Design and Implementation of Real-Time Smart Meter With Embedded Web Server Capability

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Abstract—*Recent years have witnessed steady increase in the demand of energy. Saving Energy now is very much required now for our future generation. To reduce energy consumption of the machineries used in any industry, Real-Time Smart Meter with Embedded Web Server Capability plays a key role. This paper, presents how to measure and record the energy consumption and temperature acquired by individual machinery used in an industry. Using Controller Area Network (CAN), the power consumption and temperature are monitored and send through ZigBee to remote Ethernet web server. By accessing the web server via LAN we can see the data of temperature and consumption. It also displays the power consumption and temperature at local in a liquid crystal display. Thus we can monitor the temperature and power consumption from both locally and remotely in an industry. With the help of this devise, the particular machine will automatically cut OFF based on high temperature conditions and will automatically run when the machine will reach low temperature as set. Once we have learned about the consumption of all the electrical items we will be well equipped with the knowledge of saving energy thus reducing our electricity bill.*

Keywords—, Microcontroller, Temperature, Zigbee, Energy consumption, Controller Area Network (CAN)

I. INTRODUCTION

For reducing the manual work in an industry industrial automation technology is used with the help of latest microcontrollers. These type of technologies will solve the erratic reading and providing more accuracy also real-time. It enables both user friendly and improving public sector efficiency and management level. Existing traditional (wire line) meter reading system has a large no of risks. Wires are more complex detrimental to adjust and maintenance of the system. If long term indoor and outdoor installation of equipment will leads to aging, resulting short circuit or physical damage will occur. Due to these reasons most of the industries are use automatically recording of measuring parameters. In order to solve this problems, we are going to automatically recording the data and also user can monitor the machine conditions at anywhere in the industry. In this paper, it will describes that the measurement of energy consumption and at what temperature, the machines will run. It can be done for each and every machines equipped in an industry. The data will sent to Ethernet web server through ZigBee. Consumers with this information can check the measured data of individual machines, both remotely using a web server and locally using LCD (Liquid crystal display), to directly control and handle it.. If the machine will run at high temperature conditions, the machine will automatically cut OFF. After few minutes the machine will reach low temperature and start to run. It is designed with long term reliance and convenient installation and maintenance. The paper is organized as follows: in Section II the related work, are investigated and studied for mitigation of Wireless networks. Section III is devoted to system architecture. In section IV we show the software implementation of system. The demonstration of the system is described in section V followed by some concluding remarks in section VI

II. RELATED WORK

In this section, we briefly discuss the existing system about Energy consumption DAQ system for Industries based on wireless communication technology. ChangsuSuh et al [1] proposed intelligent home control system divides and assigns different task to various components in home network. With the support of active sensor networks having both sensor and actuator components it can integrate diversified physical sensing information and control various consumer home devices. For improve the performance of active sensor networks A new routing protocol is developed LQIR (Link Quality Indicator based Routing). This paper introduces a new technology for home control system to provide intelligent services for users.

Chih-Hung Wu et al [2] proposed a wireless ARM-based automatic meter reading and control system (WAMRCS) for distribution automation. The WAMRCS is designed based on a 32-bit ARM microprocessor to deal with power data processing and relay control. In order to provide a cost-effective, wireless, always-connected, two-way data link between utility company and WAMRCS, the WAMRCS sends information of utility usage, power quality and outage alarm to utility company via GPRS network. Compared with analog utility meter reading by manpower, WAMRCS is more accurate, reliable, cost-effective, quick and free from man-made errors. It can provide extra capabilities such as distribution automation, load management and time-of-use rate.

C.Landi et al [3] proposed advanced energy/power meter based on ARM microcontroller for smart grid applications for electricity delivery system which monitors, protects and optimizes the operation of its interconnected elements from end to end. They include central and distributed renewable energy generators through the electrical network. Thus, it can easily be argued that they are characterized by great issues to manage the whole system and to assuring a proper energy quality. In this scenario the possibility to have advanced power/energy meter with energy quality monitoring and communication capabilities is of great

interest. So, in this paper the design and implementation of a wattmeter for single phase electrical systems based on an ARM microcontroller is presented. The wattmeter is composed of measurement transducers (for voltage and current), conditioning, acquisition, processing and communication sections; the last three are embedded in the microcontroller. Other than typical wattmeter tasks, the system is capable to measure some power quality parameters. Moreover communication is performed through an USB based transfer block to a Host Pc, through which it can be configured. Even if it is designed to respect on-line measurement constraint, it remains a low cost system.

D.Gallo et al [4] proposed a Multifunction DSP based real time power quality analyzer to meet high-performance real time power quality measuring instrument based on Digital signal processor (DSP) is discussed. It also continues with the presentation of power quality analyzer software design in terms of measurement accuracy and speed of execution.

J. Han et al [5] proposed more efficient home energy management system to reduce power consumption in home area with an IR remote control of a home device. The room has automatic standby power cut-off outlets, a light, and a ZigBee hub. The ZigBee hub has an IR code learning function and educates the IR remote control signal of a home device connected to the power outlet. Then the power outlets and the light in the room can be controlled with an IR remote control. A typical automatic standby power cut-off outlet has a waiting time before cutting off the electric power. It consumes standby power during that time. To eliminate the waiting time, we turn off the home device and the power outlet simultaneously with an IR remote control through the ZigBee hub. This method actively reduces the standby power. The proposed HEMS provides easy way to add, delete, and move home devices to other power outlets. When a home device is moved to the different outlet, the energy information of the home device is kept consistently and seamlessly regardless of location change. The proposed architecture gives more efficient energy-saving HEMS.

III. EXISTING SYSTEM

A. Java Based Automation System for Automatic Meter Reading

Java based home automation system. All the devices are physically connected to an embedded board. For remote access to the system a personal computer with web server is provided. Java Technology which provides built in network security features. But this type of system needs very expensive wired installation and high level PC.

B. Bluetooth Based Automation System for Meter Reading and Controlling Devices

In this technology a primary controller and a number of Bluetooth sub-controllers are used. Each device in home is physically connected to a local Bluetooth sub-controlling device. Through wired communication home devices communicate with their respective sub-controller. By wireless communication data will send from the sub-controller to the primary controller. In this system each devices in home have a dedicated Bluetooth module. In this type of architecture reduce the wired installation. Disadvantage of this system is sharing of a single Bluetooth module between numerous devices causes an access delay

IV. SYSTEM ARCHITECTURE

A. Overview of the Proposed System

The overall system consist two main section Data collection unit and Ethernet web server section. These two section are linked via zigbee communication protocol. In data collecting unit consists of two or more collection unit. Data from these units will send through zigbee via CAN protocol. Main use of CAN protocol is to reduce the wired connection and for reliable data transmission. Data collecting unit will measure two parameters power consumption of load and current temperature. Disk type watt-hour meter is used for acquiring the power consumption and LM35 is used for temperature measurement. These two information will send to the microcontrollers analog port and processing will done. There will be relay which is used to automatically cut OFF the input power supply at high temperature conditions and will run after the machines reach low temperature. These information will send by the gateway unit to the Ethernet web server which save all the information from the data collecting unit and transfer to the PC which will monitored by the client.

B. Data Collecting Unit

Data collecting unit contain a PIC microcontroller, energy meter count sensor, CAN transceiver, Temperature sensor and LCD display for local view. Energy meter count sensor will trigger for each rotation of the disc, when rotation =768 it will be equal to one unit according BOTU(board of trade unit). At the same time temperature sensor will read the temperature value, both these parameters will send to the analog input of PIC microcontroller after the analog to digital conversion data will send through CAN TX pin to the CAN transceiver for that MCP2551 IC is used. For each and every data collecting unit is having the CAN transceiver IC and data will send from MCP2551 to the zigbee via CAN L and CAN H. The LCD display is used to display the count and temperature in locally.

C. Ethernet Web Server Section

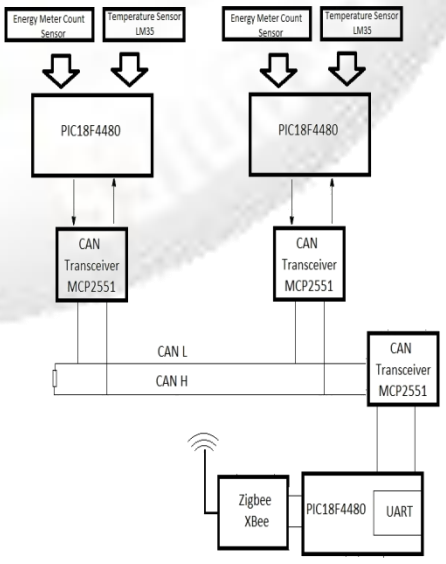

Fig. 1: Data collecting unit of the System

In Ethernet web server section using Zigbee data from the data collecting unit will receive and process by microcontroller PIC18F6722,then Processed data will be send to Ethernet controller ENC28J60 from that both parameters will fed to the PC via RJ45 connector

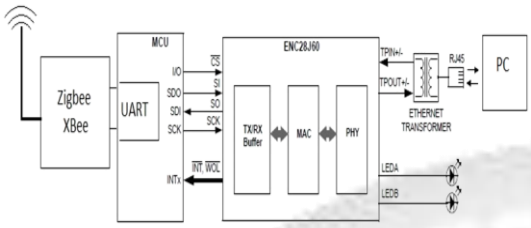

Fig. 2: Ethernet web server Section

D. UART

UART consists of three main blocks.

- Transmit shift register
- Receive shift register
- Status register

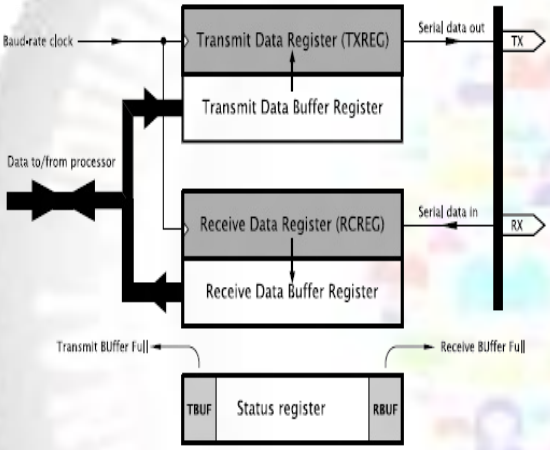

Fig. 3: Basic structure of a UART

The basic structure of a UART is shown in Fig. Any given UART circuit will have three core sections. A Transmit shift register will serialize a datum with appended Start and Stop bits to be shuffled out via a TX pin. Associated with TXREG is a Buffer register holding data for onward transmission. A Status register will hold a flag (TBUF in our diagram) indicating when this buffer is free for more data. The Receive shift register strips the Start and Stop bits off an incoming frame at a RX pin, transferring the parallelized datum when complete into one or more Buffer registers. At the same time, a flag (RBUF in our case) will be set to allow the software to determine that a new datum is ready for collection. This needs to be read before the next frame has been assembled, otherwise an overrun condition will occur and data will be lost. The transmission and reception of a frame is not locked in step; that is, they can overlap, but the baud rates are usually the same

E. Microcontroller

A microcontroller is a small integrated single chip computer that contains a processor core, memory and programmable in/out peripherals. Program memory is included in the form of OTP ROM or NOR flash. And also contain small amount of RAM. Microcontrollers are designed for embedded applications such as implantable medical devices, office machines automobile engine control systems, remote controls, power tools and other embedded systems. Microcontroller will reduce the cost of production because of the inbuilt memory I/O etc. So it can able to control more than one devices and process with minimum amount of time. To integrate analog components for controlling non-digital electronic systems mixed signal microcontrollers are used. Some microcontrollers operate at clock rate frequencies as low as 4 kHz and use 4-bit words for low power consumption here the microcontroller is used for activating and controlling various elements of the automatic distribution system. Two types of microcontrollers are used here PIC18F6722 and PIC18F4480.PIC18F6722 is used in the transmitting section. That means for collecting the power consumption and current temperature reading will be fed to this microcontroller from there it will transmitted to the receiver side through Zigbee.

F. CAN Interface

The Controller Area Network (CAN) is a serial bus communications protocol developed by Bosch in the early 1980s.In the early days of the automotive industry, various actuators and electromechanical subsystems are controlled by localized stand-alone controllers. By using CAN protocol networking of electronics in vehicle is more feasible .So from a central point ECU (engine control unit) can control all process. This will help the modularity, increasing functionality and troubleshooting more efficient. In early days CAN development was mainly used for vehicle industry, but now days CAN implemented in almost areas such as medical application, industrial automation, building automation and production machinery. CAN offers a more efficient simple, reliable, and high performance communication protocol between actuators, sensors, controllers, and other nodes in real-time applications. CAN is bus topology based communication protocol, and only two wires are needed for communication over a CAN bus. Only one device can able to send or receive the data because of the multi-master structure, and all other devices will be in listening state. If more than one devices attempt to send data at a time, the higher priority devices is selected to send its data and other devices will be receiving mode.

G. ZigBee Technology

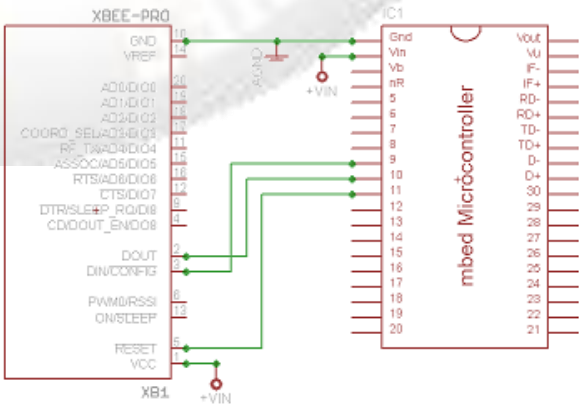

Fig. 4: Interfacing ZigBee with PIC Microcontroller

ZigBee technology is a bi-directional wireless communication technology of low power, low cost and low complexity of wireless communication technology. It is used in the application of home automation, Building automation, industrial control and industrial areas of logistics. It is responsible for receiving and transferring data. Here we are using XBee module from digi cellular productions. For providing cost-effective wireless connectivity to devices in ZigBee mesh networks, XBee and XBee-PRO ZB ZigBee modules are used It is selected around the world as the energy management and efficiency technology of choice in terms of reliably and timing.

H. Ethernet Controller

The ENC28J60 is a stand-alone Ethernet controller with an industry standard Serial Peripheral Interface (SPI™). It is designed to serve as an Ethernet network interface for any controller equipped with SPI. The ENC28J60 meets all of the IEEE 802.3 specifications. It incorporates a number of packet filtering schemes to limit incoming packets. It also provides an internal DMA module for fast data throughput and hardware assisted IP checksum calculations. Communication with the host controller is implemented via two interrupt pins and the SPI, with data rates of up to 10 Mb/s. Two dedicated pins are used for LED link and network activity. With the ENC28J60, two pulse transformers and a few passive components are all that is required to connect a microcontroller to a 10Mbps Ethernet network

V. SOFTWARE DESIGN IMPLEMENTATION

A. TCP/IP Implementation

Different collection of modules is available in our stack, such as IP, TCP, UDP and ICMP. When a corresponding packet is received some modules must be called if an application utilize the stack, certain steps will perform to ensure that the modules are called at the appropriate times. This purpose of managing stack modules remains the same. The special application layer module "StackTask", or the Stack Manager is used in TCP/IP Stack, to protect the main application from the burden of managing the individual modules. This module is implemented by the source file "StackTsk.c". It is implemented as a cooperative task; during given processing time, "StackTask.c" polls the MAC layer for valid data packets. When one data packet is received, packet will decodes and routes it to the appropriate module for further processing

B. Web Server

This module is an IP enabled device. If a public IP provided to this module it can easily accessed through the internet. Here an eight bit microcontroller is used, so it would not able to servemore number of request from the public domain. Also any intruder want to break the system, they will make more number of request to this module. So the module cannot handle the requests machine, the essence of a Web server is inevitable.

C. EXPERIMENTAL DEMONSTRATION

The system is designed to monitor and control the energy consumption and temperature reading of all machines in industries. For reading the energy consumption, disc type watt-hour meter is used; for temperature acquisition LM35 is used. A small hole will be made in the disk of energy meter. Two sensors will be placed on the both side of the disk so that each rotation sensor will trigger like one and zero condition. And if the sensor produce one, that will be equal to one rotation. LM 35 is used for temperature measurement for each 1^0 equal to 10mV. For our demonstration purpose we will use a60W bulb as load to examine our system. Both the sensor output are connected to PIC 18F4480 Microcontroller. These values are displayed in 2*16 Liquid crystal display using PIC18F4480 Microcontroller. This information can be transmitted to the Ethernet controller ENC28J60 of Ethernet web server section through ZigBee by using CAN protocol. In PIC18F series is having inbuilt CAN controller so additional CAN transceiver MCP2551 is used for communication. Two data collecting units are used here so these two units are connected to another PIC18F series via CAN L and CAN H. From this PIC microcontroller by using Zigbee data is transferred to the Ethernet web server section. UART protocol is used for the communication between the Zigbee and PIC.

Fig. 5: Screenshot of result

In web server. Through Zigbee data will be received and it will send to the PIC18F6722 for processing. After that data will be sent to the Ethernet controller ENC28J60.The energy consumption and temperature readings of every machine can

be seen in web page of PC which is connected to Ethernet controller via LAN. Based on temperature conditions, the switch will be opened automatically to cut OFF the input power supply of machines.

VI. CONCLUSION

In this paper we develop the Real time smart meter with embedded web server capability to monitor and to control the various equipment running in an industry. It is designed on the basis of low power consumption, high performance. Various protocols like low power Zigbee protocol, CAN protocol and Ethernet protocols are used in this design. For automatic reading and processing the data Zigbee technology is used, which uses wireless communication and computer network technologies for these operations. This design will save human work and also improve the speed and accuracy of energy consumption and temperature readings. Moreover no cabling is required with relatively economical investment. For the Real-Time Smart Meter with Embedded Web Server Capability will offer better scalability compared to a wired system. Based on temperature conditions the machine will automatically shut down and will run when the temperature will reach the below threshold

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