Troubleshooting Techniques

The Importance of Documentation

Documentation refers to the manuals and other materials provided by the manufacturer to the user. Always read and save any manual that comes with the equipment. While the use of printed manuals has faded, you can access important documentation and service information on the defective product by searching the manufacturer's website. It is usually listed under a tab called Support. Today, some equipment comes with a CD with the documentation on it.

It is almost dumb to try to service something without the manufacturer's documentation since there are usually procedures and suggestions for performing tests and trouble diagnosis. Using the documentation will typically save troubleshooting time.

Help Lines and Call Centers

Another option is to use any help lines or call centers that can provide directions, suggestions, and outright solutions.

When visiting the website, or using the manuals, look for information related to repair. If all else fails and you cannot fix the problem, at least you will know who to call for help or who to send the product to for repair.

Equipment Training

The importance of documentation cannot be stressed enough. Today's modern equipment is very complex and sophisticated and difficult to operate much less troubleshoot and repair.

Familiarity with the equipment is essential for repair success.

While documentation can help you, the best resource is equipment training. Many companies offer troubleshooting and repair training to those who will be regularly repairing specific equipment day after day.

Take any training you can get if you are assigned to repair equipment on a regular basis.

Useful Troubleshooting Techniques

As stated earlier, the most common troubleshooting procedures are component or module substitution, signal injection, and signal tracing. The procedures for each should be given in the instruction manuals.

Signal Tracing

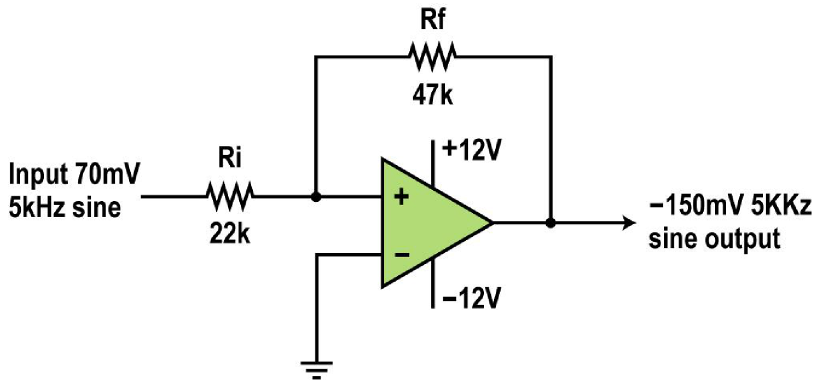
Signal tracing may be the most common troubleshooting approach. The process is, as the name implies, is to inject a signal into the equipment then trace it through the system from circuit to circuit to see where the signal does not get through.

Signal tracing is based upon the idea that most electronic circuits have an input, some processing of the input, and an output. You first look for the correct signal at the input, then look at the output for the desired signal. The circuit may be an IC or a discrete component circuit or even a complete module of some sort.

The method relies upon you knowing what the input signal should be and what the output result should be. You will normally get this from the manufacturer's documentation.

This method also means that you have a source of the input signal. This will usually come from a function generator or other signal generator to simulate the real signal that may not be available.

Signal Tracing Example #1



$$A = \frac{Rf}{Ri} = \frac{47k}{22k} = 2.14$$

The figure above shows an op amp circuit. The op amp is an IC while the resistors are discrete components. The manufacturer's manual says that the input is typically a sine wave of 70 mV at 5 kHz. You can compute the gain (A) of the circuit by knowing the resistor values or R_f/R_i. Knowing the gain, you can predict the output. The output is just the input voltage multiplied by the gain. In this case, the output is 150 mV and the sine wave is inverted because of the op amp 180° phase shift.

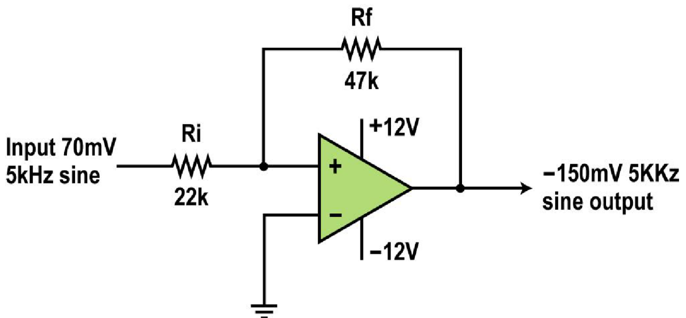
Signal Tracing: Oscilloscope

As a first step, turn on the power and use an oscilloscope to look for the stated input signal.

If the signal is not available, connect a signal generator set to an output of 70 mV at 5 kHz. You will need to disconnect the input resistor from the circuit so that any other circuits connected to it will not cause a conflict.

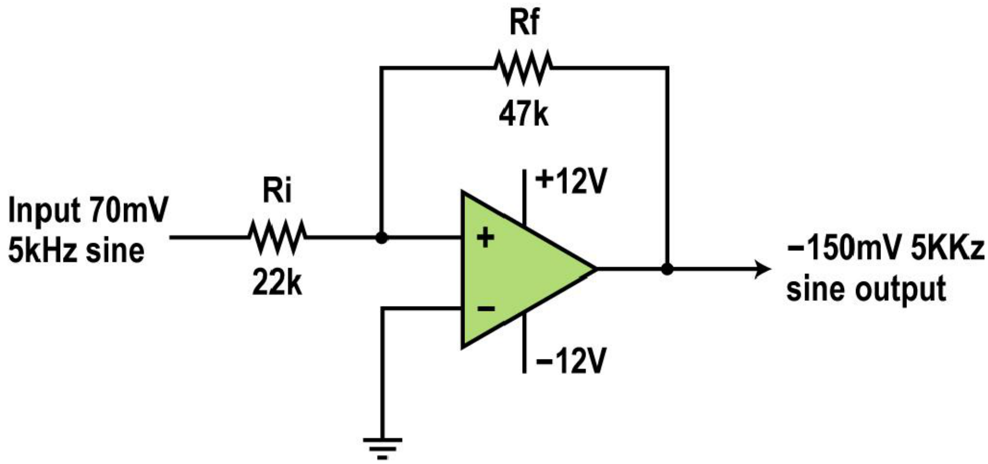
Now, use an oscilloscope to look at the output. You should see a signal with a value of 150 mV.

If you see the signal, the circuit is good. If not, additional troubleshooting is required.



$$A = \frac{Rf}{Ri} = \frac{47k}{22k} = 2.14$$

Signal Tracing: Power Supply Check

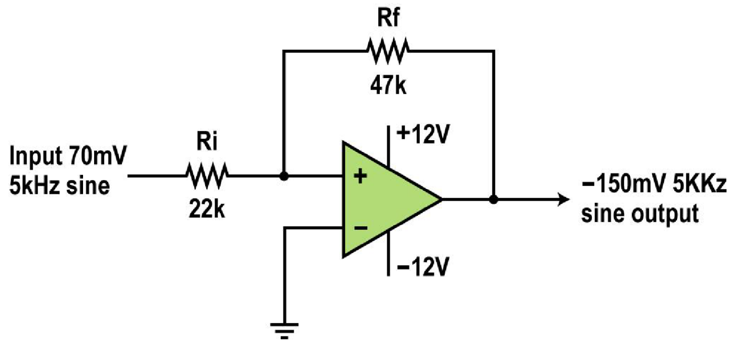


$$A = \frac{Rf}{Ri} = \frac{47k}{22k} = 2.14$$

While the power is still on, use a multimeter to measure the supply voltages on the IC. As indicated in the figure, these should be +12 volts and -12 volts.

If you get these voltages, everything is OK. If not, you should look for a power supply problem.

Signal Tracing: Other Checks



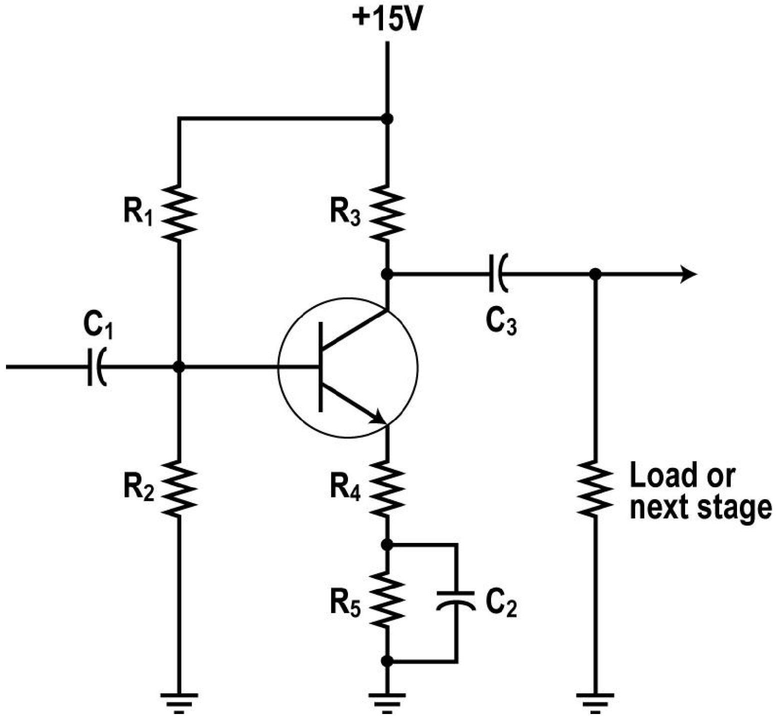
$$A = \frac{Rf}{Ri} = \frac{47k}{22k} = 2.14$$

Assume that the power supply voltages are OK. What is the next step? One possibility is a short or increased load on the IC output. Make a visual inspection to verify that.

The resistors are not likely to be defective. The IC itself may actually be bad. If you have a spare IC, you could use the substitution approach. This, in fact, is probably your only choice at this point since you cannot actually look inside the IC or test it.

Signal Tracing Example #2

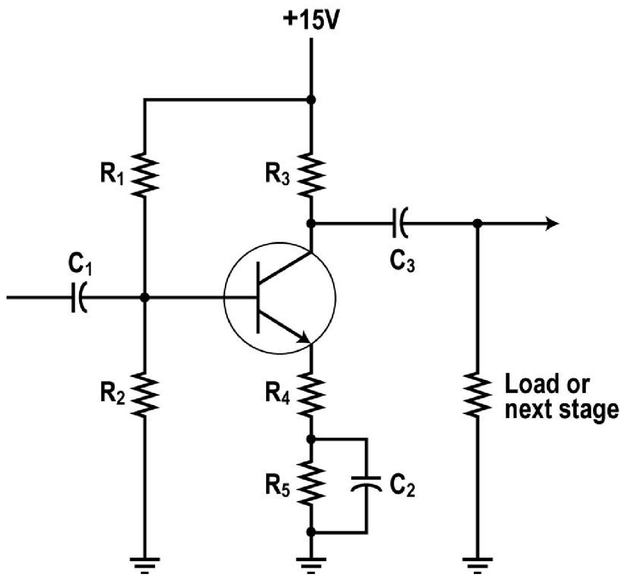
This figure shows a discrete component amplifier. While circuits like this are less common today because of ICs, you may encounter something like this if you repair older equipment. In any case, the process is useful to know.



Signal Tracing #2: Amplifier Check

Assume that the input signal of 200 mV at 1.5 MHz is present as verified by an oscilloscope. While you may not know the gain of the amplifier, you could calculate it from the values given but that would take time. A faster approach is to check the equipment manufacturer's data to see if a typical output value is given.

If no output value is known, you can still test the circuit knowing that this is an amplifier so the output should be larger than the 200 mV input. Measure the output at the collector with the oscilloscope.



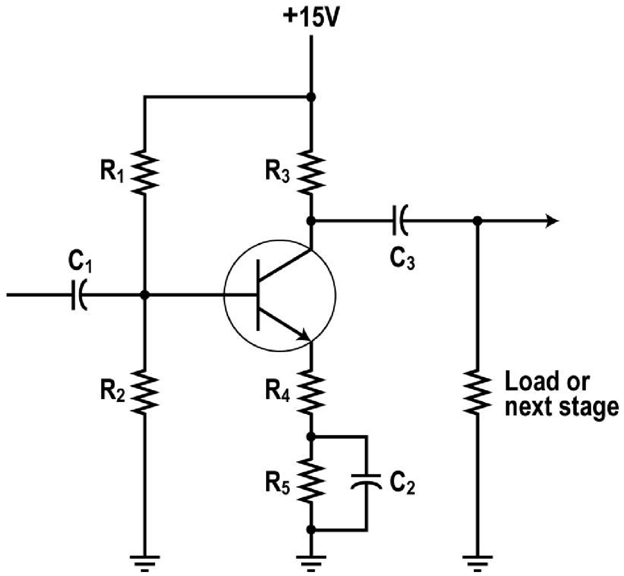
Signal Tracing #2: DC Voltage Check

If you do get an output voltage larger than the input, the circuit is probably working fine. If you do not get a larger output voltage, than the circuit is defective.

As a next step, measure the DC supply voltage. If it is present you can move on to some other approach. If the supply voltage is not present or at some other level, look for a power supply problem.

Next, measure the voltage at the collector of the transistor. It should be roughly half the value of the supply voltage. If it is, then the transistor is OK and its bias is probably correct.

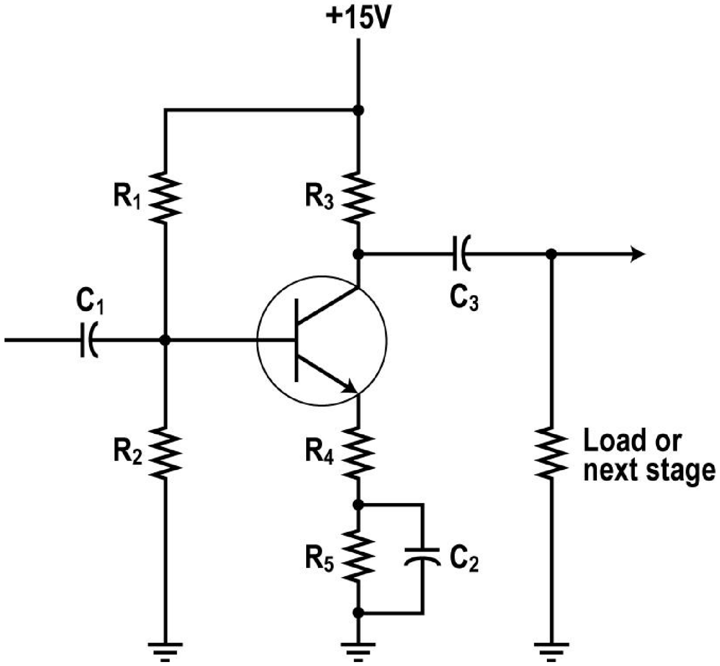
If there is still no output, the output capacitor C_3 could be open.



Signal Tracing #2: Collector voltage

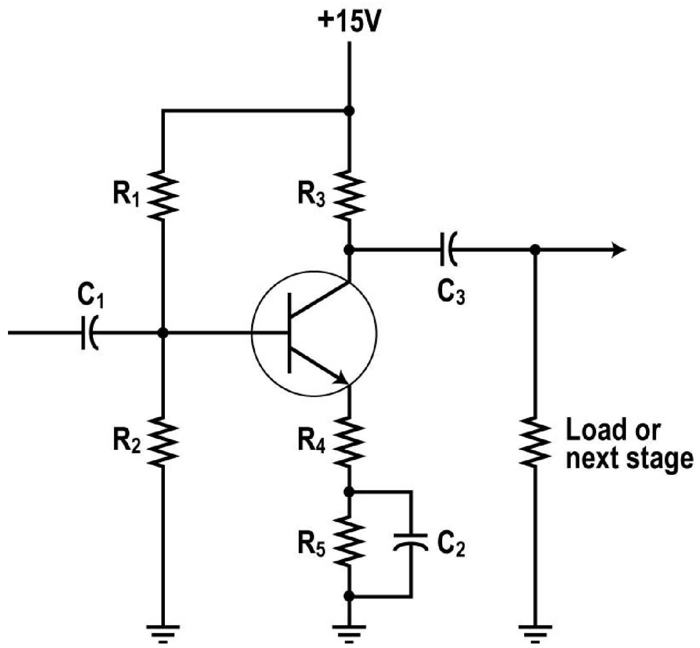
If the collector voltage is equal to the supply voltage, that indicates that the transistor is not conducting and the collector current is not producing a voltage drop across R_3. This could mean a bad transistor or defective bias resistors.

At this point you could just replace the transistor as that is the most likely problem.

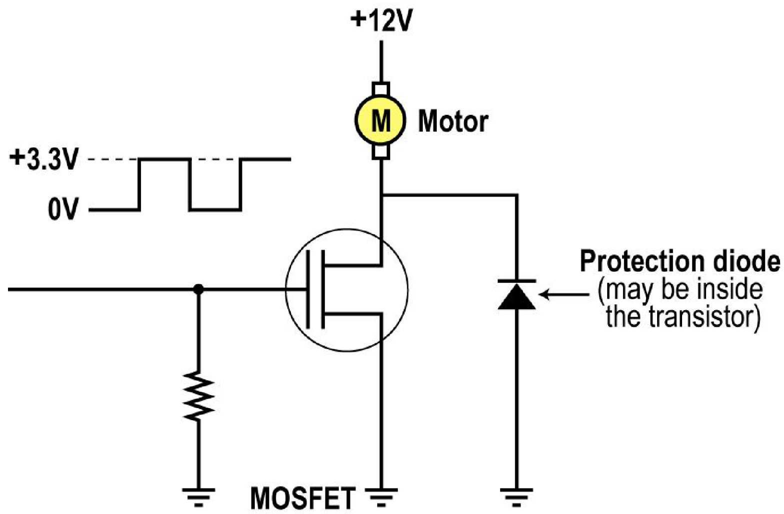


Signal Tracing #2: Emitter voltage

Otherwise, measure the emitter-base voltage drop. It should be about 0.7 volts. If it is not, look for a bad bias resistor. Any one of R_1, R_2, R_4, or R_5 could be open. Make measurements with your multimeter to pin point the bad part. For example, measure the voltage at the junction of R_1 and R_2. It should be equal to the output of a voltage divider using the standard voltage divider formula.



Signal Tracing Example #3

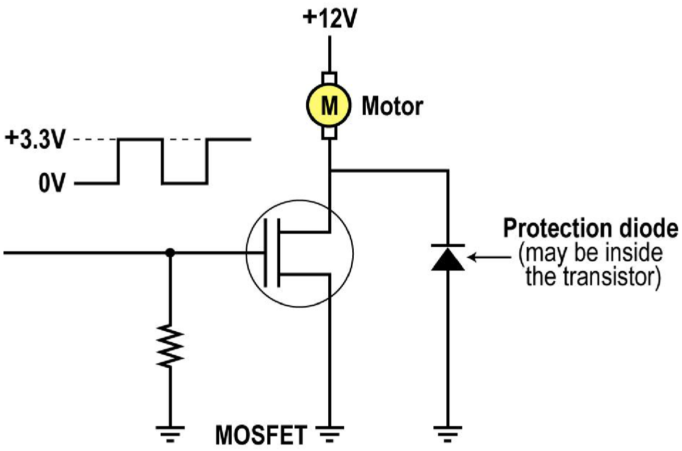


This is a MOSFET driver for a small DC motor. A two-state logic signal of zero or +3.3 volts is the input that controls the motor. If the input is zero, the MOSFET does not conduct so the motor sees an open circuit and does not turn on. If the MOSFET input is +3.3 volts, the gate threshold is exceeded and the MOSFET conducts acting as a low resistance switch between source and drain. This causes the motor to see the full supply voltage and turn on.

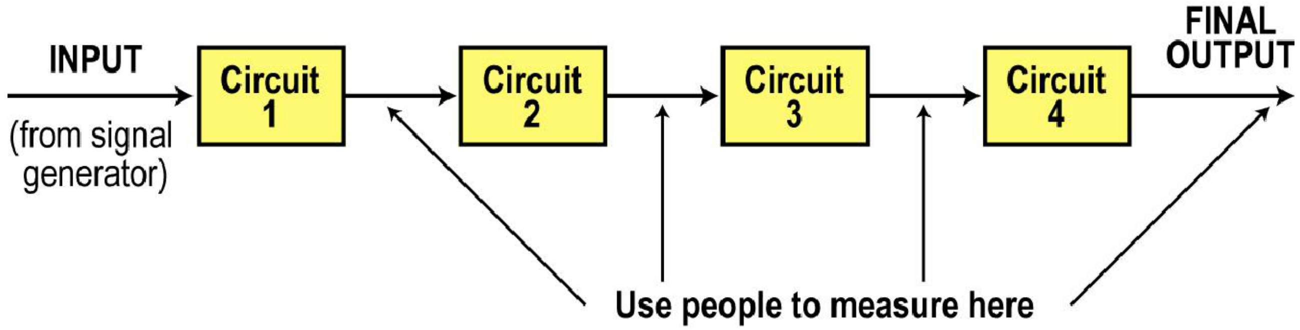
Signal Tracing #3

Follow the basic procedure described earlier. First check for the input with an oscilloscope for the stated input signal or with a DC multimeter if the change is static. You should be able to predict the state of the motor with the input.

The condition of the motor is the output, on or off. If the correct input is present, about the only problem is a bad transistor or a defective motor. The protection diode could also be open which would cause the transistor to fail. A shorted diode would cause the motor to run continuously regardless of the input state.

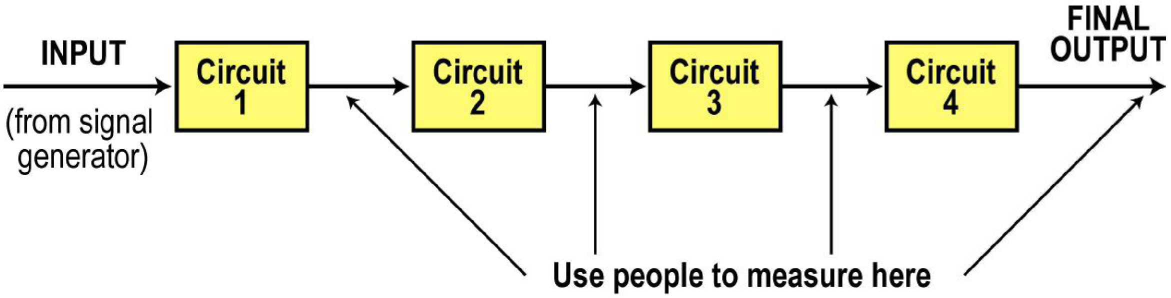


Multistage Signal Tracing



More complex equipment typically has multiple stages of signal processing as shown here. You will need to check the documentation for what the inputs and outputs of each stage should be. The level and nature of the signal at the output of each stage will depend upon what each stage is such as a filter, amplifier, mixer, or regulator.

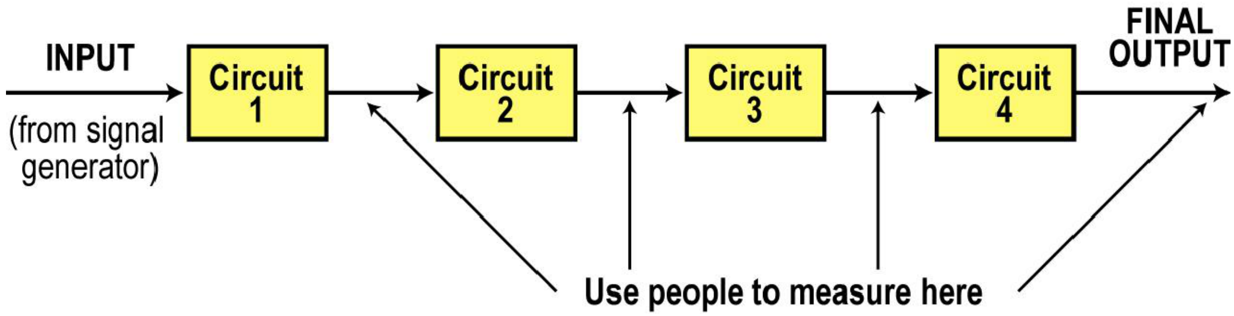
Troubleshooting Multistage Signals



The signal tracing procedure assumes that you apply the appropriate input signal. Then using an oscilloscope, you look at the output of each stage from left to right in the diagram. You should see the appropriate output at each stage. But if you do not, then the stage where the output fails is defective.

Assume that the input is correct as are the outputs from circuit stages 1 and 2. But stages 3 and 4 have no output. Then stage 3 is defective. Additional troubleshooting will allow you to determine the cause and lead to the replacement of an IC, transistor, or other part.

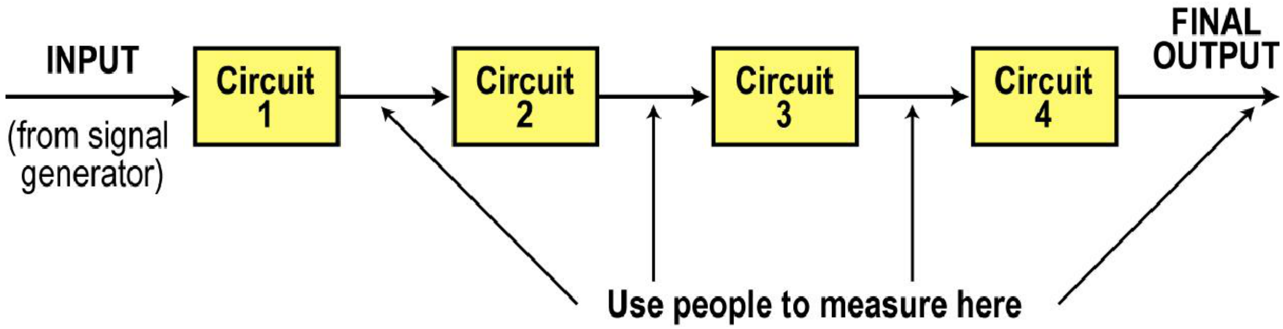
Signal Injection



Signal injection is a process similar to signal tracing but in reverse. In this process, you work from the output back to the input. For example, assume that there is no output from circuit 4. Using a signal generator suitable to the application, you first inject an appropriate level into stage 4 then observe the final output. If the output appears, then stage 4 is OK.

Next, you readjust the generator for an appropriate type and level of signal to apply to the input of stage 3. If the output appears, then stage 3 is OK too.

Signal Injection Checks



Now assume you apply the signal to the input of stage 2 and the output does not appear. Then stage 2 is bad and further troubleshooting is needed.

Signal injection is not as widely used as signal tracing because of the many different types of signals that are needed.

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Troubleshooting Techniques

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