Final Exam: ENEE 307

Part I (30pts). Analyze the Common Emitter Amplifier circuit in Figure 1 at midband frequencies. (Ignore AC capacitive effects). Take the input signal to be Vs(t) = $0.1\sin(2\pi 10^5 t)$, β=200. Include the effects of gm. Take Vbe = 0.7 for DC bias.

1. Determine the DC voltage values at the base, collector and emitter
2. Determine the small signal voltage gain, don't forget to account for the effects of Rs = 1K and RL=15K
3. Sketch the complete signal at Vc, and Vout for two periods. include the DC offsets. Carefully label your axes.
4. What is the AC swing before distortion occurs for this circuit?
5. Show how you would add an Emitter Follower (EF) circuit connected between Vc and RL=15K to reduce the loading effects of RL. Use an emitter resistor on the (EF) circuit of 10K.
6. Calculate the voltage gain of the circuit now, after you have added the Emitter Follower circuit.

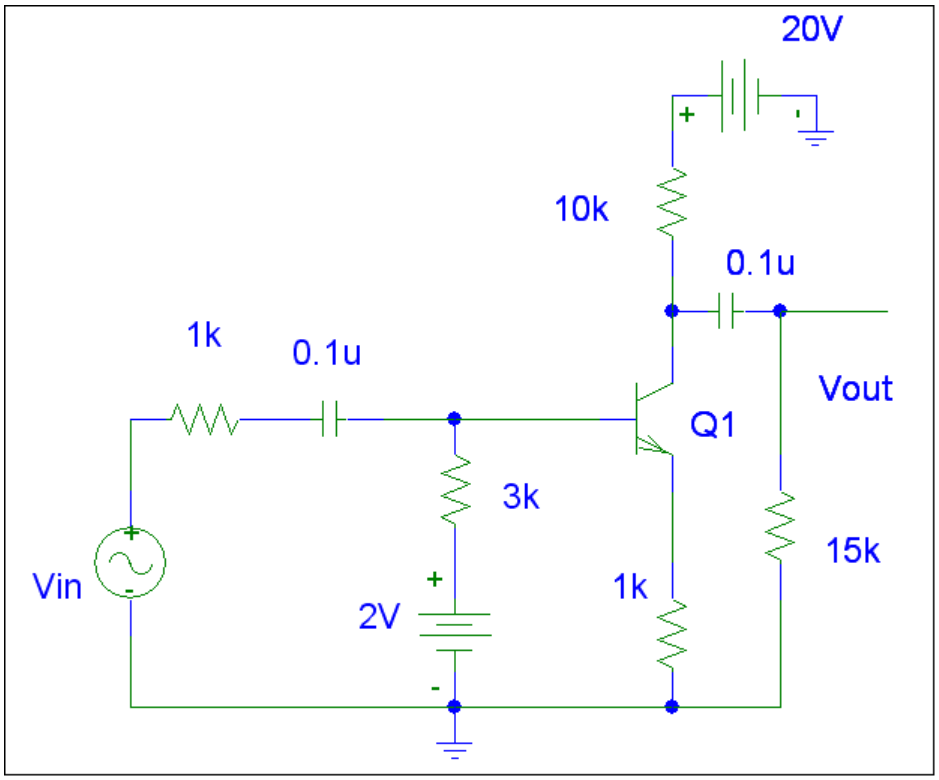


Figure 1

Part II (30pts.). Frequency Response of Common Emitter Amplifier in Figure 2. Include the effects of gm and β. Take the values of the intrinsic capacitors Cu and Cpi to both be 0.01pF. Take Vbe = 0.7 for DC bias.

1. Determine the small signal AC voltage gain of this circuit at midband frequencies.
2. Use the short circuit time constant approximation to determine the low frequency pole of this circuit.
3. Use the Miller's theorem to determine the high frequency pole of this circuit.
4. Sketch the voltage gain of this circuit as a function of frequency using a Bode plot. Indicate the poles found above, and give the slope of the lines in the sketch. Please label your plots carefully. (Y-axis: Voltage Gain in dB; X-axis: log of radial frequency (ω))
5. Describe in words why the frequency versus gain graph looks the way it does. In other words, describe what is happening as the frequency increases from very low to midband to very high frequencies. Relate your answer to the frequency limitations of the BJT.

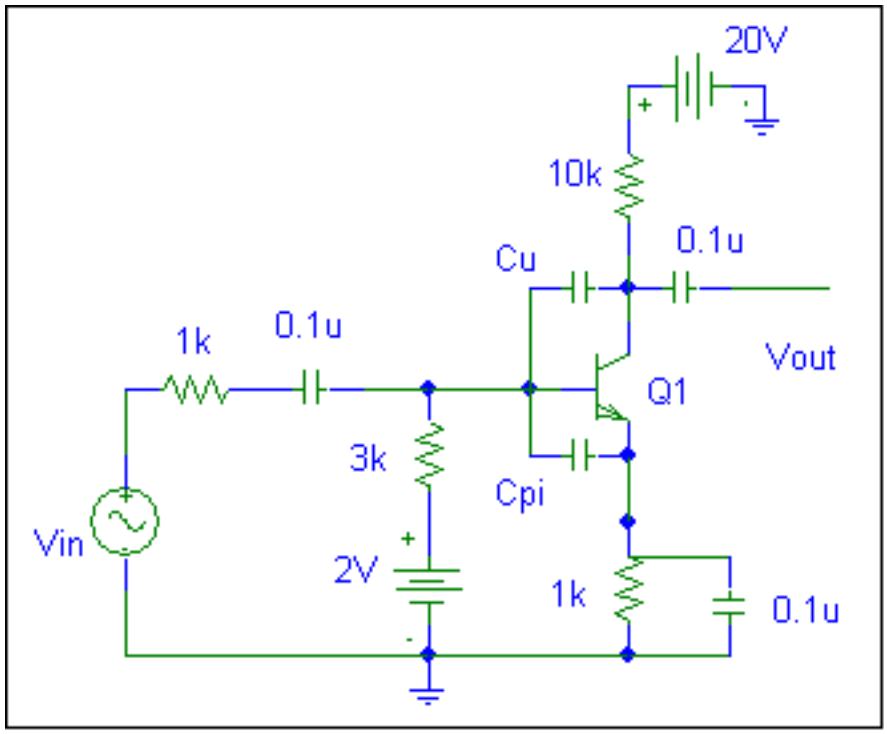


Figure 2

III. Difference Amplifier with Current Mirror DC Current Source in Figure 3. (Don't worry about frequency effects.) Include the effects of gm. Take Vbe = 0.7 for DC bias.

1. Q3 and Q4 make up a BJT current mirror, which acts as a current source for the difference amplifier composed of Q1 and Q2. Show that the value of Iee = 2.0mA. If you can not show this, don't worry about it, just use this value of Iee as the DC current source for rest of the problem.

   (Note, the BJT current mirror works just like the MOSFET current mirror, except here Vbe3 = Vbe4, so the collector currents in Q3 and Q4 are the same. Also, since Vbe =0.7, the analysis to find Iee is easier than it would be for a MOSFET which requires finding Vgs.)

2. Determine the DC values of Vc1 and Vc2.
3. If Vin1 = A $\sin(2\pi 10^5 t)$ and Vin2 = 0, which output is the inverting output, and which output is non-inverting. (Vo1 & Vo2).
4. What is the AC gain of this circuit for the output taken from Vo1? How about if output is Vo2?

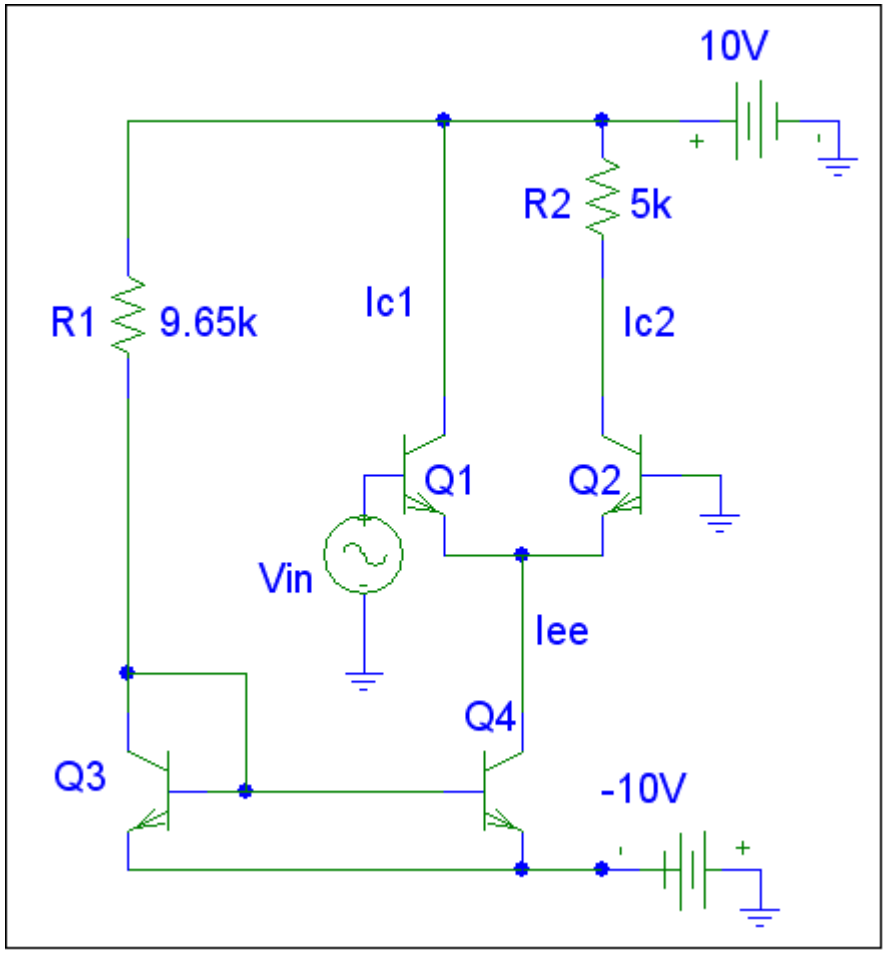


Figure 3

Part IV (25pts.) Analysis of NMOSFET Common Source Amplifier in Figure 4. Include the effects of gm. The MOSFET has the following parameters: K=2.0 x 10^{-4} A/V^2, W=5microns, L =1micron, and V_T = 1.0V. Assume the AC input signal is Vin(t) = 0.3 sin(2π 10^4 t).

1. Find the DC voltages: Vg, Vd and Vs, and find DC currents Ig, Is and Id.
2. Determine the AC voltage gain of the circuit.
3. Sketch the signal at Vd(t) and Vo(t), both the AC and DC components.
4. Add a load resistor RL = 15K to the output. What is the AC gain of the circuit now?
5. Is this MOSFET operating in the saturation or triode region, why? (Triode is also called the linear region.)

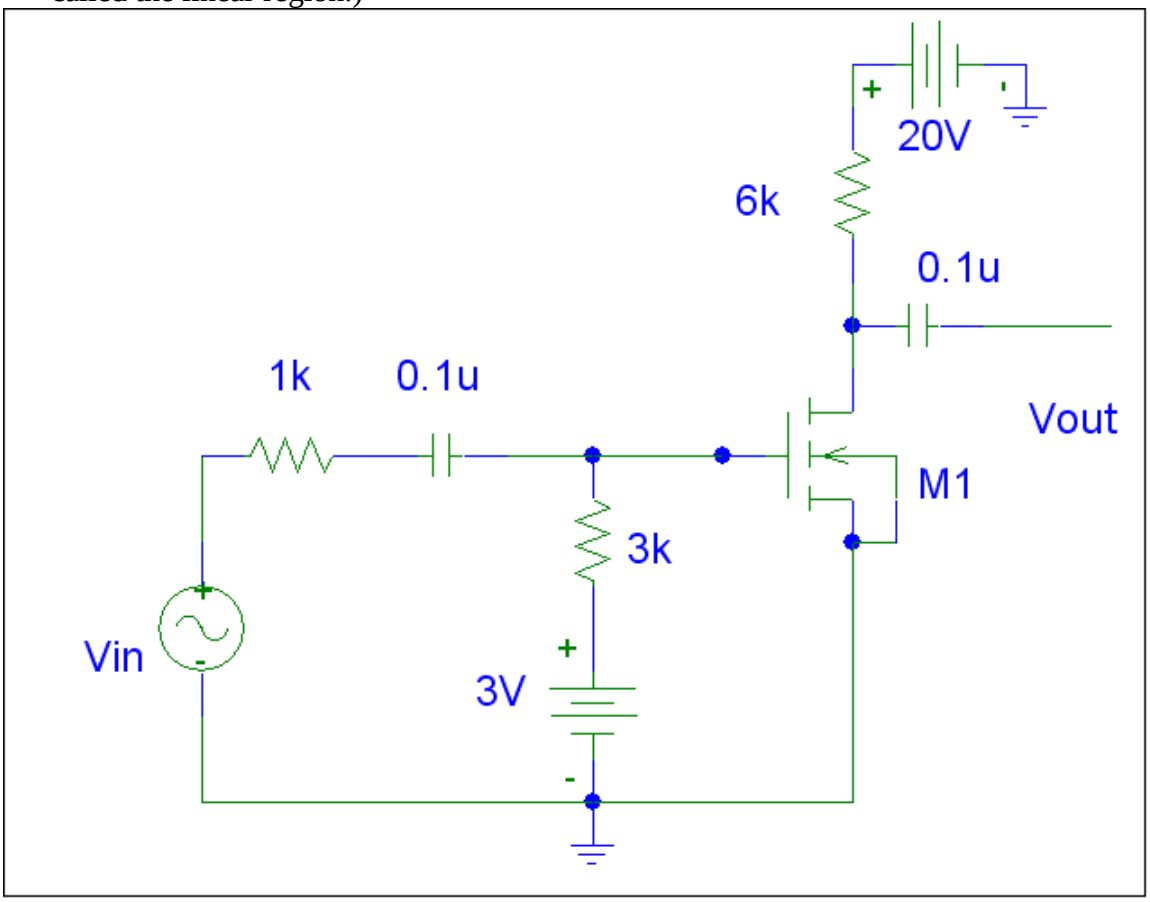


Figure 4