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WIRELESS SENSOR NETWORK FOR MONITROING OF BLAST-INDUCED GROUND VIBRATION

[1]Prashanth Ragam , [2]Prof.Singam Jayanthu , [3]Guntha Karthik

[1]Phd.Scholar, [2]Professor, [3]Phd.Scholar Mining Engg Dept., NIT Rourkela, Odisha

ABSTRACT

The major objective of blasting in mining is to fracture the rock material and move the rock. Usage of Explosive generates ground vibration which is undoubtedly influence on surrounding structure. In order to monitor the effect of the blast-induced vibration on structures, a Wireless sensor network has been proposed. Earlier, the conventional wire system like minimate, minimate plus were used to monitor the ground vibrations which are expensive. To mitigate high cost problem, we proposed a novel low cost and low power wireless sensor network and advantages and features of a wireless sensor network system is addressed and compared with conventional wired systems like Instantel Blast mate-III, Minimate, Minimate plus. Etc. Thus, the review explains a frame work of the process of monitoring and transferring sensed ground vibration data from a blast site to monitor site while blasting in mines.

Key words: Wireless network, ground vibration, ZigBee

1. INTRODUCTION

In Mines, Blasting is the principal method of rock fracture. This process gives distinct advantages like economy, efficiency, convenience and the ability to break the hardest rocks. However, approximately 20 to 30% of total energy of an explosive is utilized in fragment the rock or other materials around and remaining is dissipated [1]. The dissipated energy creates environmental harms in the form of ground vibration, air blast and fly rock. Ground vibrations are an integral part of the process of rock blasting and consequently they are unavoidable, with the general trend toward large blasts in mining and construction projects vibration problems and complaints have also increased because of causing human annoyance and structural damage.as per Directorate General of Mines Safety (DGMS) circular No.7 of 1997 in India the permissible peak particle velocity (PPV) of ground vibration at sensitive sites should be below 5mm/s at all times[2]. Therefore, it is very important to monitor the blast ground vibrations to accomplish efficient blasting. The existing wired systems like instantel Blast mate III, Minimate and Minimate plus are monitoring the blast ground vibration. But the problems of existing systems are data acquisition and transferring with in limited area, it become incapable if the wire is cut which happens frequently and must be purchased which is tremendously expensive. By way of a result it is important to the development of wireless network having an economic feasibility to effective sensing and monitoring the blast-induced ground vibration.in this paper, ZigBee based wireless communication prototype module which could change the existing wired conventional systems [3].

II. GENERATION OF GROUND VIBRATION

The ground vibration or also called as seismic energy is defined as a time varying displacement, velocity, or acceleration of a particular point (particle) in the ground. Blast ground vibrations propagating through the surface may damage adjacent structures when they touch a certain magnitude.

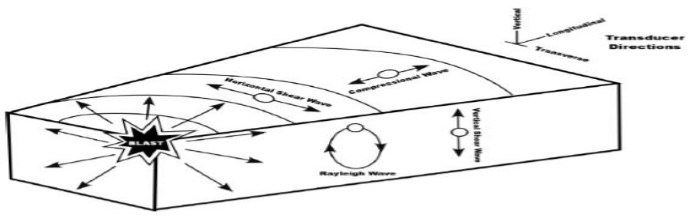

Fig.1. Movement of particles associated with the different wave types

III. TYPES OF VIBRATING WAVES

Vibrating waves are classified as Body waves and Surface waves. Body waves travel within a medium, whereas surface waves are restricted to travel along free interfaces, such as the ground surface [4]. Body waves comprise two discrete components. They are compression or P-wave and shear wave or S-wave. Two types surface waves usually produced from normal mine blasting. Rayleigh(R) waves and Love (L) waves. The P-wave is the fastest, followed by the S-wave. The wave motion of P waves is illustrated in Figures 1. The ground motion can measure in terms of peak particle velocity (PPV). Thus the peak particle velocity (PPV) is given by the following formula

$$PPV\ (mm/sec) = K * (SD)^{-\beta} \ldots\ldots\ldots (1)$$

$$\text{Where scaled distance } (SD) = \left(\frac{D}{\sqrt{Q}}\right) \ldots\ldots\ldots\ldots\ldots (2)$$

K is the ground transition coefficient and, β is a specific geological constant. D is the absolute distance between the shot and the station (m) and W_d is the maximum explosive charge per delay (kg). In ground vibration analysis, preferably square root or rarely cube root scaling in used, whereas in air overpressure analysis cube root scaling is used.

IV. EXISTING SYSTEMS

A number of manufacturers have developed different models of blasting seismograph with different failings and features and modified to reflect advancing technology. Most used Instruments in common use in India are Instantel – Blast mate-III, MiniMate and MiniMate Plus…etc… they may vary depending upon on the type, but in general, they have 1 to 8 input channels so that a variety of types of sensors for measuring ground vibrations.

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Fig. 2. Blast mate III (instantel)

As for the experimental blasting in mines, generally conventional sensors like blast mate-III, Minimate Plus and Minimate Equipped with two sensors. Figure.2. shows a blast mate III type conventional sensor systems and have one geophone and one Microphone which are used for measure blast vibration and air blast.

V. FIELD INVESTIGATION WITH EXISTING SYSTEM

IDL Explosives Limited is one of the leading manufacturers of industrial explosives of India and caters the needs of various mines of the country. Explosion clad plates are also being manufactured which are used in various applications like chemical, petrochemical, ship building, smelters etc., Cladding is being conducted on sand base surface which is spread uniformly and the plates are cladded with the help of explosives in form of powder which is initiated by remote device. In the present studies efforts are made to estimate the effect of blast due to metal cladding at various distances from the blast site based on empirical/analytical approaches on the basis of the observations of ground vibrations. With the help of Minimate, a number of Blasts were monitored near the surrounding areas and structures from the blast site. Figure.3. describes the blast site and Figure.3. represents locate the monitor point to measure ground vibration.

Fig.3. monitoring of ground vibration with minimate

VI. CALCULATED PPV BY EMPIRICAL EQUATIONS

By Regression Analysis of the data related to ground vibrations at different explosive charge and distance

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between blast site and the monitoring stations, following empirical Equation was found to represent the observed data shown in Table.1. Graph between PPV Vs. Scaled distance(SD) shown in Figure.4.by using equation 1 and 2, the site constants K and β are found out to be K=14.36 and β = -0.80

Table.1. Observations from the regression analysis

Distance(m)	PPV($\frac{mm}{sec}$)	Charge(Kg)	SD
354	1.48	540	15.23
493	1.02	180	36.74
500	1.78	300	28.86
500	1.11	90	52.70
564	0.64	50	79.76
720	0.32	200	50.91
777	0.57	195	55.64
1020	0.32	100	102.00
1320	0.25	540	56.80
1500	0.19	150	122.47
1520	0.38	530	66.02
1850	0.44	90	195.00
1990	0.32	270	121.10
2750	0.19	270	167.35

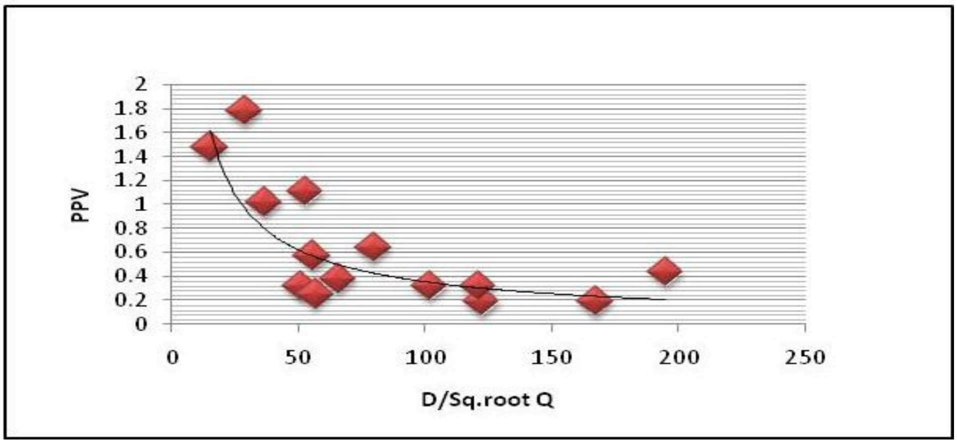

Fig.4: PPV Vs SD (sq. root Q)

Attempt was also made to understand the safe explosive charge based on the analysis of ground vibrations generated by blasting for metal cladding through and statistical techniques. Table.2. presents the results of the predicted PPV at various distances from the source of blasting for different weights of explosive charge per blast. It can be inferred that for explosive charges within 700 kg, the PPV is within the safe limit of damage to domestic or industrial structures located at a distance of 100 m from the blast site. For distances beyond 200 m from the blast site, the PPV was within safe limit of 5 mm/sec with explosive charges upto 1000 kg. For the explosive charge of about 550 kg being used as maximum explosive charge during the experimental trials at the IDL site, the PPV predicted for the structures at 100 m, 200 m, 400 m, and 600 m distance from blast site is 4.5, 2.59, 1.48, and 1.07 respectively. This indicates that even sensitive structures with safe damage limit of 2 mm/sec at a distance beyond 200 m may also be safe as per the observations and analysis of data from the blast site.

Table.2: Predicted PPV at various distances from the source of blasting for different weights of explosive charge per blast

Weight of Explosive (kg)	Predicted PPV (mm/sec) at different Distances (m) from the source of blast						
	At 100 m	At 200 m	At 400 m	At 600 m	At 800 m	At 1000 m	At 2000 m
50.00	1.72	0.99	0.57	0.41	0.33	0.27	0.16
100.00	2.28	1.31	0.75	0.54	0.43	0.36	0.21
150.00	2.68	1.54	0.88	0.64	0.51	0.42	0.24
200.00	3.00	1.72	0.99	0.72	0.57	0.48	0.27
250.00	3.28	1.89	1.08	0.78	0.62	0.52	0.30
300.00	3.53	2.03	1.17	0.84	0.67	0.56	0.32
350.00	3.76	2.16	1.24	0.90	0.71	0.60	0.34

400.00	3.96	2.28	1.31	0.95	0.75	0.63	0.36
450.00	4.15	2.39	1.37	0.99	0.79	0.66	0.38
500.00	4.33	2.49	1.43	1.03	0.82	0.69	0.39
550.00	4.50	2.59	1.48	1.07	0.85	0.71	0.41
600.00	4.66	2.68	1.54	1.11	0.88	0.74	0.42
700.00	4.96	2.85	1.64	1.18	0.94	0.79	0.45
800.00	5.23	3.00	1.72	1.25	0.99	0.83	0.48
900.00	5.48	3.15	1.81	1.31	1.04	0.87	0.50
1000.00	5.72	3.28	1.89	1.36	1.08	0.91	0.52

VII. DEVELOPMENT OF A WIRELESS SENSOR NETWORK

The proposed system suggested in this paper is equipped with a 3-axis acceleration sensor, an A/D converter, Atmega microcontroller and ZigBee-based communication system, as shown in Figure.5.

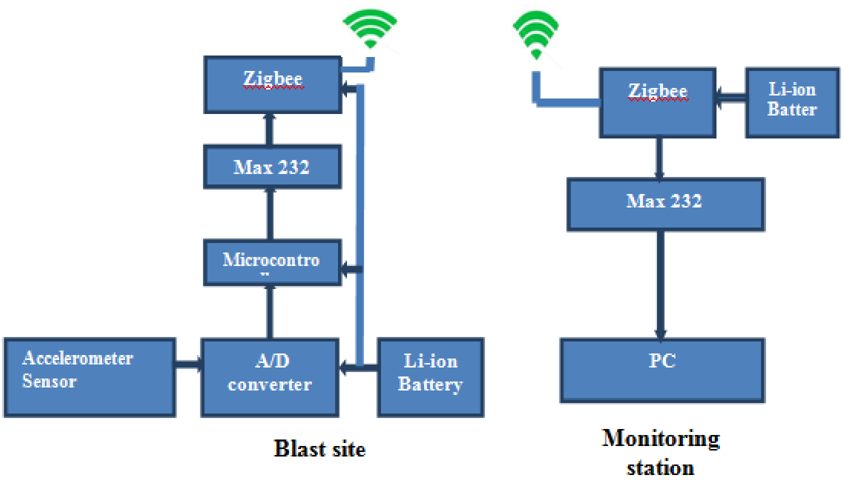

Fig.5. Block diagram of proposed system

The wireless sensor network for evaluate blast induced ground vibration presented in this paper consist of a number of sensor and a PC. Sensor has a zigbee based wireless sensor network in the PCB board so that the data can transmit wirelessly send and transmit the sensed data between each other. Figure.6. shows the proposed system diagram. Each block explained in detailed below

7.1 ACCELEROMETER SENSOR

Accelerometer sensor is a basically inertial sensor capable of a high range of sensing. Accelerometers are measure the acceleration in one, two, or three orthogonal axis. The most available 3-axis accelerometers are LIS302DL, ADXL 335, ADXL 345, DE-ACCM3D2, and ADIS16228.

7.2 A/D CONVERTERS

An analog-to-digital converter (A/D) is a converter device that used to converts a continuous signal (usually voltage) to a digital number that represents the signals amplitude.

7.3 MICROCONTROLLER

Microcontroller is a single integrated circuit which contains a processor core, memory, and programmable input peripherals on a single board. The main function of microcontroller to process the data as per commands and execute it. Program memory available in the form of Ferroelectric RAM , NOR flash included and RAM on chip

7.4 MAX 232

The main function of MAX 232 is converts signals from a TIA-232 (RS-232) serial port to signals suitable for use in TTL compatible digital logic circuits like either 0 or 1

7.5 ZIGBEE

Zigbee is a new wireless technology guided by the IEEE 802.15.4 Personal Area Networks standard. 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.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. Figure.6. indicates how the Data Flow Diagram from source to destination using of the X-Bee RF

7.6 COMMUNICATION ESTABLISHMENT

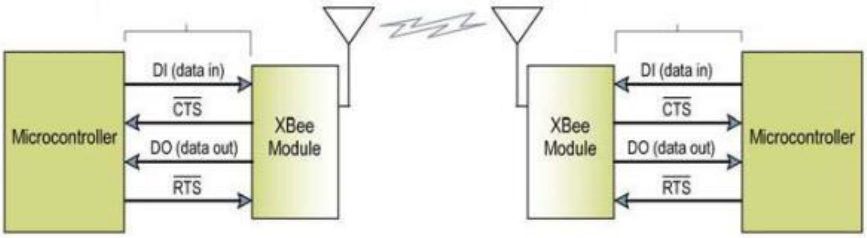

Fig.6.Data Flow Diagram of the X-Bee RF [5].

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 checking is automatically taken care of by the XBee's 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. 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 transceiver, it will send RTS (Request to Send) signal. If the transceiver is idle it sends CTS (Clear to Send) signal.

VIII. CONCLUSION

Critical review of development of a low-cost wireless sensor network by zigbee technology is a feasible alternative to conventional sensor like blast mate-III, minimate and minimateplus to monitor blast induced ground vibration. This sensor network is a product where accelerometer sensor, signal processing, transmitter/receiver and self-driving power are on PCB. Here accelerometer sensor sense and measures three-way acceleration within the range -18 to +18g (g acceleration of gravity) and vibration measurement bandwidth within the range of 0 Hz up to 1 KHz

REFERENCES

[1] A. Parida, Blast vibration analysis by different predictor approaches-A comparison, Proc. 4th Earth and Planetary Science 11. India, 2015, 337-345.

[2] S. Jayanthu, Ch. Naveen, G.V Rao and B.R.V. Susheel Kumar, ground vibrations in opencast mine blast on structures vis-à-vis a local environmental effect and its mitigation through mining technology,2010.

[3] Kwon, S. W, Wireless vibration sensor for tunnel construction, Proc. of the 23rd International Symposium on Automation and Robotics in Construction, India,2006,614-619.

[4] Pijush Pal Roy, Rock blasting: effects and operation (A.A. Blakema publishers, Leiden, The Netherlands, 2005).

[5] Chan, H. K., Agent-based factory level wireless local positioning system with ZigBee technology, IEEE Systems Journal, 4(2),2010, 179-185.