The Analysis of the Communication Distance Radio Frequency Antenna

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Abstract
We have developed a radio frequency antenna demonstrator kit as a microcontroller based wireless equipment. This system is a hybrid combination of software and hardware. This study focuses on the demonstration regarding transmitting and receiving the radio signals using the nRF24L01 device in conjunction with the PCB Antenna which are inverted F antenna, nRF24L01 connected with small piece of wire and AN043 antenna.
To analyze the performance of this PCB antennas, a transmission rate test analysis were carried out at various distance. By changing the distance, transfer the data was measured by receiver device connected with OLED display.
The AN043 PCB antenna has the optimized distance about 70 m communication device compare to other PCB antennas. The results obtained are allowed to conclude on the benefits and possibilities that the nRF24L01 device together with the PCB antenna are able to function as a transceiver.
Keywords: PCB antenna, nRF24L01

1. Introduction

The Arduino is an open-source electronics platform based on easy to use hardware and software. Usually these device are used in projects related to the Internet of Things. The device can be controlled from a distance of up to a few meters by the transmitter. It needs were identified for the transmission of data at a displacement. This being a resource that allows communication between different PCB antennas in different displacement [1].
As a general objective, it is used to verify the type of devices and their characteristics, as well as to provide an example application. It will allow transfer the data between the devices, thus allowing an understanding and testing of a basic distance, which may collaborate for future projects, involving a larger environment by considering the different range of displacement and devices.
As a specific objective, the communication scheme between the PCB antennas in conjunction with the nRF24L01 should be presented, the latter being used for data transmission. A small amount of data should be transmitted. For example, the programming language should be used the C++ language as the programming language in the Arduino Uno development tool [2].
These devices were selected because of their low cost and ease of configuration. There being a lot of technical reference, which served as the basis for this study. These devices are also commonly used during the disciplines of robotics, home and business automation, being this is a common need offered in companies, hospitals and residences [2].
The nRF24L01 component has eight pins show in figure 1 which are VCC, Ground, CE, SCK, MISO, IRQ, MOSI and CSN. This device has several features, which are 2.4GHz RF transceiver Module, Operating Voltage: 3.3V, nominal current: 50mA, range: 50 – 200 feet, operating current: 250mA (maximum), communication protocol: SPI, baud rate: 250 kbps - 2 Mbps, channel range:
125, maximum pipelines/node: 6, low cost wireless solution.

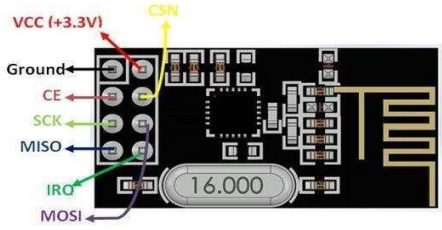


Figure 1. nRF24L01 [3].

The nRF24L01 is a wireless transceiver module, meaning each module can both send as well as receive data. They operate in the frequency of 2.4 GHz, which falls under the ISM band from 250 kbps up to 2 Mbps. The modules when operated efficiently can cover a distance of 100 meters (200 feet) which makes it a great choice for all wireless remote controlled projects.
An organic light-emitting diode (OLED) display was shown in figure 4 with a resolution of 128 x 32 pixels mounted on a 28 mm x 28 mm PCB. The effective display surface is 11 mm x 23 mm.

It has a 4-pin connector to be used with an I2C bus (with SCL & SDA signals). The display works with 5 V and 3.3 V applications.

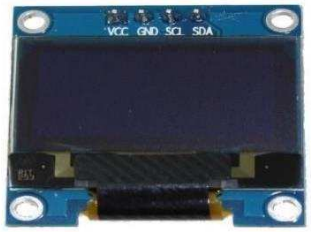


Figure 2. OLED display [4].

2. Design and Methodology

Figure 3 shows the basic setup of the sending and receiving communication system. The main functional blocks are the Arduino Uno, PCB antennas and nRF24L01.

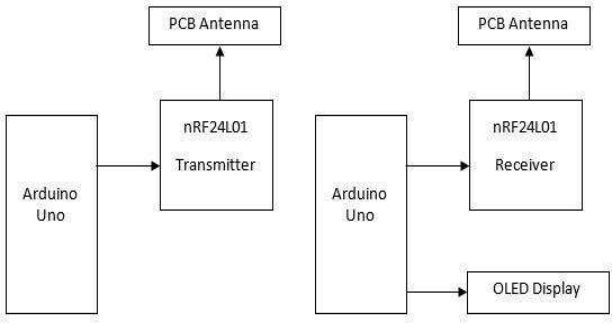
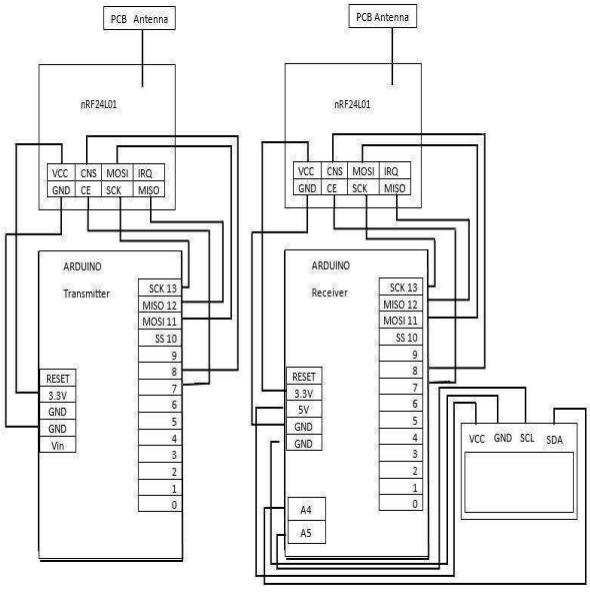


Figure 3. Block diagram

The connected circuit was shown in figure 4. The nRF24L01 range was measured by changing the distance. Then, nRF24L01 device PCB antenna was removed and inverted F antenna and AN043 PCB antennas were connected one by one. The transfer data rate was measured by changing the distance.

Figure 4 (a) shows the circuit diagram of transmitter device that was sent data in packet per second. Figure 4 (b) shows the circuit diagram of receiver device. It was connected to OLED display and receiver device data was measured via OLED display.



(a) (b)

Figure 4. Circuit diagram of (a) transmitter (b) receiver.

The nRF24L01 device PCB antenna was connected with small cupper wire around 8.5 cm long as shown in the figure 5.

Figure 5. The small wire connected to nRF24L01 device

Small changes of the antenna dimensions may have large impact on the performance. Therefore it was made an exact copy of the reference design to achieve optimum performance. The AN043 PCB antenna dimension shows the figure 6.

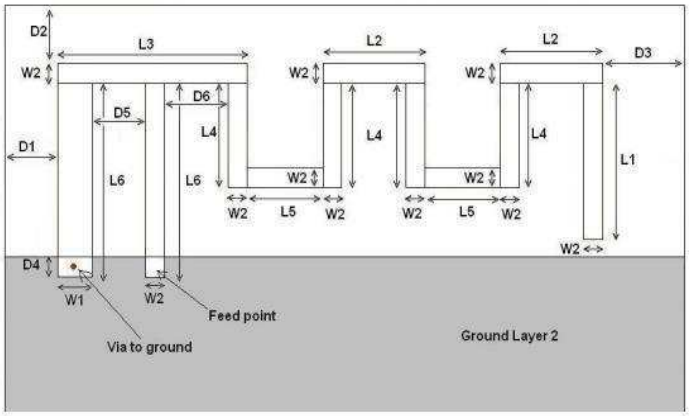


Figure 6. Antenna dimension

Table 1. AN043 antenna Dimension

L1	3.94 mm	W2	0.50 mm
L2	2.70 mm	D1	0.50 mm
L3	5.00 mm	D2	0.30 mm
L4	2.64 mm	D3	0.30 mm
L5	2.00 mm	D4	0.50 mm
L6	4.90 mm	D5	1.40 mm
W1	0.90 mm	D6	1.70 mm

The nRF24L01 device antenna was removed and constructed AN043 PCB antenna was replaced in to the nRF24L01 module. Here the PCB antenna was printed in cupper board and aluminum foil (ground plane) was attached backside of the cupper board.

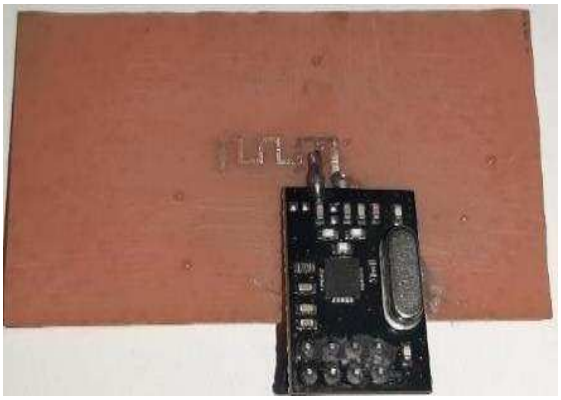


Figure 7. The AN043 PCB antenna

It was important to make an exact copy of the antenna dimensions to obtain optimum performance. The inverted F PCB antenna shows in the figure 8 and table 2.

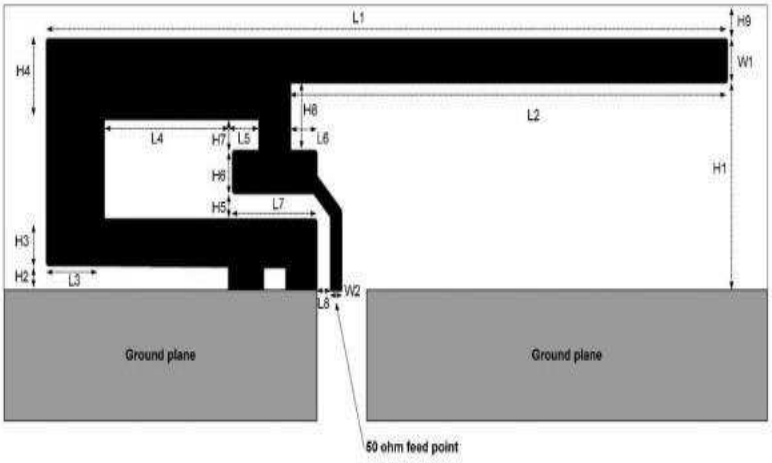


Figure 8. IFA Dimensions.

Table 2. IFA Dimension.

H1	5.70 mm	W2	0.46 mm
H2	0.74 mm	L1	25.58 mm
H3	1.29 mm	L2	16.40 mm
H4	2.21 mm	L3	2.18 mm
H5	0.66 mm	L4	4.80 mm
H6	1.21 mm	L5	1.00 mm
H7	0.80 mm	L6	1.00 mm
H8	0.61 mm	L7	3.20 mm
H9	1.21 mm	L8	0.45 mm

The nRF24L01 device antenna was removed and the inverted F PCB antenna was replaced to nRF24L01 module. Here the PCB antenna was printed in cupper board and aluminum foil (ground plane) was attached backside of the cupper board

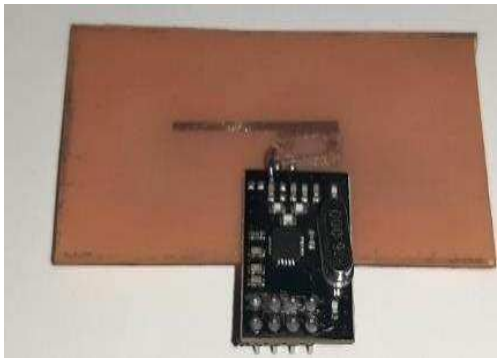
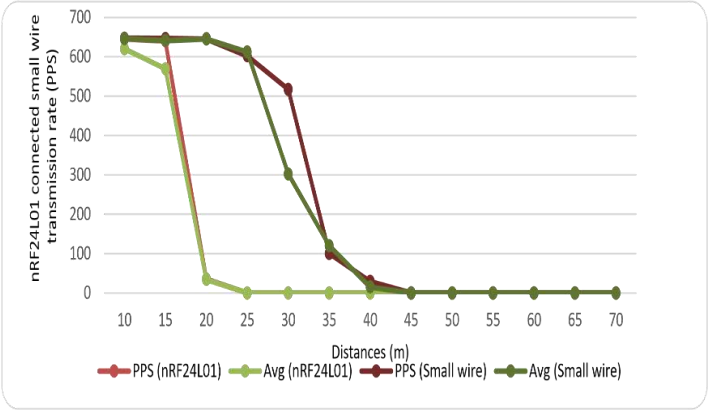


Figure 9. The inverted F antenna

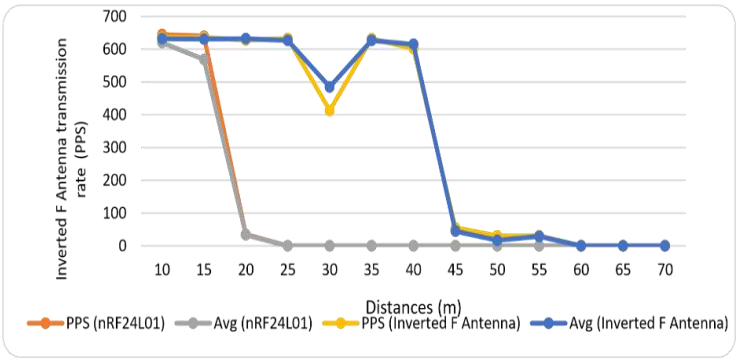
3. Results and Discussions

The nRF24L01 was connected with small wire about 8.5 cm. The transmission distance was measured by increasing step by step 5 m. The transmission rate remained constant at 650 PPS from 0 to 20 m. It dropped dramatically from 20 m to 45 m and reached zero. That nRF24L01 PCB antenna with wire has the highest distance about 45 m communication device.



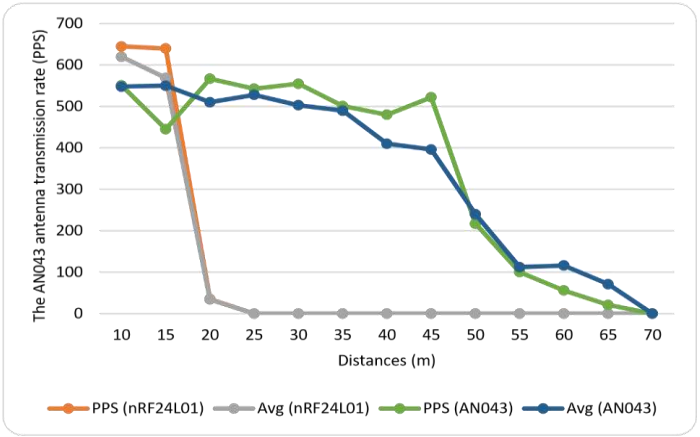
Graph 1. nRF24L01 connected small wire antenna transmission rate (Packet per second) vs. Distance.

The inverted F antenna was connected nRF24L01 device. The transmission distance was measured by increasing by 5 m steps. The transmission rate remained constant at 650 PPS from 0 to 25 m. It dropped slightly from 25 m to 30 m and reached 500 PPS. After that, it remained constant about 650 PPS from 35 m to 40 m. It decreased suddenly from 40 m to 60m and reached zero. That antenna transmission rate has the highest distance about 60 m communication device.



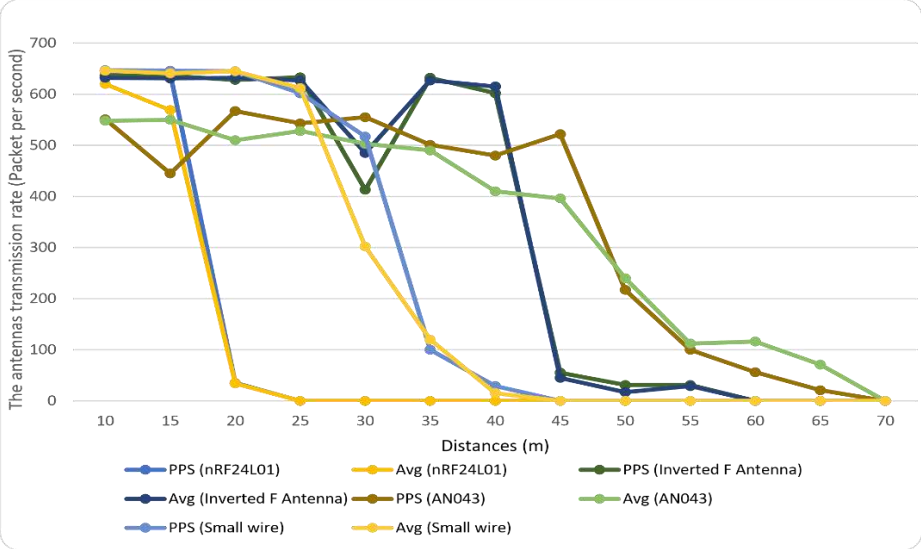
Graph 2. Inverted F Antenna transmission rate (Packet per second) vs. Distance.

The AN043 antenna was connected nRF24L01 device. The transmission distance was measured increasing by 5 m steps. The transmission rate remained constant at 550 PPS from 0 to 15 m. After that, it dropped slightly from 15 m to 70 m and reached zero. That antenna transmission rate has the highest distance about 70 m communication device.



Graph 3. The AN043 Antenna transmission rate (Packet per second) vs. Distance.

The graph shows four different types of antenna transmission distance that was measured by increasing 5 m. AN043 antenna has the highest distance about 70 m communication device.



Graph 4. The Antennas transmission rate (Packet per second) vs. Distance

4. Conclusions

The above results show that the transmission rate test and analysis were carried out for the PCB antenna at different distances. By changing the distance, the transmitted data was measured by the receiver device that connected with the OLED display.

The nRF24L01 device transmission rate has a distance of 25 m. The nRF24L01 was connected small cupper wire (8.5 cm) antenna that transmission rate has the distance of 45 m. The inverted F antenna transmission rate has a distance of 60 m. The AN043 antenna transmission rate has a distance of 70 m. The AN043 PCB antenna has the highest distance about 70 m communication device compare to other PCB antennas. The results obtained and allowed to conclude the benefits and possibilities that the nRF24L01 device and the PCB antenna can offer.

Reference

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