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# Range Enhancement of IoT Devices using LoRa

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**Abstract** -*Internet of things is one the innovative and smart technology of this era. It has enabled the ability of objects to connect and communicate via internet. There are many applications of IOT. However, what about the rural areas where there is no internet, isn't communication important and necessary for people living there, And also considering the scenario where the receiver is at far end and there is a low internet signal quality in between the transmitting and receiving end in that case we can use LoRa as a gate way. These are the two motives which drove us towards building this project. This project consists of a Transmitting and receiving end our aim is to successfully send data from transmitter to receiver without any internet, Wi-Fi, blue-tooth or any other technology apart from LoRa this prototype will help us understand how we can communicate over a long range with low power consumption in rural areas where there is no internet facility.*

***Key Words*: Lora, CSS, CRC, Symbol rate, bandwidth, spreading factor**

## 1. INTRODUCTION

"LoRa "this term can be abbreviated as Long Range, LoRa is a technology which is used to communicate over long distances without any internet. There are two main reasons for opting LoRa which are long range communication and has low power consumption rate [1]. Compared to various other technologies like internet, Wi-Fi, blue-tooth and Zigbee it is observed that LoRa consumes less power, uses low bandwidth, it has high transmission range approximately 30-40 kms, uses license free sub-gigahertz radio frequency bands like 433 MHz, 868 MHz (Europe), 915 MHz (Australia and North America) and 923 MHz (Asia), it is also multipath resistant but the data rate is comparatively low [2]. However, as every coin has two phases this budding technology has also got pros and cons. Pros of this technology include long range communication, maximum utilization of the bandwidth, low power consumption, multipath resistance and high robustness and when it comes to disadvantages the data rate is low compared to other technologies therefore video cannot be transmitted and the noise is high as it operates just below the noise floor. LoRa can be used in the rural areas to enable the connectivity and communication over long distances with low power consumption. This was the main motive behind our project as we had thought that isn't communication necessary and vital for people who are living in rural areas where there is no internet facility? In our project we have developed a prototype which has transmitting and receiving end our ultimate aim is to transmit information successfully from transmitting end to receiving end without using any kind of internet so that it gives us an idea of how data can be communicated in rural areas without any internet. Through this project we would like to prove data can be transmitted over long range with low power consumption. Usually the range of LoRa is believed to be more than several Kms. However, as this a prototype we are testing for 1Km. The principle on which it operates is CSS where spreading factor plays a major role usually spreading factor between 7-12 are used.

### 1.1 Objective of the Project

The objective of the project is to develop a prototype and simulate it to show that data transmission takes place between the transmitting and receiving end which are kept quite apart from each other by using LoRa as source of connection establishment and not by using the internet. This helps us in understanding how the long-range connectivity and communication can happen in rural areas where there is no internet available.

### 1.2 Principle Involved

LoRa uses a proprietary spread spectrum modulation that is similar to and a derivative of Chirp spread spectrum (CSS) modulation. The spread spectrum LoRa modulation is executed by representing each bit of payload information by several chirps of information. Chirp Spread Spectrum was developed for radar applications. Chirp signals have constant amplitude and pass the whole bandwidth in a linear or non-linear way from one end to another end in a certain time. Chirp spread spectrum uses complete bandwidth to transmit signals. If the frequency changes from lowest to highest, it is call up-chirp and if the frequency changes from highest to lowest, we call it down-chirp. The rate at which the spread information is transferred is referred to as the symbol rate, the ratio between the nominal symbol rate and chirp rate is the spreading factor (SF) and represents the number of symbols sent per bit of information. LoRa can trade off data rate for sensitivity with a fixed channel bandwidth by selecting the amount of spread used (a selectable radio parameter from 7 to 12). Lower SF means more chirps are Sent per second; hence, you can encode more data per second. The benefit of high SF is that more extended airtime gives the receiver more opportunities to sample the signal power which results in better sensitivity. In addition, LoRa uses Forward error correction (FEC) coding to improve resilience against interference. LoRa's high range is characterized by high wireless link budgets of around 155 dB to 170 dB. LoRa physical layer includes eight preamble symbols, two synchronisation symbols, physical payload and optional CRC.

SF8 takes exact twice the time of SF7 and SF9 takes exact twice time of SF8. Symbol Rate (Rs), Bandwidth (BW) and Spreading Factor (SF) relation:

$$Rs = BW / (2^{SF})$$

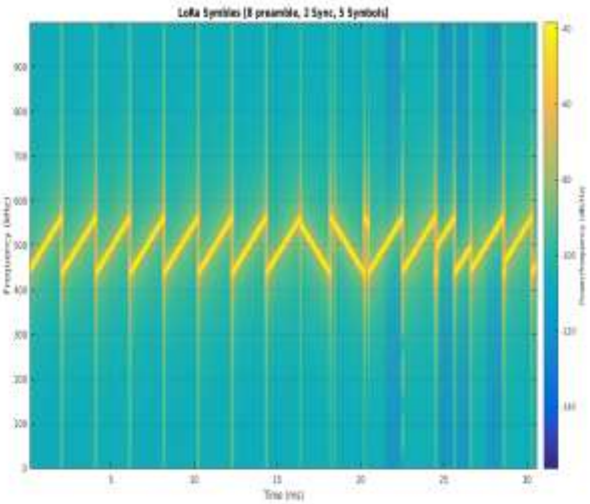

**Fig -1**: Spectrogram of lora Physical layer

First 8 up-chirp symbols are preamble symbols used to detect the LoRa chirps, next 2 down-chirp symbols are synchronization symbols used for timing synchronization followed by the 5 modulated symbols (payload). The jump in the frequency represents the modulated symbol [3].

## 2. PICTORIAL REPRESENTATION AND WORKING

### 2.1 Block Diagram

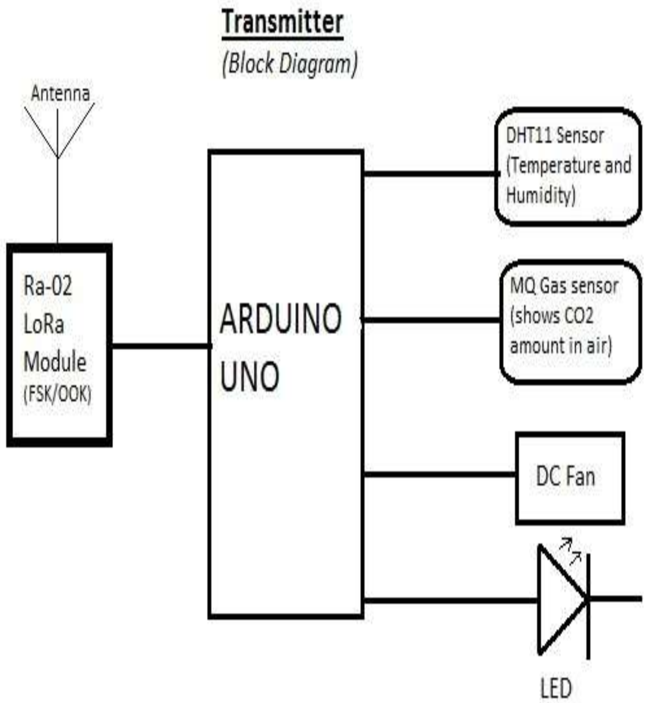


**Fig -2**: Transmitter side block diagram

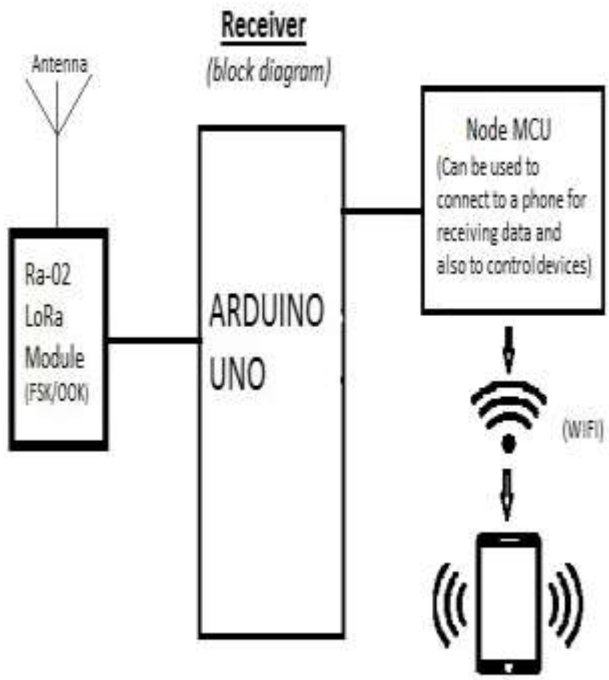


**Fig -3**: Receiver side Block diagram

## 2.2 Hardware and Software Involved (components and their description*)

**Ra-02 LoRa:** Ra-02 is used for ultra-long distance spread spectrum communication and compatible FSK remote modulation and demodulation rapidly. Ra-02 is widely used in a variety of networking processes, for meter reading, home automation, security, irrigation systems, is the best solution for networking applications. Ra-02 is available in packages called SMD packages and is used for efficient production using SMT equipment. It gives very high reliability connections based upon the respective modes reaching customers requirement. The essential features of LoRa may include high blocking resistance, provides preamble detection and half-duplex communication and many more [4].

**ARDUINO UNO:** ARDUINO UNO was developed by Arduino.cc which is a microcontroller. ARDUINO is an open source which is used for many electronic projects. ARDUINO has both hardware and software or IDE (Integrated Development Environment) running on a pc and use to upload the code to the physical board. The board has many features to run controller which is connected to the computer through the USB cable directly that is actually used to transfer the code through IDE. IDE is basically a simplified C++ version making the program much easier and convenient to the users. Apart from the USB we can also use AC or DC adapter as an alternative for the power supply.

**DHT11:** DHT11 is a digital sensor which is actually used to sense the temperature and humidity. This sensor can be ported with the microcontrollers such as Raspberry Pi or Arduino according to the user's requirement. This sensor has a resistive type humidity measurement and an NTC temperature measurement which gives rapid response, good quality and cost effectiveness. There is a single bus data format of transferring information with the NODE MCU. The power supply requirement of the DHT11 sensor is about 3-5V of DC which responds within seconds if there is any failure.

**MQ Gas Sensor:** There are many kinds of sensors developed but the most commonly used gas sensor is MQ2. When the gas interacts with the material, the detection process takes place depending upon the resistance of the sensing material.MQ sensor is a Metal Oxide Semiconductor (MOS) gas sensor which is otherwise called as chemiresistor. MQ2 gas sensor works on a digital voltage of 5V and draws power around 800Mw. It is used to detect smoke, alcohol, propane, hydrogen, LPG of different concentrations which are anywhere close to 200 to 10000ppm.

**Dc Fan:** Digital systems and microcontroller pins have many disadvantages to give sufficient current to drive the circuits like relays, buzzer circuits, DC fans and so on. These devices require current around 10milli amps to operate them but the microcontroller will provide maximum of 1-2milli amps current. For this particular reason, a driver that is a power transistor is placed in between the microcontroller and the device. The operation of this circuit is when the input to the base of the transistor is been applied from the microcontroller port pin P1.0. The transistor will be switched on when the base to emitter voltage is greater than 0.7V (cut-in voltage). Thus, when the voltage applied to the pin P1.0 is high i.e., P1.0=1 (>0.7V), the transistor will be switched ON and thus the fan will be ON. When the voltage at the pin P1.0 is low i.e., P1.0=0 (<0.7V) the transistor will be in OFF state and the fan will be OFF. Thus, the transistor acts like a current driver to operate the fan accordingly.

**LED:** LED (light emitting diode) is a solid-state light source. It is an optoelectronic device in which a forward biased p-n junction emits light that is which converts electrical energy to light energy. Injection electro luminescence is the major principle used in an LED. An LED is fabricated using semiconductors. Light emitting diode emits light which is way similar to the commonly used diodes when current flow through them.

**NODE MCU:** It is a kit which consists of ESP8266 Wi-Fi enabled chip. NODE MCU is an open source IOT platform. NODE MCU board is featured with many advantages such as Wi-Fi adaptability, analog and digital pins and different types of protocols. ESP8266 firmware has been provided in binary format that is within the chip (inbuilt). ESP8266 is cost efficient which is operated wireless and which acts as a trans receiver that can be used for end point developments.

## 2.3 Working

The entire project is divided into two parts the transmitting end and receiving end respectively. The working is as follows; on the transmitting end we have various devices or sensors like LoRa Module (FSK/OOK), ARDUINO UNO, DHT11 Sensor (Temperature and Humidity), MQ Gas Sensor (Shows CO2 amount in air), DC Fan and an LED. From the transmitting end the information like temperature and humidity is gathered or sensed by the DHT11 sensor and the CO2 level is detected by the smoke sensor then this overall information is sent to receiving end via LoRa transmitting antenna. The receiving end has a LoRa Module (FSK/OOK), ARDUINO UNO and NODE MCU. The information received from the transmitter module is encoded by the LoRa receiver. NODE MCU is connected to the mobile hotspot to view the receiving data on the mobile. This can be done as we have developed an MIT application which is used to view the data from where ever we are in the world as well as we can also control Fan and LED which we placed on the transmitting end as we have created buttons on the MIT app to do so. The same received data can also be viewed on the ARDUINO IDE interface as both the ARDUINO modules which are on transmitting and receiving end are programmed as per the functionality. This prototype which we developed successfully worked up to one 1Km.Therefore, the objective of the project to transmit and receive information through LoRa without any internet is been achieved.

### 2.4 CIRCUIT

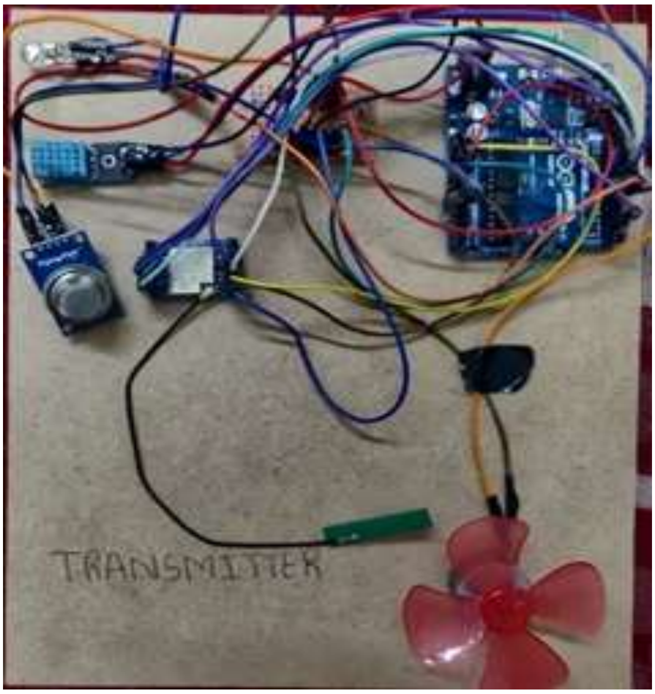


**Fig -4**: Transmitter side circuit

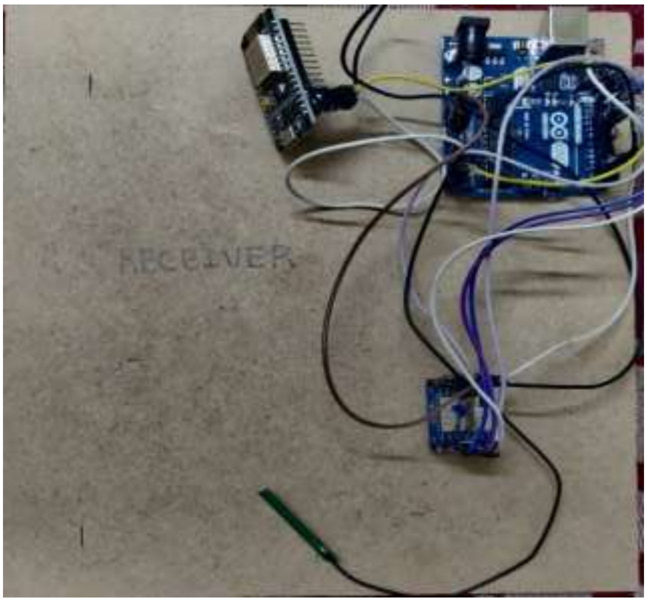


**Fig -5**: Receiver side circuit

## 3. SIMULATION AND RESULTS

The results of simulation are observed on our mobile in the MIT app which we have created as well as on the Arduino IDE, the results are as follows:


**Fig -6**: App showing output data

This is the screenshot captured of the display of received Data on MIT app in the mobile.

The display of results on Arduino IDE is as follows:

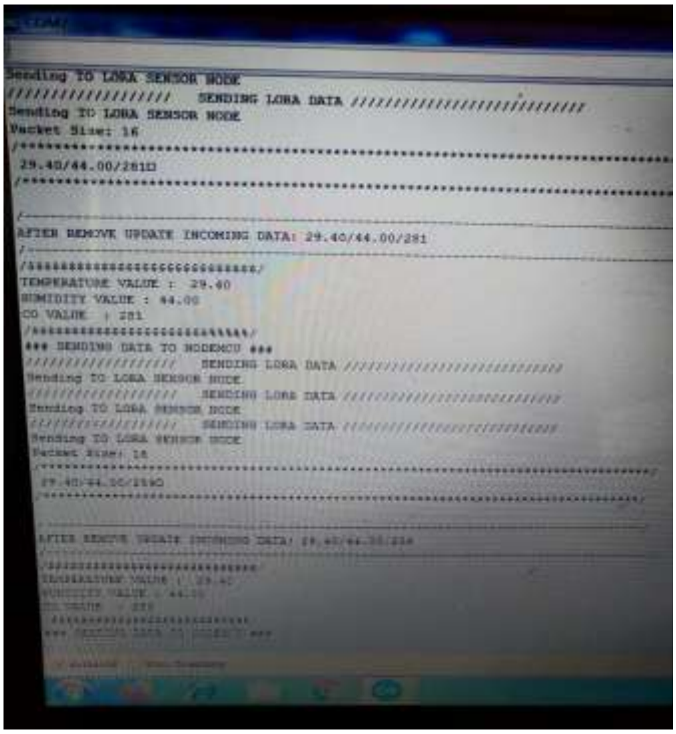


**Fig -7**: Serial monitor in arduino IDE displaying output data

## 4. CONCLUSION

LoRa can be used for achieving long range communication with low power communication. It operates in license free frequency channels and uses low bandwidth compared to other technologies like internet, Wi-Fi, Bluetooth and zig-bee. Through this project we have successfully transmitted data and received the data successfully via LoRa.

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