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PLC Communication using OOK/ASK Modulation for Automatic Meter Reading Systems for Smart Metering in Rural Smart Micro-Grids

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Abstract: Smart Grids are in performance an essential role in the current world. The current research efforts on these smart grids involve the advance in the turf of Smart Metering. The most costly, modest and straightforward to feast out abilities lie in Power Line Communications (PLC), which manufactured them useful in electric grids. Smart Metering in smart grid uses PLC technology in various architectures of LV grid. This paper proposes a scheme for a Smart Metering network with PLC expertise consuming on-off keying/amplitude-shift keying (OOK/ASK'S) Modulation. PLC with AMR schemes hand-me-down in energy conveyance system and recording, usages of illicit electricity by sleuthing because of the current network. In rural areas, the PLC with AMR Systems can minimize theft and illegal electricity use, raising the power distribution authorities' revenue. Dissolute and Consistent meter analysis gathering with minor mistakes can be accomplished AMR Systems, which removes the requirement of physically construing meters. The anticipated system for current meters has remained in MATLAB/Simulink software.

Keywords: Automatic Meter Reading, OOK/ASK and FSK Demodulator; Power Line Communication; Smart Metering; Smart Micro-Grid.

1. Introduction

With the help and great support from both factories and utility industries, the generation uses modern Meter extensively feast out modern meters [1-2] in the smart grid expansion. Modern electricity companies use this PLC technology in various applications [3].

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From the last decade, the usage of smart Metering with PLC is improved which main to early PLC systems commencement [4-5]. From the transmission side to the distribution and also in domestic, PLC can be widely used and implemented [6-7]. The essential requirement for the country's economic progress is practical energy generation. Massive generation consists of digital data by smart Metering to increase accuracy, control, security, and electric network output concluded the distribution grids to energy consumers. This improves random generation then capital storage [8-10]. AMR can detect Power loss and fraud by collecting information on power generation from meters from substations which can remain well known thru the energy supplied [11-15]. The master station receives information using Automatic meter reading (AMR) systems that automatically store data from gas, water and energy metering devices to examine and estimate the billing [16-17]. Physical reading of the Meter is not required by using AMR systems and data can be read easily in remote areas

[18]. The customers can make better decisions, thereby reducing meter reading cost and energy at peak demand and therefore have an advantage of backup for time usage of billing [19-21]. Various communication technologies have been employed recently in AMR systems, such as telephonic communication, mobile communication, power line communication with wire or without wire, and radio frequency communication [22-23]. The savings in capital and time can be achieved in information transmission by having a current mobile communication network since it requires no additional software or device tools. AMR systems with PLC communication reduce the building cost significantly [24-25]. The power systems with the smallest voltage supply are not prepared due to the limitation of bandwidth and communication [26-28]. The AMR systems with power line communication can be suitable for rural/agricultural connections.

2. AMR Architecture

2.1 Electric meter

The electronic device consists of electrically fed electronic controllers that measure electrical energy generation from the home or business utilities. A boundary transmits communicated data through the collector acting at the sending end.

2.2 Collector

The electric utility industry's various electrical meters receive the data collected and developed from the upper position of the signal concentrator collector. The concentrator enhances the moving output data with the help of the collector, and the collector controls the exact usage of smart electrical meters.

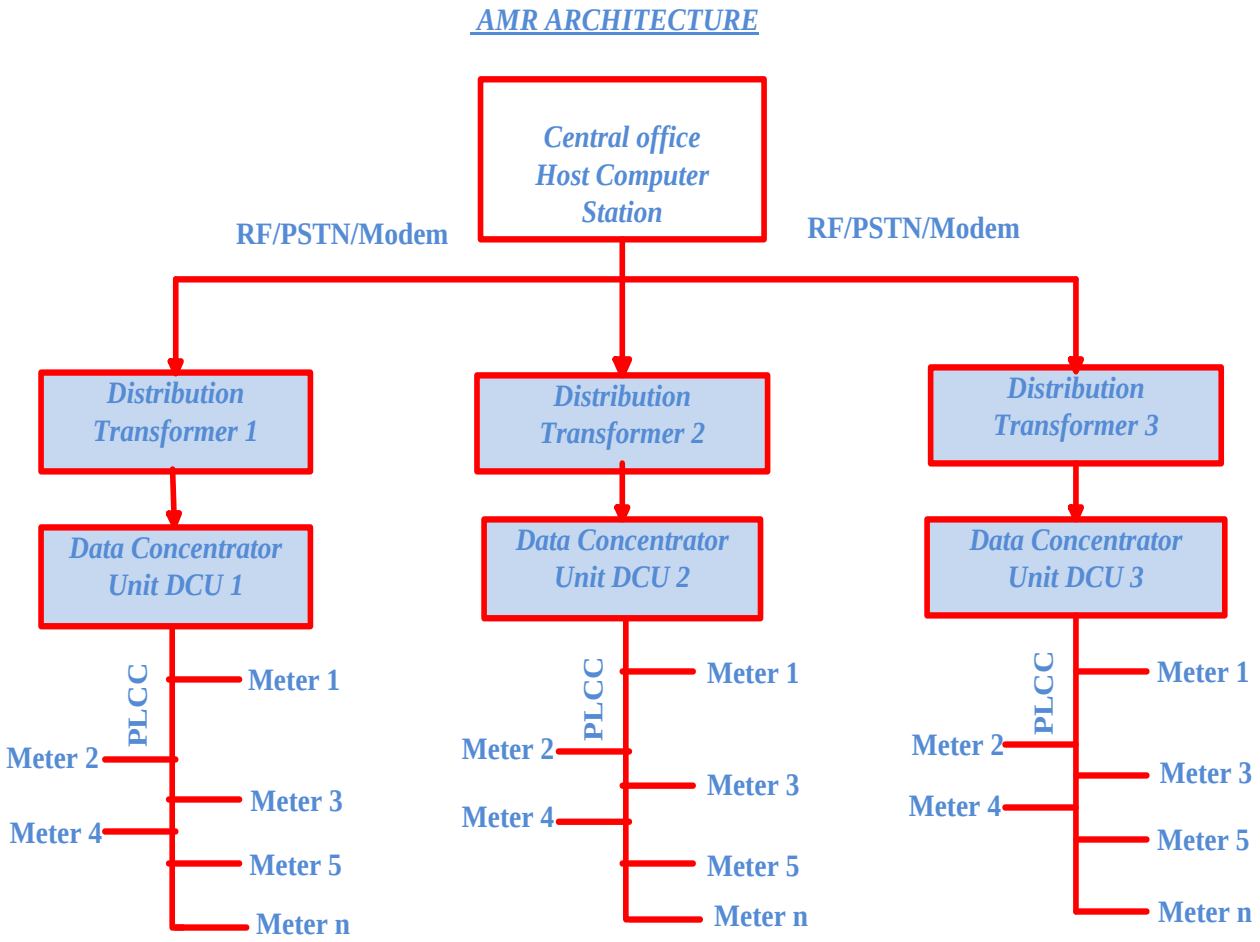

Fig.1: AMR Architecture

2.3 Concentrator

The weekly or monthly basis of electrical readings is received from the collector by giving suitable commands to the concentrator. The transmission of load survey data and meter data are transferred to the main control station database for the enhanced study.

2.4 Central Station (Control centre)

The Super capacity computers with a leveled communication network manage the error studies and disturbances in inspecting the actual position of every concentrator or the monthly basis meter reading arrangement in every section of the AMR system. The realization of collection and calculation of tariff is done with the help of power system supply interconnection.

2.5 Meter Interface Module

In AMR system, Meter is controlled properly and thriving. Directing information in digital form custom to major station is most important. The architecture of the AMR system is described in Fig.1.

2.6 PLCC Communication in AMR

Power line communication involves transferring information technology over AC power wiring without using extra wire for the communication network [3]. The addition of low energy level signal at high frequency is passed above the signal electrically for achieving communication and the propagation of another Pules at the receiving end remains done through the power network [4]. Concluded lines of electric energy can do the interconnection and management of devices. The infrastructure of a current energy line shows the attractiveness of Power line communication. The basic block diagram implementation of ASK/OOK modulator designed for Smart Micro-grid is described in Fig.2. The data is exchanged intelligently between consumers and micro-grid by having the PLC server link access information. Communication can be calculated and improved by using an intelligent digital version called the usual grid. HAN device coordinator combines intelligent meters and household utilities as described in Fig.2. Smart micro-grid involves the smart meters by coupling circuit and power line carrier communication channel. The HAN system network facilitates information exchange between the power line communication network and various household utilities [29-30]. Electrical companies can combine intelligent digital meters with household utilities with the energy line communiqué system [5]. Extensive use of two-way communication is possible by the PLC system. The information is exchanged well between electrical utility companies and consumers through the assistance of PLC which optimizes the cost problems in rural zones without another communication system. The PLC Communiqué in AMR given away Fig.3. The data concentrator consists of the load side winding of DT. The system completely modern system. The data of modulation and demodulation dated received from power line ASK/OOK does it. Its works on the ASK/OOK mothed technic. In placing the modem data receiving and transmission and vice versa from consumer side and utility side. The transfer of energy line can be done by Serial communication. Power Line Communication can obtain the readings of meter data at regular intervals. Various meters and Data Concentrator Unit (DCU) are involved in Host Computer Station (HCS) subsystem [31-34]. The subsystem setup of DCU controls the distribution transformer in low voltage power zone downstream as described in Fig.1. PLC can be well suited in the 440V LT system for detecting outages, tamper actions and execution remote disconnect. Communication technologies such as CDMA, GSM, PSTN or RF are implemented for communication at HT side as described in Fig.3.The PLC unit contains only one PCB, which renovates Electrical pulses mad about electronic devices Meters CF pulses. The microprocessor collects the electrical pulses, displays the meter readings, and thereby [6] converts this data into Power Line Modulation. The NV RAM of the microcontroller collects Meter constant, current meter measurements and meter Id before Retrofit is made into operation. One unit increment is done and stored in NV RAM Micro Controller when Retrofit senses the pulsations equivalent to meter constraints.

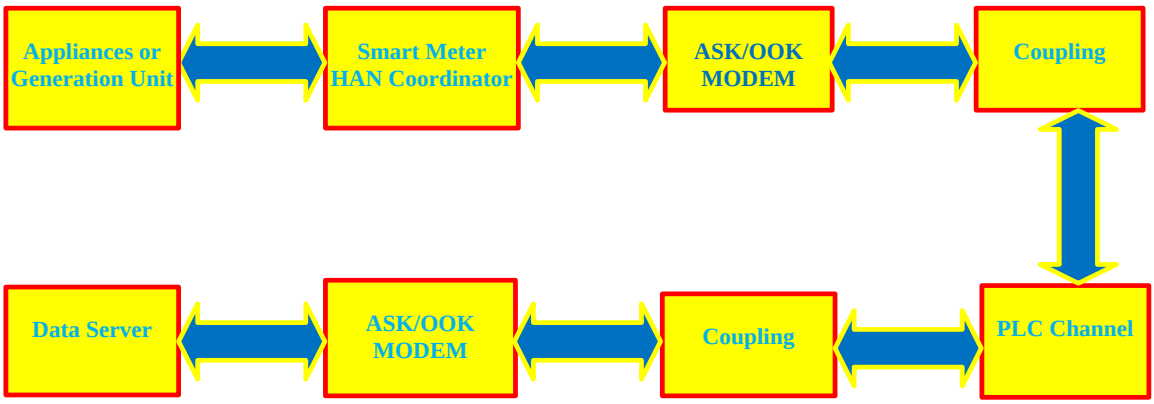

Fig. 2: Block diagram of ASK/OOK using Implementation of Smart Micro-grid.

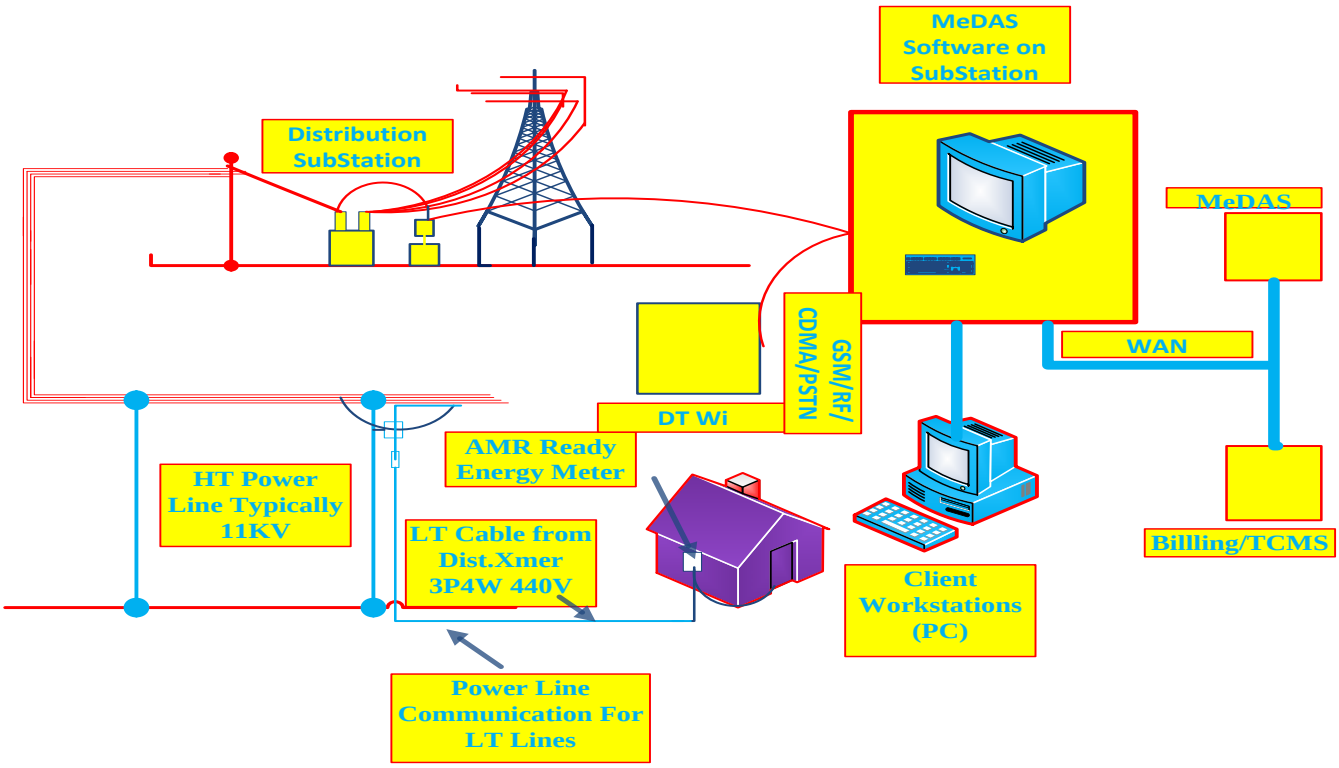

Fig. 3: AMR system with PLC

3. Modeling and Characterization of Power Line

The main focus of the Power Line network is to reduce initial operational and management expenditure costs but not initially based on its design for carrying information. Distance, noise and attenuation of the signal are the factors that affect the performance of power line communication [7]. The essential requirement for modelling and characterizing power line communication networks is to measure their Resistance, Inductance, capacitance and Conductance. The following equations below give the surge impedance and propagation constant based on the theory of transmission line.

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

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

Where,
Z_L= Surge impedance
γ = Constant of Propagation
ω = angular frequency
R = Resistance in unit length
L= Inductance in unit length
G = Conductance in unit length
α = Constant of Attenuation
β = Constant of Phase

The Surge Impedance and Constant of Propagation do not depend on the length of the transmission line but be subject to on R, L, G and angular frequency.

3.1 Proposal of PLC Channel with OOK/ASK Modem

This digital procedure involves the character movement in digital form by using modulation to receive destination information without data leakage. The pattern in modulation and signal band decides the modulated signal bandwidth. The carrier signal at high frequency involves the characters in digital form order. In these three main types of digital variety are ASK, FSK, PSK. The Quadrature Phase Shift Keying (QPSK) consists of a modulated signal grouping of two orthogonal BPSK. Digital data can be well represented in existence or not existence of carrier waves by use of a modest and easy form of amplitude-shift keying inflection which is acknowledged as OOK. Binary zero and one represented in the nonappearance and existence of a carrier aimed at a specific duration in its modest method. Wi-Fi, WiMAX, 3G and wired modem are examples of wired and wireless communication which requires an OOK/ASK modulation system. Communication technology is greatly increased by these techniques that have the merit of bandwidth optimization using OOK/ASK modulation. The pair of collected data bits and particular waveforms are identified by individual pair known as character or symbol in the OOK/ASK technique of modulation system. The ASK/OOK Inflection with scientific equations is defined in Fig.4. With this assistance of two carriers in the thought of the collection diagram, the phase and amplitude of a pulse can be resolute. The main aim of gathering illustration of ASK/OOK given away in Fig.5. The ASK/OOK constellation diagram is given in Fig.6. The ASK/OOK Modulator is represented in Fig.7. The Block illustration of ASK/OOK Demodulator is given away in Fig.8. Serial-parallel Converter at input modulator divides the binary information signal bits into I bits and Q bits. ASK/OOK modulator modulates the information of binary pulses over I and Q frequencies [8-10]. The summer amplifier connects the output of dual modulators, giving the modulated signal of the ASK/OOK modulator.

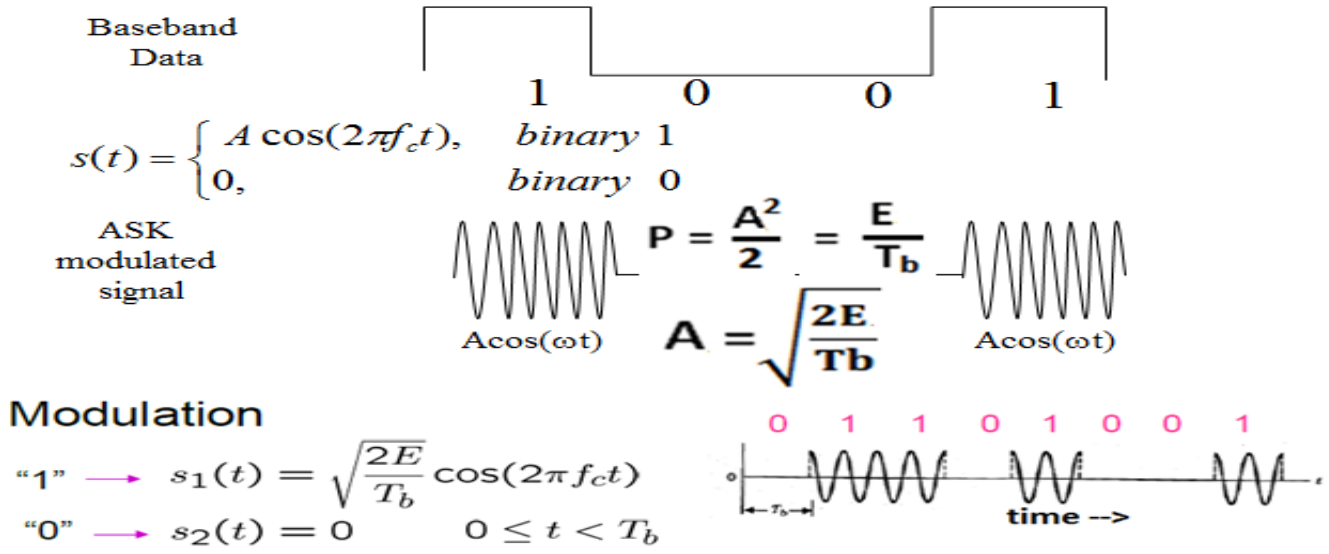

Fig. 4: ASK/OOK Modulator output with Mathematical Equations

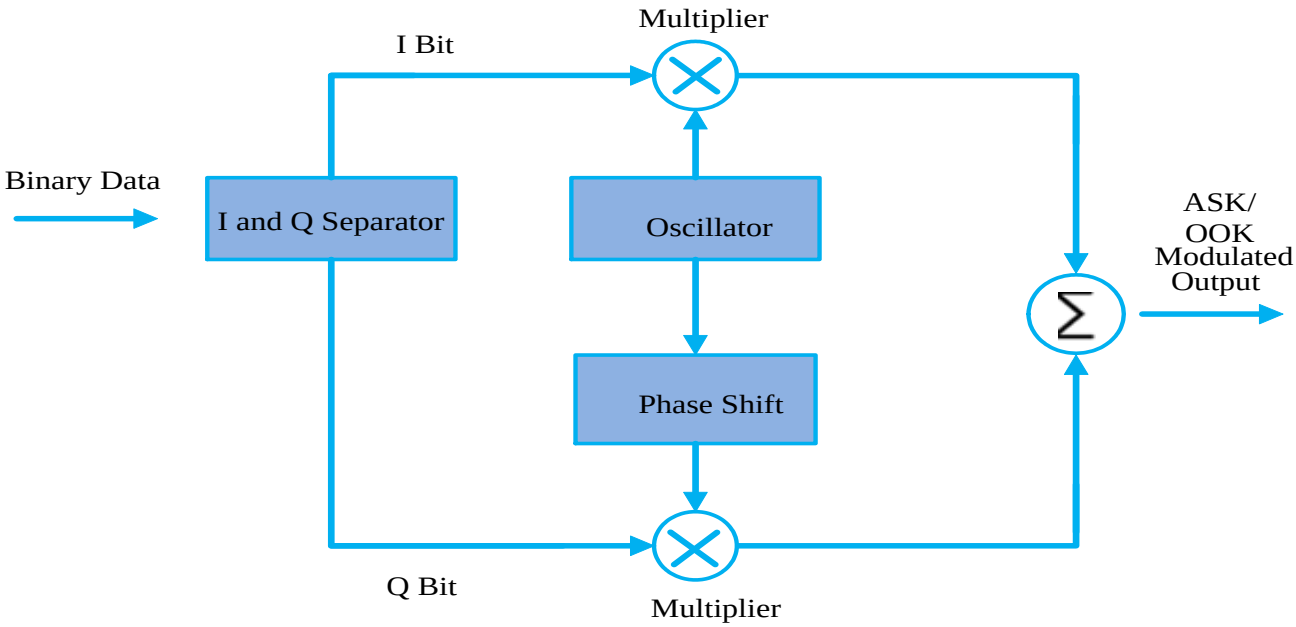

Fig. 7: ASK/OOK Modulator block diagram

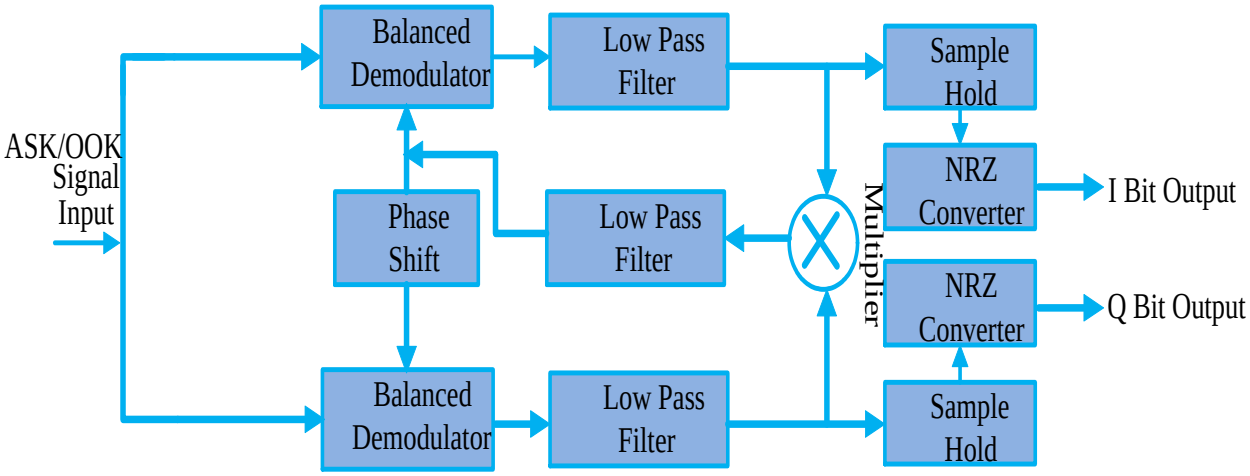

Fig. 8: ASK/OOK Demodulator block diagram

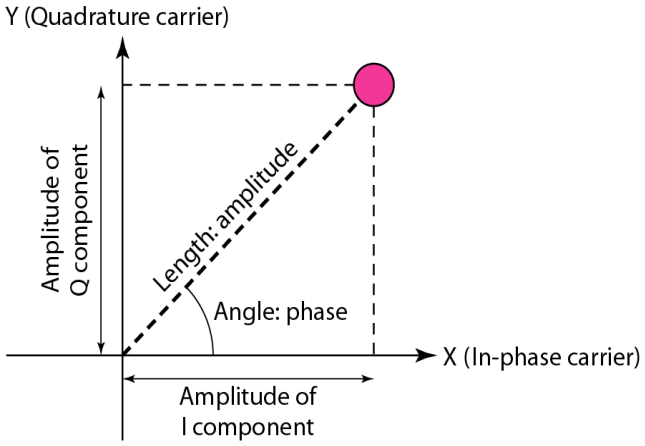

Fig. 5: Concept of Constellation diagram of ASK/OOK

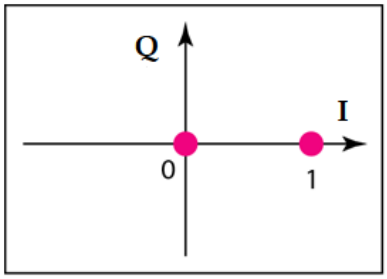

Fig. 6: Constellation diagram of OOK/ASK

In ASK/OOK demodulator block diagram is defined in Fig.8. The modulation of the digital signal be situated received by the demodulator of ASK/OOK. Suppression of receiver carrier signal consists of various performance considerations in logical

detection techniques. Generation of reference frequency multiplication is done in the demodulated received signal. Multipliers extract categories of information from synchronized bits and NRZ converter block by a low pass filter which separates into phase (I) and quadrature-phase (Q).

4. Simulation result of the proposed model

The Smart Micro-Grid basic block diagram using PLC communication with ASK/OOK Modem is described in Fig.9. ASK/OOK modulator receives the power measurement information from smart Meter and transmits the signal to distribution line with the help of coupling circuit described in the Fig.9.

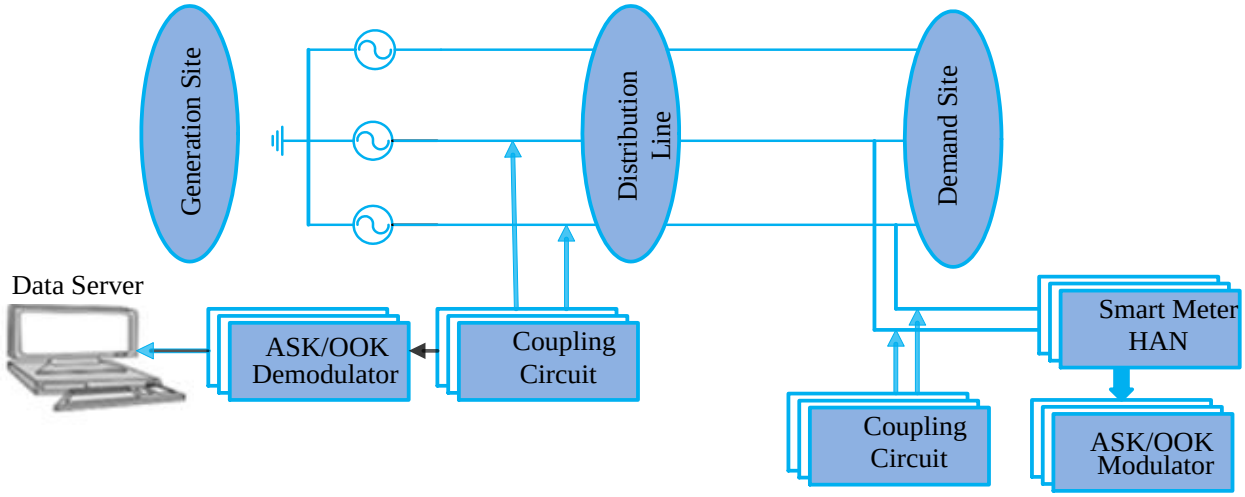

Fig. 9: Smart Micro-Grid basic block diagram using PLC communication with ASK/OOK Modem

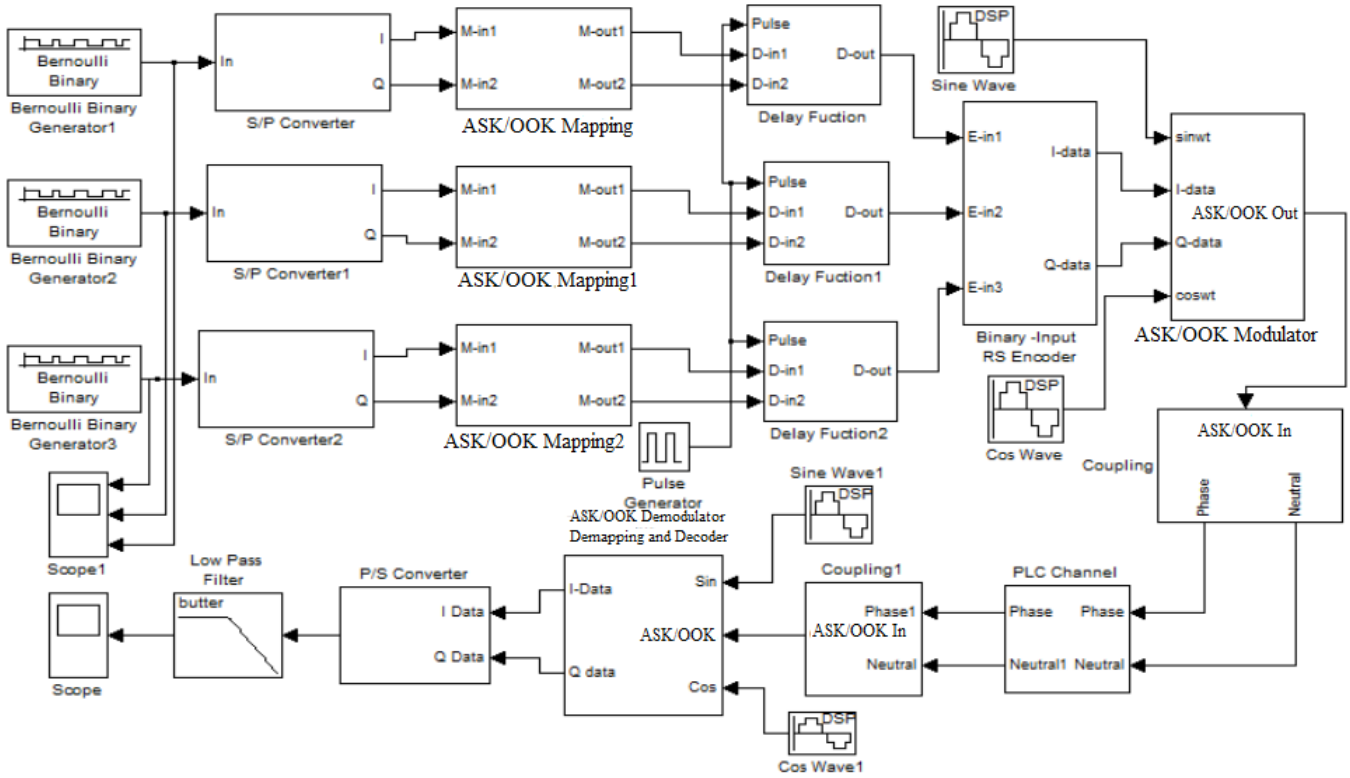

Fig.10. Propagation of information in Simulink using ASK/OOK Modem with PLC Communication channel

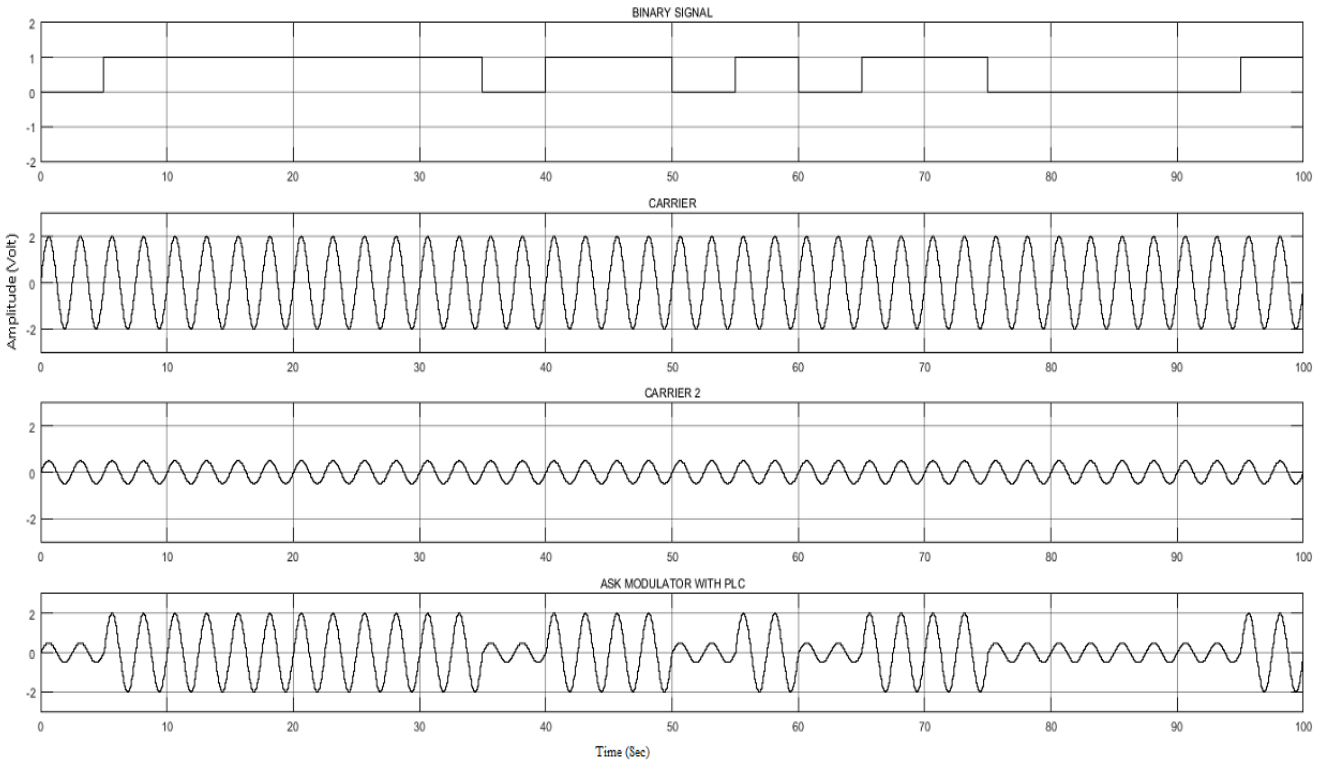

Fig. 11: ASK Modulator with PLC Result

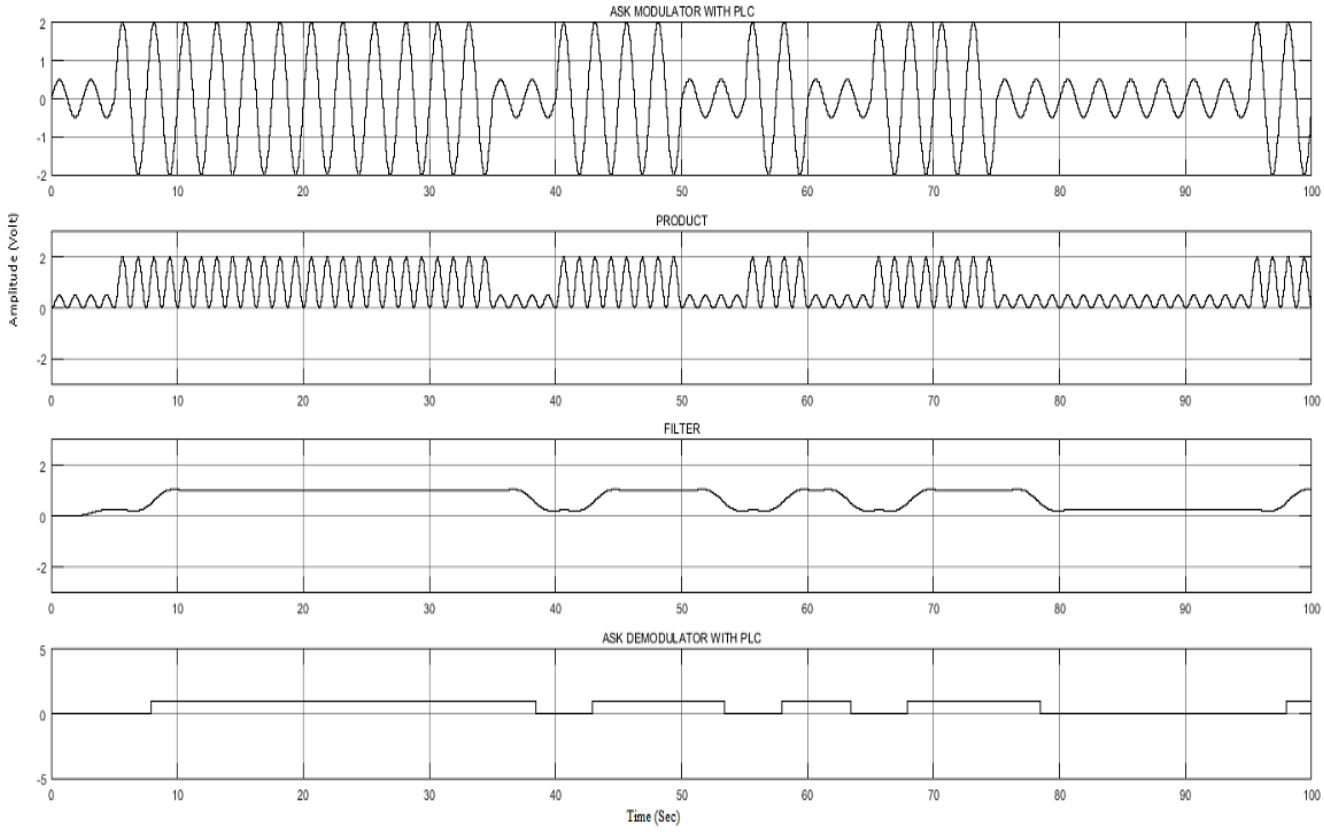

Fig. 12: PLC Result with ASK Demodulator

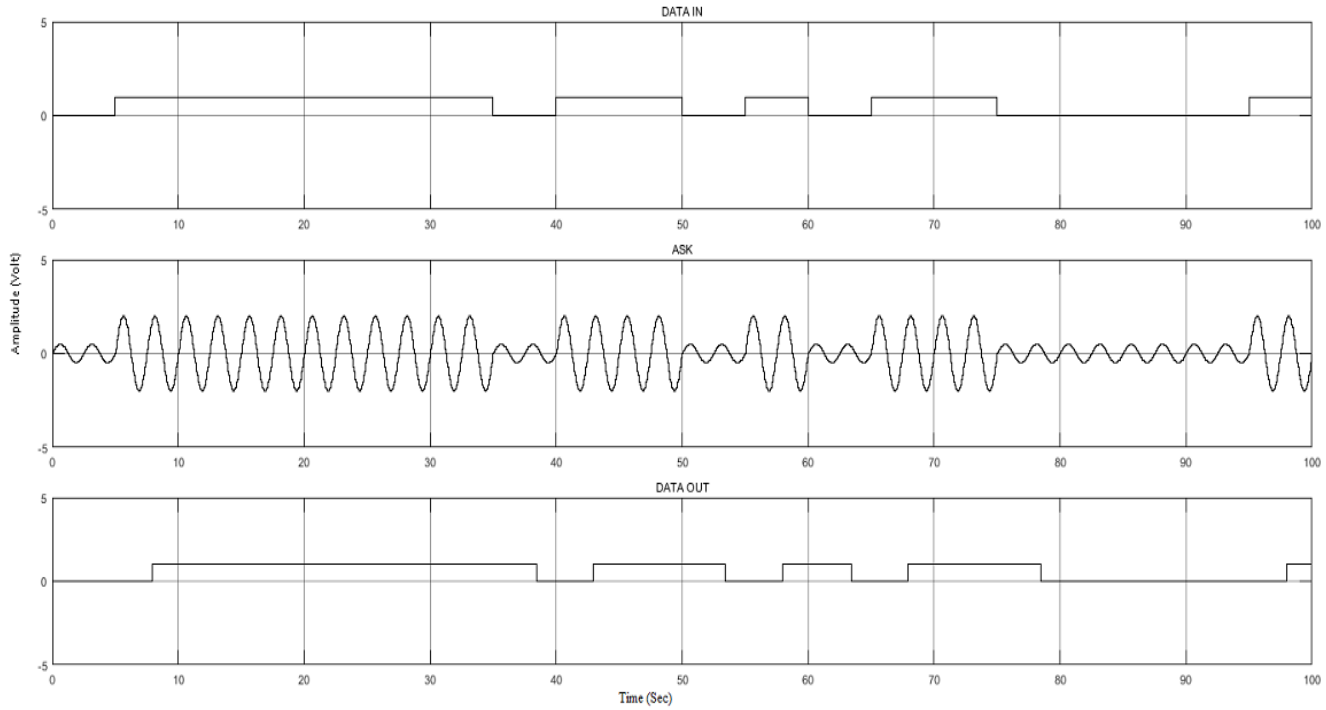

Fig. 13: ASK with Data in and Data Out

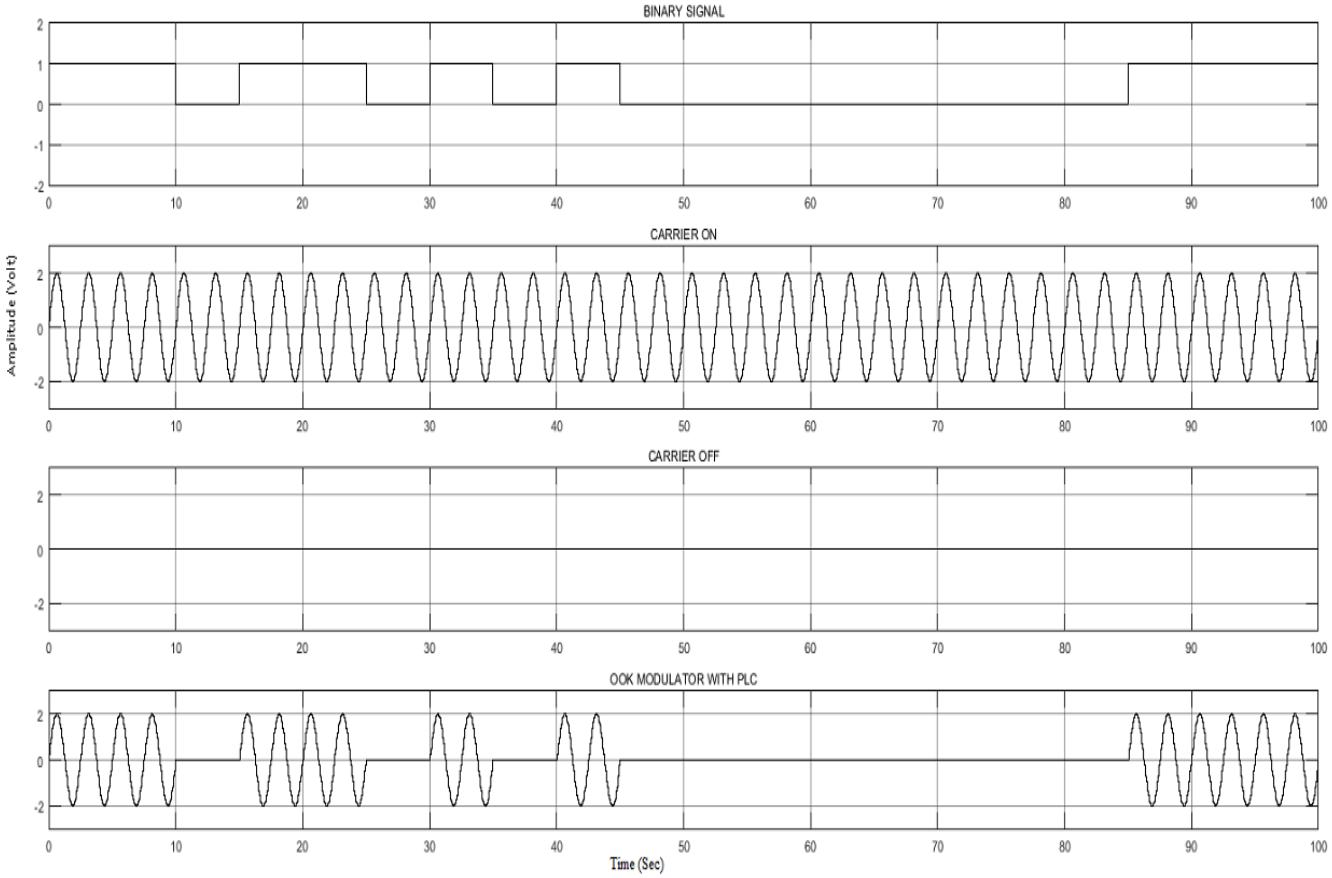

Fig. 14: PLC with OOK Modulator result

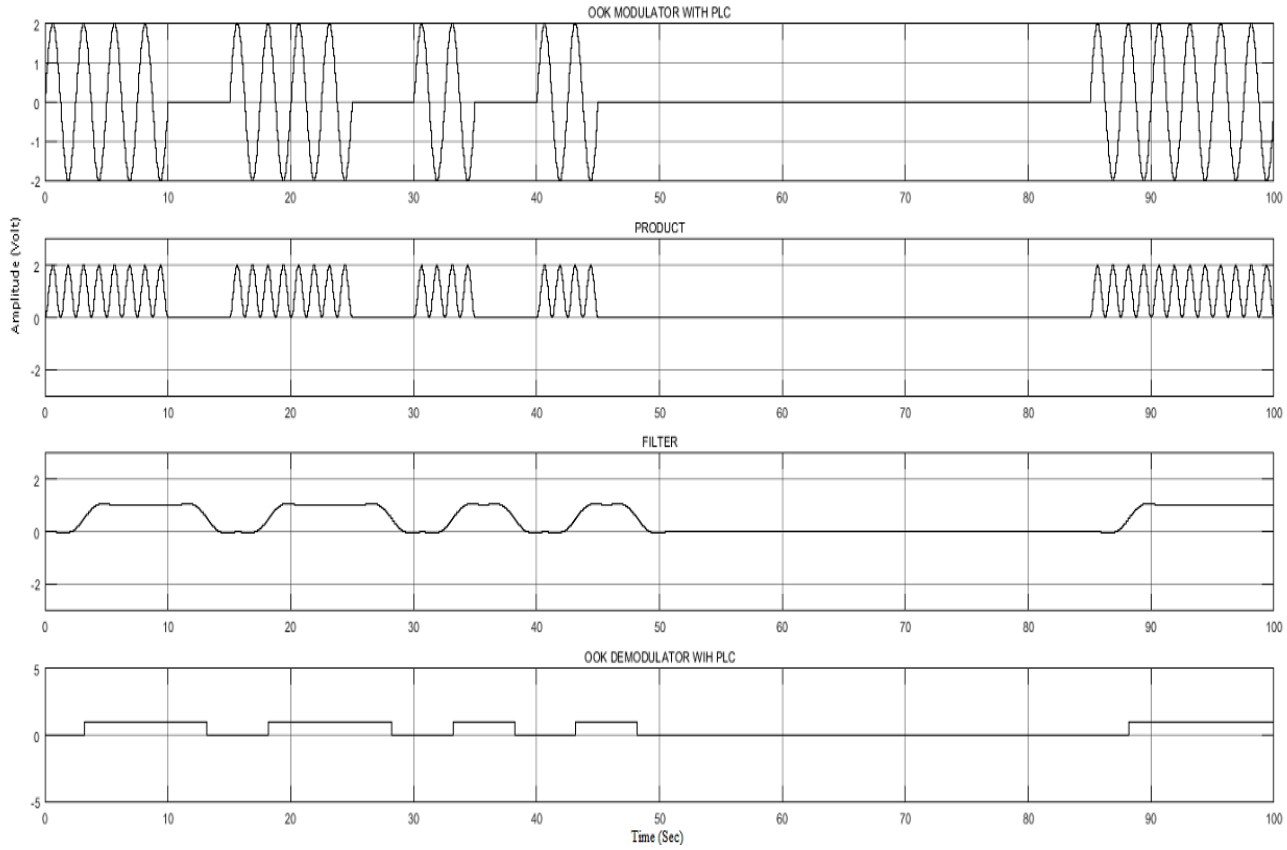

Fig. 15: OOK Demodulator simulation result.

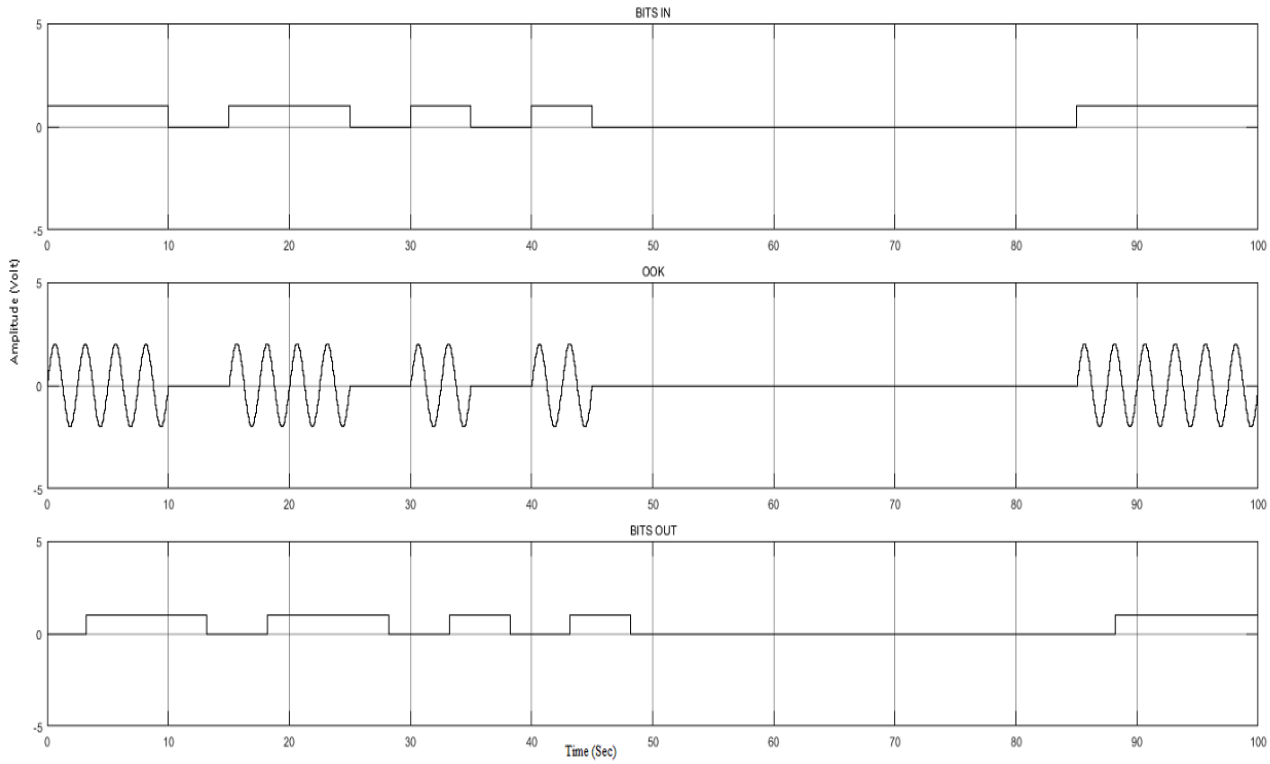

Fig. 16: OOK with **Data** Bits Out and In

The parameters of impedance are fixed with each phase for a distributed line. The proposed ASK/OOK simulation diagram for the system model is described in Fig.10. Three smart meters give digital information from the signal by using three Bernoulli Binary generator block tools box for simulation in many paths with different propagation of data. The power line communication method is used to estimate and realize energy studies and communication. Three smart meters receive the resultant power information from the modulated information of three given inputs. The modulator at output involves the addition of modulated I and Q signals. The modulator of ASK/OOK has the results of the simulation described Fig.11 also 14. In modulated ASK/OOK has Demodulated digital pulse input that is equal to the signal that is demodulated. The production quadrature-phase (Q) and Phase one channels are separated from the demodulated output signal. The ASK/OOK demodulator has simulation results described in Fig.12 and 15 presents the data out and In bits included, ASK/OOK take the simulation outcomes given away Fig.13 also 16.

5. Conclusion

The transmitting and receiving of measured data from various intelligent meters connected to intelligent micro-grid with power line communication is the main focus of the ASK/OOK modulator system. Modulator and demodulator arrangements are decided by learning the power line communication section by coupling the circuit of AC power line. The smart microgrid receives the transmitted data, which can be controlled easily by the current ASK/OOK modulation system. The reliable solution for mitigating existing power crisis, power loss and theft can be easily possible by properly implementing the proposed model due to its excellent cost-effective characteristics.

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Conflict of Interest

The authors declare that they do not have any conflict of interest.

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