الجامعة الإسلامية العالمية ماليزيا
INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA
يونيبرسيتي إسلام انتارابغسا مليسيا

Project
MCTE 4344 (Remote Sensing And Telemetry)
Semester 2, 2021/2022

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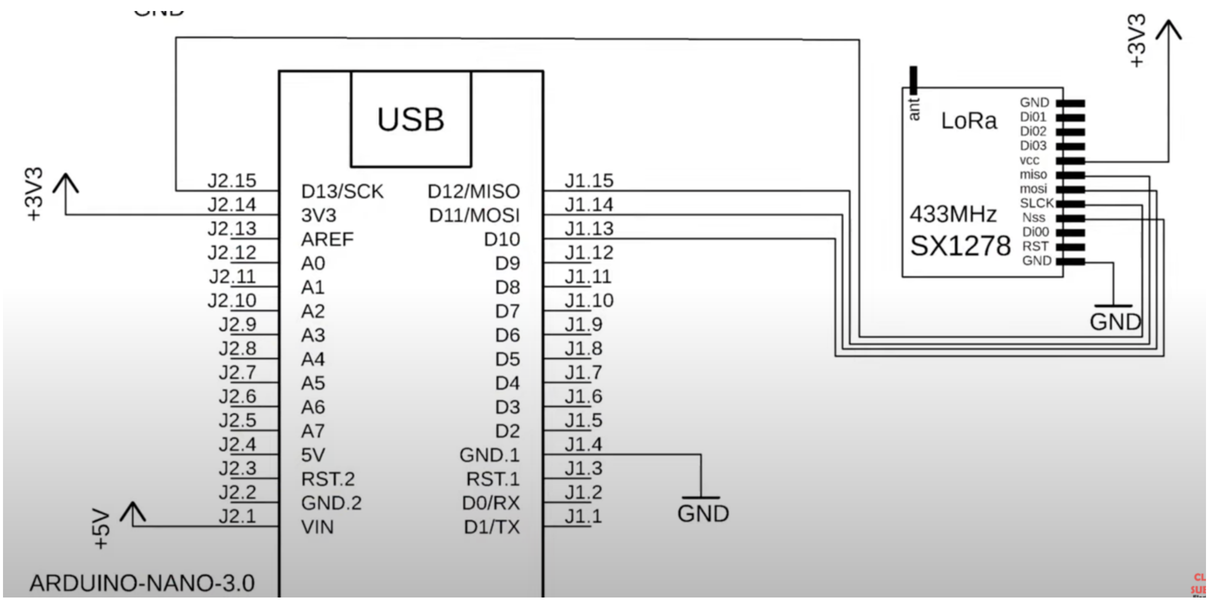
- **Introduction :**

In this project, we use LoRa to transmit and receive data obtained from a sensor.

- **CIRCUIT DESIGN**

The circuit consist of LoRa RA-02 SX1278 433MHz LoRa communication module, Arduino Nano and HC-SR04 Ultrasonic Distance Sensor.



Circuit Design

- **Wireless Data Transmission Using LoRa**

LoRa which has been developed by Semtech is a Low- Power Wide Area Network (LPWAN) modulation technique using spread spectrum modulation based on chirp spread spectrum technology. In this study we have used the LoRa RA-02 SX1278 433MHz LoRa communication module as shown in Fig. 1. The module has the advantage of allowing data to be transmitted at a longer range using a lower power consumption as compared to other wireless data transmission such as Zigbee. A star network topology was used, which consists of two sensor nodes and one gateway.

}

Fig. 1

- **SOFTWARE DEVELOPMENT**

Arduino was used for developing the code for the transmission and receiving of data.

LoRa Receiver Code:

```
#include <SPI.h>

#include <LoRa.h>

void setup() {

  Serial.begin(9600);

  while (!Serial);

  Serial.println("LoRa Receiver");


  if (!LoRa.begin(433E6)) {

    Serial.println("Starting LoRa failed!");

    while (1);

  }

}
```

```
void loop() {
  // try to parse packet
  int packetSize = LoRa.parsePacket();
  if (packetSize) {
    // received a packet
    Serial.print("Received packet '");

    // read packet
    while (LoRa.available()) {
      Serial.print((char)LoRa.read());
    }
    Serial.print(" cm");

    // print RSSI of packet
    Serial.print("' with RSSI ");
    Serial.println(LoRa.packetRssi());
  }
}
```

LoRa Sender Code :

```
#include <SPI.h>

#include <LoRa.h>

#define trigPin 7

#define echoPin 4

int counter = 0;

float duration, distance;


void setup() {

  Serial.begin(9600);

  pinMode(trigPin, OUTPUT);

  pinMode(echoPin, INPUT);

  while (!Serial);

  Serial.println("LoRa Sender");

  if (!LoRa.begin(433E6)) {

    Serial.println("Starting LoRa failed!");

    while (1);

  }

}


void loop() {

  digitalWrite(trigPin, LOW);

  delayMicroseconds(2);

  digitalWrite(trigPin, HIGH);
```

```
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  duration = pulseIn(echoPin, HIGH);

  distance = (duration / 2) * 0.0343;

  Serial.print("Sending packet: ");
  Serial.print(distance );
  Serial.println(" cm");

  // send packet
  LoRa.beginPacket();
  LoRa.print(distance);
  LoRa.print(counter);
  LoRa.endPacket();

  counter++;

  delay(5000);
}
```

- **Ra-02 LoRa Module:**

Features:

- LoRa^{TM} spread spectrum modulation technology - Receive sensitivity as low as -141 dBm - Excellent resistance to blocking

- Supports preamble detection

- Supports half-duplex SPI communication

- Programmable bit rate up to 300Kbps

- Supports FSK, GFSK, MSK, GMSK, LoRa^{TM} and OOK modulation modes

- Supports automatic RF signal detection, CAD mode and ultra-high speed AFC

- Packets with CRC, up to 256 bytes

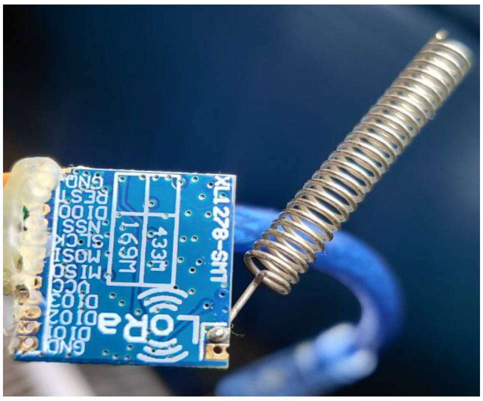
- Small package with double volume stamps

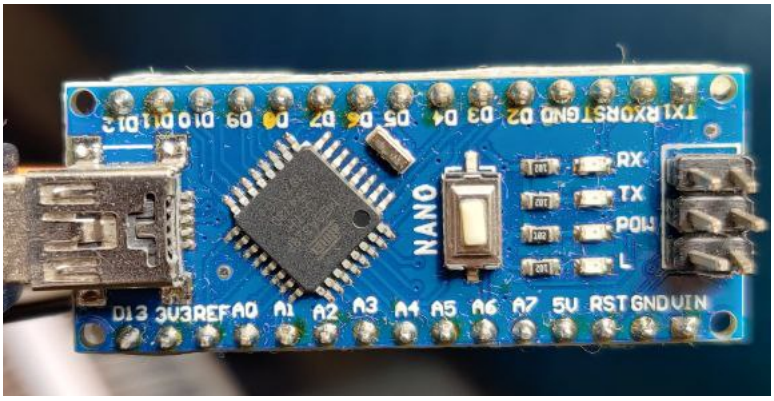
Overview:

Ra-02 can be used for ultra-long distance spread spectrum communication, and compatible FSK remote modulation and demodulation quickly, to solve the traditional wireless design cannot take into account the distance, anti-interference and power consumption.

Ra-02 can be widely used in a variety of networking occasions, for automatic meter reading, home building automation, security systems, remote irrigation systems, is the ideal solution for things networking applications.

Ra-02 is available in SMD package and can be used for rapid production by standard SMT equipment. It provides customers with high reliability connection mode.





Product Specifications:

Module Model	Ra-02
Package	SMD-16
Size	17*16*(3.2 ± 0.1) mm
Interface	SPI
Programmable bit rate	UP to 300Kbps
Frequency Range	410-525 MHz
Antenna	IPEX
Max Transmit Power	18±1 dBm
Power (Typical Values)	433MHz: TX:93mA RX:12.15mA Standby:1.6mA 470MHZ: TX:97mA RX:12.15mA Standby:1.5mA
Power Supply	2.5~3.7V， Typical 3.3V
Operating Temperature	-30 ℃ ~ 85 ℃
Storage Environment	-40 ℃ ~ 90 ℃ , < 90%RH
Weight	0.45g

Receive Sensitivity:

Frequency	Spread Factor	SNR	Sensitivity
433MHz	7	-7	-125
	10	-15	-134
	12	-20	-141
470MHz	7	-7	-126
	10	-15	-135
	12	-20	-141

- **LORA NETWORK RANGE**

Prior to commissioning, the LoRa network has been tested within the International Islamic University Malaysia campus. The first sensor node placement was fixed under a bridge at a location 500 meters away from the gateway, while the initial location of the mobile second sensor node was 450 meters away from the gateway. Although LoRa is capable of transmitting data to long ranges, the presence of obstacles such as trees, terrain and buildings between the gateway and sensor nodes may affect the range of data transmission. It was observed that when the first and second sensor nodes were located 600 meters away from the gateway, the data packets sent began to drop. In addition if the gateway was placed inside a building and away from windows the coverage of the LoRa network would have been further reduced. A spring antenna operating at a frequency of 433 Hz and a gain of 3dBi had been used in this study. Utilizing antennas with more superior characteristics may also increase the LoRa network coverage.

- **REAL TIME MONITORING**

Real time data from sensor is obtained and send to the receiver station.

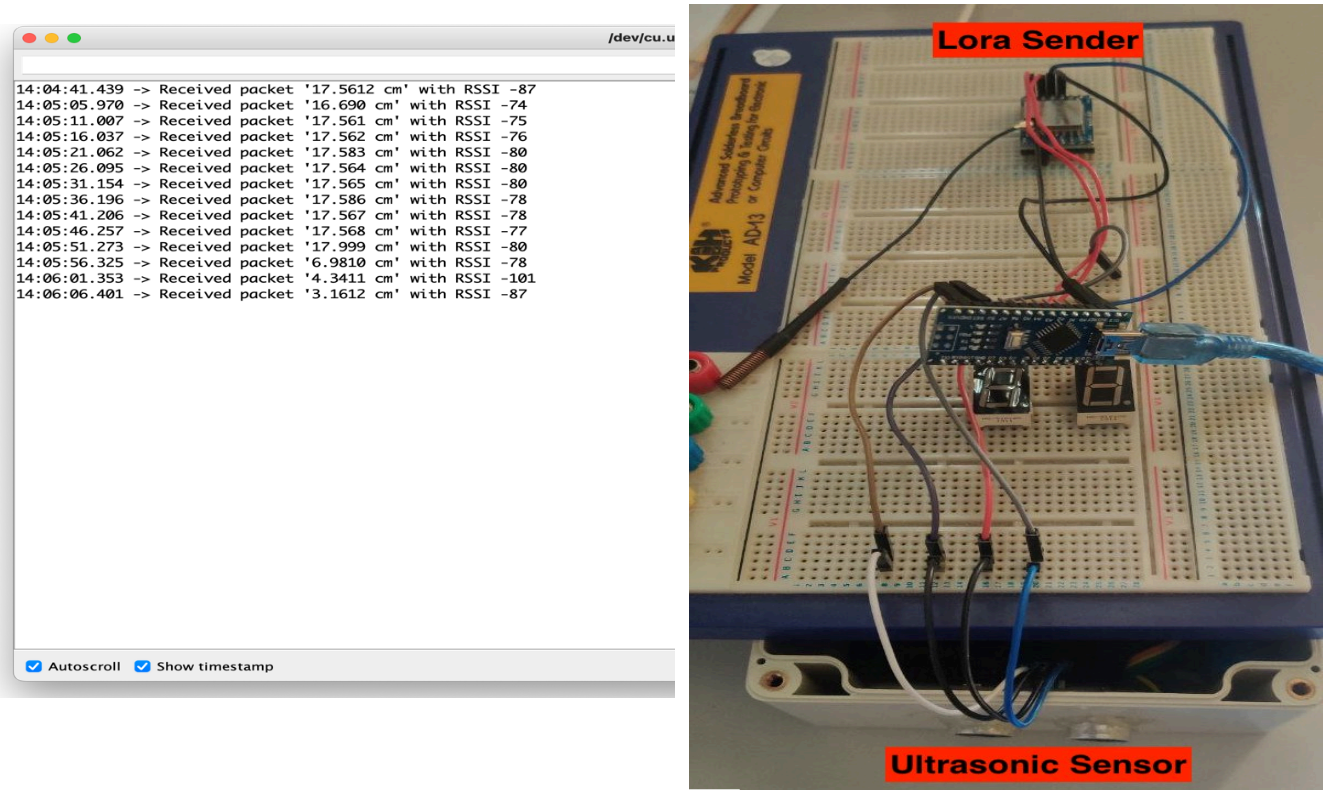


Fig 1

In the above case real time data has been obtained from the ultrasonic sensor and transmitted to the receiver LoRa. In wireless communication, a receiver needs a good signal strength and a signal-to-noise ratio to separate the original signal from the modulated carrier. RSSI (Received Signal Strength Indicator) is a relative measurement that helps to determine if the received signal is strong enough to get a good wireless connection from the transmitter. Since LoRaWAN supports bi-directional communication, RSSI is an important measurement for both gateways and end devices.

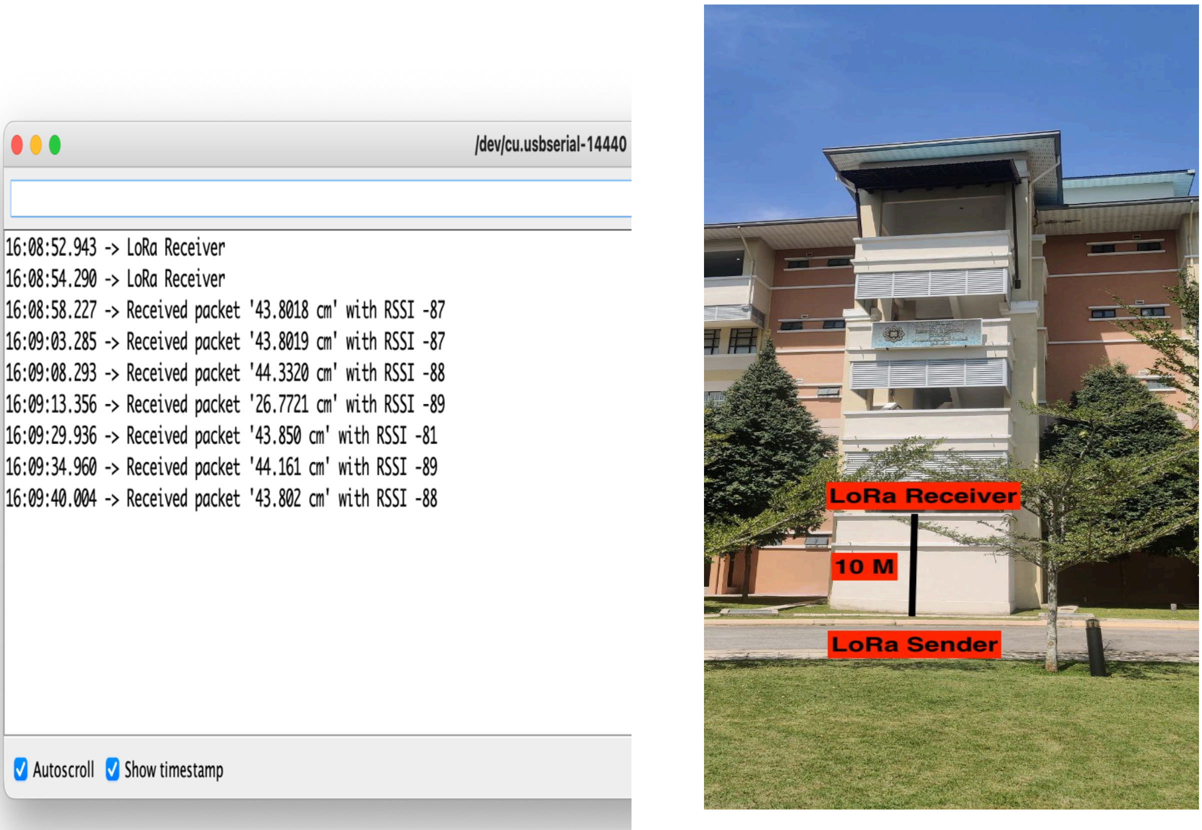


Fig 2

This is the output obtained, where the receiving station is placed at Level 2 of Kulliyah of ICT and data is sent from the sensor at ground level.

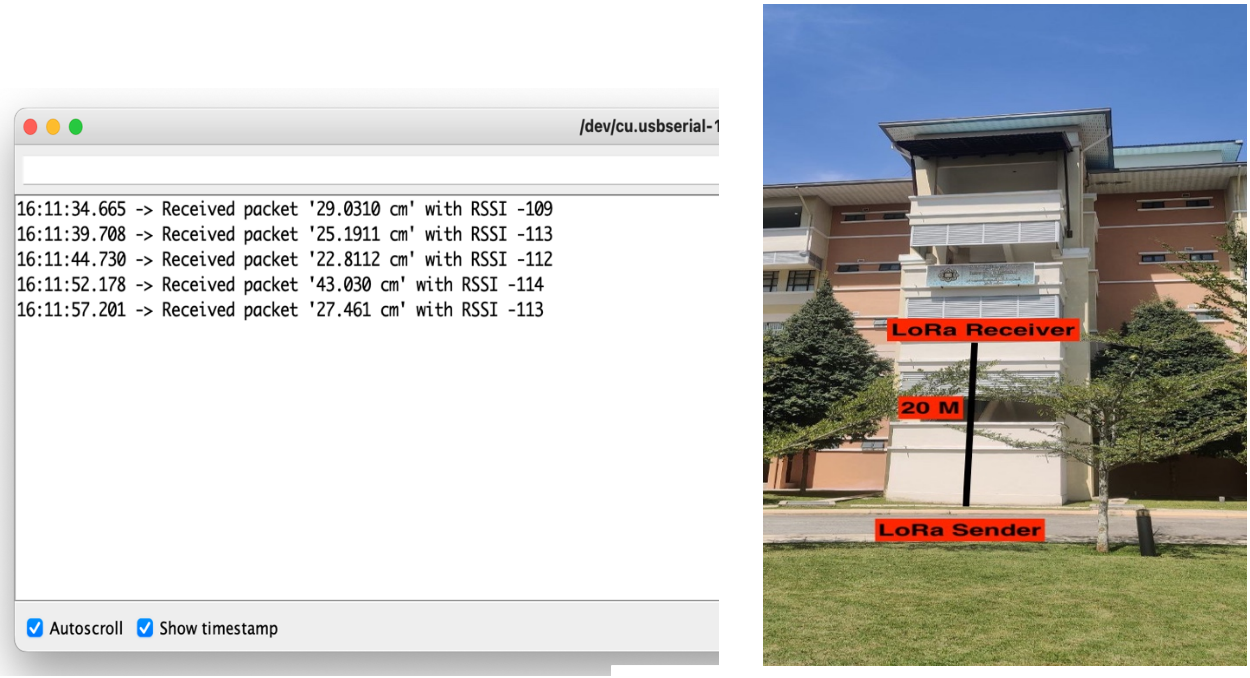


Fig 3

This is the output obtained, where the receiving station is placed at Level 3 of Kulliyah of ICT and data is sent from the sensor at ground level.

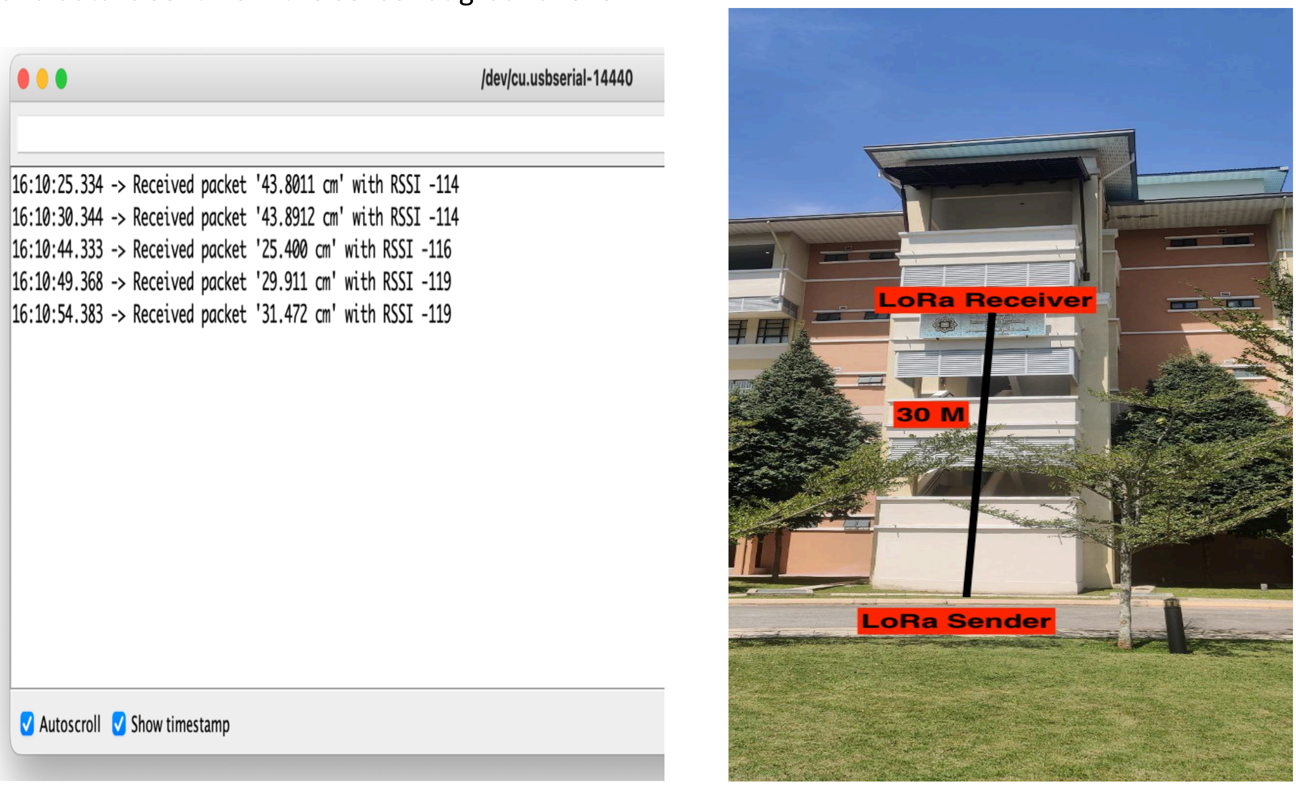
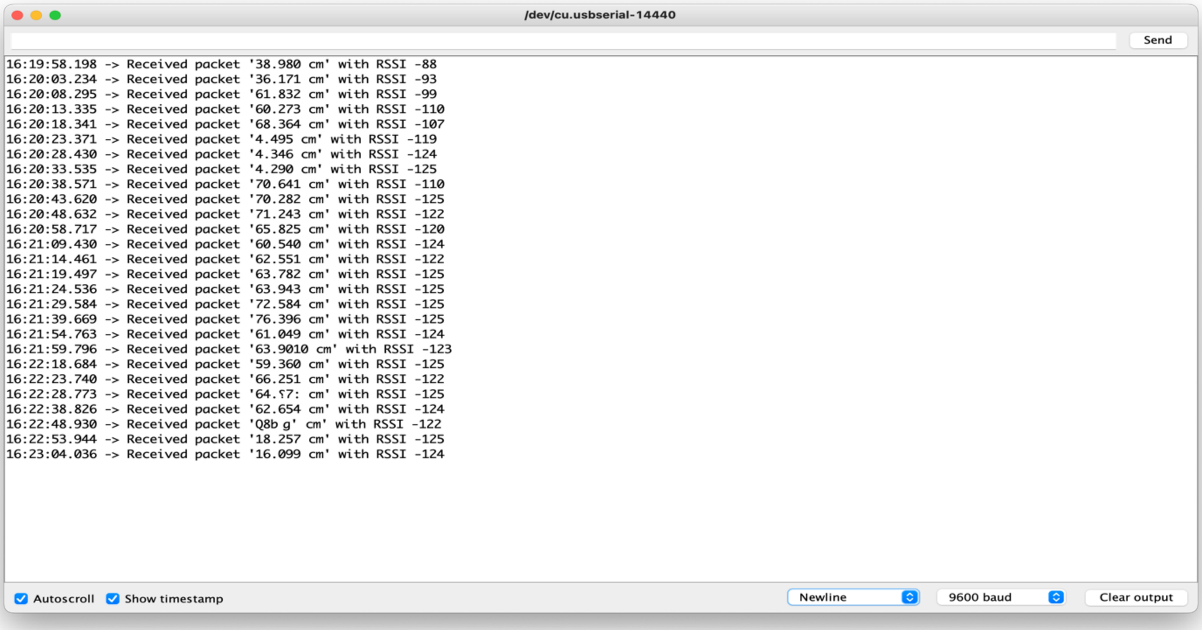


Fig 4

This is the output obtained, where the receiving station is placed at Level 4 of Kulliyah of ICT and data is sent from the sensor at ground level.

From each output it is seen that the negative value of RSSI is increasing which results in the decrease of signal strength. To get a better signal the sensors have to be placed at places with less interference.



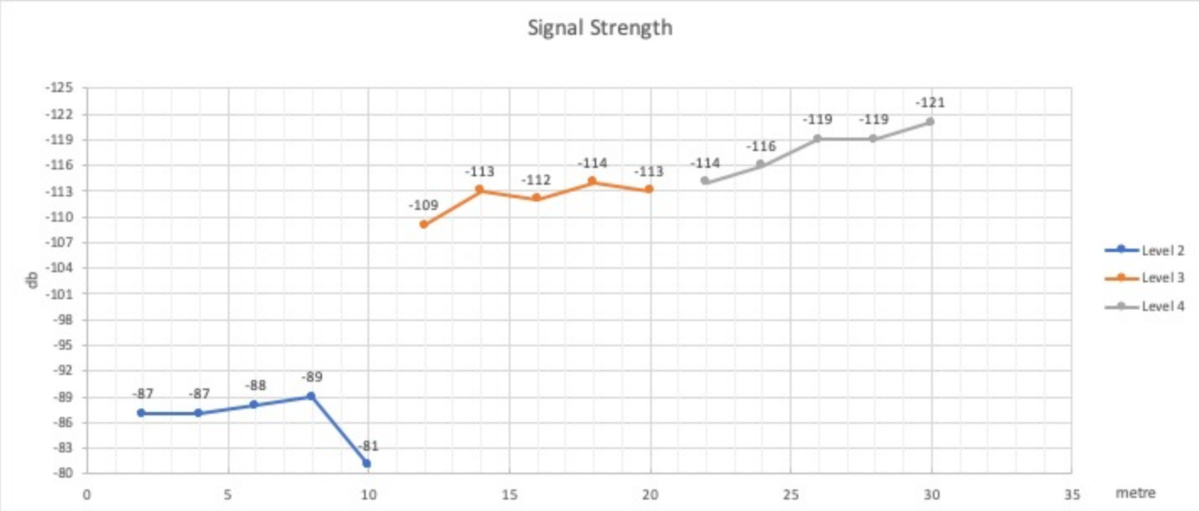
```
/dev/cu.usbserial-14440
Send
16:19:58.198 -> Received packet '38.980 cm' with RSSI -88
16:20:03.234 -> Received packet '36.171 cm' with RSSI -93
16:20:08.295 -> Received packet '61.832 cm' with RSSI -99
16:20:13.335 -> Received packet '60.273 cm' with RSSI -110
16:20:18.341 -> Received packet '68.364 cm' with RSSI -107
16:20:23.371 -> Received packet '4.495 cm' with RSSI -119
16:20:28.430 -> Received packet '4.346 cm' with RSSI -124
16:20:33.535 -> Received packet '4.290 cm' with RSSI -125
16:20:38.571 -> Received packet '70.641 cm' with RSSI -110
16:20:43.620 -> Received packet '70.282 cm' with RSSI -125
16:20:48.632 -> Received packet '71.243 cm' with RSSI -122
16:20:58.717 -> Received packet '65.825 cm' with RSSI -120
16:21:09.430 -> Received packet '60.540 cm' with RSSI -124
16:21:14.461 -> Received packet '62.551 cm' with RSSI -122
16:21:19.497 -> Received packet '63.782 cm' with RSSI -125
16:21:24.536 -> Received packet '63.943 cm' with RSSI -125
16:21:29.584 -> Received packet '72.584 cm' with RSSI -125
16:21:39.669 -> Received packet '76.396 cm' with RSSI -125
16:21:54.763 -> Received packet '61.049 cm' with RSSI -124
16:21:59.796 -> Received packet '63.9010 cm' with RSSI -123
16:22:18.684 -> Received packet '59.360 cm' with RSSI -125
16:22:23.740 -> Received packet '66.251 cm' with RSSI -122
16:22:28.773 -> Received packet '64.ʕ7: cm' with RSSI -125
16:22:38.826 -> Received packet '62.654 cm' with RSSI -124
16:22:48.930 -> Received packet 'Q8b g' cm' with RSSI -122
16:22:53.944 -> Received packet '18.257 cm' with RSSI -125
16:23:04.036 -> Received packet '16.099 cm' with RSSI -124

Autoscroll  Show timestamp    Newline    9600 baud    Clear output
```

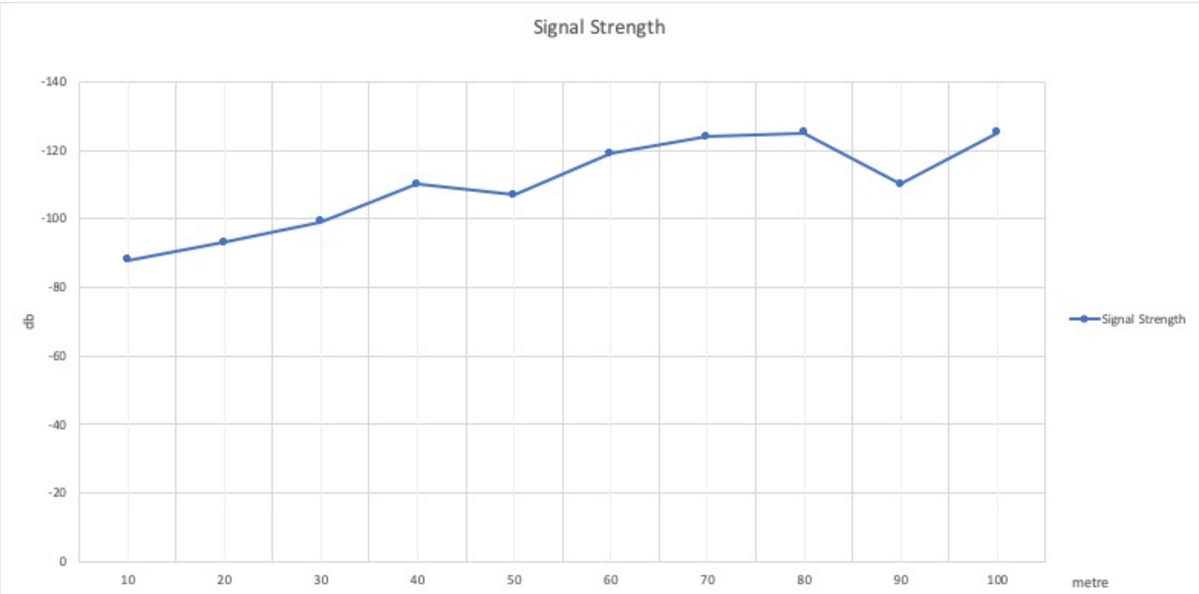
Fig 5

This is the output obtained, where the receiving station is placed at ground level of KICT and gradually the sender is kept 100 m apart. As seen in the output while the horizontal distance increases, the signal strength also decreases.

- **Result:**



The above graph shows the signal strength between the LoRa devices at various heights as seen in fig 2, fig 3 and fig 4.



The above graph shows the signal strength between the LoRa devices when kept 100m apart as seen in Fig 5

- **Conclusion:**

From the above graph it is seen that for transferring of data between LoRa devices at various height the signal strength becomes weaker as the height increases. Also it is seen from the graph as the horizontal distance between the LoRa devices increases signal strength also decreases.

There are many factors which effect radio wave frequency such as Line of sight, Antenna height, Antenna gain, Transmission Loss, surrounding frequency disturbance. Hence to improve the signal strength we suggest to upgrade the hardware required for data transfer and avoid frequency disturbances in the surrounding.