Prepaid Smart Meter Energy Management System using Arduino Microcontroller with Labview

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Abstract— This paper deals with prepaid smart meters energy management system using ARDUINO microcontroller with labVIEW has been introduced. Smart meters are the key component of the smart grid which helps both the user and supplier to control consumption of energy according to availability of resources. The proposed energy metering system consists of smart meter, zigbee communication and mobile user. Zigbee is connected for wireless data transmission between energy management and monitoring center. This meter is able to measure energy and will communicate the data to the electricity board, which stores the information and notify the consumers through SMS in mobile. The prepaid concept provides a cost efficient manner of electricity billing, which is based on the concept "pay first and then use it". The prepaid energy meter uses a recharge card which cost is depends upon usage of the units. Energy can be monitor by using labVIEW that help you to check how much electricity you consume per hour or day. A relay system has been used which shutdown or disconnect the smart meter and load through supply mains when the recharge amount is depleted. A prototype of the system has been developed with the state of the art digital and information technology and proven to be stable, reliable and easy maintenance.

Key words: Arduino Microcontroller, Zigbee Communication, MAX 232 Serial communication, GSM Module, LabVIEW

I. INTRODUCTION

The present traditional billing system have many problems like problem of payment collection, energy thefts etc. due to which the traditional billing system is slow, costly and unreliable [1]. The present billing system has chances of error and it is also time or labour consuming. A paper suggests a design of digital energy meter for improved metering and billing system [2]. Poly-phase prepaid energy metering system has also been proposed and developed based on local prepayment and card reader [3]. Prepaid energy mater using a microcontroller from microchip technology Inc. ATmega family, used due to low cost of microcontrollers. So it is essential to develop a billing system which solves the problem of billing manually and also reduces the manpower. In this paper we proposed and designed a prepaid energy meter using Arduino Uno microcontroller ATmega238 from ATMEL family. The reason for using these microcontrollers is its high performance, power efficiency or design flexibility etc. In this paper a recharge card is used which is available in various ranges (i.e. Rs. 50, Rs. 100, Rs. 20 etc.) and the energy meter to which the no. of recharge units has to be loaded [5] . Suppose a consumer buys a recharge card for Rs. 50 he/she can insert this amount through the keypad so that the prepaid energy meter will be activated According to the power consumption the amount will be reduced. An LDR circuit is used to count the amount of energy consumed and an LCD is used to display the meter readings. When the recharge card amount is nil the relay will automatically shut down the whole system [6]. LDRs or Light Dependent Resistors are very useful especially in light/dark sensor circuits [8]. Another paper suggests prepaid energy meter using a microcontroller from used due to low cost of microcontroller [4].The main aim of this paper is to read the value from the energy meter of different flats or offices in an apartment and pass this read data to the main system using Zigbee and from there to user mobile. This digital meter, that reads the number of units, is actually a digital meter. This energy meter will be interfaced with the Arduino microcontroller. The microcontroller reads the data from the energy meter and passes this data to the GSM modem via Zigbee technology. This data is also displayed on the LCD. We take the pulses from Energy Meter and calculate the number of units consumed. The consumed units or cost will be sent to the PC using zigbee communication. If the consumer wants to know about the bill and the usage of cost he can get the SMS and output also monitored in the LabVIEW is high reliable and cleared view of load voltage and current. Smart meter reading co-operate both utilizes and consumers in power management, giving them detailed information about power consumption [7]. A server computer with graphical User interface (GUI) or front end, designed using LabVIEW, receives this data and store in a database according to the meter ID. At the end of the every month, electricity bill is generated automatically and maintained in the secondary automatically and maintained in the secondary memory of the server. Every smart meter installed at the consumer end has a unique meter ID. In India, developing a low cost basic smart meters by upgrading the existing one is more acceptable [9]. In this system has to be cost-effective such that reduced implementation cost, maintenance free while providing robust and reliable performance [10]. In this paper is to read the value from the energy meter of different flats or offices in a apartment and pass this read data to the main system using Zigbee and from there to user mobile. The microcontroller reads the data from the energy meter and passes this data to the GSM modem via Zigbee technology. This data is also displayed on the LCD. We take the pulses from Energy Meter and calculate the number of units consumed and Total Bill for the consumed units will be sent to the PC using zigbee communication. Whenever the service provider/Consumer wants to know about the bill he can get it with a SMS.

II. PROPOSED METHODOLOGY

The proposed and developed based on local prepayment and card reader. Prepaid energy mater using a microcontroller

from microchip technology Inc AT mega family, used due to low cost of microcontrollers. So it is essential to develop a billing system which solves the problem of billing manually and also reduces the manpower. In this paper we proposed and designed a prepaid energy meter using Arduino Uno microcontroller ATmega328 from ATMEL family. The reason for using these microcontrollers is its high performance, power efficiency or design flexibility etc.

III. BLOCK DIAGRAM

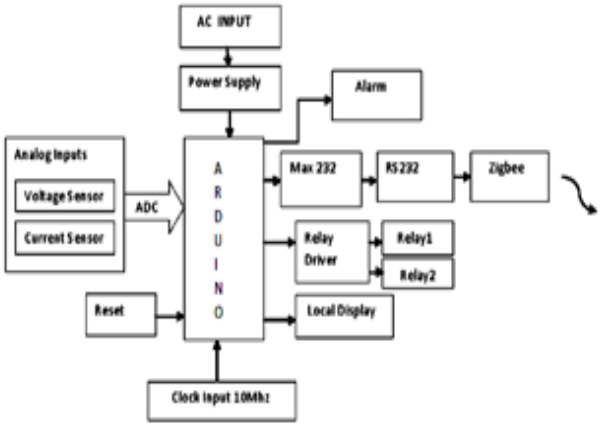

Fig. 1: Transmitter Section

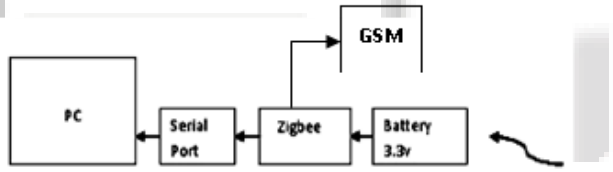

Fig. 2: Receiver Section

IV. CIRCUIT DIAGRAM

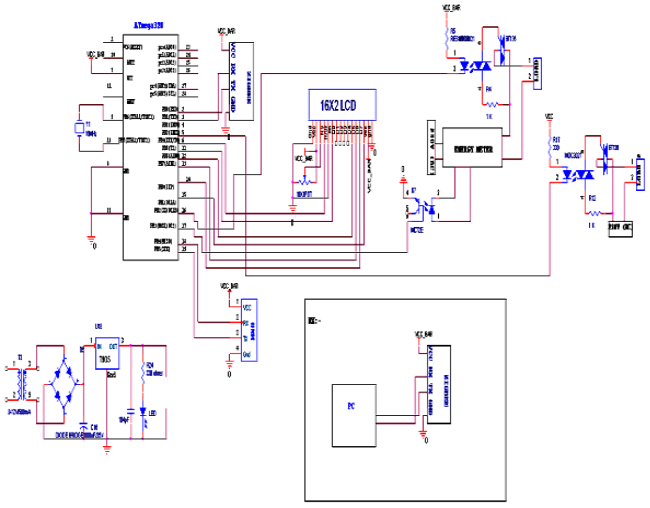

Fig. 3: Circuit Diagram

V. ARDUINO MICROCONTROLLER

The Arduino is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

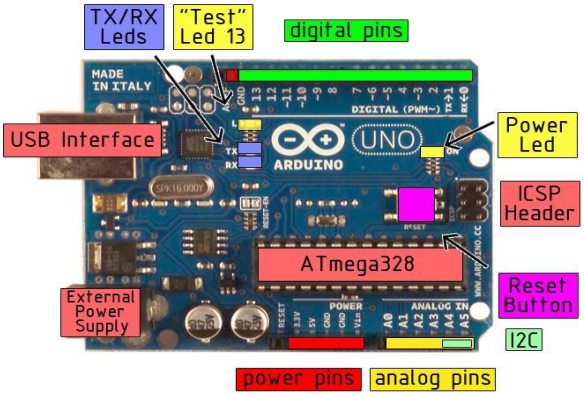

Fig. 4: Arduino Micro Controller

VI. ATMEGA328 MICROCONTROLLER

The device is manufactured using Atmel's high density non-volatile memory technology. The On-chip ISP Flash allows the program memory to be reprogrammed In-System through an SPI serial interface, by a conventional non-volatile memory programmer, or by an On-chip Boot program running on the AVR core. The Boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega328 is a powerful microcontroller that provides a highly flexible and cost effective solution to many embedded control applications. The ATmega328 AVR is supported with a full suite of program and system development tools including: C Compilers, Macro Assemblers, and Program Debugger/Simulators, In-Circuit Emulators, and Evaluation kits. The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. Arduino Microcontroller. An Atmel ATmega328 microcontroller operating at 5 V with 2Kb of RAM, 32 Kb of flash memory for storing programs and 1 Kb of EEPROM for storing parameters. The clock speed is 16 MHz, which translates to about executing about 300,000 lines of C source code per second. The board has 14 digital I/O pins and 6 analog input pins. There is a USB connector for talking to the host computer and a DC power jack for connecting an external 6-20 V power source, for example a 9 V battery, when running a program while not connected to the host computer.

VII. PIN DIAGRAM

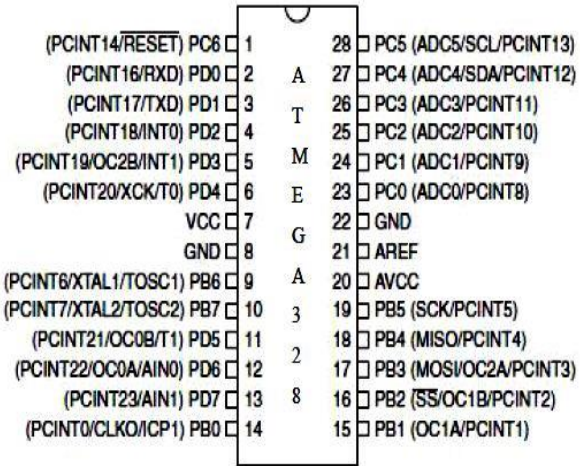

Fig. 5: Pin Diagram of ATmega328 Microcontroller

VIII. ZIGBEE COMMUNICATION

Zigbee is a new emerging technology used now days for short range communication network which works on a unique identification code. This unique ID makes this device highly reliable in terms of security. It is a wireless communication device which is comprised of a Tran's receiver just like a blue tooth device or a Wi-Fi network but data rate is slow. It has 16 bits address so it creates 65536 nodes in a network or in other words it has 16 Channels for communication. It is a monitoring and controlling device in communication networks. The only difference in Zigbee is it uses unique identity method means if one Zigbee device transmits data then it is received by only that Zigbee device which is having its decoding address. While in Bluetooth or Wi-Fi anybody can transmit or receive data. So data is prevented in Zigbee device, nobody can manipulate the data. Only authorized person or device can read data. Main features of Zigbee are low data rate and low power consumption.

Table 1: Specification of Communication

Performance	Zigbee	Bluetooth	Wi-Fi
Working frequency	2.4GHz,868/915MHz	2.4GHz	2.4GHz
System resource	50Kbyte-60Kbyte	250Kbyte	>1Mbyte
Communication range	0.1-1.5km	0.1km	0.1km
Data rate	250Kbps	1Mbps	1Mbps
Maximum network nodes	65536	8	32
Wake- up time	30ms	10s	3s
Low power consumption	Support	No support	No support
Battery life(days)	100 to>1000	1to 5	1to 7

IX. GSM MODEM COMMUNICATION

GSM modem can accept any GSM network operator SIM card and act just like a mobile phone with its own unique phone number. Advantage of using this modem will be that you can use its RS232 port to communicate and develop embedded applications. Applications like SMS Control, data transfer, remote control and logging can be developed easily. The modem can either be connected to PC serial port directly or to any microcontroller. It can be used to send and receive SMS or make/receive voice calls. This GSM modem is a highly flexible plug and play quad band GSM modem for direct and easy integration to RS232 applications. Supports features like Voice, SMS, Data/Fax, GPRS and integrated TCP/IP stack. This GSM Modem can accept any network operator SIM card and act just like a mobile phone.

Fig. 6: Block Diagram of GSM Modem Communication

X. LABVIEW

LabVIEW, short for Laboratory Virtual Instrument Engineering Workbench, is a programming environment in which you create programs using a graphical notation (connecting functional nodes via wires through which data flows); in this regard, it differs from traditional programming languages like C, C++, or Java, in which you program with text. LabVIEW is much more than a programming language. It is an interactive program development and execution system designed for people, like scientists and engineers, who need to program as part of their jobs. The LabVIEW development environment works on computers running Windows, Mac OS X, or Linux. LabVIEW can create programs that run on those platforms, as well as Microsoft Pocket PC, Microsoft Windows CE, Palm OS, and a variety of embedded platforms, including Field Programmable Gate Arrays (FPGAs), Digital Signal Processors (DSPs), and microprocessors. Using the very powerful graphical programming language that many LabVIEW users affectionately call "G" (for graphical), LabVIEW can increase your productivity by orders of magnitude. Programs that take weeks or months to write using conventional programming languages can be completed in hours using LabVIEW because it is specifically designed to take measurements, analyze data, and present results to the user.

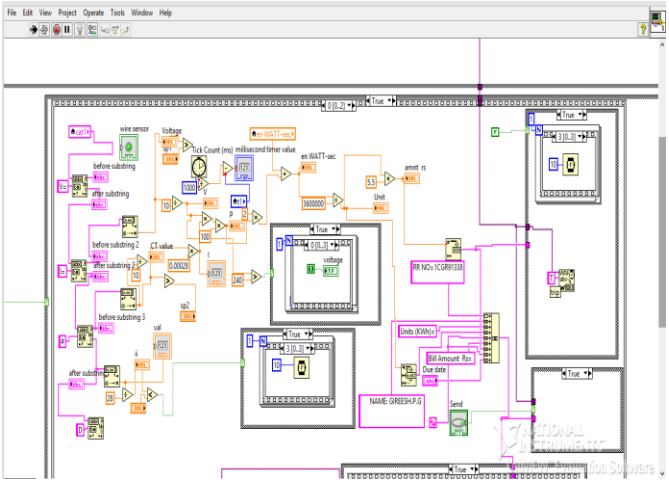

Fig. 7: Blocks Diagram of Program at Server Side

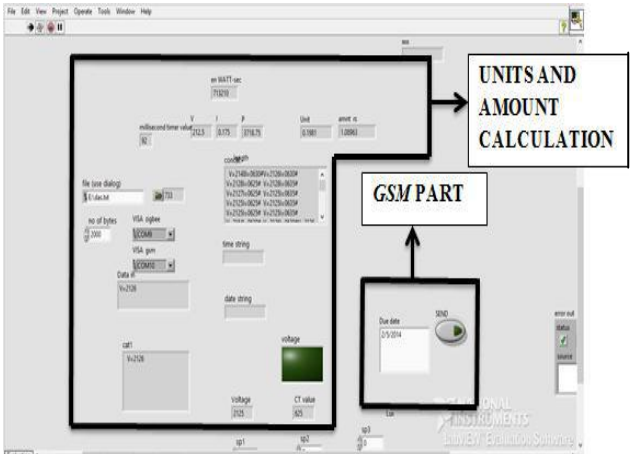

Fig. 8: Front View of Program at Server Side

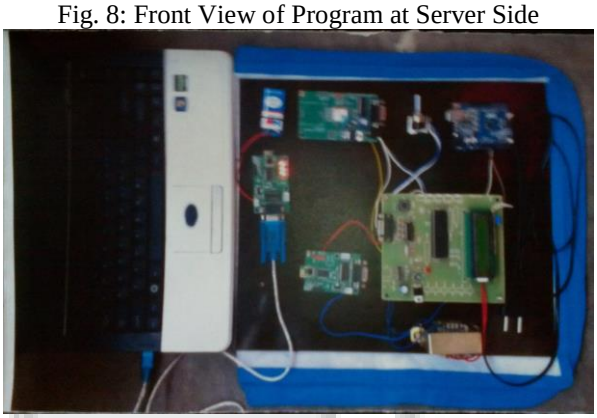

Fig. 9: Photograph of Hardware

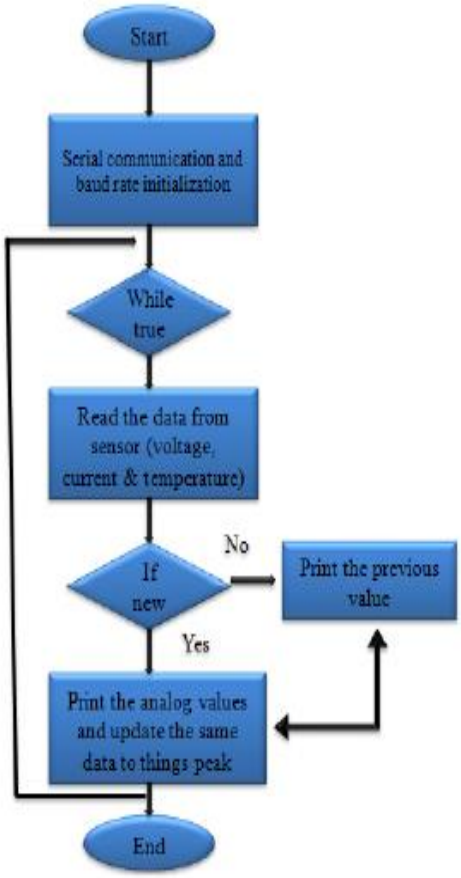

Fig. 10: Hardware

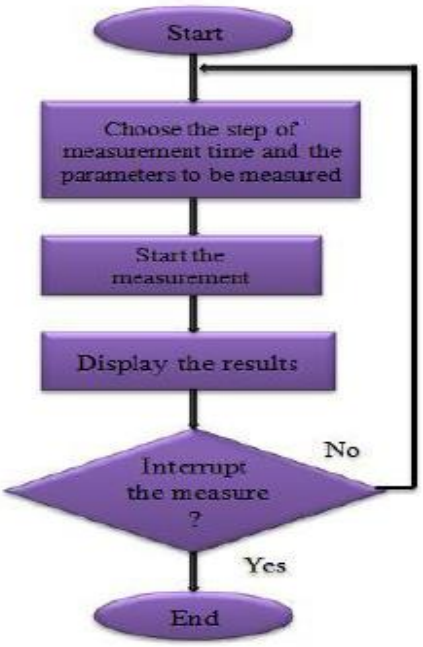

Fig. 11: LabVIEW (GUI)

XI. CONCLUSION

This paper present wireless communication based prepaid energy meter can control the usage of electricity on consumer side to avoid wastage of power. Prepaid energy meter is a concept to minimize the electricity theft with a cost efficient manner. The users are not bound to pay excesses amount of money, users have to pay according to their requirement. It can reduce problems associated with billing consumers living in isolated areas and reduce deployment of manpower for taking meter readings. Prepaid energy meter is more reliable and user friendly. From all these we can conclude that if we implement this prepaid energy meter then it can become more beneficial. We get the alert message before reach the low balance and also consumer get the periodic message about the unit and cost after the completion of a day. This is efficient and also low power consumption. In this proposed system output is clearly monitored by LabVIEW.

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