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LABORATORY AND FIELD INVESTIGATIONS ON XBEE MODULE AND ITS EFFECTIVENESS FOR TRANSMISSION OF SLOPE MONITORING DATA IN MINES

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ABSTRACT

This paper describes the laboratory and field experiment of range testing of XBee PRO module. The Time Domain Reflectometry (TDR) used as a sensor for detecting the unstable slope movements in opencast mines. The XBee-PRO modules with Arduino boards are used for transmission and reception of data to the pit office; the TDR continuously captures the data. The XBee Configuration and Test Utility (XCTU) software is utilized for configuring and testing the XBee modules. The Range test provides the detailed data of the RSSI (Received signal strength indicator value); by transmitting 100 no of packets during Range test. These investigations are carried out as the part of the project sponsored by the Ministry of Mines, Government of India. This paper described experience gained while testing the XBee-PRO radio module in an indoor environment and mine site.

Keywords: XBee-PRO, Arduino, Testing, Time Domain Reflectometry (TDR), RSSI, Packets.

I. INTRODUCTION

Developments in information and communications technology (ICT) support the collection, connection and analysis of data through sensing and monitoring of trucks in mines. Sensors are parts of all machines that gather data and have an integral role in subsequent processing and transmission of data. Monitoring is a process that observes a state in time or tracks changes in data sets to derive information. Together, sensing and monitoring provide a mechanism for harvesting digital data [1]. Wireless communication is the burning need today for the fast, accurate, flexible safety and production process in mines. Communication is the main key factor for any industry today to monitor different parameters and takes necessary actions accordingly to avoid any types of hazards [2, 3]. To prevent loss of material and damaging to human health, protection system, as well as a

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faithful communication system, is necessary for mines. In this experiment, The Time Domain Reflectometry (TDR) is used as the sensor for the detecting the shear zones in opencast mines. The fundamental principle of TDR is similar to that of radar. In TDR, a cable tester sends a pulse voltage waveform down a cable grouted in a borehole. If the pulse encounters a change in the characteristic impedance of the cable, it is reflected. This can be caused by a crimp, a kink, the presence of water, or a break in the cable.

II. DESIGN OF HARDWARE SYSTEM

In this paper, we have proposed an advanced wireless system for mines to update the slope movements in opencast mines to the base station immediately and updating it to the web server and sending an alert message to the authorized person [4]. Block diagram of the wireless system is shown in Figure.1. Here we have an opencast section and the base station section. In the underground section first step is to connect all the eight cables in the Multiplexer (MUX). From the MUX 1, Output is connected to the TDR sensor to know the updates that the cables are incorrect positions and working properly. Next is to initialize the TDR sensors to sense the corresponding sensor levels in the places. These sensed Analog values are converted into digital values by using ADC and then there is LCD shows a connection between Micro-controller (MC) and ADC and the same digital values.

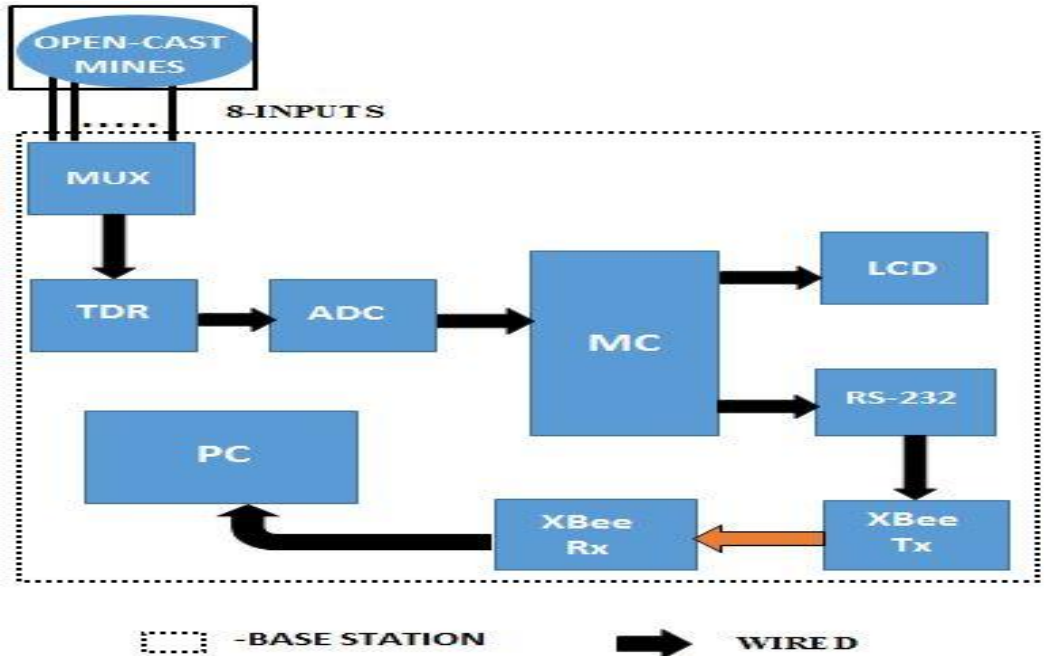

Fig.1.Block diagram of complete hardware setup.

The information is sent through RS-232 to XBee of the base station directly. If the sensor values exceed the thresholds, then the alarm in the mines gets ON to alert the miners who work at the mine site regarding the emergency.

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III. XBEE-PRO

It is primarily designed for the wide-ranging automation applications and to replace the existing non-standard technologies. It currently operates in the 868MHz band at a data rate of 20Kbps in Europe, 914MHz band at 40Kbps in the USA, and the 2.4GHz ISM bands Worldwide at a maximum data rate of 250Kbps [5, 6]. The XBEE specification is a combination of Home RF and the 802.15.4 specification. The specification operates in the 2.4GHz (ISM) radio band - the same band as 802.11b standard, Bluetooth, microwaves and some other devices. It is capable of connecting 255 devices per network. The power output of the XBee-PRO RF Modules must not exceed 10dBm.The XBee-PRO includes Asymmetric Link Handling which uses regular information exchange between nodes to select optimal links significantly improving network performance automatically. XBee-PRO security is now better than ever; a system-wide security key is mandatory and adds further protection for the primary management and distribution. Energy management is also improved in networks where ZigBee nodes run on batteries where power management is crucial. XBee-PRO allows end nodes to turn off for fixed periods of time permitting nodes to sleep longer in periods of 'Hibernation' or shorter periods of 'Napping' as needed by the host application. Two networks can overlap; something which becomes more likely in large systems. Figure.2 shows the hardware Diagram of XBee-PRO.

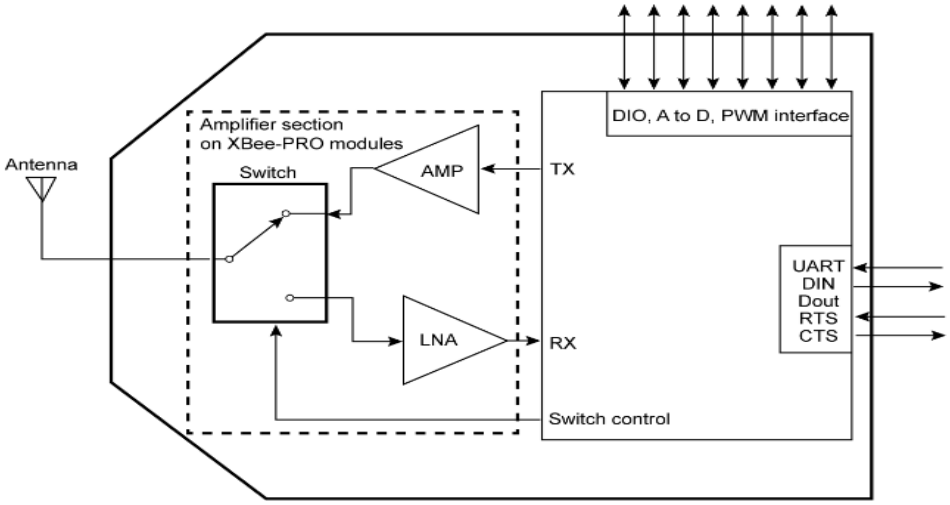

Fig.2. Hardware Diagram of XBee-PRO [4]

IV. INTERFACING

Modules interface to a host device through a logic-level asynchronous Serial port. Through its serial port, the module can communicate with any logic and voltage Compatible UART; or through a level translator to any serial device. Data is presented to the X-Bee module through its DIN pin, and it must be in the asynchronous serial format, which consists of a start bit, 8 data bits, and a stop bit. Because the input data goes directly into the input of a UART within the X-Bee module, no bit inversions are necessary within the asynchronous serial data stream. All of the required timing and parity checkings is automatically taken care of by the XBee UART. Just in case you are producing data faster than the X-Bee can process and transmit it, both X-Bee modules incorporate a clear-to-send (CTS) function to throttle the data being presented to the X-Bee module's DIN pin.

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You can eliminate the need for the CTS signal by sending small data packets at slower data rates. If the microcontroller wants to send data to the transceiver, it will send RTS (Request to Send) signal. If the transceiver is idle, it sends CTS (Clear to send) signal [7]. The RTS and CTS signals are active low. When microcontroller receives CTS command, it will send data to the transceiver through DIN pin. The transceiver will transmit the data to the microcontroller through DOUT pin. The communication between the transceiver and the microcontroller at the transmitter and receiver is similar. The communication between transmitter and receiver is through RF communication.

V. COMMUNICATION TESTING IN LABORATORY

A wireless communication system is designed for wireless transmission of the TDR data using ZigBee technology and Arduino Boards. XBee modules are the powerful RF modules transmitting data wirelessly using ZigBee wireless protocol (802.15.4). XBee module on the transmitting side is configured as a coordinator while XBee module on the receiving side as the router. XBee Configuration and Test Utility (XCTU) software is used for the configuration of the both XBee modules. Both of the Arduino are programmed separately to serve as a transmitter and a receiver. Wirelessly received data is then can check in the serial monitor of the IDE software used with Arduino. Figure.3 shows the laboratory set up including transmitter side and Figure.4 shows the receiver side to test the wireless transmission of the data.

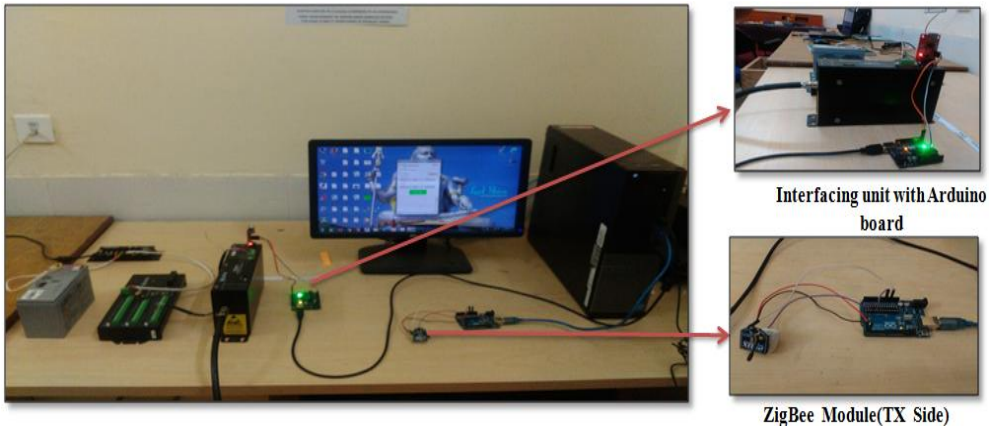

Fig.3 The lab set up including transmitter side

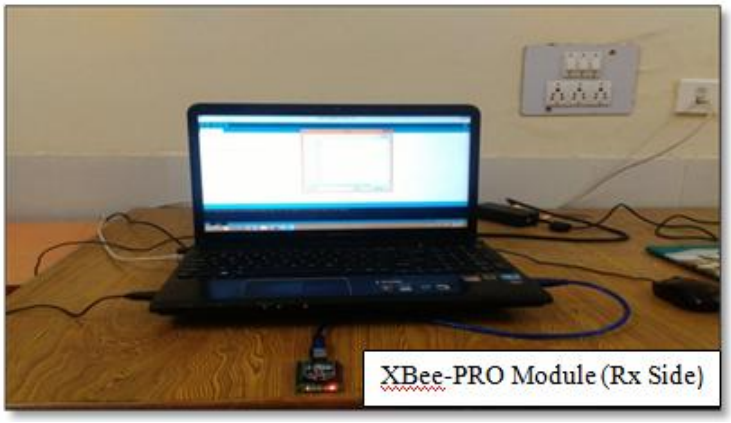

Fig.4 The laboratory set up receiver side

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TDR continuously senses the deformation present along the cable and generates the reflection coefficient values for the complete length of the cable. This real time data is continuously present on the com port of the TDR. Using the RS232 to USB breakout board, this real-time data is provided to the Arduino board. Arduino board continuously receives this data and transmits the same data to PC using USB cable. This data is then transmitted wirelessly using XBee module connected each on the transmitter and receiver side. Received data can be displayed in the serial monitor screen of the transmitter and the receiver side as shown in Figure.5.From this test, it can be concluded that TDR data can be transmitted wirelessly using XBee-PRO modules with Arduino boards. Figure.5 shows the data on serial monitor screens of the transmitter and the receiver side.

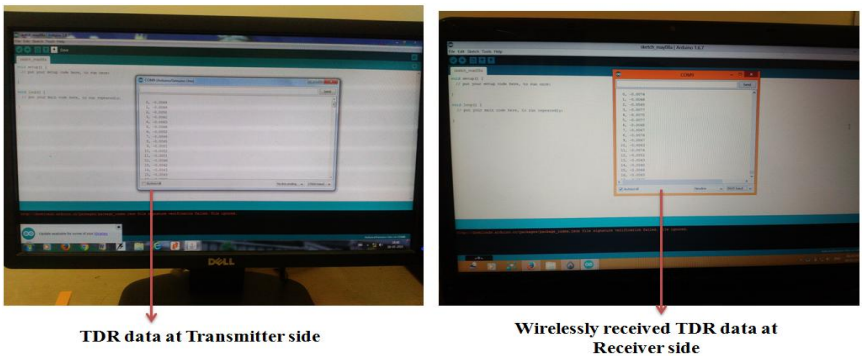

Fig.5 The serial monitor screens of the transmitter and the receiver side

VI. COMMUNICATION TEST AT THE FIELD

First field test of the developed system was carried out at the National Mineral Development Corporation Ltd, Panna Diamond Mine, MadyaPradesh. Complete set up of the developed system including TDR sensor unit, Power supply and the wireless transmission unit including XBee-PRO modules and Arduino Mega microcontroller board took at the mine site. Mine office is approximately 1Km far from the location selected for the implementation of the TDR system. Developed system transmitted the wireless sensor data up to 400m successfully and encountered a line of sight issue with increasing distance further more. Hence it is proposed to add router between two end nodes to minimize the line of sight issue. Also, one more solution is to elevate the XBee modules from a base as high as possible to reduce the attenuation of transmitted energy due to the earth surface. Figure.6 shows the communication test at mine site.

Fig.6.Communication test at mine site

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VII. RANGE TEST AT THE FIELD

A testing tool is available in the XCTU software for testing the range of the XBee RF modules. In this test the ease of the wireless transmission between the connected XBee modules is tested. One of the XBee modules generates 100 no. of packets (signals), one by one and transmits it wirelessly. XCTU software continuously updates the information after transmission of each packet. Receiver XBee provides the acknowledgement signal after receiving each of the packets. From the Figure. 7 it can be observed that 100 packets are sent from the transmitter XBee from which 99 are received successfully and 1 packet is missed during wireless transmission. Also it shows the change in the RSSI value during packets transmission. RSSI is the Received signal strength indicator value which shows the measurement of the power present in a received radio signal. Figure.8 shows the graphically how the RSSI value is varied during the packets transmission during the range test. At some points RSSI value is decreased to some extent, this is due to the line of sight issues encountered at the mine site.

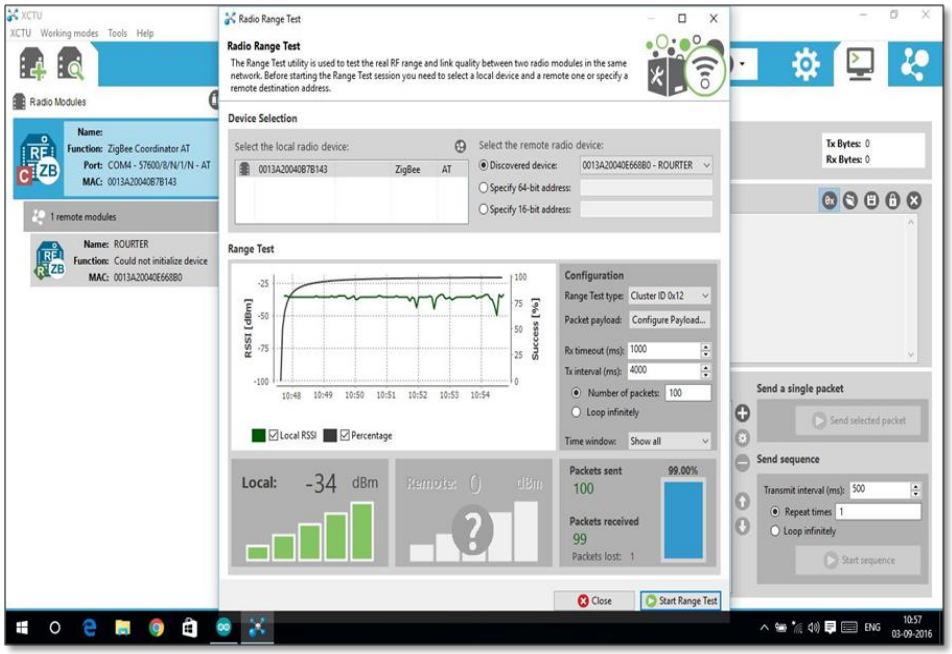

Fig.7.Screenshot taken during Range testing at mine site using XCTU software

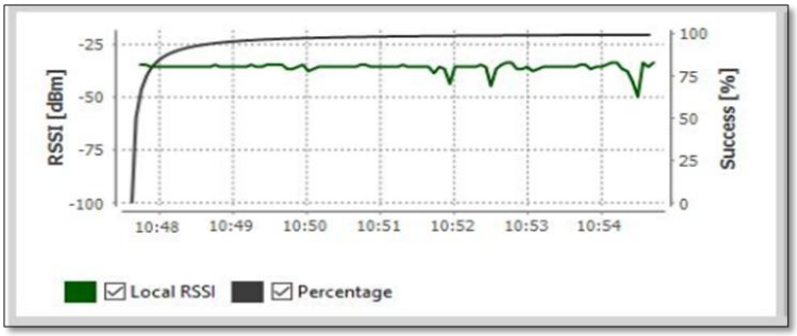

Fig.8.Graphical representation of the variation of RSSI value during Range test.

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VIII. CONCLUSION

Attempts made to develop the indigenous wireless system in typical mining conditions for transmission of real-time data generated by the TDR sensor indicated successful transmission of data without any packet loss up to 400 m. The developed wireless transmission system is much efficient as observed during range test, only a single packet is missed among the sent 100 no. of packets... Wireless transmission system integrated with the XBee-PRO RF Modules and Arduino Mega microcontroller board provides a low-cost solution for the monitoring of the sensor data remotely. Use of general-purpose electronic components have made the wireless communication system universal and can be used with different kind of sensors like tilt-meter, accelerometer, etc. as per future need. The range of the transmission can be increased by adding the routers between two end nodes as per need.

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