An Intelligent Ultrasonic Helmet System for Miner

Chandrashekar S
M.Tech Student
Department of DECS
VTU CPGS, Bangalore Region
VIAT Muddenahalli

Dr. Sarika Tale
Chariman & Associate Professor
Department of DECS
VTU CPGS, Bangalore Region
VIAT Muddenahalli

Abstract- **This project primarily focuses on navigation through underground ways in the Mining Industries and around large objects without sight, through the use of an ultrasonic rangefinder that haptically interfaces with the user via tiny vibrating motors mounted on the user's head. These features are achieved with the help of a microcontroller. The MCU (Micro Controller Unit) is interfaced via Darlington array to load vibrators, which vibrate in varying intensities individually indicating direction based on the ultrasonic sensor output. The ultrasonic sensor is directly interfaced to MCU, which rotates 0° and 360º with aid of stepper motor. In navigation when obstacle is sensed by sensor, the vibrators indicate obstacle to user indicating the obstacle distance through ZigBee transmitter. The vibrators intensify as obstacle nears. The entire process can be observed in nearest computer unit with aid ZigBee receiving unit.**

Along with the rangefinder with the use of sensor and also we have other application along with it. They are determining of concentration level of the hazardous gases like CO, SO2, NO2, pressure and temperature. They will have button in helmet which used to identify a miner removing the mining helmet off their head. Security switches at computer unit used for immediate alert of miner. This paper presents the undertaken design and implementation of a smart ultrasonic helmet haptic vision system prototype to resolve the issues raised in previous research. This smart prototype assures 100% of safety and secure to miner in the mining Industries.

Keywords- Ultrasonic Rangefinder; Vibrator; Darlington Array; Stepper Motor; Hazardous Gases; MCU; Sensor; Zigbee.

I. INTRODUCTION

The Mining industry in the Republic of India is a major economic activity that contributes significantly to the economy of India. The gross domestic product contribution of the mining industry varies from a pair of.2% to 2.5% solely, however, going by the gross domestic product of the total industrial sector it contributes around 100% to 11 November. Even mining done on little scale contributes 6 June 1944 to the complete value of mineral production. Indian mining industry provides job opportunities to around 700,000 people.

Underground coal mining over the years was notified for its dangers from explosions and fires. Technology development in all other fields, including other like the space effort of the 1960's, has given rise to the variety of new electronic and computer technologies that are now becoming more challenging, even in mining. This report presents brief explanation of the history of university that involved in the communications and monitoring, beginning with the first federal appropriation of funds in the year of 1970 under the Coal Mine Health and Safety Act of 1969 and continuing through the first half of 2016.

A smart ultrasonic helmet has been developed that is able to detect of hazardous events in the mines industry. In the development of helmet, the concentration level of the hazardous gases such as CO, SO, NO_2 was detected [1]. Air pollution from the mining industries because of the emissions of particulate matter and gases which have following chemicals like methane (CH4), Sulphur dioxide (SO2), and oxides of nitrogen (NO2), as well as carbon monoxide (CO). From different studies, it is well known that when human being comes in contact these chemicals/ pollutants it could have adverse effect on their health. These unbalanced ratios of air pollution gases, such as suspended particulate matter, increase respiratory diseases such as asthma, chronic bronchitis, and cardiovascular problems [2].

Electronic travel aids are used for detecting obstacles, identifying services, and, generally, obtaining useful information from the surroundings, thus enabling a safe and effective exploitation of the environment [3]. Ultrasonic Sensor has been improved by adding real time dimension data. This can be done in the Application part, during the reception of the sample data. Further it can be software can be implemented a program code for dimension only at the object points, whose values will be changed since the last scan. This would lead to minimizing the calculation and also produce a lighter prototype version of the robot helmet for future exploration [4]. There is a rising demand of Darlington system for the high data rate in the communication system. Darlington transistors are used in the applications for high gain is needed at a low frequency. Presently Darlington cell and Darlington topology has been reported high gain and good bandwidth for modern application [5].

An obstacle detection (OD) technique for collision avoidance applications in automobiles and unmanned aerial vehicles has been research area of interest in the present years. This technical idea is motivated to develop an underground navigation system for the haptically visually impaired individuals which are the main focus of this paper. Different types of equipment and approaches like sensors, Computer Vision (CV) methods, micro-controllers etc. are used for detecting obstacles in the unmanned ways. To enable an ultimate collision free mobility of the miner we intend to use Ultrasonic sensors [6]. In order to resolve the collision drawback of quad-rotor UAV with low flight altitude the strategy to calculate the space between the obstacles and UAV by using the supersonic sensors is proposed. And an efficient technique is devised to avoid the obstacles. Firstly, the structure of quad-rotor UAV is introduced. Then the induced velocity standard strip analysis and therefore the regulation of the ultrasonic detector area unit delineate [7]. Ultrasonic haptic feedback was one of the promising implies that of providing tactile sensations in mid-air without the encumbering the user with the associate actuator mechanism. However, it is controlled and rigorous HCI analysis is needed to the understand of the essential characteristics of perception of this new feedback medium, so that this is best to use ultrasonic haptic in the associated interface [8, 11].

A study was done to determine the best frequency to be used in mines as the attenuation of signals over a distance determines how far the signal will travel. It was found that the best frequency was 2.4 Gigahertz (GHz). The transmission was found to be effective up to 15 m from where the signal was transmitted [9]. The Internet-of-Things, where all devices are smart and interconnected, are increasingly being used in more industrial applications [12]. Forooshani, et al. presents a compressive survey of wireless propagation in tunnels and underground mines with a focus on current wireless channel modeling, technologies, and applications [13].

An overview in the past results of the development of a methodology for identifying the safety hazards inherent in underground monitoring and control equipment will be provided. Under a US Bureau of Mines contract, a methodology was been developed for determining the inherent design items that will affect safety hazards. All though serious consideration had already been given to the normal intrinsic safety and explosion-proof characteristics of a system, the problem may be in the system itself rather than the more immediately noticeable system components. In monitoring or controlling component located in underground coal mines, the hardware reliability of a system is the seldom recognized as there potential safety hazard [14]. The software or program operating such a way that the system is never considered as a potential safety hazard because it is, in many cases, located outside the hazardous area. In reality, electronic technology is outstripping in the industries normal view of safety and quickly growing in the unseen potential safety problems [15].

The existing monitoring systems underground of coal-mine principally use cable network. This type of network has poor performance of growth. The cables are simple to aging and wear, and have high incidence of failures. With the operating surface distended, a blind space for monitoring seems, and so the new value for installation and appears, then the new price for installation and especially explosion, the sensors and cables sometimes were broken fatally, and could not provide data for rescue search and detection events [16].

According to the monitoring goal, it is divided into several regions. Then set a cluster head for each region. The heads of cluster compose network, and each cluster using a different channel [17]. The communication radius of cluster head is longer than the communication radius of sensor node in cluster. In order to avoid the conflict of frequency, the distance between the cluster head d>2rs/3 [18].

II. SYSTEM OVERVIEW

The block diagram on Transmission side of the helmet is shown in the figure 1 which includes the sensor update input values using the ultrasonic rangefinder that has technique of procurement. They have bipolar stepper motor which keeps on rotating with the sensor changing the position of the sensor and gathers reading ranges completely with small vibratory motor placed to give haptic feedback mechanism to the worker's. It has given the 3 most important parts for the communication to communicate effectively.The Zigbee base station which is communicates to the receiving control station via radio-frequency communication system of the hardware state from the receiver and sensor data & shows it in an in-built approach for debugging and general informative display of the sensor data. The block diagram of the receiving end of the helmet system is shown in the figure 2.

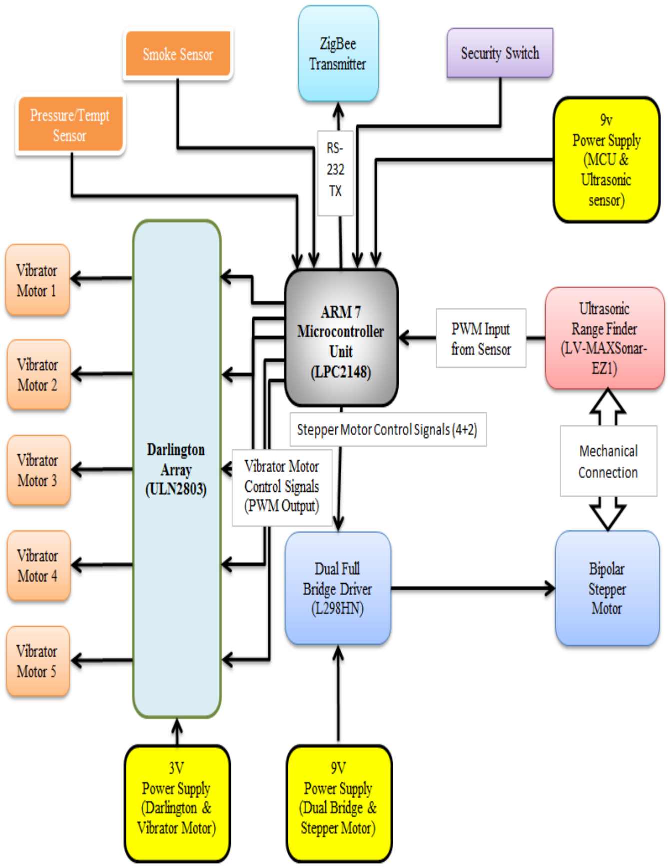

Fig. 1. Logical Structure of Transmission End

The stepper motor placed on top has exhausting with its turns along the ultrasonic rangefinder, make sure to take the reading range of the obstacles at completely different angles this info is sent to microcontroller. This successively start the vibrator to vibrate consequently, to make the worker's to alert as the obstacles is in their place nearby them at the different present range value sent back to the base stations to display on the control unit PC.

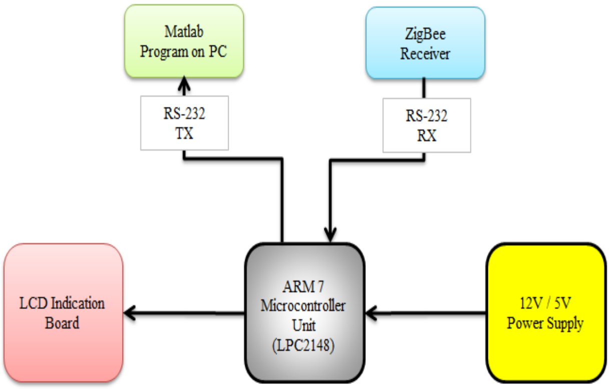

Fig. 2. Logical Structure of Receiving End

A. *Design of Obstacle Avoidance & Rangefinder*

The ultrasonic sensor was mounted on a hard yellow helmet using screws which were connected to some place of the MCU. The ultrasonic rangefinder sensor was pasted on top of the stepper motor so that the sensor will be turned with the motor. The range calculation module was responsible for reading the range input provided by the ultrasonic sensor at a particular angle. So that the motor would rotate through the anticipated angle no matter the position of the motor on start up. The two wires are in contact in the desired startup position of the stepper motor which the extreme angle read in the counter-clockwise direction. A sweep of 360° degrees was used in our design because we intended to have vibrator motors each 7.2 degrees away from each other. The motor was also mounted in the hard helmet by screwing it into the top of the helmet and drilling a hole in the middle from the top of the helmet, so the sensor could be mounted on it. So that everything was mounted in the helmet and away from the user as much as possible.

The hard helmet has an insert in it that keeps the worker head away from the top of the helmet giving us room to place the stepper motor in the top. The LCD insert also has a padded front that is in contact with the user's forehead. This padded front was perfect for mounted the vibrators inside because it keeps the padding between the user and the vibrators which makes it more comfortable. The weight on the top of the tiny stepper motor vibrators which enables them to vibrate when the obstacle, and if put in an enclosed space the motor will not turn because the weight gets stuck and thus the motor will not vibrate. As when the obstacle comes near the ultrasonic sensor, sensor will sense the obstacles that it has detected show the range at which the obstacles have been detected. Vibrator starts vibrating when the obstacle is detected and stops the stepper motor as shown in the figure 3. The rest of the mobile circuitry is outside of a plastic case aside from all of the necessary power supply. Inside of the case is the mobile MCU board which is powered by a 12V power supply. It also contains the motor driving circuit board which is made up of the L298 along with a few simple circuit elements and is powered by a 12V power supply and controlled by outputs from the MCU. Next in the case is the ULN2803 which powers the vibrating motors 12V power supply and controlled by outputs from the MCU.

Finally the case contains the Zigbee CC2500 transmitter circuitry so as to transmit the sensory data obtained from the users surroundings back to the base and ultimately a PC connected to it. This involves a board with an inverter chip and a board specifically designed to hold the CC2500 Zigbee transmitter module, as well as an antenna that had to stick out of the case in order for the signal to be transferred. The base station contained little circuitry, having an Zigbee receiver with a Max233 for RS-232 connections to the computer, CC2500 for receiving the RF packets from the transmitter on the MCU board and a led board to denote the current state of the vibrating motors on the helmet, indicating whether they are obstacles detected or not. Overall the hardware in this project took the majority of time with the mounting and testing as well as the verification that it would work as intended.

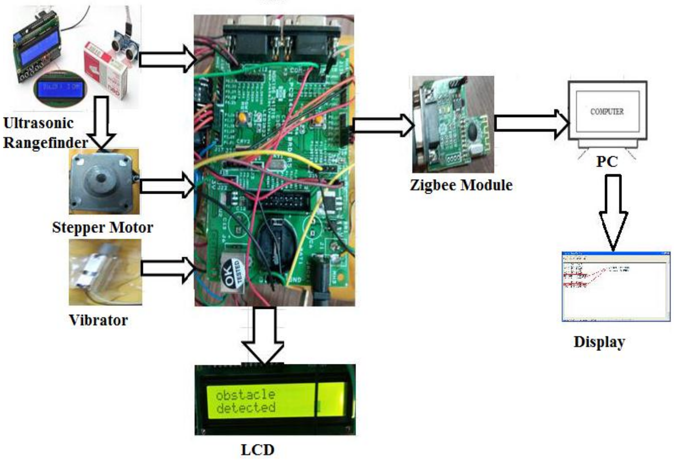

Fig. 3. Design of Obstacle detection and Rangefinder

B. *Design of Sensor System*

There are 3 environmental monitoring sensors. First MQ-2 Smoke/Gas sensor to monitor the hazardous gases which coming out in the coal mining. Hazardous gases will the effect the health of mining works. In order to protect them from the hazardous gas, we places MQ-2 sensor to monitor continuously and send the data. Similarly for Temperature and Humidity continuous monitoring done. As they exceed the threshold levels were the worker cannot work on the above the Threshold level value is given in the following Table I.

Table I: Environmental Parameter Value

Parameters	Optimum Limit	Test result at room Temperature
Temperatue	25-40	35
Humidity	15-70	48
Gas	Below 25	8

As the sensing value exceeds the threshold control unit give the signal about it with security buzzer. Which is also displayed in LCD screen and then transmission is done using Zigbee. If the value are beyond the limit, Then Turn-On the Buzzer. This is explained by the flow chart as shown fig 4.

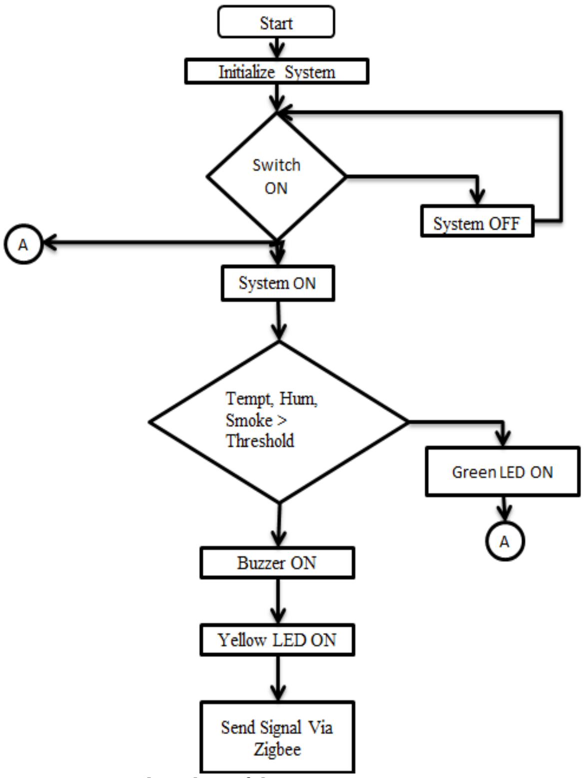

Fig 4: Flow chart of the Sensor Monitoring System

C. Helmet Removal Systems

The Push-button switches are the classic momentary switch. Typically these switches have a really nice, tactile, "clicky" feedback when you press them. Here push-button is can be used as latch button because as the miner worker wear the helmet. This made as pressed and this closed condition gives that the helmet is mounted on the head and also count the number works. If the helmet is opened then switch is in the open condition. This show the worker is not wearing the helmet in siding mining. Immediately it will provide the information to the control unit who is supervising the entire worker automatically monitoring him to mount the helmet on the head with help of Buzzer as well as display in it in the LCD display as shown in fig 5

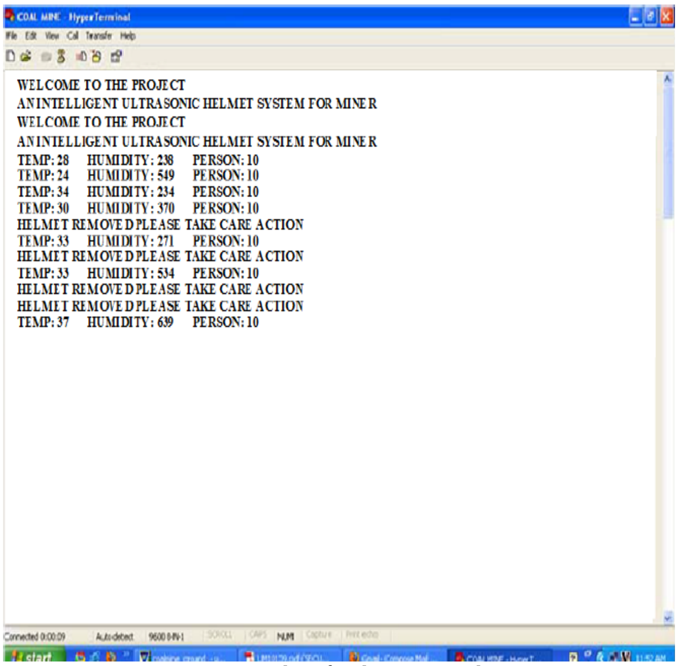

Fig 5: Display of Helmet Removal

D. Emergences/Safety switch

The push-button is used in this helmet system to alter the control unit to come fast to recuse to the worker when they are potential conflict of danger condition, fire accidence inside, miner health issues and undesirable condition of worker. In all those condition, they can press this push button to save their life with irrespective of the situation along with it there is buzzy and LCD display in the helmet will help in the underground mining as shown fig 6. This provides a huge hope and safety life of the mining worker who are working inside the underground mining.

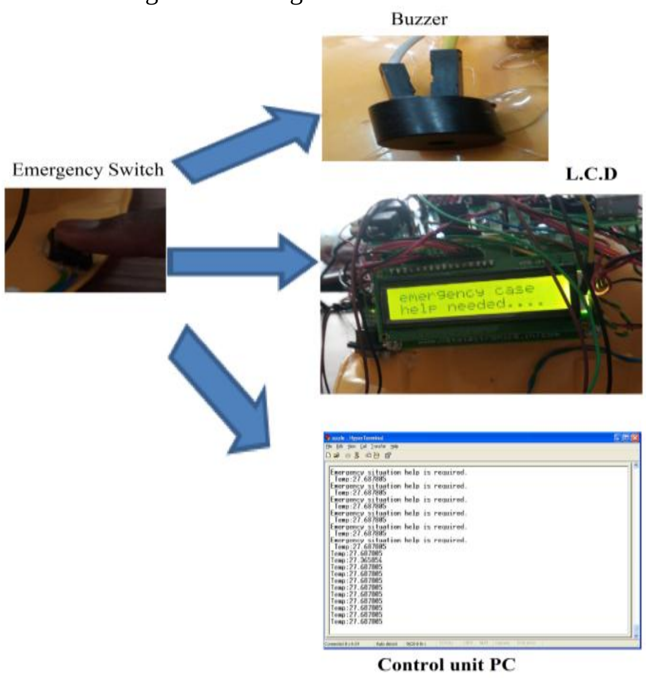

Fig 6: Emergency control System

E. Wireless Transmission

Wireless transmission between the different nodes was required. Bluetooth, Wi-Fi and ZigBee are the three types of wireless systems that are practical for the system specifications. ZigBee was created to be a low power, low data rate and a low-cost device. ZigBee has all the same benefits as a Wi-Fi system. ZigBee is based on the IEEE 802.15.4 standard. A ZigBee module is also more useful for creating larger mesh networks than Bluetooth and is therefore the better option when routers and access points cannot be implemented. In [1] all the components are attached to the safety helmet with Velcro. Some of the components are placed inside the helmet, while this helps to protect the components from bumps and gasses, this can result in electronics being embedded into the head of a miner if a seriously hard bump is experienced. In [9] ZigBee modules are the chosen wireless chip because its signals are able to penetrate walls and work very well in mines. Wireless or more specifically Wi-Fi, is sometimes used in mines, but it needs cabling throughout the mine to the routers, that can be damaged [9]. A study was done to determine the best frequency to be used in mines as the attenuation of signals over a distance determines how far the signal will travel. It was found that the best frequency was 2.4 Gigahertz (GHz).

The transmission was found to be effective up to 15 m from where the signal was transmitted. ZigBee systems can be set up to work in a few different network structures such as star, light mesh, mesh and cluster tree, are four of the most commonly used structures. Mesh structures are used when one node needs to communicate information to all the other nodes, but is in reach only of a number of nodes. Mesh network configuration is also good as it makes multiple pathways to each node. The advantage and disadvantage of the ZigBee communication was reported in [10] figure 7.

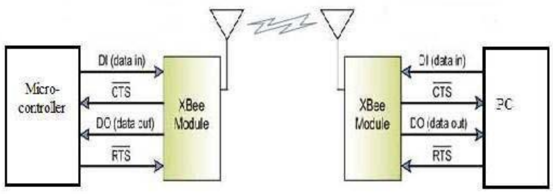

Fig. 7: ZIGBEE module and Port setting.

F. Embedded Program

This paper mainly completes the software design of system with wired and wireless parts. It mainly achieves sensor data acquisition, communication between wireless and cable nodes and uploading to PC data. In order to test wired and wireless communications, the software design of wireless sensor network nodes communications has decided into two different designs that are An embedded system is an application that contains at least one programmable computer (typically in the form of a microcontroller, a microprocessor or digital signal processor chip) and which is used by individuals who are, in the main, unaware that the system is computer-based.

III. RESULT

An Intelligent ultrasonic helmet system is a real-sensing and obstacle detection and avoidance system, which is used to confirm the reliability, usability and safety of the mine-worker's. The real time sensing is enhanced by various sensor for measuring the temperature, humidity and the critical levels of the hazardous gases such as CO, SO_2, NO_2, Methane and other concentrated gases in the mines industry has been indicated through alerting unit. Hyper Terminal is a windows-based application which provides the serially sent data through Zigbee transmitter placed in helmet was received by the Zigbee receiver in the control unit. The range test window tab will used to validate the range of communication between COM port and PC setting. Terminal connection window right to use to the computers COM port with Terminal Emulation Programs. The window also permits to send and receive predefined assemble packet data using suitable commands. It will be displayed in the hyper terminal connection screen.

The obstacle system will have the stepper motor continuously rotating 7.2^{o} at 50 steps to complete the 360 degree full rotation along with vibrator and ultrasonic range finder module. The vibration starts as worker approaches to the obstacles on an underground ways using the vibrator motor running smoothly will vary. The sensor might be reads preliminary generated ultrasonic waves to find the range with the obstacles that were place around the miner worker during underground mining's. The range of the obstacle is detected and range is sent through the zigbee transmitter to control unit and along with display unit (LCD). This will result in the obstacle avoidance in the underground mining.

A software and hardware developed was to make a communicating and consistent monitoring of environmental parameter like temperature, humidity and gas data of the underground mine are always monitored and management of sensed data and alarm. Control room will receive the data and stored in the PC as show in fig 8. The numbers of Worker's working in the underground coal mining are also monitored. If any case the data is above the threshold level (it is ultra-limits), it alters the miner worker to come out of the underground mining using the buzzer sound. It will display the environmentally friendly constraints received by ultrasonic helmet to control PC as in those manners in which displayed LCD Screen.

Manual emergency alerts switch for undesirable accidents and latch/switch were used for checking the helmet removal of the head in underground mining. This will be displayed in control unit PC using the Zigbee transrecievers. The design and implementation of the prototype of an intelligent ultrasonic helmet system result in the hardware module as shown fig 9.

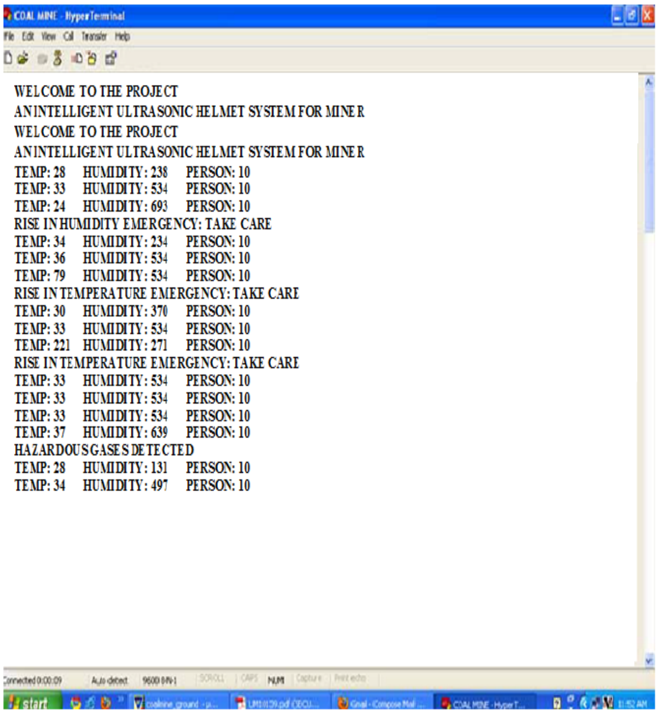

Fig 8: Value of Constraints showing in PC using HyperTerminal Connection.

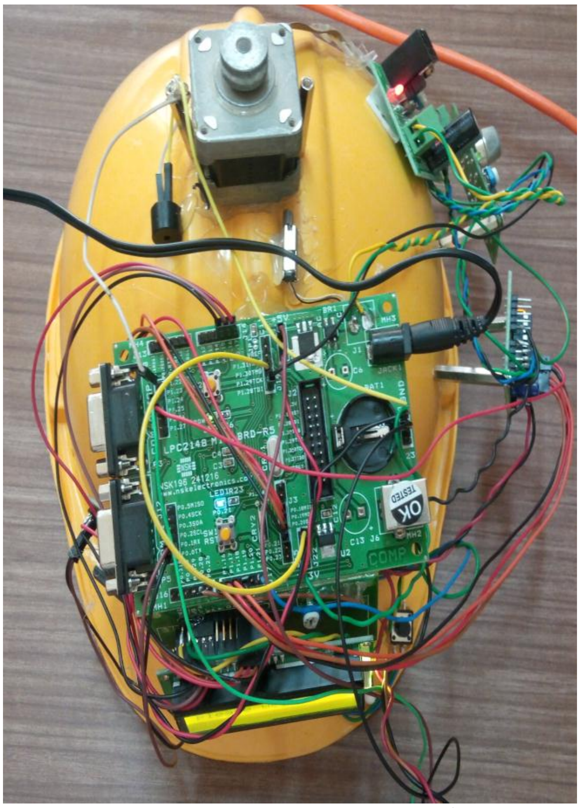

Fig 9: An Intelligent ultrasonic helmet system for Miner

IV. CONCLUSIONS

The progress in now day's technology about design and implementation of the Miner worker's security system which will be efficiently changed with the safety and surveillance system was been presented in this work. The intelligent ultrasonic helmet system paper work presents. The definite objective of an intelligent ultrasonic helmet system project was able to enhancement of the better understanding of technology in which we learn the use of sensory data via haptic-feedback mechanism which seen to be spontaneous & user friendly with possible sensing to the new technology in mandate to provide the miners with information.

The final design and implementation of system gives 100% result in safety and to detect and monitoring sense of the undesirable environmental changes like Temperature, Pressure and Methane gas and also to generate the range value by the ultrasonic sensor for obstacle avoidance inside the underground mining. The use of wireless zigbee technology improves the performance and efficiency for the data transmission to the control panel for the communication and alerts the security system. In this project, we were able to store the data that parameter in the PC, This stored data can will help to detect the hazards has they will happen before itself. This will help us to save the life of mining workers as much before, where the recuse team people staying at the control unit comes to save them.

In this paper, an intelligent ultrasonic helmet system has been presented involving its hardware design, the integration within the system, the communication method implemented for the collecting of environmental parameters from the sensor and their deployment of the system. It focuses at the safety and reliability of the mining worker and offers the personalized approaches to the safety of person life. It can avoid the death of the person in the underground mining purpose.

Further it can be improved such as:

- By the decrements of all the components, size and weight of the implemented circuit can be compacted to a much comfortable level.
- Location of the miners can be detected using GPS can be added. Usage of DSP device instead of Microcontroller to enhance speed response of the system.

ACKNOWLEDGEMENT

I would like to express my special thanks of gratitude to prof. Dr. Sarika Tale (HOD), Department of Digital Electronic and Communication Systems, Visvesvaraya Institute of Advanced Technology. Who gave me the golden opportunity to do this wonderful project on the topic (An Intelligent Ultrasonic Helmet System for Miner), which also helped me in doing a lot of research and I came to know about so many new things we are really thankful to them. And, secondly I would also like to thank my parents and friends who helped me a lot in finalizing this project within the limited time frame.

REFERENCE

[1] "A Smart Helmet for Air Quality and Hazardous Event Detection for the Mining Industry" - C. J. Behr, A. Kumar and G.P. Hancke, www.ieee.org Vol. 978-1-4673-8075-1/16/2016.

[2] "Energy efficient environment monitoring system based on the IEEE 802.15.4 standard for low cost requirements", - A. Kumar and G. P. Hancke, IEEE Sensors Journal, vol. 14, no. 8, pp. 2557-2566, Aug. 2014.

[3] "A Haptic Solution to Assist Visually Impaired in Mobility Tasks", - B.Ando, Banglio, V. Marletta, IEEE trans. On human-machine System, pp.641-646, July 2015.

[4] "Ultrasonic Sensor Explorer" - Atanas Dimitrov, Dimitar Minchev, www.ieee.org Vol. 978-1-4673-9522-9.

[5] “Analysis of Darlington Pair Amplifier at 90nm Technology” - Rashmi Singh, Dr. Rajesh Mehra, International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT) IEEE – 2016.

[6] “Quality of Obstacle Distance Measurement using Ultrasonic Sensor and Precision of Two Computer Vision-based Obstacle Detection Approaches”- Navya Amin and Markus Borschbach, International Conference on Smart Sensors and Systems (IC-SSS) Vol. 978-1-4673-9328-7, IEEE 2015.

[7] “The Application of Ultrasonic Sensor in the Obstacle Avoidance of Quad-rotor UAV”- Meng Guanglei, Pan Haibing - August 12-14, 2016 - Shenyang Aerospace University Automation Institute, Shenyang 110136, China IEEE 2016.

[8] “Perception of Ultrasonic Haptic Feedback on the Hand: Localization and Apparent Motion” - Graham Wilson, Tom Carter, Sriram Subramanian & Stephen Brewster. Vol. ACM 978-1-4503-2473-1/14– IEEE- 2014.

[9] ZigBee Alliance, "Zigbee wireless standards”. www.didgi.com/ technology/rf-articles/wireless-zigbee.

[10] “Implementing the Internet of Things vision in industrial wireless sensor networks”,- C. P. Kruger and G. P. Hancke, IEEE Int. Conf. on Industrial Informatics, pp. 627-632, July 2014.

[11] “A survey of wireless communications and propagation modelling in underground mines,” - E. Forooshani, S. Bashir, D. G. Michelson and S. Noghanian, IEEE Communications Surveys and Tutorials,B vol. 15, no. 4, pp. 1524-1545, Nov. 2013.

[12] “Hazard Evaluation Methodology for Computer-Controlled Mine Monitoring/Control Systems”,- Roy S. Nutter, Jr., Senior Member, IEEE Trans. on Industry Applications, vol. 19, pp. no. 3, May/June 1983.

[13] “Wireless Sensor Network Based Coal Mine Wireless and Integrated Security Monitoring Information System”, - Yang Wei, Huang Ying, ICN '07 Sixth International Conference, pp. 13-17, 22-28 April, 2007.

[14] “Underground Structure Monitoring with Wireless Sensor Networks. Information Processing in Sensor Networks”, - Mo Li, Yunhao Liu, IPSN 2007. 6th International Symposium on 25-27 April 2007, pp. 69-78.

[15] “Radio Propagation at 900 MHz in Underground Coal Mines”, - Y.P. Zhang, G. X. Zheng, J. H. Sheng, IEEE Transactions on Antennas and Propagation, vol.49(5), pp. 752-62, 2001.

[16] “ZigBee Based Intelligent Helmet for Coal Miners”, - C. Qiang, S. J. Ping, Z. Zhe, Z. Fan, Proc. IEEE World Congress on Computer Science and Information Engineering, pp. 433-35, 2009.

[17] “Multi-parameter Monitoring System for Coal Mine based on Wireless Sensor Network Technology”, - S. Wei, L. Li-li, Proc. International IEEE Conference on Industrial Mechatronics and Automation, pp 225-27, 2009.

[18] "A Wireless Surveillance and Safety System for Mine Workers based on Zigbee", - Tanmoy Maity, Partha Sarathi Das, Mithu Mukherjee, First International Conference on Recent Advances in Information Technology, RAIT, 2012.

[19] "Wireless Sensor Network Based Coal Mine Wireless and Integrated Security Monitoring Information System", -Wei Yang, Ying Huang, Proceedings of the Sixth International Conference on Networking (ICN'07), IEEE, 2007.