COMPUTER TECHNOLOGY

A programmable relay and amplifier I/O interface for the PDP-8/E computer

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Use of the Digital Equipment Corporation DR8 digital input/output buffer for the PDP-8/E computer is common. However, by itself the DR8 has inadequate output-driving capability for even the smallest laboratory device. A flexible low-cost control network designed to enable a DR8 interface to control any of 12 pico-reed relays for output driving or 8 programmable amplifiers for auditory signal presentation is described.

Digital Equipment Corporation's (DEC) DR8 digital I/O buffer for the PDP-8/E is designed to serve as a digital I/O interface for controlling output and sensing input events. However, we have found that the DR8 interface has inadequate power-driving capacity for even the smallest output device. The present paper describes a flexible low-cost control network designed to enable a DEC PDP-8/E computer to control any of 12 pico-reed relays for output driving or 8 programmable amplifiers for auditory signal presentation. The design emphasizes flexibility of I/O control, miniaturization and reliability of hardware, and the use of "click-free" programmable amplifiers essential for auditory stimulus presentation.

Output control is achieved by a front panel-mounted programmable matrix where the 12 logic signals originating at the DR8 are programmed to control relay and amplifier functions. This allows the experimenter maximum flexibility. Miniaturization is emphasized by the use of DIP-type reed relay switches and amplifiers as well as miniature I/O hardware enabling a large reduction in plugboard and panel mounting space. Noise-free presentation of auditory signals is achieved with the use of two four-channel, digitally controlled programmable analog amplifiers. Inputs to the DR8 are first buffered through monostable multivibrators which provide the DR8 with reliable noise immunity. The entire unit (input/output logic, connectors, programmable matrix, and power supply) occupies a 6 x 19 in rack-mountable panel.

DESIGN

Figure 1 displays a block diagram of the basic configuration.

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Each input and output operation is located on functionally separate plugboards at the rear of the panel. Logic signals originating at the DEC DR8 buffer are first tied to 12 light/relay drivers (2N1711 transistors), the outputs of which drive 12 panel indicator lamps. The approximate cost and specifications of all components are presented in Table 1. Figure 2 presents a schematic of the light/relay driver circuit. Each driver is capable of driving a maximum load of 150 mA. Parallel driver outputs are also tied to the columns of a 12 by 14 programmable matrix (Co-ord Switch Series 65000) mounted on the front of the panel. The 12 column bits represent the controlling output-driver signals, while the rows represent the selectable output functions. Any of the 12 DR8 output logic signals can control one or more of the output functions by inserting a shorting pin at the selected intersection of output bit and control function. The output functions include 12 miniature DIP-type single-pole single-throw pico-reed relays (Clare 1A005C) and two programmable amplifiers (14 pin DIP, Harris 2404). Each relay is controlled by a single output bit. Each programmable amplifier (PRAM) consists of four high-performance operational amplifiers selectable by a three-bit selection code. A block diagram

Figure 1. Functional diagram of the general-purpose I/O interface.

Table 1
Appropriate Component Cost

CO-ORD Switch Miniature Program Board, LVC Industries, Inc.

Total current capacity	3 Amps (continuous)
Breakdown voltage	600 V RMS
Approximate cost	\$32.00

Chicago Miniature Lamps CM-22-2-05-43

Total current drain	50 mA
Operating voltage	5-10 V dc
Approximate cost	\$1.71 ea.

Clare Pico-Reed Relay PRME-1A005-C (with electrostatic shield)

Operate time	500 microsec
Operating current	13 mA @ 5 V dc
Maximum current capacity	½ A at 100 V dc
Approximate cost	\$4.95 ea.

Harris Programmable Amplifier (PRAM) HA-1-2404-4

Rise time	20 nanosec
Fall time	1.5 microsec
Cross talk	80 dB
Approximate cost	\$21.80 ea.

Fairchild Monostable Multivibrator 74121

Minimum transition for trigger	1 V/sec
Output pulse length	40 nanosec to 40 sec
Approximate cost	\$1.81 ea.

Motorola 2N1711 npn High-Current Transistor

Maximum load	150 mA
Approximate cost	\$1.80 ea.

of a single PRAM is presented in Figure 3. The amplifiers can be configured for many types of applications with the selection of a proper feedback network. For example, programmable gain can be achieved with the use of four different preselected feedback resistors between the common amplifier output and the individual inputs.

All four channels in each amplifier are normally off when the "enable" line is low. Noise-free amplifier switching may be achieved by holding the "enable" line

Figure 2. One of 12 transistor drivers for lamp and relay operation. Each transistor is capable of driving up to four relays.

Figure 3. Harris programmable amplifier configuration.

high while controlling the D_0 and D_1 lines for amplifier selection. One of the four channels is sacrificed using this procedure; however, noiseless switching of the remaining three amplifiers is achieved.

Each amplifier channel has individual gain control and I/O BNC connections mounted on the front of the panel. Relay I/O connections are made with miniature banana plugs (Pomona 3542) also mounted at the front of the panel or through parallel BNC connectors.

Input to the DR8 is through 12 miniature banana plugs, each triggering a monostable multivibrator (Fairchild 74121) configured for one-shot operation. The use of "one-shots" provides the buffer with maximum noise immunity at the input. Input triggering is achieved by grounding a normally high input with an external switch.

The lamp/relay drivers, relays, and multivibrators are all DTL/TTL compatible, requiring +5 V dc. The programmable amplifiers require between ± 10 and ± 15 V dc. The total current requirement of the network does not exceed 300 mA during normal operation. There are two advantages of this interface over commercially available devices: cost and flexibility. For example, Grason-Stadler's general-purpose laboratory interface package costs approximately \$4,000. The total cost of the hardware for the present interface is less than \$200. In addition to providing the user with click-free audio amplifiers, it allows the user maximum flexibility in interfacing the 8/E with an unlimited number of experimental events—a major shortcoming of some commercially available devices.

Control of all input/output events is accomplished with the standard DR8 machine language commands. This results from the direct coupling of the two devices. For instance, in order to set or clear particular drivers on the interface, one need only execute the proper set and clear commands for the corresponding bits on the

DR8. In a similar manner, input to the DR8 is accomplished by sensing, with the appropriate commands, the particular input lines which are buffered by the one-shots.

It should be mentioned that the operation of this programmable interface is not limited to the DEC digital I/O buffer. With a few minor hardware changes this device can be interfaced with a number of recently developed microprocessors (e.g., INTEL 8080) and microcomputers (e.g., MOS Technology, Inc., KIM-II). For instance, an "intelligent" version of this interface

could be developed by coupling the relay/amplifier interface to a microcomputer provided with I/O ports. This could serve as the front end to the main computer, which could then be relieved of the timing and sampling functions. However, with this application, the cost advantage of the present relay/amplifier interface would be reduced.

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