KABARAK UNIVERSITY

UNIVERSITY EXAMINATIONS

2010/2011 ACADEMIC YEAR

FOR THE DEGREE OF BACHELOR OF COMPUTER SCIENCE

COURSE CODE: PHYS 120

COURSE TITLE: BASIC ELECTRONICS

STREAM: Y1S2

DAY: TUESDAY

TIME: 9.00 – 11.00 A.M

DATE: 14/12/2010

INSTRUCTIONS:

- Answer question **ONE** and any **THREE** of the remaining
- Question **ONE** carries **28MARKS** and the remaining carry **14 MARKS** each.
- Symbols used bear usual meaning.

YOU MAY USE THE FOLLOWING CONSTANTS

Avogadro's number is $N = 6.025 \times 10^{23}$
Electronic charge $q = 1.6 \times 10^{-19} C$
Mass of an electron $m_e = 9.1 \times 10^{-31} Kg$
Boltzmann constant $k = 1.38 \times 10^{-23} J/K$

PLEASE TURNOVER

QUESTION ONE

a) Write a sentence to define each of the following terms;
   i. Intrinsic semiconductor
   ii. Dopant
   iii. Donor
   iv. Fermi level (4marks)

b) Find the mobility of electrons in copper assuming that each atom contributes one free electron for conduction. Resistivity of copper is $1.76 \times 10^{-16}. cm$ atomic mass of copper is 63.54 density is $8.96\ g/cm^3$, (4marks)

c) For a certain p-n junction, with contact potential $0.065V$, the junction capacitance is $4.5pF$ for $V_s = -10V$ and C_j is $6.5pF$ for $V_s = -2.0V$ find the constant m and zero-biased capacitance (4marks)

d) Bipolar junction transistors are commonly referred to as "minority carrier" device explain. (2marks)

e) An important parameter of every amplifier is gain. Explain what 'gain' is, and write a simple equation defining gain in terms of signal voltage. (2marks)

f) List and explain two doping profile junctions. (2marks)

g) Show that the ripple factor for half-wave rectification and full-wave rectification is $1.21\ and\ 0.48$ respectively (4marks)

h) Cutoff voltage is not the same thing as pinch-off voltage, although the names seem quite similar. Give a concise definition for each of these field-effect transistor parameters, referencing them to a graph of characteristic curves. (2marks)

i) A very important parameter of operational amplifier performance is slew rate. Describe what 'slew rate' is, and why it is important for us to consider in choosing an op-amp for a particular application. (2marks)

j) What is a decibel? (2marks)

QUESTION TWO

a) Explain the difference between depletion capacitance and diffusion capacitance in a P-N junction. (2marks)

b) Briefly discuss critical electric field in relation to the breakdown processes at a P-N junction. (2marks)

c) An abrupt silicon ($n_i = 10^{10} cm^{-3}$) p-n junction at $300K$ consists of a p-type region containing $10^{16} cm^{-3}$ acceptors and an n-type region containing $5.0 \times 10^{16} cm^{-3}$ donors.

i. Calculate the built-in potential of this p-n junction. (2marks)

ii. Calculate the total width of the depletion region if the applied voltage is $0.5V$ (4marks)

iii. Calculate maximum electric field in the depletion region in the n-type semiconductor at $0.5V$. (2marks)

iv. Calculate the depletion width in the n type region (2marks)

QUESTION THREE

a) What is quiescent point of a transistor? (2marks)

b) A bipolar transistor with an emitter current of $1mA$ has an emitter efficiency of 0.99, a base transport factor of 0.995 and a depletion layer recombination factor of 0.998. Calculate;

i. The transport factor

ii. The current gain of the transistor.

iii. The base current, the collector current. (3marks)

c) Determine the Q point of the transistor circuit shown in Fig.1 also draw the d.c load line. Given $\beta = 200 \; and \; V_{BE} = 0.7V, V_{BB} = 10V, R_B = 47k\Omega, R_C = 330\Omega \; and \; V_{CC} = 20V$

i. What is the operating point if $V_{CC} = 10V$?

ii. What will be the operating point if $R_C = 5k\Omega$? (6marks)

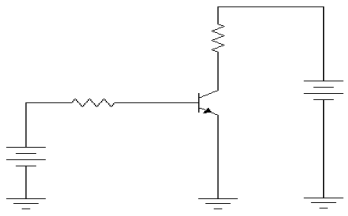

Fig. 1

d) Discuss the following regions of a bipolar junction transistor.

i. Cut off region

ii. Active region

iii. Saturation region. (3marks)

QUESTION FOUR

a) Briefly explain the overall operations of the junction field effect transistor. (2marks)

b) Determine the range of Q-point values for the circuit shown in Fig. 2

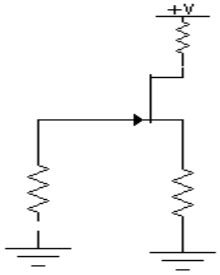

Fig. 2

Given that ;

$V_{DD} = 10V, R_D = 500\Omega, R_S = 500\Omega, R_G = 1M\Omega$

$V_{GS(off)} = -2.0V$ to $V_{GS(off)} = -8.0V$ and $I_{DSS} = 4.0mA$ to $I_{DSS} = 16.0mA$

(4marks)

c) What does the term transconductance mean, with reference to a field-effect transistor? Is the transconductance function for an FET a linear or a nonlinear relationship? Explain why, making reference to an equation if at all possible to explain your answer.

(3marks)

QUESTION FIVE

a) Define the following terms as used in oscillators;
   i. Positive feedback
   ii. Barkhausen criterion
   iii. Damping (3marks)

b) List the three requirements for proper oscillator operation. (3marks)

c) Calculate the operating frequency of the following oscillator circuit, if $C_2 and C_3 = 0.005\mu F$ and $L_1 = 80mH$:

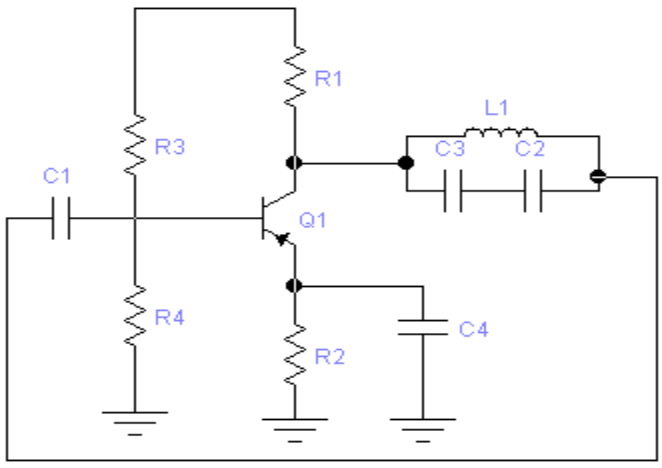

Fig. 4 (5marks)

d) Write short notes on MOSFET transistors. (3marks)

QUESTION SIX

a) State the difference between Inverting Amplifiers and Non-Inverting amplifiers. (4marks)

b) Perform the complete analysis of the Non-inverting amplifier shown in Fig. 3
Given the Op-amp parameters
$A_{CM} = 0.001, A_{OL} = 180000, Z_{in} = 1M\Omega, Z_{out} = 80\Omega(\max), slew\ rate = 0.5V/\mu s$
$R_{in} = 10K\Omega, R_f = 100K\Omega, R_L = 10K\Omega$, the voltage supply is $1V_{PP}$

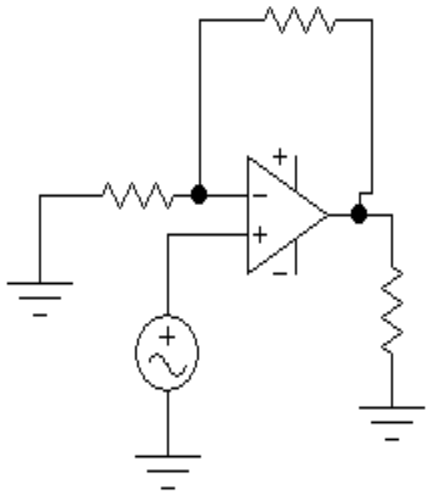

Fig. 3 (8marks)

c) Discuss the differences between class A and class B amplifiers. (4marks)