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Safety of Construction Workers using IoT based MWSN Network

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ABSTRACT

In this paper a mobile wireless sensor network (MWSN) is introduced for the purpose of worker's safety. Public authorities and Standard Committee sets the limit for the emission of dust, noise and other harmful agents based on the previous examination of endangerment for worker's and resident's health as well as environment. While emission crosses the threshold limit, the mobile sensor nodes sends notifications to the operator, then user can react upon this information and takes quicker action. For tracking the workers within the limited site, IOT based WSN network is widely used.

Keywords: *MWSN, Dust sensor, Vibration sensor, Gas sensor, Nodes.*

1. INTRODUCTION

Wireless Sensor Networks have applications in many environmental purposes like regulating water quality, regulating water and air pollution etc. The construction of building and its demolition leads to emission of dust, noise and vibrations that not only disturbs and harms the health of the workers working within site but also the nearby residents. Here, the effort is focussed on developing and installing a frame work, which monitors the gas emission, noise from the construction sites in real-time environment and monitors the safety condition of the workers in the site.

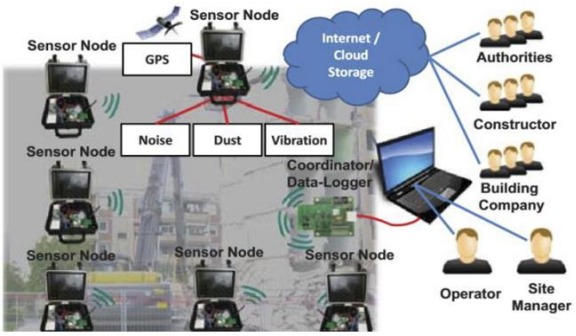

Fig.1 Real-Time wireless sensor network for monitoring harmful emissions at building and demolition site

Tracking is done by implementing the following principles namely Angle of Arrival (AOA), RSSI, Time of Arrival (TOA), Time Difference of Arrival (TDOA). Wireless positioning is done followed by assessment of technologies such as Bluetooth, Zigbee, IoT. For finding the location of tracking node two different methods can be used at construction site for determining node positioning,

- By finding distance between the nodes
- By finding angle between the nodes

2. LITERATURE SURVEY

1) SIMPLIMOTEA WIRELESS SENSOR NETWORK MONITORING PLATFORM FOR OIL AND GAS PIPELINES

Wireless sensor networks have extensively been utilized over the years for ambient data collection from diverse structural deployments including mesh, *ad hoc*, and hierarchical layouts. Several other applications of sensor networks may involve placing the nodes in a linear topology, constituting a special class of networks called linear sensor networks. In a densely deployed linear network case, issues related to optimal resource allocation and Networking may persist because the standard sensor network protocols attempt to manage the network as a mesh or ad hoc infrastructure. The proposed system provides all the features of leakage detection, localization, parameter sensing, and actuation, while operating at low energy, high data reliability, and low latencies, while comparative results prove the efficacy of the system.

2) IMPROVED RSSI INDOOR LOCATION SYSTEM BASED ON FUZZY ALGORITHM

With the Zigbee-based protocol, a system design scheme using improved RSSI ranging technology based on fuzzy algorithm for indoor localization is proposed. By fuzzy state classification to establish the fuzzy distribution parameters of climate and environmental obstacles, improve the "distance-loss" model, calculate the membership function, result in a more accurate distance formula to calculate the location information of mobile nodes. The results show that: the positioning algorithm proposed by the system for mobile nodes localization meets the actual needs in real time and accuracy, has application value.

3) UTILIZATION OF XBEE ZIGBEE MODULES AND MATLAB FOR RSSI LOCALIZATION APPLICATIONS

Localization is an important attribute for wireless sensor networks. Received signal strength indicator (RSSI) can be used to estimate distance between transceivers. Using these estimated distances, location of nodes within a network can be determined using various localization algorithms, such as trilateration. For implementation and testing of localization techniques, utilizing a sensor network development platform reduces time and difficulty during the process. Here we present a platform based on XBee ZigBee wireless modules, Arduino and MATLAB for algorithm testing and debugging. For validation of this platform, a trilateration localization method is implemented.

4) AN EFFICIENT ALGORITHM FOR LOCALIZATION USING RSSI BASED ON ZIGBEE

In this paper, we develop an algorithm that can increase the accuracy of localization especially in underground applications. Gaussian distribution is used to remove the event with high effect but low possibility. After that, the statistical average is calculated. Then, three checking points are used to measure the parameters in a tunnel. Finally, the parameters are updated to the system in real time. The results show considerable improvement compared with other methods.

3. BLOCK DIAGRAM

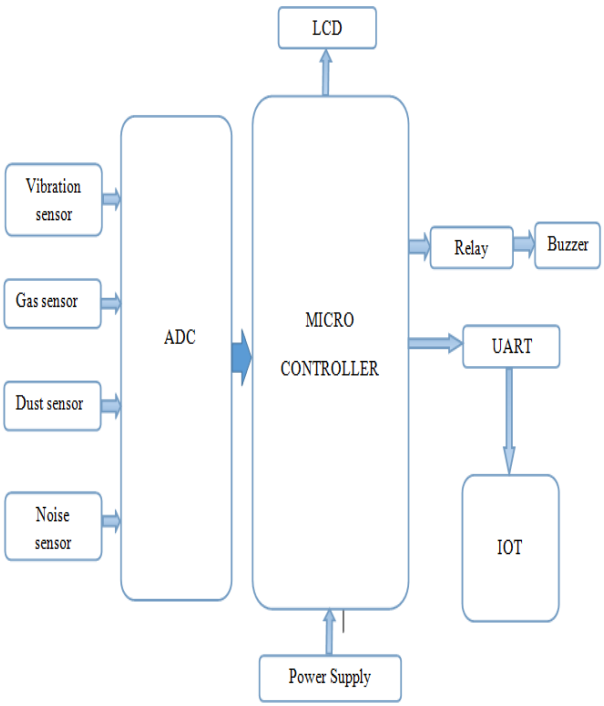

Fig.2 Transmitter Section

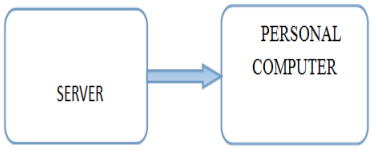

Fig.3 Receiver Section

4. EXPERIMENTAL SETUP

The important components involved in the setup are as follows:

- PIC controller
- Power supply
- Vibration sensor
- Dust sensor
- Gas sensor
- Relay
- UART
- Buzzer
- IoT

A. PIC CONTROLLER

PIC16F877A is a 40-pin package. The PIC16F874A have one-half of the total on-chip memory of the PIC16F877A. It has five I/O ports, fifteen interrupts and eight A/D input channels. The Parallel Slave Port is implemented. Here, data memory is divided into multiple banks which have General Purpose and the Special Function Registers. All implemented banks contain Special Function Registers.

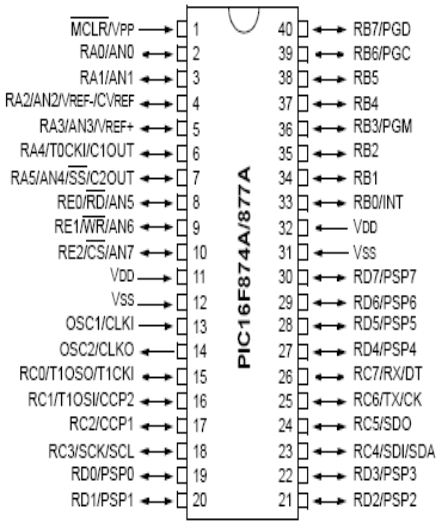

Fig.4 Pin Diagram

B. POWER SUPPLY

A device which supplies electrical energy to an output load is called a power supply unit or PSU. It is applied to electrical energy supplies.

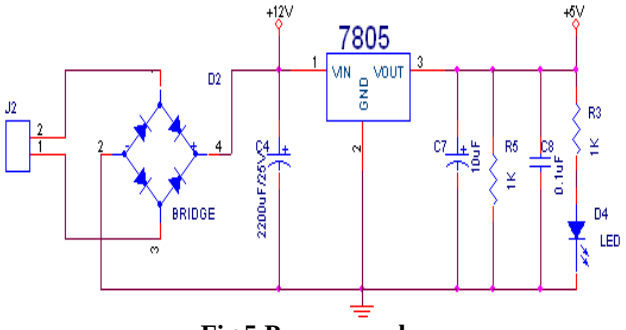

Fig.5 Power supply

In input side, 230v, 50Hz Single phase AC power supply is given to a step down transformer to get 12v supply as output. Then, the output voltage is converted to DC voltage form using Rectifier. The converted voltage is filtered by a 2200uf capacitor and then

given to regulator to obtain constant 5v supply. This supply is given to all the components. To ensure the power supply a LED is connected for indication purpose.

C. VIBRATION SENSOR

Fig.6 Vibration Sensor

It is used to gather wasted energy from mechanical vibrations. Here, Piezoelectric materials to convert mechanical strain into electrical energy.

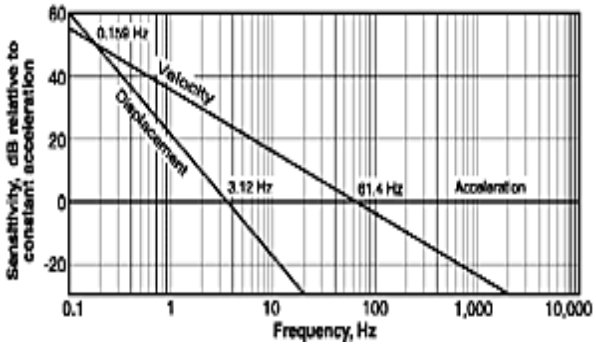

Fig.7 Relationship between velocity and displacement to constant acceleration

The selection of sensor is proportional to displacement, velocity or acceleration depends on the frequencies of interest. Figure below shows the relationship between velocity and displacement to constant acceleration.

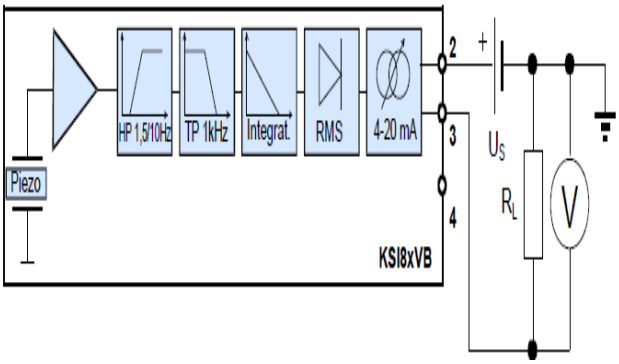

Fig.8 Function of Vibration Sensor

D. DUST SENSOR

Exact measurement of dust is nearly impossible as it keeps on varying at construction sites and depends on factors such as rain, wind, humidity etc. Dust Sensor gives the indication of dust concentration in environment and hence useful for improving air quality at construction sites.

E. GAS SENSOR

Fig.9 Gas Sensor Modules

It measures the concentration of gas in its vicinity by interacts with a gas to measure its concentration. Each gas has certain breakdown voltage i.e. the electric field at which gets ionized. The Sensor identifies gases by measuring these voltages.

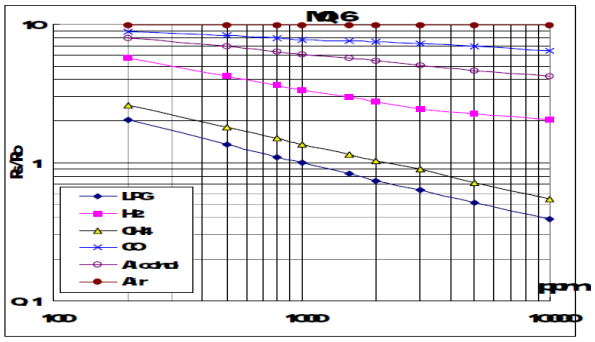

Fig.10 Sensitivity characteristic curve

LPG Gas Sensor Description:

It is suitable for sensing LPG concentrations in the air. The MQ-6 can detect gas concentrations anywhere from 200 to10000ppm. This sensor has a high sensitivity and fast response time. The sensor's output is an analog resistance and so connects the output to an ADC. Sensitive material of MQ-6 gas sensor is SnO2, which with lower conductivity in clean air. MQ-6 gas sensor has high sensitivity to Propane, Butane and LPG, also response to Natural gas.

Operation Principle: When a metal oxide crystal such as SnO2 is heated at a certain high temperature in air, oxygen is adsorbed on the crystal surface with a negative charge. Then donor electrons in the crystal surface are transferred to the adsorbed oxygen, resulting in leaving positive charges in a space charge layer. Thus, surface potential is formed to serve as a potential barrier against electron flow. Inside the sensor, electric current flows through the conjunction parts of SnO2 micro crystals. At grain boundaries, adsorbed oxygen forms a potential barrier which prevents carriers from moving freely. The electrical resistance of the sensor is attributed to this potential barrier. In the presence of a deoxidizing gas, the surface density of the negatively charged oxygen decreases, so the barrier height in the grain boundary is reduced. The reduced barrier height decreases sensor resistance.

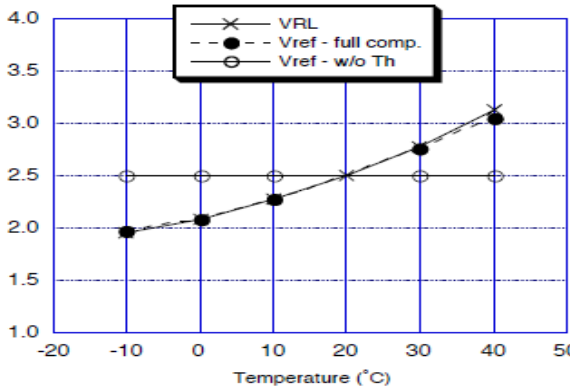

Fig.11 Effect of Compensation Circuit

Extremes of -10˚C and 40˚C could be considered, with an average value of 20˚C. Obtain sensitivity characteristic curves to the target gas at the above range of ambient conditions. Decide the thermistor and the additional resistor to approximate the average curve.

F. RELAY

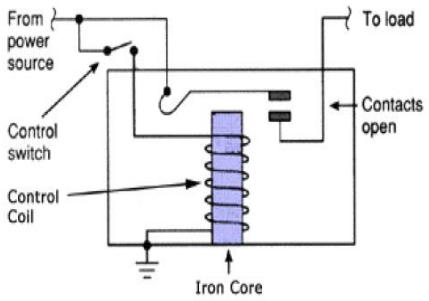

Fig.12 Actual Relay Design

It is an electrically operated switch where current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. Relays allow one circuit to switch a second circuit which can be completely separate from the first. Most relays are designed for PCB mounting but you can solder wires directly to the pins providing you take care to avoid melting the plastic case of the relay. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating

principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal or where several circuits must be controlled by one signal.

ULN2003

It consists of seven NPN darlington pairs that features high-voltage outputs with common-cathode clamp diode for switching inductive loads. The collector-current rating of a single darlington pair is 500mA. The darlington pairs may be paralleled for higher current capability. Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED gas discharge), line drivers, and logic buffers. The ULN2003 has a 2.7kW series base resistor for each darlington pair for operation directly with TTL or 5V CMOS devices.

Fig.13 ULN2003

Large relay with two coils and many sets of contacts are used in an old telephone switching system.

G. UART

A Universal Asynchronous Receiver Transmitter is usually an individual (or part of an) integrated circuit used for serial communications over a computer or peripheral device serial port. UARTs are now commonly included in microcontrollers. The UART takes bytes of data and transmits the individual bits in a sequential fashion. At the destination, a second UART re-assembles the bits into complete bytes. A UART is used to convert the transmitted information between its sequential and parallel form at each end of the link. Each UART contains a shift register which is the fundamental method of conversion between serial and parallel forms.

MAX232: It converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. It is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals.

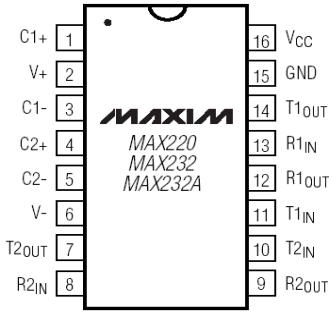

Fig.14 MAX232 Pin Diagram

The drivers provide RS-232 voltage level outputs (approx. ± 7.5 V) from a single + 5 V supply via on-chip charge pumps and external capacitors. This makes it useful for implementing RS-232 in devices that otherwise do not need any voltages outside the 0 V to + 5 V range, as power supply design does not need to be made more complicated just for driving the RS-232 in this case. The receivers reduce RS-232 inputs (which may be as high as ± 25 V), to standard 5 V TTL levels. These receivers have a typical threshold of 1.3 V, and a typical hysteresis of 0.5 V. The later MAX232A is backwards compatible with the original MAX232 but may operate at higher baud rates and can use smaller external capacitors – 0.1 µF in place of the 1.0 µF capacitors used with the original device.

H. BUZZER

Fig.15 Buzzer

A buzzer is a signaling device, which consists of a switches or sensors connected to a control unit that determines which button was pushed and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound. A Piezo buzzer is made from two conductors that are separated by Piezo crystals. When a voltage is applied to these crystals, they push on one conductor and pull on the other. The result of this push and pull is a sound wave. These buzzers can be used for many things, like signaling when a period of time is up or making a sound when a particular button has been pushed. The process can also be reversed to use as a guitar pickup. When a sound wave is passed, they create an electric signal that is passed on to an audio amplifier.

I. INTERNET OF THINGS

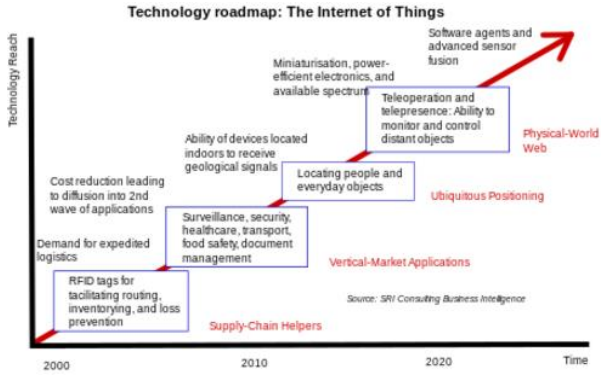

Fig.16 Technology Roadmap

The Internet of Things (IoT) is a phenomenon that has developments within IT, ICT and telecommunications to spark insights. The scholars suggest that "Things" as "combination of hardware, software, data and service". These devices gather data with help of existing technologies and then autonomously flow the data between other devices.

Automate collection of context information as well as the objects ability to detect changes in the environment, faults affecting sensors and introduce suitable mitigation measures constitute a major research trend, clearly needed to provide credibility to the IoT technology. The New modern IoT products and solutions use different technologies to support context-aware automation but more intelligence are requested to permit sensor units to be deployed in the real environments.

5. RESULT AND CONCLUSION

It proposes the detailed overview of hardware architecture of Wireless Network used at construction site. For the future implementation a limit can be set for the emission of dust, noise, vibrations at the site based on the previous experiences and accordingly a series of experiments on real construction and destruction sites can be performed.

6. ADVANTAGES

- Simple in design.
- Low cost.
- Accuracy is high.

7. ACKNOWLEDGEMENT

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