INSTRUMENTATION & TECHNIQUES

A balance panel, amplifier, and trigger device for nictitating membrane transducers

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Description and circuit are provided for a balance panel, amplifier, and trigger device for nictitating membrane devices.

In several articles, transduction devices have been described for the monitoring of the nictitating membrane response of rabbits (Gormezano, 1966; Van Dercar, Swadlow, Elster, & Schneiderman, 1969; Yehle, 1968). The commercially available equipment for processing the signals from these response transducers is, by and large, expensive and limited in flexibility. The current availability of inexpensive and hardy internally compensated integrated circuit operational amplifiers offer us an attractive alternative, particularly when a standard polygraph is not being used.

In our laboratory we have utilized such devices, replacing commercial equipment. We have found them to be simple, reliable, inexpensive, and flexible. Internal compensation has greatly simplified circuits by eliminating external phase compensation problems. Reliability has been increased by increased tolerances for input signals, and by integral short circuit protection. The flexibility of the circuit shown in Fig. 1 is improved over that of the commercially available equipment because the amplified transducer output, a binary signal

related to the response, and a high power, response dependent, trigger are available simultaneously.

This instrument has two basic functions: (1) to amplify the transducer signal and (2) to automatically detect response signals. The automatic response detection allows the E to eliminate observer judgment variability, control digital programming equipment, and to use the nictitating membrane response in an instrumental learning situation. It should be noted that although this device was designed to operate on the transduced output of the nictitating membrane response, it is not necessarily limited to that situation.

APPARATUS

Stage 1

The input to Stage 1 is to the transducer output signal, and the output is V_a . Its functions are to amplify the signal from the transducer, and to provide dc offset, or bucking current, to cancel unwanted dc voltage from the transducer. The gain of the amplifier is continuously variable from 1 ($R_2 = 0$ ohms) to about 50 ($R_2 = 50$ K ohms). The zero adjustment variable resistor (R_3) compensates for the dc offset from the transducer, individual variations between transducers, and nictitating membrane resting position variations between animals and trials.

The circuit shown in Fig. 1 shows the photocell transducer used in our laboratory. If the response

Fig. 1. Schematic device of balance pattern, amplifier, and trigger device.

Table 1
Parts List

PC	Electroresistive photopic transducer Waltke Scientific Instruments
IC 1,2	μ A 741 internally compensated operational amplifier
IC 3	FCD 810, Fairchild
SCR	HEP 300, Motorola
SW	SPST, spring loaded, normally closed
M	+15 V dc to -15 V dc
All resistors are $\frac{1}{2}$ watt, 10%	

produces a decrease in photocell resistance, the input produces a positive voltage deflection at V_a . If the response produces an increase in photocell resistance, the photocell is connected to -15 V, and R_3 is connected to +15 V in order to produce a positive voltage deflection at V_a .

The meter, M, is not essential, but is convenient for setting the zero adjustment in cases in which the transducer output is not monitored between trials. If the transducer is a variable resistor rather than a photocell (as is the case in some types of head mounts), the input configuration need not be changed. If transduction is accomplished by some other means, e.g., a strain gauge, minor modification of the input stage may be required. If very high input impedance is required, a μ A740 FET input operational amplifier may be substituted directly for the μ A 741, thus increasing the maximum input impedance to about 10^{11} ohms.

Stage 2

Stage 2 functions as a comparator with an output at V_b . If the signal voltage at the noninverting input (+) of the operational amplifier is more negative than the reference voltage at the inverting input (-), the output will approach -15 V. If the signal voltage is more positive than the reference voltage, the output will approach +V. The reference voltage, or trigger level, is set with R_6 so that in the absence of a response the output, V_b , is negative. When a response is made, the noninverting input voltage goes more positive; when it becomes more positive than the reference voltage, the voltage at V_b switches from -15 V to +15 V and then back to -15 V after the response. The response strength required to cause switching is dependent on the reference voltage set by R_6 . The adjustment of the trigger level is facilitated if R_6 is a multiturn potentiometer.

Stage 1 is coupled to Stage 2 through a capacitor, C, so that the response movement, not absolute position, will provide the comparator input signal. Therefore, when a nictitating membrane response is made, the movement per se produces the comparator input signal. It should be noted that Capacitor C and the total resistance, R_t , of the parallel resistances of R_4 and the input resistance to IC-2 (1 Mohm) form a highpass RC filter. This feature may be utilized to differentiate between fast and slow responses. The specific trigger

point depends on the gainsetting of the amplifier, the comparator reference voltage, E_r , and the R_tC product: $dV/dt = E_r/R_tC$. With the values shown in Fig. 1 and an E of +0.1 V dc, the device will be triggered by any response which produces a dV/dt of more than +2 V/sec. If desired, information regarding the absolute position of the nictitating membrane can be made to influence the comparator "decision" by simply shorting across C.

Stage 3

The function of the third stage is to provide for switching of high power. The silicon controlled rectifier (SCR) will function as an open switch until a response triggers Stage 2, at which time the SCR will turn on, acting as a closed switch applying power to the load. The SCR will remain on until it is reset by interrupting the circuit by opening Switch SW in the anode circuit. Resetting can be done manually or with programming equipment.

The isolation of Stage 3 from Stages 1 and 2 is accomplished by photon coupling. The advantages of such isolation are: (1) the voltages of the first two stages and the final power stage may be allowed to float with respect to one another, (2) any voltages within the limits of the SCR may be controlled, and (3) undesirable feedback from Stage 3 to Stage 2 is prevented. The output of the comparator is fed through a current limiting resistor, R_8 , to a light emitting diode (LED) inside IC-3. When the comparator is in the low state, no light is emitted from the LED; but when the comparator is in the high state, current through the LED causes it to emit light. This light activates a phototransistor in IC-3 which, in turn, applies trigger voltage to the gate of the SCR.

GENERAL

Stages 1 and 2 require both positive and negative voltage sources. The voltage maximum is ± 18 V dc, but the circuit will operate on less than ± 10 V dc. The current drain is small enough that lantern batteries may be used, but regulated power supplies are desirable. Stage 3 power requirements are determined by the dc load and the rating of the SCR used, and are independent of Stage 1 and 2 requirements. IC-3 will isolate Stage 3 from Stages 1 and 2 up to 750 V. Isolation of up to 1500 V can be accomplished by using an FCD 820 for IC-3.

OPERATION

The nictitating membrane response topography is somewhat variable, as is typically the case with the topography of any biological response. The definition of a CR is arbitrarily defined as a movement of given amplitude occurring within a certain period of time and at a given rate. Once the definition is determined, the trigger circuit can be adjusted to that criterion by setting gain, E_r and R_tC appropriately. The nictitating membrane is normally quite steady between responses so

that the signal/noise ratio of the response system is quite high. When the transducer is properly attached to the nictitating membrane, signals are not generated by movement of either the eyeball or the eyelid. Indeed, we have collected data independently measuring eyelid and nictitating membrane responses which indicate that eyelid closures alone do not produce responses in the nictitating membrane response channel. Multiple CRs do not occur frequently, but when they do occur, the device is triggered by the first CR; the second CR is ignored because the SCR has already been fired by the first CR. Thus, multiple responses are not a problem.

CR latency measurement can be facilitated by capacitively coupling V_b to V_a through a simple resistive summing network to the oscilloscope. In such a display,

a positive "spike" indicates the point at which the CR criterion has been met and the latency can be read directly from the oscilloscope screen.

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