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Real Time Monitoring of Power Line Using Smart Grid Based Sensors and ZigBee Wireless Communication Protocol

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ABSTRACT: Smart grid the next generation electric power system is effective way of digital transmission of electricity. It is a digital technology that allows efficient two way communications between utility and customers. We provide a system model that will monitor critical parameters such as current, voltage, power and temperature. A smart grid uses digital technology to improve reliability, security, and efficiency of the electric system. We design a system to improve the power quality and reliability of power supply. Using smart grid based sensors like current, voltage and temperature sensor along with ZigBee wireless communication protocol real time monitoring of power line parameters like voltage, current, temperature etc. can be carried out. These sensors enable the remote monitoring of equipment such as transformers and power lines. They are improving the performance and extending the life of grid components to ensure a safe and reliable operation of the electricity network. Use of ZigBee based communication protocol make system more reliable. By using this system for power line, predetermination of certain increase of current, voltage, power or temperature the damage in the grid will be avoided. This paper discussed architecture and different design aspects for implementation of smart grid based monitoring network using smart sensors.

KEYWORDS: Power line, ZigBee, Real time monitoring, Smart grid sensors, Reliability, Security

I.INTRODUCTION

A smart grid is an electrical grid that uses computer and other information technologies to gather and act in an automated fashion to improve system's reliability and efficiency. The term smart grid was coined in 2005 [1]. Transmission line monitoring is very important aspects for reliable transmission of electricity. This system used sensors for particular monitoring that means temperature or current or voltage monitoring. The sensors module is used to measure the electrical parameters of transmission line. The parameter values such as temperature, potential and current values are monitored using the temperature sensors, potential sensor, and current sensor respectively. The features of the system are it allows us to view all the parameter readings simultaneously on the screen and also allows us to maintain a data-base of the changes encountered in the parameter. The use of smart sensor makes system more efficient and reliable. ZigBee is wireless parallel communication protocol which transmits data related to parameter information over long distance. The main aim of the research is to develop a system for real time monitoring of power line parameters like voltage, current, temperature and power using ZigBee wireless communication protocol. ZigBee is wireless Parallel communication protocol which transmits data related to parameter information over long distance. ZigBee has some technical advantages over Bluetooth, WiFi, infrared rays etc. ZigBee is a kind of low power-consuming communication technology for coverage area surrounded by 200m, with a data rate ranging from 20Kbps to 250Kbps, it is appropriate for use in home area networks, mainly for the remote control of electric home appliances[2]. The use of Microcontroller to make build complete Microprocessor system that reduces system cost. The system utilizes wireless power monitoring devices and control units. The electronic wireless sensors have used to monitor electrical parameters such as voltage, current and power of the household appliances. The measured electrical parameters are transmitted to a central controller via the ZigBee node. Thus this paper presents system model for

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provided solution to avoid power loss in case of any of the parameter like voltage, current and temperature is above normal value, then the grid will automatically switched to off position.

II. LITERATURE SURVEY

Monitoring and control of smart grids is essential for its efficient and effective functioning. For this propose an author carried out detailed survey from last past decades. He discussed comparative analysis of different wireless technologies for System Set-Up. Author gives more emphasis on current research work carried out in the field of power line monitoring by review of latest research papers. Projects like Smart grids utilizing wireless sensor network technologies are being promoted by US government as a way of addressing energy independence, global warming and emergency resilience issues. A report on revenue for Smart Grid from sales of smart grid sensing, monitoring, control systems and related Software sold to the worldwide smart grid sector are $6.3 billion by 2014 and double to $13 billion by 2018. Software for home area network applications will bring revenue five times greater than $1.1 billion by 2014. While home energy monitoring has been popular in the past, subsidized smart meter deployments will make it cost effective. Wired sensor networks have already been reached and Deployed in many applications over a decade; because of the wireless extension, smart grids have witnessed a tremendous upsurge in interest and activities in recent years. New technologies include cutting-edge advancements in information technology, sensors, metering, transmission, distribution, and Electricity storage technology, as well as providing new information and flexibility to both consumers and providers of electricity. The ZigBee Alliance, the wireless communication platform is presently examining Japan's new smart home wireless system implication by having a new initiative with Japan's Government that will evaluate use of the forthcoming ZigBee Internet Protocol (IP) specification and the IEEE 802.15.4g standard to help Japan create smart homes that improve energy management and efficiency. It is expected that 65 million households will equip with smart meters by 2015 and it is a realistic estimate of the size of the home energy management market. Smart Grid and wireless sensor networks provides an intelligent functions that advance interactions of agents such as telecommunication, control and optimization to achieve adaptability, self-healing, efficiency, cyber security and reliability of power systems while reducing the cost and providing efficient resource management and utilization. A wide range of smart meter research is being carried during the last decade. Various architectural design and development methods of smart grid utility system for effectively managing and controlling the household appliances for optimal energy harvesting have been presented [3].

Current Research Scenario:

Vast work is going on worldwide on real time monitoring of power line. Current research scenario in the field of power line monitoring is presented further.

Wired communication with dedicated data networks connecting the field devices is one possibility. Dedicated wired data networks can be designed to fulfill the requirements, but the installation costs do not permit an intensive use [6], reported. A less expensive option is wireless networks. Technologies for wireless local area networks or Personal Area Networks like IEEE 802.15.4 can, in principle, be used as a replacement for wired links [4, 5]., et al.,2012 have discussed architecture of "Monitoring and Controlling Power using ZigBee Communications." P.A. Abraham et.al, 2011 have reported a simple method to implement a wireless embedded system to continuously monitor the RMS current through the power line. A low data rate ZigBee (IEEE 802.15.4) based wireless transceiver is used for the wireless communication. One of the main implementation of wireless sensor network is monitoring equipment. Wireless sensor network are able for cost efficient monitoring over enormous geo location. Construction of smart grid is based on the internet of thing (IOT) is become research of interest.(Trupti Sudhakar Somkuwar et al., January 2015). Prof. Dr. Nabeel Kadim Abid Al-Sahib et al., 2014, have proposed design and implementation of internet based remote monitoring and controlling of power generation where the platform based on the design of an interface circuit with Arduino board, implemented by LabView software ALCS (Arduino-LabView Control System).The complete system can be controlled remotely where the remote control implemented by using a VSAT (Very Small Aperture Terminal system). They focused on monitoring of coolant temperature and calculate the Mean AbsolutePercentage Error (MAPE) of temperature between the Programming Logic Controller (PLC) reading that already install on power generation unit and the ALCS reading. Prof. Dr. Nabeel Kadim Abid Al-Sahib et al.,2014 have carried out some studies concerning to the controlling through internet or mobile phones in reference (Khathair, A.Y. et al.,2006) implemented two case studies to build web-based SCADA systems based on the client/server architecture. The first case study was

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concerned with controlling the water level of a network of dams. The second case study was issued for monitoring the network traffic on a set of VSAT modems and reference. Benazir Fateh et al., June 2013 have develop a real-time situational awareness framework for the electrical transmission power grid using Wireless Sensor Network (WSN). While WSNs are capable of cost efficient monitoring over vast geographical areas, several technical challenges exist. a hybrid hierarchical network architecture composed of a combination of wired, wireless and cellular technologies that can guarantee low cost real-time data monitoring. They formulate a placement problem to find the optimal location of cellular enabled transmission towers. Further, they present evaluation results of the optimization solution for diverse scenarios. Their formulation is generic and addresses real world scenarios with asymmetric sensor data generation, unreliable wireless link behavior, non-uniform cellular coverage, etc. Their analysis shows that a transmission line monitoring framework using WSN is indeed feasible using available technologies. Their results show that wireless link bandwidth can be a limiting factor for cost optimization. V Prasanth et al.,2015 proposes a smart HEMS architecture that considers both energy consumption and generation simultaneously. ZigBee-based energy measurement modules are used to monitor the energy consumption of home appliances and lights. A PLC-based renewable energy gateway is used to monitor the energy generation of renewable energies. The remote energy management server aggregates the energy data from numerous home servers, compares them, and creates useful statistical analysis information. By considering both energy consumption and generation, the proposed HEMS architecture is expected to optimize home energy use and result in home energy cost saving.

Research Gap Identified:

- Although wireless technology used for power line monitoring has been deployed for more than 30 years through the use of proprietary radios, over the last few decades many wireless technologies have been developed to deal with issues such as cost and network complexity.
- There is wide scope of research in Internet of thing (IOT). The use of this technology in overhead transmission lines can not only carry outline state monitoring, but also advance the perception of power transmission line.
- Still there is need to develop an efficient system to monitor power line parameters like voltage, current, temperature etc.
- Detection of power theft between poles and individual subscribers is still a issue to be efficiently resolved.
- Scope of work exists in Automatic Meter Reading (AMR) for electricity using power line communication.

Problem Formulation:

Problem formulation is done on following three points:

- ZigBee wireless technology is far superior to both Wi-Fi and Bluetooth in terms of energy conservation; therefore it was preferred for this project.
- If any of the parameter like voltage, current and temperature is above normal value, then the grid is automatically switched to off position by relaying action.
- Implement a wireless embedded system to continuously monitor power consumed by grid.

III. COMPARATIVE ANALYSIS OF DIFFERENT WIRELESS TECHNOLOGIES FOR SYSTEM SET-UP

Here comparison between the existing wireless technologies like Wi-Fi, WiMAX, Bluetooth and ZigBee is discussed. As author is used ZigBee communication protocol, he discussed how it is comparatively better technology as compare to existing wireless technologies. Table 1 shows comparison of Wireless Technologies.

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Table 1: Comparison of Wireless Technologies

Parameter	Bluetooth	Wi-Fi	Wi-Max	ZigBee
STANDARD	802.15	802.11a/b/g/n	802.16	802.15.4
DATA RATE	1 Mbps	11 & 54 Mbps	70-80 Mbps	up to 250 Kbps
OPERATING RANGE	10 meters	50-100 meters	up to 50 Kilometers	10-100 meters
POWER CONSUMPTION	Medium	High	High	Very Low
SECURITY	Yes	Yes	Yes	Yes
COMPLEXITY	Medium	High	Very High	Low
LATENCY	2.5ms	1.5ms	5-40ms	20ms
NETWORKING TOPOLOGY	Ad-hoc, very small networks	Peer-Peer or point to Hub	Mesh	Ad-hoc, star, Mesh, Peer-Peer
OPRATING FREQUENCY	2.4 GHz	2.4-5 GHz	2-6.6 GHz	2.4 GHz, 950 MHz, 868 MHz
APPLICATIONS	Used Handheld devices like PDAs,	Broadband Internet Access, WLAN	WMAN	Monitoring and control

IV. SYSTEM DESIGN

In this section author has been developed a system for real time monitoring of power line parameters like voltage, current, temperature and power using ZigBee wireless communication protocol.

The Hardware implementation divided into following sections:

- Microcontroller – PIC18F4520
- ZigBee – S1/S2 Series module
- Current Sensor
- Voltage Sensor
- 16x2 LCD Display
- Relay and driver IC ULN 2803

Figure 1 shows Block Diagram of Proposed Systems. The block design of power line monitoring for the Smart Grid consists of LCD displays, sensors, PIC microcontroller, ZigBee transceiver, LCD display, power supply unit and PC. ZigBee is wireless Parallel communication protocol which transmits data related to parameter information over long distance. The use of Microcontroller to make build complete Microprocessor system that reduces system cost. By using the ZigBee transceiver, information will be transferred to the co-ordination unit, when the value of various grid parameters exceeds the particular value above which break down will be occurred in the transmission line or grid. By the predetermination of certain increase of current, voltage, gas or temperature the damage in the grid will be avoided by using relay to perform switching action of grid.

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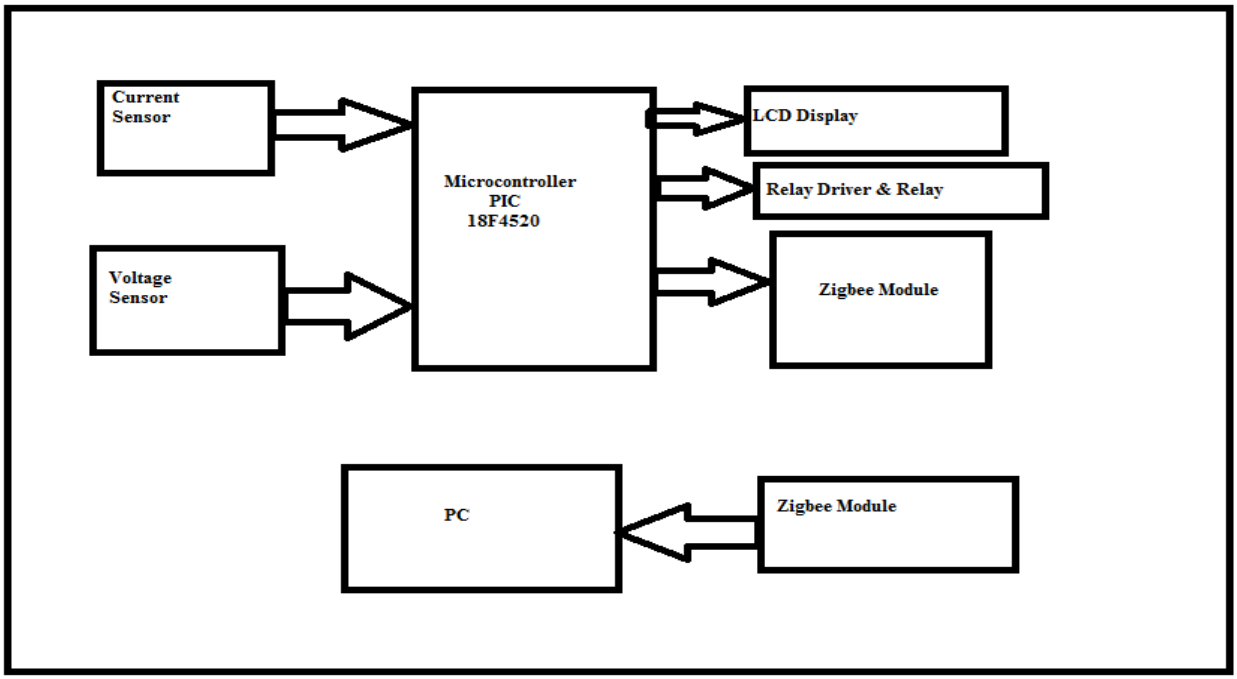

Fig.1 Block Diagram of Proposed Systems

Working Operation:

The sensors in the transmitter section consist of voltage sensor, current sensor and temperature sensor. The PIC 18F4520 the microcontroller senses the signal. As PIC 18F4520 has in built ADC, it converts the sensed parameter into Digital and used by the microcontroller unit for processing. The LCD display unit displays the values of voltage, current and temperature of the grid received by microcontroller unit. ZigBee receives the sensed data through RXD pin of RS-232 and the data is transmitted by transmitting antenna of ZigBee. In the receiver section, ZigBee module is used to receive the data from Transmitter. The received signal is feed on the Computer/Laptop and is viewed in the HyperTerminal mode in the computer/Laptop. The voltage, current, temperature and power of a transformer are monitored continuously using voltage, current and temperature sensor respectively. Here 230 V AC line voltage has been reduced to 9 V by using step down transformer and again it is regulated with IC 7805 regulator. Now output value of this regulator (5 V DC) is used as reference value for sensors used in the circuit. When the voltage or current or temperature is above the normal value, it indicates as High and if it is below the normal value it indicates Low on LCD display and on Computer as well using ZigBee. If any of the parameter like voltage, current and temperature is above normal value, then the grid is automatically switched to off position. The relay is used along with relay driver IC ULN 2803 for switching of grid. The parameter values such as temperature, potential and current values are monitored using the temperature sensors, potential sensor, and current sensor respectively.

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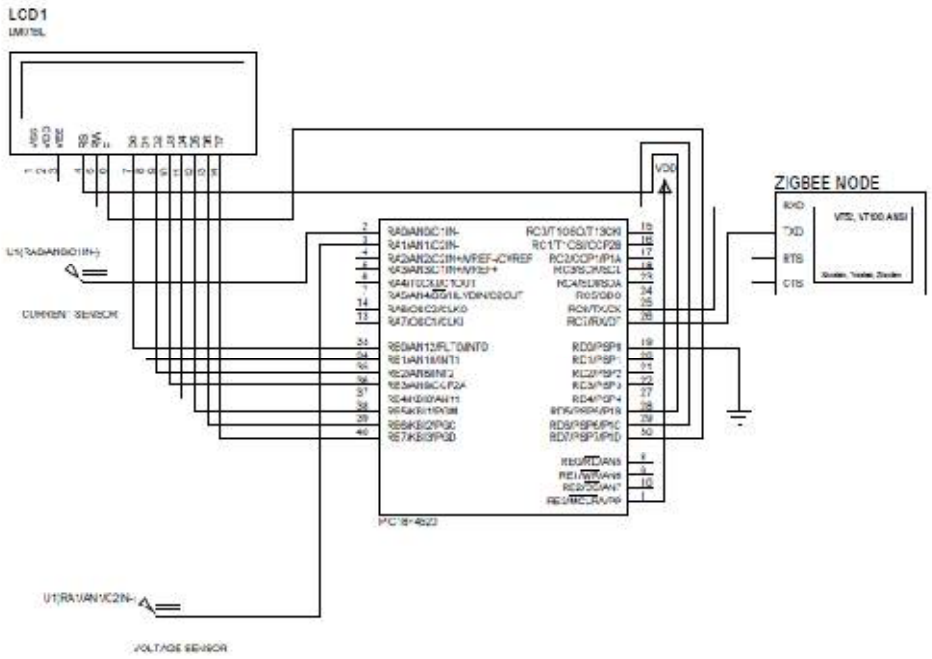

Fig. 2 Circuit Diagram of Proposed System

V. PERFORMANCE ANALYSIS

Software Used are as follows:

- MPLAB IDE
- Proteus Professional
- PCB 123

The MPLAB IDE is used for development of code used in Project. MPLAB is a proprietary freeware IDE for the development of embedded applications on PIC and PIC microcontrollers, and is developed by Microchip Technology. Here used of MPLAB Integrated Development Environment (IDE) for development of system application. The coding is done in the MPLAB. The **PROTUES** software for simulation results of proposed system. **PROTUES** combines advanced schematic capture, mixed mode SPICE simulation, PCB layout and auto routing to make a complete electronic design system. Figure 3 shows compilation using MPLAB IDE.

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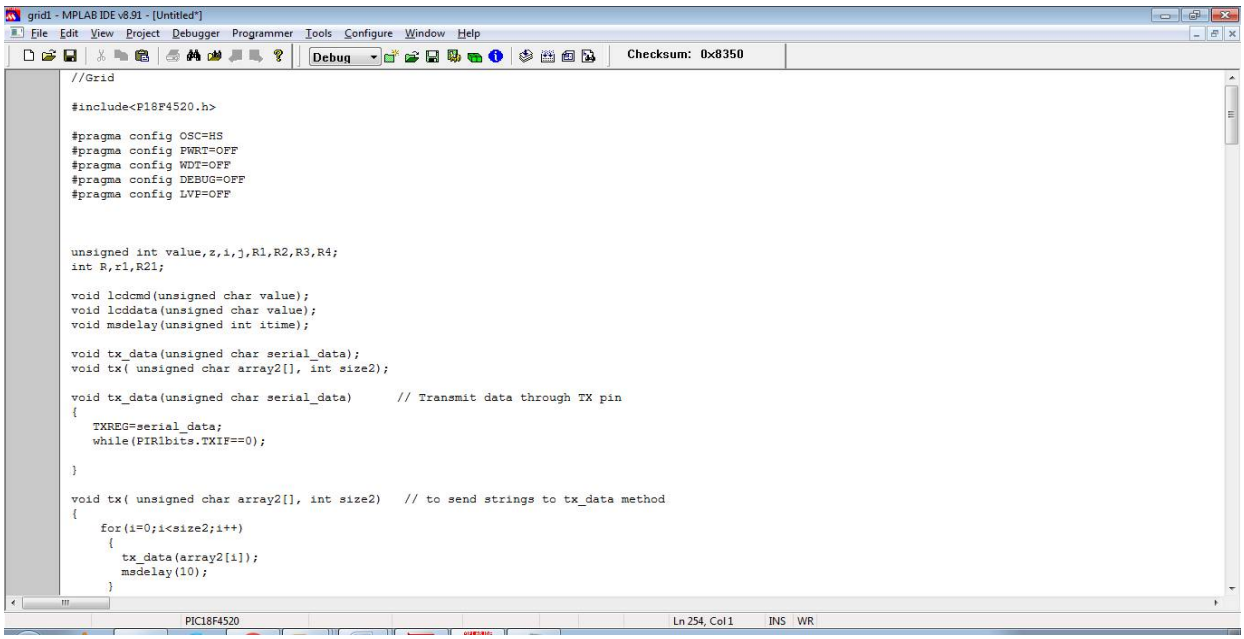

Fig.3 Pictorial view of MPLAB with application code.

The figure 4 represents simulation results of current and voltage using the **PROTUES software**. From the measured values of voltage and current the actual power consumed by the grid is easily obtained.

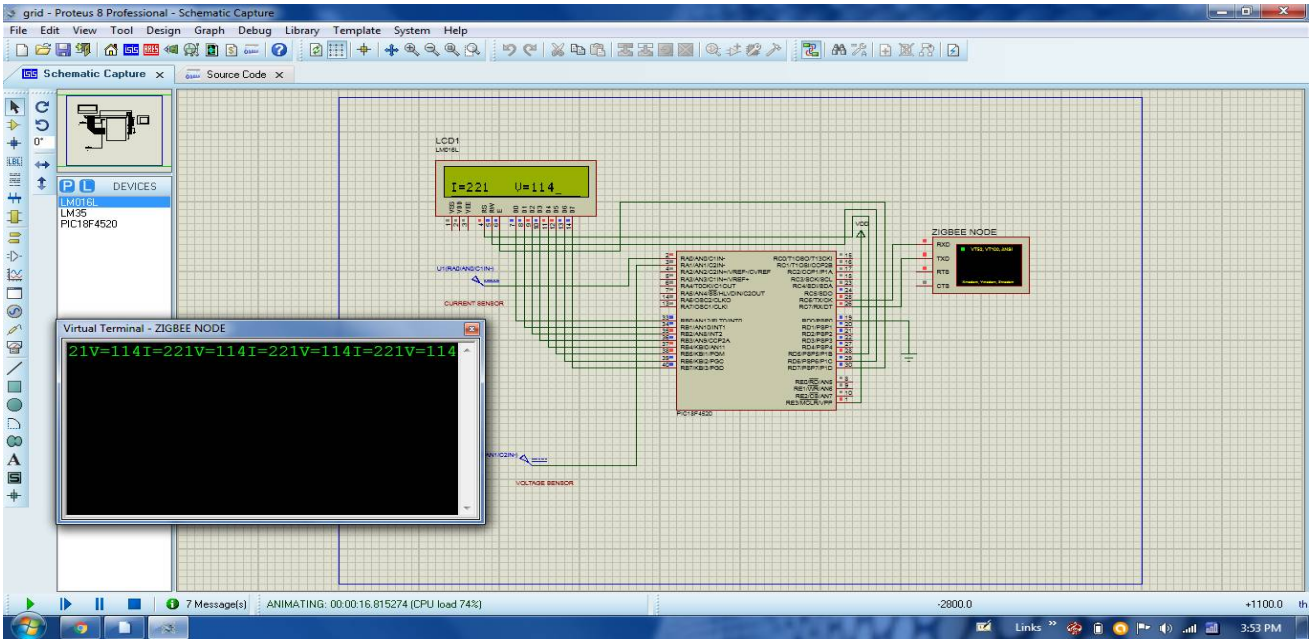

Fig. 4 Results of Current and Voltage

When the any of the parameter is above the normal value, it indicates **"Voltage Exceed/ Current Exceed**" with its value on LCD display depending on which parameter is exceeded above its normal value as shown in figure 5.

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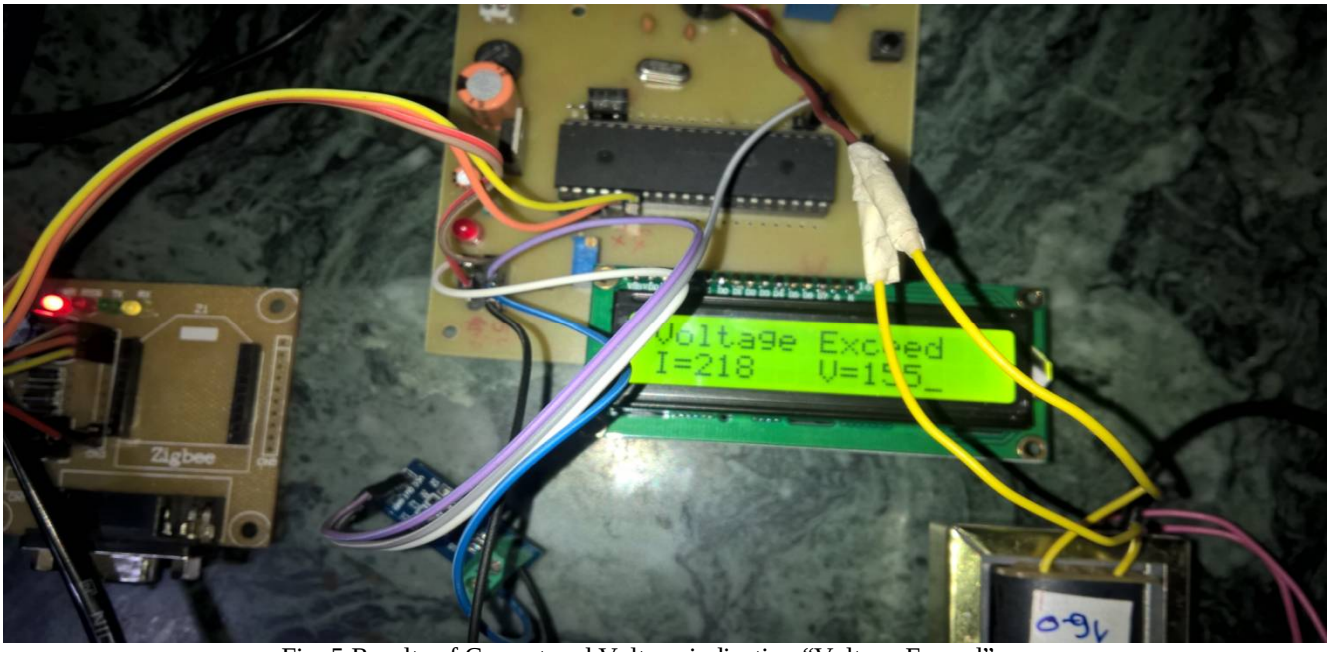

Fig. 5 Results of Current and Voltage indicating "Voltage Exceed"

VI. CONCLUSION

As per need of research, author has concluded some point by considering results obtained from simulation as follows:

1. ZigBee wireless open standard technology is being selected in this project as the energy management and efficiency technology of choice.
2. Implementing the system for real time monitoring of power line with an open standard such as ZigBee helps to keep costs down and reduced power consumption.
3. It is clear from the experimentations that the wireless sensor networks may be successfully employed to smart grids for monitoring purpose.
4. For large scale deployment, cost effective power monitoring system is essential, which requires a reliable and low cost WSN mote design. This system can be extended for smart home automation, online billing and smart metering applications also. This can also be further extended for complete distribution system monitoring with the monitoring of transformers' temperature, oil levels, over-loading, etc.

Contributions:

As there are numerous research gap have been found in past research scenario, so author has proposed a modified system to improved Power line monitoring. The following are the contributions from author for Developing a system of real time monitoring of power line parameters like voltage, current, temperature and power using ZigBee wireless communication protocol.

1. Developed an efficient ZigBee wireless technology for real time monitoring of power line to measure parameters like voltage, current, temperature and Power.
2. Provided solution to avoid power loss in case of any of the parameter like voltage, current and temperature is above normal value, then the grid will automatically switched to off position.
3. An innovative approach to remotely monitor power consumed by the grid is reported and tested.

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