International Journal of Advance Research in Science and Engineering
Volume No.07, Issue No.04, April 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Electricity Theft Prevention in Distribution System with Distribution Generation

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ABSTRACT

This paper explains how encrypting power signals helps in preventing power thefts in distribution system with distribution generation. Non-technical loss (NTL) during distribution of power is a major problem in rural India and it has been very difficult for the distribution companies to prevent illegal distribution line tapings. Illegal tapings forms a major chunk of NTL .Due to these losses the power quality decays and load on the generating station increase. The proposed work is an attempt to stop the losses by preventing the power theft; one such method is presented in this paper. In our proposed system we use power semiconductor switching systems at the low voltage side of distribution transformer in such a way that three phases (R,Y,B) & neutral is passed through this semiconductor based switched system .The switching system is operated through the bit sequence generated by the microcontroller. The same bit sequence is generated at the load circuit inbuilt in smart energy meters through RF transmitter- receiver synchronization. The power line between the distribution transformer and the energy meter is protected as encrypted power signal flows through it which cannot be used for running the home appliances, therefore providing protection against illegal distribution line tapping's in power networks.

*Keywords:****Electricity theft, NTL losses, AMI (Advanced metering infrastructure), DER (Distributed energy resources), Encryption, Decryption, Microcontroller***

I INTRODUCTION

Power/energy theft, also known as non-technical losses (NTLs), is a huge problem in distribution systems all over the world. The world loses US$89.3 billion annually to electricity theft and especially in India; NTL can be of the order of 20–30%. India loses around US$16.2 billion annually to NTL [1]. Identification of illegal tapings and consequently their prevention are crucial in stopping this menace. Whereas Technical losses are naturally occurring losses caused by power losses in transmission lines, transformers, and other power system components. These losses are computed from the total load on the station and total energy billed. Power generation losses can be technically

defined, but Transmission and Distribution (T&D) losses cannot be precisely quantified. Electricity theft by illegal tapping's (hooking) on distribution network is one of the common methods of power theft in India as well as Jammu and Kashmir [2]. Illegal tapings means the direct rigging of the distribution network which is done by installing a line to a necessary point for the purpose of bypassing the electrical energy meter. Therefore the energy meter fails to take account of the exact amount of energy used by consumers and records a lower consumption reading. In Jammu and Kashmir about 50% of the total power generated worth Rs. 6 billion per annum is lost in transmission and distribution [3]. Now, many countries have started putting in place, advanced metering infrastructure (AMI) to measure, collect, store, analyse and use power consumption information [4]. AMI essentially involves having smart energy meters and their associated communication systems in large numbers in the distribution network. In emerging economies countries like India, most of the metering is through legacy meters and installation of AMI infrastructure may take some time. While smart meters have been installed in distribution feeder nodes, they lack the ability to communicate data to a distribution substation. Taking to the current scenario of system India is suffering from serious power shortage which is expected to get worse in coming decades. With the insufficient generation capacity, the power cuts have been ranging to several hours is common in many of the cities in India. Also with the odd distribution of geographical structure of India there is problem with lack of transmission infrastructure which lead several thousands of villages are still not connected to our national grid system [5] [21].Now Smart approach make use of Information and Communication Technology (ICT) and Supervisory Control and Data Acquisition (SCADA) systems to support the monitoring and automated control distribution network [6].This paper describes how the Smart technologies like Internet Of Thinking (IOT) and high power operating switching devices uses in the existing power network for the prevention of illegal distribution line tapings in the distribution network and there by improved power quality.

II LITERATURE SURVEY

A lot of work done has been done on the detection of illegal tapings on the distribution lines and most of these ways have used common analogy of comparing the electricity billed and the amount of electricity utilized. If there is a gap between the two, then the electricity theft and losses occur. Several papers and reports on using smart meter to detect NTL can be found in the public domain. In [7] techniques using AMI data is used to detect power theft. It lists out several energy-theft detection schemes, relying on classification-based, state estimation-based and game theory-based algorithms and finally compares all these methods .Erol-Kantarciand Mouftah [8] discuss how smart meters and data collectors can provide evidence to legal proceedings in electricity theft cases. In [9], the authors discuss existing smart metering practices and the prevailing situation in the Netherlands. They also present a novel automated method to

detect tampering and theft. In [10], the authors propose a method to locate illegal tapping by using smart meter data. In this method, the network model/parameters of the distribution system and mainly the voltage measurement data from the smart meters are used to locate theft points. The voltage measurements from smart meters are compared with the estimated voltages of the network, and a probable theft current is calculated. Bharat and Joshi studied the power losses and power theft of Gujarat state of India[11] the technology used for power theft and power loss analysis were Artificial intelligence based like machine learning, support vector machine, hidden feed forward networks. It was concluded that by normalizing the data and plotting load as a function of time and weather power loss and power theft can be calculated. C.R. Paul [12] studied the power mismatch between power generated and power sold by using various mathematical models and average load of previous years. They draw the patterns; based on those patterns they calculated the power theft and power losses. A.H. Nizar et al studied the non-technical losses and by using modern technologies like machine learning, data mining [13]. Jokar and Leunghave developed a pattern-based energy theft detector [14]. They train a Support Vector Machine (SVM) with historical data for each customer. Meanwhile, Faisal et al. [15] propose an intrusion detection system that makes use of multiple points in AMI architecture to detect attacks using algorithms. Liu et al. [16] propose a system to detect data attacks to smart meters, which operates on the meter itself. In [17] a method of detection of theft by estimating a statistical model of technical losses and NTL is discussed. It does this by making the assumption that every user is connected directly to its local DT and thereby calculating effective resistances between the DTs and the customer premises. If the NTL detected goes beyond a statistical threshold, the utility can be warned of possible illegal loads. A method of identifying energy theft by using pattern recognition techniques is proposed in [18]. It uses the energy meter readings of the smart meter and the energy reading of a central observer for several time instants. A state estimation based approach for energy theft detection in micro grids, while preserving privacy is proposed in [19]. This paper mainly deals with theft involving tampering of smart meter data.

III PROBLEM STATEMENT

- Illegal distribution line tapings is one of the most accounted and easy ways of electricity theft.
- Illegal tapings can severely overburden the power network and invite frequent power outages.
- Under RTI act by central electricity authority regarding losses it was reported that in 2004-2005 the transmission losses were to the tune of 175534.96 units.
- If we multiply the cost per unit at Rs 2, then the total loss in a financial term will be Rs 35000 crores (approx.)
- India loses around US$16.2 billion annually to NTL [1].
- No any automatic systems for theft prevention are used.
- Thus the proposed system is best suited for the problem regarding theft.

IV PROPOSED SYSTEM

The proposed system describes how to prevent the illegal distribution line tapings on the distribution lines. The main advantage of this system over the other systems proposed earlier is that the systems proposed previously only detect the power theft but they do not stop it. While this system prevents the theft i.e. if the defaulter tries to steal the electricity by placing illegal tapings on distribution lines he will not be able to use this electricity. Consumer can only access the electrical energy through proper smart energy meters In our proposed system we incorporate high power operating semiconductor switching systems at the distribution transformer (power transmitter) side in such a way that phases R,Y,B& Neutral is passed through this system .This switching system is operated through the bit sequence generated by the microcontroller. As far as this bit sequence is concerned, it allocates time for the switching between these four line conductors(R, Y, B and Neutral). Therefore neutral & phase lines are shifted after each allocation period i.e. at particular time we can't say which line conductor acts as Neutral and which line conductor acts as phase conductor. The same bit sequence is generated at the load terminal (receiver) side through RF transmitter- receiver synchronization. The load circuit is inbuilt in smart meter, the output electrical energy from the energy meters can be used for running appliances. Figure (1) shows the Schematic diagram of a typical distribution feeder of proposed system. If someone tries to use electrical power by placing direct tapings on the distribution line, he will get encrypted power signals depending upon the bit sequence generated at that time period and this produces malfunction and over voltage of the service appliances. One of main advantage of proposed system is that the existing power network as far as infrastructure is concern remains unchangeable, i.e. this prevention system is directly used in existing power system. Therefore Consumer can only excess the electrical energy which comes through smart energy meters. In this way this system prevents Illegal distribution line tapings. Figure (2) shows the working single phase model of the proposed system. In our proposed system we also incorporate security system through plc and online metering system through IOT, therefore this increases reliable & power quality. In general we can say that, by using this system we not only prevent power theft but we can also convert existing power network into smart network. This network gives real time informationregarding power demand and power management in the power network.

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www.ijarse.com
IJARSE
ISSN: 2319-8354

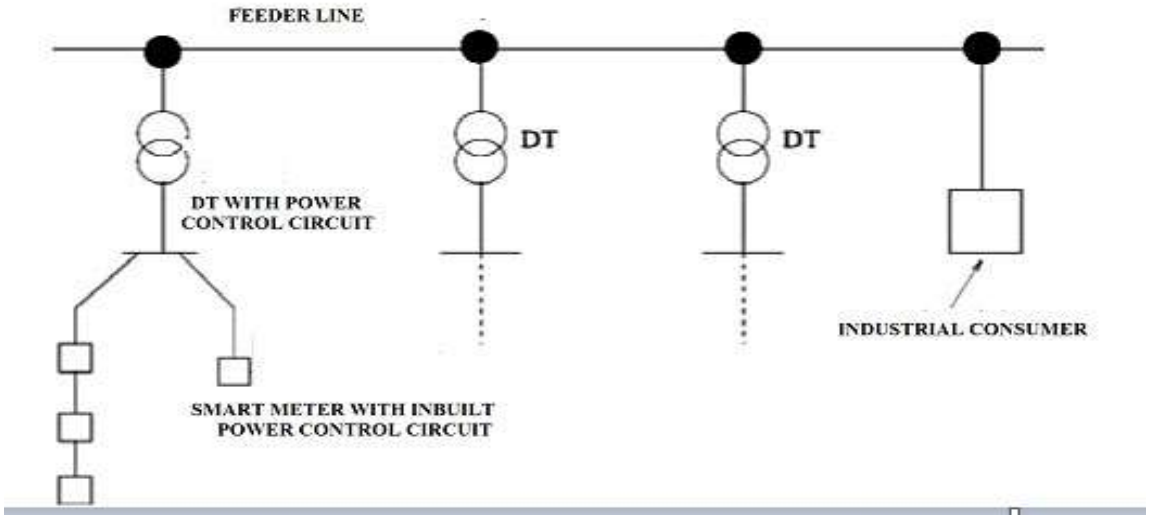
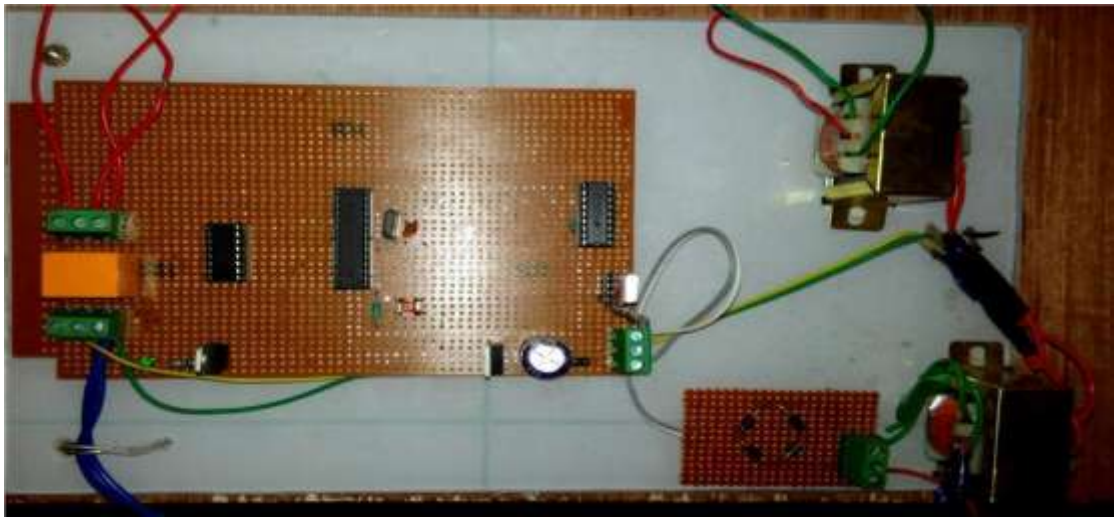


Fig (1) Schematic diagram of a typical distribution feeder

4.1 Transformer Side



4.2 Load Side

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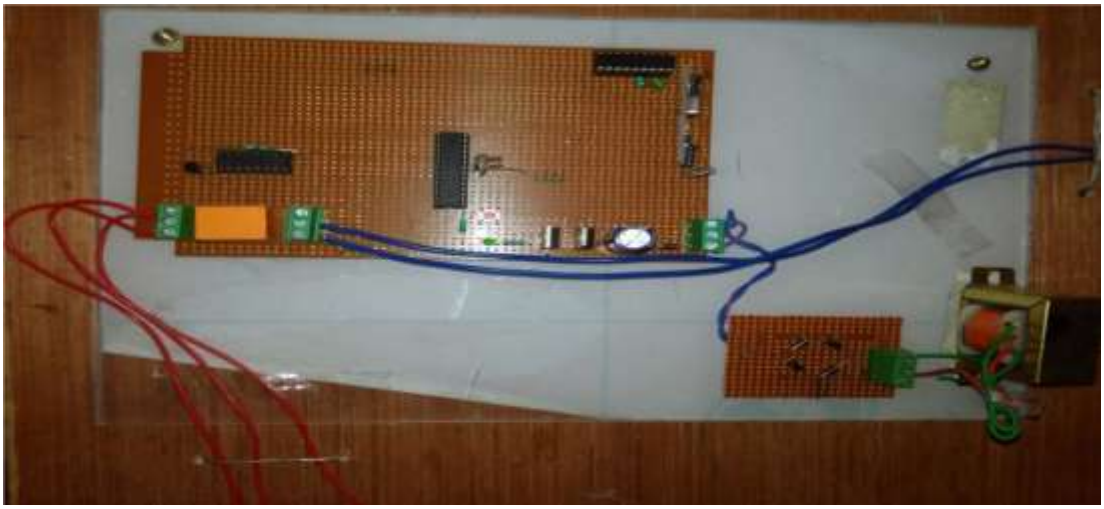

Fig (2) Single phase working model

V PRESENT POWER SYSTEM TO SMART NETWORK

Technically, the term power network is that which supports the four operations viz. power generation, transmission, distribution and control [20]. Currently our system is working in unidirectional which stop for technological developments. Here unidirectional means the communication between the user and utilities is one-way. Form the centralized supply source to demand the power flow is unidirectional. The information is flown from lower to higher side of operational centers. Fig (3) shows the present electrical power system.

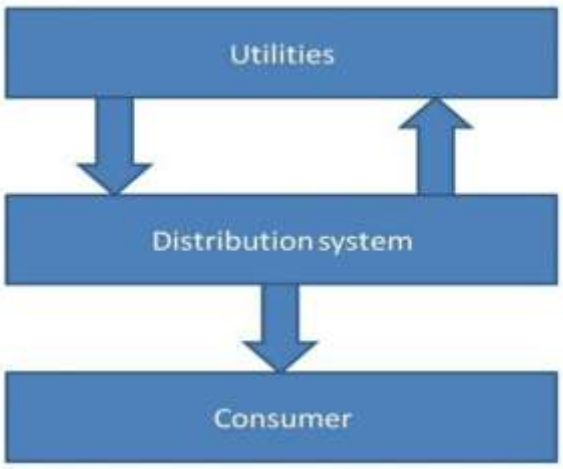

Fig (3) Existing power network

Few major problems arising in existing power network are.

- Between supply and demand a large gap is seen.
- Distribution and transmission losses are very high due to power theft.
- Operations of network are manual.
- Low metering efficiency and less friendly user involvement.
- The information technology used is not so sophisticated and is decades older.

On the other hand the operations of a smart network is basically based on the both side communication for the information flown and the power flown on the basis of power engineering, digital and information technologies and also communication engineering. Below Fig (4) shows the smart network after implementing above proposed system. The Benefits of Proposed System are.

- Illegal line tapings can be prevented.
- By implementing this system, we can eliminate non-technical losses (NTL).
- Voltage sagging problem is reduced to large extend.
- Network loading decreases.
- Improved power quality.
- System security increases.
- System is linked to a common master control room for data collection.
- Tariff rate decreases.

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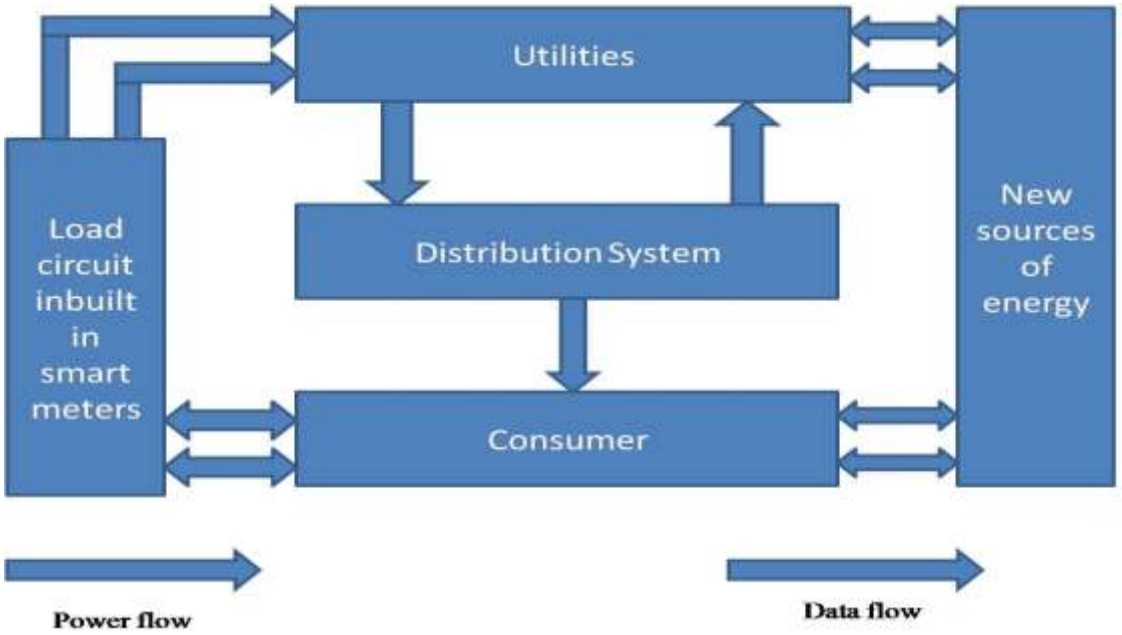

Fig (4) Proposed smart network

VI METHODOLOGY FOR PROPOSED SYSTEM

The Methodology adopted in this paper for prevention of illegal distribution line tapings is shown in Flow chart as given in Fig (5). The flow chart shows the various stages of the proposed system for the prevention of illegal distribution line tapings.

VII SWITCHING SCHEME AND RESULTS

In our proposed system power semiconductor switch is connected ac supply system or transformer output terminals and load terminals through smart meters. The power can be controlled by varying the RMS value of ac voltage applied to the load. The switch is operated by gate pulses which are operated through appropriate bit sequence generated by microcontroller. Figure (5) shows single phase switching circuit.

Mathematically sinusoidal input voltage can be represent by (I) as shown in figure (6).

$$Vs = V_m \, Sinwt \qquad (I)$$

Now rms value of output voltage can be represented by (II) where α is firing angle as shown in figure (7).

$$Vrms = [1/\pi]^{1/2}$$

$$Vrms = V_m/3.414 \, [(\pi-\alpha)/\pi + \sin 2\alpha/2\pi]^{1/2} \qquad (II)$$

Therefore load circuit can be controlled by varying the firing angle α of switching system.

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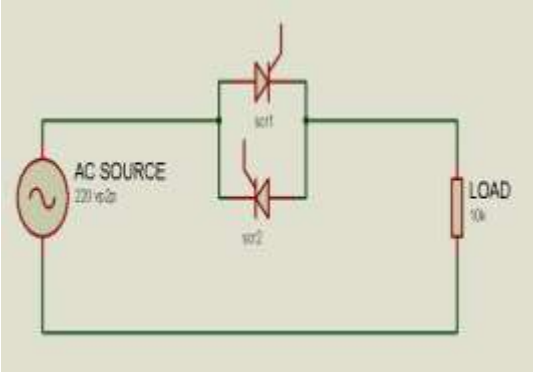

Fig (5) single phase switching circuit

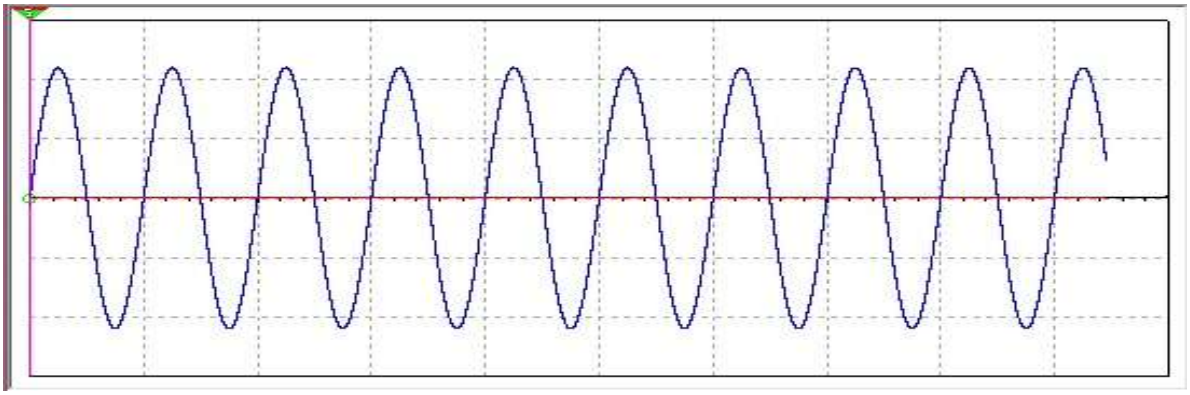

Fig (6) input voltage

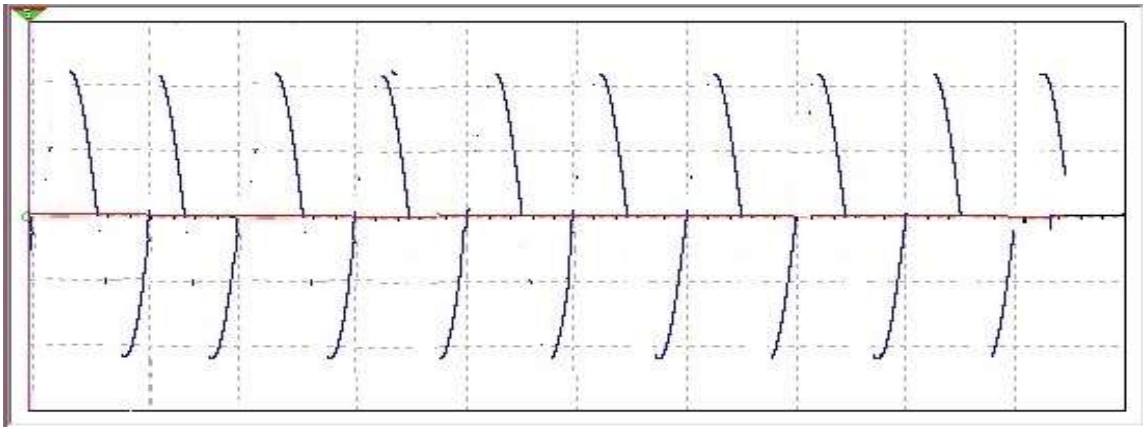

Fig (7) output voltage waveform

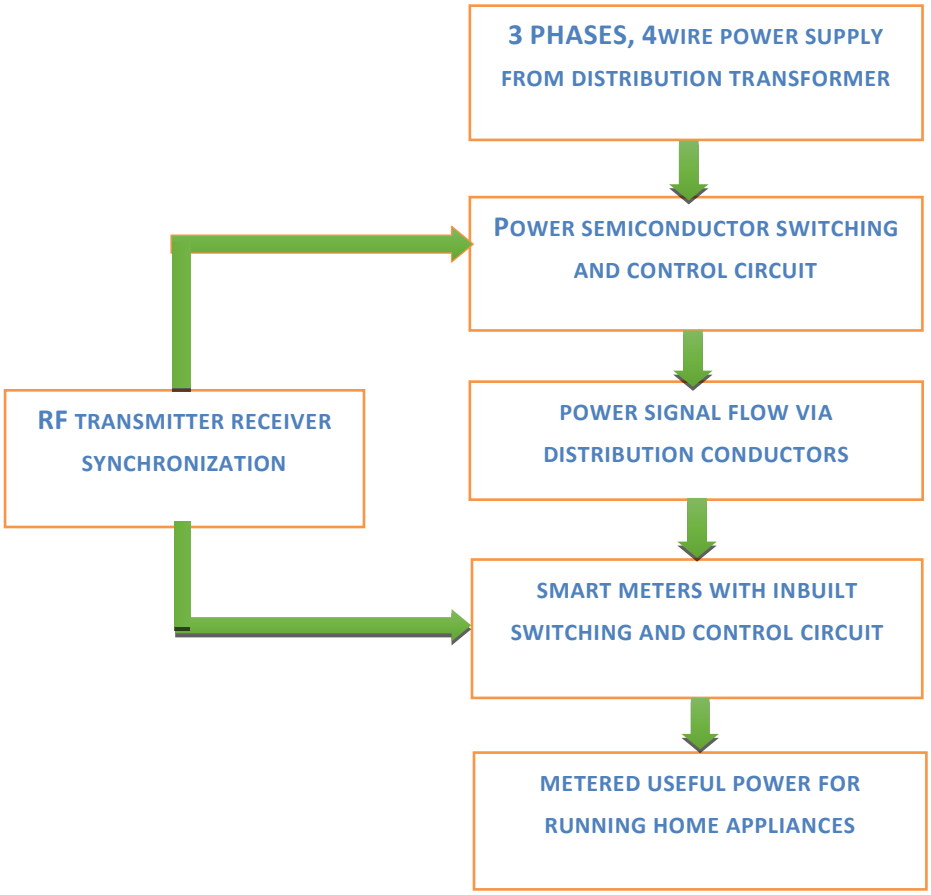

Fig (5) Methodology Flow Chart for Proposed system

VIII CONCLUSION

The successful prevention of illegal tapings from distribution lines described in this system had been based on the switching techniques of power signals in the distribution power network. This project aimed for the full prevention of illegal tapings which have created a menace in our society. The economy of the area or the economy of the utility company which is deeply affected by these illegal tapings can be saved. In this system there is no need of informing the control rooms about the occurring theft as this system will not allow any theft. The implementation of this system requires a good capital investment. The hardware circuitry under consideration for experimentation was a prototype model, the working model can be developed at a reasonable cost. The capital lost by the government or

the utility company by the electricity theft is very huge. This paper should be helpful in planning, and building up of smart network and executing it on basis of the proposed philosophy in India and subcontinents.

In our ongoing work, we are evaluating two major aspects of our approach: (I) the overhead performing calculations in a distributed manner; and (ii) the prevention performance of our approach. Initial results indicate the approach has promise to secure modern distribution networks containing distribution generation. Future work will investigate whether the distribution generation control would get affected by this proposed power theft prevention prototype model.

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