INSTRUMENTATION & TECHNIQUES

An integrated circuit shock scrambler

JOHN GRAEFE and RICHARD PISACRETA
Adelphi University, Garden City, Long Island, New York 11530

The construction of an inexpensive shock scrambler is described. The device uses integrated circuitry to drive switching transistors which, in turn, operate mercury relays. These relays are used to switch high voltage to the shock grids in a standard experimental chamber. The frequency at which shock can be scrambled across the grids can be varied.

The shock scrambler described here is silent and not subject to mechanical wear. Cost of the unit is less than \$50 (excluding power supplies) and the device has the unique feature of allowing the user to vary the frequency at which the shock grids alternate voltage polarity. Construction time is about 15 h. The first model of this scrambler built has been used for over 1,500 h without failure.

The scrambler uses integrated circuit chips to perform sequential switching of up to 16 shock grids. Integrated circuitry is interfaced via switching transistors to operate mercury relays which perform the actual switching of high voltage to shock grids. In addition to these relays, a double-pole double-throw relay is used to switch high voltage from the shock source to the mercury relays

when the shock contingency is programmed to be in effect.

All solid state components are housed in a steel box to insure isolation from any radio frequency interference that might be present when using this device in conjunction with electromechanical equipment.

The integrated circuit chips necessary for the unit can be purchased for less than \$5 from Poly Paks.¹ The switching transistors are available at electronics supply stores for less than \$1 each. The mercury relays (HGS 1059 or equivalent) can be ordered from Hanifin Electronics Corp.²

CIRCUIT OPERATION

Figure 1 illustrates the circuit diagram. When a Logic 0 (ground) condition is present at the clear pin of the flip-flop (SN 7476N), the RS 555 timer/multivibrator and the 4-bit binary counter (SN 7493N) remain in a reset state. When Logic 0 is switched to the preset pin of

Figure 1. Schematic diagram of the components used in the shock scrambler.

the flip-flop, the RS 555 is enabled by the presence of Logic 1 on its Pin 4 from the Q output of the flip-flop. Simultaneously, Logic 0 from the $\bar{Q}$ output of the flip-flop enables the 4-bit binary counter via its reset pins $R_o(1)$ and $R_o(2)$. The RS 555 now drives the binary counter via Pin 3 to input A. Each pulse from the RS 555 advances the binary counter one count. The 4-bit binary counter can perform a count of 16 (0-15 inclusive). The four outputs of the binary counter (Pins A-D) are decoded by a 4-L to 16-line multiplexer/decoder (SN 74154N) into 16 sequential outputs (Pins 0-15). Each of the 16 outputs drives the base of an NPN transistor (2N699) through a 1-kohm $\frac{1}{4}$ -W resistor. The emitter of each transistor is connected to ground. Ground is defined as the negative of both the 5- and 28-V power supplies.

The collector of each transistor is connected to one side of the operate of a mercury relay (HGS 1059 or equivalent). The other side of the operate is connected to +28 V. A diode is used to suppress the relay coil. Only the first and last transistor-relay circuit is shown in Figure 1. The mercury relay is a single-pole double-throw relay which has an operate time as fast as 1 msec.

Each grid of the experimental chamber is connected to the common of a mercury relay. Each of the two outputs of either a dc or ac shock source generator is connected to all of the normally closed and normally open contacts of the mercury relays, respectively, when the double-pole double-throw relay is operated. (The DPDT relay is not shown in Figure 1.) Thus, each grid will have the same polarity as any other, except the one being switched by the mercury relay. In order to minimize start latency, the scrambler is allowed to operate continuously. Introduction of shock to the experimental chamber is controlled by the double-pole double-throw relay.

Table 1
Parts List

1	RS 555 timer
1	SN 7476N dual J-K flip-flop with preset and clear
1	SN 7493N 4-bit binary counter
1	SN 74154N 4-L to 16-line multiplexer/decoder
1	LED
17	1-kohm $\frac{1}{4}$ -W resistors
16	2N699 transistors
16	Claire mercury relays (HGS 1059 or equivalent)
18	Diodes
1	1-megohm 2-W potentiometer
4	1-microF ceramic or electrolytic capacitors (Three used for decoupling of chips)
1	.01-microF ceramic capacitor
1	SPDT toggle switch
1	DPDT relay

The RS 555 is set up with a 1-megohm potentiometer so that the frequency with which any one shock grid changes voltage polarity can be varied. With the values shown in Figure 1, the frequency has a range from less than once/sec to greater than 80 times/sec. For a rat in contact with any two shock surfaces, the duty cycle ranges from less than two shocks/sec to greater than 160 shocks/sec.

Table 1 lists the parts.

NOTES

1. Poly Paks, P. O. Box 942, South Lynnfield, Massachusetts 01940.
2. Hanifin Electronics Corporation, Fourth and Coates Streets, Bridgeport, Pennsylvania 19405.

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