University of Ghana

Bachelor of Science in Engineering
Second Semester Examinations 2015/2016
Department of Computer Engineering
FAEN 108: Basic Electronics (3 Credits)
Time Allowed: 3 hours

INSTRUCTION: Attempt all questions in the answer booklet provided

1. (a) State Kirchhoffs voltage and current laws for linear electrical and electronic circuits.

[3 marks]

(b) Two batteries, A and B, are connected in parallel, and an 80Ω resistor is connected across the battery terminals. The e.m.f. and the internal resistance of battery A are $100V$ and 5Ω respectively, and the corresponding values for battery B are $95V$ and 3Ω respectively. Find

i. the value and direction of the current in each battery and

[4 marks]

ii. the terminal voltage.

[2 marks]

(c) With the aid of a suitable diagram, describe the essential features of a semiconductor diode and also sketch a graph showing the forward and reverse characteristics of a typical silicon diode.

[5 marks]

(d) Explain, with reference to a semiconductor material, what is meant by:

i. intrinsic conductivity;

[2 marks]

ii. extrinsic conductivity.

[2 marks]

2. (a) Sketch a circuit diagram showing how diodes may be connected to the secondary winding of a transformer in order to obtain unsmoothed full-wave rectification with four diodes

[6 marks]

(b) For the circuit drawn in 2 (a) above network above, sketch the waveform of the output voltage assuming a sinusoidal input voltage was presented.

[2 marks]

(c) Explain the importance of smoothing the output voltage in 2 (b) above before applying it to a transistor amplifier.

[2 marks]

(d) For the circuit shown below in figure 1, assume that the diode is ideal with linear forward resistance $R_F = 50k\Omega$ and the built-in potential $V_\phi = 0.7V$ and also given the following circuit parameters: $R_1 = 10k\Omega$, $R_2 = 20k\Omega$, $R_3 = 20k\Omega$, $R_4 = 20k\Omega$, $R_5 = 15k\Omega$ and Voltage $V_1 = 20V$.

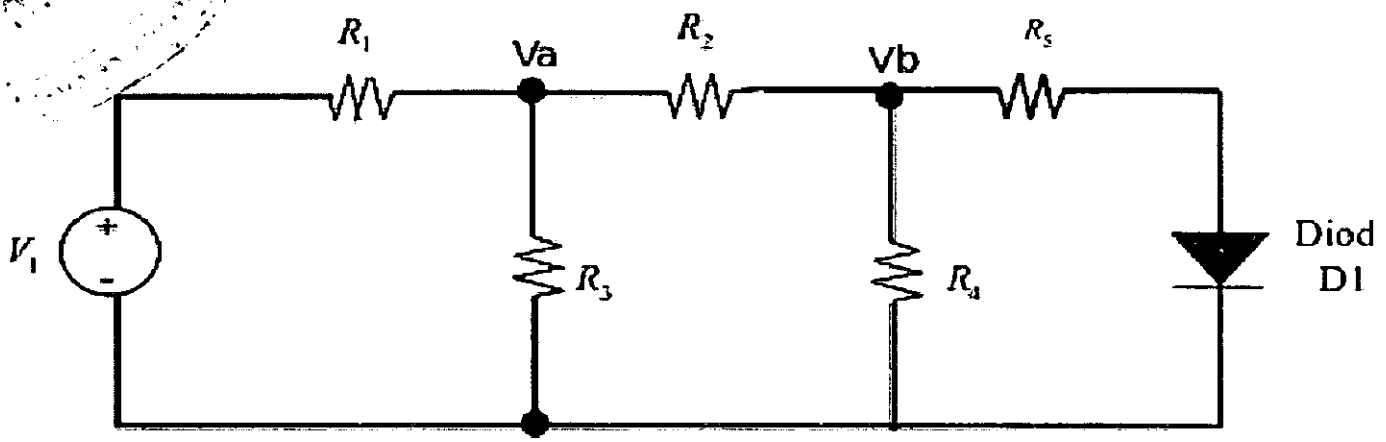

Figure 1: A simple diode circuit with resistors

i. Calculate the voltages at the nodes V_a and V_b and the corresponding currents in all branches of the circuit

[6 marks]

ii. Calculate the power dissipated in the resistor R_5

[2 marks]

iii. If the power rating of resistor R_5 is **5W**, would it be able to allow the current calculated to flow through it or not? Justify your answer.

[2 marks]

3. The common-emitter (CE) amplifier circuit shown below in figure 2 has $V_{CC} = 12V$, $R_1 = 90k\Omega, R_2 = 60k\Omega, R_E = 50k\Omega$ and $R_C = 40k\Omega$. The transistor has amplification gain $\beta = 120$ and early voltage $V_A = 100V$.

(a) Calculate the dc bias current I_E.

[5 marks]

(b) If the amplifier operates between a source for which $R_{sig} = 10k\Omega$ and a load, R_L of $2k\Omega$, determine the following:

i. Small signal equivalent diagram of the transistor circuit.

[2 marks]

ii. Calculate the values of r_π, r_o and indicate this on the small signal equivalent diagram.

[5 marks]

iii. Calculate the voltage gain v_o/v_{sig}

[8 marks]

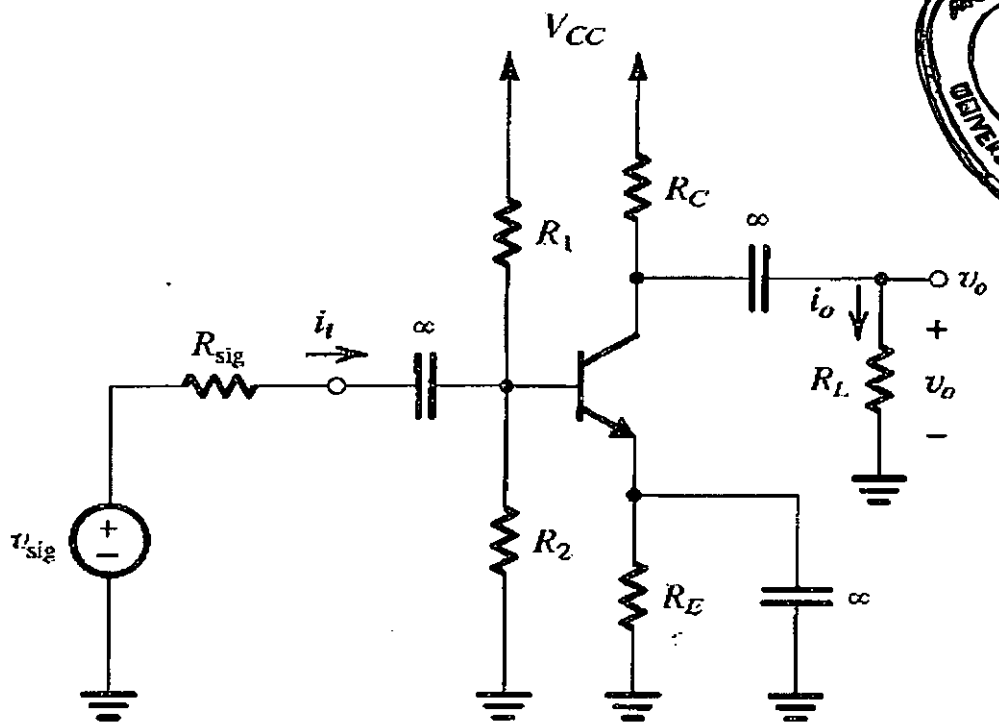

Figure 2: Common-emitter transistor circuit

4. (a) With the aid of a well-labelled diagram, describe in detail the operation of a **p-channel** MOSFET.

[6 marks]

(b) Mention the modes of operation of a **n-channel** MOSFET with their corresponding equations for the drain current.

[6 marks]

(c) Give three (3) reasons why CMOS technology is preferred to NMOS technology in modern electronic devices?

[3 marks]

(d) Analyze the circuit shown in figure 3 and determine V_G, V_D, V_S, I_G, I_S and I_D. Assume $V_t = 1V$ and $k'_n(W/L) = 1mA/V^2$. You may neglect the channel-length modulation effect(i.e. $\lambda = 0$)

[7 marks]

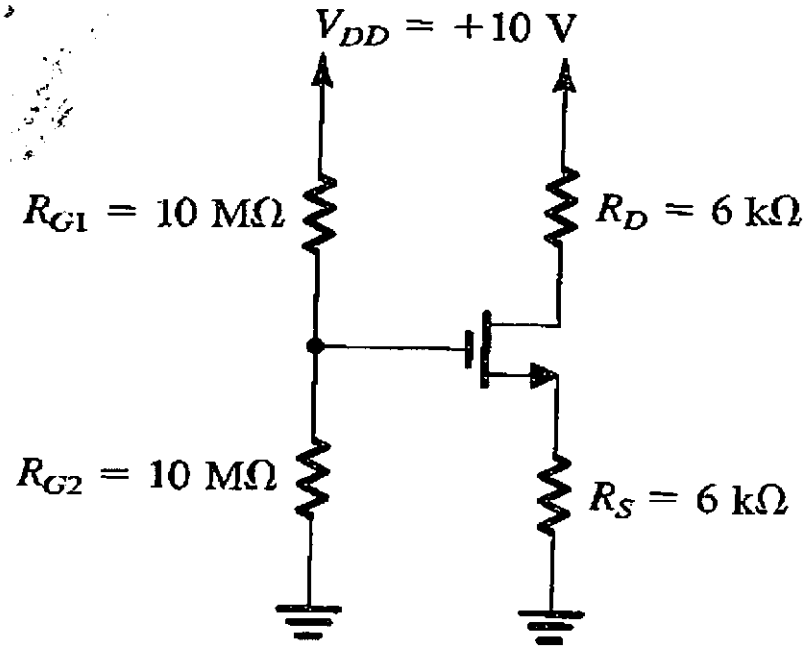

Figure 3: A MOSFET biasing Circuit

5. (a) Why are some logic gates referred to as universal gates? Mention one universal gate and provide its truth table for three (3) inputs (A, B, C).

[6 marks]

(b) The output of a combinational logic circuit for a home security system gives an output of $1(HIGH)$ only when any one of the following patterns is present at its three inputs (A, B, C)

$$\mathbf{f(A, B, C) : \sum(001, 101, 010, 011, 110)}$$

i. Draw the truth table of the output function $F(A, B, C)$.

[4 marks]

ii. Obtain the minimal Boolean expression. (i.e. simplify the resulting output function using Boolean algebra).

[5 marks]

iii. Develop a logic circuit to generate the output signal $F(A, B, C)$ after minimizing using Boolean algebra.

[5 marks]

(c) Write down the Boolean expression for the logic gate circuits shown in figures 4 and 5 below and use Boolean algebra and De-Morgan's laws to simplify the expressions.

[10 marks]

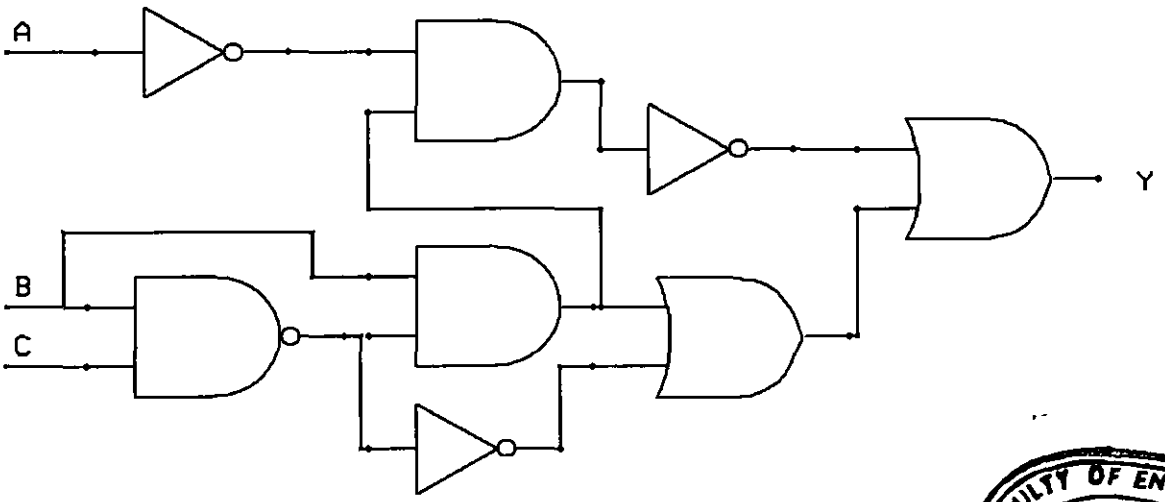

Figure 4: Logic Gate Circuit 1

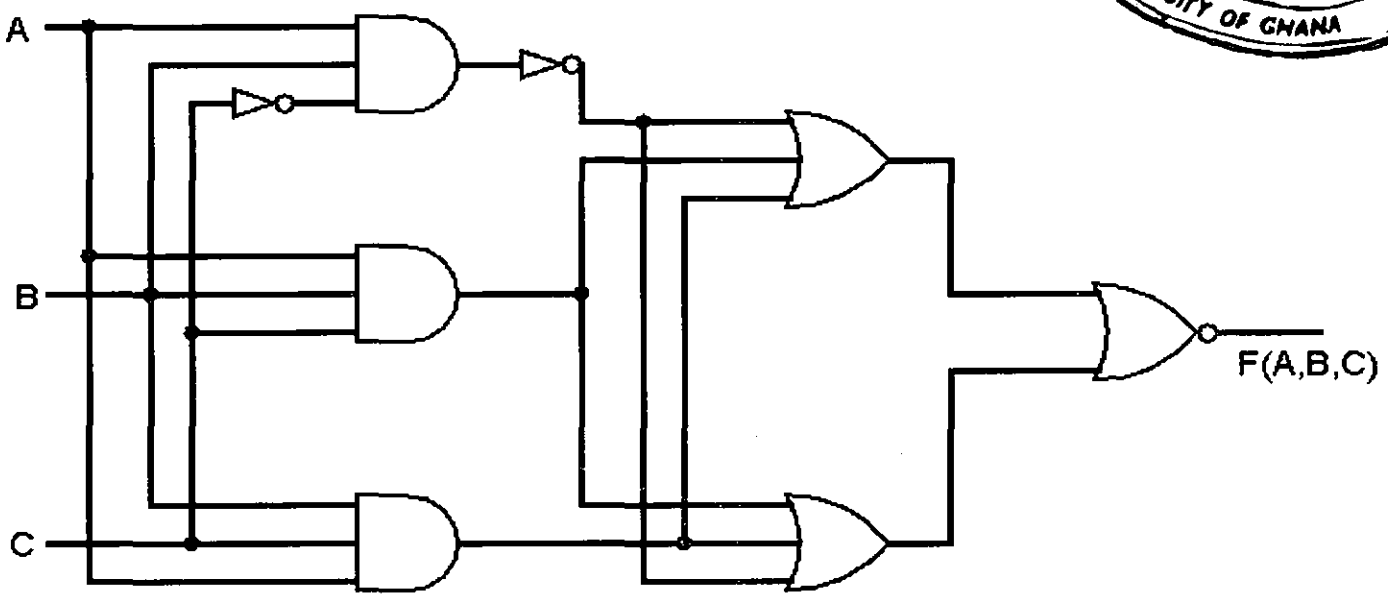

Figure 5: Logic Gate Circuit 2