# Experimenter's Corner

By Forrest M. Mims

## THE 567 TONE DECODER

THERE ARE many applications for circuits that can be made to respond to a specific tone frequency while ignoring all others. Some of these include radio controlled garage door openers and model airplanes, automatic paging systems, intrusion alarms, communications systems, and highly secure electronic locks.

Over the years, several practical circuits which respond to a specific tone frequency have been designed. Two of the best known are the resonant reed relay, once very popular with radio control modelers, and narrow bandpass active filters using one or more operational amplifiers.

The arrival of sophisticated single chip phase-locked loops (PLL's) a few years ago has made possible a variety of versatile tone-detection circuits, the 567 being designed especially for this role. Supplied in either an 8-pin mini-DIP or TO-5 can, the 567 is available from several sources listed in the Electronics Market-place in this magazine for less than $1.75.

The functional block diagram of the 567 tone decoder is shown in Fig. 1. The circuit incorporates 62 transistors to provide synchronous AM lock detection and a power output stage. In operation, a current controlled oscillator (cco) operates at a frequency determined by external components *R1* and *C1*. This frequency is called the center frequency (f ) and is equivalent to 1.1/*R1C1*. Both the input and the cco signals are fed into a pair of phase detectors. When the input frequency falls within the detection bandwidth of the circuit (0 to 14% of f ), an output transistor capable of sinking up to 100 mA turns on. The output can directly control miniature lamps, relays, and LED's.

The 567 is an incredibly flexible chip with many different operating characteristics and capabilities. For example, it has a tone detection range of from 0.01 Hz to 500 kHz and will lock onto a signal with an amplitude of only 20 mV rms! Operating voltage ranges from a TTL-compatible 4.75 volts to a high of 9 volts. Standby current consumption is a reasonably low 6 to 10 mA, while activated current consumption without load is 11 to 15 mA.

**Experimenter's Circuit.** I think the best way for you to relate to the 567 PLL is to try it in an actual circuit, such as shown in Fig. 2. This circuit is a straightforward tone decoder with a built-in variable-frequency oscillator made from a single 555 timer.

The 555 is operated in its astable mode to produce square shaped output pulses. The repetition rate of the 555 is controlled by *R4* and *C5*. Increasing the values of *R4* and *C5* slows the repetition rate, while decreasing

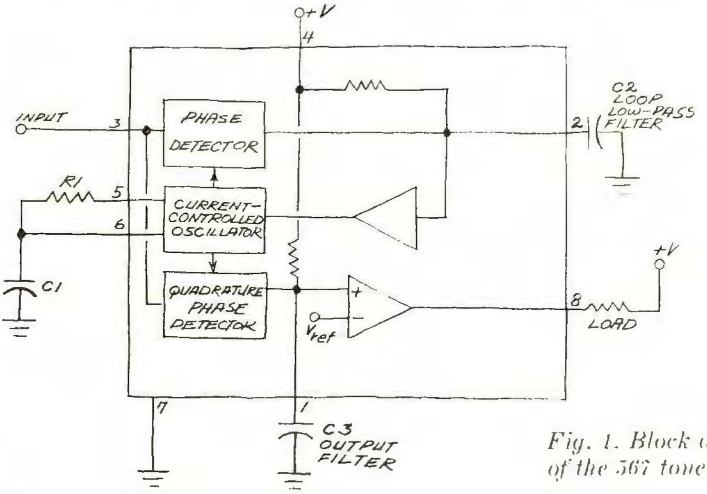


*Fig. 1. Block diagram of the 567 tone decoder.*

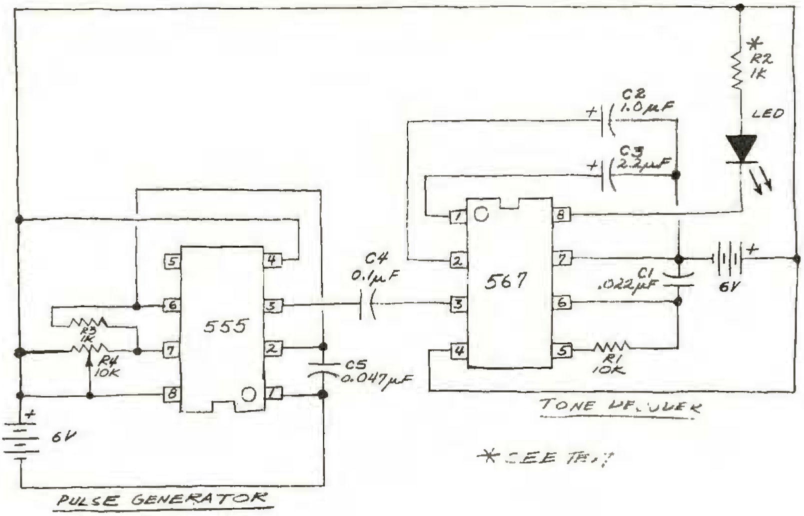


*Fig. 2. Tone decoder demonstration circuit.*

values speeds up the repetition rate.

With the component values given in Fig. 2, f should be 5000 Hz (1.1/10,000 × 0.022 × $10^{-6}$. The test circuit, however, gave an f of 4480 Hz. I measured *R1* with a digital multimeter and found its actual resistance to be 10,320 ohms. This new value gave an f of 4845 Hz, which is within 3% of the predicted frequency, and any error is traceable to the tolerance of *C1.*

After you put the circuit together, experiment with the adjustment of *R4* while watching the LED. The LED should turn rapidly on and off as you rotate *R4's* shaft past the point where the 555 oscillates at the f of the 567. If you dim the room lights, you may notice the LED flickering just before and after it turns full on and off. Resistor *R2* limits LED current to about 3.5 mA. If your workbench is brightly illuminated or your LED inefficient, you can reduce the value of R2 (say, to 500 ohms) to get more current through the LED. In any event, be sure to use a regulated dc supply or fresh batteries.

**Frequency Response.** A graph showing the response of the circuit in Fig. 2 in the acceptance bandwidth region is shown in Fig. 3. The graph shows the input frequency from the 555 versus the output current through the LED. Note that the bandwidth is fairly wide when the input frequency goes high to low and vice versa.

After you've tried changing the frequency of the input tone, replace *R1* of the tone decoder with a 2000-ohm fixed resistor in series with a 20,000- or 25,000-ohm potentiometer and readjust *R4* to provide an unknown input tone. You should easily be able to lock onto the unknown input frequency by adjusting the potentiometer. You can arrive at a rough estimate of the frequency of the unknown tone *without* using a scope or counter by measuring the total resistance of the potentiometer and its 2000-ohm series resistor and using the center-frequency formula.

At this point, the 567 would appear to work just fine, since it triggers an LED in response to any desired tone. But if you actually build the test circuit, you'll soon discover that the 567

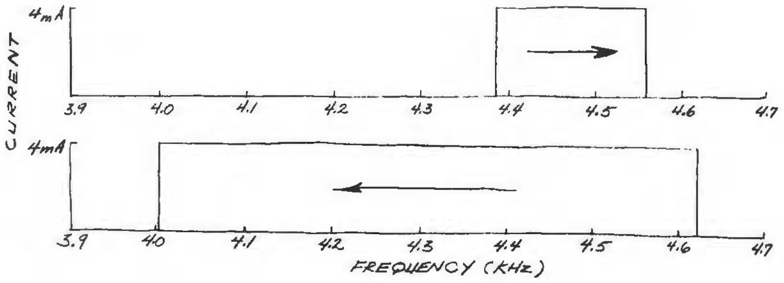


*Fig. 3. Frequency response of circuit in Fig. 2. Arrows indicate positive and negative frequency changes.*

has a tendency to trigger on what appear to be harmonics of the center frequency. The 567 will, in fact, lock onto frequencies corresponding to input signals near $f_0$ (4n + 1) (where n = 0, 1, 2, 3 . . .). Also, the square pulses from the 555 will cause an output for f /2.

Fortunately, the response of the 567 to tones other than $f_0$ is usually of no consequence. And if false triggering to undesired tones becomes a problem, you can either change the center frequency of the 567 or attenuate the offending tone with a notch filter.

**Other Applications.** After you have experimented with the 567 using the basic circuit in Fig. 2, you will probably think of lots of interesting applications. One fascinating possibility is a secret photoelectric lock activated by a tone-modulated LED. A phototransistor connected to the input of the 567 can be used to receive the signal from the LED, as shown in Fig. 4. This circuit has an optical range of a few centimeters without external lenses at either the LED or phototransistor. This is all the distance you need for most lock applications, but for more range you can add an amplifier between the phototransistor and the 567 and use a lens at each end.

Whether checking out a potential application or just for fun, don't hesitate to experiment with the basic 567 circuit in Fig. 2. For best results, Signetics recommends that the resistance of R1 be between 200 and 20,000 ohms. Capacitor C2, the loop low-pass filter, should be selected from the Bandwidth versus Input Signal Amplitude graph given in both the National and Signetics data sheets on the 567.

At very low input frequencies, the time required for the 567 to lock onto the input tone can become relatively long. For example, I found that an input tone of 500 Hz required a full second for lock to occur. These and other eccentricities of the 567 are covered in detail in the manufacturer's (Signetics) data sheet, and I urge you to obtain this well-prepared document to assist you while experimenting with the 567. Another excellent source of information on the 567 is found in the Signetics Digital/Linear/MOS Applications book (Section 6, "Phase Locked Loop Applications"). ◈

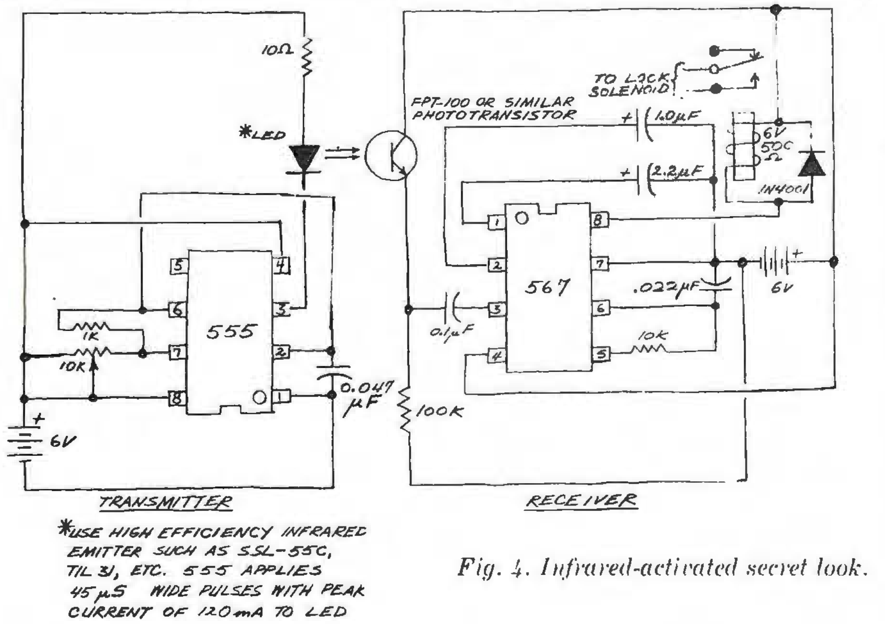


*Fig. 4. Infrared-activated secret lock.*