DEVELOPMENT OF INDIGENOUS WIRELESS TILTMETER FOR SLOPE STABILITY MONITORING IN OPENCAST MINES

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ABSTRACT

This paper presents the feasibility of using already existing triaxial accelerometer for tilt sensing in slopes. It is also proposed to design, a wireless tilt meter by Arduino boards, Global System for Mobile Communications (GSM) modules and triaxial accelerometer which could be specially tailored for the needs of monitoring hazardous rock bodies in surface mines. By recording angles of any slope, in a surface mine, over extended periods of time, changes in readings can infer instabilities in the rock mass underlying the slope being measured. By placing many tiltmeters in a mesh on a surface slope, the entire surface can be monitored. Compared to the measurements of a single point using one instrument, a dense network can be extremely useful in detecting rock movement. The recorded data will be transmitted by using the GSM modules.

Keywords: *Slope stability, Accelerometer, GSM Module, Arduino.*

INTRODUCTION

Many monitoring techniques are in use already in mines. Traditional methods of monitoring, though undeniably useful, are often time consuming. By utilizing wireless devices that transmit data back to a single location, data acquisition and analysis time can be minimized, saving the mine employee hours as well as down time. As surface mines continue to deepen, and underground mines continue to progress further from the surface, the extent of necessary monitoring continues to increase: this widening range will require greater time for proper monitoring, unless an automated system is implemented. With proper wireless equipment, real time monitoring of an entire mine is possible.

For the purpose of this paper, the term “slope” can refer anything that has a measurable angle. The depth of opencast mines can increase the dangers of slope stability issues, but deep open pit quarries are not the only victims of surface mining slope failure. Even relatively shallow mines can experience destructive consequences from undetected slope instabilities. Proper monitoring of slopes and rock masses can help a mine operator recognize when the probability of a failure is higher than usual. This pre-failure warning can help the mine in many ways. The objective of slope monitoring is to detect, before failure, possible instabilities to allow the operator to take appropriate remedial measures. The main concern and main purpose of monitoring is the protection of men and equipment.

PROPOSED SYSTEM

Arduino is an open-source single-board microcontroller. This paper is about interfacing accelerometer to Arduino. The MEMS IC is a low cost, Tri-axis thermal accelerometer capable of measuring tilt, acceleration, rotation, and vibration with a range of ±3 g. These Micro-electro-mechanical systems (MEMS) IC based accelerometers have an advantage over the conventional laboratory accelerometers that they are capable of measuring the acceleration due to gravity (represented by dynamic acceleration).

The accelerometer sensor to be interfaced with Arduino based GSM module. Coding is going to be done by using the Arduino Integrated Development Environment - or Arduino Software (IDE) which contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and other hardware to upload programs and communicate with them.The Block Diagram of proposed system shown in Figure.1.

Operation

- The data is first obtained from the accelerometer sensor.
- The obtained data is then processed using Arduino.
- Thereafter the processed data is sent to GSM module.
- Thus, user can receive the data from GSM through any displaying device.

Advantage of this Arduino based system with other existing system

- High Processing speed.
- Coding is simpler.
- Arduino is compatible with every microcontroller, even with the Intel board.
- It is a cost-effective system.

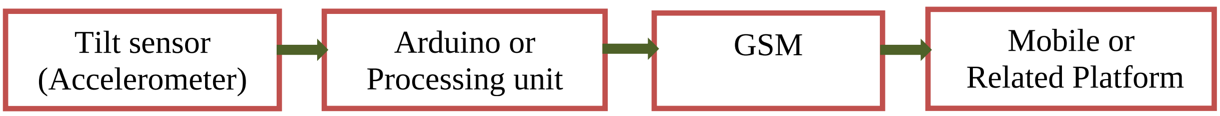

Fig.1.Block Diagram of proposed system

TRIAXIAL ACCELEROMETER(ADXL345)

In this method for inclination sensing with three axes is to determine the angle individually for each axis of the accelerometer from a reference position. The reference position is taken as the typical orientation of a device with the x- and y-axes in the plane of the horizon (0 g field) and the z-axis orthogonal to the horizon (1 g field).The ADXL345 is a small, thin, low power, 3-axis accelerometer with high resolution (13-bit) measurement at up to ±16g. Digital output data is formatted as 16-bit twos complement and is accessible through either a SPI (3- or 4-wire) or I2C digital interface (Figure.2.). The ADXL345 is well suited for mobile device applications. It measures the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion or shock. Its high resolution (4 mg/LSB) enables measurement of inclination changes less than 1.0°.Several special sensing functions are provided. Activity and inactivity sensing detect the presence or lack of motion and if the acceleration on any axis exceeds a user-set level. Tap sensing detects single and double taps.

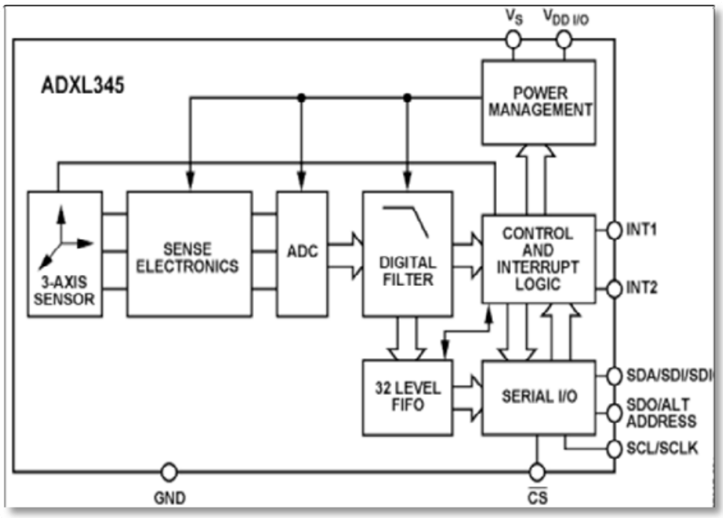

Fig.2. Circuit Diagram of triaxial Accelerometer(ADXL345)

Free-fall sensing detects if the device is falling. These functions can be mapped to one of two interrupt output pins. An integrated, patent pending 32-level first in, first out (FIFO) buffer can be used to store data to minimize host processor intervention. Low power modes enable intelligent motion-based power management with threshold sensing and active acceleration measurement at extremely low power dissipation.The ADXL345 is supplied in a small, thin, 3 mm × 5 mm × 1 mm, 14-lead, plastic package.

ARDUINO

Arduino is an open-source computer hardware and software company, project and user community that designs and manufactures microcontroller-based kits for building digital devices and interactive objects that can sense and control the physical world. The project is based on a family of microcontroller board designs manufactured primarily by Smart Projects in Italy, and also by several other vendors, using various 8-bit Atmel AVR microcontrollers or 32-bit Atmel ARM processors. These systems provide sets of digital and analog I/O pins that can be interfaced to various expansion boards ("shields") and other circuits. The boards feature serial communications interfaces, including USB on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino platform provides an integrated (IDE) based on the Processing project, which includes support for C, C++ and Java programming languages. The first Arduino was introduced in 2005, aiming to provide an inexpensive and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors. Arduino boards are available commercially in preassembled form, or as do-it-yourself kits.

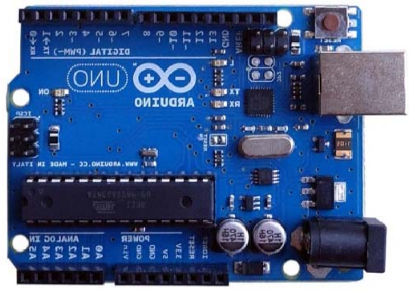

Fig.3. Arduino UNO

GSM

GSM (Global System for Mobile Communications, originally Groupe Spécial Mobile), is a standard developed by the European Telecommunications Standards Institute (ETSI) to describe the protocols for second-generation (2G) digital cellular networks used by mobile phones, first deployed in Finland in July 1991. As of 2014 it has become the default global standard for mobile communications - with over 90% market share, operating in over 219 countries and territories. Designed for global market, SIM800 is a quad-band GSM/GPRS module that works on frequencies GSM 850MHz, EGSM 900MHz, DCS 1800MHz and PCS 1900MHz. SIM800 features GPRS multi-slot class 12/ class 10 (optional) and supports the GPRS coding schemes CS-1, CS-2, CS-3 and CS-4(Figure.4).

Fig.4. GSM Module (SIM800)

Main features

- Bands: GSM 850MHz, EGSM 900MHz, DCS 1800MHz, PCS 1900MHz
- Coding schemes: CS-1, CS-2, CS-3, CS-4
- Tx power: Class 4 (2W), Class 1 (1W)
- Small package: 23 * 23 * 3mm
- Power supply voltage: 3.4 - 4.4V

- Lowe power: down to 1mA in sleep mode
- TCP/IP TCP/IP AT firmware
- Operating temperature: -40C do +85C
- Support up to 5*5*2 Keypads
- One full function UART port, and can be configured to two independent serial ports.
- One USB port can be used as debugging and firmware upgrading.
- Audio channels which include a microphone input and a receiver output.
- Programmable general purpose input and output.
- One SIM card interface.
- Support Bluetooth function.
- Support one PWM.
- PCM/SPI/SD card interface, only one function can be accessed synchronously. (default function is PCM)

PROPOSED FIELD INVESTIGATIONS

On the basis of detailed geotechnical studies carried out in the field, application rock mass classification system, numerical modeling etc, it is proposed to install the above wireless tilt meter in one of the MOIL mines (Fig 5) [4,5,6,7]. Dongri Buzurg Mine of Manganese Ore mine of M/s. MOIL is located in the Bhandara district of Maharashtra is an opencast mine that produces manganese dioxide ore used by dry battery industry.

Assessment of the stability of slopes in open pit mines at different stages of mining is important for the safe and economic mining operations. Slopes are generally designed based on the geotechnical data and physico-mechanical properties of rock/soil. From geotechnical data, the rock mass quality is assessed, and from this, the rock mass properties are estimated. Using the rock mass properties stability of the slopes is evaluated from empirical, analytical and numerical techniques. In homogenous, isotropic ground conditions, the factor of safety can be determined for predefined failure modes using limit equilibrium. Similarly, using analytical solution, flexural breaking of rock mass can be determined. Design charts can be developed using limit equilibrium method. Some design charts are available for plane, wedge, circular modes of failure, and for toppling failure. The field engineer can use them if the basic geotechnical properties are known. These charts are useful to analyse only simple types of predetermined failures, but not for determining the slope angle which depends on the rock mass stability [6].

Surface exposures were mapped to get the discontinuity data. Within the footwall strata, there are four sets of discontinuities including the schistocity. They are:

a) Schistocity - its general trend is 50^0 dips due 170^0 (striking roughly E - W).

b) Joint Set no. 1 - these are inclined joints, with roughly E-W strike (dip amount 35^0, and dip direction 345^0). The mean spacing is 40 cm, and the joint surfaces are smooth, planar.

c) Joint Set no. 2 - this set is a westerly dipping set (dip amount 40^0, dip direction 270^0). The joint surfaces were smooth and undulating, and the joint spacing is 1 to 3 m.

d) Joint Set no. 3 - this set has 50^0 dip amounts and dip direction is 220^0. The joints in this set have rough, planar surfaces, and the joint spacing is 2 m.

The hangwall strata also contain three sets of joints: one $75^0/060^0$ (planar, smooth surfaces) with a spacing of 10 to 50 cm; the second one $43^0/325^0$ (planar, rough surfaces) spaced at 15 cm; and the third set $55^0/135^0$ (rough, irregular), which occurs at 3 m interval. In addition, the schistocity has a prominent trend of $50^0/175^0$. Due to tendency of slope failures in footwall it is proposed to monitor with various instruments in footwall side in addition to monitor with total station. Joints are also observed to be favorable for instability in footwall side compared to hang wall [7].

Fig.5. Proposed location of wireless tilt meter in Footwall of the Dongri Buzurg Mine, MOIL.

CONCLUSION

In the proposed model the data will be processed using Arduino, Thereafter the processed data is sent to GSM module. The user can receive the data from GSM through any displaying device and it is a cost-effective system compared to the available wireless tilt meters. Advancements as such would allow mining operators to continually monitor the slopes, in real-time, areas of interest using dense meshes created of multiple wireless tilt sensors. The use of wireless sensors to monitor slope stability would help to improve the understanding of rock behavior, as well as increase predictability of failure(s).

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