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Monitoring of Step-Down Power Transformer in 33/11kv Distribution Substation Using XBEE with API Mode

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Abstract: ***Transformer is the heart of electrical power system and considered a very important and expensive device. According to the importance of this equipment the need of maintain and monitoring them is essential. The transmit of information from transformer in save, fast and less cost is necessary. This paper deals with the design and construction of automatic monitoring system Free Running Sensor Node System (FRSNS) for two step-down power transformers parameters. these parameters are temperature, current, voltage and oil level. this proposal depends on XBEE capability to read sensors values and transmit them periodically. Monitoring terminal received sampled data (sensors values) from all node available, this monitoring terminal designed by MATLAB program version R 2018 a [9.4.0.813654]. then by using one of the most popular SCADA protocol (MODBUS) these values reach to the RTU.***

Keywords: transformer, XBEE, FRSNS, Monitoring terminal, SCADA, RTU

1. Introduction

The world today is smart, all works in this smart world is based on an embedded system that makes human life so smarter and to feel comfortable. Electrical power system is one of the important infrastructures around the world. The need of electrical power for industrial purpose, commercial purpose and household purpose continuously increasing. The electrical power system considers a complex system consist of many operating machine units that working together. If any machine in this interconnect system failed the entire system will be affected. The power system goes through many stages: generating, transmission and distribution tothe consumers. Among these interconnected machines, transformers consider a very important and expensive parts Regardless of its location in the energy transfer stageswhether it is in transmission or distribution stations or transformers in streets. Transformer plays key role of stepping up or stepping down voltage level based on the principle of electromagnetic induction, hence careful protection and monitoring of these machines is essentialto avoid material and human losses.

In Iraq at 33/11 kV distribution substationthe process of monitoring and transferring transformer signals is still on the wired system. The wired system faces many difficulties such as installation, implementation, repair costs and otherproblems.In recent years, more research has begun to focus on the development of wireless technology and its applicability in the industrial field. WSN has many advantages compared to traditional wired system as convenient organizing network, low power dissipation, small influence to environment and low cost, etc. There are many close-range communication techniques that have been widely used such asBluetooth, infrared,wireless local area network (WLAN), etc. Butthese technologies have some disadvantages as, networking in small scale, complexity, short distance, more power dissipation, etc. Zigbee has many technical advantages or convenient features over Bluetooth, Wi-Fi, infrared rays etc. Zigbee is one type of communication technology which is low power consuming and having coverage area surrounded by 200 m. Zigbee has data rate running from 20 kbps to 250 kbps. Table 1. show the comparisons of Bluetooth, Wi-Fi, Zigbee.In this work the idea of the proposed system (FRSNS) is to rely entirely on XBEE without the use of a microcontroller to monitor the parameters of step-down power transformers at the 33/11 kV distribution substations.

Standard	No. of nodes	Range	Frequency band	Power use	Data protection
WIFI	32	100m	3.1-10.6GHz	High	32-bit CRC
Bluetooth	8	10m	2.4 GHZ	High	16-bit CRC
ZIGBEE	More than 25400	10-200m	868/915 MHz 2.4 GHz	Low	16-bit CRC

2. Zigbee Technology

ZIGBEE is a standard that defines collection of communication protocols for short-range, low data rate wireless networking [2]. ZIGBEE-based wireless devices operate in 868MHZ, 915MHZ and 2.4GHZ frequency bands. The highest data rate in ZIGBEE technology is 250,000 bps. ZIGBEE is aimed mainly for battery-powered application where, low cost, low data rate and long battery life are main requirement [3].

3. Zigbee for Power System

ZigBee technology is suitable for applications in power monitoring system, it can provide reliable protection for the operation of electric power systems. The Following points justify this statement.[4]

- Data rate: maximum transfer rate can be up to 250 kbps which compatible with data rate needed in the power monitoring system.
- Large capacity: ZIGBEE is suitable for the complex structure of power systembecause network support up to 65,000 nodes.
- Low-cost: The installation costs are low, and the maintenance is simple.

- Strong anti-interference: For the interferences from environments like, mobile, cars, generators, transformers, power distribution room, etc., this technology can prevent well.
- Short time delay: The delay usually from 15 - 20 ms, so it is very suitable for industrial system that need real-time data transmission.
- Low power-cost. In low power standby mode, two normal ordinary dry-cell batteries can be used for 6 months to 2 years. This consider the major advantage of ZigBee to ensure that the monitoring system continue working in the event of the power failure.
- Strong safety: Zigbee technology use the encryption algorithm AES-128 which provides functions of integrity data checking and authentication.

4. API Mode

The alternative to transparent mode is API mode, in this mode a protocol specifies the way information is exchanged. This mode gives flexibility to form large network and it is more appropriate to create sensor network to perform tasks like gathering data from multiple location, controlling device remotely, or automating home. Data communicated in packet called API frame, the packet has a specific format figure 1. shows the API frame [5].

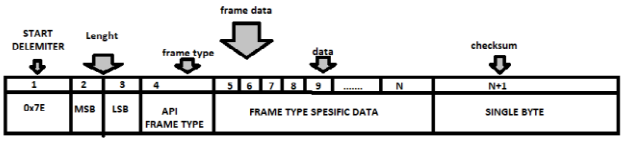


Figure 1: API frame [5].

5. System Design

This proposed system composed of free running measurement nodes (measurement is taken in a periodic fashion). Measurement is provided by XBEE node logic circuits. coordinator is also an XBEE node connected to the monitoring computer through UART-USB adapter. Three physical values need to be measured and one status these values are temperature, current, voltage and oil level see figure block diagram of (FRSNS).

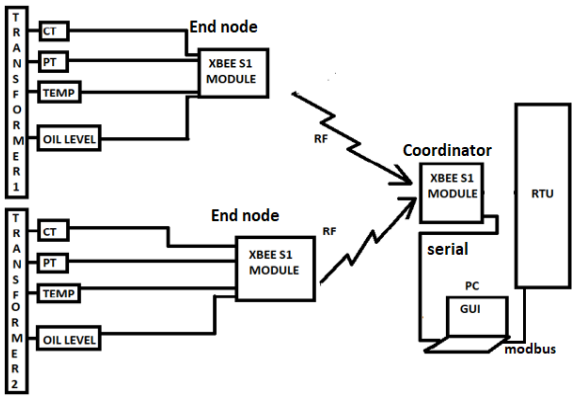


Figure 2: FNSN block diagram

Three ADCs built inside the XBEE where used and two digital I/O pins configured to be an input where used to read the status of the oil tank. Temperature is measured using LM35. Since the analog to digital converter reference is 3.3 volt supplied to AREF pin at the XBEE a circuit should be added to lower voltage level output of the LM35 sensor. This circuit is a voltage divider composed of two resistors in series the middle point of the resistor lowers the voltage to a quarter of its values, which it is suitable to be read by the ADC. Current transformer is an AC device in which the AC should be rectified to DC to properly read by the ADC of XBEE with same divider circuit. Voltage is measured using ZMPT101B sensor also with divider circuit to reduce voltage level. figure 3. Indicates the circuit of CT with temperature and voltage sensors.

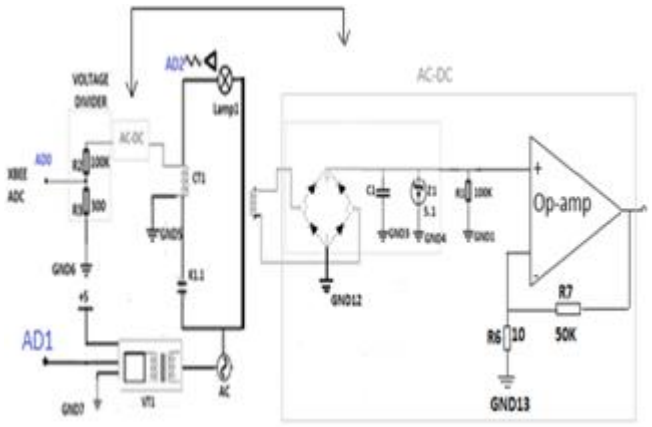


Figure 3: CT CIRCUIT with voltage sensor and lm35

Oil level status is measured using two switches to simulate the level switches in the actual tank Since one of them on the button of the tank and the other on the top.Those switches with reflect four conditions (button on, top off) is a normal tank, (button on, top on) is unnormal overflow tank, both switches are off indicating empty tank (under flow), finally (button off, top on) is an impossible state. The following figure indicate the circuit of switches.

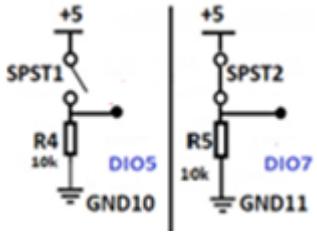


Figure 4: Oil level switches

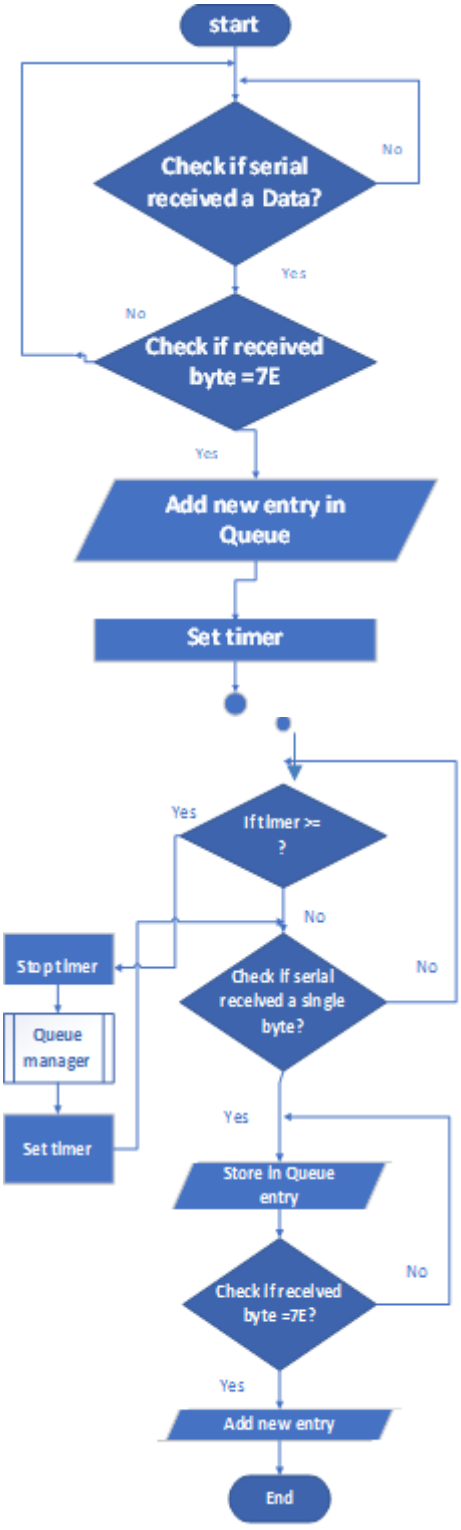
5.1 End Node and Coordinator Configuration

End node XBEE and coordinator configured to use (API) mode rather than AT command mode**.** The reason is to control all the nodes swiftly without changing from data to command mode back and forth, also if AT command mode is used each node enters the system should be manually configured to a different command mode character instead of (3+). this solution is not practical specially in dynamic systems. Hence API mode was used. To be able to send values of I/O and ADCs periodically.

5.2 Communication

Standard **API** packets has been used throughout free running. Nevertheless, in monitoring computer a program written in MATLAB to interpret received packet from coordinator node through the serial port. MATLAB depends

on serial triggered events when a single byte is received a check for that byte is made to specify whether it is a start (7E) of a new packet or another byte from previously received packet. The received packets store in queue for processing the following flowchart shows the FRSNS packet receiving. This flowchart indicates how to received packets after period of time, store them in queue, processing them then empties the queue.



5.3 System Hardware

XBEE Module

Figure 5: XBEE S1 [6]

Feature:

- Frequency band: 2.4 GHZ
- Serial data interface: 3.3 coms UART
- Interference immunity: DSSS
- Configuration methods: AT command or API mode
- ADC inputs: 6(10)-bit ADC input
- DIGITAL I/O: 8
- Serial data rate: 1200 bps- 250 kbps.[6]

LM 35 temperature sensor

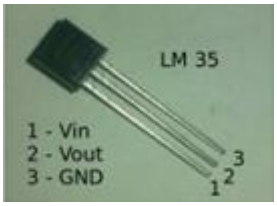


Figure 6: lm35 [7].

Features

- Calibrated Directly in Celsius (Centigrade)
- Linear + 10-mV/°C Scale Factor
- 0.5°C Ensured Accuracy (at 25°C)
- Rated for Full −55°C to 150°C Range
- Suitable for Remote Applications
- Low-Cost Due to Wafer-Level Trimming
- Operates from 4 V to 30 V
- Less than 60-µA Current Drain
- Low Self-Heating, 0.08°C in Still Air
- Non-Linearity Only ±¼°C Typical
- Low-Impedance Output, 0.1 Ω for 1-mA Load [8].

Current transformers

Figure 7: Current Sensor [9].

It is a line of fully integrated Hall-effect current sensor IC that provide highly accurate, low noise output voltage signals that are proportional to an applied AC or DC current. These ICs are in high volume production in many applications, including automotive HEV inverters and electronic power steering (EPS) systems, and in industrial and consumer inverters [9].

Voltage Sensor

Figure 8: ZMPT101B SENSOR

ZMPT101B SENSOR is a voltage sensor, simple to use made from ZMPT101B voltage transformer.it has good consistency for power measurement and voltage, and it has high accuracy. It can measure up to 250v ac. and it come with multi turn trim potentiometer for adjusting the ADC output [10].

5.4 System Software

Monitoring software written to host presented proposal, this software written in MATLAB script version R 2018 a [9.4.0.813654] used in the monitoring terminal. Monitoring program is graphical user interface-based GUI.

Figure 9: monitoring terminal

5.5 Experimental Setup

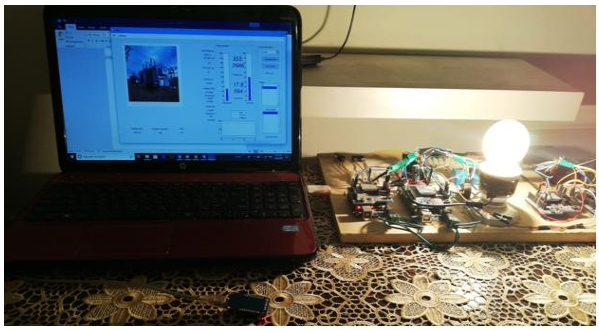


Figure 10: Setup

6. Conclusion

Low power consumption in this system is one of the advantages of XBEE, as well as do not use a microcontroller reduction the cost of the network. The processing speed is rather slow according to the complex format of the packet that required more time for processing. And this system tends to obsession channel.

7. Future Work

For future work test this system with much greater number of nodes to build large network (mesh network) and measured more parameters.

References

[1] Javaid, N., Sharif , A., Mahmood , A. , Ahmed , S. Qasim, U., & Khan ,Z. A. (2012) . Monitoring and controlling power using ZigBee communications. 2012. Seventh international conference on broadband, wireless computing, communication and applications.
[2] ZigBee Specification 053474r17, Jan. 2008; available from www.zigbee.org.
[3] Shahin Farahani. (2008). ZigBee Wireless Networks and Transceivers, Elsevier, ISBN: 978-0-7506-8393-7.
[4] Archana, R. , Malik, L. G. (2011). Zigbee In Building Industrial Control and Automation, International Journal of Wireless Communications and Networking.
[5] Website: https://www.digi.com/resources/documentation/digidocs/pdfs/90001942-13.pdf.
[6] Website: https://www.digi.com/pdf/ds_xbeemultipointmodules.pdf.
[7] Manuel Ramos. (2017). Characterization of LM35 Sensor for Temperature Sensing of Concrete. Proceedings of the International Multi Conference of Engineers and Computer Scientists 2017 Vol II , IMECS, Hong Kong. ISBN: 978-988-14047-7-0.
[8] Website: http://www2.ece.ohio-state.edu/~passino/LM35.pdf.
[9] Website:http://www.energiazero.org/arduino_sensori/5a_range_ac_current_transformer_current_sensor_module.pdf.
[10] Abubakar , S.N. kalid , M.W.Mustafa , Hussain . SHaref &M. Mustapha. (2017) . calibration of ZMPT101B voltage sensor module using polynomial regression for accurate load monitoring. ARPN journal of engineering and applied sciences, vol.12 , ISSN: 1819-6608.