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Power Line Communication - For Home Automation

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Absreact:
The human brain is always craving for new things. Doesn't it always apply that the importance of anything is always lesser when you have it in hands. So goes with the existing alternating current (AC) power wires.
Power cables have been there from more than a century and all that we have managed to do in these years is to transmit electric power through them. The question arises: why not use them for some other purpose?
If somehow it becomes possible to utilize this power cable assembly for some other purpose, it will be revolutionary. The main point to be taken into consideration is that they are already available everywhere (as electricity cannot be transferred wirelessly as of now).
In this paper the focus is on using power cables as the only transmission medium required for data and voice communication. It also throws a light on how this can be used for building automation.

Keywords— alternating current, Power cables, Data communication, Voice communication, Transmission.

INTRODUCTION:

Power line communication (PLC) refers to the technology of using power cables as the communication medium for transmission of data and/or voice. The alternative use of power cables besides electric utilities is beneficial because it reduces the complexity, cost and effort of installing a new hard-wired communication system. Hence, it can be viewed as a desirable alternative to conventional hard-wired communication systems, which cannot be employed without dedicated wiring and intricate transmitter and receiver circuits.
In this fast changing world of information and communications technology, the need for building faster and reliable communication channels is increasing day by day. The people not only want to get over the congestion of the conventional communication networks but at the same time want to save money. In this scenario PLC fits like a glove.
The power cable assembly has many inherited features and characteristics, especially its wide coverage in urban area and even in remote and rural areas, which serve as a boon. Due to this, PLC has gained much importance and can turn out to be quite promising for many applications.

TECHNOLOGY USED:

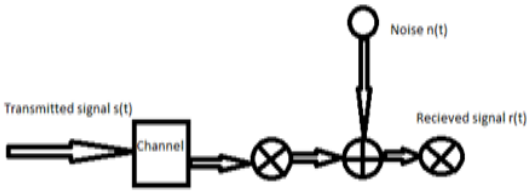
We are familiar with the fact that the main supply at our homes comprises of neutral and live wires. Live wire is used for supplying power and the neutral is only for carrying the unbalanced load, if any, as such there is not much role of neutral.
Here we are using this unused channel (neutral) as our medium for transmitting and receiving information. As this channel carries no load hence information can be easily transmitted through

it. Sending and receiving of information through home wiring can also light up the possibility of automating the appliances; hence one can manage the power of their house more smartly.

CHANNEL MODELING:

In the proposed system home wiring is used as the channel for transmitting and receiving signals. The signals sent over the channel need to be modulated for proper communication. The modulation should be between specific frequency range (20-200 kHz) for medium speed buses but the frequency of home supply is not so high. Various modulation schemes are available for this purpose such as-FSK (frequency shift keying), PSK (phase shift keying), OOK (on/off keying). Any of these techniques can be used according to the requirement.FSK is preferred as it is very simple to implement.

Moreover, while designing a PLC system, the impedance of the channel should also be taken in to account. The impedance should be maintained in such a way so as to transfer maximum power to the receiver. It is also impossible to predict the impedance of the channel being used here, so series connections of the channel can be employed. In other words, for signal transmission the channel (neutral) should be same between transmitter and receiver.

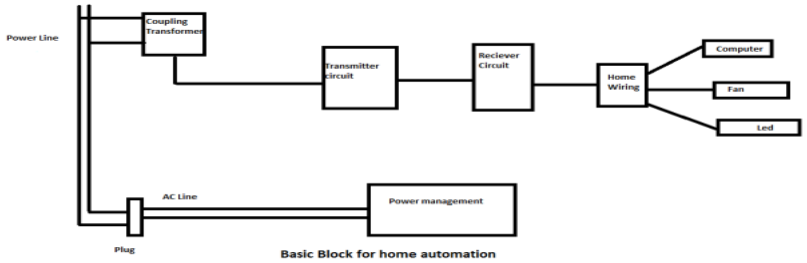


Proposed channel model with noise

AUTOMATION:

Automation through PLC is one of the most important advancements in the field of technology. There are innumerable appliances that we are using at our homes nowadays. Hence home networking technologies (PLC) can prove to be of great use.

For establishing the electrical networking, an extension can be used for connecting the existing home wiring to the circuit. The message to be sent is modulated; later the signal is amplified before it is coupled to the home wiring. The signal is further demodulated and selected by the filters on the receiver. This makes the remote controlling of home appliances through PLC very easy.



Basic Block for home automation

NOISE ANALYSIS:

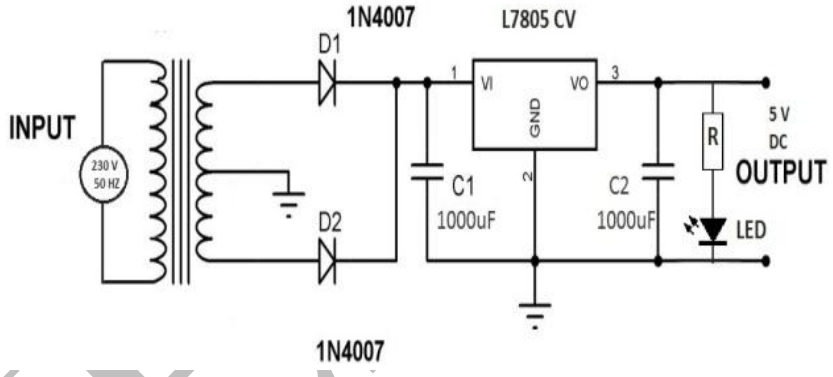
Noise is a very important factor whenever we are talking about any type of communication technique. Having the knowledge of noise characteristic in order to design a system with minimum noise is essential. DC power lines itself are very noisy, whenever we turn on a device these lines introduces impulsive noise which in turn effects the communication. Channel noise may also be caused due to static discharges, transients due to power supplies. The continuous ON/OFF switching of the circuit also causes some sort of noise. Under voltages, over voltages, frequency variations, harmonic distortions are some of the causes for wave disturbances .The transmitter and receiver should be developed in such a way so that they can be able to come up with these types of noises. The overall noise is the sum of noise by each component of the circuit, hence each component should be observed individually for minimizing noise.

PROPOSED SYSTEM DESIGN:

The system design is divided into following three parts:

1) Power supply unit
2) Transmitter circuit.
3) Receiver circuit.

POWER SUPPLY UNIT:



The proposed power supply unit for the PLC comprises of the following components:

1**)** A step down transformer is used to convert 220v ac into 6v ac along with 200mA current. The power is calculated by its V-I ratings which is 1.2watts.

2**)** As the transformer is center tapped, two 1N4007 rectifier diodes are used in cathode to cathode or anode to anode configuration to form a full wave rectifier. The rectifier has 2 peaks/cycle therefore it is best suited with single phase input.

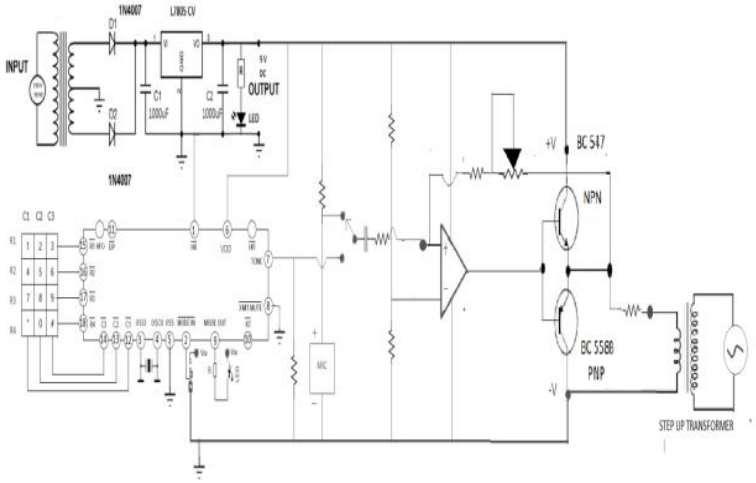
3) After rectification a unidirectional current can be obtained but the voltage is still not constant. For this problem a large value capacitor is preferred so that the troughs of ripple do not fall below the minimum voltage required by voltage regulator.

4) To ensure constant voltage IC L7805 CV is used which limits the voltage output to 5V. The maximum input voltage for this IC is 35V. The output current is 1.5A.

5) A capacitor filter is employed to steady the slow alterations in the output voltage

6) A LED coupled with its drive circuit is used to indicate the proper working of our power supply unit.

TRANSMITTER:

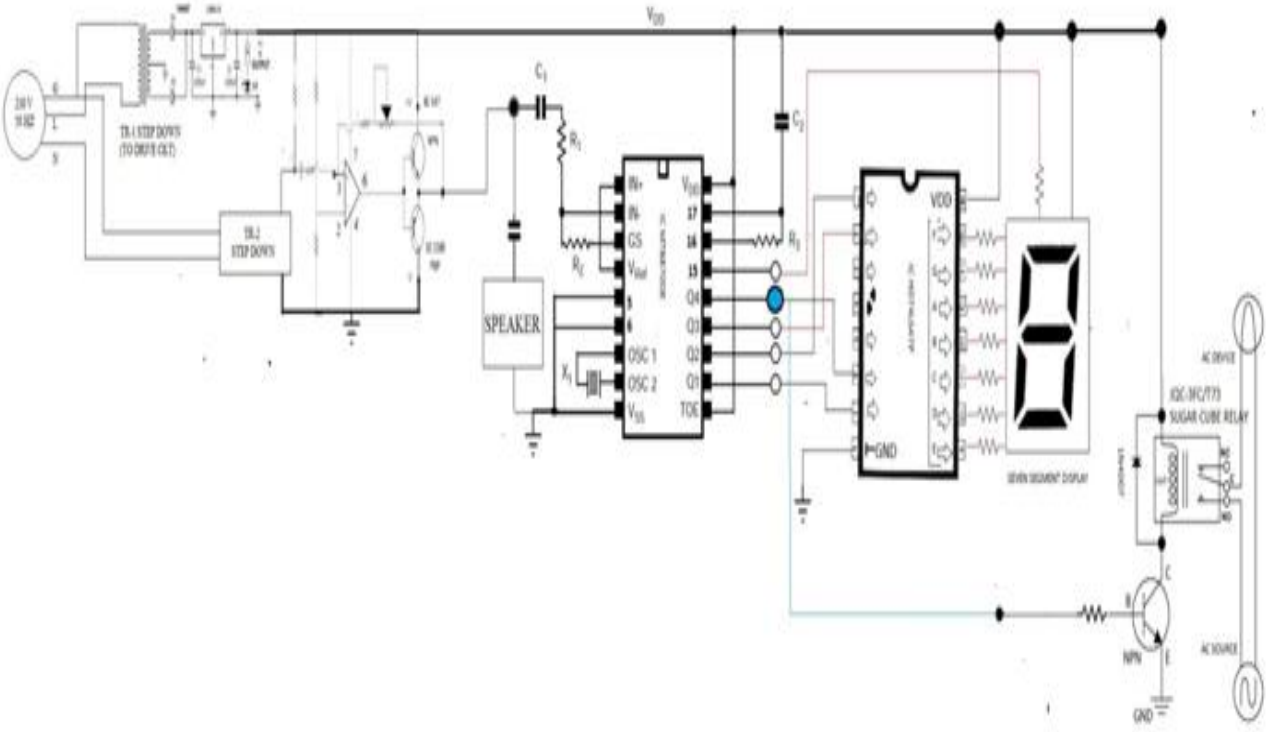


Transmitter section can work in two modes:
A) Voice transmission
B) Data transmission
Transmitter is powered through a regulated power supply unit which gives a supply of +5V dc. A change over switch (SPDT) is used for this purpose.

VOICE TRANSMISSION:
In case of voice transmission we use a microphone which converts audio signals to electrical signals and these signals are initially weak. To amplify these signals we use operational amplifier. The output is connected via a SPDT switch to IC UA741.
The output from microphone is given to the non inverting terminal of op amp IC.. The output from op amp is further amplified by the two transistors in class B Push-Pull configuration. Its has a pair of transistors BC 558B (PNP) and BC 547(NPN). The collector of NPN is connected to positive supply and the collector of PNP is connected to the negative supply. Both the transistors work alternatively. NPN works in the positive cycle and PNP works in the negative cycle. Output is available from the emitter of both the transistors. This output is now stepped up to the power line channel through a step up transformer. The output is carried through neutral and ground.

DATA TRANSMISSION:
Data transmission is done in digital form. A numeric matrix keyboard is used to input data. A DTMF signal generator (IC SC91214-dip 18) is used generate a DTMF tone in form of PWM (pulse width modulation). Here all the 9 inputs from the keyboard are connected to the inputs of the IC.
The output from DTMF generator is connected via a SPDT switch to IC UA741 which is an operational amplifier circuit.
Further amplification of op amps output is done by Push-Pull amplifiers which work alternatively. Output is available from the emitter of both the transistors. This output is now stepped up to the power line channel through a step up transformer. As in voice transmission, the output is carried through neutral and ground.

RECEIVER CIRCUIT:



The receiver circuit is designed to receive voice signals, data and signals for automation of any appliances and decode these signals for required use. The power supply unit gives a regulated supply of +5V dc to this section.

To receive the signals a step down transformer is implemented and a low voltage output is obtained. This output is generally weak so for amplification it is connected to IC UA741. Output of this IC is connected with the base of both the transistors present in Push Pull configuration. The collectors are used for the power supply. This configuration improves the signal and results in amplified signal.

This signal can again be converted into audio output through a speaker connected along with a electrolytic capacitor. Further, the output from the emitter of both the transistors is fed to the DTMF receiver (IC MT8870DE). It comprises of digital counting methods for detection and decoding of all DTMF tone pairs into a 4 bit BCD code.

The 4 outputs are available in BCD. These BCD signals are now passed through a seven segment decoder IC (HD74LS47) for displaying the data transmitted through the matrix keyboard.

When a numeric code is pressed by a user on the transmitter end, it transmits the signal through the power line. This signal is received at the receiver end by DTMF receiver and decoded by the 7 segment decoder for the numeric display.

The output signals from IC MT 8870DE can also be used for automation of any electrical appliance. The output of this IC is connected to the base of a NPN transistor BC 547B via a resistor. The emitter is grounded and collector is connected to relay JQC-FC/T73 input. And other input is connected to power supply. A diode 1N4007 is connected across the relay which protects the transistor from the high voltage produced when the relay is turned OFF.

APPLICATIONS:

1) Home automation - such as controlling lights, security systems and other devices inside the building.
2) Automatic Meter Reading -such as electricity measurement, water measurement, gas measurement and any other measurements in the whole system.
3) Traffic Light control- using PLC the efficiency of traffic control system can be improved. As it is automated it can automatically adjust to the timing required for the control of traffic.
4) Communications from the reception of a building to the rooms- One can communicate with the guests staying at the hotel easily and will be able satisfy the needs of the guests easily. Relay Protection- In this the relay is used to protect the transmission line from getting short and the PLC technology is used to control the relay properly.
5) Transport - Electronics in cars, trains and airplanes- This can be helpful in interacting to the passengers travelling also to give them the instructions during their journey time.
6) Voice and Data communications by using full duplex communication method - In this one can communicate from one other simultaneously without any discontinuity in the message.
7) Used in HAN (Home Area Networks) - In this all the appliances are connected in a mesh network through PLC and makes all the appliances automated. These appliances are also called as smart appliances.

LIMITATIONS:

1) Low user densities and large distances make it quite expensive.
2) Time to response and average distance for data transmission is inversely proportional.
3) Noise disturbance and signal attenuation due to distance and the quality of the power line severely impact the practical operation.
4) Modeling of PL Channel is difficult - It is very harsh and noisy transmission medium, time varying and is impaired by colored background noise and impulsive noise.
5) PLC faces competition from other means of communication- both wired and wireless. Ultimately the choice between these two will be decided by a mix of cost, complexity and feasibility. In present day Zigbee, Wi-Fi and GPRS are the major competing technologies to narrowband PLC.

CONCLUSION:

In power line communication we employ the power cables that are found in every dwelling whether urban or rural, as the communication channel for transmitting voice and data. People are doubtful about PLC because they have always seen these cables delivering power, not data. But they are unaware of its capabilities. It is appealing and gives a new dimension to modern day communication systems. This system is potent, innovative and unique. The cost is cheaper because of the available infrastructure. Also, it can work where radio frequency (RF) devices cannot.

The wide range of possibilities of wiring configurations in standard in-building power distribution networks, bring several challenges to the designer of the system. The typical problems include noise, attenuation on the power line, channel distortion and difficulties in interfacing components. To overcome these issues to an extent we have a variety of modulation techniques at our service. In general, PLC systems are reliable and feasible.

FUTURE ENHANCMENTS:

- In addition to data and voice, PLC can be employed to security systems by interfacing the control unit to a computer.
- Also, Broadband over power line (BPL) implementation would be a giant leap in communication field.
- PLC interfacing can also be employed in devices designed for disabled people, giving them high level of independence.

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