Design and Implementation of IoT based Energy Management System with Data Acquisition

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Abstract: Energy saving is one of the main challenge in our day to day life. Energy saving can be done only when the energy consumed by the load is monitored. Once the load is monitored, suitable control methods can be adopted to operate the load in the optimized way to save energy. Even though there are lot of technologies and solutions available to effectively monitor, control and save energy consumption of load in a house or an industry, the Internet of Things (IoT) technology is proposed to monitor, control and minimize energy consumption of load. The proposal is to design and develop an Internet of Things (IoT) based Energy Management System in which the data is collected from smart energy meter using GPRS network and displayed on web page. The proposed system is suitable for data collection and control the load in the Internet of Things (IoT) environment.

Keywords: IoT, GPRS, Energy Management System, Embedded system, Web server, IP

I. INTRODUCTION

In the previous decade, energy saving has been one of the basic issues in planning electronic apparatuses or gadgets. The Future is moving towards the energy administration which require changes from energy usage and energy supply. For the energy administration of household customers the smart meter is need of great importance.

The smart meters are an embedded system which is implemented with microcontroller. The main purpose of the microcontroller is to simplify the system design and provide flexibility.

Up to present, many energy monitoring and control methods have been proposed. An emerging technology brought about rapid advances in modern wireless telecommunication is Internet of Things (IoT). IoT is defined as a kind of network which is not only can connect the objects, can be fully automatic, can collect, transmit and process information intelligently but also can realize the scientific management at anytime and anywhere through a variety of sensing devices and the Internet. The basic characteristics of IoT are: networked, instrumented, automated and intelligentized.

Based on this understanding, an energy management system based on Internet of Things is developed in order to improve the energy management levels and to do a better job in energy saving. The energy management system based on IoT can solve the problems of collecting, transmitting, saving, and controlling of the massive data in energy running processes by using a variety of techniques such as smart meters, communicating networks, software, databases and so on.

Contrasted with different systems the information from remote or unattended area can be gathered effectively utilizing proposed framework. Gathered information can be seen, checked, and controlled anyplace from the world through web association utilizing IoT innovation. In this proposed configuration ARM is received as center controller, since it will examine data in parallel and continuously with fast.

After designing the proposed Energy Management system, the design were implemented and illustrated using the practical load in the IoT environment.

II. RELATED WORKS

[1] In this paper Energy control framework as a part of Residence was created utilizing remote installed equipment, home gateway, UI and Internet of Things (IoT). Smart socket has inbuilt Zigbee correspondence module used to speak with home portal. Smart socket will quantify the associated gadget parameters and send to home portal. Home portal will send the control message to socket utilizing cloud server arranged remotely. This framework works in four control modes, named as peak time control, energy control, automatic control and user control. Control modes are worked utilizing smart sockets.

In [2] Smart home apparatus control framework was produced in the IoT condition. Smart controller is the fundamental piece of this framework. Modules are associated through Zigbee interface to the controller utilizing the Radio frequency of 433MHz. Controller is associated with the Server, Personal PC or cell phone through web and remote switch by means of

Wi-Fi interface. Utilizing this framework can ready to control and screen the usage of energy by the appliances in the home.

In [6] explains now a day's system security is a noteworthy in the field of media transmission while transmitting or accepting of any information. In this paper they have depicted about the system security vulnerabilities in Supervisory Control and Data Acquisition (SCADA) framework and Energy Management System (EMS). They have broke down many issues identified with security and gave answer for making a skilled data security to SCADA and EMS utilized as a part of industry.

Energy administration and information obtaining framework were created in this paper [9] utilizing IoT condition. Here the required information is gathered from the gadgets utilizing the remote sensor systems. Gathered information can be distinguished and put away utilizing Zigbee arrangements. Put away information can be prepared Concepts of Internet of Things (IoT) are connected utilizing implanted processor. Correspondence between the processor and the server utilizes GPRS arrangement. The above framework proposed in this paper used to gather the information from the processor and send the SMS and Mail persistently to the website page.

[10] This paper explains the checking and controlling of energy in both system and customers point. Usage of the framework based on their SCADA and hardware system for estimation of utilization and load control. Energy checking and control was done utilizing Programmable Logic Controller (PLC). Advanced mobile phone or a modern PC is utilized to actualize the correspondence with clients. Utilizing this framework they have executed energy administration on household customer progressively.

III. IMPLEMENTATION

A. Hardware Architecture Introduction

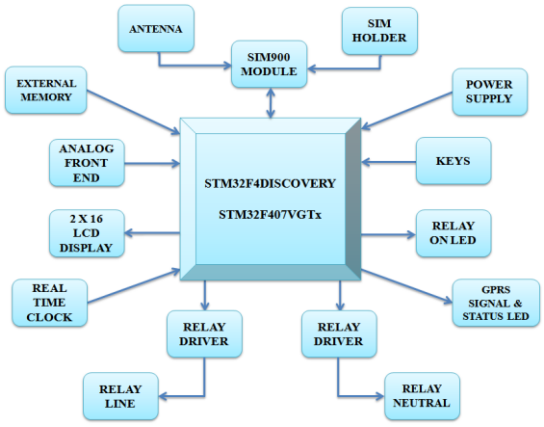

Figure 1 Hardware Architecture Block diagram

The Figure 1 shows the complete block diagram of Energy Management system hardware architecture includes hardware that consists of an ARM Cortex-M4 32b MCU, GSM/GPRS Module, Relay driver, Analog Front End Module and 2X16 Alphanumeric LCD display. The system works on 5V and 9V SMPS(Switched Mode Power Supply). Analog front end is designed with Resistor network and an op-amp for voltage section, current transformer with op-amp for current section.

The op-amp output signals are taken as 2000samples/second to process the data using true RMS measurement. Processed data will be stored in flash memory . All this processed information will be shown in terms of voltage, current, power, frequency, power factor and Energy are displayed on LCD that is interfaced with GPIO of ARM controller. The same information will be send to the monitoring station (central server) by using GSM / GPRS Module wirelessly that is interfaced with USART3 of ARM Controller as shown in Figure 2.

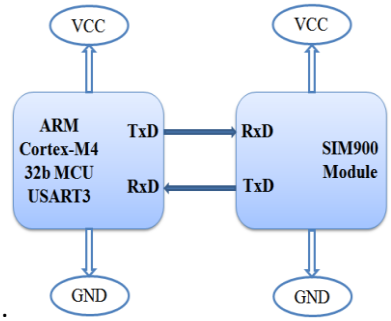

Figure 2 Interfacing Block diagram of ARM Processor and GSM/GPRS Module

B. STM32F407VGTx ARM Controller

The STM32F407VGTx controller is based on the high-performance ARM Cortex-M4 32-bit RISC core operating at a frequency of up to 168 MHz. The Cortex-M4 core features a Floating point unit (FPU) single precision which supports all ARM single precision data-processing instructions and data types. It also implements a full set of DSP instructions and a memory protection unit (MPU) which enhances application security. The STM32F407VGTx microcontroller incorporates high-speed embedded memories (Flash memory up to 1 Mbyte, up to 192 Kbytes of SRAM), up to 4 Kbytes of backup SRAM. This device offer three 12-bit ADCs, two DACs, a low-power RTC, twelve general-purpose 16-bit timers, two general-purpose 32-bit timers. Serial communication interfaces ranging from a USB 2.0 full-speed device, multiple I2Cs, SPIs, USARTs, UARTs and CANs. The device has 10/100 Ethernet MAC with dedicated DMA and 8- to 14-bit parallel camera interface. A comprehensive set of power-saving mode allows the design of low-power applications. These features make the STM32F407VGTx microcontroller suitable for a wide range of applications such as Industrial control, Medical systems and Home automation, etc,.

C. Relay Driver

The BL8023, as a bi-direction relay driver circuit. The device is used to control magnetic latching relays. It has a large output capability and ultra low power consumption and it can be widely used in intelligent electro-meter and other related field.

D. Wireless transceiver

The SIM900 is a complete Quad-band GSM/GPRS solution in a SMT module which is embedded in the proposed system application. It is an industry-standard interface, the SIM900 delivers GSM/GPRS 850/900/1800/1900MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. SIM900 is designed with a very powerful single-chip processor integrating AMR926EJ-S core. It has an embedded Powerful TCP/IP protocol stack. Module Control is done using a AT commands (GSM 07.07, 07.05 and SIMCOM enhanced AT Commands).

E. Software Architecture Introduction

In this proposed system IAR Embedded Workbench IDE, STM32CubeMX, OrCAD, .Net Frame work and MySQL Database are the software's used to implement the system.

1) STM32CubeMx:

Hardware configuration and driver codes are generated using this software for proposed system Shown in Figure 3.

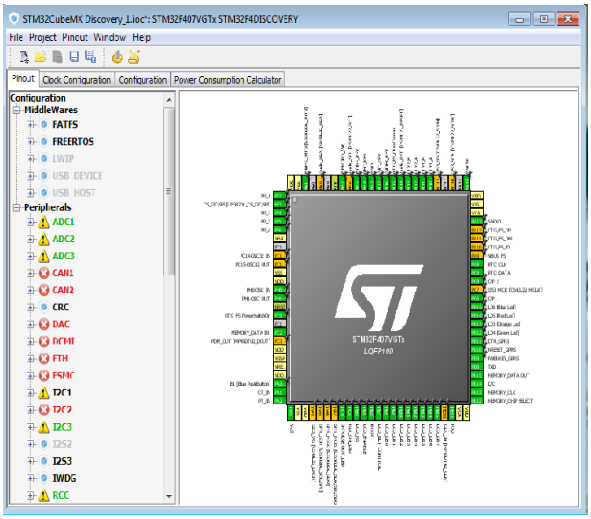

Figure 3 STM32CubeMx Software

2) IAR Embedded Workbench IDE (Version 7.0):

User application codes in Embedded C are written using this software for proposed system. Using this workbench compiling, downloading and debugging are done here Shown in Figure 4.

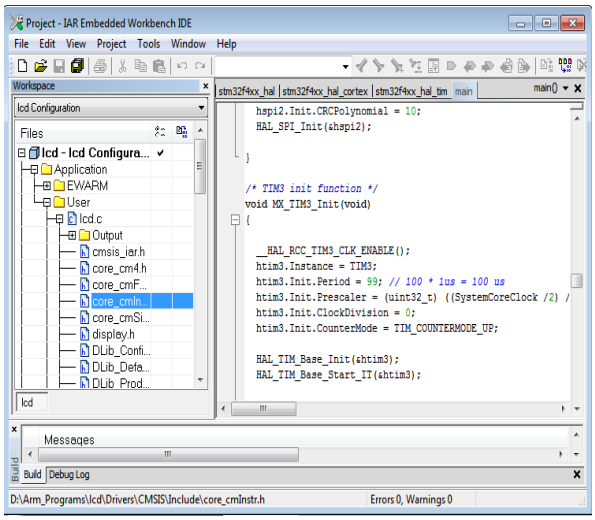

Fig. 4. IAR Embedded Workbench IDE

3) Cadence OrCAD PCB Designer Version 16.5

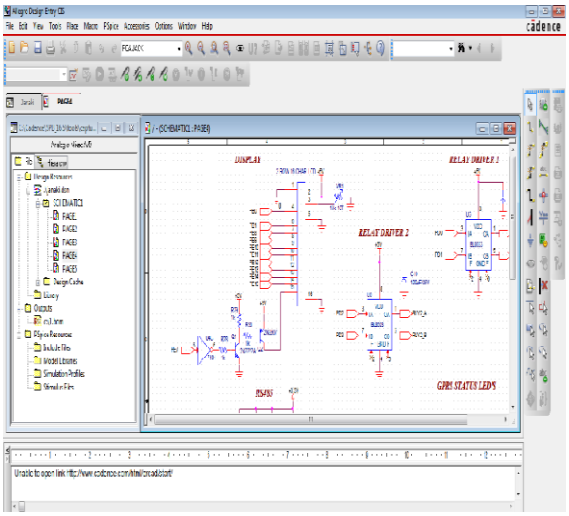

Figure 5 OrCAD Capture CIS 16.5 Software

Proposed system Schematic layout was done using this software shown in Figure 5. After completing the layout artwork on PCB (Printed Circuit Board). Started mounting the components on PCB.

4).NET Frame Work:

.NET Framework is a software framework developed by Microsoft that runs primarily on Microsoft Windows. .NET Framework led to a family of .NET platforms targeting mobile computing, embedded devices, alternative operating systems and browser plugins. Proposed system web application screens are developed by .NET Code using Microsoft Visual Studio software shown in Figure 6.

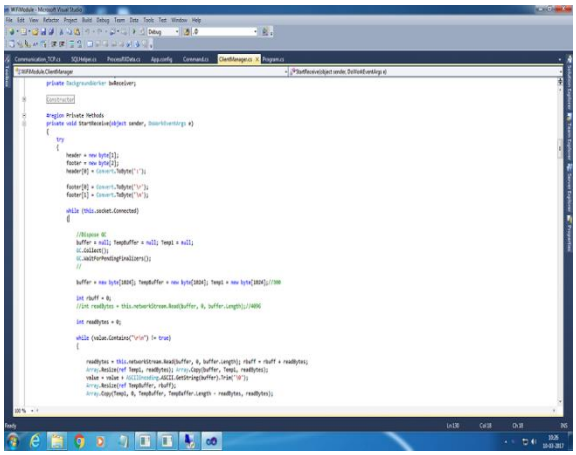

Figure 6 Microsoft Visual Studio Software

5) MySQL Database

MySQL is an open source relational database management system (RDBMS). The MySQL development project has made its source code available under the terms of the GNU General Public License, as well as under a variety of proprietary agreements. Received data from the proposed system is stored using MySQL Database.

IV. Algorithm For Proposed System

A) Algorithm

- ✓ Apply Power to the system
- ✓ Initialize all the peripherals
- ✓ Display the Starting Message and after delay show default page
- ✓ The Voltage (240V Max) and Current (10A Max) Signals are Converted to Low voltage signals by analog front end and fed to Inbuilt ADC of ARM
- ✓ The signals are sampled at every 500 µs interval and digitized
- ✓ The digitized samples are used to calculate RMS Voltage, Current, Power and Energy Parameters
- ✓ The Computed Parameters are Shown on Display one by one in Scroll mode
- ✓ The Computed parameters are transferred to the Static IP through GPRS Module at every 5 Minute Interval
- ✓ The transmitted data's are stored and hosted in a web page for remote monitoring of the load
- ✓ The load can be controlled through web page by switching ON/OFF the relay in the Meter Board

V. Application in Energy Management System

Figure 7 shown the complete IoT based Energy Management system hardware Physical setup.

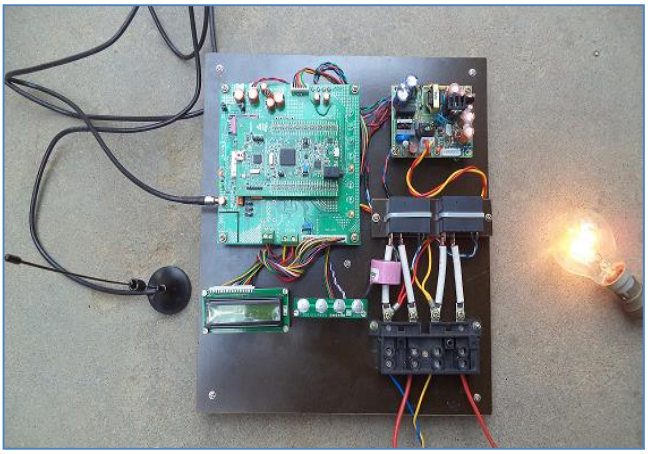

Figure 7 IoT based Energy Management system hardware Physical setup

Web Enabled IoT based Energy Management System Software consists of two modules,

- ✓ Port Listener
- ✓ Web Server

Port Listener Module collects the data through static IP with a particular port number and stores them in SQL database. Figure 8 shows the data viewed by port listener.

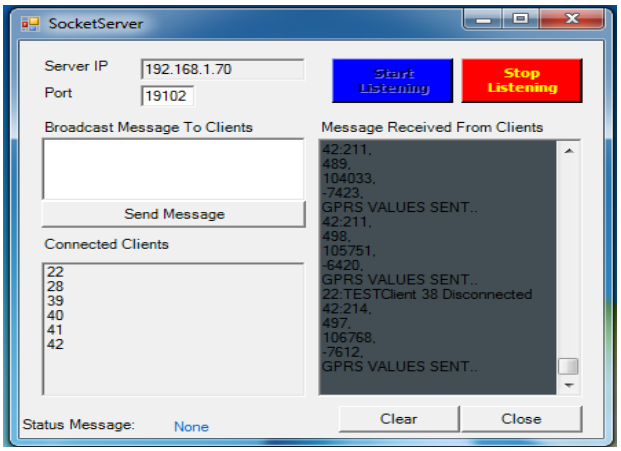

Figure 8 Data viewed by port listener

Web Server Module hosts the stored data as web pages through the same static IP but with a different port number. Figure 9 Shows the data viewed in web page. Stored data can be viewed using the web page by static IP and port number anywhere from the world. By using these application we can continuously monitor and control the system load using load ON/OFF button.

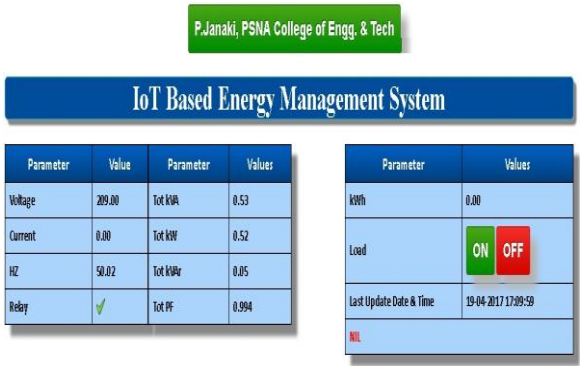

Figure 9 Data viewed in web page

VI. CONCLUTION AND FUTURE WORK

This paper describes an IoT based energy management system and data collection system to display on webpage using GPRS. IoT is the core concept of this Energy Management System project. Smart meter, GPRS communication network, web based software, database and other related technologies are used in this work. The proposed system is developed and tested using practical load with IoT environment. Implementation of IoT based energy management system plays an important role in the scheduling, monitoring, controlling, optimization of enterprise energy, and improving organization / labor productivity. It has the advantage of low power consumption and make it easy to implement with high speed. The future work is based on the proposed system is multimode with Wi-Fi interface connectivity and the collected data's will be send to the common mode with GPRS module that will be connected with remote server for monitor and control the whole network of the system.

Also this technique can be used for the following applications

- All commercial undertakings like malls
- Power utilities / power distribution companies and substations
- Billing of the actual users in quarters or tenants in a big commercial complex
- Small scale industries – manufacturing or otherwise
- Medium and large manufacturing industries
- Educational institutions of any kind
- In general any electrical consumer who has serious concern on the soaring cost of power

VII. ACKNOWLEDGEMENT

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