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Design of an Application to Minimize Noise Effect and to Reduce False Triggering in PLC based Security System

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Abstract—The power line communication system (PLC) used the existing power lines for data transmission with an advantage of eliminating the need of new wires and cost reduction. As the main purpose of power line is the transmission of electric power at low frequency, so there is extremely distortion environment for high frequency communication. The main distortion factor in PLC channel is noise, which are produced by power electronic devices. As the noise level is high it will be very difficult to detect signal at the receiving end because the signal gets hidden by noise which make false triggering at the receiver end. In this paper an application is designed to minimize the noise effect, to control false triggering in power line communication network and to use it for security purpose which will be portable and can be used anywhere in the building. In this paper a network is designed which is consist of transmitting and receiver circuit. The signal from the transmitting circuit is proceed by the microcontroller and power line communication module through power lines to the receiver circuit. In receiver circuit an application is designed which searches only the desire command in the form of three alphabets. In the lab experiment first of all single letter commands like "a", "b", "z" etc. are used to analyze the system performance. After that dual, triple and five letters commands are applied and the corresponding results are observed. The obtained results are then compared and the analysis shows that the system provide more efficient result in case of triple letters command and there is no false triggering in the system due to noise and the system become quite stable. In this paper hardware is designed to use power line communication network for security purpose to show experimentally that the false triggering due to noise is minimized and the security system is portable eliminating the need of control room.

Index terms- KQ 330 PLC module, false triggering, Impulsive noise, power line network, Atmega 328 microcontroller.

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1 INTRODUCTION

Communication over power line is not new, it has been consider since 1980's [1] but it is not taken seriously because of its adverse channel characteristics. For many years power line communication (PLC) is used for low speed data transmission. However due to inherent advantages of power line communication network researcher take a great interest to use power line network for high data rate communication.

Transmission of electric power at low frequency is the main purpose of power lines, therefore power line network offer extremely distortion environment for high frequency communication. Impulsive noise is the main distortion factor in power line communication system produced by power electronic devices.

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The PLC system has many barriers such as background noise, narrowband interference and impulsive noise. Orthogonal frequency division multiplexing (OFDM) is the most suitable method to fight against back ground noise, narrowband interference and impulsive noise [2].Moreover in [3] the achievement of using orthogonal frequency division multiplexing (OFDM) for PLC cannel is considered and it is compared with single carrier modulation system, it is concluded that OFDM improve Bit Error Rate (BER) as compare to single carrier modulation system.

Matlab/Simulink is used to model different types of noise sources [4], among all types of noise sources the impulsive and background noises are the main source of disturbance resulting signal distortion. The background noise is modeled as Additive White Gaussian Noise (AWGN) and the impulsive noise modeled as Middleton Class A noise model [5].The Bit Error Rate (BER) performance of Wireless Local Area Network (WLAN) channel in existence of Middleton Class A noise is considered in [6].

The impulsive noise elimination method for MIMO power line communication is considered in [7]. First of all MIMO detection is performed by changing the received signal into frequency domain. Then the detected signal is change back to time domain and by subtracting the detected signal from originally received signal, noise estimation is obtained in time domain. Finally by threshold detector the impulsive noise is detected from the estimation of noise and eliminated it from original received signal. Then the output signal without noise is changed back to time domain to do again the noise cancellation process till the output is unchanged. The result from the simulation indicate that this method cancel the impulsive noise in PLC channel and also improve Bit Error Rate in power line communication.

The clipping scheme and equalizer method are considered to minimize the impact of impulsive noise and attenuation in PLC system [8]. In clipping the amplitude of received signal is cut off above the threshold level without its phase change to minimize the effect of noise. The effect of PLC channel is balanced by equalizer. The performance of this method is calculated on the basis of bit error rate. The simulation shows that the given clipping scheme has better performance than conventional PLC system.

The purpose of this research is to minimize false triggering in PLC system and to practically use the power line communication system for the security purposes along with the specially designed application programmed in Visual Basic. This designed application is interfaced with power lines communication receiver circuit. The hardware designed and programmed is tested successfully with zero percent false triggering.

This paper is organized as follows. Section 2 describes the PLC system and the types of noise associated with it. The hardware description is given in Section 3. The working of proposed PLC system considered in this paper is described in Section 4. The Results and discussion are shown in Section 5. Finally, applications and conclusions are given in Section 6.

2 NOISE IN PLC DATA TRANSMISSION

Although power line communication have many inherent advantages but the main purpose of power line is the transmission of low frequency electric power signals, therefore it provide very extremely adverse environment for high frequency communication signals. Just like to other communication system noise is the main cause of interference in power line communication system. If the noise level is higher in PLC channel it will hidden the signal and due to which its detection is very difficult at receiving end. Noise in PLC includes back ground noise, narrow band noise and impulsive noise.

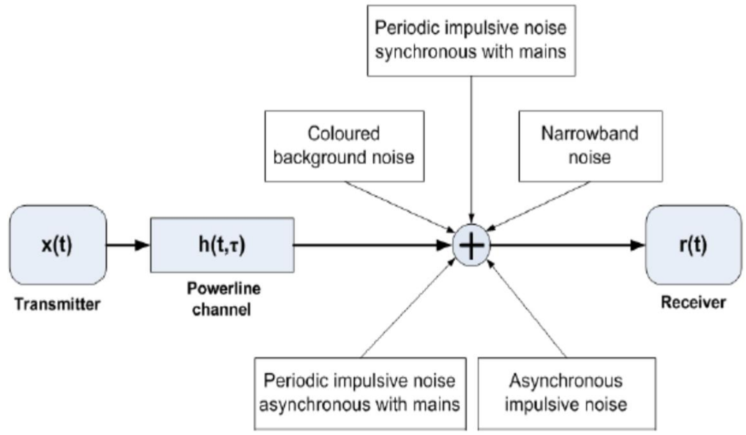

Fig.1. Types of noise in PLC system

2.1 Back ground noise

Back ground noise is caused by summation of different sources of noise having low power present in the system. Its power spectral density (PSD) is low and decrease with frequency [9].

2.2 Narrowband noise

Narrowband noise is caused by interference from radio stations. It is mainly consisting of amplitude modulated sinusoidal wave. At frequency greater than 1MHz its power spectral density (PSD) is 30 dB greater than back ground noise [10].

2.3 Impulsive noise

Impulsive noise is non stationary noise mostly generated by electrical appliances connected to the power line network. It is the most significant type of noise which cause bit error in data transmission. It is classified into the following three groups.

2.3.1 Periodic impulsive noise synchronous with main

Periodic impulsive noise synchronous with main is impulsive noise which repeated at a rate of 50 or 100 Hz and is synchronous with main power line frequency. Its duration is small in micro seconds. It is commonly originated by the rectifier diodes in power supplies which operate synchronously with main frequency.

2.3.2 Periodic impulsive noise asynchronous with main

Periodic impulsive noise asynchronous with main is form of impulsive noise which repeated at a rate between 50 and 200 kHz. This type of noise is generated by switching power supplies and AC/Dc converter [9].

2.3.3 Aperiodic noise

Aperiodic impulsive noise is generated by transient produced by connection and disconnection of electrical appliances.

3 HARDWARE DESCRIPTION

The overall power line communication system consist of Transmitting and Receiving circuits.

3.1 Transmitting Circuit

The transmitting circuit consists of different types of sensors, interfaced with Atmega 328 microcontroller. Which is further connected to KQ 330 power line communication module as shown in the Fig.2.

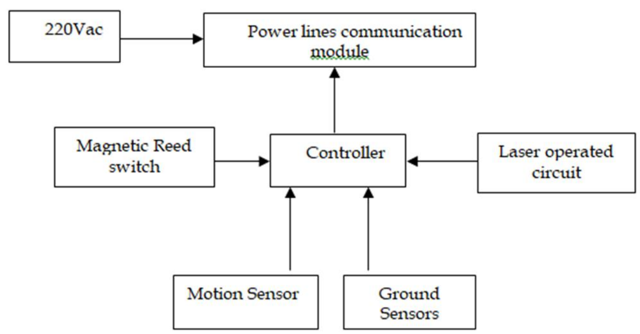

Fig.2. Block diagram of transmitting circuit

In transmitting circuit the command from the sensors are taken by microcontroller, which interpret the data and transfer it into power line communication module. The data in the power line communication module is encoded and then modulated using frequency shift keying (FSK) technique. Then it is fed to amplifier and finally the data signal enters into power line through interface circuit. The functional block diagram of transmitting circuit is shown in the Fig.3.

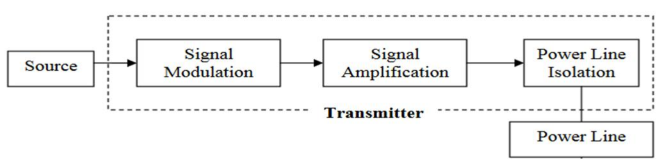

Fig.3. Transmitter Functional Block Diagram

3.2 Receiving Circuit

Receiving circuit consist of KQ 330 power line communication module, Atmega 328 microcontroller and computer with design application. Its block diagram is shown in the Fig.4.

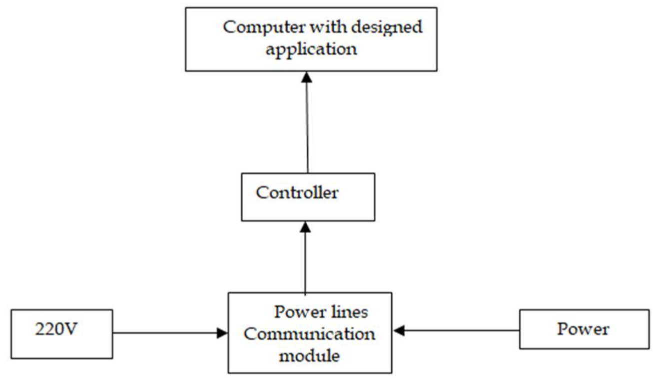

Fig.4. Block diagram of receiving circuit

The receiving circuit received data from the power line. The received data is first feed into power line communication module. Which amplify and demodulate the signal to get the original command. The microcontroller transferred the command to computer with design application to show the command on display. The functional block diagram of receiving circuit is shown in the Fig.5.

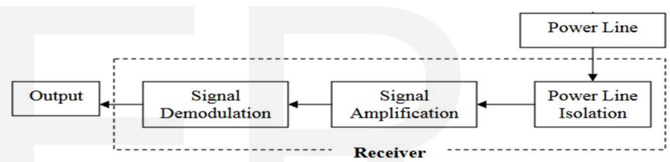

Fig.5. Functional block diagram of receiver

3.3 Power line Interface or Isolating Circuit

Power line interface is one of the important part of the transmitting and receiving circuit. As both circuits are connected to the power line having voltage of 220 v and frequency of 50 Hz, so without interfacing circuit the rest of the circuits will be burn easily.

The function of isolating circuit is to block low frequency i.e. 50 Hz signals and pass high frequency modulated signals. For this purpose a capacitor coupled with transformer are used. By placing the isolating circuit between power line and rest of the circuit, the informational signals can be received and sent to the power line and the low frequency signal will be blocked to prevent the rest of circuit from its damaging effect.

4 WORKING

The main function of the designed hardware is to minimize noise effect in power line communication system and to use it for security purpose. As the sensors in the transmitting circuit detect intruder in a specific area it send a command signal to Atmega 328 microcontroller which interpret the signal and transfer it into KQ330 power line communication module. In this module the command signal is modulated, amplified and then sent in to power line network through interface circuit. In the receiver circuit power line communication module receive the signal from the power line network. After the command signal is amplified and demodulated in power line communication module, it is sent in to microcontroller. Which send the data into computer for display. In this project a graphical user interface (GUI) software is developed in visual basic and then installed in computer. This application only search the desired command in the noisy signal and show the command by changing the color of circle assigned to particular sensor without false triggering due to noise.

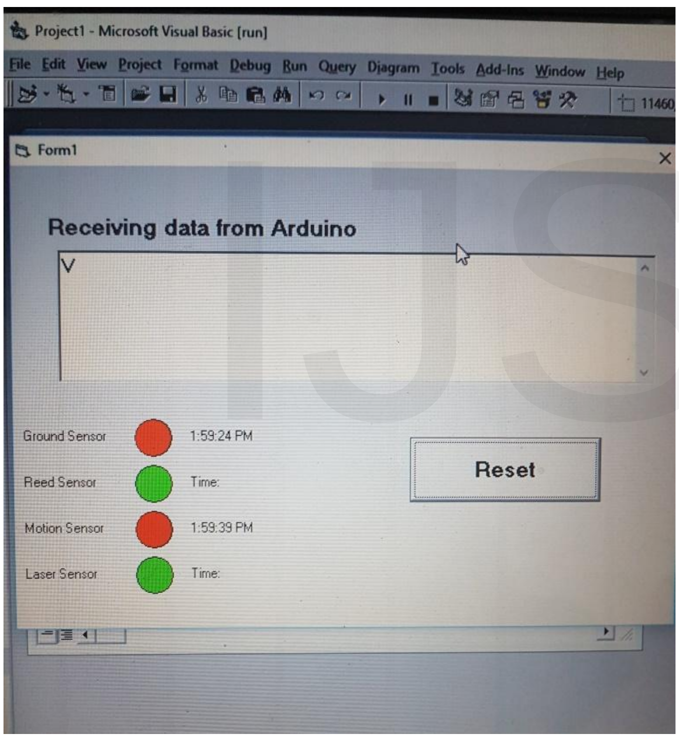

Fig.6. Computer display with visual basic application

5 Results and Discussion

By using the proposed hardware of power line communication different tests are carried out to examine the effect of noise and the system efficiency. These tests are based on the program prepared in C language for Atmega 328 microcontroller and on the programming in visual basic software.

5.1 Single letter test

In this test a single letter commands like “a”, “b”, “c”, are experimentally tested to get their results. During this test the sensors are activated by hand and the results are noted from the computer display. The results show that there are dominant noise effects due to which the rate of false triggering is very high and the system is unstable.

5.2 Double letters test

In this test two letters commands like “ab”, “bc”, “cd”, are experimentally tested. The sensors are activated by hand and the results are noted from the computer display. The results show that the noise effect in this case is reduced and there are 40% false triggering as compared to single letter command.

5.3 Triple letters test

In this test three letters commands like “grs”, “mot”, “las”, are experimentally tested. The sensors are activated by hand and the results are noted from the computer display. The results show that the noise effect is mostly minimized and there is no false triggering and the system is stable.

Fig.7. Triple letters commands

5.4 Five letters test

In this test five letters commands like “absde”, “bdrwh”, “cgstb”, are experimentally tested. The sensors are activated by hand and results are noted from the computer display. The results show that there is a little noise effect which change one of the five letters or add an extra letter to the command signal. There is no false triggering but the system become less responsive as it cannot receive the exact commands.

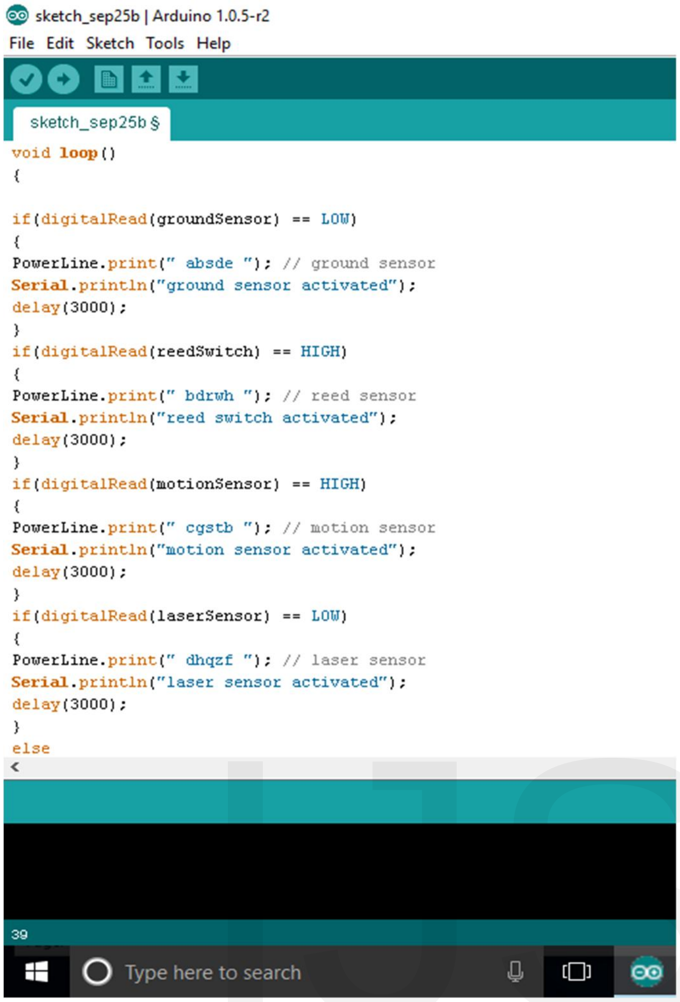

Fig.8. Five letters commands

By comparing all these results it is analyzed that the one letter commands are mostly affected by noise and there are maximum chances of false triggering. The two letters commands are less affected by noise as compared to single letter commands and the chances of false triggering is 40%. The five letters commands are less responsive. So it is concluded that the noise effect is minimized in case of three letters commands, there is no false triggering and the system is quite stable. In this proposed system three letters commands are used.

6 Conclusions

Power line communication system is very significant because of already existence infrastructure. Electrical appliances generate a lot of noise which interfere the data signal transmission in PLC network. In this paper a noise mitigation techniques are investigated. It is observed that by using a combination of different number of letters commands such as single, double, triple and five letters command different results are obtained, each of these techniques reduce the effect of noise in power line communication system but in case of three letters commands the system provide more efficient result. There is no false triggering due to noise and the system is quite stable. Moreover, the PLC system is also used for security purpose to experimentally show that the noise effect is minimized, there is no false triggering and the system is stable.

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