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Department of

ELECTRICAL AND ELECTRONICS ENGINEERING

DESIGN AND IMPLEMENTATION OF POWER SYSTEM PROTECTION AND RENEWABLE ENERGY CIRCUITS

PROJECT-BASED LEARNING

for II & III Year B.Tech I Semester Students

GENERATION | TRANSMISSION | EV | SOLAR | WIND

PREPARED BY
Dr. C. SASIKALA
Head of the Department

Hands-on Learning
Innovative Projects

Skill Development
Problem Solving

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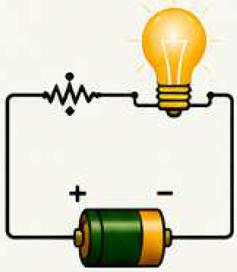

DESIGN AND IMPLEMENTATION OF POWER SYSTEM PROTECTION AND RENEWABLE ENERGY CIRCUITS

PROJECT-BASED LEARNING

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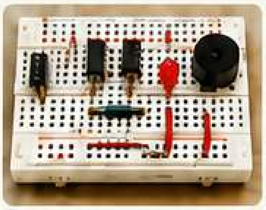
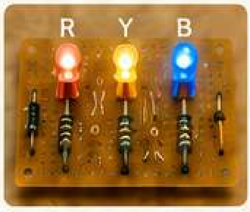
LIST OF EXPERIMENTS

1. Single Phase Preventer

2. Automatic Power Failure Indicator

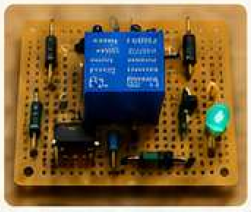


3. Three Phase Sequence Indicator



4. Over Voltage Protection Circuit

5. Under Voltage Protection Circuit



6. Transformer Overload Protection System

7. DC Motor Speed Controller Using PWM

8. DC Motor Forward and Reverse Controller

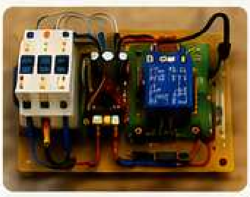
9. Solar Battery Charge Controller

10. Solar LED Street Light System

11. Transformer Oil Temperature Monitoring System

12. Mini Inverter (12V DC to 230V AC)

13. Automatic Changeover Switch



14. Earth Leakage Detection and Protection System

15. Emergency LED Lighting System with Auto Charging

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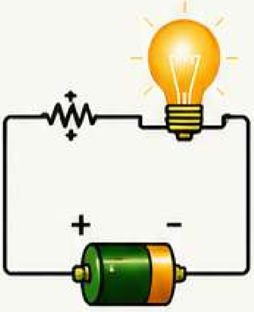

DESIGN AND IMPLEMENTATION OF POWER SYSTEM PROTECTION AND RENEWABLE ENERGY CIRCUITS

PROJECT-BASED LEARNING

for II & III Year B.Tech I Semester Students

LIST OF PROJECTS

S.No.	Project Title
1.	Single Phase Preventer
2.	Automatic Power Failure Indicator
3.	Three Phase Sequence Indicator
4.	Over Voltage Protection Circuit
5.	Under Voltage Protection Circuit
6.	Transformer Overload Protection System
7.	DC Motor Speed Controller Using PWM
8.	DC Motor Forward and Reverse Controller
9.	Solar Battery Charge Controller
10.	Solar LED Street Light System
11.	Transformer Oil Temperature Monitoring System
12.	Mini Inverter (12V DC to 230V AC)
13.	Automatic Changeover Switch
14.	Earth Leakage Detection and Protection System
15.	Emergency LED Lighting System with Auto Charging

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- Skill Development

PROJECT MANUAL

1. SINGLE PHASE PREVENTER

AIM

To design and implement a single phase preventer to protect three phase motors and electrical equipment from single phasing conditions.

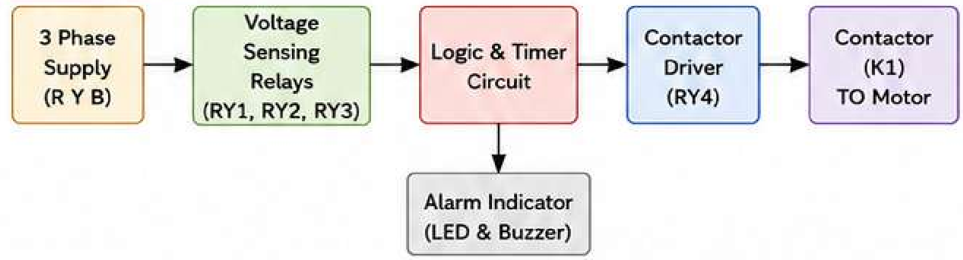
COMPONENTS REQUIRED

S.No.	Component	Specification	Quantity
1	3 Phase Supply	415V AC, 50Hz	1
2	Voltage Sensing Relays (RY1, RY2, RY3)	415V AC Coil	3
3	Auxiliary Relay (RY4)	12V DC Coil, 2CO	1
4	Contactor (K1)	3 Pole, 415V AC, 16A	1
5	Timer Relay	0–10 Sec, 12V DC	1
6	Diode (D1)	1N4007	2
7	Resistor (R1, R2)	10 kΩ, 1/4 W	2
8	LED (Red)	5mm	1
9	Buzzer	12V DC	1
10	MCB / Fuse	6A	1
11	Power Supply	12V DC, 1A	1

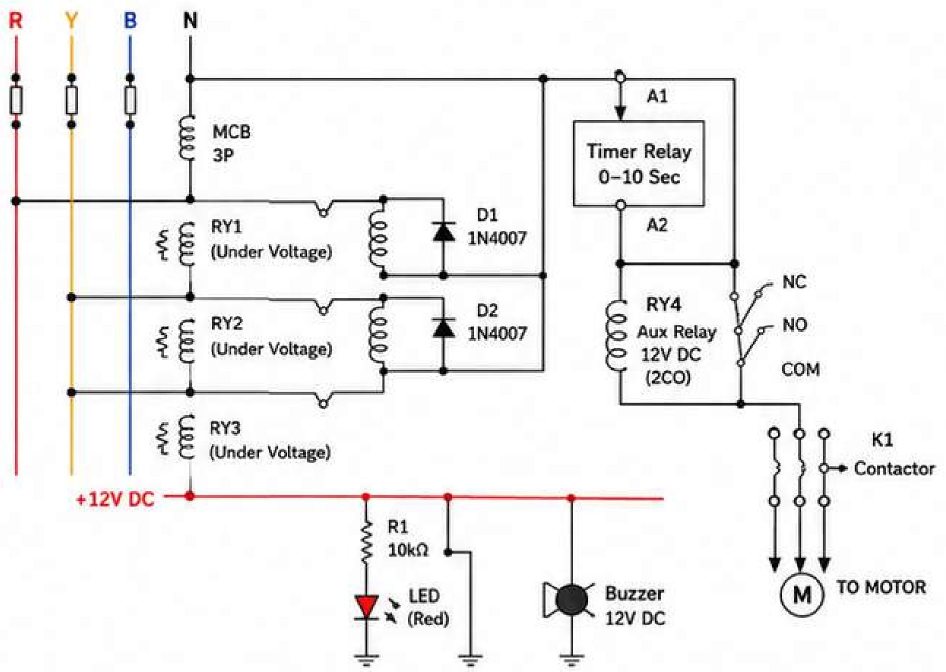
APPLICATIONS

- Protection of three phase motors from single phasing
- Used in industries, pumps, compressors and agricultural equipment
- Prevents motor burnout and equipment damage
- Improves reliability and safety

BLOCK DIAGRAM



CIRCUIT DIAGRAM



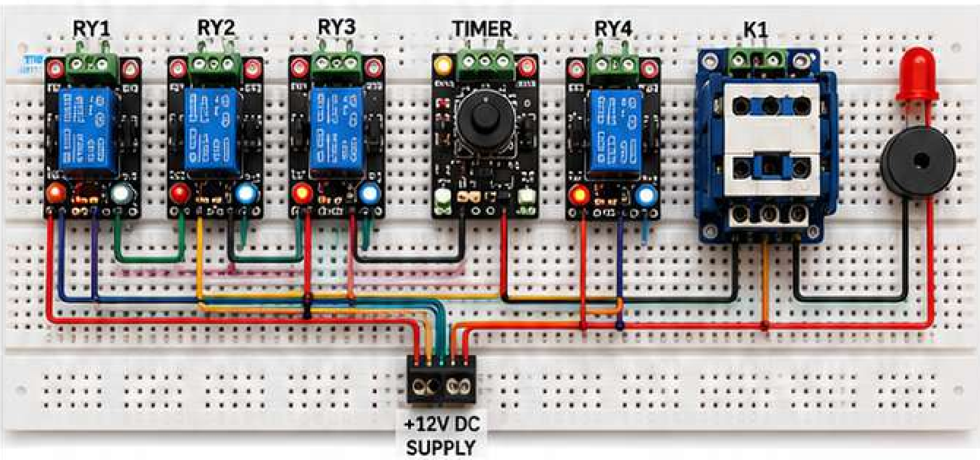
WORKING

The three phase supply (R, Y, B) is continuously monitored by the three voltage sensing relays (RY1, RY2, RY3).

If any one phase is missing (single phasing) or its voltage falls below the set limit, the corresponding relay de-energizes instantly.

This condition triggers the timer relay. After the preset delay (0–10 sec), the auxiliary relay (RY4) de-energizes, opening the contactor (K1) and disconnecting the motor from the supply.
Simultaneously, the red LED glows and the buzzer sounds to indicate single phasing fault. When all three phases are healthy, the system resets automatically (after timer delay) and the motor runs normally.

CIRCUIT DIAGRAM ON BREADBOARD



PROCEDURE

1. Connect the circuit as per the circuit diagram.
2. Provide 12V DC to the control circuit.
3. Switch ON the 3 phase supply.
4. Motor runs normally when all three phases are present.
5. Remove any one phase and observe relay operation.
6. After timer delay, contactor trips, LED glows and buzzer sounds.
7. Restore the phase and wait for timer reset.
8. Contactor closes and motor runs again.

RESULT

The single phase preventer was designed and tested successfully. It sensed single phasing condition and tripped the contactor automatically after the preset delay with visual and audible indication.

ACTUAL MODEL

PRECAUTIONS

- Ensure correct connections of all phases.
- Do not change connections while power is ON.
- Use proper rating relays and contactor.
- Keep control supply and high voltage lines separate.
- Ensure proper earthing.

FUTURE SCOPE

- Can be implemented using microcontroller for advanced protection.
- Add LCD display to show fault information.
- GSM / IoT module can be added for remote alerts.

PROJECT MANUAL

2. AUTOMATIC POWER FAILURE INDICATOR

AIM

To design and implement an automatic power failure indicator that glows a LED and sounds a buzzer when the mains power fails and restores when power returns.

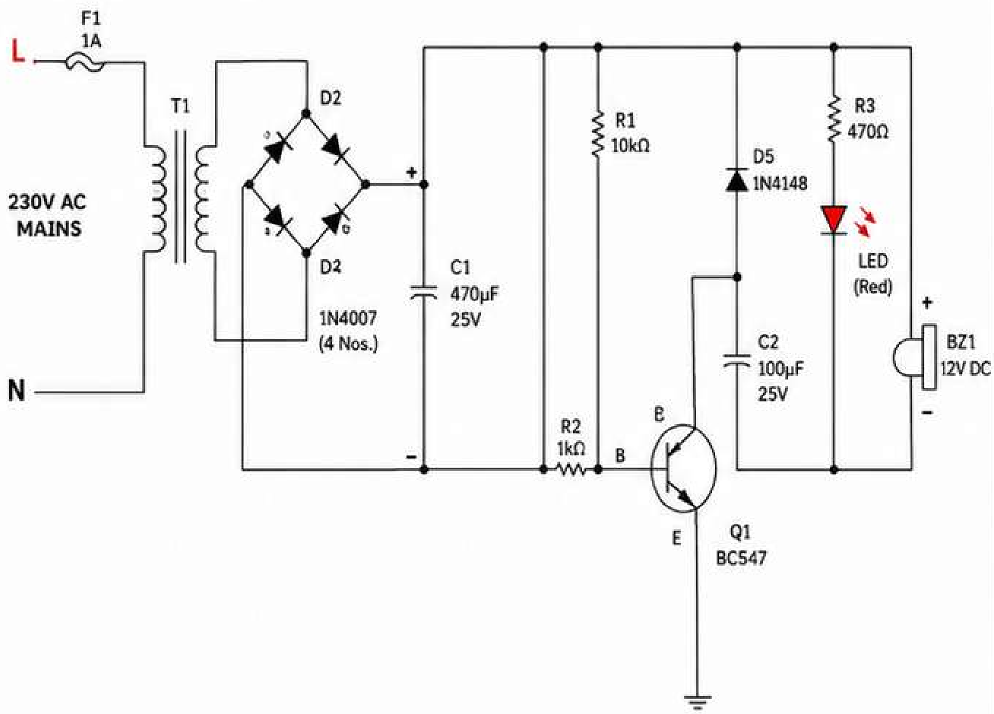
BLOCK DIAGRAM

AC Mains (230V AC) → Rectifier & Filter Circuit → Sensing & Control Circuit → Driver (Transistor) → Indicator (LED & Buzzer)

COMPONENTS REQUIRED

S.No.	Component	Specification	Quantity
1	Transformer (T1)	230V AC to 12V AC	1
2	Diode (D1–D4)	1N4007	4
3	Capacitor (C1)	470µF / 25V	1
4	Resistor (R1)	10 kΩ, 1/4 W	1
5	Resistor (R2)	1 kΩ, 1/4 W	1
6	NPN Transistor (Q1)	BC547	1
7	LED (Red)	5mm	1
8	Buzzer (BZ1)	12V DC	1
9	Diode (D5)	1N4148	1
10	Capacitor (C2)	100µF / 25V	1
11	AC Power Cord	230V AC	1
12	PCB / Breadboard	–	1

CIRCUIT DIAGRAM



APPLICATIONS

- Indicates power failure in homes and offices
- Used in industries, laboratories and shops
- Provides visual and audio alert during outages
- Protects equipment by user awareness

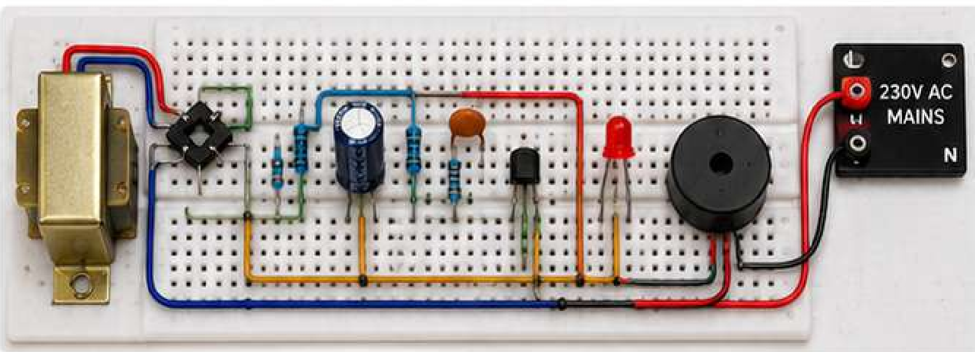
WORKING

When mains power is available, the DC voltage from the rectifier charges capacitor C2 through D5. This keeps transistor Q1 OFF, so LED and buzzer remain OFF.

During power failure, the DC voltage gradually discharges through R1 and C2. After a short delay (set by R1 and C2), the base voltage of Q1 falls below the turn ON level. Q1 turns ON and energizes the LED and buzzer to indicate power failure.

When power returns, C2 charges quickly through D5, Q1 turns OFF and the indicator stops.

CIRCUIT DIAGRAM ON BREADBOARD



PROCEDURE

1. Connect the circuit as per the circuit diagram.
2. Provide 230V AC to the primary of transformer T1.
3. Ensure all connections are correct and components are in proper position.
4. Switch ON the mains. LED and buzzer should be OFF.
5. Remove the mains supply (simulate power failure).
6. After a few seconds, LED glows and buzzer sounds.
7. Restore the mains supply. LED and buzzer should turn OFF after a short delay.

RESULT

The automatic power failure indicator was designed and tested successfully. The circuit provides visual (LED) and audio (buzzer) indication during power failure and resets automatically when power is restored.

ACTUAL MODEL

PRECAUTIONS

- Ensure proper insulation of 230V AC wiring.
- Do not touch the circuit when power is ON.
- Use correct rating of transformer and components.
- Check polarity of electrolytic capacitors.
- Keep the circuit in a suitable enclosure.

FUTURE SCOPE

- Can be implemented using microcontroller for advanced indication.
- Add LCD display to show outage duration.
- GSM / IoT module can be added for remote alerts.

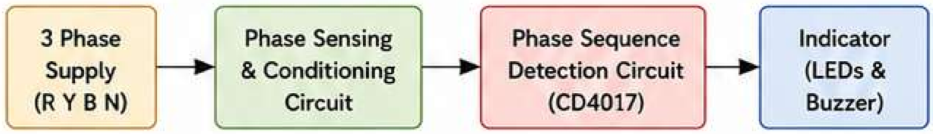
PROJECT MANUAL

3. THREE PHASE SEQUENCE INDICATOR

AIM

To design and implement a three phase sequence indicator to identify the phase sequence (R-Y-B or R-B-Y) and indicate it using LEDs.

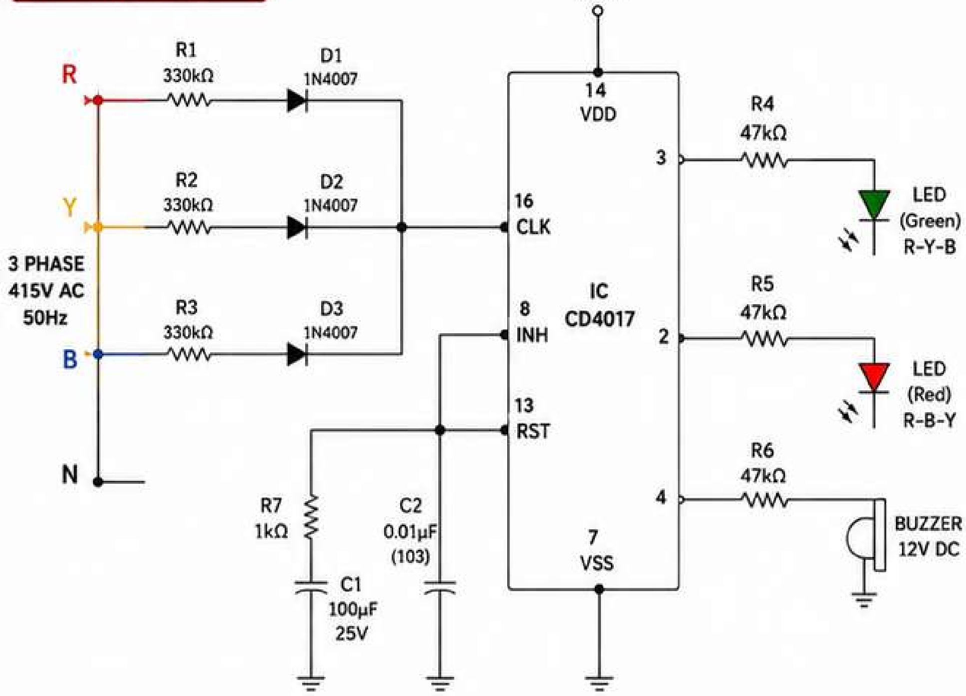
BLOCK DIAGRAM



COMPONENTS REQUIRED

S.No.	Component	Specification	Quantity
1	3 Phase Supply (R,Y,B,N)	415V AC, 50Hz	1
2	Resistors (R1–R3)	330 kΩ, 1/2 W	3
3	Resistors (R4–R6)	47 kΩ, 1/4 W	3
4	Diodes (D1–D6)	1N4007	6
5	IC (Phase Sequence Detector)	CD4017 (Decade Counter)	1
6	Capacitor (C1)	100 µF / 25V	1
7	Capacitor (C2)	0.01 µF (103)	1
8	LED (Green)	5mm	1
9	LED (Red)	5mm	1
10	Buzzer	12V DC	1
11	Resistor (R7)	1 kΩ, 1/4 W	1
12	IC Socket (14 Pin)	–	1
13	12V DC Power Supply	–	1
14	PCB / Breadboard	–	1

CIRCUIT DIAGRAM



APPLICATIONS

- Identifies phase sequence in 3 phase systems
- Useful during installation and maintenance
- Prevents damage to motors and equipment
- Used in industries, panels and laboratories

WORKING

The three phase supply (R, Y, B) is given to the phase sensing circuit through resistors R1, R2 and R3 and diodes D1, D2, D3 respectively.

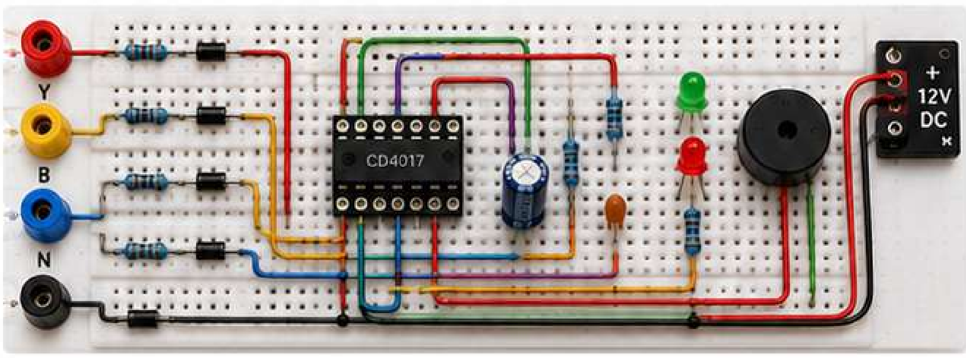
Depending on the phase sequence, pulses are applied to the clock input of IC CD4017.

If the sequence is R-Y-B, the IC output at pin 3 becomes HIGH and the green LED glows.

If the sequence is R-B-Y, the IC output at pin 2 becomes HIGH and the red LED glows.

A buzzer connected to pin 4 gives an audible indication in both the conditions.

CIRCUIT DIAGRAM ON BREADBOARD



PROCEDURE

1. Connect the circuit as per the circuit diagram.
2. Provide 12V DC to the circuit.
3. Connect 3 phase supply (R, Y, B, N) to the input terminals.
4. Switch ON the 3 phase supply.
5. Observe the indication.
   - If Green LED glows → Sequence is R-Y-B
   - If Red LED glows → Sequence is R-B-Y
6. Buzzer gives audible indication.
7. Reverse any two phases and observe the change in indication.

RESULT

The three phase sequence indicator was designed and tested successfully. The circuit correctly identified the phase sequence and indicated it using LEDs and buzzer.

ACTUAL MODEL

PRECAUTIONS

- Ensure proper connections of all three phases.
- Do not touch the circuit when power is ON.
- Use proper rating resistors, diodes and capacitors.
- Keep control supply and 3 phase supply wiring separate.
- Ensure proper earthing and insulation.

FUTURE SCOPE

- Can be implemented using microcontroller for advanced features.
- Add LCD display to show sequence.
- GSM / IoT module can be added for remote monitoring and alerts.

PROJECT MANUAL

4. OVER VOLTAGE PROTECTION CIRCUIT

AIM

To design and implement an over voltage protection circuit that disconnects the load when the supply voltage exceeds the preset limit.

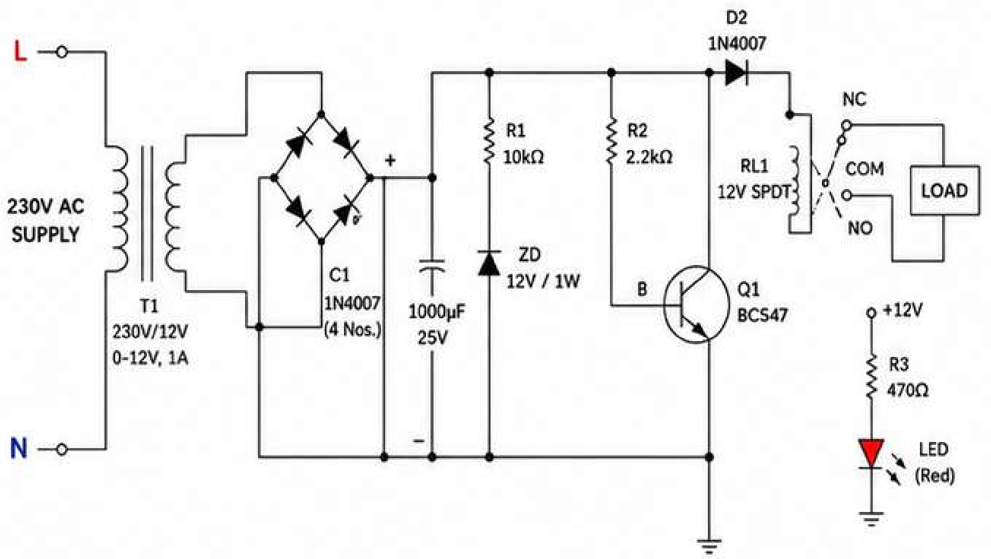
BLOCK DIAGRAM

AC Supply (230V AC) → Voltage Sensing (Zener Circuit) → Comparator (Transistor) → Relay Driver & Relay → Load (Protected)

COMPONENTS REQUIRED

S.No.	Component	Specification	Quantity
1	Zener Diode (ZD)	12V / 1W	1
2	Resistor (R1)	10 kΩ, 1/4 W	1
3	Resistor (R2)	2.2 kΩ, 1/4 W	1
4	Transistor (Q1)	BC547	1
5	Relay (RL1)	12V SPDT	1
6	Diode (D1)	1N4007	1
7	LED (Red)	5mm	1
8	Resistor (R3)	470 Ω, 1/4 W	1
9	AC Supply	230V AC, 50Hz	1

CIRCUIT DIAGRAM



APPLICATIONS

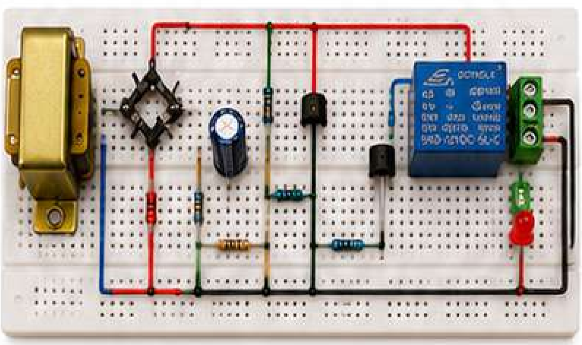
- Protects applianous from high voltage
- Used in home and industrial equipment
- Increases equipment life and reliability
- Prevents damage due to over voltage

WORKING

The circuit continuously monitors the DC voltage obtained from the rectifier. The Zener diode (12V) maintains a reference voltage. When the input voltage exceeds the preset limit (above 12V), the voltage across the Zener diode increases, forward biasing the transistor Q1.

Q1 turns ON and energizes the relay coil (RL1). The relay contact (NC) opens and disconnects the load from the supply. The red LED glows to indicate over voltage condition.

CIRCUIT DIAGRAM ON BREADBOARD



ACTUAL MODEL

FUTURE SCOPE

- Can be implemented using microcontroller.
- Add LCD to display voltage.
- Can be used in UPS and SMPS systems.

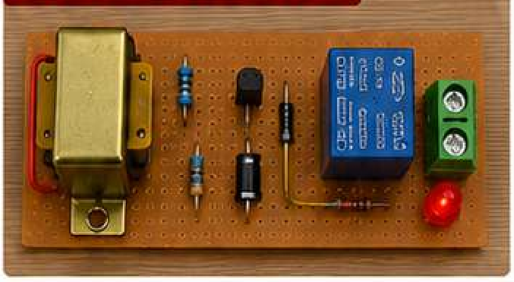
PROCEDURE

1. Connect the circuit as per the circuit diagram.
2. Provide 230V AC to the primary of transformer T1.
3. Set the preset over voltage level using Zener diode (12V).
4. Switch ON the supply.
5. Gradually increase the input voltage using a Variac / Autotransformer.
6. When voltage exceeds the preset level, relay trips, LED glows and load disconnects.
7. Reduce the voltage and observe reset condition.

RESULT

The over voltage protection circuit was designed and tested successfully. When the input voltage exceeded the preset limit, the relay got energized, the load disconnected and the red LED indicated the over voltage condition.

ACTUAL MODEL (TOP VIEW)



PRECAUTIONS

- Ensure proper isolation of 230V AC wiring.
- Do not touch the circuit when power is ON.
- Use proper rated components.
- Check polarity of electrolytic capacitor.
- Provide proper enclosure for safety.

PROJECT MANUAL

5. UNDER VOLTAGE PROTECTION CIRCUIT

AIM

To design and implement an under voltage protection circuit that disconnects the load when the supply voltage falls below the preset limit.

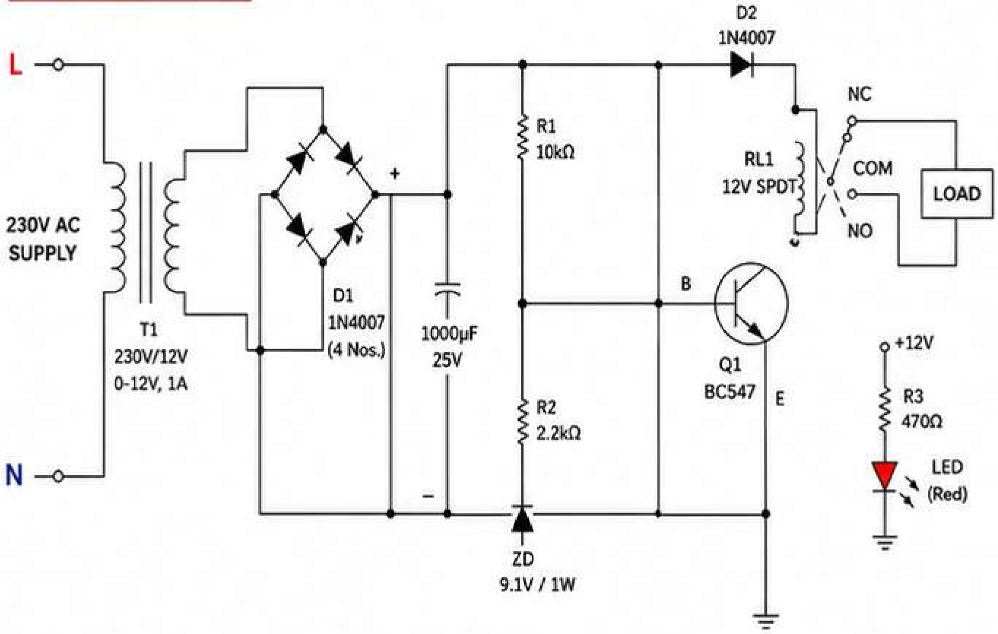
BLOCK DIAGRAM

AC Supply (230V AC) → Voltage Sensing (Zener Circuit) → Comparator (Transistor) → Relay Driver & Relay → Load (Protected)

COMPONENTS REQUIRED

S.No.	Component	Specification	Quantity
1	Zener Diode (ZD)	9.1V / 1W	1
2	Resistor (R1)	10 kΩ, 1/4 W	1
3	Resistor (R2)	2.2 kΩ, 1/4 W	1
4	Transistor (Q1)	BC547	1
5	Relay (RL1)	12V SPDT	1
6	Diode (D1)	1N4007	1
7	LED (Red)	5mm	1
8	Resistor (R3)	470 Ω, 1/4 W	1
9	AC Supply	230V AC, 50Hz	1

CIRCUIT DIAGRAM



APPLICATIONS

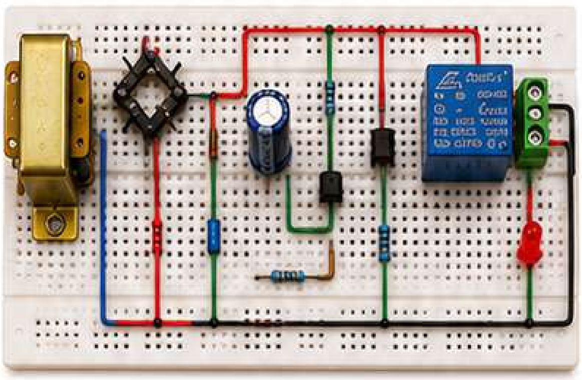
- Protects equipment from low voltage conditions
- Used in home appliances and motors
- Prevents malfunction due to low voltage
- Used in control panels and industries

WORKING

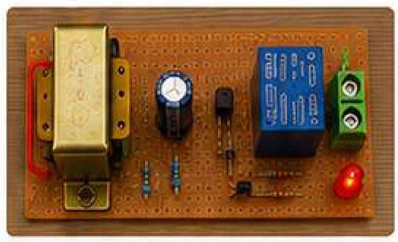
The circuit continuously monitors the DC voltage obtained from the rectifier. The Zener diode (9.1V) maintains the reference voltage. When the input voltage falls below the preset limit (below 9.1V), the voltage across the Zener diode decreases, which reduces the base bias of transistor Q1.

Q1 turns OFF and the relay coil (RL1) gets de-energized. The relay contact (NC) opens and disconnects the load from the supply. The red LED glows to indicate under voltage condition.

CIRCUIT DIAGRAM ON BREADBOARD



ACTUAL MODEL



FUTURE SCOPE

- Can be implemented using microcontroller.
- Add LCD to display voltage.
- Can be used in UPS and SMPS systems.

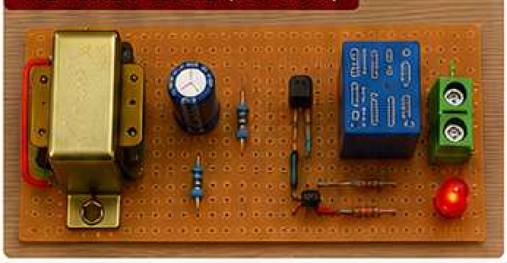
PROCEDURE

1. Connect the circuit as per the circuit diagram.
2. Provide 230V AC to the primary of transformer T1.
3. Set the preset under voltage level using Zener diode (9.1V).
4. Switch ON the supply.
5. Gradually decrease the input voltage using a Variac / Autotransformer.
6. When voltage falls below the preset level, relay trips, LED glows and load disconnects.
7. Increase the voltage and observe reset condition.

RESULT

The under voltage protection circuit was designed and tested successfully. When the input voltage fell below the preset limit, the relay got de-energized, the load disconnected and the red LED indicated the under voltage condition.

ACTUAL MODEL (TOP VIEW)



PRECAUTIONS

- Ensure proper isolation of 230V AC wiring.
- Do not touch the circuit when power is ON.
- Use proper rated components.
- Check polarity of electrolytic capacitor.
- Provide proper enclosure for safety.

PROJECT MANUAL

6. TRANSFORMER OVERLOAD PROTECTION SYSTEM

AIM

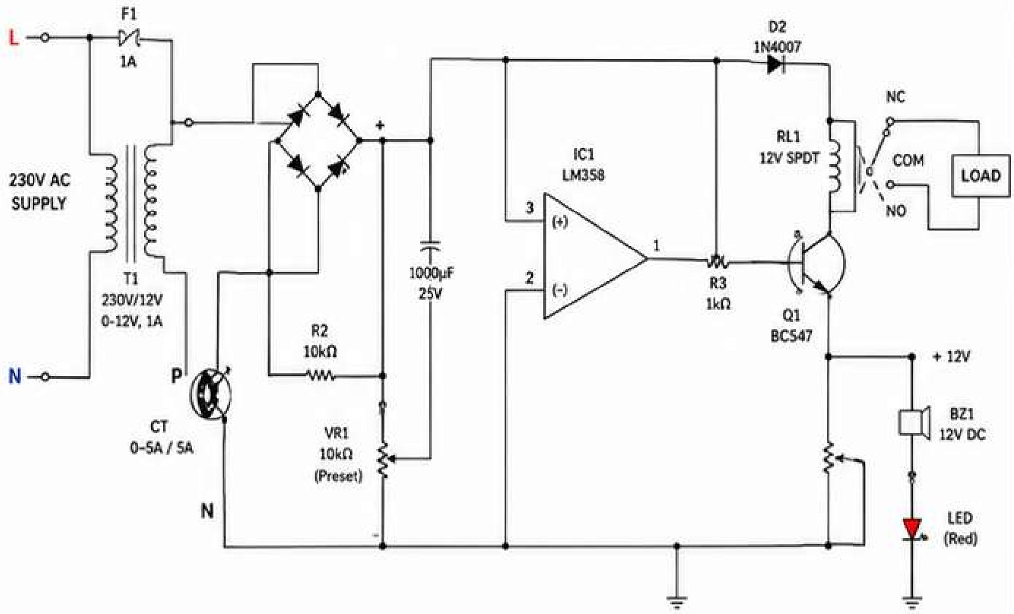
To design and implement a transformer overload protection system that disconnects the load and gives an alarm indication when the load current exceeds the preset limit.

BLOCK DIAGRAM

COMPONENTS REQUIRED

S.No.	Component	Specification	Quantity
1	Current Transformer (CT)	0-5A / 5A	1
2	Resistor (R1)	10 kΩ, 1/4 W	1
3	Resistor (R2)	10 kΩ, 1/4 W	1
4	Preset (VR1)	10 kΩ	1
5	Diode (D1)	1N4007	1
6	Comparator (IC1)	LM358	1
7	Transistor (Q1)	BC547	1
8	Relay (RL1)	12V SPDT	1
9	Diode (D2)	1N4007	1
10	LED (Red)	5mm	1
11	Buzzer (BZ1)	12V DC	1
12	AC Supply	230V AC, 50Hz	1
13	Transformer (T1)	230/12V, 1A	1

CIRCUIT DIAGRAM



APPLICATIONS

- Protects transformers from overload
- Used in distribution transformers
- Extends transformer life and reliability
- Prevents damage due to excessive current
- Used in industries, utilities and panels

WORKING

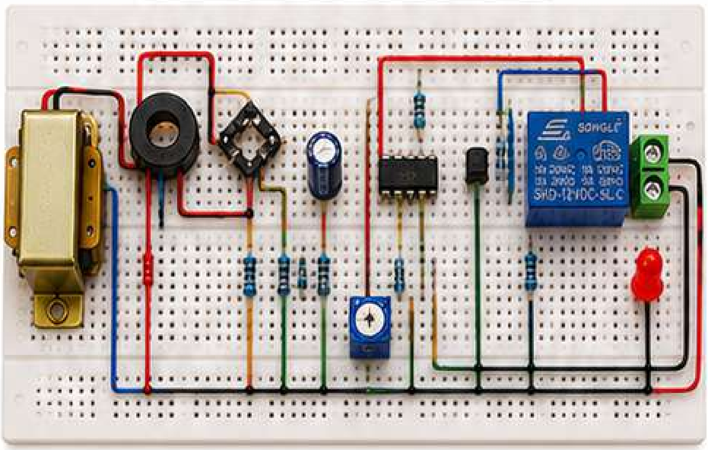
The current from the transformer secondary is sensed by the Current Transformer (CT). When the load current exceeds the preset limit, the voltage across R1 increases.

This voltage is applied to the non-inverting (+) input of the comparator.

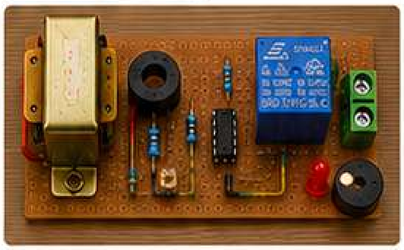
If it is greater than the reference voltage set by VR1, the comparator output goes HIGH.

This turns ON transistor Q1, which energizes relay RL1. The relay contact (NC) opens and disconnects the load. The red LED glows and buzzer gives an audible alarm.

CIRCUIT DIAGRAM ON BREADBOARD



ACTUAL MODEL



FUTURE SCOPE

- Can be implemented using microcontroller.
- Add LCD to display load current.
- Data logging and GSM alert can be added.
- Can be used in SCADA and IoT based monitoring systems.

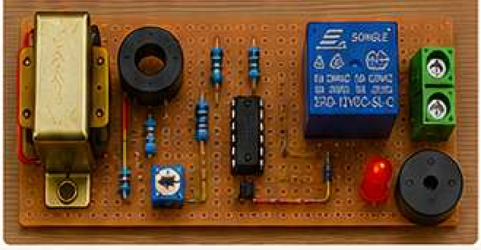
PROCEDURE

1. Connect the circuit as per the circuit diagram.
2. Provide 230V AC to the primary of transformer T1.
3. Set the preset VR1 to the required current limit.
4. Switch ON the supply.
5. Gradually increase the load connected to the transformer secondary.
6. When the load current exceeds the preset limit, relay trips, LED glows and buzzer sounds.
7. Reduce the load and observe reset condition of the relay.

RESULT

The transformer overload protection system was designed and tested successfully. When the load current exceeds the preset limit, the system disconnects the load through the relay and gives visual (LED) and audio (buzzer) alarm indication.

ACTUAL MODEL (TOP VIEW)



PRECAUTIONS

- Ensure proper insulation of 230V AC wiring.
- Do not touch the circuit when power is ON.
- Use proper rated components and relay.
- Check CT connections and polarity.
- Keep the circuit in a suitable enclosure.

PROJECT MANUAL

7. DC MOTOR SPEED CONTROLLER USING PWM

AIM

To design and implement a DC motor speed controller using PWM technique to vary the duty cycle and control the speed of the motor.

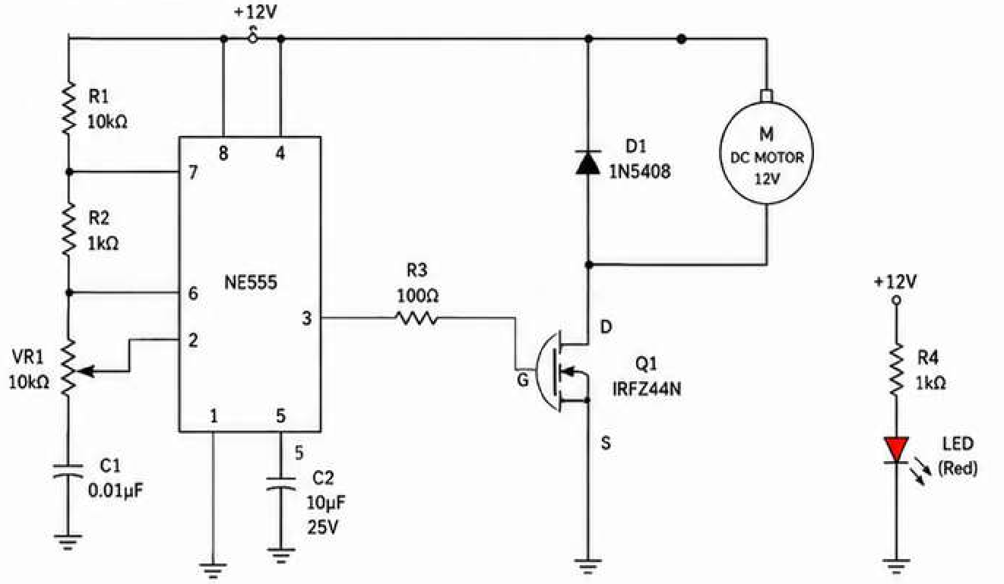
BLOCK DIAGRAM

DC Power Supply (12V DC) → PWM Generator (NE555) → MOSFET Driver & Power Stage → DC Motor → Speed Control (Output)

COMPONENTS REQUIRED

S.No.	Component	Specification	Quantity
1	DC Motor (PMDC)	12V DC, 2000 RPM	1
2	MOSFET (IRFZ44N)	N-Channel, 55V, 49A	1
3	PWM IC (NE555)	Timer IC	1
4	Diode (D1)	1N5408	1
5	Resistor (R1)	10 kΩ, 1/4 W	1
6	Resistor (R2)	1 kΩ, 1/4 W	1
7	Resistor (R3)	100 Ω, 1/4 W	1
8	Potentiometer (VR1)	10 kΩ	1
9	Capacitor (C1)	0.01 µF (103)	1
10	Capacitor (C2)	10 µF / 25V	1
11	Diode LED (Red)	5mm	1
12	DC Power Supply	12V DC, 2A	1
13	Heatsink (for MOSFET)	-	1
14	Breadboard / PCB	-	1

CIRCUIT DIAGRAM



APPLICATIONS

- Used in fans, pumps and model vehicles
- Industrial motor speed control
- Robotics and automation
- Energy saving in DC motor applications

WORKING

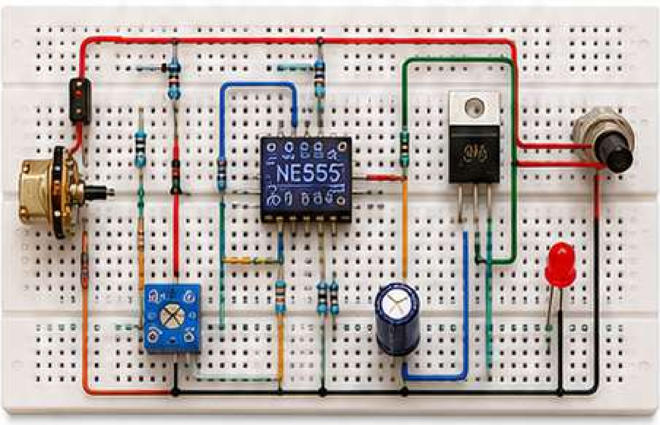
The NE555 timer is configured in astable mode to generate PWM signal. The frequency of PWM remains constant while the duty cycle is varied using potentiometer VR1.

The PWM signal from pin 3 is applied to the gate of MOSFET (IRFZ44N) through a current limiting resistor R3.

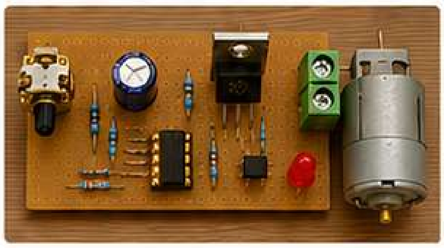
The MOSFET acts as an electronic switch and controls the power supplied to the DC motor. By changing the duty cycle, the average voltage across the motor changes, thus controlling the speed of the motor.

Diode D1 provides back EMF protection for the motor. LED indicates power ON.

CIRCUIT DIAGRAM ON BREADBOARD



ACTUAL MODEL



FUTURE SCOPE

- Can be implemented using microcontroller (e.g., Arduino) for digital control.
- Add display to show speed in RPM.
- Closed loop speed control using encoder.
- Can be used in BLDC motor drive systems.

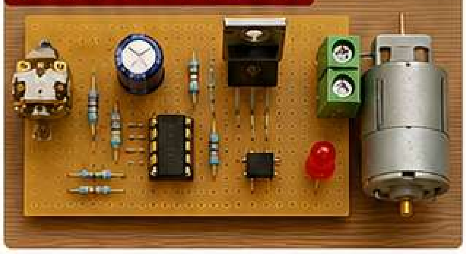
PROCEDURE

1. Connect the circuit as per the circuit diagram.
2. Provide 12V DC to the circuit.
3. Turn ON the power supply.
4. Vary the potentiometer (VR1) slowly.
5. Observe the change in motor speed.
6. LED glows indicating power ON.
7. Ensure proper heat sink for MOSFET for safe operation.

RESULT

The DC motor speed controller using PWM was designed and tested successfully. The motor speed varied smoothly with the change in duty cycle using potentiometer. The circuit provided efficient speed control with good performance.

ACTUAL MODEL (TOP VIEW)



PRECAUTIONS

- Ensure correct polarity of power supply.
- Do not exceed the rated voltage of motor.
- Use proper heat sink for MOSFET.
- Do not touch the circuit when power is ON.
- Keep connections tight and avoid loose wires.

PROJECT MANUAL

8. DC MOTOR FORWARD AND REVERSE CONTROLLER

AIM

To design and implement a DC motor forward and reverse controller using DPDT relay or H-bridge configuration to change the direction of rotation of the motor.

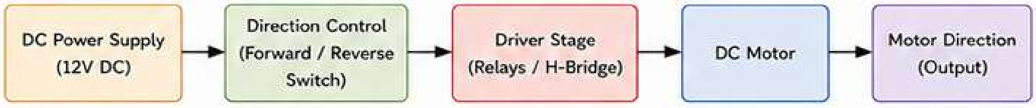
COMPONENTS REQUIRED

S.No.	Component	Specification	Quantity
1	DC Motor (PMDC)	12V DC, 2000 RPM	1
2	DPDT Relay (RL1, RL2)	12V DC Coil, 10A	2
3	Diode (D1 - D4)	1N4007	4
4	Transistor (Q1, Q2)	BC547	2
5	Resistor (R1, R2)	1 kΩ, 1/4 W	2
6	Resistor (R3, R4)	10 kΩ, 1/4 W	2
7	Switch (S1)	DPDT Center OFF	1
8	LED (Red)	5mm	2
9	DC Power Supply	12V DC, 2A	1
10	Flyback Diode (optional across motor)	1N5408	2
11	Breadboard / PCB	-	1

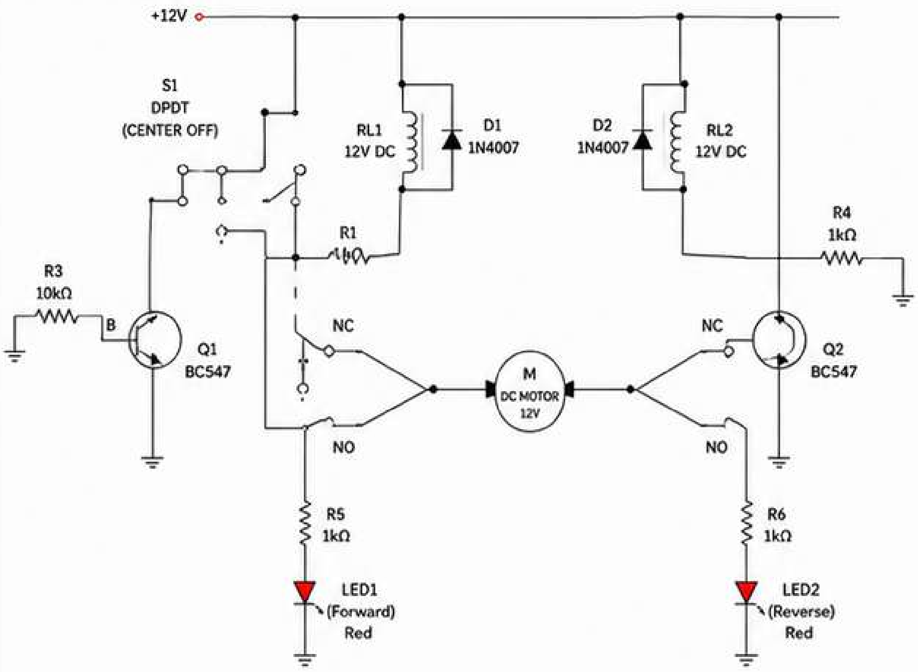
APPLICATIONS

- Used in robotics and automation
- Conveyor belt direction control
- Door and gate operation systems
- Positioning systems
- Educational and laboratory experiments

BLOCK DIAGRAM



CIRCUIT DIAGRAM



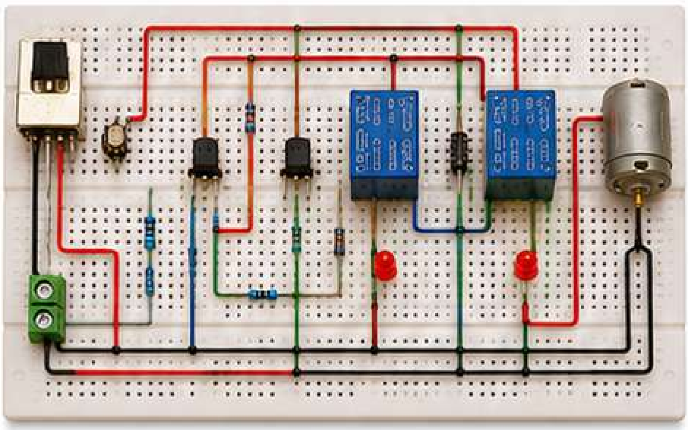
WORKING

When the switch S1 is moved to FORWARD position, relay RL1 gets energized and RL2 remains OFF. The motor terminals are connected in one polarity and the motor rotates in forward direction. LED1 glows.

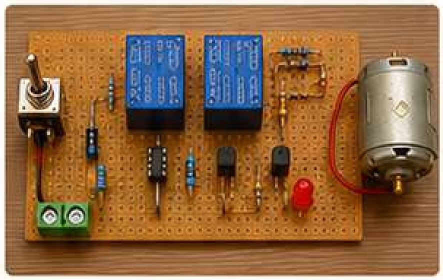
When the switch S1 is moved to REVERSE position, relay RL2 gets energized and RL1 remains OFF. The motor terminals polarity is reversed and the motor rotates in reverse direction. LED2 glows.

In center OFF position, both relays remain OFF and the motor stops.

CIRCUIT DIAGRAM ON BREADBOARD



ACTUAL MODEL



FUTURE SCOPE

- Can be implemented using H-Bridge IC (L298N).
- Speed control can be added using PWM.
- Can be controlled using microcontroller.
- Can be used in automated industrial systems.

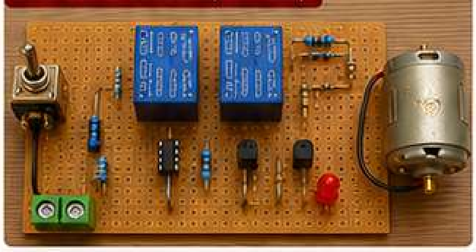
PROCEDURE

1. Connect the circuit as per the circuit diagram.
2. Provide 12V DC to the circuit.
3. Keep the switch S1 in center OFF position and switch ON the supply.
4. Move S1 to FORWARD position and observe the motor rotates forward. LED1 glows.
5. Move S1 to REVERSE position and observe the motor rotates reverse. LED2 glows.
6. Move S1 to center OFF position and observe the motor stops.

RESULT

The DC motor forward and reverse controller was designed and tested successfully. The motor rotates in forward direction when S1 is in forward position and in reverse direction when S1 is in reverse position. The LEDs indicate the direction of rotation.

ACTUAL MODEL (TOP VIEW)



PRECAUTIONS

- Ensure correct polarity of power supply.
- Do not energize both relays simultaneously.
- Use flyback diodes across relays.
- Do not touch the circuit when power is ON.
- Use proper rated components and wiring.

PROJECT MANUAL

9. SOLAR BATTERY CHARGE CONTROLLER

AIM

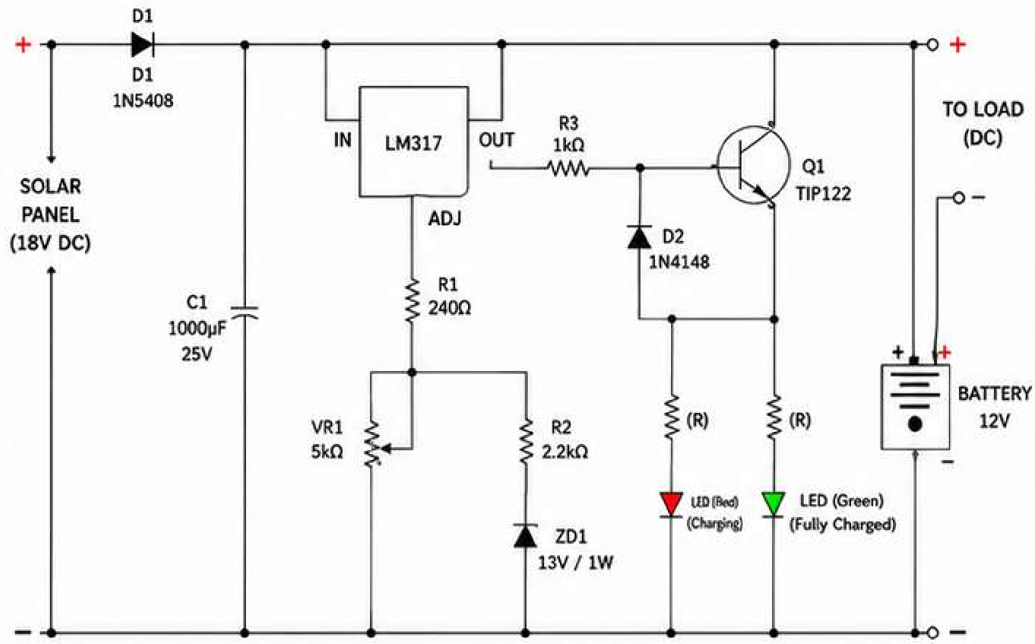
To design and implement a solar battery charge controller to regulate the charging of a 12V battery from solar panel and protect the battery from overcharge and deep discharge.

BLOCK DIAGRAM

COMPONENTS REQUIRED

S.No.	Component	Specification	Quantity
1	Solar Panel	18V, 20W	1
2	Charge Controller IC	LM317	1
3	Transistor (Q1)	TIP122	1
4	Diode (D1)	1N5408	1
5	Diode (D2)	1N4148	1
6	Zener Diode (ZD1)	13V, 1W	1
7	Resistor (R1)	240 Ω, 1/4 W	1
8	Resistor (R2)	2.2 kΩ, 1/4 W	1
9	Resistor (R3)	1 kΩ, 1/4 W	1
10	Potentiometer (VR1)	5 kΩ	1
11	LED (Red)	5mm	1
12	LED (Green)	5mm	1
13	Battery	12V, 7Ah	1
14	Capacitor (C1)	1000µF / 25V	1
15	Capacitor (C2)	0.1µF	1
16	Heat Sink (for Q1)	–	1
17	Breadboard / PCB	–	1

CIRCUIT DIAGRAM



APPLICATIONS

- Solar battery charging systems
- Off-grid solar power systems
- RVs, Boats and Solar lighting systems
- Prevents battery overcharge and deep discharge
- Prolongs battery life and improves reliability

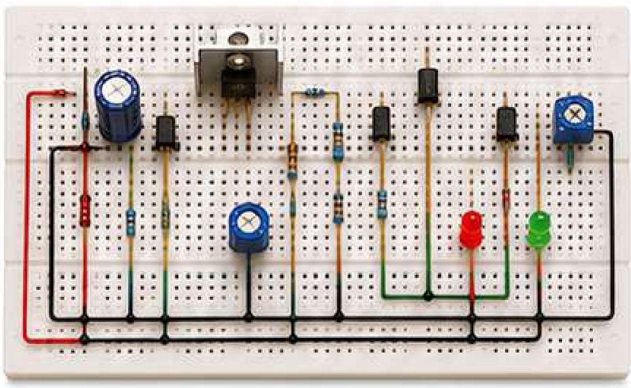
WORKING

The solar panel provides DC voltage which is fed to the circuit through diode D1 to prevent reverse current. LM317 along with transistor TIP122 acts as a current regulator to charge the battery with a constant voltage (~13.6V).

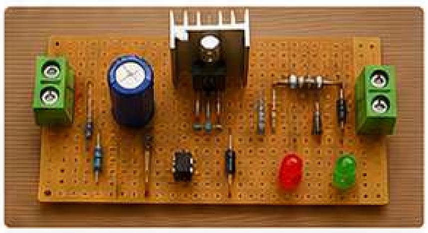
ZD1 sets the reference voltage for charging. When the battery voltage reaches the preset level, the green LED glows indicating full charge and the charging current is reduced.

When the battery discharges below the preset level, charging restarts automatically. Diode D2 protects LM317 from reverse voltage. Red LED indicates charging status.

CIRCUIT DIAGRAM ON BREADBOARD



ACTUAL MODEL



FUTURE SCOPE

- Can be implemented using microcontroller for MPPT and multi-stage charging.
- Can be used with LCD to display battery voltage and charging current.
- Can be extended for Li-ion / LiFePO4 battery charging.

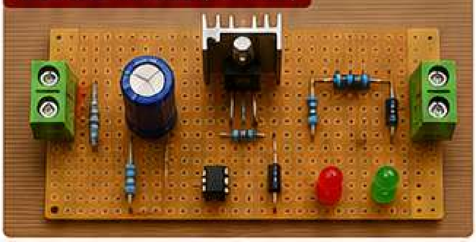
PROCEDURE

1. Connect the circuit as per the circuit diagram.
2. Connect the solar panel to the input terminals (observe polarity).
3. Connect 12V battery to the output terminals.
4. Adjust VR1 to set the charging voltage to 13.6V.
5. Expose the solar panel to sunlight.
6. Observe red LED (Charging) glows during charging.
7. When battery is fully charged, green LED glows and charging current reduces.

RESULT

The solar battery charge controller was designed and tested successfully. The circuit charges the 12V battery safely and stops charging when the battery is fully charged. The LEDs indicate the charging status.

ACTUAL MODEL (TOP VIEW)



PRECAUTIONS

- Ensure correct polarity of solar panel and battery.
- Do not exceed 18V from solar panel.
- Use heat sink for TIP122 as it may heat up.
- Do not short the battery terminals.
- Use proper rated components.
- Keep the circuit in a suitable enclosure.

PROJECT MANUAL

10. SOLAR LED STREET LIGHT SYSTEM

AIM

To design and implement a solar LED street light system using solar energy to charge the battery during day time and automatically switch ON the LED at night.

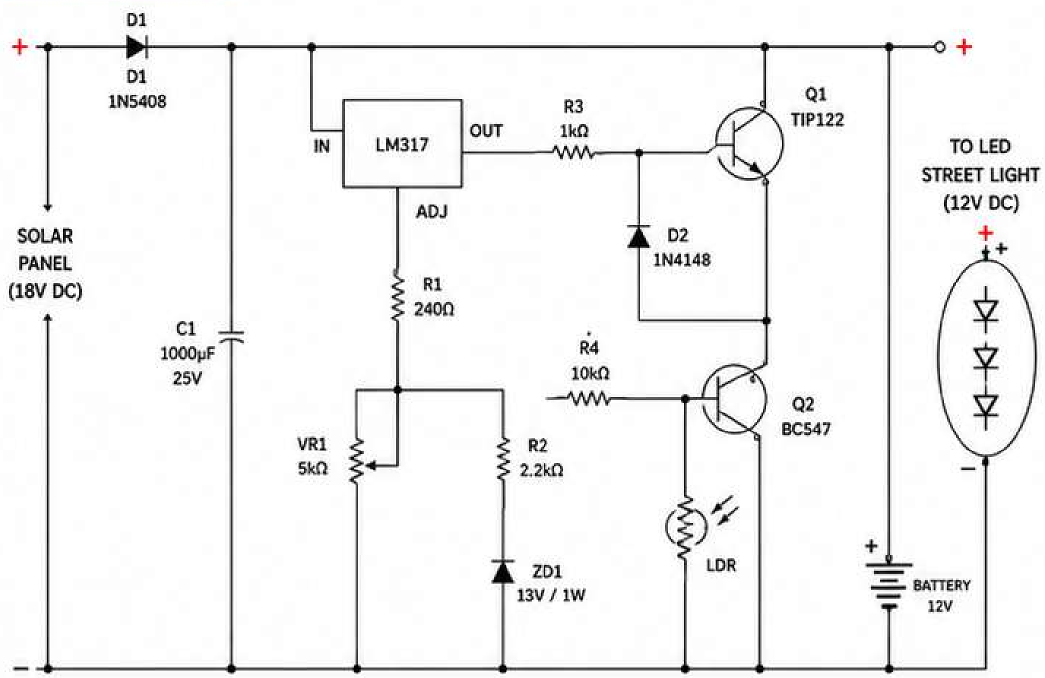
BLOCK DIAGRAM

Solar Panel (18V DC) → Charge Controller (LM317 Based) → Battery (12V) → Automatic ON/OFF (LDR + Transistor) → LED Street Light (DC Output)

COMPONENTS REQUIRED

S.No.	Component	Specification	Quantity
1	Solar Panel	18V, 20W	1
2	Charge Controller IC	LM317	1
3	Transistor (Q1)	TIP122	1
4	Transistor (Q2)	BC547	1
5	Diode (D1)	1N5408	1
6	Diode (D2)	1N4148	1
7	Zener Diode (ZD1)	13V, 1W	1
8	Resistor (R1)	240 Ω, 1/4 W	1
9	Resistor (R2)	2.2 kΩ, 1/4 W	1
10	Resistor (R3)	10 kΩ, 1/4 W	1
11	Resistor (R4)	1 kΩ, 1/4 W	1
12	LDR (Photo Resistor)	–	1
13	LED Array (White)	12V, 10W	1
14	Battery	12V, 7Ah	1
15	Capacitor (C1)	1000μF / 25V	1
16	Capacitor (C2)	0.1μF	1
17	Heat Sink (for Q1)	–	1
18	PCB / Breadboard	–	1

CIRCUIT DIAGRAM



APPLICATIONS

- Street lighting in remote areas
- Parks, gardens and parking areas
- Highways and residential colonies
- Campus and industrial premises
- Energy saving and eco-friendly lighting

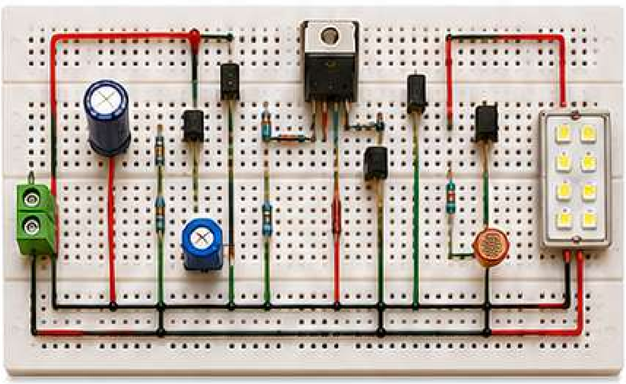
WORKING

During day time, solar panel generates DC voltage which is fed to the charge controller. LM317 regulates the charging current to charge the 12V battery safely.

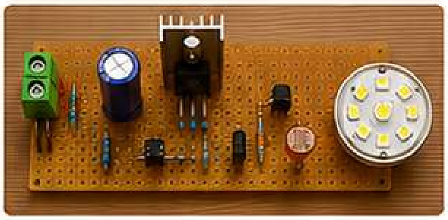
At night, the LDR resistance increases. This makes Q2 turn ON, which drives Q1 (TIP122) ON. The LED street light gets power from the battery and glows automatically.

During day time, LDR resistance is low, so Q2 remains OFF and Q1 is OFF. Thus the LED remains OFF.

CIRCUIT DIAGRAM ON BREADBOARD



ACTUAL MODEL



FUTURE SCOPE

- Can be implemented with MPPT charge controller for better efficiency.
- Can be extended with motion sensor for adaptive lighting.
- Can be used in smart city and IoT based street light monitoring systems.

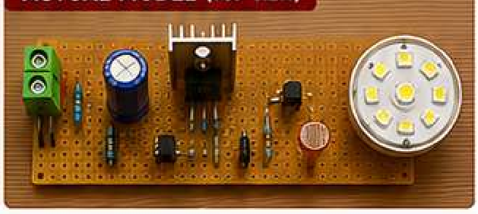
PROCEDURE

1. Connect the circuit as per the circuit diagram.
2. Connect solar panel to the input terminals (observe polarity).
3. Connect 12V battery to the output terminals.
4. Keep the circuit in sunlight and observe charging (red LED if provided or measure voltage).
5. Cover the LDR with hand or keep in dark.
6. Observe the LED street light glows.
7. Expose LDR to light, LED turns OFF.

RESULT

The solar LED street light system was designed and tested successfully. The battery charges during day time and the LED street light turns ON automatically at night and turns OFF during day time.

ACTUAL MODEL (TOP VIEW)



PRECAUTIONS

- Ensure correct polarity of solar panel and battery.
- Do not short the battery terminals.
- Use heat sink for TIP122 as it may heat up.
- Do not exceed 18V from solar panel.
- Use proper rated components and wiring.
- Keep the circuit in a suitable enclosure.

PROJECT MANUAL

11. TRANSFORMER OIL TEMPERATURE MONITORING SYSTEM

AIM

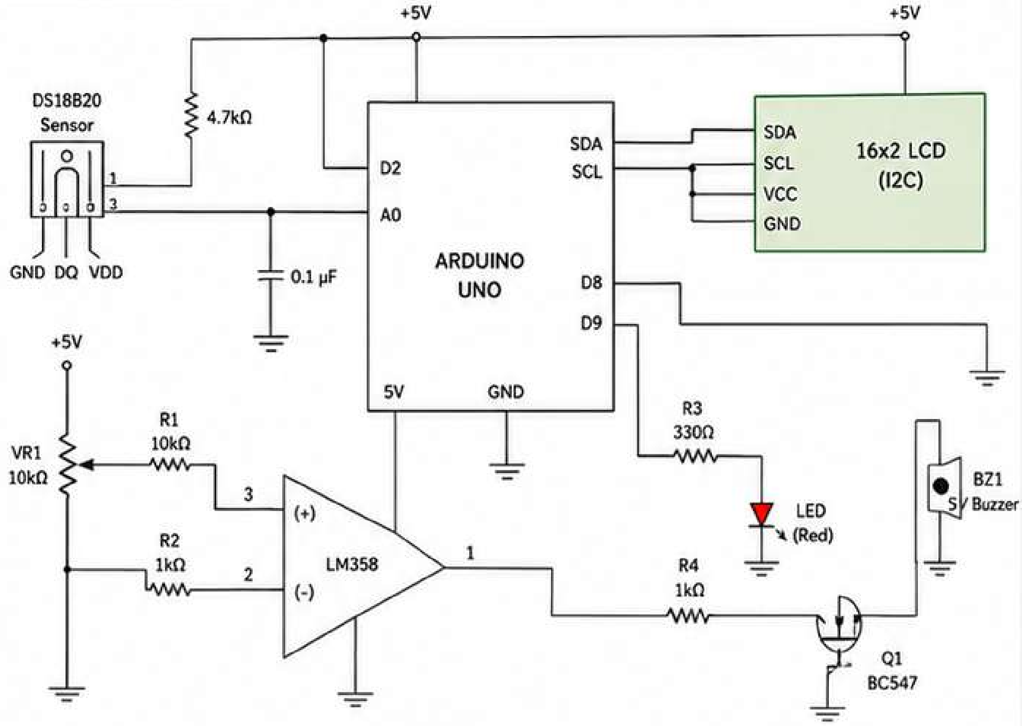
To design and implement a transformer oil temperature monitoring system that measures the oil temperature and gives visual (LED) and audible (buzzer) alarm when the temperature exceeds the preset limit.

BLOCK DIAGRAM

COMPONENTS REQUIRED

S.No.	Component	Specification	Quantity
1	Temperature Sensor	DS18B20	1
2	Comparator IC	LM358	1
3	Microcontroller	Arduino UNO	1
4	LCD Display	16x2, I2C	1
5	Buzzer (BZ1)	5V DC	1
6	LED (Red)	5mm	1
7	LED (Green)	5mm	1
8	Resistor (R1)	10 kΩ, 1/4 W	1
9	Resistor (R2)	1 kΩ, 1/4 W	1
10	Resistor (R3)	330 Ω, 1/4 W	1
11	Resistor (R4)	4.7 kΩ, 1/4 W	1
12	Potentiometer (VR1)	10 kΩ	1
13	Capacitor (C1)	100 µF / 16V	1
14	Capacitor (C2)	0.1 µF	1
15	Power Supply	12V DC, 1A	1
16	Heat Sink (for DS18B20)	–	1
17	Breadboard / PCB	–	1

CIRCUIT DIAGRAM



APPLICATIONS

- Transformer temperature monitoring
- Industrial equipment protection
- Predictive maintenance systems
- Power plant and substation monitoring
- SCADA and IoT based monitoring systems

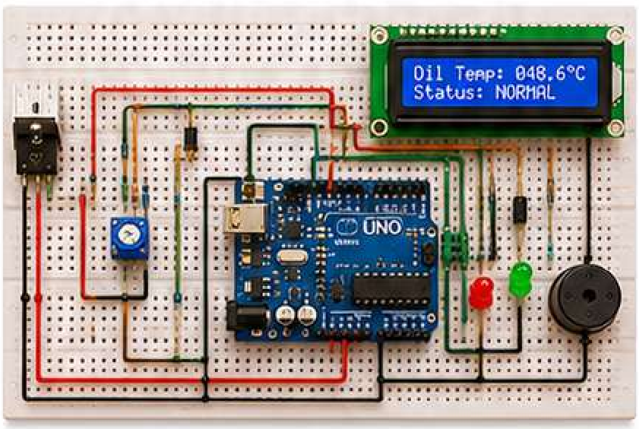
WORKING

The DS18B20 sensor senses the transformer oil temperature and sends digital data to Arduino UNO. The temperature is displayed on 16x2 LCD.

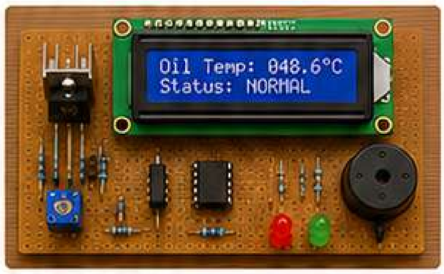
The sensor output is also compared with a preset reference voltage (set using VR1) through LM358 comparator.

If the temperature exceeds the preset limit, Arduino turns ON the red LED and buzzer as alarm. The green LED indicates that temperature is within safe limit.

CIRCUIT DIAGRAM ON BREADBOARD



ACTUAL MODEL



FUTURE SCOPE

- Can be implemented using IoT (Wi-Fi / GSM) for remote monitoring and alerts.
- Data logging and trend analysis can be added.
- Can be integrated with SCADA systems.
- Solar-powered wireless systems for remote transformers.

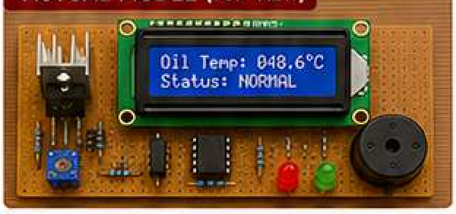
PROCEDURE

1. Connect the circuit as per the circuit diagram.
2. Provide 12V DC to the circuit (regulated to 5V for Arduino).
3. Set the preset temperature using VR1.
4. Power ON the supply.
5. Observe the temperature on LCD display.
6. Heat the sensor (simulate increase in oil temp).
7. When temperature exceeds preset limit, red LED and buzzer ON.
8. When temperature falls below preset limit, green LED glows and alarm OFF.

RESULT

The transformer oil temperature monitoring system was designed and tested successfully. The system measures and displays oil temperature on LCD and gives visual (LED) and audible (buzzer) alarm when the temperature exceeds the preset limit.

ACTUAL MODEL (TOP VIEW)



PRECAUTIONS

- Ensure proper polarity of power supply.
- Keep sensor wire short and use heat sink.
- Do not exceed 12V supply to the circuit.
- Use regulated 5V for Arduino.
- Keep the circuit in a suitable enclosure.

PROJECT MANUAL

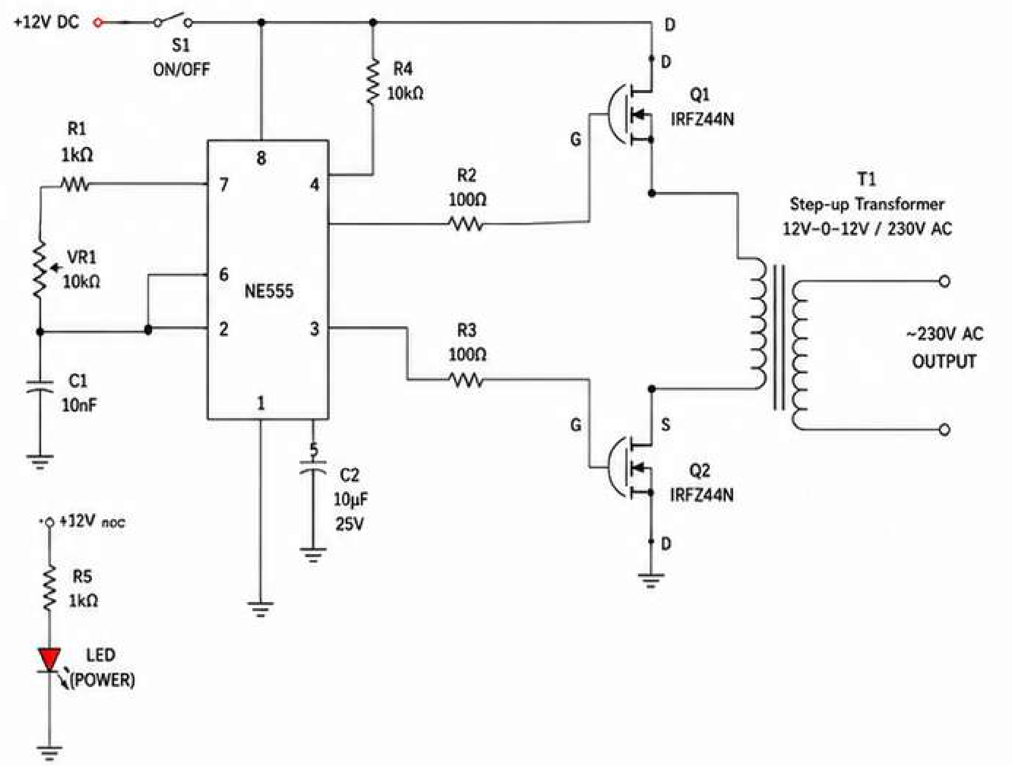
12. MINI INVERTER (12V DC TO 230V AC)

AIM

To design and implement a mini inverter to convert 12V DC from battery to 230V AC using a 555 timer based oscillator and MOSFET push-pull driver with step-up transformer.

BLOCK DIAGRAM

CIRCUIT DIAGRAM



COMPONENTS REQUIRED

S.No.	Component	Specification	Quantity
1	NE555 Timer IC	NE555	1
2	MOSFET (Q1, Q2)	IRFZ44N	2
3	Resistor (R1)	1 kΩ, 1/4 W	1
4	Resistor (R2, R3)	100 Ω, 1/4 W	2
5	Resistor (R4)	10 kΩ, 1/4 W	1
6	Resistor (VR1)	10 kΩ Pot	1
7	Capacitor (C1)	10 nF (103)	1
8	Capacitor (C2)	10 µF / 25V	1
9	DC Input (Battery)	12V, 7Ah	1
10	Step-up Transformer	12V-0-12V / 230V, 150VA	1
11	ON/OFF Switch	SPST	1
12	LED Indicator	5mm	1
13	Heat Sink (for MOSFETs)	–	2
14	PCB / Breadboard	–	1

APPLICATIONS

- Power backup for small loads
- Emergency lighting
- Small appliances (low power)
- Educational and laboratory experiments
- Camping and portable power systems

WORKING

The NE555 timer IC is configured in astable mode to generate a square wave.

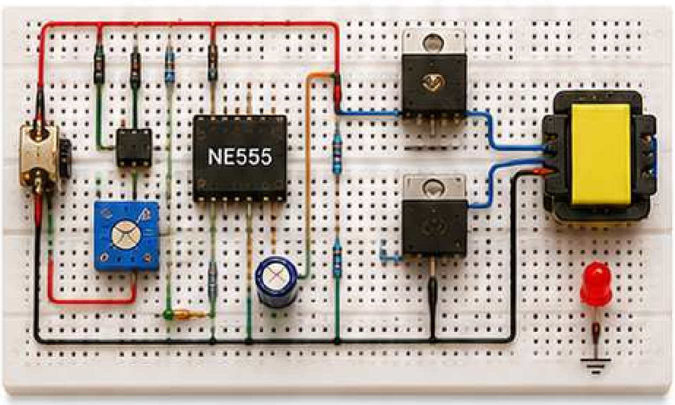
This signal drives the gates of MOSFETs Q1 and Q2 in push-pull configuration.

The MOSFETs switch the 12V DC across the primary of the step-up transformer alternately.

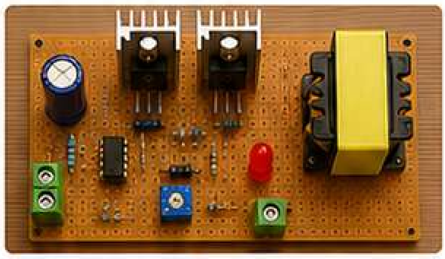
The transformer steps up the voltage to 230V AC at the secondary output.

LED indicates the power ON status.

CIRCUIT DIAGRAM ON BREADBOARD



ACTUAL MODEL



FUTURE SCOPE

- Can be improved using SPWM for better output waveform.
- Can be used with microcontroller for frequency control.
- Can be extended for higher power applications using proper MOSFETs and transformer.

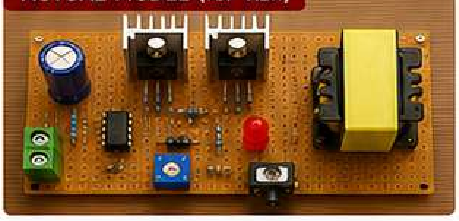
PROCEDURE

1. Connect the circuit as per the circuit diagram.
2. Connect 12V battery to the input terminals.
3. Keep the switch S1 in OFF position.
4. Check all connections properly.
5. Turn ON the switch S1.
6. Observe LED glow indicating power ON.
7. Measure output AC voltage at the transformer secondary (~230V AC).

RESULT

The mini inverter (12V DC to 230V AC) was designed and tested successfully. The circuit converts 12V DC to 230V AC using push-pull configuration with good efficiency for small loads.

ACTUAL MODEL (TOP VIEW)



PRECAUTIONS

- Ensure correct polarity of DC input.
- Do not short the output terminals.
- Use proper heat sink for MOSFETs.
- Do not connect high power loads.
- Keep the circuit in a ventilated area.
- Use proper rated transformer and components.

PROJECT MANUAL

13. AUTOMATIC CHANGEOVER SWITCH

AIM

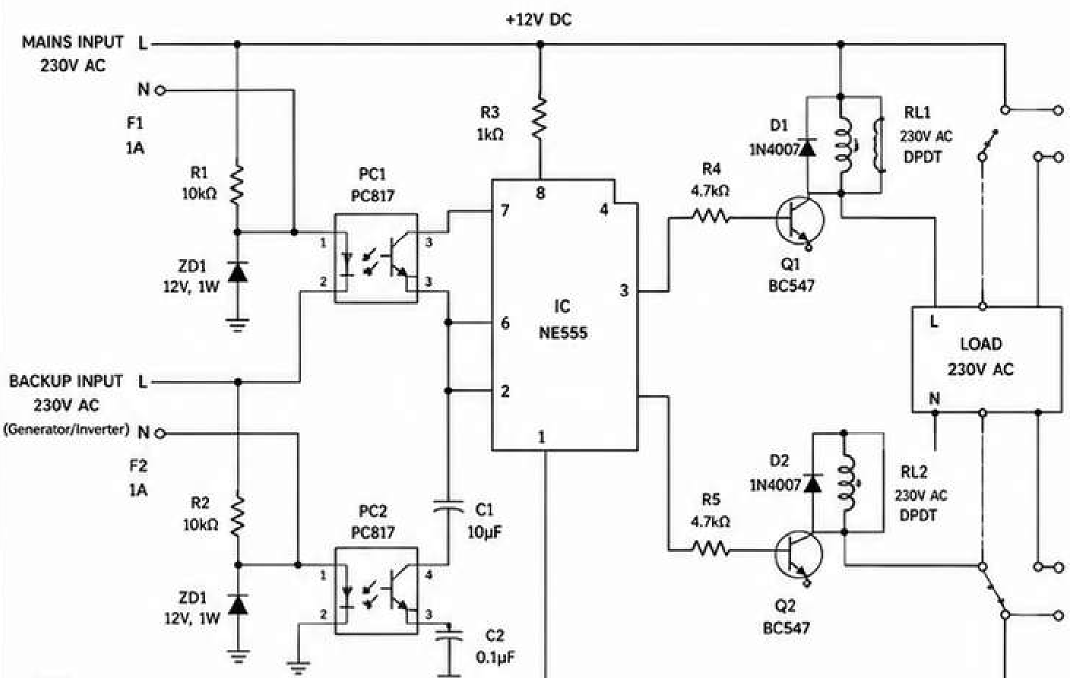
To design and implement an automatic changeover switch that selects mains supply when available and automatically switches to backup (generator/inverter) supply when mains fails and restores mains when available.

BLOCK DIAGRAM

COMPONENTS REQUIRED

S.No.	Component	Specification	Quantity
1	Relay (RL1, RL2)	230V AC, DPDT	2
2	Timer IC (NE555)	8-pin	1
3	Opto-coupler (PC817)		2
4	Resistor (R1)	10 kΩ, 1/4 W	2
5	Resistor (R2)	4.7 kΩ, 1/4 W	2
6	Resistor (R3)	1 kΩ, 1/4 W	2
7	Capacitor (C1)	10 μF, 25V	1
8	Capacitor (C2)	0.1 μF	1
9	Zener Diode (ZD1)	12V, 1W	1
10	LED (Green)	5mm	1
11	LED (Red)	5mm	1
12	Power Supply	12V DC, 1A	1
13	Terminal Block	3-pin	4
14	Fuse	1A	2
15	Breadboard / PCB	–	1

CIRCUIT DIAGRAM



NOTES:

- When mains is available, RL1 energizes and connects mains to load.
- When mains fails, after a delay set by NE555, RL2 energizes and connects backup supply to load.
- When mains is restored, RL1 energizes and RL2 de-energizes.

APPLICATIONS

- Home and office power supply systems
- Industrial backup power systems
- Hospitals and critical loads
- Data centers and servers
- Solar/inverter based systems

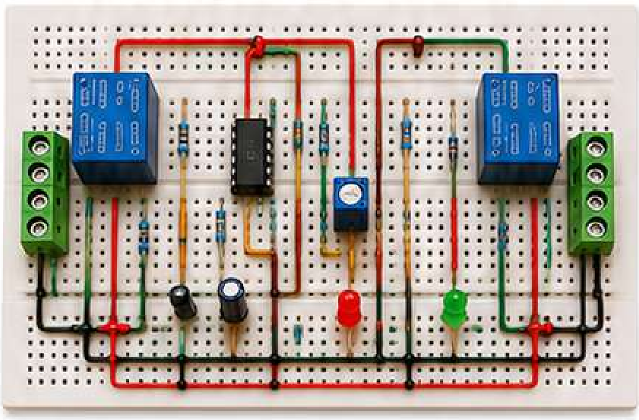
WORKING

The mains supply is continuously monitored through opto-coupler PC1. When mains is available, PC1 conducts and the NE555 keeps RL1 ON and RL2 OFF, connecting mains to the load.

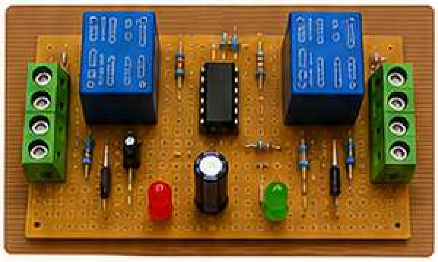
When mains fails, PC1 stops conducting. After a delay (set by R3, C1), the NE555 changes state and energizes RL2 while de-energizing RL1. Thus backup supply is connected to the load.

When mains is restored, PC1 conducts again, NE555 resets and RL1 energizes, restoring mains to the load.

CIRCUIT DIAGRAM ON BREADBOARD



ACTUAL MODEL



FUTURE SCOPE

- Can be implemented with microcontroller for advanced control.
- Can be integrated with IoT for remote monitoring and alerts.
- Can be used with solar and hybrid systems.

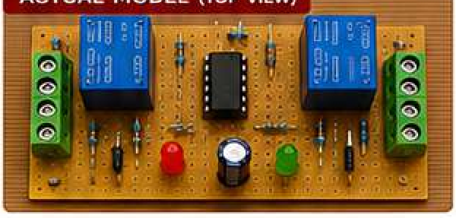
PROCEDURE

1. Connect the circuit as per the circuit diagram.
2. Connect mains and backup supply to their respective inputs.
3. Connect the load to the output terminals.
4. Provide 12V DC supply to the control circuit.
5. Switch ON the circuit.
6. Observe that load is connected to mains (green LED ON).
7. Remove mains supply and observe that load is connected to backup supply (red LED ON).
8. Restore mains and observe that load returns to mains supply.

RESULT

The automatic changeover switch was designed and tested successfully. The circuit automatically switches to backup supply when mains fails and restores mains when available. LEDs indicate the active supply status.

ACTUAL MODEL (TOP VIEW)



PRECAUTIONS

- Ensure correct polarity of 12V DC supply.
- Use good quality relays and components.
- Keep mains and backup connections secure.
- Do not touch live AC connections.
- Place the circuit in a suitable enclosure.
- Ensure proper insulation and safety.

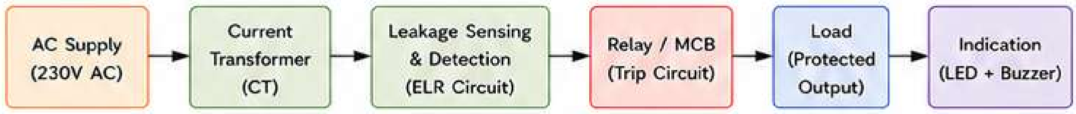
PROJECT MANUAL

14. EARTH LEAKAGE DETECTION AND PROTECTION SYSTEM

AIM

To design and implement an earth leakage detection and protection system that senses leakage current to earth and trips the load through a relay/MCB to prevent electric shock and fire hazards.

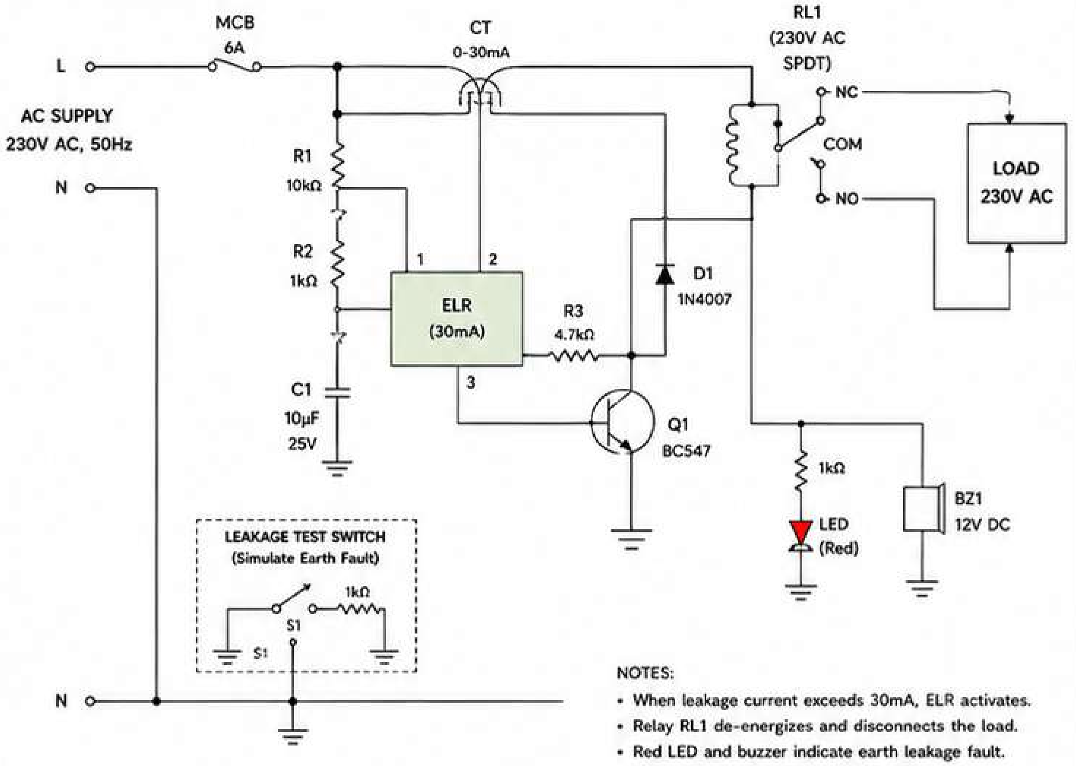
BLOCK DIAGRAM



COMPONENTS REQUIRED

S.No.	Component	Specification	Quantity
1	AC Supply	230V AC, 50Hz	1
2	Current Transformer (CT)	0-30mA	1
3	Earth Leakage Relay (ELR)	30mA, 230V	1
4	Resistor (R1)	10 kΩ, 1/4 W	1
5	Resistor (R2)	1 kΩ, 1/4 W	1
6	Resistor (R3)	4.7 kΩ, 1/4 W	1
7	Capacitor (C1)	10 µF, 25V	1
8	Diode (D1)	1N4007	1
9	Transistor (Q1)	BC547	1
10	Relay (RL1)	230V AC, SPDT	1
11	LED (Red)	5mm	1
12	LED (Green)	5mm	1
13	Buzzer (BZ1)	12V DC	1
14	MCB / Fuse	6A, 230V	1
15	Test Switch (Leakage)	Push Button	1
16	PCB / Breadboard	-	1

CIRCUIT DIAGRAM



NOTES:

- When leakage current exceeds 30mA, ELR activates.
- Relay RL1 de-energizes and disconnects the load.
- Red LED and buzzer indicate earth leakage fault.
- Green LED indicates normal condition.

APPLICATIONS

- Home and industrial wiring protection
- Prevention of electric shock
- Fire hazard prevention
- Electrical panels and distribution boards
- Earth leakage monitoring in appliances

WORKING

The current transformer (CT) senses the difference between phase (L) and neutral (N) currents. Under normal conditions, the vector sum is zero.

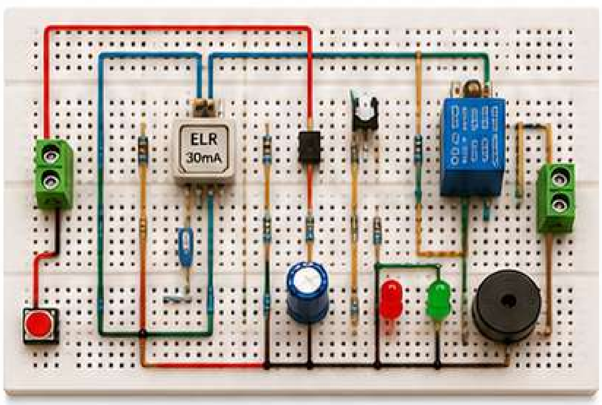
When earth leakage occurs, an imbalance current flows through earth. The CT produces an output proportional to the leakage current.

This signal is processed by the earth leakage relay (ELR). If leakage exceeds 30mA, ELR triggers the relay RL1.

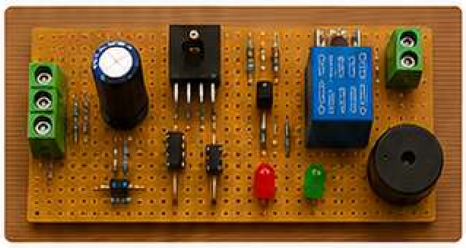
The relay disconnects the load, and red LED with buzzer indicates fault condition.

The test switch S1 is used to simulate earth leakage for checking the operation.

CIRCUIT DIAGRAM ON BREADBOARD



ACTUAL MODEL



FUTURE SCOPE

- Can be implemented with digital ELR and microcontroller for precise monitoring.
- Data logging and remote alarm transmission.
- Can be integrated with IoT for real-time monitoring.
- Can be used in smart homes and industries.

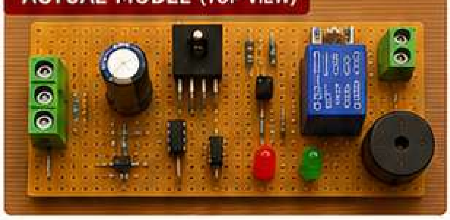
PROCEDURE

1. Connect the circuit as per the circuit diagram.
2. Connect 230V AC supply to the input terminals (after MCB).
3. Connect the load to the output terminals.
4. Power ON the circuit. Green LED glows (normal condition).
5. Press the leakage test switch (S1) to simulate earth leakage.
6. Observe that red LED and buzzer ON, and relay trips (load OFF).
7. Reset by releasing the test switch. Relay energizes and load is restored.

RESULT

The earth leakage detection and protection system was designed and tested successfully. The circuit detects leakage current above 30mA, trips the relay to disconnect the load, and alerts through LED and buzzer.

ACTUAL MODEL (TOP VIEW)



PRECAUTIONS

- Ensure correct polarity and wiring of AC supply.
- Do not touch the circuit when AC supply is ON.
- Use properly rated ELR and relay.
- Ensure proper earthing of the system.
- Keep the circuit in a suitable enclosure.
- Perform leakage test with caution.

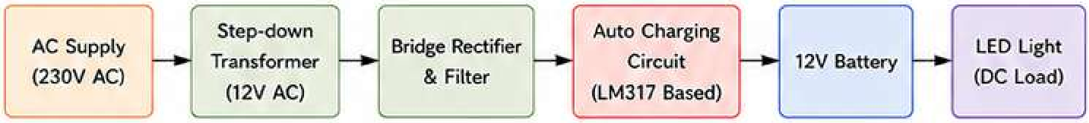
PROJECT MANUAL

15. EMERGENCY LED LIGHTING SYSTEM WITH AUTO CHARGING

AIM

To design and implement an emergency LED lighting system with auto charging that automatically charges the battery when mains is available and provides LED lighting during power failure.

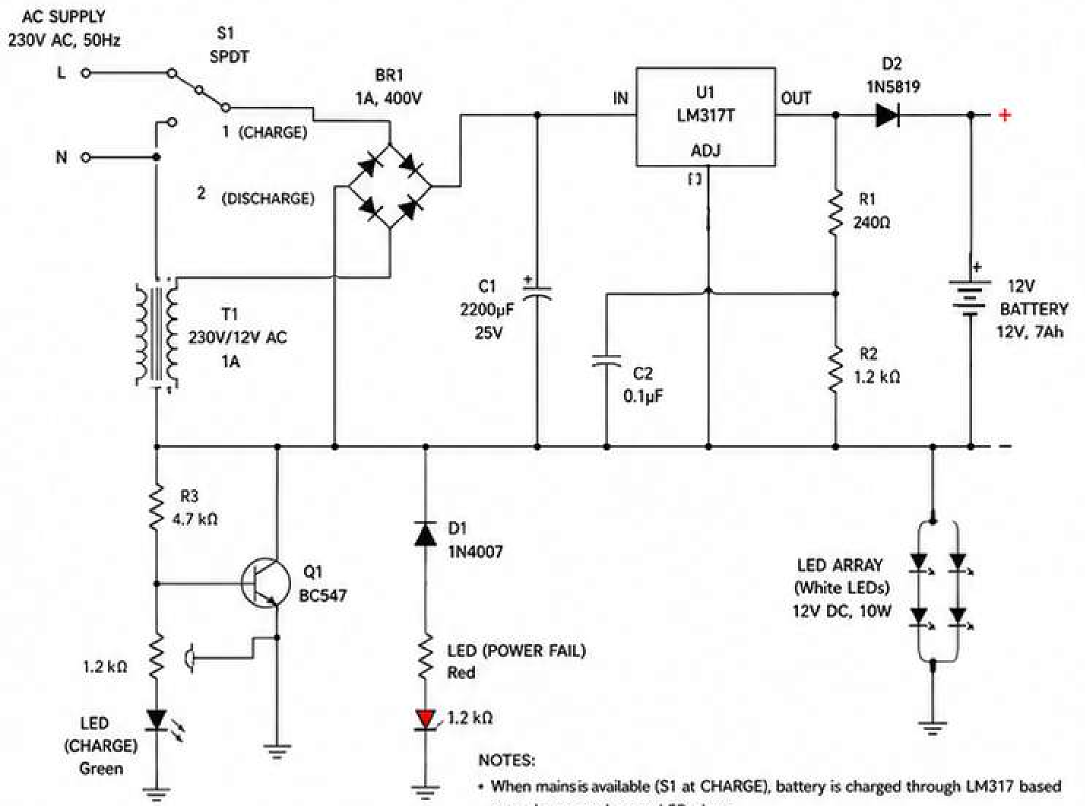
BLOCK DIAGRAM



COMPONENTS REQUIRED

S.No.	Component	Specification	Quantity
1	Step-down Transformer	230V/12V AC, 1A	1
2	Bridge Rectifier (BR1)	1A, 400V	1
3	Capacitor (C1)	2200µF, 25V	1
4	Capacitor (C2)	0.1µF	1
5	IC Regulator (U1)	LM317T	1
6	Resistor (R1)	240Ω, 1/4 W	1
7	Resistor (R2)	1.2 kΩ, 1/4 W	1
8	Diode (D1)	1N4007	1
9	Diode (D2)	1N5819 (Schottky)	1
10	Transistor (Q1)	BC547	1
11	Resistor (R3)	4.7 kΩ, 1/4 W	1
12	Battery	12V, 7Ah	1
13	LED Array	12V DC, 10W (White)	1
14	LED (Charging)	5mm Green	1
15	LED (Power Fail)	5mm Red	1
16	Switch (S1)	SPDT	1
17	PCB / Breadboard	-	1

CIRCUIT DIAGRAM



NOTES:

- When mains is available (S1 at CHARGE), battery is charged through LM317 based auto charger and green LED glows.
- When mains fails (S1 at DISCHARGE), battery supplies power to LED array and red LED glows.

APPLICATIONS

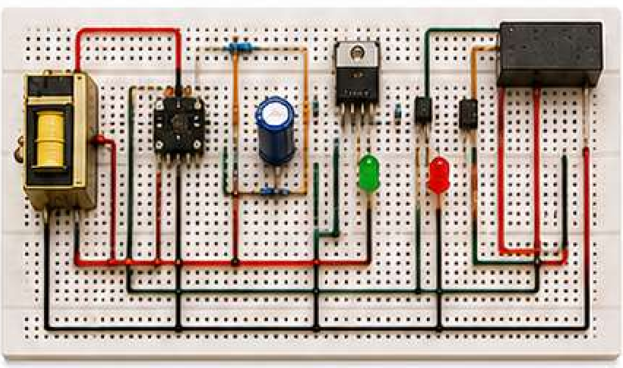
- Emergency lighting in homes and offices
- Hospitals, schools and public buildings
- Industrial and commercial establishments
- Outdoor and security lighting
- Backup lighting systems during power failure

WORKING

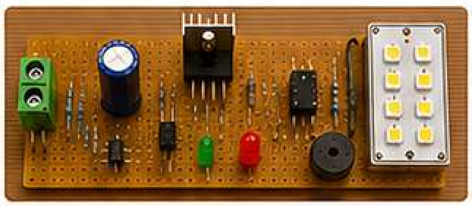
When mains is available, the SPDT switch S1 is in CHARGE position. AC is stepped down by T1, rectified by BR1 and filtered by C1. LM317 regulates the charging voltage to charge the 12V battery safely. Green LED indicates charging.

When mains fails, S1 automatically (manual switch) or can be set to DISCHARGE position. The battery supplies power to LED array through D2. Red LED indicates power failure mode.

CIRCUIT DIAGRAM ON BREADBOARD



ACTUAL MODEL



FUTURE SCOPE

- Can be implemented with automatic mains failure detection circuit.
- Can be extended with solar charging option.
- Can be integrated with IoT for remote monitoring.
- Can be designed with high brightness LED panels.

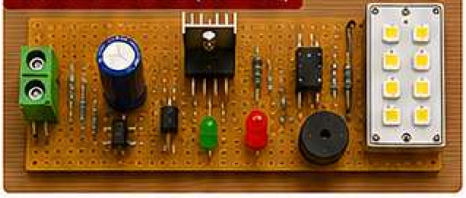
PROCEDURE

1. Connect the circuit as per the circuit diagram.
2. Ensure S1 is in CHARGE position.
3. Connect 230V AC supply and turn ON.
4. Observe green LED (charging) glows.
5. Disconnect AC supply or move S1 to DISCHARGE position.
6. Observe red LED glows and LED array lights up.
7. Switch back to CHARGE position and observe charging resumes.

RESULT

The emergency LED lighting system with auto charging was designed and tested successfully. It charges the battery when mains is available and provides LED lighting automatically during power failure.

ACTUAL MODEL (TOP VIEW)



PRECAUTIONS

- Ensure correct polarity of battery connection.
- Do not short the battery terminals.
- Use proper fuse in AC input line.
- Do not exceed the rating of transformer and LM317.
- Keep the circuit in a suitable enclosure.
- Ensure proper ventilation and safety while working with mains.