Secure Powerline Communication for Rural and Hilly Areas

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Abstract: This paper is about the provision of the modern day services such as broadband communication, internet and control of the various devices and appliances through the Electrical Power Supply lines. Since in rural and hilly areas users of these new technologies are scarce in number and hilly areas provide coverage problem for wireless media. So opting already installed power lines as communication media results in saving of the installation cost of new network plus the maintenance cost.

Keywords: *Power line Communication, Encryption-Decryption algorithm, Automation through powerline*

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1. INTRODUCTION

Power line communication involves transmission and reception of the data on the electrical power supply network. Being already installed all over the country, the power supply network covers every village and electricity is available in hilly areas too. Village being far from city lacks the provision of the modern day services as the consumer of such services are low in number and installation of a specific network require lots of efforts and capital, in hilly areas there is a problem of coverage and other interference due to multipath reception and other factors for wireless perspective.The solution to this problem can be provided through the use of power line communication. As research work in being done in this areas to use power line as "last-mile" solution. Use of already installed power lines as communication media eliminate the cost associated with installation of new networks and reduces maintenance cost. Since the power lines are not designed to carry information, hence noises encountered on these lines are very high along with the attenuation. Furthermore there is a risk of leakage of the information. Some the problem can be completely overcome such as security of the information can be achieved through encryption and noise effect can be reduced through the use of error detection and correction.

2. POWERLINE COMMUNICATION WORKING

The main focus of powerline communication is to use the existing power supply line for the information exchange whether it is for communication or control purpose. In powerline communication the data to be transmitted is modulated on the sender side and demodulated at the receiver side. Since it makes use of power supply lines, all the devices or appliances connected to the power supply can be controlled thus aiding in automation of home and industries. When discussing communication technology, it is often useful to refer to the 7-layer OSI model. Some PLC chips can implement only the Physical Layer of the OSI model, while others integrate all seven layers. One could use a Digital Signal Processor (DSP) with a pure software realization of the MAC and an external PHY circuit, or an optimized System-on-Chip (SoC) solution, which includes the complete PLC – MAC and PHY.

2.1 Powerline Technology Classification

	Low Data Rate	Medium Data Rate	High Data Rate
Data Rate	0 – 10kbps	10kbps – 1Mbps	>1Mbps
Modulation	BPSK, FSK, SFSK, QAM	PSK + OFDM	PSK + OFDM
Frequency Range	Upto 500kHz Frequency	Upto 500kHz	In MHz
Applications	Control and Command	Control and Command, Voice	Broadband over Powerline, home networking

Low data rates (0 – 10kbps) is mostly preferred for automation and control as in those applications the amount of data to be communicated is small as the amount of data increases due to low data rate the transmission time increases while the use of

medium data rate technology can be extended to use the voice signal as modulating signal. Higher data rate technology is used for broadband communication and home networking permitting large amount of Data to be exchanged.

2.2 Noises and Issues Power-line Communication

Impedance mismatch in power-line communication causes reflections and power-line communication present very harsh environment. Attenuation, Multipath and noise are some of the factors that are effecting the communication. Multipath is caused by signal reaching the receiver with different delays. Noise in power-line are classified as colored background noise having power spectral density lower and decreasing with frequency, narrowband noise which has sinusoidal form with modulated amplitude. Periodic impulse noise, asynchronous and synchronous noise and asynchronous impulse noise whose impulses are mainly caused by switching transient in the network[2].

Since power-line communication radiates signal interfering with radio communication at high frequency but since it is not doing so intentionally so it does not comply to the wireless regulation[7].

2.3 Modulation Schemes

Modulation Scheme	Bandwidth Efficiency	Complexity
BPSK	Medium	Low
FSK	Medium	Low
SFSK	Low	Medium
OFDM	High	High

Phase-shift keying (PSK) PSK is a Digital Modulation Technique in the digital is used to modulate the analog carrier signal. There are various types of PSK techniques like BPSK, QPSK etc. since a digital signal consist of only 0 and 1, in case of BPSK single frequency is used to transmit these two symbols. For 1 the signal with 0 phase shift is transmitted and for 1 the signal with 180 phase shift is transmitted.

Frequency-shift keying (**FSK**) uses two different frequencies to transmit the two digital symbols 0 and 1. It uses two oscillators at two different frequencies, the frequencies are assigned the digital symbol and a multiplexer is used to switch between the frequencies to be transmitted based on the input symbols.

Spread Frequency-Shift keying (**S-FSK**) similar to some extent to the spread spectrum technique in single symbol is transmitted using different frequencies. In SFSK a large frequency range then the required is used for transmission. This provides immunity against noise and security as it is difficult to catch the message sent over large frequency range.

In **OFDM**, Orthoganal Frequency Division Multiplexing, carriers which are 90 out of phase are selected for communication, this approach greatly reduce the interference and also aid in design of transmitter and receiver.

3. TOOLS AND TECHNIQUES

3.1 Graphical User Interface (GUI)

Graphical User Interface (GUI) is a human-computer interface (i.e. a way for humans to interact with computers) that uses *windows*, *icons* and *menus* and which can be manipulated by a mouse (and often to a limited extent by a keyboard as well). GUIs stand in sharp contrast to *command line interfaces* (CLIs), which use only text and are accessed solely by a keyboard. In this project the software used to design the graphical user (GUI) is Visual Studio 2010 and VB.NET is used to code.

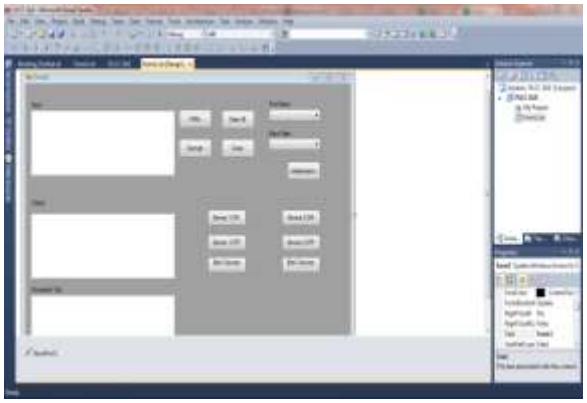

Fig 3.1.1. Graphical User Interface for Powerline Communication

3.2 AES Algorithm

The Advanced Encryption Standard (AES) was published by the National Institute of Standards and Technology (NIST) in 2001. AES is a block cipher intended to replace DES for commercial applications. It uses a 128-bit block size and a key size of 128, 192, or 256 bits. AES does not use a Feistel structure. Instead, each full round consists of four separate functions: byte substitution, permutation, arithmetic operations over a finite field, and XOR with a key. AES is a symmetric block cipher that is intended to replace DES as the approved standard for a wide range of applications. Compared to public-key ciphers such as RSA.

4 DESCRIPTION OF OPERATION

4.1 Automation

In proposed system it is decided to take power line data transfer from communication to controlling. We will be doing this by sending commands from PC through serial port which will be interfaced with microcontroller which forming an embedded system to handle PLC module. The received data will be transferred to PLC module which consists of two parts which are electrically isolated from each other. The low voltage part is interfaced with embedded system and high voltage part is interfaced with power line. On the other end

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similar embedded module receives the data and perform commanded job. And for security and reliability a feedback is generated by the receiving embedded system which is returned to the sender and hence to PC, the block diagram of Fig 4.1.2. shows the basic blocks of the embedded circuit in control part.

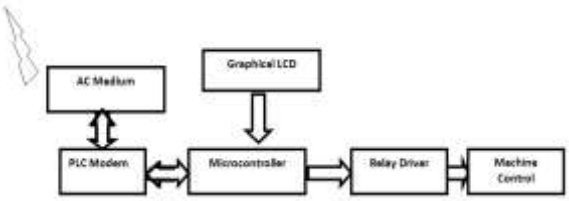

Fig 4.1.2. Automation Control Embedded System

4.2. Communication

For communication the Graphical User Interface is designed in VB.NET, the message to be transmitted is encrypted using the AES algorithm and is conveyed to the Powerline modem through serial communication port of PC, where it is modulated using FSK is transmitted over power supply lines. Provision for providing the key for encryption – decryption externally or it can be provided in the code itself which is written in VB.NET.

Figs 4.2.1 and Fig 4.2.2 show the basic block diagram of Transmitter and Receiver arrangement.

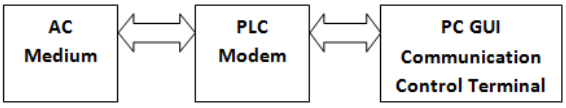

Fig 4.2.1. Transmission Terminal

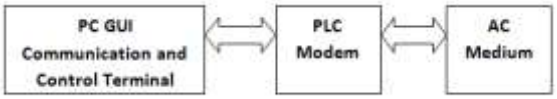

Fig 4.2.2. Receiving Terminal

5 PROJECT IMPLEMENTATION AND OUTCOMES

5.1 Secure Communication on Powerline

The project was implemented using two different laptops as transmitting and receiving terminals. Since PLC modem used in this project supports baud rate upto 9600 and uses FSK modulation. For proper operation delay between the characters to be transmitted was nearly 1 second making it slow but the higher speed modems are also available which support faster speed. It was observed due to the AES encryption of the message if even a single bit was affected that would lead to complete message undecipherable. Timer in VB.NET was used for delay adjustment between successive characters.

Fig 5.1.1. Transmitting Terminal GUI

Port Name dropdown list lists the available serial communication ports on the terminal Baud Rate dropdown list provide with different baud rate, here PLC1672 support 9600bps. After selecting baud rate and serial port, initialization is done.

The message to be transmitted is in ‘Input’ captioned field. When write button is pressed the message is encrypted and sent over powerline through PLC modem and also encrypted form is shown in ‘Encrypted’ captioned field.

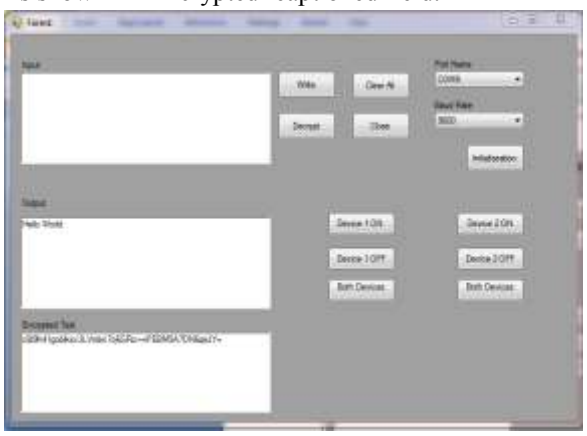

Fig 5.1.2. Receiving Terminal GUI

At the receiving end the encrypted message is received in ‘Encrypted’ Caption field and it is decrypted on pressing the decrypt button and decrypted message is shown in output field.

5.2 Automation and Control through Powerline

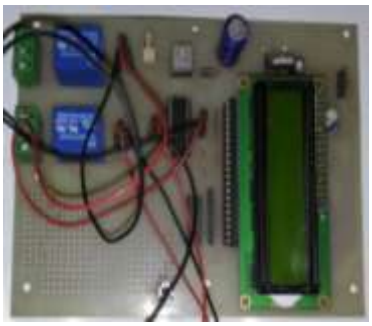

Fig 4.2.1. Embedded Module for control part.

In order to control appliances the GUI is provided with 6 buttons which are used to the two devices connect to the embedded module. Number of devices can be increased but for demonstration purpose only two devices were connected. When any of the button on GUI is pressed the code specific to that button is transmitted which is used by microcontroller to identify the respective device and the action to be performed. The output is shown in fig 4.2.2. and 4.2.3.

Fig 4.2.2. Device 1 ON on Button press

Fig 4.2.3. Device 1 OFF on Button press

CONCLUSIONS

Power line communication can be seen as the effective mean for the communication to the areas where the installation and maintenance of the communication can be proved costly. Furthermore for control application installing separate network can be avoided if we use the same network used for supplying power. As supply lines are laid as web in the house connecting to every appliance hence it can be used to control them also. Power line communication provide you with the freedom as you can move your computer or information terminal anywhere in the building still connecting to the network through a power socket. The problems associated power-line communication are the radiations associated with the high frequencies required for information systems which are generally in the range from 2kHz-30MHz. The electrical network is dynamic in nature as various appliances are introduced and eliminated affecting its characteristics as impedance.

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