Load Monitoring using Power Line Carrier Communication (PLCC) Systems

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Abstract— The Power Lines today available were built for the purpose of power transmission from one place to another. The attempt to transmit data over these power lines leads to the reception of a lot of noise. This noise is due to the numerous devices connected to the power lines. An analysis of this noise and their characteristics helps us better understand how to tackle the problem of noise elimination in the Power Lines. The characteristics of the modulation techniques and their subsequent analysis gives us an idea of the advantages and disadvantages of each technique. The receiver contains a phase locked loop. We studied the modulation techniques and compared their performance in the present of noise. Finally Spread Spectrum technology is reviewed for the use of communications on Power Lines. Spread Spectrum is a method of signal modulation where the transmitted signal occupies a bandwidth considerably higher than the minimum necessary to send the information and some function other than the information being sent is used to increase this Bandwidth. Spread Spectrum was found to be unsuitable and rather detrimental for the PLCC system. This paper deals with the implementation of the power line carrier system based load controlling using LabVIEW. The new topology of speed control of induction motor using PLCC technology is successfully implemented in this work. This is the one of the method for controlling the speed, which is employed for AC motor drives.

Keywords: Power Line, Load Control, Communication, PLCC

I. INTRODUCTION

PLC i.e. Power Line Communication can be said as communication through power lines. These lines use power to carry the sound signals between the substations. This means instead of using the line laid for the local use by the companies are not used rather these lines help in communicating between just the stations and their respective place of purpose i.e. it covers the whole system under it. PLC is used for various purposes like speech, telemetering, teleprotection, teleprotection etc. The system can be basically divided into two i.e. outdoor and indoor equipments/systems where the Wave Trap, Coupling capacitor, LMU, Lightening Arrestor, Drainage Coil, and Earthing Switch comes under outdoor equipments and indoor. Equipments consist of the Exchange and the Carrier Terminals/Cabinets. The PLCC offers optimum utilization for signal transmission conserves spectrum space and has large transmission. PLCC also provides various applications like voice communication, telemetering, teleprotection etc.

Power Line Communications (PLC) is the use of existing electrical cables to transport data, and it has been around for a very long time. Power utilities have been using this technology for many years to send or receive data on the power grid using the existing infrastructure. For instance, the electrical power utility in London used PLC to remotely control some of its equipment on the grid (such as highvoltage switches) in the 1920s. This technique is still employed by several utilities that use analog or digital devices to transfer 9.6 Kbits/s over many miles of electrical cable. "Power Line Communications" basically means any technology that enables data transfer at narrow or broad band speeds through power lines by using advanced modulation technology. Our system will mostly be implemented in areas such as institutions, offices, etc. Power line communications can be used in office or home to

Interconnect home/office computers and peripherals, and home entertainment devices that have an Ethernet Port. Power line adapter sets plug into power outlets and establish an Ethernet connection using the existing electrical wiring in the home/office. (Power strips with filtering may absorb the power line signal.) This allows devices to share data without the inconvenience of running dedicated network cables. With just a simple set up of a transmitter and receiver, and ensuring equal phase supply, one can control a host of devices and eliminates the need for additional cables. The scope of this paper is to implement data communication using existing power lines in the vicinity with the help of KQ330F modules. The system basically consists of two modules, a transmitter and a receiver that can communicate with each other using the existing power cables.

II. PROBLEM IDENTIFICATION

A. The Challenge:

The power line was devised for transmission of power at 50/60 Hz and at most 400 Hz, the use of this medium for data transmission (especially at high frequencies) presents some technically challenging problems. It is one of the most electrically contaminated environments, which makes it very hostile for transmission of data signals. The channel is characterized by high noise levels and uncertain (or varying) levels of impedance and attenuation. In addition, the line offers limited bandwidth in comparison to cable or fiberoptic links.

Power line networks are usually made of a variety of conductor types and cross sections joined almost at random. Therefore a wide variety of characteristic impedances are encountered in the network. This imposes interesting difficulties in designing the filters for these communication networks.

B. Aim:

The project aims to thoroughly explore the theoretical and practical aspects of power line carrier communications (PLCC) techniques. To this end a number of specific goals were proposed at the start of the project.

- To gain a detailed knowledge of the challenges faced by PLCC techniques-why they are not a widespread communications method.
- To research and design a working PLCC system.
- To use the design and implement a power line carrier communications system that connects two microprocessor/micro-controller kits. The devices should be able to transfer data using the power lines as their only link of communication.

III. METHODOLOGY

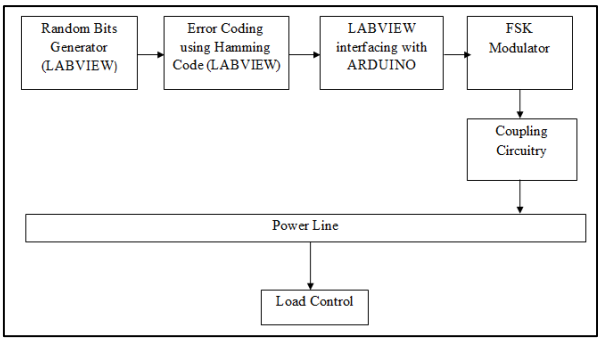

Fig. 3.1: Block Diagram of PLCC

A sequence of random bits with the use of Labview. This will act as the data given by the user which is to be transmitted to the receiver. Random bits are generated for illustration purpose. Random bits generator can generate bits form 4 bit to as many bits desired. These random bits which is considered as data cannot be directly sent over the power line because the data is bound to introduce an error due to noise present on the power line. Noise on the line cannot be curbed but the error introduced can be detected and corrected. For that Hamming codes are used which is capable of detecting multiple errors but can correct multiple errors. In hamming code check bits are appended at the end which will help the receiver to correct the error if any. Now we have a bit stream of data and check bits. We need an interfacing device will will help us interface the labview which is on the computer with the FSK modulator. That job is done by arduino. Arduino takes the bit stream from the computer and generates the same bit stream from one of its output pin. This stream of bits is now given to FSK modulator which will convert the digital data to analog form so that it can be sent over a power line. This is done because if digital data is sent over any channel then it will consume lot of bandwidth and the signal will also get corrupted very easily. FSK modulator converts logic 1 to sine wave of 2200Hz and logic 0 to sine wave of 1200Hz. Now our information is in the frequency of the sine wave. Noise on any channel affects frequency the least. So our data is safe but the power line is of high voltage so care has to be taken so that the high voltage does not enter the transmitter circuitry. For that coupling is done. Coupling provides the necessary isolation between low and high voltage.

The flow of data received is as follows: firstly, the resonance detection circuit detects the received signal; secondly, after the signal is isolated by transformer, the waveform is shaped by the resonant circuit; finally, the shaped signal is demodulated by the data module of FSK-KQ330, after the data is demodulated, it is sent back to the microcontroller through the serial ports [12]. In the receiving-data part, it has a zero- crossing detection circuit. The function of the circuit is to detect the frequency of the sine wave signal on the power line. When the level of the signal passes through the zero point, the microcontroller sends or receives data.

In the power line carrier communication system, the operation of the data transmitting circuit is described as follows: the FSK-KQ330 module's 8 pin outputs the square wave signal, and then it is coupled to the power line, after it is magnified and detected. The role of R1 and C1 is limiting the current. The transistor Q1 amplifies the signal. L1 and C2 constitute a resonant circuit. This role of the circuit is able to change the output square signal form FSK- KQ330 module's 8-pin into sine wave. Then it amplifies the signal from the transistor Q1; the function of the transformer is to isolate the interference and let the current to become lager.

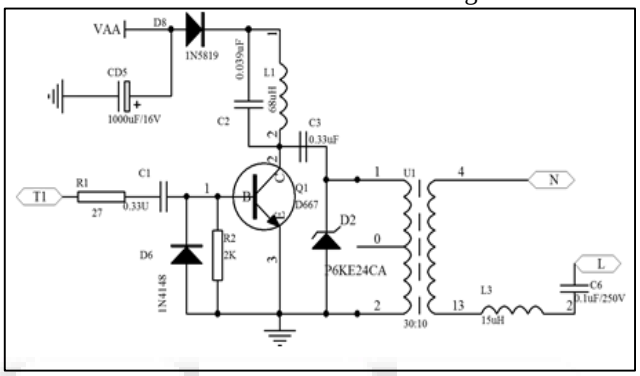

Fig. 3.2: Transmission Circuit

The data receiving circuit is mainly includes the magnifying circuit of triodes, the resonance detection circuit, the transformer isolation circuit, and the zero-crossing detection circuit. Receiving circuit is connected to power lines, and it sent the data signal to the module. The main function of the receiving circuit is detection. When the waveform signal is detected and is amplified, FSK- KQ330 module can identify the normal state.

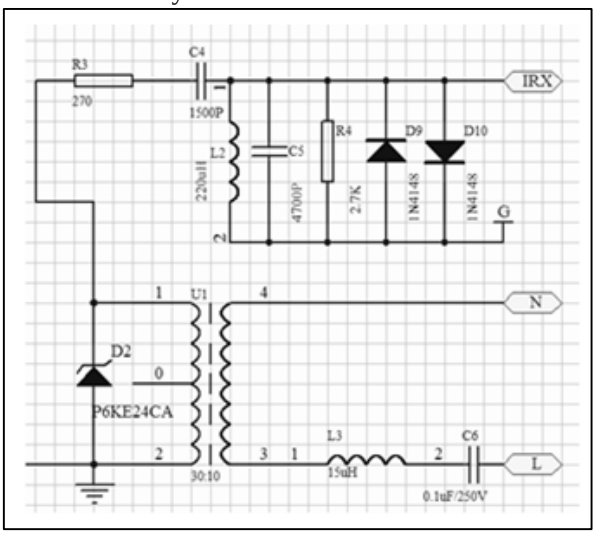

Fig. 3.3: Receiving Circuit

The workflow of receiving circuit is described as follows: firstly, the signal in power line enters the receiving pin (1 pin) of FSK-KQ330, after crossing the peripheral circuits. The function of the peripheral receiving circuit is that the resonant circuit selects frequency. Namely, it uses FSK-

KQ330 to identify the signal frequency. After the transformer isolating interrupt signal and the resonant circuit selecting signal frequency and amplifying signal, it uses two reverse diode which filter out the signal of too large magnitude to protect FSK-KQ330 module. Secondly, L3 and C6 constitute the resonance circuit, it can let the wanted signal produce resonance. The role of the resonance circuit is amplifying signal and detecting signal. It is the same as the function of the radios' resonant circuit which can extract the waveform of the signal; L2 and C5 also constitute the resonance circuit. Its roles is further amplifying signal and detecting signal to filter out the useless waveform signal. The role of two reverse diode (1N4148) is that limit the waveform amplitude and let it is less than 0.7V voltage. Therefore, the circuit can identify the useful waveform and protect the FSK- KQ330 module effectively.

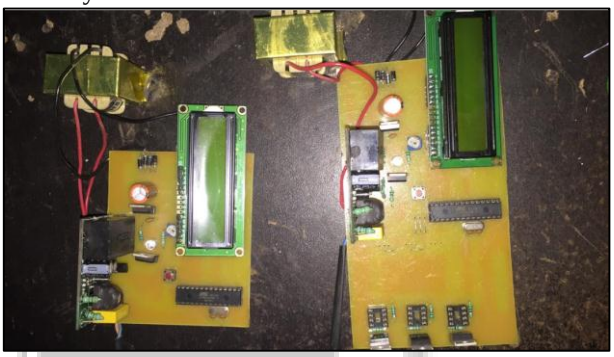

Fig. 3.4: Experimental Setup

A. KQ330 PLCC Module:

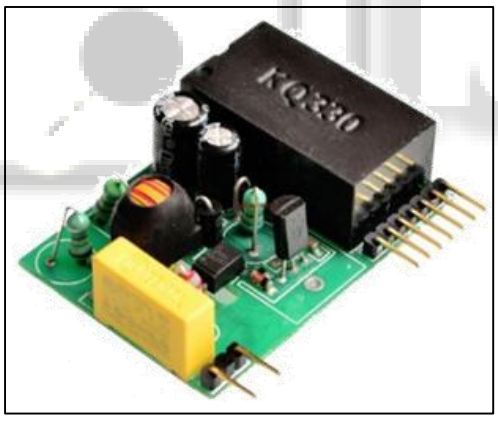

Fig. 3.5: KQ330 PLCC Module

The power line carrier communication system is designed based on a FSK-KQ330 (carrier modulation and demodulation module). The system uses STC microcontroller as the core processor and uses FSK-KQ330 as the modem module. The system includes the zero-crossing detecting circuit, the magnifying circuit of triodes, the resonant circuit and the transformer isolation circuit. Master-slave system can transmit data signals over power lines. It not only can apply to intelligent home system, but also can be used for the remote control of the intelligent switch and the intelligent equipment. The design of power line carrier communication system can be divided into data transmission and data reception according to the data flow [10]. Data transmission flow is as follows: firstly, the system uses the direct interface (serial asynchronous communication) of SCM and FSK-KQ330 module; secondly, after the transmission data is modulated by FSK- KQ330 module, through the external circuit (amplifier circuit and the resonance detection circuit), the square-wave signal changes into the sinusoidal signal; finally, after isolating the interfering signal, the signal is coupled to the power line.

B. LabVIEW:

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is created by National Instruments. It is a graphical programming language that uses icons instead of lines of text to create the applications. LabVIEW programs or codes are called Virtual Instruments. LabVIEW is used for data acquisition, signal processing and hardware control.

1) Random Bits Generator (RBG):

It is purely for simulation purposes that instead of giving any particular data, a random bits stream is applied at the input of the system. It is based on the principle of Bernoulli's noise. It generates a pseudo random sequence of one's & zero's depending on the probability p, which is given as a input. For example if p=0.7 then there is a 70% probability that the outcome of the Bernoulli's noise generator is 1.

$$P(X = i) = pi(1 – p)^(1 – i) \ (i = 0, 1)$$

Bernoulli noise is a special case of Binomial noise.

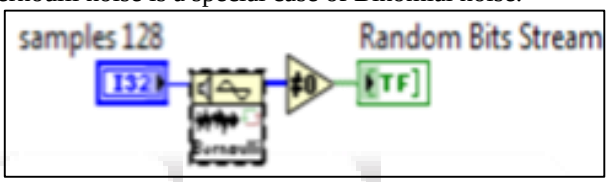

Fig. 3.6: RBG VI Block Diagram

2) Hamming Block Encoder:

Hamming code is a type of linear block code. A block of data has 'k' message bits and 'q' check bits. A random bits stream enters the hamming block encoder and output is data packets each of size 'k+q'. This 'k+q' is denoted by 'n' and is called the block size.

Where, n = 2q - 1 ; n>q k = n - q

These codes have d min = 3, which means that they can detect up to two errors or correct one single error.

Code rate : It is defined as message length divided by code word length.

Code Rate = Rc = k/n ;

Higher the code rate is better and becomes more efficient

M = message vector = (m1, m2, m3,....)1xk

C = check bits vector = (c1, c2, c3,.....)1xq

X = Code vector = (M | C)1xn

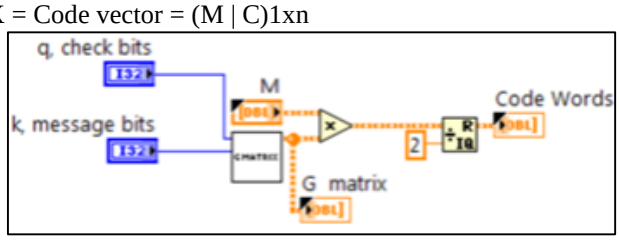

Fig. 3.7: Hamming Code Encoder

Speed control of DC motor using LabVIEW

C. Speed Control of Induction Motor:

Induction motors are the most extensively used in most power driven home appliances, agricultural and industrial applications. Because they are simple and rugged in design, low cost, low maintenance and direct connection to an ac power source are the chief advantages of an induction motor.

Many of applications need variable speed operation and one of them is a fan load. The PLC modem which generates the analogue output signal for corresponding button pressed using key pad. This analogue output is fed to PLC modem (transmitter) and sent through the power line. At the other end, plc receiver picks up the signal and feeds it to the signal decoder, there the decoding takes place and data is given to the Micro controller. The software in the Controller receives the signal and accordingly drives the MOSFET Circuit, which in turn is connected to load serially. The experimental work prototype model is built through the ATMEL microcontroller (AT 89S52) which is used to generate the PWM pulses for speed control of the half HP induction motor. The main aim of this work is to design a real time electronic control system that can be used to control the speed of motors kept at remote locations using an embedded system technology.

IV. RESULT

Fig. 4.1: LCD Display of data transmission through PLCC module

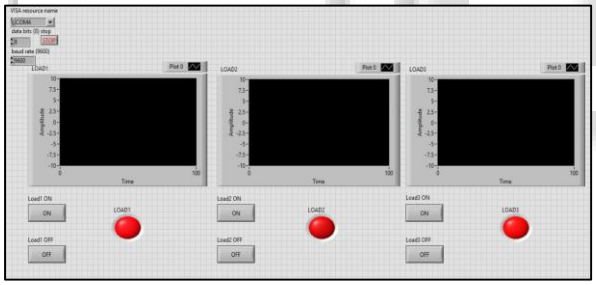

Fig. 4.2: LabVIEW front panel for load control through PLCC

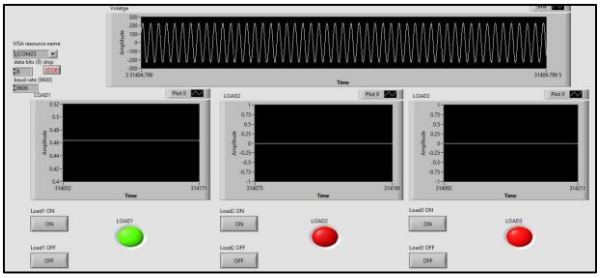

Fig. 4.3: Front panel when Load 1 is ON

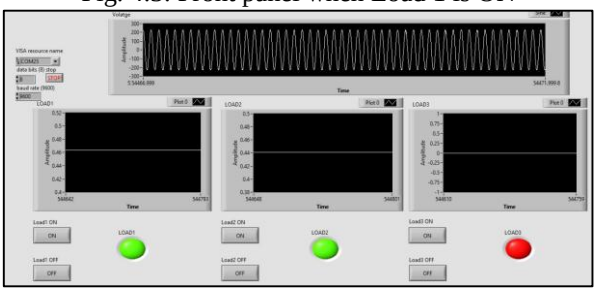

Fig. 4.4: Front panel when Loads 1 and 2 are ON

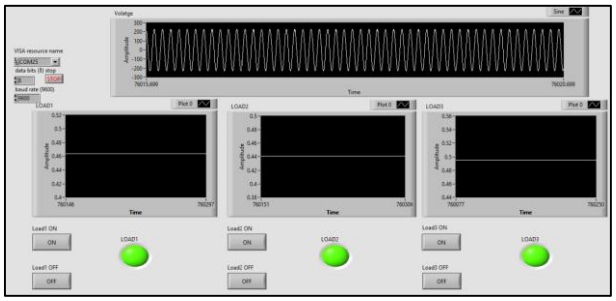

Fig. 4.5: Front panel when Loads 1,2 and 3 are ON Induction motor is connected on load 3

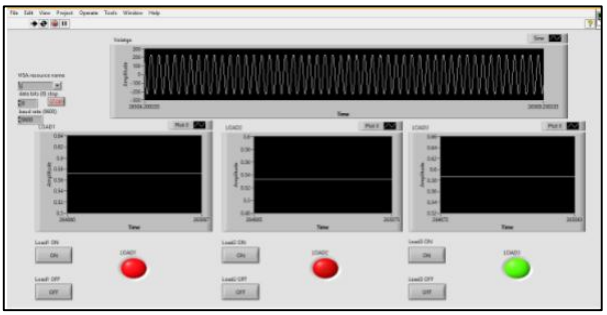

Fig. 4.6: At 100% frequency (speed) the current is 0.58 Amp.

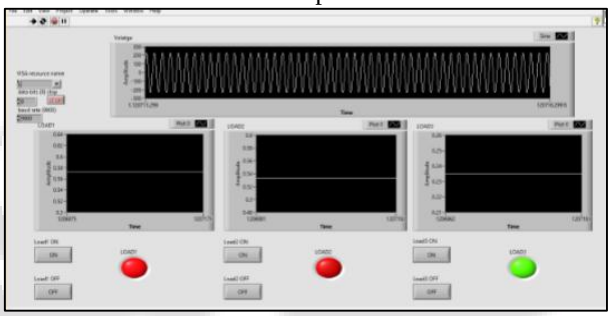

Fig. 4.7: At 30% frequency (speed) the current is 0.24 Amp.

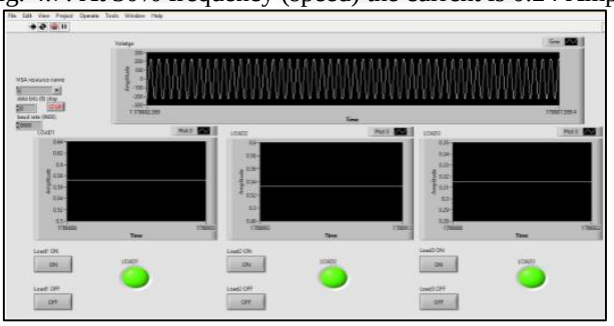

Fig. 4.8: At 70% frequency (speed) the current is 0.31 Amp.

V. CONCLUSION

The project has the capability of transforming the information highway in India. In a way that India has bypassed the land-line telephone revolution, the adaptation of PLCC can help propel India into an elite group of countries with a very deep Internet penetration. This would in turn help in dispelling the superstitions and ignorance that prevails in some of the backward areas of the country. India's image as a low cost development country in the world would get a major boost by the implementation of this technology on a wider scale. Power Lines Communication would result in a very large scale savings of the tax payers money. Efficiency of the existing infrastructure would be enhanced thus giving more

value for money. It aims to ensure that the PLCC system can be used as a plug and play device without any major investments on the part of the consumer. PLCC is a technology that has the potential to revolutionize communication and to change the lives of the citizens if factors such as cost, effectiveness and security are carefully handled. The new topology of speed control of induction motor using PLCC technology is successfully implemented in this work. This is the one of the method for controlling the speed, which is employed for AC motor drives. The speed control of AC motor is performed using PLC technology by the AT 89S52 microcontroller. It has high reliability and long life at low cost and compact.

VI. FUTURE SCOPE

A. Telecommunication:

Data transmission for different types of communications like telephonic communication, audio, video communication can be made with the use of PLCC technology. The user will be free to choose the necessary mode of communication.

B. Industrial Automation:

In an industrial environment the PLC communication networks can be used to give electric energy related services, such as meter reading, demand management and remote billing but also to give value added services like remote control and security, automation or even, education, information and e business opportunities. On the other hand it can also offer telecommunication services such as traditional telephony and Internet.

C. System Protection:

The communication link can be used to transit control signals that may be used to protect the system. For example, PLC can be successfully used in order to detect is landing operation of DER units.

D. Telecommunication Services:

Current PLC networks are able to reach speeds of 200Mbps. Telephony and Internet services can be delivered at high speed through broadband PLC networks. Traditional telephony uses Plesiochronous Digital Hierarchy, PDH. PDH uses Time Division Multiplexing, TDM. One possibility is to send the TDM frame over IP, and the voice over TDM, VoTDM.

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