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MONITORING AND CONTROLLING OF ELECTRICAL LOADS FROM THE SUBSTATION BY USING ZIGBEE TECHNOLOGY

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ABSTRACT

This paper proposes an innovative design to develop a system to monitor and control various electrical loads from the substation. The design generally consists of two units, one in the substation unit, called as transmitter unit, and another one is the Main station called as controlling and receiving unit. The transmitter unit is where the power is monitored continuously by PIC (Peripheral Interface Controller) microcontroller. Zigbee is used for transmitting the signals that are obtained. The controlling unit in the main station receives the transmitted signals by means of zigbee receiver and displays in the laptop and reacts in accordance to the received signal.

KEYWORDS: PIC Microcontroller based control system, Relay, Regulators, Sensors, zigbee and loads.

INTRODUCTION

Supplying power to customers requires power era, transmission and appropriation. At first electric force is created by utilizing electric generators such as: atomic force generators, warm power generators and pressure driven force generators and afterward transmitted through transmission frameworks utilizing high voltage. Power withdraws from the generator and goes into a transmission substation, where tremendous transformers change over the generator's voltage to a great degree high voltages (155kV to 765 kV) for long-separate (up to around 300 miles) transmission. At that point, the voltage level is decreased utilizing transformers and force is exchanged to clients through electric force appropriation frameworks. Power begins from the transmission matrix at appropriate substations where the voltage is ventured down (normally to under 10kV) and conveyed by littler appropriation lines to supply business, private, and mechanical clients. Novel electric force frameworks enveloping of force transmission and dissemination frameworks comprise of bounteous number of dispersed, self-governing overseen, capital-concentrated resources like force plants, transmission lines, transformers, and insurance hardware.

Checking and controlling of substations is a vital errand for supplying solid energy to the purchasers in this computerized period. However, because of the maturing foundation of the dissemination networks (substations) and absence of mechanization frameworks that screens the basic conditions at the substations, the danger of power outages, brownouts and flame are quickly expanding. Substations comprise of various electronic segments like transformers, circuit breakers, transfers and so forth. The transformer liquid holes or inward protection breakdown cause overheating that prompts disappointments. The customary technique incorporates intermittent manual checking of the framework which is tedious and with low precision. Moreover the substations in the country zones are significantly harder to screen physically and subsequently requires more opportunity to take individual activities.

Taking knowledge from [1] and [2] the Remote Microcontroller Based Monitoring of Substation and Control System through GSM (Global System for Mobile Communication) Modem, that monitors and controls the parameters like RMS secondary voltage of the distribution transformer, RMS secondary current of the distribution transformer, frequency of the supply, power factor, active and reactive power and complex power of the sub-station. Instead of GSM a wireless technique called zigbee is used to show the line parameters along with fault time to time to the line operators in the substation, then they can easily react and clear the particular fault.

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WORKING PRINCIPLE

Where the distribution lines are connected in the substation there the transmitter setup as shown in Fig. 1 and at the substation controlling room the receiver setup as shown in Fig 2. The pic microcontroller programed with required data and fixed the reference values of voltage, current and temperature. If these values are exceeded or decreased the controller gives command to BUZZER to ON, to LCD to display the values and LCD displays the particular exceeded or decreased one either voltage, current or temperature, to RELAYS to open the CB and to the zigbee to transmit the data to the substation receiver. The computer displays the data through the ZIGBEE at the substation.

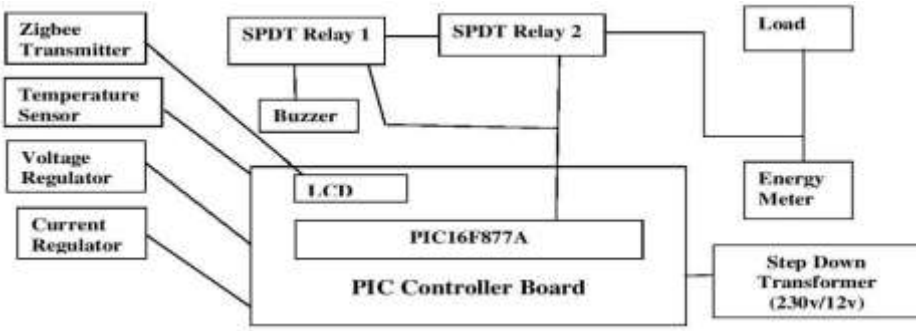

Fig 1. Block diagram of Transmitter setup

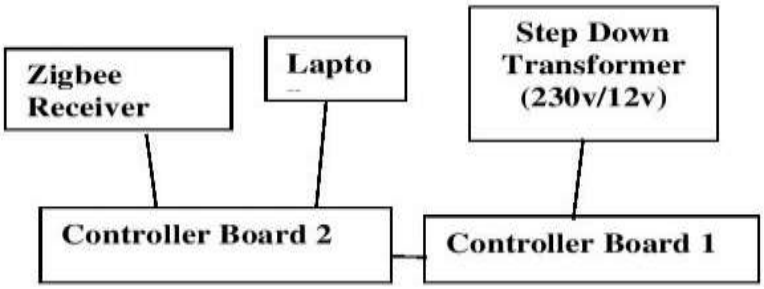

Fig 2. Block diagram of Receiver setup

HARDWARE DESCRIPTION

PIC Microcontroller

Introduction: The PIC is a microcontroller which consists of an inbuilt ADC, USART which are mainly used in this project. ADC is used for the conversion of Analog Output of sensors to digital and USART for serial asynchronous communication. [3]

The pin description of PIC16F877A is as shown in the below diagram.

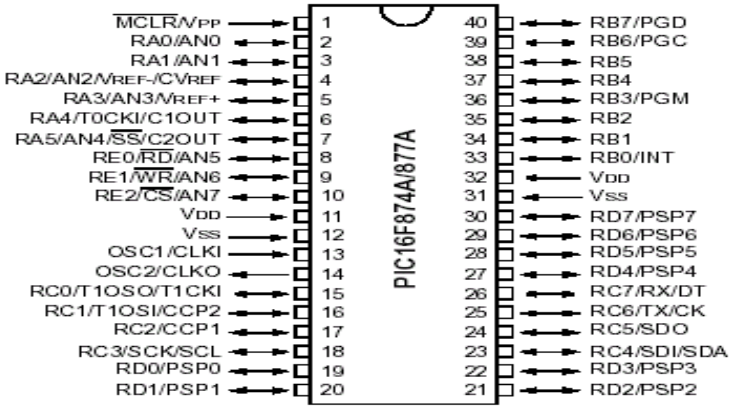

Fig 3. PIC Micro Controller

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The controller PIC 16f877A is 8-bit CMOS microcontroller with flash program it is RISC PROCESSOR with performance, fully static design it has 5 ports. Port A, Port B, Port C, Port D and Port E with 33 I/O lines. The Controller has 8kx14 words of flash memory, 368x8 bytes for data memory and 256x8 EPROM data memory. It is programmable code protection. The user code will be stored in the flash memory. The 5V supply is given to VDD and VSS of the controller. Microcontroller is used for monitoring power of a distribution transformer in a substation and to protect the system from the rise in that parameter.

Memory: This microcontroller has three types of memory ROM, RAM and EEPROM. All of them has specific functions, features and organization.

Stack: A part of the RAM used for the stack consists of eight 13-bit registers. Before the microcontroller starts to execute a subroutine (CALL instruction) or when an interrupt occurs, the address of first next instruction being currently executed is pushed onto the stack, i.e. onto one of its registers. In that way, upon subroutine or interrupt execution, the microcontroller knows from where to continue regular program execution. This address is cleared upon return to the main program because there is no need to save it any longer, and one location of the stack is automatically available for further use.

Interrupt System: The first thing that the microcontroller does when an interrupt request arrives is to execute the current instruction and then stop regular program execution. Immediately after that, the current program memory address is automatically pushed onto the stack and the default address (predefined by the manufacturer) is written to the program counter. That location from where the program continues execution is called the interrupt vector. For the PIC16F887 microcontroller, this address is 0004h. As seen in Fig below, the location containing interrupt vector is passed over during regular program execution. Finally, when the interrupt sources is recognized and interrupt routine is executed, the microcontroller reaches the RETFIE instruction, pops the address from the stack and continues program execution from where it left off.

Relay
SPDT relay: The Single Pole Double Throw SPDT relay is quite useful in this application because of its internal configuration. It has one common terminal and 2 contacts in 2 different configurations: one can be Normally Closed and the other one is opened or it can be Normally Open and the other one closed. So basically the SPDT relay as a way of switching between 2 circuits: when there is no voltage applied to the coil one circuit "receives" current, the other one doesn't and when the coil gets energized the opposite is happening.

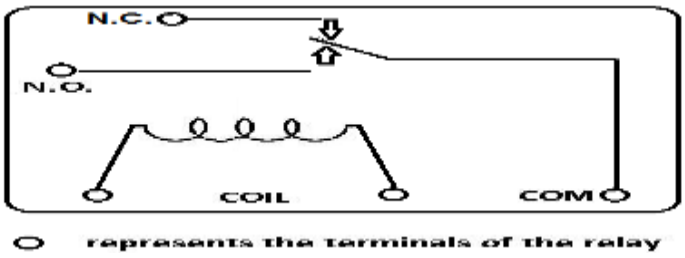

Fig 4. SPDT Relay

Power Supply:
1) Transformers: A step-down transformer of 230v to 12v.

2) Rectifier: Bridge Rectifier Diode Vsib Series Single 50 V 6A bridge rectifier is used to convert AC Voltage into DC Voltage. It is observed to be the best model for AC to DC change, over Full wave and half wave rectifiers. Utilizing the full wave rectifier model and require an inside tapped transformer and might have the capacity to utilize half of the changed voltage.

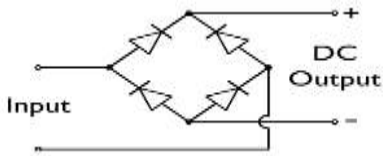

Fig 5. Diode Rectifier

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3) Filter: Filter circuit removes the A.C. component of rectifier output and allows only D.C. component to reach the load. Electrolytic decoupling capacitors 1000µF/25V. These capacitors are great transient/surge suppressors and work well in high-voltage and audio applications.

4) Voltage Regulator: A regulator is mainly employed with the capacitor connected in parallel to the input terminal and the output terminal of the IC regulator. For the checking of gigantic alterations in the input as well as in the output filter, capacitors are used. While the bypass capacitors are used to check the small period spikes on the input and output level. Bypass capacitors are mainly of small values that are used to bypass the small period pulses straightly into the Earth.

IC 7805 is a DC regulated IC of 5V. This IC is very flexible and is widely employed in all types of circuit like a voltage regulator. It is a three terminal device and mainly called input, output and ground. Pin diagram of the IC 7805 is shown in the diagram below

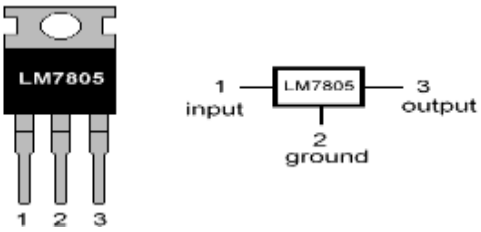

Fig 6. Voltage Regulator

Current Regulator: The circuitry which provides a constant current output is called a constant current regulator. To maintain a constant current flow, the resistance must be reduced whenever the load resistance increases. This causes the total resistance to remain constant. An increase in the input voltage must be compensated for by an increase in the resistance, thereby maintaining a constant current flow. The operation of a current regulator is similar to that of a voltage regulator. The basic difference is that one regulates current and the other regulates voltage.

LM317 Current Regulator to vary the value of the program resistor and calculate the output current from the LM317 family of three terminal adjustable regulators. This Current Regulator will work for all adjustable integrated circuit regulators with a reference voltage.

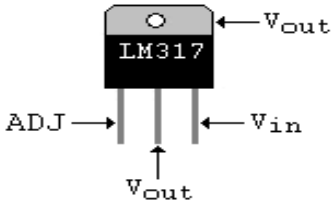

Fig 7. LM317 Current Regulator

Temperature Sensor: LM35 temperature sensor can measure temperature more accurately than a using a thermistor. The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified.

The LM35 is DC regulated IC of 5V device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range and draws only 60 µA from the supply, it has very low self-heating of less than 0.1°C in still air. The LM35 device is rated to operate over a −55°C to 150°C temperature range.

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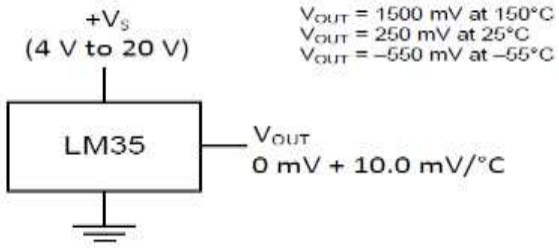

Fig 8. Basic Centigrade Temperature Sensor

How the Power Supply Section Works

The AC mains are bolstered to the transformer, which ventures down the 230 Volts to the fancied voltage. The extension rectifier takes after the transformer consequently changing over AC voltage into a DC yield and through a sifting capacitor sustains it straightforwardly into the info of the voltage controller. The regular of the voltage controller is grounded. The yield of the voltage controller is initially separated by a capacitor, and afterward the yield is taken.

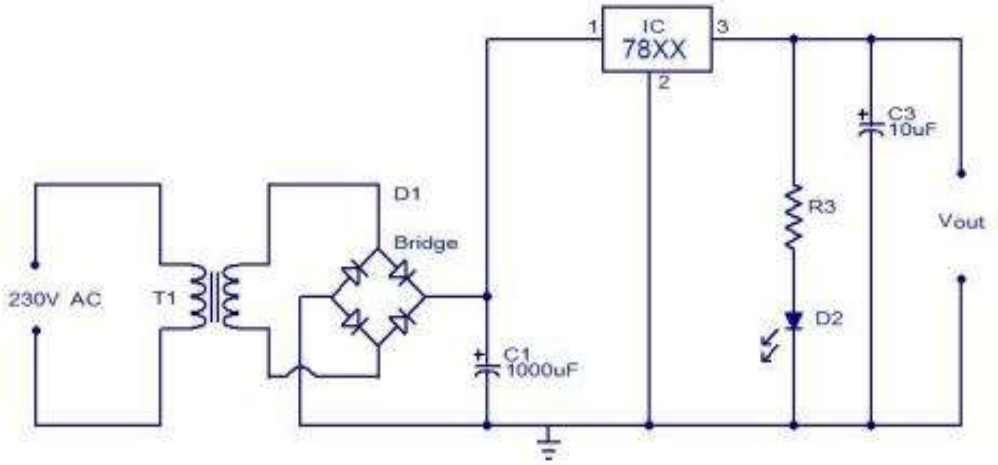

Fig 9. Power Supply Circuit Diagram

ZIGBEE MODULE

ZIGBEE Module is a low-cost, low-power, wireless mesh networking standard. The low cost allows the technology to be widely deployed in wireless control and monitoring applications, the low power-usage allows longer life with smaller batteries, and the mesh networking provides high reliability and larger range.

This module can achieve transparent data transmission between many devices, and it can form a MESH network. This device has the characteristics of small volume, ultra-low power consumption and low-cost. It can be either as an independent data transmission termination or be easily embedded into a variety of products to form a short-range wireless data transmission solution.
Ref: [4].

Working of Zigbee

The ZIGBEE standard has the capacity to address up to 65535 nodes in a single network. However, the ZIGBEE Protocol defines three general types of nodes: Coordinators, Routers and End Device, with a requirement of one Coordinator per network. While all nodes can send and receive data, there are differences in the specific roles they play.

- ZIGBEE Coordinators (Network Creator) - are the most capable of the three node types. There is exactly one coordinator in each network and it is the device that establishes the network originally. It is able to store information about the network, including security keys.
- ZIGBEE Routers (Multi-hop Routing) - act as intermediate nodes, relaying data from other devices.

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- ZIGBEE End Devices (Very low power) - can be low-power / battery powered devices. They have sufficient functionality to talk to their parents (either the coordinator or a router) and cannot relay data from other devices. This reduced functionality allows for the potential to reduce their cost.

To provide for low cost implementation options, the ZIGBEE Physical Device type distinguishes the type of hardware based on the IEEE 802.15.4 definition of reduced function device (RFD). An IEEE 802.15.4 network requires at least one FFD to act as a network coordinator.

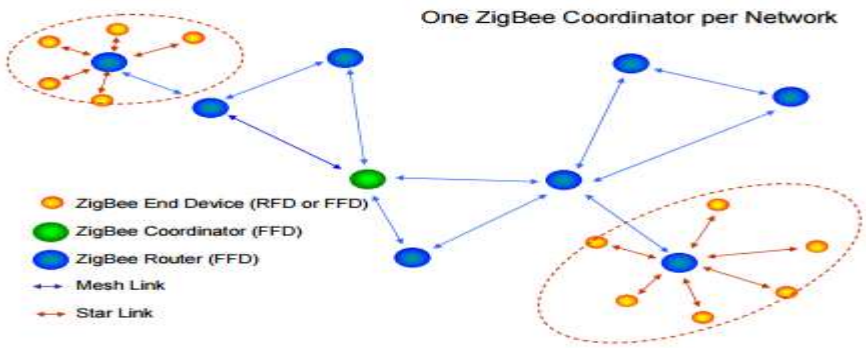

Fig 10. ZIGBEE Network Model

ZIGBEE uses two types of devices. Reduced-function devices (RFDs) are sensors that communicate with full-function devices (FFDs). FFDs are complex nodes that conform to the full 802.15.4 standard and can serve as routers. An end device gets its instructions from a ZIGBEE Coordinator. All ZIGBEE networks must include coordinator, which is a full function device that manages the network.

ZIGBEE technology provides static and dynamic star, cluster tree and mesh networking structures that allow large area network coverage, scalable networks and single point-of-failure avoidance

If the end device is out of range of its coordinator, it can communicate through a router. The diagram shows what is called a mesh network. The term mesh is used because of the routers and coordinators have multiple communication path options. network may be extended through the use of ZIGBEE routers, Using local addressing you can configure simple networks of more than 65,000 (216) nodes, thereby reducing address overhead.[5]

Uses of Zigbee in Various Fields:

- Home, building and industrial
- Automation
- Energy harvesting
- Home control/security
- Medical/patient monitoring
- Logistics and asset tracking
- Sensor networks and active RFID
- Advanced metering/smart energy
- Commercial building automation

PRACTICAL IMPLIMENTATION OF THE MODE

The aim is to monitor and control the loads continuously. The modules used to implement the system are discussed earlier. Voltage and current readings to microcontroller to LED. The controller will checks if those readings have exceeded their limit. If it happens then the controller will send signal to relay to buzzer signal is ON and load is disconnected , if the voltage or current has been decreased to rated values the controller will do the same thing and it send this information to substation via ZIGBEE module. At the substation ZIGBEE receives the information given to the controller, a MALE-FEMALE connector from controller connect to the computer and by using X-CTU application computer displays all the values of voltage, current and temperature along with the exceeded or

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decreased values. The temperature sensor used here will detect if the temperature increases due to high voltage or anything then automatically it will shut down the load and send information to the substation by zigbee.

Fig 11. Transmitting setup

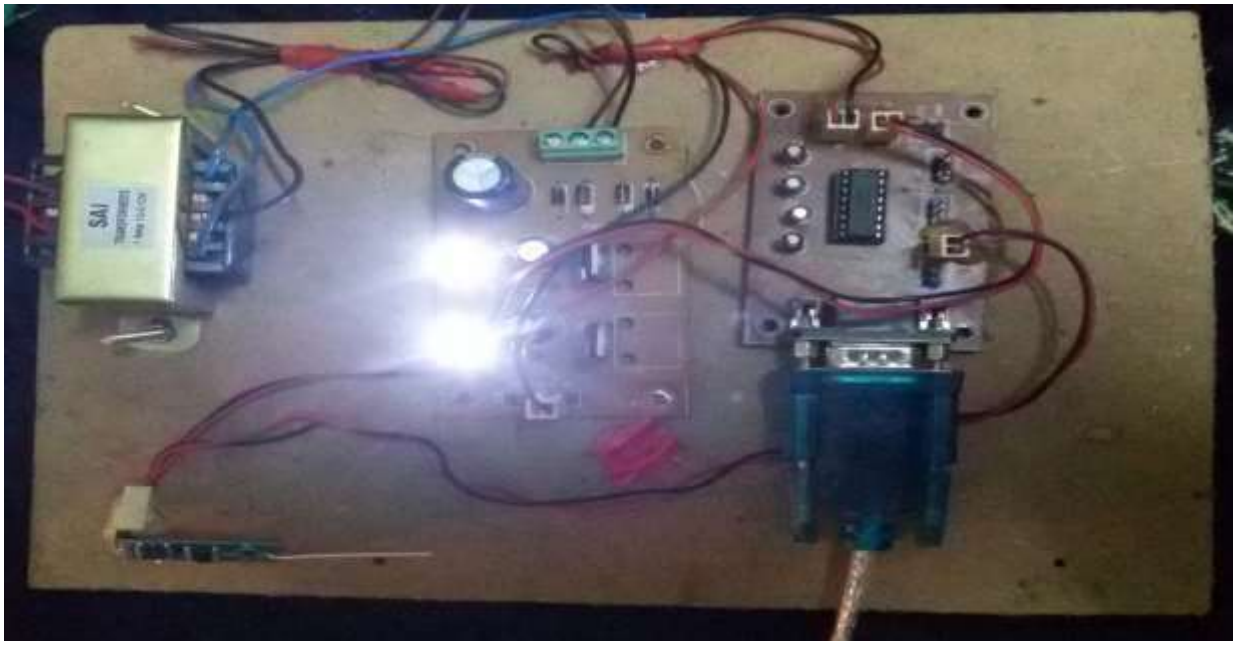

Fig 12. Receiving setup

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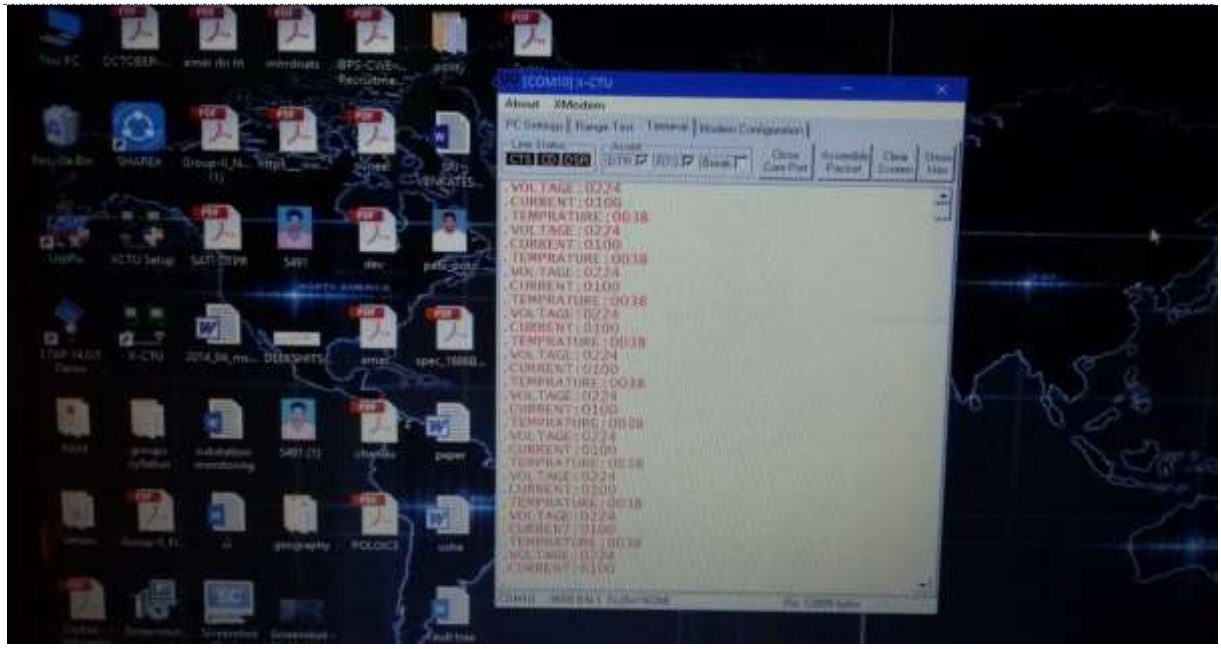

Fig 13. The result in the computer

COMPARISONS

The controlling and monitoring of a substation by using Bluetooth /Wi-Fi wireless network transmission but ZIGBEE has some advantages over them. Various comparisons of this proposal are shown in the below tabular columns.

TABLE1: Comparison of Zigbee with Other Wireless Communication Devices:

Standard	Range	Number of Nodes	Frequency Band	Data Protection	Power use
Bluetooth	10 m	8	2.4 GHz	16 bit CRC	high
Wi-Fi	100 m	32	3.1-10.6 GHz	32 bit CRC	high
ZIGBEE	10-200 m	More than 25400	868/915 MHz , 2.4 GHz	16 bit CRC	low

TABLE 2: Comparison of Zigbee with Bluetooth:

s.no.	ZIGBEE	BLUETOOTH
1	Targets low data rate, low duty cycle	Targets medium data rate continuous duty
2	250 kbps over the air, 60-115 kbps typical data transfer	1 Mbps over the air, ~700 kbps best case data transfer
3	Long battery life (in years)	Battery life in days only
4	More sophisticated networking best for mesh networking	File transfer, streaming telecom audio
5	Mesh networking allows very reliable data transfer	Point to multipoint networking
6	Uses direct spread spectrum technique	Uses frequency hopping technique
7	2 to 65535 devices per network	8 devices per network
8	Simple protocol.	Complexity is higher

TABLE 3: Present Substation v/s This Application:

S.no.	**Present Substation**	**This Application**
1	Manual Communication	Wireless Communication
2	Slow Information	Instant Information

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3	Don't Know Fault And Fault Value	Fault And Fault Value Is Shown

TABLE 4: Working of the Practical Implementation:

Parameter	**Normal condition**	**Fault condition**
voltage	230V	230V ± 10
current	100A	100A ± 10
temperature	30^0C	30^0C ± 5^0C

CONCLUSION

The monitoring and controlling of electrical loads from the distribution transformers utilize the ZIGBEE communication network, which has low investment and operation costs. It is also easy to install and use. It may reduce human efforts with the automation of the substation which increase transformer life, reduce faults and increase stability. It increases the efficiency of the system. This leads to accurate and reliable operations. It will provide fast and easy monitoring with more efficient way as compared to existing manual monitoring of the sub-station.

REFERENCES

[1]. Chan, W. L, So, A.T.P. and Lai, L., L.; "Interment Based Transmission Substation Monitoring", *IEEE Transaction on Power Systems, Vol. 14, No. 1*, February 1999, pp. 293-298

[2]. Amit Sachan "Microcontroller Based Substation Monitoring and Control System with Gsm Modem" Department of Energy & Power Engineering NIMS University, *IOSR Journal of Electrical and Electronics Engineering (IOSRJEEE)*, 2015.

[3]. Timothy D. Green "Embedded Systems Programming With the Pic16f877" *Second Edition* 2008.

[4]. Thoraya Obaid, HaleemahRashed, Ali Abou-Elnour, Muhammad Rehan, Mussab Muhammad Saleh, and Mohammed Tarique Department of Electrical Engineering, Ajman University of Science and Technology P.O. Box 2202, Fujairah, United Arab Emirates (UAE) "Zigbee Technology And Its Application In Wireless Automation Systems" *International Journal of Computer Networks & Communications (IJCNC) Vol.6, No.4*, July 2014

[5]. Chen, B. and Wu, M. and Yao, S. and Binbin, N., "ZigBee Technology and Its Application on Wireless Meter-reading System", *IEEE International Conference on Industrial Informatics*, 2006.

[6]. Jyotishman Pathak, Yuan Li, Vasant Honavar and James D. McCalley, "A Service-Oriented Architecture for Electric Power Transmission System Asset Management", *In ICSOC Workshops, pp: 26-37*, 2006.

[7]. Bellido-*Outeirino, Francisco J. (February 2012).* "Building lighting automation through the integration of DALI with wireless sensor networks". *IEEE Transactions on Consumer Electronics. 58 (1):4752.* doi:10.1109/TCE.2012.6170054

[8]. Lien, C.H. and Bai, Y.W. and Lin, M.B., "Remote-controllable power Outlet system for power management", *IEEE Transactions on Consumer Electronics (TCE),* 2007.

[9]. Luan, S.W. and Teng, J.H. and Chan, S.Y. and Hwang, L.C., "Development of a smart power meter for AMI based on ZigBee communication", *IEEE International Conference on Power Electronics and Drive Systems*, 2009.

[10]. Sen Ouyang and Jianhua Wang, "A new morphology method for enhancing power quality monitoring system", *International Journal of Electrical Power & Energy Systems Vol.29, No.2, pp.121-128,* February 2007.