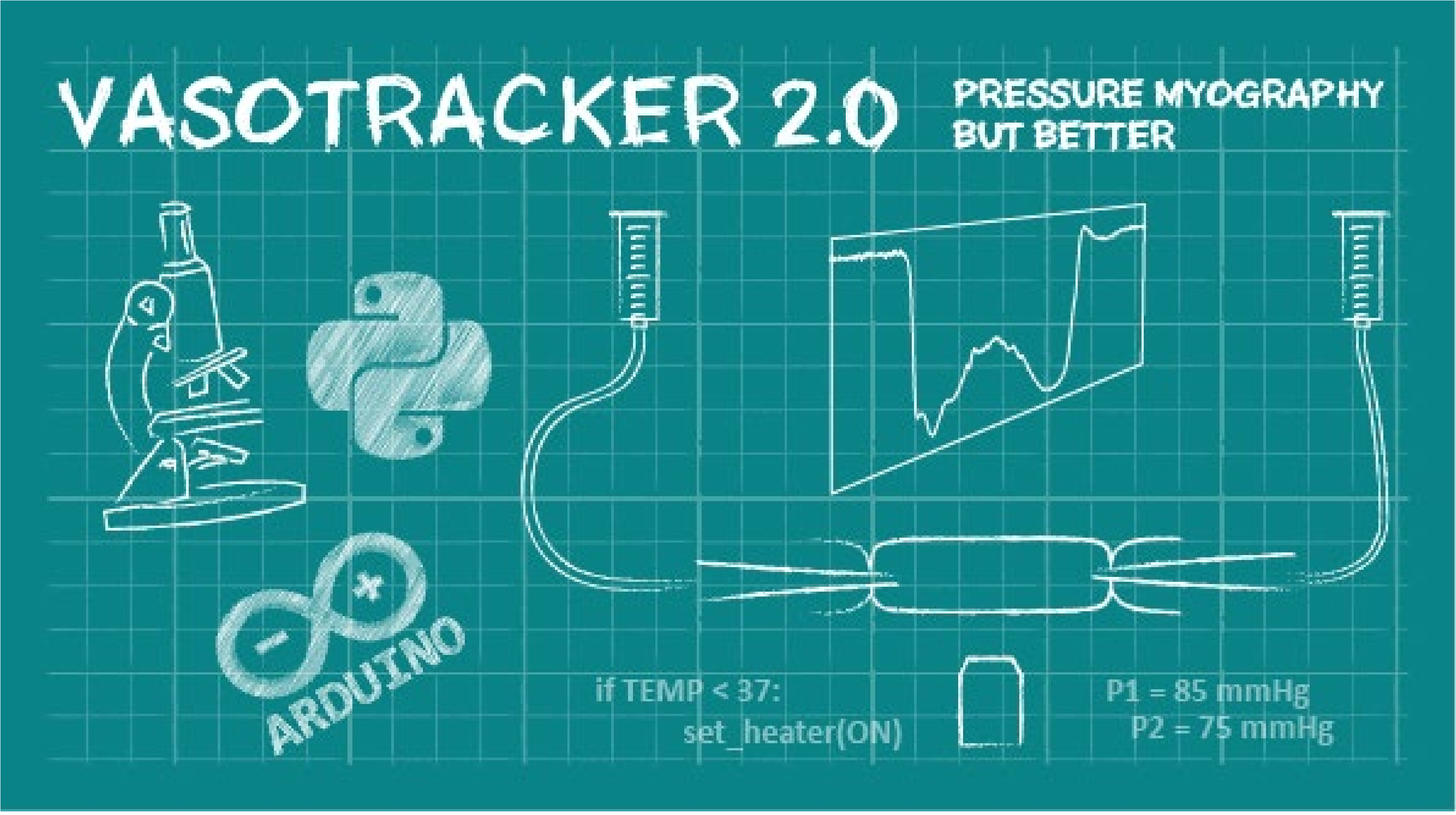

Temperature & Pressure Monitor User Manual

2024

Developed by Calum Wilson & Matthew Lee at the University of Strathclyde and Nathan Tykocki at Michigan State University

Email vasotracker@gmail.com if you need help.

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Overview

The VasoTracker 2.0 Temperature & Pressure Monitor

The VasoTracker 2.0 Temperature and Pressure Monitor is an open-source, low-cost data acquisition system for monitoring temperature and pressure. Designed to complement the VasoTracker 2.0 pressure myograph, it can be used for any other application requiring pressure/temperature measurement.

The system combines two independent monitoring subsystems from the original VasoTracker – one for temperature and one for pressure – into a single compact unit. The unit features dual LCD screens for real-time visualization of both temperature & pressure data and integrates with VasoTracker 2.0 software for seamless data recording.

General specifications

The VasoTracker 2.0 Temperature and Pressure Monitor is designed to measure pressure on either side of a cannulated blood vessel that has been mounted in a pressure myograph, and temperature in the pressure myograph chamber. Temperature is continuously measured using an epoxy-coated thermistor, while pressure is monitored through two flow-through pressure sensors. These are both processed by Arduino open-source microcontroller boards with stackable shields, convering the signals into pressure (mmHg) or temperature (oC) for display. The system can measure pressure in the range of 0 – 200 mmHg. Both pressure and temperature data are displayed in real time, allowing for precise control during experiments.

Citing VasoTracker

VasoTracker began life with the support of the Wellcome Trust and the British Heart Foundation to facilitate research on blood vessel function. Our ability to continue supporting, developing, and maintaining VasoTracker depends on further grant funding. If you use VasoTracker in any way, please cite VasoTracker in your scientific publications. For citation details, please visit:
https://vasotracker.com/publications/

Developers

Calum Wilson & Matthew Lee - University of Strathclyde:
Nathan Tykocki - Michigan State University:

Figure 1 – The VasoTracker 2.0 Temperature & Pressure Monitor

Parts List

VasoTracker Temperature & Pressure Monitor Parts						
3D Printed Parts						
3D Printed Enclosure	VasoTracker	-	1	£0	£0	GitHub
Prices correct 10/2024		**Total**			**£0.00**	

VasoTracker Temperature Monitor						
Component	**Supplier**	**Product #**	**Qty**	**Price**	**Total**	**Supplier Link**
Arduino Uno**	Arduino	RB-Ard-34	1	£26.50	£26.50	RobotShop
12V power supply	RS	903-7048	1	£8.33	£8.33	RS
Arduino Proto Shield	Skinflint	A000077	1	£13.50	£13.50	SkinFlint
LCD Shield	RobotShop	RB-Cyt-73	1	£3.64	£3.64	RobotShop
10k NTC Thermistor	Adafruit	372	1	£3.06	£3.06	DigiKey
Resistor kit	RobotShop	RES-E12	1	£13.80	£13.80	RobotShop
Jumper wire kit	RobotShop	RB-Cix-02	1	£3.77	£3.77	RobotShop
2-pin Screw Terminal	RobotShop	RB-Dfr-465	1	£0.76	£0.76	RobotShop
Prices correct 10/2024		**Total**			**£73.36**	

VasoTracker Pressure Monitor						
Component	**Supplier**	**Product #**	**Qty**	**Price**	**Total**	**Supplier Link**
Arduino Uno**	Arduino	RB-Ard-34	1	£26.50	£26.50	RobotShop
12V power supply	RS	903-7048	1	£8.33	£8.33	RS
Wheatstone bridge amplifier shield	RobotShop	RB-Onl-38	1	£45.63	£45.63	RobotShop
LCD Shield	RobotShop	RB-Cyt-73	1	£3.64	£3.64	RobotShop
Inline pressure transducers	Honeywell	26PCDFG5G	2	£74.55	£149.10	Mouser
12” 4-pin jumper wire	RobotShop	RB-Spa-1107	2	£0.60	£1.20	RobotShop
Arduino stackable headers	RobotShop	RB-Spa-928	1	£1.67	£1.67	RobotShop
Female to female jumper	RobotShop	RB-Gog-65	1	£4.31	£4.31	RobotShop
Heatshrink tubing	RobotShop	RB-Gog-47	1	£1.92	£1.92	RobotShop
Prices correct 10/2024		**Total**			**£242.30**	
Total Price					**£315.66**	

The software and instructions provided only work for Arduino Uno boards with the ATMega microcontroller chip. Other variants (e.g., SAMD51 or ESP-32 chips) cannot be used.

Building the VasoTracker Temperature Monitor (A000077 Protoshield)

The temperature monitor uses a simple voltage divider to convert the thermistor resistance (and thus temperature) to voltage

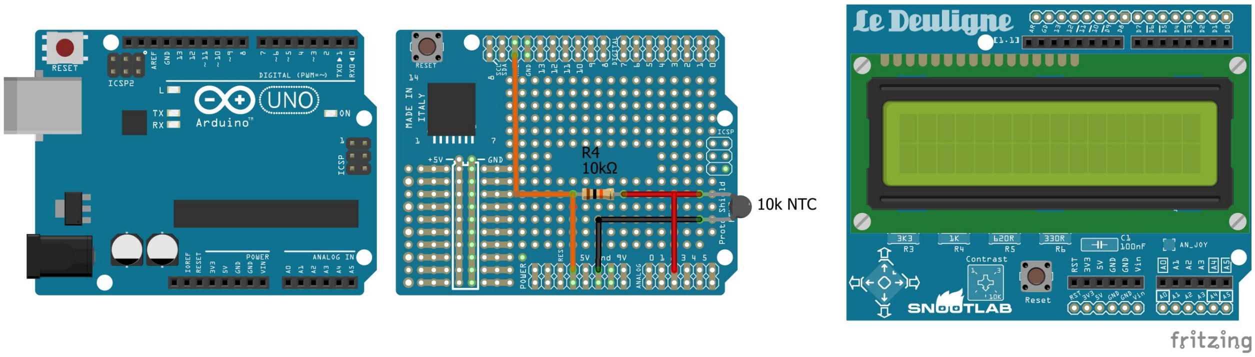

Figure 2 – The VasoTracker 2.0 Temperature Monitor Wiring Diagram

Step 1: Build the temperature sensor circuit on the Arduino Proto shield, as shown in image above. The temperature sensor is connected to a screw terminal mounted on the Proto Shield.

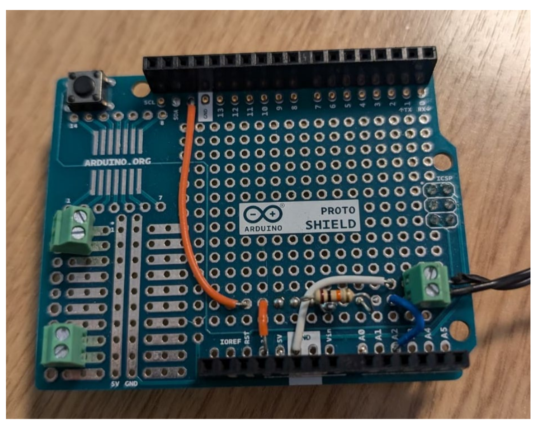

Figure 3 – The VasoTracker 2.0 Temperature Monitor Circuit

Step 2: Stack the completed Proto shield on top of the Arduino Uno.

Step 3: Stack the LCD shield on top of the Arduino Uno.

Step 4: (Optional) 3D print an enclosure to protect your VasoTracker pressure monitor. You can place the device in its own enclosure or use the dual enclosure designed for VasoTracker 2.0. The STL files for the enclosure below can be found on the VasoTracker 2 GitHub.

The software and instructions provided only work for Arduino Uno boards with the ATMega microcontroller chip. Other variants (e.g., SAMD51 or ESP-32 chips) cannot be used.

Building the VasoTracker Temperature Monitor (Sparkfun Protoshield)

If you struggled to source the A000077 Protoshield, you may have purchased the Sparkfun version…

Step 1: Snap off the test part of the sparkfun board It's not needed.

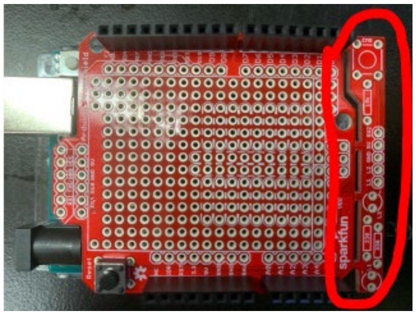

Figure 4 – The Sparkfun Prototype Shield

Step 2: Build circuit by soldering the wires/components into place.

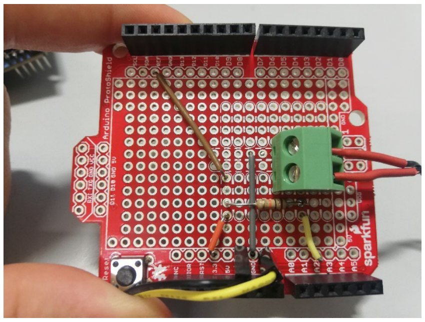

Figure 5 – Top view of the Temperature Monitor circuit.

Step 3: Ensure wires/components are connected using solder bridges on the bottom side of the protoboard.

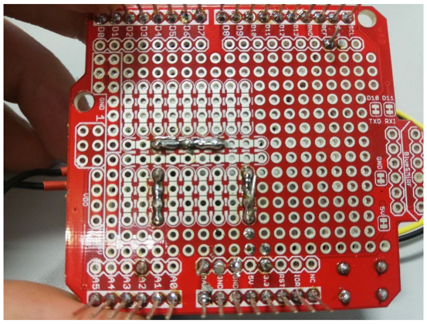

Figure 6 – Bottom view of the Temperature Monitor circuit showing solder bridges connecting the individual components.

Programming the VasoTracker Temperature monitor

The software and instructions provided only work for Arduino Uno boards with the ATMega microcontroller chip. Other variants (e.g., SAMD51 or ESP-32 chips) cannot be used.

Step 1: Download and install the Arduino IDE. This can be done using either Windows or Mac OSX; however, the VasoTracker software installer only runs in Windows.

If you want to run VasoTracker on iOS then you must install from the source code. Instructions for doing so can be found in the VasoTracker Software User Manual.

Step 2: Download the latest VasoTracker Pressure Monitor Arduino code from GitHub.

Step 3: Unzip the "VasoTracker Temperature_Monitor_V*T2*" folder. The folder name must not be changed.

Step 4: Connect the Arduino to your computer using the Arduino USB cable.

Step 5: Using the Arduino IDE software, open "VasoTracker_Temperature_Monitor_VT2.ino".

Step 6: Configure the Arduino IDE for your Arduino Uno. If you purchased an Arduino Uno clone board (e.g., Adafuit Metro, please see the instructions for configuring the board at the supplier's website).

Tools → Board → Arduino Uno

Tools → Port → COM *X* (Arduino Uno). *"X" will vary by computer and system, depending on how many USB peripherals are attached.*

Step 7: Upload the code to the Arduino by clicking the upload button. No modifications to the code are required if you are doing a standard build as outlined above.

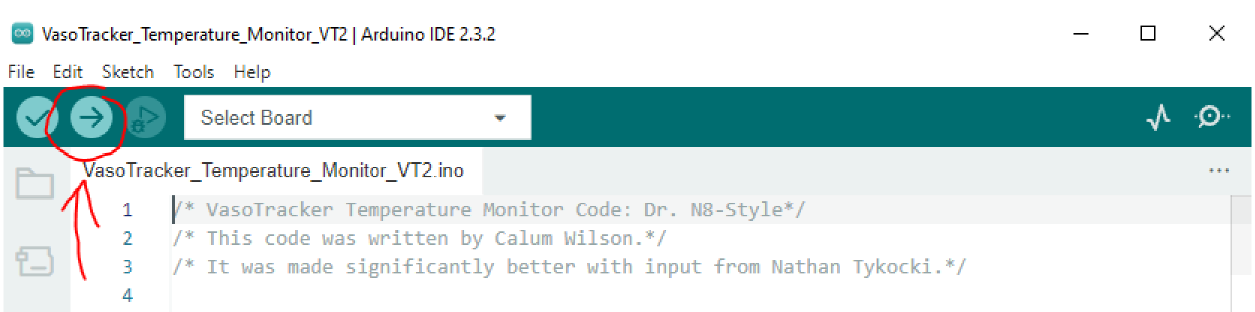

Figure 7 – Arduino IDE with upload button highlighted

Pressure Monitor Connections and Wiring

Pressure Sensor Wiring

The 26PCDFG5G pressure transducer has four pins. This version of the sensor comes with a handy cable. There are four wires:

- Pin 1 (Red wire): Vs
- Pin 2 (White wire): Signal +
- Pin 3 (Black wire): Ground
- Pin 4 (Green wire): Signal -

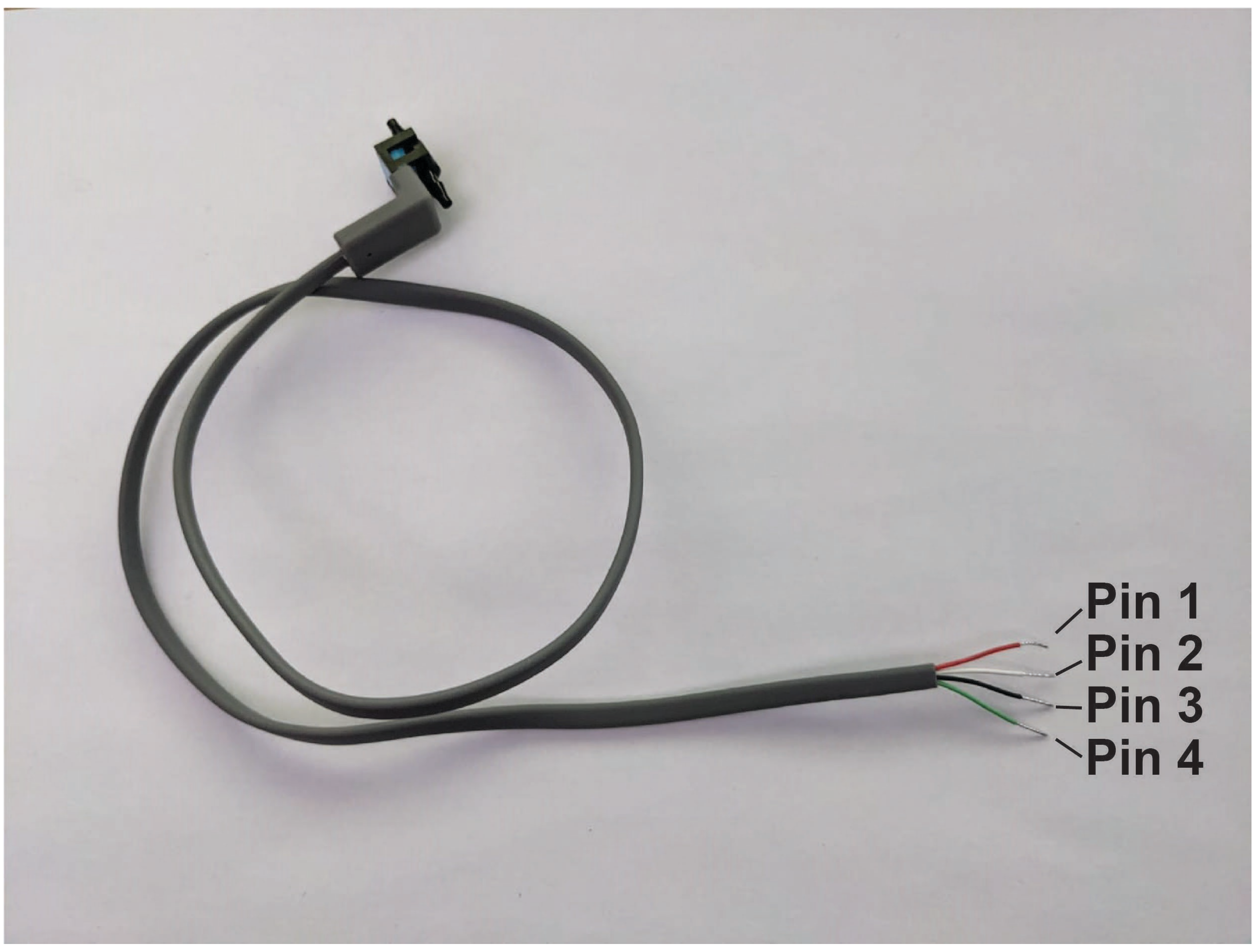

Figure 8 – Pressure sensor wiring

Wheatstone Bridge Shield connections

The following instructions are for use with the supplied Honeywell pressure transducer cable. There is a crossover within the cable header. If you make your own cable then the Pin order is different.

The Wheatstone shield uses the following Arduino pins:

- A0: Sensor 1 input
- A1: Sensor 2 input
- 5V, 3.3V, GND: to power the shield

Each pressure sensor needs to be connected to one of the 4-pin Molex connectors on the Wheatstone bridge shield. The Molex pins are as follow:

- Molex Pin 1: Vs
- Molex Pin 2: Signal +
- Molex Pin 3: Signal -
- Molex Pin 4: Ground

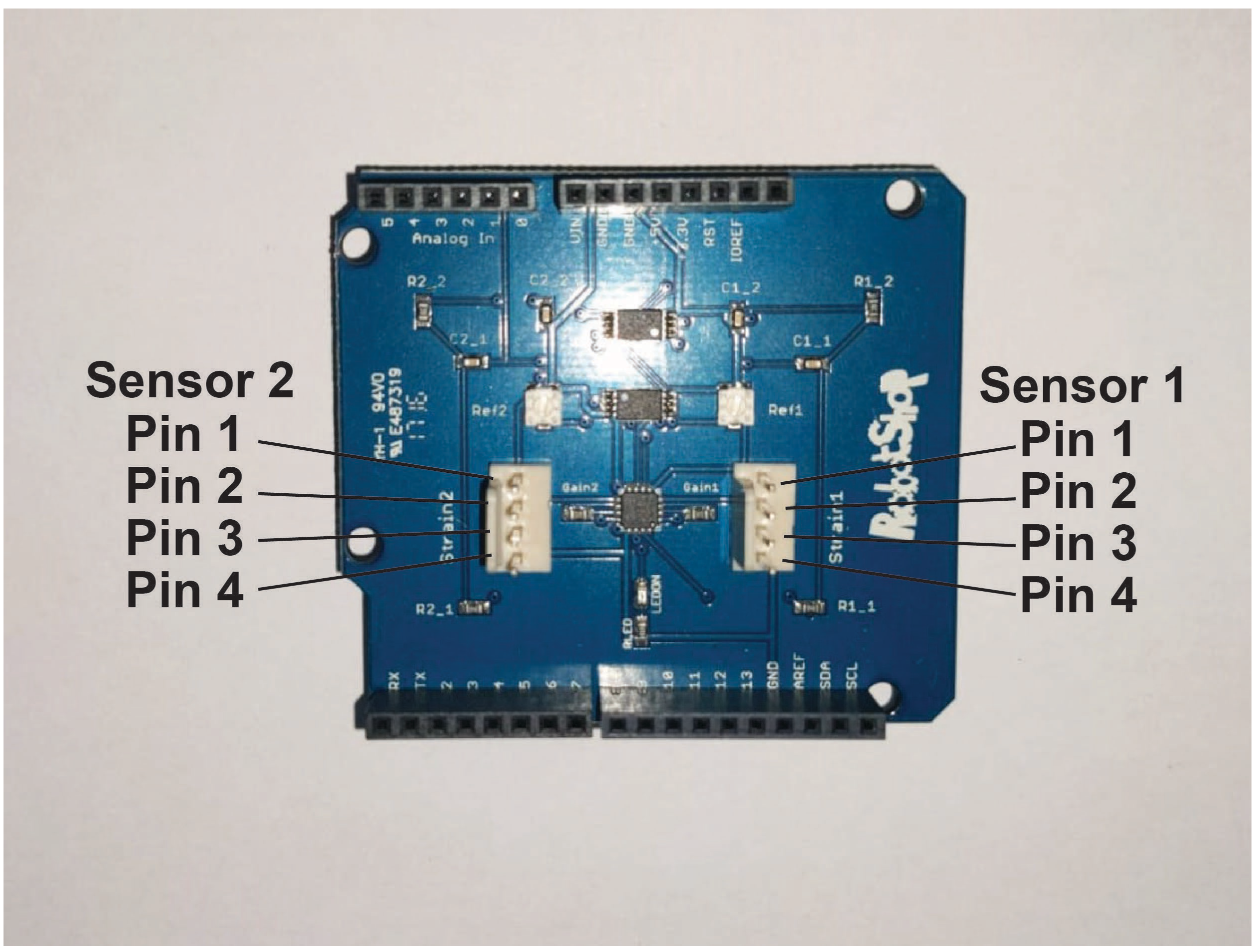

Figure 9 – Wheatstone bridge pinout.

Wheatstone Bridge Shield Setup

Each channel on the Wheatstone bridge shield has its own reference voltage that is set using specific channel potentiometers. Calibrating these is necessary to ensure that the shield works as intended.

Documentation for the Wheatstone Bridge Shield can be found on the RobotShop website.

Users need to erform the calibration procedure detailed in the “Test Procedure” pdf file (found here).

If you are too lazy to read this document, then please turn both potentiometers fully clockwise, then turn back 1/4 - 1/8 of a turn so that the potentiometer screw is parallel to the Arduino headers.

https://www.robotshop.com/en/strain-gauge-load-cell-amplifier-shield-2ch.html

The Wheatstone bridge shield contains two potentiometers

Building the VasoTracker Pressure Monitor

Mapping the pressure transducer connections to the Wheatstone bridge

The table below maps the pressure transducer connections to the Molex connector pins on the Wheatstone bridge shield:

Connection	Pressure sensor pin	Wheatstone bridge pin
Vss	Pin 1 (Red wire)	Molex Pin 1
Signal +	Pin 2 (White wire)	Molex Pin 2
Ground	Pin 3 (Black wire)	Molex Pin 4
Signal -	Pin 4 (Green wire)	Molex Pin 3

Table 1 - Mapping of pressure transducer connections to Wheatstone bridge shield

Step 1: Connect the 4-pin jumper wires to the Molex connectors on the Wheatstone bridge shield.

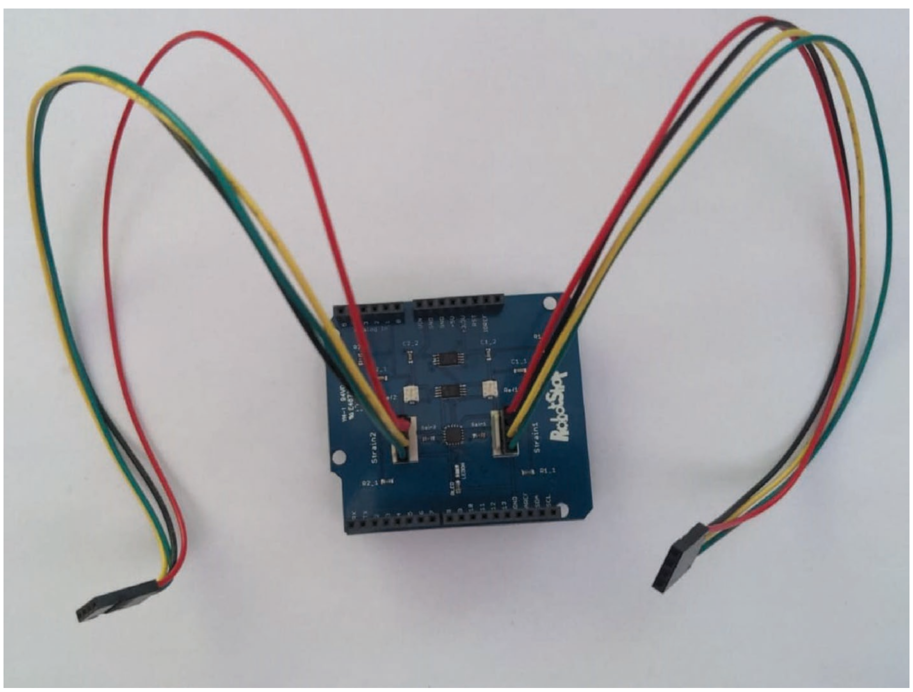

Figure 10 – Wheatstone bridge with jumper wires attached (step 1)

Step 2: Slide a piece of heatshrink tubing over the jumper wires

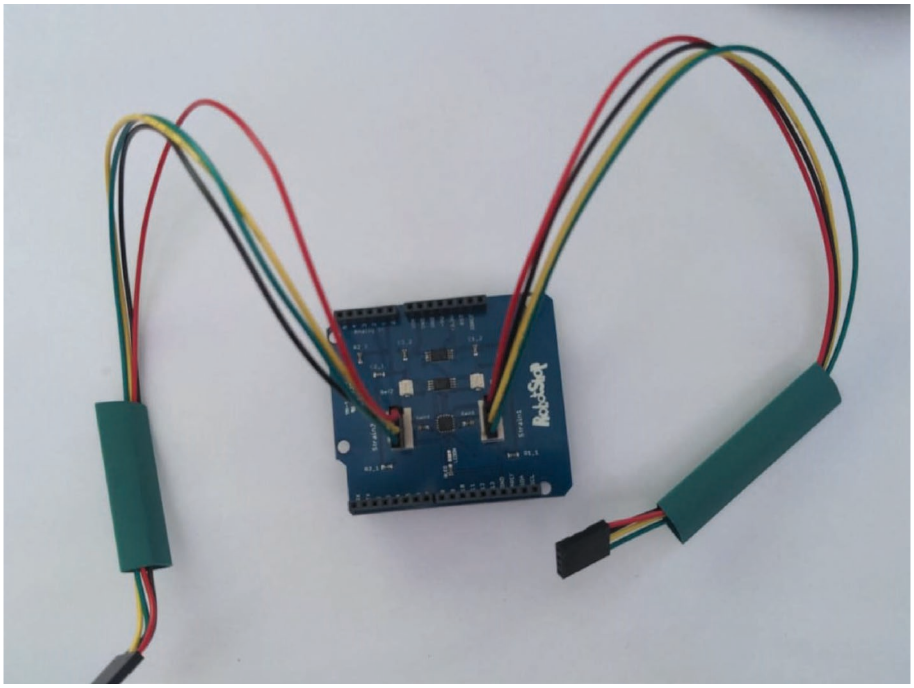

Figure 11 – Heat shrink tubing placement (step 2).

Step 3: Connect the pressure transducer cable to the jumper wire as per Table 1.
Step 4: Slide a piece of heat shrink tubing over the jumper wires. Heat gently (with heat gun or soldering iron) to shrink. Be careful not to burn the heat shrink tubing or damage the wiring insulation.

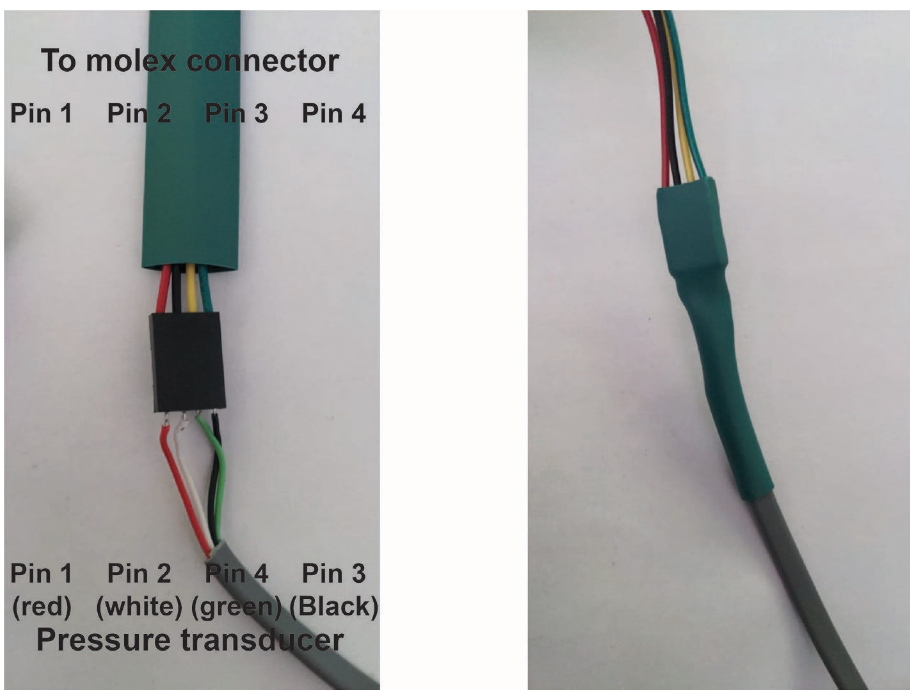

Figure 12 – Pressure sensor connections before (Step 3) and after (step 4) being secured with heat shrink tubing.

Stacking the Arduino Shields

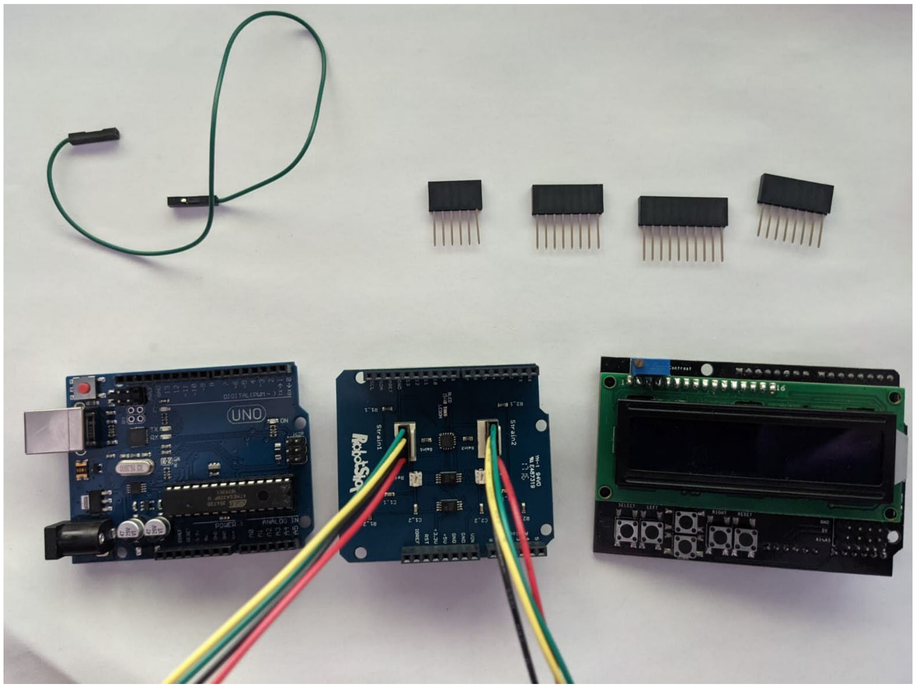

Figure 13 – VasoTracker pressure monitor components

Step 1: Stack the wheatstone bridge shield on top of the Arduino Uno.

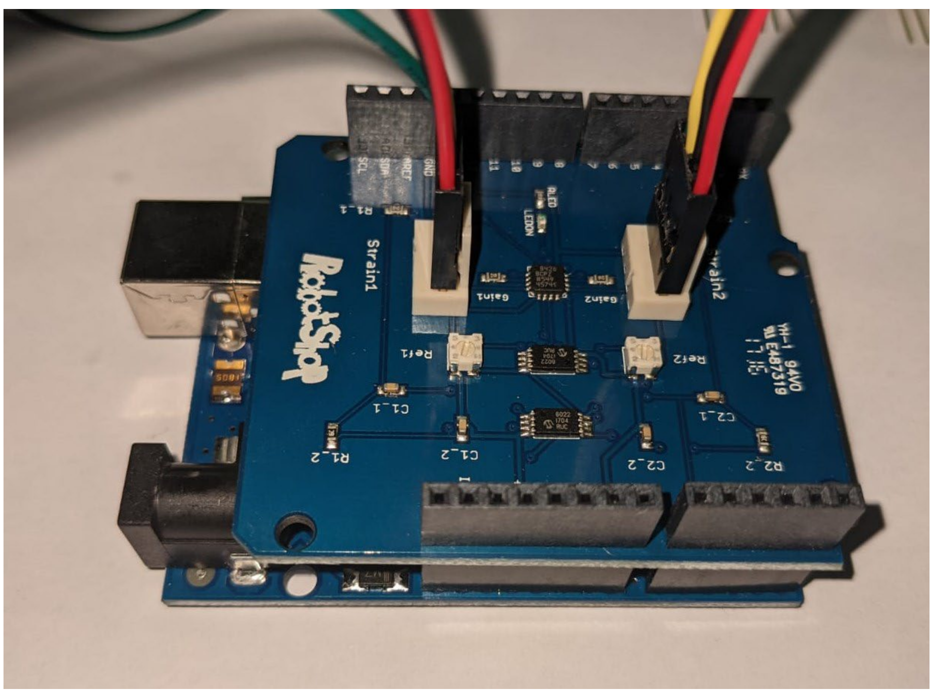

Figure 14 – Stacked Wheatstone bridge shield and Arduino Uno

Step 2: Place stackable headers on top of the Wheatstone Amplifier Shield (these are required to allow clearance for the pressure transducer connections). Bend the A0 pin on the stackable header so that it does not connect to the Arduino Uno board (see Figure 8).

The LCD shield normally uses the A0 pin for the button commands. However, the strain guage also uses the A0 (and A1) inputs on the Arduino. To get around this problem, we route the LCD A0 pin to A5.

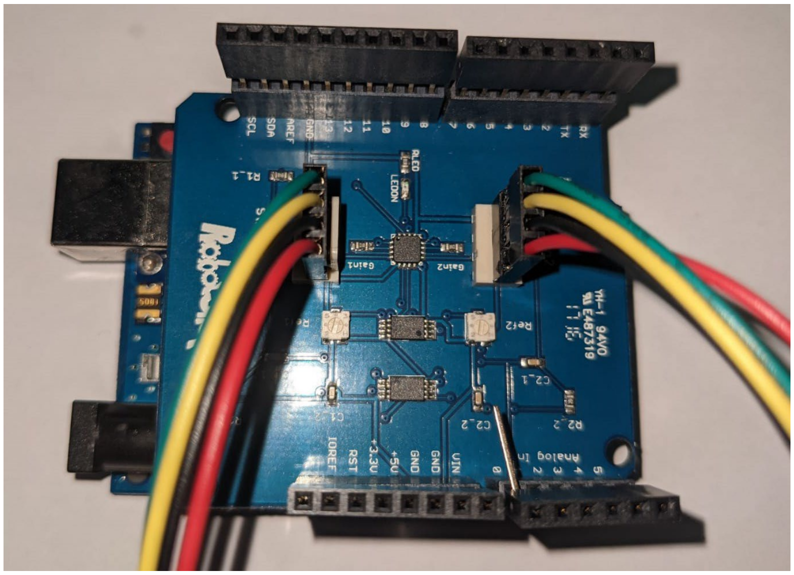

Figure 15 – Placement of stackable headers.

Step 2: Connect the jumper cable to the bent A0 pin.

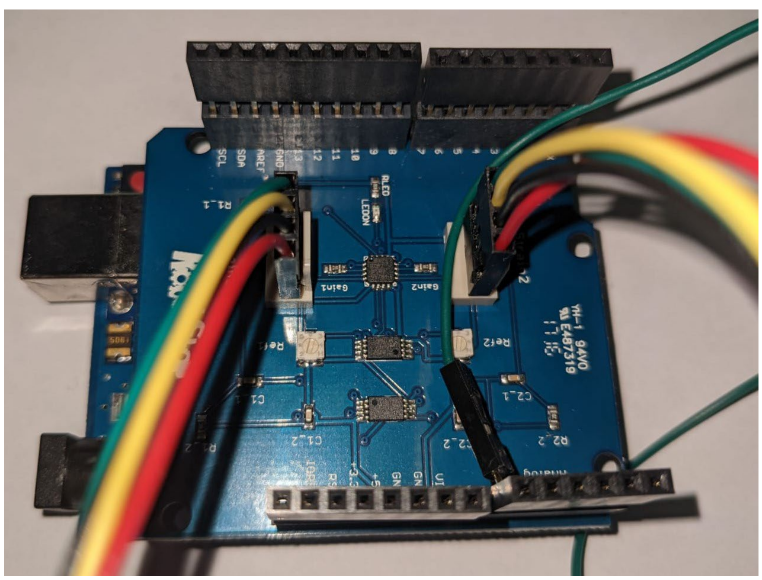

Figure 16 – Placement of LCD jumper cable.

Step 4: Stack the LCD shield on top of the headers. Route the jumper cable to the A5 pin.

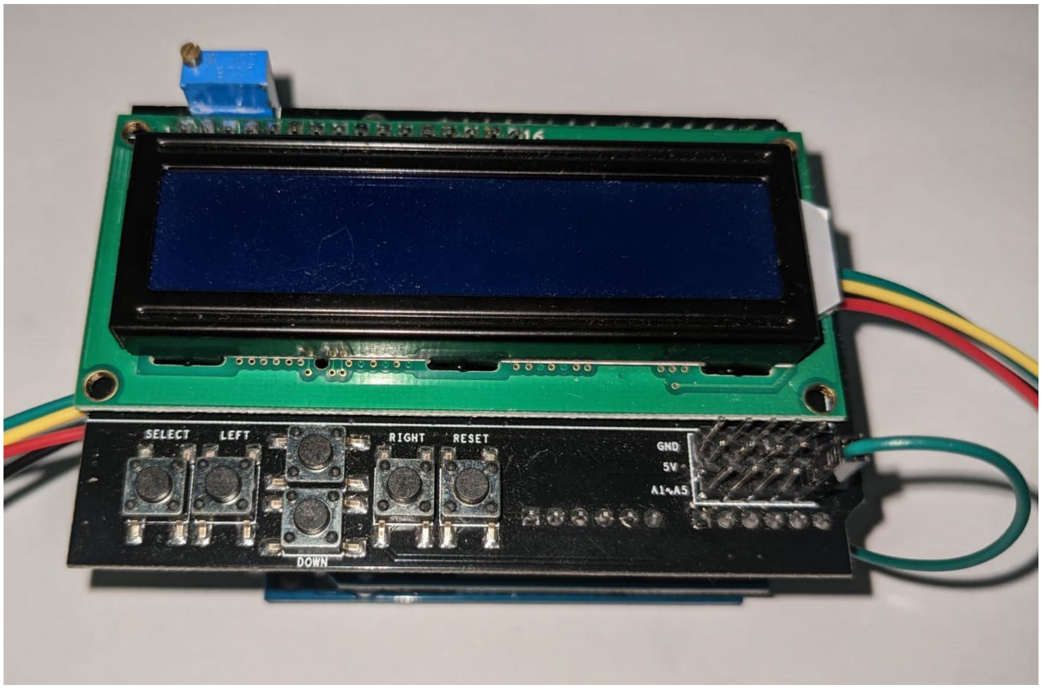

Figure 17 – Stacked LCD shield.

Alternative method for rerouting LCD pins: Remove the A0 pin from the LCD shield (heat it up with a soldering iron and pull it out using pliers). Solder a jumper wire from A0 to A5 on the board. This is a better way to do the above.

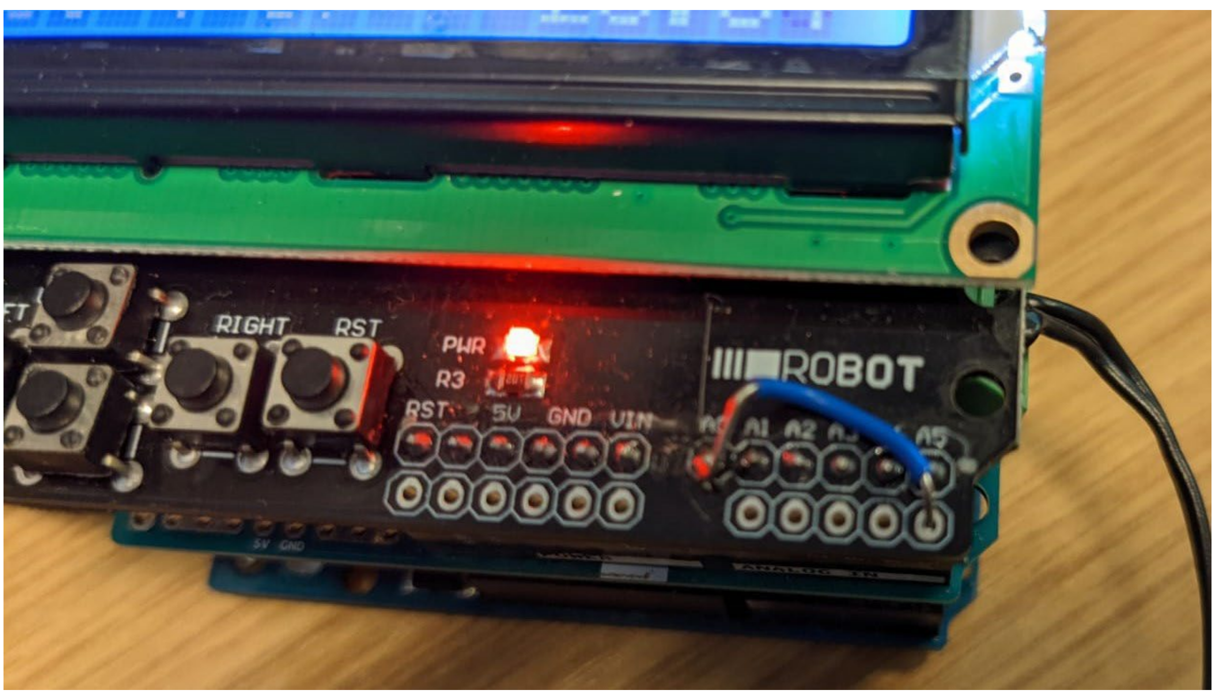

Figure 18 – Alternative way to reroute the pins on the LCD shield. You should do a neater job than we did on this one.

Step 4: If you want, 3D print an enclosure to protect your VasoTracker pressure monitor. The STL files for the single enclosure below can be found on the VasoTracker 2 GitHub. Instructions for connecting both the Temperature and Pressure Monitors within a single enclosure are available here.

Figure 19 – VasoTracker Pressure Monitor

Programming the VasoTracker pressure monitor

The software and instructions provided only work for Arduino Uno boards with the ATMega microcontroller chip. Other variants (e.g., SAMD51 or ESP-32 chips) cannot be used.

Step 1: Download and install the Arduino IDE. This can be done using either Windows or Mac OSX; however, the VasoTracker software installer only runs in Windows.

If you want to run VasoTracker on iOS then you must install from the source code. Instructions for doing so can be found in the VasoTracker Software User Manual.

Step 2: Download the latest VasoTracker Pressure Monitor Arduino code from GitHub.

Step 3: Unzip the "VasoTracker_Pressure_Monitor_VT2" folder. You must keep all the files in this folder together, and the folder name must not be changed.

Step 4: Connect the Arduino to your computer using the Arduino USB cable.

Step 5: Within the "VasoTracker_Pressure_Monitor_VT2" folder, you will find three files: (1) "pressure.cpp"; (2) "pressure.h"; and (3) "VasoTracker_Pressure_Monitor_VT2.ino". Using the Arduino IDE software, open "VasoTracker_Pressure_Monitor_VT2.ino".

Step 6: Configure the Arduino IDE for your Arduino Uno. If you purchased an Arduino Uno clone board (e.g., Adafuit Metro, please see the instructions for configuring the board at the supplier's website).

Tools → Board → Arduino Uno

Tools → Port → COM *X* (Arduino Uno). *"X" will vary by computer and system, depending on how many USB peripherals are attached.*

Step 7: Upload the code to the Arduino by clicking the upload button. No modifications to the codee are required if you are doing a standard build as outlined above.

Figure 12 – Arduino IDE with upload button highlighted

Integrating the Temperature and Pressure Monitors

The VasoTracker Temperature and Pressure Monitors can either be held as independent units, or can be enclosed in a single enclosure and powered from a single power supply.

Step 1: Download the VasoTracker 2 CombiBox and 3D print all of the parts (including two sets of buttons).

Step 2: Slide the Arduino from the Temperature Monitor into the lower slot in the enclosure.

Step 3: Slide the Arduino + Wheatstone Shield from the Pressure Monitor into the upper slot in the enclosure.

Step 4: Use jumper wires to connect the VIN and GND of the Wheatstone shield to that on the Temperature Monitor Arduino. You may need to remove two pins from the stackable headers to achieve this.

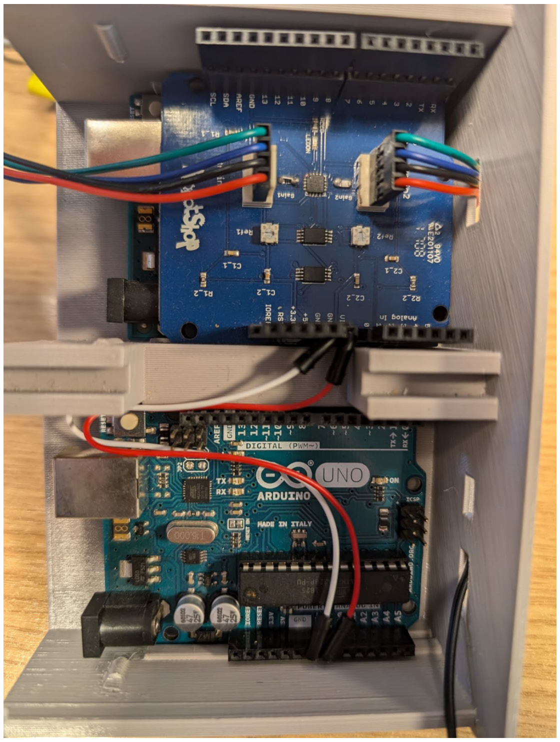

Figure 20 – VasoTracker Temperature and Pressure Monitor Wiring

Step 5: Add the remaining shields to the Arduino's (temperature monitor protoshield circuit, and LCDs). Use stackable headers to raise the height of the Pressure Monitor LCD.

Step 6: Add the front plate and the buttons.

Step 7: Power via the pressure monitor Arduino.

Figure 21 – The VasoTracker Temperature and Pressure Monitor

Setting up the VasoTracker pressure monitor

On first use, the VasoTracker pressure monitor needs to be calibrated. Once this has been done, the calibration values are saved into memory on the Arduino Uno and can be reloaded each time the pressure monitor is used – even after disconnecting the power. We recommend that you recalibrate the sensors once a week. We use a Big Ben manometer, but any calibrated manometer will suffice, such as a blood pressure cuff (with the cuff removed).

Figure 22 – Big Ben manometer.

Step 1: Use your tubing and connectors of choice to connect the first transducer to the manometer.

Step 2: On the recalibrate screen (Figure 15), use the up/down buttons until the screen reads "YES" and press the "ENTER" button (left most on LCD screen).

Step 3: The next screen is used to set the low pressure used for calibration (Figure 16). Use the UP/DOWN (10 mmHg increments) or left/right buttons (1 mmHg increments) to set the low calibration pressure to 0 mmHg. Save this value by pressing "ENTER".

Step 4: The next screen shows the reading from the pressure sensor (Figure 17). Ensure the manometer is set to the pressure set in the previous step (0 mmHg). Press "ENTER" to save this value.

Step 5: The next screen is used to set the high pressure used for calibration (Figure 18). Use the UP/DOWN (10 mmHg increments) or left/right buttons (1 mmHg increments) to set the low calibration pressure to 160 mmHg. Save this value by pressing "ENTER".

Step 6: The next screen shows the reading from the pressure sensor (Figure 19). Ensure the manometer is set to the pressure set in the previous step (160 mmHg). Press "ENTER" to save this value.

Steps 7-10: Repeat Steps 3-6 for the second pressure transducer.

Step 11: Connect the pressure sensors to your pressure myograph system and use with VasoTracker. If used with VasoTracker pressure myograph software, the pressure values with be saved along with blood vessel diameter data.

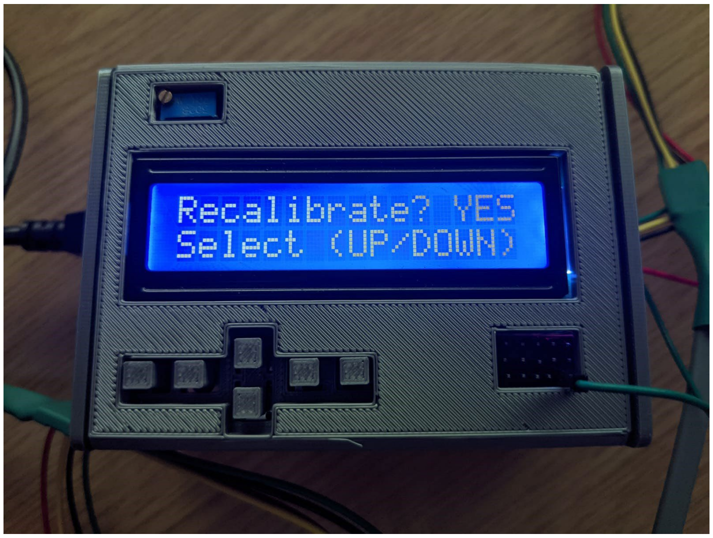

Figure 23 – Recalibration selection screen.

Figure 24 – Low pressure calibration selection screen.

Figure 25 – Low pressure reading screen.

Figure 26 – High pressure calibration selection screen.

Figure 27 – High pressure reading screen.

Figure 28 – Calibrated VasoTracker pressure monitor.

www.vasotracker.com