AHSANULLAH UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF EEE

[EEE 4154]
Power System II Lab

Report: Power Factor Improvement Automatic Device.
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Power Factor Improvement Automatic Device

Power factor is a key parameter that measures the effectiveness of electrical power utilization in a system. A low power factor results in inefficient use of electricity, leading to increased energy costs and decreased overall system performance. The Automatic Power Factor Improver addresses this issue by automatically adjusting and maintaining the power factor within an optimal range. The Automatic Power Factor Improver operates by monitoring the power factor of the electrical system in real-time. When it detects a deviation from the desired power factor, it activates reactive power compensation elements, such as capacitors or reactors, to bring the power factor back to the target level. This dynamic adjustment ensures that the electrical system operates with optimal efficiency under varying load conditions. Power factor improvement (PFI) in electrical systems can be achieved through various methods. Capacitor banks, installed in parallel, are commonly employed to compensate for reactive power and enhance power factor. In this project we use this method to improve power factor.

Equipment Required :

- Microcontroller-Arduino Nano.
- 16*4 Liquid Crystal Display.
- I2C Module.
- PZEM004T- AC Communication Box.
- PZCT-02 – Current Transformer.
- Relay Module.
- 2 Pin Socket & Plug.
- 5V Adapter.
- 1.5 microfarad Capacitor Bank.

The Arduino Nano serves as the brain of the system, providing the processing power and control for the entire setup. Its compact size and versatility make it suitable for various applications.

The 16x4 LCD display is used for visual output, providing a user-friendly interface to display relevant information or data processed by the Arduino Nano. It enhances the overall user experience of the system.

The I2C module, or I2C (Inter-Integrated Circuit) interface, facilitates communication between the Arduino Nano and other devices, such as the LCD display. It simplifies the wiring and allows for efficient data transfer.

The PZEM004T is an AC communication box that enables the measurement of electrical parameters in an AC circuit. It can measure parameters such as voltage, current, power, and energy consumption.

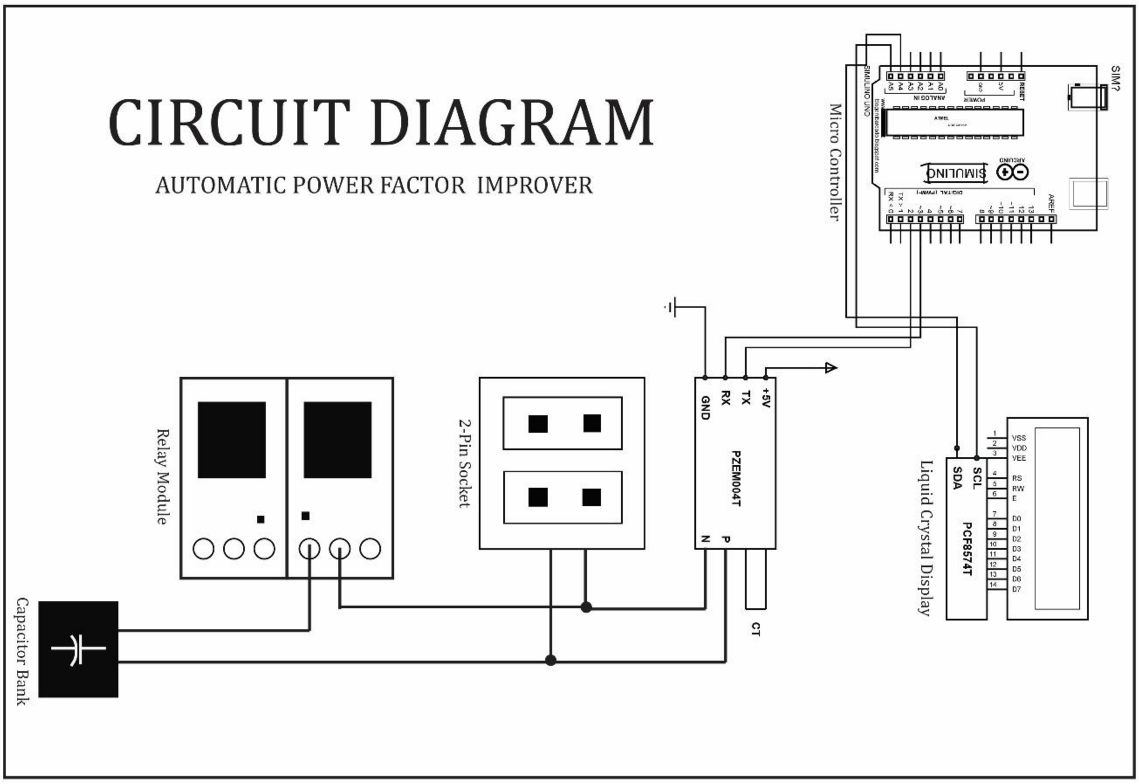
The PZCT-02 Current Transformer is used for measuring alternating current (AC) in the electrical system. It transforms the current to a level suitable for measurement and is often employed in conjunction with energy monitoring devices.

The Relay Module is an electronic switch controlled by the Arduino Nano. It is used to interface low-voltage control signals from the Arduino with higher-voltage devices, such as turning on or off electrical appliances.

The 2-pin socket and plug are likely used for connecting the device to the power source. The specific use could depend on the design of the project and the intended power supply.

The 5V adapter serves as the power supply for the entire system. It provides a stable 5-volt power source to operate the Arduino Nano and other connected components.

The 1.5 microfarad capacitor bank is likely used for power factor correction or other applications requiring the smoothing of electrical signals. Its inclusion suggests a focus on improving power quality in the electrical system.



Procedure:

Initial Observation in No-Load Condition:

In the absence of a load, observe the voltage and frequency in the electrical system. Since no current is flowing, both power and power factor remain at zero.

Connection of Lagging or Resistive Load:

Introduce a lagging or resistive load to the system. As the load is connected, the power factor begins to drop from unity due to the introduction of reactive elements.

Monitoring and Relay Control:

Monitor the power factor continuously. Initially, the relay module remains closed. When the power factor decreases below 0.9, indicating a lagging power factor, the relay triggers and opens the circuit, connecting the capacitor bank to the system. This action is aimed at improving the power factor.

Capacitor Bank Activation and Power Factor Improvement:

With the relay open, the capacitor bank becomes an integral part of the system. The added capacitive reactance compensates for the lagging power factor, leading to an improvement in power factor and a reduction in reactive power.

Monitoring for Power Factor Correction:

Continuously monitor the power factor. If the power factor rises above 0.9, indicating an improvement, the relay module closes again. This action disconnects the capacitor bank from the system, ensuring it only operates when necessary for power factor correction.

Efficient Power Factor Operation:

The relay module acts as a dynamic controller, responding to changes in power factor. By introducing the capacitor bank selectively when the power factor drops below the set threshold and disconnecting it once the desired power factor is achieved, the system ensures efficient power factor operation.

Continuous System Monitoring:

Keep the system in operation, observing the power factor under varying load conditions. The relay module's responsiveness to power factor fluctuations enhances the overall efficiency of the system, optimizing power factor and minimizing reactive power.

Code:

```
#include <PZEM004Tv30.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#define rp 6

PZEM004Tv30 pzem(2, 3);
LiquidCrystal_I2C lcd(0x27, 16, 4); // Software Serial pin 8 (RX) & 9 (TX)

void setup() {
  Serial.begin(9600);

  lcd.begin(16,4);
  lcd.backlight();
  pinMode(rp,OUTPUT);

}

void loop() {
  float voltage = pzem.voltage();
  if (voltage != NAN) {
    Serial.print("Voltage: ");
    Serial.print(voltage);
    Serial.println("V");
    lcd.setCursor(0, 0);
    lcd.print("V:");
    lcd.print(voltage);
  } else {
    Serial.println("Error reading voltage");
  }

  float current = pzem.current();
  if (current != NAN) {
    Serial.print("Current: ");
    Serial.print(current);
    Serial.println("A");
    lcd.setCursor(0, 1);
    lcd.print("I:");
    lcd.print(current);
  } else {
    Serial.println("Error reading current");
  }

  float power = pzem.power();
  if (current != NAN) {
    Serial.print("Power: ");
```

```
    Serial.print(power);
    Serial.println("W");
    lcd.setCursor(8, 0);
    lcd.print("W:");
    lcd.print(power);
  } else {
    Serial.println("Error reading power");
  }

  float energy = pzem.energy();
  if (current != NAN) {
    Serial.print("Energy: ");
    Serial.print(energy, 3);
    Serial.println("kWh");

  } else {
    Serial.println("Error reading energy");
  }

  float frequency = pzem.frequency();
  if (current != NAN) {
    Serial.print("Frequency: ");
    Serial.print(frequency, 1);
    Serial.println("Hz");
  lcd.setCursor(0, 2);
  lcd.print("Freq:");
  lcd.print(frequency);
  } else {
    Serial.println("Error reading frequency");
  }

  float pf = pzem.pf();
  if (current != NAN) {
    Serial.print("PF: ");
    Serial.println(pf);
    lcd.setCursor(8, 1);
    lcd.print("PF:");
    lcd.print(pf);

  } else {
    Serial.println("Error reading power factor");
  }

if(pf>0.1 && pf<0.9)
digitalWrite(rp,LOW);
else
```

```
digitalWrite(rp,HIGH);


  Serial.println();
  delay(2000);
}
```

Real Life Applications:

Power Factor Improvement (PFI) is a crucial aspect of power systems, and its applications extend across various industries and sectors. Here are some key applications of PFI in power systems:

Industrial Facilities:

PFI is widely used in industrial settings where large and fluctuating loads are common. By correcting power factor, industrial facilities can reduce energy losses, optimize the use of electrical equipment, and avoid penalties associated with low power factor.

Commercial Buildings:

Commercial establishments, such as offices, shopping malls, and hotels, can benefit from PFI to enhance the efficiency of their electrical systems. Improved power factor results in lower electricity bills and better utilization of power distribution infrastructure.

Data Centers:

In data centers where continuous and reliable power is critical, maintaining a high power factor is essential. PFI helps in minimizing power losses and ensuring the efficient operation of equipment, contributing to the overall reliability of data center operations.

Healthcare Facilities:

Hospitals and medical facilities often have diverse and sensitive electrical equipment. Implementing PFI ensures that medical equipment operates efficiently, reducing energy waste and promoting stable electrical conditions.

Commercial and Residential Developments:

PFI can be applied in both commercial and residential developments to optimize power factor, leading to reduced energy costs and a more sustainable electrical infrastructure.
Renewable Energy Integration:

PFI plays a role in integrating renewable energy sources, such as solar and wind, into the power grid. These sources may introduce fluctuations, and power factor correction ensures grid stability and efficient energy transfer.

Utilities and Power Distribution Networks:

Power utilities utilize PFI to improve the power factor across their distribution networks. This results in more effective power transmission, reduced losses, and enhanced overall grid performance.

Mining Operations:

Mining activities often involve heavy machinery with varying loads. PFI helps in optimizing power factor, reducing energy consumption, and ensuring the reliability of electrical systems in mining operations.

Railway Systems:

PFI is applied in railway systems to enhance the efficiency of traction systems and to minimize reactive power losses. This contributes to the reliable and energy-efficient operation of railway networks.

Telecommunications Infrastructure:

PFI is essential in maintaining the power quality of telecommunications infrastructure. By improving power factor, telecommunication facilities can enhance the reliability of their power supply and reduce energy costs.

Government and Public Facilities:

Government buildings, educational institutions, and other public facilities can benefit from PFI to optimize power factor, reduce energy expenses, and promote sustainable energy practices.
In summary, Power Factor Improvement finds applications in diverse sectors where electrical efficiency, energy savings, and system reliability are paramount. Implementing PFI measures contributes to a more sustainable and cost-effective operation of power systems across various industries.

Advantages of Power Factor Improvement (PFI):

Energy Cost Savings:

PFI reduces reactive power consumption, leading to a more efficient use of electricity and lower energy bills.

Increased System Efficiency:

Improved power factor results in reduced power losses in electrical systems, leading to overall higher system efficiency.

Capacity Release:

PFI can release the capacity of electrical systems, allowing them to handle more real power without requiring additional infrastructure.

Reduced Voltage Drop:

By optimizing power factor, voltage drop across power lines and distribution systems is minimized, ensuring stable voltage levels.

Compliance with Regulations:

Many regulatory bodies mandate a minimum power factor for industrial and commercial establishments. PFI helps organizations comply with these regulations and avoid penalties.

Extended Equipment Lifespan:

Improved power factor reduces stress on electrical equipment, leading to extended lifespan and reduced maintenance costs.

Enhanced Power System Stability:

PFI contributes to the stability of power systems by minimizing fluctuations in voltage and current, thereby improving overall grid stability.

Optimized Transformer Operation:

Transformers operate more efficiently with an improved power factor, leading to reduced energy losses and improved performance.

Disadvantages of Power Factor Improvement (PFI):

Initial Investment Costs:

Implementing PFI systems may involve upfront costs for equipment and installation, which can be a barrier for some organizations.

Maintenance Requirements:

PFI systems require regular maintenance to ensure optimal performance, adding to operational costs.

Overcorrection Risks:

Overcorrection of power factor may lead to an excessively capacitive system, potentially causing resonance issues and equipment damage.

Complexity in Design and Implementation:

Designing and implementing PFI systems can be complex, requiring expertise in power system engineering.

Environmental Impact:

The production and disposal of components used in PFI systems may have environmental impacts, although efforts are made to address these concerns.

Limited Effectiveness in Some Systems:

In systems where the power factor is already high or where loads are relatively constant, the benefits of PFI may be limited.

Risk of Capacitor Failures:

Capacitors used in PFI systems can fail over time, leading to potential disruptions in power factor correction.

Dynamic Load Challenges:

PFI systems may face challenges in dynamic load scenarios, where rapid and frequent changes in load conditions make continuous power factor correction more complex.

Conclusion:

In conclusion, the Power Factor Improvement (PFI) project, employing an Arduino Nano and dynamic relay module, is a cost-effective solution for enhancing power efficiency. The system, intelligently monitoring power factor, selectively introduces a capacitor bank to correct deviations, optimizing energy usage. Despite initial costs, the project promises substantial long-term benefits, including reduced energy bills and extended equipment lifespan. Its adaptability to various industries underscores its relevance in achieving sustainable and efficient electrical systems. The PFI project exemplifies a practical approach to power factor optimization, aligning with the global push for energy efficiency and environmentally conscious practices.