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More than a Modem Monitor

Here's another great project from the Gizmo King.

"Status: Dialing ... waiting for the connect prompt ...
"Verifying user name and password ...
"Logging on to the network ..."

While many a happy "on-line" session has begun with those comments from the monitor, many an unhappy session with the computer has started with just the first statement. Sometimes after the installation of new equipment you may spend several anxious moments waiting for the "connect" prompt. After a few unhappy sessions, waiting for a connect prompt that never appeared, I decided to take some of the guesswork out of the game.

Did the modem "pick up" the phone line? Did the computer really send out dial tones? Did a computer on the other end of the phone line really respond? Was that the voice of the computerized "operator" saying that I had misdialed? I prefer to have my mysteries from another form of the media, commercials notwithstanding.

What's my line?

Knowing some of the characteristics of an ordinary, analog phone line looked like a good starting point. When the telephone is hung up, "on hook" as the telco people call it, an analog phone line has a nominal 48 volts DC across it. When someone, or something like a computer, picks up the phone, and takes it "off hook," the voltage drops to about nine volts. These are NOMINAL values. Do not calibrate your voltmeter by using these values. They are close to the real world and make good guidelines. It amounts to about a 5 to 1 change from an "on-hook" to an "off-hook" condition.

You may use an analog voltmeter, a digital voltmeter, or an LED indicator to let you know when the phone line is in use or when it is available. Additionally, hearing what kind of signal is on the line would be most useful. A simple, isolated audio amplifier could do that: no hi-fi system, just a cheap amplifier. Oddly enough, though, a cheap, solid-state amplifier gives better quality than is needed. Let's take a closer look at what we need and what we can get or make in order to take the guesswork out of our on-line modem connections.

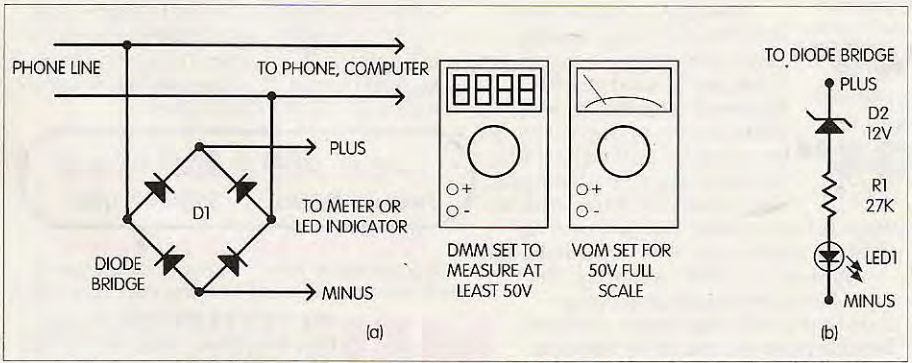

Fig. 1. Line monitor. Direct approach, two methods. (a) Voltmeter across the line. (b) LED indicator.

Voltage indicators

The phone line supplies enough current to drive most analog meters and any digital voltmeter that I have seen, and it will drive an on/off LED indicator with or without some amplification. We will let the phone line supply the current needed for that simple (LED) amplifier.

Photo A. Built-in voltmeter and speaker amplifier let you monitor the status of the phone line as well as hear what is on it.

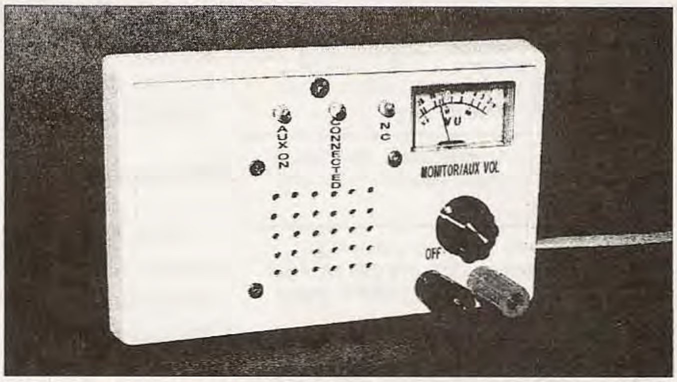

Photo B. A more compact version, but with everything included. Tell at a glance if the computer or the kids are connected to the phone or if they got disconnected. The binding posts on the lower right let you use the monitor as an auxiliary amplifier in the workshop or the ham shack.

A direct approach

Fig. 1(a) shows a direct approach: a voltmeter across the line. In the real world, sometimes the voltage changes from one of the lines being plus to the other one: something about the call going through another switching office. Whatever causes it, the lines can and do change polarity. So, many devices that connect to a phone line have a full-wave bridge rectifier across them. That keeps the voltage going in the same direction to your project: plus to the plus input. Keep in mind that the RING voltage runs around 90 V rms. So do use higher voltage diodes. And of course, your project may need some protection from the RING voltage.

On hook

When the phone is hung up, or on hook, the line sees little or no practical load. The voltage will measure about 48 V DC. As long as your measuring system draws only a small current, it may stay on the line all of the time. In fact, I have an OFF-HOOK indicator, **Fig. 2,** across the line all of the time. In the past, I left a meter like the one in **Photo B** across the line until the LED indicator was available for that duty. While I cannot give you a precise figure, the line does not seem to mind something on the order of one or two mA.

LED me see indicator

Fig. 1(b) shows an LED circuit that will let you know when the phone is on hook. As long as the phone line delivers at least the voltage dropped in the zener diode, plus what the LED needs, the LED will light. Staying within the limits just mentioned, only the extra-bright, high-efficiency LEDs will give a good light at that low a current. Of course, a cheap LED with some shade makes a useful indicator. Still, that makes a good starting point. If the light is lit, the modem did not pick up the line: for that matter, neither

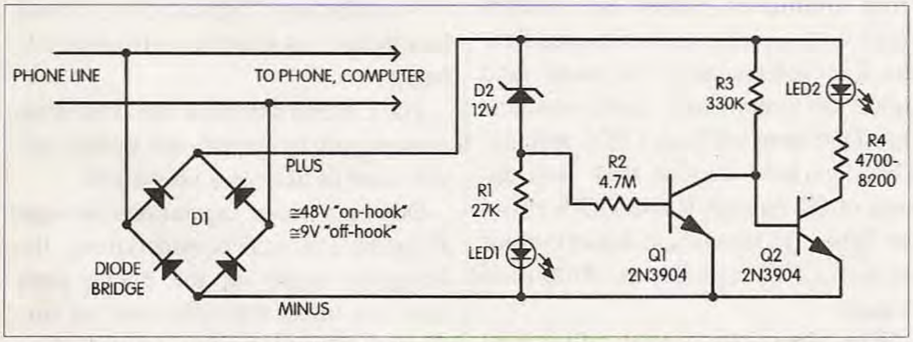

Fig. 2. Off-hook indicator. Tell at a glance if someone else is using the phone, or if it's OK for the computer to go "on-line." While you are at it, let the phone line supply the power. The diode bridge feeds the DC from the phone line to the OFF-HOOK indicator. LED1 shows when the phone is hung up, on-hook. LED2 shows when someone or something has picked up the phone, taken it off-hook. Voltage across the phone line runs about 50 V on-hook, falling to around 9 V off-hook. The different voltage levels trigger either LED1 or LED2: green, red.

R1	27k
D1	Diode bridge, 1 A 200 V bridge, 276-1161; or four 1N4003s, 276-1102 wired as bridge
D2	12–15 V zener diode, 1N4742 (12 V), 276-563; 1N4744 (15 V), 276-564
LED1	Green, orange, or yellow high-brightness LED, 276-206 (orange); 276-205 (yellow); 276-215 (green, not too bright)
Binding posts (274-662) or banana jacks (274-725) (for plugging in meter rather than building in one)	
Meter	0–1 mA (22-410) and a 56k resistor; or use a 39k resistor plus the 15k that comes with the meter
Suggested values for other common meters to get about 50 V full scale:	
0–500 μA	100k for 50 V FS
0–200 μA	250k, 50 V FS; 270k, 54 V FS (220k + 27k standard values will come close to 250k)
0–100 μA	500k, 50 V FS; 560k, 56 V FS (470k + 27k standard values will come close to 500k)
0–50 μA	1 meg for 50 V FS

Table 1. Fig. 1 parts list. Radio Shack part numbers in all parts lists.

did the teenagers at the other end of the house.

The LED, zener diode, and resistors cost little and take up little space. However, it would be nice to know, not by default, but by direct indication, when the modem or the children have picked up the phone. By adding three resistors, two transistors, and one more LED, you have a direct indication. **Fig. 2** gives the simple circuit for an OFF-HOOK indicator.

R1	27k
R2	4M7 (4,700,000 ohms)
R3	330k
R4	4.7k–8.2k
D1	Diode bridge, 1 A 200 V, 276-1161; or four 1N4003s, 276-1102 wired as bridge
D2	12–15 V zener diode 1N4742 (12 V), 276-563; 1N4744 (15 V), 276-564
Q1	2N3904 or equiv., minimum beta, H_{FE} 100
Q2	2N3904 or equiv., minimum beta, H_{FE} 100
LED1	Green, orange, or yellow high brightness (see **Table 1** for P/Ns)
LED2	Red high brightness, 276-086; 276-307 is cheaper and smaller, but perfectly usable

Table 2. Fig. 2 parts list.

Disconnect

Once in a while during a session, the screen says that it cannot find some connection. A quick glance at the LED indicator from **Fig. 2**, or the voltmeter, tells me what happened. The LED went off, and the voltmeter went high, meaning that something caused the modem to hang up. After some annoyance and a little while, the screen says something to the effect that "... connection reset by peer ... try connecting again." Not sure what that means, except that it disconnected the phone line from the computer during a session. For that reason, I built just the circuit of **Fig. 2** and leave that part of the Line/Modem Monitor across the line all of the time. That frees up the system shown in **Photo A** to go to work with my son.

How and why

In either circuit, **Fig. 1(b)** or **Fig. 2**, as long as the line voltage stays above about 18 volts, the zener diode and LED1 will conduct enough current to light the LED. R1, the 27k resistor, limits the current in LED1 to a value compatible with the telephone line. The 4.7 megohm resistor, R2, supplies base current to transistor Q1. That causes enough current to flow through the collector circuit of Q1 to keep Q2 from turning on. When the modem picks up the phone and seizes the line, the line voltage drops to about nine volts: the zener diode quits conducting. That turns off both LED1 and Q1. That lets base current flow into the base of Q2 through R3, the 330k resistor. When Q2 turns on, it draws current through LED2 and R4, the 4700 ohm resistor.

With the values shown, LED2 will have a nominal 1.5–2 mA current. Again, for best results, that calls for one of the high efficiency LEDs. I built some of these "off-hook" indicators before the high-efficiency LEDs were readily available. They worked, but with these LEDs you see the status of the line with less eye strain.

Voltmeter or LED?

Depending upon your particular application, you may find a voltmeter a quick, practical answer. The LED circuit costs little and could be left across the line without tying up a multimeter that has many other uses. When we get to the construction section, we will give this some additional consideration.

What's on my line? Or, hearing is knowing

With some sort of voltage indicator on the line, we can tell when the modem has picked up or seized the line. That does not mean that the modem has sent dial tones or that the intercept operator isn't telling you to "... please hang up and try your call again." Those are messages that your computer cannot readily give to you. Most modems let you program them to give some sort of sound until they connect. Sometimes you can even hear them. We have a cure for that with the other part of the Line/Modem Monitor.

Sound off!

The simple audio amplifier shown in the middle of **Fig. 3** can give you a real earful. It uses readily available parts and draws little current: under eight mA without an input signal. Despite what the spec sheets say, my VOM showed around eight mA, an acceptable level to give reasonable life for a 6–9 volt battery. That can come from a handful of AAA cells or from a 9 V battery.

The LM386 amplifier has more than enough gain to amplify the signals that you want to hear on a phone line.

Due to various regulations brought about by practical considerations, the outgoing signal on the phone lines runs just under 0.8 volts rms for sine waves. The incoming signal runs somewhat lower: around one-tenth of that. The outgoing dial tones from the telephone measured right at 0.77 V. The outgoing dial tones from the computer measured just about 0.5 volts. The dial tones consist of two sine

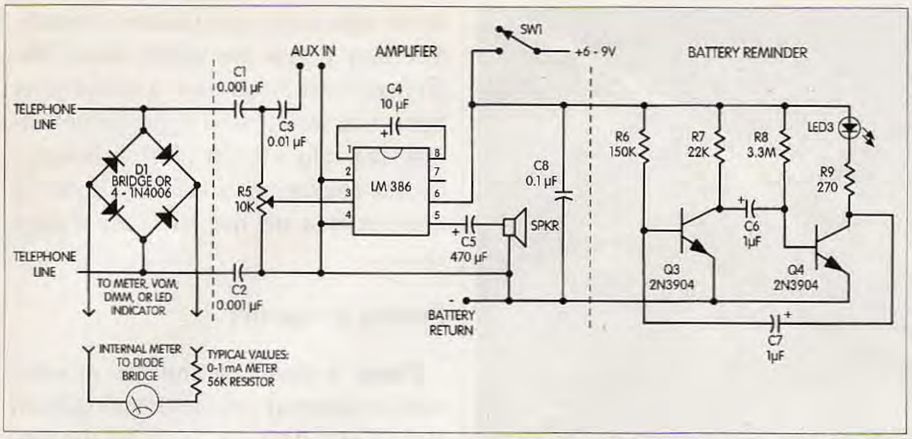

Fig. 3. Line monitor with voltmeter, monitor amplifier, and battery reminder. Meter or LED indicators let you know if the line is in use. Amplifier lets you hear beeps, tones from your computer, as well as incoming signals from the phone line. That includes answering beeps from another computer, as well as messages from the operator telling you to "... try your call again." The amplifier will let this system double as half of a speaker phone. The section to the left of the first dotted line lets you monitor the line voltage. The speaker amplifier sits between the dotted lines. The optional battery reminder is to the right of the dotted lines. It uses little power and its gentle wink can remind you that the unit is still on. The first section may connect to the internal meter which is shown, or it may connect to an external VOM/DMM or the LED OFF-HOOK indicator, ***Fig. 2.***

tones in various combinations to produce the various dial-numbers. The communication tones or pulses from the modem confuse a voltmeter. They are not sine tones. Therefore, the voltmeter cannot give accurate readings unless it is one of the special voltmeters made for this type of measurement. However, those readings can have a useful significance.

The communication pulses from my computer showed up at about the 200 mV level on the analog VOM. A more accurate measurement could be obtained by isolating a scope and connecting it to the phone line. Isolation is necessary because the phone line likes to stay balanced with respect to ground. It does not like grounds on either side of the line.

However, since the VOM is more commonplace, I suspect that most of us find the VOM readings much more practical and meaningful. A cheap DMM showed a nominal 200 mV at the same time the VOM did.

In simple English

Simply stated, you now have some readings that you can use for comparison if you start going rounds with your modem. If you use a VOM to check for these low-level AC signals, use the OUTPUT function or put a 0.1 μF capacitor between the line and the meter to keep the 48 volt telephone "battery" voltage out of the meter.

Setting up the LM386

You may set the gain on the 386 to accommodate the level of interest to you. By adding the capacitor shown in the spec sheets, you have enough gain to hear the incoming pulses, the incoming voice announcements, and, of course, the outgoing tones and pulses. The volume control lets you set a comfortable listening level. You may want a higher volume listening to the intercept operator than when listening to your computer talk to another computer.

DC isolation

As mentioned earlier, with the phone hung up, the phone line has a nominal 48 volts across it, and the ring voltage runs around 75 V (measured) to 90 volts AC at a nominal 25 Hz. Both of these voltages must be kept out of the inputs to the 386. Any size capacitor will keep the DC out, almost. When a blocking capacitor first charges, that could give enough of a pulse to damage the amplifier. Use a small capacitor and give it a parallel path to use for charging, and that will protect the amplifier. Really, it works. The 10k volume

C1, 2	0.001 μF 100 V
C3	0.01–1 μF
C4	10 μF 16 V
C5	470 μF 10 V
C6, 7	1 μF 10 V
C8	0.1 μF 10 V
R5	10k pot, 271-215 (includes On/Off switch)
R6	150k
R7	22k
R8	3M3 (3meg3, or 3.3 megs, or 3,300,000 ohms)
R9	270
Q3, 4	2N3904 NPN, minimum beta, H_{FE} 100
LED3	Red (276-068), green (276-069) — cost a bit more than others, but have a nice holder
LM386	Low power audio amplifier
8-pin DIP socket	For LM386
D1	see **Table 1**
Binding posts, banana jacks	see Table 1; jacks also used if you want to wire the AUX IN
SW1	On/Off; SPST, 275-406 (if you do not use the pot/switch above)
Meter and suggested values for other meters	see **Table 1**
Speaker	2 inch replacement type, 40-250 or a 273-092 8 ohm (4–16 ohms OK). Spkr may be as large as you like, 1 inch to on-sale 5 x 7 inch oval (bigger box needed)
Box	ABOUT 7 x 4 x 2" for system shown in **Photo A**. Smaller box (270-213) will work if you build just part of the system, or the unit shown in **Photo B**. See what they have in stock when you get there.
Circuit board	Perfboard, an easier-to-wire PCB from Far Circuits (see caption).

Table 3. Fig. 3 *parts list. PCB available from Far Circuits, 18 N 640 Field Court, Dundee IL 60118; (847) 836-9148; [farcir@ais.net]; $5.00 each.*

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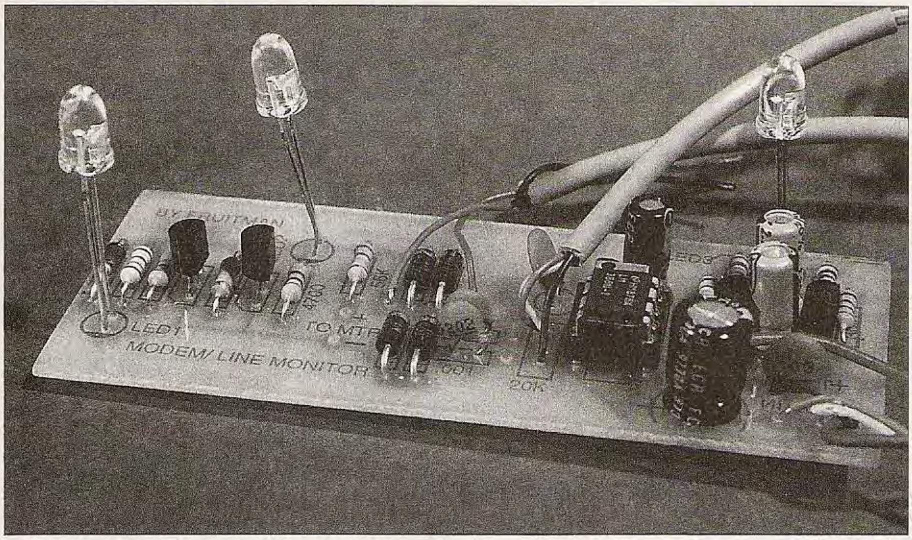

Photo C. Printed circuit board used in the second unit, Photo B. Center of board, D1, diode bridge. To the right of that, C1, C2. I used 0.002, as they were handy. Changed them to 0.001 as called for in the circuit due to an apparent problem with slower network connections. The smaller the caps, the better. To their right, the connections to the volume control. This prototype board says 20k, but the actual value is 10k. Amplifier to the right of that. Lower right is C5, 470 µF cap going to the speaker. Above that is the battery reminder and LED3. LED1 lower left.

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control combined with the two 0.001 µF capacitors in **Fig. 3** do just that.

The 25 Hz ring voltage sees a nominal 12 megohms looking at the 0.001 µF capacitors. That sends an insignificant part of the ring voltage to the input of the amplifier. If the volume control is wide open, and if my arithmetic is close, that would be around 0.2 volts. With the amplifier on, I have heard a series of pulses when the phone rang. That also meant that I got to go on-line later — after the children got off the line.

Photo D. Interior view of model B (Photo B). AUX INPUT upper left of photo. Notch in box for input connector with RJ11 plug. Volume control and ON/OFF switch, top center. Notch in circuit board allows it to fit in this box, which has a special compartment for a 9 V battery.

Another advantage of a small capacitor lies in its ability to reject low frequencies. The nominal 25 Hz ring voltage is much lower than the lowest frequency of interest in this application. So, a small capacitor will help reject both the DC voltage and the unwanted low frequencies.

Battery reminder

The battery reminder shown on the right side of **Fig. 3** can save you some consternation. You may want to include it in other battery-operated projects. It draws little current, and the friendly wink from the LED can remind you that the project is on and draining the batteries. In this case, it's a slow drain; in other projects, it might be a faster fade for forgotten battery-operated equipment.

The circuit consists of a simple cross-coupled amplifier, which makes it an oscillator, with the LED in series with one of the collectors. With the values shown, the LED will flicker on about once every two to three seconds. You may juggle the values about 20–30 percent and still have a useful pilot light. You would want to juggle or "adjust" the values to get a faster flicker, a slower flicker, or a brighter light, or because you do not have the values shown.

Putting it together

Photo A shows the finished monitor with an internal voltmeter and built-in RJ11 jacks. This one includes the amplifier and the battery reminder. You could save a bit of work by replacing the meter with a pair of jacks and simply plugging in your VOM/DMM. You could use one of the LED indicators. Either method will tell you at a glance if someone, or the computer, picked up the line.

Photo B shows a somewhat smaller model that includes everything. It has the internal voltmeter, the LED indicators, and the speaker amplifier. The modem connections consist of a wire with modular plug coming out of the unit. That saves a lot of panel space, and a lot of milling. You can get around the lack of loop-through feature by using a double plug, the type that lets you connect two plugs to the same jack. **Photo D** gives an interior view of this system. For those who like to make their own boards, **Figs. 4–6** give you the layouts.

Milling, drilling

A piece of graph paper taped to the front panel may help with the layout. Place the parts on the paper and mark their positions with pencil. That makes it easy to change if needed. The graph paper can prove most helpful if you use the speaker amplifier. By drilling on the grids, you can get nice, uniform holes for the sound, without having to put an external grill on the box. I figured that one out after cutting a large hole for the speaker and making a speaker grill out of a piece of perfboard. It covers up my 'machining' in **Photo A**.

Although I found the layout shown in **Photo A** convenient, you may make it to your liking. I used the extra large

Phone Lines

Many of us have seen the notation REN 1 on a telephone device. After checking with several authorities, I found a definition for that. It means that when the device is "on hook" hung up, it will draw no more than about 1 μA: The telephone device should not exceed that nominal limit. Actually, all of the devices connected across that line should not total more than REN 5. At least, that is my understanding of REN, Ringer Equivalence Number.

A public utility may complain if one of the systems shown in **Figs. 1, 2,** or **3** is left on the line. They should have little to say if you momentarily connect a circuit across the line in order to determine the state of that line. When trying to tell if a phone is dead or if it is the line, I have hung an analog voltmeter (Simpson 260) across the line for a few seconds.

A private telephone system, such as we have at work, has not complained, and the circuit of **Fig. 2** has proved most helpful.

If you remove everything to the left of C1 and C2 (the first dotted line) in **Fig. 3**, the rest of the circuit should not give the public utilities cause for concern. The audio amplifier will let you monitor the outgoing and incoming audio signals. The battery reminder will remind you that the amplifier is on.

Once the modem picks up the phone line, you could reconnect the first part of the circuit and have the advantage of a visual indication of the state of the line.

The voltmeters shown in **Fig. 1** draw more current than the public utilities like to see leaking out of their system. You could replace the meter with an electrometer, an ultra-high impedance meter, but that defeats the purpose of the system: It becomes a complex instrument instead of a simple, practical method of getting useful, needed information. You could use CMOS circuitry and suitable resistors to limit the current to the 4–5 μA range.

If you remove LED1 and R1 in **Fig. 2**, you should have an OFF HOOK indicator that complies. The impedance presented by the combination of the 4.7 meg resistor and the transistor figures out somewhere in the area of 15 times the minimum that they, the phone company, like to see.

In short, this article shows how to make some systems that can help you determine the state of the phone line and let you monitor the signals where that is permitted. Some of the public utilities may or may not object to your using this on their line. A private, in-house system probably will not. You will have to determine if it is suitable for your application.

I have found these systems useful while tracking down problems involving dial-up telephone connections, whether for a simple voice connection or for a computer/modem connection.

binding posts because they were available. That saved a trip to the store. There is nothing critical about how or where the parts go in the monitor.

First, drill pilot holes for everything. Then, make the large holes for the RJ11, modular jacks, should you choose that option. If you use an internal meter, make a hole for it next. Mount it last. I suggest the large holes first as they are the ones most likely to give the most trouble. On some occasions, they have given enough trouble that I had to start over: new cover.

I try to mount as much as possible on the cover. That preserves the box and simplifies the wiring. The battery holders mount on the inside of the box. The handle came from a hardware store. It is a drawer pull and looks so much nicer than the "electronic equipment" handles. You can get the drawer pulls in a variety of decorator colors: the chrome and the bright brass go well with most decors.

Photo B, a better way

The more compact unit shown in **Photo B** has the smaller binding posts. The trick with the graph paper worked

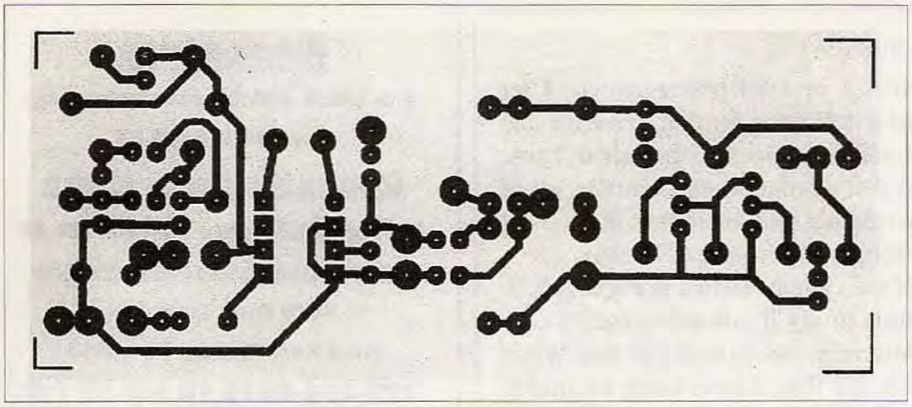

Fig. 4. Foil side 1:1.

well. It worked especially well since my neighbor Walt Olson was kind enough to mount the speaker, the LEDs, the board, and particularly the meter. He likes to spend time with his mill. I let him. The meter came from an old tape recorder and would have strained my "machining" abilities beyond the limit. Walt managed to cram 10 pounds of parts into the proverbial 9-pound box. That is why the model in **Photo B** is so much smaller than the unit in **Photo A**.

Circuit boards

The model in **Photo A** uses perfboard. However, one of the extra nice but inexpensive boards from Far Circuits went into the unit in **Photo B**. That makes construction almost a snap. As **Photo C** shows, you can populate as much of the board as needed for your application. That could include the amplifier, the battery reminder, and the OFF-HOOK indicator.

The only problem that I have had with the boards came from missing a solder connection or two. When you finish soldering the board, go over it with a reading glass and a bright light, looking for solder whiskers that extend from one run to the next. Also, look for unsoldered wires sticking through the board. That's what I said, too, until I had to go back over a board to see why it did not work.

Checkout time

If your version includes just a meter and the modular jacks, plug a suitable cord into the phone line and into the monitor. The meter should read near full scale, about 50 volts. Take a phone off-hook: The meter should drop down to about 9 volts. The NC and C marks on the meters in **Photos A** and **B** indicate Not Connected and Connected.

LED indicators

If you chose the single LED indicator of **Fig. 1(b)**, it should light when you connect the input to the phone line. Taking a phone off-hook should turn off the LED. If it does not, take a voltmeter and check the phone-line voltage. It should have dropped to around 7–9 volts. Hang up the phone and put the voltmeter across the zener diode. It should read 12–15 volts depending upon what you used. If it reads around 1/2 to 3/4 volt, disconnect the unit and reverse the connections to the zener diode. If the cathode, the end with the band, reads minus, reverse the leads from the diode bridge to the indicator.

Make sure that the LED went in the right way. Put a clip lead across the zener diode and connect a nine volt battery across the resistor and the LED. Even at that low current level, the LED will give a visible glow. If you want to be real sure, hang two or three nine volt batteries in series and try it again.

Off-Hook Indicator

If you went for the full feature OFF-HOOK indicator, **Fig. 2**, all of the above applies. When LED1 turns off, LED2 should light. You can test that with a single nine-volt battery in place of the diode bridge. Watch that you put the plus to the top of the circuit, minus to the transistor emitters. If LED2 does not light, put a clip lead from the

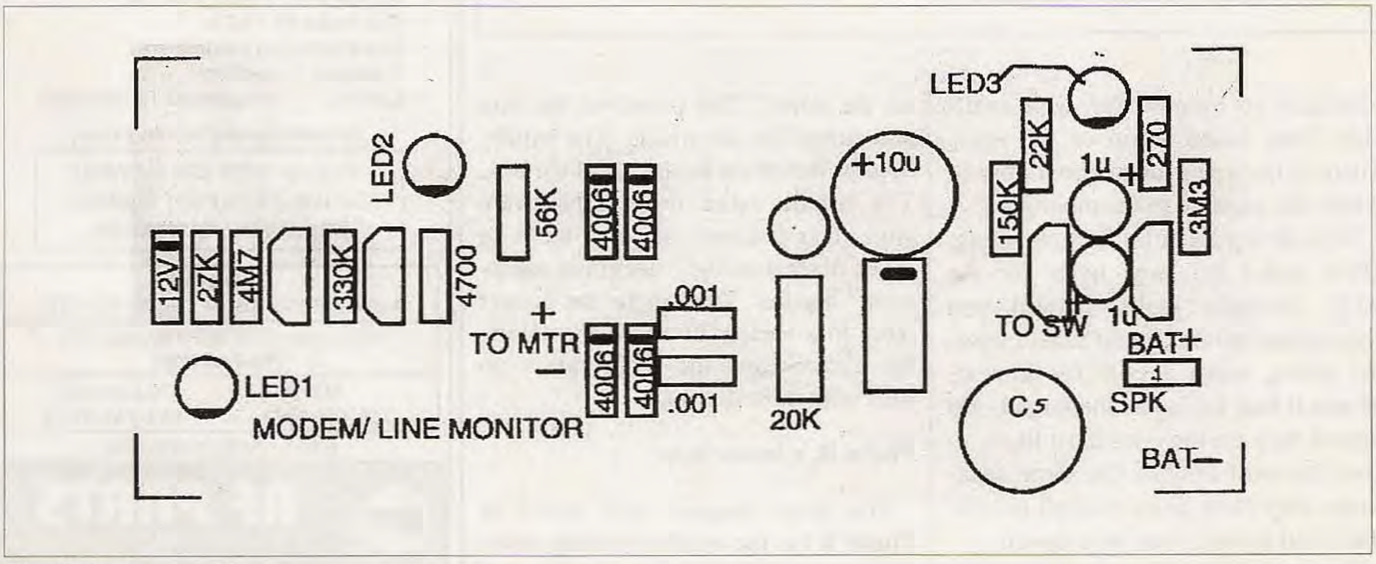

Fig. 5. Component side.

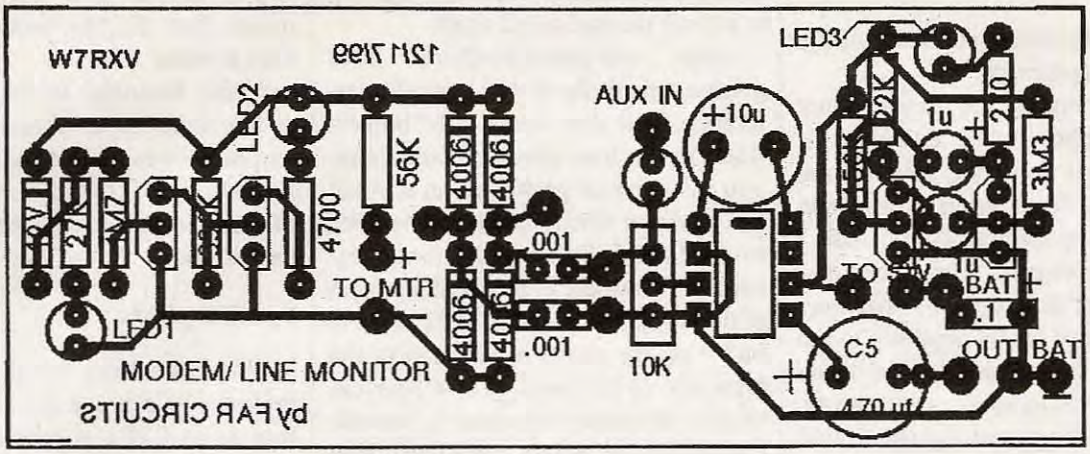

Fig. 6. X-ray view of board.

collector of Q2 to its emitter. If the LED still stays dark, check that the anode of the LED goes to the battery plus.

You are most likely to encounter these problems with perfboard construction. With a PC board from Fred, if you have a malfunction, it will probably come from a diode getting into the board the wrong way, or a missed solder connection.

Special (bug) feature

After my neighbor, Walt, kindly packaged a unit for me, I gave him a board of his own to play with. He said that when his computer went on line the red LED lit as it should. But, if he turned a bright desk light on the green LED (LED1), LED2, the red LED, turned off. After we verified that the LED did indeed respond to incoming light, I looked for a cause and a cure.

The cure came in the form of a resistor shunted across the green LED (LED1). Any value from 10k to 1 meg works well. It seems that you can excite the elements in an LED by driving a current through them the normal way, or you can shine a bright light on them and they will generate a voltage. In fact, some of them even give off their characteristic glow. I thought that it was just an overactive imagination until I asked the right people some questions.

I checked with George, ex-WA6CJZ, to find out just what was happening inside the LED. He teaches physical chemistry at Arizona State University. I work in the same department. George had a simple (to him) explanation. When a bright light hits the interior of the LED, it excites electrons. They move to a higher plane, then drop back to their original state. In the process they give off a photon and generate a nominal 1+ volts. They have only a minute current available when excited by a bright light. An ordinary DMM or VOM loaded down the "LED battery" and showed practically no output. I measured it on a scope and later on an electrometer. Under those almost ideal conditions, a red LED showed about 1.3 volts and a white LED showed close to 2 volts. The white LED has more voltage across it when driving it the normal way with a battery and a current-limiting resistor: about 3.5 volts. So, I would expect to see a bit more voltage across it when exciting it with a strong light.

With the output of the LED battery going into a high impedance circuit, **Fig. 2**, R1 and R2, it delivered enough voltage and current to turn Q1 back on turning off Q2 and LED2. Mystery solved. Annoyance abated. Walt wanted to use it as a photocell. I just wanted the OFF-HOOK indicator to work as I had seen them work for a number of years.

One more "special" feature

I happen to live in a relatively high RF field: 0.6 V/M day, 1.2V/M night. While working for local radio stations I measured that several times. A 5000-watt station has its four-tower array less than two miles from my home. Guess where the main lobe is at night. Once in a while it took a filter to get

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them out of the phone and some of my short-wave equipment.

After connecting the newer Line/Modem Monitor to the computer, it seemed that at times the network ran really slowly. No, I mean slower than normal. I lit up the old 486/66 with a DOS E-mail program. The screen displayed lots of cryptographs that may or may not have meant anything to the computer. I pulled the L/MM loose and the cryptographs went away. Winding the long cord tightly around the L/MM cured it, too. A quick check showed that the network was running at a more normal speed again.

Some computers/modems have greater sensitivity to that type of interference. This one seems to be borderline. If you think that RF could cause you this type of problem, put a small RF choke or ferrite beads in the lines to the L/MM. To keep the local "listen" show host out of the auxiliary input of the first L/MM, I put a 7 mH choke (I had it on the shelf) in series with the high side of the input. A 0.001 μF capacitor effectively bypasses it. According to my arithmetic, anything from 500 μH and up should give effective suppression.

Speak out

If you added the speaker amplifier, turn it on, and if you used the battery-reminder option, watch for the flickering LED. A good pretest consists of putting a milliammeter in series with one of the battery leads, or across the ON/OFF switch with the switch in the OFF position. It should read around 5-10 mA depending upon the battery voltage. If it reads nothing or too high, look for missed connections or shorts.

Amplifier testing

Normally, the amplifier gets its input from the phone line. However, since a utility amplifier has many additional applications, I added an external input, the oversize binding posts in **Photo A**: the AUX IN. Before connecting the unit to the phone line, you may feed a low level signal into the EXTERNAL INPUT terminals and listen for the sound. Fifty to one hundred mV from a radio or a signal generator will drive the amplifier to full output. Do not expect hi-fi, but rather a sound like you would hear from a communications receiver.

If that sounds good, disconnect the signal generator, plug the amplifier into a phone line, and turn down the volume. Pick up a phone on the same line and dial a number. You should hear the tones loud and clear. You will have to mute the telephone mic or keep it away from the speaker to prevent acoustical feedback. The first time that you hear that, it may sound like music to your ears because it means that the box works, however, after a while ...

While listening to the modem, a sound level meter indicated that the amplifier was delivering an uncomfortably loud 90 dB SPL at a distance of one meter. The amplifier still had gain to spare.

Speaker phone

When you have the telephone mic muted, you can use the amplifier feature as half of a speaker phone. Call one of the telephone on-line services and get an earful without having to hang on to the telephone receiver.

Modem, at last

When everything looks good, connect the monitor to the phone line and to your computer. You will need a second cord for the version in **Photo A**, or a two-to-one jack for the unit in **Photo B**. The two jacks are wired in parallel, so either one can go to the phone line. If you have either the voltmeter feature, or one of the LED indicators, you should know at a glance the state of the phone line. If no one else has the line tied up, tell your computer to connect to a remote site. You should hear the dial tones followed by the beeps, squeaks, and other assorted sounds that accompany a successful connect, or silence to indicate a successful disconnect.

You can get an idea of what is going on when you send a fax from your computer to another computer or to a regular fax machine. In addition to what the computer screen says, I get useful information regarding the progress of the fax transmission from the speaker amplifier. It also lets me monitor E-mail sessions and "search" sessions without having to keep an eye on the light or the meter to see why the computer cannot find some host. Try it a couple of times. I think you will like it.

Now, during your on-line sessions, you will be able to confirm the statements on your computer screen by glancing at your Line/Modem Monitor or by listening to it. 73