

ELECTRICAL ENGINEERING (Paper II)

Time Allowed : Three Hours

Maximum Marks : 300

QUESTION PAPER SPECIFIC INSTRUCTIONS

(Please read each of the following instructions carefully before attempting questions)

There are EIGHT questions divided in two Sections.

Candidate has to attempt FIVE questions in all.

Question Nos. 1 and 5 are compulsory and out of the remaining, any THREE are to be attempted choosing at least ONE question from each Section.

The number of marks carried by a question/part is indicated against it.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Word limit in questions, wherever specified, should be adhered to.

SECTION 'A'

1. (a) Why is a *LVDT* excited by high frequency and low voltage? Derive the *LVDT* output, e_o , in terms of excitation voltage, winding resistance and inductances. A bridge *ABCD* has resistors in its four arms. R_1 in arm *AB*, R_2 in arm *BC*, dummy gauge in arm *AD*, and active gauge in arm *CD*. If a strain of $1250 \mu\text{m/m}$ is applied, find the bridge offset voltage across *AC* if the bridge is supplied with a voltage of 12 V across *BD*. Assume, $R_1=R_2=R_{\text{dummy gauge}}=350 \text{ ohm}$ and $R_{\text{active strain gauge}}=350 \text{ ohm}$ has gauge factor ($GF=2.0$). 20
- (b) (i) Explain the functions of static VAR systems in *EHV AC* transmission. (ii) Discuss different types of static VAR systems (SVS) with the aid of neat figures. 20
- (c) Write an 8085 assembly level program for designing the following system: When a coin is inserted and when it is valid, port 1 gives code FFH. If it is valid, check whether the request is for tea or coffee at port 2. 04H code at port 2 is the request for tea and 40H code at port 2 is the request for coffee. Open the valve for liquid to come out with 04H code for tea and 40H code for coffee at port 3. These codes at port 3 are to be used for valve operation. When port 4 gives code 00H, valve is to be closed with code FFH. Repeat process can start with a new coin. If coin is invalid, 00 indication at port 5 is to be given and the instruction for inserting a new coin can be given. Write comments in the selected lines of the program. 20
2. (a) The loop Transfer function of a system is given by

$$G(s)H(s) = (7s+4)/(s^2(s^3+4s^2+8s+8)).$$

Find the number of roots located on the imaginary axis and also their values using the Routh table. Is there any root on the right hand side of the *s*-plane? 20
- (b) (i) Differentiate between “Restriking Phenomenon” and “Reclosing Phenomenon” in a circuit breaker. Which one is harmful and which one is useful and why? (ii) A simple power system is shown operating on NO LOAD.

[Figure: a.c. source (generator) connected through a series inductance *L* to a node; capacitance *C* from that node to the return line; from the same node a circuit breaker (box marked “CB closed”) leads to the output terminals, which are marked “open circuit” (no load connected)]

A fault occurs at the far end of the system and the breaker contacts separate. Derive an expression for the voltage across the breaker contacts. Find the frequency of oscillation of the recovery voltage. What is the highest value of the Restriking Voltage and when does it occur. 20
- (c) (i) A two bus system is shown in the figure below: 20

[Figure: Two-bus system: generator 1 connected to bus ① with power P_{G_1} injected (arrow towards bus ①); a transmission line from bus ① to bus ②; generator 2 connected to bus ② with power P_{G_2} injected (arrow towards bus ②); load taken from bus ② (downward arrow marked "Load")]

If 100 MW power is transferred from plant 1 to load, a loss of 12 MW is incurred. System incremental cost is $\lambda = \text{Rs. } 30/\text{MWh}$. The incremental costs of the two plants are given by: $dC_1/dP_{G_1} = 0.02 P_{G_1} + 16.0 \text{ Rs./MWh}$, $dC_2/dP_{G_2} = 0.04 P_{G_2} + 20.0 \text{ Rs./MWh}$. Determine P_{G_1} , P_{G_2} and power received by load. (ii) Derive the economic dispatch criterion for a power system consisting of thermal plants with transmission losses.

3. (a) (i) Explain the 'principle of the argument' of the complex-variable theory. (ii) Explain how this is adopted to determine the stability of control systems. (iii) The critical point in using the Nyquist criterion is $(-1, j0)$ in $G(s)H(s)$ plane and not the origin $(0, j0)$. Why? (iv) For minimum phase transfer function, $G(s)H(s)$, the polar plot is sufficient to determine the stability of the system. Explain. 20
- (b) (i) Explain comparatively steady state, dynamic and transient stability of a power system. (ii) Explain point-by-point method of solving swing-equation stating clearly the assumptions made. 20
- (c) A certain ring feeder has 6 sections. It is fed at one point only. Using non directional and directional overcurrent relays with suitable line lag, explain the method of protecting this feeder. Assume a minimum operating time of 60 ms for the relays. In the diagram to be drawn, the location of all the relays and whether they are directional or non directional are to be shown. Also the time of operation of all the relays is to be shown by the side of the relay. 20
4. (a) Explain, why the pointer of a single phase dynamometer type power factor meter remain in the same position even after the excitation source is switched off, that is, it does not come back to zero position. Explain the principle of operation of the power factor meter. How would the accuracy of such an instrument be affected by frequency and wave form variations. 20
- (b) Explain the similarities and differences between: (i) JUMP and CALL instructions (ii) STA and STAX instructions 20
- (c) Mention the salient points of relation between the delta modulation (DM) and differential pulse code modulation (DPCM). Draw the block diagram of delta modulator and demodulator. Explain threshold and overloading effects in delta modulation. How can a slope overload noise, which occurs due to threshold and overloading, be reduced? 20

SECTION 'B'

5. (a) A model of the attitude control of a space booster on take off is represented by an inverted pendulum mounted on a motor driven cart shown in the above figure. The objective of the attitude control problem is to keep the pendulum in a vertical position. The pendulum can be assumed to move only in one plane (say the xy plane). The control force 'u' is applied to the cart. The centre of gravity of the pendulum is at its centre. The moment of inertia of the pendulum is 'I'. The mass of the pendulum is 'm' and the cart is 'M'. Obtain a mathematical model.

[Figure: (printed above the text) Inverted pendulum on a cart: cart of mass M on wheels on a horizontal floor (x-axis to the right), a fixed wall at the left forming the y-axis; horizontal distance x measured from the wall (y-axis) to the pivot of the pendulum on top of the cart; pendulum (rod) pivoted on the cart, tilted to the right by angle θ from the vertical; total length $2l$ marked as l from the pivot to the centre and l from the centre to the top; weight mg acting downward at the centre; height of the centre above the pivot marked $l\cos\theta$; control force u applied horizontally to the cart (arrow to the right); x-direction arrows at the cart top and at the floor]

20
- (b)(i) What is "resistance switching" as applied to circuit breaker operation? Why is it resorted to? Derive an expression for the value of the resistance to be used in terms of system parameters. 10

- (b)(ii) A transmission line is protected by a three zone plain Impedance. Draw the characteristics of this relay in the $R-X$ diagram. If this relay is provided with a directional feature, what modification is to be made in the characteristics drawn on the $R-X$ diagram. Also draw the contact diagram of the arrangement assuming directional feature. 10
- (c) Pulse code modulation (PCM) is the most useful and widely used of all pulse modulations. How does an analog signal get converted to digital signal by the PCM? By which process non-uniform quantization is practically achieved? Draw a diagram of a model, which does this process. Explain its working. 20
6. (a) Explain the working principle of a “Harmonic Distortion Meter”. State some of its typical technical specifications. Also describe, how is the resistance measured with an electronic multimeter. 20
- (b) The interrupt is a process of data transfer whereby a peripheral can inform the processor that it is ready for communication. How can interrupt be masked or unmasked using a program control? List the instructions used for control of interrupts. Explain any one by taking a suitable example. 20
- (c) Two important types of error-correcting codes are: (i) block codes and (ii) convolutional codes. Write the main difference between the block codes and convolutional codes. Explain the codes, which are a subclass of linear block codes. 20
7. (a) Why is a Schering bridge particularly suitable for measurement at high voltage? Draw high voltage Schering bridge line diagram, showing the high voltage transformer. The Wien bridge is used to measure the frequency of excitation voltage. Derive the frequency relation in terms of bridge elements. 20
- (b) What are the functions of DMA (Direct Memory Access)? How are HOLD and $\overline{HLDA}$ lines used in DMA operation? List the data transfer modes of DMA controller. Describe each mode in brief. 20
- (c) The network layer of OSI (Open Systems Interconnection) has two major functions, namely (i) routing of packets through the network and (ii) a flow control. Explain each of these two functions taking suitable examples. Prove that the network layer is the most sophisticated of the layered architecture. 20
8. (a) A system is described by the following state variable equation

$$[\dot{x}_1; \dot{x}_2; \dot{x}_3] = \begin{bmatrix} 1 & 2 & 1 & 0 & 1 & 3 & 1 & 1 & 1 \end{bmatrix} [x_1; x_2; x_3] + \begin{bmatrix} 1 & 0 & 1 \end{bmatrix} u$$

 (i) Find its characteristic equation. (ii) Determine the controllability matrix. (iii) Is the system controllable? 20
- (b) (i) With the aid of a neat figure, state the main components of a converter station of HVDC transmission system and explain the function of each component. (ii) Differentiate between two-terminal point to point dc transmission link and back to back dc link with an example of these links existing in India. 20
- (c) (i) Why do you need the harmonic restraint in the application of differential protection to power transformers? With the help of relevant circuit diagram, explain how this harmonic restraint scheme operates? (ii) “Relays are comparators”. Justify this statement. Show that an inherent two input amplitude comparator can work as a phase comparator and vice-versa. 20