DESIGN DOCUMENT FOR
SHUTTLE TASK 501
SHUTTLE CARRIER AIRCRAFT TRANSCEIVER CONSOLE
(SED 36115353-301)

Job Order 17-069

Prepared By

Lockheed Electronics Company, Inc.
Aerospace Systems Division
Houston, Texas

Contract NAS 9-12200

For

SPACECRAFT SYSTEMS TEST OFFICE
TRACKING AND COMMUNICATIONS DEVELOPMENT DIVISION

National Aeronautics and Space Administration

LYNDON B. JOHNSON SPACE CENTER

Houston, Texas

March 1976

LEC-8246
SHUTTLE

DESIGN DOCUMENT FOR

SHUTTLE TASK 501

SHUTTLE CARRIER AIRCRAFT TRANSCEIVER CONSOLE

Job Order 17-069

APPROVED BY

D. C. Dittmar 5/24/76
D. C. Dittmar
Quality Engineering

W. C. Long
W. C. Long, Office Head
Spacecraft Systems Test Office

Prepared By

Lockheed Electronics Company, Inc.

For

Spacecraft Systems Test Office
Tracking and Communications Development Division

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

March 1976

LEC-8246
SHUTTLE

DESIGN DOCUMENT FOR
SHUTTLE TASK 501
SHUTTLE CARRIER AIRCRAFT TRANSCEIVER CONSOLE

Job Order 17-069

PREPARED BY

G. D. Doland, Engineer
Spacecraft Systems Test Section
Lockheed Electronics Company, Inc.

APPROVED BY

LEC	NASA
A. L. Roelse, Supervisor Spacecraft Systems Test Section	W. C. Long, Office Head Spacecraft Systems Test Office
J. S. Creamer, Manager Tracking and Communications Systems Department	D. C. Dittmar 5/24/76 Quality Engineering

Prepared By
Lockheed Electronics Company, Inc.
For
Spacecraft Systems Test Office
Tracking and Communications Development Division

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

March 1976

LEC-8246
SHUTTLE

ACKNOWLEDGMENT

This document was prepared in response to Action Document 75-17-069-44 submitted by the Spacecraft Systems Test Office of the Tracking and Communications Development Division. William C. Long, Office Head, is technical monitor for this task. George D. Doland of the Spacecraft Systems Test Section of Lockheed Electronics Company, Inc., prepared this design document for NASA/JSC Shuttle Task 501, Shuttle Carrier Aircraft Transceiver Console.

CONTENTS

ACRONYMS AND ABBREVIATIONS

AGC	Automatic Gain Control
ALT	Approach and Landing Test
dB	Decibel
dBm	Decibels relative to 1 milliwatt
FDM	Frequency Division Multiplexer
FM	Frequency Modulation
LRU	Line-Replaceable Unit
PCM	Pulse Code Modulation
RF	Radio Frequency
SCA	Shuttle Carrier Aircraft
SSO	Space Shuttle Orbiter

1. INTRODUCTION

The flight data for the Space Shuttle Orbiter (SSO) is transmitted via S-band to a transceiver in the Shuttle Carrier Aircraft (SCA) for relay to the ground during the mated portion of the Approach and Landing Test (ALT). The Transceiver is mounted in the SCA Transceiver Console for Shuttle Task 501 testing. This document defines the requirements for the SCA Transceiver Console, the design description, test plan for the console prior to installing the spacecraft equipment in the console, and the test plan for acceptance tests.

2. REQUIREMENTS

The basic requirements for the SCA Transceiver console are established by the specifications:

- S-band Transceiver Specification,
  ME 478-0133,
  Dated 7/24/75,
  by Rockwell International

Additional applicable documents are as follows:

- Orbiter Vehicle End Item Specification
  MS 070-0001-1A dated December 20, 1973
  Changes through number 8 dated June 20, 1975
- JSC/GSFC Space Shuttle
  RF Communications and Tracking
  Interface Control Document, Level II
  ICD 2-0D004 Rev. A; June 1975.
- Schematic Diagram
  Orbiter Carrier Communication and S-Band Interface
  V511-760701.

2.1 SHUTTLE TASK 501 CONSOLE REQUIREMENTS

All consoles shall be constructed in accordance with the general requirements for Shuttle Task 501 consoles delineated in the following document.

- Spacecraft Systems Test Laboratory Team Plan for the Support of Shuttle Task 501
  Document number LEC-4769 (Shuttle)
  Dated January 1975
  Prepared by Lockheed Electronics Company, Inc.

2.2 QUALITY ASSURANCE

The consoles are to be designed and constructed in accordance with the "Quality Assurance Plan for the Tracking and Communications Development Division (JSC-08954, Rev. A), Addendum B, Spacecraft Systems Test Laboratory Test Equipment."

2.3 LOG BOOKS

During the console development, a log book shall be prepared and maintained current on a daily basis. Log book requirements are delineated in Addendum B of the Quality Assurance Plan, (JSC-08954).

2.4 STANDARDS

Materials, processes, and documentation shall be in accordance with the following list of standards in effect at the time the console is designed or a later issue if incorporation does not result in a design or documentation change.

- Documentation Requirements and Standards (LEC-8424)
- Wiring Documentation Standards (LEC-8479)
- Drawing Requirements and Standards (LEC-8570)
- Digital Logic Standards
- Component Standardization
- Standard Schedule Format

Note: These Lockheed Electronics Company, Inc. (LEC) documents are currently in preparation and have not yet been formally approved. These preliminary issues are to be employed as the current practical standards where applicable.

2.5 PARTS LIST AND DRAWINGS

A complete electrical and mechanical parts list shall be prepared for the console. Complete drawings shall be prepared for the console including a drawing index, top assembly drawing, assembly drawings, piece part drawings, schematics, logic diagrams, digital logic location drawings and other drawing as applicable.

2.6 SCHEDULES AND STATUS CHARTS

Current schedules shall be maintained for the console design and construction. These schedules shall be maintained for the console development, documentation, and test program. Current status charts shall be maintained for parts procurement, documentation, and console development. Status charts shall be updated and reported weekly.

2.7 SCA TRANSCEIVER ENCLOSURE

The SCA Transceiver console shall consist of one standard 19-inch panel equipment rack, 7 feet high. The unit shall be self-contained and include the required power supplies.

2.8 COOLING

Forced air cooling shall be provided as required to maintain the temperature below the maximum temperature specified for the S-band Transceiver. In no case shall the air flow be below the minimum specified in the S-band Transceiver specifications.

2.9 AUTOMATIC TEMPERATURE PROTECTION

An automatic system for temperature sensing and shutdown shall be employed. At least two temperature sensors shall be used. The equipment shall be shut down and remain off until manually reset if the temperature limit is exceeded. The nominal

temperature limit shall be set at least 10^{o} below the maximum safe equipment operating temperature. A bypass switch shall be provided to bypass the automatic temperature protection circuit. The switch shall be located within the console. A lamp shall indicate bypass operation when illuminated.

2.10 TEMPERATURE MONITOR

A temperature monitoring thermocouple shall be provided for monitoring purposes. The thermocouple leads or terminals shall be located so that they are readily accessible from the front of the console.

2.11 RF OUTPUT SIGNAL LEVEL

The output RF signal level from the transceiver shall be attenuated by at least 30 dB of fixed attenuation.

2.12 RF LEVEL CONTROL

To support SSTL acceptance tests, the RF input signal must be made variable with sufficient attenuation to lower the signal level by -120 decibels relative to the input. The safe operating level specified for the tranceiver is +10 dBm. The input signal level shall not exceed the safe operating level specified.

2.13 ISOLATION OF SPACECRAFT CIRCUITS

The wiring of the spacecraft S-band Transceiver circuits shall be separated from other console wiring and power lines by use of an independent power supply for the S-band Transceiver. Operation shall be controlled using digital logic and relays with separate contacts for spacecraft wiring and console wiring. Remote control provisions are required.

3. DESIGN DESCRIPTION

The SCA Transceiver Console is a single bay rack containing the flight model S-band Transceiver with forced air cooling, three power supplies, two digital voltage panel meters, a digital logic board with digital logic modules, and three relays. The top assembly drawing number is SED36115353-301. A conceptual drawing for the console is shown in figure 1.

3.1 POWER

Power is supplied by a Line-Replaceable Unit (LRU) power supply, a logic power supply, and a console power supply. These are energized using individual interlocked switches remotely located on the control panel. The LRU power supply provides power only to the S-band Transceiver, a chemical type running time meter, and the (LRU) POWER ON indicator lamp. The logic power supply provides power to only the digital logic. The console power supply provides power to the relays and lamps in the illuminated switches. The normal sequence of operations requires energizing the logic supply first, the console power supply second, and finally, the LRU power supply. The power system is energized with the S-band Transceiver OFF and in LOCAL control. The sequence in which the power supplies are energized is controlled by relays.

3.2 MONITOR CIRCUITS

Zero to five volt analog voltages are available from the LRU as measures of input signal strength and transceiver power output. These measurements are obtained by digital voltmeter panel meters. These voltages are intended to provide only a relative indication for monitoring purposes and not absolute measurements. These meters provide 10 millivolts resolution.

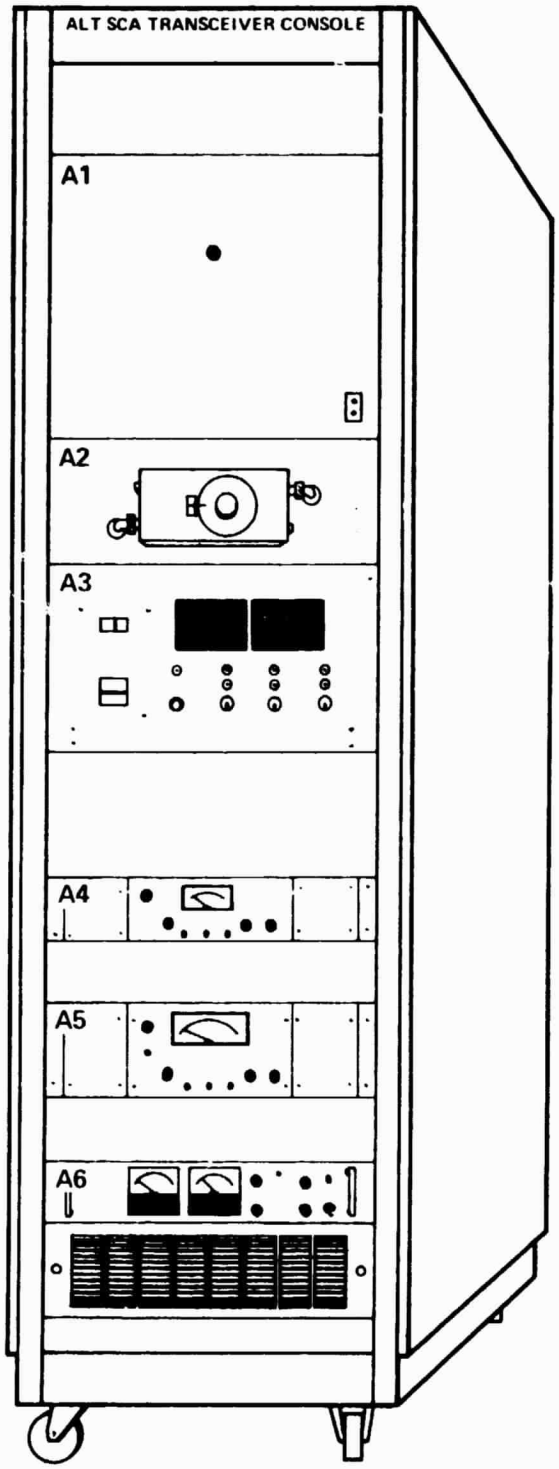

Figure 1.– SCA Transceiver Console.

3.3 FUNCTIONAL OPERATION

The S-band Transceiver is energized and deenergized by means of pushbutton switches which operate logic. The logic operates a relay which controls the power to the S-band Transceiver. When this relay is energized, the POWER ON switch illuminates. When the relay is deenergized, the POWER OFF switch illuminates.

The S-band Transceiver has controls for only the POWER ON/OFF function. The only signals available for monitoring are the AGC voltage and relative power output. The only signal input is the received signal and the only output signal is the transmitted signal.

3.4 COOLING

A centrifugal blower provides forced air cooling of the S-band Transceiver. The capacity of the cooling system exceeds the minimum specified. A pair of thermal sensors are used to sense the case temperature. If the temperature should reach the sensor set value, digital logic circuits automatically turn off the power to the S-band Transceiver.

3.5 RF PATH

The SCA Console contains radio frequency (RF) paths for the input and output RF signals. The input RF path consists of a 0 to 120 dB variable attenuator with bypass capability. The variable attenuator will be used to control signal level during SSTL tests. The RF signal source for this console is the ALT frequency modulation (FM) system. The power output of the ALT FM System Console provides a maximum signal less than the maximum specified safe signal input for the S-band Transceiver.

Fixed RF pads are provided at the S-band Transceiver output which provide a continuous load for the transceiver and lowers the signal level to a reasonable value for measurement and use with associated equipment. The output RF path provides 30 dB of attenuation. A directional coupler provides a monitor point for a spectrum analyzer or power meter.

3.6 SSTL TEST CONCEPTS

The ALT FM System provides the RF signal to the SCA Transceiver Console. The RF power output is then fed to the ALT FM System Verification Console for console acceptance tests.

4. CONSOLE TEST PLAN

The purpose of this test sequence is to insure that console wiring is correct and ready for installation of the S-band Transceiver.

4.1 POWER SUPPLIES

The SCA Transceiver power supplies will be energized and the voltages measured at specified points to verify correct polarities and voltages.

4.2 COOLING SYSTEM

Operation of the cooling system will be verified. A check will be made to insure that the blower operates when the LRU power supply is energized. Another check will be made to insure that the LRU power deenergizes and remains off when the temperature sensor(s) reaches the specified limit with the bypass switch in the NORMAL position. A check will be made with the switch in the BYPASS position to insure that the power can be reapplied to the transceiver despite operation of the temperature sensor(s).

4.3 CONTROL CIRCUITS

All switches on the control panel will be actuated and the operation of each verified.

4.4 LRU VOLTAGES

The voltage will be checked at the LRU connector end of the cable to insure correct voltage level and polarity.

4.5 MONITOR CIRCUITS

Voltages will be applied at the LRU connector end of the transceiver cable to verify operation of the AGC meter and power output meter.

4.6 INSTALLATION OF S-BAND TRANSCEIVER

The S-band Transceiver will be installed after satisfactory completion of these checks.

5. ACCEPTANCE TEST PLAN

These tests will be performed after the S-band Transceiver has been installed. The RF signal source will be the ALT FM System. The test equipment used will be that located in the Verification Consoles for the ALT FM System. Although some tests will be performed using a specific test configuration for the particular tests, most tests will be performed using the basic configuration shown in figure 2. Portions of the data obtained from these tests will be compared with the data obtained from the ALT FM System Tests.

5.1 TEMPERATURE TEST

A thermocouple bridge will be connected to the thermocouple leads, the system energized and a temperature versus time test will be run. This test will require several hours to determine the stabilized operating temperature.

5.2 POWER MEASUREMENT AND RF PATH CALIBRATIONS

The S-band Transceiver output will be measured using a power meter with calibrated attenuators and cables. The RF path from the ALT FM System Transmitter output to the input of the S-band Transceiver will be calibrated. The AGC voltage from the S-band Transceiver will be determined as a function of RF input signal level. The RF path from the S-band Transceiver to the receiver in the Verification Consoles will also be calibrated.

5.3 SYSTEM FREQUENCY RESPONSE

A variable frequency source will be used to modulate the FM Transmitter in the ALT FM System Console. The modulated RF signal will be relayed by S-band FM Transceiver to an FM receiver in the Verification Console. The demodulated output

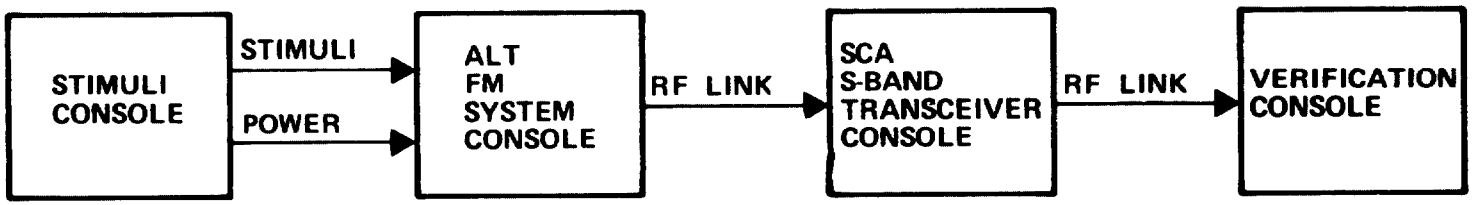

Figure 2. - Test configuration.

will be measured to determine the overall system frequency response. If the necessary equipment is available, this test will use automated test equipment.

5.4 SUBCARRIER AMPLITUDES

Amplitudes of the 15 subcarrier oscillator signals from the Frequency Division Multiplexer (FDM) will be measured at the output of the FM Receiver in the Verification Console at strong RF levels to determine if the S-band Transceiver has significantly changed the relative amplitudes.

5.5 BANDPASS FILTER RESPONSE

Response of the bandpass filter used in the Pulse Code Modulation (PCM) channel signal-to-noise (S/N) ratio tests will be measured prior to the S/N test. This test will use automated test equipment if possible.

5.6 PCM CHANNEL SIGNAL-TO-NOISE RATIO

The end-to-end PCM channel signal-to-noise ratio at 1.024 megahertz will be measured at the output of the FM Receiver in the Verification Console as a function of RF signal level into the S-band Transceiver and as a function of the RF signal level into the FM Receiver.

5.7 BIT ERROR RATE TEST

The end-to-end bit error rate will be measured at the output of the FM Receiver in the Verification Console for the PCM signal as a function of the RF signal level into the Transceiver and the RF signal level into the FM Receiver.

5.8 SUBCARRIER OSCILLATOR CHANNEL PERFORMANCE TEST

The end-to-end signal-to-noise ratio of each subcarrier oscillator channel will be measured at the Tunable Discriminator as a function of the RF signal level into the Transceiver and the RF signal level into the FM Receiver.