5.2. Command Subsystem.

The IUE command subsystem consists of redundant command decoders and a command relay unit (CRU), as is shown in the figure 5-18.The CRU contains circuit redundancy up to the individual relay and relay driver stage. Three types of commands are available; impulse and serial commands are distributed by decoders 1 and 2, and relay closures are provided by the CRU.

- The impulse command is a positive 10 volts pulse with a 15 millisecond duration. There are 128 impulse commands available from the command decoder.

- The serial command is a positive 10 volts logic signals, and the clock transfer rate is 4.27 kHz. Each serial command will provide 37 bits of programmable information. There are 48 individually buffered serial commands available from each command decoder.

- The relay closure commands are executed using a serial command to the CRU. Sixty-four latching relay closures are provided. Most of the CRU's are used to switch primary +28 volts power to spacecraft subsystems. The Pyrotechnic circuitry also used the CRU. This circuitry controls by serial and discrete commands the apogee boost motor ignition, the solar array deployment and the telescope cover release. This pyrotechnic circuitry is completely redundant.

Each command decoder can process command messages from two sources: a VHF receiver analog signal and digital information from the OBC.

Command detector and decoder characteristics	
Input signal	Modulation PCM/FSK - AM Subcarrier 8 kHz / 12 kHz Bit rate 800 Hz
Command rate	Ground station originated 13 per second Computer or stored command 33 per second
Command capacity	Discrete: 128 outputs/10 V, <1kΩ source impedance, 15 msec positive duration. Serial: 48 individually addressed and buffered 37 bits each with NRZ data, 4.27 kHz clock, 37 bit positive envelope, all 10 V logic, <1kΩ source impedance, rise fall times < 5 μs.

The command decoder contains three distinct circuit groups: analog circuits, digital logic circuits and dc/dc converter. The analog circuits demodulate the input signal and convert the information contained to three digital output signals which are data, voltage-controlled oscillator (VCO) clock and a data present signal. The first two signals transfer the uplink command information to the digital logic circuits for processing, while the last one allows the digital logic to proceed with command processing only when adequate bit error rate probability exits. The digital logic circuits

process this command information from the analog circuits and OBC command data which are assumed to be transferred by an error free channel and are executed as received. Sixty bits of data are processed for each uplink command executed, and 44 bits are processed for OBC issued commands; the only difference between them is the OBC commands do not contain the parity code or the decoder address. The OBC commands were directed to a single decoder by the selection of the corresponding output channel.

The decoders use time share command execution (15 millisecond intervals) to avoid priority conflict. OBC command data are transferred to a decoder during the time interval when uplink spacecraft commands are being executed. The time-share intervals of command decoder 1 and command decoder 2 are not synchronized. For this reason, it was thought that both the uplink and OBC commands should be addressed to the same decoder.

After the launch of the IUE, command decoder 1 was used by both the ground command and the OBC until June 1980. On June 12, 1980 a spacecraft anomaly occurred in which decoder 1 apparently malfunctioned and incorrectly interpreted a command uplinked from the ground. Although this anomaly was proved not to be related with the decoder, the command decoder function for both the ground system and the OBC was transferred to decoder 2. On January 21, 1981 the OBC was reset following an OBC crash. The command decoder 1 was automatically selected by the OBC although the related telemetry point indicated it was still using decoder 2. So, the ground commands were sent to decoder 2 while OBC commands were sent to decoder 1. This situation was not discovered until September, 1992. Since any apparent conflicts appeared during the eleven years while in this configuration, this configuration was maintained until the end of the mission. It should be noted that a conflict in commanding between the OBC and ground command would only occur if both systems were to attempt to command the same device at the same time. By 1981 ground operations had been refined to the point that it was very unlike that the ground would issue commands to the same device the OBC may be commanding.

Command verification.

When the command decoder accepts a ground generated command, it increments a command execution counter. The command encoder on the ground computer compares the number of commands it sent out to the number of commands accepted by the decoder indicated by this counter. If the two numbers agree, the command is verified. If they do not agree, the ground computer tries to send the command up to two more times before displaying a verification failure message to the initiating console and halting the executing procedure until the controller retransmits, clears or skips the command.

Critical commands and data blocks are not automatically retransmitted in the event of a verification failure on the first attempt. A command is designated as critical because accidental transmission is potentially dangerous to the spacecraft. It must be approved by the shift leader console before transmission.

Procedures.

To minimize the chance of error when sending commands to the spacecraft, most commanding is done using pre-programmed procedures (PROCs). PROCs are programs which are stored in

the ground computer and then called up, by keyboard entry, by the spacecraft controllers. A PROC executes all commands needed for equipment reconfiguration and the actual operation. Each step of a PROC is also accompanied by an explanation of what is being done. There are PROCs for most spacecraft operations as well as for ground system operations such as setting up the system after initialization and science operations.

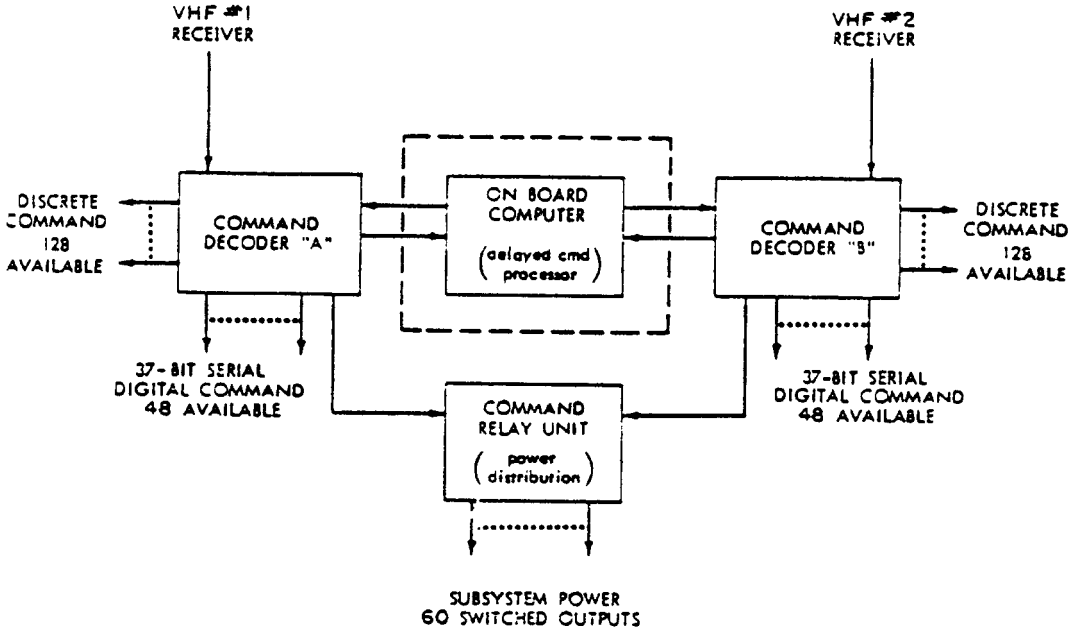

Figure 5-18. IUE Command Subsystem Block Diagram.

5.2.1. Command decoder anomalies.

Along the spacecraft life, two problems associated with the command decoders occurred.

On the 27th of May in 1980, decoder 1 was used for a few days to check out a problem with camera commanding, which did not turn out to be a decoder problem. A few days later, June 12, the OBC and radiation monitor were powered down and the spacecraft attitude was lost. A sun acquisition on jets was performed, and as the spacecraft was evaluated, both were turned on again. The crash was a result of a failure in command decoder 1. It occurred immediately following a command to the DMU. The penultimate command had been to the CRU. Serial data from the DMU command was tagged with the previous CRU address, causing several relays to be commanded. Pyrotechnic circuitry had been armed, and was immediately disarmed. As a consequence of this event, the decoders were switched again putting command decoder 2 into use.

On the 25th of May in 1982, the SWP camera was commanded to an abnormal configuration when command decoder 2 took the address of a previous command with the data portion of the intended command.