87 BJT Amplifier Troubleshooting

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Objectives

1. To evaluate a systematic method of troubleshooting a BJT amplifier.
2. To isolate faults in a BJT amplifier using voltage or current measurements.
3. To verify suspected faults with ohmmeter measurements.
4. To simulate component faults using circuit simulation software.

Equipment

6 Common-emitter amplifier printed circuit boards with one fault in each circuit.

Information

There are two overall logical approaches to troubleshooting a BJT amplifier. Some people prefer to apply an AC signal to the input and trace the signal through the circuit to confirm proper operation or to note where the signal first disappears or seems incorrect. Another approach is to first confirm correct DC operation before even applying an AC signal. Both methods have their strengths and weaknesses, and both methods are correct.

Some overall observations of troubleshooting should be considered. First, try to predict DC and AC values ahead of time if possible. In this experiment, you will do this in the preparation or simulation section. It is helpful to know what these conditions should be if the amplifier is working correctly. Very often, commercial amplifiers have DC and AC voltage values printed on the schematic diagram. This is a logical first step. After all, how can you tell if a measurement is wrong if you have no idea what the measurement should be?

If correct DC operation can be confirmed, an AC signal should be applied and the signal should be traced through the circuit. On [illegible] amplifiers this may isolate the problem to a single stage. DC measurements may also isolate the problem to a single stage.

Do not make incorrect assumptions. This is easier said than done. As an example, a person might measure zero volts across a resistor and jump to the conclusion that it is shorted. But an open circuit on either side of that resistor would cause the current flow to stop, producing a zero volt reading across the resistor. The zero volt reading should cause you to <u>suspect</u> a short circuit. You must then try to <u>confirm</u> the fault, for example by taking additional measurements to prove that current is flowing. Then, if there is zero volts across a resistor and there is current flowing through that resistor you can safely conclude that the resistor is short-circuited. By the way, short circuits in resistors are extremely rare! They most often burn out leaving an open circuit and, less often, can change their ohmic value, or be incorrectly color coded. The lesson here is to allow your suspicions to form as a result of your measurements, then you must confirm your suspicions through additional measurements.

Realize that you can do many things to confirm a suspected fault. For example, a suspected open resistor could be confirmed by an ohmmeter measurement, but watch out for parallel resistance paths! You could also connect a good resistor across a suspected open resistor and take further measurements to see if that corrects the problem. Ohmmeter measurements are also useful to check for capacitor operation by observing charging or discharging resistance.

Remember that open circuits (which are very common) usually result in voltages in unexpected places. For example, you might observe a voltage across a circuit board trace which obviously should be zero volts. This should immediately signal an open trace in the circuit board. A wire connected across the open trace should restore normal operation, unless there is a second fault (also very common). Similarly, a good capacitor placed across an open capacitor should restore normal operation.

Remember to disconnect power when making ohmmeter measurements. Try to use ohmmeter measurements only to confirm a fault found by voltage measurements. Almost all faults can be found, and usually are found, by taking voltage measurements. In a small circuit such as in this experiment, students will sometimes try to measure the resistance of everything and may stumble across a fault quite quickly. But they won't learn much, if anything! That technique, when applied to a commercial circuit board with 100 components will fail miserably–there are too many components, and too many parallel resistance paths! Current measurements, in practice, are used mostly to confirm a fault. Current is more frequently calculated (from a voltage measurement) than measured simply because of the difficulty in breaking the circuit to insert an ammeter. Current is usually only measured at the power supply connection point and sometimes by removing a fuse and connecting the ammeter across the fuse holder. A good troubleshooter finds most faults with DC and AC voltage measurements, often with only a DMM.

When you are learning to troubleshoot you may easily become frustrated. This is normal! Try not to take it too seriously. It takes a long time to get good at this. Stay with it. You will improve with time so try to enjoy the experience! One of life's oddities here is that students who are typically careless in hooking up circuits on a breadboard may actually become good at troubleshooting faster than those who are quite careful, simply because they have more troubleshooting opportunities. Seems unfair.

You may find the guide in Figure 87-1 useful as you try to find the faults in this experiment. It provides two paths you may follow to help find the fault. It will pay you to do a lot of thinking as you proceed. You will likely do better with one measurement and ten minutes of thinking, than you will with ten measurements and one minute of thinking!

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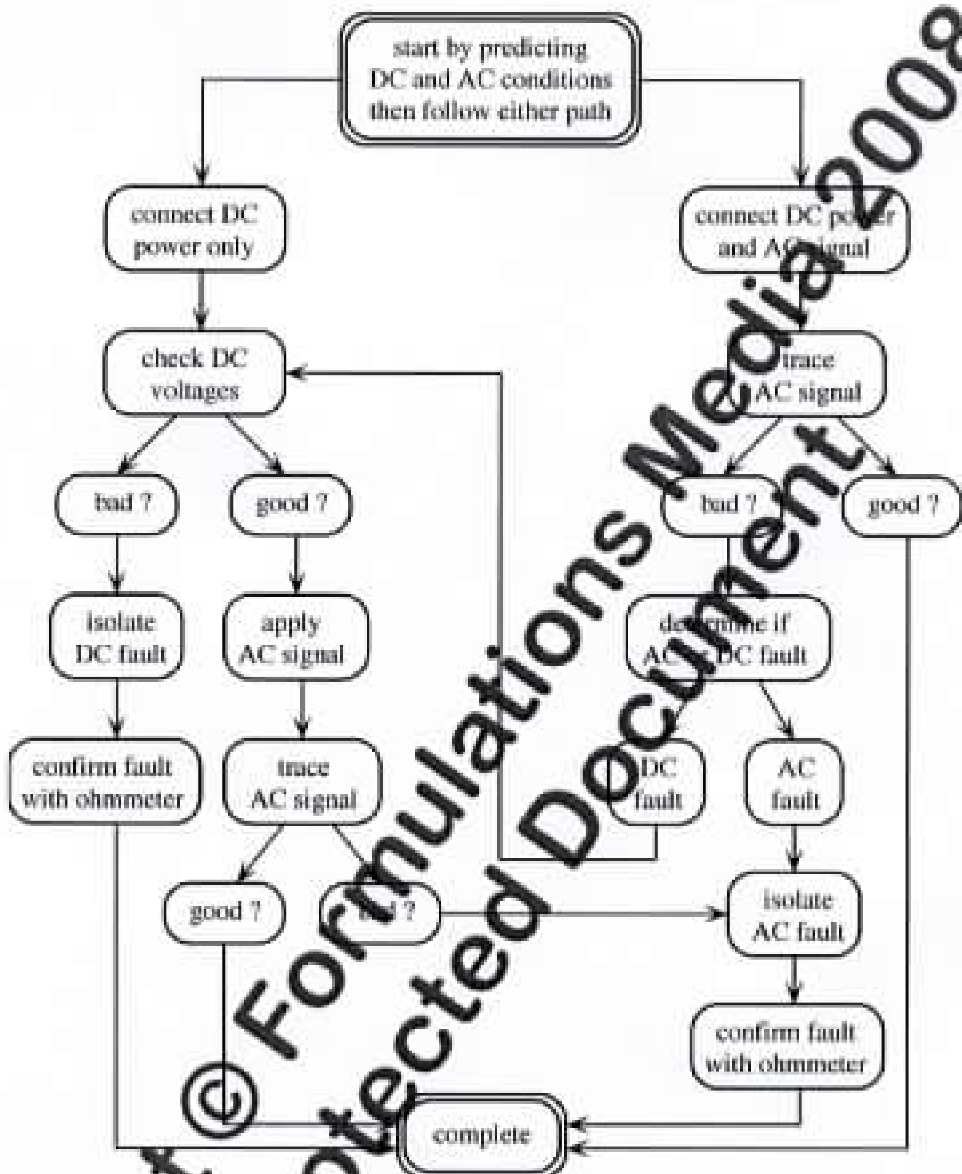

Figure 87-[illegible]: Single Stage Amplifier Troubleshooting Guide

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Circuit Simulation

1. For the circuit of Figure 87-2, simulate the circuit using software in order to predict the quantities required for Table 87-1. If circuit simulation software is not available, the student may complete the required theoretical calculations assuming h_{FE} = very large, h_{fe} = 575, V_{BE} = 600 mV, and [illegible] Ω.

Table 87-1. Circuit Predictions

V_B	V_E	V_C	V_{CE}	V_{R5}	R[illegible]	Av	Avo

2. Do all of the questions for this experiment prior to doing the [illegible] troubleshooting procedure.

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Procedure

1. The schematic diagram for the circuit used in this experiment is given in Figure 87-2.

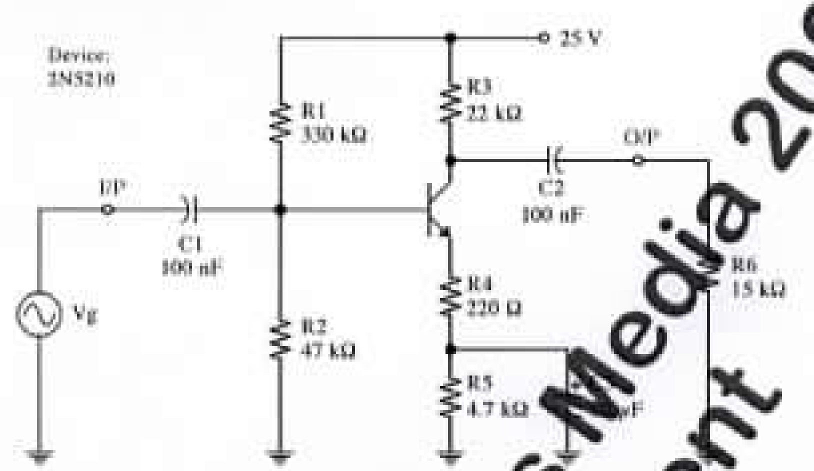

Figure 87-2. Troubleshooting Circuit

2. When using the generator, select a frequency of 5 kHz along with a suitable generator voltage so that signals are undistorted.

3. There are a fixed number of printed circuit boards for the circuit of Figure 87-2, each having only one fault unless additional faults have been introduced by prior users.

4. The fault may be an open or shorted component or an open circuit trace, or a BJT fault (open or short between any two leads). Your instructor will decide how many you will be expected to troubleshoot, and how marks will be determined.

5. Complete the required sections of Table 87-2 for each designated circuit board. The following is a guide as to the meaning of each title in the table. When completed, transfer this data into the table on the data sheet.

   Unexpected Measurements or Observations: This column allows you space to record suspicious measurements or all measurements. You might wish to compare these with the simulation data.

   Suspected Fault: This is for your use, to write down what faults you think may exist. Then you can systematically think about them and try to eliminate some suspected faults with additional measurements.

   Measurements Used to Confirm Fault: When you think you know what the fault is, this column should be reserved for listing the measurements and/or logic which, in your opinion, confirms the fault.

   Fault Description: This column is used only for the concise description of the fault. Something like "open R3" or "open trace between the left side of C1 and the top of R2" or "short from C to B." Please be very specific; writing "bad transistor" or "broken resistors" will not make the grade.

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Table 87-2. Troubleshooting Data

Board Number	Unexpected Measurements or Observations	Suspected Fault	Measurements Used to Confirm the Fault	Fault Description
A				
B				
C				
D				
E				

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87 Simulation Summary

Name ______________________________

1. Complete the data required for Table 87-1 below.

V_B	V_E	V_C	V_{CE}	V_{R5}	Ri	[illegible]	Avo

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87 Data Sheet

Name ______________________________

Board Number	Unexpected Measurements or Observations	Suspected Fault	Measurements Used to Confirm the Fault	Fault Description
A				
B				
C				
D				
E				
F				

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Questions

1. For the circuit of Figure 87-2, an AC signal is seen with a scope at the input, at the base, at the collector, but not at the output. List one fault which might cause this and explain your reasoning.

2. For the circuit of Figure 87-2, an AC signal is seen with a scope at the base but not at the collector. Also, V_E is normal but the collector is at the power supply potential. List one fault which might cause this and explain your reasoning.

3. For the circuit of Figure 87-2, an AC signal is seen with a scope at the input, at the base, at the emitter, across R5 and at the collector but the collector signal is too small. List one fault which might cause this and explain your reasoning.

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