COMMUNICATION SYSTEM FOR CONTROLLING SMART APPLIANCES USING POWER LINE COMMUNICATION

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Abstract

Microcontroller-based master and slave units are designed with serial ports for communication with a computer and a transmission port to couple the signal to modems at both ends. The programming of the microcontrollers at either end for formatting the data bits before they are sent down the power line and the development of software for putting in place the required master and slave protocols is presented.

Coupling data signals to power line through interfacing circuits is a challenging task as power line and the communication system operate at two extremes – very low frequency and high power for the power line while communication is working at very high frequency and very low voltage and current levels. Hence, the coupling circuit to be designed must be capable to withstand the high power system side in order to prevent a damage being done to the electronic side of the communication system. At the same time it must be reliable enough to make sure that data bits are transferred on to the power line with high accuracy. The interfacing circuits are designed and tuned to frequency contents making the bits of data. The frequency performance of these coupling circuits is presented, showing the range a power line can be used for communication of such data.

1. INTRODUCTION

The use of the power line communication networks has attracted much attention and has become a mature subject of research in the last few years. Power Line telecommunications is a rapidly evolving technology, aiming at the utilization of the electricity power lines for the transmission of data [1]. Thus, the emerging PLT technology opens up new opportunities for the mass provision of local access at a reasonable cost. In addition, PLT can provide a multitude of new services to the users which are difficult to implement by other technologies including SCADA (e.g., remote electricity meter reading, appliance control and maintenance, energy management,) and large scale applications for home automation [2-4].

Some of the problem areas are challenging such as unpredictability of connected loads, Frequency and time dependence of impedance, attenuation and transmission characteristics; impulse and background noise and their wide variability; limited bandwidth; harmonic Interference. These issues have been addressed in the form of modeling power before using it as a reliable communication medium [5-7]. The communication potential of power line communication has been properly explored for the application of condition monitoring of electric motors [8].

The work in this paper is mainly designed for the purpose of controlling electric appliances in premises such flood light control of golf courses or the control of high power lights on highways. The sending master and receiving end slaves modules are designed, properly coupling circuits are developed, and the software both fro the master and slave is written using C programming language with the help of a microchip debugger.

2. OVERALL BLOCK DIAGRAM SYSTEM OVERVIEW

The master that having the display unit (LCD) and 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, display the data on the LCD,

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read the data displayed on the LCD, analyze the data on the LCD 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.

The schematic for the master is presented in Fig. 3, where power unit obtained form the mains provides dc for the MODEM, LCD, microcontroller and keyboard. The modulated signal from the MODEM is serially tapped in to the power line via the single phase coupler which passes to the slave devices via the power line. Figure 4 shows the circuit diagram of the slave device. The modulated signal is fed into the PLDC modem via the single phase coupler and a small signal amplifier is used to amplify the received modulated signal attenuated while traveling down the line. Figure 5 shows the circuit diagram of three phase coupler which provides an interfacing between the different phases by allowing only the modulated signal to passes across the different phases.

4. COMMUNICATION REGIME

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. Figure 6 shows that the transmit data consists of the start bit, on/off bit, devices/ points address, slave devices address, select bit, parity bit and stop bit.

The start and stop bits were used for synchronization of the data. They ensure the data transmit has to be detected in a frame. The stop bit informs the slave devices the status of the frame. If it is not detected, then the data has overrun error. The parity bit is included to ensure there is no enter symbol detection occurred in the data transmitted. The sites are identifiable with the help of a 3-bit address code, with 000 through 111 means SITE0 through SITE7. Similarly after the salve address the next 3-bits are sued to identify one of the eight devices.

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. The data is fed to the PLDC modem by appending the start bit, parity and the stop bit to the data. The corresponding bits of some of the commands are detailed in Figure 7.

Using the interrupt capability of the controller, the start bit can be detected by the microcontroller of the slave devices. Once the start bit detected, the slave will test again the start bit at the 2/3 of the data pulse width to ensure the right timing on the data detection and to get rid of the bouncing effect of the line. If the start bit is detected successfully, the slave will read all the data transmitted and the parity bit referred to the data pulse width. The parity and the stop bit will be checked by the slave. If any one of them failed, all the data will be ignored. The experiment has been set up as shown in Figure 8 below. The three phase system is controlled by switching on and off the three phase isolator.

6. RESULTS AND CONCLUSION

The system is designed to work as expected and has been tested to be 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.

Acknowledgement

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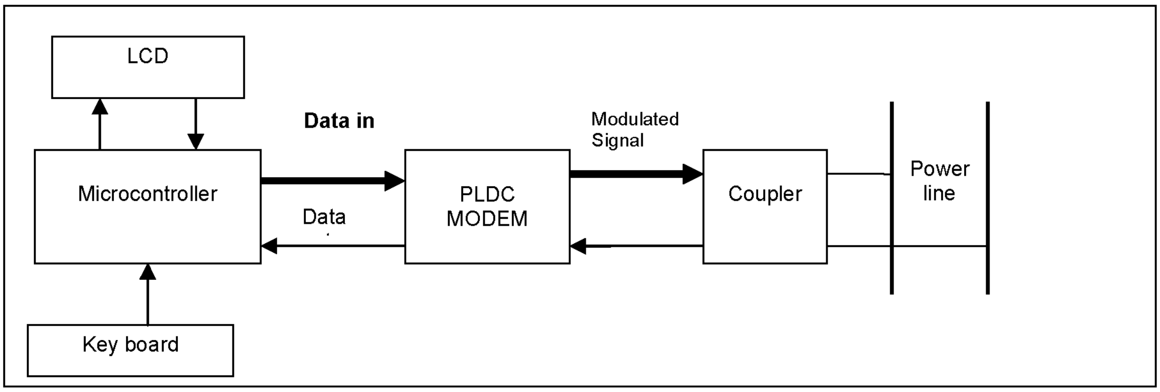

Fig. 1: Block Diagram of the Master Device

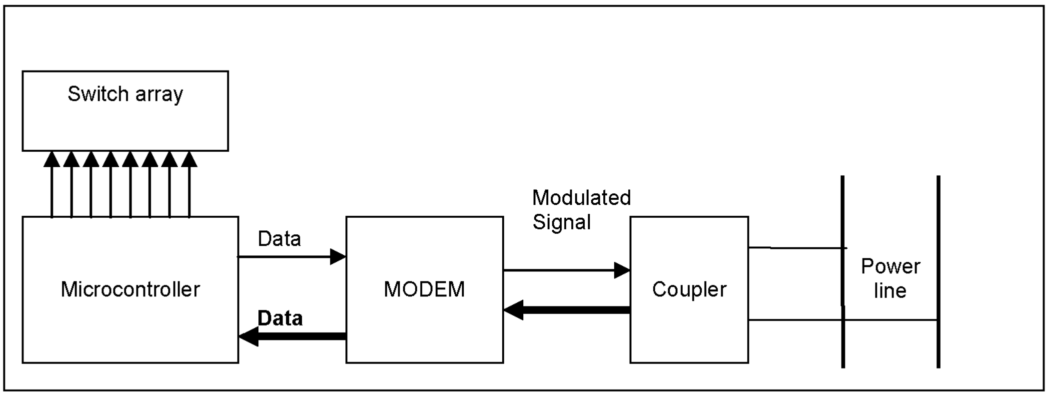

Fig. 2: Block Diagram of the Slave Device

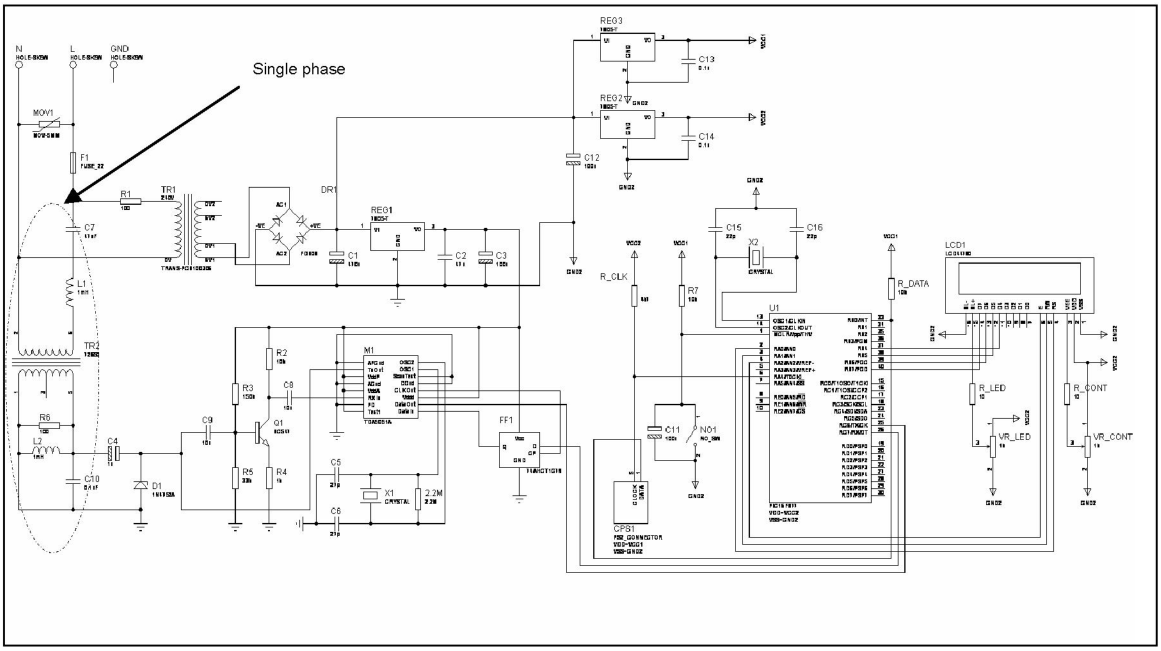

FIGURE 3: Circuit Diagram of the Master Device

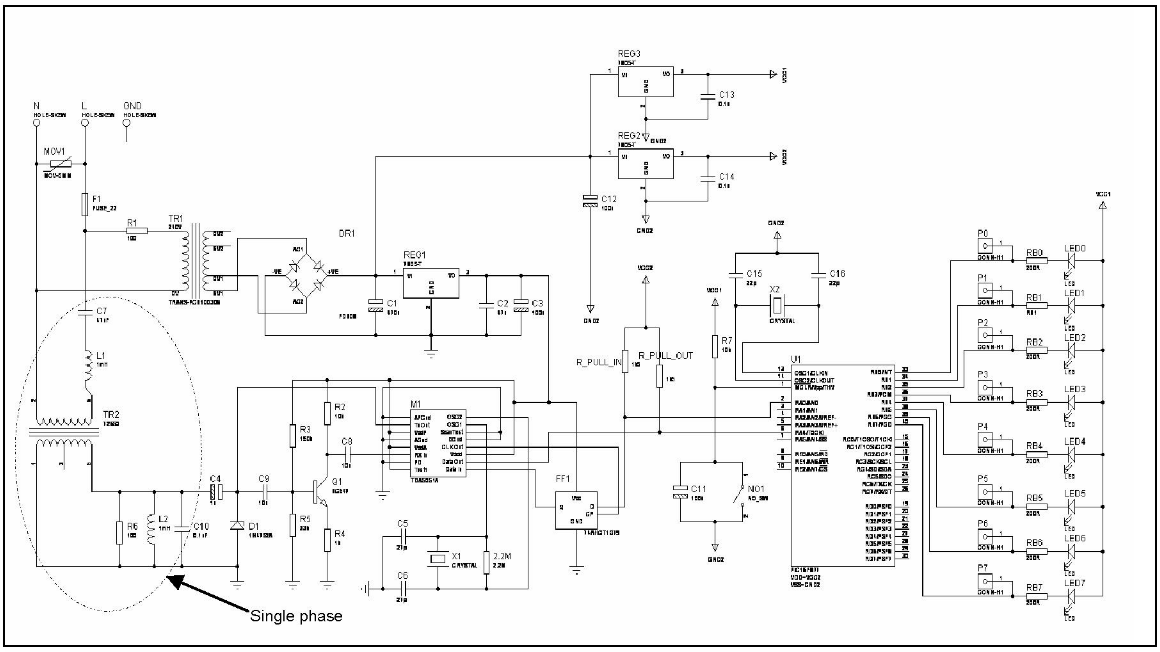

Fig. 4: Circuit Diagram of the Slave Device

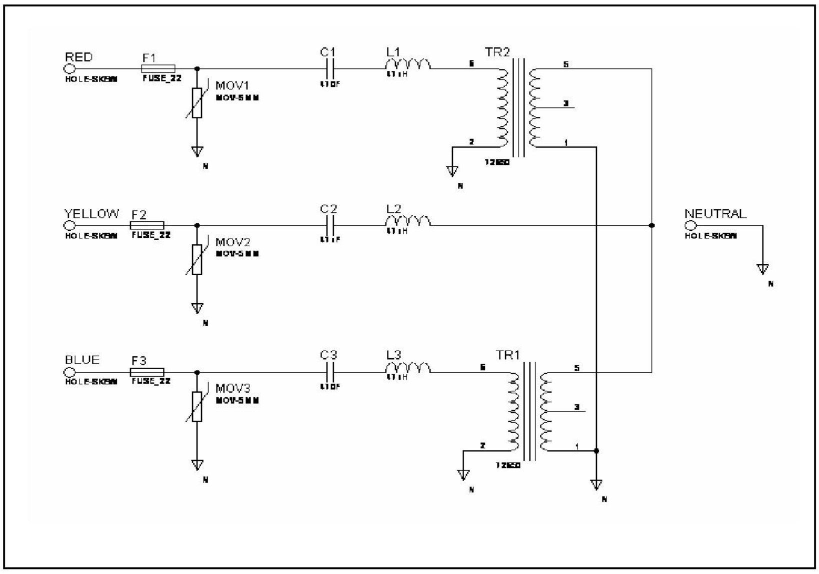

Fig. 5: Circuit Diagram of the Three Phase Coupler

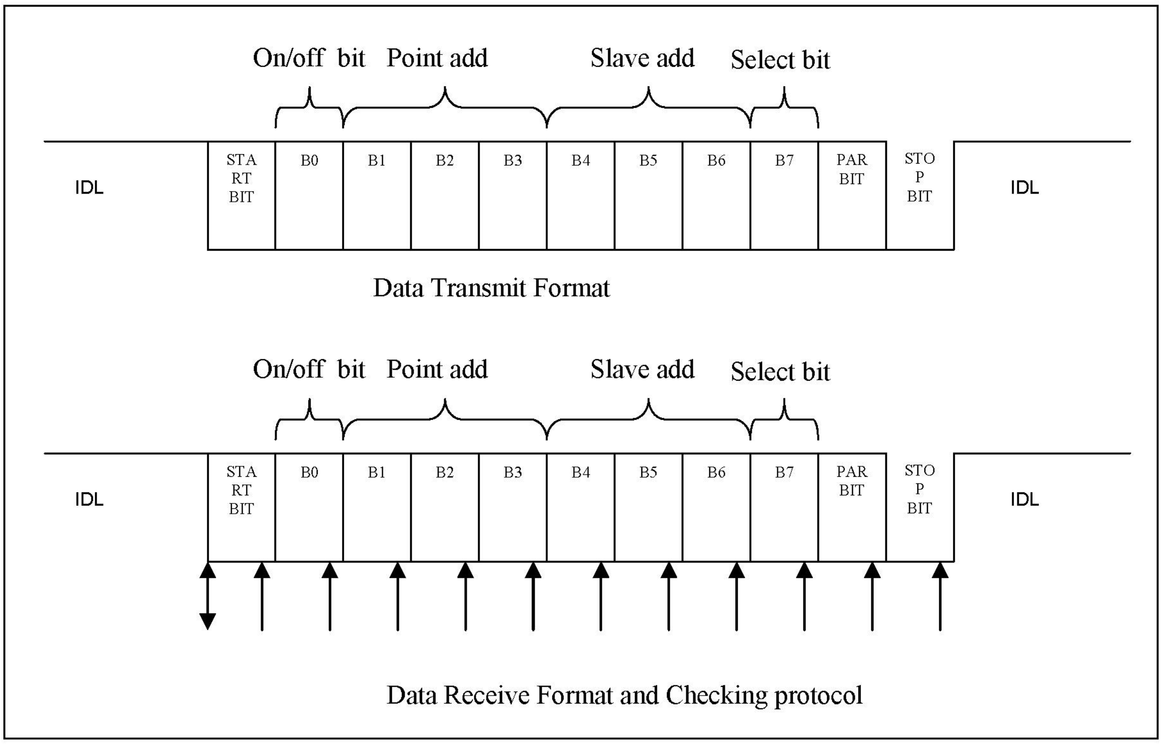

Fig. 6: Data Transmit and Receive Format and Checking Protocol

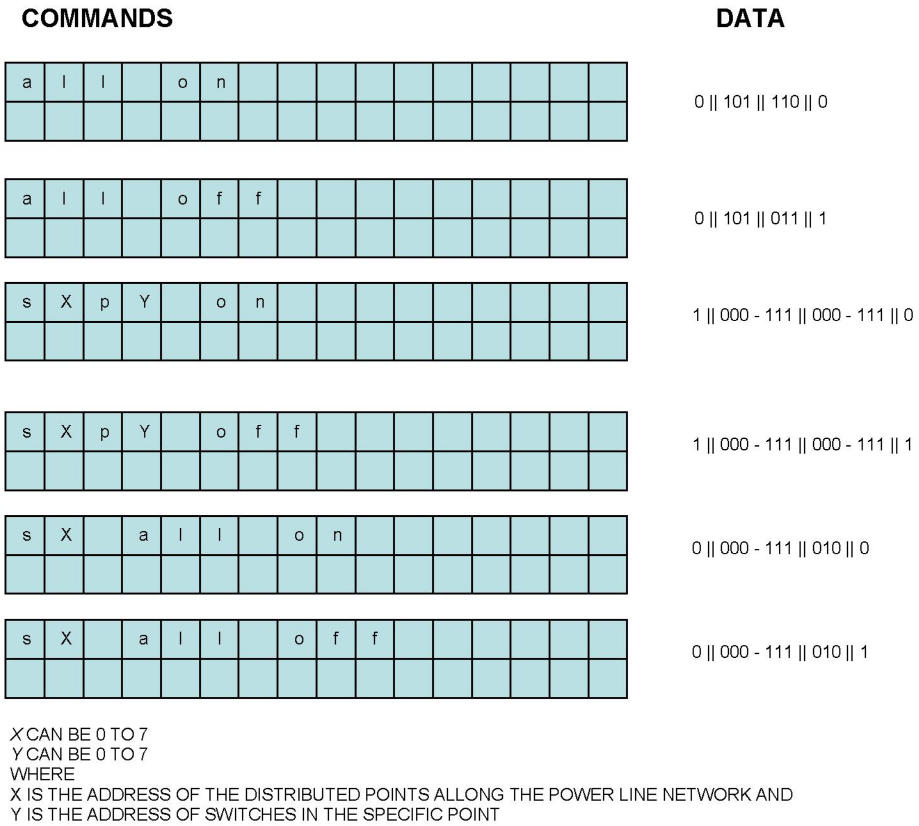

Fig. 7: Commands and Transmit Data Relationship

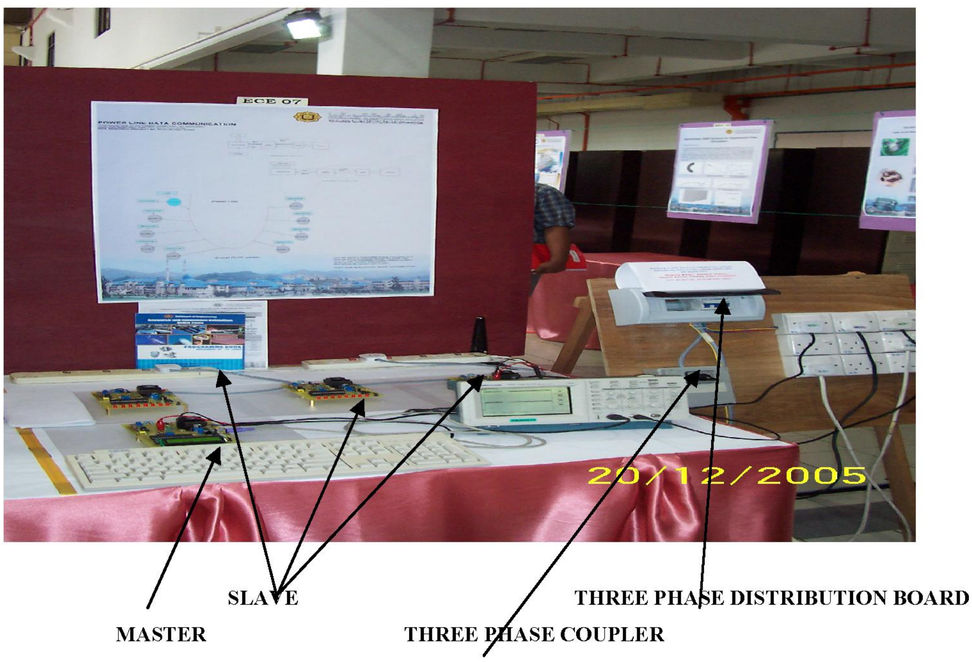

Fig. 8: Experimental Setup of Overall System