READERS' TECHNICAL ENQUIRIES

We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years' old. We are not able to answer technical queries on the phone.

PROJECTS AND CIRCUITS

All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it. A number of projects and circuits published in EPE employ voltages that can be lethal. You should not build, test, modify or renovate any item of mains-powered equipment unless you fully understand the safety aspects involved and you use an RCD adaptor.

COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured; these can be supplied by advertisers in our publication Practical Everyday Electronics. Our web site is located at www.epemag.com

We advise readers to check that all parts are still available before commencing any project.

VOLTAGE MONITOR by ROBERT PENFOLD

Keep an eye on your battery's condition with this low-cost starter project.

This simple *Voltage Monitor* device has two light-emitting diode (LED) indicators that switch on if the monitored supply voltage falls below separate threshold levels. The obvious application is in battery operated equipment where erroneous results could be obtained if the battery potential falls below a critical level.

Having twin threshold levels is very useful, as one can be set slightly above the critical voltage, and it will then give a warning if the battery will soon need replacement. The circuit can also be used with mains powered equipment to monitor the DC supply voltage, and it will then give a warning if the supply voltage drops to an inadequate level due to a malfunction.

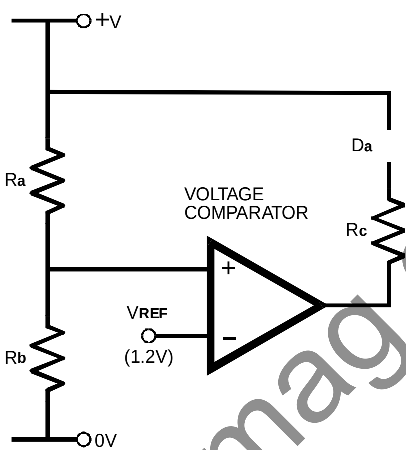


Fig.1. The basic arrangement for each voltage

ON THE THRESHOLD

With the specified resistor values the circuit provides threshold potentials of 10V and 12V, but by altering the values of four resistors these voltages are easily changed. They can be set at any potentials from about 3·5V to 30V, but note that the supply voltage to the monitor circuit must never exceed 36 volts. The mathematics required to work out the modified circuit values is extremely simple – more later.

For battery monitoring applications the current consumption of the monitor is a critical factor. There is no point in having a monitor that draws such a high supply current that battery life is greatly reduced.

This circuit has a typical current consumption of around 0·6mA under standby conditions. This should not greatly reduce the operating life of even a low capacity battery such as a PP3 type. The current consumption increases by about 4mA per LED when the circuit is activated.

COMPARATOR

The *Voltage Monitor* circuit is based on the two voltage comparators in an LM393N IC. A voltage comparator is very

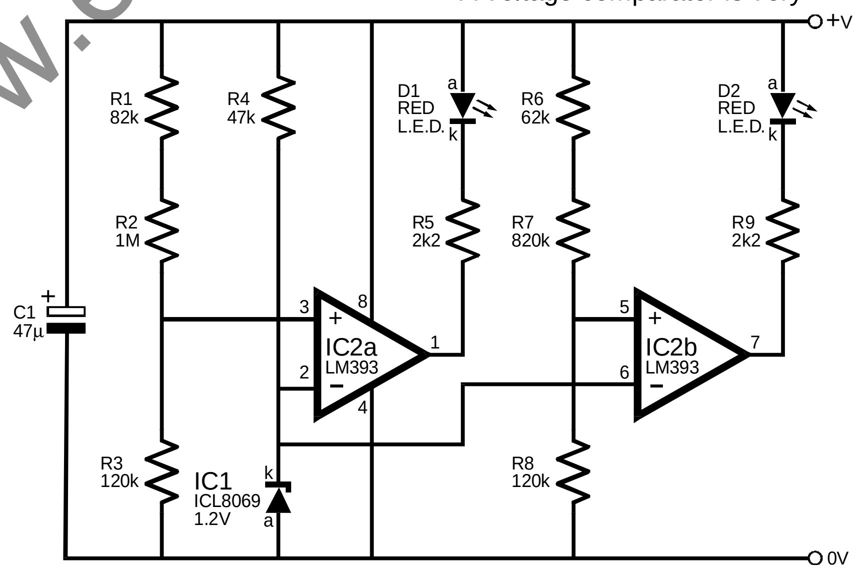


Fig.2. Full circuit diagram for the Voltage Monitor. It is essential that an in-line fuseholder, with a 100mA fuse, is included in the positive supply input lead if the monitor is to be installed in a car, boat, caravan etc.

similar to an operational amplifier (opamp). Like an operational amplifier, each comparator has inverting (–) and non-inverting (+) inputs. If the non-inverting input is at a higher voltage than the inverting input the output goes high, and if the inverting input is at the greater voltage the output goes low.

This is again the same as for an opamp, but there is a subtle difference in that the output stage of a comparator is an open collector type. In other words, there is a switching transistor at the output that is used to control a load of some kind. The load in this case is a LED indicator.

The basic scheme of things used in each of the voltage detector circuits is shown in Fig.1. The inverting input (–) of the comparator is fed with a highly stable reference potential of 1·2V, and the non-inverting input (+) is fed from the supply lines via a potential divider (Ra/Rb). A certain fraction of the supply voltage is therefore fed to the non-inverting input, and this fraction is controlled by the values of resistors Ra and Rb.

Suppose that the potential divider provides one tenth of the supply voltage to the non-inverting input. With a supply potential of 12V or more there will be 1·2 volts or more at the non-inverting input, and the output transistor of the comparator will be switched off.

If the supply voltage falls below 12V, the potential fed to the non-inverting input goes below 1·2V, and the inverting input is then at the higher voltage. The output transistor of the comparator then switches on and activates LED Da. Resistor Rc limits the output current to the required level.

COMPONENTS

Resistors
R1 82k
R2 1M
R3, R8 120k (2 off)
R4 47k 5% carbon film
R5, R9 2k2 5% carbon film (2 off)
R6 62k
R7 820k
All 0.6W 1% carbon film unless noted

Capacitor
C1 47u radial electrolytic, 40V

Semiconductors
D1, D2 5mm red LED (2 off)
IC1 ICL8069 voltage reference
IC2 LM393N dual comparator

Miscellaneous
Stripboard, size 0.1 inch pitch, having 20 holes by 17 strips; 8-pin DIL socket; multistrand connecting wire, solder pins, solder, etc.

See also the SHOP TALK Page!

Approx. Cost Guidance Only **$8**

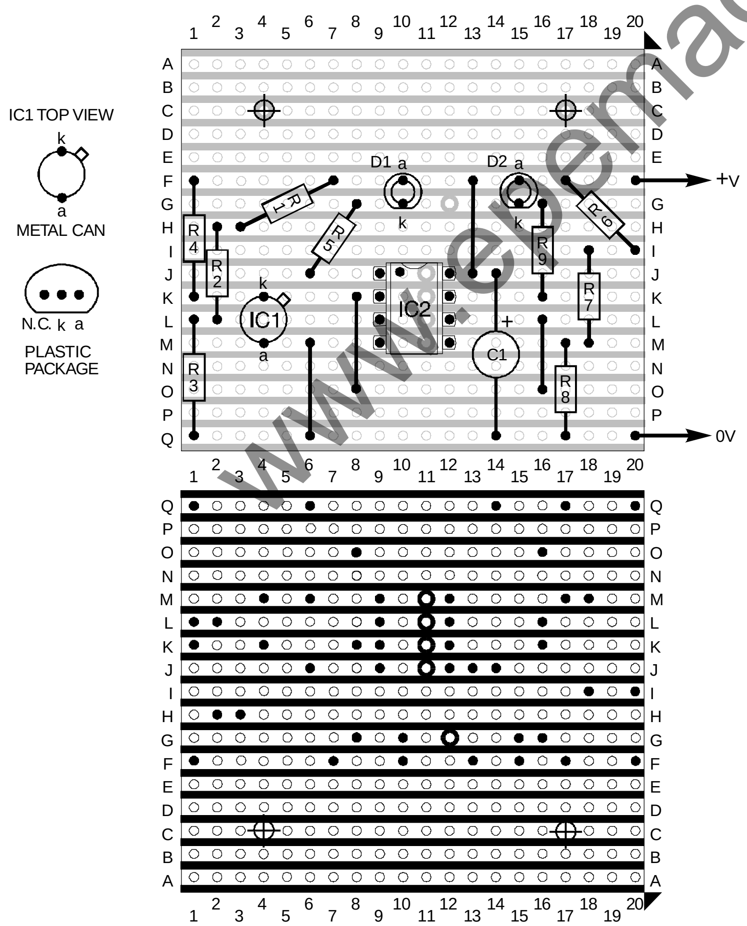


Fig.3. Stripboard topside component layout and details of breaks required in the copper tracks.

CIRCUIT DETAILS

The full circuit diagram for the *Voltage Monitor* appears in Fig.2. The two comparators, within IC2, share a common voltage reference, and this is a simple shunt regulator that has resistor R4 as the load resistor and IC1 as the voltage stabilizer.

The ICL8069 used in the IC1 position is a highly accurate and stable voltage reference chip, and not a simple Zener diode. It will operate efficiently at currents as low as 50uA, which is important in this application where low current consumption is a definite asset. It operates at a current in the region of 200uA in this circuit.

THRESHOLD VOLTAGES

The threshold voltage of the detector based on IC2a is determined by the values of resistors R1, R2, and R3. Two resistors in series are used in the upper arm of the potential divider because this enables the threshold value to be set accurately using ordinary preferred values.

With resistor R3 at 120 kilohms (120k), the threshold voltage is equal to one volt per 100 kilohms of resistance through the potential divider. This resistance is fractionally more than 1200k (1·2 megohms), giving a threshold voltage of 12V.

The switching voltage of the other comparator is controlled by the values of resistors R6, R7, and R8. With fractionally more than 1000k (1M) of resistance through the potential divider this gives a threshold potential of 10V.

It is easy to work out the resistance values for other threshold voltages provided resistors R3 and R8 are left at a value of 120k. Multiplying the required voltage by one hundred gives the total resistance through the potential divider in kilohms. Deducting 120 from this then gives the total resistance through the upper section of the divider. In other words, this gives the required series resistance through R1 and R2, or R6 and R7 in the second voltage detector.

As an example, suppose that a threshold potential of 7·5V is required. Multiplying 7·5 by 100 gives a total resistance for the potential divider of 750k. Deducting 120k from this gives an answer of 630k through the upper arm of the divider.

The required value is unlikely to conveniently match up with a preferred value, and this is certainly the case here. The nearest preferred value to 630k is 620k, which is actually an error of under two-percent. In some applications this margin of error is acceptable, and it would then be in order to use a value of 620k for resistors R1 or R6, and a link wire for R2 or R7. If an error of two percent is not acceptable, a 10k resistor and a 620k component in series give exactly the required resistance of 630k.

Things will not always work out quite this well, and in some cases it might be necessary to accept a small error even if two resistors are used. However, the error should only be a fraction of one percent, which is insignificant.

CURRENT AFFAIRS

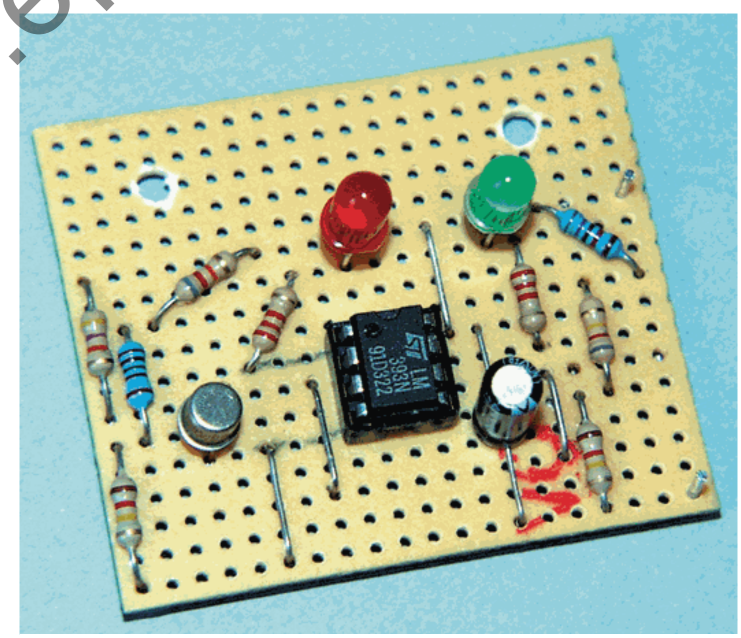
The LED current and brightness will be quite low if the unit is used to detect low threshold voltages of around five volts. To compensate for this, resistors R5 and R9 should be reduced from 2k2 to 1k.

Similarly, at high threshold potentials of around 20V to 30V, the LED current will become relatively high, although it should still be no more than about 13mA per LED. Increasing the value of R5 and R9 to 3k9 will keep the LED current at about 5mA.

The operating current of IC1 varies enormously over the operating voltage range of the circuit, but with the specified value of 47k for resistor R4 the operating current remains within the acceptable range for the ICL8069.

CONSTRUCTION

Construction of the *Voltage Monitor* project is extremely simple indeed, and it should be within the capabilities of complete beginners. The circuit is



Layout of components on the completed Voltage Monitor circuit board.

built on a piece of stripboard and the component layout, together with details of the breaks required in the underside copper tracks, are shown in Fig.3.

The stripboard measures 20 holes by 17 copper strips, and a board of this size is trimmed from one of the standard size pieces using a hacksaw. Stripboard is quite brittle, so cut carefully along rows of holes using a minimum of force. File any rough edges to a neat finish and then drill the two 3mm diameter mounting holes and make the five breaks in the copper strips.

The board is now ready for the components and link-wires to be fitted. With a small board such as this it is not necessary to worry too much about the exact order in which the components are fitted, but it is probably best to fit the resistors and link-wires first, followed by the single capacitor and the semiconductors.

The four link-wires are quite short and they can be made using some of the wire trimmed from the resistor leadouts. Be careful to fit capacitor C1 with the correct polarity. Use single-sided solder pins at the two points where the supply will be connected to the board.

Although it is not a static-sensitive component, it is still a good idea to mount the LM393N comparator, IC2, on the circuit board via a holder. There is a slight complication with IC1, which is produced in both metal cased and plastic encapsulated versions. The metal cased version (two pins), as used on the prototype, is shown in Fig.3.

However, it is actually the plastic cased version (three pins) that is available from most suppliers these days. With the plastic version the flat side of the case should be on the left as viewed in Fig.3 (i.e. facing towards resistors R2 and R3). Ignore the pin marked NC (which stands for "no connection").

ASSEMBLY

To some extent the way in which the unit is constructed and used will depend on the precise application. It can be built into a small plastic or metal box and connected to the main equipment via a twin lead. In most cases, however, it is more likely to be incorporated into another project.

Either way, the circuit board and LEDs can be dealt with in two ways. Either the board can be mounted on the case and hard wired to the LEDs on the front panel, or the LEDs can be mounted on the circuit board and then fitted into holders on the front panel of the case.

Due to the small size and weight of the circuit board this second method works well with any LED holders of reasonable quality. If the LEDs are not mounted on the circuit board, fit single-sided solder pins on the board in place of the LEDs. The pins provide an easy means of making reliable connections to the board.

Make sure the LEDs are connected with the correct polarity. The cathode (k) leadout of an LED is normally indicated by a shorter leadout wire and that side of the case being flat.

TESTING

If a suitable variable voltage supply is available, connect the output of the supply to the input of the monitor circuit and vary the voltage around the threshold levels. With the supply potential above the threshold levels both LEDs should remain off, but reducing the supply should result in the LEDs switching on at the appropriate threshold voltages.

For highly critical applications the threshold levels can be "fine tuned" by tweaking the values of resistors R1 and R6. An increase in value raises the threshold voltage, and a reduction in value decreases the threshold level. Provided one percent tolerant resistors are used in the potential dividers the accuracy of the circuit should be very good though, and for most applications no adjustment to the values should be needed.

In the absence of a suitable power supply the unit can be given a rough check using some batteries. Use a battery or batteries in series to provide a supply potential that is somewhat higher than the higher threshold level. With 10V and 12V threshold voltages for instance, a 15V or 18V battery supply could be used. Both LEDs should be switched off when using this supply potential.

Now try a lower battery voltage that is slightly less than the lower threshold level. For example, a 9V battery could be used with 10V and 12V threshold levels. Both LEDs should then switch on.

If there is any sign of a malfunction, disconnect the supply immediately and recheck the circuit board for errors.

IN USE

Note that it is essential to wire an in-line fuseholder fitted with a low current fuse (about 100mA) in the positive supply lead if the unit is used to monitor the supply of a car, boat, caravan, etc. Otherwise there is a risk of a fault causing a very large current to flow, which could result in a fire.

Experienced constructors should have no difficulty in using the unit to monitor the DC supply voltage of a mains powered project, but this is something that should not be attempted by those of limited experience.

Make sure the monitor is connected to the supply with the right polarity. The semiconductors and C1 could be damaged if the supply connections are reversed.

Go to next section