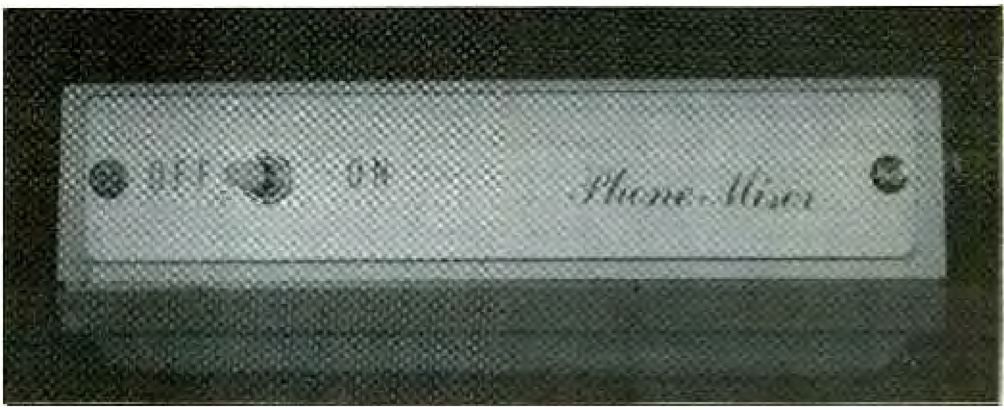
The Phone Miser

A lock-out for unauthorized long-distance telephone calls

By R.F. Sharp



Are your telephone bills sky high because of unauthorized out-of-area calls? If so, the Phone Miser project to be described can put an end to it. Phone Miser remedies this problem by automatically interrupting any attempt to reach a number outside your local calling exchange, whether the caller tries to dial directly or calls upon operator assistance. For those times when a legitimate long-distance call must be made, the project features a disable switch.

Phone Miser can be used with any selected telephone instrument, all instruments on the same line or just a few select instruments. It connects between the incoming telephone line and whatever instrument(s) it is to control. Power for the project is provided by Phone Miser's own low-voltage dc power supply so as not to load down the telephone line. The project automatically locks out any call whose number begins with the numeral 1 and any attempt to dial 0 to get the operator. (Note: If you live in an area that does not require dialing of a 1 before entry of the area code to make an out-of-area call, Phone Miser will *not* prevent the call from getting through, nor will it work with rotary-type dialers.)

Telephone Basics

Before we look at Phone Miser's actual circuitry, let us review the basics of the telephone system. To begin with, two conductors connect your home or business to the telephone system. The telephone company supplies a minimum of 20 milliamperes of direct current over this line to power your equipment. The potential across the line is approximately 48 volts dc with your telephone handset on-hook. Lifting the receiver off-hook causes this voltage to drop. The dc resistance of any device connected to the phone line is expected to be at least 600 ohms when active. (A phone's on-hook resistance is about 10 megohms.)

Ringer voltage, supplied by the telephone company, is a 20-Hz ac signal that can range from 40 to 150 volts, which is sufficient to cause injury. Therefore, always exercise caution when working with exposed telephone circuits. To avoid electrical shock hazard, always be sure to put one telephone receiver off-hook while making attachments to the line to prohibit telephone system equipment from sending a ring signal.

Older rotary-dial telephones are really pulsers that open and close the phone circuit a specific number of times for each digit dialed. They use a mechanical timing scheme to signal each dialed digit. Since Phone Miser expects to "see" an electronic tone pair for each individual digit, this mechanical "pulse" arrangement will not work with the project. If you should install Phone Miser in such a system, it will *not* inhibit long-distance calling or requests for operator assistance, and your phone(s) will work as though the project was never connected into the system.

Modern telephone instruments use all-electronic Touch Tone dialing that transmits audio signals composed of different simultaneous tone pairs for each digit. Tone frequencies range from 679 to 1,477 Hz and are tightly controlled and almost pure. For Phone Miser, our primary concern is with the digits 0 and 1. The tone pair for 0 is 1,336 plus 941 Hz and for 1 is 1,209 plus 697 Hz. This information is purely academic because all filtering and decoding are done inside a single dual-tone multiple-frequency (DTMF) receiver chip that is the heart of Phone Miser. Radio Shack supplies with this chip (see Parts List) a technical data booklet that provides additional information about interfacing with the telephone system, along with a schematic diagram that shows the DTMF chip being used with an SK4515B decoder chip. This is the circuit arrangement used in Phone Miser.

The DTMF chip is an excellent

performer. It exhibits excellent frequency response, low power drain and minimal falsing. A 10-megohm resistor and an inexpensive 3.58-MHz TV colorburst crystal are the only external components required for tone decoding.

About the Circuit

Design goals for Phone Miser included a circuit that: requires no alteration of existing equipment; meets telephone company requirements for attached devices; powers up only when the telephone is in service; and inhibits all long-distance calls. How this criteria was achieved is detailed in Fig. 1. The Current Sensor block is basically a series resistor that causes a voltage to be dropped across it when the phone receiver is off-hook. The Initialization Circuit presets values in the Register.

To prevent long-distance calls from being dialed out, calls prefixed with a "1" must be blocked. Since operator-assisted calls begin with a "0," this type of call must also be inhibited. The trick is to prevent Phone Miser from inhibiting any call not beginning with a 0 or 1 but has these numerals in another part of a legitimate local number. Therefore, the circuit must have memory of one digit, which is accomplished in the Register block in Fig. 1. The Latch is an RS flip-flop that stores information for implementing action based on decisions made by other circuitry.

A detailed block diagram of the Register is shown in Fig. 2. This circuit is made up of two D-type flip-flops from the eight available in a 74LS273. (It was wasteful of the power of the 74LS273 to use it in this application, since only two of its eight stages are used. However, I used it because I had one on hand. You can substitute a less-wasteful dual-D flip-flop, but there will probably be little or no cost advantage in doing so, and the printed-circuit board for the project will have to be modified accordingly.)

The CLR input is used to initialize the Register. A high-low-high transition sets all Q outputs low. Pin 1D is tied high to guarantee a logic 1 will always appear. With the first clock pulse, this high is shifted to 1Q and 2D, where it is stored until the next clock pulse. Pin 2Q remains at logic 0 through the first clock pulse.

The second clock signal shifts the high at 2D into 2Q, creating a unique situation here. Providing the occurrence of each digit signal is timed to coincide with the clock pulse, Register pin 2Q will be at logic 0 for only the first digit dialed. The DTMF chip generates the required timing signal, a strobe for each decoded digit.

How the low proceeds through the circuit is shown in the timing diagram in Fig. 3. This is an ideal representation because we need not be very concerned with inherent component delay. We will use the output of 2Q for comparison when the decision is made to pass or reject a dialed telephone number.

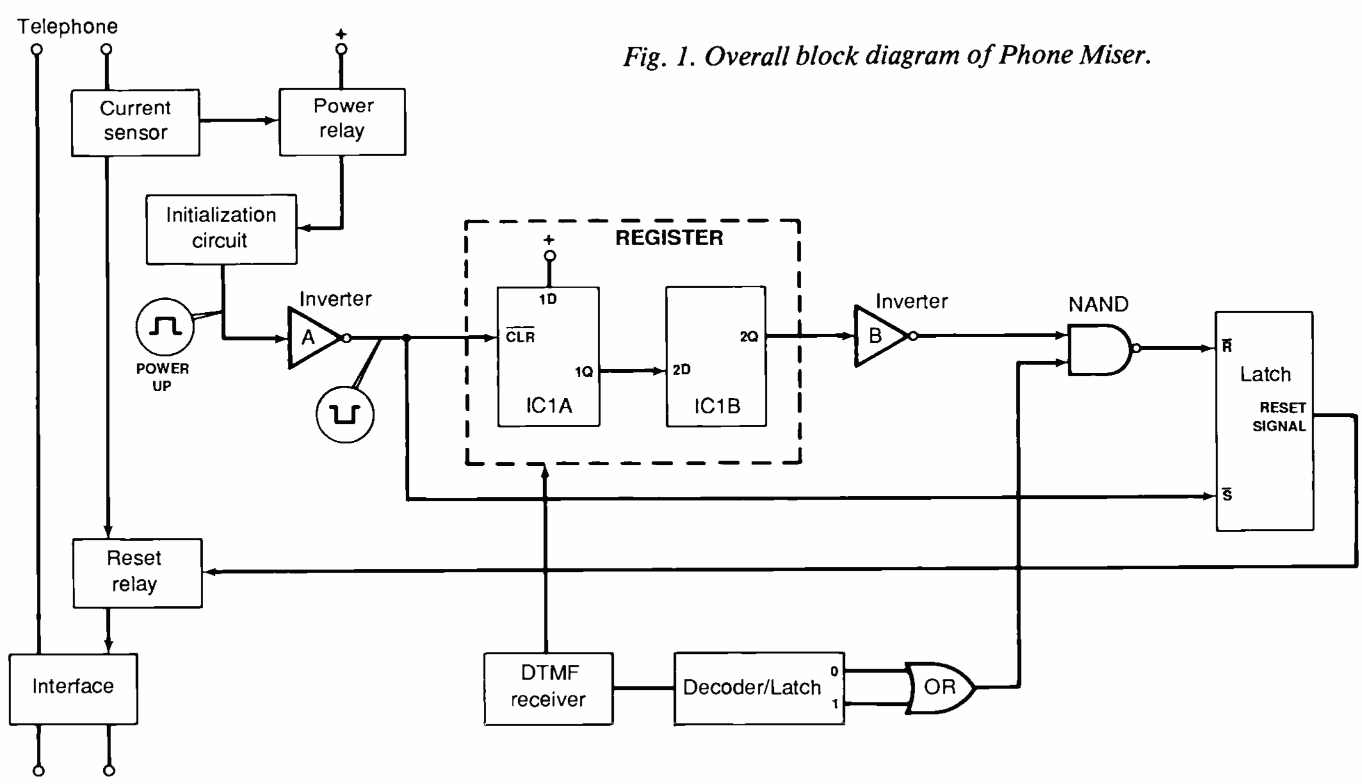


Fig. 1. Overall block diagram of Phone Miser.

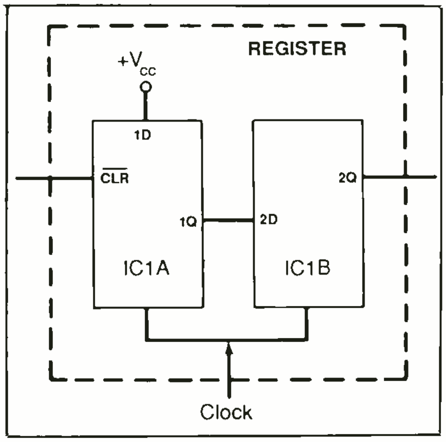


Fig. 2. Details of Register.

A complete schematic diagram of the project is shown in Fig. 4. Phone Miser is turned on and off by *S1*. This switch can be a key-type switch for security or a hidden slide or toggle switch, depending on type of phone installation. If security is a real problem, you might want to hard-wire Phone Miser between your phone and its service line. Also, the power supply used with the project should be made secure because, when unpowered, Phone Miser is transparent to *all* calls.

The power-up reset required by the Register can be provided by the phone company, which provides its own power-up signal. However, for convenience, Phone Miser is designed to generate its own pulse, via *IC4*. This 555 timer delivers a pulse at pin 3 when power is applied. Resistor *R3* and capacitor *C2* set pulse duration to approximately 0.5 second (1.1RC). This pulse is inverted by one of the inverters in *IC2*, whose pin 4 output goes to the CLR input of *IC1* at pin 1 to set the register.

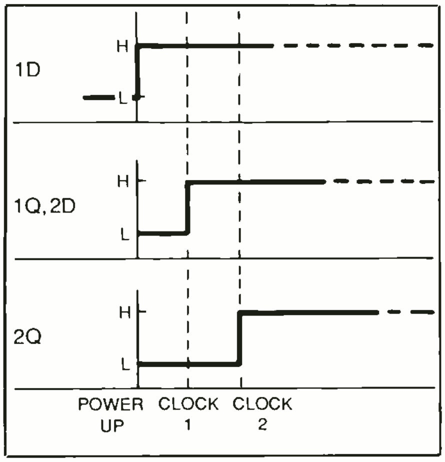


Fig. 3. Register timing diagram shows logic levels vs. time in clock increments for Register stages (neglecting component delay).

Resistor *R1* is a sensing device that provides forward bias for transistor *Q1* when the phone is in service. When *Q1* turns on, *K1* energizes and turns on power to the circuit. Diode *D3* provides a dc voltage to the base of *Q1*. Diodes *D4* and *D5* protect *Q1* by setting a maximum of 1.2 volts at the base.

Transformer *T1* and capacitors *C3* and *C4* isolate DTMF chip *IC5* from the telephone line. Ideally, *T1* should be a 600-ohm 1:1 line transformer. Zener diodes *D6* and *D7* shunt ringer voltage to ground. You may wish to shunt the line side of *T1* and *R1* with a 150-volt surge protector to guard against lightning damage if this is a problem in your area.

A pair of NAND gates inside *IC3* are used to form a latch circuit that changes state when a low is presented to either R or S (see Fig. 1).

When the handset is lifted off-hook, current flows through *R1*, causing *Q1* to turn on and energize *K1*. This powers the circuit and causes *IC4* to generate a pulse that is inverted before it is used to set *IC1*. Simultaneously, a low is sent to S of the latch to assure proper initial setting. When a "legal" first digit (2 through 9) is dialed, *IC5* interprets the tones and sends the result to *IC6*, which converts the hexadecimal to decimal code format, raising high its output corresponding to the dialed digit. Since only the 0 and 1 outputs are connected, no action is taken.

Simultaneous with the decoding process, the strobe signal is generated and clocks a high from 1D to 1Q and 2D (see Fig. 2). Output 2Q remains low, is inverted by an inverter/buffer in *IC2* and is compared with the output from the diode OR circuit made up of *D1*, *D2* and *R4*. This comparison takes place in one of the NAND gates in *IC3*. With both *IC6* outputs low, their OR combination will also be low and will combine with the high from pin 8 of *IC2* to

PARTS LIST

Semiconductors
D1,D2,D4,D5—1N914 switching diode
D3—1N34A diode
D6,D7—3.9-volt, 0.5-watt zener diode
IC1—74LS273 multiple D flip-flop
IC2—7404 hex inverter/buffer
IC3—7400 quad NAND gate
IC4—555 timer
IC5—DTMF receiver (Radio Shack Cat. No. 276-1303)
IC6—SK4514B decoder
IC7—7805 +5-volt regulator
Q1,Q2—2N2222 silicon npn transistor
Capacitors
C1—1,000-μF, 25-volt electrolytic (see text)
C2—1-μF, 10-volt electrolytic
C3—0.01-μF disk
Resistors (¼-watt, 10% tolerance)
R1—100 ohms
R2—4,700 ohms
R3—470,000 ohms
R4,R5—1 megohm
Miscellaneous
K1,K2—6-volt dc, 500-ohm spst relay (Radio Shack Cat. No. 275-004 or similar)
S1—Spst key-operated, slide or toggle switch (see text)
T1—Coupling transformer (Radio Shack Cat. No. 272-1380 or similar; see text)
XTAL—3.579545-MHz colorburst crystal
Printed-circuit board or perforated board and suitable soldering or Wire Wrap hardware (see text); DIP sockets for IC1 through IC6; project enclosure (Radio Shack Cat. No. 270-210 or similar); two ¼-inch inner-diameter rubber grommets; 6- to 18-volt dc plug-in power supply (see text); hookup wire; solder; etc.

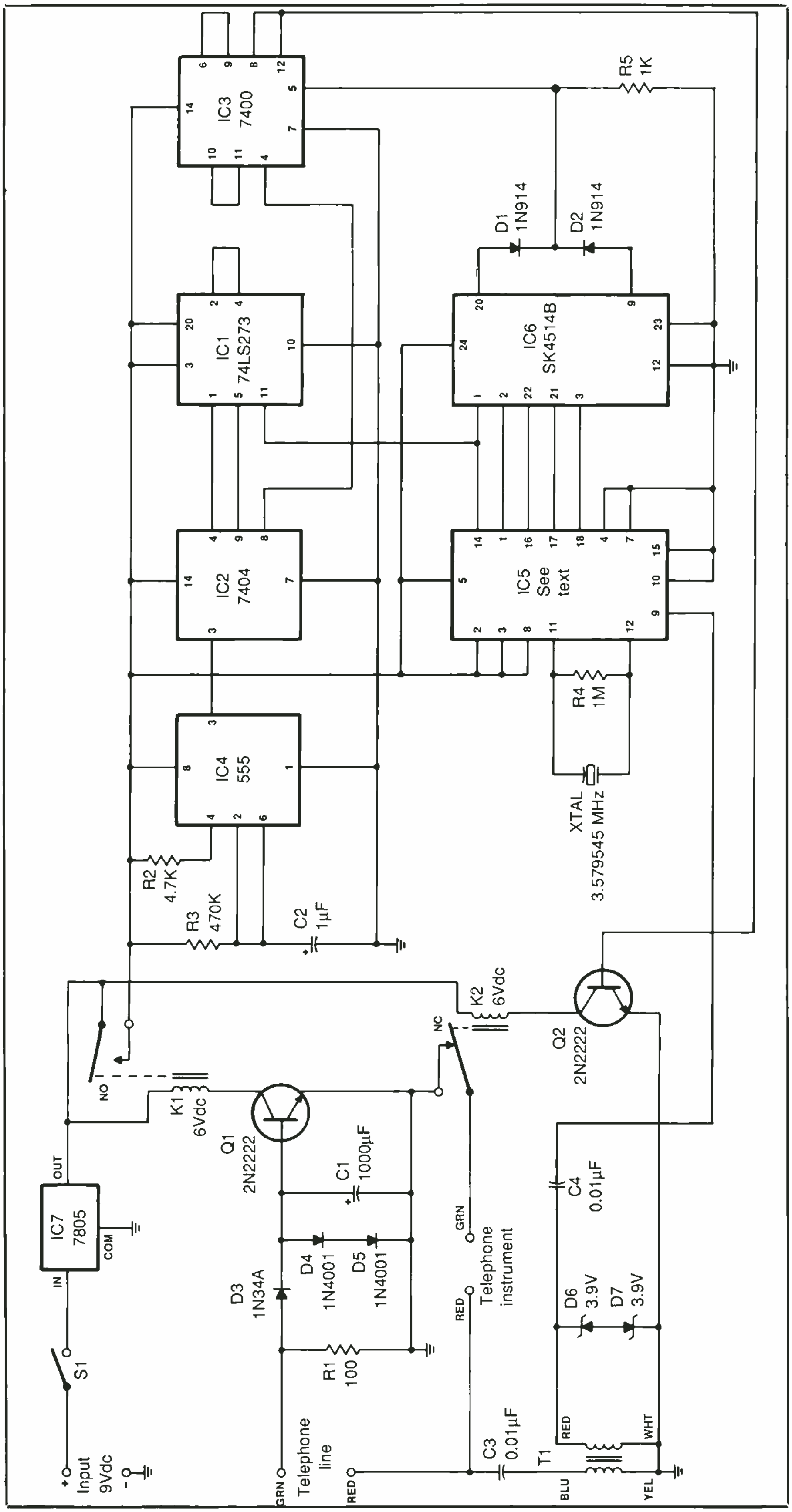


Fig. 4. Complete schematic diagram of Phone Miser.

provide a high at the NAND output, causing no change in the latch.

The next digit dialed may produce either a high or a low at the OR output, depending on whether this digit is a 0, a 1 or any remaining digit. Since the strobe simultaneously clocks a high to 2Q, which will remain high for the remaining sequence of digits, the circuit will ignore all further input. Putting the handset back on-hook causes the voltage dropped across *R1* to drop to zero and shuts off the circuit.

When an attempt is made to place a toll call, power-up occurs just as it did before. If either a 0 or a 1 is the first digit dialed, a high appears at the OR output, where it combines with the high from pin 8 of *IC2* to produce a low at the NAND output. This causes the latch to change states, sending pin 8 of *IC3* high and forward-biasing *Q2*. When *Q2* draws current, *K2* opens the phone-line circuit and aborts the call.

When *K1*'s contacts open, the voltage dropped across *R1* falls; when it goes below the bias requirements of *Q1*, power to the entire circuit, including that to *K2* (which is responsible for aborting the call), is shut off. By holding *Q2* cut off until the charge on *C2* is depleted through the base-emitter resistance of *Q1*, a valid call termination is generated. This sequence will repeat every time a 0 or a 1 is the first digit dialed. A local call can be made without putting the handset on-hook, provided you wait for a dialtone.

Power for the project is supplied from an ordinary plug-in dc power supply that is able to deliver between 6 and 18 volts. The output from the supply is regulated to a stable 5 volts by voltage regulator *IC7*.

Construction

Though it is possible to build the

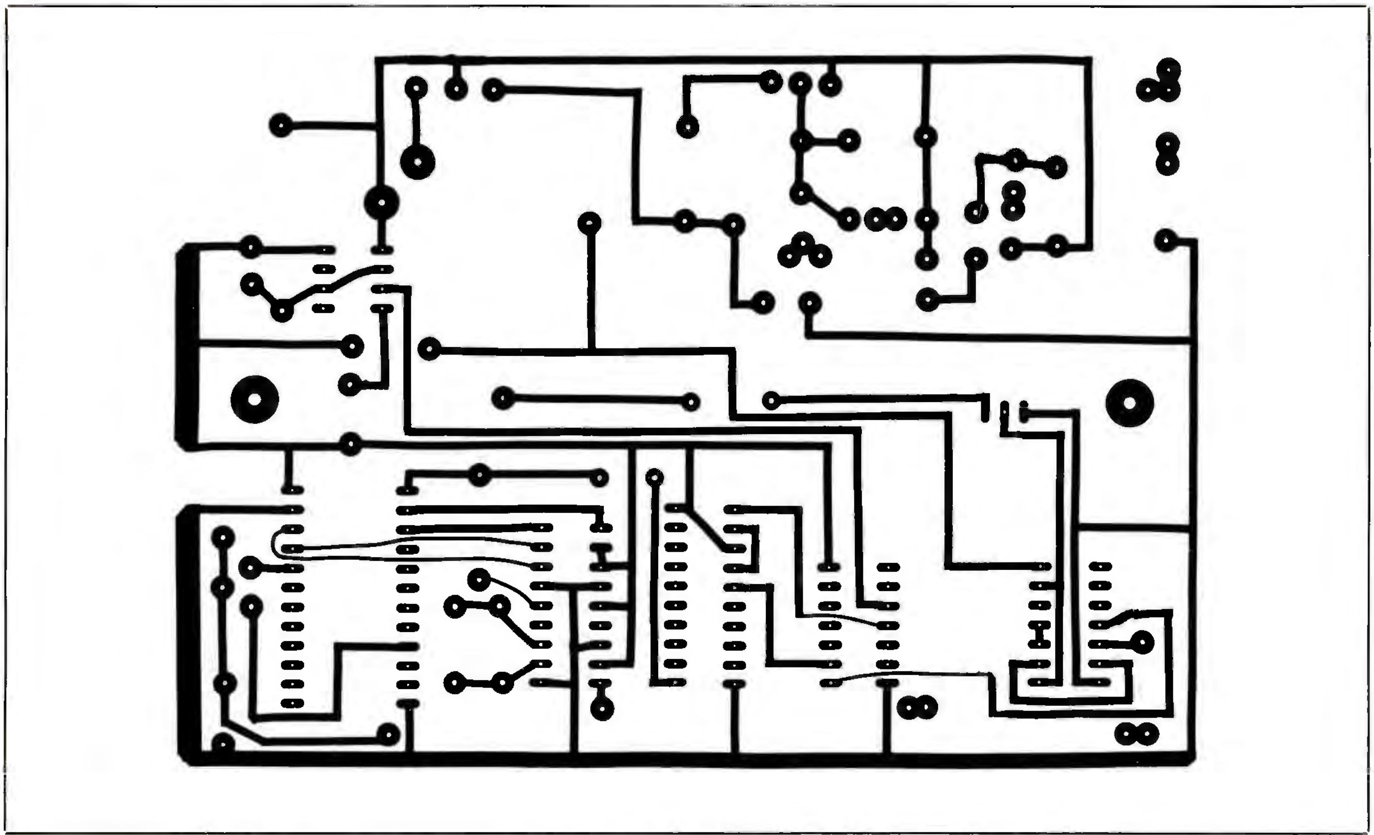


Fig. 5. Actual-size etching-and-drilling guide for printed-circuit board.

Phone Miser by other traditional wiring means, printed-circuit wiring is highly recommended. You can fabricate your own pc board from the actual-size etching-and-drilling guide given in Fig. 5, which is sized to fit inside the Radio Shack enclosure specified in the Parts List. A couple of rubber grommets forced onto the enclosure's studs will hold the wired pc board in place. The enclosure's front panel is also large enough to accommodate a keyswitch, should you choose to use it for *S1*.

If you decide to use perforated board with holes on 0.1-inch centers and suitable soldering or Wire Wrap hardware instead of a pc board, use the same layout as that for the pc board as a rough guide to component placement and orientation. Though there is nothing critical about component placement (all frequency-sensitive circuitry is contained inside *IC5*), do make sure to locate *R6* and crystal *XTAL* close to *IC5*.

Wire the pc board exactly as shown in Fig. 6. Make sure *C1*, *C2* and all diodes are properly polarized and the transistors, ICs and transformer are properly oriented before soldering their leads to the copper pads on the board. Do not install the ICs directly on the board. Instead, use a socket for each. Also, do *not* install the ICs in their respective sockets until after the preliminary voltage checks have been performed.

Note in Fig. 6 that *C1*, all diodes and all resistors except *R1* mount upright—not flat on the board. Also, use insulated solid hookup wire for the seven jumpers noted.

Do *not* use a jack-and-plug arrangement to route power from the plug-in dc power supply into the project case. Instead, cut the plug (if there is one) from the cord of the power supply you use and route it through a hole in the enclosure and solder it directly into the circuit. If you use a pluggable arrangement and someone accidentally (or purposely) unplugs it, you will lose the security Phone Miser is supposed to give you.

As a further security measure, devise a means for getting ac power to the plug-in dc power supply that cannot be easily interrupted simply by pulling the supply's housing from the wall outlet. If security is a real problem, consider replacing the plug-in supply with a 6-volt lantern battery. Do not use an ordinary 9-volt transistor battery, which would have to be replaced frequently (unless you redesign the circuit around CMOS devices instead of the TTL devices shown). More security can be provided if you *supplement* the plug-in power supply with a battery/relay arrangement that will normally power the circuit from the plug-in supply when it is plugged into an ac outlet but will automatically switch over to

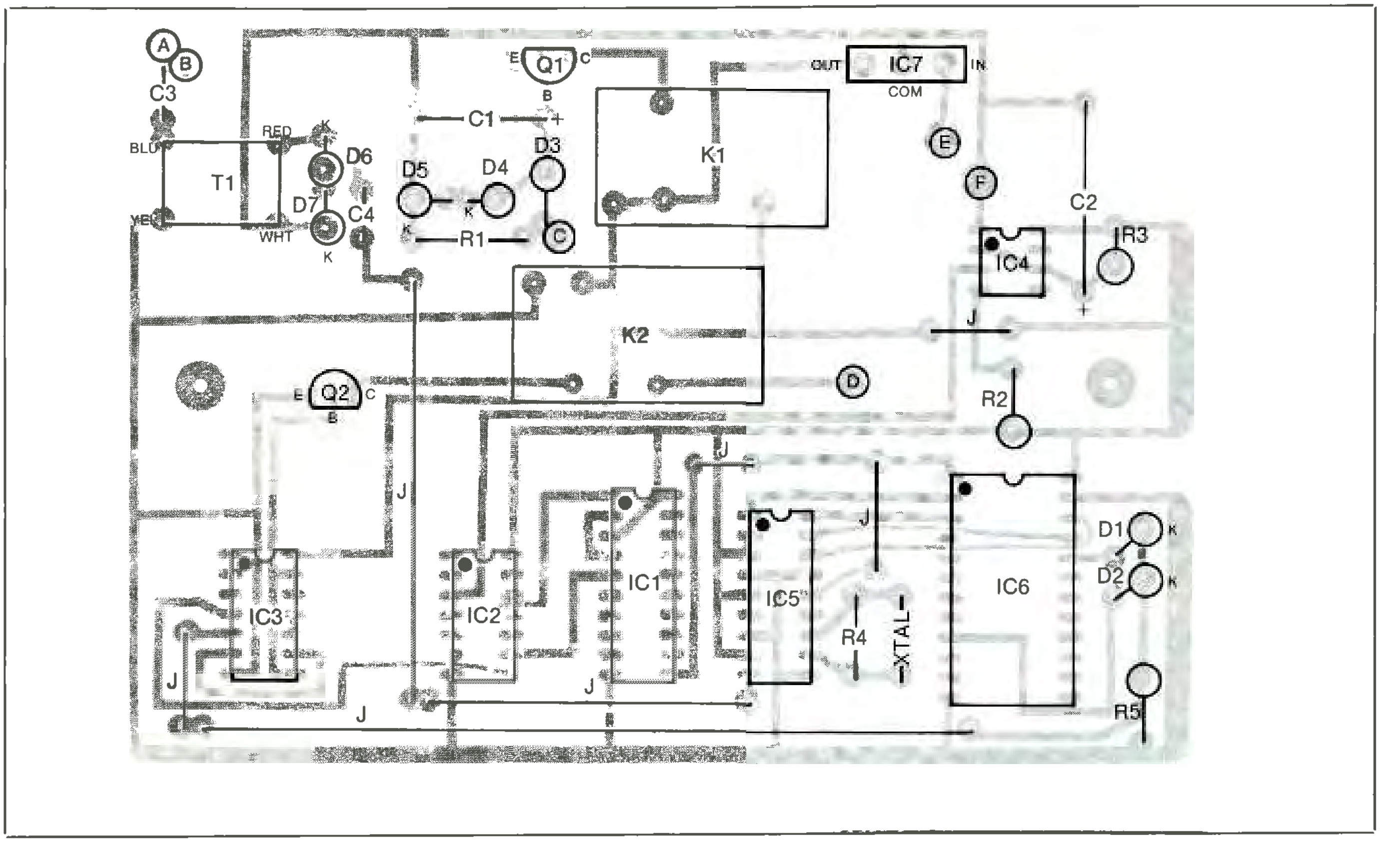


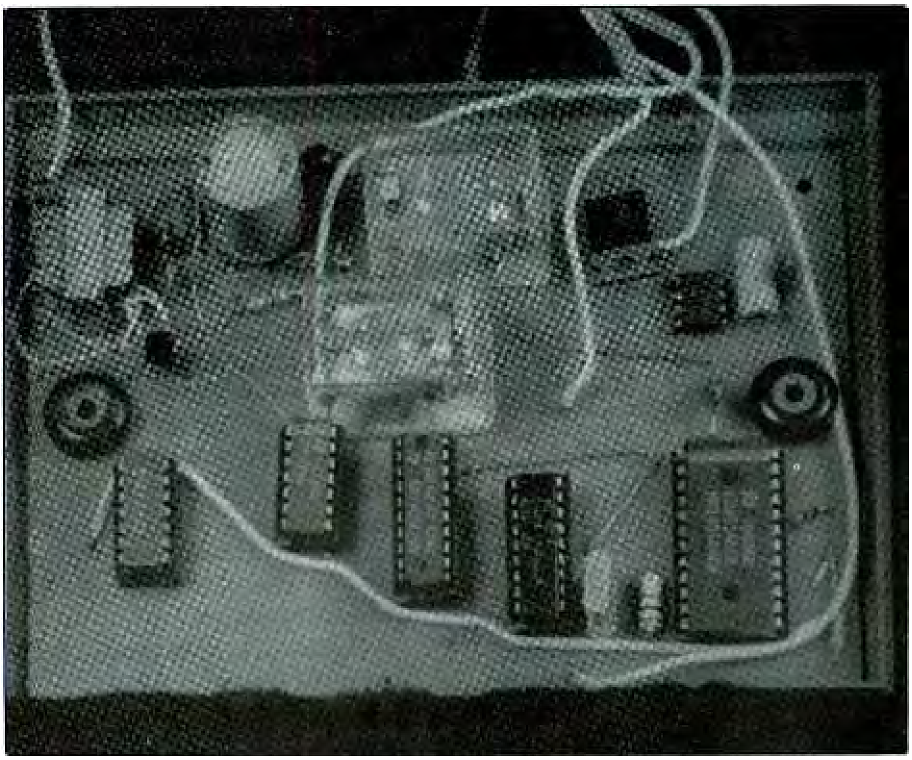
Fig. 6. Wiring diagram for pc board. Use this layout for perforated-board construction as well.

the battery should the power supply be unplugged from the ac outlet.

Checkout & Installation

After you have checked out all components for proper installation and your wiring for proper soldering, connect Phone Miser between your telephone line and an instrument. Make sure polarization is correct—that is, green line wire to green on the board and red line wire to red on the board. Plug the power supply into a convenient ac outlet.

Turn on power to the project by closing *S1* and lift the telephone's handset off-hook. Connect the negative or common lead of a dc voltmeter or a multimeter set to read dc voltage to circuit ground and touch the meter's positive probe to the OUTPUT pin of *IC7* to read +5 volts on the meter. Now check for the presence of +5 volts at pins 3 and 20 of *IC1*, pin 14 of *IC2* and *IC3*, pin 8



The wired project on a printed-circuit board.

of IC4; pins 2, 3, 5 and 8 of *IC5*; and pin 24 of *IC6*. If all readings are correct, power down the circuit, unplug the power supply from the ac outlet, disconnect the telephone line and replace the phone's receiver on-hook. If you did not obtain the proper voltage reading at any point in the circuit, recheck all wiring and soldering. Check particularly for unsoldered or poorly soldered connections and for solder bridges, especially between the closely spaced IC pads.

Once you are sure the circuit is properly wired and soldered, install the ICs in their respective sockets. Make sure that each is properly oriented and that no pins overhang the sockets or fold under between ICs and sockets.

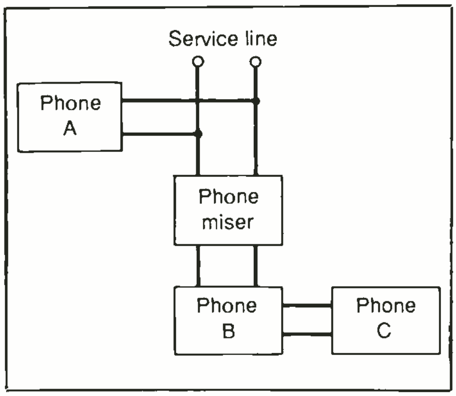


Fig. 7. Typical installation details. This arrangement has two secured (Phones B and C) and one unaffected (Phone A) telephone instruments.

Once again, lift the telephone's handset off-hook and connect the project between the telephone line and your telephone (observe color coding). When you set *S1* to ON, you should hear *K1* click as it energizes. With a voltmeter or logic probe connected to circuit ground and pin 1 of *IC6*, pressing and releasing the key for any digit between 2 and 9 on your telephone's dial pad should register a strobe signal.

Place the receiver back on-hook and then remove it and place it against your ear. You should hear a dialtone. Press and release the 1 button on the dial pad. The dialtone should disappear and *K2* should click. About a second later, the dialtone should be restored. Try pressing the 0 button. You should get the same response as before.

To observe the register counting for an in-area call, monitor pins 2/4 and 5 of *IC1*. Pins 2/4 should change from low to high when the second digit is pressed, while pin 5 should remain high until you hang up.

There is one potential problem with the Phone Miser. That is if *C2* should discharge too quickly when a reset occurs. If this should occur, it might be interpreted by the telephone system as a digit 1 from a rotary-type dial. Should you experience this, simply increase the value of *C2* to 200 microfarads or more.

If all tests are successful, you are ready to put Phone Miser into service. Before you do this, decide how you want to use the project. If you have only one telephone instrument or you want all instruments secured, simply install the project between the telephone line and the one instrument or between the telephone line and all instruments. Should you wish to secure only one or only selected instruments in a multiple-instrument system, install Phone Miser between the telephone line and the one instrument or between the telephone line and the run to which the secured instruments are connected. If all instruments you want secured are on two or more runs, you will have to redo the wiring to put all of them on the same run. Figure 7 shows how two instruments can be secured and one can be bypassed in a three-instrument system.

When installing the project, put it *between* the telephone line that feeds the instrument to be secured and its modular-jack box. In a system where more than one instrument is to be secured, install Phone Miser between the *first* instrument in the line's modular-jack box and the phone-line run. Finally, if one or more instruments are to be permanently secured, you can dispense with *S1* altogether.

A final note: Be careful with color coding when connecting Phone Miser into the telephone line. Current must flow in the proper direction through *R1* for the project to turn on. If you experience any turn-on difficulties, recheck your wiring. If it looks okay and the problem persists, try reversing the line connections.

With Phone Miser standing guard, *you* have control over calls made from your telephones. If you had a problem with long-distance calls in the past, you will find that you no longer have one. **ME**