An Off-Hook Phone Alert

This device warns you when your telephone is off the hook with an attention-getting external audible signal

By Peter A. Lovelock

An off-the-hook telephone can cut you off from the outside world. When the instrument is left off the hook for more than 20 seconds, most telephone exchanges replace the normal dialtone with a recorded message. If there is still no response after an additional 20 seconds, an attention-getting signal composed of 1,400-, 2,026-, 2,450-, and 2,600-Hz frequencies, pulsed at a 5-Hz rate, is placed on the line for 50 seconds. This irritating brew is known in the trade as "the Howler." It's delivered to the telephone instrument's earpiece at 0 dBm—the loudest signal that phone company standards permit. If all this fails to get your attention after a minute or so, service on the line is suspended! To restore service, you must hang up the phone for about 10 seconds before dialing.

As most of us have experienced at one time or another, the off-the-hook phone message and subsequent Howler often play to a person who's no longer within hearing range. By the time one returns to the area where the phone is located, the alert signals have likely ceased. To avoid being unaware of this problem, and missing an important incoming phone call, the Howler Alert project to be described picks up where the telephone left off. It plugs into the telephone line and, when a Howler signal is detected, waits until the Howler signal from the tiny phone earpiece ceases. At this point, it takes over the Howler function by sounding an attention-getting audible signal of its own.

About the Circuit

Figure 1 is a block diagram of the Howler Alert. The telephone line is coupled to two phase-locked-loop (PLL) tone decoders, one of which is tuned to 2,026 Hz and the other to 2,600 Hz. These frequencies were selected because 1,400 Hz was just too close to the 1,477-Hz dial tone the telephone company puts on the line. Using two frequencies was a compromise between circuit complexity/cost and reliability. A single decoder could have been used, of course, but it is possible that some voice component during normal conversation might match the decoder frequency and cause the alarm to activate. Twin decoders reduce the possibility of this "falsing" to a very small probability because the choice of the two frequencies occurring is very unlikely in vocalization.

The telephone line is coupled to the decoders through a balanced-to-unbalanced RC network. This network maintains a balanced interface to the telephone line, provides a high-pass characteristic that attenuates by 40 dB the 20-Hz ring voltage to prevent damage to the circuit, and provides a means for varying the at-

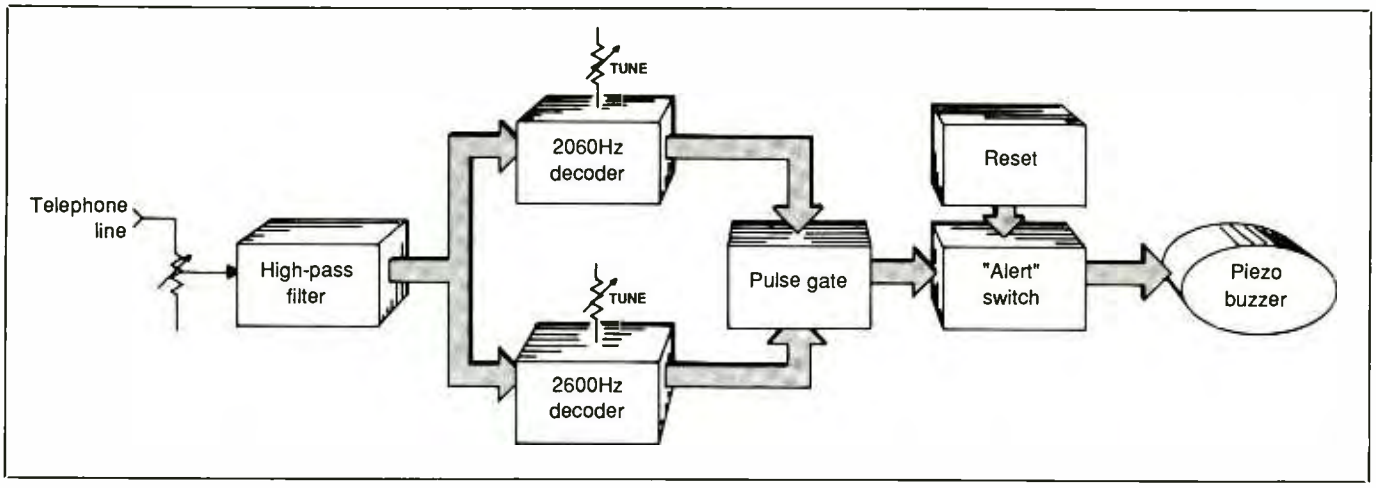

Fig. 1. Block diagram of Howler Alert.

tenuation to set the project's tones to optimum input level.

Pulsed outputs from the decoders are sent to a pulse gate that has a pulsed output only when both decoders simultaneously deliver pulses to the inputs. The output pulses from the pulse gate then trigger a 2-second timer. The first pulse starts the timing cycle. Then each succeeding pulse resets the timer so that it cannot time out until the Howler input from the telephone line ceases.

When input to the Howler Alert ceases, the timer completes its time-out sequence and sends a positive pulse to the "Alert" control. Upon receipt of this pulse, the Alert control turns on the piezo buzzer and keeps it on until the telephone is hung up and the reset button on the project is pressed and released. This puts the Howler Alert in standby, ready for the next occurrence of an off-hook condition.

Shown in Fig. 2 is the complete schematic diagram of the Howler Alert, minus its plug-in dc power supply. Notice that this arrangement combines both analog and digital circuits to provide best performance and minimum complexity.

Tone decoders *IC1* and *IC2* are the phase-locked loops that are tuned to exact lock frequencies by 15-turn trimmer potentiometers *R5* and *R8*, respectively. When an appropriate Howler frequency (2,026 or 2,600 Hz) is received the PLLs phase lock so that the outputs at pin 8 drop from the normal +5 volts to near ground potential. The pin 8 outputs of *IC1* and *IC2* separately go to the inputs (at pin 8 for the *IC1* output and pin 9 for the *IC2* output) of one of the four NOR gates contained inside *IC3*.

Both inputs to the selected gate of *IC3* must be low (logic 0) to cause the gate's pin 10 output to go high (logic 1). Thus, both PLL filters must have a tone-induced 0 output for the gate's output to go high.

A 555 timer (*IC4*) is used in this circuit to produce a 2-second time delay, which is set by the time constant of *R11* and *C14*. The capacitor is normally in a fully charged condition, and the output of *IC4* at pin 3 is low. The first pulse at pin 10 of *IC3* sends *Q1* into conduction, causing the transistor to discharge *C14* and sending pin 3 of *IC4* high. Though *C14* now starts to recharge through *R11*, the next pulse from *IC3* will discharge the capacitor. Hence, while a train of pulses is being received from *IC3*, *IC4* will be repeatedly reset, preventing it from completing the 2-second time-out cycle.

When the train of pulses stops (the phone company removes the signal from the telephone line), the timer circuit can and does complete its charge cycle to cause pin 3 of *IC4* to be toggled low.

The logic drop at pin 3 of *IC4* applies a short-duration negative-going pulse to be coupled to one input of a second gate in *IC3* at pin 12. With the other input (pin 13) of this gate tied to ground, a positive pulse is generated at the gate's output at pin 11. This pulse toggles a flip-flop made up of the remaining two gates in *IC3* so that the output of this arrangement at pin 3 goes high. This turns on *Q2*. With *Q2* conducting, the power circuit to the piezoelectric buzzer in the transistor's collector circuit is completed and the buzzer sounds. The buzzer will continue to sound until the flip-flop is toggled off by a reset signal that is applied to it by momentarily closing pushbutton switch *S1*.

It would have been convenient to power the Howler Alert from the telephone line so that only one pair of wires would have taken care of everything. However, the 567 PLLs used for *IC1* and *IC2* and the 555 timer used for *IC4* draw approximately 15 mA at 5 volts. This current drain is great enough to cause interference with the phone loop-actuating current. Therefore, the project is designed to draw its operating power from the ac line. This is done with a common plug-in dc power supply

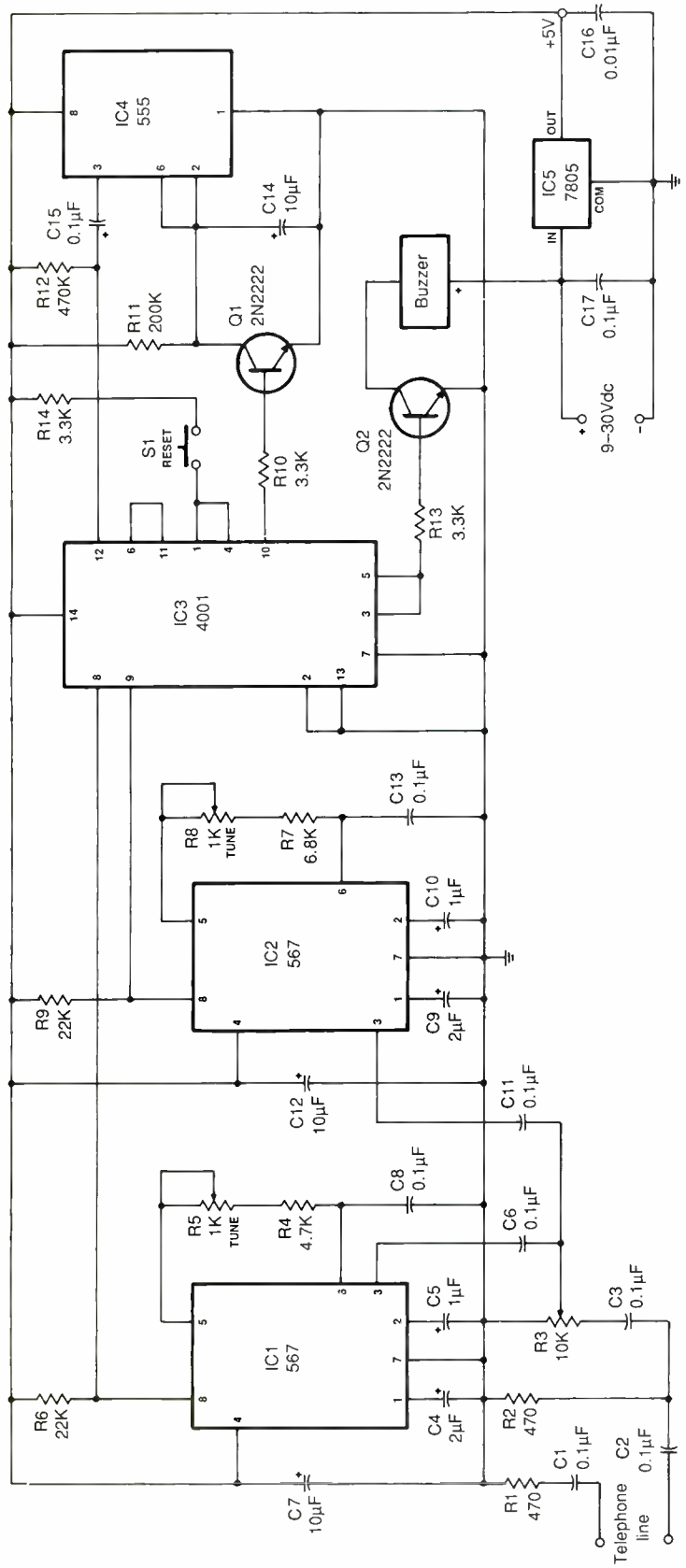

Fig. 2. Overall schematic diagram of project, minus its plug-in dc power supply.

PARTS LIST

Semiconductors

IC1,IC2—LM567 tone decoder
IC3—4001 quad 2-input NOR gate
IC4—555 timer
IC5—7805 ⁵5-volt regulator
Q1,Q2—2N2222 or similar npn silicon transistor

Capacitors

C1,C2,C6,C11—0.1-µF, 50-volt disc
C3,C16—0.01-µF, 35-volt disc
C4,C9—2.2-µF, 35-volt tantalum
C5,C10—1-µF, 35-volt tantalum
C7,C12,C14—10-µF, 16-volt tantalum
C8,C13,C15,C17—0.1-µF, 35-volt tanalum

Resistors (¼-watt, 5% tolerance)

R1,R2—470 ohms
R4—4,700 ohms
R6,R9—22,000 ohms
R7—6,800 ohms
R10,R13,R14—3,300 ohms
R11—220,000 ohms
R12—470,000 ohms
R3—10,000-ohm trimmer potentiometer (Radio Shack Cat. No. 271-333)
R5,R8—1,000-ohm, 15-turn trimmer potentiometer (Radio Shack Cat. No. 271-342 or similar)

Miscellaneous

S1—Spst normally open, momentary-action pushbutton switch
Plug-in 9-volt dc, 25-mA transformer (Radio Shack Cat. No. 273-1435 or any other 9- to 30-volt dc plug in power supply—optional; see text); panel-mount power jack for plug-in transformer; piezoelectric buzzer Radio Shack Cat. No. 273-060); printed-circuit board or perforated board and suitable soldering or Wire Wrap hardware; sockets for IC1 through IC4; suitable enclosure (Radio Shack Cat. No. 270-231 or similar 4″ × 2⅛″ × ⅝″ project box); telephone cord with modular connectors at both ends (optional); spacers; machine hardware; hookup wire; solder; etc.

Note: The following are available from T.R. Associates, 3160 Glendon, Los Angeles, CA 90034: Etched and drilled pc board, $4.75; complete kit of parts except power supply and optional items but including pc board and project box, $14.75. Add $1.50 P&H each order. California residents, please add state sales tax.

whose output goes to the input of voltage regulator *IC5*. The power supply used can have an output between 9 and 30 volts dc.

Construction

There is nothing critical about component layout. Therefore, any traditional wiring method can be used to assemble the circuit. Though a printed-circuit board is recommended, you can substitute for it perforated board with holes on 0.1″ centers and suitable soldering or Wire Wrap hardware. Whichever wiring method you choose, it is a good idea to use sockets for *IC1* through *IC4*.

You can fabricate your own pc board from the actual-size etching-and-drilling guide shown in Fig. 3. Alternatively, you can purchase a ready-to-wire board from the source given in the Note at the end of the Parts List.

Wire the board exactly as shown in Fig. 4, starting with the IC sockets—*not* the ICs themselves. Install and solder into place the resistors. Most resistors mount on-end, rather than flat against the board, to conserve space. When installing the capacitors, make sure to observe polarity with the tantalums. Before soldering their leads and pins to the copper pads on the bottom of the board, make sure that the transistors and voltage regulator *IC5* are properly installed. Finish stuffing the board by installing and soldering into place the trimmer potentiometers. Note that three jumper wires are required. These must be *insulated* hookup wire, since they go on the bottom (copper side) of the board.

Strip ¼″ of insulation from both ends of two 4″ hookup wires. Plug one end of each wire into the holes labeled S1 in Fig. 4. Then connect and solder the other ends of these wires to the lugs on the miniature pushbutton switch.

Examine your piezoelectric buzzer. If it doesn't come with wire leads already attached, you must prepare hookup wire leads for it. This time, strip ¼″ of insulation from both ends of two 6″-long wires, preferably with different-color insulation. Plug one end of these wires into the holes labeled BUZZER(+) and BUZZER(−). The other ends of these wires will be connected after the buzzer and circuit-board assembly have been mounted to the enclosure's front panel. If your buzzer comes with leads already attached, do *not* wire it to the board just yet.

A standard 4″ × 2⅛″ × 1⅝″ plastic project box with removable aluminum plate was used to house the prototype of this project. You can substitute any other type of box that has adequate room to accommodate the circuit-board assembly inside and enough panel and/or wall space on which to mount the RESET switch (*S1*) and piezo buzzer.

Now prepare the aluminum panel of the project box by drilling the mounting holes for the circuit-board assembly, pushbutton switch, power jack and piezo buzzer, as illustrated in Fig. 5. Locations of the #4 CLR holes should be exactly as shown to assure that the board will be centered in the panel. Other hole locations and sizes may have to be adjusted to suit any components you substitute for those called for in the Parts List

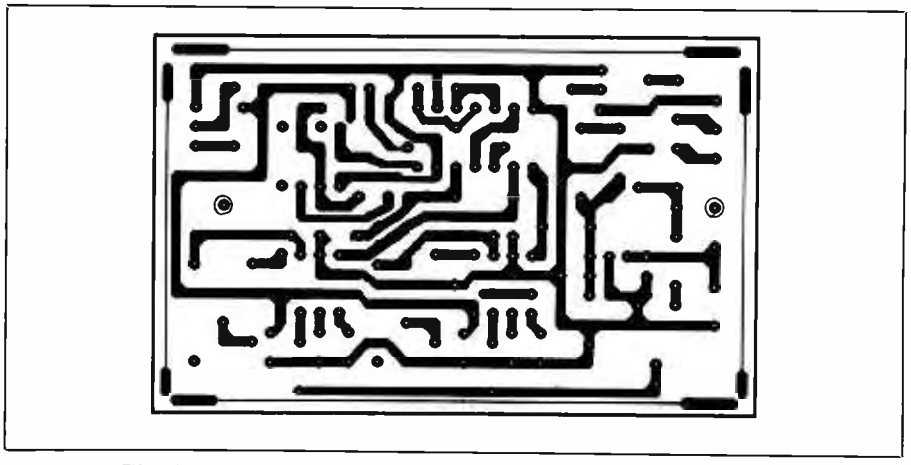

Fig. 3. Actual-size etching-and-drilling guide for pc board.

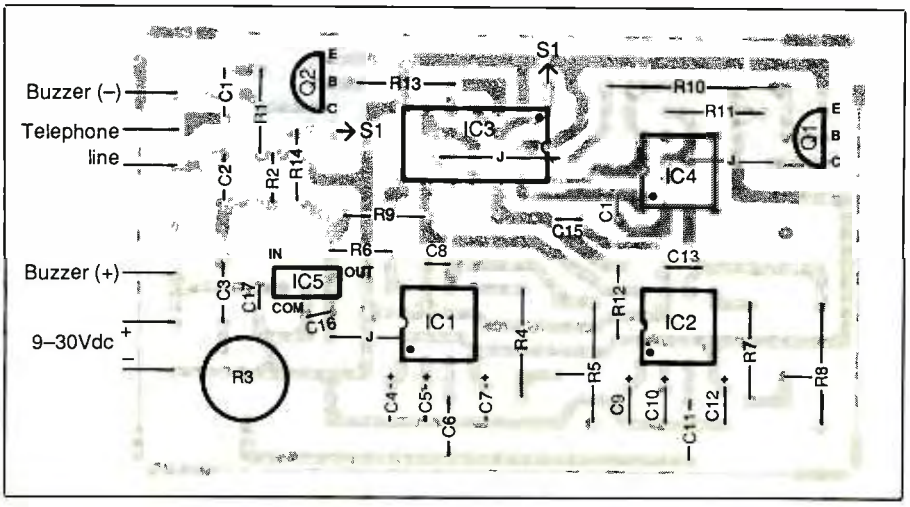

Fig. 4. Wiring guide for pc board.

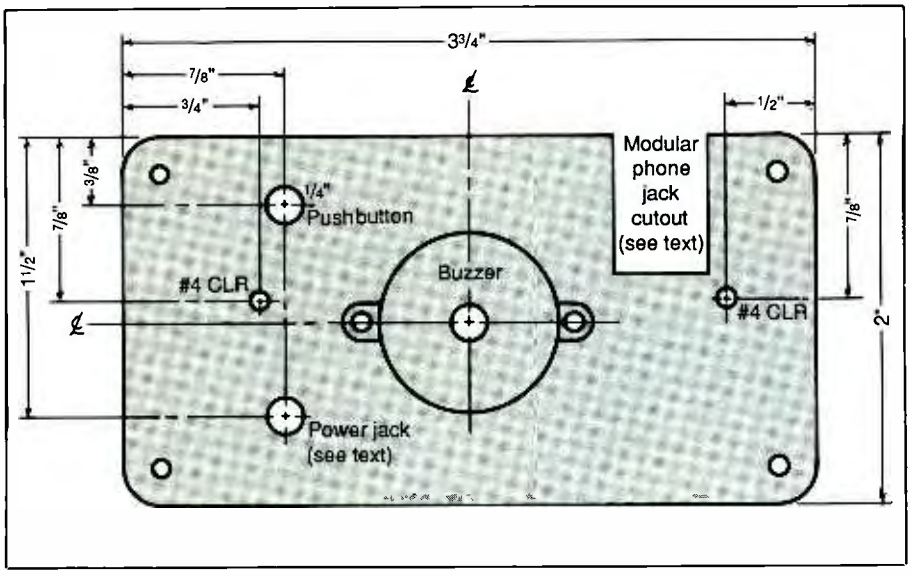

Fig. 5. Machining details for project's front panel.

(for example, a larger piezo buzzer) to avoid interference with the other components mounted on the panel.

A cutout to accommodate a modular phone jack with slotted sides is shown (see "Options & Adjustments" below for more details). If you can't locate this type of jack, you can substitute any other type of modular jack and adjust the mounting hole arrangements as needed. Alternatively, you can eliminate the jack altogether by wiring the phone cord directly to the appropriate pads on the pc board. Doing this, all you need is a single hole through which the cord can enter the box.

If you drill the entry hole for the phone cord in the aluminum panel, line it with a rubber grommet to prevent the cord from becoming frayed against the sharp edges. Otherwise, drill the entry hole in one of the box's plastic walls, in which case no grommet is needed. In either case, pass the free end of the cord through the hole and tie a strain-relieving knot about 4" from the free end inside the box.

You can also eliminate the power jack/plug arrangement by wiring the plug-in power supply's cord directly to the appropriate points on the pc board. To do this, you need an entry hole (grommet-lined if through the aluminum panel or grommet-less if through one of the box's plastic walls). Once again, tie a strain-relieving knot in the cord inside the box.

When it comes time to wire the jack or cord into the circuit, use the green- and red-insulated conductors. Some modular phone jacks come with leads attached. If you get one with solder leads, connect the wires to the two center pins. Also, make sure you connect the plug-in power supply's cord or panel jack into the circuit in the proper polarity.

If you are using the specified Radio Shack piezoelectric buzzer, pass its leads through the hole in the center of the panel and mount it in place with machine hardware, including lockwashers. Mount the pushbutton switch, power jack (if used) and modular phone jack (also if used) in their respective locations on the panel. Then, referring back to Fig. 4, connect and solder the free ends of the wires coming from the circuit-board assembly to the lugs of the switch, jack and connector. Plug into the appropriate holes (observe polarity) the leads of the piezo buzzer and solder into place.

Mount the circuit board assembly to the front panel with ⅜" or ½" spacers and machine hardware. The copper-trace side of the board should be facing toward the inside surface of the aluminum panel. At this point, *IC1* through *IC4* should still not be installed in their sockets. Only regulator *IC5* should be in place.

Checkout and Use

Plug the dc power supply into an ac outlet. Connect the negative or common lead of a multimeter, set to read dc voltage, to circuit ground (negative side of power jack). Now touch the meter's positive probe to the pin 4 contact of the *IC1* and *IC2* sockets, pin 14 contact of the *IC3* socket, pin 8 contact of the *IC4* socket and output pin of *IC5*. In all cases, the reading obtained should be +5 volts. If you do not obtain the proper readings, check for a +9- to +30-volt reading at the input pin of *IC5*. (If you're using a 10-volt dc plug-in power supply, your reading at the input pin of *IC5* should be roughly +10 volts.) If you still don't obtain the proper readings, power down the circuit and check your wiring and component placement, identification and orientation. Carefully check for poor soldering and solder bridges, especially between the closely spaced pads for the ICs.

Once you're sure that the circuit is properly wired and soldered and that the correct voltages are present at the key points in the circuit, power down the project by disconnecting the plug-in power supply from the ac outlet. Plug the ICs into their respective sockets, taking care to properly orient each and to prevent any pins from overhanging the sockets or folding under between sockets and IC bodies.

Before hooking up the Howler Alert to the telephone line, you must adjust PLL tuning and input level. Connect an audio signal generator to the telephone line input of the Howler Alert and a dc voltmeter or logic

probe to pin 8 of *IC1*. Plug the project into an ac outlet and observe the meter or logic probe. You should obtain a reading of +5 volts on the meter or a logic 1 on the probe.

Set trimmer control *R5* to either of its extremes (a faint "clicking" sound indicates when you have reached the end of the pot). Set *R3* fully clockwise. Then set the audio generator for an output frequency of 2,026 Hz and high level. Now slowly adjust the setting of *R5* until you reach a point (hopefully at about midrange) at which pin 8 of *IC1* drops to zero on the meter or logic probe. This is the point at which the circuit has phase-locked onto the 2,026-Hz signal.

With a high-level input from the signal generator, initial adjustment might be quite broad. Therefore, it is a good idea to reduce the signal level entering the project until the potential at pin 8 of *IC1* once again goes to +5 volts (or logic 1) and readjust the setting of *R5* until phase-lock occurs. Repeat this procedure with lower levels of 2,026-Hz input until the adjustment effect of *R5* is quite sharp to ensure accurate lock tuning.

Repeat the tuning procedure for *IC2*. This time, however, connect the meter or logic probe to pin 3 of *IC2* and do your trimming with *R8*.

If you don't have an audio signal generator, you can inject the "Howler" tones from the telephone line at the telephone line input to the project and adjust *R3* and *R8* for a logic-0 at pin 3 of both *IC1* and *IC2*. This is a trial-and-error procedure, but the values of the *R4/R5* and *R7/R8* networks have been selected so that they trim only a narrow range of frequencies to simplify your task.

Now test the project with the Howler tones that the telephone company puts on the line. If possible, to avoid over-use of the phone line for testing, it is a good idea to record the tones on tape and use their playback instead of the actual tones on the line during your tests.

Connect the Howler signal source —whether from the phone line or a tape recorder—to the Howler Alert via the project's telephone line inputs. Plug the project's power supply into an ac outlet and turn on the howler tones. Check the outputs of the PLLs at pin 8 of *IC1* and *IC2*. If this portion of the circuit is properly tuned, you should observe on a logic probe or oscilloscope screen activity that indicates a series of rapid pulses at both pins. You should also observe the same pulse activity at pin 11 of *IC3*.

With a dc voltmeter connected to pin 3 of *IC4*, you should obtain a reading of +5 volts. Within 2 seconds of disconnecting or turning off the Howler tones, the potential at this pin should drop to 0 volt and the buzzer should sound. If the buzzer remains silent, check the potential at pin 10 of *IC3*, which should be 0 volt. Connecting and disconnecting or switching on and off the Howler tones should cause a short positive pulse to occur at this pin. If the buzzer still Fails to sound, check pin 4 of *IC3*, which should normally be at ground potential, or 0 volt. Within 2 seconds of stopping the Howler input signal, this pin should go to and remain high (about +5 volts) to turn on *Q2*.

Once you're satisfied that the project is working as it should, connect the Howler Alert to the telephone line (if it is not already connected to it). Then connect your voltmeter to pin 10 of *IC3*. Now remove the handset of your telephone from on-hook and wait for the phone company-generated Howler signal to start. When this signal does come through, adjust input attenuator control *R3* until the pulses at pin 10 of *IC3* stop (input signal too low to phase-lock the PLLs). Back off *R3* until the pulses reappear; this is the threshold input setting. Adjustments of the project are now complete and should not require changing.

Leave the Howler Alert permanently connected to the telephone line via a modular jack used to connect your telephone instrument(s) to the telephone company. If your installation has only one modular receptacle, plug into it a duplex adapter to provide separate receptacles for the phone and the Howler Alert.

If no modular jacks are used in your telephone installation, connect one end of a green- and red-insulated wire pair directly to the telephone line inputs on the project's circuit-board assembly and the other end to the terminals on the wall connector block to which like-color wires are connected. The connector block is usually found directly behind the wall plate to which the phone's cord goes. Simply remove the wall plate by backing out on the single screw in the center of it to get at the block.

Options & Adjustments

Modular telephone jacks that mount into a metal panel may be difficult to find through normal retail outlets. Jacks sold by retail stores are usually attached to plates that mount to wall boxes. Some of these can be disassembled, though it may take some ingenuity to mount them into a panel cutout.

Some electronic parts stores carry pc-mount versions of these modular jacks. If you get one of these, use the center contacts in the upper and lower rows on them to make the connections for a single-line installation. If all else fails, use any two-wire jack, though this requires soldering two end wires of the phone cord to the matching plug.

Select the power jack to match the plug at the end of the output cable from the particular plug-in dc power supply you are using. The Radio Shack plug-in dc power supply specified in the Parts List, for example, requires a $\frac{3}{32}$" subminiature phone jack. A supply from a different source might require a different type of jack or connector.

You can use any of the plug-in dc power supplies sold through mail-order houses and electronic parts stores as long as the one selected has an output in the range of from 9 to 30 volts dc. Any supply in this range will yield +5 volts at the output of the 7805 voltage regulator shown as *IC3*.

The piezoelectric buzzer specified in the Parts List is typical of this type of audible signaling device. The Radio Shack buzzer was selected for its low current requirements. However, you can substitute any other piezo buzzer that emits a louder alert or even a two-tone "warble" alert. You can also substitute a light, with a suitable amplifier circuit to drive it, for elderly people whose hearing is deficient for the buzzer.

The phone company "Howler" is a standard "Network Call Progress" tone signal used throughout the U.S. If your local telephone company uses a single tone, such as 1,600 Hz, instead of the pulsed Howler signal described earlier, simply omit *IC2* from the circuit and connect the output from *IC1* to both pins 8 and 9 of *IC3*. Whether the off-hook warning signal delivered over the telephone line is pulsed or continuous. The time-out function of *IC4* will be inhibited in either case. The value of *R4* will have to be changed for the frequency of the single-tone Howler signal, however. The formula for calculating the value is: $R = (1/C1F_O) - 100$, where F_O is frequency. For example, if F_O = 1,600 Hz, $R = (1/0.0000001 \times 1,600) - 1,000 = 5,250$. In this example, the "−1,000" is the 1,000-ohm value of trimmer potentiometer *R5*, which makes up the trimming element of the resistance in the RC network for *IC1* in Fig. 2. A 5,250-ohm resistor is not exactly a "standard" value. Instead, you could use a 4,700-ohm resistor that, with the 1,000-ohm value of R5, can be adjusted to provide the required 5,250-ohm value.

With the Howler Alert feature built and connected to your phone, you'll never again learn from frustrated callers that they've been trying to reach you for hours but always got a busy signal. Note that a very few local phone companies do not employ any kind of Howler system. Our Howler Alert can't help you in this case, of course. **ME**