FNU FIJI NATIONAL UNIVERSITY

COLLEGE OF ENGINEERING, SCIENCE & TECHNOLOGY

SCHOOL OF ELECTRICAL & ELECTRONICS ENGINEERING.

TRADE DIPLOMA IN ELECTRICAL ENGINEERING

(ELECTRONICS/INSTRUMENTATION; COMPUTER/CONTROL; & TELECOMMUNICATION/NETWORKING; ELECTRICAL AND RENEWABLE ENERGY)

STAGE 4

EEE509 – POWER CONTROL ELECTRONICS.

FINAL EXAMINATION – SEMESTER 2 - 2015.

TIME ALLOWED : 2:10HRS

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, especially the ones that does the conversions of number systems.*
10. ***ALWAYS CHECK YOUR WORK BEFORE YOU LEAVE THE ROOM!***

QUESTION 1: [All PARTs are compulsory (25 marks)]

PART 1: MULTIPLE CHOICE

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

1. In variable speed applications, a dc motor operates in what mode:

   (a) Motoring
   (b) Regenerative Braking
   (c) Dynamic Braking
   (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. 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) schockley 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. 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

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. 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

21. If an 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

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

23. 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

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

25. 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 formulars (20 marks)]

1. Using expressions, define the following parameters in relation to rectifiers:
   a) DC output power (1.5 marks)
   b) Efficiency (1.5 marks)
   c) Ripple factor (1.5 marks)
   d) Transformer Utilization Factor (1.5 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;
   a) What is process control (2 marks)
   b) Explain the 2 basic mode of process control (3 marks)

4. This question refers to DC Motors and AC motors
   a) Name three classification of dc drives (3 marks)
   b) Name two types of ac drives (2 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 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. (3 marks)

2. A three – phase, 460V, 60Hz, six pole, Y – Connected cylindrical rotor synchronous motor has a synchronous reactance of $X_s = 2.5\Omega$ and the armature resistance is negligible. The load torgue, which is proportional to the speed squared, is T_L = 398N.m at 1200 rpm. The PF is maintained at unity by field control and the voltage – to – frequency ratio is kept constant at the rated value. If the inverter frequency is 36Hz and the motor speed is 720 rpm, calculate
   a) The input voltage V_a (1 mark)
   b) The armature current I_a (2 marks)
   c) The excitation voltage V_f (2 marks)
   d) The torgue angle δ (1 mark)
   e) The pull – out torgueT_p (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)

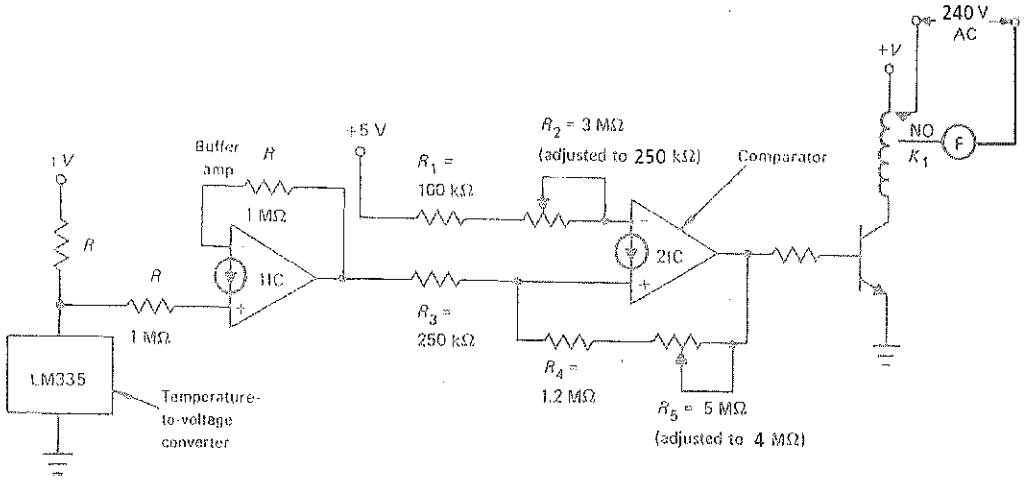


Figure 3.2 - Op-Amp Differential Gap on – off Controller

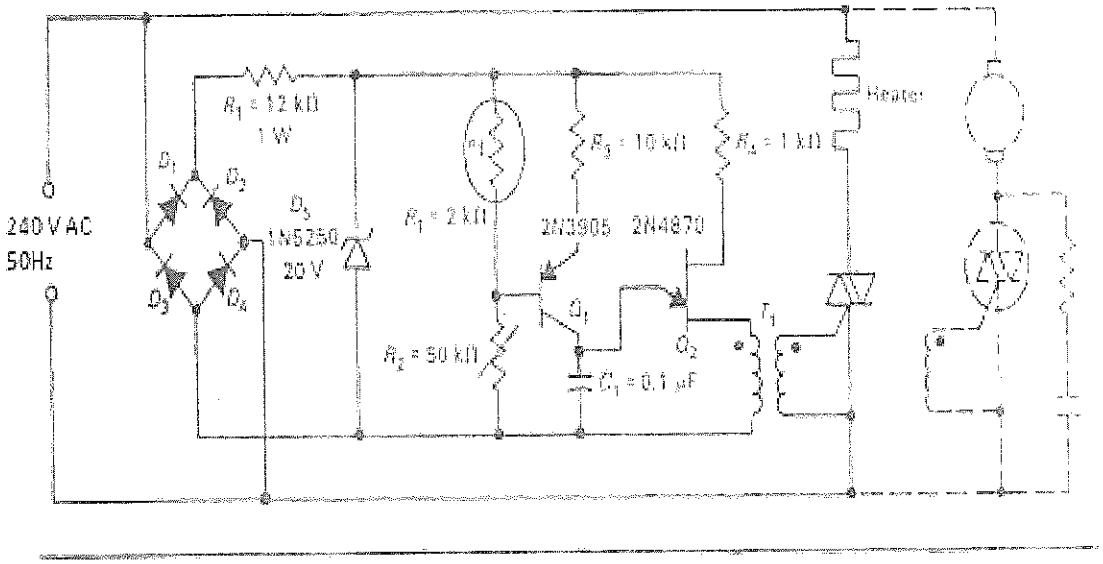
4. A separately excited DC generator has armature circuit resistance of 0.2 ohm and the total brush drop is 3V. When running at 1000 rpm, it delivers a current of 200A at 350V to a load of constant resistance. If the generator speed drops to 600rpm with the field current unaltered, find the new armature 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. A single phase full wave rectifier supplies power to a 1kW load. The ac voltage applied to the diode is 300 – 0 – 300V(rms). If diode resistance is 25Ω and the transformer secondary is negligible, determine:
   a. Average load current (1 mark)
   b. Average value of load voltage (1 mark)
   c. rms value of ripple (1 mark)
   d. Efficiency (1 mark)

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

1. 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 (1 mark)

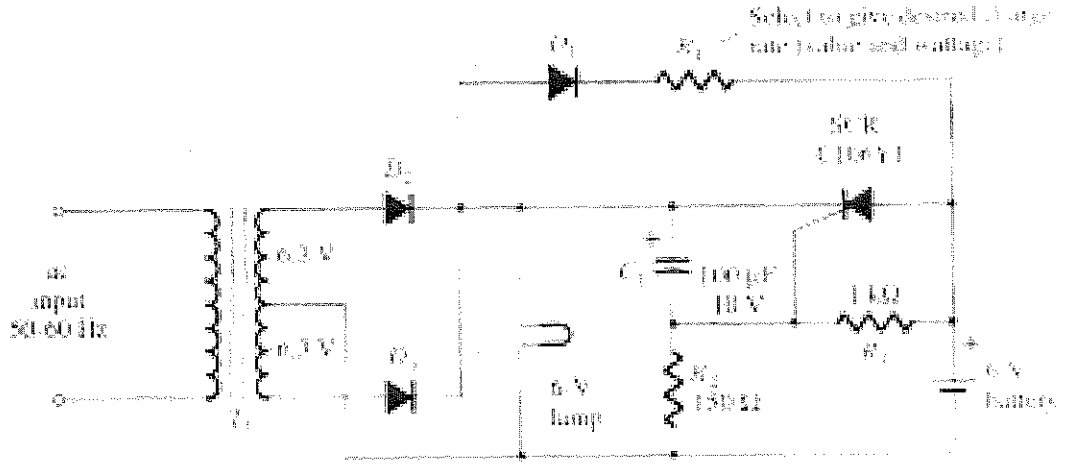
ii. R_T (1 mark)

iii Q_2 (1 mark)

iv T_1 (1 mark)

2. Draw the following block diagram and briefly explain the operation:
   a) Open Loop control System (3 marks)
   b) Closed loop control system (3 marks)

3.



a. Identify the circuit given above (1 mark)

b. Explain what type of rectifier is used. (1 mark)

c. Briefly explain the operation of the circuit. (4 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

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

Motor input current= $\dfrac{P}{efficiency \times V}$ $\qquad$ $I_{shunt} = \dfrac{V}{Rf}$

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

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

$T_d = Bw + T_L$

$T_d = K_t I_f I_a$

$I_a = \dfrac{T_d}{K_t I_f}$ $\qquad$ $E_g = K_v w I_f$

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

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

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

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

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

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