Automation using Power Line Communication with Web Based Access

Joshin P.C.[1], Melvin Joseph[2], Sam James[3], Vishnu Sasidharan[4]

B.Tech Student, Dept. of ECE, Saintgits College of Engineering, Kottayam, Kerala, India [1,2,3,4]

ABSTRACT: Our paper devices a new Automation Technique using Power Line Communication as well as with remote web access. Thiscan be implemented in already built houses or buildings and provide a great leap in energy conservation and IOT(Internet of Things) as well as easing our day-to-day life. Due to web based access we have an option of connectivity to any portable or other devices with web access. We use PLC modem at both ends and Microcontroller with Ethernet shield as the main controlling part. Another Microcontroller is used for switching inside each nodes or switch board. Internet connectivity is maintained via a router. Our paper satisfies three main part viz Automation, Power Line Communication and Web access. Combining these three parts we are able to provide a complete control over the devices in a house or building without any additional infrastructural alterations and within less cost. Many future scopes is also possible with this paper including more sensors and timers and including controls over the internal functions of devices with added security systems.

KEYWORDS: Automation, Power Line Communication, Server, Modulation, Ethernet.

I.INTRODUCTION

We live around and make use of many devices that run on electricity. The development and commercialisation of electricity production and distribution has marked a significant development in industrial revolution as well as technological advancement. We have now reached a state where almost all household have access to electricity and are using many devices that run on the same. The transition from non-electric condition to one having powered with electricity made a tremendous up gradation in the quality of our lives. But with our paper we are trying to propose an innovation that will entirely change the way we control our electronic devices. By creating an internet of things and automating the same, the man to machine and machine to machine is enhanced to an extent that will provide ease of living and added security and organization along with high productivity and energy conservation.

In this paper, it proposes an automation technique with communication between the nodes based on alternating current (AC) power line communication. This facilitates the avoidance on installation of additional infrastructure to the building as well as any alterations. The power line laid in the building should not have break or discontinuity. The web server is setup inside the controller itself. The end-user interface webpage is coded in hypertext mark-up language (HTML). The electrical network inside the building is displayed on the webpage, whose links may be used to control each of the devices. Along with web access and control, the device may also be controlled manually that provides more flexibility and interoperability. An Ethernet shield serves the purpose of interfacing with the main controller. The transmission of control words to and from the controller to power line modem as well as Ethernet shield is done via serial peripheral interface. The control data that gets through the Ethernet shield is encoded and send to power line communication modem digitally. The serially received control data bits are modulated by make use of frequency shift keying (FSK) at the power line communication modem. The modulated analogue signal is then placed onto the alternating current (AC) mains. The transmitted data will reach any switch node within same electrical network. The receiver may be placed at any location in the building as an outing at the power line switch board. The modulated signal received along with the AC mains is demodulated and converted to digital form. This data is serially input to the receiver controller where it is decoded accurately. Based on the control word the switching of the device takes place and thus controlling is done. Thus using power line communication and with web access automation is done to the entire house or building.

II.BLOCK DIAGRAM DESCRIPTION & WORKING

The block diagram of the designed system with private wireless LAN (Local Area Network) connectivity is as shown in Fig. 1.
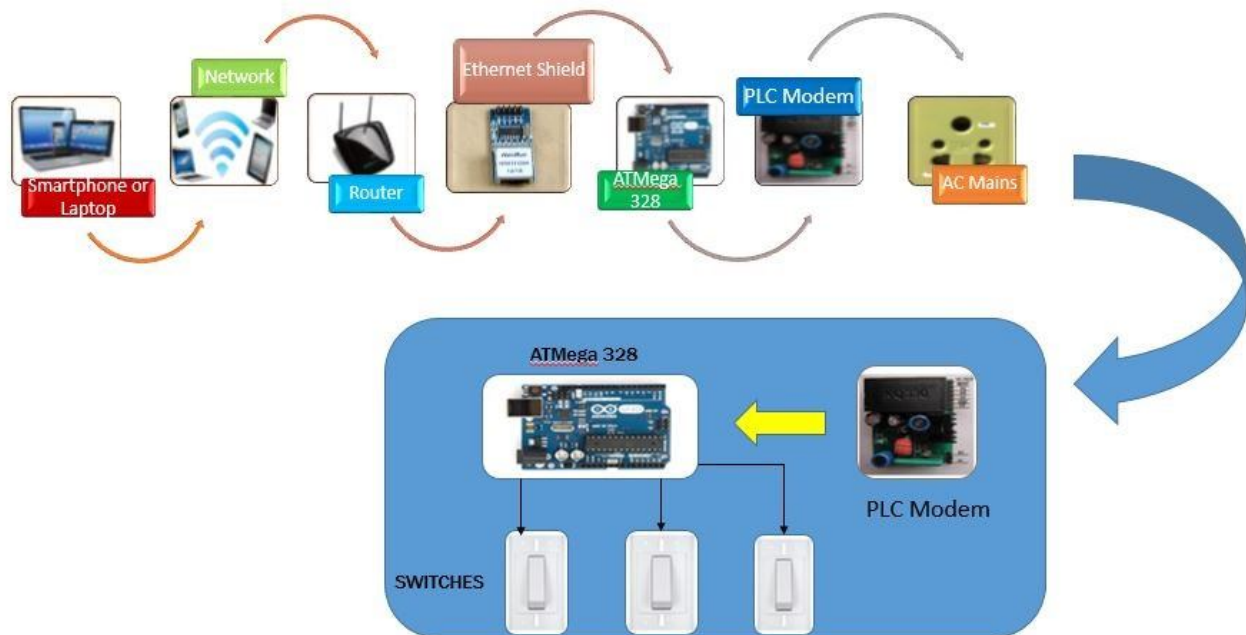

Fig. 1 Block Diagram of automation system

As pre-requisite, an active network should be setup with the controller assigned an Internet Protocol (IP) address. Required connections has to be made between each modules flawlessly. The Media Access Control (MAC) address as well as the port number is also assigned. The system starts after the power on reset. The assigned Internet Protocol (IP) address is entered to the address bar of the respective web browser. Upon receiving the service request, the controller code is executed starting with web server initialization and displaying the required web page. The transmission is done via the Ethernet shield to the router and to the end-user device. After the initialization codes, the server waits for the client activity. When the client selects a device control option of turning on or off, the corresponding reference link will be sent to the main controller. At the controller, string comparing is executed and the particular link is decoded based on the received link string. The reference link word is already assigned in the code itself. Then the data is encoded into the specified format for transmitting via the power line. The start byte and stop byte are fixed and the data bits are sandwiched in between. Using the serial transmission pins available, the encoded bits are digitally transmitted to the power line communication modem, which is specialised for transmitting data via AC mains. The digital data is modulated to continuous analogue signal based on Frequency Shift Keying (FSK) modulation scheme. Based on the digital data, either zero or one, the frequency of the carrier signal is varied.

The analogue data sent over the AC power mains will reach all the nodes in the building. Tapping out from it, we may add 'N' number of receiver modules. It contains the demodulator, which demodulates the analogue data into digital form of zeros and ones. This data is serially transmitted to the controller at the receiver end. Comparing with the control signal look-up-table (LUT) each of the control words are decoded and they are used for switching on and off the devices connected at that node. Manual switching facility is also done by digital input output connection. Relays and drivers are attached with the output.

III.HARDWARE REQUIREMENTS

The main hardware components in this system are ATMega 328, Ethernet shield and Power line Communication modem.

1. ATMega 328 : This Atmel 8-bit Advanced Virtual RISC (Reduced Instruction Set Computing)-based microcontroller combines 32 Kilo Bytes In-System Programming (ISP) flash memory with read-while-write capabilities, 1 KB EEPROM (Electrically Erasable Programmable Read Only Memory), 2 Kilo Bytes of SRAM (Static RAM), 23 general purpose input/output lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART (Universal Synchronous/Asynchronous Receiver/Transmitter), a byte-oriented 2-wire serial interface, SPI (Serial Peripheral Interphase) serial port, 6-channel 10-bit Analogue to Digital converter, programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates in between 1.8-5.5 volts. The device achieves throughputs approaching 1 MIPS per MHz, most commonly used being 16MHz.

2. Ethernet Shield: The ENC28J60 Ethernet Shield is a stand-alone Ethernet controller with an industry standard of Serial Peripheral Interface (SPI™). It is designed to serve as an Ethernet network interface for any microcontroller equipped with SPI. It meets all the IEEE 802.3 specifications. It incorporates a number of packet filtering schemes to limit the incoming packets. It also provides an internal (Direct Memory Access) DMA module for fast data throughput and hardware assisted (Internet Protocol) IP checksum calculations. Communication with the host controller is implemented via two interrupt pins and the SPI, with data rates of up to10 Mb per second. Two dedicated pins are used for LED link and network activity indication lights. With the ENC28J60, two pulse transformers and few passive components are all that is required to connect a microcontroller to a 10 Mbps Ethernet network.

3. Power line communication Modem: Useful to send and receive serial data over existing AC mains power lines of the building. It has high immunity to the electrical noise persistence in the power line and built in error checking so it never gives out corrupt data. The modem is in form of a ready to use circuit module, which is capable of providing 9600 baud rate bi-directional data communication. Due to its small size it can be integrated into and become part of the user's power line data communication system. It's main features includes : Transformer Isolation, Half-duplex frequency shift keying (FSK) transceiver, Integrated power line driver with programmable voltage and current control, Very low power consumption (Iq = 5mA), Receiving sensitivity up to 250VRMS (Root Mean Square Voltage), Carrier or preamble detection etc. The actual diagram of power line communication modem is shown in Fig. 2.
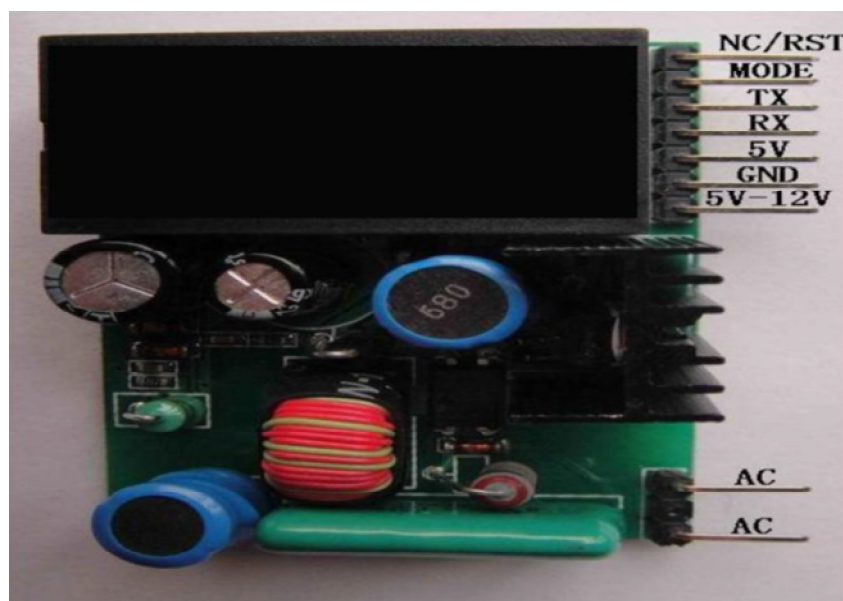

Fig. 2 Power Line Communication Modem

IV.FREQUENCY SHIFT KEYING

Binary FSK or FSK is a modulation scheme typically used to send digital information between digital equipment such as tele-printers and computers. The data are transmitted by shifting the frequency of a continuous carrier in a binary manner to one or the other of two discrete frequencies already assigned. One frequency is designated as the "mark" frequency and the other as the "space" frequency. The mark and space correspond to binary one and zero, respectively. By convention, mark corresponds to higher radio frequency between the data and the transmitted signal. The most commonly used signal parameters for describing an FSK signal are shown in Fig. 3. The minimum duration of a mark or space condition is called element length. Typical values for element length are between 5 and 22 milliseconds (ms), but element lengths of less than 1 microsecond and greater than 1 second have been used. Bandwidth constraints in telephone channels and signal propagation considerations in HF (High Frequency) channels generally require the element length to be greater than 0.5 millisecond. An alternate way of specifying element length is in terms of the keying speed. The keying speed in "bauds" is equal to the inverse of the element length in seconds. For example, an element length of 20 milliseconds (.02 seconds) is equivalent to a 50-baud keying speed.
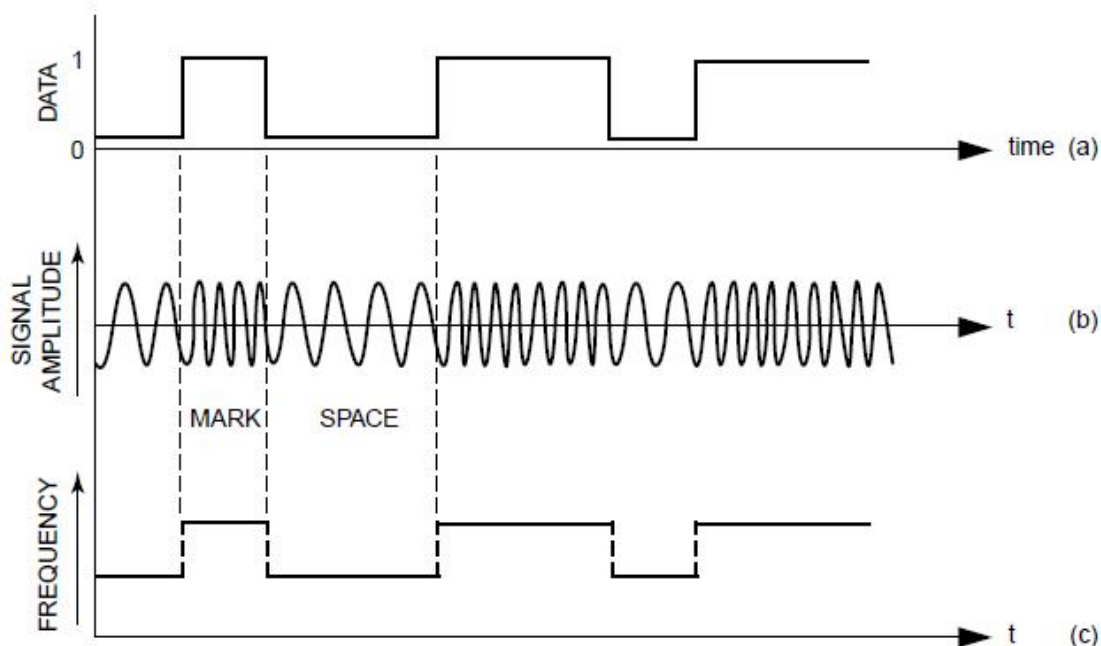

Fig. 3 Frequency Shift Keying

Frequency measurements of the FSK signal are usually stated in terms of a "shift" and centre frequency. The shift is the frequency difference between the mark and space frequencies. Shifts are usually in the ranges of 50 to 1000 Hertz. The nominal centre frequency is halfway between the mark and space frequencies. Occasionally the FM (Frequency Modulation) term "deviation" is used. The deviation is equal to the absolute value of the difference between the centre frequency and the mark or space frequencies. The deviation is also equal, numerically, to one-half of the shift. FSK can be transmitted coherently or in-coherently. Coherency implies that the phase of each mark or space tone has a fixed phase relationship with respect to a reference point.

V. SOFTWARE ENVIRONMENT

The Arduino development environment or Arduino IDE (Integrated Development Environment) contains a text editor for writing the code, a message area, a text console, a toolbar with buttons for common functions, and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them serially. Software written using

Arduino are called sketches. These sketches are written in the text editor. Sketches are saved with the file extension of .ino. It has features for cutting/pasting and for searching/replacing text as in a typical development environment. The message area gives feedback while saving and exporting and also displays errors in compiling as well as programming a sketch. The console displays text output by the Arduino environment including complete error messages and other information. The bottom right-hand corner of the window displays the current board and serial port. The toolbar buttons allow to verify and upload programs, create, open, and save sketches, and open the serial monitor menu.

VI.TESTING

The product based on this paper is tested successfully at college electronics lab. After preliminary testing the device has been tested in a real time house implementation successfully. The transmitter section is centralized and receiver units were placed at different nodes. As for testing four loads were connected with automation capability as well as manual switching functionality.

At the transmitter end, power source were connected to the micro-controller cum Ethernet shield module, the private wireless LAN router, and mains supply to power line communication modem as well as the receiver part. After power-on reset, the system is initialized the setup codes. Then the remote device or hand held smart phone or computer or laptop is connected to the wireless LAN network provided by the router with initial password security verification. Then the internet protocol address is given at the address bar of the opened browser, as per given at the source code. The server redirects to the web page coded already. The control for the connected four devices were provided at the web page and the loads are turned on and off. The testing process was also carried out in different devices with varied platforms. The testing was also done at varied ranges.

VII.RESULTS

The result showed that the response time is 1.5 seconds on average. We have arrived at a conclusion that it is due the inclusion of additional security and data loss avoidance mechanism. It can be reduced by compromising it a little bit. Also the phase isolation was clearly identified such that same phase circuits can only be controlled. To avoid this multiple transmitters can be used with real time updation into a single controller. The power quality disruptions was also minimal and does not affect the working of peripheral devices.

VIII.APPLICATIONS

1. Broadband data over Power line.

2. Public domain hosting adds the remote controllability.

3. Sensors and timers with real time status update.

4. CCTV Monitoring at different locations interconnected by power line.

5. High-security establishment.

IX.CONCLUSION

Thus by using this system, a complete automation of buildings especially houses can be done with less cost and high efficiency. It not only adds easiness and productivity to human lives, but also give a great benefit in energy conservation. The remote access and the cross platform usage is also an added benefit.

REFERENCES

[1]   Mainardi, E.; Banzi, S.; Bonfè, M. &Beghelli, S. (2005) A low-cost Home Automation System based on Power-Line Communication Links, Proceeding of ISARC 2005 (International Symposium on Automation and Robotics in Construction), September 2005, Ferrara(Italy).
[2]   Cenelec (ComitèEuropéen de Normalization Electro technique), (2007), EN 50065-1 Signaling on low-voltage electrical installations in the frequency range 3KHz to 148,5 kHz – Part 1: General requirements, frequency bands and electromagnetic disturbances, July 2007.
[3]   Cuncic, P. &Bazant, A. (2003), Analysis of Modulation Methods for Data Communications over the LOW-voltage Grid, Proceedings of 7th International Conference on Telecommunications, pp.643-648, ISBN 953-184-052-0, Croatia, June 2003, Zagreb Dhir, A.&Mousavi, S.
[4]   Ferreira, H.C.; Grovè, H. M.; Hooijen, O. &Vinck, A.J. (1996),Power line Communications: an Overview, Proceedings of 4th AFRICON Conference, Volume 2, pp. 558 - 563, 24-27 Sept. 1996

[5]　Gelman, A. (2006), Communications Society and Standards, *Proceedings of* ICC 2006 (International Conference on Communications), 11-15 June 2006, Istanbul, TURKEY Power line Communication in Home-Building Automation Systems.

[6]　Gotz, M.; Rapp, M. &Dostert. K. (2004), Power Line Channel Characteristics and Their Effect on Communication System Design, *IEEE Communications Magazine*, April 2004

[7]　Hakki Cavdar. (2004), Performance analysis of FSK power line communication systems over the time-varying channels: measurements and modeling, *IEEE Transaction on Power Delivery*, VOL. 19, No.1, January 2004.