Implementation of on-demand low rate wireless parameter monitoring system for industrial machineries.

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Implementation of on-demand low rate wireless parameter monitoring system for industrial machineries.

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Abstract- Systematic and rigorous monitoring of critical equipment is the cornerstone of any successful preventive management system in the industrial environment. Recent developments in cost-effective wireless sensor network (WSN) technologies promising a wider and more sustainable deployment of distributed sensing and processing infrastructure. In this research work, it is mainly focused on the electrical monitoring parameter and enable remote switching devices for optimal power management systems using ZigBee. This paper proposes a digital system for electrical system parameters such as voltage and current using ZigBee-based wireless sensor networks (WSNs). The main feature of ZigBee protocol, to act as a communicable medium between transmitter and receiver modules, which is suitable for the industrial environment.

Keywords - Industrial Wireless Sensor Network, Power Monitoring System, ZigBee XB, Low Cost

1. INTRODUCTION

The process of rationalization and upgrading of industrial structure has a particular phase impact on economic development, and the relationship between industrialization and the rationalization of economic development is a strong constant [1,2]. Industrialization observed as the method of change, in which various countries follow various methods that depends on their primary circumstances and the time of entrance in the race [3]. Modern monitoring and control require to collect all relevant information, statistics and data relating to the various industrial processes, motors, machinery and equipment operating on the industrial premises. It aims to produce results of controlled use, improved productivity and higher quality of industrial products [4–6]. Although conventional wired communication protocols have an important place in industrial intensive care and control grids in the past, they prove to be derisory to satisfy the largely unstable and rigorous requires of recent industrial technology, mainly because of rigorous use of wired infrastructure. Wireless technology has the potential of generating a revolution among the industries because of its applications, not only by reducing the challenges regarding wired networks, but also by generating new class advancements and their uses[7–10]. Wireless protocols play an important part in industrial monitoring and control schemes, because it has certain benefits when compared to conventional wired technology [11,12]. Along with reduction of large scale and setting up costs, the topology's modest use of wired solutions allows it to be easily deployed in unsupervised areas (for example, in moving parts) [13,14]. Changes of the mesh technology can be effortlessly done by avoiding the not required cost of wiring [15].Telecommunication, electronics, and computer engineers have made a tremendous determination to advance several topologies of digital communication, with the goal of bringing performance closer to full scale [16,17].

During late nineteenth century, digital wireless technology was put into force to increase the efficiency of satellite communication systems for the International Satellite Organization in a rapidly growing situation. Later it was used in mobile phones and gradually increased the importance of the cellular business. Currently, this wireless communication technology is used in many appliances and networks. ZigBee consumes less power and the data rate is quite low [18–21].This paper presents an implementation of on-demand low rate wireless parameter monitoring system for industrial machineries using ZigBee. The contribution can be summarized as follows Section 2 discusses the comparative study of Wireless technologies, Bluetooth and Zigbee. Section 3 discusses the methodology of achieving the wireless communication between modules. Section 4 discusses the algorithm of the proposed model. Section 5 discusses the implementation and the components used. Section 6 discusses the final results and output waveform. Finally, Section 7 concludes that Zigbee is the most suitable module for industry purpose and the makes the proposed system cost-effective. XBee, takes the place of existing Infrared technology-based devices which saves the cost of instalment. Zigbee uses lithium battery which lasts long. The network set up is very simple and easy. Therefore, the proposed implementation is both cost effective and easy to implement.

2. COMPARATIVE STUDY ON WIRELESS TECHNOLOGIES

Table I describes the major differences between the two wireless technologies, Bluetooth and Zigbee. Each technology is grounded on the IEEE standard. Generally, Bluetooth and ZigBee are used for wireless communication about 10 m. However, in some applications ZigBee can even range upto 100 meters. In this section a detailed comparative study is carried out to adapt the suitable technologies for the industrial machineries.

Table 1 Comparison of Bluetooth and Zigbee wireless technologies

Specification	**Bluetooth Module**	**Zigbee Module**
IEEE Standard	802.15.1	802.15.4
Range of Frequency	2.54 GHz	866/915 MHz
Maximum Signal Range	1 Mbps	250 Kbps
Range of Communication	10 m	10-100 m
Bandwidth of Channel	1 MHz	2 MHz
Type of Modulation	GFSK	BPSK, QPQSK
Basic cell Extension	Scannet	Cluster Tree, Mesh
Spreading	FHSS	DSSS
Primitives	151	35
Maximum cell nodes	8	More than 65000
HCL Events	37	30

2.1 Power consumed by chipset

Table 2 presents the comparison of power consumption and the detailed features of the specific chipset for each topology. Figure 1 depicts the power consumed (mW) for each topology. It is observed that power consumption is minimum in Bluetooth and Zigbee.

Table 2 Features of chipset for each topology

Protocols	Chipset	VDD(Volt)	I_{TX}(mA)	I_{RX}(mA)	Bit Rate(Mb/s)	Power(TX)	Power(RX)
Bluetooth	BlueCore2	1.8	57	47	0.72	57.0	48.6
Zigbee	CC2430	3.0	24.7	27	0.25	24.5	28.4

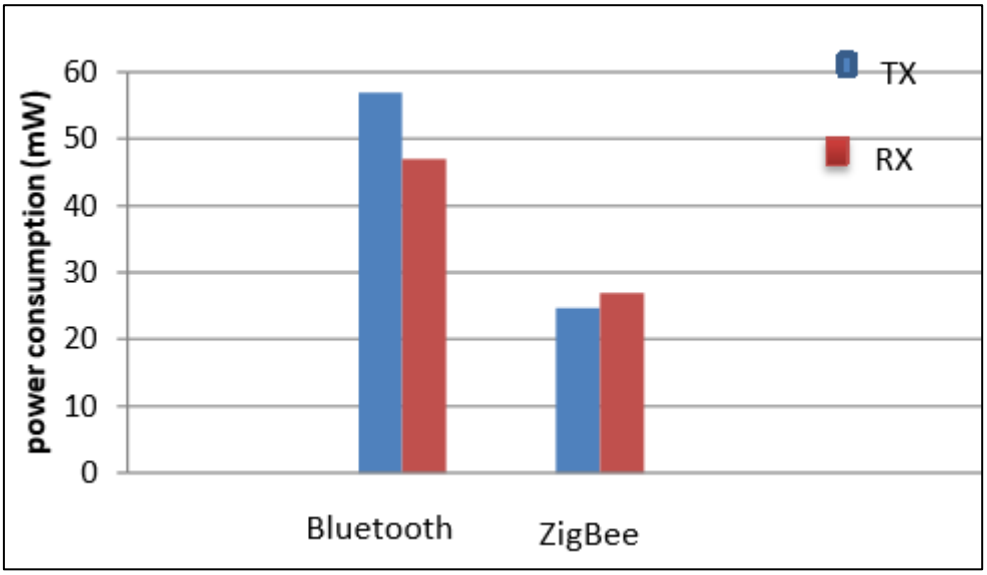

Figure 1 Power consumed in mW

2.2 Complexity of topology

The complication of each technology is distinguished on the basis of the number of primitives and events. Table 1 shows the count of primitive and Host Controller Interface (HCI) instances for Bluetooth and the PHY/MAC primitive count for ZigBee, Wi-Fi and UWB topologies. "In PHY/MAC films, Bluetooth primitives comprise HCI SAP, Client Service Access Point (SAP), Synchronous Connection-Oriented (SCO) SAP, and Logical Link Control and Optimization Protocol (L2 CAP) primitives." Bluetooth 188 is very complex topology with primitive and total events. While, "ZigBee is simpler with 48 priorities defined in 802.15.4. This is only one-fourth of the number of primitives and events defined in Bluetooth." Compared to Bluetooth, effortlessness makes ZigBee more appropriate for sensor interacting modules due to its restricted memory and computing power.

3. METHODOLOGY

Shown in Figure 2 is the proposed system that works on the fundamental of Wireless Communication. Two XBEEs are used for communicating. It is a plug-in device which consists of 2 plug-in arduinos (Transmitter and receiver). The Transmitter has sensors attached to them which takes data from the machines and transmit it and receives the data and provides the signal to the meter for various interpretations.

For achieving the wireless communication between the XBees it is required to configure the XBee to obtain a link between them. In this model, XCTU software has been used for configuring XBee.

One of the XBee is configured as coordinator node and the other XBee is configured as the router node. Table 4 shows the parameters that have to be set for enabling the XBees to transmit data. The source address of one XBee should match the destination address of another XBee. By making these changes the XBees will be able to transmit the data among themselves through the channel that they will establish with the help of same address. The frequency that is being used to communicate is defined by CH and as same frequency is required, the Channel for both the XBee has to be kept the same. The PAN ID defines the network that the XBee will communicate to. DH and DL defines the low and high destination address. DH and DL should be the serial number high and serial number low (SH and SL) respectively of the transmitter's XBee. MY enables the response of 16-bit address packets. Whenever the value changes the XBee Node2 sends the data value from the button to the XBee Node1.

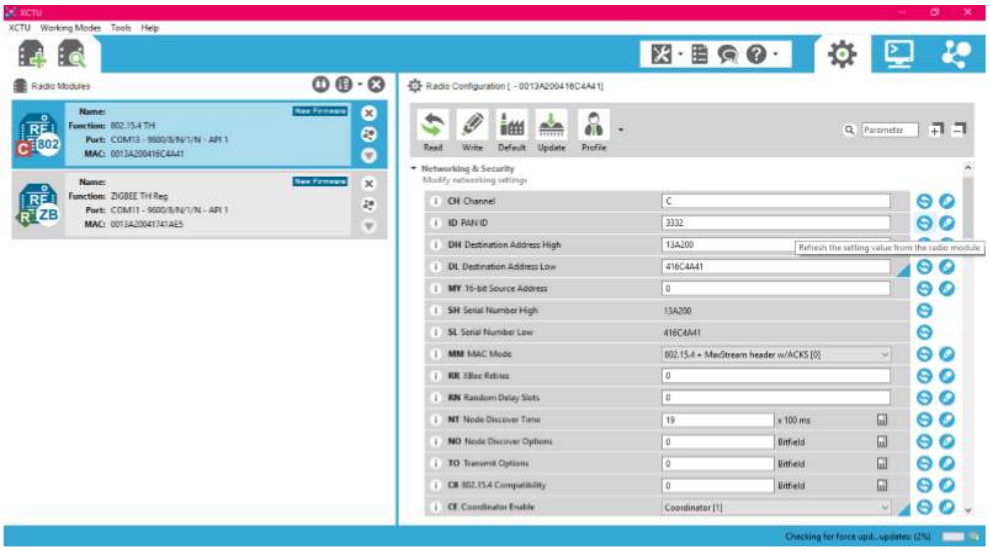

Figure 2 Selected coordinator module

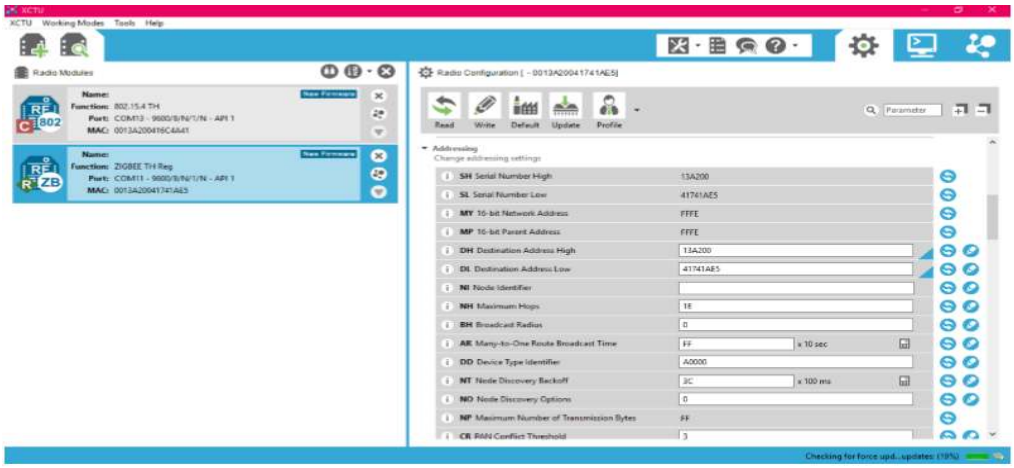

Figure 3 Selected receiver module

XCTU is a software used mainly by developers to manage radio modules such as XBee. It is a free multi-platform application which uses simple-to-use graphical interface. This application makes it easy to configure and test XBee modules as it includes all the required embedded tools. Figure 2 and 3 shows the XCTU Software and each of the coordinator and receiver modules configurations.

Table 3 Parameters for XBee Configuration

Fields to Set	**Short-Form**	**XBee Node1**	**XBee Node2**
Channel	CH	C	C
PAN ID	ID	3322	13A200
Source Address	MY	0	1
Destination Address High	DH	0	0
Destination Address Low	DL	1	0

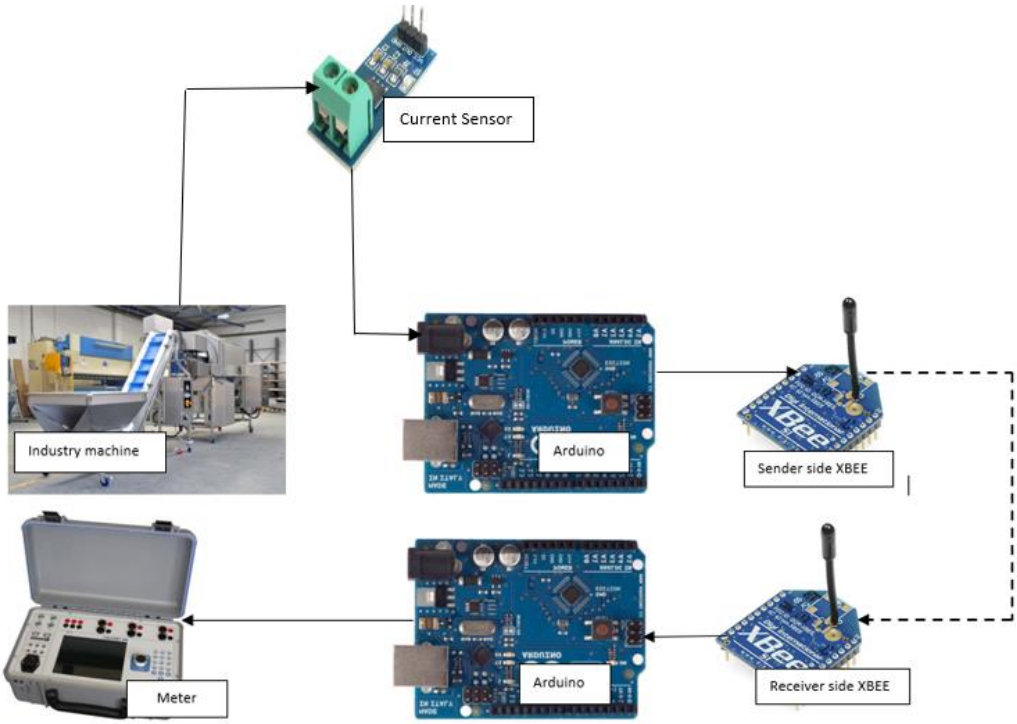

Figure 4 Schematic diagram of proposed model

Figure 4 represents the block diagram of our proposed model. It shows the flow of data from machine to the meter's monitor screen using XBee through arduino.
This model consists of S2C XBEE MODULE for communication protocol, it provides point-to-point wireless connection to various devices. At the end node or base node, it collects sensor reading from arduino and the data collected is transmitted to the monitoring junction and at the coordinator node the information sent by the base node is received. The microcontroller Arduino Uno is a development board built on the ATmega328. It helps in powering up different sensors and also establishes a connection to permit monitoring and appropriate regulation of various devices. It supports the radio communication. At the end node station or router node it helps in reading serial output and is often used as a communication station between XBee chips and sensors and at the base station or coordinator node it is used as a communication station between XBee chip and computer. LEM TRANSDUCER(LV25-P) sensor used for measuring the current. It can work upto 150khz input signal and can withstand current overloads without damage and helps monitoring the current flowing through appliance.

4. ALGORITHM

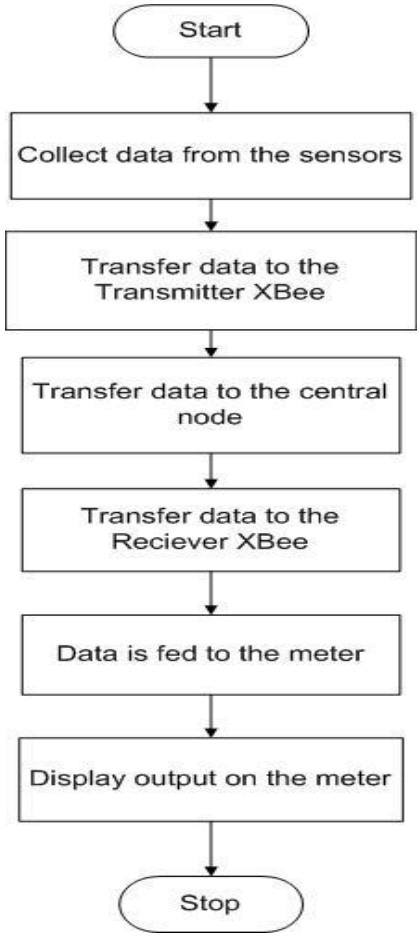

Figure 5 Flowchart of Proposed Algorithm

Figure 5 is the flowchart of the proposed system algorithm. The entire algorithm is simple and easy to implement. This model consists of current sensor which collect the current data from various machines in the industry. In order to configure the XBEEs XCTU software is used. The data collected by the

sender node is then transmitted to the receiver node using XBEE wireless communication. The XBEE transfers the data received to the meter. Finally, the meter is used to display the data.

One of the plug-in devices is connected to machine, whose parameters are to be monitored. Another plugin device is to connected to the meter, that receives data which is transmitted through the wireless channel. The data is transferred in the form of small packets. Since, the plug-in device is lightweight and portable, it is easy to use and maintain. For the proposed model, there is one coordinator node and multiple router nodes. XBee can be used to achieve point to multi point communication using star topology. This paper is based on above topology.

5. IMPLEMENTATION

For proposed model, it is first required to configure the XBEE so that they can communicate among themselves for which XCTU software is used. The Arduino code that is used was divided into parts.

- 3 different modules has been imported- XBee.h , EmonLib.h for current calculation and SoftwareSerial.h for defining the ports.
- After that the sender and receiver XBee are configured.
- The next part of the code was used to set the ports and baud rate.
- After that the data was read from the sensor connected to the arduino.
- Then the created packets of data and set the communication channel to transfer the packets.
- After receiving the data on the meter side, the data is displayed on the meter.

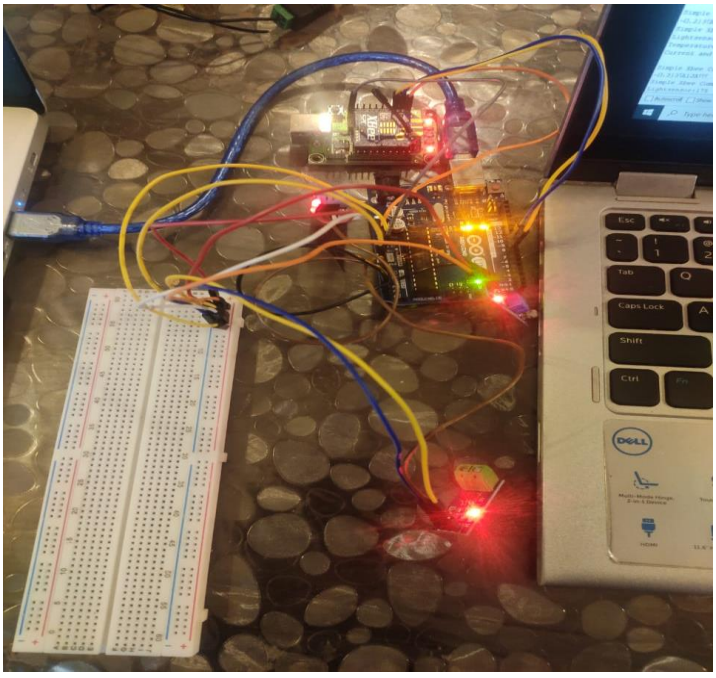

Figure 6 Proposed Model

6. RESULT AND DISCUSSION

ZigBee XBee protocol is used as the communication medium between the transmitter and receiver modules. The input signal is transmitted wirelessly to the other channel and the noise disturbance is

reduced using filter circuit. The measurement of current is carried out and a plot as shown in Figure 7 is drawn where the parameter value is on Y-axis and time is on X-axis.The above implementation can be used as a simple and cost-effective solution to transfer data to smart meters. The new ZigBee XBee standard performs well in industrial environments.

Table 4 Observed real-time data

	A	B
1	Day	Current
2	1	142.73
3	2	142.17
4	3	143.19
5	4	143.57
6	5	110.51
7	6	145.7
8	7	136.25
9	8	135.57
10	9	130.65
11	10	144.44
12	11	150.7
13	12	105.5
14	13	105.71
15	14	102.42
16	15	143.1
17	16	146.97
18	17	151.06
19	18	134.95
20	19	142.61
21	20	143.62
22	21	150.88
23	22	149.95
24	23	133.74
25	24	141.55
26	25	144.48
27	26	144.9
28	27	139.74
29	28	142.11
30	29	134.31
31	30	135.8

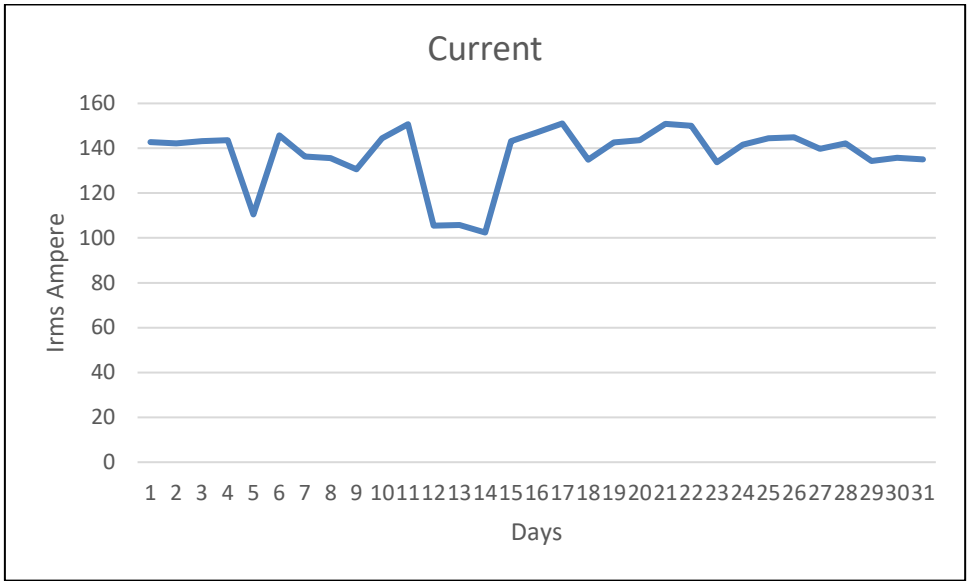

Figure 7 Output waveform between Irms(Amp) and days of the month

During the working condition, the data transmitted is wirelessly received as a small data packet on the XBee, and the XBee serial data is transmitted to the receiver pin RX of the Arduino UNO microcontroller. The required data can therefore be viewed directly on the Arduino IDE's Serial Monitor platform. The system uses a micro-SD card to store the data as a text file which can be later used to view the data on a computer. When we place XBee and Arduino in the coordinator, real time monitoring of the data received is done and it is stored as an excel file. With the help of these data the plot for variation of current is drawn.

7. CONCLUSION

This paper presents a prototype of a wireless communication system has been built based on XBee module. The flexibility of mesh networking Zigbee modules makes it a strong option for industrial automation. The initial stage was the collection of values obtained from various sensors. Then, using XBee communication, the data is communicated with the monitoring meter. It is a back and forth(both-way) communication between the smart plugs and the monitoring meter. Finally, the data is displayed on the meter. Wireless technology has already become an important application which usually integrated to a wide range of device and other technologies. This system uses the XBee as the wireless module. The combination of low-cost hardware, very good radio performance makes XBee a competitive choice on the wireless market. The use of XBee makes our entire system cost-effective and the plug-in devices have easy mobility and low maintenance.

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