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WIRELESS PROTECTIVE RELAYING SCHEME FOR SMART GRID PROTECTION

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ABSTRACT

Integration of Distributed Energy Sources (DESs) with traditional grid besides having many technical advantages, poses technical challenges to power engineers. Bidirectional power flow, dynamic fault currents are the few challenges. The relay settings need to be made adaptive to dynamic fault current levels of power system with DESs. Intelligent Electronic Devices (IEDs) can effectively be deployed to ensure the adaptive operation of relays. The state of operation of distributed energy sources are essential information to be communicated to IEDs to make relaying adaptive. The information and communication technology (ICT) plays a major role in acquiring and communicating the data pertaining to the operating conditions of DES s.This paper proposes a ZigBee based method to transmit the current or voltage values measured at various sections of power system wirelessly.The processor deployed in the control centrereceives and process the received data. Thesuitable command for tripping of circuit breaker in case of any abnormal conditions may be triggered by the processor.

Keywords: smart grid protection, wireless relaying, numeric relaying, adaptive protection.

1. INTRODUCTION

The restructuring of power systems around the world opens up the avenues for Independent Power Producers (IPPs). The reliability of power systems where the peak power demand is more than the generationwill be enhanced with the addition of distributed generation (Xi Fang*et al* 2012). Rapid growth in the renewable energy sources such as solar PV, wind, fuel cells enhances the technical viability for distributed energy sources to produce electric power. The penetration of distributed energy sources in to the power system requires suitable change in the operation and protection schemes (Eissa 2012). The intermittent nature of energy output from the distributed energy sources due to the climatic conditions and other factors,the short circuit fault levels of the system will not be constant.The dynamic fault levels during grid connected and islanded mode of power system requires adaptive protection schemes (Huimin Li *et al* 2011). The Bi-directional power flow during grid connected and islanded operating modes are the other protection issues in the smart grid environment (Eissa *et al*2012). The information about operating modes and generation levels of DES s present in the power systemneed to be communicated to the control centre. The data communicated to the control centre will be used to differentiate between operating modes, find the fault levels and subsequently fix the programmable relay setting (Roduan H khan *et al* 2013). Wireless communication is been successfully used for differential protection for transmission lines (Zhenghao Zhang *etal* 2013). This paper proposes anInformation and Communication system using ZigBee for transmitting data from various sections of power system to the control centre.

2. PROPOSED METHOD

The block diagram of the proposed communication system is shown in Figure-1. The proposed method is demonstrated by measuring the voltage values at two sections of power system shown as Line 1 and Line 2. The measured voltages are communicated through XBEE.

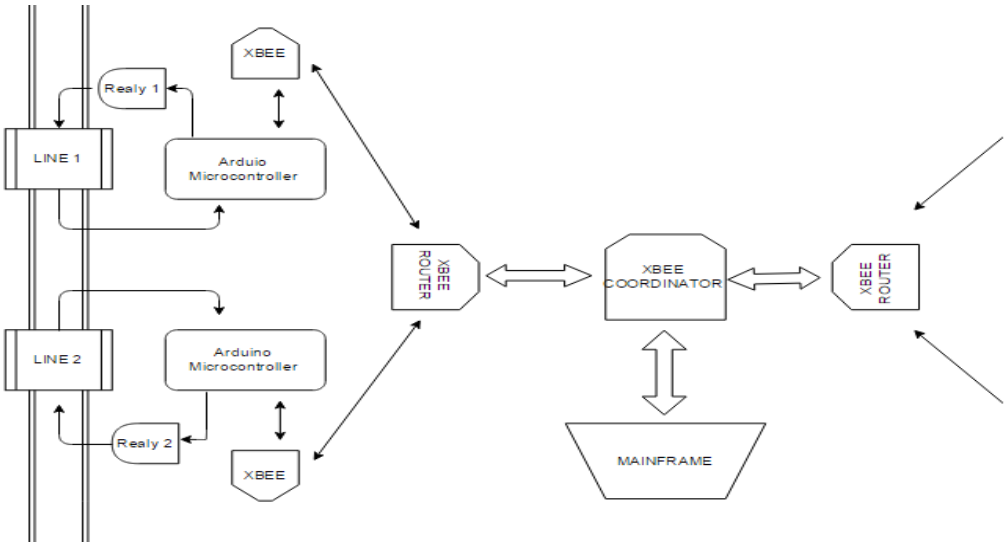

Figure-1. Block diagram of proposed method.

2.1 Zigbee module

Zigbee is a wireless technology developed as a packet based radio- protocol intended for low cost, battery operated devices. The Zigbee standard operates on the IEEE 802.15.4 physical radio specifications and operates in unlicensed bands including 2.4GHz, 900MHz and 868MHz. The protocol allows to devices to communicate in a variety of network topologies such as point to point or point to multipoint and can have battery life lasting several years due to its low duty cycle. Additionally it can support up to 65,0000 nodes per network, uses 128 bit AES encryption to ensure secure data connections and has low latency.A key component of the ZigBee protocol is the ability to support mesh networking. In a mesh network, nodes are interconnected with other nodes so that multiple pathways connect each node. Connections between nodes are dynamically updated and optimized through sophisticated, built-in mesh routing table.Mesh networks are decentralized in nature; each node is capable of self-discovery on the network. Also, as nodes leave the network, the mesh topology allows the nodes to reconfigure routing paths based on the new network structure.

3. DESIGN AND WORKING OF PROPOSED MODEL

The proposed method uses two fixed DC voltage sources connected to two variable resistances. These DC sources represent DESs of practical system. In an AC system instrument transformers along with rectifiers can be used to get proportional DC voltage or current. Microcontrollers and Xbee modules connected to the system facilitates the processing and exchange of real time information between the lines and the mains. The reason for using the microcontroller in addition to Xbee was the ability of the microcontroller to process AC signals and its ability to encrypt and send data in a desired format which the Xbee cannot achieve on its own. Attached to the microcontrollers are relays which would operate if the voltage fell below a particular threshold (indicating a short). During the testing of the system the variable resistance was changed to represent different modes of the distributed energy sources, such as normal operation, full generation and fault condition. The current flowing to the microcontroller through current transformers is converted to voltage through its inbuilt resistors. The microcontroller is programmed to calculate the AC voltage value based on the peak to peak value of the current flowing into its GPIO pins. If the voltage at one point is lower than the threshold a warning would be sent to the mains which then analyses the network and decides whether the relay needs to be tripped based on neighbouring voltage values and the present load on the system. In case of sudden sharp increases in load the system is designed to function independently and not wait for a response from the mains this is ensures that fault is limited to the second level of protection. Each node in the system has a unique id and sends unique values all of which are interpreted by the mains and processed accordingly.

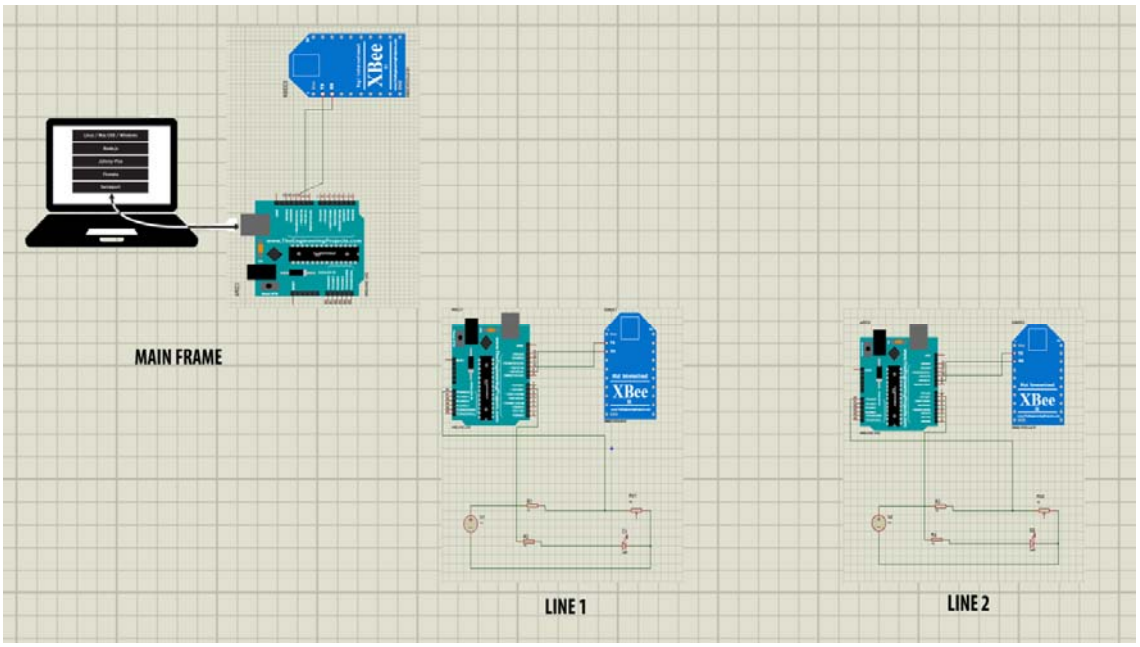

Figure-2. Schematic of the proposed method.

A single Xbee module possesses the range of a single line, this Xbee acts as in the End User Mode whose purpose is to send the sensory data. By placing another Xbee in the radius of the line it would act as a Router which would relay the sensory data from the entire the line to the Coordinator Xbee at the mains. The Coordinator Xbee can also request data from the End User devices through the Routers. This could be data regarding a single point within a distribution line or the whole line itself. This allows the bidirectional flow of data regarding system parameters allowing for the monitoring and control of the system thus making it closed loop in nature. If any node were to fail the it would not affect the data transmission from the other parts of the line due to self recovering nature of the Xbee mesh. The Xbees follow their own protocol and operate on a fixed band of radio frequencies. Not only the data the serial address of the Routers End-Users and the Coordinator Xbees have been programmed in accordance with each and all of them operate on a particular operating channel making the infiltration of the system through hacking or other means difficult. Also the entire system can be retrofitted into the existing system through the use of instrumentation transformers usually coupled to relays. These can supply power to the microcontroller and the Xbee module as well making the transition into real life applications much less cumbersome.

4. RESULTS AND CONCLUSIONS

The proposed method for transferring power system parameters wirelessly was tested with different voltage values which represents various operating states of power system. The processor was programmed in such a way that the trigger signal will be given if the difference between voltage values are above the pre fixed value. The same has been tested and found working satisfactorily. The wireless communication of power system data is a fundamental requirement for the operation,control and protection of power system with DESs. The wireless transmission can be used for transmitting the generation levels of DGs, current or voltage at a given time to check the fault condition etc. Hence the proposed method can be deployed in the actual power system to communicate the operating statuses of DGs to control center. The control center may use these data to perform adaptive relay setting depends on the status of the system. Figure.3 shows the actual hardware set up for wireless communication system.

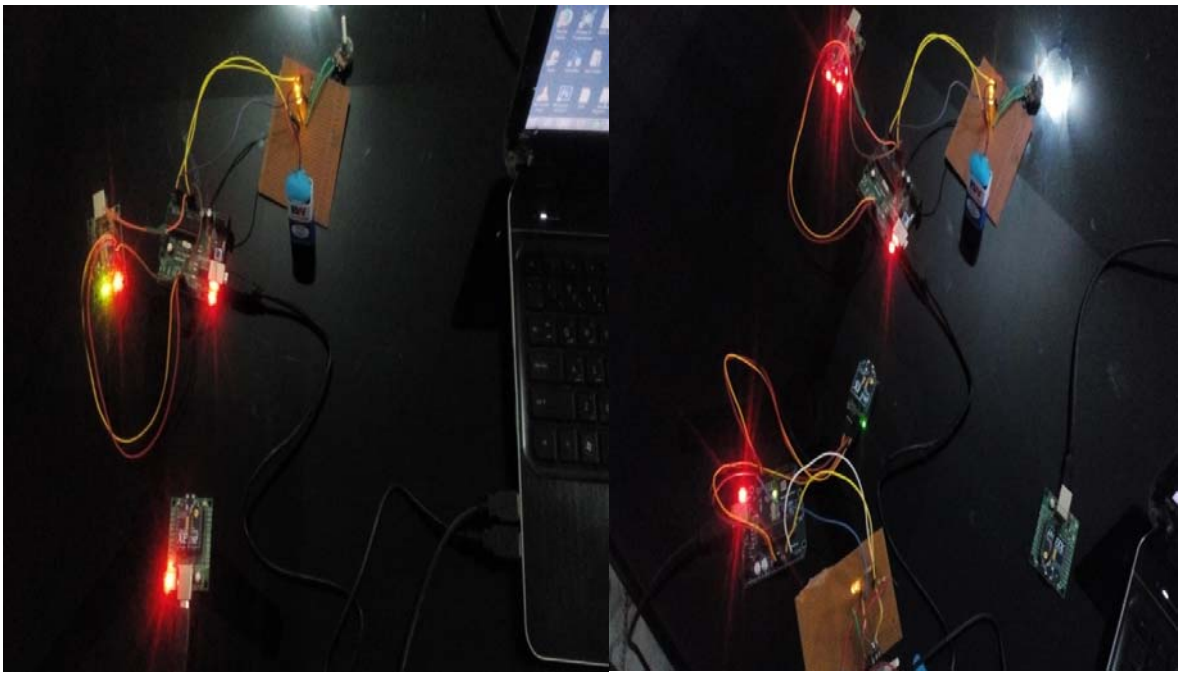

Figure-3. Hardware model of the wireless communication system.

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