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S-1C Stage Instrumentation Systems Checkout at KSC

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Summary

This paper will identify the test philosophies, describe the S-1C instrumentation systems and associated GSE, and define the test and checkout methods used at KSC, for S-1C test and checkout operations.

Introduction

The primary purpose of test and checkout is to develop confidence that flight hardware is capable of meeting flight performance requirements. This confidence is developed by means of a series of tests, starting with manufacturing checkout and proceeding through static firing tests, post static checkout, and then to prelaunch checkout. Each component, subsystem, or system is checked out to the maximum extent feasible prior to delivery to KSC. Test and checkout methods employed at KSC are designed to further increase this confidence level. Some of the basic ground rules for checkout at KSC are:

1. Primary checkout method will be total end to end systems checks.

2. Hardware removals or disconnects will be kept to a minimum.

3. Replacement will be at a lowest level component or "black box" level with in-place rework or repair only as absolutely necessary, and approved.

4. Data from testing will be used to maintain a continual monitor on vehicle systems for deviations from norms or development of trends that would indicate a degradation of system integrity.

5. Testing of systems will be kept to the minimum required to maintain integrity.

6. Flight readiness of systems will be established prior to transfer of vehicle from the VAB to the pad area.

A combination of manual and automatic checkout will be used to verify the flight readiness of the S-1C telemetry and measuring systems. Telemetry Checkout Equipment (TCE) in the Launch Control Center (LCC) will be used to manually checkout and troubleshoot S-1C telemetry systems. Usage of computerized test routines in the CIF to provide monitoring and automatic data analyses of channel behavior are presently being considered. Manual checkout of the airborne measuring system will be used during checkout in the VAB to troubleshoot individual measurements that have been identified as out-of-tolerance by the Measuring Scan Program. This Measuring Scan Program, utilizing the RCA 110A, is an automatic program that stimulates each signal conditioner and monitors the channel response against a predicted output.

The S-1C Instrumentation Systems and associated GSE involved in prelaunch checkout are shown in Figure 1, "Saturn V Instrumentation Systems Block Diagram". These equipments and their locations are:

1. Mobile Launcher and Vehicle
    - A. Airborne Measuring System
    - B. Airborne Telemetry System
        1. One (1) PCM/FM link
        2. Two (2) SSB/FM links
        3. Three (3) PAM/FM/FM links
    - C. Digital Data Acquisition System transmitter (GND)
    - D. Digital Data Acquisition System Receiving System
    - E. RCA 110A Computer
2. Vehicle Assembly Building (VAB)
    - A. Vehicle Measuring GSE
3. Launch Control Center (LCC)
    - A. Telemetry Checkout Equipment
    - B. Digital Data Acquisition Systems Receiving Station
    - C. LCC Measuring Station
    - D. RCA 110A Computer
    - E. Measuring and RF Console

S-1C Measuring Systems Checkout and Operation

S-1C Measuring Systems Description

S-1C Measuring Systems are divided into two virtually independent systems: (1) Airborne Measuring (2) Ground Measuring. The major elements of the S-1C Measuring Systems, their associated GSE, and the manner in which they interface with one another is shown by Figure 2, "Measuring Systems Block Diagram". These major elements are:

Airborne Measuring System. Airborne Measuring System consists primarily of transducers, signal conditioners, and RACS Decoder on the S-1C stage. Approximately 900 measurements will be on early vehicles and 316 on later ones.

Vehicle Measuring GSE. GSE used to calibrate and checkout the airborne measuring system when vehicle is in the VAB and as a monitor during pad operations. The four basic modules are:

1. DDAS Receiving Station
2. Digital Control Interface Unit
3. Calibration Test Position
4. Analog Recording Unit

LCC Measuring Station. The LCC Measuring Station consists of recorders and associated patching equipment.

Measuring and RF Console. Measurement and RF Console provides control and display capabilities for airborne measuring system during both VAB and pad operations in conjunction with RCA 110A computer.

RCA 110A Computer

RCA 110A computer processes test routines for automated checkout of airborne measuring systems during checkout in VAB and pad operations, in addition to other functions.

Measuring Systems Data Flow

The data flow from the vehicle measuring elements to associated GSE is also shown by Figure 3, "Vehicle Measuring GSE". Transducer outputs are modified, as required, by plug-in signal conditioners located in the vehicle measuring racks. Outputs from the measuring racks, and those measurements not requiring signal conditioning, are routed to the measuring distributor where they are patched to their pre-assigned telemeter channels. In addition, the measuring distributor contains the Remote Automatic Calibration System Decoder which is used to select calibrate modes for signal conditioned measurements. The output of the measuring distributor is fed to the three PAM/FM telemeter assemblies, which consists of a bank of SCO's operating on standard narrow band IRIG channels, a special 70 KC non standard wide band SCO, and a multiplexer. Outputs of the three PAM/FM multiplexers are then fed to a PCM/DDAS assembly which contains a scanner, A/D converter and digital programmer, and a 600 KC VCO. The 600 KC signal is then transmitted by coaxial landline to Digital Data Acquisition System (DDAS) Receiving Stations in the ML, VAB, and LCC. Outputs from these receiving stations are used to provide analog or digital inputs to the VM GSE or the LCC Measuring Stations in addition to providing inputs into the RCA 110A computers.

Airborne Measuring System Checkout and Operation

Both manual and automatic testing will be utilized to checkout and verify operation of the airborne measuring system.

An automatic program called the Measuring Scan Program, utilizing the RCA 110A computer will be conducted during both VAB checkout and pad operations. This automatic program verifies the proper adjustment and operation of most S-1C stage PAM or PCM measurements. This is accomplished by simulating high and low ranges of these measurements through the RACS, which programs the signal conditioner into High or Low mode of calibration. Prior to start of the scan test, the computer is loaded with the anticipated High (approximately 80% of full scale value), Low (approximately 20% of full scale value), and run (ambient) values. The automatic test program then allows the computer to scan, sort, and compare each measurement channel against the calibration values stored in memory. Results of the scan program are then determined by commanding the computer to dump all measurement data obtained during the test, and flag those channels whose outputs were not within allowable limits. This out-of-tolerance data can then be manually analyzed to determine possible cause of problem areas.

Malfunction isolation and troubleshooting techniques are then implemented utilizing the vehicle measurement GSE (VM GSE) Figure 3, located in Tower E of the VAB. The VM GSE operates in much the same manner as the RCA-110A scan program, however, all operations are manual, as compared to the automatic features of the computer. The RACS is used to command High, Low or Run modes of verification. The channel response is returned to the VM GSE, through DDAS and displayed on Nixie lights, recorders, or digital printers at the discretion of the operator.

LCC Measuring Station Checkout and Operation

The LCC Measuring Station (Figure 4) provides the capability to record critical launch vehicle parameters during systems tests in the VAB and during pad operations. Monitoring of the recorders will permit continuous evaluation of vehicle systems performance during checkout and launch countdown operations. Approximately 100 selected DDAS measurements, per stage, can be recorded at the same time. Low frequency signals are recorded on seven and twelve inch wide chart - dual channel/dual event recorders.

To assure the readiness of the LCC Measuring Station to support vehicle checkout, the individual recorders as well as the complete station are functionally tested. The recorders are internally calibrated using their integral calibration system. Signal distribution and calibration of the complete system is checked by using signals provided from either the calibrated power supplies or the DDAS signal simulator. To verify the complete measuring system from the vehicle to the LCC Measuring Station, a calibration run will be made by requesting, via the Measuring and RF Console, that the stage measuring systems be placed in known condition. This is accomplished via the RACS; placing the stage system in the hi-low-run conditions. The signals received can be displayed on both the LCC MS recorders and the CRT Display associated with the Measuring and RF Console.

S-1C Telemetry System Checkout and Operation

Airborne Telemetry System Description

The airborne telemetry systems (Figure 5), are divided into the PAM/FM/FM system, the SS/FM system, and the PCM/FM system. Telemetry input data from the instrumentation transducers is collected and conditioned in the measuring distributors, and routed to various telemetry systems. High frequency vibration data is transmitted by the two SS/FM telemetry links. High frequency pressures and other data is transmitted by the continuous FM/FM subcarriers included in the three PAM/FM/FM links. Low frequency data, such as fuel levels and temperatures, are time division multiplexed and transmitted over the PAM/FM/FM and PCM/FM telemetry links. To assure continuous coverage of selected critical measurements during in-flight blackouts such as retro-rocket firing, a tape recorder is included as part of the PAM/FM/FM system. After a programmed delay, the recorder plays back the recorded information over two of the PAM/FM/FM links. An "in-flight calibrator" applies precision voltages to telemetry equipment during flight for calibration purposes. The outputs of the three PAM/FM/FM multiplexers are scanned and fed into the PCM/DDAS system at a reduced sampling rate. The signal is transmitted via coax on a 600 KC carrier to the TCE, VM GSE and LCC DDAS Receiving Station and also by RF link (PCM/FM).

Ground Telemetry System Description

Ground Telemetry Checkout Equipment (TCE) is located in Room 2P10 in the LCC. Figure 6, "Telemetry Checkout Equipment" shows the equipments contained in the three basic modules that are utilized to checkout the S-1C airborne telemetry system:

Common Module. This module contains recording, PAM and SSB decommutation equipment, and limited display equipment. Any channel can be observed in real time or recorded on either of two wide band tape recorders for playback at a later date. SSB data is used for checkout of vibration measurements. Meter and/or recorder display is available on each type of telemetry system.

Stage Module. The TCE stage module contains a receiver bank, FM/FM discriminator bank, PCM/DDAS decommutator, and related display and test equipment. Stage telemetry data will be received, discriminated, demultiplexed, and prepared for analog display. The stage module has the capability to "quick look" any 10 DDAS channels (either RF, video PCM, or 600 KC PCM), or any 18 FM/FM channels, and display these channels on panel mounted meters, or patch them to the Common Module for recording. In addition, the stage module contains test equipment, allowing analysis of the RF characteristics on each telemetry link.

CIF Module. The CIF module contains a complete RF receiver bank, TCE room entry and RF patching rack, and RF calibrator, and an AGC digitizing system which interfaces with the CIF building. Each telemetry link is demodulated and then transmitted to the CIF via wide band coaxial cable using pre-detection techniques.

S-1C Telemetry System Checkout and Operation

TCE will be used for initial setup, analysis, and troubleshooting of the airborne telemetry system. Test parameters to be checked include relative RF power levels, carrier frequency and deviation, PCM format, data continuity, and preemphasis levels. Operation will be closed loop by means of RF coaxial landlines during VAB checkout and normally open loop, during pad operations. Telemetry Checkout Equipment will be used primarily for checkout and troubleshooting, and not as a data acquisition source. The Central Instrumentation Facility (CIF) will be the primary data acquisition station for monitoring and recording S-1C stage telemetry signals. The CIF Computer Complex will provide automatic data analysis of the S-1C telemetry channel behavior during major pre-launch tests of the Saturn vehicle. After problem areas are identified by the CIF or LCC Data Display Systems the TCE will perform troubleshooting and analysis of the individual telemetry channel as required.

Overall telemetry compatibility with other systems will be checked during vehicle overall tests, countdown tests, and simulated flight test. Cross comparison between the 600 KC DDAS channels, the RF DDAS channels, and the PAM/FM/FM channels can be made by the CIF to identify problem areas.

To supplement the manual troubleshooting capabilities of the TCE, development of computerized test routines is in progress to allow fast scan on all telemetry channels during pad operations. These routines would be executed by the Computer Facilities located in the CIF. Some of the test routines presently under consideration are as follows:

A. Amplitude Calibration of telemetry packages.

B. Calibration of transducer signal conditioners

C. Channel noise analysis for PCM

D. Check of expected vs. actual telemetry outputs.

Sample telemetry channels will be sorted, compared, and analyzed. A concise printout will allow the test engineer to readily identify trends or out-of-tolerance conditions. By utilizing both computerized telemetry analysis, and manual checkout techniques, the performance of the S-1C telemetry system will be thoroughly tested for launch readiness.

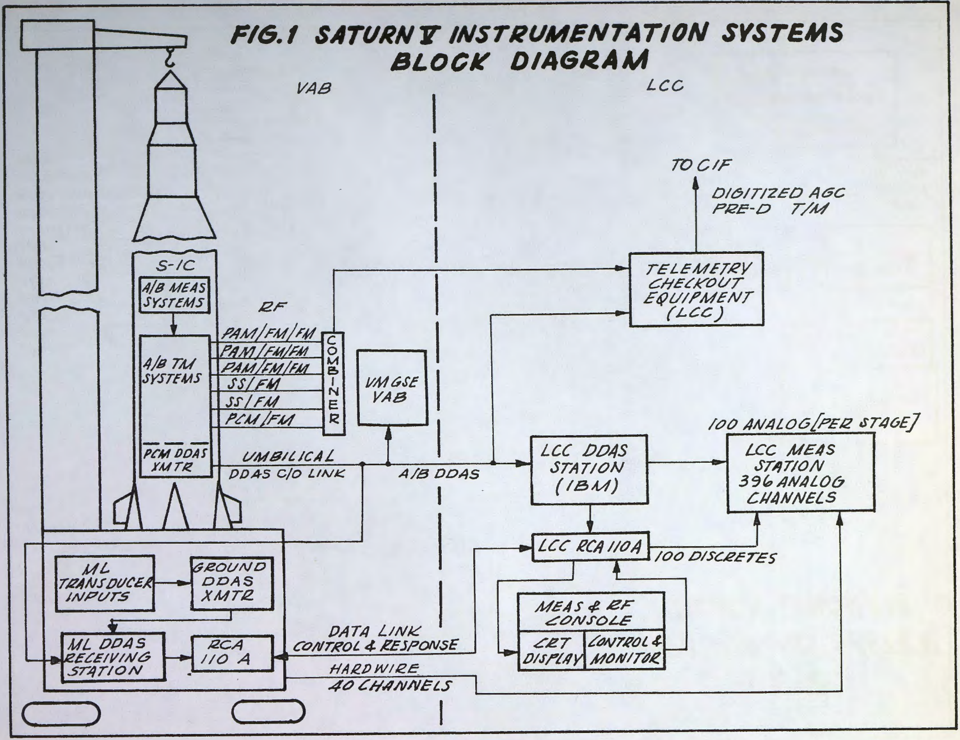


FIG.1 SATURN V INSTRUMENTATION SYSTEMS BLOCK DIAGRAM

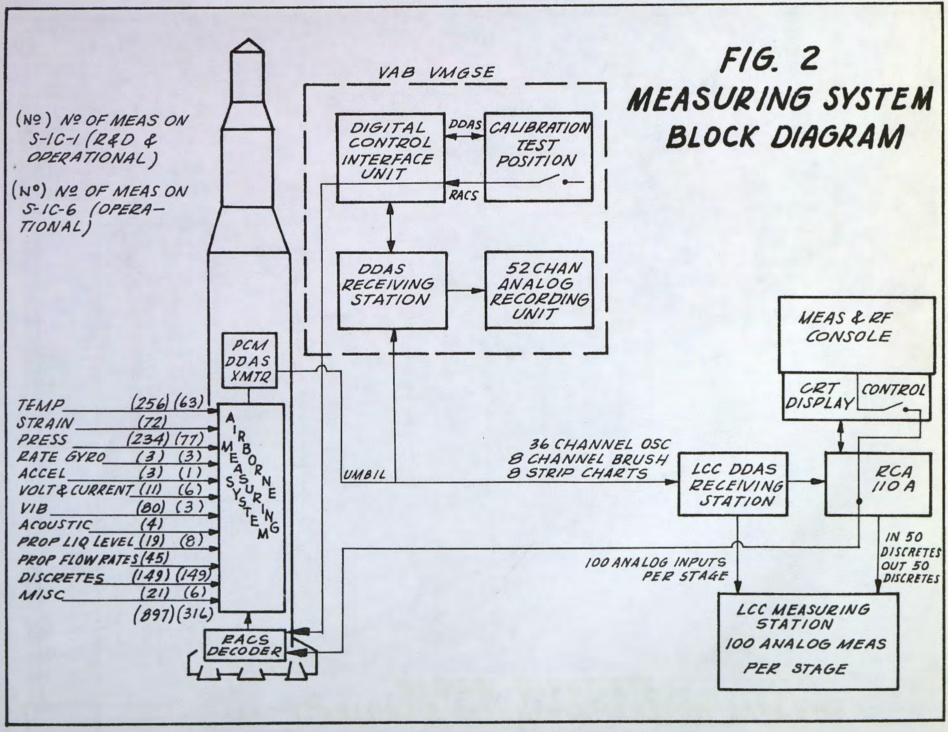
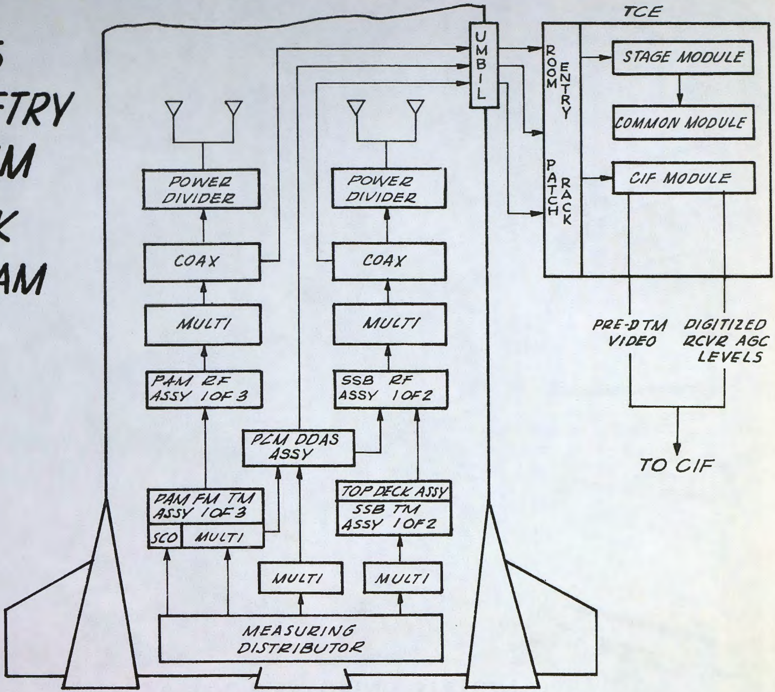


FIG. 2
MEASURING SYSTEM
BLOCK DIAGRAM

FIG. 3 VEHICLE MEASURING GSE

FIG.4 LCC MEASURING STATION

FIG. 5 TELEMETRY SYSTEM BLOCK DIAGRAM



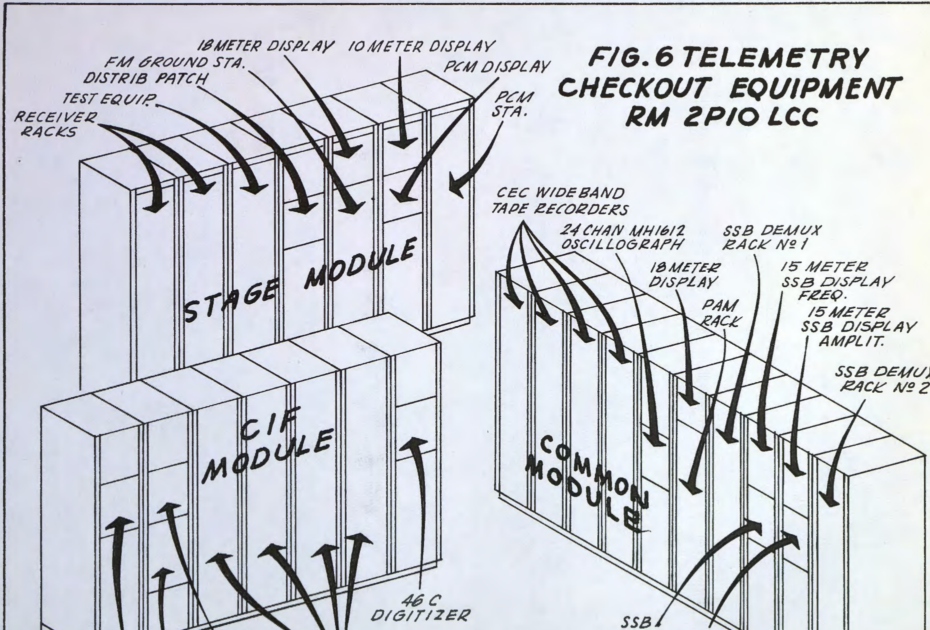


FIG. 6 TELEMETRY CHECKOUT EQUIPMENT RM 2P10 LCC