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"Distribution Powerline Communication : Issues in use of Remote Monitoring"

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Abstract

The report discusses the key parameters to effective communication using low voltage mains network. Many diverse benefits and applications of distribution line carrier communication are discussed with special emphasis on the Automatic Meter Reading(AMR). Advantages and limitation of the Power Line Carrier Communication(PLCC) are also discussed. Report also includes a comparison of power line carrier communication with other communication medium. High noise and attenuation are important aspects of PLCC. For better understanding of above parameters, different types of noise and their sources are studied. Working of AMR system and its possible implementation is discussed. Possible design and test results of modulator and demodulator part of PLCC are also presented.

Key Terms: Automatic Meter Reading (AMR), Power Line Carrier Communication (PLCC)

1 Intoduction

Deregulation of power sector is occurring in many parts of world. It opens up energy market and free up customers choice of energy suppliers. Power sector in India is also in a state of reform. Selective privatization of distribution sector and partitioning of state electricity boards into separate entities: generation, transmission and distribution will lead to increase need of transparency and managing distribution network more efficiently. Increased interest and investment in distribution sector will demand, distribution sector to be operated efficiently and effectively. Advance technology helps to increase the reliability of distribution system at reduced operating cost.

The main obstacle in realization of the cost effective communication is the investment required to provide the necessary infrastructure to the maximum number of users. The currently available technologies, like wire, cable, fiber, wireless and satellite are still unable to provide solution to this problem.

Power line carrier communication(PLCC) is a rapidly evolving technology, aiming at utilization of the electricity power lines for the transmission of data. The greatest advantage of power line as communication media is its reach to customers. Every building is connected to the power grid and moreover every room has power line contact points. The extent of this existing wiring cannot be matched to any other communication medium. Thus, the emerging PLCC technology opens up new opportunities for the mass provision of local access at a reasonable cost. In addition, PLCC can provide a multitude of new services to the users which are difficult to implement by other technologies, e.g., remote electricity meter reading, appliance control and maintenance, energy management, home automation etc.

This is a emerging field, but has its own limitation. The noise and attenuation of power line is strongly location and time dependent. As there are different load on power line, which generates very strong noise signals, power line communication is very noisy communication channel.

In section 2, advantages of PLCC and comparison with other communication medium is discussed. Different application which can be offered using PLCC are discussed in section 3. In section 4, limitation of power line, as a communication medium, are described. In section 5, noise on the distribution line is discussed. Also, different types of noise and sources of each type are presented. In section 6, signal attenuation and disturbances are discussed. Calculation of characteristics impedance is also presented. Finally AMR as a application of PLCC for kWh meter reading is studied in section 7.

2 Power Line as a Communication Medium

A power line network is a very huge infrastructure covering most of the part of the inhabited area. Power is typically generated at high voltages and transmitted over high voltage network to medium voltage line and then to low voltage line by substations. These substations then distribute the power to large number of customer using low voltage distribution network.

Power line communication uses the available power line network as a communication medium. The greatest advantage of using PLCC is its huge and fine grain network. Already every building is connected to the power grid and moreover every room has power line contact points. The extent of this existing wiring cannot be matched by any other communication network. Thus, the emerging PLCC technology opens up new opportunities for the mass provision of cost effective local access.

A communication channel is defined as the physical path, using which signal propagates between the transmitter and the receiver node. The quality of any channel depends upon the noise present and attenuation of the channel. If noise at the receiver is high, then it makes detection of the original signal difficult. Also, as the signal attenuation increases, less signal power is available at the receiver. This makes the detection harder in presence of noise.

Though PLCC is a emerging field, it has its own limitation. The main objective of power lines is to deliver power. Its characteristics depends on the load condition and varies as load changes. As there are different loads on power line which generate very strong noise signals, it is a very noisy communication channel. Also, as power line are designed to carry electrical power energy, and not for communication, it has very strong attenuation for the carrier signal frequencies. Thus, PLCC is strongly location and time dependent.

In the following subsection advantages, limitation, application and comparison with other communication medium are discussed.

2.1 Key Advantages of PLCC

There are various strong points and key advantages to consider the PLCC as a communication medium[1].

- The power grid is ubiquitous: The low-voltage power distribution network has as a very unique feature that it constitutes an already existing networked infrastructure to very large number of private customers as well as businesses. It is also a large-scale as well as very fine-grained infrastructure, connecting billions of people all over the world, but also even crossing the boundaries of homes and buildings to individual wall outlets and sockets.

- The power grid offer last mile connectivity: Through PLCC, the power line offers what is sometimes called 'the last mile connectivity' to the individual customer. In this regard, it is not the only last-mile technology, but it appears to emerge as a significant competitor to other communication medium. Depending situation, varying demands and capabilities, the overall communication infrastructure will have a hybrid character. The power line is certainly a very good alternative, since it could provide a permanent-access, two-way, always-on-line connection to the customer, 24 hours a day.

- The power grid supports information based services:Although PLCC technology is recent and in need of further advances, both in terms of telecom capabilities and equipment cost reductions, present relatively limited data rate transfer speeds are sufficient for many useful innovative applications. A number of useful services are already feasible with data transmission in the kbps range, e.g., automatic meter reading.

- The power grid is already in place, thus enhancing cost-effectiveness: As the power line infrastructure is already in place, it is potentially cheaper than other forms of local telecommunications access, as it will require tremendous investment to achieve comparable scale and grain size.

2.2 Comparing PLCC with other relevant technologies

There are several alternative technologies, beside PLCC, for the data communication and services. Each technology has its own strength and weakness. A state of art comparison between PLCC and other relevant technologies is presented in [1] and summarize as below.

- Public switched telephone network (PSTN)

  Merits

  -Mature and robust, good installed based, wide choice of product, easy to use and install, relatively cost effective

  Demerits

  -relatively slow, on demand only

- Integrated Service Digital Network(ISDN)

  Merits

  -Mature and robust, Widely available

  Demerits

  -Expensive for consumer market, on demand only

- Cable Modem

  Merits

  -Excellent Performance, permanently on line

  Demerits

  -Limited geographical coverage, currently only available in limited trial, connection based

- Microwave Communication

  Merits

  -Superior Performance, good geographical Coverage, flexible of configuration

  Demerits

  -costly compared to PLCC, coverage not wide as PLCC

- Power Line Carrier Communication

  Merits

  -Good Performance, Existing infrastructure(network), permanently on line, good geographical coverage

  Demerits

  -Still at development stage, no installation base, limited distance, possible problem in meshed power network

3 Potential and Direction for new application service

The use of the power line as a communication media will have a large impact on the operations of major industrial sectors, i.e. power utilities, commercial/residential information product users, and technology/application suppliers. Current utility objectives are:

- Cost Reduction
- Consumer retention
- New Revenues

A List of range of PLCC-enabled services that are currently being investigated and tested in different parts of world is given below [1].

3.1 Example of Application Focused services

- Automated Meter Reading: It enables the utility to remotely obtain meter readings of customer's meter, load and consumption data, and detect tampering and/or energy theft.
- Remote Connect/Disconnect: can connect or disconnect electric supply from central location, in demand side management.

- Multi-Utility Services: provide service bundles for other utilities like AMR for gas and water meters.

- Network Control: Operating efficiencies are targeted through automation of the distribution network, allowing dispatchers or computer-based algorithms to operate field devices to optimize the network (like substation automation, dynamic loading and Volt/Var control etc).

- Appliance management: Individual appliances can be monitored and managed. Customer can be informed if appliance has abnormal usage or appears inefficient compared to modern alternatives.

- Customer Load Management: Electricity consumption based on time of use and/or real-time pricing that provide incentives for more efficient use of energy; direct load control may be included as an option.

- Energy Usage Management: The customer information interface is used to provide energy usage information and advice, as well as communications regarding billing and new services offerings.

- Interactive Services: Customer interface for enabling service delivery, scheduling services appointments and selecting service options.

- Comfort and Savings: Intelligent home devices and network providing home comfort and energy/cost savings functions, like, reduction in peak current consumption.

- Telecom Intensive Applications: Fast Internet access, IP telephony, Web TV, electronic content services in education and entertainment, etc.

3.2 Why Limited Exploitation?

There are three main reasons why exploitation of PLCC to date has been limited to narrow band applications. These are summarized below [1].

- PLCC technology is recent and still evolving: Research into high speed and high frequency PLCC systems has been going for a long time. But in recent years, the complex modulation techniques have been developed which are able to support high speed digital communication within such a harsh environment as the power line.

- There is lack of standardization and interoperability of PLC relevant Product: Standards such as CENELEC which identify frequencies employed for PLCC up to 148.5 kHz restrict the capability to deploy modern voice or data communication systems. This has furthermore reduced the incentive to investigate potential higher value PLCC systems.

- This is a recent technology so, commercial incentives to exploit such a telecom infrastructure have not yet been clear. For limited applications it is not always easy to build the business case. Therefore, investigation of PLCC has to date been limited to narrow band applications, which are primarily targeted at reducing operational costs of the power supply utility (e.g. power line telemetry, AMR etc.).

4 Limitations of PLCC

The preferred method of data transmission is carrier communication with digitally modulated signal being transmitted over the power network. However, compared to other communication channels power line present unique problem.

Power line characteristics are highly time and location dependent (based on loading condition), which represent most critical obstacle for data communication. The noise signal level and attenuation depends partly on the load connected to power line, which vary with time. The communication channel, which is time variant, makes the design design of communication system very complex. Thus, at some time a strong noise source could completely block the communication. Noise is further discussed in section 5.

The line characteristics differ according to line voltage, i.e., high voltage or low voltage line. Normally in conventional communication, impedance matching is attempted. The power line network is not matched. The input and output impedance vary with time, with different load and location it can be as low as 0.5 ohms to as large as few hundreds of ohms. Variation due to cable impedance mismatch leads to poor degree of transmission.

In developing a potential communication channel using low voltage network, different component of the power line need to be taken into consideration. These include low voltage distribution substation with its inherent transformer, switchgear and cable. Different distribution line parameters vary with type of the cable, age, current, and voltage specification. Thus, the design of a proper and reliable power line communication system is very complex.

5 Noise and Disturbances on LV Power Line

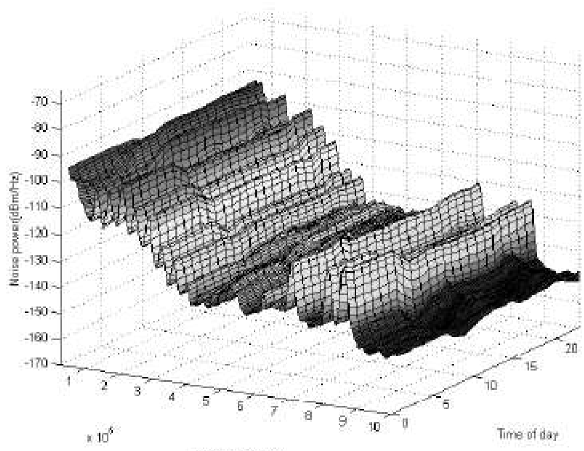

Figure 1: Mean noise spectral density as a function of day

The noise is always present in all communication media. The three voltage networks i.e., high voltage (HV), the medium voltage (MV) network and the low voltage(LV) network have different sources of channel disturbances [2]. In the HV network, some of the disturbances are due to lightning, circuit breaker operation, and transients produced within the power system. The main disturbance sources in MV networks is switching in-and-out of Power factor correction capacitor banks. The major disturbance sources in the LV network are the various household appliances, office equipments and industrial loads connected to the LV network.

The distribution line noise is strongly location and time dependent. As the load on the distribution line changes, noise intensity is reflected accordingly. This also varies according to the time of the day. In residential building the peak noise power can be observed on morning or night hours compared to other hours of the day. (Fig. 1 from [2]).

5.1 Types of Noise

An extensive set of noise measurements on the low voltage electrical power distribution network is presented in [2]. Differnet kind of noise and their sources are discussed in [3] and [4].

There are four types of disturbances that are present in the power line as discussed in [2] and [3]. These are as follows (Fig. 3 to Fig 6 are from [2])

5.1.1 Impulsive noise:

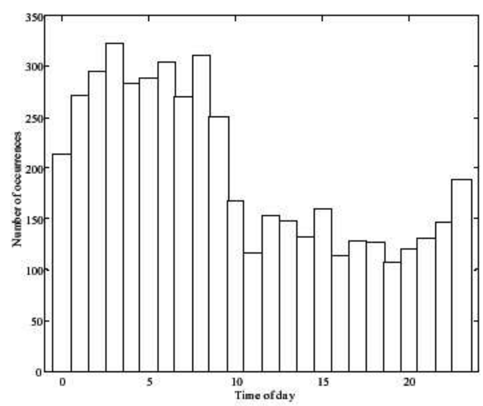

Figure 2: Histogram of noise impulses as a function of time of the day

"Impulsive noise is defined as all those disturbances on the power line that last for a very small fraction of time [2]." This type of noise is primarily due to all kinds of switching phenomena. This type of disturbance affects the whole frequency band but its duration is for very short time. Typically the duration of the noise impulse is less than $100\mu S$ and that the impulse amplitude is usually more than $10dB$ above background noise level [4]. Impulsive strength depends on which noise source are present as well as on the proximity of these noise sources to the receiver.

Fig. 2 from [2], shows histogram of the impulsive noise as a function of time of day. From the given histogram one can clearly see that there is dependency between the time of the day and the number of impulses. The number of impulses in day time are very large compare to remaining hours.

5.1.2 Switching periodic noise

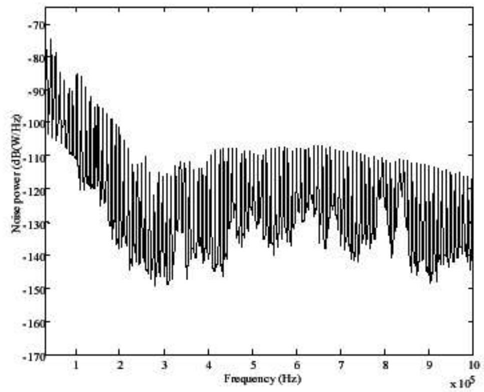

Figure 3: Switching Periodic noise

This type of noise is caused by all kinds of switching devices, which commonly work synchronously to the power system frequency (50 Hz), like light dimmers. These load uses Silicon Controlled Rectifier (SCR) which switches certain amount of time every 50 Hz cycle. Switching periodic noise is a major component in measurements. A very common measurements like the striking one shown in Fig. 3, where a persistent, high amplitude switching periodic noise is present. Theoretically, this kind of noise should produce spectral lines at multiple frequencies of power line.

Switching periodic noise are always synchronous to the power line frequency. Normally, the different frequencies are 100 Hz, and less commonly 300 Hz and 50 Hz [2]. Switching periodic noise not synchronous to 50 Hz is not present.

5.1.3 Non-switching periodic noise

The appearance of this noise is quite different from the switching periodic noise. This noise has a continuous, long-lasting behavior in the time domain. The disturbance is periodic and nonsynchronous to the power system frequency. From Fig. 4, there is existence of equally spaced peaks, with a separation of approximately 37.5 kHz between each other. This must correspond to the harmonics of some device operating at that frequency.

This kind of noise is usually generated by television set and computer monitors. The repetition of pulse depends upon the screen scanning that varies among the television and computer standards.

5.1.4 Background noise

If we subtract all different noise, mentioned earlier, from the total noise measured at a certain location, then the remaining part portion of noise is the background noise. Unlike

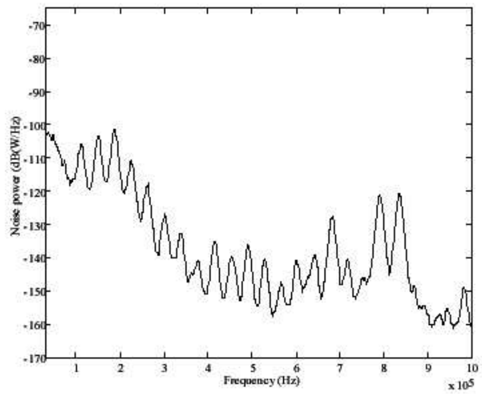

Figure 4: Non-switching periodic noise

the other noise types, the background noise is present all the time on any measurement. This produces large transient voltages on the power line, depending on the size of the capacitor. Wideband additive noise is present across the entire frequency range.

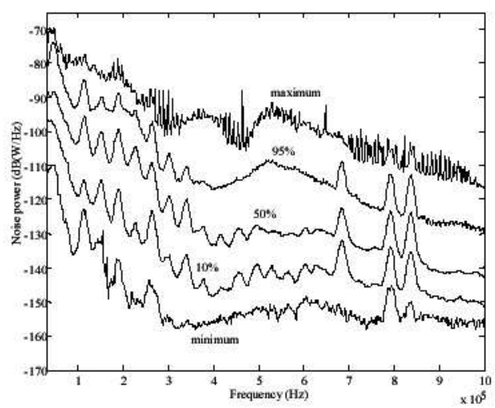

Figure 5: Averaged noise power spectral density distribution

5.1.5 Noise Model

In [2] a simple model of background noise is given The average noise power spectral density distribution is shown in fig. 6. The whole frequency band is split into three parts: 30-400 kHz, 400-700 kHz, 700-1000 kHz and the model for this is given as

$$N(f) = 10^{(K+\alpha f)}[W/HZ] \tag{1}$$

where f is expressed in Hz. The parameters K and α are consider to be normally distributed.

Fig. 6 from [2], shows the result of the given model superimposed to the curve that present the mean value of all averaged measurements. The mean value of k is -9.89 for 30-400 kHz, -15.23 for 400-700 kHz, and -10.58 for 700-1000 kHz. The mean value of α for these range is $-1.13 * 10^{05}, 2.09 * 10^{06}, -4.54 * 10^{06}$ respectively. Similar value ranges are reported in [5].

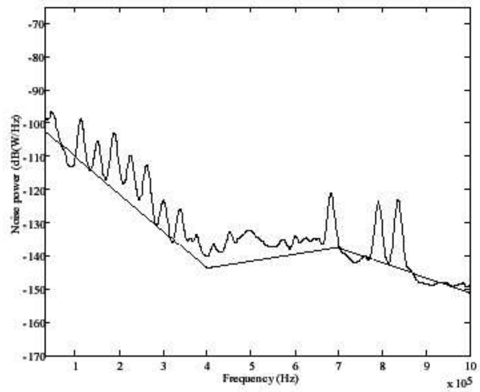

Figure 6: Noise Model

From the above discussion we can conclude that noise is strongly frequency as well as time dependent. As the frequency increases noises power is less and decreases as frequency increases.

6 Signal Attenuation

The attenuation of power line is of prime importance in carrier application because it determines the fraction of transmitted energy available at the receiving end to overcome noise and interference. There are different signal attenuation in the distribution line, as a communication channel,which are as follows [3].

- To transmit the modulated signal on distribution line an isolation of transmitter from high voltage signal is required. This is done using a coupler both at transmitter and receiver. The signal experiences attenuation due to coupling circuits, both coupling-in and coupling-out. Such attenuation is unavoidable because direct injection of signal is impossible without isolation. But it can be reduce through better coupling circuit.

- There are attenuation due to the branching of the circuits. Branching causes discontinuities in power lines, which results in that part of the signal gets reflected and part of its gets transmitted. Reflection is undesirable as it causes signal attenuation.

- The signal attenuation that is due to the impedance of the power line is called 'Line attenuation'. The power line impedance is dependent on the size and length of the line.

The line and branching impedance are more severe and are also very difficult to reduce.

It is possible to approximately calculate attenuation of power line. But, calculation of resistance (R) is difficult for usual transmision line using standard conductors, because 'Skin effect' formules apply accurately only to round conductors. Method of calculation of impedance and admittance matrices based on generalized formula is given in [6]. Also, the method which converts arbitrary shaped conductor into equivalent cylindrical shape conductor is mentioned.

Although signal attenuation over the power line increases monotonically with frequency, it is not significantly greater in the range 70 kHz to 150 kHz. Because noise as well as wanted signal are subjected to attenuation, noise sources close to the receiver will have the greatest effect on receiver noise structure, particularly when network attenuation is large.

Average attenuation or noise power changes over time. This happens as a result of appliances being switched in or out of the load. The change can be expected to take place as a step when the channel rapidly changes from one relatively stable state to another.

Attenuation increases with frequency. Few references have reported a frequency tilt in attenuation vs frequency graph. It is given in [5] that a frequency tilt of -0.5 dB/kHz with a standard deviation of 4 dB in 10 kHz. A linear best fit yields a value of -0.1 dB/kHz for domestic home supply in the range $0-250kHz$ in U.S. The average attenuation between homes in U.K. ranges from $15dB$ to $25dB$ per $100m$ for the frequency range $3to150kHz$ is reported in reference [5].

The consensus in the literature is that while attenuation increases with frequency over CENELEC range(3 kHz to 148.5 kHz), this increase is less rapid than the decrease in noise level. A working assumption is that the signal-to-noise ratio (SNR) improves by about 0.2 dB/kHz on average [5]. The significance of this from the viewpoint of narrow-band communications is that channels at the higher end of the CENELEC frequency range can be expected to have a better signal-to-channel induced noise ratio.

Results from study [5] shows that, at a given frequency the probability that the average noise spectral density changes during the course of an hour by more than 3dB is $\sim 30\%$. The probability that the attenuation changes by more than 3 dB is $\sim 20\%$.

6.1 Impedance of Load Line

Carrier signal response depends upon propagation characteristics of distribution line. The characteristics impedance of an unloaded transmission line can be obtain from standard parameter model.

6.1.1 General Network Equation for a uniform line

Consider a case of uniform line with repeated array with of
Series impedance element $Z_s = (R + jwL)l$
and parallel admittance of $Y_p = (G + jwC)l = \frac{1}{Zp}$
where, the distributed parameters R as series resistance, L is series branch inductance, G is shunt branch conductance and C is shunt branch capacitance. Fig 7 shows the distributed Parameter Transmission line

Line is assumed to be infinitely long and uniform, the impedance seen looking into any section is same as that of other subsection. Fig 7 can be simplified to form as shown

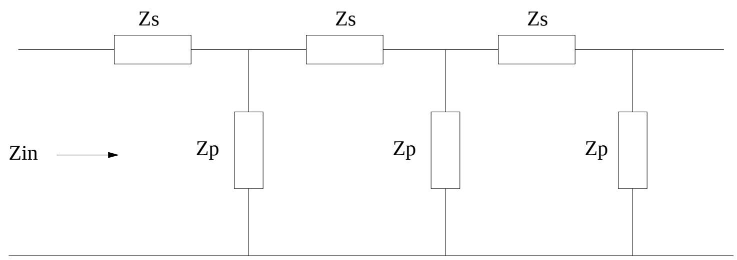

Figure 7: distributed Parameter Transmission line

in Fig. 8 and Z_{in} must be equal to Z_T

Fig. 8 shows a Simplified network diagram.

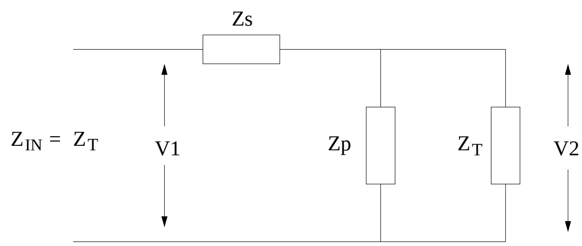

Figure 8: Simplified network diagram

From the above figure it can be seen that

$$Z_{in} = Z_s + \frac{Z_p Z_T}{Z_p + Z_T} = Z_C \tag{2}$$

The solution to above equation becomes.

$$Z_c^2 - Z_c * Z_s - Z_p * Z_s = 0 \tag{3}$$

$$Z_c = \frac{1}{2} l(R + jwL) \pm \frac{1}{2} \sqrt{l^2 (R + jwL)^2 + 4 * (\frac{R + jwL}{G + jwC})} \tag{4}$$

In order to obtain simplified solution for Z_T it is necessary to recognize that as the size of subsection is reduced as R,C,L,G are constant, because of this, ratio of $(R + jwL)/(G + jwC)$ will remain constant. Thus size of subsection can be reduced sufficiently so that both terms involving $(R + jwL)l$ are negligible as compared to constant ratio of $(R + jwL)/(G + jwC)$ in equation of Z_c (Equ. 4).
Then Z_c reduces to Z_o

$$Z_o = \sqrt{(\frac{R + jwL}{G + jwC})} = \sqrt{Z_s Z_p} = \sqrt{\frac{Z_s}{Y_p}} \tag{5}$$

This is called as characteristic impedance of line. It depends upon characteristic parameters like R,L,G,C and is a complex quantity and depends upon frequency.

At the frequency range of interest for the PLCC (3-148.5kHz) the ideal transmission line is well approximated as having mainly resistive characteristics impedance given by $Z_o = \sqrt{\frac{L}{C}}$ where L, C are the line inductance and capacitance per unit length [3].

Analytical and experimental studies suggest a typical value of 450 ohm for uniform unloaded distribution line [3]. However a uniform distribution line is not a suitable model for PLCC, since all lines have many tributary connections to other overhead and underground lines. Further, as load on the secondary of distribution transformer reduces the characteristic impedance is capacitive at the primary. As the loads are largely capacitive in the frequency range of interest leading to lower value of the loaded line impedance. For uniform line typically 1-20 ohm for loaded 240 V line and 5-150 ohm for medium voltage line [3].

Important parameters about the Low Voltage Power Line impedance are as follows [9].

- The low voltage distribution network impedance is rarely greater than 20 ohm.
- 90% of the value of the low voltage distribution network impedance are in the range of 0.5 ohm to 10 ohm.
- The nominal impedance is 5 ohm.
- The impedance value depends on where the measurement is taken on low voltage network.

The impedance of the distribution line increases with frequency. The impedance depends on the two prime characteristics, the load connected to the network and the impedance of the distribution transformer in that part of the network. The loads at a neighbors residence can affect this impedance. The impedance is normally inductive.

6.2 CENELEC standard

European Committee for Electrotechnical Standardization (CENELEC). This standard has identified a number of key parameters to be specified which will provide the potential for efficient communication between utilities and customer. Different parameters are as follows

- Frequency Range
- Modulation System
- Signal flow
- Protocols
- Impedance characteristics of low voltage wiring
- Immunity against disturbances of other signals
- Filter

6.2.1 Frequency Range

CENELEC standard defines Signaling on low-voltage electrical installations in the frequency range 3 kHz to 148.5 kHz. Fig. 9 from [6] shows the different subband of the CENELEC standards The frequency range is subdivided into the sub-bands. The first frequency band which is from 3 kHz to 9 kHz is mainly meant for utility company. The second frequency band 9kHz to 95kHz is reserved for utility companies to signal into different buildings industrial, commercial and residential. The final frequency band from 95 kHz to 148.5 kHz is reserved for the customer of the energy provider.

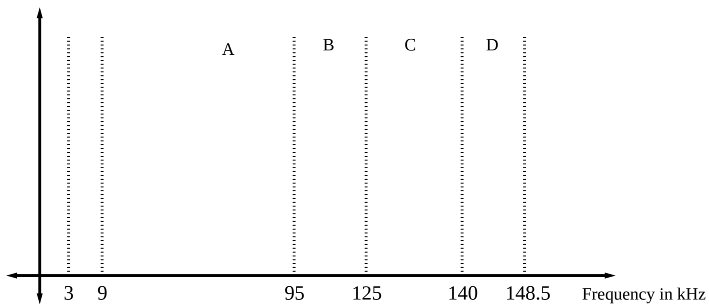

Figure 9: CENELEC frequency Band for PLCC

6.3 Modulation Technique

To overcome the impedance variation and noise in channel, a range of modulation technique have been mentioned in many papers and is listed as follows

- Phase Shift Keying (PSK)
- Frequency Shift Keying(FSK)
- Spread Spectrum System(SSS)

Combination of these modulation system Have provided further technique

- Spread Phase Shift Keying (S-PSK)
- Spread Frequency Shift Keying(S-FSK)
- Orthogonal Frequency Division Multiplexing (OFDM).

Though Spread Spectrum Modulation supports very high data rates, this techniques, till date, is unable to support reliable communication. In recent years, Orthogonal Frequency Division Multiplexing Modulation is becoming popular in power line carrier communication applications.

7 Application of PLCC for Remote Monitoring : AMR

Originally, power lines are used to supply electrical energy to machineries of varies types of low level of impedance. Due to their irregularity in their composition and abrupt change arising from load properties, using the power line for any other purpose, such as communication, is a challenging task. In the last few years, however, high growth in digital modulation technology and signal processing technology has been supporting a great efforts for developing a control network or even a home network through the PLCC. PLCC has its strongest advantage in being able to provide connection to existing devices and create a network without additional line installation. There are two main benefits of using power line as a communication medium. Firstly, the power grid is ubiquitous. LV network has a wide geographic coverage. Secondly, the cost effectiveness of the power grid will be greatly enhance by exploiting it as a telecommunication network.

Automatic meter reading (AMR) in simple term emphasizes the meter reading aspect of particular utility function without any human intervention. AMR is the remote collection of consumption data from customers utility meters, from thousands of separate locations (the meters) to one location (Utility's office). AMR system can be classified by the technology links used to communicate. Telephone, radio and powerline carrier are three most popular. Thus AMR saves cost, labour, more accurate record as well as have ability to perform many other different functions.

Experimental results [7], to ascertain the reliability of the bit rates in connection using PLCC, suggest that the success rate ranges from 96.9% to 99.8 % on the first attempt, with a second attempt virtually providing 100%, are possible.

7.1 How AMR works?

In [7] and [8], method of remote meter reading using power line carrier communications discussed. The blockdiagram for AMR is as shown in fig. 10 (adopted from [8]). Conceptually remote metering works as follows. The utility information system request for account reading from a particular customer, which is sent to master computer (Central Controller). The controller then converts the account I.D. to the corresponding address of metering modem unit(MMU) and transmits information via Master Controller Board(MCB). MCB, using its own power line channel, communicate to the MCB at the distribution substation. MCB at distribution substation, sends digital information modulated on power line carrier signal and injected into distribution power line using voltage coupler. The signal is received by addressed MMU. The MMU then completes the metering task and transmits the meter information back to master computer via the distribution MCB, on distribution line. The information is carried by high voltage coupler and passed onto central controller via suitable medium.

7.2 Working of Metering Operation with MMU

The AMR system starts at the meter. In case of electromechanical meters, some means of converting rotating disk into digital form is necessary. A very simple method to convert electromechanical movement into digital pulses is by using optical sensor. These pulses are then given to the microcontroller which counts the pulses from meter, thus reads the kWh consumption of the meter. These counted pulses i.e., meter reading is

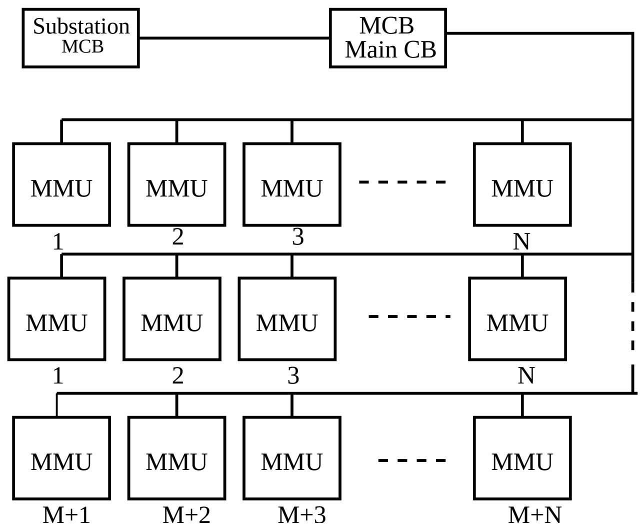

Figure 10: Structure of AMR System

require to be transmitted at a remote MCB for further processing. This is done using serial port of the microcontroller. This digital data is then modulated to transmit it to receiver using Power Lines. To overcome the channel attenuation and noise, different digital modulation technique, as mention in [9],[10], can be used. In the experiment FSK modulation technique using frequency 98 kHz and 110 kHz are used to transmit symbols logic one and logic zero respectively. This is implemented using (IC XR 2206) FSK modulator. Powerline coupler are used to couple the low voltage signal to the Distribution line of comparatively high voltage (240 V). This coupler provide isolation between source and channel as it acts as high pass filter, has very high impedance for power line frequencies and low impedance for signal frequency. At the receiver, coupler is use to decouple the signal from power line voltage. At the receiver signal is considerably attenuated and mixed with noise so it is then amplified and given to the FSK demodulator. The demodulator (IC XR2211) is used to demodulate and recover original digital data, which is then given to the serial port of microcontroller. This is then given to host PC. A simple block digram of Controller board is given in fig. 11.

7.3 Test Results

The modulator part XR2206 has been designed to give exact frequencies of 98 kHz for logic one and 110 kHz for logic zero. Also the distortion of the output sinusoidal wave has been minimized by providing compensation. The XR2206 which operate on +12 V, provide the output voltage swing of 3.2 V peak, is superimpose on the dc level of 3.8 V. The demodulator at the receiver part using XR2211, which is operating on +12 V supply, has also been designed to provide exact frequency decoding. The output of demodulator produces 0 V (logic zero) when input signal frequency is 110 kHz and +12 V output (logic one) when input frequency is 98 kHz. The minimum voltage require at the receiver (pin 2) of XR2211 without any noise is 200 mV peak or 141 mV rms. A square wave of 600Hz has been given to the modulator and its output connected directly

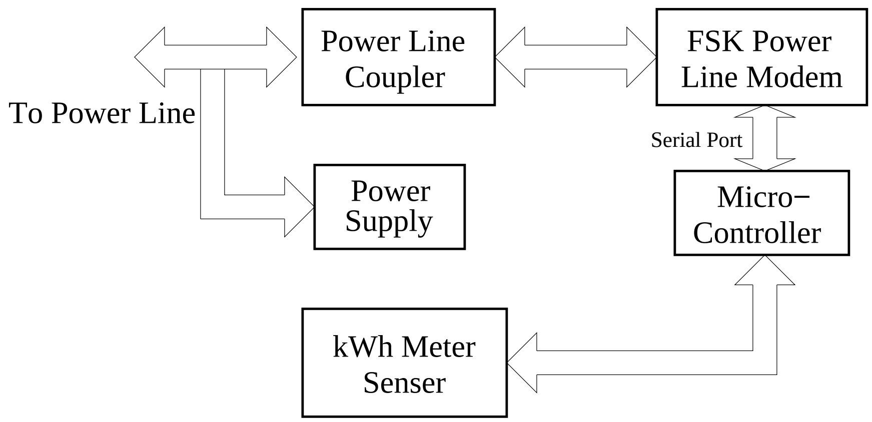

Figure 11: AMR System

to the demodulator. The results were as expected. The coupler which provides isolation between transmitter/receiver and power line, has attenuation of 5.2 dB, without any load. This has been done by connecting two coupler back to back to simulate transmitter and receiver part.

8 Conclusion

In this report the *Distribution powerline carrier communication* and different issues in use of remote monitoring have been discussed in detail. The noise, which is main limitation of PLCC has been studied. All kinds of noise and difference between them have been discussed along with their sources. In addition, a simple model for background noise has been explained. Characteristic impedance and attenuation issues have been also discussed. A powerline as a communication medium along with its advantages and limitations over other communication medium have been given. Working of AMR as a specific application of PLCC has been studied. The prototype of an automated kWh reading system, employing a low voltage power line as a communication medium, has been studied. Also modulator and demodulator part of it have been designed and tested successfully.

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