I.E.S. (Conv.) - 2001

ELECTRICAL ENGINEERING

PAPER – I

Time Allowed: 3 Hours ***Maximum Marks: 200***

Candidates should attempt SIX questions, selecting TWO question from Section - A, ONE from Section - B, ONE from Section - C and TWO from Section - D.

Assume suitable data, if necessary and indicate the same clearly.

SECTION A

1. The network si1own in the Fig. (1.1) has reached steady state when the switch S moves from a to b.

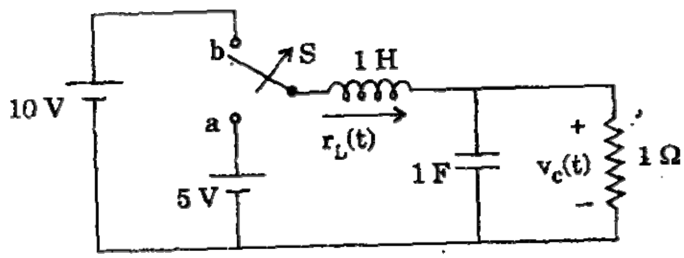

Figure (1.1)

(a) Determine initial values for $r_L(t)$ and $v_c(t)$ and their first derivatives with switch in position b.

(b) Determine $v_c(t)$ for $t > 0$. Sketch $v_c(t)$ as a function of time.

20

(c) Determine damping ratio, undraped and damped natural frequencies.

6

2. The driving point admittance of a network is given by the following equation

$$Y(s) = \frac{s^3 + 2s^2 + 3s + 1}{s^3 + s^2 + 2s + 1}$$

(a) Perform a continued fraction of admittance function Y(s) given in the above equation.

10

(b) Realise a network from the continued fraction of Y(s).

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(c) With the help of Routh-Hurwitz criteria, show that neither the numberator, nor the denominator of Y(s) given in the above equation has any zeros on the right half of s-plane.

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3. (a) The block diagram of a control system is shown in Fig 3.1

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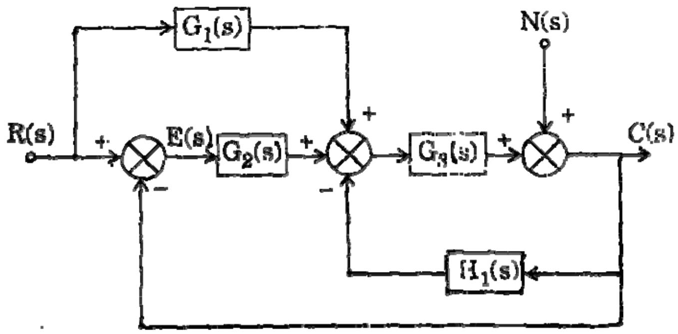


Figure (3.1)

(i) Draw the Signal Flow Graph of the control system shown Fig. (3.1)

(ii) Obtain the transfer functions $\left.\frac{C(s)}{R(s)}\right|_{N=0}$ and $\left.\frac{C(s)}{R(s)}\right|_{R=0}$ by use of Masons Gain formula.

14

(b) The open loop transfer function of a unity feedback control system is given by the expression

$$G(s) = \frac{K}{(s+2)(s+5)}$$

Draw the Nyquist plot of the closed loop system and comment upon the stability of the system

10

(c) Describe a zero-order sample and hold circuit. Obtain the Laplace transform of the output of S/H circuit when discrete inputs are sampled at regular intervals of T seconds.

8

SECTION B

4. (a) State and explain Gauss's law. A spherical volume charge distribution ρ is given by

$$\rho = \begin{cases} \rho_0\left(1-\frac{r^2}{100}\right) & for \;\; r \le 10\, mm \\ 0 & for\; r > 10\, mm \end{cases}$$

Show that the maximum value of electric field intensity E occurs at r = 7.45 mm. Obtain the value of E at r = 7.45 mm.

12

(b) Define Poynting's vector and flynting's theorem. Show that ratio of Poyntings vector to energy density is $\le 3 x\ 10^8$ m/s.

12

(c) Explain traveling waves on a transmission line and define Standing Wave Ratio (SWR). A high frequency lossless transmission line has a characteristic impedance of 600 Ω. Calculate the value of current SWR when the load is (500 + j300)Ω.

12

5. (a) A tong straight cylindrical wire of radius 2 mm is placed parallel to a horizontal plane conducting sheet. The axis of the wire is at a height of 100 mm above the sheet. Calculate the stress in the medium at the upper surface of the sheet just vertically below the wire. The potential difference between the wire and sheet is 3.3 1411 Derive any formula used and state assumptions made.

12

(b) "A handy 'curl meter' in the form of a pin wheel is used to indicate curl of a vector field." Justify the statement.

12

(c) Two infinite and conducting cones both on z-axis, one is $\theta = \theta_1 = 45°$ (constant) cone and the other is in $\theta = \theta_2 = 150°$ (constant) cone.. The region between them is characterized by $\rho_v = 0, V = 0 \; at \; \theta_1 \; and \; V = 10V \; at \; \theta_2$. Find the expression for V between $45° < \theta < 150°$.

12

SECTION C

6. (a) A conducting wire has a resistivity of 1.5×10^{-8} Ω m at 300 K. Its Fermi energy is 5 eV. Its volume of 1 m^3 contains 6×10^{28} conducting electrons. Calculate the relaxation time of conducting electrons. Hence or otherwise obtain the value of drift velocity of electrons, when the conductor is subjected to an electric field of 100 V/m. Write the significance of relaxation time and drift velocity.

12

Given

Mass of electron = 9.107×10^{-31} kg

Electron charge = 1.601×10^{-31} coulomb

(b) What is critical field in a superconductor? How is it affected by temperature? Write the application of a superconductor as an electrical switching element. The critical temperature (Ta) f Nb-60%. Ti is 8.7K. The value of T for Nb3AI in K will be (pickup correct value)

(i) 1.8 (ii) 4.8 (iii) 8.7 or (iv) 18. 12

(c) Write the properties and applications of any two noble metals used in electrical contacts.

12

7. (a) Explain Hall effect in P-type semiconductor. Hence or otherwise define Hall coefficient. Resistivity of a sample semiconductor is 9 milliohm meter. Its holes have mobility of 0.03 m^2/v.s. Calculate the value of Hall coefficient of the sample. State assumptions made.

12

(b) Define spontaneous magnetization. How does it behave in ferromagnetic materials below Curie point? Match List I of Materials with List II of their Curie point in K.

List I (Material)	**List II (Curie point K)**
A. Cobalt	1. 340
B. Iron	2. 400
C. Nickel	3. 630
D. 30% Permalloy	4. 1040

12

(c) What are ceramic materials? Differentiate between two types of ceramics having their permittivity less than 12 and greater than 12. Name two ceramic materials in each of above two types and mention one application of each type.

12

SECTION D

8. (a) (i) What is the dimension of a quantity? Derive dimensions of capacitance resistance and inductance in electrostatic and electromagnetic systems. Find a relation between two systems of units.

8

(ii) Describe briefly the primary and secondary standards of mass and length.

4

(b) Derive the general torque equation for a moving iron instmment. The inductance of a moving iron ammeter is given by the following expression

$L = (20 + 10\theta - 2\theta^2)\ \mu H$

where θ is deflection in radians. The spring constant is 24×10^{-6} Nm/rad. Calculate the value of deflection for a current of 5 A.

8

(c) Describe the construction and working principle of a single-phase Electrodynamics Pbwer Factor Meter. Compare its working with a Moving Iron type Power Factor Meter.

12

9. (a) How can frequency be determined using a bridge? Draw this bridge and derive condition for balance. Why and how two resistances and capacitances are made equal?

8

(b) What are the advantages of a 'digital' voltmeter over 'analog type'? What are its types? With block diagram, explain working of an integrating type. Compare its performance with other types.

12

(c) What are Electronic Counters? How can these be used to measure frequency? Explain the working of a Decade Counter

12

10. (a) What are Digital to Analog converters ? Describe, with necessary diagrams, working of a 'binary weighted resistance D/A converter.'

12

(b) What are thermostats? Explain the working, construction and applications of thermistors. Compare resistance-temperature characteristics of a typical thermistor and platinum.

8

(c) How does a 'Piezo-Electric Transducer' work? What are the common materials used for it? Derive an expression for its (i) voltage and (ii) charge sensitivities. Draw an equivalent circuit for this transducer. Write uses of Pizeo-electric materials and transducers.

12

I.E.S-(Conv.) - 2001

ELECTRICAL ENGINEERING

PAPER - II

Candidates should attempt FIVE questions in all, including Question No. 1 which is compulsory. The remaining FOUR questions are to be attempted by selecting at least ONE question from each of the Sections A, B, C and D.

SECTION A

(Question No. 1 is compulsory)

1. A. Choose and write the correct answer

(a) The hysteresis and edd-current loss of 1-phase transformer working on 200 V 50Hz are P_1 and P_e respectively. The percentage decrease in these losses when operated on a 160 V 40 Hz supply would respectively be

(i) 32, 36 (ii) 20, 36

(iii) 25, 50 (iv) 40, 80

(b) In a transformer core, third and fifth harmonic components of fluxes are respectively 10% and 4% of the fundamental flux. The third and fifth harmonic induced e.m.fs. in the winding, in terms of the fundamental induced e.m.f. are respectively

(i) 30%, 20% (ii) 10%, 12%

(iii) 50%, 20% (iv) 50%, 12%

(c) Consider the following statements regarding the speed control of d.c. motors

(i) Ward-Leonard method is suitable for constant-torque drives

(ii) Ward - Leonard method is suitable for constant - power drives

(iii) Field-control method facilitates speed control below base speed

(iv) Armature - resistance control method is more efficient than Ward - Leonard method

(v) Field - control method is suitable for constant-torque drives

(vi) Armature - resistance control method is suitable for constant - torque drives

From these the correct answer is

(I) (i), (ii), (vi)

(II) (i), (ii), (v)

(III) (i) (vi)

(IV) (i), (iii), (v)

(d) In transformer protection, harmonic restraint feature is incorporated to guard against

(i) magnetizing inrush current

(ii) Lightning

(iii) Over voltage surges

(iv) Unbalanced operation

(e) The voltage of a particular bus is regulated by controlling the

(i) Active power of the bus

(ii) Reactive power of the bus

(iii) Phase angle

(iv) Phase angle and reactive power

(f) A 3-phase circuit breaker is rated at 2000 MVA. 33 kV; its making current will be

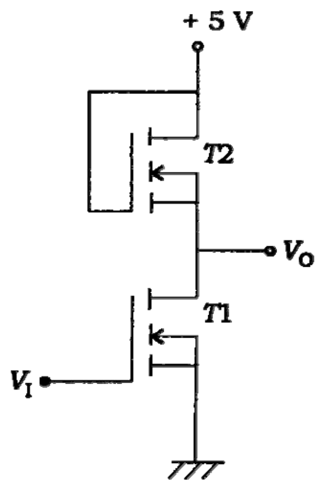
(i) 40 kA

(ii) 50 kA

(iii) 70 kA

(iv) 90 kA

(g)



$r_{d(ON)}$ for T2 = 100 kΩ

$r_{d(OFF)}$ for T2 = 10^5 MΩ

$r_{d(ON)}$ for T1 = 1Ω

$r_{d(OFF)}$ for T1 = 10^4 MΩ

The value of V0 for V1 in logic for the above figure is

(i) 5 V (ii) 4.8 V

(iii) 0.05 V (iv) 0 V

(h) The Fermi function for hole is expressed as

(i) $$\frac{1}{1+\exp\left(\frac{E-E_F}{kT}\right)}$$

(ii) $$\frac{1}{1+\exp\left[-\left(\frac{E-E_F}{kT}\right)\right]}$$

(iii) $$\exp\left[-\left(\frac{E-E_F}{kT}\right)\right]$$

(i) In a 3-phase semi converter, for firing angle equal to 120° and extinction angle equal to 110°, each SCR and freewheeling diode conduct, respectively for

(i) 60°, 50° (ii) 300, 50°

(iii) 60°, 10° (iv) 30°, 50°

(j) A step-down chopper operates from a d.c. voltage source V_s and feeds a d.c. motor armature with counter e.m.f. E_b. From oscilloscopic traces, it is found that the current increases for on-time $t_r(=T_{on})$, falls to zero over time t_f and remains zero for time t_o(off-period = $t_f + t_o = T_{off}$) in every chopping cycle. Then the average voltage across the motor would be

(i) $\dfrac{V_s.t_r}{\left(t_r + t_f + t_0\right)}$

(ii) $\dfrac{V_s.t_r + E_b.t_f}{\left(t_r + t_f + t_0\right)}$

(iii) $\dfrac{V_s.t_r + E_b.t_0}{\left(t_r + t_f + t_0\right)}$

(iv) $\dfrac{V_s.t_r + E_b\left(t_f + t_0\right)}{\left(t_r + t_f + t_0\right)}$

$2 \times 10 = 20$

B. Explain the following with proper reasoning

(a) Why does the external characteristic of a d.c. shunt generator turn back as it is overloaded?

(b) What are the terms air-gap powers, internal mechanical power developed and shaft power? How are these terms related with, each other?

(c) Why is one of the buses taken as slack bus in load flow studies?

(d) Why the feedback diodes are connected in antiparallel with thyristors in inverter circuits? How do these diodes come into play?

(e) A JFET has channel length, l = 10 μm, channel width, W = 100 tm, channel height without any depletion 2.5 = pm.

The channel is n-type with donor level of N0 = $10^{22}/m^3$ and $\mu_n = 0.1500\ m^2/V$. sec

The depletion width from each side of the gate junction is 025 pm. How does this semiconductor bar behave without forward biasing of the gate junction between two ends of the channel Length?

$4 \times 5 = 20$

2. (a) (i) What are the no-load rotational losses in electrical machines? How can these be determined?

(ii) Which of the losses in rotating electrical machines are influenced by the magnitude of the flux the load and the square of the load?

Write a general expression for all the losses occurring in rotating electrical machines and prove there from that maximum efficiency occurs when losses proportional to square of current = constant losses,

14

(b) Explain the effect of armature reaction on the main field flux by using the developed view of armature-current sheet and poles of a d.c. machine. Hence, outline the bad effects of armature reaction.

Discuss how the resultant flux density waveform obtained above gets modified with the use of interpoles.

18

(c) A 2200/220 1-phase transformer has maximum possible voltage regulation of 6% and it occurs at a p.f. of 0.3, Find the toad voltage at full-load at p.f. at 0.8 lead.

8

3. (a) A star-connected alternator is synchronized with an infinite bus of 11kV; its steam input is then increased till its output power is 15 MW. Now, when its excitation e.m.f. is increased to 130%, the synchronous machine starts operating at a p.f. of 0.8 lagging. Compute the synchronous reactance of the machine. Neglect armature resistance.

Determine the power factor, load angle and armature current of the machine before the excitation e.m.f. is increased.

16

(b) Explain how the desirable features of high-starting torque and low-operating slip are obtained in a double-cage polyphase induction motor

A double-cage motor has standstill impedance of 1 + j 1Ω and 0.3 + j 5Ω for its two cages. Compare the relative torques of the two cages (i) at standstill and (ii) at a slip of 0.05

12

(c) Why is it advantageous to use double revolving field theory for determining the running performance of a single-phase induction motor?

Draw torque - speed characteristics of a single - phase induction motor based on double - revolving field theory and discuss about the magnitude of torque at zero speed and synchronous speed.

Sketch waveform of rotor current under normal running conditions of the single-phase induction motor.

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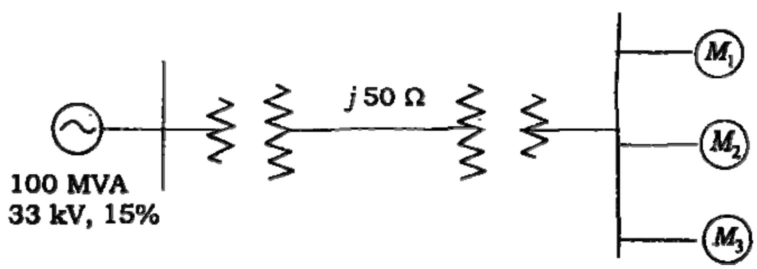
SECTION B

4. (a) List the advantages of using per-unit values in power system calculations.

8

(b)



A 100-MVA, 33-kV, 3-phase generator has a substransient reactance of 15%. The generator is connected to the motors through transmission line and transformers as shown in figure given above. The motors have rated inputs of 30 MVA, 20 MVA and 50 MVA at 30 kV with 18% sub transient reactance. The three phase transformers are rated at 100 MVA, 33 kV (Δ) / 110 kV(λ) with leakage reactance of 9%. The line has a reactance of 50 ohms. Selecting the generator ratings as base quantities. Obtain the P.V. reactance diagram of the system.

10

(c) A 50- MVA, 11 -IN, 3-phase alternator was subjected to different types of faults. The fault currents were:

3-phase fault - 1870 A

Line to line fault - 2590 A

Single line to ground fault - 4130 A

The alternator is solidly grounded. Find the p.u. values of three sequence reactance’s of the alternator

10

(d) Draw the reactance diagram of the system whose bus admittance matrix is given below. First, second, third and fourth rows refer to the buses 1, 2, 3, 4 respectively:

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$$Y_{bus} = j\begin{bmatrix} -3.78 & 1.25 & 2.50 & 0 \\ 1.25 & -3.42 & 1.11 & 1.00 \\ 2.50 & 1.11 & -4.89 & 1.25 \\ 0 & 1.00 & 1.25 & -2.31 \end{bmatrix}$$

5. (a) Derive an expression for total complex power in a 3- phase system in terms of symmetrical components of voltages and currents.

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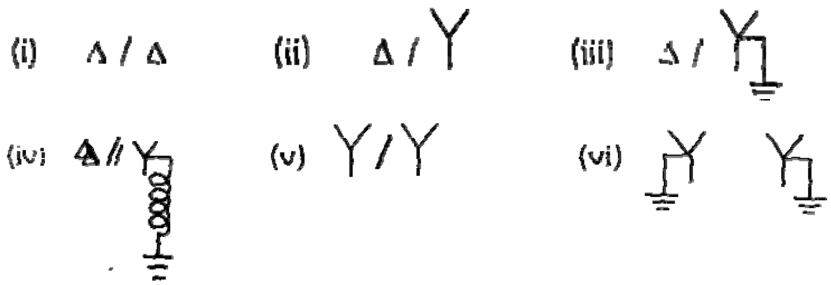
(b) Draw the zero sequence equivalent circuits of 2-phase transformers with the following connections of the windings



(c) Using equal area criterion, derive the expression for critical clearing angle for a system having a generator feeding a large system through a double circuit transmission line.

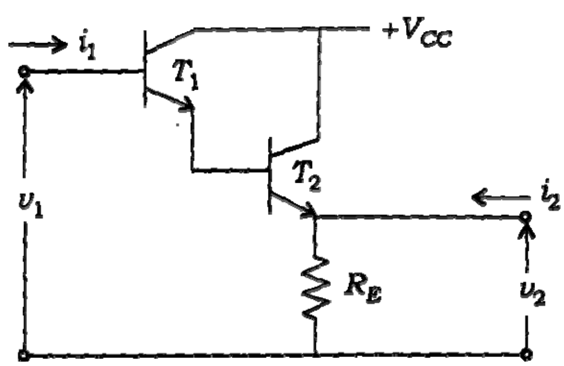
10

(d) A large generator is delivering 1.0 pu power to an infinite bus through a transmission network The maximum powers which can be transferred for pre-fault, fault and post-fault conditions are 1.8 pu, 0.4 pu and 1.3 pu respectively. Find critical clearing angle.

10

SECTION C

6. (a)



For the Darlington amplifier shown in figure above, obtain its Z-matrix for identical T_1 and T_2 having $h_{fe} = 100$, $R_E = h_{ie} = 1$ k

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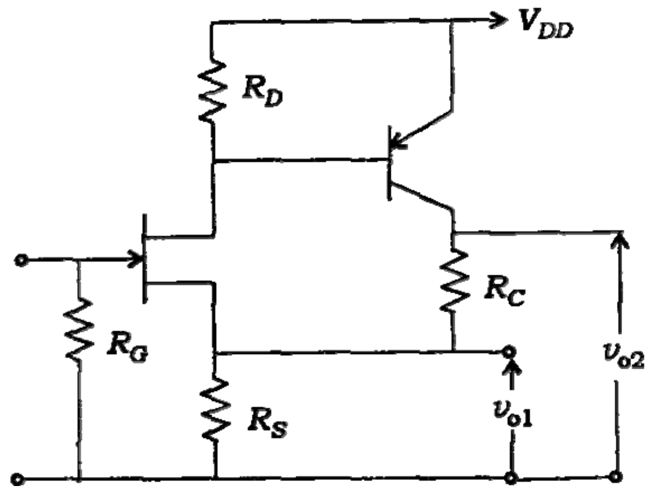
(b)



Obtain υ_{01} and v_{02} in figure above.

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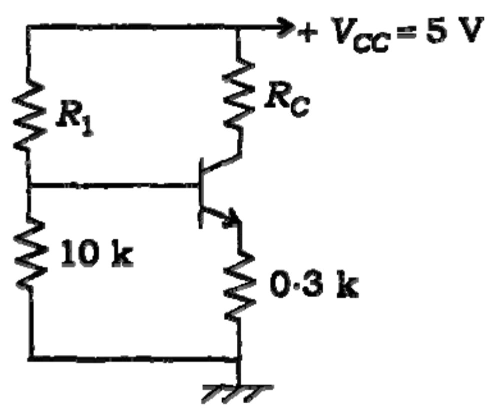
(c)



The BJT in amplifier of figure above has $h_{fe} = 100$, $V_{BE} = 0.7V$, $I_{CO} = 0$. Calculate the values of R_1 and R_C such that its $I_C = 1$ mA and $V_{CE} = 2.5$ V.

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7. (a) A microprocessor uses RAM chips of 1024*1 capacity:

(i) How many chips are required to yield the capacity of 1 k byte? How will the address and data lines of these chips be connected?

2 + 3

(ii) How many chips will be required to provide the capacity of 16 k bytes? How are they connected?

5 + 5

(b) Show diagrammatically the flow of signal of FETCH and execute cycle for ADI A, 05 indicated by arrow.

10

(c) What do the following instructions do? What happens if RET is removed from location 2106?

15

2000	START :	MVI A, CO
2002		SIM
2003		CALL 2100
2006		MVI A, 40

2008		SM
2009		CALL 2107
200C		JMP START
2100		NM B, 2A
2102	MOON :	DCR B
2103		JNZ MOON
2106		RET
2107		MVI C, 9F
2109		DCR C
210A		JNZ SUNY
210D		REF

8. (a) Implement the following expression:

$F = \overline{x}\,\overline{y} + xy + \overline{y}x$

using

(i) NAND gates only;

(ii) NOR gates only;

(iii) AND and NOT gates;

(iv) OR and NOT gates;

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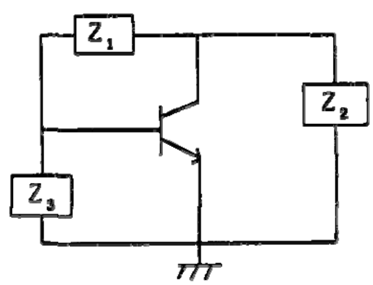
(b)



Neglect h_{re} and h_{oe} in RJT model.

The simplified circuit of radio frequency oscillator is shown in figure above. Obtain the condition of oscillation. Select the suitable components in place of Z_1, Z_2 and Z_3 to yield a Colpitts oscillator.

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SECTION D

9. (a) Describe the turn-off process in a GTO with relevant voltage and current waveforms.

Enumerate the advantages and disadvantages of a GTO as compared to a conventional thyristor.

12

(b) A single-phase semi-converter feeds RLE load such that load current is constant for a firing angle of 30°

Sketch waveforms for source voltage υ_s. Load voltage υ_0, load current i_0, source current i_s, one thyristor current and freewheeling diode current for firing angle $\alpha = 30°$.

Prove that input power factor for the above semi-converter for a = 90° is 0.63662.

12

(c) What is PWM? Explain sinusoidal - pulse modulation as used in PWM inverters. Discuss the conditions leading to the number of pulses generated per half-cycle as or $\frac{f_c}{2f}$ *or* $\left(\frac{f_c}{2f}-1\right)$

Here f_c and f are the frequencies of carrier and reference signal respectively.

Bring out the important features of sinusoidal –pulse modulation.

16

10. (a) Show that the efficiency of single tone AM is 33.3% for the modulation index to be equal to unity

10

(b) A modulating signal $E_m \sin \omega_m t$ passes through a square law device before entering the FM modulator. The FM modulator is characterized by its deviation in frequency as

$$f = f_c + ke_m(t)$$

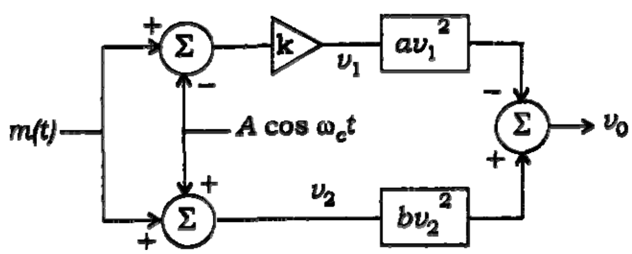
where

k = constant $e_m(t)$ = signal entering FM modulator.

Determine the FM signal.

15

(c)



What would be the value of gain k in figure above to yield the suppressed carried DSB signal?

10

(d) What do you understand by vestigial sideband? Where is it used?

5