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170LC

Lab 2

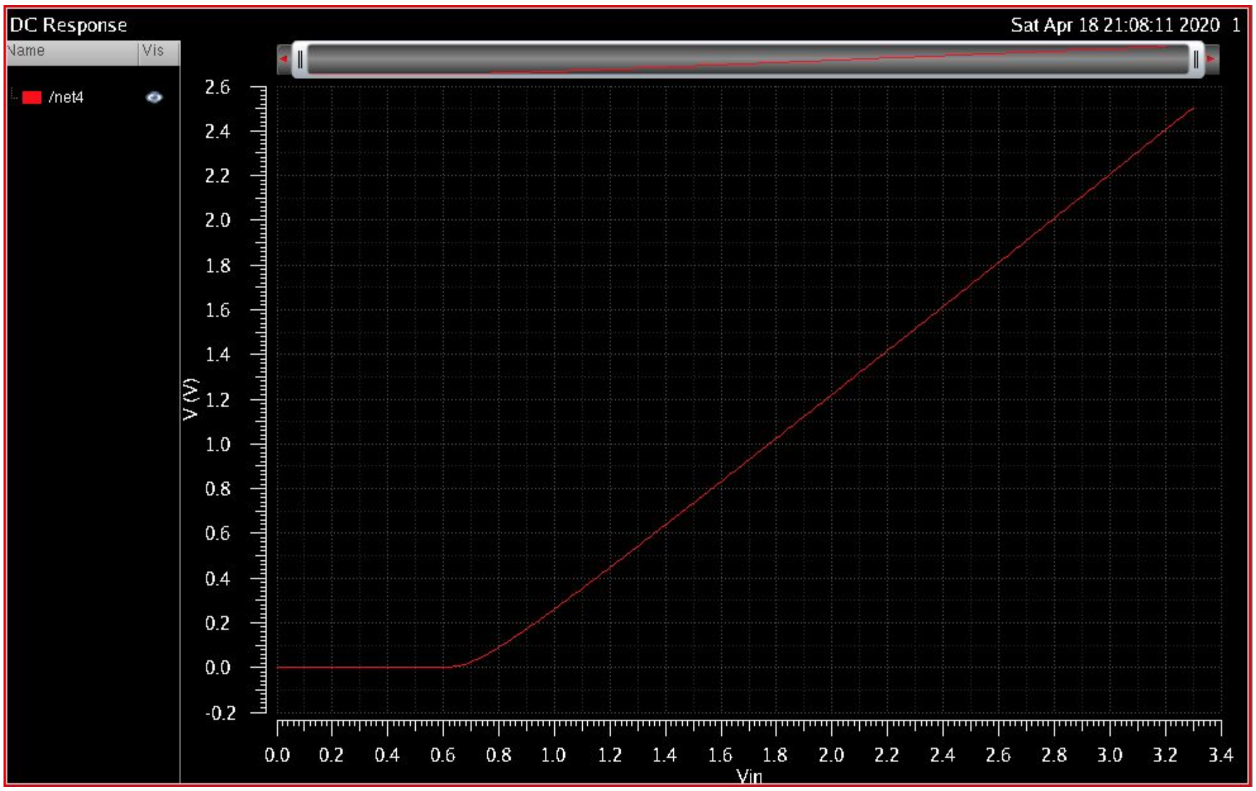
4/21/2020

Problem 1

Common Collector

A.

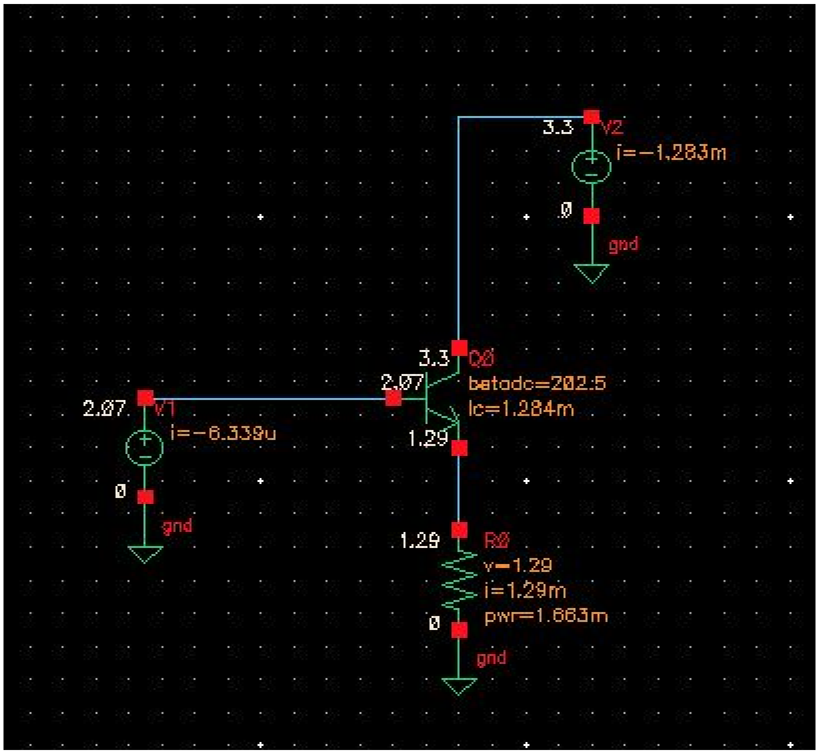
Vout vs. Vin



- $V_{in} = V_{in(eq1)}$: $\frac{3.3V - 0.706V}{2} = 1.297V$
- Region of operation (from bottom to top of graph): 1) cutoff, 2) forward active

B.

DC Operating Point Analysis



C.

Calculations

Small signal parameters from simulation:

- gm = 49.61m
- ro = 78.87kΩ

Calculated small signal parameters

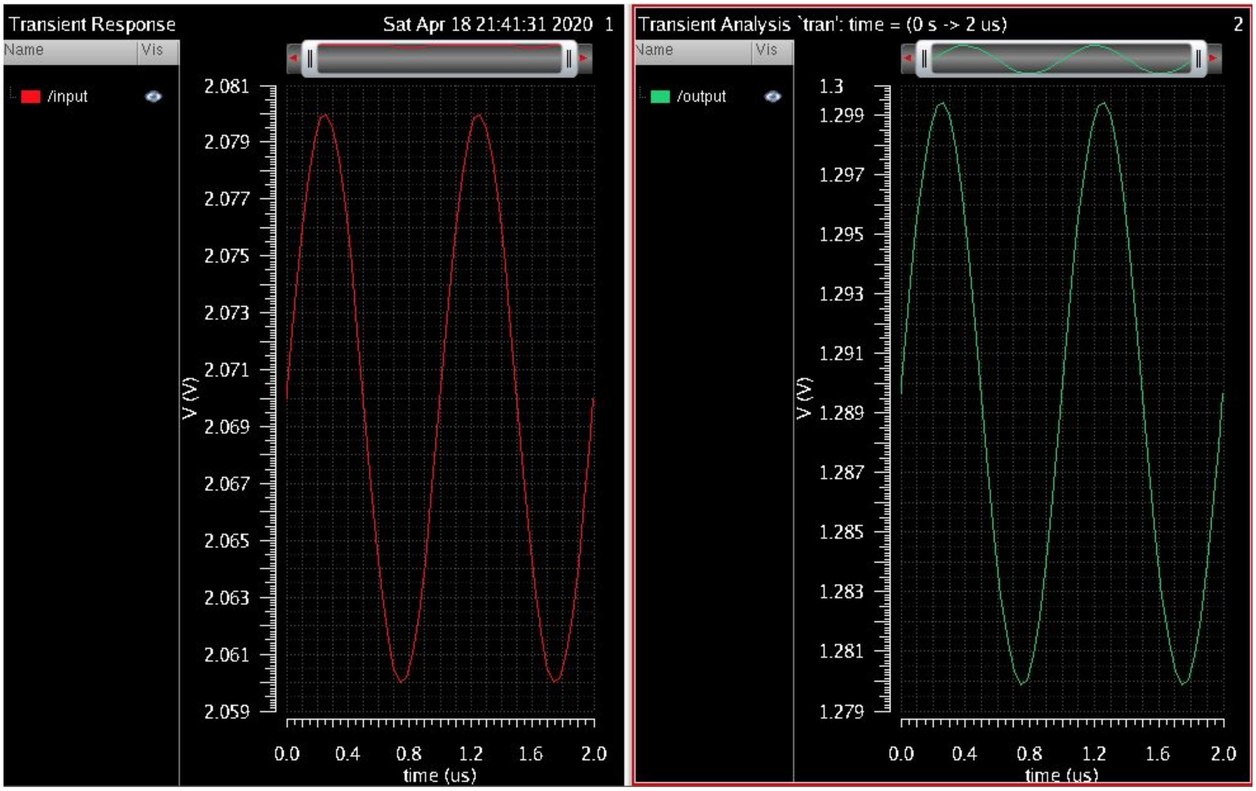
- gm = $\frac{Ic}{VT}$ = (1.284/26) = 49m
- ro = $\frac{VA}{Ic}$ = (100/1.284) = 77.88kΩ

Percent error:

- gm % error = 49.61m-49m/49.61m *100% = 1.23%
- ro % error = 78.87 kΩ - 77.88 kΩ/78.87 kΩ *100% = 1.25%

D.

Comparing AC and DC components of Vin and Vout



- DC input level: 2.07V
- DC output level: 1.289V
- Amplitude_Vin: 19.96mV
- Amplitude_Vout: 19.56mV
- Gain = Amp_Vout/Amp_Vin = 19.56/19.96 = <u>0.98</u>
- DC and AC output levels decrease when adding a sine wave input and the gain is small.

E.

Increase Vin(eq1) by 10mV

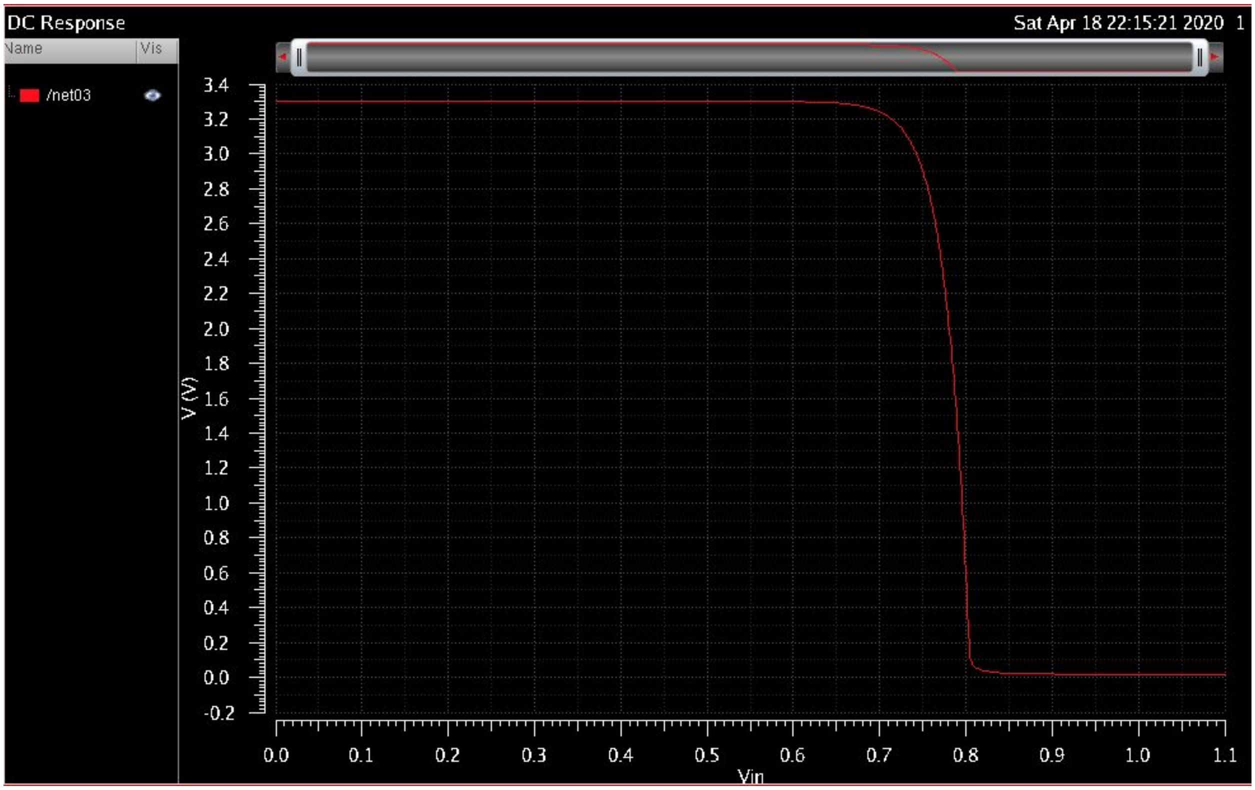
- Increasing the amplitude by 10mV causes the input and output amplitude levels to also increase to 39.92mV and 39.12 mV, respectively. The DC levels remain the same.

Problem 2

Common Emitter

A.

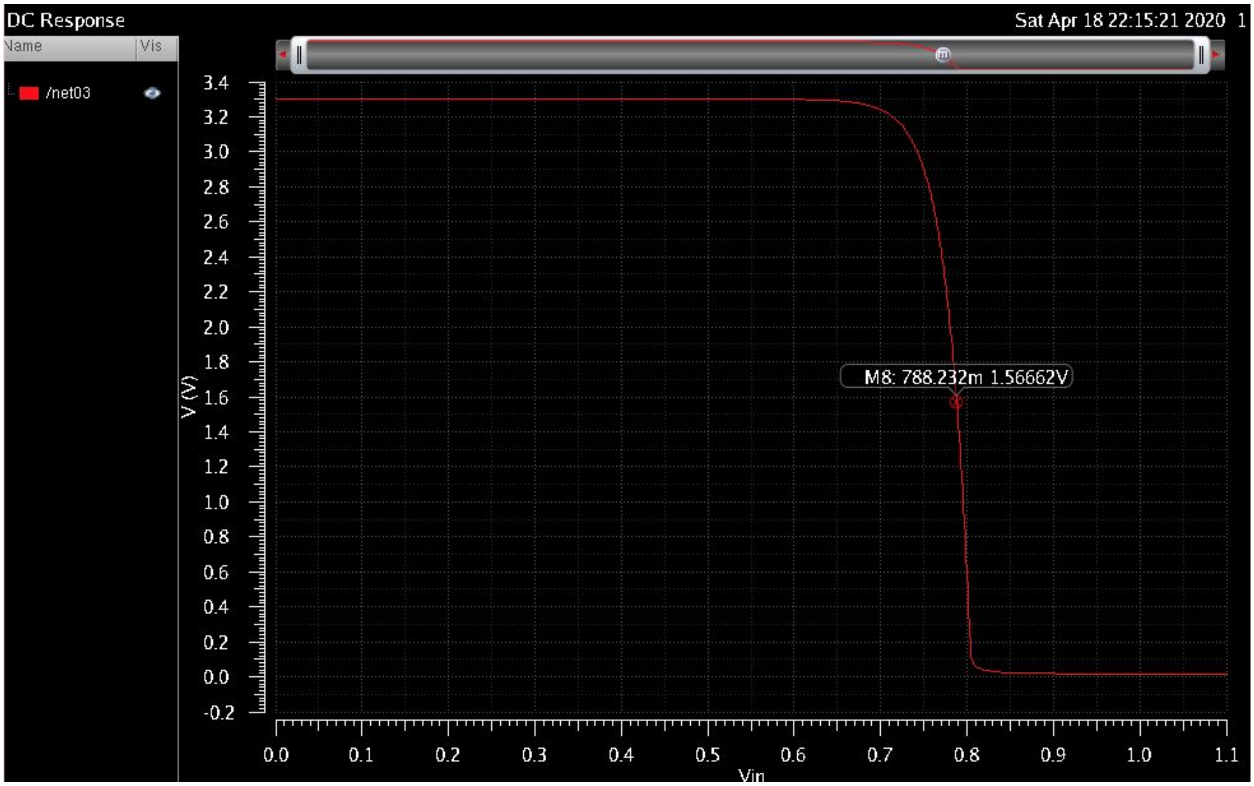
Vout vs. Vin



- Region of operation (from top to bottom of graph): 1) cutoff, 2) forward active, 3) saturation

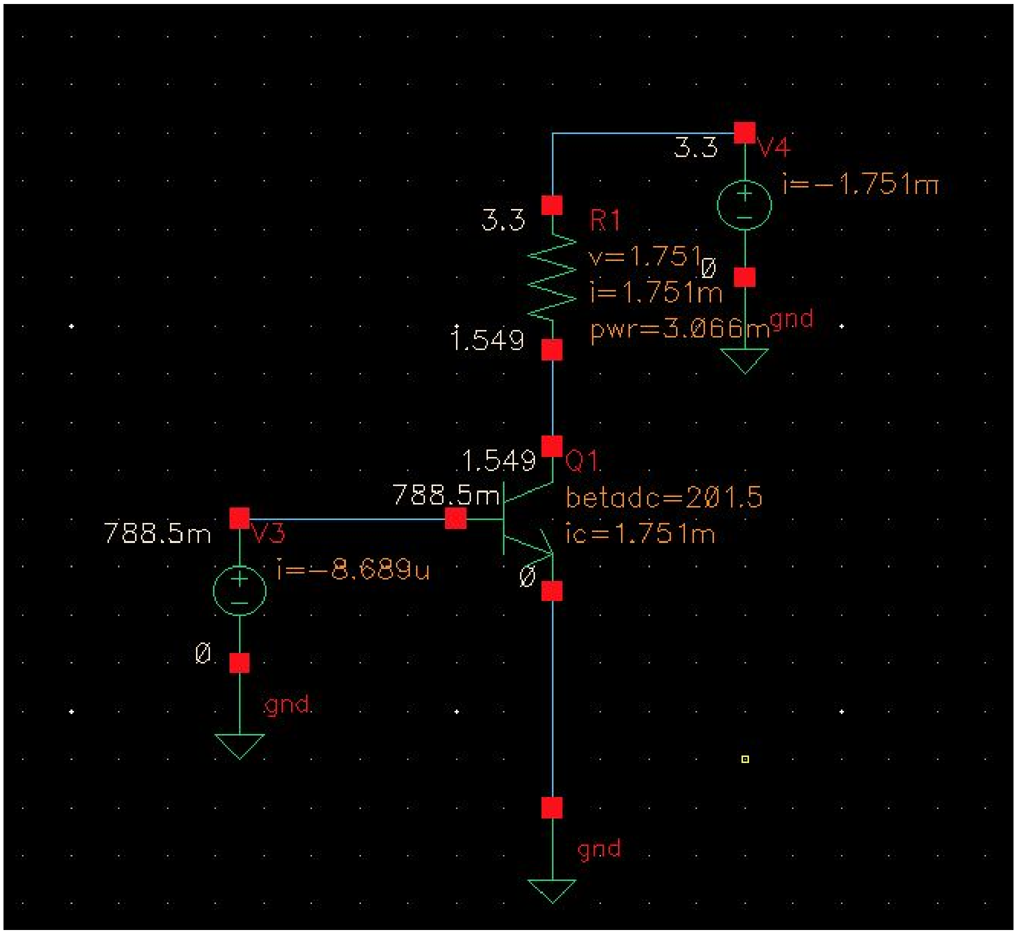
B.

Vin = Vin(eq2)



- Vout = 1.56V
- $V_{in} = V_{in(eq2)}$: $\frac{3.3V - 0.18V}{2} = 1.56V$

DC Operating Point Analysis



- The transistor is operating in the forward active region since Ib > 0 and Vce > 0.

C.

<u>Calculations</u>

Small signal parameters from simulation:

- gm = 67.68m
- ro = 57.55kΩ

Calculated small signal parameters

- gm = $\frac{Ic}{VT}$ = (1.751/26) = <u>67m</u>
- ro = $\frac{VA}{Ic}$ = (100/1.751) = <u>57.11kΩ</u>

Percent error:

- gm % error = 67.68m-67m/67.68m*100% = <u>1%</u>
- ro % error = 57.55 kΩ - 57.11 kΩ/57.55 kΩ*100% = <u>0.76%</u>

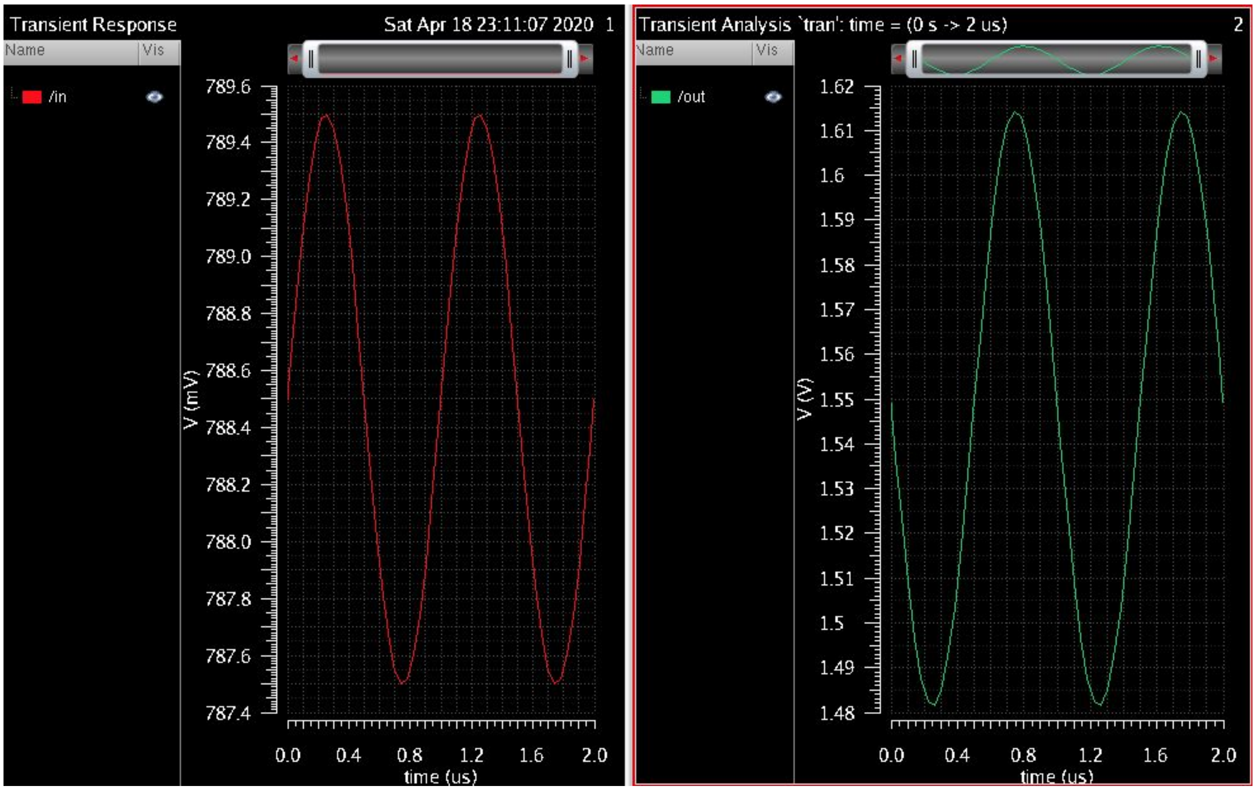
D.

Gain for common emitter circuit

- A = -gm*Rc = 67.68m * 1k = -<u>67.68</u>
- Slope (3.24-0.136)/(0.698-0.806)= <u>-28.74</u>

E.

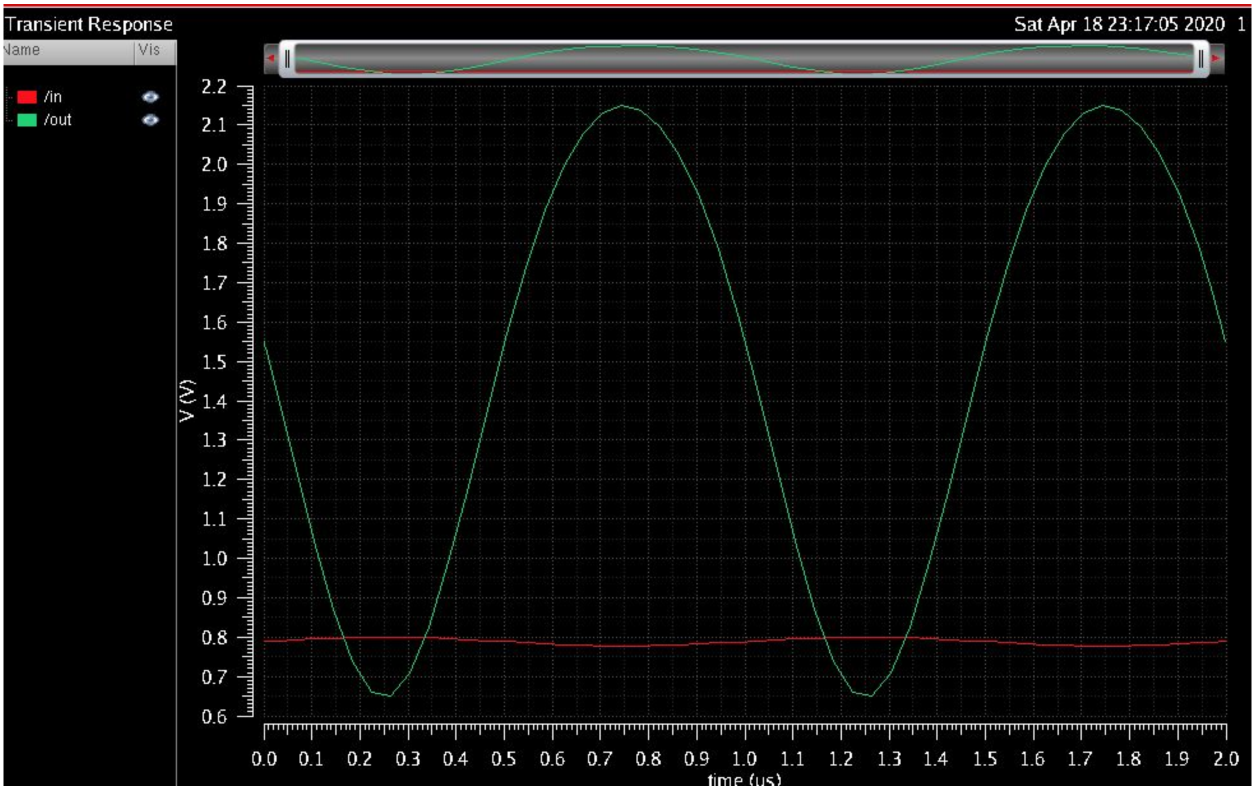
Comparing AC and DC components of Vin and Vout



- DC input level: 788.5 mV
- DC output level: 1.54V
- Amplitude_Vin: 1.996 mV
- Amplitude_Vout: 132.8mV
- Gain = Amp_Vout/Amp_Vin = 132.8/1.996 = <u>66.5</u>
- DC and AC output levels increase when adding a sine wave input and the gain is high. The amplitude of the input signal is very low compared to the output signal.

F.

Increase Vin(eq2) by 10mV

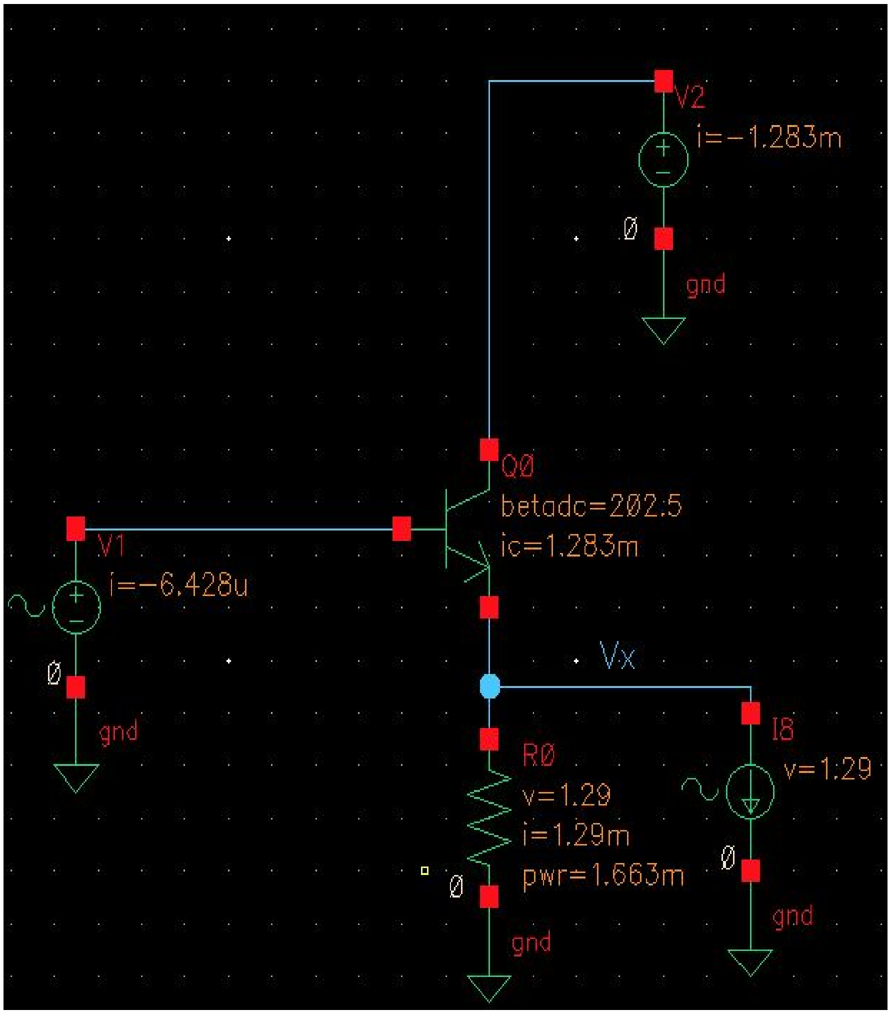


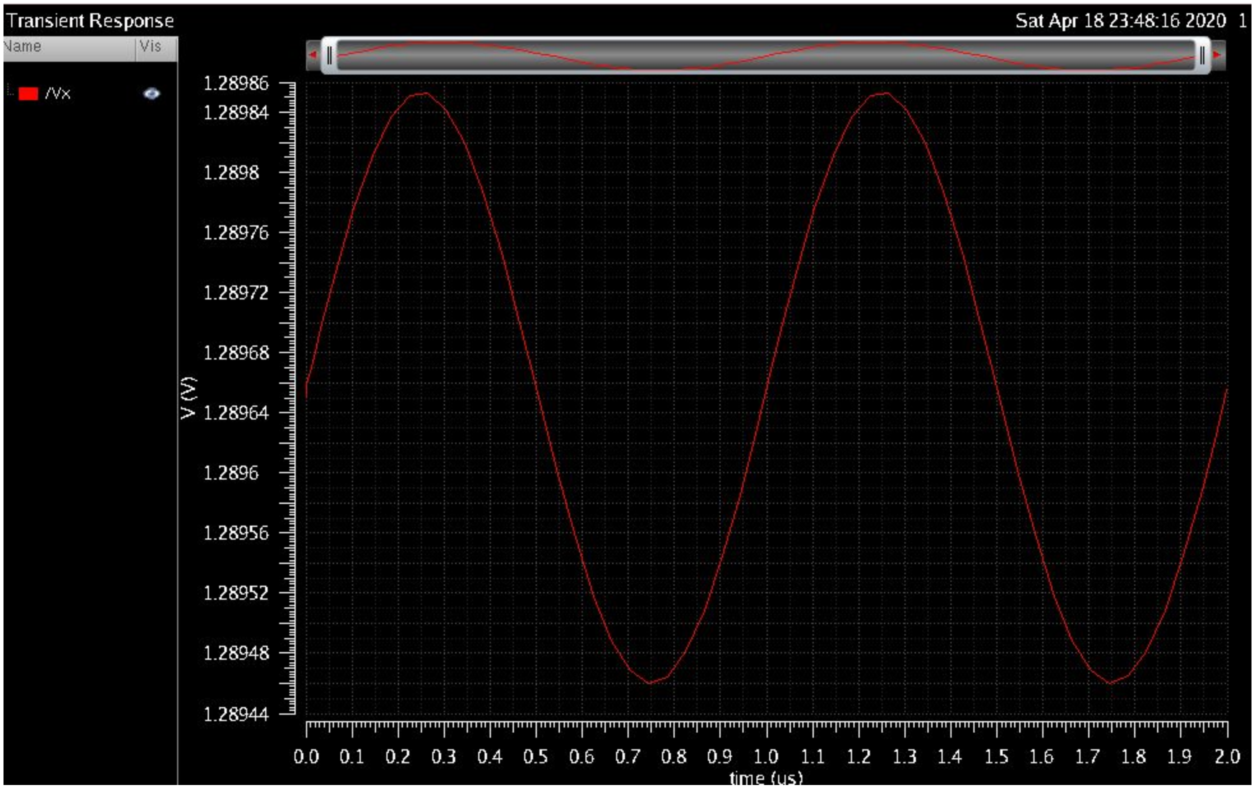
- Increasing the amplitude by 10mV causes the amplitude of the input and output levels to increase. The input amplitude is 21.96mV and output amplitude is 1.499V. The gain is increased to <u>71.3</u>.

Problem 3

A.

Calculate Rout for a common collector circuit

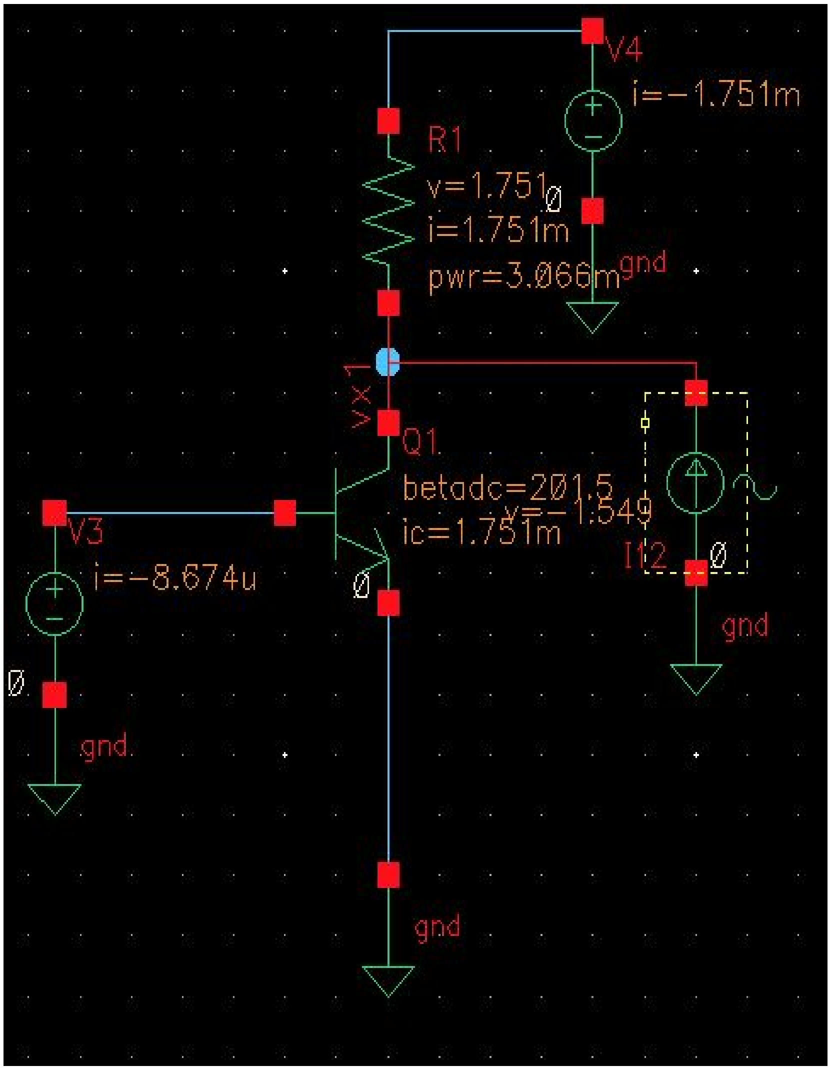


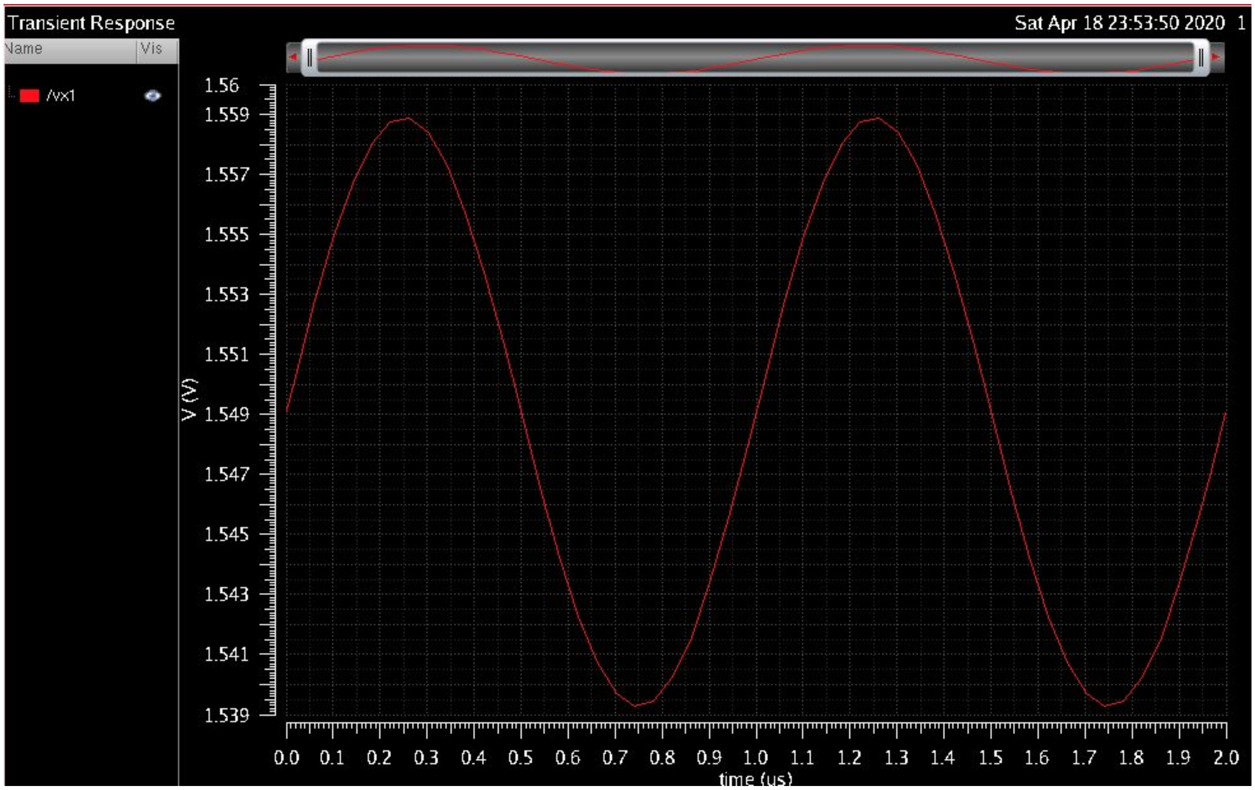


- Rout: Amp_vx/Amp_ix
- Amp_Vx = 392.3u
- Amp_Ix = 20u
- Rout = 392.3uV/20u = <u>19.61Ω</u>

B.

Calculate Rout for common emitter circuit



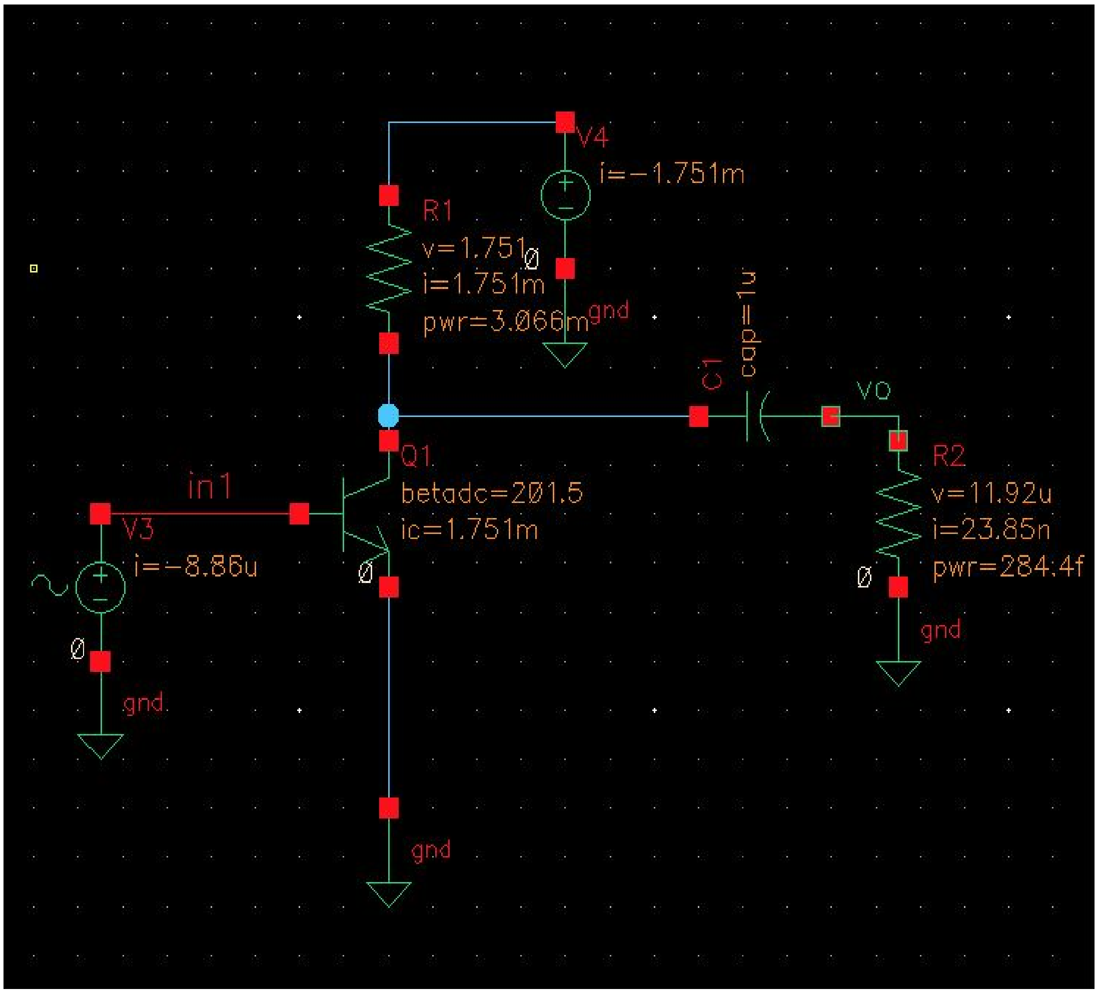


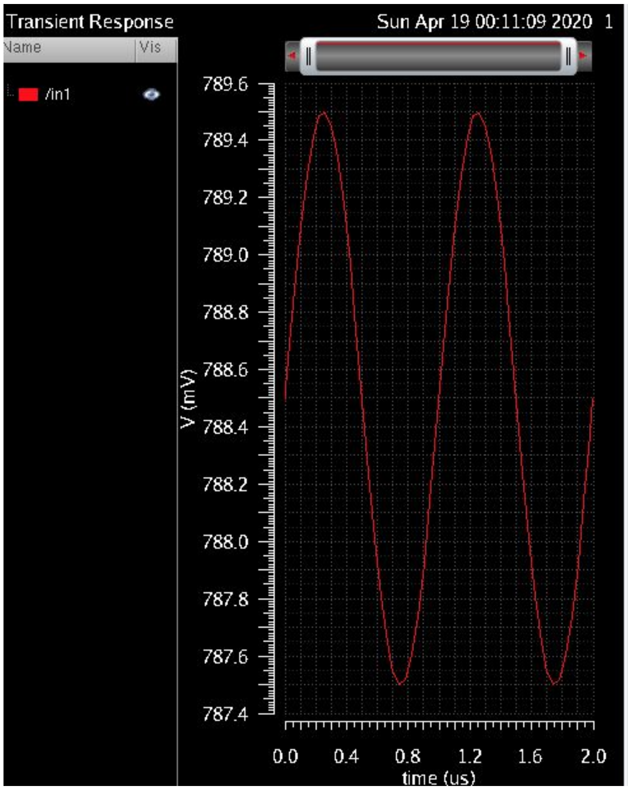
- Rout: Amp vx/Amp_ix
- Amp_Vx = 19.62mV
- Amp_Ix = 20uA
- Rout = 19.62mV/20uA = <u>981k</u>

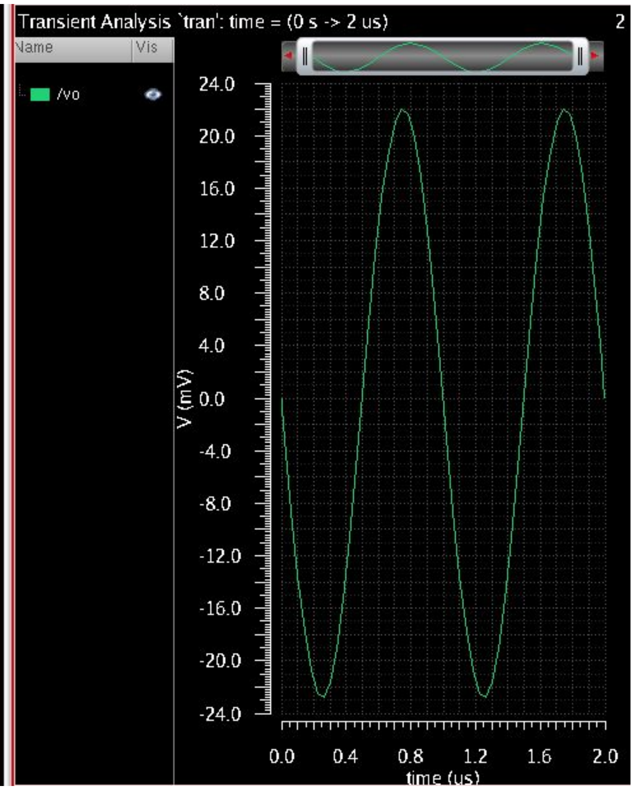
Problem 4

A.

Small-signal gain Vout/Vin



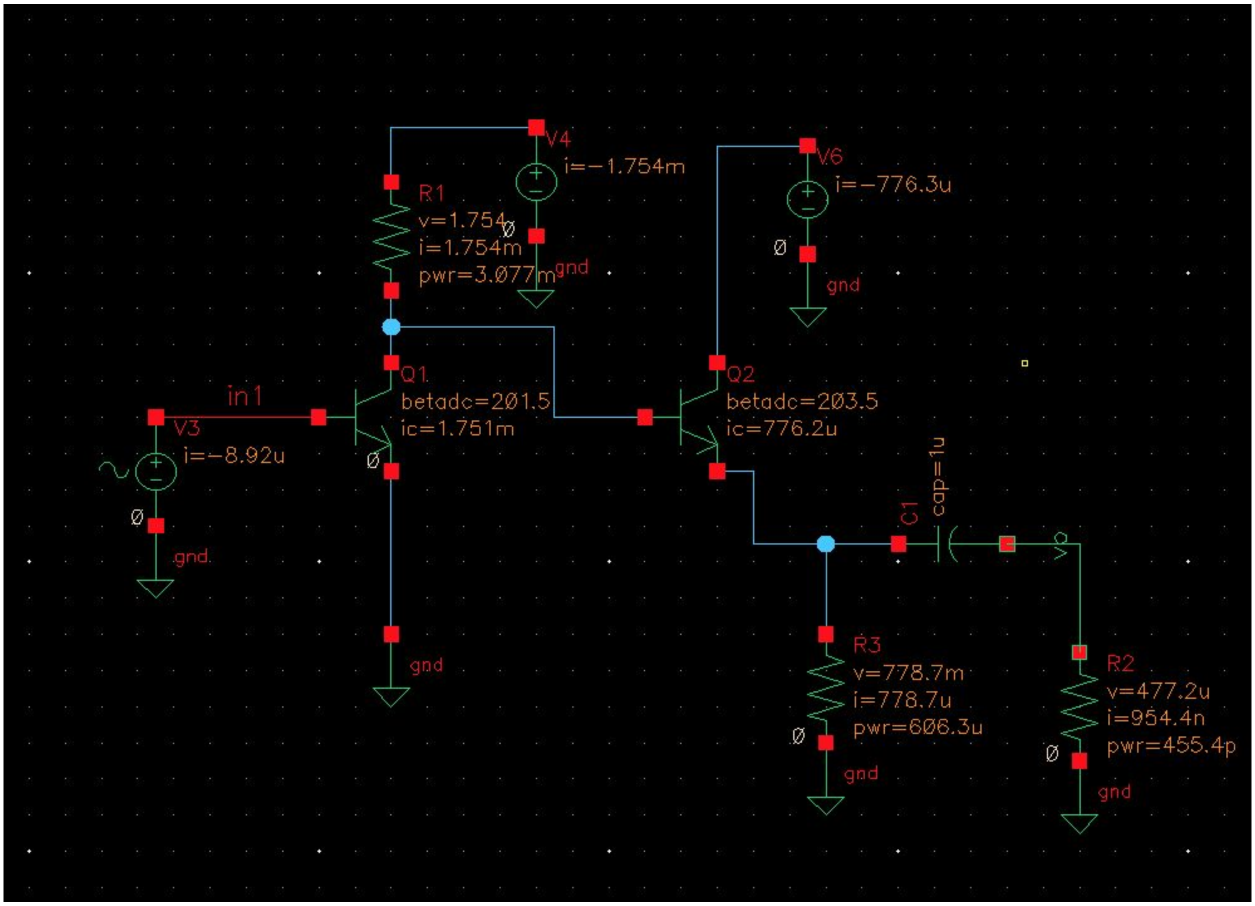


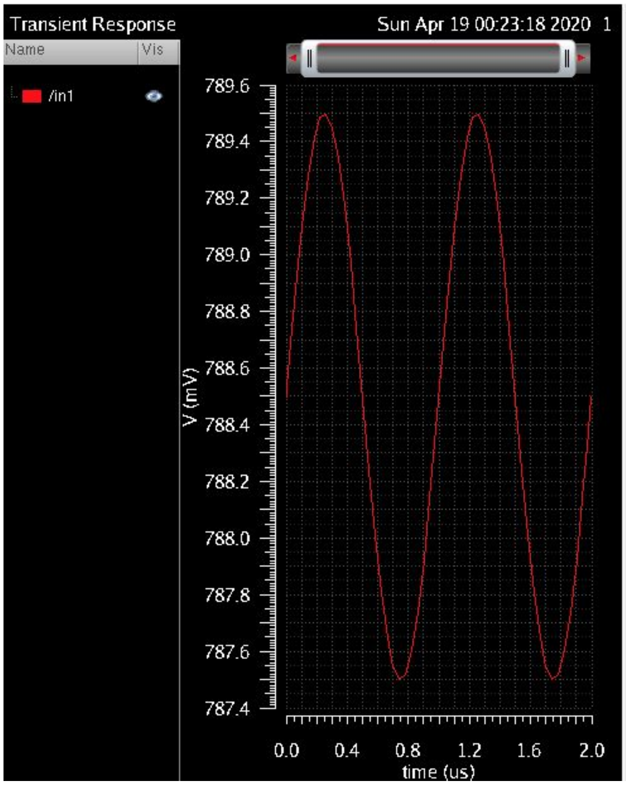


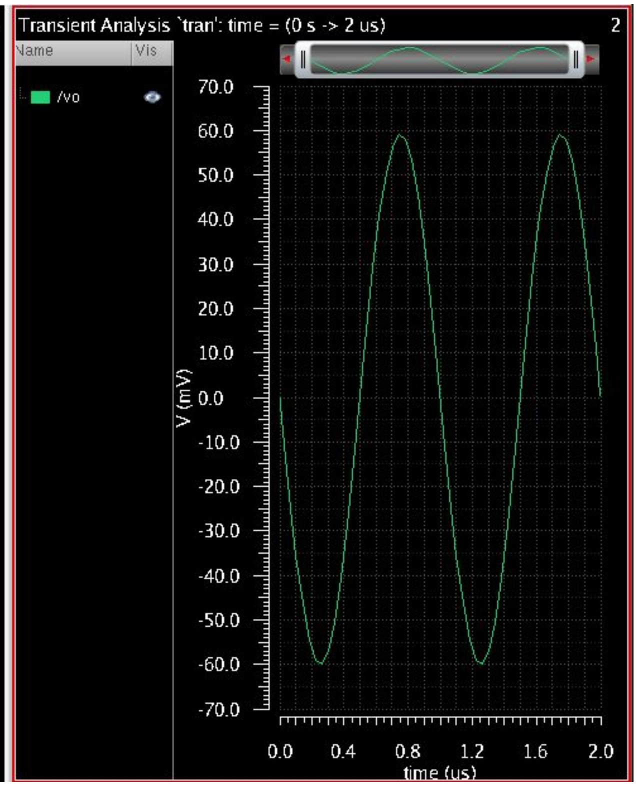
- A= gm* (Rc || ro || Rl)
- Amp_vout = 44.78mV
- Amp_vin = 1.996mA
- A = 44.78mV/1.996mA = <u>22.43</u>

B.

Small signal gain Vout/Vin for two stage amplifier







- A_vout=119mV
- A_vin=1.996mA
- Gain =119mV/1.996mA = <u>59.6</u> which is a lot higher than previous one-stage amplifier

Conclusion

The effects of each circuit were observed with both DC and AC sources. With the DC sources, the operating point was determined along with the calculations for the small-signal parameters. Adding an AC source demonstrates what happens to the input and output levels. For the common collector, the DC and AC output levels decreased when adding a sine wave input and the gain is small. On the other hand, the common emitter had increased output levels when adding a sine wave input and the gain is high. For both circuits, increasing the amplitude increases the gain. The value of Rout is determined by adding a test source to the output and calculating the peak to peak value of the test voltage and current. For the last part, a capacitor was added to observe the gain of a one stage and two stage amplifier. Compared to the one stage amplifier, the gain in the two stage amplifier is almost tripled. This is due to the buffer stage in the circuit which prevents Rl from loading the amplifier.