Project Title:-
Automatic Voltage Regulator for 230V AC Using Inductive and Capacitive Banks

Project Objective:-
To design an automatic voltage regulation (AVR) system that stabilizes the output AC voltage of 230V by dynamically switching between inductive and capacitive banks, ensuring a steady voltage despite load variations.

Key Components & Instruments
1. Inductive and Capacitive Banks:

Inductive Bank: A series of inductors or reactors that will be used to absorb reactive power when the output voltage exceeds the desired value.

Capacitive Bank: A series of capacitors that will be added to the circuit when the output voltage is below the desired value to provide reactive power and boost the voltage.

2. Voltage Sensing:

Voltage Sensor (ZMPT101B or similar): This sensor is designed for 230V AC systems and provides feedback to the microcontroller about the real-time voltage level.

This sensor will be used to monitor the output AC voltage, and its output is typically a scaled-down analog signal that can be read by the microcontroller.

3. Microcontroller:

Arduino, ESP32, STM32, or any suitable microcontroller to process the voltage readings from the voltage sensor and control the switching of inductive and capacitive banks.

The microcontroller will execute the control algorithm based on the input from the voltage sensor.

4. Relay/SSR (Solid-State Relay):

Relay/SSR for Switching Banks: These will be used to switch the inductive and capacitive banks on and off. Solid-State Relays (SSRs) are preferred for faster switching and better durability in high-voltage applications.

SSRs are connected between the microcontroller and the inductive or capacitive bank, and the microcontroller sends control signals to operate the SSRs.

6. Display and User Interface:

Meter Display: A display to show the current output voltage and the status of the inductive or capacitive banks.

7. Power Supply:

AC to DC Power Supply: For powering the microcontroller, sensors, and relays. Typically, you will need a 5V DC or 12V DC power supply.

Working Principle:-

1.Voltage Sensing:-
The ZMPT101B voltage sensor constantly measures the output AC voltage (230V in this case). The sensor will output a proportional DC signal (scaled down) corresponding to the measured AC voltage. This signal is read by the microcontroller.

2.Control Logic:-
The microcontroller compares the measured voltage to the desired setpoint (e.g., 230V). If the voltage is higher than the setpoint, the microcontroller will activate the inductive bank to absorb reactive power, reducing the voltage.

If the voltage is lower than the setpoint, the microcontroller will activate the capacitive bank to supply reactive power, raising the voltage.

3.Switching of Banks:-
The microcontroller sends control signals to the SSRs or relays to switch the capacitive and inductive banks in and out of the circuit, based on the voltage conditions.

4.Continuous Feedback and Adjustment:-
The system constantly monitors the voltage and adjusts the reactive power banks to stabilize the output voltage at the desired value.

Step-by-Step Implementation

Voltage Sensing: The ZMPT101B sensor will measure the 230V AC and output a scaled-down DC signal proportional to the voltage.

Microcontroller: The microcontroller will read the voltage from the sensor and implement the control logic.

Relay/SSR Control: The microcontroller will send signals to the SSRs to control the inductive and capacitive banks.

User Interface: Connect an LCD display to show real-time voltage and the status of the reactive banks.

2. Programming the Microcontroller:-
Program the microcontroller to read the voltage sensors output and implement the control algorithm to switch the inductive or capacitive banks accordingly.

Use a PID control loop or a threshold-based switching algorithm to manage the switching of the reactive power banks.

3. Testing and Calibration:-

Test the system with no load and varying loads (resistive and inductive) to ensure proper voltage regulation.

Calibrate the voltage sensor for accurate voltage readings.

Fine-tune the switching thresholds or PID parameters to ensure smooth voltage regulation.

4. Safety Checks

Implement fuses or circuit breakers for overcurrent protection.

Ensure surge protection is in place to prevent damage from voltage spikes.

Properly insulate all high-voltage components and ensure safety measures for handling the 230V AC.

Circuit Diagram

```
  +--------------------------+
  |    AC Power Source  |
  |   (230V AC Input)     |
  +-------------------------+
         |
         |
 +--------------------+
 | Voltage Sensor|  ------> (Scaled DC Output to Microcontroller)
 | (ZMPT101B)     |
 +--------------------+
         |
         |
  +----------------------+             +-----------------------+
  |    Microcontroller |<------->   |LCD/OLED Display |
  | (Arduino/ESP32)  |             +------------------------+
  +----------------------+                  |
         |                                  |
  +------------------------+        +-------------------------+
  | Inductive Bank (L) |        | Capacitive Bank (C)|
  +------------------------+        +-------------------------+
         |                                    |
    +---------------+              +----------------+
    | SSR/Relay  |     <--------->    |  SSR/Relay   |
    +---------------+               +----------------+
         |
  +--------------------------+
  | Output AC Voltage   |
  +--------------------------+
```

Power Factor Correction:

Measure the power factor and dynamically switch the inductive or capacitive banks to correct it, thereby optimizing the system's reactive power.

Load Sensing:
Add load sensors to automatically detect load variations and adjust the compensation (inductive or capacitive banks) to maintain stable voltage.

Over-voltage/Under-voltage Protection:-
Implement over-voltage and under-voltage protection to prevent the system from operating outside of safe limits.

Conclusion:-
This project will help you build a dynamic voltage regulation system that adjusts the reactive power in an AC circuit by automatically switching inductive and capacitive banks, ensuring stable 230V AC output voltage regardless of the load conditions.