Deep Space Network Test and Training System

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A description of the Deep Space Station Test and Training Subsystem is presented including the evolution and usages of the Simulation Conversion Assembly, capabilities of the present subsystem (Mark III-73) and planned expansion (Mark III-75) to meet Viking requirements. A brief discussion of present and planned capabilities of the Network Control Test and Training Subsystem is included. These are both subsystems of the Deep Space Network Test and Training System.

I. Deep Space Station Test and Training Subsystem

The block diagram in Fig. 1 shows the elements and flow paths of the Deep Space Station (DSS) Test and Training Subsystem, Mark III-73, and also the new elements to be implemented at DSS 14, 42/43, and 61/63 to upgrade the subsystem to the Mark III-75 configuration in the 64-m subnet. The Mark III-73 configuration is currently in operation at all DSSs and CTA 21 and MIL 71. The Mark III-75 configuration will be implemented in the latter part of 1974 and will become operational in the early part of 1975.

A. Telemetry System Test Support

Telemetry System testing and participation in mission telemetry simulation are supported by the Simulation Conversion Assembly (SCA) at each DSS[1] and CTA 21 and MIL 71. The SCA is interfaced to an XDS-910 computer, which serves as the Simulation Processing Assembly (SPA) when operating with Test and Training subsystem software[2]. Provisions are made for both manual and computer control of a multiplicity of SCA functions.

The original SCA configuration was implemented in 1970 as part of the former DSN Simulation System (Ref. 1). The SCA replaced the earlier Multimission Telemetry (MMT) Test Assembly and also the DSIF/GCF Interface (DGI) Assembly that had supported Mariner Mars 1969

[1]A single SCA at each conjoint station (DSS 42/43 and DSS 61/63) supports both the 26-m and the 64-m DSS telemetry strings.

[2]The XDS-910 computer in the 26-m DSSs is also used for operation of the Antenna Pointing Subsystem.

mission preparations. The SCA was used for Mariner Mars 1971 and Pioneer 10 and 11 pre-mission testing and training.

Upgrading to the present SCA-I configuration (Fig. 2) was completed at all stations by early 1973. The modification consisted primarily of the addition of the Data Selection Panel which incorporated new functions required for simulation of Mariner Venus/Mercury 1973 telemetry characteristics and also increased the operational versatility of the SCA. The SCA-I configuration was extensively utilized for Mariner Venus/Mercury 1973 mission preparations, and it is currently supporting Helios mission testing and training.

SCA-I capabilities provide composite output signals to represent up to two dual-channel spacecraft. Additional SCA equipment and new software are being fabricated for use in the 64-m subnet, to provide an SCA-II configuration for the DSS Test and Training Subsystem Mark III-75 configuration. SCA-II will supply signals representing up to three dual-channel spacecraft, to support DSN preparations for the planetary operations of the Viking-Mars 1975 mission (Ref. 2).

B. Digital Telemetry Simulation

The digital section of the SCA (Fig. 1) has the capability to output multiple data streams at controlled rates and also the capability to provide various types of coding on one or more of the streams, as described in Table 1. SCA-I has a 4-channel output capacity and SCA-II has a 6-channel output capacity.

Each channel can be independently operated in any of three modes as described in the following paragraphs.

1. Manual mode. In the manual mode the channel can be operated independently of the 910 computer. Simple data patterns such as square-wave, pseudonoise sequence, etc. can be generated in this mode. The manual mode is used primarily for checkout and calibration of station equipments.

2. Computer-local mode. In the computer-local mode, the channel can be supplied with simulated telemetry data generated in the XDS 910 computer. The computer-generated data can be patterned to include frame synchronization codes and other repetitive features so that it can be processed and decommutated when received at the Mission Control Center. The computer-local mode is used primarily for prepass data transfer checks and for DSN operational verification tests.

3. Computer-remote mode. In the computer-remote mode, data from an external simulation source (such as the MCCC Simulation Center) is inputted to the XDS 910 computer via the GCF high-speed data (HSD) subsystem or the GCF wideband data (WBD) subsystem. The computer extracts and buffers a specified number of data words from each HSD or WBD block for conversion into an SCA data stream. Control of SCA functions in this mode is typically exercised from the remote simulation source by transmitting HSD blocks containing appropriate mnemonic entries to establish initial conditions or to change conditions during a test sequence.

High-speed and wideband data block format requirements for this operating mode are described in Ref. 3.

The computer-remote mode is utilized for "long-loop" Ground Data System testing, joint Flight Project and DSN training, and for operational readiness tests. This mode of operation permits Flight Project-furnished, dynamic, command-responsive simulated telemetry data to be transmitted and processed through the entire ground data system.

C. Analog Telemetry Simulation and Radio Frequency Controls

The analog section of the SCA (Fig. 1) provides "video conditioners" (video-bandwidth signal conditioners), driven by subcarrier-frequency generators, to modulate subcarriers onto the telemetry data streams. Other capabilities include subcarrier mixing, modulation-index control, and downlink carrier modulation and signal level control, as described in Table 2.

The interface between the digital and analog sections of the SCA is through the switching matrix of the Data Selection Panel (Fig. 3). Each of the functions on this panel can be exercised by either manual or computer control. The switch matrix allows each digital data stream to be assigned to any signal conditioner. The panel provides local display of switching assignments and modulation index attenuator settings, by pushbutton selection.

D. Command System Testing

On-site testing of the DSS command subsystem is accomplished by operating a test program in the Digital Instrumentation Subsystem (DIS) computer (XDS 920) to output HSD blocks to the station communications terminal for loop-back to the Telemetry and Command Processor (TCP) XDS 920.

For end-to-end DSN Command System testing the DSS command subsystem is operated in its normal configuration, except that the uplink signal is radiated to a dummy load. The command data blocks are transmitted to the DSS via the GCF HSD subsystem from either the Network Control System or the Mission Control and Computing Center.

E. Tracking System Test Support

DSS test and training functions related to the tracking subsystem presently include the following:

(1) Test signals from the Tracking Data Handling (TDH) assembly provide inputs to the DIS XDS 920 which formats and outputs radio metric data in HSD blocks for transmission to the MCCC and NCS to test loading and to exercise accountability processing.

(2) The Block IV Receiver/Exciter Subsystem that is being installed at the 64-m DSSs offers an opportunity to simulate doppler-frequency shifts by manual input of ramp-control parameters into the frequency synthesizer control unit, as indicated in Figure 1.

F. Time Simulation

A time code generator mounted on the SCA provides a simulated time signal which can be substituted for the standard GMT input to the DSS time distribution assembly (Fig. 1). The simulation time code generator is driven by signals from the DSS frequency distribution assembly.

II. Network Control Test and Training Subsystem

Table 3 describes the test and training capabilities for each of the three implementation blocks of the Network Control System (NCS).

A. NCS Block I

The Block I NCS, currently in operation, includes a capability for DSN Command System testing and a capability for transmission of pregenerated HSD blocks for "short-loop" testing of the NCS.

B. NCS Block II

A Block I software modification, tentatively planned for Block II implementation in the latter part of 1974 would add a capability for transmitting control messages to the SCA in the same manner that commands are transmitted to the TCP.

C. NCS Block III

Design of the Block III NCS, planned for implementation in the latter part of 1975, includes a Test and Training Subsystem with capability for real-time generation of data patterns required for testing of the Block III NCS telemetry, tracking, command, monitor, support, and display subsystems and for DSN systems testing and operations training. Reference 4 provides the Block III functional requirements for the NC Test and Training Subsystem.

References

1. Thorman, H. C., "DSN Simulation System," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. VI, pp. 5–7, Jet Propulsion Laboratory, Pasadena, Calif., Dec. 15, 1971.

2. Mudgway, D. J., and Johnston, D. W., "Viking Mission Support," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. XIX, pp. 10-22, Jet Propulsion Laboratory, Pasadena, Calif., Feb. 15, 1974.

3. *DSN System Requirements, Detailed Interface Design, JPL Document 820-13*, Rev. A, Sect. VII (JPL internal document in modular form, continuously updated).

4. Deep Space Network Control System Requirements, NC Test and Training Subsystem, JPL Document 822-8, Feb. 1, 1973 (JPL internal document).

Table 1. Digital channel capacities of DSS simulation conversion assembly

Capability	SCA I	SCA II
Total output of independent data streams	4 channels	6 channels
Variable rate control, 1 bit/s to 250 ksymbols/s	Available on 3 channels	Available on 4 channels
Selection of discrete rates, 8-1/3, 16 2/3, 33-1/3, 133-1/3 bits/s	Available on 2 channels	Available on 3 channels
Selection of block coding (32, 6) and (16, 5)	Available on 2 channels	Available on 4 channels
Selection of convolutional coding, systematic (1/2) and (1/3) or non-systematic (1/2) and (1/3)	Available on 1 channel	Available on 1 channel

Table 2. Analog channel capacities of DSS simulation conversion assembly

Capability	SCA I	SCA II
Data and subcarrier signal conditioning	Biphase modulation, 4 subcarrier channels	Biphase modulation, 6 subcarrier channels
Subcarrier frequency generation	3 Different frequencies, 1 Hz to 10 MHz range	4 Different frequencies, 1 Hz to 10 MHz range
Selection of interplex modulation	Available on all signal conditioners	Available on all signal conditioners
Modulation-index angle control	Controllable attenuator on output of each signal conditioner	Controllable attenuator on output of each signal conditioner
Subcarrier mixing and downlink carrier modulation	In pairs onto each of 2 S-band carriers	In pairs onto each of 3 S-band carriers
Downlink carrier signal level control	Controllable attenuator on output of each test transmitter	Controllable attenuator on output of each test transmitter

Table 3. Network control test and training subsystem capabilities

Functions	Block I capability	Block II capability	Block III capability
Radio metric data patterns	Canned block stream only	Same as block I	Realistic enough to exercise pseudo-residuals
Telemetry data patterns	Canned block stream for NCS self test only	Same as block I	Yes, real-time frame synched
Remote control of DSS simulation conversion assembly	None	Possibly, using block I command capability	Yes
Simulation of project commands	Yes, in NC CMD subsystem	Same as block I	Yes, in T & T Subsystem
Simulation of DSS CMD responses	None	None	Yes
Simulated DSS monitor data	Canned block stream only	Same as block I	Yes, real-time controllable

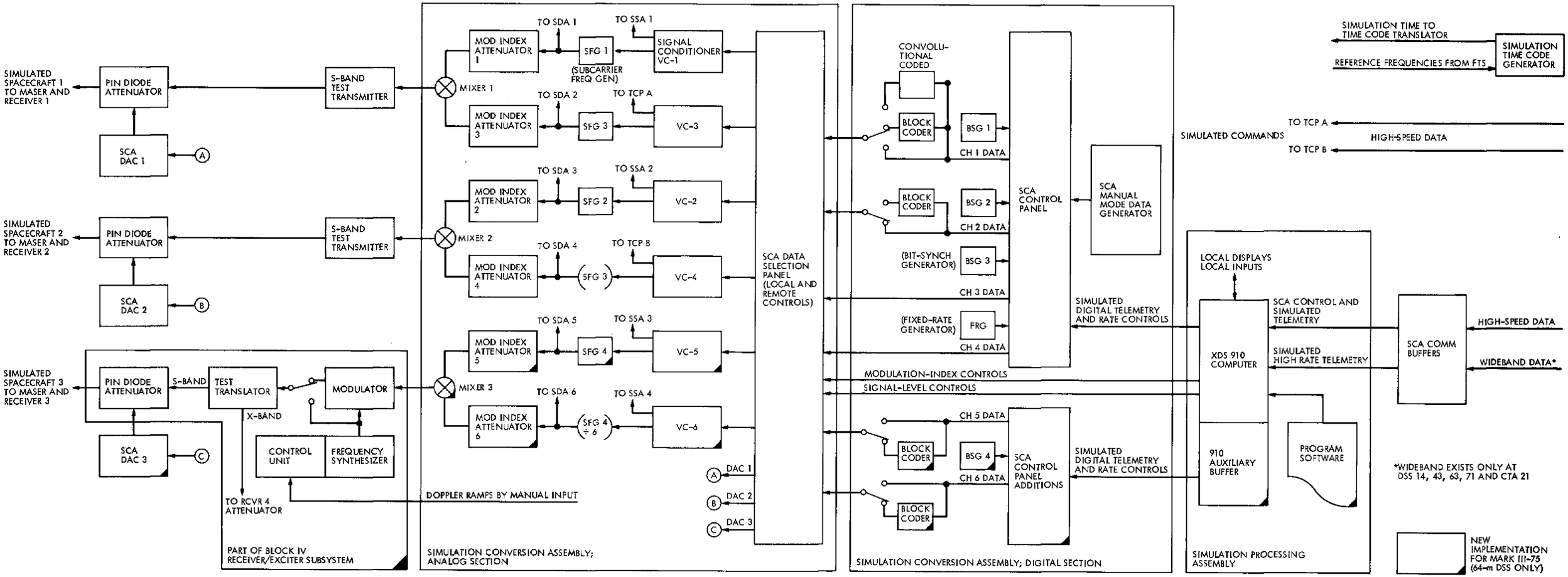

Fig. 1. DSS Test and Training Subsystem block diagram, Mark III-73 and Mark III-75

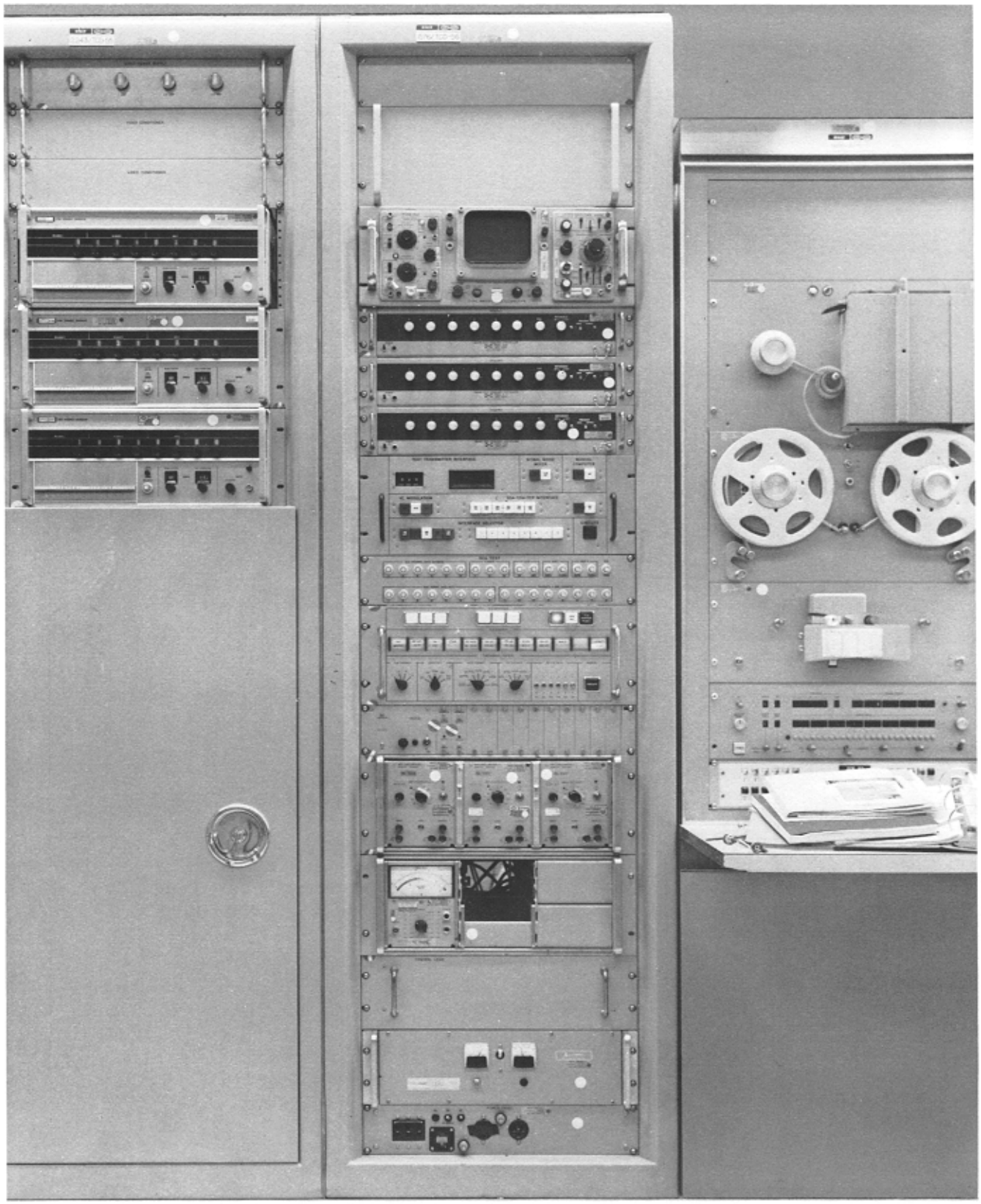

Fig. 2. DSS simulation conversion assembly and XDS 910 computer

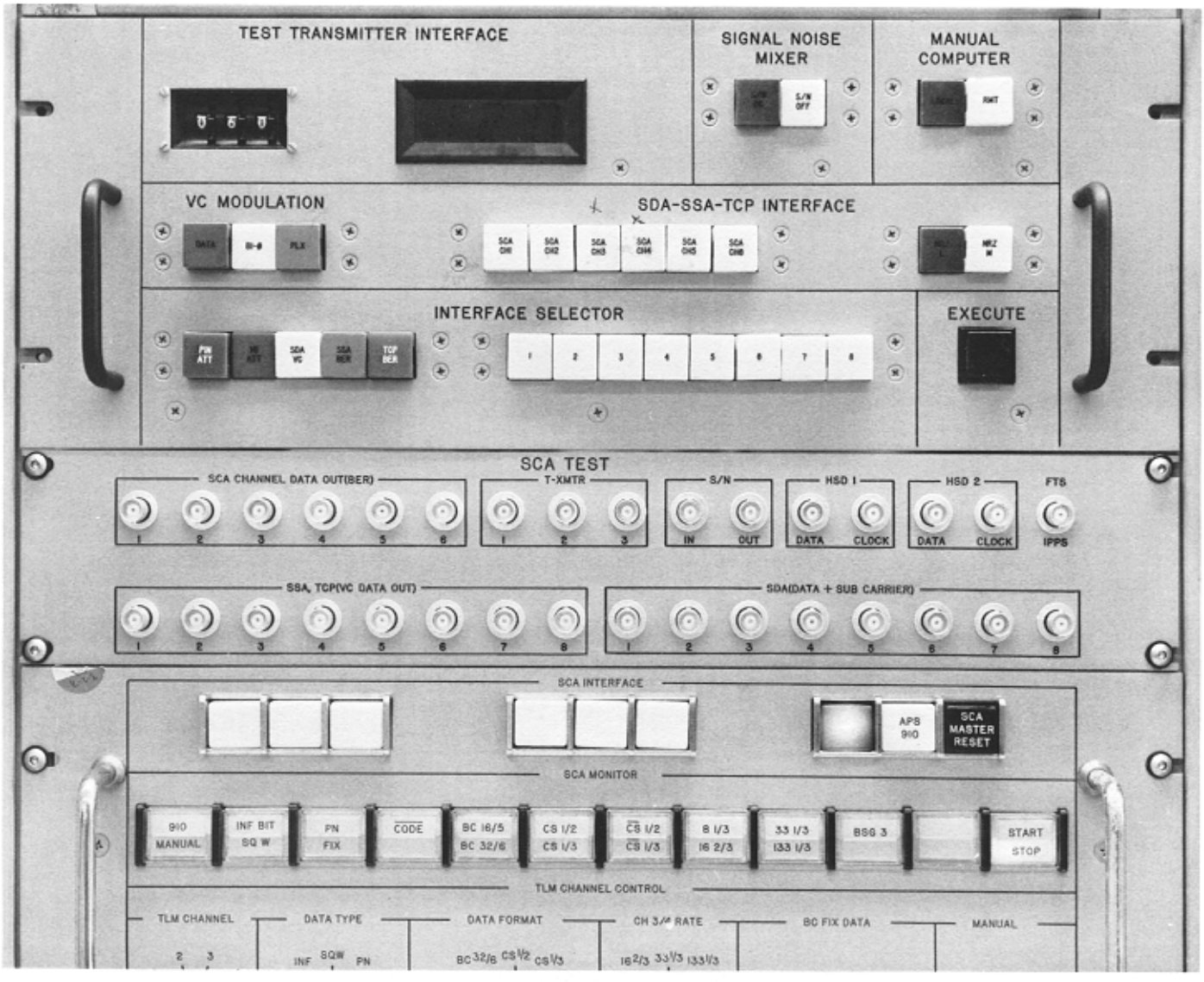

Fig. 3. SCA data selection panel, test panel, and control panel