Experimenter's Corner

By Forrest M Mims

IC INTERVAL TIMERS

AN INTERVAL timer is a circuit that provides an output pulse of predetermined width at periodic intervals. This can be readily accomplished using any one of several timer ICs available to today's electronic experimenter. Many IC timers, such as the well-known 555, are not only capable of such astable operation but can also function as monostable multivibrators or "one-shots."

Figure 1 is a timing diagram comparing the operation of a monostable to that of an interval timer. Note that a one-shot timer is designed to activate an external device or circuit for or after a fixed period. An interval timer, on the other hand, provides uniform output pulses at an adjustable interval.

You are probably already familiar with numerous applications for conventional one-shot timers. Common examples include automatic switches that extinguish the headlights of a car a minute or so after the ignition is turned off, delayed-action intrusion alarms, switch debouncers, kitchen and darkroom timers, etc.

Although the applications for interval timers are not as numerous, they include two that are particularly interesting: time-lapse photography and time-lapse sound recordings.

You have probably seen many examples of time-lapse photography—the opening of a flower, formation of clouds, construction of a building, etc. Time-lapse sound recordings can store periodic samples of data encoded as an audio tone as well as simply capture ambient sounds. In the latter category, an interesting possibility is to compress a 24-hour history of the sounds at a busy street corner into a one-minute recording. Another is entertaining your family or friends at a party by sampling brief segments of a record, radio program or conversation and playing back the string of sound "snapshots."

Of course, time-lapse photography and sound recordings are not the only applications for interval timers. Before you've finished reading this column, you will probably have thought of several more.

Basic 555 One-Shot. Although most experimenters have assembled either breadboard or permanent circuits that use a 555 timer, many do not fully understand how this IC works. For those of you in this category, the following paragraphs will provide a quick overview of the monostable operation of the 555. If you're already familiar with 555 basics, you can skip ahead to the next section.

Figure 2 is a simplified block diagram of a 555 connected as a monostable or one-shot timer. The key sections of the 555 are the two comparators, *VC1* and *VC2*. They sense when the timing capacitor (*C1*) has charged or discharged to a predetermined level.

To understand how the 555 works, assume the circuit in Figure 2 is "off." This means the control flip-flop is reset and *Q1* is on. Capacitor *C1* is therefore short circuited by *Q1* and cannot charge. The output of the circuit (pin 3) is low. A negative pulse applied to the TRIGGER input (pin 2) momentarily causes the output of comparator *VC2* to go high, setting the control flip-flop. This cuts off *Q1*, which allows *C1* to charge exponentially at a rate determined by the values of *C1* and *R1*. During this period, the output at pin 3 is high.

Notice the three series-connected 5000-ohm resistors in the 555. These resistors form a voltage divider that biases the noninverting input of comparator *VC2* at one-third of the supply voltage and that of comparator *VC1* at two-thirds of the supply voltage. When the voltage across *C1* reaches two-thirds of the supply voltage, the output of comparator *VC1* goes high and resets the control flip-flop. This turns *Q1* on and shorts out *C1*. The output at pin 3 returns to ground and remains there until the entire timing cycle is repeated. This is

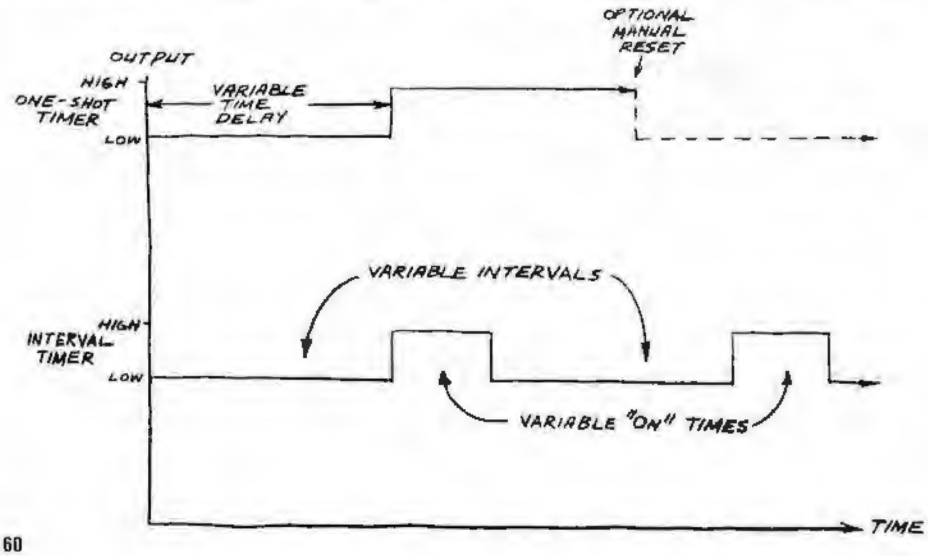


Fig. 1. Timing diagrams of the output waveforms generated by monostable multivibrator or one-shot (top) and interval timer (bottom).

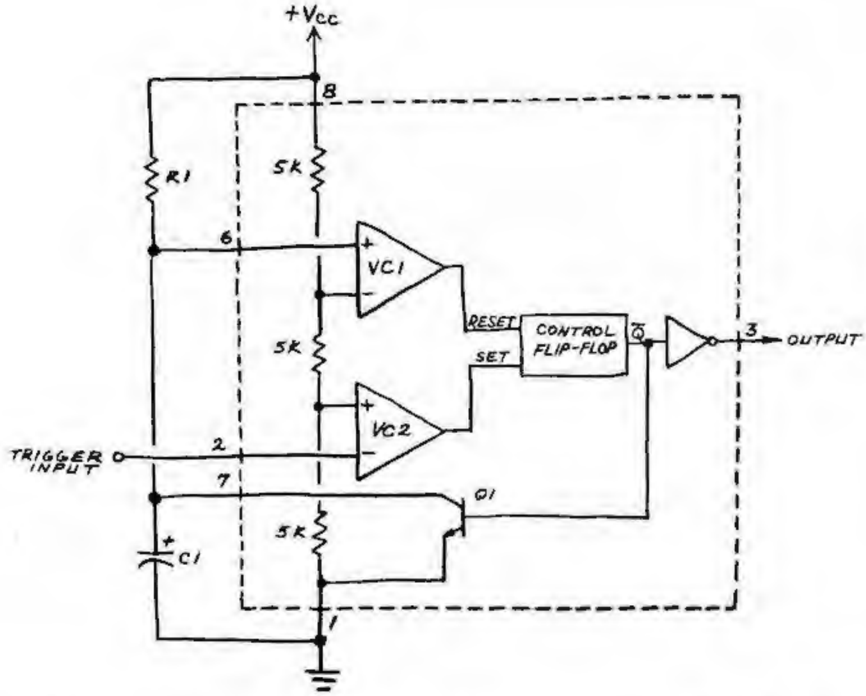


Fig. 2. Simplified functional diagram displays inner workings of a 555 timer IC. External components R1 and C1 control timer's period.

accomplished by applying a new trigger pulse at pin 2.

This explanation should give you some insight into the operation of the 555 in its monostable mode. It should now be obvious that you can easily select the time delay by the proper choice of components for *R1* and *C1*. If long delays (more than several minutes) are to be obtained, it's important to use a component with extremely low leakage for *C1*. Otherwise, the capacitor will never be able to charge as it should and the circuit will not function properly.

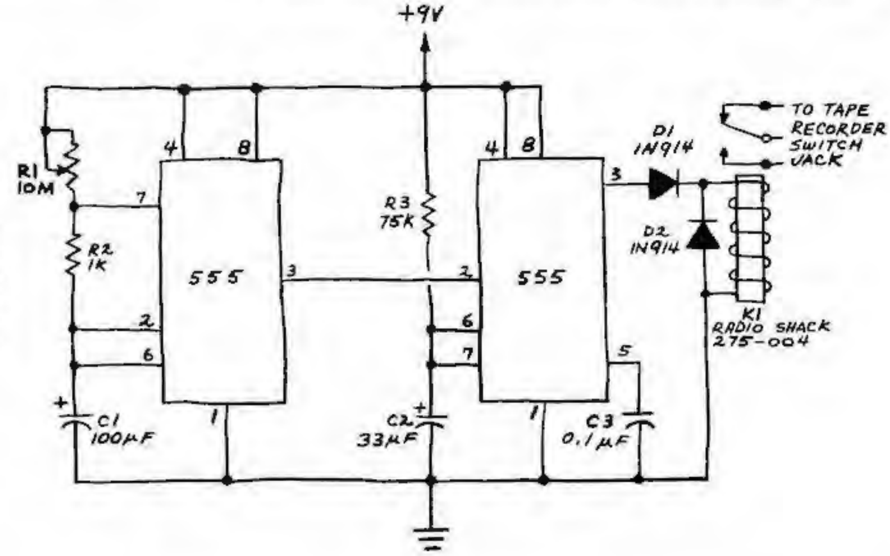
555 Interval Timer. A 555 monostable can function only as a single-delay timer. A reset pulse is required to initiate a new delay period. An interval timer, however, can be made by connecting the output of a 555 operated as a free-running (astable) oscillator to the TRIGGER input of a 555 monostable. The period of oscillation of the astable will determine the interval time. The *RC* time constant of the monostable will determine the duration of the output pulse that follows each timing interval.

Figure 3 shows the schematic of a working dual-555 interval timer. Interval times (determined by the values of *R1* and *C1*) of up to several minutes are achievable with the values shown. Note that the output pulse from the first 555 is directly coupled into the input of the 555 monostable. The output of the monostable is connected to a low-voltage relay coil through *D1*. Diode *D2* shorts out the powerful inductive kick produced across the relay coil when current to it is interrupted, thereby protecting the 555's output stage from damage.

The values of *R3* and *C2* determine how long the relay is energized after each timing interval. Those specified keep the relay energized for almost exactly 5 seconds (4.98 seconds for the breadboard circuit I built). Change the value of *R3* or *C2* or both to obtain different times.

The relay contacts can be used to switch many different circuits or devices on or off. Figure 3, for example, shows the normally-off contacts connected to the switch jack of a tape recorder. This jack is commonly found adjacent to the microphone jack on many cassette recorders. It allows the recorder

Fig. 3. Interval timer employs one 555 as an astable multivibrator to trigger a second IC operating as a monostable. Relay K1 keys external circuit.



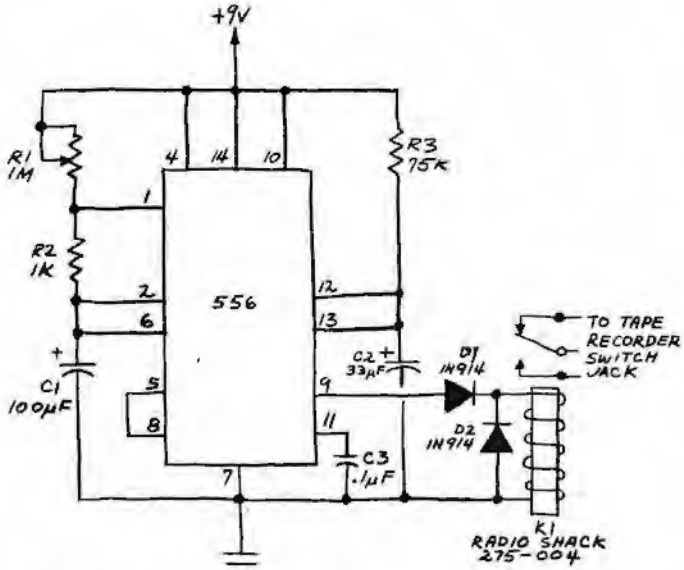


Fig. 4. This circuit, which employs a 556 dual timer, is functionally identical to the one shown in Fig. 3.

to be turned on and off remotely by means of a small switch such as one mounted on the case of the microphone.

If you want to connect the relay to a tape recorder, use an appropriate plug. You'll have to improvise when connecting the relay contacts to other equipment or circuits. (A few words of caution—*never* connect the relay to a circuit that exceeds the maximum ratings for the relay's contacts. Also, *never* switch ac line power with an unenclosed relay. Personally, I prefer to play it safe with low-voltage applications only.)

556 Interval Timer. The 556 is a pair of 555 timers on a single silicon chip. The circuit in Figure 3, as you might suspect, can be readily assembled with a single 556 dual timer rather than separate 555's. Figure 4 shows the functionally identical circuit.

XR-2240/555 Long-Duration Timer. Because of leakage in the timing capacitor, the maximum period of a 555 operated as an astable oscillator is usually limited to several minutes. The XR-2240 (or XR-2340) is a specialized IC timer that incorporates a self-contained flip-flop divider chain to increase the length of the fundamental time delay by a factor of up to 255. Because the output of each flip-flop in the chain is directly accessible, many different time intervals can be selected without having to alter the values of the circuit's timing capacitor and resistor.

Figure 5 is the schematic of a long-duration, programmable interval timer made from an XR-2240 connected as an astable oscillator and a 555 operated as a monostable. Timing components *R1* and *C1* control the oscillation rate of the XR-2240. The values shown give an adjustable interval *T* of up to about 100 seconds. The outputs at pins 1 through 8 allow you to select multiples of *T* ranging from 1 to 128. Therefore, selecting pin 8 will give you a time delay of up to 128 × 100 seconds or more than 200 minutes!

The selected output of the XR-2240 is inverted by *Q1* and coupled through *C4* to the 555 monostable, a circuit essentially identical to the monostable in Figure 3. The timing period of the monostable is controlled by the time constant *R6 C5*.

The XR-2240/555 interval timer is far more versatile than the dual 555 or 556 version because intervals of several hours can easily be obtained. Calibrating the circuit, however, can pose problems if you attempt to perform the operation when output pin 8 is selected. Calibration is much easier if you select output pin 1. If, for example, you want a timing interval of one hour (3600 seconds), adjust *R1* until the interval at pin 1 is 28.13 seconds. Pin 8 will then output a pulse at 128 × 28.13 seconds or every 3600 seconds.

Incidentally, it's possible to select various combinations of XR-2240 outputs to achieve any time interval of from *T* to *255T* when the chip is operated in its triggered, monostable mode. However, this procedure does not give the desired results when the astable mode is used.

It might be possible to obtain the full versatility of the XR-2240 by operating the chip in its one-shot mode and triggering it externally. The XR-2240 would continue to trigger the 555 one-shot to provide the brief "on" time after each interval. The time delay would be selected by shorting combinations of outputs to a common bus. The delay would be the sum of the delays of the selected outputs. Thus, outputs *4T*, *8T* and *128T* will give a total delay of 4 + 8 + 128 or *140T*.

I'll leave the details to those readers who like challenges. See the XR-2240 data sheet for design tips. ◇

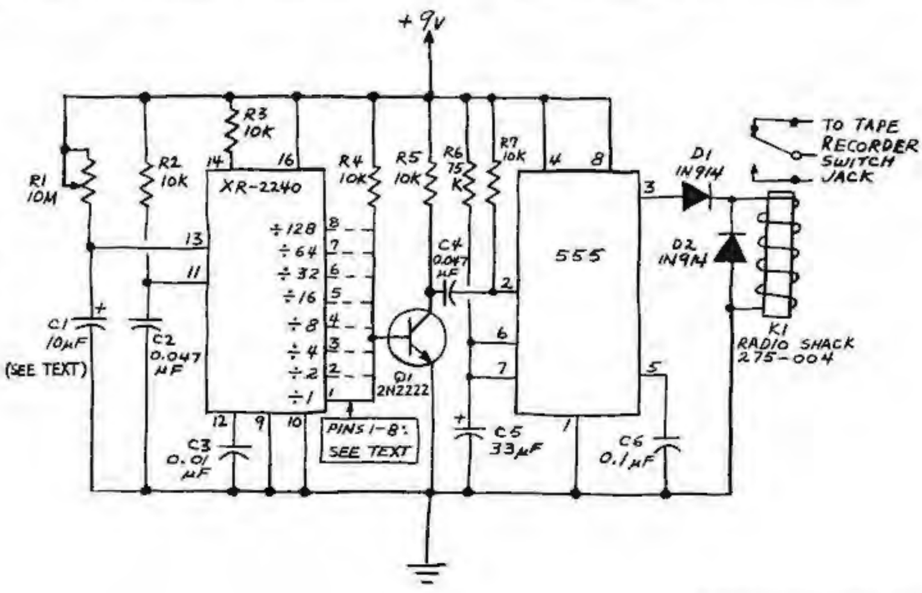


Fig. 5. Long-duration, programmable interval timer employs XR-2240 as an astable and 555 as a monostable. Relay K1 keys external circuit.