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tech tips

More Uses of the LC102 AUTO-Z™ Power Supply

The power supply built into the LC102 AUTO-Z has many additional uses besides capacitor leakage testing. The LC102 manual explains high-potential ("hi-pot") testing, and testing resistances up to 1 gigohm (1000 megohms). This Tech Tip explains some typical uses for the supply. These uses may remind you of other applications needing a good source of portable power. Before we look at some typical uses, we will take a moment to explain the power supply features.

Understanding The LC102 Supply

The LC102 leakage supply provides a DC output which is regulated, well- filtered, current-limited, and adjustable in 0.1 volt steps from 1.0 to 999.9 volts. The LC102 supplies currents from 2 mA to 200 mA, depending on the selected voltage (see Fig. 1). Since the LC102 can be battery operated, it provides portable power.

The LC102 digital readout monitors current drawn from the supply. Autoranging allows direct reading of currents from less than 0.1 microampere all the way to 19.99 mA. Currents over 20 mA will cause the display to over- range, but you can use an external meter to monitor currents above the LC102's current range. The supply is current limited. It will not be damaged when drawing higher current levels, even though the display is overranging.

Some applications may require automation. Common uses are in design, research, or production-line testing. The addition of either the optional IEEE 488 or the RS232 Bus Interface accessory adds computer control to the LC102. The software written for the application can control the LC102's output voltage and when power is connected and removed. The computer can also monitor the amount of current drawn from the LC102 or the resistance of the load it is powering.

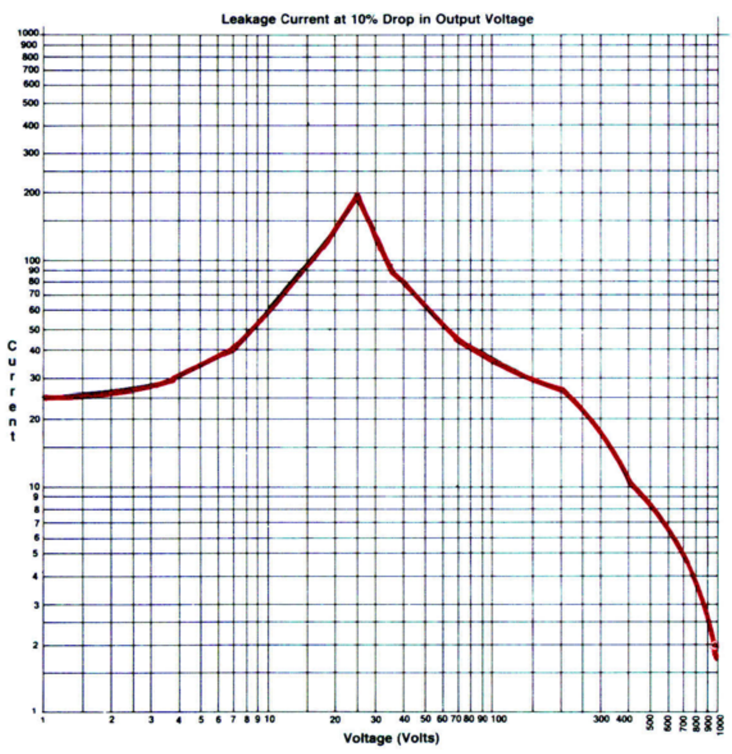


Fig. 1: The LC102 power supply provides current outputs from 2 to 200 mA, depending on the voltage selected.

A Remote Voltage Source

Many applications need a DC supply away from AC power lines. The battery operation of the LC102 lets you take your power source anywhere you need it. Sometimes, you will use the LC102 for a few minutes to get you out of a pinch. At other times, you may need to use the AUTO-Z for longer periods. If so, the LC102 carrying pouch has room for two charged batteries, allowing you to have a total of three batteries (one in the unit plus two spares) for extended usage.

Stop Testing Alarm

If at any time the STOP TESTING alarm is activated, you should immediately stop all testing with the LC102. The alarm is triggered by either the fuse opening, the protection circuits opening, or connecting the test leads to a charged circuit. The alarm is equipped with two methods to alert you, an audible buzzer and a flashing LED.

If the STOP TESTING alarm activates:

1. Stop all testing with the LC102.

2. Carefully discharge the capacitor you are testing by connecting a 10k ohm 1 watt resistor accross the terminals.

3. Replace the test lead fuse if blown, or remove the voltage from the point the test leads are connected to.

4. Resume testing.

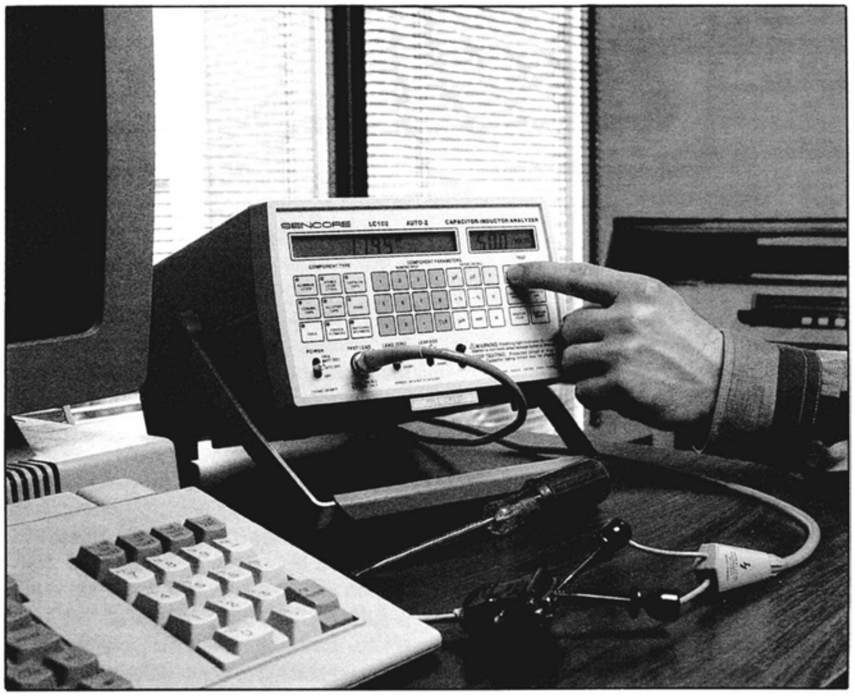


Fig. 2: When tracing a wire in a cable, connect the LC102 at one end, while you look for the DC voltage with a meter at the other end.

Powering Low-Powered Devices

The LC102 provides a source of power for many applications needing a low- current power supply. Use it to power small radios, remote controls, pocket pagers, etc. The filtering and regulation provide a stable power source without finding special batteries. Since the LC102 is current limited, you don't need to worry about a defective unit damaging it by pulling too much current. The digital current readout also helps guide you in your troubleshooting.

Line Tracing

The LC102 supply can identify one pair of conductors out of a large cable. For example, professional sound systems often include dozens or hundreds of wires returning to a single junction point. Or, a telephone system may have junction boxes scattered throughout a building, and you may need to trace a conductor from box to box. The LC102's battery operation simplifies these tests.

To trace the wire, connect the LC102 to one end of the line that needs to be traced and a common ground (such as an electrical conduit). Then, use a voltmeter to look for its voltage at the opposite end. If some lines already have a DC voltage, set the LC102 to a completely different voltage. Then, look for the line that has the Z Meter voltage. For example, if you are working in a telephone system with a 48 volt common battery, set the LC102 to a lower voltage, such as 12 or 24 volts.

Testing More Components

The LC102 power supply lets you test many components besides capacitors and inductors. Most of these applications also need a general-purpose voltmeter to monitor the results.

A current-limiting resistor is needed for most tests. The resistor protects the component from damage due to excessive power. The value depends on the current rating of the device you are testing. Have both a 1000 ohm and a 10,000 ohm resistor available. Use 1 watt (or larger) resistors to allow ample power dissipation when testing shorted parts.

The only other thing you need is a clip lead to connect the resistor in series with the component you want to test. When you have your meter, resistors, and clip lead, you're ready to use the power supply for a wide range of component tests.

Zener Diodes

The LC102 lets you check a zener diode's conduction voltage. Check the zener by applying a voltage higher than the zener's rated voltage, through your current-limiting resistor. Monitor the voltage drop across the diode with the external voltmeter.

Make your connections as shown in Fig. 3. Reverse-biase the diode by connecting the red Z Meter lead to the *anode* (the end marked with the polarity stripe). If you reverse the connections, the diode will be forward- biased, and will show

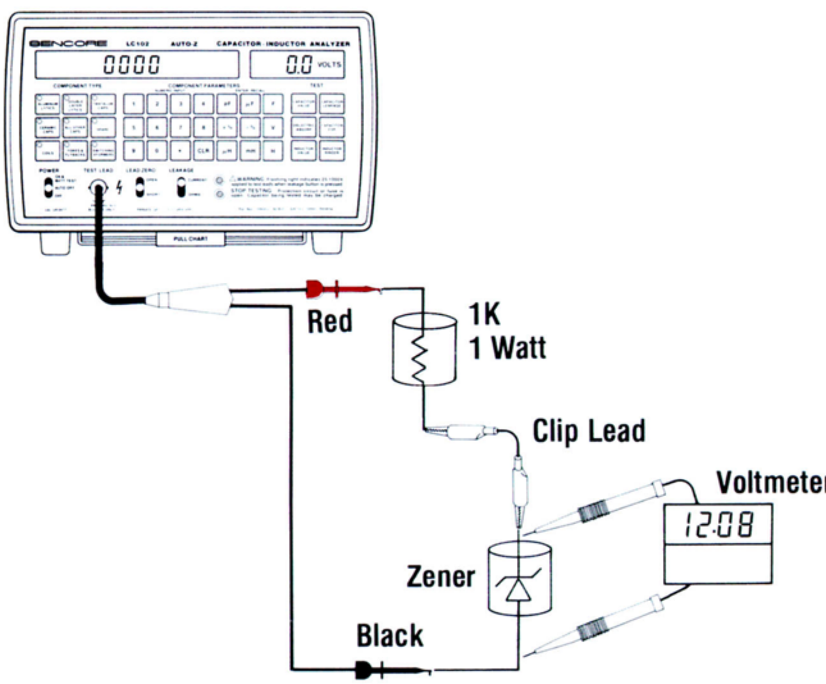


Fig. 3: Use a current limiting resistor and a DC voltmeter to test the voltage drop across a zener diode. Be certain the polarity is correct.

less than 1 volt of drop. You may damage the diode, since extra current may be forced through it.

Set the LC102 about 5 volts higher than the rated voltage of the zener to ensure proper diode turn-on through the current-limiting resistor. The LC102 current meter should indicate that current is being drawn. If the current reading only shows a few microamperes, the diode is not conducting. Step the LC102 voltage up an extra 5 volts and check again. If you see conduction, the zener voltage is the reading on the voltmeter.

If you don't know the zener's rating, start with a low test voltage, and then work up until the diode begins to conduct (shows a current reading). Start with 10 volts. If the diode does not conduct, start increasing the voltage in 10 volt steps until the diode conducts, or until the voltage is higher than the circuit which would use the diode. Zener diodes are rarely rated above 200 volts, so this makes a good upper test limit.

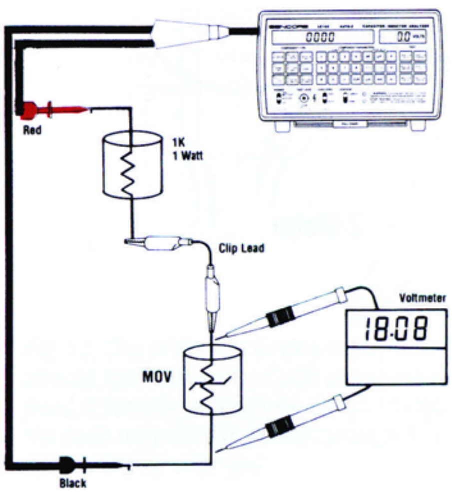


Fig. 4: MOVs are tested nearly the same as zeners, except for the applied voltage. There is no polarity to worry about when testing MOVs.

Varistors

Metal-oxide-varistors (MOVs) act very much like zener diodes. They should not conduct until a threshold voltage is reached. At that voltage, they should switch from a high impedance to a low impedance and conduct current easily.

MOVs are often used to protect circuits from excessive voltages or from transient spikes. They are often placed across the AC line input to absorb spikes riding on the power line. Some computer modems or telephone answering units use an MOV across the telephone line to prevent surges from entering through that route. The MOV acts like a crowbar regulator, shunting spikes to ground before they get inside the unit. MOVs protect circuits by converting the excessive energy into heat. An MOV may open if the current surge is too large or present for too long a time. Testing with the LC102 confirms whether it still conducts at the proper voltage.

The biggest difference between testing an MOV and a zener diode is the applied voltage. MOVs have ratings as high as 700 volts. To test the MOV, set the LC102 to a voltage higher than the rated voltage and watch the LC102 readout to confirm it conducts. Measure the clamping voltage with the external voltmeter.

You may want to confirm the MOV does not have leakage at voltages below its clamping voltage. If so, be sure to disconnect the external voltmeter. Otherwise, the sensitive LC102 current function will show the few micro- amperes of current flowing through the parallel voltmeter.

LED And LED Displays

The LC102 can test light emitting diodes (LEDs) to confirm that they light and that they do so at the proper voltage level. Before you test the LED, however, you need to know if it is a discrete LED, or whether it has built- in current limiting. If you're not sure, treat it like a discrete LED and use the 1 kilohm current-limiting resistor. If it has its own internal current limiting, determine the normal circuit voltage, and duplicate that voltage in your testing.

Digital display modules usually have a numeral made up of seven bar seg- ments, plus one or two decimal points. Each of these segments is a separate LED and should be tested separately. You will need to determine whether the display has all the anodes or all the cathodes tied to a single pin. Connect the correct LC102 lead to the common pin, and then test each segment by moving the other lead from pin to pin.

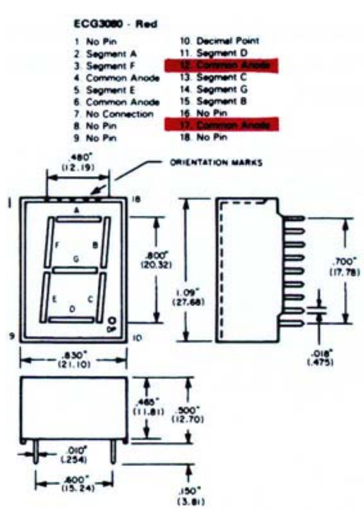


Fig. 5: Each segment, plus the decimal points, of a numerical display are tested as individual light emitting diodes.

An LED must be forward-biased to produce light. Therefore, connect the *red LC102 lead* to the *anode*, and the *black lead* to the *cathode.*

Most LEDs need 2 to 2.4 volts to light. After making connections, set the LC102's power supply to 2 volts. Press the LEAKAGE button, and watch if the LED lights. If it doesn't, increase the voltage in 0.1 volt steps and repeat the test. If the diode is not emitting light at several tenths of a volt above its rated level, it is bad.

Infrared LEDs

Many remote control transmitters use infrared LEDs. You test the infrared diode in the same way as a normal LED, with one exception. You will need some way to tell if an infrared LED is emitting light, since it is invisible to the naked eye. Two methods work: an infrared detector card, or an electronic pickup.

The low-cost detector card has a special chemical which emits visible light when struck by infrared light. You poin t the LED at the card, while powering it with the Z Meter. Follow the instructions on the card to determine whether the LED is putting out infrared.

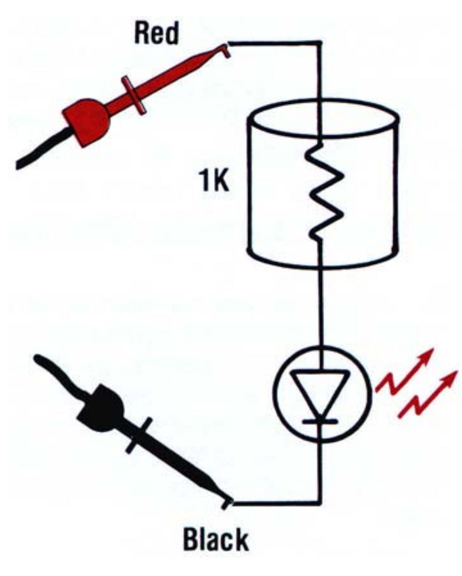
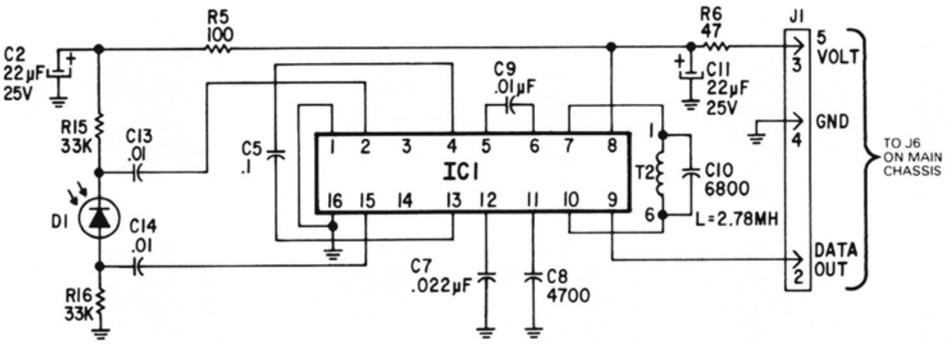


Fig. 6: The red lead of the LC102 must be connected to the anode in order to test an LED. The LED should light with an applied voltage of 2 to 2.4 volts.

The second way is to use a photo diode or phototransistor capable of picking up infrared. The



Courtesy North American Phillips

Fig. 7: The pickup from a remote-control TV or VCR may be used as a sensor to confirm that an infrared LED is putting out light. Bias the detector with a battery and check for an output with a DC voltmeter.

remote control inputs circuits of an old VCR or TV may serve this purpose well. Placing the diode and detector inside a light shield, ensures that room light will not produce a false output. Monitor the output with a meter or a scope to tell whether the sensor is detecting light from the diode under test.

Photo Detector Diodes And Transistors

The current passing through a photo diode or transistor should change in step with light in its clear window. The LC102 digital reading shows how much current is passing through the device.

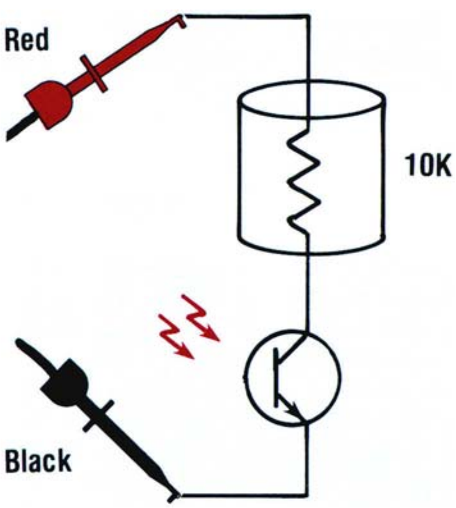


Fig. 8: The current drawn by a photo transistor or diode should increase when the window is exposed to light.

First, determine the maximum voltage you can safely apply through your current-limiting resistor and remain under the maximum rating of the device you will be testing. Ohm's law (I=E/R) applies directly. Before connecting the photo-pickup, double-check your calculation by connecting the LC102 directly to the resistor. Press the LEAKAGE button and note the current reading. This will be the value that flows when the device is fully turned on, bringing it close to a short-circuit condition.

Connect the detector in series with a current-limiting resistor. The LC102 must forward-bias the device, as shown in Fig. 8. With the device shielded from light, adjust the LC102 power supply until the current reading shows a few milliamp of current. Notice that the exact voltage needed for this part of the test depends on the size of your current-limiting resistor and on the device you are testing, so start with a voltage of about 4 volts, and then increase or decrease the voltage until you have a usable value. Don't, however, exceed the maximum safe voltage determined earlier.

Now, shine a light on the device. The current should increase, showing that the device responded to the light. You should see a larger increase when testing a photo-transistor than a diode. A photo-darlington should show an even larger difference than a single transistor.

Transistor Breakdown Voltage

A transistor acts like a zener diode when a voltage is applied between its collector and the emitter. The transistor blocks the flow of current until the applied bias becomes larger than its breakdown voltage. It then conducts heavily. If the transistor begins to conduct at a voltage lower than the operating voltage of the circuit in which it is used, it will not work correctly.

If done correctly, the breakdown test will not damage the transistor. The current-limiting resistor holds the current below destructive levels. You use the external DC voltmeter to monitor the transistor's breakdown voltage, so that you don't need to calculate the voltage dropped in the series resistor.

Connect the voltage to agree with the transistor's NPN or PNP polarity. Fig. 9 shows the correct connections. (This, incidentally, is the opposite

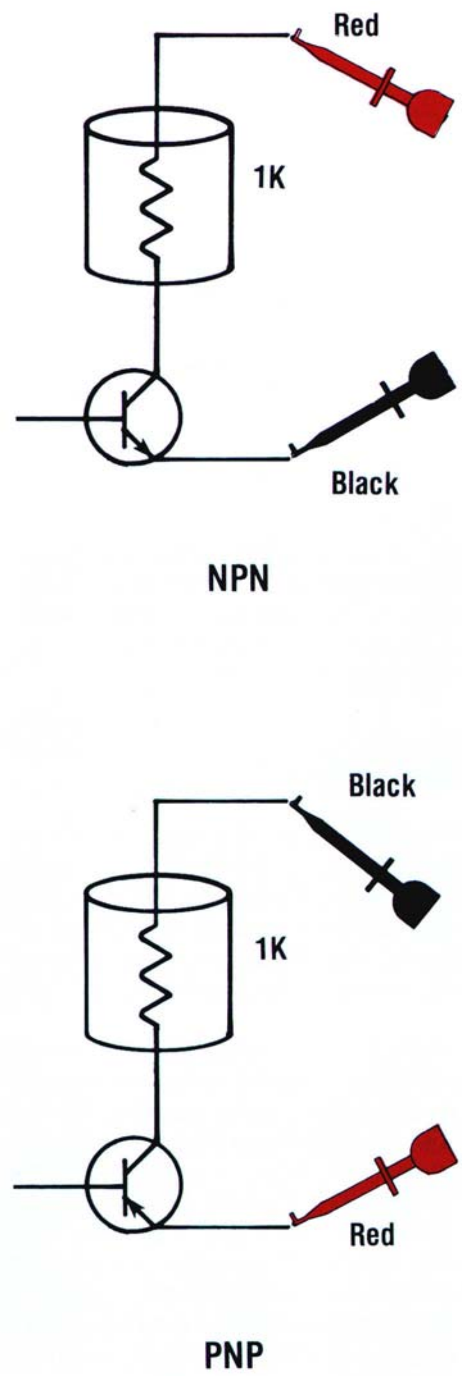


Fig. 9: Test a transistor for breakdown by monitoring the voltage drop between collector and emitter. The breakdown voltage must be higher than the circuit's voltage for correct operation.

of the diagram in the LC102 manual used to make *capacitance* and individual junction breakdown measurements.)

Test the transistor using the zener diode test covered earlier. The voltmeter reading must be higher than the circuit's operating voltage for reliable operation.

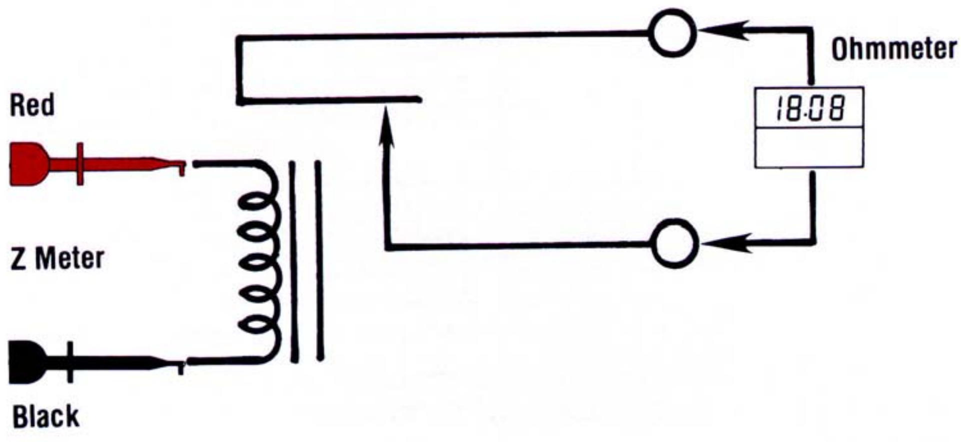


Fig. 11: Monitor contact closure with an ohmmeter while powering the coil from the Z Meter. The contact resistance should be low when they are closed.

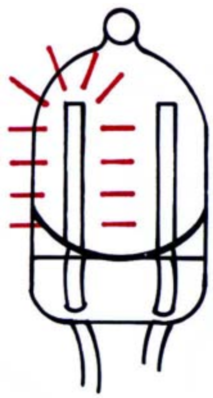


Fig. 10: One of the electrodes in a neon bulb should light when the LC102 voltage is applied. If the firing voltage becomes too high, the bulb may not light, even though it will light at higher voltages.

Neon Bulbs

Neon indicators should be tested for two conditions: light output and firing voltage. A neon bulb should fire at a fixed voltage. The firing voltage often increases as the bulb ages. If the voltage drop is higher than the circuit's operating voltage, the neon bulb is defective, though it lights.

Place your 10k resistor in series with the bulb and test the voltage drop with your voltmeter. Set the LC102 power supply to the operating voltage of the circuit which used the bulb. Use 90 volts if you aren't sure. Apply the test voltage and confirm that the light lit. (***NOTE****: Only one of the electrodes in the bulb will glow, because the LC102 tests with DC. Both electrodes glow when connected to an AC voltage source, because the current reverses at a 60 Hz rate.)* Then note the voltage drop across the bulb to confirm it is conducting at the correct voltage.

Microprocessor Relays

The LC102 tests relays which have coil ratings within the range of the LC102 power supply. Such relays are often used with microprocessors, either connected directly to the microprocessor output, or through a driver transistor or IC. You can use the LC102 to confirm that the relay has the proper pull- in voltage. If the voltage is too high, the relay may not work correctly when signaled by the microprocessor.

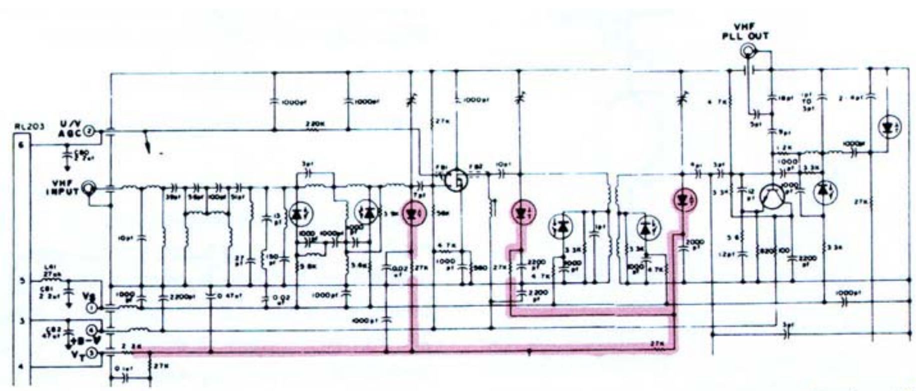
Use the LC102 to drive the relay's coil, while you watch for switching with an ohmmeter connected across the relay's contacts. Begin by testing the relay at the power supply voltage used in the relay circuit. Then, reduce the voltage until the relay no longer activates reliably. The lowest pull-in voltage should be less than the "high" level for the digital logic family which drives the relay. For a TTL level system, for example, the relay should still pull in at 2 volts.

The ohmmeter confirms that the relay contacts have closed. Also, measure the contact resistance. If the resistance becomes higher with lower activation voltages, the relay may not provide reliable operation, though it is partly closing.

NOTE: *See Sencore Tech Tip #109 for details on using the SC61 Waveform Analyzer to test other aspects of the microprocessor system.*

Varactor And AFT Tuning Voltages

Almost all RF applications use electronically tuned "varactor" circuits. Varicap diodes are controlled by a DC voltage to tune the circuits.



Courtesy of GE

Fig. 12: The varactor diodes in a tuner change the operating frequency of the local oscillator. The LC102 can substitute for the tuning voltage while monitoring the output with a frequency counter.

Varactor circuits are common in TV tuners, FM receivers, communications radios, and RF generators. The LC102 lets you test the tuning circuits to confirm they are responding correctly to the tuning voltage.

This is especially helpful when troubleshooting a digitally controlled phase-locked-loop (PLL) which is not correctly locking to the correct frequency. The best way to test the VCO output is with a frequency counter. If the PLL produces the correct output with the LC102 voltage applied, you know that the voltage-controlled-oscillator (VCO) is working correctly and that you must troubleshoot the control circuits. If, by comparision, the VCO does not produce the correct output frequency, the VCO should be serviced.

NOTE: *The LC102 has special protection circuits which sense whether a voltage is present. These circuits prevent damage to the LC102 from externally applied voltages. They prevent the LC102 from "swamping" existing voltages, so you should disconnect the circuit voltage source before applying the substitute signal.*

Connect the LC102 leads in place of the tuning control voltage. Start with the LC102 set to produce a voltage half way between the normal top and bottom operating points. Observe the VCO's output frequency. Then, change the LC102 voltage a few tenths of a volt and check the frequency again. The VCO should change frequencies. Finally, try tuning voltages at the top and the bottom ends of the tuning voltage range. This should move the VCO through its full range of output frequencies.

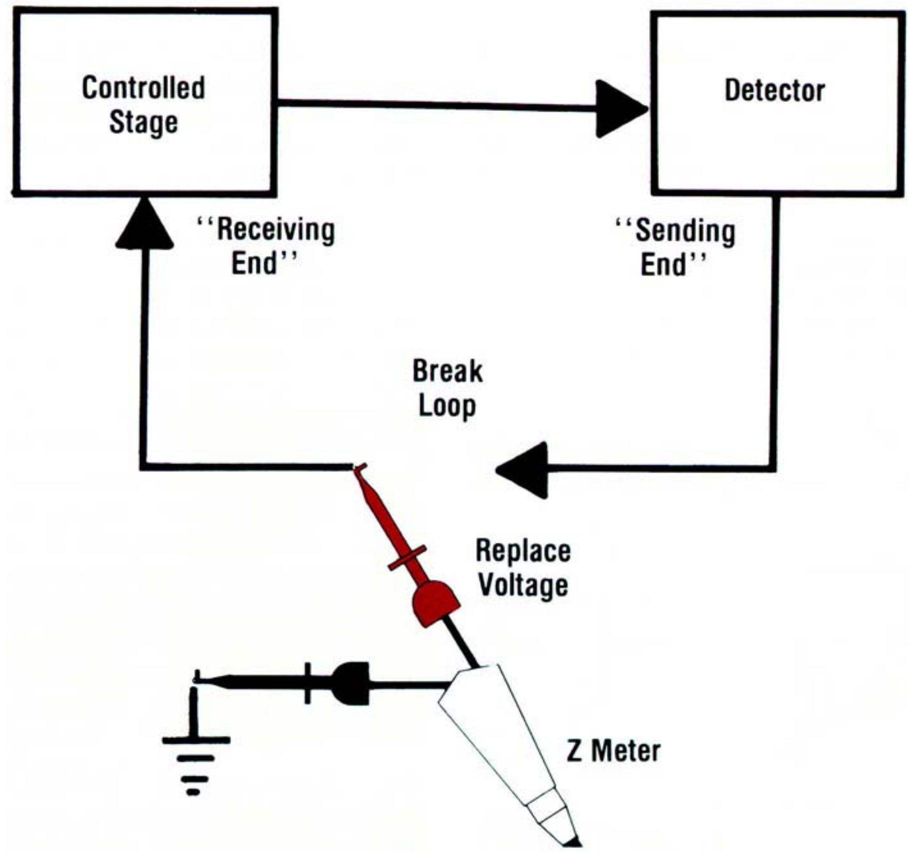


Fig. 13: The DC voltage from the Z Meter can feed into an automatic circuit in place of the correction voltage. If the "receiving end" does not change, it is defective. If it does, repair the "sending end".

DC Controls And Feedback Circuits

The LC102 can be used in a similar manner to test any DC-controlled circuit. For example, most "volume controls" in TV receivers are actually DC potentiometers which vary the bias on a pin of an IC. The circuits inside the IC then change in gain (or attenuation) to control the audio level. The audio signal does not get near the volume control.

Similarly, DC-controlled circuits are part of automatic feedback loops. A detector converts the output of a circuit to DC which, in turn, feeds back to a DC-controlled stage. The constant adjustment holds the output nearly constant. In a television, these loops automatically control color saturation (ACC), tint (VIR control), and frequency (AFPC); horizontal sync (HAFC); CRT beam current (ABL); tuner and IF gain (AGC); and fine tuning (AFT) of the tuner. Similar circuits are found in VCRs, hi-fi, and communications equipment.

The main test of a feedback circuit is to determine whether a problem exists in the DC-controlled circuit (called the "receiving" end) or in the detector (called the "sending" end). Substituting with a DC voltage lets you take manual control of the circuit to see whether the receiving end of the circuit responds to the correction voltage. If you have *no control of the receiving end,* troubleshoot it. If you can control the receiving end, troubleshoot the sending end or circuits between the two.