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EET 2141
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Lab 8 Bipolar Junction Transistors – Common Emitter 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 9) look at two different common amplifier circuits which use bipolar junction transistors. This study in particular analyses common emitter amplifiers, which takes a small ac signal into the base of a transistor and exhibits a greatly increased amplitude ac signal at the collector. These types of amplifier circuits are used in a myriad of applications, such as broadcasting devices (i.e. radio, TV) and computers. Only one circuit with slight modifications will be analyzed to showcase the behavior of a common emitter amplifier.

Bench Parts and Equipment List:

Components

- 10kΩ, 1kΩ, 2.2kΩ, 3.6kΩ Resistors
- Numerous Connector Wires
- 1uF, 47uF Capacitors
- BJT Transistor (2N3904)
- 500kΩ Potentiometer

Equipment

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

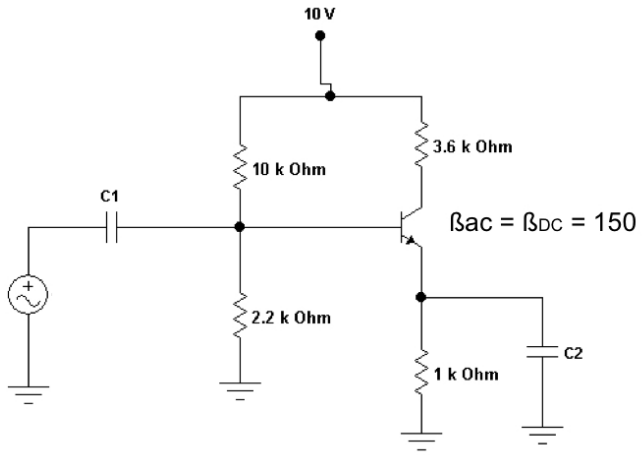
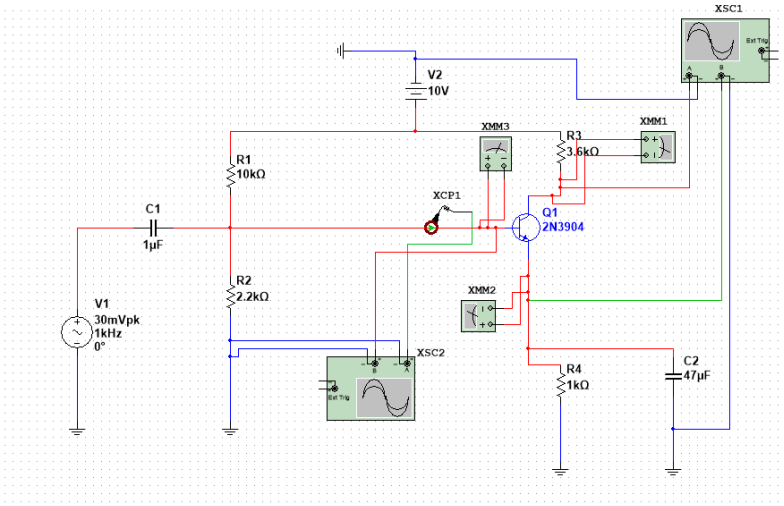


Figure 1 - Circuit 1 Diagram Provided by Lab Manual

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 2 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 emitter amplifier, which takes the small ac signal at the base (around 15uA) and resulting in a higher value at the emitter (around 350uA). The significance of this is that this circuit officially amplifies the AC signal provided through the base and out of the emitter.

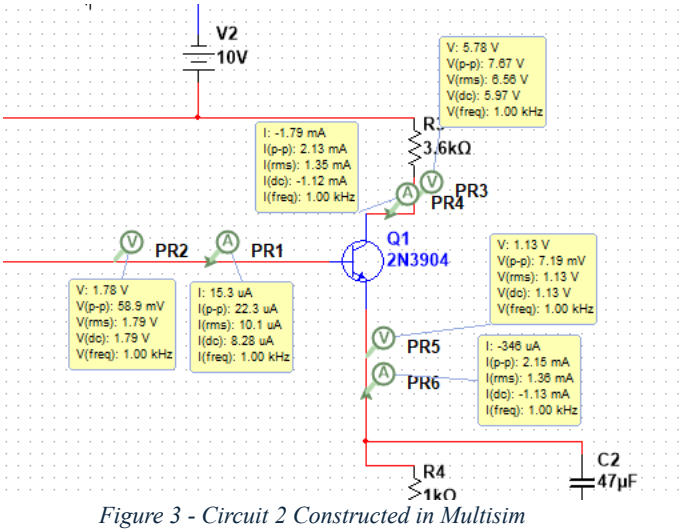


Figure 3 - Circuit 2 Constructed in Multisim

Circuit 1 is a BJT series-parallel circuit, with a single transistor and 4 value-varying resistors. There are two different power sources, one acting as a sinusoidal AC voltage source with a value of 30mVpk, and one acting as a 10v DC source at the top of the circuit. As stated before, this circuit functions as a common emitter amplifier, who's purpose it is to increase the value of the ac signal at the base and push it out of the emitter of the bipolar junction transistor. Applications such as broadcast devices and computers which use this behavior of amplification for large scale signal delivery and processing use this. 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:

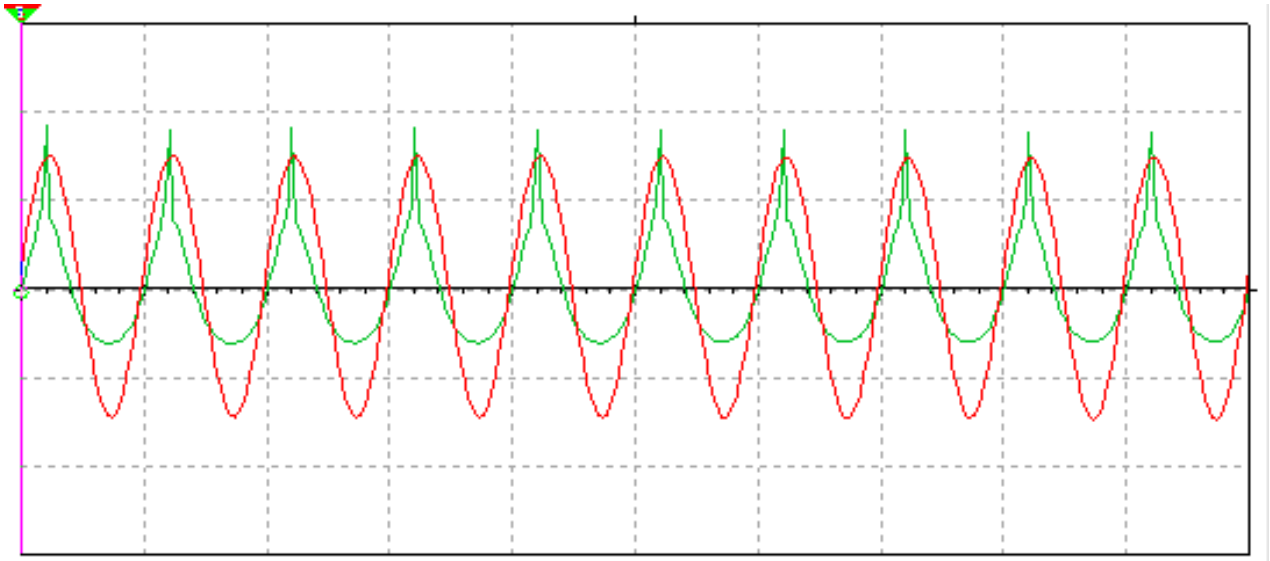


Figure 4 – Waveform of Simulation Data (Red – Collector) (Green – Emitter)

Part 2 – The Bench

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

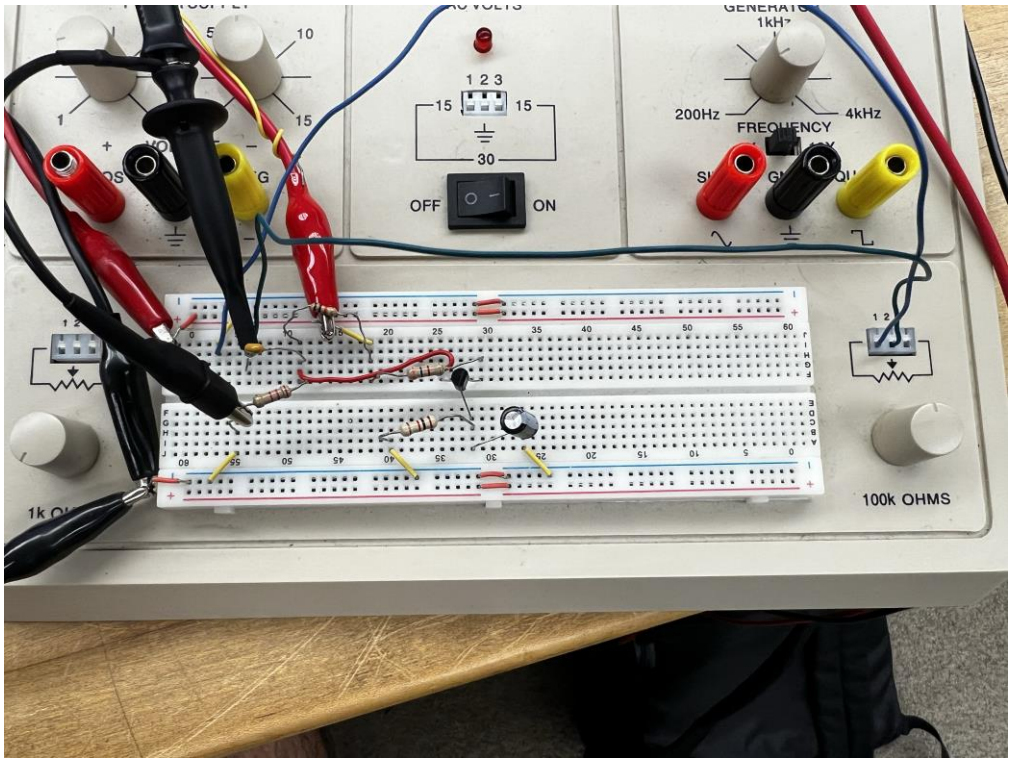


Figure 5 – Circuit 1 Constructed on the Bench

Note that above the *variable resistor* is used instead of a potentiometer to obtain a more accurate reading of the input resistance being used (that being around 49.76kΩ)

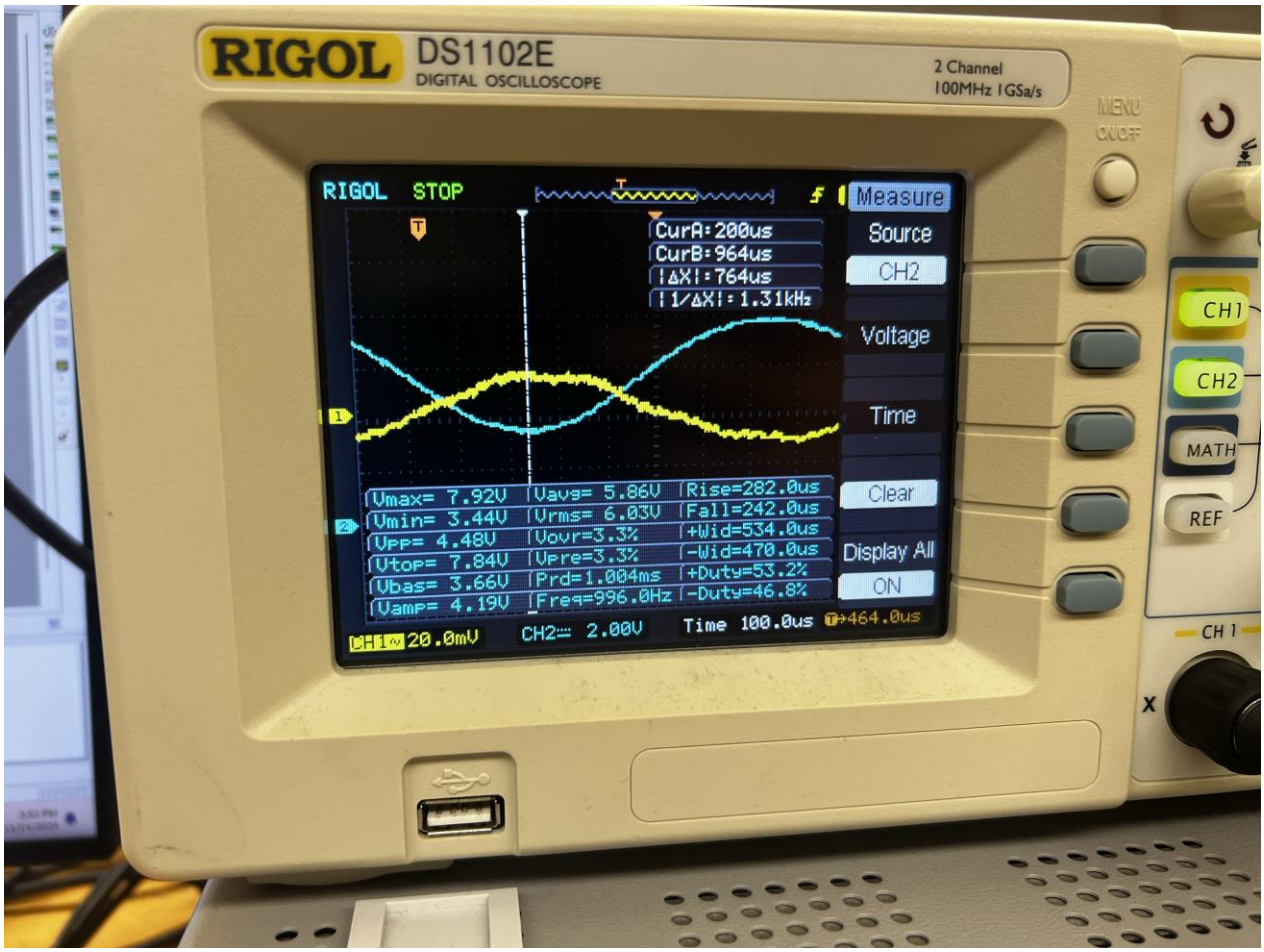


Figure 6 – Circuit 1 waveform of emitter and base of BJT

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	2.2kΩ	2.201kΩ
R3	3.6kΩ	3.6104kΩ
R4	1kΩ	980.4Ω

Table 2 – 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	1.77	1.83	29.3m	29.6m
Emitter Voltage	1.12	1.15	0	148.00u
Collector Voltage	6.43	5.86	4.7	5.86
Base Current	4.91u	6.53u	5.93u	
Emitter Current	394u	309.81u	1.32m	
Collector Current	1.23m	1.15m	830.10u	

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:

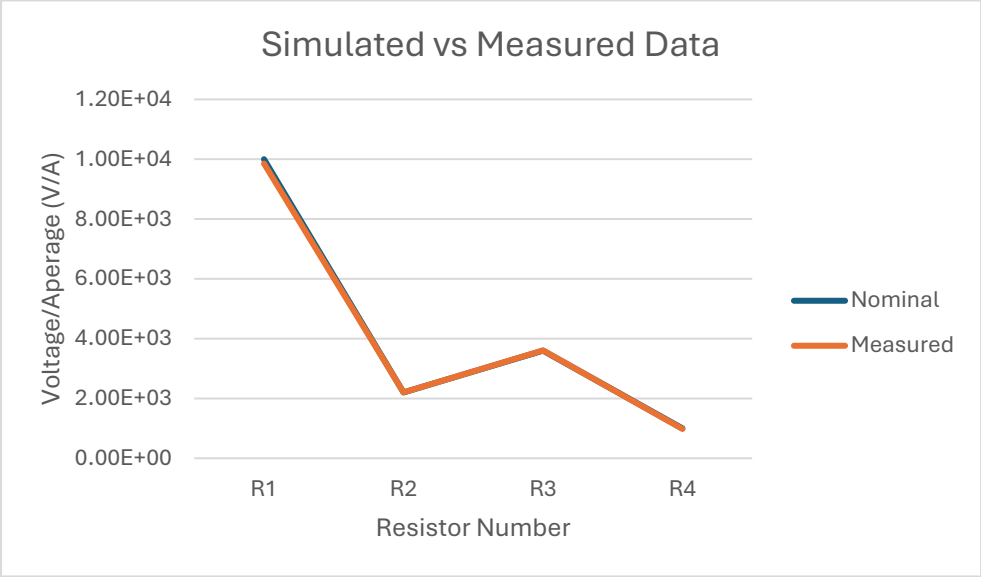


Figure 8 - Data Comparison of Circuit 2 Measurements

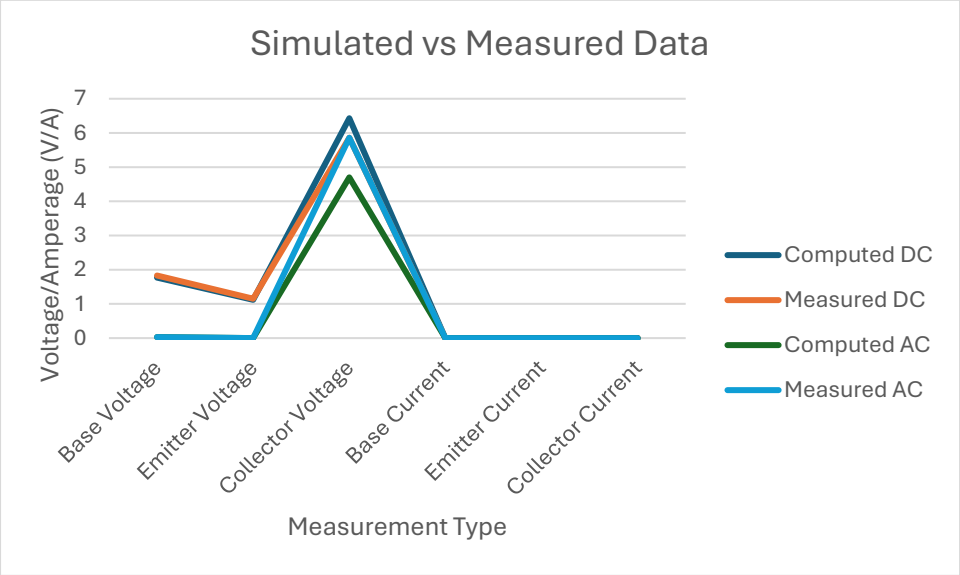


Figure 9 - Data Comparison of Circuit 1 Measurements

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- Measure and record the amplifier's DC and AC currents and voltages in Table 1.

	DC parameter		AC parameter	
	Computed	Measured	Computed	Measured
Base Voltage	4.2V	4.23V		95.3mV
Emitter Voltage	3.34V	3.49V		0V
Collector Voltage	10.0V	10.07V		186mV
Base Current	218μA	385.7μA		
Emitter Current	34.3mA	29.78mA		
Collector Current	34.1mA	583.30μA		

4- Determine the AC resistance of the emitter diode, r_e'.

5- Measure the amplifier's input resistance. (Use a potentiometer).
Note: Follow the steps for "Measuring Rin of the Amplifier with a Potentiometer" listed in the Appendix and record the potentiometer value as the amplifier's input resistance.

6- Determine the amplifier's voltage gain from the measured data.

7- Show below the process for calculating the voltage gain.

8- Elaborate on the results of the calculated and measured voltage gains.

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Conclusion:

The objective of this lab is to obtain an understanding and visualization of the behavior and purposes of BJTs in common emitter amplifier circuits. The particular behavior of this circuit is to increase the ac signal obtained through the base of the bipolar junction transistor, and push this increased signal out of the emitter of it. 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 emitter amplifier. If this lab were to be conducted again, it would be prudent to analyze more, and more complex common emitter 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 ben ch measurements, as they not only follow the same trends, but also match data values very closely.