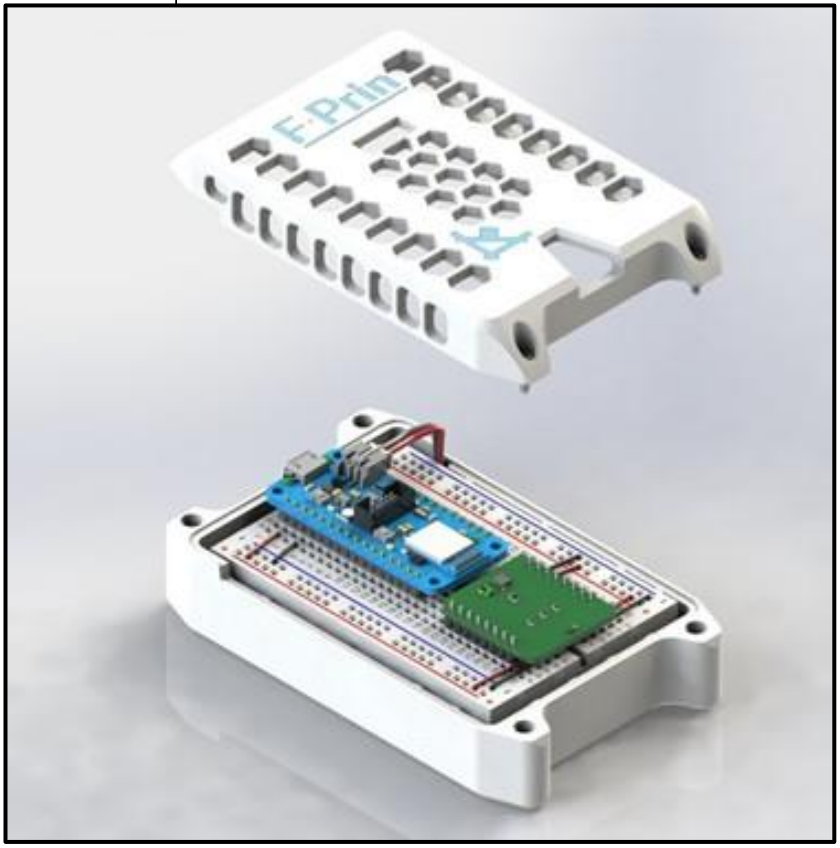
BLE Temperature Sensor Module User Manual



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State	**In-Work**
Authors	**L Parrish**
Project	**FP05**

Contents

1 Introduction

Temperature measurement devices are ubiquitous in engineering and other scientific fields because temperature is a parameter that affects nearly all systems and is often essential to measure and control. Through recent work at FPrin involving temperature measurement and analysis we surveyed a series of temperature sensors and found that many common sensors have a surprisingly wide rated accuracy specification. For example, perhaps the most used type of temperature measurement device, the thermocouple, typically has a range of ±1-2 °C. For some applications this is an acceptable level of accuracy, but often is insufficient. FPrin aims to provide a cost-effective, easy to build and program, and most importantly highly accurate temperature sensor module that allows the user to measure ambient temperature with a high degree of confidence.

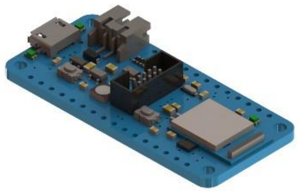
A primary development consideration was the accuracy of the temperature sensor used in the module. To achieve this, we incorporated the AS6221 digital temperature sensor from AMS. The integrated circuit features I^2C communication for data transmission, low power consumption, and most importantly an excellent temperature accuracy rating of ±0.09 °C. Additionally, all components used to build the module can be easily sourced and assembled with minimal soldering and hand tools. Finally, a housing for the module can be easily fabricated using FDM 3D printing with PLA. The latest design features wireless data transfer to a host PC via Bluetooth Low Energy (BLE) communication and an easy-to-use interface for data visualization and logging. The CAD, Code, and documentation for the project are hosted on FPrin's GitHub Repository Here:

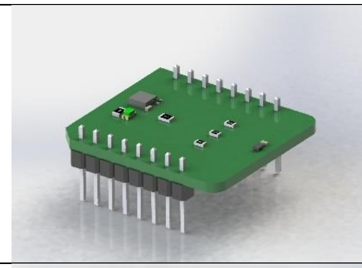
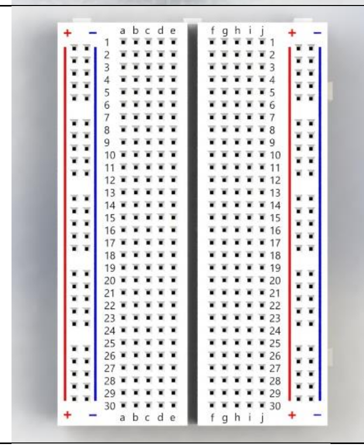
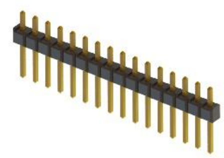
https://github.com/FPrinLLC/FPrin_Temperature_Sensor_Module.git

2 Assembly

2.1 Solderless Breadboard and Circuit

2.1.1 Materials and Tools

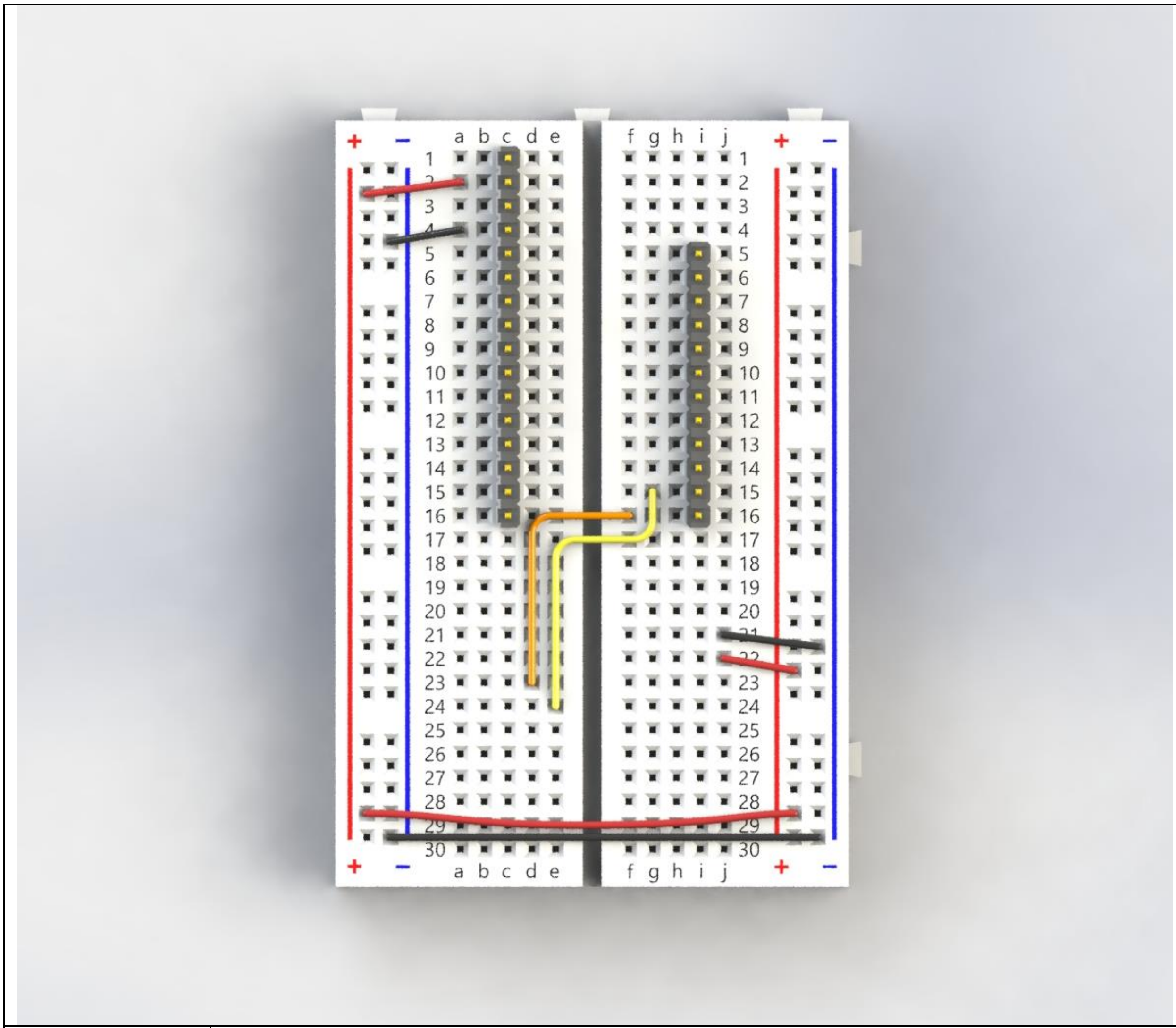
Description	Quantity	Image
nRF52840 Feather Development Board	1	

MikroE Thermo 28 Click PCBA	1	
Solderless Breadboard	1	
0.1” Pin Header Standoffs	2 x 16	
Breadboard Jumper Wires	~6 inches	

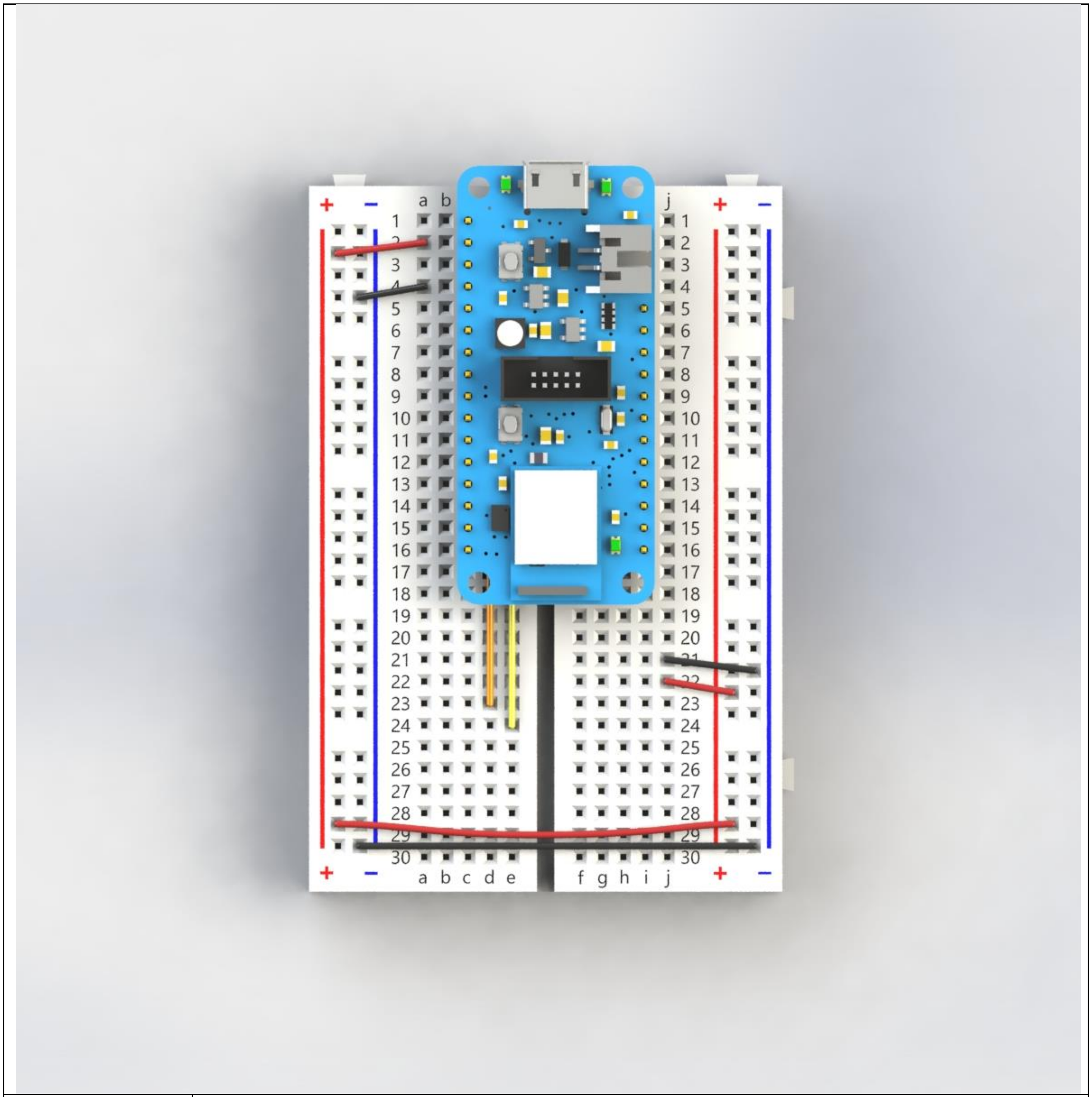
The following tools are required to assemble the solderless breadboard and circuit:

- Flush cutters
- Wire Strippers
- Soldering Iron
- Solder

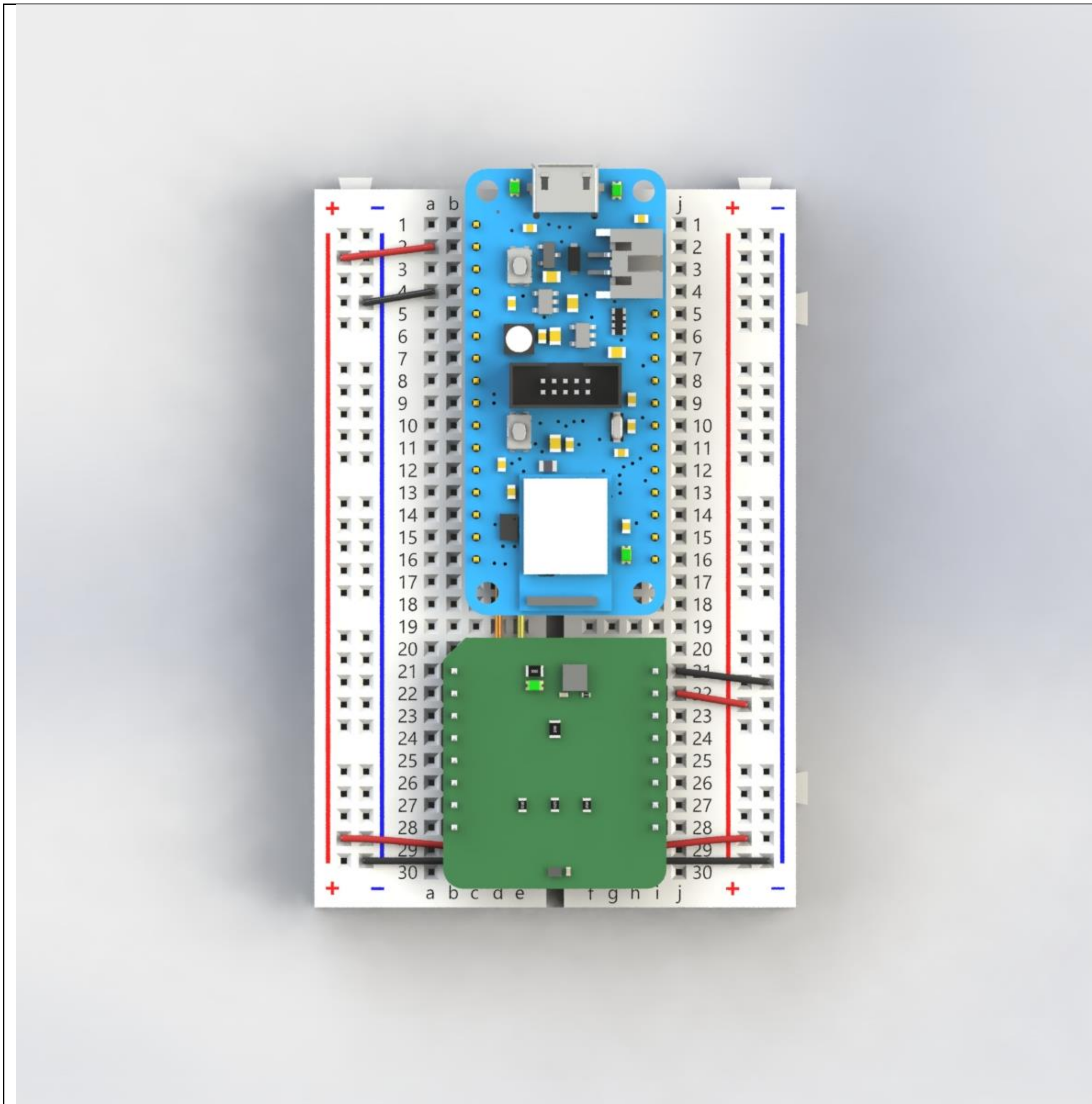
2.1.2 Solderless Breadboard Assembly Instructions



Step 1:	Install the pin headers into the solderless breadboard with the first row starting at position C1. Then cut the second pin header to remove 4 positions from the end, then install into position I5. Note that both rows should end at row 16.
Step 2:	Cut prototyping wire to length and insert into the breadboard as shown in the image above. Note that the wires should be pressed down flush to the top surface of the breadboard.



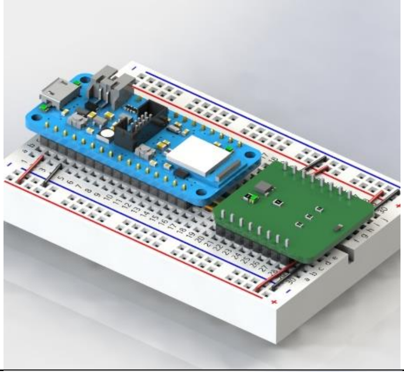
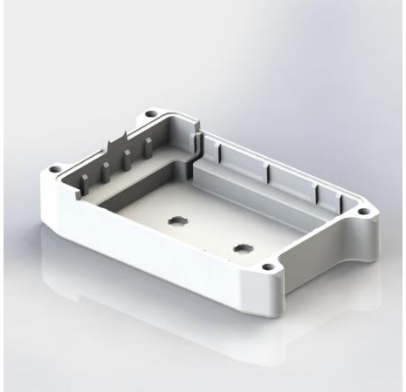
Step 3:	Place the nRF52840 Feather Dev. Board onto the pin headers as shown. Note that the upper left pin next to the USB connector is in breadboard position c1.
Step 4:	Solder the pin headers in place to secure the electrical connection using a soldering iron and solder.

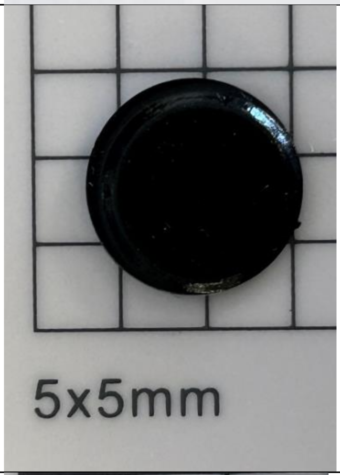
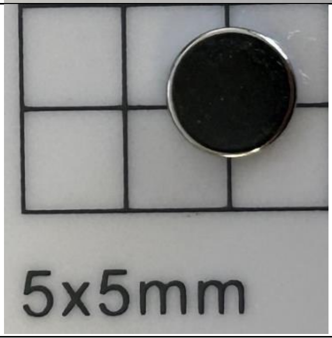
	
Step 5:	Press the MikroE Thermo 28 Click PCBA into the breadboard as shown. Note the pin labeled 3V3 should be in breadboard position I22.

2.2 Module Housing

2.2.1 Materials and Tools

The following parts are required to assemble the module housing:

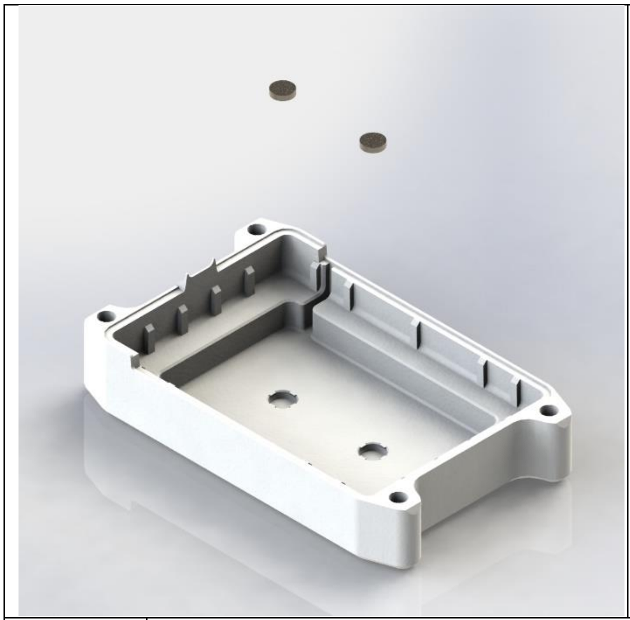
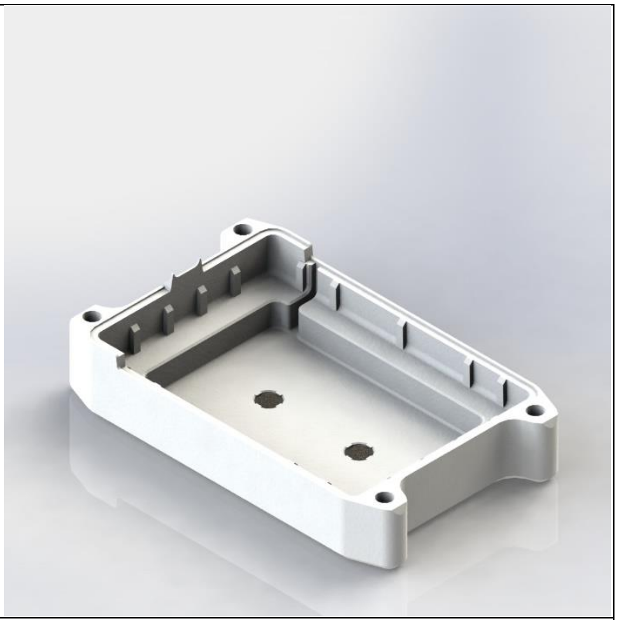
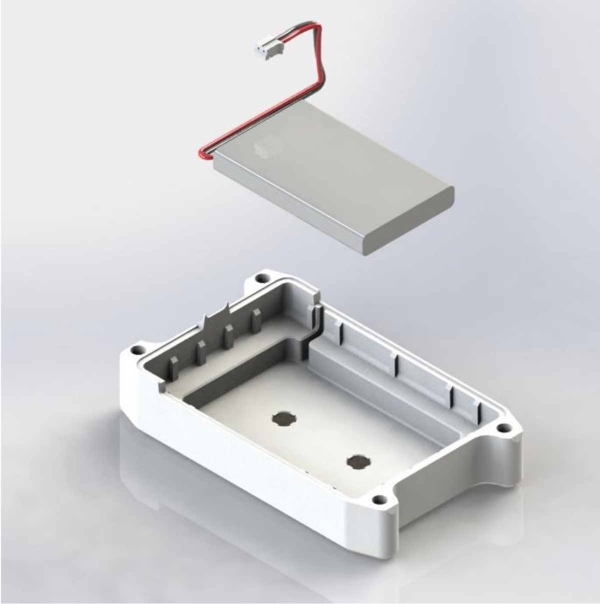
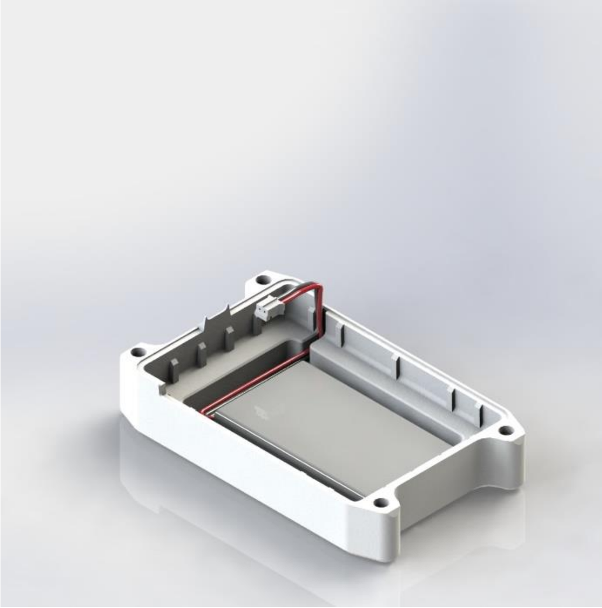
Description	Quantity	Image
Solderless Breadboard Assembly	1	
Housing Lower Half	1	
Housing Upper Half	1	

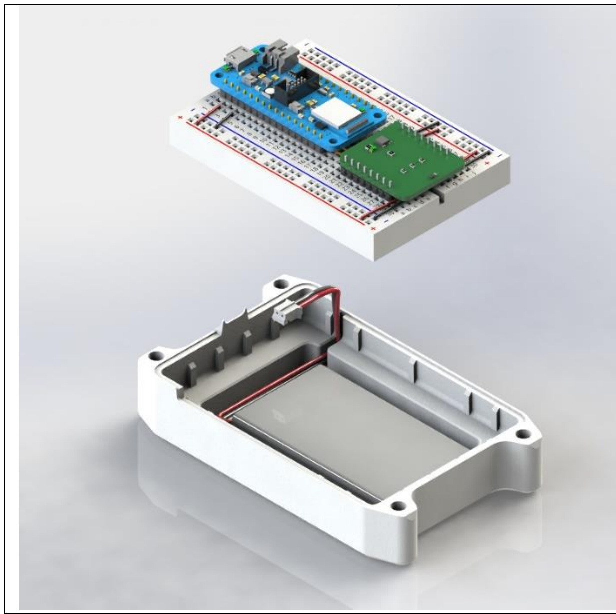
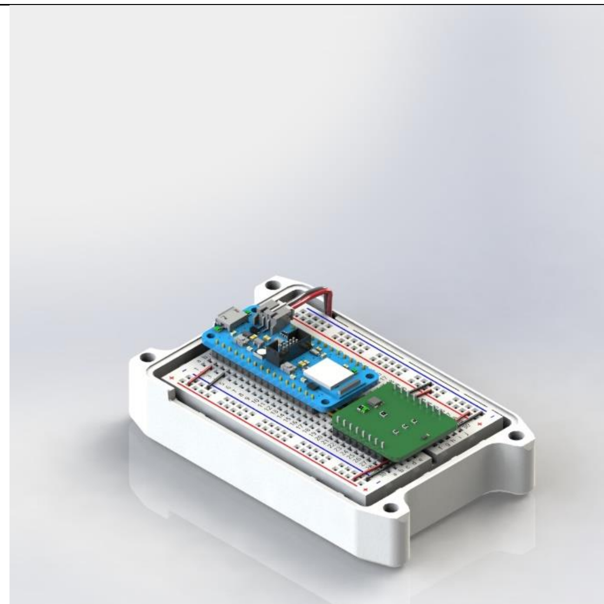
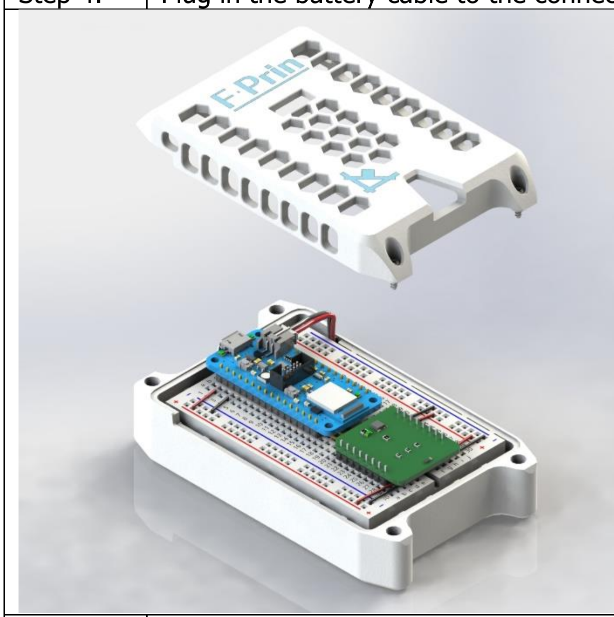
2000 mAh Li-Poly Battery	1	
Thread-forming Screws for Plastic	4	
Rubber Feet	4	
1/16" Thick, ¼" Neodymium Magnets*	2	

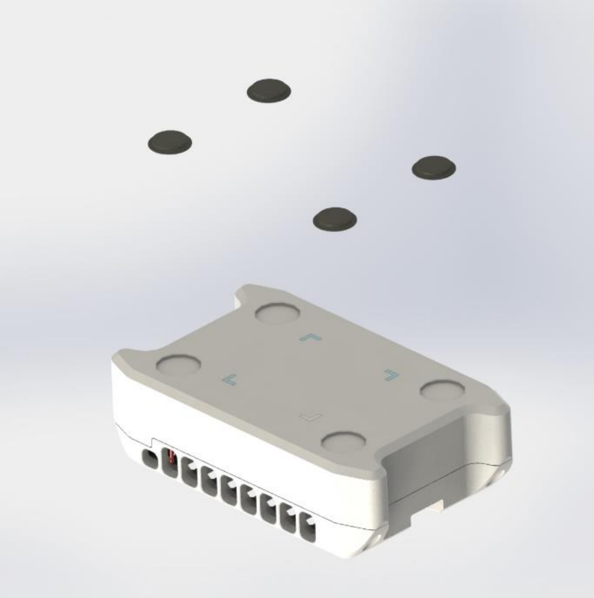
Assembly Tools:

- Size J0 Phillips Screw Driver

2.2.2 Module Housing Assembly Instructions

<table>
<tr><td colspan="2"></td><td></td></tr>
<tr><td>Step 1:</td><td colspan="2">Press the magnets into the recesses in the lower housing until they snap into place.</td></tr>
<tr><td colspan="2"></td><td></td></tr>
<tr><td>Step 2:</td><td colspan="2">Place the LiPo Battery into the battery cavity oriented so that the battery cable can fit into the cable management slot. We also recommend securing the battery to the bottom of the cavity with double-sided tape.</td></tr>
</table>

	
Step 3:	Remove the adhesive backing from the solderless breadboard and place the assembly into the lower housing above the battery. Be careful that the USB port is lined up facing towards the raised opening.
Step 4:	Plug in the battery cable to the connector on the nRF52840 Feather
	
Step 5:	Lower the upper housing onto the assembly and secure using the four thread forming screws in each of the four corner screw bosses. Note: You may need to tuck the excess battery cable length inside the module so that it does not get pinched.

		
Step 8:	Flip the module upside down, remove the adhesive backing on the rubber feet, then place into the large corner recesses to adhere.	

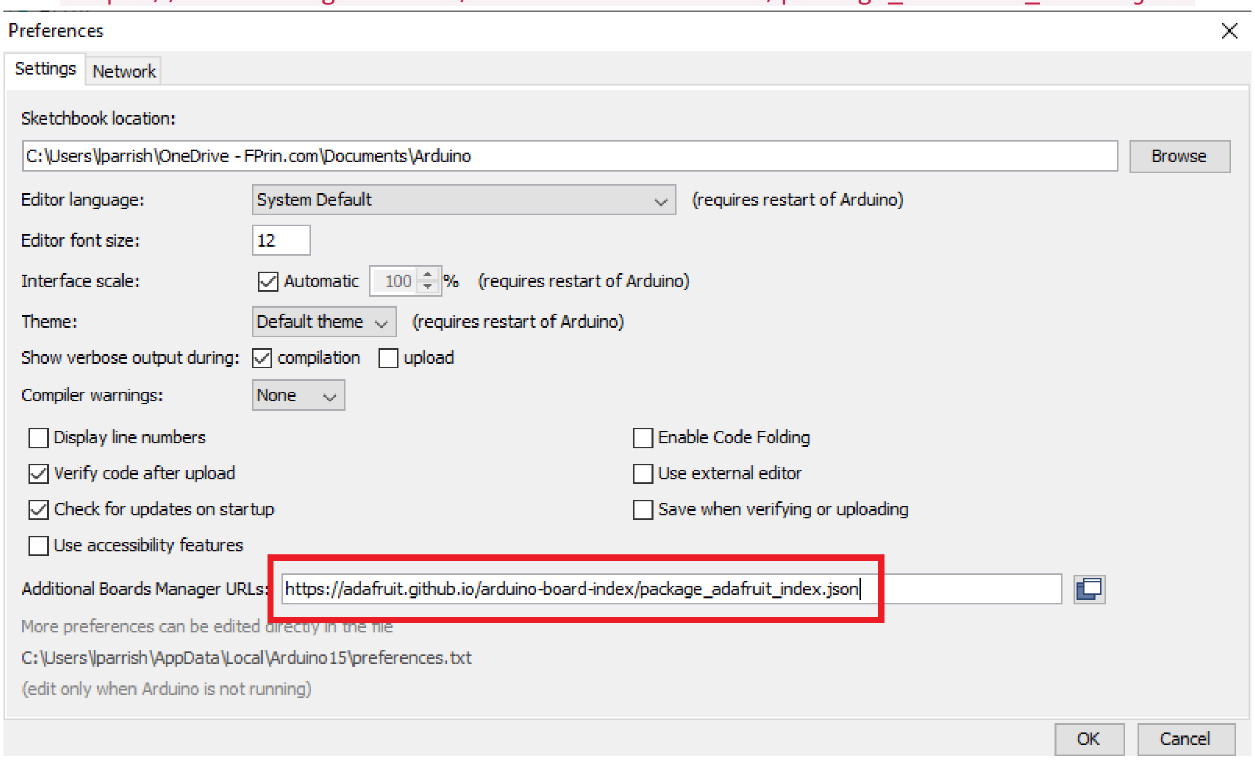
3 Firmware Installation

3.1 Arduino IDE and nRF Board Manager Installation

To download the Arduino IDE required for programming, navigate to the following link and download the latest Arduino IDE version for your operating system: ***https://www.arduino.cc/en/software***

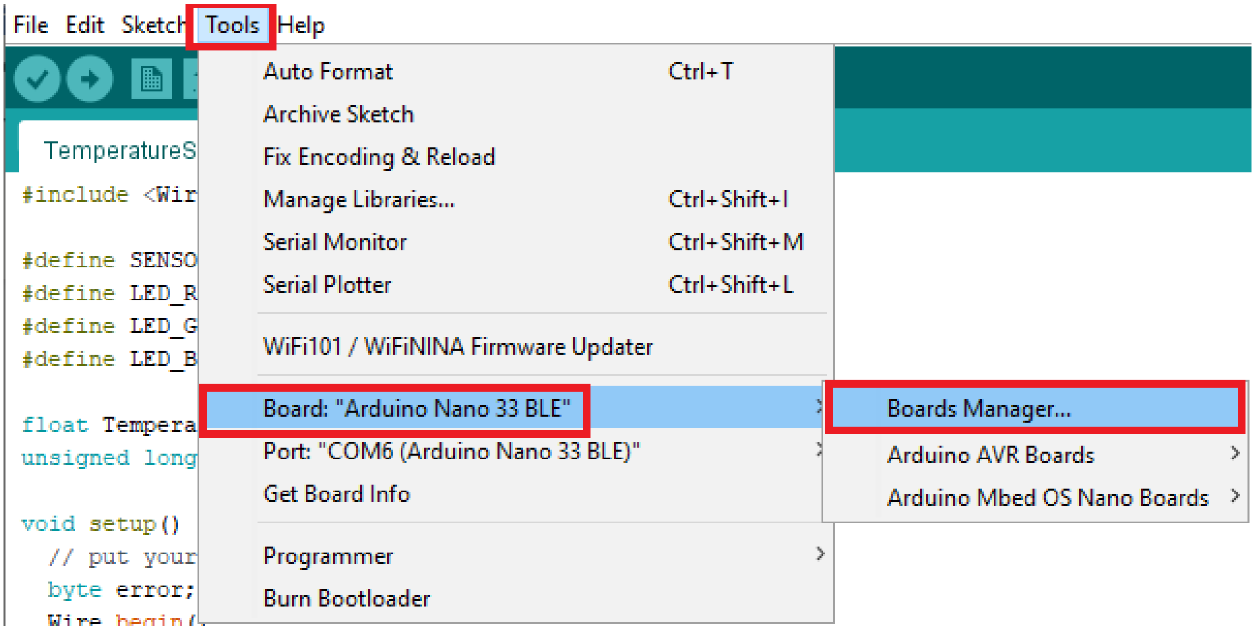
After installing the Arduino IDE, launch the IDE and navigate to the Preferences Menu under File > Preferences. Under the "Additional Board Manager URLs" paste the following URL:

`https://adafruit.github.io/arduino-board-index/package_adafruit_index.json`

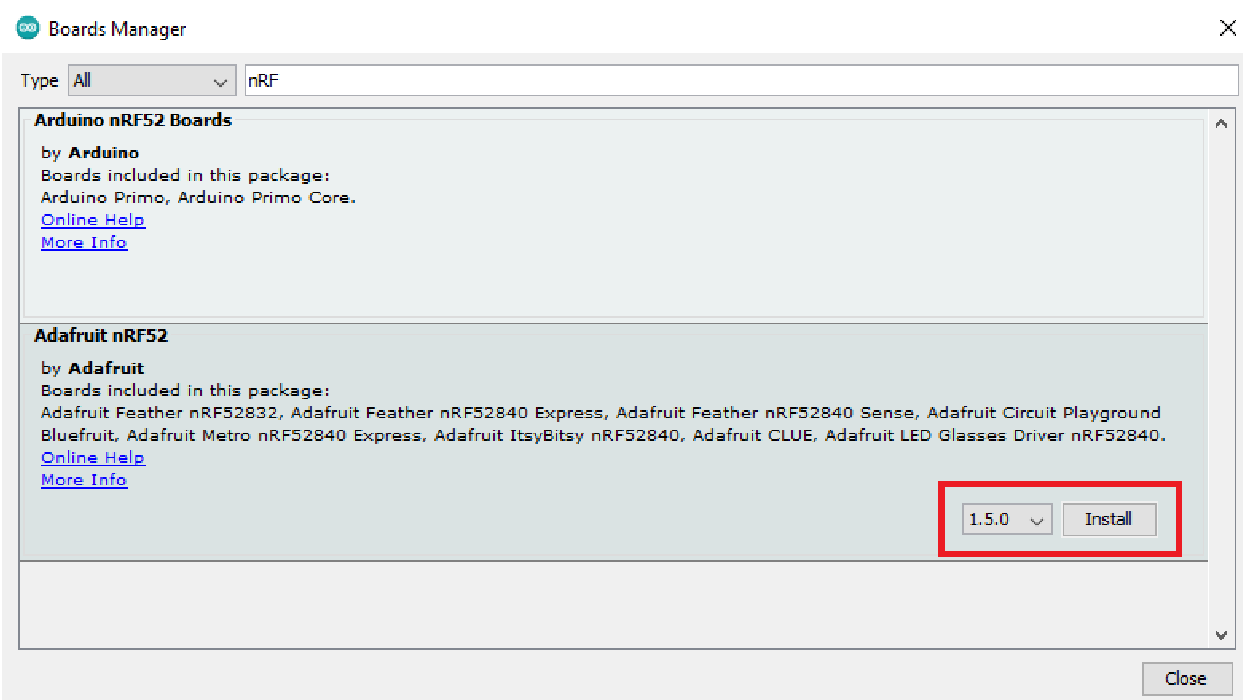


After adding the board manager URL, you will need to restart your Arduino IDE before continuing.

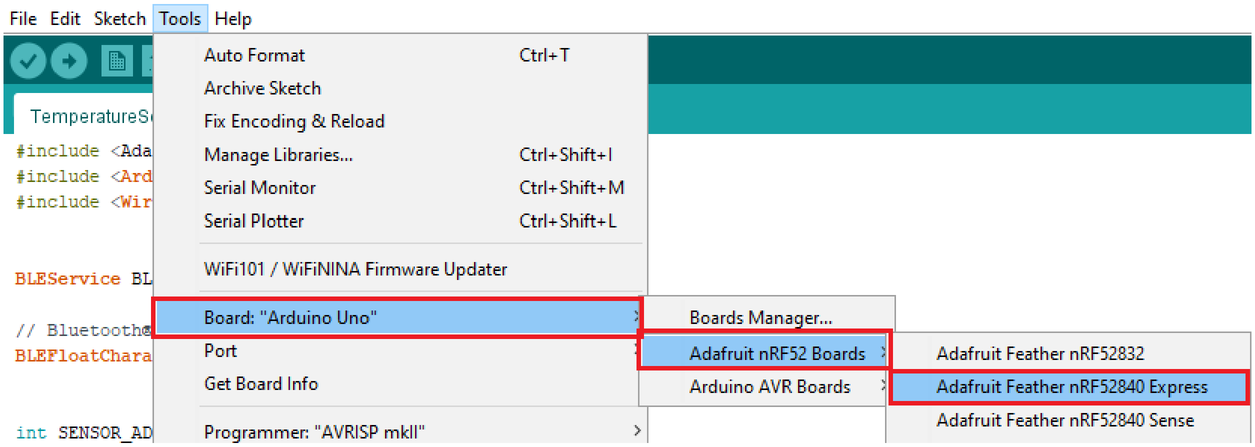
Next, navigate to the boards manager using the following path: Tools > Boards > Boards Manager



After opening the board manager interface, find the installation for "nRF" and click the install button to download the board profile.



Finally, navigate to Tools > Boards > Adafruit nRF52 Boards > Adafruit Feather nRF52840



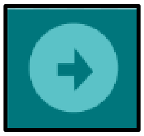
3.2 Firmware Upload

To upload the temperature sensor firmware to the nRF52840 Dev. Board, first connect the assembled temperature sensor module to the PC using a micro-USB cable. After first powering up, the LED's on the microcontroller should light up indicating the board is receiving power. Then open the file "Temperature_Sensor.ino" in the Arduino IDE and select the COM port for the Dev. Board.

To download the source code, clone the Temperature sensor GitHub Repository from the link below:

https://github.com/FPrinLLC/FPrin_Temperature_Sensor_Module.git

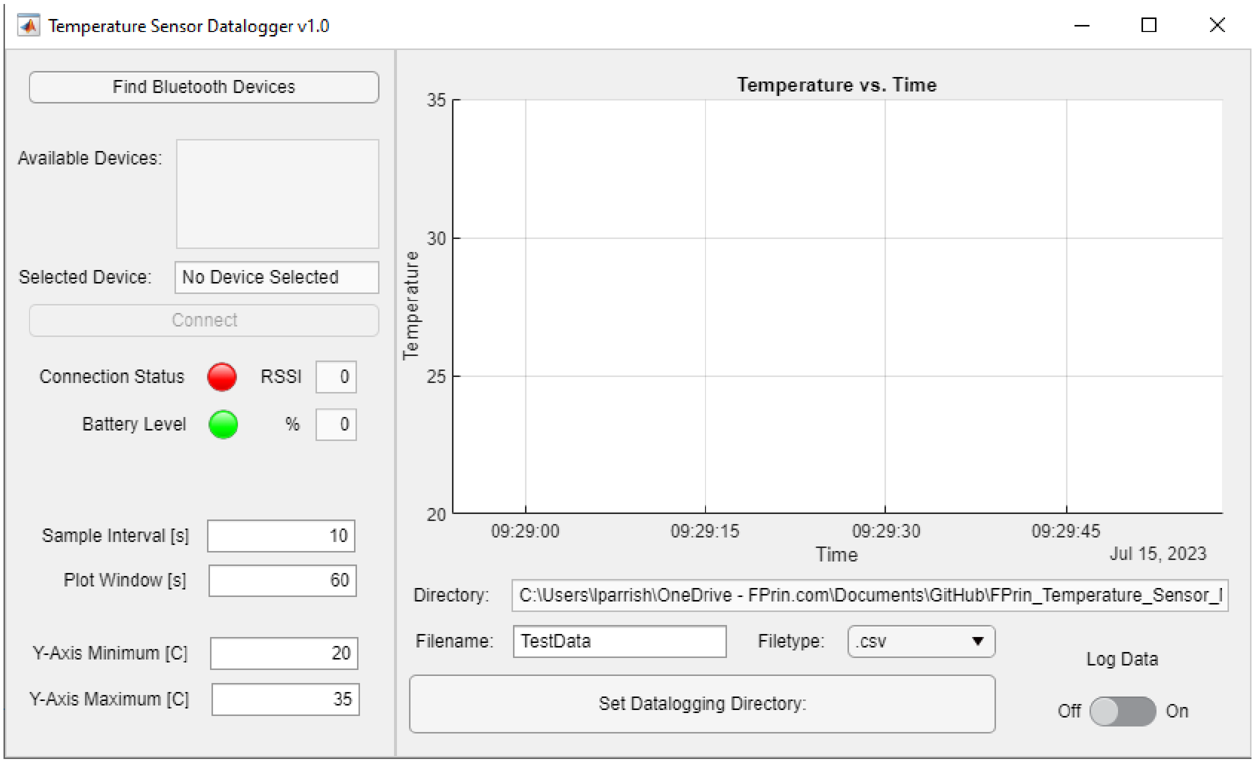
To flash the firmware, click the Blue Arrow Icon at the top of the IDE. When the firmware is flashed, you will see the following message in the command log indicating that the firmware flash was successful.



After the firmware flash is complete, the temperature sensor module is ready to connect to a computer over Bluetooth, indicated by a blinking LED. See section 4 for more information on using the datalogging GUI.

4 Datalogging Setup

To log data wirelessly using the temperature sensor module, FPrin has developed a MATLAB application that can be used to connect to a temperature sensor via Bluetooth for Realtime data viewing and logging of data. The executable can also be found at FPrin's Temperature Sensor GitHub repository. The basic interface is shown below:



4.1 Connecting to a Temperature Sensing Module

To begin using the datalogging and visualization interface, the first step is to find an available temperature sensor to connect to by clicking the "Find Bluetooth Devices" button which will populate the available devices menu below. Select the BLE device identifier to populate the selected device field, then click connect to initialize communication with the module.

If a successful connection is made, the connection status lamp will turn green and display the RSSI signal strength and device battery level. Temperature data received from the device should also begin to update on the plot to the right. To disconnect from the temperature sensing module, click the disconnect button to stop receiving data.

4.2 Plotting and Sample Frequency Tools

To change the data sampling frequency, enter a new sampling frequency into the "Sample Interval" text field in seconds. To update the plot limits, the user can alter the horizontal axis scale in seconds, and the temperature axis minimum and maximum values in degrees Celsius.

4.3 Datalogging Tools

To capture data and save to a file, simply toggle the "Log Data" slide switch. When the switch is active, the interface will write the paired time and temperature data points to a datafile at the specified Sample Interval defined in the plot tools section. By default, datalogging files are saved as a CSV file format to your active MATLAB directory with a default filename of "TestData". To change the default parameters, the "Set Datalogging Directory" button will allow the user to select the directory that all future datafiles will be saved to. Similarly, the test file name and filetype can be changed by using the text entry field and dropdown menu. Currently the interface supports saving files as CSV text files. Finally, each time the "Log Data" slide switch is turned on, the interface will create a new datalogging file with an appended auto-incrementing name to keep datafiles from separate log sessions independent. Note: the Datalogger will not be able to write to open CSV files.

5 Revision History

Rev	Description of Change	Project No.	Originator	Date
01	Initial Draft	FP05	L. Parrish	3 Nov 2023

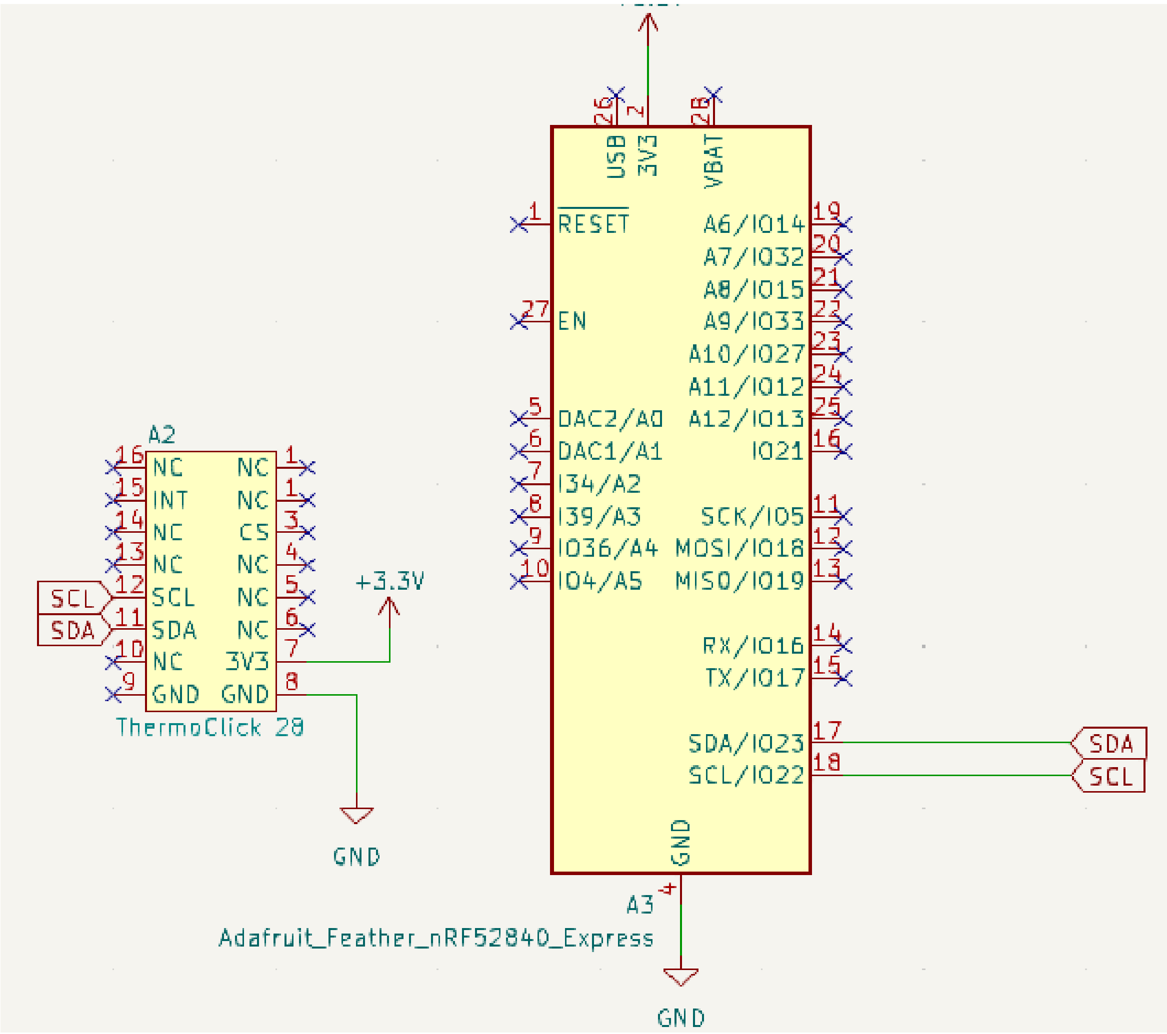
6 Appendix

6.1 Bill of Materials

ASSY NO:	FPR12096
DESCRIPTION:	BLE Temperature Sensor Module
REV:	1
PROJ #	FPR05
BOM Cost (USD):	$52.01

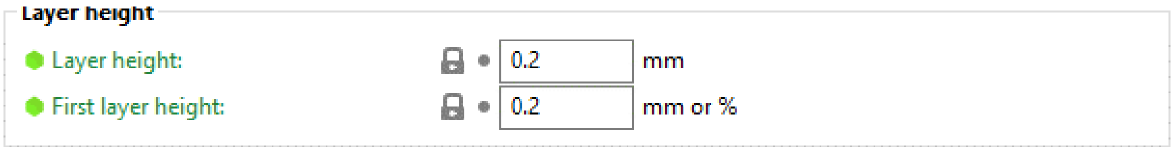
Qty	UOM	P/N	Title	Vendor	Unit Cost	Total Cost
0.167	pack of 6	B07LFD4LT6	Solderless Breadboard	Amazon	$8.49	$1.42
1	each	4062 nRF52840 Feather	nRF52840 Feather	Adafruit	$24.95	$24.95
1	each	2011 3.7V Lipo Battery	2000 mAh 3.7V Lipo Battery	Adafruit	$12.50	$12.50
1	each	MIKROE-5466	MikroE Thermoclick 28	Mikroelektronika	$11.00	$11.00
1	each	FPR12097	Bottom Housing	N/A	$0.00	$0.00
1	each	FPR12098	Upper Housing	N/A	$0.00	$0.00
0.08	pack of 50	95495K18	Rubber Feet	McMaster-Carr	$4.13	$0.33
2	each	5862K141	Neodymium Magnets	McMaster-Carr	$0.77	$1.54
0.16	pack of 25	99461A916	M2 Threadforming Screws	McMaster-Carr	$8.62	$1.38

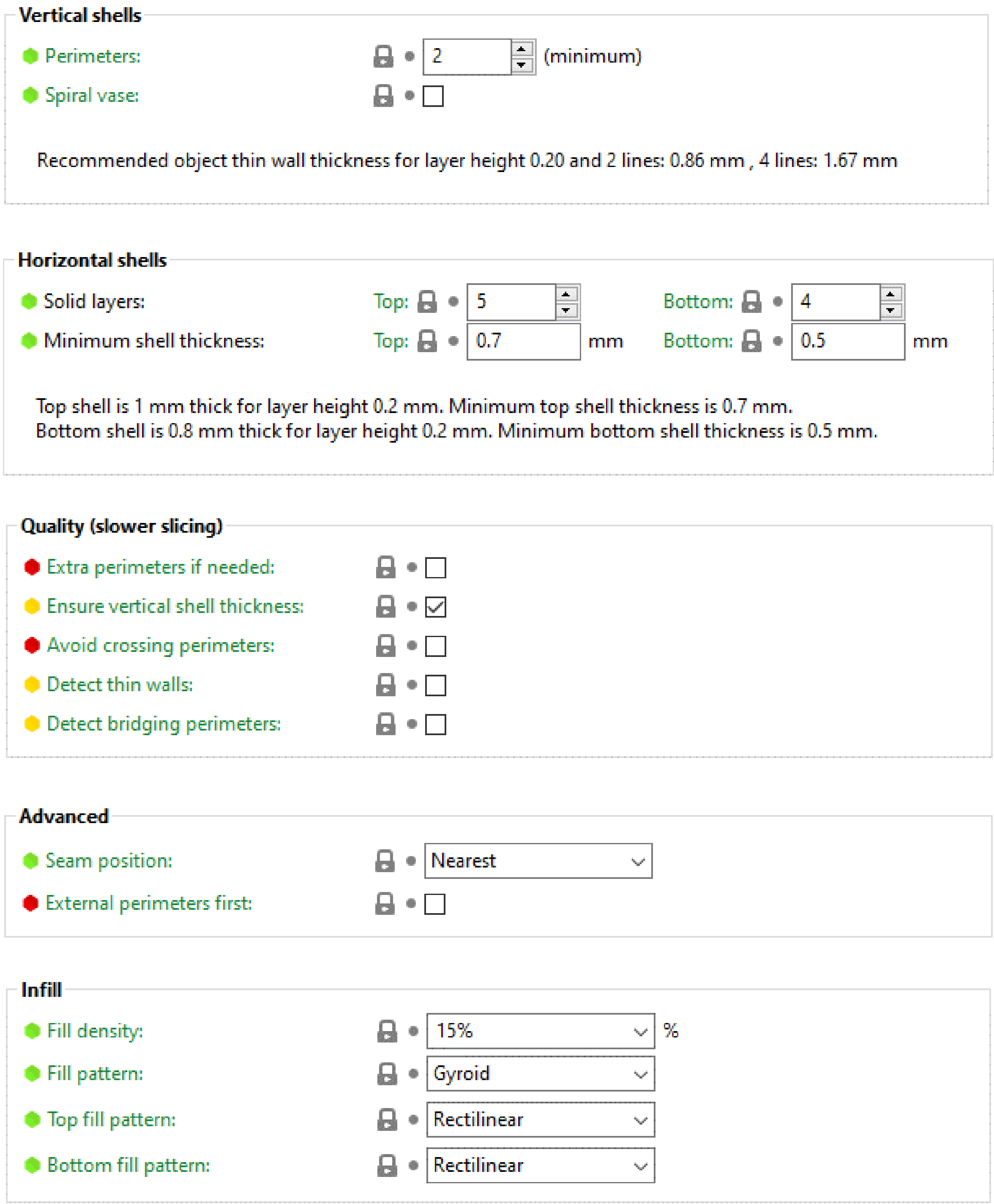
6.2 Circuit Diagram

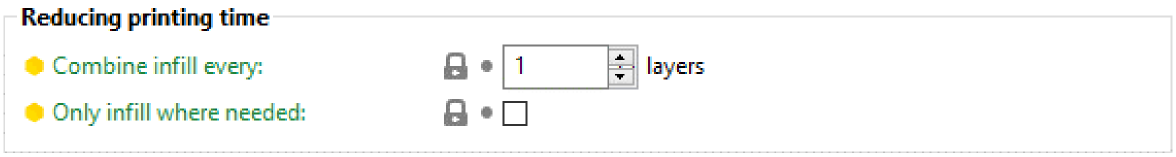


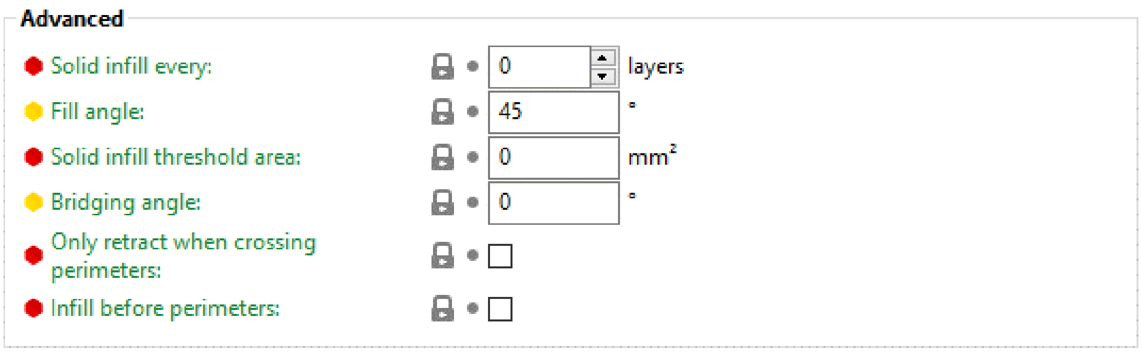
6.3 Plastic Part 3D Print Settings

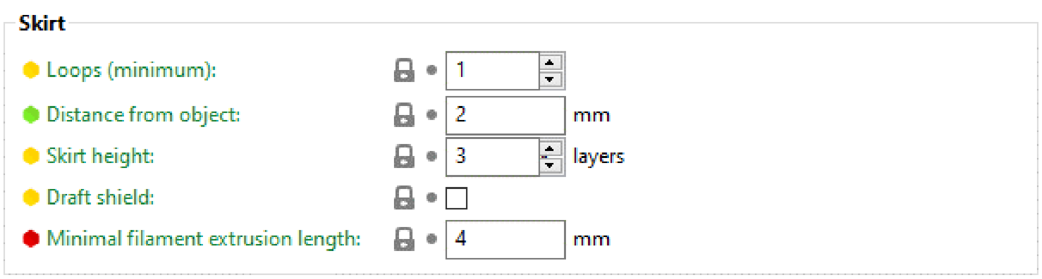
The 3D printed housing components were fabricated on a Prusa i3MK3S FDM 3D printer with a default 0.4 mm nozzle with Hatchbox PLA and the associated filament profile. The solid models were prepared using PrusaSlicer with the settings below:




Vertical shells
Perimeters:
2
(minimum)
Spiral vase:
Recommended object thin wall thickness for layer height 0.20 and 2 lines: 0.86 mm , 4 lines: 1.67 mm
Horizontal shells
Solid layers:
Top:
5
Bottom:
4
Minimum shell thickness:
Top:
0.7
mm
Bottom:
0.5
mm
Top shell is 1 mm thick for layer height 0.2 mm. Minimum top shell thickness is 0.7 mm.
Bottom shell is 0.8 mm thick for layer height 0.2 mm. Minimum bottom shell thickness is 0.5 mm.
Quality (slower slicing)
Extra perimeters if needed:
Ensure vertical shell thickness:
Avoid crossing perimeters:
Detect thin walls:
Detect bridging perimeters:
Advanced
Seam position:
Nearest
External perimeters first:
Infill
Fill density:
15%
%
Fill pattern:
Gyroid
Top fill pattern:
Rectilinear
Bottom fill pattern:
Rectilinear


Reducing printing time
Combine infill every:
1
layers
Only infill where needed:


Advanced
Solid infill every:
0
layers
Fill angle:
45
°
Solid infill threshold area:
0
mm²
Bridging angle:
0
°
Only retract when crossing perimeters:
Infill before perimeters:


Skirt
Loops (minimum):
1
Distance from object:
2
mm
Skirt height:
3
layers
Draft shield:
Minimal filament extrusion length:
4
mm


Brim
Brim width:
0
mm