

## DEVICE CONTROL USING PLCC: AN EMBEDDED SYSTEM APPROACH

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### ABSTRACT

Home power consumption tends to grow in proportion to the increase in the number of large-sized electric home appliances. An embedded system without any new additional wiring has been developed for home power management. By using Power Line Communication (PLC) technology, electric home appliances can be controlled and monitored through domestic power lines. We describe a PPCOM (PLC Power-Controlled Outlet Module) which integrates the multiple AC power sockets, the power measuring module, the PLC module and a microcontroller into a power outlet to switch the power of the sockets on/off and to measure the power consumption of plugged-in electric home appliances. We are also designing an embedded home server which supports the Web page user interface, thus allowing the user to easily control and monitor the electric home appliances by means of the Internet. In addition, the field experiments reported have demonstrated that our design can be practically implemented and provides adequate results.

### INTRODUCTION

Power monitoring and control through home networks is becoming important for electric home appliances. Together with the construction of access networks, several standards for wired home networks have been proposed and developed.

RS-232 hardware is an interface of easy design and in common use in today's industrial environment. However, RS-232 communications have some drawbacks in that floor environments often generate not only electrical noise but also transients that can cause errors in transmission and damage to the interface components. The other drawbacks of RS-232 are its point-to-point characteristic and a distance limitation of 15 m [2].

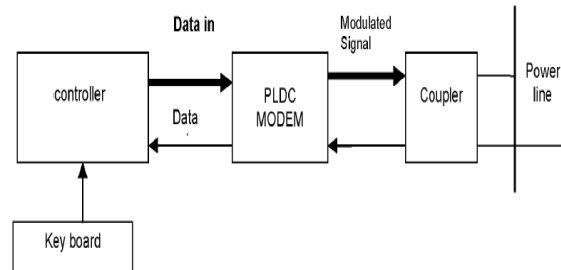
Radio frequency (RF) technology is more flexible and allows the user to link electric home appliances distributed throughout the house. RF can be categorized as a narrow band or spread spectrum. Narrow band technology requires a clear channel uninterrupted by other digital appliances. Since each Transmitter / receiver appliance transmits using its own frequency; it is unlikely to interfere with other RF appliances connected to the home network. However, if the wireless appliance is moved to another location in the house, it is possible that interference may occur. This limitation makes the use of this technology unsuitable for a number of home network applications.

Bluetooth technology provides a universal bridge to existing data networks, a peripheral interface and a mechanism to form small private ad hoc groupings of connected devices away from fixed network infrastructures. Designed to operate in a noisy radio frequency environment such as a home, the Bluetooth technology uses both a fast acknowledgement and a frequency-hopping scheme to make the link robust. Bluetooth technology, therefore, can replace the cumbersome cables used today to connect the PDA to any other digital device [6].

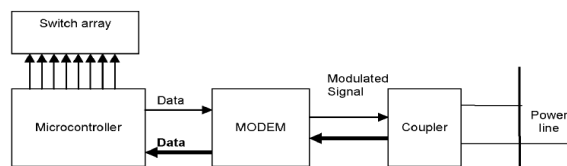
To implement home power management, both networked electric home appliances with control/monitoring capabilities and home networks without new wiring are indispensable. Power line communication (PLC) is used to utilize a domestic power line as a communication cable. Home network devices are categorized as wired devices. The PLC provides high bit-rate data services by using the power grid residing in the vast infrastructure already in place for power distribution, which means that the potential effect of the service could be much higher than that of any other wire line alternative. Because PLC is a home network medium without any new additional wiring, it is easily installed in an existing residence [8]. In this paper we describe an embedded system using PLC technology which has been developed to remotely monitor/control the power of electric home appliances for home power management.

## PROPOSED HARDWARE IMPLEMENTATION

The module provides bi-directional half-duplex communication over the mains of any voltage up to 250VAC and for frequency 50hz or 60hz. Half Duplex communication means it can either transmit or receive data at a time but not both at same time

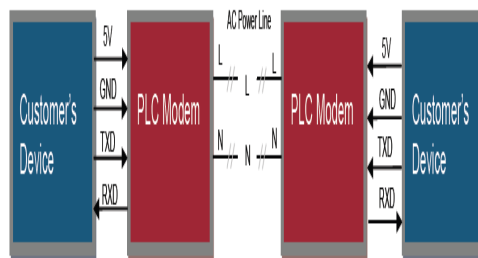


**Figure 1 : Transmitter**

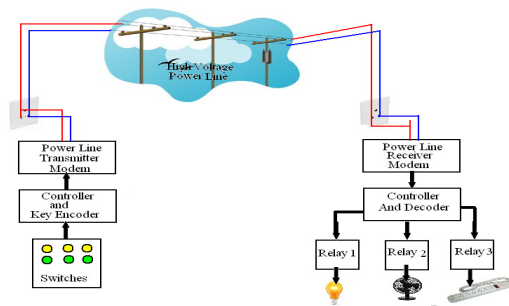


**Figure 2 : Receiver**

Normally module is in receiving mode all the time listening to incoming communication on the power line. Once your application gives serial data to transmit on its RX-IN pin, it switches over to transmit and transmits the data through power line. Once transmit process is complete it switches back to receive mode. The transmission of data is indicated by Red LED. The reception of data by modem is indicated by Green LED which is on TXout pin itself. Data communication of the modules is transparent to user's data terminals and protocol independent; as a result, multiple units can be connected to the mains without affecting the operation of the others. There is no hassle of building interface circuits. Interface to user's data devices is a simple data-in and data-out serial link.



**Figure 3 : System Block Diagram**



**Figure 4 : System Representation**

Transmission is based on byte by byte basis. Once you give one byte to module for transmission, you will have to wait at least 500ms(mili second) before a new byte is given to module again since the module waits for zero crossing of AC mains to transfer a bit. For AC 50Hz system the zero crossing of AC signals happens every 10ms and modem needs 50 zero crossings to transmit one byte with error checking data. That is why it takes 500ms for one byte. For example we want to transmit character “TEST”, then we will have to transmit ‘T’, then wait 500ms, then transmit ‘E’ and wait 500ms, then transmit ‘S’ and wait 500ms, then transmit ‘T’ and wait 500ms. This can be quite slow speed for big data transfer, but the purpose of this module is transfer of small data bytes like sensor readings and remote control for which this speed is ok to implement

## OVERALL SYSTEM OVERVIEW

The master that having input console (board) is coupled to power line at the sending end for sending data to the slaves devices at other ends of the power line (Fig. 1). The master has the features to encode, modulate the commands before they are sent down the power line, while the slave has been designed to demodulate and decode the commands received from the power line.

In the case of a wrong command being keyed in, the master prompts the user. The modulated signal contains start bits, control bits, address bits and stop bit for system control and identification. If the signal detected is for the specific slave device, the slave decodes the control bit appended to the signal and results into the appropriate action accordingly. The system has been developed for working with a maximum number of eight slave devices in simplex mode. Hence, the protocol and algorithm developed were developed to suit such application only.

The microcontroller is used to handle the input from the key board, and produce the appropriate serial data to be fed into the PLDC modem. The single phase coupler passes only the modulated signal into the power line and protects the modem from the enormous power line over shoot voltages. The darken line from micro controller to the PLDC modem and from PLDC modem to single phase coupler marked the direction of the signal from the microcontroller. Even the data is not received in other direction but, it has been connected appropriately for future work. Similarly a more detailed block diagram for the slave devices is shown in Fig. 2. The micro controller is programmed to detect and decode the data signal (data out) received from MODEM and drive the LED's array accordingly.

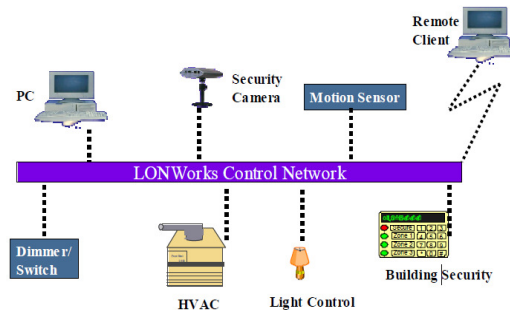
Again, there is single phase coupler which allows the signal of interest to pass and attenuate another signal including that of the power line voltage. The darken line from the single phase coupler into the PLDC modem and from PLDC modem to the microcontroller shows the direction of the signal. The connection for data to be transmitted in other direction has been spared for future work.

## COMMUNICATION / OTHER APPLICATIONS

The reliability of any data transmission is influenced substantially by modulation and coding schemes, as the sensibility against disturbances and noise pickup could be reduced significantly by efficient modulation procedures, error correction codes and check sums.

At idle the data line is pulled up, once it is pulled down the transmission started. Then, the appropriate data for specific command will be sent follows the format discussed above.

**LonWorks** is a networking platform specifically created to address the needs of automation control in industrial, home, transportation, and buildings systems such as lighting and HVAC. The platform is built on a protocol LonTalk created by Echelon in 1999, and is defined by ANSI Standard ANSI/CEA 709.1 [10, 11]. The LonWorks is an open, but proprietary technology and is not subject to use power line as media. Communication between devices may be either peer-to-peer (distributed control) or master-slave (centralized control)



**Figure 5: LON Works Control Network**

## RESULTS AND CONCLUSION

The system is designed to work as expected for showing good response in a noise free environment. The device identity codes sent down the line are properly received and identified by their respective slaves and devices. Also, the slaves act to result into appropriate action on the devices connected to the slaves concerned. However, the circuit shows picking up noise in environment with loads such as exhaust fans, air conditioners and flood lamps. Hence, in the ongoing work, the filter circuits are to be made altered to have high selectivity, which can be improved by increasing the order of the filter (coupler) or replacing the passive by an active filter.

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