SEMESTER II EXAMINATION, 2017/2018 ACADEMIC SESSION

COURSE TITLE: INDUSTRIAL ELECTRONICS DESIGN

COURSE CODE: EEE 526

EXAMINATION DATE: 30TH JULY, 2018

COURSE LECTURER: DR R. O. Alli-Oke

HOD's SIGNATURE

TIME ALLOWED: 2 HRS

INSTRUCTIONS:

1. ANSWER **QUESTION 1** AND ANY OTHER <u>THREE QUESTIONS</u> **(TOTAL OF 4 QUESTIONS**

2. SEVERE PENALTIES APPLY FOR MISCONDUCT, CHEATING, POSSESSION OF UNAUTHORIZED MATERIALS DURING EXAM.

3. YOU ARE **NOT** ALLOWED TO BORROW CALCULATORS AND ANY OTHER WRITING MATERIALS DURING THE EXAMINATION.

4. BOLTZMANN'S CONSTANT $k = 1.38 \times 10^{-23} \, JK^{-1}$

QUESTION #1

a) Suppose the voltage-divider bias network is used to set the quiescent point of a 2N3904 NPN transistor in a common-emitter configuration. Explain, with the aid of load lines, why the choice of the collector resistor R_C would lead to a trade-off between voltage gain and current gain. **(4 marks)**

b) Briefly explain how the SCR application shown in Figure 1 can be used as a DC switch. Your explanation should highlight the various operating modes of an SCR.
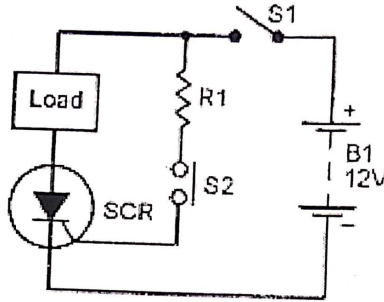
(5 marks)

Figure 1: Silicon Controlled Rectifier (SCR) Application

c) Sensor noise is the unwanted fluctuations in the output signal of the sensing system when the measurand is not changing.

    (i.) Define four (4) types of sensor noise?

           (2 marks)

    (ii.) The rise and fall time of a sensor signal are generally inversely proportional to its bandwidth. Assume that the rise time of a thermistor response is 0.05s and the bandwidth is $\tau_{rise} = 1/(2\Delta f)$. Compute the magnitude of the thermal noise at ambient temperature of 27^0 if the thermistor resistance is $5k\Omega$. **(2 marks)**

    (iii.) Compute the signal-to-noise ratio of the sensor in (ii) if the average current through the thermistor is 0.2 mA.

           (2 marks)

d) You are provided with a water tank, ultrasonic sensors, a 5-pin single pole double -throw (SPDT) electromechanical relay, and a water pump. Design a microcomputer-based system that senses the water level in the tank without any contact with the tank and accordingly controls the pump to fill water into the tank. In addition, the system should light up an LED indicator when water is being pumped. Use any micro-controller of your choice and make necessary assumptions. Your answer should include the block diagram and the schematic diagram of the system.

(6 marks)

QUESTION #2

a) With the aid of suitable diagrams, describe the full-wave rectification using two IN4001 diodes. How would you modify the circuit to output a voltage waveform of opposite polarity?

(7 marks)

b) The SCR shown below has a latching current of 5 mA and is fired by a pulse of width 50us. Determine if the SCR is fully ON or not (i.e. if the SCR is latched-on). Suppose that current through the resistor in the ON state is given by $i(t) = \frac{V_S}{R}(1 - e^{-t\frac{R}{L}})$
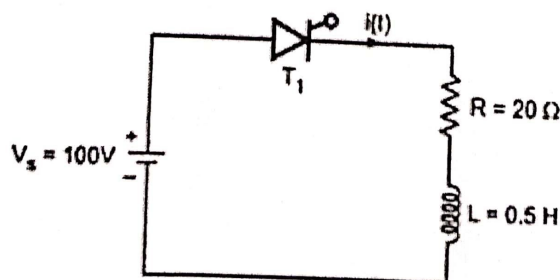
(6 marks)

Figure 2: Silicon Controlled Rectifier (SCR) Application

JESTION #3

a) Using a suitable circuit, briefly explain SCR half-phase control. Assume that the holding current $I_H = 0$. **(8 marks)**

b) Consider the circuit in your answer to question 3(a).
- (i.) Modify the circuit to achieve full-wave phase control **(1 mark)**
- (ii.) Draw the output wave form of this modified circuit in (i) **(1 mark)**
- (iii.) Use the circuit in (i) explain what you understand by asymmetric switching. Modify the circuit in (i) so as to mitigate the occurrence of asymmetric switching in the circuit. **(2 marks)**
- (iv.) Give a relative advantage of using two "anti-parallel" SCRs instead of a single thyristor component. **(1 mark)**

QUESTION #4

a) With the aid of suitable examples and diagrams, explain briefly what you understand by smart sensors. **(5 marks)**

b) What are the categories of performance characteristics of sensors? Define and explain any three specifications within each category. **(8 marks)**

QUESTION #5

a) With the aid of diagrams, **(4 marks)**
- (i.) explain the difference between electromechanical solenoids and electromechanical relays.
- (ii.) explain how a rack and pinion mechanism can be used to convert the rotary motion of rotary actuators to linear motion and give a real-life application example. **(4 marks)**

b) State any five criteria for selection of actuators for a particular application. **(5 marks)**

QUESTION #6

With the aid of a well-labelled diagram, explain the processes involved in printed circuit board (PCB) design. **(13 marks)**