California State University, Northridge

College of Engineering & Computer Science

Department of Electrical and Computer Engineering

ECE 340 Electronics I Laboratory Report

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Fall 2021

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California State University, Northridge
College of Engineering and Computer Science
Electrical and Computer Engineering Department

ECE 340L Electrical Engineering Fundamentals Laboratory Reports Title

No.	Main Lab Topics	Design Specifications
1	Operational Amplifiers	
2	Diode Characteristics	
3	Clipper and Clamper Circuits	
4	Power Supply Circuits	Ignore transformer and use DC supply
5	Bipolar Junction Transistors	
6	Design of Common Emitter Amplifiers	
7	Design of Common Base Amplifiers	
9	MOSFET Characteristics and DC Biasing	Skip experiment 8

Operational Amplifiers

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ABSTRACT:

This experiment investigates voltage amplifiers. Specifically the LF411 operational amplifier

MATERIALS:

Resistors

LF411 Op Amp

THEORY:

An op amp is an integrated circuit that can amplify electrical signals. The op amp is constructed of transistors and resistors

KEYWORDS:

Voltage, Amplifier, Gain, Op Amp

1.1 EXPERIMENTAL & SIMULATION SETUP:

Preliminary Calculations:

$$\frac{-V_{OFF}}{R_1} + \frac{-V_{OFF} - V_0}{R_2} = 0$$
$$\frac{-V_{OFF}}{R_1} + \frac{-V_{OFF}}{R_2} - \frac{V_0}{R_2} = 0$$
$$\frac{-V_{OFF}}{R_1} + \frac{-V_{OFF}}{R_2} = \frac{V_0}{R_2}$$
$$R_2\left(\frac{1}{R_1} + \frac{1}{R_2}\right) * -V_{OFF} = V_0$$
$$R_2\left(\frac{R_1 + R_2}{R_1 R_2}\right) * -V_{OFF} = V_0$$
$$\left(\frac{R_1 + R_2}{R_1}\right) * -V_{OFF} = V_0$$
$$\left(\frac{R_1}{R_1} + \frac{R_2}{R_1}\right) * -V_{OFF} = V_0$$
$$\left(1 + \frac{R_2}{R_1}\right) * -V_{OFF} = V_0$$

a. $\frac{V_o}{V_i} = 10$

$$10 = (1 + \frac{R_2}{R_1})$$
$$99k = \frac{R_2}{R_1}$$
$$99k = R_2$$
$$10k = R_1$$

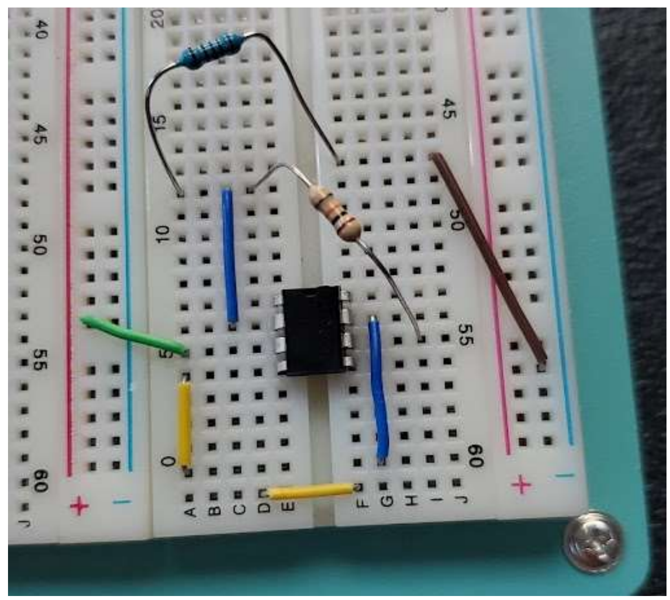


Figure 1.1 Experimental Circuit

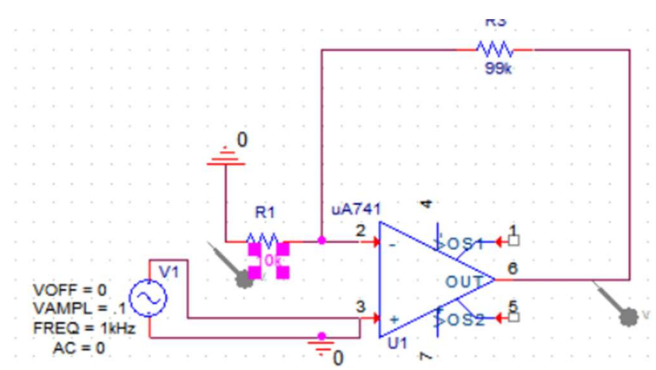
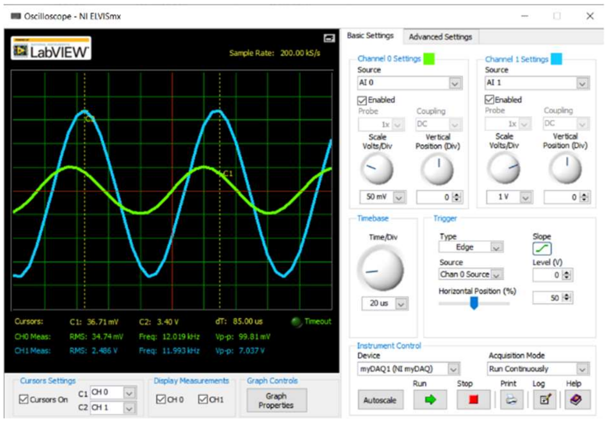


Figure 1.2 Simulated Circuit

1.2 EXPERIMENTAL & SIMULATION DATA & RESULTS:



$$\boldsymbol{\theta} = \frac{\mathbf{360}}{\mathbf{85}} * \mathbf{8}$$

$$\boldsymbol{\theta} = \mathbf{34}°$$

1.3 DISCUSSION & CONCLUSION

From the experimental data I concluded that my phase shift was about 34 degrees. This was done by measuring the difference in x position based on the time/div for the input and output waves in order to calculate the 3dB. In the simulation the phase shift was 40° but I believe that to have been an error as the gain was not what was calculated in the simulated version of the circuit

1.4 REFERENCES

[1] *Electrical Electronics I Laboratory Experiments 1-13 Electrical Engineering ECE 340L Laboratory Manual*. California State University Northridge.

[2] Ou, Jack, et al. *PSPICE Simulation*, California State University, Northridge, 2020, www.csun.edu/~jou/classes/ece240l/2020f/website/20f/20f.html

Diode Characteristics

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ABSTRACT:

The purpose of this lab is to verify diode characteristics and understand forward and reversed biased. A diode is a device that allows current to travel in one way only

MATERIALS:

Resistor

D1N4002 Diode

THEORY:

A diode is an electrical component that allows the flow of current in only 1 direction. It is essentially like a valve for current. A diode is said to be forward biased if the it is in the direction of the voltage and revered biased if the voltage is in the opposite direction.

KEYWORDS:

Ideal Diode, I-V characteristic, thermal voltage, biasing

2.1 EXPERIMENTAL & SIMULATION SETUP:

Preliminary calculations:

$$i_D = I_S[e^{\frac{v_D}{n*V_t}} - 1]$$

Show that ln $(i_D) = \ln(I_S) + \frac{v_D}{nV_t}$

$$i_D = I_S[e^{\frac{v_D}{n*V_t}} - 1]$$

$$ln(i_D) = ln(I_S\left[e^{\frac{v_D}{n*V_t}} - 1\right])$$

$$ln(i_D) = ln(I_S) + ln\left[e^{\frac{v_D}{n*V_t}} - 1\right]$$

$$ln(i_D) = ln(I_S) + ln(e^{\frac{v_D}{n*V_t}}) - ln(1)$$

$$ln(i_D) = ln(I_S) + \frac{v_D}{n*V_t} - 0$$

$$ln(i_D) = ln(I_S) + \frac{v_D}{n*V_t}$$

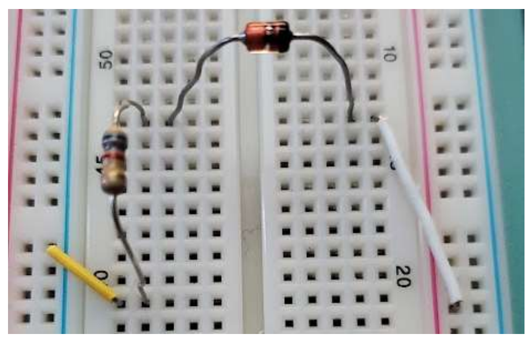

Figure 2.1 Experimental Circuit

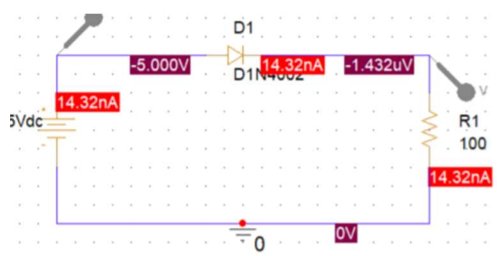

Figure 2.2 Simulation Circuit

2.2 EXPERIMENTAL & SIMULATION DATA & RESULTS:

Vi	Id
-5	0
-4	0
-3	0
-2	0
-1	0
0	0
0.05	0
0.1	0
0.15	0
0.2	0
0.25	0
0.3	0
0.35	1.0959e-10
0.4	4.435e-10
0.45	1.7363e-09
0.5	5.9538e-09
0.55	1.8683e-08
0.6	5.8646e-08
0.65	1.9027e-07
0.695	6.0382e-07

Figure 2.3 Values for Vd and Id

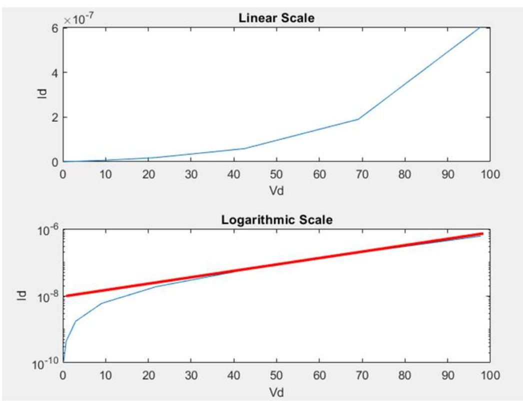

Figure 2.4 Log and Linear scale of Vd vs Vi

Using the logarithmic scale plot we can see that the Y intercept is 10 nA which is i_D

2.3 DISCUSSION & CONCLUSION

From the experiment I concluded that the diode equation for i_D was correct. I had trouble with finding the simulated value for i_D because the PSpice simulation output seemed off. From the probe that measures i_D on the experimental circuit I got that i_D was 14nA experimentally which is off from the 10nA I found experimentally. The diode was reverse biased

2.4 REFERENCES

[1] *Electrical Electronics I Laboratory Experiments 1-13 Electrical Engineering ECE 340L Laboratory Manual*. California State University Northridge.

[2] Ou, Jack, et al. *PSPICE Simulation*, California State University, Northridge, 2020, www.csun.edu/~jou/classes/ece240l/2020f/website/20f/20f.html

Clipper and Clamper Circuits

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ABSTRACT:

This experiment allows us to learn about different uses for the diode which allow you to make clipper and clamper circuits. This lab utilizes Zener diodes

MATERIALS:

Resistors

1N4002 & 1N744A Diode

Capacitors

THEORY:

A Zener diode is a special type of diode designed to allow current to flow backwards once a certain voltage is reached. Zener voltages vary and some Zener diodes have variable Zener voltages. A capacitor is a component that stores voltage for a small amount of time.

KEYWORDS:

Clipper, Clamper, Diode, Zener Diode

3.1 EXPERIMENTAL & SIMULATION SETUP:

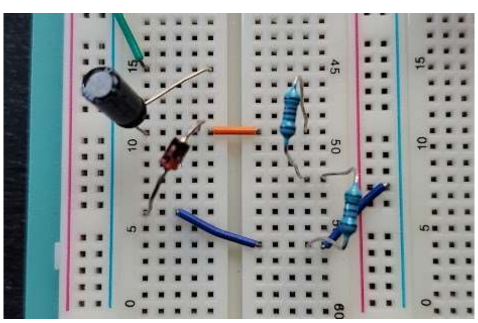

Figure 3.1 Experimental Circuit

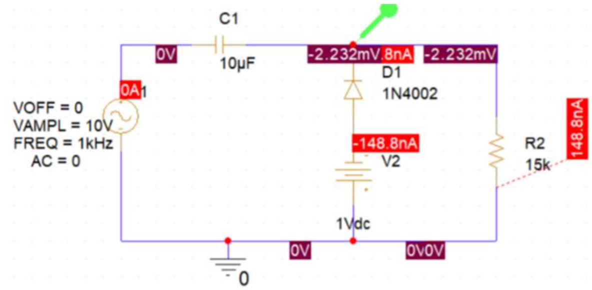

Figure 3.2 Simulated Circuit

3.2 EXPERIMENTAL & SIMULATION DATA & RESULTS:

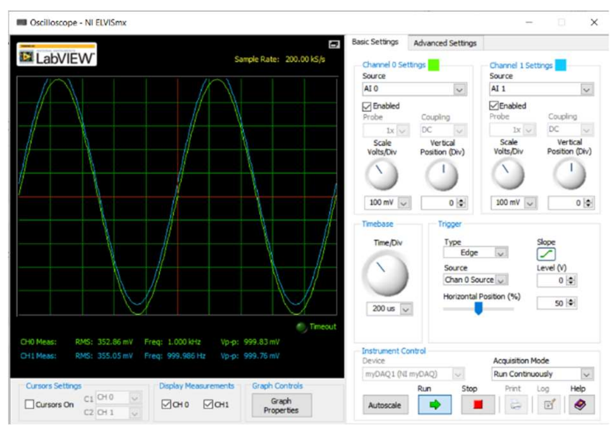

Figure 3.3 Experimental Results

Figure 3.4 Simulation Results

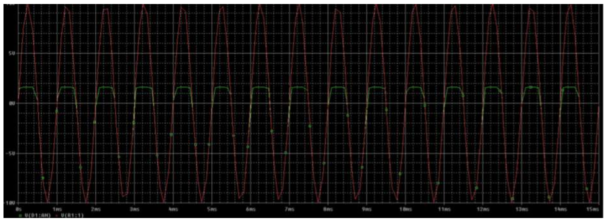

Figure 3.5 Simulation Results

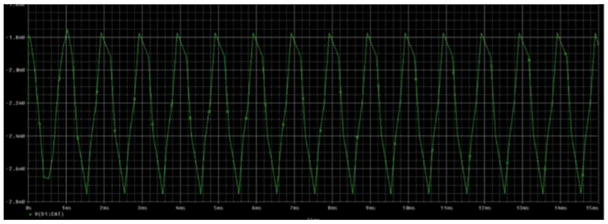

Figure 3.6 Simulation Results

3.3 DISCUSSION & CONCLUSION

In simulation all of the circuits looked good including the clipper and clamper. Experimentally I struggled with the clipper but was able to get the clamper circuit to work.

3.4 REFERENCES

[1] *Electrical Electronics I Laboratory Experiments 1-13 Electrical Engineering ECE 340L Laboratory Manual*. California State University Northridge.

[2] Ou, Jack, et al. *PSPICE Simulation*, California State University, Northridge, 2020, www.csun.edu/~jou/classes/ece240l/2020f/website/20f/20f.html

Power Supply Circuits

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ABSTRACT:

This experiment allows us to learn about a variety of direct current circuits.

MATERIALS:

1N4002 & 1N957A Diodes

Capacitor

Resistors

THEORY:

The rectifier can be half or full wave and it allows alternating current to flow in one direction. The filter reduced fluctuation in the rectifier to create the direct current.

KEYWORDS:

Rectifier. AC, DC. Filter, Rectifier. Regulator

4.1 EXPERIMENTAL & SIMULATION SETUP:

Preliminary calculations:

$$I = I_z + I_L$$

$$I_{max} = \frac{V_i - V_t}{R}$$

$$I_{max} = \frac{9.2 - 6.8}{100}$$

$$I_{max} = 0.024$$

$$I_{max} = I_L$$

$$R_L = \frac{6.8}{0.024} = 283\Omega$$

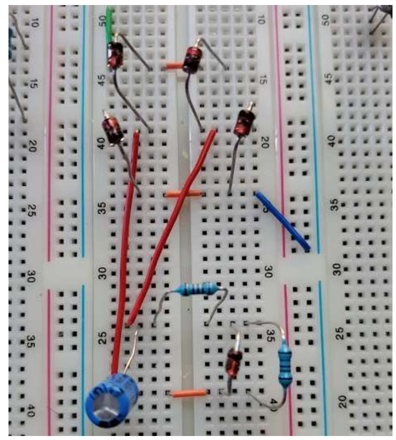

Figure 4.1 Experimental Circuit

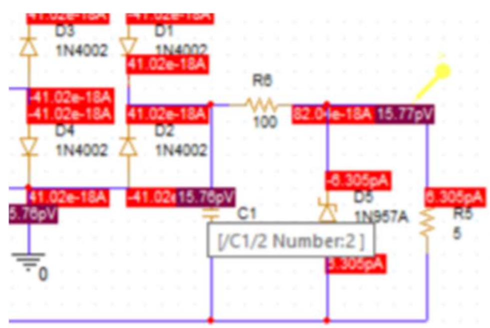

Figure 4.2 Simulated Circuit

4.2 EXPERIMENTAL & SIMULATION DATA & RESULTS:

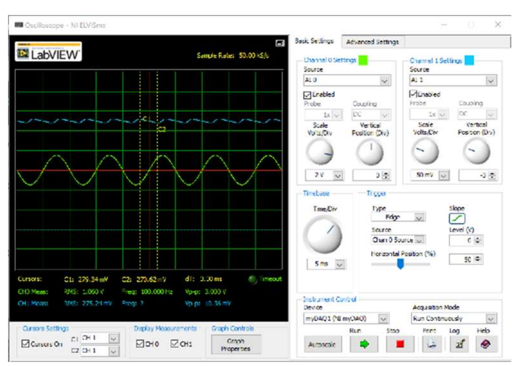

Figure 4.3 Experimental Results

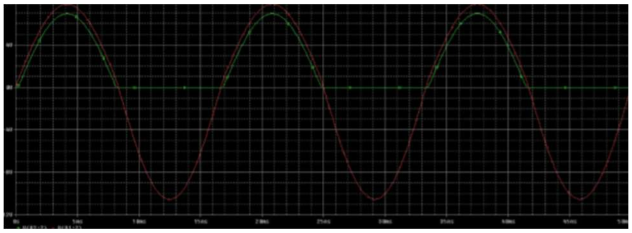

Figure 4.4 Simulation Results

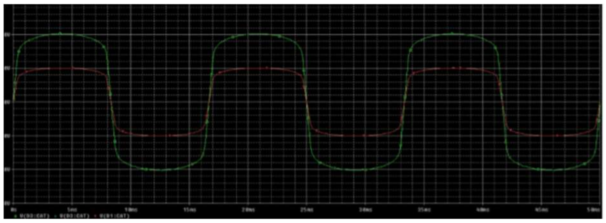

Figure 4.5 Simulation Results

4.3 DISCUSSION & CONCLUSION

I was able to get the half and full wave rectifier outputs in the simulation but only the rect experimentally.

4.4 REFERENCES

[1] *Electrical Electronics I Laboratory Experiments 1-13 Electrical Engineering ECE 340L Laboratory Manual*. California State University Northridge.

[2] Ou, Jack, et al. *PSPICE Simulation*, California State University, Northridge, 2020, www.csun.edu/~jou/classes/ece240l/2020f/website/20f/20f.html

Bipolar Junction Transistors

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ABSTRACT:

This experiment examines the properties of bipolar junction transistors (BJT)

MATERIALS:

Resistors

2N2222A Transistor

THEORY:

A BJT comes in two different types which are PNP and NPN. The difference between them is that a PNP will turn on when there is no current at the base. An NPN turns on when there is current at the base. A transistor can act as an amplifier under certain conditions known as the active mode.

KEYWORDS:

BJT, Transistor, NPN. PNP, Base, Emitter, Collector

5.1 EXPERIMENTAL & SIMULATION SETUP:

$$I_C = \frac{V_{cc} - V_B}{R_1}$$

$$V_{ce} = V_{cc} - R_2 I_c$$

$$I_C = V_{cc} - R_2 \frac{\beta(V_{cc} - V_{E)}}{R_1}$$

$$V_{ce} = 8, I_c = 1mA, \beta = 161, V_{cc} = 15V$$

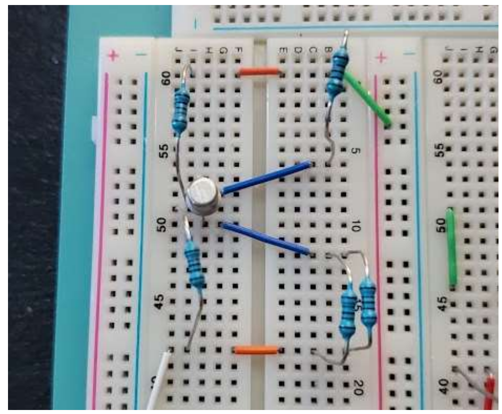

Figure 5.1 Experimental Circuit

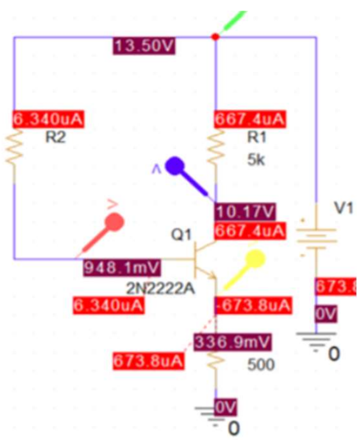

Figure 5.2 Simulated Circuit

5.2 EXPERIMENTAL & SIMULATION DATA & RESULTS:

Figure 5.3 Simulation Results

Ic (mA)	Measured Ic	Measured Ib	DC Beta
0.1	0.104 mA	0.001 mA	75.12
0.2	0.189 mA	0.002 mA	85.55
0.4	0.381 mA	0.004 mA	95.25
0.8	0.779 mA	0.006 mA	105.88
1	1.011 mA	0.009 mA	109.12
2	2.000 mA	0.016 mA	117.13
4	3.953 mA	0.031 mA	121.98

Figure 5.4 Transistor Beta Table

$$B_F = \frac{0.912\beta}{1 - 0.912\beta\left(\frac{.779\ mA}{14.34 * 10^{-15}}\right)}$$

5.3 DISCUSSION & CONCLUSION

By using the formula $\beta = \frac{I_C}{I_B}$ I was able to find the DC beta from measured values in the simulation. I was supposed to use 2 different types of transistors but my kit only came with the metal can ones so I wasn't able to compare the difference between the plastic and metal 2N2222A transistors

5.4 REFERENCES

[1] *Electrical Electronics I Laboratory Experiments 1-13 Electrical Engineering ECE 340L Laboratory Manual*. California State University Northridge.

[2] Ou, Jack, et al. *PSPICE Simulation*, California State University, Northridge, 2020, www.csun.edu/~jou/classes/ece240l/2020f/website/20f/20f.html

Design of Common Emitter Amplifiers

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ABSTRACT:

This experiment explores the most common use of the transistor which is a common emitter amplifier

MATERIALS:

Capacitors

2N2222A Transistor

Resistors

THEORY:

The β affects AC and DC characteristics of the BJT. By changing the β you can manipulate a circuit to obtain a desired output using the 2N2222A transistor by increasing or decreasing the gain

KEYWORDS:

Amplifier, Transistor, Common Emitter, Gain, beta (β)

6.1 EXPERIMENTAL & SIMULATION SETUP & PROCEDURES:

$$I_C = \frac{V_{cc} - V_B}{R_1}$$

$$V_{ce} = V_{cc} - R_2 I_c$$

$$I_C = V_{cc} - R_2 \frac{\beta(V_{cc} - V_{E})}{R_1}$$

$$V_{ce} = 8, I_c = 1mA, \beta = 100 \,\&\, 300,$$

$$V_{cc} = 20V$$

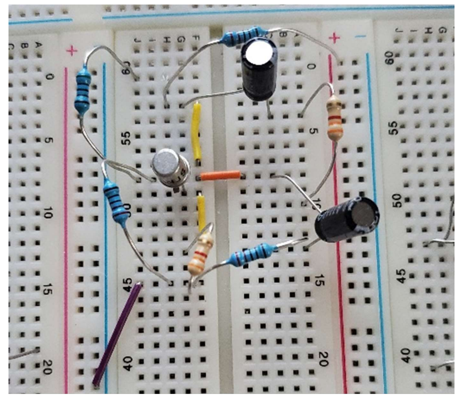

Figure 6.1 Experimental Circuit

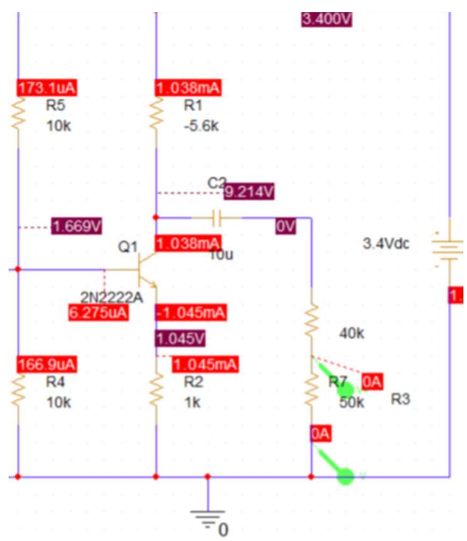

Figure 6.2 Simulated Circuit

6.2 EXPERIMENTAL & SIMULATION DATA & RESULTS:

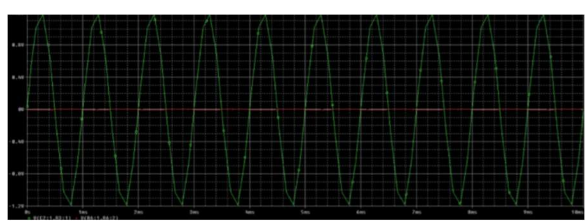

Figure 6.3 Simulated Results

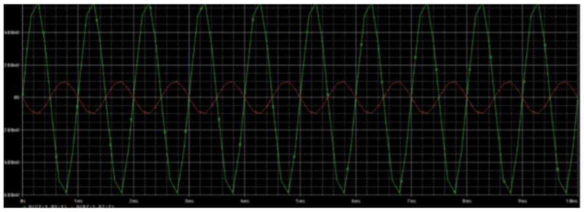

Figure 6.4 Simulated Results

6.3 DISCUSSION & CONCLUSION

I was successful in changing values of the BJT by using different components and using techniques in PSpice. This experiment taught me how to get a gain using a BJT and how to change its values as well. You can get a different gain from the BJT by changing resistance values or changing the output signal. In this experiment I struggled with the PSPICE measuring of input impedance, output impedance, and swing.

6.4 REFERENCES

[1] *Electrical Electronics I Laboratory Experiments 1-13 Electrical Engineering ECE 340L Laboratory Manual*. California State University Northridge.

[2] Ou, Jack, et al. *PSPICE Simulation*, California State University, Northridge, 2020, www.csun.edu/~jou/classes/ece240l/2020f/website/20f/20f.html

Design of Common Base Amplifiers

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ABSTRACT:

This experiment allows us to explore the Common Base Amplifier which was the first circuit used to show that transistors could produce a gain in 1948

MATERIALS:

Capacitors

2N2222A Transistor

Resistors

THEORY:

This circuit was used to demonstrate the gain of new transistors. It is best with a low input impedance. The Common Base Amplifier is typically used as a current buffer or a voltage amplifier

KEYWORDS:

Common base, amplifier, gain,

7.1 EXPERIMENTAL & SIMULATION SETUP & PROCEDURES:

Preliminary calculations:

$$V_{cc} = I_C R_C + V_{CB} + I_E R_E$$

$$R_E = 16k\Omega$$

$$V_E = 8V$$

$$V_B = 8V$$

$$I_C = 16V$$

$$R_2 = 8k\Omega$$

$$R_1 = 11k\Omega$$

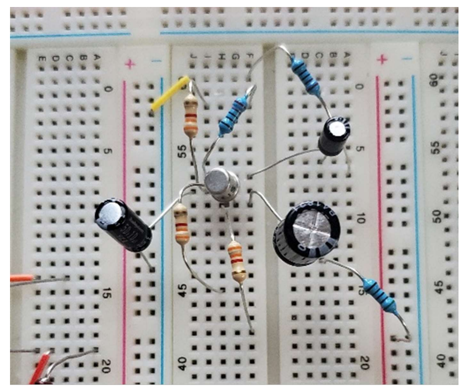

Figure 7.1 Experimental Circuit

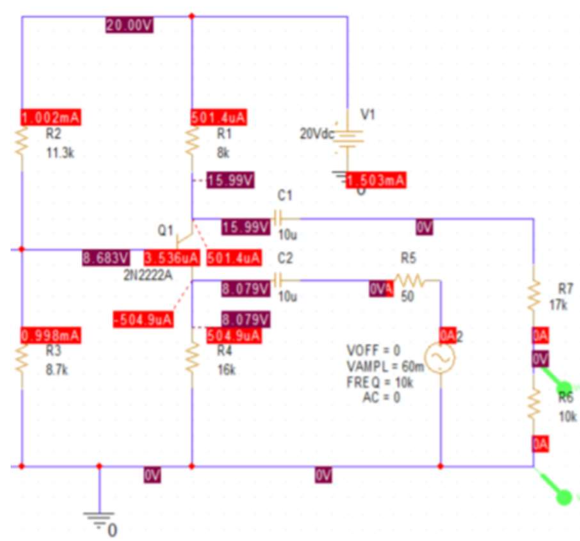

Figure 7.2 Simulated Circuit

7.2 EXPERIMENTAL & SIMULATION DATA & RESULTS:

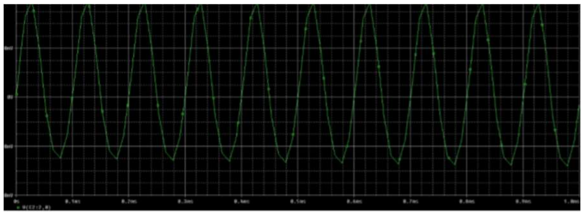

Figure 7.3 Simulated Results

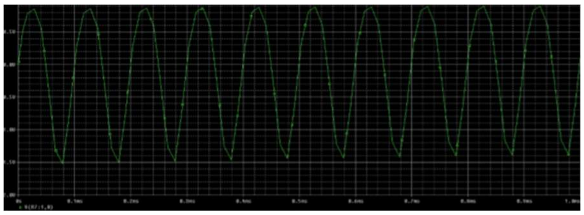

Figure 7.4 Simulated Results

$$Z_i = \frac{[50v_1 - (R_S + 50)V_2]}{v_2 - v_1}$$

$$Z_i = \frac{[100 - (160)1.2]}{-0.8} = 115\Omega$$

Figure 7.4 Simulated Results

7.3 DISCUSSION & CONCLUSION

This experiment was very similar to experiment 6. I further learned how to manipulate the BJT but this time as a common base amplifier instead of a common emitter amplifier. In this experiment the input impedance was lower and the output impedance was higher compared to the common emitter experiment

7.4 REFERENCES

[1] *Electrical Electronics I Laboratory Experiments 1-13 Electrical Engineering ECE 340L Laboratory Manual*. California State University Northridge.

[2] Ou, Jack, et al. *PSPICE Simulation*, California State University, Northridge, 2020, www.csun.edu/~jou/classes/ece240l/2020f/website/20f/20f.html

MOSFET Characteristics and DC Biasing

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ABSTRACT:

This experiment introduces us to MOS transistors used in most significant designs.

MATERIALS:

Resistors

2N2222A Transistor

THEORY:

KEYWORDS:

MOSFET, MOS, biasing,

9.1 EXPERIMENTAL & SIMULATION SETUP & PROCEDURES:

9.2 EXPERIMENTAL & SIMULATION DATA & RESULTS:

9.3 DISCUSSION & CONCLUSION

9.4 REFERENCES

[1] *Electrical Electronics I Laboratory Experiments 1-13 Electrical Engineering ECE 340L Laboratory Manual*. California State University Northridge.

[2] Ou, Jack, et al. *PSPICE Simulation*, California State University, Northridge, 2020, www.csun.edu/~jou/classes/ece240l/2020f/website/20f/20f.html