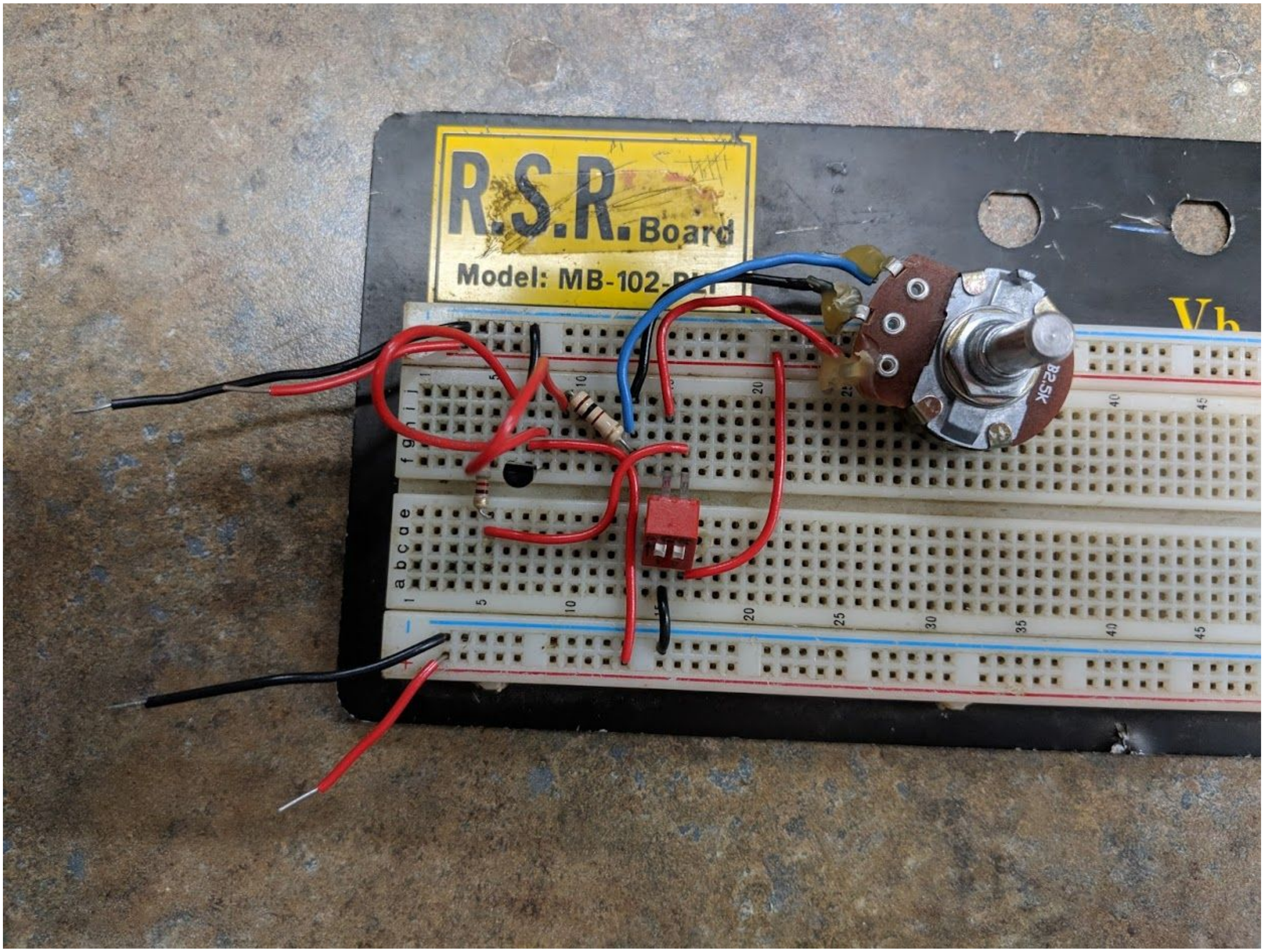
Experiment 10
Transistor Familiarization



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12/13-21

Objective: The objective of the lab was to become familiar with transistor biasing, to measure the effect on current when an emitter-base is set in forward and reverse biasing, measure the effects on collector current when forward and reverse biased, and to measure I_{CBO}.

Materials:

- **Power supply: 12-V and 6-V dc sources**
- **2 20,000 Ohm Digital Multimeters**
- **A 1000 and a 820 ohm resistor**
- **3904 and 3906 Transistors**
- **2,500 Ohm Potentiometer**
- **2 SPST Switches**
- **Computer with Multisim installed**

Procedure: To begin a circuit as shown in figure 1-2 was constructed on multisim using a PNP transistor. Once constructed the voltage of the transistors' emitter-base, collector-base, and collector-emitter along with the voltage drop of resistor 3 and the amperage of the collector, emitter, and base and the data collected is represented in tables below and the points of measurement are shown in figure 1-1 for all of the steps. In step 2 both switches were closed, the potentiometer was set to max resistance, and the voltage and current of each branch was measured. In step 3 the potentiometer was set for minimum resistance and the values were re-measured. In step 5 the switch labeled S2 was opened thus opening the emitter-base circuit the measurements were yet again retaken along with the measurement of the collector-base current, called Icbo in the table.

After the first circuit was measured in multi-sim the second circuit as shown in 1-3 was constructed in multisim using an NPN transistor. For step 7 the 2 switches were closed and the potentiometer was set to the maximum and the voltage drop of the third resistor was measured along with the voltages of the collector base, emitter-base, and collector-emitter along with the current of the collector, emitter, and base and put in the table. In step 8 the potentiometer was set to minimum and the data was remeasured and placed in step 8 on the table. To complete step 10 S2 was opened and only the voltage of the collector-base and the current of the collector-base when the switch was opened was measured. Once all of the data was collated in the multisim table the circuit was built physically as shown on the cover page and all of the steps were repeated then the measured data was placed in the real world table.

Real World Transistor Amplifier Characteristics

Step	I_E	I_C	V_{EB}	V_{CB}	V_{CE}	I_{CBO}	I_B	V_{R3}
2	300 uA	500 uA	630 mV	350 mV	6.37 V	N/A	0uA*	410 mV
3	1.5 mA	150 uA	720 mV	6.02 V	450 mV	N/A	1.35mA	123 mV
5	2 uA	1 uA	720 mV	330 mV	330 mV	0 uA	1 uA	.820mV
7	333 uA	84uA	660 mV	5.73 V	6.37 V	N/A	249 uA	68.8mV
8	3.63mA	85 uA	698 mV	527 mV	166 mV	N/A	3.55mA	69.7mV
10	0 uA	0 uA	0 mV	2.15mV	0 mV	0 uA	0 uA	0 V

***negative current omitted**

Multisim Transistor Amplifier Characteristics

Step	I_E	I_C	V_{EB}	V_{CB}	V_{CE}	I_{CBO}	I_B	V_{R3}
2	806 uA	799 uA	694 mV	5.34 V	6.04 V	N/A	7uA	655 mV
3	240 uA	238 uA	662 mV	5.81 V	6.47 V	N/A	2uA	195 mV
5	11.2 nA	16.8 nA	380 mV	6 V	6.38 V	5.59 nA	0nA*	13.8 uV
7	7.78mA	7.73mA	721 mV	.342 V	.379 V	N/A	0.05mA	6.34 V
8	333 uA	330 uA	634 mV	5.73 V	6.36 V	N/A	3uA	271 mV
10	11.5 nA	16.9 nA	345 mV	6 V	6.35 V	5.39 nA	0nA*	13.9 uV

E= Emitter C= Collector B= Base

Figure 1-1

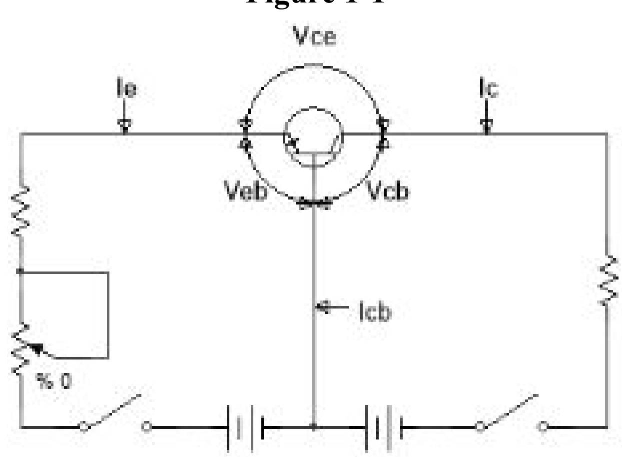


Figure 1-2

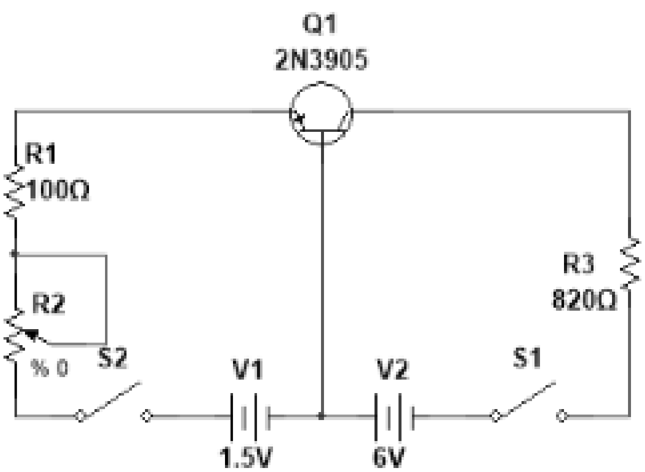
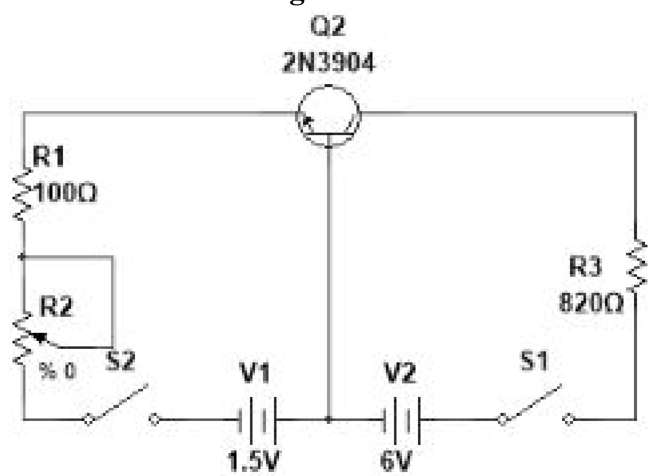


Figure 1-3



Questions:

1. What is the effect on collector current of increasing emitter bias?
    a. With increasing emitter bias the current of the collector should increase.
2. Compute the base current ($I_B = I_E - I_C$) for each set of readings in the table.
    a. These values were calculated and can be found in *Table 1*.
3. Compare and explain the differences in Ic and Icbo.
    a. I_c is the current at the collector when both switches are closed. I_{CBO} is the leakage current.
4. Compare and explain the differences in V_{ce} in steps 2 and 3.
    a. The voltage of the collector-base is greater in step 3 than step 2 due to the fact that the circuit has less total resistance, increasing the circuit current.
5. Compute the voltage across R_3 ($V_{R3} = I_c * R_3(820\Omega)$ for each set of readings in *Table 1*. Comment on the relationship between V_{R3} and V_{EB}.
    a. The results of computation are shown in *Table 1*. The emitter-base voltage is higher than the voltage of resistor 3.
6. An amplifier gain is computed by dividing output current (Ic in this experiment) by input current (Ie). What is the current gain of the common-base amplifier used in this experiment under normal Operation?
    a. The gain of the common base amplifier is 1.5 uA under normal conditions.

Discussion: When trying to run the multisim circuit it wouldn't run with both switches closed and a convergence error would pop up. At first, it was believed that the error was caused by the usage of digital voltmeters and they were replaced with digital reference points and the measurements were correct. When physically measuring the circuit with the 2N3904 we originally found values that were very different from our recorded multisim values. But after consulting with a different groups data, these values despite being different they were correct. While measuring current and voltage in the circuit shown in figure 1-3 on a breadboard it was found out that we can’t measure both current and voltage at the same time, in order to measure voltage we would need to remove the ammeters from the circuit. Another problem that was encountered while breadboarding is that the variable resistor was set up as a potentiometer instead of a rheostat so the values were incorrect so they were remeasured.

Conclusion: There is a small amount of leakage when voltage is applied to the transistor (I_{CBO}), but it is not activated. To bias a PNP transistor properly, the negative side of a battery is applied to the base and the positive side is applied to the emitter. The positive side of another battery must then be applied to the base, and the negative side should be applied to the collector. The base-emitter junction will then be activated, allowing current to flow from the collector to the emitter. The reverse is true for an NPN transistor.