AN EFFICIENT ELECTRICITY THEFT AND FAULT DETECTION SCHEME IN DISTRIBUTION SYSTEM

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***ABSTRACT*:** *Currently the world is facing energy (electricity) crisis and it is becoming severe with the passage of time. Every country is striving to produce and save electricity. In developing countries, especially, a considerable amount of revenue is lost due to electricity pilferage and fault occurrence on the distribution system. Therefore, it is required to design a system that would be able to detect electricity theft as well as the faults on the distribution system. This paper presents an efficient and simple technique which operates efficaciously as an electricity theft detector and also serves the function of a protective relay. In this scheme, each customer is provided with smart meter and a main observer meter is connected to distribution transformer. Meters send the readings to the data acquisition center where the proposed algorithm is applied to detect theft or fault scenario. Electricity theft can be considerably reduced by using this proposed metering technique. This algorithm can also identify associated areas of electricity theft.*

Keywords: distribution system, electricity pilferage, protective relay, smart meter, theft detector.

INTRODUCTION:

Electricity theft is the major factor for distribution losses in electrical networks. It is increasing day by day in developing countries due to high electricity rates and low literacy rate. Electricity theft not only damages the economic growth of the regulating authorities, but also leads to the electricity shortfall and deterioration in power quality. Developing countries, like Pakistan, are already facing electricity short fall and one of its major cause is electricity theft. Mainly, rural areas are involved in electricity theft due to poverty and illiteracy. A world bank report shows that up to 50% of electricity is acquired by theft in the developing countries [1].

According to the article published in The Express Tribune, the total installed capacity of electricity generation in Pakistan is about 22,797MW [2]. According to another report, the average generated power in July, 2013 was about 14,424MW whereas the electricity demand was about 18,884MW, showing a supply demand gap of 4,460MW [3]. This supply demand gap is also increasing with the increase in electricity theft ultimately creating burden over the regulating authorities (in terms of loss of revenue) and legitimate customers (in terms of load shedding and increased electricity costs). Revenue of hundreds of millions of dollars is lost annually due to electricity theft in Pakistan [4]. Circular debt of about 872 million rupees was reported in 2012 due to substantial losses and electricity theft in Pakistan [5].

The statistics mentioned above clearly visualize the harmful effects of electricity theft and losses due to the fault occurrence on distribution lines. The necessary actions to avoid electricity theft and need of protection of distribution lines should also have same priority considerations as of electricity generation. Detection of electricity theft in energy meters and timely operation of circuit breaker on fault occurrence is one of the major concerns to keep the system healthy.

Research work is being conducted to detect electricity theft and faults on the distribution system. Electricity theft detection technique is proposed in [6], in which the smart meter monitors the non-technical losses. If they exceed certain limit, the customers are disconnected and harmonics are introduced in the distribution line which will damage the appliances of illegal users. This is an effective technique to avoid electricity theft, but the equipment is expensive and legitimate customers have to be disconnected for some duration. Support Vector Machines (SVM) [7], game theory model [8] ,GSM [9] and Zigbee [10] based smart metering techniques have also been proposed for theft detection in the past.

Due to overhead distribution system in Pakistan, fault occurrence on distribution lines is quite frequent. It is required to properly monitor and timely detect the presence of fault. Research is being conducted to develop efficacious fault detecting techniques. Neural networks [11], fuzzy logics [12], neural fuzzy inference [13] based efficient fault detection techniques, for power system, have been proposed in the recent past.

This paper focuses on a electricity theft and fault detection technique. The proposed technique is simple and results have shown its effectiveness. The proposed scheme is modeled and simulated in Matlab/Simulink. This paper is organized as: sections below presents the proposed model. Then, simulation and results are discussed and the last section concludes this article.

PROPOSED METHOD:

Due to increase in electricity pilferage in developing countries like Pakistan, it is the utmost need to eradicate such problems. Due to low economic growth, the electricity theft and fault detection techniques should be efficient and cost effective. For this, a simple and efficient method is proposed which not only detects electricity theft, but it can also be used as a fault detecting relay. The proposed technique is modeled and simulated in Matlab/Simulink software.

In the proposed metering technique, every customer is provided with a smart meter and associated distribution transformer is connected to an observer meter. Each smart meter monitors load profile of the customer and sends reading to the acquisition center wirelessly. At every instant, readings of the customer smart meters are added and compared with the reading of the observer meter of the associated transformer. If the observer meter current is more than 5% of collective current of smart meters, there may be two cases. Firstly, there may be an electricity theft and secondly, fault may have occurred on the distribution line.

The proposed algorithm is capable of discriminating both cases by applying another decision rule. If there is some disturbance in voltage then there will be a fault in the distribution line. Otherwise, there will be a theft case. Finally, the display panel at the acquisition center would notify the active case. In case of theft, a person may be sent to the associated area for checking and for fault case, a trip signal would be automatically passed to the associated circuit breaker for disconnecting the line at the very instant. The algorithm of the proposed metering technique is given in Fig.1.

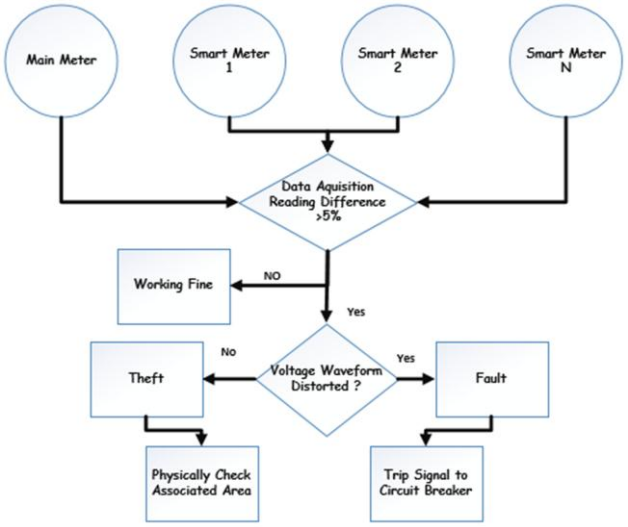

Fig. 1 Flow Chart for the proposed metering technique

wireless technique that may be WiFi, GSM, WiMAX, ZigBee and Bluetooth (for short distance), etc. Normal working, theft and fault cases are discussed below. The simulation diagram of the proposed system is shown in Fig. 2.

Normal Operation Case:

In this case, all the electricity users are legal customers and no fault has occurred on the line. Cumulative reading of the customer meters and main meter would be equal or would have difference less than 5%. The proposed scheme would identify this operating condition as normal operation of the system and the display panel in the acquisition center would become green and show "normal" on its display (refer to Fig. 2).

Electricity Theft Case:

For this case, a power electronic switch has been connected to a "theft load". When the switch is turned on, the "theft load" is connected to the system (practically theft is achieved by meter tampering or by the use of "kunda system (illegal tapping)". Once theft load is in the system, main meter reading would be more than 5% of the cumulative reading of the customer meters and the proposed scheme will check its voltage. If voltage waveform is not distorted then it would be recognized as a theft case and "theft" would be displayed on the display panel and its color will change to blue (refer to Fig. 2). If the theft scenario sustains for some minutes, then a person can be sent to the associated area for physical checking. Meter readings are shown in Fig. 3 giving a clear idea of the theft scenario.

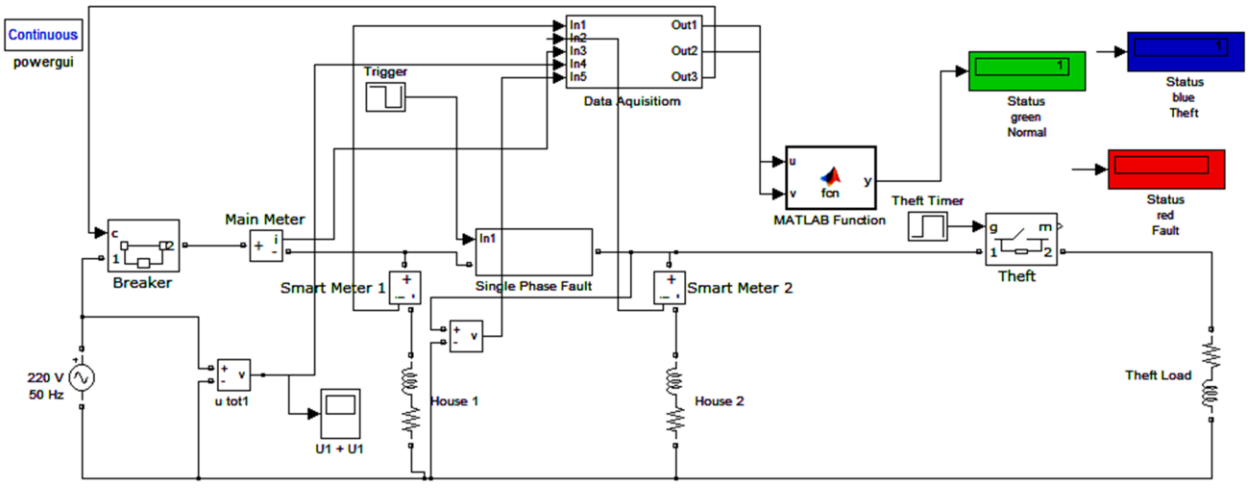

Fig. 2 Proposed System implemented in SimPower System

Fault Case:

In this case, if a fault occurs on the distribution line, similar check would be performed as described in a theft case. If voltage waveform is distorted then proposed algorithm would identify this case as a fault and a trip signal would be sent at very instant to the associated circuit breaker. In this case, "fault" would be displayed on the display panel and it would change its color to red (refer to Fig. 2). Fault occurs at 5 seconds of the simulation time. The circuit breaker operation can be visualized from Fig. 4.

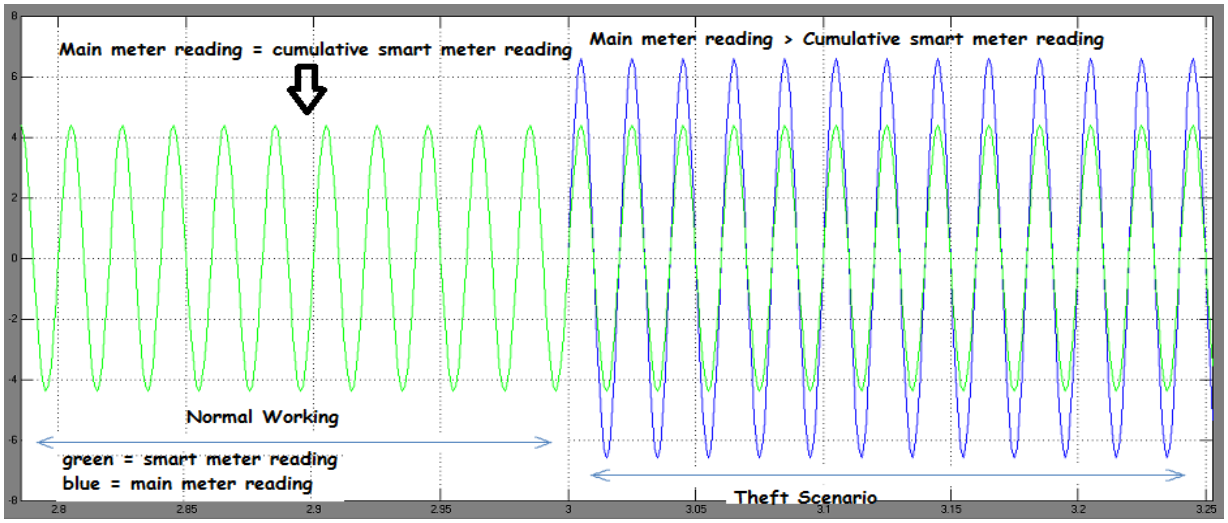

Fig. 3 Meters reading during normal and theft scenarios

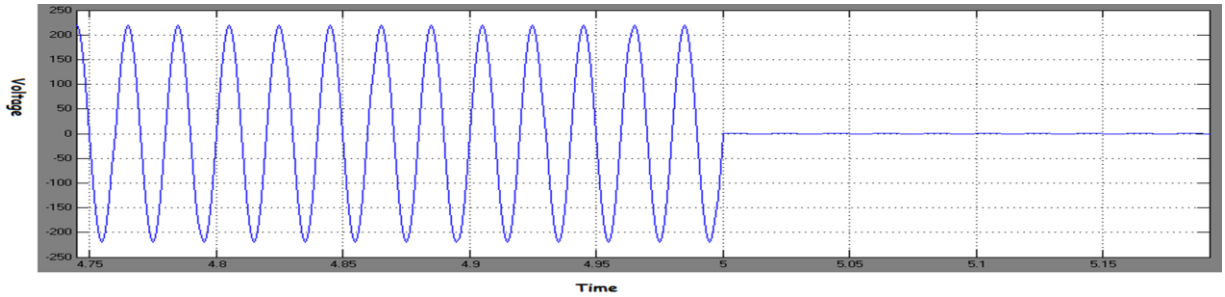

Fig. 4 Voltage waveform during fault

CONCLUSION:

This paper presents a simple, efficient and cost effective solution for electricity theft and fault detection. The proposed scheme is designed in such a way that every customer smart meter and associated main meter transfer the readings (by means of any wireless technology) to the acquisition center where they are compared. If the difference between the readings is more than 5%, then the proposed algorithm diagnoses the theft or fault case. The results have shown that the system is completely reliable, efficient and it is able to discriminate between theft and fault scenarios. The system also works like a protective relay and sends the trip signal to the circuit breaker upon occurrence of fault. The proposed system definitely decreases electricity theft when applied to the system because every transformer is provided with an observer meter that would show the associated area of theft.

REFERENCES:

[1] Antmann, P. (2009). *Reducing technical and non-technical losses in the power sector*. World Bank, Tech.

[2] *Pakistan's energy security, available at*: http://tribune.com.pk/story/655573/pakistans-energy-security/. (Accessed on 18-03-2015)

[3] *Pepco data shows no increase in power generation in a year*, available at: http://www.dawn.com/news/1117810. (Accessed on 18-03-2015)

[4] Smith, T. B. (2004). *Electricity theft: a comparative analysis. Energy Policy*, 32(18), 2067-2076.

[5] Commissioned by Planning Commission of Pakistan. (2013). *The Causes and Impacts of Power Sector Circular Debt in Pakistan*. Funded by the United States Agency For International Development (USAID).

[6] Depuru, S. S., Wang, L., & Devabhaktuni, V. (2010, July). *A conceptual design using harmonics to reduce pilfering of electricity*. IEEE PES General Meeting, Minneapolis, MA.

[7] Nagi, J., Yap, K. S., Tiong, S. K., Ahmed, S. K., & Mohammad, A. M. (2008, November). *Detection of abnormalities and electricity theft using genetic support vector machines*. In TENCON 2008-2008 IEEE Region 10 Conference (pp. 1-6). IEEE.

[8] Cárdenas, A. A., Amin, S., Schwartz, G., Dong, R., & Sastry, S. (2012, October). *A game theory model for electricity theft detection and privacy-aware control in AMI systems*. In Communication, Control, and Computing (Allerton), 2012 50th Annual Allerton Conference on (pp. 1830-1837). IEEE.

[9] Mohammad, N., Barua, A., & Arafat, M. A. (2013, February). *A smart prepaid energy metering system to control electricity theft*. In Power, Energy and Control (ICPEC), 2013 International Conference on (pp. 562-565). IEEE.

[10] Pandey, V., Gill, S. S., & Sharma, A. (2013). *Wireless Electricity Theft Detection System Using Zigbee Technology*. International Journal on Recent and Innovation Trends in Computing and Communication.

[11] Rezaei, N., & Haghifam, M. R. (2008). *Protection scheme for a distribution system with distributed generation using neural networks.* International Journal of Electrical Power & Energy Systems, 30(4), 235-241.

[12] Haris, M., Salik, M., Safdar, A. A., & Rashid, U. (2013, June). *Improved fuzzy logics based differential protection scheme.* In Power Engineering and Optimization Conference (PEOCO), 2013 IEEE 7th International (pp. 261-266). IEEE.

[13] Etemadi, A. H., & Sanaye-Pasand, M. (2008). *High-impedance fault detection using multi-resolution signal decomposition and adaptive neural fuzzy inference system*. IET generation, transmission & distribution, 2(1), 110-118.