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Lab 1: Design of a Common-Emitter BJT Amplifier

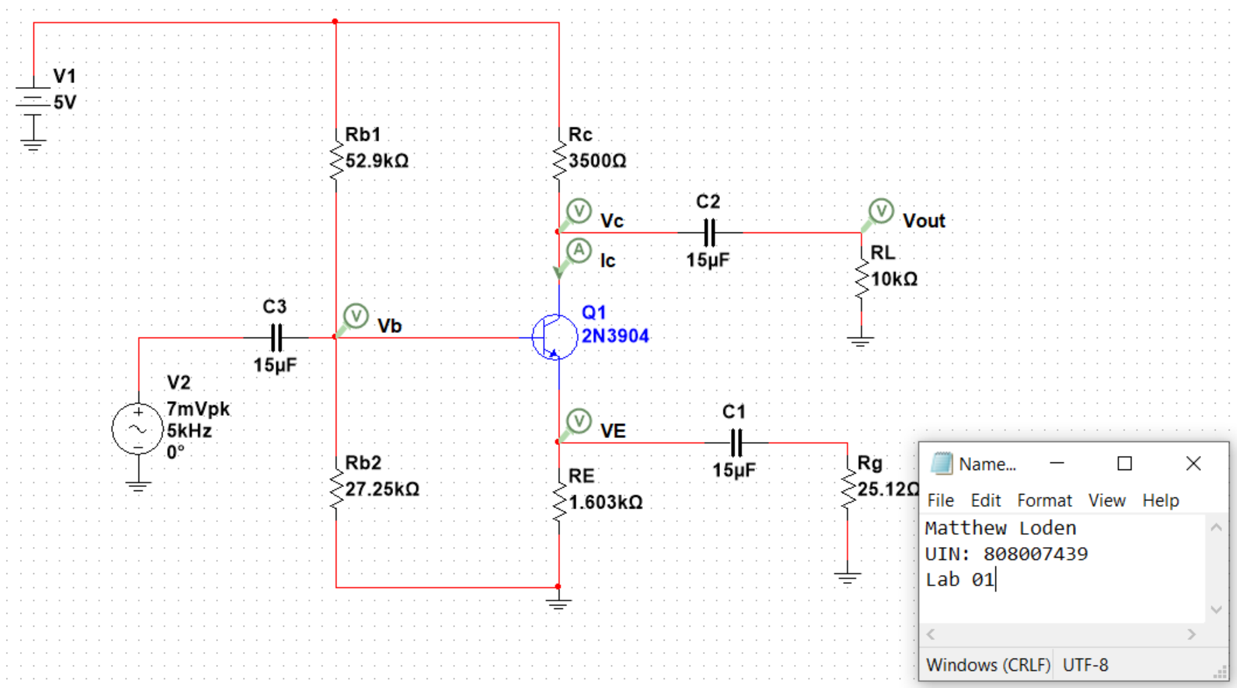
Purpose:

The purpose of this lab was to use a single BJT amplifier to produce a given gain and within a level of swing and THD.

Calculations:

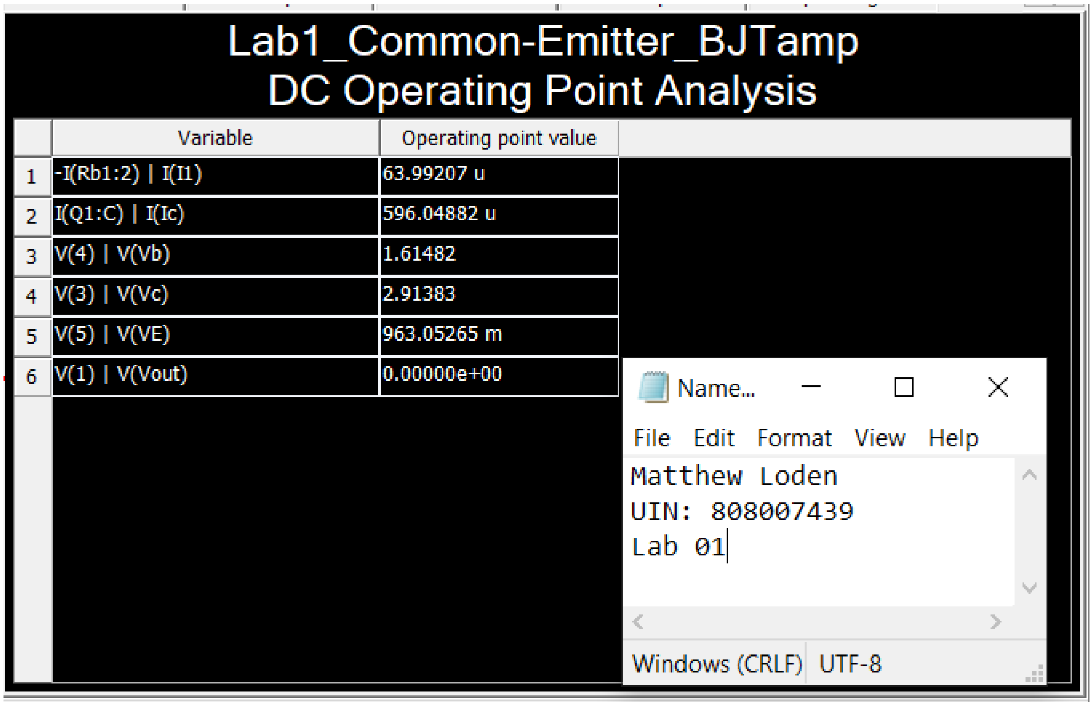
Included at End of Document

Schematics:



Simulations:

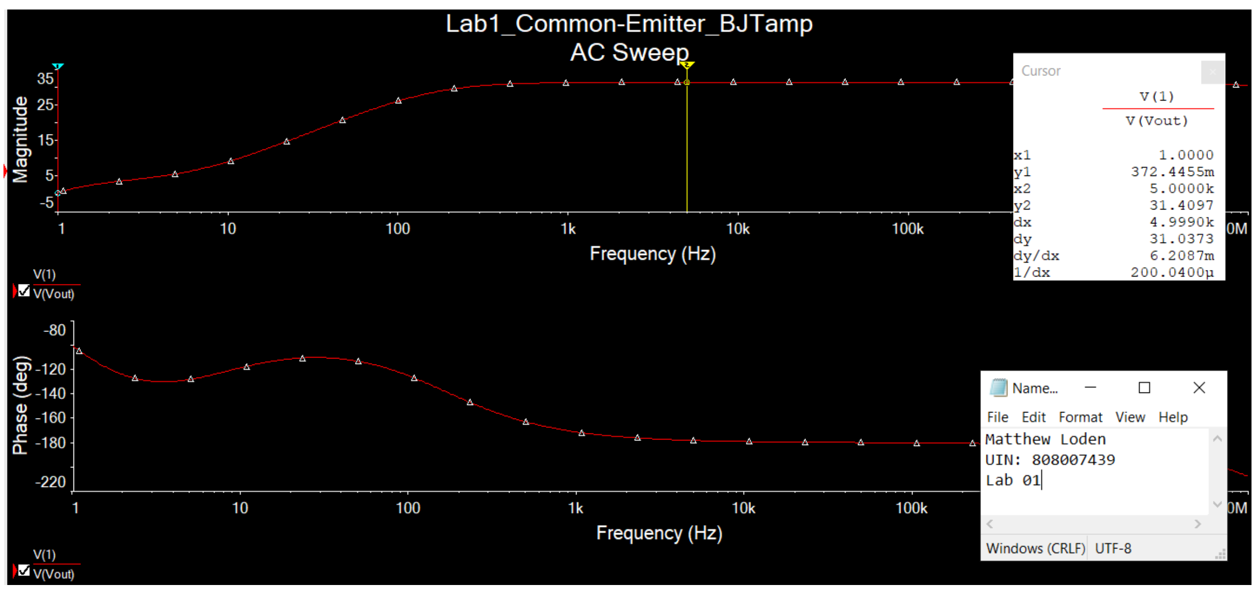
DC Operation Point



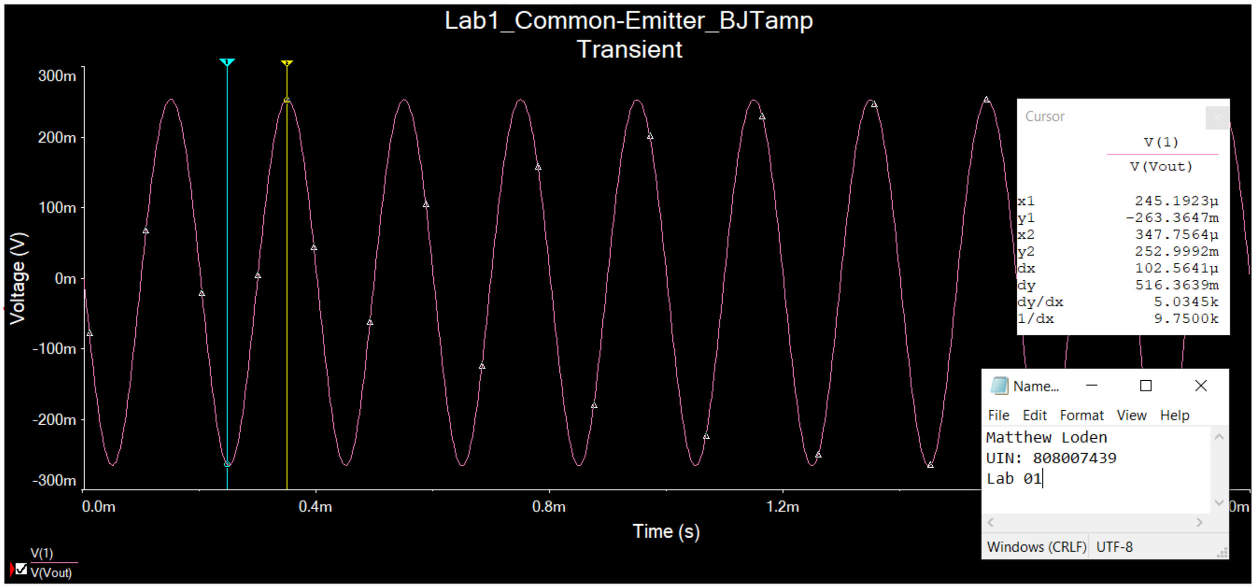
Lab1_Common-Emitter_BJTamp
DC Operating Point Analysis

	Variable	Operating point value
1	-I(Rb1:2) | I(I1)	63.99207 u
2	I(Q1:C) | I(Ic)	596.04882 u
3	V(4) | V(Vb)	1.61482
4	V(3) | V(Vc)	2.91383
5	V(5) | V(VE)	963.05265 m
6	V(1) | V(Vout)	0.00000e+00

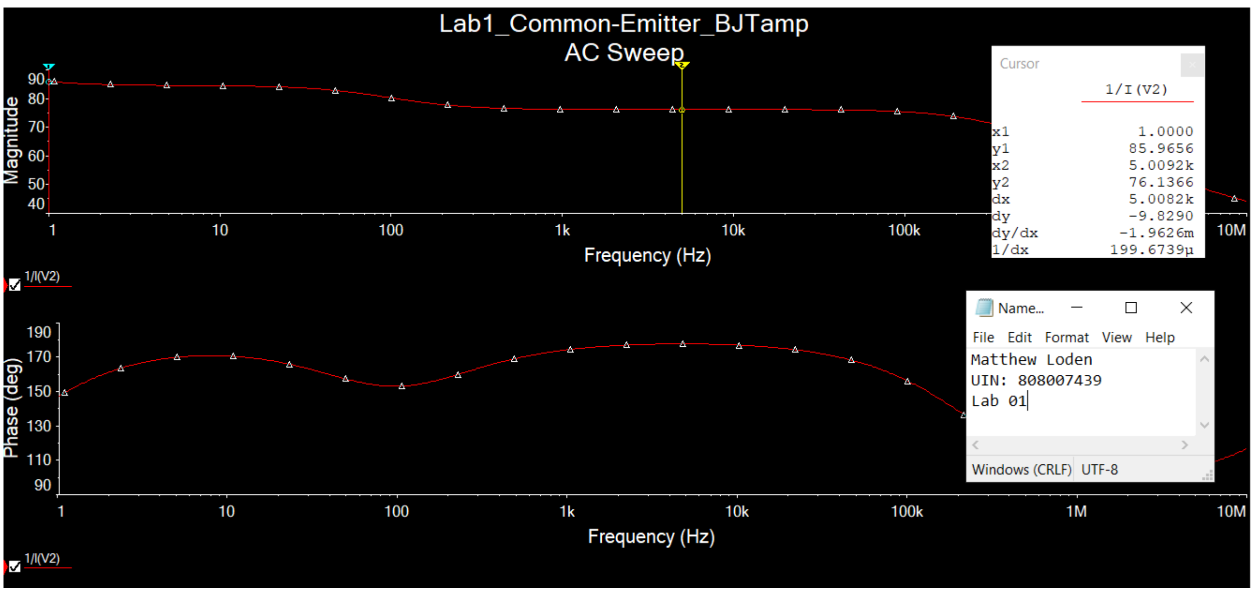
Magnitude of the Gain



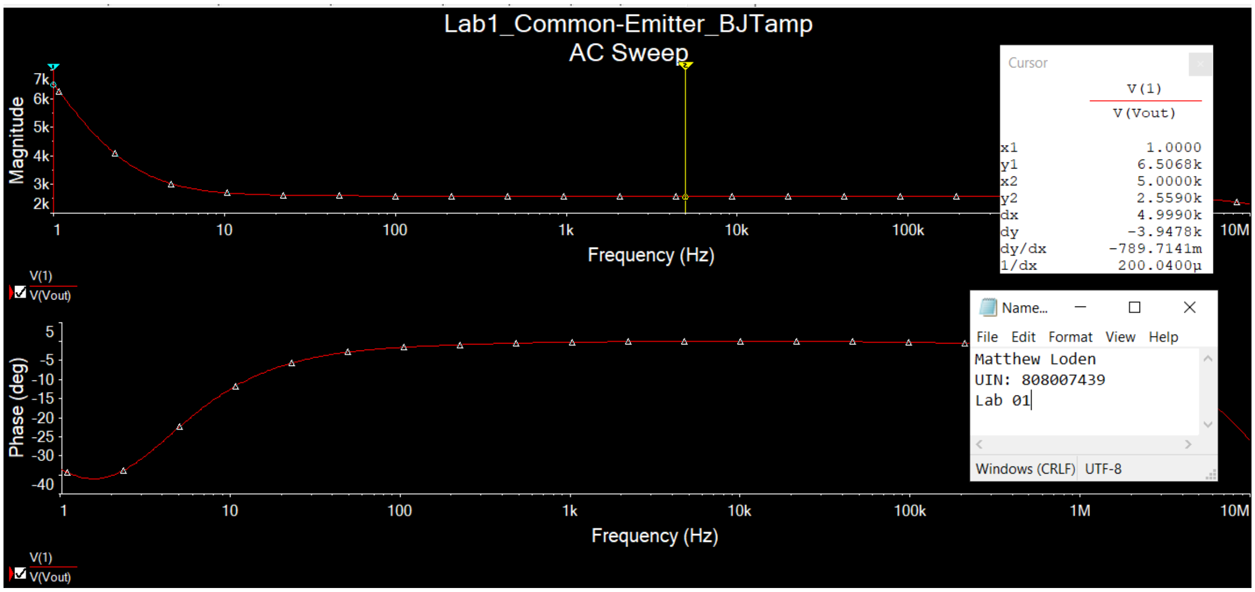
Waveform



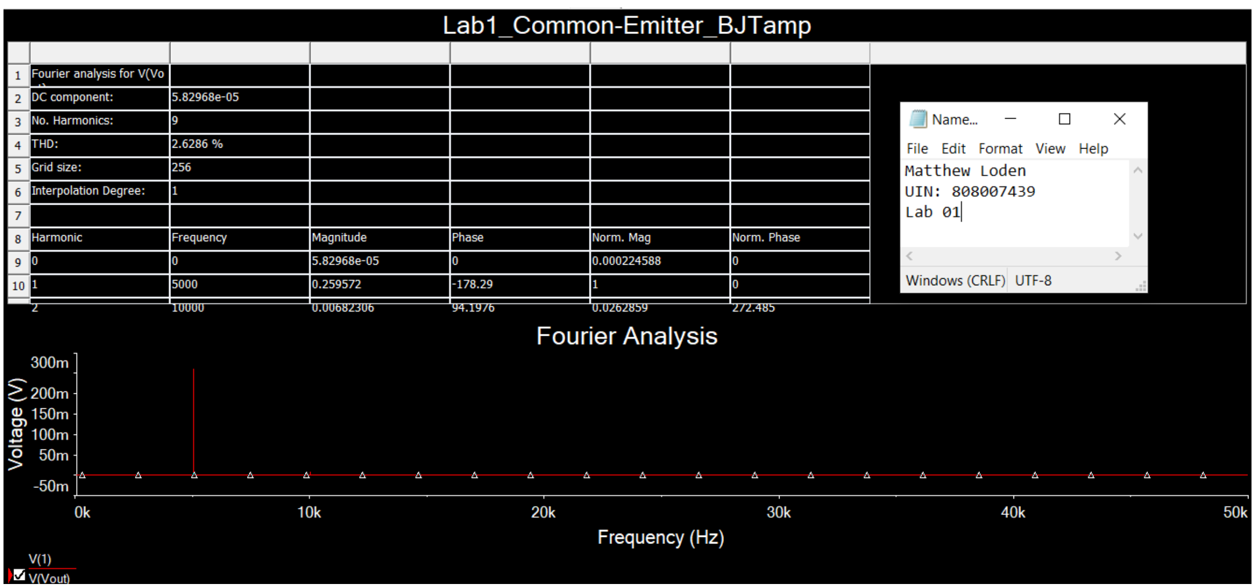
R in



R out

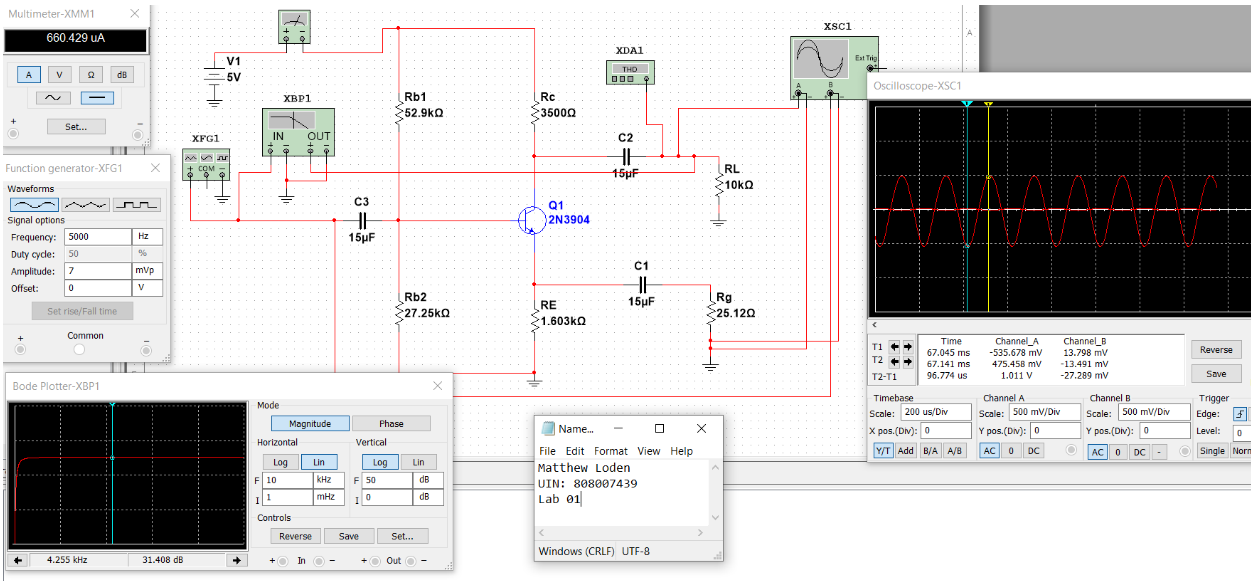


Fourier Simulation(THD)



Measured

General Collected Data


Multimeter-XMM1
660.429 uA
Function generator-XFG1
Frequency: 5000 Hz
Amplitude: 7 mVp
Offset: 0 V
V1
5V
XBP1
XFG1
Rb1
52.9kΩ
Rc
3500Ω
C2
15µF
RL
10kΩ
C3
15µF
Q1
2N3904
C1
15µF
Rb2
27.25kΩ
RE
1.603kΩ
Rg
25.12Ω
XDA1
XSC1
Oscilloscope-XSC1
Bode Plotter-XBP1
4.255 kHz
31.408 dB
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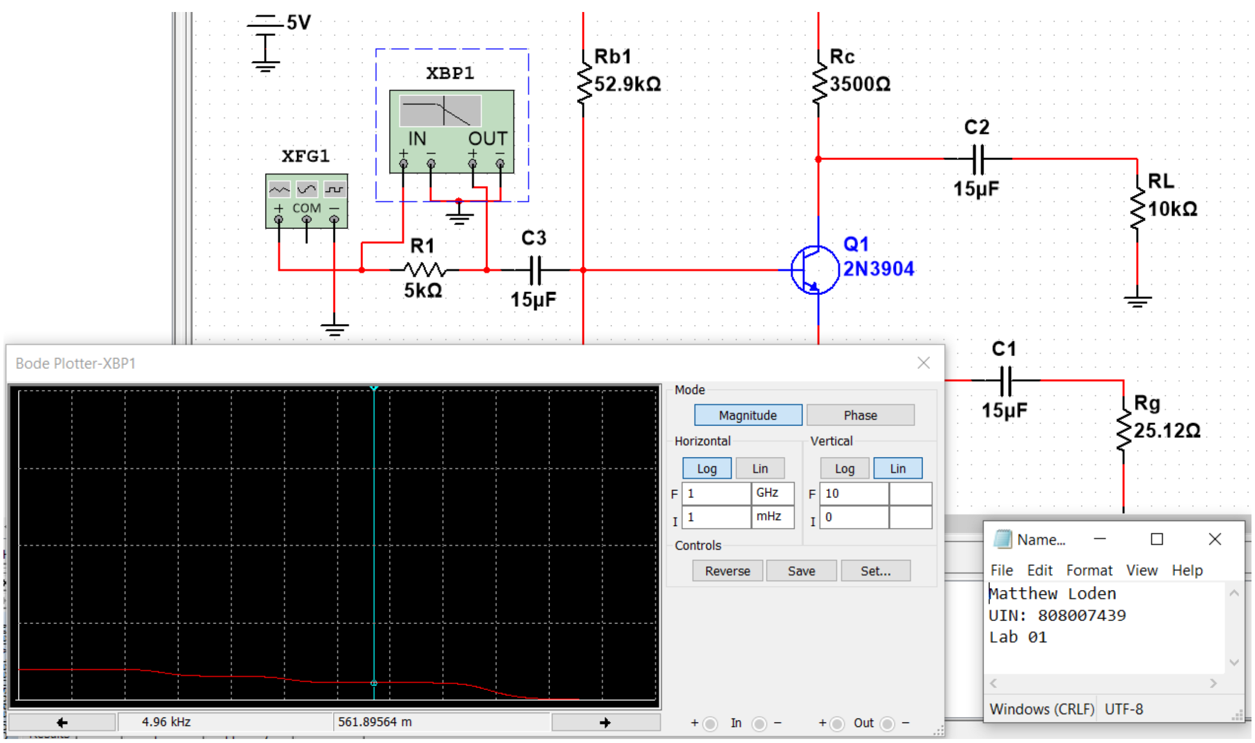
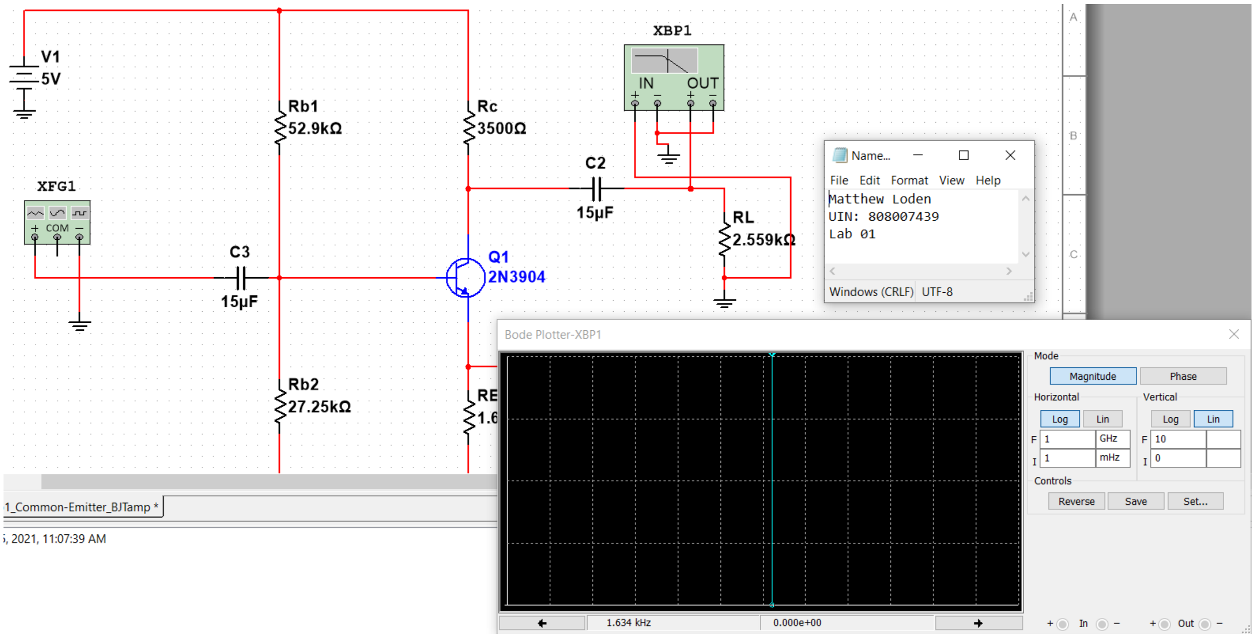
Lab 01

R in


5V
XBP1
XFG1
Rb1
52.9kΩ
Rc
3500Ω
C2
15µF
RL
10kΩ
R1
5kΩ
C3
15µF
Q1
2N3904
C1
15µF
Rg
25.12Ω
Bode Plotter-XBP1
4.96 kHz
561.89564 m
Matthew Loden
UIN: 808007439
Lab 01

R out



(Please Note: I could not get this value to display, I'm not sure why it doesn't show up but I was wondering if you could point me in the right direction for next time)

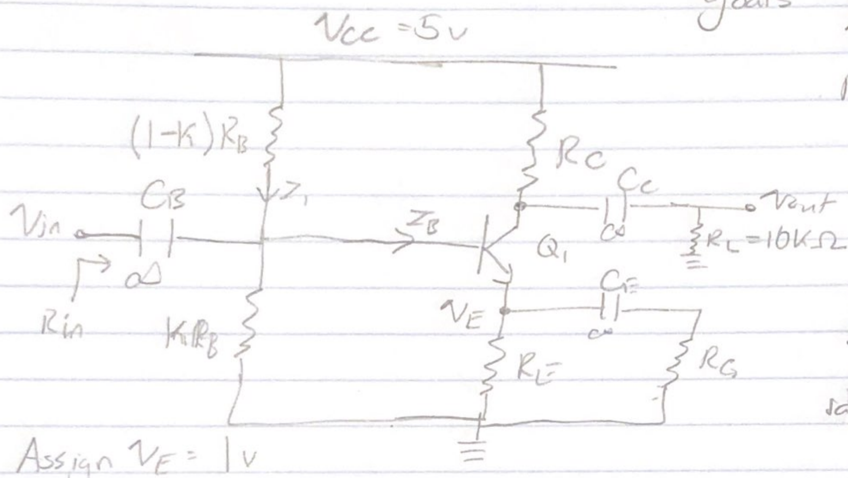
Results Discussed:

Value	Calculated	Simulated	Measured
V Emitter	1v	0.963v	0.964v
V Collector	2.1805	2.91383v	1.192v
V Base	1.7v	1.61482v	1.615v
Ic	0.6mA	0.596mA	1.49mA
Isupply	0.6623mA	0.6604mA	0.660429mA
Rin	5kΩ	5.0092kΩ	6.412kΩ
Rout	n/a	2.559kΩ	n/a

The measured and simulated results largely line up with the calculated values. Some discrepancies are in the voltage at the collector, the measured Rin and the Rout values. The voltage measured at the collector was very different based on the way the data was collected because I believe that there were errors on where I placed the probe for this point as the math is sound given that the current through the collector is the same for each data retrieval method. The Rin value is slightly off due to the transition from the math to the measurement simulation and then back to math. This flip-flopping of data retrieval caused the slight error. The last problem is the calculated value and measured value for Rout. I was not able to calculate the value of Rout directly by hand and my simulation for this measurement also failed. I'm not sure why either weren't successful, but I would like some pointers for future labs.

Lab 1

goals $V_E \geq 1v$ $R_{in} \geq 5k\Omega$
$V_{cc} = 5v$ $|A_v| = 40$
$R_L = 10k$ $I_S \leq 1.5mA$



$\beta = 190$

ratio $= \frac{R_i}{R_i + \cancel{tot}}$

$R_{out} = 2.559k\Omega$
calc

Assign $V_E = 1v$

$V_x = V_{CC} - V_{CE,sat} - V_E = 5v - 0.2v - 1v = 3.8v$

$K = \frac{V_E + 0.7}{V_{cc}} = \frac{1.7}{5} = 0.34$ $N = 10$

$Q = \frac{N V_x}{K(1-K)V_{cc}} = 33.86$

$R_C^2(\beta R_L - R_{in,d} A_v) + R_C(2\beta R_L - 3R_{in,d} A_v - QR_{in,d})R_L - R_L^2 R_{in,d}(Q+d$

$R_C^2(17e^5) + R_C(2353300)10K - 1.2467e^{14} \geq \phi$

$R_C \geq 1.713k\Omega$

$R_C \leq R_L\left(\frac{V_x}{V_{swd}} - 2\right)$ $R_C \leq 3.750k\Omega$ $\boxed{R_C = 3.5k\Omega}$

$I_C = \frac{V_x}{R_C + (R_C \| R_L)} = \boxed{0.6mA}$

$R_B = \frac{\beta V_{cc}}{N I_C} = \boxed{52.9k\Omega}$

$R_E = \frac{V_E}{I_C} = \boxed{1.6k\Omega}$

$R_G = \frac{1}{\frac{1}{\left(\frac{R_C \| R_L}{A_v} - r_e\right)} - \frac{1}{R_E}} = \boxed{25.12\Omega}$

$g_m = \frac{I_C}{V_t} = \frac{1mA}{25mV} = 0.04$

$V_B = 5\left(\frac{27.25k}{27.25k + 52.9k}\right) = 1.6999$

$r_e = 25$

$I_{supply} = \frac{5 - 1.7}{52.9k\Omega} + 0.6mA = 0.66mA$