Power Line Communication of Sensor Data in Mines

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Abstract: **This project presents a digital system for transmission/reception of data through existing power lines in mining applications. Power Line Communication (PLC) system uses pre-existing infrastructure and due to the wide availabilities of power lines and communication media for PLC technology, they are preferred over other communication technologies like Satellite, Wireless and Optical fiber communications. In remote areas for High data rate and less cost, an advanced PLC system can be established for communication or a power-grid. Communication over power lines occur through simultaneous transmission of data over AC electric power or power distributions which is then carried across to the end users. The health of miners and workers are of major concern in any mining industry. Toxic gases, like methane and carbon monoxide are one of the vital threats while operating with power based equipment or fuel driven instruments. High concentration (ppm) of gases above safety threshold levels can pose significant risks of health hazards and quality of life of these workers. Therefore, round the clock monitoring of factors that pose serious threats must be implemented. A mine safety monitoring system is proposed in this paper to achieve the safety factors using PIC18 and PLC Modem. Various environmental parameters, such as Temperature Sensor, Gas Sensors, Water Sensors and an Emergency Push Button (for cases of urgent crisis), from underground mine, with the help of sensor node structure is collected by the system and that data is transmitted for processing. If any of the sensors detect extreme variations in the analysed environment data, the system displays "alert messages" with respective LED indications.**

Index terms: **Power Line Communication, Security monitoring system, Environment Sensors, Mining Industry, PLC Modem.**

I. INTRODUCTION

The use of already accessible electrical power lines for data transportation is termed as Power Line Communication (PLC's). It has been in use for a very long time for monitoring power grid through already present electrical foundation. An example is the London power utility which remotely controlled some of its machines on the same grid (like switches operating at extreme voltages) using PLC in the 1920s. It is still used to send data at a speed of 9.6 Kbits/s over long distances of power cable using Analog or digital devices. PLC can also be defined as a technology that allows transfer of data through power cables at narrowband or broadband speeds with use of advanced modulation techniques.

The system implementation is mostly in the areas of mines, institutions, offices, etc. In offices or homes, it can be used in interconnection of computers, peripherals or entertainment devices having an Ethernet port. An Ethernet connection can be established using existing electrical lines in the home/office by setting plug into power outlets with the help of a power line adapter. (Power line signal may be absorbed by power strips comprising of filtering capability). This enables data sharing from devices without the tedious tasks of setting up specific cable networks. Host can control a number of devices by simply setting up a transmitter and receiver having equal phase supply and thereby eliminating the use of extra cables.

The paper's scope is the realisation of two modules: Transmitter and a receiver which perform data communication with each other using pre-existing power lines.

II. LITERATURE SURVEY

The concept of communication over a compact Power Grid has existed since about half a century, but mostly in the lines of home automation or public lighting. While only the narrow band tele-applications were applied in the Mid 1900s for research in data transmission or implementation of relay remote control in towns.

On comparison with wireless communication, PLC interfaced with a solid framework and design establishment, has the highest efficiency of transmission. The monitoring system involves a dynamic network and routing technology for reliable communication using a cobweb networkmodel and varied experimentation to obtain a noiseless channel at the rate of 24Kb/sec.

III. IMPLEMENTATION

As every communication module, our project includes a Transmitter and a Receiver, both of which are controlled by an individual PIC (Peripheral Interface Controller) micro-controller. PIC (PIC18F46K22) at the transmitter unit is interfaced with several environment sensors, such as Temperature sensor (LM35), Water/humidity sensor (YL-83), Gas sensor (MQ135) and also a manual emergency switch, to detect changes in the conditions of mines. A PLC Modem (KQ330), connected to UART pin of the micro-controller, sends the sensor(s) data through the 230V power line to the Receiver PLC Modem, which then transfers it to the UART of PIC. MPLab is the software used to code the micro-controller and Serial Bootloader AN13 to write (dump) the code to the chip.

Our project is divided into two units:

1. Monitoring Unit (Transmitter): This unit is positioned at the underground mining area. Whenever the connected sensors detect variations, or if the emergency switch is pushed, the

micro-controller sends a unique data (as per the sensor shown in Table 1) to the PLC modem through UART. The following symbol is transmitted on detection of each sensor:

Gas Sensor	'#'
Temperature sensor	'@'
Water sensor	'&'
Emergency Switch	'*'

Table 1: UART Transmitted Data

The Block Diagram for the Monitoring Unit is shown in Fig.1. Some of the sensors specifications are:

(i) Gas Sensor: The digital mode of the MQ6 Gas sensor detects gas concentrations of 200-10000 ppm, according to which the voltage levels drops from 1 to 0 (micro-controller pin turns LOW if Gas or smoke is detected)

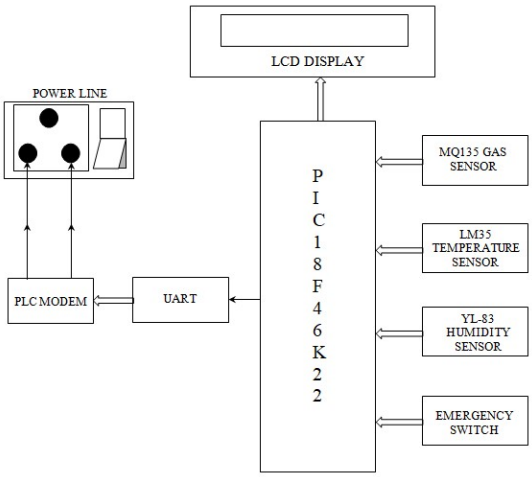

Fig.1: Block Diagram of Monitoring Unit

(ii) Temperature Sensor: The LM335 Temperature sensor can detect temperatures from -55˚C to 150˚C and can be converted to 10-bit input that varies from 0 to 1023 and is translated to ˚C by multiplying the Analog value by "0.488" which equates the 1024th part of 5V. If the calculated value bests the routine atmospheric temperature (here set at 40˚C), the sensor triggers the PIC micro-controller to send '@' through UART to the PLC Modem.

(iii) Water Sensor: The YL-83 rain sensor is set up by two components: the electronic board to interface the sensor to the micro-controller and secondly, the collector board that monitors the latency of water. If the humidity value reaches a certain threshold, the digital pin of PIC is set off and transmits '&' through the power line over the Modem.

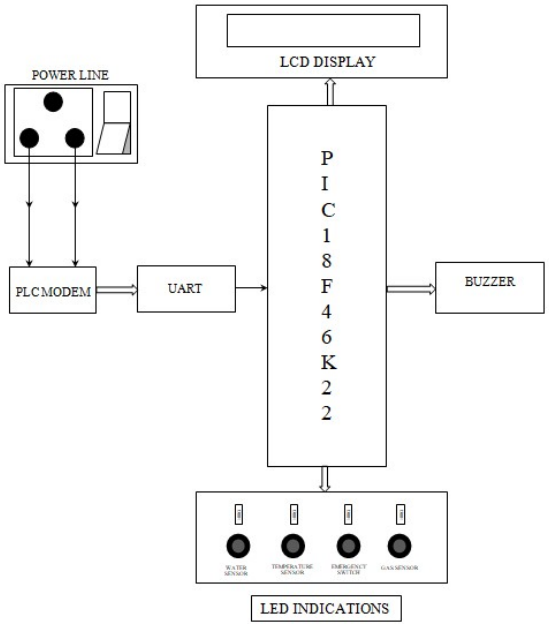

Fig.2: Block Diagram of Control Unit

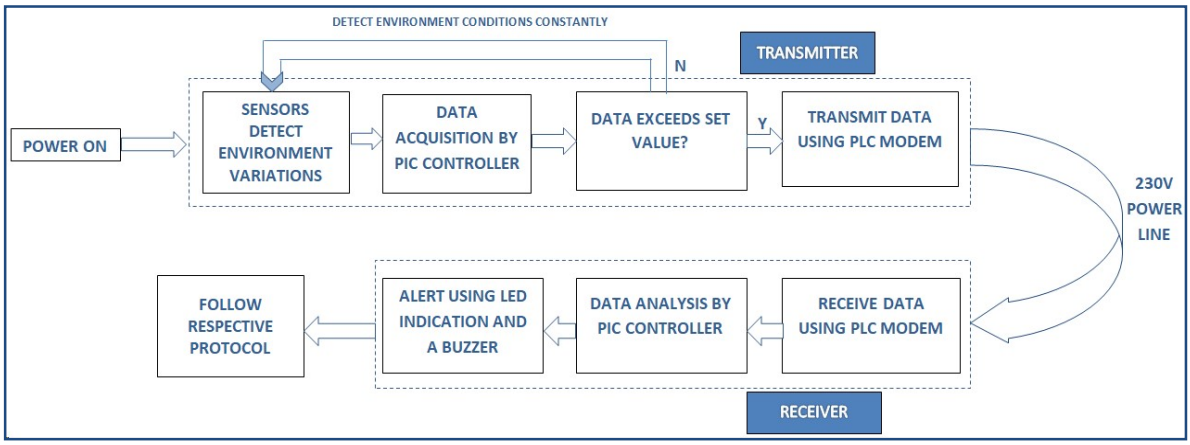

Fig.3: Working Setup

2. Control Unit (Receiver): The micro-controller at the Receiver end will obtain the data from PLC Modem over the power lines. Hence, on analysing the transmitted data (refer Table 1 for UART transmitted data for each sensor); the respective command is displayed on the LCD along with its LED indications and a buzzer to alarm the workers. The Block Diagram of Control Unit is as shown in Fig.2. A buzzer is installed to alert the workers if any sensors detect variations in environment.

The Working of the project is shown in Fig. 3 and the demonstration can be done using small props like lighting up incense sticks (or matches) to activate the gas sensor and any source of heat to set the Heat sensor and a few drops of water on the collector board of the rain detector to activate the water sensor (for the purpose of project demonstration).

IV. EXPERIMENTAL ANALYSIS

The Transmitter (Monitoring Unit) is shown inFig.4, which comprises of PIC18 Microcontroller development kit and the sensor module. Fig. 5 shows the Receiver (Control Unit) that consists of an LED panel, with respective LED for each sensor. A buzzer is included to alert the workers when any set conditions are exceeded.

The snapshots of the output display using LCD and LED indications are shown in Fig. 6-9 (Water sensor – Fig. 6, Temperature Sensor – Fig. 7, Gas Sensor – Fig. 8, Emergency Situation – Fig. 9). The text displayed on the LCD is shown in Table 2.

Water Sensor	"WATER DETECTED"
Temperature Sensor	"HIGH TEMPERATURE"
Gas Sensor	"GAS DETECTED"
Emergency Situation	"EMERGENCY! NEED HELP"

Table 2: Text displayed on LCD

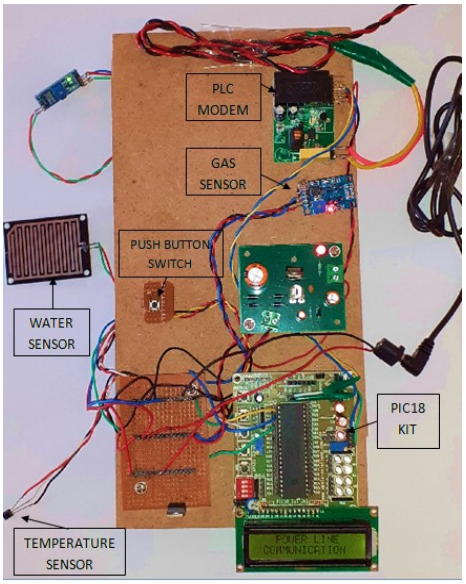

Fig.4: Monitoring Unit

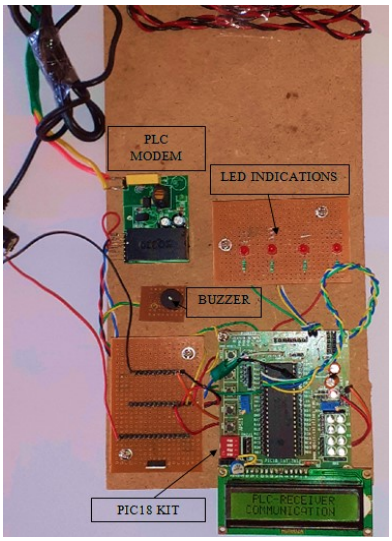

Fig.5: Control Unit

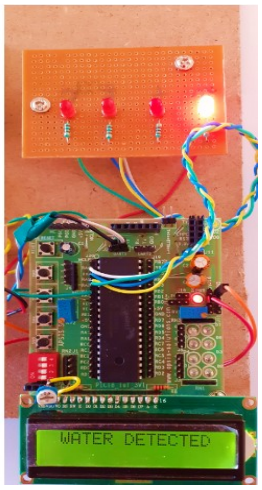

Fig.6: Water Sensor

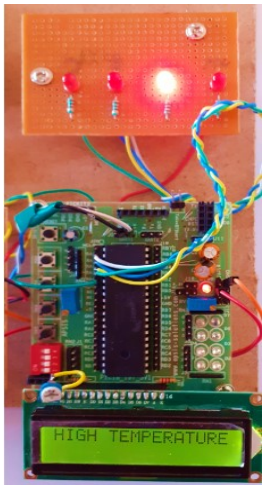

Fig.7: Temperature Sensor

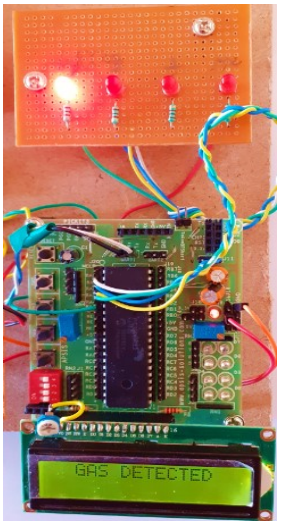

Fig.8: Gas Sensor

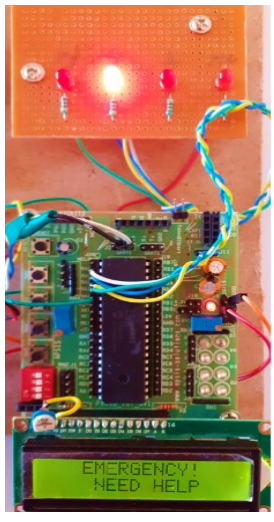

Fig.9: Emergency Situation

V. APPLICATIONS

Some of the applications include:

1. Continuous monitoring of network elements and devices.(Example: Automatic meter reading)
2. Remote access control for safety alert systems and detection of faulty conditions.
3. Manage networks and maintain them to reduce errors and harmful events.
4. Industrial monitoring and automation systems.
5. Power line modemscan be used to establish an Ethernet connection in homes/offices, as a part of home system, to interconnect computers.
6. By interconnecting computer peripherals, can monitor and control home entertainment devices.
7. New PLC models for smart power grids are being implemented all over the globe, providing moreefficient, reliable and convenient control factors.
8. The application used in this paper is "mining applications", but on further modifications, PLC can be implemented on ships, trains or any locomotives to diagnose any faults in the system

VI. ADVANTAGES AND LIMITATIONS

A few advantages are listed below:

1. Does not require installation of new network lines as it uses the existing power lines.
2. The cost reduces abruptly to establish the network system.
3. Installation of the system is very easy i.e. just plug-in to socket to use.
4. Provides alternative mode of communication where wireless networks fail.
5. Any layman can easily use the device and the availability of power sockets is almost everywhere.

Although there are quite a few perks to this setup, there are also some limitations:

1. Prone to Electro-magnetic radiation issues.
2. Noise interference.
3. Little delay in communication in large network and lines.
4. Regulatory and standardization issues.
5. Addressing issue

VII. CONCLUSION

With the emerging trend of wireless transmissions mediums, PLC provides a unique method for transmission/ reception using the existing power lines, which allows the user to transmit data with encryption standards. Another added advantage is the amount of space which is saved by not using any extra cabling. Due to their high mechanical strength of power line cables, compared to the underlying telephone cables, they can sustain the vigorous changes in the climatic conditions and work even in such situations. This paper analyses the monitoring condition in mines to alert the workers in respective of exceeded environmental conditions that are detected by implemented sensor.

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