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Wireless Design for Power Theft Monitoring

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***Abstract*— Aiming at the disadvantage of current anti-theft technology, a novel smart grid based wireless power theft monitoring system is proposed in this paper. The system consists of multiple smart wireless transformer sensor node, smart controlling station, smart transmission line sensor node, and smart wireless consumer sensor node. The proposed software module also incorporates different data aggregation algorithms needed for the different pathways of the electricity distribution system. This design incorporates effective solutions for problems faced by India's electricity distribution system such as power theft, and transmission line fault. The proposed architecture is designed for single phase electricity distribution system, and this design can be implemented for three phase system of electricity distribution with minor modifications.**

***Index Terms*— smart grid, wireless sensor networks, single phase system, three phase system.**

I. INTRODUCTION

Many developing countries confront widespread theft of electricity from government owned power utilities. In India electricity theft leads to annual losses estimated at US$4.5 billion, about 1.5 percent of GDP. Who are the losers? Honest consumers, poor people, and those without connections, who bear the burden of high tariffs, system inefficiencies, and inadequate and unreliable power supply. Line faults may be caused due to over current or earth fault. If there happens to be a connection between two phase lines then over current fault occurs. Earth fault occurs due to the earthing of phase line through cross arm or any other way. Now in India, there is not any technique to detect the specific location of the fault immediately. Power theft is another major problem faced by Indian electrical system.

These two problems can be solved effectively through this architecture. By the proposed architecture the above mentioned problems can be solved.

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II. THE PROPOSED ARCHITECTURE

The whole system architecture is based on integrating wireless network with existing electrical grid. The architecture consists of four modules namely, Controlling Station (CS), Wireless Transformer Sensor Node (WTSN), Transmission Line Sensor Node (TLSN), Wireless Consumer Sensor Node (WCSN). The proposed architecture is shown in Figure1.

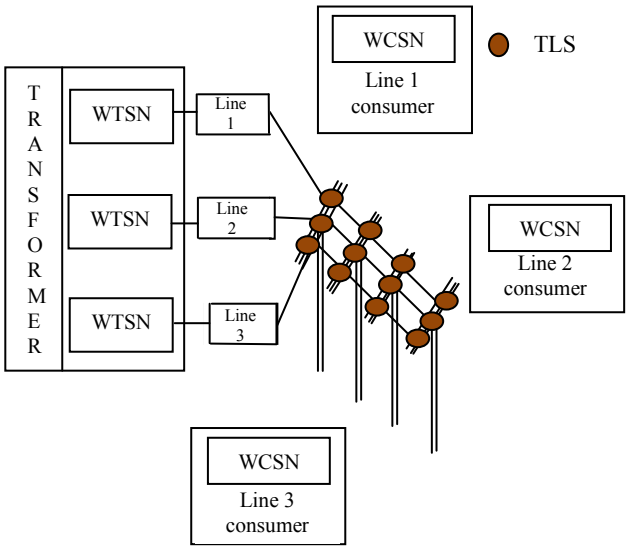

Figure 1. Proposed Architecture

WCSN is a consumer power metering device that measures the power consumed by the consumer and send the data periodically to the WTSN. Each feeder of the transformer has a WTSN which monitors power through each line and collects data from WCSN aggregate it and send to the CS. TLSN is another module associated with distribution line, mounted in each distribution line posts [1].

III. BLOCK DIAGRAM

A. Block diagram description

1) Zigbee:

We are using XBee-PRO OEM RF Module. It is engineered to meet IEEE 802.15.4 standards and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between devices. The modules operate within the ISM 2.4 GHz frequency band and are pin-for-pin compatible with each other. The XBee-PRO OEM RF Modules interface to a host device through a logic-level asynchronous serial port.

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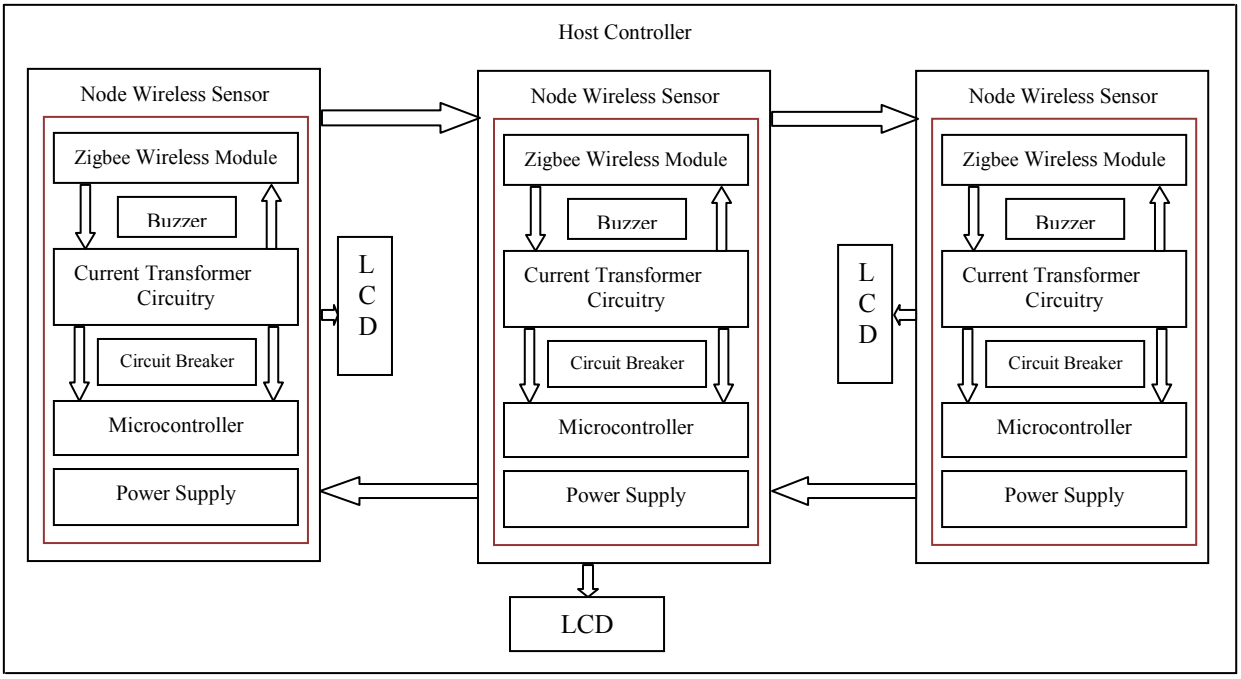

Figure 2. Block diagram of Power theft monitoring system

Through its serial port, the module can communicate with any logic and voltage compatible UART; or through a level translator to any serial device.

2) *Current Transformer Circuitry:* We are using Allegro ACS709 current sensor IC. The ACS709 consists of a precision linear Hall sensor integrated circuit with a copper conduction path located near the surface of the silicon die. Applied current flows through the copper conduction path, and the analog output voltage from the Hall sensor IC linearly tracks the magnetic field generated by the applied current. The accuracy of the ACS709 is maximized with this patented packaging configuration because the Hall element is situated in extremely close proximity to the current to be measured.

3) *Microcontroller:* The LPC2148 microcontroller is based on a16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support that combine the microcontroller with embedded high-speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty. Due to their tiny size and low power consumption, LPC2148 is ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale. Serial communications interfaces ranging from a USB 2.0 Full-speed device, multiple UARTs, SPI, SSP to I2C-bus and on-chip SRAM of 8 kB up to 40 kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power.

4) *LCD:* LCD stands for Liquid Crystal Display. As the output of our circuit should be displayed in some form or the other, so we have selected LCD display as it can display 16 characters at a time. It is also easy to interface with the microcontroller without any decoder. So it is better than the seven segment display.

IV. ALGORITHM

- System powered on
- System initializing
- Slave Zigbee acknowledges to master addressing.
- Master microcontroller (attached to master zigbee) compares the power consumption from all slave zigbee to that of itself.
- Node microcontroller plus zigbee compares power consumption downstream its position.
- If the comparison in last step (5th) is equal, that sector is OK.
- If the comparison in last step (5th) is unequal, i.e. response from all consumers zigbee is less than power being provided; sensor/zigbee at that node will transmit a theft signal to its master along with difference.
- Master node will compare the power consumption from all its slave nodes & last consumer.
- If the comparison in the 8th step the shortage is equal to the shortages from all slave nodes (under the authority of that master node), then consumers directly consuming from that master node is not stealing electricity. That sector is ok.
- If the comparison in the 8th step the shortage of master node is more than that of all slaves node under its authority, then the consumer under its direct controller is also involves in theft.

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- All areas can be scanned & red alert of theft can be transmitted to the master zigbee along with the information of sectors where power loss is occurring whether due to theft or other means.

V. WORKING OF WIRELESS SENSOR NETWORK

The sensor network monitors the electrical grid for a specified period of time, which may be daily, monthly or yearly. Thus the WTSN stores the maximum demand for each consumer including the losses. This value is updated only when a new consumer becomes the part of the network [7]. The measured data from each WCSN is send to the neighboring TLSN. The aggregated data is then sent to the next nearby WLSN. Thus the data transfers from WCSN to the corresponding WTSN through TLSN. The collected data is compared with the measured data by the energy meter plus DL*l* in each TLSN. Normally these two data are almost same. If there is any difference (dmc) in the collected data and the measured data, there may be a line fault or a power theft in that segment. Large value of dmc indicates a line fault and small value of dmc indicate a power theft.

VI. ADVANTAGES AND LIMITATIONS

The advantages are:

- The proposed system provides the solution for some of the main problems faced by the existing Indian grid system, such as wastage of energy, power theft, manual billing system, and transmission line fault.
- This method will reduce the energy wastage and save a lot of energy for future use.
- We can detect the location from where the power is being stolen which was not possible before.
- Optimized use of energy.
- Real time theft monitoring
- Currently used energy meters can be modified into this sensor, so no need to replace currently used energy meters.

The limitations are:

- One major disadvantage of this project is that it is not capable of detecting the exact location from where the power is being stolen.
- Cannot determine who is stealing, but no any other existing system is capable.
- If implemented on a large scale it may take a lot of time and manual input.

VII. RECENT TRENDS AND DEVELOPMENTS

The National Electricity Policy aims at laying guidelines for accelerated development of the power sector, providing supply of electricity to all areas and protecting interests of consumers and other stakeholders keeping in view availability of energy resources, technology available to exploit these resources, economics of generation using different resources, and energy security issues.

The National Electricity Policy aims at achieving the following objectives:

- Access to Electricity – Available for all households in next five years
- Availability of Power – Demand to be fully met by 2012. Energy and peaking shortages to be overcome and adequate spinning reserve to be available.
- Supply of Reliable and Quality Power of specified standards in an efficient manner and at reasonable rates.
- Per capita availability of electricity to be increased to over 1000 units by 2012.
- Minimum lifeline consumption of 1 unit/household/day as a merit good by year 2012.
- Financial Turnaround and Commercial Viability of Electricity Sector.
- Protection of consumers' interests [4].

Stiff penalties for the offence under section 135 of EA2003 are provisioned The Act describes electricity theft as - "Whoever, dishonestly,-

a) taps, makes or causes to be made any connection with overhead, underground or under water lines or cables, or service wires, or service facilities of a licensee; or

b) tampers a meter, installs or uses a tampered meter, current reversing transformer, loop connection or any other device or method which interferes with accurate or proper registration, calibration or metering of electric current or otherwise results in a manner whereby electricity is stolen or wasted.

c) damages or destroys an electric meter, apparatus, equipment, or wire or causes or allows any of them to be so damaged or destroyed as to interfere with the proper or accurate metering of electricity, so as to abstract or consume or use electricity shall be punishable with imprisonment for a term which may extend to three years or with fine or with both".

Like western countries, India has also treated this as a criminal offence. However due to difference in electricity theft and other commodity theft that you cannot find it physically after it is stolen makes its detention more difficult. There are certain loop holes still in the establishment of theft that the power thieves are not being booked the way they should have booked. Most of the places the theft is done with connivance of the licensee's employees which further makes it difficult to book the actual culprit [5].

VIII. FUTURE SCOPE

In future, this project can be implemented and validated in remote areas. Future enhancements can be incorporated to suit the system for three phase electric distribution system in India. Along with all this new architectural components can be incorporated, so that the system can be completely used for optimizing the energy consumption. This method will reduce the energy wastage and save a lot of energy for future use. GSM module can also be used in place of Zigbee module.

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IX. RESULT

Power theft can be calculated by using the following formula:

Difference (dmc) = collected data – measured data

Where, collected data is the data stored in the WTSN and measured data is the data transmitted by the WCSN.
If difference is negligible then there is no power theft otherwise there is a power theft.

X. CONCLUSION

This paper is aimed at reducing the heavy power and revenue losses that occur due to power theft by the customers. By this design it can be concluded that power theft can be effectively curbed by detecting where the power theft occurs and informing the authorities. Also an automatic circuit breaker may be integrated to the unit so as to remotely cut off the power supply to the house or consumer who tries to indulge in power theft. The ability of the proposed system to inform or send data digitally to a remote station using wireless radio link adds a large amount of possibilities to the way the power supply is controlled by the electricity board. The system design mainly concentrates on single phase electric distribution system, especially. The proposed system provides the solution for some of the main problems faced by the existing Indian grid system, such as wastage of energy, power theft, and transmission line fault.

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