Automatic Voltage Regulation for Home Appliances using Power Sensor Tag

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***Abstract*— In the transmission lines, the current that flows need to be analyzed for the proper calculation of power that is supplied to homes in general. The previous system had used the power sensor tags to monitor the amount of current flowing through the lines. Based on the current monitored and the voltage across the lines, the power supplied to the homes can be calculated. Using this application and with the help of GSM, the power consumed by the users can be sent as a message for paying the bill along with notification when the bill is not paid in time. These kinds of applications can also be used in industries and can alert the users about the usage of power. This paper is presented with a model for automatic power supply monitoring and billing system. The simulated results show that model can be adapted for practical implementation of such a system.**

Keywords—AT Command; CT; EB Station; GSM; Power Sensor tag; PIC-MCU; Voltage Regulator

I. INTRODUCTION

The current plays a vital role in our day-to-day lives. The flow of current is required for wide range of electrical and electronics applications. Each of this application requires different performance such as cost, size, measurement range, precision etc and there are several current measurement techniques have been introduced to satisfy those demands. Nowadays, the information of the current is available in digital form for monitoring purpose. So the output of a current sensing technique should be acquired by ADC converter.

The current is used for almost everything we do and it is transmitted to our home whenever we need it by means of electrical transmission lines and distribution system .The electricity or current is the type of electrical energy used in house appliances. The current or electricity is a stream of electrons flowing through a conductor. The houses are supplied electricity by means of current through transmission lines. The power plants use electromagnets for producing electricity and that is transmitted through wires to houses. For transmission lines, the flow of power can be measured by using current and voltage sensors. These types of sensors are used in many other industrial and domestic appliances also. Sensors are used to determine the flow of current. The examples include Rogowski coil, Flux gate sensor, Hall-Effect sensor, Magnetoimpedance, Gaint Magnetoresistance (GMR) sensor, current transformer etc.

Rogowski coil is an air-filled core used for measuring current based on Faraday's law of induction. This coil is similar to wounding a non-magnetic toroid like an inductor. The output voltage is proportional to the current flowing through the coil. It is necessary to reset the integrator to zero. This reduces the offset voltage, if any at initial condition, when the current is large and its frequency component has volatile changes in its value. Reset in a sensor plays a very important role. In case of semiconductors, it is controlled through a switch. The main drawback of Rogowski coil is that it cannot be used in domestic appliances because it detects current only on single current carrying conductor [1] [2].

Flux gate current sensor consists of two coils along with ferromagnetic core used for measuring *dc* current. This sensor is also used to detect the change in magnetic flux lines. Flux gate sensor works based on the winding of the coil. The hysteresis loss is small in this sensor. The characteristics of linearity do not change but depends upon the temperature. In order to make the offset value zero, it transmits the current to the secondary windings. The transmission of current is possible with the help of load resistance. The feedback current is used to obtain the relative output current. This makes the sensor to be used in high current prediction [3]. The drawback of this technique is that while measuring current using this sensor, the detection errors occur.

Magnetoimpedance sensor have been used to measure the external magnetic field and Gaint Magnetoresistance (GMR) sensor are used as a magnetic sensor based on testing of eddy current technique. This sensor is mainly used for measuring the position, angular sensing and current sensing. The flow of current through a metal wire produces magnetic field around it and the output of GMR sensor is used to measure the flow of current in the wire. Sensor should be placed close to the wire and it is also used to detect even very small current [4] [5]. Drawback of this sensor is that it does not give output parameter directly. Signal processing is required for determining the desired output for meaningful interpretation for further improving the measuring process.

Hall Effect sensors are used for measuring current and voltage transmitted on the power chords. The current sensors are used for monitoring the flow of current ideally. The magnetic flux density can be measured with the help of Biot-Savart law. While measuring the power, the things to be considered are the dimensions of power cord, thickness of the

substrate and number of turns of the coil. The voltage sensors are used to detect the sinusoidal electric field in the power cord. In order to measure the voltage in the power cord, the capacitance consideration is necessary [6]. The fringing effect must be considered. If it is ignored, the leakage can cause reduction in efficiency. The fringing leakage normally occurs at the perimeter of sensing electrode. The Hall Effect sensor is not capable of measuring a current flow at a distance greater than 10 cm, it has very low output drive capability and it is difficult to operate in the presence of strong external magnetic fields.

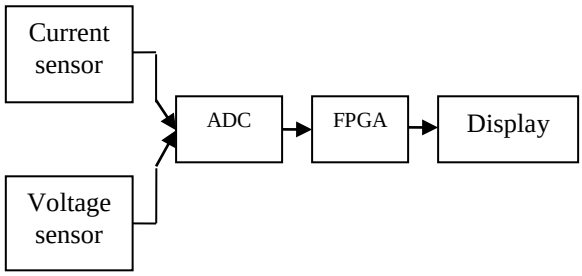

Fig. 1. Design of measuring power in transmission line using FPGA

Fig. 1 shows that the power sensor tag that has been used for accurate monitoring of current and voltage subsequently using typical Service Parallel Thermoplastic (SPT) cord such as SPT-2 18 AWG zip-cord power line [7] [8]. Meanwhile, the resultant output of the sensors which are normally in analog form, may be converted into digital form by means of A/D converters. This is necessary as FPGA accepts only the digital form of output and display the monitored power on display panel.

To overcome all the drawbacks mentioned of the above discussed techniques, the current transformer are used for measuring the current which is possible through internal magnetic field produced. Current transformer allows heavy currents to be measured using conventional ammeters and it can electrically isolate the ammeters from high voltage primary circuits. This sensor is used for many applications such as electric board and in industrial applications.

II. SYSTEM IMPLEMENTATION

A. Regulated Power Supply

Microcontroller gets supply from direct AC line through power supply unit. The power supply unit consists of transformer, rectifier and regulator as shown in Fig. 2. Generally, transformer is an electrical device which transfers energy between two or more circuit through electromagnetic induction. In this design, step-down transformer is used to step-down the voltage from main AC to the required voltage level (i.e., 230V to 12V). The winding ratio between primary and secondary of the transformer is adjusted to obtain the required voltage level. The output of this is given as an input to the rectifier. Normally, the input of the rectifier is AC, which converts an alternating voltage or current into corresponding DC. Power supply unit uses bridge rectifier which does not require centre tapped transformer. Instead of this, it uses a single secondary winding which is attached to the one side of the diode. The rectified voltage is filtered by a capacitive filter to produce a *dc* voltage.

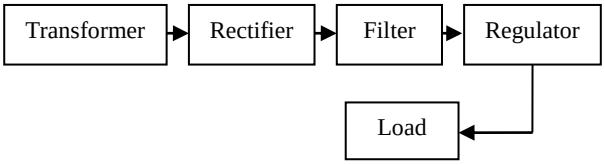

Fig. 2. Design of regulated power supply

The output of the rectifier is given to the regulator to convert the unregulated *ac* to a constant *dc* output voltage (i.e., 12 v to 5 v) in case of any change or fluctuations that may occur in the input power. Because PIC Microcontroller accepts only (0-5) volt supply.

B. Current Transformer and Voltage Measurement

Current Transformer (CT) is used for monitoring the flow of current in the power line. The CT works on the basis of Faraday's law of induction. The construction of the current transformer is similar to that of Rogowski coil for measuring current. The main difference between these two sensors is that the secondary winding of the CT sensor is loaded with sense resistor. When current flow through the line is only AC and does not contain DC then CT offer simple and isolated current measurement.

CT is used for measuring alternating current. CT along with the voltage transformer is known as instrument transformer. CT consists of primary and secondary winding. If an alternating current in its secondary winding is high, then it can't be directly applied to the measuring instrument. In such a case a CT can scale down it. The alternating current normally depends upon the current flow in transmission lines.

Voltage measurement is used to measure the potential energy of the electric field that causes an electric current to flow in a conductor. The monitored current and voltage are given to analog-to-digital converter, which converts the incoming analog signal to digital whose output is given to the PIC Microcontroller. It subsequently displays the sensed voltage and current ideally on the LCD as shown in Fig. 3.

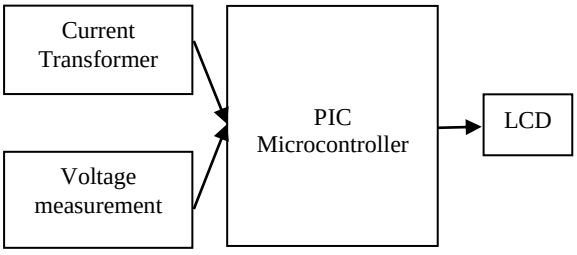

Fig. 3. Block diagram for monitoring current and voltage

C. Interfacing of GSM Module and PIC Microcontroller

The PIC Microcontroller is interfaced with the GSM modem using RS-232 to transmit and receive data simultaneously. GSM module is controlled by Attention (AT) command instruction set that includes SMS related command such as AT+CMGF for setting the communication to text mode, AT+CMGS for sending SMS message, AT+CMGR for reading SMS message. RS-232 act as interface between GSM modem and microcontroller which includes an IC, MAX232IC to enable communication with interfaced peripheral, as shown in Fig. 4.

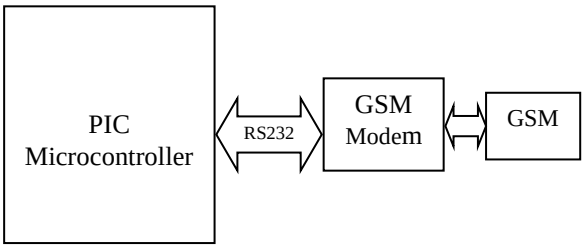

Fig. 4. Interfacing of Microcontroller with GSM

D. Application

The voltage regulator and the power sensor as a whole can be used in the application of electricity billing. The bill can be paid through mobile using E-Billing technique. For every month the amount of current used in a typical house is sent as an SMS to EB station. From EB station, the reply message of the units and amount to be charged from a house is sent as a reply message and a notification message is sent the same house. If bill is not paid in the time, power will be withdrawn or stopped for a period of time till the users pay the bill. This is done with the help of a particular security code at the EB station.

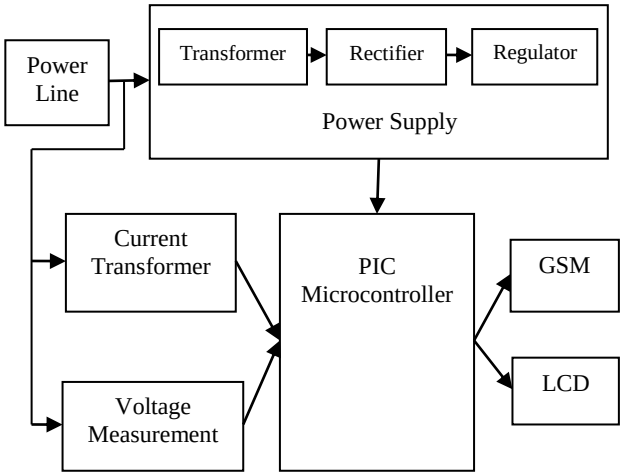

Fig. 5. Overall block diagram for automatic voltage regulation

III. RESULT AND DISCUSSION

The simulation is done by using Proteus 8 professional edition of a software platform. It is a virtual system modelling and circuit simulation application software. The suite combines animated components and microprocessor models to facilitate co-simulation of complete microcontroller based designs to solve engineering problems. The main advantages of the Proteus software, it also has the ability to simulate the interaction between software running on a microcontroller and any analog or digital based electronic system connected to it. The current version used for this research work is 8.0 and is available as an open source software for simulation tests. One can design and simulate very advanced electronics circuits and systems. The simulated results are shown in Fig. 6, with overall design. The Fig. 7 shows monitored current and voltage with number of units of energy consumed. Fig. 8 is shown with monthly bill and notification. The Fig. 9 shows warning display that the power is disconnected due to non-payment of bill by due date

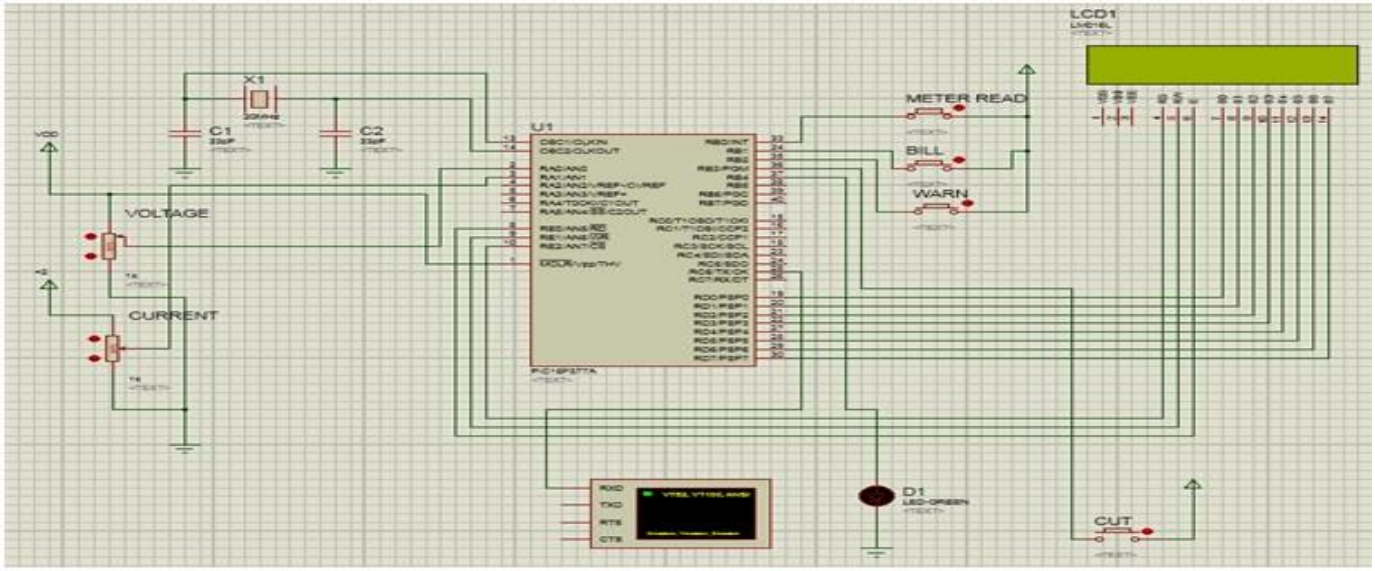

Fig. 6. Overview simulation diagram

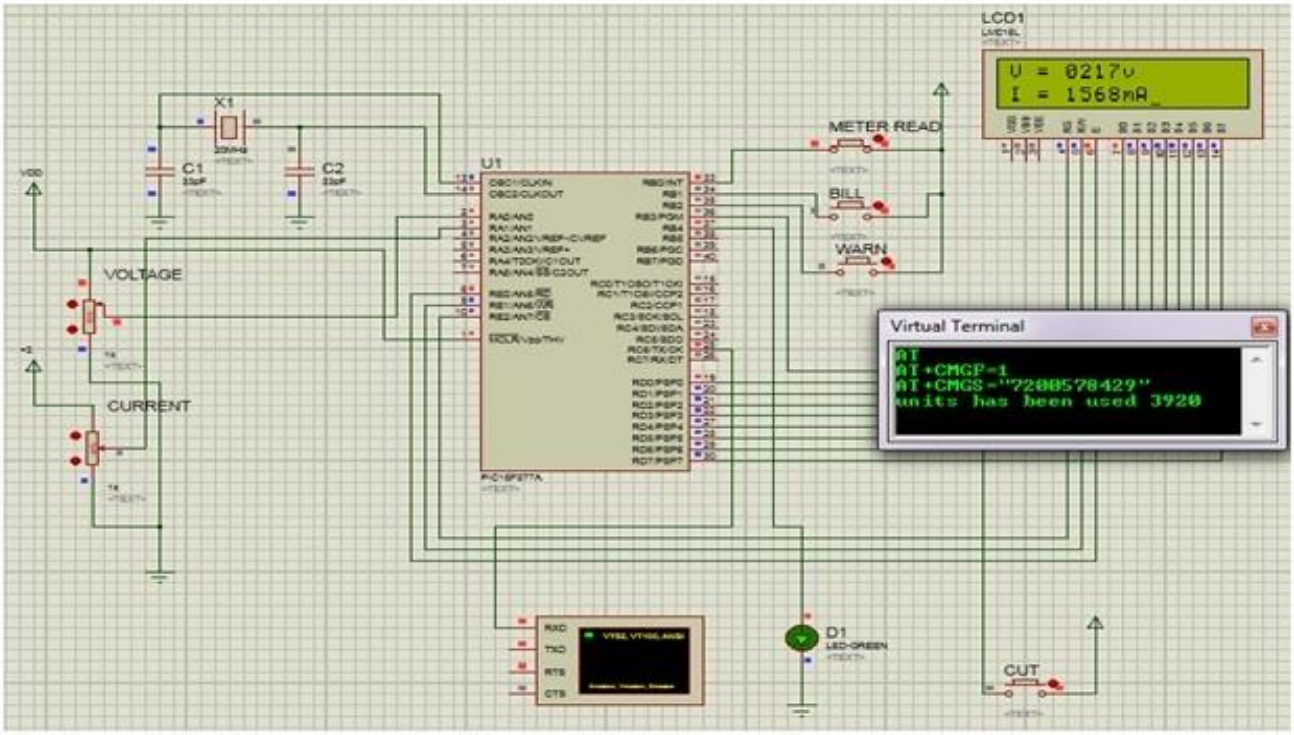

Fig. 7. Simulation results for monitoring current and voltage which are displayed on LCD with total consumed units

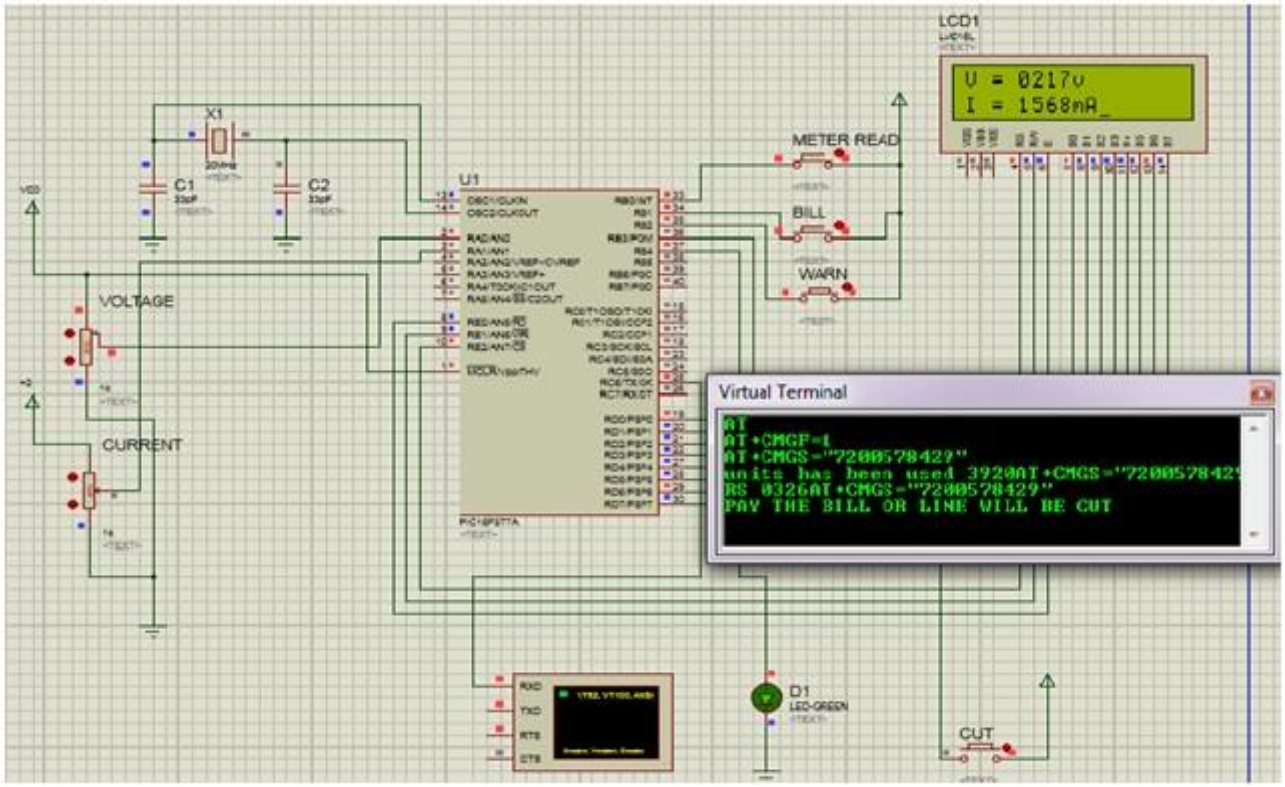

Fig. 8. Simulated results displaying monthly bill and due date notification for a consumer

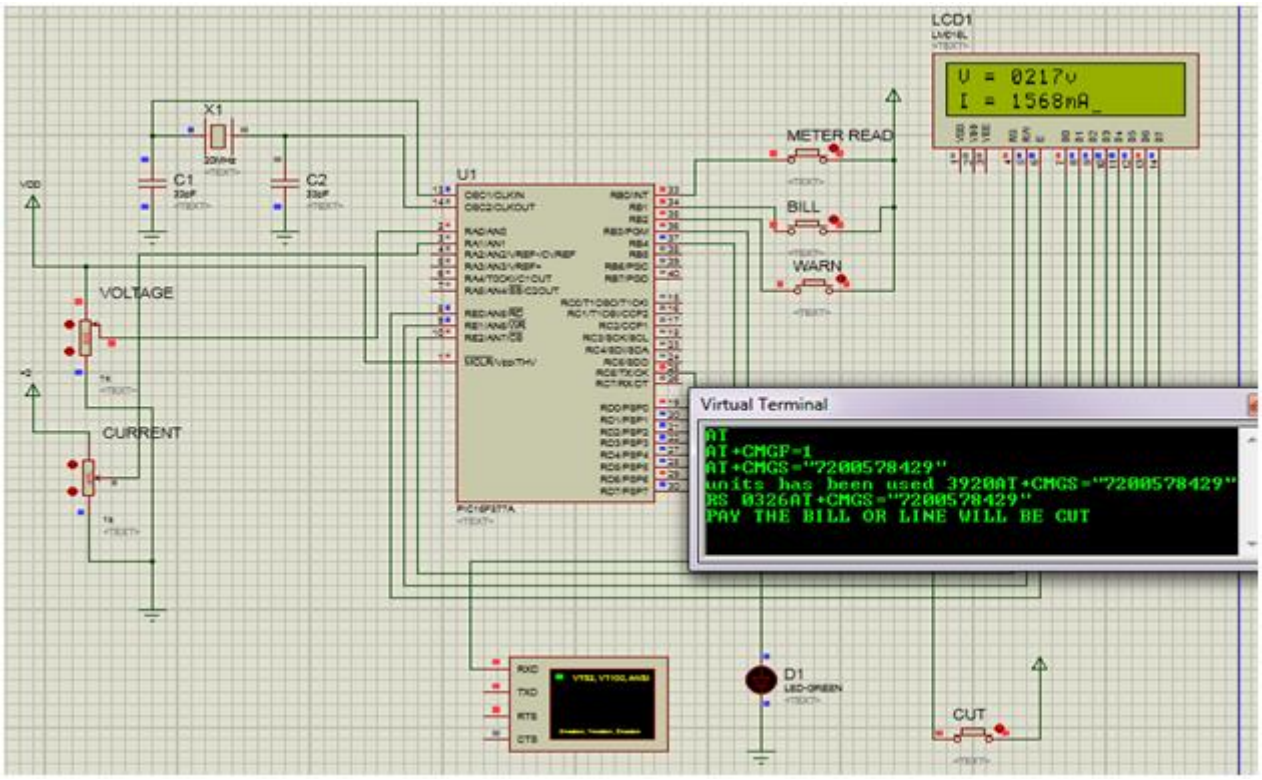

Fig. 9. Simulated results to notify due date to consumer and a flashing LED indication is given if a particular bill is not paid by due date

IV. CONCLUSION

The proposed automatic voltage regulator using power sensor tag is analyzed and simulated using the software Proteus 8 professional version. The system is less risky since human interaction has been minimized by the use of GSM in this particular system. It has numerous advantages over other conventional methods.

The future scope of the project is to implement it in industrial applications for the purpose of effective power utilization.

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