1. (a) Explain the working of a hoist for the following operations:
   (i) Lifting a loaded cage
   (ii) Lowering a loaded cage

   In which quadrant of speed-torque plane does the motor operate for the above operations?

   OR

1'(a) Derive the expression for the overloading factor for a motor subjected to an intermittent periodic duty load.

1(b) Figure 1 shows plots of speed vs motor torque (T) and load torques ($T_{L1}$ and $T_{L2}$).

   Comment on the stability of the operating points A, B, C and D.

   ![Figure 1](image)

2(a) Explain the braking of dc motor by dynamic braking method. Explain why the value of braking resistance should be gradually decreased as the motor speed decreases. What is the advantage of this method over regenerative braking?

   OR

2'(a) Draw the circuit of a single-phase fully-controlled rectifier fed separately excited dc motor. Draw and explain the waveforms of the armature voltage and current for discontinuous conduction mode. Clearly indicate the conduction intervals of each thyristor. Find the expression of output voltage.

Contd.....2.
2(b) A 220 V, 1500 rpm, 50 A, separately excited dc motor has an armature resistance of 0.5 Ω. It is fed from a 3-phase fully-controlled rectifier with an ac source voltage of 400 V, 50 Hz. A star-delta transformer is used to feed the armature so that the motor terminal voltage equals the rated voltage when converter firing angle is zero. Calculate the transformer turn ratio. Also determine the firing angle when
(a) the motor is running at 1200 rpm and rated torque
(b) the motor is running at −800 rpm and double the rated torque
Assume continuous conduction.

3. Draw the block-diagram of a microprocessor based closed-loop rectifier controlled dc motor drive. Explain the functions of various blocks. If the reference speed signal is changed, explain the algorithm that the microprocessor follows to make motor speed equal to the desired speed.

3'(a) Draw the circuit of a chopper that can be used for regenerative braking of a separately excited dc motor. Explain its working with the help of relevant waveforms.

3'(b) A 230 V separately excited dc motor takes 50 A at a speed of 800 rpm. It has an armature resistance of 0.4 Ω. The motor is fed from a chopper with source voltage of 230 V and frequency of 500 Hz. Assuming continuous conduction
(a) Calculate the motor speed for motoring operation for duty ratios of 0.6 at rated torque
(b) Calculate the motor speed for braking operation for duty ratios of 0.4 at half the rated torque

4(a) Explain the following with reference to a frequency controlled induction motor drive:
(a) The voltage applied to the motor has to be decreased as the frequency is decreased to decrease the speed.
(b) The motor torque capability reduces if the frequency is increased above the rated frequency for speed control above the rated speed.

4(b) A 440 V, 50 Hz., 6-pole, 945 rpm, delta connected squirrel-cage induction motor has the following parameters:
\[ R_s = 2Ω, R_r' = 2Ω, X_s = 3Ω, X_{r'} = 4Ω \]
When driving a fan at rated voltage it runs at rated speed. The motor speed is controlled by stator voltage control. Determine the motor terminal voltage, current and torque at 800 rpm.

5. Draw schematic diagram of a static Scherbius drive and explain its working. Explain why this drive is preferred for speed control in a narrow range only.

5'(a) With the help of a schematic diagram explain the speed control of a wound rotor induction motor by static rotor resistance control method.

5'(b) A 440 V, 50 Hz., 6-pole, star connected squirrel-cage induction motor has the following parameters:
\[ R_s = 0.5Ω, R_r' = 0.4Ω, X_s = X_{r'} = 1.2Ω, X_m = 50Ω \]
Stator to rotor turn ratio is 3.5.
The motor speed is controlled by static rotor resistance control. Determine the value of external resistance such that the breakdown torque is produced at standstill for a duty ratio of zero.
2015-16  
B.TECH. (WINTER SEMESTER) EXAMINATION  
ELECTRICAL ENGINEERING  
Power Semiconductor Controllers  
EE422  

Maximum Marks: 60  
Credits: 04  
Duration: Three Hours

Answer all the questions. Assume suitable data if missing. Notations used have their usual meaning.

Q.No.  
Question  
M.M.

1(a)  
What are requirements of a gate driver circuit used for switching of power MOSFET and IGBT?  
4

1(b)  
Why is, in general, an HRC fuse unable to protect power semiconductor devices? What is the arrangement/method which can be used to protect sensitive devices or converters, explain?  
8

OR

1'(b)  
What are arrangements/methods which can be used for better heat transfer? Also, mention different methods employed for improvement of cooling of heat sinks.  
8

2(a)  
With help of block diagram and waveforms, explain the control of SMPS.  
4

2(b)  
Explain the different line-conditioning devices/equipment used for voltage regulation.  
8

3(a)  
Explain the merits and demerits of high-level language based equation solvers and dedicated software packages used for power electronic system analysis.  
4

3(b)  
Why is an air-gap provided in an inductor and not in a transformer? Prove any one reason, mathematically. Why is an air-gap provided in a transformer of fly-back converter?  
8

OR

3'(b)  
A single-phase, full-converter as shown in Figure 1, operates in continuous-conduction mode, to charge a 12V, 200AH lead-acid battery. The charging current is 8A and the ac voltage at load side, \(v(\omega t)=30 \sin \omega t\). Find  
4

(a) the average value of the output voltage (at 8A charging current)  
(b) the switching angle (at 8A charging current),  
(c) the switching angle, at maximum possible charging current, and  
(d) the maximum possible charging current

4(a)  
For an inductive load, explain the switching transition with the help of current and voltage trajectories and hence show that ZVS and ZCS offer better performance.  
4

4(b). With the help of waveforms, explain the working of a resonant switch (ZCS type), dc-to-dc converter.  
8

Contd....2.
4'(a). Show the circuit configuration of a current source based resonant converter which works as resonant dc link converter to generate three-phase ac output voltage. Also show the waveforms of the output at different stages.

4'(b). For a parallel-loaded LC resonant converter circuit shown in Figure-2, find the expression of the average value of the output (dc) voltage (across R) at maximum switching frequency. Explain the assumptions made.

5(a) Show different power electronic circuit configurations used in wind energy systems. Why these systems are better than conventional mechanical system?

5(b) Compare the performance of a conventional single-phase, ac-to-dc, semi-converter with a single-phase, 2-stage, series semi-converter and hence show their switching angles for given output voltage.

OR

5'(a) Explain the advantages of renewable energy based distributed power generation.

5'(b) Compare the performance of a conventional single-phase, ac-to-dc, full-converter with a single-phase, 2-stage, series full-converter and hence show their switching angles for given output voltage.
Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.
Grading will be done on correct and complete answers only.
Draw relevant graphs and write equations in detail
Try to attempt questions in sequence preferably starting each question from a new page.

Q.No. 

1  While the solar radiation incident on the Earth's atmosphere is relatively constant, the radiation at the Earth's surface varies widely due to:
   a) Atmospheric effects, including absorption and scattering;
   b) Local variations in the atmosphere, such as water vapors, clouds, and pollution;
   c) Latitude of the location; and
   d) The season of the year and the time of day.
   Explain in detail all the above four factors through relevant theory, equations and graphs.

   OR

   1' (a) The instantaneous measured radiations on a south facing surface at a tilt of 45° at sea level and at latitude 39.22° on May 14th, 2016 is 648.3 W/m². Photovoltaic cells with a typical glass cover are mounted at the same orientation. Estimate the ratio of absorbed radiation S to the absorbed radiation for a reference condition of 1000 W/m² at normal incidence.

2 (a) With the help of block diagram, explain in detail the operation of a solar thermal water heating system with necessary data and relevant equations.
2(b) With the AMU’s ongoing Green Campus Mission, it is expected that the water geysers in all the hostels will be replaced by solar thermal water heaters. Assuming, that the contracting company provided an inefficient solar thermal water heating system. The design of solar thermal absorber surface is covered by a 4mm thick glass tubular cover of 90 mm outer diameter. On a cold (2-10°C) windy (5m/s) day in December, calculate the loss coefficient for a 60 mm cylindrical solar thermal receiver at 200°C installed on rooftop of Sulaiman Hall.

3(a) Determine the range of operating voltage for which a 36 identical cell module will have power output within 90% of maximum power. You may assume $I_o = 10^{-10} A$ and $V_{oc} = 0.596 V$ at an operating temperature of 300K.

OR

3(a') A PV module is found to operate at a temperature of 60°C under conditions of $T_A=30{}^\circ C$ and $S = 980 \text{ W/m}^2$. Determine the NOCT of the PV module

3(b) Due to shortage of fresh water and high cost of pumping water from electricity, A state government has mandated solar PV based water pumps (with MPPT charge controller) to be installed to pump 2500 gal/ day from 150ft deep wells. The pump will have a wire to wire efficiency of 30% and will be installed in battery backup system where the the pump is set to run 12hr/ day. If a typical solar PV array received 6 peak sun hours of solar radiations every day, Determine i) the size of the PV array needed to power the pump if the efficiency of the MPPT controller is 96%, ii) the size of battery pack for one day storage.

4(a) Calculate a set of reasonable conditions on interest rate, term of loan and cost per installed kW, for a Solar PV system that generates power for an average of 5 peak sun hours per day so the annual loan repayment can be recovered if the value of the electricity generated is ₹ 0.20/kWh

OR

4(a') The value of electricity during utility peaking hours is ₹0.25/kWh and the money for grid interactive solar PV system with a 30 year expected lifetime can be borrowed at

Contd.....3.
an interest rate of 75. Calculate the installed cost per kW for the system that will result in annual loan payments equal to the value of electricity produced by the system if the electricity is produced during utility peak hours.

4(b) As you are aware that AMU is going to have a 3 MW solar PV plant operating by end of 2016. Compare and explain which of the following strategy viz: stand-alone, grid connected and grid-tied interactive solar PV system will be most efficient for the University’s current power distribution system.

5 Explain the various stages of the solar cell production in detail. Name few leading manufacturers of Solar PV modules in India and abroad. Comment on how the manufacturing process of solar PV modules is directly related to the cost and efficiency of the solar PV modules.
Question

(a) Explain the difference between a zero order hold and a first order hold.

(b) Z transform is not a completely reversible process. Why?

(c) Find the overall transfer function of the system shown in figure 1.

Fig. 1

OR

(e') Examine the stability of the following characteristic equation using Jury’s stability criterion.

\[ D(z) = z^2 + 1.3 z^2 - 0.08z + 0.24 \]

(a) Check the controllability and observability of a system represented by its state model as:

\[ \dot{x} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u \]

\[ Y = \begin{bmatrix} 1 & 1 \end{bmatrix} x \]

(b) A system is represented by its state model as:

\[ \dot{x} = \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix} x \]

\[ Y = \begin{bmatrix} 1 & 1 \end{bmatrix} x \]

Consider a linear transformation defined as:

\[ z = \frac{1}{z} \begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix} \]

Contd....2.
Develop a state model in $z$ and show that the input output relationship of the system remains unchanged under linear transformation. Assume the initial conditions as:

$$x(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

OR

2'. (a) Define and explain
   i) State feedback      ii) Stabilizability     iii) Observer

(b) A system is represented by its state model as

$$\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -5 & -7 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} -2 & 4 & 3 \end{bmatrix} x$$

It is desired to place the close loop poles at $s=-4$, -4, and -5. Find the required state feedback gain matrix using Ackerman's formula.

(c) Discuss the role of observer in the design of control systems. What are the conditions to be satisfied for the successful design of an observer? Also explain the concept of a reduced order observer.

3. (a) Define and explain:
   (i) Jump Resonance (ii) Multivalued Response (iii) Limit Cycle (iv) Frequency Entrainment

(b) Derive the Describing Function of a relay with dead zone. Also explain the conditions under which Describing Function analysis is valid.

OR

(b') Discuss the principle involved in the stability analysis of non linear systems using describing function.

4. (a) Define and explain:
   (i) Local stability (ii) Global Asymptotic Stability (iii) Limit Cycle (iv) Autonomous system

(b) Consider the system described by

$$\dot{y} + y - 2.5y^2 + 5y = 0$$

Determine the nature of singular points and comment on their stability.
4’. (a) Derive the Liapunov’s equation for Linear Time Invariant System

(b) Consider the system described by its dynamic equation as
\[ \ddot{y} + 0.6y + 1 = 0 \]

Draw the phase trajectory using method of isoclines.

5. (a) Define and explain
   i) Admissible control ii) Performance Measure iii) Fuzzy logic iv) Intelligent Control

(b) Derive the Euler-Lagrange equation for solution of two point boundary value problem