Department of Electrical Engineering
Assignment
Date: 13/04/2020

Course Details

Course Title: Research Methodology for Engineers   **Module:**   MS EE

Instructor: **Engr.DR.Shahryar Shafique Qureshi**   **Total Marks:**   30

Student Details

Name: Asad ullah khan   **Student ID:**   15435

Q1.		Choose a research **paper (journal/conference)** from your **engineering discipline** (area of interest) that was published approximately five years ago, you may use academic web search or journal/conferences publisher digital libraries. Read the paper and answer the following questions:	
	(a)	What are the **aims** and **objectives** of this research paper?	Marks 07
	(b)	Write down the **research question(s)** you think the authors have addressed in undertaking this research.	Marks 03
	(c)	What are the **verification methods** and **software tools** used to accomplish/get the results?	Marks 03
	(d)	What are the major **conclusions** and **outcomes** of the paper?	Marks 05
	(e)	What can be the significant **future research directions** in light of the selected research paper?	Marks 05
	(f)	What is the **referencing style** being followed in this paper?	Marks 02
	(g)	Write **reference** of **your selected research paper** in **APA, MLA, Harvard, Vancouver, Chicago** styles.	Marks 05

Note: Student must attach the research paper he/she has chosen, with his/her answer sheet.

Wireless power meter monitoring with power theft detection and intimation system using GSM and Zigbee networks

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Abstract: *With the electric industry undergoing change, increased attention is being focused on power supply reliability and power quality. Power providers and users alike are concerned about reliable power, whether the focus is on interruptions and disturbances or extended outages. Monitoring can provide information about power flow and demand and help to identify the cause of power system disturbances. The proposal in this paper is to monitor the power consumed by a model organization such a household consumers from a centrally located point. Monitoring the power means calculating the power consumed exactly by the user at a given time. The power consumed by the user is measured and communicated to the controlling substation whenever needed by the person at the substation. The feedback from the user helps in identifying usages between authorized and unauthorized users which helps in controlling the power theft, one of the major challenges in current scenarios. Communication between user/household and substation can be of wired and wireless*
Keywords*: Zig Bee, power theft, GSM, AT commands, wireless meter reading.*

I. Introduction

Power theft is the biggest problem in recent days which causes lot of loss to electricity boards. In countries like India, these situations are more often, if we can prevent these thefts we can save lot of power. Electrical power theft detection system is used to detect an unauthorized tapping on distribution lines. Implementation part of this system is a distribution network of electrical power supply system. Existing system is not able to identify the exact location of tapping. This proposed system actually finds out on which electrical line there is a tapping. This is a real time system. Wireless data transmission and receiving technique is used. This will provide an additional facility of wireless meter reading with the same technique and in same cost. This will protect distribution network from power theft done by tapping, meter tampering etc.

There are two types of techniques to deliver the information to the authorized agency to control the theft of the electricity via bypassing the energy meter, those are wired and wireless. Wired networks require lot of setup and maintenance cost. In wireless technologies there are many technologies. In this project we implemented using Zigbee technology because of its effective communication, self-healing networks, low power consumption, zero traffic and they can handle over 60000 devices and more over Zigbee communication installation require no special permissions in most of the places. It uses unlicensed 2.4 GHz ISM band which is available worldwide. ZIGBEE has range between 10 m to 2 km and it works well with networks such as Wi-Fi, Ethernet and GPRS and also provides scalable networking solution which makes it suitable to be used in controlling and monitoring application. And we selected other communication network to be GSM to send SMS to authorities in case of theft, because GSM has a built in transport layer encryption, which is supported by most network providers. GPRS offers a number of security enhancements over existing GSM security. The standards themselves also offer technical features, which a network operator may choose to use. Aside of that, a different form of security might be desired in addition to the provided transport layer security.

II. Block Diagram

The developed prototype consists of a transmitter tapped to meter of the consumer and a receiver at a junction place. Their respective block diagrams are as follows
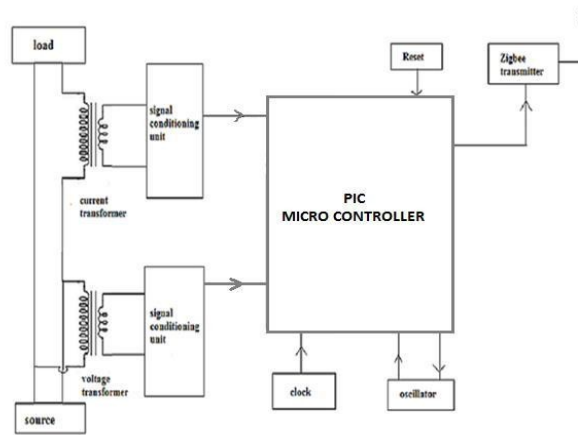
Fig: Transmitter Block diagram

It consists of Load, current transformer, voltage transformer, PIC micro controller, and a differential relay. The household load supplied is connected in series to the AC supply mains through a switch which is operated by the action of a relay. Current transformer is used to measure the current required for the user and the voltage transformer is used to measure the voltage of operation for the user. The measured values are given to the PIC micro controller which has inbuilt ADC with RISC architecture to convert the analog values to the digital values. These values are stored in microcontroller registers and the information is transmitted to the receiver, whenever there is a request for the data from the remote controlling station. Oscillator is provided to the microcontroller for the clock signal and the reference voltage is given for the each of the IC used.
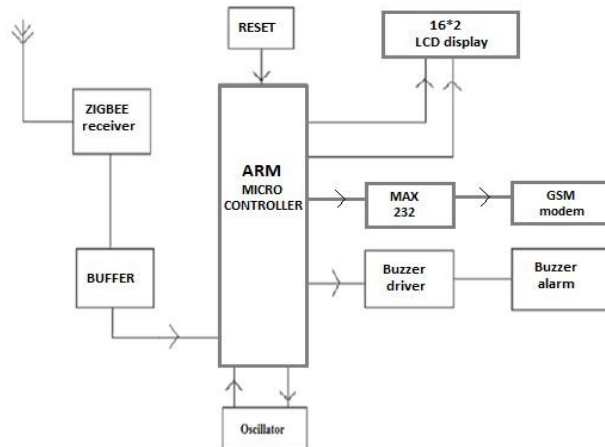

Fig: receiver block diagram

The receiver part of this prototype consists of an ARM micro controller, Zigbee receiver LCD display and alarm to pop out theft case, and also an external GSM modem to inform theft case to authorities via SMS.

III. Automatic Meter Reading (Amr)

Now a day utility company personnel goes at every house to take the readings of meters for billing purpose. It will create problem when consumer is out of Town or home is locked due to other reasons. This system of wireless meter reading is based on the same principle of wireless data transmission that is used in power theft detection Utility company personnel will have a device consists of wireless data receiver with microcontroller and display
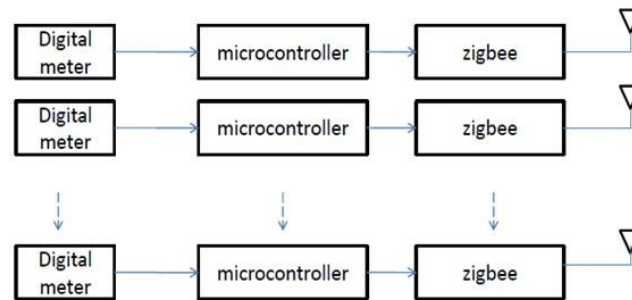
Fig: Architecture of AMR

The Base station unit will be consists of a zigbee module attached with a Transceiver micro-strip antenna, microcontroller attached to digital meter. The frequency of communication will be in 900 MHZ. the data will transmitted to the central station at regular intervals. The end station consists of an ARM micro controller receiving data from different PIC micro controllers through Zigbee receiver. The data thus received is processed and calculated the exact amount of power consumed by specific customer

IV. Power Measurement And Theft Detection

Aim of the Remote power monitoring is to measure the exact amount of power that is consumed by the user at a given instant of time so the power measurement unit is essential and is connected on the consumer side. The power is measured by using the instrument transformers. Instrument transformers are used for measurement and protective application, together with equipment such as meters and relays. Their role in electrical systems is of primary importance as they are a means of "stepping down" the current or voltage of a system to measurable values, such as 5A or 1A in the case of a current transformers or 110V or 100V in the case of a voltage transformer. This offers the advantage that measurement and protective equipment can be standardized on a few values of current and voltage. The types of instrument transformers available are
•   Voltage transformers
•   Current transformers.

A. Voltage transformers

The voltage transformer is one in which "the secondary voltage is substantially proportional to the primary voltage and differs in phase from it by an angle which is approximately zero for an appropriate direction of the connections." In an "ideal" transformer, the secondary voltage vector is exactly opposite and equal to the primary voltage vector, when multiplied by the turn's ratio. In a "practical" transformer, errors are introduced because some current is drawn for the magnetization of the core and because of drops in the primary and secondary windings due to leakage reactance and winding resistance. One can thus talk of a voltage error, which is the amount by which the voltage is less than the applied primary voltage, and the phase error, which is the phase angle by which the reversed secondary voltage vector is displaced from the primary voltage vector.

B. Current transformers

A current transformer is defined as "as an instrument transformer in which the secondary current is substantially proportional to the primary current (under normal conditions of operation) and differs in phase from it by an angle which is approximately zero for an appropriate direction of the connections." This highlights the accuracy requirement of the current transformer but also important is the isolating function, which means no matter what the system voltage the secondary circuit need be insulated only for a low voltage.

The current transformer works on the principle of variable flux. In the "ideal" current transformer, secondary current would be exactly equal (when multiplied by the turn's ratio) and opposite of the primary current. But, as in the voltage transformer, some of the primary current or the primary ampere-turns are utilized for magnetizing the core, thus leaving less than the actual primary ampere turns to be "transformed" into the secondary ampere-turns. This naturally introduces an error in the transformation. The error is classified into two-the current or ratio error and the phase error.

Thus by considering all these parameters we program micro controllers to calculate the amount of power actually consumed.

C. Theft detection method

The simple formula behind theft detection is whenever input power is passing from supplier to the receiver, at that time if the total amount of power is not received by the receiver then there is possibility of theft

of energy.

ΣPsent = ΣPconsumed + Loss ……..No Theft ΣPsent ≠ ΣPconsumed + Loss ……..Theft Occur
Here,

Psent = Power measured by pole side energy meter Pconsumed = Power measured by load side energy meter

Consider a distribution system shown in conceptual diagram. Two single phase loads L1 and L2 are supplied from two different phases. M1 and M2 are the energy meters that measure power consumed by these loads over a period. Pole based system (P) have been installed to detect power theft.
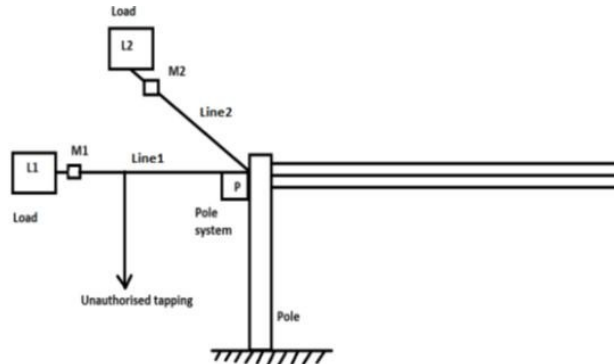

FIG2.3.1: Conceptual diagram
L1, L2 Single phase loads M1, M2 Digital energy meters

P Pole based system (installed on a distribution pole) There are three different types of systems to monitor power sent

A. *pole based system*
It consists of Wireless data receiver, Micro-controller, Digital energy meter. Digital energy meter will measure power sent over each line for a certain time period.

B. *Pole Side Energy Meter*
One energy meter is installed in a pole based system. This meter is capable to measure a power sent over each line connected to that pole.

C. *Load Side Energy Meter* **(M1, M2):**
Meter is installed on load side to measure a power consumed by load over a time. Also it has an additional feature of transmitting that data to receiver using wireless technique ZigBee network.
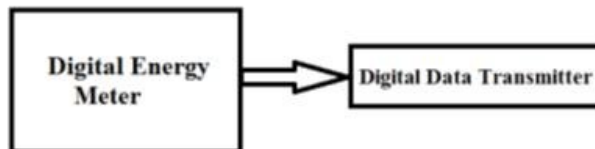

Fig: load side meter

D. *Power theft detection*
Suppose there is tapping done by any unauthorized person on the line to connect his appliance. Over a certain period there will be difference between meter reading and pole based reading.

Microcontroller will compare these two values and if the measured value on pole is more than value send by meter by some tolerance then power theft is happening on line. This theft signal generated on pole system can be transmitted to substation by power line communication technique, Tolerance should be provided for losses of line. Because over a long period there will be difference in reading of meter on load side and pole side due to loss of line between pole and load. Therefore tolerance should be provided through programming of micro-controller.

V.   Working

The setup is build such that every consumer is provided with an automated meter reader with inbuilt microcontroller to monitor the data consumed at regular intervals, the PIC microcontroller is employed at consumers end and Arm microcontroller is employed on pole station. PIC sends data continuously and ARM processes data, it already has the record of amount of power sent to each line and it compares this to received feedback, if the difference between these two values exceeds the prescribed limits then the ARM microcontroller understands that power theft was happened and raises an alarm, also sends this information to local authorities via GSM modem

There is a prescribed limit because, we have to keep track of all general power losses other than theft and PIC was employed at consumers end, while ARM at pole station. This is because both has inbuilt ADC and RISC architecture but PIC is 8-bit and cheaper it serves the purpose perfectly, while on pole station ARM receives data from various PIC's and need higher RAM and architecture to process data quickly, so ARM with 32-bit architecture is employed.

VI.   Conclusion

The progress in technology about electrical distribution network is a non-stop process. New things and new technology are being invented. The proposed system found to be little bit complex   as   far   as distribution network is concerned, but it's an automated system of theft detection. It saves time as well as help to maximize profit margin for utility company working in electrical distribution network. Utility company can keep a constant eye on its costumer. And the extension of this project with GSM modules helps company to monitor the amount of usage by the specified customer and generate bill periodically and send it to customer via SMS, thus saving lot of labor work, time and cost of reading.

References

Journal Papers
[1]   C. Jägerlind, "Improvements for the automatic meter reading process in electricity distribution companies," Master Thesis, Dep. Industrial Info and Control Systems, Royal Institute of Technology, Stockholm, Sweden 2006.
[2]   A. Abdollahi, M. Dehghani, and N. Zamanzadeh , "SMS-based reconfigurable automatic meter reading system," IEEE International Conference on Control Applications (CCA 2007), Oct, 2007, pp. 1103 – 1107.
[3]   C. Brasek, "Urban utilities warm up to the idea of wireless meter reading," The IEE Computing and Control
[4]   C. Nunn, P. Moore, & P. Williams "Remote meter reading and control using high- performance plc communication over the low voltage and medium voltage distribution networks," in 7th International Conference on Metering Apparatus and Tariffs for Electricity Supply, 1992, pp. 304-308.
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Books
[6]   V.K.Mehta and Rohit Mehta, "Principles of Power System", 4th ed, S. Chand publication, 2008.

Thesis
[7]   M.A.O liveira and C.C. Barioni, "Technical loss calculation by distribution system segment with corrections from measurements", Proc.20th
[8]   J. Tsoi, "Device management of largescale amr systems," MSc thesis, Dep. of Industrial Information and Control Systems, Royal Institute of Technology in Stockholm (KTH), Stockholm, Sweden 2006.

1. <u>Aims and Objectives:</u>

Selected research paper is a journal from IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) that aims the implementation of smart, efficient and accurate systems for power distribution management. As the relevant authorities are clearly and evidently concerned about the reliability and power quality because of the power theft, rigorous meter reading process and respective bill compilation of the consumers. This research paper/journal devises a solution referring to all the problems mentioned. This paper provides following solutions:

- Power Theft Detection
- Automatic Meter Reading
- Communication between Base, End and Load Stations:

Power Theft Detection:

Research paper devises a power theft detection system apparently divided into three modules that communicate wirelessly with each other using **ZigBee Networks**.

1. **Load Side Energy Meters:**
   Energy used by the load will be measured by a meter installed on the load's side and that measurement will be transmitted to the receivers of Pole Side Energy Meters.
2. **Pole Side Energy Meters:**
   Energy meter will be installed on each pole that will measure the power sent over each line for that specific pole.
3. **Pole Based System:**
   Pole Based System will consist of a Micro-controller, a Digital Meter and a Wireless Data Receiver and it will have the capability to measure the power transferred over each line but for the specific time interval.

Automatic Meter Reading:

The currently observed process for meter reading is very tedious and time consuming as the service provider personnel must walk over to each house and check the meter so that bill compilation could be carried out each month. Through the proposed solution, the personnel will have a wireless data receiver with a microcontroller and display to get the reading as wireless data transmission is already set-up at each load.

Communication between Base, End and Load Stations:

ZigBee Networks are primarily used as a medium of communication. There will be ZigBee transmitter and receiver at the consumer end and service provider end respectively to support communication in between. While there will also be a GSM modem at the receiver to notify the authorities about power theft via SMS.

2. Research Questions author is answering:

Selected Research Paper is trying to provide solutions and answers for many previously raised questions.

- ➢ Is power theft detection practical? What are the probable solutions? OR Why is it not practical?
- ➢ According to the modern advancements in the technology what system can be proposed to handle power theft?
- ➢ Power Distribution System is getting devastated at the hands of power thieves, is there an efficient way to control it and maintain reliability?
- ➢ How modern communication systems/standards be used to help maintain power distribution quality and control power theft?
- ➢ Automatic Meter Reading is the necessity of the time, how do you propose to get Automatic Meter Reading done efficiently and accurately?

3. Verification Methods/Software Tools:

Communication Technologies:

The implementation of communication of the proposed work could have been carried out by wired networks but they are difficult and costly to set-up and manage. So, ZigBee networks are used because of their effective and self-healing nature and moreover they can manage up to 60000 devices. Similarly, GSM is used to notify the authorities in case of theft only because most of the network providers support GSM due to its built-in transport layer encryption.

Microcontrollers:

Two microcontrollers are to be used in the implementation of the proposed system namely PIC Microcontroller and ARM Microcontroller. PIC Microcontroller is used at the consumer end to handle the measurement of power consumption and transmission of this data. PIC has 8-bit RISC architecture with built-in ADC (Analog to Digital Converter) so it can easily handle the consumer end. Meanwhile, ARM Microcontroller is used at the pole station and it has a 32-bit architecture that can easily handle and manage data received from multiple lines coming from different PICs.

Results Verification:

For the verification of the results needed to take the decision of power theft, the value of power consumed at the consumer end will be compared with the value of power sent and if the value of power sent is greater than the tolerance than its decided that the power theft took place. Meanwhile, value for tolerance must be provided at the time of programming the micro-controllers because the loss of lines over time can also cause the difference in compared values.

4. <u>Conclusions and Outcomes:</u>

Conclusion:

It can be concluded from the implementation of the proposed system that the problem of power theft can be easily tackled by efficiently using the technology we currently possess. Moreover, power distribution method can be made more efficient and reliable by using wireless communication and power line communication (PLC) by accurately measuring the power units transmitted on each line and power consumed by that line. It can easily identify where exactly power cable was tapped and, to some accuracy, who tapped it. Henceforth, it can also be concluded that the work of meter reading personnel can be minimalized and made much more feasible then the current system of manually reaching out to each meter and capture the reading.

Outcomes:

A much reliable and efficient power distribution system that is capable of providing quality power with minimalized power loss and managed power distribution. Such system has knowledge of whereabouts of its power distribution and usage along with keeping a complete record of where and how much it was used. Moreover, such system with extended communication channel can be used, in future, to add more functionalities to it. This system provides its personnel ease of work because of automatic meter reading and, in bill compilation as the consumption data is measured efficiently by the embedded system and transmitted back to the base station.

5. <u>Future Research Directions:</u>

Future research work regarding the power systems and identification of power theft is of very diverse nature that covers many techniques, technologies and different models that reach out to the topic using varying approaches.

- ✓ This could lead out to the consideration of power factor and reducing it to increase the efficiency of the system. The system with just increased efficiency can prove itself much more capable in the practical environment even without using any power techniques.

- ✓ Further Research could be carried out on the data collected, recorded and stored related to the power transmission and power consumption. This data could be used for Data Analysis Operations to predict future of power consumption and expected increase in it.
- ✓ Research and Development of more smart and efficient communication systems that can be used as an embedded tool in power distribution channels to enhance their capabilities.
- ✓ Smart data measurement techniques could be implemented along enhanced communication channels that can increase the capability of the system exponentially regarding quality and theft control and reducing power loss.
- ✓ Research and Development of an electronic system for handling the power distribution, power quality checks, theft control, automatic meter reading and bill compilation and e-accounts (Electronic Accounts) of the consumers to easily manage billing.

6. Reference Style Followed:

The reference style being followed in the selected research paper is **Vancouver Referencing Style**.

Vancouver Reference Style:

Vancouver Reference Style, also known as author-number referencing, is used to provide a referencing system where a number is used in text and a complete reference is provided at the end in the reference list using the same number which was mentioned in the in-text citation.

7. Selected Research Paper's References in Different Styles:

The Selected Research Paper's references are provided in different reference styles as follows:

MLA Referencing Style:

Journals:

- C. Jägerlind. *Improvements for the automatic meter reading process in electricity distribution companies.* 2006. Master's Thesis Royal Institute of Technology, Stockholm, Sweden Dep. Industrial Info and Control Systems.
- Abdollahi, M. Dehghani, and N. Zamanzadeh. *SMS-based reconfigurable automatic meter reading system.* Oct 2007, pp. 1103 – 1107. IEEE International Conference on Control Applications (CCA 2007).

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APA Referencing Style:

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Harvard Referencing Style:

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Chicago Referencing Style:

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