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Real Time Energy Monitoring for Single Phase System

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Abstract: *This paper proposes the Real Time Energy Monitoring of a system. The Real Time Energy Monitoring is done in order to educate and empower the consumer about their energy consumption. This will help us to analysis the occurrence of faulty conditions and to take appropriate safety measures. The analysis will be carried out by measuring the Voltage (V), Current(C), Power factor (cos Ø), Active Power (P), Reactive Power (Q) and Apparent Power (S) of the connected single phase system. The data is calibrated with the use of Arduino Uno Atmega328 and the monitoring can be done for every second and every minute so that continuous and accurate data can be obtained and thus it can be analyzed to reduce the unnecessary consumption of power and help the consumer to rectify the faulty conditions.*

Keywords: *Empower, Power factor, Active power, Reactive power, Apparent power.*

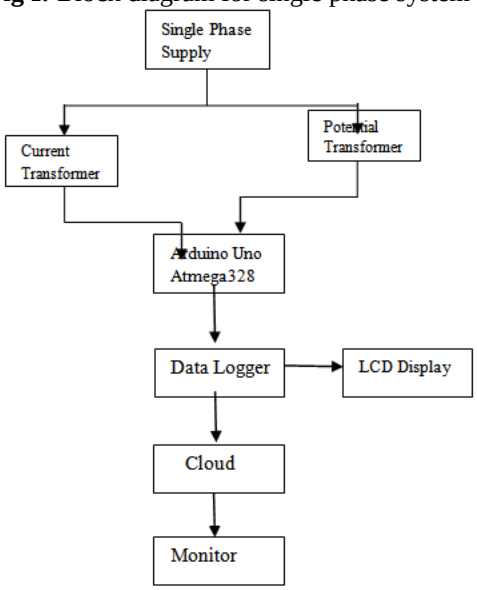
I. Introduction

The demand for power has increased exponentially with time. One avenue through which today's energy problems can be addressed is through the reduction of energy usage in households. This has increased the emphasis on the need for economic methods of power monitoring and power measurement which needs to be accurate. The goal of providing such data is to optimize and reduce their power consumption.

Energy saving is cheaper than energy production. In order to increase the efficiency of the system the proper usage of power is necessary and hence the wastage of power should be minimum. The production of energy involves various steps which overall is a very costly process. But saving energy and efficient use of energy at the consumer side is comparatively cheaper. This can be achieved by proper monitoring of the data which will help the consumers to achieve this goal. Many different types of methods were used in order to accomplish this. Various energy monitoring devices incorporated with microprocessors and Zigbee module has being developed. But these energy meters involve a lot of cost in their manufacturing and are costly. This paper proposes a power

The block diagram for the proposed work for the single phase can be represented as

Fig I: Block diagram for single phase system



II. COMPONENTS Arduino Uno

The Arduino Uno is an open source microcontroller board based on the microchip Atmega328P microcontroller. The Arduino board is equipped with sets of digital and analog input and output pins that can be interfaced to various expansion boards and other circuits. Arduino board has 14 digital pins, 6 analog pins and it is programmable with Arduino IDE (Integrated Development Environment) via a type B USB cable. The analog pins are labeled A0 to A5 each of which provides 10 bits resolution (i.e 1024 different values). Arduino board can be powered by an external 9 volts battery or by a USB cable and it can withstand voltage between 7 to 20 volts. Each pin (I/O) can receive or provide 20mA as recommended operating conditions to avoid the permanent damage a maximum of 40mA current value that must not be exceeded.

Fig II: Arduino Uno

Current Transformer:

Current Transformer is a type of instrument transformer which is used to measure the value of alternating current flowing in the circuit. Secondary current produced in the current transformer is in proportion to the primary current which depends upon the turns ratio provided. Primary of the current transformer is connected in series with the load and the secondary side is connected with measuring instruments so that it can measure proportionate value of large primary current flowing in the circuit. It is widely used in the generating stations, electrical substations and in industrial and commercial electrical power distribution. The clamp type of CT is used here so that the device is portable for us to carry along.

Fig III: Current sensor

Potential Transformer:

Potential Transformer is a voltage step down transformer which is used for the purpose of measurement of high value of voltage. These are connected across the line which is to be monitored. In addition these transformers isolate the measuring circuits from the main circuits which are operating at high power levels. Primary winding consists of a large number of turns which is connected across high voltage side. The secondary winding has lesser number of turns which is connected to the voltmeter. Irrespective of the primary voltage these are designed to have secondary voltage of 110 volts.

Fig IV: Potential sensor

III. Parameters

The Power quality analyzer calculates various parameters like Voltage, Current, Power factor, Active power, Reactive power and Apparent power. The instantaneous values of voltage and current are obtained and the RMS values and waveforms are displayed.

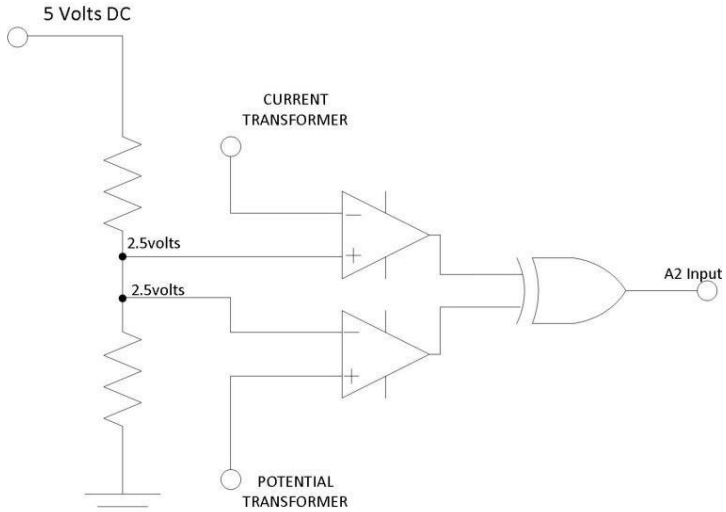


Fig V: Circuit representation for comparator circuit.

The figure(Fig V) shows the circuitry for the implementation of the power factor using two opamp IC741. The power factor is calculated by calculating the time difference between the occurrence of voltage waveform and current waveform at a certain instant. The time is used to calculate the phase difference between the two waveforms.

$\Theta = 360*F*\Delta t$; $\Theta = 2\pi Ft$;

The frequency here is 50 Hz and thus by calculating the time interval and putting this together we get the phase angle. The cosine of this angle is the power factor. The power factor is calculated by using a comparator. The comparator does this comparison. Two operational amplifiers IC 741 are used here as a comparator.

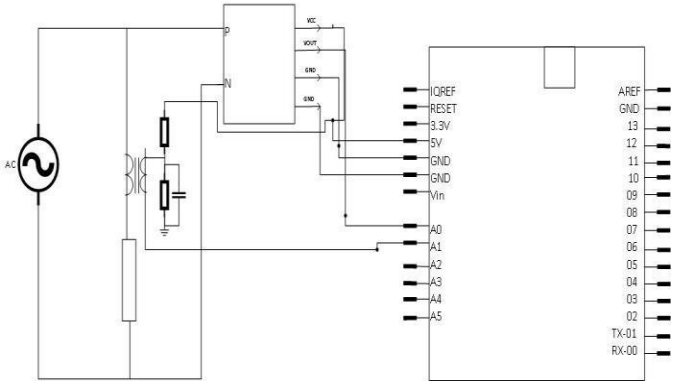


Fig VI: Single phase circuit diagram

The above figure shows the circuit diagram for the proposed work. Wherein the CT is connected in series with the load and the PT is connected in parallel. The outputs of the PT are connected to the analog inputs of the Arduino UNO Atmega328. The voltage divider circuit is necessary to be connected across the CT so that the appropriate value of current is obtained. A capacitor is also connected across this circuit. The capacitor filters the harmonics and high frequency signals and allows only low frequency signals to enter and a normal sinusoidal waveform is obtained. The output of CT is also given to the other analog inputs of the Arduino UNO Atmega328. Now the digital data is obtained by using certain programming. A reference program for the Arduino is already available but it can be just used as a reference. Here we have done the programming as per the CT and PT wherein we have calibrated the CT and PT using our own codes. And the programming is carried out independently.

The data can be seen in the serial monitor which is already installed in the Arduino. Similarly the waveforms are seen in the serial plotter present in the Arduino. The data can be also directly seen in the excel sheet but the plotter and the monitor should be turned off at that time. They cannot operate simultaneously.

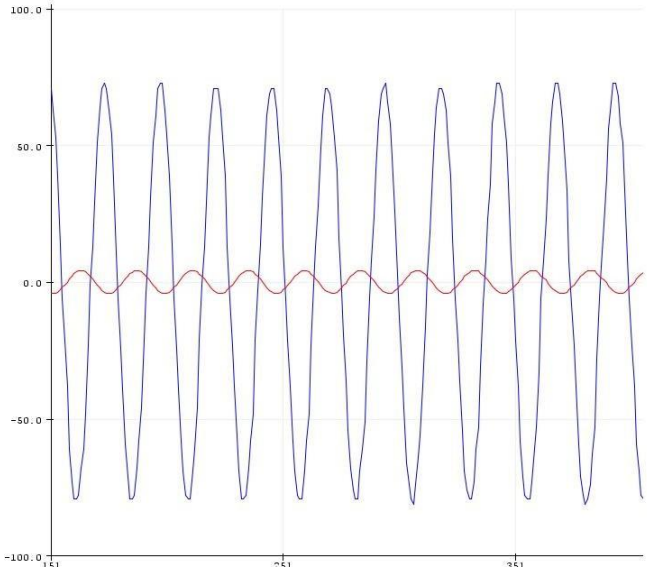


Fig VII: Waveform for voltage and current.

The above figure shows the waveforms of the incoming current and voltage of a single phase system. The smaller waveform shown in red colour represents the current waveform and the other waveform shown in blue colour represents the voltage waveform.

The various parameters are calculated as, $\Theta = 2\pi Ft$ (radians)

$\Theta = 360*F*\Delta t$ (degrees)

$P = V\ I \cos \Theta$ (Watts)

$Q = V\ I \sin \Theta$ (VAR)

$S = V.\ I$ (KVA)

Where,

P is 'Active Power' Q is 'Reactive power' S is 'Apparent power'
Θ is 'Angle between voltage and current' The basic parameters to be measured are,

1. RMS voltage
2. RMS current
3. Power factor

The various other parameters can be calculated by using these basic parameters.

IV. Conclusion

The objective of this study was to develop a single phase energy monitoring device or can be called as a power quality analyzer that can accurately measure the certain parameters by using a low cost general purpose microcontroller board. The developed prototype is able to display the voltage, current, power factor, active power, reactive power and apparent power with the incorporation of Arduino Uno of the single phase system.

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