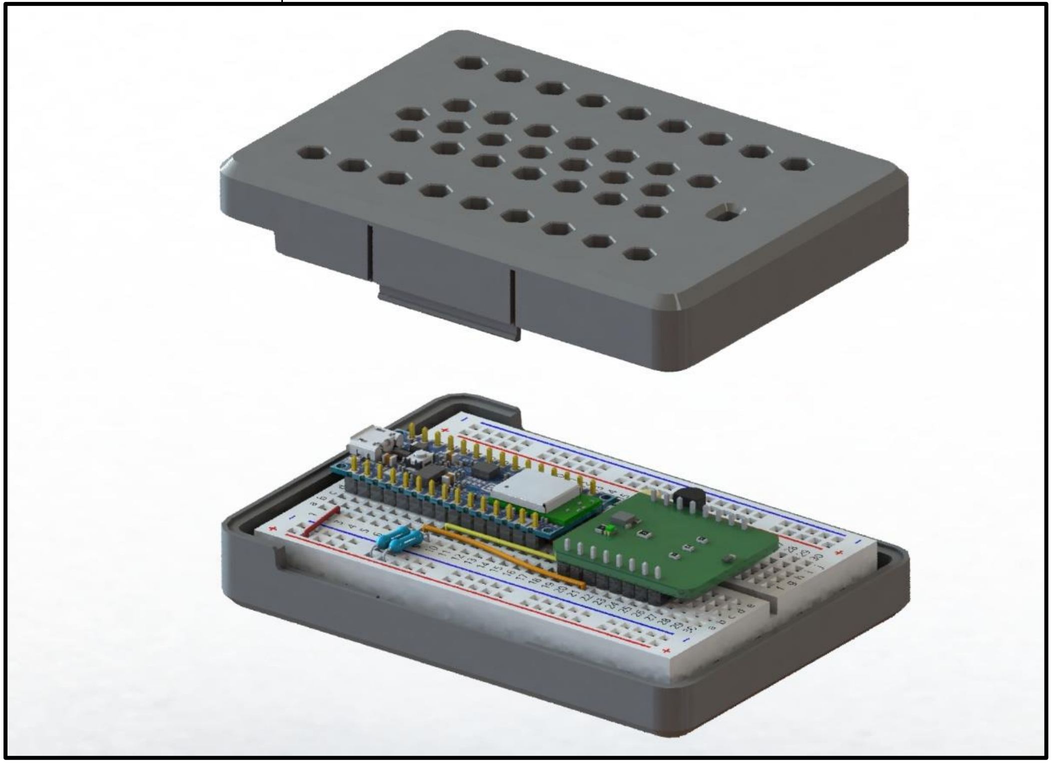
DIY Temperature Sensor Module User Manual



Document No.	**FPR12095**
Type	**RPT**
Revision	**01**
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 large 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.

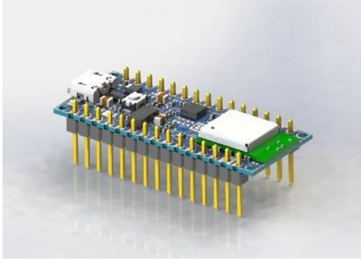
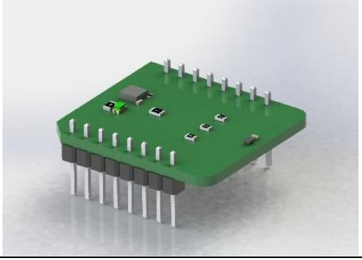
A primary development consideration was the accuracy of the temperature sensor used in the module. To achieve this, we incorporated the AS6221 digital temperature sensor from AMS. The integrated circuit features I^{2}C communication for data transmission, low power consumption, and most importantly an excellent temperature accuracy rating of ±0.09 °C. Additionally, all components used to build the module can be easily sourced and assembled with no soldering and minimal hand tools. Finally, a housing for the module can be easily fabricated using FDM 3D printing with PLA. Currently there are two configurations for the module housing, one that joins the upper and lower housing with a plastic snap-fit flexure, and a second configuration that uses thread-forming screws for a more secure connection. The CAD, Code, and documentation for the project are hosted on FPrin's GitHub Repository Here:

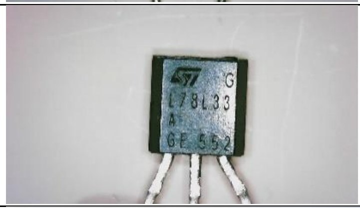
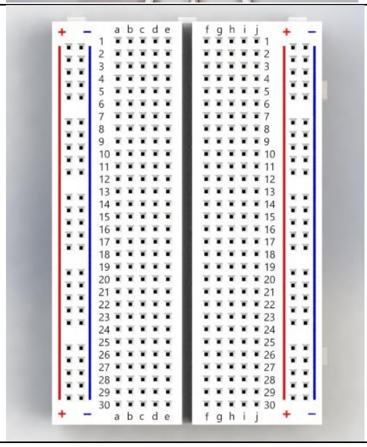
https://github.com/FPrinLLC/FPrin_Temperature_Sensor_Module.git

2 Assembly

2.1 Solderless Breadboard and Circuit

2.1.1 Materials and Tools

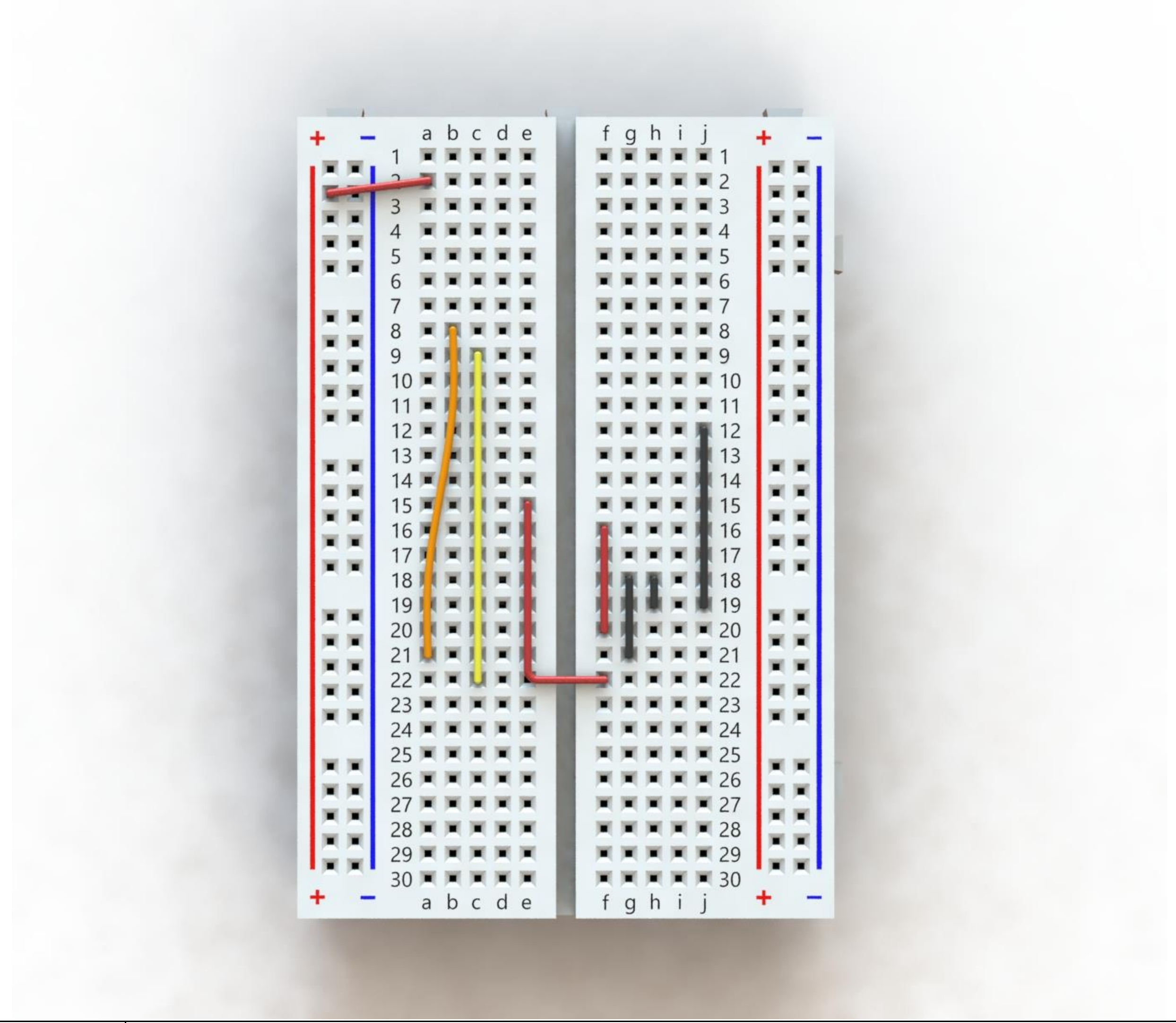
Description	Quantity	Image
Arduino Nano 33 BLE	1	
MikroE Thermo 28 Click PCBA	1	

Through Hole Resistor 2 kΩ	2	
Through Hole Ceramic Capacitor 0.33 µF	1	
Through Hole Ceramic Capacitor 0.1 µF	1	
L878L33 Linear Voltage Regulator	1	
Solderless Breadboard	1	
Breadboard Jumper Wires	~6 inches	

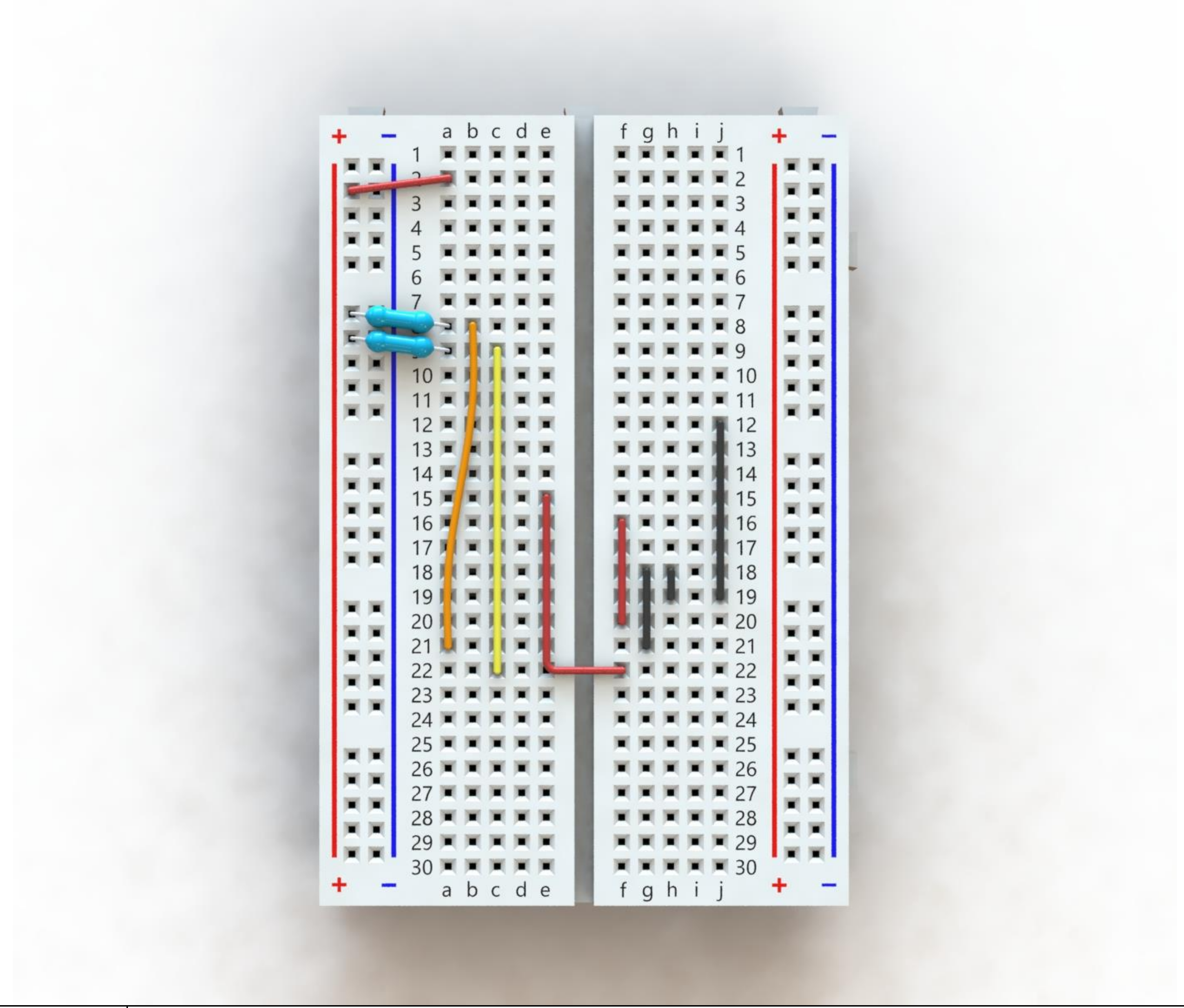
The following tools are required to assemble the solderless breadboard and circuit:

- Flush cutters
- Wire Strippers

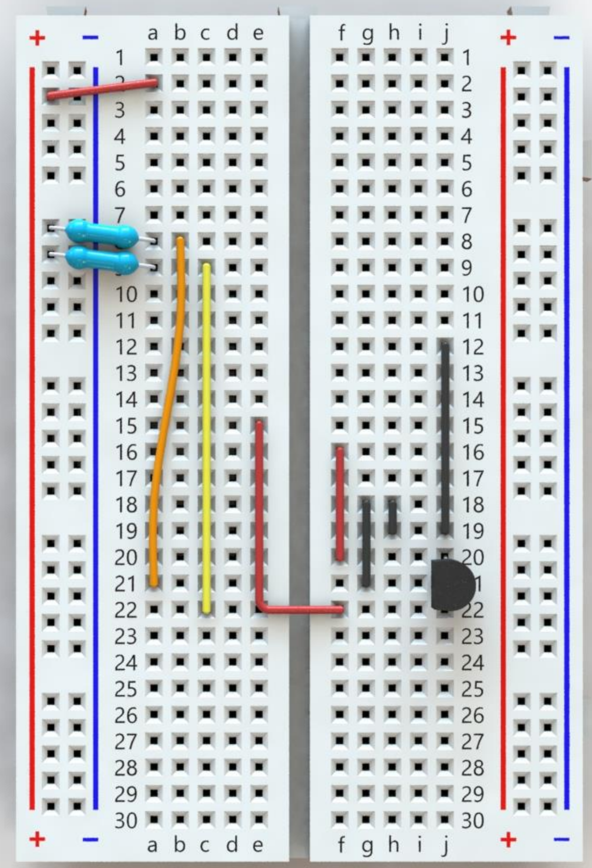
2.1.2 Solderless Breadboard Assembly Instructions



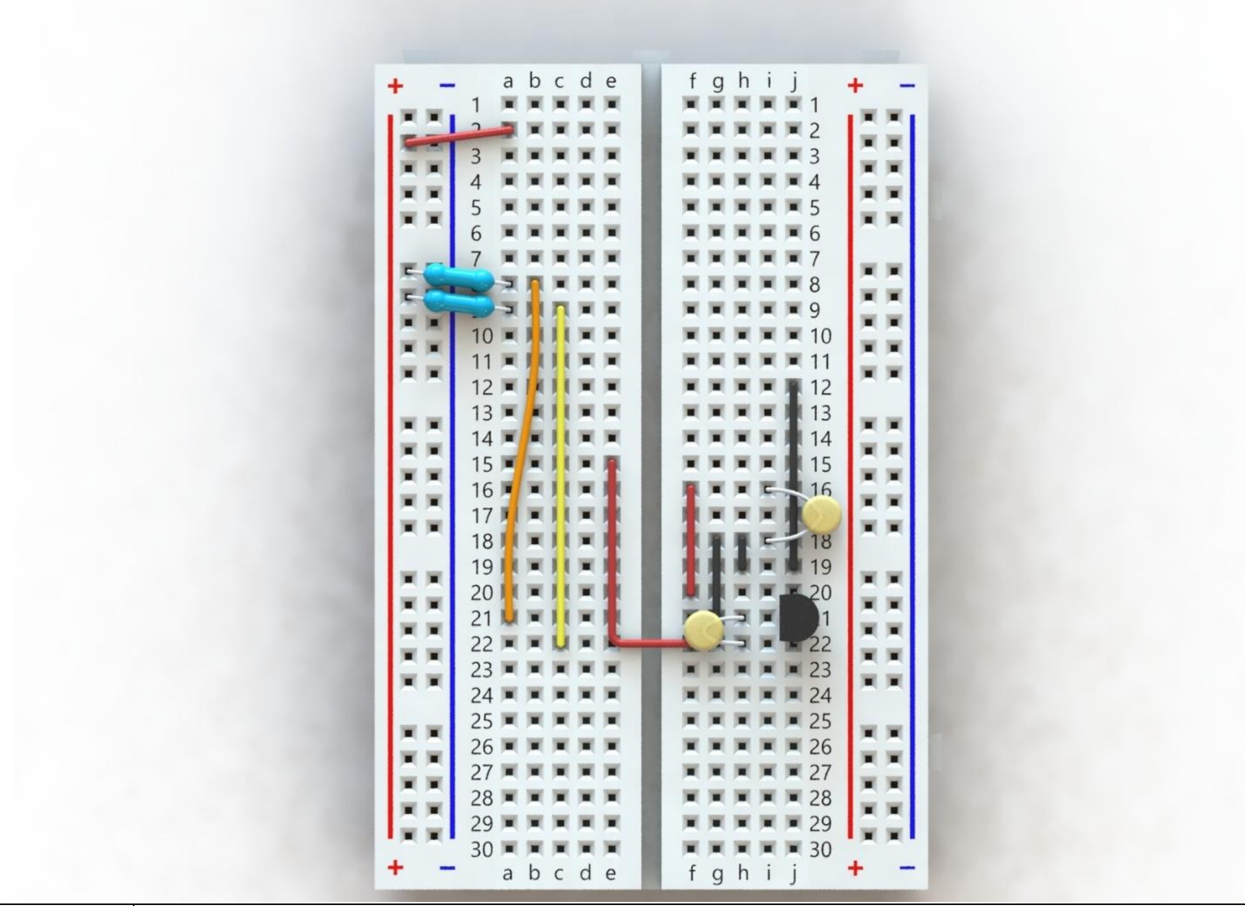
Step 1:	Cut prototyping wire to length and insert into the breadboard as shown in the image above. Note that the wires should be pressed down flush to the top surface of the breadboard.



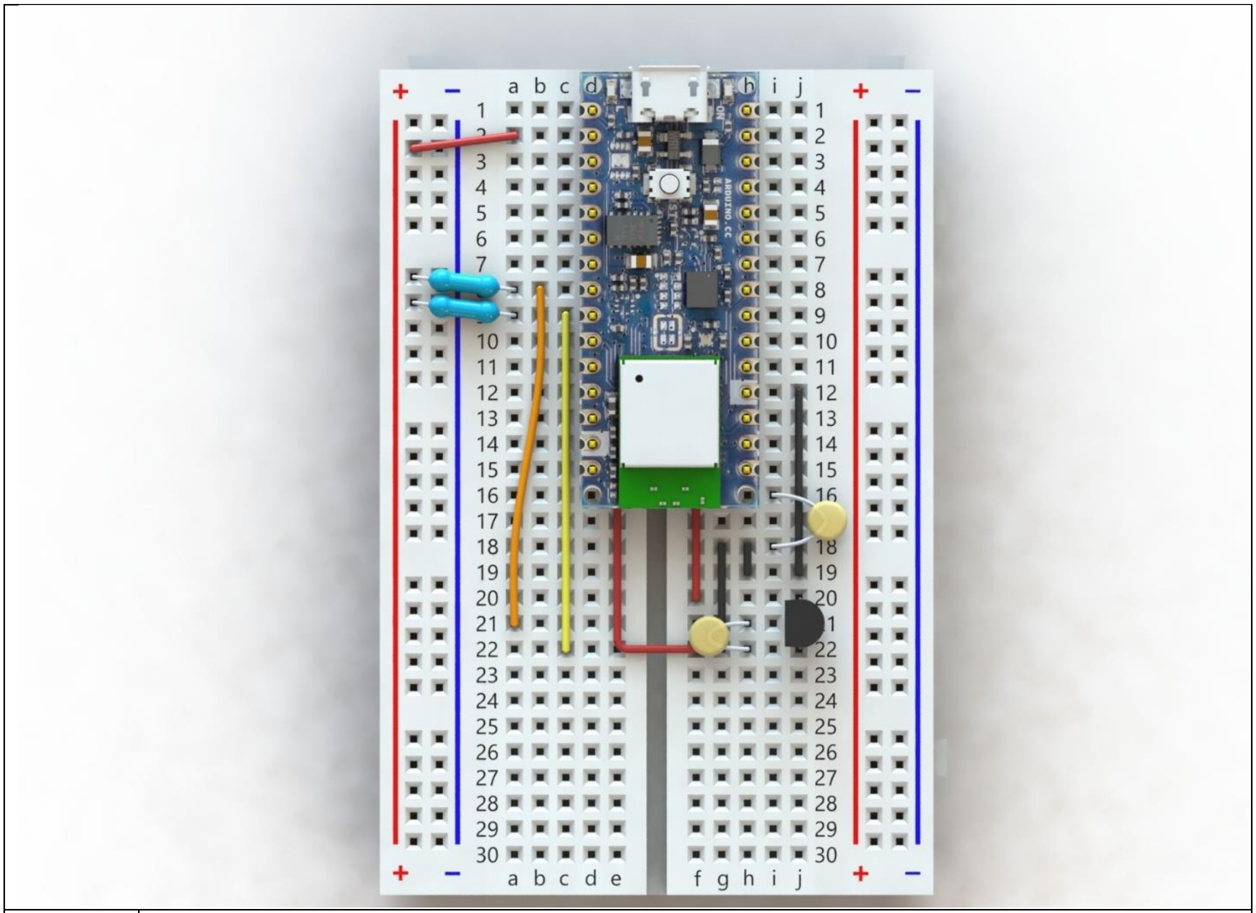
Step 2:	Connect the two 2k Resistors across the left positive voltage terminal and terminal rows 8 and 9.
Step 3:	Trim the leads of the L878L33 linear regulator to between 8-9 mm in length from the bottom of the IC. This will ensure the linear regulator is positioned close to the breadboard.



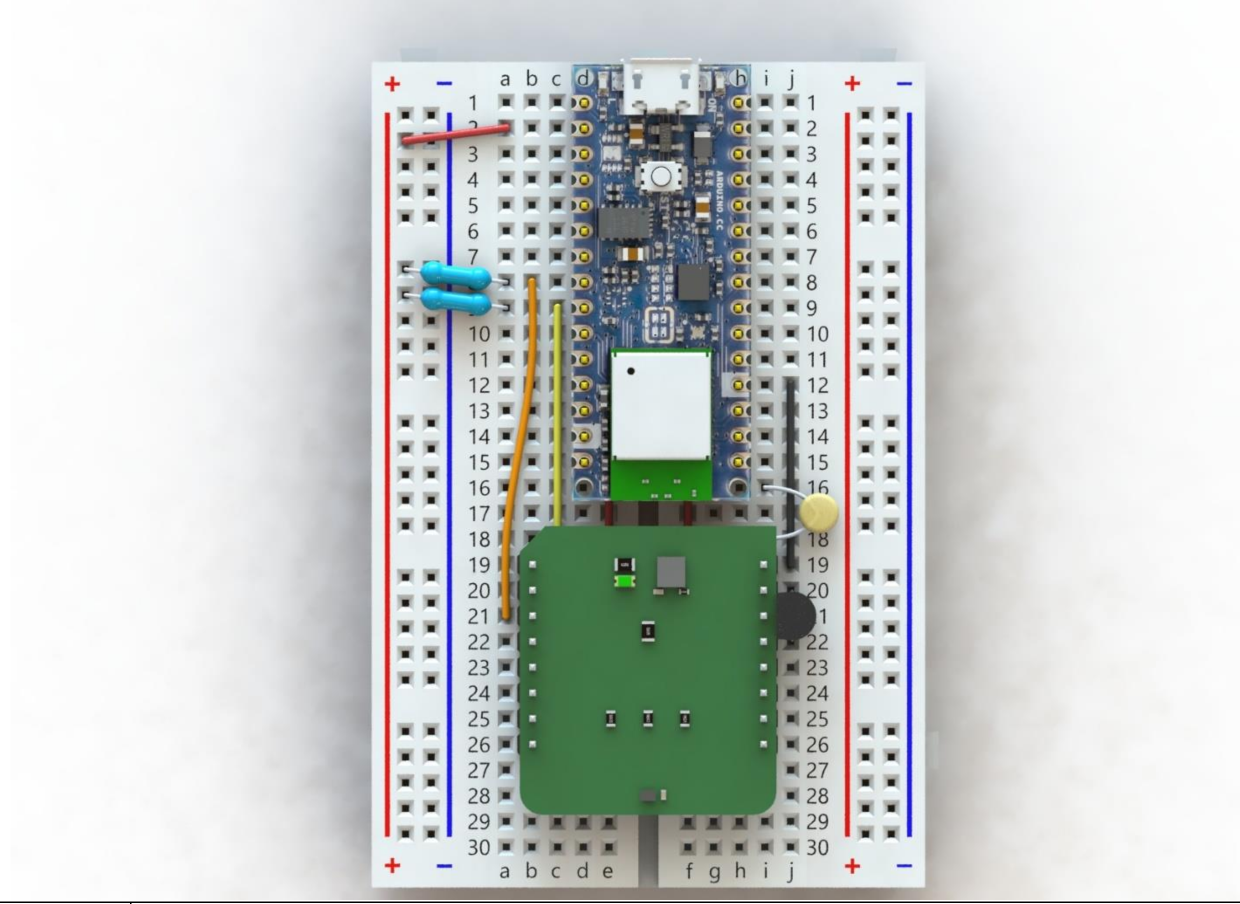
Step 4:	Insert the linear regulator into the solderless breadboard as shown. Note that the flat side of the integrated circuit faces towards the center of the breadboard.



Step 5:	Insert the ceramic capacitors into the solderless breadboard as shown. Note that the capacitor across rows 16 and 18 is the 0.1 μF capacitor and the capacitor across rows 21 and 22 is 0.33 μF. After inserting the capacitors into the breadboard, bend the capacitors down towards the surface of the breadboard as shown. This will ensure that the rest of the components can assemble without interference.



Step 6:	Press the Arduino Nano 33 BLE into the breadboard as shown. Note that the upper left pin next to the USB connector is in breadboard position d1.

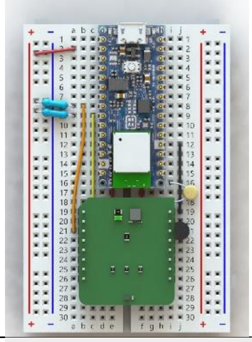
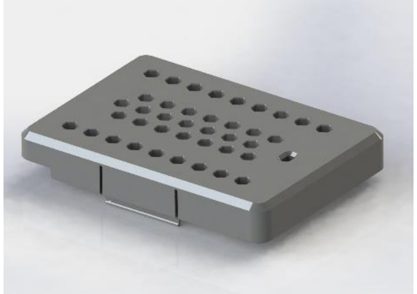


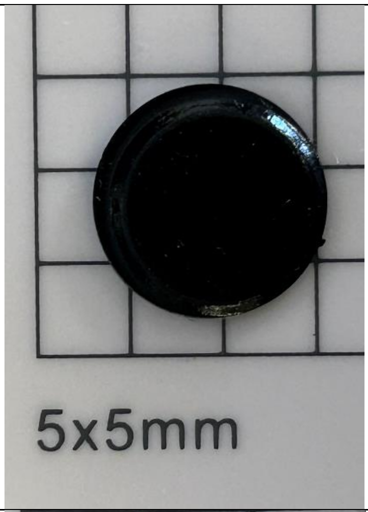
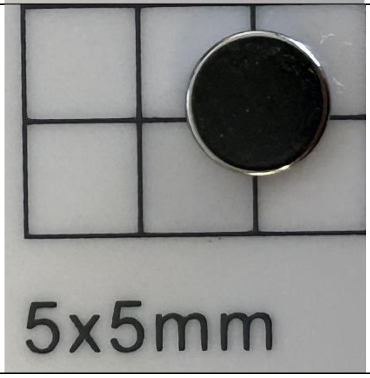
Step 7:	Press the MikroE Thermo 28 Click PCBA into the breadboard as shown. Note the pin labeled 3V3 should be in breadboard position i20.

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	

Rubber Feet	4	
1/16” Thick, ¼” Neodymium Magnets*	2	

*If adding magnets to the bottom of the module housing.

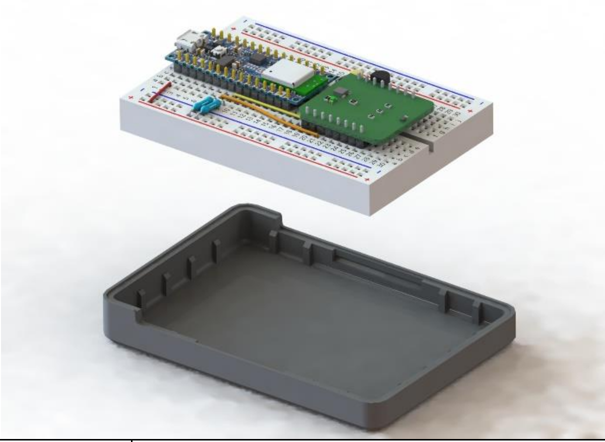
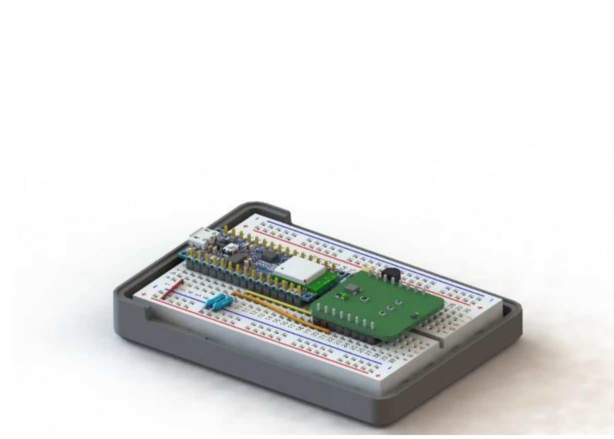
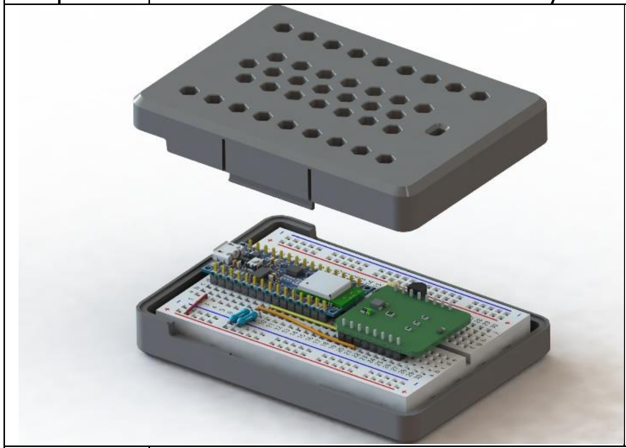
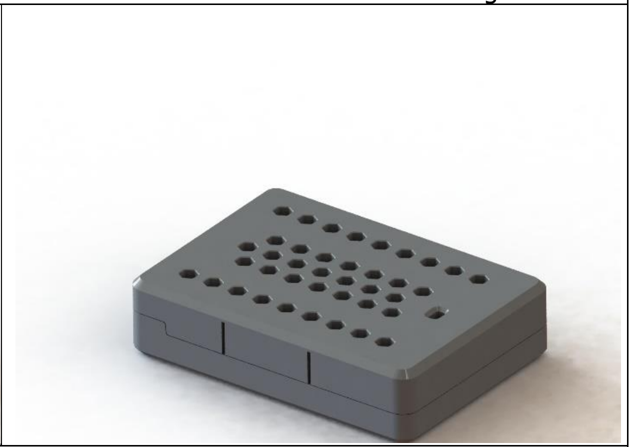
The following tools are required if adding magnets to the bottom of the module housing:

- Superglue or cyanoacrylate glue
- Gloves (nitrile or similar)

The following tools are required if building the housing configuration with screw bosses:

- Size J0 Phillips Screw Driver

2.2.2 Module Housing Assembly Instructions

	
Step 1:	Peel the adhesive backing from the bottom of the solderless breadboard, then place the solderless breadboard in the lower housing so the USB connector is on the same side as the raised lip.
Step 2:	Press the breadboard down firmly to adhere the breadboard to the lower housing.
	
Step 3:	Align the upper housing with the lower housing, then press the upper housing down until the locking features click into place. Note: If building the housing configuration with screw bosses, insert the screws into the upper half of the enclosure, then tighten to secure using a Phillips screwdriver.

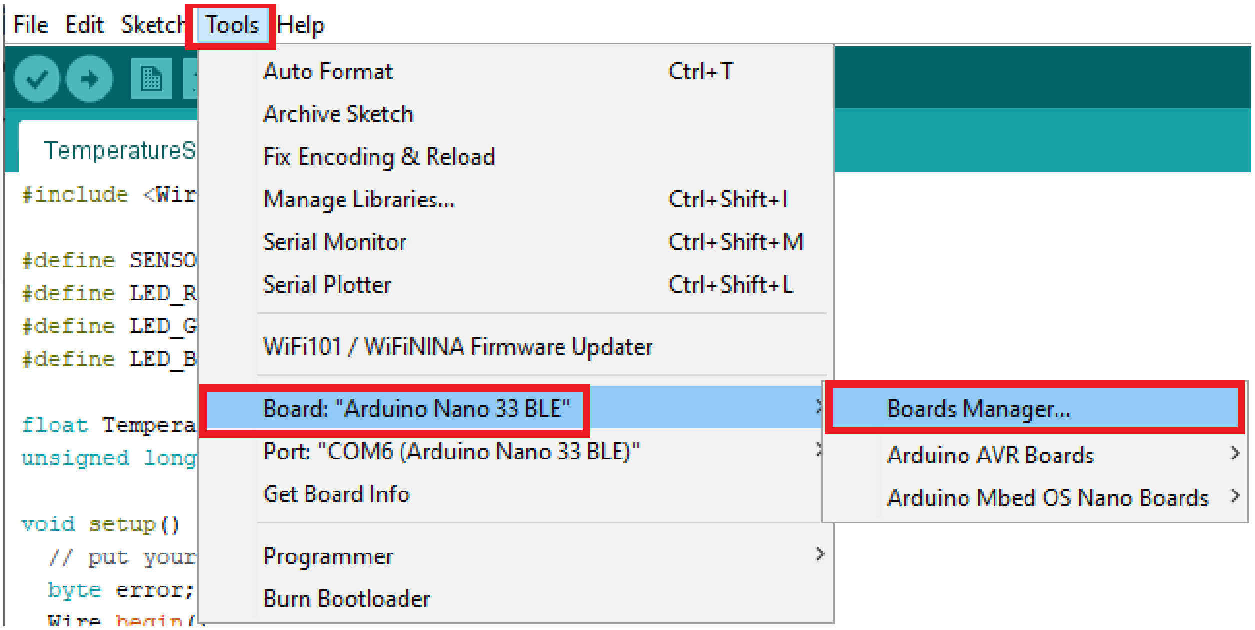
	
Step 4:	Flip the module upside down, remove the adhesive backing on the rubber feet, then place into the large corner recess to adhere.
	
Step 5:	(Optional) Place a drop of glue in each of the smaller central recesses, then carefully press a magnet into each recess and wait at least 30 minutes for the glue to harden. During this process be sure to use gloves when handling super glue or cyanoacrylate glue.

3 Firmware Installation

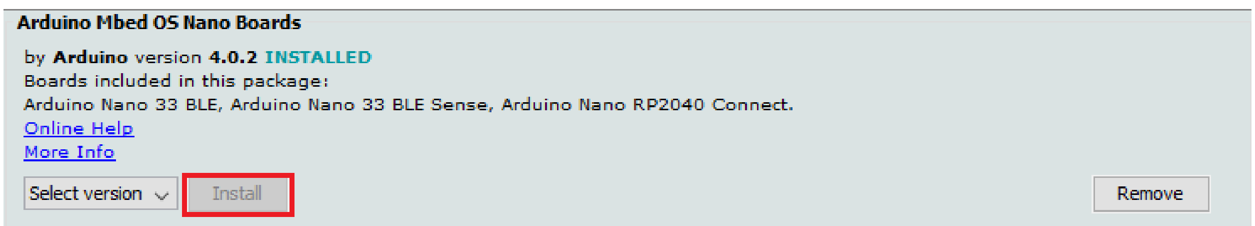
3.1 Arduino IDE and Nano 33 BLE Board Manager Installation

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***

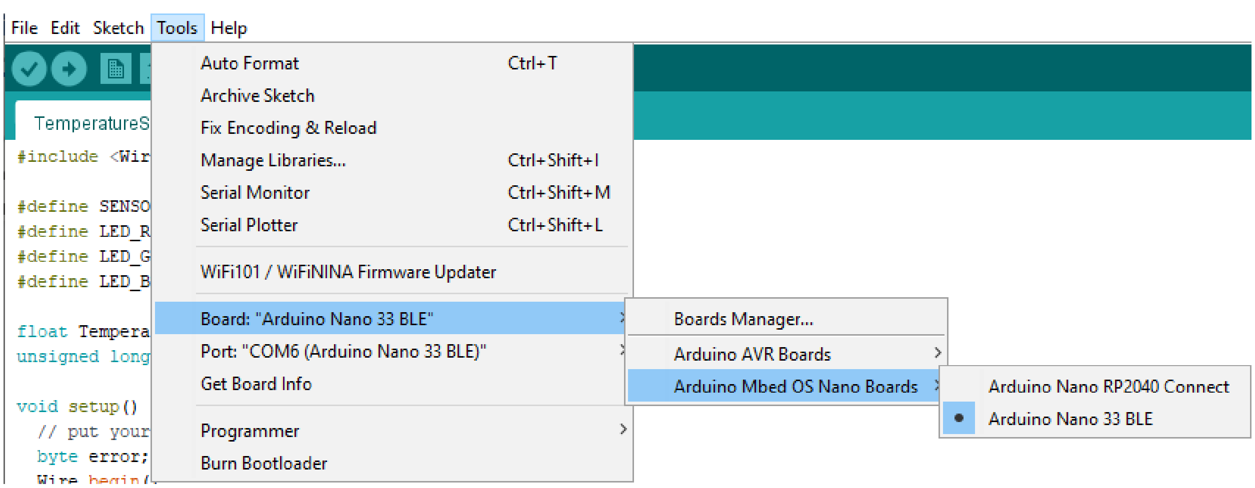
After installing the Arduino IDE, launch the IDE and navigate to the boards manager using the following path: Tools > Boards > Boards Manager



After opening the board manager interface, find the installation for "Arduino Mbed OS Nano Boards" and click the install button to download the board profile.



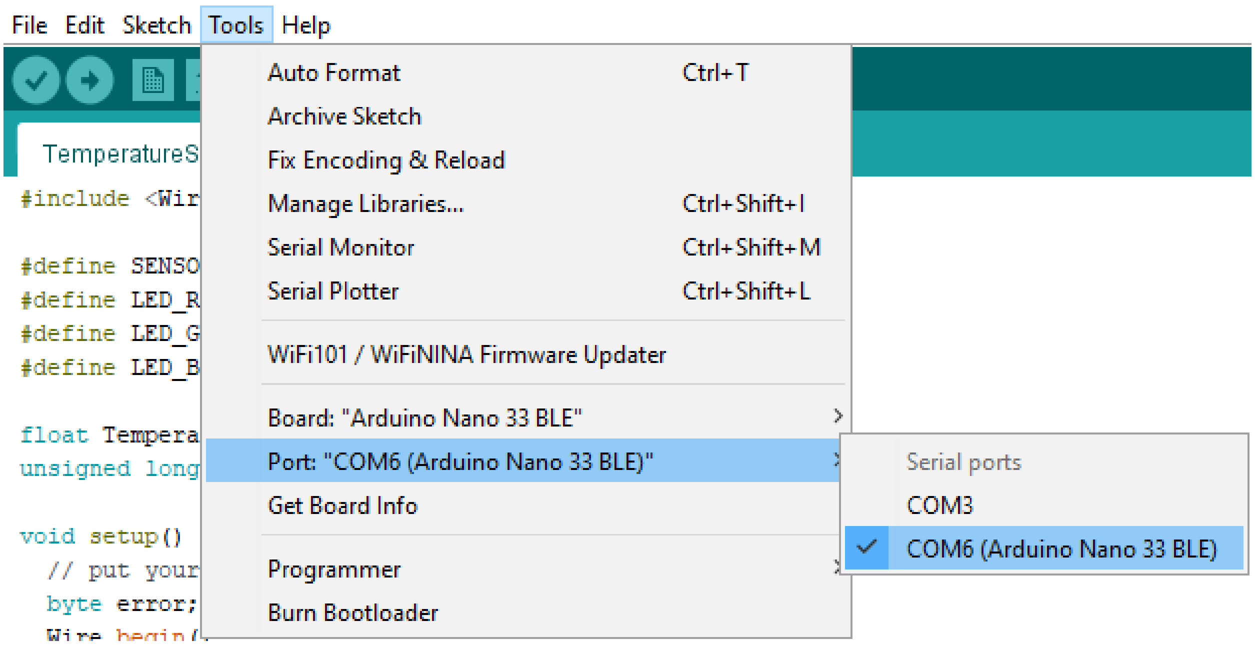
Finally, navigate to Tools > Boards > Arduino Mbed OS Nano Boards > Arduino Nano 33 BLE



3.2 Firmware Upload

To upload the temperature sensor firmware to the Arduino, first connect the assembled temperature sensor module to the PC using a USB cable. Then open the file "Temperature_Sensor.ino" in the Arduino IDE and select the COM port for the Arduino Nano 33 BLE under the "Tools" tab. The Arduino sketch can be downloaded from the project GitHub Repository here:

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.

```
Sketch uses 93608 bytes (9%) of program storage space. Maximum is 983040 bytes.
Global variables use 45936 bytes (17%) of dynamic memory, leaving 216208 bytes for local variables. Maximum is 262144 bytes.
Device       : nRF52840-QIAA
Version      : Arduino Bootloader (SAM-BA extended) 2.0 [Arduino:IKXYZ]
Address      : 0x0
Pages        : 256
Page Size    : 4096 bytes
Total Size   : 1024KB
Planes       : 1
Lock Regions : 0
Locked       : none
Security     : false
Erase flash

Done in 0.000 seconds
Write 93616 bytes to flash (23 pages)
[==============================] 100% (23/23 pages)
Done in 3.793 seconds
```

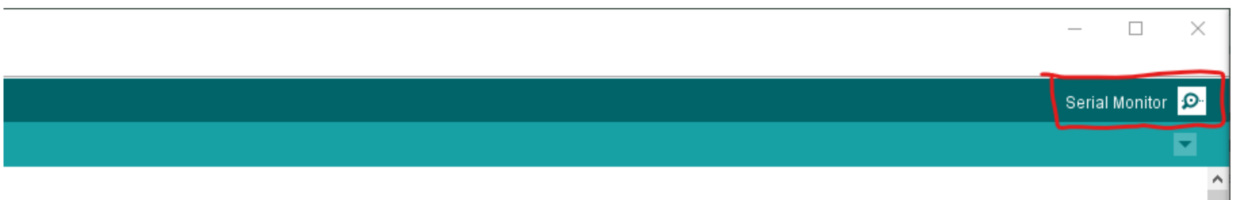
4 Datalogging Setup

To test the temperature sensor the built-in serial monitor in the Arduino IDE can be used to easily access temperature data and test the module. For longer term temperature measurement and datalogging, we recommend Tera Term, an open-source terminal simulator that can log data to an output file with a timestamp.

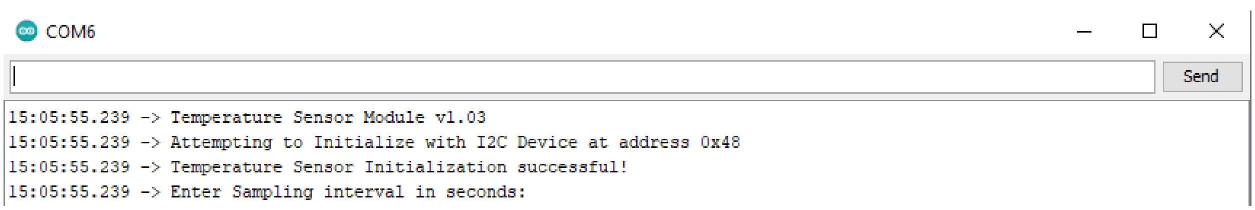
To connect to the temperature sensor module, you'll need to connect to your PC using a USB micro to USB Type A cable. After plugging in the module, the green LED on the MikroE PCBA should light up indicating that the PCBA is receiving power.

4.1 Using the Arduino IDE Serial Terminal

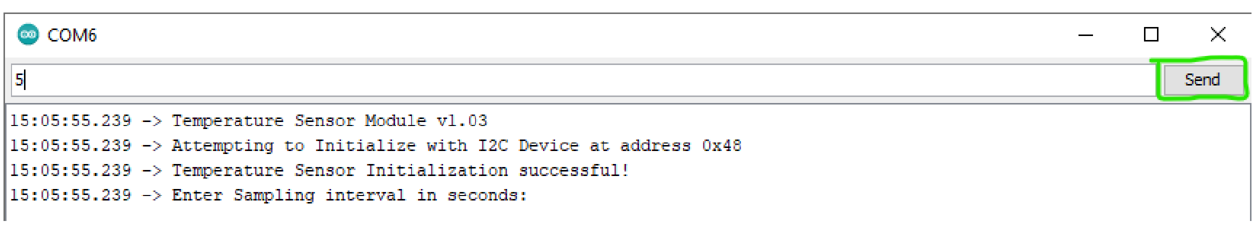
After connecting the module to power, open the Arduino IDE and select the COM port for the module using the same procedure in section 3.2. Then click the serial monitor icon in the top right corner of the Arduino IDE:



The serial monitor should open in a new window and request the user for a sampling interval. This is the time interval in seconds between temperature measurements reported by the temperature sensor module.



To enter the sampling interval, type a numeric value into the entry bar at the top of the serial monitor, then, click the send button or press enter.

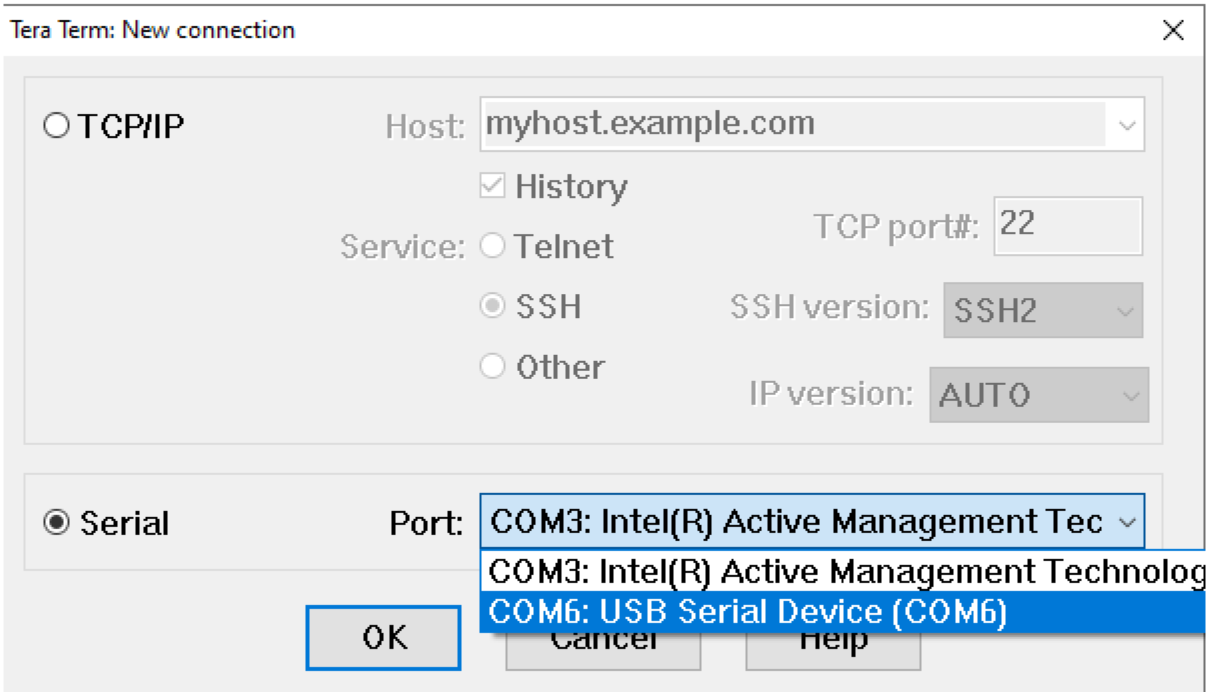


After the command is sent, the serial monitor will confirm the sampling interval and begin printing temperature data to the serial monitor.

4.2 Using Tera Term Serial Terminal

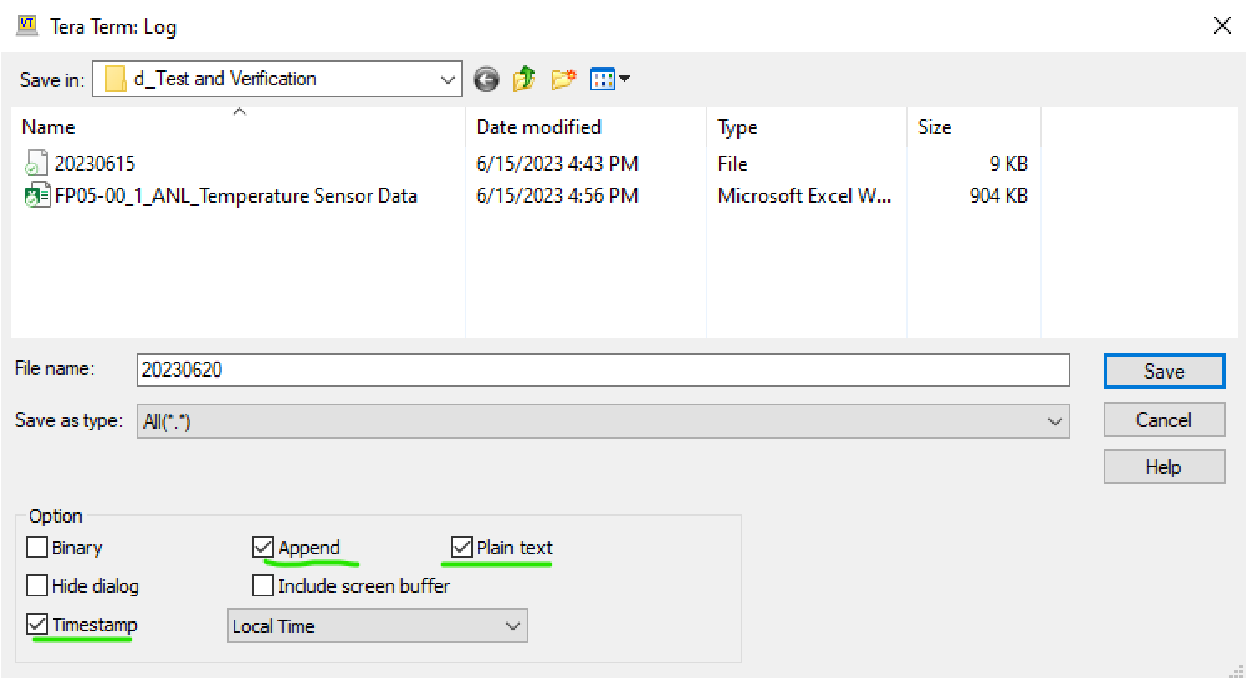
To download Tera Term, use the following link: ***https://ttssh2.osdn.jp/index.html.en***

After connecting the module to power through the USB cable, launch Tera Term and select 'Serial' for a new connection type followed by the COM port, then press 'OK' to connect.



After connecting to the temperature sensor module, a terminal window will pop-up and request a sampling interval in seconds. Enter the sampling interval in seconds and the module will begin acquiring data.

To log data to a file, navigate to File > Log and a pop-up will request a location to save the file as well as a file name. Additionally, there are several check box options for the saved data file, which we recommend selecting Timestamp, Append, and Plain Text.



Click Save when ready to begin logging data. Now as long as the terminal is open, any data received will be appended to the datafile that can easily be read using a text editor such as notepad or imported into a spreadsheet or data analysis tool like MS Excel.

To stop logging data, navigate to File > Stop Logging. To disconnect from the temperature sensor module, navigate to File > Exit, this will close the terminal and stop receiving data.

5 Revision History

Rev	Description of Change	Project No.	Originator	Date
01	Initial Draft	FP05	L. Parrish	20 Jun 2023

6 Appendix

6.1 Bill of Materials

ASSY NO: FPR12008

DESCRIPTION: DIY Temperature Sensor Module

REV: 1

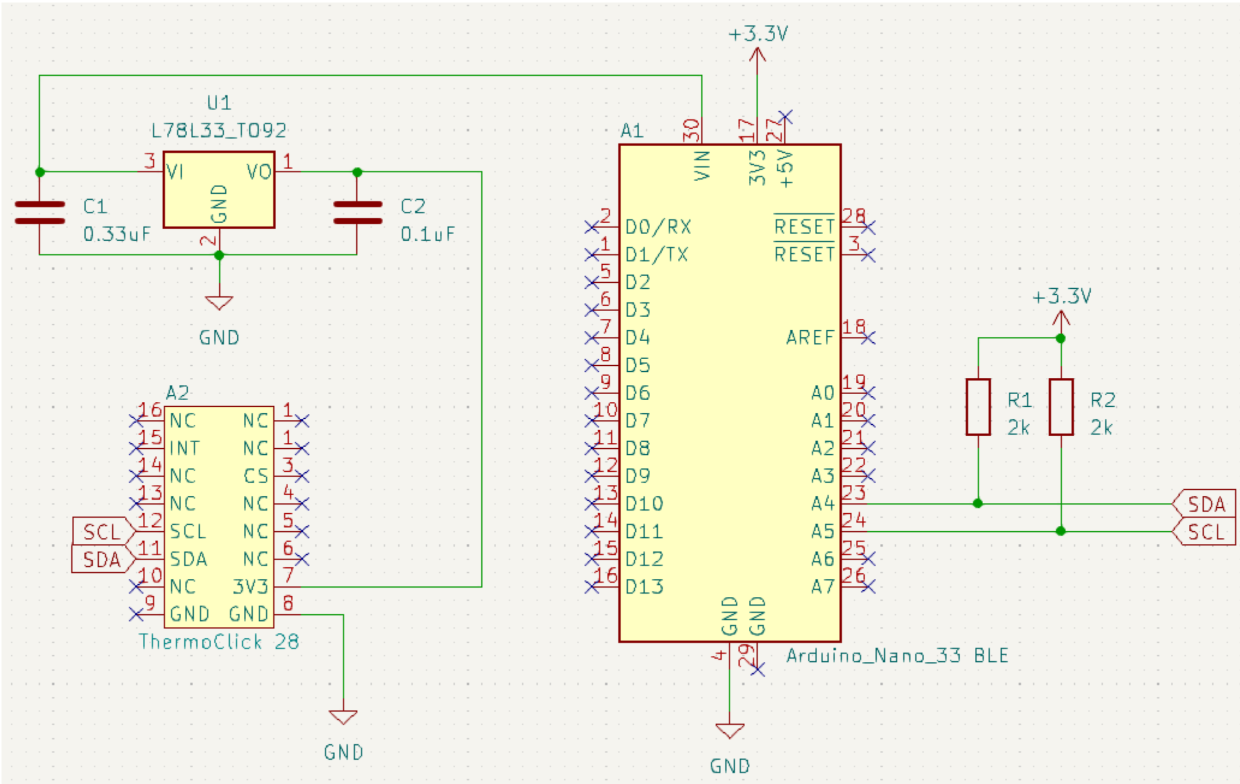
PROJ # FPR05

BOM Cost (USD): $52.21

Item	Qty	P/N	Title	Vendor	Unit Cost
1	1	B07LFD4LT6	Solderless Breadboard	Amazon	$7.59
2	1	ABX00034	Arduino Nano 33 BLE	Amazon	$26.40
3	1	MIKROE-5466	MikroE Thermoclick 28	Mikroelektronika	$11.00
4	1	FPR12089	Bottom Housing	N/A	$0.00
5	1	FPR12090	Upper Housing	N/A	$0.00
6	1	95495K18	Rubber Feet	McMaster-Carr	$4.13
7	2	5862K141	Neodymium Magnets	McMaster-Carr	$0.77
8	2	2.00KXBK-ND	2k Through-hole Resistor	Digikey	$0.10
9	1	497-16176-2-ND	3.3V Linear Voltage Regulator	Digikey	$0.54
10	1	399-9882-2-ND	0.33 µF Ceramic Capacitor	Digikey	$0.49
11	1	399-9859-2-ND	0.1 µF Ceramic Capacitor	Digikey	$0.32
12[1]	1	99461A916	M2 Threadforming Screws	McMaster-Carr	$8.62

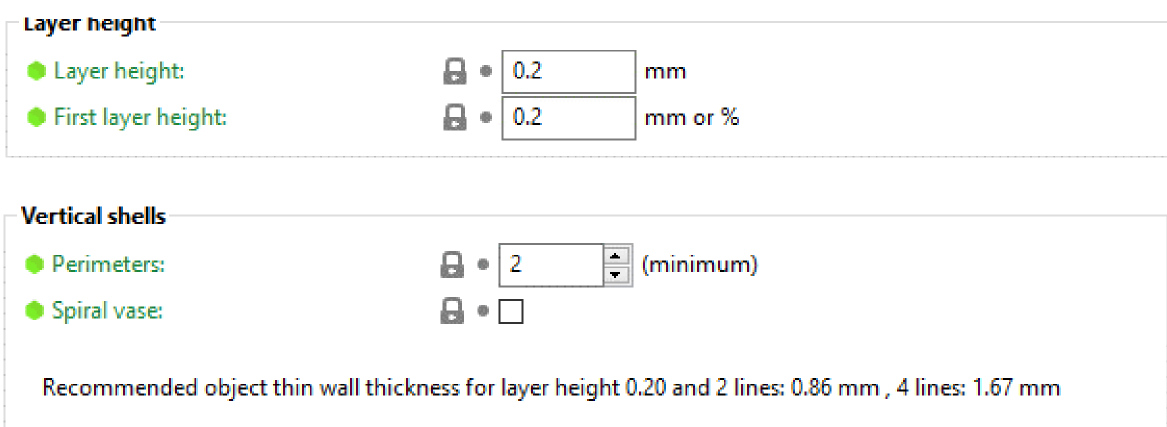
[1] Only required for the enclosure variation with screw bosses

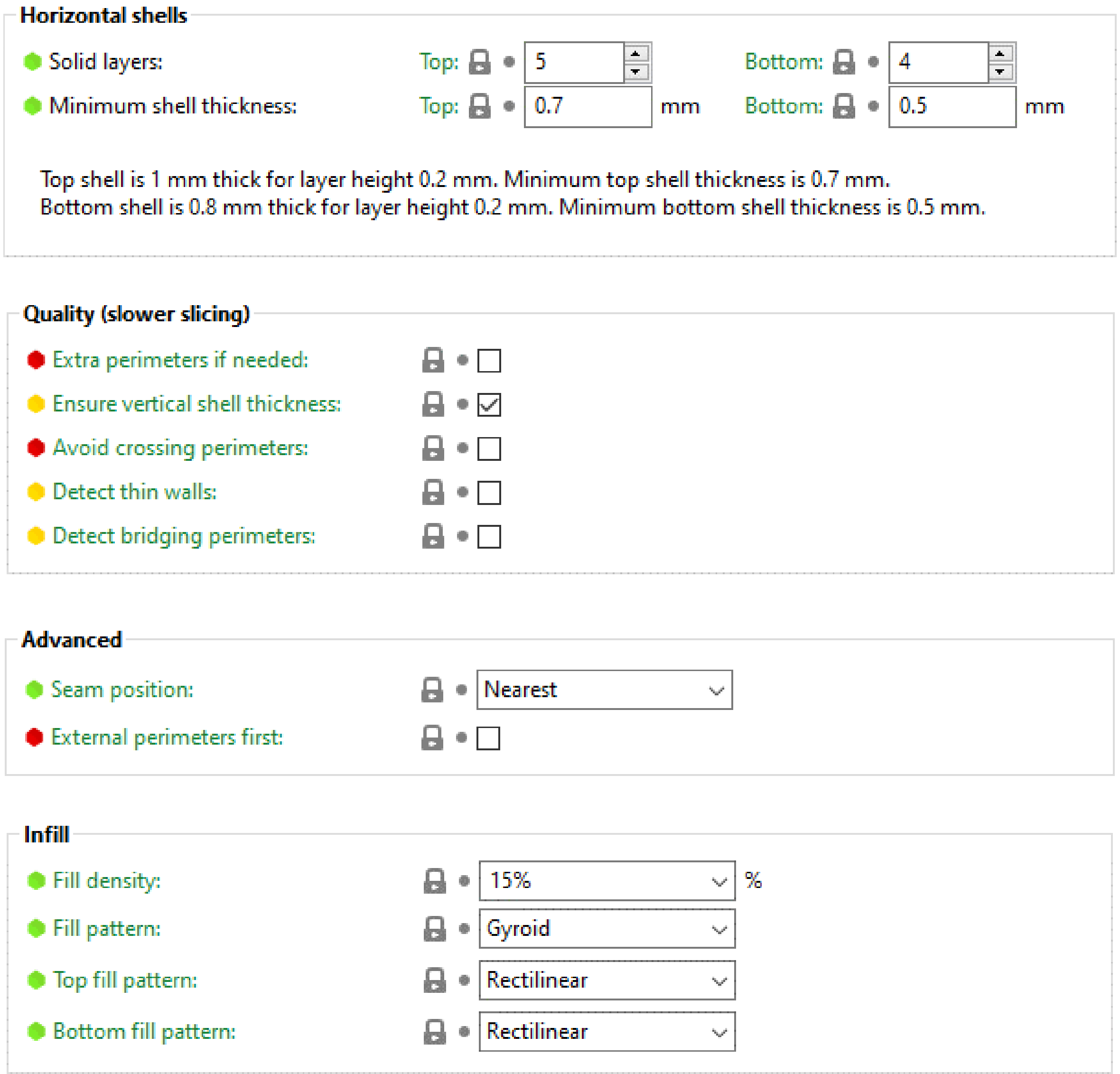
6.2 Circuit Diagram



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:




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	mm^2
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