A SCADA System For Next Generation Distribution System Using Zigbee Technology

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Abstract

This paper presents a new mode of transmitting and receiving the data for the future distribution system which can solve the problems caused by the connection of numerous distributed generators. The communication between Supervisory control and data acquisition(SCADA) and the substation or the generator is established through the Zigbee technology which is simple, less expensive and it has a long battery life. The SCADA system executes earth fault with the help of Zigbee technology within the required time. It can provide secured networking and has a defined data transmission speed of 250 kbps.

Key words: SCADA, ZigBee technology, Distributed generator, power system communication.

I. Introduction

A SCADA system using ZigBee technology for the future distribution system is proposed. This future distribution system is an Autonomous Demand Area Power System (ADAPS). The ADAPS is defined as the segment that includes the distribution system and the secondary system of power supply side. The ADAPS formation deals with the power flow congestion due to the interconnection of multiple distributed power sources and increased power demand in urban areas. It has two additional equipments while comparing with the existing distribution system. The additional equipments are loop power flow controller (LPC) and demand supply interface (DSIF).The loop power flow controller limits the short circuit current and its control unit changes its operating mode from LPC operation mode to continue power supplying mode when it receives the fault notification[1]-[10]. The demand supply interface monitors and controls a distributed generator and/or load device.

In order to maintain an "open system", a ZigBee Bridge has been developed, this device lets the operator connect to a third party Modbus Master via the ZigBee wireless network, devices using the Gateway, Bridge and other 4 Noks modules. The Zigbee device receives the data from substation and delivers it to the SCADA system through the sensor units. Those sensors may be various wireless, configurable and battery-operated detectors and control units. The temperature, lighting and humidity detectors - digital and analogue detector inputs - relay controller units - pulse, phase and hall-effect detectors. The requirements of the proposed SCADA system are:

• economic efficiency

• flexibility in terms of changing the system configuration or functions;

• operation in real time and reliability for protection.

It has been conceived for building automation, including such diverse items as control for lighting, air onditioning, smoke and fire alarms, and other security devices. The responsibilities of the ZigBee network layer include several mechanisms used to join and leave a network, and to route frames to their intended destinations. The routing may involve using multiple intermediate relay devices within the network. The discovery and maintenance of routes (there is no preset routing table) between devices devolves to the network layer. Also the discovery of one-hop neighbors and the storing of pertinent neighbor information are done at the network layer. The default routing in a Zigbee network is based on a tree-topology. This has the significant advantage that Routers do not have to maintain extensive tables but more importantly do not have to perform route discovery.

Conversely, the Zigbee device provides economical broadband communications, allowing the transmission of data dispatched by various applications. Specifically, we show how this SCADA system is capable of protecting against an earth fault on a distribution line, even though communication failure adversely affects the system communication. This paper is organized as follows.Section II illustrates the SCADA system for ADAPS, while Section III shows the circuit diagram and its description. The section IV shows the protection against earth fault and section V shows the simulated results during the earth fault in generator and in the substation. The conclusion of this project will be discussed in section VI. The block diagram is shown in fig.1. It shows the communication of data from the substation to the SCADA system. The controller is been provided to control the communication device[11]-[25].

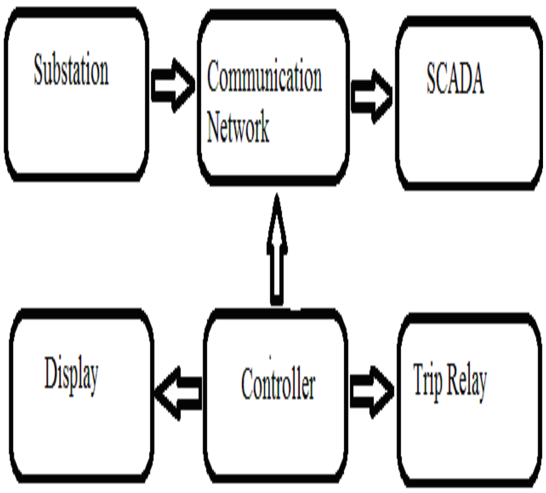

Fig.1. Block diagram of proposed SCADA system using ZigBee technology.

II.SCADA System for ADAPS

The SCADA system for the ADAPS consists of three basic elements namely control devices as hardware, mobile agents as software and ZigBee device as the communication network that transmits and receives the data between the hardware and software.

A.Conrol Devices

There are five types of control devices in the SCADA system, as follows.

• The main operation system (Main OpS) operates the entire ADAPS and determines the LPC settings and a tap position in the power transformer.

• The suboperation system (Sub OpS) monitors and controls a specific section and interacts with control devices in its section, the Main OpS, and other Sub OpSs.

• The control unit in the section switch measures the current and voltage at the section switch to which it is installed as well as opening and closing the section switch itself.

• The control unit in the LPC operates the LPC in which it is installed. In cases where this unit receives a fault notification, it switches the LPC operation mode to continue supplying power to a sound section.

• The DSIF monitors and controls a distributed generator and/or load device. In cases where it receives a fault notification from the Sub OpS, it disconnects all of the generators it controls.

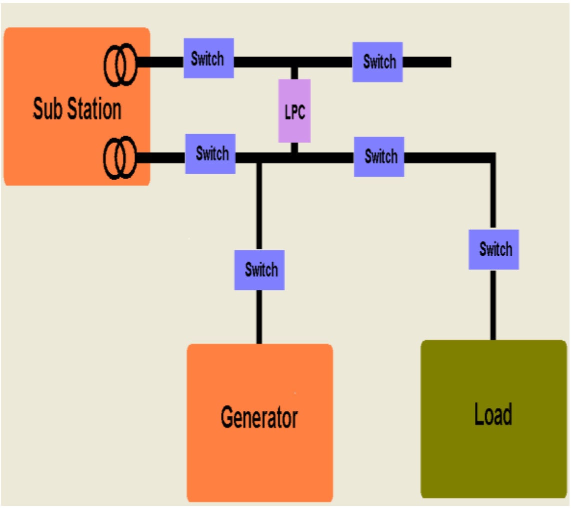

Fig.2. Control devices in the ADAPS.

B.Mobile Agents

The mobile agents are considered as the software part of the ADAPS. They are the measured values of current, voltage and frequency of the substation and generator. These values should be migrated from the substation to the SCADA system and similarly from the generator to the SCADA system where the decisions will be made depending on the preset values of the current, voltage and frequency. If there is no mismatch or if they did not exceed the set values, there will not be any change in the operation.

C.Communication Network

The communication between the substation and the SCADA system is established by the ethernet in the existing system and it is replaced by means of ZigBee technology in the proposed system. The ZigBee is a low power, simple and expensive device. It requires low data rate with long battery life. It can execute the earth fault within the required time period. The mobile agents can be transmitted effectively from the substation to the SCADA system without internet facility but it is mandatory in the case of existing system using ethernet.

III.CIRCUIT DIAGRAM AND ITS DESCRIPTION

The mobile agents of the substation are measured values of voltage, current and frequency. These values of all the substations are measured frequently with the required time interval. The substation in this circuit diagram is been modelled with the required parameters for simplification. Those values can be changed by using the up and down arrows of the component. The microcontroller receives all four parameters from both the generator and the substation. The frequency for the operation of controller will be generated by the crystal oscillator. The microcontroller operates at the frequency of 20 MHz.

The microcontroller is provided with the display which will update the actions taken by it. It also sends a trip signal to the trip relay through the NOT gate on the detection of fault notification. This relay operation will disconnect either the generator or the substation according to the measured values of voltage, current or frequency.

The ZigBee technology is used here for transmitting and receiving the data and is connected to the substation through the communication port of the controller. The port number 4 is used here for the communication port. Through this port only all the data will be transferred with the specified data rate of 9600.

This communication device sends the data to the SCADA system which makes the decision by comparing the preset values of mobile agents and the measured values. If there is any mismatch in the measured and the set values, a trip signal will be sent to the trip relay which will disconnect the device as soon as possible for the security purpose.

The SCADA system has the facility of providing warning message and it is updated in fraction of seconds. So each and every change can be noticed using the SCADA system. It also has a data log which is capable of storing the last five records of data of every simulation of fault. The system can show the variation of voltage, current or frequency with the graph. The substation and the generator parameters can be verified with the graph by appropriate selection.

After the neighbouring sections prepared to continually supply power, the Sub OpS directed that the section switches be opened and the generators disconnected. The mobile agents performed all processing and communications other than those between the Sub OpS and the section switches. The protection was completed when the section switches were opened and the generators disconnected. Finally, the mobile agent migrated to the Main OpS to indicate the completion of protection.

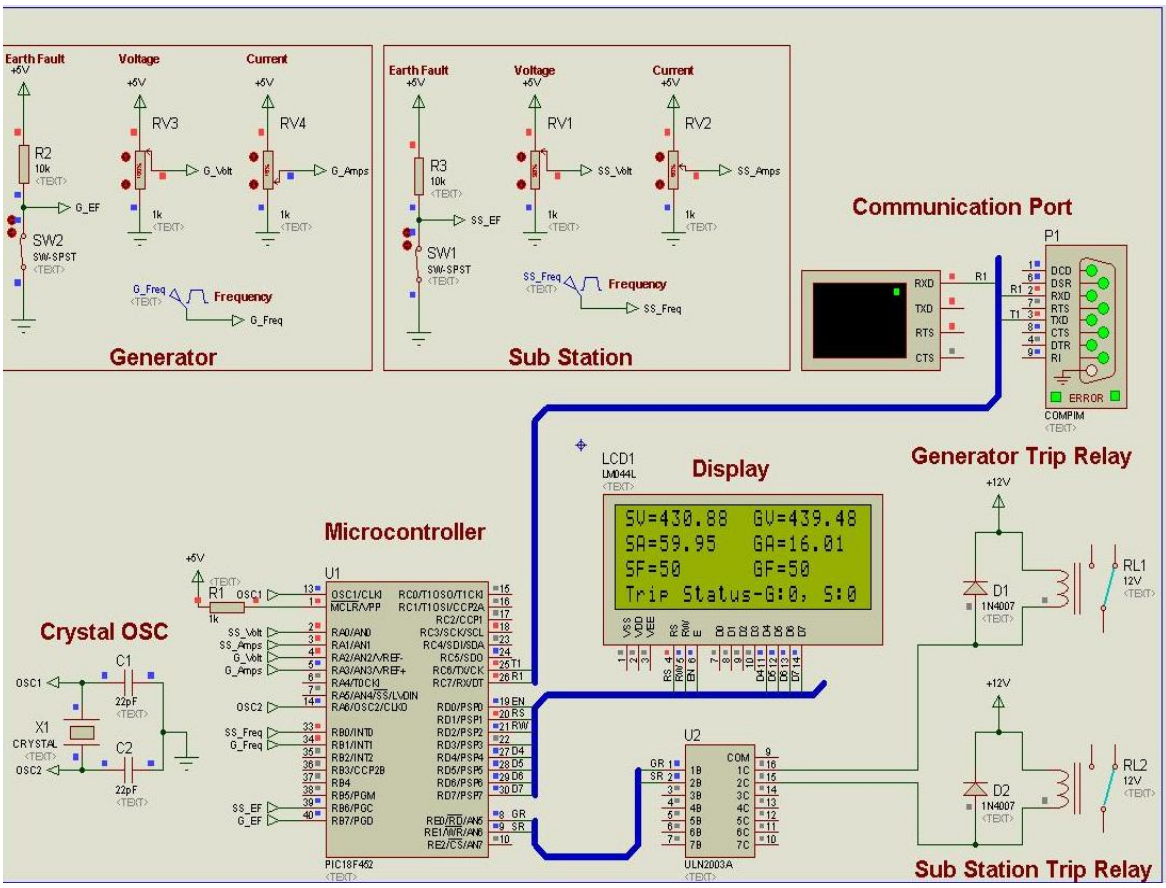

Fig.3. Circuit diagram of proposed SCADA system using ZigBee technology.

A.SCADA System Display

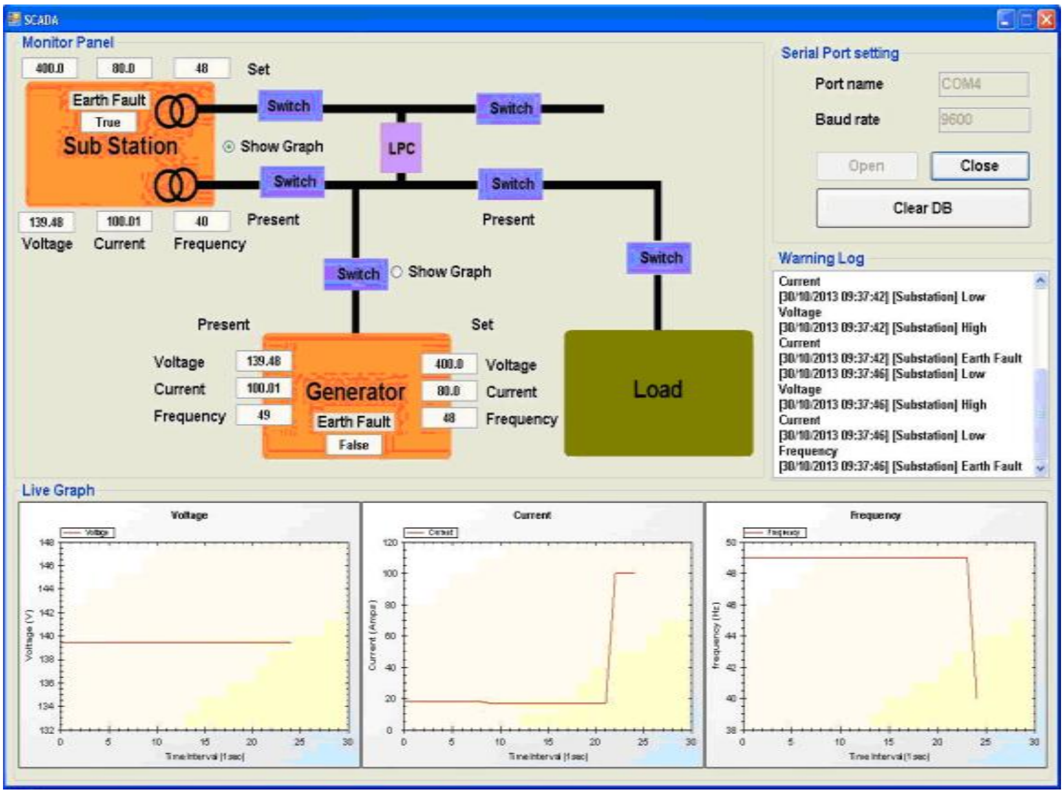

Fig.4. SCADA system display

The general SCADA system display is shown in fig.4. The variation in the parameters like voltage, current and frequency will be displayed with the help of graph for each and every parameter separately. It has a data log block which can store the last five records. It also has a warning log block which will display the current position of substation or generator.

B.SCADA System Configuration

The SCADA system in the experimental system comprised a Sub OpS in each section, a DSIF in section 2, and a Main OpS in the substation, respectively. The section switches have sensors and a processing unit. The processing unit did not support Java. Hence, communication between the section switch and Sub OpS was established through a TCP connection. The data transmission is accomplished with the help of Zigbee instead of Ethernet. The communication between the substation and the SCADA system is established by the ethernet in the existing system and it is replaced by means of ZigBee technology in the proposed system. The ZigBee is a low power, simple and expensive device . It requires low data rate with long battery life. It can execute the earth fault within the required time period. The baud rate of this device is 9600 b/Sec.

IV.Protection Against Earth Fault

The real-time performance and reliability of the SCADA system can be calculated from the action taken by it during the clearance of the earth fault and how fast it works. It can be done using a system which is protected against an earth fault on a distribution line. The earth fault protection is the function with the shortest period provided in the SCADA system, because a short circuit will only be protected by local sensing data. It must also be completed within very short period. In addition, processing time of the SCADA system in cases where a communication failure occurred has to be considered simultaneously. The section switch judged that a fault had occurred on the distribution line when the following two conditions were met. The first was zero-phase-sequence voltage exceeding 10 V for 50 ms. The second consisted of the products of the zero-phase sequence current and zero-phase sequence voltage exceeding 5 VA for 50 ms.

The section switches notified the Sub OpS in section 2 that they had detected a fault, when one was detected. The Sub OpS judged whether the fault had occurred in section 2 or outside. In the former case, mobile agents migrated to the Sub OpSs in the neighbouring sections to change their operational mode and continue power supply. The Sub OpSs in the neighbouring sections then called for a mode change of the LPC, which was processed by a mobile agent that simulated migration to the LPC.

The agents migrated back to the Sub OpS in section 2 after the LPC had changed its mode. In experiments involving communication failure, the fault interrupted the agent migration from the Sub OpS in section 2 to that in section 1.We measured two types of time for the protection. One was the time from an earth fault to the section switch open status, while the other was to generator disconnection.

After the neighbouring sections prepared to continually supply power, the Sub OpS directed that the section switches be opened and the generators disconnected. The mobile agents performed all processing and communications other than those between the Sub OpS and the section switches. The protection was completed when the section switches were opened and the generators disconnected. Finally, the mobile agent migrated to the Main OpS to indicate the completion of protection.

V.Results

A.Disconnection of Generator During Earth Fault

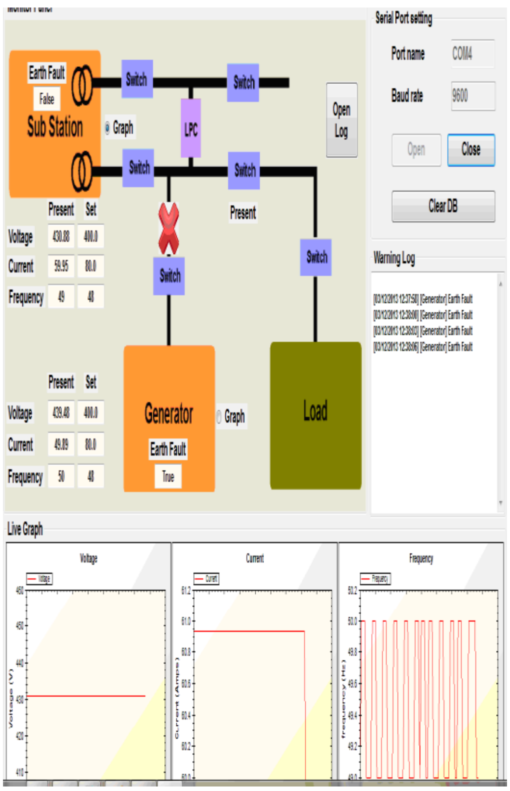

Fig.5. Simulated earth fault in the generator

If the zero phase voltage or current exceeds the pre set value then the earth fault is said to be occurred. When the earth fault is been noticed, the mobile agents sent to the SCADA system will not match with the preset values. So the generator will be disconnected from the system as soon as possible as shown in fig 5. There will not be any change in the power flow through other devices.

In the display both the presently measured values and the set values will be displayed for verification. The voltage, frequency and current values would be updated for every second. As soon as it is disconnected, all the section switches connected to this device would be disconnected.

B. Disconnection of Substation During Earth Fault

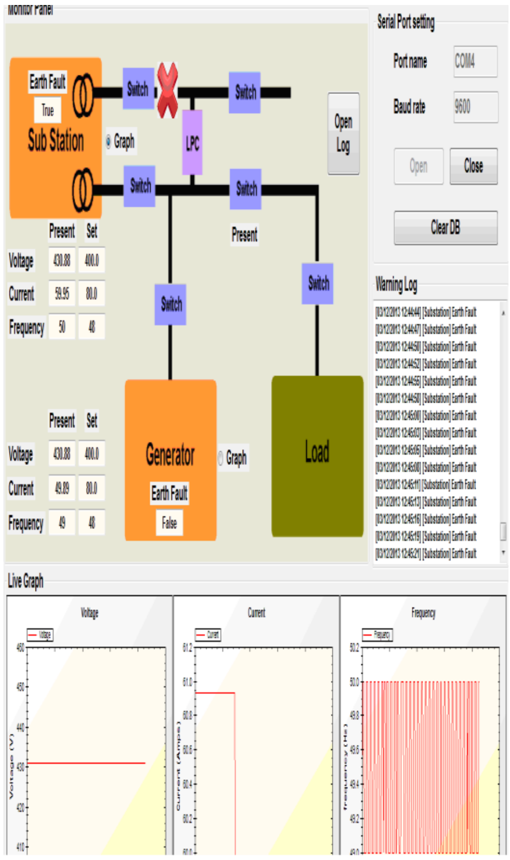

Fig.6. Simulated earth fault in the substation

When the earth fault is been occurred, the mobile agents sent to the SCADA system will not match with the preset values. So the substation will be disconnected from the system as soon as possible. The simulated earth fault in the substation is shown in fig 6.

VI.Conclusion

This project proposes a SCADA system for the ADAPS using mobile agents and a ZigBee device. It could be made economical and flexible due to the characteristics of these two technologies. The corresponding generator would be disconnected under fault notification in a very short duration. So that the nearby generators could be prevented before they get affected. In addition, the agents can be migrated based on the three priorities, and communication congestion would be avoided. It is capable of establishing an alternative route in case of communication failure. The system can complete the earth fault protection within the required time (1 s).

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