

S T U D Y G U I D E

LM

COMMUNICATIONS SUBSYSTEM

For Training Purposes Only



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For Training Purposes Only

DATE: April 1967

Prepared By:

Communications Section

LM Training

PREFACE

This document is designed to support all levels of Communications Training, and is oriented toward the Design Reference Mission configuration.

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REFERENCE LIST

LSP 380-2B, Communication S/S, Design Control Specification

LSP 380-17, LM-MSFN S-Band, System, Signal

LSP 380-5, Antenna Assemblies, Inflight and EVA

LSP 380-20, Digital Uplink Assembly

LESP - (P) - 4110C S-Band Steerable Antenna

LESP - (P) - 4120 S-Band Erectable Antenna

LESP - (P) - 4130B S-Band Transmitter-Receiver

LESP - (P) - 4140A S-Band Power Amplifier

LESP - (P) - 4270 VHF Transmitter-Receiver

LESP - (P) - 4300C Signal Processor Assembly

INTRODUCTION

The Lunar Module (LM) Communications Subsystem provides the only link between the LM and the Manned Spacecraft Center (MSC). The MSC, which is the control point of the Apollo mission, is provided this constant link capability via a worldwide network of tracking stations. These stations comprise the Manned Space Flight Network (MSFN).

Communications with the Command Service Module (CSM) and the Extravehicular Astronaut (EVA) are also accomplished through this subsystem.

The data interchange via the various communications links can consist of one or more of the following types of data:

1. Deep Space Inflight Tracking and Ranging
2. Voice
3. PCM Telemetry (LM Vehicle and Subsystem Status)
4. Biomedical (Electrocardiogram)
5. LGC Digital Uplink
6. Television
7. Extravehicular Mobility Unit (EMU)
8. Keyed Continuous Wave

A combination of S-Band equipment, VHF equipment, and signal processing equipment is utilized to provide the above capability.

While the astronauts are within the LM vehicle, hardwire connection via an umbilical cord routes received voice to the headset, and voice and biomedical data to the Communications Subsystem for transmission.

Transducers located at various places on the LM vehicle and within the various subsystems report on vehicle and subsystem status. The transducer outputs are routed to the Instrumentation Subsystem for conversion to a data format suitable for transmission to the MSFN via the Communications Subsystem.

During the Lunar Stay phase of the mission, a video camera will be connected directly to the Communications Subsystem, thus providing television transmission capability. Also during this phase, voice and Extravehicular Mobility Unit* (EMU) data transmission from the EVA will be accepted by the Communications Subsystem for further signal processing and signal routing.

* Page 42

To provide for all communication functions, an S-Band Transceiver, a two-channel VHF transmitter-receiver, a Signal Processor Assembly, a Digital Uplink Assembly, a portable television camera, an antenna system, and the necessary switches are used.

The S-Band link is used for voice transmissions from the MSFN to the LM, and for voice, biomedical, EMU, PCM telemetry, emergency key, and television transmissions from the LM to the MSFN. In addition, the S-band transceiver acts as a transponder for a pseudo-random noise (PRN) ranging code. The transmitted PRN ranging code, which is in phase-coherence with the received signal, allows the MSFN to accurately determine LM range and range rate. The S-Band link is also used for uplink transmissions of digital data for purposes of updating the LGC and controlling LGC functions.

The VHF link is capable of being operated in either a simplex mode or a duplex mode. Normal LM-CSM inflight voice communications utilizes simplex operation, while the LM-EVA voice/EMU link utilizes duplex operation. In addition, a 10-bit-rate PCM data transmission via VHF is available for the LM-CSM link during those portions of the mission when the LM-MSFN line-of-sight is lost.

LM-MSFN-CSM and LM-MSFN-EVA conference capabilities are provided utilizing both S-Band and VHF equipments.

SECTION I

LM COMMUNICATIONS SUBSYSTEM

A. Manned Space Flight Network (MSFN)

The communications link between the LM vehicle in deep space and earth cannot be accomplished with only one earth station, as line-of-sight (LOS) is mandatory. Because of this requirement, a network of tracking stations are required and spaced, so that as the earth rotates on its axis, at least one station will be in LM LOS. The location of the Unified S-Band stations, which are part of the Manned Space Flight Network (MSFN), is shown in Figure 1. This integrated network allows constant communications for purposes of vehicle tracking, data recording, and direct voice communications with the astronauts.

B. Lunar Module (LM) Communications Capability

Operation of the LM Communications Subsystem during the Inflight and Lunar Stay phases of the mission are described below.

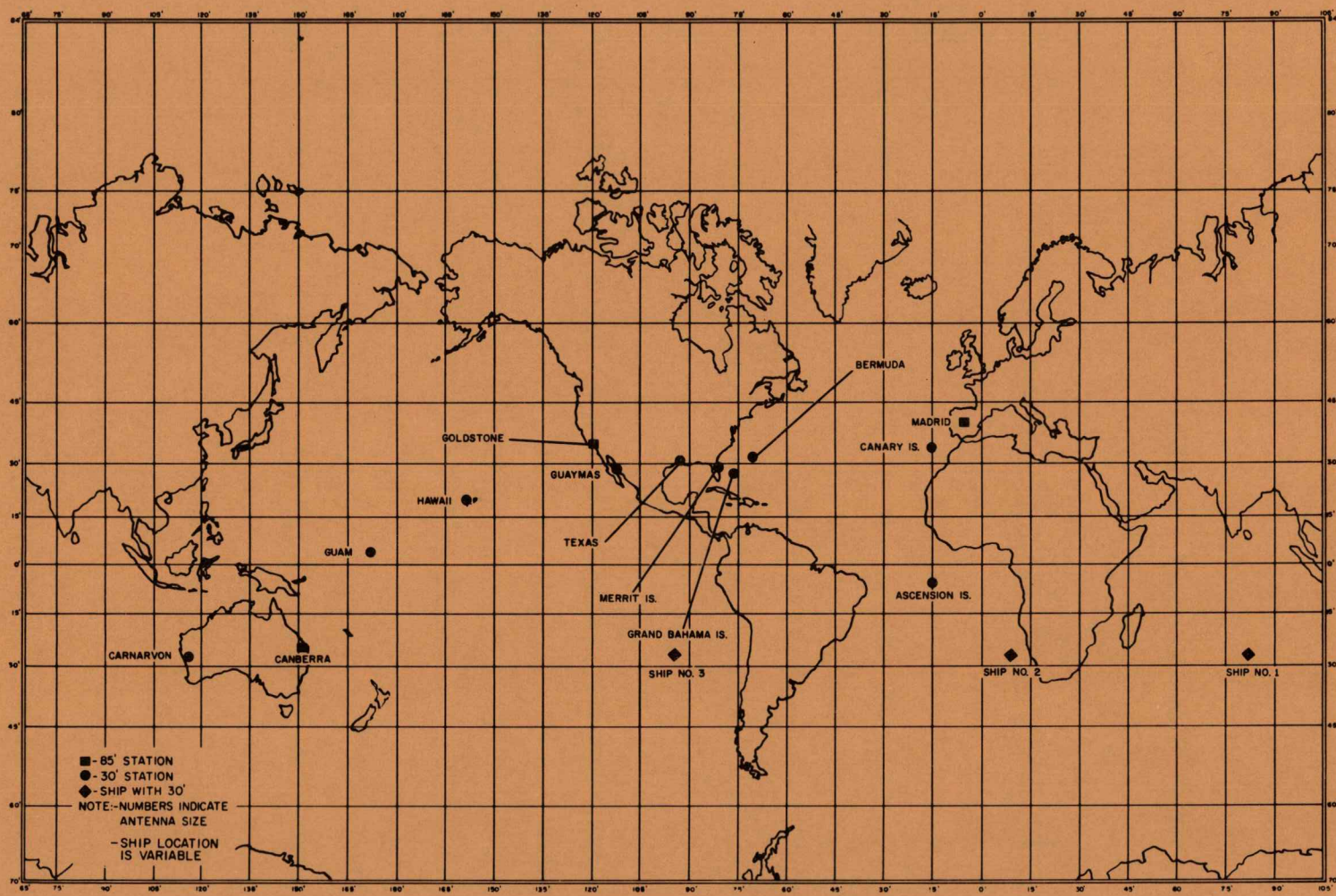
1. Inflight Communications Capability, Earth Side

The Inflight Communications Requirement, Earth Side, shown in Figure 2, calls for S-Band transmission of voice, biomedical data, PCM telemetry data, and the turn-around PRN ranging code. Received from the MSFN is voice, the PRN ranging code, and the digital uplink signal.

The signals to be transmitted are combined before phase modulating the 2282.5-mc carrier. Subcarriers are used to allow a simultaneous transmission of voice, biomedical data, PCM data, and the ranging code. A diplexer permits use of a single antenna for a transmission at 2282.5-mc and a simultaneous reception at 2101.8-mc.

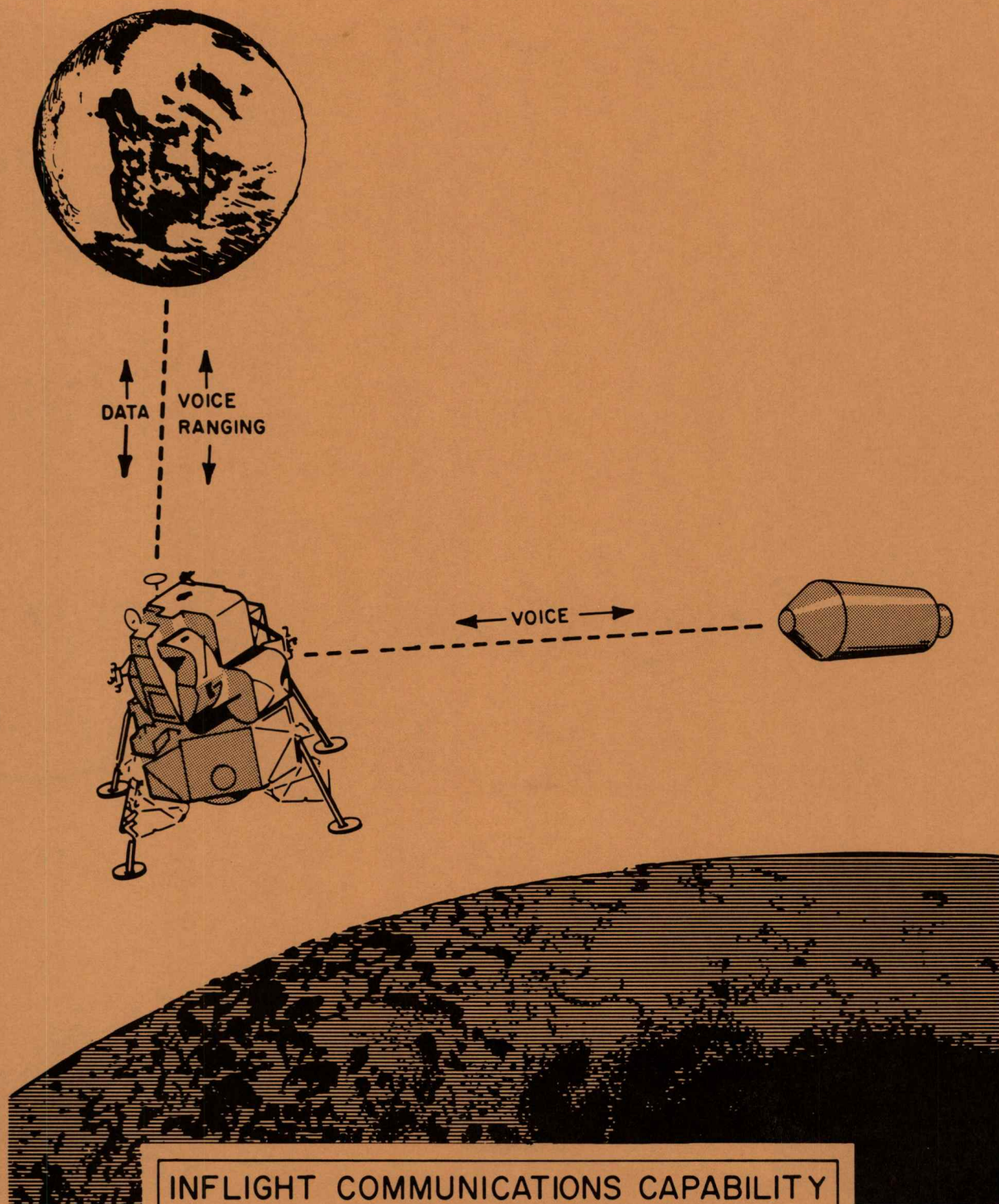
Inflight requirements also call for VHF voice communication between the LM and the CSM. This is accomplished by operating one channel, which is designated VHF "A", of the two-channel VHF Transmitter-Receiver in simplex. VHF "B" is available as a backup.

A three-way voice conference between the CSM, LM, and MSFN can be provided by the real time relay switching capability available on LM, on the CSM, and at the MSFN.



**MANNED SPACE FLIGHT NETWORK
UNIFIED S-BAND COVERAGE ONLY**

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INFLIGHT COMMUNICATIONS CAPABILITY
EARTH SIDE

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2. Inflight Communication Capability, Far Side (CSM/LM not in LOS with MSFN)

During this phase of the mission, which is depicted in Figure 3, S-Band communication with MSFN is not possible. However, the CSM-LM link will still be operational.

VHF Channel "A", which is operating at a frequency of 296.8-mc, is used for simplex voice transmission and reception.

In addition to the two-way voice communication, a one-way data link exists from LM to CSM. The LM VHF "B" transmitter operating at a frequency of 259.7-mc is used to transmit lo-bit-rate split-phase data. A data storage unit (having record and playback capability) aboard CSM is used to record this data. The tape recorder speed is slowed down during this phase of the mission to allow a two hour record time capability. When CSM-MSFN become LOS again, the tape recorder speed is increased 32 times allowing the recorded LM data to be transmitted to MSFN in 2-3 minutes.

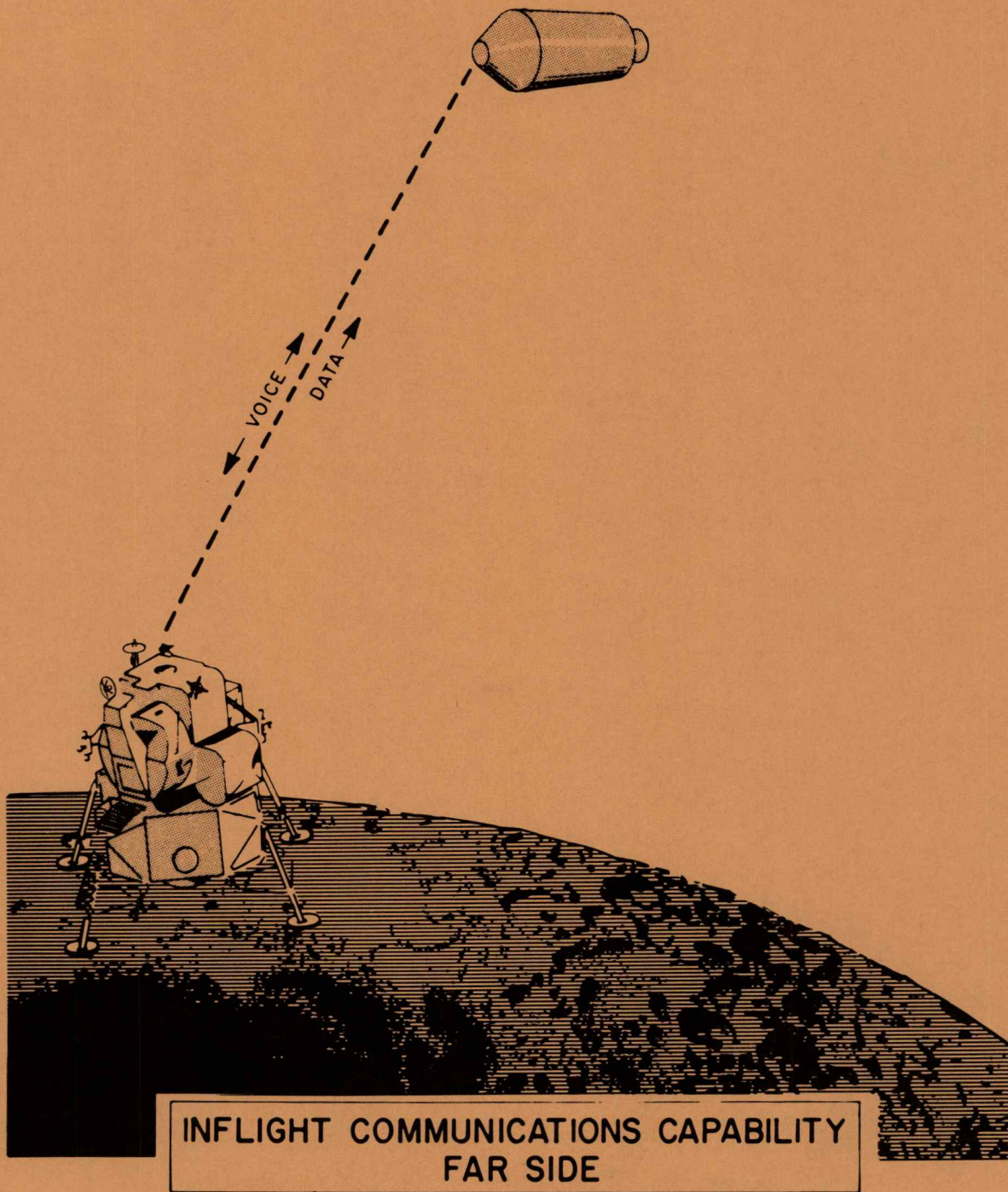
3. Lunar Surface Communication Capability

The Lunar Surface Communications Capability, shown in Figure 4, is expanded by the addition of EVA and the TV camera.

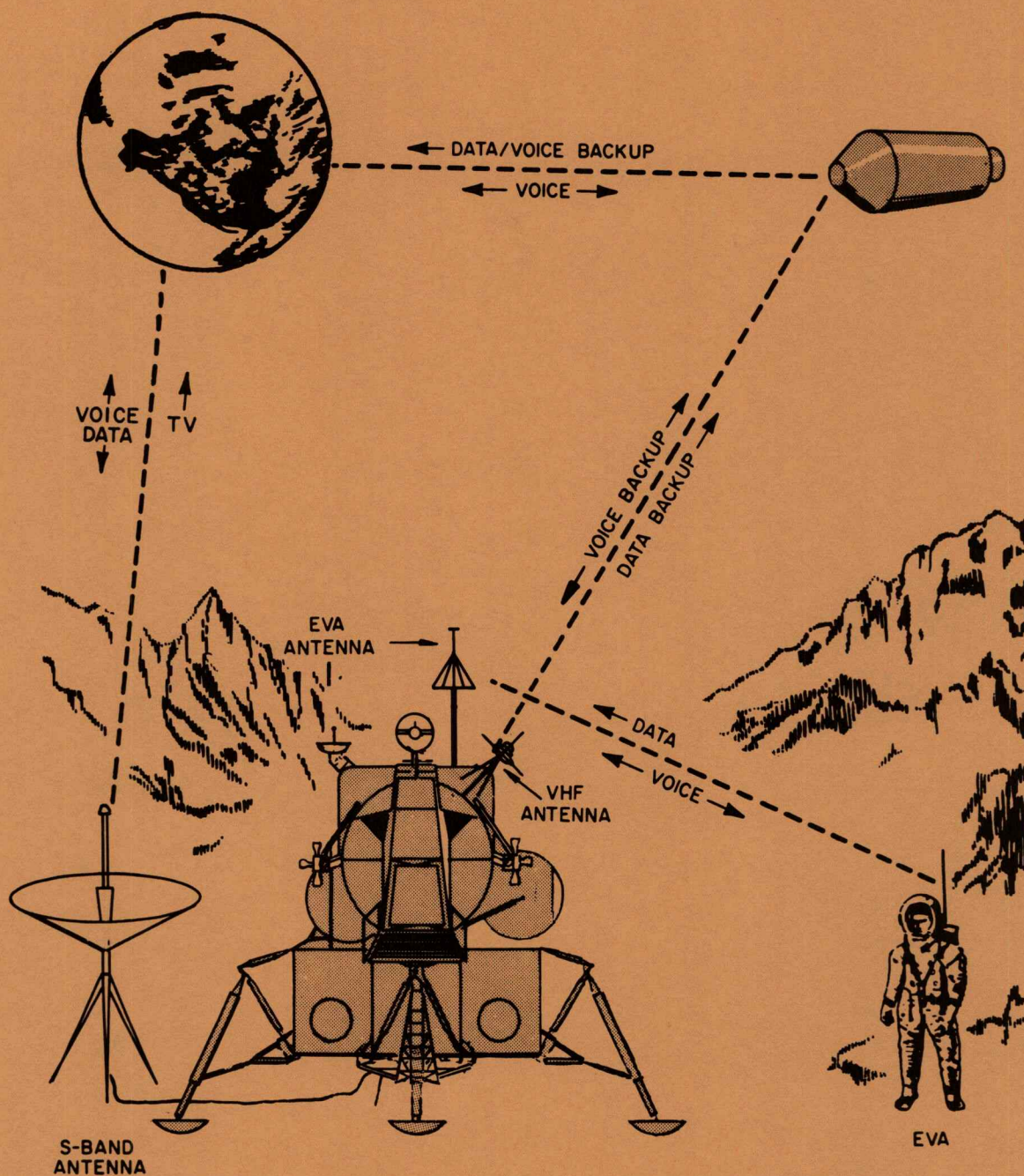
Prior to egressing from the LM vehicle, the commander or system engineer will deploy a VHF antenna to be used for LM-EVA communication. As soon as practical after leaving LM, the EVA will erect and properly position the S-Band Erectable Antenna. The erectable antenna is stored in a cylindrical container located in Quad area No. 1 of the descent stage. A series of steps showing the erection procedure can be seen in Figure 17. The fully extended erectable antenna is shown in Figure 18.

The VHF link is used for voice and data transfer between the LM and EVA. Operation is duplex, with voice transmissions from the LM to EVA using VHF "A", and voice and EMU data transmission from EVA to the LM using VHF "B". If there is a malfunction in the VHF equipment in use, duplex operation will continue, with LM-EVA voice transmission on VHF "B" and EVA-LM voice transmission on VHF "A". The EMU data will be lost, as EMU data transmission via VHF "A" does not exist.

The S-Band link is used for voice, data, and TV transfer between the LM and MSFN. The signals to be transmitted are combined before frequency modulating the 2282.5-mc carrier.



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**LUNAR SURFACE COMMUNICATIONS
CAPABILITY**

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4. Relay Operation

During EVA activity, communications with the CSM are via MSFN relay via S-Band. The time required for a radio transmission to traverse the distance between earth and moon is in the order of 1.2 to 1.5-seconds. It must be remembered that LM-MSFN-CSM relay operation can occur only during MSFN-CSM LOS.

Relay operation is also made available for the EVA-LM-MSFN link. Operation is controlled by LM switching. EVA voice and EMU data transmissions to the LM which are via VHF channel "B", are routed to the S-Band equipment for transmission to MSFN. Voice transmissions from MSFN, which are via S-Band, are routed to the LM VHF transmitter "A" for transmission to the EVA.

5. Communications Links

Table One is a tabulation of the various inflight and lunar stay communications links described in the preceding paragraphs.

C. Electronic Replaceable Assembly (ERA)

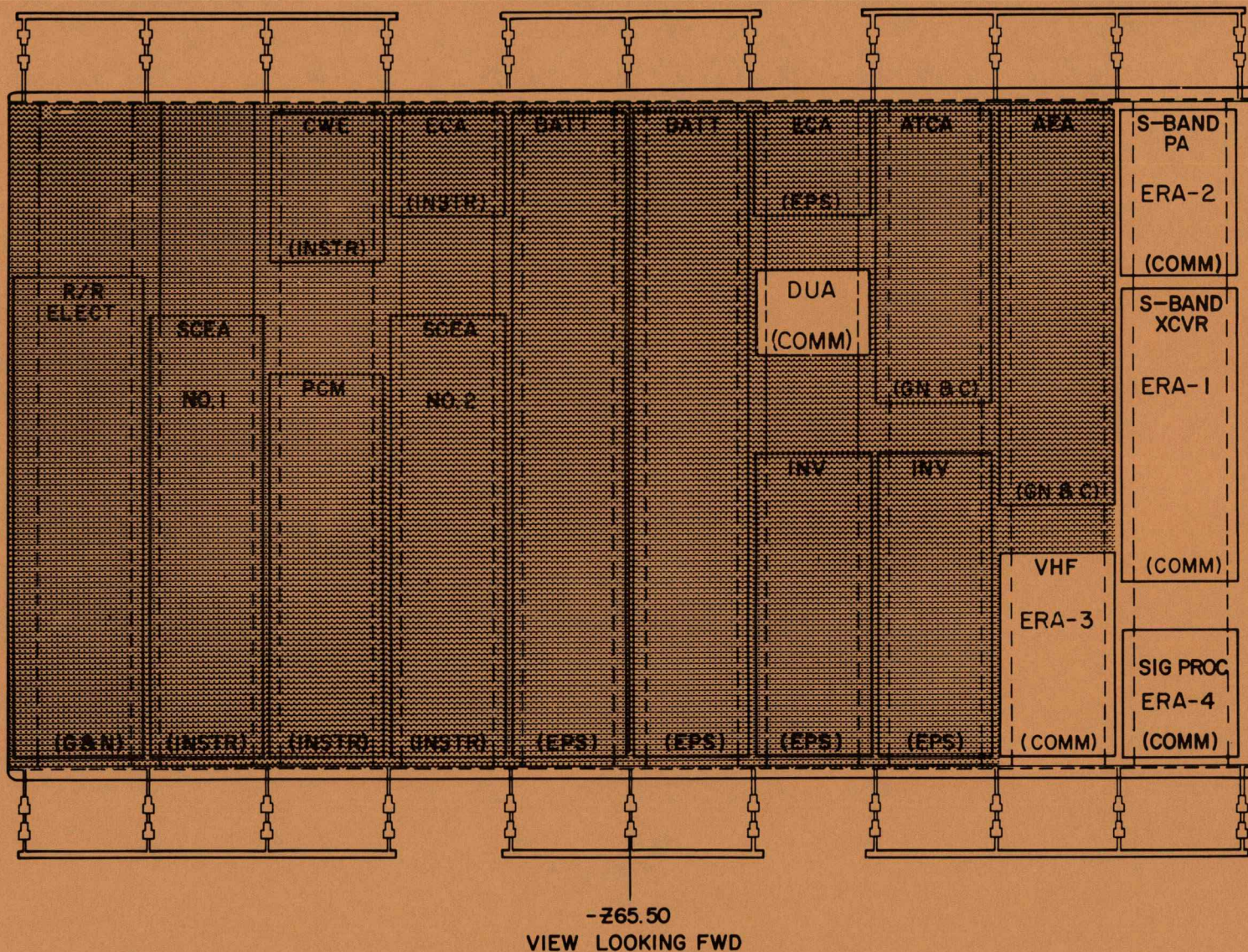
The Communications Subsystem is comprised of five (5) numbered Electronic Replaceable Assemblies (ERA's) and a Digital Uplink Assembly (DUA). The name of each ERA and their numerical designation is given below:

- ERA-1: S-Band Transceiver
- ERA-2: S-Band Power Amplifier and S-Band Diplexer
- ERA-3: VHF Transmitter-Receiver and VHF Diplexer
- ERA-4: Signal Processor
- ERA-5: S-Band Steerable Antenna

With the exception of ERA-5, all ERA's are mounted on the cold plate in the Aft Equipment Bay. The Aft Equipment Bay Cold Plate and ERA Arrangement is shown in Figure 5. It is the function of the cold plate to maintain the ERA temperature within the specified operating points. This is accomplished by heat transfer from the ERA mounting flanges to the cold plate. A glycol-water solution, which is flowing through the cold plate, absorbs the cold plate heat, thereby maintaining ERA operating temperature. ERA-5, which is the S-Band Steerable Antenna, is mounted at the end of a tripod boom located on the LM vehicle star-board side, looking forward. Heaters are used to maintain Steerable Antenna operating temperature.

TABLE ONECommunications Links

<u>LINK</u>	<u>DATA</u>	<u>BAND</u>	<u>MISSION PHASE</u>	<u>PURPOSE</u>
MSFN-LM-MSFN	Pseudo-random Noise (PRN) Ranging Code	S-Band	Inflight	Ranging & Tracking
MSFN-LM	Voice	S-Band	Inflight & Lunar Stay	
MSFN-LM	Digital Uplink	S-Band	Inflight & Lunar Stay	Update LGC
LM-MSFN	Voice, Biomedical, PCM, Telemetry	S-Band	Inflight	Commands, EKG and LM Status
LM-CSM-LM	Voice	VHF	Inflight	
LM-CSM	Lo-bit-rate split- phase PCM Data	VHF	Inflight, Far Side	Future Transfer CSM-MSFN
LM-EVA-LM	Voice	VHF	Lunar Stay	
EVA-LM	EMU Data	VHF	Lunar Stay	PLSS status & EKG information to be relayed (real time to MSFN)
LM-MSFN	Voice, Biomedical, EMU, TV, and PCM Telemetry	S-Band	Lunar Stay	
LM-CSM-MSFN	Voice	VHF/S-Band	Inflight	Conference
LM-MSFN-CSM	Voice	S-Band	Inflight & Lunar Stay	Conference
EVA-LM-MSFN	Voice	VHF/S-Band	Lunar Stay	Conference



AFT EQUIPMENT BAY COLD PLATE AND ERA ARRANGEMENT

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D. ERA and DUA Description

The Communications Subsystem Black Box Level Diagram, which is shown in Figure 6, depicts the DUA, the ERA's, and the basic subsystem signal interchange. A functional description of each ERA and the DUA follows.

1. ERA-1: S-Band Transceiver

The S-Band Transceiver provides deep-space communications between the LM and the MSFN. The S-Band Transceiver, which is a completely solid-state device, is comprised of two independent transceivers. One is designated primary and the other secondary. Only one transceiver is capable of being energized at a time, with the selection being controlled by the S-Band XMTR-RCVR PRIM-OFF-SEC switch.

2. ERA-2: S-Band Power Amplifier and S-Band Diplexer

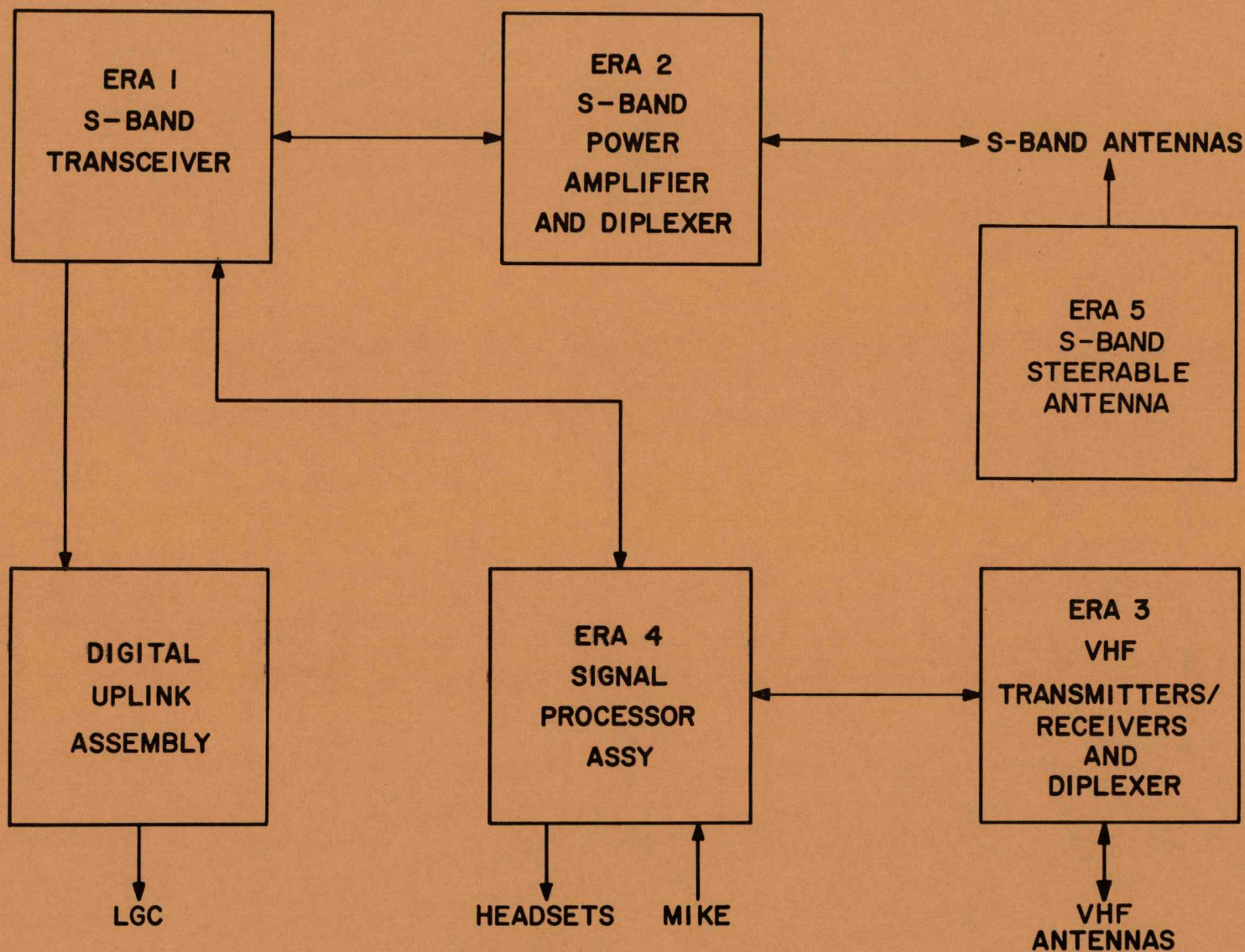
The S-Band Power Amplifier amplifies the S-Band transmitter output when additional signal strength is required. This assembly consists of two power amplifier-power supply arrangements which are designated primary and secondary. Power amplifier selection is controlled by the S-Band Power Amplifier PRIM-OFF-SEC switch.

3. ERA-3: VHF Transmitter-Receiver and VHF Diplexer

The VHF Transmitter-Receiver is used for the voice communications link between the LM and the CSM and between the LM and the EVA. This assembly is comprised of two AM-type transmitters, two AM receivers, and the diplexer. One transmitter-receiver combination is designated "A" and the other combination is designated "B". The VHF control switches allows the two transmitters and the two receivers to be energized individually. This switching arrangement allows various operational configurations.

4. ERA-4: Signal Processor

The Signal Processor is the focal point of the LM Communications Subsystem since all signals, with exception of the PRN ranging code, 10-bit-rate split-phase data, and the TV signals, are processed by it. The Signal Processor functions as a premodulation processor and a dual audio center in processing signal inputs and outputs.



**COMMUNICATIONS SUBSYSTEM
BLACK BOX LEVEL**

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5. ERA-5: S-Band Steerable Antenna

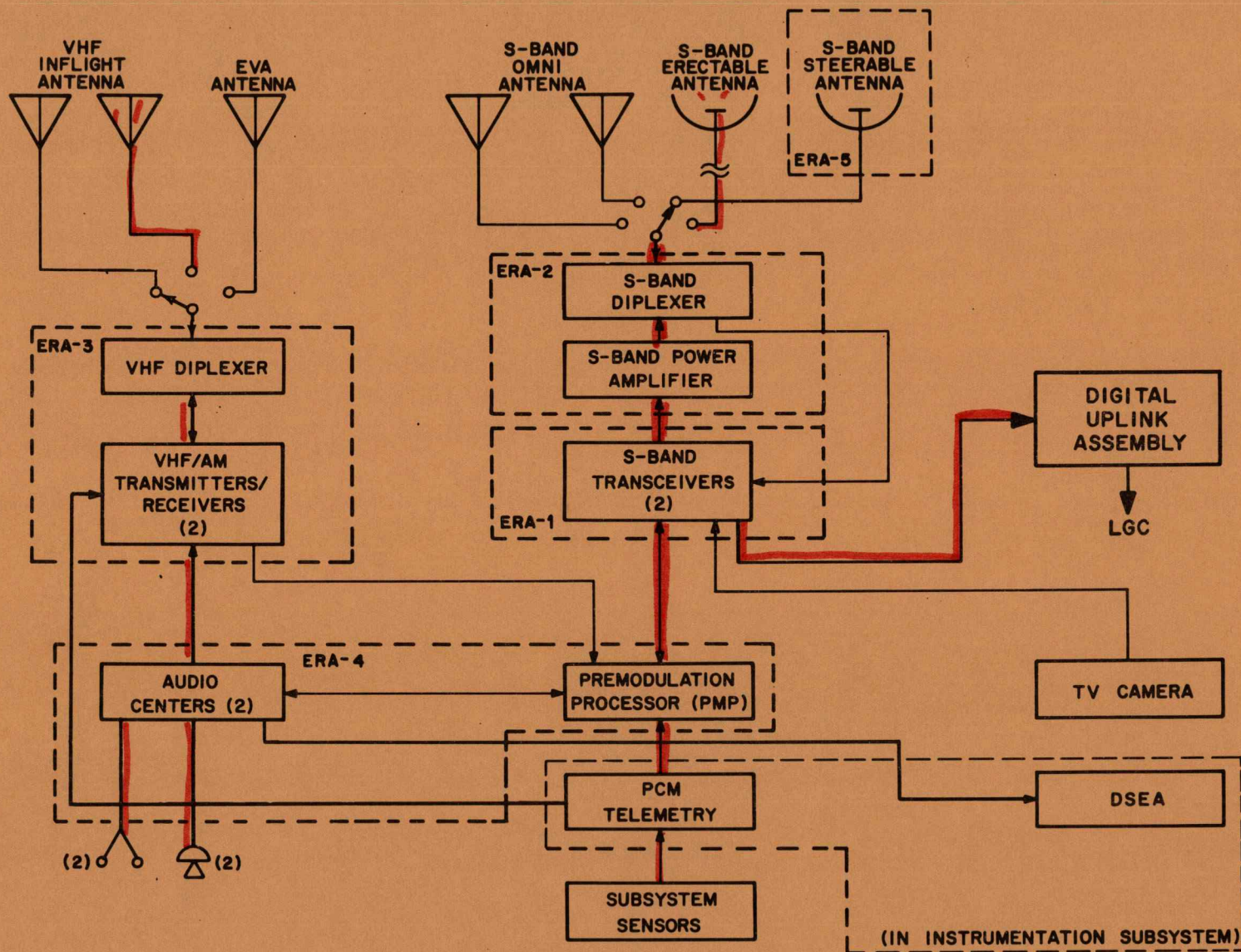
The S-Band Steerable Antenna will transmit and receive LM-MSFN communications from occupancy of the LM vehicle through lunar orbit, descent, and landing until the erectable antenna is placed in operation by the EVA. It will also serve as a backup link to the MSFN during the lunar stay phase of the mission. The steerable antenna will be activated again during pre-ascent checkout and will operate throughout the lunar ascent, rendezvous, and the LM-CSM docking.

6. Digital Uplink Assembly

The Digital Uplink Assembly will provide the means of controlling LGC functions from the MSFN. Digital commands, which are modulated on a subcarrier, will be demodulated, decoded, and applied to the LGC. These digital uplink commands parallel the LGC inputs available via the onboard Display and Keyboard (DSKY).

E. LM Communications Subsystem

Audio inputs from either the commander or system engineer are hard-lined to their respective audio centers located in the Signal Processor. This is depicted in Figure 7. If a VHF transmitter has been selected, the audio center will route the voice input to the correct VHF modulator, and provide keying of the transmitter. After amplification to approximately 7.6-watts peak power, the signal is routed through the VHF diplexer to the selected VHF antenna. The VHF inflight antennas and their locations on the LM vehicle is shown in Figure 8. Any received RF is routed through the VHF diplexer to the Receiver section. The detected output of the receiver is routed to the Premodulation Processor section of the Signal Processor, where the received signal is further amplified and routed to both audio centers. Application of the audio signal to the headsets is controlled by switches on the astronaut's control panels.



LM COMMUNICATIONS SUBSYSTEM

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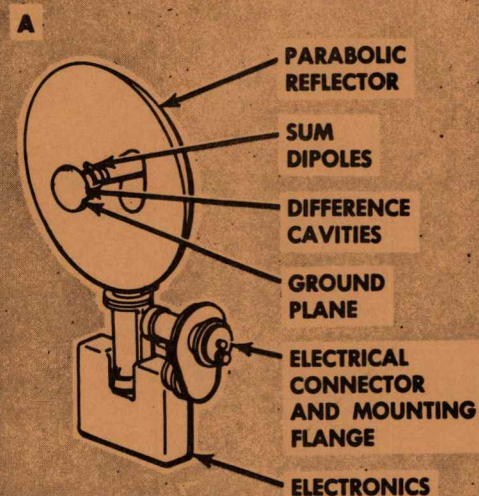
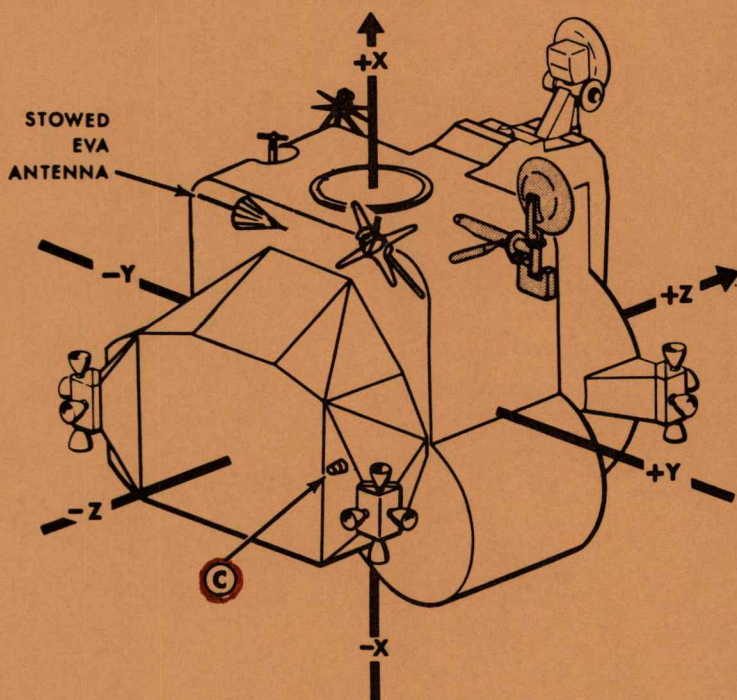
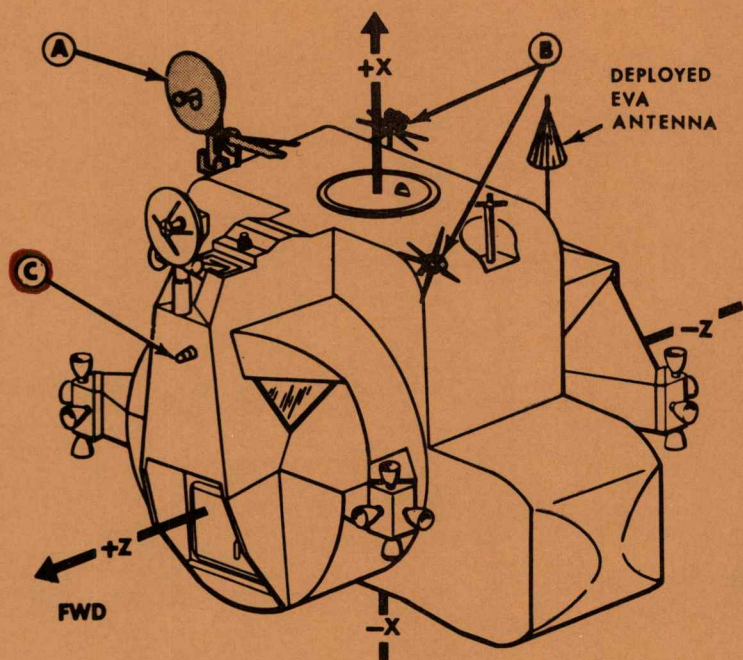
If the S-Band equipment is selected, the audio input to the Audio Center is amplified and routed to the Premodulation Processor for placement on a subcarrier. The Signal Processor output is applied to the S-Band Transceiver, where phase modulation of the carrier is accomplished. The transmitter output is applied to the S-Band Power Amplifier for power amplification, through the S-Band Diplexer to the selected S-Band antenna, which is normally the steerable antenna during inflight conditions. The steerable antenna, whose location is shown in Figure 8, has approximately 20-db of gain. The erectable antenna will be the primary antenna used during lunar stay. It has a gain of approximately 32-db. The two S-Band inflight antennas, whose locations are shown in Figure 8, are used as backup to the steerable antenna. Any received RF is routed through the S-Band Diplexer to the receiver section of the S-Band Transceiver. The detected PRN ranging code is internally applied from receiver to transmitter modulator. The detected voice subcarrier is applied to the Premodulation Processor for voice detection. The detected audio signal is then applied to the Audio Centers for amplification and routing to the selected headset.

Signals from subsystem sensors are applied to the instrumentation subsystem for conversion to a PCM data format. During LM-MSFN LOS, pulse code modulation (PCM) non-return-to-zero (NRZ) data is applied to the Premodulation Processor for placement on a subcarrier and eventual transmission via S-Band. If loss of LM-MSFN LOS, 10-bit-rate split-phase PCM data is transmitted to the CSM via VHF.

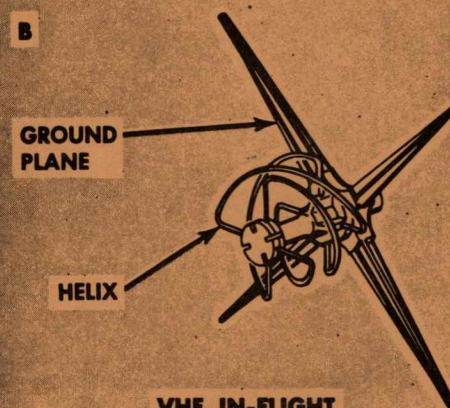
During Lunar Stay Mode, both the VHF EVA antenna and the S-Band erectable antenna will be selected. Video signals from the TV camera are routed directly to a frequency modulator, which is located in the S-Band Transceiver, for transmission to the MSFN via the erectable antenna.

All voice signals are capable of being recorded by the Data Storage Electronics Assembly (DSEA) (voice tape recorder) located in the Instrumentation Subsystem. A definite switching arrangement must be selected to provide this capability.

Digital uplink commands, which are modulated on a 70-kc subcarrier, are applied to the Digital Uplink Assembly for decoding. These commands parallel the inputs available to the LGC via the DSKY and provide for LGC operation in the event of a DSKY malfunction.



S-BAND STEERABLE ANTENNA



VHF IN-FLIGHT ANTENNA



S-BAND IN-FLIGHT ANTENNA

OMNI

LM COMMUNICATIONS ANTENNA CONFIGURATION

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SECTION II

LM COMMUNICATIONS SUBSYSTEM ERA FUNCTIONAL DESCRIPTION

The following paragraphs will describe individual ERA operation of the S-Band Section, VHF Section, and Signal Processor to a functional block diagram level.

A. S-Band Section

1. Introduction

The S-Band section of the LM Communications Subsystem provides the deep-space communications capability. Various types of data are transmitted via the MSFN-LM-MSFN link. This data interchange is depicted in Figure 9. Tabulated below are the carrier frequencies, the types of data transmitted, and the frequency range of each type of data.

MSFN-LM

Carrier Frequency: 2101.8-mc

Data: a. Voice: 300 to 3000 cps (Frequency modulated on a 30-kc subcarrier).

b. PRN Ranging Code: 990.6 kb/s

c. Digital Uplink: 1 kb/s (Frequency modulated on a 70-kc subcarrier)

NOTE: The Voice subcarrier, the Digital Uplink subcarrier, and the PRN Ranging Code phase modulate the up-link carrier.

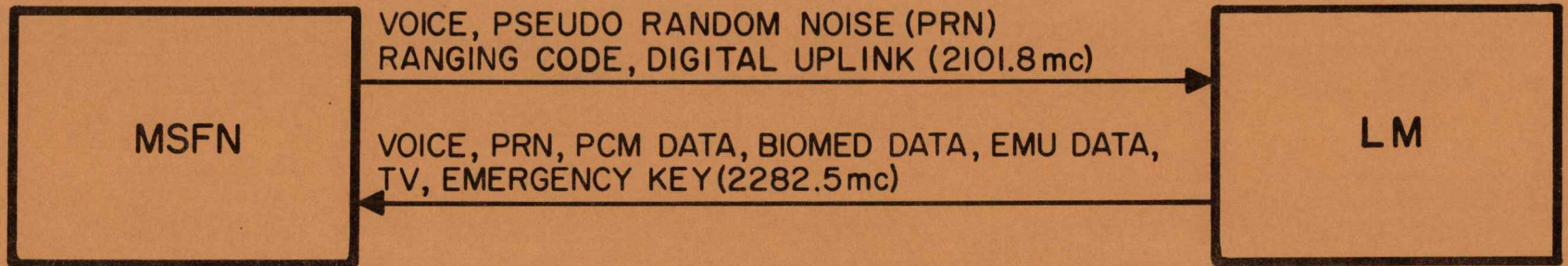
LM-MSFN

Carrier Frequency: 2282.5-mc

Data: a. Voice: 300 to 3000 cps

b. EMU: 4-kc to 12.4-kc (7 types)

DUPLEX



S BAND CAPABILITIES

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MAR 67

c. Biomed: 14.5-kc

NOTE: Voice, EMU, and Biomed data are normally placed on a 1.25-mc sub-carrier. Direct carrier modulation is used for backup operation.

d. TV: 10-cps to 500-kc

e. PRN: Coherent retransmission of uplink code.

f. PCM: Non-Return-to-Zero (NRZ)

1. Hi-bit-rate: 51,200 bits/sec or

2. Lo-bit-rate: 1,600 bits/sec

NOTE: PCM-NRZ data is always placed on a 1.024-mc sub-carrier.

g. Emergency Key: 512-kc

Application of the listed LM-MSFN data to cause frequency or phase modulation of the down-link carrier is controlled by external switch closures. Discussion of these controls is in subsequent paragraphs.

The S-Band Section is comprised of the following:

ERA 1: S-Band Transceiver

ERA 2: S-Band Power Amplifier and S-Band Diplexer

S-Band Antenna Select Switch

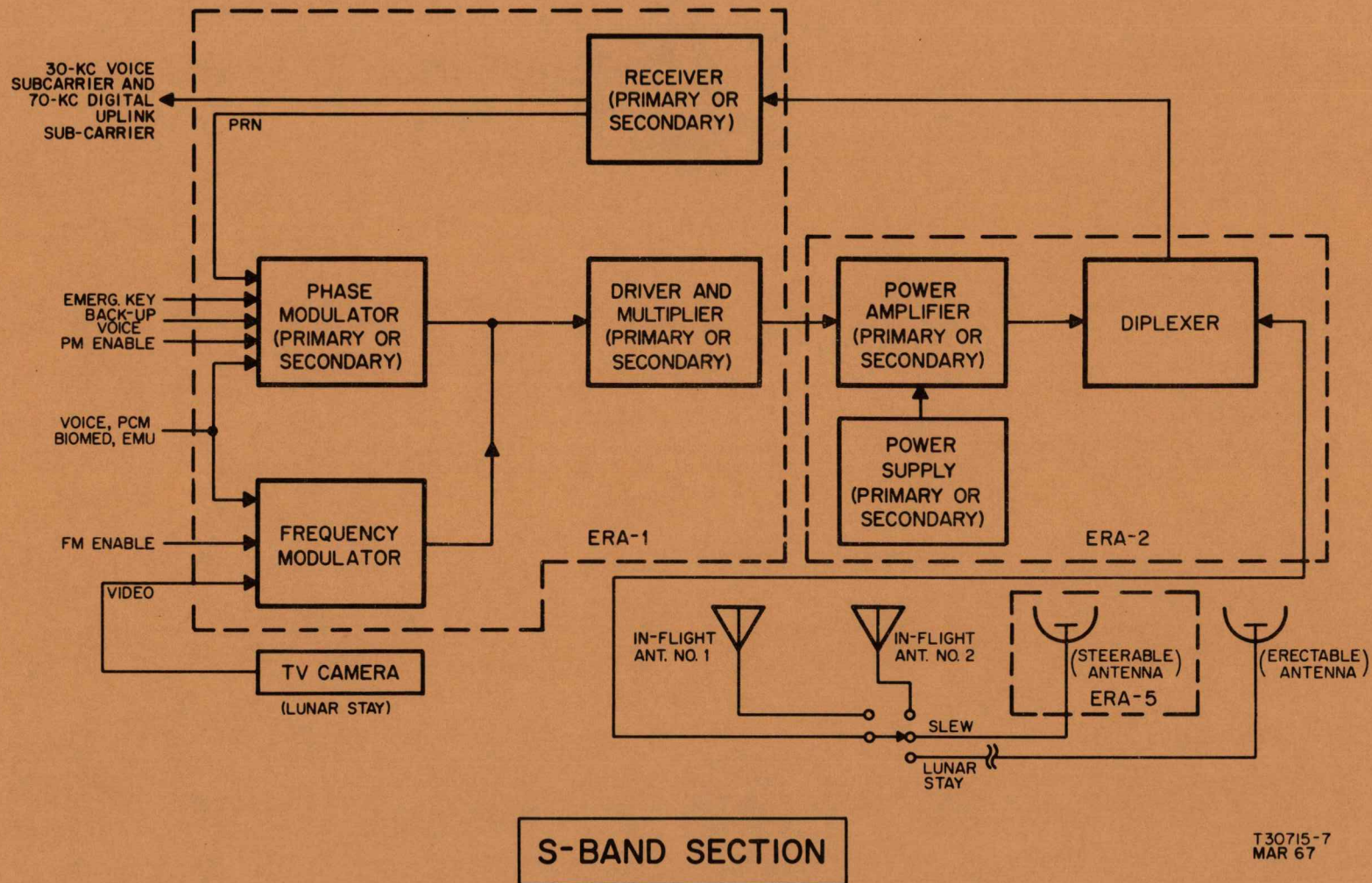
Inflight Omni Antennas (2)

ERA 5: S-Band Steerable Antenna

S-Band Erectable Antenna

TV Camera

Digital Uplink Assembly



Signal flow is depicted in the functional block diagram of major S-Band Section Assemblies shown in Figure 10. It should be referred to while proceeding through the following descriptonal paragraphs.

2. ERA-1 S-Band Transceiver

The S-Band Transceiver Functional Block Diagram is depicted in Figure 11. It can be seen that the transceiver consists of:

- Two phase-locked receivers (PRIM & SEC)
- Two phase modulators (PRIM & SEC)
- A frequency modulator
- Hybrid coupler
- Two driver and multipliers (PRIM & SEC)
- A combiner
- Two power supplies (PRIM & SEC)

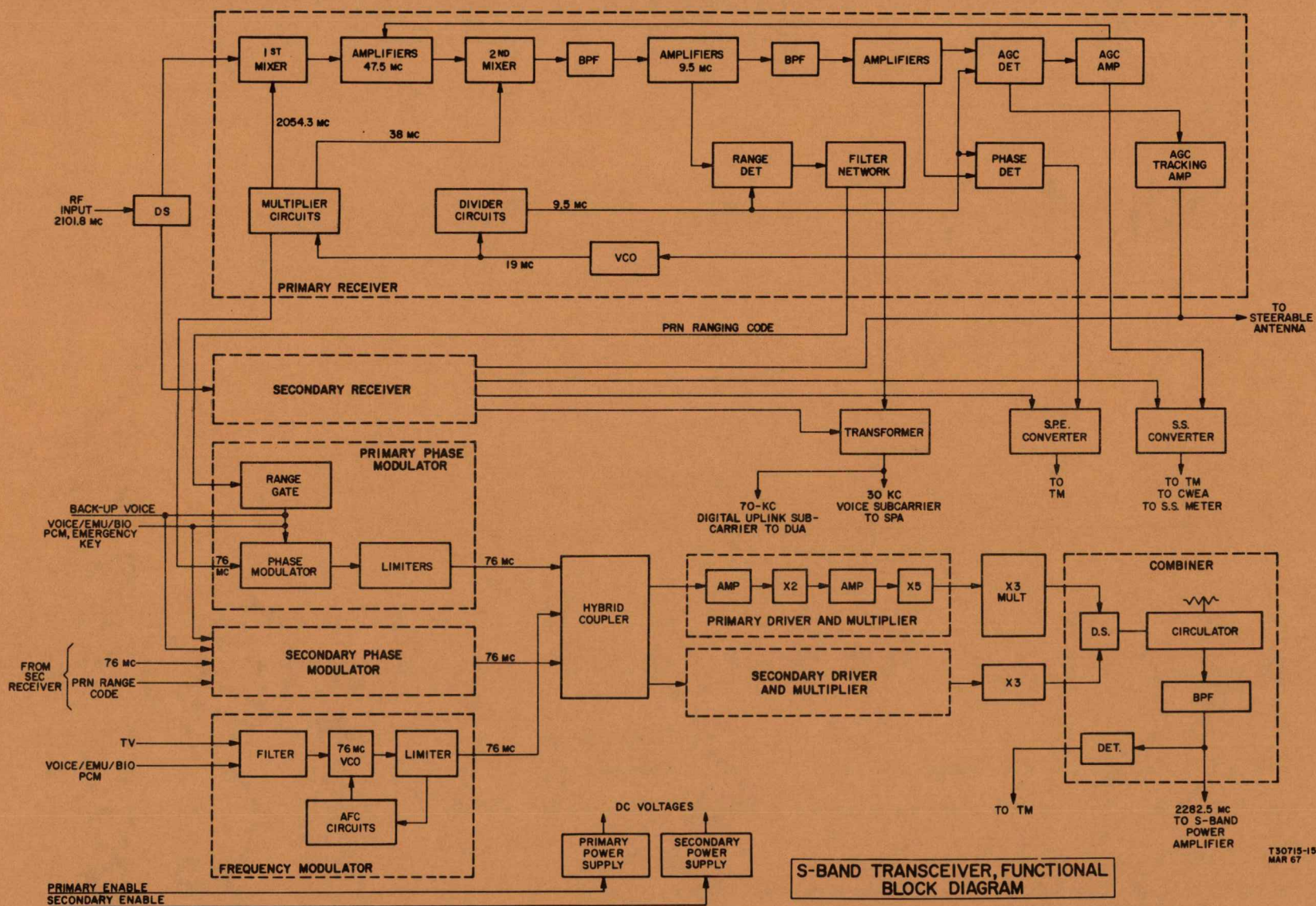
The received uplink carrier, which is phase-modulated by the PRN ranging code, the 30-kc voice subcarrier, and the 70-kc digital uplink subcarrier, is applied to a diode switch (DS). Passage through the diode switch to either receiver is controlled by the position of the XMTR/RCVR PRIM-OFF-SEC switch. Because primary and secondary receiver functional operation is the same, the following description will be limited to the primary action.

The output of the 19.02083-mc voltage controlled oscillator (VCO) is chain multiplied to 2054.3-mc and is injected into the first mixer. (For sake of simplicity, the .02083-mc is dropped, leaving a basic 19-mc VCO (fo) output.) The mixing action results in an intermediate frequency of 47.5-mc (1st IF). After sufficient amplification, the 47.5-mc is injected into a second mixer stage along with a 38-mc signal, thus producing a 2nd IF of 9.5-mc.

The 2nd mixer output is applied through a BPF to a 9.5-mc amplifier chain. One output, which is known as the wide-band output, is applied to the range detector along with a 9.5-mc reference signal derived from the VCO. The mixing action results in a range detector output consisting of the PRN ranging code, the 30-kc voice subcarrier, and the 70-kc digital uplink subcarrier. The common output is applied to a filter network that passes the 30-kc voice subcarrier and the 70-kc digital uplink subcarrier to a transformer and the PRN ranging code to the range gate in the primary phase modulator. The 30-kc voice subcarrier is applied to the Signal Processor Assembly for demodulation and signal routing, and the 70-kc digital uplink subcarrier is applied to the digital uplink assembly for decoding and signal routing.

The second output of the 9.5-mc amplifier is applied through a 10-kc BPF to an amplifier chain. One of the narrowband outputs is applied to an AGC Detector where it is referenced to a 9.5-mc reference signal derived from the VCO. The DC voltage output is amplified and applied to the 47.5-mc amplifiers, the AGC Tracking Amplifier, and the Signal Strength (S.S.) Converter. The AGC Tracking Amplifier output is applied to the S-Band Steerable Antenna and is used by the servo system for the automatic tracking function. The S.S. Converter output is applied to the telemetry equipment (TM), to the Caution and Warning Electronics Assembly (CWEA) to provide a visual indication of loss of S-Band signal, and to the control panel S.S. meter to provide a visual indication of received signal strength.

The second narrowband output is applied to the Phase Detector. The detector compares the phase of the received signal at the 2nd IF frequency (9.5-mc) and a 9.5-mc signal derived from the VCO. If a phase difference exists, the DC output voltage is used to vary the capacitance of the VCO tank circuit, thereby changing the oscillator frequency to correspond to the received frequency. This condition provides a receiver phase-locked loop. The phase-locked condition is required for proper receiver operation and to provide the desired coherency between the received and transmitted frequency. (Ft=240Fr/221)



Phase-locked loop operation (as used in MSFN-LM Communications link), provides range and range rate data to MSFN as well as allowing the receivers to be designed with a narrow bandpass to reject unwanted signals (noise) while passing all useful signals.

The PRN ranging code, which is transmitted by MSFN, received and coherently retransmitted by LM S-Band equipment, is used by MSFN to determine the range of LM. Present tracking and ranging techniques call for an initial range fix determination through use of PRN ranging techniques.

After the initial fix, carrier doppler shift measurement will suffice for continued ranging.

The Phase Detector DC output is also applied to the Static Phase Error (SPE) Converter for conversion to a signal that is compatible with the TM equipment. This signal will indicate to the MSFN the status of the phase-locked loop.

The Phase Modulator utilizes the output of the VCO multiplier chain, which is at four times the VCO frequency, as its operating frequency. The input signals, which will cause phase modulation of the $4 f_o$ signal can consist of:

- (1) PRN Ranging Code, a 1.024-mc PCM-NRZ subcarrier, and a 1.25-mc voice/EMU/Biomed Subcarrier
- (2) A 1.024-mc PCM-NRZ subcarrier and direct voice/EMU/Biomed carrier modulation
- (3) A 1.024-mc PCM-NRZ subcarrier and voice only on carrier
- (4) Emergency Key Only

The phase modulated signal is applied to the Primary Driver and Multiplier stage through a hybrid coupler. The driver and multiplier output is at a frequency of $40 f_o$ and of sufficient strength to drive the X3 multiplier. The $120 f_o$ signal output of the X3 multiplier is routed through a diode switch, which is controlled by the PRIM-OFF-SEC switch, located in the Combiner.

The diode switch output is applied through a circulator*, which provides circuit isolation, to the output BPF. The BPF output is applied to the S-Band Power Amplifier and to a RF detector. The detector output is applied to the TM equipment to provide the MSFN with an indication of S-Band Transmitter power output.

Also provided is a Frequency Modulator whose prime purpose is that of video transmission. For continuance of the voice-data link, it also accepts the 1.024-mc PCM-NRZ subcarrier and the 1.25-mc voice/EMU/Biomed subcarrier. The frequency modulator has a self-contained 76-mc oscillator whose frequency is compared with, and held fixed, relative to a reference oscillator frequency.

The frequency modulated output of the 76-mc VCO is amplitude-limited and applied through the hybrid coupler to both the Primary and Secondary driver and Multiplier chains. Which chain will be used for amplification and multiplication is dependent upon the position of the PRIM-OFF-SEC switch. The frequency modulated signal, now at the transmitted frequency, is applied to the S-Band Power Amplifier through the Combiner.

3. ERA-2 S-Band Power Amplifier and S-Band Diplexer

The S-Band Power Amplifier Functional Block Diagram is depicted in Figure 12. The S-Band Power Amplifier consists of two power amplifiers (QKS 1300 Amplitron tube) and their associated power supplies (primary and secondary), and input and output circulators. The S-Band Diplexer is physically attached to the power amplifier case.

The RF input from the S-Band Transceiver, whose power level ranges from 0.75-watts to 1.5-watts, is applied to the Secondary QKS 1300 Amplitron** tube through the input circulator. The input circulator provides isolation between the Transceiver output circuitry and the Amplitron tube. Any reflected power is absorbed by the 2-watt load connected to port-3 of the circulator.

*Appendix A

**Appendix B

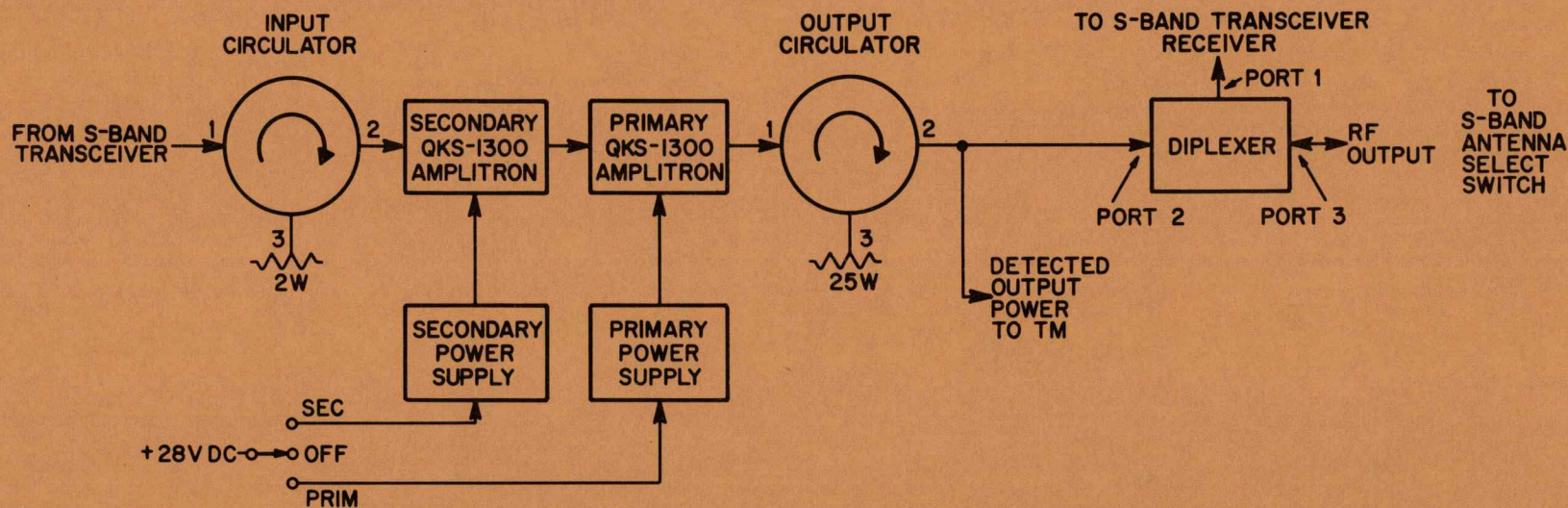
With the PRIM-OFF-SEC switch in the OFF position, the RF passes through the secondary Amplitron tube, the primary Amplitron tube, the output circulator, and the diplexer to the S-Band Antenna Select switch. The output circulator protects the primary amplitron tube from any reflected power caused by circuit mismatches or a shorted antenna.

The total signal loss in the "feed through" mode is less than 3.2-db. This relatively low signal loss is an important power amplifier characteristic, for it allows redundancy without paralleling RF components. It also allows S-Band transmission if both amplitron tubes fail, or if both power supplies fail.

If power amplification is required, the PRIM-OFF-SEC switch is placed to the PRIM position. This applies +28V DC to the primary power supply and starts an automatic sequence of events within the power supply. A closed-loop current regulated heater circuit produces the heater warm-up power. After a timed warm-up period, the closed-loop current regulated high voltage circuit is enabled, and -1800V DC is applied to the Amplitron tube. The Amplitron tube will now "lock" onto the input RF signal and produce an S-Band Power Amplifier output of approximately 18.6-watts. In the event of failure of the Amplitron to "lock" onto the input RF signal, the power supply will automatically revert to the warm-up mode and the cycle is again repeated.

If a failure exists in either the primary Amplitron tube or primary power supply, the PRIM-OFF-SEC switch is placed to the SEC position. The RF power output level is approximately 14.8-watts. This decrease in output power is attributed to the primary Amplitron tube insertion loss, which is approximately 0.8-db, and RF cable losses. The power out of the output circulator is also detected and applied to the TM equipment.

The diplexer is a three-port device that allows use of a single antenna for simultaneous transmission and reception of two different frequencies. Circuits tuned to the transmitted and received frequency are connected from a common port, which feeds the antenna, to the diplexer ports that connect to the transmitter and receiver.



ERA-2 S-BAND POWER AMPLIFIER
FUNCTIONAL BLOCK DIAGRAM

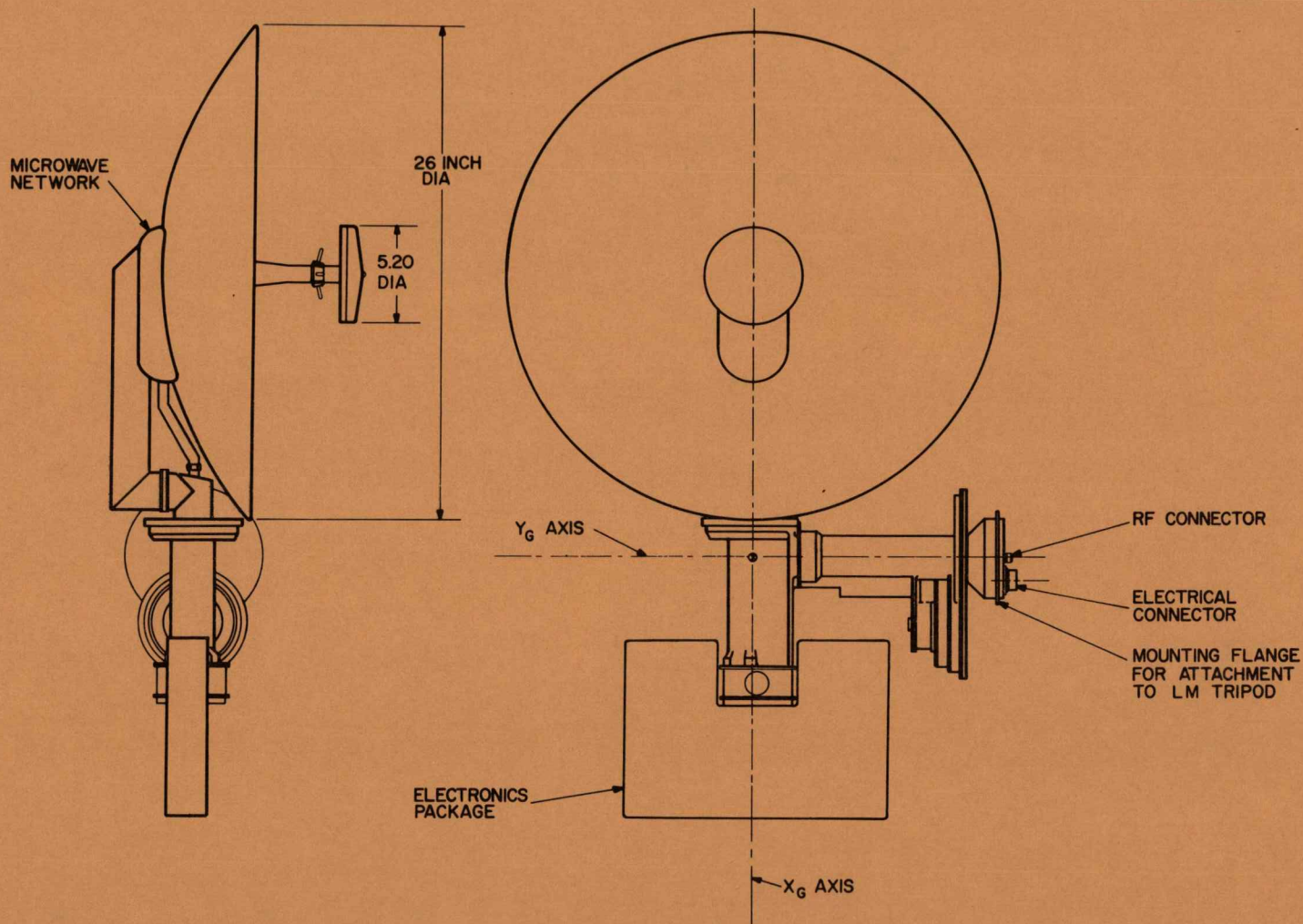
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4. ERA-5 S-Band Steerable Antenna

The Steerable Antenna will be used to increase the signal level of LM S-Band transmissions and receptions. Initial earth acquisition is accomplished by the use of manual inputs. Once within the steerable antenna capture angle, which is $\pm 12^{\circ}$, the TRACK MODE switch is placed to the AUTO position. A sample of the S-Band Transceiver receiver detected AGC voltage is applied to the antenna servo system to complete acquisition and to maintain Steerable Antenna-MSFN LOS during LM vehicle maneuvers.

The Steerable Antenna is a replaceable assembly consisting of a radiation assembly, a microwave network, and an electronics package. The antenna assembly, which is shown in Figure 13, is externally mounted at the end of a tripod approximately 4-feet in length. The reflector is a heat resistant paraboloid 26-inches in diameter, and is illuminated by a crossed-dipole circularly polarized feed at the end of a tapered pylon mounted to the reflector. Rigid coaxial line and rotary joints carry the signal to and from the feed to the RF coaxial connector at the boom interface. Cable wrap-ups at the axes permit transposition of power and control wiring without the utilization of slip-rings.

For the following discussion of a transmitted RF signal, a Steerable Antenna-MSFN LOS condition is assumed to exist. The phase modulated or frequency modulated signal generated in the S-Band Transceiver transmitter, which is depicted in Figure 14, is applied to the S-Band Power Amplifier where desired power amplification occurs. The RF output is fed through the diplexer to the frequency sensitive power divider (FSPD) located in the Steerable Antenna microwave network. The FSPD is so designed that all transmitted power is coupled to the circular polarization (CP) hybrid. The output of the CP hybrid, which provides equal power division, is applied to the crossed dipoles to produce the required circular polarization. The parabolic reflector forms a concentrated beam with a 13.6 beam width at the half-power points.



VIEW LOOKING IN MINUS Y
DIRECTION AS MOUNTED ON LM

VIEW LOOKING IN MINUS Z
DIRECTION AS MOUNTED ON LEM

OUTLINE AND DIMENSIONS
LM S-BAND
STEERABLE ANTENNA ASSEMBLY
ERA-5

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For the following discussion of a received RF signal, a Steerable Antenna-MSFN LOS condition is assumed to exist. Received RF reflected by the parabolic reflector excites the crossed dipoles. The induced RF is fed through the CP hybrid, the FSPD, and the diplexer to the selected S-Band Transceiver receiver for detection of the PRN ranging code, the voice subcarrier, and the digital uplink subcarrier.

The Steerable Antenna automatic tracking function is described in the following paragraphs. As previously mentioned, initial earth acquisition is accomplished by the use of manual inputs. After closing the appropriate circuit breakers and placing the TRACK MODE switch to the SLEW position, the system engineer will position the Yaw and Pitch Manual Slew controls to earth angle references provided by positioning data obtained from the Display and Keyboard (DSKY). These manual inputs will cause the antenna to position within the $\pm 12^\circ$ automatic tracking capture angle.

To complete acquisition and to maintain Steerable Antenna-MSFN LOS, an RF tracker system is used. RF tracking is accomplished by generating a tracking signal from the received RF signal. The tracking signal will indicate the angular displacement of the radiation axis from MSFN LOS and the direction of offset.

The sum feed, the difference feed, the microwave network, and certain circuits within the electronics package are utilized in the generation of the tracking signal. The sum feed output is constantly being applied to the frequency sensitive power divider (FSPD) through the circular polarization (CP) hybrid. Also being applied to the FSPD, on a time shared basis, is the output of the difference feed.

The difference feed is comprised of four tuned cavities located in the ground plane. The cavities are displaced 90° , with two aligned in the Xg axis and two aligned in the Yg axis. The design is such that if a steerable Antenna-MSFN LOS exists, the output of the two pairs of cavities is zero. If an off LOS condition develops in the Xg plane, for example, the RF output of the Xg cavity pair will indicate the direction and amount of offset. The cavity pair output will be passed through the enabled Xg diode switch and applied to the FSPD.

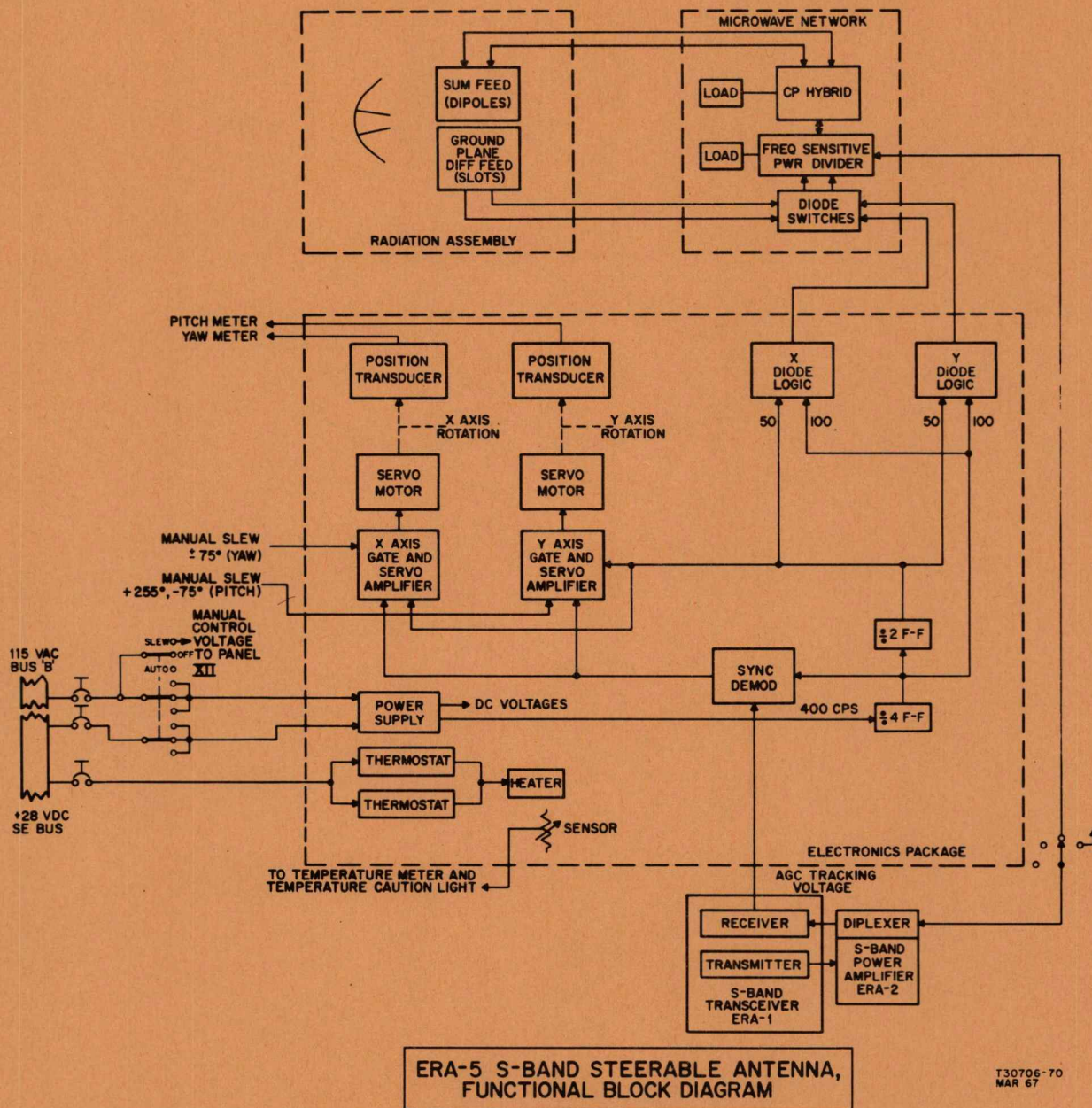
Coupling of the difference RF to the sum portion of the FSPD is accomplished with an attendant 10-db signal loss. Whether the RF will be added to the sum RF or if it will be subtracted from the sum RF is dependent upon the direction of antenna offset.

The resultant tracking signal is routed through the diplexer to the in-use S-Band receiver. The signal is detected and amplified, and routed to the steerable antenna electronics package as an AGC tracking voltage. The applied signal is demodulated and the resulting output is applied to both X and Y axes gates. Passage through the X axis gate is controlled by a synchronous signal that also enabled the Xg diode switch in the microwave network.

The error signal, which is amplified by the X axis servo amplifier, causes the X axes servo motor to turn in a direction to reduce the error signal voltage. The X and Y position transducers sense the angular position of the antenna about the LM X and Y axis, respectively. The transducer outputs are applied to Yaw and Pitch meters that provide a visual indication of antenna position to the astronauts.

The enabling of the diode switches in the microwave network and the X and Y axes gates is controlled by signals derived from the 400-cps input. A divide-by-4 flip-flop circuit and a divide-by-2 flip-flop circuit are used to produce 100-and 50-cps square waves that are applied to the X and Y diode logic circuits. The X diode logic and the X axis gate are enabled simultaneously, as are the Y axis circuits. This arrangement provides separation of the two axes and a minimum of cross-coupling between the two axes.

Because of the external location of the Steerable Antenna, it is subjected to the temperature extremes encountered during inflight and lunar stay phases of the mission. To maintain the temperature of the antenna, a heater and redundant thermostat combination is located in the microwave network, the electronics package, and one each on the X and Y axes spindles. This combination maintains the temperature between $0 \pm 12^{\circ}\text{F}$ and $-40 \pm 12^{\circ}\text{F}$. A temperature sensor located in the electronics package feeds the temperature meter and the temperature caution lite, to give respective indication of Steerable Antenna temperature, and a visual indication of an over or under temperature condition.



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5. LM S-Band Section Signal Flow

Depicted in Figure 15 is a simplified LM S-Band Section Signal Flow Diagram. All signals that interface with the S-Band Section and all switches that control S-Band Section functions are included.

For purposes of simplicity, the signal processing, subcarrier generation, etc., performed by the Signal Processor Assembly (ERA-4) is not shown. Refer to Section II, Paragraph C, for detailed operation.

Also shown are the four signals monitored for telemetry purposes. These are:

- AGC voltage
- Static Phase Error (ST \emptyset ERRO)
- RF Power
- PA Power

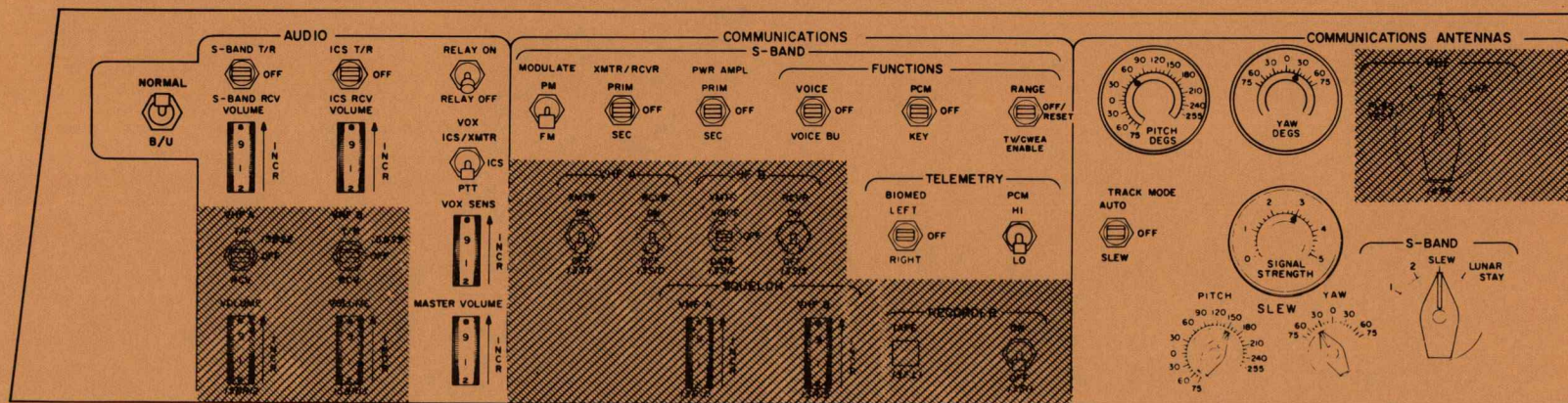
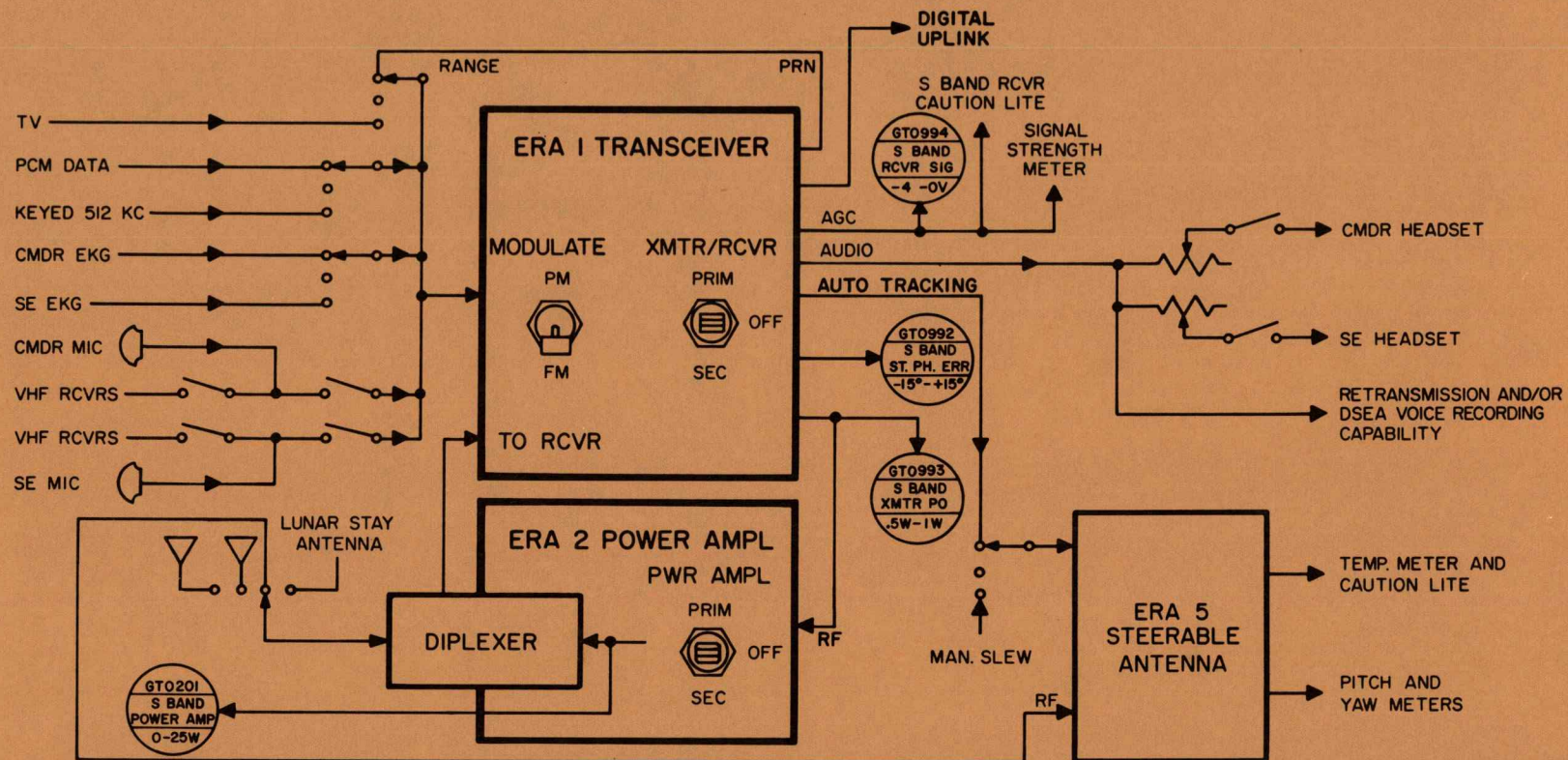
6. S-Band Inflight Antenna (OMNI Backup)

The S-Band section utilizes two inflight antennas as backup to the Steerable Antenna. The inflight antenna is depicted in Figure 16, and the physical location of the two inflight antennas is shown in Figure 8.

The spiral is cut in the cone to produce right-hand circular polarization. The radiation pattern provides a minimum gain of -3db over 85% of the spherical area with respect to a circularly polarized isotropic radiator. This minimum gain and coverage is accomplished by employing manual switching between the two antennas.

7. S-Band Erectable Antenna

The Erectable Antenna Assembly will be used for S-Band communications from the lunar surface to the MSFN after the LM lunar landing. A manually unfolding assembly, it consists of the reflector, feed assembly, aiming device, tripod, and RF connection all designed for operation on the lunar surface. The assembly will be transported from earth in a container in Quad area No. 1 in the descent stage.



LM S-BAND SECTION
SIGNAL FLOW

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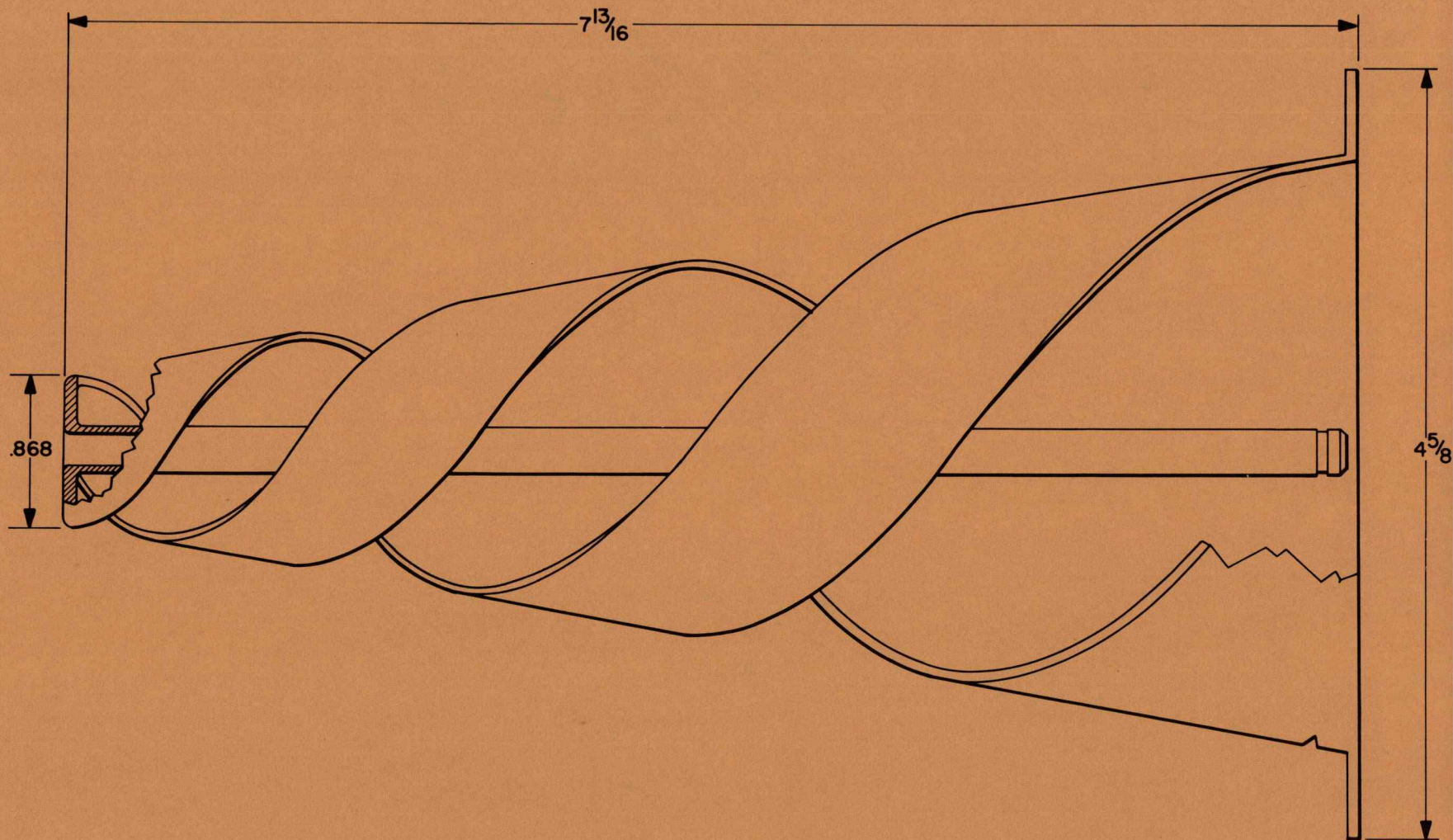


Figure 16

S-BAND IN FLIGHT ANTENNA

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When erected, the antenna is a 10-foot-diameter parabolic reflector, illuminated by a pylon-mounted feed system. The reflector, which is supported on an extendable tripod, is a flexible membrane attached to 21-folding, radial, spring-load parabolic ribs. A spring-loaded deployment release is actuated by the astronaut to unfurl the reflector after he has opened and rough pointed the tripod. The feed pylon is of trombone construction, and the tripod is hinged and collapsible.

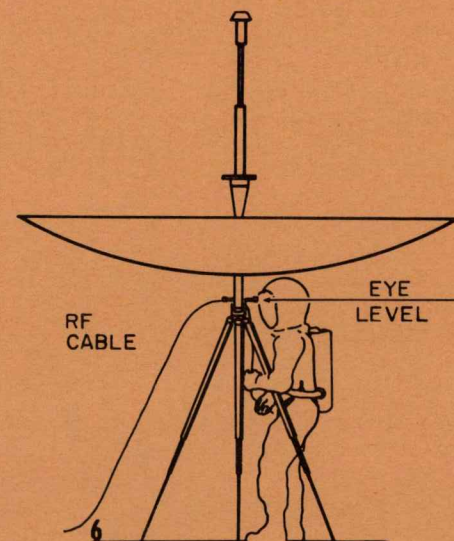
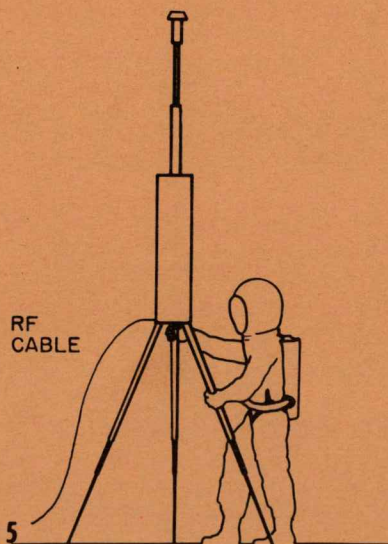
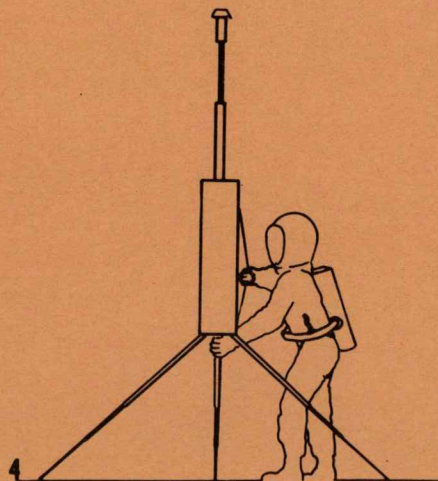
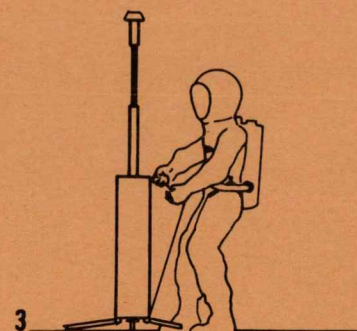
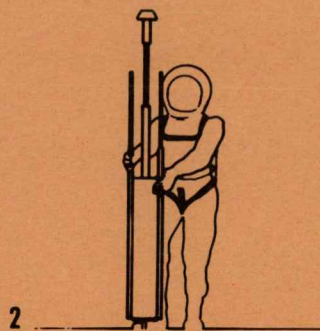
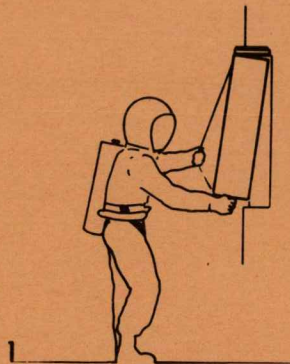
All mechanisms and controls are designed for operation by EVA under lunar environment. The antenna assembly incorporates a sighting device and limited azimuth-elevation adjustments to aid the astronaut in orienting the antenna's line-of-sight to the earth. A RF cable will connect the LM vehicle to the erected antenna. Since the erectable antenna will remain on the lunar surface, no provision has been made for collapsing and restowing the assembly.

The azimuth and elevation drive is designed to be operated with a single crank on the end of a flexible cable. Sliding the crank in shifts from azimuth to elevation drive. An azimuth travel of 360° and an elevation travel of 60° from zenith is provided. The tripod leg design allows placement of the antenna on a maximum lunar slope of 5° .

The Erectable Antenna produces a right-hand circularly polarized pattern, and provides a gain of approximately 32-db at the transmitted and received frequencies.

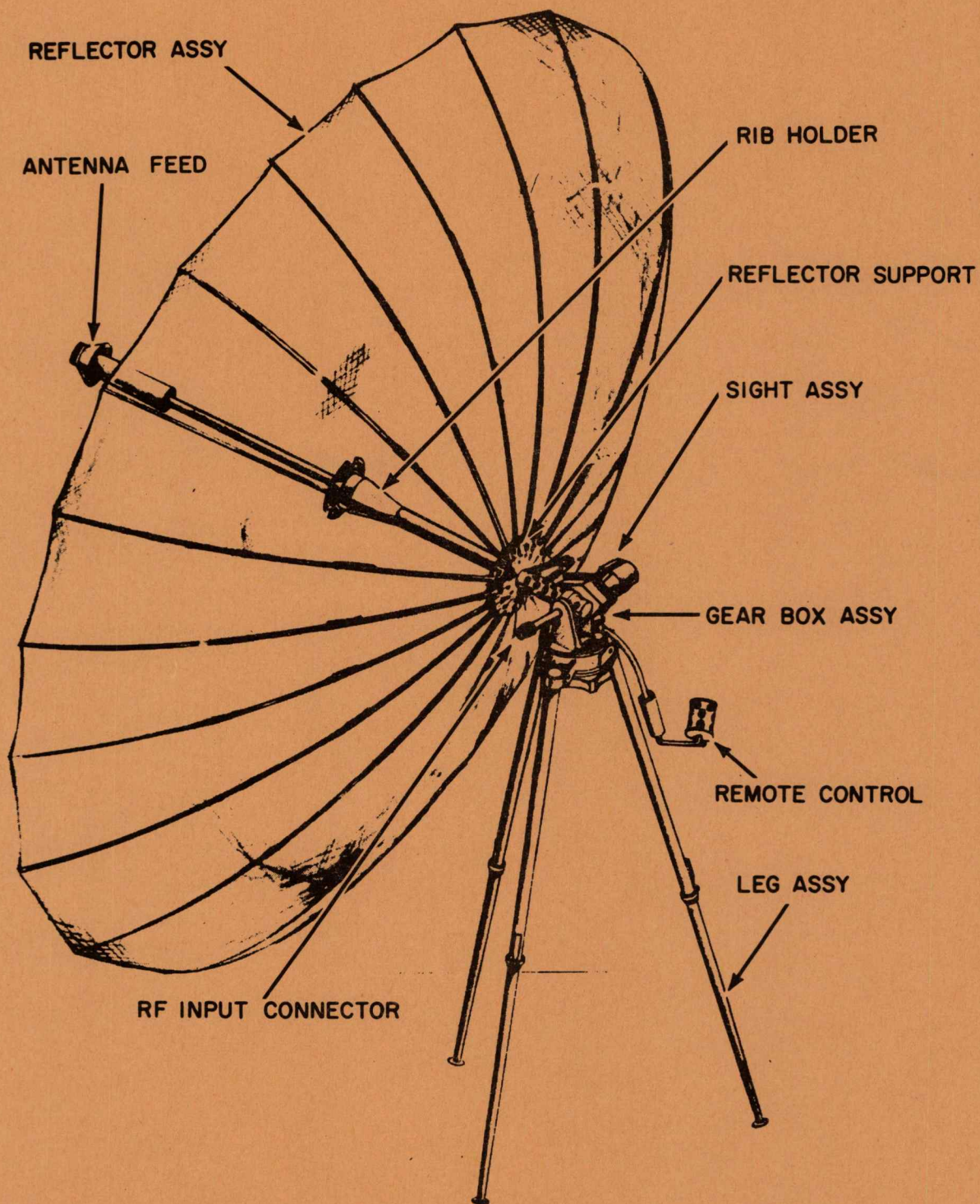
The antenna erection and aiming procedure given below is to be used in conjunction with the erection procedure shown in Figure 17.

- a. The astronaut removes the Erectable Antenna from its stowage place on the LM descent stage.
- b. The astronaut sets the 39-x 10-inch antenna cylinder on the lunar surface, releases the telescoping feed and legs and extends them.
- c. The astronaut lifts the assembly---
- d. ---until the legs position in the first detent position. The RF cable is connected to the coaxial connector.



ERECTABLE ANTENNA-ERECTION SEQUENCE

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ARTIST'S CONCEPT OF ERECTABLE ANTENNA
MODEL 7 AND 12

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- e. The astronaut lifts the assembly to the second detent position.
- f. The release trigger unfurls the package into a 10-foot-diameter parabolic reflector. Utilizing the optical sighting device and the azimuth/elevation drive, the antenna is properly oriented.

Shown in Figure 18 is the fully erected antenna with various antenna parts labeled.

B. VHF Section

1. Introduction

The VHF section of the LM Communications Subsystem provides the LM-CSM and LM-EVA communications capability. The various types of information transmitted via the two links is depicted in Figure 19. Tabulated below are the carrier frequencies, and the type and frequency range of the transmitted information.

NOTE: LM-CSM and LM-EVA transmissions, as shown in Figure 19, are not simultaneous during normal operation.

LM-CSM-LM

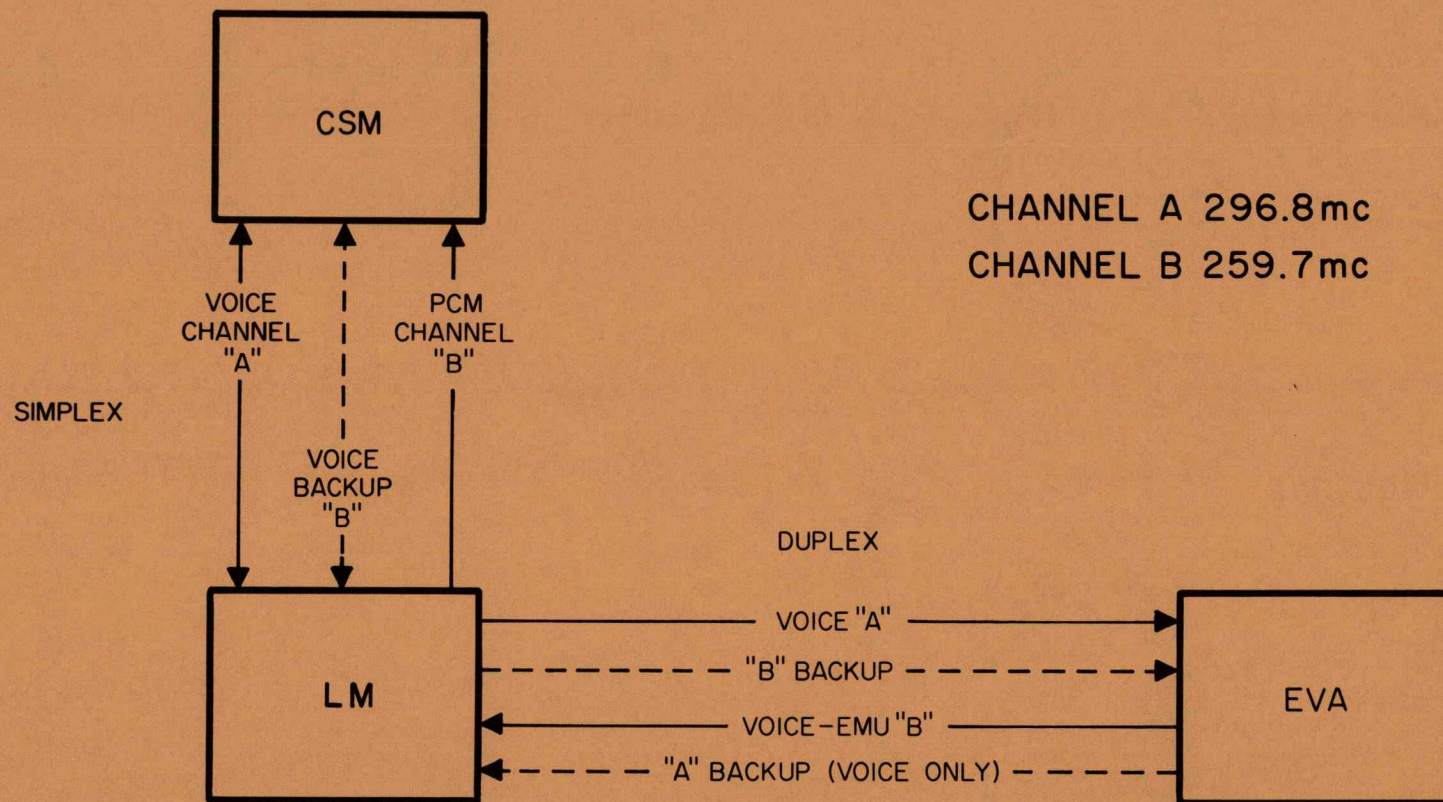
During normal operation, voice transmission will be via VHF Channel "A", Simplex.

VHF Channel "A" - Carrier - 296.8-mc
- Modulation - Voice
300 to 3000 cps

During normal operation, far side, 10-bit-rate PCM data transmission to CSM only, via VHF Channel "B".

VHF Channel "B" - Carrier - 259.7-mc
- Modulation - 10-bit-rate (1600-b/s)
PCM data

VHF Channel "B" will be used as back-up for VHF Channel "A" Simplex Voice transmission.



LM VHF CAPABILITIES

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LM-EVA-LM

During normal operation, voice transmissions to EVA will be via VHF Channel "A" and the voice and EMU data transmission from the EVA will be via VHF Channel "B". This type of operation, i.e., transmit on one frequency and receive on a different frequency, is known as duplex operation.

The EMU data are obtained from seven transducers located at various points on the astronaut, his suit, and the PLSS. The transducer outputs frequency modulate seven-subcarriers ranging in frequency from 4-kc to 12.4-kc. The seven subcarriers in turn amplitude modulate the 259.7-mc carrier. Tabulated below are the frequencies of the seven subcarriers and the information modulated on each of them.

<u>SUBCARRIER</u>	<u>DATA</u>
1. 4-kc	Battery Current*
2. 5.4-kc	Suit Temperature
3. 6.8-kc	Suit Pressure
4. 8.2-kc	Oxygen Quantity
5. 9.6-kc	Suit Water Temperature Rise
6. 11.0-kc	Water Quantity
7. 12.4-kc	EKG

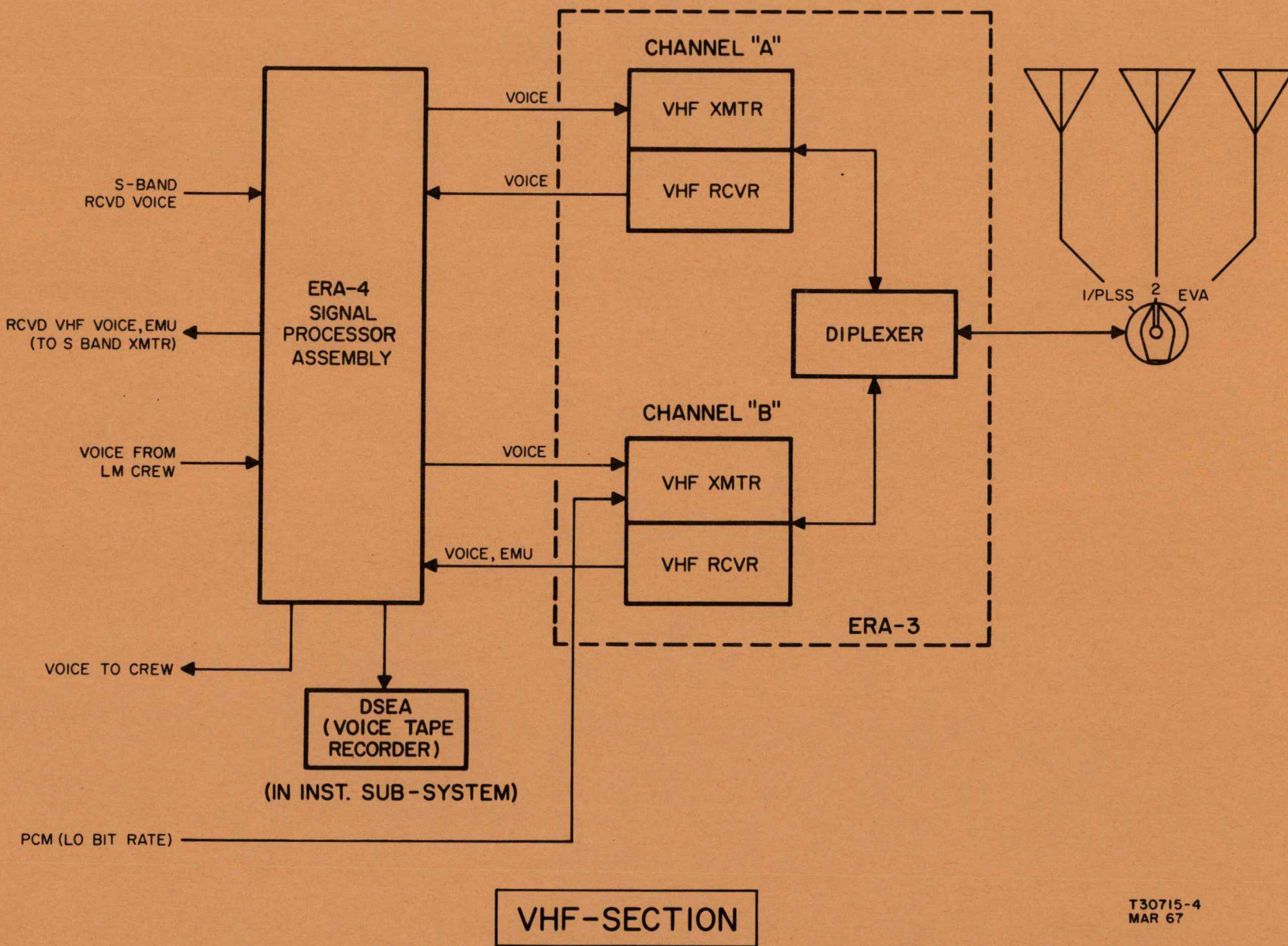
*Battery voltage instead of Battery Current transmitted in position 5 of the PLSS Communications Selector Switch.

For LM-EVA back-up operation, voice transmission to the EVA will be via VHF Channel "B" and voice transmission from the EVA to the LM will be via VHF Channel "A". Because the PLSS VHF Channel "A" is not designed for EMU data transmission, it will be lost during back-up operation.

The Space Suit and Helmet/Portable Life Support System (PLSS) interface is depicted in Figure 50.

The VHF Section is comprised of the following:

- ERA-3: VHF Transmitter-Receiver and VHF Diplexer
- VHF Antenna Select Switch
- Two Inflight Antennas (OMNI)
- One EVA Antenna



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Signal flow is depicted in the functional block diagram of the VHF Section shown in Figure 20. This figure should be referred to while proceeding through the following descriptive paragraphs.

2. ERA-3 VHF Transmitter-Receiver and VHF Diplexer

The VHF Transmitter-Receiver is comprised of two-AM-type transmitters, two-AM receivers, and two-voltage regulators. The VHF Channel "A" Transmitter-Receiver Functional Block Diagram is depicted in Figure 21. The VHF Channel "B" Transmitter-Receiver is identical to the VHF Channel "A" combination with the exception of operating frequency and the modulator circuitry. The frequency differences are given in the following paragraphs, and the VHF Channel "B" modulator is depicted in Figure 22.

The transmitter portion is comprised of the voltage regulator, modulator, and exciter-PA. Placing the VHF "A" XMTR switch to the ON position applies +28V DC to T1 in the voltage regulator. The regulator has two loops that operate independently of each other

The sensing circuit, which is comprised of Q1, CR5, C8, Q2, and Q3, controls the amount of voltage coupled from the primary of T1 to the secondary windings of T1. CR5 and C8 sense the induced secondary voltage and causes the rate circuit to increase or decrease the conduction time of Q1. For a decrease in input voltage, the conduction time of Q1 will increase. Because of the controlled conduction time, a fairly constant voltage will be maintained at the input of the regulator circuit during input voltage variations.

The regulator circuit, which is comprised of CR4, C10 through C13, Q4, Q5, and Q6, will maintain a constant +28V DC output under varying load conditions. The regulated +28V DC is applied to the Modulator and Exciter-PA. The transmitter remains inactive until the application of VOX or PTT key signal to the R/T relay. The key signal, which originates in the Signal Processor Assembly, is the return for the +28V DC applied to the R/T relay.

Upon receipt of a key signal, the R/T relay energizes and connects the LPF output to the diplexer and applies signal return to the Exciter-PA oscillator, Q1-Y1. VHF Channel "A" crystal frequency is 98.933-mc, and that of VHF Channel "B" is 85.566-mc. The enabled oscillator output is amplified by Q2 and Q3, tripled in frequency by varactor diode CR1, and applied to the keyed amplifier, Q4. Thus, the RF applied to Q4 is 296.8-mc and 259.7-mc for VHF Channel "A" and "B" respectively. Passage through Q4 is controlled by the Modulator.

The transmitter is designed to utilize clipped speech type amplitude modulation. In clipped speech, the speech waveforms are reduced to square waves with the feature of retention of high intelligibility. The conversion of the speech waveforms to square waveforms is provided by the modulator circuitry.

The Modulator input is an audio signal limited in frequency and power level by the SPA. The audio range is from 300 cps to 3000 cps and the signal is at a nominal 0-dbm level. The balanced audio input is routed through a pre-emphasis network, which provides high frequency emphasis, to a differential amplifier. The amplifier provides a signal gain of 20db and converts the system from balanced to unbalanced.

Following Q1 and Q2 are a series of limiters and amplifiers. This circuit combination converts the input audio waveforms to square waveforms and causes the keyer, Q9 to be turned on-and-off at the audio input rate. Whenever the keyer is turned on, it saturates and +28V DC is applied to the keyed amplifier, Q4. Whenever Q4 is enabled, RF is gated through and amplified by Q5 and Q6. The push-pull power amplifier, Q7 and Q8, increases the power level to approximately 7.6-watts peakpower. The amplified RF is routed through a LPF, the now closed contacts of the R/T relay, the diplexer, to the selected VHF antenna.

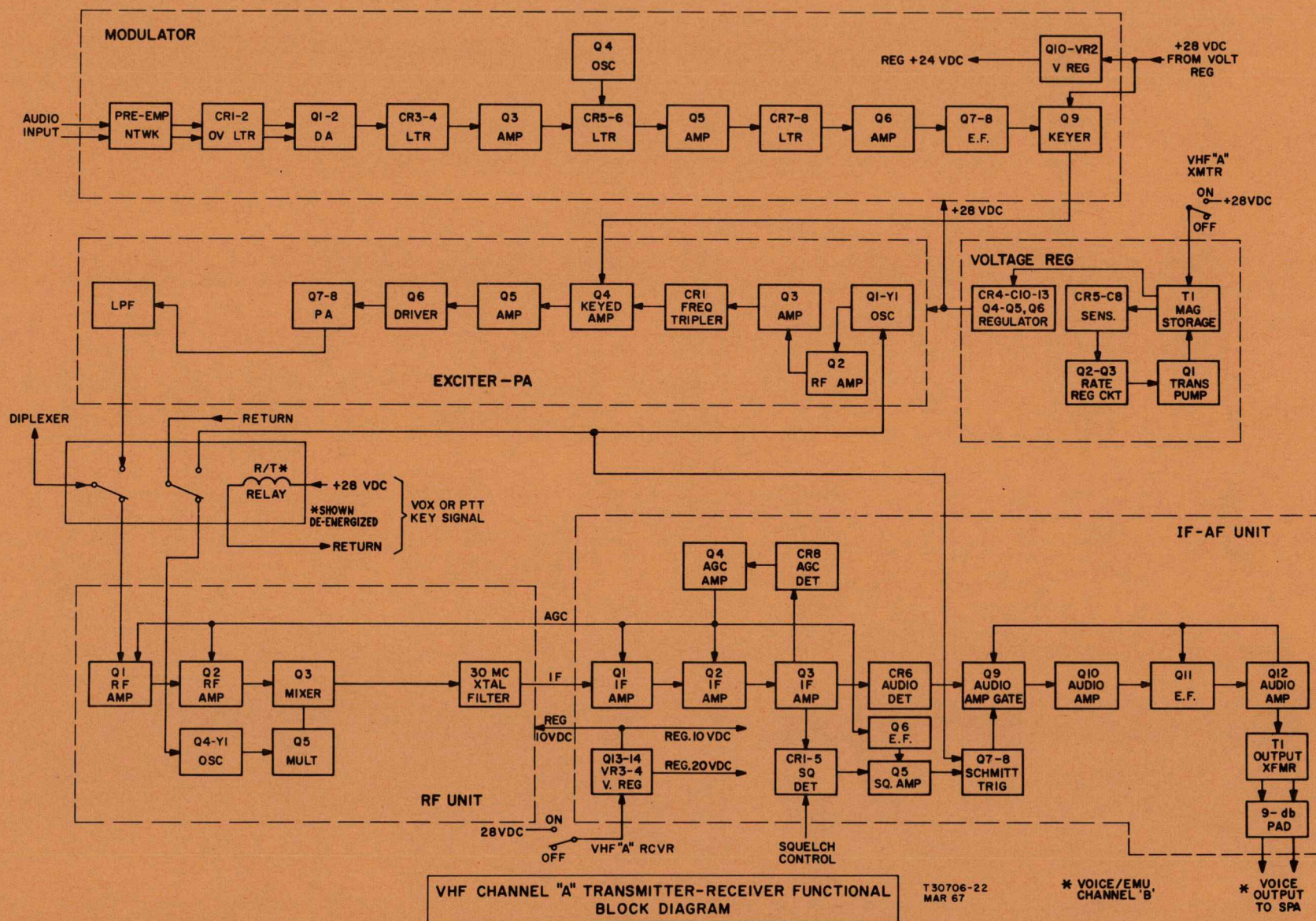
Received RF is routed through the diplexer and the normally closed contacts of the R/T relay to RF amplifier Q1. Following amplification by AGC controlled amplifiers Q1 and Q2, the signal is applied to mixer Q3. Also applied to the mixer is the local oscillator signal frequency.

The oscillator, which consists of Q4 and Y1, is enabled when the R/T relay is de-energized. The frequency of the VHF Channel "A" crystal is 88.933-mc with Q5 circuitry tuned for the third harmonic, and the frequency of VHF Channel "B" crystal is 114.85-mc with Q5 circuitry tuned for the second harmonic.

The mixing action produces a 30-mc intermediate frequency (IF). The signal is applied to the first IF amplifier through a 30-mc crystal filter. The first two IF stages are AGC controlled and overall IF amplifier gain is 70db. The third IF amplifier feeds the AGC detector, the audio detector, and the squelch detector.

The AGC detector output feeds AGC amplifier Q4. The DC output voltage is applied to the above mentioned stages and to emitter following Q6. Q6 operates in conjunction with squelch amplifier Q5 to provide for AGC controlled operation of the Schmitt trigger.

The squelch system used in the VHF receiver is a carrier-operated type. It is the function of the squelch circuit to inhibit receiver signal output from occurring in the range of preset threshold signal levels of 0 to 44-microvolts (-80dbm). The operating point of the squelch detector, which is comprised of CR1 through CR5, is controlled by a voltage developed across the Squelch Control Potentiometer located on the System Engineer's Lower Side Console Panel (PANEL XII).



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Figure 21

Upon receipt of the carrier, the DC voltage output of the squelch detector and AGC voltage will cause Q5 to conduct and trigger the Schmitt trigger. When the Schmitt trigger changes state, the output voltage enables Q9, the Audio Amplifier gate.

The audio signal is amplified by Q9, Q10, and Q12, and applied to a 9db pad through matching transformer T1. The signal level is approximately -3dbm.

The voice output if VHF Channel "A" receiver, or the voice and EMU data if VHF Channel "B" receiver, is hardwired to the SPA for further processing.

The signal return applied to the Schmitt trigger Q7 and Q8, will disable it during periods of VHF transmissions, thereby inhibiting the passage of receiver noise to the SPA.

The VHF Channel "B" Modulator, which is shown in Figure 22, is similar to the VHF Channel "A" Modulator with the exception of the voice and data mute circuit and the data amplifier.

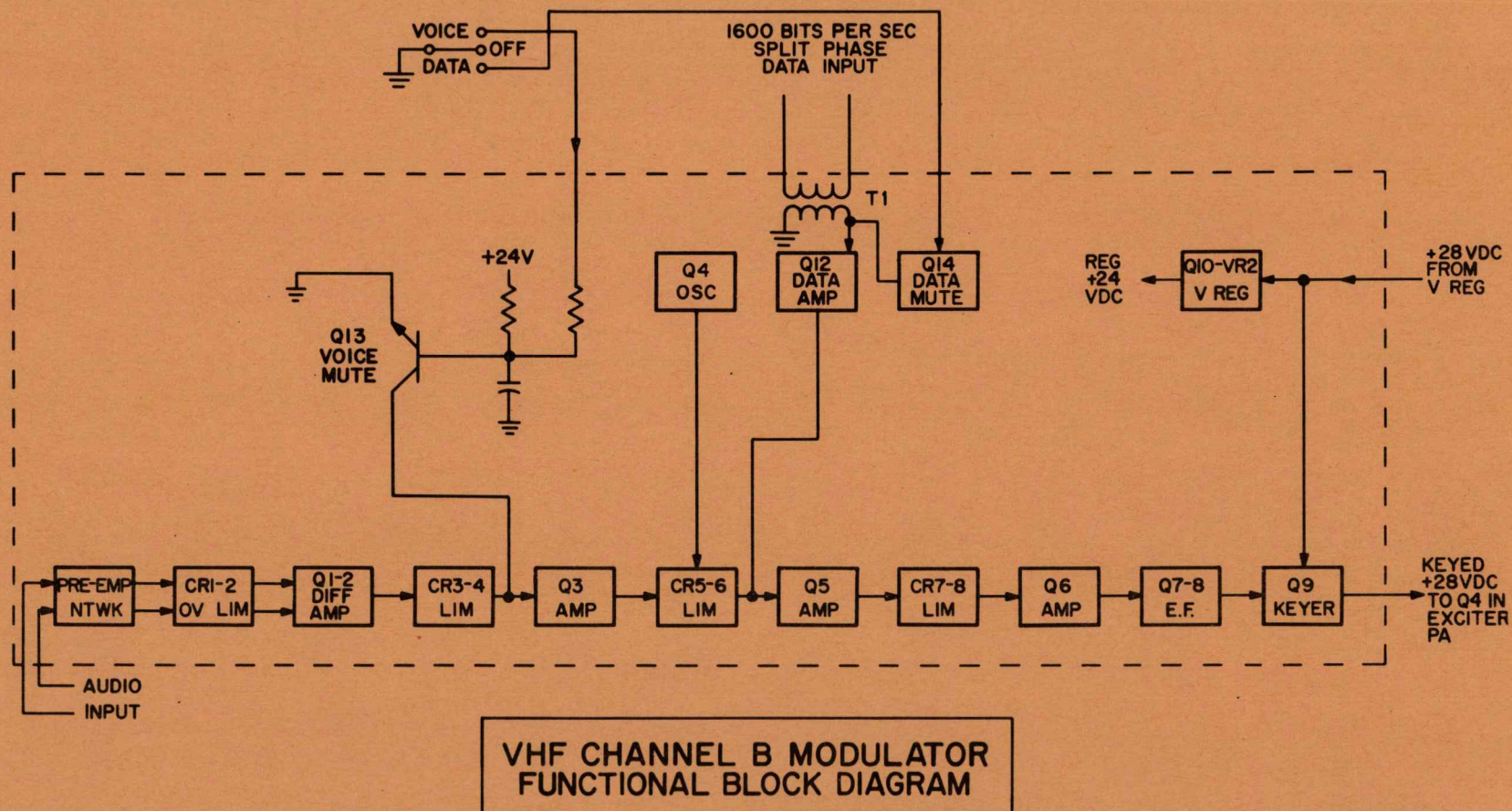
Transmission of either voice or 10-bit-rate split-phase PCM data, is controlled by the VOICE-OFF-DATA switch. Placing the switch to the VOICE position places a ground on the voice mute transistor, Q13. The ground disables Q13 and allows passage of an audio input. At this time, data mute transistor Q14 saturates and places a ground on the secondary of T1, thus inhibiting a data input.

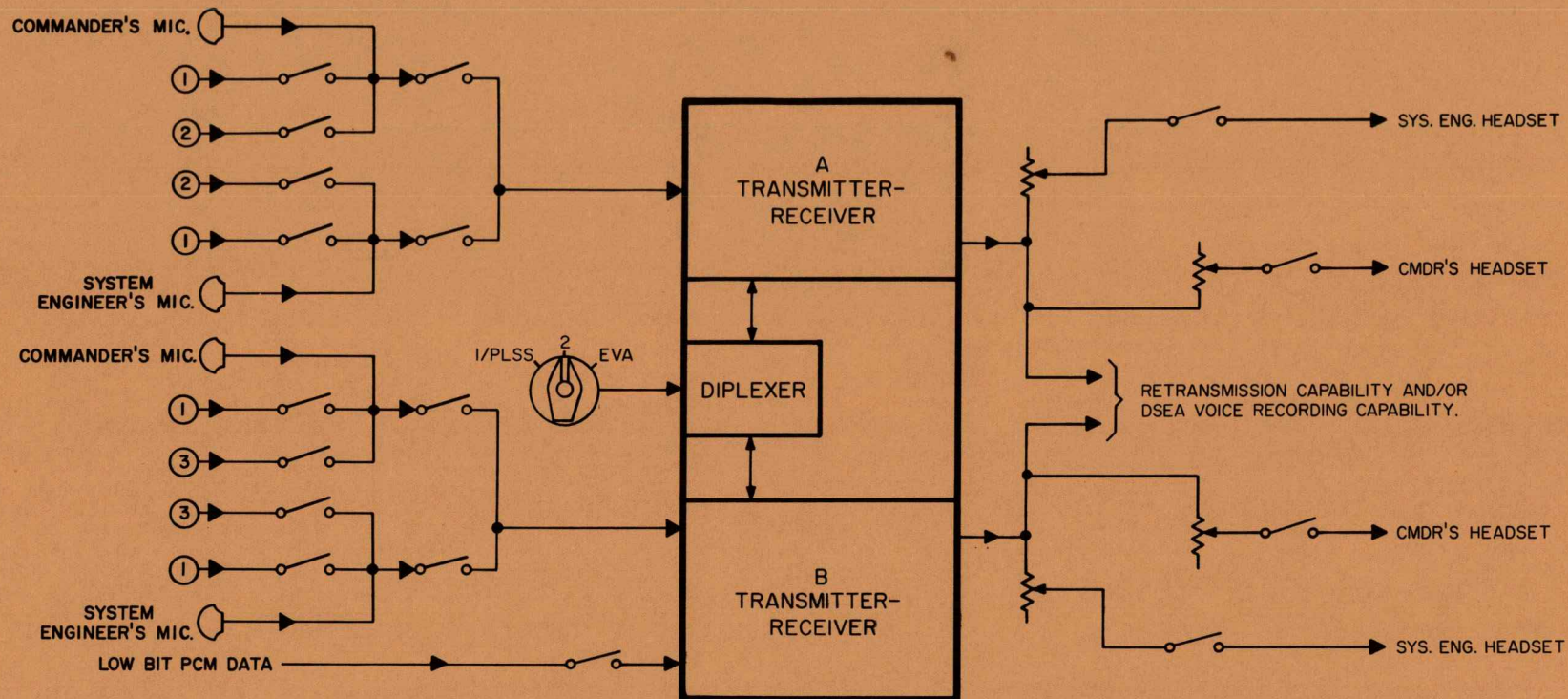
Placing the switch to the DATA position reverses the above operation and permits passage of a data input from the PCMTE*. The split-phase data, which is applied at a rate of 1600-bits-per-second, is coupled across T1 to the data amplifier, Q12. After amplification, the signal is applied to the modulator amplifier-limiter chain to cause keying of the keyed amplifier, Q4, at the data input rate.

3. LM VHF Section Signal Flow

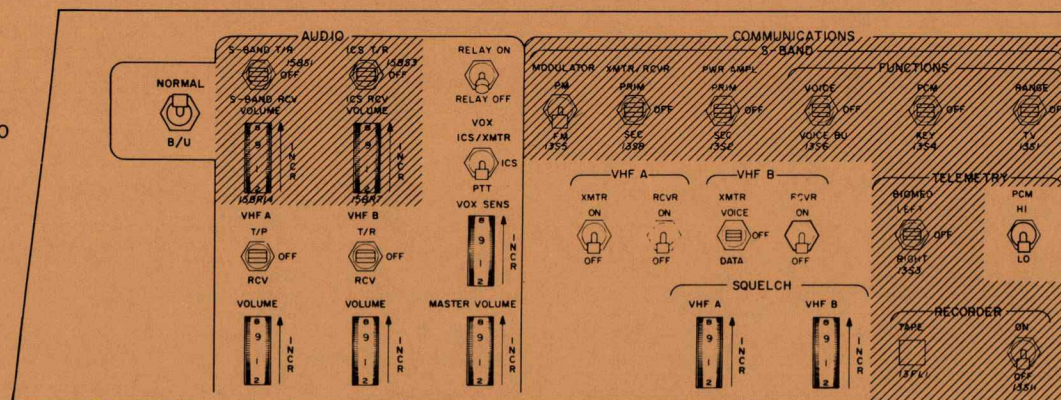
Depicted in Figure 23 is a simplified LM VHF Section Signal Flow diagram. All signals that interface with the VHF Section and all switches that control VHF Section functions are included.

*The DATA position also supplies the required voltage and return for energizing the R/T relay of Channel "B".





- ① S BAND RCVR AUDIO
- ② VHF B RCVR AUDIO
- ③ VHF A RCVR AUDIO



LM VHF SECTION SIGNAL FLOW

4. VHF Inflight Antenna

The VHF section utilizes two inflight antennas for communications with the CSM. The VHF inflight antenna is depicted in Figure 24, and the physical location of the two antennas is shown in Figure 8.

The radiation pattern will provide, as nearly as possible, four steradian coverage with a minimum gain of -6db with respect to the CSM linearly polarized VHF antennas when the antenna assembly is mounted on the LM and terminated in a free phase space environment. The antenna is designed to produce right-hand circular polarization. The minimum gain and coverage requirement is accomplished by employment manual switching between the two antennas.

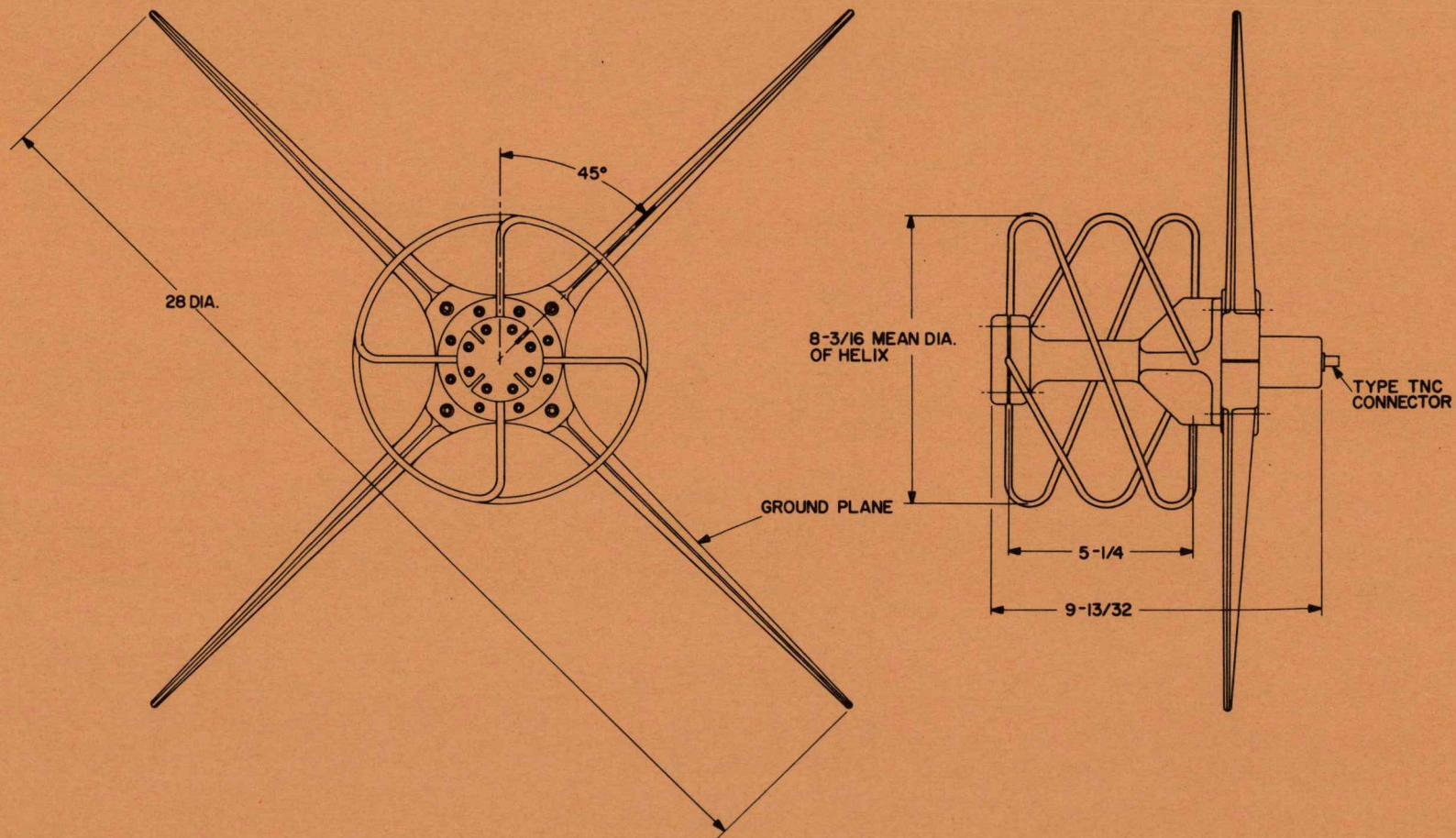
5. EVA Antenna

The EVA antenna is deployed after lunar landing by use of a T-handle located in the cabin. The EVA antenna is depicted in Figure 25.

The EVA antenna is a pencil cone antenna consisting of a monopole 8 inches long, and a modified ground plane of 10-radials, 12 inches long, with an included angle of 40° . The radiation pattern will provide omnidirectional azimuthal coverage with a minimum gain of -3db at the zero degree elevation angle. These gain magnitudes are with respect to a vertically polarized isotropic antenna when the EVA antenna is mounted on the LM in the erected position and terminated in a free space environment. The EVA antenna is linearly polarized in a vertical plane.

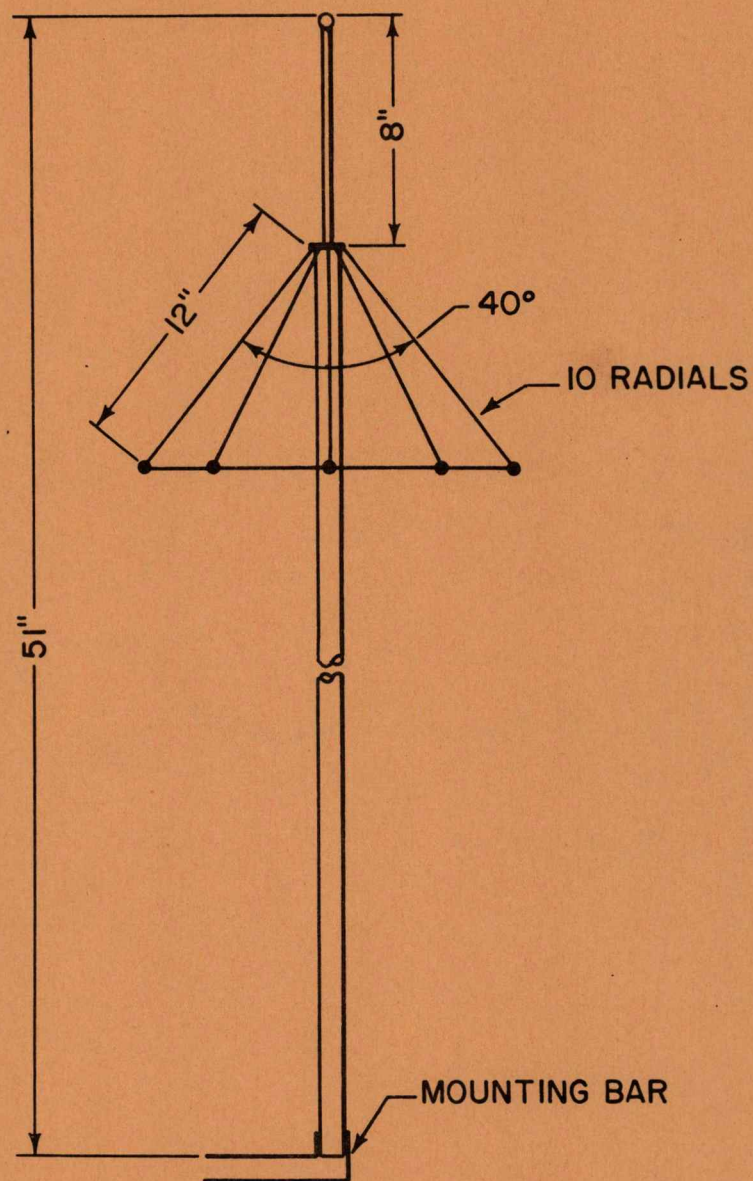
6. VHF-PLSS Test Configuration

The requirement for PLSS operational checkout prior to LM egress is provided by the 1/PLSS position of the VHF RF manual switch located on Panel XII. Connecting the PLSS RF output to the PLSS test input connector, which is depicted in Figure 26, provides hardline connection to the LM VHF Communications Section. Proper positioning of audio panel switches provides direct communication between the MSFN and the crewman using the PLSS.



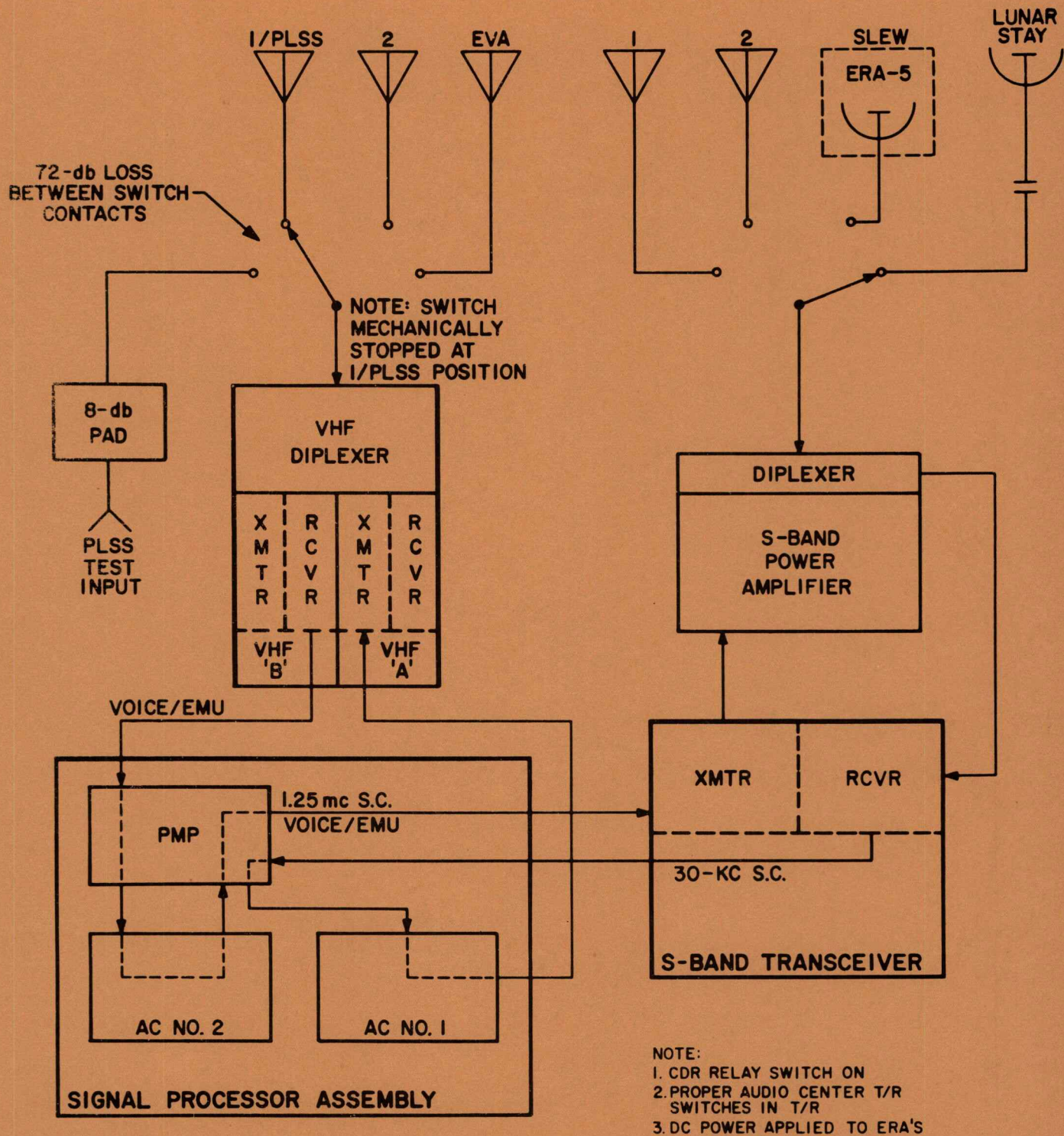
VHF IN-FLIGHT ANTENNA

T30706-74
JULY 66



EVA ANTENNA

T30715-26
JULY 66



PLSS TEST CONFIGURATION

T30715-48
MAR 67

C. Signal Processor Assembly

1. Introduction

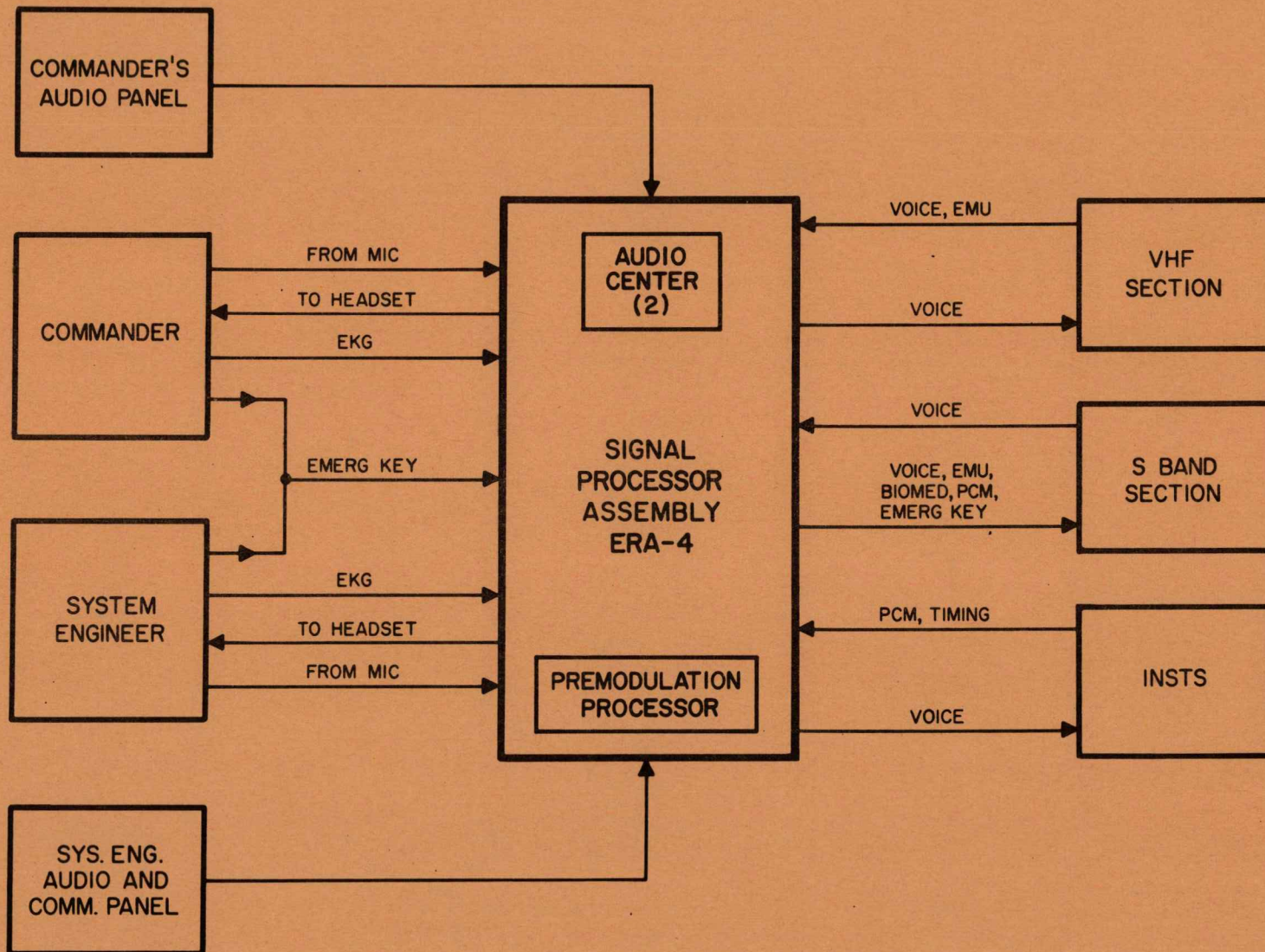
The Signal Processor Assembly (SPA) is the common acquisition and distribution point for various Communications Subsystem received and transmitted data. The SPA functions as a premodulation processor and an audio center in processing these signals. Tabulated below are the capabilities provided by the SPA:

- a. Isolation, switching, and amplification of microphone and received audio inputs.
- b. Processing of PCM-NRZ data from the Instrumentation Subsystem.
- c. Processing, switching, and mixing of voice, biomedical data, and EMU data so that the correct intelligence corresponding to a given mode of operation is transmitted.
- d. Utilization of the LM Communications Subsystem as a relay station for communications between the EVA, the MSFN, and the CSM.
- e. Modulation and demodulation.
- f. Emergency code keying.

The premodulation processing circuitry contains the necessary filters, subcarrier oscillators, mixing networks, amplifiers, and electronic switches to provide for data processing, and the audio center circuitry contains the necessary amplifiers, isolating networks, and electronic switches to provide for voice signal processing and transmitter keying.

The SPA Interface is depicted in Figure 27. Microphone inputs from the commander are routed to the commander's audio center. Selection of transmission via VHF or S-Band, storage on the voice tape recorder, or conversing with the system engineer is made with switches located on the commander's audio panel. These switches also control the application of received voice or internal communications system voice to the commander's headset.

The system engineer has an identical panel to control voice transmissions and voice routing to the headset. In addition, the system engineer has a Communications Panel whose switches control the selection of either the commanders or systems engineers EKG, the transmission of an emergency key signal, the type of S-Band modulation to be used, and the various modes of operation.



SIGNAL PROCESSOR ASSEMBLY INTERFACE

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SEPT. 66

The Instrumentation Subsystem accepts voice for storage on the voice tape recorder (DSEA). The PCM-NRZ data and timing signals are applied to the premodulation processor circuitry.

The S-Band Section accepts PCM-NRZ data, which is on a 1.024-mc subcarrier, voice/EMU/Biomed data, which is normally on a 1.25-mc subcarrier, and the emergency key signal, if selected. Voice transmissions from the MSFN are applied to the premodulation processor for demodulation and routing to audio centers.

The VHF Section accepts voice signals from the audio centers and applies received VHF voice signals to the audio centers. EMU data is applied to the premodulation processor for processing prior to routing to the S-Band section for transmission to the MSFN.

2. Audio Centers

Before proceeding with the description of the audio centers and premodulation processor (page 61), an explanation of the switching arrangement shown is necessary. The switch contacts shown and the associated switch names, indicate the control panel switch position necessary to energize the circuit and produce an output. It is not to be misconstrued that the signal passes through the switch contacts.

As previously mentioned, there are two identical audio centers, one each for the commander and system engineer. The audio centers are depicted in Figure 28. Due to the similarity in operation, the following paragraphs will only describe the operation of the commander's audio center.

Voice signals from the commander's microphone are amplified and applied to the voice-operated transmitter (VOX) circuitry. The VOX circuitry enables the output of the amplifier and permits passage of the amplified voice signal to the four T/R switches. If for example the VHF "A" T/R switch is in the T/R position, the VOX trigger circuit will energize the VHF Channel "A" R/T relay, and the voice signal will be passed to the VHF Channel "A" modulator.

Transmission via VHF or S-Band and ICS operation can also be accomplished by utilizing the appropriate T/R switch and either of the commander's push-to-talk (PTT) switches.

Voice for transmission via VHF is routed directly to the VHF modulator, while voice for S-Band transmission is routed to the PMP for placement on a subcarrier prior to transmission. In case of subcarrier circuitry failure, control panel switches are so arranged as to permit the voice signal, which is labeled Back-up voice, to be applied to back-up circuitry within the PMP, thus allowing for continued S-Band voice transmissions.

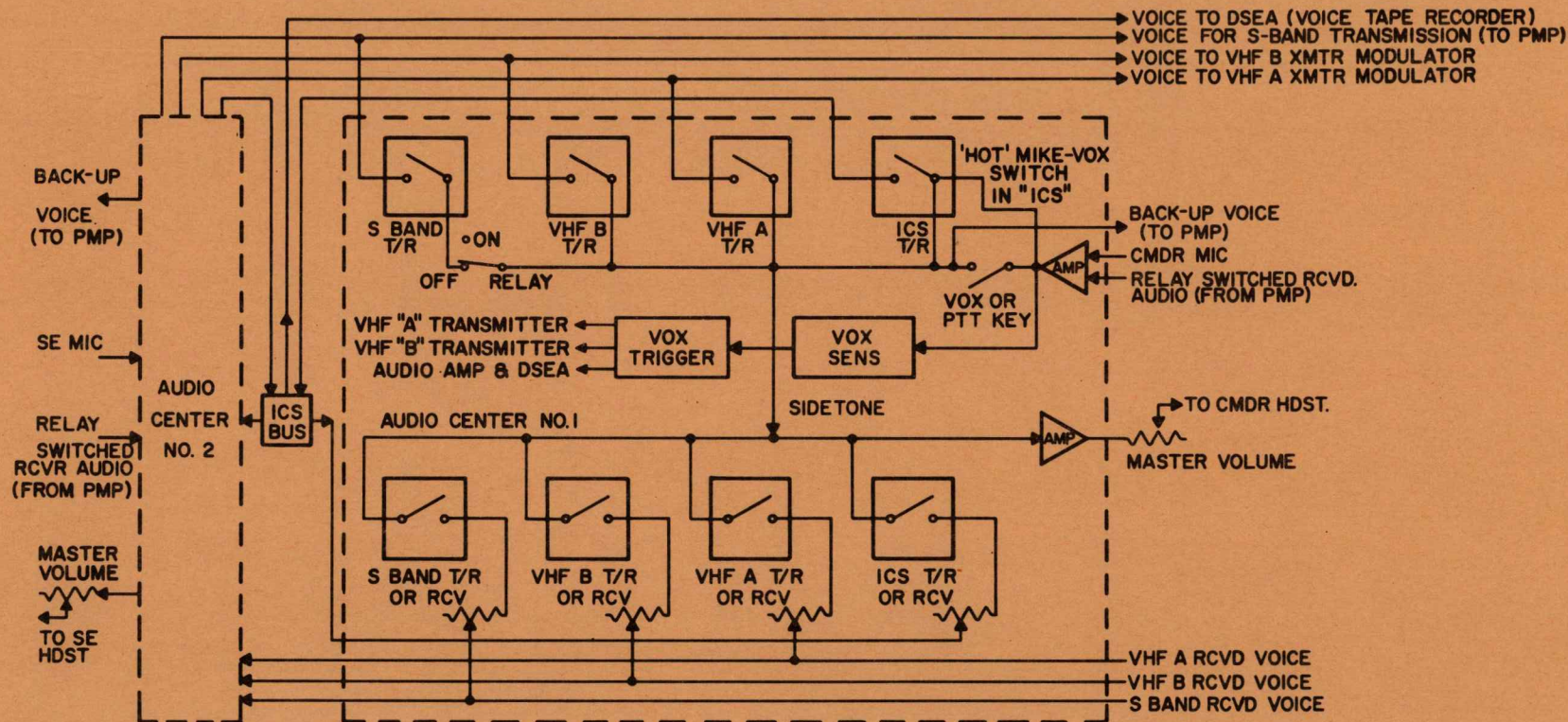
Internal Communications System (ICS) operation is provided when both crewmen place their ICS T/R switch to the T/R position and both VOX switches to the ICS position. The ICS position of the VOX switch provides a "hot mike" capability, i.e., constant keying of the audio amplifier and the DSEA, since both key signals originate in the same circuit. Because of the constant key of the DSEA, the position of the Tape Recorder switch must be monitored to conserve tape.

With "hot mike" operation, a voice input will immediately be present on the ICS bus. One output of the ICS bus feeds the DSEA, and if the tape recorder power switch is on, the voice signal will be recorded. The other output of the ICS bus feeds the audio center headset circuitry for application to the crewman's headset.

In the event of an audio center failure, the affected crewman will place his AUDIO CONTROL switch to the "BU" position. This permits the crewman to utilize the remaining operative audio center. The audio center switching and circuits controlled by the AUDIO CONTROL switch are depicted in Figure 29.

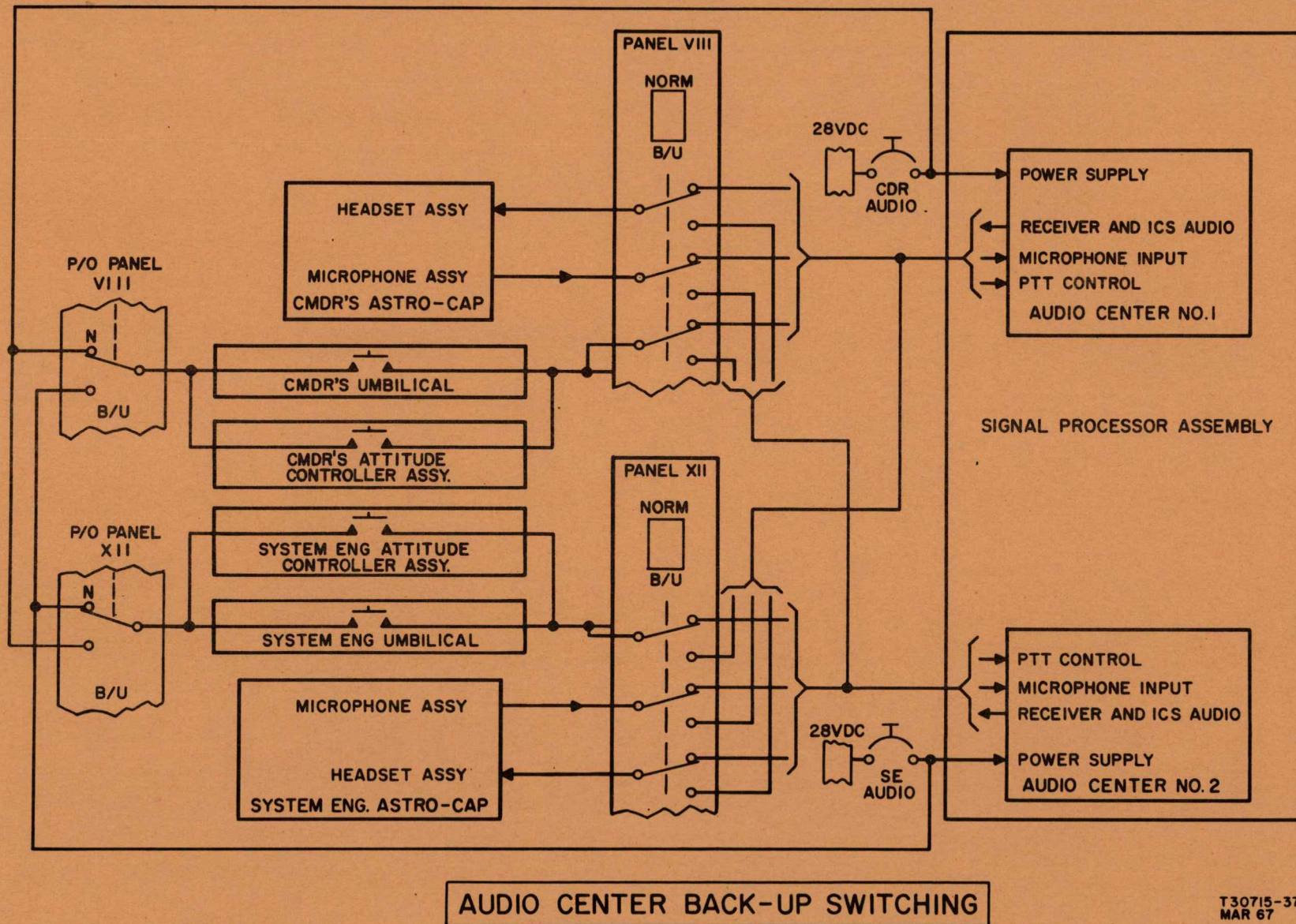
Received audio, either VHF or S-Band, can be retransmitted. Audio switching is performed in the PMP when either RELAY switch is in the ON position. The relay switched audio is applied to the microphone amplifier in the "switched to" audio center. By utilizing VOX operation and closing the appropriate T/R switch, the audio signal will be transmitted via the selected transmitter.

When a RELAY switch is ON, audio transmissions via S-Band are prevented from being made from the audio center associated with that RELAY switch. This disabling function is depicted in Figure 28.



AUDIO CENTERS (SIGNAL PROCESSOR)

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AUDIO CENTER BACK-UP SWITCHING

T30715-37
MAR 67

3. Premodulation Processor (PMP)

A functional signal flow schematic of PMP is shown in Figure 30.

The data AM limiter receives PCM-NRZ data from the PCMTE at a rate of 51.2-kilobits per second or 1.6-kilobits per second. After processing, the data are fed to the biphasic modulator where it shifts the phase of the 1.024-mc sine wave, which is derived from the 512kc reference input, by $180^\circ \pm 10^\circ$. This phase shift occurs for each logic level change of the PCM-NRZ data input. The PCM circuits are enabled by placing the PCM-OFF-KEY switch to the PCM position. The phase shifted signal is applied through an amplifier and filter circuit to an attenuator circuit controlled by the S-Band Power Amplifier PRIM-OFF-SEC switch. Because both PRIM and SEC contacts of this switch deck are connected, the switch function has been reduced to ON and OFF.

The 1.024-mc PCM-NRZ subcarrier is applied directly to the FM mixer, and through an attenuator to the PM mixer. Passage to either the S-Band transmitter frequency or phase modulator is controlled by the position of the FM-PM switch. The purpose of the PM mixer associated attenuators will be discussed at the conclusion of discussion of the 1.25-mc subcarrier channel.

If emergency key operation is required, the PCM-OFF-KEY switch is placed to the KEY position, and either commander's or system engineer's umbilical PTT switch is depressed. This switching arrangement will enable the tuned amplifier and gate through the applied 512kc sync signal. This signal is applied directly to the phase modulator.

Normal operation calls for voice, EMU data, and biomedical data being placed on a 1.25-mc subcarrier prior to S-Band transmission. Selection of either the commander's or system engineer's biomedical data (EKG) is controlled by the LEFT-OFF-RIGHT switch. Selecting either input will cause the frequency of the 14.5kc subcarrier oscillator (SCO) to deviate. The SCO output is applied to a mixer circuit. Also applied to the mixer circuit is a voice signal from either audio center. During the lunar stay phase of the mission, EMU data will be received from the astronaut via VHF Channel "B". This received signal is applied to a high pass filter (HPF) that passes EMU data only. Application of the EMU data to the mixer circuit is controlled by either commander's or system engineer's RELAY switch being placed to the ON position.

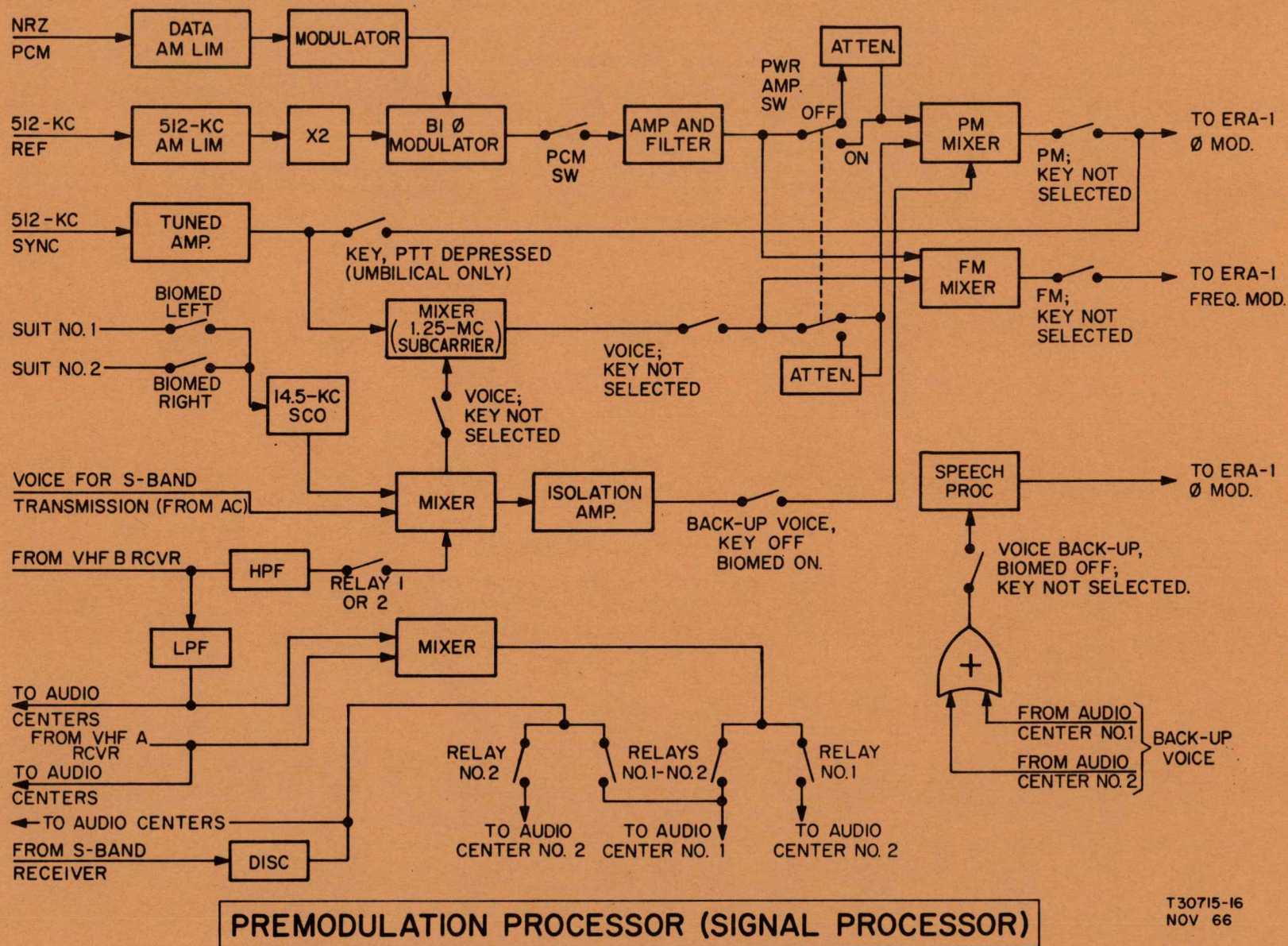
The combined voice/EMU/biomedical signal is applied to the 1.25-mc subcarrier mixer circuit if the VOICE-OFF-VOICE Back-up (B.U.) switch is in the VOICE position. The mixer output, which consists of the composite signal on the 1.25-mc subcarrier, is applied to the FM and PM mixers.

It can be seen that with the S-Band Power Amplifier switch in the OFF position, the 1.024-mc subcarrier applied to the PM mixer is attenuated, while the 1.25-mc subcarrier is applied unattenuated. The above condition is reversed when the power amplifier switch is placed to the ON position (PRIM or SEC).

In order to optimize the circuit margins, the phase deviations for the two subcarriers modulating the PM carrier are reversed. During the inflight mode, wide-band-high-bit-rate (51,200 bits per second) PCM-NRZ is transmitted, and during the lunar stay phase when not transmitting TV, the lo-bit-rate PCM-NRZ can be transmitted. The power in the two subcarriers may then be balanced, enabling the lo-bit-rate/voice combination to perform well with low-power transmission and the erectable antenna, contrasted to the alternative of operating full power.

Received VHF Channel "A" audio, VHF Channel "B" audio and EMU data, and received 30-kc voice subcarrier from MSFN are routed to the PMP prior to application to the audio centers. The received VHF "A" audio is routed to a mixer along with VHF "B" audio that has been passed by the low pass filter (LPF). The mixer output is applied to both RELAY switches. The 30-kc voice subcarrier is applied to a discriminator for purposes of demodulating the voice signal. The discriminator output is applied to both audio centers and both relay switches.

As previously mentioned, relay operation is an operational capability that permits EVA-LM-MSFN-LM-EVA interchange. Both commander and system engineer have a relay switch, which is designated Relay 1 and 2 respectively, located on their audio control panels. Voice signals received from EVA would be applied to Audio Center No. 2 if RELAY switch No. 1 is closed. Audio Center No. 2's S-Band T/R switch is placed to the T/R position to provide for S-Band transmission to MSFN. The received S-Band voice is routed to Audio Center No. 1. The VHF "A" T/R switch is placed to the T/R position and keying of the transmitter and application of the voice signal to the modulator will be accomplished. Thus the link is completed.



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NOV 66

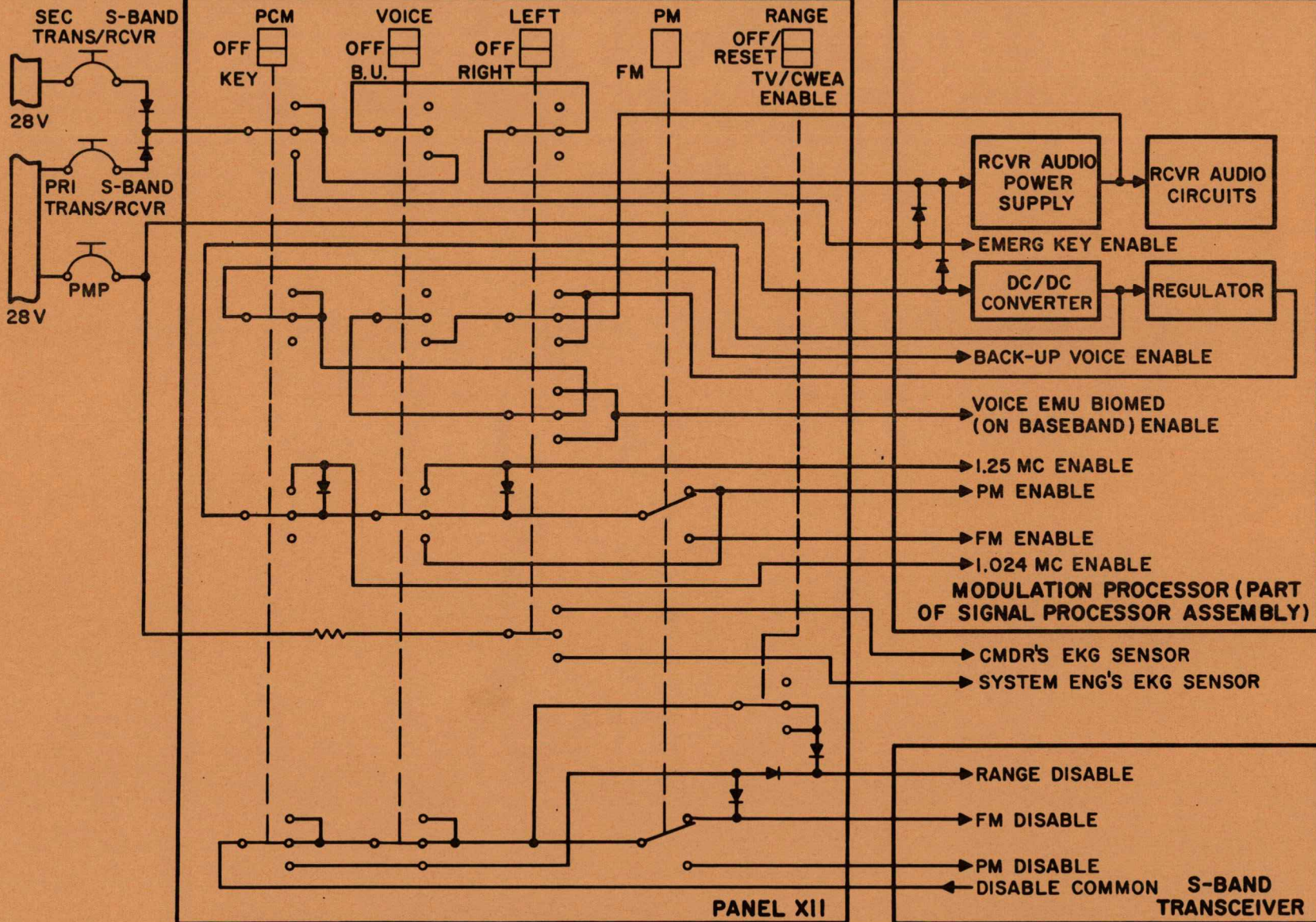
If there is a malfunction in the 1.25-mc subcarrier circuits, VOICE/EMU/Biomedical data can still be transmitted to MSFN by direct modulation of the S-Band carrier. The mixer output is applied to the PM mixer through an isolation amplifier if the VOICE-OFF-VOICE B.U. switch is in the B.U. position, and either biomed position selected.

If there is a malfunction in both the 1.25-mc subcarrier and the direct carrier modulation circuits, the speech processor is selectable by placing the VOICE-OFF-VOICE B.U. switch to the B.U. position, and by placing the BIOMED LEFT-OFF-RIGHT switch to the OFF position. The enabled speech processor will amplify voice signal inputs from either audio center and route the amplified signal to the phase modulator for direct carrier modulation.

4. Modes of Operation (S-Band)

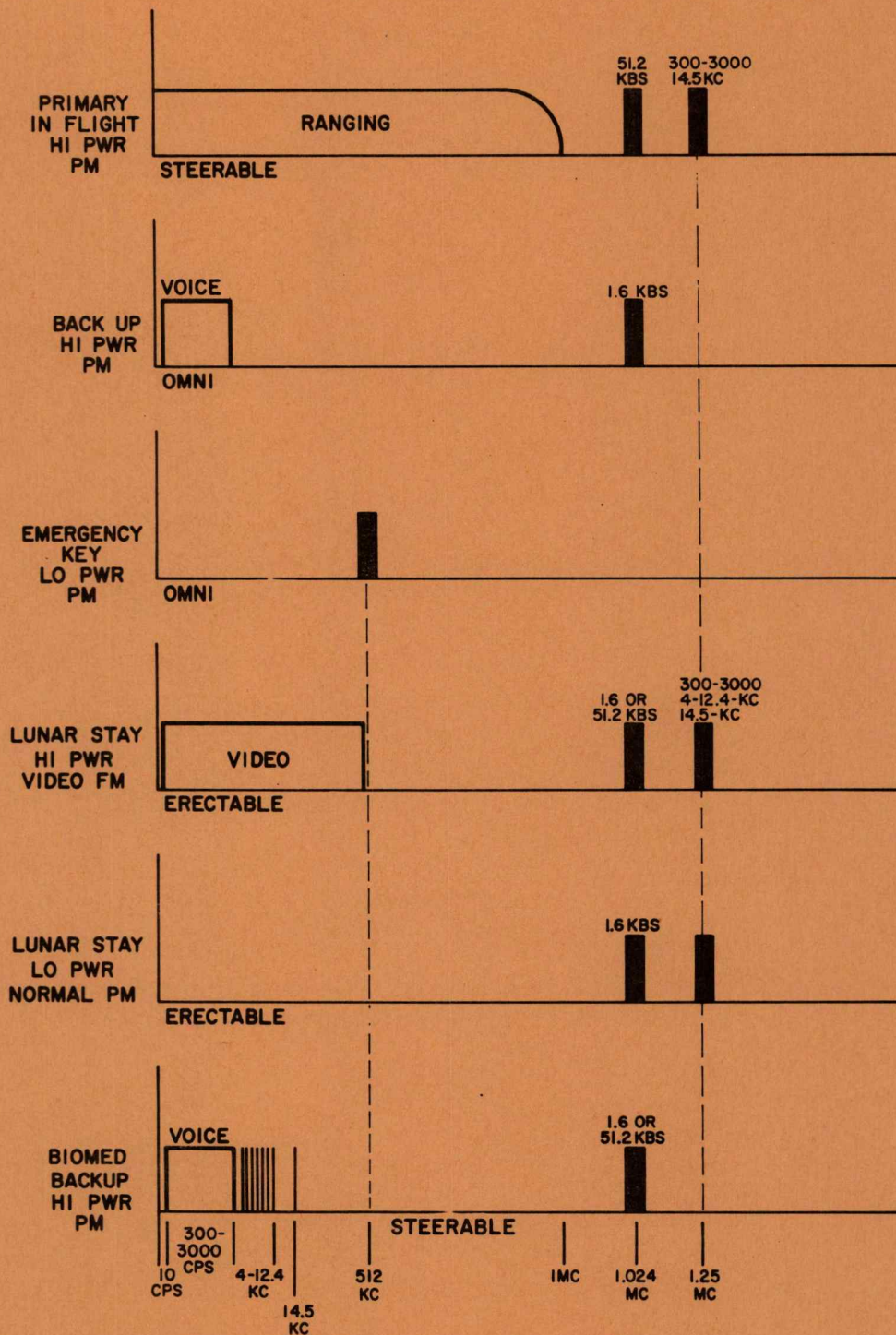
A functional schematic of S-Band mode switching is depicted in Figure 31.

There are various modes of operation, all of which are controlled by control panel switches. The various modes of S-Band transmissions are depicted in Figure 32. Also shown in Figure 32 is the S-Band antenna utilized for the specific mode, whether or not the S-Band Power Amplifier is being utilized (LO Power or Hi Power), and the type of modulation (FM or PM).



S-BAND MODE SWITCHING-NORMAL AND BACK-UP

T 30715-38
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MODES

T30706-48
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D. Digital Uplink Assembly

1. Introduction

The Digital Uplink Assembly (DUA) provides the capability to update and/or command the LGC and to process and effect real time commands. As of this writing, the implementation of the real time command capability is not anticipated, but is available for contingency operation.

The Digital Uplink messages are frequency modulated on a 70-kc subcarrier which is in turn phase modulated on the S-Band up-link RF carrier.

The Digital Uplink messages addressed to the LGC parallel those inputs to the LGC available to the crewman via the Display and Keyboard (DSKY).

The DUA consists of five major subassemblies:

70-kc Discriminator

PSK Demodulator

Decoder (A and B)

Power Supply

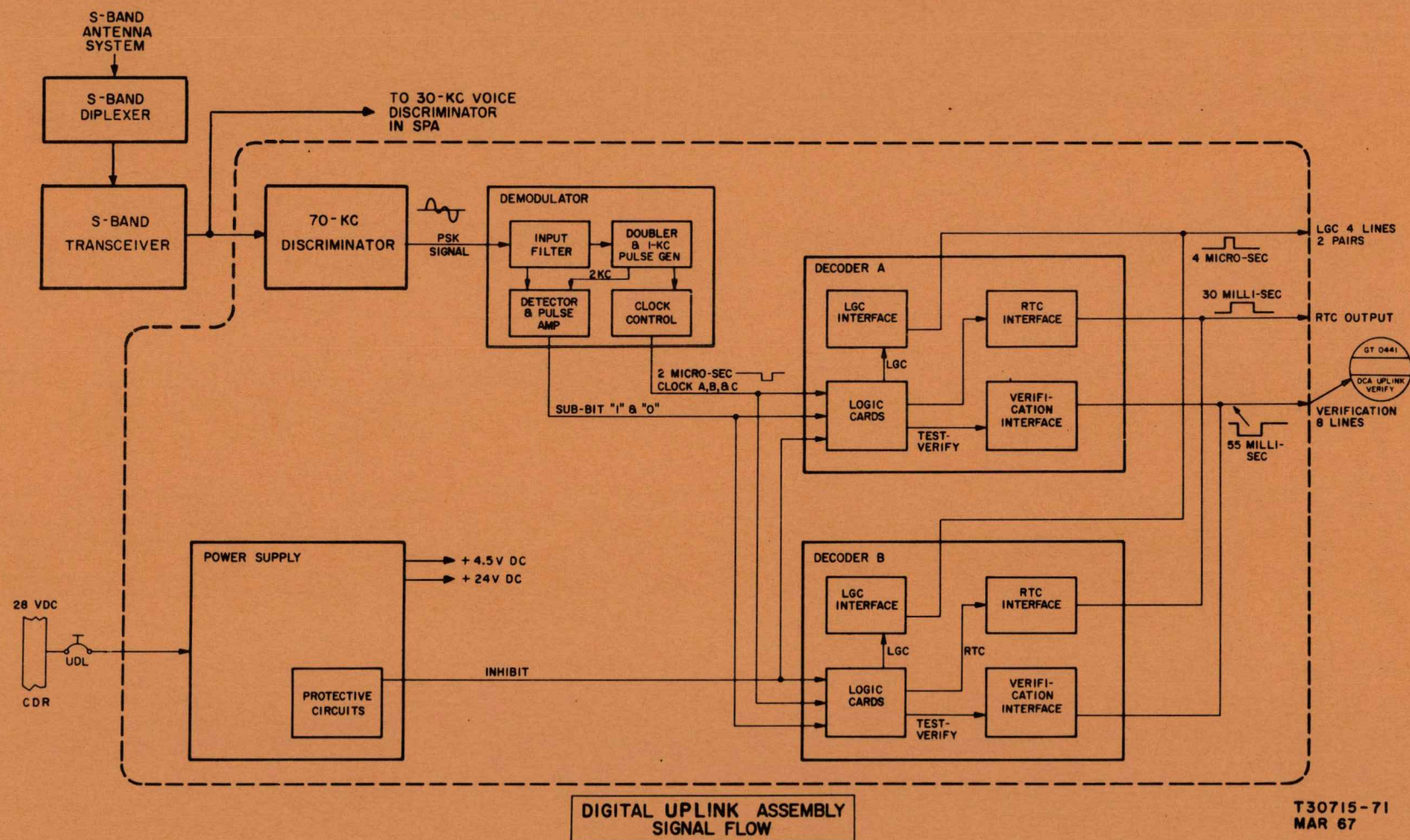
Figure 33 depicts the major subassemblies and the interconnections between the various subassemblies within the DUA. This figure should be referred to while proceeding through the following descriptional paragraphs.

2. DUA Functional Analysis

The following paragraphs contain a description of the DUA. Included will be decoder flow diagrams and the various DUA interfaces.

a. 70-kc Discriminator

The 70-kc Discriminator, which is located in the DUA and is depicted in Figure 33, accepts the 70-kc output of the S-Band Transceiver, demodulates the signal, and routes the resultant 1-kc and 2-kc composite phase shift keying (PSK) signal to the DUA PSK demodulator.



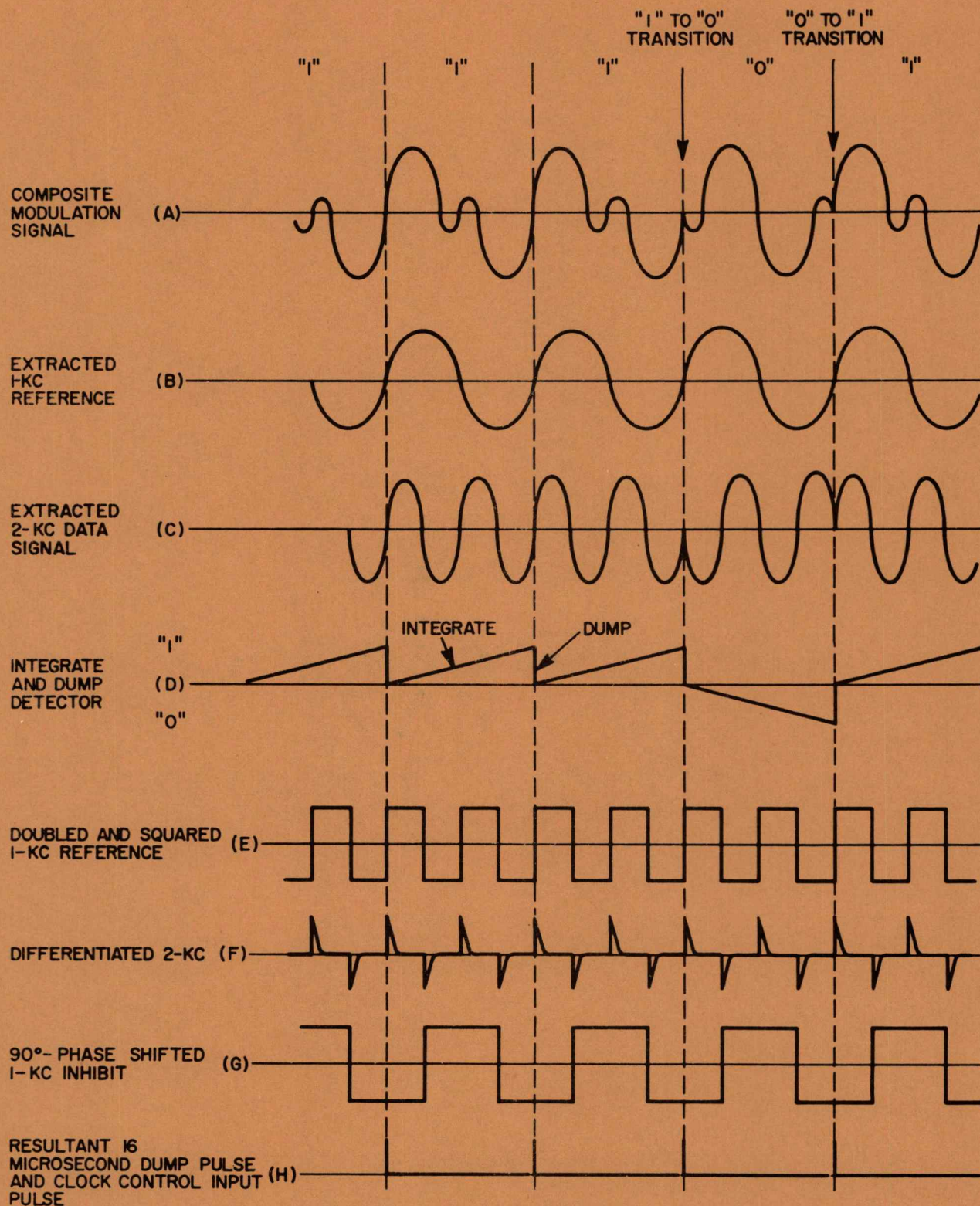
The 70-kc Discriminator is comprised of a broadband clipped amplifier with a gain of approximately 15db driving the 70-kc Discriminator. The discriminator circuit utilizes two amplifier stages tuned at approximately 62-kc and 78-kc, which are the extremes of the FM deviation of the subcarrier. The output of each amplifier circuit is rectified, summed and integrated, amplified by an audio amplifier, and applied to the demodulator.

b. Demodulator

The function of the demodulator is to convert the phase shift keyed signal from the 70-kc Discriminator into a series of digital "ones" and "zeros" for the decoder. It also provides a set of reference clock pulses for the decoder.

At this time a discussion of the PSK signal is necessary. Figure 34 depicts a number of signals found in the demodulator. The PSK signal consists of a 1-kc sine wave reference tone to which is added a 2-kc PSK tone of equal amplitude. This composite modulation signal is depicted in Figure 34A. The 2-kc tone is phase shifted 180° at the transmitter by the message sub-bit. The switching of the 2-kc from in-phase to out-of-phase occurs at the positive going, zero-crossing of the 1-kc reference. An in-phase 2-kc tone with the 1-kc reference tone signifies that a "one" sub-bit is being received. An out-of-phase 2-kc tone signifies that a "zero" sub-bit is being received. Each sub-bit is one millisecond long, which is the same duration as one cycle of the 1-kc reference tone.

The 70-kc discriminator demodulates the PSK/FM signal and feeds the composite audio signal into a 1-kc filter located in the demodulator, as depicted in Figure 35. This 1-kc filter is a narrow band filter that separates the composite signal into two parts. The 1-kc component, which is depicted in Figure 34B, is used as a reference signal for determining the end of a sub-bit and for generating a 2-kc reference signal for the Phase Detector. The filtered 1-kc signal is also used as an inhibit signal in the Control Circuit and its use will be described in a subsequent paragraph. The 2-kc PSK signal output of the 1-kc filter, which is depicted in Figure 34C, is fed to the Phase Detector.



DEMODULATOR WAVEFORMS

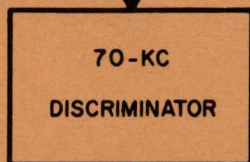
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The filtered 1-kc output of the filter is used to drive a frequency doubler circuit to provide a phase-locked 2-kc reference signal for the Phase Detector. The frequency doubler is a conventional push-pull doubler circuit which pulses a high-Q 2-kc tuned circuit. The outputs are in-phase and out-of-phase 2-kc square waves which drive the Phase Detector's choppers.

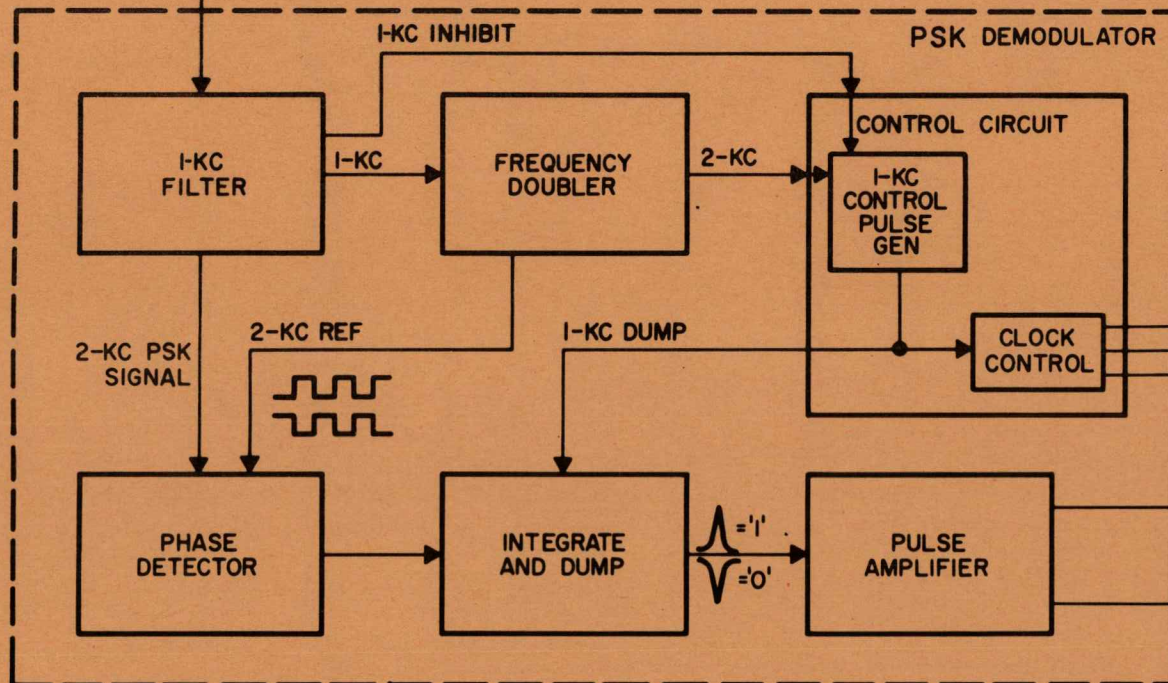
The Phase Detector determines the phase of the 2-kc PSK signal. It is similar to a product detector which alternately switches the phase of the input signal each half cycle. The switching is controlled by the 2-kc reference square waves from the Frequency Doubler. Under conditions of low signal-to-noise ratio, the presence of receiver noise mixed with the 2-kc signal may cause the phase of any specific half cycle to be unidentifiable. However, by integrating over the four half cycles of each sub-bit, the average detected signal can be determined over the one-millisecond bit interval. After integrating for one millisecond, the integrator voltage is sampled as it is being reset to zero prior to the next one-millisecond integration period. The "integrate-and-dump" is referred to as a "matched filter", which is used to extract the best signal-from-noise for a square shaped data bit. Typical integrate and dump waveforms are depicted in Figure 34D. The time of dump is synchronized with the 1-kc positive-slope zero crossing by a 1-kc pulse generated in the control circuit. The pulse generated at the time of dump is fed through a Pulse Amplifier, where pulse amplification, squaring, and limiting occurs, to the 5-bit Shift Register located in the Decoder.

The Control Circuits generate a 16-microsecond pulse at a 1-kc rate which is used to dump the integrator at the end of a 1-millisecond sub-bit and to generate three clock pulses for use in the decoder. The 1-kc control pulse, whose generation is depicted in Figure 34E, F, G, and H is obtained from the 2-kc output of the Frequency Doubler and the 1-kc inhibit from the 1-kc Filter. The 2-kc signal from the Frequency Doubler is shaped, differentiated, and applied to a circuit that has a 90-degree phase-shifted 1-kc signal applied. The phase-shifted 1-kc signal inhibits alternate positive excursions of the differentiated 2-kc signal; resulting in 16-microsecond pulses at a 1-kc rate occurring at the end of each sub-bit.

PSK-FM
FROM
S-BAND TRANSCEIVER



COMPOSITE
1-KC AND 2-KC



DECODER A

CLOCK-A
CLOCK-B
CLOCK-C

5-BIT
SHIFT
REGISTER

DECODER B

CLOCK-A
CLOCK-B
CLOCK-C

5-BIT
SHIFT
REGISTER

DUA DEMODULATOR BLOCK DIAGRAM

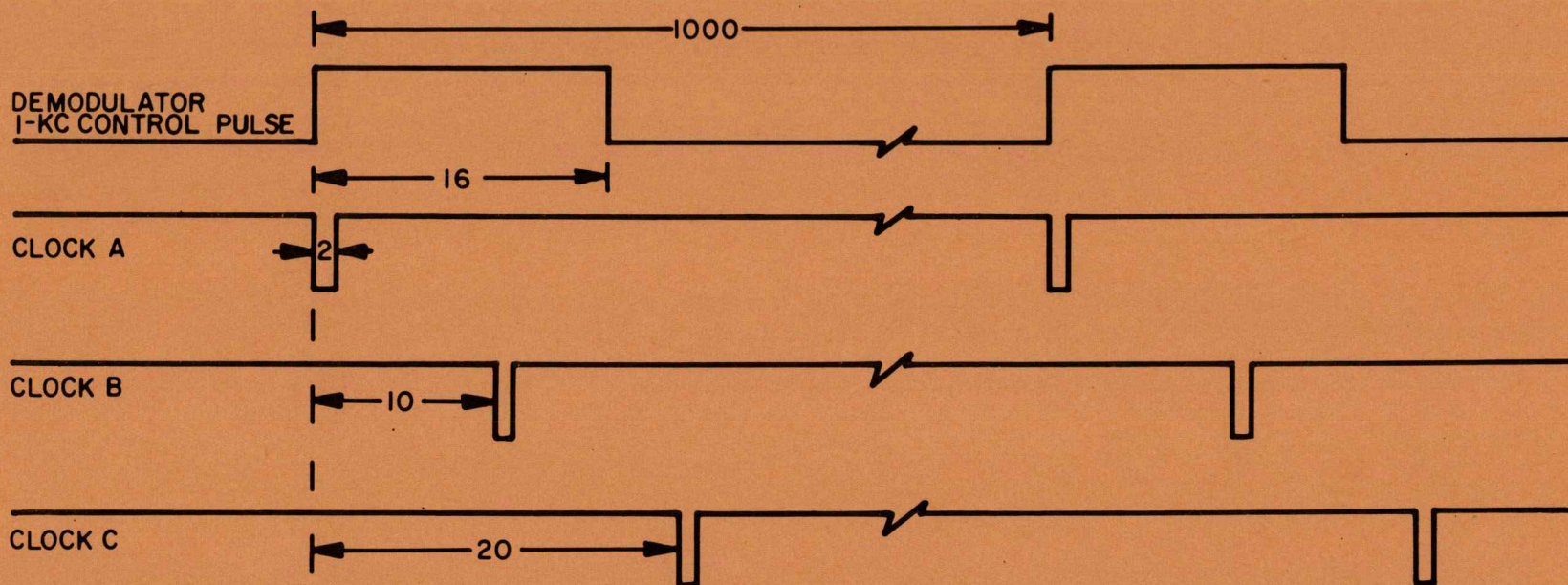
The Clock Control circuit generates clock signals for both Decoders. It produces three 2-microsecond pulses, which are depicted in Figure 36, spaced 10 microseconds apart at the basic 1-kc data rate. Clock A occurs first and is synchronized with the start of the 1-kc control pulse. Clock B, also a 2-microsecond pulse, is delayed approximately 10 microseconds from the leading edge of Clock A, while Clock C also trails Clock B by approximately 10 microseconds. These clock pulses are used for strobing information into the proper registers during the various phases of Decoder operation and will be discussed in subsequent paragraphs.

c. Decoder

The DCA Decoder section consists of two decoders in a redundant configuration that accepts serial digital information from the demodulator, processes this information, and issues commands to other systems within the LM vehicle via the interface units. The decoder is capable of receiving a message consisting of three vehicle address bits, three system address bits, and up to sixteen data bits. Each bit of the possible twenty-two information bits that comprises a message consists of five sub-bits. A code consisting of five sub-bits is used for each vehicle address bit, while another five sub-bit code is used for both the system address bits and the data bits.

The five sub-bit pattern for the vehicle code "0" is the complement of the vehicle code "1" pattern. In the same manner, the system address and data bit code for a logic "0" is the complement of the five sub-bit code chosen for a system address and data bit logic "1". Also, since each sub-bit is received at a 1-kc rate, the information bit is received at a 200-bit per second rate.

Input message format to DUA is shown in Figure 37.



NOTE: TIMING SHOWN IN MICROSECONDS

**DUA DECODER
CONTROL CLOCK TIMING**

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SYSTEM ADDRESS \ INFO BIT	VEHICLE ADDRESS			SYSTEM ADDRESS			MESSAGE DATA															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
RTC	0	1	1	1	0	0	X	X	X	X	X	X										
LGC	0	1	1	0	0	1	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TEST	0	1	1	1	0	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

DIGITAL UPLINK ASSEMBLY
INPUT MESSAGE FORMAT

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The digital uplink decoder is capable of recognizing, processing, and routing messages to the LM Guidance Computer (LGC), and uniquely identifying and issuing one of 64-Real Time Commands (RTC). In addition a test message of 22-bits may be processed to check the operation of the decoder. Upon receipt of an acceptable RTC input signal, the digital command decoder executes the Real Time Command immediately. In the case of the LGC word, the decoder serially transmits a 16-information bit word into the LM Guidance Computer.

The Decoder accepts only those command messages which have the correct vehicle address, a valid system address, and the correct message length. A message in which a sub-bit code error or other error occurs is immediately interrupted and the message that has been received cleared out to await the transmission of another message. For each message that is processed by the command decoder, a verification signal is sent to the PCM telemetry equipment only when the following conditions have been satisfied:

That all sub-bit codes required for the message have been received without error.

That all decoding, buffer storage, and relay-actuation or data transfer have occurred without the occurrence of a power deviation. (A power deviation is defined as any voltage excursion which results in an out-of-limits reading of the internal regulated power supply. These limits correspond to input limits of 25 to 31.5V DC.

That no other error has been detected within the decoder logic.

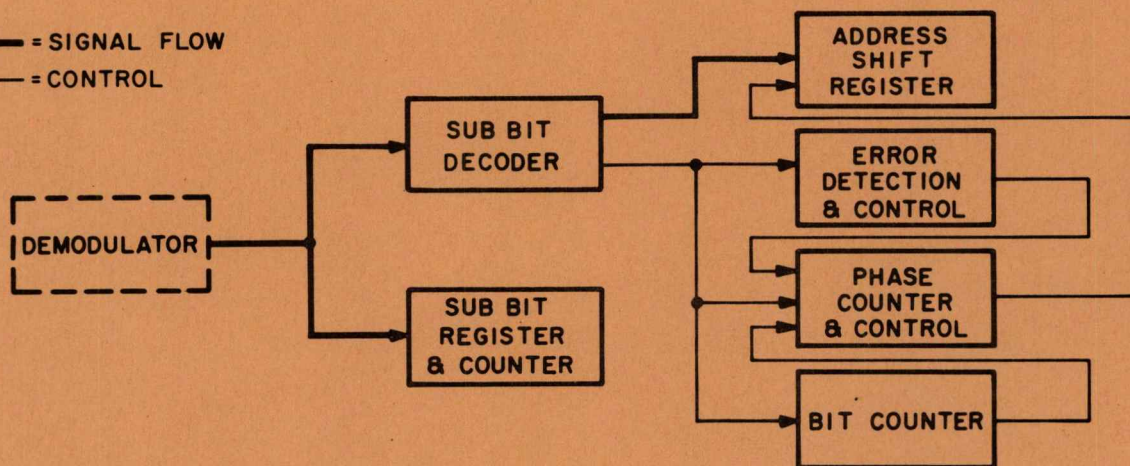
(1) Decoder Signal Flow and Control - Figure 38

The various states through which the decoder proceeds as it receives, recognizes, and processes a command word are controlled by a phase counter within the decoder. This Phase Counter has four phases and two sub-phases which are combined to form the eight modes of operation as shown below:

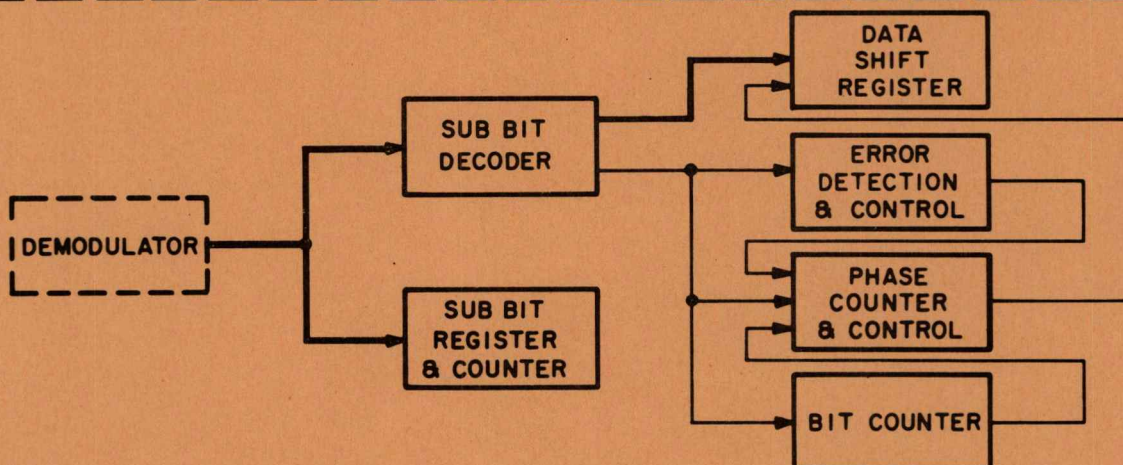
PHASE FUNCTIONS

PHASE	SUB-PHASE	FUNCTION
1	0	System Idle (Standby)
	1	Reception of Vehicle Address
2	0	Reception of System Address
	1	Reception of System Data
3	0	Data Register Information Checked
	1	Correct Message Length Checked
4	0	Command Processed
	1	Message Verified to Telemetry

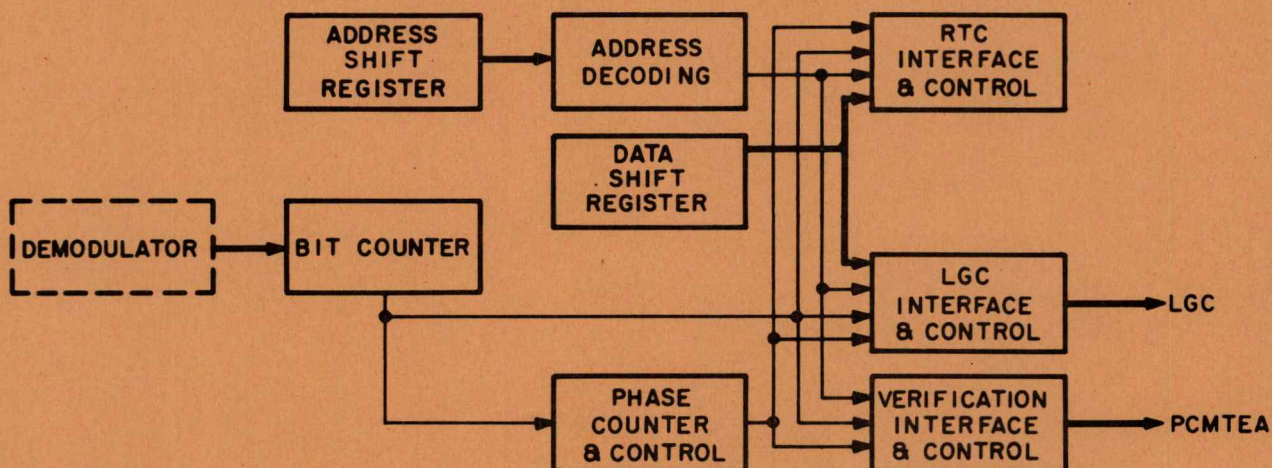
— = SIGNAL FLOW
 — = CONTROL



PHASE 1, SUB PHASE 0 TO PHASE 2, SUB PHASE 1



PHASE 2, SUB PHASE 1 TO PHASE 4, SUB PHASE 0



PHASE 4, SUB PHASE 0 AND PHASE 4, SUB PHASE 1

DUA DECODER-SIGNAL FLOW AND CONTROL

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Logic "1" and logic "0" sub-bits are transmitted from the Demodulator to the Sub-bit Register and Counter. Upon the reception of a proper vehicle address or system address code, a logic "1" or "0" information bit is sent to the Address Shift Register where the vehicle address or the system address are stored. Since the Address Shift Register is only a three-bit shift register, the three vehicle address bits are shifted out as the system address bits are shifted in. Therefore, the last bits stored within this register are the three system address bits. These three bits are then decoded to determine whether the system address is for the LM Guidance Computer or a Real Time Command. Upon the reception of the three system address bit into the Address Shift Register, all further data is transferred to the Data Shift Register. Here, information is entered serially, one information bit at a time, and stored until ready to be processed. The bit counter and phase counter are used to steer information bits from the sub-bit decoder to either the Address Register or the Data Shift Register and to indicate when the proper number of information bits have been transferred. The Bit Counter is also used to check the integrity of the data stored in the Data Shift Register, to generate RTC and Verification Pulse Widths, and to allow the proper word length to be shifted to the LGC interface. The LGC interface, the Real Time Command decoding matrix, and the telemetry interface perform the necessary translation and buffering required for the DUA output.

(2) Detailed Theory of Signal Flow and Control

The Decoder Flow Diagram is depicted in Figure 39, Sheets 1, 2, and 3. An explanation of the Flow Diagram symbols is required prior to proceeding through the various phases.



Depicts a yes or no decision circuit.



Depicts a work function being performed



First number indicates sheet number of Figure 39, where signal flow is continued.

Sub-phase = Sub-Phase 0

Sub-phase - Sub-Phase 1

Prior to the start of a command message, there will be a one in the last position of the sub-bit register due to the fact that at least fifteen one's are sent prior to the transmission of a vehicle address code. As a result, the Sub-bit Register and Counter will be examined upon the reception of each sub-bit until a valid vehicle address code is recognized.

Phase 1, Sub-Phase 0

The system is continually monitoring the Sub-bit Register for the reception of a vehicle code "0". If it has been received, an information bit is strobed into the address shift register, the bit counter incremented by one, and the phase counter set to Phase 1, Sub-phase 1. This is accomplished by Clock A, Clock B, and Clock C. Clock A is used to strobe the sub-bit into the sub-bit register while Clock B is used to strobe the vehicle address code logic "0" into the Address Shift Register and also to increment the bit counter by one. The occurrence of Clock C will preset the sub-bit register to the state 100000, and also advance the phase counter to Phase 1, Sub-phase 1.

Phase 1, Sub-Phase 1

The sub-bit register is used to segregate the received sub-bits in groups of five. The system then determines whether a valid code has been received. If so, the vehicle address code logic "1" will be strobed into the Address Shift Register and the bit counter incremented by one, this again occurring on Clock B. The Bit Counter will be checked on Clock C to determine if the count is three and the Sub-bit Register also preset to the state 100000 at this time.

If the Bit Counter does not equal three, the system will then await the arrival of another five sub-bit code. If the counter does equal three, the three bit code in the Address Shift Register will be checked to determine whether this is the vehicle address for this spacecraft. If so, the system will be advanced on Clock C to Phase 2, Sub-phase 0, and a logic "1" set in the Data Shift Register. (The use of this logic "1" is described in more detail in Phase 3, Sub-phase 0 paragraph.) If the three bit code in the Address Shift Register is an invalid vehicle address, the system will not accept any additional message data and will be preset to Phase 1, Sub-phase 0 at the conclusion of the 250-millisecond decoder enable pulse. The reception of a five bit sub-code which is not a valid vehicle code logic "1" will cause the system to immediately preset to Phase 1, Sub-phase "0" to await the reception of a valid vehicle code logic "0".

Phase 2, Sub-Phase 0

The setting of the phase counter to Phase 2, Sub-phase 0 states that the system is ready to receive the three information bits defining the system address. The reception of a five bit sub-code will allow a check to be made to indicate whether the data code received is valid. If not valid, the system is cleared out and set to Phase 1, Sub-phase 0. If the data code is valid, the data code logic "1" or "0" will be strobed into the Address Shift Register on Clock B and the Bit-Counter also incremented by "one" on Clock B. The Bit Counter will be checked to determine whether it has arrived at a count of six. If not, the system will wait for the arrival of another information bit. If the bit counter is six, a check will be made to determine whether a valid system address has been received. That is, the three information bits stored in the Address Shift Register will be checked to determine that a valid address has been received, indicating either a Real Time Command, an LGC word, or a Test Word. If the system address is valid, the arrival of Clock C will preset the sub-bit register; advance the phase counter to Phase 2, Sub-phase 1, and strobe a logic "0" into the data shift register. (The use of this logic "0" is described in more detail in the Phase 3, Sub-phase 0 paragraph.)

Phase 2, Sub-Phase 1

The system is now ready to receive a number of information bits as determined by the three information-bit system address previously received. A check is again made to determine whether a valid data code has been received. If not, the system is cleared out and reset to Phase 1, Sub-phase 0. If the data code is valid, the information bit logic "1" or "0" is strobed at this time into the Data Shift Register on Clock B, and the Bit Counter incremented by one. If the system address stored in the Address Shift Register is that for a Real Time Command, the arrival of a sufficient number of data bits to increment the Bit Counter to 12 will then initiate a signal that will advance the Phase Counter to Phase 3, Sub-phase 0 and preset the sub-bit register. If the system address is that for a LGC word, or a test message, the arrival of a sufficient number of bits to set the bit counter to 22 will also initiate the same signal.

Phase 3, Sub-Phase 0

The entering of the system into Phase 3 indicates that all data required for the command message has been received. At this time, two checks are provided prior to the transmission of a Real Time Command or Data Transfer to the other spacecraft systems. The logic "1" and "0" entered on bit count 3 and 6 respectively, are checked to insure that the logic "1" and "0" have been shifted correctly through the register indicating proper operation of each applicable stage of the Data Shift Register. If the check is successful, the system is advanced to Phase 3, Sub-phase 1. If the check is not successful, the system is cleared and the phase counter reset to Phase 1, Sub-phase 0.

Phase 3, Sub-Phase 1

The second check that is performed within Phase 3, is to determine whether the message received is of the correct length. This is determined by waiting until the next five sub-bit code is received and determining whether it is a valid data code or not. If a valid code is received, the system is cleared, and returned to Phase 1, Sub-Phase 0. If a valid data code is not received, this indicates that the command message was of correct length and, therefore, the system is advanced to Phase 4, Sub-phase 0.

Phase 4, Sub-Phase 0

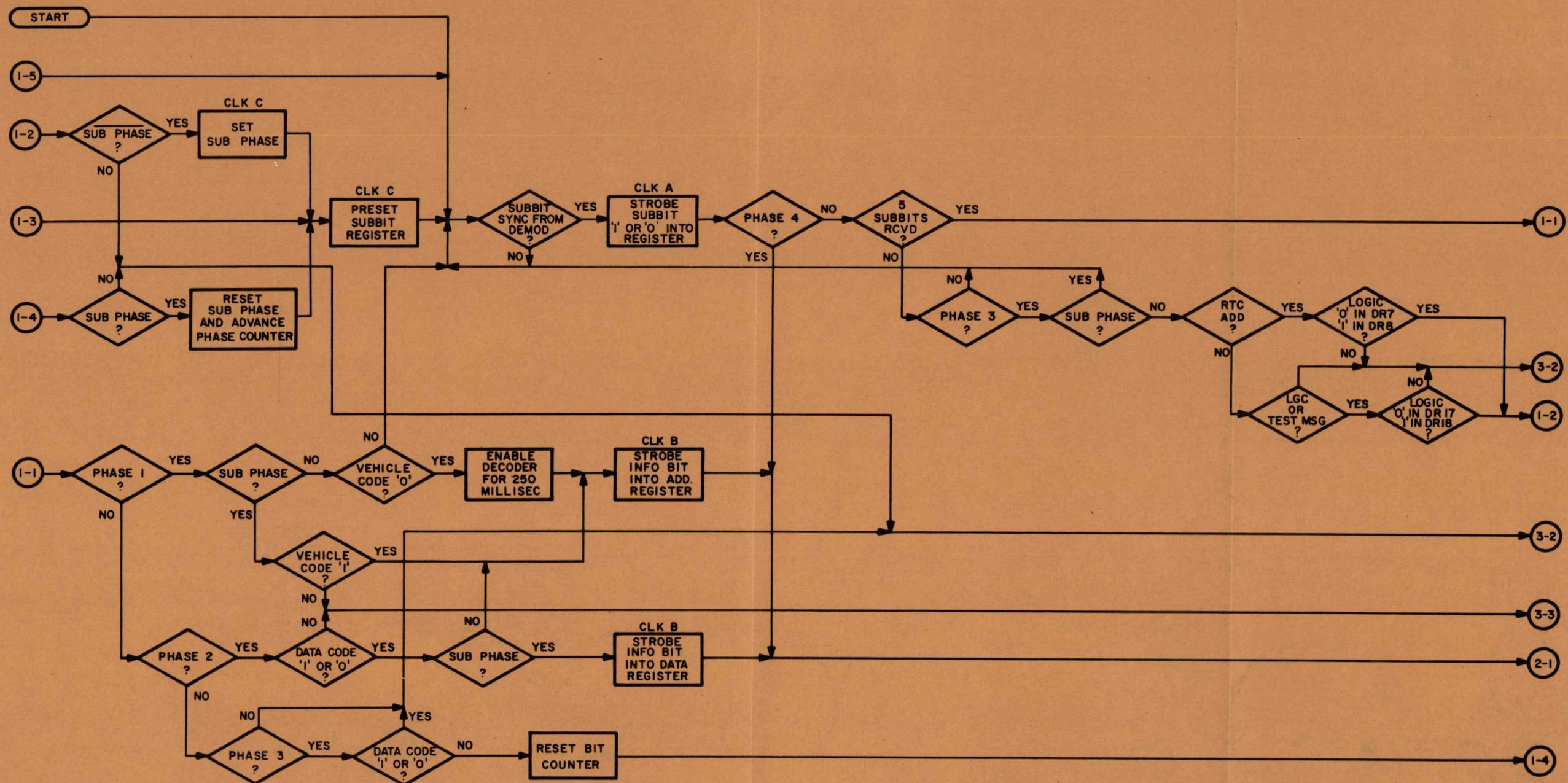
Upon the arrival of the system in the Phase 4 state, commands are sent either to the Real Time Command interface or the LGC interface.

Phase 4, Sub-Phase 1

Upon proceeding into Phase 4, Sub-Phase 1, a verify signal of 55-milliseconds is initiated and sent to the PCM telemetry interface. Upon the completion of the verification signal, a pulse is initiated by the A clock to clear the Address Shift register, clear the Data Shift Register, preset the Bit Counter, preset the Sub-Bit Register, and to advance the Phase Counter to Phase 1, Sub-phase 0. The system is then ready to receive another message.

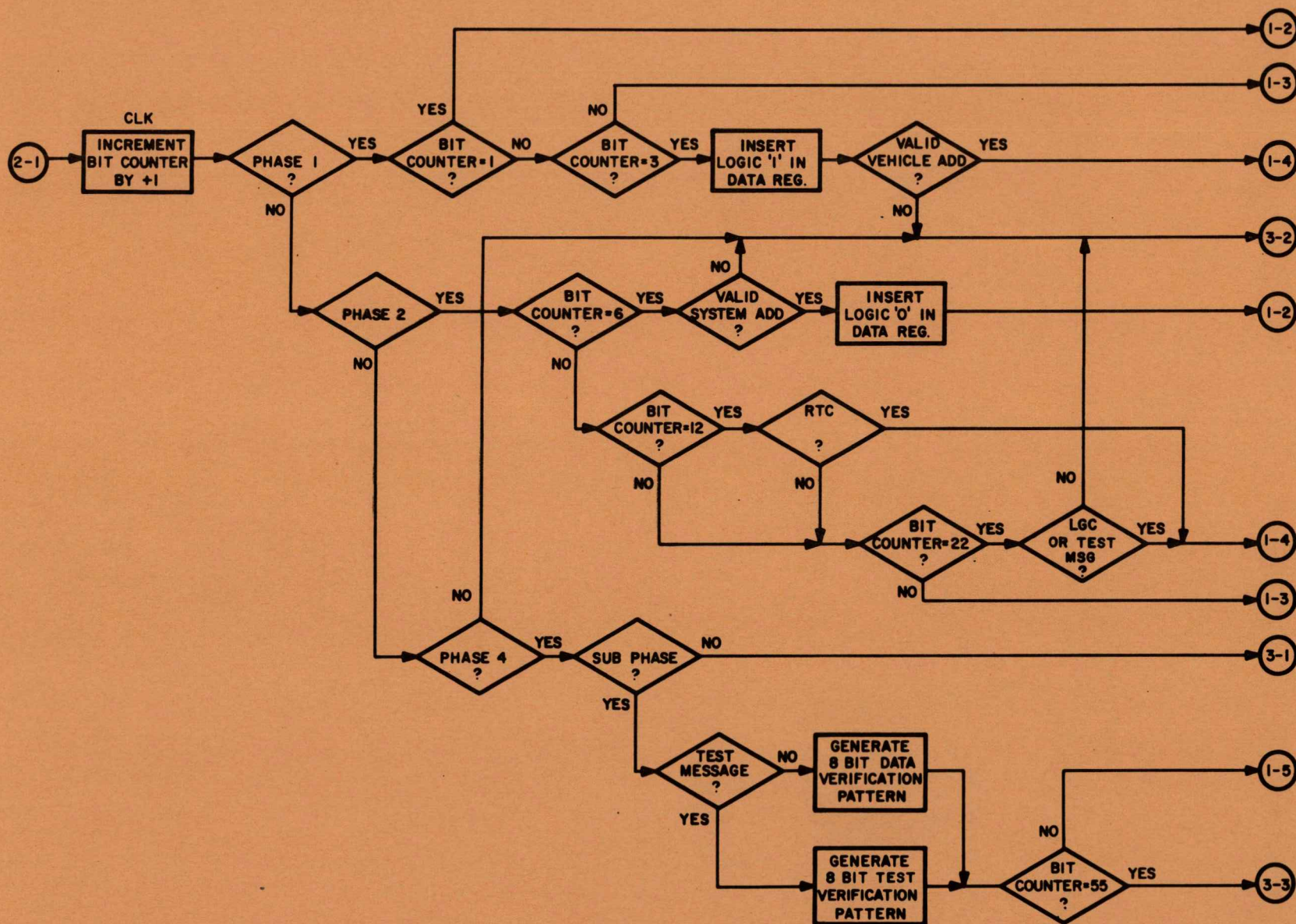
d. Power Supply

The DUA Power Supply converts the +28V DC into regulated outputs of +4.5V DC and +24V DC and produces an Inhibit signal during power turn-on, turn-off, and either a low or high voltage condition.

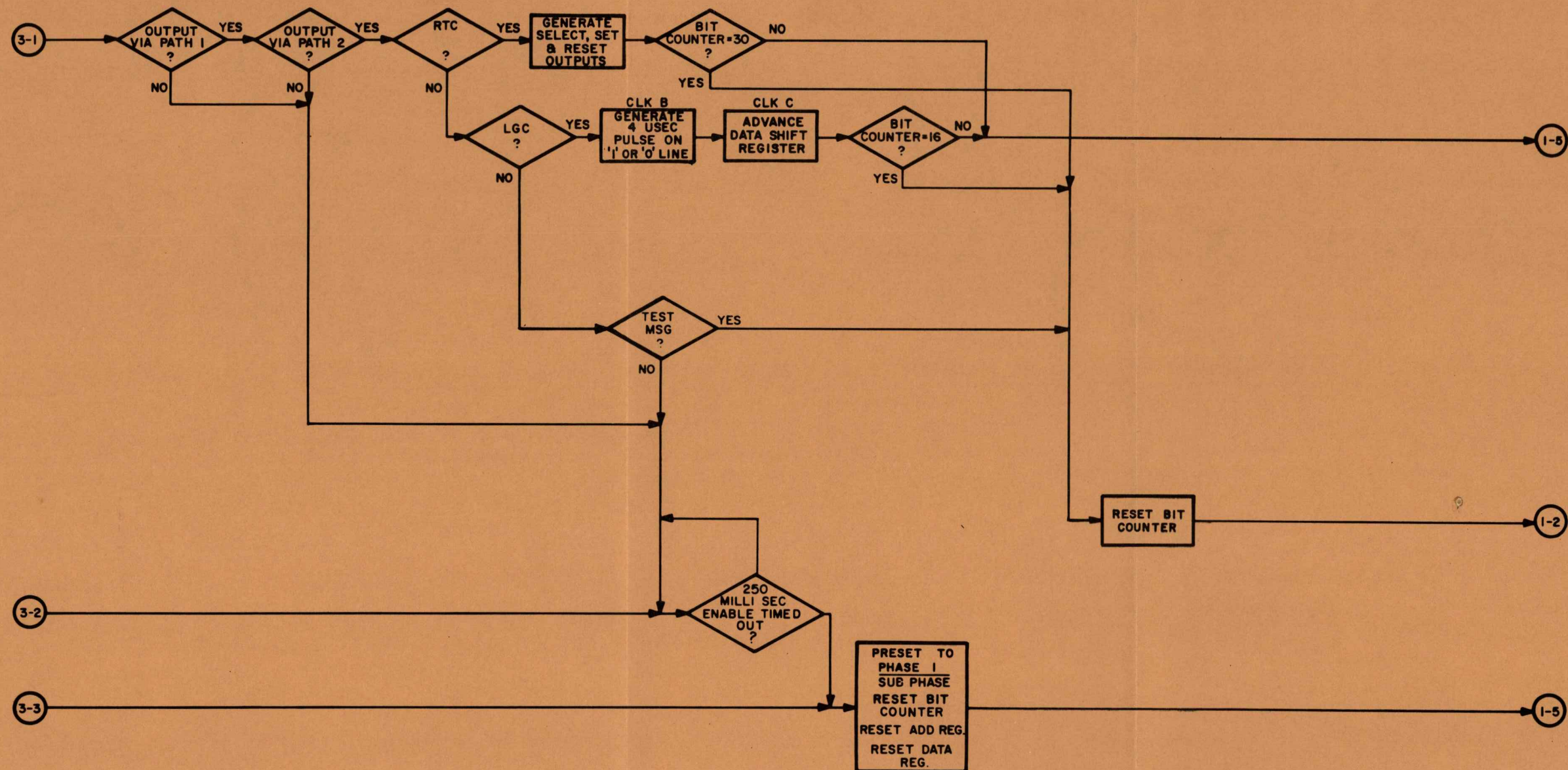


DUA DECODER FLOW DIAGRAM

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SHEET 1 OF 3



DUA DECODER FLOW DIAGRAM



DUA DECODER FLOW DIAGRAM

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SHEET 3 OF 3

The Inhibit signal prevents the DUA from generating erroneous commands during a high or low voltage condition, and power turn-on and -off. The Inhibit signal clamps to ground the sub-bit "1" and "0" input lines of the redundant decoders, thereby preventing an erroneous command from being generated.

3. DUA Interfaces

As previously stated, the DUA interfaces with the LM Guidance Computer (LGC) and an external relay assembly. Following is a brief description of the DUA-LGC interface and the DUA-external relay assembly interface.

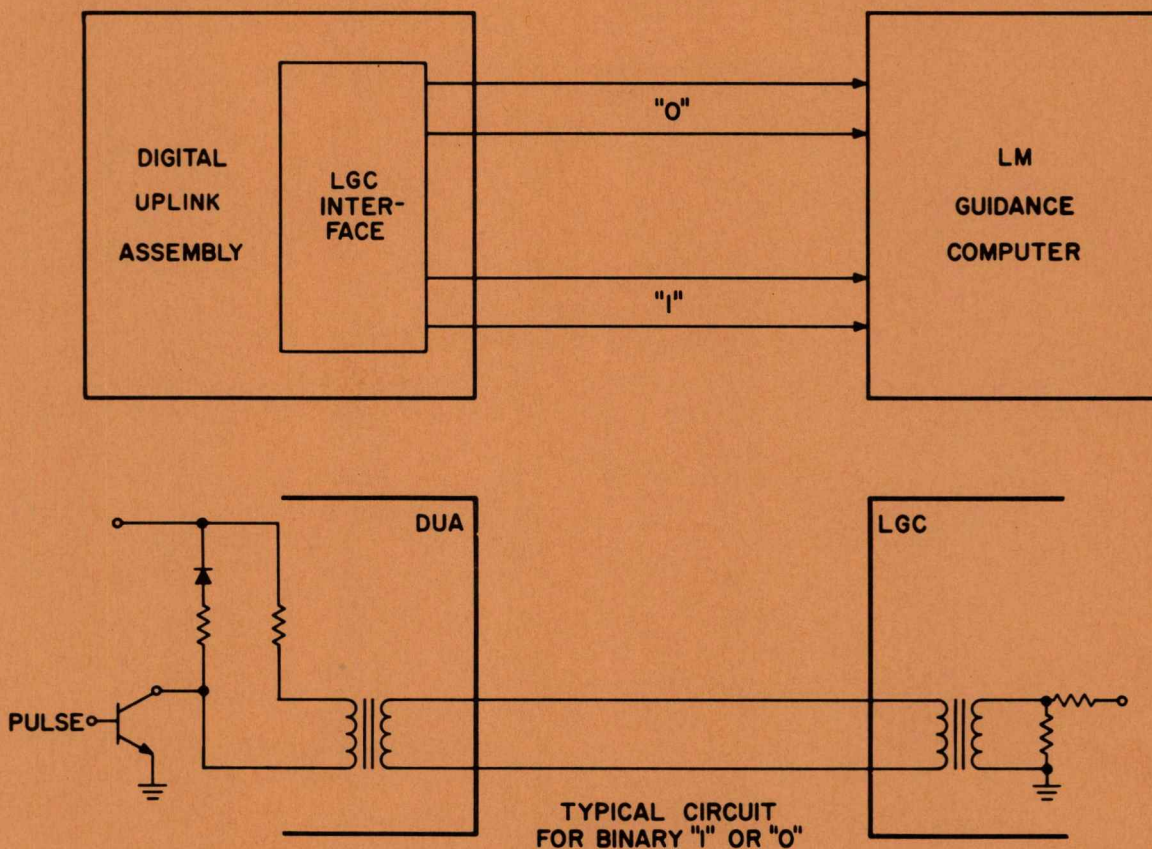
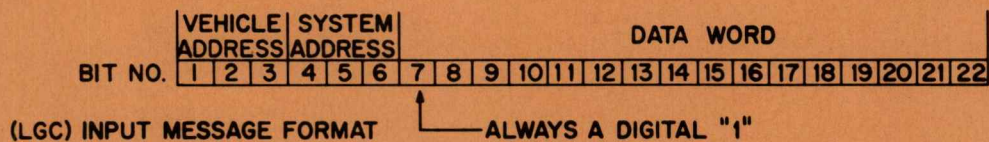
a. DUA-LGC Interface

Figure 40 depicts the LGC input message format and DUA-LGC interface. The first three-bits of the LGC message contain the LM vehicle address (011). Bits 4, 5, and 6 contain the system address; i.e., RTC, LGC, etc. The LGC address is (001). Bit 7 is a sync bit and will always be a (1). Bits 8-22 contain a triply redundant 5-bit word.

There are two sets of lines between the DUA and LGC. One pair is used for a binary "1", and the other for a binary "0". The message bits are shifted out of the DUA serially into the LGC, bit 7 first, and then sequentially through and including bit 22 at a nominal rate of 1000-message bits-per-second.

b. DUA-RTC Interface

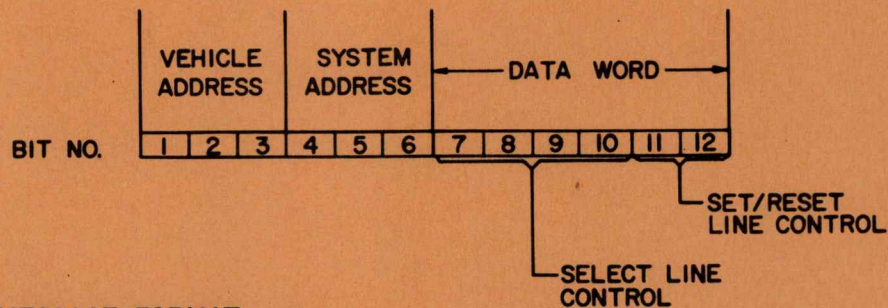
Figure 41 depicts the RTC input message format and DUA-RTC interface. The first three-bits of the RTC message contain the LM vehicle address (011). Bits 4, 5, and 6 contain the RTC address (100). Bits 7 through 12 contain the data word, with 7 through 10 being the select line control and bits 11 and 12 being the set/reset line control.



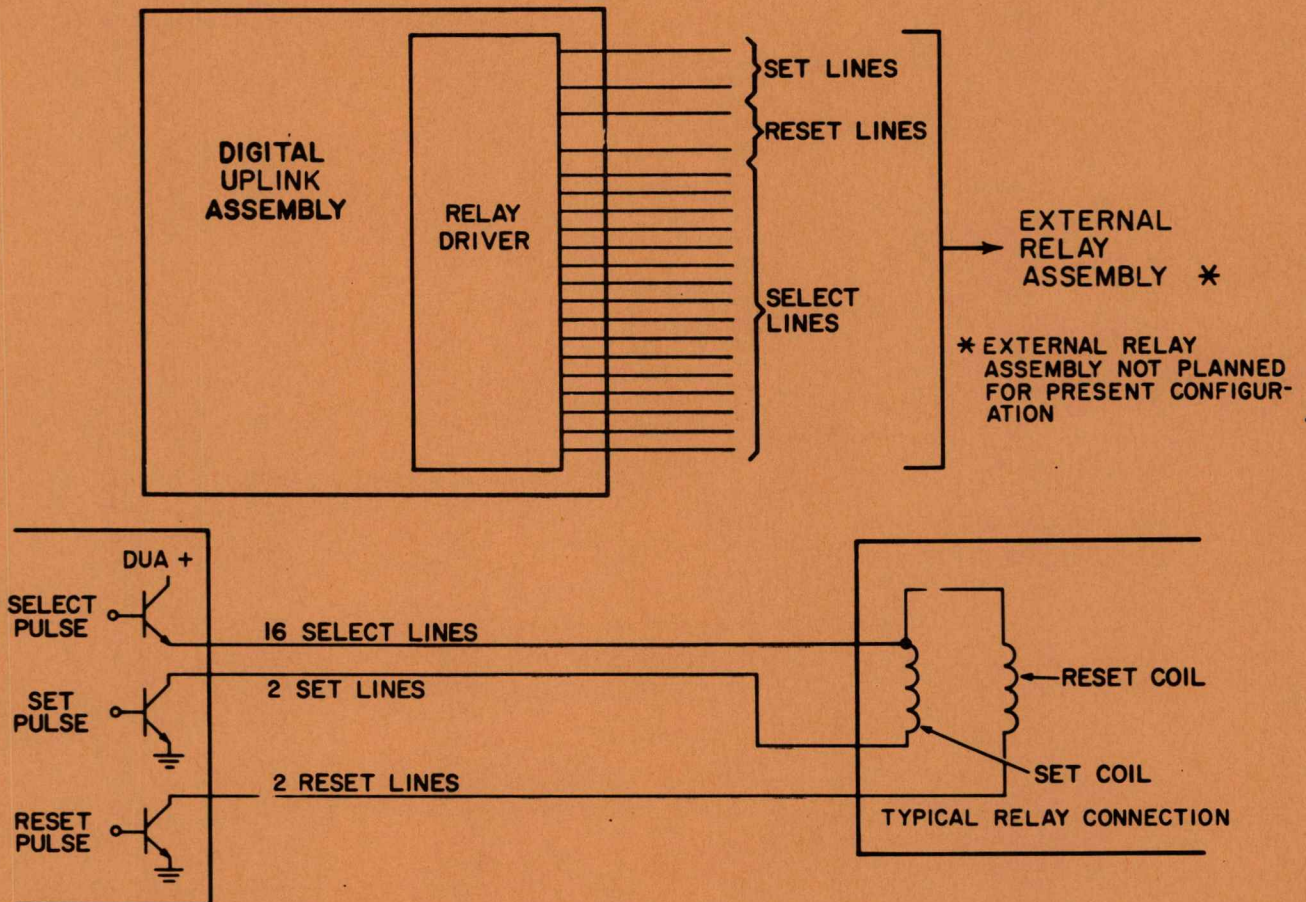
MESSAGE BITS ARE SHIFTED OUT OF THE DUA SERIALY INTO THE LGC,
 BIT 7 FIRST, AND THEN SEQUENTIALLY THROUGH AND INCLUDING
 BIT 22 AT A NOMINAL RATE OF 1000 MESSAGE BITS PER SECOND,
 PULSE WIDTH = 4 MICROSECONDS.
 PULSE AMPLITUDE = 7 ± 3 VOLTS PEAK TO PEAK

**DIGITAL UPLINK ASSEMBLY —
 LM GUIDANCE COMPUTER INTERFACE**

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(RTC) INPUT MESSAGE FORMAT



64 RELAY COILS OF AN EXTERNAL RELAY ASSEMBLY CAN RECEIVE POWER FROM DIGITAL UPLINK ASSEMBLY. +24 VOLTS DC IS PROVIDED ON ONE OF 16 SELECT LINES. A RETURN PATH WILL BE PROVIDED ON ONE OF 2 SET OR 2 RESET LINES. OUTPUT PULSE DURATION WILL BE 30±5 MILLISECONDS.

DIGITAL UPLINK ASSEMBLY-
REAL TIME COMMAND INTERFACE

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The DUA relay driver interface has the capability of controlling 64-relay coils. A +24V DC, 30±5 millisecond pulse is provided on one of 16 select lines and a return path will be provided on one of 2-set or 2-reset lines.

4. DUA Test and Verification

An 8-bit parallel word is generated by the DUA for the verification signal sent to the PCM telemetry equipment. Three different 8-bit code patterns, which are depicted in Figure 42, are sent to the PCM telemetry equipment. The DUA Standby (Power On) pattern is transmitted while power is applied to the DUA except when a message verification is being sent. A different verification pattern is transmitted following the Test message than that which is transmitted following the processing of a RTC or LGC message.

The 55-millisecond verification pulse is sent to the PCM telemetry equipment after a positive check has been made on the sub-coding of the entire message and the decoding, buffer storage, and relay actuation or data transfer has been accomplished without the occurrence of a power deviation that would inhibit the message verification.

The interface switch provides transistor switch closure to common for a logic "0" and a +5V DC signal for a logic "1", since the telemetry interface must constantly provide signal (i.e., power on standby).

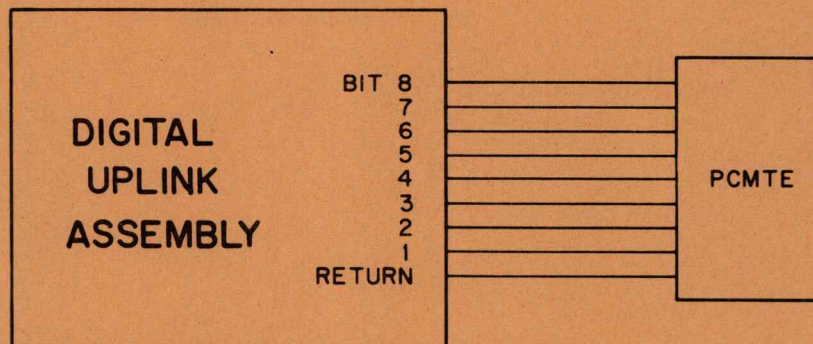
The test message format is depicted in Figure 42. Bits 1, 2, and 3 contain the vehicle address (011). Bits 4, 5, and 6 contain the system address (101). Bits 7 through 22 contain the test message data.

5. Error Detection Circuits

Error detection circuits have been included to insure the detection of a malfunction during the data processing. The controlling phase counter is monitored to insure that only one of the four phases is activated at any one time. The system address decoding circuitry is checked to insure that no more than one of the currently required three system addresses is activated at any one time. The data shift register is checked for proper propagation of binary ones and zeros immediately preceding the execution of any commands or the transmission of the output data.

BIT NO.	VEHICLE ADDRESS			SYSTEM ADDRESS			DATA WORD															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22

(TEST) INPUT MESSAGE FORMAT



THE OUTPUT VERIFICATION SIGNAL SHALL BE AN EIGHT
 BIT PARALLEL DIGITAL WORD OF 55 ± 5 MILLISECONDS
 A DIGITAL "0" = 0+.5 VDC
 A DIGITAL "1" = $5 \pm \begin{smallmatrix} 1 \\ 0 \end{smallmatrix} \text{ VOLT}$

	BIT NO.	1	2	3	4	5	6	7	8
STANDBY		1	0	1	0	0	1	0	0
DATA TRANSFERRED TO LGC, RTC		0	1	0	1	1	0	1	1
TEST		0	1	0	0	0	1	0	0

OUTPUT VERIFICATION FORMAT

DIGITAL UPLINK ASSEMBLY
 TEST AND VERIFICATION

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The check of the data shift register is accomplished by inserting logic "1" and "0" bits in the two high order positions of the register, and checking them again at the lower end of the register after the data has been received and shifted into the register. This insures that each stage of the data register is operating properly.

E. Displays and Controls

1. General

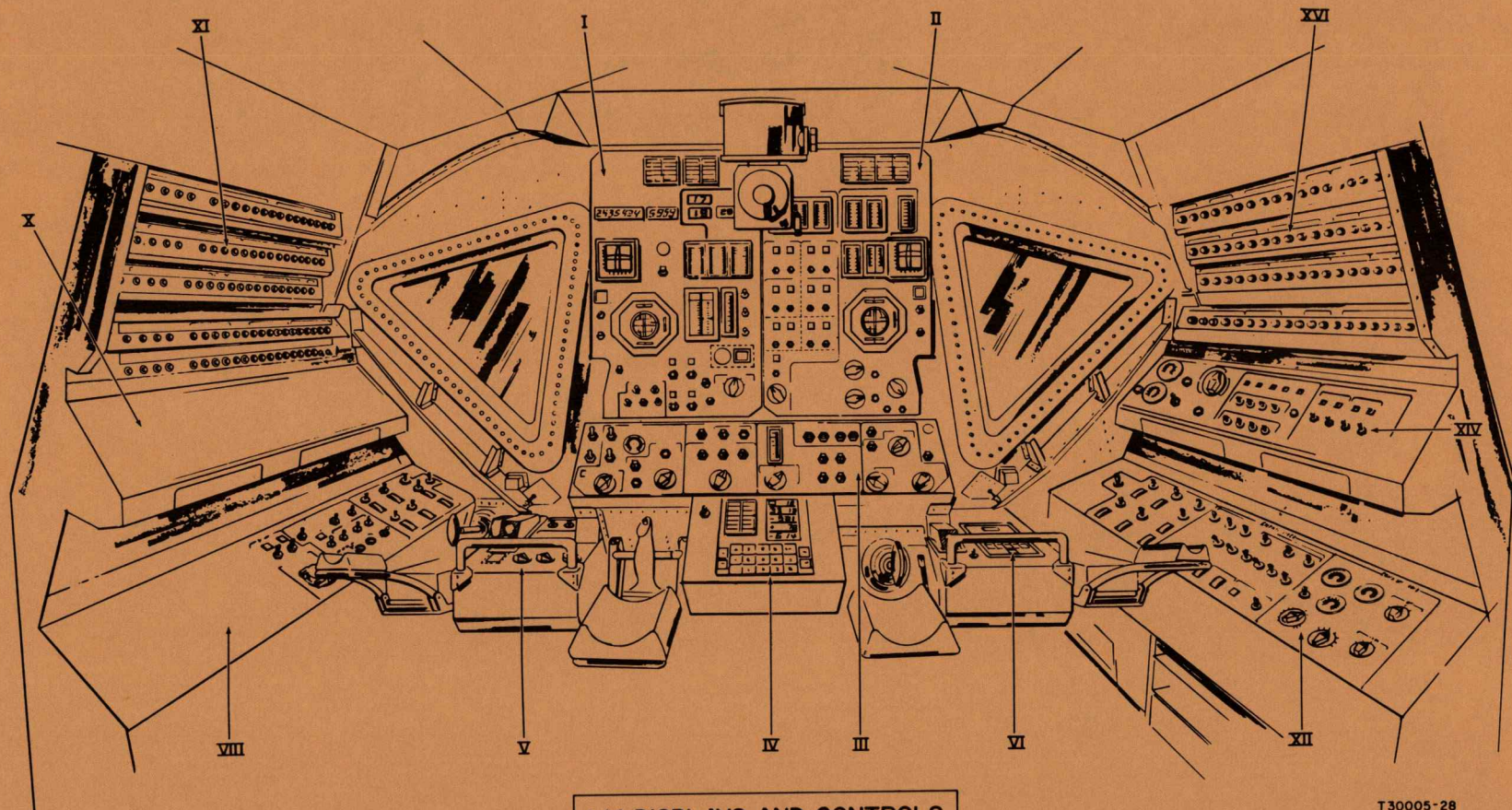
Figure 43 depicts the displays and controls available to the crew of the LM. The following list of panels interface with the communications subsystem and will be discussed in subsequent paragraphs.

Panel XII	System Engineer's Lower Side Console Panel
Panel VIII	Commander's Lower Side Console Panel
Panel III	Lower Center Panel
Panel II	System Engineer's Center Panel
Panel XI	Commander's Upper Side Console Circuit Breaker Panel
Panel XVI	Systems Engineer's Upper Side Console Circuit Breaker Panel

2. Panel XII - System Engineer's Lower Side Console Panel

Depicted in Figure 44, panel XII consists of three sections: An audio panel, a communications panel, and an antenna panel.

- a. Audio Panel: Provides system engineer with capability of selecting which receiver audio is connected to his headset and which transmitter will be modulated by his microphone input. Automatic transmitter keying (VOX) and conference relay control is also provided the system engineer. Refer to Table II for a functional description of switch use.
- b. Communications Panel: Provides "on-off" control of each VHF transmitter and each VHF receiver. Provides "on-off" control of S-Band transceiver (primary or secondary) and S-Band power amplifier (primary or secondary). Also provides control over which signals will be placed on the down link carrier to MSFN. Refer to Table III for a functional description of switch use, and to Figure 30 for a schematic diagram of switch interconnection.



LM DISPLAYS AND CONTROLS

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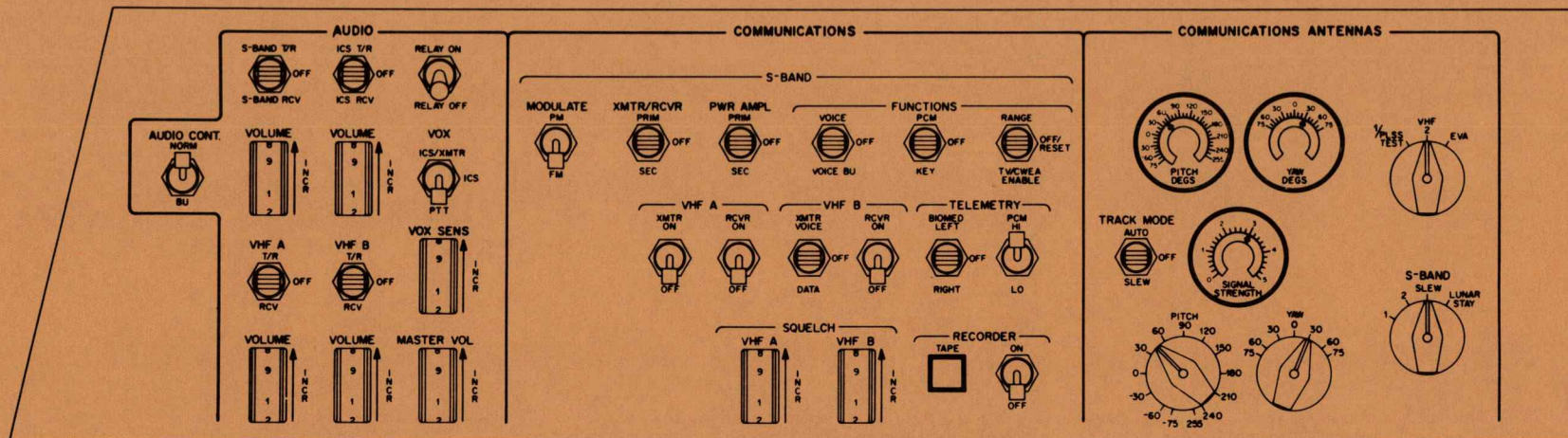
- c. Antenna Panel: VHF Antenna select switch is used to control which antenna will be in use for VHF communications. The #1/plss position selects the AFT VHF inflight antenna and also inserts 80-db of attenuation between LM VHF transmitter/receivers and the portable life support system (PLSS) communications test jack. This will allow a pre-egress test of the PLSS by permitting MSFN to monitor the EMU data being relayed from the LM VHF receiver to the S-Band transmitter. The #2 position selects the FWD inflight antenna. The EVA position selects the EVA antenna used during lunar stay. S-Band antenna select switch is used to control which antenna will be in use for S-Band communications. The #1 position selects the forward inflight (back-up) antenna. The #2 position selects the AFT inflight (back-up) antenna. The SLEW position selects the Steerable Antenna (ERA-5) and LUNAR STAY selects the Erectable Antenna.

To provide proper operation and control of the steerable antenna, a track mode switch, two slew controls (pitch and yaw), and two position meters (pitch and yaw) are used. The TRACK MODE switch determines whether the antenna control will be from the slew controls or from the AGC tracking voltage (from S-Band receiver). As previously stated, initial acquisition by LM of uplink carrier from MSFN is accomplished by positioning the manual slew controls to correspond with angular data provided by the DSKY.

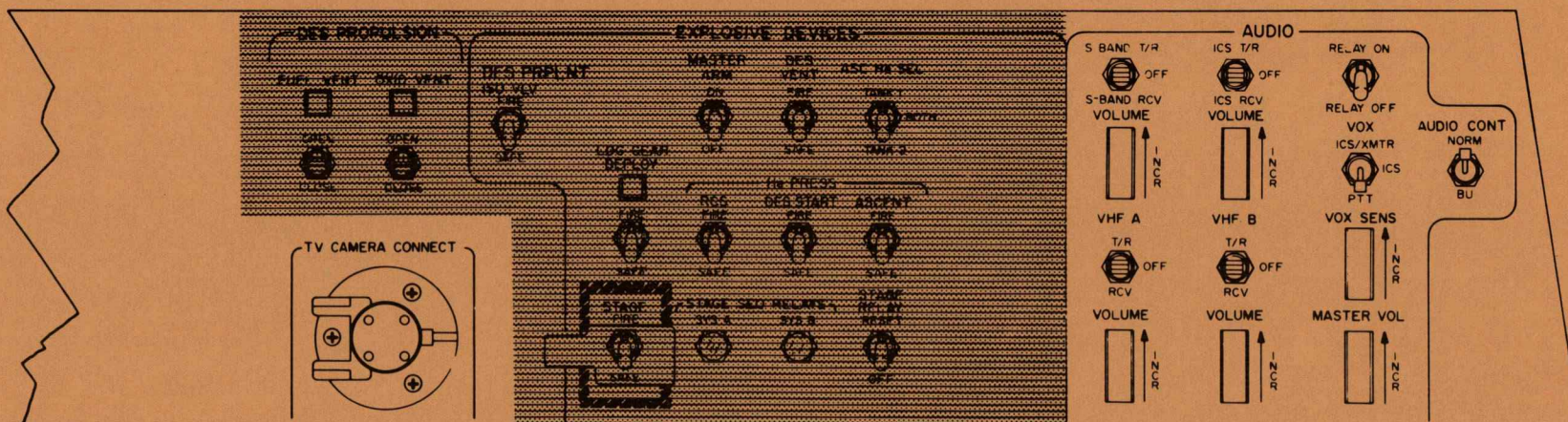
Also found on the antenna panel is the S-Band receiver signal strength meter. This meter will provide a visual indication of MSFN-LM link and also be useful for manual slew operation of steerable antenna and optimum S-Band inflight (back-up) antenna selection. The meter is controlled by the S-Band receiver AGC voltage.

3. Panel VIII - Commander's Lower Side Console Panel

Panel VIII, which is depicted in Figure 44, is used by the commander for his audio control. He can select which receiver audio is connected to his headset and which transmitter will be modulated by his microphone input. Automatic transmitter keying (VOX) and conference relay control is also provided the commander. Refer to Table IV for a functional description of switch use.



PANEL XII SYSTEM ENGINEERS' LOWER SIDE CONSOLE



PANEL VIII COMMANDER'S LOWER SIDE CONSOLE

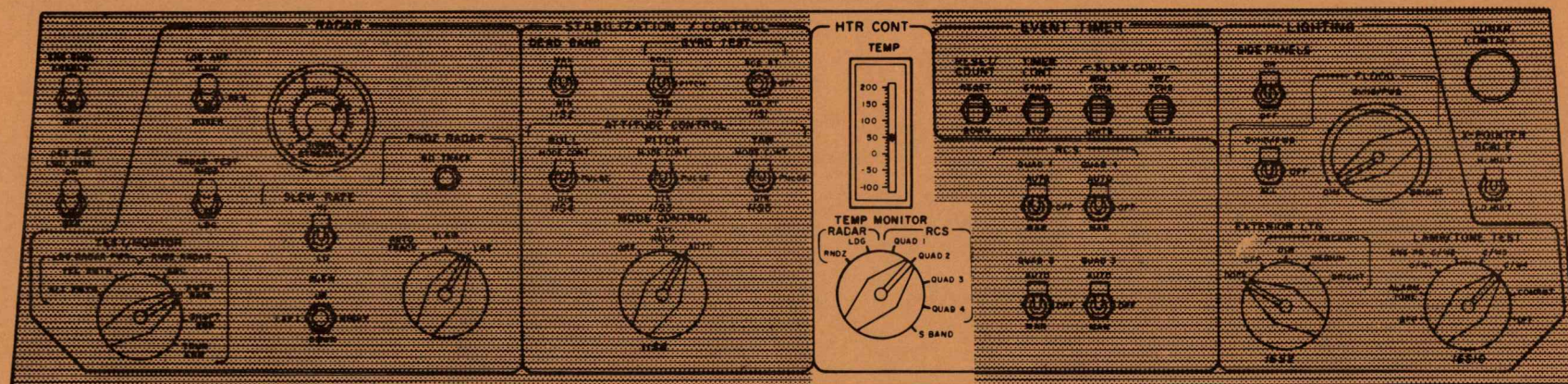
4. Panel III - Lower Center Panel

Panel III, which is depicted in Figure 45, contains the temperature meter and temperature monitor switch. In the communications subsystem, the temperature within the electronics package of the Steerable Antenna (ERA-5) is monitored. In the event that the temperature is not contained within the range of -60°F and $+160^{\circ}\text{F}$, the "HEATER" caution light will be illuminated. By selecting S-Band on the temperature monitor switch, a reset is provided to turn the "HEATER" light off, and the S-Band Steerable Antenna temperature is routed to the temperature meter for display.

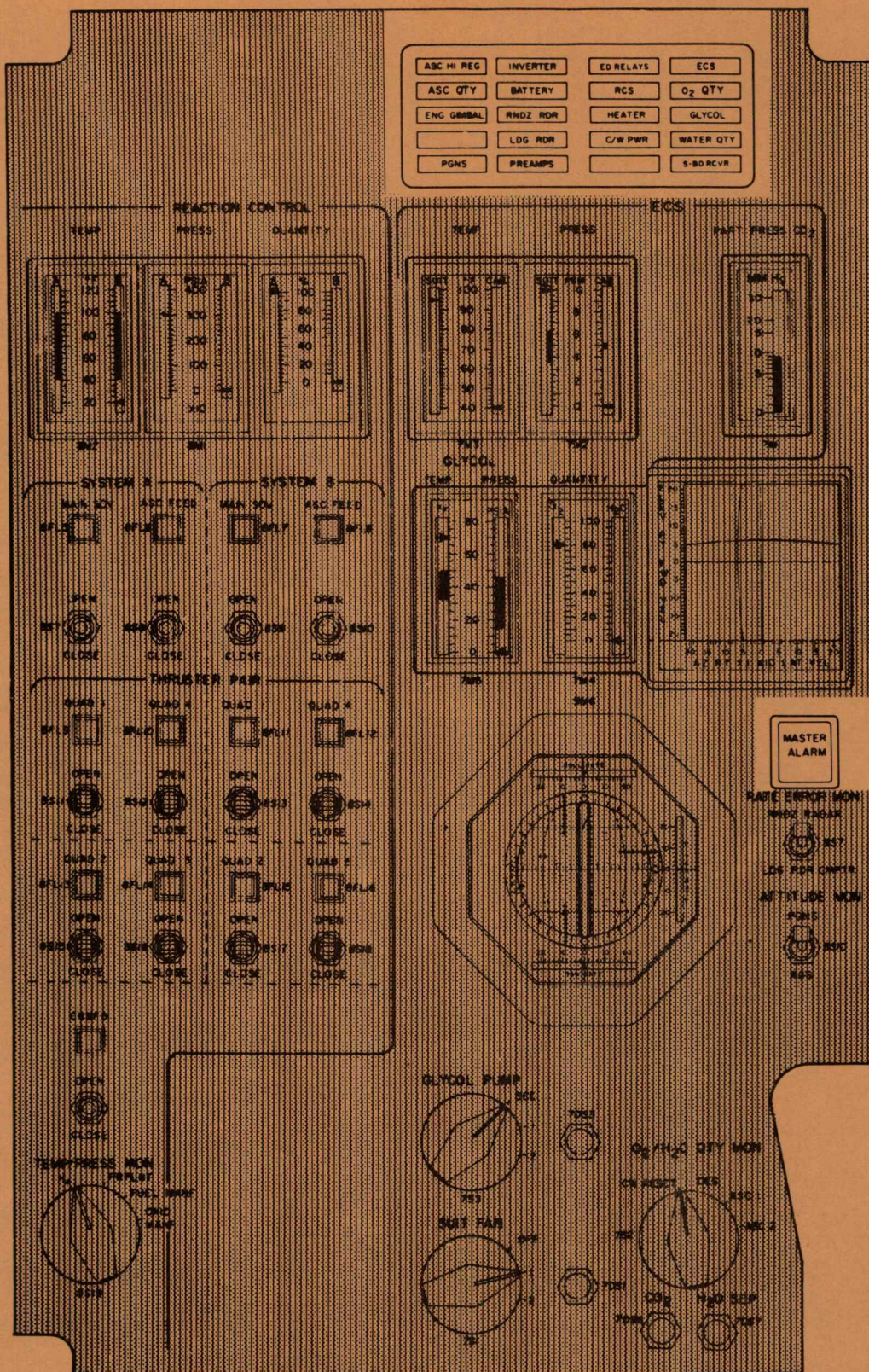
5. Panel II - System Engineer's Center Panel

At the top of this panel, which is depicted in Figure 46, are the caution annunciator lights. Two of these caution lights can be illuminated due to faults within the communication subsystem. The "HEATER" caution light, as previously discussed, is one, and the other is the "S-Band Receiver" caution light. It will come on if the selected S-Band receiver AGC drops below 1 volt. This light is to provide a visual (and aural) warning that the S-Band link from MSFN to LM has been broken during the Lunar Stay sleep cycle. The aural warning is provided by the master alarm warning tone. The caution light circuit can be disabled or enabled as required by the position of the "RANGE, OFF/RESET, TV/CWEA ENABLE" switch located on Panel XII, the System Engineer's Lower Side Console Panel. Putting switch to "TV/CWEA ENABLE" will enable the circuit and if the light illuminates, the circuit is reset by placing switch to the "OFF/RESET" position.

When either communication subsystem caution light illuminates, a 3000-cps tone is heard in the commander's and system engineer's headset, and both master alarm lights are activated. Each master alarm light is located on their respective center panel. Pushing in on either light capsule cover activates a switch to disable the master alarm lights and the 3000-cps tone.



PANEL III



6. Panel XI - Commander's Upper Side Console Circuit Breaker Panel

The circuit breakers utilized by the Communications Subsystem are depicted in Figure 47 and are tabulated below:

- Secondary S-Band Power Amplifier
- VHF "A" Receiver
- Secondary S-Band Transceiver
- VHF "B" Transmitter
- Commander's Audio Center
- Digital Uplink Assembly
- S-Band Steerable Antenna

7. Panel XVI - System Engineer's Upper Side Console Circuit Breaker Panel

The circuit breakers utilized by the Communications Subsystem are depicted in Figure 48 and are tabulated below:

- SE Audio Center
- VHF "A" Transmitter
- VHF "B" Receiver
- Primary S-Band Power Amplifier
- Primary S-Band Transceiver
- S-Band Steerable Antenna (Control)
- Premodulation Processor
- Television Camera
- Display (Signal Strength and Pitch and Yaw Position)
- S-Band Steerable Antenna (Heater)

Figure 49 depicts the electrical power distribution to the Communications Subsystem.

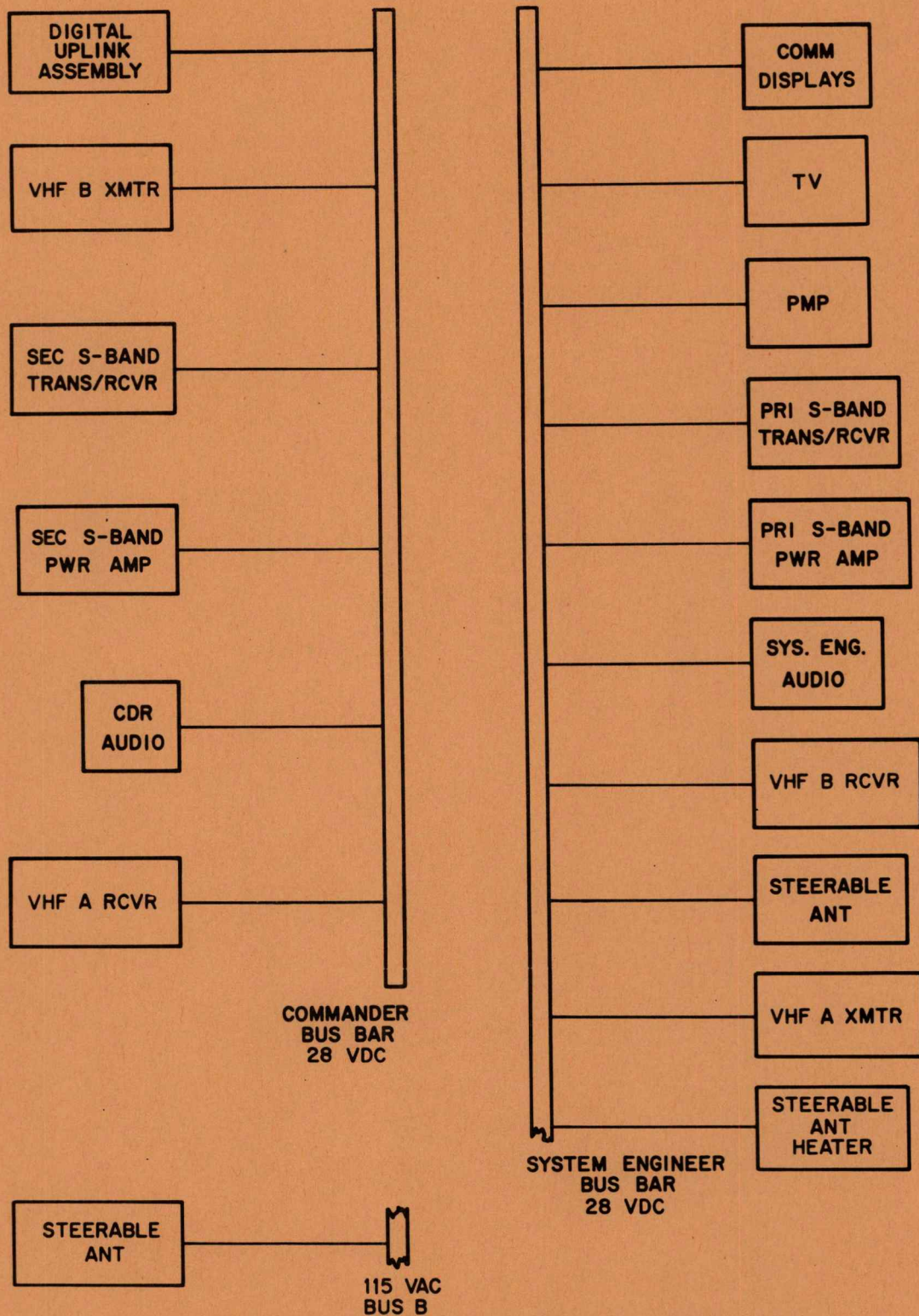


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Figure 48

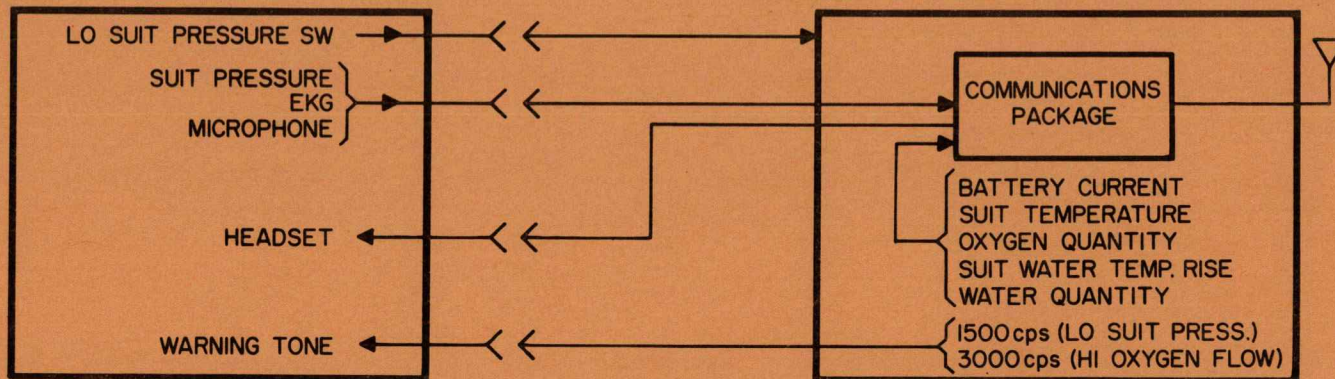


ELECTRICAL POWER DISTRIBUTION COMMUNICATION SUBSYSTEM

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SPACESUIT AND HELMET ASSEMBLY

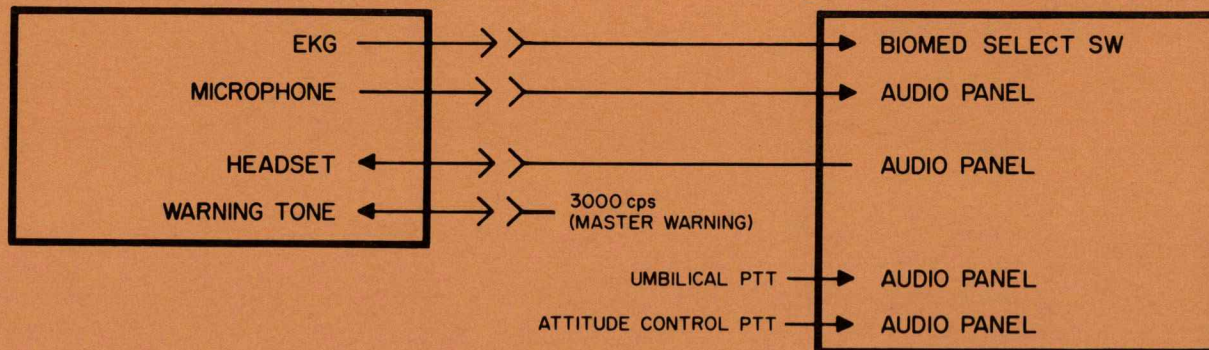
PORTABLE LIFE SUPPORT SYSTEM (PLSS)



SPACESUIT AND HELMET ASSEMBLY CONNECTED TO PLSS

SPACESUIT AND HELMET ASSEMBLY

LM COMMUNICATIONS SUBSYSTEM



SPACESUIT AND HELMET ASSEMBLY CONNECTED TO LM COMMUNICATIONS SUBSYSTEM

SPACE SUIT AND
HELMET ASSEMBLY

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TABLE II (AUDIO PANEL PORTION OF PANEL XII)

SWITCH NAME	POSITION	FUNCTIONAL USE	ADDITIONAL SWITCHING REQUIREMENTS
NORMAL/BACK-UP SW.	NORMAL	SYSTEM ENG MICROPHONE, HEADSET, AND PTT CIRCUITS ARE CONNECTED TO AUDIO CENTER NO. 2.	
	BACK-UP	SYSTEM ENG MICROPHONE, HEADSET, AND PTT CIRCUITS ARE CONNECTED TO AUDIO CENTER NO. 1.	
S-BAND AUDIO CONTROL SW.	S-BAND T/R	1. SYS ENG HEADSET CONNECTED TO S-BAND RECEIVED AUDIO.	1. SYS ENG RELAY SW "OFF". 2. SYS ENG VOX SW IN "ICS/XMTR" OR PTT USED. 3. VOICE SW IN "VOICE" OR "VOICE B/U". 4. PCM/KEY SW <u>NOT</u> IN "KEY" POSITION.
		2. SYS ENG MIC AUDIO PLACED ON S-BAND DOWNLINK CARRIER.	
		3. VHF A AND VHF B RECEIVED AUDIO PLACED ON S-BAND CARRIER.	
	OFF	SYS ENG HEADSET AND MIC NOT CONNECTED TO S-BAND RECEIVER AND TRANSMITTER.	1. CDR RELAY SW "ON". 2. SYS ENG VOX SW IN "ICS/XMTR". 3. VOICE SW IN "VOICE" OR "VOICE B/U". 4. PCM/KEY SW <u>NOT</u> IN "KEY" POSITION.
	S-BAND RCV	SYS ENG HEADSET CONNECTED TO S-BAND RECEIVER.	
VHF "A" AUDIO CONTROL SW	VHF "A" T/R	1. SYS ENG HEADSET CONNECTED TO VHF A RECEIVER.	SYS ENG VOX SW IN "ICS/XMTR" OR PTT USED. 1. CDR RELAY SW "ON". 2. SYS ENG VOX SW IN ICS/XMTR.
		2. SYS ENG MIC AUDIO PLACED ON VHF A CARRIER	
		3. VHF B RECEIVED AUDIO PLACED ON VHF A CARRIER	
		4. S-BAND RECEIVED AUDIO PLACED ON VHF A CARRIER	
	OFF	SYS ENG HEADSET AND MIC AUDIO NOT CONNECTED TO VHF A RECEIVER AND TRANSMITTER.	1. SYS ENG RELAY SW "ON". 2. SYS ENG VOX SW IN ICS/XMTR.
	VHF "A" RCV	SYS ENG HEADSET CONNECTED TO VHF A RCVR.	
VHF "B" AUDIO CONTROL SW	VHF "B" T/R	1. SYS ENG HEADSET CONNECTED TO VHF B RECEIVER.	1. SYS ENG VOX SW IN "ICS/XMTR" OR PTT USED. 2. VHF XMTR B POWER SW (TABLE III) IN "VOICE". 1. CDR RELAY SW "ON". 2. SYS ENG VOX SW IN "ICS/XMTR". 3. VHF XMTR "B" POWER SW IN "VOICE".
		2. SYS ENG MIC AUDIO PLACED ON VHF B CARRIER	
		3. VHF A RECEIVED AUDIO ON VHF B CARRIER.	
		4. S-BAND RECEIVED AUDIO ON VHF B CARRIER.	
	OFF	SYS ENG HEADSET AND MIC AUDIO NOT CONNECTED TO VHF B RECEIVER AND TRANSMITTER.	1. SYS ENG RELAY SW "ON". 2. SYS ENG VOX SW IN "ICS/XMTR". 3. VHF XMTR "B" POWER SW IN "VOICE".
	VHF "B" RCV	SYS ENG HEADSET CONNECTED TO VHF B RECEIVER.	

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TABLE II (AUDIO PANEL PORTION OF PANEL XII) (CONT.)

SWITCH NAME	POSITION	FUNCTIONAL USE	ADDITIONAL SWITCHING REQUIREMENTS
ICS AUDIO CONTROL SW	ICS/TR	1. SYS ENG MIC AUDIO PLACED ON ICS BUS AND SUPPLIED TO VOICE TAPE RECORDER.	SYS ENG VOX SW IN EITHER "ICS/XMTR" OR "ICS" OR PTT USED.
		2. VHF A AND VHF B RECEIVED AUDIO SUPPLIED TO VOICE TAPE RECORDER.	1. SYS ENG VOX SW IN EITHER "ICS/XMTR" OR "ICS". 2. CDR RELAY SW "ON".
		3. S-BAND RECEIVED AUDIO SUPPLIED TO VOICE TAPE RECORDER	1. SYS ENG VOX SW IN EITHER "ICS/XMTR" OR "ICS". 2. SYS ENG RELAY SW "ON".
		4. ICS BUS AUDIO CONNECTED TO SYS ENG HEADSET.	
	OFF	SYS ENG MIC AUDIO AND HEADSET NOT CONNECTED TO ICS BUS.	
	ICS/RCV	ICS BUS AUDIO CONNECTED TO SYS ENG HEADSET.	
VOX CONTROL SW	ICS/XMTR	1. SYS ENG MIC AUDIO WILL ENERGIZE VOICE TAPE RECORDER POWER RELAY AND BE APPLIED TO ICS BUS.	SYS ENG ICS AUDIO CONTROL SW IN "T/R".
		2. SYS ENG MIC AUDIO WILL ENERGIZE VHF "A" XMTR RELAY.	SYS ENG VHF A AUDIO CONTROL SW IN "T/R".
		3. SYS ENG MIC AUDIO WILL ENERGIZE VHF B XMTR RELAY	SYS ENG VHF B AUDIO CONTROL SW IN "T/R".
		4. SYS ENG MIC AUDIO WILL BE APPLIED AS INPUT TO S-BAND XMTR. MODULATOR.	1. SYS ENG S-BAND AUDIO CONTROL SW IN "T/R". 2. VOICE SW IN "VOICE" OR "VOICE B/U". 3. PCM/KEY SW NOT IN "KEY" POSITION.
		5. RECEIVED VHF A OR VHF B AUDIO WILL ENERGIZE VOICE TAPE RECORDER POWER RELAY, VHF A XMTR RELAY, VHF B XMTR RELAY, AND BE APPLIED AS INPUT TO S-BAND XMTR MODULATOR.	1. CDR RELAY SW "ON". 2. APPLICABLE AUDIO CONTROL SW IN "T/R".
		6. RECEIVED S-BAND AUDIO WILL ENERGIZE VOICE TAPE RECORDER POWER RELAY, VHF A XMTR RELAY AND VHF B XMTR RELAY.	1. SYS ENG RELAY SW "ON". 2. APPLICABLE AUDIO CONTROL SW IN "T/R".
	ICS	ENERGIZE VOICE TAPE RECORDER POWER RELAY AND VOICE APPLIED TO ICS BUS	SYS ENG ICS AUDIO CONTROL SW IN "T/R".
	PTT	TRANSMITTER AND VOICE TAPE RECORDER KEYING MUST BE ACCOMPLISHED WITH PTT BUTTONS.	
RELAY SW	ON	1. DISABLES S-BAND VOICE TRANSMISSIONS FROM SYS ENG AUDIO CENTER.	
		2. RETRANSMITS RECEIVED S-BAND AUDIO ON VHF B TRANSMITTER CARRIER.	1. SYS ENG VHF B AUDIO CONTROL SW IN "T/R". 2. SYS ENG VOX CONTROL SW IN "ICS/XMTR". 3. VHF "B" POWER SWITCH IN "VOICE".
		3. RETRANSMITS RECEIVED S-BAND AUDIO ON VHF A TRANSMITTER CARRIER.	1. SYS ENG VHF A AUDIO CONTROL SW IN "T/R". 2. SYS ENG VOX CONTROL SW IN "ICS/XMTR".
		4. RETRANSMITS RECEIVED VHF A AND VHF B AUDIO ON S-BAND CARRIER (AS CONTROLLED BY CDR'S AUDIO PANEL)	1. CDR S-BAND AUDIO CONTROL SW IN "T/R". 2. CDR VOX CONTROL SW IN "ICS/XMTR". 3. VOICE SW IN "VOICE" OR "VOICE B/U". 4. PCM/KEY SW NOT IN "KEY" POSITION.
		5. RETRANSMITS EVA EMU DATA ON S-BAND CARRIER	1. VOICE SW IN "VOICE". 2. VOICE SW IN "VOICE B/U" AND BIOMED SELECT SW IN "LEFT" OR "RIGHT". 3. PCM/KEY SW <u>NOT</u> IN "KEY".
	OFF	ENABLES S-BAND VOICE TRANSMISSIONS FROM SYS ENG AUDIO CENTER.	

TABLE III (COMMUNICATIONS PANEL PORTION OF PANEL XII)

SWITCH NAME	POSITION	FUNCTIONAL USE	ADDITIONAL SWITCHING REQUIREMENTS
MODULATION CONTROL SW	PM	ENABLES PHASE MODULATOR IN S-BAND TRANSMITTER AND DISABLES FREQ MODULATOR, ENABLES SPA PM MIXER	
	FM	ENABLES FREQUENCY MODULATOR IN S-BAND TRANSMITTER AND DISABLES PHASE MODULATOR, ENABLES SPA FM MIXER	1. VOICE CONTROL SW NOT IN "VOICE B/U". 2. PCM/KEY SW <u>NOT</u> IN "KEY" POSITION.
XMTR/RECEIVER POWER SW	PRIM	1. SUPPLIES 28VDC TO PRIMARY POWER SUPPLY IN S-BAND TRANSCEIVER. 2. ENABLES S-BAND POWER AMPLIFIER SW. 3. SUPPLIES 28 VDC to PREMODULATION PROCESSOR FOR EMERGENCY KEY FUNCTION. 4. SUPPLIES 28VDC TO PREMODULATION PROCESSOR FOR VOICE B/U FUNCTION.	PCM/KEY SW IN "KEY" POSITION. 1. VOICE SW IN "VOICE B/U" POSITION. 2. BIOMED SW IN "OFF" POSITION.
		NO S-BAND TRANSMISSION OR RECEPTION. POWER AMPLIFIER SW DISABLED.	
	SEC	1. SUPPLIES 28VDC TO SECONDARY POWER SUPPLY IN S-BAND TRANSCEIVER. 2. ENABLES S-BAND POWER AMPLIFIER SW. 3. SUPPLIES 28VDC TO PREMODULATION PROCESSOR FOR EMERGENCY KEY FUNCTION. 4. SUPPLIES 28VDC TO PREMODULATION PROCESSOR FOR VOICE B/U FUNCTION.	PCM/KEY SW IN "KEY" POSITION. 1. VOICE SW IN "VOICE B/U" POSITION. 2. BIOMED SW IN "OFF" POSITION.
POWER AMP POWER SW	PRIM	1. SUPPLIES 28VDC TO PRIMARY POWER SUPPLY IN S-BAND POWER AMPLIFIER. 2. SUPPLIES 24VDC TO 1.25 mc SUBCARRIER INDEX SW IN PMP. (MODULATION INDEX OF VOICE, BIOMED, EVA EMU SIGNALS IS LOWERED).	
	OFF	1. BOTH POWER AMPLIFIERS ARE DISABLED. S-BAND XMTR RF CAN STILL PASS THROUGH POWER AMP (3.2 DB MAXIMUM INSERTION LOSS) 2. SUPPLIES 24VDC TO 1.024 mc SUBCARRIER INDEX SW IN PMP. (MODULATION INDEX OF PCM NRZ DATA IS LOWERED).	
	SEC	1. SUPPLIES 28VDC TO SECONDARY POWER SUPPLY IN S-BAND POWER AMPLIFIER. 2. SUPPLIES 24VDC TO 1.25 mc SUBCARRIER INDEX SW IN PMP. (MODULATION INDEX OF VOICE, BIOMED, EVA EMU SIGNALS IS LOWERED).	
VOICE CONTROL SW	VOICE	A 1.25 mc SUBCARRIER (FREQUENCY MODULATED BY VOICE, BIOMED, AND EVA EMU SIGNALS), IS SUPPLIED AS AN INPUT TO PHASE MODULATOR AND FREQUENCY MODULATOR OF S-BAND TRANSMITTER.	PCM/KEY SW <u>NOT</u> IN "KEY" POSITION.
	OFF	TRANSMISSION OF VOICE, BIOMED, AND EVA EMU SIGNALS IS DISABLED.	
	VOICE B/U	1. FREQUENCY MODULATOR OF S-BAND TRANSMITTER DISABLED. 2. RANGE FUNCTION DISABLED. 3. VOICE, BIOMED, AND EVA EMU SIGNALS PHASE MODULATE S-BAND CARRIER FREQUENCY 4. VOICE SIGNALS ONLY PHASE MODULATE S-BAND CARRIER FREQUENCY.	1. BIOMED SW IN "LEFT" OR "RIGHT" POSITION. 2. PCM/KEY SW NOT IN "KEY" POSITION. 1. BIOMED SW IN "OFF" POSITION. 2. PCM/KEY SW <u>NOT</u> IN "KEY" POSITION.

TABLE III (COMMUNICATIONS PANEL PORTION OF PANEL XII)(CONT.)

SWITCH NAME	POSITION	FUNCTIONAL USE	ADDITIONAL SWITCHING REQUIREMENTS
PCM/KEY SW	PCM	A 1.024 mc SUBCARRIER (PHASE MODULATED BY PCM NRZ DATA), IS APPLIED AS AN INPUT TO PHASE MODULATOR AND FREQUENCY MODULATOR OF S-BAND TRANSMITTER.	MORSE CODE KEYING ACCOMPLISHED WITH PTT BUTTON SWITCH ON COMMANDER OR SYS ENG'S UMBILICAL.
	OFF	THE 1.024 mc SUBCARRIER CIRCUITRY IS DISABLED.	
	KEY	1. FREQUENCY MODULATOR DISABLED. 2. VOICE, BIOMED, EVA EMJ, RANGE, AND PCM FUNCTIONS DISABLED. 3. A KEYED 512 KC SUBCARRIER PHASE MODULATES THE S-BAND CARRIER FREQ.	
RANGE/TV SWITCH	RANGE	1. RANGE FUNCTION ENABLED. 2. S-BAND RCVR CAUTION LIGHT CIRCUITRY DISABLED.	1. MODULATOR SW IN "PM" POSITION. 2. PCM/KEY SW NOT IN "KEY" POSITION. 3. VOICE SW NOT IN "VOICE B/U" POSITION.
	OFF/RE-SET	1. RANGE FUNCTION DISABLED. 2. RESETS S-BAND RCVR CAUTION LIGHT (IF ILLUMINATED). 3. DISABLES S-BAND RCVR CAUTION LIGHT CIRCUITRY.	1. MODULATOR SW IN "FM" POSITION. 2. PCM/KEY SW NOT IN "KEY" POSITION. 3. VOICE SW NOT IN "VOICE" B/U" POSITION.
	TV/CWEA ENABLE	1. RANGE FUNCTION DISABLED. 2. S-BAND RCVR CAUTION LIGHT CIRCUITRY ENABLED. 3. TELEVISION CAMERA VIDEO FREQUENCY MODULATES S-BAND CARRIER.	
VHF A XMTR SWITCH	ON	28VDC APPLIED TO VHF A TRANSMITTER POWER SUPPLY.	
	OFF	NO OPERATING POWER TO VHF A TRANSMITTER.	
VHF A RCVR SWITCH	ON	28VDC APPLIED TO VHF A RECEIVER.	
	OFF	NO OPERATING POWER TO VHF A RECEIVER.	
VHF B XMTR SWITCH	VOICE	1. 28VDC APPLIED TO VHF B TRANSMITTER POWER SUPPLY. 2. DATA CIRCUITRY DISABLED.	TRANSMISSION OF DATA VIA VHF CARRIER REQUIRES PCM SW TO BE IN "LO" POSITION.
	OFF	NO OPERATING POWER TO VHF B TRANSMITTER.	
	DATA	1. 28VDC APPLIED TO VHF B TRANSMITTER POWER SUPPLY. 2. TRANSMIT RELAY IN VHF B TRANSMITTER ENERGIZED. 3. VOICE CIRCUITRY DISABLED.	
VHF B RCVR SWITCH	ON	28VDC APPLIED TO VHF B RECEIVER.	
	OFF	NO OPERATING POWER TO VHF B RECEIVER.	
BIOMED SELECT SWITCH	LEFT	COMMANDER'S EKG APPLIED TO PREMODULATION PROCESSOR FOR SIGNAL PROCESSING PRIOR TO S-BAND TRANSMISSION.	1. VOICE SW IN "VOICE" OR "VOICE B/U" POSITIONS. 2. PCM/KEY SW NOT IN "KEY" POSITION.
	OFF	COMMANDER AND SYS ENG'S EKG CIRCUITRY DISABLED.	1. VOICE SW IN "VOICE" OR "VOICE B/U" POSITIONS. 2. PCM/KEY SW NOT IN "KEY" POSITION.
	RIGHT	SYS ENG'S EKG APPLIED TO PREMODULATION PROCESSOR FOR SIGNAL PROCESSING PRIOR TO S-BAND TRANSMISSION.	

TABLE III (COMMUNICATIONS PANEL PORTION OF PANEL XII) (CONT.)

SWITCH NAME	POSITION	FUNCTIONAL USE	ADDITIONAL SWITCHING REQUIREMENTS
PCM CONTROL SWITCH	HI	PCM NRZ DATA APPLIED TO PMP (51.2 KBS) FOR S-BAND-----	REFER TO PCM/KEY SW USE.
	LO	1. PCM NRZ DATA APPLIED TO PMP (1.6 KBS) FOR S-BAND ----	REFER TO PCM/KEY SW USE.
		2. PCM SPLIT PHASE DATA APPLIED TO VHF B TRANSMITTER----- (1.6 KBS) FOR VHF TRANSMISSION.	REFER TO VHF B TRANSMITTER CONTROL SW USE.
RECORDER SW	ON	VOICE TAPE RECORDER PLACED IN STANDBY. -----	REFER TO TABLE II AND TABLE IV FOR REQUIRED AUDIO PANEL SWITCHING.
	OFF	NO OPERATING POWER TO VOICE TAPE RECORDER.	

TABLE IV (AUDIO PANEL PORTION OF PANEL VIII)

SWITCH NAME	POSITION	FUNCTIONAL USE	ADDITIONAL SWITCH REQUIREMENTS
NORMAL/BACK-UP	NORMAL	COMMANDER'S MICROPHONE, HEADSET, AND P.T.T. CIRCUITS ARE CONNECTED TO AUDIO CENTER NO. 1.	
	BACK-UP	CDR'S MIC, HEADSET, AND PTT CIRCUITS ARE CONNECTED TO AUDIO CENTER NO.2	
S-BAND AUDIO CONTROL SW	S-BAND T/R	1. CDR'S HEADSET CONNECTED TO S-BAND RECEIVED AUDIO. 2. CDR'S MIC AUDIO PLACED ON S-BAND DOWNLINK CARRIER.	1. CDR'S RELAY SW "OFF". 2. CDR'S VOX SW IN "ICS/XMTR" OR PTT USED. 3. VOICE SW (TABLE III) IN "VOICE" OR "VOICE B/U". 4. PCM/KEY SW (TABLE III) <u>NOT</u> IN "KEY" POSITION.
		3. VHF "A" AND VHF "B" RECEIVED AUDIO PLACED ON S-BAND CARRIER.	1. SYS ENG'S RELAY SW "ON". 2. CDR'S VOX SW IN "ICS/XMTR". 3. VOICE SW IN "VOICE" OR "VOICE B/U". 4. PCM/KEY SW <u>NOT</u> IN "KEY" POSITION.
	OFF	CDR'S HEADSET AND MIC NOT CONNECTED TO S-BAND RECEIVER AND TRANSMITTER.	
	S-BAND RCV	CDR'S HEADSET CONNECTED TO S-BAND RECEIVER.	
VHF "A" AUDIO CONTROL SW	VHF "A" T/R	1. CDR'S HEADSET CONNECTED TO VHF "A" RECEIVER. 2. CDR'S MIC AUDIO PLACED ON VHF "A" TRANSMITTER CARRIER. 3. VHF "B" RECEIVED AUDIO PLACED ON VHF "A" TRANSMITTER CARRIER. 4. S-BAND RECEIVED AUDIO PLACED ON VHF A TRANSMITTER CARRIER.	CDR'S VOX SW IN ICS/XMTR OR PTT USED. 1. SYS ENG'S RELAY SW "ON". 2. CDR'S VOX SW IN "ICS/XMTR"
			1. CDR'S RELAY SW "ON". 2. CDR'S VOX SW IN "ICS/XMTR".
	OFF	CDR'S HEADSET AND MIC AUDIO NOT CONNECTED TO VHF "A" RECEIVER AND TRANSMITTER.	
	VHF "A" RCV	CDR'S HEADSET CONNECTED TO VHF "A" RECEIVER.	
VHF "B" AUDIO CONTROL SW	VHF "B" T/R	1. CDR'S HEADSET CONNECTED TO VHF "B" RECEIVER. 2. CDR'S MIC AUDIO PLACED ON VHF "B" TRANSMITTER CARRIER.	1. CDR's VOX SW IN "ICS/XMTR" OR PTT USED. 2. VHF XMTR "B" POWER SW (TABLE III) IN "VOICE".
		3. VHF "A" RECEIVED AUDIO PLACED ON VHF B TRANSMITTER CARRIER.	1. SYS ENG'S RELAY SW "ON". 2. CDR'S VOX SW IN "ICS/XMTR". 3. VHF XMTR "B" POWER SW IN "VOICE".
		4. S-BAND RECEIVED AUDIO PLACED ON VHF "B" TRANSMITTER CARRIER	1. CDR's RELAY SW "ON". 2. CDR'VOX SW IN "ICS/XMTR". 3. VHF XMTR B POWER SW IN "VOICE".

TABLE IV (AUDIO PANEL PORTION OF PANEL VIII) (CONT.)

SWITCH NAME	POSITION	FUNCTIONAL USE	ADDITIONAL SWITCHING REQUIREMENTS
ICS AUDIO CONTROL SW	ICS T/R	1. CDR'S MIC AUDIO PLACED ON ICS BUS AND SUPPLIED TO VOICE TAPE RECORDER 2. VHF "A" AND VHF "B" RECEIVED AUDIO SUPPLIED TO VOICE TAPE RECORDER. 3. S-BAND RECEIVED AUDIO SUPPLIED TO VOICE TAPE RECORDER. 4. ICS BUS AUDIO CONNECTED TO CDR'S HEADSET.	--- CDR'S VOX SW IN "ICS/XMTR" OR "ICS" OR PTT USED. 1. SYS ENG'S RELAY SW "ON". 2. CDR'S VOX SW IN "ICS/XMTR" or "ICS". 1. CDR'S RELAY SW "ON". 2. CDR'S VOX SW IN "ICS/XMTR" OR "ICS".
	OFF	CDR'S MIC AUDIO AND HEADSET NOT CONNECTED TO ICS BUS.	
	ICS/RCV	ICS BUS AUDIO CONNECTED TO CDR'S HEADSET.	
VOX CONTROL SW	ICS/XMTR	1. CDR'S MIC AUDIO WILL ENERGIZE VOICE TAPE RECORDER POWER RELAY AND BE APPLIED TO ICS BUS. 2. CDR'S MIC AUDIO WILL ENERGIZE VHF "A" XMTR RELAY. 3. CDR'S MIC AUDIO WILL ENERGIZE VHF "B" XMTR RELAY. 4. CDR'S MIC AUDIO WILL BE APPLIED AS INPUT TO S-BAND XMTR MODULATOR. 5. RECEIVED VHF "A" OR VHF "B" AUDIO WILL ENERGIZE VOICE TAPE RECORDER POWER RELAY, VHF "A" XMTR RELAY, VHF "B" XMTR RELAY, AND BE APPLIED AS INPUT TO S-BAND XMTR MODULATOR. 6. RECEIVED S-BAND AUDIO WILL ENERGIZE VOICE TAPE RECORDER POWER RELAY, VHF "A" XMTR RELAY AND VHF "B" XMTR RELAY.	--- CDR'S ICS AUDIO CONTROL SW IN "T/R". --- CDR'S VHF "A" AUDIO CONTROL SW IN "T/R". --- CDR'S VHF "B" AUDIO CONTROL SW IN "T/R". 1. CDR'S AUDIO CONTROL SW IN "T/R". 2. VOICE SW IN "VOICE" OR "VOICE B/U". 3. PCM/KEY SW NOT IN KEY POSITION. 1. SYS ENG'S RELAY SW ON. 2. APPLICABLE AUDIO CONTROL SW IN "T/R". 1. CDR's RELAY SW "ON". 2. APPLICABLE AUDIO CONTROL SW IN "T/R".
	ICS	ENERGIZE VOICE TAPE RECORDER POWER RELAY AND AUDIO APPLIED TO ICS BUS.	CDR'S ICS AUDIO CONTROL SW IN "T/R".
	PTT	TRANSMITTER AND VOICE TAPE RECORDER KEYING MUST BE ACCOMPLISHED WITH PTT BUTTONS.	
RELAY SW	ON	1. DISABLES S-BAND VOICE TRANSMISSIONS FROM CDR'S AUDIO CENTER. 2. RETRANSMITS RECEIVED S-BAND AUDIO ON VHF "B" TRANSMITTER CARRIER. 3. RETRANSMITS RECEIVED S-BAND AUDIO ON VHF "A" TRANSMITTER CARRIER. 4. RETRANSMITS RECEIVED VHF "A" and VHF "B" AUDIO ON S-BAND CARRIER. (AS CONTROLLED BY SYS ENG'S AUDIO PANEL) 5. RETRANSMITS EVA EMU DATA ON S-BAND CARRIER.	1. CDR's VHF B AUDIO CONTROL SW IN "T/R". 2. CDR'S VOX CONTROL SW IN "ICS/XMTR". 3. VHF "B" POWER SW IN "VOICE". 1. CDR'S VHF "A" AUDIO CONTROL SW IN "T/R". 2. CDR'S VOX SW IN "ICS/XMTR". 1. SYS ENG'S S-BAND AUDIO CONTROL SW IN "T/R". 2. SYS ENG'S VOX CONTROL SW IN "ICS/XMTR". 3. VOICE SW IN "VOICE" OR "VOICE B/U". 4. PCM/KEY SW NOT IN "KEY" POSITION. 1. VOICE SW IN "VOICE". 2. VOICE SW IN "VOICE B/U" AND BIOMED SELECT SW IN "LEFT" OR "RIGHT". 3. PCM/KEY SW NOT IN "KEY".
	OFF	ENABLES S-BAND VOICE TRANSMISSIONS FROM CDR'S AUDIO CENTER.	

SECTION III

APPENDICES

A. Circulators

Ferrite circulators have application in the S-Band Transceiver and the S-Band Power Amplifier to act as circuit isolators.

As seen in Figure 51, the circulator is a three port device, with driving RF power applied to port one, the output at port two, and a 50-ohm load connected to port three. Also circulators exhibit low attenuation in the forward direction.

An RF input at port one will be rotated to port two by a strong magnetic field. Signal coupling to port three is not accomplished because of incorrect phase polarization.

Any reflected power caused by circuit mismatches, etc., is absorbed by the Load at port three. The amount of attenuation in the reverse direction is in the order of 20-25 db.

B. Amplitron Tube (1)

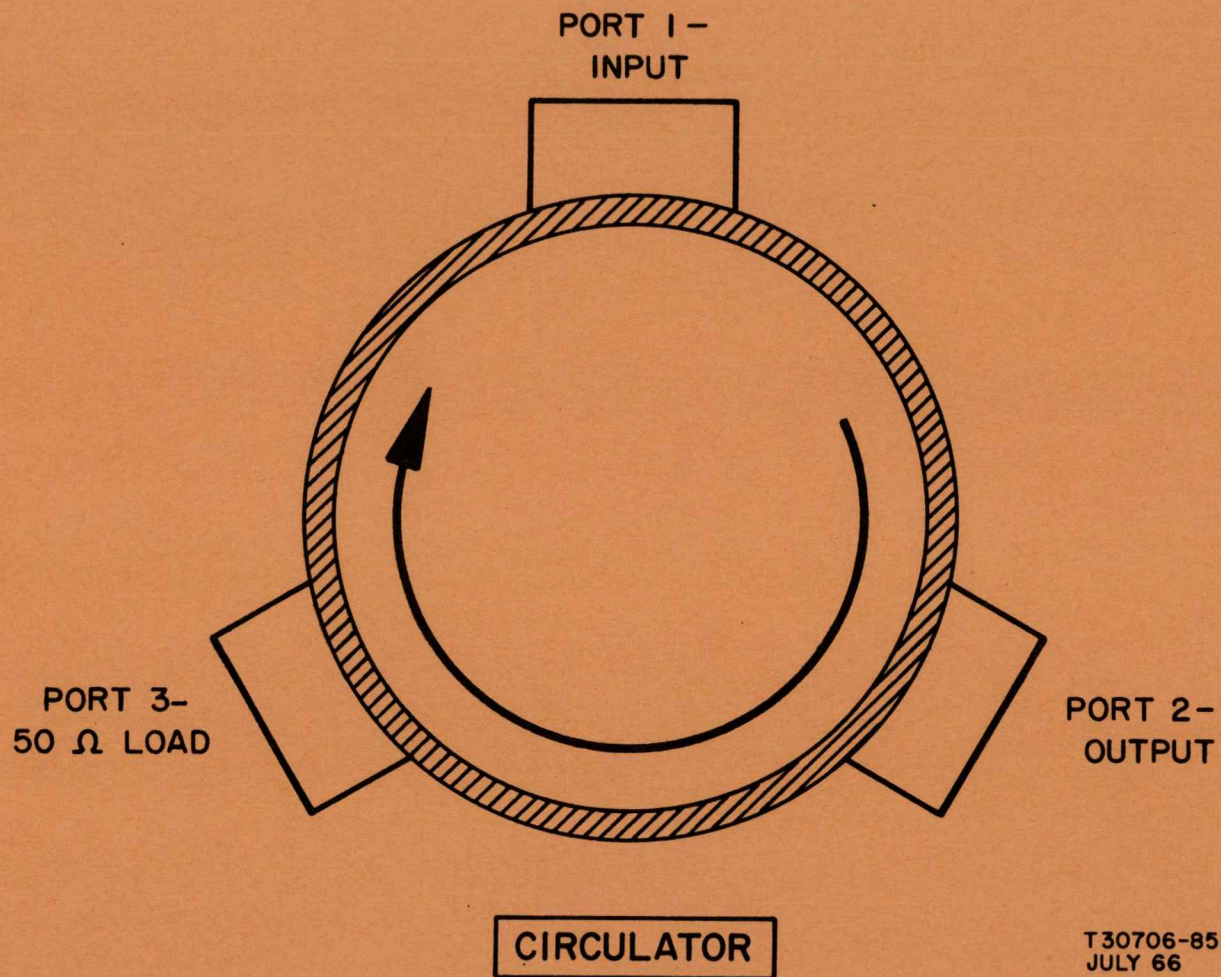
The Amplitron is a crossed-field amplifier characterized by a high peak and average power output, broad bandwidth, exceptionally high efficiency, but low gain.

The physical structure of the magnetron oscillator and the Amplitron are similar, but their characteristics are quite different. The chief physical difference between the two is that the Amplitron uses two external couplings (an input and an output) and the magnetron has but one.

A drawing of the workings of an Amplitron is shown in Figure 52. The electrons originate from a continuously coated cathode coaxial to the RF circuit. The anode consists of a series of vanes. It acts as both a slow-wave RF circuit with which the electrons interact, and as an electrode for the collection of electrons.

The Amplitron is a crossed-field device in that the electron beam is perpendicular to both the electric and magnetic fields, just as in the magnetron.

(1) McGraw-Hill, Introduction to Radar Systems, Skolnick



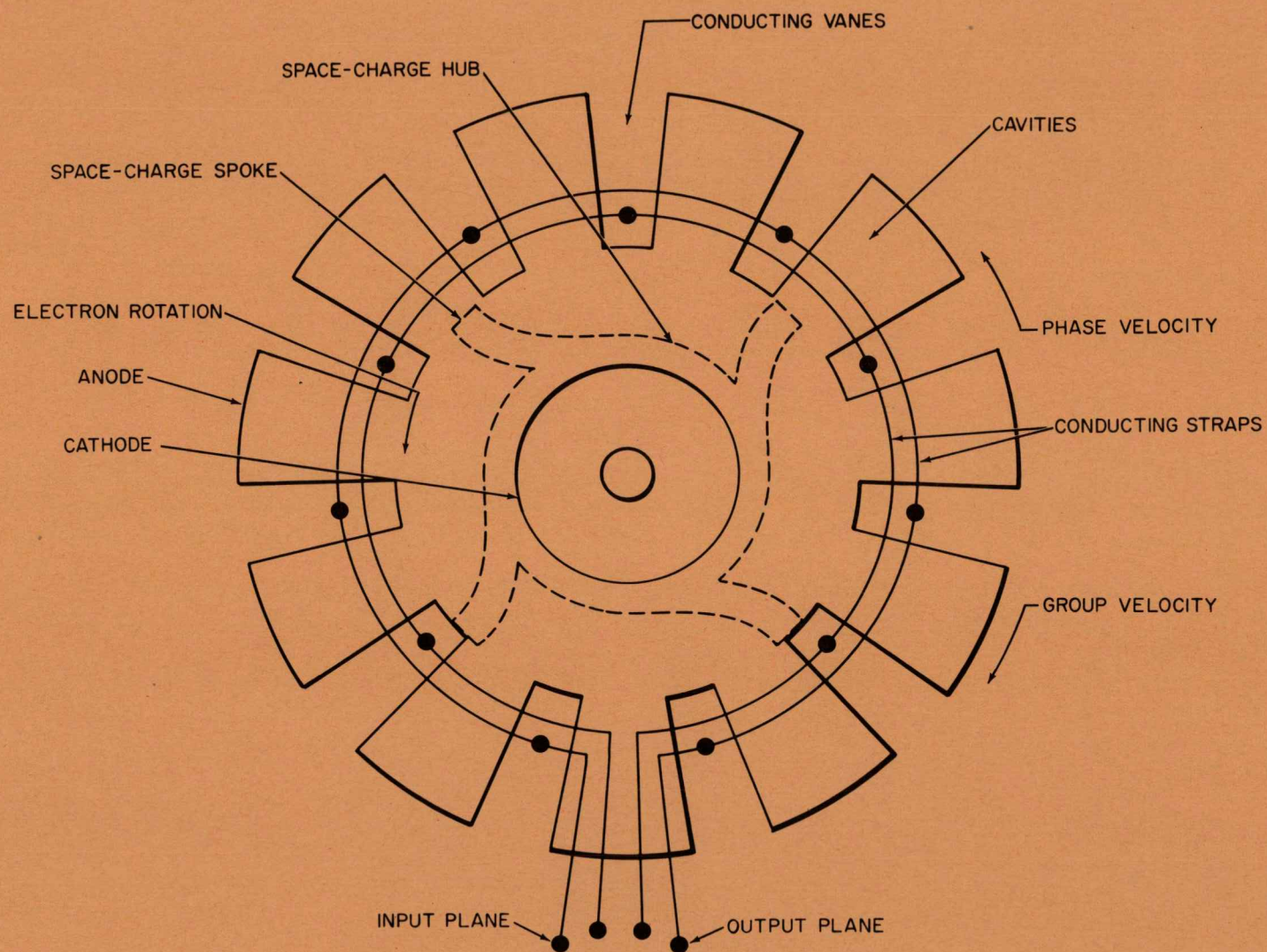
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Its operation is similar in some respects to the traveling-wave tube amplifier since amplification occurs because of an interaction between a traveling electromagnetic wave and a rotating space-charge wave. The space-charge waves in the Amplitron are formed by the interaction between the electron beam and the crossed electric and magnetic fields. In the traveling-wave tube amplifier the space-charge wave interacts with a forward wave, that is, a wave whose phase velocity is in the same direction as the power flow. It is also possible for the RF periodic structure to support backward waves, or waves whose phase velocity is opposite to the power flow. A traveling-wave tube in which the space-charge wave is coupled to a backward wave is known as a backward-wave amplifier. Space-charge waves in a crossed-field-magnetron-type device can couple with either a forward or a backward wave. The crossed-field device called the magnetron amplifier uses the forward wave and can attain efficiencies of about 50 percent, bandwidths of 15 percent, gains of 15 db, and output power of several megawatts peak. The crossed-field device which couples the backward-wave to the space-charge wave (Amplitron) has a higher rate of gain than the forward-wave device (magnetron amplifier) and for the same length will be more efficient.

Figure 52 shows that the electron beam reenters the interaction space just as in the magnetron oscillator. However, unlike that of the magnetron, the RF circuit is not reentrant. The RF output and the RF input are decoupled. In this sense, the RF circuit of the Amplitron is related more to that of the traveling-wave tube than to the magnetron. The nonreentrant circuit of the Amplitron permits a broader bandwidth than the reentrant circuit of the conventional magnetron oscillator.

The Amplitron behaves as a saturated amplifier rather than as a linear amplifier. The characteristic of a saturated amplifier is that the magnitude of the RF output is independent of the RF input, but dependent on the DC input. Although a saturated amplifier cannot be used in some applications, such as, for example, AM voice communications, there are but few restrictions on its use as a pulsed amplifier for most radar applications. A saturated amplifier is compatible with frequency modulation, and it may be used with radars designed with pulse compression.

A plot of the RF power output as a function of the RF and DC modulator input power is shown in Figure 52 for the Raytheon QK 520 L-Band Amplitron. For constant DC input power, the RF output power is relatively independent of the RF input power, except when the RF input becomes comparable with the RF output. This departure from saturated amplifier behavior results from a slight increase in efficiency with large RF input power and because the input power reappears unattenuated at the output and adds to the RF power



BASIC STRUCTURE OF THE AMPLITRON

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generated by the Amplitron itself. If, at a given level of DC power, the RF input is reduced below a certain level, the device ceases to act as an amplifier. In this region (shown shaded in Figure 53), the RF output is noisy, poorly defined, and at some other frequency than the input signal. The transition region between the area in which the input does not control RF output and the area in which performance is satisfactory is well defined and of negligible width.

The conversion efficiency of an Amplitron is defined as follows:

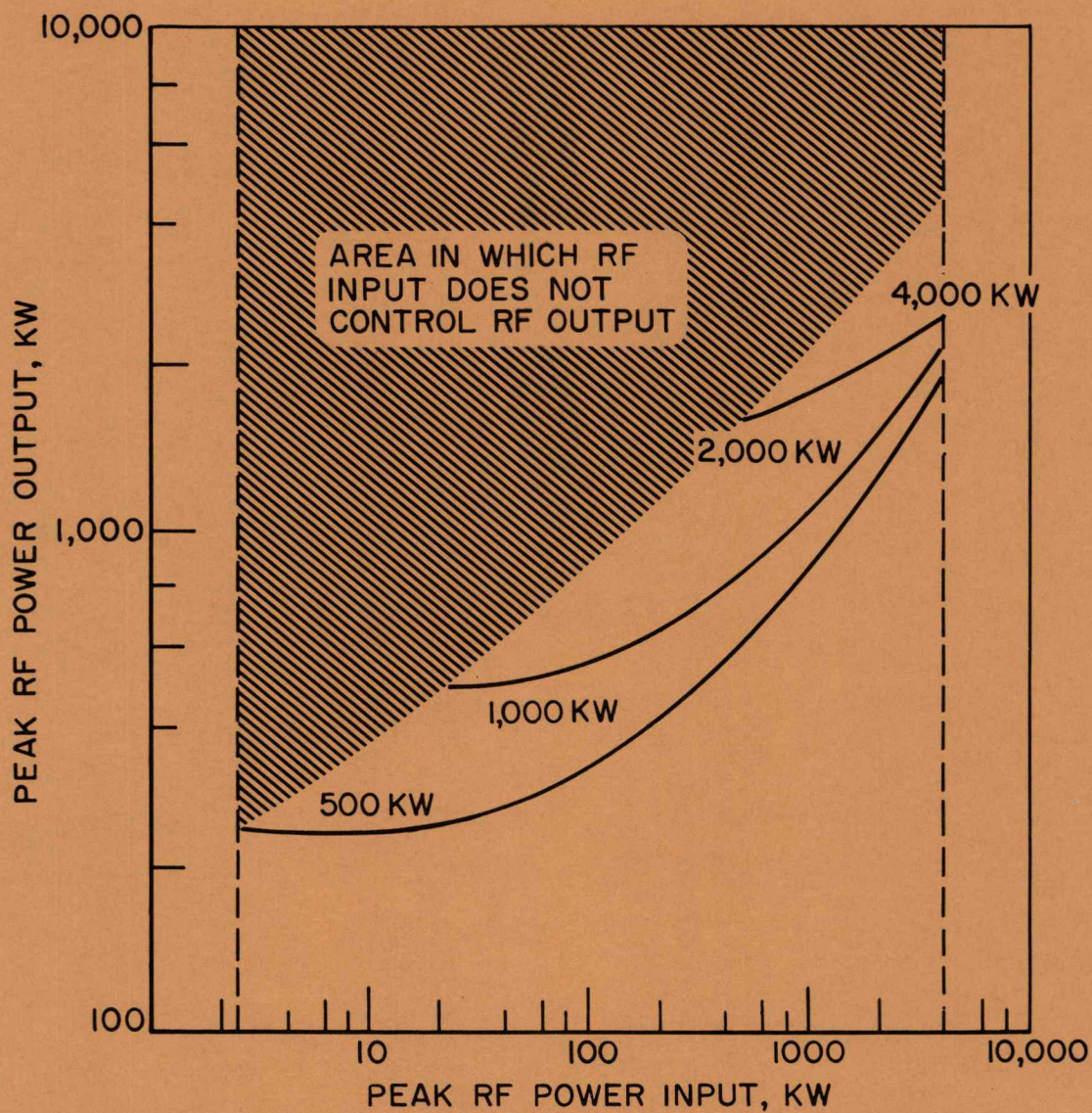
$$\text{Efficiency} = \frac{\text{RF power output} - \text{RF power input}}{\text{modulator power input to Amplitron}}$$

This is a conservative definition since the RF input power is not lost but appears as part of the output. In a low-gain amplifier the input power which appears at the output may be sizable fraction of the total.

The phase shift through the Amplitron caused by a change in the DC current applied to the device is called phase pushing, by analogy with the term frequency pushing, which describes a similar phenomenon in oscillators where the frequency is changed or pushed as the current is changed. Phase pushing in an Amplitron is usually quite small compared with other microwave amplifiers, being of the order of a fraction of a degree per ampere. Low phase pushing is important in radar applications where zero or negligible phase shift must be maintained between input and output.

The Amplitron acts as a passive transmission line when the high voltage is removed. Its insertion loss is low, typically 0.2 to 1.0 db. Therefore an RF signal traveling in the reverse direction from the output to the input suffers little attenuation. This differs from other amplifiers in which the reversed signal is highly attenuated. This low attenuation in the backward direction requires that a circulator or some other isolation device be used between Amplitron and driver to prevent the reflected power from interfering with the driver portion of the transmitter or from building up into oscillation.

Amplitron voltages are lower than those of the klystron or the traveling-wave tube and are comparable with those of the magnetron. A magnetic field is required just as with the magnetron. Permanent magnets are usually used. The magnitude of the magnetic field represents a compromise between magnet weight and the higher efficiency which can be obtained with large magnets.



QK 520 L-BAND AMPLITRON CHARACTERISTICS

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C. Communications Abbreviations and Acronyms

AGC	Automatic Gain Control
BPF	Band Pass Filter
CP	Circular Polarization
CSM	Command Service Module
CWEA	Caution and Warning Electronics Assembly
DA	Differential Amplifier
DET	Detector
DS	Diode Switch
DSEA	Data Storage Electronics Assembly
DUA	Digital Uplink Assembly
EF	Emitter Follower
EKG	Electrocardiogram
EMU	Extravehicular Mobility Unit
ERA	Electronic Replaceable Assembly
EVA	Extravehicular Astronaut
FSPD	Frequency Sensitive Power Divider
HPF	High Pass Filter
ICS	Internal Communications System
Kb/s	Kilo bits/second
LESP	LM Equipment Specification
LM	Lunar Module
LOS	Line of Sight
LPF	Low Pass Filter
LSP	LM Specification
LTR	Limiter
MSC	Manned Spacecraft Center
MSFN	Manned Space Flight Network
NRZ	Non Return to Zero

OMNI	Omnidirectional
PCM	Pulse Code Modulation
PLSS	Portable Life Support System
PMP	Premodulation Processor
PRN	Pseudo-Random Noise
PTT	Push-to-Talk
RF	Radio Frequency
SCO	Subcarrier Oscillator
SPA	Signal Processor Assembly
SPE	Static Phase Error
SS	Signal Strength
TM	Telemetry
VCO	Voltage Controlled Oscillator
VHF	Very High Frequency
VOX	Voice Operated Transmit

LSG 770-430-27 - LTA-8

COMMUNICATIONS SUBSYSTEM

STUDY GUIDE

LUNAR MODULE

LTA-8

CONTRACT NAS 9-1100

EXHIBIT E; PARAGRAPH 3.7.4

TYPE III DOCUMENT

FOR TRAINING PURPOSES ONLY; IN
SUPPORT OF LTA-8 SUBSYSTEM BRIEFINGS

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LTA-8 DATA SHEET

I ON-BOARD EQUIPMENT

<u>Nomenclature</u>	<u>Location</u>
ERA-1 S-Band Transceiver	Aft Equipment Bay
ERA-2 S-Band Power Amplifier	Aft Equipment Bay
ERA-3 VHF Transmitter/Receiver	Aft Equipment Bay
ERA-4 Signal Processor Assembly	Aft Equipment Bay
ERA-5 S-Band Steerable Antenna	Tripod Boom, +X, +Y
C-Band Transponders }	-Y, +X, Between Cabin and Exterior Skin
C-Band Power Dividers }	
Modulation Packages }	Cabin Interior, Rear Bulkhead and -Y Bulkhead
DFI-VHF Transmitters }	
UHF/VHF Multiplexer }	
UHF/VHF Diplexer }	
Dual Feed Coupler }	
Digital Command Assembly }	
Ascent Engine Arming Assembly }	
Four Port Power Divider }	+X, +Y, Between Cabin and Exterior Skin
Pri and Sec SLA/LM Transfer Relays }	

II EQUIPMENT CHARACTERISTICS, FREQUENCIES, AND DATA INTERCHANGE

A. S-Band

1. Transceiver

- | | |
|-----------------------------|-----------|
| a. Power Requirements | 36 watts |
| b. Receiver Characteristics | |
| (1) Phase lock | |
| (2) Frequency | 2101.8 mc |
| (3) Sensitivity | -127 dbm |

c. Transmitter Characteristics

- | | |
|---------------------|----------------------------------|
| (1) Modulation | PM or FM |
| (2) Frequency | FM-2282.5 mc
PM-240/221 Fr mc |
| (3) RF Power Output | 0.75 to 1.5 watts |

2. Power Amplifier

- | | |
|---------------------------|------------|
| a. Power Requirements | ≈ 70 watts |
| b. Minimum RF Drive Level | 0.72 watts |
| c. RF Power Output | ≈ 20 watts |

3. Steerable Antenna

- | | |
|---|----------------------|
| a. Power Requirements - DC | ≈ 15.7 watts |
| - AC | ≈ 4.15 watts |
| b. Stow Position - Xg | -30° |
| - Yg | +255° |
| c. Gimbal Coverage - Xg | +75° |
| - Yg | -75° to +255° |
| d. Track Performance - Velocity | 20°/sec |
| - Acceleration | 60°/sec ² |
| e. Manual positioning by Panel XII controls and position indication displayed on Panel XII. | |

B. VHF

1. Receiver Characteristics

- | | |
|--------------------------|-------------|
| a. Power Requirements | ≈ 1.4 watts |
| b. Frequency - Channel A | 296.8 mc |
| - Channel B | 259.7 mc |
| c. AM, Fixed Tuned | |
| d. IF | 30.0 mc |

2. Transmitter Characteristics

- a. Power Requirements - Transmit \approx 28.9 watts
- b. Frequency - Channel A 296.8 mc
- Channel B 259.7 mc
- c. Modulation - Clipped Speech
Type AM (Voice)

Input - Channel A Voice
- Channel B Voice, Low Bit Rate
Split Phase PCM
- d. RF Power Output 3.8 watts average

C. C-Band Transponder

- 1. Power Requirements \approx 56 watts
- 2. Receiver Characteristics
 - a. Frequency 5690 mc
 - b. Sensitivity -70 dbm
- 3. Transmitter Characteristics
 - a. Frequency 5765 mc
 - b. PRF 0-2670 pps
 - c. RF Power Output 500 to 750 watts peak
- 4. Double Pulse Interrogation, Single Pulse Reply

D. DFI-VHF

- 1. Power Requirements \approx 56 watts/transmitter
- 2. RF Power Output \approx 10 watts peak

3. Operating Frequencies

a. VHF A	230.9 mcs
b. VHF B	237.8 mcs
c. VHF C	241.5 mcs
d. VHF D	247.3 mcs
e. VHF E	257.3 mcs

E. Digital Command Assembly (DCA)

1. Power Requirements ≈ 15 watts
2. Receiver-decoder for digital uplink
3. RF Carrier 450-mc
4. Modulation
 - a. Of Subcarrier Phase Shift Keying (PSK)
 - b. Of Carrier FM
5. Sensitivity -99 dbm

F. Data Interchange

1. S-Band
 - a. Uplink - voice on 30 kc subcarrier
 - b. Downlink
 - (1) PCM Data on 1.024 mc subcarrier
 - (2) Voice - 300-3000 cps
 - EMU - 4 kc - 12.4 kc
 - EKG - 14.5 kc
- } on 1.25 mc subcarrier

2. VHF

- a. Channel A - Transmit or Receive Voice
- b. Channel B - Transmit Voice or Low Bit Rate Split Phase Data
 - Receive Voice and Extravehicular Mobility Unit (EMU) Data

3. C-Band

- a. Uplink - Double pulse input; Pulse spacing = 3.5 usec; Pulse width \approx 5 usec
- b. Downlink - Single pulse out approximately 3 usec after double pulse interrogation input; Pulse width = 0.75 usec

4. DFI-VHF

- a. PCM data transmitted on Channel B
- b. Temperature, vibration, and strain measurements transmitted on Channel A, C, D, and E.

III GROUND SUPPORT EQUIPMENT (GSE)

A. 410-32280-5 - Communication Test Station (CTS)

The CTS consists of an integrated combination of modified commercial and special purpose electronic test equipment. Racks 1 through 10 of the CTS are used to perform acceptance level tests on the LM Communications Assemblies (ERA-1 through ERA-4). These racks provide RF stimulus and measurement capability for interface with the LM Communications Subsystem via GAEC or NASA facilities for bench testing, hard-line testing, or radiation link testing. Rack 11 contains those equipments necessary for the checkout of the LM television equipment.

B. 410-92112-1 - C-Band Checkout Unit

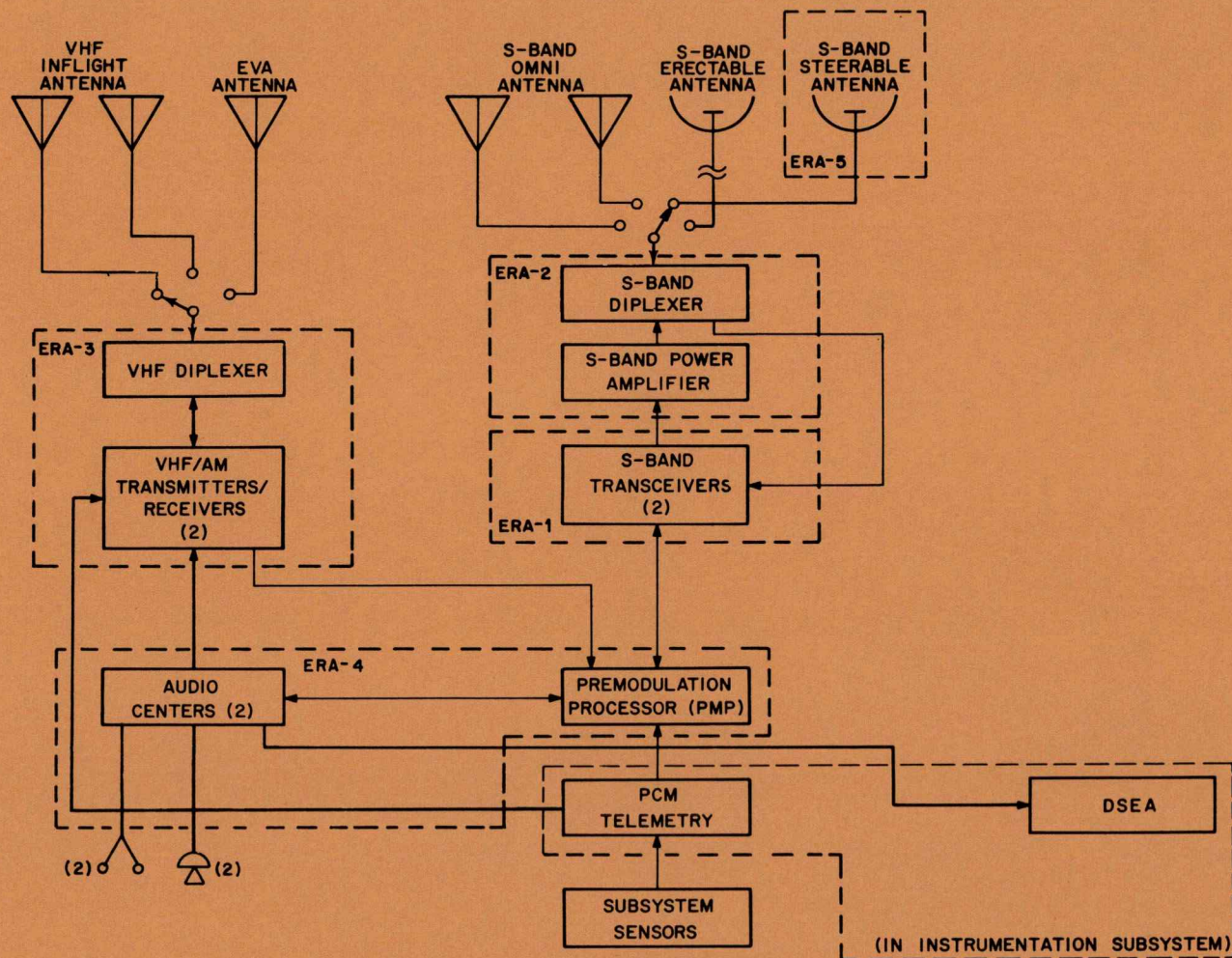
The C-Band Checkout Unit, is used for testing and operational checkout of the C-Band Transponder. The checkout unit develops the pulse-modulated R-F signals used to interrogate the transponder and provides facilities for monitoring the resultant signals developed by the C-Band Transponder under test.

C. 410-11085-1 - Data Acquisition Rack

The Data Acquisition Rack is used for the control of the DFI equipment and the recording or display of LTA-8 modulation package outputs and VHF-DFI transmitter outputs.

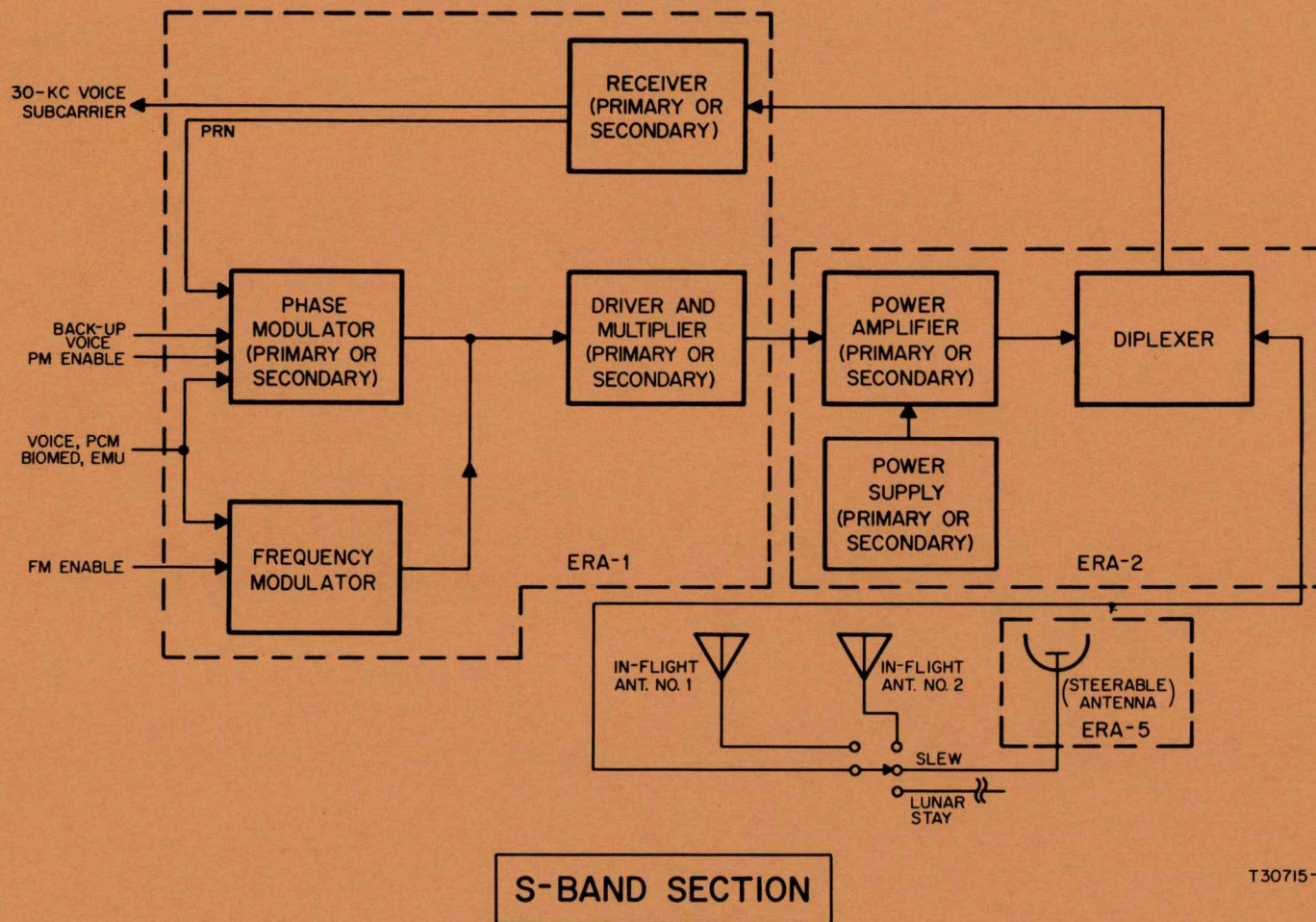
D. 410-11225-1 - RF Junction Box

The RF Junction Box is utilized to interconnect the vehicle with the test equipment listed above.

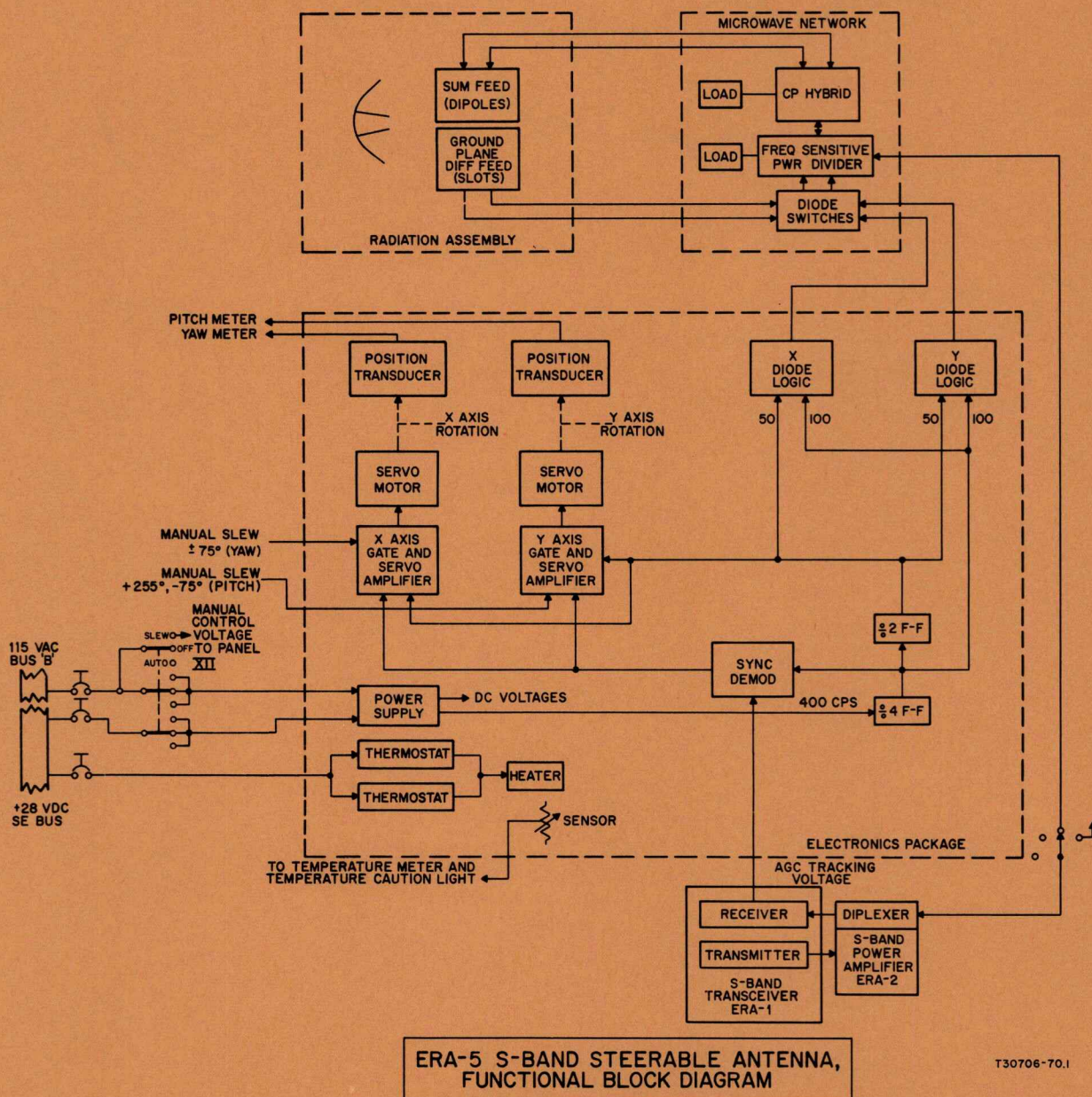


LM COMMUNICATIONS SUBSYSTEM

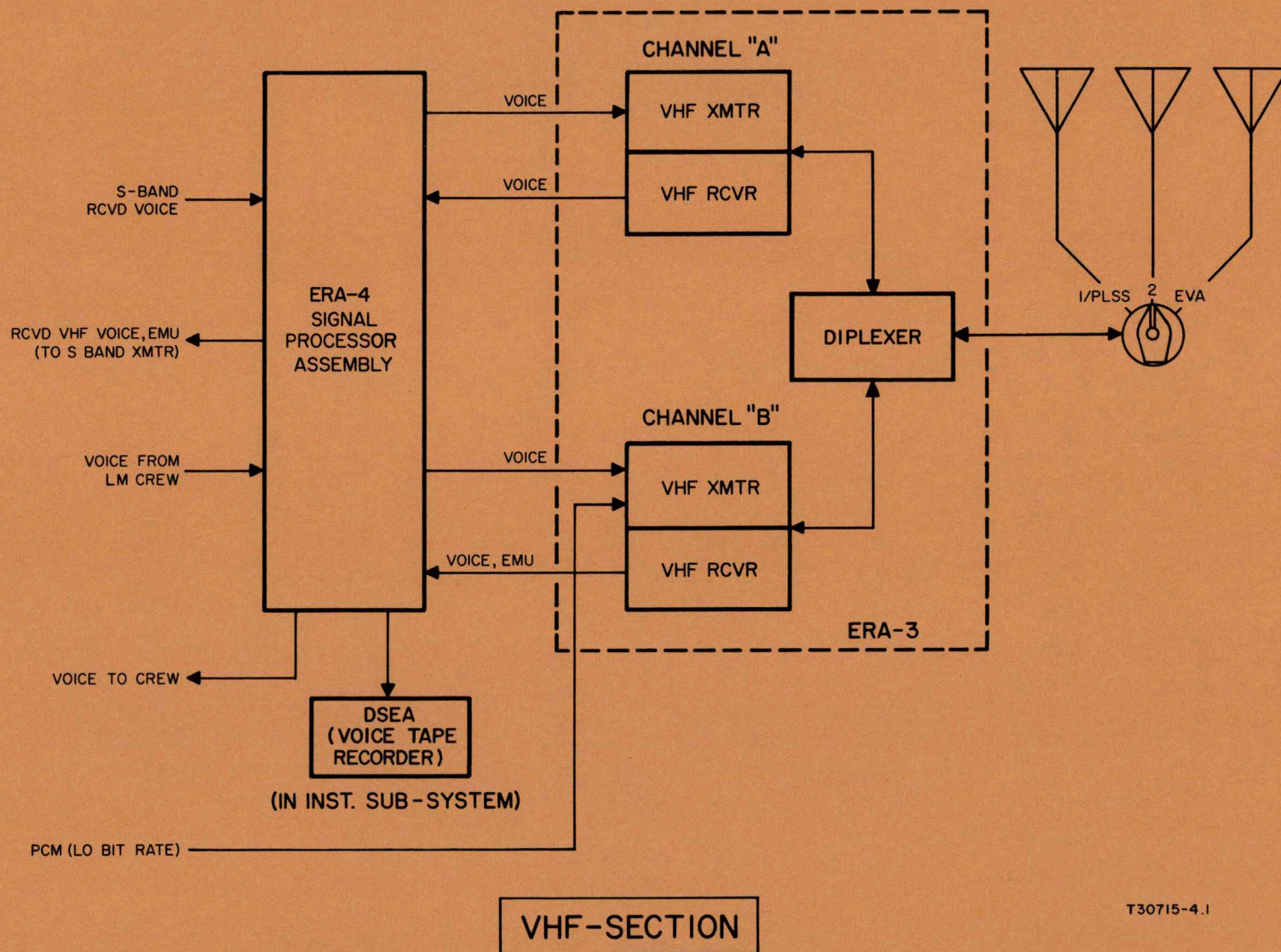
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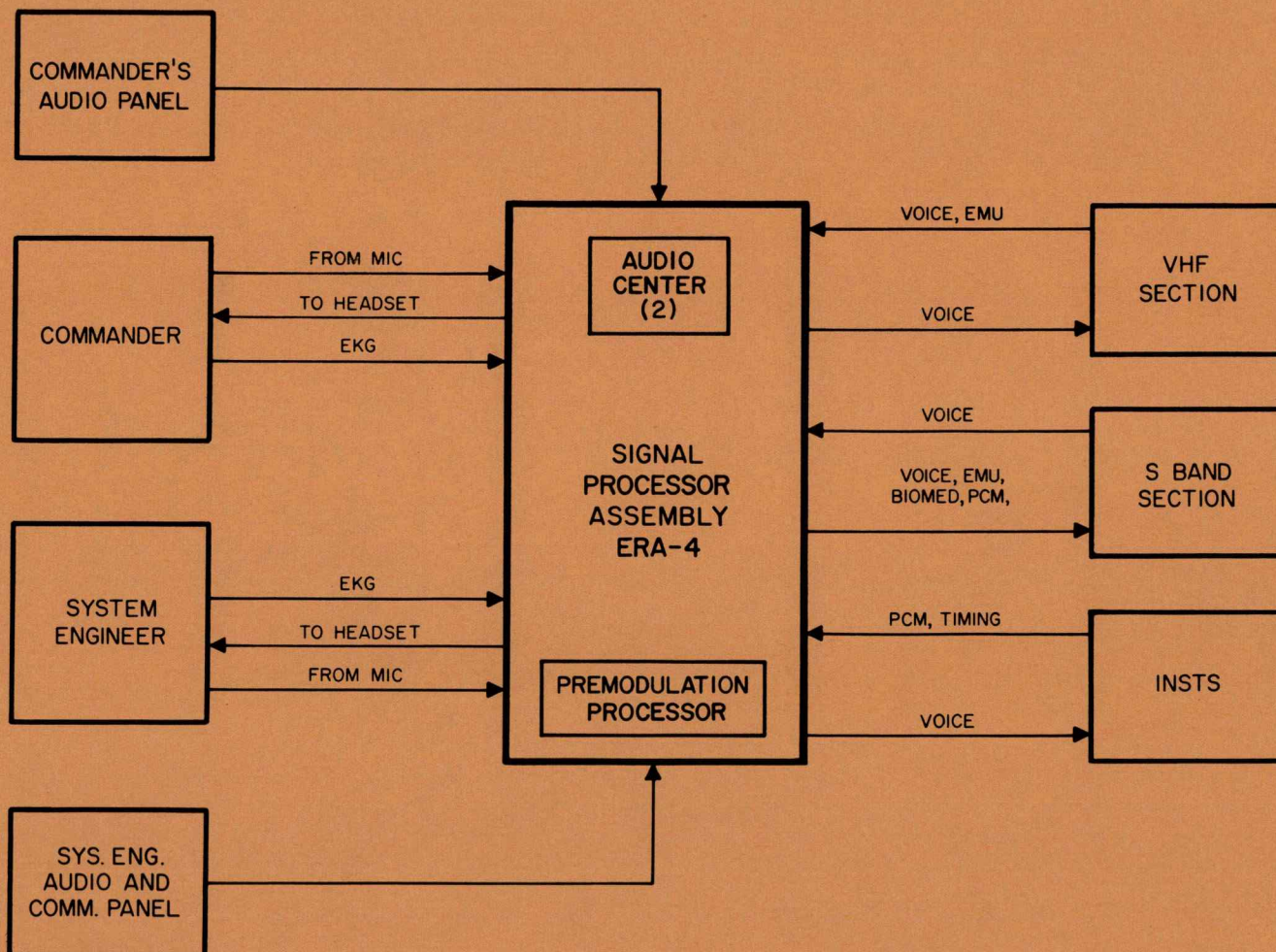
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T30706-70.1

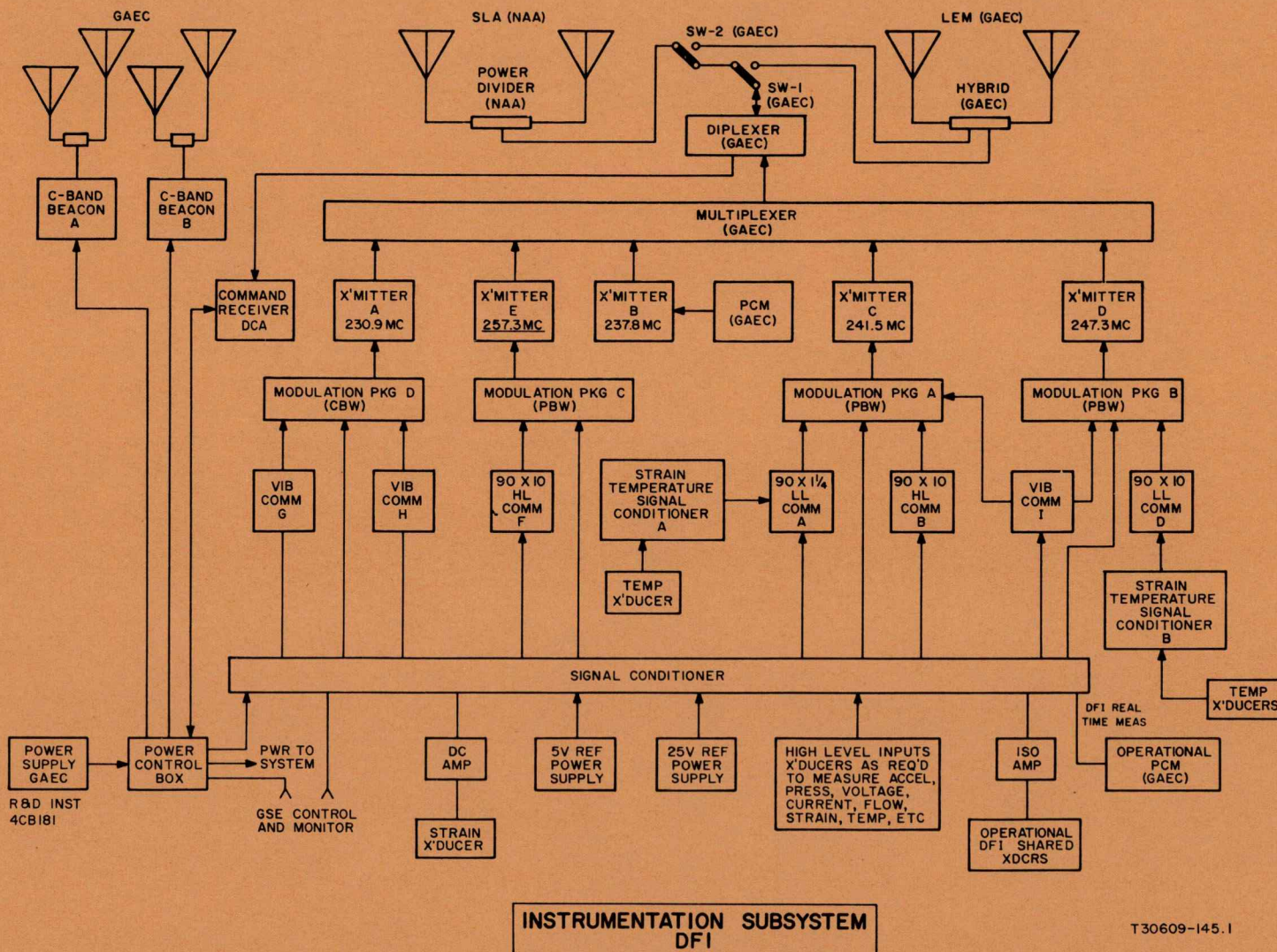


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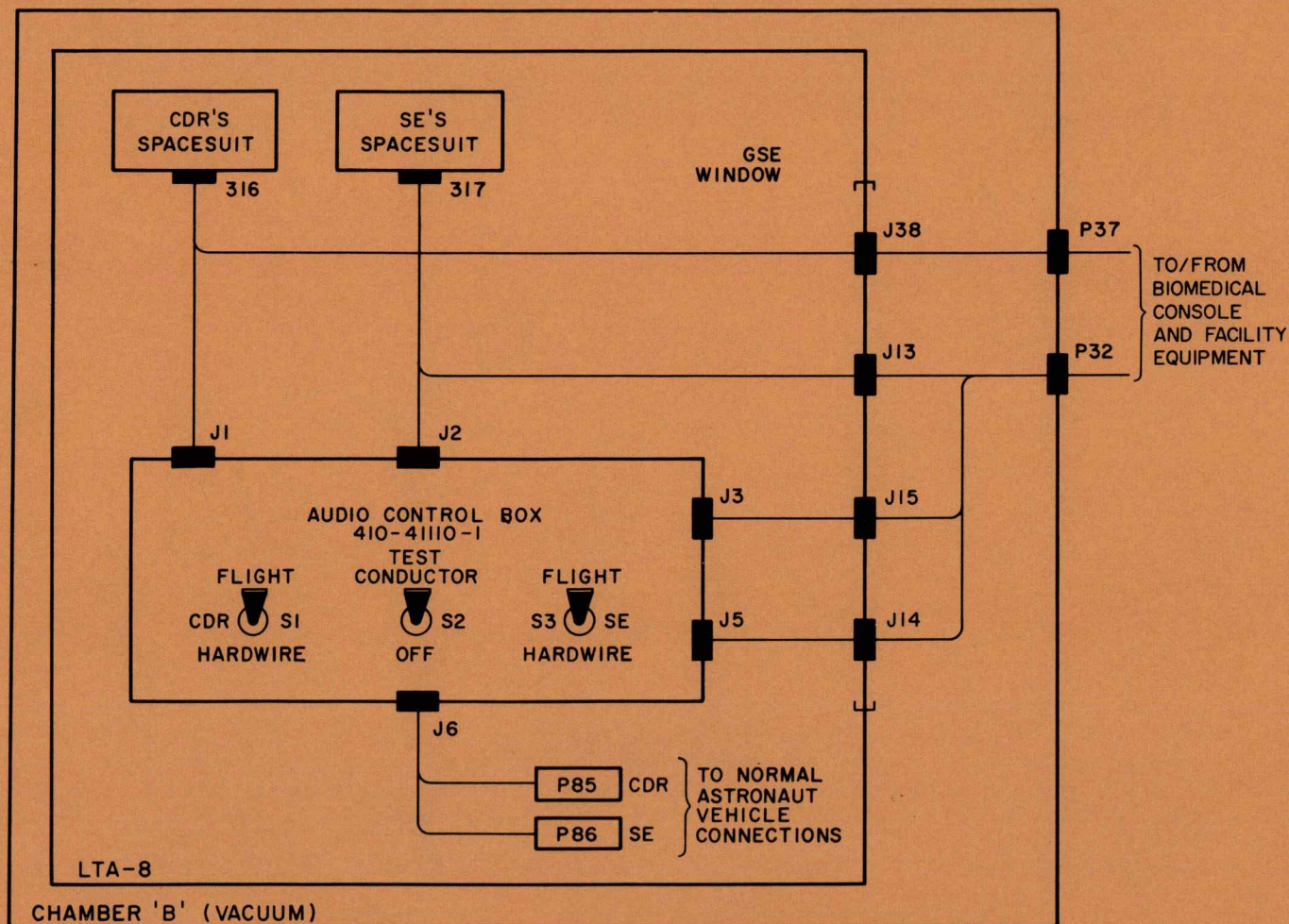


SIGNAL PROCESSOR ASSEMBLY
INTERFACE

T30715-11.1



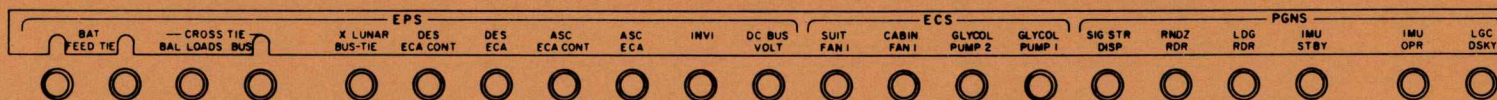
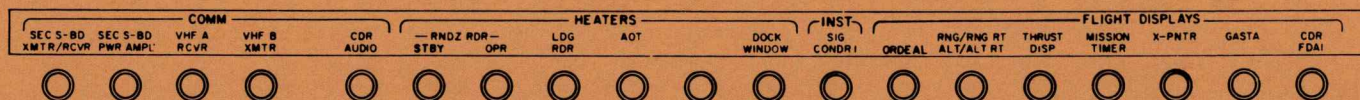
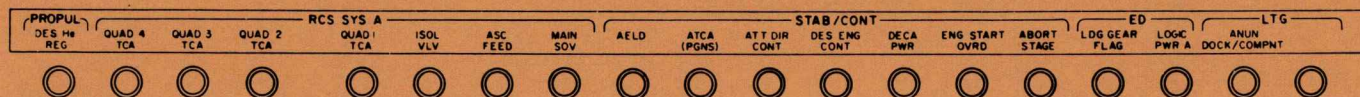
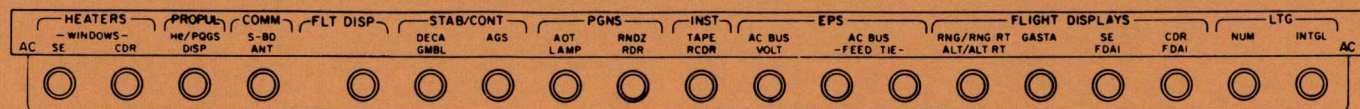
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LTA-8 AUDIO CONTROL BOX INTERFACE

T30715-76.1

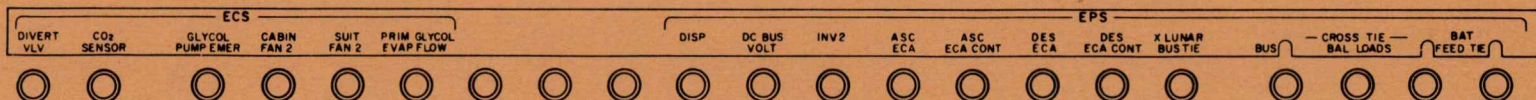
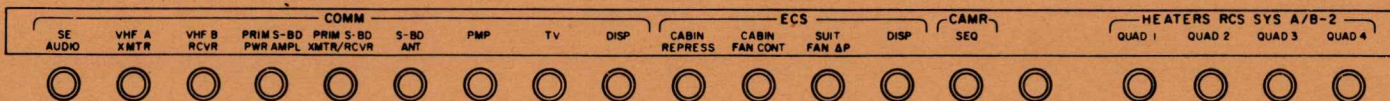
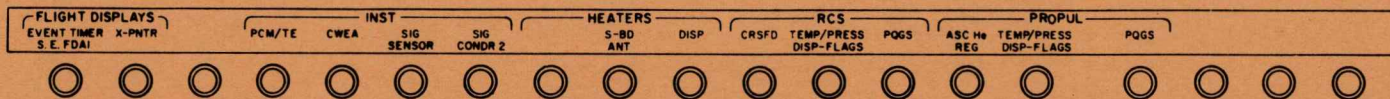
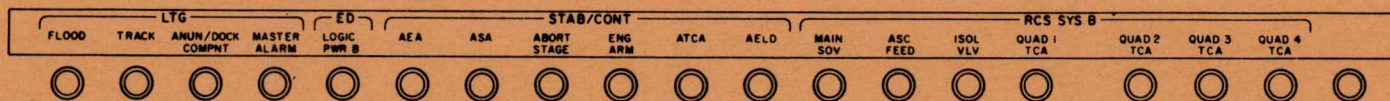
LTA-8



PANEL XI

T30900-94.1

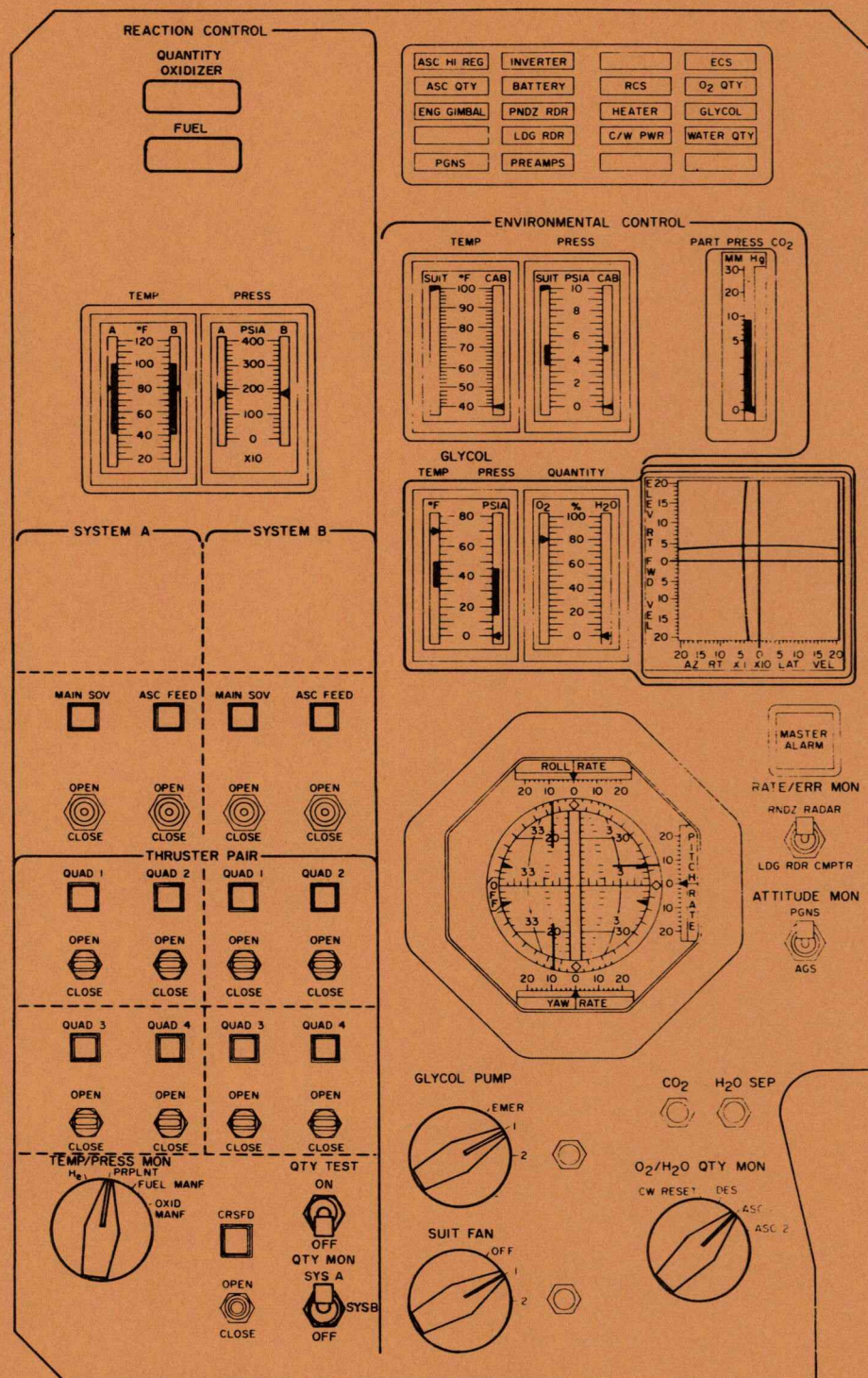
Date: August 1967



PANEL XVI

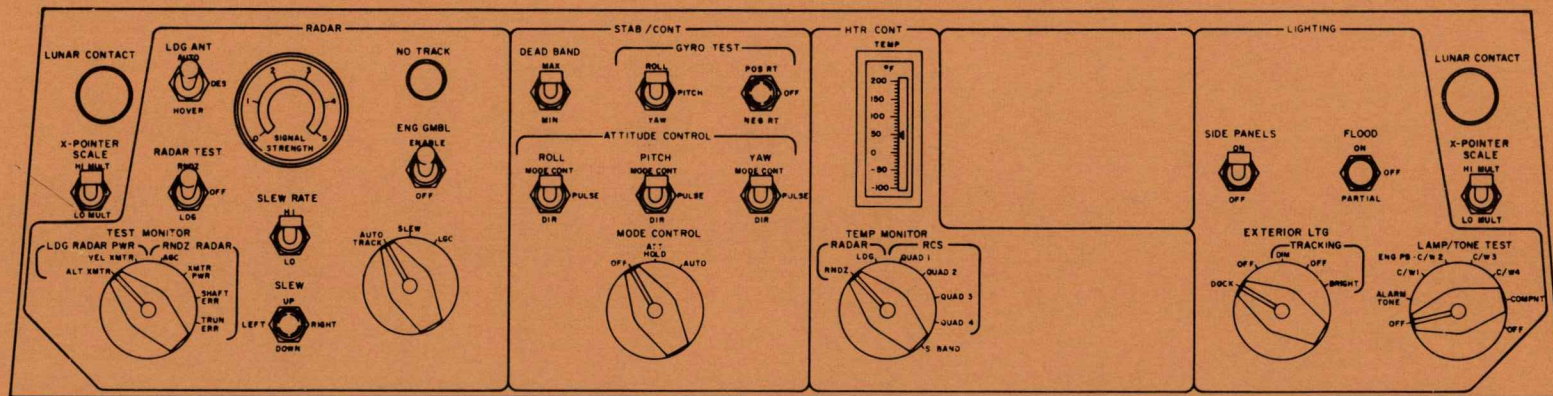
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LTA-8



PANEL II
LTA-8

T30900-110.1

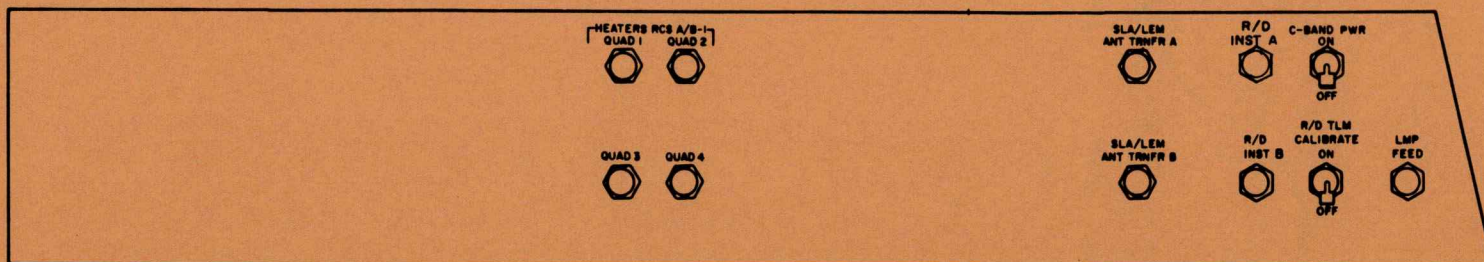


PANEL III
LTA 8

T30900-109.1

LTA-8

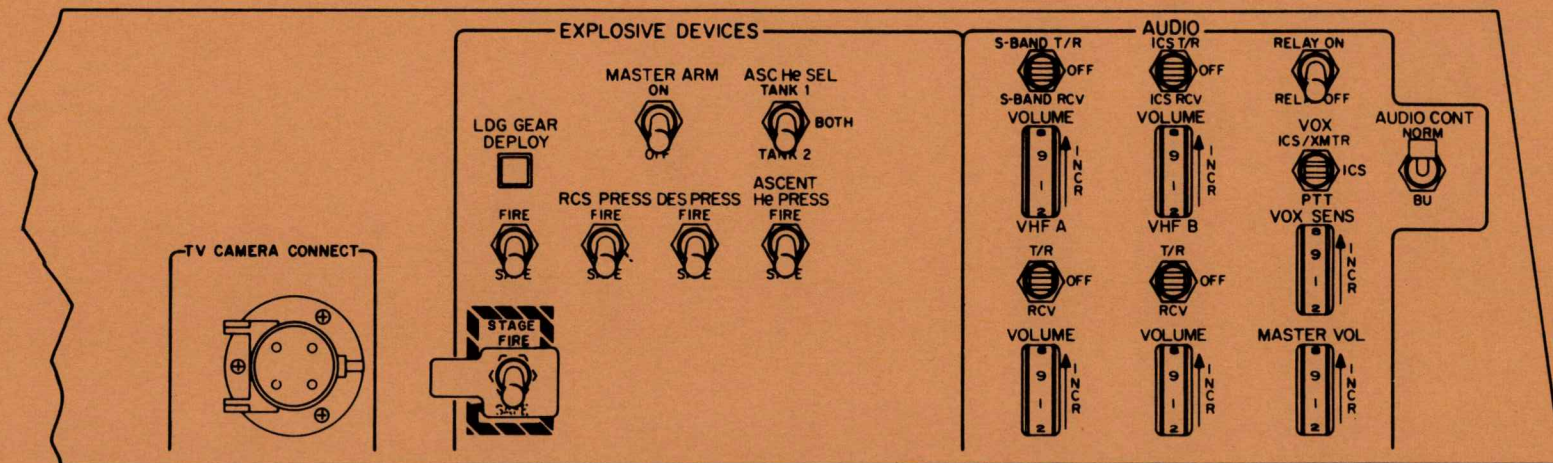
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PANEL X
LT8/LMI

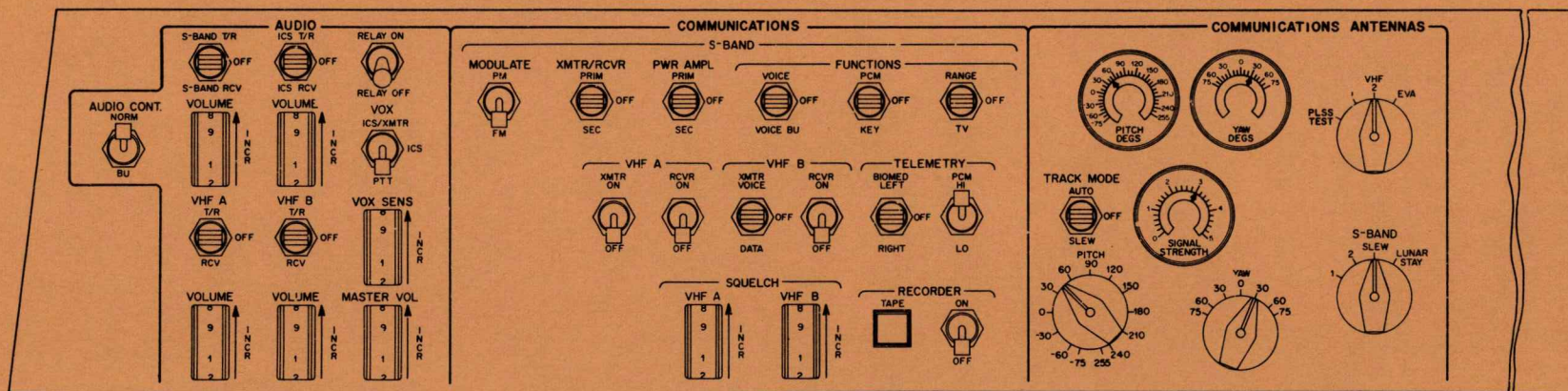
T30900 - III.1

ITA-8



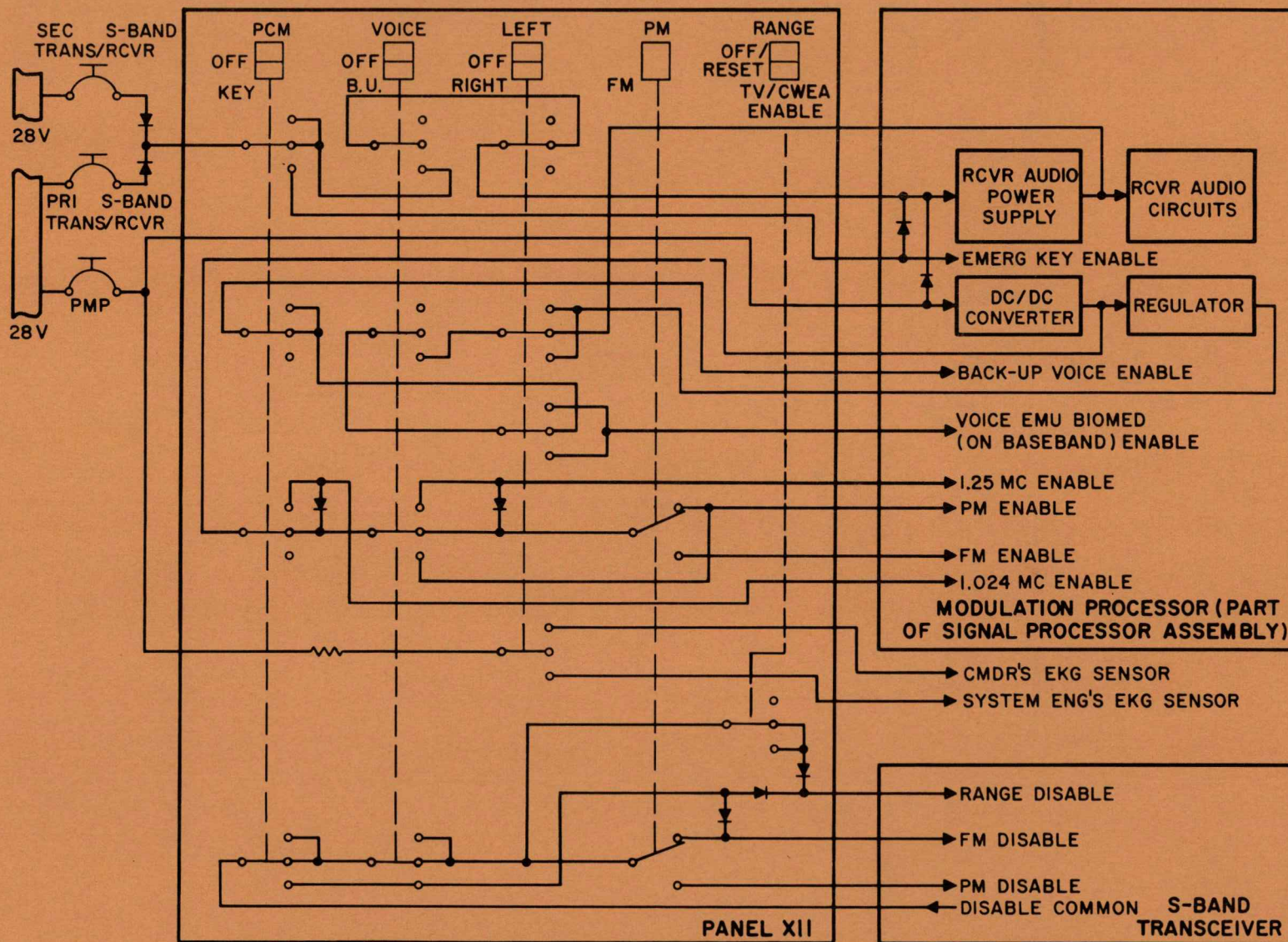
PANEL VIII
LTA-8

T30900-112.1
JULY 67



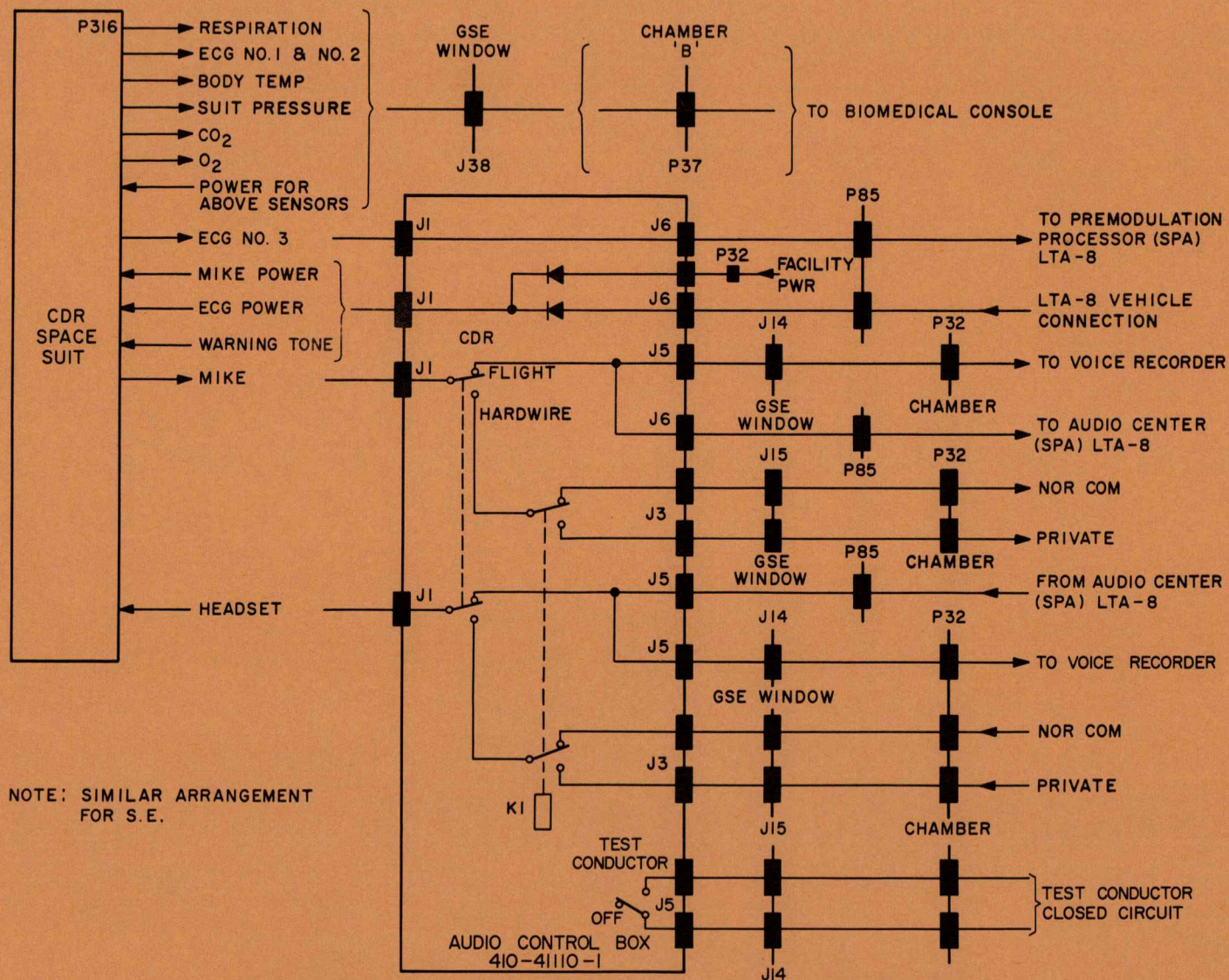
PANEL XII

T30900-91.1



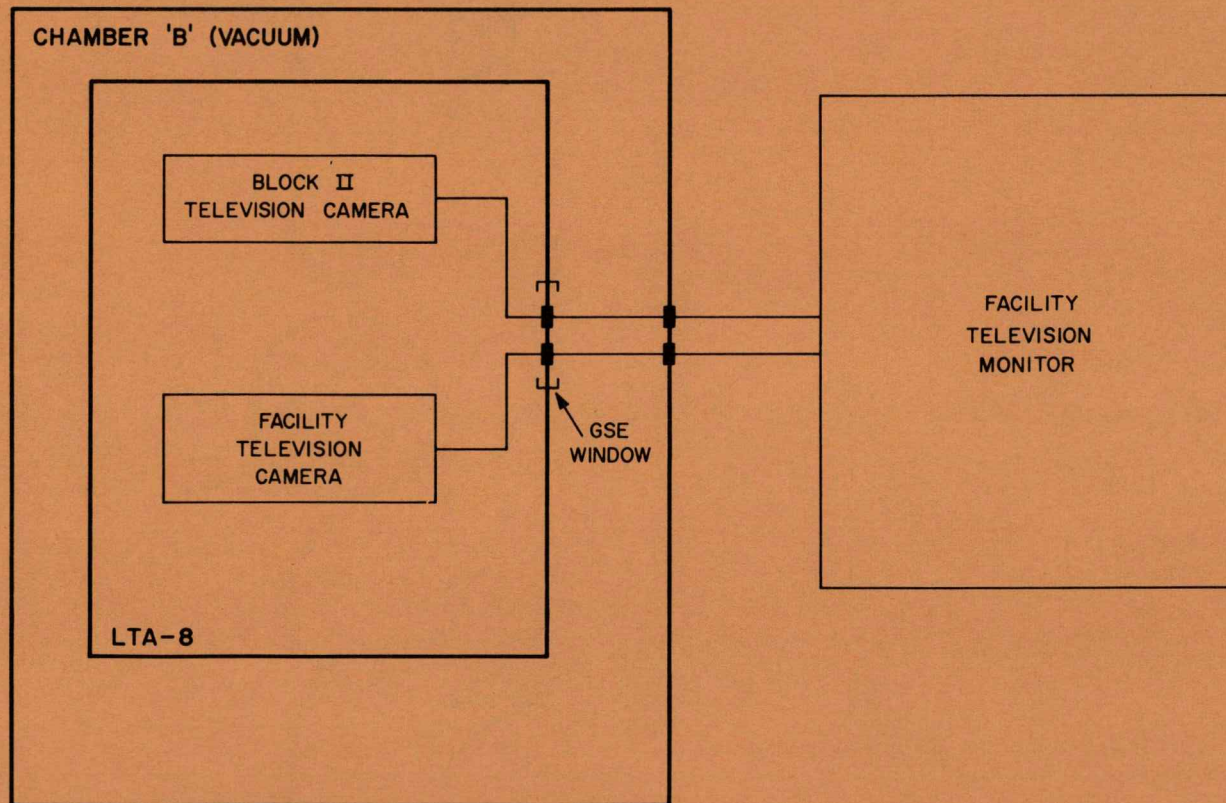
S-BAND MODE SWITCHING-NORMAL AND BACK-UP

T 30715-38.1



SPACE SUIT/AUDIO CONTROL BOX INTERFACE

T30715-77.1



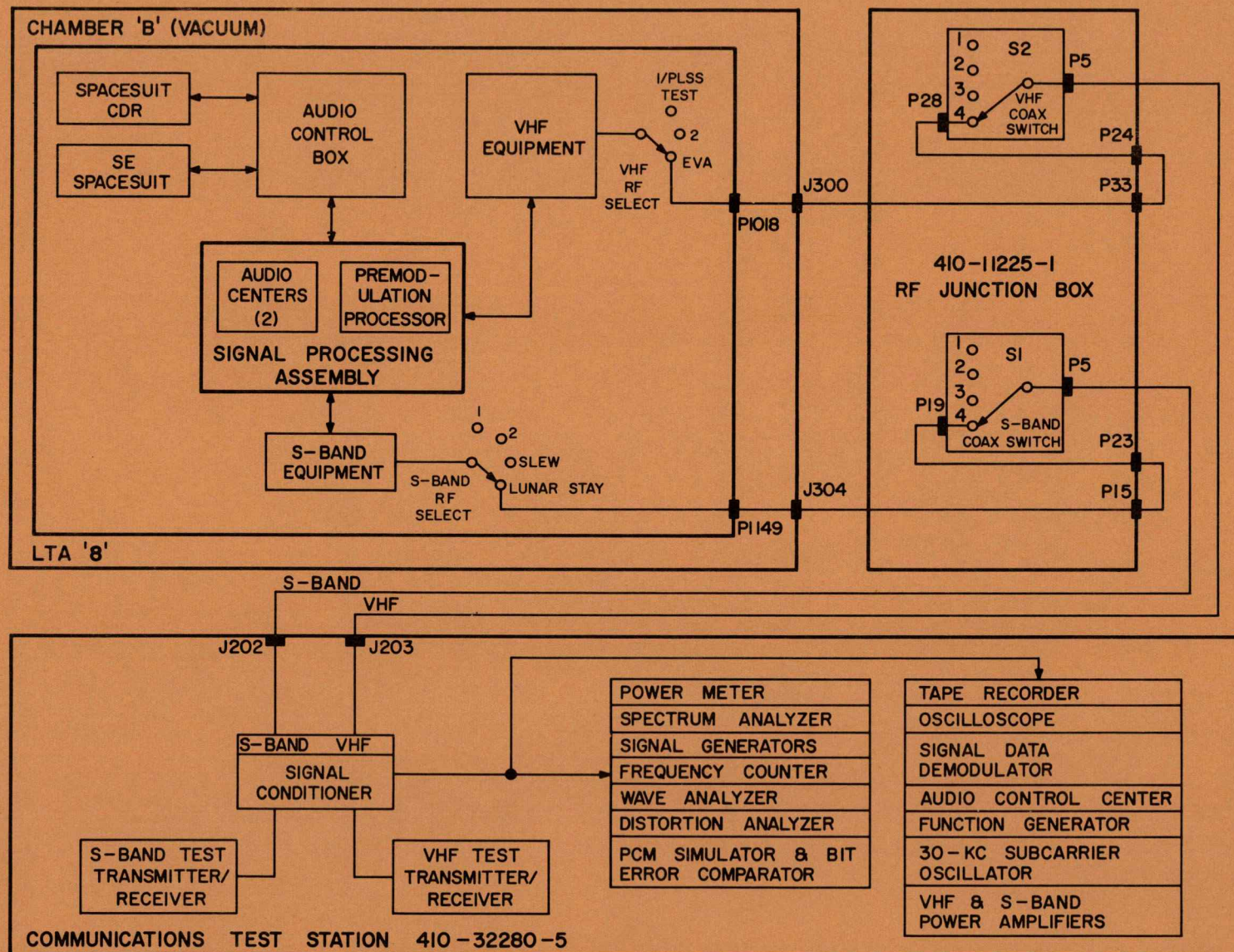
LTA-8 TELEVISION INTERFACE

T30715-79.1

LTA-8

Date: August 1967

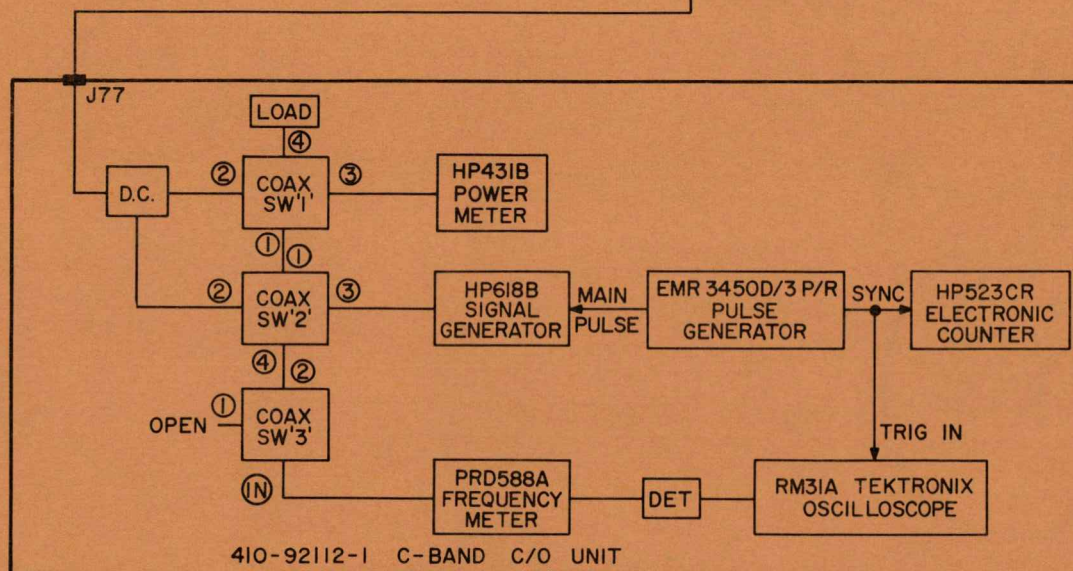
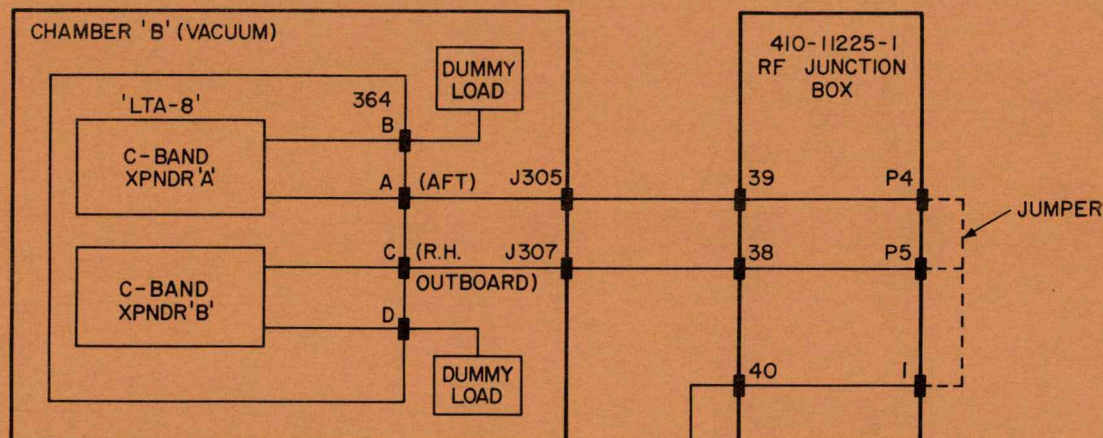
Page 24



S-BAND AND VHF CHECKOUT

T30715-78:1

ITA-8



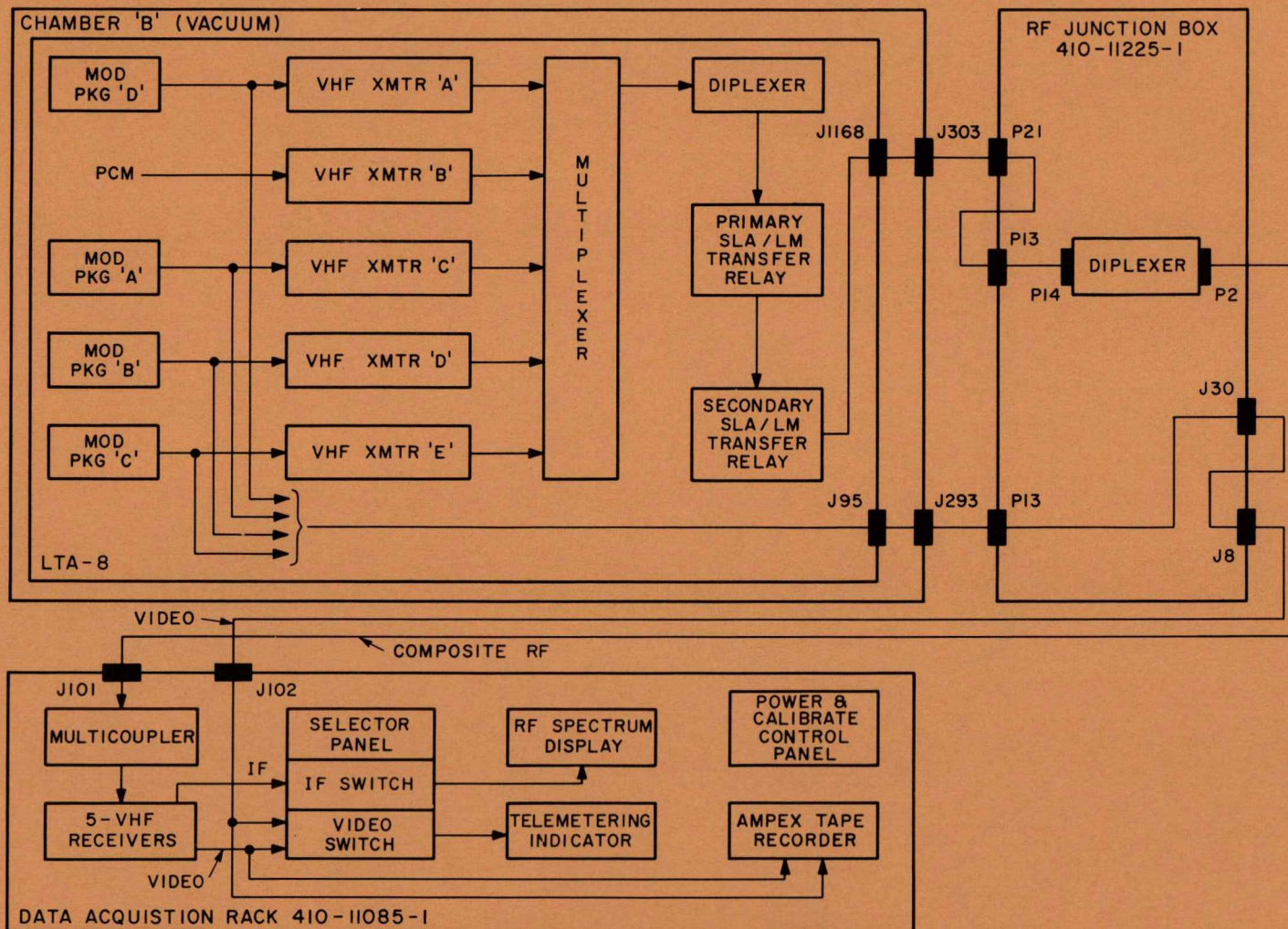
C-BAND C/O UNIT COAX SWITCH LEGEND

PANEL NAME	CLOSES CONTACTS
SW-1-PWR TEST	— 2 & 3 1 & 4
- FREQ REPLY	— 1 & 2 3 & 4
SW-2-INTERROGATE	— 1 & 4 2 & 3
- FREQ REPLY	— 1 & 2 3 & 4
SW-3-PRF REPLY	— 1 & IN
- PRF INTERROGATE	— 2 & IN

LTA-8 C-BAND CHECKOUT

T30715-75.1

LTA-8



DFI COMM CHECKOUT

T30715-80.1

LTA-8



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