Deep Space Communications Complex Command Subsystem Mark IVA

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The Deep Space Communications Complex Command Subsystem will require major changes for the Mark IVA era. A description of the subsystem and its assemblies is contained in this article.

I. Introduction

The requirements for the Mark IVA Deep Space Network will result in major changes to the Deep Space Communications Complex Command Subsystem (DCD). While the basic functions of the subsystem remain the same, the subsystem will undergo major changes to satisfy the Mark IVA requirements. The changes are driven by basically two new requirements: (1) add new flight projects to the existing mission set, and (2) reduce Deep Space Communications Complex (DSCC) operations costs.

The addition of new missions to the existing mission set will require the implementation of a new Block II Command Modulator Assembly (CMA). The existing Block I CMA was first installed in the DSN for the Mariner 71 mission to Mars, and has successfully supported the Deep Space Missions since that time. However, the Block I CMA cannot support the data rates and/or waveforms required by some of the missions in the new mission set.

One of the major goals of the Mark IVA DSN is to reduce operating costs at the Deep Space Communications Complex. For this reason, the Mark IVA plan is to centralize all possible equipment at Goldstone, Spain, and Australia into a Signal Processing Center (SPC). Furthermore, the equipment is to be remotely controllable from a central location within the SPC. The concepts of centralized equipment and remotely controlled equipment is to be accomplished as part of the Mark IVA DSN implementation. This in turn is to reduce the total number of maintenance and operations personnel at the DSCC. The effect of these concepts on the DSCC Command Subsystem will require (1) a new Command Switch Assembly (CSA) to permit any CMA to interface with any exciter at the SPC, and (2) hardware and software modifications to the Command Processor Assembly to support remote control capability.

II. Mark IVA DSCC Command Subsystem Description

The Command Subsystem (DCD) is an element of the Deep Space Network (DSN) Command System. The subsystem consists of hardware and software assemblies for data processing, command-waveform generation, and switching such that command information can be transmitted to the planetary and highly elliptical earth orbiter spacecraft supported by the DSN.

The subsystem will consist of three assemblies:

(1) Command Processor Assembly (CPA).

(2) Command Modulator Assembly (CMA).

(3) Command Switch Assembly (CSA).

The CPA will serve as the data processing assembly for the subsystem. The CMA will generate the command composite waveform for transmission to the spacecraft. The CSA will provide switching capability to the appropriate antenna at the Deep Space Communications Complex (DSCC). The subsystem will serve as the link in the total end-to-end command system and will accept and store command data from the missions operations centers, modulate the data on the command subcarrier, and route the signal to the appropriate antenna for radiation to the spacecraft. Figure 1 shows the subsystem as the link in the end-to-end command system. Figure 2 shows the allocation of the subsystem functions to the assemblies.

As part of the reconfiguration of the DSN for the Mark IVA era, all subsystem equipment shall be located at the DSCC Signal Processing Center (SPC). Figure 3 provides a block diagram of the subsystem equipment at the SPC. As shown in Fig. 3, four CPA-CMA links will exist at the SPC at the Goldstone, Spain, and Australia complexes. Each link will have the capability to operate independently of any of the other CPA-CMA links. For operational considerations, the design provides for three links to be configured and actively commanding, while the fourth link is to serve as backup. Also shown in Fig. 3 are two links, one active link and one backup at CTA-21 and one link at MIL-71.

III. Assembly Description

A. Command Processor Assembly

The CPA will consist of a minicomputer and special interface hardware. Figure 4 provides a block diagram of the minicomputer and the special hardware.

1. Minicomputer. The heart of the CPA will be the Modcomp II/25, a general-purpose 16-bit digital minicomputer, which will have the following characteristics:

(1) 64K core memory module.

(2) Four-port memory logic.

(3) Power fail-safe option.

(4) Executive feature option.

(5) Priority interrupt levels.

(6) Console I/O device controller.

(7) Paper-tape reader controller.

(8) Dual-asynchronous communications interface (2 each)

(9) Six digital input channels (16 bits per channel)

2. Interface hardware. The CPA will interface with special hardware required for command waveform generation, intersubsystem communication, timing, and external signal interrupts. These interfaces include:

(1) IEEE-488 interface with the Local Area Network (LAN).

(2) IEEE-488 interface with the CMA.

(3) A special frequency and timing interface assembly which receives timing signals and periodic interrupts into the subsystem.

B. Command Modulator Assembly

The CMA consists of a microcomputer and special-purpose hardware (Fig. 5). Each CMA will be connected to a specific CPA (nonswitchable). The output of the CMA is then switchable to any exciter by use of the CSA.

1. Microcomputer. The CMA will use a single-board microcomputer with an SBC 340 memory expansion module. Included in this configuration will be the following:

(1) An 8086 microprocessor.

(2) 32K bytes of RAM.

(3) 32K bytes of ROM.

(4) 24 lines of parallel interface to CMA special-purpose circuits.

(5) RS-232C maintenance port.

The CMA microprocessor will receive command and control data from the CPA. These data will be used by the microprocessor to configure the CMA special-purpose hardware for generating the command composite waveform for radiation to the spacecraft. The microprocessor will also monitor the status of CMA special-purpose hardware to ensure correct operation.

2. Special-purpose hardware. The CMA special-purpose hardware provides the multiple-mission signal generation capability for supporting the planetary and high-earth orbiter missions. The missions to be supported require various uplink acquisition sequences, different modulation methods, etc. The CMA special-purpose hardware provides this required multiple-mission capability and includes the following:

(1) Subcarrier and data clock synthesizers. The synthesizers are controlled by the CMA microprocessor to

output the required frequencies for the subcarrier and data rate.

(2) Digital function generators that convert the subcarrier and data clock synthesizer outputs to digital waveforms. These function generators are also capable of synthesizing and scaling sine and square waveforms and resolving the phase of the subcarrier waveform.

(3) A modulator that accepts the digital function generator outputs and creates the required modulated subcarrier. The modulator selectively creates coherent binary phase shift keyed (CBPSK) modulation with or without data rate amplitude modulation, continuous phase frequency shift keyed (CPFSK) modulation with or without data rate amplitude modulation, or direct data modulation. In addition, the CBPSK data modulator may be Manchester encoded, as required.

(4) Digital-to-analog circuitry that converts the digitally modulated subcarrier streams into an analog signal, adjusts the amplitude of the signal, and outputs the signal to the exciter.

(5) Verification and confirmation circuitry that ensures correct operation of the CMA signal-generation hardware and confirms that the correct signal has been modulated onto the carrier by the exciter.

C. Command Switch Assembly (CSA)

The CSA provides the switching interface between the multiple CMAs and exciters at the SPC. The switch is remotely controllable by the Complex Monitor and Control (CMC) operator via the CPA. Figure 6 provides a block diagram of the CSA.

IV. Software and Firmware Description

A. Command Processor Assembly Software

The software used by the subsystem will reside on the CPA's disk storage unit. The disk will be divided into three areas: the CPA operating system and application software files, disk-resident command files, and a temporary command data log area.

The operational program will basically consist of two types of tasks: tasks activated and operating under external interrupt control, and tasks initiated and executed under program control. Each task will bear an assigned priority and will be supported by a standard operating system. Program operation, because of its interrupt-dependent, real-time nature, may be characterized as time-multiplexed or time-shared processing.

Within the program, data areas and files will be maintained in support of the command processing functions. These data structures will be either static or dynamic in nature. That is, information will either be inserted when the program is assembled, resulting in an invariant data structure, or information will be dynamically stored or altered in specified program areas during program operation. Data structures which are embodied in the program include:

(1) Mission-dependent data tables.

(2) Canned program messages.

(3) Text keywords.

(4) GCF communication codes.

(5) DSS internal communication codes.

(6) Configuration/standards and limits tables.

(7) Command stacks and queues.

(8) Command files.

(9) CRT display files.

B. Command Modulator Assembly Firmware

The firmware used by the subsystem will reside on ROM within the microcomputer. The firmware will be divided into three areas: test and diagnostic routines for the computer and preliminary initialization routines, executive routines, and application routines.

The test and diagnostic routines are executed when power is applied or a software reset is invoked.

The real-time, interrupt-driven nature of the CMA will be addressed through the use of the real-time, multi-tasking executive routines. The executive response to hardware interrupts and software calls and schedules the appropriate application routines.

The application routines control and monitor the operation of the CMA special-purpose hardware and interface with the CPA to receive control and command data.

V. Mark IVA Command Subsystem Implementation

The implementation of the assemblies of the Mark IVA Command Subsystem is in process and in varying stages of completeness.

The Block II CMA prototype is in the final stage of checkout. A fabrication contract is in place for production of the units to be installed in the DSN. The Block II CMA will be the subject of a subsequent article in which detailed design and performance will be discussed.

The CSA prototype is being manufactured. After the prototype is tested, the production units will be built for installation in the network.

The CMA firmware has been coded and is being tested concurrently with the prototype CMA hardware. This firmware will be integrated into the subsystem (interfacing with the CPA and production CMA hardware) at the Verification and Test Facility (VTF) in 1983.

The CPA software is being defined (new interfaces) and will be integrated into the subsystem and the command system at the VTF in 1983.

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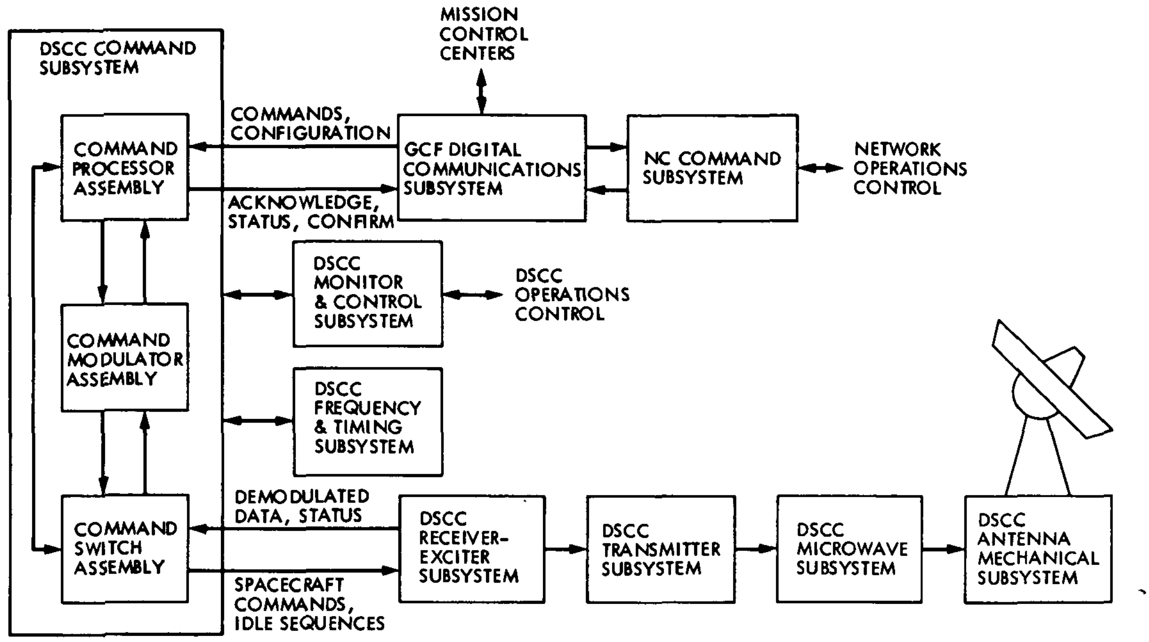

Fig. 1. DSCC Command Subsystem within DSN Command System

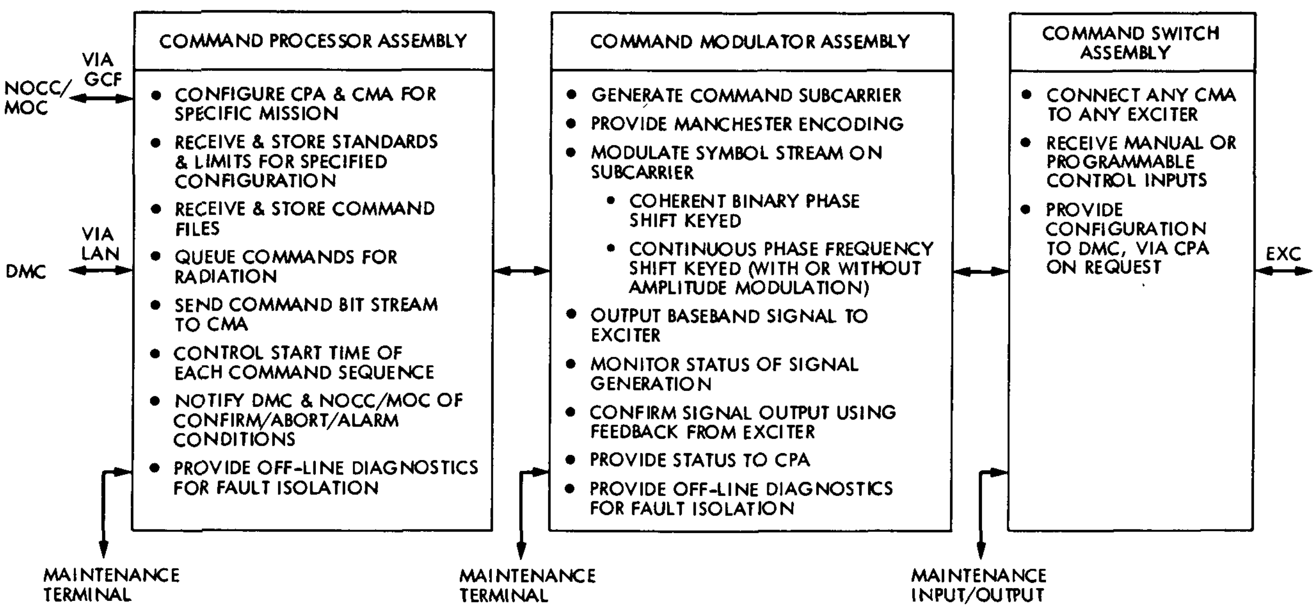

Fig. 2. Allocation of functions to assemblies

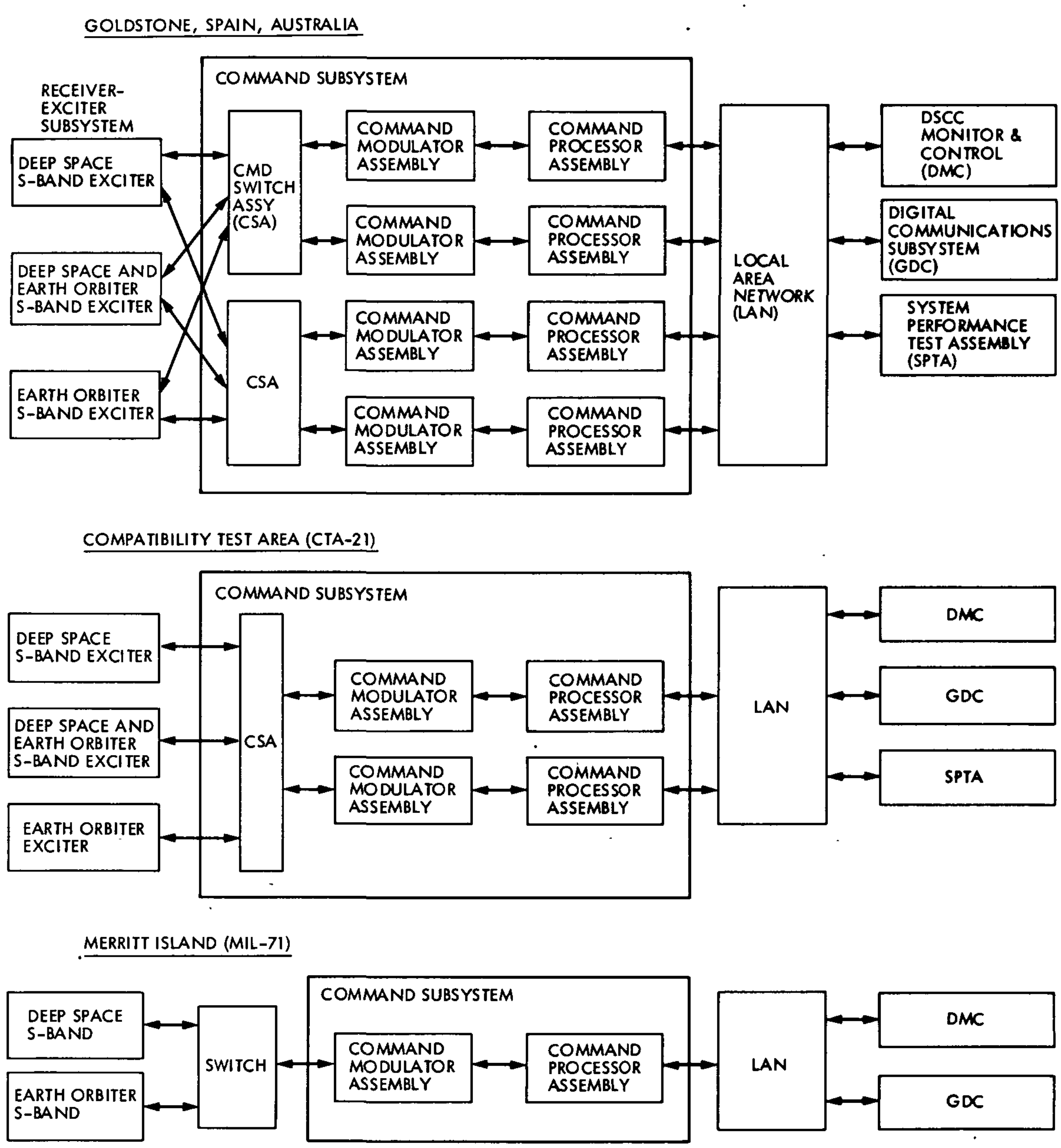

Fig. 3. Command Subsystem configurations

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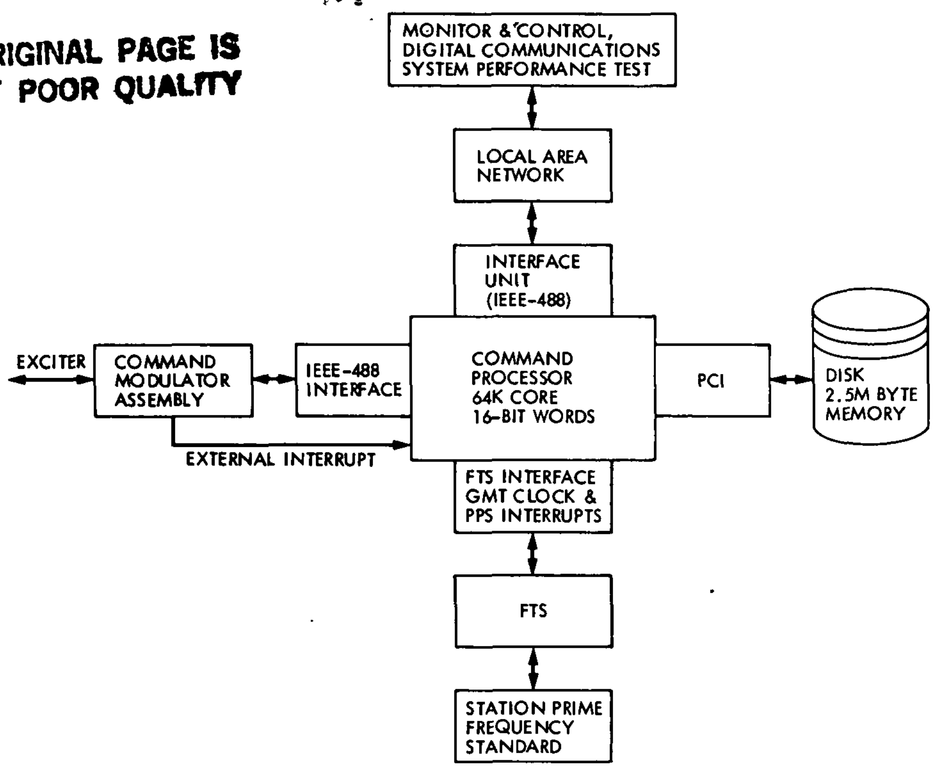

Fig. 4. CPA and associated equipment, functional block diagram

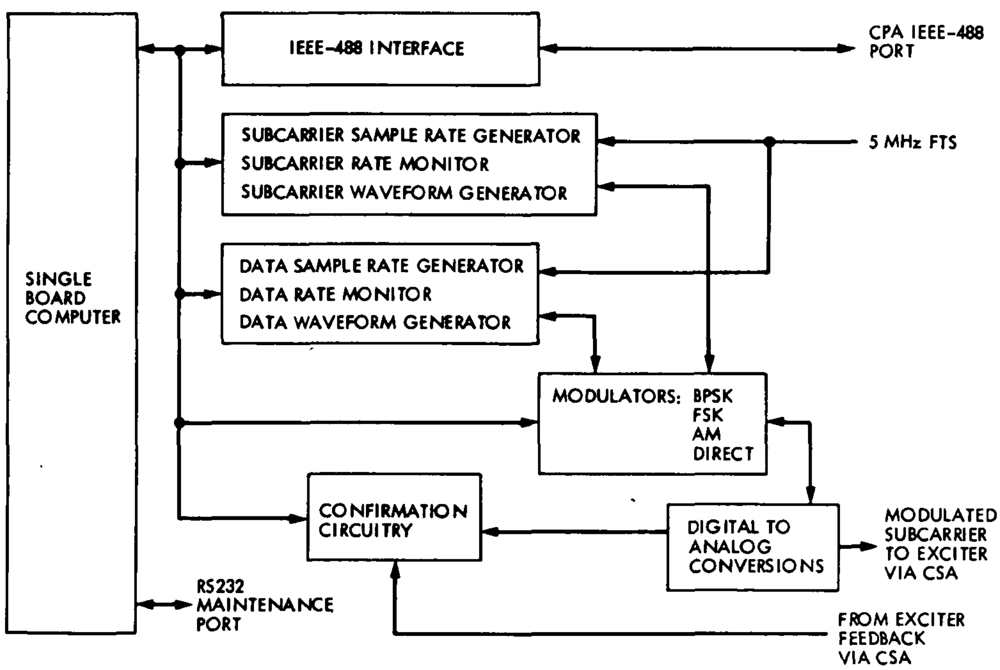

Fig. 5. Command modulator assembly, functional block diagram

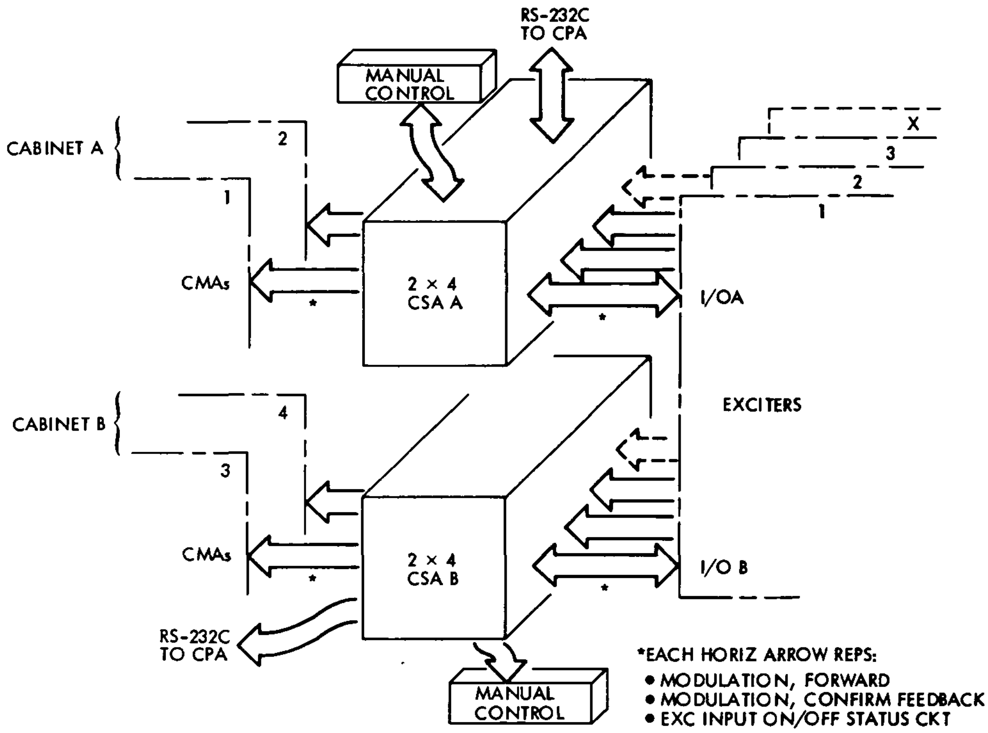

Fig. 6. Command switch assembly, functional block diagram