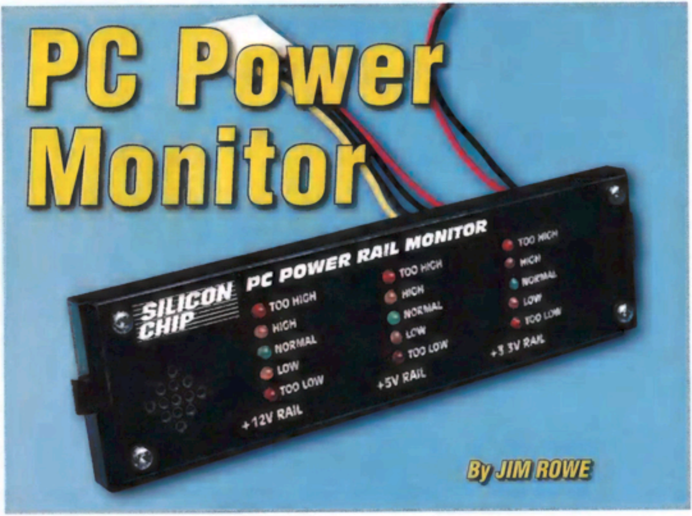
# PC Power Monitor




By JIM ROWE

**Does your PC crash intermittently? Maybe the hard disk or something else within the machine is not getting the right rail voltage but how would you know? This unit lets you easily monitor the main power rails – it clips into your PC and has three LED bargraphs and an alarm to indicate if any of the supply rails swings too high or too low.**

AS WELL AS HAVING to provide a number of different DC voltages, your PC's power supply has to deliver an appreciable amount of power – hundreds of watts. This is the main reason why switchmode power supplies are used, because they're much more efficient than the older "linear" type of power supply. However, they're also more complex and this tends to make them slightly less reliable.

Also, some PC power supplies really do have trouble supplying all that current and sometimes they fail to deliver just the right voltage at critical times – like when you are in middle of a big download off the Internet. If you build this unit, it will give you a visual and audible warning of the problem so that you can have it fixed.

Of course, apart from data loss, if a PC's power supply does happen to develop a fault, this can have quite disastrous (and costly) consequences. Replacing a blown CPU chip can involve many hundreds of dollars, while replacing blown DIMM modules can be almost as costly.

Fortunately, many of the latest PC power supplies incorporate special circuitry to detect when any of the main power rail voltages fail or go high and shut down the supply if such a fault occurs. However, such protection circuitry does not always do the job, so this monitoring circuit can still be a worthwhile addition. It's good to know that if a fault develops, you'll be warned straight away so you can "pull the plug" before much damage is done.

So that's the idea of this project. It's a low-cost, easy-to-build circuit which can continuously monitor the main power rails in a PC and display their status via columns of LEDs. At the same time, whenever it senses that any of the rail voltages has moved out of the safe operating range (too high or too low), it sounds a small piezo buzzer to draw your attention to a possible problem.

How many supply rails does it monitor? The answer is "just three" but they are the three that are now the most important. These are the +12V line (used for the motors on most disk drives), the +5V line (used for most of the logic on drives and plug-in cards) and the +3.3V line (used to power the memory modules, the chipset and motherboard logic and the CPU).

By the way, as you can see from Table 1, PC processor voltages have varied a great deal in recent years. In most cases, the processor supply voltage(s) are derived from the +3.3V line from the power supply, either directly or via a DC-DC converter, which has its output voltage(s) set either manually by jumper shunts on the motherboard or automatically via "VID" (voltage identification) coding pins on the processor itself. So in most cases, it's sufficient to monitor the +3.3V line in order to keep an eye on processor voltage.

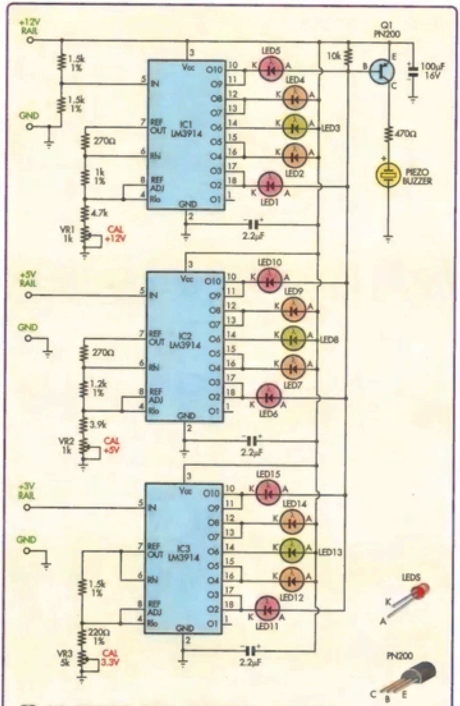
The only exception to this is with the latest generation of PCs using very fast P4 processors, where the chip's DC-DC converter is run from the motherboard's auxiliary +12V line (rather than the +3.3V line) in order to be able to supply the extra power. In these cases, monitoring the +12V line is probably sufficient to keep an eye on processor voltage, although you'd still be advised to monitor the +3.3V line as well because this is used for the memory modules and the chipset.

## Forget -5V and -12V

It isn't really necessary to monitor the -5V line any more, because this was actually only used by a few of the older ISA bus cards (like RS-232C serial port and modem cards). Similarly, it's no longer necessary to monitor the -12V line, because this too is rarely used in most PCs made in the last 10 years or so.

So by monitoring just the +12V, +5V and +3.3V lines, we're likely to be able to detect just about any fault in a PC power supply that could result in data loss or damage to critical circuitry or components.

It's very easy to monitor the +12V and +5V lines, because these are available from any disk drive cable connector – and there's usually at least one of these spare. The +3.3V line is a little more awkward, though. You generally have to run one or two wires connecting directly to the motherboard at the main power connector. We'll give you the details of this later in the article.




**PC POWER RAIL MONITOR/TESTER**

**Fig.1: the circuit is based on three LM3914 dot/bar display driver ICs (IC1-IC3) – one to monitor the +12V rail, one for the +5V rail and one for the +3.3V rail. Each IC drives five LEDs which indicate the status of each supply rail at a glance.**

## How it works

To keep the project as simple as possible, each of the three power lines is monitored by an expanded-scale LED voltmeter circuit based on an LM3914 dot/bar display driver IC. As you can see from the circuit diagram (Fig.1), IC1 is used to monitor the +12V line while IC2 and IC3 monitor the +5V

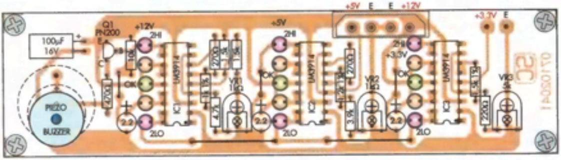



**Fig.2: install the parts on the PC board as shown here, taking care to ensure that all polarised parts are oriented correctly. Note that trimpots VR1-VR3 are mounted on the copper side of the board.**

and +3.3V lines respectively.

Although each LM3914 has 10 output lines, designed to drive 10 LEDs in a normal dot or bar type display, here we use only nine of the outputs to drive a total of five LEDs per chip. Output O6 in the centre of each chip's voltage range is used to drive the green "OK" LED for that power line, while the remaining eight outputs are connected as four tandem pairs to power the "HIGH", "TOO HIGH", "LOW" and "TOO LOW" LEDs for each supply line.

All three ICs are actually powered from the PC's +12V line and the LEDs are all connected to this line as well. This means, of course, that if the PC's +12V line fails completely, the complete monitoring circuit will go dead as well. But as this in itself will be a clear indication that your PC's power supply has a serious problem, we don't see it as a disadvantage.

As you can see, the inputs of IC2 and IC3 are connected directly to the +5V and +3.3V rails of the PC. However, to allow IC1 to correctly monitor the +12V rail, we use a simple 2:1 resistive voltage divider to allow it to monitor half the voltage – ie, a nominal +6V rail which is directly proportional to the +12V rail.

The reference voltage and sensing range of each IC are tailored using the resistors connected to pins 4, 6, 7 & 8 to give the correct "centre voltage" and measuring range for each of the three voltage rails. But each IC also has a trimpot (VR1, VR2 and VR3), so that each monitor can be calibrated independently for correct indication and alarm sensing.

By the way, calibration trimpot VR3 has a higher value than the other two so that the centre of IC3's sensing range can be adjusted to suit whatever voltage is used in the PC for running the CPU. So you're not forced to monitor just the motherboard's +3.3V line; you can monitor the actual CPU supply voltage if you prefer. We recommend that you do monitor the +3.3V line though, because it's easier to do this and therefore less risky.

How do we do the alarm sensing? Ah, that's easier than you'd think. As you can see, the three LEDs which are used to indicate "OK", "HIGH" and "LOW" in each monitor are all connected directly to the +12V line. So when any of these LEDs is illuminated (because there's no serious problem), nothing else happens.

On the other hand, the LEDs at the top and bottom of each monitoring range (ie, LED1 and LED5, etc) are not connected directly to +12V but instead to an "alarm sense" rail which in turn connects to the +12V rail via the base-emitter junction of transistor Q1.

This means that if any of the ICs happens to detect a "TOO HIGH" or "TOO LOW" condition and lights one of these LEDs, this draws base current through Q1 and turns the transistor on. As a result, it conducts collector current and turns on the piezo buzzer. Nifty, don't you think?

**PROCESSOR SUPPLY VOLTAGES**

| Motherboard Setting | Processor |
|---|---|
| 'VRE' (3.5V) | Early Intel Pentium, AMD K5, Cyrix 6x86 |
| 'STD' (3.3V) | Later Intel Pentium |
| 'MMX' (3.3V & 2.8V) | Intel MMX Pentium |
| '3.2V' (3.3V & 3.2V) | AMD K5 |
| '2.9V' (3.3V & 2.9V) | AMD K6, Cyrix 6x86/M-II |
| '2.4V' (3.3V & 2.4V) | AMD K6-2, K6-3 |
| '2.45V' (3.3V & 2.45V) | Cyrix 6x86LV |
| AUTO VOLTAGE SELECTION VIA VID CODING* | |
| 10000 (3.5V) | Intel Pentium Pro (4 VID pins) in Socket 370<br>CPU voltage derived from motherboard 3.3V line |
| 10001 (3.4V) | |
| 10010 (3.3V) | |
| 10011 (3.2V) | |
| 10100 (3.1V) | |
| 10101 (3.0V) | |
| 10110 (2.9V) | |
| 10111 (2.8V) | |
| 11000 (2.7V) | |
| 11001 (2.6V) | |
| 11010 (2.5V) | |
| 11011 (2.4V) | |
| 11100 (2.3V) | |
| 11101 (2.2V) | |
| 11110 (2.1V) | |
| (11111= No CPU) | |
| 00000 (2.05V) | Intel Pentium II, Celeron, PIII (5 VID pins) in Slot 1, Pentium 4 in Socket 423 & 478; also AMD Athlon & Athlon XP in Slot A and Duron in Socket A<br>CPU voltage derived from motherboard 3.3V line (or auxiliary 12V for later P4 processors) |
| 00001 (2.00V) | |
| 00010 (1.95V) | |
| 00011 (1.90V) | |
| 00100 (1.85V) | |
| 00101 (1.80V) | |
| 00110 (1.75V) | |
| 00111 (1.70V) | |
| 01000 (1.65V) | |
| 01001 (1.60V) | |
| 01010 (1.55V) | |
| 01011 (1.50V) | |
| 01100 (1.45V) | |
| 01101 (1.40V) | |
| 01110 (1.35V) | |
| 01111 (1.30V) | |
| *Voltage selection by four or five coding pins on CPU itself | |

## Construction

All the components for the power monitor are mounted on a compact PC board measuring 146 x 38mm and coded 07102041. This board is designed so that it can be mounted directly behind a 5.25-inch drive blanking plate, with the status indicator LEDs protruding via matching 3.5mm holes. An array of even smaller holes at one end of the panel allows the sound from the piezo buzzer to emerge.

Fig.2 shows the parts layout. All parts are mounted on the top side of the PC board except for the three calibration trimpots (VR1-VR3) and the PC board terminal pins, which are used for the power input connections.

The location and orientation of all of the components can be seen clearly in the board overlay diagram. As usual, fit the wire links first, so that you don't forget them. The three short vertical links can be made from tinned copper wire or resistor lead offcuts, while the two longer horizontal links (near the bottom edge of the board) should be made from insulated hookup wire.

Once the links are in, fit the six PC board terminal pins that are used for the input connections. As mentioned earlier, these are fitted from the rear of the board and soldered on that side as well.

The fixed resistors can go in next, making sure that you fit each one in the correct position. That done, install the three 2.2μF tantalum capacitors – they all mount with their positive leads towards the top of Fig.2. The last capacitor to fit is the 100μF electrolytic but note that although it mounts on the front of the board as usual, it is mounted on its side to provide clearance when the board is mounted behind a blanking plate or box panel. This capacitor is also mounted with its positive lead uppermost.

The next components to fit are transistor Q1 and the three LM3914 ICs. Note that the ICs all mount with their notched (pin 1) ends facing downwards, as shown in Fig.2.

### Fitting the LEDs

You're now ready to fit the 15 LEDs. These are all 3mm-diameter types and there are three green LEDs, six orange LEDs and six red LEDs as shown.

They should all be mounted with 10mm lead lengths (ie, the bottom of each LED should be 10mm above the board), so they they'll later all protrude evenly through the holes in the front panel when the board is mounted behind it. The easiest was to do this is to cut a short strip of cardboard 10mm wide and then fit each column of LEDs with their leads straddling the cardboard strip. That way, they'll all be automatically set to the correct height before their leads are soldered. It's a simple trick but it works well.

By the way, notice that each LED is fitted with its cathode (flat side) towards the right.

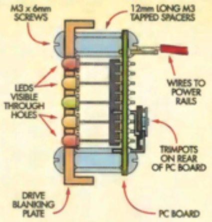
The last component to fit to the front of the board is the small piezo buzzer. This mounts directly to the board via two pins. Because there are several different types of buzzers available, with different pin spacings, we've provided extra pads and holes on the board for flexibility. Note that the buzzer's negative pin should always go through the bottom hole.

### Installing the trimpots

The final components to fit are the three trimpots, which mount on the back (ie, copper side) of the PC board. This is done so that they're easy to adjust from the back when the board is mounted on a blanking plate or panel. Make sure you use the 1kΩ trimpots for VR1 and VR2, and the 5kΩ trimpot for VR3.

Once the board is fully assembled, you can place it aside for a few minutes while you drill the holes in the blanking plate or box panel. You can use a photocopy of the front panel artwork (Fig.5) as a drilling guide and template. Note that the holes for the LEDs and the four board mounting holes (in the corners) are all 3.5mm diameter, while those for the buzzer "grille" are 2mm in diameter.

Once the holes in the blanking plate have all been drilled and deburred, you might want to attach another photocopy of the artwork to the front




SIDE VIEW SHOWING ASSEMBLY DETAIL

**Fig.3: this diagram shows how the PC board is secured to the rear of the blanking plate using 12mm spacers and M3 x 6mm machine screws. The LEDs protrude through matching holes in the blanking plate – see text.**

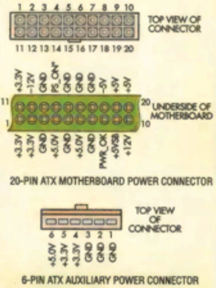



**Fig.4: here are the pin connections for a 20-pin ATX motherboard power connector and for a 6-pin ATX auxiliary power connector which is sometimes used on older motherboards.**

**Table 1: Resistor Colour Codes**

| | No. | Value | 4-Band Code (1%) | 5-Band Code (1%) |
|---|---|---|---|---|
| ❑ | 1 | 10kΩ | brown black orange brown | brown black black red brown |
| ❑ | 1 | 4.7kΩ | yellow violet red brown | yellow violet black brown brown |
| ❑ | 1 | 3.9kΩ | orange white red brown | orange white black brown brown |
| ❑ | 3 | 1.5kΩ | brown green red brown | brown green black brown brown |
| ❑ | 1 | 1.2kΩ | brown red red brown | brown red black brown brown |
| ❑ | 1 | 1kΩ | brown black red brown | brown black black brown brown |
| ❑ | 1 | 470Ω | yellow violet brown brown | yellow violet black black brown |
| ❑ | 2 | 270Ω | red violet brown brown | red violet black black brown |
| ❑ | 1 | 220Ω | red red brown brown | red red black black brown |

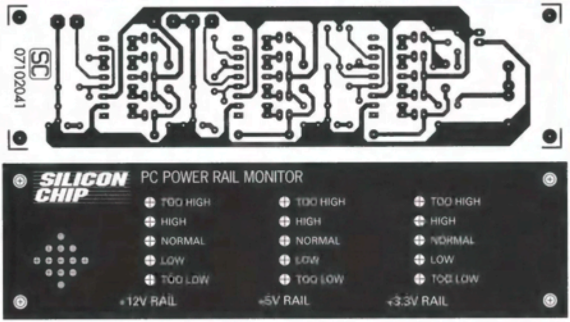




**Fig.5: here are the full size artworks for the PC board and front panel. Check your board carefully for defects by comparing it against the above pattern before installing any of the parts.**

using double-sided tape, so it will dress the panel up and give a professional look. Alternatively, you may be able to buy a kit of parts that includes a professionally made "sticker" for the front panel.

The PC board assembly can now be mounted behind the panel on four 12mm-long M3 tapped spacers and secured using 6mm-long M3 machine screws. Fig.3 shows the details. We suggest that you also fit a star lockwasher under each of the rear mounting screws, to ensure that they don't loosen with vibration.

## Connecting it up

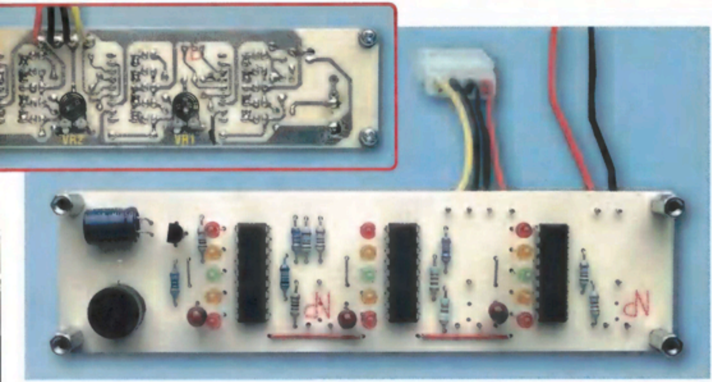
The easiest way to connect the +12V, +5V and earth (ground) inputs of the monitor board to the corresponding power rails of the PC is by cannibalising the 4-pin plug and one set of wires from a disk drive "Y adaptor" power cable. These are readily available from computer stores and electronics suppliers. The free ends of the wires are then soldered to the four main input pins on the monitor board but make sure you connect them correctly: the red wire goes to the +5V input, the yellow wire to the +12V input and the two black wires to the centre ground pins.

The 4-pin plug can then be mated with one of the power connectors in the PC, to make all these connections.

The connections to the PC's +3.3V rail are a little trickier but simple and safe enough if you're careful. To do this, solder a pair of insulated hookup leads about 500mm long to the two remaining pins on the monitor board, using wire with orange insulation for the +3.3V lead and wire with black insulation for the ground lead. That done, remove the cover from your PC so you can gain access to the underside of the motherboard, just below the main power connectors.

In most PCs made in recent years, you should find that the main DC power lead from the power supply mates with the motherboard using a 20-pin Molex type plug and socket (called the ATX power connector). If that's the case with your PC, you can connect the +3.3V and ground wires from the monitor to the underside of the 20-pin motherboard connector, to pins 1, 2 or 11 (orange wire) and 3 (black wire) respectively. Fig.4 shows


**The completed PC Power Rail Monitor simply clips in the front of the PC's case, in place of an existing drive blanking plate.**




The above view show the completed PC board from the top, while the inset shows how the three trimpots (VR1-VR3) are mounted on the copper side.

how to identify the pins on the motherboard ATX connector.

On some earlier model PCs, you may find that this 20-pin ATX connector is "missing". Instead, there will be a pair of 6-pin in-line main power connectors (P1 and P2), together with a third 6-pin in-line connector providing the +3.3V power and an additional +5V line. This is known as the 6-pin ATX auxiliary power connector (see Fig.4)

If your PC has this arrangement, the +3.3V lead from the monitor board (orange) should be connected to either pin 4 or pin 5 of the auxiliary connector (under the motherboard), while the remaining ground wire (black) can be connected to either pin 2 or pin 3.

If your PC is even older and doesn't even have the ATX auxiliary connector but just the P1 and P2 connectors, this means that it doesn't have a +3.3V rail. In that case, you won't need to worry about monitoring the non-existent +3.3V rail, so simply remove the orange and black wires from the monitor board pins and ignore the third column of LEDs (which won't light anyway).

## Calibration

Calibrating the monitor is quite easy but you'll need a reliable digital voltmeter. The basic idea is that you will be adjusting the relevant trimpot for each of the monitor's three LED voltmeters so that the green LED glows when the input voltage is at the correct nominal value for that power line. When this is done, the other LEDs will glow for the correct higher and lower voltage levels.

Step one is to measure the +12V line with your DVM. If it's very close to the correct reading (say within ±100mV of +12V), all that you then need to do is adjust trimpot VR1 until the green LED glows steadily in the first column of LEDs. In fact, you should set VR1 to the centre of the small adjustment range over which the green LED glows.

What if the PC's +12V rail actually measures a little below 11.9V, or a little above 12.1V? That's no great problem but it does mean that you should adjust VR1 so that one of the two orange LEDs glows instead – ie, adjust VR1 so that either the lower orange LED is just glowing if the voltage is just below 11.9V, or the upper orange LED is glowing if it's just above 12.1V.

Calibration of the +5V and +3.3V monitors is done in exactly the same way. You simply measure the actual voltage of these power rails first with your DVM, then adjust each trimpot so that either the green LED or one of the orange LEDs for that monitor is glowing, depending on the reading on the DVM.

## Parts List

1 PC board, code 07102041, 146 x 38mm
1 piezo buzzer, PC mount
6 1mm PC board terminal pins
4 12mm x M3 tapped spacers
8 M3 x 6mm machine screws
4 M3 star lockwashers
2 1kΩ horizontal trimpots (VR1, VR2)
1 5kΩ horizontal trimpot (VR3)

**Semiconductors**
3 LM3914 display drivers (IC1-IC3)
1 PN200 PNP transistor (Q1)
3 3mm green LEDs (LEDs 3, 8, 13)
6 3mm orange LEDs (LEDs 2, 4, 7, 9, 12, 14)
6 3mm red LEDs (LEDs 1, 5, 6, 10, 11, 15)

**Capacitors**
1 100µF 16V RB electrolytic
3 2.2µF 35V TAG tantalum

**Resistors** (0.25W, 1%)

| | |
|---|---|
| 1 10kΩ | 1 1kΩ |
| 1 4.7kΩ | 1 470Ω |
| 1 3.9kΩ | 2 270Ω |
| 3 1.5kΩ | 1 220Ω |
| 1 1.2kΩ | |

Once you've set all three trimpots in this way, your PC Power Rail Monitor is calibrated and ready for use. **SC**