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X10 PROTOCOL BASED POWER-LINE AUDIO COMMUNICATION AND AUTOMATION SYSTEM

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Abstract — This paper serves as a general and technical reference to transmission of audio using a power line carrier communication system which is a preferred choice over wireless or other home networking technologies due to the ease of installation, availability of AC outlets, higher throughput, low cost, reliability and security. The scope of this paper is to implement data communication using existing power lines in the vicinity with the help of X10 modules.

Here in this project wired type of communication is used. But transmission is done on existing electrical line of 230 volts. This paper is about power-line voice communication over the low-voltage network. Power-line communications is the use of in-house power supply network for communication perseverance. Power-line network has very widespread arrangement in every building and power-line is developed for transmission of power at 50-60 Hz and 230 volts. Hence use of power-line network for transmission of voice with power supply has increased considerations. The communication approach that eventually could be used for voice transfer over the power-line network is described. Power transmission is achieved by using the principle of superimposition of voice over power in power-line cables. The structure described can be improved and reformed for future requirements.

In this paper DTMF decoder and encoder as well as micro controller in this project to pursue AUTOMATION. X10 protocol is used for communicating in between transmitting and receiving modem

I. INTRODUCTION

To achieve communication between any two points, several paths are available. However, of lately the traditionally used channels have come to a saturation level and there was need to explore new kind of technology which is simpler to implement and is not as expensive as other related technologies. The basic idea of power line carrier communication system (PLCC) is to use the existing power cable infrastructure for communication purpose. This system will mostly be implemented in small areas such as residences, offices, etc. and with the use of this system; various kind of devices can be controlled remotely. The main benefit of this system stands to the residential users of making their dream of automation of their house. With just a simple set up of a transmitter and receiver, and ensuring equal phase supply, one can control a host of devices and enjoy the leisurep of living in a fully automated house. Another major factor is the ubiquity of the medium - power outlets are commonly found and available throughout the house or the office and may very well serve as communication nodes. The external electrical grid can also be used for many applications whose solutions provide many opportunities for equipment vendors and utilities to offer new services, features and products, cut costs of current services, fully automate manual processes and procedures. It can also be used to improve current products, monitor and collect valuable data, offer remote service options and create new business and revenue streams utilizing the existing infrastructure [1].

The scope of this paper is to implement audio communication using existing power lines in the vicinity with the help of X10 modules. The system basically consists of two modules, a transmitter and a receiver that can communicate with each other using the existing power cables in residential and commercial areas. This paper elaborates the transmitter end and receiver end of the PLCC system.

The paper is organized as follows. Section II discusses various PLCC standards. Section III explains the technology used and Section IV presents the system design considerations. The advantages, disadvantages and applications are mentioned in Section V. Conclusion and future enhancement explained in section VI.

II. PLCC STANDARD

There are various standards available that involve modulation of the signal using carefully selected frequency range. These standards also provide robustness to the system to work properly under any conditions, since power lines may have many undesirable influences on the communication systems. These standards are briefly described as follows.

2.1. Consumer Electronics Power Line Communication

Consumer Electronics Power Line Communications Alliance (CEPCA) is a PLCC standard being developed by Sony, Mitsubishi and Panasonic. CEPCA is expected to deliver speed up to 170 Mbps using existing power lines

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2.2. European Telecommunications Standards Institute

Consumer European Telecommunications Standards Institute (ETSI) will progress the necessary standards and specifications to cover the provision of voice and data services over the mains. Power transmission and distribution network and/or in-building electricity wiring, the standards will be developed in sufficient detail to allow interoperability between equipment from different manufactures and co-existence of multiple power line system within the same environment.

2.3. Home Plug Power Line Alliance

The Home Plug Power Line Alliance has defined a number of standards that are mentioned as follows. Home Plug 1.0: specification for connecting devices via power lines in the home. Home Plug AV: designed for transmitting HDTV and VoIP around the home. Home Plug BPL: a working group to develop a specification for to- the-home connection. Home Plug CC: Command and Control is a low-speed, very low-cost technology intended to complement the alliance's higher-speed power line communications technologies. The specification will enable advanced, whole house control of lighting, appliances, climate control, security and other devices.

2.4. X10 Communication Protocol

X10 communication protocol is developed by Pico Electronics. It is an international and open industry standard for communication among devices used for home automation. It primarily uses power line wiring for signaling and control, where the signals involve brief radio frequency bursts representing digital information [2].

III. TECHNOLOGY USED

This system uses the X10 protocol. The advantages of using the X10 protocol is that all the components are designed to work with the existing power lines. X10 products are available from a number of manufacturers, and the range of devices that are available provide a variety of applications that can be achieved using simple plug-in or wire-in modules. X-10 transmission is synchronized to the zero crossing point of the AC power line. The design goal should be to transmit as close to the zero crossing point as possible but certainly within 200 microseconds of the zero crossing point. The X-10 powerhouse power line interface modules PL513 and TW523 provide 60 Hz square wave with a maximum delay of 100 microseconds from the zero crossing point of the AC power line. The maximum delay between signal envelop input and 120 kHz output burst is 50 microsecond. Therefore it should be arranged that outputs to the PL513 and TW523 be within 50 microsecond of this 60 Hz zero crossing reference square wave. The PL513 and TW523 modulate their inputs with 120 kHz, therefore only 1 ms “envelope” need to be applied to these inputs. These 1 millisecond bursts should actually be transmitted three times to coincide with the zero crossing points of all the three phases in a three phase distribution system. Fig below shows the timing relationship of these bursts relative to zero crossing.

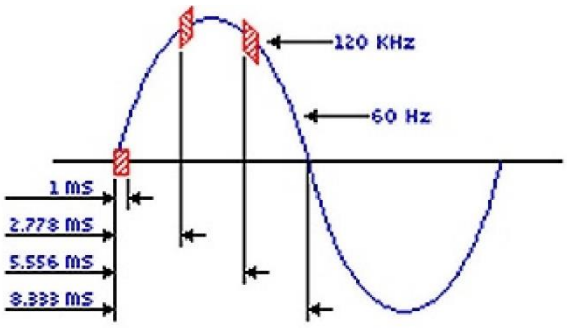

Fig. 23 Timing relationship of X-10 signals

There are two different ways by which we can connect a PLC unit with the power lines – capacitive coupling and inductive coupling. In capacitive coupling, a capacitor is used to superimpose the modulated signal on to the network’s voltage waveform. Another way is inductive coupling which employs an inductor to couple the signal with the network’s waveform.

No physical connection is required to establish inductive coupling. This makes it safer as compared to capacitive coupling. However this method has higher tendency to lose the signal during coupling.

IV. SYSTEM DESIGN

In power-line voice communication the module used for transmitting the signal is also used for reception. The Voltage control oscillator (VCO) present in Phase Lock Loop (PLL) is used to modulate the signal during transmission. The same PLL is used for demodulating the signal when the Module is working as a receiver. Due to this, when the receiver is aligned, the transmitter gets aligned automatically. The speaker used for receiving the audio is also used as the buzzer to alert the user.

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In the receive mode, the mains coupling unit separates the carrier signal present in the main line and passes it to the phase comparator input of the PLL transceiver. Since the free running frequency of the VCO present in the PLL unit is set to the carrier frequency, the frequency deviation in the carrier is reflected as voltage deviation at the output of the PLL unit. This will be the demodulated signal, which is amplified using an audio amplifier, and is fed to the speaker.

In the transmitting mode, the signal from the Microphone is fed to the VCO of the PLL unit. Therefore, the frequency of the VCO is varied with the instantaneous amplitude variation in the Microphone signal and appears at the output. This FM signal is then transmitted to the mains using the coupling unit.

4.1. MIC and Speaker:

The microphone (MIC) contains mouth piece for voice signals. It converts voice signal into suitable electrical signal. In the system design a condenser MIC is used for voice communication. The speaker converts electrical signal into suitable voice signal. This audio output device is for ring tone alerts at the other module. In this system a 20 watt 4 ohm speaker is used, which have hi-fidelity output handling capacity.

4.2. PLC transmitter:

In transmitter modem, the input is given through MIC, the audio signal is amplified in signal amplifier then given to PLC-X10 transmitting module. X-10 will detect the zero crossing then at zero crossing AC mains sin wave and audio signal will get superimposed then coupled with AC active line and transmitted.

4.3 PLC reciver:

At receiver side when the signal is detected the buzzer will buzz and if recipient will switch the plug to audio amplifier means recipient will pick up the call then transmitted audio will be output at speaker. For automation signal is further given to microcontroller and then respective relay will switch as per user input at transmitter using 3x4 keypad.

The DTMF encoder and decoder is the main part of automation.

4.4 Signal Amplifier:

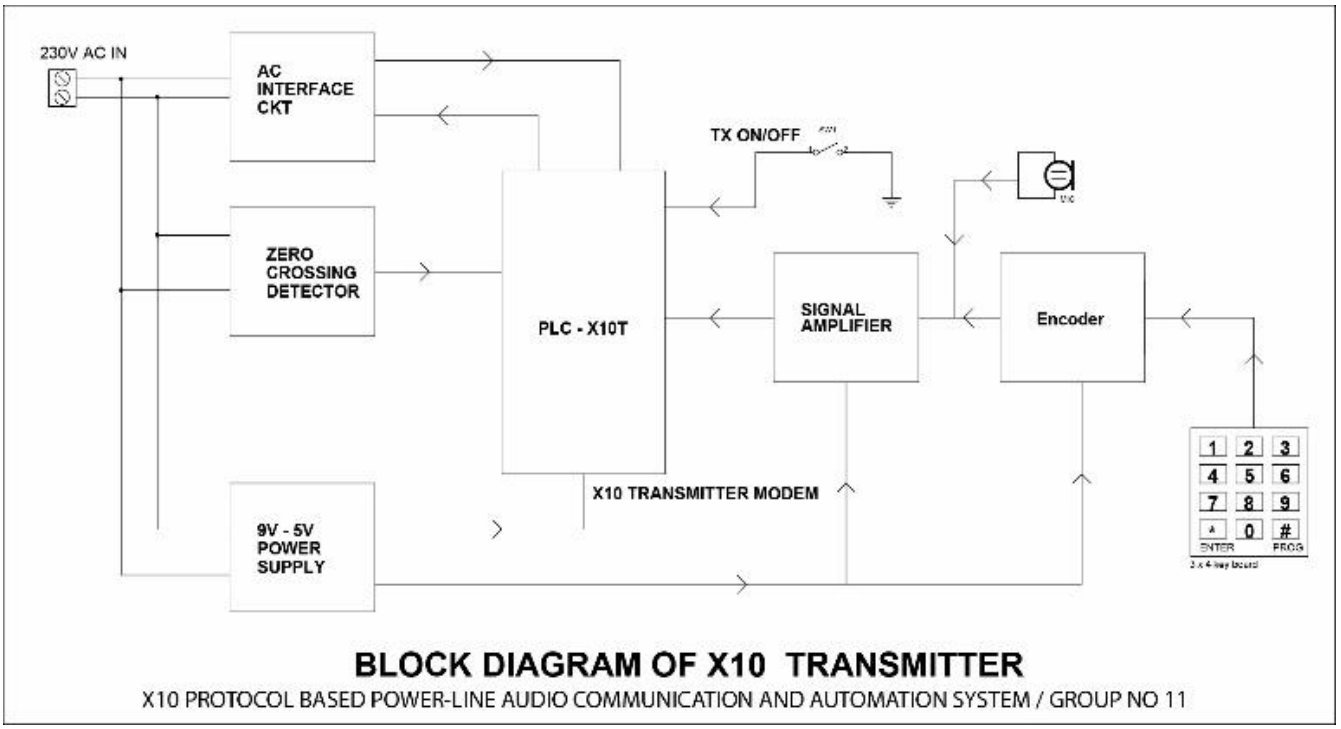
The audio amplifier amplifies caller and called party's audio signals with a gain of 200. The amplification is necessary as a voice signal has to travel long distance from one module to another. This block is bidirectional as each module receives/transmits voice signals simultaneously. The power amplifier provides the higher current necessary to drive speakers.

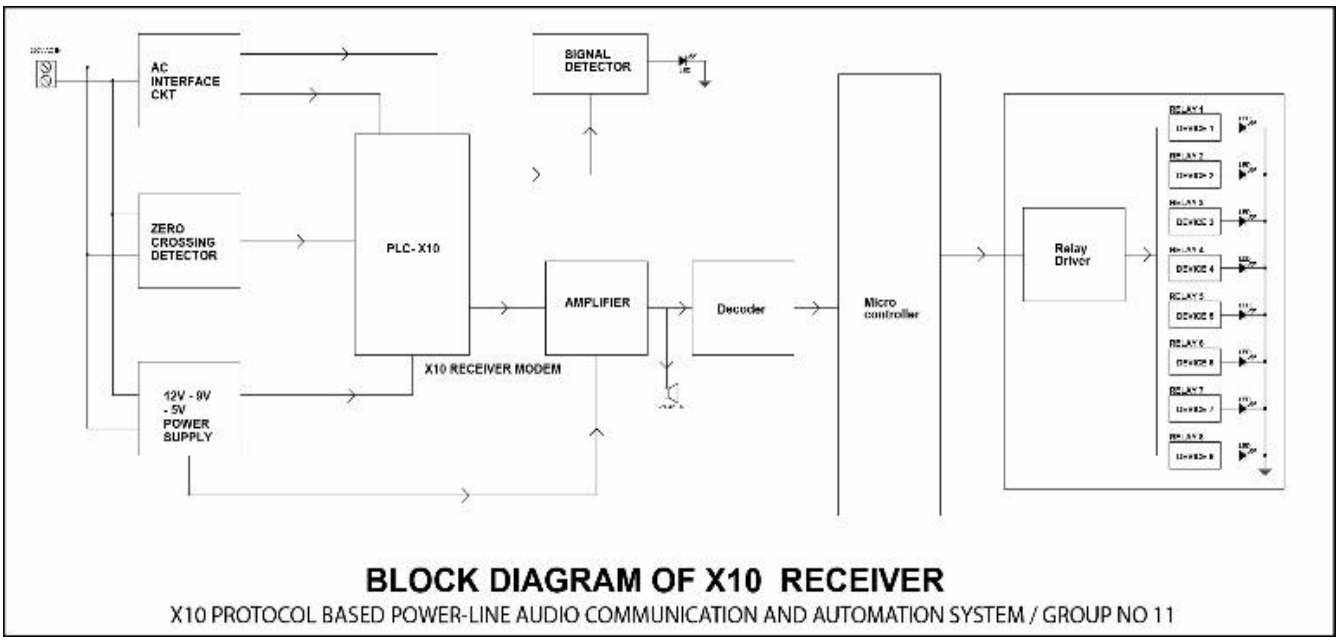
4.5 Amplifier:

A preamplifier is a component normally used with sound equipment to enhance the whole quality of the voice signal. Using preamplifier and the power amplifier, the Voice is not changed in quality, but it will be much louder. The preamplifier only supplies a voltage gain.

4.6 Coupling unit:

Coupling unit helps to connect the communicating module to the power-line. The purpose of the coupling circuits is to prevent the damaging of the communication modules by 50 Hz, 230 volts signal used for power supply. Also it confirms that the most important portion of the received/transmitted signal is within the frequency band used for communication.





4.7 Working:

The basic block diagram of the transmitter for data communication using power line carrier communication system is shown in Fig. The existing electrical layout is used to transmit the data or command for the proposed control system from one point towards other without any interference in the electrical signal within the same house. The system can be used to transmit a data signal in the frequency range of 3 KHz to 148.5 KHz. Since PLC is a audio communication device, The voice is modulated using any of the popular digital modulation techniques and after that it is fed to the amplifier. Soon after amplification the signal is given to the X10 module which has the inbuilt zero crossing detectors. As soon as the signal arrives to the X10 module it will sense the signal and according to the zero crossing occurs actual signal is transmitted. Later the signal enters to the power line through the interface circuit that includes a resistor and a capacitor. The coupling capacitor is used so that we can couple the 12V signal to the 230V signal so that the circuit will not get disturbed. The detailed block diagram of transmitter and reviver is shown in figure.

V. ADVANTAGES, DISADVANTAGES AND APPLICATIONS

5.1. Advantages:

This section highlights the advantage of using power-line as transmission medium for in-house communication.

- Affordable and Easy to install: Power-line communication allows user to use their already existing electrical wiring to connect to the different devices. Hence does not require separate wiring for the purpose of communication.
- Mobility: This system can be helps for occasionally-connecting for communication and removing when not in use.
- Flexibility: Power-line communication extends connectivity to all electrical outlets in the home. The same electrical outlets that provide power will also serve as access point for the network devices.

5.2. Disadvantages:

The proposed system have some problems that have to be overcome and some aspects that have to be taken into account to realize a successful communication. They are listed as below

- Minimum-security levels: Power-lines do not necessarily provide a secure media because each electrical sink inside a building acts as access point for communication.
- Voice attenuation: Due to the presence of numerous elements on a power-line network, voice attenuation is likely to be an issue.
- Noise: The greater amount of electrical noise on the power-line limits practical transmission speed.

5.3. Application :

- Accessibility -The power line communication finds many applications because of its easy accessibility. This communication can be stretched to areas where telephone lines cannot reach. .In advanced future prospects we may be able to enhance the system by providing multiple receivers.
- Home Automation By using the loads as switched and controlling different appliances will give rise to the home automation technology for the new smart homes and offices. The typical applications of in-house power-line Voice communication is that, this system allows easier and more efficient Voice communication between the end users inside a building.

VII. CONCLUSION AND FUTURE ENHANCEMENT

6.1. Conclusion:

The transmission voice through power-line concept has many advantages and adds new aspect for communication. The system is inexpensive when compared with other technologies for example wireless technology for in-house application. This system also has high potential in terms of innovation and commercial value due to the uniqueness and the effectiveness. The power-line communication is a valid technique that allows the exchange of voice by means of the power-line cables that are present in every dwelling and in every building. Information transmitted through the power-line can be used to share voice and also to control home and building automation systems. Equipping a home environment with a smart power-line communication system will increase the comfort. A smart home system can improve the independence in the every day's activities, in a comfortable environment which is very personal and peculiar for everyone, in any case different from a hospital like setting. A communication system using power-line communication is successfully designed, implemented and tested.

6.2. Future enhancement:

The Voice PLC can be implemented with the security to the system. Besides that, for further research interfere that may occur in power-line should be concern and consider to avoid or reduce the attenuation and noise.

The application and future prospects can be summarized as follows:

- Low cost audio communication
- PC to PC files transfer
- Intercom system
- Industrial control system
- Home automation system
- Wireless security

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