

COLLINS SPACECRAFT COMMUNICATION SYSTEMS





Communications and Data Subsystem undergoes systems testing with allied equipment in configuration very similar to actual installation in lower equipment bay of Command Module.

The subsystem units, which are installed in the Command Module's lower equipment bay beneath the astronauts' instrument panel, include:

1. *Audio Center* — Provides each astronaut with a communication link with other crew members. Includes selection, isolation and amplification of audio for all transmitters and receivers.

2. VHF/AM Transmitter-Receiver — Dual transmitters and receivers enable simplex or duplex operation. The units provide voice communication between Command Module and earth during near-earth and recovery phases. Also used for Command Module communication with LM and EVA. Data from LM and EVA may also be received over these channels.

3. *HF Transceiver* — Employed for direction finding and voice communication over long ranges during the post landing phase. Operates on single sideband, compatible AM or CW.

4. *VHF Recovery Beacon* — Transmits a VHF direction finding signal to aid recovery forces in locating the Command Module after splash-down.

5. *VHF Triplexer* — Allows up to three VHF Transmitter-Receivers to share a single antenna on the Command Module.

6. PCM Telemetry — Receives and samples bio-medi-

cal, operational and scientific data — both analog and digital — and converts it to a single serial pulse code modulated output.

7. Data Storage Equipment — Data and voice information which cannot be transmitted in real time may be stored in this 14 track (including 4 spares) tape unit for later transmittal. This equipment is especially useful when the spacecraft is behind the moon or when communication to earth is otherwise temporarily interrupted.

8. *Pre-Modulation Processor* — Serves as the central interface between the radio equipment and the audio, data and TV equipment. It selects and multiplexes information for modulation of transmitting equipment. In reception it demodulates and separates the incoming composite signal, and routes the information to the proper equipment.

9. Unified S-Band Equipment — Combines voice and data communication, tracking, ranging and telemetry on a unified RF system. Includes two phase locked transponders and one FM transmitter. The Unified S-Band Equipment is employed in duplex operation throughout the flight phases, providing the sole communications link after the spacecraft leaves the vicinity of the earth.

10. S-Band Power Amplifier — Amplifies the signal from the Unified S-Band Equipment to provide the necessary communication power during translunar coast and lunar operations. Two selectable power output levels are available from two selectable power amplifiers. COMMUNICATION/COMPUTATION/CONTROL



1M-JPC-12-66

COLLINS RADIO COMPANY / DALLAS, TEXAS • CEDAR RAPIDS, IOWA • NEWPORT BEACH, CALIFORNIA • TORONTO, ONTARIO Bangkok • Beirut • Frankfurt • Hong Kong • Kuala Lumpur • Los Angeles • London • Melbourne • Mexico City • New York • Paris • Rome • Washington • Wellington

074 3295 000



COLLINS COMMUNICATIONS AND DATA SUBSYSTEM

APOLLO (BLOCK II)

The essential link between spacecraft and earth during NASA's Apollo moon expedition is accomplished by one of the most intricate subsystems aboard the Command Module - the Communications and Data Subsystem.

Through this subsystem pass voice communication, tracking and ranging information, telemetry, television and recovery beacon signals. It is operative throughout all mission phases.

Development of the subsystem challenged existing technology because of mission complexity; multiple system interrelationships; size, weight and power constraints; and the requirement for utmost reliability.

Spacecraft tasks performed by the Communications and Data Subsystem include:

1. Transmission of voice, telemetry and television data from the Command Module to the Manned Space Flight Network on earth.

2. Reception and demodulation of voice transmission from earth.

3. Reception and retransmission of a coded signal from earth, enabling earth stations to derive spacecraft range and velocity.

4. Reception and response to C-band radar signals for tracking during the first earth orbital missions of the program.

5. Data processing to time multiplex, encode and assemble data for transmission to earth.

6. Intercommunication between astronauts.

7. Two-way voice communication between the Command and Service Modules and the Lunar Module (LM) or Extra Vehicular Astronaut (EVA).

8. Relay of voice and data from the LM or EVA to earth.

9. Reception, demodulation, decoding and routing of Manned Space Flight Network digital data for control and updating of spacecraft systems.

Under contract to North American Aviation, Collins is systems manager for the Communications and Data Subsystem, directing the efforts of five subcontractors. In addition to program management and systems planning, engineering and test, Collins is also designing and manufacturing many of the equipment units.

The current Apollo configuration is designated Block II. The earlier configuration, Block I, was produced for the early earth orbital missions. Block II replaces it in later missions leading to the lunar flights.

Basically there are two major differences between the two configurations. The C-Band Transponder is deleted in the Block II subsystem because of the NASA decision to expand the Unified S-Band ground network to provide Sband tracking and communication for near earth as well as deep space phases. An FM Telemetry Transmitter is also eliminated, since this function is now performed by the S-band network.

Secondly, the hardware philosophy has been updated to add redundancy, operational flexibility and reliability and to reduce weight. This has been accomplished by discarding the inflight module replacement concepts of Block I, which required numerous internal connectors and additional support and cooling complexity.



Apollo astronauts, portraved here in Command Module mockup, rely on Collins Communications and Data Subsystem throughout all phases of the eight day lunar mission.



Bench Maintenance Equipment has been designed by Collins to provide integrated test facilities under centralized control for all Communications and Data units except the PCM Telemetry and Data Storage Equipment.

Allied to the Communications and Data Subsystem are the Central Timing Equipment, Up Data Link Decoder, Signal Conditioner, C-Band Transponder, antennas and television system. The Communications and Data Subsystem also interfaces with other spacecraft systems; for example, it supplies ground tracking inputs for the Guidance and Navigation System.

The ground Unified S-Band network consists of 12 stations, supplemented by ships and aircraft, for horizon-tohorizon coverage during earth orbital phases. Three stations with 85-foot antennas, located in California, Spain and Australia, will provide deep space coverage. Collins is prime systems contractor for the ground stations.

The dominant consideration throughout the design and production of the Communications and Data Subsystem has been reliability. Such programs as reliability analysis, parts qualification, traceability, operator training, and quality control have been pursued with an intensity which is unprecedented.

Collins constructed and equipped two special Apollo facilities — a mission life laboratory and a system test laboratory — to augment its extensive test facility. Equipment units are qualified by extended testing under temperature variations, vibration, shock, voltage and vacuum, with special attention to mission life.

Collins has the responsibility for testing the Communications and Data Subsystem and its allied equipment as a complete system. In this program the system is exercised through all combinations of modes for a complete lunar mission. Checks are made on performance, with attention to any interaction, electromagnetic interference or temperature effects.

Each unit manufactured receives an acceptance test. In addition to bench tests, an operating vibration test is performed as a quality check, and at least one hundred hours of operation as a complete unit must be accumulated prior to shipment.

This heavy emphasis on reliability — to provide the highest possible degree of success probability - underscores the importance attached to the Communications and Data Subsystem in achieving the goals of the Apollo lunar mission.





1000 cps. Attack time — no greater than 50 milliseconds. Release time — 2.0 ± 0.67 seconds at 1000 cps.

INPUT IMPEDANCE:

Microphone input — 600 ohms $\pm 20\%$ balanced at 1000 cps. Receiver inputs — not less than 18,000 ohms with one station selecting a receiver and not less than 6,000 ohms with all three stations selecting the receiver at 1000 cps.

Environmental Specifications

RANDOM VIBRATION:

3 db per octave increase from $0.008 \text{ g}^2/\text{cps}$ at 10 cps to $0.06 \text{ g}^2/\text{cps}$ at 70 cps. Constant from 70 to 2000 cps at 0.06 g²/cps. This profile is equivalent to an average level of 10.9 g rms.

THERMAL:

Continuous operating test conducted with average coldplate temperature of 118° F and surrounding air and wall tempera-

ture at 160° F. Transient reentry simulation with no coolant flow in coldplate and with peak wall temperature 200° F. VACUUM: 100 hours at 1 x 10⁻⁵ mm Hg. SHOCK:

78 g, 11 millisecond sawtooth pulse.

ACCELERATION: 20 g, for 5 minutes in each direction. Mechanical Specifications

SIZE:

Maximum unit envelope dimensions (including connectors) — 4.70" W, 4.66" H, 8.65" D (11.94 cm W, 11.83 cm H, 21.97 cm D). WEIGHT: 7.9 lbs. (3.58 kg) maximum.

Specifications subject to change without notice.



C28-1A110

COMMUNICATION/COMPUTATION/CONTROL





Audio Center APOLLO (BLOCK II)



APOLLO (BLOCK II)

DC CONTROL LINES DIODE SWITCHES VHF/AM RCVR ISOLATION PADS HF RCVR AND PRE-MOD PROCESSOR (S-BAND) VOLUME CONTROLS INTERCOM BUS MICROPHONE VOX SENSITIVITY

Diode volume control and switching of all low level circuits reduces interface wiring and interference susceptibility. Cordwood construction is hermetically sealed in a machined aluminum box with quick-disconnect connectors.

Automatic gain control circuitry is contained in all microphone outputs.

High reliability is assured on the basis of 200 hours operation.

The Collins Audio Center equipment (Apollo Block II) is a solid state audio amplification and control unit that provides a complete and independently operated audio station for each astronaut in the spacecraft. The unit provides each astronaut with microphone and earphone amplifiers, diode switching circuits that control audio signals to and from operating RF equipment or an intercom system common to the other astronauts, and VOX circuitry to permit voice keying of transmitters.

Three electrically identical functions of audio and switching circuitry are contained in thirty-one cordwood assemblies, which are housed in the gasket-sealed box of machined aluminum with hermetically sealed, guick-disconnect connectors. The cordwood construction and sealed box ensure a rugged, compact unit which is highly resistant to extremes of temperature, humidity, shock and acceleration.

Equipment Description

Each of the three electrically identical functions performs the following:

1. Amplification of microphone inputs to any combination of three transmitters and an intercom bus. The microphone amplifier contains an AGC circuit.

2. Amplification for earphones of any combination of intercom and three receiver input signals. The earphone amplifier contains remotely controlled diode volume control circuitry.

3. Voice-operated transmission (VOX) capability for intercom and/or remote keying of two transmitters. The VOX circuitry provides for remotely controlled sensitivity adjustment.

4. Diode switching controlled remotely by manual

switching for selection of any combination of intercom and three transmitter-receivers.

Each Audio Center station has an amplifier for received audio (earphones), an amplifier for transmitted audio (microphone), and VOX circuitry necessary to perform the keying function. Each amplifier contains diode switching circuitry, an isolation amplifier, pre-amplifier, push-pull driver, and a push-pull output amplifier.

All inputs and outputs for each Audio Center equipment are controlled at a remote control panel, which is not part of the Audio Center. In order to utilize the full capabilities of the Audio Center equipment, the control panel provides the operator a means of:

1. Selecting any of four audio inputs to the earphones. 2. Selecting any of four audio outputs for the microphone.

3. Adjusting the level of each receiver or intercom signal and the overall level of the earphones.

4. Selecting either push-to-talk (PTT) or voice-operated transmission (VOX) operation.

5. Controlling VOX sensitivity.

Reliability and Quality Assurance

Failure rates have been employed to predict mission reliability of R=0.999998 for 200 hours of operation based on two out of three channels required for success. Parts and materials have been selected carefully, tested and inspected thoroughly to ensure the highest practical equipment reliability. Circuit performance has been assured by extensive electrical and environmental testing and by the use of analysis techniques such as failure effect evaluation, parameter variation analysis, and stress analysis.

This equipment was developed to a quality assurance program incorporating the provisions of NASA Quality Publication NPC 200-2, Quality Assurance Provision for Space System Contractors.

The equipment is qualification tested for manned space flight.





The Communications and Data Subsystem for the Apollo spacecraft was designed and developed by Collins Radio Company under contract for North American Aviation, Space and Information Systems Division. As Subsystem Manager, Collins Radio established all equipment specifications for both Collins developed and subcontracted equipments, and coordinated all technical, reliability, quality, documentation and fiscal requirements to ensure a complete, well integrated system. The Audio Center was designed, developed and manufactured by Collins.

Specifications Electrical Specifications
FREQUENCY RESPONSE: Flat within 2 db from 300 to 3000 cps
AUDIO OUTPUTS:
Earphone Amplifier— $+20 \text{ dbm} \pm 3 \text{ db}$ into 600 ohms with gain control set for 13 db attenuation
Microphone Amplifier — 0 dbm ± 3 db into 600 ohms.
AUDIO INPUTS: 0 dbm nominal.
INPUT POWER: 28 v dc nominal, 20 watts maximum.
AGC CHARACTERISTICS: Dynamic range of AGC is 40 db. Attack time of microphone amplifier AGC circuit is less than 50 milliseconds. Release time is not less than one second.
VOX CHARACTERISTICS: Sensitivity — adjustable between -10 dbm and $+10$ dbm at

AUDIO INPUT LEVEL: AUDIO DISTORTION: -12 dbm from a 5400 ohm source impedance. MODULATION CAPABILITIES: 100%. **RF OUTPUT POWER:** 5 watts average into 50 ohm resistive load. **RF OUTPUT IMPEDANCE:** 50 ohm — unbalanced with 2:1 VSWR maximum. LIMITING: 300-3000 cps, no more than 1.5 db. NOISE SUPPRESSION: 30 kc suppression oscillator to suppress noise during speech lulls. Receiver WARMUP TIME: 500 milliseconds initially; 100 milliseconds after transmitting. FREQUENCIES: 296.8 mc and 259.7 mc. FREQUENCY SELECTIVITY: Response within ± 20 kc and flat to ± 1 db. **RF INPUT IMPEDANCE:** Nominally 50 ohms. SENSITIVITY: 1.5 uv modulated 30% with a 1000 cps tone. AUDIO FREQUENCY RESPONSE: 300-3000 cps + 2, -3 db for output number 1; 300-13,000 cps, ± 2 db for outputs number 2 and number 3. AUDIO OUTPUT IMPEDANCE: No less than 480 ohms, no more than 720 ohms, balanced center tapped. AUDIO OUTPUT LEVEL: 0.25 v rms ± 3 db across a 5000 ohm load with 6 uv, 30%, 1000 cps modulated RF input.

6% with 70% modulation, 70-100,000 uv RF input. AGC CHARACTERISTICS: No more than 5 db change for RF signal input 4-100,000 uv. No more than 7 db change for RF signal input 4-500,000 uv. SQUELCH: Remotely variable from audio control panel. PRIMARY POWER: Input voltage — 28 v dc nominal. Input power — duplex 36.2 watts; simplex 32.2 watts; receive 2.0 watts. **Environmental Specifications** RANDOM VIBRATION: 3 db per octave increase from 0.008 g²/cps at 10 cps to 0.06 g^2/cps at 70 cps. Constant from 70 to 2000 cps at 0.06 g^2/cps . This profile is equivalent to an average level of 10.9 g rms. THERMAL: Continuous operating test conducted with average coldplate temperature of 118° F and surrounding air and wall temperature at 160° F. Transient reentry simulation with no coolant flow in coldplate and with peak wall temperature 200° F. VACUUM: 100 hours at 1 x 10-5 mm Hg. SHOCK: 78 g, 11 millisecond saw-tooth pulse. ACCELERATION: 20 g, for 5 minutes in each direction. Mechanical Specifications SIZE: 4.7" W, 6" H, 12" D (11.94 cm W, 15.24 cm H, 30.48 cm D). WEIGHT: 13.5 lbs. (6.12 kg). Specifications subject to change without notice.

COMMUNICATION/COMPUTATION/CONTROL



COLLINS RADIO COMPANY / DALLAS, TEXAS • CEDAR RAPIDS, IOWA • NEWPORT BEACH, CALIFORNIA • TORONTO, ONTARIO Bangkok · Beirut · Frankfurt · Hong Kong · Kuala Lumpur · Los Angeles · London · Melbourne · Mexico City · New York · Paris · Rome · Washington · Wellington









VHF/AM Transmitter-Receiver APOLLO (BLOCK II)

VHF/AM Transmitter-Receiver

APOLLO (BLOCK II)

Dual transmitters and receivers provide two channels with duplex or simplex capability and full voice redundancy. Voice power is enhanced by speech clipping which produces

a square wave RF envelope.

Noise is reduced during speech lulls by 30 kc suppression oscillator.

Constant voltage is maintained by a regulator circuit using a magnetic storage transformer.

The VHF/AM Transmitter-Receiver provides simultaneous voice and data communication for manned aerospace application.

There are two transmitters and receivers assembled within a single enclosure. The Transmitter-Receiver frequencies are fixed at 296.8 mc and 259.7 mc. The 296.8 mc Transmitter-Receiver is for voice only. The 259.7 mc frequency is used for PCM and bio-medical information, although it can be used as a redundant voice channel.

Modulation employed is low level clipped speech, where the waveform is reduced to a square wave envelope. This speech processing provides nearly maximum voice power and yet retains high intelligibility and natural voice sound.

The VHF/AM Transmitter-Receiver operation modes are selected at the vehicle communication control panel. Selectable modes of operation are: (1) two simplex (2) two duplex, and (3) two receive only combinations.

Simplex operation is where the transmitter and receiver are on the same frequency. Duplex operation is where one transmitter is used with the other receiver (296.8 or 259.7 mc).

The VHF/AM Transmitter-Receiver enclosure is pressurized and designed to mount on a coldplate for cooling. The maximum input power is 36.2 watts operating from 28 v dc. The transmitter delivers 5 watts average RF power into a nominal 50 ohm resistive load. Weight of the VHF/ AM equipment is 13.5 pounds, and dimensions are 6 inches high, 4.7 inches wide and 12 inches long.

Equipment Description

Receiver

The receiver consists of three subassemblies: RF amplifier, IF amplifier and audio amplifier. The audio amplifier subassembly has three audio outputs, output number 1 to the spacecraft Audio Center outputs, and number 2 and number 3 to the spacecraft Pre-Modulation Processor.

Selection of any of the switch positions on the power panel supplies 28 v dc to the receiver. When the simplex mode is selected, the receiver will be turned on and the transmitter will be either in standby or transmit, depending on the position of the PTT switch. When the duplex mode is selected, a receiver will be turned on, along with the transmitter on the other side.

In receive position, the coaxial relay switches the antenna through a bandpass filter to the RF amplifier. The signal is amplified in two RF stages. The output of the oscillator-multiplier for each receiver injects a frequency into a mixer 30 mc higher than the receiver frequency.

The mixer output is fed to a 30 mc amplifier stage on through a 30 mc crystal filter to the IF stages. Each receiver amplifies the signal through three IF's before it is detected. The detector demodulates the 30 mc signal and applies the audio output to the squelch gate. A "VHF/AM Squelch" control is mounted on the communication control panel and is used to vary the squelch setting of the receiver.

The AGC receives a signal from the third IF amplifier. The AGC detector signal is passed to an amplifier stage, and the output of this amplifier is fed back to the receiver to achieve a constant level output.

From the spacecraft electrical system, +28 v dc is applied to a series regulator and transient suppressor in the receiver. The outputs of the receiver voltage regulator are +20 v dc and +9 v dc.

Transmitter

The audio input is obtained from the spacecraft Audio Center. A pre-emphasis network is employed to increase the higher voice frequencies prior to the clipping action of the overload limiter. The overload limiter is set to clip on peak levels of the audio input signal. A 30 kc suppression oscillator is employed in the modulator circuit to suppress noise in the information bandwidth at the receiver during speech transmission lulls.

The local oscillator for the 296.8 mc transmitter operates at a frequency of 98.9333 mc, and for the 259.7 mc transmitter at 86.5666 mc. The signal from the local oscillator is amplified before being multiplied in the frequency tripler.

Output of the tripler stage is then passed to the buffer

TO ANTENNA BANDPASS FILTER AND COAXIAL 296.8 MC ALIDIC 296.8 MC XCITER AND MODULATOR INPU POWER AMPLIFIER FROM TRANSMITTER SECTION AUDIO CENTER 259.7 MC 259.7 MC EXCITER AND POWER AMPLIFIER AUDIO MODULATOR VHF/AM Transmitter-Receiver Block Diagram

amplifier. The buffer amplifier B+ is controlled by the keyer circuit to obtain 50% duty cycle.

The transmitter operates from +28 v dc. The power regulator uses a magnetic storage transformer. A rate monitor follows source voltage fluctuation and supplies a proportionate voltage to the magnetic storage transformer. The closed loop arrangement combats source voltage fluctuations.

An identical arrangement is employed in the output of the regulator to supply constant +28 v dc to the transmitter.

On the connector, pins are supplied for monitoring the various functions of the Transmitter-Receivers, along with telemetry PCM outputs. The telemetry points to be monitored are the transmitter temperature, detected RF output level and receiver AGC voltage.

Reliability and Quality Assurance

The reliability prediction for successful completion of the required mission is:

1. 296.8 mc simplex voice - R=0.99987 for 10 hours of transmit operation and 50 hours of receive operation.

2. Duplex voice - R=0.999985 for 1.4 hours of transmit operation and 7 hours of receive operation.

3. Data receive - R=0.999974 for 12.3 hours of operation.

Parts and material have been selected and tested to ensure high reliability. Reliable circuit performance has been assured by electrical and environmental testing and the use of analysis techniques, such as failure effect evaluation, parameter variation analysis, and stress analysis.

This equipment is provided under a quality assurance program incorporating the provisions of NASA Quality









Publication NPC 200-2, Quality Assurance provisions for Space System Contractors.

The equipment is qualification tested for manned space flight.

The Communications and Data Subsystem for the Apollo Spacecraft was designed and developed by Collins Radio Company under contract for North American Aviation, Space and Information Systems Division. As Subsystem Manager, Collins Radio established all equipment specifications for both Collins developed and subcontracted equipments, and coordinated all technical, reliability, quality, documentation and fiscal requirements to ensure a complete, well integrated system. The VHF/AM Transmitter-Receiver equipment was designed, developed and manufactured under Collins direction by RCA Communications Systems Division, Camden, New Jersey.

Specifications **Electrical Specifications** Transmitter WARMUP TIME: 250 milliseconds. TYPE OF EMISSION: Square wave. FREQUENCIES: 296.8 mc and 259.7 mc. FREQUENCY ACCURACY: $\pm 0.003\%$, except $\pm 0.006\%$ during recovery. AUDIO INPUT IMPEDANCE: 600 ohms $\pm 20\%$, balanced center tapped.



Specifications

Electrical Specifications

TRANSMITTER POWER OUTPUT: 20 watts minimum PEP into a 50 ohm load in SSB; 5 watts minimum carrier in AM or CW. TRANSMITTER AUDIO INPUT: Balanced center-tapped 600 ohm impedance. Nominal input 0 dbm peak. Frequency response 350-2800 cps ± 3 db. TRANSMITTER CLIPPING: Nominal 16 db of IF clipping. TRANSMITTER NOISE LEVEL: Not less than 35 db below carrier. TRANSMITTER ACTIVATION TIME: 100 milliseconds maximum. FREQUENCY STABILITY: ± 50 cps under all environmental conditions. RECEIVER SELECTIVITY: 6 db bandwidth not less than 4000 cps; 60 db bandwidth not more than 12.5 kc maximum. RECEIVER SENSITIVITY: 10 db minimum S+N/N ratio with 1 uv input to 50 ohm dummy antenna on SSB. **RECEIVER AUDIO OUTPUT:** Balanced center-tapped 600 ohm output impedance. Nominal output 0 dbm, ± 3 db 300-2800 cps with 10 uv input on SSB. Less than 3 db rise with 100,000 uv input.

POWER REQUIREMENTS:

+28 v dc nominal. Typical receiver power consumption is $\frac{1}{2}$ watt. Typical transmitter power consumption is 19 watts in CW and 24 watts in SSB with voice modulation. Environmental Specifications

RANDOM VIBRATION:

3 db per octave increase from 0.008 g^2/cps at 10 cps to 0.06 g^2/cps at 70 cps. Constant from 70 to 2000 cps at 0.06 g^2/cps . This profile is equivalent to an average level of 10.9 g rms. THERMAL:

Continuous operating test conducted with average coldplate temperature of 118° F and surrounding air and wall temperature at 160° F. Transient reentry simulation with no coolant flow in coldplate and with peak wall temperature 200° F. VACUUM: 100 hours at 1 x 10⁻⁵ mm Hg. SHOCK:

78 g, 11 millisecond saw-tooth pulse.

ACCELERATION: 20 g, for 5 minutes in each direction.

Mechanical Specifications

SIZE:

4.0" W, 6.0" H, 8.5" D (10.16 cm W, 15.24 cm H, 21.59 cm D) maximum. (Envelope size)
WEIGHT:
6.3 lbs. (2.86 kg) maximum.
Specifications subject to change without notice.

COMMUNICATION/COMPUTATION/CONTROL







HF Transceiver (APOLLO BLOCK II)

APOLLO (BLOCK II)

Maximum talk power with minimum distortion is provided by use of automatic level control.

System efficiency is enhanced through IF clipping which raises average output power level.

Low power consumption has been achieved through unique power supply and modulator design,

High stability is gained through use of a temperature-compensated crystal-controlled oscillator.

Wide range distortion-free AGC is provided by use of attenuator bridges.

The Apollo Block II HF Transceiver provides a signal for direction finding and voice communication beyond the line of sight during the post-landing phase of the Apollo Spacecraft mission.

Operating modes are SSB, compatible AM, or CW with preassigned carrier frequency of 10.006 mc. The output is 20 watts PEP in SSB, and 5 watts carrier in AM and CW.

Equipment Description

Transmitter

In the SSB mode, the audio input and the 455 kc IF oscillator output are mixed in a balanced modulator. The upper sideband is removed by a mechanical filter. The lower sideband is amplified, clipped and mixed with the HF oscillator output. The sum frequency is passed through a crystal filter to remove spurious frequencies. After passing through the automatic level control (ALC) attenuator bridge, it is amplified by the PA and fed to the antenna. In the AM and CW modes, the 455 kc IF oscillator output, representing the carrier frequency, is reinserted after the IF clippers.

The ALC provides a feedback signal to the ALC attenuator bridge to maintain a constant peak power output from the transmitter on SSB, and to maintain a constant carrier level in AM or CW.

Increased average power output, improved efficiency, less distortion over a wider input voltage range are achieved by use of a unique power supply. A detected envelope signal is applied to the switching regulator power



Bottom and top covers.



supply, causing its output to modulate the collector voltage of the driver and final stages at an audio rate.

The power amplifier design and ALC circuits allow operation into a 2:1 VSWR without readjustment. Receiver

The input signal from the antenna passes through a crystal filter to provide high selectivity to reject adjacent channel interference and other image and spurious responses.

The RF amplifier, mixer and 455 kc IF amplifier each are preceded by an AGC attenuator bridge which allows wider range of AGC control than conventional design.

An SSB product detector and an AM detector provide an audio signal which is amplified to the 600 ohm output. An AGC detector provides a feedback voltage for the AGC attenuator bridges.





Power amplifier section of transceiver.

Reliability and Quality Assurance

The reliability prediction for successful completion of the required mission is:

1. Voice — R=0.999862 for 13 hours transmit and 35 hours receive operation.

2. CW - R=0.999813 for 48 hours transmit operation.

Parts and material have been selected and tested to ensure high reliability. Reliable circuit performance has been assured by electrical and environmental testing and the use of analysis techniques, such as failure effect evaluation, parameter variation analysis, and stress analysis.

This equipment is provided under a quality assurance program incorporating the provisions of NASA Quality Publication NPC 200-2, Quality Assurance provisions for



Translator section of transceiver.

Space System Contractors.

The equipment is qualification tested for manned space flight.

The Communications and Data Subsystem for the Apollo Spacecraft was designed and developed by Collins Radio Company under contract for North American Aviation, Space and Information Systems Division. As Subsystem Manager, Collins Radio established all equipment specifications for both Collins developed and subcontracted equipments, and coordinated all technical, reliability, quality, documentation and fiscal requirements to ensure a complete, well integrated system. The HF Transceiver was designed, developed and manufactured by Collins.







COLLINS RADIO COMPANY / DALLAS, TEXAS • CEDAR RAPIDS, IOWA • NEWPORT BEACH, CALIFORNIA • TORONTO, ONTARIO Bangkok • Beirut • Frankfurt • Hong Kong • Kuala Lumpur • Los Angeles • London • Melbourne • Mexico City • New York • Paris • Rome • Washington • Wellington

VHF Recovery Beacon APOLLO (BLOCK II)

APOLLO (BLOCK II)

Solid state construction results in size and weight reduction. Low power drain is realized because of interrupted cycle.

The Apollo Block II VHF Recovery Beacon is a tone-modulated AM transmitter that provides a signal for line-ofsight radio direction finding during reentry and recovery operations.

The Recovery Beacon, transmitting with 3-watt minimum power output at 243 mc, has an automatic transmission interruption cycle of 2 seconds on and 3 seconds off. During the 2-second transmit interval, the transmitter output is 30% modulated by a 1 kc square wave.

Equipment Description

The VHF Recovery Beacon consists of a modulator-regulator assembly and an RF amplifier-oscillator assembly.

The modulator-regulator section contains the modulator, interruption timer, and the voltage regulators. Two voltage regulators, operating from the spacecraft power bus, supply a regulated +22 v dc to all stages and 6.2 v dc for biasing. Multivibrator circuits provide the 1000 cps square wave modulating signal and the interruption timing.

The RF amplifier-oscillator assembly contains an 81 mc crystal oscillator, frequency multipliers, and RF and power amplifiers.

The output of the beacon during the 2 second-on period is typically 4.2 watts into 50 ohms with a minimum of 3 watts into 2:1 VSWR.

Reliability and Quality Assurance

The probability of success of the VHF Recovery Beacon is R=0.999957 for 48 hours of operation in the reentry and earth recovery phases of the Apollo mission. Parts and material have been carefully selected, tested, and inspected to ensure high reliability, and reliable circuit performance has been assured by extensive electrical and environmental tests and by the use of analysis techniques such as failure effect evaluation, parameter variation analysis, and stress analysis.

Equipment is qualification tested for manned space flight.





This exploded view shows all circuit assemblies in the recovery beacon.







COLLINS RADIO COMPANY / DALLAS, TEXAS • CEDAR RAPIDS, IOWA • NEWPORT BEACH, CALIFORNIA • TORONTO, ONTARIO Bangkok•Beirut•Frankfurt•Hong Kong•Kuala Lumpur•Los Angeles•London•Melbourne•Mexico City•New York•Paris•Rome•Washington•Wellington

VHF Triplexer APOLLO (BLOCK II)

Simultaneous operation of three VHF channels is enabled on one antenna.

Channel isolation exceeds 48 db.

Bandwidth of each channel is 1 mc minimum.

Signal loss is minimized, measuring 1.5 db maximum at channel center frequency.

Rejection of unwanted signals is 60 db in 50-1000 mc frequency range.

Continuous power capability of 20 watts for channels 1 and 2, and 5 watts for channel 3 is offered.

The Apollo Block II VHF Triplexer provides simultaneous connection and operation of three VHF equipment units with a single antenna system. The triplexer consists of three bandpass filters which provide the required isolation between the three input channels. The output of each of these filters is connected to the spacecraft VHF antenna.

This unit contains no active components and therefore requires no power source.

Equipment Description

Packaging is a machined aluminum case with hermetically sealed spacecraft connectors. Unit cover sealing is accomplished with a molded-in-place elastomer seal.

The VHF Triplexer chassis is divided into six coaxial resonators grouped to operate as three 2-pole bandpass filters. Each resonator contains an adjustable, telescoping center conductor assembly which is factory-tuned for resonance at the operating frequency.

The VSWR is 1.5:1 maximum with the outputs terminated in a matched 50 ohm load. The bandwidth of each of the three channels is 1 mc minimum, and the isolation between the channels is greater than 48 db.

Passband insertion loss at center frequency is 1.5 db maximum, while the insertion loss to frequencies outside the passband and within the 50-1000 mc frequency range is 60 db. Channels 1 and 2 are capable of carrying 20 watts of continuous power, and channel 3 is capable of carrying 5 watts.

Reliability and Quality Assurance

Failure rates have been employed to predict mission reliability of R=0.999999 for 103 hours of operation when subjected to any one or a natural combination of flight environments.

Parts and materials have been selected carefully, tested and inspected thoroughly to ensure the highest practical equipment reliability. Circuit performance has been assured by extensive electrical and environmental testing and by the use of analysis techniques such as failure effect evaluation, parameter variation analysis, and stress analysis.

This equipment was developed to a quality assurance program incorporating the provisions of NASA Quality Publication NPC 200-2, Quality Assurance Provision for Space System Contractors.

The equipment is qualification tested for manned space flight.

The Communications and Data Subsystem for the Apollo Spacecraft was designed and developed by the Collins Radio Company under contract for North American Aviation, Space and Information Systems Division. As Subsystem Manager, Collins Radio established all equipment specifications for both Collins developed and subcontracted equipments, coordinated all technical, reliability, quality, documentation and fiscal requirements to ensure a complete, well integrated system. The VHF Triplexer equipment was designed, developed and manufactured under Collins direction by Rantec Corporation, Calabasas, California.



Specifications Electrical Specifications

•

OPERATING FREQUENCIES:

Channel 1, 296.8 mc; channel 2, 259.7 mc; channel 3, 228.2 mc. VSWR:

Less than 1.5:1 at center frequency with output and unused inputs terminated in matched 50 ohm loads.

BANDWIDTH:

3 db bandwidth of 1 mc minimum for all channels.

ISOLATION BETWEEN CHANNELS:

Greater than 48 db.

PASSBAND INSERTION LOSS:

Not more than 1.5 db at center frequency from any input connector to antenna connector.

SIGNAL REJECTION:

Greater than 60 db for each channel from input connector to antenna connector over following frequency ranges — channel 1, 50-220 mc and 375-1000 mc; channel 2, 50-180 mc and 340-1000 mc; channel 3, 50-150 mc and 305-1000 mc.

Environmental Specifications

RANDOM VIBRATION:

Linear increase in level from 0.008 g^2/cps at 10 cps to 0.06 g^2/cps at 70 cps. Constant level of 0.06 g^2/cps from 70 to 2000 cps.

THERMAL:

Continuous operating test conducted with surrounding air and wall temperature at 160° F. Equipment subjected to transient reentry simulation with peak wall temperature reaching 200° F. VACUUM:

100 hours 1 x 10⁻⁴ mm Hg.

SHOCK:

78 g, 11 millisecond saw-tooth pulse.

Mechanical Specifications

SIZE: 3.93" W, 3.35" H, 4.6" D (9.98 cm W, 8.51 cm H, 11.68 cm D). WEIGHT: 1.7 lbs. (0.77 kg) maximum. Specifications subject to change without notice.





COLLINS RADIO COMPANY / DALLAS, TEXAS · CEDAR RAPIDS, IOWA · NEWPORT BEACH, CALIFORNIA · TORONTO, ONTARIO Bangkok · Beirut · Frankfurt · Hong Kong · Kuala Lumpur · Los Angeles · London · Melbourne · Mexico City · New York · Paris · Rome · Washington · Wellington



Pulse Code Modulation Telemetry Equipment

APOLLO (BLOCK II)





Pulse Code Modulation Telemetry Equipment

APOLLO (BLOCK II)

51.2 kilobits per second serial NRZ output is provided, derived from parallel analog, parallel digital and serial digital inputs.

Reduced format of 1600 bits per second may be selected to conserve transmission bandwidth.

High reliability is obtained by block and quad redundancy, fail-safe and majority logic circuit design.

The Apollo Block II Pulse Code Modulation (PCM) Telemetry Equipment receives and samples analog and digital spacecraft data, converting it to a single serial PCM output. It provides two fixed programs for sampling rate and sequence which supplies a non-return-to-zero (NRZ) PCM output of either 51,200 or 1600 bits per second.

The system is switched externally to "NORMAL" or "REDUCED" format. Data output in the NORMAL mode is 51.2 kbps in the form of 6400 8-bit words per second. Input data consists of 365 high level (0-5 v) analog inputs, 304 parallel digital inputs and one 40-bit serial digital input word. A 32-bit sync/ID word and an 8-bit format identification word is generated inside the PCM Telemetry Equipment.

The data output in the REDUCED mode is 1.600 kbps in the form of 200 8-bit words per second. Input data for this operating mode consists of 100 high level (0-5 v) analog inputs, 288 parallel digital inputs, and one 40-bit serial digital input word. Internally generated words are of the same type as those generated for the NORMAL operating mode. These inputs are sampled at various rates from 0 to 200 samples per second.

The system is designed as a high level system; however, it will synchronize and accept data from an external low level (0-40 mv) subsystem. The necessary timing signals required to operate the low level amplifier and multiplexer circuitry are generated in the high level telemetry unit. Fifty 1 sps low level channels are multiplexed in the external unit and fed to the high level unit as a 50 pps high level pulse amplitude modulation (PAM) input.

Equipment Description

The programmer contains the basic timing and control circuits for controlling the sequence of analog signal multiplexing, coding digital data multiplexing, controlling external data sources (serial digital data), and transferring data from the PCM system.

The basic subsections of the programmer are the oscillator, counters (period, bit, word and frame), and prime and sub-prime matrices. Normally, an external 512 kc input signal is used as the system clock. If this signal is absent, detection circuitry in the PCM switches the timing source to an internal clock (this is returned to the external timing upon return of the external 512 kc clock).

When the PCM is using the external clock, a 1 pps external signal is used to synchronize the programmer counters. The 1 pps signal is inhibited when using the internal clock. Counters and matrices within the programmer permit the forming of various time interval combinations required to provide the specific format and program sequencing commands required by the PCM and external equipment.

Format change from NORMAL to REDUCED mode is accomplished in the programmer by the activation of a switch to ground external to the PCM system. No data is lost during the transition between formats.

The analog multiplexer is used to sequentially sample a number of transducers into a fixed format. Each input is a single-ended 0.5 v signal. A typical gate consists of five channel gates fed to a sequencer gate. The sequencer gate is used for further multiplexing, for reduction of capacitance, and to prevent the failure of one channel gate from degrading more than five channels.

The outputs of the sequencer gates are further multiplexed into three quad-redundant high speed gates. The use of the high speed gates also reduces wiring capacitance and simplifies the timing requirements.

The outputs of the high speed gates are routed to the sample and hold circuitry. To achieve a high input impedance to the transducers and to minimize the droop on the charging capacitor, unity gain buffer amplifiers preceed and follow the sample and hold capacitor.

The output of the sample and hold circuitry is then fed to a half-split type analog-to-digital converter. The analogto-digital conversion is accomplished by eight successive comparisons providing an 8-bit output to the digital multiplexer. With a zero volt input the converter generates the binary equivalent of the decimal one (00000001). The code is increased by a binary equivalent of a decimal one for each 19.7 millivolts of input voltage up to 4.98 volts, which produces a binary equivalent of decimal 254 (1111110). All input levels below zero volt will produce a binary code of 00000001, and all input levels above 4.98 volts will produce a binary code of 11111110.

The function of the digital multiplexer is to sample each parallel digital channel in the sequence determined by the programmer. The sampled 8-bit parallel digital word is read into the output register each time its digital multiplexer gate is enabled.

The eight parallel bit words, from the digital multiplexers, and serial data binary inputs, from an external source, are received by the output shift register. The output register converts the serial and parallel data into an NRZ and RZ form synchronous with the system bit rate. NRZ data is used for the spacecraft output and RZ is used for checkout of the telemetry system by ground support equipment (GSE).

Data transfer buffers are provided to supply redundant and nonredundant system outputs having specified characteristics. These signals consist of serial data control pulses, GSE data and timing signals, and spacecraft data and timing signals. All GSE drivers are transformer isolated and are powered by an external dc source to reduce power consumption during flight.

A calibrator is included in the PCM telemetry equipment. This calibrator provides precision voltages $(\pm 0.2\%)$ which may be routed to other spacecraft equipment or reinserted into the PCM system for checking the coding of the PCM analog channels.

Reliability and Quality Assurance



tions of quad redundancy, block redundancy, majority logic and fail-safe logic were used in the PCM design.

Parts and material have been selected and tested to ensure the highest practical equipment reliability. Circuit performance has been assured by extensive electrical and environmental testing and by the use of analysis techniques



lizes four quadrants. Foamed modules for one of the quadrants are shown in place in this interior view.

such as failure effect evaluation, parameter variation analysis, and stress analysis.

Equipment is qualification tested for manned space flight.

The Communications and Data Subsystem for the Apollo Spacecraft was designed and developed by the Collins Radio Company under contract for North American Aviation, Space and Information Systems Division. As Subsystem Manager, Collins Radio established all equipment specifications for both Collins developed and subcontracted equipments, coordinated all technical, reliability, quality, documentation and fiscal requirements to ensure a complete, well integrated system. The PCM Telemetry Equipment was designed, developed and manufactured under Collins direction by Radiation, Inc., Melbourne, Florida.

Specifications

Electrical Specifications

POWER:

Input voltage — 115/200 v, 3 phase, 400 cps; 11 v dc source for GSE drivers. Input power — 21 watts maximum for 115 v; 2.2 watts peak for dc source.

INPUT SIGNALS:

Analog data channels — 365 (0-5 v). Digital parallel data — 304 (bits). Digital serial data — one 40-bit word. Timing signals — 512 kc clock, 1 pps synchronization pulse.

SPACECRAFT OUTPUTS:

Digital Serial Data Control Pulses

Bit Sync — 51.2 kbps in NORMAL, 1.6 kbps in REDUCED. Start Pulse — 50 pps in NORMAL, 10 pps in REDUCED. Stop Pulse — 50 pps in NORMAL, 10 pps in REDUCED.

Serial Data

2 non-return-to-zero (NRZ-C).

Data Rate Timing

51,200 pps in NORMAL, 1,600 pps in REDUCED; in phase with NRZ outputs.

Subcarrier Reference

512.000 pps.

Data Rate Indicator

Positive voltage indicates NORMAL format. Zero voltage indicates REDUCED format.

GROUND EQUIPMENT CHECKOUT OUTPUTS:

Serial Data — Return-to-Zero (RZ). Data Rate Timing — 51,200 pps in NORMAL, 1,600 pps in REDUCED in phase with RZ output. Subcarrier Reference — 512,000 pps. Sub-frame Rate Timing — 1 pps. Test Points — all test points are made accessible.

PROGRAMMING:

Format — fixed format for NORMAL (51.2 kbps) and RE-DUCED (1.6 kbps). Format Selection — controlled by an external switch (not a part of PCM). Synchronization Code — 32 bits (last 6 bits are frame identification). Format Identification — special 8-bit word inserted once per second.

Environmental Specifications

VIBRATION:

Non-destructive (not required to meet above specifications) — 10-70 cps, linear increase from 0.008 g²/cps to 0.06 g²/cps; 70-2000 cps, 0.06 g²/cps. Operating — 10-70 cps, linear increase from 0.002 g²/cps to 0.015 g²/cps; 70-2000 cps, 0.015 g²/cps.

VACUUM:

1 x 10⁻⁴ mm Hg for 100 hour period.

TEMPERATURE:

 0° F (base temperature 35° F); 150° F (base temperature 118° F); 140° F with no base coolant for a period of 15 minutes, capable of withstanding non-operating exposure from -45° F to $+150^{\circ}$ F.

ACCELERATION:

20 g acceleration for 5 minutes in each of three axes.

Mechanical Specifications

SIZE:

13.3" W, 7.0" H, 14.2" D (33.78 cm W, 17.78 cm H, 36.07 cm D).

WEIGHT:

44 lbs. (19.9 kg).



ANALOG INPUT LEVEL: 5 v peak-to-peak. ANALOG INPUT FREQUENCIES: 3.75 ips — 12.5 cps to 6250 cps. 15 ips — 50 cps to 25 kc. ANALOG FREQUENCY RESPONSE: 4 db maximum to minimum, 50 cps to 10 kc; 6 db maximum to minimum, 50 cps to 25 kc. ANALOG INPUT IMPEDANCE: 100,000 ohms minimum. ANALOG OUTPUT IMPEDANCE: 200-600 ohms. TAPE TRANSPORT: Start up time — less than 5 seconds. Wow and flutter — less than 3% peak-to-peak when recorded at 15 ips under ascent environment with playback at 15 ips under orbital conditions. Record time — 30 minutes at 15 ips.

Environmental Specifications

RANDOM VIBRATION: 10-70 cps — linear increase in level from 0.0025 g^2/cps to

 $0.0187 \text{ g}^2/\text{cps}$ (linear refers to a straight line plotted on log-log paper). 70-2000 cps — constant at 0.0187 g²/cps. THERMAL: Continuous operation with average coldplate temperature of

 $+118^{\circ}$ F. Equipment subjected to transient reentry simulation with no coolant flow in coldplate for 15 minutes.

VACUUM:

100 hours at 1 x 10⁻⁴ mm Hg. SHOCK: 78 g, 11 millisecond pulse (non-operating).

Mechanical Specifications

SIZE: 22" W, 9½" H, 6" D (55.88 cm W, 24.13 cm H, 15.24 cm D) maximum. WEIGHT: 40 lbs. (18.12 kg) maximum with tape. Specifications subject to change without notice.

COMMUNICATION/COMPUTATION/CONTROL



COLLINS RADIO COMPANY / DALLAS, TEXAS • CEDAR RAPIDS, IOWA • NEWPORT BEACH, CALIFORNIA • TORONTO, ONTARIO Bangkok • Beirut • Frankfurt • Hong Kong • Kuala Lumpur • Los Angeles • London • Melbourne • Mexico City • New York • Paris • Rome • Washington • Wellington



074 3297 000

Data Storage Equipment APOLLO (BLOCK II)

Data Storage Equipment

APOLLO (BLOCK II)

Serial-parallel data converter converts serial data to parallel data to be recorded on five tracks at an input-output rate of 51.2 kbps.

Data dump mode provides fast reproduction of data stored at a slower rate, permitting fast transmission of stored data. Reel drive, utilizing a differential and hysteresis clutch, maintains tape tension from beginning to end of reeling. Cooling is accomplished by grouping the heat generating devices (motors, power supplies, etc.) in a location nearest to the coldplate mounting surface.

The Apollo Block II Data Storage Equipment - which operates in conjunction with the PCM Telemetry Equipment and analog data sources - records, stores and reproduces analog and digital data. Data may be recorded and stored when the spacecraft is in the back portion of the lunar orbit. It is reproduced and transmitted to earth when the spacecraft is again within communication range.

The equipment is operational during lift-off, space flight and reentry. During lift-off, it records telemetry information and bio-medical data.

Equipment Description

The equipment is contained in a gasket-sealed case. A desiccative breather valve in the case makes the container a semisealed unit. Spacecraft connectors are hermetically sealed, quick disconnect type.

The equipment electronic circuits, which are of cordwood type construction, include the record and reproduce electronics, signal conversion electronics, and speed detection and switching electronics.

Tape motion and end-of-tape sensors provide the tape transport with controlling signals. The end-of-tape sensor ensures against tape loss by stopping the tape transport.

A 1-inch wide, 14-track Mylar tape is the recording medium. The tape transport has three speeds: 3.75, 15, and 120 ips. Data or voice recorded at 3.75 ips will be reproduced at 120 ips. The 15 ips speed is used for either record or playback. The third speed, 120 ips, is used for data rapid playback — that is, the rapid transmission of analog or digital low-bit-rate data recorded at 3.75 ips and

stored while the spacecraft is out of communication range.

Five of the fourteen recorder tracks are used for digital data and nine for analog data. Digital non-return-to-zero (NRZ) data of two separate rates may be recorded: 51.2 kbps or 1.6 kbps plus a return-to-zero (RZ) clock signal of 51.2 kc and 1.6 kc.

Analog data signals are in the 12.5 cps to 25 kc range. One channel is used for LM/PCM split bit data, one for voice, three for scientific data, and four are spare channels. Additional plug-in modules will permit use of the spare channels.

Serial-to-parallel conversion and parallel-to-serial conversion for data inputs and outputs are accomplished in the Data Storage Equipment. The converter is a bidirectional, dynamic shift register with both serial and parallel readout capabilities. Countdown and shift register functions are handled with magnetic core elements. Solid state circuits are used for signal conditioning and other logic functions.

Input data is single serial non-return-to-zero (NRZ) data. An external return-to-zero (RZ) clock pulse is required for the conversion. Two data input rates are acceptable by the conversion electronics. The high data rate of 51.2 kbps is recorded and reproduced only in the 15 ips mode; the low data rate of 1.6 kbps is recorded at 3.75 ips and reproduced at 120 ips.

Reliability and Quality Assurance

Failure rates have been employed to predict mission reliability of R=0.99932 during mission duration of 14 hours.

Parts and materials have been selected carefully, tested and inspected thoroughly to ensure the highest practical equipment reliability. Circuit performance has been assured by extensive electrical and environmental testing and by the use of analysis techniques such as failure effect evaluation, parameter variation analysis, and stress analysis.

This equipment was developed to a quality assurance program incorporating the provisions of NASA Quality Publication NPC 200-2, Quality Assurance Provision for Space System Contractors.

The equipment is qualification tested for manned space flight.



Data Storage Equipment Block Diagram.

The Communications and Data Subsystem for the Apollo spacecraft was designed and developed by the Collins Radio Company under contract for North American Aviation, Space and Information Systems Division. As Subsystem Manager, Collins Radio established all equipment specifications for both Collins developed and subcontracted equipments, coordinated all technical, reliability, quality, documentation and fiscal requirements to ensure a complete, well integrated system. The Data Storage Equipment was designed, developed and manufactured under Collins direction by Controls Division, Leach Corporation, Azusa, California,

ANALOG OUTPUT

POWER SUPPLY

AUTOMATIC SPEED DETECTOR



Specifications **Electrical Specifications** POWER REQUIREMENT: 35 watts total from a 115/200 v, 400 cycle ac source and +28v dc source. NUMBER OF CHANNELS: 11 channels — 1 serial data channel (on 4 tracks), 1 clock channel, 9 analog channels. TAPE SPEED: 3.75, 15, and 120 ips. SERIAL INPUT DATA RATE: 51.2 kbps and 1.6 kbps. SERIAL BINARY INPUT LEVELS: High $- 6.0 \pm 0.6$ v dc. Low - 0.0 + 0.8, -0.0 v dc. SERIAL INPUT IMPEDANCE: 100.000 ohms minimum. SERIAL BINARY OUTPUT LEVELS: High $- 6.0 \pm 0.6$ v dc. Low - 0.0 + 0.5, -0.0 v dc. SERIAL OUTPUT IMPEDANCE: 600 ohms $\pm 10\%$.







COLLINS RADIO COMPANY / DALLAS, TEXAS • CEDAR RAPIDS, IOWA • NEWPORT BEACH, CALIFORNIA • TORONTO, ONTARIO Bangkok • Beirut • Frankfurt • Hong Kong • Kuala Lumpur • Los Angeles • London • Melbourne • Mexico City • New York • Paris • Rome • Washington • Wellington

Pre-Modulation Processor

APOLLO (BLOCK II)

Pre-Modulation Processor

APOLLO (BLOCK II)

Modular construction permits broad modification of mission and communication capabilities without extensive system changes.

High reliability is obtained by solid state design, generous component derating, and use of redundant, simplified circuitry.

Emergency communication capability is provided by switching signal processing circuits for voice and/or by keying the 512 kc clock input.

Low power consumption results from energizing only the circuits required for the selected transmission mode and by use of solid state active circuitry.

The Apollo Pre-Modulation Processor (PMP) provides the signal processing and interfaces between the voice, data and recording equipment and the RF transmitting and receiving equipment.

Because it combines in a single package several functions usually common to several spacecraft equipment units, the Pre-Modulation Processor permits broad modification of mission data transmission and communication capabilities without extensive modification of the interface equipment. Its modular construction enhances this capability by permitting substitution of new modules for functions which may be required.

Equipment Description

The PMP performs the following functions:

1. NORMAL OPERATING MODES (DOWN LINK - PM)

The following signal processing is performed prior to PM transmission via the Unified S-Band Equipment (USBE):

(a) *CM Voice Signal Processing* Provides pre-emphasis, clipping, filtering and mode switching of real time Command Module (CM) voice which frequency modulates a 1250 kc subcarrier. Filtering and associated switching is performed to band limit the signal when time sharing with the Extra Vehicular Astronaut (EVA) signal to prevent interference with the EVA biomedical data.

(b) LM/EVA Signal Processing Provides automatic gain control (AGC), over a wide dynamic range, of voice signals received from the Lunar Module (LM) or voice and bio-medical signals from the EVA.

(c) Down Voice Relay and Conference Capability Provides for voice relay and conference capability by linearly mixing (time sharing) real time CM voice, LM voice or EVA voice and bio-medical data for frequency modulation of a 1250 kc subcarrier. Mode switching is provided to allow for transmission of real time LM/EVA signals only in the RELAY mode and to provide for filtering the CM voice signal in the RELAY/EVA mode to prevent interference with the EVA bio-medical data.

(d) *CM PCM Telemetry (Real Time — Normal)* Provides biphase modulation of a 1024 kc subcarrier by real time, high or low rate, CM Pulse Code Modulation (PCM) data.

(e) Voice and CM PCM Telemetry Multiplexing Provides mode switching and frequency multiplexing of the PCM telemetry signal (1024 kc subcarrier) and the voice/ bio-medical signal (1250 kc subcarrier) for PM transmission via the USBE.

2. NORMAL OPERATING MODES (DOWN LINK – FM)

The following signal processing is performed prior to baseband FM transmission via the USBE. All data or voice signals transmitted via FM are recorded signals played back from the Data Storage Equipment (DSE), except for scientific data which can be transmitted in real time.

(a) INTERCOM/LM Voice to DSE

Provides for linear mixing (time share) of real time IN-TERCOM and LM voice signals to be recorded. Wide range AGC of the LM voice signal controls the level. Mode switching permits only the mixing of LM, but not EVA, voice signals with INTERCOM voice for recording.

(b) LM PCM Channel to DSE

Provides limiting circuitry to process LM PCM data (1.6 kbps) to be recorded.

(c) Analog Telemetry to DSE (Switching) Provides switching of real time analog scientific data signals to be recorded or to frequency modulate a subcarrier oscillator (SCO) in real time. Three such channels are provided. The three subcarriers, which are generated in the PMP equipment, are 95 kc, 125 kc and 165 kc.

(d) *CM PCM Telemetry (Recorded — Auxiliary)* Provides PCM telemetry by biphase modulation of a second 1024 kc subcarrier with recorded CM PCM data. The PCM data is either high bit rate (51.2 kbps) at a playback/record ratio of one or low bit rate recorded at 1.6 kbps and a playback/record ratio of 32.

(e) FM Channel Multiplexing

Provides mode switching and frequency multiplexing of recorded signals for baseband FM transmission via the USBE for each of the following combinations:

TAPE/PCM ANALOG MODE

Recorded INTERCOM/LM voice (32:1 playback); three channels of analog telemetry with recorded scientific data frequency modulated on subcarriers of 95 kc, 125 kc and 165 kc; and recorded CM PCM telemetry (51.2 kbps) on a 1024 kc subscriber.

TAPE/LM PCM MODE

Recorded LM PCM data only. The LM PCM data is recorded at 1.6 kbps and transmitted baseband FM via the USBE at a playback to record ratio of 32.

SCIENTIFIC DATA MODE

Three channel analog telemetry with real time scientific data frequency modulated on subcarriers of 95 kc, 125 kc and 165 kc.

(f) Television Channel

Provides a hard-wire channel through the PMP of a video signal from a television camera for FM transmission via the USBE. An output is provided, through isolation circuitry, to the spacecraft umbilical for pre-launch monitoring.

3. BACK UP MODES (DOWN LINK - PM)

(a) CM Voice Channel

Provides pre-emphasis, clipping and mode switching of real time CM voice for baseband PM transmission via USBE. Mode switching is performed such that Normal and Back Up CM voice cannot be transmitted simultaneously. Mode switching provides for changing the Back Up CM voice level and resulting PM modulation index as a function of the CM PCM data rate.

(b) CM PCM Telemetry Channel

Redundant, identical biphase modulators and associated

mode switching circuitry provides for modulation of either modulator with CM PCM data (1024 kc subcarrier) for PM transmission via the USBE.

(c) Emergency Key and Sidetone

Provides for keying the 512 kc subcarrier for PM transmission via the USBE. The 512 kc signal is derived by amplifying and filtering the Central Timing Equipment (CTE) clock input and providing it as an output whenever the KEY mode is selected and the Emergency Key is depressed. A 400 cps sidetone signal is also provided at this time as an audible tone to the astronaut headset.

4. NORMAL OPERATING MODES (UP - LINK)

(a) Normal Up Voice and Up Data Detection

Provides separation and detection of a multiplexed up link signal consisting of a 30 kc subcarrier, frequency modulated with voice, and a 70 kc subcarrier, frequency modulated with data.

(b) Up Voice Relay

Provides for relay of detected up voice for re-transmission to LM via the VHF/AM Transmitter. When not in the RELAY mode (VOICE mode) a microphone input is conducted through the PMP to the Audio Center equipment.

5. BACK UP OPERATING MODES (UP - LINK)

Provides for mode switching and back up detection of up voice using the 70 kc up data detector. Relay of back up voice is provided when the RELAY mode is selected. In the VOICE mode the microphone input is again conducted through the PMP to the Audio Center equipment.

6. POWER SUPPLY REGULATOR OPERATION AND SWITCHING

The PMP contains two identical, switchable power supply regulators which operate from an input of +28 v dc and provide an 18 ± 0.18 v dc output to power all active circuitry including mode switching, except for the relay required to switch regulators in the AUXILIARY mode. This relay operates from the primary +28 v dc input. All other mode switching is performed using the regulated 18 v dc output which is conducted to the Communication Control Panel, switched through appropriate mode control switches, and conducted back to the PMP to operate relays or power active mode switching circuitry.



Reliability and Quality Assurance

High reliability is achieved through use of high reliability components which are qualified to rigid Apollo requirements, generous component derating, use of solid state proven circuitry, and incorporation of circuit redundancy for several functions. High reliability has been demonstrated by successful qualification testing to the rigid requirements of the Apollo program.

The predicted probability of success ranges from R=0.999702 to R=0.999999 for the several functions described for this equipment. These probabilities of success relate to the specified mission times which range up to 214 hours.

Equipment is qualification tested for manned space flight.

The Communications and Data Subsystem for the Apollo Spacecraft was designed and developed by Collins Radio Company under contract for North American Aviation, Space and Information Systems Division. As Subsystem Manager, Collins Radio established all equipment specifications for both Collins developed and subcontracted equipments and coordinated all technical, reliability, quality, documentation and fiscal requirements to ensure a complete, well integrated system. The Pre-Modulation Processor was designed, developed and manufactured by Collins.

Input Impedance — 600 ohms $\pm 20\%$ balanced (audio input) 100 ohms $\pm 10\%$ (CTE clock input). Input Signal — Voice to a maximum level of 5 v p-p. Signal Processing - Pre-emphasis, 6 db/octave; clipping, 0 db nominal for NORMAL mode and 12 db nominal for BACK UP mode at 1 kc and 2.2 v p-p input. Minimum Bandwidth — After correction for pre-emphasis EVA mode, 300 cps to 2.3 kc (4 db); NOT EVA mode, 300 cps to 3 kc (4 db); BACK UP mode, 300 cps to 2.3 kc (3 db). Deviation Sensitivity - EVA mode, 3.63 kc/v below clipping; NOT EVA mode, 6.82 kc/v below clipping; BACK UP mode, N/A (baseband PM). Distortion — Below clipping, less than 8% for the detected audio signal; BACK UP mode, less than 3%. S/N Ratio - 26 db minimum at a nominal 2.2 v p-p input. LM/EVA CHANNEL:

Input Impedance — 5,000-10,000 ohms balanced.



Input Signal - Voice/data from 0.11 to 9.0 v p-p. Signal Processing - AGC to 3 db over a 38 db range. Minimum Bandwidth (2 db) — 300 cps to 13 kc. Deviation - 8.55 kc, nominal peak deviation. Distortion — Less than 6% for the detected signal. S/N Ratio — 32 db minimum. INTERCOM VOICE CHANNEL (RECORD): Input Impedance — 9,400-15,000 ohms balanced. Input Signal — Voice to a maximum level of 5 v p-p. Signal Processing - Isolation; insertion loss, 0-6 db. Minimum Bandwidth (2 db) - 300 cps to 2.3 kc. Distortion — Less than 6%. INTERCOM/LM VOICE CHANNEL (PLAYBACK): Input Impedance - 10,000 ohms minimum, balanced. Input Signal — Voice to a maximum level of 6 v p-p. Signal Processing — Peak clipping, 0 db nominal for a 1.5 v p-p input. Insertion loss below clipping is 18 db nominal. Bandwidth (1 db) - 300 cps to 73.6 kc. Distortion (below clipping) — Less than 5%. S/N Ratio — 30 db, minimum at 6 v p-p input. CM PCM TELEMETRY CHANNEL (NORMAL AND AUX-ILIARY):

Input Impedance — 9,000-50,000 ohms (data input); 10,000 ohms minimum (clock input).

Input Signal — PCM NRZ data, 0-6 v, up to 51.2 kbps.

Signal Processing — Biphase modulation of a 1024 kc subcarrier.

PCM Clock Signal — 512 kc square wave at 6.0 v p-p. Bandwidth (3 db) - 150 kc, nominal, centered about 1024 kc.

LM PCM CHANNEL (RECORD):

Input Impedance — 5,000-10,000 ohms balanced.

Input Signal — Split bit PCM NRZ data at 1.6 kbps and 0.14 to 8.77 v p-p.

Signal Processing — Symmetrical limiting to an output level of 4-5 v p-p open circuit.

Minimum Bandwidth (1 db) — 600 cps to 2.8 kc below 1 limiting.

S/N Ratio — 30 db minimum, at limiting threshold.

LM PCM CHANNEL (PLAYBACK):

Input Impedance — 10,000 ohms minimum, balanced.

Input Signal — Split bit PCM NRZ data at 51.2 kbps to a maximum level of 6.3 v p-p.

Signal Processing — Isolation; insertion loss, 22.8-24.6 db. Bandwidth — Flat to 1 db from 15 kc to 90 kc.

Distortion – Less than 2%.

95 kc, 125 kc and 165 kc.

S/N Ratio — 30 db minimum, at maximum input.

SCIENTIFIC DATA CHANNEL — THREE CHANNELS (REAL TIME):

Input Impedance — 300,000 ohms minimum.

Input Signal — Analog input from 0 to 5 v.

Signal Processing — Frequency modulation of a subcarrier at 95 kc, 125 kc and 165 kc.

Subcarrier Frequency Stability — $\pm 0.15\%$ of center frequency. Linearity — Deviation from best straight line is less than 0.15% of center frequency.

Deviation Sensitivity — 3% of center frequency per volt. Minimum Bandwidth (2 db) — DC to 3% of center frequency. S/N Ratio and Crosstalk — 30 db, minimum (detected signal) for maximum input.

SCIENTIFIC DATA — THREE CHANNELS (PLAYBACK): Input Impedance – 10,000 ohms minimum, balanced. Input Signal — AC to a maximum of 8 v p-p. Signal Processing — Frequency modulation of a subcarrier at

Deviation Sensitivity — 1.86% of center frequency per volt. Distortion — Less than 4.5% at maximum input. S/N Ratio and Crosstalk — 30 db minimum (detected signal) for 5 v p-p input. TV CHANNEL — HARD WIRED THROUGH THE PMP: Insertion Loss — Less than 0.5 db. Minimum Bandwidth (0.5 db) — DC to 500 kc. TV UMBILICAL CHANNEL: Input Impedance - Determined by TV channel load impedance. Input Signal — Unipolar to a level of 1.9 v p-p. Signal Processing — Isolation: Insertion loss, 0-5.6 db across 100 ohm load. Minimum Bandwidth (3 db) — 10 cps to 500 kc. UP VOICE CHANNEL: Input Impedance — 5,000 ohms minimum, balanced over band from 20 kc to 40 kc. Input Signal — Multiplexed voice and data subcarriers. FM voice subcarrier at 30 kc from 0.4 to 17 v p-p; 7.5 kc maximum deviation. Signal Processing - FM detection and mode switching for NORMAL, RELAY and BACK UP VOICE. Minimum Bandwidth (2 db) — 300 cps to 3 kc. Limiting — Greater than 10 db at minimum input. Distortion — Less than 7% for maximum deviation. S/N Ratio - 35 db minimum, for maximum deviation. UP DATA CHANNEL: Input Impedance — 5,000 ohms minimum, balanced over band from 60 kc to 80 kc. Input Signal — Multiplexed voice and data subcarriers. FM data subcarrier at 70 kc from 0.4 to 17 v p-p; 5 kc peak deviation (7.5 kc for back up voice). Signal Processing - FM detection and mode switching for UP DATA and BACK UP VOICE. Limiting — Greater than 10 db at minimum input. Time Delay — Constant to within 20 microseconds. Linearity — 2% of full scale from best straight line up to peak deviation of 5 kc. Minimum Bandwidth (3 db) — 300 cps to 4 kc. S/N Ratio — 30 db minimum, for 5 kc peak deviation.

Subcarrier Frequency Stability — $\pm 0.45\%$ of center frequency.

Minimum Bandwidth (2 db) - 12.5 cps to 3% of center fre-

quency.

MICROPHONE CHANNEL: Output directly connected to input through switchable rela contacts. **EMERGENCY KEY CHANNEL:** Input Impedance (CTE Clock) — 100 ohms $\pm 10\%$. Input Signal — 512 kc square wave, unipolar, 3 v p-p. Signal Processing - Mode switching and on-off keying of th filtered 512 kc subcarrier. Insertion loss, 2.9-3.7 db for keye signal. **OUTPUT IMPEDANCES:** PM Channel - 110 ohms maximum. FM Channel - 150 ohms maximum. Back Up CM Voice Channel — 600 ohms ±20% balanced TV Channel — 100 ohms $\pm 5\%$. TV Umbilical Channel — 100 ohms +5%. Intercom LM Voice (Record) — 600 ohms $\pm 20\%$ balanced LM PCM (Record) — 600 ohms $\pm 20\%$ balanced. Scientific Data (Record) - Equal to scientific data source in pedance. Up Voice Channel -600 ohms $\pm 20\%$ balanced. Microphone/Up Voice Relay Channel - Relay, 600 ohm $\pm 20\%$ balanced. Microphone, equal to microphone source in pedance. Up Data Channel — 600 ohms $\pm 20\%$ balanced. **OUTPUT LEVELS:** PM (Unmodulated subcarriers) -MODE PCM TLM VOICE PCM/HI RATE/VOICE 2.52 v p-p ±5% 1.46 v p-p ±5% PCM/LO RATE/VOICE 1.46 v p-p ±5% 2.52 v p-p ±5% PCM only $3.40 \text{ v p-p} \pm 5\%$ VOICE only 2.52 v p-p ±5% BACK UP CM VOICE/PCM 2.52 v p-p ±5% FM (Unmodulated subcarriers) -MODE PCM TLM 9 TAPE/PCM ALG $1.2 v p-p \pm 5\%$ 0.15 v SCIENTIFIC None 0.15 v

	UP VOICE — Normal, 0.8 ± 0.07 v rms into 18,000 ohms.
ay	Relay, 0.707 v rms ± 3 db into 600 ohms. Back up, 0.8 ± 0.07 v
	rms into 18,000 ohms.
	UP DATA — 0.99 v rms $\pm 10\%$ into 600 ohms.
	Environmental Specifications
ne	RANDOM VIBRATION:
ed	10-70 cps — Linear increase in level from 0.0025 g ² /cps to
	0.0187 g ² /cps (linear refers to a straight line plotted on log-log
	paper). 70-2000 cps — Constant at 0.0187 g^2/cps .
	THERMAL:
	Continuous operation with average coldplate temperature of
d.	+118° F. Equipment subjected to transient reentry simulation
	with no coolant flow in coldplate for 15 minutes.
	VACUUM:
d.	100 hours at 1 x 10-4 mm Hg.
	SHOCK:
n-	78 g, 11 millisecond pulse (non-operation).
	Mechanical Specifications
ns	ENVELOPE SIZE:
n-	4.69" W, 5.977" H, 10.58" D (11.91 cm W, 15.18 cm H,
	26.87 cm D) maximum.
	WEIGHT:
	11.3 lbs. (5.12 kg) maximum.
	Specifications subject to change without notice.
6	
6	
1_	

SCIENTIFIC	SUBCARRIERS	(Each)
------------	-------------	--------

5 kc	125 kc	165 kc
p-p ±8%	0.22 v p-p ±8%	0.34 v p-p ±8%
p-p ±8%	0.22 v p-p ±8%	0.34 v p-p ±8%

TRACKING THRESHOLD: Less than -157 dbw (nominally -165 dbw). DYNAMIC RANGE: To 76 db above threshold. ACOUISITION RANGE: Capable of acquiring when the received frequency is swept at a rate of 35 kcps/s or less out of ± 90 kc at -144 dbw. RANGING TURNAROUND CHANNEL BANDWIDTH: 10 kc to 1.2 mc. INFORMATION CHANNEL BANDWIDTH: 10-100 kc. WIDEBAND PHASE DETECTOR SENSITIVITY: 1 v peak out for 1 radian peak carrier deviation. DEMODULATION CAPABILITY: Linear from 0.2 radian to 1.5 radians carrier deviation. RF TRACK OUTPUT: 0.5 v rms/1% amplitude modulation at 50 cps. PM Transmitter FREQUENCY: 240/221 times received frequency or 2287.5 mc $\pm 0.0015\%$ in the auxiliary oscillator mode. POWER OUTPUT: 275-400 milliwatts into a 1.3:1 load at any phase angle. MODULATION SENSITIVITY: 1 radian carrier deviation for 1 v input. Capable of 2.4 radians

carrier deviation.

WIDEBAND MODULATION BANDWIDTH:

300 cps to 1.5 mc.

FM Transmitter REST FREOUENCY:

 $2272.5 \text{ mc} \pm 455 \text{ kc}.$

POWER OUTPUT:

100-145 milliwatts into 1.3:1 load at any phase angle.

MODULATION SENSITIVITY:

1 mc carrier deviation for 1 v input for frequencies from 300 cps to 1.2 mc.

TV MODULATION INPUT:

1 mc per volt offset for 1.3 v input for center frequency from dc to 500 mc.

Environmental Specifications

RANDOM VIBRATION:

Linear increase in level from 0.008 g^2/cps at 10 cps to 0.06 g^2/cps at 70 cps. Constant level of 0.06 g^2/cps , 70 cps to 2000 cps. Time duration 2.5 minutes in each of three major axes. TEMPERATURE/VOLTAGE:

Continuous operating test conducted with average coldplate temperature of 35° F, surrounding air and wall temperature of 0° F and input voltage set at 113 v ac. Continuous operating test conducted with average coldplate temperature of 118° F, surrounding air and wall temperature of 150° F and input voltage set at 117 v ac. Equipment subjected to reentry simulation with no coolant flow with air and surrounding wall at 140° F and input voltage set at 117 v ac.

VACUUM:

100 hours of operation at 1 x 10⁻⁴ mm Hg.

Mechanical Specifications

SIZE: 9.5" W, 6" H, 21" D (24.13 cm W, 15.24 cm H, 53.34 cm D). WEIGHT: Less than 38 lbs. (17.22 kg). Specifications subject to change without notice.











1M-JPC-12-66

Unified S-Band Equipment

APOLLO (BLOCK II)

Unified S-Band Equipment

APOLLO (BLOCK II)

Unified S-band system combines voice and data communication, tracking, ranging and telemetry on a single radio frequency in the S-band range.

Dual transponders, either one of which can operate simultaneously with a frequency modulated transmitter, offer operational flexibility and redundancy.

Compact construction enables packaging of both transponders and the frequency modulated transmitter in a single, gasket-sealed, machined-aluminum case, with hermetically sealed connectors.

Phase locked transponders generate their transmission frequency coherently with the received signal, or, when the phase lock loop is not closed, utilize an auxiliary oscillator.

The Unified S-Band Equipment is utilized for a primary communications link in space communications systems. This highly versatile unit provides a completely redundant transponder and simultaneous FM transmitter capabilities in the S-band frequency range.

When this unit is used in conjunction with Collins' Pre-Modulation Processor (which performs the functions of subcarrier generation, modulation, mixing and detection), it is capable of simultaneously performing many communication functions which ordinarily would require separate receivers and transmitters.

The transponder receives and coherently detects a phase modulated carrier and transmits a phase modulated carrier coherently related to the received carrier. When no receive frequency is present, the transponder transmits a phase modulated carrier generated from an auxiliary oscillator.

Coherent detection and turnaround circuitry allows reception and retransmission of ranging signals in the PM modes. With proper design of the modulation, subcarrier channels may be received and transmitted simultaneously with the ranging channels. These subcarriers in turn may be modulated with voice or both digital and analog data. The down-link carrier also has baseband modulation capability.

The FM transmitter provides the capability of frequency modulation for transmitting voice or analog and digital information via subcarriers or wideband information such as television.

Equipment Description

The receiver accepts a 2106.4 mc phase modulated signal and converts it to a frequency of 9.5 mc at the output of the second mixer.

A narrowband amplifier provides the input to the receiver phase-lock loop which in turn generates the reference signal for conversion of the IF spectrum to baseband and coherent AGC control of the first IF amplifier. The coherent amplitude detector has an output that is sent to the antenna mechanism for tracking purposes.

The output of the second mixer is also fed through a wideband amplifier and limiter and mixed with the reference signal in the phase detector. An output from the detector is provided for extraction of the up-link information, including undetected subcarriers if present. The ranging signal, if present, is sent to the phase modulator for retransmission.

The transponder down-link carrier is derived from the coherent voltage controlled oscillator, or from the auxiliary oscillator. The phase modulator combines the wideband (subcarrier), ranging turnaround, and voice modulation inputs and phase modulates the carrier. The phase modulator's output is then connected to the transmitter amplifiers and multipliers.

Both transponders are connected to a power combiner, eliminating the necessity of RF switching between units.

The FM transmitter operates simultaneously with the PM transponder. The FM exciter has two modulation inputs — either a wideband input (subcarriers and analog or digital data) or an offset TV input. The FM exciter connects to the transmitter amplifier and frequency multiplier and an isolation network.

Reliability and Quality Assurance

The probability of success for the dual transponder and FM transmitter for 200 hours of operation in the Apollo mission is R=0.999965 for the transponder and R=0.997998 for the FM transmitter. Parts and material have been selected





Modular construction of Unified S-Band Equipment is shown in this interior view. Each module is foamed and shielded.

and carefully tested to ensure high reliability, and reliable circuit performance has been assured by extensive electrical and environmental testing and analysis techniques such as failure effect evaluation and parts stress analysis.

This equipment is developed to a quality assurance program incorporating the provisions of NASA Quality Publication NPC 200-2, Quality Assurance Provisions for Space Systems Contractors.

Equipment is qualification tested for manned space flight.

The Communications and Data Subsystem for the Apollo spacecraft was designed and developed by Collins Radio Company under contract for North American Aviation, Space and Information Systems Division. As Subsystem Manager, Collins established all equipment specifications for both Collins developed and subcontracted equipment, coordinated all technical, reliability, quality, documentation and fiscal requirements to ensure a complete, well integrated system. The Unified S-Band Equipment was designed, developed and manufactured under Collins direction by Motorola Aerospace Center, Scottsdale, Arizona

Specifications Electrical Specifications POWER SOURCE: 3 phase, 115 v ac, 400 cps and +28 v dc. INPUT POWER: Less than 34 watts ac and 2.4 watts dc. Receiver (double heterodyne, phase lock loop) FREQUENCY: 2106.40625 mc. VCO STABILITY: ±0.002%.

Specifications

Electrical Specifications

POWER REQUIREMENTS:

115/200 v ac, 3 phase - 180 watts with both TWT amplifiers in full power mode; 80 watts with both TWT amplifiers in reduced power. 28 v dc - 5 watts steady state and 350 watts during switching for 0.5 second maximum. INPUT RF DRIVE POWER: 2287.5 mc (PM) - 230-365 mw; 2272.5 mc (FM) - 83-132 mw. INPUT IMPEDANCE: 50 ohms (all ports). INPUT VSWR: 1.6:1 maximum (all ports). OUTPUT POWER: 2287.5 mc (PM) - 11.2 watts minimum. 2272.5 mc (FM) - 11.2 watts minimum. **REDUCED OUTPUT POWER:** 2287.5 mc (PM) - 2.8 watts minimum. 2272.5 mc (FM) - 2.5 watts minimum. DUTY CYCLE: Continuous. OUTPUT IMPEDANCE: 50 ohms nominal. PHASE STABILITY: Shall not add more than 0.05 radians rms phase jitter to the RF signal. PM BYPASS ATTENUATION: 2.6 db maximum. TRANSMISSION BANDWIDTH (0.5 db points): 2287.5 mc — ±2.0 mc; 2272.5 mc — ±2.5 mc.

RECEIVE CENTER FREQUENCY: 2106.4 mc. RECEIVE BANDWIDTH (0.5 db POINTS): 2106.4 mc — ±2.0 mc. RECEIVE INSERTION LOSS: 2.5 db maximum. RECEIVE ISOLATION: 60 db minimum between PM or FM signal frequencies and the receiver output connector.

Environmental Specifications

RANDOM VIBRATION:
10-70 cps — Linear increase in level from 0.0025 g²/cps to 0.0187 g²/cps (linear refers to a straight line plotted on log-log paper). 70-2000 cps — Constant at 0.0187 g²/cps.
THERMAL:
Continuous operation with average coldplate temperature of +118° F. Equipment subjected to transient reentry simulation with no coolant flow in coldplate for 15 minutes.
VACUUM:
100 hours at 1 x 10⁻⁴ mm Hg.
SHOCK:
78 g, 11 millisecond pulse (non-operating).

Mechanical Specifications

ENVELOPE SIZE: 5.75" W, 5.95" H, 22.2" D (14.61 cm W, 15.11 cm H, 56.39 cm D) maximum. WEIGHT: 32 lbs. (14.5 kg) maximum.

Specifications subject to change without notice.

COMMUNICATION/COMPUTATION/CONTROL







S-Band Power Amplifier APOLLO (BLOCK II)

S-Band Power Amplifier

APOLLO (BLOCK II)





Simultaneous amplification of two frequencies is possible by use of two independent power amplifiers.

Flexibility is achieved through use of coaxial transfer switch which allows either power amplifier to amplify either frequency.

Power economy is realized by bypassing the phase modulated signal around the power amplifier directly to the antenna when amplification is not required. High or low level amplification may be selected depending on communication distance.

Simultaneous transmit and receive functions are provided by a triplexer.

The S-Band Power Amplifier uses a traveling wave tube (TWT) power amplifier to provide high power amplification of the low level outputs of the spacecraft Unified S-Band Equipment. The unit contains two independent power amplifiers for amplification of the 2287.5 mc phase modulated (PM) and the 2272.5 mc frequency modulated (FM) input frequencies.

Either TWT may be selected for amplification of the PM or FM signal. The PM input signal is bypassed (without amplification) to the antenna jack whenever PM amplification is not required. No bypassing capability is provided for the FM signal.

The S-Band Power Amplifier provides two power levels (11.2 and 2.8 watts) of the PM signal, plus the bypass mode, and two power levels (11.2 and 2.5 watts) of the FM signal. The unit also contains a triplexer to allow use of a single antenna for simultaneous transmission and reception.

The S-Band Power Amplifier is packaged in a single sealed and pressurized case.

Equipment Description

The S-Band Power Amplifier, operating at both 2272.5 mc and 2287.5 mc, provides two selectable operating modes: reduced power and full rated power.

A bypass mode is provided for the PM signal. During the PM bypass mode, the 230-365 mw input drive signal is routed past the TWT to the triplexer and is attenuated approximately 2.6 db at the antenna connector.

The reduced power mode permits TWT operation at reduced input power and will produce a minimum of 2.5 watts for FM and 2.8 watts for PM at the antenna connector. The full rated power mode enables maximum output of the TWT and increases the output signal to a minimum of 11.2 watts for both FM and PM channels.

Should the loss of one or more phases of the 400 cycle primary power occur, automatic protection circuits activate, immediately switching the power amplifiers off and bypassing the PM drive signal to the antenna jack.

The modes of operation are selected remotely on the Communication Control Panel. One control switch, PRI-

lunar mission. Parts and material have been selected care-MARY/SECONDARY, operates the transfer switches to select the TWT to be used for amplification of the PM signal. fully, tested, and inspected thoroughly to ensure the highest practical equipment reliability. Circuit performance has The FM drive signal is automatically routed to the TWT not been assured by extensive electrical and environmental testselected for the PM signal. Another control switch is used to select FULL POWER, ing and by the use of analysis techniques such as failure OFF, or REDUCED POWER for the TWT selected for effect evaluation, parameter variation analysis, and stress PM amplification. When this control switch is in the OFF analysis.

position, the PM drive signal is bypassed around the TWT, through the triplexer and out the antenna connector.

A third control function applies power to the TWT not selected for PM use and selects the full power mode or the reduced power mode for FM signal amplification.

The S-Band Power Amplifier contains a triplexer to put both the transmit (PM and FM) carriers on one transmission line and allow a receive output from the antenna via the same transmission line. The receive channel of the triplexer is centered on 2106.4 mc.

The S-Band Power Amplifier requires sources of +28v dc and 115 volt line to neutral, 400 cps, 3 phase power for operation and utilizes a maximum of 180 watts with both TWT amplifiers in full power mode. The dc power is used for switching and control purposes only.

Reliability and Quality Assurance

The probability of success of the S-Band Power Amplifier is R=0.999931 for 200 hours of operation in the Apollo



This equipment is being developed to a quality assurance program incorporating the provisions of NASA Quality Publication NPC 200-2, Quality Assurance Provisions for Space System Contractors.

Equipment is qualification tested for manned space flight.

The Communications and Data Subsystem for the Apollo spacecraft was designed and developed by Collins Radio Company under contract for North American Aviation, Space and Information Systems Division. As Subsystem Manager, Collins Radio established all equipment specifications for both Collins developed and subcontracted equipments, and coordinated all technical, reliability, quality, documentation and fiscal requirements to ensure a complete, well integrated system. The S-Band Power Amplifier was designed, developed and manufactured by Collins.





COLLINS RADIO COMPANY / DALLAS, TEXAS · CEDAR RAPIDS, IOWA · NEWPORT BEACH, CALIFORNIA · TORONTO, ONTARIO Bangkok · Beirut · Frankfurt · Hong Kong · Kuala Lumpur · Los Angeles · London · Melbourne · Mexico City · New York · Paris · Rome · Washington · Wellington

APOLLO (BLOCKS I AND II)

S-Band Bench Maintenance Equipment

APOLLO (BLOCKS I AND II)

Integrated test facility for the following:

Unified S-Band Equipment—S-Band Power Amplifier Versatility and flexibility result from building block approach using unmodified standard and non-standard test equipment.

Collins S-Band Bench Maintenance Equipment (S-Band BME) is a manually operated test console providing functional test capabilities for the Apollo Block I and Block II Unified S-Band Equipment and S-Band Power Amplifiers. The S-Band BME is used to accomplish the following:

1. Verify spacecraft equipment performance at acceptance test level.

2. Detect and isolate malfunctions.

3. Provide end-to-end tests between the Unified S-Band Equipment and the S-Band Power Amplifier.

Designed for simplicity of operation and maintenance, the S-Band BME consists of both standard and special test components mounted in six standard 19-inch racks. These equipments are integrated by means of RF cables and wiring harnesses to form a centralized testing and maintenance facility.

Test Capabilities

Components in the S-Band BME are interconnected to perform three basic functions:

1. Provide necessary electrical/mechanical interface with the equipment under test.

2. Supply the correct stimuli and power to exercise the equipment under test.

3. Receive and evaluate the responses from the equipment under test.

The S-Band BME provides electrical parameter test capability at acceptance test level for the USBE and S-Band PA. In addition, it provides for simultaneous operation of both S-band equipments so that the units may be evaluated as a system.

Provisions are included for interfacing the BME with external equipments. One such provision is a Ranging Interface Panel which permits the BME to be connected with external equipment for evaluating the ranging characteristics of the S-band system. Other provisions include modulation inputs to subcarrier oscillators for possible interface with voice and/or data systems and demodulated outputs for interface with other processing equipments.

All S-band RF interface between the BME and the spacecraft equipment is via the S-Band RF Patch Panel. The patch panel contains loads, directional couplers, attenuators, load isolators, power dividers, etc., which facilitate S-band signal monitoring and distribution throughout the BME. Also, contained in the RF Patch Panel is a triplexer which separates the two S-band transmit frequencies and simultaneously permits injection of the receive signal onto one common antenna line.

S-band signals are patched into and out of the RF Patch Panel through 19 front panel connectors. These connectors are low loss quick-disconnect General Radio connectors.

Within the S-Band BME are several specialized systems involving power distribution and temperature control. These are:

1. Spacecraft equipment mounting plates with forced air cooling and temperature monitoring.

2. Metering and voltage control of 400 cps circuits.

3. Transient protection on 400 cps line.

4. Independent power systems for spacecraft equipment.

5. Power interlocks on all rear doors and major special test equipment drawers.

6. Rack forced air cooling.

One of the most important design considerations in the development of the S-Band BME involved an attempt to achieve a test accuracy of ten to one (10:1) better than the maximum allowable spacecraft tolerance. As a result of achieving this for most parameters tested, the S-Band BME is a highly sophisticated piece of test equipment which, in many respects, approaches the limits of the stateof-the-art and represents the ultimate in testing accuracy.

Adaptability/Convertibility

Although originally designed to perform tests on Apollo Block I and Block II S-Band Equipments (Unified S-Band Equipment and S-Band Power Amplifier), the S-Band BME has extreme versatility and flexibility that permit it to be easily adapted to other S-band equipment.

The building block concept on which the design of the S-Band BME was based, allows individual usage of all standard and special test equipment. The S-Band BME has two control panels; the USBE Control Panel and the S-Band Power Amplifier Control Panel. These control panels provide the necessary control of the spacecraft power and operational modes as well as test point monitoring. These panels are easily removed and may be replaced with similar control panels for other S-band equipment. All of the special test exciters and receivers in the S-Band BME are of modular construction which permits the frequencies and other parameters of these units to be changed from their present configuration.

The patching techniques incorporated in the S-Band RF Patch Panel provide adaptability to any S-band system, thus facilitating S-band interfaces between the BME and the unit under test.

Test Equipment Summary

NON-STANDARD TEST EQUIPMENT

PM Transmitter

RF OUTPUT: 2106.40625 mc ± 100 kc, 0 dbm ± 3 db into 50 ohm load. 2106.40625 mc ± 100 kc, -20 dbm to -140 dbm variable into 50 ohm load.

PM LINEARITY: $\pm 1\%$ of best straight line for deviations up to 2 radians peak, and $\pm 5\%$ up to 3 radians peak.

PM FREQUENCY: 1 radian/v rms $\pm 10\%$ modulation sensitivity. Shall not vary more than 1% from 10 cps to 1.5 mc, or more than 5% to 4 mc.

FREQUENCY MODULATION: Capable of being swept at least ± 100 kc from f_c at a rate of 35,000 cps/second.

SWEEP OUTPUT: DC to 10 cps clipped triangular wave at $\pm 0.15 \text{ v} \pm 20\%$ for maximum $\pm \text{delta F}$ with 50,000 ohms maximum output impedance.

VCO FREquency OUTPUT: 21.94173 mc ± 1.05 kc at 0 dbm ± 3 db, 50 ohm output impedance.

RF Track Panel

MODULATION CAPABILITY: Shall amplitude modulate a 2106.4 mc carrier between 0% and 80% over a frequency

bandwidth of dc to 25 kc. The modulated carrier level shall be -35 dbm to -125 dbm ± 3 db with a maximum output VSWR of 1.3:1.

USBE OUTPUT DEMODULATION LINEARITY: $\pm 1\%$ of best straight line for input signals from 0.1 v to 2 v rms, and within $\pm 5\%$ up to 5 v rms for a 50 cps square wave.

PM Receiver

Input Frequency: 2287.5 mc ± 0.1 mc.

INPUT LEVEL: 0 to -50 dbm.

SWITCH SELECTABLE OUTPUTS: Switch selects the following output at 0 dbm. ± 1 db/50 ohms:

$10 \text{ kc} \pm 1 \text{ kc}$	(3	db	bandwidth)
100 kc ± 5 kc	(3	db	bandwidth)
500 kc \pm 12.5 kc	(3	db	bandwidth)
$1.024 \text{ mc} \pm 10 \text{ kc}$	(3	db	bandwidth)
$1.25 \text{ mc} \pm 10 \text{ kc}$	(3	db	bandwidth)
Wideband video at 1 radian			

BACKUP VOICE OUTPUT: 0.1 v/kc to 10 kc with 3 db bandwidth 300 cps to 2 kc.

10 MC Ranging Output: $-10 \text{ dbm} \pm 1 \text{ db/50}$ ohms with unmodulated carrier.

10 MC Reference: $\pm 10 \text{ dbm} \pm 2 \text{ db/50 ohms}$.

Tracking Bandwidth: BL = 21.2 cps. BL = 400 cps.

PHASE STABILITY (SYSTEM): 3° rms maximum, in 21.2 cps bandwidth (including stability of PM Signal Generator and Frequency Converter).

FM Receiver

Input Frequency: 2272.5 mc ± 0.5 mc.

INPUT LEVEL: 0 to -50 dbm.

INPUT IMPEDANCE: 50 ohms with 1.3:1 VSWR.

OUTPUTS: Flat within 0.2 db for modulating frequency dc to 1.5 mc and deviations up to 1 mc; 0.3 v/mc $\pm 10\%$ with nominal output impedance of 75 ohms.

Flat within 1 db, 10 cps to 2 mc; 60 v/mc $\pm 10\%$ with nominal output impedance of 75 ohms.

Impedance Simulator

Subcarrier Filters (30 kc, 50 kc, 70 kc):

Input Impedance — 10,000 ohms minimum.

Output Impedance — 50 ohms maximum.

Input Levels — 0.1-4.0 v rms.

Output Levels — 30 kc and 70 kc adjustable.



0-0.5 rms; 50 kc, linear with respect to input within $\pm 1\%$ of best straight line.

1.25 MC, BIPHASE MODULATOR AND DOWN LINK SUBCAR-RIER SUMMING AMPLIFIER:

Auxiliary Input — 0.1 v rms minimum, 300 cps to 1.5 mc, 50 ohms input impedance.

1.25 mc VCO input — 1.5 v peak, 160 cps to 15 kc, 6,000 ohms minimum, input impedance.

PCM Input — 0-6.5 v p-p, dc to 250 kc, 5,000 ohms $\pm 5\%$ input impedance.

Output - 0.1-9.0 v p-p 300 cps to 2 mc within \pm 0.5 db, 8 ohms maximum output impedance.

TV BIAS AND SUMMING AMPLIFIER:

TV — Input 0-1.5 v peak, dc to 500 kc, 50 ohms $\pm 10\%$ input impedance.

Output — 0-2.4 v (dc offset adjustable 0.2-2.5 v dc) over 0.1 db bandwidth of dc to 500 kc, output impedance 95 ± 5 ohms. Backup voice and wideband FM provided as direct feed through signals.

30 KC AND 70 KC VCO'S AND SUMMING AMPLIFIERS:

30 kc VCO Input — 0-5 v p-p, 30 cps to 3 kc, input impedance 680 ohms $\pm 10\%$.

70 kc VCO Input — 0-5 v p-p, dc to 4 kc, input impedance 680 ohms $\pm 10\%$.

External Modulation Input — 0-1.5 v rms, 300 cps to 2 mc, input impedance 50 ± 5 ohms.

PRN Input - 0 to -5.5 v maximum, 300 cps to 3 mc, input impedance 50 \pm 5 ohms.

Output -2 v rms maximum, 300 cps to 2 mc, flat within ± 0.1 db within ± 1 db to 4 mc.

Phase Lock Receiver

2287.5 mc, 0-25 dbm input 40 or 100 cps loop bandwidth; ± 50 kc lock range.

30 mc IF for PM and narrowband FM; 70 IF for wideband FM.

Phase detection, 300 cps to 1.5 mc deviation to 90° peak. Wideband FM, 5 cps to 3 mc deviation, 100 kc to 3 mc. Narrowband FM, 240 cps to 10 kc. Deviation 0-20 kc. Crystal Controlled Signal Generator

2287.5 mc, +10 dbm output.



Phase Modulation Test Set

Provides for frequency conversion from 2106.40625 mc to 2287.5 mc; also provides for precise demodulation of a phase modulated signal on 2106.40625 mc. USBE Control Panel

Provides for control of USBE power and operational modes; also test point monitoring.

S-Band PA Control Panel

Provides for control of S-band PA power and operational modes; also test point monitoring.

S-Band RF Patch Panel

Provides all S-band interface requirements between spacecraft equipments and stimuli and responses measuring equipment in BME.

Ranging Interface Panel



Interconnecting Box

Power interface among S-Band BME power source, 6.7 v power supply, 150 v power supply and phase lock receiver.

Transtent Suppressor Tanet	
Suppresses transients on 400 cp	s primary power to equip-
ment under test.	
Power Distribution Panel	
Provides front panel voltage co	ontrol and monitoring, and
interlock override.	
Power Distribution Box	
Interface between external power	r sources and S-Band BME
includes filtering and circuit brea	aking.
Temperature Monitor	
Displays spacecraft equipment	mounting fixture tempera-
ture; contains overtemperature a	alarms and blower control.
Centrifugal Fans	
Two fans provide cooling air	to spacecraft equipment
mounting fixtures.	
Transponder Test Panel	
Centralized access to Unified S-B	Band Equipment test points.
Power Amplifier Test Panel	

STANDARD TEST EQUIPMENT Function Generator Hewlett-Packard 3300A/3302A

Digital Voltmeter Dymec 2401C-M123 **Test Oscillator** Hewlett-Packard C24-651A TWT Amplifier (Quantity of 2) Hewlett-Packard 491C Tektronix RM45A with Type CA Plug-In Oscilloscope **UHF Signal Generator** Hewlett-Packard 8614A Precision Power Supply Power Design 2005 Power Meter Calibrator Hewlett-Packard 8402A Power Meter Hewlett-Packard H20-431B Differential Voltmeter Fluke 803B **RMS** Voltmeter Hewlett-Packard 3400A Thermal Transfer Standard Fluke 540B NJE SR-28-10 Power Supply Power Supply, 150-Volt Lambda LE-110-M Lambda LA8-08BM Power Supply, 6.7-Volt Beckman 7360 JR Counter Transfer Oscillator Beckman 7580 R Wattmeter Voltron 19.015 Blower Three blowers supply cooling air to S-Band BME

Specifications

Electrical Specifications POWER REQUIREMENTS: $28 \pm 2 v dc, 15 amp.$ 120 v ac + 3%, -10%, 60 cps, 3 phase, 5 -wire, 3500 watts. $208/120 \pm 2$ v ac, 400 ± 10 cps, 3 phase, 4-wire, 300 watts.

Environmental Specifications

TEMPERATURE: 60°-80° F, 52°-105° F for 1 hour. ALTITUDE: Up to 6000 ft. **RELATIVE HUMIDITY:** Less than 75% at 70° \pm 10° F.

Mechanical Specifications

SIZE: 1261/2" W, 771/2" H, 453/4" D (321.31 cm W, 196.85 cm H, 116.21 cm D), including work shelf. WEIGHT: 3000 lbs. (1359 kg). Specifications subject to change without notice.





Communications Bench Maintenance Equipment Block Diagram.

COMMUNICATION/COMPUTATION/CONTROL



COLLINS RADIO COMPANY / DALLAS, TEXAS • CEDAR RAPIDS, IOWA • NEWPORT BEACH, CALIFORNIA • TORONTO, ONTARIO Bangkok · Beirut · Frankfurt · Hong Kong · Kuala Lumpur · Los Angeles · London · Melbourne · Mexico City · New York · Paris · Rome · Washington · Wellington

IM-JPC-12-66



Communications Bench Maintenance Equipment

APOLLO (BLOCKS | AND ||)





Communications Bench Maintenance Equipment

APOLLO (BLOCKS I AND II)



Audio Center — VHF/AM Transmitter-Receiver — HF Transceiver — Recovery Beacon — Pre-Modulation Processor — VHF/FM Transmitter.

Versatility and flexibility result from building block approach using unmodified standard and non-standard test equipment.

Collins Communications Bench Maintenance Equipment (COMM BME), is a manually operated test console providing functional test capabilities for the Apollo Block I and II communications equipments. The COMM BME is used to accomplish the following:

1. Verify spacecraft equipment performance at acceptance test level.

2. Detect and isolate malfunctions.

3. Provide for subsystem tests on interconnected communications equipment.

Designed for simplicity of operation and maintenance, the COMM BME consists of both standard and special test components mounted in seven standard 19-inch racks. These equipments are integrated by means of RF cables and wiring harnesses to form a centralized testing and maintenance facility.

Test Capabilities

Basically, the COMM BME consists of six testing subsystems, one for each spacecraft equipment tested. A Special Test and Maintenance Unit (STMU) is provided for each type of spacecraft equipment tested; i. e., the Audio Center, VHF/AM Transmitter-Receiver, HF Transceiver, Recovery Beacon, Pre-Modulation Processor, and VHF/FM Transmitter. The STMU, other special test equipments, and standard test equipments are integrated and interconnected to perform three basic functions as follows:

1. Provide necessary electrical/mechanical interface with the equipment under test.

2. Supply the correct stimuli and power to exercise the equipment under test.

3. Receive and evaluate the responses from the equipment under test.

The test equipment is mounted in the seven-rack structure in such manner as to be adjacent to the equipment under test and the STMU. The configuration of the COMM BME provides electrical parameter test capability at acceptance test level for both the Block I and Block II versions of all Apollo communications equipment listed.

The STMU provides the necessary switching, signal conditioning, metering and loading. Test signals from the BME stimuli generators are routed through the STMU to the equipment under test. The response or output signals from the equipment under test are routed back through the STMU and then to standard test equipment evaluators as necessary for measurement and analysis.

Multiple use of standard test equipment is provided by signal distribution panels which contain selector switches to control routing to the STMU.

Test points are provided on individual test panels to provide access to key test points within the Apollo equipment under test. This permits more extensive fault isolation than could otherwise be provided.

Significant equipment interface signals may be intercepted at access panels and rerouted for end-to-end tests of various spacecraft equipment combinations.

Interface with the spacecraft equipment is made through connector panels. This provides further flexibility and change over from Block I to Block II test.

Within the COMM BME are several specialized systems involving power distribution and temperature control. These are:

1. Spacecraft equipment mounting plates with forced air cooling and temperature monitoring.

2. Metering and voltage control of 400 cps circuits.

3. Transient protection on 400 cps line.

4. Independent power systems for spacecraft equipment.

5. Power interlocks on all rear doors and major special test equipment drawers.

6. Rack forced air cooling.

A design goal was an attempt to achieve a test accuracy of ten-to-one (10:1) better than the maximum allowable spacecraft tolerance. As a result of achieving this for most parameters tested, the COMM BME is a highly sophisticated piece of test equipment for space communications equipment.

Adaptability/Convertibility

Although originally designed to perform tests on Apollo Block I and Block II spacecraft equipments, the COMM BME has extreme versatility and flexibility that permit it to be easily adapted to other similar equipments.

The building block concept on which the design of the COMM BME was based, allows individual usage of all standard and special test equipment. Standard test equipment is unmodified and is adapted for use by adjacent frontto-rear connector panels. The COMM BME STMU provides the necessary control of the spacecraft power and operational modes as well as test point monitoring. These are easily removed and may be replaced with similar units for other equipments.

Test Equipment Summary

NON-STANDARD TEST EQUIPMENT Audio Center STMU Provides switching and signal conditioning to verify performance of the Audio Center. Recovery Beacon STMU

Provides controls, meters and loads to verify performance of the VHF Recovery Beacon.

VHF/AM STMU

Provides controls, meters and RF loads to verify performance of the VHF/AM Transmitter-Receiver.

VHF/FM STMU

Provides controls, meters and RF loads to verify performance of the VHF/FM Transmitter.

HF STMU

Provides switching and signal conditioning required to verify performance of the HF Transceiver.

Pre-Modulation Processor STMU

Provides subcarrier oscillator and PCM signals, switching and signal conditioning to verify performance of the Pre-Modulation Processor.

Power Distribution Box

- Provides interface between COMM BME and facility power
- sources, and contains power control relays and circuit breakers.

Power Distribution Panel

- Provides control and monitoring for the COMM BME power circuits.
- Transient Suppressor
- Protects spacecraft equipments using 120 v, 3 phase, 400 cycle power from destructive transients.
- Temperature Monitor
- Provides an alarm circuit, temperature indicator, and individual coldplate blower controls.
- Access Panels
- Provide facilities for altering the normal signal routing in
- the COMM BME to enable simultaneous testing of two or more spacecraft equipments.
- Signal Distribution Panel

Provides selector switches to interconnect an individual STMU with companion stimuli and evaluator test equipment. Provides signal conditioning and routes sync lines. STANDARD TEST EQUIPMENT

- Mixer
- Combines the output frequencies from two separate audio oscillators to provide a two-tone signal for the HF and VHF/AM STMU's.
- <u>Audio Oscillator (two)</u> FREQUENCY RANGE: 5 cps to 600 kc. HF Signal Generator
- FREQUENCY RANGE: 50 kc to 65 mc. Modulation: 0%-100%. VHF Signal Generator
- FREQUENCY RANGE: 10-420 mc. MODULATION: 0%-95%. Digital Voltmeter RANGE: 0.001-999.0 v dc.
- VTVM Ohmmeter
- RANGE: 0-300 v ac, 0-1000 v dc, 0-500 megohms.
- AC Voltmeter
- FREQUENCY: 5 kc to 2 mc. RANGE: 0.001-300.0 v ac.
- INPUT: Isolated from ground.



Special Test and Maintenance Units, like this one for the Pre-Modulation Processor, are provided for each of the six Apollo spacecraft subsystems tested by the Communications Bench Maintenance Equipment.



The STMU's perform switching, signal conditioning, metering and loading functions.

RF Voltmeter RANGE: 1 my to 3 y ac. FREOUENCY: 10 kc to 500 mc. RMS Voltmeter RANGE: 1 my to 300 y ac. FREQUENCY: 10 cps to 10 mc. **RF** Power Meter RANGE: 0.001-1000.0 milliwatts. FREQUENCY: 0-10 gc. 3-Phase Wattmeter RANGE: 1-120 watts. Distortion Analyzer DISTORTION: 0.3%-100%. VOLTAGE: 0.03-300.0 v ac. Oscilloscope (Dual Channel) FREQUENCY: DC to 30 mc. SWEEP RATES: 0.1 usec/cm to 5 sec/cm and 2 usec/cm to 1 sec/cm. Counter FREQUENCY: DC to 2 mc. Transfer Oscillator FREQUENCY: DC to 12 gc. Spectrum Analyzer FREQUENCY: 2.5-40.0 mc. Discriminator All IRIG channels plus 95 kc, 125 kc, 165 kc and 1.25 mc. FM Deviation Meter FREQUENCY: 4-1024 mc. Range: ± 125 kc. Power Supply RANGE: 0-38 v dc, 0-15 amps. Noise Generator

FREQUENCY: 5 cps to 5 mc. SPECTRUM LEVEL: ± 1 db to 20 kc; ± 3 db to 50 kc; ± 8 db to 5 mc. Wave Analyzer FREQUENCY: 20 cps to 50 kc. BANDWIDTH: $+3\frac{1}{2}$ cycles. RANGE: 30-300 v ac. Unit Amplifier FREQUENCY: 5 cps to 500 kc. GAIN: 32 db. OUTPUT: 1.5 watts into 600 ohms up to 100 kc. Specifications Electrical Specifications POWER REQUIREMENTS: $28 \pm 2 v dc, 15 amps.$ 120 v ac, +3%, -10%, 60 cps, 3 phase, 5-wire, 4000 watts. $208/120 \pm 2$ v ac, 400 ± 10 cps, 3 phase, 4-wire, 100 watts. **Environmental Specifications TEMPERATURE:** 60°-80° F; 52°-105° F for one hour. ALTITUDE: Up to 6000 ft. **RELATIVE HUMIDITY:** Less than 75% at 70° $\pm 10^{\circ}$ F. Mechanical Specifications 1471/2" W, 771/2" H, 453/4" D (321.31 cm W, 196.85 cm H, 116.21 cm D), including work shelf. WEIGHT: 4000 lbs. (1812 kg).

Specifications subject to change without notice



Lunar Module

COMMUNICATIONS SUBSYSTEM



COMMUNICATIONS SUBSYSTEM

The Lunar Module communications subsystem is a versatile group of equipments that provide voice, video, range, spacecraft telemetry and crew bio-medical communications for the moon landing vehicle. The same equipments serve as a relay station between the command module, extra vehicular activity and earth.

Collins Radio Company is supplying the Signal Processor for the LM subsystem, under contract to Radio Corporation of America, who in turn is a contractor of Grumman Aircraft Engineering Corporation for the Grumman Lunar Module. It provides switching and signal processing for two VHF Transmitter-Receivers, Data Storage Equipment and an S-Band Transponder.

One of the two VHF channels receives seven bio-medical data subcarriers transmitted by an extra vehicular astronaut's backpack, in addition to providing two-way voice communications.

The astronauts have a choice of simplex or duplex VHF voice communications.

The LM communications subsystem transmits to and receives voice and data signals from earth by means of the S-Band Transponder. Very high frequency voice and data communications are maintained with the command module and extra vehicular astronauts.

By means of the Signal Processor, the LM is able to relay

S-band or VHF signals. This includes conversion of received VHF to S-band, or received S-band to VHF for retransmission.

The Signal Processor is one unit with three electrical sections on five cordwood subassemblies. These sections are pre-modulation processor, audio control circuits and audio centers.

The pre-modulation processor section conditions and switches analog and digital inputs to the S-Band Transponder. Digital inputs are pulse code modulation telemetry. Analog inputs are bio-medical and voice from each astronaut.

The audio control section processes and routes VHF "A" and "B" channels and S-band inputs to the pre-modulation processor for transmission, or to the audio center section for the crew to hear.

The audio center section services the microphones and headsets, including intercom between LM commander and engineer. Each crewman is provided with separate audio center circuitry on a cordwood subassembly. One subassembly circuit is capable of serving both astronauts.

The Collins Signal Processor also provides two emergency backup communication modulations, keyed code and clipped voice, that are independent of the pre-modulation processing circuits.



1M-WP-9-66

Printed in U.S.A.







COLLINS RADIO COMPANY / DALLAS, TEXAS · CEDAR RAPIDS, IOWA · NEWPORT BEACH, CALIFORNIA · TORONTO, ONTARIO

Bangkok · Beirut · Frankfurt · Hong Kong · Kuala Lumpur · Los Angeles · London · Melbourne · Mexico City · New York · Paris · Rome · Washington · Wellington

Signal Processor

COMMUNICATIONS SUBSYSTEM

Signal Processor LUNAR MODULE

Solid state cordwood construction results in low power consumption and light weight.

Emergency communication may be accomplished by either voice or CW, using the 512 kc clock input.

Independent audio control is provided for two stations.

Digital and analog data is multiplexed for PM or FM transmission via S-Band Transponder.

Performance is assured by extensive electrical and environmental testing.

The Lunar Module (LM) Signal Processor is the focal point of all LM communications. Signals transmitted and received by the LM are processed and switched by this unit. This includes spacecraft telemetry information, as well as voice and bio-medical data from the LM commander, engineer or an extra vehicular astronaut (EVA).

Switching provides for: (1) recording of data or voice on the Data Storage Equipment, (2) transmitting stored data or voice, (3) transmitting data or voice using the spacecraft's transmitters, and (4) intercommunication between the two-man crew, including during EVA activities.

The LM Signal Processor design uses cordwood circuit construction. Electrically the design is divided into three functions: (1) pre-modulation processor (PMP), (2) audio control, and (3) audio center.

Equipment Description

The PMP circuit processes and switches analog and digital data to provide the S-Band Transponder input. Data input, in the form of a non-return-to-zero signal, modulates a 1.024 mc subcarrier.

A 512 kc PCM Telemetery Equipment clock pulse is doubled to obtain the 1.024 mc subcarrier.

A 512 kc Central Timing Equipment clock pulse is used for an emergency key gate circuit to provide an output to the S-Band Transponder.

The analog portion of the PMP circuits consists of biomedical data from each astronaut. These signals and voice inputs from the audio centers are used to frequency modulate a 1.25 mc subcarrier. The 1.25 mc signal is obtained by doubling the sum of the 512 kc Central Timing Equipment clock pulse and a 113 kc voltage controlled oscillator signal.

The audio control circuits switch the input signals from the two VHF transceivers and S-band equipment. The biomedical portion of the VHF "B" signal received from an EVA pack is channeled to the PMP circuits where further processing is accomplished for transmission on S-band.

The audio center receives, switches, and processes voice signals from the microphone inputs of the astronauts to provide voice outputs for modulation of the VHF "A," VHF "B," Data Storage Equipment and S-band units, and for each astronaut's headset.

Specifications

PCM DATA SUBCARRIER FREQUENCIES: 1.024 mc. PCM DATA INPUT VOLTAGE: 0-6 v. PCM DATA SIGNAL LEVELS: Logic zero: 0 + 0.5, -0.0 v dc. Logic one: 6.0 ± 0.5 v dc. PM OUTPUTS: 1.024 mc data subcarrier, 1.25 mc voice/bio-medical subcarrier. or baseband voice/bio-medical subcarrier. PM 1.024 MC DATA SUBCARRIER: 0.65 v peak $\pm 10\%$ for PCM "HI," 0.35 v peak $\pm 10\%$ for PCM "LO." PM 512 KC DATA SUBCARRIER: 0.233 ± 0.02 v peak. PM 1.25 MC VOICE/BIO-MEDICAL SUBCARRIER: 0.65 v peak $\pm 10\%$ for PCM "LO," 0.45 v peak $\pm 10\%$ for PCM "HI." PM BASEBAND VOICE: 0.366 v peak - 30% + 60%. PM EMU: 0.10 v peak -33% +63%. PM HARDLINE 14.5 KC SUBCARRIER OSCILLATOR: 0.10 v peak $\pm 15\%$.

FM OUTPUTS:

1.024 mc data subcarrier, and 1.25 mc voice/bio-medical subcarrier, or baseband voice/bio-medical.



FM 1.024 MC DATA SUBCARRIER: 0.30 v peak $\pm 10\%$. FM 1.25 MC VOICE/BIO-MEDICAL SUBCARRIER: 0.15 v peak $\pm 10\%$. FM BASEBAND VOICE/BIO-MEDICAL: 0.366 v peak - 30% + 60%. AUDIO CONTROL INPUTS:

30 kc up voice subcarrier received on S-band, voice/bio-medical received on VHF, and voice from audio center output.

AUDIO CONTROL OUTPUTS: Up voice audio to audio center and bio-medical data to PMP. AUDIO CENTER INPUTS: VHF A and B audio, S-band audio and audio from other audio center circuitry. AUDIO CENTER OUTPUTS: VHF A and B modulation, data storage, S-band modulation, and audio from other audio center circuitry. Specifications subject to change



Gemini

COLLINS VOICE COMMUNICATION SYSTEM



Gemini is the second generation of spacecraft to be supplied with high frequency and ultra high frequency voice communications equipment by Collins Radio Company.

Under contract with McDonnell Aircraft Corporation, Collins has designed, built, tested and supported this equipment throughout the Gemini mission, just as it did in the Mercury program.

The Gemini system by Collins includes two 618L-1 UHF Transmitter/Receiver units, a 618N-1 Transmitter/Receiver and a 76H-1 Voice Control Center. Collins also has assembled special test benches for checking this equipment down to the submodule level.

Total weight of the voice communication system is only 17.4 pounds.

The system is solid state except for transmitter driver and power output stages. A transmitter, receiver and two regulated power supplies are packaged in one compact unit.

Two 618L-1 UHF Transmitter/Receiver units provide astronauts with high-quality, line-of-sight primary voice communications links.

The 618N-1 HF Transmitter/Receiver is a long-range system that is used as a secondary medium during orbit and furnishes communications and direction finding during recovery.

The 76H-1 Voice Control Center provides in one unit control of all transmitter/receiver units, intercom and an external voice recorder. This panel-mounted unit also contains the circuitry and amplifiers for microphones and headsets. It tone modulates the HF transmitter during the recovery phase so that it serves as a radio beacon.

All system units conform to high specifications regarding temperature, pressure, shock, acceleration and vibration.





618N-1 HF Transmitter/Receiver

618L-1 UHF Transmitter/Receiver



76H-1 Voice Control Center





COLLINS RADIO COMPANY / DALLAS, TEXAS · CEDAR RAPIDS, IOWA · NEWPORT BEACH, CALIFORNIA · TORONTO, ONTARIO Bangkok · Beirut · Frankfurt · Hong Kong · Kuala Lumpur · Los Angeles · London · Melbourne · Mexico City · New York · Paris · Rome · Washington · Wellington GEMINI

618L-1 UHF Voice Transmitter/Receiver

GEMINI

Transmitter/receiver and power supplies are contained in a compact 3.44-pound unit.

Simplex amplitude modulation is provided on stable 296.8 mc frequency.

Extensive solid state circuitry requires low power inputs.

Two Collins 618L-1 UHF Voice Transmitter/Receivers are used in the Gemini spacecraft to provide high quality line-of-sight voice communications throughout the mission. Transmission is controlled by either a push-to-talk switch or voice-operated (VOX) circuitry.

The 618L-1 transceivers are activated by a selector switch on the panel-mounted Collins 76H-1 Voice Control Center. The voice center also has volume and squelch controls that are common to both UHF transceivers.

To enhance effective communication power, the transmitter modulation system employs 12 db speech clipping. This amount of speech clipping produces an effective improvement in transmitter power output of approximately 8 db. This level of speech processing provides nearly maximum circuit improvement while retaining high intelligibility and natural voice sound.

Spacecraft power is conserved by separate 24 v dc receiver, and 24 v dc and 150 v dc transmitter power supplies. This allows astronauts to monitor UHF communications while the spacecraft transmitter is not in use.

Equipment Description

An ultra high frequency transmitter/receiver and two power supplies are contained in one foam-filled, sealed unit.

All circuits are solid state except the transmitter driver and power amplifier output stages.

The transmitter consists of a crystal-controlled oscillator, tripler, modulator and power amplifier.

The stable oscillator frequency is tripled to the final frequency of 296.8 mc. The driver and power amplifier tube grids are grounded to reduce noise generation. Amplified audio intelligence is applied to the power amplifier for high-level modulation.

The receiver section consists of RF, conversion, IF, detection, automatic gain control and audio amplification circuits.

Received signals are amplified in two stages and heterodyned with a 276.25 mc output from a stable local oscillator. The 20.55 mc IF is applied to a crystal lattice filter to determine receiver bandwidth. The IF signal is amplified by five stages, detected and applied to the audio amplifiers.

Automatic gain control is used in the RF amplifier and first four IF amplifier stages.



Specifications

POWER SOURCE: 18.0-30.5 v dc from buses. **POWER REQUIREMENTS:** Receive-4 watts.





Transmit-42.5 watts maximum at 50% modulation. **OPERATING FREOUENCY:** 296.8 mc. TRANSMITTER POWER OUTPUT: 3 watts minimum into 50 ohm load. AUDIO INPUT: +3 dbm. **RECEIVER BANDWIDTH:** 50 kc minimum at 6 db down; 200 kc maximum at 60 db down. **RECEIVER SENSITIVITY:** Maximum of 3.5 uv closed circuit. NOISE FIGURE: 14 db. SIZE: 2.9" W, 2.9" H, 8.3" D (7.37 cm W, 7.37 cm H, 21.08 cm D). WEIGHT: 3.44 lbs. (1.56 kg).

Specifications subject to change without notice.

Standby-14 watts maximum.







COLLINS RADIO COMPANY / DALLAS, TEXAS · CEDAR RAPIDS, IOWA · NEWPORT BEACH, CALIFORNIA · TORONTO, ONTARIO Bangkok · Beirut · Frankfurt · Hong Kong · Kuala Lumpur · Los Angeles · London · Melbourne · Mexico City · New York · Paris · Rome · Washington · Wellington

074 3289 00

1M-WP-9-66

618N-1 HF Voice Transmitter/Receiver GEMINI

COLLINS VOICE COMMUNICATION SYSTEM

618N-1 HF Voice Transmitter/Receiver

GEMINI

Transmitter/receiver and power supplies are in one rugged 4.25-pound unit.

Stable frequency of 15.016 mc is provided for simplex voice communication.

Durable construction withstands shocks to 32.9 g in critical axes.

The Collins 618N-1 HF Voice Transmitter/Receiver provides long range AM communication after landing and serves as a secondary voice link during the orbital portion of the Gemini mission. When tone modulated by the Collins 76H-1 Voice Control Center, the high frequency transmitter serves as a homing beacon for recovery operations.

The 618N-1 is activated by a selector switch on the panel-mounted Voice Control Center. The control center also has volume and squelch controls for the transmitter/receiver.

Transmitter modulation uses 12 db speech clipping for more effective communications power. This produces an approximate 8 db improvement in transmitter power output. High intelligibility and natural voice sound are retained while obtaining nearly maximum circuit improvement.

One 618N-1 is normally used in each Gemini flight. However, the Voice Control Center provides circuitry for the inclusion of a second HF unit.

Transmission is controlled by push-to-talk switch or voice-operated (VOX) circuitry.

Equipment Description

The Collins 618N-1 is a high frequency transmitter/receiver and two regulated power supplies contained in a single foam-filled, sealed unit. Voltages are 24 v dc for receive, and 24 v dc and 300 v dc for transmit.

All circuits are solid state except the transmitter power amplifier output stage. The receiver section is completely solid state.

The transmitter section is composed of a crystal-controlled oscillator and amplitude-modulator circuitry. Parallel-connected drivers are used and high-level modulation is accomplished by applying the audio signal to the parallel-



allows receiver section (top) to be detached. Transmitter, modulator and audio amplifier (middle) attach to bottom of chassis. Regulator power supply



(bottom) fits to back of chassis

connected amplifier tubes.

The receiver section consists of a crystal lattice filter, RF, conversion, IF, detection, automatic gain control, squelch and audio amplification circuits. The received signal is amplified in two stages before being heterodyned with a stable local oscillator. The 4.516 mc IF signal is amplified in three stages, detected and applied to the audio amplifiers.

Automatic gain control is used in the RF amplifiers and the first two IF stages.



Specifications

POWER SOURCE: 18.0-30.5 v dc from buses. POWER REQUIREMENTS: Receive-3 watts. Standby-15 watts maximum. Transmit-48 watts maximum at 50% modulation. **OPERATING FREQUENCY:** 15.016 mc. TRANSMITTER POWER OUTPUT: 5 watts minimum into 50-ohm load.

AUDIO INPUT: +3 dbm. **RECEIVER BANDWIDTH:** 10 kc minimum at 6 db down; 25 kc maximum at 60 db down. **RECEIVER SENSITIVITY:** Maximum of 5 uv closed circuit. NOISE FIGURE: 17 db. SIZE: 3.4" W, 3" H, 8.8" D (8.64 cm W, 7.62 cm H, 22.35 cm D). WEIGHT: 4.25 lbs. (1.92 kg).







COLLINS RADIO COMPANY / DALLAS, TEXAS • CEDAR RAPIDS, IOWA • NEWPORT BEACH, CALIFORNIA • TORONTO, ONTARIO Bangkok•Beirut•Frankfurt•Hong Kong•Kuala Lumpur•Los Angeles•London•Melbourne•Mexico City•New York•Paris•Rome•Washington•Wellington

76H-1 Voice Control Center GEMINI

COLLINS VOICE COMMUNICATION SYSTEM

76H-1 Voice Control Center

Crew intercom is provided throughout mission.

Pre-launch intercom is maintained with ground complex. Four transmitter/receivers can be controlled by two astronauts at single panel.

Beacon modulation tone is provided for recovery operations.

The Collins 76H-1 Voice Control Center allows Gemini crews to select voice communications on two UHF and one HF transmitter/receivers, with circuitry provided for a second HF unit. Squelch and volume controls are common for UHF and HF radios.

Two independent audio systems with dual microphone and headset amplifiers use parallel active networks powered by separate supply buses.

The parallel dual microphone amplifier circuits each have independent automatic gain control.

Headsets may be turned off individually while crew members sleep.

Transmitter keying circuitry in the Voice Control Center provides push-to-talk (PTT) or voice-operated keying (VOX). Reinforced voice modulation operates a Schmitt trigger to complete the keying circuit.



Connections for modules in the Voice Control Center are located where they are readily accessible.

A control switch on the Voice Control Center provides for momentary or continuous activation of a voice recorder.

Equipment Description

Transistorized modular construction results in a compact unit that performs within specifications to 32.9 g in the critical axis while operating and 44.7 g in nonoperating condition.

Acceleration standards are 7.25 g for 1 second on three axes and for 326 seconds on spacecraft longitudinal axis during launch. Re-entry standards are simultaneous 15 g for 30 seconds on spacecraft longitudinal axis and 4.5 g for 30 seconds on lateral axis.

Volume displacement is only 193.6 cubic inches.

Specifications

POWER SOURCE: 18.0-30.5 v dc from buses. POWER REQUIREMENTS: 4.5-6.5 watts. VOLUME CONTROL RANGE: $55 \pm 10 \text{ db.}$ ALARM TONE: 1050 ± 200 cps square wave, 2 mw ± 6 db. VOICE INPUTS T/R: 17 dbm \pm 3 db. VOICE OUTPUTS T/R: +3 dbm. VOX SENSITIVITY: Adjustable -20 to -85 dbm. VOX ATTACK TIME: 0.05 second. VOX RELEASE TIME: Adjustable 1.2-6.0 ± 3 seconds. OUTPUT IMPEDANCE: 600 ohms to transmitters; 19 ohms to headphones. AGC ATTACK TIME: Not more than 0.20 second. AGC RELEASE TIME: 1-4 seconds. AGC SLOPE: Not more than 3 db with input increase from -55 dbm to +35 dbm. SIZE : 6.4" W, 6.4" H, 7.0" D (16.26 cm W, 16.26 cm H, 17.78 cm D), 5.9" (14.99 cm) behind panel. WEIGHT: 6.68 lbs. (3.03 kg).

Specifications subject to change without notice.







Amplifier circuits for microphones (top), alarm tone (middle), and headsets are contained in separate modules.









COLLINS RADIO COMPANY / DALLAS, TEXAS • CEDAR RAPIDS, IOWA • NEWPORT BEACH, CALIFORNIA • TORONTO, ONTARIO Bangkok • Beirut • Frankfurt • Hong Kong • Kuala Lumpur • Los Angeles • London • Melbourne • Mexico City • New York • Paris • Rome • Washington • Wellington 978H-1 UHF Radio Test Bench Set GEMINI

COLLINS VOICE COMMUNICATION SYSTEM

GEMINI

Overall performance level of UHF transceivers is evaluated by integrated test equipment.

Central control panel provides semiautomatic checks on circuits.

Specific circuit tests isolate malfunctions to the submodule level.

Complete calibration and alignment capability is available in single test bench.

Test bench is capable of testing other UHF communications equipment.

The Collins 978H-1 UHF Radio Test Bench Set is designed to test all functions of the Collins 618L-1 UHF Voice Transmitter/Receiver.

It provides interface with the equipment under test; furnishes the proper stimuli, loads and power to activate circuits under test; and gives the test technician a visual display for monitoring test parameters.

The interfacing of the test equipment through a central control panel mounted in the rack speeds repair and periodic tests.

Additional portable test equipment is provided with the UHF test bench to obtain VSWR and frequency values.

Equipment Description

Specific test circuits are selected at the control panel, causing proper stimuli to be routed through control relays to the circuit under test. The response to the stimuli is routed to the control panel and applied to an evaluator. Additional connections on the control panel allow the operator to monitor the stimuli and response signals.

Three submodule testers check transmitter, receiver and power supply circuits in the UHF radio under test.

Monitor equipment includes alternating and direct current vacuum tube voltmeters, output power meter, dual channel oscilloscope, milliameter and VSWR meter.

Specifications

POWER SOURCE: 115 v ac ± 6 v, 60 cps, single phase, 30 amps. POWER REQUIREMENTS: 2600 watts. DC REGULATED OUTPUT: 0-36 v dc, 0-6 amps.

SIGNAL GENERATOR: Five bands, 10-420 mc.

DISTORTION ANALYZER: Frequency response 10 cps to 100 kc. Distortion 0.3 to 100 percent. Voltage 0.03 to 300 v ac.

RANGE EXTENSION UNIT: Extends 55-260 mc receiver ranges to 50-500 mc.

UHF RECEIVER: AM, FM, CW, 40-260 mc. IF bandwidth, 1.3 mc.

TRANSFER OSCILLATOR: 10 cps to 15,000 mc.

AUDIO OSCILLATOR: 5 cps to 600 kc.

LINE STRETCHER: 5000 mc, 50 ohms.

TUNING STUB: 200-1000 mc, 50 ohms.

SIZE: Three 19" (48.26 cm) test equipment racks.

Specifications subject to change without notice.





Standard and special test equipment, such as submodule testers, fit in standard 19-inch racks. A centrally located power supply provides uniform voltages to individual equipments.







COLLINS RADIO COMPANY / DALLAS, TEXAS • CEDAR RAPIDS, IOWA • NEWPORT BEACH, CALIFORNIA • TORONTO, ONTARIO Bangkok • Beirut • Frankfurt • Hong Kong • Kuala Lumpur • Los Angeles • London • Melbourne • Mexico City • New York • Paris • Rome • Washington • Wellington

1M-WP-9-66

978J-1 HF and Audio Test Bench Set GEMINI

COLLINS VOICE COMMUNICATION SYSTEM

978J-1 HF and Audio Test Bench Set

GEMINI



Central control panels reduce test and maintenance time.

Displays of test parameters are provided to operator.

Module test sets incorporated in bench perform audio system checks.

Bench interfaces with spacecraft equipment under test.

The Collins 978J-1 HF and Audio Test Bench consists of two groups of equipment to evaluate performance of the Collins 618N-1 HF Transmitter/Receiver and 76H-1 Voice Control Center. The test bench is adaptable to checking other similar equipment.

The test bench applies the proper stimuli to the equipment under test and evaluates the performance to the response signal.

Testing may be of the overall performance of the tested equipment or of individual modules in the equipment.



A common power supply mounted in the center section of the HF test bench is used for all equipments. Air-operated interlocks are used to guard against overheating.



Equipment Description

The equipment consists of two individually operated test benches, one for the HF radio and the other for the Voice Control Center. One power panel controls both benches.

In the audio test bench, outputs from a signal generator are applied to the Voice Control Center and the unit's outputs are determined. Test sets within the bench check the performance of the microphone amplifier, headset amplifier and HF signal tone generator.

The HF test bench provides a selective load for the transmitter under test, and a signal generator to check receiver performance.

Monitor displays include alternating and direct current vacuum tube voltmeters, oscilloscopes and power output meter.

Specifications

POWER SOURCE: 115 v ac ± 6 v, 60 cps, single phase, 30 amps.



POWER REQUIREMENTS: 2600 watts for HF; 1050 watts for audio.

AUDIO SIGNAL GENERATOR: 20 cps to 20 kc.

DISTORTION ANALYZER: 0.3 to 100 percent.

OUTPUT POWER METER: 0.1 mw to 20 watts.

HF FREQUENCY: 540 kc to 30.5 mc.

SIGNAL GENERATOR: 10-420 mc.

SIZE: Five 19" (48.26 cm) test equipment racks.

Specifications subject to change without notice.