EECS 105 – Microelectronic Devices and Circuits

Spring 2001, **Prof. A. R. Neureuther**
Dept. EECS, **510 Cory 642-4590**
UC Berkeley **Office Hours M11, (Tu2), W2, Th2, F11**
Course Web Site http://www-inst.EECS.Berkeley.EDU/~ee105/

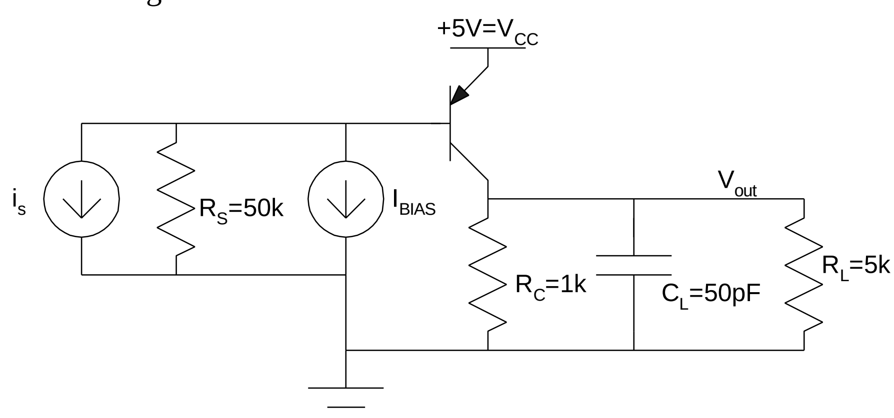
Homework Assignment # 9, Due *Wednesday* March 21, 2001

The second mid-term exam will be on Friday March 23 from 10:10-11am.
Please try to show up early so we can start on time and give you the full 50 minutes.

Use the following parameters for all BJT devices.

NPN	PNP
ß=100	ß=50
V_{CE-SAT}=0.1V	V_{EC-SAT}=0.1V
V_{BE}=0.7V	V_{EB}=0.7V
V_A=20V	V_A=25V
W_B=1µm	W_B=1µm
$N_{ED}=10^{19}/cm^3$	$N_{EA}=10^{19}/cm^3$
$N_{BA}=5x10^{17}/cm^3$	$N_{BD}=5x10^{17}/cm^3$
$N_{CD}=10^{16}/cm^3$	$N_{CA}=10^{16}/cm^3$
Area=10µm x 10µm	Area=10µm x 10µm

8.1) **Common Collector Amplifier (Using the bipolar models in circuits).**
Consider the following circuit:

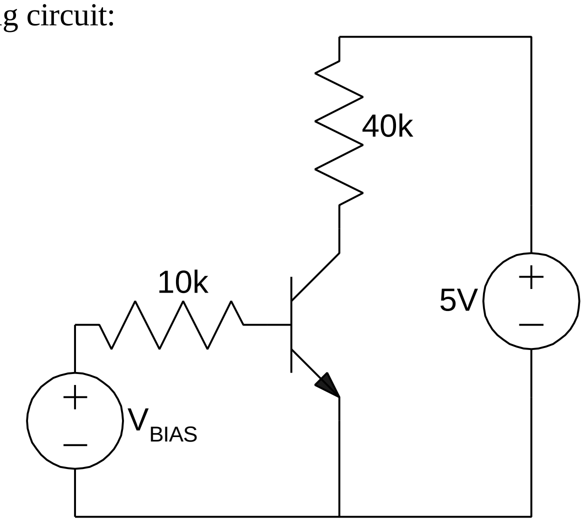


a) If V_{OUT}=2.5V, what region is the BJT operating in?
b) Solve for the large signal current exiting the collector, I_C.
c) Determine I_{BIAS} such that V_{OUT}=2.5V.
d) Draw the small signal version of the circuit and find values for all components. For the transistor small signal model only include C_p, r_p, r_0 and the dependent source. Let $n_i^2=10^{20}/cm^3$.
e) Symbolically solve for the overall small signal voltage gain of the circuit, v_{out}/v_{in} as a function of ? . You can leave your answer in terms of the small signal components. You will want to do a Norton to Thevenin transformation on i_s and R_s to get v_{in}.

f) Draw the approximate (straight lines only) magnitude Bode plot of voltage gain for this circuit. Use radian/sec for the horizontal axis, not Hertz. Label all important values.
g) Draw the approximate (straight lines only) phase Bode plot of voltage gain for this circuit. Use radian/sec for the horizontal axis, not Hertz. Label all important values.

8.2) **Base Doping (Review of basic physics through examining assumptions)**
In this class we are making the assumption that V_{BE}=0.7V for an NPN BJT that has a positive current going from collector to emitter. This is good enough to get a first order feel for what the circuits are doing, however you should understand this is far from exact. For an NPN BJT with $N_{ED}=10^{19}/cm^3$, W_B=1um and a cross sectional area of 10um by 10um:
a) Determine the doping in the base such that V_{BE}=0.7V and current exiting the emitter is 1mA. Since the doping of the emitter is high, you only need to consider the current from electrons. Let $n_i^2=10^{20}/cm^3$.
b) Repeat for 100uA.
c) Repeat for 10uA.

8.3) **Regions of Operation (Review of basic circuits)**
Consider the following circuit:



Find V_{BIAS} such that the transistor is at the transition point between saturation and forward active.