# EGERTON UNIVERSITY

## UNIVERSITY EXAMINATIONS
**NJORO CAMPUS**

**SECOND SEMESTER 2010/2011**

**SECOND YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN INSTRUMENTATION AND CONTROL ENGINEERING**

**ICEN 221: ELECTRONIC DEVICES**

**STREAM:** Y2S1 BSC ICEN **TIME:** 2 HRS

**DAY:** FRIDAY: 12.00 – 2.00 PM **DATE:** 9/12/2011

**INSTRUCTIONS:**

1. You should have the following for the examination.
   - Answer Book
   - Scientific calculator
2. This paper consists of SIX Questions
3. Attempt any 4 questions
4. All questions carry equal marks.

**Question One**

a) Skecth and explain the energy band diagrams for conductors, insulators, and semiconductors.

(3mrks)

b) Define

(i) n-type material

(ii) p-type material

(iii) minority charge carriers

(iv) majority charge carriers

(v) positive temperature coefficient. Give an example

(vi) negative temperature coefficient. Give an example

(3mrks)

c) Skecth a pn-junction showing the depletion region. Briefly explain how this region is formed.

(2mrks)

d) Explain the origin of the barrier voltage at a pn-junction. Discuss the effect of the barrier voltage on minority and majority charge carriers.

(2mrks)

e) Define for a pn-junction diode

i. Static or d.c resistance ($R_D$)

ii. Dynamic a.c resistance (rd)

iii. Average a.c resistance ($r_{av}$)

Use appropriate graphs to illustrate your answer.

(6mrks)

f) Discuss the effect of temperature change on forward and reverse biased pn-junctions. Which semiconductor material is more sensitive to temperature change between Silicon (Si) or Germanium (Ge). Explain.

(4mrks)

**Question Two**

a) A diode with a 700mW maximum power dissipation at 25°C has a 5mW/°C derating factor. If the forward voltage drop remains constant at 0.7V, calculate the maximum forward current at 25 °C and at 65 °C temperatures.

(2mrks)

b) Define the terms for a pn-junction diode

(i) Peak reverse voltage ($V_{BR}$ or $V_{RRM}$)

(ii) Steady-state forward current ($I_o$ or $I_{F(av)}$)

(iii) Repetitive peak surge current ($I_{FRM}$)

(iv) Static forward voltage drop ($V_F$)

(v) Power dissipation

(6mrks)

c) Explain the following for a pn-junction diode

(i) Transition capacitance ($C_T$)

(ii) Diffusion capacitance ($C_D$)

(iii) Reverse recovery time ($t_{rr}$)

(6mrks)

d) Draw the symbol, with appropriate polarities, and equivalent circuit for each of the following cases. Give equivalent circuits for both d.c and a.c conditions.

i. Reverse-biased diode

ii. Forward-biased diode (all models)

(6mrks)

**Question Three**

a) The network in figure 3(a) has a +5V input and is to produce a 4.5 minimum output when the load current is 2mA. Determine a suitable resistance for $R_1$, and specify the diode forward current and reverse voltage . What kind of clipper is this ?

(2mrks)

b) Determine the upper and lower levels of the output voltage for the circuits shown in figure 3(b) when the input voltage is +/- 6V. A also calculate the capacitor voltage in each case.

(6mrks)

c) Explain the operation of the circuit in Figure 3(c). What kind of application is this circuit useful for?.

(5mrks)

d) For the AND gate circuit in figure 3(d) determine each diode forward current level.

i. When all 3 inputs are low
ii. When only input A is HIGH
iii. When input A and B are both HIGH and input C is LOW.

(2mrks)

e) Draw the circuit diagram of a center-tapped full-wave rectifier and briefly explain its operation.

(5mrks)

## Question Four

a) Draw the sketch to show the various current components in a transistor. Briefly explain the origin of each current. Write the equation relating $I_E$, $I_B$, and $I_C$. Assume amplifier operation conditions

(4mrks)

b) Define $\alpha_{DC}$ and $\beta_{DC}$ and state typical value for each. Also give the relationship between both.

(6mrks)

c) Sketch a circuit diagram to show how a transistor can be used for amplification of alternating signal voltages. Explain, clearly the amplification action. Consider a circuit with $R_C$=12KΩ, $V_{CC}$=20V, $V_{DC(INPUT)}$=0.7V, $V_{(a.c)}$= 20mV and a typical $I_B$~$V_{BE}$ characteristic as in figure 4(c). Calculate $I_C$, and the d.c voltage gain. Assume $\beta_{DC}$=50.

(10mrks)

## Question Five

a) For the circuits shown in figure 5(a), (b), (c)

i. Calculate the values of $V_{CE(mi)}$ and $V_{CE(max)}$, for $\beta_{DC(min)}=50$ and $\beta_{DC(max)}=200$. Draw the load-line and show the respective Q-pts.

(7mrks)

ii. Tabulate the values of $V_{CE(mi)}$ and $V_{CE(max)}$ obtained in (i) for the 3 different bias circuits. Draw the respective load-lines and show clearly the Q-point ranges (variations) along the load-lines i.e $Q_{(min)}$-pt for $\beta_{DC(min)}=50$ and $Q_{(max)}$-pt for $\beta_{DC(max)}=200$. Use these results to compare the 3 bias circuits. Explain clearly the PRACTICAL implications of your results.Which of these circuits is the preferred bias circuit practically.

(4 mrks)

iii. What is the advantage of circuit in figure 5(b) over the others.

(1mrks)

b) Discuss the thermal stability of a transistor bias circuit with regard to $I_{CBO}$ and $V_{BE}$. Give approximate variations of these parameters with temperature changes. Define the stability factor for a transistor.

(4mrks)

c) Show how a voltage divider bias circuit may be compensated for $V_{BE}$ changes with temperature. Draw an appropriate circuit and derive and equation for $I_C$.

(4mrks)

**Question Six**

a) With the help of JFET drain characteristics describe the 3 distinct regions of operation of an n-channel JFET. Draw an appropriate circuit to illustrate the ideas involved.

(9mrks)

b) Define and compare the terms pinch-off and cut-off voltage for an n-channel JFET.

(3mrks)

c) Describe the operation of a D-MOSFET and E-MOSFET. Include exemplary transfer characteristics.

(6mrks)

d) What are the major differences between a Bipolar Junction Transistor (BJT) and a Field Effect Transistor (FET). Name at least 2 of them.

(2mrks)

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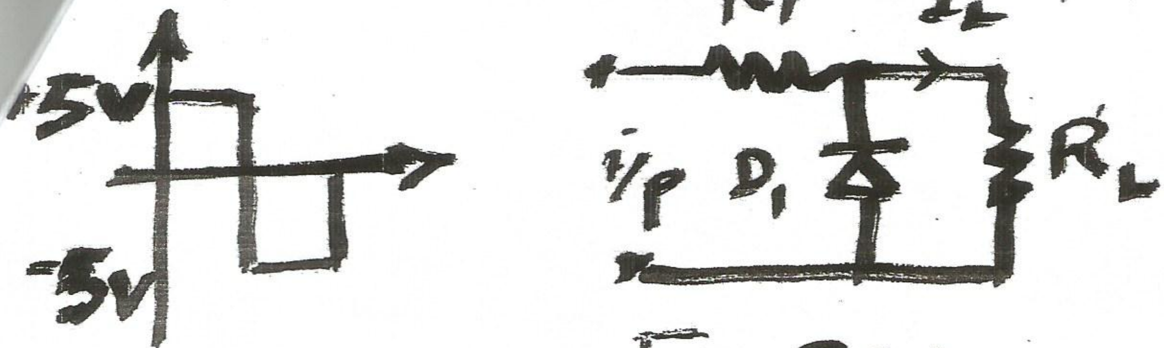
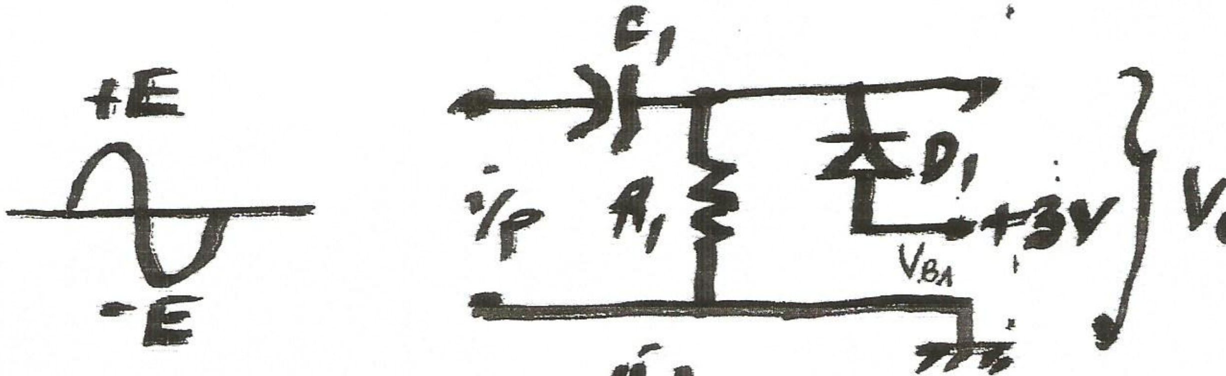
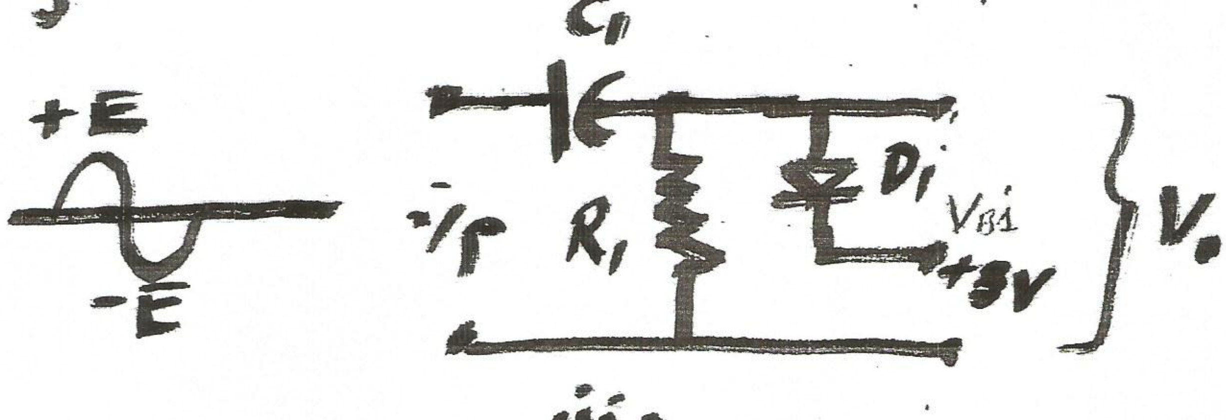



Fig-3(a)




(i)

Figure 3 (b)




(ii)