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An encoding multiple-key response unit

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Many computer-controlled psychophysical studies allow subjects multiple response alternatives. Encoding the activated response key before signalling the computer makes possible more rapid stimulus/response interaction, simplifies software interrogation of response-key status, and automatically resolves double strikes. We describe an inexpensive unit which uses a priority encoder for up to seven response alternatives.

In computer-controlled psychophysical measurements, the subject's response interactively controls a stimulus parameter, often according to a complex tracking algorithm (e.g., Corwin, Kintz, & Beaty, 1979). Many situations require a multiple-alternative response unit using several push buttons.

The simplest design is to connect each response key to the computer input bus, so that each key, when depressed, sends a bit to the input port. The contents of the input port are then detected and encoded by the computer. In the case of a seven-alternative response unit, the following subroutine could be used:

```
10 KEY=1
15 K=PEEK(KEYPORT)
20 IF K=0 THEN 15
25 K=K/2
30 IF K>=2 THEN KEY=KEY+1:GO TO 25
35 ON KEY GOTO 100,200,300,400,500,600,700
```

In Line 15, the computer's input port is sampled; the contents, if nonzero, are stored in location K. If only one response key is depressed, the allowable values of the keyport are 1, 2, 4, 8, 16, 32, or 64. This value is determined by successively halving K until K < 1, incrementing the variable KEY on each pass. In case of a double strike, only the highest valued line activated is retained. Line 35 creates branches to subroutines which service each response alternative.

This design has two drawbacks: (1) N output lines are needed for a system with N response alternatives, making for unwieldy connectors and cables, and (2) the decoding subroutine takes a relatively long time to execute (up to seven passes of a GO TO loop), which might produce a noticeable delay in subsequent stimulus presentation. This delay might be unacceptable in an interactive system which must respond rapidly to a subject's inputs. Another disadvantage is that the execution time varies depending on which response key is depressed.

These problems can be eliminated by encoding each key before transmitting its signal to the computer. We have designed a circuit which puts out a 3-bit binary representation of any of seven depressed push buttons. Encoding

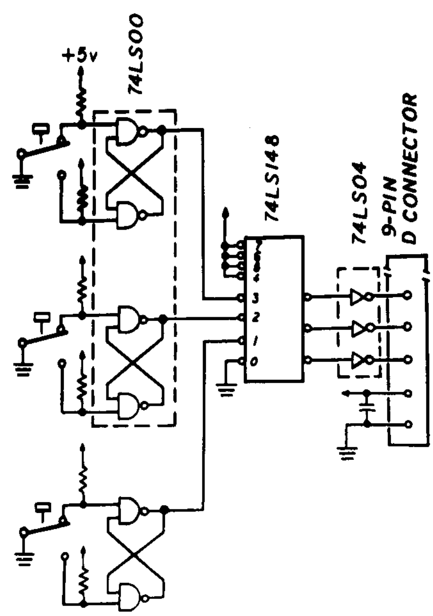

Figure 1. Encoding multiple response circuit. Arrowheads denote 5 V. Subject response keys shown on left. Only three are shown to indicate details of debouncing circuit. A maximum of seven keys may be used with the circuit shown. IC chip 74LS148 at center is priority encoder. Note inverting inputs and outputs. Input 0 is grounded to produce a "0" output when no push button is depressed. Unused inputs, if any, are tied to 5 V (Pins 4-7 in the figure). Encoded outputs are inverted (74LS04) before being sent to the connector. Power is taken from the computer power supply (bottom right). All resistors are 4.7K, .25W; the noise-limiting capacitor is 22μF tantalum.

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the response keys simplifies subsequent software and makes response-contingent stimulus control more efficient.

Our circuit uses an inexpensive TTL 74LS148 priority encoder that encodes up to eight inputs into a 3-bit binary output (Horowitz & Hill, 1980, p. 337). The output is a binary representation of the activated input line (0-7). If more than one line is activated, the output corresponds to the highest numbered input. Thus, double strikes are handled automatically without additional software or hardware.

The circuit is depicted in Figure 1. The encoder chip accommodates up to seven response keys, but only three are shown for illustration. Each push button is debounced in a conventional way, using a pair of TTL NAND gates configured as a flip-flop (Horowitz & Hill, p. 342). An inexpensive 14-pin IC (74LS00) contains four NAND gates, enough to debounce two push buttons. Note that a key press sets the flip-flop to zero, because the priority encoder chip inverts all inputs. For the same reason, unused inputs, if any, must be tied to 5 V, as are Pins 4-7 in Figure 1. Likewise, the encoder's output lines are inverted, making it necessary to reinvert them before input to the computer input port. This is done with a 74LS04 chip, which contains six inverters, only three of which are used in the present application.

The circuit is powered by 5 V taken from the computer power supply (lower right of Figure 1). To prevent noise pickup by the connecting cable, which might produce spurious key-press signals, a 22μF tantalum capacitor is connected across the power input lines.

The logic signal from each key drives the encoder inputs 1-7. Input 0 is wired low (as if permanently activated) so that the output signal is "0" with no key depressed.[1] This design reduces the software interrogation of responses to the following:

```
5 KEY=0
10 KEY=PEEK(KEYPORT)
15 IF KEY=0 THEN 10
20 ON KEY GOTO 100,200,300,400,500,600,700
```

Because tactile response feedback is important, we use a SPDT push button with a click detent when the key is fully depressed (Radio Shack #275-1549; current price about $2.25). The response unit is connected to the computer by an Atari joystick 6-ft extension cable (less than $5). Compatible DB-type connectors can be obtained from Radio Shack.

Circuit elements are wired on a small piece of perfboard and mounted in a plastic electronic enclosure kit measuring 2 × 3 × 6 in. This size provides enough room for spacing the keys to minimize misstrikes. Excluding the push buttons, the total cost of electronic components was less than $5.

We have used the circuit described here with a five-alternative configuration, in association with an automated perimeter device controlled by an Apple IIe microcomputer. A light flash is presented at one of four locations in the visual field; the subject responds by pressing one of four keys corresponding to the location of the perceived flash. A fifth response alternative is used as a start key. On detecting a given key press, the program determines whether the response was correct or incorrect and modifies the intensity of the corresponding target. Thus, four up-down tracking sequences are maintained simultaneously.

REFERENCES

Horowitz, P., & Hill, W. (1980). *The art of electronics*. Cambridge: Cambridge University Press.

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NOTES

1. If encoder input Pin 0 were to be wired to an 8th push button, use of the decoder chips' output strobe would be required to detect the occurrence of a key press. This would require an extra input line to the computer and would make the program more complex because it would have to detect a strobe signal prior to reading the encoder output.

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