This question paper contains 8 printed pages]

CODE : FRO-2017

ELECTRICAL ENGINEERING

Roll. No. .....

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

Note :— (*i*) Question paper consists of two parts viz. Part I and Part II. Each part contains *four* questions. The paper as a whole carries *eight* questions. Question Nos. **1** and **5** are compulsory. The candidates are required to attempt *three* more questions out of the remaining six questions taking at least *one* question from each part i.e. this is in addition to the compulsory question of each part. Attempt *five* questions in all. *All* questions carry equal marks. The parts of a question are to be attempted at one place in continuation. Answers should be brief and to the point.

(*ii*) Parts of same question must be attempted together and not to be attempted in between the answers to other questions.

P.T.O.

Part I

1. (*a*) For the system shown in Fig. 1 :

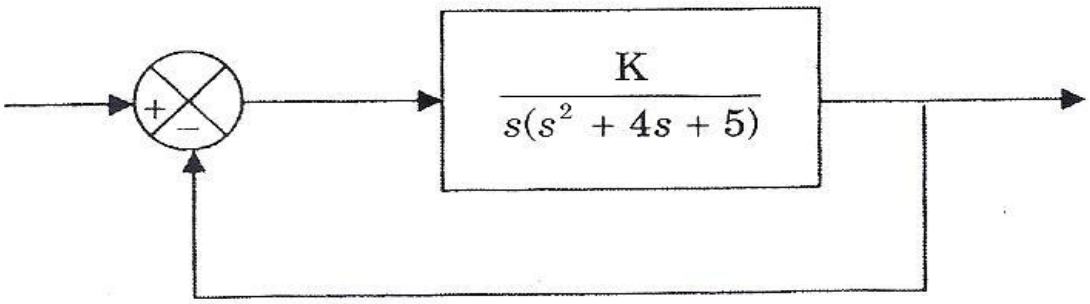

Fig. 1

(*i*) Sketch the root loci for the system.

(*ii*) Find the range of K for which all the closed-loop poles are real.

(*iii*) Find the range of K for which the system is underdamped.

(*b*) Solve the difference equation to obtain X(z) :

$$x(k + 2) - 3x(k + 12) + 2x(k) = 4^k;$$

$$x(0) = 0,\ x(1) = 1.$$

Also find $x(k)$ in terms of initial condition response and forcing function response.

2. (*a*) In spherical coordinates, V = 865V at r = 50 cm and $\vec{E} = 748.2\,\hat{a}_r$ V/m at r = 85 cm.
Determine the location of the voltage reference if the potential depends only on r.

(*b*) Define polarization. Differentiate between electronic and ionic polarizations. Explain mechanism of orientational polarization with neat sketches. Derive the formula for electronic polarizability in terms of atomic radius.
Calculate the electronic polarizability of an isolated Se atom, which has atomic radius r_0 : 0.12 nm.

3. (*a*) (*i*) Describe a method by which the insulation resistance to earth of each of a pair of live mains can be measured by a voltmeter of known resistance. Discuss the limitations of the method.

(*ii*) The following readings were taken with a 250 volt, 1000 ohms/volt voltmeter :
Between two mains : 218 volt
Positive main to earth : 188 volt
Negative main to earth : 10 volt
Calculate the insulation resistance of each main.

(*b*) Find current in the 6 Ω resistance in the circuit shown in Fig. 2 using Thevenin's theorem :

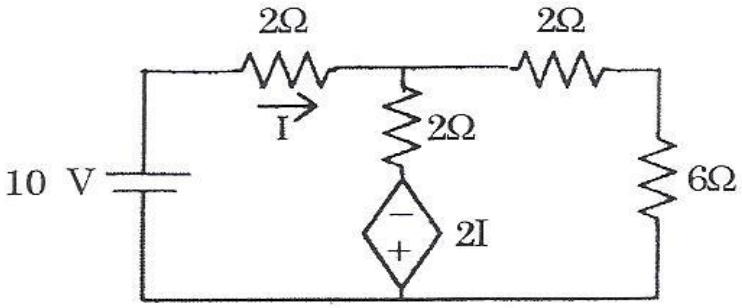

Fig. 2

4. (*a*) (*i*) Explain the conditions that must be fulfilled for operating two 3-phase transformers in parallel.

(*ii*) Two 3-phase transformers, rated at 500 kVA and 450 kVA respectively, are connected in parallel to supply a load of 1000 kVA at 0.8 pf lagging. The per phase resistance and per phase leakage reactance of the first transformer are 2.5% and 6% respectively and of the second transformer 1.6% and 7% respectively. Calculate the kVA load and power factor at which each transformer operates..

(*b*) A 3-phase, 6-pole, 50 Hz, 400 V induction motor develops maximum torque at a slip of 10%. In a particular application, it runs at 5% slip at rated voltage, driving a load whose torque demand is proportional to square of the speed. What is the minimum value to which the supply voltage can drop if the speed of the motor is not to decrease below 900 rpm ? Neglect stator impedance drop.

Part II

5. (*a*) A generator connected through a 3-cycle circuit breaker to transformer is rated 10 MVA, 13.8 kV with reactance of $X_d'' = 10\%$, $X_d' = 15\%$ and $X_d = 100\%$. It is operating at no load and rated voltage when a 3-phase short circuit occurs between the breaker and the transformer. Determine :

(*i*) The sustained short circuit current in the breaker.

(*ii*) The initial symmetrical rms current in the breaker.

(*iii*) The maximum possible d.c. component of the short circuit current in the breaker.

(*iv*) The current to be interrupted by the breaker and

(*v*) The interrupting kVA.

(*b*) Show mathematically how the distance relays should be connected so that they provide equally sensitive protection against three-phase and phase-to-phase faults. Give the connection diagram also.

6. (*a*) Why is analog-to-analog modulation technique required ? Derive the relation between output power of an AM transmitter and the depth of modulation.

(*b*) Discuss the microprocessor based scheme to measure and display phase angle and power factor. Draw the schematic diagram of interface. Draw the flow chart and write the program.

7. (*a*) Determine R_B and R_C for the transistor inverter shown in Fig. 3 if I_{Csat} = 10 mA.

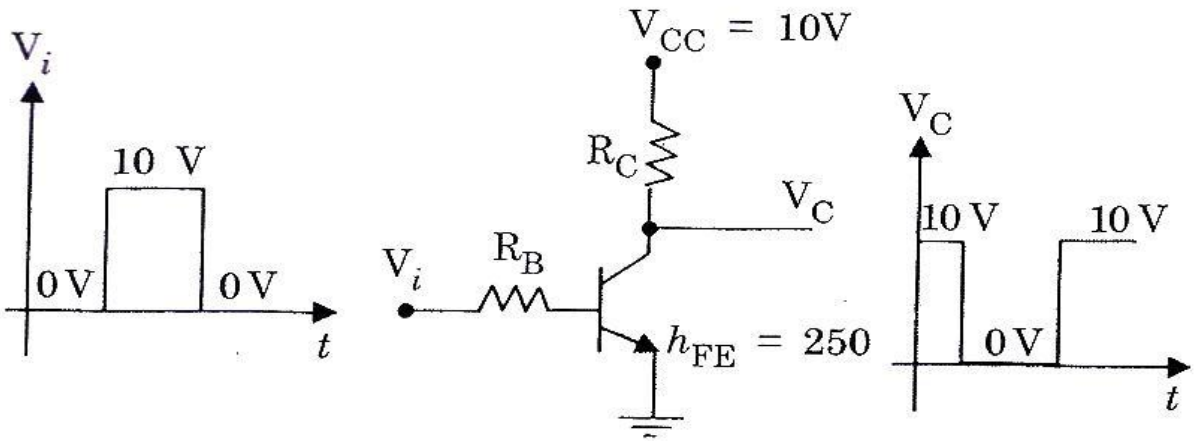

Fig. 3

(*b*) Design a decade counter using SR Flip Flop and explain its operation.

8. (*a*) A single-phase full-bridge thyristor inverter has a resistive load of R = 3Ω, and the dc input voltage of 50 V. Calculate :

(*i*) The RMS output voltage at the fundamental frequency

(*ii*) The output power

(*iii*) The average and peak currents of each thyristor

(*iv*) The peak reverse-blocking voltage of each thyristor.

(*b*) A step-down dc to dc converter connected to source V_s = 220 V is feeding an RL load, where R = 5 Ω, L = 7.5 mH. The switch is operating at f = 1 kHz with duty ratio k = 0.5. Calculate :

(*i*) The minimum instantaneous load current.

(*ii*) The peak instantaneous load current.

(*iii*) The maximum peak-to-peak load ripple current.

(*iv*) The average and rms values of load current.

(*v*) The effective input resistance seen by the source.