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Development of intercom system using power line carrier communication utilizing existing AC electrical wiring

[1]Karthick.D.M

[1]PG Student, Dept. of EEE, Jayam College of Engg. & Tech, Dharmapuri, Tamilnadu, India

Abstract *– Telephony system is been a existing for decades, but till today the user has to rely on some service provider for communication. Nowadays the power line network has globally evolved so that they are present even in remote localities. So the idea of making use of existing power lines as a communication channel for telephony system is proposed in this article. Although this system cannot be utilized for long distance communication it can be used for small businesses, offices, home and organizations instead of a separate intercom system. An electronic interface with the power line network and its design considerations and practical implementation to the power line infrastructure is presented. The deal is to design a power line communication network for low voltage distribution lines. Here the existing electrical wiring of in-house power supply is utilized for voice communication. Power line network has developed and wide spread worldwide in every building and infrastructures. We develop a plug and play design so that the device can be portable and can be inserted into any electrical plug socket anywhere any time without need for any change in settings or adjustments. This voice over power line network is designed to operate at frequency of 50Hz and 220 volts AC supply.*

Keywords: Power Line Communication, Frequency Modulation, Phase lock loop, Intercom, Power filter, Carrier frequency, Audio amplifier, Harmonics.

I. INTRODUCTION

In most of the small companies wired telephone communication by telephone is a medium through which they can interact between company staffs and customers. For daily activities small telephony systems are used by companies but most available systems are designed to be most expensive and to accommodate large number of users. This system is looking for a reliable way and cheaper solution for small businesses and companies around the world. A voice over power line cable communication network approach is eventually used to transfer voice over the electrical wirings is described [1]. The principle of superimposition of power frequency and voice frequency is achieved by analog modulation technique and injecting high frequency modulated carrier signals into the power cables along with the low frequency of AC power.

Power-Line Communication (PLC)

Power line communication (PLC) is a term referring to transferring of voice or data information through power lines which acts as a channel or medium of communication [2]. A low cost and flexible approach to a reliable communication network in industrial and home environment is PLC. Information is transmitted from a transceiver towards one or more transceivers are by means of alternating current (AC) power wires that work as a signal medium.

As a subsequent advantage no extra wires are necessary for making of power line communication systems, which results in significant decrease in struggle and difficulty of installation in power line communication systems. Thus this kind of technology promotes ease of communication between any devices by connecting each other by means of electrical sockets installed in every room in a house [3]-[5].

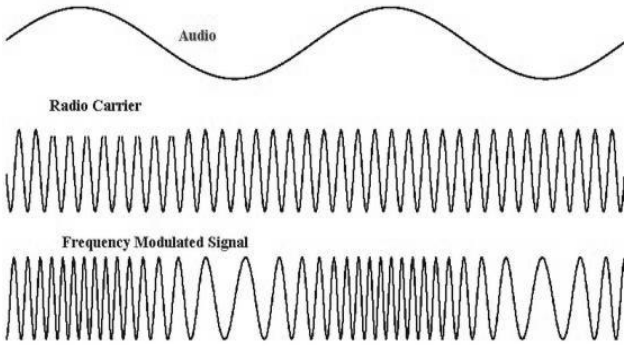

Figure 1: FM Carrier Modulation

In a typical PLC voice system there is a transmitter unit which transmits alternating power frequencies of 50Hz along with voice signals together. The receiver receivers and filters only the voice signal frequencies form the power frequency. The superimposing of a modulated carrier frequency signal with an AC signal is done in the PLC modulator circuit. The modulation used in PLC communication is analog type frequency modulation technique which is highly resistive to interference and noises.

A wave representation of superimposition of audio signals with carrier signal is represented in the figure 1. The superimposition principle is applied to these signals whenever two or more signals are passing through a common communication channel at a same time [6]-[8]. But these signals pass through each of other of them without any disturb in their shape. The total displacement of a superimposed signal at any point of time period is just the sum of individual signal displacement at that point of time. Power line voice communication is a method of transmitting speech signals at high speed through a power line in any building or indoor structures. It consists basically of three elements; first one is a transmission line which acts a channel for transmitting of carrier signal. Second one is a coupling unit which isolates the device hardware form transmission line high voltage. Finally the transmitter modulates by mixing AC signal with the voice signal while the receiver separates the voice signal form AC signal [9].

II. FUNCTIONAL BLOCKS

Block of complete power line voice communication architecture is represented in figure-2. The module that is used for transmitting signal is also used for reception in a power line communication system. For modulation of the signal in transmission, a voltage control oscillator (VCO) in a phase lock loop is used. When working as a receiver, the same configuration of PLL module is used for demodulating the speech signal. Thus the transmitter gets aligned automatically at the same time when receiver is aligned by locking to their phase [10]. For alerting the user while making a call the same speaker user for receiving the audio is used. The module designed for transmitting of signal in power line communication is also used for reception of signal. The inbuilt voltage controlled oscillator (VCO) in a phase lock loop IC is used for modulation the signal during transmission. When working as a receiver the same PLL IC is used for signal demodulation [11].

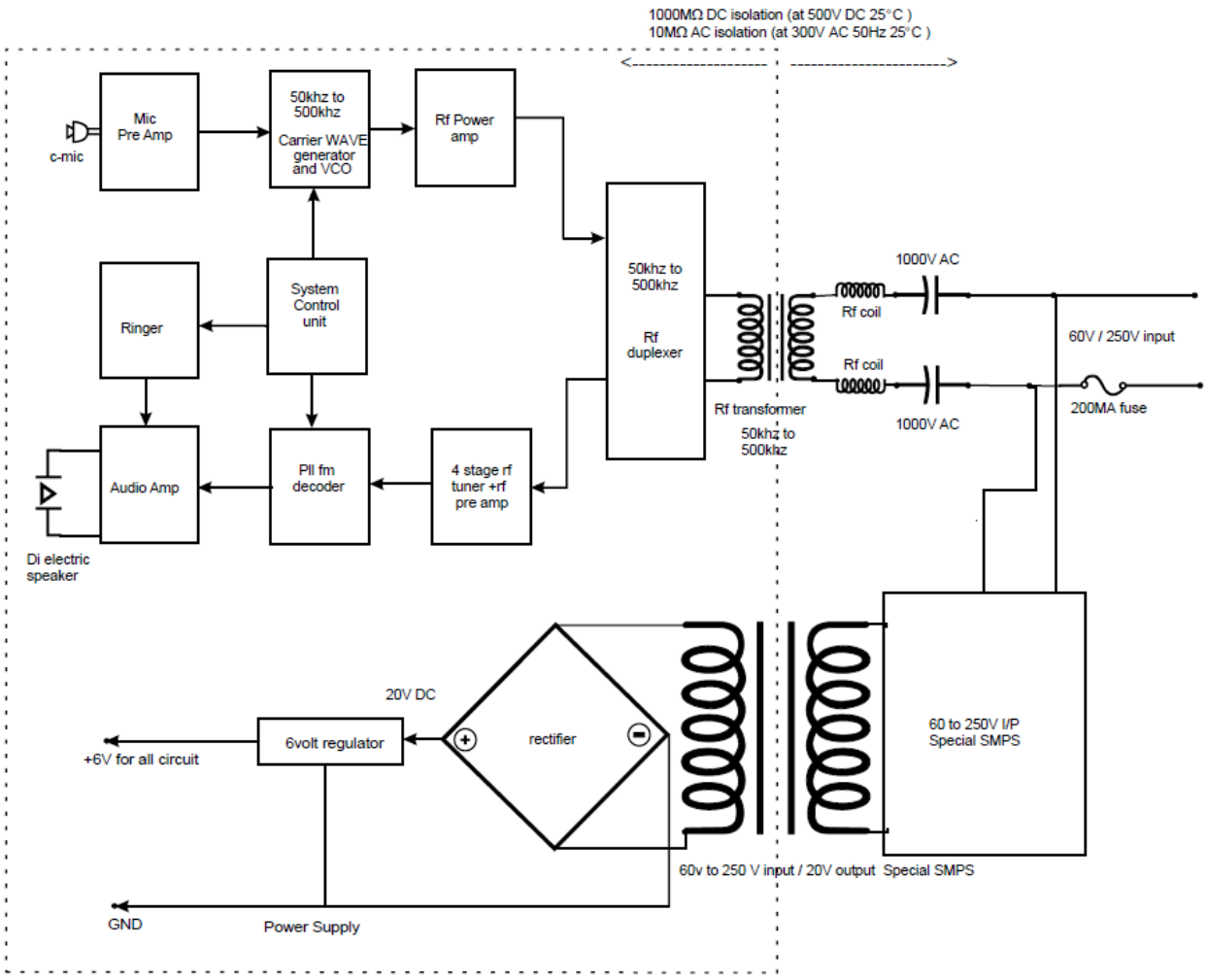

Figure 2: Block diagram of voice communication over power-line

During operation at the receiver mode, the high frequency carrier present in AC line is separated by the mains coupling unit. Then the separated carrier signal is passed to a phase comparator input in the PLL transceiver. The carrier frequency deviation in the carrier waveform is also reflected as voltage deviation at the PLL unit output since it VCO is set at a free running frequency. The output of PLL will be the demodulated signal which is given to an audio amplifier and heard through a speaker [12]. Speech signals from a microphone are fed to input of a VCO inside the PLL IC unit during the transmitting mode. The instantaneous variation of amplitude in VCO is reflected as variations of frequency of the VCO and appears at the output. As a result a frequency modulated (FM) signal is obtained at the coupling unit.

a) Microphone and Speaker

The mouth piece of a microphone (MIC) receivers the voice signals and converts them into corresponding varying electrical signals. In the proposed system design a condenser microphone is used for voice communication. A speaker is used for converting the electrical signals into voice signal through its diaphragm and coil. At the other module end this audio output device is used as ringer for tones. For hi-fidelity audio output handling a 25watt 8ohm speaker is used in the system.

b) PLC Transceiver Unit

This phase locked loop is bidirectional and controlled by a duplexer switching block and so can both transmit and receive signals. During the receiving mode operation of duplexer a ring tone signal is send to ring tone generator for alerting the party to be called. The unit switched to transceiver mode automatically when if the called party lifts the hand set and thus allowing both parties to make a conversion.

c) Duplexer Unit

Duplexer is a basically a multiplexer which acts as a digital switch whose change over switching is so fast that it changes each unit as a transmitter and receiver as per the signal. When a voice signal gets modulated during transmission then the duplexer switches the PLL into transmitting mode and to receiver mode if voice signals occur at modulator.

d) Power Amplifier

Audio power amplifier is one which amplifies caller and the other end called parties speech signals with higher gain of up to 200. For a weak voice signal to travel for long distance from one device to the other device an amplification process is necessary. This amplifier block both receives and transmits signals simultaneously and hence it is bidirectional. Power amplifier stage provides necessary high current for driving the speakers.

e) Preamplifier

For enhancement of quality of voice signal every sound equipments uses a component called preamplifier at the input. By usage of power amplifier and pre amplifier the quality of the voice and loudness also gets improved. A typical preamplifier only increases the voltage gain not the power.

f) Coupling Unit

Coupling unit provides an isolation and help connecting the communication module to power line. Preventing of damages to the communication modules from 220v AC signal is the main purpose of the coupling circuits. And also the confirmation of receiver and transmitted signals contain important information within the frequency band is done.

III. SCHEMATIC DIAGRAM

a) FM Modulator and Voice Transmitter Block

A power line has the main function of distributing electric energy. But here in this case a new high frequency signal is injected to power line. According to the FCC rule for sending data or signal through a power line a frequency between 65 kHz-75 kHz is used. A modulator circuit is used to send the audio signal in FM mode and demodulator circuit to decode the speech signal from the FM signal.

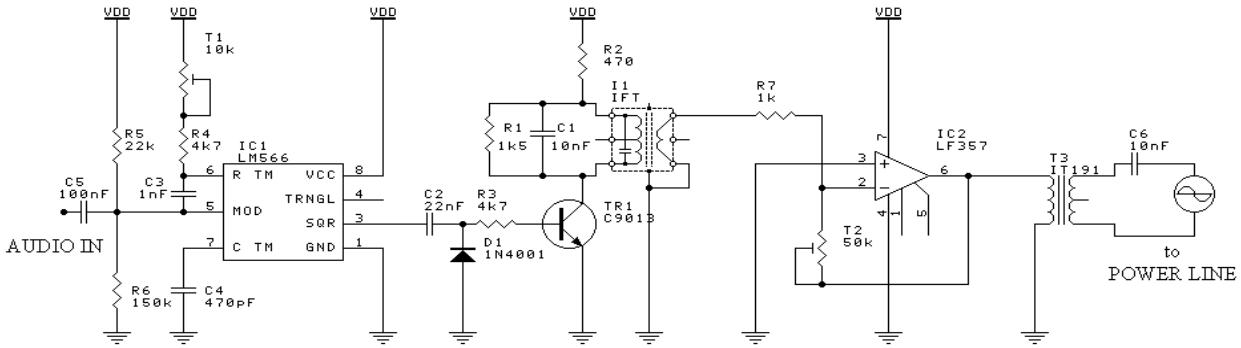

Figure 3: FM Modulator and Voice Transmitter Circuit

The electrical power flowing in a power line has a shape of sinusoidal wave and electrically it contains high amplitude and low frequency. So the injected signal not to distort the main AC signals the amplitude is maintained low.

But there are significant noise signals in power lines, so the amplitude of transmitted signal should be maintained higher and less than power line signals. Here a carrier frequency of 70 kHz is used in frequency modulation which is maintained within permitted range.

b) FM Demodulator and Voice Receiver Block

Most typically this system of voice communication allows the end to end users within a building to communicate easily and efficiently. LM358 an 8-pin audio IC is used to build the power amplifier along with a speaker circuit. When the cradle is ON-hook the audio power amplifier comes into action to transmit ring tone and in conversation to transmit caller's voice to loud speaker.

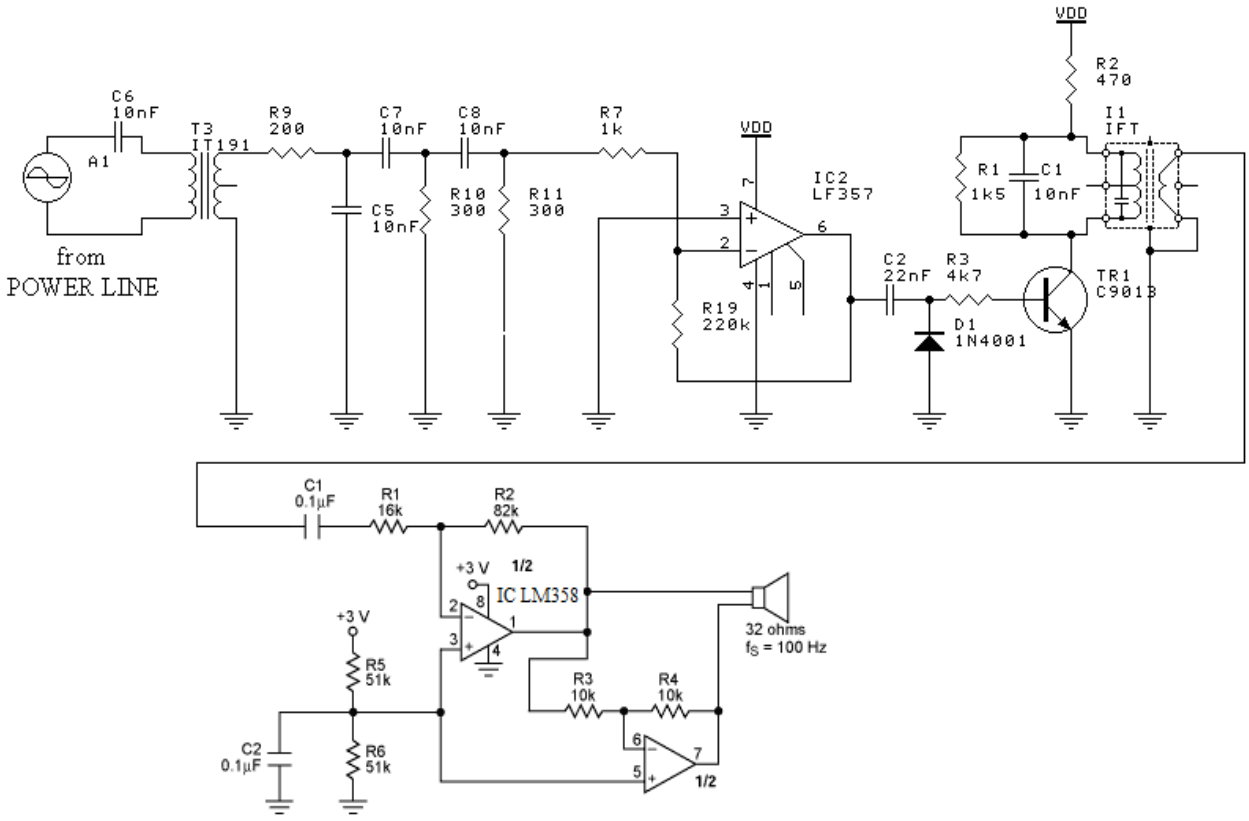

Figure 4: FM Demodulator and Audio Receiver Circuit

Two pins (1 and 8) make LM358 a versatile amplifier by providing gain control. For obtaining gain up to 200(46dB) a capacitor is connected from pin 1 to pin 8. In higher gain levels of LM358 a bypassing resistor of the 1.35 KΩ should be inserted between pins 1 and 8. It is also necessary to bypass the unused input pins when LM358 is used at higher gains to prevent degradation of signal gain and major instabilities. The bypassing is done by using a 0.1uF capacitor from the pin to ground of the DC source on the driven input.

IV.CONCLUSION

A prototype of the power line based intercom units are designed and tested. The pair of power line units is mounted with existing sockets from a single phase 220v power outlet and communication is tested. A maximum range of up to 150meters is achieved using a 1sqmm wiring cable of domestic wiring. Due to the higher gain the units should not be connected within a 5meter range which may damage them. A magnetic sensor at the handset provides automatic ringing of the intercom if it is lifted for call. Both units perform good with excellent audio quality without any noise interfere or distortion under normal house hold wiring. This design consumes very low power during operation and idle state, so the electric power consumption by this unit is negligible. Finally this prototype model can be used as a base for modeling real time power line intercom which can be used widely at almost any electrical lines at lower design and operating cost with outstanding performance replacing existing intercom units.

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