POWER MANAGEMENT IN INTELLIGENT BUILDINGS USING WSN

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***Abstract*— *The design and development of a smart monitoring and controlling system for household electrical appliances in real time has been implemented. The novelty of this system is the implementation of the controlling mechanism of appliances in different ways. The developed system is a low-cost and flexible in operation and thus can save electricity expense of the consumers. The precision rectifier rectifies the received A.C waveform to pure D.C waveform within a range of (0-5V) D.C. The values are used for computation by the controller and as well as transmitted by the controller to the PC through the Zigbee medium. The relay is activated and deactivated by the driver as per the output of the Input Output pins. The PC uses Visual Basic GUI interface to handle more WSN nodes. The prototype has been extensively tested in real-life situations and experimental results are very encouraging. Thus the whole function of the WSN is monitored and controlled using embedded and wireless systems.*

***Keywords*— Power Management; WSN; Zigbee; Visual basic GUI**

1. INTRODUCTION

Deployments of wireless unattended ground sensor (UGS) networks are primarily used to support mission objective surveillance capabilities such as threat presence detection, classification and geo-location, within a security-sensitive region. UGS surveillance in Para-military mission scenarios present challenges for application and protocol developers because of their dynamic network operating environment. Such environments are characterized by their ad-hoc nature, unstable wireless communication links with limited bandwidth, coupled with a changing threat situation. UGS devices are also inherently limited by their sensing, computation and communication capabilities, which are dictated by their battery energy reserves. Therefore, consumption of energy therefore becomes crucial in extending the operational longevity of the overall UGS network field.

The deployment of UGS devices may be conducted in a covert manner, which can prevent devices being accessible for manned battery replenishment for long periods of time. Continuing advances in battery, renewable energy sources and low power computation technologies are opening up opportunities for the deployment of autonomous wireless sensor networks. Smart Grid utility system encapsulates the net metering system for facilitating consumers to optimally utilize the power consumption.

The gaining importance and urgency of an integrated smart grid monitoring system use wireless sensors network for advancements in metering of the electrical meters to provide more efficiency, reliability and options to consumer. Smart meters Advanced Metering Infrastructure (AMI) provide interface between the utility and its customers providing bidirectional control mechanism, advanced functionalities, real-time electricity costing, accurate load characterization and outage detection or restoration. Here a circuit for smart monitoring and controlling system for household electrical appliances has been implemented.

The developed system has software recovery strategies such as exception-handling, auto restart, and alert text mechanism for sensors failure. The exception handling procedure can handle errors such as no sensor data reception and high range values of analog-to-digital-converted values and computational errors resulted during the normalization of voltage and current sense data values. The Sensor Node is a device that can communicate via radio link. The task of the sensor nodes is to gather information about physical or environmental conditions and transmit (i.e. Sink). In this work, it is aimed at monitoring temperature of various rooms of specified infrastructure. An in-built temperature sensor of the microcontroller MSP430 is used to sense the temperature of the surrounding environment

1.1 WIRELESS SENSOR NETWORK FOR HOME AUTOMATION

It is realized that service and personal care wireless mechatronic systems will become more complicated at home in the near future and will be very useful in assistive healthcare particularly for the elderly and disabled people. Wireless mechatronic systems consist of numerous spatially distributed sensors with limited data collection and processing capability to monitor the environmental situation.

Wireless Sensor Networks (WSNs) have become increasingly important because of their ability to monitor and manage situational information for various intelligent services. Due to those advantages, WSNs has been applied in many fields, such as the military, industry, environmental monitoring, and healthcare. A wide variety of WSNS can operate continuously or under demand in the market with a reduced cost for reconfiguring the material flow systems.

1.3 OBJECTIVE OF THE WORK

Objective is to sense and control the appliances or devices at the point of wireless sensor network using Zigbee communication module. The developed system has software recovery strategies such as exception-handling, auto restart, and alert text mechanism for sensors failure. The exception handling procedure can handle errors such as no sensor data reception and high range values of analog-to-digital-converted values and computational errors resulted during the normalization of voltage and current sense data values.

Depending on the inhabitant usages, appliances connected by smart sensing units are controlled either by automation based on the tariff conditions or by the inhabitant locally using GUI.

2. SYSTEM DESCRIPTION

2.1 PIC 16F877 CONTROLLER

The original PIC was built to be used with General Instrument's new CP1600 16-bit CPU. While generally a good CPU, the CP1600 had poor I/O performance, and the 8-bit PIC was developed in 1975 to improve performance of the overall system by offloading I/O tasks from the CPU. The PIC used simple microcode stored in ROM to perform its tasks, and although the term was not used at the time, it shares some common features with RISC designs. The microcontroller that has been used for this project is fro0m PIC series. PIC microcontroller is the first RISC based microcontroller fabricated in CMOS (complementary metal oxide semiconductor) that uses separate bus for instruction and data allowing simultaneous access of program and data memory. The main advantage of CMOS and RISC combination is low power consumption resulting in a very small chip size with a small pin count. The main advantage of CMOS is that it has immunity to noise than other fabrication techniques. Various microcontrollers offer different kinds of memories.

2.2 HIGH PERFORMANCE AND IMPROVED EFFICIENCY

The architectural decisions are directed at the maximization of speed-to-cost ratio. The PIC architecture was among the first scalar CPU designs and is still among the simplest and cheapest. The Harvard architecture in which instructions and data come from separate sources simplifies timing and microcircuit design greatly, and this benefits clock speed, price, and power consumption. The PIC instruction set is suited to implementation of fast lookup tables in the program space. Such lookups take one instruction and two instruction cycles.

The constant interrupt latency allows PICs to achieve interrupt driven low jitter timing sequences. An example of this is a video sync pulse generator. In PIC models, they have a synchronous interrupt latency of three or four cycles. Microchip's High Performance Architecture encompasses the PIC18 family of devices. These microcontrollers utilize 16-bit program word architecture with 18 to 80-pin package options. The PIC18 devices are high performance microcontrollers with integrated A/D converters. All PIC18 microcontrollers incorporate an advanced RISC architecture that supports Flash and OTP devices.

2.3 REDUCED COSTS AND LOWER POWER FOR SENSITIVE MARKETS

PIC microcontrollers achieve low-risk product development by providing seamless program size expansion. Pin compatibility facilitates drop-in replacements of package types as well as variations of reprogrammable and one-time programmable (OTP) program memory without having to completely re-write code. Microchip's MPLAB Integrated Development Environment (IDE), a simple yet powerful development environment, supports low-risk product development by providing a complete management solution for all development systems in one tool.

2.4 INTEGRATION AND TRACE FOR FASTER TIME TO MARKET

Microchip's seamless migration path with standard pin schemes and code compatibility allows engineers to reuse verified code and a proven printed circuit board layout. Adding higher memory options, incremental I/O and analog peripherals can be accomplished without losing their software investment, reducing time to market. Embedded systems typically have no graphical user interface making software debug a special challenge for programmers. The PIC microcontroller family offers easy migration within the complete range of products. Migration between the different PIC microcontrollers enables several advantages such as future cost reductions, feature enhancements and late development changes with minimal impact to the existing hardware, software and the engineering development environment.

2.5 MIGRATION FROM THE PIC7 PROCESSOR FAMILY FOR BETTER PERFORMANCE

As part of an inherent strategy to offer customers a low-risk development environment, the PIC microcontroller family offers easy migration within the complete range of products. Migration between the different PIC microcontrollers enables several advantages such as future cost reductions, feature enhancements and late development changes with minimal impact to the existing hardware, software and the engineering development environment.

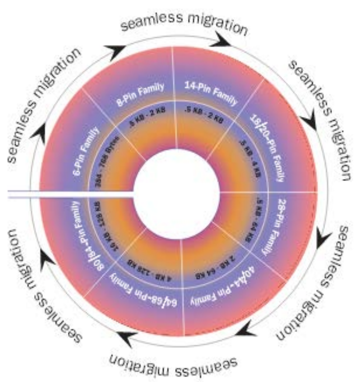

Figure 1. PIC Microcontroller Migration Strategy

2.6 PIPELINING

PIC architecture is divided into two parts: any execution of "memory access" will be on the Data store and each store has its own bus the fetch and execution processes can progress in parallel. The instruction codes for both the current and the immediate next instructions are held in the two Instruction registers IR2 and IR1 respectively. During each cycle, except for the first, one fetch and one execution are proceeding simultaneously.

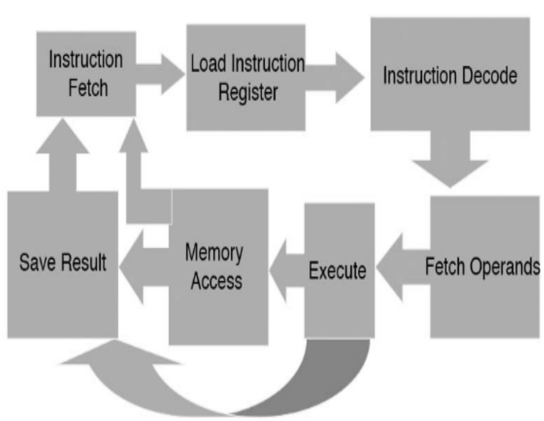

Figure 2.Pipeline Operation in MPU

The core pipeline has 3 stages: Instruction Fetch, Instruction Decode and Instruction Execute. When a branch instruction is encountered, the decode stage also includes a speculative instruction fetch that could lead to faster execution. The processor fetches the branch destination instruction during the decode stage itself. Later, during the execute stage, the branch is resolved and it is known which instruction is to be executed next.

The separate instruction and data buses of the Harvard architecture allow a 16-bit instruction word with separate 8-bit data. The two-stage instruction pipeline enables all instructions to execute in a single cycle, except for program branches, which require two cycles. The PIC18 family has special features to reduce external components, thus minimizing cost, enhancing system reliability and reducing power consumption.

3. HARDWARE DESCRIPTION

In this system, the potential transformer lowers the voltage and sends the signal to the precision rectifier. The precision rectifier rectifies the received A.C waveform to pure D.C waveform within a range of (0-5V) D.C. The current transformer with shunt resister converts the current to voltage and sends the signal to the precision rectifier. The precision rectifier rectifies and filters the received A.C waveform to pure D.C waveform within a range of (0-5V) D.C. The values are used for computation of the controller and as well as transmitted by the controller to the PC through the Zigbee medium. The instruction from the PC is transferred to the pc and the pc interprets the signal and activates the I/O pins accordingly. The relay is activated and deactivated by the driver as per the output of the I/O pins. The PC uses Visual Basic GUI interface to handle more WSN nodes. Thus the whole function of the WSN is monitored and controlled using embedded and wireless systems.

3.1 TOOLS USED

3.1.1 Hardware Tools

- Universal Programmer
- Zigbee modules
- PIC controller 16F877A
- Potential Transformer
- Current Transformer
- Precision Rectifier
- Relay with Driver

- LCD Display (2X16)

3.1.2 Software Tools
- Programming Language: Embedded C
- Development Tool: MPLab IDE

3.2 EMBEDDED PROTOCOLS
- UART
- RS232

3.3 ADVANTAGES

- To Monitor and control through a mesh wireless network
- Uses hopping technology to transfer the data.
- High Performance RISC CPU.
- Greater performance efficiency, without increasing the frequency or power requirements.
- Energy consumption and used in home automation.
- PIC16F877 microcontroller operates with very less power yet providing superior performance.

4. RESULTS AND DISCUSSION

The prototype is in operation in a trial home with various electrical appliances regularly used by an inhabitant. The following appliances were tested: room heaters, microwave, oven, toasters,water kettle, fridge, television, audio device, battery chargers, and water pump. In total, ten different electrical appliances were used in the experimental setup; however, any electrical appliance whose power consumption is less than 2000Wcan be used in developed system. The sampling rate for the fabricated sensing modules was setup with 50 Hz, so that electrical appliance usages within (less than 10 s) interval of time will be recorded correctly. By monitoring consumption of power of the appliances, data are collected by a smart coordinator, which saves all data in the system for processing as well as for future use. The parameters will be entered in the data coordinator in software from appliances include voltage, current, and power. These parameters will be stored in a database and analyzed.

Collected data will be displayed on the computer through graphic user interface (GUI) window so that appropriate action can be taken from the GUI. The processed voltage, current, and power values are displayed on the graphical user interface running on a computer. The processed data are accurate and user friendly. The sensing system in the sensor node measures the parameters (voltage and current). The raw data (i.e., converted ADC values) are transmitted to the coordinator. The computer then collects the data from the coordinator and processes them. The computer then applies the necessary formulas to get the actual voltage, current, and power consumption of the electrical appliances. The voltage and current readings are processed using C sharp programming.

The developed system has software recovery strategies such as exception-handling, auto restart, and alert text mechanism for sensors failure. The exception handling procedure can handle errors such as no sensor data reception and high range values of analog-to-digital-converted values and computational errors resulted during the normalization of voltage and current sense data values.

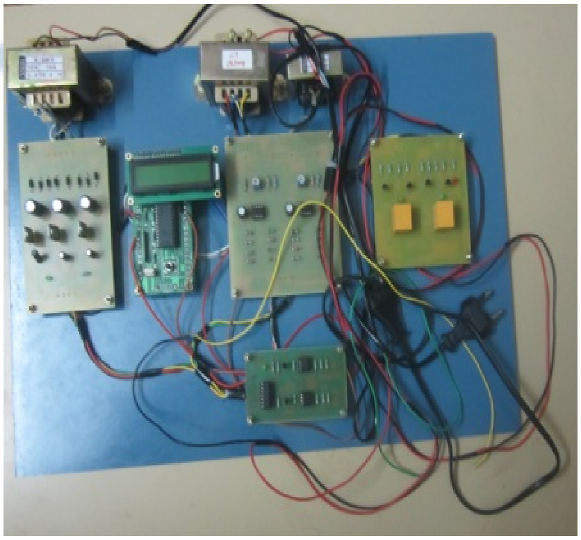

Figure 3. Image of the Project

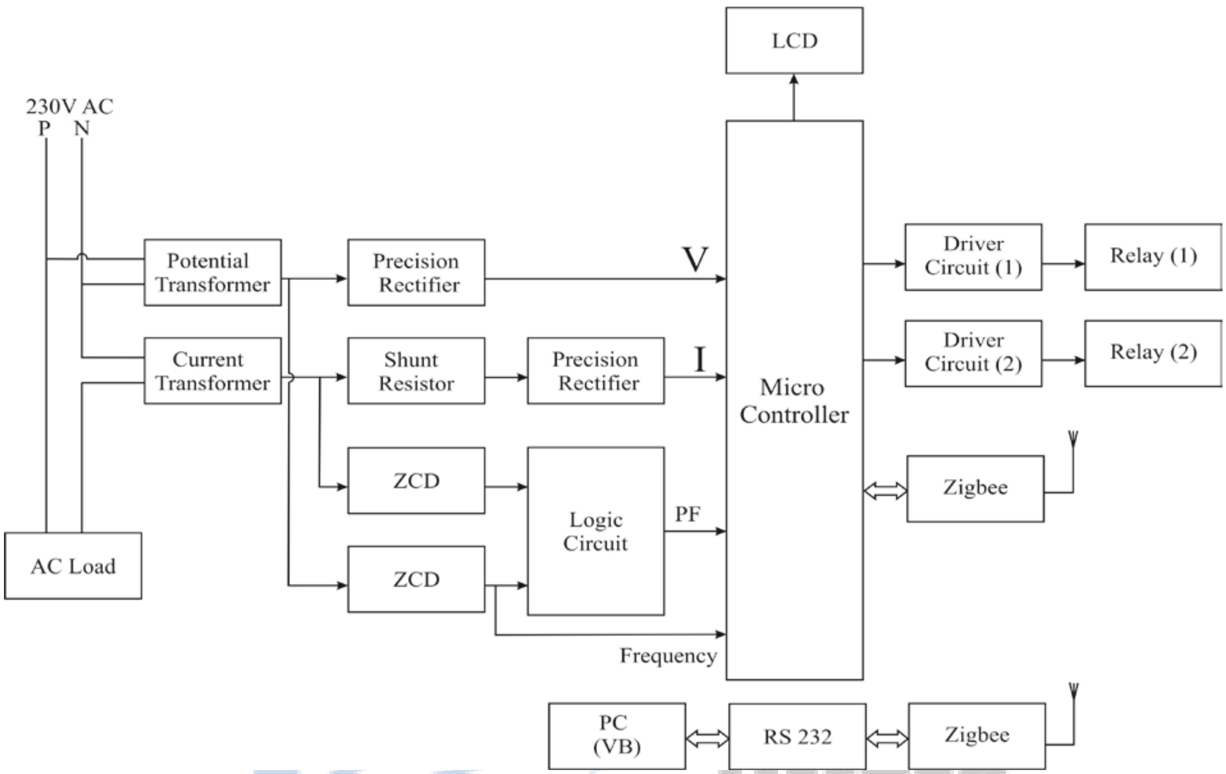

Figure 4. Block Diagram

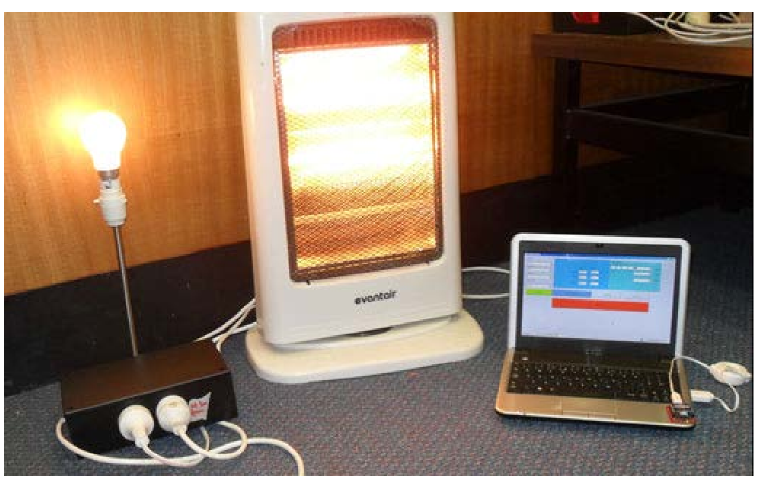

Figure 5. Smart power monitoring and control system at the residence.

4. CONCLUSION

This work has been designed and developed toward the implementation of an intelligent building. The developed system effectively monitors and controls the electrical appliance usages at an elderly home. Thus, the real-time monitoring of the electrical appliances can be viewed. The system can be extended for monitoring the whole intelligent building. We aim to determine the areas of daily peak hours of electricity usage levels and come with a solution by which we can lower the consumption and enhance better utilization of already limited resources during peak hours. The sensor networks are programmed with various user interfaces suitable for users of varying ability and for expert users such that the system can be maintained easily and interacted with very simply.

This study also aims to assess consumer's response toward perceptions of smart grid technologies, their advantages and disadvantages, possible concerns, and overall perceived utility. By monitoring consumption of power of the appliances, data are collected by a smart coordinator, which saves all data in the system for processing as well as for future use. The parameters will be entered in the data coordinator in software from appliances include voltage, current, and power. These parameters will be stored in a database and analyzed. Collected data will be displayed on the computer through graphic user interface (GUI) window so that appropriate action can be taken from the GUI.

5. FUTURE WORK

In future, the system will be integrated with co-systems like smart home inhabitant behavior recognitions systems to determine the wellness of the inhabitant in terms of energy consumption.

6. REFERENCES

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