

ELECTRICAL ENGINEERING

Time : 3 hours]

[Full Marks : 100

- Notes :** (i) Answer the questions as directed.
(ii) The figures in the right-hand margin indicate full marks for the questions.
(iii) Group—A is compulsory and attempt *any four* questions from Group—B.

GROUP—A

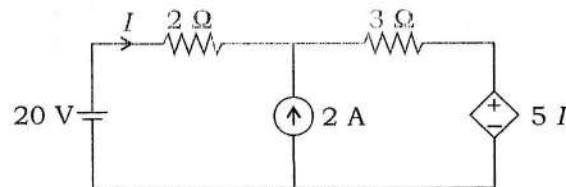
(Compulsory Group)

1. Attempt any *ten* questions from the following :

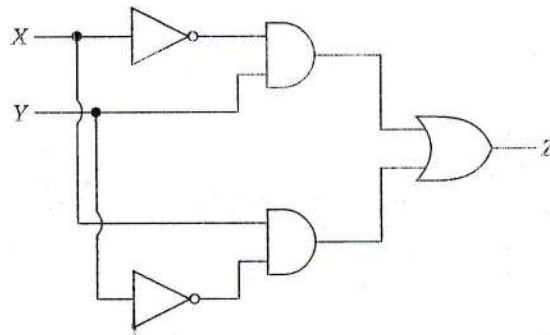
2×10=20

(a) A 5 kVA, 50 V/100 V, single-phase transformer has a secondary terminal voltage of 95 V when loaded. What is the voltage regulation of the transformer?

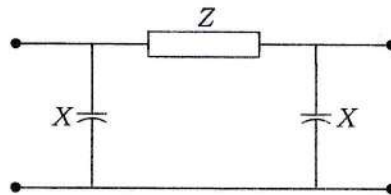
(b) Find out the current I flowing in the circuit shown below in amperes :



- (c) The total impedance of the secondary winding, leads and burden of a 5 A CT is 0.01Ω . If the fault current is 20 times the rated primary current of the CT, compute the VA output of the CT.
- (d) A moving-coil instrument having a resistance of 10Ω gives a full-scale deflection when the current is 10 mA. What should be the value of the series resistance, so that it can be used as a voltmeter for measuring potential difference up to 100 V?
- (e) For the logic circuit shown below, X and Y are digital inputs, and Z is a digital output. Represent the function of the circuit with the help of a single logic gate :



- (f) What will be the task for the 8085 microprocessor for the instruction LXIH, 2500H?
- (g) The measured value of resistance is 10.25Ω , whereas its value is of 10.22Ω . What is the absolute error of the measurement?
- (h) The line currents of a three-phase, four-wire system are square waves with an amplitude of 100 A. These three currents are phase shifted by 120° to each other. What will be the rms value of neutral current?
- (i) A $0.1 \mu\text{F}$ capacitor charged to 100 V is discharged through a $1 \text{ k}\Omega$ resistor. How much time is required for the voltage across the capacitor to drop to 1 V?
- (j) A 4-pole induction machine is working as an induction generator. The generator supply frequency is 60 Hz. The rotor current frequency is 5 Hz. Calculate the mechanical speed of the rotor.
- (k) A phase-controlled, single-phase, full-bridge converter is supplying a highly inductive DC load. The converter is fed from a 230 V, 50 Hz AC source. Calculate the fundamental frequency in Hz of the voltage ripple on the DC side.
- (l) The nominal π circuit of a transmission line is shown below :



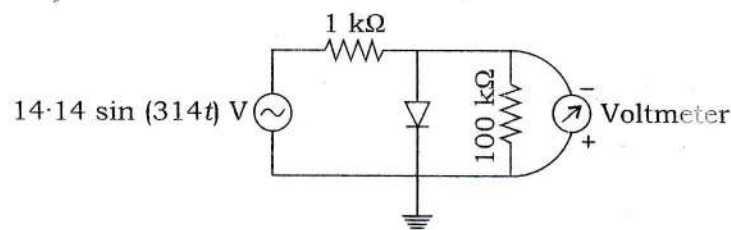
Impedance $Z = 100 \angle 80^\circ \Omega$ and reactance $X = 3300 \Omega$. Compute the magnitude of the characteristic impedance of the transmission line.

GROUP—B

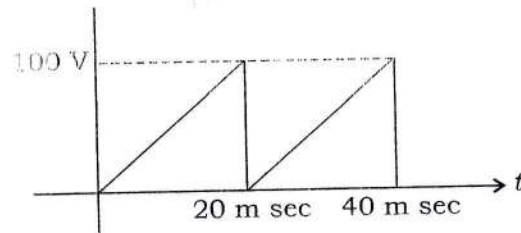
2. Attempt any *four* questions from the following :

5×4=20

- (a) Prove that single-phase induction motors are not self-started.
- (b) Explain Ferranti effect in case of high-voltage long transmission lines.
- (c) The input impedance of the permanent magnet moving coil (PMMC) voltmeter is infinite. Assuming that the diode shown in the figure below is ideal, what will be the reading of the voltmeter?



- (d) The sawtooth voltage waveform shown in the figure below is fed to a moving iron voltmeter. What will be the reading of the voltmeter?



- (e) Derive the average output voltage in case of a three-phase, six-pulse uncontrolled rectifier.
- (f) A bulb in a staircase has two switches, one switch being on the ground floor and the other one on the first floor. The bulb can be turned ON and also can be turned OFF by anyone of the switches irrespective of the state of the other switch. The logic of switching of the bulb resembles with which of the logic gate?

3. Attempt any *four* questions from the following :

5×4=20

- (a) Explain the pin diagram of a programmable interrupt controller INTEL 8259.
- (b) If the fault current is 2000 A, the relay setting is 50% and CT ratio is 400:5, then calculate the plug setting multiplier.
- (c) In a 2-pole lap-winding d.c. machine, the resistance of one conductor is $2\ \Omega$ and the total number of conductors is 100. Find the total resistance.
- (d) If two meters X and Y require 40 mA and 50 mA respectively to give full-scale deflection, identify the meter which is more sensitive than the other.
- (e) Two heaters, rated 1000 watt, 250 V, each is connected in series across a 250 V, 50 Hz AC mains. Calculate the total power drawn from the supply.
- (f) Two wires A and B of the same material and length l and $2l$ have radius r and $2r$ respectively. Calculate the ratio of their specific resistances.

4. Attempt any *four* questions from the following :

5×4=20

- (a) An SCR has half-cycle surge current rating of 3000 A for 50 Hz supply. What will be one-cycle surge current?
- (b) Four identical alternators each is rated for 20 MVA, 11 kV having a sub-transient reactance of 16% are working in parallel. Calculate the short-circuit level at the bus bar.
- (c) Convert the binary number (1111000011110000) to hexadecimal number.

- (d) The speed of the salient pole rotor of a synchronous generator, used in hydropower plants, is 200 rpm. What will be the number of poles required when its output frequency is 50 Hz?
- (e) What will be the total flux emitted by a source of 60 candle power?
- (f) A step-up chopper has input voltage 110 V and output voltage 150 V. Calculate the value of the duty cycle.

5. Attempt any *four* questions from the following :

5×4=20

- (a) For a short transmission line with R/X ratio of 1 and the voltage regulation zero, what will be the load power factor?
- (b) Using the Routh-Hurwitz criterion, determine the number of roots of the equation $s^4 + s^3 - 5s^2 + s - 6 = 0$ with negative real parts.
- (c) Explain the process of measuring an unknown inductance using Maxwell's inductance bridge.
- (d) A single-phase, 30 km long overhead transmission line consists of two parallel long straight conductors with 5 mm diameter each and spaced 1.5 m apart. If the line voltage is 50 kV and frequency is 50 Hz, determine the charging current of the open-circuited line.
- (e) Realize the following function using only NAND gates :
- $$f = \bar{A}B(\bar{C} + \bar{D}) + A\bar{B}C + \bar{B}CD$$
- (f) A four-pole, lap-wound, 11.5 kW, 230 V DC shunt generator has an armature resistance of 0.2Ω and shunt field resistance of 100Ω . Calculate e.m.f. generated if the brush contact drop is 1 V/brush and the generator is driven at 1000 rpm. Assume, 1200 number of conductors are in the armature.

6. (a) A three-phase, 500 V, star-connected alternator supplies power to a 1500 kW delta-connected induction motor operating with a power factor of 0.85 (lag.) and an efficiency of 0.93. Calculate the active and reactive components of currents in each motor phase.

10

- (b) A 10 kVA, 5000 V/440 V, 25 Hz, single-phase transformer has a copper loss, eddy current loss and hysteresis loss of 1.5%, 0.5% and 0.6% of output on full load. What will be the percentage of losses, if the transformer is used on a 50 Hz system keeping the full-load current constant? Assume unity power factor operation.

10

7. (a) Two point charges $2 \mu\text{C}$ and $4 \mu\text{C}$ are located in free space at $(0, 0, 0)$ and $(0.8, 0, 0)$ respectively. Determine the electric field intensity at the point $P(0.4, 0.3, 0)$. 10
- (b) A dynamometer wattmeter with its voltage coil connected across the load side of the instrument reads 220 watt. If the load voltage is 200 V, what power is consumed in the load if the voltage coil has a resistance of 4000Ω ? Neglect the current coil resistance. 10
8. (a) A unit feedback system has an open-loop transfer function of $G(s) = \frac{K \cdot s(1+3s)}{s^3 + 2s + 3}$. Find the values of the parameter K for which the closed-loop system is stable. 10
- (b) A hydroelectric station operates under a mean head of 50 m. The reservoir employed has a catchment area of 500 km^2 . The average rainfall is 150 cm per annum. Determine the capacity of the station. Assume 25% of rainfall is lost due to evaporation and 7.5% of the head is lost in the penstock. Given, the efficiency of the turbine and alternator as 85% and 95% respectively. 10
