California State University Sacramento
Electrical and Computer Science Department

EEE 108L Lab - Section 05
Laboratory Experiment Number 7: Lab Report

BJT Application
Common-Emitter Biasing and Amplification Fundamentals

Author: John Jimenez
Lab Partner: Jonas

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ADDENDUM

Abstract

For this laboratory experiment we are experimenting on factors affecting the DC bias of a common-emitter amplifier stage. When the stage is biased, the base voltage will be driven with an AC signal to illustrate principles of common-emitter amplifier operation. In this lab the SPICE Simulations and the experimental portion of the circuit will use 2N2222 small-signal amplifier transistor.

Part 1: Preliminary Calculations

STEP 1:

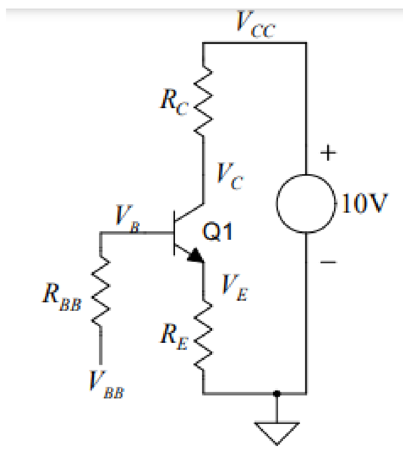
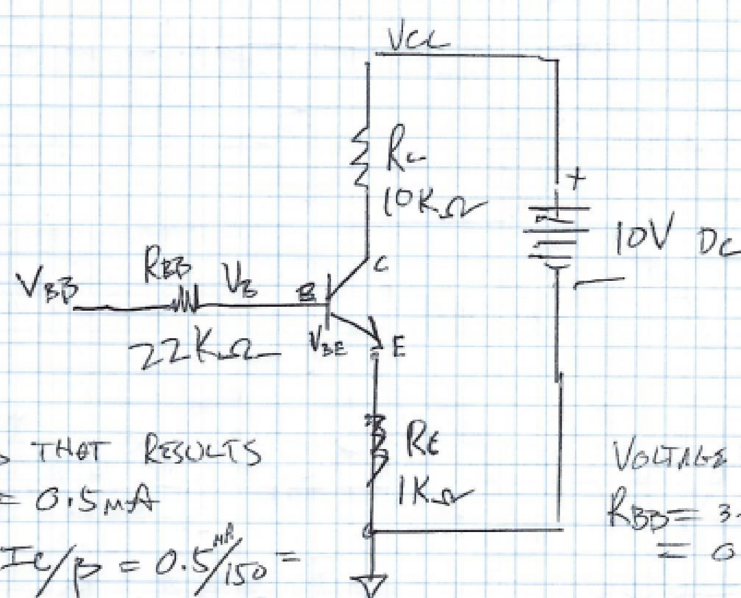


Figure 1. BJT Bias Circuit

①



FIND VBB THAT RESULTS IN $I_C = 0.5mA$

$I_B = I_C/\beta = 0.5mA/150 =$

$I_B = 3.33 \times 10^{-6}$ A OR 3.33μA

VOLTAGE DROP ACROSS $R_{BB} = 3.33 \times 10^{-6} \cdot 22K$
$= 0.0733$ V

$V_{BB} = (3.33\mu A)(22k\Omega) + \underbrace{0.7V}_{V_{BE}} + 0.5 \cdot 1K\Omega = 1.2733$ V

STEP 2:

②

$$1.2733V = I_B\,22K\Omega + 0.7V + I_B \cdot 225 \cdot 1K$$

$$0.5733V = 247K\Omega \cdot I_B$$

$I_B = 2.32\mu A$ $\qquad$ $I_C = 0.522mA$

$\boxed{\begin{array}{l} 50\%\ \text{INCREASE} \\ \text{IN } \beta \\ 150 \cdot 1.5 = \underline{225} \end{array}}$

$$\frac{0.522mA}{0.5mA} = 1.044$$

$\therefore I_C$ CHANGES BY 4.4%

STEP 3:

③

$V_{BB} = 1.2733V$

$V_{BE} = 0.7V \cdot (-2mV/°C)(\cdot 40°C) = 0.62V$

$\cancel{\beta = 150 \cdot (0.0125) \cdot 40}$

BETA CHANGES BY $(0.0125/°C)(40°C) = 0.5$
50%

$\beta = 225$

$1.2733 = I_B \cdot 22K + 0.62 + I_B \cdot 225 \cdot 1K\Omega$

$0.6533 = I_B \cdot 22K + I_B \cdot 225{,}000$

$0.6533 = I_B\ 247{,}000$

$I_B = 2.6447 \times 10^{-6}$, $2.64\mu A$

$I_C = 2.64\mu A \cdot 225 = 0.595\ mA$

$\frac{0.595mA}{0.500mA} = 1.19$ $\qquad$ 19% INCREASE IN I_C

STEP 4:

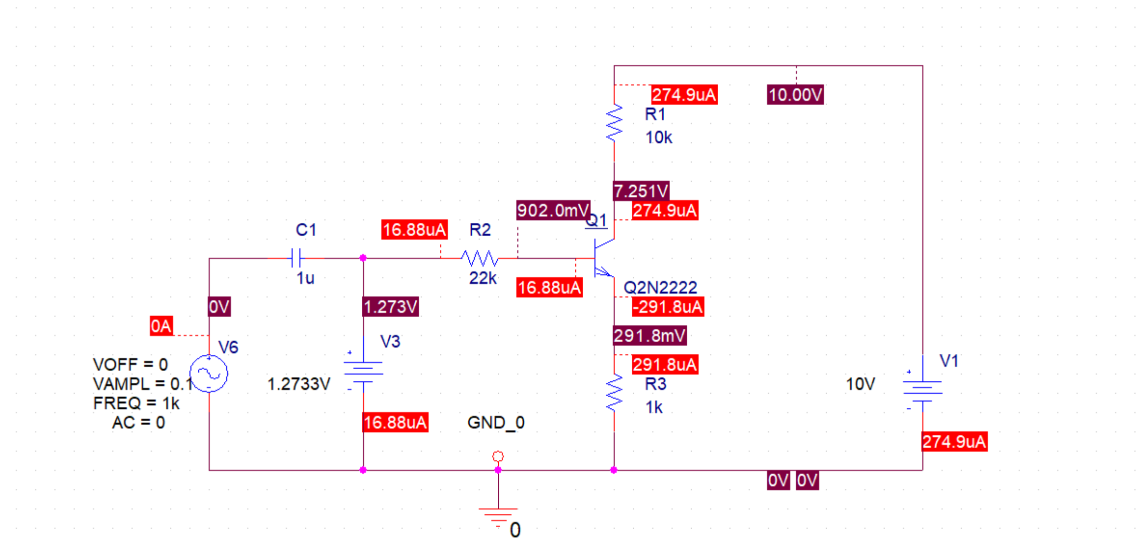
(4) $$\frac{\Delta V_C}{\Delta V_B} = \frac{V_{CC} - I_C R_C}{V_{BE} + I_E R_E} \qquad I_E = I_C \cdot \frac{\beta}{\beta+1} \approx I_C$$

CHANGE

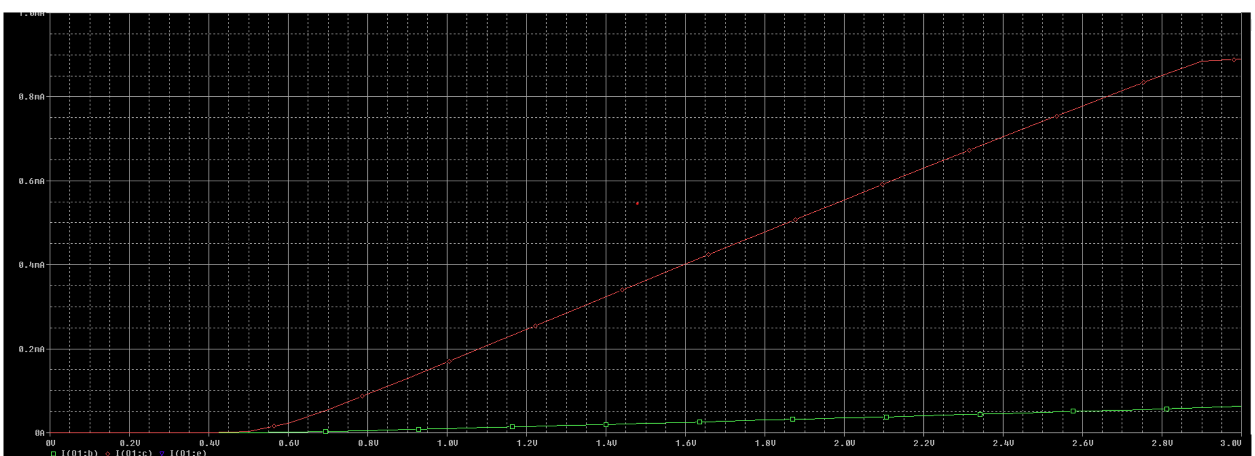
$$\frac{\Delta V_C}{\Delta V_B} = \frac{\cancel{V_{CC}} - \cancel{I_C} R_C}{\cancel{V_{BE}} + \cancel{I_C} R_E} = \frac{-R_C}{R_E}$$

Part 2: Spice Simulations

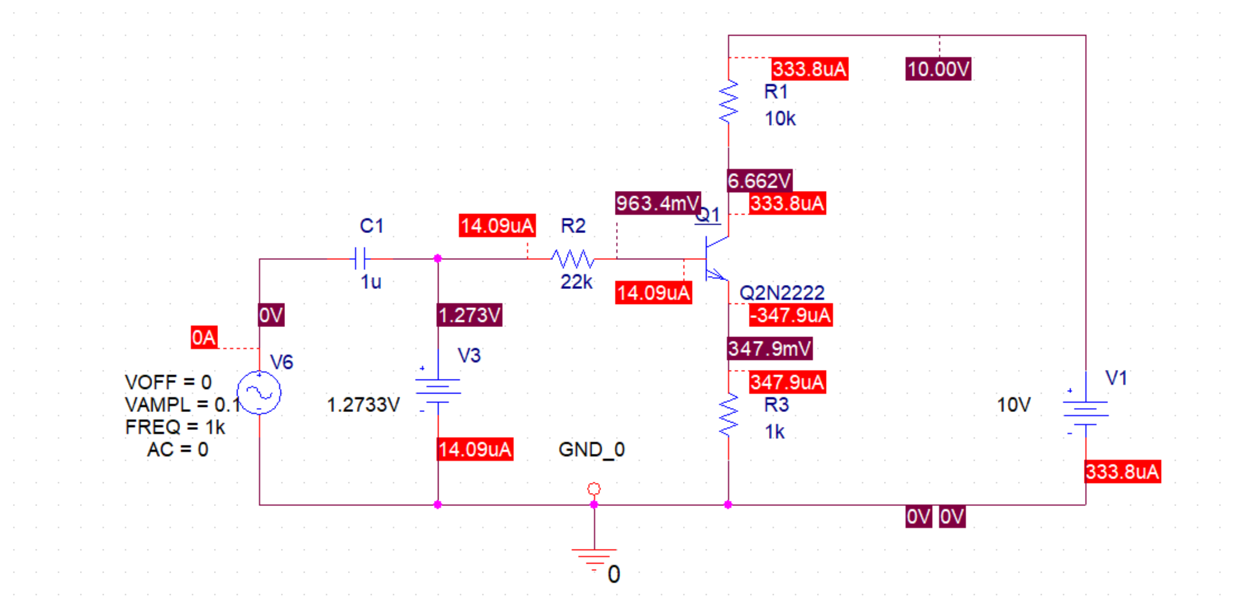
STEP 5: B = 150, I = 274.9uA



Current Trace

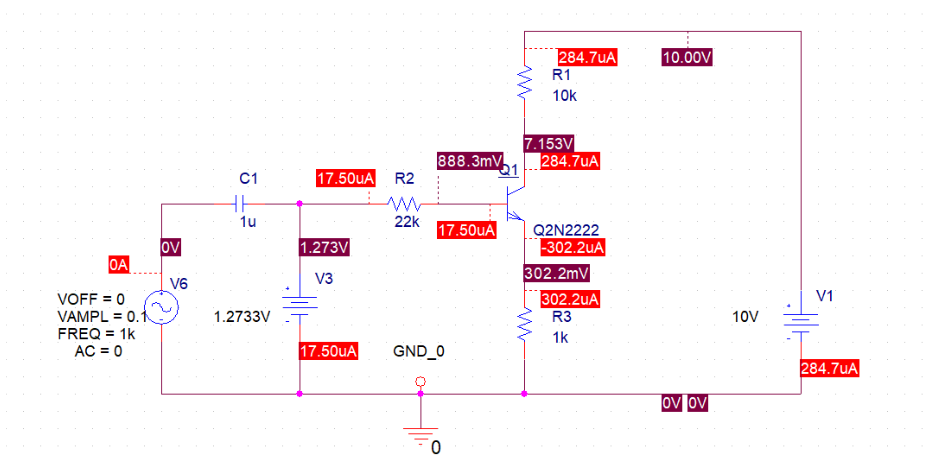


STEP 6: switch B to 225

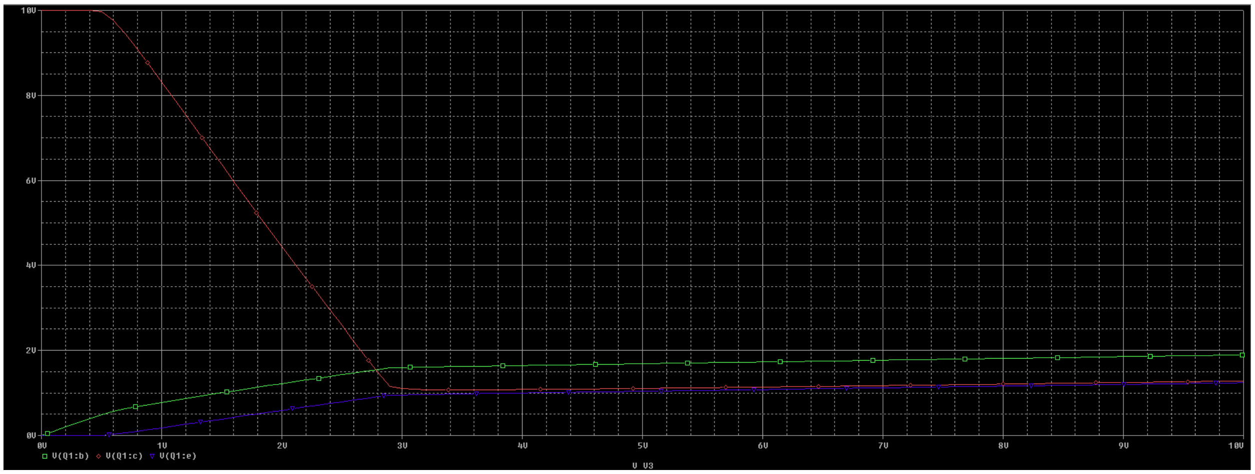


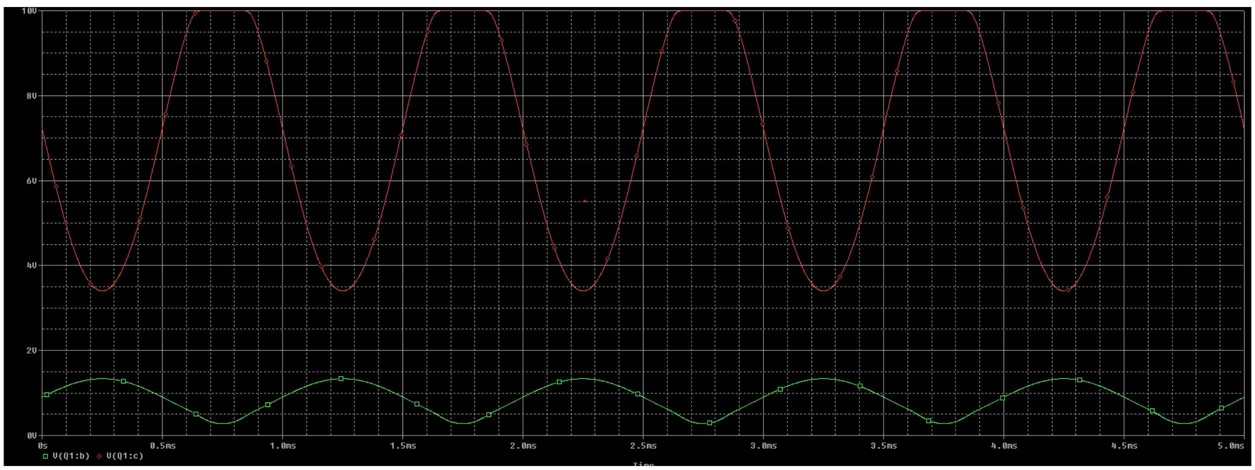
We found a 17% increase after increasing the value of Beta.

STEP 7: Circuit bias point at 40 degrees C. Also Beta value = 150, I = 284.7uA. We found that there was only a slight increase of 3% = (284.7-274.9)/284.7 = 0.034*100



STEP 8:


10V
8V
6V
4V
2V
0V
0V
1V
2V
3V
4V
5V
6V
7V
8V
9V
10V
V(Q1:b) V(Q1:c) V(Q1:e)
V V3


10V
8V
6V
4V
2V
0V
0s
0.5ms
1.0ms
1.5ms
2.0ms
2.5ms
3.0ms
3.5ms
4.0ms
4.5ms
5.0ms
V(Q1:b) V(Q1:c)

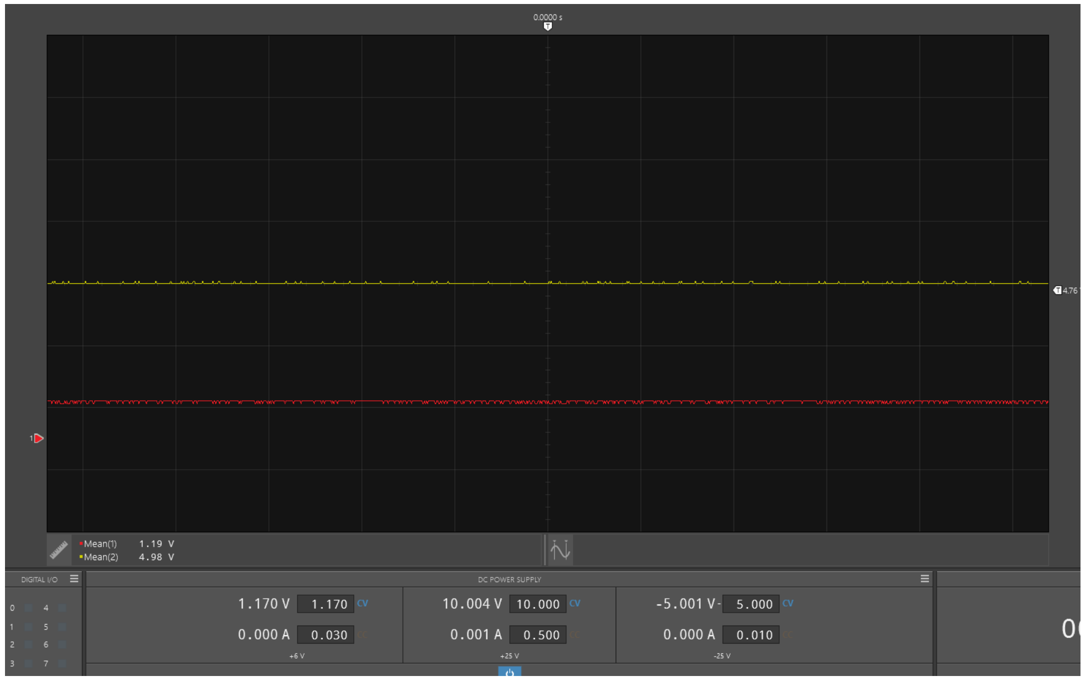
Part 3: Laboratory Experiment

STEP 9:

Vcc= 10V

RC= 10kOhm

Rbb= 22kOhm

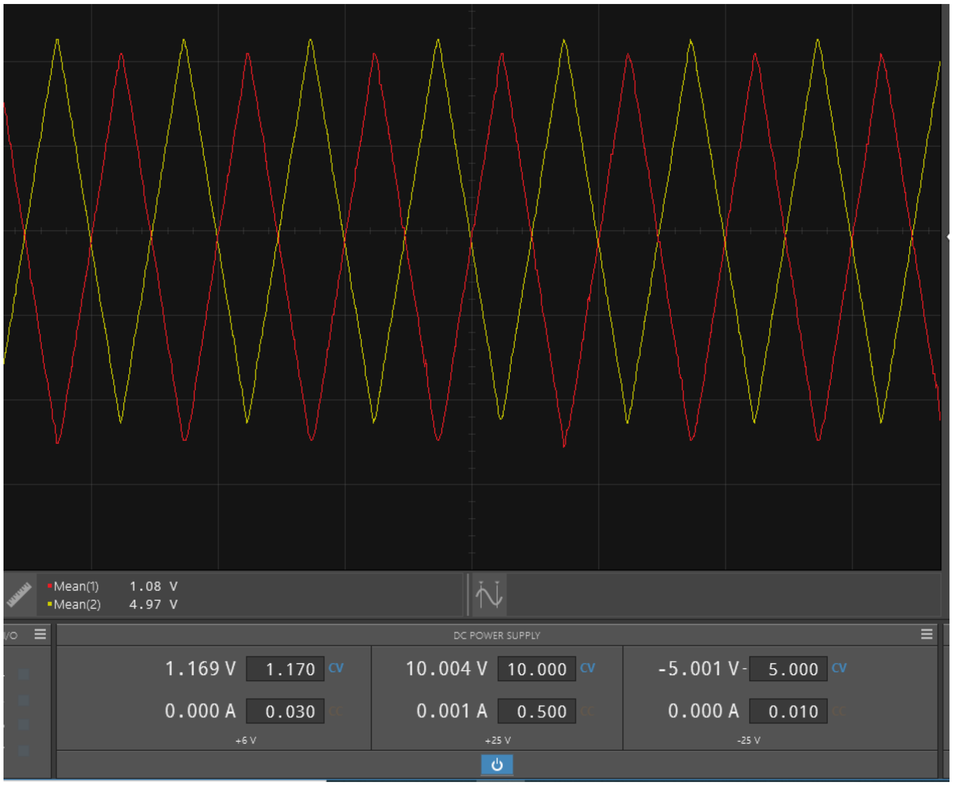


V_{BB}	V_B	V_c	$I_c = \frac{V_{cc} - V_c}{R_c}$	Large signal Gain
0	0.1V	9.8V	2×10^{-5}	
0.5	0.42V	9.8 V	2×10^{-5}	$\Delta V_c = 4.21$
1	0.8V	6.4V	3.6×10^{-4}	$\Delta V_B = 0.45$
1.5	1.25V	2.19V	7.81×10^{-4}	$= 9.35$
2	1.42V	1V	9×10^{-4}	
2.5	1.43V	1.02	8.98×10^{-4}	
3.	1.59 V	1.03V	8.97×10^{-4}	

When $I_c = 0.5mA$

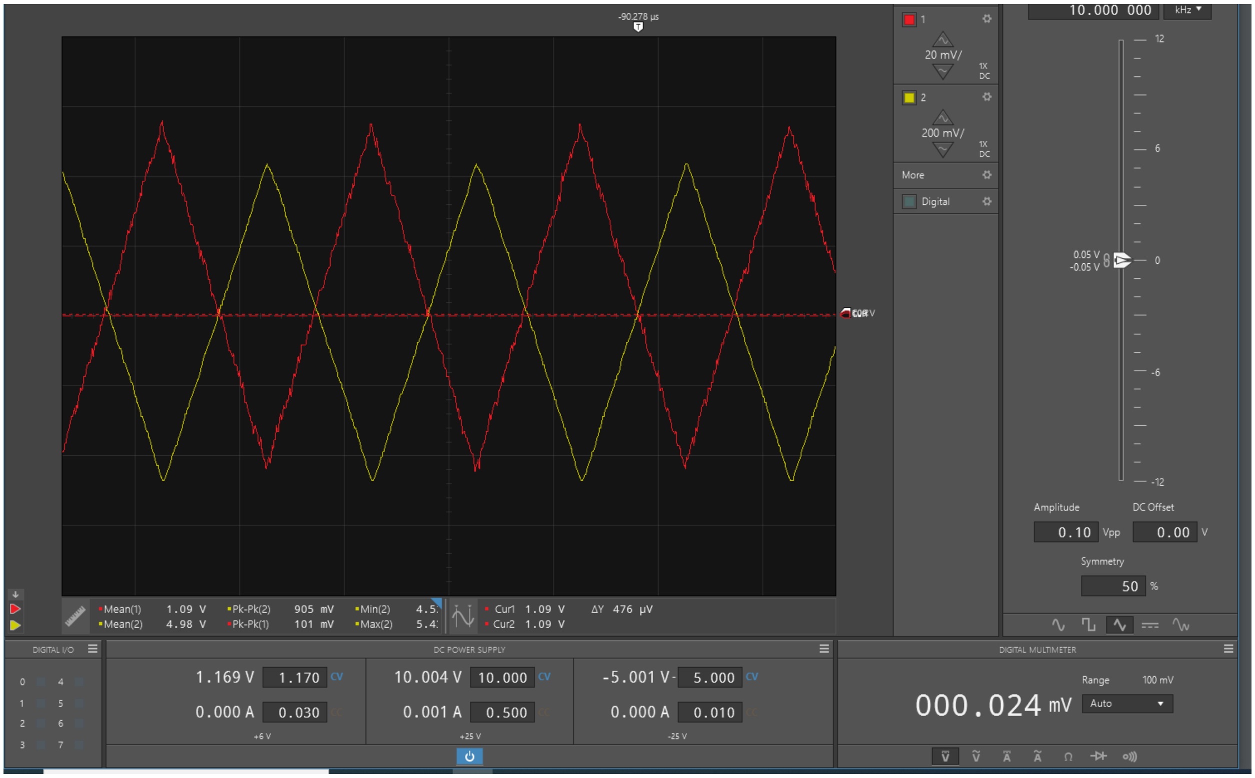
when the $V_{BB} = 1.170V$

STEP 10: Cap= 22uF

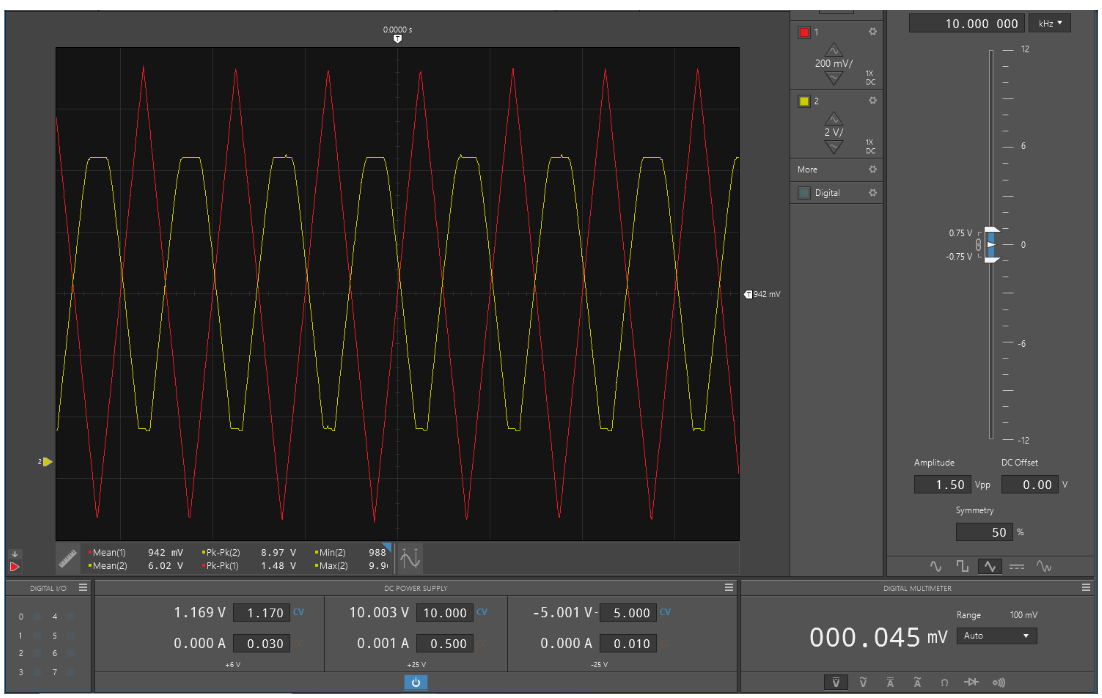


Small signal gain = Vc/Vb = 914mV/91mV = 10.04

STEP 11:



STEP 12:



Max = 9.9 supply V, Min = 0.916 emitter V

STEP 13: Replace VBB and the RBB

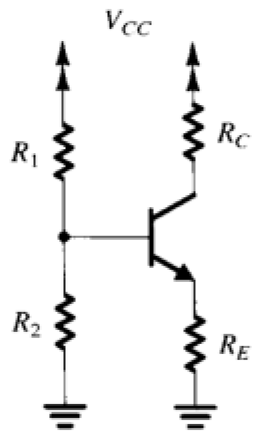
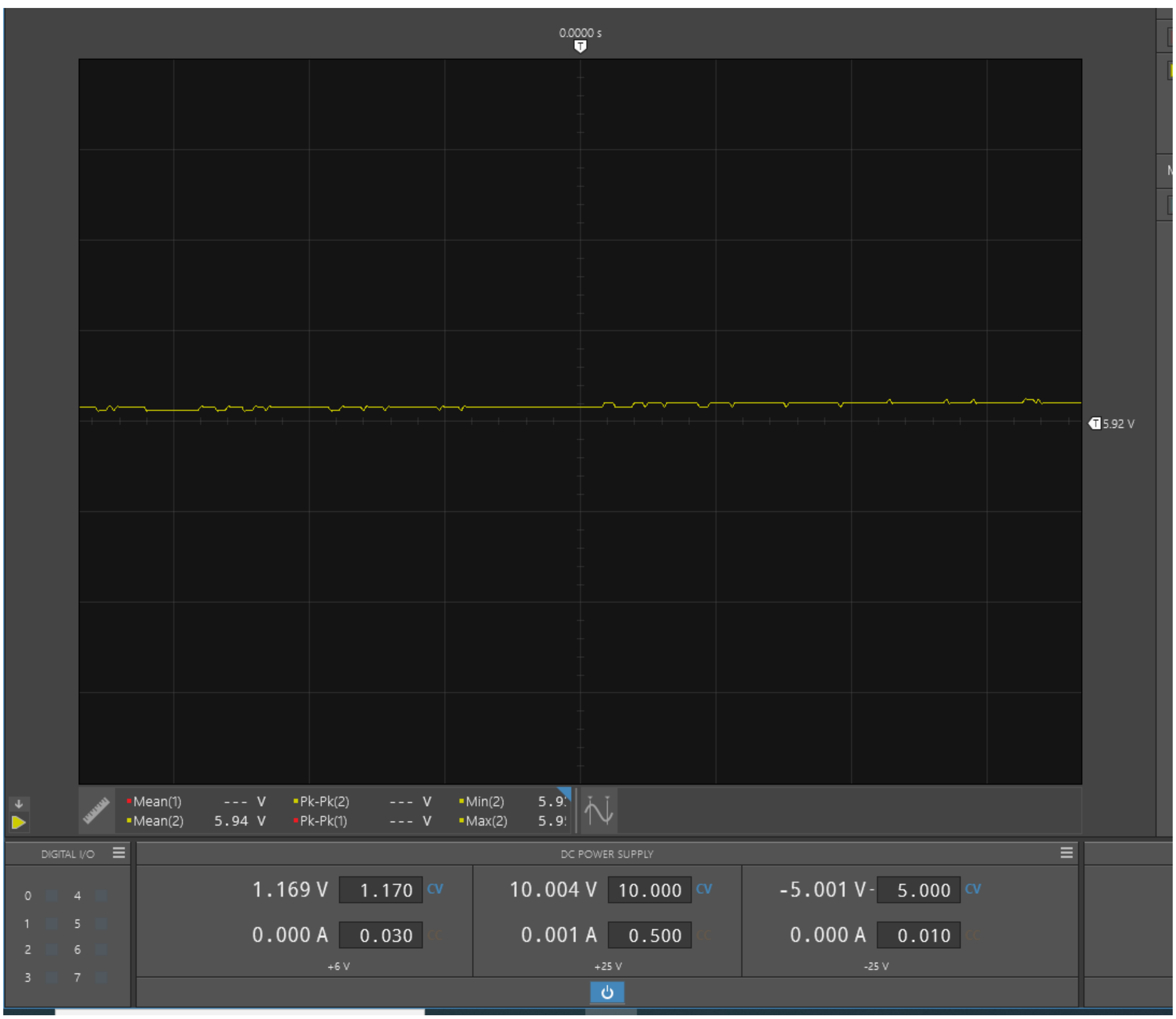


Figure 3. Alternate Input Bias Circuit



Lab 7

Part 13 continuation

$$\frac{1.17R_1}{10}$$

$$R_2 = \frac{1.17R_1(0.883)}{10}$$

$$22k = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

$$22k = \frac{R_1\left(\frac{1.17R_1(0.883)}{10}\right)}{R_1 + \left(\frac{1.17R_1(0.883)}{10}\right)}$$

$$22k = \frac{R_1 \cdot 0.103R_1}{1R_1 + 0.103R_1}$$

$$22k = \frac{.103R_1^2}{1.103R_1}$$

$$22k = .093R_1$$

$R_1 = 235543$ or $188{,}034\ \Omega$

$R_2 =$ or $25K\Omega$

$$I_C = \frac{10-5.93}{10k} = 0.407$$

solve for pecent error $\rightarrow$ $0.5 - 0.407 = \frac{0.093}{0.5} \times 100 = 18.6\%$

CONCLUSION:

ITEM 1: What spice does differently is having different Beta values. And VBE is not easy to find as it has more specific calculations that just do not appear on spice.

ITEM 2: It is not septical to change. This is because the Tolerance to B is strong.

ITEM 3: Sor the changes after the change in temp was basically non existent as the change was only 3.4%

ITEM 4: The current gain which is (Vcc-Vc)/Rc = Ic

ITEM 5: We can conclude that the small signal gain was about 9.35

ITEM 6:If comparing step 10 small signal gain to the slope of the transfer in step 9, we see that the difference is only 10.04- 9.35 = 0.69

ITEM 7: The shape of the clipping seen in step 12 compared to the Vc in step 8. We see that They clip around 1.5VPP at around 9.9V.