DESIGN OF DOMESTIC POWER LINE CARRIER COMMUNICATION

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Abstract

This report discusses the power-line communication over the low-voltage grid, which has A very high potential growth in the near future. The main advantage with power-line communication is the use of an existing infrastructure. Wires exist to every household connected to the power-line network.

This report starts with a general introduction to power-line communication. Then it discusses the application of an existing home automation system, then communicating over a low-voltage grid is investigated in order to obtain some knowledge of how the power line acts as a communication channel. The power-line communication channel can in general be modeled as a system with frequency dependent signal-to-noise ratio varying with time over the communication bandwidth. Finally we describe the basic parts of the system that eventually could be used for information transfer over the power-line communication channel.

1. INTRODUCTION

In the last decade there was a large growth in small communication networks in the home & in the office places. Several computers & their peripherals interconnected together resulting the network to expand globally to the state of Internet. A number of networking technologies are invented which purely concentrates on home networks. But users are limited due to its nature of high cost. Some are over engineered or difficult to install in pre-existing buildings. This report is based on one such communication medium, which has a very high potential growth. I.e. the power line, which give rice to power line carrier communication. Power line carrier communication refers to the concept of transmitting information using the mains power line as a communications channel. Our project mainly aims at applicability of power line carrier communication techniques towards home networking.

Communication over the power line will have the following advantages.

- The modern electric grids are well maintained & far superior to any of the wired communication networks.
- No. of electrical consumers are higher than telephone, cable or other wired communication customers. This will give a high potential market for the investors.
- The analog spread spectrum waves have much greater bandwidths or carrying capacity than the digital switched systems.

2. PROJECT AIMS:

Power line carrier techniques would appear to be an economical and user-friendly method of installing a home network in any building. This project explores such a claim, investigating the challenges of using the power line for communication and to identify the possible methods to overcome these challenges. We expect to send a data from one computer to another computer through the exiting domestic power line.

3. APPLICATIONS OF PLCC SYSTEM:

- Home Automation
- Automatic Meter Reading
- Process Control
- Heating and Ventilation Control
- Air Conditioning Control
- Lighting Control
- Status Monitoring and Control
- Low Speed Data Communication Networks
- Intelligent Buildings
- Signs and Information Displays
- Fire and Security Alarm System
- Power Distribution Management

4. POWER LINE CARRIER CHALLENGES

Power lines and their associated networks are not designed for communication use. They are hostile environments that make the accurate propagation of communication signals difficult. Two of the biggest problems faced in using power lines for communications are excessive noise levels and cable attenuation. Noise levels are often excessive, and cable attenuation at the frequencies of interest is often very large. The most common causes of excessive noise in a domestic situation are the various household devices and office equipment connected to the network. Noise and disturbances on the power network include over voltages, under voltages, frequency variations and so on. However, the most harmful noise for PLCC applications is that superimposed on a power line. Switching devices such as light dimmers, induction motors in many common appliances and high-frequency noise caused by computer monitors and televisions often causes such superimposed noise.

For a power line carrier communications system to perform reliably it must be able to avoid, or cope with, the different types of noise encountered on its communications channel. These different types of noise exist at different frequencies, and occur at unpredictable times. Thus, it is not sufficient to design a system that simply avoids using certain parts of the available bandwidth. Rather, a technique called frequency hopping can be used to overcome this problem. When a frequency-hopping communications system encounters noise at a certain bandwidth, it skips to a different bandwidth, moving away from the original interference.

4.1 Available Bandwidth & Regulatory Standards:

Bandwidth available for power line communication is not limited by the physical capabilities of the line. Rather, regulatory authorities limit the available bandwidth for power line communication in order to prevent radio interference, other device interference and other such contentions.

It is to be noted that bandwidth is proportional to the bit rate, thus a large bandwidth is needed in order to communicate with high bit rates. Various standards exist that provide regulations on the operating specifications of PLC systems. In our project we followed the European standard viz. CENELEC. The standard only allows frequencies between 3 kHz and 148.5 kHz. This puts a hard restriction on power-line communications and might not be enough to support high bit rate applications, such as real-time video, depending on the performance needed.

5. PRACTICAL ISSUES:

In designing the Power line communication system we were to address even some the salient features. Modulation techniques, transmission methods and so on were selected to give suitable performance in the communication environment which we were expect to use.

5.1 Modulation Methods:

Various types of modulation methods are available for digital transmission Viz.

- Digital Amplitude Modulation.
- Quadrature Amplitude Modulation.
- Phase Shift Keying.
- Frequency Shift Keying.

Due to the nature of high attenuation prevailing in the power line Frequency Shift Keying and Phase Shift Keying will give simpler results over others though both of them are robust.

<u>Frequency Shift Keying (FSK)</u>: In this form of modulation carrier wave frequency is varied by a binary input stream. As the binary input signal changes from logic '0' to logic '1' and vice-versa, the FSK output shifts between two frequencies.

<u>Phase shift keying(PSK)</u>: In this form of modulation phase of the carrier wave is varied by a binary input stream. As the binary input signal changes from a logic '0' to a logic '1', and vice-versa, the PSK output shifts between two angles that are 180 degrees out of phase while keeping the frequency a constant.

In order to decide the method of modulation to be used in power line communication it is important to keep in mind the hostile environment in which it operates. It is difficult to say which method to use, whether FSK or PSK. Phase delay in the PLC channel is expected and unpredictable in the case of PSK technique. The reliable performance of FSK with any reasonable amount of phase delay makes it the modulation scheme of choice for PLCC techniques.

5.2 The Coupling Network:

A coupling circuit is used to connect the communication system to the power-line. The purpose of the coupling circuits is two-fold. Firstly, it prevents the damaging 50 Hz signal, used for power distribution, to enter the equipment. Secondly, it certifies that the major part of the received/transmitted signal is within the frequency band used for communication. This increases the dynamic range of the receiver and makes sure the transmitter introduces no interfering signals on the channel. Thus the ultimate coupler network design becomes a compromise between the different characteristics for receive and transmit direction, plus impedance.

Different ways exist in order to couple a communication device in to an electrical power line.

Two main categories can be described as below.

1. Differential mode coupling: In this case the line or active wire is used as one terminal, and the neutral wire as the second terminal. In cases where a neutral line is not present (high voltage networks), the ground line acts as the second terminal.
2. Common mode coupling: In this case the line (active) wire and neutral wires are used together forming one terminal and the ground wire serves as the second terminal. One might think this coupling mode is impossible, due to the connection of neutral and ground wires at the transformer.

In practice, the inductance between points of coupling and the short-circuit point is large enough to allow signal transmission. However, problems exist in using common mode coupling in the presence of earth leakage protection devices, and certain countries do not allow common mode coupling because of the perceived dangers to customers.

Considering the physical implementation of the coupling two methods can be identified.

1. Capacitive coupling: A capacitor is used to couple the communication signal on to the power line.
2. Inductive coupling: An inductor is used to couple the communication signal onto the power network. Inductive coupling provides a physical separation between power network and communications network, making it safer to install.

Our project is focused with using capacitive coupling method for safety reasons. In practice the coupling is achieved by connecting a 47nF (230V) capacitor with a 1:1 transformer. The capacitor posses a very high impedance to the 50Hz power signal and allows HF signals to pass through it. The purpose of the transformer is to provide electrical isolation.

6. PRACTICAL IMPLEMENTATION:

Figure 1 gives the block diagram of the PLCC system which we design on our project.

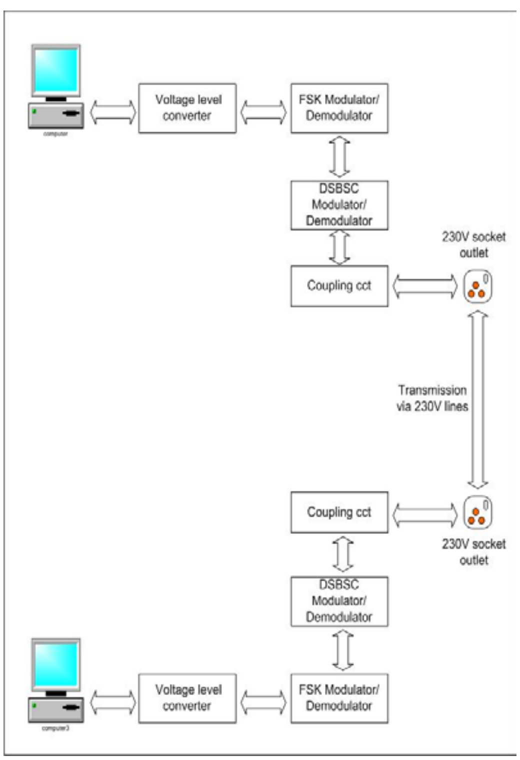

Figure 1. Schematic Diagram of PLCC System

6.1 FSK modulation circuit:

FSK modulation is performed by the application of a Voltage Controlled Oscillator (VCO) IC, the XR-2206. A voltage controlled oscillator produces an AC waveform of which the output frequency is directly proportional to the DC input voltage. The resistors and capacitors are selected such that they will produce the required mark and space frequencies. By using the binary waveform as the input to the VCO we can vary the frequency of the output sinusoidal giving FSK modulation. The system is designed to operate at a mark '1' frequency of 30kHz, and a space '0' frequency of 15kHz.

6.2 FSK Demodulation Circuit:

FSK demodulation is performed using the Raytheon Devices RC-2211N IC. This IC is based on a phase locked loop topology.

6.3 Spread Spectrum Modulator:

Spread-spectrum modulation and demodulation is performed using the MC1496 IC from National Semiconductor. This IC performs DSB-SC modulation and demodulation. External components are selected such that the transistors internal to the IC are biased correctly for linear operation.

6.4 Spread Spectrum Demodulator:

This circuit is a slight modification of the spread-spectrum modulator circuit.

6.5 Spread Spectrum Carrier Generator:

The spread spectrum carrier circuit is based on EXAR ICL8038 function generator IC. This IC can generate a triangle, sine and square wave of which frequency varies with input voltage and values of external component.

6.6 RS-232 Driver/Receiver:

The RS232 line driver circuit is based on the Maxim devices MAX232 IC. This is used to interface the modem to the host computer's serial port. The serial port uses +15V to represent a binary '1' and -15V to represent a binary '0'. The RS-232 driver circuit converts these voltages to and from the +5V and 0V binary values suitable for the rest of the modem.

7. CONCLUSIONS:

This project has been a successful one with all project aims and goals are met, except for the FSK Modulation stage.

Addressing the individual project goals, a number of conclusions can be made.

- After detailed studies, we have gained an in-depth knowledge of the issues faced with power line carrier communications.

- We have addressed possible methods to overcome these issues, mainly noise and attenuation caused in the power line.
- We introduced the possible uses of PLC techniques.

The PLCC system we designed is a primary stage of a home networking system in which we tried to send a data from one computer to another which are installed in the same building.

A successful power line carrier communication link could be created by the addition of frequency hopping , variable gain stage and error correction techniques.

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