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An IOT Based Real Time Efficient Power Controlling and Monitoring

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ABSTRACT: The fossil fuels used for generation of electrical energy are depleting day by day. Many alternative and innovative ways of generating power using renewables are coming up. Renewable Energy Sources (RES) have been developed with the need of maintaining continuity of supply but has a disadvantage of uncontrollability and inconsistency. Thus there is a need of conserving the available resources and energy. This paper suggests the design and development of Internet of Things (IOT) based system which does real time monitoring and controlling of electrical power and thus indirectly result in saving energy wherever and whenever possible without being physically present at the place where the devices are installed. The system principally calculates the value of power consumed by the electrical appliance connected and sends this information to a microcontroller through a regulator unit. The design overcomes the major challenge of co-coordinating different signals with sensors and communication protocols. The innovation in the developed system is the implementation of controlling mechanism used. The developed system is adaptable and can be operated from anywhere in the world provided connecting to internet is possible. HTTP GET and POST method is used to communicate between user and server. A prototype has been developed and the controlled and monitored data will be displayed on the computer through graphic user interface (GUI) continuously.

KEYWORDS: Internet of Things (IOT), Wireless Sensor Networks (WSN), GET and POST method, Graphic User Interface (GUI)

I.INTRODUCTION

With the devise of Automation and Green Buildings wireless sensor networks (WSN) is becoming more and more ubiquitous and is proving to be very assistive in energy conservation techniques. WSN is like the eyes and ears of IOT. It connects the real world to a digital world. Thus it is a hardware communication. IOT is the brain as it can store real world data in cloud services or databases and can be used to monitor the real world parameters, making meaningful interpretation and even making decision based on sensed data. WSN have an ability to monitor and manage situational data for various intelligent services such as military, industry, environmental monitoring and healthcare [1]. WSN have transformed the design of embedded systems and stimulated a new set of potential applications [2]. An embedded system is a microcontroller-based software-driven, reliable real-time control system, autonomous or human or network interactive, operating on diverse environments, and sold into a competitive market [15]. It has three main components i.e. hardware similar to computer, embedded application software and embedded real time operating system (RTOS). The said work combines the technologies discussed above to come up with a system that ultimately helps energy conservation.

This paper focuses on user friendly technical solutions for controlling and monitoring of electrical power. Implementation method used for controlling power is novel in this work. A regulator unit which is an integration of zero crossing detector, PIC 12F675 and Traic switching unit is designed and implemented for controlling the connected device. An ARM 7 LPC2148 was given the task of switching the regulator unit on or off and controlling the conduction time of Traic so as to control the voltage supply of connected device. Also ARM 7 LPC2148 was used for communicating with LCD and SIM900A, the GSM/GPRS TTL modem, to allow remote controlling of connected device via internet. The GSM/GPRS TTL Modem is having internal TCP/IP stack to enable you to connect with internet via GPRS. It is suitable for SMS as well as DATA transfer application in M2M interface. Also to prevent the transients due to switching of load, the system has isolated both the microcontroller circuit from high power load circuit. Isolation techniques used in the project avoids use of pulse transformer but instead uses MCT2E[12] and

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MOC3023[11]. They provide best opto-isolation thus protecting the microcontrollers. The wattmeter module used in the developed system for measuring power is based on IC ADE7755. The ADE7755 supplies average active power information on the low frequency outputs on two pins namely F1 and F2 [7]. These logic outputs can be used to directly drive an electromechanical counter or interface to an MCU. The Clock Frequency logic output gives instantaneous active power information. This output is intended to be used for calibration purposes or for interfacing to an MCU. This system uses CF pin for taking the output from wattmeter to ARM 7.

The structure of the paper is as follow. In section II, the complete description of design of developed system and working of all blocks is discussed. In section III, brief description of the developed prototype is discussed. In section IV experimental results are presented and with the help of an example the flow of project is discussed. The last section IV concludes the paper with final remarks.

II. SYSTEM DESIGN AND WORKING

The designed system uses HTTP method and is divided into three parts i.e. Device Side Block, communication block and PC side Block. Figure 1 shows the block diagram of developed system for monitoring the connected device and controlling it as per the requirements of the user.

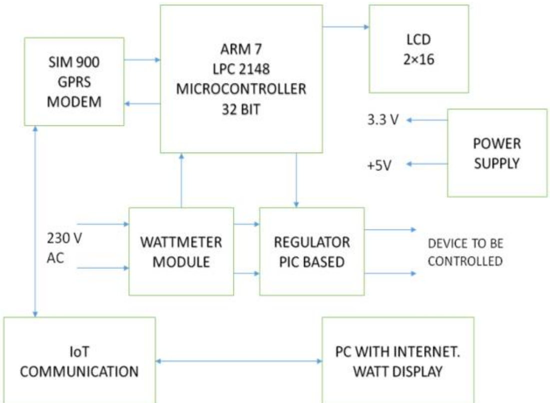

Figure 1 Functional Block Diagram of System

A. Device Side Block: This block has been designed for measurement of electrical parameters of the connected device and exchanging this information with the server via SIM900A. Two power supplies will be required for the system i.e. 5V and 3.3V and are provided on the main hardware board. 5 V will be required for the PIC and opto-couplers of regulator unit and 3.3 V will be required for the ARM 7 unit. Also 12 V, 1A will be required for SIM900A. The project uses a 12V, 1 A transformer based adapter for powering the board. The main units of this block is a PIC based Regulator which is made of three sub-blocks viz. Zero-crossing detector (ZCD), PIC 12F675 and Traic switching circuit. Figure 2 shows the circuit diagram of regulator block implemented in this system. ZCD plays a very important role in power control circuits using thyristor. If zero crossing detection is not properly done, the firing of traic using PIC cannot be materialized. The circuit designed for ZCD is simple and employs very few components like bridge rectifier IC DB107G, a transistor BC547 and an opto-coupler MCT2E. The function of this block is to generate a pulse of fixed width at zero crossing of each cycle. PIC is coded to generate an external interrupt at the falling edge of each pulse at pin 5[9]. When an interrupt is generated ZC flag is set and a pulse of any controlled width can be generated on pin 2 of PIC. After this the ZC flag is cleared. In the main code always ZC flag is checked. Figure 3 shows the flowchart for coding of PIC. The Traic is an inexpensive solution for controlling the ac power delivered to load. Traic has three terminals, MT1, MT2 and gate. During each half cycle of ac, a gate pulse is required to turn it on. PIC 12F675 pin 2 is used to drive Traic gate (BT139-800E). So in phase angle control a gate pulse is sent to the traic. This is sent at the time between one zero crossing and the next. Without gate pulse sent to traic, right after zero crossing the traic is off and no current flows through it. After certain time the gating signal is given to the traic and it turns on. The traic then stays on till the current through it becomes zero i.e. at the next zero crossing. The current through the traic when

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ON is larger than the latching and holding current of the traic and hence it stays ON once it is fired on until the current through it is zero. This means that the voltage is supplied to the load for a fraction of cycle, determined by how long the traic is on which in turn is determined by the delay time between the zero crossing and the applying of traic gating signal.

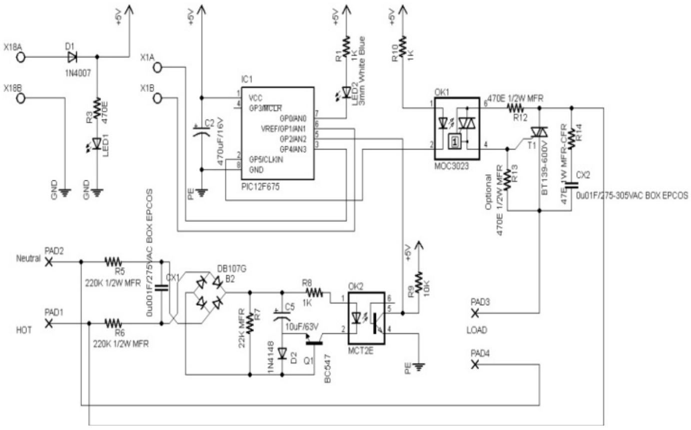

Figure 2 Implementation of Regulator Block

Arm 7 LPC 2148 [8] has to process the input from the wattmeter module and display it on the LCD i.e. the live wattage consumption of the connected device. At the same time it transmits this data to SIM900A through UART. The GPRS modem creates transmission packet for uploading this information on the server after it is initialized. Figure 4 shows the flowchart for coding of ARM7. The ARM 7 has to also monitor the response from server and perform two tasks viz. if the command is zero wattage at the server switch off the connected device and if not regulate the device to the server wattage value.

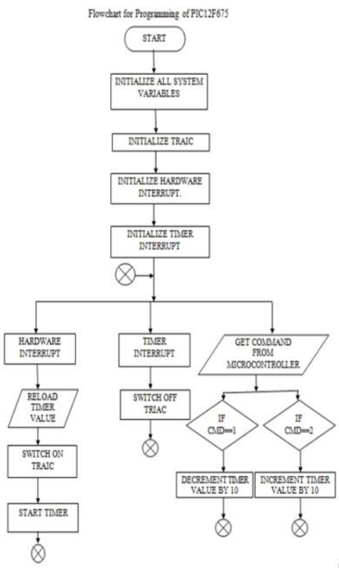

Figure 3 Flowchart for Coding of PIC12F675

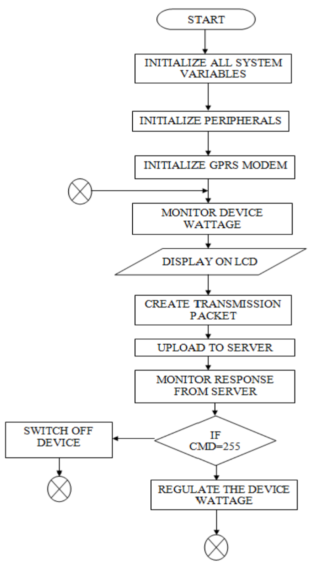

Figure 4 Flowchart for Coding of ARM 7 LPC2148

B. Communication Block: GSM/GPRS TTL-Modem used in developed system is built with SIMCOM Make SIM900A Quad-band GSM/GPRS engine. The baud rate can be configurable from 9600-115200 through AT command. Initially Modem is in auto baud mode. This GSM/GPRS TTL Modem is having internal TCP/IP stack to enable you to connect with internet via GPRS. It is suitable for SMS as well as DATA transfer application in M2M interface. This project

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uses SAPBR mode of IP applications i.e. HTTP. The Hypertext Transfer Protocol (HTTP) is designed to enable communications between clients and servers. HTTP works as a request-response protocol between a client and server. A web browser may be the client, and an application on a computer that hosts a web site may be the server. Example: A client (browser) submits an HTTP request to the server; then the server returns a response to the client. The response contains status information about the request and may also contain the requested content. Two commonly used methods for a request-response between a client and server are: GET and POST. GET - Requests data from a specified resource. POST - Submits data to be processed to a specified resource. These methods are used in the developed system. The flow diagram for the Communication block is shown in figure 5. It is clear from the flow diagram that the system works in a loop and is a feedback system.

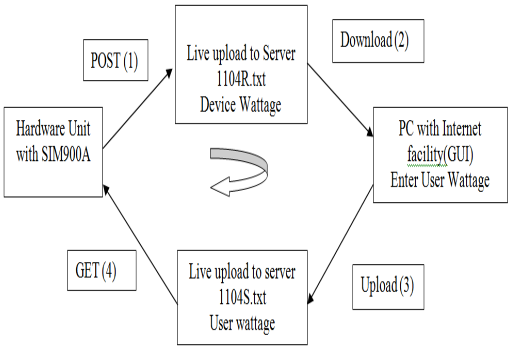

Figure 5 Flow Diagram for Communication Block

C. PC Side Block: This block only needs a PC with internet facility on it. A Graphical User Interface (GUI) was developed in Visual Basic as shown in figure 6. This GUI allows the user to monitor the device from remote location by connecting to the GPRS modem. It is possible for the user to give command from the GUI for the load to be controlled i.e. increasing or decreasing the wattage of the device connected. HTTP GET and POST method is used for communication between hardware and remotely located PC. Figure 7 shows the flowchart for coding of PC software.

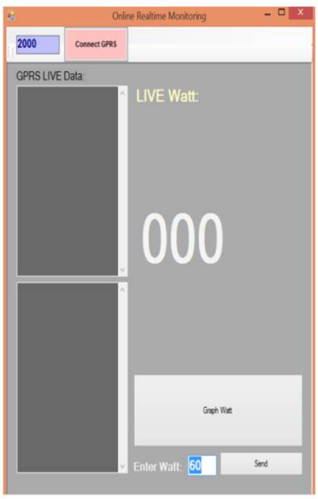

Figure 6 Graphical User Interface (GUI) for the system

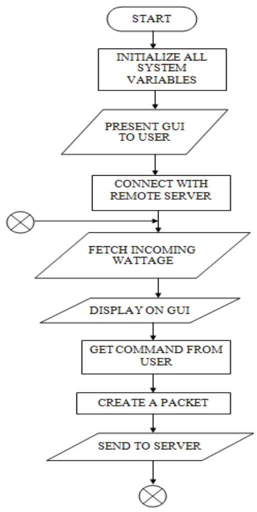

Figure 7 Flowchart for Coding of PC software

The PC side coding basically connects with the remote server while fetching the incoming wattage. It displays the live wattage on GUI and fetches the command from the user, creates its packet and transmits to the server.

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III. PROTOTYPE

An IOT and integrated MCU based real time monitoring and controlling unit has been implemented in this project. The hardware sections were tested at every step before final code was burned in the ARM 7 LPC2148. The prototype was tested for a 100 watt bulb however any device consuming less than 1200 watts can be used in the developed system. With this prototype switching OFF the device, switching it ON as well as controlling the voltage of device can be done remotely from anywhere in the world by connecting to internet once the GUI is setup on the PC. The live wattage of the connected load as well as graph of wattage of load is displayed on GUI running on computer so that appropriate action can be taken from GUI. Figure 8 shows the designed and developed prototype.

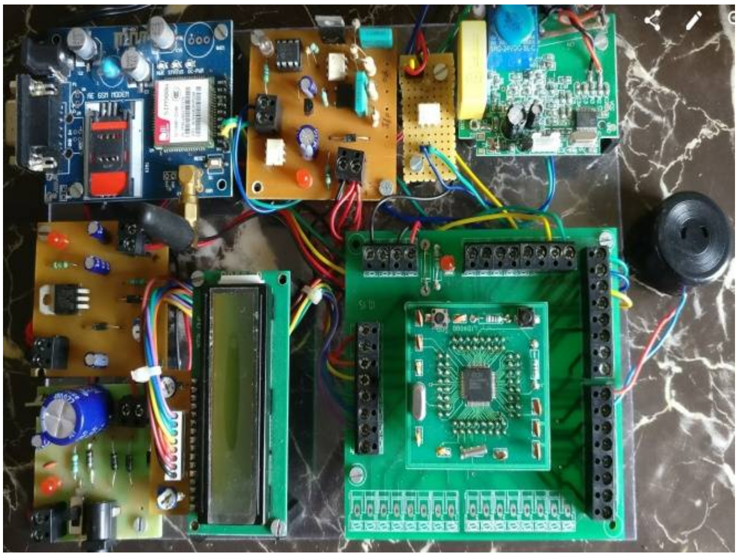

Figure 8 Designed & Developed Prototype

To understand the basic working of this block we take an example of a 100 Watt bulb as a load connected to the system Suppose the device live wattage is 93 watts. The SIM900A uploads the device wattage on a server with the help of POST command. Then the device wattage is downloaded from the server by the remote PC and displayed on the GUI window. User can refer this wattage and accordingly send a user wattage command as per his needs say 50 watts. This user wattage is uploaded on the server by the send command in GUI. Then SIM900A will fetch this wattage with the help of GET command from the server. The process of checking the difference between the user wattage and device wattage i.e. 93-50 watts is continuously going on in the code of microcontrollers and accordingly regulation process goes on till device and user wattage is same. Also there is a facility of seeing the live wattage graph on the GUI.

IV. EXPERIMENTAL RESULTS

The below figure 9 shows the prototype in operation in a trial home with 100 Watt bulb as connected device. The following devices were tested: hair dryer, battery chargers, T.V., DVD player. Any electrical appliances which consume less than 1200 watts can be tested on the developed system. Before the system is started a registered SIM is to be inserted inside the SIM cardholder of GSM/GPRS Modem and the RF antenna is to be fixed to the SMA Antenna connector and tightened it by rotating the nut. There are three LED on this module i.e. Red indicates power on, Green indicates status and Blue indicates network registration and GPRS connectivity. When the modem is powered up, the status LED will blink every second. After the Modem registers in the network (takes between 10-60 seconds), LED will blink in step of 3 seconds. At this stage you can start using Modem for your application. The on board LCD displays the user wattage and device wattage on it. Now start the GUI and click on connect GPRS window. Enter any wattage

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on which the device is to be run in enter watt window. The device wattage will change according to the given command which can be verified from the live wattage window on GUI.

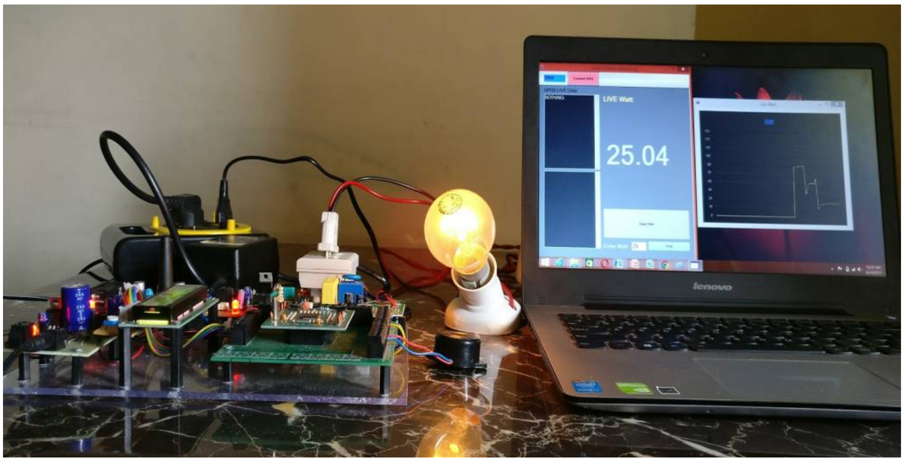

Figure 9 Prototype of Developed System with Load ON

In the above picture of working model it can be seen that the live wattage of bulb is 25.04 and the command given in GUI enter watt window is also 25 watts. Also the live wattage graph can be seen. Thus a common household appliance is controlled by integration of sensors, microcontrollers and AT commands.

V. CONCLUSION AND FUTURE SCOPE

A smart IoT based real-time power controlling and monitoring system has been designed and developed. The ability of proposed system to send data digitally to a remote PC using live data transmission through GSM/GPRS technique optimize use of energy thus making it an energy conserving system. The project is thus useful in real day to day environment. IOT is an efficient wireless protocol which is used while implementing the system. A GUI application which is developed on VB platform provides a simple way of controlling and monitoring various loads. Also the power measuring unit continuously monitors the power consumption and displays a real time graph enabling the user to detect over/under rated power consumption of the rated load. It will ultimately help the user to detect some fault in the device or load connected to the system. This system is very useful for cutting the phantom load. In future the system can be integrated with co-systems like smart home dweller behaviour recognitions systems to determine the wellness of dweller in terms of energy consumption.
The disadvantage of the developed system is its speed of communication is slow since connection to server is via GPRS. Alternately Wi-Fi connection will work better. The project is been implemented for one device controlling and monitoring at present. In future we can use the same module for multiple devices by connecting more number of regulator and wattmeter per device. By recording the graph of various devices we can find out the peak loading hours of the connected load of a particular building and redistribute the working hours of the connected devices to reduce the load during the peak hours and get tariff benefits to reduce the overall electricity bill. In future the history recording of the usage can be done and bill estimation can be added.

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