Communication Management System Based On Smart Grid

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Abstract

In modern era, Smart grid is a new technology that explains lack of software programs that simulate the principles of Smart grid. The prime intention of Smart grid simulation is to provide a better platform for user interaction. Smart grid system makes it possible to have an intelligent communicating network by integration and combination of electrical power grids. Smart meters are connected by the system through RF signals to a central point with the PLC as the medium. The main intention of this system is to explain the transfer of data and the intermediate processes involved in data transfer to the utility from different houses. The paper further describes the implementation of the entire process using MATLAB, thus demonstrating the flow of smart metering data to utility from different houses.

Keywords: *Smart grid, PLC, Simulation, MATLAB*

INTRODUCTION

Smart grid is an advanced version of traditional power grid. It uses advanced technique to meet the needs of traditional grid [1]. Success of managing communication is an essential attribute. Smart grids are considered to be intelligent grids with wide range of features[5].Reliability, self-monitoring, flexibility, secure communication, are some of the features of Smart grids[3].Population growth and increasing demands are main issues for the failure of existing grids[1].

In the research area, Communication technologies pertaining to implementation of Smart grids are actively evolving[8].With the integration of smart grid technologies traditional electrical grids are able to be more robust and interactive[4].Countries especially where energy crisis is extreme these grids can be a reliable solution[1].Newly emerging grid technologies are able overcome the challenges in the existing power grids[3].In the network consumption of electrical energy is controlled and managed by the smart grids[4].To monitor and maintain electric grids, Information and Communication Technologies are needed.

Traditional grids are highly inefficient due to frequent power failure. Due to increase in population, need for energy sources is higher than energy supply, in such a situation emergence of smart grids can be considered as a boon to the coming generation[4].

Management of data flow from generating point to the utility point is facilitated by the future grids. Advent of these grids has led to easier information exchange. Due to the special features employed by smart grids enables them to respond to variations occurring at any section of transmission, production and distribution[2].The difficulties of detecting faults in a particular region or a part of a system is simplified in modern system. The necessity of physical presence of an individual in order to repair the faults is eliminated by this technology. A quick response to major power related problems is provided using this process [2].

In many countries power line communication is widely used for remote monitoring by the utilities. PLC plays a significant role for power transmission. PLC can be viewed as a medium for transmission from houses to the central point of collection [10].Through transformers, Propagation of data signals is not possible so modulated carrier signals are sent on the transmission wires by power line technology. Currently connectivity to the utility is supported by advanced metering infrastructure networks [7]. For more connectivity, huge requirement of bandwidth is essential. Bi-directional energy flow is an important feature of these grids [6].

Increased consumer demand can be met through this technology. For environment improvement smart grids can slow the advance of global climate change. Effects of blackouts can be prevented by these grids. Without wasting energy and utilizing it to a maximum extent is made possible by smart grids [2].

LITERATURE REVIEW

F.A. Rahimi., [1] presented a system that addressed the challenges in implementing the smart grid technique in India. Renewable resources can be controlled by this technology and can provide additional benefits.

M. Amin., [3] proposed a system that contained a detailed analysis of Next Generation Networks for future grids. In this system complete assurance of security was not addressed.

Y. Yan et al.,[4] explained various issues and measures taken to develop a better system for future applications. It also addressed the requirements for better functioning of the system.

R. Ma., [6] described the problems faced in existing grids and revolutionized techniques for further progress in the system.

J. Stephens., [8] described the entire history of smart grids and presented a clear report on cost benefit analysis.

S. Galli., [10] discussed mainly about power line communications, its advantages and processes involved.

REQUIREMENTS OF COMMUNICATION TECHNOLOGIES

A Smart grid is an advanced technology that facilitates sensing, monitoring, communication of grids [10]. It has following requirements.

a) Performance:
For network applications data volumes of only few Kbytes per data transfer and latency less than 100ms are critical. Thus performance is an important aspect in communication system.

b) Availability:
For smart grid, availability of end-to-end service depends on time availability and location. Location availability only depends on homes connected for fixed networks [9].For advanced metering service availability is less demanding with respect to time.

c) Costs:
Cost is an important attribute in development of any technology. Any system which involves less cost is considered to more reliable.

d) Control:
Due to lack of end-to-end control utilities cannot rely on commercial operators, hence utilities take a standpoint. As the system involves a number of components therefore control of these components is very essential for the successful operation.

e) Security:
The most important requirement in Smart grid system is security. Care should be taken in order to prevent misuse of consumer related data. Since a number of components are interconnected in Smart grid, possibilities of cyber-attacks are more [6].In order to eliminate these effects security is very essential.

METHODOLOGY

The system consists of smart meters connected to a central point with PLC as the medium. Information collected from home network to an access point needs to traverse to a central point. The overall system structure is depicted in Figure 1. To send the data, private networks such as star networks, fiber optic cable, and T1 cable are available from collector to utility. Through free space the readings are then retransmitted, further utility receives these readings. Any number of houses can be tested using this system.

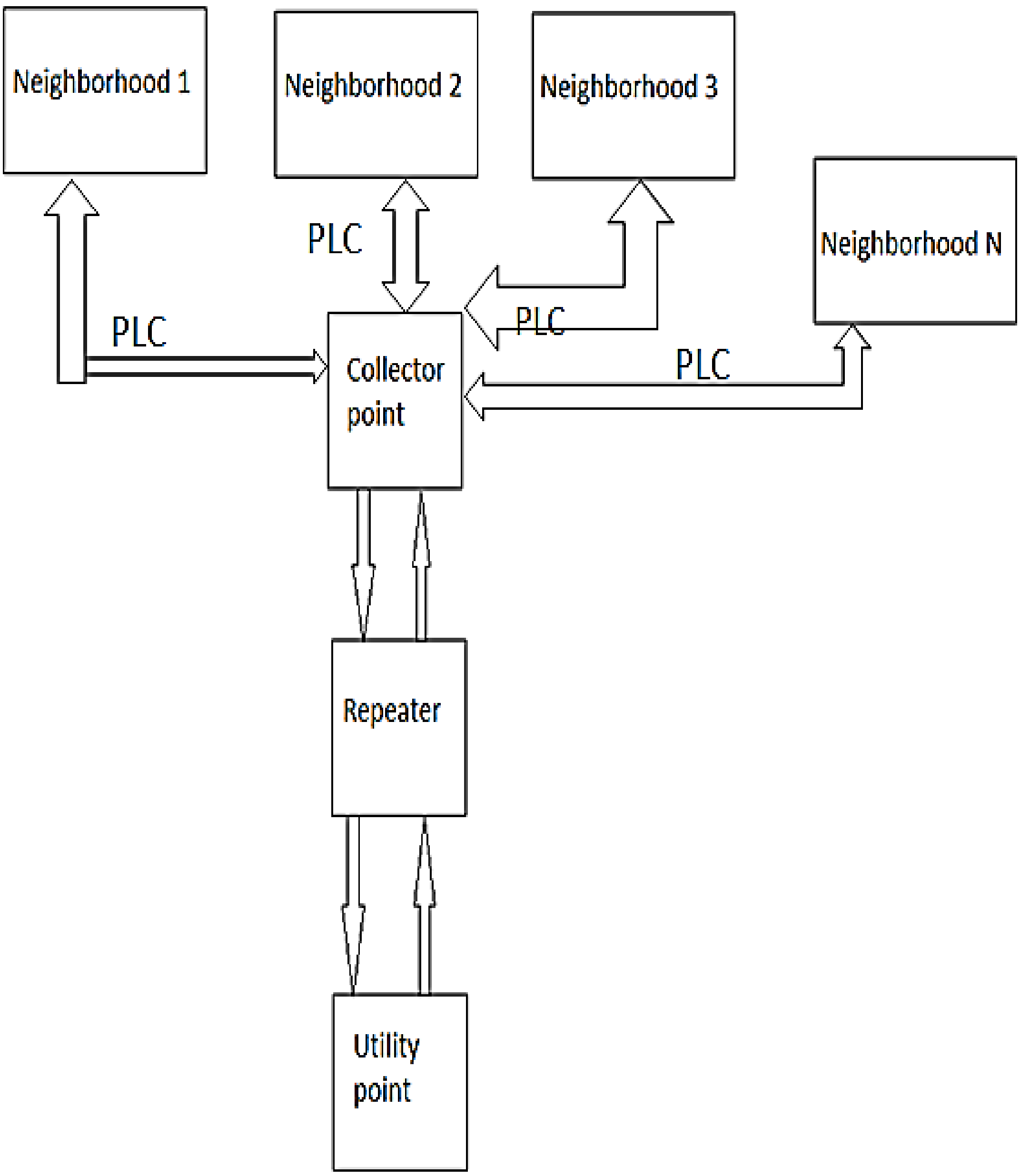

***Fig 1:** Smart grid structure*

Modeling of system is done such that user can easily interact. The system describes with figures the house readings from the moment they are generated until reaching the utility point, thus enabling the user to keep track of readings and analyze the whole process. The overall flow of the system is described in Figure 2.

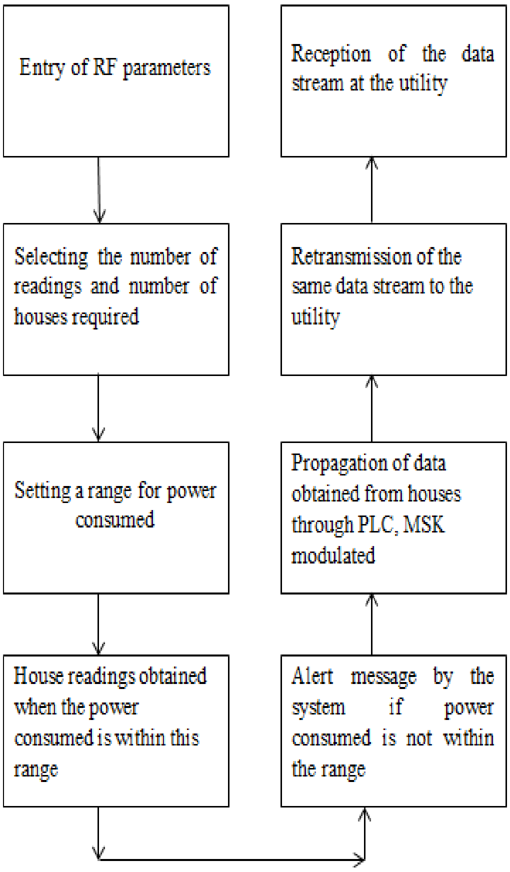

Fig 2: *Flow of the system*

RESULTS AND DISCUSSIONS

At the beginning, system asks the user to enter the RF parameters namely the frequency at which the system functions is selected as 11GHz, distance between the transmitter and receiver is set to 9 km, gain of transmitter antenna is equal to the gain of receiver antenna which is taken as 2.3 and finally the transmitted power amplitude is taken as 4.2 V. Multiple values are tested simultaneously to get a better outcome. The Figure 3 shows the simulated output.

```
Enter operating frequency(GHz):=11
Enter the distance(km):=9
Enter the gain of transmitter antenna:=2.3
Enter the gain of receiver antenna:=2.3
Enter the amplitude of transmitted power:=4.2
   1.0476e-04
```

Fig 3: *Parameter entry*

On completion of entering parameters, the user is asked for information regarding the number of houses in the tested neighborhood and the number of readings required. Number of readings and number of houses chosen is dependent on user. Any number of readings can be taken. For illustration the number of readings is considered as 2 and number of houses in each neighborhood 1, 1 and 3 in Figure 4.

```
Enter the number of readings required:=2
Enter the number of houses for neighborhood 1:=1
Enter the number of houses for neighborhood 2:=1
Enter the number of houses for neighborhood 3:=3
```

Fig 4: *House numbering entry*

```
Enter the required house number:=1
Enter the required neighborhood number:=1
```

Fig 5: *Determination of location*

After entering the number of houses and readings needed as shown in Figure 4, along with location of house and the neighborhood of interest as shown in Figure 5, the PLC characteristic curve in Figure 6 is obtained. Power line channel characteristic described by the following figure shows the magnitude response.

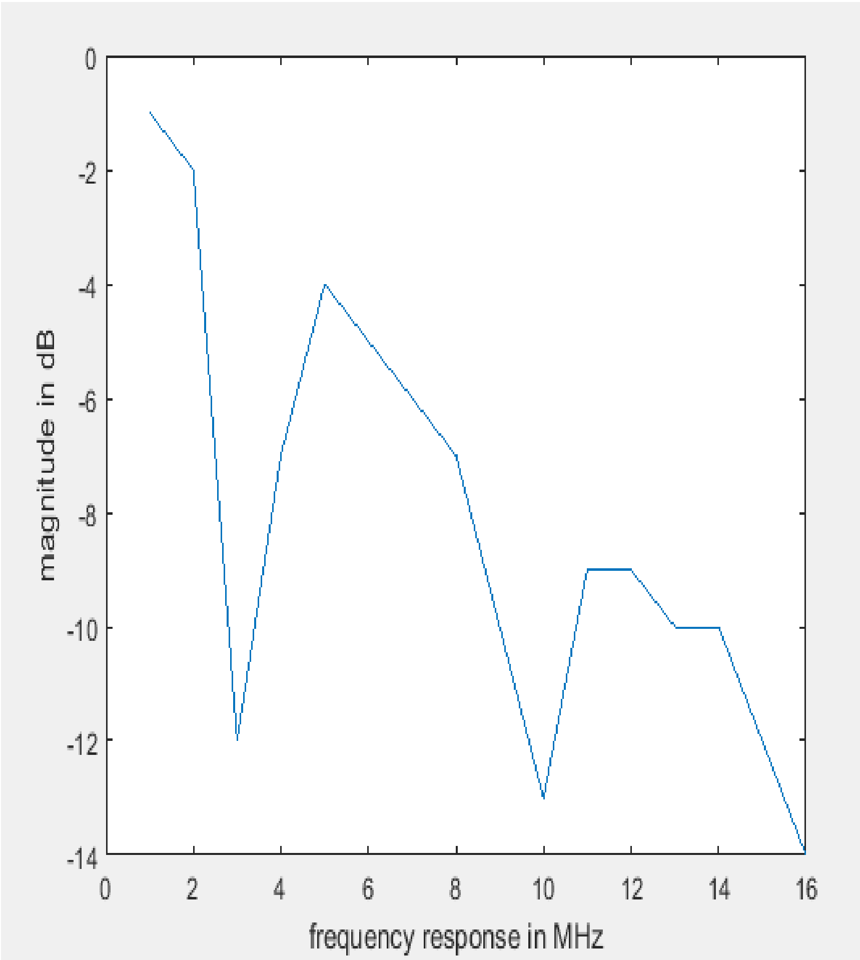

Fig 6: *PLC characteristic curve*

Once this is done the information regarding the houses will be sent to the utility point. A range of 300-1000 watt hour is set. If the readings of power consumed by the houses exceed the range, then an alert message indicating overconsumption of power is displayed. Suppose the power readings of houses is below the threshold range then again an alert message indicating that the power is less than the threshold is displayed. But if the power readings of the houses is within the range of 300-1000watt hour then house reading is displayed in the form of a graph. The figure below illustrates the house reading. Similar procedure is repeated for all the houses in the neighborhood one by one. After displaying the first house reading, system checks for the next house readings in the same neighborhood, if only one house is entered in that neighborhood then the system checks for second neighborhood, again the same procedure is followed namely checking the power readings of the house, displaying alert message if power readings obtained exceeds or goes below the threshold. The graph below shows the readings obtained from the House. Readings of houses will be in the form of binary values as shown in the Figure 7.

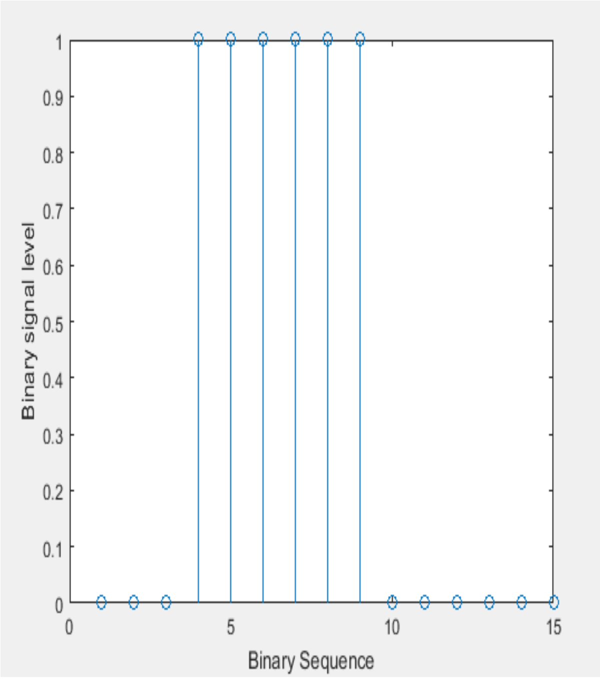

Fig 7: *Readings of the first house*

The alert message indicated by the system if the power is over consumed or power readings of the house is less than the range is as shown in the Figure 8.The same procedure is followed for all the houses.

```
   100

power consumed is below the threshold
   200

power consumed is below the threshold
   300

power consumed is below the threshold
```

Fig 8: *Alert message indication by the system when the power consumed is below the threshold*

```
        1100

Overconsumption of power
        1200

Overconsumption of power
        1300

Overconsumption of power
        1400

Overconsumption of power
        1500

Overconsumption of power
```

Fig 9: *Alert message indication by the system when the power consumed is above the threshold*

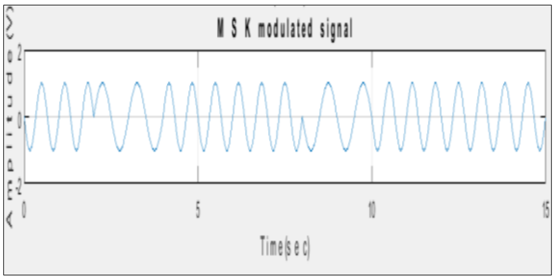

Fig 10: *Propagation of MSK signal*

Furthermore through PLC the binary information obtained in Figure 6, is transmitted to the collector from the smart meter. The signal propagating through PLC is a minimum shift keying (MSK) modulated signal. MSK signal in Figure 9 is then retransmitted to the utility point. Now the utility receives the bit stream, this retransmission and reception of bit stream at the utility is shown in Figure 10 and Figure 11.

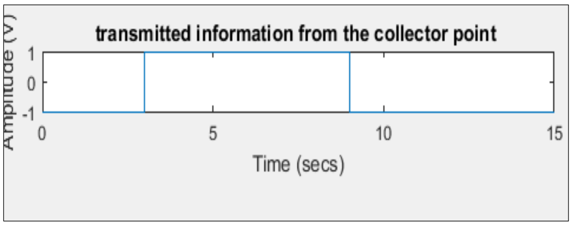

Fig 11: *Retransmitted bit stream*

MSK modulated data is retransmitted to the utility, so at the utility digital data is obtained.

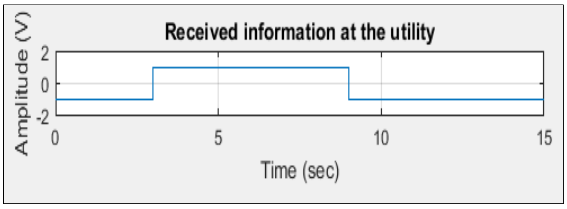

Fig 12: *Received bit stream*

The utility receives the digital data as shown in Figure 11 and takes necessary action if required.

ADVANTAGES

The system used in this paper is very beneficial in modern era. As all the features of the system are controlled automatically using the software, it is very easy to test and implement. This kind of system allows the user to take quick actions whenever required. Complexity of hardware design and issues pertaining to hardware are eliminated. It also saves time, as the operation is software based. In case of faults the user can easily modify the parameters of the system without the necessity of physically going to the place of fault. Thus users can easily alter the functioning of the system whenever required. The difficulties in existing system are eliminated to a certain range.User can change the functioning of system whenever necessary. Maintainence of hardware is reduced to certain extent.In real time consumers can know the energy consumed through smart meter. Necessary power quality can be delivered through this technology. In transmission lines automatic fault restoration is possible through the use of sensors.This technology improves overall reliability and strengthens the system.

DISADVANTAGES

Failure of software used in this system can lead to failure of entire operation. As this technique is computer based, worst thing will happen if it is hacked. Malfunctioning in software may lead to improper functioning of system leading to delay in processing. It requires high cost of installation.

CONCLUSION

Data from smart meters reaching the collector point and propagation of bit stream through PLC and then retransmission of the same bit stream and its reception at the utility point is successfully performed using Matlab programming. ThusSmart grid communication Management system is successfully implemented.

FUTURE SCOPE

In future, while materializing the smart city into reality smart grids will be implemented. In the long run, just like internet smart grids will be used everywhere. Smart grids create new opportunities for companies thus creating more jobs.

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