Multi Sensor IoT Network System for Safety Applications Based on LoRa Technology

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Abstract – ***Poor environmental conditions leads to severe health problems. Especially, for people working under hazardous environments. So it is necessary to develop a reliable systems for environmental monitoring. This paper presents a low-power sensor nodes for environmental monitoring Internet of things (IoT) applications, forming a wireless sensor network based on LoRa technology. Environmental data is monitored by the sensor node in real-time and then transmitted to remote cloud server via WSN. The data can be displayed to authorized users through a web-based application located in the cloud server and this will alert the user via a mobile application called "Blynk" when an emergency condition is detected.***

Keywords –***LoRa-based sensor node, safety applications, Sensors, Monitoring, Internet of things***

I. INTRODUCTION

Internet of things (IoT) is a new technology that is gaining attention from the vast research fields in the past few years [1].This provides the connectivity of embedded objects like sensors and other devices with software technologies for the purpose of exchanging information over the internet.

Wearable sensor network field have become more ubiquitous now-a-days, carrying more sensors, due to advancements in miniaturization and manufacturing. Here the technology is at the point where these smart devices can embed multiple sensors and continuously monitor the environment [2]. This work presents the prototype of smart, low power, reliable system that can be used for environmental monitoring[10]. It is a customized node, where we can use multiple number of sensors based on our requirements.

Each sensor node consists of a sensing unit and a wireless module. The total sensor node is low power consuming 5.6µA.The collected data is transmitted to gateway via a long-range LoRa technology and it is delivered to authorized users through a web-based application located in the cloud server.

Sensor nodes are the key components in wireless sensor network as they collect the data from the environment for further usage. Researchers from multiple disciplines have presented different sensor systems for various applications. In [3] the authors presents a wearable wireless sensor network for indoor smart environmental monitoring in safety applications. Another wearable sensor is presented in [4], Which is designed for real-time monitoring of toxic environmental volatile organic compounds. Smart, low power wearable multi-sensor data acquisition system for environmental monitoring is presented in [5]. Seeger et al propose a middleware solution for the wearable sensor node system of WBAN. Which is based on the smartphone applications [6]. The remainder of the paper is organized as follows : section II describes the system architecture, section III describes experimental results of the sensor node. Lastly, the paper is concluded with a discussion of future improvements in section IV.

II. SYSTEM ARCHITECTURE

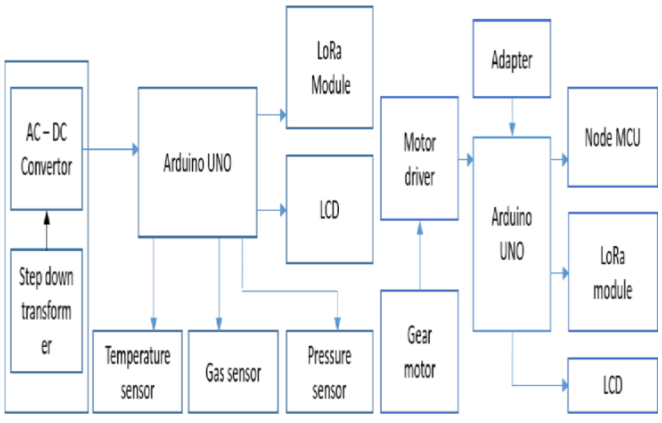

Fig.1 Multi sensor IoT network system architecture

This paper presents the implementation of a multi sensor IoT network system for safety applications based on LoRa technology.

It consist of 3 major blocks : The sensor block, power supply block and wireless transmission. Fig.1 shows the architectural view of sensor network with LoRa technology.

A. SENSOR BLOCK

Arduino Uno R3 is one kind of ATmega328P based microcontroller board from Atmel corporation is selected as micro-controller (MCU) in this work [7].It collects the data from multiple sensors and interfaces with LoRa chip. The MCU is of low cost and has high performance features. It has 14 digital I/O pins, which can support various functions required by sensor node. The operating voltage of arduino is 5volts.

The entire block uses 3 sensors to measure the desired parameters.

1. TEMPERATURE SENSOR

DHT11 sensor from Adafruit Industries LLC® is selected to measure temperature and humidity. It features accuracy of ±5% and its operating temperature ranges from 0℃ - 50℃. DHT11 is small in size with operating voltage from 3v – 5v.The maximum current used while measuring is 2.5mA.This sensor communicates with the MCU via an I2C interface.

2. GAS SENSOR

The second onboard sensor is MQ2 sensor.MQ2 is a metal oxide semiconductor type gas sensor. Concentrations of gas is measured using voltage divider network present in the sensor. This sensor works on 5v DC voltage. It can detect gases at a range of 200 to 10000ppm.

3. PRESSURE SENSOR

BMP180 sensor from BOSCH – sensortec is used in this work to measure pressure [8]. BMP180 sensor can measure barometric pressure from 300 to 1100 hPa. The pressure measurements are much precise with a low altitude noise of 0.25m, you can even use it as an altimeter with ±1 meter accuracy. The module comes with an on-board LM6206 3.3V regulator, so you can use it with a 5V logic microcontroller like Arduino. We can easily interface this module with any microcontroller. Because it features a simple two-wire I2C interface.

B.POWER SUPPLY

The power management of sensor node is a major challenge in many devices. Because it requires regular battery replacement or charging. There is a need for an effective and efficient system to address this power supply issues [11]. Solar energy provides the highest power density. But the drawback is that solar energy will not serve at night and this should be considered in the power management unit. A 12V step down transformer is used to convert high primary voltage to a secondary voltage. Our present day electronics is heavily dependent on it. Transformer works based on the mutual induction between the windings. This transformer is available at low cost with high reliability, durability and provides more than 99% of efficiency and also useful in stepping down the voltage, thereby making the transmission power easier and cheaper. Transformer is a static apparatus, with no moving parts, which transforms electrical power from one circuit to another with no change in frequency and changes in voltage, current.

In this paper we use 12-0-12 centre tapped transformer to step down the input voltage of 220V AC to 12V AC current.

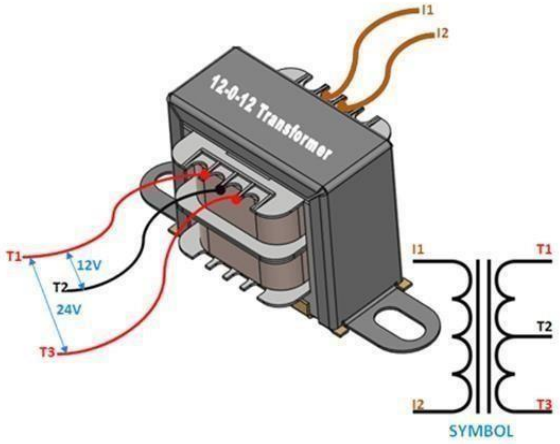

Fig.2: 12-0-12 Centre tapped transformer

I1 and I2 are the input wires, it is connected to the phase and neutral of AC mains

T1 and T3 are the output terminals, the voltage across it will be 12V AC.T2 is the centre tapped wire of the transformer, this wire can be combined with T1 or T3 to get 12V AC across it.

12-0-12 centre tapped transformer specifications:

- Input voltage : 220v AC at 50Hz
- Output voltage : 12v
- Output current
- Vertical mount type
- Low cost and small package

To convert 12v AC to 5v DC an AC to DC convertor is used. It supplies 5v DC to Arduino Uno microcontroller.

C.WIRELESS TRANSMISSION

In the last couple of years, there is a number of communication technologies available for interaction between IoT devices. The most popular ones are the Wi-Fi technology and Bluetooth module. But they have few limitations like limited range and access points. The power consumption of Wi-Fi and Bluetooth technology is high. which drains the battery if you go for battery driven devices [13].

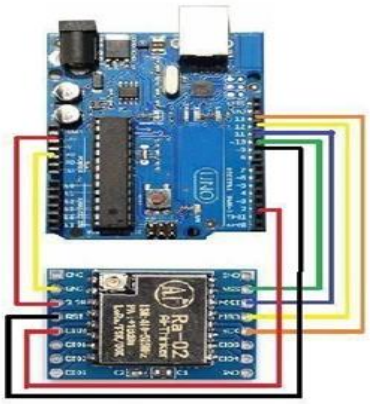

Fig.3 LoRa module interface with Arduino Uno

In this work, SX1278 433MHz module from semtech corporation is selected as LoRa module [9].This can achieve a sensitivity of over -148dBm using a low cost crystal. The high sensitivity combined with the integrated +20dBm power amplifier yields industry leading link budget making it optimal for any applications requiring range or robustness. LoRa module provides significant advantages in both blocking and selectivity over conventional modulation techniques, it also serves better in design, range, interference immunity and energy consumption.

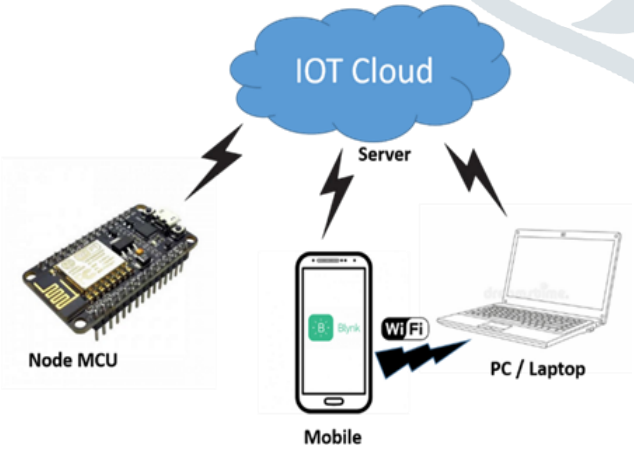

Fig .4 Wireless transmission

Some important characteristics of LoRa SX1278 module is listed below :

- Operating voltage : 3.3V
- Operating frequency : 433Mhz
- Packet size : 256 bytes
- Sensitivity : -148db

SX1278 LoRa module works with SPI communication protocol so it can be used with any microcontroller that supports SPI [12]. It is mandatory to use an ariel (antenna) along with module, else it might damage the module permanently. Interface between Arduino and LoRa module is done via three different protocols such as SPI, serial and I2C protocol.

NODE MCU :

Node MCU is a low-cost open source IOT platform. Which include firmware that runs on ESP8266 Wi-Fi microchip from Expessif systems and its hardware is based on ESP12 module[Fig.4]. Besides, adding Wi-Fi capability, the main claim to fame for the ESP8266 processor of the Arduino is that it has a larger 4MB of Flash memory and runs at the clock speed of 80Mhz and can sometimes optionally be overclocked to 160Mhz and therefore has a fast processing speed.ESP8266 module is a low cost standalone wireless transceiver that can be used for end-point IoT developments. It enables internet connectivity to embedded applications which uses TCP/UDP communication protocol to connect with server/client. This module allows our microcontroller to connect to a Wi-Fi network or to create an access point for our device.

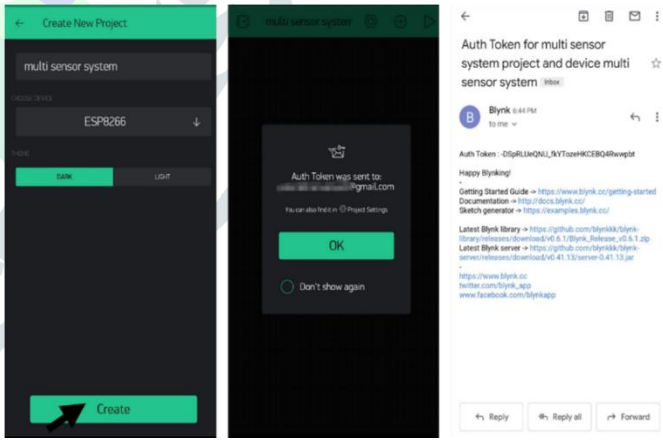

Fig . 5 Blynk application process

The application that we need to download in our mobile is “Blynk” from Google play store. Now, sign in into the project by providing an E-mail id.

A unique authentication token code will be sent to the respective E-mail id.We need to copy the authentication token in the string used in the software program. Similarly we have to provide name of our Wi-Fi network and its password. Then, the programming commands are followed based on our application. This will alert the user when an emergency condition is occurred.

GEAR MOTOR

A 12v DC gear motor is used in this work to replicate the heavy machines used in industries. The motor can rotate both in clockwise and anti-clock wise direction depending on the instruction given based on our applications. To drive this motor L293D motor driver is used where it acts as an interface between Arduino and motor.L293D is a 16pin IC with 8 pins on each side dedicated to control the motor. It consists of two H-bridge. H-bridge is the simplest circuit for controlling low current rated motor.

When parameters like gas, temperature and pressure are detected then the motor stops rotating and attains idle state. Otherwise the motor will be in rotation throughout the process. In some industries human interaction is required to operate heavy machines. In such cases this ideology can be applied to alert the workers when an emergency condition is occurred.

III. EXPERIMENTAL RESULTS

A 16×2 Liquid crystal display is used in this work to view the detected parameters like temperature, pressure, gas in transmitter as well as in receiver. It also displays the status of data packets.

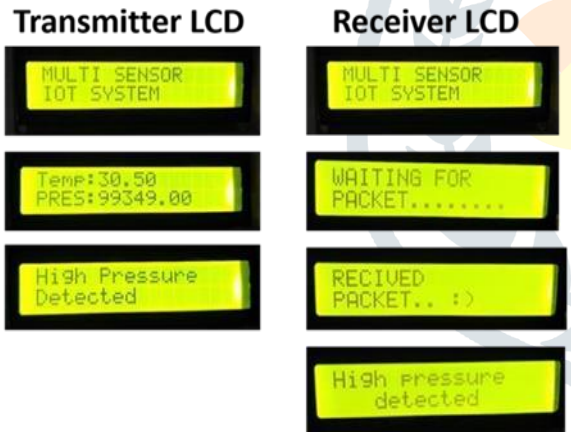

Fig.6 Pressure Measurement

Fig.6 shows the measurement of pressure that is detected in the environment which is transmitted by transmitter LoRa and the data received by the Receiver LoRa is displayed in 16×2 liquid crystal display. In this work we have used BMP 180 sensor for the measurement of pressure in the environment. Also, when the pressure that is detected exceeds the constant pressure level then it is displayed as high pressure detected both in transmitter as well as in receiver end. Once, high pressure is detected this will alert the user via E-mail.

Fig.7 shows the pressure alert received by the authorized user where this process takes place with the help of Node MCU in the receiver end.

Fig. 7 Pressure alert received via E-mail

For the measurement of temperature we have used DHT11 sensor. Its operating temperature ranges from 0℃−50℃. This sensor consists of inbuilt humidity sensing element as well as a thermistor for sensing temperature in the environment. When the temperature detected by the sensor node exceeds the normal temperature level, then transmitter LoRa module transmits a data packet via wireless communication technology. It is then received by the receiver LoRa module and display the output via liquid crystal display. Also, it alerts the user via mobile application.Fig.8 shows the measurement of temperature in transmitter and receiver nodes of liquid crystal display.

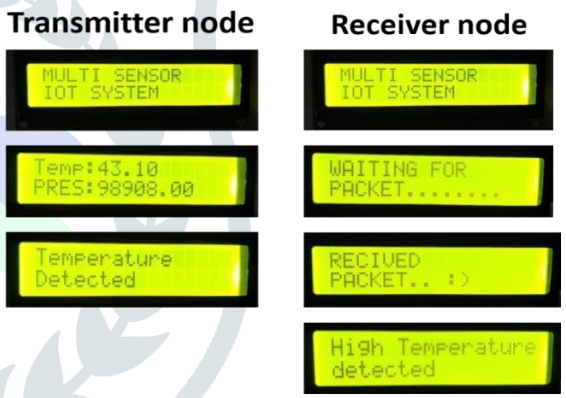

Fig.8 Temperature Measurement

Fig. 9 Temperature alert received via E-mail.

When temperature in the environment exceeds the limited range then the authorized user will receive an alert message via E-mail as show in fig.9. In this work, to measure gases we have used MQ2 sensor it can detect gases at a range of 200 – 10000ppm.This sensor is choosen because it has high sensitivity and fast response time. Fig.11 shows that gas detected by transmitter LoRa module and then it is transmitted to receiver Lora module

via a wireless technology.MQ2 sensor can detect gases like LPG, propane, hydrogen, CO etc. So if any gases out of those will be detected, then an alert mail will be sent to authorized users.

Fig.10 MQ2 sensor indicating detection of gas

To operate MQ2 sensor 5v input power supply is given,When some gas is detected in the environment then the LED in the sensor glows indicating the presence of harmful gases fig.10.Otherwise,the LED will remain turned off which means the digital output pin remains in 0v.

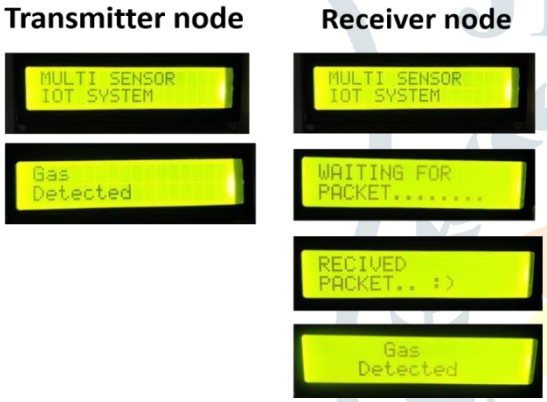

Fig. 11 Gas Measurement

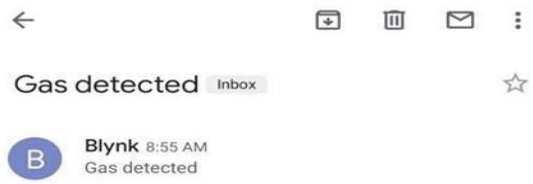

Fig. 12 Gas detected alert received via E-mail

When gas is detected in the atmosphere then the authorized user will receive an alert message via E-mail as shown in fig.12. If none of the above parameters are detected then the sensor node remains in idle position indicating in the LCD as temperature, pressure, gas are normal.

IV CONCLUSION AND FUTURE WORK

This paper presents a multi sensor IoT network system for safety applications based on LoRa technology. Environmental data is monitored by the sensor node in real-time and is transmitted to remote cloud server. Also, the detected data is delivered to authorized users via a mobile application based technology. The main aim of this paper is to provide an efficient and effective solution for people working in hazardous environments.

In Future, the work can be further improved in terms of usability and wearability. Also, it can be improved in terms of power management with durable and long term power supply without human interaction such as battery replacement or charging.

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