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SMART ENERGY METER

Naveenkumar, Jagadeesh S K
Dept. of Electrical and Electronics
BVB College of Engineering and Technology
Hubli, India
naveenkumar.tuppad@gmail.com

Abstract — Efficient power consumption and savings has become a major issue these days as the need for power is increasing day by day. Domestic energy consumer is unaware of his power usage, means to save it, and also sometimes finds ways to steal power without paying for it. One more issue is that service provider can't predict the power consumption of a specific consumer or a specific area which can further be used to analyze the load changes of the same. This has increased the emphasis on the need for accurate and economic methods of power measurement. The goal of providing such data is to optimize and reduce their power consumption. The Energy Meter proposed here deals with the measurement of line voltage, phase current, neutral current, computation of active power, and energy being consumed by a consumer and display the information to the consumer and then send the power and energy being consumed to the service provider, identify theft and cut the line for a period when the voltage and current exceed specific limits so that no equipment fails.

Keywords — Consumer, Energy, Power, Power theft, Service provider.

I. INTRODUCTION

The system as shown in Fig. 1 consists of three units.

A. Data acquisition unit

Acquires the data and processes it as per the requirements so as to suit the controller. Here we have an analog data which we convert into the digital form. Again care should be taken to check the ADC requirements so that the data is faithfully sampled. The block consists of Hall Effect sensors, transformer and level shifter circuits.

B. Data manipulation unit

Performs calculations using the sensed online data, voltage and current to get parameters like power and energy being consumed, and also identify theft if the difference between phase and neutral current is above limit. We are using microcontroller Atmega328p that has inbuilt EEPROM. A 16x2 LCD is used to display the measured parameters.

C. Data transmission unit

The power and energy measured at the consumer end along with customer id will be then sent to the service provider via Zigbee for further analysis. On the service provider end, received data is fed to database using serial communication (RS232) through hyperterminal.

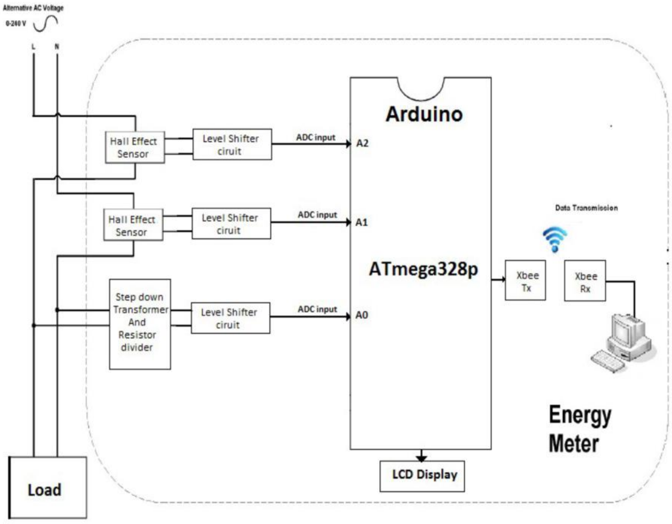

Fig. 1 Block diagram of Energy Meter

II. METHODOLOGY TO MEASURE ENERGY

A. *Interfacing analog front end*

The analog front end is the part, which interfaces with the high voltage lines. It conditions high voltages and high currents down to a level which can be measured directly by the ADC of the microcontroller.

1. *Voltage front end*

Line voltage is first downsized using resistors, and then applied to anti-aliasing filter. Simple resistor dividers can be used as voltage sensors. The resistor values are chosen to divide the AC mains voltage to fit the input range of the analog-to-digital converter (ADC). For example 230V rms ac supply is stepped down to 0.23V rms using resistors as shown in Fig. 2. The voltage measurement circuit connects to the Arduino board through analog pin.

2. *Current sensing circuit*

Line current is first downsized using Hall effect sensor. The sensor and measuring resistance are chosen to divide the AC line current to fit the input range of the ADC. For example if 1A line current is flowing it is downsized to 0.1A. Taking measuring resistance of 100ohm this 0.1A is converted to equivalent voltage of 0.1V as shown in Fig. 3. Now this voltage is applied to ADC input terminal of Arduino through analog pins. Both phase and neutral currents are measured by same method.

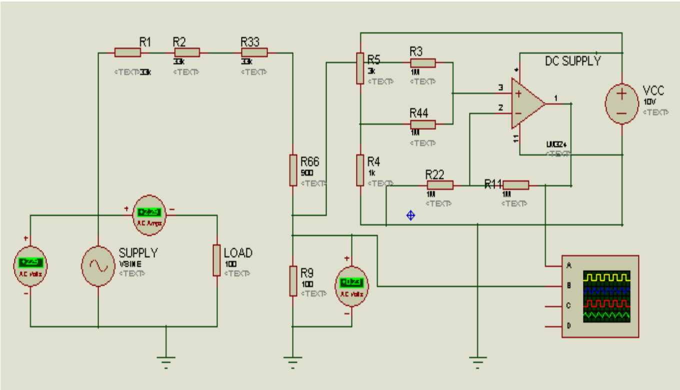

Fig. 2 Simulation of voltage sensing circuit in Proteus

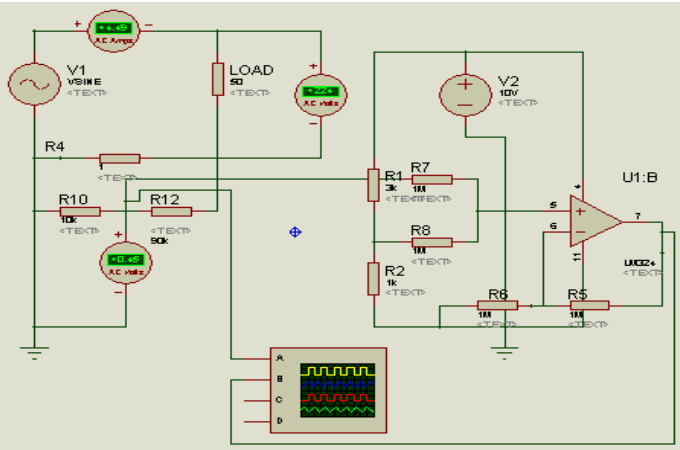

Fig. 3 Simulation of current sensing circuit in Proteus

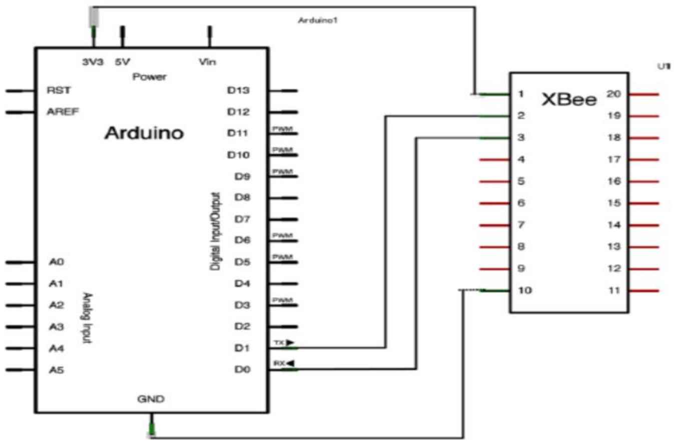

Fig. 4 Interfacing Arduino and ZigBee module

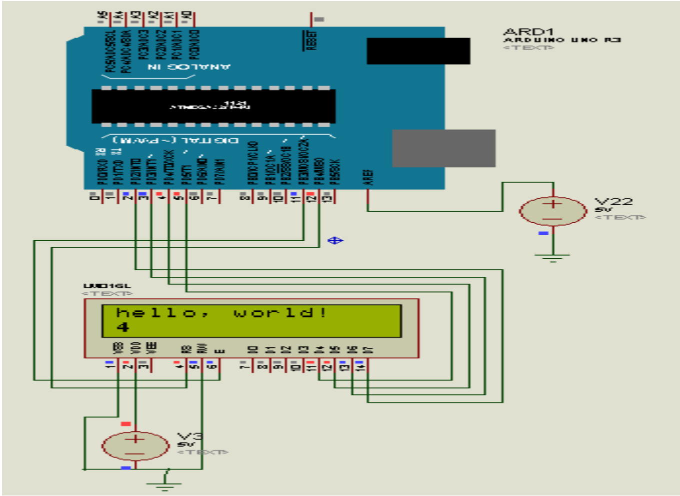

Fig. 5 Interfacing Arduino with LCD

B. Interfacing Arduino with ZigBee module

Zigbee based wireless communication subsystem is responsible for receiving and transferring data. Zigbee wireless open standard technology is being selected as the energy management and efficiency technology of choice in terms of reliably and timing. Microcontroller is playing a major role in how energy is priced and used. Remote monitoring and manipulation is achieved through this Zigbee module in this work as shown in Fig. 4.

C. Interfacing arduino with LCD

The LCDs have a parallel interface, meaning that the microcontroller has to manipulate several interface pins at once to control the display. The Hitachi-compatible LCDs can be controlled in two modes: 4-bit or 8-bit. The 4-bit mode requires seven I/O pins from the Arduino, while the 8-bit mode requires 11 pins. For displaying text on the screen, you can do most everything in 4-bit mode, so example shows how to control a 2x16 LCD in 4-bit mode as shown in Fig. 5.

D. Interfacing ZigBee module with computer

To interact with service provide, receiver end ZigBee module is interfaced with computer to communicate serially using RS232 through hyperterminal. The data received is then updated to a file and safely saved in the computer. Refer Fig. 10 for hardware implementation of the same.

III. POWER AND ENERGY CALCULATION

Voltage and current values are sampled for a certain time and calculations for RMS Volatge Vrms (Volts), Average power Pavg (Watts), Apparent power Papp (watts), Energy consumed (KWhr) and power factor pf is made using following equations, where, N indicate the number of sampled values, Fs indicate Sampling frequency.

$$(1)\ Vrms = \sqrt{\sum_{n=0}^{N-1} (V(n) * V(n)) \Big/ N}$$

$$(2) Pavg = \sum_{n=0}^{N-1} (V(n) * I(n)) \Big/ N$$

$$(3) Energy = \sum_{n=0}^{N-1} (V(n) * I(n))) \Big/ Fs$$

$$(4) Papp = Vrms * Irms$$

$$(5)\ pf = Pavg \,/\, Papp$$

IV. Simulation Result

Refer Fig. 6, Simulation software Proteus is used to simulate every circuit and the results are as shown in below figures. Refer Fig. 7, blue and yellow lines indicate input signal and output signal reference respectively. Fig. 8 and Fig. 9 show amplified and offset form of voltage and current signal respectively.

V. Hardware implementation result

Hardware implementation of the proposed system is as shown in Fig. 10 and Fig. 11. Refer table I and II, known input voltage using Autotransformer is applied to the system in steps. Similarly load current is varied in steps using adjustable lamp loading equipment. Both the measured values are checked against actual ones. As seen there is no much difference in values.

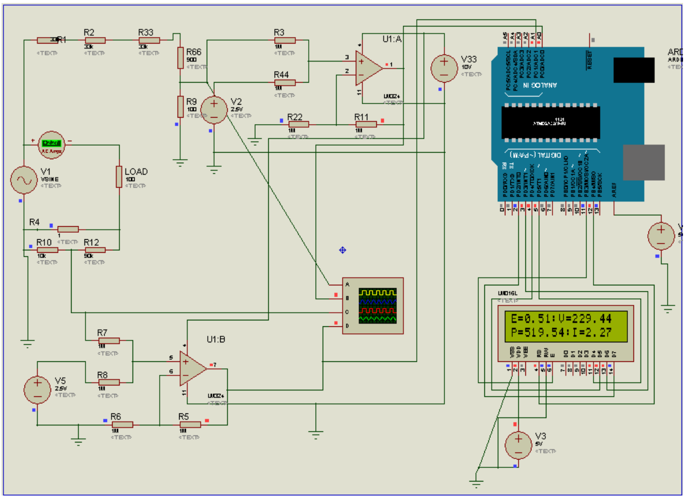

Fig. 6 Simulation of complete circuit using ATMEGA 328p

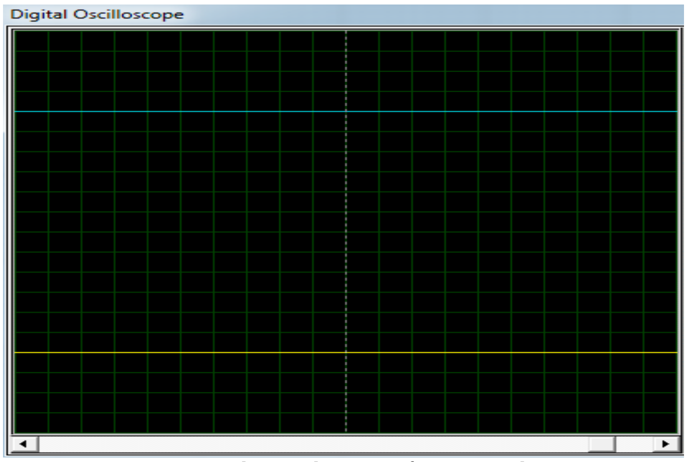

Fig. 7 Voltage and current reference signal

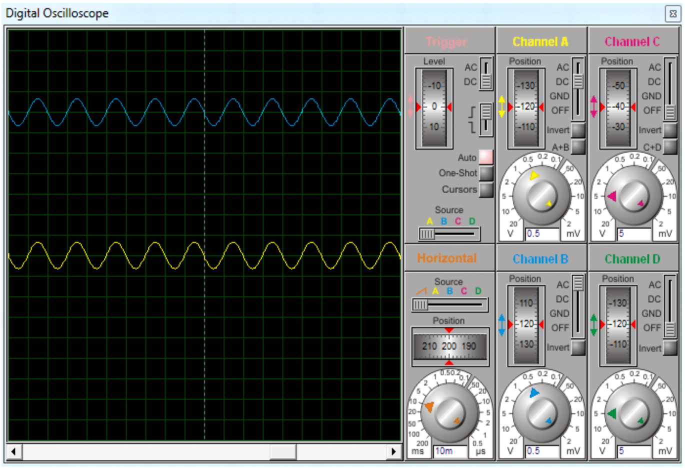

Fig. 8 Voltage front end input and output signal

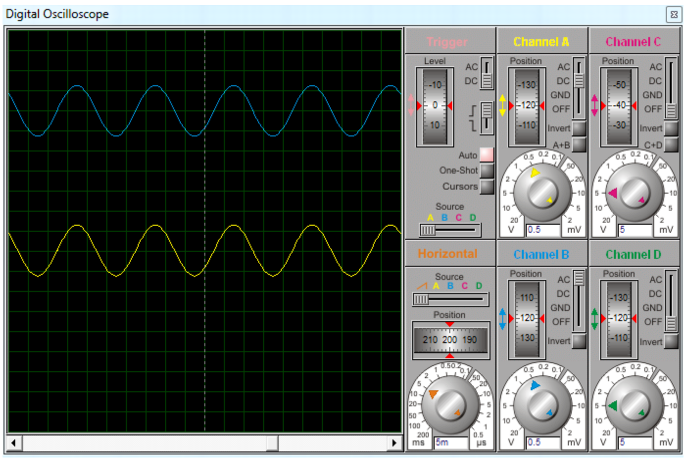

Fig. 9 Current front end input and input signal

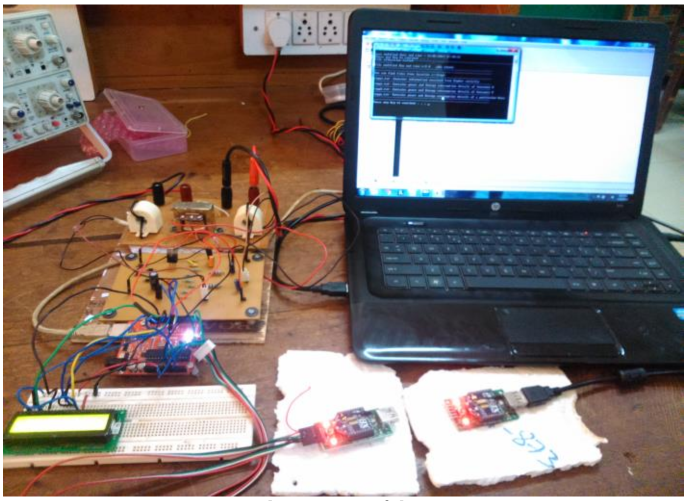

Fig. 10 Hardware setup of the experiment

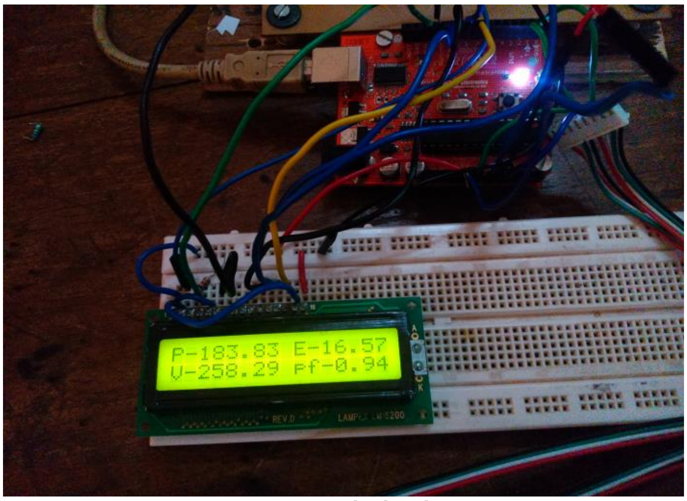

Fig. 11 Parameters displayed on LCD

TABLE I. VOLTAGE VARIATION USING AUTOTRANSFORMER

Observation	**Actual value**	**Obtained value**
1	100	101
2	140	137
3	180	179
4	220	217
5	240	236

TABLE II. CURRENT VARIATION THROUGH LOAD CHANGE

Observation	**Actual value**	**Obtained value**
1	0.73	0.69
2	1.42	1.39
3	2.07	2.13
4	2.33	2.38
5	2.46	2.41

VI. CONCLUSION AND FUTURE SCOPE

The designed and developed device is capable of handling 1000V and 35A that monitors the power and energy consumption of a consumer and identifies theft and then send the data by a wireless transmission system. This device enables consumers to easily monitor and track their energy usage accurately with a relatively fast update rate, thus helping the user optimize and reduce their power usage. The service provider can monitor power and energy usage of individual consumer and of specific area in real time.

Future scope of the project is that the proposed system can be more efficiently implemented using RTOS, auto cutting of power supply to the consumer in case bill is due, and online billing can be more additions to the system.

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