Smart Power Flow Monitoring and Control

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Abstract

With the ever growing demand for electrical energy across the world, we, as electrical engineers, are put in a state of responsibility to conserve the energy as Energy Saved is Energy Generated. A sincere attempt is made in this work to conserve the electrical energy, by designing an autonomous system that monitors the inflow of the electrical energy, limits the consumption so as to comply with the maximum load constraints and transfers the critical loads to captive / co-generation systems for our campus. In the present system, the monitoring and control is done manually which is very hassle process, leading to unnecessary tripping of loads across entire campus. In the proposed system the current, voltage and the frequency are measured and monitored continuously by a processor through appropriate sensors. Using these data, other information such as KVA, KVAR, KW and power factor are estimated by the processor. Once the any of the above parameter exceeds its threshold value, the processor generates control signals to actuate the respective relays to trip-off the connected loads hierarchal manner. In addition, if the EB supply is tripped-off completely, the processor automatically switches the generator on and connects only the essential loads to the generator. Upon the restoration of the EB supply, as per the predefined precautionary measures, the loads are shifted back to EB line and the generator is set to idle condition. Atmega 328 processor based Arduino-UNO is the heart of the proposed system which is supported by required interfaces for both data acquisition and control. The proposed system has been fabricated and tested. The performance is found to be satisfactory.

Keywords: PMCS, SCADA, PLCs

I. INTRODUCTION

A. Power System Monitoring:

The Power Monitoring and Control System (PMCS) is a fully customizable/configurable, user friendly, integrated solution for reliable and accurate energy management. The system solution centralizes acquisition data, monitoring then controlling, disturbance recording and providing a virtual window into the system for analysis and Reporting through an integrated network of metering and protection devices across a single or multiple facility locations are also parts of the process.

B. Measurement:

Measurement is one of important concept in Power system Automation. The real time information about a substation or equipment is collected and displayed in the control centre and stored in a data base for further manipulations. It erases the personnel to go to substation or switching area collect the information cutting down workloads. The information collected can assist in doing network studies like load flow analysis, planning ahead and preventing disturbances in the Power network. Previously the word ‘Measurement’ refer to voltage, current and frequency, and the word ‘Metering’ refer to power, reactive power and energy (KWh). The different terms used because different instruments were used for these applications, now the two functions are integrated in modern devices hence the terms are used interchangeably in the text.
**Monitoring:**
Monitoring is specified for the maintenance of the Power system Automation. It monitors sequence of records, status and condition of the system, maintenance information and relay settings etc. The information can help in fault analysis, what where when why it happened. It is used to improve the efficiency of the system.

**Control:**
Control application of a Power system Automation includes local and remote control. Local control consists of actions the control device can logically take by itself (Bay interlocking, switching sequences, and synchronizing check). Human intervention is limited and the risk was greatly reduced. Remote control functions to control Substations remotely from the SCADA. Commands can be given directly to the remote control devices (open and close of circuit breakers, relay settings, requests for information from the SCADA station).

This eliminates the personnel performance switching operations, actions can be performed faster. A safe working environment is created for personnel and the operator or engineer at the SCADA has a complete overview of the entire Power network.

**II. Power System Automation**
Power System Automation is a system for managing, controlling and protecting the various components connected to the power network. It obtains the real-time information from the system, local and remote control applications with advanced electrical system protection. The core of power system automation stands on local intelligence, data communications with supervisory control and monitoring. Structure of Power System Automation. The functional structure of power system automation shown in Fig 1.2.

- Electrical Protection
- Control
- Measurement
- Monitoring
- Data Communications

**E. Electrical Protection:**
Electrical Protection is the most important concept of the Power system Automation, to protect the equipment and personnel and to limit the damage at fault. It is a local function and it has the capability to function independently from the Automation if necessary, although it is a part of Power system Automation the function of electrical protection never restricted in Power system Automation.

**III. Literature review**
The design and development of a Smart Power monitoring device has reported in this paper. System has been designed that can be used to monitor electrical parameters such as voltage, current and power of household appliances. The system consists of a smart sensing unit that detects and controls the home electrical appliances used for daily activities by following different tariff rates. It can reduce costs for the consumers and thereby improve grid stability. A developed prototype has been extensively tested and experimental results have compared with conventional measuring devices.
IV. PROPOSED SYSTEM

A smart power monitoring and control system is a technique which is used for monitoring the electrical parameters such as voltage, current, frequency, real power, reactive power, apparent power and power factor and to take appropriate control actions, when the measured parameters exceed their limits:

- Voltage sensing through voltage transformer and its associated components.
- Current sensing through current transformer and its associated components.
- Frequency can be sensed by zero crossing techniques.
- Power factor estimation with voltage and current signals.
- To trip off the loads hierarchically in the event of current exceeding the set value.
- To switch on the generator and shift the loads from EB to Generator using PLCs when there is a shutdown.
- Restoration of loads back to EB on the resumption of EB supply and to switch off the generator/stand by resource.

V. BLOCK DIAGRAM

A. Monitoring of Electrical Parameters:

The power supply includes single phase 230v AC in which the electrical parameters are to the monitored, the electric system block consists of voltage transformer and current sensor in which voltage can be reduced according to the input range of arduino microcontroller and the values are displayed in LCD. The fig 4.1 shows that over view of monitoring the electrical parameters.

B. Measurement of Voltage:

Ideal for situations where power quality is an issue, Voltage sensors facilitate monitoring of supply voltage levels. They identify under voltage or overvoltage concerns and help protect critical motors and electronics. Because we have standard value of 0-5A output, they are easily coupled to a data logger, panel meter or PLC for real-time monitoring and reporting. The block diagram of voltage measurement system is depicted in Fig 4.2(a).

Voltage transformer is a transformer used in power systems to step down high voltage signals to provide low voltage signals, for metering or operating a protective relay.

Arduino analog inputs are used to measure DC voltage between 0 and 5V (on 5V Arduino such as the Arduino Uno when using the standard 5V analog reference voltage). However, the incoming signals from the voltage is AC and need to be conditioned for proper functioning.
The range over which the Arduino can measure the AC voltage is shifted by using two resistors to create a voltage divider as shown in Fig 4.2(b). The voltage divider decreases the voltage being measured to within the range of the Arduino analog inputs. Code in the Arduino sketch is then used to calculate the actual voltage being measured. This allows voltages greater than 5V to be measured.

1) **EB Power Supply**

![Block Diagram of Voltage Measurement](image)

**Fig. 4.2(a): Block Diagram of Voltage Measurement**

2) **Voltage Divider Circuit**

In this project, Single phase voltage is measured by converting the 230V into 12V by step-down transformer (230/12V). Generally the input to the any microcontroller is DC, but here in the quantities being monitored is AC and hence, in order to convert AC into DC, we have designed the Voltage divider circuit shown in Fig 4.2(b).

The output signal from the AC voltage transformer is a sinusoidal waveform. To measure ac we need to:

1) Scale down the waveform.
2) Add an offset so there is no negative component.

By using divider circuit, input voltage to the Arduino is 5V unidirectional AC and hence, the voltage is measured and displayed in LCD by the processor. A voltage divider circuit consisting of two resistors in series will divide the input voltage to bring it within the range of the Arduino analog inputs. The wave form of voltage divider circuit is shown in the fig 4.2(b).

![Wave Form of Voltage Divider Circuit](image)

**Fig. 4.2(b): Wave Form of Voltage Divider Circuit**

The circuit with the particular values shown has an input impedance and suitable for measuring DC voltages up to about 50V.

### C. Measurement of Current:

A current sensor is a device that detects and converts current to an easily...
Measurable output voltage, which is proportional to the current through the path. When a current flows through a wire or in a circuit, voltage drop occurs. Also, a magnetic field is generated surrounding the current carrying conductor. Both of these phenomena are made use of in the design of current sensors.

A current transformer (CT) is an electric device that produces the reduced alternating current (AC) in its secondary which is proportional to the high AC current in its electrical system, by induction. The fig 4.2(c) shows that block diagram of current measurement.

1) **EB Power Supply:**

![Fig. 4.2(c): Block Diagram of Current Measurement](image)

- A CURRENT SENSOR is a device that detects electric current in a system and generates a signal proportional to it.
- ACS712 module is used as interference between Arduino and power supply. The ACS712 Current Sensors offered on the internet are designed to be easily used with micro controllers like the Arduino. These sensors are based on the Allegro ACS712ELC chip. These current sensors are offered with full scale values of 5A, 20A and 30A.
- This circuit is designed to monitor the current. The current that has to monitor is step down by the current transformer. Usually we are using the 0-5A current transformer. The step down current is rectified by the precision rectifier. The precision rectifier is a configuration obtained with an operational amplifier in order to have a circuit behaving like an ideal diode or rectifier.

2) **Current Divider Circuit**

By connecting the current transformer or CT sensor (ACS712), the current value is measured. In order to safeguard the arduino, CT sensors are connected as same as voltage divider circuit. The divider circuit is shown in fig 4.2 (d).

![Fig. 4.3: Wave Form of Current Divider Circuit](image)

The wave of current divider circuit can be achieved by two main parts:

1) The CT sensor & burden resistor
2) The biasing voltage divider (R1 & R2).
**D. Measurement of Frequency:**

Frequency describes the number of waves that pass a fixed place in a given amount of time. So if the time it takes for a wave to pass is 1/2 second, the frequency is 2 per second

1) **EB Power Supply**

![Block Diagram of Frequency Measurement](image)

**VI. EXPERIMENTAL SETUP**

![Overall Project Kit](image)

**VII. RESULTS AND JUSTIFICATIONS**

Table - 6.1

<table>
<thead>
<tr>
<th>S.NO</th>
<th>LINE VOLTAGE (Volt)</th>
<th>LOAD CURRENT (Ampere)</th>
<th>FREQUENCY (Hz)</th>
<th>PF</th>
<th>KW</th>
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<td>49.60</td>
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<td>0.90</td>
<td>49.68</td>
<td>0.93</td>
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</table>
Thus we have designed the project on SMART POWER FLOW MONITORING for single phase AC by using arduino microcontroller. Single phase supply voltage and current measured. Correspondingly frequency (Hz), power factor, real power (KVA), reactive power (KVAR) and apparent power (KW) are calculated and the values are shown in LCD display.

**A. Future Scope:**

In the event of any of the above parameter exceeds its threshold value, the processor generates control signals to actuate the respective relays to trip-off the connected loads hierarchal manner. In addition, if the EB supply is tripped-off completely, the processor automatically switches the generator on and connects only the essential loads to the generator. Upon the restoration of the EB supply, as per the predefined precautionary measures, the loads are shifted back to EB line and the generator is set to idle condition.

**REFERENCES**