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BPSK Modulation and Demodulation with Power Line Carrier Communication and GSM Communication for Smart Metering

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ABSTRACT

GSM/GPRS and PLC communication are used for Automatic Meter Reading (AMR) applications. These AMR systems have made substantial progress over the recent years in terms of functionality, scalability, performance and openness such that they can perform remote metering applications for very demanding and complex systems. By using BPSK (Binary Phase Shift Keying) modulation with Power Line Carrier Communication, Smart Metering can be done in Rural Smart Micro-grids. The design and Simulation of BPSK Modulation and Demodulation are successfully done by using MATLAB/Simulink software. The advantages of using BPSK modulation over the QPSK modulation and the advantages of PLC Communication over the GSM Communication is identified in this paper.

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1. INTRODUCTION

Energy generation is one of key factors for the economic development of a country. Smart metering make use of technology in digital form to enhance steadiness, accuracy, Safety and electric network productivity from bulky generation, over the distribution networks to electricity consumers and enhancing scattered generation and storing capitals. Since the amount of electricity generated and its flow through out electrical substations is known by energy supplier which allows him to make use this AMR to detect energy loss and fraud. For the estimation and examining the purpose of billing, Automatic meter reading (AMR) technology can be used which automatically collects information from water, gas, and energy metering devices and transfers it to the master station. There is no requirement for reading the meter bodily; remotely information can be read easily [1]. The peak demand for energy and cost of meter reading can be reduced which enables customers to make informed decisions and thus backup the particular time usage idea for billing. So this can be an advantage. Recently different communication technologies in AMR have been planned which includes radio frequency based, mobile tools, the platforms of telephonic, or the power line communication (wired or wireless). Developing a present mobile network for data transmission requires no extra tools or software, resulting in an important savings in both time and capital. The significant reduction in the cost of building a new communication network can be achieved by Power Line Carrier (PLC) which make PLC best for AMR systems [2]. The communication and bandwidth is limited, thus the minimum-voltage supply power systems are not made. In addition to other shortages, PLC can be difficult in scaling to support a large network. GPRS, which is a method of wireless communication, can be very effective and essential in future for sending information fixed at suitable charge from domestic buildings and houses to

main centers of billing and giving additional facilities for the requirement of customer. GPRS is very convenient for the power applications because of high-speed and unlimited transmission assortment.

2. PROPOSED METHOD

2.1. AMR System Architecture

Components of AMR System

i. Electrical Meter

The content of generating electrical energy to domestic or commercial utilities is measured by an electronic device. It consists of electronic controllers which are fed electrically. It acts as a border that transfers information which can be communicated through the source end acting at the collector.

ii. Collector

Basing on the signal of the concentrator which is in upper position, collector will collect and develop the information which is received from several meters of electrical utility industry. It has the ability to forward, enhance and giving out information needed by the concentrator. The collector has to do the controlling of smart electrical meters which are found in precise usages.

iii. Concentrator

The commands are to be given by the concentrator which can be fed to collector for receiving readings of electrical meter occasionally like weekly or monthly basis. For advance analysis, load survey data and meter readings can be transmitted to the database of main control station.

iv. Central Station (Control center)

AMR system has each and every section in the arrangement like reading of meter on monthly basis or inspection of actual position of each and every concentrator involving analysis of error and disturbing can be managed by super capacity computers through the leveled communication network. Furthermore, with the help of interconnection with the power supply system, the tariff calculation and collection can be realized.

v. Meter Interface Module

The meter is controlled at the AMR System. In order to send metering of digital data from the consumer site to a main point by the action of converting meter readings fed from turning meter dials, or cyclometer style meter dials, into digital form are essential. The AMR Architecture as shown in Figure 1.

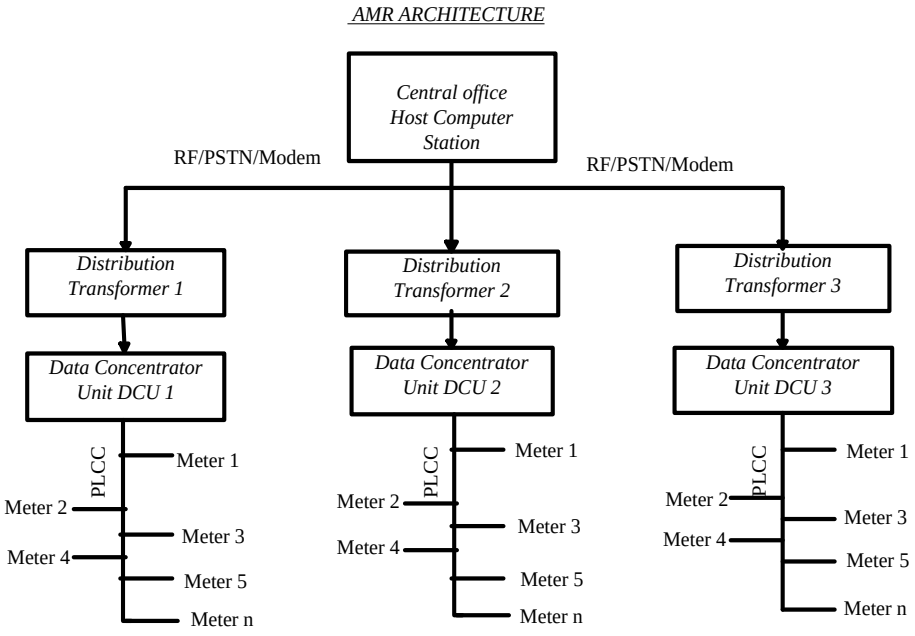

Figure 1. AMR Architecture

2.2. GSM Based Communication

Communication can be used in Meter and Central station in one point by GSM Modem. Developing a present mobile system for information transmission needs no extra tools or software causing an important

reduction in time and as well as capital. Encryption technique can be used in mobile technology to stop an external cause from getting the communicated Information [3]. Planned reading, Demand reading, alarm and incident writing, power outage writing and power re-establishment writing can be allowed by complete two way communications provided by cellular network. The GSM Communication in AMR as shown in Figure 2.

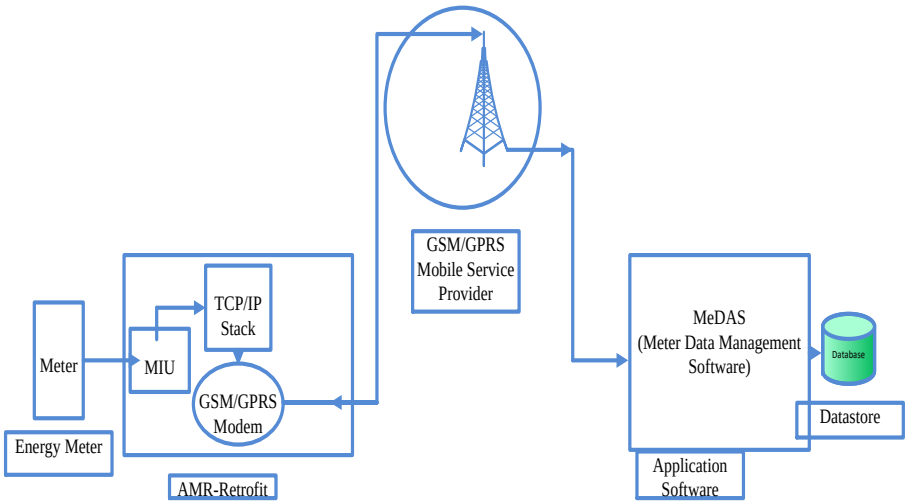

Figure 2. GSM communication in AMR

2.3. PLCC Based Communication

The technology that involves transferring information over wiring of AC power is called Power Line Communication. So there is not necessity of any additional wiring for network communication. Communication is achieved by adding a high frequency signal at low energy levels over the electric signal and the second signal is propagated through the power network to the receiving end [4]. Electrical devices can be easily interconnected and managed through power lines. Power line communication is appealing because it uses the existing power line infrastructure. The implementation of Smart Micro-grid using basic block diagram of BPSK shown in Figure 3. Developing information server to access several links of PLC for convenient monitoring of swapping information between intelligent micro-grid and consumers. The customary grid is an intelligent digital version involving improved technologies of communication and calculation. Domestic utilities and intelligent meters are combined with HAN device coordinator as shown in Figure 3. With the help of Power Line Carrier Modem and linking circuit, Smart meter and Smart micro-grid are combined. HAN system of network swapping information between each and every domestic utilities and Power line communication network. So with the help of Power line communication system, the companies will have the ability to combine not only the intelligent meters but also current domestic electrical utilities [5]. Power Line Communication system has the ability to communicate in two ways and existing extensively. So in the absence of other communication system, power line communication system can be well adapted in slum zones and optimizing cost problems to exchange information between consumers and electrical utility companies. The PLCC Communication in AMR as shown in Figure 4.

The secondary winding of the distribution transformer contains data concentrator. It is the 'modem' system of the setup. It modulates and demodulates the data that is to be sent through the power line. QPSK modulation technique is followed by the unit. It is placed at the consumer as well as utility side for transmission and reception and vice versa. Serial communication method is used for the power line transfer. Power Line Communication System can be used to gather meter readings from all the meters with the help of serial communication method at predefined breaks. A subsystem of Host Computer Station (HCS) consists of Data Concentrator unit (DCU) and every meter connecting to it. The power zone in low voltage downstream of a Distribution Transformer can be controlled by DCU Subsystem setup as shown in Figure 2. The noticing outages, tamper events and performing remote disconnect can be done by PLCC in 440V LT network. It can be perfectly suitable for rural/agricultural connections because of using equivalent power lines as communication media. The implementation of HT side communication can be done through the best of

CDMA, GSM, PSTN or RF as shown in Figure 4. The conversion of electronic Energy Meters CF pulses into Electrical pulses can be done by PLC unit which consists of a single PCB. The displaying of meter reading and collection of electrical pulses can be done by Microprocessor [6] which in turn converts this data into Power Line Modulation. Before Retrofit is made into operation, the Meter Constant, Current Meter reading and Meter ID are accumulated in Micro Controller NV RAM. The pulses equal to Meter constant which can be sensed by Retrofit then one unit is incremented which is stored in Micro Controller NV RAM.

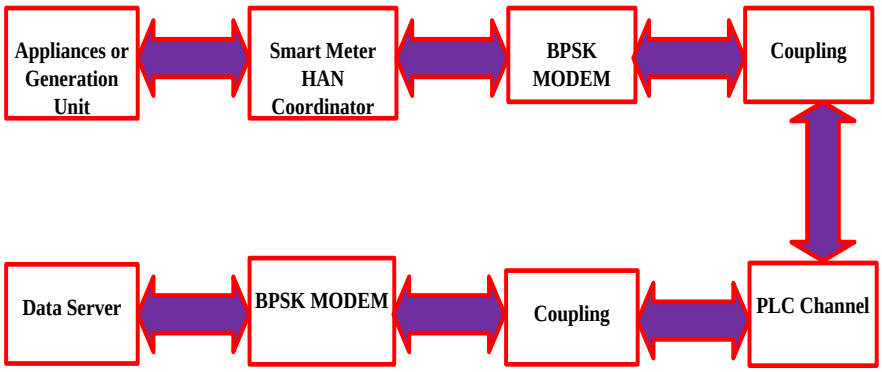

Figure 3. Implementation of Smart Micro-grid using basic block diagram of BPSK

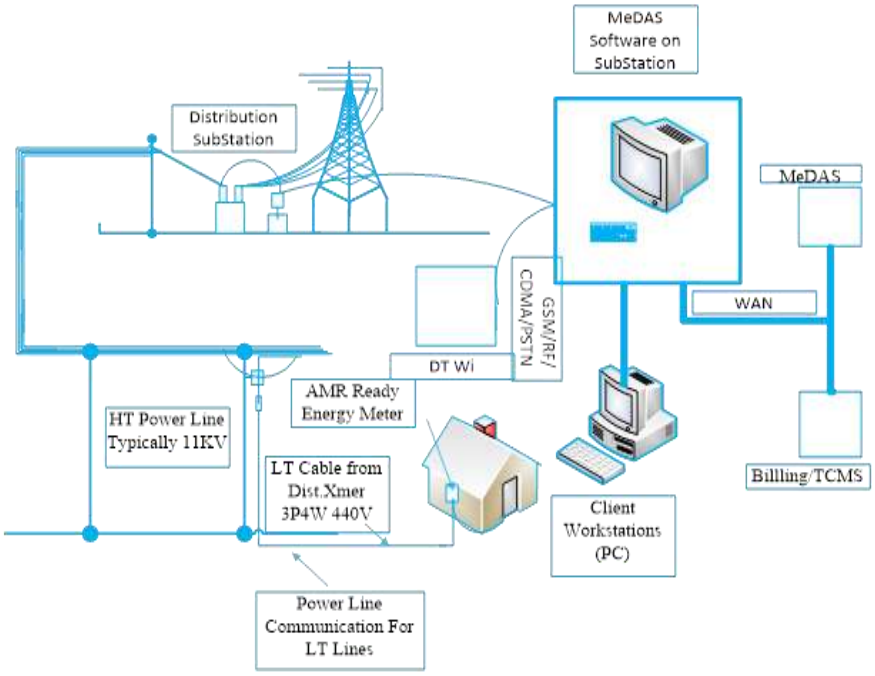

Figure 4. PLCC Communication in AMR

3. RESEARCH METHOD

3.1. Power Line Characterization and Modeling

Power Line network is not initially designed to carry information. But reduced operation and management with initial cost expenditures. However it has also disadvantages such as noise and signal attenuation. Distance is another issue that affects the power line communication performance [7]. The inductance, resistance, capacitance and conductance must be measured for characterization and modeling of communication channel. According to the line theory of pair power cable of surge impedance and propagation constant can be estimated by following equations.

$$Z_L = \sqrt{\frac{R+j\omega L}{G+j\omega C}} \quad (1)$$

$$\gamma = \sqrt{(R+j\omega L)(G+j\omega C)} \quad (2)$$

where,
Z_L= Characteristic impedance
γ= propagation constant
ω= angular frequency
R = unit length resistance
L= unit length inductance
G = unit length conductance
α = attenuation constant
β = phase constant

Propagation constant and characteristic impedance depend on R, L, G and angular frequency but not length of line.

3.2. Design of BPSK Modem with PLC Channel

Modulation in a digital is a procedure which moves a character which is in digital form having indicator appropriate to receive indication at destination end for held together communication or unbounded stage of communication without having data leakage. The modulated signal bandwidth is based on band signal and modulation pattern needed. Characters in digital form order are needed for high frequency carrier signal. Phase Shift Keying (PSK), Frequency Shift Keying (FSK) and Amplitude Shift Keying (ASK) are the three main types of modulation in digital. The combination of two orthogonal Binary Phase Shift Keying (BPSK) modulated signals from Quadrature Phase Shift Keying (QPSK). The QPSK Modulation system is the base structure of wired and wireless communication such as wired modem, 3G, WiFi and WiMAX. This technique has the advantage of optimizing the bandwidth use of QPSK system which is highly useful in communication technology. BPSK is considered to be robust modulation scheme compare to the QPSK as it is easy in the receiver to receiver the original bits. With BPSK, higher distance coverage can be achieved from the base station cellular cell or fixed station to the mobile subscribers compare to QPSK. The constellation diagram of BPSK as shown in Figure 5. The BPSK signal is mathematically described by the following equation:

$$S_{BPSK} = \left\{\left[s_1(t) = \sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t)\right], \left[s_2(t) = -\sqrt{\frac{2E_b}{T_b}}\,cos(2\pi f_c t);\right]\right\}; 0 \le t \le T_b \quad (3)$$

where, $E_b = Energy\ per\ bit;\quad T_b = Bit\ period;\quad f_c$ is the carrier frequency

For this single set, there is a single basic signal

$$\phi_1(t) = \sqrt{\frac{2}{T_b}}\cos(2\pi f_c t)\,, 0 \le t \le T_b \quad (4)$$

So, expression of BPSK signal is given as:

$$S_{BPSK} = \{[\sqrt{E_b}\phi_1(t)],\ [-\sqrt{E_b}\phi_1(t)]\} \quad (5)$$

Each symbol of original has a different phase angle. The BPSK modulation has the basic block diagram as shown in Figure 6. The binary bits of information signal are separated to I bits and Q bits by serial to parallel converter at input modulator. BPSK signal of binary data is added to modulated signal over I and Q channels [8], [9], [10]. Dual modulators output is connected by summer amplifier, that results BPSK modulator modulated signal. Demodulator of BPSK has the basic block diagram as shown in Figure 7. The signal modulated in digital form is given to BPSK Demodulator. In coherent detection technique, receiver is suppressed carrier signal which involves several performance considerations. In demodulator received signal is multiplied by reference frequency generators. Non-return-to-zero (NRZ) converter block and synchronized bits have the information categories phase (I) and quadrature phase (Q) extracted by Multipliers which are low pass filtered.

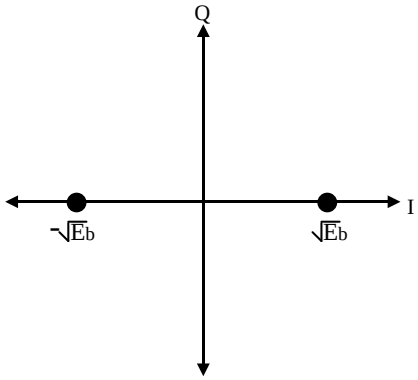

Figure 5. Constellation Diagram of BPSK

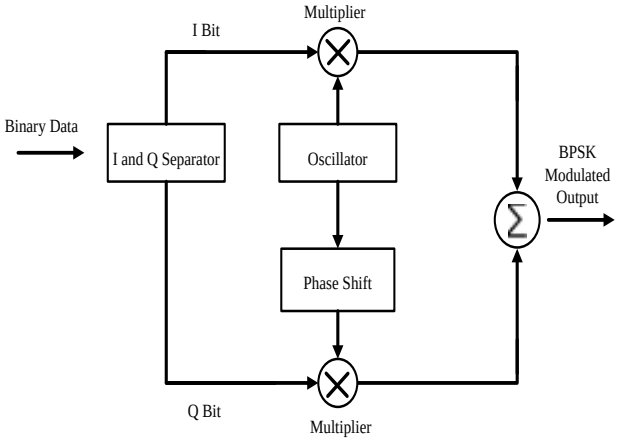

Figure 6. Block Diagram of BPSK Modulator

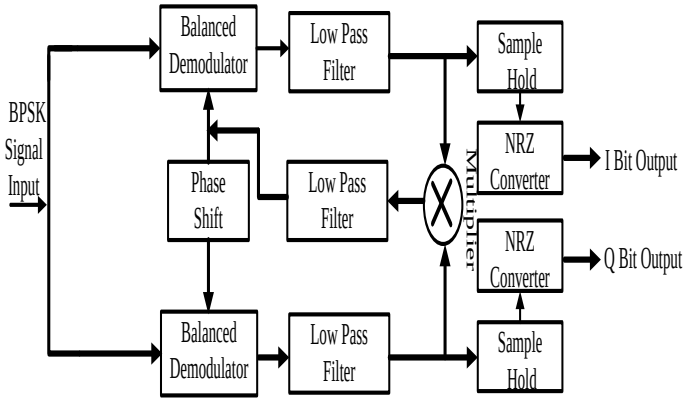

Figure 7. Block Diagram of BPSK Demodulator

4. RESULTS AND DISCUSSION

The PLC network with BPSK modem has the simplified block diagram for intelligent micro grid as shown in Figure 8. The power measurement information of smart meter is supplied to modulator part of BPSK modem and that signal feed to distribution line by coupling circuit is shown in Figure 8. Distribution

line is depicted for each phase with fixed line impedance parameters. The simulation diagram in Simulink of proposed model with QPSK modem is shown in Figure 9. For simulation in multi-path with multiple data propagation purpose, we have considered three Bernoulli Binary generator block tools box as a sources of digital signal of three smart meters. Estimation and realization of power line communication method can be done in energy and communication analysis. The information modulated for the three inputs are designated as the resultant power information to three smart meters. Modulated I signal and Q signal are added at output modulator. Modulator of BPSK has the simulation results as shown in Figure 10. The Demodulator of BPSK has the modulated signal input and the input which is in digital form is equivalent to the demodulated signal. On the side of demodulation, the resultant demodulated signal is free from phase (I) and Quadrature phase (Q) channels output. Demodulator of BPSK has the simulation results as shown in Figure 11. The data in and data out with BPSK as shown in Figure 12.

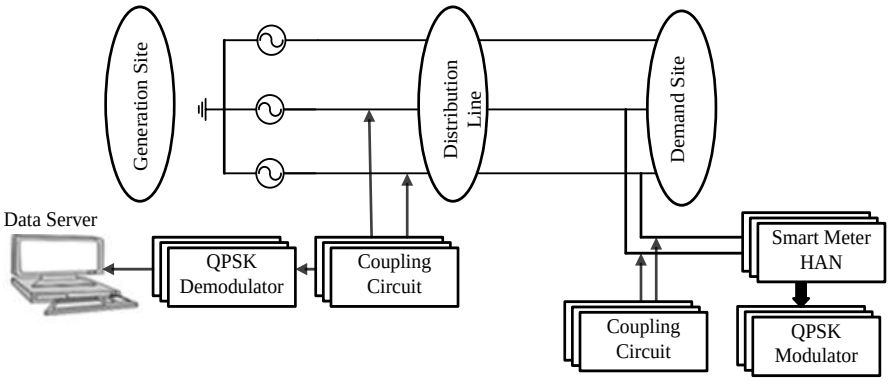

Figure 8. Simplified Diagram of PLC Network with BPSK Modem for Smart Micro-Grid

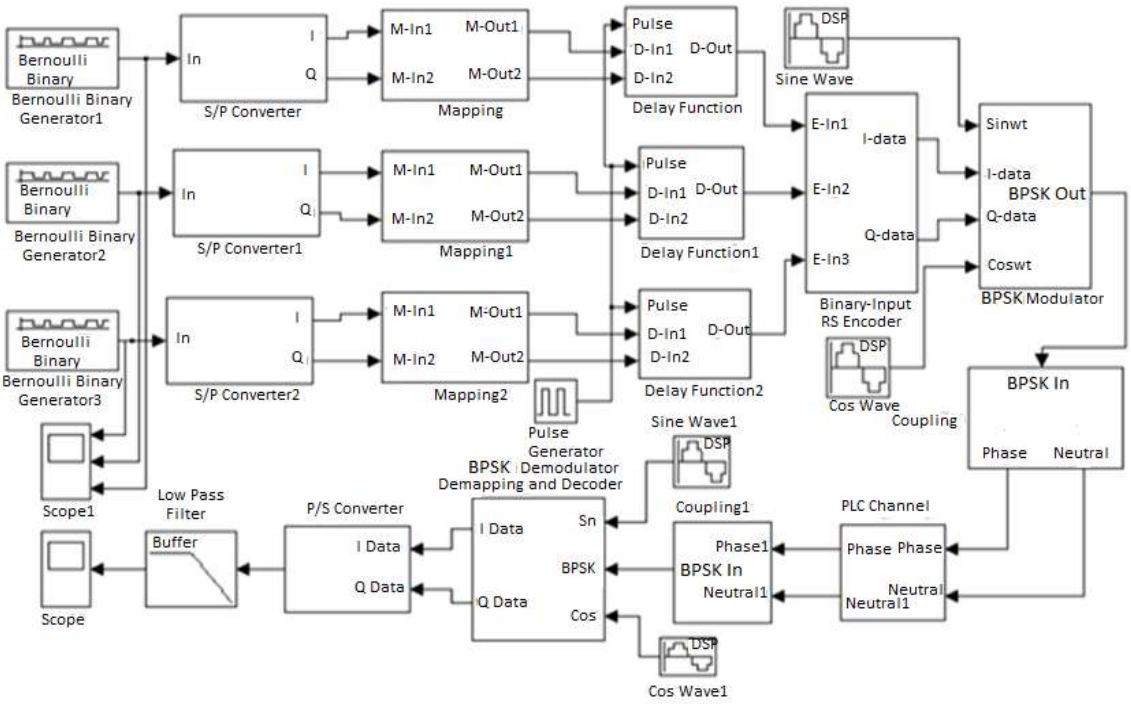

Figure 9. BPSK Modem with PLC Channel for Data Propagation in Simulink

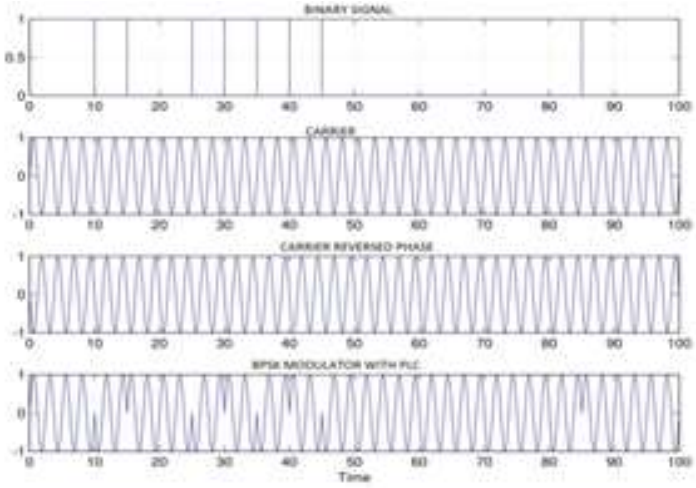

Figure 10. Simulation Result BPSK Modulator with PLC

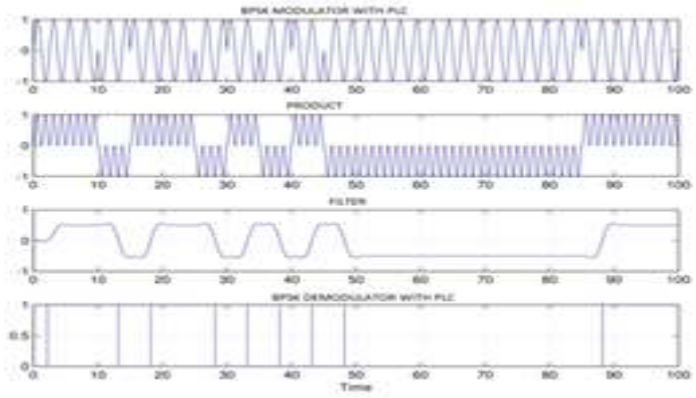

Figure 11. Simulation Result BPSK Demodulator with PLC

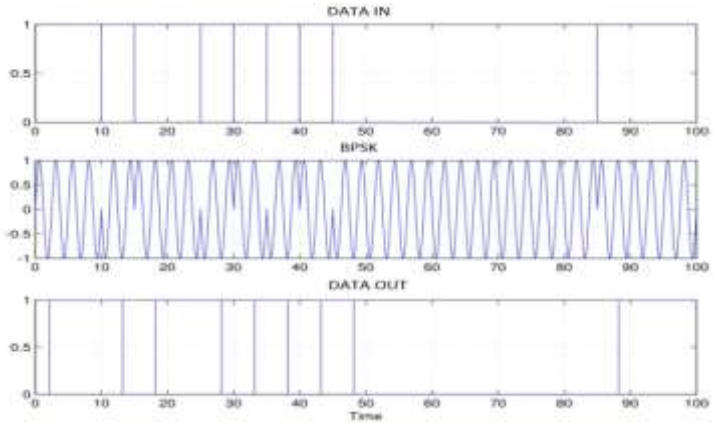

Figure 12. Data In and Data Out with BPSK

5. CONCLUSION

The BPSK system focuses on transmitting and receiving the measure data of multiple smart meters in smart micro-grid system by using power line communication. The arrangement of modulation and demodulation is focused and depended by section of the power line communication learning through the

alternating current power line with coupling. The present BPSK modem is simple, inexpensive and has ability to control the data transmission for smart micro-grid. It can be an excellent, cost effective and also a reliable solution to mitigation the existing power crisis if properly implements this proposed model.

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