Build Tutorial for SNR based GNSS Reflectometry (GNSS-R) Project

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Based on Fagundes, M.A.R., Mendonça-Tinti, I., Iescheck, A.L. et al. An open-source low-cost sensor for SNR-based GNSS reflectometry: design and long-term validation towards sea-level altimetry. GPS Solut 25, 73 (2021). https://doi.org/10.1007/s10291-021-01087-1

Table of Contents

Parts

The parts list can be found here: Parts List Excel File

1. Preparing Arduino

You will need:

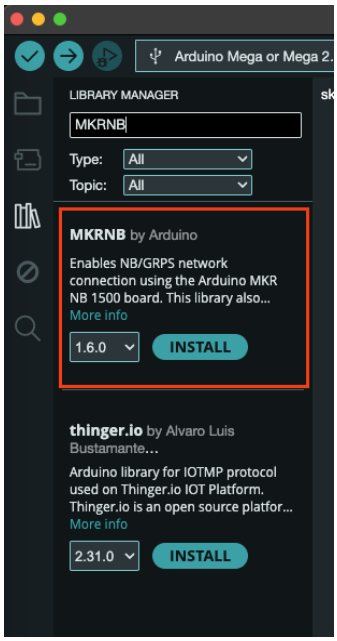
1. Arduino MKR NB 1500
2. Micro SD Card

1.1 Arduino IDE Setup

Download the latest version of the Arduino IDE from here: https://www.arduino.cc/en/software

The first thing to do is install the board group from the Board Manager. To do this click the second icon in the sidebar and search for "Arduino SAMD". The board group you want to install is called "Arduino SAMD Boards (32-bits ARM Cortex-M0+)", install the latest version of this.

You can then install the library that we will need for this project. We will need the MKRNB library which handles communication between the cellular network and our device. To do this click the library icon below the boards manager and search for MKRNB and install it.



1.2 Format the SD Card

Before you can use the SD card with the Arduino you will need to format it. The link below has instructions on how to do this for both Windows and MacOS. Ensure that the SD card is formatted as FAT32 so that the Arduino can read it. https://support.garmin.com/en-NZ/?faq=QqSbC0YZTz57kLm7uRQxZ7

1.3 Uploading the Firmware

Now that we have the board group and library installed we can upload the firmware to the Arduino. To do this create a new sketch and copy the code found here into the sketch.

Now plug the Arduino into your computer and select the board group that we installed earlier. Then select the board from the board selector beside the upload button. It should be indicated as "Arduino MKR NB 1500". If it is not go to Tools -> Board -> Arduino SAMD Boards (32-bits ARM Cortex-M0+) and select the Arduino MKR NB 1500. You can then click the Upload button, Right Arrow Icon, to upload the firmware to the Arduino.

2. Connecting the Electronics

2.1 Connecting the Arduino and SD Shield

You will need:

1. Arduino MKR NB 1500
2. Micro SD Card
3. Arduino MKR SD Shield
4. Header Pins
5. Breadboard

First you will need to solder the header pins to the MKR SD Shield. To do this cut the header pins to the correct length and solder them to the shield. The pins should be soldered to the two rows of holes on either side of the shield lengthwise. Then put the header pins into the breadboard so that the longer side goes into the breadboard, then place the SD Shield on top of the header pins. You can then solder the header pins to the SD Shield.

Add photo in here from building one of our test ones for the soldering

Once you have soldered the header pins to the SD Shield you can plug the SD Shield into the Arduino. The pins should line up with the headers on the Arduino. The SD Shield should be plugged into the Arduino so that the SD card slot is facing away from the USB port on the Arduino.

Then insert the SD card into the SD Shield.

Add photo in here from building one of our test ones for the completed package.

2.2 Connecting the Arduino and GPS Module

You will need:

1. Arduino MKR NB 1500
2. Sparkfun NEO-M9N GPS Module
3. Breadboard
4. Jumper Wires
5. GNSS Antenna

To connect the GPS Module to the Arduino you will first need to solder the header pins to the GPS Module. To do this cut the header pins to the correct length and solder them to the GPS Module. The pins should be soldered to the empty row that is on the USB port side of the PCB. Follow the same steps as before for the SD Shield to solder the pins to the GPS module. Cut to length, put in breadboard, and solder.

Add photo in here from building one of our test ones for the soldering

Once it has been soldered you can plug the GPS Module and Arduino into the breadboard. To do this place the Arduino on one end of the breadboard and the GPS module on the other end. Ensuring that none of the pins from the GPS Module are connected to the same tracks that the Arduino is on. You can then connect the two devices using jumper wires.

Show photo of bad connection, e.g. arduino and GPS on same traces, and show photo of good connection

The connections are as follows:

- GPS Module VCC -> Arduino 3.3V
- GPS Module GND -> Arduino GND
- GPS Module RX -> Arduino TX
- GPS Module TX -> Arduino RX

You can then connect the GNSS Antenna to the GPS Module. To do this plug the GNSS Antenna into the SMA connector on the GPS Module. This is the big gold connector on the side of the board, to connect it simply screw the antenna onto the connector.

Add in info about sim card needed.

Add photo of completed board

2.3 Preparing the Power System

Euan to write or give information for me to write this up

3. Mounting the system

Craig to write or give information for me to write this up

4. Testing the system

4.1 Activity LEDs

There is a red LED on the Arduino that will blink every time data is written to the SD card. Ensure that this is flashing to make sure that data is saved. There is also a LED on the GPS module that will blink once a second when it has a fix. This means that it has a connection to the satellites and is ready to record data. The red LED on the arduino will only start to blink once the GPS module has a fix.

Add photo highlighting these LEDs

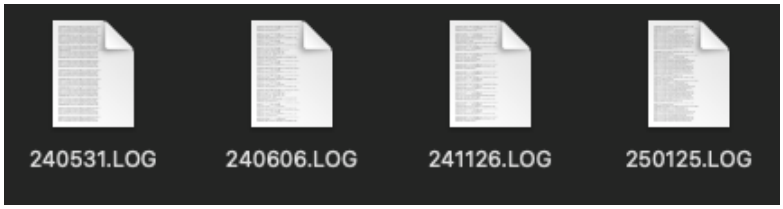
4.2 Serial Monitor

You can also check that the NMEA sentences look correct through the serial monitor. To do this follow the steps for plugging the arduino into the computer from 1.3 Uploading the Firmware. Then open the serial monitor by clicking the magnifying glass icon in the top right of the Arduino IDE. The baud rate should be set to 9600.

Add photo of serial monitor showing NMEA sentences

4.3 Data Files

The files that are saved to the SD Card will have an .log extension. The file names will look like the below photo:



Where the first two digits are the year, the second two digits are the month, and the last two digits are the day. This date is in UTC.

The data in the file should look like the below example

```
$GNGGA,000018.000,4443.0117,S,16910.7100,E,2,17,0.65,345.2,M,6.1,M,,*5E
$GPGSV,3,1,12,03,62,297,48,26,59,075,49,31,58,126,48,04,52,236,43*7D
$GPGSV,3,2,12,16,40,018,44,28,25,119,42,50,23,307,40,09,14,243,40*7A
$GPGSV,3,3,12,06,09,222,46,29,06,131,38,195,06,330,27,194,,,25*45
$GLGSV,2,1,08,80,79,002,43,70,71,203,35,79,40,142,43,69,37,054,46*69
$GLGSV,2,2,08,73,23,330,43,71,20,221,39,87,08,197,24,86,05,244,33*67
$GNRMC,000018.000,A,4443.0117,S,16910.7100,E,0.03,0.00,310524,,,D*6A

$GNGGA,000028.000,4443.0117,S,16910.7099,E,2,17,0.65,345.3,M,6.1,M,,*5D
$GPGSV,3,1,12,03,62,297,48,26,59,075,49,31,58,126,48,04,52,236,43*7D
$GPGSV,3,2,12,16,40,018,44,28,25,119,42,50,23,307,40,09,14,243,38*75
$GPGSV,3,3,12,06,09,222,45,29,06,131,38,195,06,330,24,194,,,25*45
$GLGSV,2,1,08,80,80,003,43,70,71,203,34,79,39,142,43,69,37,054,46*61
$GLGSV,2,2,08,73,24,330,42,71,20,221,33,87,08,197,24,86,05,244,32*6A
$GNRMC,000028.000,A,4443.0117,S,16910.7099,E,0.01,0.00,310524,,,D*6A
```