LAACES:MEGASAT ASSEMBLY MANUAL

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Background

This document provides step-by-step instructions for assembling the LaACES MegaSat board. Students should not start working on the MegaSat until they have practiced SMT soldering using the provided practice kit.

The assembly of this board should be expected to take students a few weeks and should be done in parallel with their payload process.

System Operation

The MegaSAT is a microprocessor sensor board designed to provide a set of commonly useful sensors and interfaces for a LaACES Payload. Combining the MegaSAT, an Arduino Mega, and the Adafruit Ultimate GPS Logger Shield, teams build a solid baseline payload.

The baseline MegaSAT stack can be expanded to add additional sensors to meet the team's Science Goals. A high-level diagram of the basic LaACES payload is shown below.

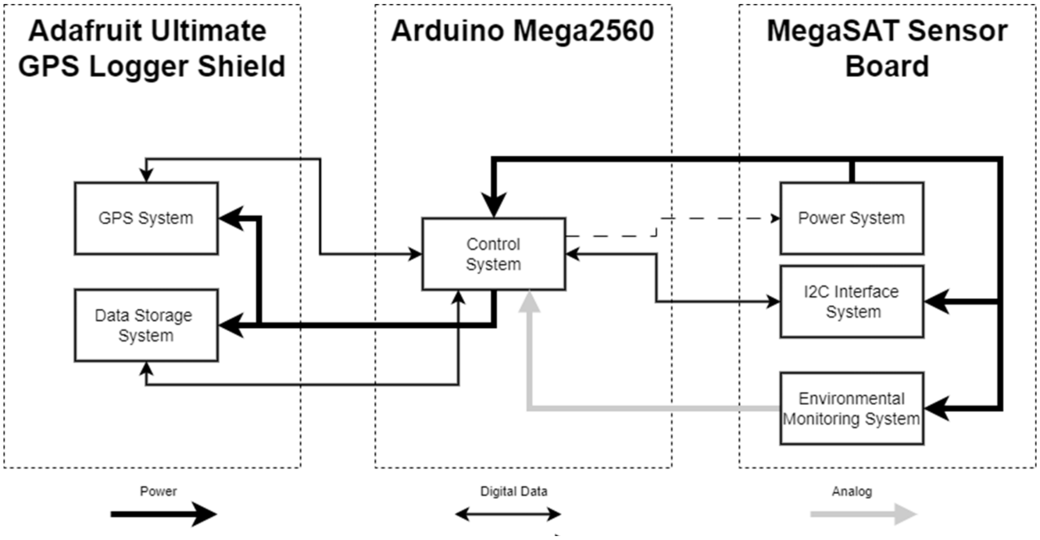


Figure 1: MegaSAT system diagram.

The Arduino Mega acts as the control system, the GPS Shield provides the Data Storage System and GPS System, and the MegaSAT board powers the stack, provides data interfaces, and includes environmental sensors.

A full schematic of the board is included in this document in Appendix A: Full Schematic. The layout of major sections of the board are shown in Figure 2.

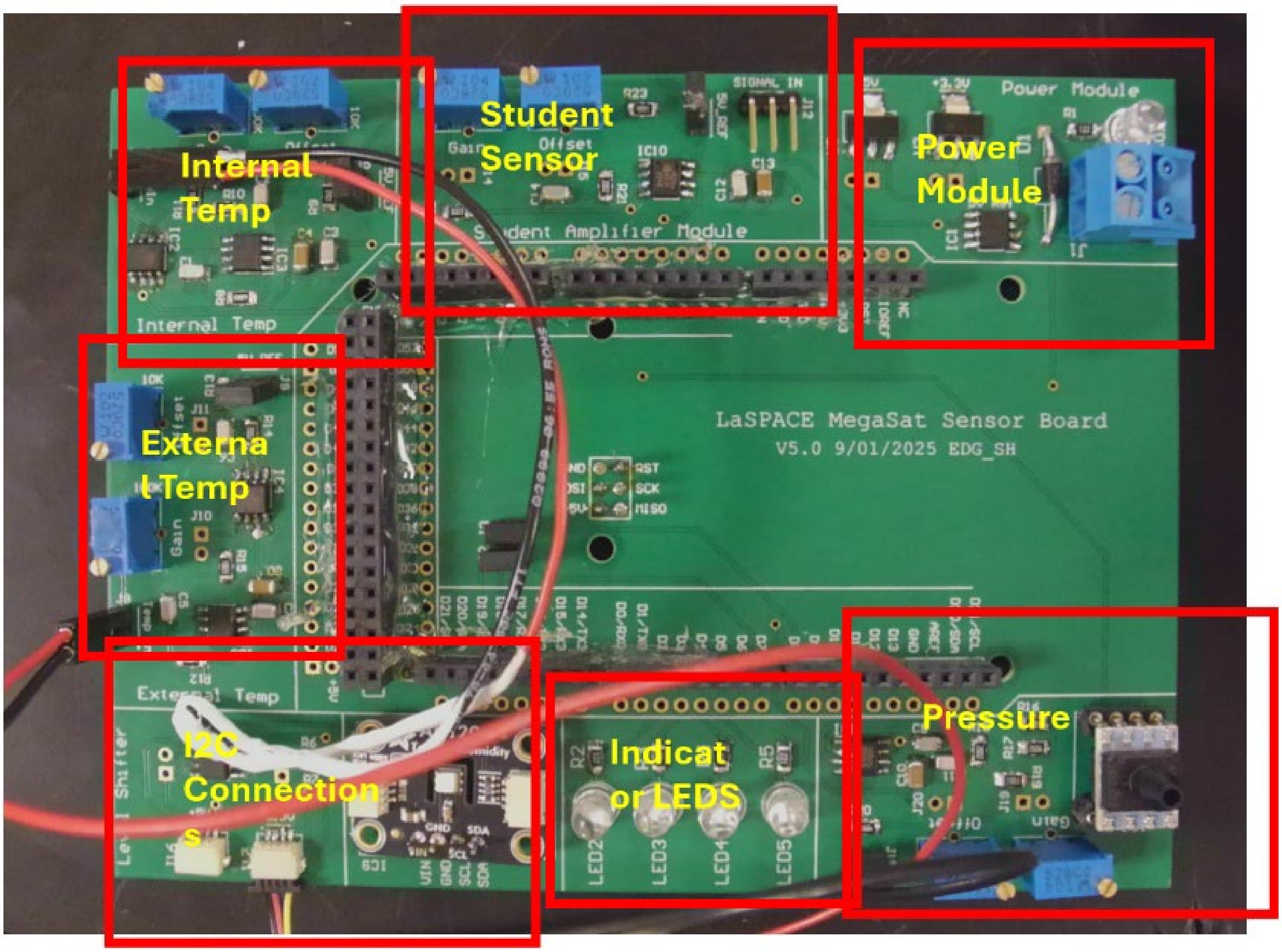


Figure 2: Layout of major sections of the MegaSat.

General Tips for Success

- Work on a clean and well-lit surface to prevent you from losing components
- Use tweezers or forceps to handle components
- Secure the board while working
- Clean and prepare the PCB before soldering
- Choose a tip and solder that are an appropriate size for your work
- Add solder slowly and sparingly
- Frequently clean and tin the tip of your soldering iron
- Reposition the board as needed while working

Breakaway Headers

There are two sets of breakaway headers included in your kits. These are used to solder jumpers to the board at various steps during assembly. You will need to break off the

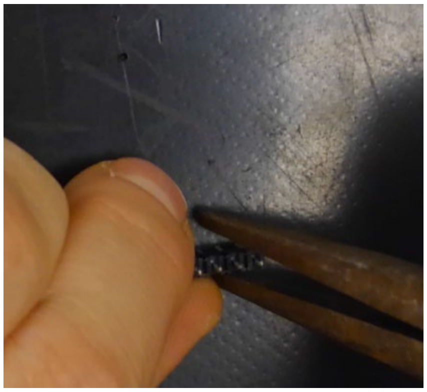


Figure 5: Use pliers to hold the header just to one side of where you want to break the header.

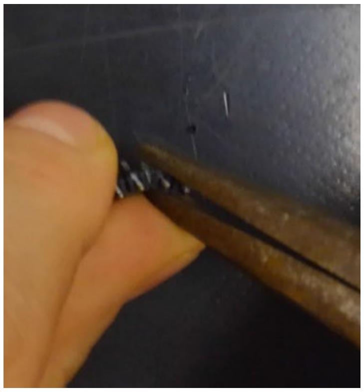


Figure 5: Bend the header with the pliers until they break.

Figure 5: You should now have the desired number of pins.

Power Module

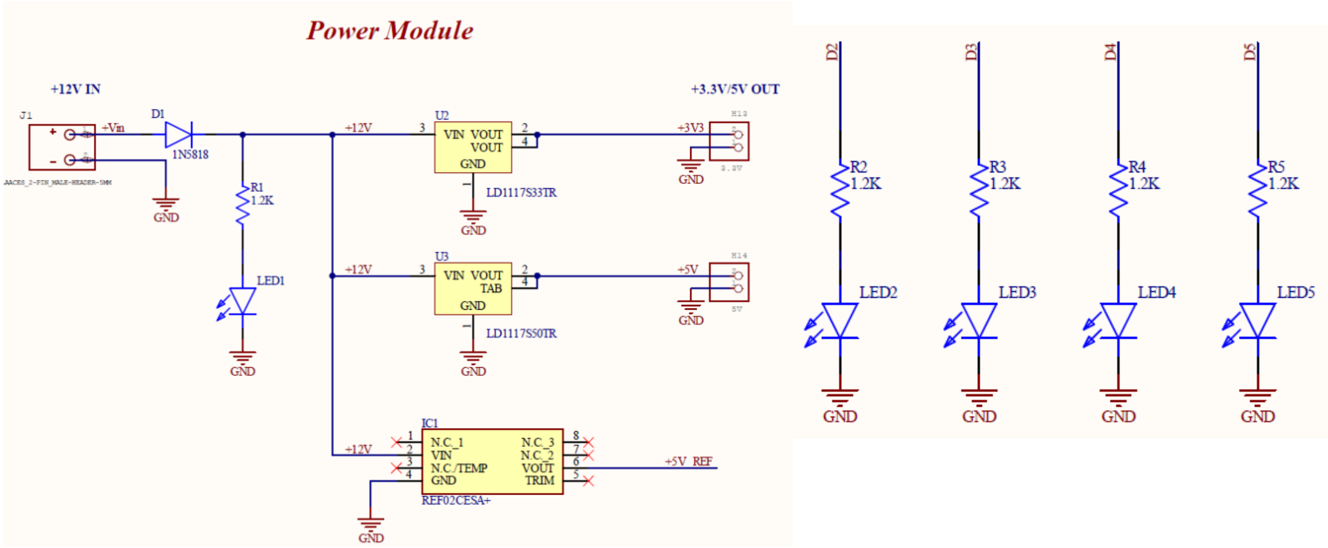


Figure 7: Schematic for power module circuit.

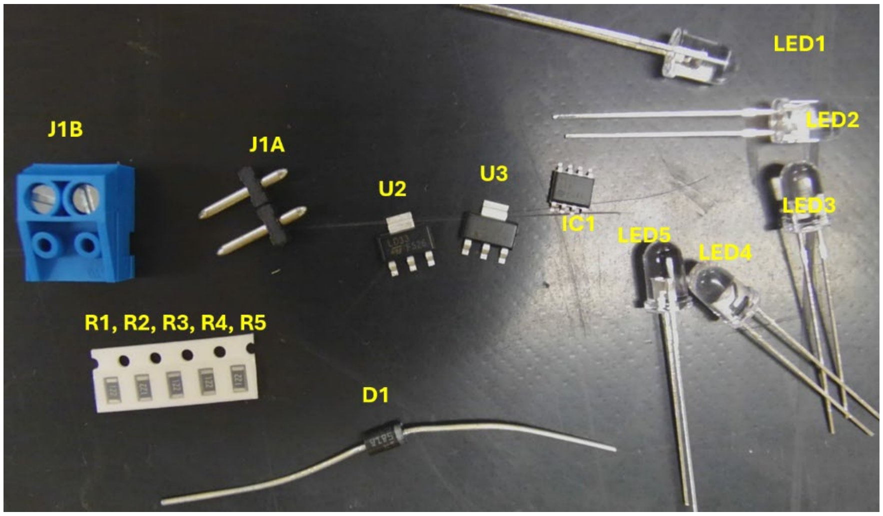


Figure 6: Power module parts. Note that the 3.3V regulator is marked LD33 and the 5V regulator is marked LD50.

Table 1: Power Module Parts list

Designator	Component
J1A	Power Header
J1B	Screw Terminal Power Connector
IC1	REF02CESA 5V Reference
U2	LD1117S33 3.3V Regulator
U3	LD1117S50 5V Regulator
LED1	Power Indicator LED
R1, R2, R3, R4. R5	1.2 KΩ Resistor
LED2, LED3, LED4, LED5	Digital indicator LEDS
D1	Schottky Diode

1. 3.3V Regulator (U2)
    1.1. Start by soldering the 3.3V Regulator U2.
    1.2. For the regulators, it is recommended to it recommended to use the large top pad/pin to hold the regulator in place and then adjust the position so that the smaller 3 lower pins are lined up with their pads.

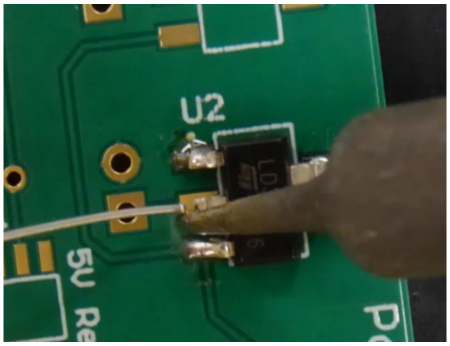


Figure 8: Soldering 3.3V Regular U2

2. 5V Regulator (U3)
    2.1. Repeat the process for the 5V regulator U2.
    2.2. After both regulators are soldered, double-check to make sure none of the pins are floating above the pads, and add solder if necessary.

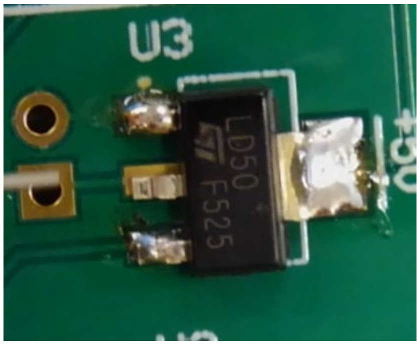


Figure 9: Soldering 5V Regular U3

3. 5V Reference (IC1)
    3.1. The 3.3V and 5V regulators are designed to supply power to loads at those nominal voltages. But those regulators can be tenths of a volt off of their nominal voltages (i.e., 4.8V instead of 5V).
    3.2. IC1 is designed to supply a highly accurate 5V for reference usage, such as voltage comparison or offset voltages for amplifiers. While it is very accurate, it cannot supply more than a few mA of current.
    3.3. Solder IC1 the 5V reference. Pin 1 is indicated by a line above the pin. This should line up with the pin indicated by a small circle on the chip. All of the other ICs on the board use the same indicators for pin 1.

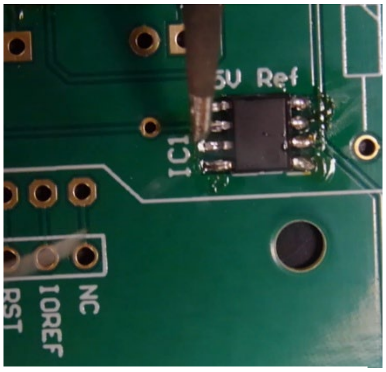


Figure 10: 5V Reference IC1, note the pin 1 marking on the lower right.

4. LEDs and Schottky Diode
    4.1. Next, solder the 1.2KΩ resistor R1 in place. This is a current-limiting resistor designed to limit the current through the power indicator LED to less than 10 mA.
    4.2. For surface-mount resistors, the last number indicates the power of 10, with 2 or 3 digits before that giving the value. For example, 122 for R1 is 12 x 10^2 or 1.2 KΩ.
    4.3. Repeat the process for resistors R2, R3, R4, and R5. These resistors, along with their matching LEDs, are connected to pins D2 – D5 to be used as indicator lights for the team's needs.

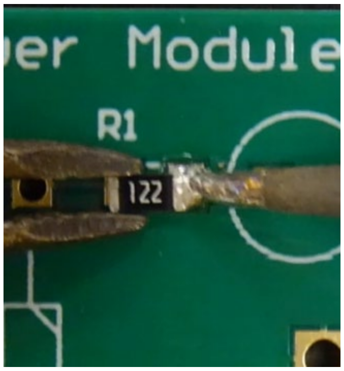


Figure 11: Current limiting resistor R1.

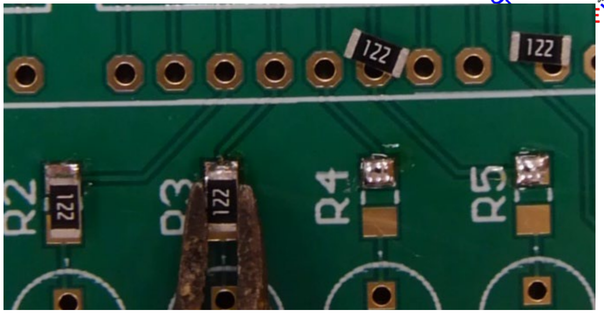


Figure 12: Current limiting resistors R2-R5.

4.4. Diode D1 is a high-current Schottky diode. In the event that power is connected backwards to the MegaSAT, it will block the current flow and protect the Arduino and MegaSAT.
4.5. The diagonal line on the silkscreen indicates the cathode and matches the band on the diode.
4.6. Install the diode D1 flush with the board.
4.7. Bend the leads out to hold it in place, flip the board over, and solder the diode in place.
4.8. After the diode is soldered, trim the excess leads using wire cutters.
4.9. For LED1 – LED5, remember that the longer leg of an LED is the positive lead.
4.10. You can verify this using the diode setting on your meter. When the meter is connected to LEDs, positive to positive and negative to negative, the LED will dimly light up.
4.11. Install LED1 and solder the leads on the back side of the board.
4.12. Repeat this process for LED2, LED3, LED4, and LED5.
4.13. Once all LEDs are soldered, trim the excess leads with wirecutters.

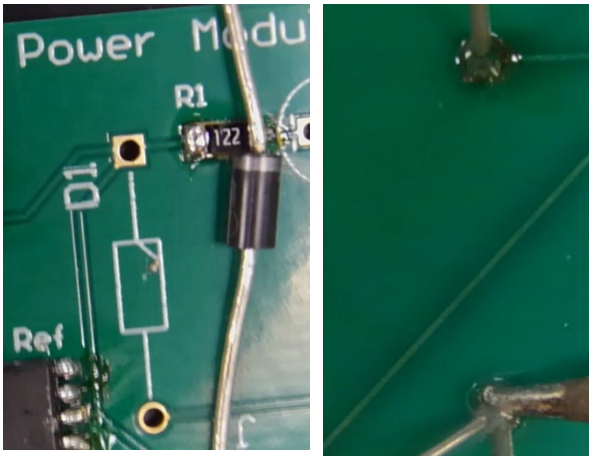


Figure 13: Installing diode D1 in place.

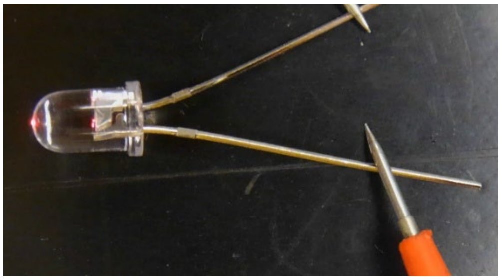


Figure 14: Checking LED polarity

5. Battery Connector
   5.1. Next, install the battery header J1A. Note: The battery header looks similar to breakaway headers but has different spacing. Also, the connector itself does not have a polarity; the + and – are to indicate which power lead to connect to which pin.
   5.2. Use masking tape or hot glue to hold the header in place when you flip the board.
   5.3. Solder the header in place. The pins should not need to be trimmed.
6. Power System Check

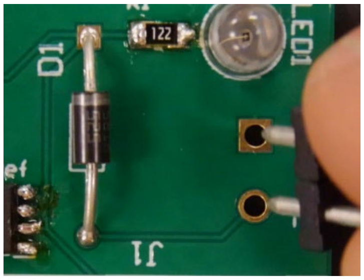


Figure 15: Battery Connector Header.

6.1. Connect a power supply to the positive and negative leads of J1A. Supply power at 12V.

6.2. LED1 should light when power is supplied.

6.3. Using your multimeter, measure the output of the three voltage regulators. The 5V and 3.3V regulator outputs can be measured at the test points just below the regulators. The 5V reference output may be measured at the small test point just to the left of the reference chip.

6.4. Record the output values of all three regulators in your lab notebook.

Table 2: Regulator output voltage

Regulator	Expected Voltage	Measured Voltage
5V	5V	
3.3V	3.3V	
5V Reference	5V	

6.5. Your power module should now look like Figure 16

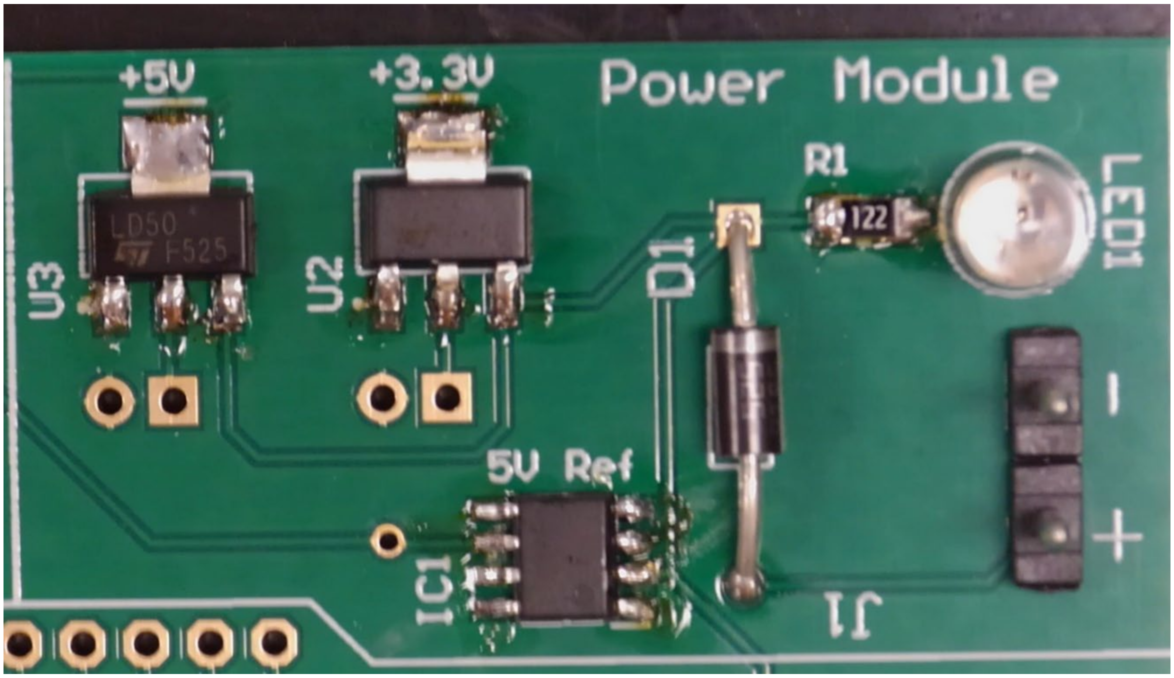


Figure 16: Assembled power module.

Internal Temperature Module

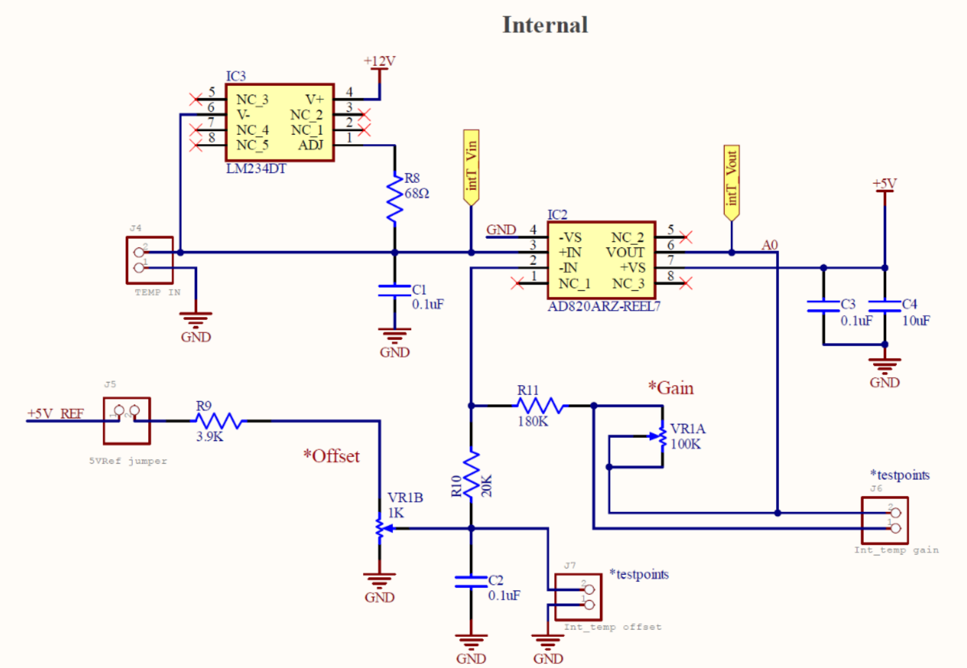


Figure 17: Schematic for internal temperature circuit.

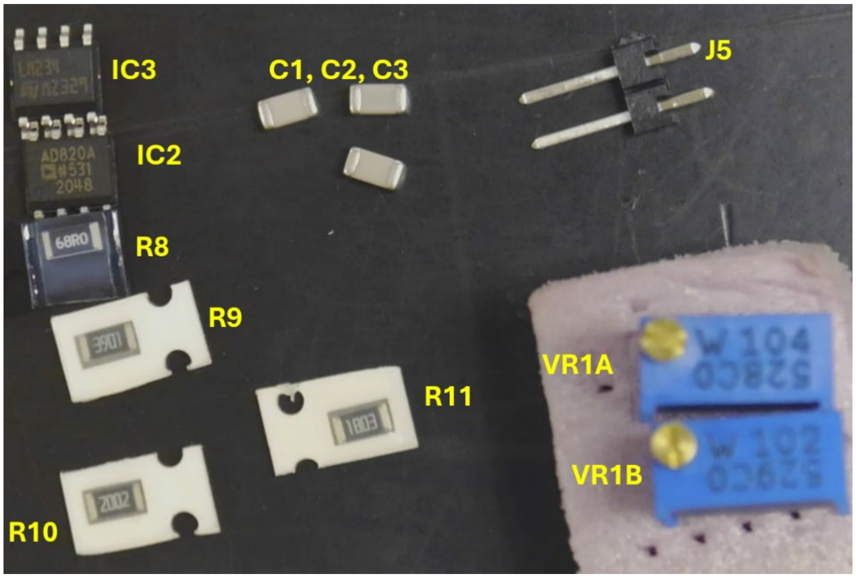


Figure 18: Internal temperature parts.

Table 3: Internal Temperature Parts list

Designator	Component
IC2	AD820 Op Amp
IC3	LM234 Current Source
C1,C2, C3	0.1 µF Capacitor
R8	68 Ω Resistor
R9	3.9 KΩ Resistor
R10	20 KΩ Resistor
R11	180 KΩ Resistor
VR1A	100K Potentiometer
VR1B	1K Potentiometer
J5	Reference Voltage Jumper

7. Current Source
    7.1. Current Source (IC3)
        7.1.1. Start by soldering the soldering IC3, the current source for the internal temperature diode.
    7.2. 68 Ohm Resistor (R8).
        7.2.1. Solder the 68 Ohm resistor R8. This resistor sets the IC3 output to 1 mA, maintaining a constant current through the diode temperature sensor.

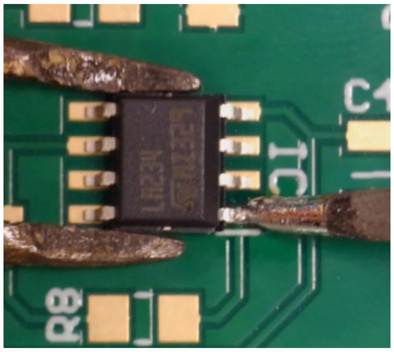


Figure 19: Internal Temperature current source.

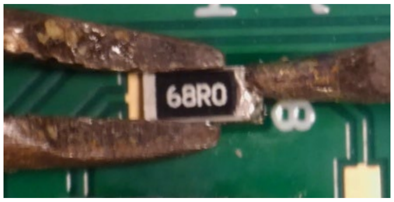


Figure 22: Current set resistor R8.

8. Current Source Check
    8.1. Now check that IC3 is operating correctly.
    8.2. Connect power to J1 to power the board.
    8.3. LED1 should light when the board has power.
    8.4. With your meter in current touch the leads of the meter to the two pads for J4. You should measure ~1mA current. Record the value in your lab notebook. The meter will act as the diode, allowing current to flow.
    8.5. If you measure a negative value, make sure your positive lead touches the pad with the +.
    8.6. If you do not measure any current, make sure your meter is set to current and that you do not have a blown meter fuse.
    8.7. If you measure no current, verify IC3 has 5V on pin 4.

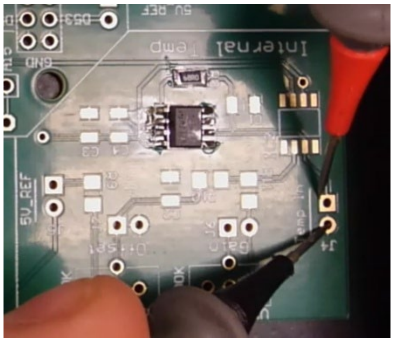


Figure 20: Using your multimeter to check IC3 current. The meter should read 1 mA.

Table 4: IC3 Current

J4 Expected Current	J4 Measure Current
1 mA	

9. Op Amp (IC2)
    9.1. Once you have verified that IC3 is operating correctly, solder the AD820 Op Amp IC2.
10. 0.1 µF Capacitors (C1, C2, C3)
    10.1. Capacitors C1, C2, and C3 are all 0.1 µF and can be soldered at the same time or one at a time.

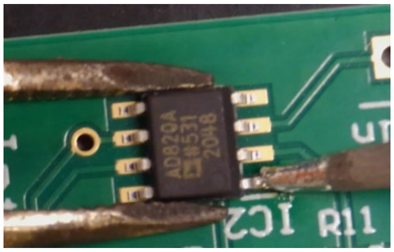


Figure 21: Soldering the internal temperature Op Amp IC2.

10.2. C4 is a 10 µF capacitor. Because the capacitors do not have markings, all of the 10 µF capacitors are located in a separate bag to ensure they are mixed with the 0.1 µF capacitors.

10.3. Solder C1, C2, and C3 to the board. Ensure you have soldered both pads for all capacitors. When working in batches, it is possible to forget to add solder to the second pad.

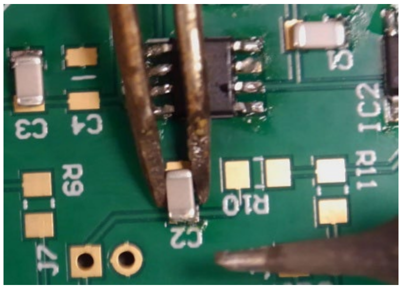


Figure 23: Capacitors C1, C2, and C3 after soldering one side. Next solder will be added to the other pad of all 3 capacitors. The board was modified to place C3 and C4 closer to IC2 after this photo was taken.

11. Amplifier Resistors

11.1. Next, solder the resistors for the amplifying circuit. These may be assembled in any order, but it is recommended to solder them one at a time to avoid soldering the resistor in the incorrect position.

11.2. 3.9 kΩ R9.

11.3. 20 kΩ R10.

11.4. 180 kΩ R11.

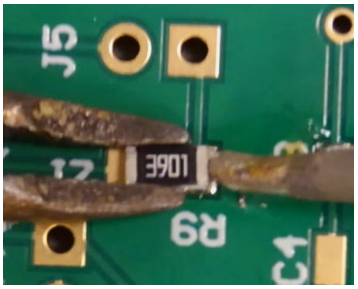


Figure 26: Resistor R9, 3.9 kΩ

Figure 25: Resistor R10, 20 kΩ

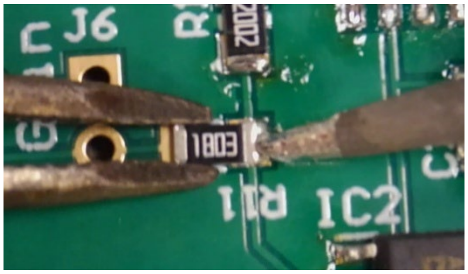


Figure 24: Resistor R11, 180 kΩ

12. Gain 100kΩ Potentiometer (VR1A)

12.1. All surface-mount components except for capacitor C4 should now be in place. It is recommended that you thoroughly inspect your soldering before soldering the through-hole components.

12.2. Insert the 100K Potentiometer (W104) into VR1A.

12.3. Bend the leads so that the potentiometer will be held in place while soldering.

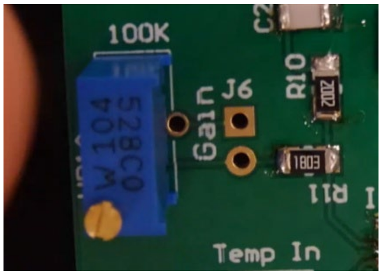


Figure 28: VR1A 100K Potentiometer.

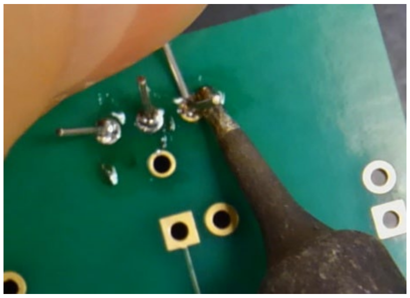


Figure 27: Soldering the back of VR1A.

12.4. Flip the board over and solder the leads on the back of the board, ensuring the potentiometer sits flush with the board.

12.5. Trim the excess leads using wire cutters.

13. Offset 1kΩ Potentiometer (VR1B)

13.1. Now repeat the process for the 1K Potentiometer (marked W102), soldering it into VR1B.

NOTE: J6 and J7 are test points to allow you to easily measure the setting of the potentiometer when setting your gain and offset.

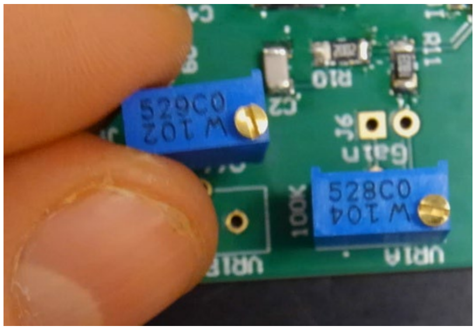


Figure 30: 1K Potentiometer VR1B.

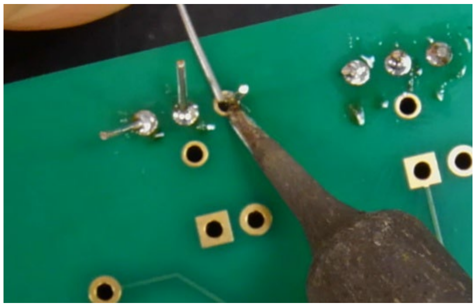


Figure 29: Soldering the back of VR1B.

14. Offset voltage jumper J5

14.1. Because all of the amplifiers are connected to the same 5V reference for the offset voltage, all of the offset potentiometers are in parallel with each other. To allow us to correctly measure VR1B, we need to be able to isolate it from the 5V reference. To accomplish this 5V reference voltage must come through J5.

14.2. Using needle-nose pliers, break off a 2-pin jumper from the straight breakaway jumpers. Install this short side down into J5. You may then want to use masking tape or hot glue to hold the jumper in place while you solder it.

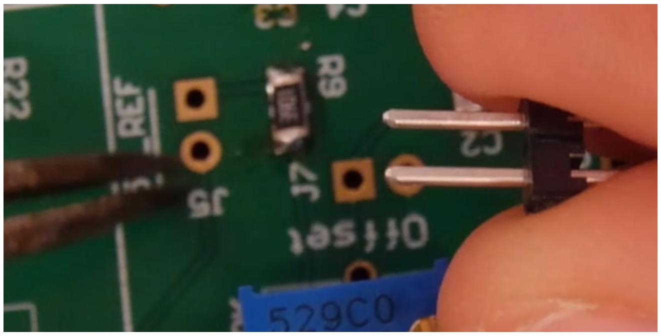


Figure 31: 5V Reference Jumper J5.

14.3. Flip the board over and solder jumper J5 in place. The leads on the back should not require trimming.

14.4. We will install all of the shorting jumpers onto the pins on the board at a later step.

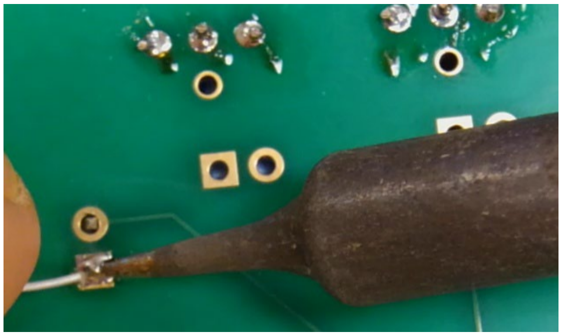


Figure 32: Soldering jumper J5.

15. The initial assembly of the internal temperature circuit is now complete. Your board should look similar to the image shown in Figure 33

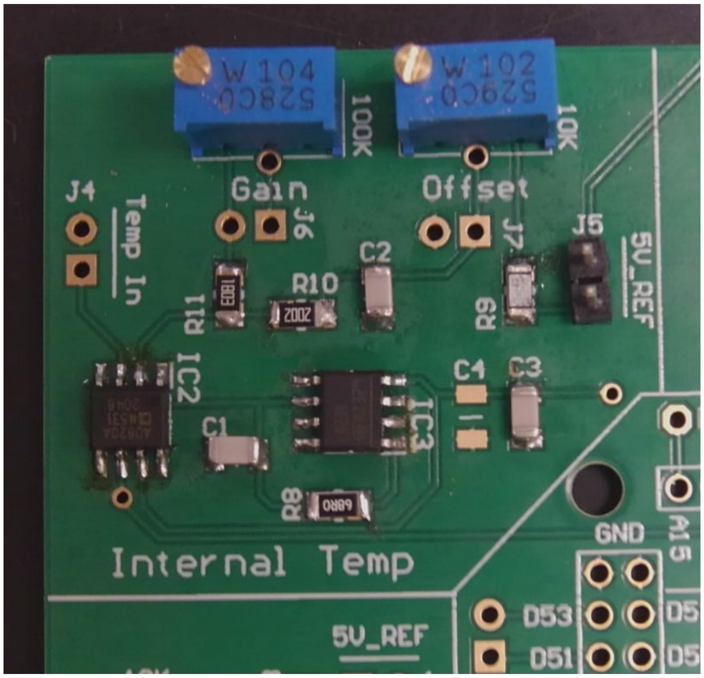


Figure 33: Initial Assembly of internal temperature circuit.

External Temperature Module

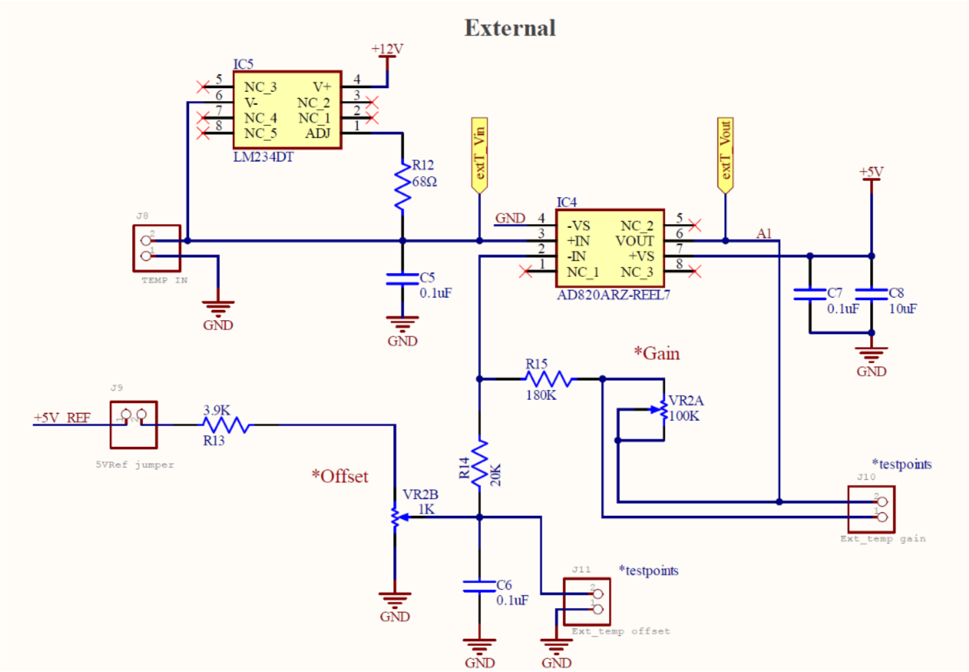


Figure 34: Schematic for external temperature circuit.

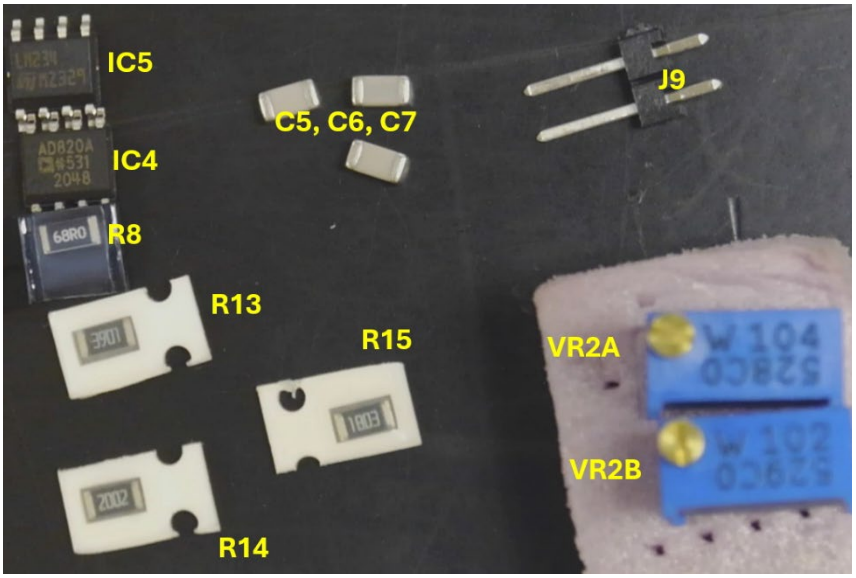


Figure 35: External temperature parts.

Table 5: External Temperature Parts list

Designator	Component
IC4	AD820 Op Amp
IC5	LM234 Current Source
C5, C6, C7	0.1 µF Capacitor
R12	68 Ω Resistor
R13	3.9 KΩ Resistor
R14	20 KΩ Resistor
R15	180 KΩ Resistor
VR2A	100K Potentiometer
VR2B	1K Potentiometer
J9	Reference Voltage Jumper

NOTE: The external temperature circuit is identical to the internal temperature on. Because of that, we have forgone the step-by-step assembly photos for this section. All assembly steps are identical to those performed for the internal circuit.

16. Current Source
    - 16.1. Current Source (IC5)
        - 16.1.1. Start by soldering the soldering IC5, the current source for the internal temperature diode.
    - 16.2. 68 Ohm Resistor (R12).
        - 16.2.1. Solder the 68 Ohm resistor R12. This resistor sets the IC5 output to 1 mA, maintaining a constant current through the diode temperature sensor.
17. Current Source Check
    - 17.1. Now check that IC5 is operating correctly.
    - 17.2. Connect power to J1 to power the board.
    - 17.3. LED1 should light when the board has power.
    - 17.4. With your meter in current touch the leads of the meter to the two pads for J8. You should measure ~1mA current. Record the value in your lab notebook. The meter will act as the diode, allowing current to flow.
    - 17.5. If you measure a negative value, make sure your positive lead touches the pad with the +.
    - 17.6. If you do not measure any current, make sure your meter is set to current and that you do not have a blown meter fuse.
    - 17.7. If you measure no current, verify IC5 has 5V on pin 4.

Table 6: IC5 Current

J8 Expected Current	J4 Measure Current
1 mA	

18. Op Amp (IC2)
    - 18.1. Once you have verified that IC5 is operating correctly, solder the AD820 Op Amp IC4.
19. 0.1 µF Capacitors (C5, C6, C7)
    - 19.1. Capacitors C5, C6, and C7 are all 0.1 µF and can be soldered at the same time or one at a time. Solder C5, C6, and C7 to the board.
    - 19.2. Similar to C4, C8 will be assembled at a later step
20. Amplifier Resistors. Again, ensure you do not mix the resistors up.
    - 20.1. 3.9 kΩ R13.
    - 20.2. 20 kΩ R14.

    20.3. 180 kΩ R15.

21. Gain 100kΩ Potentiometer (VR2A)
    21.1. Insert the 100K Potentiometer (W104) into VR2A.
    21.2. Bend the leads so that the resistor will be held in place while soldering.
    21.3. Flip the board over and solder the leads on the back of the board, ensuring the potentiometer sits flush with the board.
    21.4. Trim the excess leads using wire cutters.
22. Offset 1kΩ Potentiometer (VR2B)
    22.1. Now repeat the process for the 1K Potentiometer (marked W102), soldering it into VR2B.

NOTE: J10 and J11 are test points to allow you to easily measure the setting of the potentiometer when setting your gain and offset.

23. Offset voltage jumper J9
    23.1. J9 provides 5V reference power for the external temperature circuit.
    23.2. Using needle-nose pliers, break off a 2-pin jumper from the straight breakaway jumpers. Install this short side down into J9. You may then want to use masking tape or hot glue to hold the jumper in place while you solder it.
    23.3. Flip the board over and solder jumper J9 in place.
24. The initial assembly of the external temperature circuit is now complete. Your board should look similar to the image shown in Figure 36.

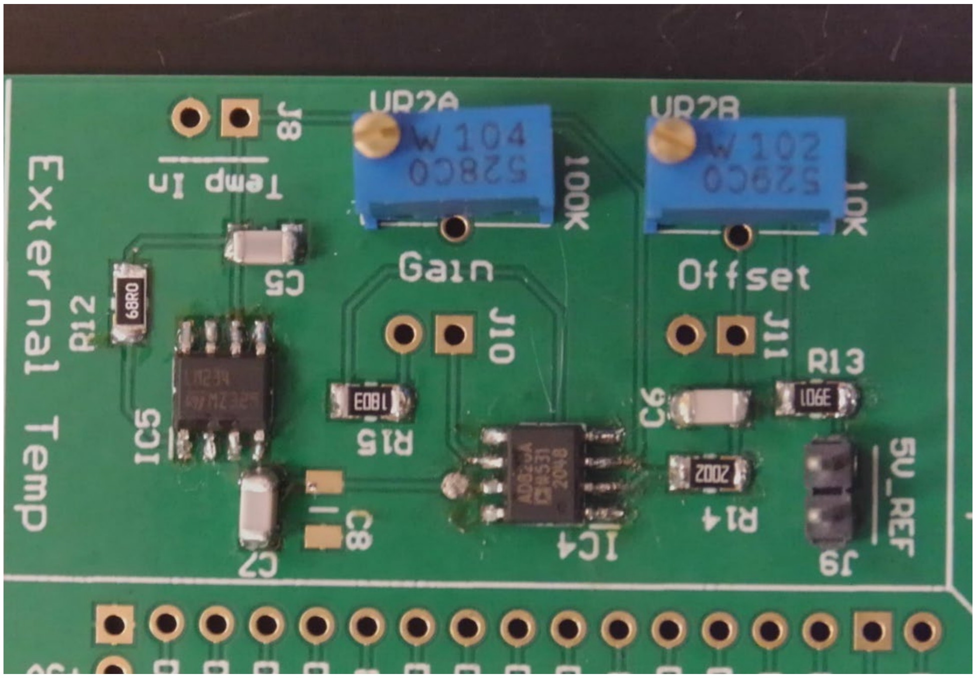


Figure 36: Initial Assembly of external temperature circuit.

Pressure Module

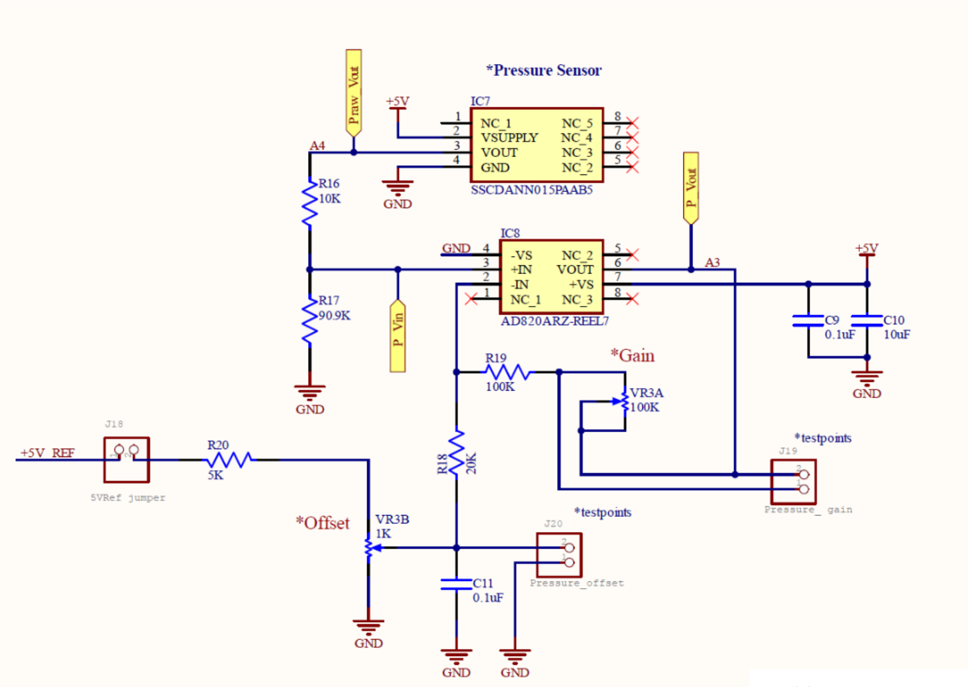


Figure 38: Schematic for pressure sensor circuit.

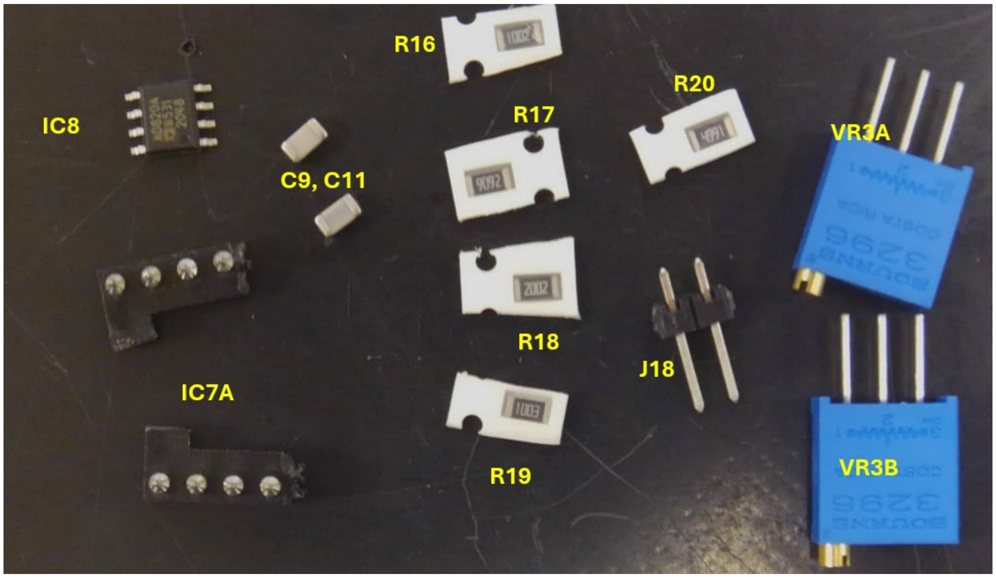


Figure 37: Pressure Sensor Parts.

Table 7: Pressure Sensor Parts list

Designator	Component
IC7A	Pressure Sensor Socket
IC8	AD820 Op Amp
C9, C11	0.1 µF Capacitor
R16	10 KΩ Resistor
R17	90.9 KΩ Resistor
R18	20 KΩ Resistor
R19	100 KΩ Resistor
R20	4.99 KΩ Resistor
VR3A	100K Potentiometer
VR3B	1K Potentiometer
J18	Reference Voltage Jumper

25. Op Amp (IC8)
    25.1. Ensure you match the pin 1 markings on the board and IC.
    25.2. Solder the Op Amp first so that no other components are in the way when working on the small IC pins.
26. 0.1 µF Capacitors
    26.1. Capacitors C9 and C11 are 0.1 µF and can be soldered at the same time or one at a time.
    26.2. Solder C9 and C11 to the board.
    26.3. C10 will be assembled at a later step

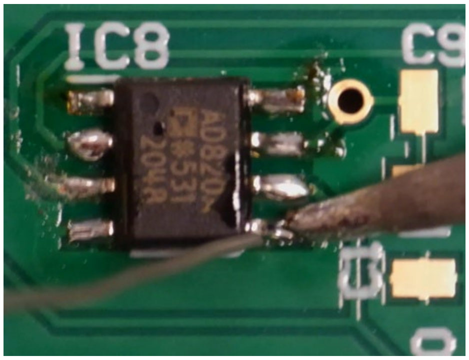


Figure 39: IC8 the pressure circuit Op Amp.

27. Pressure Circuit Resistors. Again, it is recommended to solder the resistors one at a time, ensuring you do not mix them up.
    27.1. 10 KΩ Resistor (R16), this is the resistor marked 1002 (100x10^2), not 1003
    27.2. 90.9 KΩ Resistor (R17).
    27.3. 20 KΩ Resistor (R18).
    27.4. 100 KΩ Resistor (R19), this is the resistor marked 1003 (100x10^3).
    27.5. 4.99 KΩ Resistor (R20), because 5KΩ is not a standard resistor value, a 4.99 KΩ resistor is used.

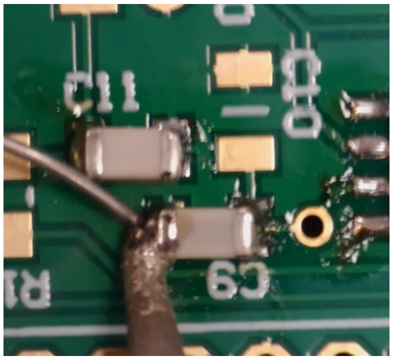


Figure 40: Pressure circuit capacitors.

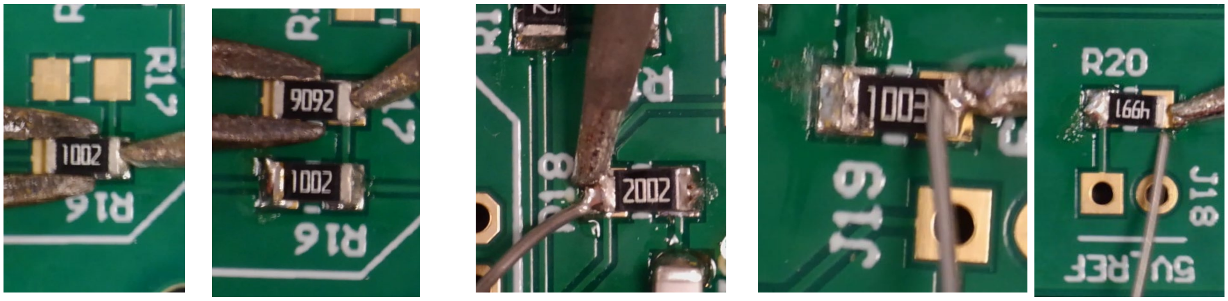


Figure 41: Soldering the pressure sensor amplifier resistors.

28. Pressure Socket (IC7A)
    28.1. The pressure sensor is wider than a standard DIP package, so the socket has been cut into two pieces to allow them to be set farther apart.
    28.2. The orientation of the socket does not matter. Only the orientation of the pressure sensor once installed is critical.
    28.3. It is recommended to do one side of the socket at a time.
    28.4. Install the socket into IC7 and use glue or tape to hold it in place while soldering.

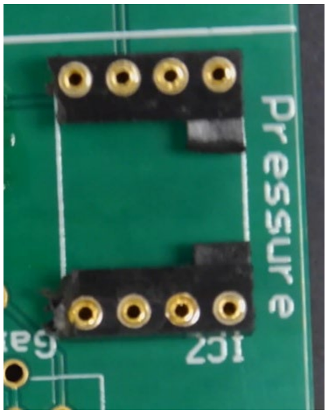


Figure 42: Pressure sensor socket installed on board.

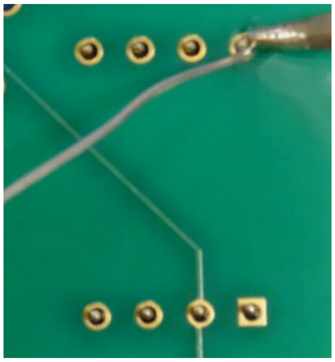


Figure 43: Soldering the pressure sensor socket.

28.5. Take care to ensure the socket rows are straight and flush with the board; otherwise, they will not line up with the pressure sensor pins.

28.6. Flip the board over and solder the pins on the back side.

28.7. The pins should not need trimming

28.8. Repeat for the second set of pins.

29. 100 KΩ Gain Potentiometer (VR3A)

29.1. Insert the 100K Potentiometer (W104) into VR3A.

29.2. Bend the leads so that the resistor will be held in place while soldering.

29.3. Flip the board over and solder the leads on the back of the board, ensuring the potentiometer sits flush with the board.

29.4. Trim the excess leads using wire cutters.

30. 1 KΩ Offset Potentiometer (VR3B)

30.1. Now repeat the process for the 1K Potentiometer (marked W102), soldering it into VR3B.

NOTE: J19 and J20 are test points to allow you to easily measure the setting of the potentiometer when setting your gain and offset.

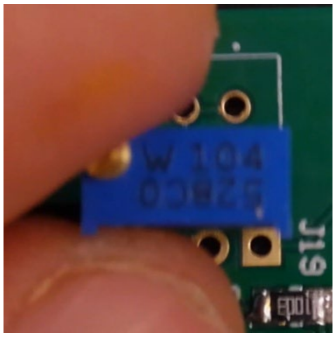


Figure 46: VR3A 100K Potentiometer.

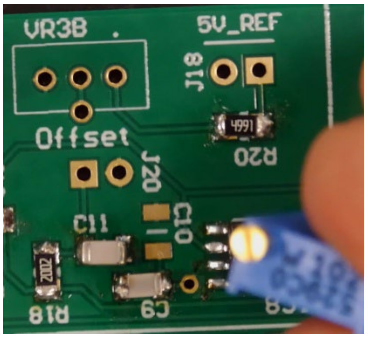


Figure 45: VR3B 1K Potentiometer.

31. Offset voltage jumper J18

31.1. J18 provides 5V reference power for the pressure circuit.

31.2. Using needle-nose pliers, break off a 2-pin jumper from the straight

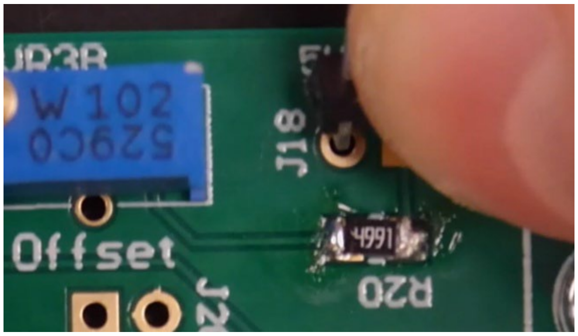


Figure 44: 5V Reference Jumper J18.

breakaway jumpers. Install this short side down into J18. Again, use masking tape or hot glue to hold the jumper in place while you solder it.

31.3. Flip the board over and solder jumper J18 in place.

32. Your assembled pressure circuit should now look like Figure 47

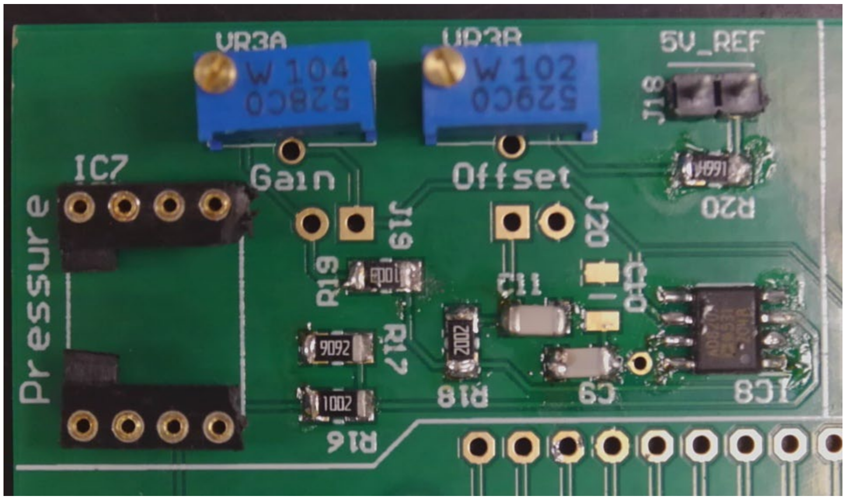


Figure 47: Assembled Pressure Sensor Circuits.

Student Amplifier Module (Optional)

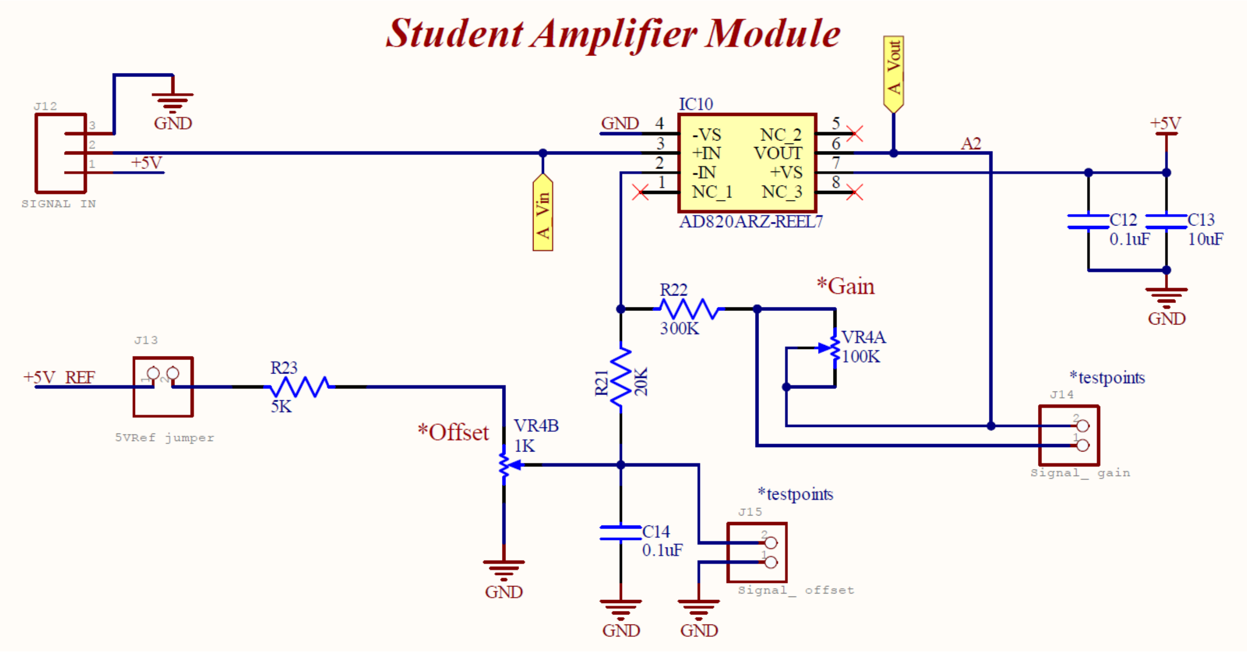


Figure 48: Schematic for student sensor amplifying circuit.

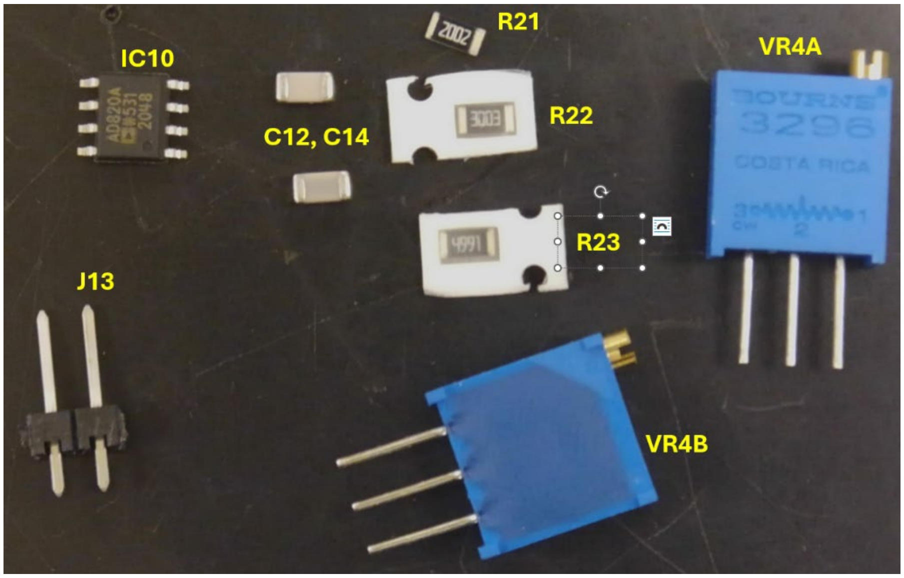


Figure 49: Student Sensor parts.

Table 8: Student Sensor Parts list

Designator	Component
IC10	AD820 Op Amp
IC3	LM235 Current Source
C12 ,C14	0.1 µF Capacitor
R21	20 KΩ Resistor
R22	300KΩ Resistor
R23	4.99 KΩ Resistor
R11	180 KΩ Resistor
VR4A	100K Potentiometer
VR4B	1K Potentiometer
J13	Reference Voltage Jumper

33. **NOTE: This circuit is designed to allow the connection of an additional analog sensor at J12 for expansion. No sensor is included in the MegaSAT kit. Also, the provided resistors may not give the needed gain and offset for all use cases. It is recommended that teams only assemble this part of the board once they have a sensor selected and have determined the amplifier settings they need.**

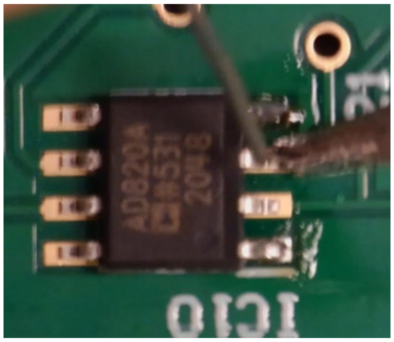


Figure 50: IC10 the student sensor circuit Op Amp.

34. Op Amp (IC10)
    34.1. Ensure you match the pin 1 markings on the board and IC.
    34.2. Solder the Op Amp first so that no other components are in the way when working on the small IC pins.
35. 0.1 µF Capacitors
    35.1. Capacitors C12 and C14 are 0.1 µF and can be soldered at the same time or one at a time.
    35.2. Solder C12 and C14 to the board.
    35.3. C13 will be assembled at a later step

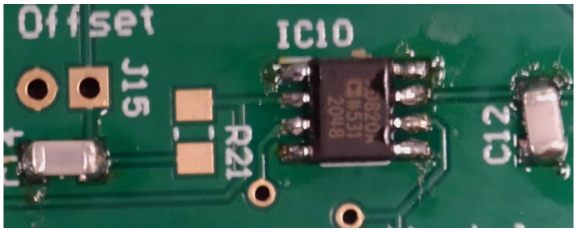


Figure 51: Student sensor capacitors.

36. Amplifier Resistors. Again, it is recommended to solder the resistors one at a time, ensuring you do not mix them up.
    36.1. 20 KΩ Resistor (R21).
    36.2. 300 KΩ Resistor (R22)
    36.3. 4.99 KΩ Resistor (R23), because 5KΩ is not a standard resistor value, a 4.99 KΩ resistor is used.

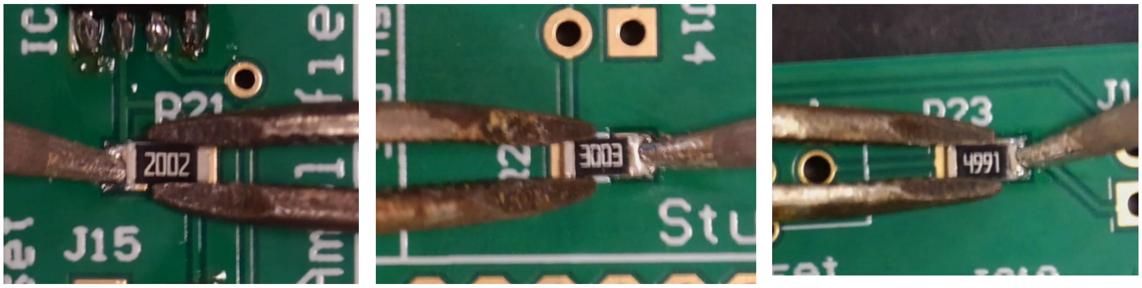


Figure 52: Soldering the student sensor amplifier resistors.

37. Gain 100kΩ Potentiometer (VR4A)
    37.1. Insert the 100K Potentiometer (W104) into VR4A.
    37.2. Bend the leads so that the resistor will be held in place while soldering.

37.3. Flip the board over and solder the leads on the back of the board, ensuring the potentiometer sits flush with the board.

37.4. Trim the excess leads using wire cutters.

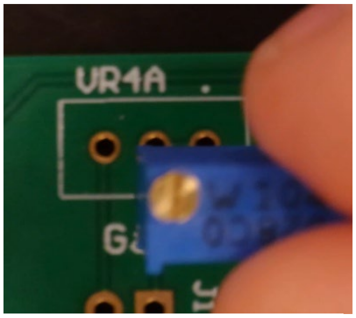


Figure 55: VR4A 100K Potentiometer.

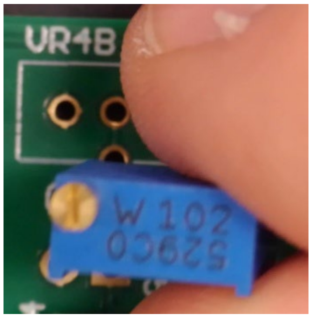


Figure 53: VR4B 1K Potentiometer.

38. Offset 1kΩ Potentiometer (VR4B)

38.1. Now repeat the process for the 1K Potentiometer (marked W102), soldering it into VR4B.

NOTE: J14 and J15 are test points to allow you to easily measure the setting of the potentiometer when setting your gain and offset.

39. Offset voltage jumper J13

39.1. J13 provides 5V reference power for the student sensor circuit.

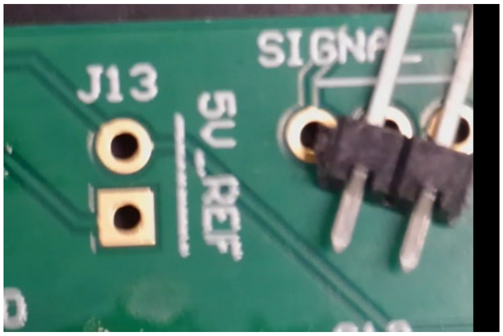


Figure 54: 5V Reference Jumper J13.

39.2. Using needle-nose pliers, break off a 2-pin jumper from the straight breakaway jumpers. Install this short side down into J13. Again, use masking tape or hot glue to hold the jumper in place while you solder it.

39.3. Flip the board over and solder jumper J13 in place.

40. Your assembled pressure circuit should now look like Figure 56.

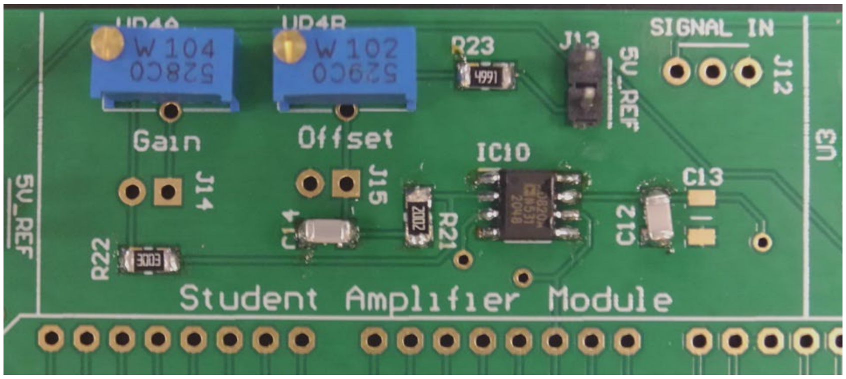


Figure 56: Assembled Student Sensor Amplifier Circuit.

10 µF Bulk Capacitors

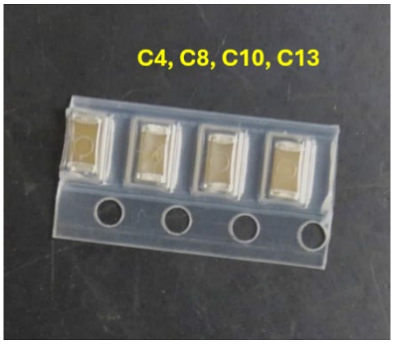


Figure 57: 10 µF capacitors, located in the I2C module envelope. These are slightly darker and larger than the 0.1 µF capacitor.

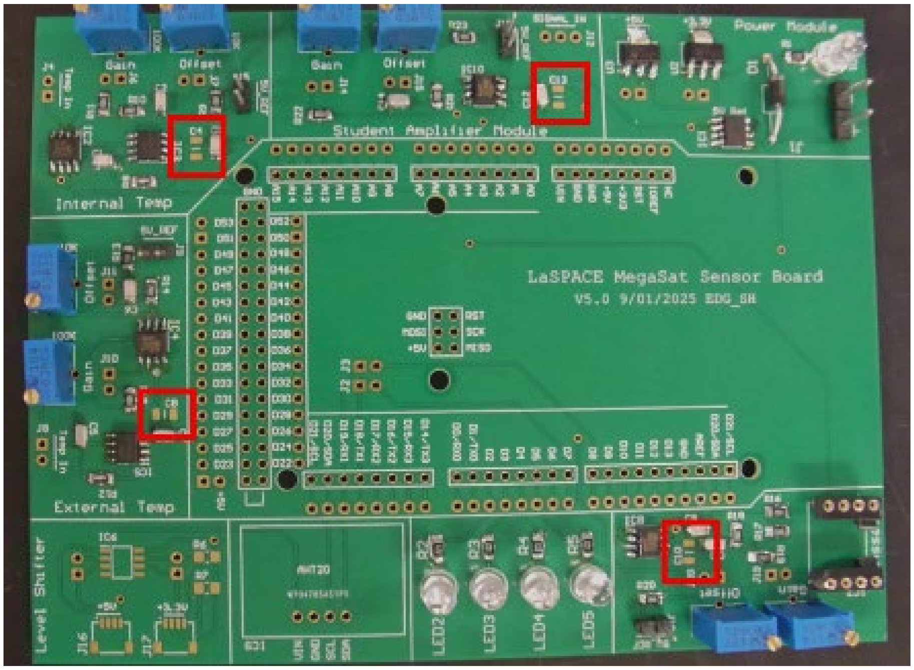


Figure 58: Location of 10 µF capacitors on the board.

41. There should be a 10 µF capacitor unpopulated for each of the amplifier circuits. These are C4(Int. Temp), C8(Ext. Temp), C10(Pressure), and C13 (Student Sensor).
42. Locate the 4x10 µF capacitor packed with I2C module.
43. Because the capacitors are not located near each other on the board, it is recommended to do each capacitor one at a time.
44. Solder C4.
45. Solder C8.
46. Solder C10.
47. Solder C13.

Table 9: 10 µF Capacitors

Designator	Component
C4	Internal Temp. 10 µF Capacitor
C8	External Temp. 10 µF Capacitor
C10	Pressure 10 µF Capacitor
C13	Student 10 µF Capacitor

I2C Module

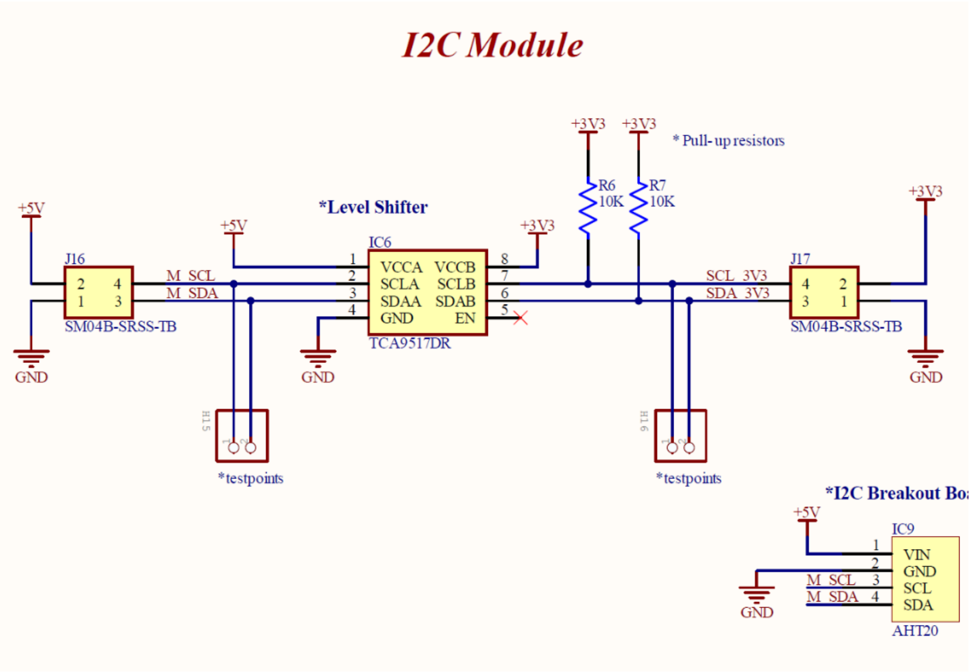


Figure 60: Schematic for I2C Module.

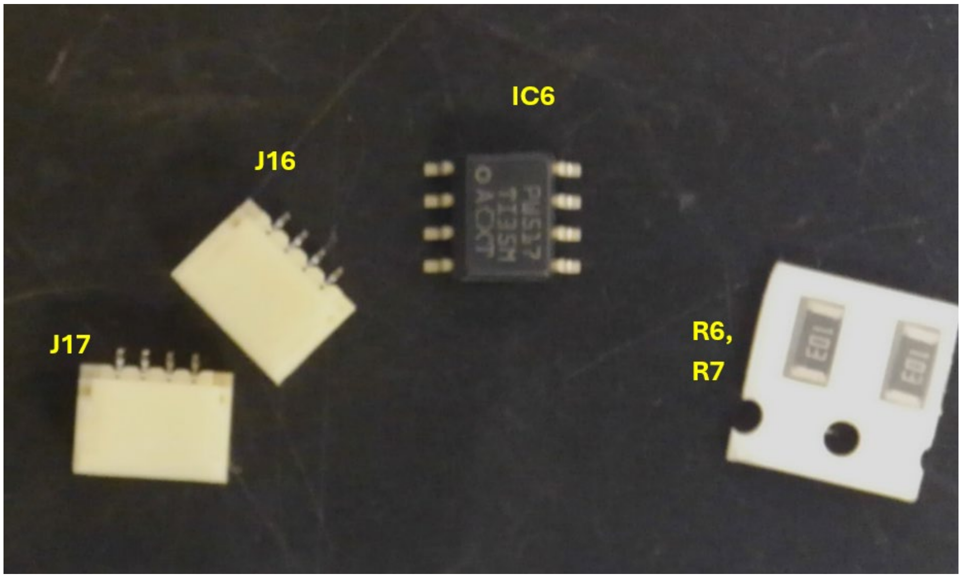


Figure 59: I2C Module parts.

Table 10: I2C Module Parts list

Designator	Component
IC6	TCA9517 Level Shifter
J16	5V JST Connector
J17	3.3V JST Connector
R6	10 KΩ Resistor
R7	10 KΩ Resistor
R10	20 KΩ Resistor
R11	180 KΩ Resistor

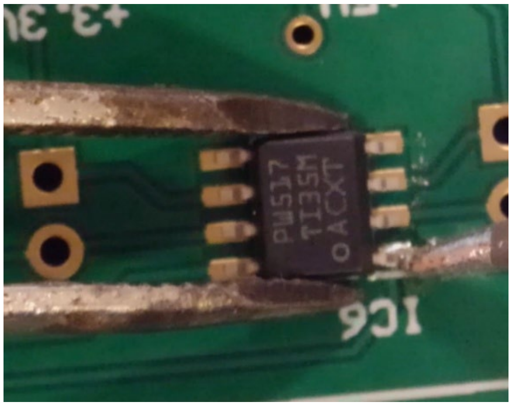


Figure 61: IC6, the I2C Level Shifter.

48. 3.3V to 5V Level Shifter
    48.1. The Arduino operates at 5V logic, but many I2C sensors you may want to use may operate on 3.3V. The level shifter will translate the clock and data signals from the Arduino to 3.3V. You can then use connector J17 or SCL and SDA pads to connect a 3.3V device.
    48.2. Solder IC6 the same as you soldered the other ICs. Ensuring pin 1 is correctly oriented.
49. JST Connectors (Optional)
    49.1. The connectors J16 and J17 are compatible with a number of sensor boards available from Adafruit (STEMMAQ) and Sparkfun(Qwiic). Once properly assembled, you could connect those sensors using a cable. But the pins on these connectors are very small. Because of the challenging nature of soldering these connectors, it is recommended to only solder them if you have identified a component you wish to use.
    49.2. 5V Connector J16.
        49.2.1. Solder these connectors using the same technique used for ICs, soldering one pin first to hold it in place.
        49.2.2. Take great care to ensure the pins are lined up before continuing. You may need a flashlight to see them.
        49.2.3. Solder the remaining pins on the back of the connector.
        49.2.4. There are two remaining pads at the front of the connector. These are not electrically connected but provide mechanical support, so the pins don’t break off when a cable is inserted. There are small metal contacts on the front of each connector to solder to these pads.

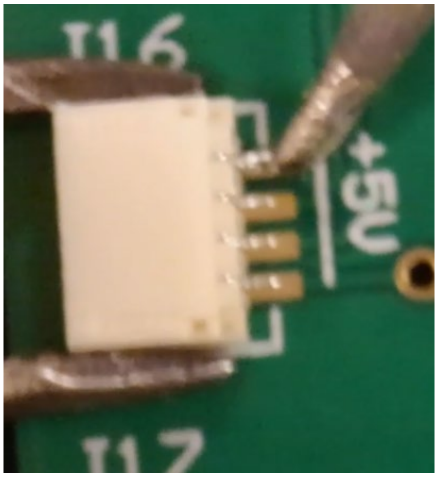


Figure 62: Soldering pins for J16.

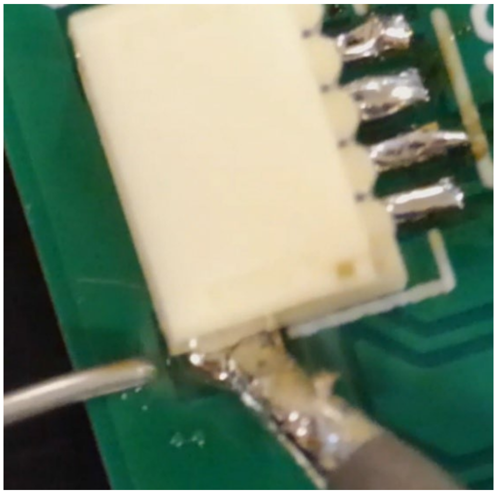


Figure 63: Soldering the front pads of the JST connector.

Try to avoid touching the plastic of the connector with the iron. Solder the two pads.

49.3. 3.3V Connector

49.3.1. Repeat the above steps for the 3.3V connector, J17

50. 10KΩ Pullup Resistors.

50.1. The Arduino provides pull-up resistors for the 5V side of the I2C bus. 10 KΩ resistors R6 and R7 perform the same function for the 3.3V side of the level shifter.

50.2. Solder resistors R6 and R7.

51. Your assembled I2C Module should not look like Figure 65.

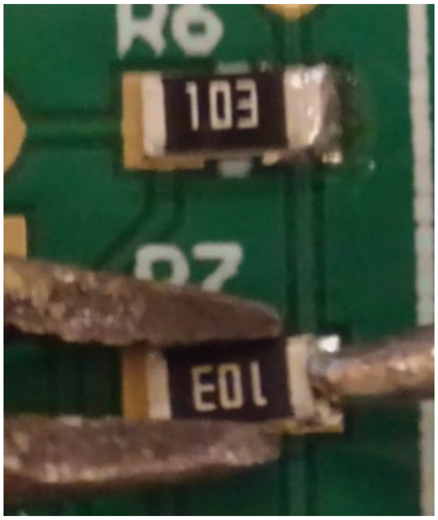


Figure 64: Soldering R6 and R7.

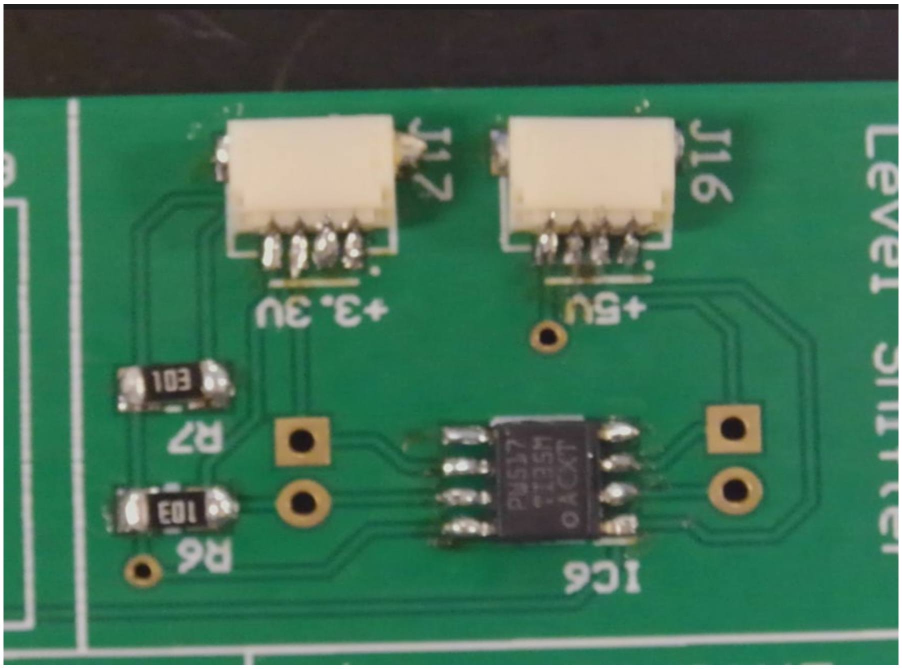


Figure 65: Assembled I2C Module

GPS Jumpers

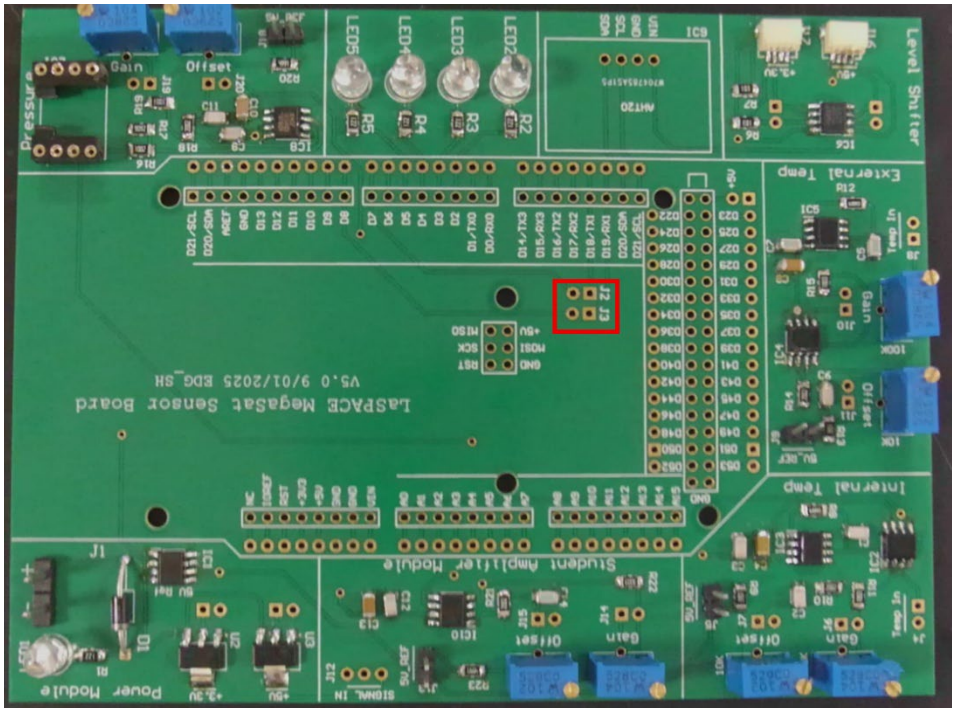


Figure 66: GPS Jumpers J2 and J3 in the middle of the board.

52. Jumpers J2 and J3 connect the “Soft Serial” output of the GPS to the pins for Serial1 (TX1/RX1).
53. This replaces the wire jumpers we needed to use for GPS programming activities. When the shorting jumpers are installed on the pins, the connection is complete.
54. The orientation for J2 and J3 is shown in Figure 67.

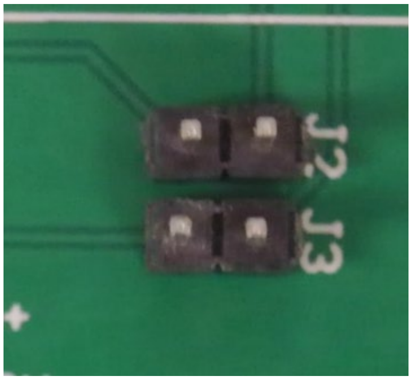


Figure 67: Correct orientation for J2 and J3.

55. Jumper J2
    - 55.1. Using needle-nose pliers, break off a 2-pin jumper from the straight breakaway jumpers. Install this short side down into J2. Again, use masking tape or hot glue to hold the jumper in place while you solder it.
    - 55.2. Flip the board over and solder jumper J2 in place.
56. Jumper J3
    - 56.1. Using needle-nose pliers, break off a 2-pin jumper from the straight breakaway jumpers. Install this short side down into J3. Again, use masking tape or hot glue to hold the jumper in place while you solder it.
    - 56.2. Flip the board over and solder jumper J3 in place.

Installing Shorting Jumpers

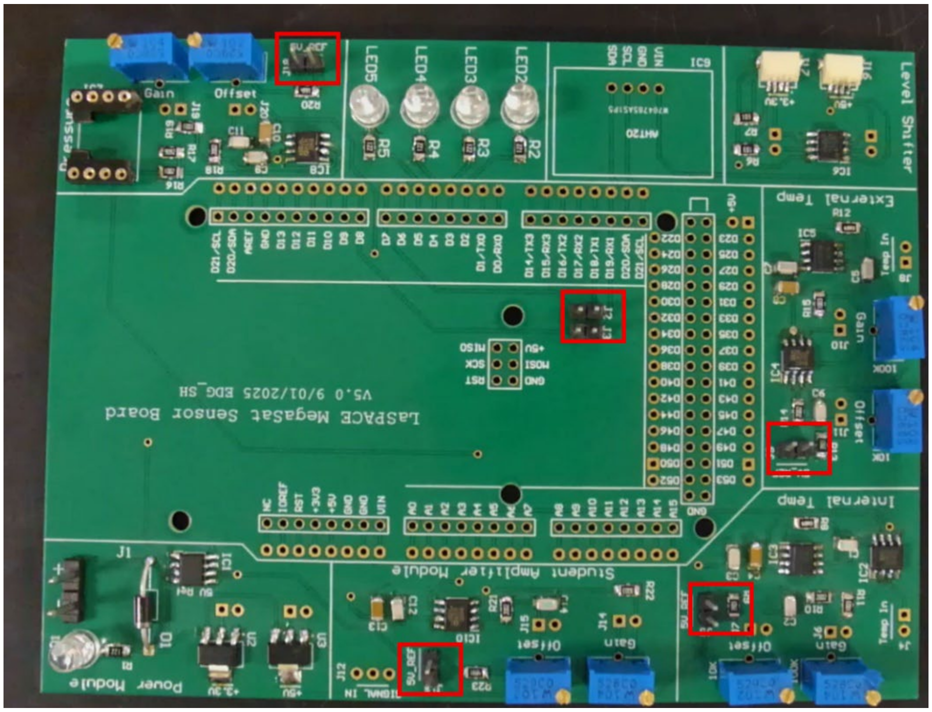


Figure 68: Location of jumpers previously soldered to the board.

57. We previously installed 6 sets of jumper pins(4 for the 5V reference on the amplifiers and 2 for the GPS) on the board. By installing a shorting jumper onto these pins, we can easily connect or disconnect those pins.
58. Inside your connectors module are 6 shorting jumpers. Install those on J2, J3, J5, J9, J13, and J18.
59. The jumpers should slide on by hand and should go all the way down to flush with the plastic at the base of the header.
60. The jumpers should be installed for operation and should only be removed when needed (for example, when adjusting the offset resistors).

Temperature Sensor Assembly


Figure 69: Sensor Diode

61. Locate the 1N457 diodes. These will be our temperature sensors; it is recommended to use one inside your payload and one outside.
62. Just like with the calibration activity, we need to prepare the diodes to use them as temperature sensors. Solder wire to the leads of the diode. It is recommended to use different-colored wires, such as red for the anode and black for the cathode, to provide a visual cue to the diode's polarity. Remember that the stripe indicates the cathode(-).
63. Remember to give your lead wires enough length to allow you to place your sensor where you want for your final payload. Also, you can always shorten the wire later if needed.
64. After soldering with wires, try to bend the leads in a way so that the sensor will be compact and unlikely to break.
65. **Be sure to mark + and – before covering the diode.** Apply liquid electrical tape or heat shrink to waterproof your temperature sensors.

Sensor Connections

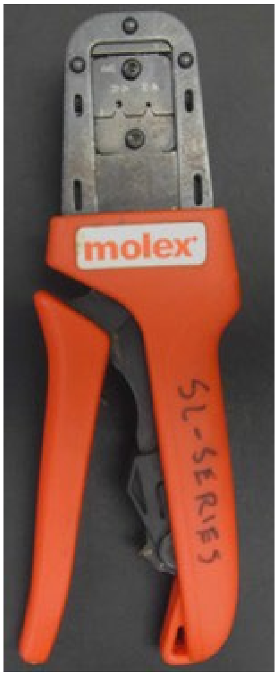


Figure 70: Crimping tool for provided crimps.

66. You can connect your temperature sensors to the board in two ways. Permanently soldered or removable crimped connectors. Read the following sections before proceeding and determine which method you will use.
67. Soldering in your diodes
    - 67.1. To solder your temperature sensor, just solder your diode wires into the pads at J4 for J8 in the correct orientation. The + pad is marked on the board.
    - 67.2. After soldering, reinforce the wire with hot glue around the base.


Figure 71: Provided wire crimps

68. Alternatively, your kit includes crimps and connectors, but this requires a

specialized crimping tool. The provided crimps are Molex SL series 22-24 AWG crimps.

69. Crimping the temperature sensors.
    - 69.1. Strip a small section of wire from the end of the sensor lead. This should not be excessively long. If you look at the crimp, there are 2 sets of jaws that get bent over the wire. The rear set of jaws is meant to clamp onto the bare wire, providing the electrical connection.
    - 69.2. You want to strip enough wire to allow for a good electrical connection, but not so much that you cannot get the uninsulated portion over under the rear jaws.

Figure 72: A properly crimped connector.

    - 69.3. Insert the crimp and wire into the correct-size jaws of the crimping tool. They will be labeled with a size(for example20-24AWG). Squeeze the crimping tool until the ratchet releases. The crimp and wire should be relatively straight, and both sets of crimp jaws should be clamped onto the appropriate part of the wire. The back set should be squeezing the insulation, and the front the bare wire.
    - 69.4. In the event of a bad crimp, you should cut with wire just behind the crimp and reattempt to crimp.
    - 69.5. Now insert the crimped wire into one of the two pin receptacles. Note on the back of the crimp, there is a tab designed to stick up into a matching hole in the receptacle. This holds the crimp in the receptacle when inserted.
    - 69.6. Align the crimp with the receptacle and insert until a click is heard. Then repeat with the other wire.

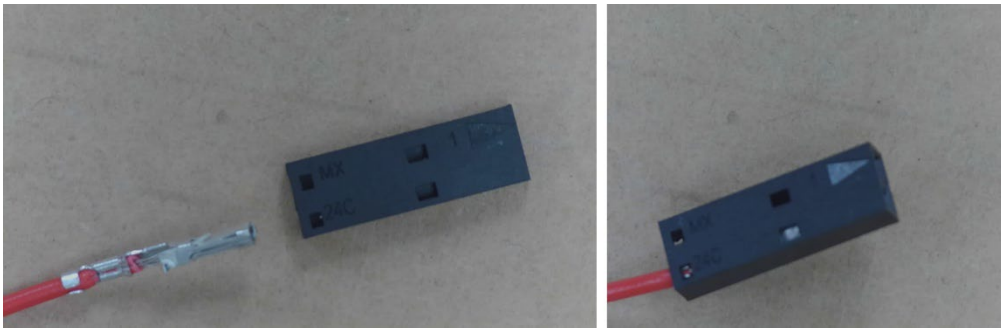


Figure 73: Installing the crimp into the connector housing.

    - 69.7. The kit also includes a 3-pin housing for use with the student sensor circuit if needed.

70. Soldering board connectors for crimped connectors. (Crimp method only)

70.1. To connect the crimped connector to the board, you need to solder a matching connector to the board.

70.2. The provided breakaway headers can be used for this. The straight headers may be used, but the right-angle headers may allow a more compact payload. If you use the right-angle headers, they should be installed with the plastic flush with the board.

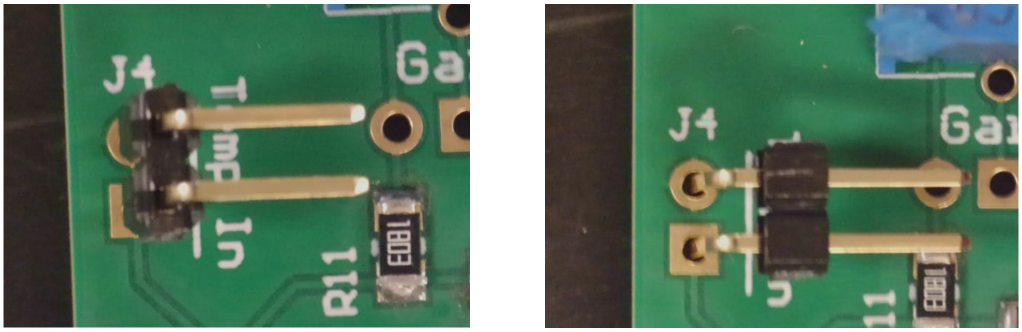


Figure 74: Right-angle heads. The left image shows the preferred orientation,

70.3. Solder header pins or wires directly to J4(internal temperature), J8 (external temperature), and J12(student sensor) as needed to connector your sensors. **IF SOLDERING SENSORS DIRECTLY TO THE BOARD, IT IS RECOMMENDED TO WAIT UNTIL AFTER THE ARDUINO HEADERS ARE SOLDERED.**

Power, I2C Jumpers and Test points

71. A number of additional jumpers and test points are available on the board. These are primarily intended to provide a spot to make measurements, but could be used to connect external components if needed by soldering wires. They are listed in the table below.

Table 11: Additional test points.

Board Label	Usage
J6	VR1A Resistor Setting
J7	VR1B Resistor Setting
Int_Vin	Internal Temp Amplifier Input Voltage
Int_Vout (near A0)	Internal Temp Amplifier Output Voltage
J10	VR2A Resistor Setting
J11	VR2B Resistor Setting
Ext_Vin	External Temp Amplifier Input Voltage
Ext_Vout (near A1)	External Temp Amplifier Output Voltage
J14	VR3A Resistor Setting
J15	VR3B Resistor Setting
A_Vin	Student Amplifier Input Voltage
A_Vout (near A2)	Student Amplifier Output Voltage
J19	VR4A Resistor Setting
J20	VR4B Resistor Setting
P_Vin	Pressure Amplifier Input Voltage
P_Vout (near A3)	Pressure Amplifier Output Voltage
P_Raw (near A4)	Unamplified Pressure Sensor Output
SCL/SDA (5V Side)	5V I2C
SCL/SDA (3.3V Side)	3.3V I2C
5V/GND (Below 5V Regulator)	5V Power
3.3V/GND (Below 3.3V Regulator)	3.3V Power

Installing the Humidity sensor

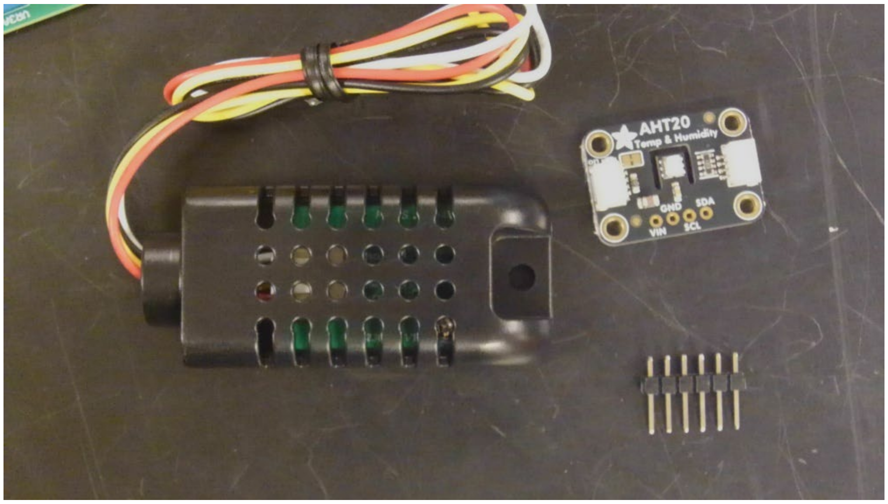


Figure 75: The two versions of the humidity sensor included in the kit. The sensor is identical, the wired version can be mounted externally if needed.

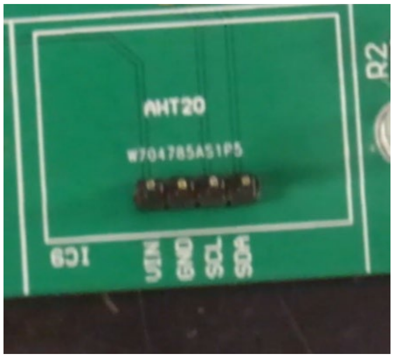


Figure 77: The breakaway header should be installed on top of MegaSat with the longer pins up.

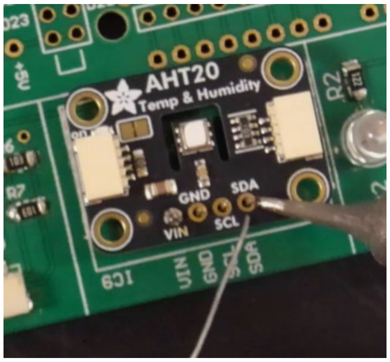


Figure 76: Soldering the humidity board.

72. Either of the two humidity sensors can be added to the board; the actual sensor is the same.

73. Internal mounting via breakout board.

    73.1. First, break the provided breakaway header to 4 pins.

    73.2. Install the header onto the MegaSat board with the longer pins facing up.

    73.3. Use tape or glue to hold the header in place and flip the board over. Solder all 4 pins to the board.

    73.4. Flip the board back over and install the humidity sensor board on top of the pins, making sure to orient the board so the pins match.

    73.5. The breakaway pins should stick through the board. Solder the humidity board to the breakaway header pins.

74. External mounting via wire leads.

    74.1. For an external sensor solder with wires directly into the 4 VIN, GND, SCL and SDA pins.

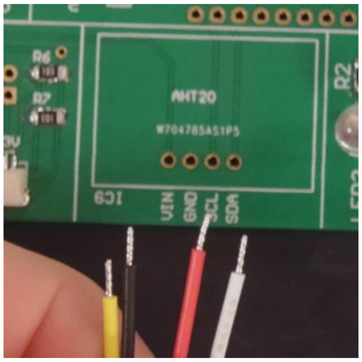


Figure 78: Wired humidity sensor. Red is power, Black Ground, White is SCL, Yellow is SDA.

IF SOLDERING SENSORS DIRECTLY TO THE BOARD, IT IS RECOMMENDED TO WAIT UNTIL AFTER THE ARDUINO HEADERS ARE SOLDERED.

Arduino Headers

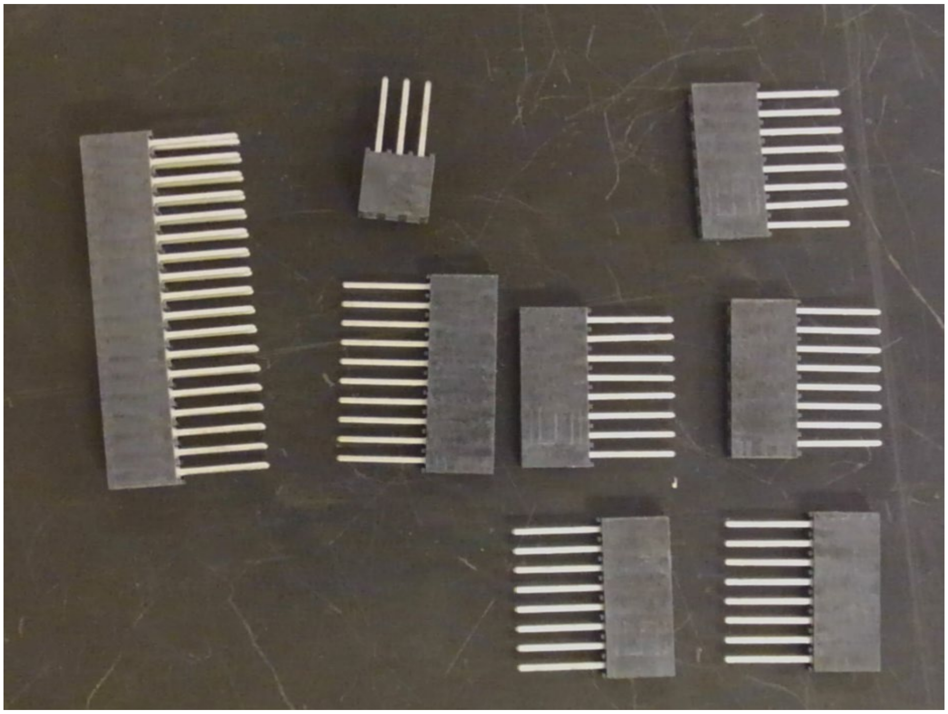


Figure 79: Arduino headers

75. We now need to solder the stackable headers that will connect the MegaSat to the Arduino. This will be similar to assembling the GPS shield, but there are many more pins. Go slowly and take caution when performing these steps to ensure you have the pins lined up and avoid bending them during assembly.
76. You should have 8 headers in your kit. Five 8-pin headers, one 10-pin header, one 18x2 18x2-pin header, and one 2x3-pin header.
77. We will use an Arduino as a guide to keep the headers lined up while we are working.
78. The 2x3-pin header has the opposite orientation of all the others; the plastic part will be on the bottom of the MegaSAT with the metal pins sticking upwards. Install the 3x2 onto the center ICSP header on the Arduino.
79. Now install the MegaSAT on top of the Arduino, making sure all 6 pins stick up through the matching holes in the center of the MegaSat.
80. Now the headers on the Arduino should be lined up with the matching hold on the MegaSat.

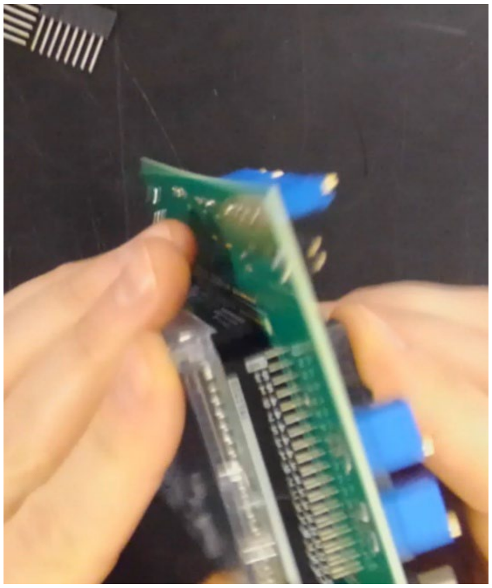


Figure 80: Stacking the headers with the Arduino.

81. Starting with the 2x18-pin header, install all of the headers on top of the MegaSat, so that the pins go through the board into the Arduino headers.
82. Once all the headers are installed, press down so the bottom of the plastic is flat against the surface of the MegaSat PCB.
83. Now solder the 6 pins of the center header. Because the pins are facing up, you should be able to freely access the pins and the pads.

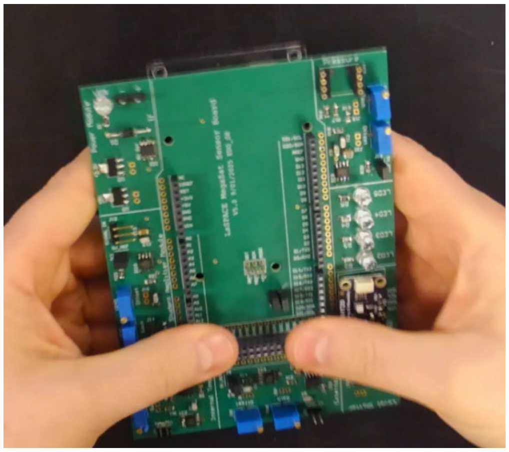


Figure 81: Once all headers installed make sure they are pressed all the way down.

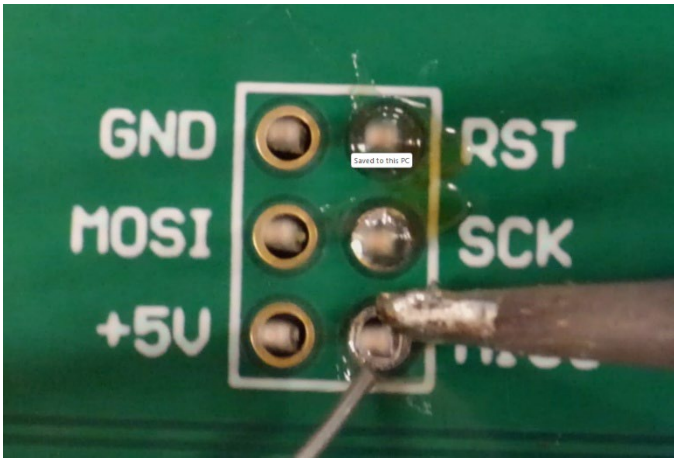


Figure 82: Soldering the 3x2 ICSP header.

84. Since the remaining headers are lined up with Arduino, we want to use hot glue to hold them in place. That will allow us to unstack the board(to get access to the pins on the bottom) without the headers moving.
85. Apply hot glue liberally to all of the outer headers; feel free to glue both sides of the headers. Hot glue is nonconductive, so it is ok if some gets on the pads next to the headers

Figure 83: Hot-gluing the headers in place

86. Allow the glue to fully cool and harden.

87. Carefully remove the Arduino from the MegaSat. Try to avoid bending any of the header pins as you do so. It is recommended to use a set of snap ring pliers and work slowly around the Arduino.
88. Now you should be able to freely access the pins and pads for the headers on the bottom of MegaSat.
89. Solder all header pins.
90. Once you are done, double-check all of the pins. There are a large number of pins, and it is easy to skip a pin or bridge a pair of adjacent pins.
91. Once all of the pins are done, reinstall the Arduino. The pins should be close to lined up but you may need to slightly adjust the pins to get them to slide into the Arduino headers.
92. It is recommended to keep the board stacked with an Arduino to protect the pins, even if you are not programming.

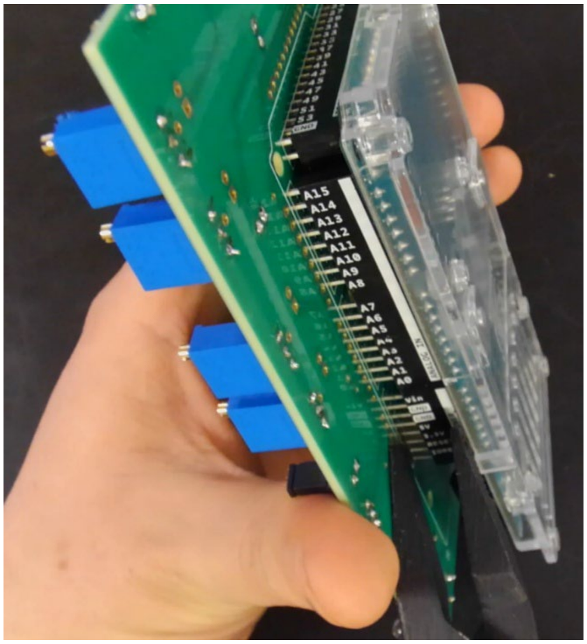


Figure 84: Unstacking the MegaSAT.

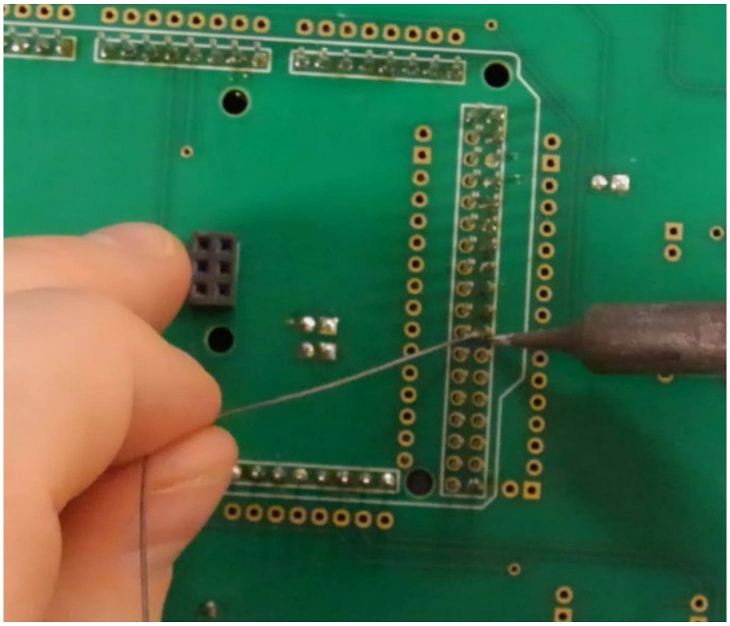


Figure 85: Soldering the header pins.

Installing the Pressure sensor

93. The pressure sensor should be installed directly into the socket you installed earlier.
94. The pin marking for the pressure sensor is a small divot on the black plastic portion of the sensor.
95. Make sure the pins of the sensor are lined up with the socket before pressing it down. You may need to slightly adjust the pins with pliers or a small screwdriver.
96. If you are soldering any sensors directly to the board, return to those sections and complete that soldering.

Congratulations, your MegaSAT should now be fully assembled. It should look similar to Figure 87.

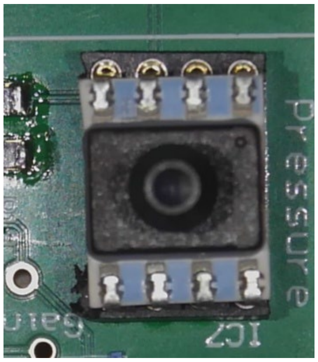


Figure 86: Caption for Figure Text, copy and paste, replace images and text as needed

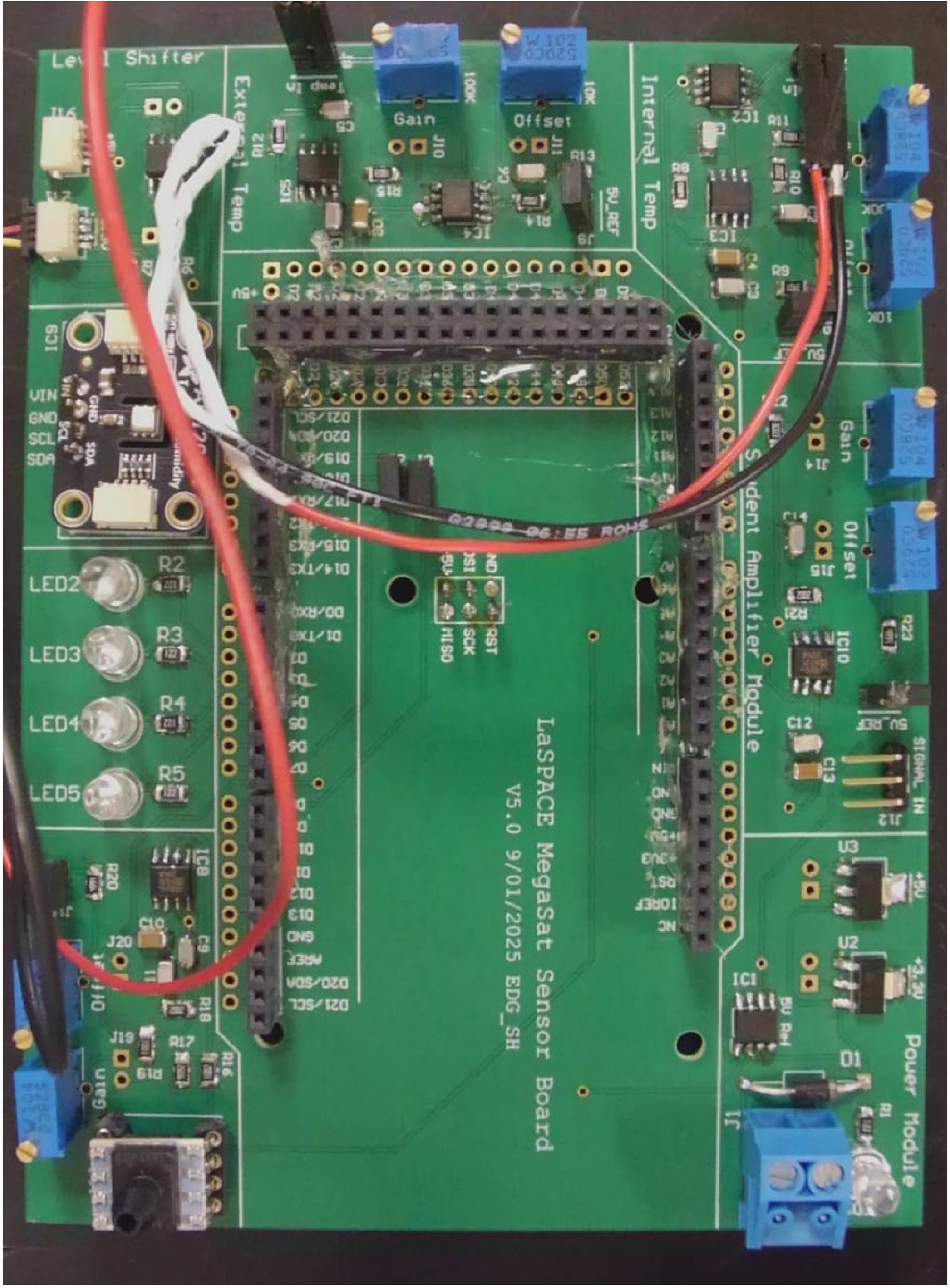
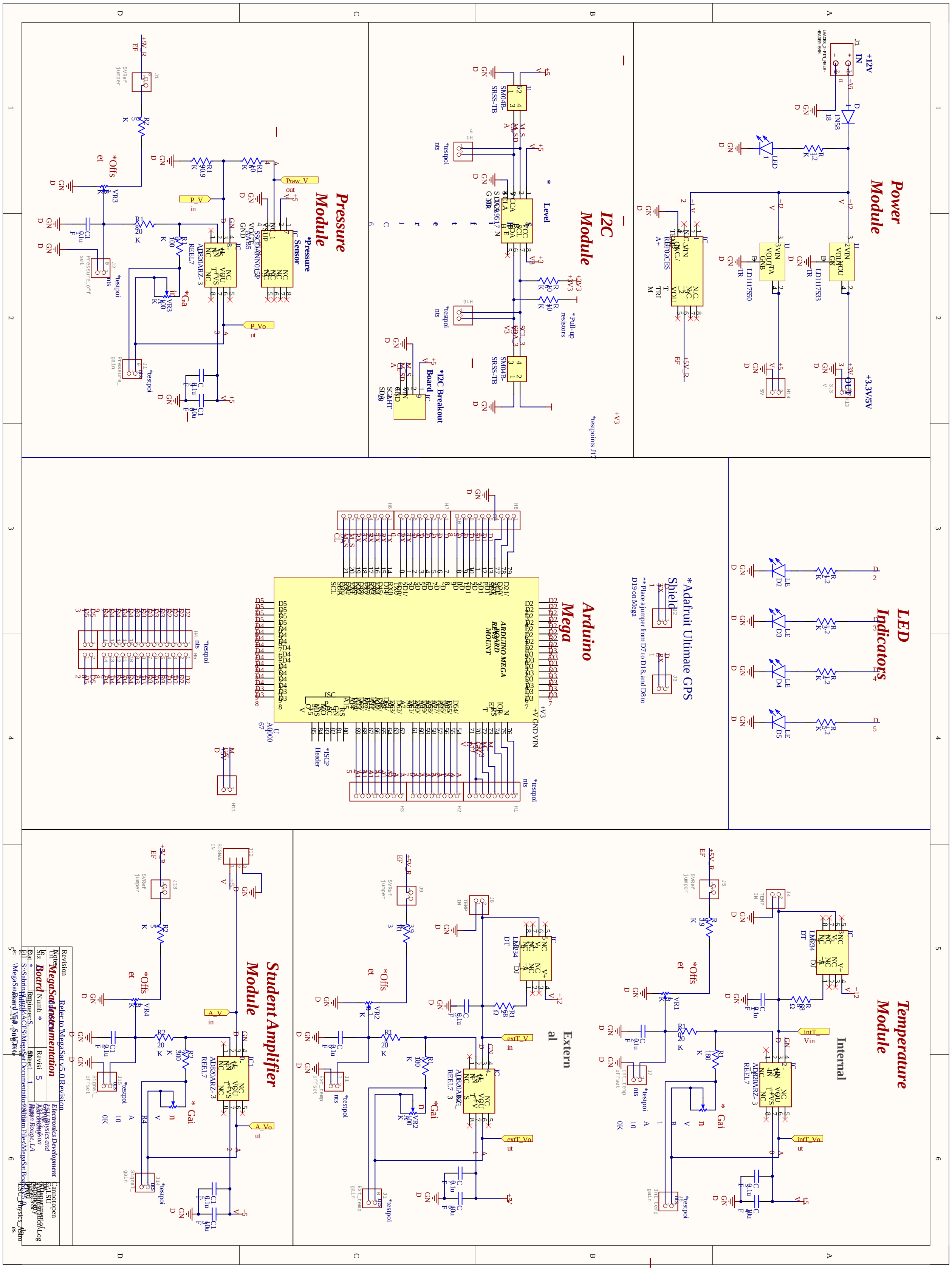


Figure 87: Fully Assembled MegaSAT


Power Module
+12V IN
+3.3V/5V OUT
I2C Module
*Level
*I2C Breakout Board
*Pull-up resistors
Pressure Module
*Pressure Sensor
P_V in
Praw_V out
P_Vo ut
Arduino Mega
ARDUINO MEGA REV3 R3 MOUNT
*Adafruit Ultimate GPS Shield
**Place a jumper from D7 to D18, and D8 to D19 on Mega
LED Indicators
Temperature Module
Internal
External
Student Amplifier Module
*Offs et
*Gai n
*testpoints
AD8202ARZ-REEL7
LD1117S50TR
LD1117S33TR
LM234
Refer to MegaSat v5.0 Revision
MegaSat Instrumentation Board

Appendix B: Arduino Pin Usage

Table 12: The table below lists the Arduino I/O pins that are used in the fully assembled MegaSAT stack.

Arduino Pin Number	Usage
D0/RX0	USB Serial Port
D1/TX0	USB Serial Port
D2	Indicator LED2
D3	Indicator LED3
D4	Indicator LED4
D5	Indicator LED5
D7	GPS Soft-Serial Data to GPS, Connects to D18 via J2
D8	GPS Soft-Serial Data from, GPS, Connects to D19 via J3
D10	SD Card Chip Select Pin
D18	TX1, Connects to D7 via J2
D19	RX1, Connects to D8 via J3
D20 (SDA)	I2C, Connected to Level Shifter and Humidity Sensor
D21 (SCL)	I2C, Connected to Level Shifter and Humidity Sensor
D50	SPI MISO, connected to SD Card
D51	SPI MOSI, connected to SD Card
D52	SPI SCK, connected to SD Card
A0	Internal Temperature Amplifier Output
A1	External Temperature Amplifier Output
A2	Student Amplifier Output
A3	Pressure Amplifier Output
A4	Unamplified Pressure Sensor Output