TROUBLESHOOTING TRANSISTOR AMPLIFIERS

Before discussing troubleshooting any type of circuit, always keep in mind that a procedure for troubleshooting cannot be taught, but each individual can develop a method or procedure that suits his/her own needs. This lesson will show you a procedure that is used in this school and while you are in school this is the procedure that will be followed. You may feel that a voltage or resistance check is not necessary to locate a malfunctioning part and you may be totally correct, but some procedure has to be followed when a person first begins to troubleshoot and that is the purpose of this lesson.

Your job, once you are finished with school, will be to repair malfunctioning circuits in a missile system. Before you can repair a malfunctioning circuit, you must first know how the circuit operates under normal conditions. You have already studied the theory of operations of the three basic amplifiers, CE, CB, and CC, so now you will discuss troubleshooting a malfunction in these circuits.

Before beginning with the three basic circuits, take a look at a very basic circuit. If a procedure can be followed to troubleshoot a simple circuit, it can be used in any circuit. Refer to Figure 1.

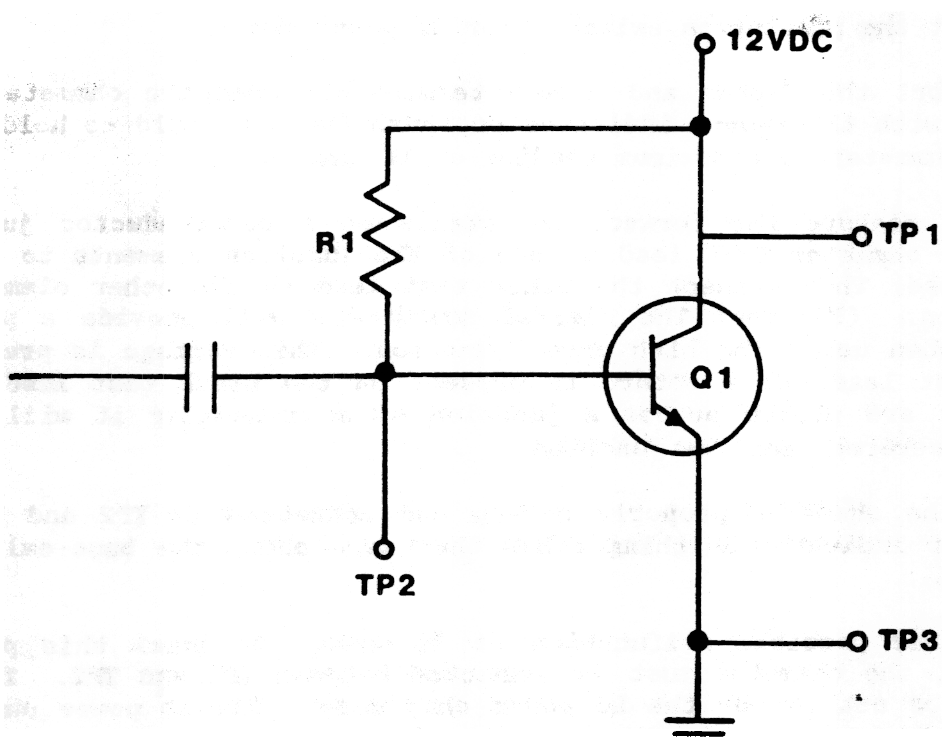


FIGURE 1

Under normal conditions, the voltage readings at TP1 should be 12VDC, TP2 will be some voltages less than 12VDC because of the voltage dropped across R1, so for simplicity we will assume TP2 reads 1VDC, and TP3 will be zero volts. With these voltages Q1 will conduct and current will flow thru Q1. Without a collector load resistor the voltage at TP1 should always be 12VDC. Lets assume someone measured the voltages of this circuit, the first measurement would be made at TP1, the second at TP2 and the last at TP3. These three measurements will give a good indication of possible malfunctions.

If these measurements were made and 12VDC was measured at TP1, OVDC was measured at TP2 and OVDC was measured at TP3, this would indicate something is wrong with this circuit. The symptom of this malfunction is TP2 indicating OVDC. In this circuit only two malfunctions will cause these measurements. If R1 was open, TP2 would measure OVDC because the voltage could not be felt across R1 to TP2. The other possible problem could be the base shorted to the emitter of Q1. If this was the malfunction, the ground that is tied to the emitter will be felt on the base of Q1. Ground is always zero volts. To determine which of these is the actual malfunction, resistance measurements must be made. After the power is turned off, an ohmmeter is connected between TP2 and TP3. The ohmmeter must be setup to read the resistance of a semiconductor junction. In order to measure semiconductor junction resistance, the measurement must be down ranged to the lowest ohms range. This can be accomplished by performing the following procedure.

1. Set the pushbutton switches for HI power ohm.

2. Short the V-ohms and common terminals. When the ohmmeter indicates zero with the K-ohms indicator on, push the auto hold to hold. This holds the ohmmeter to a maximum reading of 1K ohm.

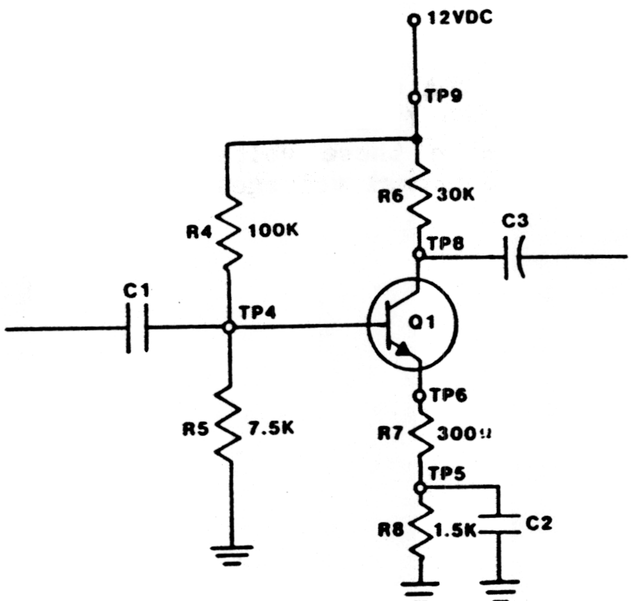
3. To measure the forward resistance of a semiconductor junction, connect the ohmmeter test lead to one of the junction elements to be measured. (Base) Then connect the other test lead to the other elements of the junction. (Emitter) The digital multimeter will provide a positive 2.5 volts when using the high power function. This voltage is present on the red test lead and a return is present on the black test lead. When these leads are placed across a junction of a transistor it will either forward or reverse bias the junction.

With the ohmmeter properly set-up and connected to TP2 and TP3, if the ohmmeter indicates anything other than zero ohms, the base-emitter is not shorted.

The other possible malfunction is R1 open. To check this possible malfunction, the ohmmeter must be connected between TP1 and TP2. The ohmmeter must be set up for the LO power ohms mode. The LO power ohms mode is useful for measurements which require low power dissipation, low voltage drop across the resistance, and low open-circuit voltage (less than 350 millivolts). These features are especially desirable for in-circuit resistance measurements which require non-conduction of semiconductor junctions. The low open-circuit voltage (.35VDC) in the LO power ohms mode eliminates the possibility of damaging certain semiconductor junctions or of forward biasing the junction and receiving an incorrect ohms reading. The ohmmeter indicates a very high reading, (in the MEG ohm range or higher), so R1 is open. Remember, when measuring resistance in a transistor circuit, always use the LO power ohms mode to prevent forward biasing a semiconductor junction.

Again assume voltage measurements are made and TP1 is 12VDC, TP2 is 12VDC and TP3 is 0VD. With these measurements, TP2 is not indicating a normal reading. Look at the circuit and try to determine what components would cause these symptoms. With R1 shorted, the emitter of Q1 open and the collector-base shorted, this would cause the reading of 12VDC at TP2. Connect an ohmmeter to TP1 and TP2, if the ohmmeter indicates zero ohms then R1 is shorted, or the collector-base is shorted. This is one problem that cannot be determined without further isolation. If R1 is soldered into the circuit, then one side of R1 will have to be unsoldered and a resistance check will have to be made across the resistor. While the resistor is unsoldered the collector-base junction can be measured to determine if a short exist across the junction. To measure the base-emitter junction to determine if the emitter is open, set the ohmmeter to measure a semiconductor junction and connect the leads to TP2 and TP3, take the reading and then reverse the leads and make another measurement of the same point. If the resistance is low during one reading and high during the other reading, the emitter-base junction is good. The meter indicated zero ohms when connected to TP2 and TP3 in both the forward and reverse readings. This is proof that the base to emitter is shorted.

Refer to Figure 2.



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The first of the basic amplifier circuits that will be discussed is the common emitter amplifier. If you were told that this circuit was malfunctioning and your job was to repair it, you would have to know how this circuit operates when it does not have a malfunction. For instance, if you measured the voltage on the collector of Q1 and it measured 11.5VDC, you would have to know if that was a normal or abnormal reading. Most schematic books have the normal reading listed on the schematic for that circuit. The schematic books you will be using in the transistor team does not have the normal voltage readings so you will have to make the normal measurements before troubleshooting any of the circuit used in the transistor area. Each of the schematics that you will be using will have a chart for you to record the normal voltages and AC signals during the theory portion of the practical exercise.

If you know the normal voltage and signal measurements, it becomes very simple to locate something that is malfunctioning. Perform the same measurements that were performed to obtain the normal voltage, if any of these voltages or signals is different from the normal, then you have a starting point. For instance, above it was stated that 11.5VDC was measured on the collector of Q1, under normal operation, the collector voltage of Q1 measured 7.5VDC. This indicates something in this circuit is not performing correctly. When an abnormal voltage or signal measurement is made, it is commonly referred to as a symptom. A symptom in electronics is a sign or indication that something is not working correctly. The difference in the voltage readings on the collector of Q1 (11.5VDC and 7.5VDC) would be an indication that something is malfunctioning.

The remainder of this block of instruction will be devoted to troubleshooting the three basic amplifiers and if you will follow the same procedure used in this block you will be able to use it to locate any malfunction in any circuit.

Using circuit card PC-130-30A as an example to begin troubleshooting, it will have an operating voltage (Vcc) of 12VDC and an input AC signal of 100millivolts peak-to-peak. With these voltage and signals present, it will be possible to measure the normal voltages.

TP9 = 12VDC

TP7 = 7.6VDC

TP4 = .84VDC

TP6 = .26VDC

TP5 = .219VDC

SIGNAL MEASUREMENTS

TP7 = SINEWAVE 6VAC P/P

SINEWAVE 100millivolts AC P/P

= SINEWAVE 60 millivolts AC P/P

Now, assume there is a malfunction in this circuit. Again, the first thing that must be done is to measure the voltages to determine the symptoms of this circuit with a malfunctioning component.

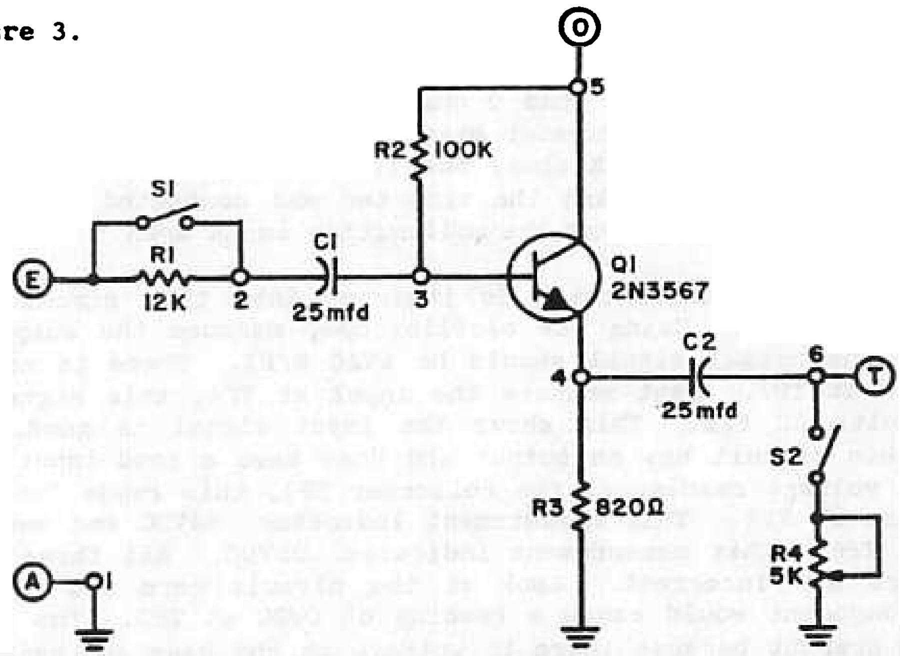
First measure the output signal to determine if the output is present. Then measure the input to insure the input is present. At TP7 there is no signal present but the signal is normal at the input. Next measure the collector voltage at TP7. This voltage measures 11.98VDC. This measurement indicates the transistor is not conducting. The next measurement is the base of Q1 at TP4. This voltage measures 0VDC. With this measurement at 0VDC, this indicates that the bias voltage has been removed and verifies the first reading that indicated the transistor was cutoff. Look at the circuit to determine what would cause this indication, R4 open or R5 shorted will cause these symptoms. With the power off, an ohmmeter can be connected between TP4 and TP1, if the ohmmeter measures anything other than 0 ohms, this would eliminate R5 being shorted. Next connect an ohmmeter between TP9 and TP4, if R4 is good the ohmmeter will indicate 100K ohms, but if R4 is open, the ohmmeter will indicate infinite ohms. When the ohmmeter was connected to TP9 and TP4, it read infinite, this proves the malfunction is R4 open.

If another malfunction is inserted into this circuit it will give another symptom. Using the oscilloscope, measure the output at TP7 (remember the normal signal should be 6VAC P/P). There is no output signal present at TP7. Next measure the input at TP4, this signal measures 100 millivolts AC P/P. This shows the input signal is good. The symptoms are, this circuit has no output and does have a good input signal. Next, make a voltage reading at the collector TP7, this reads 0VDC. Now measure the base at TP4. This measurement indicates .64VDC and measure the emitter at TP6. This measurement indicates .05VDC. All three of the voltage readings are incorrect. Look at the circuit card and try to determine what component would cause a reading of 0VDC at TP7. The operating voltage is present because there is voltage on the base and emitter. To verify this, perform a voltage measurement at TP9. If this measurement indicates 12VDC it is normal. If R6 were open, it would cause these symptoms, so turn the power off and connect an ohmmeter between TP9 and TP7. The ohmmeter indicates infinite ohms, R6 is open. With R6 open, the voltage at TP4 would decrease from the normal reading because the paths for current flow has changed and now R4 will drop more voltage. The collector of Q1 was eliminated from this problem because if the collector was open, the voltage reading at TP7 would have been 12VDC. If the collector of Q1 opened, no current would flow in the collector circuit so no voltage drop would be developed across R6. With no voltage dropped across R6, if there was 12VDC applied at TP9 then it would be present at TP7.

To review what has been discussed in this block of instruction, look at the order of our signal, voltage and resistance measurements.

The first thing to do is check the output signal, normally if the output signal is good, then the circuit is operating correctly. Next, if the output signal is missing, check the input signal at the base of Q1. If this signal is present it indicates that all components associated with the input signal from this point back to the signal source is operating normally, so there is no reason to go back any further. After the signal measurements have been completed, the next check will be to measure the voltage at the collector, base, and emitter. Under some circumstances, it may seem that some of these checks may not be necessary, but if a habit is formed from the beginning to make these checks in a specific order, then maybe none of the symptoms of the malfunctions will be overlooked. After the voltage measurements are completed, it is time to make resistance measurements to isolate the exact component that is malfunctioning.

Refer to Figure 3.



The next circuit is the common collector amplifier, this is the easiest of the three basic amplifiers to troubleshoot. This is because there are fewer components and the collector voltage should always be 12VDC.

Again the first thing that must be known is the normal signals and voltages. The same procedure will be followed to troubleshoot this circuit that was used to troubleshoot the common emitter.

With 12VDC applied as the Vcc and a 6VAC P/P sinewave applied to the input at TP3, the normal signal and voltage readings are as follows:

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Signal Measurements

TP4 = 6VAC P/P

TP3 = 6VAC P/P

Voltage Measurements

12VDC (Collector)

5.92VDC (Base)

5.93VDC (Emitter)

Notice the measurements on the base and emitter, they are extremely close to the same value. Some readings will show a higher emitter voltage than the base voltage and this indicates the transistor is conducting. This reading is caused by the meter that is being used to measure these voltages. The meter, when connected into the circuit, places another load on the base of the transistor and will cause the path for current flow to change. If two meters are used at the same time to measure both the base and emitter, the extra load of the base meter will not cause a problem with the normal readings. A normal reading in this circuit should be 6.47VDC on the base and 5.94VDC on the emitter. This circuit can still be repaired using only one meter and the readings obtained as the normal voltages.

With a malfunction in this circuit, the first check will be the output at TP4. If the circuit has no output, the next check will be the input at TP3. If the input is good and there is no output, the transistor circuit is malfunctioning. If the output signal is distorted in anyway, the circuit is malfunctioning.

Before continuing your troubleshooting procedure the AC input signal must be removed from the circuit. If the AC signal is connected to the input, the oscilloscope or the multimeter will complete the circuit and may cause the transistor to conduct. For instance, if the emitter resistor of this circuit is open, the oscilloscope will complete a path for current to flow.

Refer to Figure 4

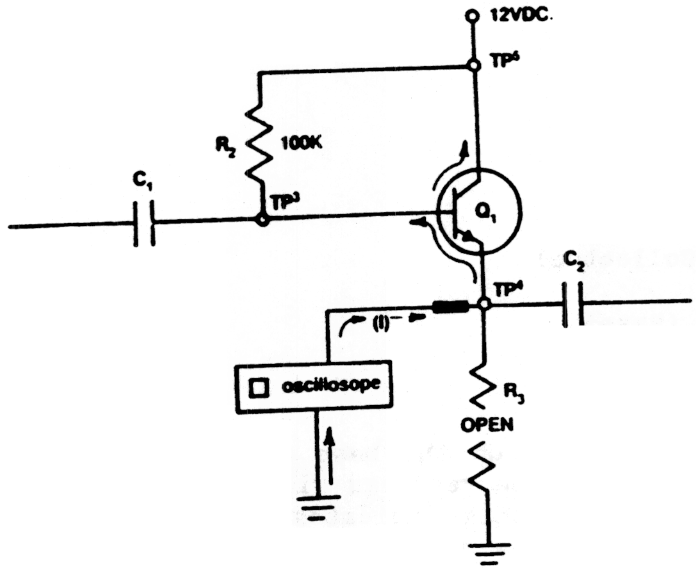

FIGURE 4

When the oscilloscope is connected to the circuit and the AC signal is applied, the positive portion of the sinewave will forward bias the transistor and cause an output signal to be developed across the 1 MEG ohm resistance offered by the oscilloscope. When the negative portion of the sinewave is present on the base, the transistor will be reversed biased and cutoff, so no output signal will be developed.

Refer to Figure 5.

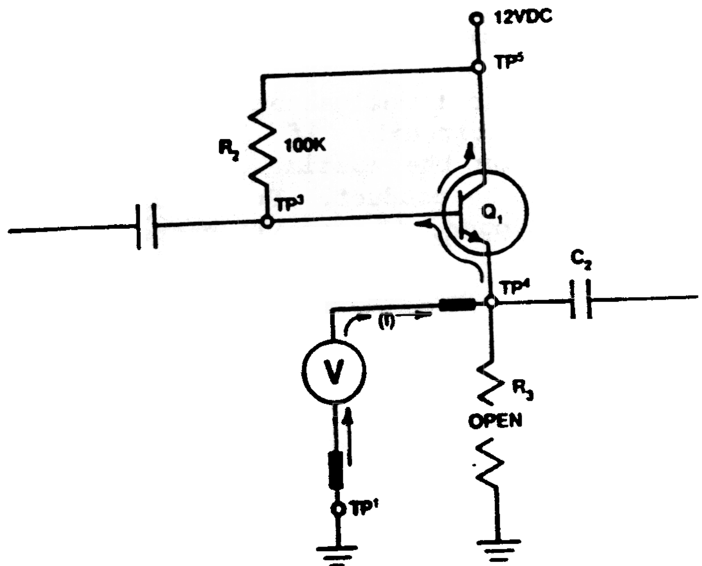

FIGURE 5

In the circuit shown in Figure 5, the voltmeter will again complete the circuit and allow current to flow. Before the multimeter was connected there was no path for current to flow so the transistor will be cutoff. When the meter is connected the circuit will change totally. (Refer to Figure 6)

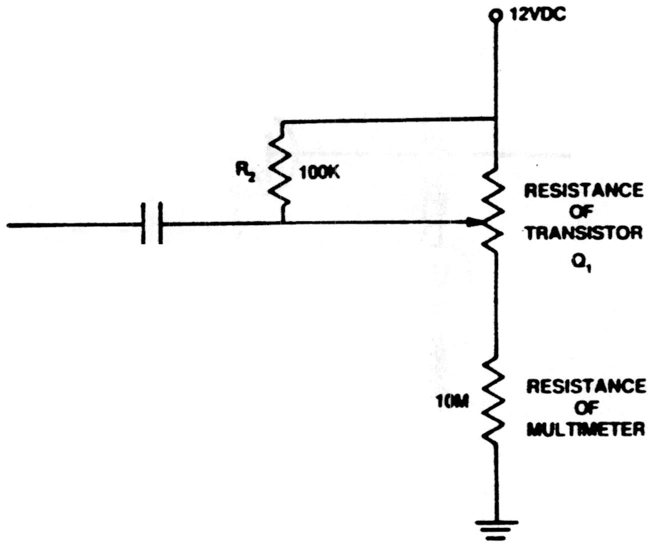

FIGURE 6

With this circuit, when the transistor is forward biased the resistance of Q1 is small, the resistance of R2 remains 100K ohms and the load resistance (which is the 10 MEG ohms offered by the multimeter) is very high. Under these conditions, the multimeter will drop most of the voltage in this circuit. By using the comparison method to make a quick calculation for voltage drops, the multimeter will drop approximately 100 volts for every 1 volt dropped by the resistor R2 and the transistor. With this in mind, the multimeter in this circuit will indicate approximately 11.4VDC.

Refer to Figure 7.

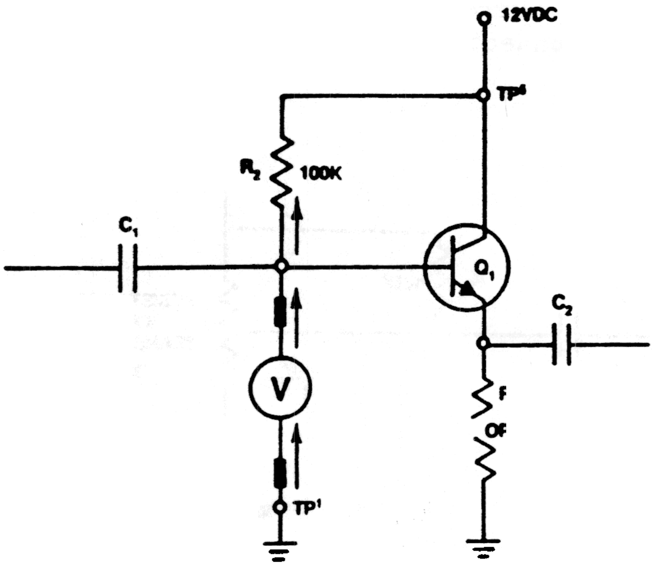

FIGURE 7

With the multimeter connected to the base of Q1, again a path for current flow has been created thru the meter. The meter will indicate something less than the Vcc because some small amount of voltage will be dropped across R2 due to the current flow. The meter will indicate approximately 11.8VDC. Now the voltmeter will drop about 100 volts for every 1 volt dropped by the biasing resistor R2. Anytime signal or voltage measurements do not seem to agree with the actual theory, look for an alternate path of current flow when any item of test equipment is connected to a circuit. Remember that current will always take the path of least resistance and the 1 MEG ohm of the oscilloscope and the 10 MEG ohms of resistance offered by the multimeter offers less resistance than an open circuit.

Now to continue the troubleshooting procedure, check the collector voltage at TP5, then the base voltage at TP3 and the emitter voltage at TP4. If any of these are abnormal it will help to pinpoint what area is malfunctioning. For instance, if there is 12VDC at TP5 (which is normal), OVDC at TP3 which is abnormal) and OVDC at TP4 (which is abnormal), this indicates a problem exist in the base of Q1. Now the ohmmeter can be used to determine what element or component is malfunctioning. If an ohmmeter is connected between TP5 and TP3, with the ohmmeter set to read resistance in the circuit, it would indicate infinite ohm if R2 was open. To check the base to ground for a short, connect the ohmmeter to TP3 and TP1, the ohmmeter indicates zero ohms, this indicates the base is shorted to ground.

If a malfunction is suspected in one of the elements of the transistor, they can be checked with an ohmmeter using the set up procedure for semiconductor junctions.

Remember, the most important step in troubleshooting the common collector is to remove the AC input signal after the input and output signals have been measured. Also, the oscilloscope and the multimeter will complete a path for current flow and change the circuit, so if the measurements are not correct look for a path for current flow thru the test equipment.

The last circuit to be discussed is the common base amplifier. Again the same procedure for troubleshooting will be followed. First obtain the normal readings without a malfunction in the circuit. When a malfunction is in the circuit, the first step is to measure the output signal to determine whether the circuit is working. If the output signal is missing or distorted, measure the input signal to insure it is correct and not being received at the input of the circuit distorted. If the input signal is good, measure the voltages at the transistor until a symptom is observed. Measure the collector, base, and emitter in this order even if you feel you may not need to measure them all. If you can gather all the indications of the malfunction, it is easier to make a determination of the actual malfunction than it would be if you only saw one symptom. After the voltage measurements are completed, try to decide which malfunctioning component would cause the symptoms that were observed during the signal and voltage measurements. Once this decision is made, perform the resistance checks that is necessary to prove the component is bad.

Refer to Figure 8.

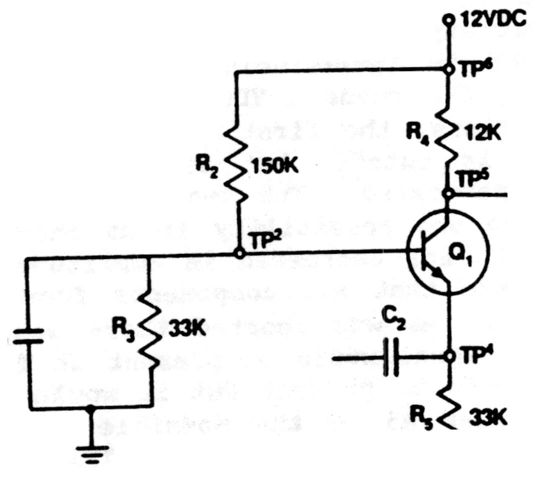

FIGURE 8

The normal signal and voltage measurements for this circuit are as follows:

Signal Measurements

TP5 = 4VAC P/P

20millivolt AC P/P

Voltage Measurements

= 6.81VDC

TP2 = 2.04VDC

TP4 = 1.43VDC.

Now when a malfunction is inserted in this circuit, the symptoms can be recognized. If the voltage was measured in this circuit and one of the readings was TP5 is 12VDC, this would indicate two possibilities, the transistor is cutoff or the collector load resistor is shorted. Without knowing the other two voltage measurements, it would be difficult to determine which of these malfunctions is occurring, but if the base measured two volts and the emitter measured one volt, the indications now point toward the collector resistor being shorted. Again to prove this, make a resistance check using the low power setting of the ohmmeter. when an ohmmeter is connected between TP6 and TP5 it indicates zero ohms, proving R4 is shorted.

Another malfunction in this circuit will cause the following symptoms. There is no output signal at TP5, no input signal at TP4, the signal at TP3 has decreased to 15millivolts, TP5 reads .05VDC, TP2 reads .6VDC, TP4 read 0VDC and TP6 reads 12VDC. With this malfunction, there are four abnormal indications, the first is no signal at TP5 which would indicate the transistor is cutoff, but the collector voltage (.05VDC) shows the transistor is saturated. The second is no input signal at TP4 and TP4 measures 0VDC, so one possibility is R5 shorted. The signal is present at TP3 although it has decreased in amplitude. If the signal is present this would indicate that all components from this point back to the generator is good. If R6 was shorted there would be no signal at TP3. If R1 was open, no signal would be present at TP3. Also if C2 was open the signal at TP3 would be present but it would not be decreased in amplitude. This only leaves R5 as the possible cause of this problem. When an ohmmeter is connected between TP4 and TP1, it would indicate 0 ohms, confirming R5 is shorted.

As stated at the beginning of this instruction, there is not a set procedure to troubleshoot, everyone has their own method after working in electronics for any length of time. The procedure that was discussed here is the one used in this school. The steps for troubleshooting here are simple and easy to follow.

1. Measure the output signal using an oscilloscope.

2. Measure the input signal using an oscilloscope

3. Measure the collector voltage using a DC voltmeter

4. Measure the base voltage using a DC voltmeter

5. Measure the emitter voltage using a DC voltmeter.

6. Look at all the symptoms gathered by these measurements and determine what component will cause these symptoms.

7 Perform resistance measurements to confirm the malfunction.

There may be times when a component cannot be isolated from another component to perform a confirmation check, but normally when this happens, one of the components can be proven to be good with signal, voltage, or resistance measurements and can be eliminated.

Refer to Figure 9.

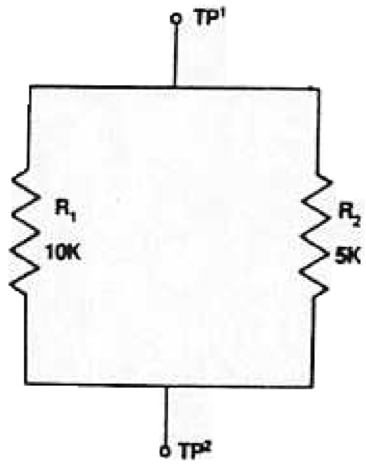

FIGURE 9

If an ohmmeter was placed between TP1 and TP2, under normal conditions it would read 6K ohms, but if the meter indicated 10K ohms, the possible malfunction would be R2 open, because the resistance has increased which indicate an open in the parallel. There is no way to isolate the individual resistor without using a soldering iron. If the ohmmeter indicates the exact value of one of the resistors, such as 10K ohms. This measurement proves that R2, the 5K ohm resistor, is open.

If one of the resistors is shorted, the ohmmeter will indicate zero ohms when connected between TP1 and TP2. There are two ways to prove which resistor is shorted. If an ammeter can be connected in series with each of the resistors, it will indicate current flow in the resistor that is shorted and no current flow in the resistor that is good. The other way to prove which resistor is shorted is to remove one end of one resistor from the circuit and then measure both resistors, one will read the correct ohms and the bad resistor will indicate zero ohms.