C.S.E. (MAIN)

ELECTRICAL ENGINEERING

PAPER - I - 2004

Time Allowed : Three Hours *Maximum Marks : 300*

Candidates should attempt Questions 1 and 5 which are compulsory and any **three** of the remaining questions selecting at least **one** question from each Section.

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

SECTION A

1. Answer any **three** of the following :

(a) (i) What will be the impedance of a parallel connected LCR network at resonance frequency ? 4

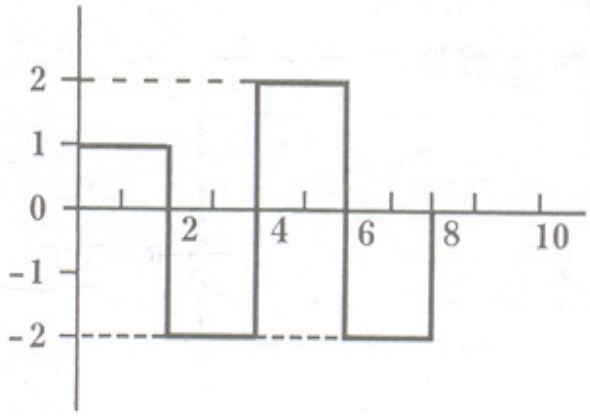
(ii) If an impedance Z_L is connected across a voltage source V with source impedance Z_S, then for maximum power transfer, what will be the load impedance ? 4

(iii) The voltage across an impedance in a network is V(s) = Z(s) . I(s) where V(s), Z(s) and I(s) are the Laplace transforms of the corresponding time functions v(t), z(t) and i(t). What will be the relation among them in the time domain of v(t), z(t) and i(t) ? 4

(iv) Develop the relation between unit step sequence and unit sample sequence. 4

(v) How can you express a discrete signal as a sequence of a sum of scaled delayed unit sample sequence? 4

(b) (i) Determine Laplace transform of the waveform f(t) as shown in the figure below : 4



(ii) Draw the block diagram of the system represented by the following constant coefficient difference equation

$$y(n) = b_0 x(n) + b_1 x(n-1) + a_1 y(n-1)$$

where $x(n)$ = input sequence

and $y(n)$ = output sequence. 10

(c) (i) What is the principle of operation of a repulsion motor ? What are its main features, advantages and applications ? 15

(ii) Describe the working of a stepper motor. 5

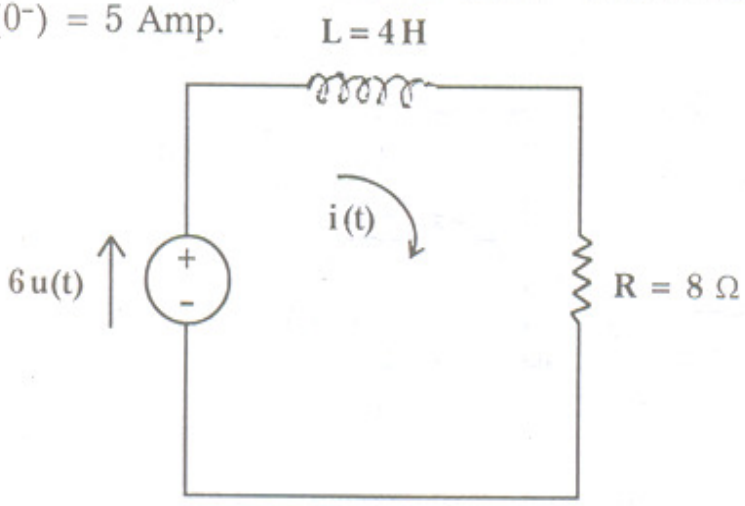
(d) (i) A cable transmission system with a loss of (L) 240 dB and has m = 6 equal-length repeater sections and the SNR at the destination $(S/N)_D$ = 30 dB. Find the new value of $(S/N)_D$ if (a) m is increased to 12 and (b) m is decreased to 4. Express your answer both in ratio and in dB. 10

(ii) A helix travelling wave tube operates at 4 GHz with a beam voltage of 10 kV and a beam current of 500 mA. The helix impedance is 25 ohm and interaction length is 15 cm. Determine the output power gain in dB. 10

2. **(a)** (i) Use final value theorem to find $f(\infty)$ for the function $(1 - e^{-\beta t})\, u(t)$, where $\beta > 0$.

(ii) Find the current i(t) through the 8 Ω resistor of

the circuit diagram shown below with initial current $i(0^-) = 5$ Amp. 6



(iii) Obtain the frequency response of the first-order recursive system represented by constant coefficient difference equation

$$y(n) = a\, y(n-1) + x(n).$$

Consider the system is initially relaxed. 10

(b) What are commutation circuits ? Design a commutation circuit for an inverter. 5 + 15 = 20

(c) (i) Discuss transformer noise and means adopted to reduce it. 5

(ii) A 30-kVA, single phase transformer has an iron loss of 457 W and copper loss of 125 W, when delivering half the full load. At what percent of the full load will the transformer have maximum efficiency ? 15

3. **(a)** (i) Consider the function of complex frequency s of the following expression :

$$X(s) = \frac{s + 3}{s^2 + 4s + 5}$$

Find the Laplace inverse function of the above expression. 8

(ii) What do you understand by the mathematical relation between continuous and discrete system as given

below ?

$$X(e^{j\omega T}) = \frac{1}{T}\sum_{m=-\infty}^{\infty} X_A\left(\omega + \frac{2\pi}{T}m\right)$$

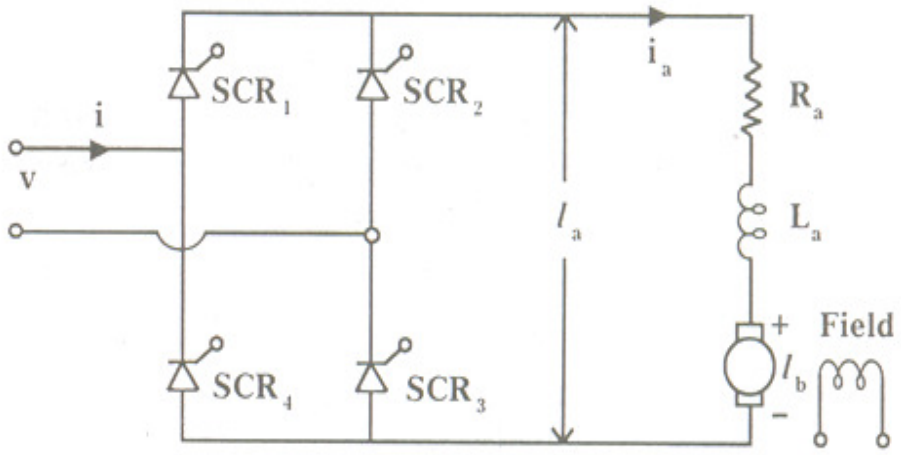
where $X(e^{j\omega T})$ is the frequency response of the sequence x(nT), T is the sampling period and $X_A(j\,\Omega)$ is the Fourier transform of the continuous-time waveform. If the analog frequency response is band limited to the range $|\,\Omega\,| \leq \pi/T$ what will the new relation be ?

2 × 6 = 12

(b) (i) Illustrate and compare speed-current and torque-current characteristics of a compound wound d.c. motor with that of series and shunt motor. **5**

(ii) A 3-phase, 50 Hz, 16 pole generator with connected windings has 144 slots with 10 conductors star slot. The flux/pole of 24.8 mWb is sinusoidally distributed. The coil is full pitched. Find the line emf. **15**

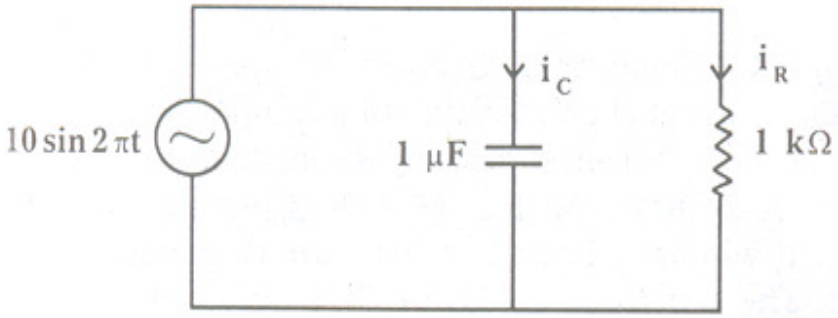
(d) The speed of a 20 HP, 460 V, 1000 rpm separately excited d.c. motor is controlled by a single-phase full-wave bridge circuit as shown in the figure :



The rated motor armature current is 35 A and the armature resistance is 0.15 Ω. The a.c. supply voltage is 480 V. The motor back emf constant is $k_b\,\phi$ = 0.45 V/

rpm. The motor current is continuous and ripple free. For rectifier operation (d.c. machine running as a motor) and for a firing angle $\alpha = 60°$ and rate armature current, calculate (i) torque, (ii) speed and (iii) supply power factor. **20**

4. **(a)** (i) A sinusoidal voltage source is applied to the parallel RC network as shown in the figure below. Find the energy stored and energy dissipated in the resistor over the interval $0 < t < 0.5$ sec. **10**



(ii) Find the output response to an input $x(n) = u(n) - u(n - p)$ for the system whose unit sample response is as follows :

$h(n) = \alpha^n$ for $n \geq 0$

$= 0$ for $n < 0$. **10**

(b) The joint probability density of the random variables X and Y is $f(x, y) = K e^{-(x+y)}$ in the range $0 \leq x \leq \infty$ and $0 \leq y \leq \infty$ and $f(x, y) = 0$ otherwise.

(i) Find the value of the constant K.

(ii) Find the probability density f(x), the probability density of X independently of Y.

(iii) Find the probability $P\begin{pmatrix} 0 \leq X \leq 2; \\ 2 \leq Y \leq 3 \end{pmatrix}$

(iv) Are the random variables dependent or

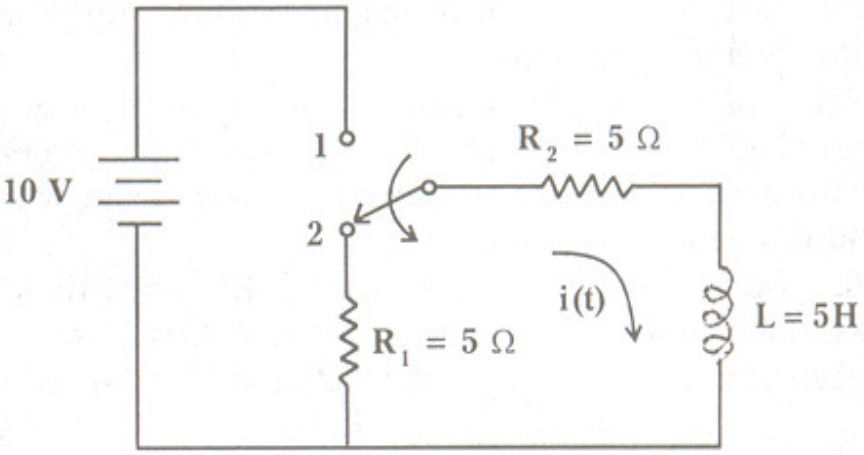
independent ? Justify. 20

(c) What is troposphere ? State the parameters that characterise troposphere. Write empirical formulae for the variation of these parameters within the first 1 – 2 km of the troposphere. Write expressions for the permittivity (ε_r) and refractive index (n) of the tropospheric medium. What is the value of n at an altitude of 1 km ? 20

SECTION B

5. Answer any **three** of the following :

(a) (i) Circuit diagram shown below is initially under steady-state condition, the switch is moved from *position 1* to *position 2* at t = 0. Find the current after switching. 8



(ii) Find the z-transform of $\cos(n\pi/2) \cdot u(n)$. 12

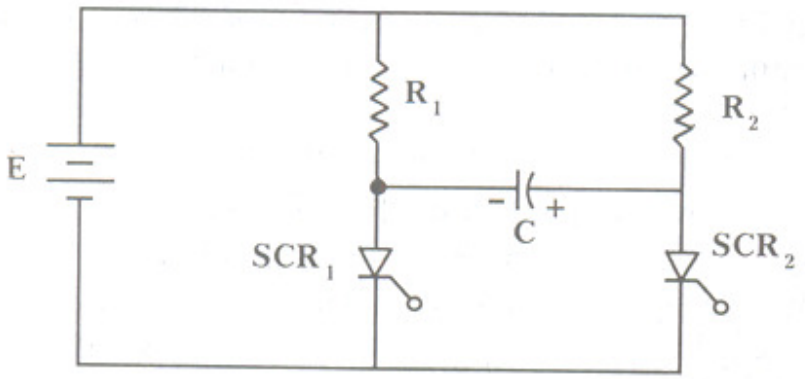
(b) (i) For plane waves in free space, show that the intrinsic impedance of free space is given by $120\pi\ \Omega$. 10

(ii) An EM wave travels in free space with the electic field component

$$\vec{E}_s = 100\, e^{j(0.866\, y + 0.5\, z)}\, a_x \text{ V/m.}$$

Determine ω and λ. 5+5=10

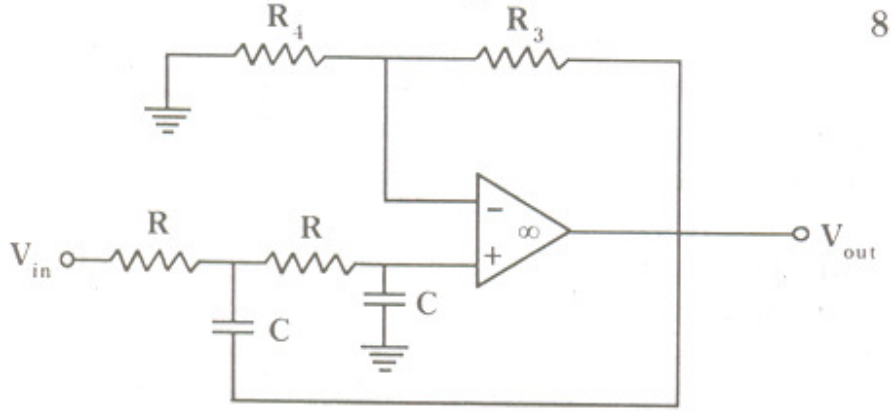
(c) (i) In the circuit of the figure shown below, the source voltage E = 120 V and the current through loads R_1 and R_2 is 20 A. The turn-off time of both the SCRs is 60 μ sec. Find the value of C for successful commutation. **10**



(ii) Give interpretation of negative, unity and > unit slips of induction motor. **10**

(d) A paraboloidal reflector antenna of cross-sectional area of 8000 cm^2 works at 3 GHz. Calculate the (i) beam width between first nulls, (ii) half power beam width, and (iii) gain of the antenna. **20**

6. (a) (i) Design a second-order Butterworth low-pass filter with cut off frequency of 1 kHz. Use only Sallen and Key network configuration as shown below: **8**



(ii) Find the impulse response of the system whose transfer function is given as follows :

$$H(z) = \frac{1}{1 - 2\,r\cos\theta\,.\,z^{-1} + r^2 z^{-2}}$$

which converges $|z| > r$, it has a pair of poles at $z = r\,.\,e^{\pm j\theta}$ and a double zero at $z = 0$. **12**

(b) It is desired to transmit an audio signal which has a bandwidth of 10 kHz with an output SNR of 40 dB. The channel introduces a 30 dB power loss and channel noise is AWGN with power spectral density $\eta/2 = 10^{-9}$ W/Hz. Assume $\mu^2 S_x = 0.5$ for AM.

Calculate the (i) transmission bandwidth B_T (ii) required transmitter power S_T for DSB, SSB and AM systems. **20**

(c) A microstrip line is to be designed on alumina substrate having relative dielectric constant $\varepsilon_r = 8.2$. The W/h ratio = 0.95.

Compute

(i) effective relative dielectric constant

(ii) characteristic impedance Z_o

(iii) phase velocity

(iv) guide wavelength **20**

7. (a) Draw the circuit diagram of a half wave rectifier with a reservoir capacitor that smooths the output. Draw its output waveform. Determine the reservoir capacitor value for a HWR and smoothing circuit to supply 20 V to a load of 500 Ω. Maximum ripple amplitude is to be 10% of the average output voltage, and the input signal frequency is 50 Hz. **20**

(b) In an Armstrong modulator, the crystal oscillator frequency is 200 kHz. The angular deviation is set to 0.2. The system is to accommodate modulation frequencies

between 50 Hz and 15 kHz. The carrier frequency at the output is 108 MHz and the maximum frequency deviation is 80 kHz. Draw the block diagram of the modulator showing the details and select multiplier and mixer oscillator frequencies to accomplish this end. **20**

(c) Find the field strength at distances of 500 m and 2,500 m from a dipole centre fed with $I_m = 0.1$ A. Dipole has a length of 200 cm and the frequency of operation is 3 GHz. Consider E_θ only in the maximum direction. **20**

8. **(a)** The discrete time system is described by the constant coefficient difference equation

$y(n) = x(n) + a\, y(n-1)$ with initial condition $y(-1) = K$. If the input $x(n) = e^{j\omega n}.u(n)$ is applied to the system, what will be the output response ?

[Solve the problem using z-transform and its inverse transform operation only] **20**

(b) (i) Derive conditions for maximum starting torque to be obtained in case of an induction motor. **5**

(ii) A 4-pole, 50 Hz, 7.46 kW motor at rated voltage and frequency has a starting torque of 160% and a maximum torque of 200% of full-load torque. Determine (a) full load speed and (ii) speed at maximum torque. **15**

(c) A 6 MW, 3-phase, 11 kV, Y-connected, 6-pole, 50 Hz, 0.9 (leading) power factor synchronous motor has $X_s = 9\ \Omega$ and $R_s = 0$. Rated field current is 50 amperes. Machine is controlled by variable frequency control at constant (V/f) ratio upto the base speed and at constant V above base speed. Determine the torque and field current for the rated armature current, 750 rpm and 0.8 leading power factor. **20**

C.S.E. Electrical Engg. (MAIN) - 2004

PAPER - II - 2004

Time Allowed : Three Hours *Maximum Marks : 300*

Candidates should attempt Questions 1 and 5 which are compulsory and any **three** of the remaining questions selecting at least **one** question from each Section.

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

SECTION A

1. Select any THREE of the following statements, read them carefully and identify the correct and the incorrect ones. Justify your answer using not more than 200 words in each case :-

(a) At any point on the root locus with angle condition satisfied, the value of K-variable parameter (for this point to be a root) is obtained as

$$K = \frac{\text{product of lengths of vectors from poles}}{\text{product of lengths of vectors from zero}}$$

(b) Bridges are used to measure inductance of coils having different values of Q and capacitances are used therein to obtain the balance.

(c) Is voltage control necessary in power systems ? Various current control methods are used. Permissible voltage variations are known. Any advantage of current control ?

(d) Digital transmission has more advantages than disadvantages as compared to analog transmission.

$20 \times 3 = 60$

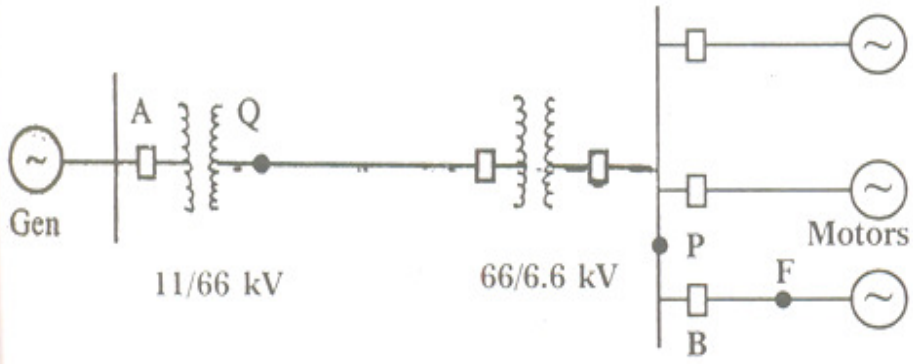
2. (a) What do you understand by lead compensator ? Draw the approximate Bode plot for a typical lead compensator. Design a suitable control system for a missile to introduce a lead of 35° and gain of 6.5 db at 2.8 rad/s. What will be the transfer function of this lead

compensator that will satisfy the above requirement? **20**

(b) A 25 MVA, 11 kV generator with $X''_d = 20\%$ is connected through a transformer, line and a transformer to a bus that supplies three identical motors as shown in fig. below. Each motor has $X''_d = 25\%$ and $X'_d = 30\%$ on a lease of 5 MVA, 6.6 kV. The three-phase rating of the step-up transformer is 25 MVA, 11/66 kV with a leakage reactance of 10% and that of the step-down transformer is 25 MVA, 66/6.6 kV with a leakage reactance of 10%. The bus voltage at the motor is 6.6 kV when a three-phase fault occurs at the point F. For the specific fault, calculate :

(a) the subtransient current in the fault
(b) the subtransient current in the breaker B
(c) the momentary current in breaker B

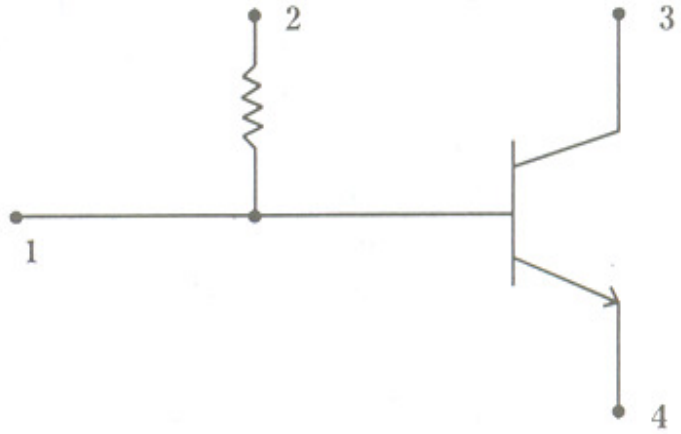
Given : Reactance of the transmission line = 15% on a base of 25 MVA, 66 kV. Assume that the system is operating on no load when the fault occurs. **20**



(c) What is wave energy ? Explain the difficulties facing wave-power development. Give a list of devices developed for converting wave energy into electrical energy and fully describe one of these. **20**

3. (a) Describe the various steps involved in the

fabrication of a monolithic circuit shown below : 20



(b) Draw a block diagram of Remote Terminal Unit (RTU), having different components/subsystems, communication bus etc. Write the functions it generally carries out. Briefly explain the distributed control system. Bring out the features of Data Highway. 20

(c) State and explain the basic requirements (i.e. essential qualities) of protective relaying. 20

4. (a) Justify that the stack and subroutine offer a great deal of flexibility in writing programs. Point out the differences between stack pointer and program counter, PUSH and POP, CALL and RET. Give examples for each. Write a program to add two numbers which generate the carry over, store the carry over in memory locations XX50 and sum XX60 in 8085 microprocessor. 20

(b) A CW radar operates at a frequency of 10 GHz. What is the doppler frequency produced by

(i) an air plane flying at a speed of 250 kms per hour

(ii) a man crawling at a speed of 2.5 cms per second ? 20

(c) The guided missile tracking radar operates at 5

GHz and a 1.0 MW peak power output. If the antenna diameter is 4 meters, the receiver band-width 1.6 MHz and the receiver has a 10 dB noise figure, what is its maximum detection range for 1 m^2 targets ? 20

SECTION B

5. Select any THREE of the following statements, read them carefully and identify the correct and the incorrect ones. Justify your answer using not more than 200 words in each case :-

(a) Latch is used at input and tristate is used for output purposes in the microprocessor based system.

(b) Capacitors in integrated circuits are obtained by using the transition capacitance of a reverse-biased p-n junction.

(c) An HVAC circuit breaker of a given voltage, current and MVA rating can be used as an HVDC circuit breaker of the same voltage, current and MVA rating.

(d) Do we have a system which makes a fuller utilization of the transmission capacity of an optical fibre and needs multiplexing ? $20 \times 3 = 60$

6. (a) (i) Explain the construction of single-phase induction-type energymeter.

(ii) A 230 V single-phase watt hour meter has a constant load of 4 A passing through it for 6 hours at unity p.f. If the meter disc makes 2208 revolutions during this period, what is the meter constant in revolutions per kWh ? Calculate the power factor of the load if the number of revolutions made by the meter are 1472 when operating at 230 V, and 5 A for 4 hours. 20

(b) How is digital data converted into analog signals for telephone lines ? Compare them with respect to

(i) Waveforms

(ii) Bit rate

(iii) Baud rate. 20

(c) State Kepler's three laws of planetary motion. Illustrate in each case their relevance to artificial satellites orbiting the earth. 20

7. (a) Describe the band structure of an open-circuited P-N junction. 20

(b) How I, Q and Y signals are generated in a colour TV transmitter ? Explain with tube and matrix arrangement. 20

(c) What is meant by carrier to noise ratio ? How is it related to SNR ? An FM system has modulation index of 10. Given that C/N is 25 dB, calculate the receiver processing gain and the S/N. 20

8. (a) Write the discrete forms of P, PI and PID controllers. What are various methods of tuning them ? Discuss in brief. 20

(b) Explain briefly the techno-economic advantages and disadvantages of HVDC transmission system. 20

(c) Explain on-line real-time computer system for protection of a line. Draw a sample fault program flow diagram. 20

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