Time : 3 hours

Full Marks : 300

The figures in the right-hand margin indicate marks.

*Candidates should attempt Q. No. 1 from Section – A and Q. No. 5 from Section – B which are compulsory and any **three** of the remaining questions, selecting at least **one** from each Section.*

SECTION – A

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

    (a) (i) The following figure shows a three-phase, 33kV line feeding a per-phase load of 10 MW. If the impedance of the line is $Z = j20\Omega$, determine the load angle and the reactive power to be supplied

by the capacitive source connected at the load end to maintain a line voltage of 33kV at the load. 10

(ii) If the capacitive source is removed, what is the maximum real power load which can be supplied ? What will be the power angle and the voltage to supply the load ? 10

$Z = j20 \ \Omega$

Q_G

10 MW
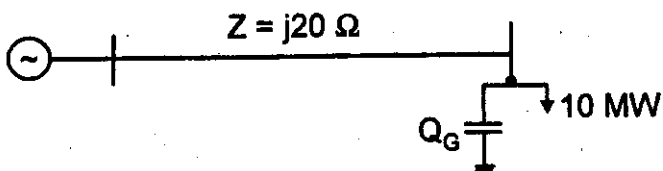
(b) On investigation a power company found that the poly phase meter through which an industrial plant was being served was incorrectly connected. The error resulted from incorrect polarity markings of one of the potential transformers. During two months the indicated demand has been 400 and 600kW and the watt hour meter has registered

17000 and 25000kWh. A careful test showed that power factor was 72 percent most of the time.

(i) By what factor should the demand meter and watthour meter readings be multiplied to obtain the actual readings ?

(ii) The demand charge was Rs. 40 per kW per month and the energy charged 50 paise per kWh. Calculate the loss suffered by the company because of the error. 20

(c) A PV array of 500 watts has been installed to pump water from a bore-well of 2 meters deep using a submergible motor and pump system to an over-head tank. The length of pipe required to pump the water is 30 meters. Following are the costs involved for the sub-systems and their life spans : PV Array : $8/peak watt; Life span – 15 years Motor and

pump : $2/watt; Life span – 7.5 years Pipe cost : $8/meter; Life span – 5 years cost of digging the bore-well : $20/meter Maintenance Cost : $80/year Miscellaneous Cost : $3.5/watt if the interest rate is 10%, calculate the Life Cycle Cost of the water for a period of 15 years and also water cost per year (ALCC). 20

(d) A piezo-electric transducer has a capacitance of 1000 pF and a charge sensitivity of $40 \times 10^3 \frac{c}{m}$. The connecting cable has a capacitance of 300 pF while the oscilloscope used for readout has a readout input resistance of 1MΩ with a parallel capacitance of 50 pF : 20

(i) What is the sensitivity (V/m) of the transducer alone ?

(ii) What is the high frequency sensitivity (V/m) of the entire measuring system ?

(iii) What is the lowest frequency that can measured with 5 percent amplitude error by the entire system ?

(iv) What is the value of an external shunt capacitance that can be connected in order to extend the range of 5 percent error down to 10Hz ?

2. (a) Find the value of gain k for the feedbacks control system shown in the figure, such that the system will be underdamped and will respond with 16 % overshoot. 20

$$R(s) \xrightarrow{\;+\;} \bigcirc \xrightarrow{\;-\;} \boxed{G(s) = \dfrac{k}{s(s + 5)}} \xrightarrow{\;C(s)\;}$$
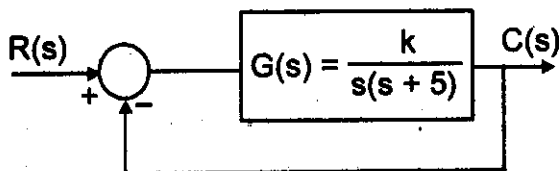
Then calculate the following parameters of the system :

(i) Un-damped natural frequency, w_n

(ii) Damping ratio, ζ

(iii) Time required to reach the first maximum or peak, T_p

(iv) Time required for the transient to reach within 2% of the study-state value, i.e., settling time, T_s

(v) Damped natural frequency, w_d

(b) (i) Consider a closed loop system whose loop transfer function is

$$G(s)H(s) = \frac{Ke^{-T_s}}{s(s+1)}$$

Determine the maximum value of the gain K for stability as a function of dead time T.   10

(ii) Consider a third order system with characteristic equation $S^3 + 3408.3\ S^2 + 1.0204 \times 10^6 S + 1.5 \times 10^7 K = 0$. Find the critical value of K for stability using Routh-Hurwitz criterian. Also find the un-damped frequency corresponding to the zero input response and the critical value of K.   10

(c) The response of a second-order control system has an overshoot of 30% for a step input and the overshoot takes place 0.05 second after the application of the input. Find the transfer function of the system.   20

3. (a) (i) What are the problems arising in differential protection in power transformer and how are they overcome ? 10

(ii) Discuss the various classifications of a circuit breaker with advantages and disadvantages. Also explain how a circuit breaker is to be rated. 10

(b) (i) Certain metal works as superconductor below the critical temperature $T_C = 7.2\,^{\circ}K$. The critical magnetic field for the metal at $0\,^{\circ}K$ is $7.8 \times 10^5\,Amp/m$. What is the critical magnetic field for the metal to be usable as superconductor at $5\,^{\circ}K$? 5

(ii) What are superconductors ? Explain the Meissner effect. Show that perfect diamagnetism and zero resistivity are two independent properties of the superconducting state. 5

(iii) Establish the condition of population inversion in LASERs. How would you justify the presence of negative exponent in the expression ?   5

(iv) Derive an expression for current density in an n-type semiconductor in terms of drift velocity. Show that the conductivity is given by $\sigma = ne\mu_n$.   5

(c) For the power system shown in the figure listed below, calculate the phase voltages and currents, if phases b and c, at node 3, experience a short circuit through a resistance of 6.6 Ω.   20
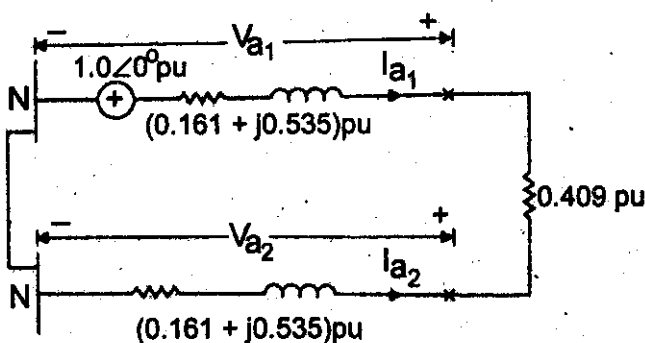
4. (a) Explain using a heat block schematic, why delay lines are used in vertical deflection circuit of a Cathode Ray Oscilloscope (CRO). Name at least two types of delay lines used in a CRO. 20

(b) (i) A copper constant thermocouple was found to have linear calibration between 0 to 400°C, with emf at maximum temperature (reference junction at 0°C) equal to 20.68 mV. Determine the correction which must be made to the indicated emf if the cold junction temperature is 25°C. If the indicated emf is 8.92 mV in the thermocouple circuit, determine the temperature of the hot junction. 10

(ii) Draw and explain the Peak-power-tracking scheme in a wind-energy system. How Specific Rated capacity (SRC) of wind turbine is calculated ? What will be the SRC for a 300/30 wind turbine ? 10

(c) (i) Determine the binary o/p of a successive approximation register type digital voltmeter with 10-bit o/p and the

reference voltage of +5 v for an i/p 2.567 v. Draw the block diagram for the display in $3\frac{1}{2}$ digit LCD.   10

(ii) Explain briefly about sensitivity and loading effect of a voltmeter. The voltage across the 50 kΩ resistor in the circuit shown below in fig. are measured with two voltmeters separately. Voltmeter 1 has a sensitivity of $1000\frac{\Omega}{V}$ and voltmeter 2 has a sensitivity of $20000\frac{\Omega}{V}$. Both the meters are used on their 50 V range. Calculate (i) the reading of each meter and (ii) the error in each reading, expressed as a percentage of the true value,   10
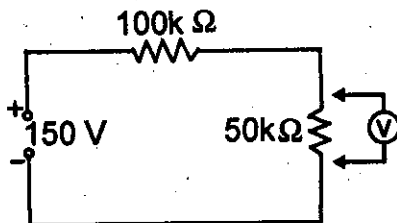
SECTION – B

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

(a) Design a PCM multiplexing system using a 256 levels signal quantizer for the transmission of 3 signals m_1, m_2, m_3, band limited to 5 kHz, 10 kHz and 5 kHz respectively. Assuming that each signal is sampled as its Nyquist rate and 8 bits are transmitted simultaneously.

Compute :   20

(i) Maximum bit duration

(ii) Channel bandwidth required to pass the PCM signal

(iii) The commutator speed in RPM

(iv) The increase in the channel bandwidth if 512 quantization levels are used

(b) State and explain what is meant by G/T ratio of a satellite ground station indicating its significance in satellite communication. How

these components of the ratio are generated in the systems ? State the methods of improving the ratio. 20

(c) Explain the principle of FMCW radar illustrating the block diagram. Discuss the frequency-time relationship considering the Doppler effect. Discuss the advantages and disadvantages of FMCW radar. 20

(d) (i) How many interrupt lines are there in Intel 8085 ? Name them in order of priority. Give their restart location also. 10

(ii) How many Hamming bits are required for a block length of 20 message bits to correct 1-bit error ? 10

6. (a) (i) Why do we use silicon in IC fabrication ? 10

(ii) What is Wafer cleaning and explain its methods ? 10

(b) (i) Describe the Ion implantation process in IC fabrication with suitable diagram. 10

(ii) Explain the suitability of dry etching process in IC fabrication. **10**

(c) Interface an 8-bit microprocessor with a 2K × 8 ROM chip and two 1K × 8 chips such that the following address map is realized : **20**

Device Assignment	Size	Address
ROM chip	2K × 8	0000-07FF
RAM chip 1	1K × 8	0800-0BFF
RAM chip 2	1K × 8	1000-13FF

7. (a) (i) Determine the signal-to-quantization ratio of a Delta modulator for a sinusoidal signal with a bit rate of 64kb/s and input signal bandwidth of 40 kHz. **10**

(ii) An FSK system transmits binary data at the rate of 2.5×10^6 bits per second. During the course of transmission, white Gaussian noise of zero mean and power spectral density 10^{-20} watt per hertz is added to the signal. In the absence of noise, the amplitude of the received

sinusoidal wave for digit 1 or 0 is 1 microvolt. Determine the average probability of symbol error, assuming coherent detection.

[You may use the approximation below].

$$erfc(z) = \frac{exp(-Z^2)}{\sqrt{\pi}.Z}$$

10

(b) An information source produces 8 different symbols with probabilities 1/2, 1/4, 1/8, 1/16, 1/32, 1/64, 1/128, 1/256 respectively. These symbols are encoded as 000, 001, 010, 011, 100, 101, 110 and 111 respectively :   20

(i) What is the amount of information per symbol ?

(ii) What are the probabilities of occurring for a 0 and a 1 ?

(iii) What is the efficiency of the code so obtained ?

(iv) Give an efficient code with the help of the method of Shannon.

(v) What is the efficiency of the code so obtained in (iv) above ?

(c) (i) A radar has a maximum range of 300 km. What will be the maximum allowable pulse repetition frequency for unambiguous reception ? 10

(ii) A pulsed radar operating at 10 GHz has an antenna with a gain of 28 dB and a transmit power of 2 KW. If it is defined to detect a target with cross section of $12m^2$ and the minimum detectable signal S_{min} = – 90 dBm. What is the maximum range of radar ? 10

8. (a) Explain the scanning process in a television system with the help of appropriate diagram. Why Interlaced scanning is preferred over the sequential scanning ? 20

(b) (i) The carrier frequency of an uplink is 6 GHz, the transmitting earth station EIRP is 80 dBW. The satellite receiver G/T is –8dB/K and the transmission losses are 0.6dB. Determine the CNR at the satellite receiver input for an earth station-to-satellite distance of 35,860 km. 10

(ii)In a Fiber Optics Communication link optical fiber with attenuation 0.4 dB/km is used, – 3 dBm optical power is launched from the source on to the fiber. The link uses 3 splices with 1 dB power loss in each and there comes a 1 to 10-star coupler with 3 dB coupling loss at 10 km from the transmitter. Each of the ten receivers uses a photo-detector with 10 nW/M. bit/sec sensitivity. What can be the maximum link length if data rate is 100 Mbit/sec ?   10

(c) An optical fiber cable has a core of 1.45 refractive index and 10 μm diameter, with a fractional index difference of 0.3%. Determine its numerical aperture, permissible wavelengths for single-mode and multi-mode operations, acceptance and critical angles.   20

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