AN IRREDUNDANT POWER LINE DATA COMMUNICATION

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Abstract

The mere fascination provided by the idea of devices "talking" with each other, without any other medium besides the electric cable that is necessary for their existence, is the fountain head for this paper. Here, the power line data communication takes center stage. It has brought about a paradigm change in networking. It uses one of the most ubiquitous transportation medium available for signaling and communication. Thus it has the potential of heralding the smart appliances into the next generation.

I. INTRODUCTION

power line communication (PLC) refers to transmitting the data using power lines as the communication media. The PLC has become a flexible way to implement low cost and reliable networks in the domestic environment. PLC is often the most economical and reliable high-speed dedicated channel available for protective relaying. It is relatively economical because of its available infrastructure. A PLC system includes three basic elements, they are, a transmission line, presenting a channel for the transmission of carrier signal; coupling equipment, providing a means of connection to the high-voltage transmission line; and transmitters, receivers and relays. The use of PLC expands into household applications for control of lights, alarming and heating devices. [1]

In the past, the PLC systems were limited in their applications because they have suffered from unreliable signal transmission, due to the large amounts of electrical noise and transients found on power lines. This electrical noise is caused by the normal use of appliances and machinery in homes, offices, and factories. The development of the technology has gone through a long path to reach today's state. The PLC now applies much higher frequencies of the order of Mega Hz and substantially reduces the signal levels.PLC refers to provisioning of communication services such as internet access and telephony over the electricity grid.

It uses existing power cable and extensions to enable two-way broadband and phone connectivity between a user and a service provider. Current PLC systems use low and medium voltage power lines. [2]

II. Power Line Data Communication

Power line communication (PLC) is a technique of transmitting voice or data at a rapid speed through a power line in a house, an office, a building, and a factory, etc. Power-line communication systems have become increasingly employed as an attractive alternative to conventional hard-wired communication systems, which require dedicated communication wiring, which involve complex and costly transmitter and receiver circuits. In power line communication, 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 or loads connected downstream from an AC source. There is a significant advantage to use the AC power lines for purpose of communication between electronic devices using a power line communication system.

Since no new wires are required to implement the function of communication, power-line communication systems greatly reduce the complexity and effort of installation. Particularly in building retrofit applications in which it is highly desirable to be able to install an energy control system with little or no alteration of the existing electrical wiring. This technology makes it possible to perform communication between pluralities of communication devices by connecting each of those devices to a receptacle installed in each room in a house. Such a power line communication system can be used for monitoring and controlling basic functions including energy management, security, and safety control in applications including homes, factories, offices, automobiles and aircraft. Electric utility companies utilize power line communication systems to provide a means for a central station to communicate command signals to remote receivers which are located at the sites of electric energy consumers.

In PLC communication, the usual power distribution system in a building is a system of wires, electric outlet receptacles, fuses and/or circuit breakers, switches and controls and permanently wired fixtures and appliances, installed for the purpose of distributing low frequency AC power in the building.

In the PLC system, communication signal is transmitted together with an alternating power to a power line supplying the alternating power having the frequencies of 50 to 60 Hz to houses, and a private access device receives only the communication signal for communicating.A power line communication system typically operates by superimposing a modulated carrier frequency signal on the AC signal carried on a power line. A basic PLC system consists of a transmitter unit capable of adding the communication signal to the AC power line signal and a receiver unit capable of separating the communication signal from the AC power component signal. In a PLC system, a transmitter generates modulated signals at one location in the building, which are coupled to the existing power distribution system via an appropriate coupling network and a receiver at another location receives and demodulates the signal providing the desired transmission of voice and data signals from the one location to the other. [4]

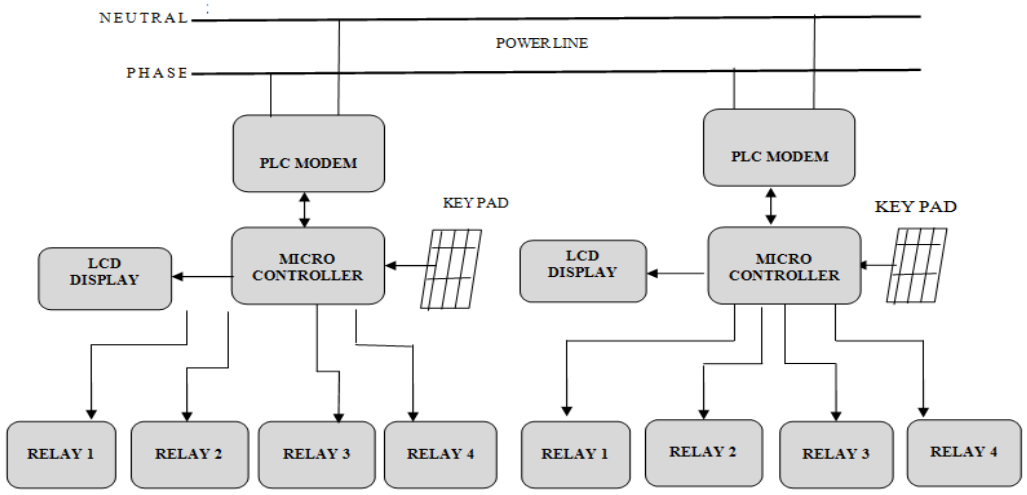

Figure 1: Data communication over power line

The basic principle of the system designed is a high frequency low voltage signal that is superimposed on low frequency high voltage mains at the transmitter. While at the receiver the high frequency low voltage signal is separated from low frequency high voltage signal. The main network is used for data communication. In Power line data communication, the module used for transmitting the signal is also used for reception. The PLC circuit is used to modulate the signal during transmission. The same PLC circuit is used for the demodulation at the receiver.

Transmission mode

The main function of the Micro-controller is to scan the Key board continuously by sending scanning pulses to detect and identify the key pressed. Once the Key is detected, the microcontroller transmits the corresponding ASCII value to the PLC modem (TD 5051).

To provide strict stability with respect to environmental conditions, the carrier frequency is generated by scanning the ROM memory under the control of the microcontroller clock. High frequency clocking rejects the aliasing components to such an extent that they are filtered by the coupling LC network and do not cause any significant disturbance.

At PLC modem, the data is applied through pin DATA_IN and supplied to specific digital circuits to undergo ASK modulation. Harmonic components are limited in this process, thus avoiding unacceptable disturbance of the transmission channel. A -55 dB Total Harmonic Distortion (THD) is reached when the typical LC coupling network is used. The DAC and the power stage are set in order to provide a maximum signal level of 122 dBìV (RMS) at the output. The output of the power stage (TX_OUT) must always be connected to a decoupling capacitor, because of a DC level of 0.5VDD at this pin, which is present even when the device is not transmitting. This pin must also be protected against overvoltage andnegative transient signals. The DC level of TX_OUT can be used to bias a unipolar transient suppressor, as shown in the fig. 1. Direct connection to the mains is done through an LC network for low-cost applications. However, an HF signal transformer could be used when power-line insulation has to be performed.

Reception mode

The input signal received by the modem is applied to a wide range input amplifier with Automatic Gain Control (AGC) of -6 dB to +30 dB. This is basically for noise performance improvement and signal level adjustment, which ensures a maximum sensitivity of the ADC. An 8-bit conversion is then performed, followed by digital band-pass filtering. After digital demodulation, the baseband data signal is made available after pulse shaping. The signal pin (RX_IN) is a high-impedance input which has to be protected and DC decoupled for the same reasons as with pin TX_OUT. The high sensitivity (82 dBìV) of this input requires an efficient 50 Hz rejection filter (realized by the LC coupling network), which also acts as an anti-aliasing filter for the internal digital processing.

The Microcontroller receives the data and depending upon the data received it will display it on the LCD and the corresponding relay is turned ON/OFF.

III. DATA FORMAT

Transmission mode

The data input (DATA_IN) is active LOW: this means that a burst is generated on the line (pin TX_OUT) when DATA_IN pin is LOW. Pin TX_OUT is in a high-impedance state as long as the device is not transmitting. Successive logic 1s are treated in a Non-Return-to-Zero (NRZ) mode. The modulation at Modulator (TDA 5051) is presented on the fig. 2.

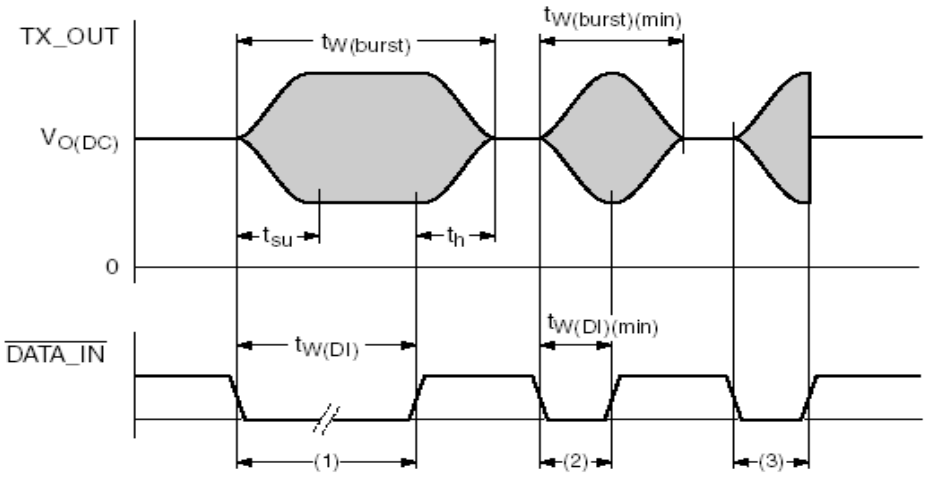

Figure 2: Relationship between DATA_IN and TX_OUT

Here, TX_OUT is analog signal output, V_O is output DC level at TXOUT, t_{su} is set-up time of the shaped burst, t_h is hold time of the shaped burst, $t_{W(DI)}$ is pulse width of DATA_IN signal, $t_{W(DI)}$(min) is minimum pulse width of DATA_IN signal, $t_{W(burst)}$(min) is minimum burst time of $V_{O(DC)}$ signal.

Reception mode

The data output (pin DATA_OUT) is active LOW; this means that the data output is LOW when a burst is received. Pin DATA_OUT remains LOW as long as a burst is received. The pulse shape characteristics are as shown in the figure 3.

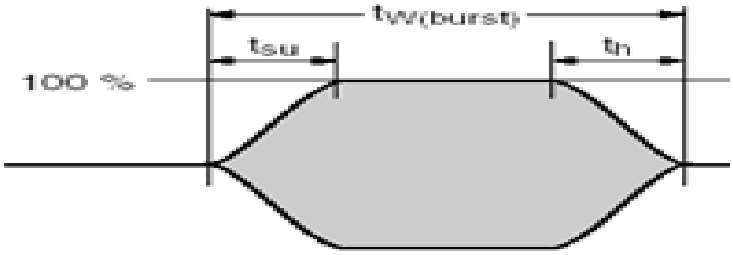

Figure 3: Pulse shape characteristics

IV. APPLICATIONS

The typical applications of in-house power line communication can be broadly classified into three categories: Data sharing, voice communication and Home automation.

Data sharing: This system allows all users to access data and can be successfully used to distribute data across the building with a speed of 600 to 1200 baud rate.

Voice communication: This system allows easier and more efficient Voice communication between the users inside a building.

Home automation: This system is useful in home automaton. The most important home automation applications include controlling lights, security systems and other devices inside a building.

V. RESULTS

The challenges faced in the PLC communication are noise, disturbances, power line channel impedance variation, and signal attenuation. In the distribution network, the most common interference can be caused by the various house hold appliances and office equipment. The PLC communication system has a transmitter and a receiver with sufficiently low output/input impedance to approximately match channel impedance in the most operating situations.

Test Set up for Data communication

The Test setup for data communication over power line is as shown in figures 4 and 5. The Module1 and Module2 are transceivers connected to electrical sink at two different ends inside a building for data transmission and device control.

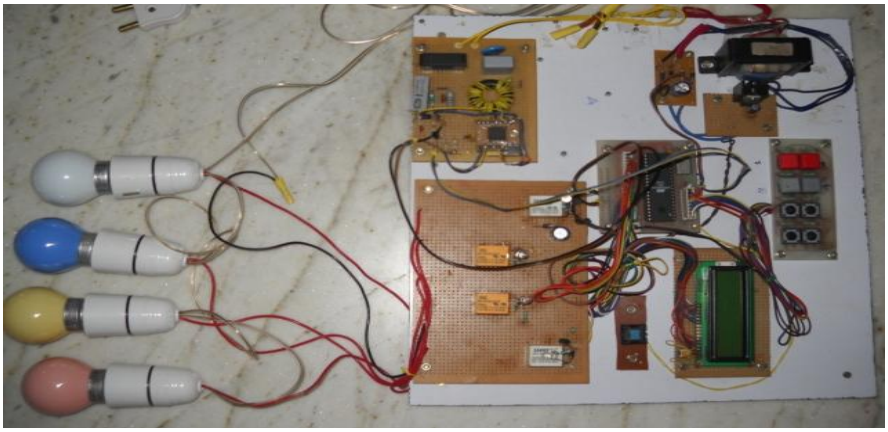

Figure 4: Data communication Module1

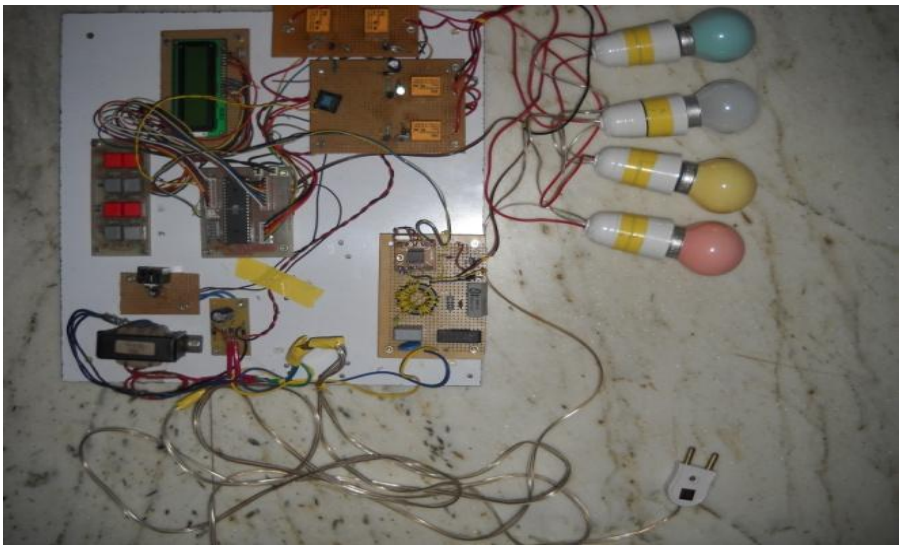

Figure 5: Data communication Module 2

The programming microcontroller 8515 is programmed for data communication and control applications. At transmitting end, the micro controller senses the key pressed and the corresponding ASCII value is transmitted to the PLC modem circuit. At receiving end, it takes the ASCII value from the PLC modem circuit and sends information to LCD for display. It also controls different devices connected to it through relays. The input key and the corresponding ASCII value is specified in the table 1.

Table 1: ASCII value for keys

Module	Input Key	ASCII Value	Binary Equivalent
1	**1**	31	0011 0001
	2	32	0011 0010
	3	33	0011 0011
	4	34	0011 0100
2	**E**	45	0100 0101
	F	46	0100 0110
	G	47	0100 0111
	H	48	0100 1000

LCD is used to display the data at receiving module. It is connected to Port A of the microcontroller 8515.An LCD is easy to interface with a micro-controller because of an embedded controller. The key input and the corresponding display on LCD is shown in the table 2.

Table 2: LCD display of Module2 when keys are pressed in Module1

Key input In module-1	Event	LCD Display On Module 2
1	pressed once	Load 1: ON
	pressed second time	Load 1: OFF
2	pressed once	Load 2: ON
	pressed second time	Load 2: OFF
3	pressed once	Load 3: ON
	pressed second time	Load 3: OFF
4	pressed once	Load 4: ON
	pressed second time	Load 4: OFF

Table 3: LCD display of Module1 when keys are pressed in Module2

Key input In module-2	Event	LCD Display On Module 1
E	pressed once	Load E: ON
	pressed second time	Load E: OFF
F	pressed once	Load F: ON
	pressed second time	Load F: OFF
G	pressed once	Load G: ON
	pressed second time	Load G: OFF
H	pressed once	Load H: ON
	pressed second time	Load H: OFF

VI. CONCLUSION

The transmission of data through power line concept has many advantages and adds new dimension for communication, the cost is cheaper when compared with other technologies for example wireless technology. This system also has high potential in terms of innovation and commercial value due to the uniqueness and the effectiveness. Power line communication is a valid technique that allows the exchange of data by means of the power line cables that are present in every dwelling and in every building. Information transmitted through the power line can be used to share data and also to control home and building automation systems.

Equipping a home environment with a smart power line communication system will increase the comfort. A smart home system can improve the independence in the every day's activities, in a comfortable environment which is very personal and peculiar for everyone, in any case different from a hospital-like setting.A communication system using power line communication has successfully designed, implemented and tested.

Future enhancement

Other than Data, PLC can also be implemented to the security system. The main controlling unit can be interfaced to a computer. Scheduling capability can be added to the system. In addition, implementation towards internet connection through PLC system is also a new advancement in broadband internet connection.

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