B.Sc. (HONS.) in ECE
Part-III, Sixth Semester Examination – 2020
Subject: Industrial and Power Electronics (ECE-313)
Duration: 3 Hours
Full Marks: 80
[N.B. The figures in the right margin indicate full marks. Answer any five questions.]

Marks

Question 1

(a) What is a transducer? What are the basic constituent elements of a transducer? ***(4 Marks)***

A **transducer** is a device that converts one form of energy into another, typically physical quantities into electrical signals.

Constituent Elements:

1. **Sensing Element** – Detects the physical quantity.
2. **Transduction Element** – Converts sensed quantity into electrical signal.
3. **Signal Conditioning Unit** – Amplifies/modifies the signal.
4. **Output Device** – Displays or transmits the signal.

(b) Define temperature. Differentiate between active and passive transducer. ***(6 Marks)***

Temperature is the measure of the average kinetic energy of particles in a substance, indicating its thermal state.

Active Transducer:

- Generates output without external power.
- Example: Thermocouple.

Passive Transducer:

- Requires external power to operate.
- Example: RTD (Resistance Temperature Detector).
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Feature	**Active Transducer**	**Passive Transducer**
Power Requirement	No	Yes
Output Signal	Self-generated	Needs excitation
Example	Thermocouple	RTD

(c) What is Zener diode? Write down the advantages and disadvantages of thermocouple. ***(6 Marks)***

A **Zener diode** is a semiconductor device that allows current to flow in reverse direction when the voltage exceeds a specific value (Zener breakdown voltage).

Advantages of Thermocouple:

- Wide temperature range.
- Fast response.
- Rugged and simple.

Disadvantages:

- Non-linear output.
- Requires reference junction.
- Low output voltage.

Question 2

(a) Operation and I-V characteristics of SCR ***(6 Marks)***

SCR (Silicon Controlled Rectifier) is a four-layer, three-terminal device used for switching.

Operation:

- Remains OFF until gate is triggered.
- Once ON, conducts until current drops below holding value.
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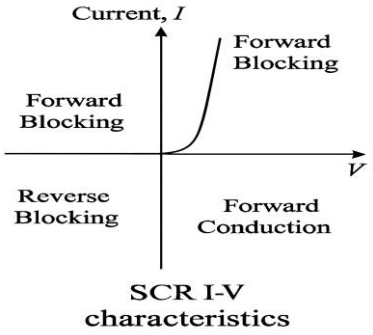
I-V Characteristics:

- Forward Blocking Region
- Forward Conduction Region
- Reverse Blocking Region



SCR I-V characteristics

📌 *Diagram: Show I-V curve with regions labeled.*

(b) Ways of thyristor turn-on ***(4 Marks)***

1. **Gate Triggering** – Applying gate pulse.
2. **Voltage Triggering** – Increasing forward voltage.
3. **dv/dt Triggering** – Rapid voltage change.
4. **Temperature Triggering** – Heating junction.

(c) Gauge Factor of Strain Gauge ***(6 Marks)***

Gauge Factor (GF) is defined as:
[GF = \frac{\Delta R / R}{\varepsilon}]
Where:

- (\Delta R) = Change in resistance
- (R) = Original resistance
- (\varepsilon) = Strain

It represents sensitivity of strain gauge to mechanical deformation.

Question 3

(a) What is thyristor? Explain operation principle with figure ***(6 Marks)***

A **thyristor** is a four-layer (PNPN), three-terminal device used for power control.

Operation:

- Forward biased but OFF until gate is triggered.
- After triggering, conducts until current drops below holding level.
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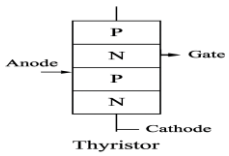

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Diagram: Show thyristor layers and terminals.

(b) Applications of SCR ***(4 Marks)***

- Motor speed control
- Light dimming
- Battery chargers
- Controlled rectifiers
- Overvoltage protection

(c) Schottky Diode and its Operation ***(6 Marks)***

A **Schottky diode** is a metal-semiconductor junction diode with low forward voltage drop and fast switching.

Operation:

- Electrons flow from semiconductor to metal.

- No minority carrier storage → fast recovery.

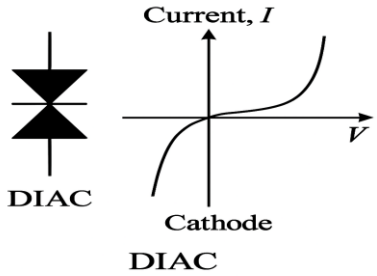
Used in high-speed switching and RF applications.

Question 4

(a) Operating Principle of DIAC ***(4 Marks)***

A **DIAC** is a bidirectional device that conducts only after reaching breakover voltage in either direction.

- Once triggered, it conducts until current drops below holding value.
- Commonly used to trigger TRIACs.



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📌 *Diagram: DIAC symbol and V-I characteristics.*

(b) Step-Up DC Chopper Operation ***(6 Marks)***

Step-Up Chopper increases output voltage above input.

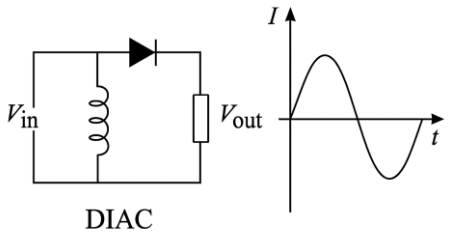
Working:

- Switch ON → Inductor stores energy.
- Switch OFF → Inductor releases energy to load.

[V_o = \frac{V_{in}}{1 - D}]
Where (D) = Duty cycle.

(c) Single-Phase Full Wave Converter ***(6 Marks)***

- Converts AC to DC using two thyristors or diodes.
- Both halves of AC cycle are used.
- Output is pulsating DC with higher average voltage.



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📌 *Diagram: Circuit and waveform.*

Question 5

(a) Four Quadrant Converter *(4 Marks)*

Allows control of voltage and current in both directions.

Quadrants:

1. Forward Motoring
2. Forward Braking
3. Reverse Motoring
4. Reverse Braking

Used in regenerative motor drives.

(b) For α = π/2 in Half-Wave Converter *(6 Marks)*

(i) Efficiency:
[\eta \approx 40.5%]
(ii) Form Factor:
[FF \approx 1.57]
(iii) Ripple Factor:
[RF = \sqrt{FF^2 - 1} \approx 1.17]

(c) Programmable UJT *(2 Marks)*

A **PUT (Programmable UJT)** is a four-layer device whose characteristics can be adjusted using external resistors.

Used in timing and triggering applications.

(d) PLL Control of DC Drives *(4 Marks)*

Phase-Locked Loop (PLL) synchronizes motor speed with reference signal.

- Compares phase of feedback and reference.
- Adjusts control signal to maintain speed.

✅ Question 6

(a) PLL Control Principle *(6 Marks)*

PLL uses:

- **Phase Detector** – Compares input and feedback.
- **Low-Pass Filter** – Removes high-frequency noise.
- **Voltage-Controlled Oscillator (VCO)** – Adjusts output frequency.

Maintains constant speed under load variations.

(b) Fourth Quadrant Converter *(4 Marks)*

Operates in reverse voltage and reverse current mode.

- Enables regenerative braking.
- Power flows from load to source.

(c) Cycloconverter and Single-Phase Cycloconverter *(6 Marks)*

Cycloconverter converts AC of one frequency to AC of another (usually lower).

Single-Phase Cycloconverter:

- Uses controlled switches to synthesize output.
- Suitable for low-speed, high-power applications.
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📌 *Diagram: Basic circuit and waveform.*

✅ Question 7 – Short Notes (Any Four × 4 = 16 Marks)

(i) TRIAC

- Bidirectional thyristor.
- Controls AC power.

- Triggered by gate in both directions.
- Used in dimmers and motor control.

(ii) PWM Inverter

- Converts DC to AC using Pulse Width Modulation.
- Controls output voltage and frequency.
- High efficiency and low harmonic distortion.

(iii) Optical Transducer

- Converts light into electrical signal.
- Examples: Photodiodes, phototransistors.
- Used in encoders, sensors.

(iv) Schottky Diode

- Metal-semiconductor junction.
- Low forward voltage drop (~0.2–0.3V).
- Fast switching, used in RF and power circuits.

(v) Microprocessor-Based Motor Drive

- Uses microprocessor for control logic.
- Enables precise speed and torque control.
- Supports feedback and programmable settings.

(vi) Silicon Bilateral Switch (SBS)

- Similar to DIAC but with gate terminal.
- Switches ON in both directions.
- Used in triggering TRIACs.