FIJI NATIONAL UNIVERSITY

COLLEGE OF ENGINEERING, SCIENCE & TECHNOLOGY

SCHOOL OF ELECTRICAL & ELECTRONICS ENGINEERING.

TRADE DIPLOMA IN ELECTRICAL ENGINEERING

EEE574 – POWER CONTROL ELECTRONICS.

SUPPLIMENTARY ASSESSMENT EXAMINATION – TRIMESTER 1 - 2018.

TIME ALLOWED : 2HRS

DAY/DATE: As per Timetable TIME: As per Timetable ROOM: As per time table.

INSTRUCTIONS TO STUDENTS'

1. You are allowed 10 minutes Extra reading time during which you are NOT to write.

2. Begin each answer 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 string

5. For all sheets of paper on which rough/draft work has been done, cross it though and you MUST ATTACH to your answer scripts.

6. Write clearly the number(s) of the question(s) attempted on the top of each sheet.

*7. **ANSWER ALL QUESTIONS**.*

8. Show all workings where necessary.

9. Do not use programmable calculators.

*10. **ALWAYS CHECK YOUR WORK BEFORE YOU LEAVE THE ROOM!***

QUESTION 1: [All PARTs are compulsory (20 marks)]

PART 1: MULTIPLE CHOICE

Instructions: Select the appropriate answers of each question by identifying the suitable alphabet(s).

1. A Diac and Triac are similar in that both devices

   (a) Can use breakover triggering
   (b) Can be used in ac circuits
   (c) Are bidirectional
   (d) All of the above

2. The speed of a dc motor can be varied by controlling

   (a) The armature voltage
   (b) The field current
   (c) The armature current
   (d) All of the above

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. 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

7. SCR is essentially a
   (a) zener diode with an extra terminal added
   (b) rectifier diode with extra terminal added
   (c) schockley diode with extra terminal added

(d) varactor diode with extra terminal added

8. A triac has similar operation as a back to back connected
   (a) diode
   (b) SCR
   (c) transistor
   (d) diac

9. 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

10. 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

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

12. 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

13. One of the advantages of Bridge Rectifier is
   (a) Uses large transformer
   (b) It has high PIV rating per diode
   (c) It is suitable for high – voltage applications
   (d) It uses centre tap transformer

14. 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

15. Light dimmers work by essentially
   (a) Fully utilizing ac voltage

(b) Chopping parts out of the ac voltage
(c) Inverting parts of the ac voltage
(d) Step up ac voltage

16. If equipment is to be tested with manufacturers specifications, it should be tested with
(a) modified square wave
(b) True sine wave
(c) modified sine wave
(d) true square wave

17. In process control, the controller is the
(a) control element
(b) microprocessor-based system
(c) measuring element
(d) controlled variable

18. In process control, the control element is the device
(a) that determines the physical amplitude of a parameter of a material
(b) that compare the set point to the sensed signal
(c) that determines the difference between the amplitude of the measured variable
(d) that controls the incoming material to the process

19. For symmetrical firing, triac is always connected with
(a) diac
(b) diode
(c) capacitor
(d) resistor

20. State way of switching off Silicon control rectifier
(a) removing the gate pulse
(b) anode current interruption
(c) forced commutation
(d) both answers in b and c

QUESTION 2: [Definitions, statement of facts and formulas (20 marks)]

1. Using expressions, discuss the following parameters in relation to rectifiers:
   a) Ripple factor (2 marks)
   b) Transformer Utilization Factor (TUF) (2 marks)
   c) Peak Inverse Voltage (PIV) (2 marks)

2. This question is related to inverters.
   a) Why is there a need for astable multivibrator in an invertor circuit? (1 mark)
   b) Briefly explain the three criteria of selecting a suitable inverter. (3 marks)

3. This question is related to Process controls systems;
   With aid of sketches, differentiate between open loop and closed loop systems in process control (4 marks)

4. This question refers to DC Motors and AC motors
   a) Categorize 3 ways of varying the speed and torque of induction motors (3 marks)
   b) In variable speed applications, a dc motor may be operating in one or more modes. Outline three modes of operation. (3 marks)

QUESTION 3: [Analysis and Calculations (35 marks)]

1. With the following information given below; the transistor is specified to have Beta (β) in the range 20 – 40. The load resistance is $R_C = 15\Omega$. The dc supply voltage is 180V and the input voltage to the base circuit is $V_B = 15V$. If $V_{CE(sat)} = 1.5$ Volt and $V_{BE(sat)} = 2$ 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. (3 marks)

2. A three phase 11.2 KW, 1750 rpm, 460 V, 60Hz four pole, Y – Connected induction motor has the following parameters: $R_s = 0.66\Omega$, $R'_r = 0.38\Omega$, $X'_s = 1.14\Omega$, $X'_r = 1.71\Omega$ and $X_m = 33.2\Omega$. The motor is controlled by varying both the voltage and frequency. The volts/hertz ratio, which corresponds to the rated voltage and rated frequency, is maintained constant.
   a. Calculate the maximum torque, T_m and the corresponding speed ω_m for 60 Hz and 30 Hz. (6 marks)
   b. Repeat if R_s is negligible. (2 marks)

3. 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)

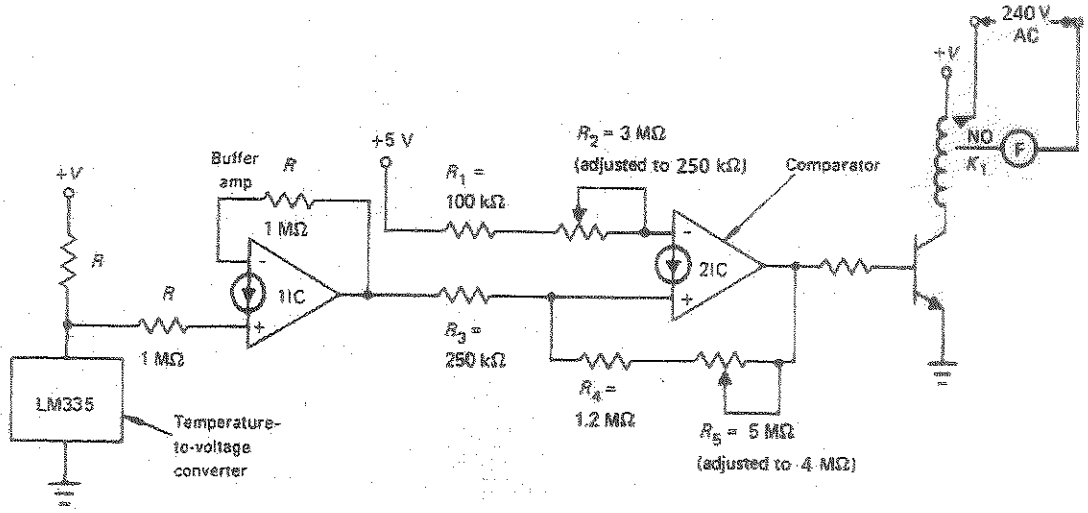


Figure 3.2 - Op-Amp Differential Gap on – off Controller

4. A separately excited DC generator has armature circuit resistance of 0.2 ohm and the total brush drop is 3V. When running at 1000 rpm, it delivers a current of 200A at 350V to a load of constant resistance. If the generator speed drops to 600rpm with the field current unaltered, find the new armature current. (5 marks)

5. 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 = 0.02Ω and the field resistance is Rf = 0.03Ω. 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)

6.

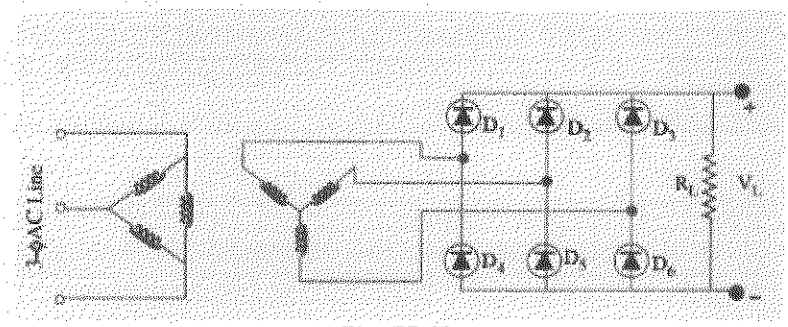


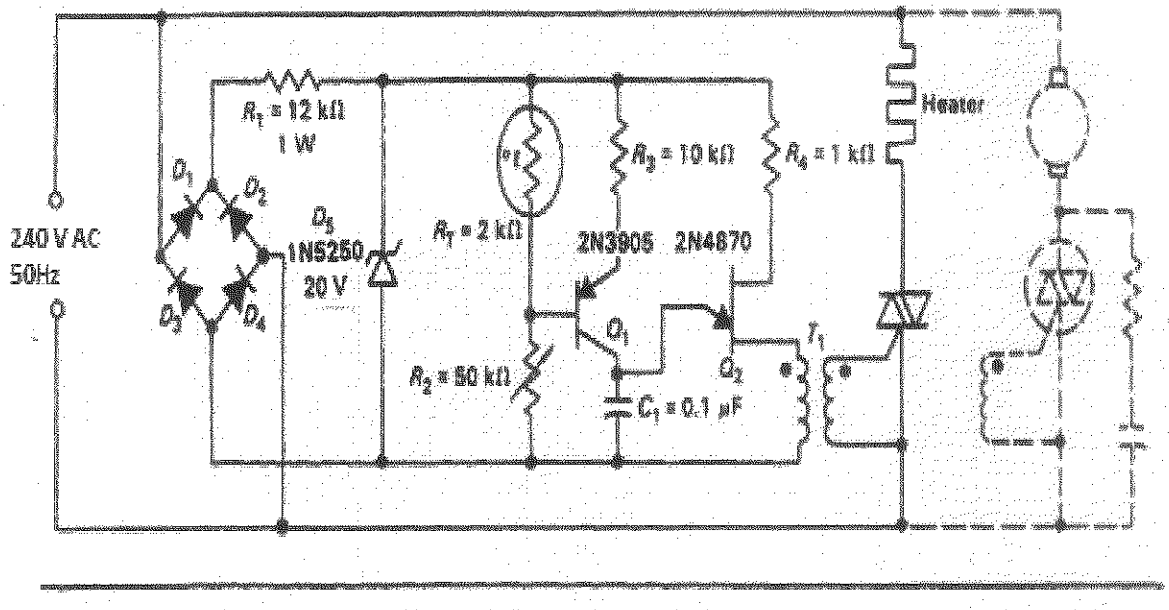
Fig 6

The r.m.s value of transformer secondary voltage per leg (Vs) in a full – wave, D/Y, 6 Phase rectifier is 150V shown in **Fig - 6**. If average value of load current is 2A, calculate

a. dc voltage (V_{dc}) (1 mark)
b. Peak and average current through each diode (2 marks)
c. Average power delivered to the load (P_{dc}) (1 mark)

QUESTION 4: [Diagram and Applications (20 marks)]

1. Refer to diagram for question below:

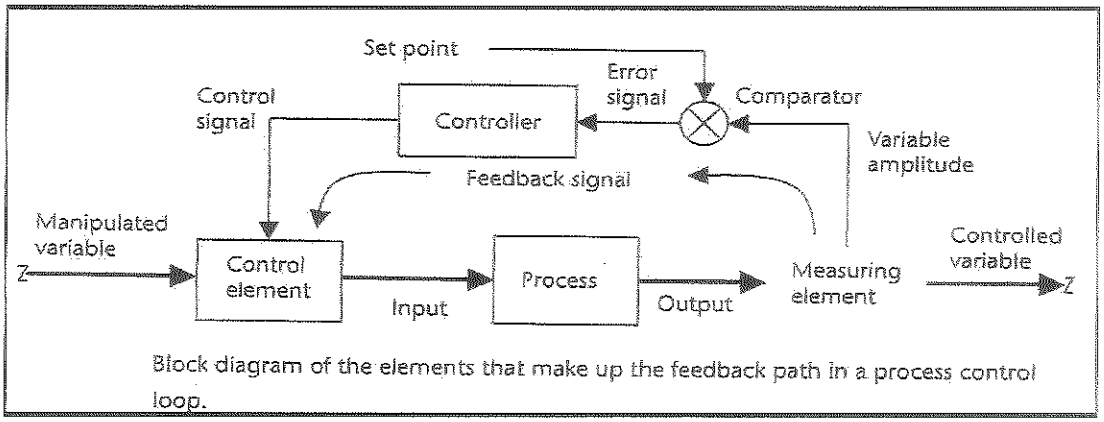


a. Sketch the block diagram of the circuit given above. (3 marks)
b. Discuss the function of the following components:
   i D_5 (1.5 marks)
   ii Q_2 (1.5 marks)

c. What expected voltage should be at the base of Q1 (2 marks)

d. If transistor Q1 is used as a switch, what continuous current should be flowing through the transistor? (2 marks)

2.



Block diagram of the elements that make up the feedback path in a process control loop.

Discuss the functions of the following blocks in a process control loop:

a. Controller (2 marks)

b. Control Element (3 marks)

c. Measuring element (3 marks)

d. Process (2 marks)

THE END

TOTAL MARKS = 100

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Candidate No: .....

Section A **Multiple-Choice Matrix** [25 marks]

Circle correct letter (A, B, C or D) against each of numbers 1 through 20.
Remove and attach to your Answer Booklet.

1.	A	B	C	D
2.	A	B	C	D
3.	A	B	C	D
4.	A	B	C	D
5.	A	B	C	D
6.	A	B	C	D
7.	A	B	C	D
8.	A	B	C	D
9.	A	B	C	D
10.	A	B	C	D
11.	A	B	C	D
12.	A	B	C	D
13.	A	B	C	D
14.	A	B	C	D
15.	A	B	C	D
16.	A	B	C	D
17.	A	B	C	D
18.	A	B	C	D
19.	A	B	C	D
20.	A	B	C	D
21.	A	B	C	D
22.	A	B	C	D
23.	A	B	C	D
24.	A	B	C	D
25.	A	B	C	D

Formulas

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

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

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

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

$T_d = Bw + T_L$

$T_d = K_t I_f I_a$

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

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

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

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

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

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

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

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

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

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

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