Design and Implementation of Intelligent Energy Distribution Management with Mesh Topology

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Abstract

Traditional meter reading for electricity consumption and billing is done by human operator from houses to houses and building to building. This requires huge number of Lab our operators and long working hour to achieve complete area data reading and billing. Human operator billing or prone to reading error as sometime the houses electric power meter is place in a location where it is not easily accessible. The concept of dynamic assignment of priorities to interrupts is discussed which reduces the time delay for a lower priority task which under some circumstances becomes a higher priority task. Slicing of interrupt timings is also discussed which can be used to improve the performance. The highest priority task is serviced more number of times and with lesser time period. Hence it need not wait for the slack time of other previously higher priority interrupts. If power will be less in grid, automatically power will be manage.Automated metering is expected to facilitate the transport of meter readings from meters to the utility provider and potentially information in the other direction. This paper describes a mesh networking solution based on Routing Protocol for Low power and Lossy networks to realize Automated Metering Infrastructure (AMI) network communication. It consists of self-organizing algorithms to enable energy meters to automatically discover connectivity and recover from the loss of connectivity. The development of automatic metering system is presented in this paper .The power management system consists of Zigbee Digital Power meters installed in every consumer unit and an Electricity e-Billing system at the energy provider side. The Zigbee Digital Power meter (ZPM) is a single phase digital kWh power meter with embedded Zigbee modem which utilize the Wireless sensor network to send its power usage reading using information back to the energy provider wirelessly. At the power provider side an e-billing system is used to manage a received zigbee meter reading, compute the billing cost, update the database, and to publish billing notification to its respective consumer through wireless.

I. INTRODUCTION

The power management system consists of Zigbee Digital Power meters installed in every consumer unit and an Electricity e-Billing system at the energy provider side. The Zigbee Digital Powe147fwv 8 meter (ZPM) is a single phase digital kWh power meter with embedded Zigbee modem which utilize the Wireless sensor network to send its power usage reading using information back to the energy provider wirelessly. At the power provider side an e-billing system is used to manage a received zigbee meter reading, compute the billing cost, update the database, and to publish billing notification to its respective consumer through wireless.

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The highest priority task is serviced more number of times and with lesser time period. Hence it need not wait for the slack time of other previously higher priority interrupts. If power will be less in grid, automatically power will be managed.

The AC voltage, typically 220V rms, is connected to a transformer, which steps that ac voltage down to the level of the desired DC output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.

A regulator circuit removes the ripples and also remains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. Peak shaving was realized by load adjustment of devices with soft schedules. Devices with hard deadlines did not participate in the demand response. Schedulable appliances' requests were altered by systematically switching them off and on.

From the TOU probability distribution, each appliance in a cluster is automatically assigned a schedule. Considering that each time zone has been allocated a limited amount of energy and the energy prices are updated hourly, these schedules are continually altered so as to minimize. To reduce customer frustration, the schedulable loads have been designed such that after two consecutive interruptions, they are assigned maximum priorities. Therefore they will be allowed to run first in the subsequent periods.

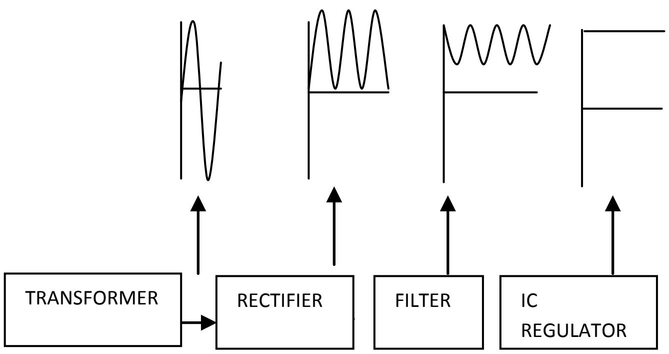

Fig 1.Block Diagram of Power Supply

II. ENERGY DISTRIBUTION

The potential transformer will step down the power supply voltage (0-230V) to (0-6V) level. Then the secondary of the potential transformer will be connected to the precision rectifier, which is constructed with the help of op–amp. The advantages of using precision rectifier are it will give peak voltage output as DC, rest of the circuits will give only RMS output.

A transformer is a device that transfers electrical energy from one circuit to another through inductively coupled conductors—the transformer's coils. A varying current in the first or primary winding creates a varying magnetic flux in the transformer's core and thus a varying magnetic field through the *secondary* winding. This varying magnetic field induces a varying electromotive force (EMF) or "voltage" in the secondary winding. This effect is called mutual induction.

If a load is connected to the secondary, an electric current will flow in the secondary winding and electrical energy will be transferred from the primary circuit through the transformer to the load. In an ideal transformer, the induced voltage in the secondary winding (V_s) is in proportion to the primary voltage (V_p), and is given by the ratio of the number of turns in the secondary (N_s) to the number of turns in the primary (N_p) as follows:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

Transformers range in size from a thumbnail-sized coupling transformer hidden inside a stage microphone to huge units weighing hundreds of tons used to interconnect portions of power grids. All operate with the same basic principles, although the range of designs is wide. While new technologies have eliminated the need for transformers in some electronic circuits, transformers are still found in nearly all electronic devices designed for household ("mains") voltage. Transformers are essential for high voltage power transmission, which makes long distance transmission economically practical.

The transformer is based on two principles: first, that an electric current can produce a magnetic field (electromagnetism), and, second that a changing magnetic field within a coil of wire induces a voltage across the ends of the coil (electromagnetic induction). Changing the current in the primary coil changes the magnetic flux that is developed. The changing magnetic flux induces a voltage in the secondary coil.

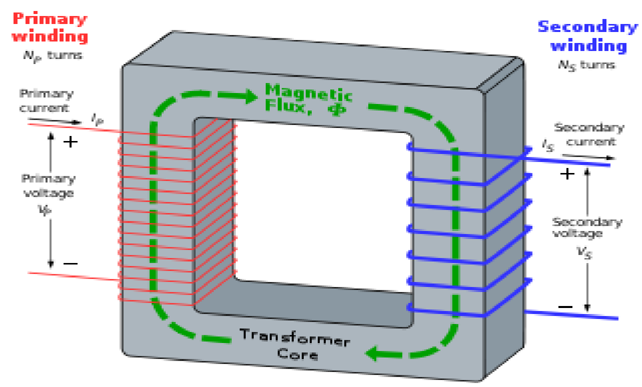

Fig .2. Transformer

A. Bridge Rectifier

When four diodes are connected as shown in figure, the circuit is called as bridge rectifier.
The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners.

Assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point B. the positive potential at point A will forward bias D3 and reverse bias D4.

The negative potential at point B will forward bias D1 and reverse D2. At this time D3 and D1 are forward biased and will allow current flow to pass through them; D4 and D2 are reverse biased and will block current flow.The path for current flow is from point B through D1, up through RL, through D3, through the secondary of the transformer back to point B. This path is indicated by the solid arrows.

One-half cycle later the polarity across the secondary of the transformer reverse, forward biasing D2 and D4 and reverse biasing D1 and D3. Current flow will now be from point A through D4, up through RL, through D2, through the secondary of T1, and back to point A. This path is indicated by the broken arrows. Waveforms (3) and (4) can be observed across D2 and D4. The current flow through RL is always in the same direction.

One advantage of a bridge rectifier over a conventional full-wave rectifier is that with a given transformer the bridge rectifier produces a voltage output that is nearly twice that of the conventional full-wave circuit.

The peak voltage developed between points X and y is 1000 volts in both circuits. In the conventional full-wave circuit shown—in view A, the peak voltage from the center tap to either X or Y is 500 volts.

Since only one diode can conduct at any instant, the maximum voltage that can be rectified at any instant is 500 volts.

The maximum voltage that appears across the load resistor is nearly-but never exceeds-500 v0lts, as result of the small voltage drop across the diode.

In the bridge rectifier shown in view B, the maximum voltage that can be rectified is the full secondary voltage, which is 1000 volts.

Therefore, the peak output voltage across the load resistor is nearly 1000 volts. With both circuits using the same transformer, the bridge rectifier circuit produces a higher output voltage than the conventional full-wave rectifier circuit.

B. Voltage Regulators

Itcomprises a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC.

IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustable set voltage. The regulators can be selected for operation with load currents from hundreds of milli amperes to tens of amperes, corresponding to power ratings from milli watts to tens of watts.

A fixed three-terminal voltage regulator has an unregulated dc input voltage, Vi, applied to one input terminal, a regulated dc output voltage, Vo, from a second terminal, with the third terminal connected to ground.

The series 78 regulators provide fixed positive regulated voltages from 5 to 24 volts. Similarly, the series 79 regulators provide fixed negative regulated voltages from 5 to 24 volts.

III. COMMUNICATION USING MESH TOPOLOGY

Microchip, the second largest 8-bit microcontroller is the manufacturer of the PIC microcontroller and a number of other embedded control solutions.

PIC microcontrollers have a data memory bus of 8-bit and a program memory bus of 12, 14 or 16 bit length depending on the family.

All PIC microcontrollers have a mix of different on-chip peripherals like A/D converters, Comparators, weak pull-ups, PWM modules, UARTs, Timers, SPI, I2C, USB, LCD.

The assembler for PICs is known as MPASM and it comes with MPLAB. The MPLAB integrated development environment (IDE) is a free, integrated toolset for the development of embedded applications employing Microchip's PIC micro and dsPIC microcontrollers. MPLAB also has a simulator for PIC microcontrollers known as MPSIM.

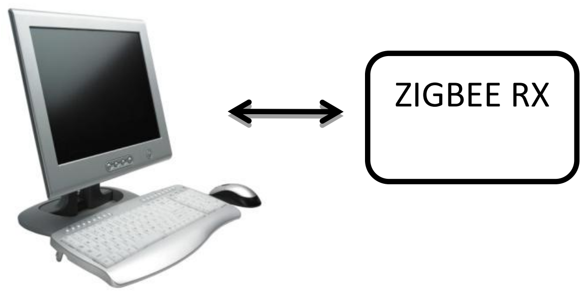

Fig 3.EB section

The JDM programmer draws power from the serial port and most serial ports are not designed for such a task. There are some versions of the JDM programmer which use an external supply. So, if someone wants to build a JDM programmer he should look for versions with an external power supply.

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MPLAB also has a simulator for PIC microcontrollers known as MPSIM. Check Microchip's website for the latest version of MPLAB. MPLAB will assemble your code into a ".HEX" file.

Then next step is copying the contents of the ".HEX" file to the program memory of your PIC microcontroller. If you are using a David Tait programmer then either Nigel Goodwin's WinPicProg or ICProg will work.

If you are using the JDM programmer ICProg will be your first choice. For those of you who want to develop codes in C there are a number of compilers available for PIC microcontrollers.

Microchip has only made a compiler for the 18-series of PIC microcontrollers and another one for dsPIC microcontrollers.

There is a student version of the C18 compiler available at Microchip's website. If you want to program the 12, and 16 series of PICs with C, you would have to look for third party tools like the ones from IAR (very expensive), HiTech, CCS and microelectronic.

In addition to the assembler and C compilers available for PIC microcontrollers there are also basic compilers like the PIC basic compiler from MELABS or proton plus Compiler from crown hill or micro basic from microelectronic.

There is even a Pascal compiler for PIC microcontrollers from microelectronic. If that's not enough, there is a compiler for JAL for PICs as well. Third party simulation software for PIC microcontrollers is also available like the Proteus VSM.

The latest ICD2 from Microchip has a hefty price tag of $299 excluding shipping and taxes. The ICD2 clone by LotharStolz is the simplest of all the ICD2 clones I have seen on the internet.

PIC microcontrollers with ICD capability can be programmed and debugged directly from within MPLAB using an ICD so that there is no need for a multitude of programming tools.

A. Serial Communication

It is basically the transmission or reception of data one bit at a time. Today's computers generally address data in bytes or some multiple thereof. A byte contains 8 bits. A bit is basically either a logical 1 or zero.

Every character on this page is actually expressed internally as one byte. The serial port is used to convert each byte to a stream of ones and zeroes as well as to convert a stream of ones and zeroes to bytes.

The serial port contains an electronic chip called a Universal Asynchronous Receiver/Transmitter (UART) that actually does the conversion.

The serial port has many pins. Electrically speaking, whenever the serial port sends a logical one (1) a negative voltage is effected on the transmit pin.

Whenever the serial port sends a logical zero (0) a positive voltage is affected. When no data is being sent, the serial port's transmit pin's voltage is negative (1) and is said to be in a MARK state.

When transmitting a byte, the UART (serial port) first sends a STARTBIT which is a positive voltage (0), followed by the data (general 8 bits, but could be 5, 6, 7, or 8 bits) followed by one or two STOP Bits which is a negative(1) voltage. The sequence is repeated for each byte sent. Figure 1 shows a diagram of what a byte transmission would look like.

When transmitting a character there are other characteristics other than the baud rate that must be known or that must be setup.

These characteristics define the entire interpretation of the data stream. The first characteristic is the length of the byte that will be transmitted. This length in general can be anywhere from 5 to 8 bits.

The second characteristic is parity. The parity characteristic can be even, odd, mark, space, or none. If even parity, then the last data bit transmitted will be a logical 1 if the data transmitted had an even amount of 0 bits.

If odd parity, then the last data bit transmitted will be a logical 1 if the data transmitted had an odd amount of 0 bits.

If MARK parity, then the last transmitted data bit will always be a logical 1. If SPACE parity, then the last transmitted data bit will always be a logical 0. If no parity then there is no parity bit transmitted.

The third characteristic is the amount of stop bits. This value in general is 1 or 2. Assume we want to send the letter 'A' over the serial port. The binary representation of the letter 'A' is 01000001.

B. LCD display

Our 2-line 16-Character LCD feature is easy to read messages and prompts for users and installers supplying system operation and programming.

A built in speaker provides status and alarm sounds to alert persons on the premises of the system status.

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C. ZIGBEE

The XBee and XBee-PRO OEM RF Modules were engineered to meet IEEE 802.15.4 standards and support the unique needs of low-cost, low-power wireless sensor networks.

The modules require minimal power and provide reliable delivery of data between devices. The modules operate within the ISM 2.4 GHz frequency band and are pin-for-pin compatible with each other.

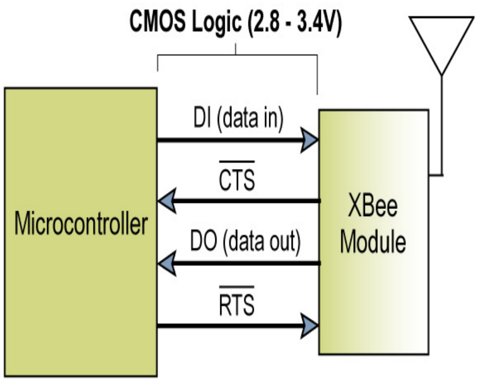

Fig5.Zigbee Communicating with Microcontroller

IV. SOFTWARE TOOLS

A. MPLAB IDE

MPLAB IDE is a Windows Operating System (OS) software program that runs on a PC to develop applications for Microchip microcontrollers and digital signal controllers. It is called an Integrated Development Environment, or IDE, because it provides a single integrated "environment" to develop code for embedded microcontrollers.

MPLAB Integrated Development Environment (IDE) is a comprehensive editor, project manager and design desktop for application development of embedded designs using Microchip PIC MCUs and dsPIC DSCs.

The initial use of MPLAB IDE is covered here. How to make projects, edit code and test an application will be the subject of a short tutorial. By going through the tutorial, the basic concepts of the Project Manager, Editor and Debugger can be quickly learned.

The complete feature set of MPLAB IDE is covered in later chapters. It is followed by a simple step-by-step tutorial that creates a project and explains the elementary debug capabilities of MPLAB IDE.

Someone unfamiliar with MPLAB IDE will get a basic understanding of using the system to develop an application. No previous knowledge is assumed, and comprehensive technical details of MPLAB IDE and its components are omitted in order to present the basic framework for using MPLAB IDE.

B. PIC KIT 2 PROGRAMMER

It is a software that is used to dump the hex file into the pic controller

C. ORCAD

It really consists of tools. Capture is used for design entry in schematic form. You will probably be already familiar with looking at circuits in this form from working with other tools in your university courses. Layout is a tool for designing the physical layout of components and circuits on a PCB. During the design process, you will move back and forth between these two tools.

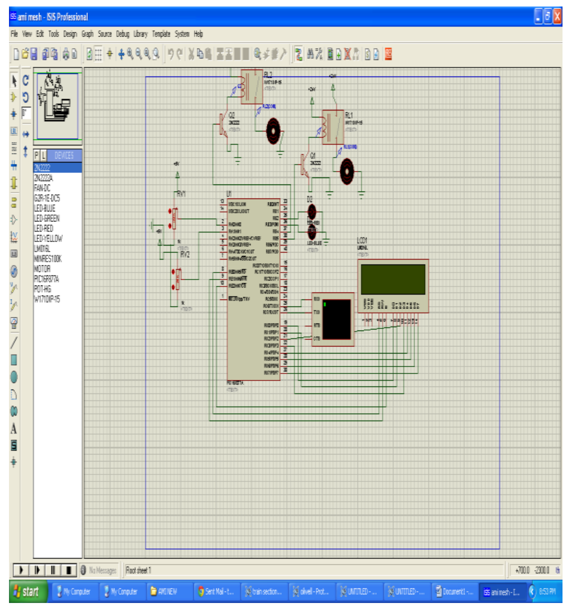

Fig 6. Priority scheduling

V. RESULTS AND DISCUSSION

The main idea is to encourage customers not only to participate in energy generation but also in efficient electricity consumption. From the simulated results, we observed that considerable savings in energy costs could be realized by consumers as compared to the traditional energy users.

In this method, appliances time of use probabilities have been applied as a technique of learning the customers' electricity demand pattern. These past power consumption behaviors are converted to device schedules that are then used to autonomously regulate energy use.

VI. FUTURE WORK

Priority scheduling based on load can be implemented and could prove to be highly efficient, when the improved control techniques are proposed. More savings could further be achieved through appropriately scheduling load consumption. Through a carefully designed energy billing model, appliance scheduling could offer available solution to optimal power management among residential energy users.

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