Enhanced In-house Voice Communication over Power-Line Network

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Abstract- 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 voce over power in power-line cables. The structure described can be improved and reformed for future requirements.

Index Terms- Power- line Communication, Superimposition, Phase lock loop, Pre amplifier, Power amplifier

I. INTRODUCTION

The word Communication can be defined as the transfer of meaningful information from one point to another point over a medium or a channel. The power-line communication (PLC) refers to transferring the information using power-lines as the communication media or channel. The PLC has turn out to be a flexible approach to implement low cost and reliable networks in home and industrial environment. In PLC, the present alternating current (AC) power wires in a building work as a communication medium or a channel, by means of which information is transmitted from a transceiver toward one or more transceivers.

Subsequently no new wires are necessary for the purpose of communication in power-line communication systems. As a result it significantly decreases the difficulty and struggle of installation of new wires, mainly for in-house applications. This technology helps to perform communication between the devices by connecting each of those to the electrical plug installed in each room in a house.

In the voice PLC system the transmitter transmits the voice signal together with an alternating power having the frequencies of 50 Hz. The receiver receives only the voice signal. A power-line communication system typically operates by superimposing a modulated carrier frequency signal on the AC signal in a power-line.

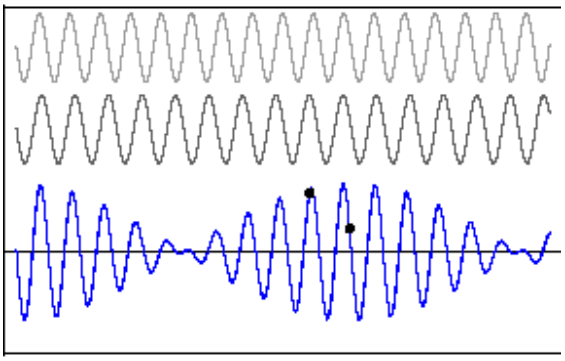

Fig 1: Superimposition of two signals

The superimposition of two signals is represented in the figure-1.The principle of superimposition possibly will be applied to signals whenever two (or more) signal moving through the common channel at the same time. The signals pass through each other without getting disturbed. The net displacement of superimposed signal at any point of time is merely the sum of the individual signal displacements.

In-housePower-line voice Communication is a method of transmitting voice signals at swiftness through a power-line in a building, which consist of three basic elements, firstly a transmission line that act as a channel for the transmission of carrier signal, next the coupling unit that isolates the device from the high-voltage transmission line finally the transmitter which modulates by adding the voice signal to the AC signal and receivers which demodulates by separating the voice signal from AC signal.

II. SYSTEM DESIGN

The Voice communication over Power-line is represented as shown in figure-2. 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.

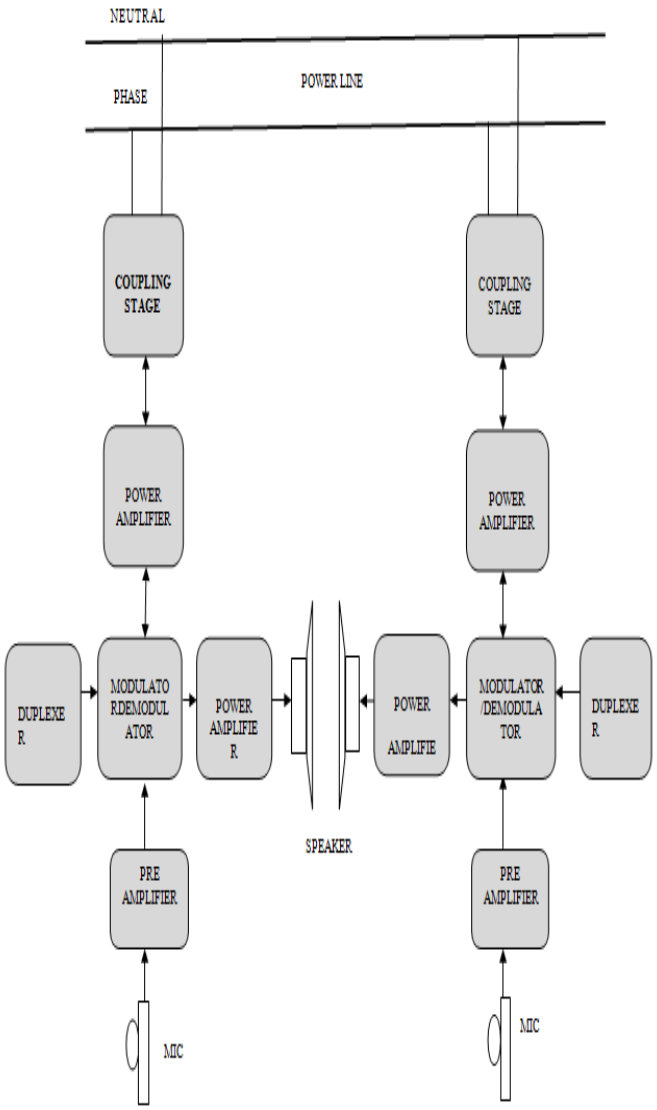

Fig 2: Block diagram of voice communication over power-line.

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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.

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.

PLl transceiver:

This Phase Locked Loop block transmits and receives voice signals, hence PLL is bidirectional and controlled by a switching block Duplexer. If duplexer is in receiving mode, ring tone is fed to Ring Tone Generator unit to alert the called party. If called party lifts the hand set, this unit switches to transceiver mode and hence allows both parties to make a conversation.

duplexer:

The duplexer is a multiplexer and acts as digital switch. This change-over-switch is fast enough to change each unit as signal transmitter and receiver, as per the need. When the voice signal is modulated while transmission, the Duplexer changes the PLL into transmitting mode and while receiving the voice signal is demodulated the duplexer changes the PLL into the receiving mode.

power 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.

Preamplifier:

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.

Coupling unit:

A 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.

III. TESTING AND RESULTS

The challenges faced in the PLC communication are noise, disturbances, power-line channel impedance variation, and signal attenuation. In the distribution network, the most common interference can be caused by the various house hold appliances and office equipment. The PLC communication system has a transmitter and a receiver with sufficiently low output/input impedance to approximately match channel impedance in the most operating situations.

Set up for Voice communication

The setup for Voice communication over power-line is as shown in figure 3 & figure 4. The Module1 and Module2 are transceivers connected to electrical sink at two different ends inside a building for voice transmission and this device is helpful in bilateral voice communication over power-line.

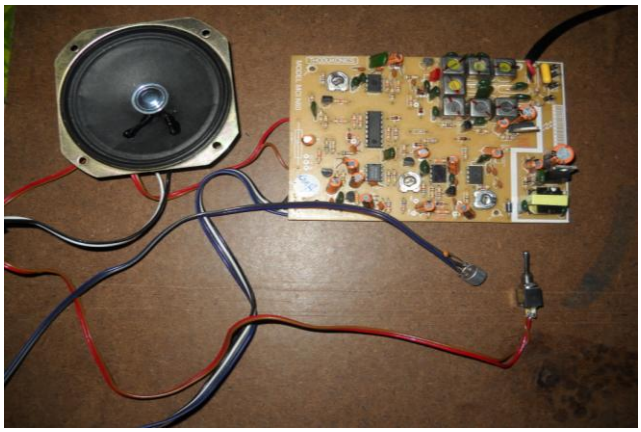

Fig 3: Voice communication transceiver Module1

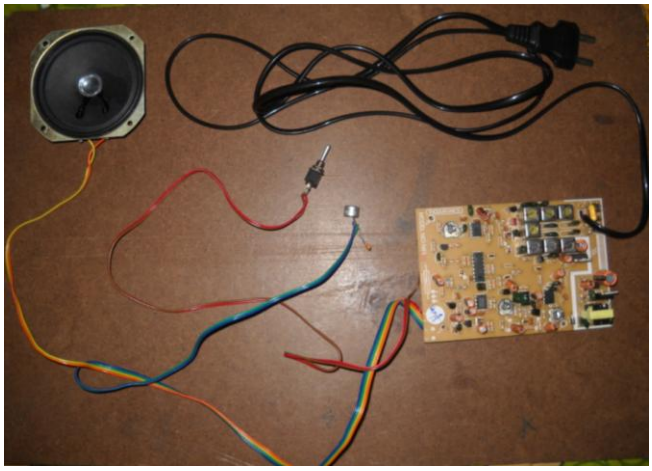

Fig 4: Voice communication transceiver Module 2

The designed Module is divided into these parts: Mains Coupling Unit, Phase Locked Loop Transceiver, Duplexer and Audio Amplifier.

The Mains Coupling Unit couples the voice communication unit with power-line. This unit also provides working voltage of 9V to the system and allows ring tone & voice signals to enter the gadget. The switch decides which section of the Module has come-in-to-action. When caller switches ON for communication, called party's system switch is in OFF state. In such situation the cradle switch activates PLL Transceiver section, such that ring tone generator gets activated and attract the called party's attention towards the Intercom. When called party switches on the PLL Transceiver with a digital change over switch Duplexer acts as telephone and switch over the Intercom circuit between listening mode and talking mode, as per the need. The Audio Power Amplifier circuit amplifies the ring tone and voice signals to a gain of 200.

Mains coupling unit provides the working voltage of 9V to the module and allows voice signals to flow between two units over power-line. The Mains step down transformer with voltage rating of 0-9V is used to draw the required voltage. This stepped down 9V across secondary winding is AC in nature but circuits need DC. Hence bridge rectifier is constructed using four 1N4007 rectifier diodes and gets rectified +9V across end points. This is further regulated continuously by employing two filter capacitors, 470µF/50V & 0.1µF and 9V rating zener diode.

The coupling stage uses coupling transformers between power-line and Voice communication unit. The incoming signals are filter using two 022µF/680V paper capacitors. The coupling transformer isolates the mains from +9V regulated DC and allowing only low frequency voice signals to pass through it.

Phase locked loop (LM567) is a tone decoder IC consists of a frequency voltage-controlled oscillator [VCO] and quadrature dividers which establish the reference signals for phase and amplitude detectors. The phase detector and VCO form a phase-locked loop [PLL] which locks to an input signal frequency which is within the control range of the VCO. When the PLL is locked and the input signal amplitude exceeds an internally pre-set threshold, a switch to ground is activated on the output pin. External components set up the oscillator to run at twice the input frequency and determine the phase and amplitude filter time constants.

The IC can be operated at supply voltages of 2V to 9V and at input frequencies ranging from 1 Hz up to 500 KHz. Pin 4 is supply pin, which gets its working voltage from coupling transformer through cradle switch transistor.

The phase-locked loop [PLL] Pin 2 is the combined output of the phase detector and control input of the VCO. Capacitor 1µF/50V in conjunction with the nominal 80Kohm pin 2 internal resistance forms the loop filter. For small values of the capacitor, the PLL will have a fast acquisition time and the pull-in range will be set by the built in VCO frequency stops, which also determine the largest detection bandwidth [LDBW]. Increasing the capacitor value results in improved noise immunity at the expense of acquisition time, and the pull-in range will become narrower than the LDBW. However, the maximum hold-in range will always equal the LDBW.

The Duplexer is nothing but a digital switch, whose switching action takes place only if any one of two inputs goes low. The CD4093 has Quad 2-Input NAND Gates which are acting like Schmitt Trigger and gets triggered whenever anyone input goes low. In this Module duplexer IC's three NAND gates are used to carry over the switching action between PLL Transceiver and Audio Power Amplifier with Speaker. The switching action is again depends upon the condenser Microphone, whose voltage variations are fed as input to two

NAND gates. It simply means no voice signals at Microphone end then audio amplifier with speaker comes into action.

Audio Power Amplifier with Speaker circuit is made using 8-pin Audio Power Amplifier IC LM386. It comes into action when cradle is ON-Hook to transmit Ring tone and in conversation to transmit called party's voice via loud speaker.

To make the LM386 a more versatile amplifier, two pins (1 and 8) are provided for gain control. A capacitor is put from pin 1 to 8 the gain will go up to 200 (46 dB). When using the LM386 with higher gains (bypassing the 1.35 KΩ resistors between pins 1 and 8) it is necessary to bypass the unused input, preventing degradation of gain and possible instabilities. This is done with a 0.1 µF capacitor or a short to ground depending on the dc source resistance on the driven input.

IV. APPLICATIONS, ADVANTAGES AND DISADVANTAGES OF VOICE PLC

Applications:

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.

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.

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.

V. CONCLUSIONS AND FUTURE ENHANCEMANTS

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.

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.

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.

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