Mark IIIA Simulation Center Interactive Alphanumeric Television System

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The Mark IIIA Simulation Center is capable of simultaneously simulating two spacecraft and three deep space stations using the Univac 1108 and the EMR 6050 computers. The control consoles of the Mark II system were inadequate for controlling a simulation of the size required for the Mark IIIA system. A new control and display system was designed using interactive cathode-ray tube data terminals and high-speed printers. This design upgrades the control and display system for future use in more complex missions. Development, capabilities, and operation of this system are described.

I. Introduction

The purpose of this article is to describe the development, capabilities, and operation of the interactive alphanumeric television (IATV) system. This equipment configuration is an assembly of the DSN Simulation Center (Simcen), designated the Mark IIIA Simcen, which is located in the SFOF.

The installation of the IATV system is part of the current development activity that is taking place in the DSN Simcen in preparation for *Mariner* Mars 1971 and *Pioneer F* support. This activity was described in Ref. 1.

The Mark II Simcen configuration was capable of simulating one spacecraft and one DSS. The Mark IIIA configuration is capable of simultaneously simulating two separate spacecraft and three DSSs.

Since the control consoles which existed in the Mark II system were inadequate for controlling a simulation of the size required for the Mark IIIA system, a new control and display system had to be designed. Originally, the plan was to fabricate the necessary control consoles using discrete components. After doing a preliminary design on these consoles, using the requirements specified by the DSN, it was determined that hardware implementation costs would approach the $100,000 mark and that the configuration of the consoles could not be easily upgraded for follow-on projects with greater complexity. The use of interactive cathode-ray tube (CRT) display terminals was decided upon since they would provide the desired flexibility to upgrade the control consoles for more complex missions with few, if any, hardware modifications, and a lesser cost for software changes than if the job were done with discrete components.

II. Description

The IATV display system is functionally diagrammed in Fig. 1. The system contains eight CRT–keyboard display terminals and two printer terminals, and operates from a buffered input/output word channel of the EMR 6050 computer.

The equipment for the IATV system was obtained from an outside source and, with the exception of the channel adapter, is standard off-the-shelf equipment. The channel adapter was designed and built for JPL by the manufacturer.

A. CRT Display Stations

Each of the eight CRT display stations of the IATV display system is comprised of three physically separate units (Fig. 1):

(1) CRT/TV display unit (14 in.).

(2) Station controller.

(3) Keyboard.

Each station controller contains a 1024 byte core memory for storing characters to be displayed on the associated CRT/TV display unit. The station controller is the central control unit of the station and responds directly to the commands and data received either from the keyboard or the computer (through the remote multiplexer). The same type controller is also used as the primary controller for the two hard copy printout stations.

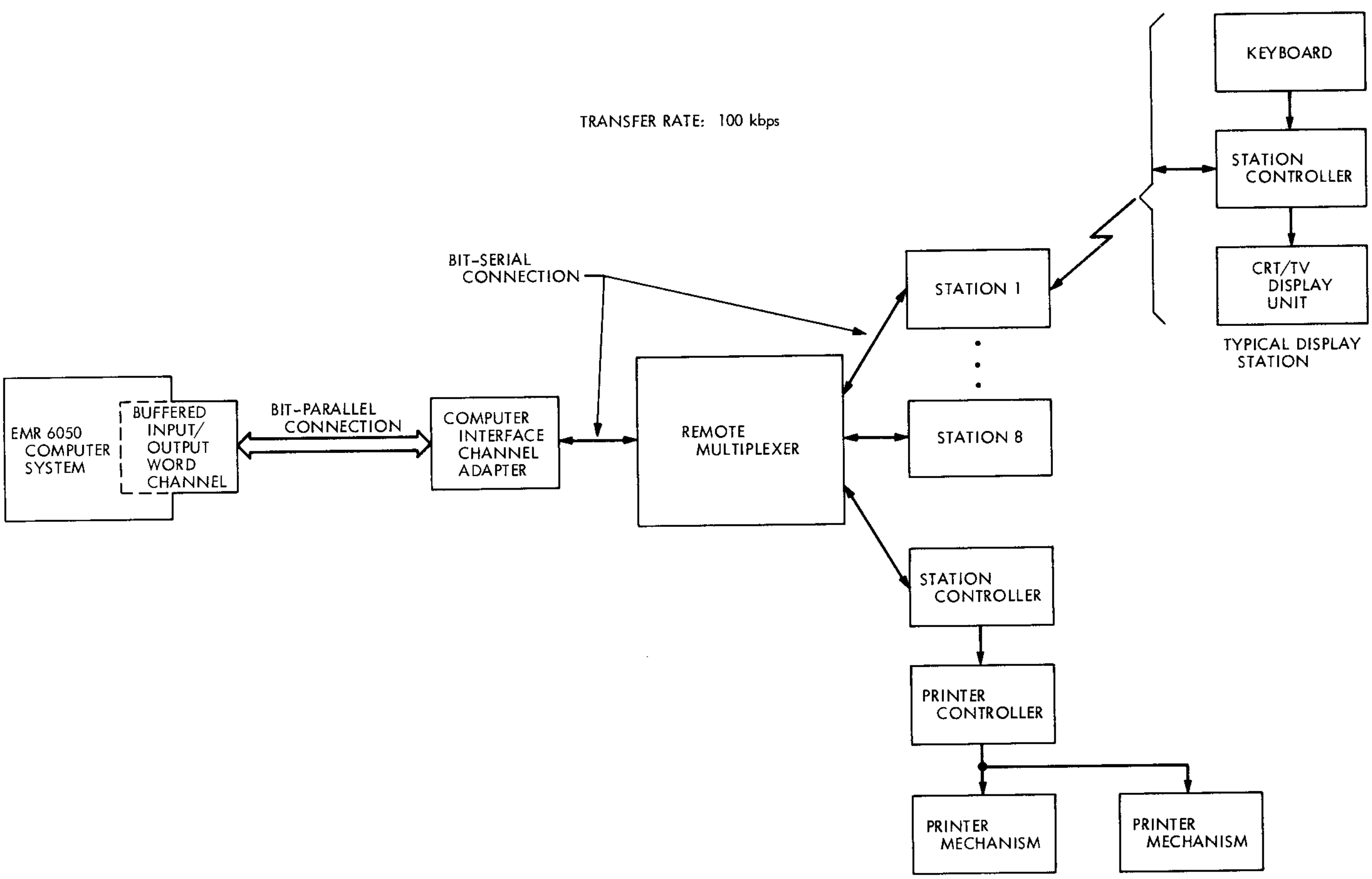

Fig. 1. Functional block diagram of interactive alphanumeric television display system

B. Hard Copy Printout Stations

The two nonimpact, high-speed, hard copy printout stations of the IATV display system are implemented using four physically separate interconnected functional units (Fig. 1):

(1) Station controller.

(2) Printer controller.

(3) Nonimpact printer mechanism (two units).

The station controller and the printer controller are time-shared by the two printer mechanisms.

C. Unit Operations

The operations of each of the five major functional units used in the IATV display system are briefly described in the following subsections. The five major functional units are:

(1) EMR 6050 computer.

(2) Computer interface channel adapter.

(3) Remote multiplexer.

(4) Display communications station.

(5) Printout station.

1. EMR 6050 computer. The EMR 6050 computer interface with the display station is by means of a buffered input/output word channel. A number of data, address, and control signals are involved in the interface between the computer and the channel adapter. The data is transferred in parallel between the computer and the channel adapter, 24 bits at a time. Three 8-bit characters are packed into each 24-bit computer word. The characters can be for display or printout or for control of the subsystems of the IATV system.

a. IATV interrupts. The IATV display system is assigned two external device interrupt levels in the computer and is capable of generating four distinct interrupt conditions. Two of these conditions are indicated by bits in the channel adapter status word, which will be discussed later. These conditions are as follows:

(1) *BM = BL interrupt.* This condition occurs when the channel adapter receives a BM = BL signal on the BM = BL line from the computer, which indicates that the information block in memory has been filled (input) or that the last word is available (output).

(2) *End of operation interrupt.* This condition occurs when a block read or write operation is terminated by the transfer of all the characters or words, and the channel adapter returns to the not busy condition and has been instructed to return an end-of-operation interrupt.

(3) *Time out interrupt.* This interrupt provides the channel adapter with the ability to terminate the read operation if a data character is not received from the remote multiplexer within a given time period. This time period is determined by the channel adapter. When a time out occurs, a bit is set in the channel adapter status word.

(4) *Interrupt character received interrupt.* This condition occurs when the channel adapter receives an interrupt character from a station controller. A bit is set in the channel adapter status word when this occurs.

2. Computer interface channel adapter. The computer interface channel adapter is compatible with the buffered input/output word channel of the EMR 6050 computer and acts as a device controller on this channel. The channel adapter performs four major interrelated functions:

(1) Transforms the bit-parallel interface to a bit-serial communications channel and conversely.

(2) Manages the flow of data between the buffered input/output word channel and the devices (stations) serviced by the bit-serial communications line (through the remote multiplexer).

(3) Responds to the command and control signals generated by the buffered input/output word channel in a functionally and electrically compatible manner.

(4) Generates the correct transmission format which is compatible with the "line discipline" used on the bit-serial communications line.

a. Commands. The computer can issue the following control commands to the channel adapter:

(1) *Initiate block write.* This command initiates the transfer of a block of data from the computer to the channel adapter.

(2) *Initiate block read.* This command initiates the transfer of a block of data from the channel adapter to the computer.

(3) *Enable interrupt character received interrupt.* This command enables the channel adapter to transmit an interrupt to the computer when an interrupt character is received by the channel adapter from a station controller.

(4) *Disable interrupt character received interrupt.* This is opposite from command (3).

(5) *Clear channel adapter.* This command resets the logic and data registers in the channel adapter to a known state.

(6) *Enable end-of-operation interrupt.* This command enables the channel adapter to return an end-of-operation interrupt, which was previously described.

b. Status conditions. The channel adapter is capable of indicating its status to the computer by means of a status word. Seven status conditions can be indicated and are as follows:

(1) *Data overrun on input.* Set when a write operation is attempted while the channel adapter has a character waiting to be transferred to the EMR 6050 computer.

(2) *Input transmission parity error.* Set by the detection of a character parity error during receive operation.

(3) *Character in read buffer.* Set whenever any character is placed in the channel adapter input data register.

(4) *Time out interrupt.* Set whenever the time out interrupt (discussed previously) is activated.

(5) *Interrupt character received interrupt.* Set whenever the interrupt character received interrupt (discussed previously) is activated.

(6) *Remote multiplexer busy.* Set whenever the remote multiplexer is performing a block read or a block write operation.

(7) *Data lost.* Set if the channel adapter fails to receive a read command before the channel adapter must begin to assemble the next bit-parallel word.

3. Remote multiplexer. The remote multiplexer functionally performs as an electronic switch controlled by the computer through the computer interface channel adapter. The "address" character transmitted to the remote multiplexer from the computer causes the remote multiplexer to select one of several long line adapter interfaces, which in turn are connected to the "remote" stations (CRT display or printout stations). The address character always precedes the "text" transmitted to the selection station. The previously selected long line adapter interface and, therefore, the corresponding station is automatically deselected by the SYN character which always precedes the address character.

The remote multiplexer also accepts and responds to control function codes which are effectively addressed to it.

The remote multiplexer functionally consists of a data "shift through" register, control logic, function decode logic, a special character generator, several status registers, and a set of long line adapters. Each long line adapter provides two bit-serial interfaces. One remote type station can be connected to each bit-serial interface. Each long line adapter functionally is an integral part of the remote multiplexer and contains two bit positions of the station acknowledge status (SAS) register, four bit positions of the double rank station interrupt status (SIS) register, and the address/select logic for the two bit-serial interfaces provided by each long line adapter. The shift through register in the basic remote multiplexer is the only storage register provided for data transfer in the remote multiplexer. This register introduces a *one* character delay in data transfer through the remote multiplexer. The SAS and SIS registers contain data relative to the status of the remote stations, which the computer can sample.

a. Operation. The remote multiplexer operates either in the transmit or receive mode. It can either transmit information to the computer or receive from the computer, but not simultaneously. It is a half duplex device and can "turn around" in one bit time period. The data transfer rate through the remote multiplexer is 100 kbps. The remote multiplexer is designed primarily as a hard-wired logic multiplexer for data transfer between the computer and the several terminals (stations) connected to the remote multiplexer. In addition, it can also:

(1) Execute certain control functions received from the computer.

(2) Propagate to the computer interrupts generated at any one of the several remote stations connected to the remote multiplexer.

(3) Present to the computer status word(s) in response to requests from the computer.

4. Display communications station. The display communications station is comprised of the CRT/TV display unit, the station controller, and the keyboard (Fig. 1). The station recognizes and responds to:

(1) 17 control characters.

(2) 13 function command characters for the station controller.

USASCII coding is used for all characters. The station can display up to 800 characters (40 characters per line by 20 lines) per display and can display 67 different characters as follows:

26 alpha
10 numeric
28 pictorial
3 special pictorial

a. Significant features. Some of the significant features of the display station are as follows:

(1) Capability to address any displayable location on the CRT screen. This enables the computer to transmit either a full or a partial line and/or screen (split screen capability) *or* to selectively update any symbol displayed anywhere on the CRT screen without need to send any "space" codes.

(2) Capability to determine the location of the cursor.

(3) Ability to send an interrupt code from the display station at any time.

(4) Computer can enable or disable transmitting from the display station.

(5) Ability to obtain a STATUS byte from the station informing the computer of the station status.

(6) Ability to enable or disable refreshing of the information displayed on the CRT screen.

5. Printout station. Two nonimpact-type printout stations are provided in the IATV display system. Each station is connected to the remote multiplexer and receives data for printout from the computer through the remote multiplexer. The printer mechanisms are connected to the remote multiplexer through one printer controller and one station controller (Fig. 1). The printer controller is connected to the remote multiplexer through a long line cable consisting of three twisted wire pairs. A separate pair is used for data transfer in each direction. The third pair provides bit-serial timing down from the remote multiplexer to the station controller of the printout station.

The station controller provides storage for up to 1,024 characters of data. (To store up to 1,024 characters in the station controller, the program must first set the "cursor" to the first nondisplayable memory location in the station controller. If the cursor is set to memory location 0/0 in the station controller, then up to 960 characters can be stored in the station controller core-memory.)

The printer controller contains the printer control and interface electronics for the printer mechanism. The printer controller also converts each USASCII coded character received from the core memory in the station controller into a 5×7 dot matrix and transmits the dot pattern generated to the printer mechanism. This printer can operate at a rate of 300 characters/s (225 lines/min at up to 80 characters/line, or at 450 lines/min with up to 40 characters/line).

In the system, the computer can select any one of the two printout stations for data printout, and through the remote multiplexer, transfer data for printout by the selected station. Data for printout is first transferred at high speed (100 kbps) to the core memory of the station controller, stored, then transferred, one character at a time, to the printer controller for printout by the printer mechanism at a rate of 300 characters/s.

D. Control and Display

1. Control. All operational control is accomplished through the CRT keyboard. The first 20 positions of line 20 are used exclusively for control input during operations. The last 20 positions of line 20 will be used by the system for response messages, so as not to conflict with other displays or the request portion itself.

Each user of the keyboard must first identify himself before submitting his message. Identification pertains to the various elements of the operating system, such as telemetry, command, etc. Upon receipt of each message, the system will make the necessary identification and route to the applicable processor or program.

2. Display. All display will be accomplished on either a CRT or a line printer.

a. CRT displays. CRT display capability consists of 8 CRT units (with attached keyboard). All units will have identical functionality, that is, any unit has total control and display capability. Each CRT screen has a display grid of 20 lines of 40 characters each.

The system will initially supply 3 formats which are designed to cover all display needs in an efficient and standard manner. There are two types of format: GRID and ROLL. GRID formats are displays representing current status; ROLL formats show parameter history as well as current status. A synopsis and example of each format used in the system follows.

GRID formats (Figs. 2 and 3)

Format A (24 displays, 4 × 6 MATRIX)

(1) 8-character DESCRIPTOR

(2) 8-character VARIABLE

(3) Fixed point—8 significant digits

(4) Floating point—5 significant digits, 2-digit exponent

(5) ALPHANUMERIC—8 characters

(6) ALL CONVERSIONS (BCD, BINARY, OCTAL, DECIMAL)

Format B (18 displays, 3 × 6 MATRIX)

(1) 12-character DESCRIPTOR

(2) 12-character VARIABLE

(3) Fixed point—12 significant digits

(4) Floating point—9 significant digits, 2-digit exponent

(5) ALPHANUMERIC—12 characters

(6) ALL CONVERSIONS

15.48.19	T/M REQUEST S/C 2		FORMAT 123
AUX BAT	CMD LOCK	RATE	IRR MIRR
ON	OFF	33	NOT STOW
MANACT	CCO	CCONE	GRS2
INHIBIT	INCREASE	88.50	324-01
PYGPEN	DC64S	DC63S	AUPPEN
OFF	POST INS	NT IN EF	FALSE
GES3	SVAC01	TWT10	VBSTCV
764+02	146.5	12345+02	332241
ST A AGC	ST A SPE	SA GTPWR	SA GFREQ
1234-02	77+00	1234-02	4321-05
ST A HA	ST A DEC	ST A RUG	ST A DCC
138.5	35.0	12345678	8570
T, F123$		THIS HALF FOR REPLY	

Fig. 2. GRID format (format A)

07.32.16	TRK REQUEST S/C 1	FORMAT 062
DSS 41 HA	DSS 41 DEC	DSS 41 RNG
4127347	1647236	212476733
S41 1-WY DOP	S41 2-WY DOP	S41 3-WY DOP
1234567890	1234567890	1234567890
S41 RESOLVER	S41 EX VCO C	DSS 41 DCC
862	28987654321	8570
DSS 11 HA	DSS 11 DEC	DSS 11 RNG
1234567	1234567	123456789
S11 1-WY DOP	S11 2-WY DOP	S11 3-WY DOP
1234567890	1234567890	1234567890
S11 RESOLVER	S11 EX VCO C	DSS 11 DCC
123	12345556789	1234
K, F062$	THIS HALF FOR REPLY	

Fig. 3. GRID format (format B)

ROLL formats (Fig. 4)

Format C (16 line displays)

(1) 3-column DESCRIPTORS (11 characters each)

(2) First column always time

(3) Variable has 11 characters

(4) Fixed point—11 significant digits

(5) Floating point—8 significant digits, 2-digit exponent

(6) ALPHANUMERIC—11 characters

(7) ALL CONVERSIONS

Display formats are determined at initialization time. This is in the form of format cards entered into the system via the card reader. The user may choose any of the three formats.

b. Line printer displays. Line printer displays are handled in a manner identical to CRT displays. Formats are defined for several lines of print, each line having a separate format description card. Activation of a line printer display is also accomplished via the keyboard.

10.35.59 STA DATA REQUEST FORMAT 001

GMT	AGC	SPE	14 1-WY DOP
35.42	66.5	77.6	1234567890
35.43	66.5	77.6	1234567890
35.44	66.5	77.6	1234567890
35.45	66.5	77.6	1234567890
35.46	66.5	77.6	1234567890
35.47	66.5	77.6	1234567890
35.48	66.5	77.6	1234567890
35.50	66.5	77.6	1234567890
35.51	66.5	77.6	1234567890
35.52	66.5	77.6	1234567890
35.53	66.5	77.6	1234567890
35.54	66.5	77.6	1234567890
35.55	66.5	77.6	1234567890
35.56	66.5	77.6	1234567890
35.57	66.5	77.6	1234567890
35.58	66.5	77.6	1234567890
S,F1$		THIS HALF FOR REPLY	

Fig. 4. ROLL format (format C)

c. Operation. The execution of all displays is the responsibility of the several display processors, and not the individual programs, which, in general, do not initiate a display. All displays are initiated at the operator's request. Upon receipt of a display request, the keyboard message processor (part of the system) will identify the user, unit, and format number. The format descriptors and map will be retrieved from the drum, the data will be retrieved from the program interface file, and the display will be executed.

III. System Integration

The IATV system integrated fairly easily with the EMR 6050 computer. The main problems encountered were in the checkout of the logic of the channel adapter. Since the channel adapter was a new design, these problems were not unexpected.

After the system was made operable, checkout with user software uncovered a few problems in the printer subsystem of the IATV system. The most significant of the problems uncovered was the lack of an interrupt from the printer subsystem. Since the initial design of the printer subsystem was not capable of generating an interrupt to indicate when a given block of data had been printed, a wait loop was incorporated in the software sufficiently long to insure that the previous block of data had been printed before an attempt was made to print another data block. This proved to be an unsatisfactory solution because of the limited memory space available in the computer for use as a printer data buffer. To solve this problem, the manufacturer changed the station controller used in the printer subsystem to provide an interrupt to the computer whenever a block of data has been completely printed. This proved to be very satisfactory.

Another minor problem with the printers was the lack of paper take-up reels. In this system, the printers are used as data logging devices, and therefore output a large quantity of paper as well as data. Since there were no take-up reels for the paper, the large quantity of paper output was somewhat of a problem. To solve this problem, some surplus teletype reelers were salvaged from some unused printers and were mounted behind the printers.

IV. Summary

The need for a viable user–computer interface is an ever-present requirement. In this case, an interface was needed in which the computer could output data in set formats and in which the user could enter changes to this data to the computer. This interface could have been implemented with discrete components as the Mark II system had been; but, because of the development of interactive CRT data terminals, a better alternative was available.

The choice of a CRT data terminal system for this interface proved to be satisfactory. In addition to being a satisfactory interface, it is also a flexible interface. It can provide a good base for the development of other information display and control systems for future more complex missions.

Reference

1. Polansky, R. G., "DSN Mark IIIA Simulation Center Development," in *The Deep Space Network,* Space Programs Summary 37-65, Vol. II, pp. 94–96. Jet Propulsion Laboratory, Pasadena, Calif., Sep. 30, 1970.