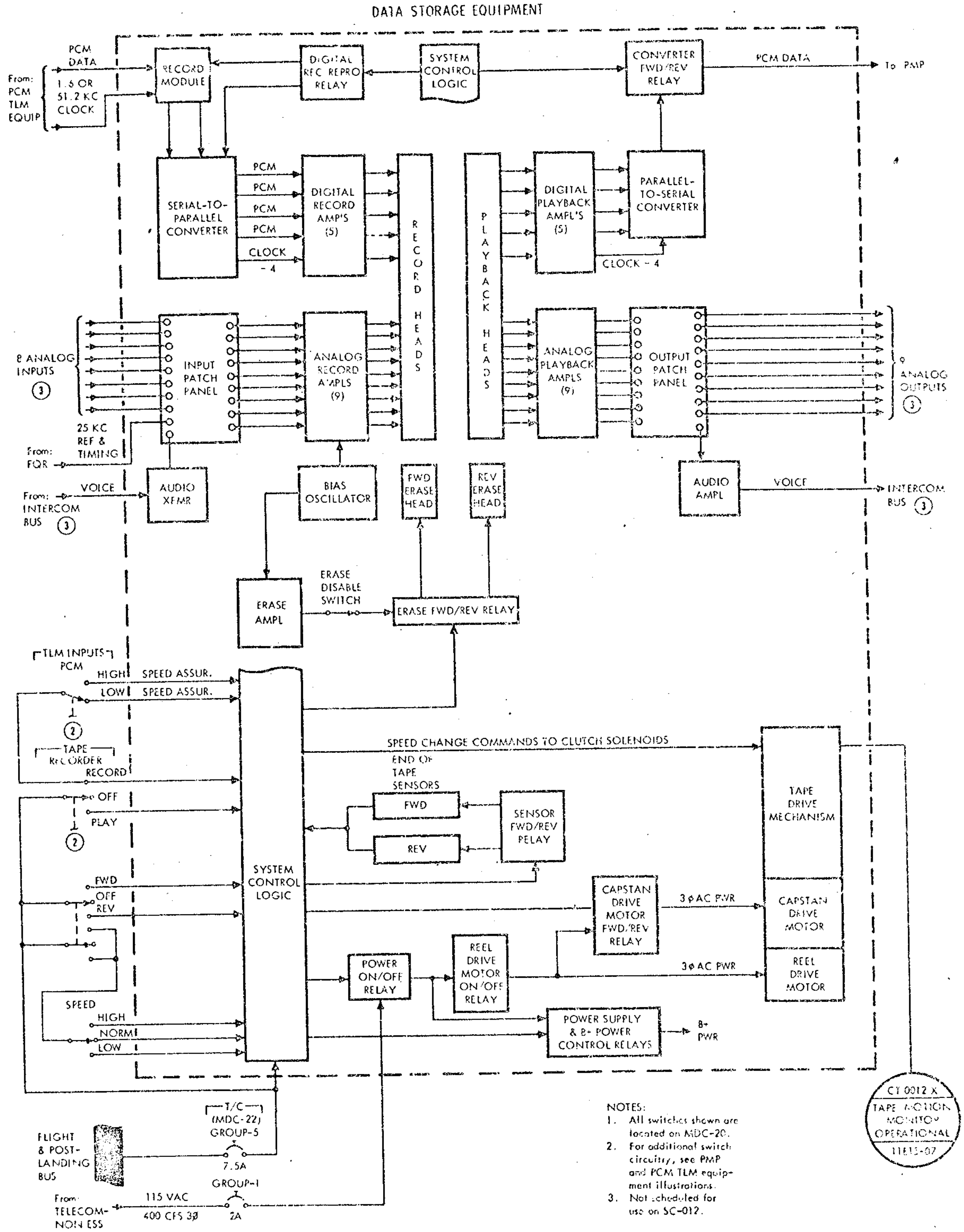


Figure 2.8-10. Data Storage Equipment

Tape speed and direction are controlled by the TAPE RECORDER – SPEED and – FWD/OFF/REV switches on MDC-20. Other TAPE RECORDER switches are the RECORD/PLAY switch which selects the record or playback mode, and the PLAY switch which selects the type of data to be reproduced. The PLAY switch has two positions: PCM and NORM. In either position, only PCM TLM data is reproduced and routed to the PMP equipment. The S-BAND – VOICE – TAPE switch must be set to TAPE before the TAPE RECORDER – PLAY switch becomes effective. The TLM INPUTS – PCM switch also affects tape recorder operation when recording. The interlock circuit in the DSE system control logic, which prevents selection of conflicting operational modes, locks the tape speed at 15 ips (normal) when the TLM INPUTS – PCM switch is set to HIGH. When set to LOW, the tape speed is locked at 3.75 ips. The proper control switch configuration for all DSE modes is shown in the table at the end of this paragraph.

An end-of-tape sensing circuit in the DSE automatically removes power from the tape drive mechanism and electronic circuits when the end of the tape is reached.

	Switch Positions					
	S-BAND–VOICE	TAPE RECORDER				TLM INPUTS
DSE Functions	TAPE-Off-ANALOG	PLAY PCM-NORM-ANALOG	SPEED HIGH-NORM-LOW	RECORD-Off-PLAY	FWD Off-REV	PCM HIGH-LOW
Record high bit rate	OFF	Any	NORM	RECORD	FWD* or REV	HIGH
Record low bit rate	OFF	Any	LOW	RECORD	FWD or REV	LOW
Playback recorded high bit rate	TAPE	PCM or NORM	NORM	PLAY	FWD or REV	Any
Playback recorded low bit rate	TAPE	PCM or NORM	HIGH	PLAY	FWD or REV	Any
Playback recorded** mixed bit rate	TAPE	PCM or NORM	NORM	PLAY	FWD or REV	Any
Reposition tape to end of reel (rewind)	OFF	Any	HIGH	PLAY	FWD or REV	Any

*Since the DSE is a bidirectional machine, it can record, play back, or rewind in either direction.
**Under present mission procedures, this mode should not be necessary.

Illegal Modes:

1. High bit rate must be recorded at normal speed or tape motion will stop.
2. Low bit rate must be recorded at low speed or tape motion will stop.
3. If tape is played back at low speed, the tape will move, but there will be no playback data available to the transmitters.
4. If tape is played back at high speed and contained high bit rate data, the playback data will be garbled.
5. If a FWD or REV command only is given to initiate a rewind, there will be no tape motion. A mode must also be selected (preferably PLAY) before tape will move.

2.8.3.2.7 Flight Qualification Recorder (FQR).

The FQR is a 14-track magnetic tape recorder which is used to record certain flight qualification measurements during critical phases of the mission. (See figure 2.8-11.) This data will be used for postflight analysis only; the FQR has no in-flight playback or transmission capability. It will be activated in a record mode during the ascent and entry phases of the mission and during SPS burns.

Flight qualification data is recorded in analog form. (Digital data cannot be recorded on the FQR.) Two recording tracks (one record head in each of two record-head stacks) are used for reference and time code recording. To accomplish this, an elapsed time code generator is used to modulate a narrow-band VCO. The output of the VCO is then mixed with the output of a 50 kc reference oscillator. This composite signal is presented to each of the two record heads through two direct record amplifiers.

The FQR operates at a record speed of 15 ips and a rewind speed of 120 ips. The 15 ips record speed allows a total of 30 minutes recording time per reel of tape. Because there are no provisions for crewmembers to change tape reels during the mission, the FQR must be used conservatively. Normally, the rewind function will not be used unless it is required to back the tape up to the beginning during prelaunch activities. End-of-tape sensing is provided, which will automatically halt the tape motion and remove power from the electronic circuits when the end of the tape is reached in either direction.

Crewman control of the FQR is provided by the FLIGHT QUAL RCDR, 3-position toggle switch on MDC-19. In the STOP position, all a-c and d-c power is removed. Placing the switch to RECORD activates all electronic circuitry and the tape transport mechanism, which moves the tape forward at 15 ips. The REWIND position activates the tape transport mechanism to move the tape backward at 120 ips.

The measurement numbers and names of the parameters stored in the FQR are presented in the following list. This does not include the two FQR channels utilized for storage of reference and timing code storage.

Measurement Number	Identity
CG 2010 V	X PIPA output, in phase
CG 2030 V	Y PIPA output, in phase
CG 2050 V	Z PIPA output, in phase
CK 0004 A	Linear acceleration structure X axis A
CK 0005 A	Linear acceleration structure Y axis A

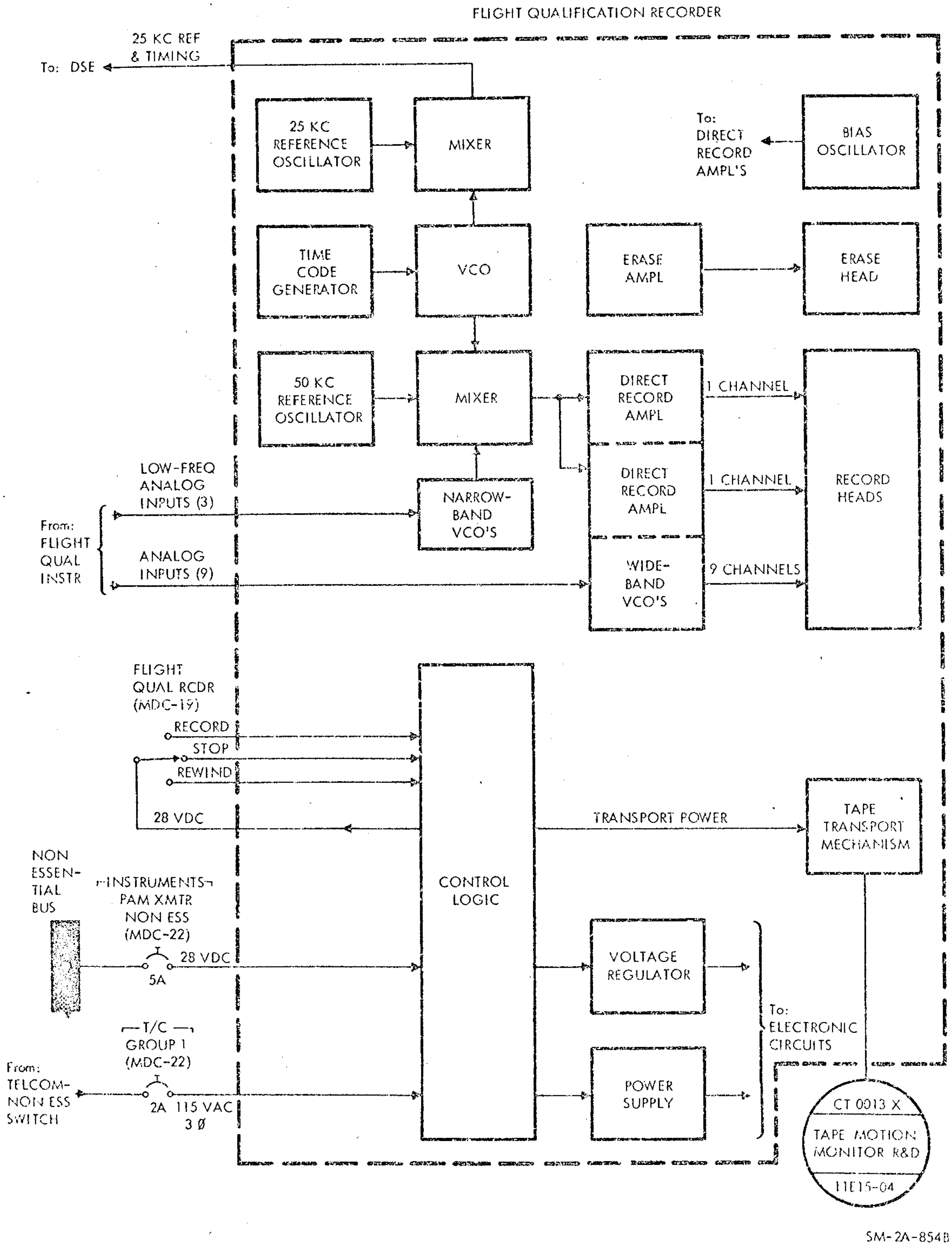


Figure 2.8-11. Flight Qualification Recorder Equipment

Measurement Number	Identity
CK 0006 A	Linear acceleration structure Z axis A
CR 0514 P	CCW roll engine pressure, system A
CR 0520 P	CCW roll engine pressure, system B
CR 0623 P	Fuel line pressure, system A
CR 0624 P	Fuel line pressure, system B
CR 0625 P	Oxidizer line pressure, system A
CR 0626 P	Oxidizer line pressure, system B

2.8.3.2.8 Up-Data Link (UDL) Equipment.

The function of the UDL equipment is to receive, verify, and distribute digital up-dating information sent to the S/C by the MSFN at various times throughout the mission to up-date or change the status of operational systems. The UDL (figure 2.8-12) consists of a UHF-FM receiver, a transistor mode switch, detecting and decoding circuitry, a buffer storage unit, output relay drivers, and a power supply. The UDL provides the means for MSFN to update the AGC, the CTE, and to select certain vehicle functions.

Two operational modes are possible: UHF and S-band. The mode normally used is UHF. In this mode, the incoming 450-mc up-data carrier is received by the VHF omni-antenna equipment and fed to the UHF receiver in the UDL. The intelligence is detected from the carrier and routed through the mode switch to the sub-bit detector, which converts it to a serial digital signal. The digital output from the sub-bit detector is fed to the remaining UDL circuitry, which stores and checks the digital data, determines the proper destination of the data, and processes it to the appropriate S/C system or equipment.

Real-time commands from the real-time command (RTC) drivers are supplied to the UDL RTC relay box which contains four, RTC, 2-position, latching relays. Thus eight real-time commands are possible: four "set" commands and four "reset" commands. The chart on the following page lists the eight commands by number and function.

The S-band up-data mode can be selected when the USBE is in operation. In this mode, the UHF receiver in the UDL is deactivated and its function is replaced by the USBE receiver and the PMP. Up-data information can be transmitted to the S/C within the 2-kmc S-band signal. When this signal is received by the USBE receiver, the 70-kc subcarrier containing the up-data information is extracted and sent to the up-data discriminator in the PMP. The resulting composite audio frequency signal is routed to the sub-bit detector in the UDL.

There are three external controls for the UDL equipment. One is the three-position, center-off, UP-DATA switch on MDC-20. When set to the

UDL Real-Time Commands

Command	Action	UDL Relay	MDC-20 SW Position	Results
00	Deactivates system A abort request light	K1 (RESET)		MDC-3
01	Activates system A abort request light	K1 (SET)		MDC-3 turns on abort light.
02	Effect on C-band equipment operation determined by position of C-band switch on MDC-20	K3 (RESET)	C-BAND 1 PULSE	C-band equipment continues to operate in 1-pulse mode.
			OFF	C-band equipment remains off.
			2 PULSE	C-band equipment continues to operate in 2-pulse mode.
03	Turns C-band equipment on in 2-pulse mode	K3 (SET)	C-BAND 1 PULSE	C-band equipment continues to operate but switches to 2-pulse mode.
			OFF	Energizes C-band equipment which operates in 2-pulse mode.
			2 PULSE	No effect on C-band operation.
04	Effect on VHF-FM transmission of PCM data determined by position of VHF-FM-ON/OFF and TLM INPUTS-HIGH/LOW switches on MDC-20	K4 (RESET)	VHF-FM ON	No effect on VHF-FM transmitter.
			OFF	No effect on VHF-FM transmitter.
			TLM INPUTS PCM HIGH	PCM TLM remains in 51.2 KBS.
			LOW	PCM TLM output is 1.6 KBS.
05	Turns VHF-FM transmitter on and changes bit rate from low to high	K4 (SET)	VHF-FM ON	No effect on VHF-FM transmitter.
			OFF	Energizes VHF-FM transmitter.
			TLM INPUTS PCM HIGH	No effect on bit rate.
			LOW	Switches from 1.6 KBS to 51.2 KBS. NOTE If data is being recorded, DSE will automatically stop if TAPE RECORD-SPEED switch is not positioned to HIGH.
06	Deactivates system B abort request light	K2 (RESET)		MDC-3
	Activates system B abort request light	K2 (SET)		MDC-3 turns on abort light.

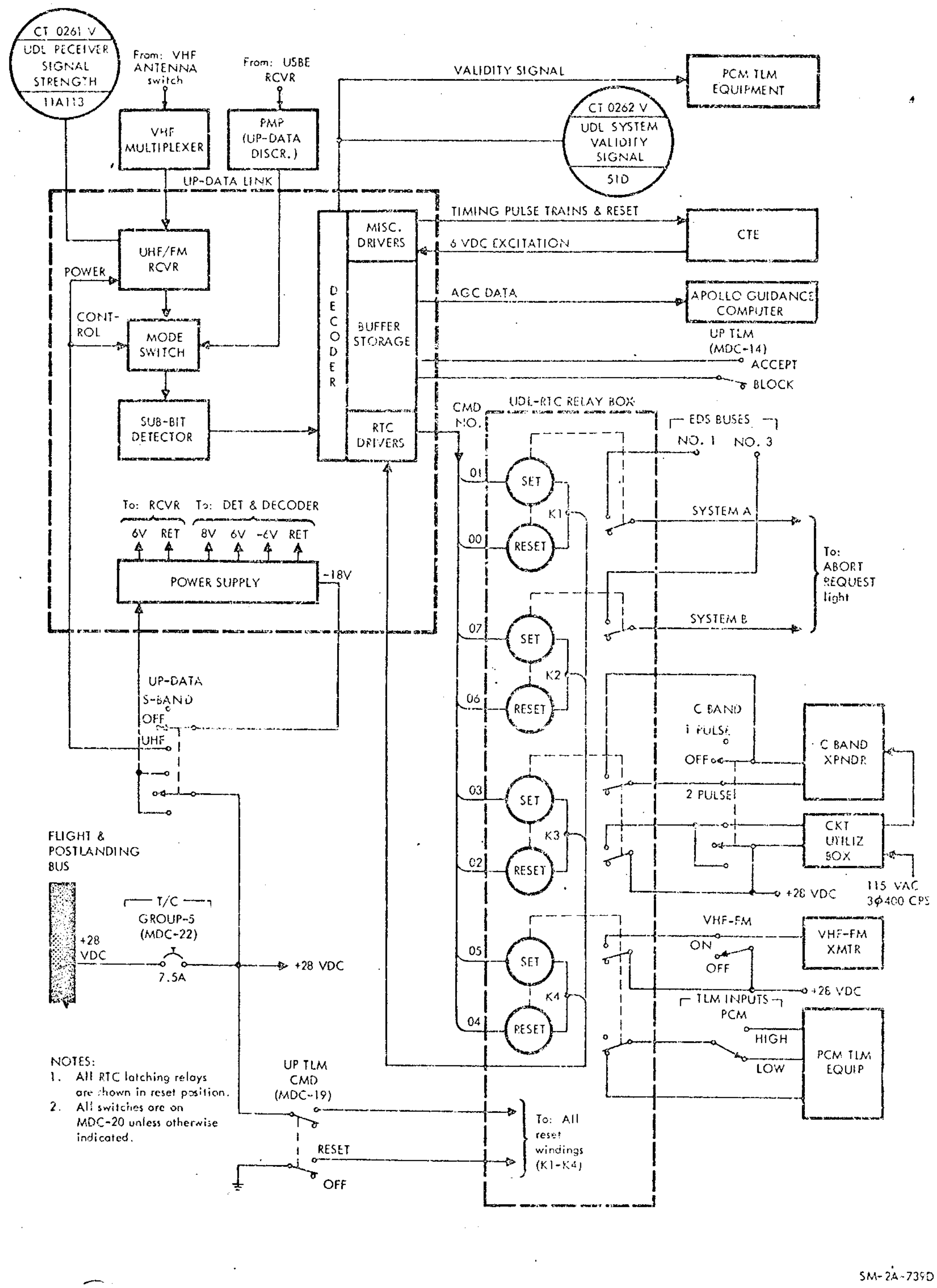


Figure 2.8-12. Up-Data Link Equipment

UHF position, the UHF up-data mode is selected and 28-volt d-c power is applied to the UDL power supply. The S-BAND position also applies 28-volt d-c power, but selects the S-band up-data mode and deactivates the UHF/FM receiver. Another control, located on MDC-19, is the two-position spring-loaded UP TLM CMD switch. When set momentarily to the RESET position, all "reset" commands listed in the UDL real time commands chart are commanded. This nullifies all "set" commands which have been received from the MSFN. An UP TLM – ACCEPT/BLOCK switch (MDC-14) is also provided which enables the crew to permit or prevent G&N up-data from affecting the guidance computer.

2.8.3.2.9 Central Timing Equipment (CTE).

The CTE provides precision square wave timing pulses of several frequencies to time-correlate all S/C time-sensitive functions. It also generates and stores the real-time day, hour, minute, and second time-from-launch (TFL) in binary-coded decimal (BCD) format for display and transmission to the MSFN. (See figure 2.8-13.)

In the primary or normal mode of operation, the Apollo guidance computer (AGC) provides a 1024-kc sync pulse to the CTE. This automatically synchronizes the CTE with the AGC and provides a stability of $\pm 2 \times 10^{-6}$ parts in 14 days. In the event of sync pulse failure, the CTE automatically switches to the secondary mode of operation with no time lapse and operates using its own crystal oscillator at a stability reduced to $\pm 2.2 \times 10^{-6}$ parts in 5 days.

The CTE contains two power supplies for redundancy. Each one is supplied from a different power source and through separate circuit breakers. These circuit breakers, CENTRAL TIMING SYS – MN A and – MN B on MDC-22, provide the only external means of control for the CTE. The two power supplies provide parallel 6-volt d-c outputs, either one of which is sufficient to power the CTE.

The timing signals generated by the CTE, and their applications, are listed in the CTE Outputs chart.

CTE Outputs

Signal	Destination	Purpose
512-kc square wave	PCM TLM equipment	Synchronization of internal clock
	PMP equipment	Modulating signal for S-band emergency key transmission
6.4-kc square wave	EPS inverters (three)	Synchronization of 400-cycle a-c power

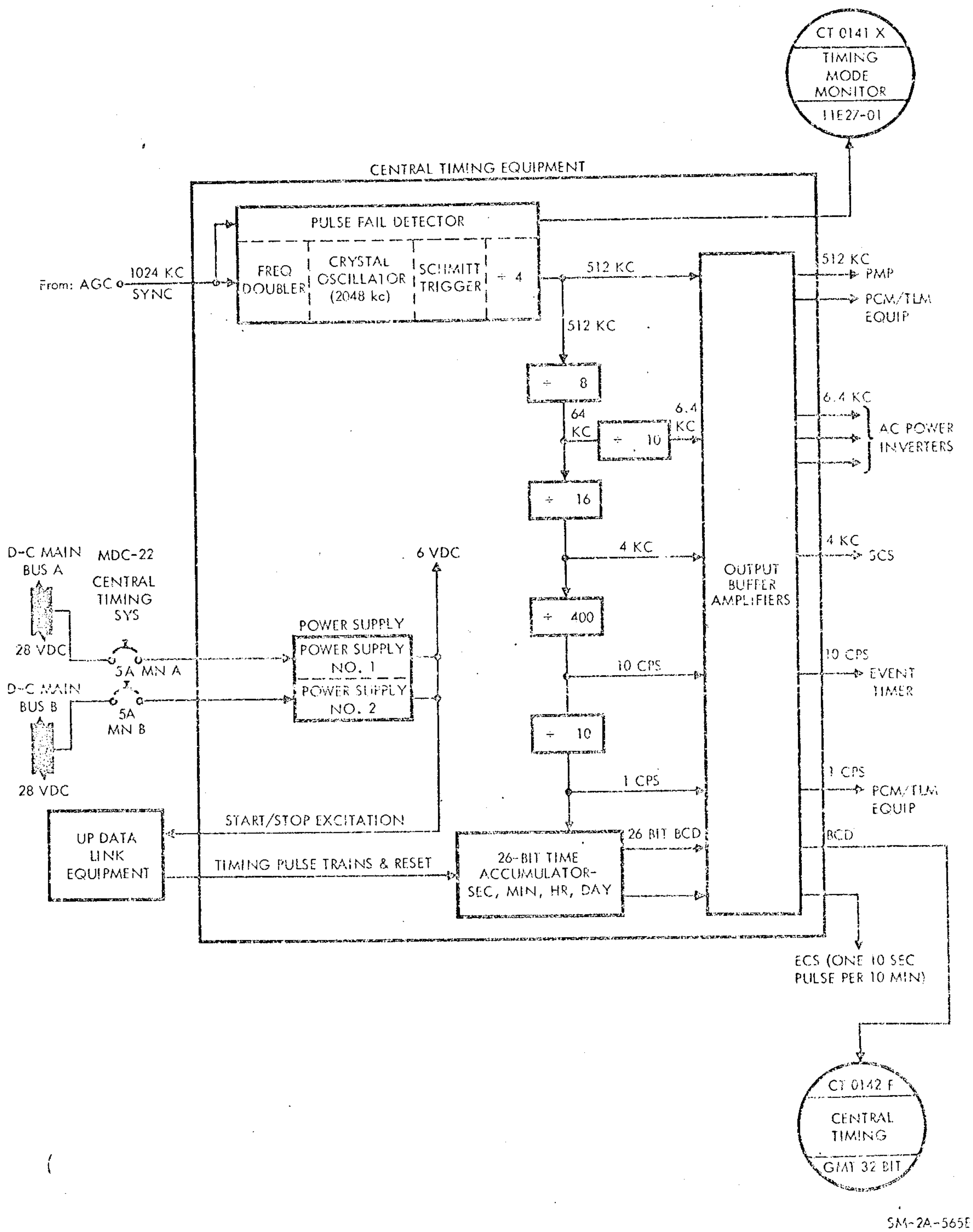


Figure 2.8-13. Central Timing Equipment

Signal	Destination	Purpose
4-kc square wave	SCS	Synchronization of X-axis accelerometer integrator
10-cps square wave	Displays	Digital event timer
1 cps	PCM TLM equipment	Synchronization of subframe of PCM data, Displays, and T-Timer
DC	PCM TLM equipment	Pulse-fail detection and indication. (Sampling rate equals 10 samples/sec, 5μ sec pulse duration.)
Binary coded decimal time code	PCM TLM equipment	Provides time code data to TLM in BCD format (TLM measurement No. CT0142F, C T-GM5 32 bit).
1 pulse per 10 minutes	ECS	Supplies pulse every 10 minutes to ECS circuitry which opens a solenoid for 10 seconds in every 10 minutes to remove water from space suits.

2.8.3.2.10 Voice Recorders

Two voice recorders have been provided to enable the crewmembers to keep a voice log of mission activites. Both units are mounted in the right-hand equipment bay, one in an operating condition and the other stowed. Changeover to the inoperative recorder is made by changing the electrical power connector.

Each tape recorder provides 450 feet of 1/4-inch tape which operates at a speed of 0.6 inches per second. The use of tape reversal, automatic head switching, and four individual recording heads provide ten hours of usable recording time per tape recorder. The information contained on the tape cannot be dumped during flight but must be played back utilizing suitable GSE.

To ready the connected voice recorder for operation, the following switch positions must be selected: the RCDR/HF switch to T/R (MDC-13, -23, -26), the intercom switch to T/R, the HF power switch to OFF (MDC-20), and the mode selector to SSB or AM. (See figure 2.8-14.) Actual activation of the voice recorder is possible three ways: two correct; one wrong. The first correct activation path has the POWER switch at PTT (MDC-13, -23, -26) and the PTT pushbutton on the cobra cable depressed. The other correct method of activation requires the POWER switch to be at VOX and the VOX circuit enabled or the PTT pushbutton

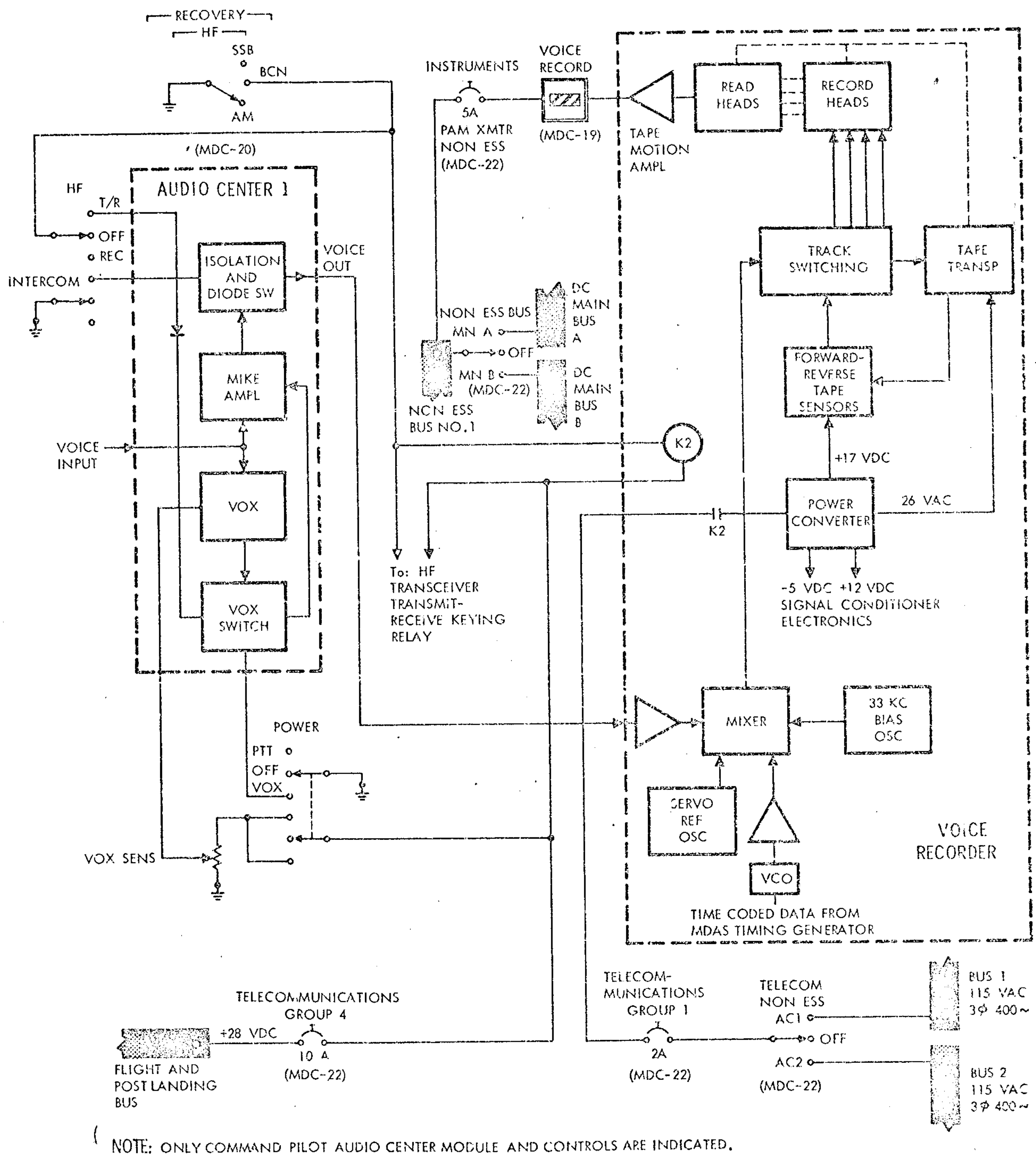


Figure 2.8-14. Voice Tape Recorder

depressed. The connected voice tape recorder can be inadvertently activated by positioning the HF mode switch to BCN (MDC-20). This would continuously run the connected voice tape recorder until it used up its tape. A VOICE RECORD flag indicator (MDC-19) will display the striped area when recording is in progress. The indicator grey area will be displayed when voice recording is not in progress or the tape supply has been exhausted during recording.

The stowed voice recorder may be placed in operating condition by moving the RCDR/HF switch to OFF (MDC-13, -23, and -26), removing the electrical connector from the exhausted recorder, and installing it to the connector on the stowed recorder. Operation is resumed by moving the RCDR/HF switch to T/R (MDC-13, -23, or -26).

NOTE To include the timing reference while recording on the voice tape recorder, the MDAS MAIN POWER switch must be ON (LEB compartment C) and the TIMER switch must be at "NORMAL."

2.8.3.3 RF Electronics Equipment Group.

The RF electronics equipment group includes all T/C equipment which functions as RF transmitters or receivers. The antenna used by this equipment are mentioned only briefly in this paragraph. More information on the antennas can be found in the paragraph on antenna equipment.

2.8.3.3.1 VHF/AM Transmitter-Receiver Equipment.

The VHF/AM transmitter-receiver equipment (figure 2.8-15) provides the primary means for in-flight voice communications with the MSFN. It is contained in the same electronics package as the VHF recovery beacon equipment, in the LEB.

Two modes of operation are possible: simplex and duplex. The simplex mode will normally be utilized. The duplex mode will be used on future missions for EVA and LEM communications. During recovery, the transmitter can be utilized as a backup VHF recovery beacon by holding down the PTT key.

The transmitter operates at 296.8 mc in both operational modes. The receiver contains two "front ends." The receive 1 front end operates at 296.8 mc and is used for simplex operations. For duplex operations, the receive 2 front end, which operates at 259.7 mc, is selected.

The VHF/AM transmitter-receiver is controlled by the VHF-AM controls on MDC-20. The T/R/OFF/REC switch activates the transmitter and receiver when in the T/R position; the REC position activates the receiver alone; the OFF position removes power from both. Simplex or duplex operation is selected by placing the RCVR switch to 1 or 2, respectively. The remaining, thumbwheel-type SQUELCH control can be rotated up or down to increase or decrease the sensitivity of the squelch gate.

Audio to and from the VHF-AM is controlled by the VHF-AM-T/R/OFF/REC switch on MDC-13, -23, -26. Voice transmission is possible when this switch is at T/R, the POWER switch is at PTT, the cobra cable PTT/CW switch is at PTT and the PTT key is pressed.

NOTE The POWER switch can also be at VOX, but actual keying of the VHF/AM must be via the PTT circuit.

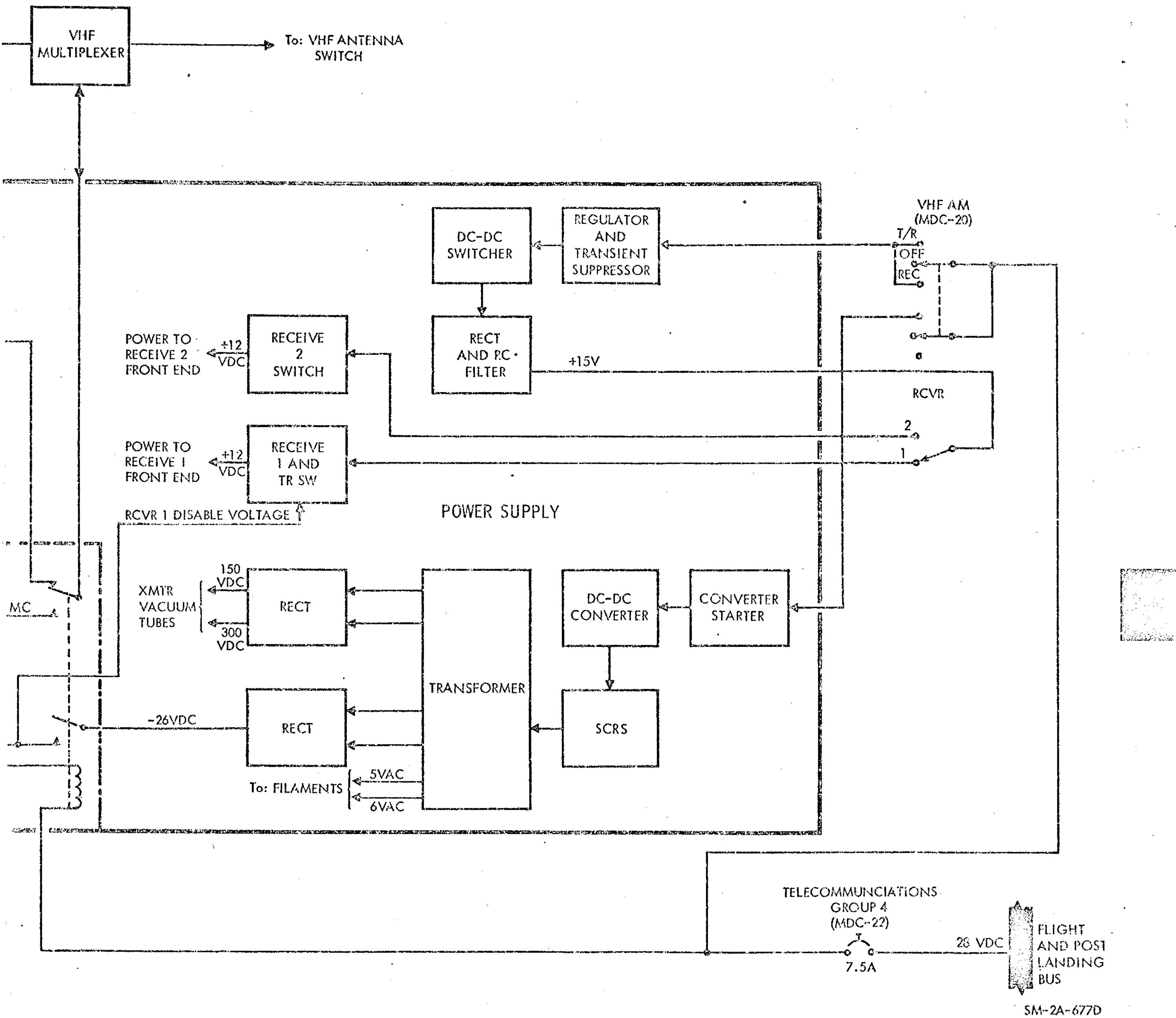
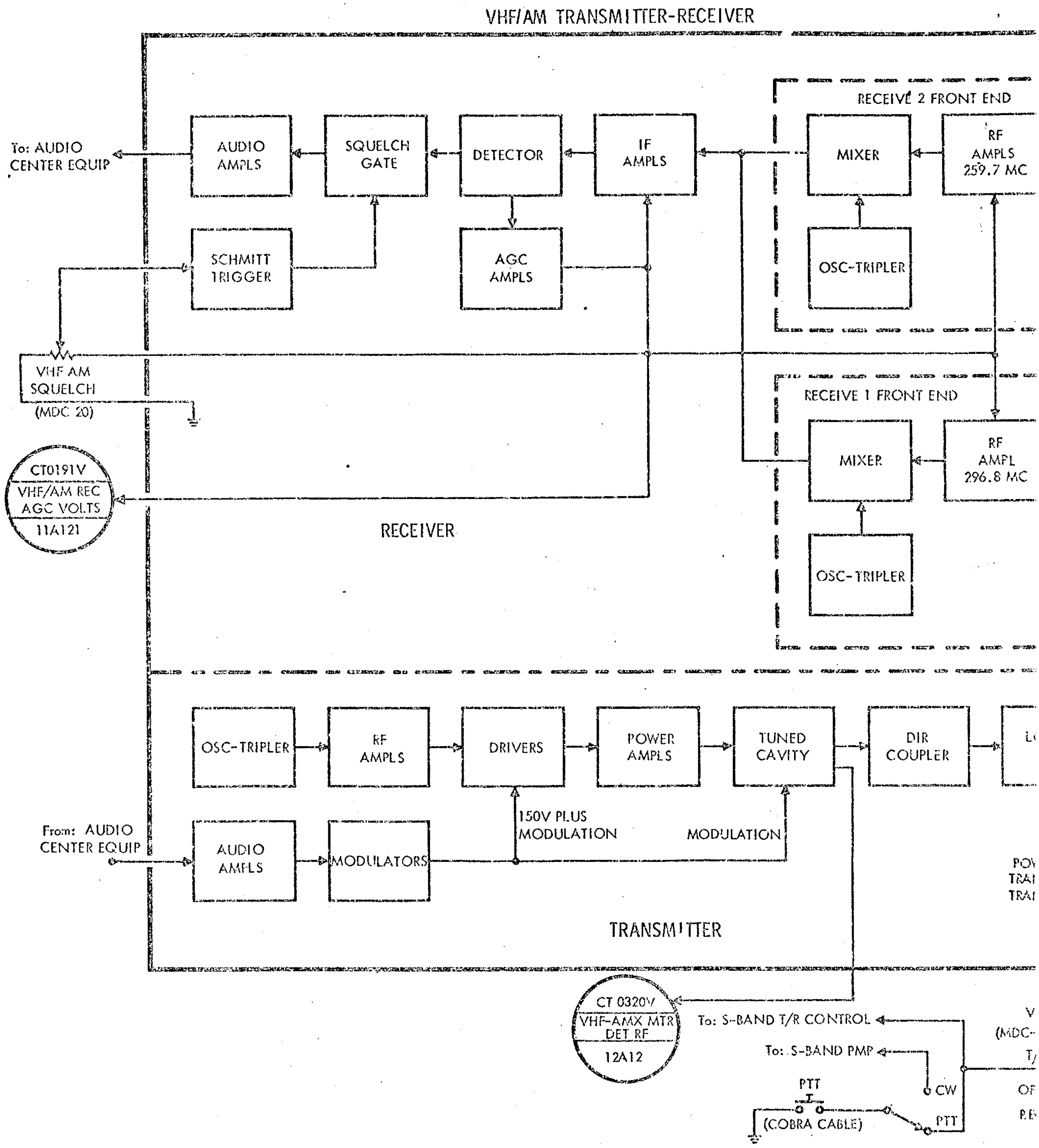


Figure 2.8-15. VHF/AM Transmitter-Receiver Equipment


VHF/AM TRANSMITTER-RECEIVER
RECEIVE 2 FRONT END
To: AUDIO CENTER EQUIP
AUDIO AMPLS
SQUELCH GATE
DETECTOR
IF AMPLS
MIXER
RF AMPLS 259.7 MC
SCHMITT TRIGGER
AGC AMPLS
OSC-TRIPLER
VHF AM SQUELCH (MDC 20)
RECEIVE 1 FRONT END
CT0191V VHF/AM REC AGC VOLTS 11A121
MIXER
RF AMPL 296.8 MC
RECEIVER
OSC-TRIPLER
OSC-TRIPLER
RF AMPLS
DRIVERS
POWER AMPLS
TUNED CAVITY
DIR COUPLER
150V PLUS MODULATION
MODULATION
From: AUDIO CENTER EQUIP
AUDIO AMPLS
MODULATORS
TRANSMITTER
CT 0320V VHF-AMX MTR DET RF 12A12
To: S-BAND T/R CONTROL
To: S-BAND PMP
PTT
CW
PTT
(COBRA CABLE)

The VHF portion of the upper or lower SCIN antenna is used during flight. VHF recovery antenna No. 2 is used during recovery. Antenna selection is made with the VHF ANTENNA switch on MDC-20.

2.8.3.3.2 HF Transceiver Equipment.

The HF transceiver equipment (figure 2.8-16) is the primary means to aid recovery operations during the postlanding phase of the mission by providing long-range, simplex, voice communications and beyond line-of-sight direction finding capabilities. It is contained in the same electronics package as the VHF-FM transmitter equipment in the LEB.

The HF transceiver equipment is controlled by the RECOVERY-HF switches on MDC-20. The ON/OFF switch, when placed to ON, connects d-c power to the transceiver. The SSB/BCN/AM switch is used to select the operational mode. Three modes of operation are available; single sideband (SSB), beacon (BCN), and amplitude modulation (AM). The BCN mode is used to transmit an unmodulated, continuous wave, direction finding beacon. The SSB and AM modes are used for long-range, simplex, voice communications. The operating frequency is 10.006 mc for the transmitter and receiver in all modes.

The audio center equipment supplies the audio input to the modulator in the translator module and accepts the detected audio signal from the receiver module of the transceiver. The HF transmitter is keyed by VOX or PTT.

The HF recovery antenna is used for transmission and reception and will be deployed after touchdown as part of the postlanding sequence of operations. The transceiver must not be operated prior to antenna deployment or damage may occur.

2.8.3.3.3 VHF/FM Transmitter Equipment.

The sole function of the VHF/FM transmitter equipment (figure 2.8-17) is to transmit PCM TLM data to the MSFN. These data are supplied to the VHF/FM transmitter by the PMP in the form of a 3-volt p-p pulsating d-c, modulating signal at a rate of 51,200 bits per second (bps) or 1600 bps. The bit rate depends on the PCM rate selected.

The nominal (center) frequency of the emitted RF carrier is 237.8 mc. Because the transmitter is frequency modulated, the 3-volt p-p modulating signal causes a frequency deviation of ±125 kc. The resulting 10-watt RF output is fed to the VHF portion of the VHF/2-KMC SCIN antennas.

The only external control for the VHF/FM transmitter equipment is the VHF-FM — ON/OFF switch on MDC-20 which energizes a relay in the transmitter, applying a-c power to the equipment. If the switch is set to OFF, the VHF/FM transmitter can be activated from the MSFN by a real-time command via the UDL equipment.

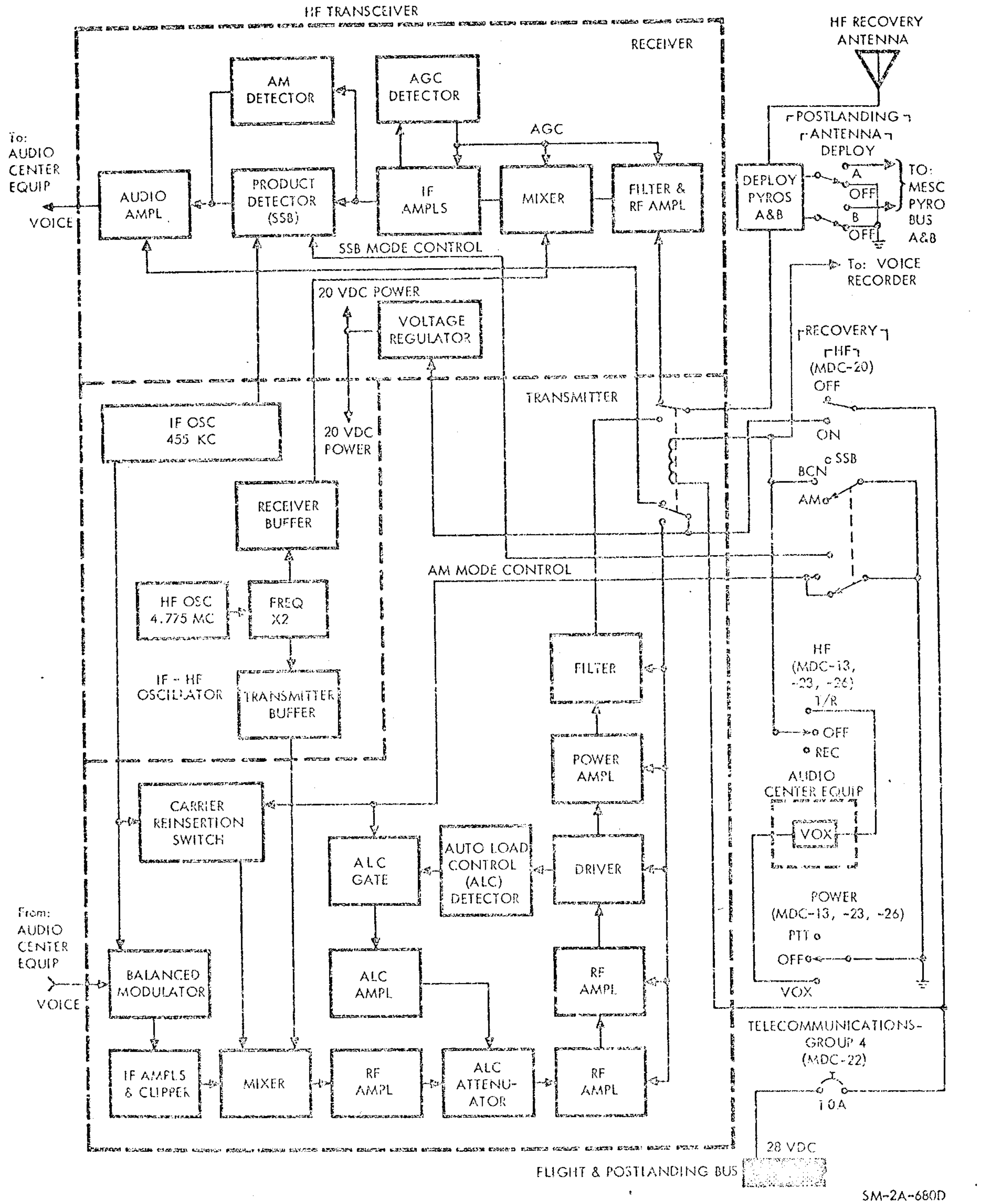


Figure 2.8-16. HF Transceiver Equipment

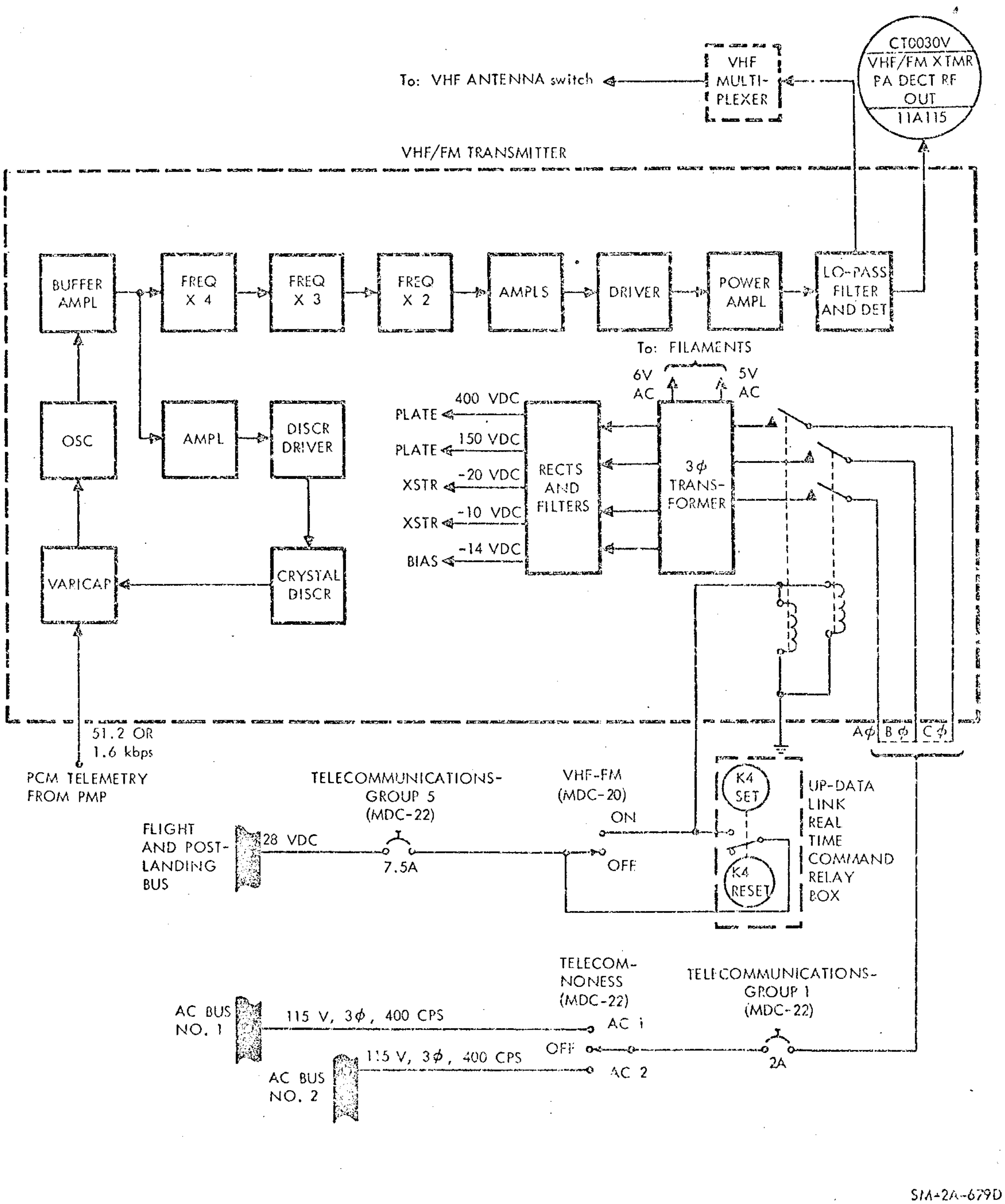


Figure 2.8-17. VHF/FM Transmitter Equipment

2.8.3.3.4 Unified S-Band Equipment (USBE).

The USBE (figure 2.8-18) consists of a receiver, transmitter, and power supply contained in a single electronics package in the lower equipment bay. Although primarily designed for deep-space communications, the USBE will be tested on this mission and used as backup for in-flight voice communications, tracking and ranging, transmission of PCM data, and reception of up-data. The USBE also provides the sole means for transmission of TV

The USBE tracking method employed is the two-way or double-doppler method. In this technique, a stable carrier of known frequency is transmitted to the S/C where it is received by the phase-locked receiver, multiplied by a known ratio, and then retransmitted to the MSFN for comparison. Because of this capability, the USBE is also referred to as the S-band transponder. From the double-doppler tracking method, S/C velocity, acceleration, and range can be determined.

For determining S/C range, the MSFN phase-modulates the transmitted carrier with a pseudo-random noise (PRN) binary ranging code. This code is detected by the S/C USBE receiver and used to phase-modulate the carrier transmitted to the MSFN. The MSFN receives the carrier and measures the amount of time dealy between transmission of the code and reception of the same code, thereby obtaining an accurate measurement of range. Once established, this range can be continually up-dated by the double-doppler measurements discussed earlier. The MSFN can also transmit up-data commands and voice signals to the S/C USBE by means of two subcarriers: 70 kc for up-data and 30 kc for up-voice.

The USBE receiver is a phase-tracking receiver that accepts a 2106.4-mc, phase-modulated RF signal containing the up-data and up-voice subcarriers and a pseudo-random noice (PRN) code when ranging is desired. This signal is supplied to the receiver via the diplexer in the S-band power amplifier equipment and presented to two separate detectors: the loop phase detector and the ranging phase detector. In the ranging phase detector, the 9.531-mc IF is detected; and the 70-kc up-data and 30-kc up-voice subcarriers are extracted, amplified, and routed to the up-data and up-voice discriminators in the PMP equipment. Also, when operating in a ranging mode, the PRN ranging signal is derived, filtered, and routed to the USBE transmitter as a modulating signal input to the phase modulator. In the loop phase detector, the 9.531-mc IF signal is detected by comparing it with the loop reference frequency. The resulting d-c output is used to control the frequency of the 19.0625-mc voltage-controlled oscillator (VCO). The output of the VCO is used as the reference frequency for receiver circuits as well as for the transmitter. The receiver is also provided with automatic gain control (AGC) and antenna selector circuitry which automatically selects the proper SCIN antenna when the S-BAND ANTENNA switch is in the AUTO position. The AGC circuitry also supplies a signal to the S-BAND ANT S-meter located on MDC-19. By observing this meter and rotating the S/C, the optimum S/C attitude for S-band communications can be attained.

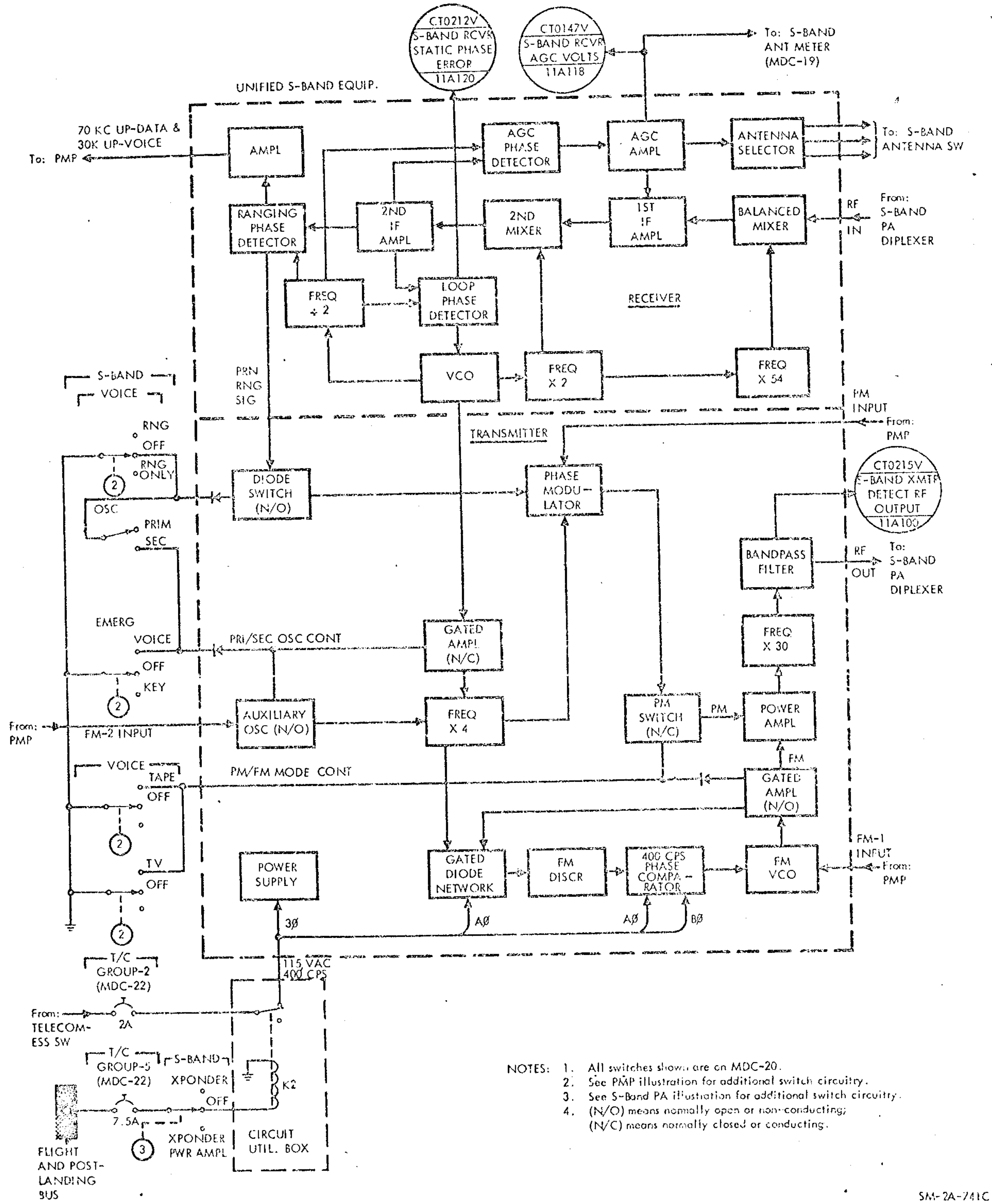


Figure 2.8-18. Unified S-Band Equipment

The USBE transmitter is capable of transmitting a 2287.5-mc signal, either phase-modulated or frequency-modulated. In the PM mode, the initial transmitter frequency is obtained from one of two sources: the VCO in the phase-locked USBE receiver or the auxiliary oscillator in the transmitter. When operating in the FM mode, the VCO or auxiliary oscillator initial frequency is not multiplied and used directly, but is used to control the frequency of a third oscillator, the FM VCO. The FM VCO is the source for the frequency-modulated 2287.5-mc signal.

Output mode and frequency source are controlled by the S-BAND group of switches on MDC-20. The VOICE and EMERG switches, contained in this group, also have an effect on PMP operation, thus ensuring compatibility between USBE and PMP modes. All data to be transmitted by the USBE is supplied by the PMP. Normally, the initial transmitter frequency is obtained from the receiver VCO. In case of failure of the VCO or S-band PA equipment, the auxiliary oscillator can be selected. This is done by moving the OSC switch from PRIM to SEC (with the RNG/RNG ONLY switch at the normal, center position) or by placing the EMERG switch to VOICE. If the latter is done, the PMP will provide a voice modulating signal directly to the auxiliary oscillator.

With all three S-BAND – VOICE switches and the S-BAND – EMERG switch set at their center positions, the USBE transmits a phase-modulated signal containing PCM TLM and voice data from the PMP. Setting the RNG/RNG ONLY switch to RNG, enables the PRN ranging code to be transmitted also. Setting this switch to RNG ONLY, adds the PRN ranging code but eliminates the PCM TLM portion of the PM input from the PMP. This mode is used to increase the strength of the PRN ranging code received by the MSFN. The other two S-BAND – VOICE switches are the TAPE and the TV switches. For PM operation, both of these switches must be at their center, off position. Setting either of them to any other position changes the USBE mode to FM for increased band-width and selects the FM-1 output of the PMP. Thus, these four switches (the three VOICE switches and the EMERG switch) are used to establish the operational mode. Only one switch at a time may be placed to any position other than center for proper operation of the USBE and PMP. For further description of PMP outputs, refer to the discussion of the PMP equipment.

The USBE is activated by the S-BAND – XPONDER/XPONDER PWR AMPL switch. Setting this switch to XPONDER or XPONDER PWR AMPL energizes a relay that applies 115 volts ac to the USBE power supply, which provides +15 volts dc and -15 volts dc outputs to the USBE transmitter and receiver. The RF output of the USBE transmitter is fed to the S-band power amplifier equipment. Here, the signal is either bypassed directly to the S-BAND ANTENNA switch or amplified and then fed to the S-BAND ANTENNA switch.

2.8.3.3.5 S-Band Power Amplifier Equipment.

The S-band power amplifier (PA) equipment (figure 2.8-19) is used to amplify the RF output from the USBE transmitter when additional signal

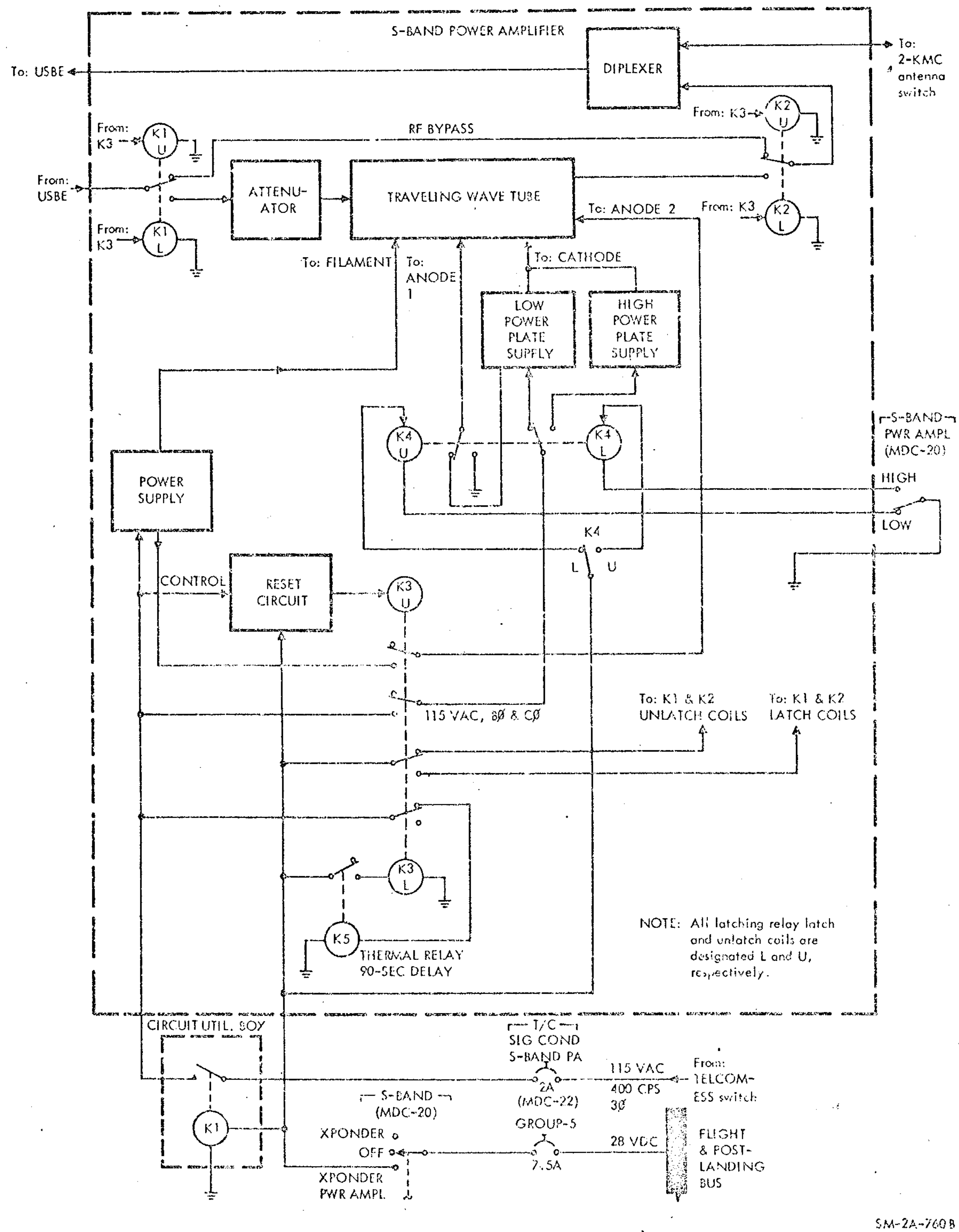


Figure 2.8-19. S-Band Power Amplifier Equipment

strength is required for adequate reception of the S-band signal by the MSFN. It consists of a diplexer, a traveling-wave tube for amplification, power supplies, and the necessary switching relays and control circuitry. The S-band PA is contained in a single electronics package located in the lower equipment bay.

All received and transmitted S-band signals pass through the S-band PA diplexer. The 2106.4-mc S-band carrier received by the S/C enters the S-band PA diplexer from the S-band antenna equipment. The diplexer passes the signal straight through to the USBE receiver. The 2287.5-mc output signal from the USBE transmitter enters the S-band PA where it is either bypassed directly to the diplexer and out to the S-band antenna equipment, or amplified first and then fed to the diplexer. There are three power amplifier modes of operation: bypass, low power, and high power.

Two of the S-BAND switches on MDC-20 are used to control the S-band power amplifier. Setting the XPONDER/XPONDER PWR AMPL switch to the XPONDER PWR AMPL position energizes the USBE power supply and applies 3-phase 115-volt a-c power to the S-band PA through relay K1 in the circuit utilization box. This also activates the 90-second time-delay relay in the S-band PA. Upon initial application of power, only the low-voltage power supply is energized, which applies power to the traveling wave tube heater. After 90 seconds, the RF signal from the USBE transmitter is switched from the bypass circuit to the amplifier circuit and 3-phase 115-volt a-c power is applied to either the low power or high power section of the high-voltage power supply, which supplies the correct operating voltages to the remaining elements of the traveling-wave tube. Selection of the low power (LOW) or high power (HIGH) mode is controlled by the S-BAND – PWR AMPL – HIGH/LOW switch.

2.8.3.3.6 C-Band Transponder Equipment

An earth-based C-band tracking and ranging system is used to provide S/C position data to the MSFN during the launch, near-earth, and entry phases of the mission. The function of the S/C C-band transponder equipment (figure 2.8-20) is to effectively extend the range of the system beyond that which would be possible using skin-tracking techniques only. Upon reception of a properly coded pulsed interrogation from the earth-based equipment at 5690 mc, the C-band transponder transmits a response pulse to the earth after a 3-microsecond delay at 5765 mc.

The C-band transponder contains four receivers, a transmitter, a power supply, and associated circuitry for comparing and decoding received signals and switching antennas. There are four C-band antennas, one for each receiver, located around the perimeter of the command module. The interrogation may be received by any one or more of the four antennas and routed through circulators to the associated receivers. If the pulses are properly coded the comparator determines which antenna received the strongest signal and activates the switch driver, which drives the RF

Function \ Switch Name	S-Band Power	Pwr Ampl	OSC	Ranging	Tape	TV	Emergency UP Data S-Band Ant			Remarks
	XPONDER-OFF-XPONDER PWR AMPL	HIGH LOW	PRIM SEC	RNG-Off-RNG ONLY	TAPE-Off	TV-Off	Voice-Off-Key	S-Band-Off-UHF	AUTO-UPPER-LOWER	
S-band PM mode real time voice, telemetering and ranging	XPONDER PWR AMPL	LOW	PRIM	RNG	Off	Off	Off	As reqd	UPPER or LOWER as reqd	
S-band PM mode real time voice and data	XPONDER PWR AMPL	LOW	PRIM or SEC	Off	Off	Off	Off	As reqd	UPPER or LOWER as reqd	
S-band FM mode real time voice, data and TV	XPONDER PWR AMPL	LOW or HIGH	PRIM or SEC	Off	Off	TV	Off	As reqd	UPPER or LOWER as reqd	TV camera power switch must be on.
S-band FM mode real time voice, play back data	XPONDER PWR AMPL	LOW	PRIM or SEC	Off	TAPE	Off	Off	As reqd	UPPER or LOWER	DSE switches must be properly configured for play back.
S-band emergency voice	XPONDER PWR AMPL	LOW or HIGH	PRIM or SEC	Off	Off	Off	VOICE	As reqd	UPPER or LOWER	
S-band emergency key	XPONDER PWR AMPL	LOW or HIGH	PRIM or SEC	Off	Off	Off	KEY	As reqd	UPPER or LOWER	Cobra cable mode switch at CW and PTT button used as key.
S-band reception of up-data	XPONDER or XPONDER PWR AMPL	LOW or HIGH	PRIM or SEC	RNG Off RNG ONLY	Off	Off	Off	S-band	UPPER or LOWER	

Notes: 1. TAPE and TV switches are 3-position switches with the down position no longer performing a valid function. The down position of these switches should not be selected.

2. The TAPE and TV switches should never be in the UP position together.

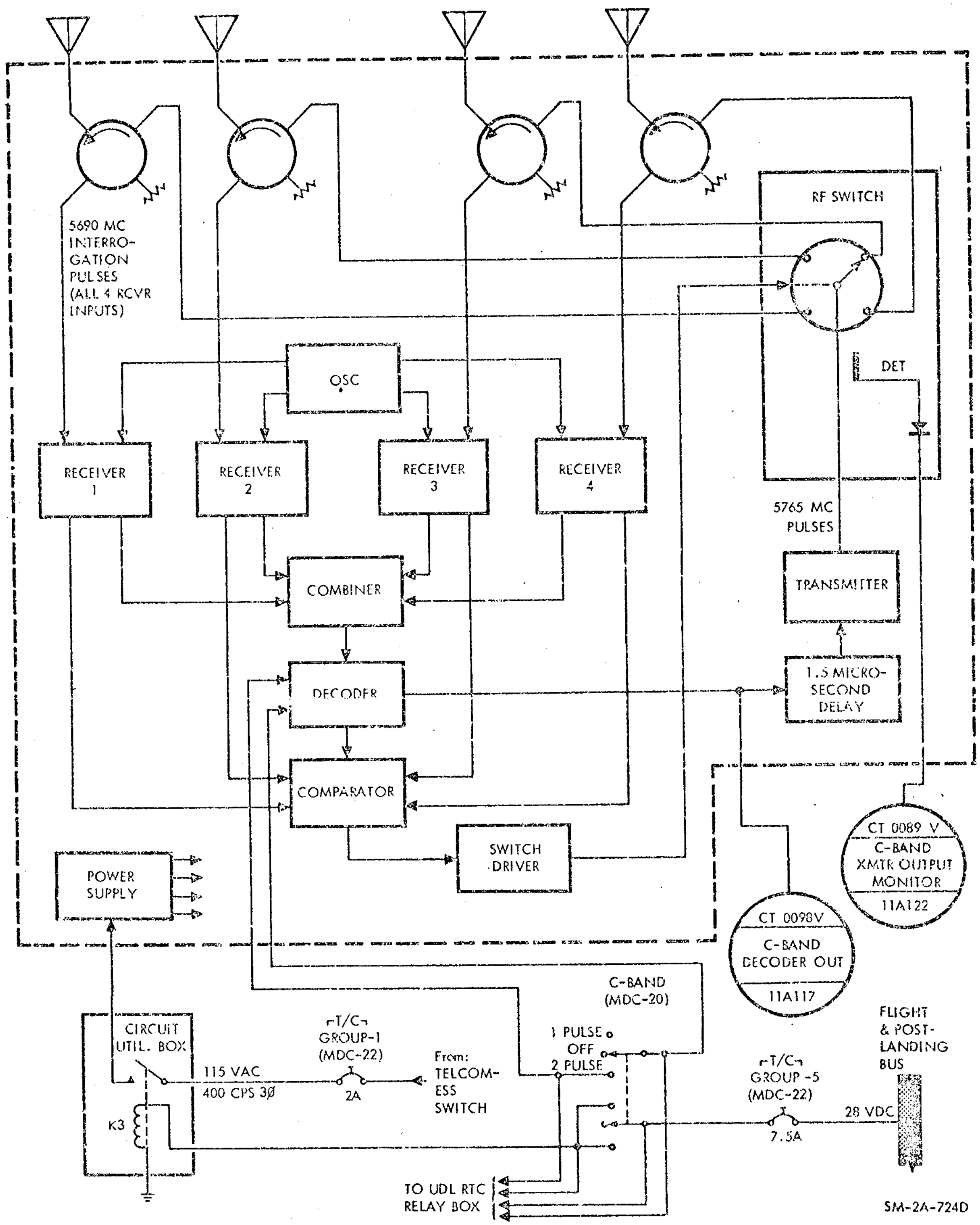


Figure 2.8-20. C-Band Transponder Equipment

switch to the proper antenna position. Three microseconds after interrogation, the transmitter sends a response pulse to the selected antenna. This 3-microsecond delay gives the RF switch time to operate. It also enables MSFN personnel to simultaneously observe the transponder reply and the skin track reply on the same visual display device (cathode ray tube), for comparison.

Two modes of operation can be selected: 1 pulse or 2 pulse. Mode selection will depend on the type of earth-based radar equipment that is being used at a particular area in the orbital path. During the launch and ascent phases of the mission, the 2-pulse mode will be used.

The only external control for the C-band transponder equipment is the C-BAND three-position toggle switch on MDC-20. The OFF position removes a-c power from the equipment; the 1 PULSE and 2 PULSE positions apply a-c power to the equipment and select the mode of operation. Activation and mode selection can also be commanded from the MSFN by a real-time command via the UDL equipment.

2.8.3.3.7 VHF Recovery Beacon Equipment.

The VHF recovery beacon equipment (figure 2.8-21) provides a line-of-sight direction finding capabilities to aid in locating the S/C during the recovery phase of the mission. It is located in the same electronics package as the VHF/AM transmitter-receiver equipment in the LEB. The beacon signal emitted is an interrupted 243-mc carrier, modulated by a 1000-cps square wave. The signal is transmitted for 2 seconds, then interrupted for 3 seconds.

Manual control of the equipment is provided by the RECOVERY — VHF-BCN, two-position ON/OFF switch on MDC-20.

The output of the VHF recovery beacon equipment is fed to VHF recovery antenna No. 1, which is deployed automatically when the main chutes are deployed.

2.8.3.3.8 GFE VHF Survival Beacon/Transceiver.

The VHF beacon/transceiver is a hand-held GFE item to be used in the recovery phase of the Apollo mission. The unit, plus an extra battery, is stored with the survival equipment.

Figure 2.8-22 shows the three major parts of the unit, the transmitter-receiver assembly, the battery pack assembly, and the quarter wave antenna.

The receiver-transmitter assembly and battery pack assembly mate to form a water-tight unit measuring 8 by 4-1/2 by 3 inches. The antenna is an 11-1/2-inch-long tapered flexible steel tape, terminated in a coaxial RF connector, and is normally stored in a retaining spool and clip on top of the radio unit.

The radio is capable of line-of-sight operation in either of two modes (beacon or voice) through use of either its own antenna or a suitable connected remote antenna. The transmitter output is protected against damage while operating due to accidental shorting of the antenna or submergence of the unit in salt water. In the beacon mode, the transmitter operates unattended, for periods up to 24 hours, to transmit an interrupted 1000-cps tone, amplitude modulated 25 percent on the 243-mc RF carrier. In the

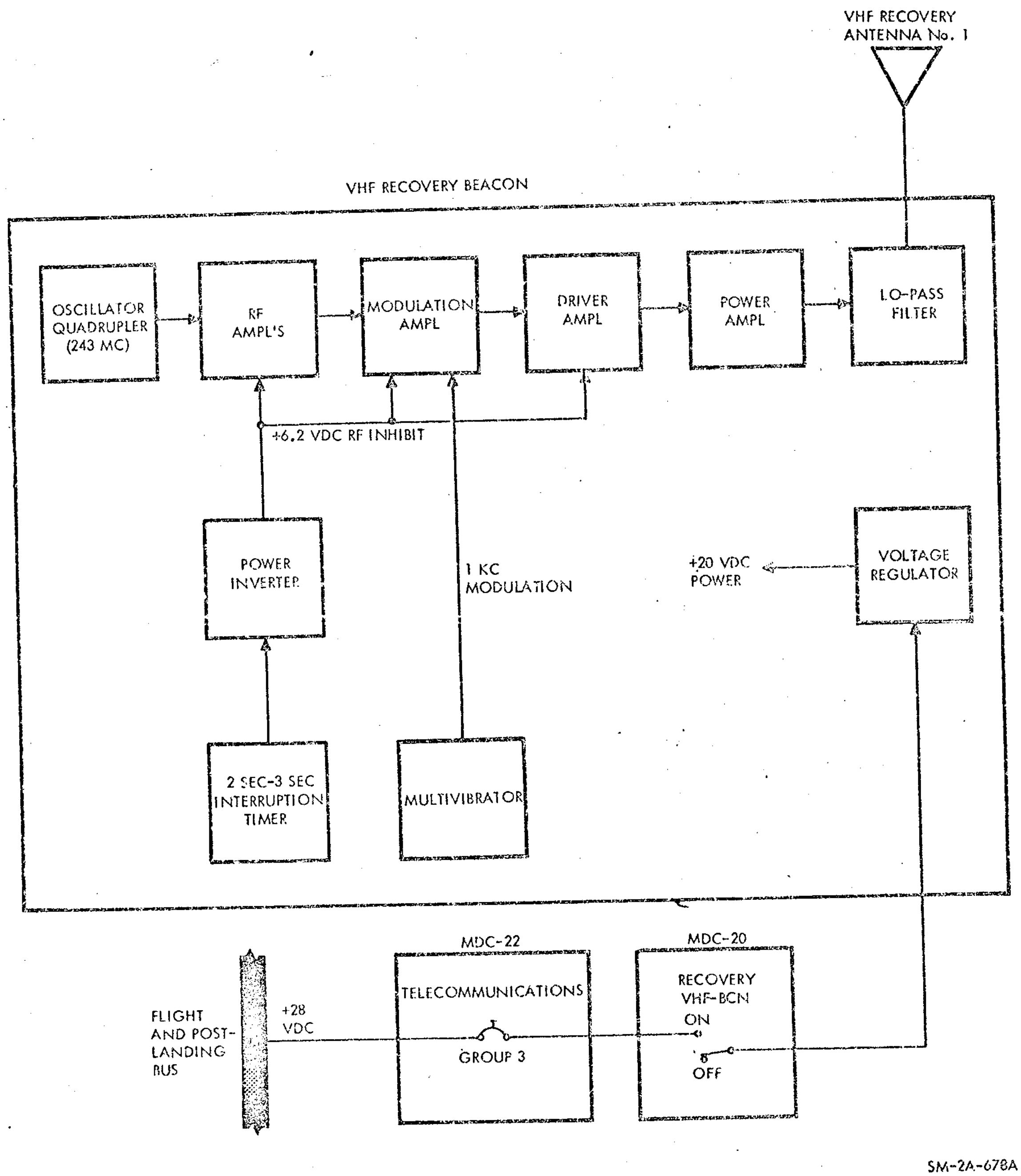


Figure 2.8-21. VHF Recovery Beacon Equipment

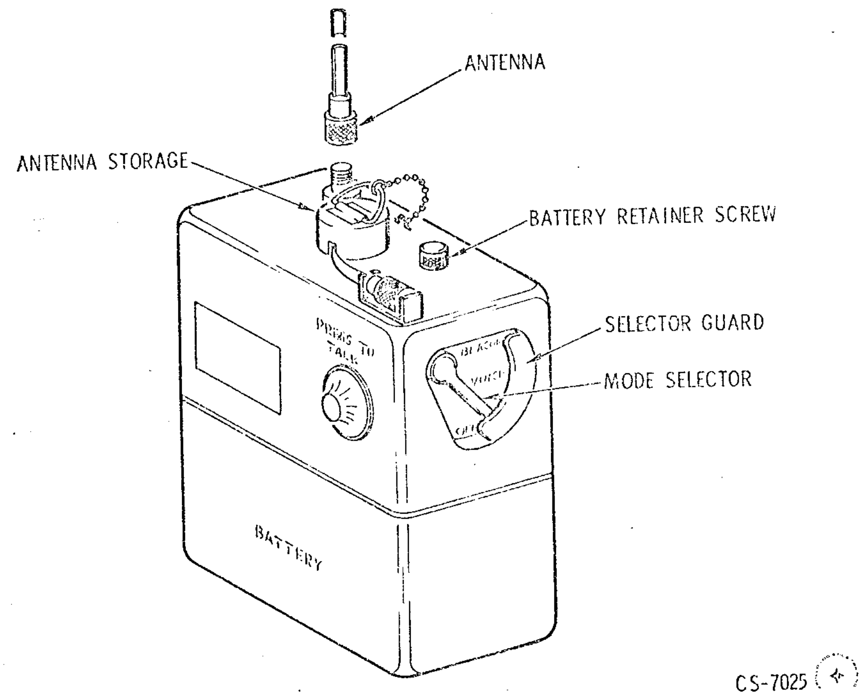


Figure 2.8-22. Survival Beacon/Transceiver Radio

voice mode, the radio provides two-way AM voice communication through use of an integral speaker-microphone and PUSH-TO-TALK switch.

2.8.3.4 Antenna Equipment Group.

The antenna equipment group contains all of the S/C antennas and ancillary equipment used in the T/C system. (See figures 2.8-23 and 2.8-24.)

2.8.3.4.1 VHF/2-KMC Omni-Antenna Equipment.

The VHF/2-kmc omni-antennas and corresponding ancillary equipment consists of two VHF/2-kmc SCIN antennas, a VHF multiplexer, a VHF antenna switch, a 2-kmc antenna switch, and the necessary signal and control circuits. The function of this equipment is to provide capabilities for radiation and pickup of RF signals in the VHF and S-band spectrums. The VHF portion of this equipment is used in conjunction with the up-data link (UDL) receiver, the VHF/FM transmitter, and the VHF/AM transmitter-receiver on two frequencies. The 2-kmc portion of this equipment is used with the USBE.

The VHF multiplexer is a passive, six-channel, filtering device which enables six items of VHF transmitting or receiving equipment to utilize one VHF antenna simultaneously. The six channel filters are composed of two or three tuned cavities, each of which function as bandpass filters. No power is required by the device and there are no external controls.

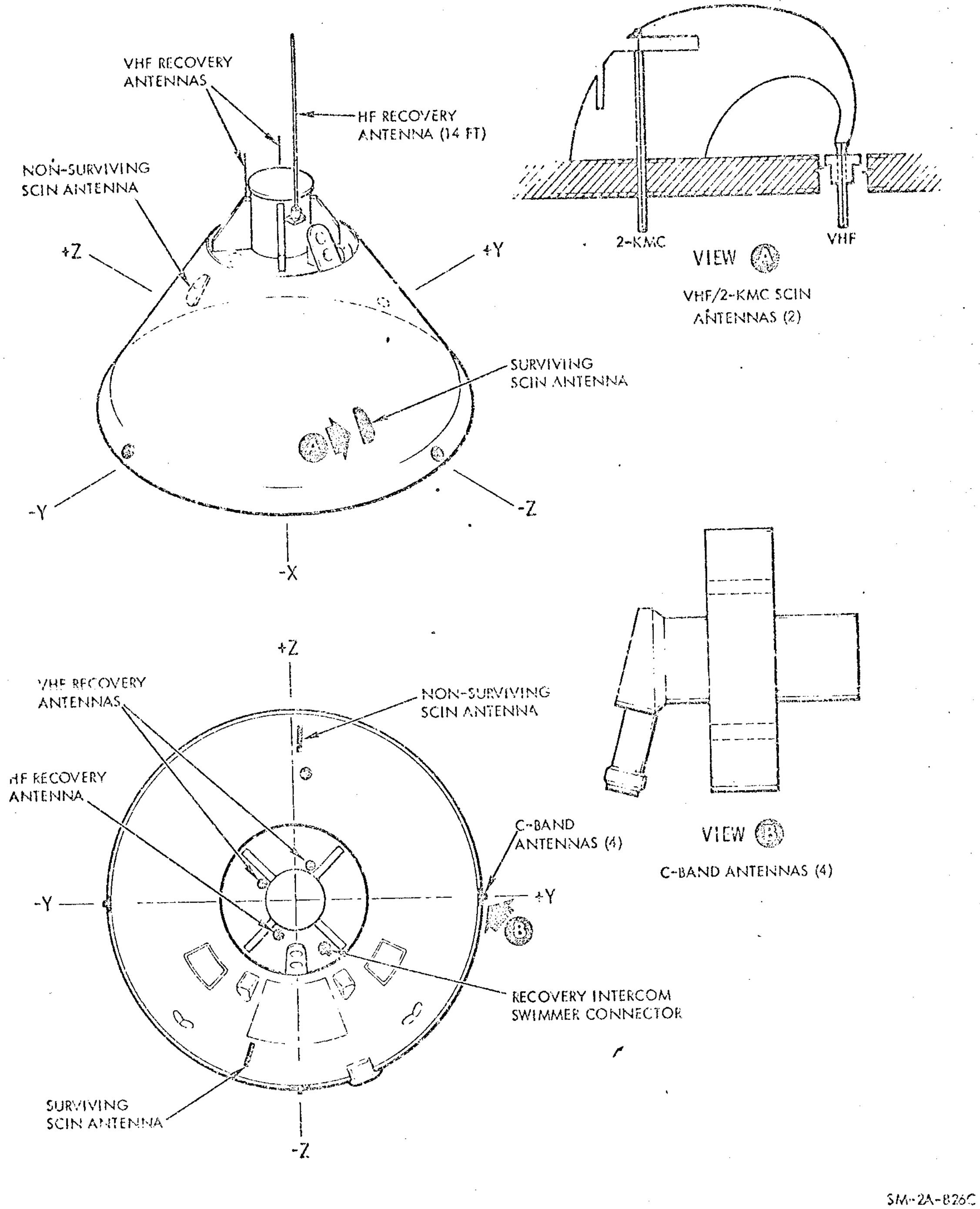


Figure 2.8-23. Antenna Locations

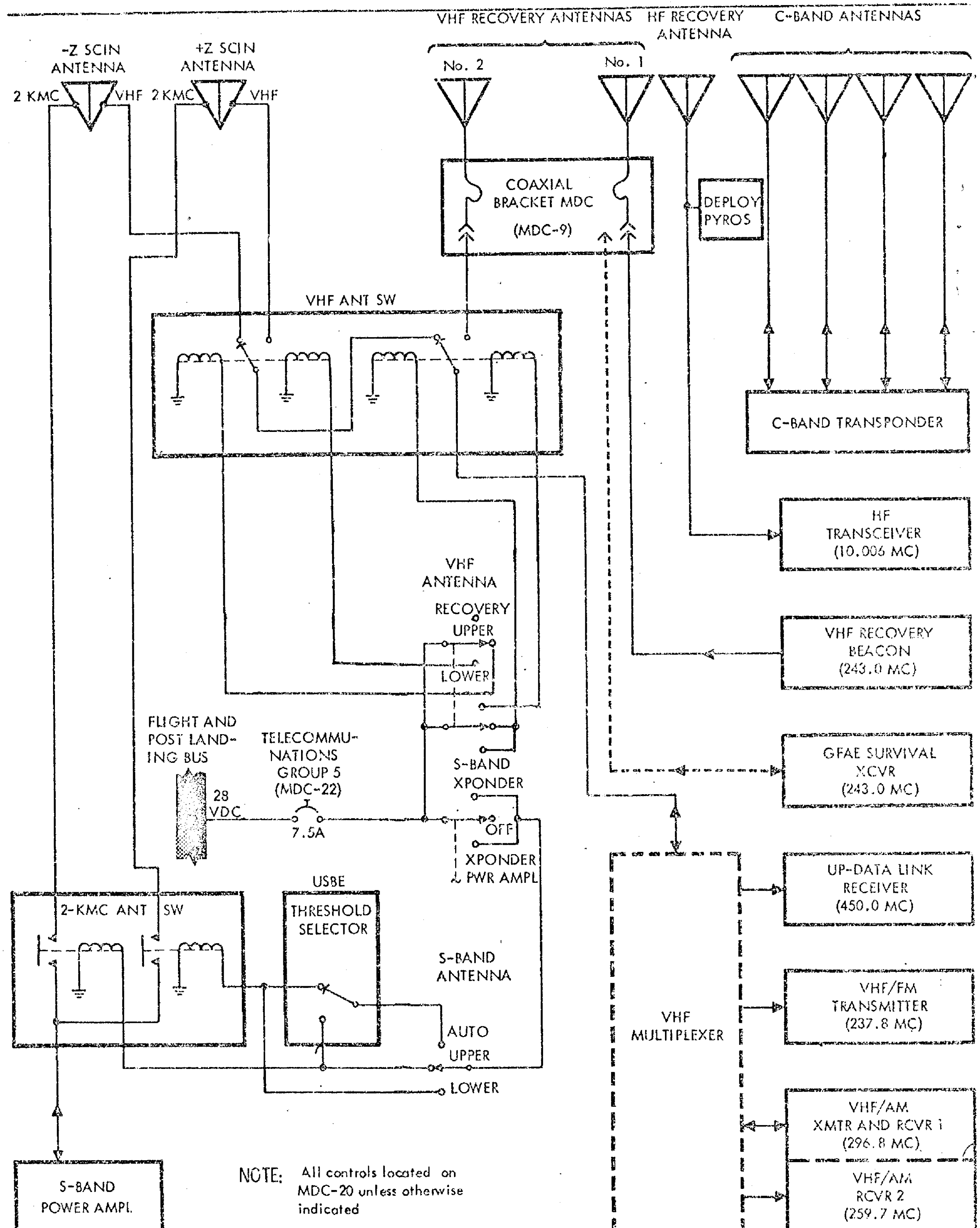
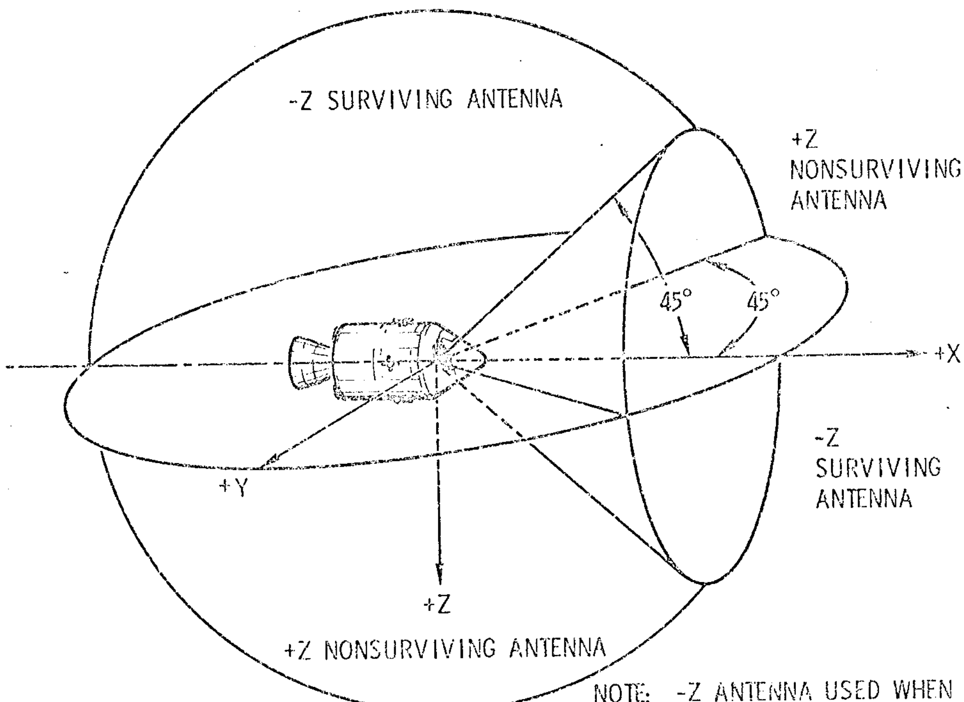


Figure 2.8-24. Antenna RF and Control Circuitry

SM-2A-721C

The VHF/2-kmc SCIN antennas are dual-purpose antennas with approximately hemispherical radiation patterns. Figures 2.8-25 and 2.8-26 show the propagation patterns of the VHF-UHF and S-band portions of the antenna, respectively. The word "SCIN" is an acronym for "SCImitar" and "Notch." Because of its characteristic shape, that portion of the antenna used for VHF is called a scimitar. In the broad end of the scimitar is a notch which functions independently and is used for S-band frequencies.

There are two VHF/2-kmc SCIN antennas; they are located on opposite sides of the S/C. One is located near the +Z axis and is called the +Z or lower SCIN antenna; the other is located near the -Z axis and is called the -Z or upper SCIN antenna. Because of their approximate hemispherical radiation patterns, fully omnidirectional capabilities can be obtained only by switching from one antenna to the other. This is accomplished with the VHF ANTENNA remote control switch on MDC-20 for VHF communications, or with the S-BAND ANTENNA remote control switch, also on MDC-20, for S-band communications.



NOTE: -Z ANTENNA USED WHEN VEHICLE/MSFN LINE OF SIGHT IS IN -Z HEMISPHERE, +Z ANTENNA USED WHEN VEHICLE/MSFN LINE OF SIGHT IS IN +Z HEMISPHERE; EXCEPT WHEN LINE OF SIGHT IS WITHIN 45 DEGREES OF +X AXIS; THEN USE OPPOSITE ANTENNA.

CD-272

Figure 2.8-25. Antenna Switching Regions, VHF-UHF

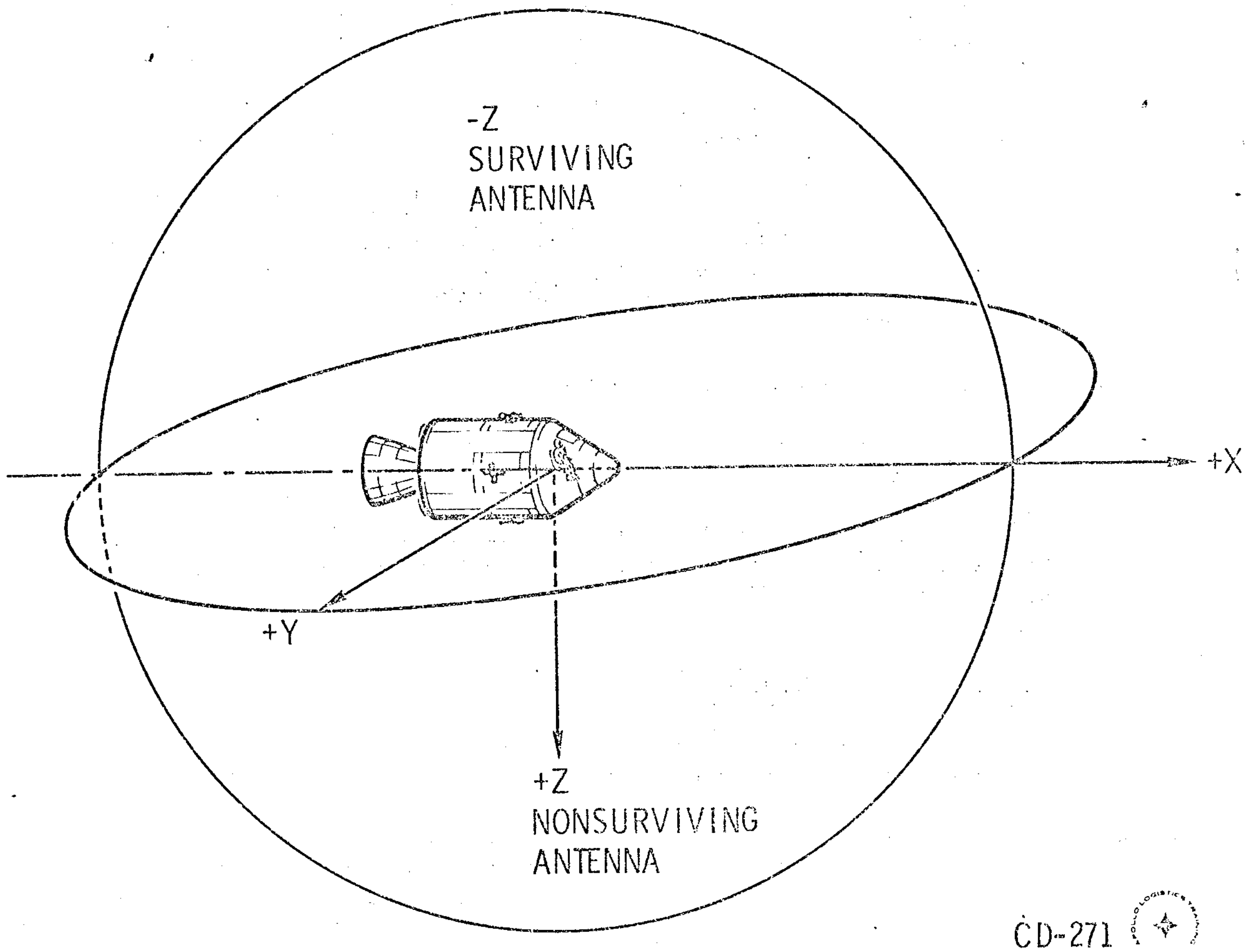


Figure 2.8-26. Antenna Switching Regions, S-Band

The lower (+Z) SCIN antenna may be burned off during entry. The upper (-Z) SCIN antenna is located at a minimum heat point and is covered with ablative material to provide thermal protection for entry survival.

2.8.3.4.2 HF Recovery Antenna Equipment

The HF recovery antenna is provided solely for use with the HF transceiver to provide for voice communication with recovery forces after touchdown. It is stowed inside a canister, located in the forward compartment of the S/C, until deployed by manual activation of a pyrotechnic device. The pyrotechnic device is activated by setting the POST LANDING — ANTENNA DEPLOY switches to their upper positions (A and B), while the MASTER EVENT SEQ CONT switches (2) are at PYRO ARM (MDC-24) position.

2.8.3.4.3 VHF Recovery Antenna Equipment.

There are two VHF recovery antennas, No. 1 and No. 2, stowed in the forward compartment of the S/C. Each antenna consists of a quarterwave stub, 11 inches long, and a ground plane. They are automatically deployed 8 seconds after main parachute deployment during the descent phase of the mission.

VHF recovery antenna No. 1 is connected to the VHF recover beacon equipment through a coaxial connector on the coaxial bracket, MDC-9. VHF recovery antenna No. 2 is to be used with the VHF/AM transmitter-receiver equipment, thus it is connected to the VHF antenna switch, also through a connector on the coaxial bracket. The purpose of the coaxial bracket is to allow either of the VHF recovery antennas to be used with the GFAE survival transceiver. This requires that the coaxial cable from one of the antennas be manually disconnected at the coaxial bracket and reconnected to the survival transceiver.

2.8.3.4.4 C-Band Beacon Antenna Equipment.

There are four, flush-mounted, C-band beacon antennas located around the perimeter of the S/C near the four S/C axes: +Z, -Z, +Y, and -Y. All four antennas are connected at all times to the C-band transponder equipment with reception by all four antennas. Circuitry in the C-band transponder equipment determines which antenna received the strongest signal and automatically selects that antenna for transmission of response pulses.

2.8.3.5 Electrical Power Distribution.

Electrical power distribution for the voice and data, and the RF equipment groups is shown on sheet 1 of figure 2.8-27. Instrumentation equipment power distribution is shown on sheet 2. Electrical power to most of the equipment on sheet 1 is controlled by the T/C switches on MDC-20. These switches and control circuits can be found on the illustrations for the individual components in paragraphs 2.8.3.3 and 2.8.3.4.

2.8.4 PERFORMANCE AND DESIGN DATA

The following chart contains the a-c and d-c power consumption values for the T/C voice, data, and RF equipment.

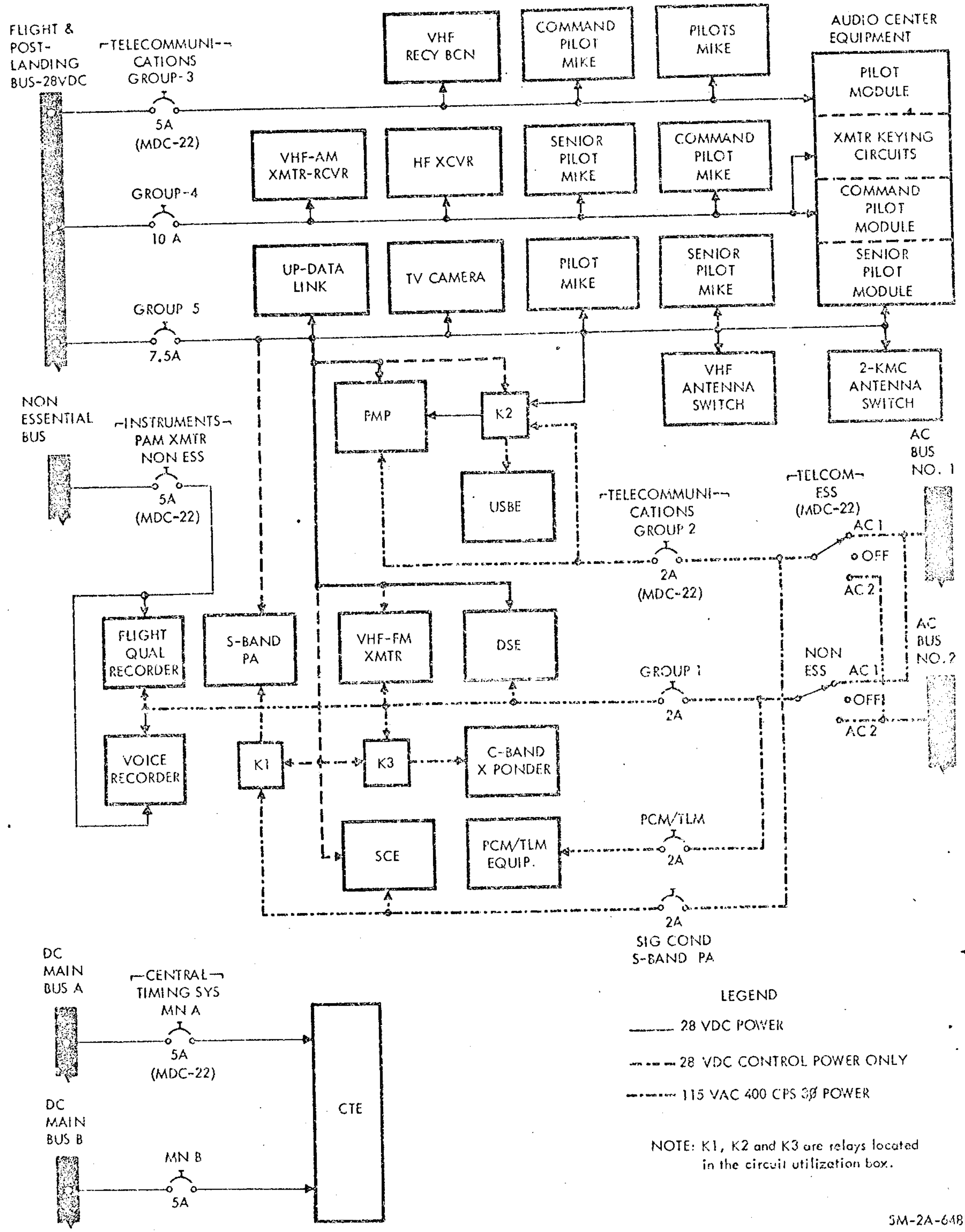


Figure 2.8-27. Telecommunications Power Distribution (Sheet 1 of 2)

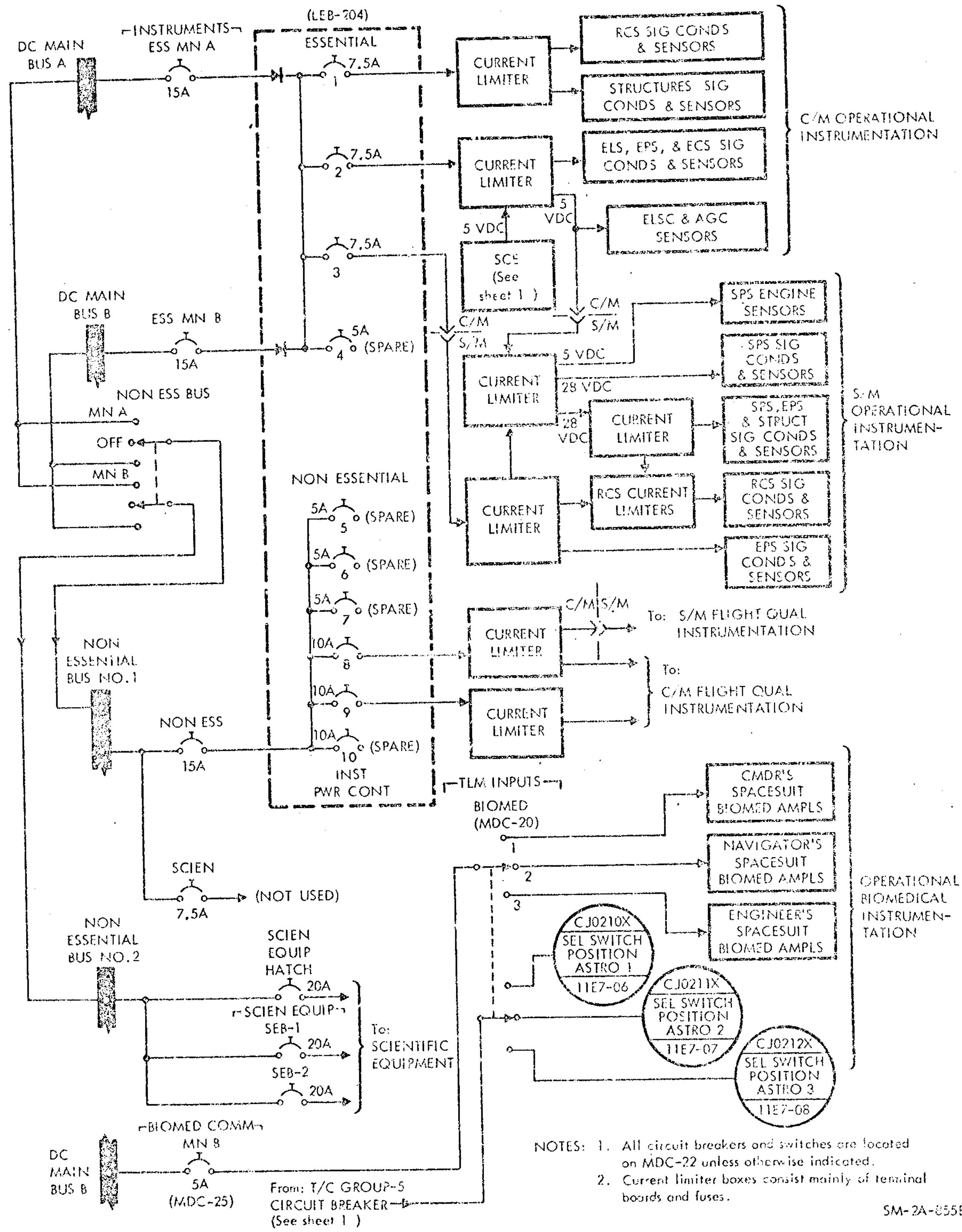


Figure 2.8-27. Telecommunication Power Distribution (Sheet 2 of 2)

T/C Equipment Power Consumption

Equipment	Quantity	Control	D-C Watts	A-C Watts	Total D-C Watts	Total A-C Watts
A-C equipment	3	PWR switch to VOX, MDC (13, 23, 26)	4.3		12.8	
SCE	1	SCE PWR switch ON, MDC 20		45.0		45.0
PCM TLM equipment	1	PCM control button ON, MDC 22		10.5		10.5
TV camera	1	PWR switch ON, TV camera handle	6.0		6.0	
PMP	1	PMP PWR switch ON, MDC 20	2.6	4.0	2.6	6.4
		+ TAPE SWITCH ON, MDC 20	2.6	6.4	2.6	6.4
		EMER VOICE switch ON, MDC 20	3.2		3.2	
		EMER KEY ON, MDC 20	3.6		3.6	
DSE	1	RECORD/PLAYBACK switch other than OFF, MDC 20	0.5	32.5	0.5	32.5
FQR	1	RECORD switch to RECORD MDC 19	34.0	15.0	34.0	15.0
UDL	1	UDL switch to VHF, MDC 20	9.6		9.6	
CTE	1	2-CTE control buttons ON, MDC 22	21.0		21.0	
VHF/AM transmitter-receiver		VHF/AM switch to REC, MDC 20	1.5		1.5	
		VHF/AM switch to T/R, MDC 20	15.5		15.5	
		VHF/AM switch to T/R, PTT button ON, cobra cable MODE switch to PTT	61.5		61.5	
HF transceiver	1	HF POWER switch ON, MDC 20	0.6		0.6	
		HF PWR switch ON, MODE switch to BCN or AM, MDC 20, cobra cable PTT button ON	29.0		29.0	
		HF PWR switch ON, MODE switch to SSB, PTT button on cobra cable ON	40.0		40.0	
VHF/FM transmitter	1	VHF FM switch ON, MDC 20	1.5	50.0	1.5	50.0

SYSTEMS DATA

Equipment	Quantity	Control	D-C Watts	A-C Watts	Total D-C Watts	Total A-C Watts
USBE	1	S-BAND XPONDER switch to XPONDER MDC 20		13.5		13.5
S-band PA	1	S-BAND XPONDER switch to XPONDER PWR AMP, PWR AMP switch LOW, MDC 20	3.0	27.4	3.0	27.4
		S-BAND XPONDER switch to XPONDER PWR AMP, PWR AMP switch HIGH	3.0	80.0	3.0	80.0
C-band transponder	1	C-BAND PWR switch 1 pulse or 2 pulse, MDC 20	3.0	75.0	3.0	75.0
VHF recovery beacon	1	VHF BCN switch ON, MDC 20	8.0		8.0	
2-KMC antenna switch	1	S-BAND XPONDER switch ON S-BAND switch changed, MDC 20	15.0		15.0	
Voice recorder	1	HF switch and INTERCOM switch to TR, MDC 20; PTT button ON on cobra cable	0.025	1.99	.025	1.99

2.8.5 OPERATIONAL LIMITATIONS AND RESTRICTIONS.

2.8.5.1 Antennas.

For S-band transmission and reception, the SCIN antenna on the side of the S/C nearest to the MSFN station must be utilized. For VHF transmission and reception, the SCIN antenna indicated in figure 2.8-25 should be utilized. This may require switching between the upper (-Z) and lower (+Z) SCIN antennas while making a single station pass. For VHF operations this must be done manually with the VHF ANTENNA switch. For S-band operations, this can be accomplished either manually or automatically with the S-BAND ANTENNA switch.

At greater slant ranges, null points may exist in the SCIN and C-band beacon overall antenna patterns along the centerline of the S/C, forward and aft of the C/M. Pointing either of these null points at the MSFN station may cause communications to be interrupted.

The lower (+Z) SCIN antenna will be burned off during entry. Thus after entry, the upper (-Z) SCIN antenna or VHF recovery antenna No. 2 must be utilized for communications via the VHF/AM transmitter-receiver.

2.8.5.2 Data Storage Equipment.

a. Maximum DSE running times for the entire reel of tape at the three operating speeds are as follows: 3.75 ips (LOW – 120 minutes, 15 ips (NORM) – 30 minutes, 120 ips (HIGH, for rewind and LBR PCM dump only) – 3.75 minutes.

b. Stored HBR and LBR PCM data, if intermixed on the tape, cannot be dumped within one station pass, due to the different playback speeds required. LBR PCM must be recorded at 3.75 ips and may be played back at 15 ips or 120 ips; HBR PCM must be recorded at 15 ips and played back at 15 ips.

c. Stored PCM TLM need not be played back in the same direction in which it was recorded. Playback in the direction of recording requires rewinding of the tape between recording and dumping.

d. There is no provision for recording TV data.

e. High-bit rate PCM must be recorded at normal speed or tape motion will stop.

f. Low-bit rate PCM must be recorded at low speed or tape motion will stop.

g. If tape is played back at low speed, the tape will move but there will be no playback data available to the transmitters.

h. If high-bit rate data is played back at high speed, the transmitter data will be garbled.

i. If only a FWD or REV command is given to initiate a rewind, there will be no tape motion. A mode (preferably PLAY), must also be selected before tape will move.

j. Refer to paragraph 2.8.3.2.6 for proper DSE operating functions.

2.8.5.3 Unified S-Band System.

a. S-band operations will be limited due to the limited number of MSFN stations that will have operational S-band capabilities.

b. If one of the S-band mode switches (TAPE - OFF - ANALOG or TV - OFF - PLSS) is moved from the OFF position, the FM selection of the S-band transmitter will be selected, reducing the circuit margins and disabling the S-band tracking.

c. TV can only be transmitted via the USBE.

d. The secondary oscillator can only be selected in normal operation with the RNG-RNG only switch in the off position and the OSC switch is SEC.

e. The TAPE and TV switches are 3-position switches with the down position no longer performing valid functions. The down position of these switches should not be selected.

f. The TAPE and TV switches should never be positioned up simultaneously.

g. Refer to paragraph 2.8.3.2.5 for valid unified S-band equipment operational modes and their attendant switching configuration.

2.8.5.4 General.

a. The maximum slant range for reliable VHF-FM TLM communications should not exceed 1500 nautical miles. Also, the maximum elevation angle from the earth to the S/C should not be less than 5 degrees.

b. Real-time and recorded PCM TLM cannot be transmitted simultaneously. One or the other, however, can be transmitted via the VHF/FM transmitter and the USBS at the same time, and real-time PCM data may be recorded while it is being transmitted.

c. The FQR has a maximum recording time of approximately 30 minutes. To maintain sufficient time for all scheduled recordings of flight qualification analog data, the FQR must be used conservatively.