ECE 255 Spring 2019

Homework 4

Due 5:00 PM **Monday**, Feb. 4 in Dropbox

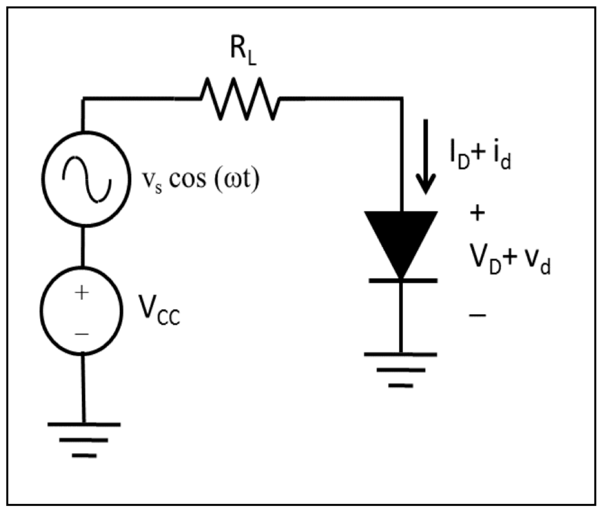
1) Consider the circuit shown below with R_L = 2 kΩ, V_{CC} = 3V, and $v_s << V_{CC}$. In forward bias, the diode can be approximated by V_D = 0.7V. Assume T = 300 K so that $V_T = 0.026$ V.

   a) First, consider the DC operating point. Find the value of the diode current, I_D.

   b) Next, consider the ac small-signal model. What is the value of r_d at this operating point?

   c) What is the magnitude of the small-signal diode current, i_d, in terms of v_s?

   d) What is the magnitude of the small-signal voltage across the diode, v_d, in terms of v_s?



2) Consider an **NPN** transistor with the voltages below applied. Identify the region of operation for each case (Active, saturation, or cut-off).

Case	Emitter	Base	Collector	Region
1	0	+0.7	+1.0	
2	0	+0.7	+0.1	
3	-0.8	0	+3.0	
4	-0.7	0	-0.5	
5	+1.5	+2.2	+3.0	
6	+1.0	0	+3.0	

HW 4 (continued)

3) Consider a **PNP** transistor with the voltages below applied. Identify the region of operation for each case (Active, saturation, or cut-off).

Case	**Emitter**	**Base**	**Collector**	**Region**
1	0	-0.7	-1.0	
2	0	-0.7	-0.2	
3	+0.7	0	-3.0	
4	+0.7	0	+0.5	
5	+1.5	+0.8	-2.0	
6	-1.0	0	-3.0	

4) Consider an NPN transistor in the active region with $V_{BE} = 0.78$ V at $I_C = 6$ mA. Answer the following questions. Assume $T = 300$ K so that $V_T = 0.026$ V.

a) What is the current at $V_{BE} = 0.72$ V?

b) What is V_{BE} at $I_C = 6\ \mu$A?

5) For an NPN transistor in the active region, we measure $I_C = 0.7$ mA and $I_B = 20\ \mu$A. Answer the following questions.

5a) What is β?

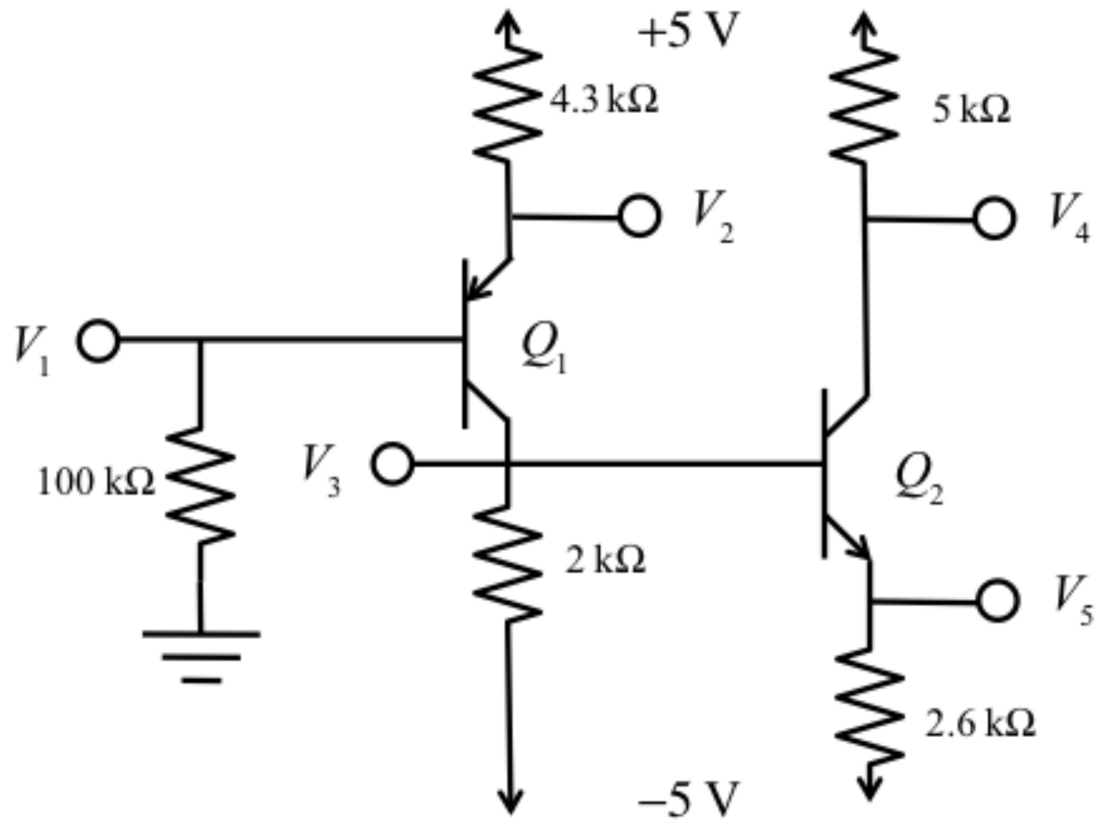
5b) What is α?

5c) What is I_E?

6) For the circuit below, you may also assume that $V_{BE} = 0.7$ V and that all transistors operate in the active mode. The voltages, $V_1 - V_5$, on this figure are voltage probes – places that we want to determine the voltage – they are NOT voltage sources. Answer the following questions:

5a) Assume that $\beta \to \infty$ (i.e. ignore base currents) and compute the five voltages labeled in the figure. Also, verify that the two transistors are biased in the active mode.

5b) Assume that $\beta = 50$, and compute the five voltages labeled in the figure.



7) Consider the npn BJT circuit shown below, with an ideal current source providing I_B.

For parts a)-c), use R_C = 12 kΩ and assume that the BJT operates in forward active mode.

a) What is the value of I_C?

b) What is the value of V_{CE}?

c) What is the value of V_{BC}?

d) In this part only, assume that R_C can be varied. What is the maximum value for R_C such that the transistor remains in forward active mode, i.e. that the B-C junction remains reverse biased?