CSM – 25/16
Electrical Engineering
Paper – II

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 **three** of the remaining questions, selecting at least **one** from each Section.*

SECTION – A

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

   (a) (i) Explain Silsbee effect and write the expression for critical current density.

   (ii) Calculate the critical current density which can flow through a long thin superconducting wire of aluminium of diameter 1 mm the critical magnetic field for Al is 7.9×10^3 A/m. Also derive Claussius-Mosotti equation. **[20]**

(b) A 20 MVA, 11 kV generator with $X_d'' = 15\%$ is connected through a transformer to a bus which supplies five identical motors as given below.

The sub transient reactance X_d'' of each motor is 20% on the base of 5000 kV A, 6.6 kV. The 3-φ rating of the transformer is 25,000 kV A, 11 kV/6.6 kV with leakage reactance of 10%. The bus voltage at the motor is 6.6 kV. when 3 – φ fault occurs at a point P.

Calculate the sub transient current through the breaker A utilising the Z-bus matrix. **[20]**

Motors
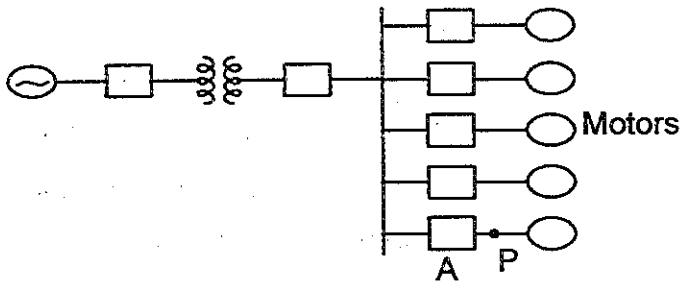
(c) In a certain telemetry systems, eight message signals having 2 – kHz band widths each are time-division multiplexed using a binary PCM. The error in sampling amplitude

cannot be greater than 1% of the peak amplitude. Determine the minimum transmission bandwidth required if raised - cosine pulses with roll off factor $\alpha = 0.2$ are used. The sampling rate must be at least 25% above the Nyquist rate. [20]

(d) Sketch the root locus from the open loop transfer function given below and determine its stability : [20]

$$G(s)\,H(s) = \frac{k(s+1)}{s(s-0.2)(s^2 + s + 0.6)}$$

2. (a) A C-band earth station has an antenna with a transmit gain of 54 dB. The transmitter output power is set to 100 W at a frequency of 6.100 GHz. The signal is received by a satellite at a distance of 37,500 km by an antenna with a gain of 26 dB. The signal is then routed to a transponder with a noise temperature of 500 K, a bandwidth of 36 MHz, and a gain of 110 dB : [20]

(i) Calculate the path loss at 6.1 GHz. Wavelength is 0.04918 m.

(ii) Calculate the power at the output port (sometimes called the output waveguide flange) of the satellite antenna, in dBW.

(iii) Calculate the noise power at the transponder input, in dBW, in a bandwidth of 36 MHz.

(iv) Calculate the carrier power, in dBW and in watts, at the transponder output.

(b) Derive the relations of acceptance angle in terms of refractive index of core and cladding.

A single-mode fiber is made with a core diameter of 12 μm and is coupled to a laser diode that produces 1.3 μm light. Its core glass has a refractive index of 1.55 :   **[20]**

(i) Find the maximum value required for the normalized index difference.

(ii) Find the refractive index required for the cladding glass.

(iii) Find the fiber acceptance angle.

(c) With the help of block diagram, show the interfacing of a digital computer with the

analog required for controlling and monitoring of a physical variable (assumed to be analog). Explain the function of its importance blocks.

Interface an 8-bit microprocessor with a 2K × 8 ROM chip and two 1K × 8 chips such that the following address map is realised : **[20]**

Device	Size	Address Assignment
ROM chip	2K × 8	0000 – 07FF
RAM chip 1	1K × 8	0800 – OBFF
RAM chip 2	1K × 8	1000 – 13FF

3. (a) A 20 MVA, 50 Hz generator delivers 18 MW over a double circuit line to an infinite bus. The generator has kinetic energy of 2.52 MJ/MVA at rated speed. The generator transient reactance is $X'_d = 0.35$ pu. Each transmission circuit has R = 0 and a reactance of 0.2 pu on a 20 MVA base. $|E'| = 1.1$ pu and infinite bus voltage V = 1.0 $\angle 0^\circ$. A three-phase short circuit occurs at the

midpoint of one of the transmission lines. Plot swing curves with fault cleared by simultaneous opening of breakers at both ends of the line at 2.5 cycles and 6.25 cycles after the occurrence of fault. Also, plot the swing curve over the period of 0.5 sec if the fault is sustained. **[20]**

(b) What is the principle of solar photovoltaic power generation ? What are the main elements of PV system integrated with power grid ? Mention the advantages and disadvantages of photovoltaic solar energy conversion. **[20]**

(c) Describe the Hall effect in semiconductor bar specimen. Derive the expression for the Hall voltage.

An n-type Ge sample is 2 mm wide and 0.2 mm thick. A current of 10 mA is passed through the sample (x-direction) and magnetic field of 0.1 Wb/m^2 is directed perpendicular to the current flow (z-direction).

The developed Hall voltage is $- 1.0$ mV. Calculate the Hall coefficient and electron concentration. [20]

4. (a) Sketch the Nyquist plot and examine the closed loop stability of a control system having open loop transfer function given below : [20]

$$G(s)H(s) = \frac{ks(1+2s)}{s^3 + 4s + 8}$$

(b) A plant with the transfer function G(s) H(s) = $\frac{900}{s(s+1)(s+9)}$ with a unity feedback is to be compensated such that the gain crossover frequency of the compensated system become same as the phase crossover frequency of the uncompensated system and has a phase margin of $45°$. Suggest the suitable compensator and determine its transfer function. [20]

(c) What is the difference between accuracy and precision of a measuring instrument ? Explain the sensitivity of Voltmeter.

WG – 25/6 (7) (Turn over)

Suppoose that the components shown in figure below have the following values :

$R_1 = 400\Omega$, $R_2 = 600\Omega$, $R_3 = 1000\Omega$, $R_4 = 500\Omega$ and $R_5 = 1000\Omega$.
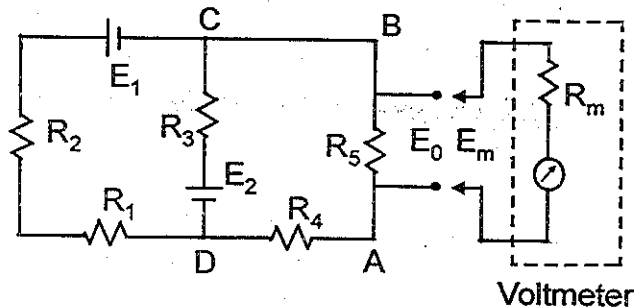
Voltmeter

The voltage across AB is measured by a voltmeter whose internal resistance is $9500\ \Omega$. What is the measurement error caused by the resistance of the measuring instrument ?

[20]

SECTION – B

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

(a) Consider the 4-bus system of Figure below. Buses 1 and 2 are generator buses, and 3 and 4 are load buses. The generators are

rated at 11 kV, 100 MVA, with transient reactance of 10% each. Both the transformers are 11/110 kV, 100 MVA with a leakage reactance of 5%. The reactances of the lines to base of 100 MVA, 110 kV are indicated on figure. Obtain the short circuit solution for a three-phase solid fault on bus 4. Assume prefault voltages to be 1 pu and pre-fault currents to be zero. [20]
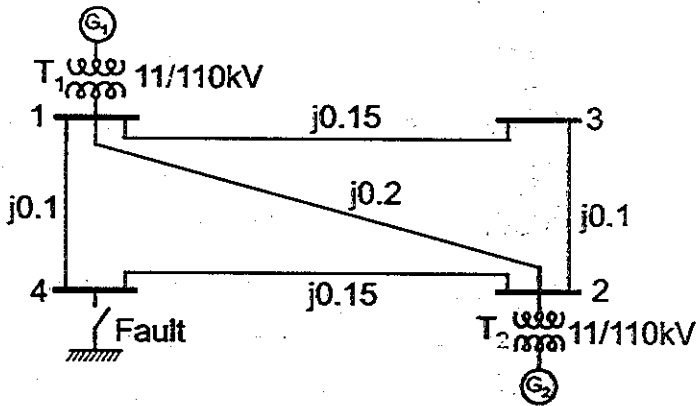
(b) What are the basic components of Wind Energy Conversion System ? Draw the block diagram of WECS (Wind Energy

Conversion System). Explain the purpose of aero turbine and controller.

Wind at 1 standard atmospheric pressure and 15° C has velocity of 15 m/s, calculate : [20]

(i) The total power density in the wind stream.

(ii) The maximum obtainable power density ?

(iii) A reasonally obtainable power density.

(iv) The total power.

(v) The torque and axial thrust.

(c) Define Transducers and classify the transducers on the basis of Active and Passive Transducer. Give examples.

And LVDT has a maximum core motion of ±1.5 cm with a linearity of $\pm0.3\%$ over that range. The transfer function is 23.8 mV/mm. If used to track work-piece motion from -1.2 to $+1.4$ cm, what is the expected output voltage ? What is the uncertainty in position determination due to non linearity ? [20]

(d) Determine the damping ratio and undamped natural frequency of oscillatory roots and percent peak overshoot for a unit step input given that: [20]

$$\frac{C(s)}{E(s)} = \frac{1}{s(1+0.5s)(1+0.2s)}$$

and the system is feedback type.

6. (a) For a (6, 3) systematic linear block code, the three pairty check bits c_4, c_5 and c_6 are formed from the following equations: [20]

$$c_4 = d_1 \oplus d_3$$
$$c_5 = d_1 \oplus d_2 \oplus d_3$$
$$c_6 = d_1 \oplus d_2$$

(i) Write down the generator matrix G.

(ii) Construct all possible code words.

(iii) Suppose that the received word is 010111. Decode this received word by finding the location of the error and the transmitted data bits.

(b) A geosynchronous satellite link at 36000 km has the following parameters:

WG – 25/6 (11) (Turn over)

At satellite :

(i)   Transmitting Power = 40 dBm.

(ii) Dish Antenna diameter = 0.5 m.

At earth station :

(i)   Dish Antenna diameter = 10m.

(ii) Receiver's equivalent noise temperature = 270° K.

(iii) Receiver of bandwidth = 10 MHz.

Estimate the downlink budget at 12 GHz and the C/N ratio at earth station receiver assuming 65% aperture efficiency for both the antenna. **[20]**

(c) 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, 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 channel bandwidth if 512 quantization levels are used.

7. (a) List the five basic processes involved in fabrication of an IC, assuming you already have a substrate.

How is the surface layer of SiO_2 formed ? How thick is this layer ? What are the reasons for forming the SiO_2 layers ? **[20]**

(b) A synchronous generator is rated at 20 MVA, 13.8 kV. It has $X_1 = 0.25$ p. u, $X_2 = 0.35$ p. u., $X_0 = 0.10$ p. u. The neutral is solidly grounded. The machine is on no load and is operating at rated voltage when a D-L-G fault occurs at its terminals. Find the subtransient current in all the phases and fault (all in amps) and the line-to-line voltage in all the phases (in kV). **[20]**

(c) What are superconductors ? Explain Meissner effect. Show that the perfect

diamagnetism and zero resistivity are two independent properties of the superconducting state.

Certain metal works as superconductors below the critical temperature $T_c = 7.2°K$. The critical magnetic field for the metal at $0°$ K is 7.8×10^5 Amp/m. What is the critical magnetic field for the metal to be usable as superconductor at $5°K$? [20]

8. (a) A thermistor is to monitor room temperature. It has a resistance of 3.5 kΩ at $20°C$ with a slope of $-10\% /°C$. The dissipation constant is $P_D = 5mW/°C$. It is proposed to use the thermistor of figure given below to provide a voltage of 5.0 V at $20°C$. Evaluate the effects of self heating. [20]

10 V

3.5 kΩ

$\rightarrow V_D$

R_{TM}
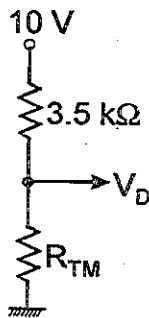
(b) Differentiate between step index and graded index fibers.

Determine the optical power received in dBm and watt for a 20 km optical fibre link with the following parameters :

LED output power of 30mW. Four 5-km sections of optical cable each with a loss of 0.5 dB/km. Three cable to cable connectors with a loss of 2 dB each. No cables splices. Light source-to-fibre interface loss of 1.9 dB. Fibre-to-light detector loss of 2.1 dB. No losses due to cable bands. [20]

(c) Distinguish between hardwired control and micro-programmed control. For an 8085 microprocessor :

(i) Write an instructions to left shift 16-bitdata stored in 16-bit register pair.

(ii) What should generally be the first instruction for an assembly language program containing CALL instructions ? What is its significance ?

(iii) An assembly language program is given below :

MVI	A, B5H
MVI	B, 0EH
XRI	69H
ADD	B
ANI	9BH
CPI	9FH
STA	3010H
HLT	

What is the status of "carry" and "zero" flags after the execution of the program ?

[20]

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