American University of Beirut

Department of Electrical and Computer Engineering

EECE 310 Electronics — Final Exam - Closed Book

3 hours (180 minutes) — Jan. 24, 2012

ALL QUESTIONS ARE GRADED EQUALLY

PENALTY IS 5 TO 1

NAME ________________________ ID number ________________ signature here

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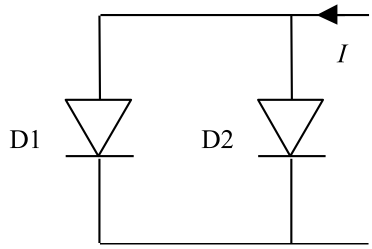
❖ Unless otherwise specified, assume that:

- V_T = 25 mV
- $|V_{BE(ACTIVE)}|$ = 0.7 V
- $|V_{BE(SAT)}|$ = 0.7 V
- $|V_{CE(SAT)}|$ = 0.2 V
- $|V_{CE(EDGE\ OF\ SAT)}|$ = 0.3 V
- All capacitors are very large
- Body effect, base-width modulation, and channel-length modulation are negligible

1. In the circuit shown below, diode D1 has $I_{s1} = 10^{-16}$ A and $n_1 = 1$ while diode D2 has $I_{s2} = 10^{-15}$ A and $n_2 = 1$. The total current is $I = 7.48$ mA. Calculate the forward current (in mA) in diode D1.

a) 0.68 b) 0.62 c) 0.54 d) 0.58 e) 0.50



2. In the previous problem, compute the small-signal resistance r_d (in Ω) of diode D2.

a) 4.03 b) 3.68 c) 4.31 d) 5.00 e) 4.63

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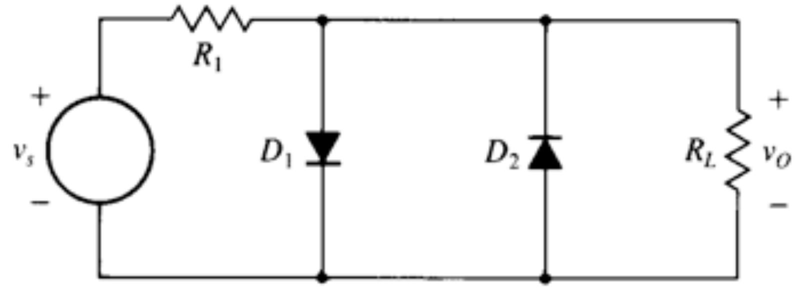
3. In the circuit shown below $R_1 = R_L = 180$ Ω. The two diodes D_1 and D_2 are modeled by $V_{D0} = 0.6$ V, $r_D = 10$ Ω, when conducting, and by an open circuit when OFF. Find the value of the source voltage v_s (in V) if the output voltage v_O is –0.70 V.

a) –4.0 b) –4.8 c) –2.4 d) –3.2 e) –1.6



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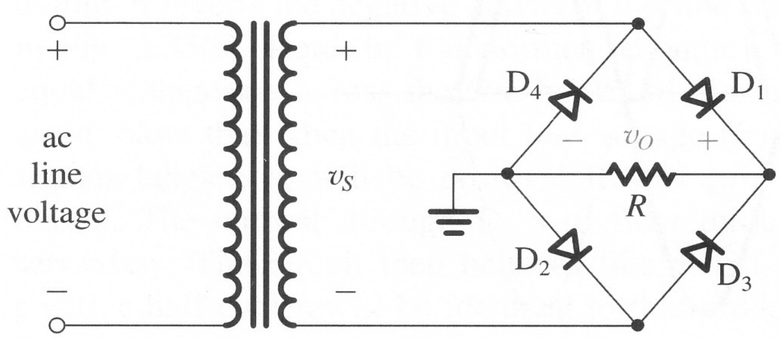
4. In the bridge rectifier shown below, the RMS value of the sinusoidal voltage v_S is 20 V. The diodes are modeled by a short circuit when conducting and by an open circuit when OFF. If the average *diode* current is 1.3 mA, compute the resistance R (in kΩ).

a) 6.9 b) 6.4 c) 9.0 d) 8.2 e) 7.5



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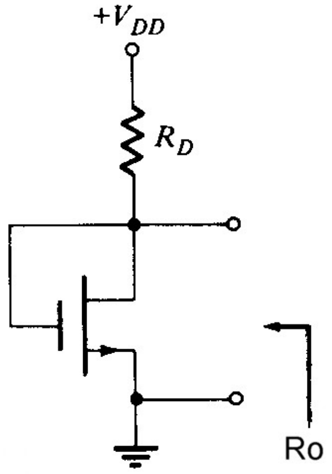
5. The NMOS transistor shown below has $V_t = 1$V and $V_A = 50$ V. It is biased to give $V_{GS} = 5$ V and $I_D = 0.5$ mA when $R_D = 20$ kΩ. Find the small-signal output resistance R_o (in Ω).

a) 943.7 b) 1787.5 c) 2547.2 d) 3235.3 e) 3862.1



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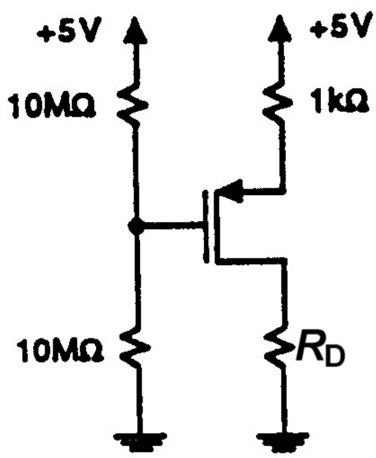
6. The PMOS transistor shown below has $V_t = -1$V and $k_p' W/L = 1\,\text{mA/V}^2$. If the power dissipated in R_D is 0.5 mW, find R_D (in kΩ).

a) 3 b) 4 c) 6 d) 5 e) 2



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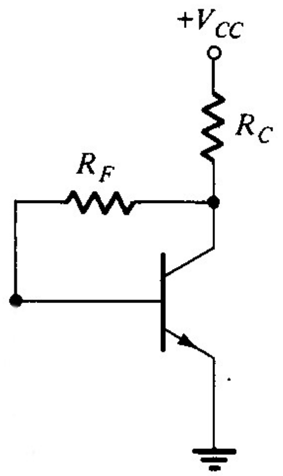
7. A BJT for which the Early voltage is $V_A = 48$ V operates at $V_{CE} = 2$ V and at a collector current of 100 μA. Find the value of V_{CE} (in V) at which the collector current becomes 115 μA. Assume that V_{BE} is positive and remains constant.

a) 14.5 b) 9.5 c) 12 d) 4.5 e) 7

The circuit shown below is used to establish V_{CE} = 3 V with V_{CC} = 10 V and R_C = 5 kΩ. The BJT used has β = 27.



8. Determine I_C (in mA).

a) 0.771 b) 1.54 c) 1.35 d) 1.16 e) 0.964

9. Determine R_F (in kΩ).

a) 120.4 b) 185.5 c) 46 d) 77 e) 22.8

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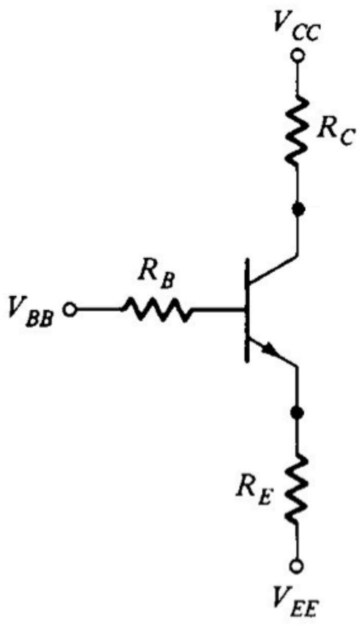
10. The circuit shown below has R_C = 0.5 kΩ, R_E = 1.0 kΩ, V_{CC} = 14 V, V_{EE} = –15 V, and V_{BB} = 12 V. Determine the value of R_B (in kΩ) so that the transistor *saturates* with β_{forced} = 10.

a) 4.1 b) 4.7 c) 3.1 d) 2.7 e) 3.6



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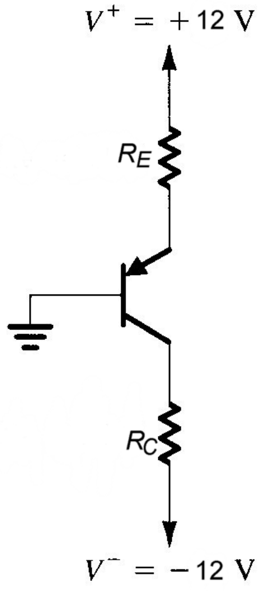
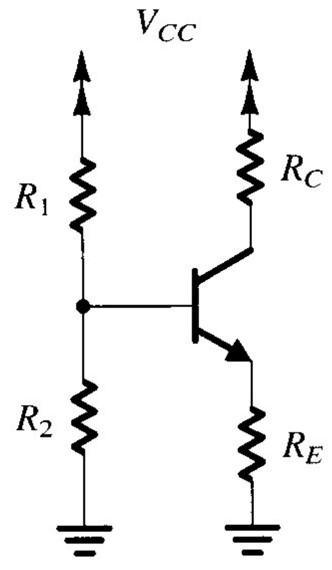
11. The circuit shown below uses a PNP transistor having $\beta = 79$. The largest value to which R_C can be raised while the transistor remains in the active mode, but at the edge of saturation, is 3 kΩ. Find R_E (in kΩ). Assume $V_{EC(Edge\ of\ Sat)} = 0.3$ V.

a) 5.4 b) 4.5 c) 1.8 d) 3.6 e) 2.7



The circuit shown below uses a transistor having $\beta = 99$. Assume $R_C = 2$ kΩ, $R_E = 2$ kΩ, and $V_{CC} = 16$ V.



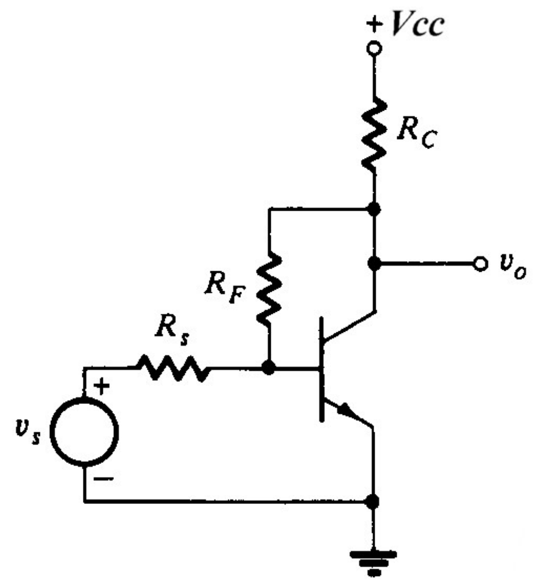
12. Determine V_{CE} (in V) if $R_1 = 80$ kΩ and $R_2 = 20$ kΩ.

a) 2.2 b) 6.8 c) 4.5 d) 11.4 e) 9.1

13. Determine the ratio I_C / I_B if $R_1 = 20$ kΩ and $R_2 = 80$ kΩ.

a) 2.9 b) 2.3 c) 15.5 d) 6.3 e) 4.0

In the circuit shown below, the transistor has $\beta = 50$. It is biased in the active region such that the BJT transconductance $g_m = 50$ mA/V. The resistors used are $R_S = 1$ kΩ, $R_C = 3$ kΩ, and $R_F = 20$ kΩ.



14. Determine the base current I_B (in μA).

a) 45 b) 25 c) 30 d) 35 e) 40

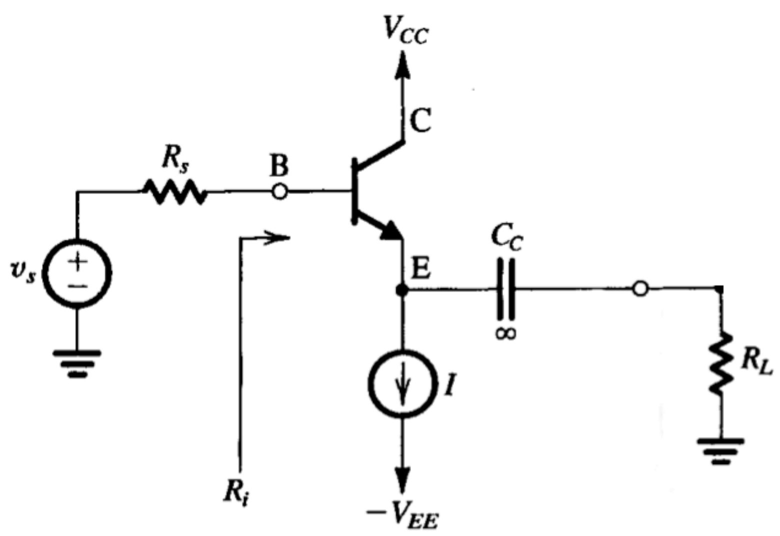
15. Determine the BJT small-signal resistance r_e (in Ω) that appears in the T model.

a) 14.0 b) 16.3 c) 19.6 d) 10.9 e) 12.2

16. Determine the small-signal voltage gain v_o/v_s (in V/V).

a) –6.7 b) –8.2 c) –5.6 d) –15.2 e) –10.7

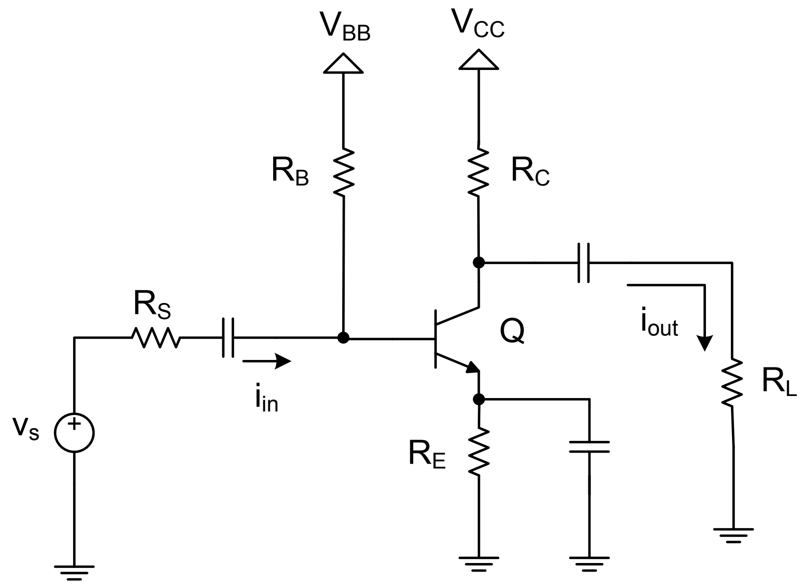
The circuit shown below has $I = 1$ mA. The transistor is in the active region and has $\beta = 60$.



17. Determine the BJT small-signal resistance r_π (in kΩ).
a) 3 b) 2 c) 1 d) 2.5 e) 1.5

18. The amplifier small-signal input resistance R_i is 200 kΩ. Find the value of R_L (in kΩ).
a) 4.85 b) 3.25 c) 2.44 d) 1.95 e) 1.63

In the circuit shown below, the BJT has $\beta = 80$ and $V_A = 15$ V. The BJT is biased at $V_{CE} = 5$ V, and $I_C = 1$ mA. Assume that $R_C = 4.7$ kΩ, and that R_B is 10 kΩ. V_{BB} and V_{CC} are pure DC sources.



19. A 26 mV peak voltage at the signal source v_s results in a 5 mV peak signal at v_{be}. Find the value of R_S (in kΩ).
a) 8 b) 9 c) 5 d) 6 e) 7

20. The small-signal voltage gain (v_{ce}/v_{be}) is –100 V/V. Find the value of R_L (in kΩ).
a) 4.9 b) 7.3 c) 21.3 d) 10.7 e) 5.8

21. Find the small-signal output current i_{out} (in terms of v_{be}) when the load R_L is equal to 20 kΩ. $i_{out} / v_{be} =$
a) $-0.14g_m$ b) $-0.12g_m$ c) $-0.20g_m$ d) $-0.16g_m$ e) $-0.18g_m$

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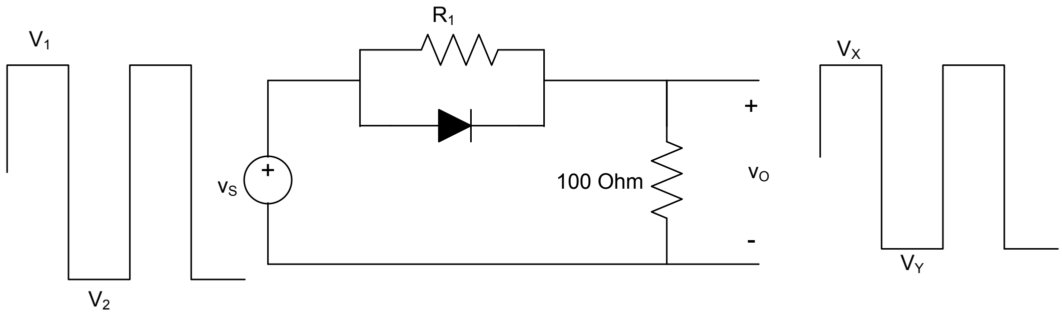
22. In the circuit shown below, the diode is ideal. The source voltage v_S is a square wave with a maximum value of V_1, and a minimum value $V_2 = -10$ V. The resulting output is a square wave with a maximum value of V_X and a minimum value of V_Y. Find the value of V_1 (in V) if the value of the voltage level V_X at the output is 7 V and $R_1 = 100$ Ω.
a) 10 b) 8 c) 9 d) 7 e) 6



23. In the previous problem, find the value of the resistor R_1 (in Ω), if the value of the voltage level V_Y at the output is –3.33 V.

a) 100 b) 400 c) 150 d) 300 e) 200

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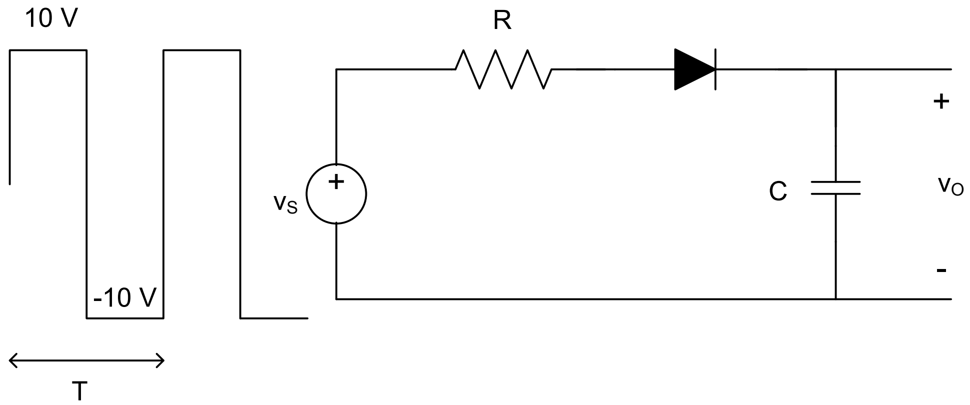
24. In the circuit shown below, the diode is ideal, and the source voltage is a periodic square wave with levels –10 V (minimum) and 10 V (maximum). The period of the square wave is $T = 10$ ms, while the time constant is $\tau = RC = 4$ ms. Assuming that the capacitor is uncharged initially at $t = 0$, find the output voltage v_o (in V) at time instant $t = 7$ ms.

Hint: The resistor-capacitor transient equation is $V_{final} + (V_{initial} - V_{final})\exp(-t/\tau)$.

a) 7.1 b) 6.3 c) 5.1 d) 5.6 e) 8.1



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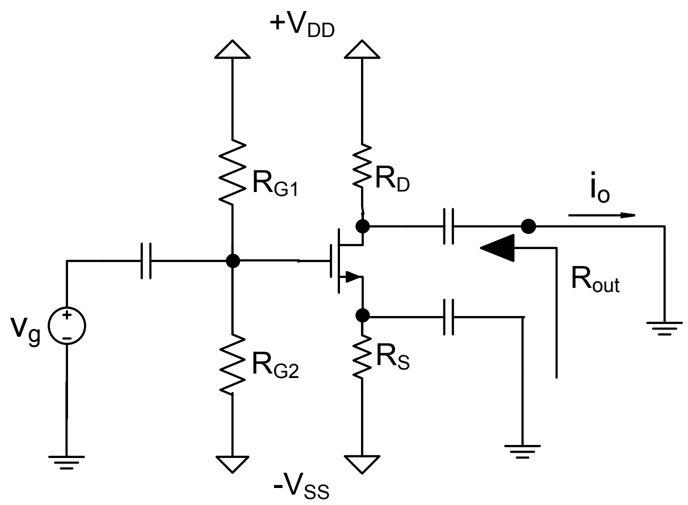
25. The noise margins in a MOS inverter are equal to 1.5 V. Find the value of V_{IH} (in V) if the output high voltage V_{OH} is 3.1 V.

a) 1.6 b) 1.7 c) 2.0 d) 1.8 e) 1.9

In the circuit shown below, the MOSFET is characterized by $k'_n(W/L) = 1$ mA/V^2 and $V_t = 1$ V. We want to design for $I_D = 1.2$ mA and $V_{DS} = 4$ V. Assume $V_{DD} = V_{SS} = 5$ V, $R_D = 4.3$ kΩ, and $R_{G2} = 18$ MΩ.



26. The required value of R_S (in Ω) is
a) 300 b) 122.2 c) 435.5 d) 700 e) 229.4

27. The resulting value of V_{GS} (in V) is
a) 2.84 b) 3.00 c) 3.32 d) 3.49 e) 2.55

28. Find the total power dissipated in the DC power supplies, in mW.
a) 12 b) 17 c) 20 d) 27 e) 31

29. If $v_g = 0.01 \cos(\omega t)$ V, then what is the expression of i_o (in μA)
a) $-24.9 \cos(\omega t)$ b) $-15.5 \cos(\omega t)$ c) $-18.4 \cos(\omega t)$
d) $-20.0 \cos(\omega t)$ e) $-23.2 \cos(\omega t)$

30. Consider now the effect of channel length modulation by assuming $V_A = 16$ V. What is the value of the output resistance R_{out} (in kΩ)?
a) 1.2 b) 1.6 c) 3.4 d) 2.6 e) 2.1
