Load Automation Via Power Line Communication

[illegible]tion Via Power Line Communication

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LIST OF ACRONYMS

PLC	Power Line Communication
AC	Alternating Current
DC	Direct Current
UK	United Kingdom
USA	United States of America
dB	deciBel
HF	High Frequency
TRIAC	Triode Alternating Current Switch
HV	High Voltage
MV	Medium Voltage
LV	Low Voltage
ASK	Amplitude Shift Keying
FSK	Frequency Shift Keying
BFSK	Binary Frequency Shift Keying
PSK	Phase Shift Keying
QPSK	Quadrature Phase Shift Keying
OFDM	Orthogonal Frequency Division Multiplexing
NBPLC	Narrow Band Power Line Communication

	d Band Power Line Communication
IEEE	Institute of Electronics and Electrical Engineering
CENELEC	European Committee for Electro Technical Standardization
AMR	Automatic Meter Reading
PLL	Phase Locked Loop
AM	Amplitude Modulation
FM	Frequency Modulation
PCB	Printed Circuit Board
IC	Integrated Circuit
UPS	Uninterruptable Power Supply
LED	Light Emitting Diode
AMI	Automatic Metering Infrastructure
DG	Distributed Generation
RF	Radio Frequency
V2G	Vehicle to Grid
EV	Electric Vehicle
PHEV	Plug in Hybrid Electrical Vehicle

ôPower line communicationô is a technology that sends data through existing electrical power cables alongside the electrical current. We aim at implementing the concept practically on a limited scale by means of an FSK modulated PLC system with its complete system design. In our project we shall design all the components and interface them together in order to create an indoor environment whereby appliances (loads) are controlled using Power lines. We have also worked on its computer interface and a method of monitoring / controlling the voltages and currents flowing in appliances.

Introduction

1.1 Introduction

Power line communication (PLC) means the communication over the low frequency voltage lines. PLC is a technology that employs the infrastructure of electrical power distributed system as communication medium i.e., data is carried on a conductor, as a mean of communication, that is also used simultaneously for AC electric power transmission or electric power distribution to consumers. The data to be sent is first preserved through communication techniques and is then fed to the line. The communication techniques are also required at the receiving end to get the same accurate sent data. It evolved soon after the widespread establishment of electrical power supply distribution systems. In the latest, typical household appliances are made to exchange information by transmitting data over the domestic mains wiring for useful purposes. As a result, there is no need to install extra control cables and appliances can be connected to the network simply by plugging them into the nearest wall socket. The main uses of PLC include transmission of broadband internet access to consumers and automation for household and commercial networks. It also finds its uses in remote protection of power systems, also called pilot protection. [1]

1.2 Historical Background

Power line communicationô history goes back to the distribution of electrical power for commercial purposes. Engineers and Scientists tried to use the power lines for others useful purposes for quite some time. It is said that the earlier developments in this regard were based on the 1910 demonstration by Major George Squier of the United States Army Signal Corps of his "wired wireless" technique for transmitting multiple telephone channels over one pair of wires.

is comparatively costlier. Telephone Circuits Telephone Lines were found to be unable to sustain the harsh weather conditions in the mountainous terrain and the extreme weather. In addition the electrical interference between the parallel power lines and the telephone lines was a case of concern. On the flip side the power Lines were much more robust and reliable. Since power lines were already available it made much more sense to use them rather than investing in the making of new lines. In the 1920ôs at least two patents were issued to the American Telephone and Telegraph Company in the field of ñCarrier Transmission over Power Circuitsò.

United States Patents numbers 1,607,668 and 1,672,940, filed in 1924 show systems for transmitting and receiving communication signals over three phase AC power wiring. Others have suggested that what was required for power line communication to move into the main stream was a commercialized version of military spread spectrum technology. It has been suggested that this is what was needed in order to overcome the harsh and unpredictable characteristics of the power line environment.

Commercial spread spectrum power line communication has been the focus of research and product development at a number of companies since the early 1980ôs. In 1950, one-way: town lighting, relay remote control at a frequency of 10Hz, 10kW of power was developed. In the Mid 1980s, the beginning of research into the use of the electrical grid to support data transmission on bands between 5 ï 500 KHz in a one-way direction took place. In 1997, first tests for bidirectional data signal transmission over the electrical supply network and the beginning of research by Ascom (Switzerland) and Norweb (U.K.) took place. Broadband over PLC only began at the end of the 1990s. In 2000, first tests of Broadband were carried out in France by EDF R&D and Ascom. [2]

The modern electrical world we are living in right now is changing rapidly and with each passing day the world is developing in the field of communication and electrical systems. From Edisonôs DC Generators to Teslaôs AC Supply System, from wired slow analog communication to swift digital wireless communication and from wired electrical supply to wireless supply of electricity the world is developing day by day. But even then we are stuck with long transmission lines with only one purpose to serve without sharing the burden of those billions of dollars we spend on fiber optics and other wired media for Broadband Internet and automation purposes. But then the engineers started working on the project to somehow broaden the use and purpose of power transmission lines. Due to these developments we heard about the Mangla Dam High Voltage Transmission Line communication Systems. Also, during our internship period we get to realize the problem faced by industry by using separate wires for the control and protection of thousands of their equipment. Therefore, the idea of using the same power transmission lines for the communication purposes simultaneously with the power signal seemed fascinated enough for a final year project. Not only the project title aroused curiosity with a sense of familiarity but it also created a feeling of wonder and awe, which was also quite a motivation.

1.4 Objective

The basic objective of the paper is the design and implementation of data transmission system over the low voltage domestic power lines. The paper includes the design of each and every individual component and systems along with the complete understanding of the total system. The paper would also discuss the problems and deviations faced by the designed system briefly.

PLC Methodology

2.1 Definition

Power line communication (PLC) is the use of the existing infrastructure of the electrical transmission lines to transmit communication signals delivering various services. The fundamental purpose of PLC is the transmission of high frequency communication data simultaneously with the AC power signals at 50 Hz or 60 Hz from the power plants to the end consumer.

2.2 Power Lines – A Communication Channel?

The power line has been designed for distribution of energy, the characteristics for data transmission are most unfavorable. An unpredictable and widely varying channel characteristics and electromagnetic compatibility restrictions are the major challenges for the implementation of power line communication. The harsh medium for power line communication is because of unpredictable and varying characteristics of time, frequency and location of a particular power line. Due to which the limited and inaccurate theoretical models of power line channels and its environment are one of the main reason for the slow development in this area. The main technical challenges associated with the implementation of PLC can be generally divided into three types;

- Signal Attenuation and Distortion
- Signal Noise

2.2.1 Signal Attenuation and Distortion

The varying impedance and the regulatory and the technical problems facilitate transmission of quite low data rates in the range of a few Kbits. Impedance is highly varying with frequency and ranges between a few Ohm and a few kilo ohm. At some frequencies, there are peaks in the impedance characteristics. At these peaks the network behaves cuit. In most frequency ranges, the impedance itive behavior. Characteristic impedance of a power line cable is typically in the range of 90 Ohm. Net impedance is not only influenced by characteristic impedance but also by network topology and connected loads, which may have highly varying impedances as well. Other than that multi-phase system, power transformers, wire resistance and reflection effects are also the causes of attenuation and distortion. [4]

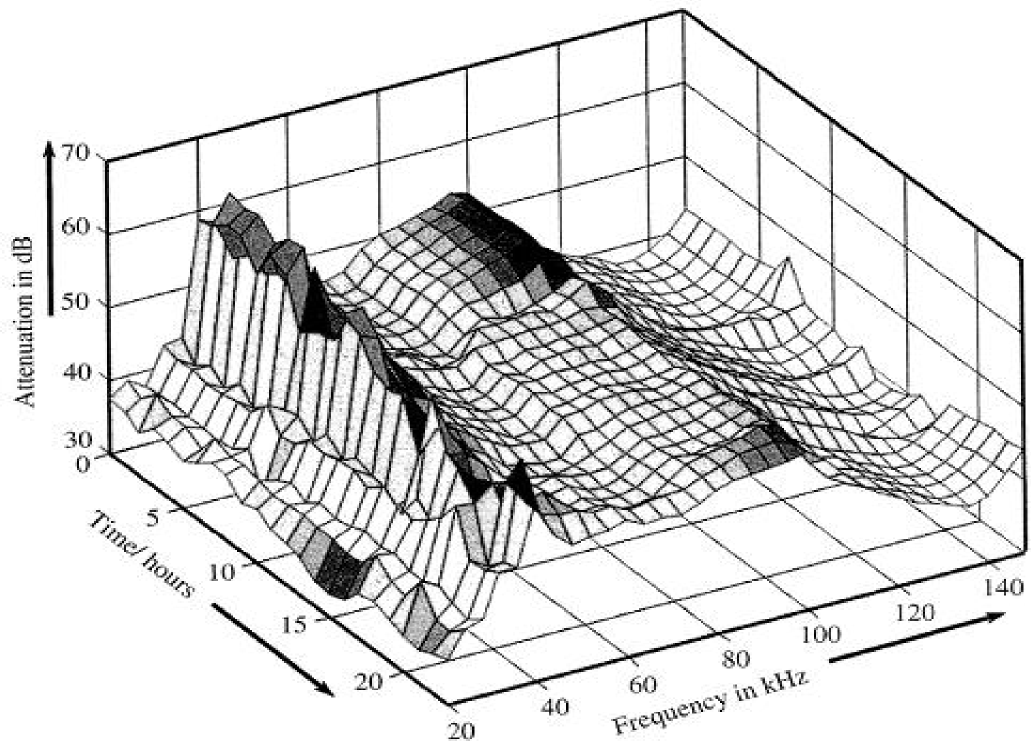


Figure 2.1 Signal Attenuation vs Frequency Graph.

A full transmission line model, complete with high frequency models of each load, is required to fully characterize power line attenuation, there is one simplification which can be used as a first order approximation. In many instances a lumped model which includes only wire inductance and low impedance loads closely approximates actual signal attenuation. Frequently the only other effect which must be considered in order to match measured values is the loss encountered when the communication signal must cross power phases. This loss, typically in the range of 5 to 25dB, is influenced by a number of variables including distribution transformer coupling, distribution wire cross-coupling, multi-phase load hich are explicitly installed to reduce this loss. ffects we find that 96% of the time the attenuation within a single residence falls in the range of 6-54dB near 120 kHz. A distribution of power line attenuations measured at 100 kHz using thousands of randomly selected socket pairs in hundreds of homes from 5 different countries is shown in the figure.

If attenuation were the only impairment, then receiver gain could simply compensate for this signal loss. The distortion characteristics of the power line must also be considered before we have a picture of the operating environment which is adequate for use in technology comparison.

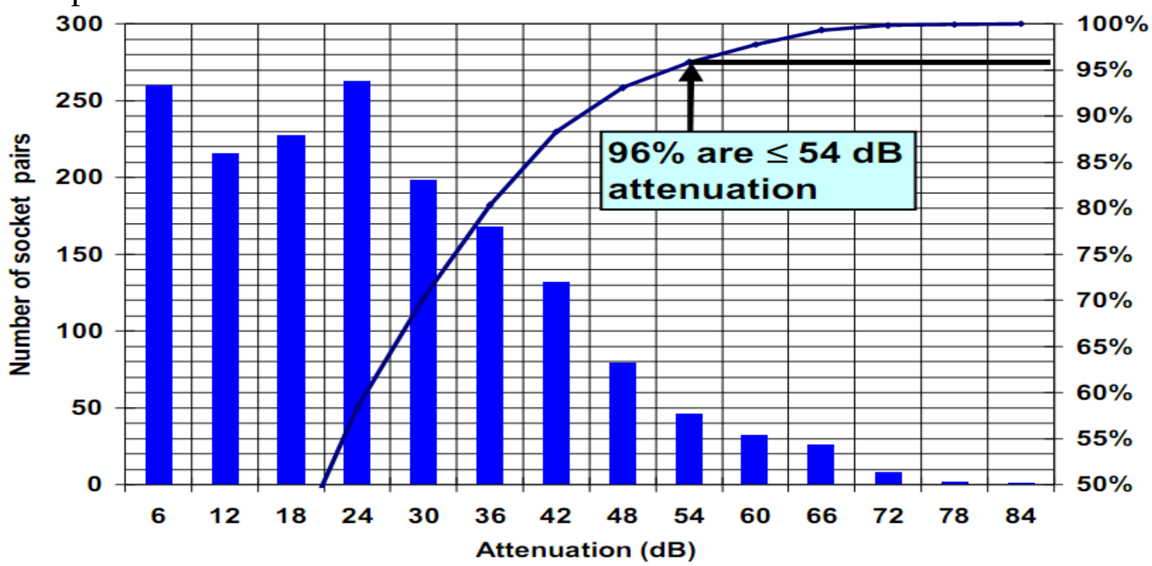


Figure 2.2 Attenuation in Homes at 100 kHz

2.2.2 Signal Noise

The noise spectrum is highly varying with frequency and time. There is an overall decay of the noise level with increasing frequency. Noise at the power line is influenced by a large number of different noise sources with different characteristics. There are broadband disturbances, e.g. Universal motors, and narrowband disturbances, e.g. HF-radio signals, power supplies. The shape of the noise curve is very much depending on location and time.

Many electrical devices which are connected to the power mains inject significant noise back onto network. The characteristics of the noise from these devices varies widely. Examination of the noise from a wide he observation that the noise can be classified

- Impulse noise (at twice the AC line frequency)
- Tonal noise
- High frequency impulse noise

The most common impulse noise sources are TRIAC-controlled light dimmers. These devices introduce noise as they connect the lamp to the AC line part way through each half AC cycle.
The most common sources of tonal noise are switching power supplies.
High frequency impulse noise finds its source in a variety of series-wound AC motors. This type of motor is found in devices such as vacuum cleaners, electric shavers and many common kitchen appliances. [5]

2.2.3 PLC at Different Voltages

The major problems concerned with the implementation of Power Line Communication at HV power lines is due to the severe periodic short duration impulsive interference, broad band interference and attenuation at high voltages. Thatôs why PLC technologies make use of the Medium Voltage (MV) and Low Voltage (LV) power networks to deliver communications services to the home or office as well as establishing in-building networking via power lines. [6]

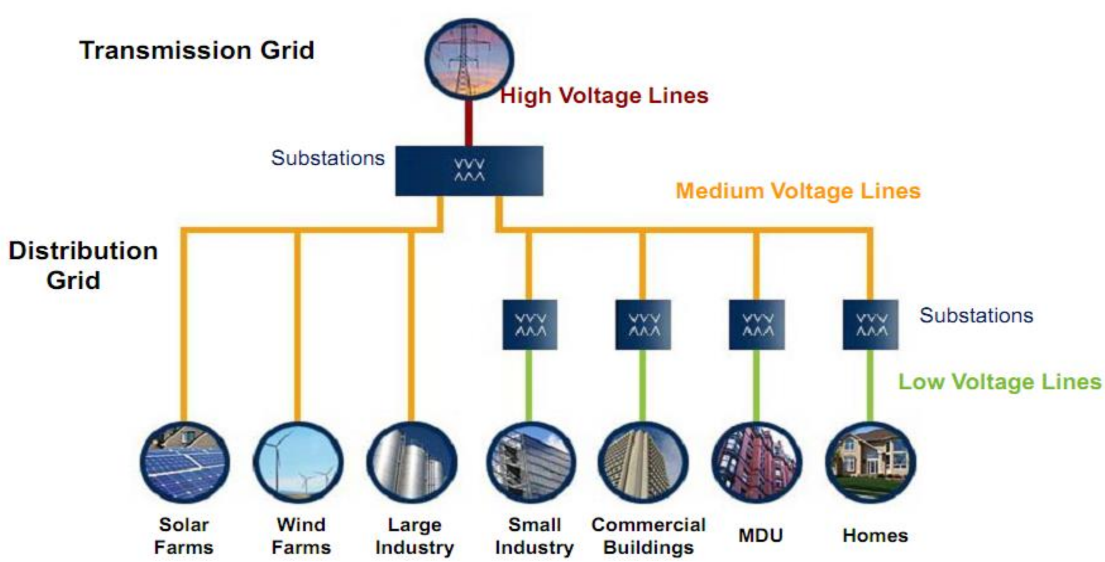


Figure 2.3 Different Voltages Level in a Power System

niques

Communication is the process of accurately data transfer between two places. For communication, there must be at least one receiver, a transmitter and a transmission medium. Transmission medium can be air, wire or fiber cable. Modulation is process for moving a signal in a transmission medium via a high frequency periodic signal. High frequency signal called carrier frequency. Data signal can change of carrier frequencyôs amplitude, frequency or phase values. These are general ways for modulation. At the continuous wave operation, if the carrier is a continuous periodic wave and the data signal is analog, this is called amplitude modulation, frequency modulation and phase modulation.

If the data signal is digital these are:

- Amplitude Shift Keying (ASK)
- Frequency Shift Keying (FSK)
- Phase Shift Keying (PSK).
- Orthogonal Frequency Division Multiplexing (OFDM)

Characteristics of the power line channel continuously vary with time and load. So conventional modulation techniques like ASK, FSK or PSK can be employed with them. PLCC needs a technique that can deal with the unpredictable attenuation and phase shifts. Modulation techniques that opt lower frequency ranges of 35 KHz to 95 KHz can perform better as compared to the ones using the whole available frequency band. This project is based on digital communication techniques; therefore this section describes only the digital communication techniques. [7]

2.3.1 Amplitude Shift Keying (ASK)

At amplitude shift keying, every bits changes the carrier signalôs amplitude. If the data bit is logic ó1ô then output is equal to carrier signal otherwise output is zero. ASK is so sensitive for noise and propagation conditions. ASK is inexpensive and quite simple modulation technique than other modulation types.

ying (FSK)

In frequency shift keying, the data signalôs every bits change the carrier signalôs frequency. For instance, if the data bit is logic ñ1ò then output gives 70 kHz sinusoidal wave and for logic ñ0ò gives 60 kHz sinusoidal wave. The Frequency corresponding to logic 1, is called Mark frequency and the frequency corresponding to logic 0, is called Space frequency. FSK is very immune to noise because noise can change the signals amplitude but it canôt change the signals frequency easily.

2.3.3 Phase Shift Keying (PSK)

At phase shift keying, the data bits change the carrier signalôs phase. Generally PSK uses two different angles for communication. For instance, if the data signal bit is digital low, output sinusoidal waveôs phase angle 0º and for digital high bit, phase angle is 180º. So two different angles can transmit 1 bit and four or more angle can transmit 2 or more bit at 1-cycle. Quadrature Phase-Shift Keying (QPSK) uses four phase. QPSK is the most known PSK type.

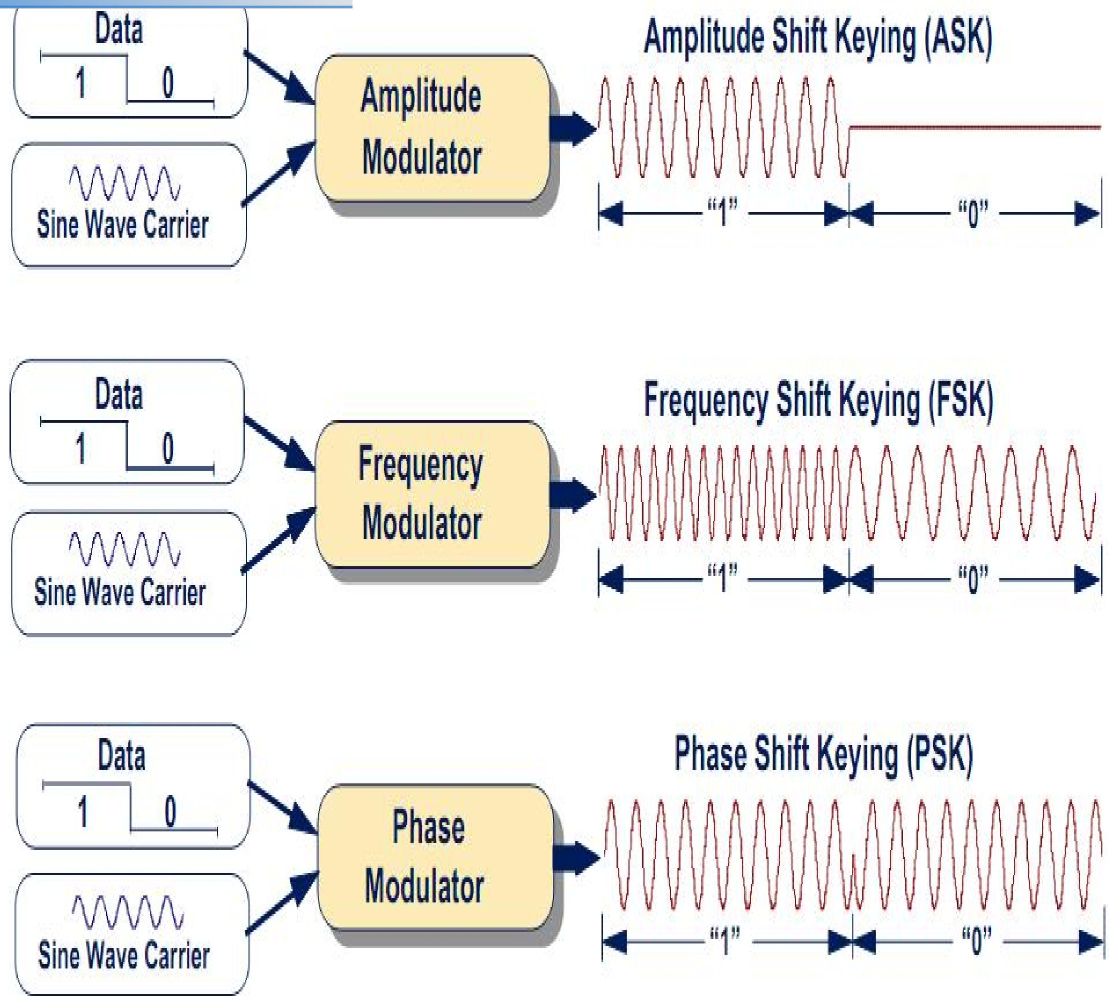


Figure 2.4 Digital Modulation Techniques.

These three above mentioned techniques are also explained graphically in the figure 2.3.

2.3.4 Orthogonal Frequency Division Multiplexing (OFDM)

The OFDM concept is based on spreading the data to be transmitted over a large number of carriers, each being modulated at a low rate the carriers are made orthogonal to each other by appropriately choosing the frequency spacing between them. A multicarrier system, such as FDM divides the total available bandwidth in the spectrum into sub-bands for multiple carriers to transmit in parallel. It combines a large number of to construct a composite high data rate FDM is robust against noise and multipath propagation. [8]

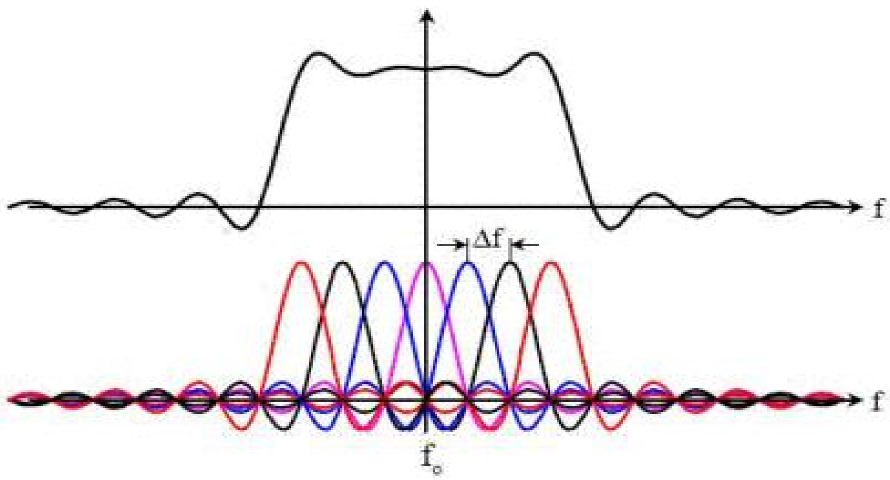


Figure 2.5 OFDM Frequency Spectrum.

The comparison of all these four techniques are given in the figure below on the bases of their bandwidth efficiency, complexity and PLC efficiency.

Modulation Scheme	Bandwidth efficiency	Complexity	PLC efficiency
ASK	Low	Low	Low
FSK	Medium	Low	High
PSK	Medium	Medium	Medium
OFDM	High	High	High

Figure 2.6 Comparison of modulation techniques

…andards

PLC can be divided into two types based on the frequency range of the carrier signal and the voltage of the line.

1. Frequency Based PLC
2. Voltage Based PLC

2.4.1 Frequency Based PLC

PLC, on the bases of frequency range of the carrier signal, can be broadly viewed as:

- Narrowband PLC
- Broadband PLC

Narrowband PLC works at lower frequencies (3-500 kHz), lower data rates (up to 100s of kbps), and has longer range (up to several kilometers), which can be extended using repeaters.

Recently, narrowband Power Line Communication has been receiving widespread attention due to its applications in the Smart Grid. Another application that narrowband PLC has been used in is smart energy generation, particularly in micro-inverters for solar panels.

	rowband PLC	Broadband PLC
Data rate	Up to 200kbps	Over 1Mbps
Frequency	Up to 500kHz	Over 2MHz
Modulation	FSK, S-FSK, BPSK, SS, OFDM	OFDM
Applications	Building Automation Renewable Energy Advanced Metering Street Lighting Electric Vehicle Smart Grid	Internet HDTV Audio Gaming
Providers	Renesas Maxim ST Microelectronics Texas Instruments Echelon Yitran Cypress Ariane Controls	Atheros Maxim Sigma Broadcom Lantiq Marvell

Figure 2.7 Narrowband vs Broadband PLC

Broadband PLC works at higher frequencies (1.8-250 MHz), high data rates (up to 100s of Mbps) and is used in shorter-range applications.

Broadband PLC has mainly found acceptance as a last-mile solution for Internet distribution and home networking. With its high data rates and no additional wiring, broadband PLC is seen as an exciting and effective technology for multimedia distribution within homes. [9]

LC

PLC, on the bases of voltage signal flowing in the power lines, are divided into two types.

- PLC over AC lines
- PLC over DC lines

Most companies are currently geared towards providing AC-PLC solutions but PLC in DC lines also has applications. Two such applications are PLC over the DC-bus in distributed energy generation, and PLC in transportation (electronic controls in airplanes, automobiles and trains). This use reduces wiring complexity, weight, and ultimately cost of communications inside vehicles.

2.4.3 International Standards

To provide efficient transparent communication over the power line network for communication into buildings and provide a range of energy saving services together with other communication services a series of standards are currently under development.

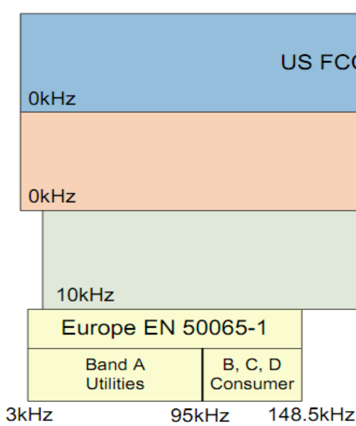


Figure 2.8 International Standards for PLC.

In the USA, the frequency range is limited to the 50 kHz to 450 kHz range. The development of this work is centered on the IEEE Power Engineering Society.

In Europe, CENELEC, the Electro-technical Standards Body are currently developing standard EN50065, Low Voltage Mains Signaling. The standard has, and is still, in the course of investigating a series of parameters that will lead to efficient communication over the power line. The standard is addressing communication standards through the power line to buildings and within buildings to provide a range of services for the electricity utility and customers including, AMR, tariff control, load and energy management services.[10]

For indoor and household purposes only one such standard currently exists, the American: *Homeplug V1.0.1* standard. This standard is only applicable for "indoor" installations and is not interoperable with current "outdoor" applications. Other standards will emerge over the coming months or years. [11]

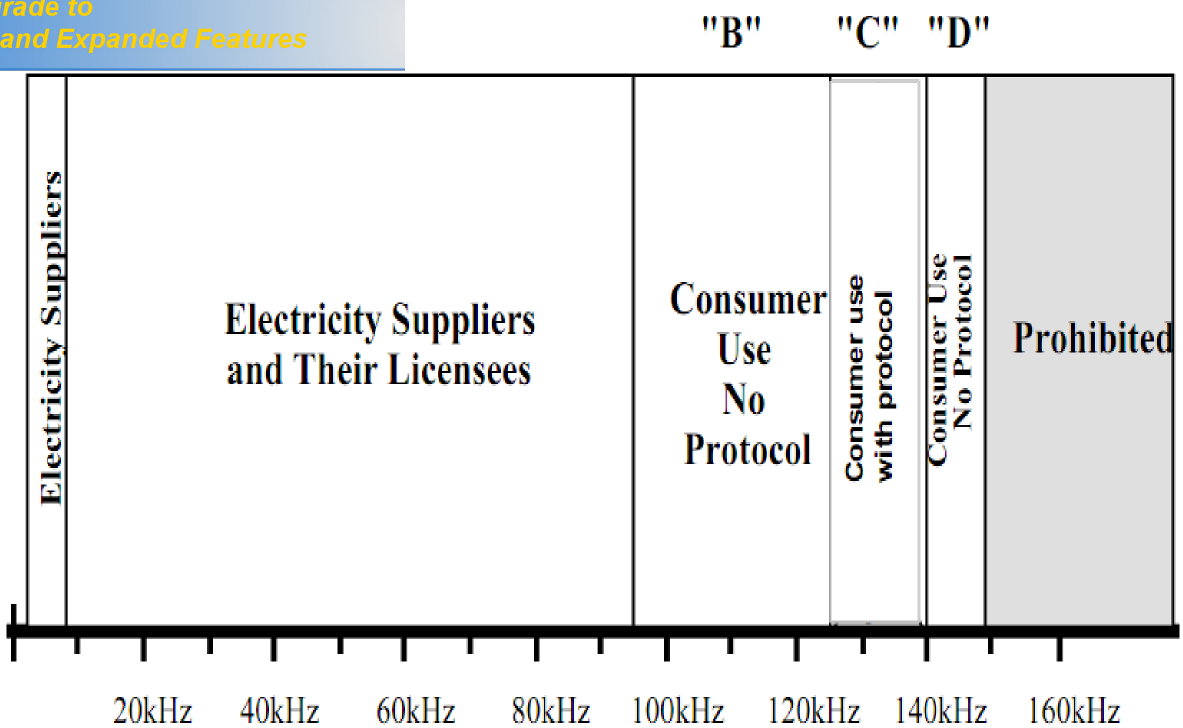


Figure 2.9 European PLC Frequency Band Standard.

2.4.4 Summary

After Analyzing all the channel characteristics of power line at different voltages and frequency, weôve observed that a high frequency (from 50 KHZ to 130 KHZ) PLC implementation at LV (220-230 Volts) system would be feasible for practical purposes. The modulation scheme selected is the BFSK after studying the comparison of all digital modulation techniques. According to international standards, our system falls in the domain of Narrowband PLC and our frequency range is although restricted for utility uses only but it is quite feasible and practical for the prototype demonstration of the system.

DESCRIPTION OF THE COMPONENTS

3.1 Microcontroller PIC 16F877A:

PIC microcontrollers (Programmable Interface Controllers), are electronic circuits that can be programmed to carry out a vast range of tasks. They can be programmed to be timers or to control a production line and much more. They are found in most electronic devices such as alarm systems, computer control systems, phones, in fact almost any electronic device.PIC 16F877 is one of the most advanced microcontrollers from Microchip. This controller is widely used for experimental and modern applications because of its low price, wide range of applications, high quality, and ease of availability. It is ideal for applications such as machine control applications, measurement devices. The PIC 16F877 features all the components which modern microcontrollers normally have.

3.1.1 Key Features:

- Maximum operating frequency is 20MHz.
- Flash program memory (14 bit words), 8KB.
- Data memory (bytes) is 368.
- EEPROM data memory (bytes) is 256.
- 5 input/output ports.
- 3 timers.
- 2 CCP modules.
- 2 serial communication ports (MSSP, USART).

3.1.2 Limitations:

- One accumulator
- Register-bank switching is required to access the entire RAM of many devices

rs are not orthogonal; some instructions can nediate constants, while others can use the accumulator only.

3.1.3 Usage in project:

We have used PIC16F877A Microcontroller. We have preferred PIC Microcontroller because of following reasons.

- It is built in A/D coveters.
- It is easily programmable.
- Is has reduced set of instruction set.
- It is easily available in Market.

3.1.4 Datasheet for PIC 16F877A:

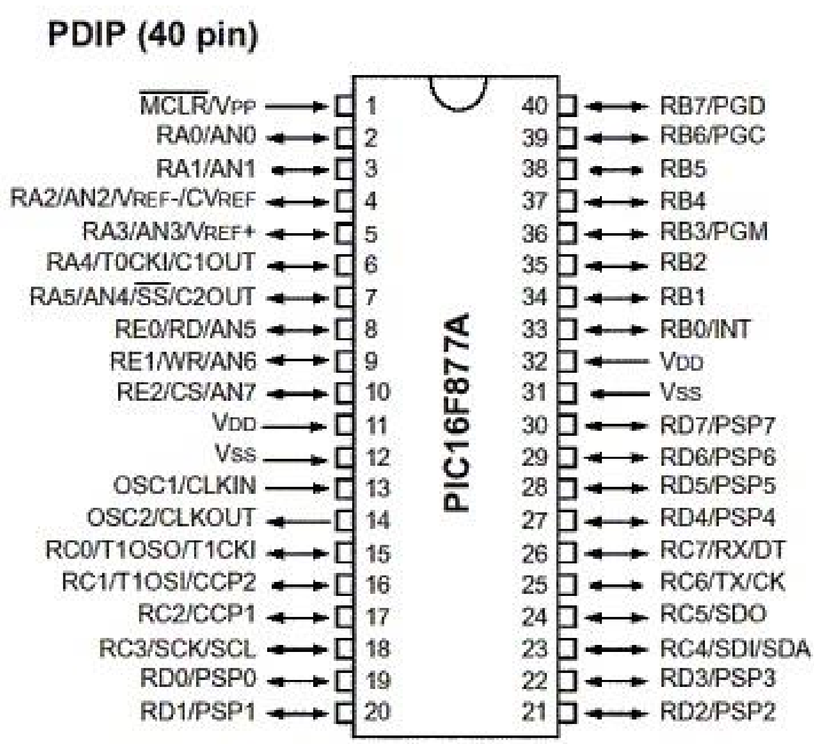


Figure 3.1 –PIC pin configuration

A voltage regulator is designed to automatically maintain a constant voltage level. A voltage regulator may be a simple "feed-forward" design or may include negative feedback control loops. It may use an electromechanical mechanism, or electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages. Voltage regulator any electrical or electronic device that maintains the voltage of a power source within acceptable limits. The voltage regulator is needed to keep voltages within the prescribed range that can be tolerated by the electrical equipment using that voltage.

3.2.1 78XX family:

The **78xx** is a family of self-contained fixed linear voltage regulator integrated circuits. The 78xx family is commonly used in electronic circuits requiring a regulated power supply due to their ease-of-use and low cost. For ICs within the family, the *xx* is replaced with two digits, indicating the output voltage (for example, the 7805 has a 5 volt output, while the 7812 produces 12 volts). The 78xx line are positive voltage regulators: they produce a voltage that is positive relative to a common ground.

7805 IC do not require additional components to provide a constant, regulated source of power, making them easy to use, as well as economical and efficient uses of space. Other voltage regulators may require additional components to set the output voltage level, or to assist in the regulation process. They have built-in protection against a circuit drawing too much power. They have protection against overheating and short-circuits, making them quite robust in most applications.

3.2.3 Regulator 7805 in project:

Basically we need a supply of +5v at different pointôs i-e PIC microcontroller, LCD display, MAX232, temperature sensor. We have different circuitry which will help in getting 5v that consist of capacitors, Db107, resistances, diodes and regulator

3.3 Capacitors:

A **capacitor** (originally known as a **condenser**) is a passive two-terminal electrical component used to store energy electro statically in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors (plates) separated by a dielectric (i.e., insulator). Capacitors can be used in many ways.

We are using different value capacitors as according to the requirement at different points of circuits. Some capacitors are used for the removal of noise they act as filters. Some capacitors are used as couplers and decouplers.

3.3.2 Value of the components using in project:

Power supply	1000uF, 100uF, 2 of 0.1uF
Potential transformer	2 of 100uF
Current transformer	2 of 100uF
Crystal oscillator	2 of 33pF
MAX232	4 of 104pF

Table no 3

3.4 Crystal Oscillator:

A **crystal oscillator** is an electronic oscillator circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a very precise frequency. The most common type of piezoelectric resonator is the quartz crystal.

3.4.1 Crystal oscillator of 4MHz in project:

The microcontroller we use in project does not have internal oscillation so there is need to provide external oscillation that is why using crystal of 4MHz is used.

3.5 Serial cable port:

A **serial cable** is a cable used to transfer information between two devices using a serial communication protocol. The form of connectors depends on the particular serial port used.

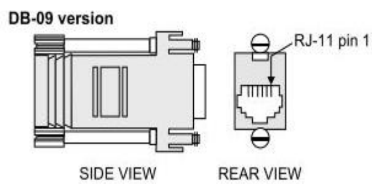


Figure 3.2 external and internal view of serial port

3.5.1 Description:

The DS9097U is a sophisticated RS-232 to 1-Wire adapter, which performs RS-232 level conversion and actively generates the 1-Wire communication signals. Together with an adequate software driver, it enables a Windows-based PC to directly communicate with any 1-Wire device connected to the adapter's port. The serial port must support a data transmission rate of 9600bps. Under software control, the adapter can be set up for RS-232 data rates of 19200bps, 57600bps, and 115200bps. The two higher rates are recommended for communication at overdrive speed with overdrive-capable operates in a byte mode, every data byte received from the RS-232 port generates eight time slots on the 1-Wire line.

3.5.2 Key features:

- True-Ground Interface to an RS-232 COM Port for Reading and Writing 1-Wire Devices.
- Works with Bipolar as well as Unipolar Logic Signals
- Compatible to COM port of (±)5V to (±)12V (DB9 Version Only)
- Supports Reading and Writing at Standard and Overdrive Speeds
- Provides Strong Pull up to 5V for Temperature and EEPROM 1-Wire Devices
- Programs 1-Wire EPROM Devices (DB-25 Version with External 12V Power Supply Only)
- Communicates at Data Rates of 9.6kbps (default), 19.2kbps, 57.6kbps, and 115.2kbps
- Standard DB9 or DB25 Female Connector and 6-Lead RJ11 Connector for Easy Attachment of Standard 1-Wire Cables and Probes

3.5.3 Usage in project:

Serial cable will be attached to the PC (personal computer) or laptop. It is basically used to have communication between PC and circuitry used so that instructions can be send to the devices which have to be controlled.

ax 232:

The MAX232 is an IC that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals. The MAX232 is a dual driver/receiver that includes a capacitive voltage generator to supply TIA/EIA-232-F voltage levels from a single 5-V supply. Each receiver converts TIA/EIA-232-F inputs to 5-V TTL/CMOS levels. These receivers have a typical threshold of 1.3 V, a typical hysteresis of 0.5 V, and can accept ±30-V inputs. Each driver converts TTL/CMOS input levels into TIA/EIA-232-F levels.

3.6.1 Features:

- Meets or Exceeds TIA/EIA-232-F and ITU
- Operates From a Single 5-V Power Supply With 1.uF Charge-Pump Capacitors
- Operates Up To 120 kbit/s
- Two Drivers and Two Receivers
- ±30-V Input Levels
- Low Supply Current (8 mA Typical)

3.6.2 Application:

The MAX232 has two receivers (converts from RS-232 to TTL voltage levels), and two drivers (converts from TTL logic to RS-232 voltage levels). This means only two of the RS-232 signals can be converted in

...air of a driver/receiver of the MAX232 is used for TX and RX signals, and the second one for CTS and RTS signals.

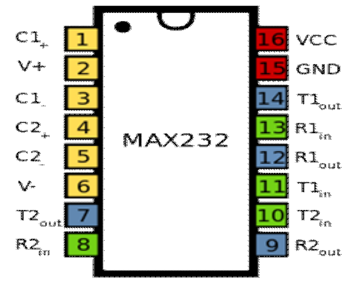


Figure 3.3

3.7 Liquid Crystal Display (LCD):

A liquid-crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock.

3.7.1 16*2 LCD Display:

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

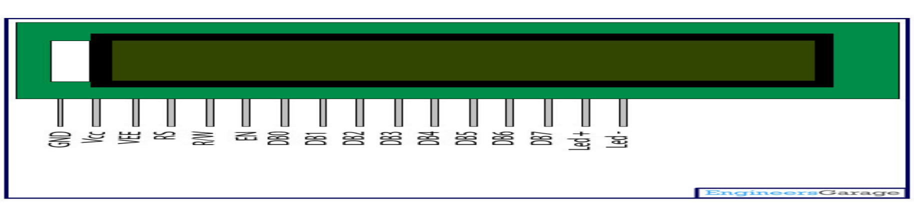


Figure 3.4 LCD

- 16 Characters x 2 Lines
- Built-in HD44780 Equivalent LCD Controller
- Works directly with ATMEGA, ARDUINO, PIC and many other microcontroller/kits.
- 4 or 8 bit data I/O interface
- Low power consumption

3.7.3 <u>Usage of LCD JHD 16*2:</u>

LCD is the component where we have display of the present situation.PIC microcontroller connections from 35-40 are connected with LCD different pins. LCD has connection of supply 5v along with resistances of 100ohm and 10kohm. LCD will display the temperature and the devices which are controlled there condition.

Data transmission and line interfacing of Hardware

4.1 Data transmission using X-10 protocol:

The method used by X-10 is based on a simple data frame with eight data bits (one byte) proceeded by a predetermined start code. The complicated Part of this technology was not the system of binary data, but the method in which it was transmitted from one device (the transmitter) to another device (The receiver). The key was for every device to have an integral "zero Crossing" detector so that all of them were synchronized together (figure 4. 1). A receiver opens itõs receiving "window" twice each sine wave (figure 4. 2), that Is 120 times each second or 7,200 time each minute.

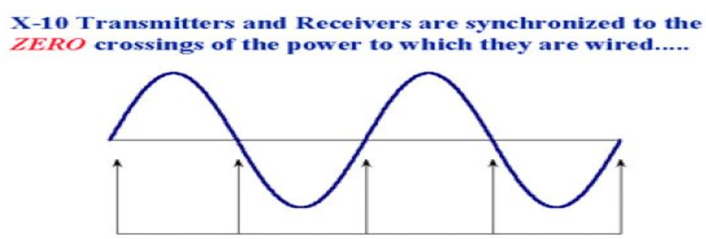


Figure 4.1

Since these devices would not have any direct wiring between them, it was necessary to devise a way of sending the data over the existing electrical wiring. The actual binary data is transmitted by sending 1ms bursts of 120 kHz just past the zero crossing of the 50Hz power. It was also obvious that complementary bit pairs were necessary. Therefore, a binary ñ1ò was defined as the
presence of a pulse, immediately followed by the absence of a pulse. A binary ñ0ò was defined as the absence of a pulse, immediately followed by the presence of a pulse (figure 4. 3)

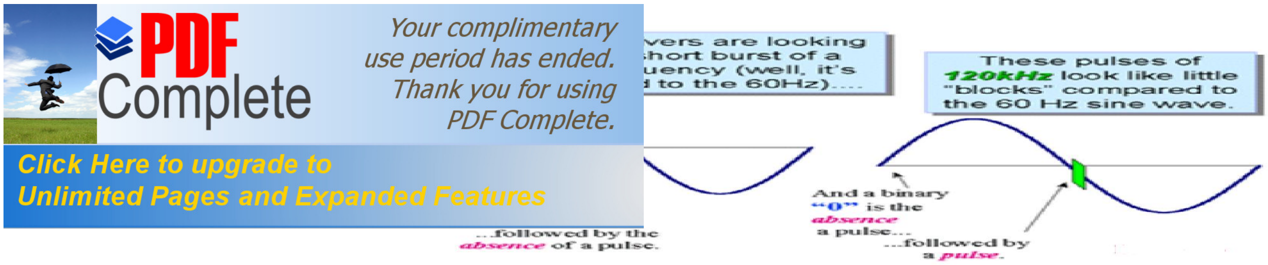


Figure 4.2, 4.3

While the transmitted pulses were to be a full 1ms in duration, the receivers were designed to open a receive window of only .6ms. That allowed for the loose tolerances of the 1978-era components to ñslopò plus/minus 200m sec. In order to provide a predictable start point (figure 4.4), every data frame would always begin with at least 6 leading clear zero crossings, then a start code of ñpulseò, ñpulseò, ñpulseò, ñabsence of a pulseò (or 1110).Once the Start Code has been transmitted, the first nibble is sent. (If you are not familiar with the term ñnibbleò, that means 4 bits or half a byte.) In order to make it easier for the consumers to operate the devices, these first 4-bits were given ñletterò code designations (figure 5). It was also decided to randomly rearrange the patterns so that the ñAò, ñBò, ñCò codes, etc., did not fall in the predicable binary pattern. It is easy to see that in reality, the ñMò code is first in the binary progression.

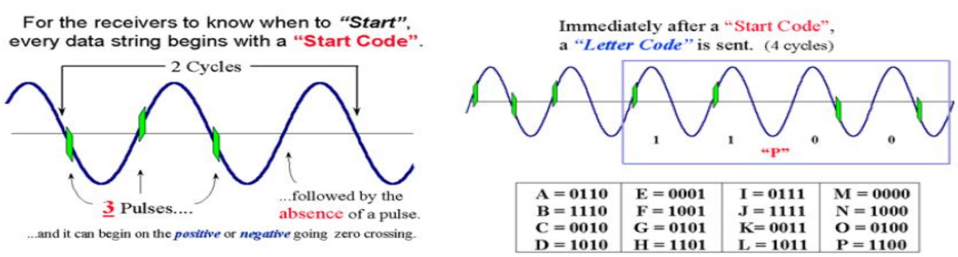


Figure 4.4, 4.5

In one contiguous bit stream, the second nibble provides the second half of the address (figure 4.6). The last bit appears to be a part of the "number" code but in reality it is a function bit. Whenever this function bit is a "0", it designates the preceding nibble as a number code and therefore a part of the address. For purposes of redundancy, reliability and to accommodate line repeaters, the X-10 protocol calls for every frame of data to be transmitted twice (figure 4.7).

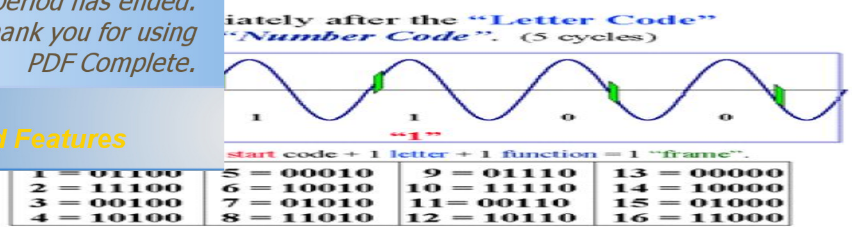


Figure 4.6

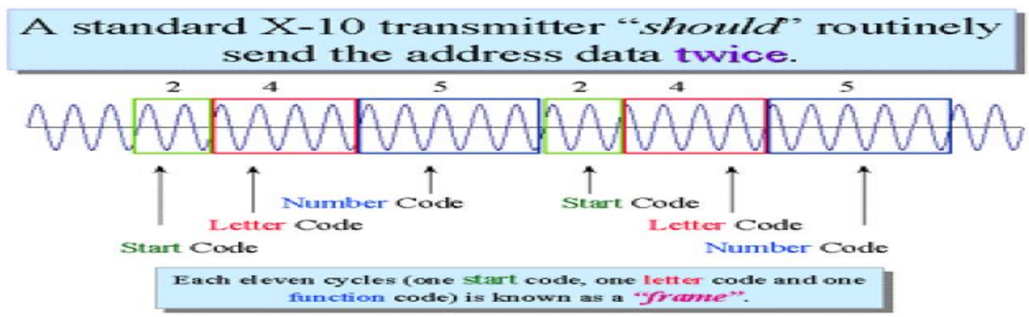


Figure 4.7

Whenever the data changes from one address to another address, from an address to a command, from one command to another command or from one command to another command (figure 4.8), the data frames must be separated by at least 6 clear zero crossings (or "000000"). When teaching classes in this stuff, I often say that this gap "*gives the receivers a chance to catch their breath*". In reality, of course, the sequence of six "zeroôs" resets the shift registers.

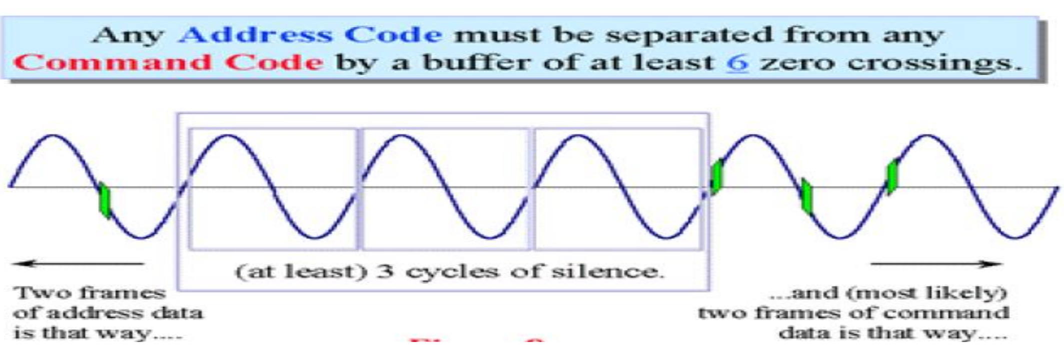


Figure 4.8

Once a receiver has processed its address data, it is ready to receive a command. As before, all data frames must begin with a start code. Then the following nibble gives the letter code (figure 4.9). The next nibble is the

the function bit (bf = 0 = address number, bf = ds end in a binary 1

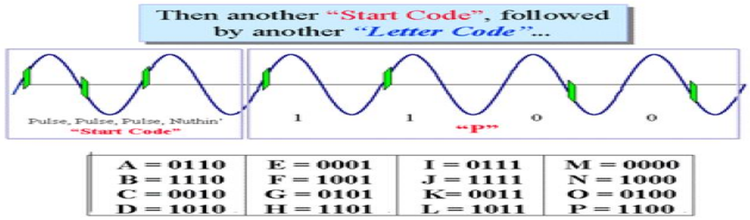


Figure 4.9

This diagram (figure 4.10) only shows the six most often used commands. A later graphic will illustrate all the available commands. As before, all X-10 protocol transmitters send their data frames twice (figure 4.11).

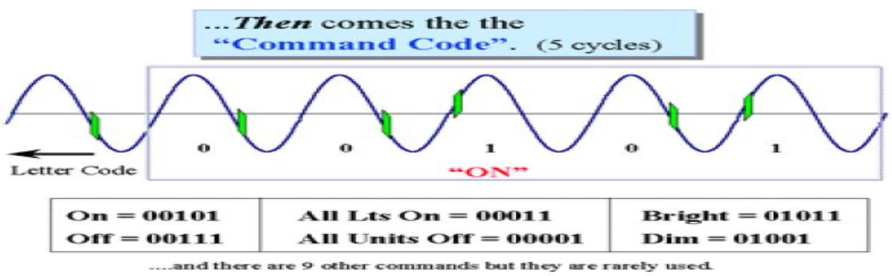


Figure 4.10

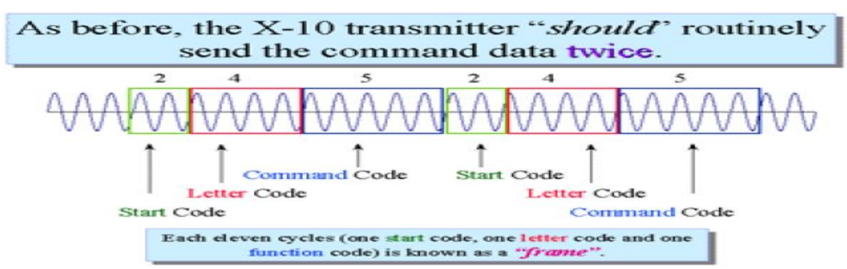


Figure 4.11

Figure 4.12 shows that an example transmission of two data frames (A1 A1 A-On A-On, for instance) would take 47 cycles of the 50Hz sine wave. That would equate to 0.7833 seconds, or in practical terms, just under 1 second. Of course, some commands take less time. When sending an "All- Lights-On" command, for example, no address needs to be sent. Therefore the entire two frame sequence takes only one third of a second (actually, 0.3666

). If your receivers react on the first frame, it f a second (0.1833 seconds).

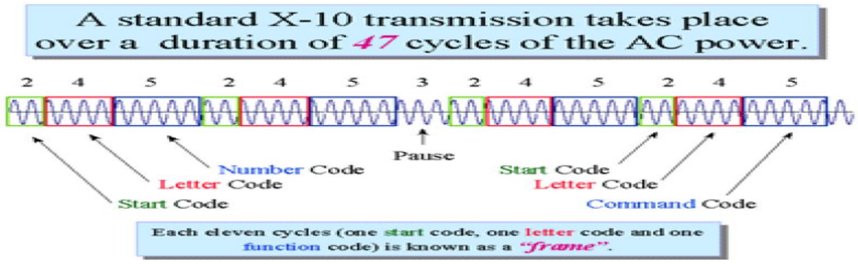


Figure 4.12

4.2 <u>X-10 Codes:</u>

Start code	House code	Unit code	Pause	Start code	House code	Command code

Command codes		
Dim=01001	On=00101	Off=00111
Bright=01011	All lights on=00011	All lights off=00001

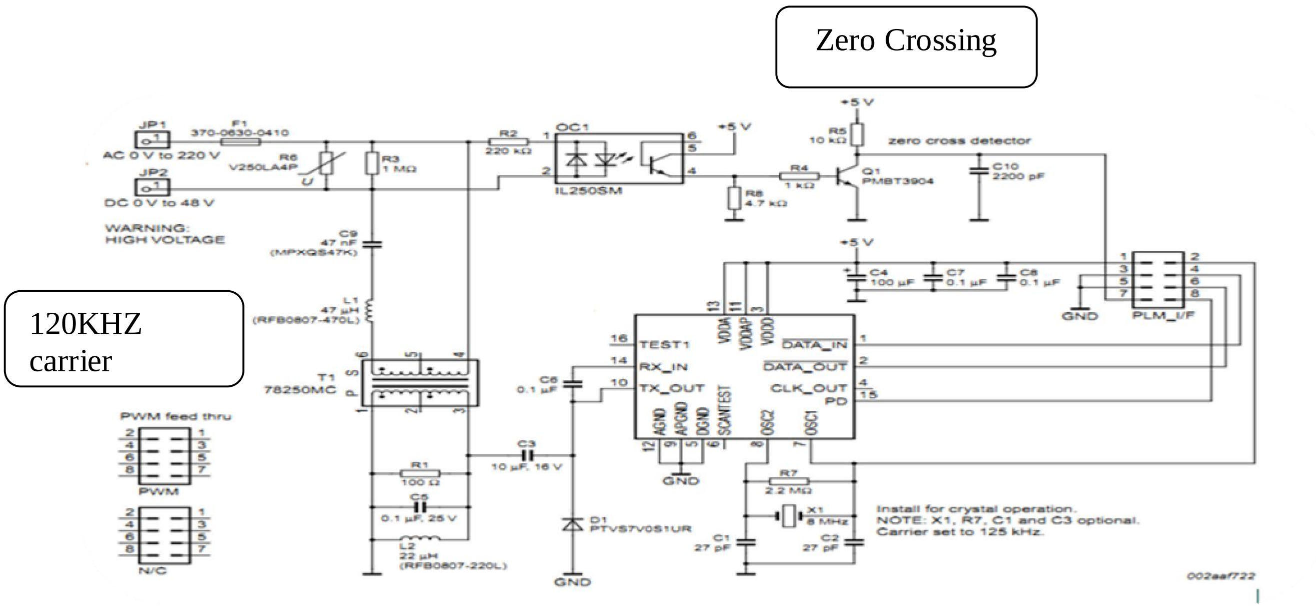
House codes			
A = 0110	B=1110	C=0010	D = 1010
E = 0001	F = 1001	G = 0101	H= 1101
I=0111	J= 1111	K=0011	L =1011
M = 0000	N = 1000	O = 0100	P = 1100

Table : 5 for X-10 codes

4.3 <u>ZERO-CROSSING & 120KHZ CARRIER GENERATOR:</u>

In module two things are important zero crossing and 120KHZ carrier. In the figure we can see the T1 (78250MC) & TD5051A, both are producing the 120KHZ carrier. And TD5051A TD5051A consists of ROM,a logic control , convertor which internally modulates and ...nd outgoing data respectively. Practically a 7.87MHz crystal is chosen and 115KHz signal is generated by utilizing timer 0 and prescalar 64 of microcontroller .The calculation is as following

f=crystal value /prescalar =7.873MHz/64=115KHz



PLC Module explaining functions

4.4 LCD INTERFACING:

The 2-line x 16-character display uses the HD44780UDisplay Controller. Eight data lines and three control lines are used to interface to the PICmicro MCU. If fewer I/O pins are available, the LCD can be operated in Nibble mode using only four data lines, with some additional software overhead. A basic LCD library is included in this application, which provides the necessary functions for controlling this type of LCD.

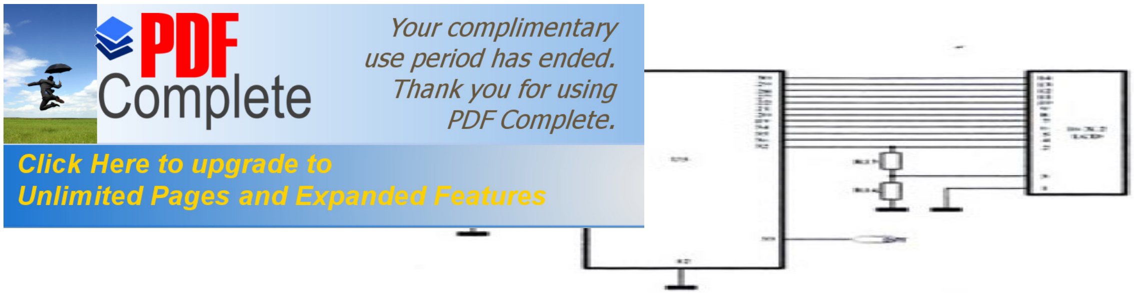


Figure 4.13 LCD interfacing

4.5 Line communication and interfacing:

4.5.1 Communication over Power lines:

Power line communication (PLC) is used in this module. A PLC transmitter that is bridged between the PC and coupling circuit is suppose to modulate the low voltage data that is received from the PC and impress it upon the high voltage on the power line channel. Coupling circuit prevents high voltage flow into PC. The modulated signal travels on power lines until it encounters a demodulator via a coupler. The demodulated data is then analyzed by the microcontroller and appropriate command is sent to the appliance. Low voltage or high frequency data coming from PC comprise of control command to ON / OFF the specific appliance.
The basic architecture of the system we designed shown in figure 4.14.

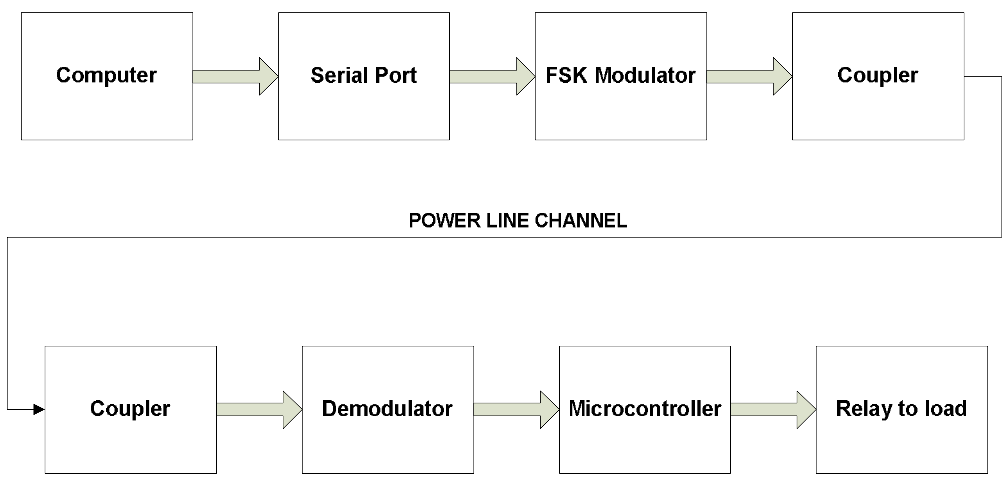


Figure 4.14 system architecture

The above system architecture provides the complete insight of how to actually make communication over power lines possible.

The computer is used as a centralized control unit for controlling devices. This computer also serves as a server which entertains request from a client website. The command it receives from the website is sent to the serial port.

4.5.3 Serial Communication:

This project uses serial communication based on UART protocol (Universal asynchronous receiver-transmitter) for the purpose of networking on the power line channel. Note that with the complexity of the channel we only used simplex transmission.

4.6 UART Protocol:

Asynchronous serial data communication is widely used for character-oriented transmissions. In asynchronous method, each character is placed between start and stop bits. This is called framing. In data framing for asynchronous communication, the data, such as ASCII characters, are packed between a start and stop bit. The start bit is always one bit, but the stop bit can be one or two bits. The start bit is always 0 (low) and the stop bit/bits is 1 (high). Note that the LSB is sent out first.

Note when there is no transfer, the signal is 1 (high), which is referred to as mark. The 0 (low) is referred to as space. The transmission begins with a start bit followed by bit 0, which is the LSB, then the rest of the bits until the MSB (bit 7), and finally one stop bit indicating the end of the character. We havenôt used parity bit. The protocol we have used for serial communication in our project is shown in figure 4.2.

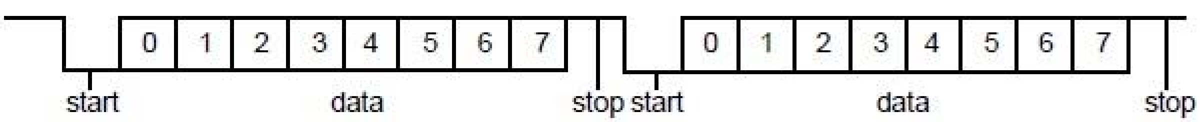


Figure 4.15 serial communication

The RS ï 232 interface is used for level conversion. The line driver IC we have used is MAX 233 which converts the RS-232 (+3 V to +25 V for Logic ô) signal to TTL voltage levels (0 V to +0.8 V for Logic ó1ô), and vice versa.

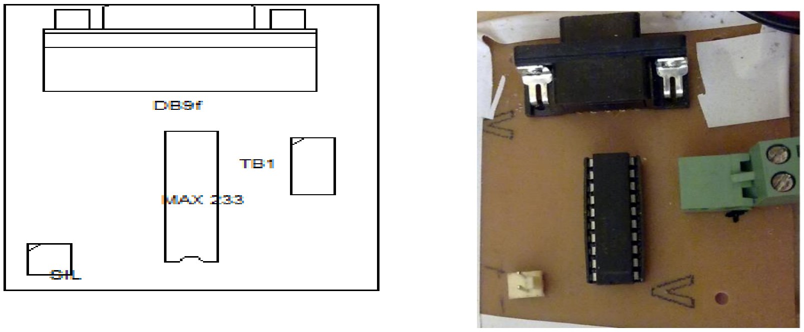


Figure 4.16: silk screen and picture of 233 circuits **PCB (left) MAX**

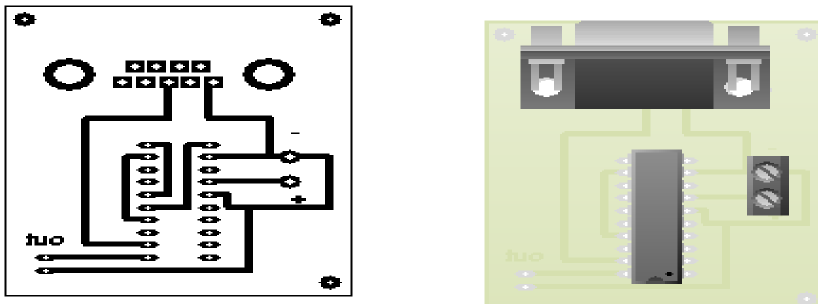


Figure4.17: MAX 233 Circuit for voltage level conversion, Art work (left) and prototype circuit

The serial data sent from computer to the above circuit is shown on oscilloscope is shown in figure 4.5. The following image shows the data coming on receiver pin (in yellow) and bounced back from the transmitter pin (in blue)

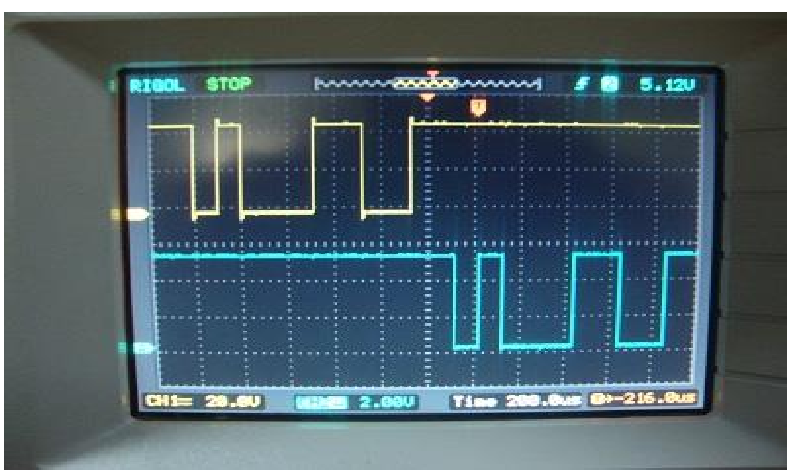


Figure4.18: Data on serial port

$$f0 \cong \frac{1}{22Rc\,(C1 + Cs)}$$

Rc = 100 Ω
C_1 = external cap in farads
Cs = stray capacitance

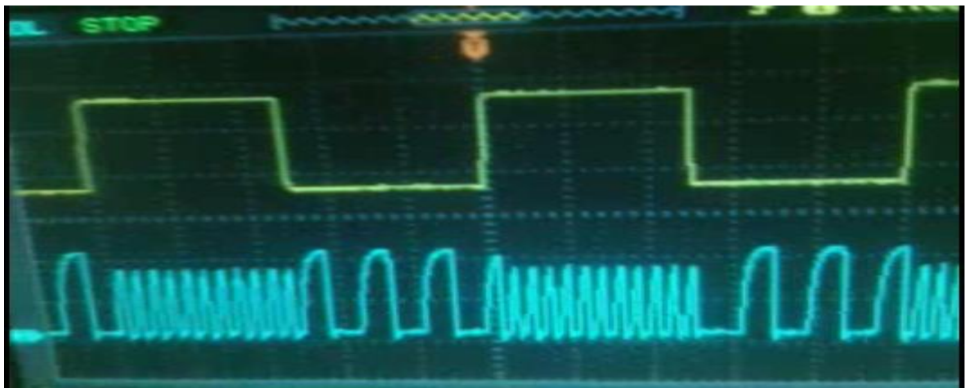


Figure 4.19: FSK modulation achieved

4.6.2 Power line coupler:

One of the most critical components of any power line communication (PLC) system is its interface circuit (coupling circuit) with the power distribution network. This is by no means a simple unit considering the challenging characteristics of the PLC channel. Due to high voltages, varying impedances, high amplitudes and time dependant disturbances, coupling circuits need to be carefully designed to provide both the specific signal transmission with the appropriate bandwidth and safety level.
The superimposing of a PLC signal on a power waveform implies that the coupler circuitry and the power circuitry would have to be carefully designed and interfaced for optimal compatibility between the two systems. Power systems and the communication system operate at the two extremes ð power system at very low frequency and very high power, current and voltage levels and communication systems at much higher frequencies and very low power, current and voltage levels.

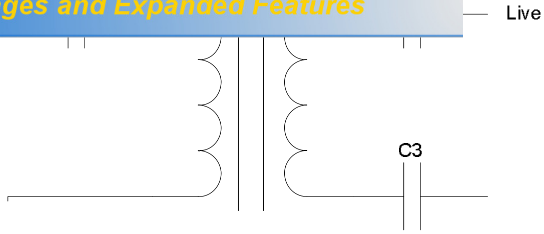


Figure 4.20: Power line Coupler

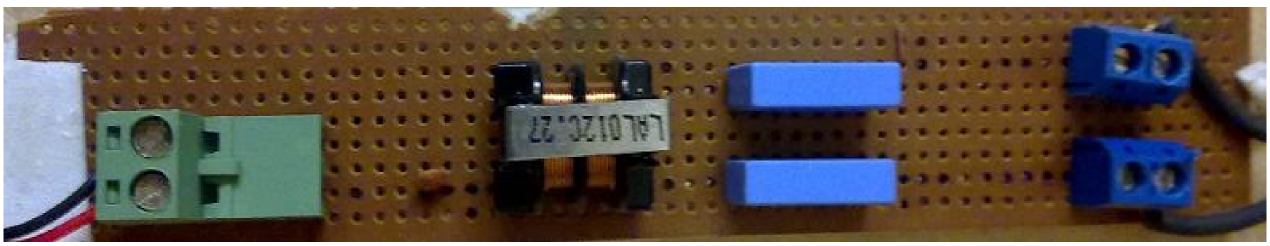


Figure 4.21: Power line coupler

Since we need to have the high frequency FSK signals coupled with the 220 V mains there must be some circuitry to couple the high frequency to the power lines and prevents the modulator/demodulator circuitry from 220 V ac. This intermediate isolation and coupling circuitry is going to be a filter which will only pass a specific band of high frequency and stops all low frequencies.

Coupling circuit provides necessary isolation of the PLC system from the power line, which can be achieved through inductive or capacitive coupling. Inductive coupling is known to be rather lossy up to several decibels. However, it avoids physical connection to the network, which makes it safer and often easier to install than the coupling circuit. Capacitive coupling, on the other hand, realizes the required high-pass filtering with a straight forward electronics that is easy and compact to design. Practical coupling circuits often apply a combination of both techniques. The circuit consists of

4.6.2.1 <u>DC blocking capacitor:</u>

C1 is 1nF DC blocking capacitor which prevent the modulator / demodulator ICôs from the DC load of the transformer.

ors:

C3 and C4 are 1nF, 275V coupling capacitors. They combine with the transformer inductance to form a filter.

4.6.2.3 Transformer:

Choosing transformer was not in any way a simple job. Since the purpose was to pass high frequency signal, therefore traditional transformers available in market failed to serve the purpose. Then we tried ferrite core transformers which actually worked. Ferrite core is known for high frequency applications. Itôs a 1:1 transformer and is also called DC chopper in layman language. One can also use a 1:1 audio transformer.

4.7 FSK modulation:

Communication over power lines are done in analogue. Digital communication is even hardly possible on power lines because of the limited bandwidth and noise issues. So to make the data suitable for transmitting over power lines we must first map the digital bits onto some monotone. Monotone refers to single frequency representing a single bit in digital sense.

The reason we have used FSK modulation is because frequency shift keying is a low order modulation scheme. It maps only a single bit onto a single frequency which indirectly means that there are less chances of bits get corrupted while being transmitted over power lines. The second reason why we chose FSK is that its IC is indigenously available in the market. Phase shift keying i.e. PSK ICôs are used in military applications so are not available in the local market.

4.8 FSK Demodulation:

Once the signal is being extracted from the power lines by the power line coupler, it must be demodulated into digital bits to be interpreted by the microcontroller.

FSK demodulation is NE 564. This IC uses stage which helps in providing robust output. Schmitt trigger introduces a dead band which makes the circuit less prone to low noise levels and gives perfect voltage levels for the output digital data.

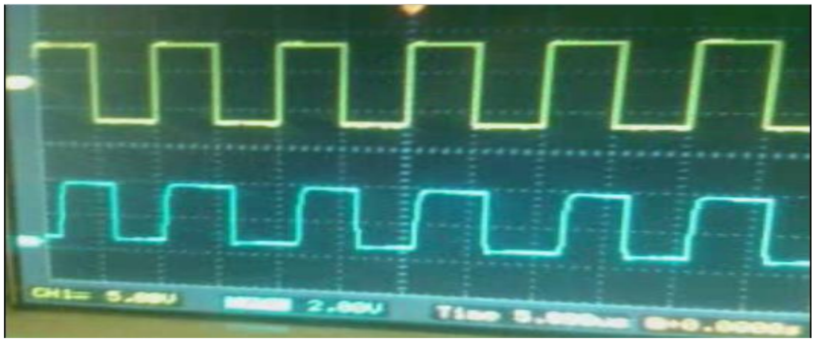


Figure 4.22: FSK Demodulation achieved

The yellow signal in the above diagram is the input signal given from the function generator to the FSK modulator circuit. Its frequency is 100 KHz. This signal travels through the line coupler, going through the power lines and finally through another line coupler, and then fed to the demodulator circuit. The signal in blue is the output of the demodulator circuit. It can be seen that both the input and output signals are of the same shape.

4.9 Relay Driver Board:

To control the electric appliances we have used 6V ï 240V, 10 Amps relays. The circuit is given below:

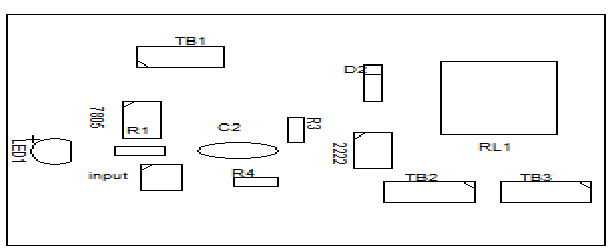


Figure 4.23: Relay Driver, PCB silk screen

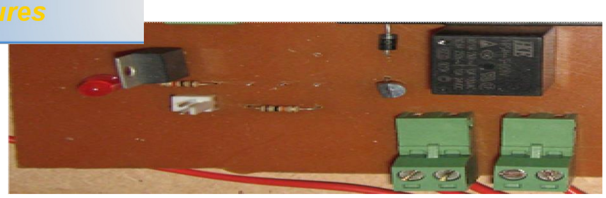


Figure 4.24: Relay driver picture

Figure 4.25 :Hardware picture

Chapter : 5

Controlling devices via pc

5.1 Hyper terminal:

HyperTerminal is a communications program that is included free with Windows 95 and later. Although the program has some quirks, it's handy for sending data to serial displays. Most Spectra com products have an RS-232 Com port to configure selectable parameters and retrieve operational status and performance logs. Connect the Spectra com RS-232 Com (Setup) port to a computer using a one to one pinned DB9 serial cable. This cable has a DB9 male on one end and a DB9 female on the other end. Do not try to use a null modem cable with gender changers to get the ñcorrectò pin configuration. A null modem cable reverses transmit and receive lines and therefore will not work in this application. To allow communication the computer must be running a terminal emulation program such as HyperTerminal.

5.1.1 Steps for using hyper terminal:

- Sometimes you need to access serial port of your PC/LAPTOP to perform some actions like if you want to connect a GSM modem or if you are an embedded systems programmer then to access program or interface your micro-controllers to your system.
- If you are performing these tasks on either Windows or Linux then you will requires some program that can communicate with your hardware and system. In the old days, Windows used to be provided Hyper terminal but now from Windows Vista they donôt provide such a tool, could not understand the reason though
- However you can still use Hyper terminal in Windows 7 as well as you can use other freely available serial communication utilities like Putty. Putty is a great and free tool and available for both Windows and Linux platforms.

Now you have to follow below steps to communicate with your device:

Step ï 1: Connect your device with your system through RS-232 cable or USB-to-Serial adapter and check whether itôs connected successfully or not.

r and check for COM ports , it get assigned a creen shot.

Step ï 3: Note down the ñCOM port numberò as we will require it.

Step ï 4: Check user manuals or other reference documents related to your hardware for the following information:

Baud Rate
Data bits
Stop bits
Parity
Flow control

Above properties are critical to make the communication correctly, if you donôt configure these properties properly then you will get either junk data or no data.

If you are going to use Hyper terminal than follow Step-5 to Step-9 otherwise follow Step-10 to Step-12.

Serial Communication using Hyper Terminal

Step – 5 Extract the downloaded ñhypertermina.rarò file in your system, open the ñHyper terminalò folder and double click on hyper terminal application. You should see the window like the screen shot given below.

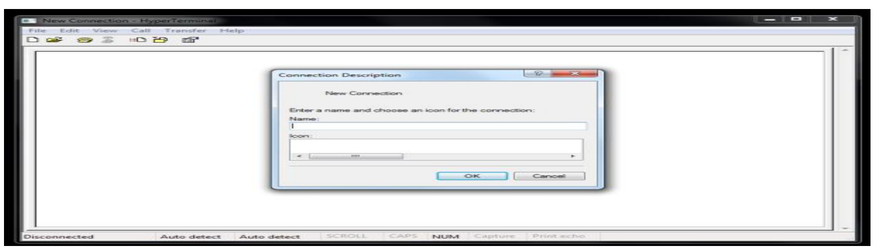


Figure 5.1

Step – 5 b Insert a name for the connection, for ex. ñTechawarey_HT_Testò.

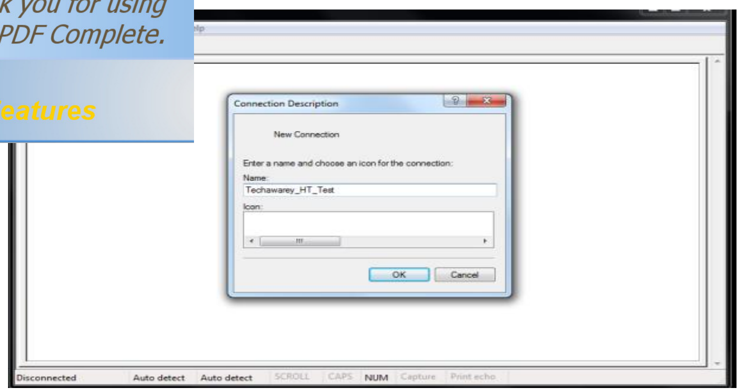
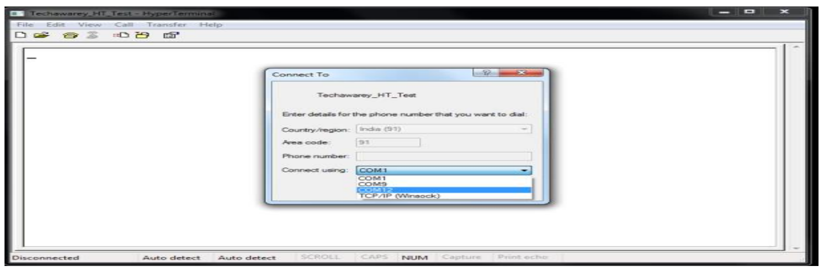


Figure 5.2

Step – 5 c select your ñCOMò i.e. Serial port.



5.3 Figure

Step – 5 d You will see the window like below screen shot. Set the values, you noted before remember i.e. According to your device requirements.

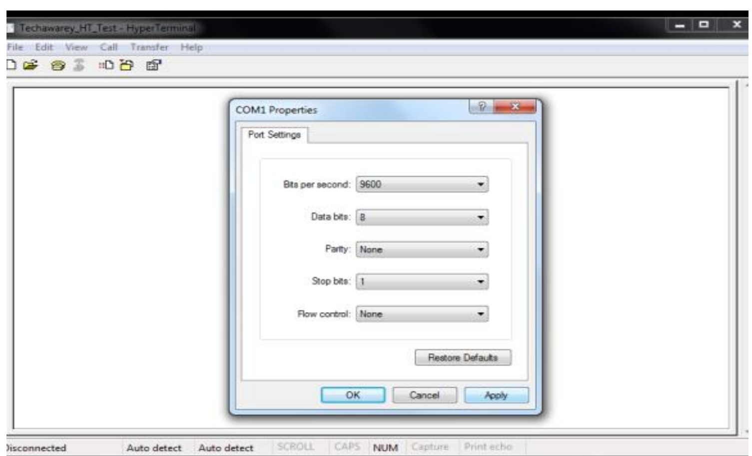


Figure 5.4

Step – 5 e now you are ready to communicate with your device. I am inserting a screen shot which shows a messages received by the device.

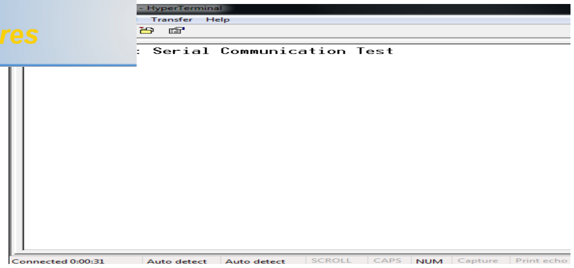


Figure 5.5

Step – 6 a Click on ñsettingsò, you will see the window like below, click on óASCII Setupô

Figure 5.6

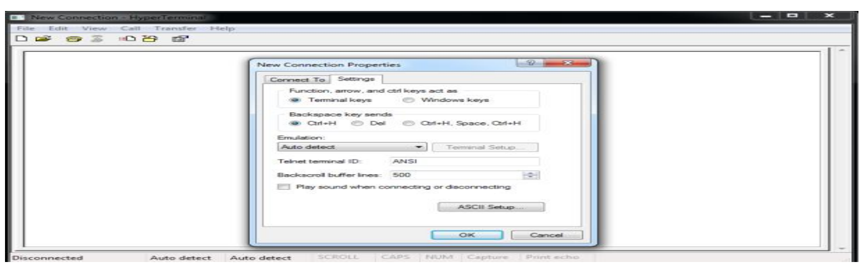


Figure 5.7

Step-6 b Select ñEcho typed character locallyò, see screen shot below:

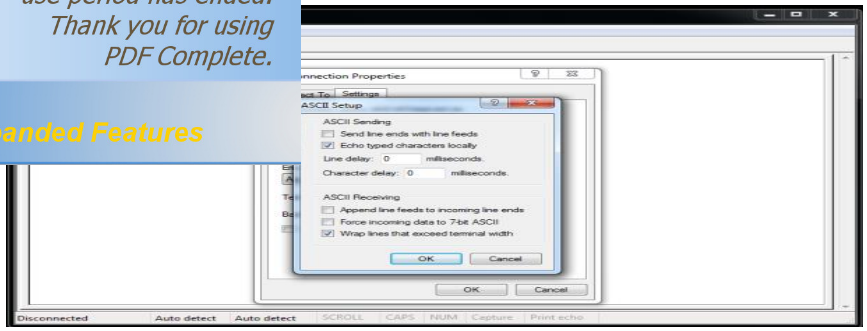


Figure 5.8

Step – 7 a If you want to receive a file from your device the click on ósettingsô, then select ôReceive fileô option.
Step – 7 b Choose the receiving protocol whatever your device support, see attached screen shot.

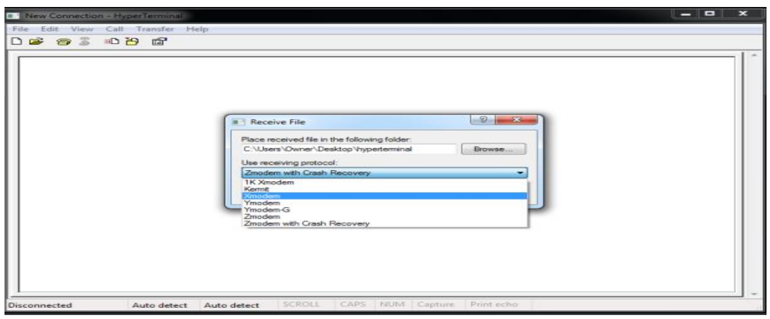


Figure 5.9

Step – 8 If you want to send a file, then select ñSend fileò option and sending protocol.
Step – 9 similarly you can capture the text and save it in a file.
Serial Communication using Putty
Step – 10 Double click on downloaded ôPutty.exeô, you will see a window like this:

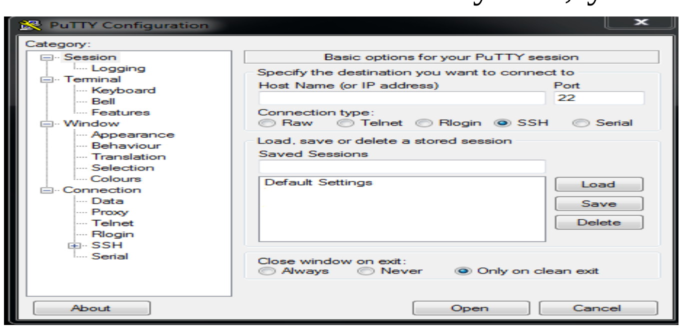


Figure 5.10

Step – 11 Select óserialô, insert com port and baud rate value and click on ôSerialô (Left pan), you will see a window look like this:

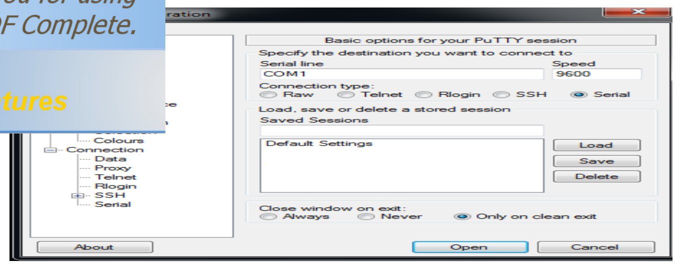


Figure 5.11

Step – 12 Enter all the setting according your device and then click on open,

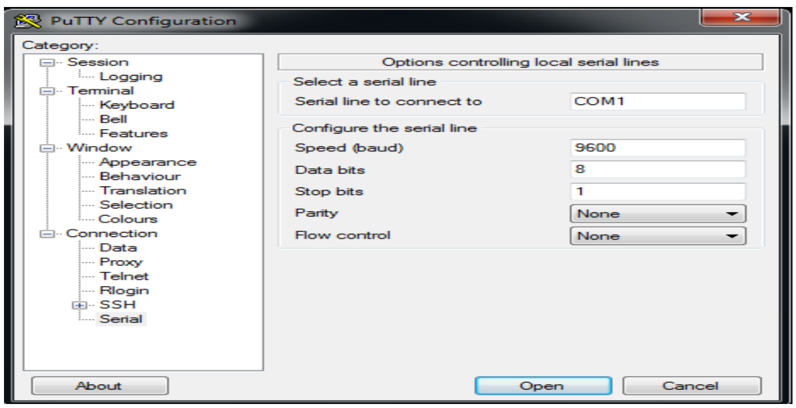


Figure 5.12

Step -13 after clicking on óopenô; you will see a window like this, now you are ready to communicate with your device.

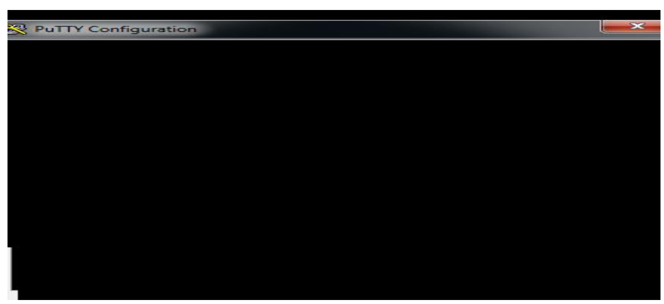


Figure 5.13

Chapter: 6

Software Section

6.1 Introduction to Proteus:

mous simulator. It can be used to simulate electrical field. It is very easy to use because of GUI interface that is very similar to the prototype board. Moreover, it can be used to design printed circuit board PCB.

6.1.1 <u>System components:</u>

- ISIS Schematic Capture - a tool for entering designs.
- PROSPICE Mixed mode SPICE simulation - industry standard SPICE3F5 simulator combined with a digital simulator.
- ARES PCB Layout - PCB design system with automatic component placer, rip-up and retry auto-router and interactive design rule checking.
- VSM - Virtual System Modeling lets co-simulate embedded software for popular microcontrollers alongside hardware design.
- System Benefits Integrated package with common user interface and fully context sensitive help.

6.1.2 <u>How to use Proteus:</u>

To review the Proteus software, as we know that Proteus software, we can create to design electronic circuit schematic using Proteus software, we also can design PCB layout using Proteus software easily. And the main and urgent facilities that provided by Proteus software is simulation P-Spice schematic level to know how are our project will work

When we want to use Proteus to create the electronic schematic circuit, firstly we can draw electronic circuit schematic according our schematic project the needed. We can use many tools that provided by Proteus software. We can use tools like components that needed connector, and also wiring that needed.

After we drawing our circuit schematic, we can continue take simulation our schematic to know how our project is work properly. We also can use many tools to simulate our project.

layouts and simulations:

n:

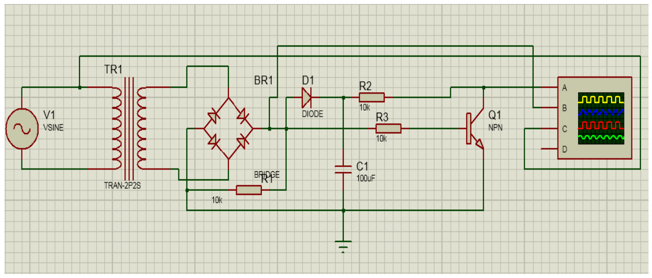


Figure 6.1 zero crossing pcb layout

6.2.2 Zero crossing simulation:

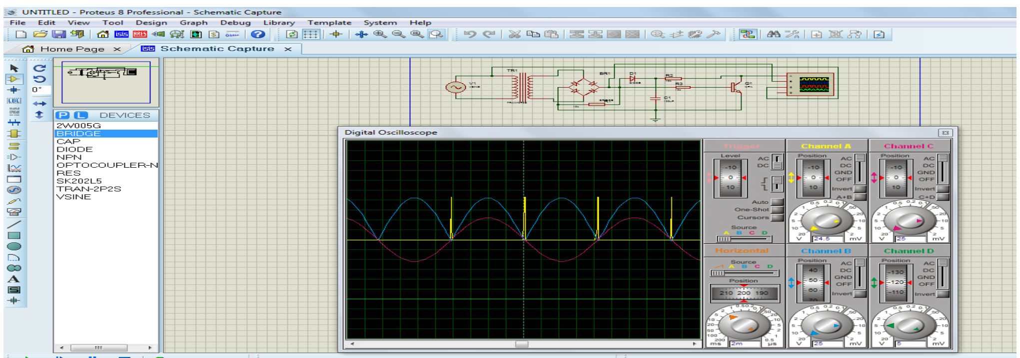


Figure 6.1.2 zero crossing simulation

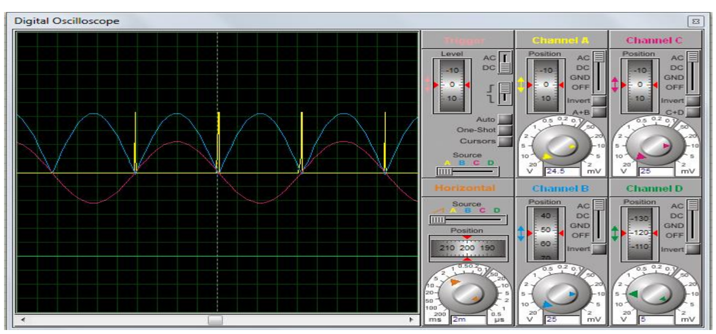


Figure 6.2 zero crossing simulation by oscilloscope

...esign:

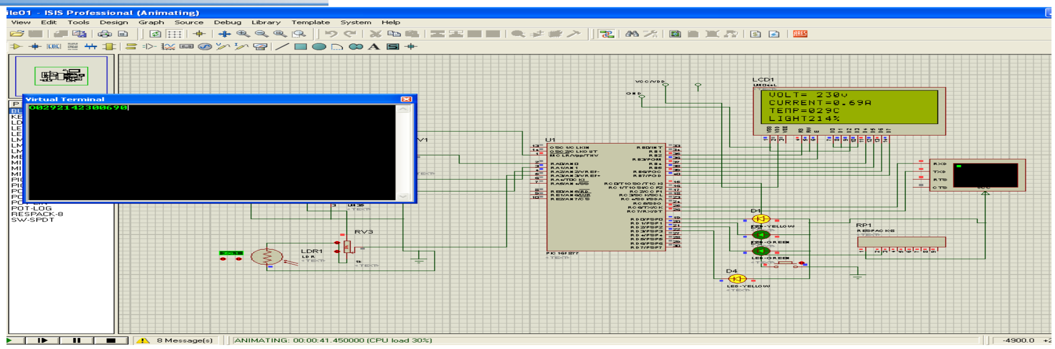


Figure 6.3 Transmitter end layout

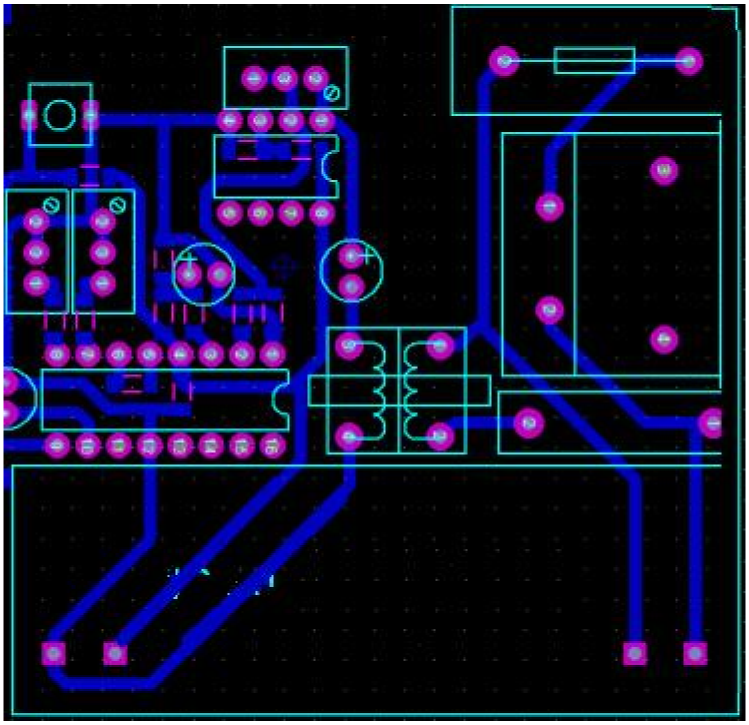


Figure 6.4 Tr. Pcb layout

6.2.4 <u>Receiver layouts:</u>

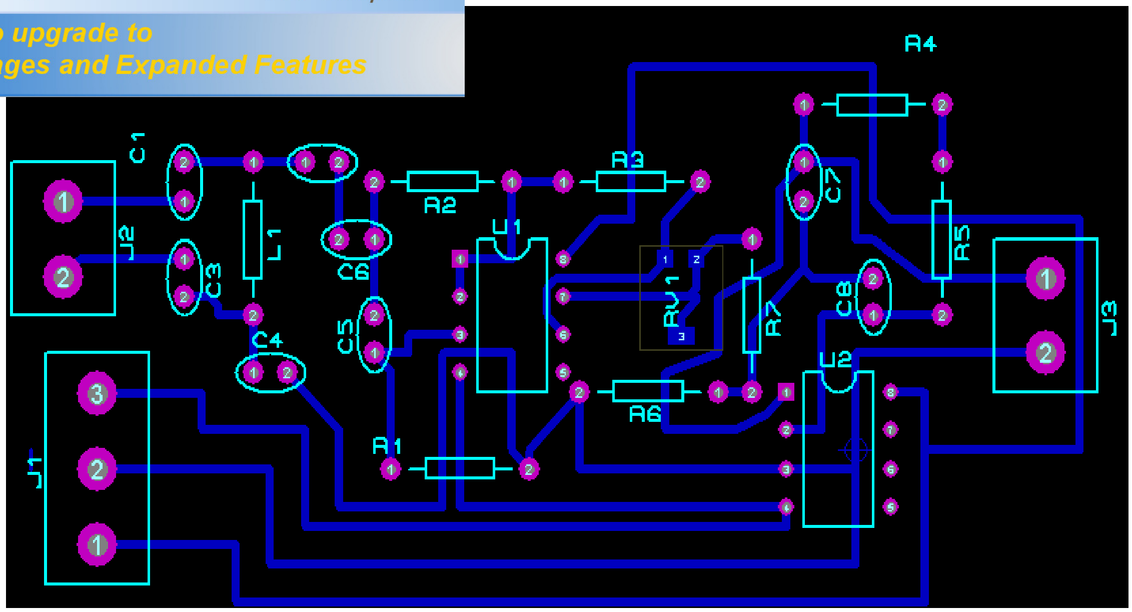


Figure 6.5 receiver Pcb layout

6.3 Advantages of using Proteus:

- Proteus PCB design combines the ISIS schematic capture and ARES PCB layout programs to provide a powerful, integrated and easy to use suite of tools for professional PCB Design.
- All Proteus PCB design products include an integrated shape based auto router and a basic SPICE simulation capability as standard.
- More advanced routing modes are included in Proteus PCB Design Level 2 and higher whilst simulation capabilities can be enhanced by purchasing the Advanced Simulation option and/or micro-controller simulation capabilities.

6.4 Software Compilation:

6.4.1 Micro C. Proteus PCB design combines the ISIS schematic capture and ARES PCB layout programs to provide a powerful, integrated and easy to use suite of tools for professional PCB Design. All Proteus PCB design products include an integrated shape based and a basic SPICE simulation capability as standard. More advanced routing modes are included in Proteus PCB Design Level 2 and higher whilst simulation capabilities can be

Advanced Simulation option and/or micro-
y

In some cases, these may well be PIC microcontrollers from Microchip Inc., and as with any CPU, we need tools to make them work - let us see what this one is capable of.

MikroC PRO for PIC is a complete IDE for coding, simulating, programming, and debugging your PICs. Writing your code in C brings advantages over writing it in assembler - for example, you do not have to switch between register banks. But the most important advantage is that C is easier to use, maintain, understand, and share.

You can always write and simulate your code with the IDE, but for programming and debugging the PIC you need one thing ï Mikro Elekronikaôs PIC Flash. If you want to use a different one, you just need to assemble one on your own, or use one of the many already available on the Internet. Unfortunately, PIC Flash interface is not open, so most of the time programming and

Usually, when programming a tool that requires some port interface (SPI, UART, USB, etc.), testing becomes crucial. This IDE offers you a series of interface windows for that purpose. For instance, if your prototype includes a UART interface, you can use the ñUART Terminalò to configure the number of bits, the parity, the baud rate, and anything else you may need to verify how well your idea works. This helps a lot in finding common problems beforehand.

It is also very helpful to have access to a number of built-in libraries. These falls into three categories: Standard ANSI C, Hardware PIC-specific, and Miscellaneous. Most of the time, hardware libraries require specific hardware parts to be available inside the PIC, but in some cases it is possible to emulate its functions, like we have seen with UART. Their hardware counterparts will work better, but if the PIC does not have the necessary hardware components, all we can do is emulate them. Some libraries will not need any special PIC model (they can work with any of them), but they require some external hardware bits - for example, with the Music library you can play your songs in MIDI only if a buzzer (or other hardware component) is installed.

This IDE is only for 8-bit PICs, but you can see it as your first step to learn PIC programming, which might later help you to move up into 16-bit and 32-bit, and even \PICs. Imagine everything you can do, from a simple blinking LED to a robot that can beat you playing chess. mikroC can certainly help you with the entire process of developing - think about the unlimited possibilities, only you set the limit.

6.5.1 Algorithm for transmitter:

Step1: Do the basic initialization

Step2: Start code, House code, device code and function code are stored in Arrays according to X-10 protocol.

Step3: Display ôPower line communication ô

Step4: Give 2 second delay.

Step5: Display ôDevice:ô on LCD

Step6: PWM generates 120 KHz with 50% duty cycle.

Step7: Enable external interrupt.

Step8: Display device number

Step9: Display device status as ON, Off, ON all, OFF all.

Step10: Interrupt routine.

Step11: Start code, House code, device code, and device status are Generated according to the input keying.
Step12: Send address once.

Step13: Send address twice.

Step14: Send function key once.

Step15: Send function key twice.

Step16: 1ms delay.

Step17: Call LCD command.

Step19: Delay.

Step20: Send code.

6.5.2 Algorithm for Receiver:

Step 1: Do the basic initialization

Step2: Check zero crossing for 1 ms.

Step 3: Compare the received bits initially with start code.

Step 4: If start code received is correct, store the remaining bits Received after start code

Step5: Check whether the stored bit sequence match with the house Code

Step6: If house code is correct compare the device code to select the Device.

Step7: Now compare the function code to select the function (if Function is ON then output high to corresponding RB pins).

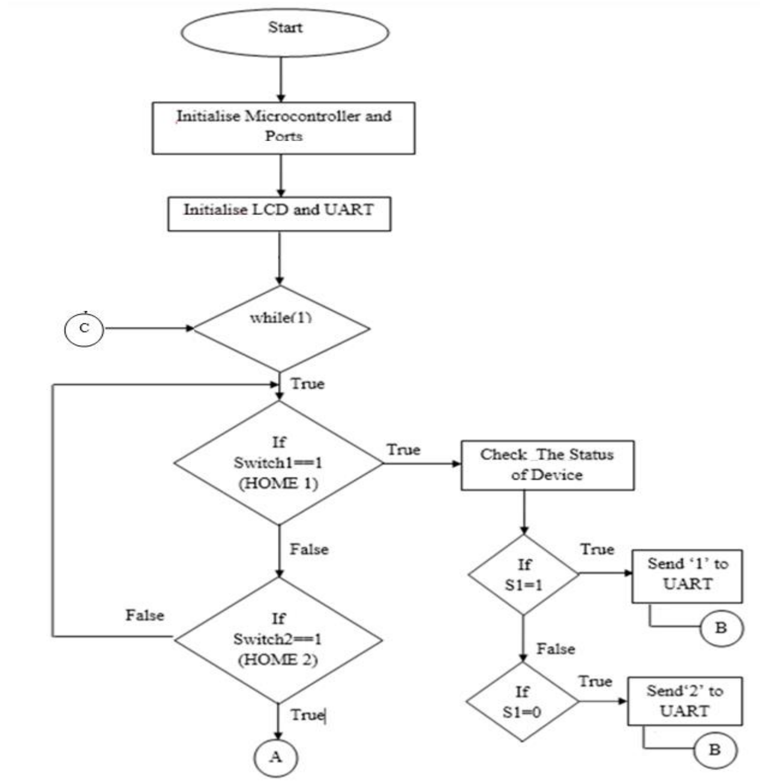
Step8: Check for sensor data.

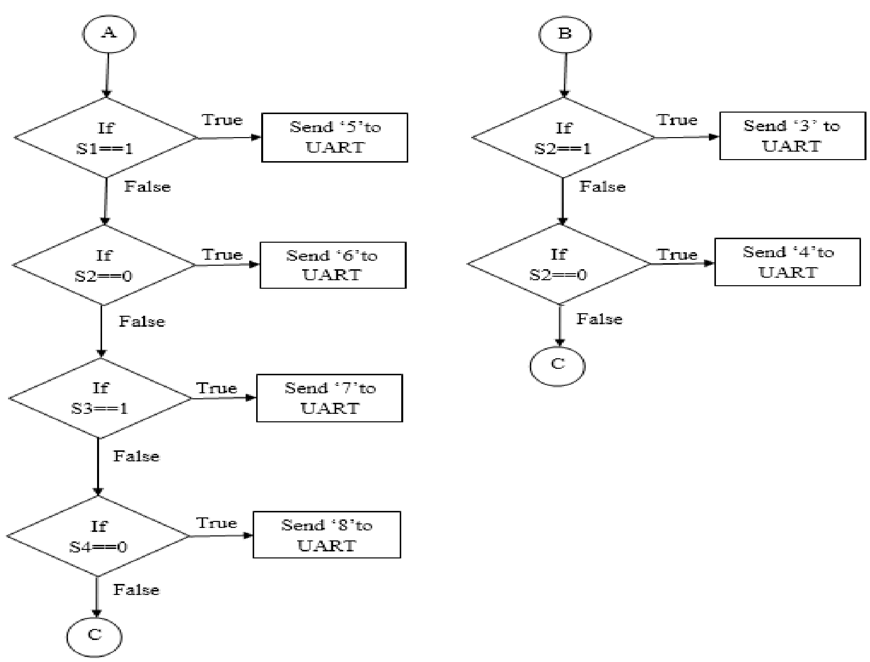
Step9: Transmit the sensor data.

Step10: End

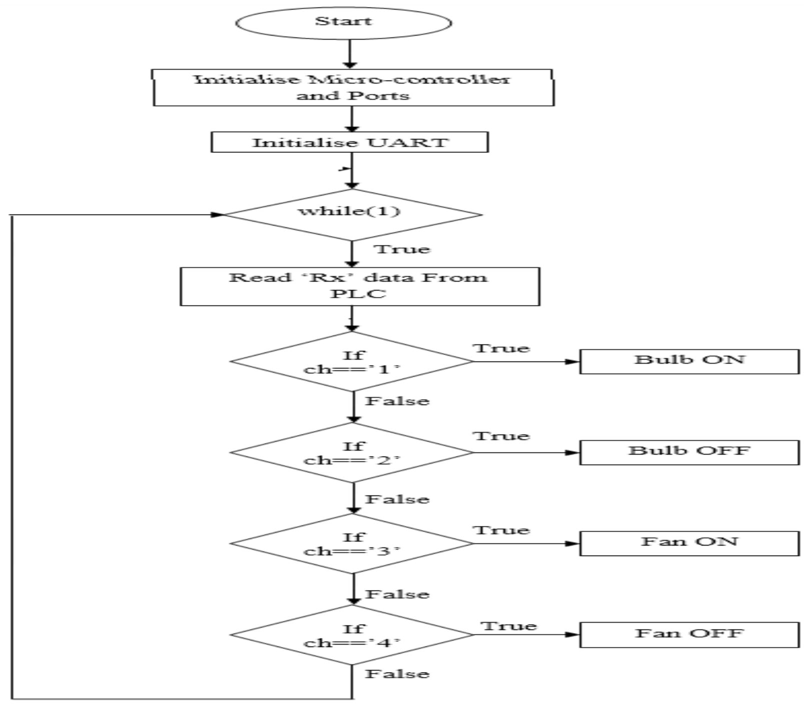
6.6 Flow charts:

smitter:


Start
Initialise Microcontroller and Ports
Initialise LCD and UART
while(1)
C
True
If Switch1==1 (HOME 1)
True
Check The Status of Device
If S1=1
True
Send '1' to UART
B
False
If S1=0
True
Send'2' to UART
B
False
False
If Switch2==1 (HOME 2)
True
A


A
If S1==1
True
Send '5'to UART
False
If S2==0
True
Send '6'to UART
False
If S3==1
True
Send '7'to UART
False
If S4==0
True
Send '8'to UART
False
C
B
If S2==1
True
Send '3' to UART
False
If S2==0
True
Send '4'to UART
False
C

iver:


Start
Initialise Micro-controller and Ports
Initialise UART
while(1)
True
Read 'Rx' data From PLC
If ch=='1'
True
Bulb ON
False
If ch=='2'
True
Bulb OFF
False
If ch=='3'
True
Fan ON
False
If ch=='4'
True
Fan OFF
False

Future Scope and Applications

The project can be extended to further use in daily household applications to complex industrial and commercial purposes which are discussed in the section below.

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. PLC can be used as a cheaper alternative to intercom. Many loads may be connected to the output instead of the speaker. These loads may be switches controlling the various appliances or it can be the relays that activate various security systems. 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.

Figure 7.1 Range of Applicability of PLC.

n other applications like lighting (e.g. traffic ng), industrial (e.g. UPS communicating to a network device, irrigation control), machine-to-machine (e.g. vending machines, a hotelðs reception-to-room communication), telemetry (e.g. offshore oil rigs), transport (e.g. Electronics in cars, trains and airplanes).

PLC is also widely used in the micro-inverters. PLC was first adopted in the electrical transmission and distribution system to transmit information at a fast rate. PLC technology is used in home control and automation. This technology can reduce the resources as well as efforts for activities like power management, energy conservation, etc. PLC is used to distribute the multimedia content throughout the home. Data transmission for different types of communications like telephonic communication, audio, video communication can be made with the use of PLC technology. In monitoring houses or businesses through surveillance cameras, PLC technology is far useful. [13]

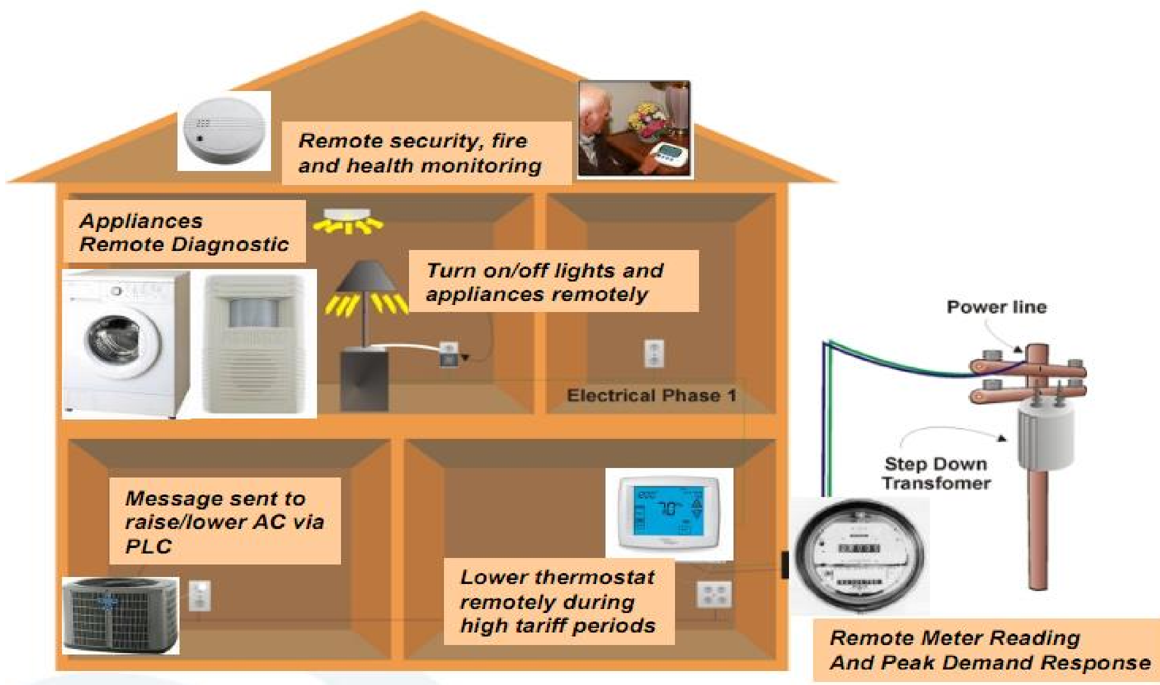


Figure 7.2 PLC Domestic and In-building Application

The two main and revolutionary applications of PLC are in the Automatic Metering Infrastructure and in the Smart Grid.

7.1 Automatic Meter Reading

Automatic Meter reading applications use the PLC technology to send the data from home meters to Host Central Station. The whole measurement and collection system that includes meters at the customer site, communication networks between the customer and a service provider, such as an electric, gas, or water utility, and data reception and management systems, that make the information available to the service provider, are referred to as AMI. The Smart Meters transmit the collected data through commonly available fixed networks such as Power Line Communications (PLC), Fixed Radio Frequency (RF) networks, and public networks (e.g. landline, cellular, paging) which is aggregated by a concentrator, sent to the utility and then to a Meter Data Management System for data storage, analysis and billing. Studies show that Narrowband PLC is best suited for AMI with over a 100 million NB-PLC devices installed to date. [14]

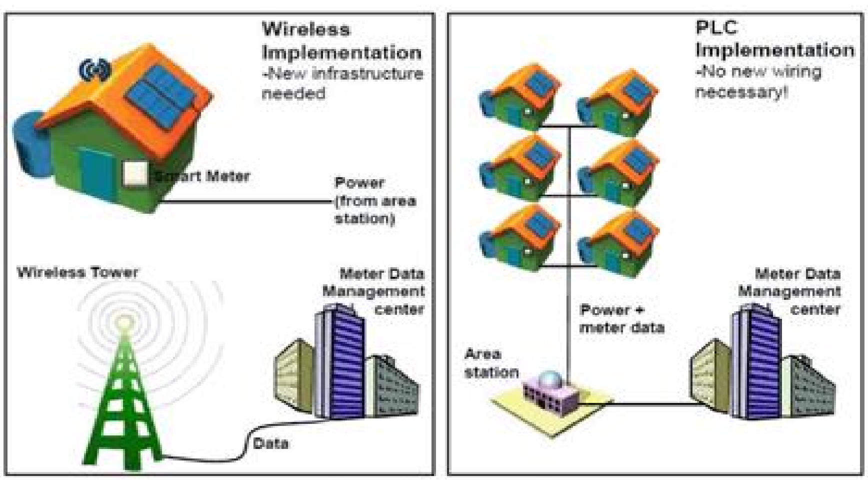


Figure 7.3 AMI Application using PLC

The óSmart Gridô is essentially modernization of the transmission and distribution aspects of the electrical grid. This intelligent power distribution infrastructure enables two-way communication between the consumers and the utility. The consumers use home networks to communicate with their smart meter, which further communicates with the utility (Advanced Metering Infrastructure-AMI). The Smart Grid definition does not stop at energy utilization; supply of energy to the grid from Distributed Generation (DG) sources such as solar and wind fall into the same category. The DG system also includes Vehicle-to-Grid (V2G) - bi-directional sharing of electricity between Electric Vehicles (EVs) and Plug-in Electric Hybrid Vehicles (PHEVs) and the electric power grid. [14]

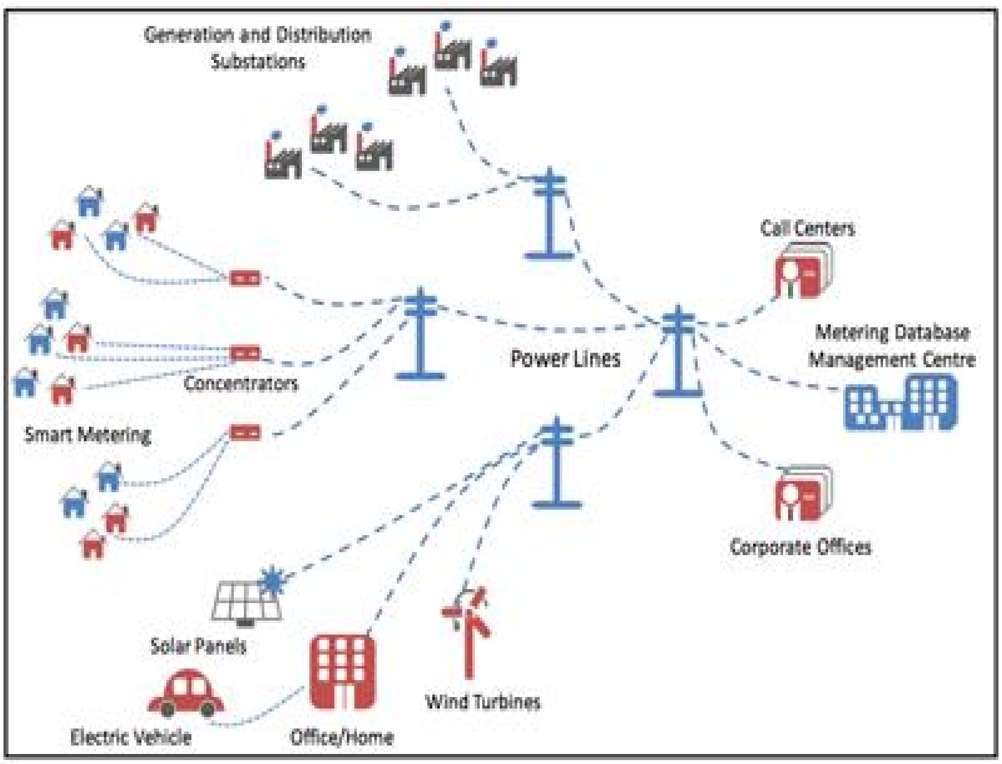


Figure 7.4 PLC Application in Smart Grid Technology.

Conclusion. Societyôs demand for power will continue to grow as new technologies are invented. This is a reality of living in an industrialized age. However, the same technologies that are created to make our lives more comfortable, convenient, and safe can sometimes cause traumatic results. Our power suppliers are given the burden of supplying us with a constant power supply, but this burden cannot always be met.We proposed the idea of a device that would allow communication between the power suppliers and their large industrial clients in the hope that the communication would lower the probability of power failures. We also done the monitoring and control of different loads. The interesting feature about the device is that it communicates solely through the power lines. This is an implementation of data transmission through power lines. A successful implementation of this type of technology would open the door to new data services that could also be provided through the power lines.The implementation of the device began with the design of a transmitter and receiver circuit. The circuit would need to be able to receive data, modulate it, and then interface with the power line. We successfully created such a circuit using an FSK modulating chip and power amplifiers. The receiver was also built using a FSK demodulating chip and power amplifiers to interface with the circuit. The final step was to build filters that would allow us to retrieve the original message. Although we encountered several problems on the way, we were able to successfully design, simulate, and implement the transmitter and receiver circuits with monitoring and controlling different loads. In conclusion, we accomplished the task that we set forth to do at the beginning of this project which was to send data over the power lines with monitoring and controlling the different loads. Through the work we have done we learned about the high interference that must be overcome to make high-speed data transmission over power lines successful.

ES

[1] Power line Communication, Wikipedia the free encyclopedia; **en.wikipedia.org/wiki/Power-line_communication**

[2] **http://en.kioskea.net/contents/126-introduction-to-power-line-communications-plc**

[3][4][8][13] **http://www.renesasinteractive.com/file.php/1/CoursePDFs/DevCon-OntheRoad/DevCon_OntheRoad/Automotive/Narrowband_Powerline_Communication_Applications_and_Challenges.pdf**

[5][7] **http://www.itk.ntnu.no/fag/TTK4545/TTK2/Pensum-filer/PowerLineCommunication.pdf**

[6] **www.isplc.org/docsearch/Proceedings/1998/pdf/0450_001.pdf**

[9][10] **http://www.eetimes.com/document.asp?doc_id=1279014**

[11] **researchbank.rmit.edu.au/eserv/rmit:13700/Al_Mawali.pdf**

[12] **http://www.bcae1.com/trnimpmt.htm**