Microelectronic Devices and Circuits- EECS105
Second Midterm Exam

Wednesday, April 16, 2003

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Your Name: ____
(last) *(first)*

Your Signature: ____

1. Print and sign your name on this page before you start.
2. You are allowed two, 8.5"x11" handwritten sheet. No books or notes!
3. A correct expression is worth 70% of the credit. The calculation gets you the rest.
4. You have until 4/25/03 to bring any grading issues to Prof. Spanos' attention.

Problem 1	________	*/ 48*
Problem 2	________	*/ 16*
Problem 3	________	*/ 16*
Problem 4	________	*/ 20*
TOTAL	________	*/ 100*

MOS Device Data[1] (you may not have to use all of these...)

$\mu_n C_{ox} = 50\mu A/V^2$, $\mu_p C_{ox} = 25\mu A/V^2$, $V_{Tn} = -V_{Tp} = 1V$, Lmin = 2μm. $V_{BS} = 0$.
$\lambda_n = \lambda_p = 0.1V^{-1}$ when L = 1μm, and it is otherwise proportional to 1/L
$C_{ox} = 2.3fF/\mu m^2$, $C_{jn} = 0.1fF/\mu m^2$, $C_{jp} = 0.3fF/\mu m^2$, $C_{jswn} = 0.5fF/\mu m$,
$C_{jswp} = 0.35fF/\mu m$, $C_{ovn} = 0.5fF/\mu m$, $C_{ovp} = 0.5fF/\mu m$

BJT Device Data[1] (you may not have to use all of these...)

$\beta_f = \beta_o = 100$, $I_S = 10^{-17}A$, $V_{CE\,SAT} = 0.1V$, $V_A = 25V$, $\tau_F = 50ps$, $C_{je} = 15fF@V_{BE} = 0.7V$,
$C\mu = 10fF@V_{BC} = -2.0V$

[1] Except as indicated on the particular problem…

Problem 1 of 4: Answer each question briefly and clearly. (6 pts each, 48 total)

1.1 What are the *typical* values of R_{in}, R_{out} for a decent CC voltage buffer?

Rin	5-10 Ω	100-1000 Ω	10-20 kΩ	100-300 kΩ	1-10 MΩ
Rout	5-10 Ω	100-1000 Ω	10-20 kΩ	100-300 kΩ	1-10 MΩ

1.2 Why is it important to make the base of a BJT as short as possible? (choose one)

- ❑ So that the transistor occupies less space
- ❑ So that there are no ohmic losses in the base
- ❑ So that almost all injected minority carriers make it across
- ❑ So that holes and electrons stay uniformly distributed

1.3 What happens when the base of a BJT is very short? (choose one)

- ❑ The transonductance drops in value
- ❑ The beta drops in value
- ❑ The r_o drops in value
- ❑ The Early voltage gets delayed

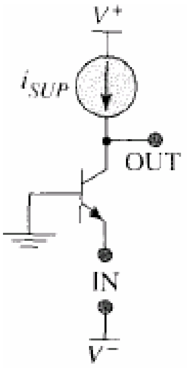
Provide a brief explanation of the mechanism responsible for the above:

1.4 What happens when the channel of a MOSFET is very long? (choose one)

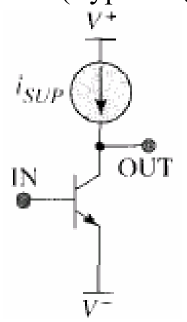
- ❑ The transconductance increases
- ❑ Velocity saturation kicks in
- ❑ The transistor gets too hot
- ❑ The r_o increases in value

Provide a brief explanation of the mechanism responsible for the above:

1.5 Why it is important to have a current supply with a huge (i.e. tens of MOhms) internal resistance when you design a current buffer utilizing a Common Base BJT? (Typical r_o for a BJT is 100kOhms)



1.6 Why it is NOT so important to have a current supply with an internal resistance greater than ~1MOhm when you are designing a Common Emitter amplifier? (Typical r_o for a BJT is 100kOhms)

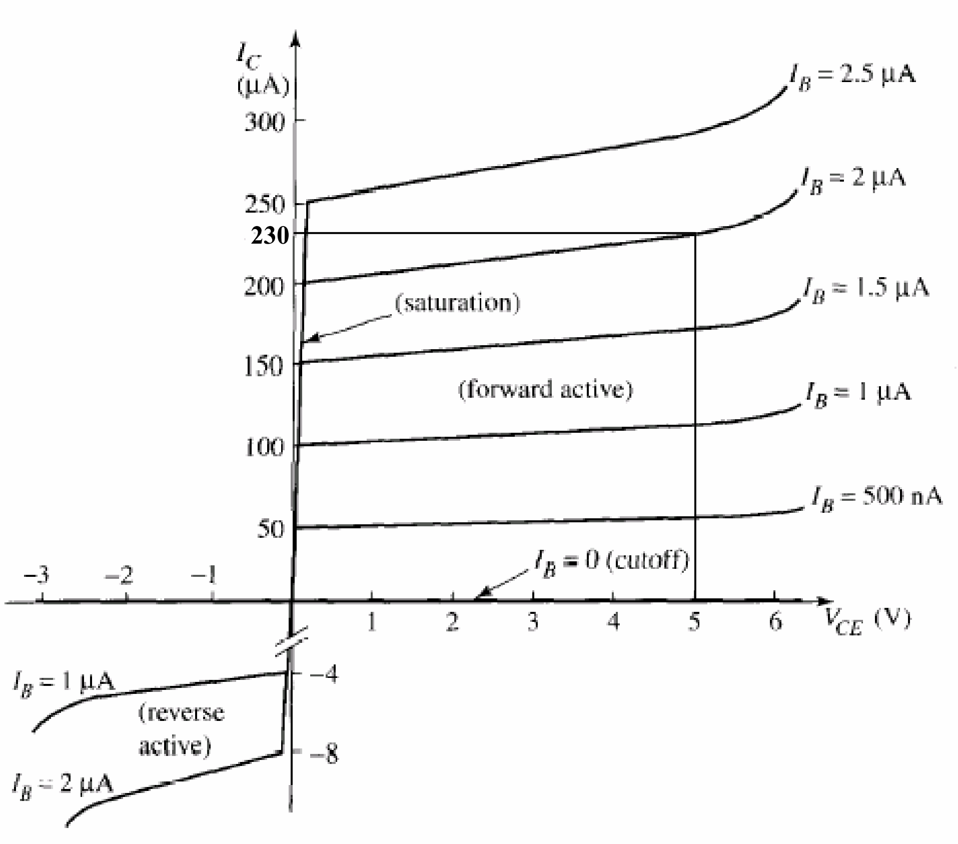


1.7 Draw the small signal model of the forward biased diode. Name all distinct capacitive components.

1.8 Provide a brief definition of the transition frequency ω_t of the BJT transistor.

Problem 2 of 4: Answer each question briefly and clearly. (16 points)

From the graph below, please estimate β_F and β_R, as well as r_o. Also, estimate g_m r_π and $V_{CESAT\ min}$ when $I_B = 2\mu A$ at room temperature ($V_{th} = 0.025mV$. Do NOT use the default BJT values on the front page of this exam for this question. *Hint: in reverse active mode the role of the collector and emitter are reversed*. Mark the graph to clarify your method as needed.)

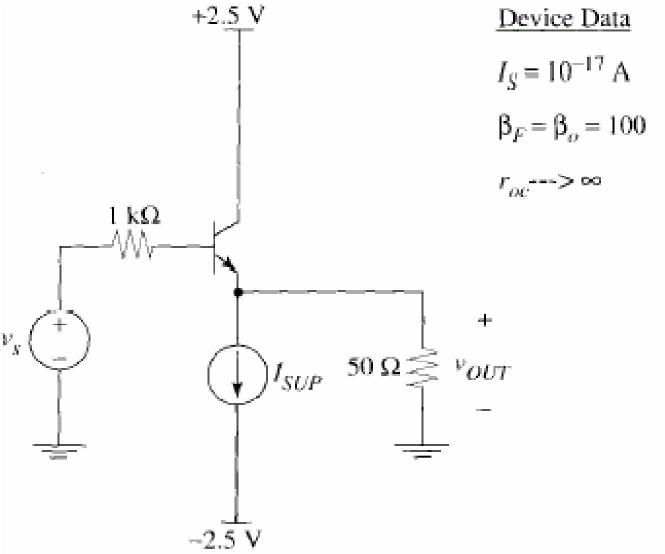


	expression	value & units
β_F =		
β_R =		
r_o =		

Assuming $I_B = 2\mu A$:

g_m =	
r_π =	
$V_{CE\ SATmin}$ =	

Problem 3 of 4: Answer each question briefly and clearly. (16 points)



You are given the above Common Collector amplifier, with an ideal current supply source, and with values as shown above. Please do the following:

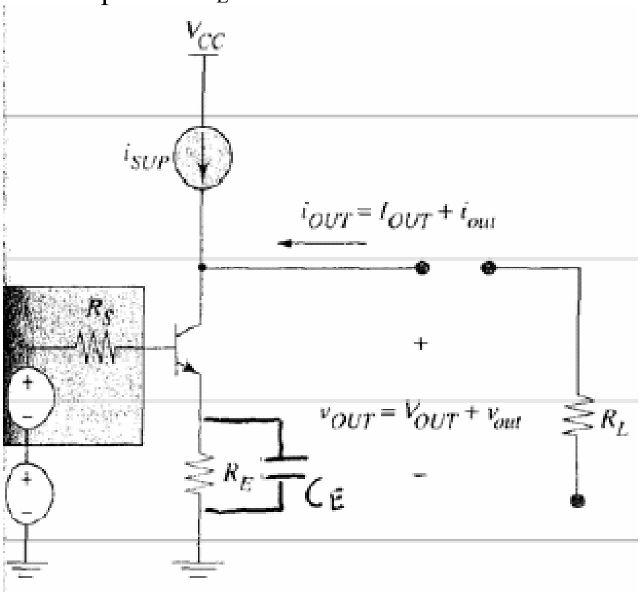
3.1 Calculate the output voltage swing, assuming that the I_{SUP} needs a minimum of 0.5Volts across it in order to operate properly, and $V_{CE\,SATmin}$ is 0.1V.

Expression	Value
v_{OUTmax} =	
v_{OUTmin} =	

3.2 Draw the equivalent small signal circuit of the common collector amplifier shown on the preceding page.

Problem 4 of 4: Answer each question briefly and clearly. (20 points)

You are given a common emitter amplifier with R_E (degeneration emitter resistor), and an extra capacitor C_E connected across that resistor.



Recall that without the capacitance C_E, the formulae for this amplifier are:

G_m	R_{in}	R_{out}
$\dfrac{g_m}{(1+g_m R_E)}$	$r_\pi(1+g_m R_E)$	$r_o[1+g_m R_E] \parallel r_{oc}$

4.1 Write expressions for R_{in}, R_{out} and G_m as a function of ω when C_E is present (neglect all the transistor small signal capacitances).

expression

G_m =
R_{in} =
R_{out} =

4.2 Given the following values: R_E = 10kOhms, g_m =0.9mS, and C_E = 100nF, write the expression $G_m(\omega)$, restate it to show its pole(s) and zero(es) and plot it on a Bode Plot, whose vertical axis is in units of $20\log_{10}(|Gm|/mS)$. (These units are actually db-mS with reference of 1mS, i.e. a value of 1mS will show as 0db, 10mS will show as 20db, etc.)

Expression	Value
$G_m(\omega)$ =	
G_m when ω very low =	
G_m when ω very high =