Put the IC timer to work in a myriad of ways

These versatile devices can be used in numerous applications ranging from simple timers to pulse-width modulators.

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The introduction of the first integrated circuit timer last year added a new dimension to the field of linear integrated circuits. Since then these versatile timing circuits have replaced both thermal relays and electromechanical devices in a variety of timing functions. Their popularity is such that they are now made by at least three manufacturers: Signetics, National Semiconductor and Texas Instruments.

The salient features which make the IC timers useful in a wide variety of applications include:
- One-shot operation from microseconds through minutes
- Typical one-shot temperature stability of 40 ppm
- Oscillator operation up to 300 kHz
- Push-pull output capable of sinking or sourcing up to 200 mA of current.

This article will describe the various modes of operation of the new timers and the types of applications for which they are suited.

Monostable operation

Probably the most popular timer mode is monostable (one-shot) operation. Fig. 1 shows a block diagram of the IC timer, in this case the Signetics NE/SE555, plus the external circuitry needed for monostable operation.

In operation, the external capacitor is initially held discharged by a transistor inside the timer. Upon application of a negative trigger pulse to pin 2, the flip-flop is set. This releases the short circuit across the external capacitor and drives the output HIGH. The voltage across the capacitor now increases exponentially with a time constant \( \tau = R_A C \). When the voltage across the capacitor equals 2/3 \( V_{CC} \), the comparator resets the flip-flop which, in turn, discharges the capacitor rapidly and drives the output to its LOW state.

![Diagram](image-url)
Once triggered, the circuit remains that way until the set time is elapsed, even if it is triggered again during this interval. Since both the charge rate and the threshold level of the comparator are directly proportional to supply voltage, the timing interval is independent of supply voltage. Applying a negative pulse simultaneously to the reset terminal (pin 4) and the trigger terminal (pin 2) during the timing cycle discharges the external capacitor and causes the cycle to start over again. The timing cycle will now commence on the positive edge of the reset pulse. During the time the reset pulse is applied, the output is driven to its LOW state. When the reset function is not in use, it is recommended that it be connected to \( V_{CC} \) to avoid any possibility of false triggering.

**Astable operation**

If the timer is connected as shown in Fig. 2 (pins 2 and 6 connected), it will trigger itself and operate as a free-running multivibrator. The external capacitor charges through \( R_A \) and \( R_B \) and discharges through \( R_B \) only. Thus, the duty cycle may be precisely set by the ratio of these two resistors.

In this mode of operation, the capacitor charges and discharges between \( \frac{1}{3} V_{CC} \) and \( \frac{2}{3} V_{CC} \). If the trigger input is held LOW and \( V_{CC} \) is increased, the output voltage will change gradually. It is recommended that the output voltage be increased only slightly in order to avoid the danger of improper triggering of the timer.

**Application hints**

As mentioned previously, triggering of the timer occurs on the negative-going edge of the trigger pulse. The threshold which must be attained for triggering is less than \( \frac{V_{CC}}{3} \). A significant problem arises, though, when the trigger terminal is held at ground potential. Although the output will switch to a ONE state and will normally time out as expected, erratic time intervals will result if the trigger terminal is held at ground for long periods relative to the required timing cycle.

**Waveforms for a divide-by-three circuit**

Fig. 5 shows how the circuit of Fig. 1 can be used for frequency division.
Fig. 6—When the 555 is used as a manually started timer, both a normally ON and normally OFF load can be controlled.

Another problem that can occur is that the trigger terminal may respond to positive-going transitions rather than negative ones when it is driven from a logic source. To avoid this, triggering should either be generated from the unit’s own timing capacitor, as in the oscillator mode, or ac coupled through a 0.01- to 0.001-μF capacitor, as shown in Fig. 3. A pull-up resistor of 10–30 kΩ should also be included from pin 2 to \( V_{CC} \).

Many uses of the timer involve the application of power to the device, i.e., a delay or a time-operating function is generated when \( V_{CC} \) is applied. The problem here is that reliable triggering must be guaranteed during the power application period. If, for instance, a slow-rising supply voltage is used, no trigger information may be produced. Also, application of power via a switch often produces spikes caused by contact bounce, and these will trigger the device most of the time. Therefore, the function desired may or may not take place.

The solution to these problems is shown in the circuit of Fig. 4. By tying the trigger to pin 6, the timing capacitance holds the trigger LOW while power is coming up. Triggering is then guaranteed, and timing occurs in the normal manner. However, \( V_{CC} \) must be removed from this circuit before retrigering can occur for the next cycle.

**Frequency divider**

If the input frequency is known, the timer can easily be used as a frequency divider by adjusting the length of the timing cycle. Fig. 5 shows the waveforms of the timer of Fig. 1 when used as a divide-by-three circuit. This application makes

Fig. 7—Test sequencing is possible by connecting a number of timers in tandem.

Fig. 8—For pulse width modulation the amplitude of a signal applied at pin 5 controls the pulse width of a pulse train applied to pin 2.
Fig. 9—In a tone-burst oscillator application, one timer is used as a slow astable multivibrator and a second as an audio-frequency oscillator.

use of the fact that the circuit cannot be retriggered during the timing cycle.

Manually started timer

Fig. 6 shows the NE555 connected as a manually started timer. The time can be set from 1 to 60 seconds either with a potentiometer or with a thumb-wheel switch and fixed resistors. Two loads, one normally ON, the other normally OFF,
can be connected to the circuit simultaneously. In this application, the circuit could power a relay, a lamp or a controlled rectifier.

**Test sequencer**

Test sequencing is another application for the IC timer. Fig. 7 shows several timers connected sequentially. The first timer is started, either with a pulse or by momentarily connecting terminal 2 to ground, and runs for 10 msec. At the end of its timing cycle, it triggers the second circuit, which runs for 50 msec; after this time the third circuit is triggered. It should be noted that the timing resistors could be digitally programmed in this application. Also each circuit could easily trigger several other timers to start similar concurrent sequences.

**Pulse-width modulator**

In this application, the timer is connected in the monostable mode as shown in Fig. 8a. The circuit is triggered with a continuous pulse train (clock input) while the threshold voltage is modulated by the signal applied to the control voltage terminal (pin 5). This has the effect of modulating the pulse width as the control voltage varies. Fig. 8b shows the actual waveforms generated with this circuit.

**Tone-burst oscillator**

In this circuit (Fig. 9), the first timer is a slow astable multivibrator whose output is used to gate an audio-frequency oscillator on and off through the reset terminal (pin 4) to provide repeatable tone-burst generation.

Other types of applications that are possible with an IC timer are shown in Fig. 10.

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**Author's biography**

Eugene R. Hnatek is presently linear marketing manager at Signetics Corp. He is responsible for new product development, advertising and management of the entire linear product line. Gene was previously with National Semiconductor Corp., where he was military/aerospace product marketing manager. He received both a BSEE and MSEE from Bradley University.