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VIDEO CONTROL CENTER AND COCKPIT SIMULATOR.(U)
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VIDEO CONTROL CENTER AND COCKPIT SIMULATOR

System Simulation Branch
System Avionics Division

April 1979
TECHNICAL REPORT AFAL-TR-79-1081
Final Report for Period 1 October 1976 - 30 September 1978

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This report covers work done under Project 20030322 and now continuing under Project 20030342. It is intended to be for general information on the cockpit simulator design. The report gives the basic concepts for the use of the system but does not give all circuitry details. These details will be in the report of Project 20030342.

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FOREWORD

This document represents the final report under Project 20030322. Although Work Unit 22 will close with this report, the work effort is continuing under Work Unit 42. This report therefore covers the progress and designs to this point and as such is not intended to cover the video console and cockpit completely or in great depth. Detail schematics of all circuitry are not included since such items will be included in the report of Work Unit 42. AFAL-TR-76-164 covered the video console in detail as built under Work Unit 10. The final report of Work Unit 42 will update that document as well as cover the cockpit design in great detail. This document will only discuss designs and procedures for use. It is hoped that potential system users with requirements beyond the capabilities described will contact the project engineer with their needs for possible inclusion in the basic design.

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LIST OF ILLUSTRATIONS

LIST OF ABBREVIATIONS

BCC	Bus Control Cage
CPU	Central Processing Unit
LDC	Lamp Driver Cage
LED	Light Emitting Diode
MOS	Metal Oxide Semiconductor
PIV	Peak Image Voltage
RAM	Random Access Memory
ROM	Read Only Memory
VTR	Video Tape Recorder

SECTION I

VIDEO CONSOLE UPDATE

The video console is modified and updated as new requirements occur. A continuing effort exists to improve reliability and flexibility. AFAL TR-76-164 covers the console in some detail. An updated edition of that information will be published in the future. This section will cover the major changes to the console since the writing of AFAL-TR-76-164.

One addition to the capability is the Datatron tape editor. The Datatron is interfaced to the two IVC-870's in the console. The detailed operation is explained in the Datatron manual, but the basics are as follows. The system generates and uses a time-code recorded on audio channel one. The keyboard makes reference to three VTR's: A, B and RECORD.

VT1 is the record machine, VT2 is the A machine and the B circuitry is not implemented. The Datatron keyboard can remotely control the VTR's manually. However, if time code exists on the tape the Datatron can locate and queue any specific point on the tape. To edit, the time code of the start and stop points on both machines are entered. The Datatron will control the transport and put VT1 in record at the correct time to perform the edit. Additionally, an edit can be previewed by the operator before the actual performance.

One main feature of this system is that the Datatron will be interfaced to a computer thus allowing segments of tapes to be selected and played by simulation software. An essential point to be considered when using the system is that the time code must be on the audio one channel not audio two as might be expected.

Other new equipment items included a portable color camera, a portable U-matic VTR, a chroma keyer and a video titling system.

The color camera is an RCA TK-76 complete with zoom-macro lens and battery belt. The system is a broadcast quality camera which can easily be operated from a shoulder position or on a light-duty tripod. This camera in conjunction with a JVC CR-4400 portable U-matic VTR comprises a totally independent and battery operated system which can go anywhere. This portability allows greater freedom for shooting documentary or training material.

New capabilities for the console include a chroma keyer and titler. A Datavision D-3000 titling system is available. The D-3000 can generate letters and symbols in a standard video format for insertion in other video signals. The D-3000 also generates a keying signal for use in conjunction with the Mark VII effects generators. The chroma keyer can be used to mix two video signals and switch on the basis of a selected color. As explained in TR-76-164 a "chroma key" outputs signal A except when a specific color is detected,at which time signal B is output. By this method a target may be "keyed" into a terrain background.

The chroma keyer and the titler as well as video tape input/output (I/O) ports are all available on newly installed patch panels. The final configuration of these points is not yet determined at this writing, hence, no "roadmap" will be given at this time. The panels can be used at present and all jacks are labeled.

In the interest of improved reliability some replacements have been made. Since the reliability of the World Video monitors proved to be orders of magnitude less than desired, the units are being replaced with Conrac monitors. The picture quality is also much improved. Conrac's are given to failure also, but a given fault usually only occurs once. However, with the possible exception of one foreign-made unit, no other monitor equals the picture quality and precision of a Conrac monitor.

Other improvements will be made as deemed necessary. Future equipment items to be purchased are a slow motion VTR and a U-matic "playback only" machine with 25" monitor for use in conference rooms or for demonstrations. An update of the total system will be described in a report under Work Unit 20030342.

SECTION II

COCKPIT SYSTEM

The cockpit simulator may appear as a very intricate and special purpose system. In reality the only feature which is "special purpose" is the mechanical configuration. Electrically the system is a series of standard video displays, some analog voltage inputs, and a large number of independent switches and lamps. When a given switch is for the "landing gear" or a given lamp is for "flaps down" is controlled by the software on the host PDP-11. Thus the system can be totally reconfigured by software. By use of the DMA-10, the main simulation and aircraft model is resident on the DEC-10 and the PDP-11 is freed for the interpretive software necessary to interface to the cockpit.

The cockpit control console serves as a control point for the entire simulation. The main electronics for the cockpit are actually in the console and contain hardware monitoring and test circuitry. The console also contains CRT terminals to the PDP-11 and DEC-10. Thus a single operator has access to the total system from one location.

The cockpit control system was designed with several basic criteria in mind.

The cockpit will have as little resident electronics as possible. The main system will reside in the control console. This allows for cockpit change without rewiring the system. Of course the video monitors and similar devices must be resident in the cockpit, but all switch and lamp control circuitry is in the console.

The system has wide flexibility with minimum load on the host computer. The switch and lamp interfaces communicate with the host only when a change occurs and are otherwise transparent. For example, the switch controller samples all switches and only interrupts the host if a switch is activated.

The system is designed for quick simulation set-up or cockpit modification. By having uniform connectors for both switches and lamps a given configuration can be "plugged in." The tally lights and test circuits on the console allow for quick check of new configurations without using the host computer. The tally lights and the modular circuit design also facilitate rapid failure isolation. Details of the component parts follows.

Switch Interface

The requirements of the switch interface are as follows. The system must have a capacity of at least 500 switches. It must monitor the switches and communicate to the host computer only if a change occurs. Only momentary switches are actually used; however, the system can create alternate-action switches through software. (A momentary switch as defined here is one in which the activator position determines the state. An alternate-action switch complements its state upon actuation. Thus a conventional toggle switch is momentary, whereas a push-on push-off button is alternate-action.)

The above requirements suggest a system wherein the switches are scanned continuously for changes and an interrupt to the host generated if a change occurs. This implies remembering of the switch states from one scan to the next. To generate alternate-action switches from software the system must also determine if the change in state is from open to closed or vice-versa. Also, a map must be generated to flag the switch as being momentary or alternate-action. Other desirable features can be considered also. For example, if only 100 of the 500 switch capacity is used in a given simulation it would not be necessary to scan the other 400. Furthermore, some switch functions may be more critical than others. For example, the pilot's activating of the landing gear switch need not be sensed at the precise millisecond of occurrence but the trigger button or target designation button is somewhat critical. Since scanning a number of switches takes a finite amount of time, some functions will not be sensed immediately on activation. However, if the system could be told to scan certain switches more often, then the time delay of sensing those functions would be reduced.

These requirements imply a level of decision making ability on the part of the system. For this reason a microprocessor is employed. At the time of this writing the hardware is not built but the following is a description of the proposed system.

A microprocessor chip operates using a data bus, an address bus, and several command/status bits. The command/status bits signal various processor states and command I/O or memory operations. The data bus is for input and output to the CPU of both instructions and data. The address bus is obvious. When the CPU wishes to read a memory location, the address is placed on the address bus and the appropriate command line is activated. The CPU then reads the data bus and accepts that information as having come from the addressed location. The main point to consider is that the CPU has no way of checking the validity of the data. That is to say, whatever is on the data bus is accepted. There is no way of checking if the address is correct or from what sort of storage device the data came from. Similarly, if the CPU does a memory write operation the address is established and the data to be written is placed on the data bus. The memory write command is then given. There is no automatic check to see if the data was accepted by memory or if that memory location even exists.

The switch interface utilizes these characteristics and treats a given switch as a memory bit. Each switch corresponds to a specific memory address and represents one bit of that 8-bit word. Thus, the switches may be scanned by having the CPU sequentially read what appears to be memory as far as the busses are concerned.

With the switch representing one of 8 bits, seven bits remain to use for the decision making of the system. One bit is used to store the switch state on the previous scan. Another bit flags the switch as either momentary or alternate-action. The remaining five are as yet unassigned.

Assume for the moment that the switch is bit 1, bit 2 is the previous state, and bit 3 flags the switch type. Assume further that all switches are normally open contacts and that a zero represents this state and a one represents the activated state. Also a one in bit 3 indicates an alternate-action switch. With no switches activated, all bits 1 and 2 will be zero. The CPU reads a location and determines if either bit 1 or 2 is a one; if both are zero the CPU goes on to the next location. If, however, a one is detected the CPU compares bits 1 and 2. If <u>both</u> are one the scan goes on to the next location since two one's indicates <u>no change</u> from previous scan. If bit 2 is zero and bit 1 is one, the CPU loads the address into a buffer to the host computer and generates an interrupt. It then loads a one in bit 2 and goes on. If bit 2 is a one and bit 1 is a zero, the deactivation of the switch is indicated. For example, a push-button is released. For momentary switches the deactivation should be acknowledged, but for alternate-action switches it should be ignored.

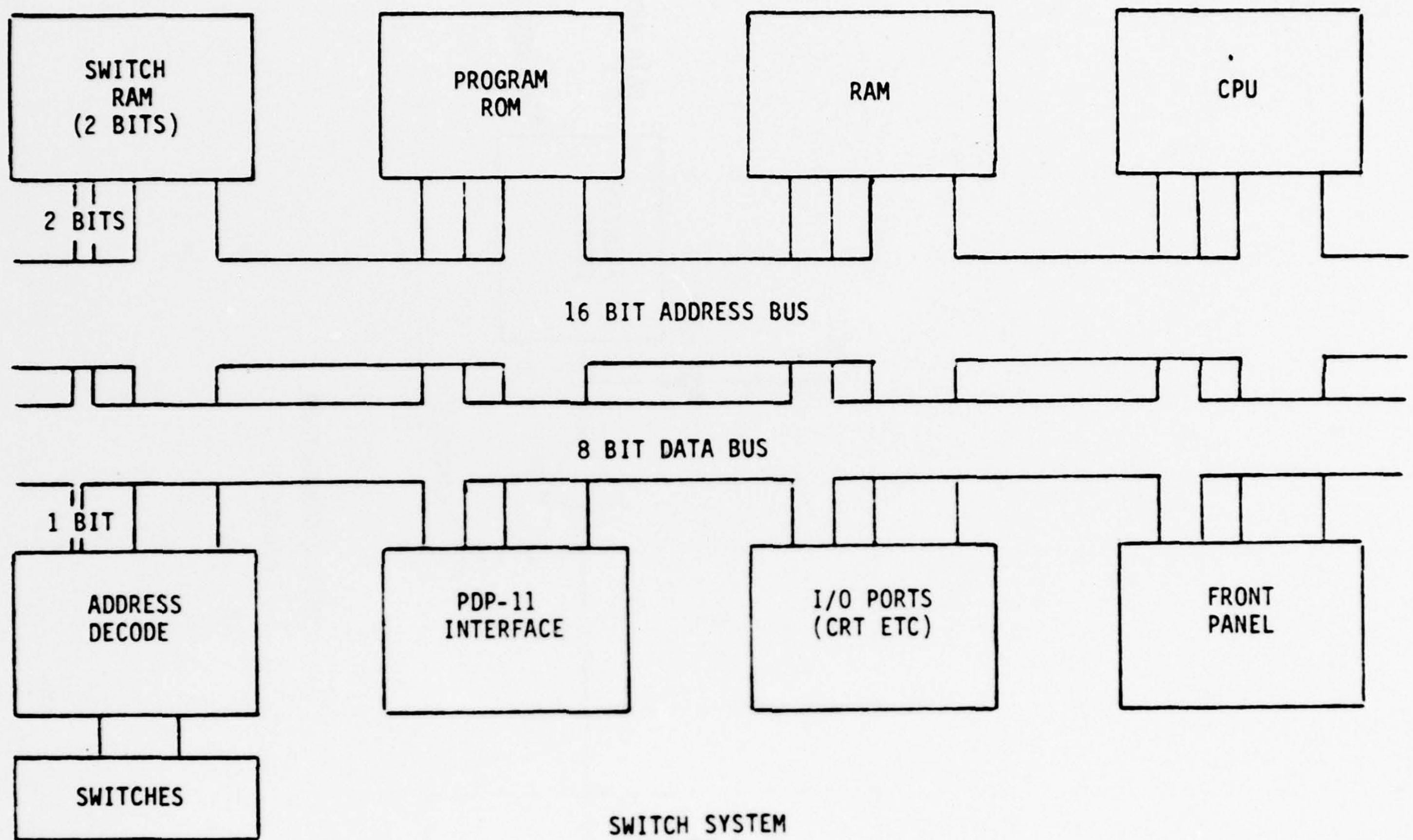
Therefore, if bit 2 is one and bit 1 is zero the CPU checks bit 3; if bit 3 is a one (indicates alternate-action) bit 2 is loaded with a zero but no interrupt is generated and the scan goes on. If bit 3 is a zero an interrupt is generated. Bit 2 is loaded with a zero and the scan moves on. Thus the contents of bit 3 controls how a switch functions. Even though the switch is electrically a momentary device it can appear as a latching type to the host computer.

Figure 1 is a block diagram of the system. A portion of memory will be made up of some metal oxide semiconductor (MOS), random access memory (RAM), and the switches. The operational program to implement the scanning will be in read only memory (ROM). Additional RAM is available for scratch pad or to load special programs.

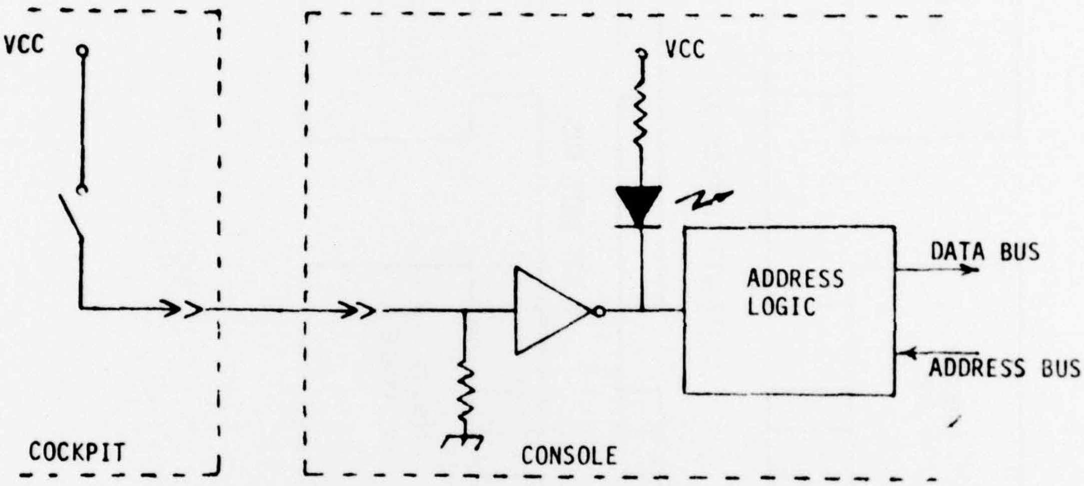
The PDP-11 interface not only allows for interrupts for switch activation during normal operations, but also permits the host to load the system memory. This allows the switch type flags to be set and also allows special programs to be down loaded. Similarly, the front panel can take control of the system.

The use of software control in this system allows for one or more schemes of switch detection and/or interpretation to be stored in ROM. Then by selecting and running the appropriate program the system can be custom "wired" for a specific simulation. Having RAM and the down load capability allows for very special programs or for test programs. It is also proposed to interface this processor system directly to the lamp driver system,thus allowing programs on the microprocessor to drive the lamps for test or set-up purposes.

The switch hardware is implemented using TTL logic. Figure 2 shows a typical installation. All inputs are through Schmitt triggers with pull-down resistors. Light emitting diodes (LED's) monitor the state of the trigger. The inputs are cabled to 24 pin connectors in the cockpit. The switch need



SWITCH SYSTEM
FIGURE 1



SWITCH CONNECTION

FIGURE 2

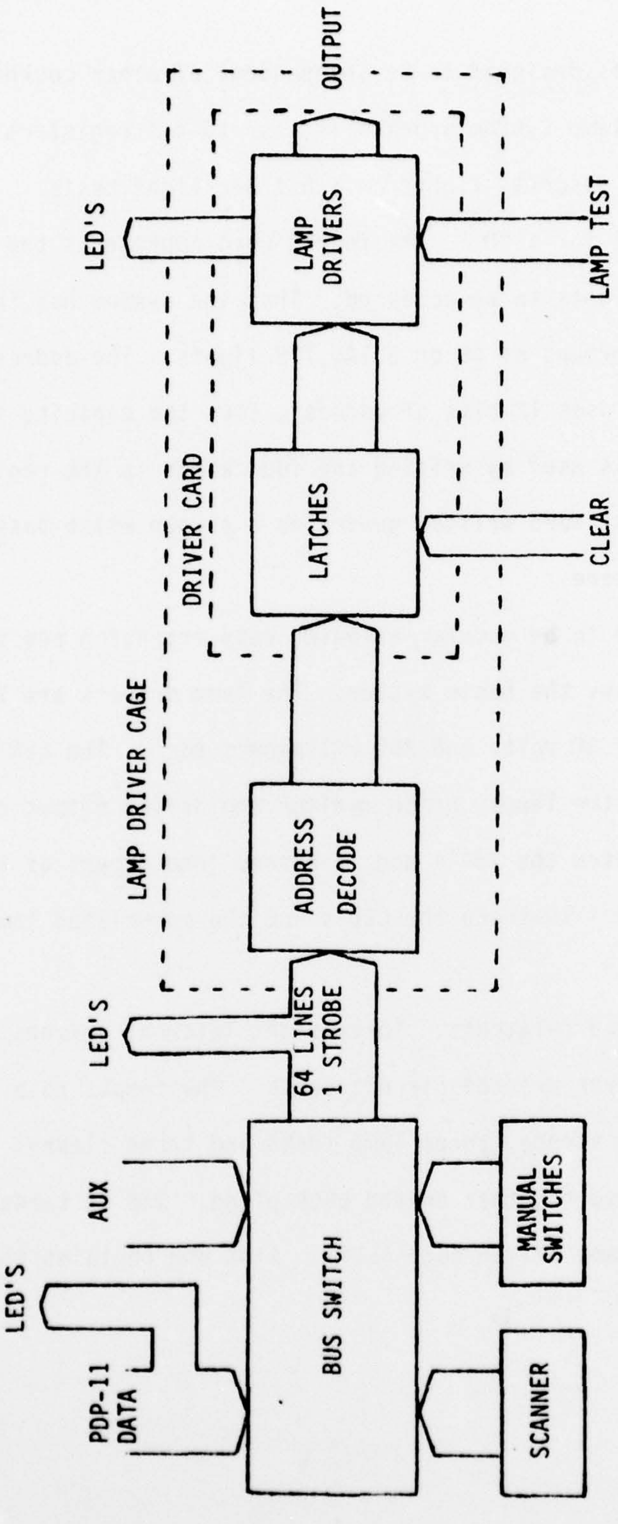
only provide VCC. However, since the input is TTL the switch may in fact be an elaborate TTL circuit if desired. High speed circuits should be avoided; however, since the cabling is not tuned in any way and reflections are likely.

Lamp Interface

The lamp driver system is designed to be independent of other cockpit systems. To the PDP-11 the lamp system appears as four 16-bit registers. Three registers represent 48 discrete lights on a bit per light basis. The light is on for a "1" and off for a "0." The fourth word represents the address of the group of 48 lights to be accessed. Thus the system has the theoretical capacity of 2^{16} groups of 48 or 3,145,728 lights. The address decode hardware however only uses 12 bits of address, thus the capacity is 196,608 lights. The system is used by writing the four words to the registers in a specific order. The last word written generates a strobe which passes the data to the lamp driver hardware.

The hardware is designed to be modular, allowing easy expansion and several levels of test. Figure 3 shows the basic system. The lamp drivers are 75464 peripheral drivers capable of 30 volts and 300 millampers each. The LED's are essentially in parallel with the lamps, hence monitor the driver output directly. The lamp test directly activates the 75464 and is bussed into groups of 16. Activating the lamp test will illuminate the LED's and the associated lamps regardless of other inputs.

The latches are 74175 quad D-latches. Forty-eight latches, drivers, and LED's form each of the 12 driver printed circuit cards. The inputs to a card consist of 48 data lines, one strobe, three lamp tests, and three clears. The three clear lines are connected together on the back plane. The 12 cards reside in slots 2-13 of the lamp driver cage (LDC). Slot one contains the



LAMP DRIVER CIRCUITRY
FIGURE 3

address decodes and the data-in cable. The driver cards are identical and interchangeable. The position in the cage determines the address. This facilitates troubleshooting and allows unused cards to be removed to conserve power. The address card may be jumper selected for any of 256 groups of 16. The decoder generates 16 strobes but only 12 are used at present.

The driver cage operates as a unit with 64 lines plus a strobe as data input and 576 open collector lines as output. For test purposes 12 clear inputs and 36 lamp test inputs are provided. Details of lamp connections will be discussed later.

Since total control of the driver cage is through the 65 input lines a 66-bit wide bus is provided (one spare bit). Normally this bus is driven by data from the PDP-11 but other circuitry is provided for manual control and test (see Figure 3). The bus is implemented on the back plane of the Bus and Control Cage (BCC). The bus switch uses 74365 tri-state buffers as drivers. Each buffer card contains 66 lines, hence one card represents one data source to the bus. The bus select control merely enables one of the four buffer cards. The cards are identical and interchangeable. The bus select switch can select one of four inputs: PDP-11, manual switches, scanner, or auxiliary (unassigned).

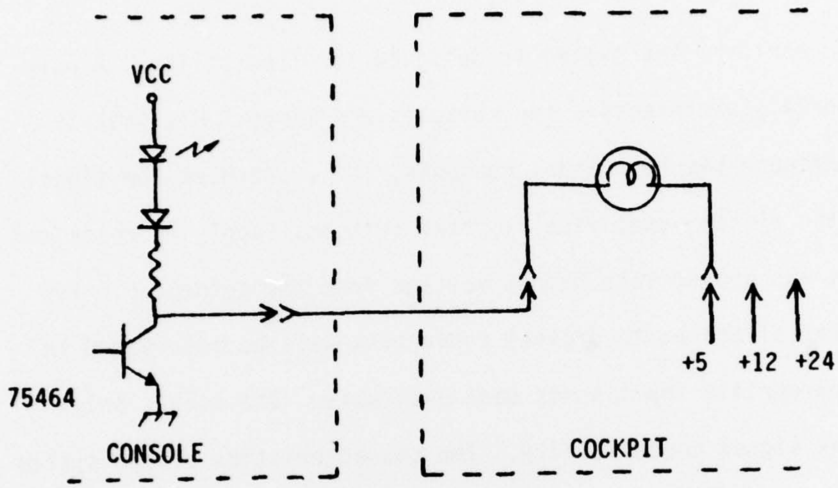
All data connections are via 70 pin edge connectors. The pin assignments are the same whether used for data output to LED panels or the LDC, or data input from switches or PDP-11. In this manner maintenance is greatly eased. For example, the cable from the manual switch panel normally connected to a tri-state buffer via the bus and control cage, may be used as the data input to the driver directly, thus bypassing the control cage. Similarly, the manual entry could be interchanged with the PDP-11 data. However the 48 line scanner is a card resident in the BCC and as such is not connected via a cable.

The LED display panels are separately powered and have internal drivers leaving the interface cable for TTL level inputs and ground reference only. The strobe LED's are driven by one-shots to make short pulses visible. Thus the LED display panel can be used to check the 65 lines at any point where an appropriate connection is available.

The scanner was installed as a circuit exerciser. The card generates a 4-bit address, one of the 48 data lines and a strobe. Beginning at address OH the module will sequentially activate the 48 lines, one at a time, generating a strobe each time. After scanning the 48 lines the address is incremented to 1H and the process repeats. As mentioned previously, the lamp driver decoder card requires 12 bits. The least 4 bits are from the scanner and the remaining 8 bits are from the manual input panel address word D. The scanner produces 16 addresses (OH to FH) but since the lamp driver cage has only 12 cards, four addresses are ignored.

Control of the scanner is by two switches and a speed control. The speed control is for the rate of the scan. The start-stop switch not only stops the scan but resets the counter to zero. Selecting "scanner" on the bus switch engages the tri-state buffers and places the scanner on line.

The output of the LDC is through six 100 pin connectors. These outputs are cabled to a junction box in the cockpit. The junction box provides several 24 pin connectors. Each connector contains 16 lamp driver lines and 3 voltage sources. As shown in Figure 4, the lamps are wired such that one side of the bulb is connected to the driver and the other side is connected to the appropriate voltage source. With this design a mixture of voltage ratings is possible and only one connector is required for every 16 lamps. Figure 4 also shows how the LED monitors the driver output stage directly. The diode in series with the LED is for reverse voltage protection since the LED PIV is only 20 volts.



LAMP CONNECTION
FIGURE 4

SECTION III

CONCLUSION

As discussed earlier, the system is designed for flexibility. A user is presented with 24 pin connectors for switches and lamps. His task is to physically configure his keyboards, readouts, etc., and meet the signal requirements of the system; specifically, that switches supply +5 volts and that lamps select the appropriate supply voltage from the connector. For analog inputs a set of analog to digital converters will be interfaced to the PDP-11 and appropriate input ports made available. The user's only restriction is the signal compatibility. The characteristics of the system are then controlled by software.

By having the hardware in the console the cockpit per se could be replaced or even a second cockpit or crew station added by simply plugging in.

It is assumed that the design is flexible enough for most requirements. The system does allow for easy expansion or modifications, however. For this reason suggestions are encouraged and welcomed. The purpose of the system is a simulation tool which changes with needs and does not become obsolete.