



Wi-Fi Based Real Time Monitoring and Control System Using Power Line Communication

Dr.V.Gajendra Kumar

Professor, Department of ECE

Sri Sai Institute of Technology and Science, Rayachoti

Email: gajendrakumar@gmail.com

Abstract— In this paper an embedded remote monitoring and controlling system has been developed for electrical appliances using Wi-Fi based Power Line Communication is presented here. This has high suitability for automatic power management of electrical equipments. It requires no new re-lay out, as the existing power lines are used as physical media to transmit data over 220V/50 Hz signal to control the appliances. Major issue is the continuous isolation required for measuring instruments. This paper describes the simple method to continuously control and monitor the appliances through the power line. Use of open source Hardware, power line communication and microcontroller collectively reduces the cost of controlling appliances remotely.

Keywords: PLC, DCSK, Wi-Fi, PIC Microcontroller

I. INTRODUCTION

With the construction of network techniques, there have been several standard family wire network developed and suggested. To implement the management of the power supply sockets of home electric appliances, those home electric appliances that function with network monitoring and controlling capabilities don't require any network re-layout. Power line communication (PLC) carries out high speed data transmission through Power Lines [1].

Automation essentially involves leveraging the power of technology to reduce the dependency on human presence and decision making for any process. It leverages different electronic equipment (either standalone or interlinked with appropriate applications) to control different parameters of any process. In these days of energy scarcity, it is prudent to save energy in every way possible. It is paramount to make such systems as easy to use as possible so that people can use their appliances in a smarter way to save energy. It also enables people to be more energy conscious by enabling them to have a real time status of electric appliances.

Automation also helps reduce peak hour power consumption by enabling people to turn off appliances at will remotely. This facilitates a constant power supply by having varied pricing policies for different times of day and night. Aim of this project is to simplify the process of human-machine interaction through the use of a generic interaction system and to make things around us smarter and interactive. We envisaged building an interaction system that would allow us to interact with the physical/analog world.

Earlier systems are mainly based on the use of telephone lines, such as a phone-based system for home automation using a hardware-based remote controller [2][3], and a personal computer[4]. The technologies used in existing automation systems have a number of limitations. Most of them require rewiring or connecting every appliance to a central unit, for example the systems which use Ethernet [5]. This escalates the cost and deters users from using such systems. Some of the other existing systems use archaic user interfaces which are neither natural nor intuitive, for example [6]. Also RF-Bluetooth based automation systems have limitations in being employed in areas which have concrete walls and surroundings[7][8]. Monitoring is not done in PLC based automation system[9]. These problems necessitate a solution based on already existing infrastructure, one of which is using existing power lines, to overcome the limitations posed by the above technologies.

The purpose of the system is to provide convenience to the user and also to reduce power consumption and save energy. This system requires no modification to the appliances, and it works for all appliances using electricity since electricity to the socket is

controlled and not the appliance directly. The number of appliances needed to be controlled can be easily increased by increasing the range of addresses of the receiver units. Also the hardware and software used to build the system are licensed under open source license, unlike commercial systems which are proprietary in nature, thus lowering the cost of the system significantly.

II. SYSTEM OVERVIEW

A Wi-Fi enabled device is used as means of input. A Cell phone with Wi-Fi & Android based is used for this purpose, which provides the user with a touch screen interface facilitating ease of use. A Wi-Fi network is first setup using a wireless router. The PC connects to the PLC Modem through a RS232 interface. An application on the device consists of keypad that enables us to send signals to the PC through Wi-Fi .These signals are send to PLC modem. When a user presses a particular number, specific messages are sent over the Wi-Fi network to the PLC modem through PC . PLC modem transmits data signals through the existing power lines to the other side PLC Modem. PLC modem sends this data signals to the Microcontroller. The microcontroller converts these messages into simple control signals. The commands sent by the micro-controller to switch ON/OFF an appliance are not sent directly to the appliance, but rather these commands are broadcasted over the power lines using a Power Line Communication (PLC) transmitter. The micro- controller sends data to the PLC modem using UART protocol. Each end appliance has a PLC receiver plus micro-controller combination to listen to these commands, if the commands are intended to the corresponding appliance; it switches ON/OFF the appliance.

On the other hand if the parameters of a particular appliance exceed a threshold or preset limit then the microcontroller sends data signal to the PLC modem using UART Protocol. The other side PLC modem receives this signal through existing Power lines. These signals are send to the PC through RS232 interface .PC will send information to the cell phone via Wi-Fi for monitoring parameters.

Here we are monitoring the temp and when this crosses the set limit the data is sent back to the PC and this will send the data to the cell phone and the user can get to know the temp details.

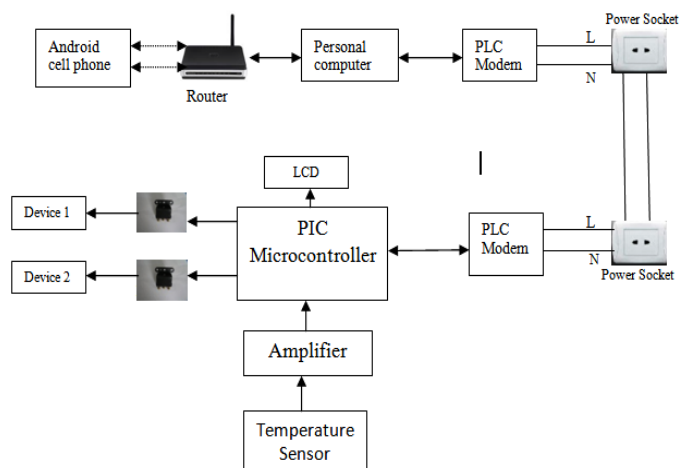


Figure (1): System Overview

III. HARDWARE DETAILS

(A) Power Line Communication

Power Line Communication is a technology which uses power lines as physical media for data transmission. PLC offers a no new wires solution because the infrastructure has already been established. PLC modems are used for transmitting data at a rapid speed through a power line in a house, an office, a building, and a factory, etc. Here, the existing alternating current (AC) power wires serve as a transmission medium by which information is relayed from a transmitter or control station to one or more receivers.

A. PLC Modem description

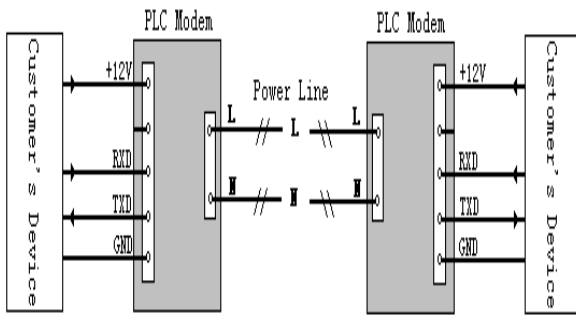


Figure (2): Application Diagram

The ATL90115 series Embedded PLC Modem is a ready-to-go circuit module, which is capable of transferring data over the power cable at the low voltage end of the power transformer of a 3-phase/ 4-wire distribution network [9]. A pair of Embedded PLC Modems connected on the power line can provide low speed bi-directional data communication at a baud rate of 300 bps. It is built in a small form factor that can be easily integrated into and become part of the user's power line data communication system. The PLC modem is based on the Direct Sequence Spread Spectrum Technology, which ensures high noise immunity and reliable data communication. Application Circuitry - It contains the relay circuit which provides the interface for connecting the appliance.



Figure (3): PLC Modem

The modules provide bi-directional half-duplex data communication over the mains of any voltage up to 250v a. c., and for frequency of 50 or 60 Hz. It does not require any protocol to function and therefore is protocol independent. Data flow through PLC modem as if it is a channel and therefore it is transparent to the Data Devices. As a result, with user's proper addressing and communication protocol, multiple units can be connected to the mains without affecting the operation of one another. There is no hassle of building interface circuits. It has a built-in on board AC coupling circuit, which allows direct and simple connection to the mains. Interface to user's data devices is a simple data -in and data-out serial link. Power to the PLC Modem circuit module is a single +12v DC supply. Applications of the Power Line Modem include status monitoring, control and data communication of devices connected on the power line, such Home Automation, Lighting Control, HVAC control, Low Speed Data Networks, Automatic Meter Reading, Signs and Information Display, Fire and Security Alarm, and so on.

(B) Modulation

DCSK (Differential Code Shift Keying) modulation technique is known for its extreme robustness and belongs to the family of spread spectrum modulation technologies. Spread spectrum modulation is a technique in which a signal is transmitted on a bandwidth considerably larger than the frequency content of the original information [10]. Spread spectrum modulations provide many advantages: they are less susceptible to narrowband and burst noises, able to work when the signal level is lower than the noise level (negative SNR). They are also less susceptible to multi-path fading, signals arriving via different routes, and impedance modulation.

A communication medium such as the AC Power Line may be corrupted by fast fading, unpredictable amplitude and phase distortion and additive noise. In addition, communication channels may be subjected to unpredictable time varying jamming and narrowband interference. In order to transmit digital data over such channels it is preferable to use as wide a bandwidth as

possible for transmission of the data. This is achieved using spread spectrum techniques; in particular a type of spread spectrum called “Differential Code Shift Keying” is used for the modulation technique [11].

DCSK modulates the symbol by cyclic shifting of the basic symbol in the transmitter, and detection of the shift in the receiver. The first picture in figure 4 shows the original none shifted symbol, which may also represent ‘0000’ information. The second and third picture in figure 4 (below) demonstrate modulated symbols that are created from the original symbol by cyclic shift according to the data value.

DCSK is spectrum modulation technology that enables extremely robust Power Line Communication. The features of DCSK which make it one of the best technologies for Power Line communication are as follows: Resistance to pulse noise, Resistance to linear and non-linear distortion, Adaptive operation handles fast variations in medium characteristics, Resistance to synchronization errors & timing jitters, Fast recovery from severe fade or jamming.

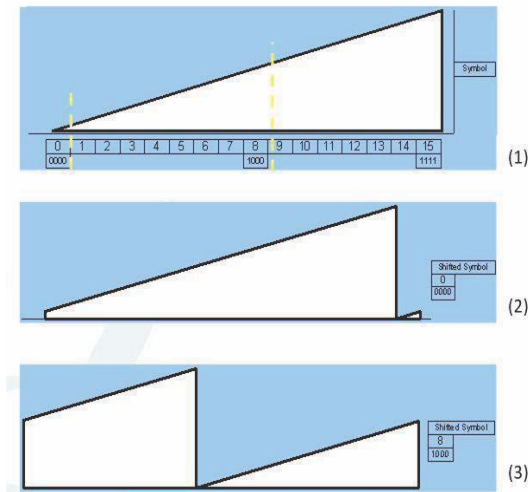


Figure (4): DCSK Modulation

(C)Wi-Fi:

Wi-Fi is a popular technology that allows an electronic device to exchange data wirelessly (using radio waves) over a computer network, including high-speed Internet connections. The Wi-Fi Alliance defines Wi-Fi as any "wireless local area network (WLAN) products that are based on the Institute of Electrical and Electronics Engineers' (IEEE) 802.11 standards".

(d) PIC Microcontroller

The microcontroller used for his system is PIC 18F458. The PIC families of microcontrollers are developed by microchip Technology Inc.

Features

The CPU uses Harvard architecture with separate program and variable (data) memory interface. This facilitates instruction fetch and the operation on data accessing of variables simultaneously. Basically, all PIC microcontrollers offer the following features:

- RISC instruction set
- On-chip timer with 8 bit prescaler
- Power on reset
- Watchdog timer
- Power saving SLEEP Mode
- Direct, indirect and relative addressing modes
- External clock interface
- RAM data memory
- EPROM Program memory

Some devices offer the following additional features:

- Analogue input channels
- Analogue comparators
- Additional timer circuits
- EEPROM data memory
- Flash EEPROM program memory
- External and timer interrupts
- USART serial interface
- Internal oscillator

Pin Description:

PIC18F458 is a 40 pin microcontroller. It has 5 ports

Port A, port B, port C, port D, port E. All the pins of the ports for interfacing input output devices.

Port A: It consists of 6 pins from A0 to A5

Port B: It consists of 8 pins from B0 to B7

Port C: It consists of 8 pins from C0 to C7

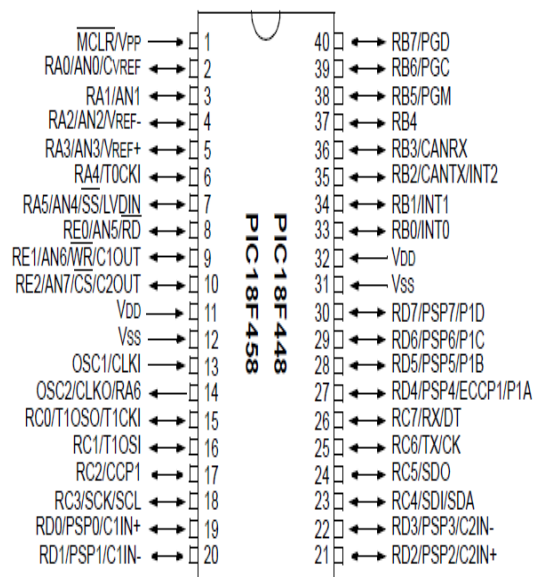
Port D: It consists of 8 pins from D0 to D7

Port E: It consists of 3pins from E0 to E2

The rest of the pins are mandatory pins these should not be used to connect input/output devices.

Pin 1 is MCLR (master clear pin) also referred as reset pin.

Pin 13, 14 are used for connecting the crystal oscillator to generate a frequency of about 20MHz.



Figure(5): Pin Description

IV.APPLICATIONS OF PLC

Mining ,Central monitoring systems, Agriculture, Soil monitoring, Weather station reporting, Remote data acquisition, Power line fault monitoring, Home and industrial automation, Home networking, Automatic meter reading systems, Real time monitoring of energy consumption, Building management solutions.

Use of the system shown above for the implementation of a particular application is explained briefly- The increase in

public demand for energy creates the need for Energy Saving and Energy Management procedures. Utilities can lower cost by reading meters remotely, charging according to time of use or according to level of power used, automating power failure recovery and lowering the investments in new power stations. Utilities can increase revenue by offering more services to the customers (besides just offering power).

In some areas of the world, 30% and more of the electricity is stolen. AMR/AMM is used to detect electricity looting. Real time remote monitoring of energy consumption: Every socket in a particular environment could be monitored for energy consumption, and the data could be transmitted over the power lines by using PLCs and then the data could be uploaded onto the web for visualization. Access to the data could be enabled

Using mobile devices so that the user knows which appliance is consuming the maximum power and could also provide data to the electricity company about the electricity consumption patterns in various homes/residences.

v.FUTURE ADVANCEMENTS/ENHANCEMENTS

- One can use advanced communication interface (GPRS, EGPRS, UMTS) for extended range of control.
- The entire setup could be miniaturized using SMD components and multiple layer PCBs. The resulting size will be small enough to be fixed inside a switch board. High speed Power Line modems could be used for last mile broadband connectivity.
- Implementation of PLC-Zigbee Hybrid combination could further enhance the functionality of the system.

IV. RESULTS AND CONCLUSION

The system was tested using a Power Line transmitter and two receivers connected to appliances kept at different locations but within the same electric network. The appliances were controlled by sending specific commands to trigger the relays which were the switch link in the circuit. The signals do not get transmitted through the MCB so the signals sent from one house don't interfere with that of the neighbor's.

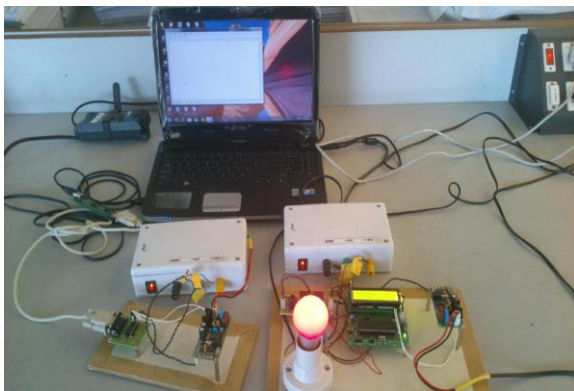


Fig 6.a Working Setup

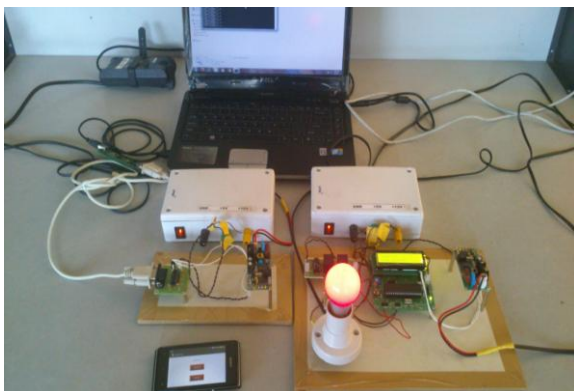


Figure 6.b: Working Setup with Cell Phone

Some of the challenges faced during the course of implementation of the system.

- To improve the reliability of data reaching the end receiver redundancy was introduced by sending the data twice from the Power Line transmitter.
- The noise on the Power Line and interference if beyond a threshold could corrupt the data being transmitted on the Power Line.
- The range of control primarily depends upon the range of the Wi-Fi router as the range of the PLC modem has been validated to be 300m in a straight-line environment.

The system was extensively tested for various conditions/cases such as AC power, UPS and no power and practical conditions were simulated artificially; for example resetting automatically from no power state. The system uses Power Line as a physical media for communication so in spite of no activity on the Power Line data was being transferred reliably.

REFERENCES

- [1] Chia-Hung Lien, Ying-Wen Bai, Hsien-Chung Chen and Chi-Huang Hung: "Home Appliance Energy Monitoring and Controlling Based on Power Line Communication", 978-4244-2559-4/09/\$25.00©2009 IEEE
- [2] Wong, E.M.C: "A Phone-based Remote controller for home and Office automation," Consumer Electronics, IEEE Transactions on , vol.40, no1, pp.28-34, Feb 1994 doi: 10.1109/30.273654
- [3] Coskun, I.; Ardam, H., "A remote controller for home and office appliances by telephone Consumer Electronics, IEEE Transactions on , vol.44, no.4, pp.1291-1297, Nov 1998 doi: 10.1109/30.735829
- [4] Koyuncu, B., "PC remote control of appliances by using telephone lines," Consumer Electronics, IEEE Transactions on , vol.41, no.1, pp.201-209, Feb 1995 doi: 10.1109/30.370328
- [5] Zhang X.; Sun J.; Zhou L., "Development of an Internet Home Automation System using Java and Dynamic DNS Service", Sixth International Conference on Parallel and Distributed Computing, Applications and Technologies (PDCAT '05) 0-7695-2405-2/05
- [6] Rosendahl, A.; Hampe, J. Felix and Botterweck, G., "Mobile Home Automation-Merging Mobile Value Added Services and Home Automation Technologies", Sixth International Conference on the Management of Mobile Business (ICMB 2007) 0-760695-2803-1/07
- [7] Sriskanthan N.; Tam, F.; Karande, A. "Bluetooth based home automation system", Microprocessors and Microsystems 26, 2002, pp 281-289.
- [8] Poole, I. "What exactly is Zigbee?", Communications Engineer, Volume 2. Issue 4, August-September 2004, pp 44-45.
- [9] Karthik Shivaram, Nikil Rajendra, Kavi Mahesh, Balasubramanya Murthy K.N, Padmavathy Jawahar : "Power Line Communication Based Automation System Using a Handheld Wi-Fi Device", 978-1-4673-1356-8/12/\$31.00©2012 IEEE.
- [10] Yitran ATL90115 Power Line Communication Modem Data Sheet
- [11] Shwehdi, M.H.; Khan, A.Z., "A power line data communication interface using spread spectrum technology in home automation," Power Delivery, IEEE Transactions on , vol.11, no.3, pp.1232-1237, July 1996 doi: 10.1109/61.517476.
- [12] Raphaeli, D. "Spread Spectrum Communication System Utilizing Differential Code shift Keying", Itran Communications, Israel.