ESCUELA DE
CIENCIAS MATEMÁTICAS Y
TECNOLOGÍA INFORMÁTICA

Wireless Network

LAB11: nRF24 Project

Objective

1. Develop a wireless communication system between two microcontrollers
2. Utilize the capabilities of the radio to their full potential via Arduino

Discussion of fundamentals

The nRF24L01+ is a single chip 2.4GHz transceiver with an embedded baseband protocol engine (Enhanced ShockBurst), suitable for ultra low power wireless applications. The nRF24L01+ is designed for operation in the world wide ISM frequency band at 2.400 - 2.4835GHz. The radio front end uses GFSK modulation. It has user configurable parameters like frequency channel, output power and air data rate. nRF24L01+ supports an air data rate of 250 kbps, 1 Mbps and 2Mbps. The high air data rate combined with two power saving modes make the nRF24L01+ very suitable for ultra low power designs.

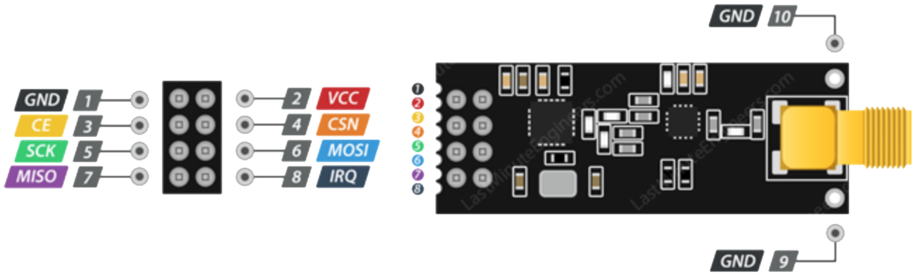


Figure 1: nRF24L01+ Pinout

- GND is the Ground Pin. It is usually marked by encasing the pin in a square so it can be used as a reference for identifying the other pins.
- VCC supplies power for the module. This can be anywhere from 1.9 to 3.9 volts. You can connect it to 3.3V output from your Arduino. Remember connecting it to 5V pin will likely destroy your nRF24L01+ module!
- CE (Chip Enable) is an active-HIGH pin. When selected the nRF24L01 will either transmit or receive, depending upon which mode it is currently in.
- CSN (Chip Select Not) is an active-LOW pin and is normally kept HIGH. When this pin goes low, the nRF24L01 begins listening on its SPI port for data and processes it accordingly.

- SCK (Serial Clock) accepts clock pulses provided by the SPI bus Master.
- MOSI (Master Out Slave In) is SPI input to the nRF24L01.
- MISO (Master In Slave Out) is SPI output from the nRF24L01.
- IRQ is an interrupt pin that can alert the master when new data is available to process.

Features of the nRF24L01+

Features of the nRF24L01+ include:

- Radio
  - Worldwide 2.4GHz ISM band operation
  - 125 RF channels
  - Common RX and TX interface
  - GFSK modulation
  - 250kbps, 1 and 2Mbps air data rate
  - 1MHz non-overlapping channel spacing at 1Mbps
  - 2MHz non-overlapping channel spacing at 2Mbps
- Transmitter
  - Programmable output power: 0, -6, -12 or -18dBm
  - 11.3mA at 0dBm output power
- Receiver
  - -82dBm sensitivity at 2Mbps
  - -85dBm sensitivity at 1Mbps
  - -94dBm sensitivity at 250kbps

2.4 GHz ISM band

2.4 GHz band is one of the Industrial, Scientific, and Medical (ISM) bands reserved internationally for the use of unlicensed low-powered devices. Examples are Cordless phones, Bluetooth devices, near field communication (NFC) devices, and wireless computer networks (WiFi) all use the ISM frequencies.

Exercise 0. Simplex transmission - Rf24 Library.

Connect the nRF24L01+ Transceiver Module to an Arduino microcontroller, set up 2, one as Transmitter and other as Receiver. Before making the connection make sure to unplug the power source from Arduino UNO. Make following circuit.

	nRF24	Arduino Uno
1	GND	GND
2	V+	3.3V
3	CE	7
4	CSN	8
5	SCK	13
6	MOSI	11
7	MISO	12
8	IRQ	

Programming Transmitter

Open up the Arduino IDE and write the following code into a new sketch:

Code

```
#include "RF24.h"
RF24 myRadio (7, 8); // in Mega can use> (48, 49);
byte addresses [][6]  = {"0"};

struct package
{
  int id=1;
  float temperature = 18.3;
  char text[100]  = "Text to be transmitted";
};
typedef struct package Package;
Package data;

void setup()
{
  Serial.begin(115200);
  delay(100);
  myRadio.begin();
  myRadio.setChannel(115);
  myRadio.setPALevel(RF24_PA_MAX);
  myRadio.setDataRate( RF24_250KBPS ) ;
  myRadio.openWritingPipe( addresses[0]);
}

void loop()
{
  myRadio.write(&data, sizeof(data));
  Serial.print("\nPackage:");
  Serial.print(data.id);
  Serial.print("\n");
  Serial.println(data.temperature);
  Serial.println(data.text);
  data.id = data.id + 1;
  data.temperature = data.temperature+0.1;
  delay(50);
}
```

Programming Receiver

Open up the Arduino IDE and write the following code into a new sketch:

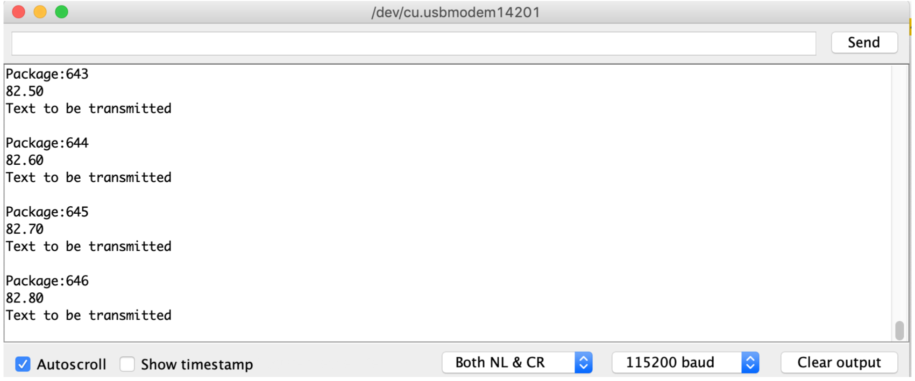
Code

```
#include ”RF24.h”
RF24 myRadio (7, 8);
byte addresses[][6] = {”0”};

struct package
{
  int id=0;
  float temperature = 0.0;
  char text[100] =”empty”;
};
typedef struct package Package;
Package data;

void setup()
{
  Serial.begin(115200);
  delay(100);
  myRadio.begin();
  myRadio.setChannel(115);
  myRadio.setPALevel(RF24_PA_MAX);
  myRadio.setDataRate( RF24_250KBPS ) ;
  myRadio.openReadingPipe(1, addresses[0]);
  myRadio.startListening();
}

void loop()
{
  if ( myRadio.available())
  {
    while (myRadio.available())
    {
      myRadio.read( &data, sizeof(data) );
    }
    Serial.print(”\nPackage:”);
    Serial.print(data.id);
    Serial.print(”\n”);
    Serial.println(data.temperature);
    Serial.println(data.text);
  }
}
```

Output Result

Once you have successfully set up the circuit connections and your arduino code has been uploaded, you can connect a power source to your arduino board. Remember to check the port, click `Tools -> Port` and select the COM port which your nRF24L01+ module is connected. See the result on Serial Monitor

The distance or range between modules nRF24L01+ will depend on the model they are using and where they are working, if there are walls, noise, or if they are in open places. Those that come without antenna are of little reach a little less than the WIFI signal, but the models that come with antenna and power amplifier can communicate up to 1km away.



```
Package:643
82.50
Text to be transmitted

Package:644
82.60
Text to be transmitted

Package:645
82.70
Text to be transmitted

Package:646
82.80
Text to be transmitted
```

Figure 2: Serial Monitor

Questions

1. How many channels are available in the 2.4 Ghz frequency of the device
2. What is the modulation scheme used by the device?
3. What does Receiver (Rx) sensitivity mean?
4. What are the maximum communication distances that can be reached without an antenna and with an antenna in noise scenarios and without line of sight. Justify your answer

Exercise 1. Humidity & Temperature Monitoring using nRF24L01+

In this exercise, you must design a wireless system to transmit the temperature and humidity data measured in the transmitter usign nRF24L01+ modules.

Exercise 2. nRF24L01+ Wireless Transceiver

In this exercise, you must design a wireless system where each nRF24L01+ device should function as a transmitter and receiver at the same time. The system must turn on and off a led on each device using a push button

Excersice 3. Hand-in (at the start of final project)

1. Write a report considering the following format
   (a) Course Title, Lab no, Lab title, your name, and date.
   (b) Section on the lab experiment:
      - Insert all the generated graphics
      - Share your open source code via GitHub
   (c) The lab report is an important part of the laboratory. The report is individual. Write it carefully, be clear and well organized using LaTeX.