exposure to inescapable shock. Psychological Reports, 1956a, 2, 43-49.
DINSMOOR, J. A., & CAMPBELL, S. L. Level of current and time between sessions as factors in "adaptation" to shock. Psychological Reports, 1956b, 2, 441-444.

FOWLER, H., & TRAPOLD, M. A. Escape performance as a function of delay of reinforcement. Journal of Experimental Psychology, 1962, 63, 464-467.
McDONALD, S. G., PORTER, J. J., & MADISON, H. L. Changes following asymptotic instrumental performance as a

function of shifts in drive. Psychonomic Science, 1970, 19, 33-34.
TRAPOLD, M. A., & FOWLER, H. Instrumental escape performance as a function of the intensity of noxious stimulation. Journal of Experimental Psychology, 1960, 60, 323-326.

Voltage sensing with a unijunction transistor*

BARRY GLASGOW

University of Minnesota, Minneapolis, Minnesota 55455

A voltage-sensing device with very little hysteresis and variable threshold voltage setting is described. Application of the device as a voltage-sensitive variable-duration monostable multivibrator in recording rabbit nictitating membrane conditioning is also discussed.

The device pictured in Fig. 1 is a general-purpose voltage-sensing comparator that closes a relay when the input voltage exceeds a predetermined level (G.E. Transistor Manual, 1964). The duration of the relay closure is variable, from less than 10 msec to greater than 10 sec, depending upon the component values selected.

In Fig. 1, Section 1 is the voltage-sensing segment of the circuit and Section 2 is the relay driver. The voltage-sensing function of Section 1 is based upon the operating characteristics of Q_1 , a unijunction transistor. The circuit is basically a relaxation oscillator which puts out a spike waveform at B_1 whenever the voltage at the emitter (E) of Q_1 exceeds the threshold voltage of the transistor. When this occurs, C_1 discharges through D_2 the transistor, and R_1 resulting in an elevated voltage across R_1 , having a fast rise time and a slow fall time. Immediately after Capacitor C_1 discharges, it starts recharging toward the transistor threshold voltage. For the device depicted, this spike is used to trigger an SCR which operates a relay.

The voltage divider string, R_2 , R_3 , R_4 , sets the level of voltage at the emitter of Q_1 . This voltage is set to a value below the threshold value of the transistor, such that a small additional positive voltage at the input is required to raise the voltage at the emitter of Q_1 above its threshold voltage. The difference between the threshold voltage and the preset voltage from R_2 , R_3 , R_4 determines the magnitude of voltage that will trigger the device. The preset voltage can be set to detect input voltages as small as 10 mV. The

hysteresis is usually less than 5 mV. Diodes D_1 and D_2 , besides providing a discharge path for C_1 , also protect the input transistor from overload voltages far in excess of the triggering voltage. If a precision potentiometer is used for R_3 , a high degree of sensing resolution can be achieved. It should be noted that so long as the voltage at the emitter of Q_1 exceeds the threshold voltage, the transistor will continue to put out a series of spike pulses capable of driving a series of flip-flops or triggering an SCR.

The relay driver shown in Section 2 is composed of two SCRs and a unijunction transistor (Q_2). When SCR_1 is on, its anode is near ground potential, so that Q_2 is inoperative. When the input triggers

the sensing circuit of Section 1, SCR_1 is driven into conduction, shutting off SCR_2 by discharging the commutating capacitor, C_5 . As SCR_1 turns off, its anode voltage rises toward the positive supply voltage, enabling Q_2 to act as a relaxation oscillator, similar in operation to Q_1 . When the voltage on C_5 reaches the threshold voltage of Q_2 , it puts out a spike across R_{10} , driving SCR_2 back into conduction. This action discharges C_5 and shuts off SCR_1 . By adjusting R_8 , one can control the duration for which SCR_1 and the relay are on.

The circuit in Fig. 1 includes a simple floating power supply with Zener diode regulation. This particular power supply configuration affords complete freedom of choice in connecting the signal source, since there are no common grounds.

The device described above has been used in the laboratory to sense the output voltage of a Brush oscillograph which was coupled to a rabbit nictitating membrane through a minitorque potentiometer. A response was defined as a 50-mV increase in the output voltage of the oscillograph. Accordingly the voltage sensor was set to trigger when the voltage at the sensor input exceeded 50 mV. To avoid false triggering during the

Fig. 1. A voltage-sensitive monostable multivibrator. Section 1 performs the voltage sensing and Section 2 is the multivibrator.

*The construction of this device was supported by funds from Grant MH 18053 to Dr. M. A. Trapold.

Table 1
Parts Price List Derived from the 1971 Allied Electronics Catalogue

Components		Unit Price
R1, R2, R4, R5, R6, R7, R9, R10, R11, R13 (IRC)		\$.07
R3	(Amphenol 10 turn potentiometer)	5.95
R8	(Ohmite)	2.25
R12	(Ohmite)	.66
C1		.78
C2, C3		.34
C4, C7		.60
C5		1.91
C6		.45
C8		1.30
D1, D2		.87
D3, D4		.46
D5		3.96
Q1		3.62
Q2		1.20
SCR1, SCR2		.94
T1		4.52
K1	(Magnecraft reed relay SPDT)	6.83
		\$40.55
(Incidental costs, i.e., chassis box, circuit board, etc.)		10.00
		\$50.55

intertrial interval, the output of the amplifier was gated through a relay which connected it to the voltage sensor at the start of each trial and disconnected it at UCS onset. The output relay of the sensing device was used to increment a counter when the device sensed a response and triggered the relay on. The same relay was used to record the latency of the response by gating the output of a pulse stream generator connected to a printout counter. At the onset of the CS, the pulse stream generator initiated a series of pulses of a known frequency. If a response occurred before onset of the UCS, the relay disconnected the pulse generator from the print counter. The number of pulses recorded by the printout counter provided the duration between CS onset and response initiation.

A parts list for the unit is provided in Table 1.

REFERENCE

G.E. *Transistor manual*. (7th ed.) Syracuse: General Electric Co., 1964. Pp. 324-325.