FIJI NATIONAL UNIVERSITY

COLLEGE: COLLEGE OF ENGINEERING, SCIENCE & TECHNOLOGY (CEST)

SCHOOL: SCHOOL OF ELECTRICAL & ELECTRONICS ENGINEERING

PROGRAMME: TRADE DIPLOMA IN ELECTRICAL ENGINEERING - STAGE 5

UNIT CODE: EEE574

TITLE: POWER CONTROL ELECTRONICS

FINAL EXAMINATION – TRIMESTER 2, 2017

TIME: 3 HOURS & 10 MINUTES
ROOM: AS PER TIMETABLE

INSTRUCTIONS TO STUDENTS

1. You are allowed **10 minutes** extra **reading time** during which you are NOT to write.
2. Begin each SECTION on a fresh page and use both sides of the sheet.
3. Write your candidate number at the top of each attached sheet.
4. Insert all written foolscaps, graph paper, drawing paper, etc. in their correct sequence and secure with a string.
5. For all sheets of paper on which rough/draft work has been done, cross it through and ATTACH these to your answer scripts.
6. Write clearly the number(s) of the question(s) attempted on the top of each sheet.
7. Use of programmable calculator(s) is prohibited.
8. ANSWER ALL QUESTIONS
9. Show all working where necessary.
10. ALWAYS CHECK YOUR WORK BEFORE YOU LEAVE THE EXAM ROOM.

SECTION A **MULTIPLE CHOICE** **[20 MARKS]**

Choose the appropriate answer from each question by writing the alphabet beside the question number:

1. When reverse breakdown occurs in a diode:
   (a) Voltage increases and current is constant
   (b) Voltage increases and current also increases
   (c) Voltage is constant and current increases
   (d) Both are constant

2. Which motor is not suitable for the application of centrifugal pumps?
   (a) Shunt motor
   (b) Series motor
   (c) Cumulative compound motor
   (d) Differential compound motor

3. In dc motor, for operation in the reverse direction;
   (a) The field excitation must be reversed
   (b) Change it to full wave converter
   (c) The plugging must be reversed
   (d) Increase the field current

4. AC motors have advantage over DC motor because of
   (a) High Speed
   (b) Are in expensive
   (c) Lighter in weight
   (d) Answer b and c

5. One of the function of Unijunction transistor is to provide
   (a) Rectification
   (b) Transformation
   (c) Relaxation oscillator
   (d) Amplification

6. Silicon control switch can be turned on
   (a) By a negative pulse at the cathode
   (b) By a negative and positive pulse at the anode
   (c) By a positive pulse at the anode
   (d) By a positive pulse at the cathode or negative pulse at the anode.

7. A positive pulse applied to the gate of an SCR triggers it into conduction until
   (a) Pulse is reduced to 0.3V
   (b) The anode to cathode voltage drops to 0.3V
   (c) Pulse is reduced to zero
   (d) The anode to cathode voltage drops to zero

8. SCR is essentially a
   (a) Zener diode with an extra terminal added
   (b) Rectifier diode with extra terminal added
   (c) Shockley diode with extra terminal added
   (d) Varactor diode with extra terminal added

9. A triac has similar operation as a back to back connected
   (a) Diode
   (b) SCR
   (c) Transistor
   (d) Diac

10. To trigger an SCR, the voltage must be applied between
    (a) Anode and gate
    (b) Anode, gate and cathode
    (c) Gate and cathode
    (d) Anode and cathode

11. The function of a process control is to keep the controlled variable constant when it tends to be changed by a
    (a) Measurement
    (b) Disturbances
    (c) Component
    (d) Chemical

12. When rectifying a polyphase alternating current, it gives
    (a) A much smoother dc waveform
    (b) Fluctuating dc waveform
    (c) A much smoother ac waveform
    (d) Fluctuating ac waveform

13. Thyristors are best described as:
    (a) Amplifying devices
    (b) Voltage switch control
    (c) Power supply rectifiers
    (d) Signal generator

14. Invertors provides the conversion process from
    (a) DC to AC
    (b) AC to AC
    (c) DC to DC
    (d) AC to DC

15. In Process control system, the process of comparing the information from a sensor to a reference is called:
    (a) Error condition
    (b) Process load
    (c) Set point
    (d) Evaluate condition

16. The difference between the sensor and the set point reference is called
    (a) Error condition
    (b) Process load
    (c) Set point
    (d) Evaluate condition

17. Static ac switches eliminates
    (a) Bounce
    (b) Contact sticking
    (c) Wear
    (d) All of the above

18. Increasing the number of pulses (N), _____
    (a) reduces the output voltage amplitude
    (b) reduces the inverter efficiency
    (c) improves the inverter efficiency
    (d) none of the mentioned

19. A motor soft starter is a device used to
    (a) Temporarily reduce the load and torque
    (b) Oppose load and torque
    (c) Reduce torque
    (d) Reduce load

20. The rotational losses in d.c. machines is equal to the:
    (a) Kinetic energy of armature
    (b) Half of the kinetic energy of armature
    (c) Square of the kinetic energy of armature
    (d) Rate of change of kinetic energy

SECTION B **[30 MARKS]**

1) The technology of controlling a series of events to transform a material into a desired end product is called process control. Briefly explain the two forms of process control. **(3 marks)**

2) A dc – dc converter is used in regenerative braking of a series dc motor. The dc supply is 600V. The armature resistance is $R_a = 0.02\Omega$ and the field resistance is $R_f = 0.03\Omega$. The back emf constant is $K_v = 15.27mV/A$ rad/s. The average armature current is maintained constant at $I_a = 250A$. The armature current is continuous and has negligible ripple. If the duty cycle of the dc – dc converter is 60%, determine:

a) The average voltage across the dc – dc converter, V_{ch} **(1 mark)**
b) The power regenerated to the dc supply, P_g **(1 mark)**
c) The equivalent load resistance of the motor acting as a generator, R_{eq} **(1 mark)**
d) The minimum permissible braking speed , ω_{min} **(1 mark)**
e) The maximum permissible braking speed, ω_{max} **(1 mark)**
f) The motor speed, E_g **(2 marks)**

3) With the following information given below; the transistor is specified to have Beta (β) in the range 10 – 50. The load resistance is $R_C = 10\Omega$. The dc supply voltage is 150V and the input voltage to the base circuit is $V_B = 12V$. If $V_{CE(sat)} = 1.0$ Volt and $V_{BE(sat)} = 1.5$ Volts.

a) Sketch the bipolar power transistor circuit **(3 marks)**
b) Find the value of R_B that result in saturation with an overdrive factor of 5. **(4 marks)**

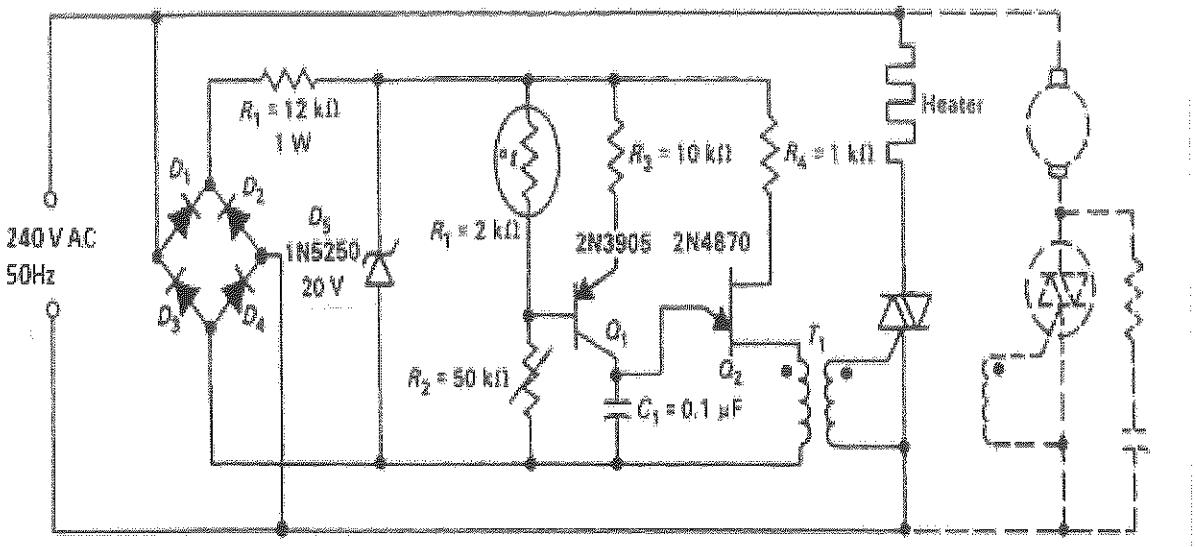
4) In control system evaluation, briefly explain the following:
a) Stability **(2 marks)**
b) Regulation **(2 marks)**
c) Transient Response **(2 marks)**

5) The four layer (or shockley diode) is a type of thyristor that acts something like an ordinary diode but conducts in the forward direction only after a certain anode to cathode voltage called the forward- breakover voltage is reached. Draw the following for Shockley diode.
a) Basic construction **(2 marks)**
b) Schematic diagram **(2 marks)**
c) Equivalent circuit **(3 marks)**

SECTION C [50 MARKS]

1) The pressure sensor has an accuracy of ± 2.2% of reading, and a transfer function of 27mV/kPa. If the output of the sensor is 231mV, then what is the range of pressures that could give this reading? **(2 marks)**

2) Refer to diagram for question below:



a. Identify the circuit above. **(1 mark)**

b. Draw the block diagram of the circuit above. **(3 marks)**

c. Identify and explain the function of the following components:

i. D_5 **(2 marks)**

ii. R_T **(2 marks)**

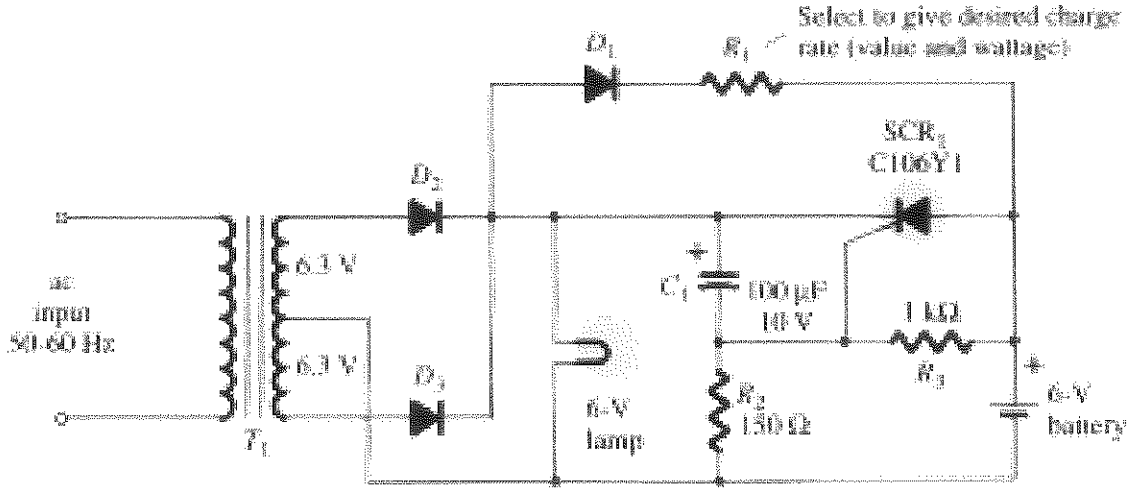
iii Q_2 **(2 marks)**

iv T_1 **(2 marks)**

3) Briefly discuss the three criteria of selecting a suitable inverter. **(3 marks)**

4) Why is there a need for astable multivibrator in an invertor circuit? **(1 mark)**

5)



a. Name the circuit given above **(1 mark)**
b. Explain what type of rectifier is used. **(1 mark)**
c. Write the operation of the circuit. **(4 marks)**

6) Given the CDA differential – gap controller in Figure 3.2 below with R2 set to 250KΩ and R5 set to 4MΩ, find:

a) The upper and the lower trip points **(3 marks)**
b) The temperatures that trip the comparator and the differential gap in temperature and voltage **(2 marks)**

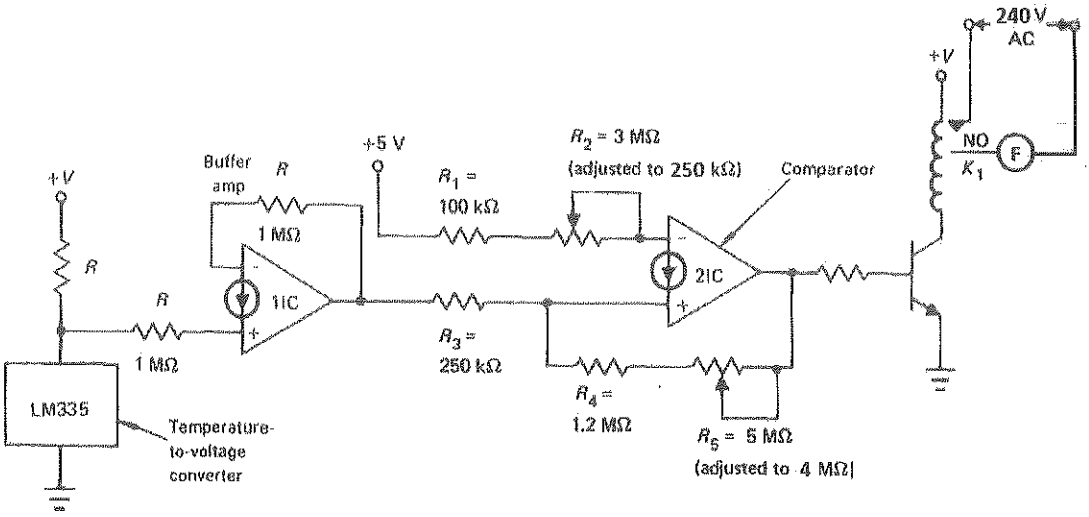


Figure 3.2 - Op-Amp Differential Gap on – off Controller

7) A half wave rectifier using silicon diode has a secondary emf of 14.14 V (rms) with a resistance of 0.2Ω. The diode has a forward resistance of 0.05Ω and a threshold voltage of 0.7V. If the load resistance is 10Ω, determine:

a) dc load current **(4 marks)**
b) dc load voltage **(2 marks)**
c) voltage regulation **(2 marks)**
d) efficiency **(2 marks)**

8) Name three types of signal control. **(3 marks)**

9) Sketch and label the block diagram of the elements that make up the feedback path in a process control loop. **(5 marks)**

10) An AC motor is an electric motor driven by an alternating current (AC). The AC motor commonly consists of two basic parts, an outside stationary stator having coils supplied with alternating current to produce a rotating magnetic field, and an inside rotor attached to the output shaft producing a second rotating magnetic field. State three advantages of AC motors. **(3 marks)**

**********THE END**********

Formulas

$Eg = V + IaRa$ $\quad Eb = V - IaRa$

Motor input current= $\frac{P}{efficiency \times V}$ $\quad I_{shunt} = \frac{V}{Rf}$

$E_b = V - (Ia \times Ra)$

$T_d = K_t I_f I_a$ $\quad I_f = \frac{V_f}{R_f}$

$T_d = Bw + T_L$

$T_d = K_t I_f I_a$

$I_a = \frac{T_d}{K_t I_f}$ $\quad E_g = K_v w I_f$

$V_a = R_a I_a$ $\quad Ics = \frac{Vcc - Vce(sat)}{Rc}$ $\quad UTP = \frac{Vref}{R1 + R2} \times R3$

$Ibs = \frac{Ics}{\beta}$ $\quad Rb = \frac{Vb - Vbe(sat)}{Ib}$ $\quad LTP = (\frac{Vref}{R1 + R2} - \frac{Vsat}{R4 + R5}) \times R3$

$V_a = d\omega_s$ $\quad P_o = 3V_aI_aPF$ $\quad V_f = V_a\angle 0 - I_a(R_a + jX_s)$

$T_p = T_m = \frac{3V_aV_f}{X_s\omega_s}$ $\quad V_{ch} = (1 - k)V_s$ $\quad P_g = I_aV_s(1 - k)$

$R_{eq} = \frac{Eg}{Ia} = \frac{Vs}{Ia}(1 - k) + Rm$ $\quad \omega_{min} = \frac{Rm\ Ia}{Kv\ If}$ $\quad \omega_{max} = \frac{Vs}{Kv\ If} + \frac{Rm\ Ia}{Kv\ If}$

$E_g = K_v\omega_{min}\ I_f = R_mI_a$

$V_{L(dc)} = \frac{2\sqrt{2}V_{LM}}{\pi} : V_{L1}$

$V_{L(ac)} = \sqrt{V_{L1}^2 + V_{L2}^2}$

$I_{L(ac)} = I_{r(rms)} = \sqrt{I_{L1}^2 + I_{L2}^2}$

$\gamma = \frac{V_{L(ac)}}{V_{L(dc)}} = \frac{V_{r(rms)}}{V_{L(rms)}}$