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EET 2141
Fall ‘24

Lab 9 Bipolar Junction Transistors – Common Collector Amplifier

Introduction:

The objective of this lab is to analyze bipolar junction transistors, specifically, the interactions and behaviors of measurable data such as voltage and current across collectors, bases, and emitters within amplifier circuits. This study in congruence with its following study (lab 8) look at two different common amplifier circuits which use bipolar junction transistors. This study in particular analyses common collector amplifiers, which has a voltage gain of approximately 1V, which acts as a buffer, essentially isolating two circuits. These types of amplifiers tend to have a very high input impedence, and a very low output impedance. Only one circuit with slight modifications will be analyzed to showcase the behavior of a common collector amplifier.

Bench Parts and Equipment List:

Components

- 10kΩ (x2), 100kΩ Resistors
- BJT Transistor (2N3904)
- Numerous Connector Wires
- 500kΩ Potentiometer
- 100uF Capacitor

Equipment

- Programmable DMM
- ELENCO Trainer Board
- Windows Machine w/ Multisim
- Triple Power Supply
- Function Generator
- Oscilloscope

Discussion:

Part 1 – The Simulation

The first step of this lab is to construct the given circuit in Multisim, of which there is only one for this specific study (two if you count the circuit addition in the second part of the study). The following is the provided image for each given circuit purposed toward the study of this lab

(See below)

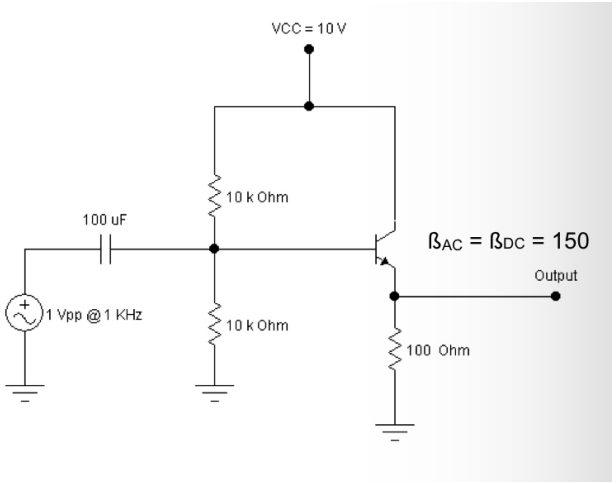
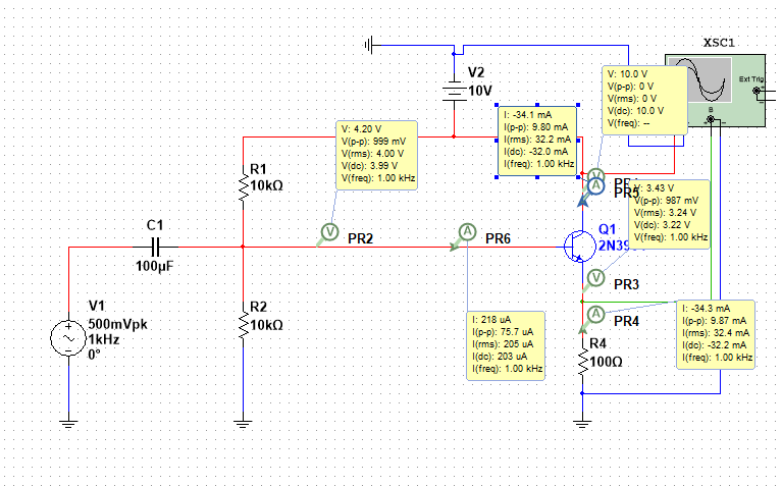


Figure 1 - Circuit 1 Diagram Provided by Lab Manual

The constructed Multisim circuit is as follows:



Note that attached are both digital multimeters, as well as Multisim analysis probes used for obtaining simulation measurements (notably the probes are used for current measurements as to eliminate the requirement for disconnecting the circuit, while digital multimeters are used for voltage measurements as they can simply be connected in parallel).

Figure 2 - Circuit 1 Constructed in Multisim

Viewing the resulting values of current and voltage throughout the circuit, it it is evident that the behavior of this circuit matches the original provided definition of a common collector amplifier, which takes any signal and amplifies it by around 1 volt. The significance of this is that this circuit officially amplifies, or acts as a buffer to other circuits, the AC signal provided through the base and out of the emitter.

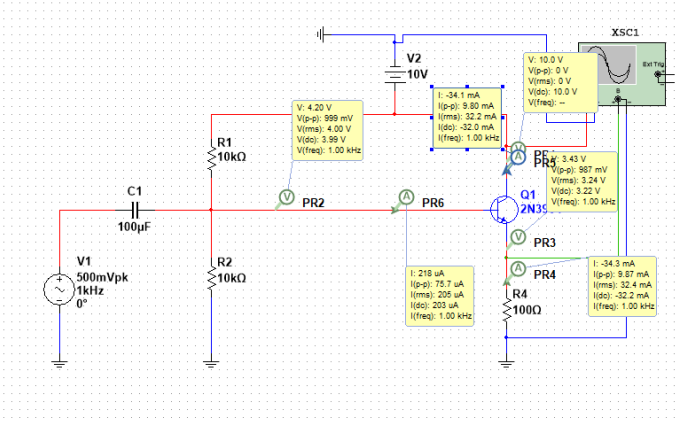


Figure 3 - Circuit 1 Constructed in Multisim with data probes

Circuit 1 is a BJT series-parallel circuit, with a single transistor and 3 value-varying resistors. There are two different power sources, one acting as a sinusoidal AC voltage source with a value of 500mVpk, and one acting as a 10v DC source at the top of the circuit. As stated before, this circuit functions as a common collector amplifier, who's purpose it is to increase the value of the ac signal by approximately 1 volt and in essence act as a buffer. Applications such as impedance matches (due to the nature of the high input and low output impedance), and driving speakers. Note the orientation of the BJT (denoted by the arrow indicating the emitter) is aligned with the bias of the current, which is known as *forward bias*.

The multimeter used to conduct testing was later changed to a multimeter following the capture of these images, in other words, the current probes appearing in the images was no longer used.

Finally, below are the waveforms associated with this portion of the study, provided are the voltage measurements for the base, emitter, and collector of the bipolar junction transistor:

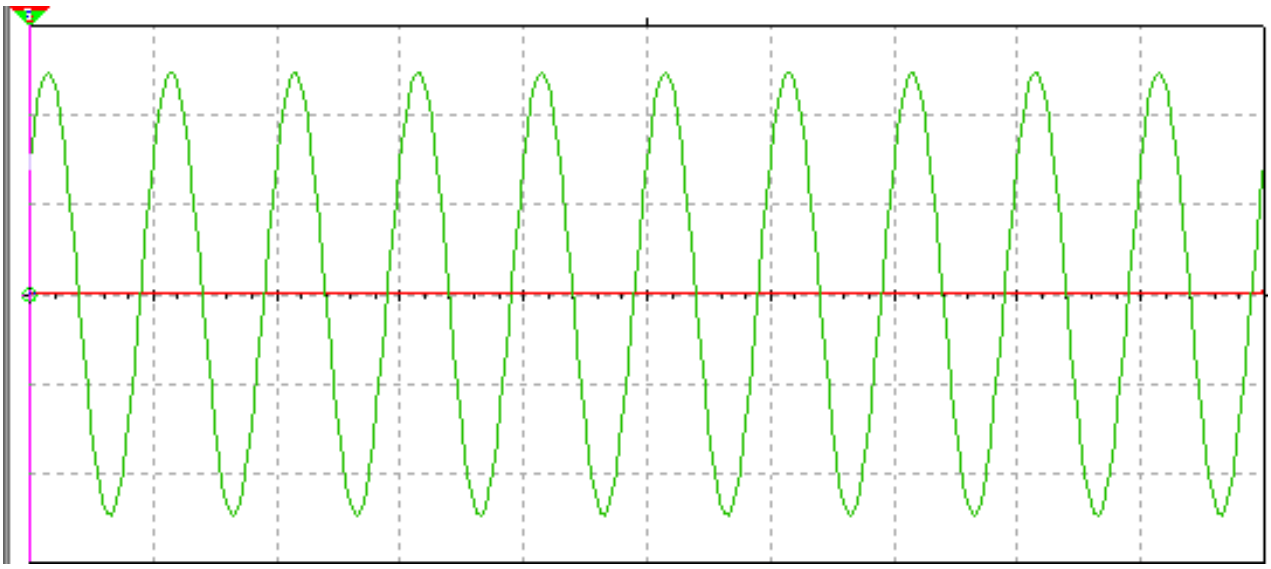


Figure 4 – Waveform of Simulation Data (Red – Emitter) (Green – Collector)

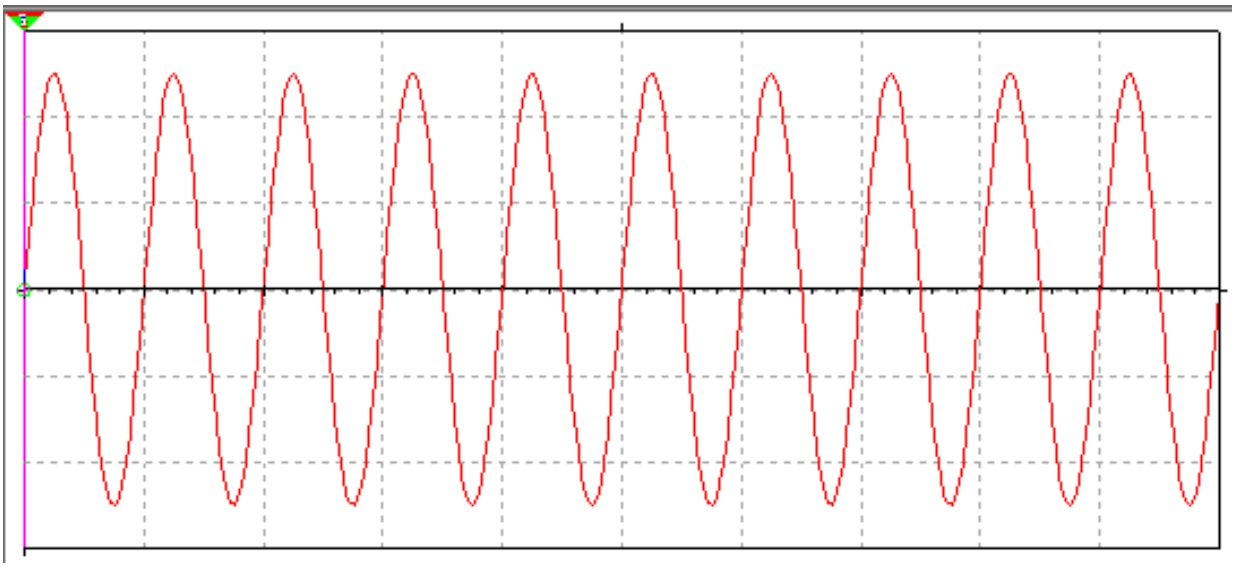


Figure 5 – Waveform of Simulation Data (Red – Base)

Part 2 – The Bench

The circuit is now constructed on the bench, below are captures of each circuit constructed:

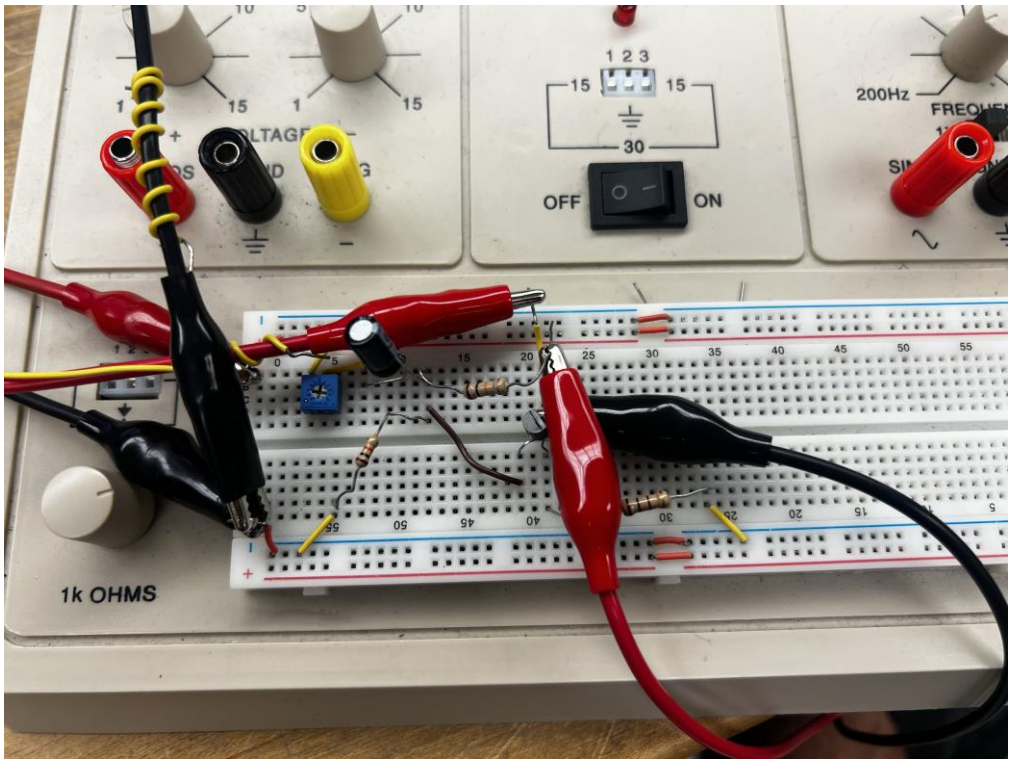


Figure 6 – Circuit 1 Constructed on the Bench

Note that above, a 500kΩ resistor is used to manage the input AC signal, and bring it down to the low value of 500Vpk. The function generator provided alone is incapable of providing this low of a voltage value with a 1kHz frequency, thus assistance is required in some form or another. In the

previous lab, the *ELENCO Variable Resistor* was used, and here, a potentiometer was used. This allows for two different input resistance management methods to be used and observed in a BJT based amplifier circuit.

Now, below is the waveform found for the base of the BJT on the bench:

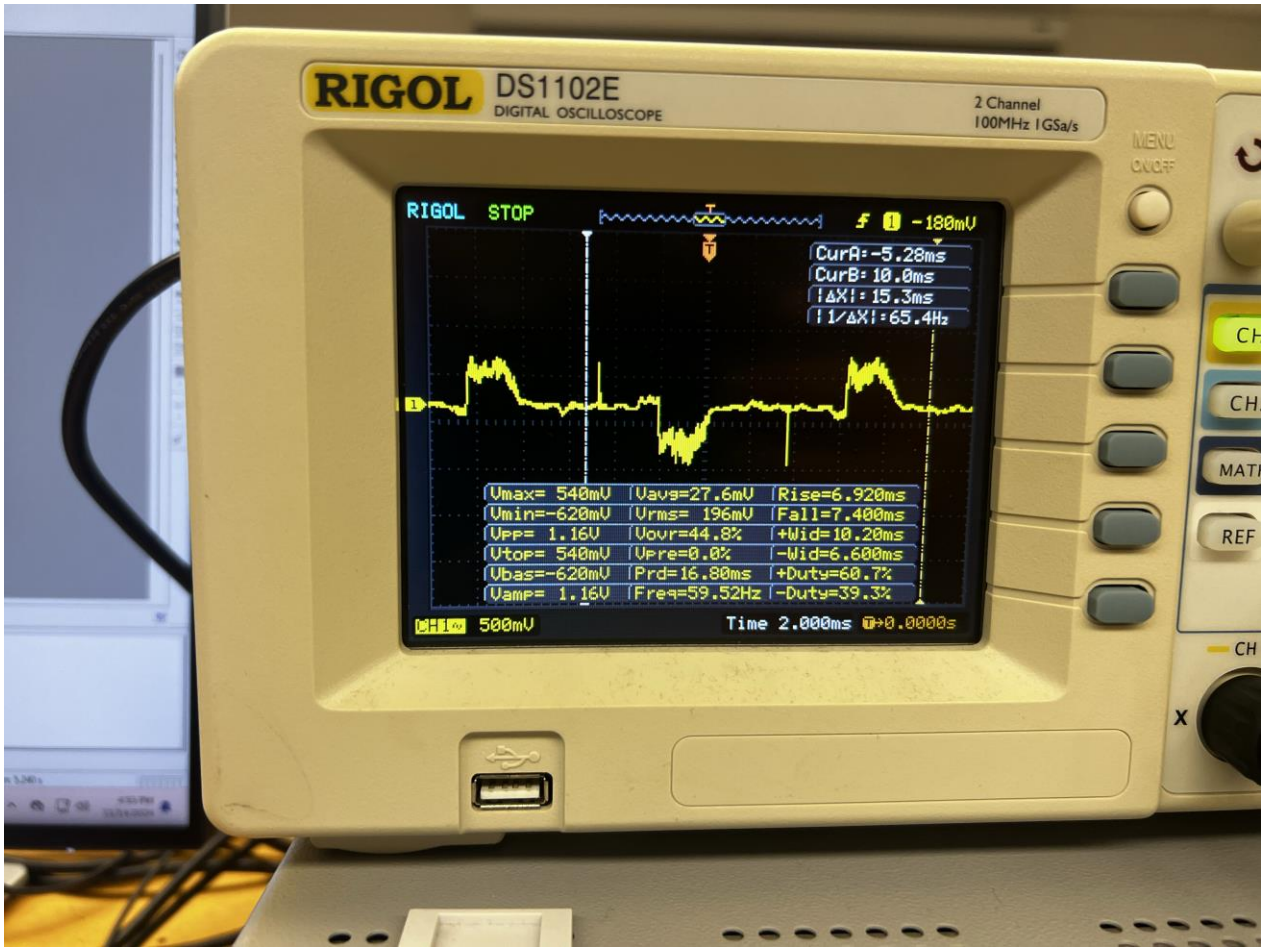


Figure 7 – Circuit 1 waveform of emitter and base of BJT

Below is an analysis of the data obtained on the bench:

Table 1 – Resistor Nominal and Measured Values

Resistor	Nominal	Measured
R1	10kΩ	9.856kΩ
R2	10kΩ	9.761Ω

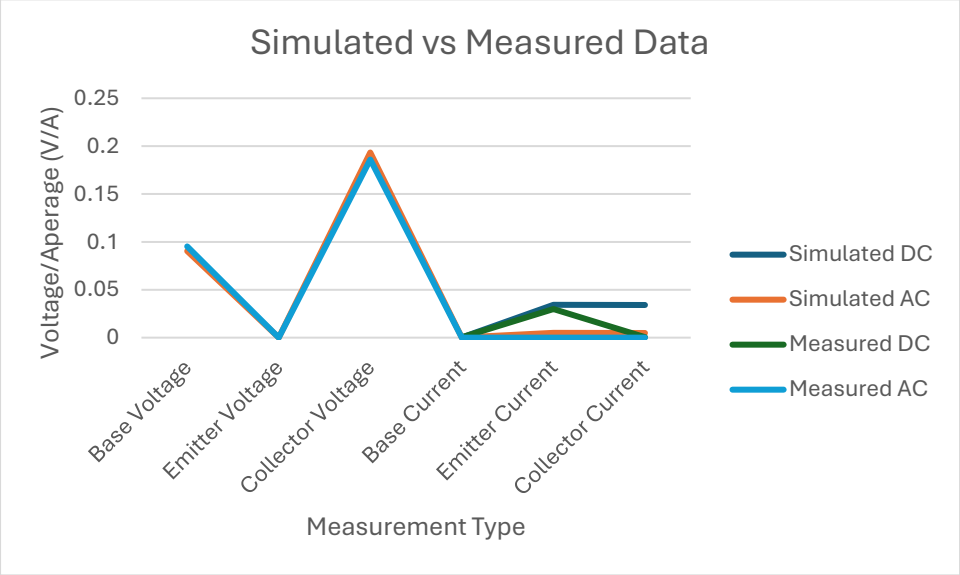
R3	100Ω	96.73Ω

Table 1– Bench vs Simulation Data (Circuit 1)

Collector to Emitter Voltage (V_{CE})	**DC Parameter**		**AC Parameter**	
	Computed (V/A)	**Measured (V/A)**	**Computed (V/A)**	**Measured (V/A)**
Base Voltage	4.2	4.23	90.37m	95.3m
Emitter Voltage	3.34	3.49	0	0
Collector Voltage	10.0	10.07	193.38m	186m
Base Current	218u	385.7u	241.98u	
Emitter Current	34.3m	29.87m	4.94m	
Collector Current	34.1m	583.30u	4.90m	

Part 3 – The Comparison

Thus, it would appear that the bench measurements and simulation data both follow the same trend, and are relatively close in terms of values. Below is a graphical comparison of the two datasets:



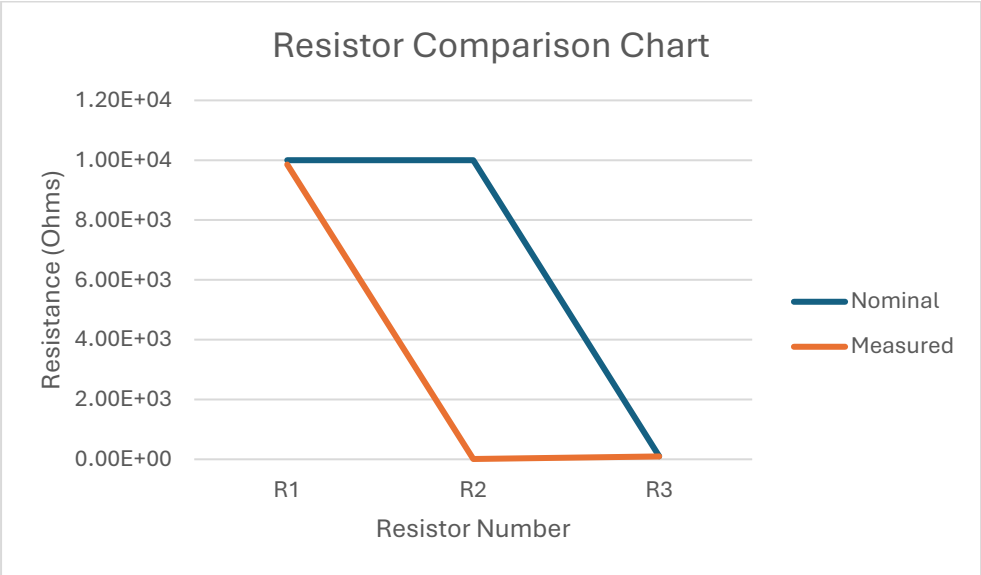


Figure 8 - Data Comparison of Circuit 2 Measurements

Finally, for certification purposes, below the instructor sign-off can be found. As a reminder, this signature is obtained by either the course instructor or a certified lab assistant to ensure proper results are being obtained.

3- Determine the input resistance (use a potentiometer). 49.76KΩ

4- Complete Table 1.

	DC parameter (sim)		AC parameter (sim)	
	~~Computed~~	Measured	~~Computed~~	Measured
Base Voltage	1.77V	1.83	29.3mV	29.6mV
Emitter Voltage	1.12V	1.15V	0V	148mV
Collector Voltage	6.43V	5.86V	4.7V	5.86V
Base Current	4.91μA	6.53μA	5.93μA	
Emitter Current	399μA	309.81μA	1.32mA	
Collector Current	1.23mA	1.15mA	830.1μA	

Table 1

5- Use the data in Table 1 and draw in the space below the DC and AC load lines.

6- Calculate the AC output resistance.

7- Determine the amplifier's voltage gain. This gain is also known as unloaded gain.

Conclusion:

The objective of this lab is to obtain an understanding and visualization of the behavior and purposes of BJTs in common collector amplifier circuits. The particular behavior of this circuit is to increase the ac signal obtained through the bipolar junction transistor, by approximately 1V, alongside having a high input impedance, with a low output impedance. Thus, the primary measurements being taken throughout the circuit will be voltage and current, however it is pertinent to test the resistance values of all resistors, as well as determining the input resistance of the ac source signal. While only one circuit is analyzed, it demonstrates the essential nature of a common collector amplifier. If this lab were to be conducted again, it would be prudent to analyze more, and more complex common collector amplifier circuits, as well as analyze some real-world applications of such a circuit. It should be noted that while there are other BJT-oriented circuits, they will be analyzed and discussed in later studies found in the *Semiconductors Devices Circuit* course at Valencia College. That being said, the lab was conducted successfully based on the comparison of the data between simulation and bench measurements, as they not only follow the same trends, but also match data values very closely.