PROJECT

Fuse Tester

A simple method of checking the condition of your fuses.

CHRIS BOWES

Although a simple fuse tester can be made very easily by connecting a LED, through a suitable dropping resistor, to a battery via the fuse under test, the output does need a little bit of understanding (to work out that an illuminated LED means a working fuse). In order to both make the understanding of the result of the test easier and to make the project a little more interesting this circuit has been designed to produce an unambiguous result by using two LEDs, one of which signifies a good fuse while the other signifies a blown fuse.

How it Works

The Fuse Tester described here makes use of the operation of two simple amplifiers (op amps) used as comparators. All op amps have an inverting and a non-inverting input. These are identified on circuit diagrams with a minus sign and a plus sign.

Normally op amps are used with a feedback resistor between the output and the amplifiers inverting input. This is used to set the gain of the amplifier. If this "feedback" resistor is omitted then the amplifier has basically an infinite gain, limited only by the voltages of the power supply available to it.

The amplifier then amplifies the difference between the voltages available at the inverting and non-inverting inputs by a factor determined by the value of the feedback resistor. Because the infinite gain of an op amp used without a feedback resistor, the output voltage swings from the most negative voltage available to the most positive voltage available depending upon whether the inverting input or the non-inverting input is at the higher voltage. In this project the voltage of the non-inverting input of both op amps is set to half the battery voltage, so that the voltage presented to the inverting input is used to control the operation of the op amp.

Circuit Description

The circuit diagram for the Fuse Tester is shown in Fig.1. ICa and ICb are each one half of a CMOS operational amplifier type CA3420.

This integrated circuit contains two individual op amps which are pin compatible with other dual op amp integrated circuits. These particular op amps are, however, designed to work from a single power supply, such as a 9V battery. Resistors R1 and R2 are used to set the input voltage to the non- inverting input of IC1a (pin 2). Because they are of equal value the voltage available at pin 2 is approximately 4.5V (50 percent of the battery voltage).

Similarly resistors R5 and R6 are used to set the voltage at the non-inverting input of IC1b (pin 7) to 4.5V.

IC1a is used as a comparator to detect whether the voltage at its inverting input (pin 1) is at a higher or lower voltage than the reference voltage at the non-inverting input. Resistor R3 is used as a pull up resistor which sets the voltage at pin 1 of IC1a to the battery supply voltage when the fuse under test is an "open circuit".

In this condition the voltage at the inverting input is greater than the voltage available at the non-inverting input. This causes the output voltage of IC1a to be forced to 0V.

If the fuse under test is in good condition it presents a "short circuit", which causes the voltage available at pin 1 of IC1a to be "pulled down" to 0V. In this condition the voltage at the inverting input is less than the voltage at the non-inverting input and the output of IC1a is forced to the battery voltage.

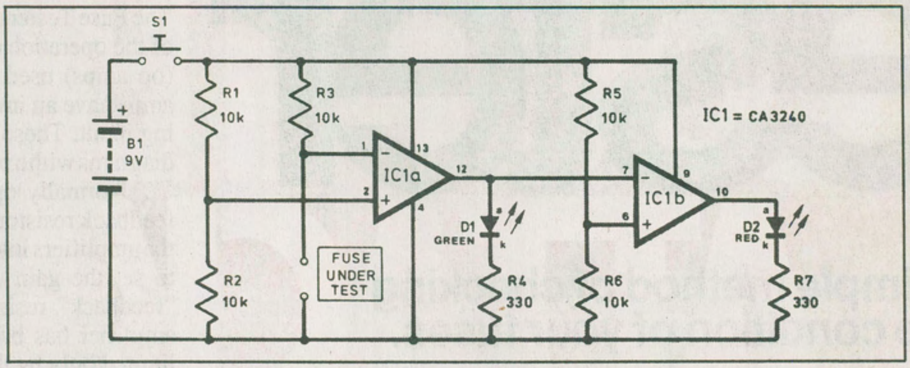


Fig. 1. Complete circuit diagram for the fuse tester.

This allows a current to flow through D1, and its associated series resistor R4, and D1 glows. Resistor R4 is included in this circuit to limit the current flowing through D1 to its safe value of approximately 10mA.

The second stage, IC1b acts as an inverter in that if the output from IC1a is at 0V then the voltage at the inverting input of IC1b (pin 6) is less than the voltage at the non-inverting input (pin 7). This causes the output of IC1b to rise to the battery voltage causing a current to flow through D2 in the same way as does the current through D1.

If the output from IC1a is at the battery voltage this causes the input voltage at the inverting input of IC1b to be greater than the voltage at the non-inverting input. This causes the output voltage to be at 0V and no current can flow through D2. The effect of this arrangement is that D1 is illuminated when the fuse under test is sound and D2 is illuminated when the fuse under test is blown.

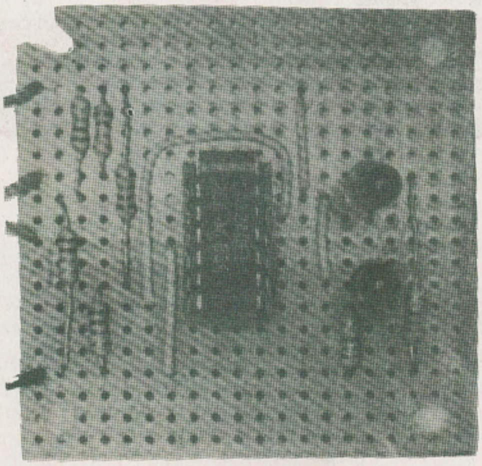
Switch S1 is a push-to-make type which is incorporated in the circuit so that the circuit only becomes active when S1 is operated. This reduces battery wear by making sure that the battery is only used when a fuse is actively being tested.

Construction

The Fuse Tester is constructed on a piece of stripboard and the component layout and breaks required in the underside copper tracks is shown in Fig. 2 and the photographs. You will probably find it useful to look at these while you are constructing the project.

The first stage of construction is to cut a piece of stripboard 20 holes by 20 strips. The four mounting holes shown in Fig. 2 should be drilled in the board using a 4mm drill bit.

The next task is to carefully make the track breaks in the area where the integrated circuit is to be mounted, as shown in Fig. 2. These can be made by using a stripboard cutter or alternatively a suitable size drill bit may be used. It is very important that these breaks in the tracks are made completely and that you ensure that there is not even the most minute trace of conductive material left to bridge the sections between the broken tracks.



Completed circuit board showing the four insulated wire links.

Once the board has been prepared then the components may be inserted and soldered into position. The operation of the circuit is not affected by the order in which the components are installed on the circuit board but you will find it easier to handle the board if the components are inserted in ascending size order.

The first components to be inserted are the four link wires shown in Fig. 2. These links are made with insulated wire, which you will need to "tin", pre-solder, before installing. If you are using stranded wire you should carefully twist the exposed strands between your finger and thumb so as to make a neat compact end to the stripped wire before "tinning".

To install the wire link it is necessary to count up or down along the edge of the board until you find the correct strip and then count along that strip until you find the correct hole where the link should be inserted as shown in Fig. 2. Once you have found the correct place to insert the wire link then the prepared end should be passed through the appropriate hole on the board, the board turned over and the link soldered into place.

The next components in ascending order of size are the resistors. Insertion of these components is made easier if the leads are first bent at 90 degrees with a small pair of long-nosed pliers, at the correct places where they need to pass through the holes in the board as indicated in Fig. 2. It is important when soldering any components onto a stripboard that the soldering iron should be left in contact with the component wire *and* copper track long enough for the applied solder to flow and make a good joint between the component and the connecting strip.

Now insert the IC holder and LEDs in the position shown. CAre should be taken with the IC socket to make sure that the notch on the holder points towards the top of the board as shown in Fig. 2. This also applies to the LEDs. You will find that the LED carries a flat on the otherwise circular base of the components; this flat is nearest to the cathode (k) connection, see Fig. 2.

The final stage before inserting the integrated circuit is to connect the battery connections and the wires leading to the fuse carrier. The easiest way to connect the battery to the circuit board is to use a suitable battery connecting clip.

The red (positive) wire from the battery clip should go to one of the two connecting tags on the push-to-make switch (S1). Another piece of wire will be required to go from the other connection of S1 to the point marked B1 +Ve on the board, as shown in Fig. 2.

The two connections to the fuse carrier are made with two wires terminated at the points marked "To fuse" on Fig. 2. You will find it easier to make the connection to the fuse carrier "brackets" at a later stage if these wires are each fitted with a small solder tag prior to the other ends being connected to the board.

Testing

Before connecting the battery and installing the board in a suitable case it is advisable to check the underside of the board to ensure that there are no solder blobs shorting out adjacent tracks or breaks in the track where you do not wish them to occur. It is also advisable to check that IC1 and the two LEDs are inserted into the board with the correct orientation.

Assuming that all is correct here than the circuit should work as soon as the battery is connected and S1 is operated.

The test sequence, with the battery correctly installed, is to operate S1 with the two wires going to the fuse carrier held apart.

As soon as S1 is operated then D2 should light. When the two wires going to the fuse carrier are shorted together with S1 operated than D2 should be extinguished and D1 should light.

If the circuit does not operated as described above then it will be necessary to start fault finding. It is really impossible to fault find on this circuit without access to a d.c. voltmeter or alternatively a multimeter.

A simple meter will, however, be suitable for all the fault finding processes necessary for this circuit.

Fault Finding

The first stage in fault finding is to repeat the visual check described earlier in the testing section. If this visual inspection produces no signs of anything wrong with the construction of the circuit then it is advisable to check that the battery connections are the correct way round.

This will probably be most easily done by connecting the voltmeter across the strips carrying the positive and negative battery supply along the stripboard and pressing S1. If all is well with the battery and the connections then the voltage read on the voltmeter should be the same as that produced by the battery.

If no voltage, or a very low voltage, is measured across these rails when S1 is pressed than the positive probe of the voltmeter should be connected to the contact on S1 which is connected to the battery. The battery voltage here should be the same as that produced by the battery irrespective of whether S1 is depressed or not.

If the battery voltage is present when S1 is not operated but disappears when S1 is pressed then this indicates that there is a short circuit on the stripboard and this should be examined carefully, especially the area around IC1.

If this inspection produces no enlightenment then IC1a should be removed from its socket and the test repeated. If the removal of IC1 cures the problem then it would indicate that this component is faulty and it should be replaced.

Comparator Tests

Following on the fault finding procedure, check that the comparator formed by IC1a and its associated components is functioning correctly. If S1 is operated with an open circuit across the fuse carrier wires then the output from IC1a should be 0V.

When the two wires going to the fuse carrier are shorted out and S1 is operated then a voltage, approaching the battery voltage, should be measurable at pin 12 of IC1a. If this does not occur then the voltages at pins 1, 2, 3, 4 and 13 of IC1a should be checked.

The voltages at pins 1, 2 and 13 should be measured with the negative connection of the voltmeter connected to any contact of the 0V track. The voltage at pin 13 should be at the battery voltage for as long as S1 is operated. If this does not happen then the link between pin 13 and the strip carrying the Batt+ connection should be checked.

Now check the voltage between the positive battery input to S1 and pin 4 of IC1a. Again the battery voltage should be measurable when S1 is operated.

If either of these checks produced no voltage reading at all then it is necessary to check back along the connections to the

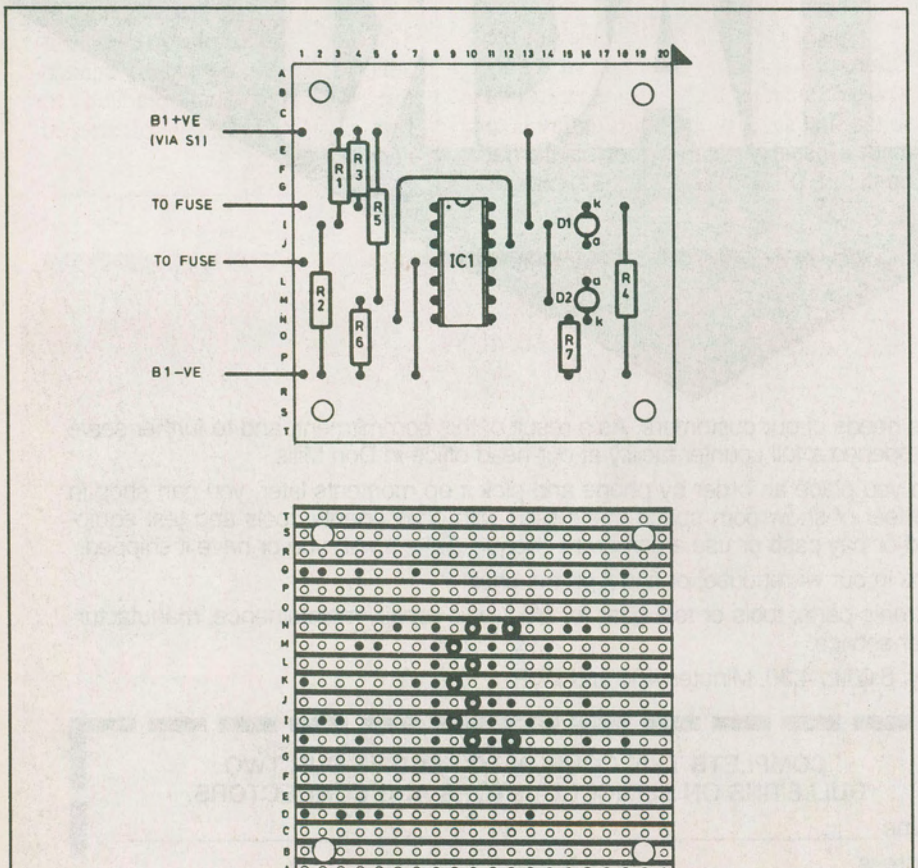


Fig. 2. Stripboard components layout and details of the breaks required in the underside copper tracks.

stripboard, battery and S1 until you find the place where the battery voltage appears. The fault will be found to be immediately after that point.

With the voltmeter's negative probe connected to a suitable 0V point, the voltages at pins 1 and 2 of IC1a should be checked. The voltage at pin 2 should be approximately 4.5V. The precise voltage measurable at this point is not *critical* as long as it is somewhere in the range between 3V and 6V.

If this voltage is not measurable or is considerably higher or lower than the range given then the potential divider formed by resistors R1 and R2 is the most likely cause of the problem. The voltage at the positive end of resistor R1 should be the battery voltage (when switch S1 is pressed) and 0V at the negative end of R2.

The voltage at the junction of resistors R1 and R2 should be approximately 4.5V and this voltage is connected, via the appropriate line on the stripboard, to pin 2 of IC1. If the voltage at the junction of R1 and R2 is considerably higher than 4.5V then it is most likely that the connection between R1 and R2 or that the connection of the 0V end or R2 are not properly made.

Similarly if the voltage at the junction of R1 and R2 is considerably lower than 4.5V then either the connection between R1 and R2 is faulty or the positive connection of resistor R1 to the positive power supply rail is faulty. In all of these cases it is advisable to check the quality of the joints, and if necessary, remelt the joints by applying the soldering iron once more at that point.

Fuse Carrier

The voltage at pin 1 at IC1a is determined by the state of the two wires which connect to the fuse carrier. When two wires going to the fuse carrier are connected together pin 1 of IC1a is effectively connected to 0V. When the two wires going to the fuse carrier are *not* connected together then the current from the positive battery rail flows through resistor R3 to pin 1, causing the voltage at this point to be at battery voltage.

The voltage at pin 1 should be monitored under both of these conditions with S1 pressed. If the battery voltage at pin 1 remains at 0V, irrespective of whether the fuse carrier wires are shorted out or not, then the fault is most likely to lie with the connections to resistor R3. If the battery voltage is always present at pin 1, irrespective of the connection or disconnection of the two wires going to the fuse carrier then the connections to the fuse carrier, via the wires and the appropriate strips on the stripboard should be checked carefully.

If all of these tests give the correct result then the output at pin 12 of the IC should be determined by the voltage measured at pin 1 of IC1a. If pin 1 is at 0V when S1 is pressed then there should be battery voltage present at pin 12. If pin 1 is at battery voltage when S1 is pressed then the output voltage at pin 12 of IC1a should be approximately 0V.

If this does not occur then the connections to pins 12 and 6 of the IC and in the vicinity of D1 and resistor R4 should be carefully checked to ensure that there is no inadvertent short of the output of IC1a to 0V. If no short circuit is found then IC1a must be suspected of being faulty and should be replaced.

If an output voltage approaching the battery voltage is produced at pin 12 of IC1 but D1 does not light than the next stage is to check through the connections from pin 1 of IC1 to the anode of D1, from the cathode of D1 to resistor R4, and from R4 to the 0V line of the stripboard should be checked for continuity.

One of the most likely causes of the failure of D1 to illuminate is that it may well be connected in the wrong way round so the first stage of the fault finding is to make a visual check to ensure that the flat on the LED's base is adjacent to resistor R4. If all is found to be correct than an LED which is known to be working can be connected across D1, taking care to ensure correct polarity is maintained. If the substituted LED works then D1 should be removed and replaced.

If D1 illuminates correctly and D2

PARTS LIST

Resistors

R1,3,5,6 .... 10k
R4,7 .... 330 ohms
All 0.25W 5% carbon

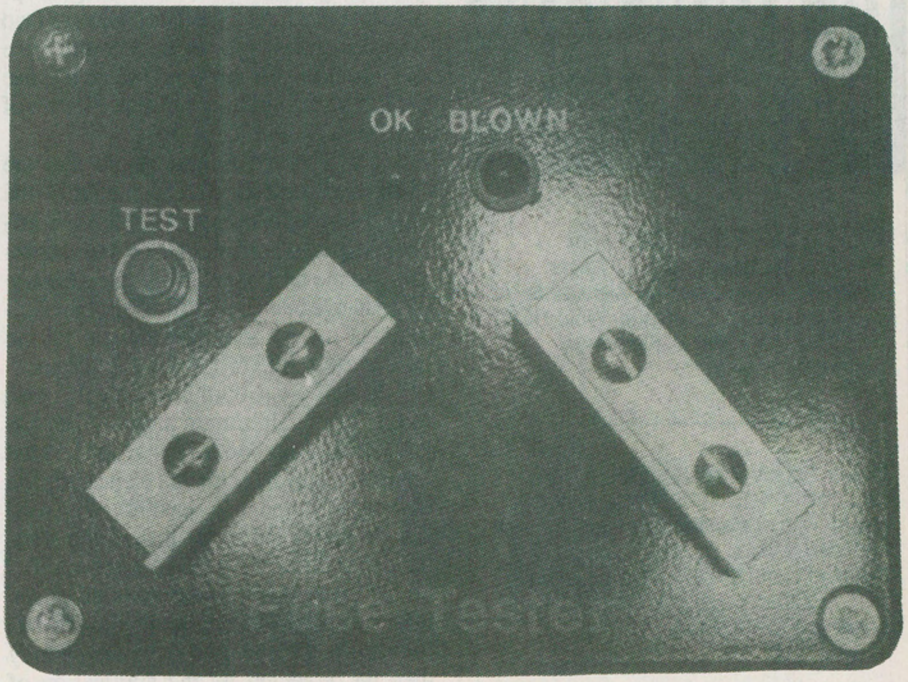
Semiconductors

D1 .... green LED
D2 .... red LED
IC1 CA3240E Dual CMOS op amp

Miscellaneous

S1 Single-pole push-to-make switch
B1 .... 9V battery

Stripboard, 20 holes x 20 strips; 14-pin IC socket; plastic case; self-adhesive stand-offs; battery connector; solder tags; aluminum angle for fuse carrier (see text); solder; connecting wire, etc.



Completed Fuse Tester showing the LEDs, push-to-test switch and the fuse carriers made out of aluminum angle.

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does not then the circuitry associated with IC1b should be checked in the same way as details for IC1a. The positive supply connection to IC1b is a separate one to that connected to IC1a so the voltage between 0V and pin 9 should be checked. When S1 is pressed the voltage measured between pins 4 and 9 of IC1b should be the battery voltage.

The second difference to check is that the voltage at the inverting input (pin 6) of IC1b is the same as that at pin 12 of IC1a. This should be checked with a voltmeter and if the two voltages do not correspond then the connections between these pins should be checked. Apart from these differences IC1b can be fault found in the same way as IC1a.

Case

The fuse tester is designed to be mounted inside a case and for this reason the LEDs have been positioned so that the board can be mounted on the back of the case lid, with the LEDs protruding through the front of the case. The fuse carrier has been designed to be made from two small pieces of aluminum angle strip drilled in such a way that they may be mounted on the front of the case as shown in the photograph. The two strips are mounted at an angle to each other, so that a number of different lengths of fuse may be tested.

The first task is to cut two pieces of one centimetre aluminum angle approximately three centimetres long. Two holes sufficiently large to accommodate the mounting bolts you intend to use should be drilled into one side of each of the pieces of aluminum angle.

Place the aluminum angle and the push to test switch (S1) in the lid of the case, taking care to ensure that there is sufficient space underneath the lid to accommodate the stripboard. Once appropriate places have been determined for the components these should be marked on the case and the holes of correct size drilled.

Switch S1 should be relatively close to one of the aluminum angles. This has been deliberately done so that one handed operation may be achieved by holding the fuse against the fuse carriers with two fingers and using the thumb of the same hand to operated the push-to-test switch.

Once the appropriate holes have been marked and drilled the case may be lettered with rub down lettering which may then be protected by the application of several layers of clear varnish. Once the varnish is dry carefully mount the fuse carriers with nuts and bolts, ensuring that there is sufficient clearance between the end of the bolt and board when mounted underneath the case.

The two LED clips should now be positioned in their appropriate holes in the case. The stripboard should be mounted on the underside of the lid in such a way that the two LEDs fit into the two clips.

Ideally the board should be held in place by means of self- adhesive standoffs. These should be placed, from the component side, in the holes drilled in the stripboard to accommodate them. The protective backing should then be peeled off the sticky pads and the board carefully offered into place, ensuring the LEDs fit through the holes in the case front.

When the position of the component board has been accurately determined then the sticky pads should be pushed firmly onto the surface of the case so that they stick firmly on the case lid. Once the pads are in place then the board should be carefully removed and the connections made to the two fuse carriers.

If solder tags have become attached to the end of the two wires which connected to the fuse carrier then connection becomes simply a matter of placing the solder tag of one of the wires underneath one of the two bolts holding each of the two fuse carriers. Switch S1 can also be installed and the wire connections made to it, at this stage.

The final stage of fitting the project into its case is simply a matter of placing the rings which secure each of the LEDs in to its clip, around each of the two LEDs and offering the stripboard into its position on the already attached standoffs. Care should be taken to ensure that the LEDs fit neatly through the two clips already installed in the case before sliding the securing rings around the base of the clip to lock them into position.

The battery can then be attached to the battery clip and the circuit checked for correct operation, as described above. This check should, of course, be carried out before fitting the back of the case onto the lid and securing the lid to the case with the four screws.

In Use

The Fuse Tester is very simple to use. All that is necessary to do is to place the suspect fuse so that it makes good contact with the two strips of aluminum angle, which form the fuse carrier, and press the test button (S1). One of the two LEDs should illuminate, indicating whether the fuse is sound or not. ■