NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Even Semester End-term Examination, 2021-22

Course Code: EEE612 Full Marks: 30

Course Name: MODERN CONTROL SYSTEMS Time: 1:30 Hours

Question Paper No.: NITDGP/ EEE612/1 Date of Exam: 22/04/2022

Instructions: Answer questions from each group.
Materials to be supplied: NONE.

GROUP A

Answer Any Six questions.

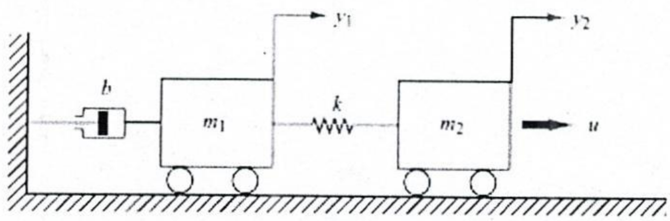
<table>
<tr><th>Question No.</th><th>Body of the Question</th><th>Marks</th><th>Mapped CO</th></tr>
<tr><td>1</td><td>Derive the mathematical modelling for the system shown in Figure 1.


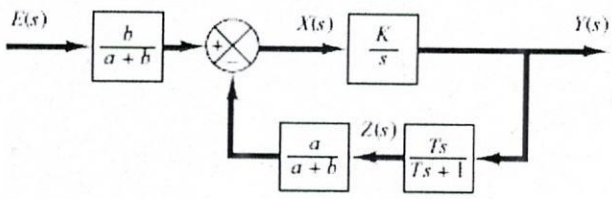
Figure 1</td><td>03</td><td>CO1</td></tr>
<tr><td>2</td><td>Figure 2 shows a block diagram of a hydraulic proportional-plus-integral controller. Obtain the state space model for the same with output $y(t)$ and error $e(t)$ as input to the controller.


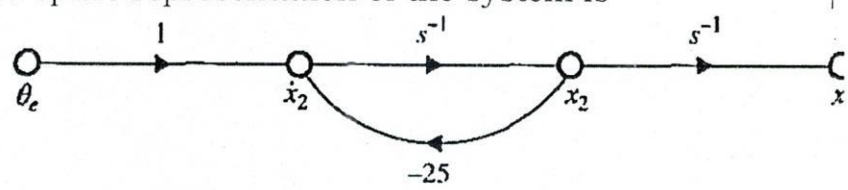
Figure 2</td><td>03</td><td>CO1</td></tr>
<tr><td>3</td><td>A system is represented by the state-space representation as $\dot{x}(t) = Ax(t) + Bu(t), y(t) = Cx(t) + Du(t)$ where $A = \begin{bmatrix} 0 & 1 \\ -25 & -4 \end{bmatrix}$; $B = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$; $C = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$; $D = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$. Find out the transfer matrix of the system.</td><td>03</td><td>CO2</td></tr>
<tr><td>4</td><td>Consider the system $\dot{x}(t) = Ax(t)$ where $A = \begin{bmatrix} -2 & 1 \\ 0 & -2 \end{bmatrix}$. Evaluate the state transition matrix using Caley-Hamilton method.</td><td>03</td><td>CO2</td></tr>
<tr><td>5</td><td>A process is described by $\dot{x}_1(t) = x_1(t) + x_2(t) + u$; $\dot{x}_2(t) = -x_2(t)$. Check the controllability and observability of the system.</td><td>03</td><td>CO2, CO3, CO5</td></tr>
<tr><td>6</td><td>Transform a system described by $\dot{x}_1(t) = x_1(t) + x_2(t)$; $\dot{x}_2(t) = 2x_1(t) - x_2(t) + u(t), y(t) = x_1(t)$ in controllable canonical</td><td>03</td><td>CO2, CO3</td></tr>
</table>

Course Outcomes
CO1: To understand the states for physical systems
CO2: To analyse LTI continuous systems with state variable representation
CO3: To understand the advantages of state variable feedback control
CO4: To understand optimal control
CO5: To learn the concept of optimal filtering and state estimation as an essential part of control system design

	form.		
7	Using Similarity transformation technique, find out the state transition matrix for the system $\dot{x} = \begin{bmatrix} 0 & 1 \\ -4 & -5 \end{bmatrix} x + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u$.	03	CO2
8	A linear time invariant system is characterized by the state variable model $\dot{x}(t) = Ax(t) + Bu(t), y(t) = Cx(t)$ where $A = \begin{bmatrix} -3 & 2 \\ 4 & -5 \end{bmatrix}, B = \begin{bmatrix} 1 \\ 0 \end{bmatrix}, C = [0 \quad 1]$. Draw the state diagram for the system.	03	CO1

GROUP B

Answer Any Four Questions.
Multiple Choice Questions.
Choose the correct Answer with proper justification.

Question No.	Body of the Question	Marks	Mapped CO
9	Obtain the response $y(t)$ of the following system: $\dot{x}_1(t) = -x_1(t) - 0.5x_2(t) + 0.5u(t)$; $\dot{x}_2(t) = x_1(t), y(t) = x_1(t)$; $x_1(t) = 0, x_2(0) = 0$. where $u(t)$ is the unit-step input occurring at $t = 0$. The output response of the system is (i)$e^{-t} \sin t$, (ii) $e^{-0.5t} \sin 0.5t$, (iii) $e^{-t} \sin 0.5\, t$, (iv) $e^{-0.5t} \sin t$.	03	CO2
10	If a system has its state transition matrix as $e^{At} = \begin{bmatrix} 1 & 0 \\ 1 - e^{-t} & e^{-t} \end{bmatrix}$, its system matrix is (i) $A = \begin{bmatrix} 0 & 0 \\ 1 & -1 \end{bmatrix}$, (ii) $A = \begin{bmatrix} 1 & 0 \\ 1 & -1 \end{bmatrix}$, (iii) $A = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$, (iv) $A = \begin{bmatrix} 0 & 0 \\ -1 & 1 \end{bmatrix}$.	03	CO2
11	If the plant transfer function of a system is given by $G(s) = \frac{-200(s^2+6s+8)}{(s+10)(s-3)(s+5)}$, the state space representation of the system in Jordan diagonal form is (i)$A = \begin{bmatrix} -10 & 0 & 0 \\ 0 & -3 & 0 \\ 0 & 0 & -5 \end{bmatrix}, B = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}, C = [14 \quad 67.5 \quad 15]$, (ii)$A = \begin{bmatrix} -10 & 0 & 0 \\ 0 & 3 & 0 \\ 0 & 0 & -5 \end{bmatrix}, B = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}, C = [-147.7 \quad -67.31 \quad 15]$, (iii) $A = \begin{bmatrix} 10 & 0 & 0 \\ 0 & -3 & 0 \\ 0 & 0 & -5 \end{bmatrix}, B = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}, C = [14.65 \quad 67.5 \quad 15]$, (iv) $A = \begin{bmatrix} -10 & 0 & 0 \\ 0 & -3 & 0 \\ 0 & 0 & -5 \end{bmatrix}, B = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}, C = [-14 \quad 67.5 \quad -15]$.	03	CO2
12	The state diagram of a system is shown in Figure 3. The state-space representation of the system is  Figure 3	03	CO1

	(i) $\dot{x} = \begin{bmatrix} 0 & 1 \\ -1 & -25 \end{bmatrix} x + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u; y = \begin{bmatrix} 2500 & 0 \end{bmatrix} x$, (ii) $\dot{x} = \begin{bmatrix} 0 & 1 \\ 0 & -25 \end{bmatrix} x + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u; y = \begin{bmatrix} 1 & 0 \end{bmatrix} x$, (iii) $\dot{x} = \begin{bmatrix} 0 & 1 \\ 0 & -25 \end{bmatrix} x + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u; y = \begin{bmatrix} 1 & 0 \end{bmatrix} x$, (iv) $\dot{x} = \begin{bmatrix} 0 & 1 \\ 0 & -25 \end{bmatrix} x + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u; y = \begin{bmatrix} 2500 & 0 \end{bmatrix} x$.		
13	A canonical representation for a linear time variant system is represented as $\dot{x} = \begin{bmatrix} 0 & 0 & -10 \\ 1 & 0 & -17 \\ 0 & 1 & -8 \end{bmatrix} x + \begin{bmatrix} 4 \\ 1 \\ 0 \end{bmatrix} u, y = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix} x$. The transfer function of the system is (i) $\frac{s+4}{s^3+8s^2+17s+10}$, (ii) $\frac{s^2+4}{s^3+8s^2+17s+10}$, (iii) $\frac{s(s+4)}{s^3+10s^2+17s+8}$, (iv) $\frac{s+4}{s^3+10s^2+17s+8}$.	03	CO2
14	A linear time variant system is represented as $\dot{x} = \begin{bmatrix} -2 & 1 & 0 \\ 0 & -2 & 0 \\ 0 & 0 & -1 \end{bmatrix} x + \begin{bmatrix} 0 \\ 4 \\ 3 \end{bmatrix} u, y = \begin{bmatrix} 3 & 0 & 1 \\ 4 & 0 & 2 \end{bmatrix} x$. The system is (i) controllable, unobservable, (ii) uncontrollable, unobservable, (iii) controllable, observable, (iv) uncontrollable, observable.	03	CO2, CO3, CO5

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Even Semester End-term Examination, 2021-22

Course Code: EEE-615 | Full Marks: 30

Course Name: ADVANCED POWER ELECTRONICS | Time: 90 Minutes

Question Paper No.: NITDGP/EEE615/8 | Date of Exam: 21/04/2022

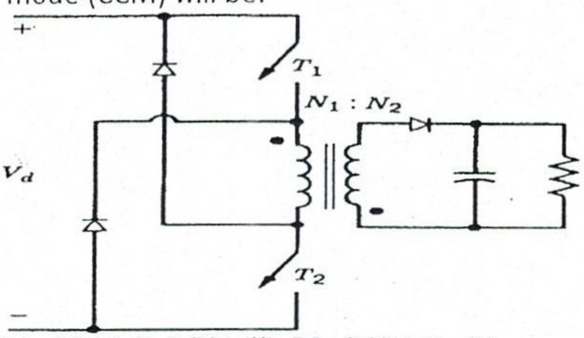
The figures in the margin indicate full marks.

Answer should be brief and to the point.

All questions of each GROUP must be answered at one place.

GROUP-A

Answer Question No.1 & any Five from the rest

Question No.	Body of the Question	Marks	Mapped CO
1.	(a) A buck-boost converter has an input voltage of 12 V and a load resistance of 24 Ω. The switching frequency is 10 kHz. The values of the inductor & output capacitor are 1 mH and 100 μF respectively. If the output voltage is required to be twice that of the input, then the peak-to-peak inductor current ripple will be: (i) 0.8 A (ii) 0.2 A (iii) 2.2 A (iv) 3 A	2	CO2
	(b) In the following converter the two switches are to be ON & OFF simultaneously. If 'd' is the duty cycle & V_0 is the load voltage, the DC gain (V_0/V_d) of the following converter under continuous conduction mode (CCM) will be:  (i) $(N_2 d)/\{N_1(1-2d)\}$ (ii) $(N_1 d)/\{N_2(1-d)\}$ (iii) $(2N_2 d)/\{N_1(1-d)\}$ (iv) $(N_2 d)/\{N_1(1-d)\}$	1	CO2
	(c) The following two H-Bridge cell having unsymmetrical input		CO3

Course Outcomes

CO1: To review of basic Power Electronic Systems

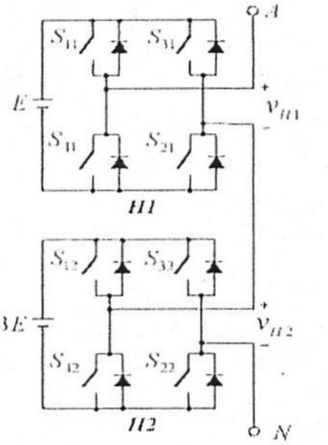
CO2: To learn the operation of isolated and non-isolated type Switch-Mode DC-DC Converters

CO3: To understand the concept of Multilevel Converters and modulation techniques

CO4: To understand converter dynamics and control, modelling techniques

CO5: To familiarize with different Gate and Base Drive circuits for Power Devices

CO6: To get acquainted with the state of the art applications of power electronics in Industry and utility systems

	voltages (E & 3E) can be able to produce a maximum level of load voltage waveform between the point A & N:  (i) 4E (ii) 2E (iii) 9E (iv) 5E	1	
2	Compare between BJT, MOSFET& IGBT while using in switching converter circuits.	2	CO1
3	"Switch-mode power amplifier is preferred than linear mode power amplifier in many power electronic applications". Justify with neat circuit diagrams.	2	CO1
4	Compare between Half-H-Bridge & Full-H-Bridge converter with circuit diagrams.	2	CO2
5	Explain in brief the working of Push-Pull converter with circuit diagram and determine the overall DC gain of the converter.	2	CO2
6	Draw and explain the working of a five level CHB Multilevel Inverter with modes of operation and key voltage waveforms.	2	CO3
7	Using state-space averaging technique prove that the transfer-function for the Buck converter under CCM is as follows $$\frac{V_o(s)}{V_i(s)} = \frac{D/LC}{(s^2 + s/RC + 1/LC)}$$ Where 'L' is inductor, 'C' is filter capacitor, 'R' is the output load resistance and 'D' is the operating duty cycle.	2	CO4
8	Draw& explain one complete gate driver circuit using pulse transformer for the following circuit	2	CO5

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
Even Semester End-term Examination, 2021-22

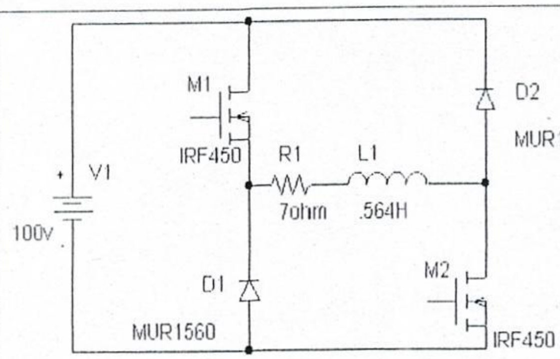
Course Code: EEE613 Full Marks: 30

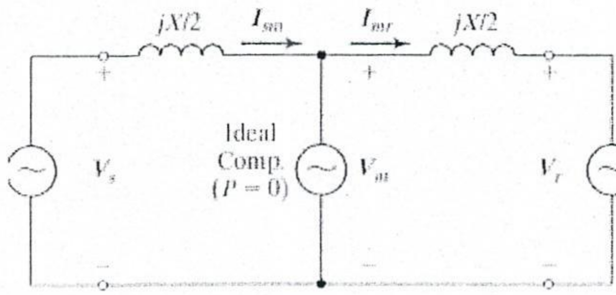
Course Name: Special Electrical Machines Time: 90 Minutes

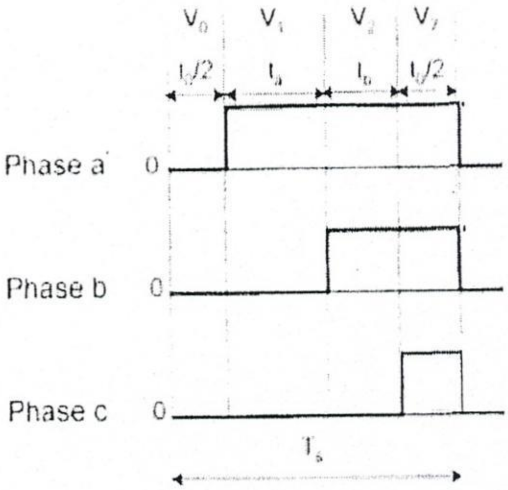
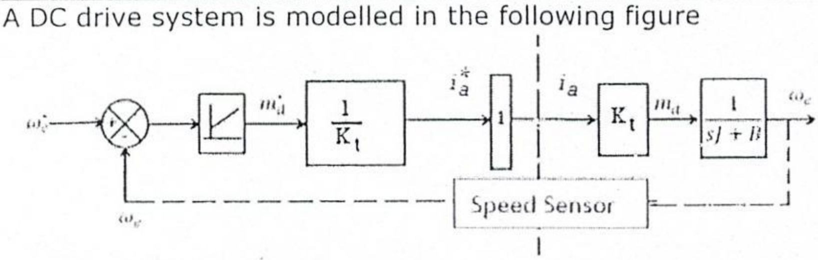
Question Paper No.: Date of Exam: 21/04/2022

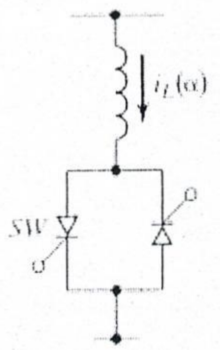
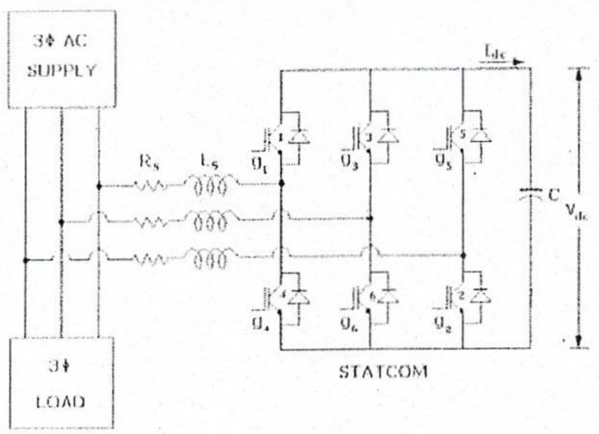
Instructions: All questions are compulsory.

Question No.	Body of the Question	Marks	Mapped CO
1	Compare the single-phase On mode and two-phase On mode operation of a stepper motor.	2	CO3
2	What is the slewing mode of operation for a stepper motor?	2	CO3
3	What are the drawbacks of using a permanent magnet stepper motor?	2	CO3
4	A stepper motor is wound for two phases and has four poles. It has 10 rotor poles. Find its resolution.	2	CO3
5	Discuss the advantages of closed loop control of a stepper motor.	2	CO3
6	Discuss some advantages of using the switched reluctance motor in electric drive applications.	2	CO4
7	Sketch the L-θ profile of a switched reluctance motor with stator pole arc equal to the rotor tooth arc.	2	CO4
8	Why is information of the rotor position required for the control of a switched reluctance motor.	2	CO4
9	Draw a power converter circuit for a switched reluctance motor using $(n + 1)$ switching devices.	2	CO4
10	Discuss why the hybrid stepper motor is the most widely used motor among the various types of stepper motors.	3	CO3
11	Define the following terms for a stepper motor: a) Step angle b) Resolution c) Stepping error	3	CO3
12	Derive the torque equation of a switched reluctance motor.	3	CO4
13	List some applications of the switched reluctance motor.	3	CO4

GROUP-B			
Answer Question No. 9& any five from the rest			
Question No.	Body of the Question	Marks	Mapped CO
9.	(a) A space vector PWM techniques is developed to supply 3 phase line voltage of 400V, 50 Hz, by a two level three phase VSI. The minimum DC voltage required by the VSI is: (i) 490V (ii) 535 V (iii) 565 V (iv) 655 V	2	CO3
	(b) A DC machine is driven by one H bridge dc-dc converter. The machine armature resistance is 2 Ω and rated current is 10 A. The input dc voltage is 300V. The control voltage to get an armature voltage of 220 V at rated load is: (i) 0.7 p.u.(ii) 0.7333 p.u.(iii) 0.7667 p.u.(iv) 0.8 p.u.	2	CO2 and CO6
	(c) With the following shunt compensation scheme consider the power angle as 30^0 and line inductance 3.8 mH. The maximum possible power in the compensated system, with both end voltages as 400 V is:  (i) 54 kW (ii) 59 kW (iii) 64 kW (iv) 69 kW	1	CO6

	(d) The switching states of a three phase two level VSI are shown as  What will be the angle of the resultant voltage vector with the said switching combinations? (i) 40^0, (ii) 70^0 (iii) 100^0 (iv) 130^0	1	CO3
10	A two level **three phase** inverter is having the switching state as [110]. Calculate the a-phase voltage for balanced load and 800 V dc input for the inverter.	2	CO3
11	A two level **five phase** inverter is having the switching state as [11001]. Calculate the a-phase voltage for balanced load and 800 V dc input for the inverter.	2	CO3
12	Draw the possible switching states of three legs of a three phase two level VSI to generate a voltage vector of 600 V at 75^0. Consider the DC voltage is sufficient to generate the same.	2	CO4
13	What is the advantage of having four quadrant chopper in a dc motor drive system?	2	CO6
14	A DC drive system is modelled in the following figure  What will be the final transfer function of the system?	2	CO6

15	A TCR for shunt compensation is having the fundamental current as:  $$I_{LF}(\alpha) = \frac{V}{\omega L}\left(1 - \frac{2}{\pi}\alpha - \frac{1}{\pi}\sin 2\alpha\right)$$ If the line voltage is 400 V and TCR reactance is 2 Ω, find line current of the compensated system of question 9 (c). Consider the firing angle is 15^0 and power angle at the operating condition is 70^0.	2	CO6
16	A STATCOM is connected to supply reactive power at load end of a distributed system. The power circuit is as follows:  Draw the Phasor diagram while the supply is made operative at unity power factor.	2	CO6
17	For the question number 16, justify the choice of switching topology to generate necessary converter output voltage during the STATCOM operation.	2	CO4 and CO6

B. Tech. Even SemesterEnd-Term Examination 2021-2022
Soft-computing Theory and Applications (EEE 616)

Full Marks: 30 **Time: 90 mins**

Answer should be brief and to the point.
All parts of a question should be written in one place in sequence.
All standard abbreviations are used.

1. **Answer any five questions.**

(a) How do you solve a maximization problem as a minimization problem? [1]

(b) How will judge the performances of algorithms? [1]

(c) Is there any difference between stagnation and local optima? Justify your answer. [1]

(d) What are the necessities of Search techniques? [1]

(e) If any problem is solved by direct analytical method as well as soft computing technique, which method will you apply to get solution? Justify your answer. [1]

(f) What do you mean by optimal and sub-optimal solution? [1]

(g) What do you mean by SOP and MOP? [1]

2. **Answer any two questions.**

(a) How can you convert multiple numbers of objectives into single objective? Give example. [2]

(b)State at least eight practical / industrial applications of Fuzzy Logic controller. [2]

(c) What is the basic concept of elitism procedure in evolutionary technique? When will you apply this procedure? [1+1]

(d) Critically analyse the limitations of Fuzzy Logic Controller. [2]

3. **Answer any seven questions.**

(a) How are the particles updated randomly? Illustrate with vector diagram in 2D. [3]

(b) What do you mean by local optima? What are the possible reasons of local optima? How can you get rid of local optima? [3]

(c) Illustrate intensification and diversification for the equation of particle's velocity. [3]

(d) Derive and explain exponential inertia weight factor. [3]

(e) Differentiate genotype and phenotype with examples. [3]

(f)Exemplify roulette wheel selection procedure with suitable example. [3]

(g) illustrate real coded mutation for RCGA with suitable example. [3]

(h) Differentiate crisp and fuzzy set with proper example. [3]

(i) Compare the similarity and dissimilarity of Mamdani and Takagi-Sugeno Fuzzy Logic Methods. [3]