**2015-2016**  
**CODE NO. 3519**  
**VI SEMESTER (WINTER SEMESTER) B. TECH. EXAMINATION**  
**(ELECTRICAL ENGINEERING)**  
**POWER ELECTRONICS-II**  
**(EE-322N)**

Maximum Marks: 60  
Credits: 04  
Duration: Three Hours.

**Note:**  
(i) Answer all questions.  
(ii) Symbols have their usual meaning.  
(iii) Assume suitable value for missing data.

<table>
<thead>
<tr>
<th>Question</th>
<th>Description</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>Give the neat sketch of I-V characteristics of IGBT. Explain the different regions.</td>
<td>3</td>
</tr>
<tr>
<td>1(b)</td>
<td>With the help of neat sketch describe the structural features of n-channel power MOSFET.</td>
<td>4</td>
</tr>
<tr>
<td>1(c)</td>
<td>Give the waveforms of relevant variables for turn-on operation of power MOSFET.</td>
<td>5</td>
</tr>
<tr>
<td>OR</td>
<td>-</td>
<td></td>
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<tr>
<td>1'(a)</td>
<td>Sketch neatly the output characteristics and transfer characteristics of a typical npn power transistor and mark on it different values and regions. Explain, in brief, the nature in different regions.</td>
<td>6</td>
</tr>
<tr>
<td>1'(b)</td>
<td>How inversion layer is formed in power MOSFET?</td>
<td>2</td>
</tr>
<tr>
<td>1'(c)</td>
<td>With the help of neat diagram discuss the structure and principle of operation of Static Induction Transistor (SIT). How Static Induction Thyristor (SITH) is different from SIT?</td>
<td>4</td>
</tr>
<tr>
<td>2(a)</td>
<td>With the help of labeled diagram as well as switching diagrams and waveforms explain the working of dc-dc a Cuk converter. Derive the relationship between output and input voltages.</td>
<td>5</td>
</tr>
</tbody>
</table>
| 2(b)     | A buck-boost converter circuit (as shown in Fig. 1) has the following parameters:  
\[ V_d = 24 \text{ V}, \ D = 0.4, \ R = 5 \text{ } \Omega, \ L = 100 \text{ mH}, \ C = 400 \text{ pF}, \]  
and switching frequency \( f_s \) = 20 kHz. | 7     |

*Contd.....*
Determine the output voltage, average as well as minimum and maximum values of the inductor current, and ripple in output voltage.

![Circuit Diagram](image)

**Fig. 1**

3(a) Draw the circuit diagram of a single-phase ac voltage regulator with RL-load and explain its operation with phase control. Sketch the relevant waveforms. Establish the relationship for the rms value of the output voltage.

(b) The circuit diagram of a 3-phase AC voltage regulator is shown in Fig. 2, in which the regulator is connected to a balanced, three-phase star-connected resistive load. Draw the waveform of line currents $i_A \& i_C$ for a firing angle of $\alpha = 45^0$. Also show the gating sequence of the thyristors.

**OR**

3'(a) Explain the differences between integral-cycle control and phase-angle control of ac regulators.

(b) Consider a 1-phase ac regulator feeding a purely inductive load. For a suitable value of $\alpha$’ draw the waveform of the output voltage and current. Establish the relationship for rms load voltage, rms load current, rms thyristor current and average thyristor current.

(c) Draw a neat labeled circuit diagram of a 3-phase AC voltage regulator connected to a balanced, 3-phase delta-connected resistive load (as in Fig. 3). Draw the waveform of current in one of the phases for a firing angle of your choice. Draw also the waveform of one of the line currents.

![Circuit Diagram](image)

**Fig. 2**

![Circuit Diagram](image)

**Fig. 3**

*Contd....3.*
4(a) Draw a labeled diagram of a parallel inverter. Explain its operation with the help of switching diagrams and relevant waveforms, assuming R-load. Derive the relevant expressions which indicates the nature of the waveforms.

(b) A single-phase full-bridge thyristor based inverter feeds power at 50 Hz to a RLC load with $R = 5 \Omega$, $L = 0.3$ H and $C = 50 \mu$F. The dc input voltage to the inverter is 220 V. (i) Find an expression for load current up to fifth harmonic. Also calculate: (ii) power absorbed by the load and fundamental power; (iii) the rms and peak values of the current through each thyristor; (iv) conduction time of thyristors and diodes if only fundamental component is considered.

OR

4'(b) Draw a labeled diagram of a Modified McMurray half-bridge inverter. Also draw the relevant neat waveforms.

5(a) The dc input to a single phase full bridge inverter with single pulse PWM control is 200 V. Determine (i) the rms value of the fundamental and two lower most harmonics for pulse width of $120^\circ$, (ii) the THD of the output voltage, and (ii) the pulse width in degrees that will eliminate the $3^{rd}$ and $7^{th}$ harmonics.

(b) Describe the methods of harmonic elimination and reduction techniques that can be implemented in single-phase full-bridge inverter. Show the relevant diagrams and waveforms.

OR

(b') (i) For a multiple pulse PWM inverter with selective elimination of harmonics control, explain, how the two lowermost harmonics in the output voltage can be eliminated.

(ii) For a 3-phase inverter with $120^\circ$ conduction control, show the line and phase voltage of one of the phases with the gating sequence of the switches.
1(a) What do you understand by energy conservation? Explain its various aspects. [06]
1(b) On what basis energy storage systems are classified? What are the main advantages and limitations of compressed energy storage and battery storage systems? [06]

2(a) What is the need of MPPT in a Solar Photovoltaic system, explain various control strategies used for operation of an MPPT? [06]
2(b) With the help of block diagrams, explain the operations of stand-alone and grid interactive Solar Photovoltaic systems. [06]

OR

2'(a) What do you understand by cell mismatch in a solar module and what are its implications? What is the effect of partial or complete shadowing of a cell in a module? [06]
2'(b) With the help of schematic diagram, explain the working of Solar thermal power plant. [06]

3(a) Explain the process of production of biogas from biomass? What are the main advantages of anaerobic digestion of biomass? What are the factors affecting the performance of biogas digester? [08]

Contd.....2.
3(b) Compare the relative performance of a floating drum and fixed dome type of biogas plants.

4(a) Using Betz model of a wind turbine, derive expression for power extracted from wind. What is the maximum theoretical power that can be extracted from wind?

4(b) What do you understand by (a) upwind and downwind machines, (b) yaw active and yaw fixed machines (c) Teetering of wind rotor?

OR

4'(a) Sketch the diagram of Vertical Axis Wind Turbine (VAWT). Comment on relative features of HAWT and VAWT.

4'(b) A propeller type wind turbine has free wind velocity of 12m/s at a height of 10m, air density=1.226 Kg/m³, alpha= 0.14⁰, height of tower= 100m, Diameter of rotor= 80 metre, wind velocity at the turbine reduces by 20 percent, generator efficiency = 85 percent. Find
   (a) Total power available in wind.
   (b) Power extracted by the turbine.
   (c) Electrical power generated.

5(a) What do you understand by geothermal energy? What are the main advantages and applications of geothermal energy?

5(b) Describe the basic principle of operation of MHD generator. What are the major advantages and limitations of MHD generating system?

5(c) What is the source of tidal energy? What are the main hurdles in the development of tidal energy?

OR

5'(c) What are the potential applications of fuel cell? With the help of schematic diagram explain the operation of Phosphoric acid Fuel cell (PAFC).
Q. No. | Questions | MM.
--- | --- | ---
1(a). | What is an amplitude comparator? Derive the general equation of the amplitude comparator. | (06)
1(b). | A 40 MVA transformer, which may be called upon to operate at 30% overload, feeds 33 kV busbars through a circuit breaker (CB); other circuit breakers supply outgoing feeders. The transformer CB is equipped with 500/5 A CTs and the feeder CB with 1000/5 A. The relays on the feeder CBs have a 150% plug setting and a 0.5 time setting. If a three phase fault current of 7500 A flows from the transformer to one of the feeders, find the minimum plug setting and time multiplier setting of the transformer relay. Assume a discriminative time margin of 0.5 second. At TMS = 1, operating time of relays at various PSM are given in Table 1. | (06)

Table 1

<table>
<thead>
<tr>
<th>PSM</th>
<th>2</th>
<th>4</th>
<th>5</th>
<th>8</th>
<th>10</th>
<th>15</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating time (sec)</td>
<td>10</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2.8</td>
<td>2.7</td>
<td>2.5</td>
</tr>
</tbody>
</table>

2(a). | Describe the following abnormal conditions in a large synchronous generator against which protection is necessary: loss of excitation, failure of prime mover and unbalanced loading. | (06)
2(b). | What are the types of faults that are likely to occur in a three-phase induction motor? Explain single phasing and loss of synchronism with reference to synchronous motors. | (06)

OR
2'(a). Why definite-distance method used for protection of transmission lines is better than distance-time method? Explain the effect of arc resistance on the reach of impedance relay employed in definite-distance scheme?

2'(b). Describe the protection scheme for internal faults in a three phase delta/star connected power transformer. Draw a neat sketch and explain clearly why the CTs are to be connected in a particular fashion only.

3(a). What is the effect of power factor of fault current, asymmetry in fault current and armature reaction on the recovery and restriking voltages?

3(b). Calculate the RRRV of a 220 kV circuit breaker with earthed neutral. The short circuit test data obtained is as follows:
The current broken is symmetrical and the restriking voltage has an oscillatory frequency of 15 kHz. The power factor of fault is 0.2
Assume the short circuit to be an earthed fault.

4(a). Explain the terms symmetrical breaking current, asymmetrical breaking current and making current as applied to circuit breakers.

4(b). Explain with a neat sketch the working of axial-blast explosion pot used for arc quenching in arc control oil circuit breakers. What are the two limitations of explosion pots?

OR

4'(a). Discuss the principle of arc extinction in an oil circuit breaker. Upto what voltage level and breaking capacity bulk oil and minimum oil circuit breakers are used.

4'(b). Enumerate the chief requirements of the contact material for a vacuum circuit breaker.

5(a). Why the design of transmission lines above 700 kV is based on switching surges? Why switching overvoltages are more severe than lightning overvoltages? What are the Indian Standard specifications of standard lightning impulse and standard switching impulse voltage wave?

5(b). How travelling waves are produced on a transmission line? Discuss the variation of voltage and current in an open-ended line.

OR

5'(b). Explain with suitable figure and characteristic the principles and functioning of overhead ground wire and surge arrester.
1(a) Discuss the advantages of using $Y_{Bus}$ in load flow study. [4]  
(b) For the system shown in Fig-1, the table-1 gives the line admittances identified by the buses on which these terminate. Values of real and reactive powers are listed in table-2. Determine

I. $Y_{Bus}$ of the system

II. Assuming a flat voltage start and an acceleration factor of 1.6, find the voltage and phase angles at bus 3 at the end of first Gauss-Siedal iteration.

![Diagram of power system](image-url)
Table-1

<table>
<thead>
<tr>
<th>Line</th>
<th>G(p.u.)</th>
<th>B(p.u.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>2.0</td>
<td>-6.0</td>
</tr>
<tr>
<td>1-3</td>
<td>1.0</td>
<td>-3.0</td>
</tr>
<tr>
<td>2-3</td>
<td>0.666</td>
<td>-2.0</td>
</tr>
<tr>
<td>2-4</td>
<td>1.0</td>
<td>-3.0</td>
</tr>
<tr>
<td>3-4</td>
<td>2.0</td>
<td>-6.0'</td>
</tr>
</tbody>
</table>

Table-2

<table>
<thead>
<tr>
<th>Bus No</th>
<th>P_i(p.u.)</th>
<th>Q_i(p.u.)</th>
<th>V_i(p.u.)</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1.04∠0°</td>
<td>Slack bus</td>
</tr>
<tr>
<td>2</td>
<td>0.5</td>
<td>-0.2</td>
<td>-</td>
<td>P-Q Bus</td>
</tr>
<tr>
<td>3</td>
<td>-1.0</td>
<td>0.5</td>
<td>-</td>
<td>P-Q bus</td>
</tr>
<tr>
<td>4</td>
<td>0.3</td>
<td>-0.1</td>
<td>-</td>
<td>P-Q Bus</td>
</tr>
</tbody>
</table>

OR

Q1'(a) Deduce expressions for real and reactive powers used in load flow studies.

(b) What is Fast Decoupled load flow method? Develop necessary equations to perform load flow study using this method.

Q2(a) Derive the "co-ordination equation" for economic allocation of power among the various plants of a power system, include transmission losses.

(b) A power system with two generating stations supply a total load of 300 MW. Neglecting transmission losses, the economic schedule for the plant generation is 175 MW and 125 MW find the saving in production cost in Rs/hr. due to this economic schedule as compared to equal distribution of the same load between the units.

Q3(a) Derive mathematical equations in matrix form to show that the positive and negative sequence impedances of a transmission line are equal while the zero sequence impedance is much greater than positive or negative impedance. Also mention the

Contd......3
assumptions made.

(b) Single line diagram of a power system is shown in fig 2. Draw zero sequence diagram for it. The system data is as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>MVA</th>
<th>Voltage</th>
<th>X₀ pu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generator G₁</td>
<td>50</td>
<td>11KV</td>
<td>0.08</td>
</tr>
<tr>
<td>Generator G₂</td>
<td>30</td>
<td>11KV</td>
<td>0.07</td>
</tr>
<tr>
<td>Transformer T₁</td>
<td>50</td>
<td>11/220 KV</td>
<td>0.1</td>
</tr>
<tr>
<td>Transformer T₂</td>
<td>30</td>
<td>11/220 KV</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Zero sequence reactance of the line is 555.6 Ohms.

\[ \text{Fig 2} \]

OR

Q3'(a) What are the different types of faults which may occur on a power system? Draw a diagram showing interconnection of sequence networks for “Two conductor open” fault. Also derive necessary equations for it.

(b) A three phase synchronous generator with solidly grounded neutral is subjected to line to line fault on phase B and C accompanied by a ground fault on phase A. Assume that synchronous generator was running on no load, derive necessary equations and draw the sequence networks simulating the above fault conditions.

Q4(a) Explain equal area criterion for transient stability analysis when one of the double circuit lines feeding an infinite bus is switched off.

(b) A 3-ph static capacitive reactor of reactance 1 p.u. per phase is connected through a switch at motor bus bar as shown in fig 3. Calculate the steady state power limit with and without capacitor in circuit. Assume the internal voltage of generator to be 1.2 p.u. and that of motor 1 p.u.
(b') Discuss various methods of improving transient stability limit of a power system.

5(a) Show that for overhead distribution system the ratio of volumes of copper require in

I. D.C. two wire mid-point earthed.
II. Single phase two wire mid-point earthed.
III. 3ph-4wire system is given by:

\[ \frac{1}{2\cos^2\phi} : \frac{8}{3\cos^2\phi} \]

(b) A two wire distributor is loaded as shown in fig 4, the distances between sections are given in meters. The voltage at each end is 230. Determine the cross section of conductor for a minimum consumer voltage of 220. Assume the specific resistivity of conductor material as 1.78*10^-8 \( \Omega \)-m.
Q.No. | Question                                                                 | M.M. |
---|---|---|
1(a) | Obtain the block diagram representation of the circuit given in Figure 1  | [06] |

![Figure 1](image1.png)

1(b) | Obtain the transfer function of the gear train system shown in figure 2 where, $T_m$ is the input & $\theta$ is the output. | [06] |

![Figure 2](image2.png)

Contd.....2.
2(a) Using Mason's gain formula obtain the transfer function of the signal flow graph as shown in Figure 3.

![Figure 3](image)

2(b) Explain with the aid of diagram the construction and operation of Synchro pair as error detector.

3(a) Find the restriction on k for which the system given in Figure 4 is stable:

![Figure 4](image)

3(b) Obtain the expression of the output response of a second order system subjected to unit step input.

OR

3' Sketch root locus of a unity feedback control system given in Figure 5

![Figure 5](image)

4(a) Determine the frequency domain specifications for a second order system with unity feedback whose open loop transfer function as \( \frac{225}{s(s+6)} \)

4(b) Sketch the Bode plots of a unity feedback control system with open loop transfer function:

Contd.....3.
\[ G(s) = \frac{10}{s(1+0.5s)(1+0.1s)} \]

**OR**

4' Sketch the Nyquist plot for the transfer function given below:

\[ G(s) H(s) = \frac{100}{s(s+3)(s+5)} \]

5(a) Draw the control system schemes for different types of compensation. Also obtain an electrical network for the phase-lead and phase-lag compensation.

5(b) What are the different members of PID family? Describe the effects of incorporating a PI and PD controller on the response of the system.