GUJARAT TECHNOLOGICAL UNIVERSITY

BE-4 SEMESTER – OLD PAPER – S22 TO W25 – QUESTION BANK

Subject Name & Code:
Power Electronics (3140915)

Unit 1 – Power Switching Devices

Diode, Thyristor, MOSFET, IGBT; Static characteristics; Switching losses; Firing/gate drive circuits.

Repeated Questions:

1. **Draw and explain static characteristics of SCR.**
   - S25 (Q1a, 03 marks)
   - W25 (Q1b, 04 marks)
   - W24 (Q1b, 04 marks)
   - W23 (Q1b, 04 marks)
   - S23 (Q1b, 04 marks)
2. **Explain construction, VI characteristics of SCR.**
   - S23 (Q1b, 04 marks)
3. **Draw the symbol of Transistor, SCR, MOSFET, IGBT, DIAC, TRIAC, GTO.**
   - S24 (Q1b, 04 marks)
   - S23 (Q1a, 03 marks)
   - W25 (Q1a, 03 marks)
4. **Explain basic structure of IGBT/MOSFET with schematic diagram.**
   - S25 (Q5a, 03 marks) – IGBT
   - S25 (Q5a, 03 marks) – MOSFET (OR part)
   - S24 (Q1a, 03 marks) – Both MOSFET & IGBT
   - S22 (Q1c, 07 marks) – IGBT operation
   - W24 (Q1a, 03 marks) – IGBT construction & characteristics
   - W23 (Q1a, 03 marks) – IGBT equivalent circuit & characteristics
5. **Discuss two transistor model of SCR/Thyristor.**
   - S25 (Q5b, 04 marks)
   - S23 (Q5a, 03 marks)

Other Important Questions:

1. **Draw only basic structure of power MOSFET and IGBT and name each layer and part.**
   - S24 (Q1a, 03 marks)
   - W22 (Q1a, 03 marks)
2. **Explain three different modes of operation of a thyristor with the help of its static V-I characteristics.**
   - S24 (Q1c, 07 marks)
   - W22 (Q1c, 07 marks)
3. **Explain forward blocking and forward conduction mode of SCR using V-I characteristics.**
   - S22 (Q1b, 07 marks)
4. **Draw and explain any three triggering methods for Thyristors.**
   - S23 (Q1c, 07 marks)
5. **List various SCR turn on methods. Discuss any one in detail.**
   - S25 (Q5b, 04 marks) – OR part
6. **Explain RC firing circuit / R-C triggering / Resistance triggering.**
   - W23 (Q1c, 07 marks)
   - W22 (Q4a, 03 marks) – OR part
7. **Draw switching characteristics of SCR during turn-on and turn-off.**

- W23 (Q2a, 03 marks)

8. **Explain turn-on and turn-off characteristics of SCR.**
   - W24 (Q4b, 04 marks)
9. **Discuss the requirement of Snubber circuit for reliable operation of SCR.**
   - S25 (Q2b, 04 marks)
10. **Define Holding current, latching current for SCR.**
    - S23 (Q2b, 04 marks)
11. **Describe the working of UJT Relaxation Oscillator circuit.**
    - S23 (Q4a, 03 marks) – OR part
    - W24 (Q1c, 07 marks)
12. **Explain pulse transformer and opto-coupler.**
    - W24 (Q3b, 04 marks) – OR part
13. **Determine 7 important parameters which can be derived from datasheet of SCR.**
    - S22 (Q4c, 07 marks) – OR part
14. **Analyze briefly 7 technical parameters required for selection of power electronic switch.**
    - S22 (Q4c, 07 marks)
15. **Explain the operation of IGBT using sectional view.**
    - S22 (Q1c, 07 marks)

Unit 2 – DC-DC Converters (Switching Voltage Regulators)

Buck, Boost, Buck-Boost, CCM/DCM, control techniques, isolated converters, multi-quadrant operation.

Repeated Questions:

1. **Explain Buck converter with circuit diagram and waveforms.**
   - S25 (Q5c, 07 marks) – OR part
   - S24 (Q3a, 03 marks)
   - S24 (Q3b, 04 marks)
   - S23 (Q3a, 03 marks)
   - W22 (Q1b, 04 marks)
2. **Describe the principle of step-up chopper / Boost converter. Derive output voltage equation.**
   - S24 (Q3c, 07 marks)
   - S22 (Q4c, 07 marks) – OR part
   - W22 (Q4c, 07 marks)
3. **Discuss operation of Flyback converter.**
   - S25 (Q4a, 03 marks)
   - S23 (Q3b, 04 marks) – OR part
   - W24 (Q3c, 07 marks) – OR part
4. **Explain multi-quadrant operation of DC-DC converter.**
   - S25 (Q5c, 07 marks)
   - W25 (Q2c, 07 marks) – OR part
   - W23 (Q4c, 07 marks)

Other Important Questions:

1. **What is buck regulator? Draw circuit and waveforms for voltage across freewheeling diode, current through inductor.**
   - S24 (Q3a, 03 marks)
   - S22 (Q2a, 03 marks)
2. **Give classification and types of DC-DC converter topologies.**
   - S23 (Q2a, 03 marks)
3. **Compare linear voltage regulator and switching voltage regulator.**
   - W25 (Q2a, 03 marks)
4. **Explain working of 2-quadrant chopper.**
   - S22 (Q2b, 04 marks)
   - W25 (Q2b, 04 marks)
5. **Explain working of buck-boost converter with circuit diagram of different modes of operation.**
   - W22 (Q5c, 07 marks) – OR part
6. **Discuss discontinuous mode of operation in buck-boost converter with waveforms.**
   - W24 (Q2c, 07 marks) – OR part
7. **Closed loop control for voltage regulation** – (Implied in control techniques questions)
8. **Concept of CCM and DCM** – (Part of many explanation questions)
9. **Applications of DC-DC converter** – Listed in:
   - S22 (Q5a, 03 marks) – 3 applications

Numerical Questions from Unit 2:

1. **A step-up chopper has input voltage 220 V and output voltage 660 V. If turn-off time is 100 µs, compute turn-on time.**
   - S23 (Q2c, 07 marks)
2. **A boost converter has input voltage 6 V, average output voltage 15 V, switching frequency 20 kHz. Find duty cycle.**
   - S23 (Q2c, 07 marks) – OR part
3. **For type A chopper, dc source voltage = 230 V, load resistance 10 Ω, voltage drop 2 V**

across chopper when on, duty cycle 0.4. Calculate average and RMS output voltage and chopper efficiency.
    - W22 (Q5b, 04 marks) – OR part
4. **For boost regulator, derive formula of rise time and fall time of inductor current and output voltage.**
    - S22 (Q3b, 04 marks) – OR part

Unit 3 – DC-AC Converters (Inverters)

Half/full bridge, single/three-phase, square wave, PWM, SPWM, SVPWM, 120°/180° conduction, harmonics.

Repeated Questions:

1. **Explain three-phase inverter (120° or 180° mode) with waveforms.**
   - **120° mode:**
     - S25 (Q3c, 07 marks)
     - S24 (Q3c, 07 marks) – OR part
     - S23 (Q3c, 07 marks) – OR part
     - W25 (Q3c, 07 marks)
     - W23 (Q2c, 07 marks)
     - W22 (Q3c, 07 marks)
   - **180° mode:**
     - S25 (Q3c, 07 marks) – OR part
2. **Describe SPWM control technique.**
   - S25 (Q3b, 04 marks) – OR part
   - S24 (Q3a, 03 marks) – OR part
   - S22 (Q3b, 04 marks) – OR part
3. **Describe SVPWM control technique.**
   - S25 (Q3b, 04 marks)
   - W25 (Q3c, 07 marks) – OR part
   - W23 (Q2c, 07 marks) – OR part
   - W22 (Q3c, 07 marks) – OR part
4. **Explain cause of harmonics in inverter output and effects of switching frequency on harmonic spectrum.**
   - S24 (Q4c, 07 marks)
   - S22 (Q3c, 07 marks)
   - W25 (Q3b, 04 marks) – OR part
5. **Compare 120° and 180° conduction modes.**
   - S22 (Q5a, 03 marks)
   - W24 (Q4b, 04 marks)

Other Important Questions:

1. **Explain working of half-bridge inverter with R-L load using waveforms.**
   - S22 (Q2c, 07 marks)
2. **Describe full-bridge single-phase voltage source inverter with circuit and waveforms.**
   - S24 (Q4c, 07 marks) – OR part
   - S23 (Q3c, 07 marks)
3. **What is PWM? State advantages and disadvantages.**
   - S24 (Q3a, 03 marks) – OR part
   - W22 (Q3a, 03 marks) – OR part
4. **Describe unipolar and bipolar PWM for inverter.**
   - S22 (Q3b, 04 marks) – OR part
   - W25 (Q3a, 03 marks) – OR part
5. **Classify voltage control techniques of inverter and explain any one.**
   - S25 (Q3a, 03 marks) – OR part
   - W23 (Q3b, 04 marks)
6. **State advantages & disadvantages of CSI & VSI.**
   - W25 (Q3b, 04 marks)
   - W23 (Q2b, 04 marks)
7. **Explain difference between line commutated and force-commutated inverters.**
   - W22 (Q3a, 03 marks)
8. **Define Harmonic Factor, THD, LOH, DF.**
   - S23 (Q3b, 04 marks) – OR part

9. **Explain the principle of pulse width modulation for inverter.**
    - W25 (Q3a, 03 marks)
10. **Discuss bipolar PWM techniques in detail.**
    - S25 (Q1b, 04 marks)
11. **Determine applications of inverters in power system.**
    - S22 (Q4b, 04 marks) – OR part
12. **What is the purpose of connecting diodes in antiparallel with thyristors in inverter circuits?**
    - W23 (Q3a, 03 marks) – OR part
13. **Derive inverter output voltage equation.**
    - W22 (Q2b, 04 marks)
14. **Describe positions of space vector on the basis of switching states.**
    - S24 (Q4a, 03 marks)
    - S22 (Q3a, 03 marks)

Numerical Questions from Unit 3:

1. **The single-phase half-bridge inverter has DC input 100 V, load resistance 10 Ω. Determine RMS output voltage and fundamental component of RMS value.**
    - S22 (Q5b, 04 marks) – OR part

Unit 4 – AC-DC Converters (Rectifiers)

Half/full wave, single/three-phase, controlled/semi-controlled, continuous/discontinuous modes, dual converters, power factor improvement.

Repeated Questions:

1. **Explain single-phase full-wave controlled rectifier with R/RL load.**
   - S25 (Q2c, 07 marks)
   - S23 (Q4c, 07 marks) – OR part
   - W22 (Q2c, 07 marks) – OR part
2. **Explain three-phase full converter/semi-converter with RL load and waveforms.**
   - **Full converter:**
     - S25 (Q1c, 07 marks) – three-phase semi-converter
     - S24 (Q2c, 07 marks)
     - W25 (Q4c, 07 marks) – OR part
     - W23 (Q3c, 07 marks)
   - **Semi-converter:**
     - W25 (Q2c, 07 marks)
     - W23 (Q3c, 07 marks) – OR part
3. **Discuss need of freewheeling diode in phase-controlled rectifier.**
   - S25 (Q2a, 03 marks)
   - S24 (Q2b, 04 marks)
   - S23 (Q4a, 03 marks)
   - W25 (Q4a, 03 marks)
   - W23 (Q4a, 03 marks)
4. **Derive output voltage equation for single-phase half/full wave rectifier.**
   - **Half-wave:**
     - S24 (Q4b, 04 marks)
     - W23 (Q3b, 04 marks) – OR part
     - W22 (Q4b, 04 marks) – OR part
   - **Full-wave:**
     - S25 (Q2c, 07 marks)
     - W25 (Q4a, 03 marks) – OR part

Other Important Questions:

1. **Draw circuit of 1-φ half-wave controlled rectifier with R load and waveforms (α=30°).**
   - S24 (Q2a, 03 marks)
   - S22 (Q1a, 03 marks)
   - W25 (Q4b, 04 marks)
2. **Explain working of single-phase semi-converter with voltage/current waveforms under resistive load.**
   - W25 (Q2c, 07 marks)
   - W23 (Q3c, 07 marks) – OR part
3. **Explain dual converter operation with circulating current mode (single-phase supply).**
   - S25 (Q4c, 07 marks)
4. **Discuss power factor improvement techniques for AC-DC converter.**
   - S22 (Q4a, 03 marks)
   - W24 (Q3c, 07 marks) – OR part
5. **Explain effect of source inductance in converters** – (Implied in theory questions)
6. **Explain single-phase fully controlled center-tapped converter with R load, derive V_RMS.**
   - W22 (Q2c, 07 marks)
7. **Draw circuit of single-phase fully controlled converter with R-L load, derive equations, sketch waveforms.**
   - W24 (Q2c, 07 marks) – OR part
8. **Describe working of single-phase full converter in rectifier mode with RLE load, derive**

average output voltage.
- W24 (Q4c, 07 marks)
- W22 (Q2c, 07 marks) – OR part

9. **Distinguish between fully controlled and half-controlled bridge converter.**
   - W24 (Q3a, 03 marks) – OR part
10. **Define and explain need of snubber circuit for SCR.**
    - S25 (Q2b, 04 marks)
    - W24 (Q2b, 04 marks) – OR part

Numerical Questions from Unit 4:

1. **A single-phase full-wave AC-DC converter supplied by 230 V, 50 Hz, load R=10 Ω, α=30°. Determine average output voltage and current.**
   - S23 (Q4b, 04 marks) – OR part
2. **Derive expression for average output voltage for 1-φ half-wave controlled rectifier with RL load.**
   - S22 (Q4a, 03 marks) – OR part
3. **Derive expression for resistance used for static voltage equalization for series-connected string.**
   - W22 (Q3b, 04 marks) – OR part

Unit 5 – AC Voltage Controllers

Triac, phase control, on-off control, single/three-phase controllers, integral cycle control, applications.

Repeated Questions:

1. **Explain single-phase full-wave AC voltage controller with circuit and waveforms.**
   - S25 (Q4a, 03 marks) – OR part
   - S23 (Q5a, 03 marks) – advantages/disadvantages/applications
   - W23 (Q4b, 04 marks) – OR part
2. **Explain three-phase AC voltage controller with star-connected R load, waveforms for α=60°.**
   - S24 (Q2c, 07 marks) – OR part
   - S22 (Q2c, 07 marks) – OR part
   - W24 (Q4c, 07 marks)
   - W23 (Q4c, 07 marks) – OR part (on-off & integral cycle control)
3. **List industrial applications of AC voltage controllers, merits/demerits.**
   - S24 (Q5a, 03 marks)
   - S23 (Q5a, 03 marks)
   - W25 (Q5a, 03 marks) – OR part
   - W24 (Q5a, 03 marks) – OR part
   - W22 (Q5a, 03 marks)
4. **Distinguish between on-off control and phase angle control.**
   - S24 (Q3b, 04 marks) – OR part
   - W25 (Q5a, 03 marks)
   - W24 (Q3b, 04 marks)
   - W22 (Q3b, 04 marks)

Other Important Questions:

1. **Explain integral cycle control of AC voltage controllers with equations and waveforms.**
   - S25 (Q4c, 07 marks) – OR part
2. **Describe application of TRIAC as single-phase fan regulator with circuit and waveform.**
   - S23 (Q5b, 04 marks)
   - W23 (Q4b, 04 marks) – OR part
3. **Draw only possible configurations of single-phase voltage controller.**
   - W23 (Q4a, 03 marks) – OR part
4. **Derive RMS output voltage equation for single-phase full-wave AC voltage controller with R load.**
   - W22 (Q4a, 03 marks)
5. **Derive AC voltage controller average output voltage equation.**
   - W24 (Q4a, 03 marks) – OR part
6. **Derive output voltage equation of single-phase AC voltage controller.**
   - W22 (Q5b, 04 marks)
7. **Explain working of single-phase full-wave bidirectional controller, derive RMS output voltage for 230 V input, α=45°.**
   - S22 (Q3c, 07 marks) – OR part

Unit 6 – Miscellaneous (Cycloconverters, Matrix Converters, Protection, EMI, Datasheets)

Cycloconverters, matrix converters, device selection, protection circuits, EMI, snubber design.

Repeated Questions:

1. **Explain working of 1-φ to 1-φ cycloconverter with input 50 Hz, output 10 Hz.**
   - S25 (Q2c, 07 marks) – OR part
   - S24 (Q5c, 07 marks)
   - S23 (Q5c, 07 marks)
   - W25 (Q5c, 07 marks)
   - W23 (Q5c, 07 marks) – OR part
2. **What is a cycloconverter? List industrial applications.**
   - S24 (Q5b, 04 marks)
   - W23 (Q5a, 03 marks)
3. **Write short note on / Explain matrix converter.**
   - S25 (Q4b, 04 marks) – OR part
   - S24 (Q5a, 03 marks) – OR part
   - W25 (Q5b, 04 marks)
   - W24 (Q5b, 04 marks) – OR part
   - W22 (Q4b, 04 marks)
4. **Describe adverse effects of EMI and remedial steps.**
   - S25 (Q1c, 07 marks)
   - W25 (Q5b, 04 marks) – OR part
   - W24 (Q2a, 03 marks)
5. **Explain snubber circuit and its design.**
   - W24 (Q2b, 04 marks) – OR part
   - W23 (Q5b, 04 marks) – OR part

Other Important Questions:

1. **Explain midpoint cycloconverter briefly.**
   - W25 (Q4b, 04 marks) – OR part
2. **Explain operation of three-phase to single-phase cycloconverter.**
   - W23 (Q5c, 07 marks)
3. **Draw basic circuit diagram of 3-phase to 3-phase cycloconverter.**
   - W23 (Q5a, 03 marks) – OR part
4. **Show that fundamental RMS output voltage per phase for m-pulse cycloconverter is:**

$$V_{or} = V_{ph}\left(\frac{m}{\pi}\right)\sin\left(\frac{\pi}{m}\right)$$

   - W25 (Q5c, 07 marks) – OR part
   - W22 (Q5c, 07 marks) – OR part
5. **Discuss why 3-phase to 1-phase cycloconverter requires positive/negative group converters, and when they work as inverters/rectifiers.**
   - W22 (Q5c, 07 marks) – OR part
6. **List any six applications of power electronics.**
   - W22 (Q5a, 03 marks) – OR part
7. **Explain working of series inverter with diagram and waveforms.**
   - W24 (Q5c, 07 marks) – OR part
8. **Explain working of 1-φ current source inverter with waveforms.**
   - S22 (Q5c, 07 marks) – OR part
9. **Compare CSI and VSI.**
   - W24 (Q5a, 03 marks) – OR part

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