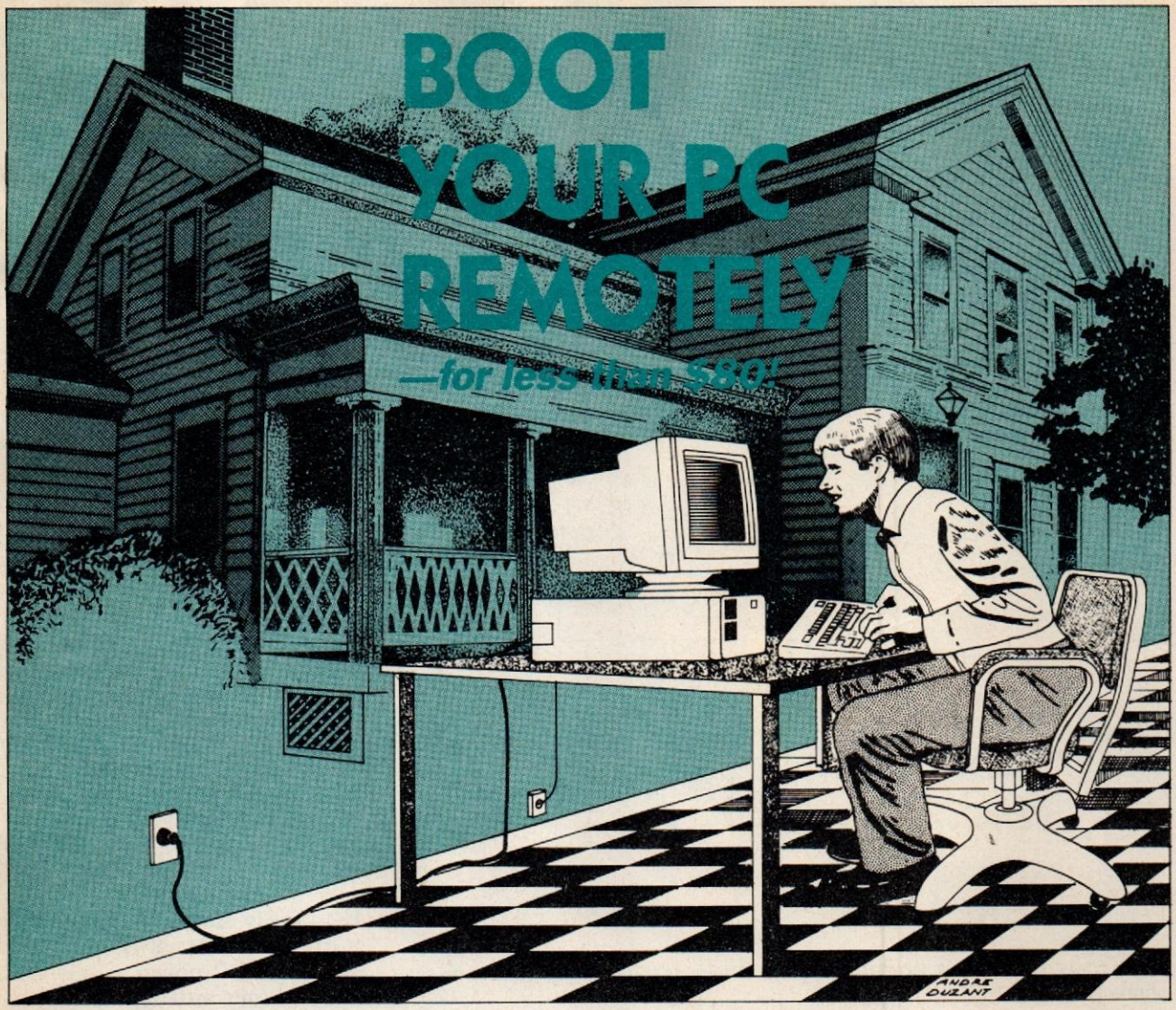


Part 2 of building a remote-boot controller for your PC.

THOMAS E. BLACK

RING-THING IS AN INEXPENSIVE YET extremely useful telephone-based AC power controller. You connect Ring-Thing to your phone line, and an AC-powered device to Ring-Thing. When Ring-Thing recognizes a set number or pattern of ring signals, it turns on a relay that applies 117 volts AC to whatever is plugged into the power strip. After the phone connection terminates, Ring-Thing waits about five minutes and then removes power from the power strip. Ring-Thing can control both computers and other equipment.

Last time we described operating modes and began a detailed circuit description. This time we'll complete the circuit description and move on to construction details. You can order partial and complete parts kits, and software can be found on the RE-BBS (516-293-2283, 1200/2400, 8N1).

In the descriptions that follow, remember that the control unit has three separate ground circuits: analog for the ring detector, digital for the microcontroller and functional units, and a separate relay ground.

LPT interface

Referring to Fig. 4 (shown last time), ports PB0 and PB1 of the microcontroller support the PC power-down feature by detecting inputs from the parallel port of a PC. Those inputs receive a stream of two-bit code values from a standard Centronics parallel printer port (LPT1–4). There is no false triggering because Ring-Thing must receive a specific series of codes.

The PC interface also depends on the microcontroller's PA7 output, whose main function is to control the LED2 (POWER), but which is also used to provide a handshaking signal. (The LED drive circuit was shown last time in Fig. 5.) Incidentally, LED2 will blink while Ring-Thing sends handshaking messages, but normal operation will resume thereafter.

The PC interface circuit, shown in Fig. 6, works as follows: Optoisolators IC3–IC5

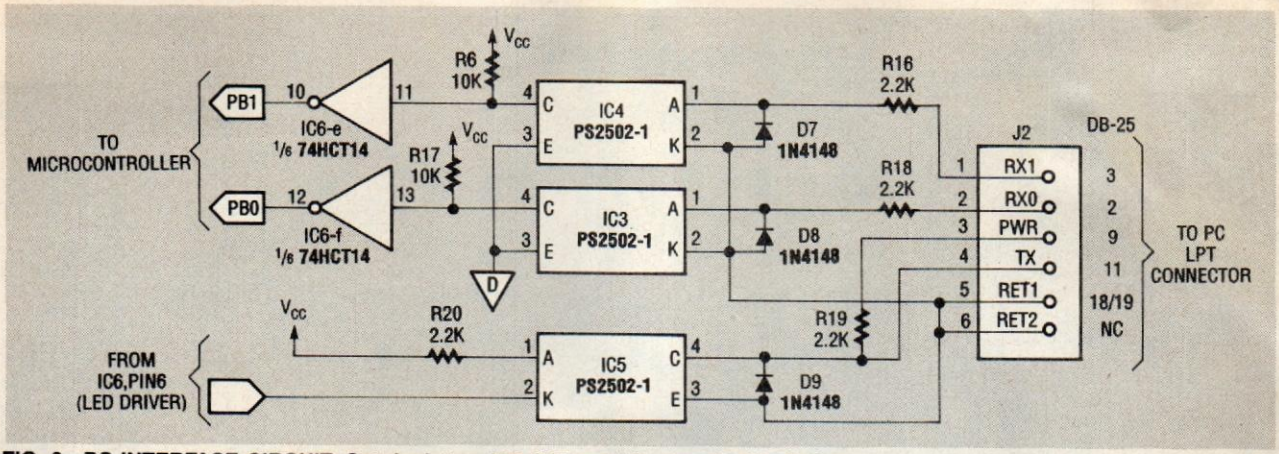


FIG. 6—PC INTERFACE CIRCUIT. Optoisolators IC3–IC5 provide electrical isolation between Ring-Thing and the attached PC.

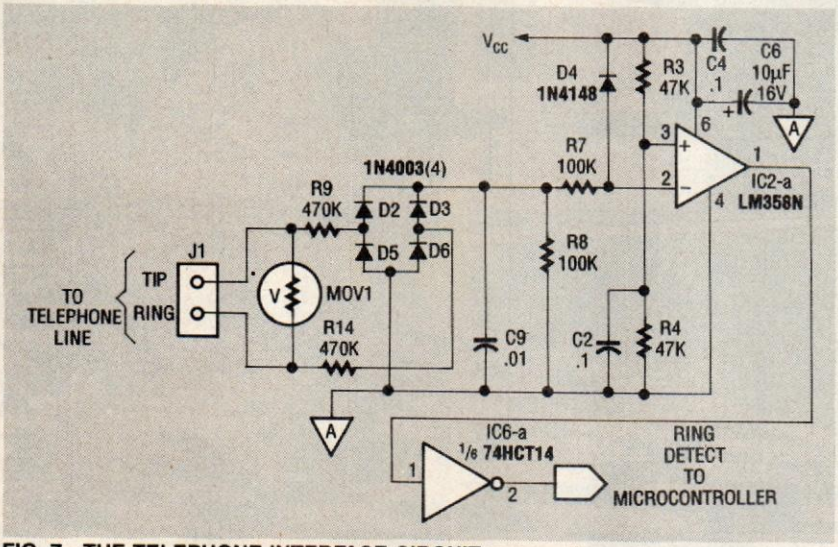


FIG. 7—THE TELEPHONE INTERFACE CIRCUIT senses the voltages present on the phone line.

provide electrical isolation between Ring-Thing and the attached PC. The Schmitt triggers in IC6-e and IC6-f condition the optoisolator outputs for the microcontroller. Diodes D7–D9 protect the optoisolators from reverse voltages that might occur if the interface were accidentally plugged into a PC's serial (RS-232) port.

Telephone interface

The telephone interface circuit, shown in Fig. 7, senses the voltages present on the phone line. A standard phone line sits at −48-volts DC when it is not in use (on-hook). When it is in use (off-hook), the nominal voltage is approximately −7-volts DC. While ringing, the phone receives a 90-volt 20-Hz AC signal. Because of the circuit's high input impedance (about 1 megohm), the phone line does not recognize that Ring-Thing is connected.

Surge absorber MOV1 protects against minor lightning strikes. Diodes D2, D3, D5, and D6 form a bridge rectifier and provide polarity protection. Op-amp IC2-a functions as a voltage comparator with a threshold reference of 2.5-volts DC, provided by the R3/R4 voltage divider. Resistors R9, R14, and R7 scale the rectified phone-line voltage by a factor of 1/10. Diode D4 limits the attenuated ring voltage present at IC2-a to safe levels. With the phone line on-hook, the input voltage at pin 2 of IC2-a is about 4.8-volts DC, which when compared with the 2.5-volt reference sets the op-amp's output (pin 1) high. Schmitt trigger IC6-a inverts that signal and feeds it to the microcontroller's active-low $\overline{IRQ}$ input (pin 4).

If the phone line goes off-hook, the input voltage at pin 2 of IC2-a drops to about 1 volt, which sets the output of IC2-a high. That, in turn, raises the output of IC6-a and triggers the microcontroller's interrupt input. If the phone is ringing, the output of IC6-a switches at the 20-Hz AC-ringing frequency. The microcontroller firmware can quickly determine whether the phone is ringing or simply off-hook.

DC supply and AC connections

Figures 8-*a*, 8-*b*, and 8-*c* show the DC power supply, AC transformer, and bypass capacitor wiring, respectively. The bypass capacitors in Fig. 8-*c* mount on the main board, as do the DC supply components in Fig. 8-*a*. The transformer and relay in Fig. 8-*b* mount on a separate board that installs inside the AC power strip. The main circuit board installs in a separate case.

The power supply (Fig. 8-*a*) provides several interesting features. Bridge BR1 rectifies the 12-volt AC input, which after filtering by C17 powers the switching relay. The unregulated DC voltage also drives IC8, which provides 5 volts for the digital circuitry. The regulator IC differs from most in that it has very low quiescent current drain, and operates with minimal input voltage. If AC power goes down while Ring-Thing is in operation, battery B1 can re-

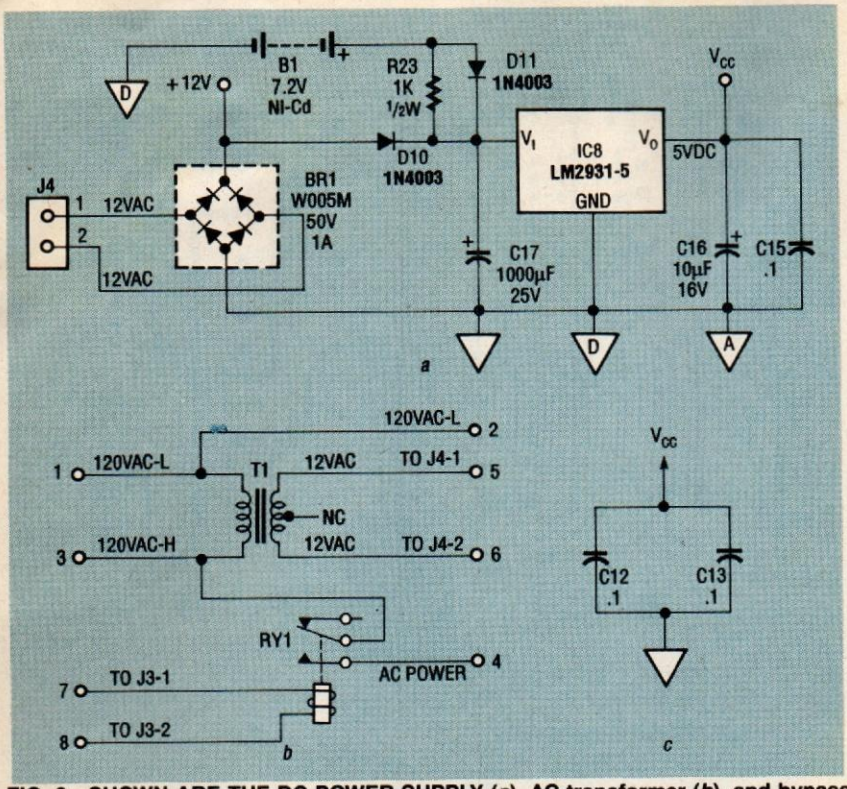


FIG. 8—SHOWN ARE THE DC POWER SUPPLY (*a*), AC transformer (*b*), and bypass capacitor wiring (*c*).

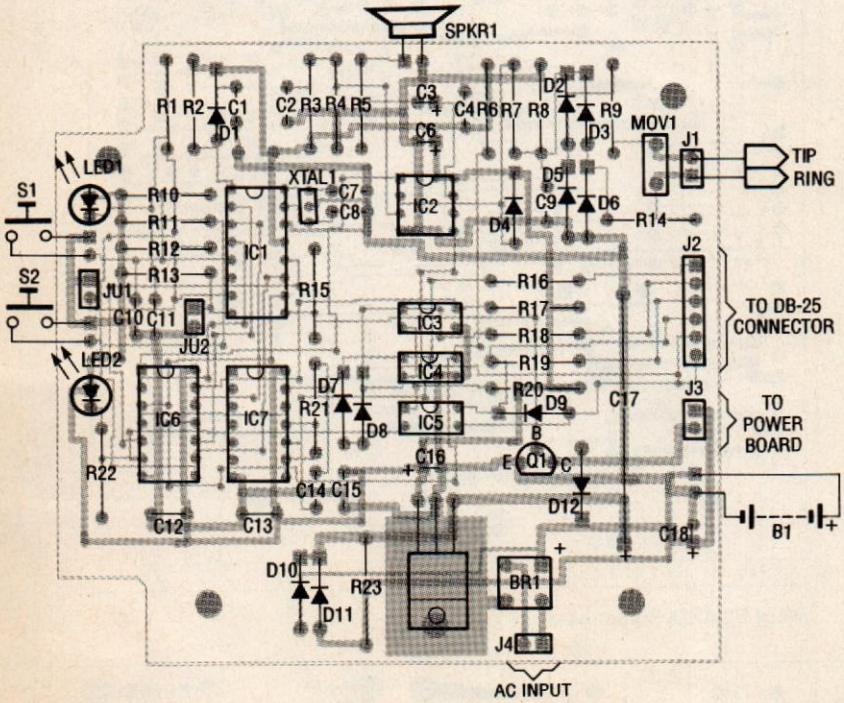


FIG. 9—PARTS-PLACEMENT DIAGRAM for the main board. If you do not want the PC power-down feature, do not install IC3–IC5, D7–D9, R16, R18–R20, and the DB-25 cable.

tain settings for about two hours. In general, all components were chosen carefully to minimize current drain and maximize battery life.

Diode D10 isolates the AC transformer during power failures, and steering diode D11 provides battery voltage to regulator IC8. Battery B1 is a rechargeable nickel-cadmium (Ni-Cd) type packaged like a traditional transistor-radio battery. It actually puts out 7.2–8.4 volts DC, which is more than adequate to drive the regulator. During AC operation, resistor R23 limits end-of-charge current to less than 5 milliamps. Note: *Do not install R23 if nonrechargeable batteries are used.*

Now that we understand how Ring-Thing works—let's put it together!

Construction

First a few general notes. Use a 25–47 watt soldering iron; temperature-controlled irons set at 700–800° work best. Use only 60/40 rosin core solder. Use the components shown in the Parts List; substitutions are not recommended. Be especially careful in selecting parts for the telephone interface—low-leakage components are a must! Read through all assembly instructions before beginning, and make sure you understand each step before continuing.

Component XTAL1 can be either a quartz crystal or a ceramic resonator. Delete C7 and C8 if you use a ceramic resonator with built-in capacitors. Use care in handling the IC's; they are static discharge-sensitive CMOS devices that can be damaged through mishan-

TABLE 4—POWER CABLE WIRING

Function	Jack/Pin No.	Cable Color
Relay power	J3/1	Red
Relay ground	J3/2	Black
12 VAC	J4/1	White
12 VAC	J4/2	Green

TABLE 5—POWER DOWN CABLE WIRING

J2 Pin No.	Cable Color	DB-25 Pin No.
1	White	3
2	Green	2
3	Red	9
4	Brown	11
5	Black	18+19

dling. Use high-quality sockets for all IC's, especially IC1 (the microcontroller).

Foil patterns for both PC boards have been provided; component-mounting diagrams for the main and power boards appear in Fig. 9 and Fig.

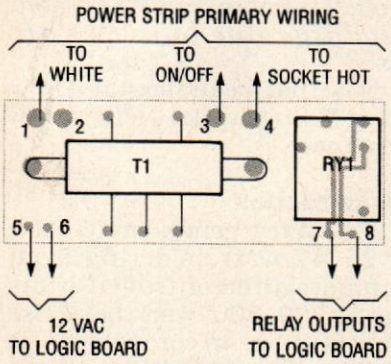


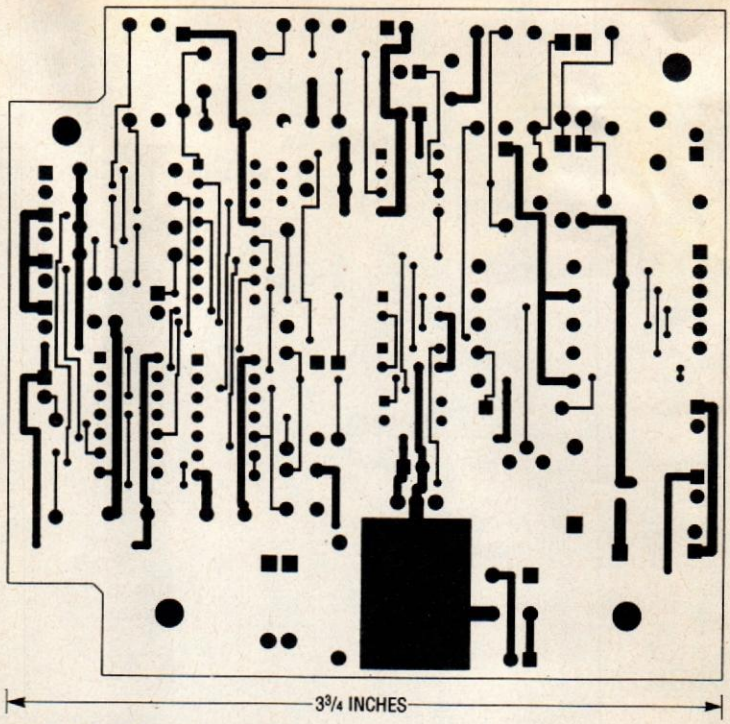
FIG. 10—PARTS-PLACEMENT diagram for the power supply board.

ORDERING INFORMATION

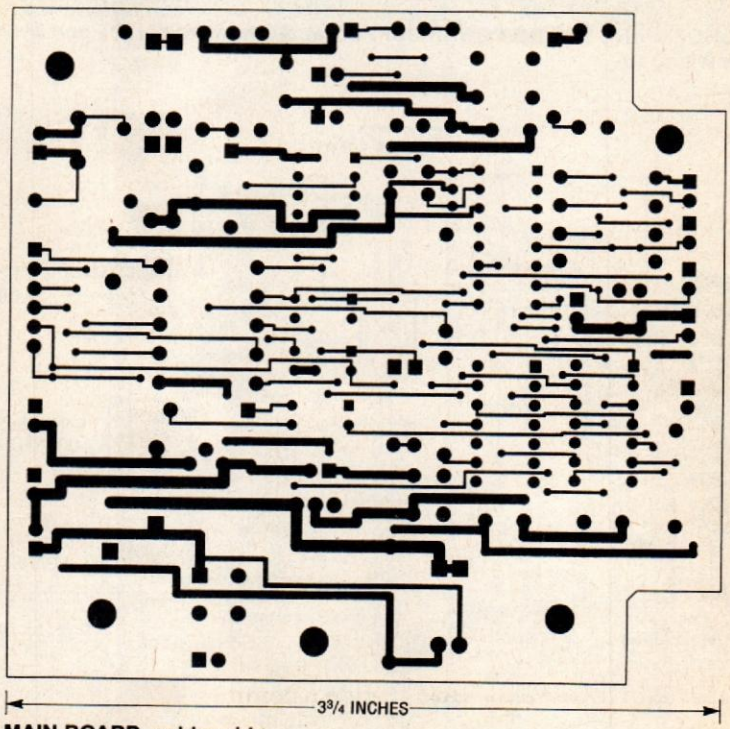
The following parts are available from Digital Products Company, Attn: Thomas E. Black, 134 Windstar Circle, Folsom, CA 95630, 24 hr phone/FAX: (916) 985-7219:

- **Ring-Thing Kit (all components, programmed microcontroller, enclosure, PC board set, documentation (no PC power-down feature)—$79.95**
- **PC power-down kit (parts, DB25 cable, and software)—$9.95**
- **Basic kit (PC board set, microcontroller, transformer, relay, software, and documentation)—$59.95**
- **PC board set (#RT001)—$24.95**
- **Programmed MC68HC705K1 microcontroller—$14.50**
- **Six-outlet metal power strip with fuse kit—$16.00**
- **Rechargeable battery (9-volt Ni-Cd)—$7.00**
- **Documentation package with schematic—$4.75**
- **PC software (5-inch disk only, includes RT.EXE source)—$7.50**

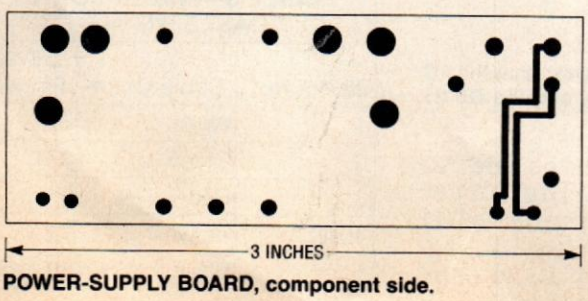
All orders add $4.50 S&H ($9.50 to Canada). CA residents add applicable sales tax. U.S. funds only. MasterCard and Visa accepted. Prices subject to change.



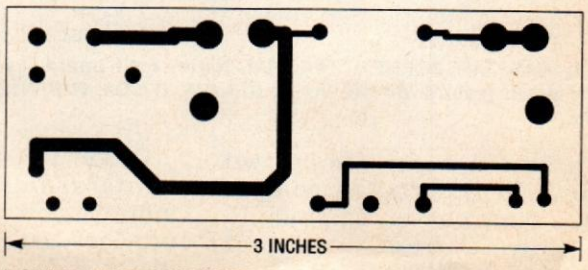
MAIN BOARD, component side.



MAIN BOARD, solder side.



POWER-SUPPLY BOARD, component side.



POWER-SUPPLY BOARD, solder side.

```
      RING-THING PC CONTROL
          Version 1.00
        Copyright (c) 1992
        By Thomas E. Black
        Digital Products Co
        134 Windstar Circle
        Folsom, Calif 95630
          (916) 985-7219

-> From DOS, Execute RT.EXE as shown below:
   RT [/LPTn ¦ /LPT:nnnn] {/NOPRT} {/STAT ¦ /OFF}

   USAGE NOTES: [] = Required, {} = Optional, ¦ = Or
   /LPTn ..... LPT Port Number, where n = 1,2,3,4.
   /LPT:nnnn . LPT Port I/O Addr, where nnnn is addr (hex).
   /NOPRT .... Don't Print Status Messages to Screen.
   /STAT ..... Return Status Value (see /NOPRT).
   /OFF ...... Shut Power Off (w/ 1 Minute Delay).
```

FIG. 11—THE SOFTWARE ACCEPTS command-line parameters to specify which LPT port and which I/O port you use, and a built-in help screen, shown here, that you can view by typing RT or RT /? at the DOS prompt.

10, respectively. Using those figures as a guide, mount all components. Note: *If you do not want the PC power-down feature, do not install IC3–IC5, D7–D9, R16, R18–R20, and the DB-25 cable.* Be sure to orient all the polarized components properly on the board.

Anchor the voltage regulator to the PC board with a 4-40 × ½" machine screw. Install the main PC board in a small plastic enclosure with two machine screws mounted at opposite corners (it is not necessary to use all four screw locations).

By carefully bending the LED leads, you can insert them through the PC board and still have the bezel protrude through the front of the enclosure.

After mounting all components, trim any long component leads, and clean the flux off the circuit board, especially in the telephone interface area.

Install and label S1 and S2 on the enclosure's front panel. Check for proper clearance around the speaker, drill the vent holes, and then glue the speaker to the lid of the case.

Now make the external connections. Connect the Tip input of the telephone interface to the red wire and the Ring input to the green wire of the modular telephone cord. Solder the red and black leads of a snap-type battery holder to the appropriate inputs on the PC board. Be sure to observe correct polarity.

Drill two holes at the rear of the enclosure for the three cables: four-conductor power, modular telephone cord, and (optional) five-conductor PC power-down. Limit the cable length to seven feet each for best results.

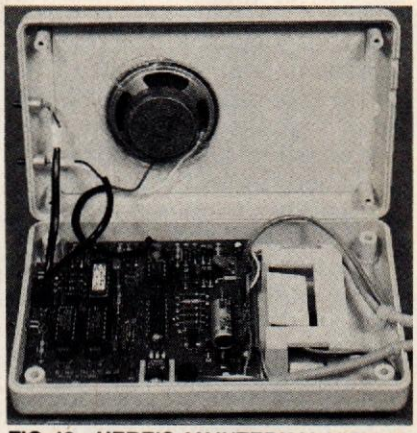


FIG. 12—HERE'S AN INTERNAL VIEW of the main board.

Wire the power cable to the main PC board as shown in Table 4. If you will use the PC power-down feature, wire a DB-25 male to the main PC board as shown in Table 5.

The power board mounts inside a common six-outlet power strip. Use a metal unit that is screwed (not riveted) together. For safety, remove the strip's 15-amp circuit breaker and replace it with a 6-amp fuse. The reduced current limit will provide greater protection for the power board's relay—and your computer equipment.

Carefully mount the PC board on plastic standoffs, and verify that no part of it contacts the power strip's conductive surfaces. For best results, install the board near the main power switch. Some power strips may require removal of one outlet to provide room for the PC board. If so, cover the opening with a blank plate.

TABLE 6—STATUS MESSAGES	
0	Abort: <message> (Usage Error)
1	Power is Off
2	Power is On
3	Power Fail: Power is <off/on>
4	Power is shutting Down
5	Auto Answer Mode
6	Unit Not Connected to PC
7	Unknown Status

Install the relay contacts in series with the hot side of the power strip's outlets by disconnecting the black 120-volt AC wire at the output of the switch. Then solder the free end to the power board at pad four. (Refer back to Fig. 3 for explicit wiring details.) The other end of the wire should still be connected to the outlets in the strip. You might want to replace the wire with an equivalent stranded wire to ease handling. Using 14-gage insulated wire, connect the power strip's 120-volt AC wiring to the power PC board. Drill a hole in the power strip near the PC board, mount a plastic strain relief, insert the four-conductor cable, and connect the ends referring to Fig. 3 and Table 4.

Double check all wiring to ensure accuracy. Any mistakes could be exciting—and dangerous—so use an ohmmeter to ensure that nothing is shorted. While you are at it, inspect the existing wiring for cold solder joints and look for loose screws (most power strips are poorly assembled). Last, reinstall the power strip's cover.

Now let's test the circuit. If any of the following tests do not give the as specified results, correct the problem before continuing. Note: *If troubleshooting is necessary you must use AC-isolated test equipment. Use battery-powered devices or an isolation transformer. Failure to do so will cause in-*

correct operation of the telephone-interface circuit.

LED and switch tests

1. Disconnect the line cord from your phone system. Plug a table lamp into the power strip as a test load.

2. Apply AC power and listen for a short beep. Verify that the table lamp is off.

3. Observe that LED1 (green) is flashing rapidly, and that LED2 (red) is flashing somewhat slower. This LED combination indicates that Ring-Thing has detected a power failure.

4. Press S1 (ON/STANDBY); you should hear a short modulated beep. Now LED1 should be blinking slowly, and LED2 should be off. Push S1 again; the modulated beep should sound, and LED1 should go out.

5. Press S2 (POWER ON/OFF); you should hear a short beep. Now LED2 should be on, and so should the table lamp. Hold S2 down; you should hear a beep, and both LED2 and the table lamp should go out. (Be sure to hold S2 for a moment; this push-and-hold requirement prevents power loss if the switch is bumped accidentally.

Power fail battery test

1. With AC power still applied, install Ni-Cd battery B1.

2. Turn LED1 back on by pressing S1. Disconnect AC power and verify that the green LED continues to blink.

3. Leave the battery in place and restore AC power.

Telephone interface tests

1. Unplug the table lamp from the power strip and plug in your computer.

2. Now plug the modular phone cord into a spare telephone jack or the back of your modem. Correct operation requires that you use a standard telephone line. Electronic keysets and PBX's are not compatible. If you can use a generic telephone or modem, Ring-Thing will probably work; if you use a special telephone set, Ring-Thing will probably not work correctly.

3. With the phone line connected, verify that LED1 blinks when a telephone is in use (off-hook), and that the LED lights steadily when the phone line is inactive.

4. Enable ring-counting mode by installing jumper JU1. Enable answer on one ring by removing jumper JU2.

5. Configure Ring-Thing as described above so that LED1 is on and LED2 is off.

6. Have someone call you and verify that Ring-Thing chirps and that LED1 flashes rapidly while the phone rings. Also, computer power should be enabled after the first ring, and LED2 should be blinking slowly to indicate ring-activated power.

7. Have the caller hang up and then do not use the phone. After about four minutes LED2 will flash rapidly, indicating that power will shut down shortly. With one minute remaining, a continuous warning tone will sound. After five or six minutes, computer power will turn off, warning beeps will cease, and LED2 will stop blinking.

If the phone line is placed off-hook during this step, the shut-down mode will be reset. In that case, merely wait an additional 5–6 minutes after the phone line becomes inactive.

Software usage

You can control Ring-Thing power via software. The software is available from the author and from the RE-BBS (516-293-2283, 1200/2400, 8N1). The file is called RINGTHNG.EXE; it is a self-extracting archive that contains source and object code for the PC control program, and object code for the firmware.

Create a directory for the software on your hard disk, put a copy of RINGTHNG.EXE there, and then run it. Several files will be extracted into the directory; READ.ME explains the purpose of each. The file called RT.EXE is the only one required to operate Ring-Thing. You may want to move it to a utilities directory.

Connect the DB-25 connector to a spare LPT port; you can use LPT1–4. The software accepts command-line parameters to specify which LPT port and which I/O port you use. The program has a built-in help screen, shown in Fig. 11, that you can view by typing RT or RT /? at the DOS prompt.

Note that the LPT port parameter is required whenever you communicate with Ring-Thing. For example, if you were connected to LPT2 and wanted to view current status, you would type: RT /LPT2 /STAT followed by the Enter key. Assuming a proper connection between Ring-Thing and your PC, you would see one of the messages listed in Table 6.

The numerical values in column one are ERRORLEVEL numbers returned by the program; your batch files can use these values to branch to appropriate routines. (See your DOS manual on how to use the IF statement to test ERRORLEVEL values.) Also, include the /NOPRT parameter before the /STAT switch to obtain ERRORLEVEL values without displaying screen messages.

Although the program is designed for PC (or compatible) operation, the C++ source code could easily be modified for other architectures. Or you could use it as the basis of your own custom application.

Power down test

1. Plug the DB-25 connector into your LPT1 printer port. (Any LPT port could be used, but for the first test, use LPT1.)

2. Turn on your computer by pushing S2.

3. Execute RT.EXE by typing RT /LPT1 /OFF-CS followed by pressing ENTER key.

4. You should immediately hear the one-minute warning beep, and LED2 should be flashing. After one minute the PC will shut off. To cancel the power-down, tap S2.

Final installation

Ring-Thing's handy AC power switch will let you place your tested unit in a convenient location. One recommended mounting arrangement uses velcro or double-sided tape to mount it to the side of your computer case or monitor. **R-E**