



4 Add-On Phone Devices

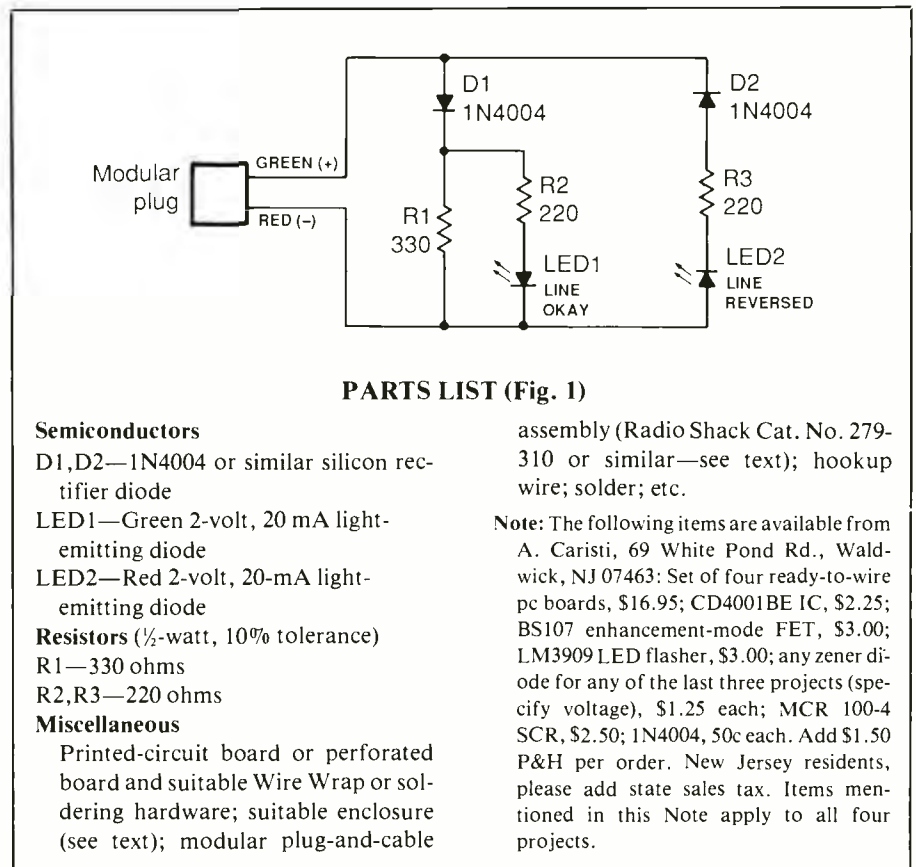
- *Telephone-Line Checker*
- *Extension Phone Lockout*
- *Extension Phone Busy Indicator*
- *Automatic Hold Device*

By Anthony J. Caristi

You've probably noticed in mail-order catalogs a variety of devices that can be added to a basic home or business telephone instrument to improve performance, add new features or both. These telephone add-ons are hot items, but don't expect to find most of them in any of Ma Bell's Phone Stores or AT&T's direct-sales catalogs. Four such items are presented here. All are low in cost and easy to build. And they are powered by the telephone line (each presenting an extremely small load on the line), so no batteries are needed.

Projects included in this roundup include a handy test device that lets you diagnose and check any telephone jack, outlet or line for proper operation. Another is an automatic hold device, while the remaining two projects are designed to help you avoid accidental or purposeful eavesdropping on an extension instrument.

Each of the projects presented here



PARTS LIST (Fig. 1)

Semiconductors

D1,D2—1N4004 or similar silicon rectifier diode

LED1—Green 2-volt, 20 mA light-emitting diode

LED2—Red 2-volt, 20-mA light-emitting diode

Resistors (1/2-watt, 10% tolerance)

R1—330 ohms

R2,R3—220 ohms

Miscellaneous

Printed-circuit board or perforated board and suitable Wire Wrap or soldering hardware; suitable enclosure (see text); modular plug-and-cable

assembly (Radio Shack Cat. No. 279-310 or similar—see text); hookup wire; solder; etc.

Note: The following items are available from A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463: Set of four ready-to-wire pc boards, \$16.95; CD4001BE IC, \$2.25; BS107 enhancement-mode FET, \$3.00; LM3909 LED flasher, \$3.00; any zener diode for any of the last three projects (specify voltage), \$1.25 each; MCR 100-4 SCR, \$2.50; 1N4004, 50c each. Add \$1.50 P&H per order. New Jersey residents, please add state sales tax. Items mentioned in this Note apply to all four projects.

Fig. 1. Schematic diagram of Telephone-Line Checker circuit.

can be built and used independently of the others, and each connects to the telephone line via a common modular plug/jack arrangement (an FCC requirement for telephone accessory devices). Add one, two, three or even all four projects to your existing telephone line to enhance the

utility of your telecommunications system.

Preliminary Information

Each of the projects described here can be assembled in a single evening. To simplify matters, all four projects are accompanied by actual-size art-

work for fabricating printed-circuit boards for them and complete Parts Lists, along with details about how the circuits operate. Each project can be used alone. The only outside connections in each case is to the telephone line via a modular jack/cable arrangement. The modular jack is an FCC requirement for all accessories connected to the telephone line, including those described here. It's best to obtain a modular plug-and-cable assembly for the telephone-line connection. Otherwise, you'll have to manually connect the cord to the modular plug, which can be a tedious, frustrating experience without the proper tool.

Although the modular plug assembly may have as many as four conductors connected to it, only the two wires closest to the center are to be used. These conductors have green and red insulation on them. Telephone convention normally assigns the positive (+) polarity to the green-insulated conductor and the negative (-) polarity to the red-insulated conductor. For all four of these projects this green-for-plus and red-for-minus convention must be followed.

If the modular plug/cable assembly comes with spade lugs on the end opposite the plug, do *not* snip them off. Instead, make whatever connections are to be made by splicing wires to the lugs or soldering the lugs themselves directly to the copper pads on the printed-circuit boards on which the projects are assembled.

The reason for not removing the spade lugs is that the conductors in many telephone cords are made up of a delicate "tinsel"-like wire wrapped around a fabric cord that assures a long useful life and maximum flexibility. Because this wire isn't easily solderable, matters are expedited more easily by leaving on the spade lugs. Obviously, if your cord comes with no spade lugs on one end, the conductors there are can be plugged into the appropriate holes in the board and be soldered into place.

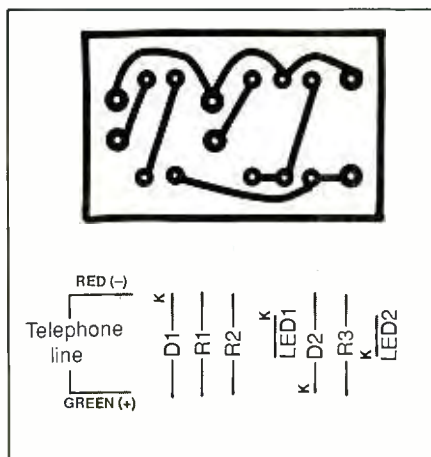


Fig. 2. Actual-size etching-and-drilling guide (A) and wiring diagram (B) for Telephone-Line Checker pc board.

When wiring any of the projects, be very careful to observe proper orientation of all polarized components (electrolytic capacitors, diodes, light-emitting diodes, transistors and integrated circuits). All important orientations are clearly indicated in the wiring guides that accompany each project. Just one component improperly installed will result in an inoperative project and may even result in damage to that component or/and other components in the project.

When you're finished wiring a project, very carefully examine it for cold or poorly soldered connections, solder bridges between closely spaced pads and conductors, etc. If you suspect any connection, reflow the solder on it and, if necessary, add any that may be needed. Solder bridges can be cleared with a soldering iron and wicking type desoldering braid or a vacuum-type desoldering tool. Then resolder the connection. Keep in mind that it's much easier to detect and correct a problem with a newly wired circuit-board assembly than it is after installing the assembly into your telephone system and putting it into service.

Though in this article we assume printed-circuit board construction, any and all of these circuits can also

be assembled by traditional point-to-point wiring techniques on perforated board. Use board that has holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware. Regardless of the type of board used, however, it's a good idea to use sockets for all DIP ICs.

The Projects

As stated earlier, a total of four projects is presented here. In this section, we'll discuss how each works and give special construction information appropriate to each. Let's start with the simplest of the projects:

- **Telephone-Line Checker.** This self-powered instrument can help you to quickly determine if a fault is in your telephone instrument or in the line. Armed with the result obtained with the Telephone-Line Checker, you can troubleshoot your telephone instrument if you've determined that's where the problem is, or place a call to your local telephone company office for a service call should the result indicate that the problem is with the line.

A single telephone line that enters your home or business consists of just two conductors. Across these conductors is a potential of about 50 volts dc under the off-hook condition. When a telephone instrument is in use, this potential drops to between 6 and 8 volts or so as current is drawn from the line. Therefore, it's a simple matter to check for proper line operation by determining the polarity of the two conductors and the approximate amount of current drawn by a simulated telephone load.

A suitable simulated load is shown schematically in Fig. 1. This Telephone-Line Checker circuit is extremely simple in design. With a properly operating telephone line, diodes *D1* and *D2* will be conducting and cut off, respectively. As a result, resistor *R1* loads the line and draws current to simulate a telephone instrument. Light-emitting diode *LED1*

turns on to indicate that the line is operational and of the correct polarity.

Should there be a polarity reversal in the telephone line, LINE OKAY LED1 will be off and LINE REVERSED LED2 will be on. Should the telephone line be dead, of course, neither LED will be on.

The light-emitting diodes need not be labeled in this circuit. In fact, it's probably simpler to use a green emitter for LINE OKAY LED1 and a red emitter for LINE REVERSED LED2, for at-a-glance indication of line condition. The colors green and red are almost universally the accepted to indicate go and no-go, safe and danger, etc.

An actual-size etching-and-drilling guide for the printed-circuit board for this circuit is shown in (A) in Fig. 2. The wiring guide for this board is shown in (B). Wire the board exactly as shown. Making sure to observe proper polarity, mount the LEDs and silicon diodes in their respective locations on the board. Leave about 1/4 inch of space between the bottoms of the LED cases and the surface of the board but mount the diodes flat against the board.

House the project inside its own enclosure. Preferable is a miniature clear plastic enclosure, though a small utility box will do if that's all you can obtain. If you use a clear plastic box, use rectangular LEDs. If you use a standard project or utility box, use round LEDs, mounting them in suitably sized holes drilled in the top panel. Interconnect the LEDs with the appropriate holes in the board with short lengths of hookup wire and insulate both connections to the LED leads with small-diameter heat-shrinkable tubing or plastic tubing. Secure the board in place inside its enclosure with a 1-inch-square piece of nonconductive foam tape.

• **Extension Lockout Device.** If you have more than one telephone instrument connected to the same line, you may wish to ensure privacy by automatically disabling one or more ex-

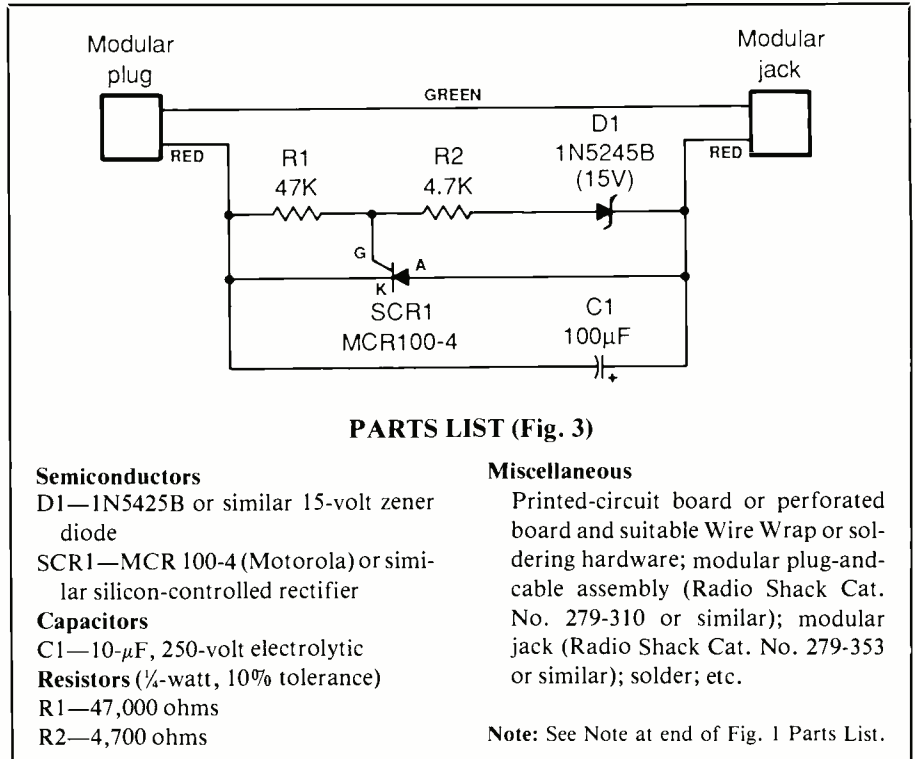


Fig. 3. Schematic diagram of Extension Phone Lockout circuit.

tension instruments when the line is in use. The circuit shown in Fig. 3 can be used to automatically lock out any or all telephone instruments connected to the line.

To accomplish the lockout, you must place the project between the telephone line and the controlled instrument, as shown in Fig. 3. This can be done by using a separate modular telephone plug and jack as shown. For a professional installation, the circuit-board assembly can be installed inside a standard box that has a modular jack on its cover plate and hard wiring the project in series with the telephone line via the red-insulated (-) conductor.

This circuit operates on the principle that the controlled telephone instrument must be powered by activation of silicon-controlled rectifier RECT1. When the line isn't in use and the telephone instrument's handset is lifted off-hook, the 50-volt dc potential across the telephone line is sufficient to overcome the zener rat-

ing of zener diode D1. When this occurs, current flows into the gate (G) of SCR1 and triggers the silicon-controlled rectifier into conduction, at which point the telephone instrument is placed across the telephone line.

If another telephone instrument connected to the same line is in use when the controlled instrument's handset is picked up, the low voltage across the line isn't sufficient in magnitude to cause D1 to go into zener action. Hence, SCR1 won't be triggered into conduction. Consequently, the instrument will not be operational.

Shown in (A) in Fig. 4 is the actual-size etching-and-drilling guide for the Extension Lockout device's printed-circuit board. When this board is ready to be populated, install and solder into place first the resistors, then the capacitors and zener diode and, finally, the silicon-controlled rectifier. Make sure C1, D1 and SCR1 are properly oriented before soldering their leads to the cop-

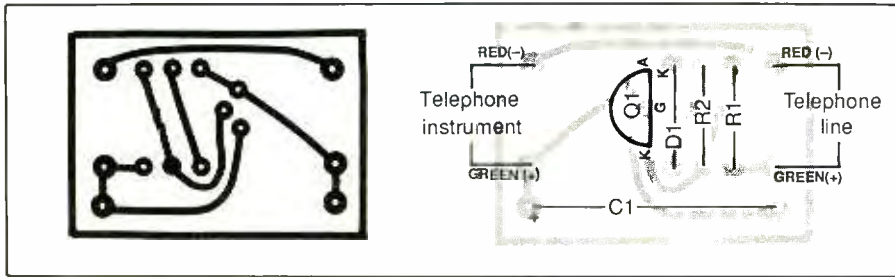


Fig. 4. Actual-size etching-and-drilling guide (A) and wiring diagram (B) for Extension Phone Lockout pc board.

per pads on the bottom of the board.

• **Extension Busy Indicator.** You may wish to avoid the problem of you or someone else lifting the receiver of an extension telephone instrument off the hook when the line is in use but would rather not have such a drastic solution of disabling the instrument as was done above. An Extension Busy Warning Indicator on any or all instruments connected to the same telephone line will light a

LED to warn others when the line is in use. It won't stop someone from picking up a receiver and listening in, though, as will the Lockout device shown in Fig. 3; it's simply an alerting device.

A circuit that serves the function of an alerting device is shown schematically in Fig. 5. It automatically lights a LED when the line is in use, providing a visible alert to anyone who wishes to use the instrument not

to pick up the receiver. This circuit is recommended for use with Touch Tone telephone instruments since some telephone-line current is required to light the warning LED at the extension instrument. Rotary or pulse-dial instruments require the line current to be interrupted during pulse dialing sequences.

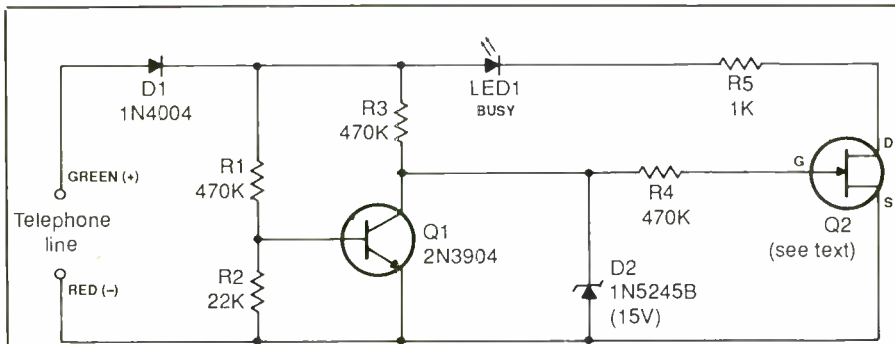
A Busy Indicator can be placed at each instrument on a given line. This way every instrument will signal when the line is in use.

The project operates by monitoring the voltage across the telephone line at all times. When no telephone instrument is being used, the 50-volt dc potential across the line is sufficient to saturate bipolar transistor Q1. This results in essentially zero gate-to-source voltage at n-channel field-effect transistor Q2. Since Q2 is an enhancement-mode FET, its drain-to-source impedance is almost infinite, resulting in zero drain current and a LED that is off.

When the telephone line is in use, the potential across it is not sufficient in magnitude to cause Q1 to conduct. Under this condition, Q2 becomes forward biased by Q3 through R3 and draws a small current from the line to illuminate LED1. When LED1 lights, the caller is warned that an extension instrument on the line is busy and the handset should not be lifted off-hook.

An actual-size etching-and-drilling guide for the printed-circuit board for this project is shown in (A) in Fig. 6. The wiring guide for the board is shown in (B). As mentioned above for the previous two projects, make sure polarity- and orientation-sensitive components are properly installed on the board before soldering their leads into place.

• **Automatic Hold Device.** How many times have you wished that you could continue a conversation on an instrument other than the one you used to answer or originate a call? It's cases like this that call for a "hold" function similar to the one



PARTS LIST (Fig. 5)

Semiconductors

D1—1N4004 or similar silicon rectifier diode

D2—1N5254B or similar 15-volt zener diode

LED1—Red 2-volt, 20-mA light-emitting diode

Q1—2N3904 or similar npn silicon transistor

Q2—BS107 or equivalent n-channel enhancement-mode field-effect transistor

Resistors (1/4-watt, 10% tolerance)

R1, R3, R4—470,000 ohms

R2—22,000 ohms

R5—1,000 ohms

Miscellaneous

Printed-circuit board or perforated board and suitable Wire Wrap or soldering hardware; modular plug-and-cable assembly (Radio Shack Cat. No. 279-310 or similar); solder; etc.

Note: See Note at end of Fig. 1 Parts List.

Fig. 5. Schematic diagram of Extension Phone Busy Indicator circuit.

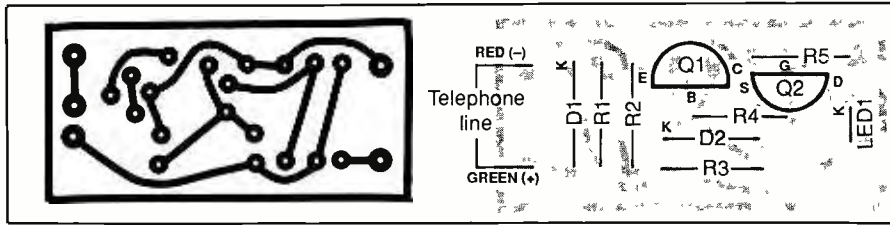


Fig. 6. Actual-size etching-and-drilling guide (A) and wiring diagram (B) for Extension Phone Busy Indicator pc board.

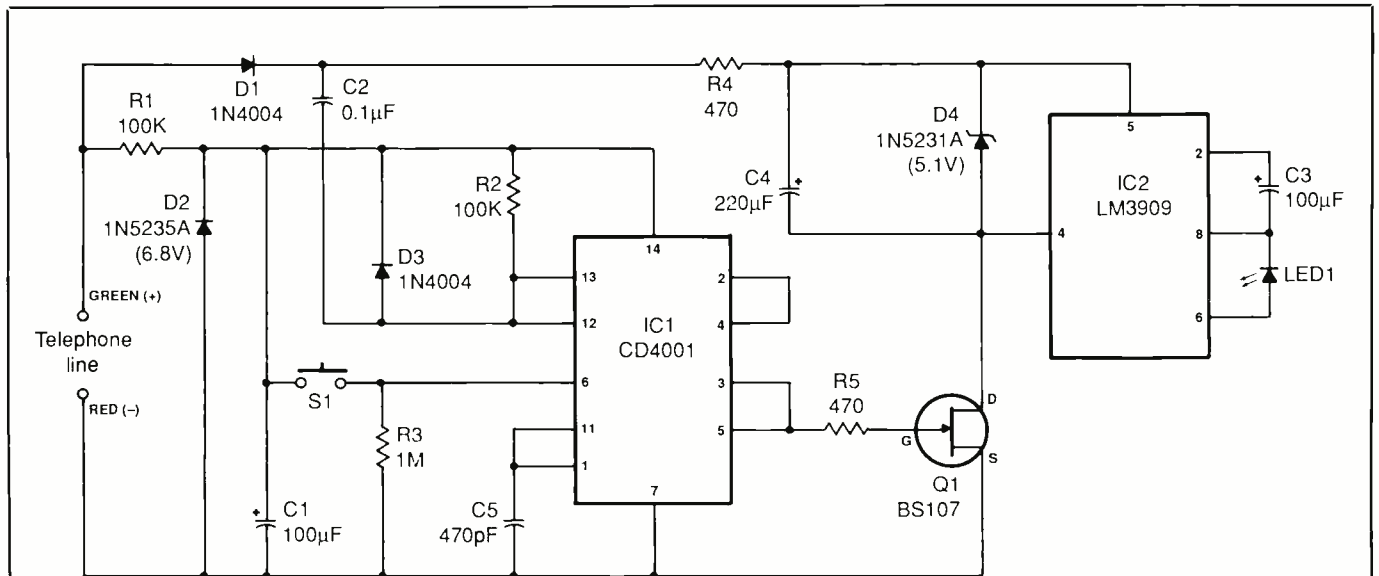
that is standard equipment with virtually every multiple-line business phone. If this is what you want, the circuit shown schematically in Fig. 7 should fill your desires.

The Fig. 7 circuit provides the

same feature business phones have and is completely automatic in operation. When you press normally open pushbutton switch S1, the circuit seizes the telephone line and holds it while flashing light-emitting

diode LED1. Once the circuit is in this condition, the instrument's handset can be replaced on the cradle without loss of the connection to the telephone line. When the same instrument's handset or the handset of any other instrument on the same line is lifted from its cradle, the hold feature is automatically disabled and the conversation is allowed to continue in the normal manner.

In the Fig. 7 circuit, a bistable multivibrator or latching circuit made up of two of the four two-input NOR gates inside IC1 is used as a memory that monitors the status of the telephone line at all times. A bistable



PARTS LIST (Fig. 7)

Semiconductors

- D1, D3—1N4004 or similar silicon rectifier diode
- D2—1N5235A or similar 6.8-volt zener diode
- D4—1N5231A or similar 5.1-volt zener diode
- IC1—CD4001BE quad 2-input NOR gate
- IC2—LM3909N LED flasher (National Semiconductor)
- LED1—Red 2-volt, 20-mA light-emitting diode

- Q1—BS107 or equivalent n-channel enhancement-mode field-effect transistor

Capacitors

- C1—100- μ F, 25-volt electrolytic
- C2—0.1- μ F, 200-volt ceramic or metal-film
- C3—100- μ F, 10-volt electrolytic
- C4—220- μ F, 10-volt electrolytic
- C5—470-pF ceramic

Resistors ($\frac{1}{4}$ -watt, 10% tolerance)

- R1, R2—100,000 ohms
- R3—270,000 ohms

- R4—470 ohms

- R5—470,000 ohms

Miscellaneous

- S1—Normally-open, momentary-action pushbutton switch
- Printed-circuit board or perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware; sockets for IC1 and IC2; modular plug-and-cable assembly (Radio Shack Cat. No. 279-310 or similar); solder; etc.

Note: See Note at end of Fig. 1 Parts List.

Fig. 7. Schematic diagram of Automatic Telephone Hold Device circuit.

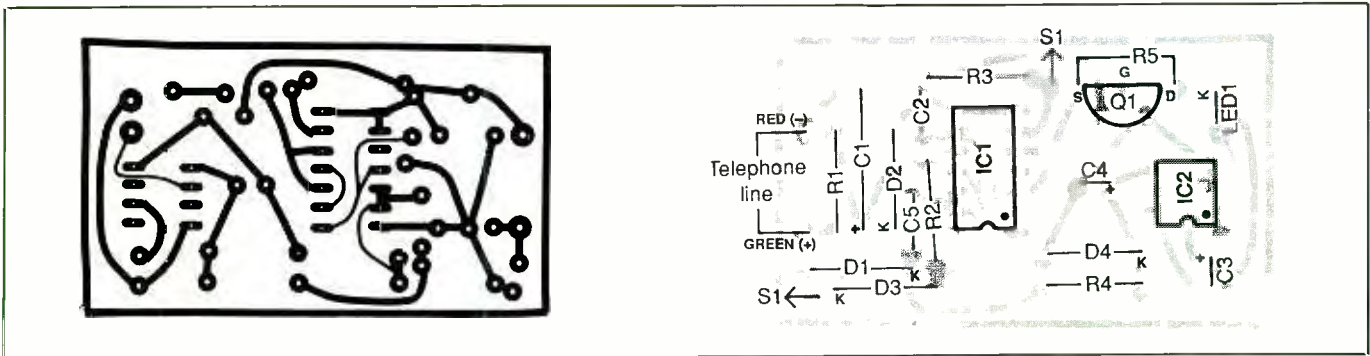


Fig. 8. Actual-size etching-and-drilling guide (A) and wiring diagram (B) for Automatic Telephone Hold Device pc board.

multivibrator has two stable states. At any given moment, the state it assumes depends on the logic levels fed to the multivibrator's two inputs at pins 1 and 6 of *IC1*.

During normal telephone operation, pin 3 of *IC1* is held at logic low since pin 1 of the NOR gate has been fed a logic-high pulse when the telephone instrument's handset was taken off-hook and the connection to the telephone line was made. As a result, *Q1* is cut off and no collector current flows.

When the hold function is activated by briefly pressing and releasing *S1*, the resulting positive pulse fed to pin 6 of *IC1* causes the bistable multivibrator to toggle into its alternate state. This causes pin 3 of *IC1* to go to logic high, and the resulting positive output voltage switches field-effect transistor *Q1* into conduction. Current is then permitted to flow from the telephone line into LED flasher chip *IC2*. Additional current is also drawn by *D4* to ensure that the total current through *Q1* is sufficient to seize the telephone line.

Once the line is seized, the handset can be replaced in the instrument's cradle to hold the call. The flashing LED, driven by *IC2*, provides visual indication that the call is on hold.

When the hold function is activated and the instrument's handset is hung up, the current drawn by the circuit is less than that required by a standard telephone instrument.

Hence, the potential across the line rises to about 15 volts from the normal 6 to 8 volts.

When the handset of any instrument connected to the telephone line is removed from the cradle to continue the conversation, the resulting drop in telephone-line potential feeds a negative-going pulse into a third NOR gate inside *IC1*. This gate is configured as an inverter. Its positive output pulse at pin 11 restores the multivibrator to its original standby state, disabling the hold function.

This project is best built into a telephone instrument, with the pushbutton switch and LED installed in a location that makes them accessible from outside the instrument. If your instrument is too small to accommodate the project, build the Hold device into a separate enclosure and equip it with its own modular plug and cable.

Refer to (A) in Fig. 8 for the actual-size etching-and-drilling guide for this project. When the board is ready, wire it exactly according to the wiring diagram in (B). Once again, make sure that electrolytic capacitors, rectifier and zener diodes and the light-emitting diode are properly polarized and that the integrated circuits are properly oriented before soldering their leads or pins to the copper pads on the bottom of the board.

With all these projects, it is important that you keep all parts of the circuit-board assemblies from touch-

ing any parts of the telephone instruments with which they are used. The *only* connections used are to be made to the two identified Telephone Line points clearly identified for each project—observe polarity! If you install a project inside a telephone instrument, make certain that it's insulated from the instrument. Similarly, if a project is housed inside a metal enclosure or a plastic enclosure that has a metal panel, make sure no parts of the circuitry touch any metal. Other than these admonitions, assembly, installation and use of each project are simple and straight-forward.

If you exercise care in assembly, none of the projects should fail to operate properly. If you do encounter a problem, however, the best way to determine what's causing it is with a dc voltmeter or a multimeter set to the dc volts function. The meter should have an input resistance of at least 1 megohm.

When troubleshooting any of these projects, always clip the meter's negative or common probe to the negative (red-insulated) side of the telephone line and touch the meter's "hot" test probe to the various points in the circuit. Check voltage levels and polarities as you work from the input (green-insulated telephone-line conductor) through the remainder of the circuit. Refer to the appropriate schematic and circuit description.

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