AUTOMATIC CONTROL SYSTEM FOR ROUTING OF TELEMETRY DATA SIGNALS

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Summary. The primary role of the Space and Missile Test Center (SAMTEC) is to provide support for the relatively large number of various types of missiles launched from Vandenberg Air Force Base (VAFB). Associated with this function is the requirement to provide telemetry decommutation/data processing systems capable of processing the telemetry transmitted by the missiles. At present, the telemetry data is routed to and from the analog tape recorders and bit synchronizers through patch boards, which totals over 200 inputs. This represents a myriad of patching combinations when considering the number of different missile formats and outputs that have to be manually patched and unpatched.

SAMTEC contracted with Electrospace Systems, Inc., (ESI) for a dry reed relay switching system. The switching system, Analog Data Equipment Switching System (ADESS), consists of seven matrices under the control of a Digital Equipment Corporation (DEC) Model PDP-11/05 minicomputer. The ADESS matrices 1 and 2 are three stage switching systems with the respective input/output - 100 x 90 and 60 x 70. Matrices 3 through 7 range from a 40 x 40 down to a 10 x 20 rectangular matrix configuration. Matrix 1 has a frequency response range of DC-12MHz, matrices 2 through 6 have a range from DC-3MHz, and matrix 7 ranges from DC-15MHz. The PDP-11/05 peripherals include a CRT/Keyboard and dual floppy disk which controls the latching and status of the matrix switches and stores the mission set up files which can be rapidly called up by the operator. The ADESS will decrease turn around by up to ten times as compared to present operations.

Introduction. The ADESS switches signals from a microwave interface subsystem to data processing subsystems and recording subsystems, and distributes data processing subsystem outputs to displays and data analysis equipment. The system is shown functionally in Figure 1. The ADESS consists of seven computer-controlled matrices

(Table 1), control interface units, and an operator control unit (control/display subsystem). The control system exercises control of the signal flow through the switching matrices, and displays the status of the matrix configurations. Control commands are entered by the operator at the keyboard. The keyboard commands are translated by the processor to binary signals which are applied to the switch matrices. Status and busy signals are returned from the matrices to the control interface units; status and busy information are returned from the control interface units to the processor. Operator requested information is displayed on the CRT, through the CRT controller, and upon operator command. The floppy disk unit provides storage of frequently used mission configurations, and the ADESS program.

Table 1. ADESS Matrix Allocations

Matrix Number	Size (Input/Output)	Comments
1	100 x 90	3 level, 2 racks
2	60 x 70	3 level, 1 rack
3	40 x 40	Rectangular, part of 1 rack
4	20 x 40	Rectangular, part of 1 rack
5	20 x 80	Rectangular, part of 1 rack
6	10 x 20	Rectangular, part of 1 rack
7	Five panels, each containing six 2 x 1 switches	

ADESS Special Characteristics.

Discrete Address Capability

The crosspoints are discretely addressable, i.e., they can operate from source to load (input to output) in any order. Two or more inputs cannot be connected to one output.

Confirmation

Crosspoint confirmation paths parallel the signal paths. Positive confirmation of the crosspoint activation or deactivation from within the matrix is provided. Activation or deactivation means that the crosspoint is closed or opened in accordance with the command from the control subsystem.

Crosspoint Configuration Retention

If primary power fails, the crosspoint matrix configuration (connected or disconnected) of the signal and confirm paths is maintained in the pre-power loss state.

Paralleling
The matrix can parallel up to ten loads (outputs) to one source (input). This capability makes it possible to progressively select and connect any random combination of all ten loads to one source, and to progressively disconnect all crosspoints in random order; during this process no unwanted crosspoints are connected and no wanted crosspoints are disconnected.

Attenuation

The matrices when in a paralleling mode and when one source is connected to ten loads, do not attenuate the input signal level more than 0.2 dB.

Failures

No failures in one matrix address affects any other matrix subsystem address.

Maintenance
Software and hardware provide automated diagnostics to functional modules within the system.

Operator Control Unit. The operator control unit permits the operator to actuate the switching matrices through the logic unit, and the unit displays the status of the matrices. The operator control unit provides the following capabilities:

- Functually prepares an operational configuration with a minimum number of actions.

- Displays the configuration, as implemented by the operator, in a continuous format.

- Provides a “road map” display of the system configuration; the display configuration presents the source (input), load or loads (output or outputs), and the command(s) function.

- Provides a status display of the total matrix configurations by a single command.

- Allows the operator to alter or delete a non-implemented configuration setup, and replace the source/load selection with other operational requirements.

- In the event of primary power failure during the preparation and/or implementation of a configuration, retains the commands in a nonvolatile memory format unit. After power is restored, the unit contains the information input previous to the interruption, and continues with the implementation and/or setup procedures.

Software Description. One of the design constraints was the PDP-11/05 memory size of 16K words. The ADESS program was written primarily in FORTRAN. The logic interface and power fail recovery routines were written in assembly language.

Software control of the three-level matrices was designed to find a path between a specified input and a specified output while minimizing the possibility of blocking. Blocking is defined as the condition existing when a usable path between an input and an output does not exist.

When designing an algorithm for connecting paths in a three-level matrix, the primary consideration was the memory limitation. Also, the speed of a three-level connect had to be reasonably fast, necessitating a minimization of the number of overlay swaps.

In an effort to minimize blocking, a word was maintained in common which was used to store the number of the last submatrix in level 1 through which the connection of an input/output path was attempted. Each time a submatrix in level 1 is required to connect an input/output path, the contents of the word in common is incremented by three. When the contents of the word exceeds nine, it is decremented by ten. Also, a new path between levels is created only if an existing path cannot be used.

Both drives of a DEC Model RX01 floppy disk unit are utilized when running the ADESS program. Drive 0 contains selected operating system programs, ADESS object modules, and the ADESS relocatable binary load module. Drive 1 contains various files produced and/or used by the ADESS program (including crosspoint name files, bad crosspoint files, an optional log file, mission files, alternate mission files and mission error files). Because of slow disk access time (483ms), disk input/output was used only when speed was not a consideration (swapping in overlays for display commands), when it was necessary to read name files (core availability was inadequate to store the crosspoint names).

Matrix Hardware. ADESS matrix hardware consists of control interface and switchcard modules. The control interface is the hardware that allows the computer to latch and unlatch the reed relay crosspoints. It consists of buffers, registers, relay drives, and etc. Switchboards are configured as 10 input by 2 output modules which are used as building blocks for the ADESS system. The important signal parameters for the two largest matrices are listed in Table 2.

Conclusion. Categorizing the analog telemetry equipment frequency range of the inputs and outputs to the telemetry data processing centers was the first step in systematizing the matrix requirements. The predetection and video signals were concentrated into a high frequency range of DC-12MHz. Whereas the other analog signals such as tape speed

Table 2. Signal Matrix Parameters

Item	Description
Data Matrix 1	
Size	100 input x 90 output
Frequency response	Dc to 12MHz ±0.5 dB
Impedance	75-ohm input and output
Voltage level	2V P-P nominal
VSWR	1.1:1
Isolation (open crosspoint)	70 dB minimum
Crosstalk	-60 dB minimum
Gain	0 dB; adjustable
Distortion	1% maximum
P-P Signal-to-rms noise ration	60 dB minimum (12-MHz bandwidth)
DC stability	±50 millivolts
Data Matrix 2	
Size	60 input x 70 output
Frequency	Dc to 3MHz ±1.0 dB
Impedance	75-ohm input and output
Voltage level	2V P-P nominal
VSWR	1.5:1
Isolation (open crosspoint)	60 dB minimum
Crosstalk	-50 dB minimum
Gain	0 dB; adjustable
Distortion	1% maximum
P-P Signal-to-rms noise ratio	60 dB minimum (3-MHz bandwidth)
DC stability	±50 millivolts

compensation, timing, data streams to bit synchronizers and subcarrier discriminators, and decommutated data signals to analog display devices were grouped into a frequency range of about 3MHz and below. In order to achieve a common set of switchcards in this system, two types of cards were used throughout the matrices (DC-12MHz and DC-3MHz) which reduced maintenance and logistic considerations. Another major system design feature that required consideration was the type of operational control of the matrices that should be selected. This area required determination of the use of mnemonics for labeling of the inputs and outputs which will increase the operator’s ability to make changes rapidly and accurately. As an aid to the operator in making up operational support configurations, a file system management module was required. The file system was one of the main areas of design consideration in determining the size of processor memory and mass storage media such as a disk or tape system. Also, another system parameter because quite apparent as the matrix system was being integrated into the data center. In this application, it was determined that the matrix controller should not experience a downtime of more than five minutes. To achieve a low Mean Time To Repair (MTTR) for the controller, a second controller and peripherals were scheduled for integration.

As the system design considerations point out, a thorough analysis becomes a vital step in developing a reliable matrix system. The integration of the ADESS into the SAMTEC telemetry data reduction center in late 1976 will demonstrate its capability to support the rapid turnaround of the telemetry data reduction operations.

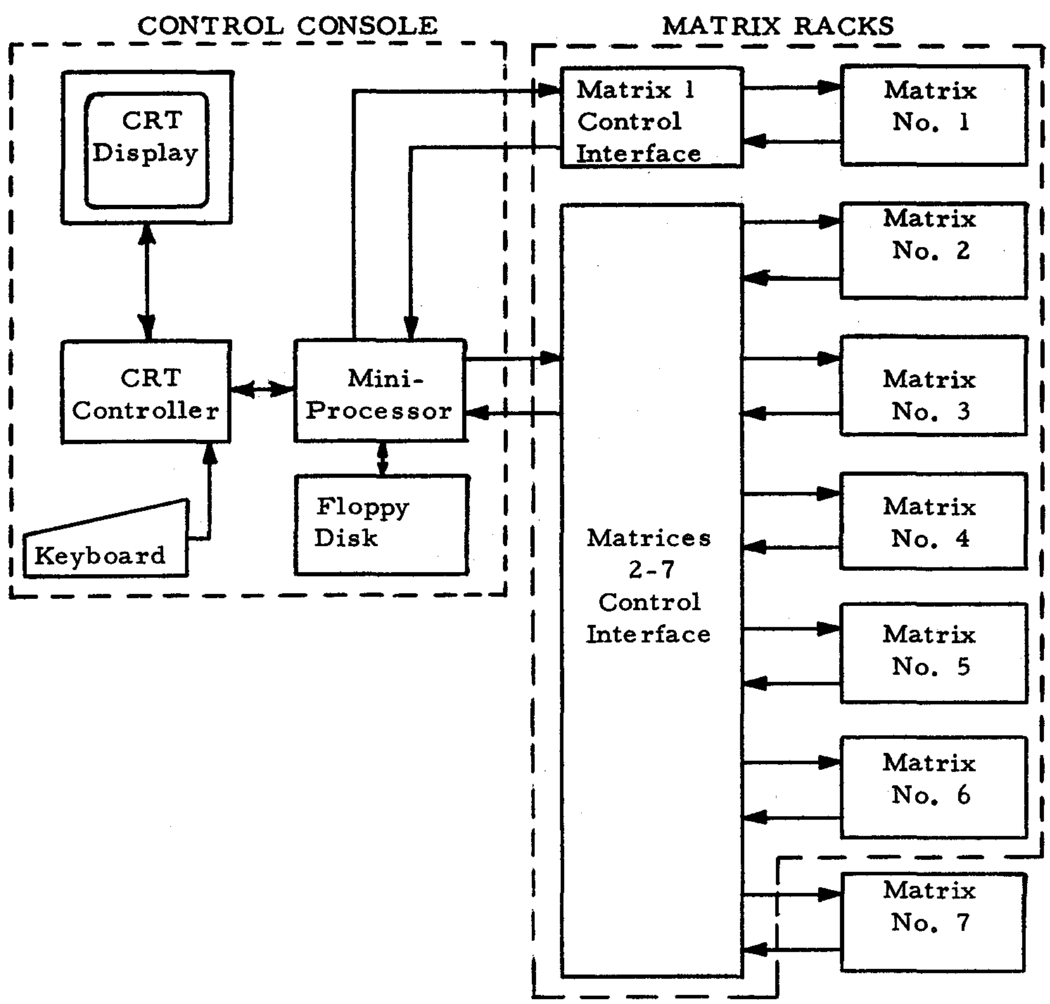

Figure 1. ADESS Functional Block Diagram