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A CERTAIN INVEST IGATION ON MINE ENVIRONMENT MONITORING USING SMART LOW POWER WIRELESS SENSOR NETWORKS.

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Abstract—This project describes the work carried out on the design and construction of a mine safety system prototype using a wireless sensor network with the objective of building a safety system to monitor the ambient characteristics of the mining environment. A review of the current literature relating to the health and safety of mine workers and mine safety systems is done..Now we use here a IOT (internet of things) to send the information in a long distance to the main base station where the necessary actions can be passed immediately.we use here a different type of sensors for temperature , humidity, air flow,noise measurement. The average mine worker is exposed to the harsh underground environment which can sometimes incur an injury or cause loss of life. A portion of these injuries/fatalities can be attributed to human error.

Index Terms—Mining industry, sensor systems, temperature measurement, humidity measurement, airflow measurement, noise sensor measurement, wireless sensor networks, Zigbee,internet of things(IOT).

I. INTRODUCTION

Mining as defined by the Oxford Dictionary is the process or industry of obtaining coal or other minerals from a mine. The activities carried out in order to obtain these minerals have a dangerous element to them. The average mine worker is exposed to the harsh underground environment which can sometimes incur an injury or cause loss of life. A portion of these injuries/fatalities can be attributed to human error

Here is an specific systems or schemes which are put into place for these hazardous environments in order to protect the worker from harm. The higher level term for these systems/schemes is the Occupational Health and Safety. The International Organization of Standardization or ISO have a standard namely the ISO 45001. This standard aims to reduce the liability of occupational injuries and diseases not only to benefit the workers but also the economy upon which this work builds. These accidents can lead to losses due to early retirements and increased insurance premiums for the mine. The cooperation of this standard is crucial and is observed by the certification to a majority of the major mining companies in South Africa. This standard can be reinforced through the implementation of modern technology alongside policies to obtain the best result.

The method of communication is largely dependent upon the network topology or architecture that is implemented. The two main topologies which will be considered in the scope of this project is the mesh and star network topologies. A mesh topology sees each node connected to a minimum of two nodes. The star network sees each node connected to a hub or central node; therefore each node can only communicate with this hub directly. The use of wireless sensors networks provide a variety of advantages including but not limited to a reduction of wiring, ease of implementation and it provides a non-invasive method of monitoring the state of the mine's conditions i.e. monitoring without having to expose a person to the potentially hazardous environment. In addition to these, control can be imposed on the environment from a remote location allowing a person to interact with the surrounding environment without having to be in that environment.

This Requirement first be measured by the use of sensors. These sensors measure analog voltage values based upon specific ambient characteristics. The applications of sensors are vast in that there are a large number of characteristics which can be measured. The utility of sensors is apparent in applications where the characteristic measurement is required in real-time. The characteristics measured in this project include: temperature, air-flow, humidity, noise, dust and gas concentration.

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The practice of mining can be dangerous and unsafe. The previous statement is only true for mines that do not monitor conditions inside the mine. There exists a relationship between three entities namely a hazard, latent danger and an accident which find their existence due to this dangerous and potentially unsafe practice.

The system was completely designed from first principles, this includes the sensor hardware, device hardware, PCB layout, software algorithms, as well as a graphical user interface. The proposed system designed examines and implements certain functionality that solves the above-mentioned short comings or limitations in real-time mining environment monitoring. The system allows for monitoring of multiple different zones inside the mine, the protection of mine workers from excessive noise levels and the storage of measurement data for purposes of reference

This paper is organised as follows. Section II discusses the system components and the containing interfaces. Lastly we completed our paper.

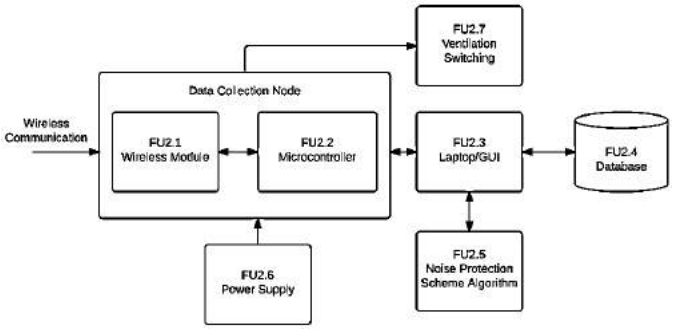
2. Project OVERVIEW

We see the wireless based mine safety system functional level description over here.

This is the component should be responsible for all measurements made. The measurement node should contain many different sensors that will return values such as gas concentration, temperature, humidity, air flow and noise levels. These values should then be transferred via a wireless link to data collection station ; this station will have the necessary hardware and software to perform the required processing, displaying and storage of values. In addition to this the data collection station is also responsible for producing a safety scheme for workers using the values collected. The measurement node and the data collection node should communicate only via the ZigBee wireless protocol.

The various sensors is the focal point of this project without which the creation of the desired system can be

sensors.



Collection Node Functional Level Diagram.

This is the necessary hardware required to communicate the sensor data to the laptop computer/GUI (FU2.3). The visual illustration of testing data is vital to the project's outcomes and overall impression. The GUI (FU2.3) will display the values which originate from the measurement node (FU1). These values are originally input to the laptop via the USB interface from the microcontroller's (FU2.2) output commands. The data collection node should be powered by a power supply (FU2.6). The power supply unit should take the domestic voltage supply (220 – 240 V_{ac}) and convert it to two smaller DC voltages which will power this node. Depending on the conditions measured by the air-flow and gas sensors, a ventilation switching module (FU2.7) will be controlled. Another functional unit that interfaces with the GUI will be called the noise protection scheme algorithm (FU 2.5). This unit is the module which will provide the noise protection scheme depending on past and present values obtained from the measurement node. The values obtained from testing should also be stored in a database format. Records of the values measured should be stored in a Database (FU2.4). This database will allow for the comparison between past and present testing results which should be used to evaluate the state of the mines safety conditions.

3.SYSTEM DESIGN

Ambient air temperature can be measured in mine by this sensor. This sensor was built from first principles using a load balanced thermistor circuit. This circuit acts as a voltage divider between the thermistor and the applied resistor . A thermistor is a temperature dependent variable resistor. Although all resistors are sensitive to temperature changes, thermistors are especially sensitive to temperature due to the material it is constructed from. This material has a specific resistivity. This resistivity is a constant for that material. The temperature sensor.

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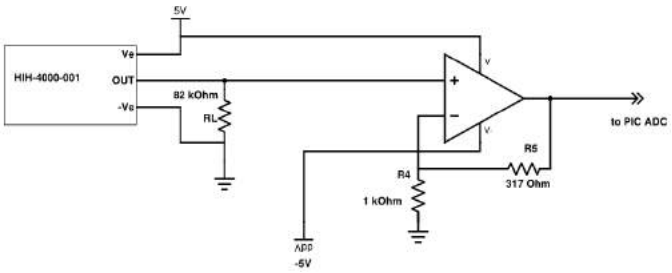
The thermistor used has a resistance of 2000 ohms at 24 °C. Before the load resistor value choice is justified, the process of calibration and measurement from this sensor will be elaborated. The 3-Point calibration method was used. This involves measuring the resistance of the thermistor at 3 different temperatures. Solving for the thermistors characteristic constants, the following values were found.

$k_a = 1.694 \times 10^{-3}$
$k_b = 1.886 \times 10^{-4}$
$k_c = 4.412 \times 10^{-7}$

This equations are used for the temperature measurement need constants.

Humidity:



Humidity Sensor Circuit

A Humidity sensor senses ,measures and reports the relative humidity in the air. It therefore measures both moisture and air temperature. Relative humidity is the ratioof actuval moisture in the air to the highest amount of moisture that can be held at the air temperature.The warmer the air temperature is the more moisture. This operational amplifier is used to add the required gain to increase the output range. By adding this gain, the resolution of the humidity measurement is made larger.

Airflow Sensor :

Ambient airflow can be measured by this sensor. A slotted optical switch is a component which consists of an led and a phototransistor. The led emits a near infrared light directly through a small aperture towards the phototransistor. The slotted optical switch used in this design is the OPB804. Upon detecting this light, the transistor will activate and switch on thus the voltage level changes from low to high. The schematic in figure 9 on the following page illustrates the circuit used for the airflow sensor.

The resistance value of R_{23} is chosen to be 1kΩ; it is used as a current limiting resistor to protect the optical switch's led. The current flowing through the LED is 4/1000 = 4 mA which is below the maximum rating of the optocoupler which is 50 mA. The resistor R_{24} is chosen to be 10kΩ as the output of the optical switch will be input as a high or low level voltage value to the microcontroller. This pull down resistor allows for the value to settle at the appropriate level. The optical switch works in conjunction with a small piece of metal mounted onto the bearing of the anemometer. As the anemometer rotates, this metal interrupter crosses the slot of the slotted optical switch

Noise Sensor :

The input transducer for this sensor is an electret microphone. The microphone's output provides the input to the filter and amplification circuit. Finally to obtain a constant voltage value which can be accurately measured by the microcontroller a peak detector was used.

Noise Sensor Functional Level Diagram.

The filtering stage included a band pass filter for the frequency range of 15Hz to 20kHz.

Dust Sensor :

. This sensor comprises the use of an off the shelf component and some additional hardware to facilitate measurement.. This sensor is an optical type dust sensor. This means that the sensor uses detected light intensities to measure the dust concentration in the air. It has a current consumption of 9mA . To obtain the correct output from this sensor, the sensor needs to be connected.

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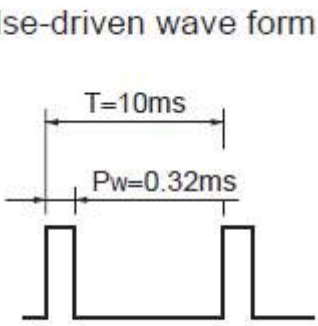

Dust Sensor LED Drive Signal.

4.RESULTS AND OBSERVATIONS

A different tests given to the system in order to note down the many readings and should calculate the main average test result and value. Each test had a focus on a specific subsystem. These results are summarized. This would include the use of a smoke sensor and a controllable fire retardant system. subsystem that could be considered for addition to the mine. This would include the use of a smoke sensor and a controllable fire retardant system

A major risk that can cause a large amount of damage in the mine environment is fire. An additional subsystem that could be considered for addition to the mine. This would include the use of a smoke sensor and a controllable fire retardant system.

TABLE I
SYSTEM RESULTS

Intended Outcome	Actual Outcome
Temperature Sensor should have a - Range = 20 - 35°C - Resolution = 0.5°C	Temperature Sensor has a - Range = 2 - 45°C - Resolution = 0.105°C Accuracy = 89.01%
Humidity Sensor should have a - Range = 0 – 90% - Resolution = 5%	Humidity Sensor has a - Range = 0 – 100% - Resolution = 0.12% Accuracy = 98.55%
Airflow Sensor should have a - Range = 0 m/s – 15m/s - Resolution = 0.5m/s	Airflow Sensor has a - Range = 0 m/s – 15m/s - Resolution = 0.05m/s Accuracy = 90.5%
Noise Sensor should have a - Range = 0 – 95dB SPL - Resolution = 5dB SPL	Noise Sensor has a - Range = 50 – 95dB SPL - Resolution = 0.23dB SPL Accuracy = 89.53%
Gas (CH_4) Sensor should have a - Range = 0 – 70ppm - Resolution = 1ppm	Gas (CH_4) Sensor has a - Range = 0 – 2554.75ppm - Resolution = 0.9ppm Accuracy = undetermined
Dust Sensor should have a - Range = 0 – 10mg/m_3 - Resolution = 0.5 mg/m_3	Dust Sensor has a - Range = 0 – 0.554mg/m_3 - Resolution = 0.003 mg/m_3 Accuracy = undetermined
The wireless communication should have a maximum range of 50 m. All data captured and transmitted to the GUI should be recorded within a database allowing for all historical information to be viewable at a later stage.	The wireless communication has a maximum range of 51.1m indoor and 150m outdoor. System is able to recall historical data with 100% accuracy.

4. WORK TO BE NEED IN FUTURE

While the wireless communication implemented in this design shows success with urban/indoor communication, in order to enhance the system even further, multiple identical sensor nodes could be introduced. This would allow for a sensor node to be out of range with the collection node, but as long as that sensor node can communicate to another sensor node, the data can be passed along from the end sensor node to the collection node through intermediary sensor nodes. This would increase the communication range inside the mine.

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5 . INTERNET OF THINGS

THE IOT IS KNOWN TO BE INTERNET OF THINGS. IN WHICH WE CAN SEND THE INFORMATION THROUGH THE LONG DISTANCE BY USING INTERNET.

6. CONCLUSION

Therefore a complete mine safety system was constructed such that the system is compact and modular, using a combination of mechanical hardware, electronic hardware and specific software. This system can measure present characteristics inside the mine environment and communicate them between two nodes using the ZigBee communication protocol.

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