Question 1(a) [3 marks]

Draw characteristics of Opto-Isolators, Opto-TRIAC and Opto-transistor.

Answer:

Characteristics of Opto-Electronic Devices:

Opto-Isolator	Opto-TRIAC	Opto-Transistor
		
Linear relationship between LED current and photodetector current	Non-linear triggering response with threshold	Linear current transfer characteristic
CTR (Current Transfer Ratio) is key parameter	Triggering occurs at specific current threshold	Collector current depends on base illumination

- **CTR (Current Transfer Ratio)**: Ratio of output current to input current
- **Trigger Current**: Minimum current needed to activate the device
- **Linearity**: How proportional the output is to the input light

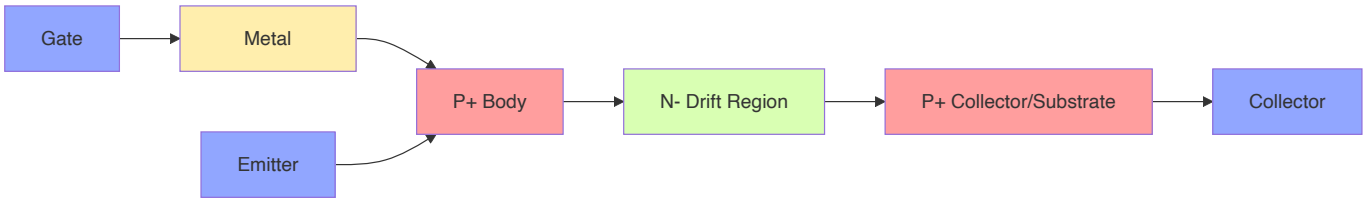
Mnemonic: "LTL - Light Transfers Like current flows – Linear for isolators/transistors, Triggered for TRIACs"

Question 1(b) [4 marks]

Describe working & constructional features of IGBT.

Answer:

IGBT Structure and Operation:



Feature	Description
Structure	Combines MOSFET input with BJT output
Layers	Gate/Metal Oxide/P+ Body/N- Drift/P+ Collector
Advantages	High input impedance, low conduction loss
Switching	Faster than BJT, better power handling than MOSFET

- **Voltage Controlled**: Device is controlled by gate voltage like MOSFET
- **Conductivity Modulation**: P+ collector injects holes into drift region
- **Low On-State Voltage**: Conduction losses lower than MOSFET

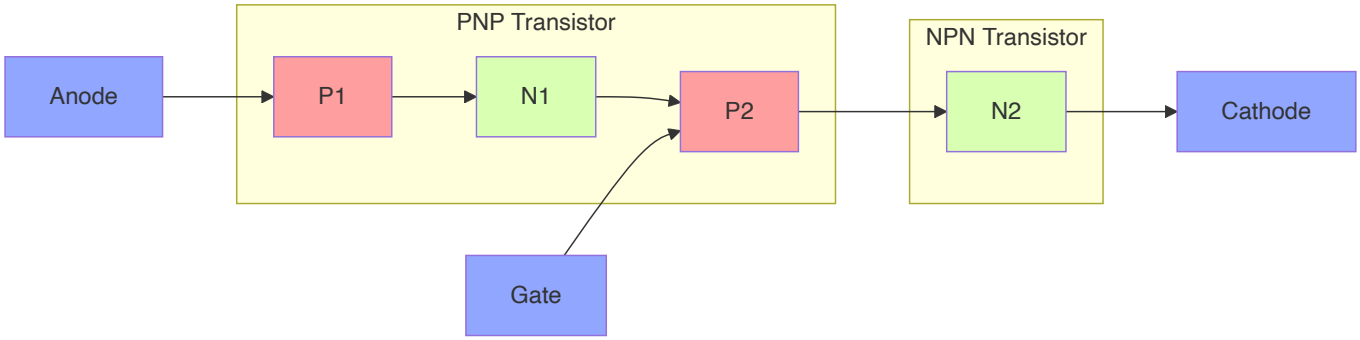
Mnemonic: "IGBT MBC" - "Input from MOS, Body handles current, Collector acts like BJT"

Question 1(c) [7 marks]

Explain working of SCR using two-transistor analogy.

Answer:

SCR as Two-Transistor Model:



Two-Transistor Explanation:

Component	Function	Connections
PNP (T1)	Upper transistor	Emitter to Anode, Collector to N1, Base to P2-N1 junction
NPN (T2)	Lower transistor	Emitter to Cathode, Collector to P1-N1 junction, Base to Gate
Feedback	Regenerative action	T1's collector current = T2's base current & vice versa

- **Latching Mechanism**: Once triggered, transistors keep each other ON
- **Triggering**: Small gate current → T2 turns ON → T1 gets base current → Both remain ON
- **Holding Current**: Minimum current needed to maintain regenerative action
- **Turn-OFF**: Anode current must fall below holding current

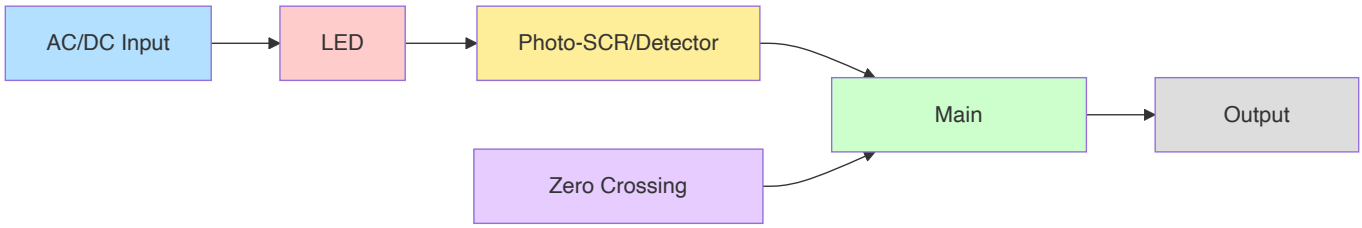
Mnemonic: "PPFF" - "Positive feedback Perpetuates Forward conduction"

Question 1(c) OR [7 marks]

Explain the working of Solid state relay using Opto-SCR.

Answer:

Solid State Relay with Opto-SCR:



Working Principle and Components:

Stage	Function	Advantage
Input	Low voltage control signal activates LED	Isolation from high power
Opto-Coupler	LED light triggers photo-sensitive SCR	Electrical isolation
Driver Circuit	Photo-SCR activates main switching device	Amplification of switching capacity
Output Stage	Main SCR/TRIAC controls high-power load	Handles load current
Snubber	RC circuit protects from voltage spikes	Prevents false triggering

- **Electrical Isolation**: Complete separation between control and power circuits (>1000V)
- **Zero-Crossing**: Switching only at zero voltage reduces EMI/RFI noise
- **Silent Operation**: No mechanical clicks unlike traditional relays
- **Long Life**: No mechanical wear as in conventional relays

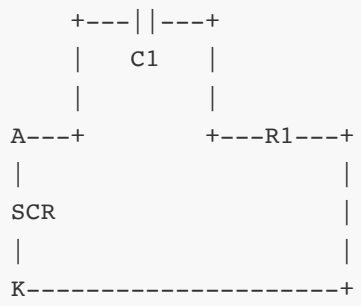
Mnemonic: "LIPO" - "Light In, Power Out - isolation guaranteed"

Question 2(a) [3 marks]

Explain the working of snubber circuit for SCR.

Answer:

Snubber Circuit for SCR:



Component	Purpose	Sizing Consideration
Capacitor (C1)	Limits dv/dt rate	Based on max dv/dt rating of SCR
Resistor (R1)	Limits discharge current	Based on capacitor value and switching frequency

- **dv/dt Protection**: Prevents false triggering due to rapid voltage rise
- **Turn-OFF Support**: Helps in commutation by providing alternate path
- **Energy Absorption**: Absorbs energy from inductive loads during switching

Mnemonic: "CARD" - "Capacitor And Resistor Damp unwanted triggering"

Question 2(b) [4 marks]

Write the differences between forced commutation and natural commutation.

Answer:

Comparison of Commutation Methods:

Parameter	Forced Commutation	Natural Commutation
Definition	External circuit forces SCR to turn OFF	AC source naturally reduces current to zero
Application	DC circuits primarily	AC circuits primarily
Components	Requires additional components (capacitors, inductors)	No extra components needed
Complexity	More complex circuit design	Simpler circuit design
Energy	Extra energy needed for commutation	Uses existing source energy
Control	Can be controlled precisely	Happens at fixed points of AC cycle
Cost	Higher due to extra components	Lower cost implementation

- **Timing Control**: Forced commutation offers better timing control
- **Circuit Size**: Natural commutation results in smaller circuit size

- **Reliability**: Natural commutation has fewer components to fail

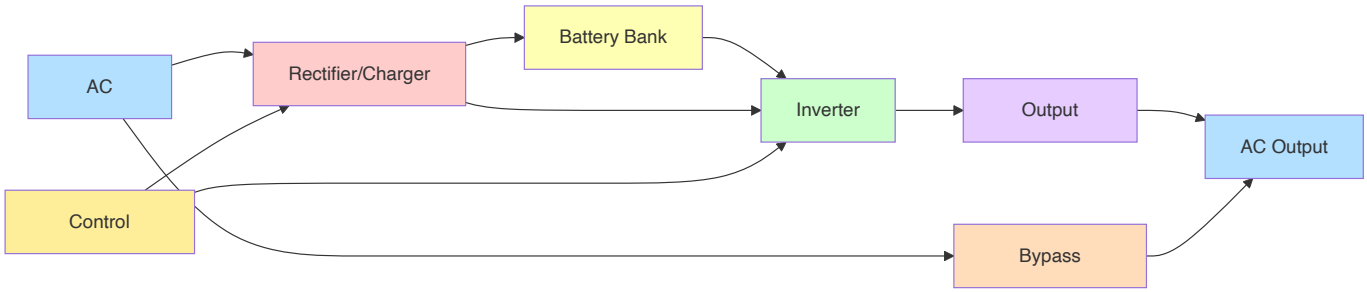
Mnemonic: "DANCE" - "DC needs Active commutation, Natural for AC, Costs Extra for forced"

Question 2(c) [7 marks]

Describe the working of UPS with the help of block diagram.

Answer:

UPS Block Diagram and Operation:



UPS Operation Modes:

Mode	Description	Power Path
Normal	AC source powers load via rectifier and inverter	AC Input → Rectifier → Inverter → Output
Battery	Battery powers load when AC fails	Battery → Inverter → Output
Bypass	AC directly connects to load for maintenance	AC Input → Bypass Switch → Output
Charging	Battery charges while in normal mode	Rectifier → Battery

- **Online UPS**: Power always flows through rectifier/inverter (double conversion)
- **Offline UPS**: Power flows directly to load, switches to battery when power fails
- **Line-Interactive**: Similar to offline but with voltage regulation
- **Backup Time**: Depends on battery capacity and load requirements

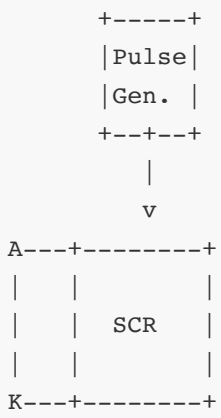
Mnemonic: "BRIC" - "Battery Ready when Input Cuts off"

Question 2(a) OR [3 marks]

Explain pulse gate triggering method of SCR.

Answer:

Pulse Gate Triggering Method:



Parameter	Specification	Advantage
Pulse Width	10-100 μs	Ensures proper turn-on
Amplitude	1-3V above threshold	Reliable triggering
Rise Time	Fast (<1 μs)	Quick turn-on
Frequency	Single or train of pulses	Control over timing

- **Precise Control**: Exact timing of SCR turn-on
- **Noise Immunity**: Less susceptible to false triggering
- **Power Efficiency**: Low average gate power consumption
- **Isolation**: Can be coupled through pulse transformer or opto-isolator

Mnemonic: "TRAP" - "Timed, Reliable, Amplitude-controlled Pulses"

Question 2(b) OR [4 marks]

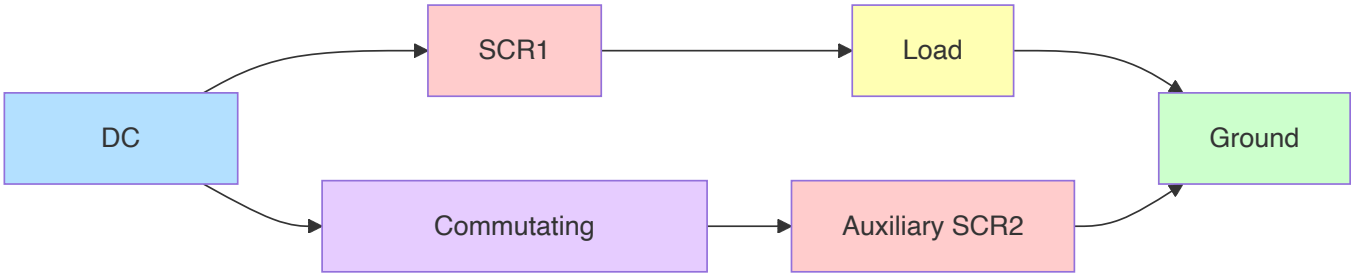
List the commutation methods of SCR and explain any one in detail.

Answer:

Commutation Methods of SCR:

Method	Circuit Type	Application
Class A	Self-commutated by resonating LC	Low-power inverters
Class B	Self-commutated by AC source	AC power control
Class C	Complementary SCR commutation	DC choppers
Class D	External pulse commutation	DC/AC converters
Class E	External capacitor commutation	DC power control
Class F	Line commutation	AC line controlled rectifiers

Detailed Explanation of Class E (Capacitor Commutation):



- **Working Principle**: When SCR1 is ON and carrying load current, firing SCR2 connects pre-charged capacitor across SCR1, reverse biasing it
- **Turn-OFF Time**: Determined by capacitor value and circuit resistance
- **Applications**: DC choppers, power control circuits, inverters
- **Advantages**: Simple circuit, reliable operation, cost-effective

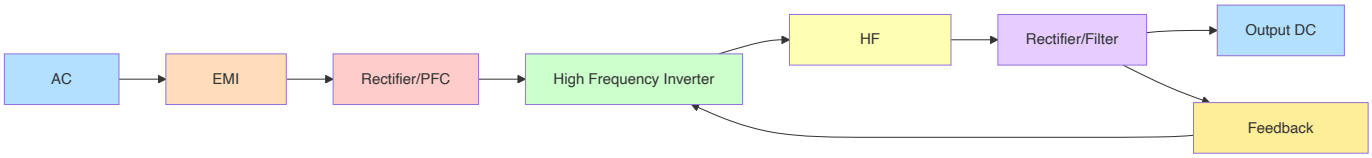
Mnemonic: "CARE" - "Capacitor Applies Reverse voltage for Extinction"

Question 2(c) OR [7 marks]

Describe the working of SMPS with the help of block diagram.

Answer:

SMPS Block Diagram and Operation:



SMPS Working Principles:

Block	Function	Key Components
EMI Filter	Suppresses noise	Inductors, capacitors
Rectifier/PFC	Converts AC to DC, improves power factor	Diodes, boost converter
HF Inverter	Creates high-frequency AC	Switching transistors (MOSFET/IGBT)
HF Transformer	Isolates and transforms voltage	Ferrite core transformer
Output Stage	Rectifies and filters to clean DC	Fast diodes, LC filter
Feedback	Regulates output voltage	Opto-isolator, PWM controller

- **High Efficiency**: 70-95% efficient compared to 50-60% for linear power supplies
- **Size Reduction**: High-frequency operation allows smaller transformers
- **Regulation**: Feedback loop maintains stable output despite input/load changes
- **Protection**: Built-in overcurrent, overvoltage, and thermal protection

Mnemonic: "RELIEF" - "Rectify, Energize at high frequency, Isolate, Extract DC, Feedback"

Question 3(a) [3 marks]

State the method to protect SCR against over voltage.

Answer:

SCR Overvoltage Protection Methods:

Method	Circuit Implementation	Protection Level
Snubber Circuit	RC network across SCR	dv/dt protection
MOV (Metal Oxide Varistor)	Connected across SCR	Transient suppression
Voltage Clamping	Zener diodes in series	Fixed voltage limiting
Crowbar Circuit	Sensing and shunting circuit	Complete shutdown

- **Voltage Rating**: Always use SCR with voltage rating 2-3 times normal operating voltage
- **Rate-of-Rise**: Protect against fast transients with snubber circuits (dv/dt protection)
- **Breakdown Voltage**: Never exceed reverse breakdown voltage of SCR junction
- **Coordinated Protection**: Use multiple methods for critical applications

Mnemonic: "SCRAM" - "Snubber Circuits Reduce Abnormal Maximum voltages"

Question 3(b) [4 marks]

State any four advantages of polyphase rectifiers over single-phase rectifiers.

Answer:

Advantages of Polyphase Rectifiers:

Advantage	Explanation	Impact
Higher Power Handling	Distributes load across phases	Suitable for high-power applications
Reduced Ripple	Overlapping phases reduce output ripple	Less filtering required
Better Transformer Utilization	Higher transformer utilization factor (0.955 vs 0.812)	More economical design
Improved Power Factor	Better line utilization	Reduced line losses
Lower Harmonic Content	Harmonics start at higher frequencies	Reduced EMI issues
Higher Efficiency	Reduced losses due to better distribution	Lower operating costs

- **Form Factor**: Lower form factor means better DC quality
- **Ripple Frequency**: Higher ripple frequency is easier to filter
- **Balanced Load**: Polyphase draws balanced current from supply
- **Size Reduction**: Smaller filter components needed

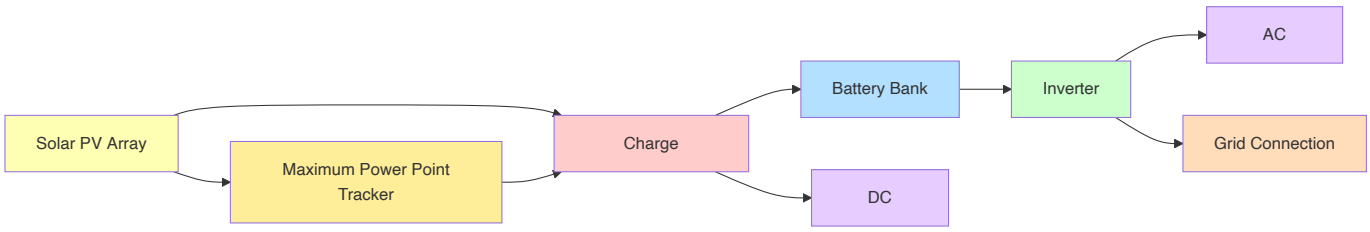
Mnemonic: "HERBS" - "Higher efficiency, Even load, Reduced ripple, Better PF, Smaller filters"

Question 3(c) [7 marks]

Describe the working of solar Photovoltaic (PV) based power generation with the help of block diagram.

Answer:

Solar PV Power Generation System:



System Components and Functions:

Component	Function	Key Features
PV Array	Converts sunlight to DC electricity	Multiple series/parallel connected panels
MPPT	Maximizes power extraction	Tracks optimal operating point
Charge Controller	Manages battery charging	Prevents overcharging/deep discharge
Battery Bank	Energy storage	Deep cycle batteries for reliability
Inverter	Converts DC to AC	Pure sine wave for sensitive equipment
Distribution Panel	Routes power to loads	Includes protection devices

- **Grid-Tied Systems**: Connected to utility grid, can sell excess power
- **Off-Grid Systems**: Standalone systems with battery storage
- **Hybrid Systems**: Can operate in both modes with battery backup
- **Efficiency**: Typical system efficiency 15-20% from sunlight to usable electricity

Mnemonic: "SIMPLE" - "Sun In, Maximum Power, Local Energy"

Question 3(a) OR [3 marks]

State the method to protect SCR against over current.

Answer:

SCR Overcurrent Protection Methods:

Method	Implementation	Response Time
Fuses	Fast-acting semiconductor fuses	Very fast (microseconds)
Circuit Breakers	Magnetic/thermal breakers	Medium (milliseconds)
Current Limiting Reactors	Series inductors	Instantaneous
Electronic Current Limiting	Sensing and control circuits	Fast (microseconds)

- **Current Rating**: Always use SCR with current rating above maximum operating current
- **di/dt Protection**: Limit rate of current rise to prevent junction damage
- **Thermal Management**: Proper heatsinking to prevent thermal runaway
- **Coordination**: Protection device must act before SCR is damaged

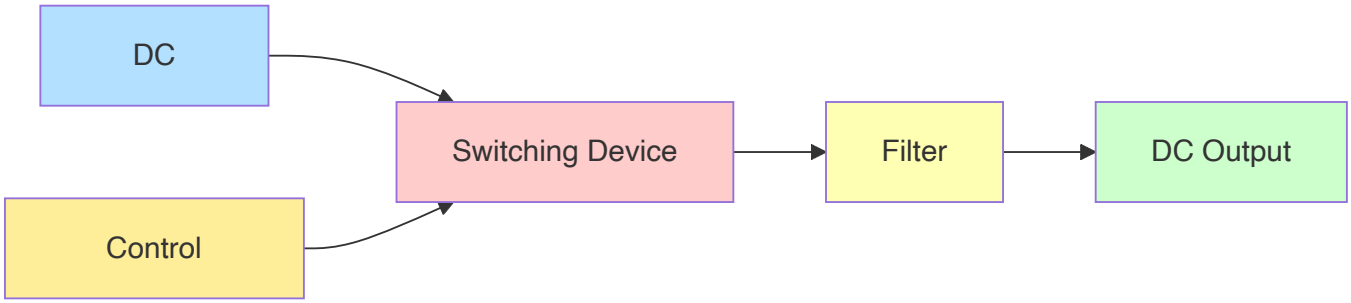
Mnemonic: "FIRE" - "Fuses Immediately Restrict Excessive current"

Question 3(b) OR [4 marks]

Explain basic principle of DC chopper.

Answer:

DC Chopper Basic Principle:



Parameter	Description	Effect
Duty Cycle (α)	Ratio of ON time to total period	Controls output voltage
Switching Frequency	Number of ON/OFF cycles per second	Affects ripple and filter size
Chopping Method	Step-up, Step-down, Buck-boost	Determines voltage conversion
Control Strategy	PWM, Current mode, etc.	Affects system response

- **Basic Equation**: Vout = Vin × Duty Cycle (for step-down chopper)
- **Operating Principle**: Rapid switching controls average voltage
- **Advantages**: High efficiency, precise control, compact size
- **Applications**: DC motor drives, battery charging, DC voltage regulation

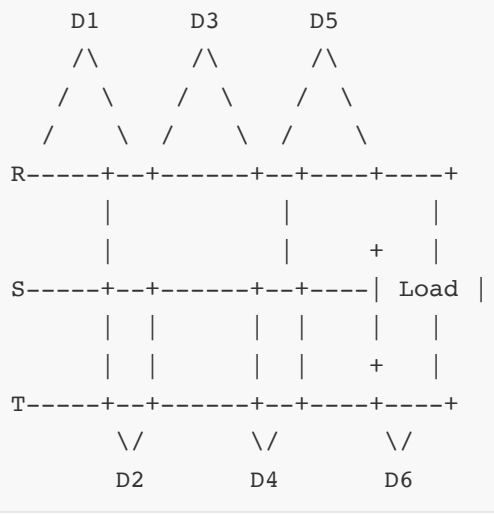
Mnemonic: "DISC" - "Duty cycle Influences Switching to Control output"

Question 3(c) OR [7 marks]

Draw the circuit diagram of 3-Φ Full Wave rectifier using diode and explain it's working.

Answer:

3-Phase Full Wave Diode Rectifier (Bridge Configuration):



Working Principles:

Phase	Conduction Pattern	Output Characteristics
0°-60°	D1 and D6 conduct	R and T phases connected to load
60°-120°	D1 and D2 conduct	R and S phases connected to load
120°-180°	D3 and D2 conduct	S and R phases connected to load
180°-240°	D3 and D4 conduct	S and T phases connected to load
240°-300°	D5 and D4 conduct	T and S phases connected to load
300°-360°	D5 and D6 conduct	T and R phases connected to load

- **Ripple Frequency**: 6 times the input frequency (300/360Hz for 50/60Hz input)
- **Ripple Factor**: Approximately 4.2% (much lower than single-phase)
- **Average Output Voltage**: Vdc = 1.35 × Vrms (line voltage)
- **Conduction Angle**: Each diode conducts for 120° of cycle

Mnemonic: "PRESTO" - "Pairs of diodes Rectify Efficiently, Six Times per cycle Output"

Question 4(a) [3 marks]

Write the applications of Induction heating.

Answer:

Applications of Induction Heating:

Application Area	Specific Uses	Advantages
Metal Heat Treatment	Hardening, annealing, tempering	Precise control, localized heating
Melting	Foundry operations, precious metals	Clean, efficient melting
Welding	Pipe welding, brazing, soldering	Concentrated heat, no contact
Forging	Pre-heating billets, hot forming	Rapid heating, energy efficient
Domestic	Induction cooktops	Safety, efficiency, control
Medical	Hyperthermia treatment	Controlled deep tissue heating

- **Industrial Advantages**: Fast heating, energy efficiency, clean process
- **Control Benefits**: Precise temperature control, repeatable results
- **Environmental Impact**: Reduced emissions compared to fossil fuel heating
- **Metallurgical Quality**: Improved material properties in many applications

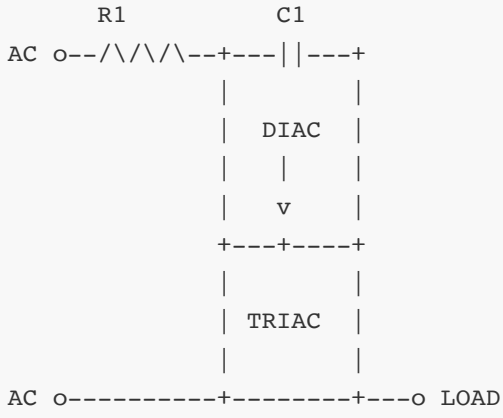
Mnemonic: "HAMMER" - "Hardening, Annealing, Melting, Medical, Eddy-current cooking, Reshaping metals"

Question 4(b) [4 marks]

Draw and explain the circuit of controlling AC load using TRIAC and DIAC.

Answer:

AC Load Control with TRIAC and DIAC:



Circuit Operation:

Component	Function	Effect on Circuit
R1	Variable resistor	Controls charging rate of C1
C1	Timing capacitor	Creates phase shift for triggering
DIAC	Bi-directional trigger	Provides sharp triggering pulse
TRIAC	Power control device	Controls current to load
RC Network	Phase-shift network	Determines firing angle

- **Phase Control**: Adjusting R1 changes phase angle at which DIAC triggers
- **Power Control**: Varying firing angle controls average power to load
- **Bi-directional Control**: Works on both half-cycles of AC input
- **Applications**: Light dimmers, fan speed control, heater control

Mnemonic: "CRAFT" - "Capacitor and Resistor Adjust Firing Time"

Question 4(c) [7 marks]

Explain Spot Welding with Working and Applications.

Answer:

Spot Welding Process and Applications:

Spot Welding Working Principle:

Stage	Process	Parameters
Setup	Material placed between electrodes	Sheet thickness, material type
Contact	Electrodes apply pressure	200-1000 pounds pressure
Current Flow	High current passes through workpiece	1000-100,000 amperes
Heating	Resistance creates localized heating	Temperatures around 2500°F
Fusion	Material melts and forms nugget	0.1-1 seconds duration
Cooling	Pressure maintained during cooling	Electrode cooling important

Applications of Spot Welding:

- **Automotive**: Car body assembly, sheet metal joining
- **Electronics**: Battery tabs, small component assembly
- **Appliances**: Refrigerators, washing machines, dishwashers

- **Aerospace**: Aircraft panel assembly, lightweight structures
- **Medical**: Surgical instruments, implantable devices
- **Consumer Products**: Metal furniture, containers, toys

Mnemonic: "PCAFRI" - "Position, Compress, Apply current, Form nugget, Release after cooling, Inspect"

Question 4(a) OR [3 marks]

Write the applications of Dielectric heating.

Answer:

Applications of Dielectric Heating:

Industry	Applications	Advantages
Food Processing	Defrosting, cooking, pasteurization	Uniform heating, speed
Wood Industry	Drying, glue curing, delamination	Reduced time, improved quality
Textile	Drying yarns, fibers, finished goods	Energy efficiency, speed
Plastics	Preheating, molding, welding	Uniform heating, no surface damage
Pharmaceutical	Drying, sterilization	Controlled process, speed
Paper	Drying, glue setting	Uniform moisture removal

- **Process Benefits**: Volumetric heating (heats throughout, not just surface)
- **Speed Advantage**: Significantly faster than conventional heating
- **Quality Improvement**: More uniform heating, better product quality
- **Energy Efficiency**: Direct energy transfer to material

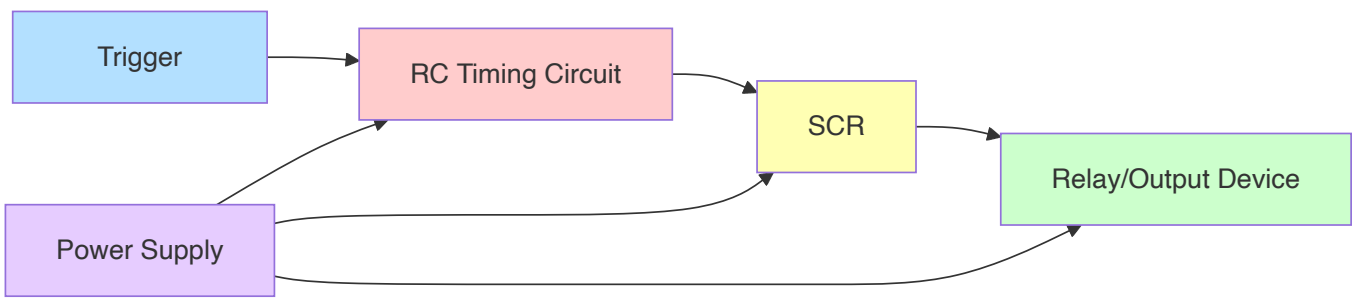
Mnemonic: "FITPP" - "Food, Insulation drying, Textiles, Plastics, Pharmaceutical products"

Question 4(b) OR [4 marks]

Write short note on SCR Delay timer.

Answer:

SCR Delay Timer:



Component	Function	Selection Criteria
RC Network	Determines time delay	R×C gives approximate timing
SCR	Switching element	Current rating based on load
UJT/Trigger	Provides gate pulse	Reliable triggering circuit
Output Stage	Controls load	Relay or direct load connection

- **Timing Principle**: RC charging time determines delay period
- **Accuracy**: Typically ±5-10% of set time
- **Applications**: Industrial process control, sequence control, protection circuits
- **Advantages**: Simple design, reliable operation, cost-effective

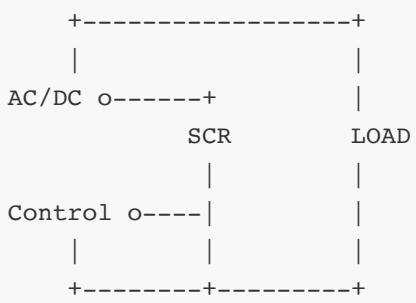
Mnemonic: "TIME" - "Timing Is Managed by Electronics"

Question 4(c) OR [7 marks]

Explain the working of SCR as static switch. Write the advantages of static switch.

Answer:

SCR as Static Switch:



Working Principles:

Mode	State	Characteristics
OFF State	No gate signal	High impedance, minimal leakage
ON State	Gate triggered	Low impedance, high current flow
Turn-ON	Gate pulse applied	Fast transition (μs range)
Turn-OFF	Current falls below holding	Automatic in AC, needs commutation in DC

- **DC Operation**: Requires commutation circuit for turn-off
- **AC Operation**: Natural turn-off at zero crossing

- **Control Methods**: Direct gate drive, pulse triggering, opto-isolation
- **Protection**: Requires snubber circuits, current limiting

Advantages of Static Switches:

Advantage	Description	Comparison with Mechanical
No Moving Parts	No mechanical wear or tear	Longer lifetime (millions of operations)
Silent Operation	No audible noise during switching	Important in noise-sensitive applications
Fast Switching	Microsecond range switching	Much faster than mechanical contacts
No Arcing	No contact bounce or arcing	Safer in hazardous environments
Size & Weight	Compact and lightweight	Significant space savings
EMI/RFI	Less electromagnetic interference	Better for sensitive electronics

- **Reliability**: Higher MTBF (Mean Time Between Failures)
- **Compatibility**: Works with electronic control systems
- **Voltage Isolation**: Can incorporate opto-isolation
- **Surge Handling**: Better transient protection with proper design

Mnemonic: "FANS" - "Fast switching, Arc-free operation, No moving parts, Silent operation"

Question 5(a) [3 marks]

What is DC Drive? Give Classification of DC Drives.

Answer:

DC Drive Definition and Classification:

Aspect	Description
Definition	Electronic system that controls speed, torque, and direction of DC motors
Basic Function	Controls armature voltage and/or field current to regulate motor parameters

Classification of DC Drives:

Classification Basis	Types	Characteristics
Power Rating	Fractional, Integral, High Power	Based on horsepower rating
Control Method	Open Loop, Closed Loop	Based on feedback mechanism
Quadrant Operation	Single, Two, Four Quadrant	Based on speed/torque direction
Power Supply	Single-phase, Three-phase	Based on input power configuration
Converter Type	Half-wave, Full-wave, Chopper	Based on power conversion method
Application	General Purpose, Servo, Specialized	Based on intended use

- **Power Range**: From fractional HP to several thousand HP
- **Control Precision**: From basic to high-precision (0.01%)
- **Response Time**: From milliseconds to microseconds
- **Protection**: Various built-in protection features

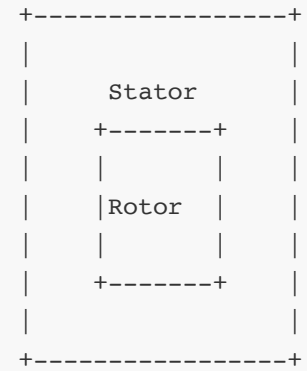
Mnemonic: "PQCAS" - "Power rating, Quadrants, Control type, AC input phases, Switching method"

Question 5(b) [4 marks]

Draw and explain the construction of variable reluctance type Stepper motor.

Answer:

Variable Reluctance Stepper Motor Construction:



Component	Construction	Function
Stator	Laminated steel with multiple poles and windings	Creates magnetic field when energized
Rotor	Soft iron with multiple teeth, NO permanent magnets	Aligns with energized stator poles
Air Gap	Small space between rotor and stator	Affects step accuracy and torque
Windings	Multiple phase windings on stator	Sequential energizing creates rotation

- **Tooth Configuration**: Typically rotor teeth fewer than stator teeth
- **Step Angle**: Determined by: Step angle = 360° ÷ (Number of rotor teeth × Number of phases)
- **Construction Simplicity**: No permanent magnets or windings on rotor
- **Operating Principle**: Magnetic reluctance path seeks to minimize when phases energized

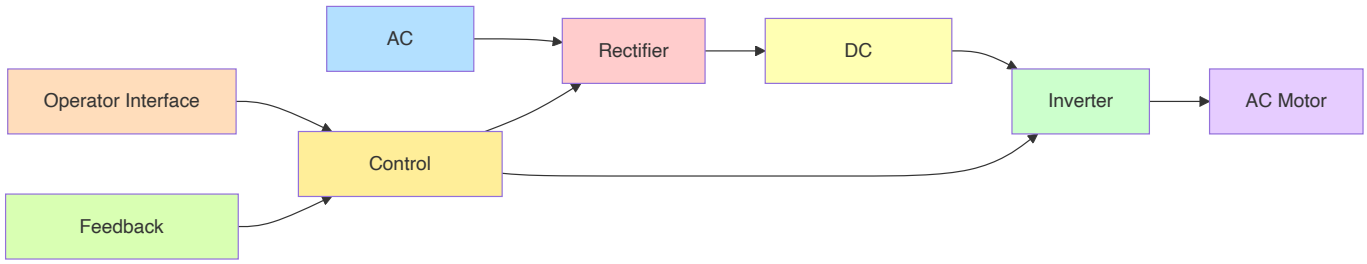
Mnemonic: "STAR" - "Stator energizes, Teeth Align with minimum Reluctance"

Question 5(c) [7 marks]

Explain the working of VFD (Variable Frequency Drive).

Answer:

Variable Frequency Drive (VFD) Working:



VFD Components and Functions:

Component	Function	Features
Rectifier	Converts AC to DC	6-pulse or 12-pulse designs
DC Bus	Filters and stores energy	Capacitors and inductors
Inverter	Creates variable frequency AC	IGBT or MOSFET based
Control System	Manages overall operation	Microprocessor based
HMI	User interface	Display, keypad, communication
Protection	System protection	Current, voltage, temperature sensors

Working Principles:

- **Speed Control Equation**: Motor Speed (RPM) = (Frequency × 120) ÷ Number of poles
- **Torque Control**: Maintaining V/F ratio controls torque output
- **Soft Start**: Gradual frequency/voltage ramp-up reduces inrush current
- **Braking Methods**: Regenerative, dynamic, or DC injection braking
- **Energy Savings**: Significant energy savings at reduced speeds
- **Advanced Features**: PID control, network communication, programmable functions

Mnemonic: "DRIVE" - "DC conversion, Regulation, Inverter creates, Variable frequency, Efficient motor control"

Question 5(a) OR [3 marks]

What are Hall effect sensors and what is their role in DC motors?

Answer:

Hall Effect Sensors in DC Motors:

Aspect	Description
Definition	Semiconductor-based sensors that detect magnetic fields
Principle	Voltage difference generated perpendicular to current flow in magnetic field
Signal Output	Digital (ON/OFF) or analog (proportional to field strength)
Size	Compact, can be integrated into motor housing

Role in DC Motors:

Function	Application	Benefit
Position Sensing	Rotor position detection	Precise commutation timing
Speed Measurement	Pulse generation for RPM calculation	Accurate speed feedback
Direction Detection	Phase sequence monitoring	Rotation direction control
Current Sensing	Non-contact current measurement	Overload protection

- **BLDC Motors**: Critical for electronic commutation (replacing mechanical commutator)
- **Precision**: Higher accuracy than mechanical sensors
- **Reliability**: No mechanical wear, longer service life
- **Integration**: Can be integrated with drive electronics

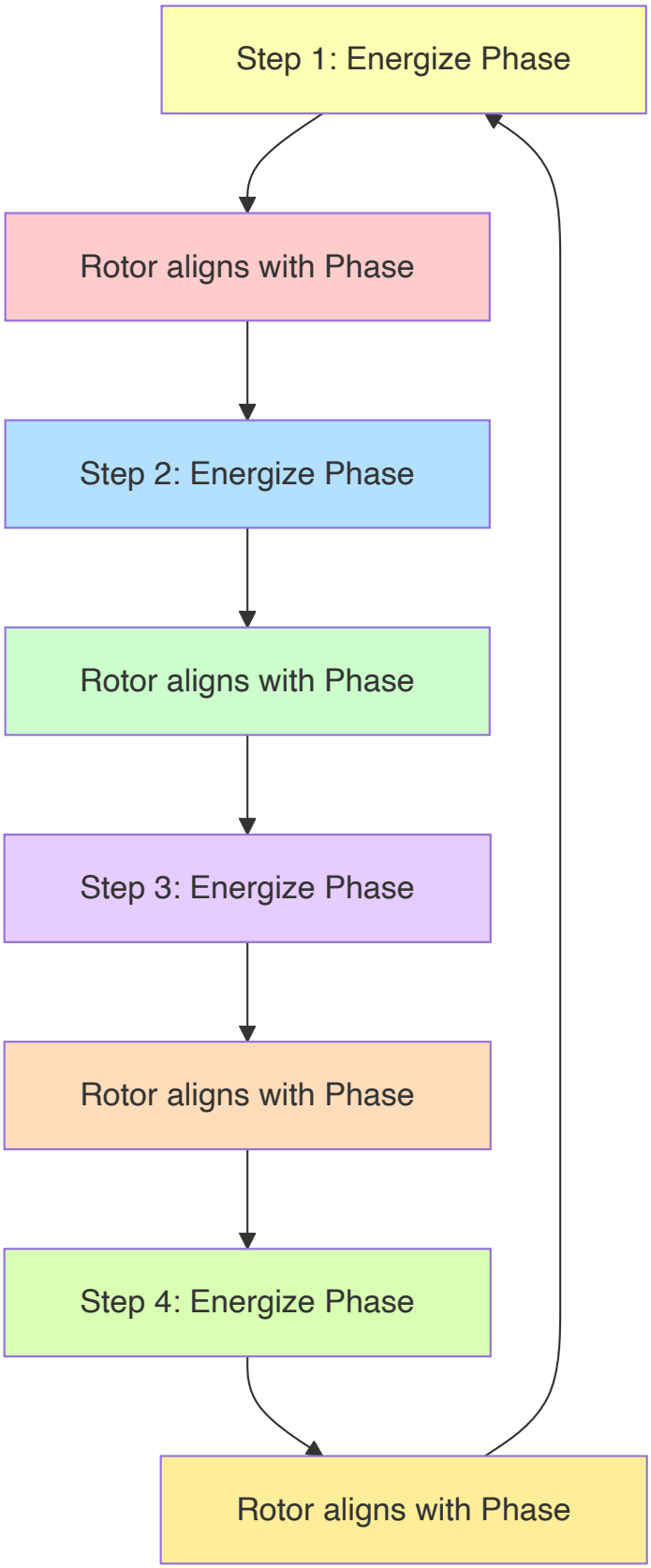
Mnemonic: "MAPS" - "Measures position, Aids commutation, Provides speed data, Senses magnetic fields"

Question 5(b) OR [4 marks]

Explain working principle of stepper motor.

Answer:

Stepper Motor Working Principle:


Step 1: Energize Phase
Rotor aligns with Phase
Step 2: Energize Phase
Rotor aligns with Phase
Step 3: Energize Phase
Rotor aligns with Phase
Step 4: Energize Phase
Rotor aligns with Phase

Operating Mode	Description	Advantages
Full Step	One phase energized at a time	Maximum torque
Half Step	Alternating one and two phases energized	Double resolution, smoother
Microstepping	Proportional current in phases	Very smooth motion, high resolution
Wave Drive	Sequential single phase energization	Lower power consumption

- **Position Control**: Precise angular positioning without feedback
- **Step Angle**: Common step angles are 1.8° (200 steps/rev) or 0.9° (400 steps/rev)
- **Holding Torque**: Maintains position when phases energized at standstill
- **Open-Loop Control**: No position feedback normally required
- **Speed-Torque**: Torque decreases as speed increases

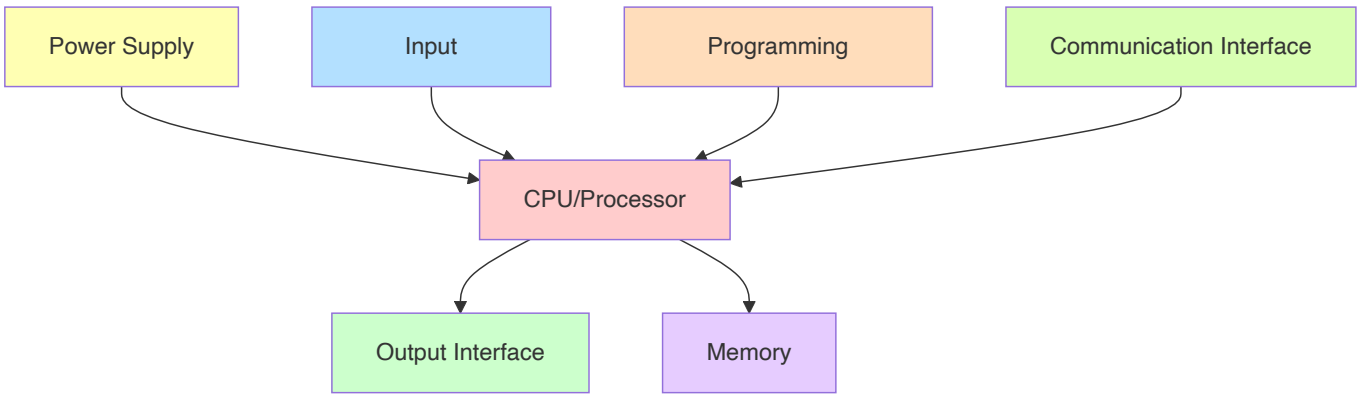
Mnemonic: "STEPS" - "Sequential Triggering of Electromagnetic Phases causes Stepping"

Question 5(c) OR [7 marks]

Draw the block diagram of PLC and explain the function of each block.

Answer:

PLC Block Diagram and Functions:



Functions of Each Block:

Block	Function	Characteristics
Power Supply	Converts main power to system voltages	Regulated, protected, with isolation
CPU/Processor	Executes program, controls operations	Speed measured in scan time (ms)
Input Interface	Connects to sensors and switches	Digital/analog, isolation, filtering
Output Interface	Connects to actuators and indicators	Relay/transistor/triac outputs
Memory	Stores program and data	Program, data, and system memory areas
Programming Device	Used to develop and load programs	PC, handheld programmer, software
Communication	Connects to networks/other devices	Industrial protocols, remote I/O

- **Scan Cycle**: Sequential process of reading inputs, executing program, updating outputs
- **Programming Languages**: Ladder Diagram (LD), Function Block Diagram (FBD), Structured Text (ST), Instruction List (IL), Sequential Function Chart (SFC)
- **Modularity**: Expandable with additional I/O modules
- **Robustness**: Designed for harsh industrial environments
- **Reliability**: Typically MTBF >100,000 hours

Mnemonic: "PICO MPC" - "Power, Inputs, CPU, Outputs, Memory, Programming interface, Communication"