A SIMPLE ELECTRONIC TIMER FOR ANIMAL-BAITED INTERMITTENT SUCTION INSECT TRAPS

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ABSTRACT. A versatile integrated circuit timer for intermittent suction, animal-baited insect traps is described. Various attributes of this circuit include continuously and independently variable on and off periods, extremely low power consumption, accurate timing range from microseconds through hours, operation on 5–17 VDC, and miniaturization.

INTRODUCTION

The development of the intermittent suction animal-baited trap by Lumsden (1957, 1958) provided a useful, highly effective method for trapping insects that are attracted to a specific host. These traps have a fan that collects flying insects attracted by a bait animal, and deposits them in a holding cage. The fan operates with a continuous duty cycle, turning on for relatively short periods separated by longer off periods. Several variations of this trap have been used (Mintner 1961, Corbet and Ssenyubuge 1962, De Kruijf 1970, Service 1971, Tikasingh and Davies 1972, Davies 1973, Walters and Lavoipierre, pers. com.). Considering the kind of data that can be gathered with these traps, they have been used infrequently (Service 1976). Some reasons for this are these traps require a large power source, the various complicated trap mechanisms are not commercially available and must be adapted from other devices or fabricated *de novo,* the large physical size and a potentially high failure rate in the field.

A necessary mechanism required by this kind of trap is a timer that will turn the trap on and off with continuous, consistent and repeatable accuracy. The on and off periods regulated by the timer must be continuously variable and the adjustment of one period must not alter the other.

An ideal device for constructing timing mechanisms is the LM555 integrated circuit (IC) which in various configurations is used for sequence timing, precision timing, in pulse generators, square wave generators and in multivibrators. The LM555 is capable of timing periods from microseconds through hours, operating at voltages from 4.5 to 17 volts DC, and consumes only 3.5 milliamps at 6 volts DC. It is available in a number of packages, with the 8 pin dual-in-line package (DIP) being most common. A related device is the LM556 which contains 2 LM555 timers in a single 14 pin DIP. Both of these ICs are inexpensive (costing approximately $.50) and readily available at electrical parts houses.

TIMER DESCRIPTION

The timer circuit we used to control baited suction traps (Davies 1973) is shown in Fig. 1. Two LM555 timer ICs in monostable or "one-shot" configurations determine the on and off times for the fan; IC1 controls the on time while IC2 controls the off time. A monostable is a circuit that has one stable and one astable output voltage. The output remains at the stable voltage until the circuit is externally switched (triggered) to the astable voltage. The output remains at the astable voltage for a period after which the circuit automatically returns to the stable output voltage.

The timing period (astable period) for each LM555 IC is controlled by a resistor-capacitor (RC) network; R1, R3, and C1 determine the on time for IC1 and R2, R6, and C2 perform the same function for IC2 (Fig. 1). The period for each timer can be determined by substituting the values of these resistances and capacitances in the following formula:

$$T = 1.1RC$$

where: T = time in seconds,
R = resistance in Ohms,
C = capacitance in Farads.

In Fig. 1, each variable resistor (R1 and R2) is paired in series with a fixed resistor (R3 and R6) to limit the range of resistance and to protect the ICs from being inadvertently shorted. The value R in the formula is the sum of the variable and fixed resistance. From the formula, the fan on period which is controlled by IC1 is adjustable from 0.3 to 110 sec and the fan off period which is controlled by IC2 is adjustable from 3 sec to 18 min. In practice the actual period may vary from the calculated value because of the relatively wide tolerances on large capacitors (20%) and resistors (5%). We adjusted the R1 variable resistor for a fan on period of 5 sec and R2 for a fan off period of 5 min. Using the formula we could have substituted fixed resistances of about 100K for R1 and R3 and about

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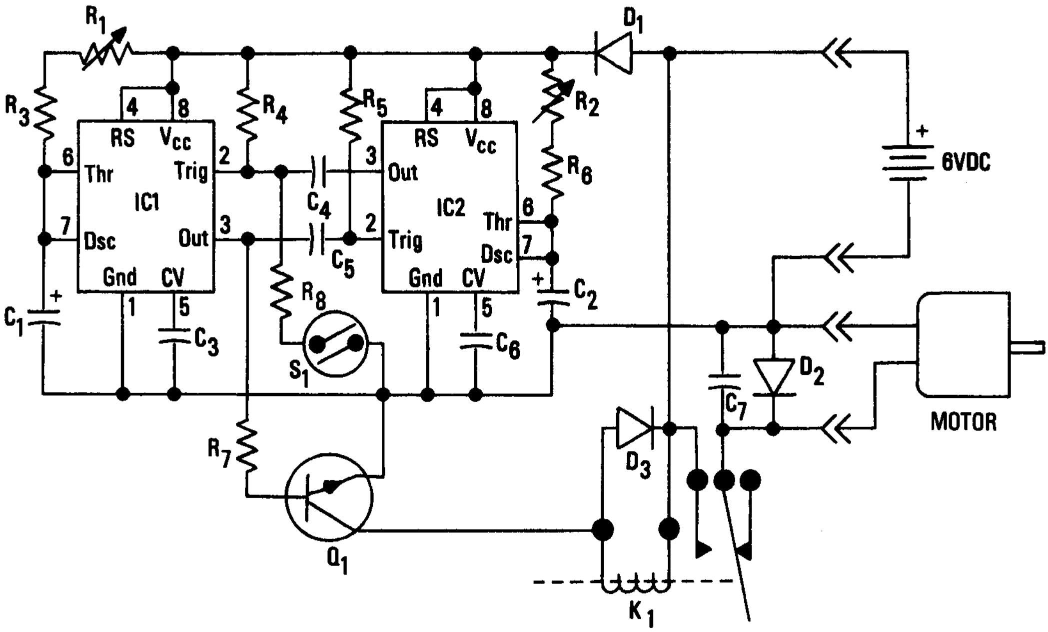

Fig. 1. Complete LM555CN timing circuit used to control Davies suction traps. Parts description and list: C1, 100 μf, 12WVDC electrolytic capacitor; C2, 1000 μf, 12WVDC electrolytic capacitor; C3, 4, 5, 6, 7, 0.01 μf ceramic capacitors; D1, 1N34A diode; D2, 3, 1N914 diodes; K1, 6VDC, SPDT, 2 amp, R50–E2–Y1–6V relay, (Potter & Brumfield) or equivalent; Q1, 2N2222A transistor; R1, R2, 1 Meg Potentiometer, Linear; R3, 4, 5, 6, 2.7k ¼ watt resistors; R7, 8, 4.7K ¼ watt resistors; S1, Reed switch. LM555 (1C1, 2) pin codes: 1 (Gnd) Ground, 2 (Trig) Trigger, 3 (Out) Output, 4 (RS) Reset, 5 (CV) Control voltage, 6 (Thr) Threshold, 7 (Dsc) Discharge, 8 (V_{cc}) Positive power supply. The motor used in the Davies traps was a 6 volt, Barber Colman Co. # BYQM–2184.

300K for R3 and R6, and then made some small empirical adjustments to achieve the exact desired periods.

In the following discussion, voltages are measured with respect to the negative terminal of the battery, which is also referred to as ground or the ground state. The supply voltage is the voltage at the positive terminal, in this case 6 volts, with respect to ground. As a matter of convenience, a LM555 is said to be on when the output pin (Out) shows the same voltage as the supply voltage (6 volts) and off when this pin is at the ground state (0 volts).

The LM555 integrated circuit has two pins for power and a number of pins for controlling inputs and outputs. The positive supply voltage from the battery must be applied to pin 8 (V_{cc}) and negative to pin 1 (Gnd). We do not use 2 of the inputs to the LM555: the reset input (RS) and the control voltage input (CV). RS is connected to V_{cc} to preclude accidental resetting and CV is connected to ground through a 0.01 μf capacitor to keep the circuit from oscillating.

To illustrate the functioning of this circuit we will follow various changes through a complete cycle, beginning just before IC1 turns on. The output of IC2 is at 6 volts, the output of IC1 is at 0 volts; the discharge pin (Dsc) of IC1 is at 0 volts, maintaining C1 in a discharged state. When IC2 turns off and its output pin goes to 0 volts the R4-C4 network presents a negative going pulse to the trigger input (Trig) of IC1. This event causes IC1 to turn on and raise the voltage at the Out pin to 6 volts. At the same time the Dsc pin (IC1) is isolated from ground and C1 begins to accept charge. As C1 accumulates charge, the amount of charge (proportional to the voltage across the capacitor) is monitored by the threshold input (Thr). When the voltage at the Thr pin reaches 2/3 of the supply voltage (4 volts), IC1 "turns off" by lowering the output voltage to 0 volts and grounding the Dsc pin which discharges C1. When the Out pin voltage of IC1 goes to 0 volts, the R5-C5 network presents a negative going pulse to the trigger of IC2 turning it on. The Dis and Thr pins of IC2 act the same way as in IC1, returning the circuit to the state where we began.

The transitor, Q1, acts as a switch to turn on the relay, K1. The transitor must be used because the LM555 IC is not capable of providing the current necessary to turn on the relay. When IC1 is off, Q1 is also "off" by not allowing any current between the relay (K1) and ground. When IC1 turns on, the increased current in R7 turns on Q1 which allows current through the relay to ground, turning on the relay. When the relay turns on, it switches power to the fan motor, turning it on.

Most ICs are destroyed when the DC power supply is reversed, for example, by reversing the connections to the batteries that supply power to the timer and trap. A germanium diode (D1) in series with the timing circuit eliminates this hazard (Fig. 1).

The magnetic reed switch, S1, permits manual triggering of IC1, which turns on the fan. This facilitates spot checking trap function in the field during the relatively long off periods.

DISCUSSION

Four of these timers were used with baited suction traps in a Panamanian lowland moist forest 24 hr a day for 5 wk, (3260 hours) with no failures. The 8 amp-hour gel-cell rechargable batteries (Eagle-Pritcher Corp.) used to power these traps were recharged every 7 days. During this 5-wk period, the accuracy of the timers was checked numerous times by measuring the on and off intervals with a stop watch. No change or drift in the duration of the on or off periods could be detected. Two years after this study was completed, during which time the timers were not used, the on and off periods were checked again and found to be unchanged. This suggests that the components used in this circuit including the large electrolytic capacitors in the R-C networks are very stable, at least in this application.

The largest power drain in our circuit is the relay. Since we designed our circuit, improved semiconductor technology has provided semiconductor devices which may be used to replace the relay. The use of such devices as Darlington pairs, FET power transistors, semiconductor relays or optoisolators may allow much longer battery life and smaller packaging.

Detailed descriptions of the LM555 IC are presented in Berlin (1976) and the National Semiconductor Linear Data Book (1982). These references should be consulted for details of the internal functions and other applications of this simple integrated circuit.

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