Robot Systems Learning Kit Construction Plan

This is a guide to build the TI-RSLK Robot using the TI-RSLK kit purchased for the curriculum.

There are two kits available TI- Basic and Advanced that will have all the parts and components needed to build a robot and also complete labs from all 20 learning Modules. We also have an upgrade kit for users interested in moving from Basic to Advanced modules and enhance their learning experience with BLE and Wifi.

The kits come with the following
a) Robot Parts and sensors b)TI EVMS c) Robot Power Pack d) Misc electronic components and mechanical parts.Below is a bill of Material and whats needed. Note: You don't need all parts and components to build the robot, some of these are for doing experiments in lab and hands on learning.
The kits can be purchased through Element 14 for your regions.

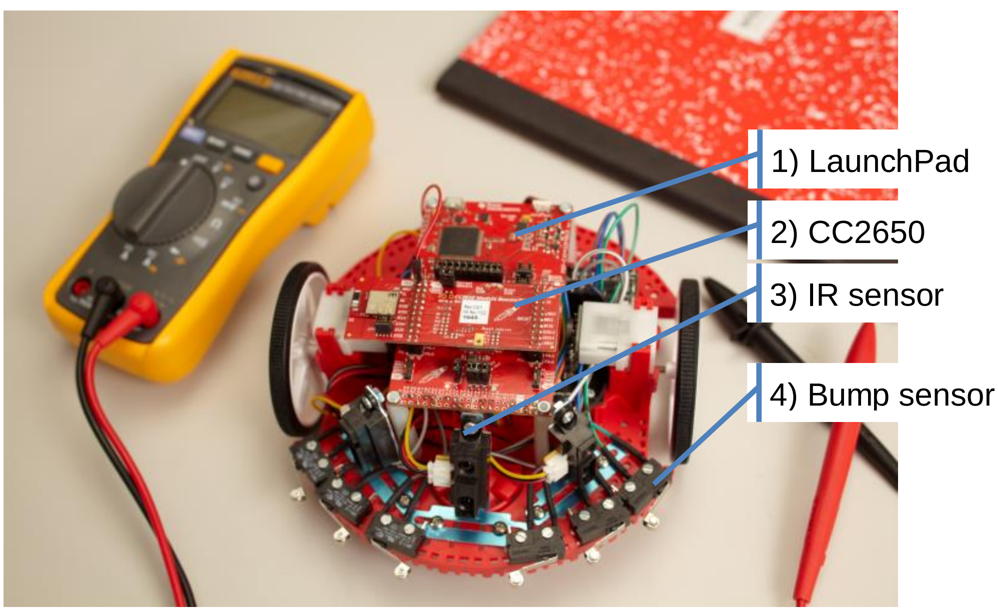
Kit Types			
Advanced	**Basic**	**Upgrade**	**Part**
1	1	0	red chassis
1	0	1	shaft encoder
1	1	0	Motor Driver and Power Distribution board
1	1	0	line sensor array
2	0	2	IR bracket pair with 4X bolt and 4X nut
3	0	3	IR sensor
3	0	3	IR cable
6	6	0	bump switches
			TI EVMs
1	1	0	LaunchPad: MSP-EXP432P401R
1	0	1	BLE: BOOSTXL-CC2650MA
1	0	1	Wifi: CC3120BOOST
			Robot Battery Pack/wires
1	1	0	Wire/ cables
1	1	0	Charger w/ 2 batteries
1	1	0	4 - AA batteries
1	0	1	Nokia 5110 LCD display
Full kit & Min. kit *only*			Misc. Elec. & Mech.
6	6	0	0.5in 4-40 plastic machine screw
1	1	0	3.25in white solderless breadboard
2	2	0	0.75in 4-40 metal standoff
8	8	0	0.187in 4-40 metal nut
4	4	0	1.375in 4-40 plastic standoff
2	2	0	0.5in 2-56 metal standoff
1	1	0	2x30, 0.1in male header
1	1	0	1x20, 0.1in, straight male header

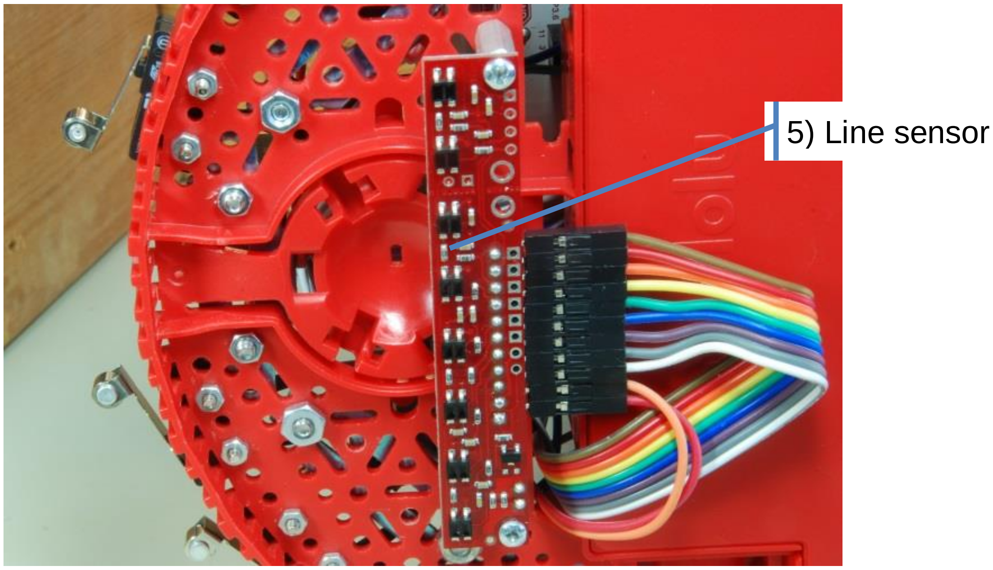
1	0	0	1x8 straight male header (for Nokia 5110 into breadboard)
1	1	0	Heat Shrink Tubing, Flexible 0.175" (4.45mm) 2 to 1 Black 3.28' (1.00m)
1	1	0	1x14 right-angle male header
1	1	0	Red 10mA 5mm, LTL-10223W
1	1	0	Red 2mA 5mm, HLMP-4700
1	1	0	Carbon 1/6W, 5%, 220, CFR-12JB-52-220R
1	1	0	Carbon 1/6W, 5%, 470, CFR-12JB-52-470R
1	1	0	Carbon 1/6W, 5%, 22k, CFR-12JB-52-22K
1	1	0	Carbon 1/6W, 5%, 33k, CFR-12JB-52-33K
1	1	0	Wirewound 5W, 5%, 10 ohm
2	2	0	Ceramic, Z5U, -20/+80%, 0.47 uF,C320C474M5U5TA
3	3	0	B3F-1052 tactile push button switch
12	12	0	0.5in 2-56 screw
3	0	0	10 uF Tantalum capacitors, 10% 20V
12	12	0	2-56 nut for bumpswitches

This guide will help you build a robot and control its movements through BLE and commands through your phone.

For more infornation on the robot chassis, please go to www.polulu.com
https://www.pololu.com/product/3502

TI RSLK robot will have a Launchpad (1), a CC2650 (2), IR sensors (3), bump sensors (4), and a line sensor (5).



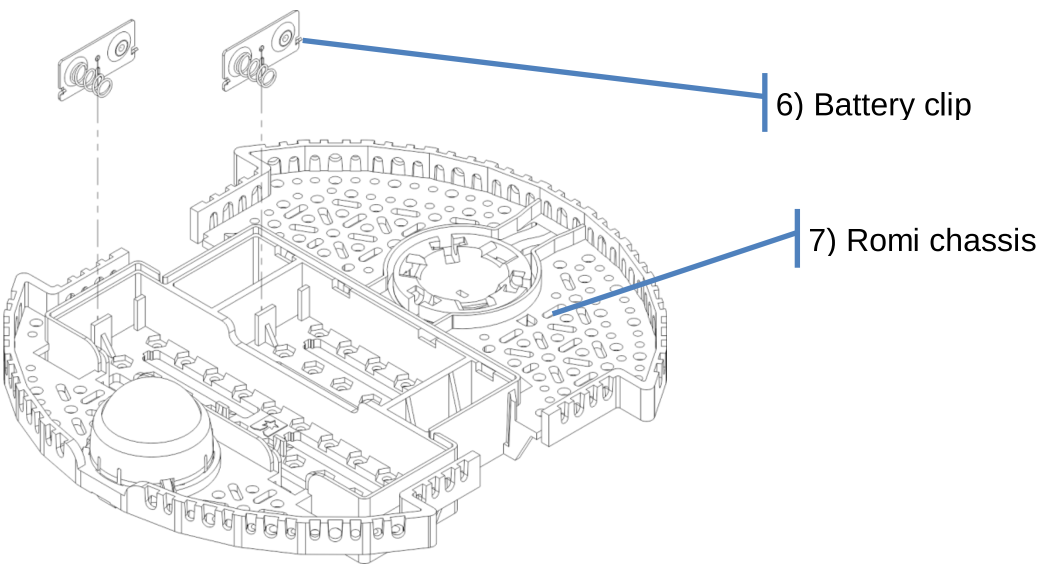


Stage 1) Configure the Romi chassis with snap-together steps.

Useful video: https://youtu.be/0MP7cw9P4x8

Step 1) Double-sided battery terminals

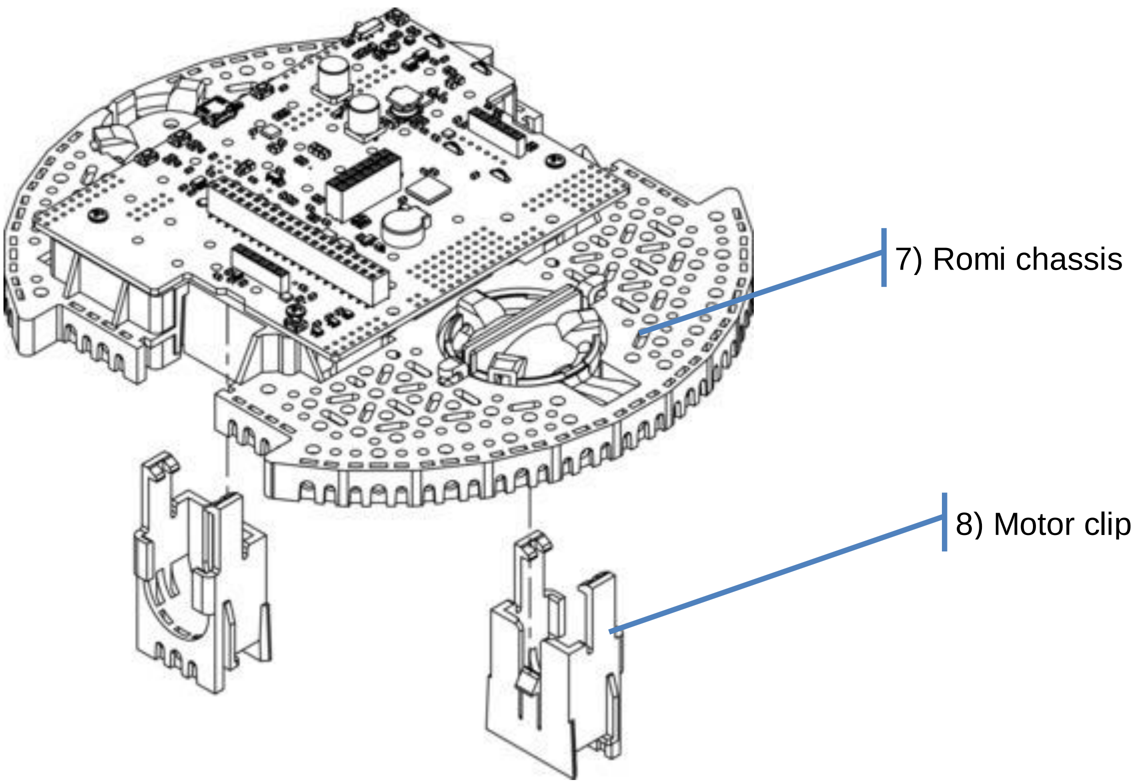
Attach the two double-sided battery terminals (6) into the chassis (7) by pressing them into their indentations inside the battery compartment. Be sure that the spring matches with the flat (negative) side of the battery. The battery polarity can be seen as outlines cut through the chassis.



Step 2) Motor clips

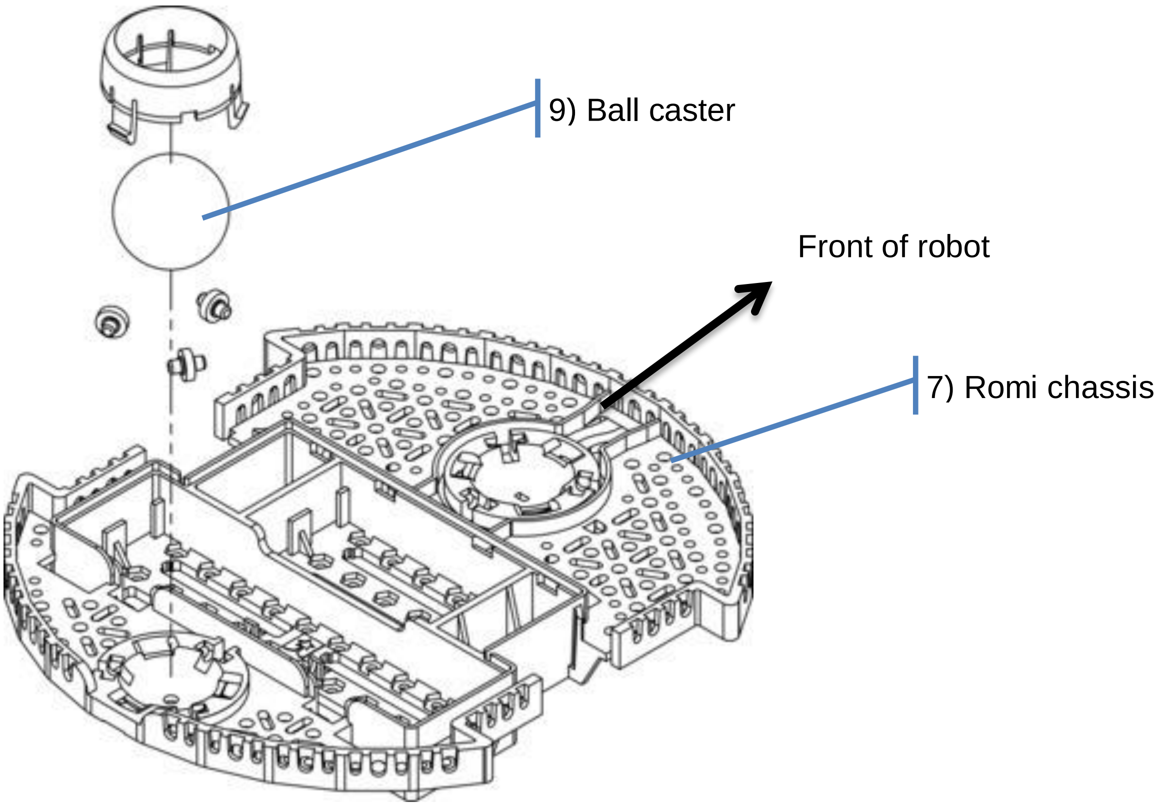
Attach the two motor clips (8) to the chassis (7). They should slide into place from the bottom and hold snugly without needing glue. The clip part will point up, where it will eventually fit around the rectangular part of the motor gear box. The side that faces out towards the wheels has three little indentations that continue the same pattern that goes around the rest of the chassis. The Pololu has a very detailed assembly guide on their website at:

https://www.pololu.com/docs/0J68/4



Step 3) The ball caster

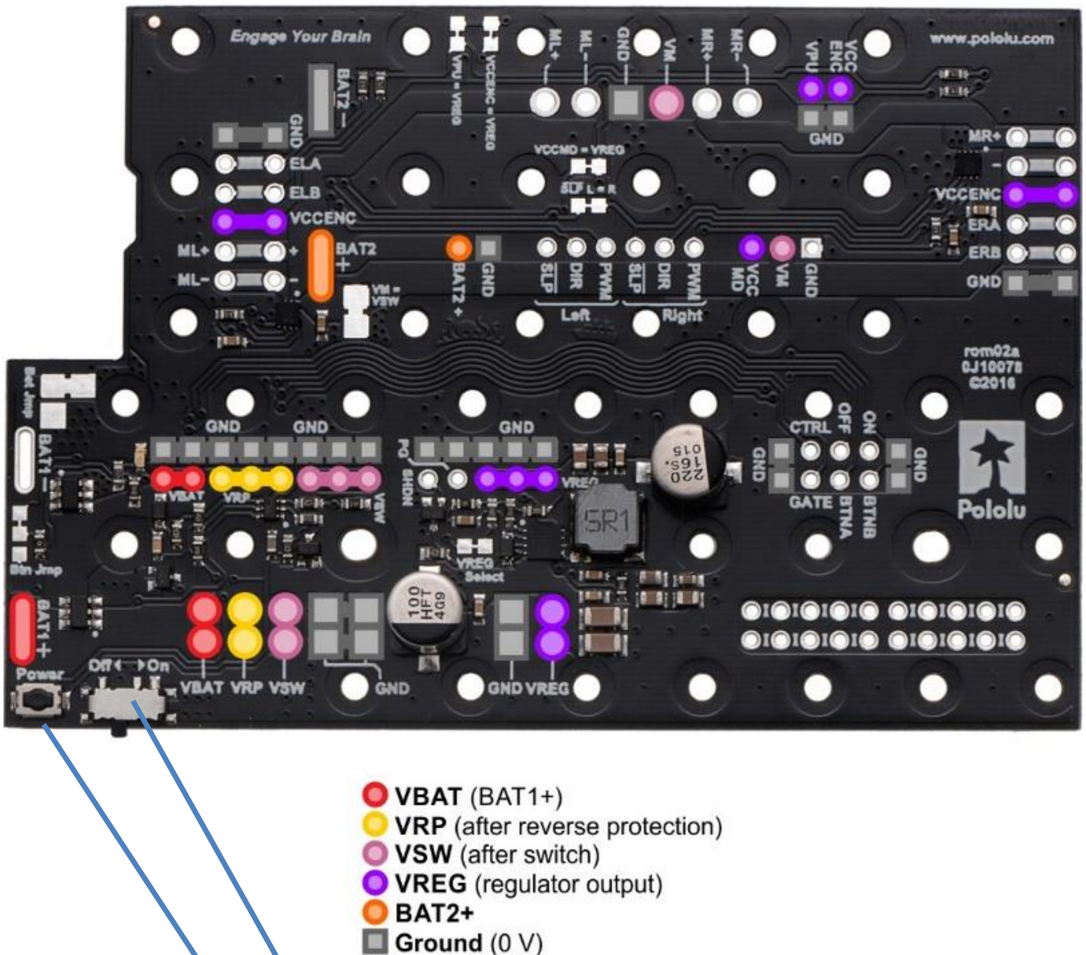
Attach the ball caster (9) to the back of the chassis (7). Be careful to use the slot in the back of the chassis; it will be the rigid one without the suspension. This provides the robot with stability with minimal additional friction. You might consider skipping this step for last, since it might be more convenient if the chassis can sit flat while you are attaching other components. See the following image from Pololu:



Stage 2) Configure the MDPDB for use on the robot.

Step 0) The Two Power switches

Move the switch to “Off” (10) and leave it there for the entire project. You will be pressing the “Power” button (11) to turn on and off the battery power to the robot.

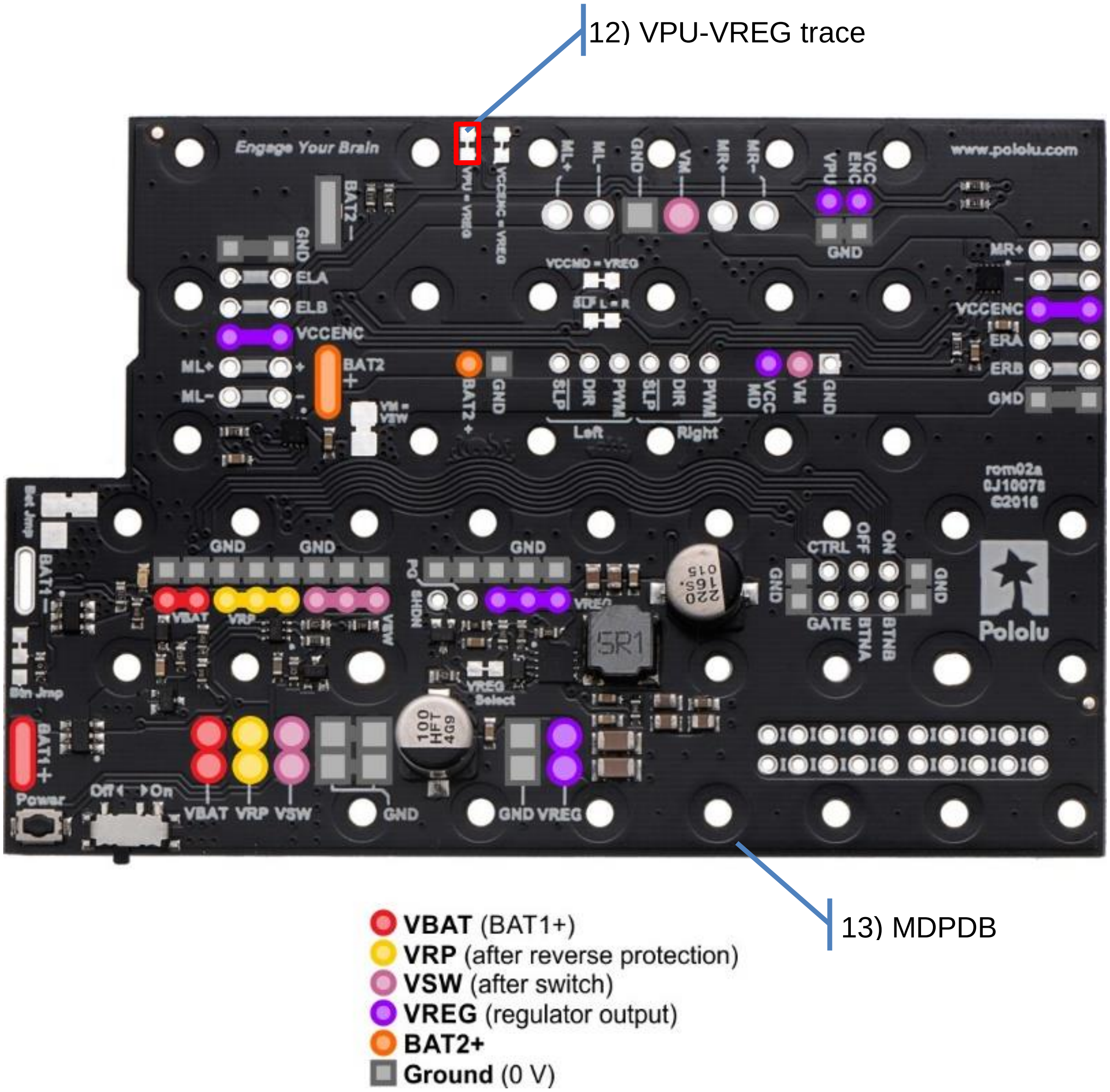


10) Switch to “off”

11) On/off power button

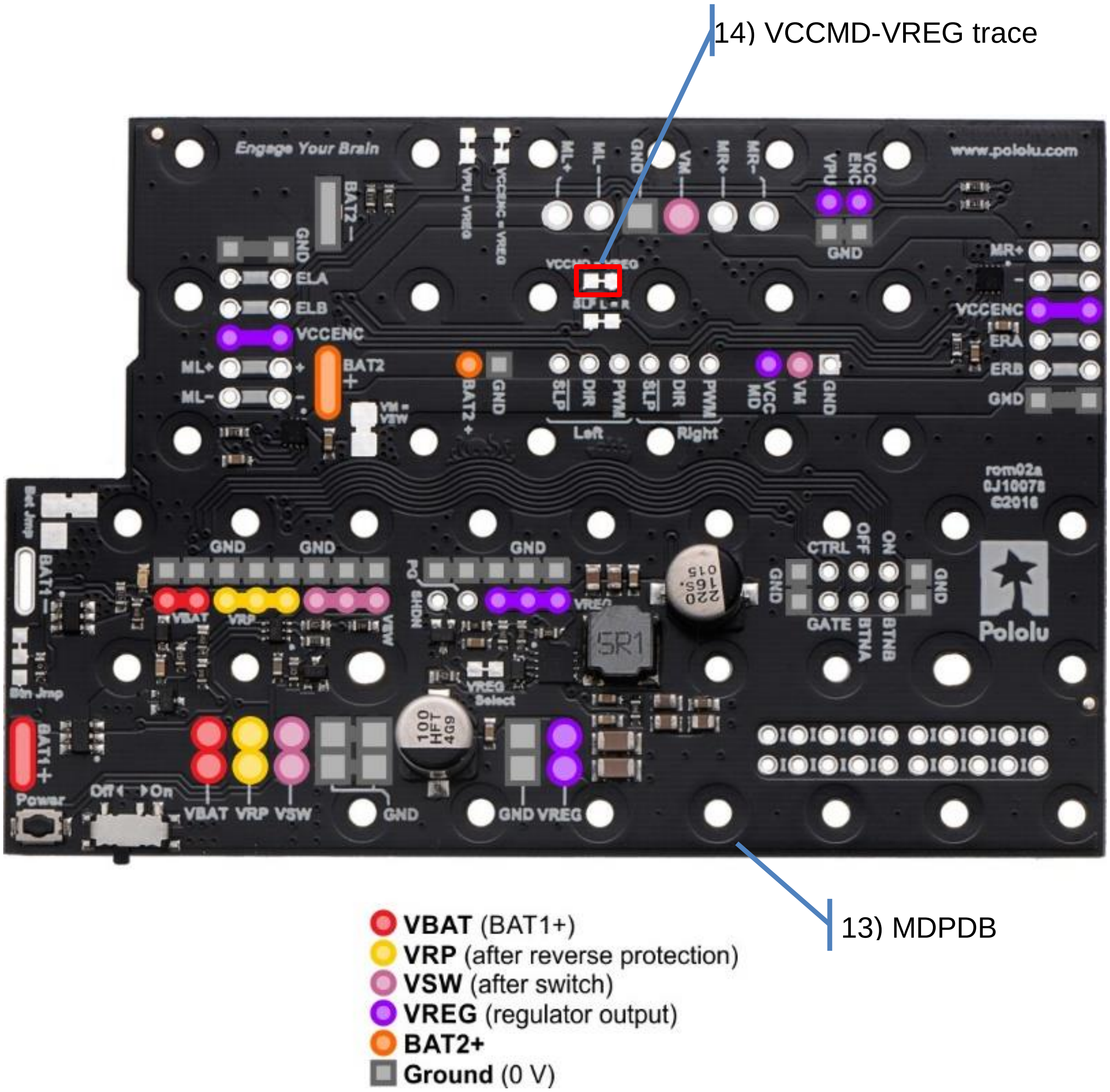
Step 1) The VPU-VREG trace

Cut the VPU—VREG trace (12) on the **MDPDB** (13). This will allow the shaft encoders to run at 3.3V as required by the LaunchPad.



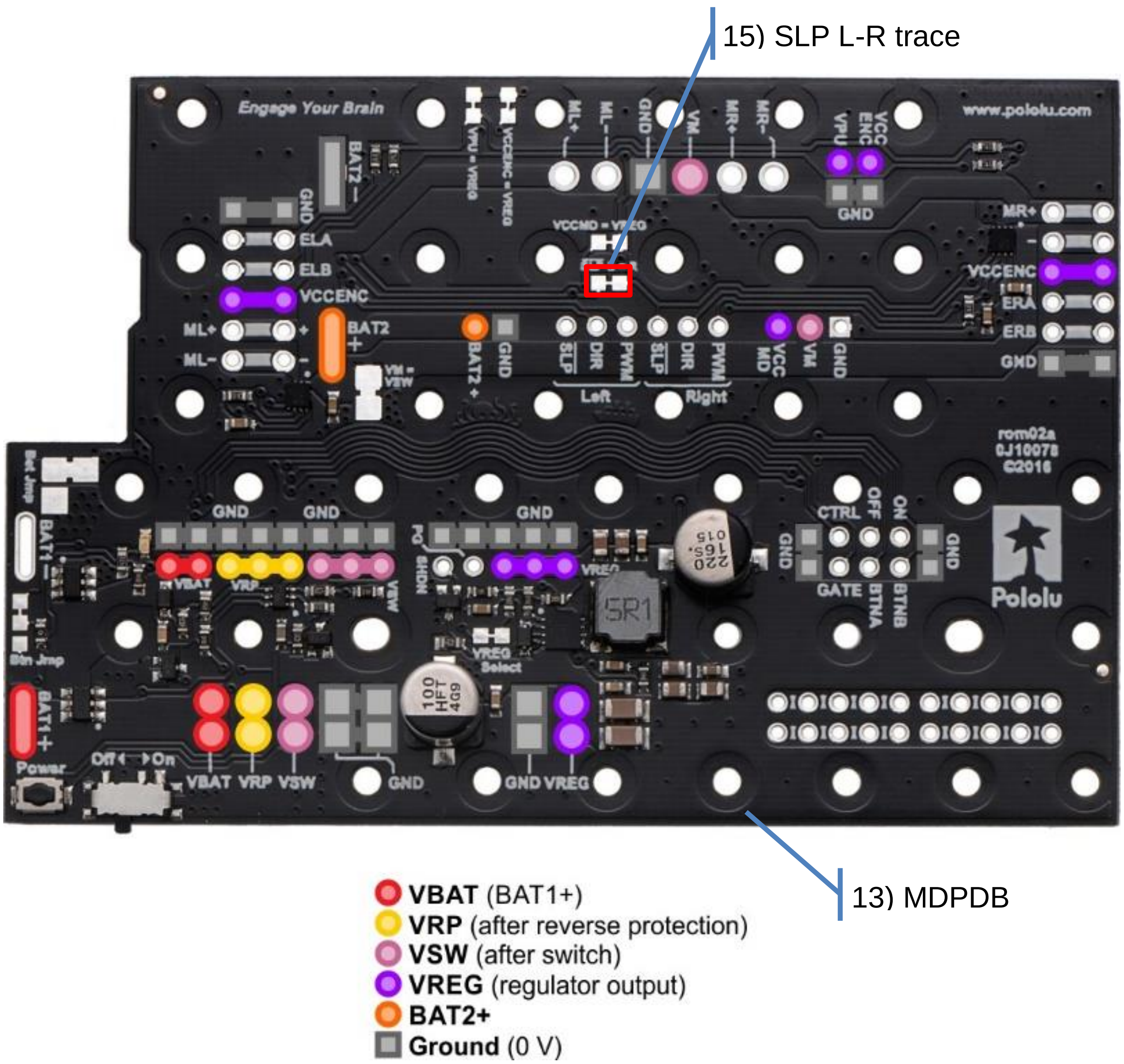
Step 2) The VCCMD-VREG trace

Cut the VCCMD-VREG (14) trace on the **MDPDB** (13). This will allow the DRV8838 motor driver chips to run at 3.3V to accept 3.3V inputs so the LaunchPad can control the motors.



Step 3) The SLP L-R trace

Cut the SLP L-R trace (15) on the **MDPDB** (13). This will allow the left and right motor driver chips to sleep separately from each other. Each of the sleep pins will be tied to a separate GPIO pin, so this trace must be cut.

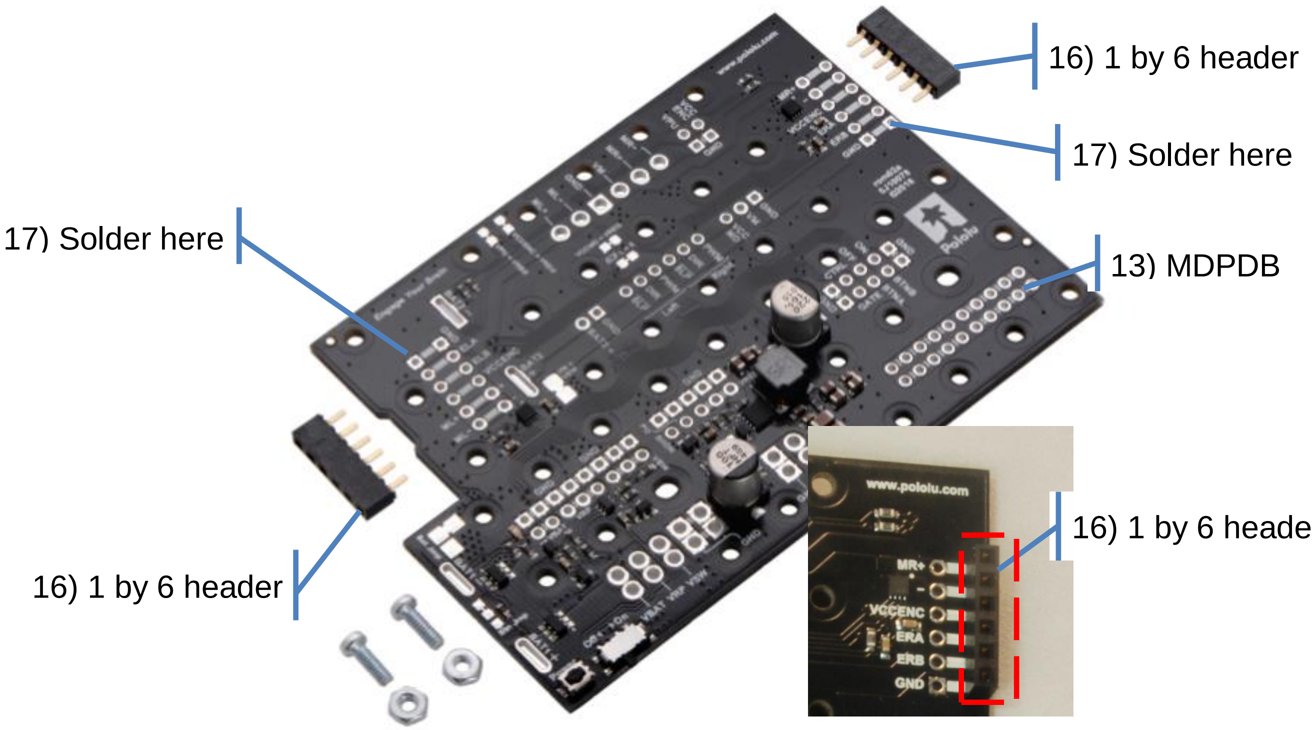


Step 4) Test the trace cuts

Use an ohmmeter to verify that the traces have been successfully cut.

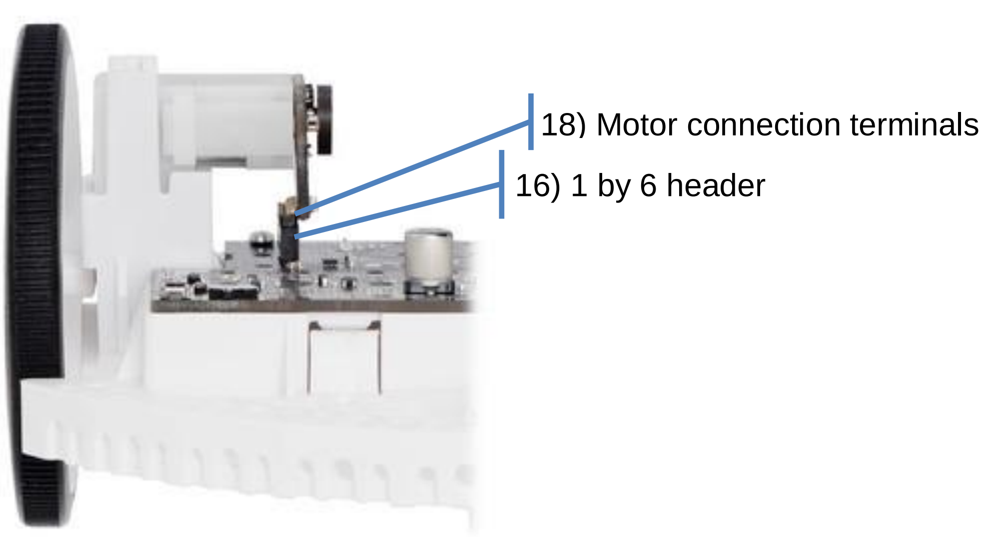
Step 5) Motor connection headers

Both the **MDPDB** (13) board and the **Romi Encoder Pair Kit** came with a pair of 1x6 female headers (16). Solder one pair in each column of motor connection terminals closest to the edge (17) of the **MDPDB** (13).



Motor Driver and Power Distribution Board for Romi Chassis with included hardware.

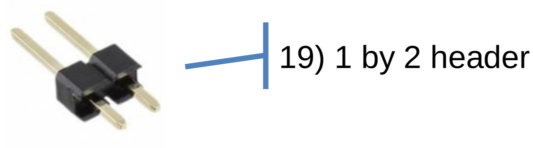
The motor connection terminals (18) are where the motors will physically plug in once they are inserted into the Romi chassis. The other pair of female headers is extra. Ultimately, it should look like this image from Pololu:

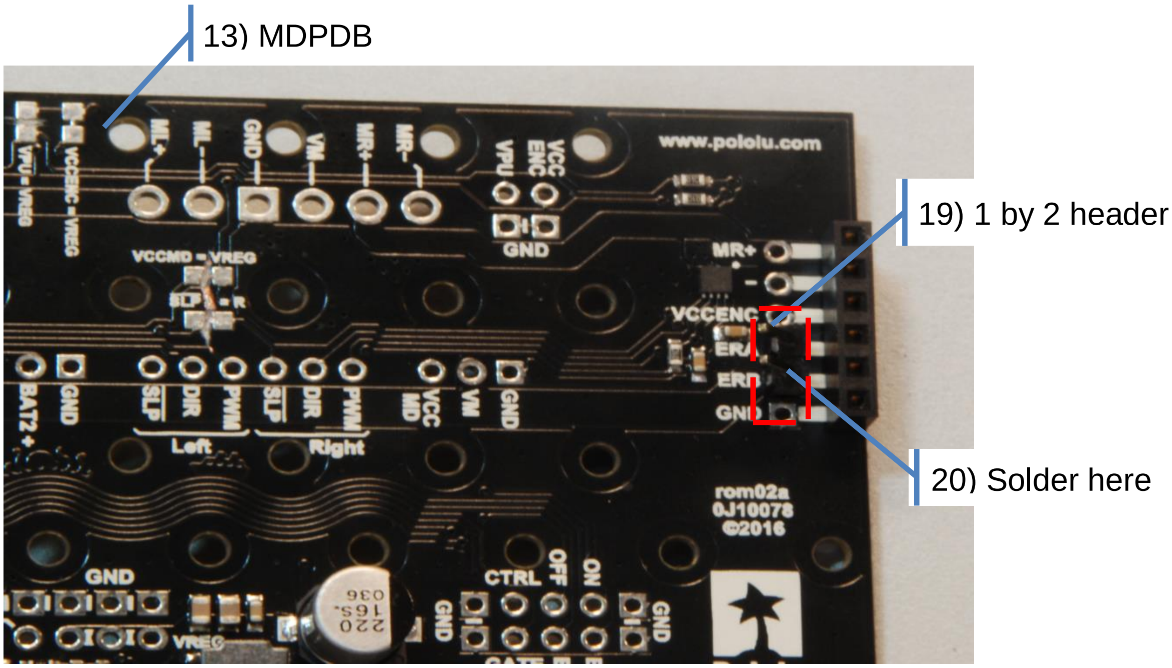


Before soldering anything together, it might help to arrange the components to visualize how it will ultimately look. Also consider Step 6):

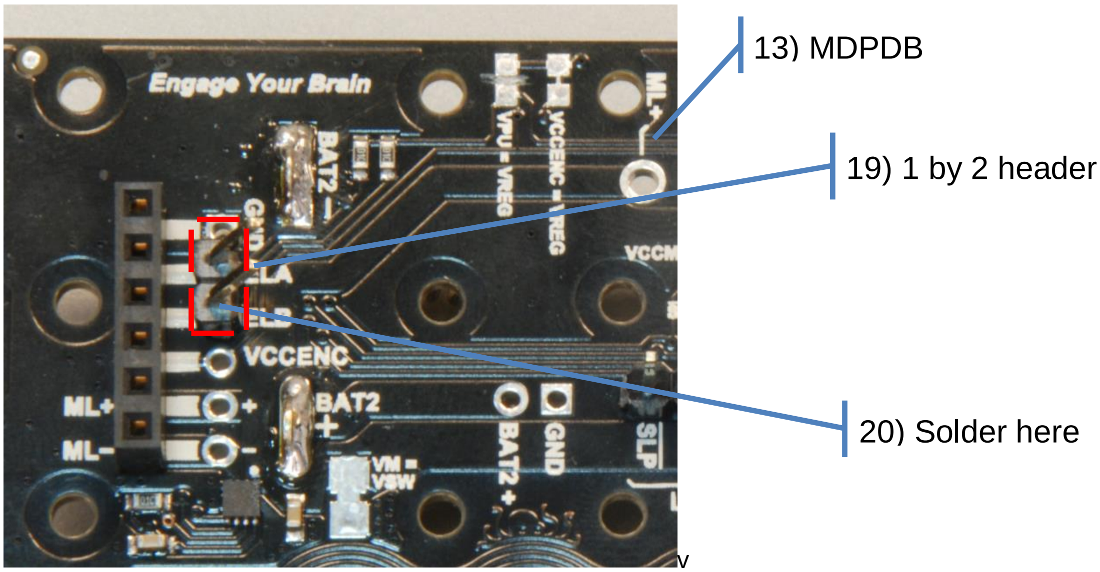
Step 6) Shaft encoder headers

Break off a 1x2 male header (19) and solder it into the ERA/ERB position (20) not occupied by the female header from Step 5). The wires recommended with this kit are long, and they might physically get in the way of the spinning motor or shaft encoder magnet. If this is the case, then **the easiest fix is to bend the headers** about 45 degrees away from the motor.





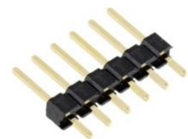
Break off another 1x2 male header (19) and solder it into the ELA/ELB positions on the other side not occupied by the female headers from Step 5). Notice the 45 degree angle.



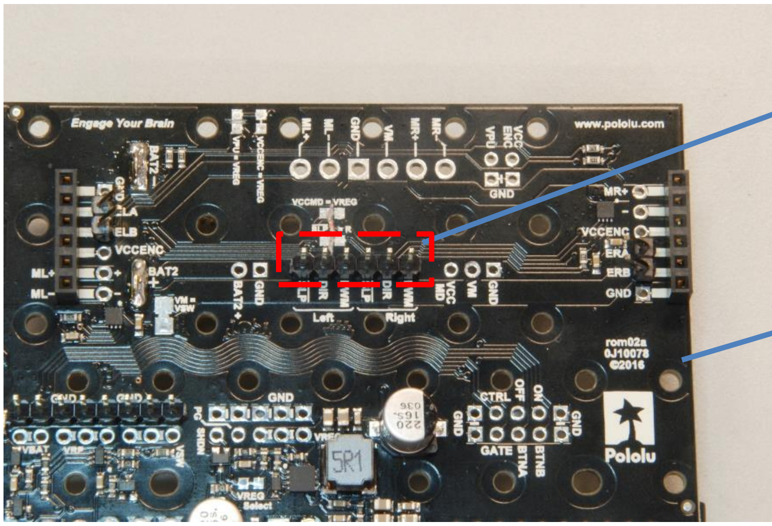
v

Step 7) Motor control headers

Break off a 1x6 male header (21) and solder it into the row of left and right motor control terminals (22).



21) 1 by 6 header



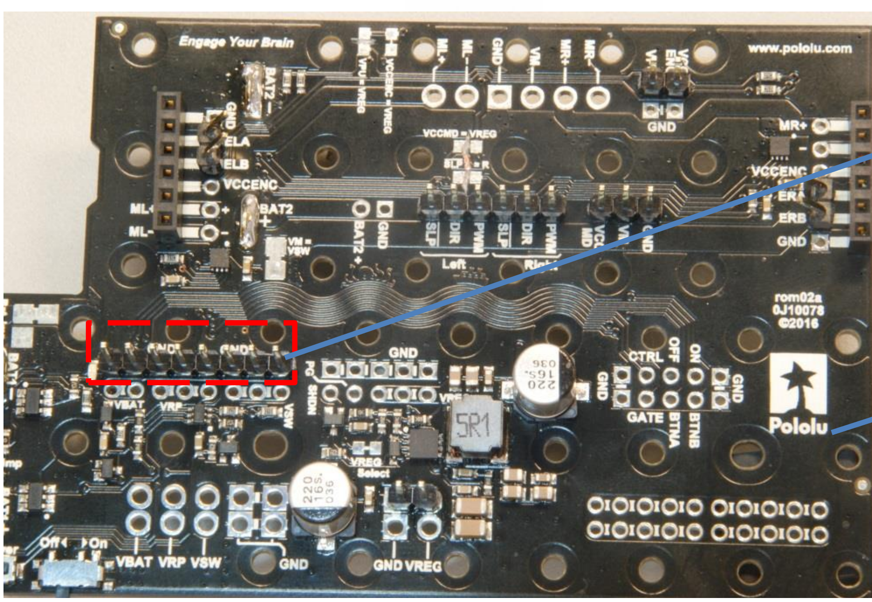
22) Motor control

13) MDPDB

Step 8) Ground headers

Break off a 1x8 male header (23) and solder it into the row of ground terminals (24). Six of these will be used for the negative-logic bump sensors on the front of the robot. Two are extra.

23) 1 by 8 header

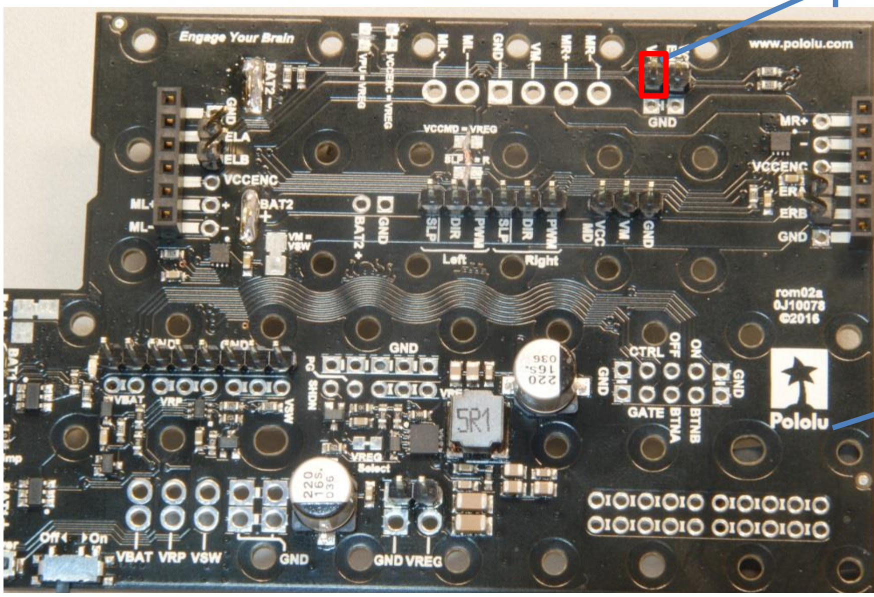


24) Ground pins

13) MDPDB

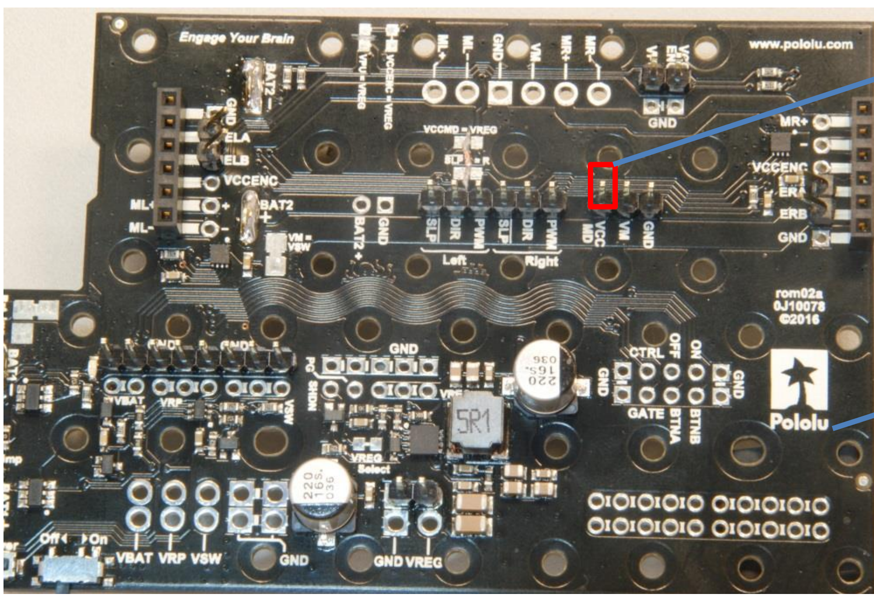
Step 9) The VPU header

Break off a male header with one pin and solder it into the VPU terminal (25).



Step 10) The VCCMD header

Break off a male header with one pin and solder it into the VCCMD terminal (26).

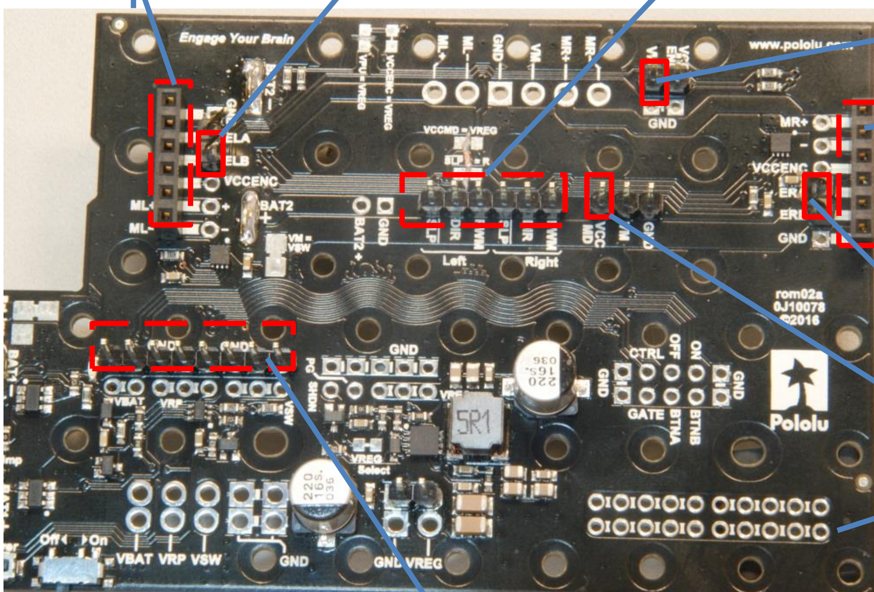


Your final board should look like this …

16) 1 by 6 header

19) 1 by 2 header

22) Motor control



25) VPU pin

16) 1 by 6 header

19) 1 by 2 header

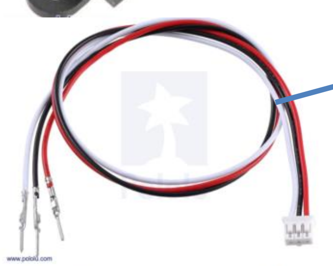
26) VCCMD pin

13) MDPDB

24) Ground pins

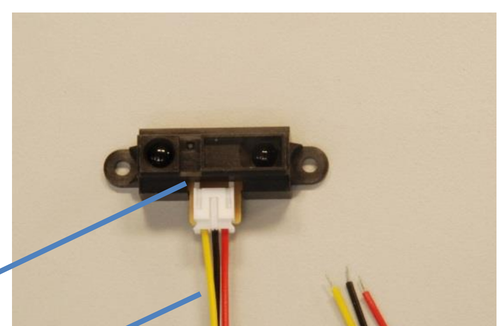
Step 11) Powering the IR sensors

27) IR sensor



3-pin female JST PH-style cable (30 cm) with male pins for 0.1" housings.

28) IR sensor cable

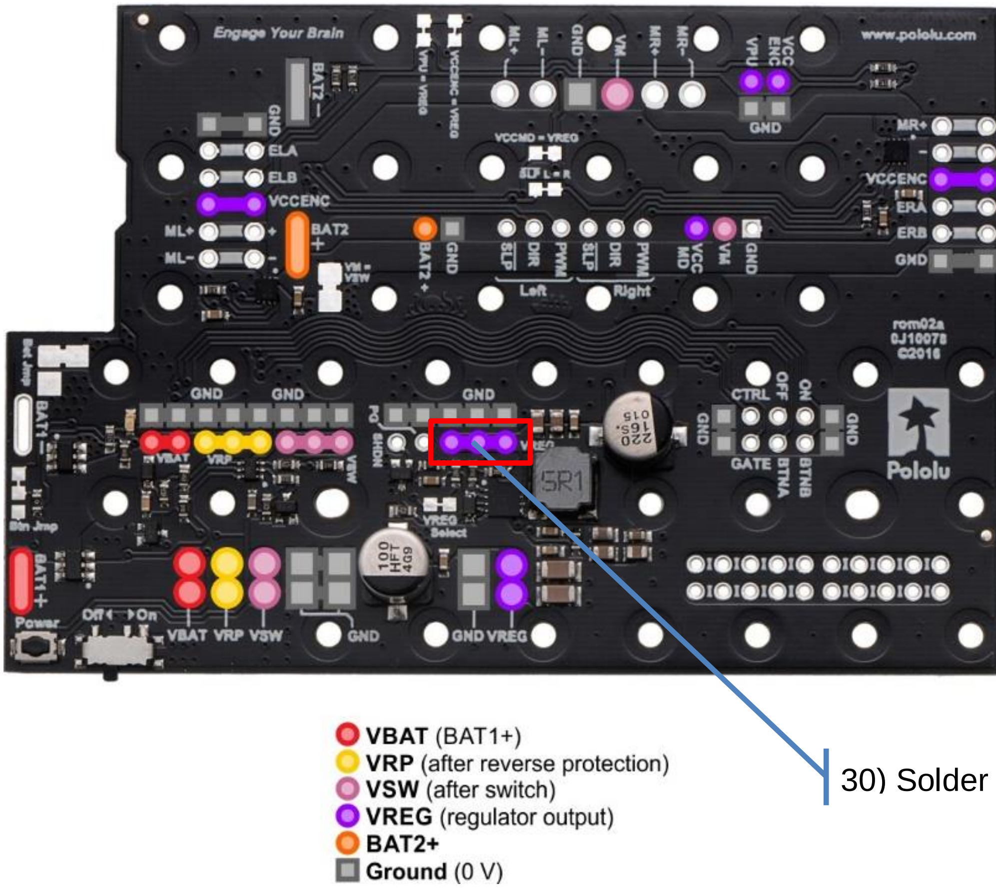


27) IR sensor

28) IR sensor cable

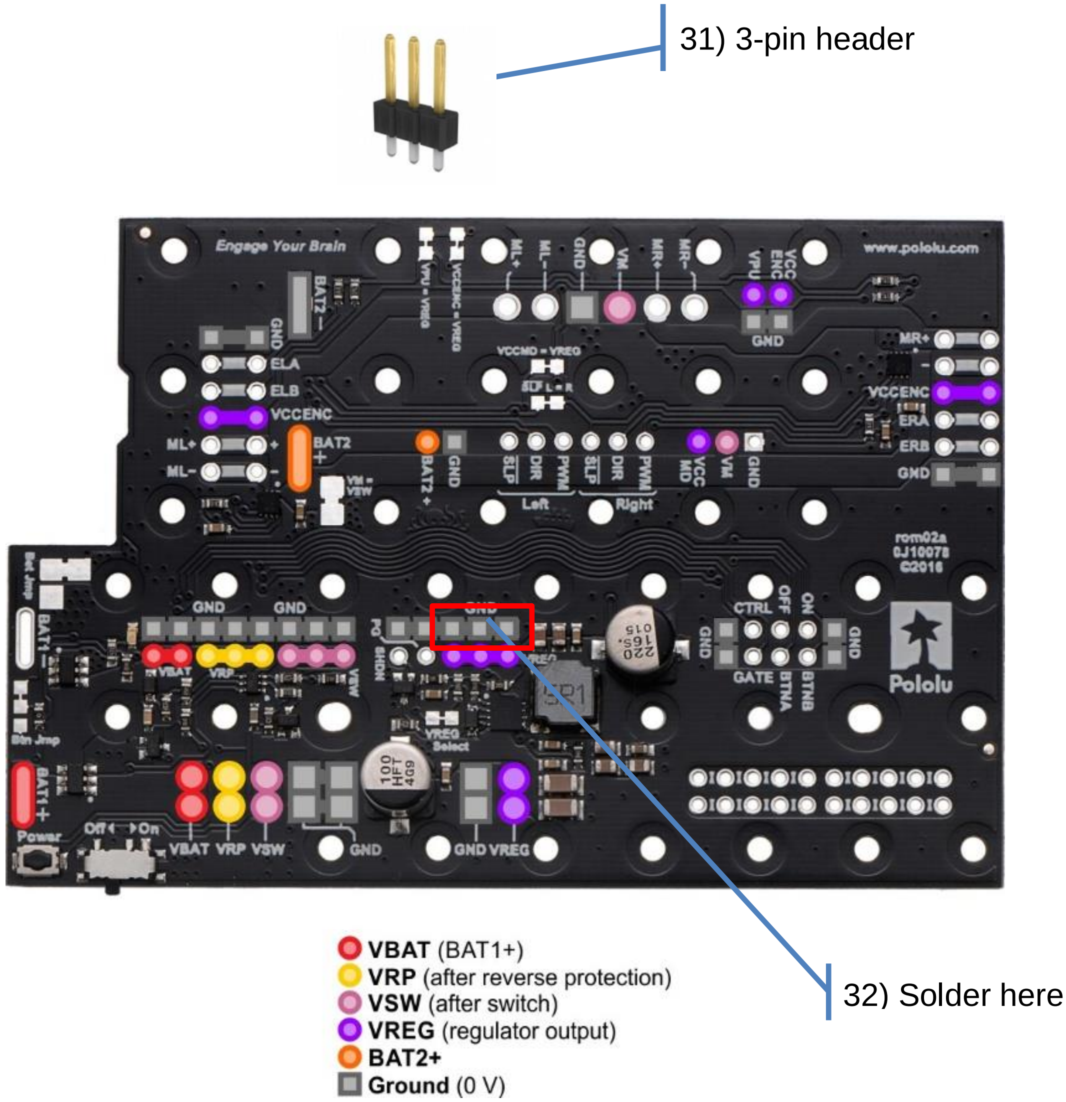
Consider power delivery to the IR sensors.
Break off a 1x3 male header (29) and solder it into the row of VREG=+5V (30) of the MBPD terminals.

29) 3-pin header

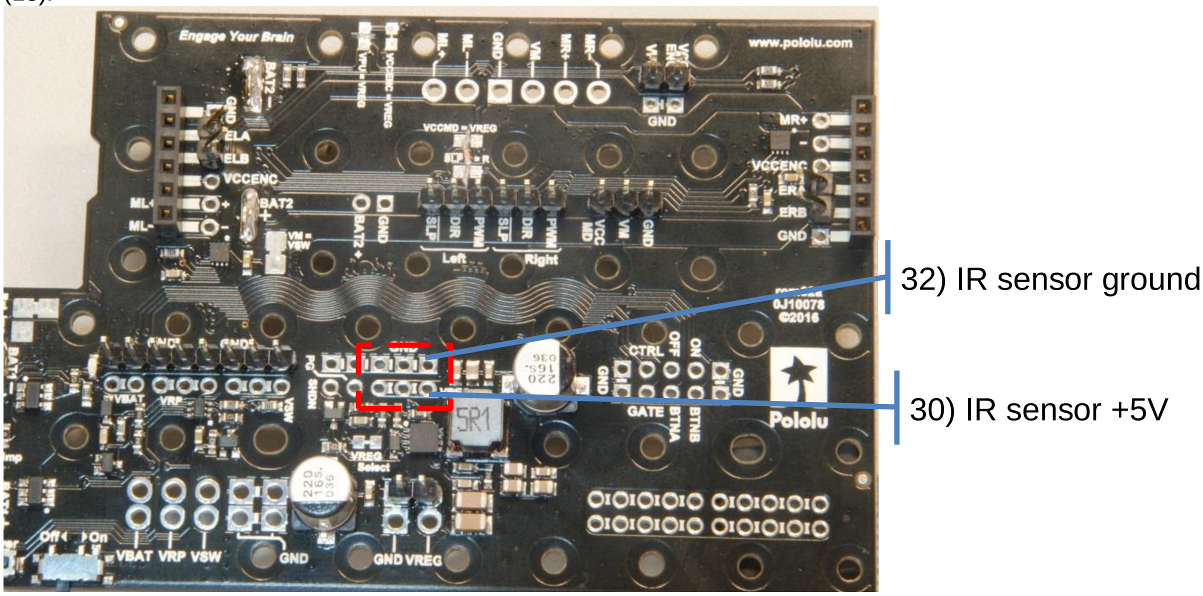


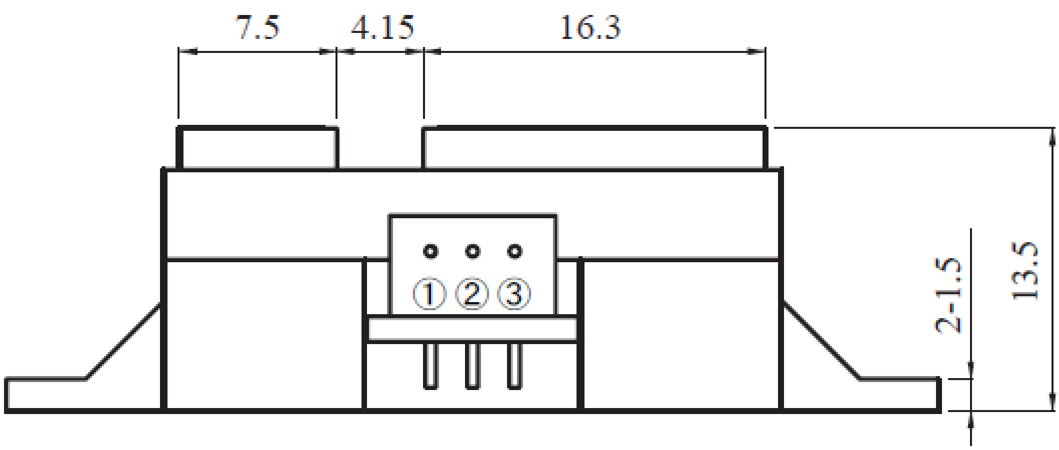
30) Solder here

Break off a 1x3 male header (31) and solder it into the row of GND terminals nearby (32).



Cut off six female connectors from the ribbon cables, splice them onto the power and ground IR cables, and cover the solder joint with heat shrink. Use the female connector from the IR sensor to attach the male header on the **MDPDB** (13).





Connector signal

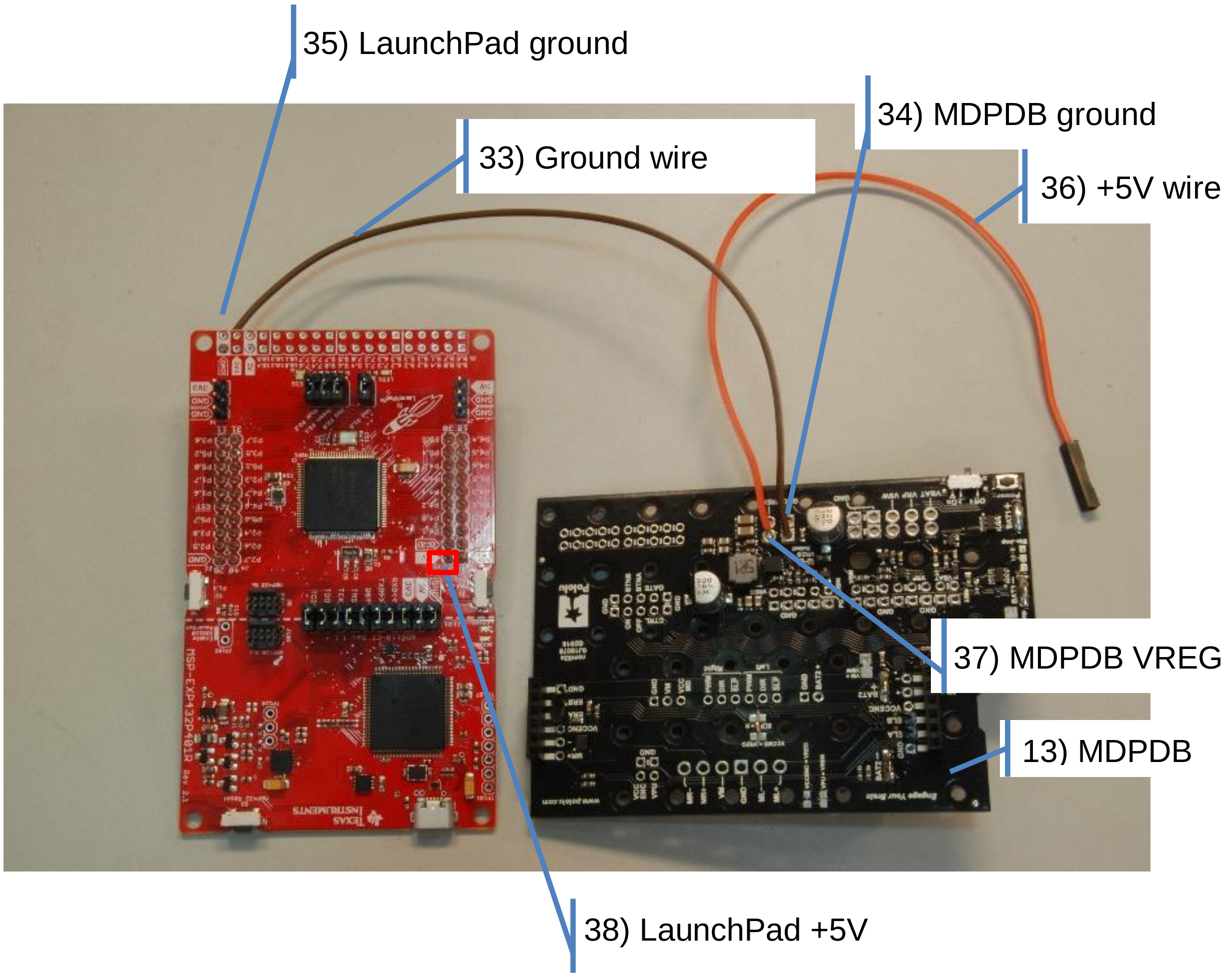
	signal name
①	Vo
②	GND
③	Vcc

Connector :
J.S.T.TRADING COMPANY,LTD,
S3B-PH

Double check which wire is which, because red is not necessarily +5V, and black is not necessarily ground.

Step 12) Powering the LaunchPad

Consider power delivery to the LaunchPad.
Option A)
Solder a wire (33) from a ground terminal of the **MDPDB** (34) to a ground terminal of the LaunchPad (35). Take a ribbon cable that has a female connector (36), cut off the other end, and solder the cut end to the big VREG=+5V (37) terminal of the **MDPDB**. When powering the LaunchPad from the robot's batteries, connect this female connector to +5V on the LaunchPad (38). When powering the LaunchPad from USB, disconnect this connector and leave it floating.



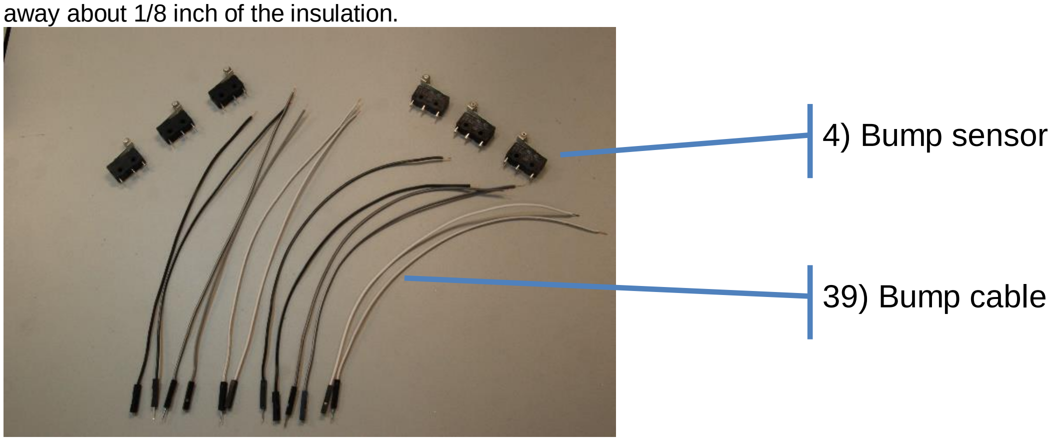
Option B)
Solder male headers to VREG (+5) and ground terminals of the **MDPDB**. Use a ribbon cable to connect these to the LaunchPad. Be sure that the +5V wire is able to be easily removed to prevent two different power sources (USB power and **MDPDB** robot batteries) from being connected together.

Note: The kit includes a 1x20 male header. If you need more headers, the **QTR-8RC Reflectance Sensor Array** also contains an unused 1x25 male header, which may be substituted. This IR reflectance sensor will use a 1x11 *right angle* male header.

Stage 3) Prepare the bump switches

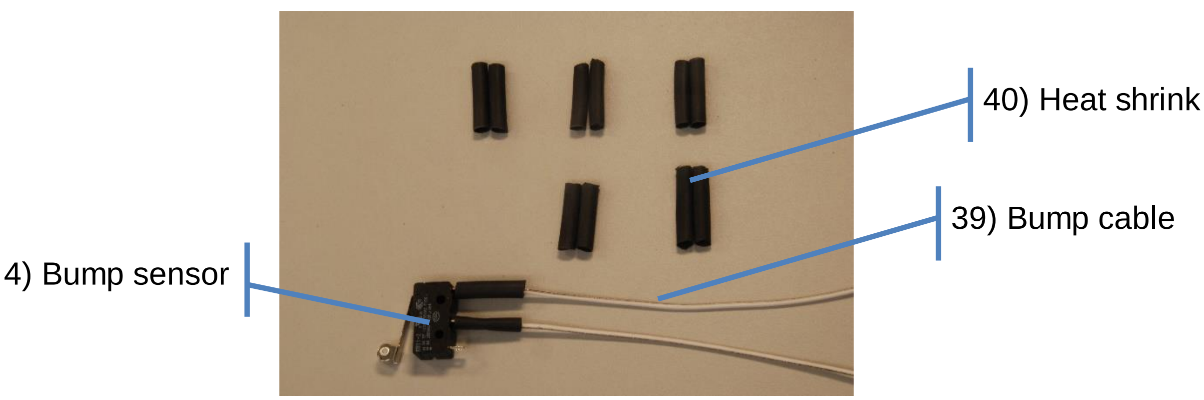
Step 1) Wires

Separate 12 individual wires (39) from the ribbon cable. Consider which genders you want to use and if you want the switches (4) to be positive logic or negative logic. Also consider if the switches will connect to the top or bottom of the LaunchPad. If you installed a male header in Stage 2), Step 8), you will want at least 6 female wires. It might be more convenient later if you use six pairs of the same color wires. Cut off the unneeded end of the wires and strip away about 1/8 inch of the insulation.



Step 2) Heat shrink

Cut 12 pieces of heat shrink tubing (40) about 3/4 to 1 inch long. These will cover the solder joints, providing a little bit of mechanical and electrical stability. Test if the heat shrink tubes fit over the ends of the ribbon cable. If not, you must now slip them over the cut ends of each of the 12 wires. Otherwise, you can apply the heat shrink tubes at your convenience later.

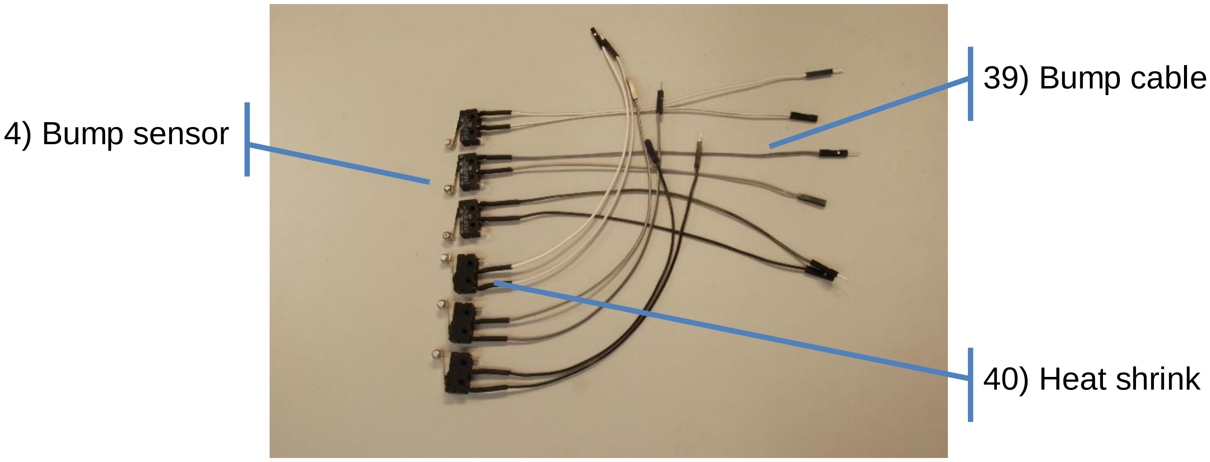


Step 3) Soldering

Solder the wires (39) to the bump switches (4). For the example code in the labs to work without modification, wire the switches in normally open configuration. This means to solder one wire to the terminal marked “1” or “C” and to solder the other wire to the middle terminal marked “3” or “NO”. Use an ohmmeter if you are still not sure which terminal is which. “Normally open configuration” means high impedance when the switch is released and low impedance when the switch is pressed.

Step 4) Shrink the heat shrink

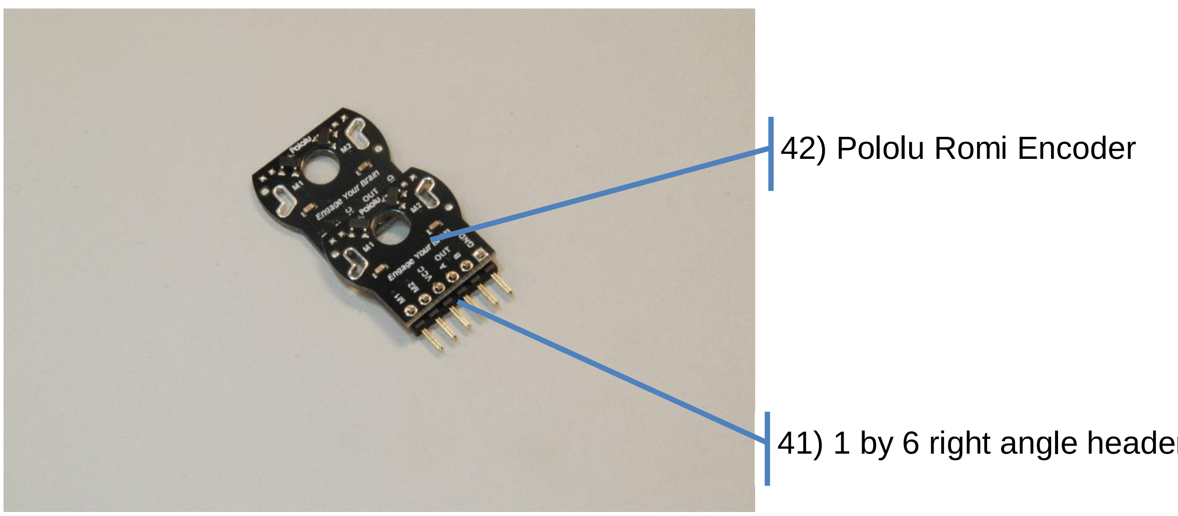
Slide the twelve heat shrink tubes (40) over the solder joint and use a heat source to shrink it.

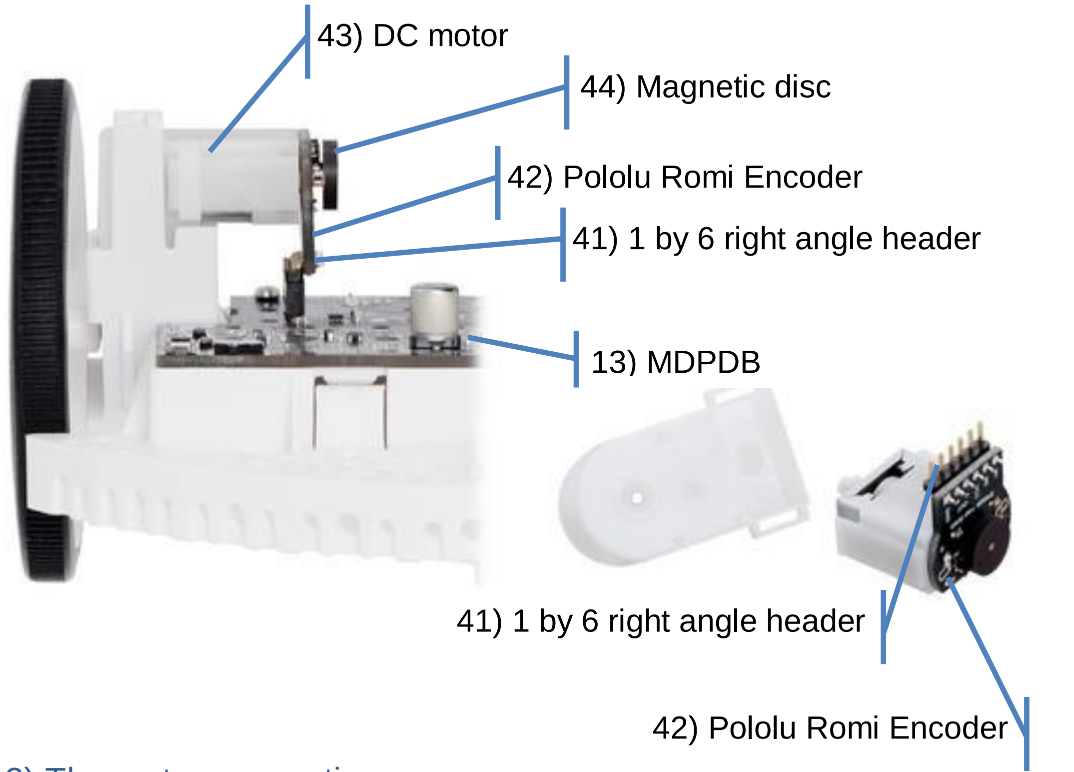


Stage 4) Prepare the motor gearboxes

Step 1) The right-angle headers

Solder the 6-pin right-angle male headers (41) to both PCBs in the Pololu **Romi Encoder Pair Kit** (42). The right-angle male header is not exactly symmetrical, so note the location of the black plastic piece in these images from Pololu. The bulk of the header will be on the flat side of the shaft encoder PCB, the side without the silkscreen and without the components.

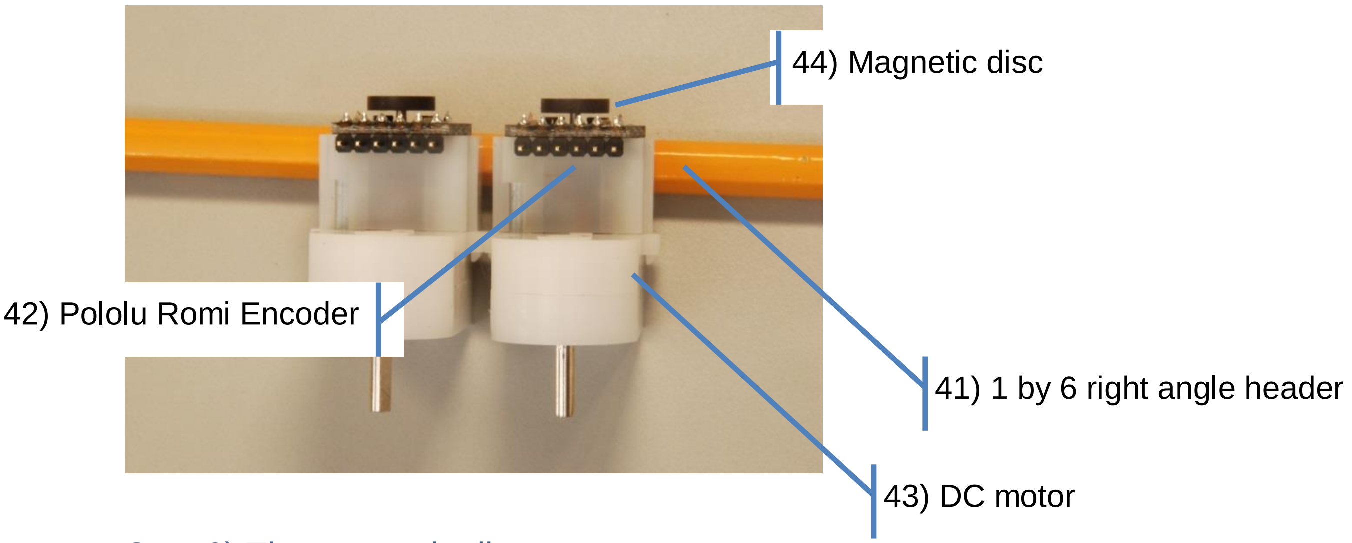




Step 2) The motor connections

Slide the shaft encoder PCBs (42) over the motor (43) shafts and motor power wires and align them to be straight and snug with the motor housings. The Hall Effect sensors should be on the opposite side of the board as the motors. The Pololu assembly instructions suggest,

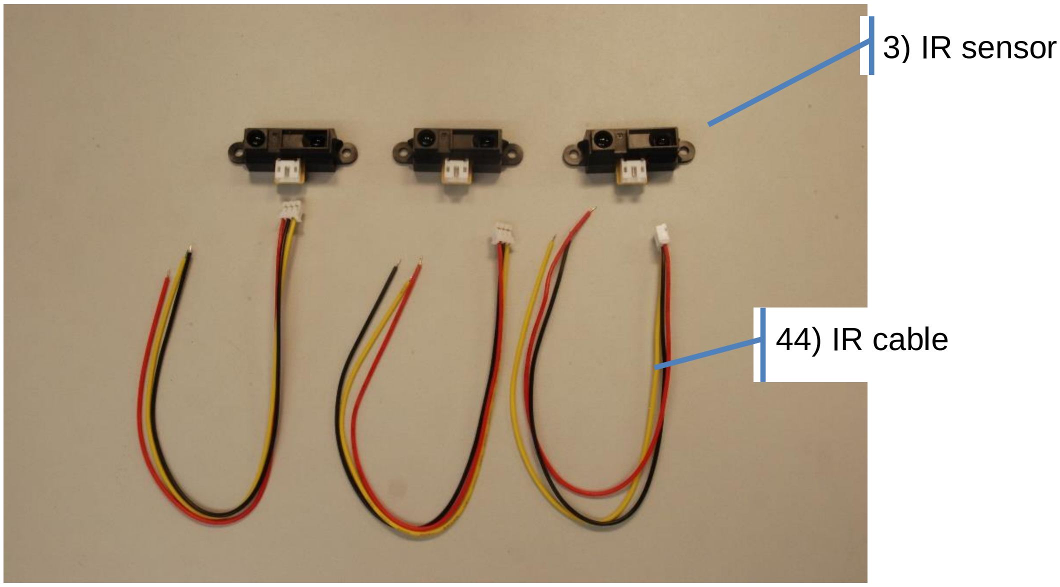
"One way to achieve good alignment between the board and the motor is to tack down the board to one motor pin and to solder the other pin only when the board is flat and well aligned. Be careful to avoid prolonged heating of the motor pins, which could deform the motor case or brushes."
https://www.pololu.com/product/3542



Step 3) The magnetic disc

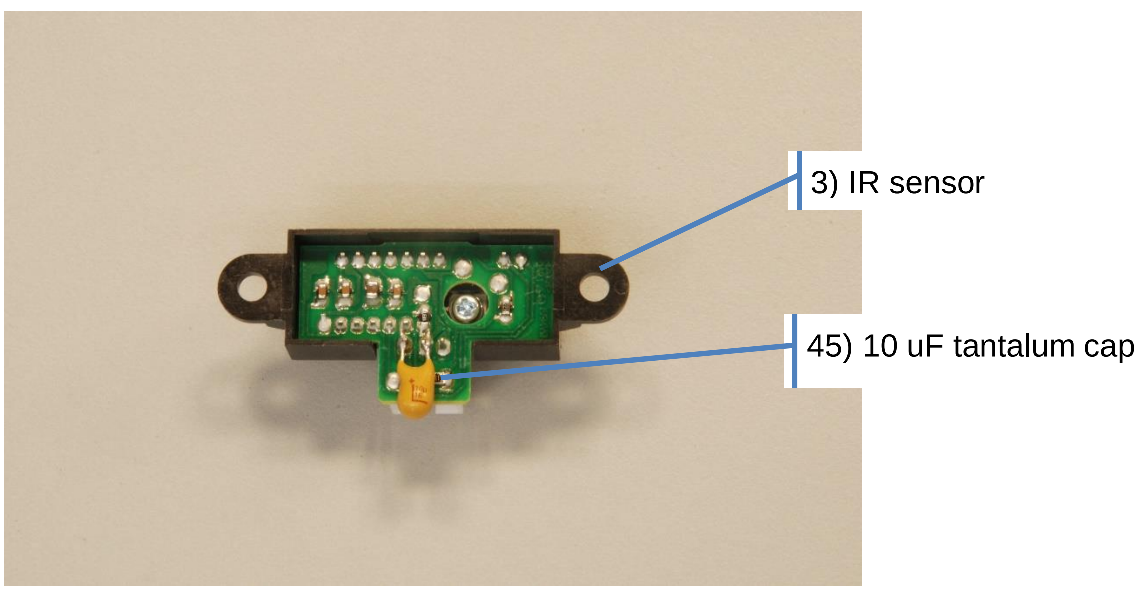
Gently press the 6-pole magnetic discs (44) onto the exposed motor shafts.

Stage 5) Prepare the IR distance sensors



Step 1) 10 µF bypass capacitors

The manufacturer of the **Sharp GP2Y0A21YK0F** recommends placing a 10 µF capacitor (45) across the power and ground physically near the sensor (3). One way to do this is to solder it directly to the leads of the connector that protrude out from the bottom of the sensor's PCB. The tantalum capacitor in the kit is polarized, so it is important to connect it the correct direction. See Stage 2), Step 11) or the datasheet for a review of which pin is which. After soldering, use an ohmmeter to confirm that there is a non-zero impedance between the VCC and GND pins. Repeat this step for all three IR sensors.

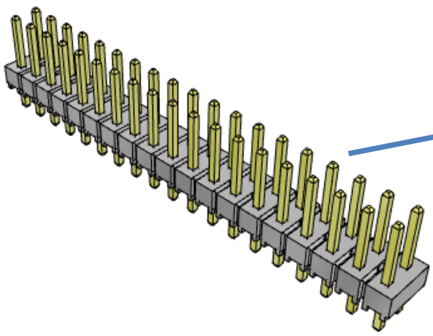


If your soldering iron's tip is too big, it will be excessively difficult and frustrating to avoid shorting one or more pins together or melting the plastic. If that is going to be the case, then you should use the solderless breadboard or skip this step if the power wires are already soldered from a previous step.

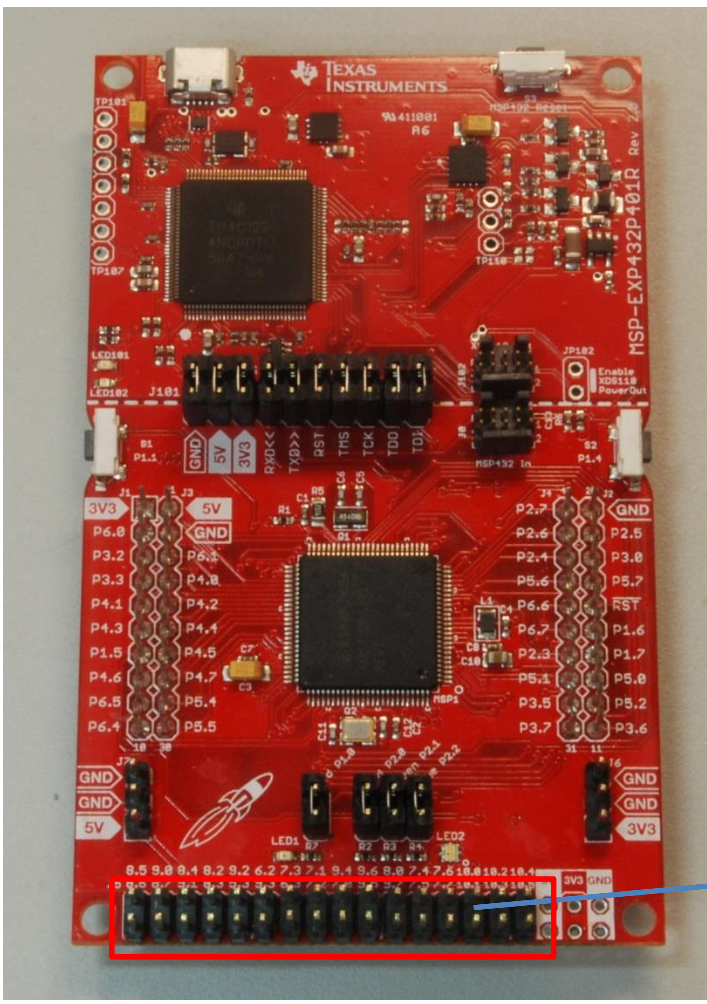
Stage 6) Prepare the LaunchPad

Step 1) J5 header

Break the two-row male header into 2x19 (46) and solder it in J5 (47). If you soldered directly to the power terminals on the right in Stage 2), Step 12), then break the header into 16 columns (2 by 16 header) before soldering.



46) 2 by 19 male header

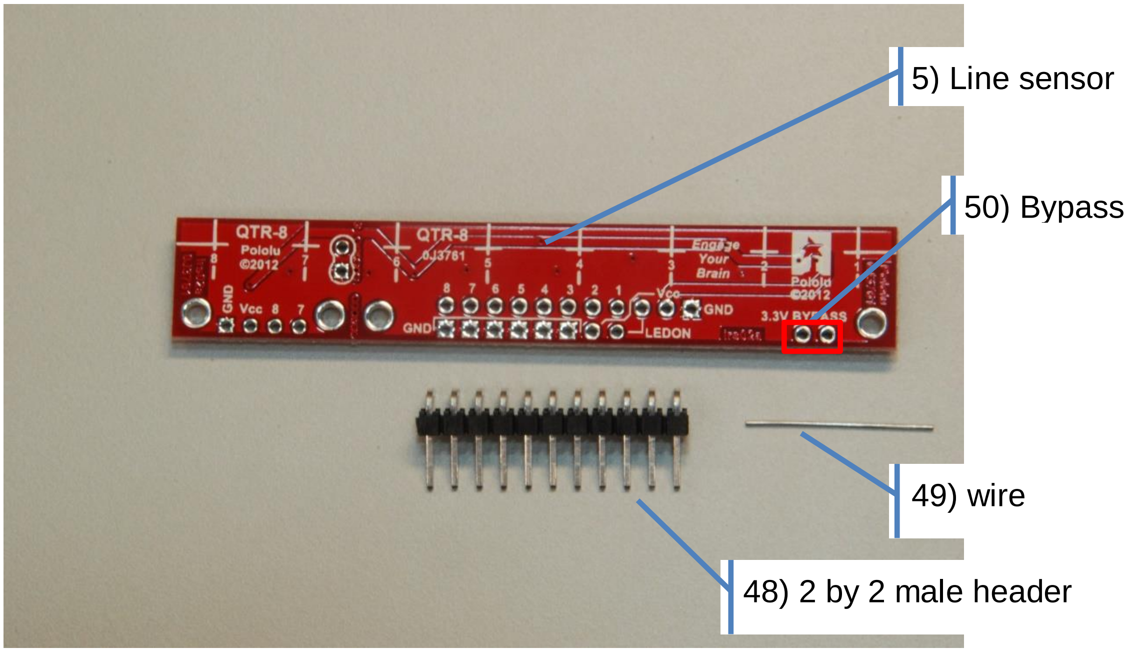


47) J5

Stage 7) Prepare the IR reflectance sensor

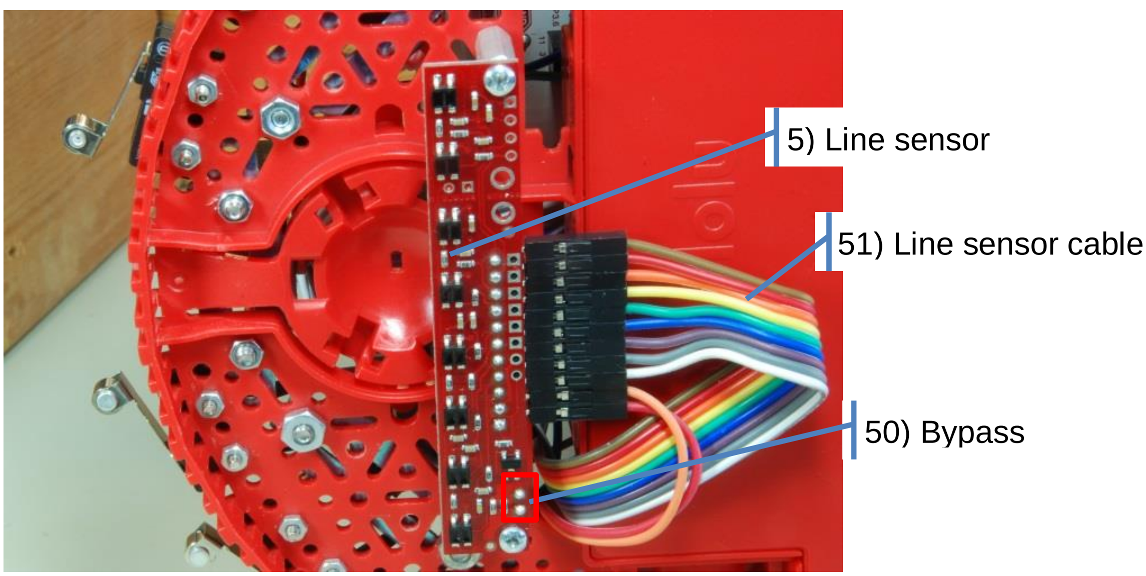
Step 1) The 11-pin right-angle header

Break the right-angle male header into 1x11 and solder it into the long row of terminals, which include the 8 sensor outputs, the IR illumination LED input, power, and ground. To prevent the wires (51) from dragging on the ground below the robot, attach it so the bulk of the header is on the flat side of the PCB, the side opposite the components.



Step 2) The 3.3V bypass

Solder a short piece of wire between the two terminals labeled "**3.3V BYPASS**". This will make the IR reflectance sensor 3.3V compatible. A single piece of solid wire bent into a 'U'-shape will work (49). Solder it on the flat side of the PCB, same as the previous step.



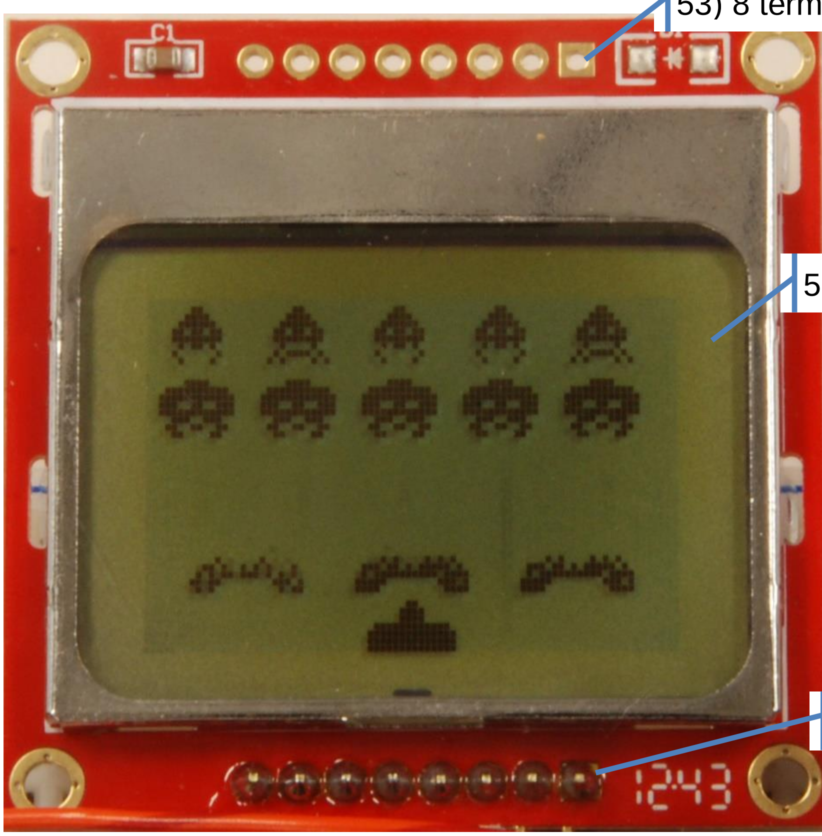
Step 3) The extra resistor and straight header

The **QTR-8RC Reflectance Sensor Array** comes with an extra 100 Ohm resistor and 25-pin 0.1 inch straight header. The resistor is for an unneeded mode (if you choose to split the 8 sensors into separate 6 and 2), and it is extra. The right-angle header included in the kit and recommended in Step 1) allows for a more compact connection than the straight header. The straight header might have been useful in Stage 1) for attaching to the **MDPDB** or for a spare in case you have trouble breaking it cleanly. Otherwise, it too is extra.

Stage 8) Prepare the Nokia 5110 LCD

Step 1) The header

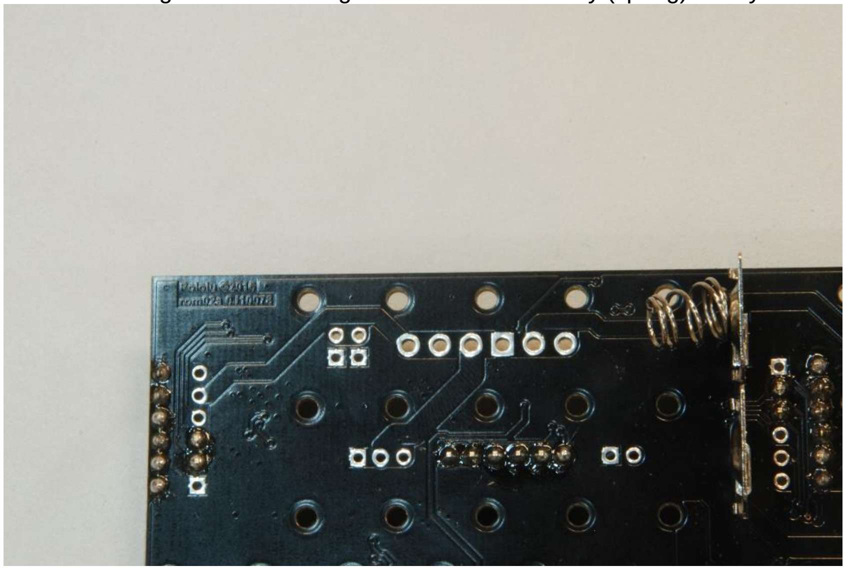
Break off a 1x8 male header (52) and solder it into the row of terminals for the **Nokia 5110** interface (53). These LCDs are sometimes attached to PCBs with more than one row of terminals (54). This allows the screen to be installed in different orientations. Double check the datasheet for your specific part to avoid choosing the wrong row and soldering your display upside down. However, if you connect each wire to the proper pin, it will work, and you will see an upside down image. Then, the image can be reversed by modifying the software to send the data in the opposite order.



Stage 9) Attach the MDPDB

Step 1) The four battery terminals

Drop the four battery terminals from the top, and orienting the Bat+ signals with the positive side of the battery (tab) and the Bat- signals with the negative side of the battery (spring). They will fit loosely in place.



Step 2) The two screws

Screw the **MDPDB** to the chassis using the two screws and nuts provided in the **MDPDB** kit. There are numerous mounting holes that can be used, but try to pick two that are far apart. The battery terminals will protrude through slits in the **MDPDB**.

Step 3) Solder the battery terminals

Solder the four battery terminals. Take care to heat up the large area of the terminal enough that the solder flows between the metal plates and makes a good connection. It should be shaped more like a hill and less like a sphere. It takes some patience, but the **MDPDB** can still be removed from the chassis by unscrewing it, compressing the battery springs, and gently pushing them up through the holes in the chassis.

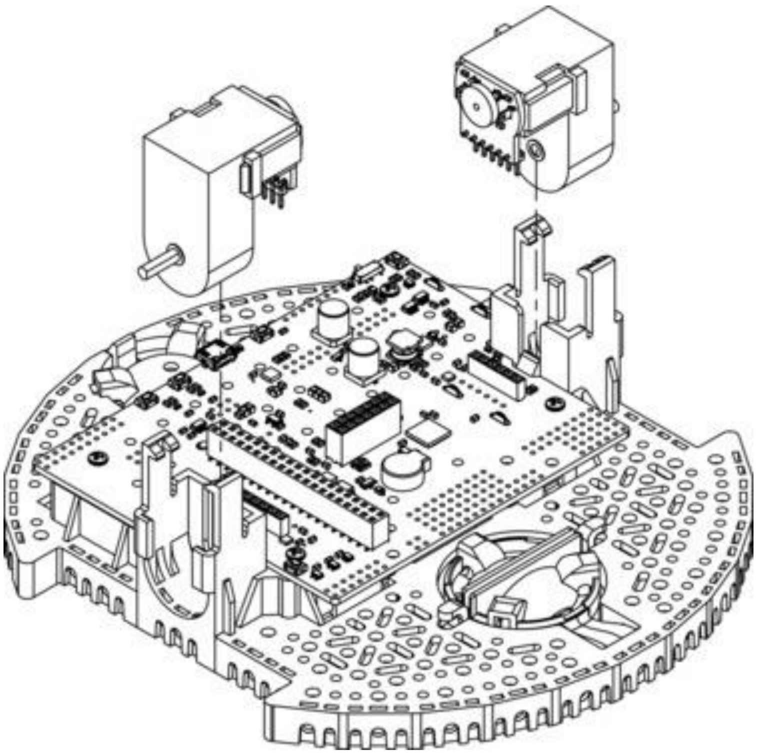
Stage 10) Attach the motor gearboxes

Step 1) The tires

Gently stretch the rubber tires over the plastic wheel frames. Be careful and patient; the tire is only barely stretchy enough to go around the wheel, and it will be a snug fit.

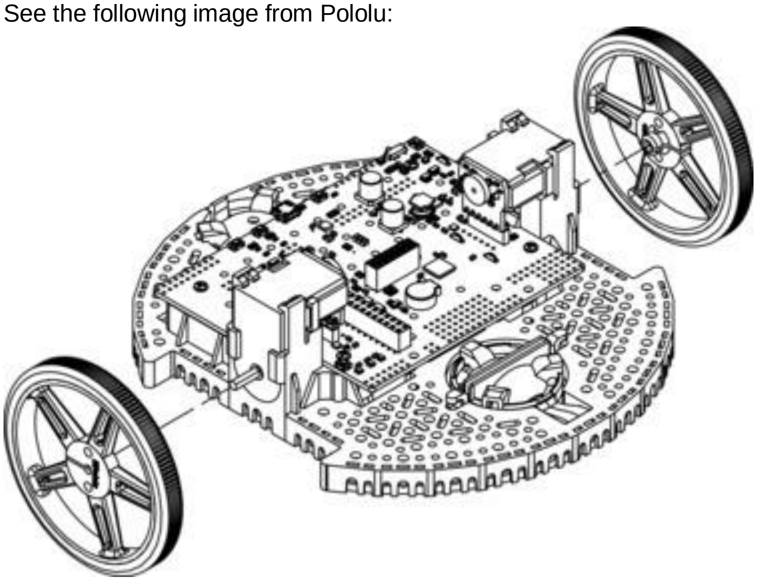
Step 2) Snap into place

Gently lower the motor gearboxes into the motor clips with the wires and the round side down. The right-angle male headers on the **Romi Encoder Pair Kit** should plug into the female headers on the **MDPDB**. The motor gearboxes snap securely in place. See the following image from Pololu:



Step 3) The wheels

Gently press the plastic wheel frame onto the metal shaft that extends out of the motor gearbox until the motor shaft is flush with the outer face of the wheel. Notice that the holes are 'D' shaped, so they need to be aligned properly. See the following image from Pololu:



The Pololu assembly instructions suggest,
"One way to do this is to set the wheel on a flat surface and line the chassis up with it so that the flat part of the motor's D-shaft lines up correctly with the wheel. Then, lower the chassis, pressing the motor shaft into the wheel until it contacts the surface."
https://www.pololu.com/docs/0J68/4 (Step 12)

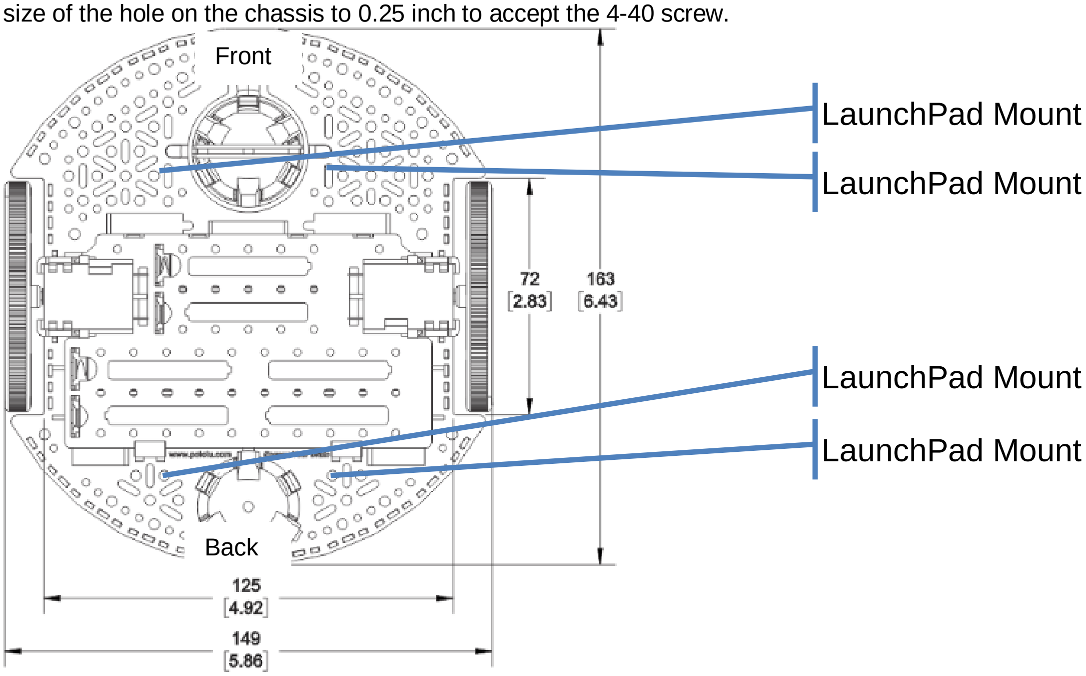
Stage 11) Attach the LaunchPad

Step 1) Electrical connections

Attach the following wires to the MDPDB because after this Stage, it will be physically obscured by the LaunchPad:
Separate a 1x6 female-to-female ribbon cable and attach one end to the row of motor control headers.
Separate a 1x2 female-to-female ribbon cable and attach one end to the left wheel shaft encoder header.
Separate a 1x2 female-to-female ribbon cable and attach one end to the right wheel shaft encoder header.
Separate a single female-to-female ribbon cable and attach one end to the VPU header.
Separate a single female-to-female ribbon cable and attach one end to the VCCMD header.
If in Stage 2), Step 12), you used male headers for the power to the LaunchPad, attach two single female-to-female ribbon cables to these headers.
If in Stage 3), Step 1), you used female ribbon cable wires for all 12 terminals of the bump switches, it might be easier to plug 6 of these into the ground headers of the **MDPDB** now. The LaunchPad does not completely obscure these pins, and these connections can be made later. Alternatively, if you used male ribbon cable wires for all 12 terminals of the bump switches, you must connect them to Port 4 on the bottom of the LaunchPad now.

Step 2) The four Nylon standoffs

Attach four 1.375in 4-40 Nylon standoffs to the robot chassis using 0.25in screws. Align the standoffs with the four holes on the LaunchPad. Depending on where you choose to mount the LaunchPad, you may have to increase the size of the hole on the chassis to 0.25 inch to accept the 4-40 screw.



Step 3) Secure the LaunchPad

Bolt the LaunchPad in place using two 0.187in 4-40 metal nuts. They should fit snugly near J5 if the 2x19 male header is used. Otherwise, without the male header, there is slightly more room to turn. Attach J5 facing the front of the robot, and the USB cable on the LaunchPad facing the back of the robot (like a tail). Bolt the other end of the LaunchPad in place using two 0.75in 4-40 metal standoffs.

Step 4) Check mechanical fitting

The default holes in the unmodified Romi chassis are not perfectly LaunchPad-shaped, although the orientation suggested above is very close. Nevertheless, it is very important that the side of the LaunchPad and any nearby wires do not scrape against the spinning shaft encoder disk and protruding axle. Frequently check that the motors can spin freely.

Step 5) Prepare the solderless breadboard (not needed for Demo so will move to the bottom (any concern?)

Drill two 0.25in holes in the solderless breadboard to align with the two 0.75in standoffs. If the solderless breadboard has 30 rows, estimate to drill through the center channel at rows 5 and 26.

Step 6) Secure the solderless breadboard

Attach the breadboard to the standoffs using two 0.5in Nylon screws.

Step 7) Power the solderless breadboard

Attach the +3.3V and ground wires to the breadboard. A pair of female-to-male ribbon cables can be used to go from the top of J1/J3, the end of J5, or the seldom-used J6 on the LaunchPad to the red and blue columns on the breadboard.

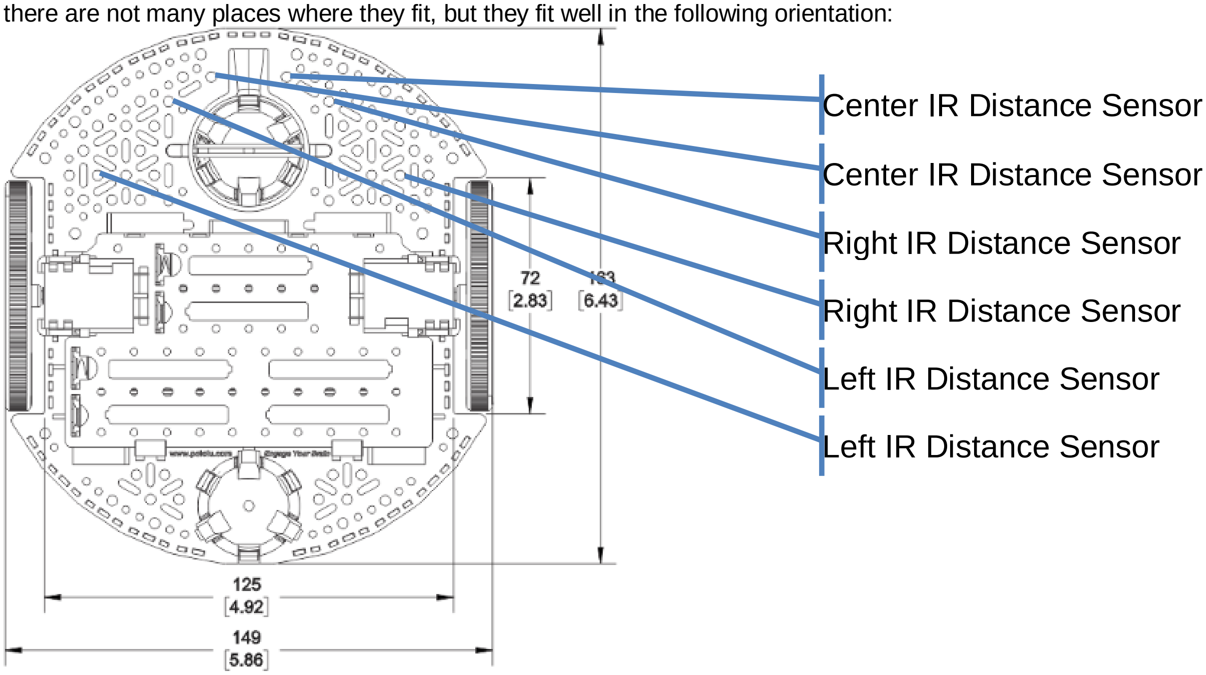
Stage 12) Attach the IR distance sensors

Step 1) Attach sensors to brackets (does Polulu have a video or guide for this)

Bolt the three **Sharp GP2Y0A21YK0F** IR distance sensors to three of the **Bracket Pairs** from Pololu. The **Bracket Pairs** come with 4 or 5 pairs of 4-40 screws and nuts that work well here. There will be one completely extra bracket and possibly a few extra pairs of 4-40 screws and nuts, which may be used in the next Step.

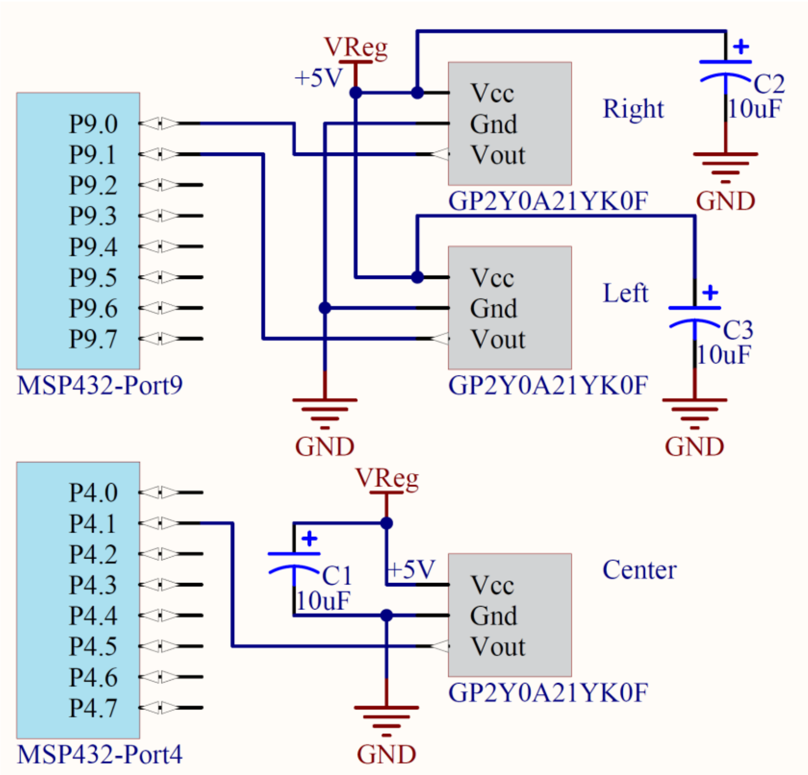
Step 2) Attach brackets to chassis

Bolt the sensor and bracket assemblies to the Romi chassis. The kit includes enough 0.25in 4-40 screws and nuts (also used to attach the Nylon standoff to the bottom of the Romi chassis and the LaunchPad to the top of the standoff), but extras from the previous Step can be interchanged. In theory, these should be as close to the center of the robot as possible (due to the 10 cm “blind spot” of the sensor) and looking forward and at 45 degrees. In practice, there are not many places where they fit, but they fit well in the following orientation:

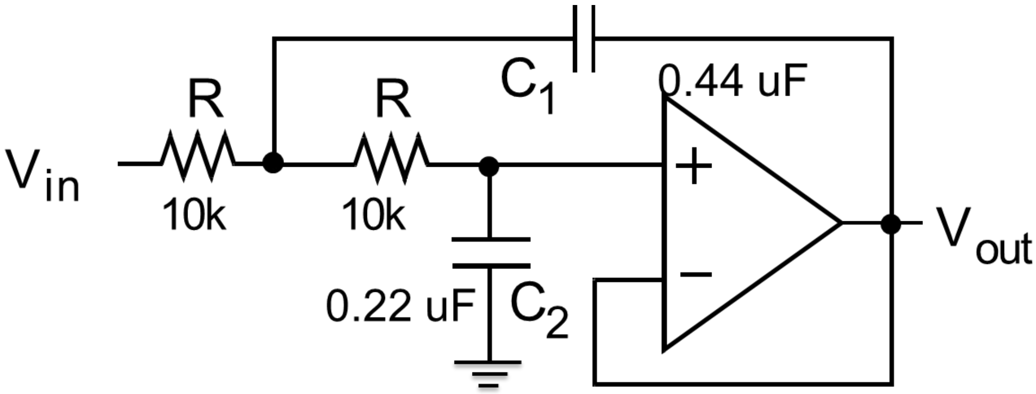


Step 3) Electrical connections (Pictures would help)

Plug in the three connectors to the three IR distance sensors. Connect the other end of the wires as shown in the following schematic. Power and ground might have been done in an earlier Step. For Vout, one way to connect to the male headers on P9.1 and P9.0 is to use the ribbon cables in the kit. The IR distance sensor cable probably terminates in a crimped header or a bare wire, but the female connector from the ribbon cable is sturdy and more convenient. Separate two strands of ribbon cable, save the female connector and cut off the other end (or cut a female-to-female strand in half), strip it, solder it to the IR distance sensor cable, and cover the solder joint with a piece of heat shrink. For P4.1, there is the flexibility to use the female headers on the bottom of the LaunchPad or the male headers on the top. The IR distance sensor cables with the crimped header can conveniently plug into the female headers (although the LaunchPad will need to be removed and Stage 11) will need to be repeated). Otherwise, the same process can be repeated three times to splice female ribbon cable connectors to all three Vout wires.



As an option, you could build three analog low pass filters (LPF) and place them between the sensor and ADC. If the sampling frequency is 1000 Hz, then the cutoff for the analog LPF should be about 100 Hz. This is important because these IR distance sensors generate a very noisy output, and a filter can greatly improve the sensors' accuracy. The lab procedure uses software to implement this filter, but this solution requires a lot of time and processing power. A faster filter will allow the robot to get more accurate sensor readings more frequently, which will allow it to make better decisions more often, which in turn enables it to go around the track more smoothly and quickly. Physically, this filter could be built on the solderless breadboard. In that case, it would be better to splice male ribbon cable connectors to plug the three Vout signals into the breadboard.



Stage 13) Attach the bump switches

Step 1) Attach switches to chassis

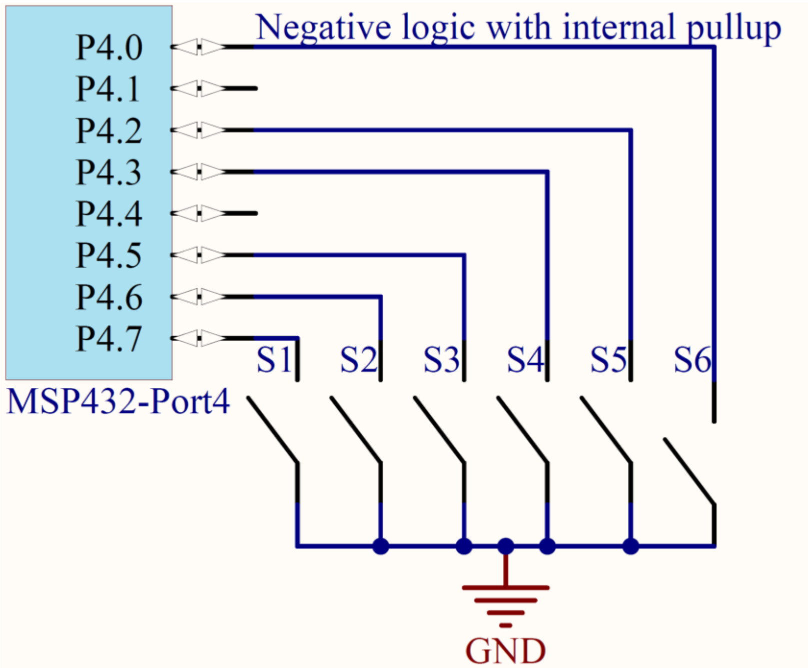
Bolt the six bump switches to the Romi chassis. Consider all the different angles from which the robot can hit the wall, and attach the switches so that each collision presses at least one switch. The twelve 0.5in 2-56 (or M2) screws and 2-56 (or M2) nuts fit through the holes along the edge of the chassis. Mounting half of the switches “upside down” relative to the others allows the arms to stick out in the following configuration:

Bump sensors attached to the front of the robot (bottom view).

Step 2) Electrical connections

Consider which labs you are going to do.
Option A:
If you are going to do the Wifi lab, we recommend using pins P8.7-P8.3, P8.0 for the six bump sensors, because these pins do not conflict with the Wifi Booster Pack.
Option B:
If you are going to do the edge-triggered interrupt lab, we recommend using pins P4.7-P4.2 for the six bump sensors, because these pins can cause edge-triggered interrupts.

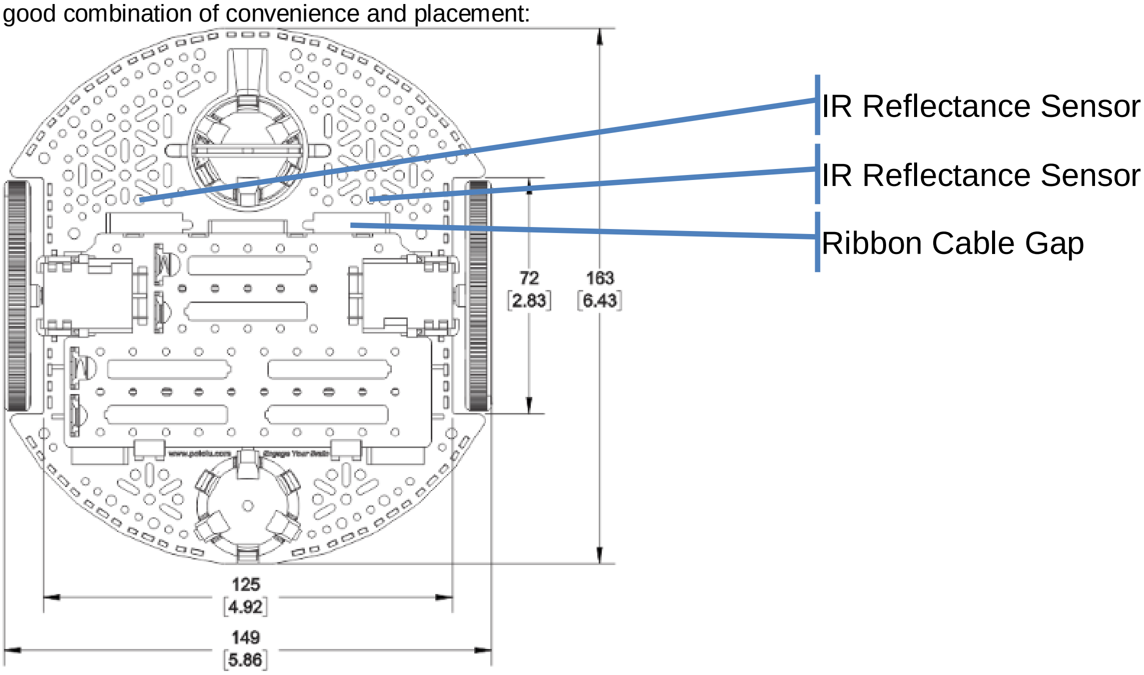
To make the switches negative logic, connect the C (common) pin of all switches to ground, connect the NO pins (normally open) of the switch to a GPIO input pin, and activate internal pull up on all the pins. Bump0/S1 is on the robot’s right, and it is wired to the lowest numbered pin. Bump5/S6 is on the robot’s left, and it is wired to the highest numbered pin.



Stage 14) Attach the IR reflectance sensor

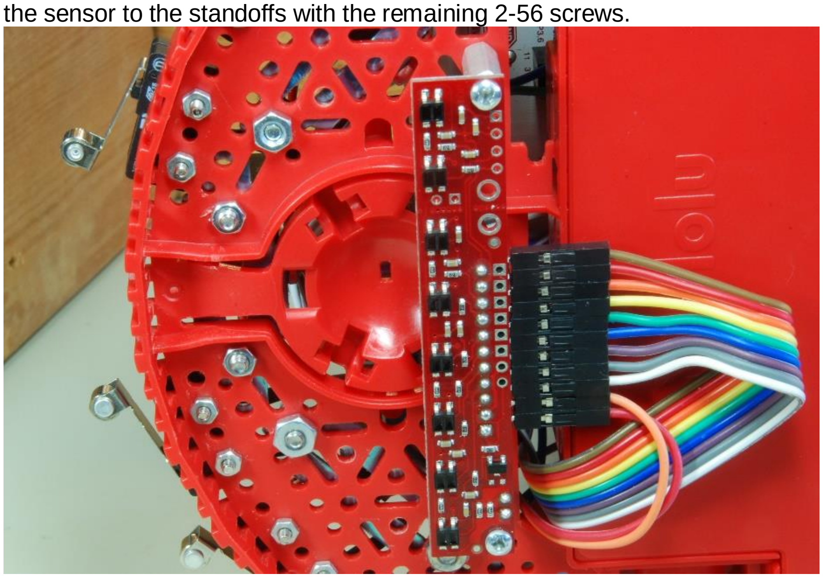
Step 1) Attach standoffs to chassis

Bolt the two 0.5in 2-56 metal standoffs to the bottom of the Romi chassis. In theory, these should be as close to the wheels as possible and centered equally between them. The optimal distance from the **QTR-8RC Reflectance Sensor Array** to the track is 0.125in (3mm), and the maximum distance is 0.375in (9.5mm). The battery cover and low robot clearance make it difficult to mount the sensor exactly between the wheels, but the following orientation is a good combination of convenience and placement:



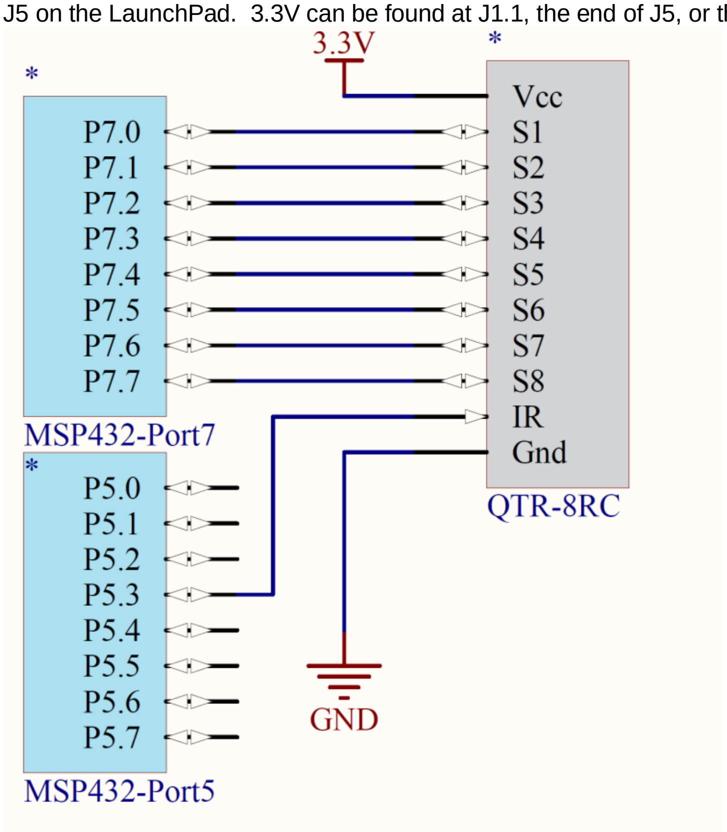
Step 2) Attach sensor to standoffs

Separate a 1x11 female-to-female ribbon cable and attach one end to the IR reflectance sensor. Bend it over to keep it from dragging on the ground under the robot, and feed the free end up through one of the gaps in the chassis. Bolt the sensor to the standoffs with the remaining 2-56 screws.



Step 3) Electrical connections

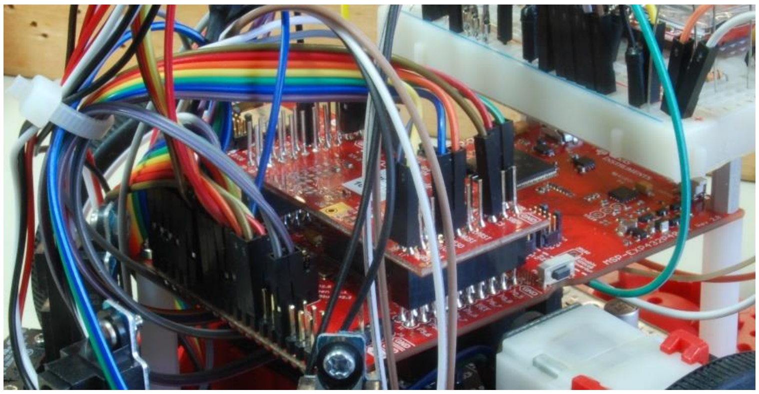
Connect the other end of the ribbon cable as shown in the following schematic. Port 5.3 and all of Port 7 are part of J5 on the LaunchPad. 3.3V can be found at J1.1, the end of J5, or the seldom-used J6 on the LaunchPad.



Stage 15) Double check final electrical connections

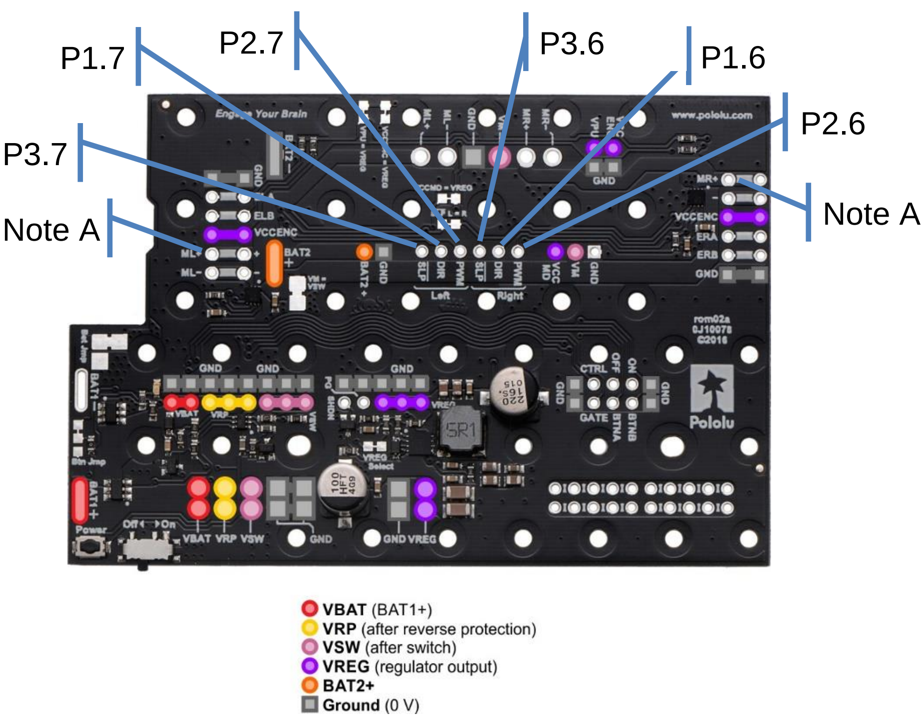
Step 1) Attach the CC2650 Bluetooth Booster Pack (need all the connections of the BLE and where they go – this photo does not represent the demo

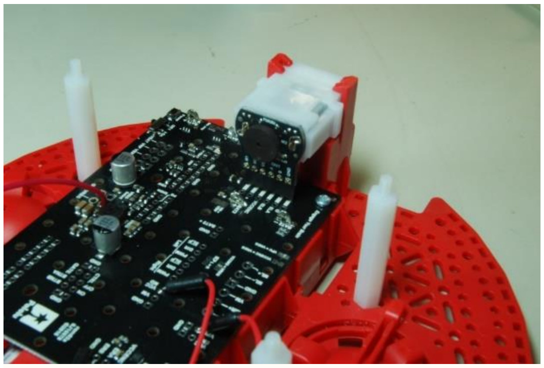
If you are going to use a CC2650 Bluetooth, attach it to the top side of the LaunchPad. Be careful because these modules can easily physically fit together in a way that is electrically incorrect. The text on the silkscreens should be facing the same direction on the LaunchPad as on the Booster Pack, and some Booster Packs have additional pins labeled to help show the proper alignment. Also verify that the connection is not “off by one”.

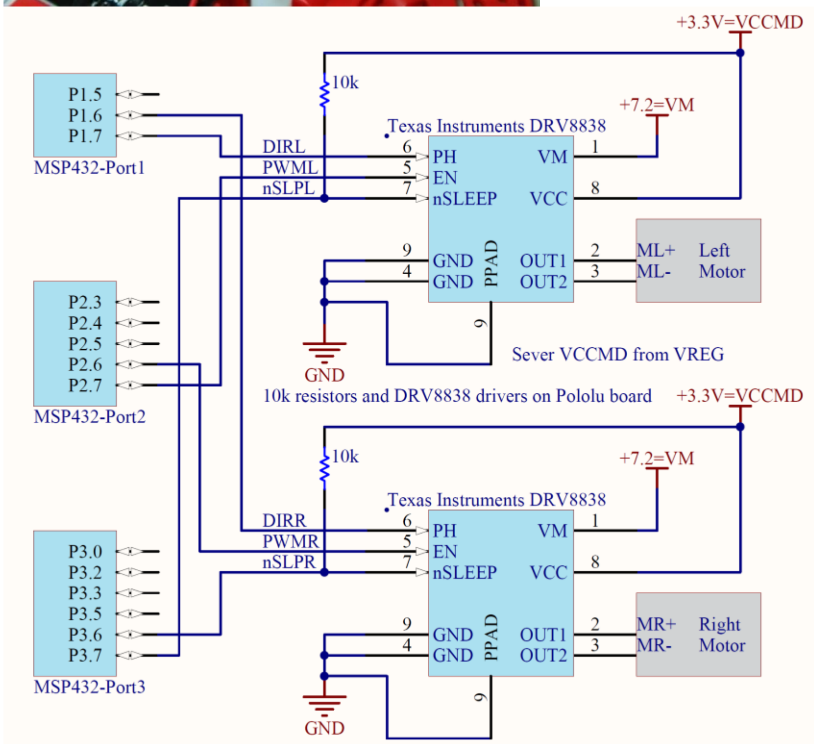


Step 2) Connect the motor control wires

Connect the 1x6 ribbon cable to the male headers on top of the LaunchPad or Booster Pack as shown.
Next, you will connect six wires from the **MDPDB** to the LaunchPad. Since these signals are on the regular LaunchPad connectors, you can use either male or female wires on the LaunchPad side (the robots in the figures use female connectors). On the **MDPDB** side you can solder wires directly, or solder a male header into the **MDPDB** and use female-female cables. Refer to the data sheet of the DRV8838 to see how the software output values to these six signals affect motor behavior.

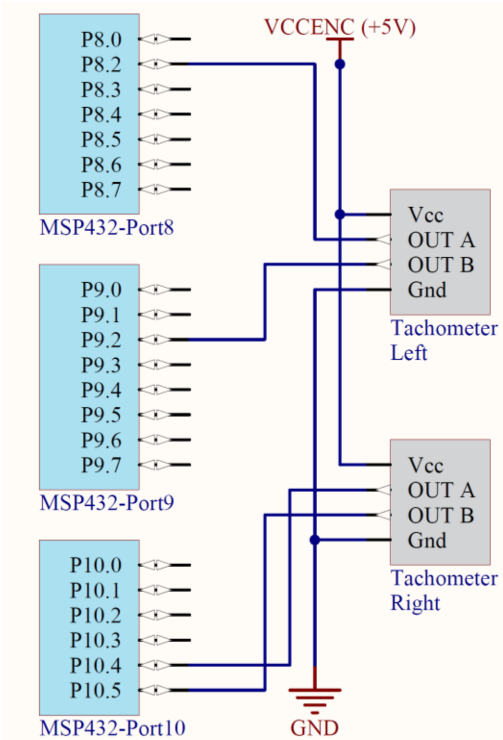




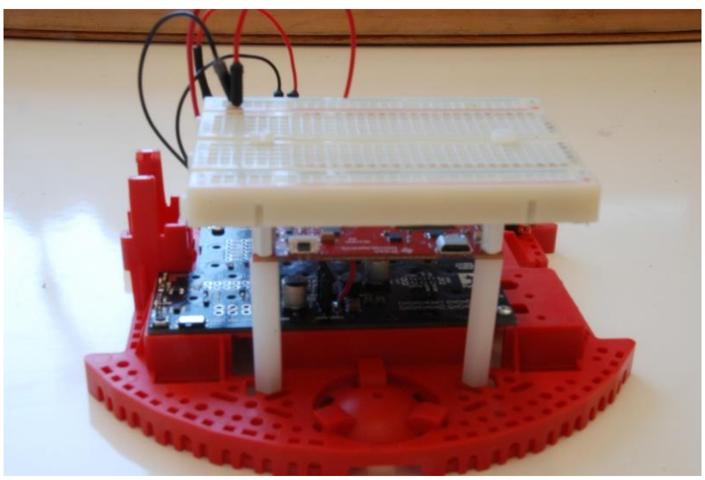


Step 3) Connect the shaft encoder wires

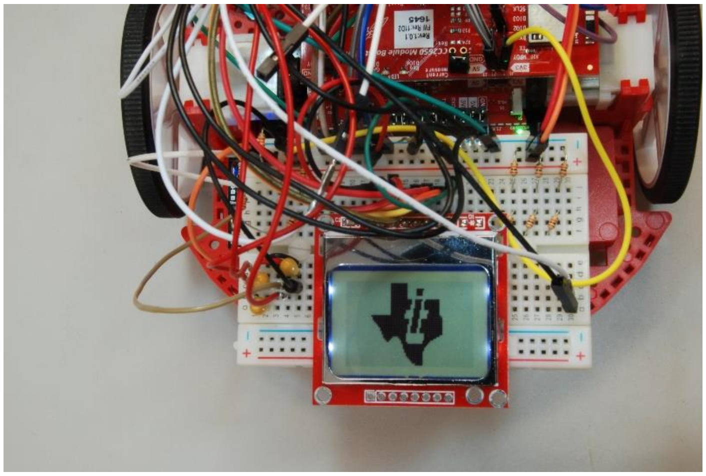
Connect the 1x2 ribbon cable from the left wheel such that ELA is connected to P8.2 and ELB is connected to P9.2. Connect the 1x2 ribbon cable from the right wheel such that ERA is connected to P10.4 and ERB is connected to P10.5.



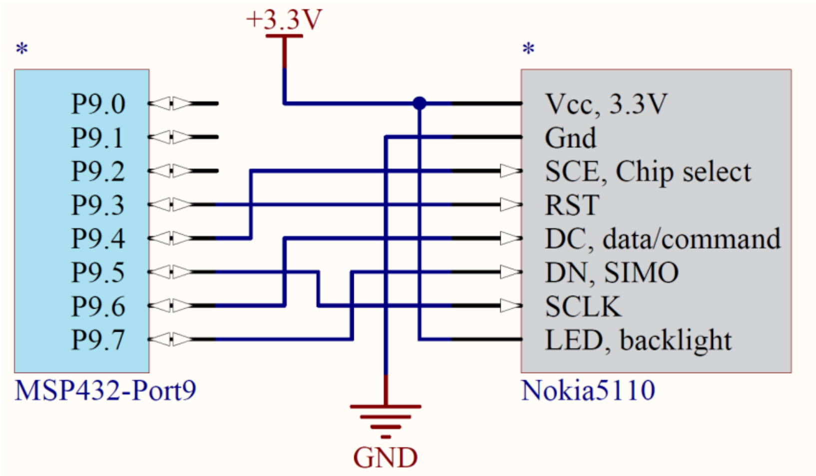
Step 4) Connect the Nokia 5110 LCD



Place the LCD on the solderless bread board.

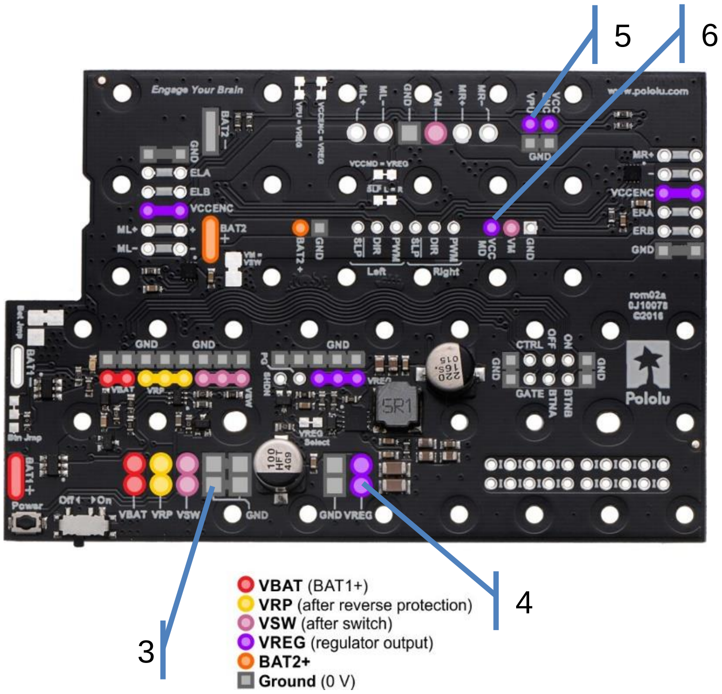


Connect the LCD to a SPI port of the MSP432. Double check the datasheet or the silkscreen on the actual part for your specific display because your wires are not necessarily in the same order as the ones shown.

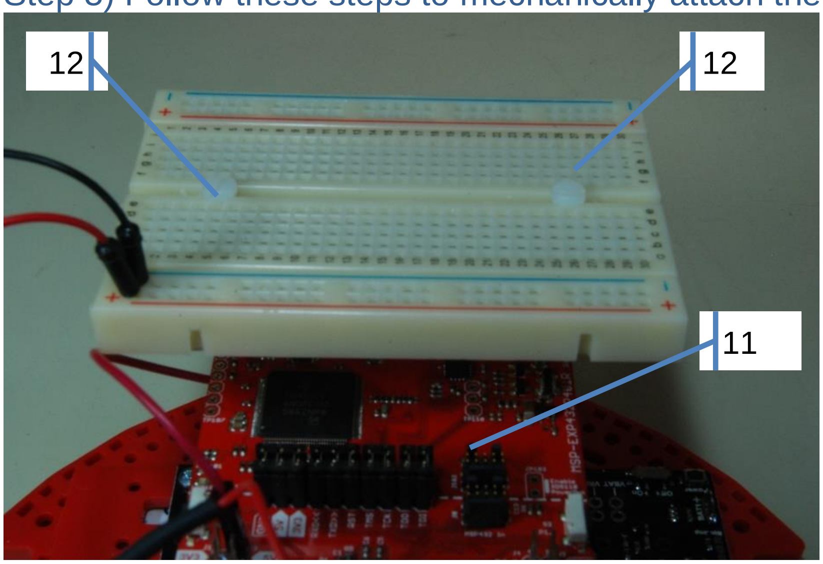


Step 4) Connect the MDPDB for use on the robot

3) Solder a ground wire from the **MDPDB** to ground on the LaunchPad
We suggest you review the entire MDPDB User's Guide
Make sure not to use holes needed later for the motors
4) Connect VREG (+5V) from the **MDPDB** to +5V on the LaunchPad
You will need a way to connect/disconnect +5V.
We suggest you solder one end of a wire to the VREG signal on the **MDPDB** and use a female header to connect it to +5V on the LaunchPad.
5) Connect VPU from the **MDPDB** to 3.3V on the LaunchPad
6) Connect VCCMD from the **MDPDB** to 3.3V on the LaunchPad
7) Solder a wire with a male header to the +3.3V power. Solder a second wire with a male header to ground. These two will be used to bring power to the solderless breadboard (shown in Figure 4).

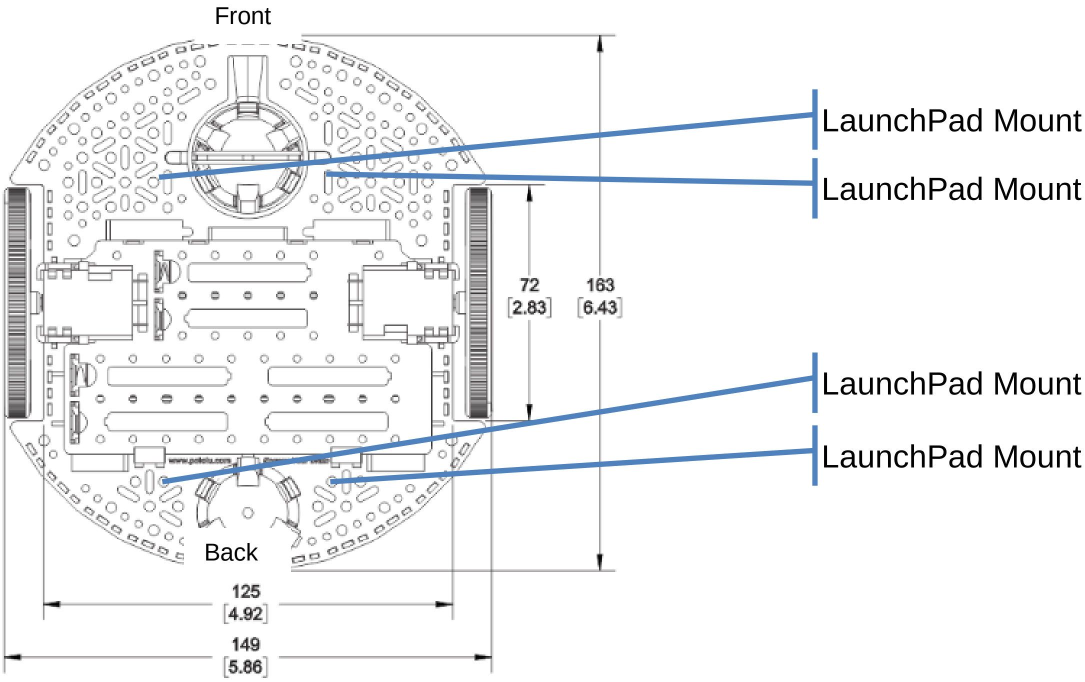


Step 5) Follow these steps to mechanically attach the boards to the chassis:



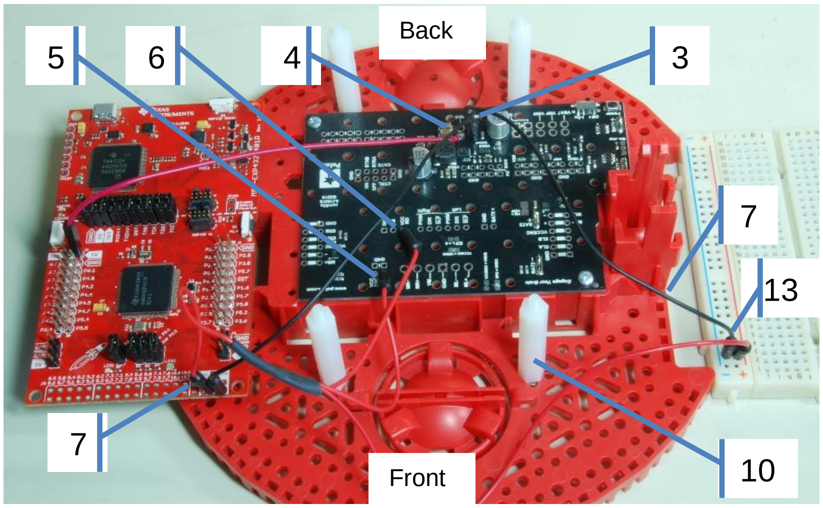
Solderless breadboard attached to the robot.

8) Drop the four battery terminals from the top, and orienting the Bat+ signals with the positive side of the battery (tab) and the Bat- signals with the negative side of the battery (spring). Screw the **MDPDB** to the chassis using the two screws and nuts provided in the **MDPDB** kit. See Figure 1 and follow directions from Pololu.
9) Double check the positive and negative alignment. Solder the four battery terminals from the chassis to the **MDPDB**. We suggest you solder the terminals after it is aligned with the screws and nuts. The board can still be detached from the robot by removing the screws and squeezing the battery springs. See Figure 1 and follow directions from Pololu.
10) Attach four 1.375in 4-40 Nylon standoffs to the robot chassis using 0.25in screws. Align the standoffs with the four holes on the LaunchPad. Depending on where you choose to mount the LaunchPad, you may have to increase the size of the hole on the chassis to ¼ inch to accept the 4-40 screw.



11) Place the LaunchPad on top of the standoffs orienting the USB cord out the back of the robot (the LaunchPad shown in Figure 7 will not be rotated before placement). Use two nuts in the front and two 0.75in 4-40 metal standoffs in the back to secure the LaunchPad.
12) Drill two ¼ inch holes in the solderless breadboard to align with the two 0.75in standoffs. Attach the breadboard to the standoffs using two ½ inch Nylon screws.
13) Attach the +3.3V and ground wires to the breadboard.

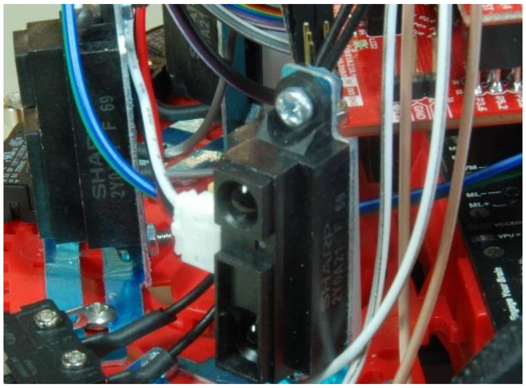
> Warning: Disconnect the VREG↔+5V wire when the LaunchPad USB cable is connected to the PC. Connect the VREG↔+5V wire when the robot is running on battery power.

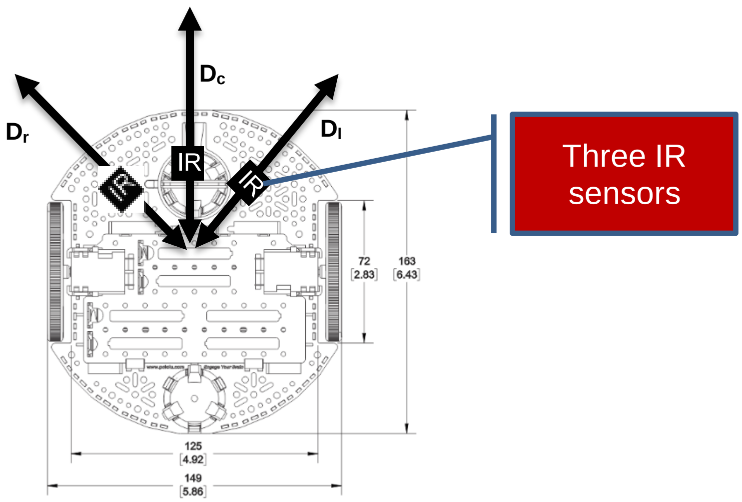


Motor Driver and Power Distribution Board connected to the LaunchPad. Grounds connected. VREG (MDPDB) to +5V (LaunchPad). +3.3V (LaunchPad) to VPU (MDPDB) and VCCMD (MDPDB).

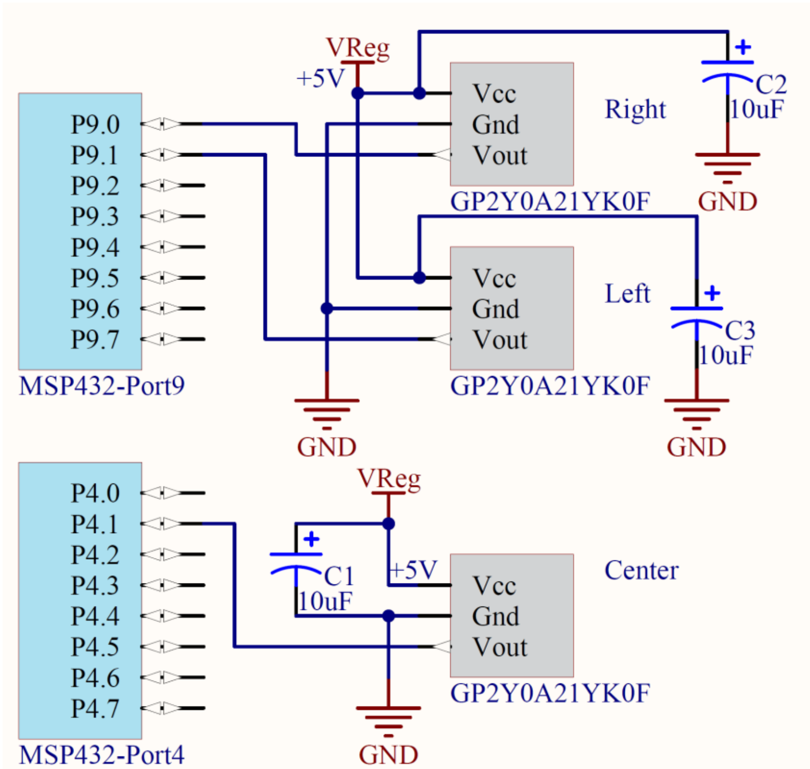
Step 6) Interface IR sensors

Attach three GP2Y0A21YK0F IR distance sensors to the robot, and then interface the outputs of the sensors to inputs of the ADC on your MSP Launchpad.





Define distance measured from a central point on the robot.



As an option, you could build three analog low pass filters (LPF) and place them between the sensor and ADC. If the sampling frequency is 1000 Hz, then the cutoff for the analog LPF should be about 100 Hz.