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महाराष्ट्र विद्युत अभियांत्रिकी सेवा (मुख्य) परीक्षा - २०२३, दि. २८ जानेवारी, २०२४

(पेपर - II)

2023

R18

BOOKLET NO.
400101

Electrical Engineering
Paper – II

Time Allowed : Three Hours **Maximum Marks : 200**

Medium : English **Type of Paper : Conventional**

Question Paper Specific Instructions

Please read each of the following instructions carefully before attempting question :

1. There are **EIGHT** questions divided in two sections, out of which **FIVE** are to be attempted.
2. Questions no. 1 and 5 are compulsory. Out of the remaining questions, THREE are to be attempted choosing at least ONE question from each Sections.
3. The number of marks carried by a question/sub question is indicated against it.
4. Keep in mind the word limit indicated in the question if any.
5. Wherever option has been given, only the required number of responses in the serial order attempted shall be assessed. Unless struck off, attempt of a question shall be counted even if attempted partly. Excess responses shall not be assessed and shall be ignored.
6. Candidates are expected to answer all the sub-questions of a question together. If sub-question of a question is attempted elsewhere (after leaving a few page or after attempting another question) the later sub-question shall be overlooked.
7. Any page or portion of the page left blank in the Answer Booklet must be clearly struck off.
8. Unless otherwise mentioned, symbol and notation have their usual standard meanings. Assume suitable data, if necessary and indicate the same clearly.
9. Neat sketches may be drawn, wherever required.
10. The medium of answer should be mentioned on the answer book as claimed in the application and printed on admission card. The answers written in medium other than the authorized medium will not be assessed and no marks will be assigned to them.

Note : 1. Candidates will be allowed to use Scientific (Non-programmable type) calculators.

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SECTION – A

Q1. Answer **any five** of the following :

(a) With reference to operational amplifier explain following terms with their ideal and practical values :

i) Slew rate

ii) Open loop gain. **(4×2=8)**

(b) With neat circuit diagram explain voltage follower circuit of the operational amplifier. **8**

(c) Draw only block diagram of analog communication system. Name each block. Explain function of each block in one line. **8**

(d) State difference between the digital combinational and sequential logic circuits. **8**

(e) State advantages of digital communication system. **8**

(f) Draw forward and reverse V-I characteristic of thyristor (SCR) and clearly indicate on it

i) Holding current

ii) Latching current

iii) Effect of increase in gate current

iv) Reverse breakdown voltage. **8**

(g) In single phase half wave controlled rectifier SCR is fired at 'α' angle for a resistive load. Derive expression of a average load voltage (V_{dc}) across load. (Assume into the rectifier is pure sinusoidal voltage).

Also calculate output voltage if

i) $\alpha = 0°$

ii) $\alpha = \pi/2$ or $90°$.

(6+2=8)

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Q2. (a) With neat circuit diagram explain op-amp based high pass filter (1st order) write down expression for

i) Voltage gain (A_V) in terms of operating frequency (f) and cut-off frequency (f_c)

ii) Maximum pass band gain of the filter (A_{max}).

Also draw ideal characteristic of high pass filter. **15**

(b) What is modulation ? Why modulation is necessary in communication system ? With simple diagram show amplitude modulation and frequency modulation used in analog communication system. **15**

(c) Do the following :

i) Convert $(25.75)_{10}$ to equivalent binary number.

ii) Find the 2's complement of given binary number – 11010. **10**

Q3. (a) What is time domain multiplexing used in digital communication system ? Draw and explain the block diagram of time domain/division multiplexing process used in digital communication circuits. **15**

(b) With the help of simple schematic diagram explain fundamental circuit of series inverter. Also state few disadvantages of series inverter. **15**

(c) Draw and explain chopper controlled step-down/buck regulator with suitable waveform of the operation. **10**

Q4. (a) Simplify the following three variable minterms expression using algebraic simplification.

$Y = \sum m (1, 3, 5, 7)$ **15**

(b) Draw symbol, VI characteristics and 2 applications of following power devices

i) GTO

ii) MOSFET

iii) IGBT. **15**

(c) Discuss various frequency bands and their names/short names used in connection with communication system in practice (Any five frequency band will do). **10**

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SECTION – B

Q5. Answer **any five** of the following :

(a) Draw basic block diagram of electric drive system and explain function of each block in one line. **8**

(b) Find inverse Laplace transform of the following : **8**

$$F(s) = \frac{1}{(s+1)\,s}$$

(c) Mathematically only express following properties of Fourier transform

i) Linearity

ii) Time scaling

iii) Time shifting

iv) Symmetry or duality. **8**

(d) Find the system function and impulse response of the system described by the difference equation : $y(n) = x(n) + 2x(n-1) - 4x(n-2) + x(n-3)$. **8**

(e) State advantages and disadvantages of digital filters over along filters. **8**

(f) A closed loop control system is having forward path TF G(s), feedback path TF H(s) and input signal R(s). For this system write the formula for system error calculation on time domain basis. Also state on which parameters error depends. **8**

(g) State the effect of P, PI, PD controllers on the performance of the control system in brief. **8**

Q6. (a) Speed control of d.c. separately excited motor is done by single phase full converter. Show the schematic representation of the operation. Draw the supply voltage waveform, output/armature voltage waveform and armature current waveform. Also draw speed-torque characteristics of the operation if converter SCR firing angle is increased in steps. **15**

(b) Determine the solution of following differential equation using Laplace transform method. **15**

$$\frac{d^2y}{dt^2} - 3\frac{dy}{dt} + 2y = t \text{ if } y(0) = 0 \text{ and } \left.\frac{dy}{dt}\right|_{t=0} = 1.$$

(c) Determine inverse z transform of the function $= \frac{z}{(z-5)(z+4)}$. **10**

Solve this problem by Residue Theorem.

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Q7. (a) Determine stability of a system whose transfer function is given by

$$TF = \frac{s+9}{s^5 + 1.5\,s^4 + 2s^3 + 4s^2 + 5s + 10}$$

For the same system, how many roots are on the LHS of 's' plane ? **15**

(b) Obtain state model of the system whose transfer function is

$$\frac{Y(s)}{U(s)} = \frac{s+3}{s^2 + 3s + 4}$$

Also draw state diagram of the system. **15**

(c) Two sequences

$x(n) = \{3, 2, 1, 2\}$ and $h(n) = \{1\ \underset{\uparrow}{2}\ 1\ 2\}$

Determine convolution sum for them by any one method. **10**

Q8. (a) What is FACT system ? Benefits offered by FACTS controllers in electrical transmission system. Also state clearly operational difference between SVC (Static VAR Compensator) and STAT COM. **15**

(b) System having openloop transfer function

$$G(s)\,H(s) = \frac{k}{s(s+1)(s+3)}$$

Draw root locus plot and show on it

i) Angle of asymptotes
ii) Breakaway point
iii) Range of 'k' for stability
iv) Intersection of root locus with imaginary axis. **15**

(c) Transfer function of the system is given by

$$\frac{Y(s)}{U(s)} = \frac{s+3}{s^2 + 3s + 2}$$

Obtain state model of above system in canonical form. **10**

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