MACHAKOS UNIVERSITY

University Examinations for 2023/2024 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION TECHNOLOGY)

EEE 308: ANALOGUE ELECTRONICS I

DATE: **TIME:**

INSTRUCTIONS

Answer question **ONE** and **ANY OTHER TWO** questions

QUESTION ONE (COMPULSORY) [30 MARKS]

(a) Figure 2 represents a portion of battery-charger circuit for a battery with a voltage V_B. The sine-wave input V_S = 12V(rms), while the battery voltage varies from 12V to 14V from the discharged to fully charged states. The charging source resistance Rs = 10Ω. Assuming that D is an ideal diode, and Rc = 50Ω is a current-controlling resistor established by the designer:

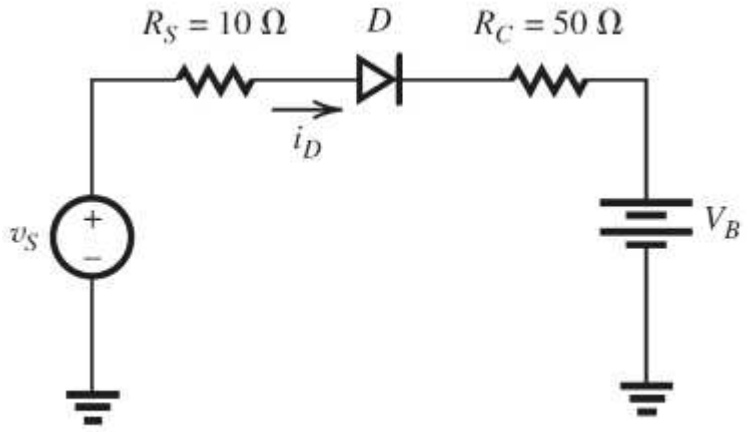

FIGURE 2. Battery-charger circuit

(i) Sketch and label the voltage wave forms of the voltage across the diode and the current through the diode for V_B =12V.

(5 marks)

(ii) What is the peak diode current?

(5 marks)

(b) For the common-emitter circuit in Figure 4

(i) Calculate the base current, collector current, emitter currents, the V_{CE} voltage and the transistor power dissipation. Assume $\beta = 200$ and $V_{BE}(on) = 0.7V$

(5 marks)

(ii) What is the mode of operation for the BJT in figure 4? Briefly explain your answer.

(5 marks)

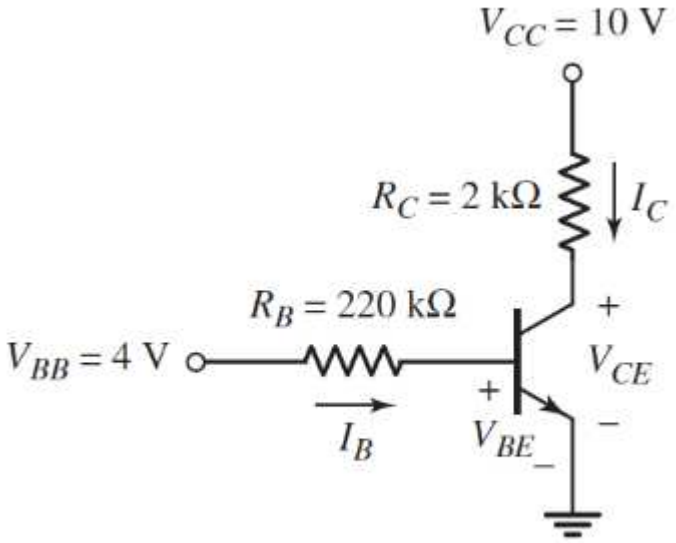

FIGURE 4. Common-emitter BJT circuit

(c) For the NMOS transistor in Figure 3, determine the values of R_D and R_S so that the transistor operates at i_D= 0.4mA and V_D = +0.5V. The NMOS transistor has V_t= 0.7V, $\mu_n Cox$ = 100μA/V^2, L = 1μm, and W = 32μm. Neglect the channel-length modulation effect (i.e,λ =0).

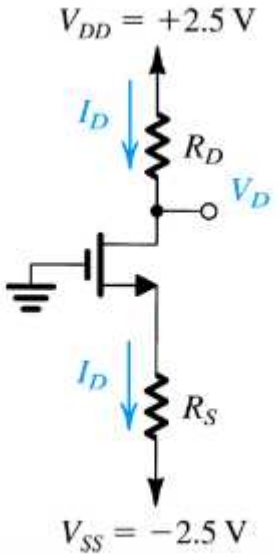

FIGURE 3. NMOS transistor

(6 marks)

(d) For the network of Fig 2.188, determine the range of V_1 that will maintain V_L at 8 V and not exceed the maximum power rating of the Zener diode.

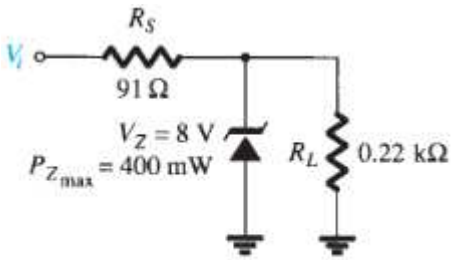

FIG. 2.188
Problems 44 and 52.

(4 marks)

QUESTION TWO (20 MARKS)

(a) The 6.8.V zener diode in the circuit of Fig. 4.19(a) is specified to have V_Z=6.8V AT I_Z =5mA, r_Z = 20Ω, and I_{ZK}= 0.2 mA. The supply voltage V+ is nominally 10 V but can vary by ±1 V.

(i) Find V_o with no load and with V^+ and its nominal value.

(ii) Find the change in Vo resulting from the ±1-V change in V^+. Note that ($\Delta V_o/\Delta V^+$), usually expressed in mV/V, is known line regulation.

(iii) Find the change in Vo resulting from connecting a load resistance RL that draws a current I_L = 1 mA, and hence find the load regulation ($\Delta V_O/\Delta I_L$) in mV/mA

(iv) Find the change in V_O when R_L = 2kΩ (10 marks)

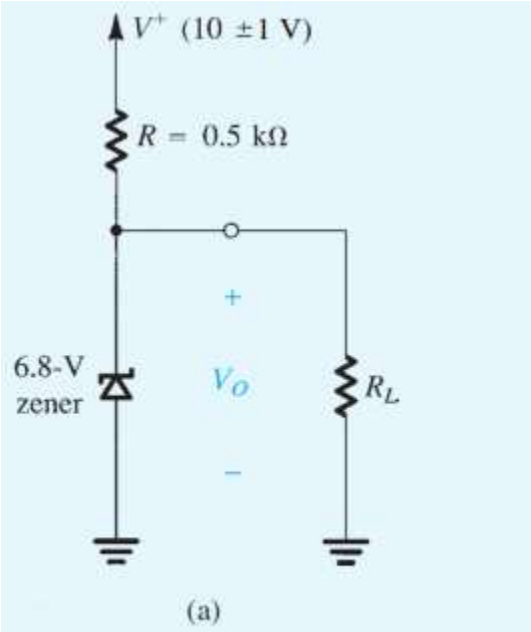

Figure 4.19 **(a)** Circuit for Example 4.7.

(10 marks)

(b) A full-wave bridge rectifier with a 120-V rms sinusoidal input has a load resistor of 1 kΩ

(i) If silicon diodes are employed, what is the dc voltage available at the load?

(ii) Determine the required PIV rating of each diode.

(iii) Find the maximum current through each diode during conduction.

(iv) What is the required power rating of each diode?

(10 marks)

QUESTION THREE (20 MARKS)

(a) An NMOS Transistor is fabricated in a 0.13 µm CMOS process (i.e., L_{min}=0.13µm) with L = 1.5 L_{min}, W = 1.3 µm. The process technology is specified to have an oxide layer t_{ox}= 2.7 nm, µn = 400 cm^2 V-1 s and V_{tn}= 0.4V

i. Find the oxide capacitance, Cox, the process trans-conductance, k'$_n$ and the MOSFET transconductance parameter, Kn. The permittivity of the silicon dioxide, $\varepsilon_{ox} = 3.45 \times 10^{-11}$F. m^{-1}

ii. Find the overdrive voltage Vov and the minimum value of V_{DS} required to operate the transistor in saturation at a current $I_D = 100\mu A$. What gate-to-source voltage is required?

(12 marks)

(b) An npn transistor having $I_S = 10^{-15}A$ and $\beta = 100$ is connected as follows: The emitter is grounded, the base is fed with a constant-current source supplying a dc current of 10 μA, and the collector is connected to a 5-V dc supply via a resistance R_C of 3 kΩ. Assuming that the transistor is operating in the active mode, find V_{BE} and $V_{CE.}$ Use these values to verify active-mode operation. Replace the current source with a resistance connected from the base to the 5-V dc supply. What resistance value is needed to result in the same operating conditions? (8 marks)

QUESTION FOUR (20 MARKS)

(a) Consider a process technology for which L_{min} =0.4 μm, t_{ox} =8nm, μ_n =450 $cm^2/V.s$, and V_t = 0.7 V.

(i) Find C_{ox} and k'_n.

(ii) For a MOSFET with W/L = 8 μm/0.8 μm, calculate the values of $V_{OV,}$ V_{GS} and V_{DSmin} needed to operate the transistor in the saturation region with a dc current I_D = 100 μA.

(iii) For the device in (b), find the values of V_{OV} and V_{GS} required to cause the device to operate as a 1000-Ω resistor for very small v_{DS}. (10 marks)

(b) For the circuit in fig 6.21, it is required to determine the value of the voltage V_{BB} that result in the transistor operating

(i) In the active mode with V_{CE} = 5 V

(ii) at the edge of saturation

(iii)deep in saturation with β_{forced} = 10

For simplicity, assume that V_{BE} remains constant at 0.7 V. The transistor β is specified to be 50.

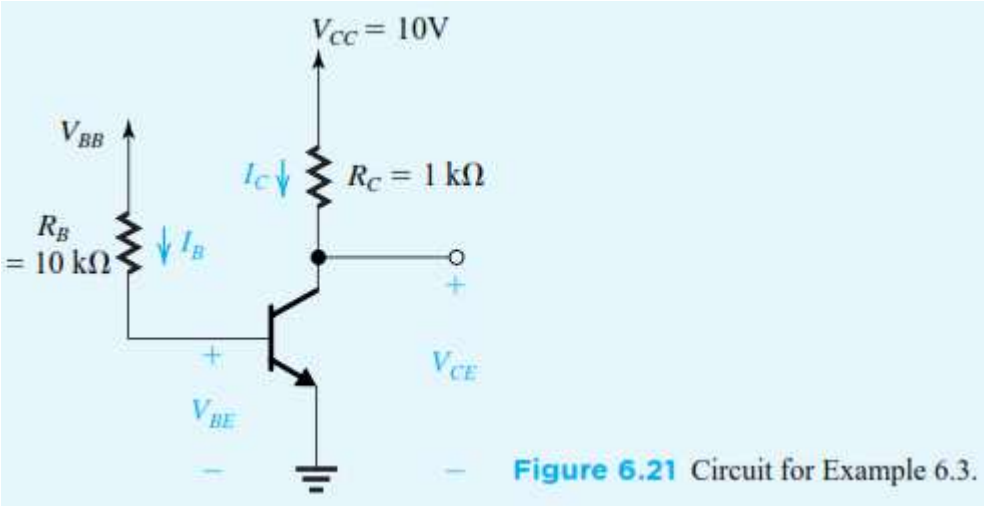

Figure 6.21 Circuit for Example 6.3.

(10 marks)

QUESTION FIVE (20 MARKS)

(a) The NMOS transistor in the circuit in Figure 5 has $V_{tn} = 0.5V$, $k'_n = 400\ \mu A\ V^{-2,}$ W/L=10 and $\lambda = 0$

(i) Find the transistors operating mode when $V_D = +0.5V$;

(2 marks)

(ii) Find the required values of R_S and R_D to obtain $i_D = 180\ \mu A$ and $V_D = +0.5V$. Also, find the voltage V_S that results;

(4 marks)

(iii) What is the largest value to which R_D can be increased while the transistor remains in the saturation mode?

(4 marks)

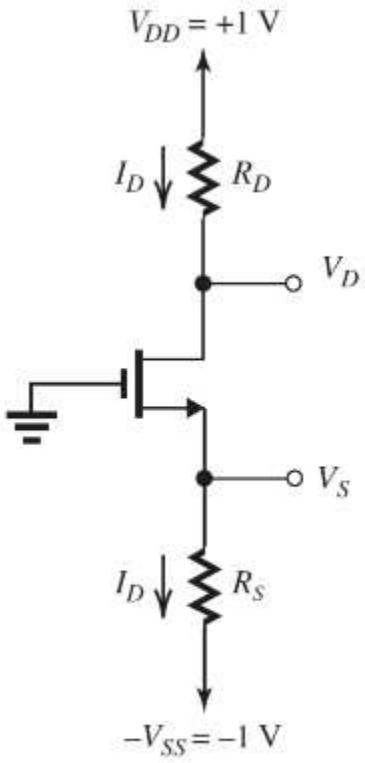

FIGURE 5

(b) The BJT figure 6 has $\beta = 100$, $V_{CESat} = 0.3$ V_B (on) = 0.7 V. Find V_E, V_C and I_B and the transistors mode of operation:

(i) When $V_B = 0$V;

(3 marks)

(ii) When $V_B = 3$V;

(3 marks)

(iii) When $V_B = 5$V

(4 marks)

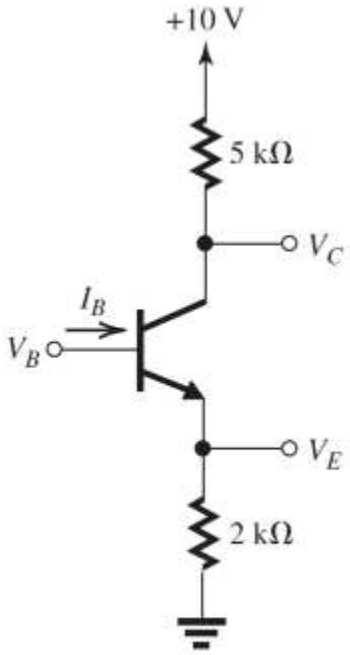

FIGURE 6

(10 marks)

END