CSE 325 Project 2
Robot Car Assembly & Test Drive

Project Description

The purpose of this project is to assemble and test the car which is used for the rest of the projects.

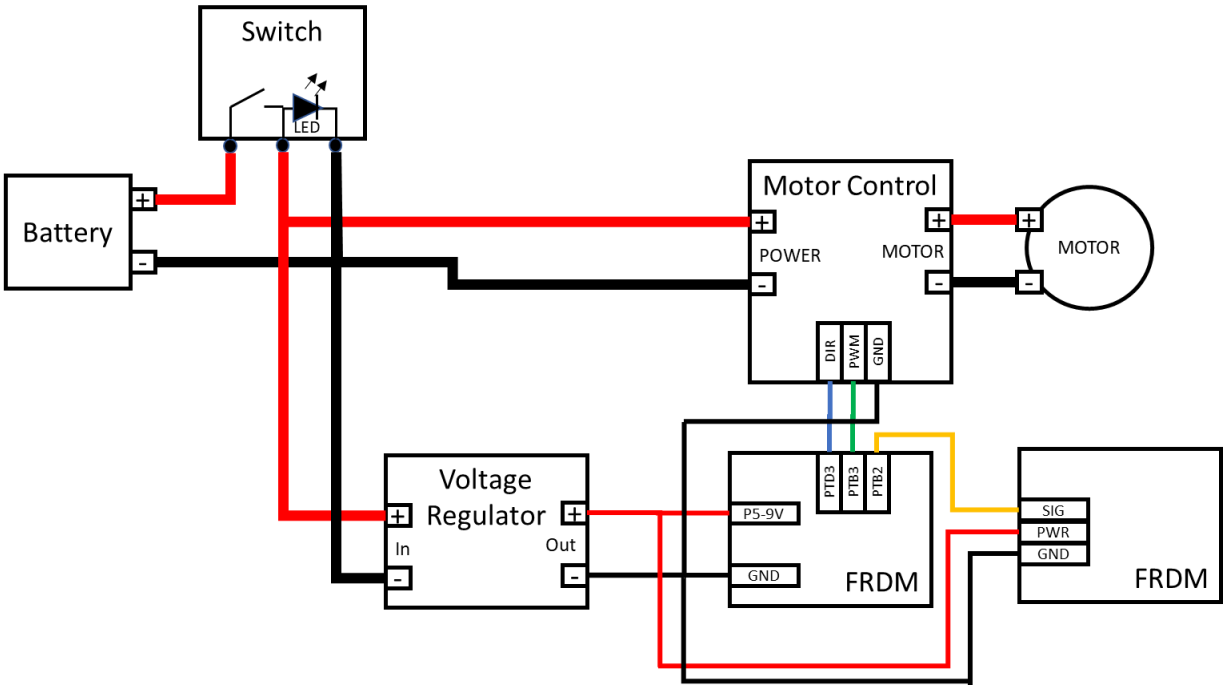
Required Hardware:

FRDM-KL46Z and cable.
Breadboard
30A motor driver (Motor driver)
3 Wires for PWM (FRDM to motor driver)
Battery Connector (Battery to motor driver)
Assorted Wires
Traxxas RC Car chassis
Black mounting top Plate
Power switch
Encoder Sensor & Mounting Hardware

The manual of FRDM-KL46Z and motor driver are available in the reference section of the course website.

Since this project uses the car that has been used previously, your car may have some mismatches with this document. In that case, please look at the same document prepared for new cars. All steps are explained carefully so you will figure out how to mend the parts.

Part 1: Wiring Motor and Servo



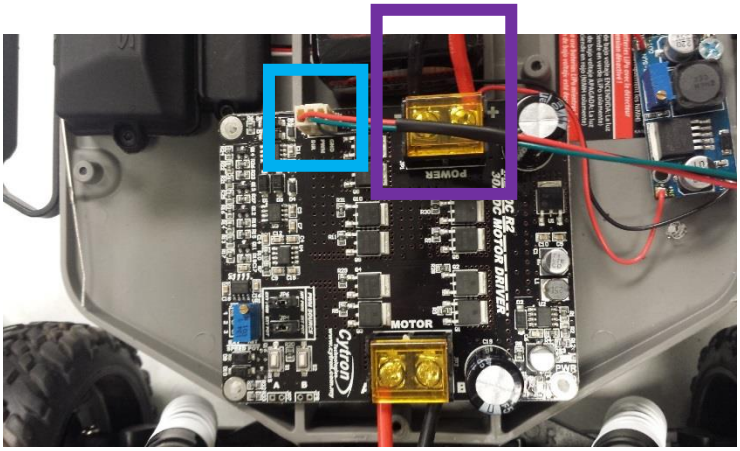


Figure 1 – Motor driver and its connections

Adding the power switch

In this step you need to add a new power switch if it's not there. The power switch is used to disconnect the battery from the circuit.

First, drill the top black plate when it's fixed on two woods.

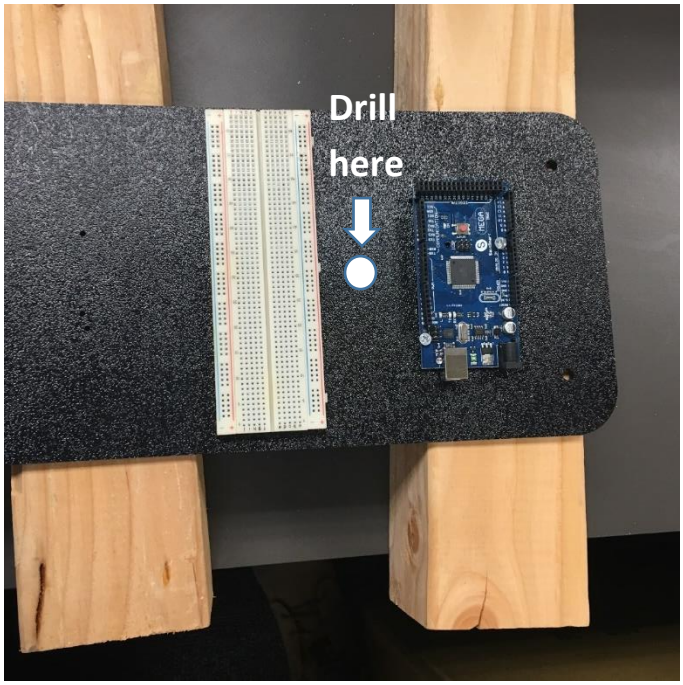


Figure 6 – Preparing the top plate to drill a hole for power switch

Then, take the switch and find out which borer size matches the cylinder under the switch. The drilled hole should be a little bit bigger than the cylinder and it shouldn't be so large that it can wiggle around.

Figure 7 - Choosing the suitable drill for the hole

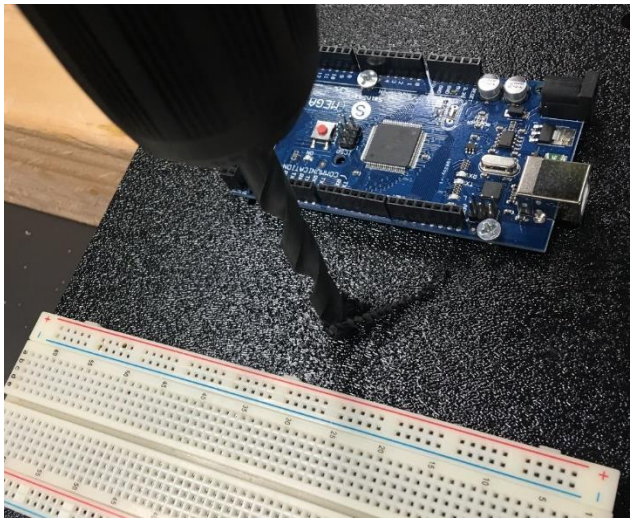


Figure 8 - Drilling the top Plate

Make a hole near the center of the top plate, in between the FRDM-KL46Z and the breadboard.
Be careful not to drill the table!

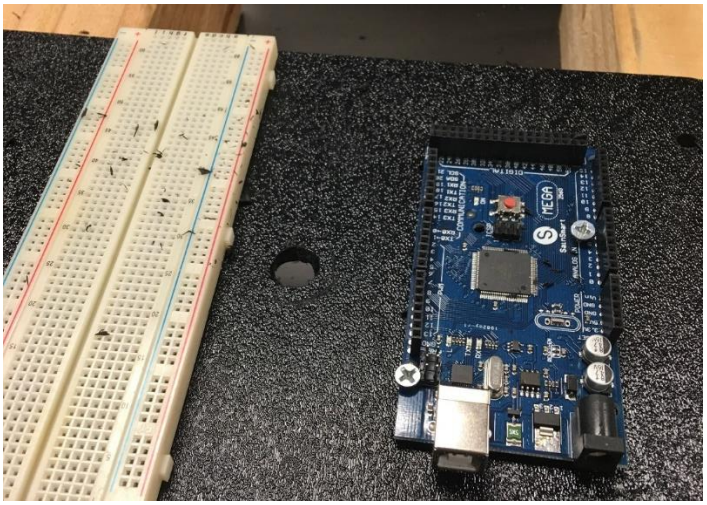


Figure 9 - The hole for the switch

The finished drill location should look like the above picture.

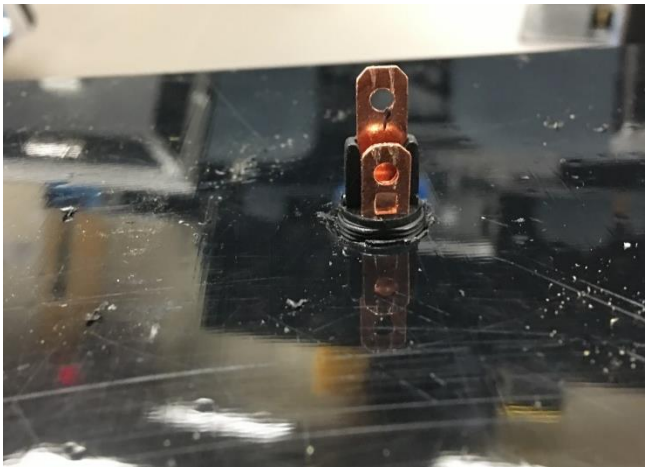


Figure 10 - Putting the switch in the hole

Next, put the switch on the top plate. Note that the switch side should be facing upwards. The image 10 was taken from the bottom view of the plate.

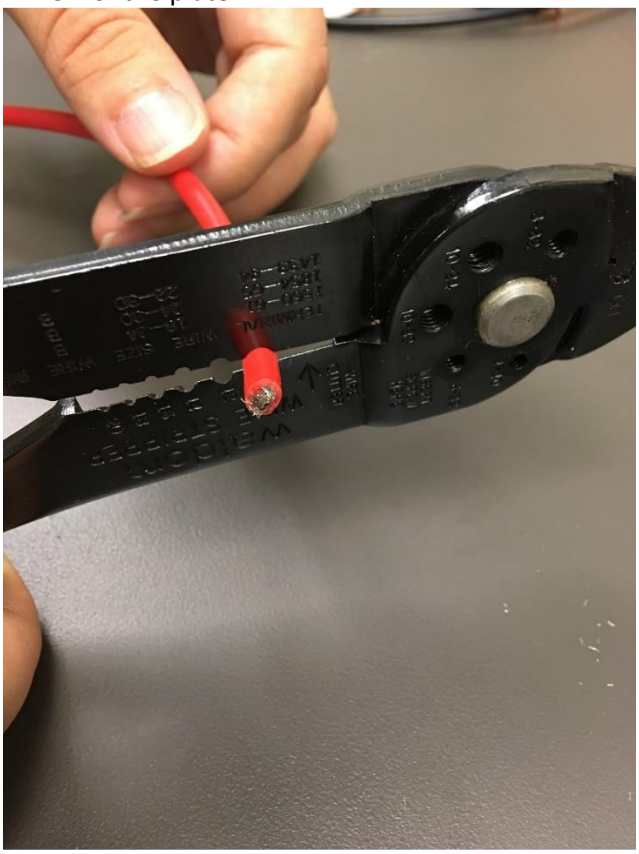


Figure 11 - Peeling the wires for the power switch

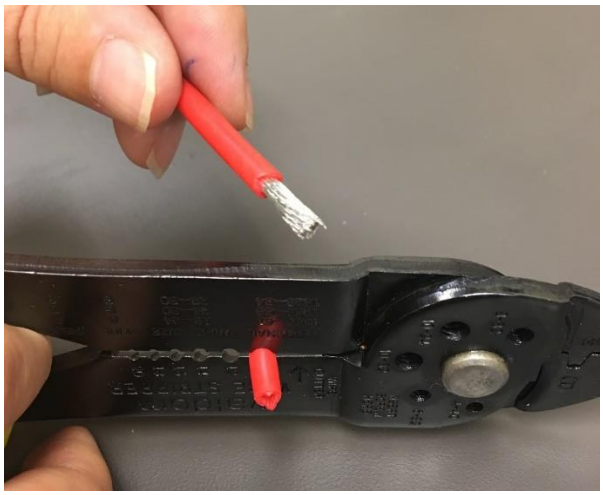


Figure 12 - Peeling the wires to connect to the switch

Take the extra red wire included in your box, and peel both ends of the wire for about ½”.

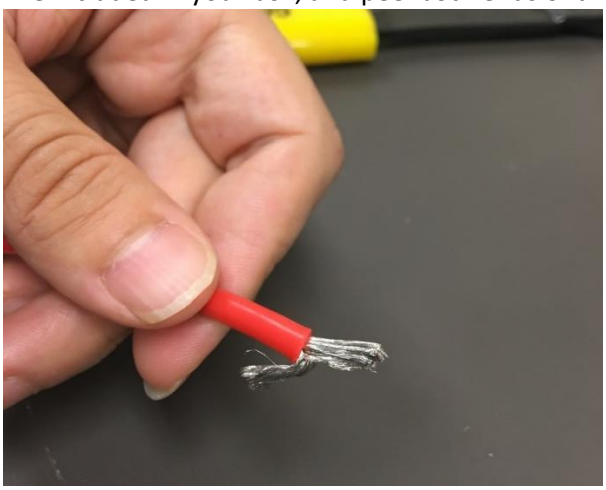


Figure 13 - Make the wire thinner to connect to the connector

Unfortunately the wire is too thick for the crimps we have, so we need to cut half of it away. Twist ½ of the wire into a separate strand.

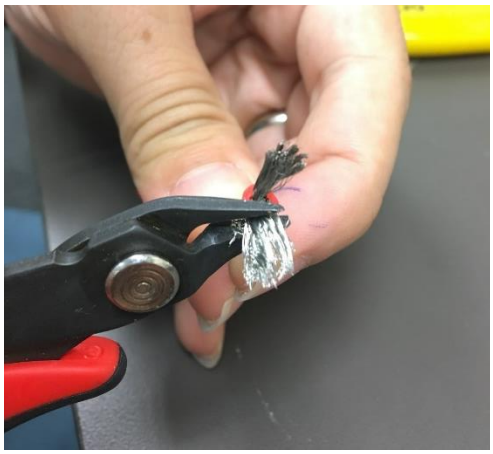


Figure 14 - Make the wire thinner to fit into the blue crimp

Cut the second strand (roughly ½ the wire) away

Figure 15 - Make the wire thinner to connect to the connector

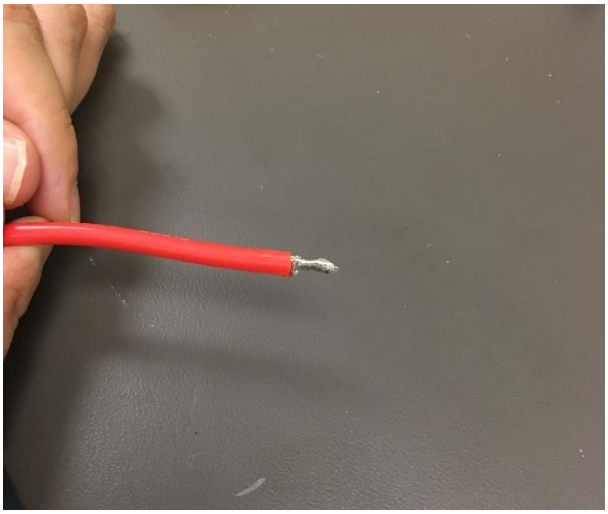


Figure 16 - Twist the remaining wire

Twist the remaining wire into one nice strand.

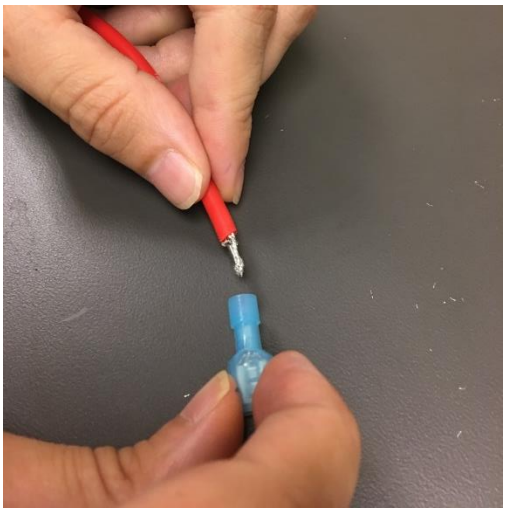


Figure 17 - Inserting the wire into the blue crimp

Insert the wire end into one of the 3 female wire crimps you were given in the kit.

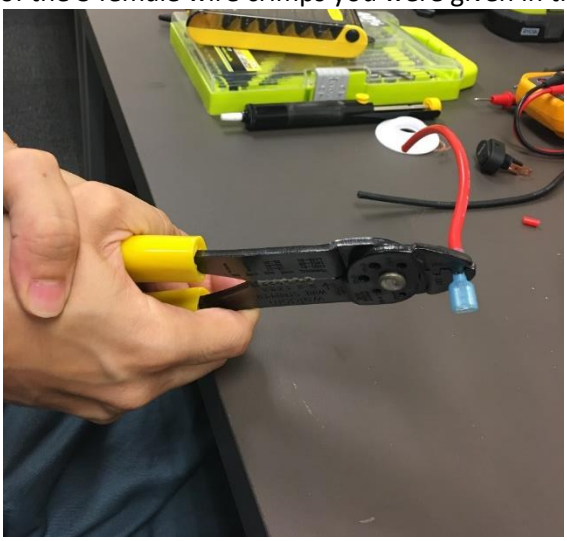


Figure 18 – Press the wire inside the blue crimp

Use the wire strippers crimping tool in the largest position to press the female crimp onto the wire inserted into it.

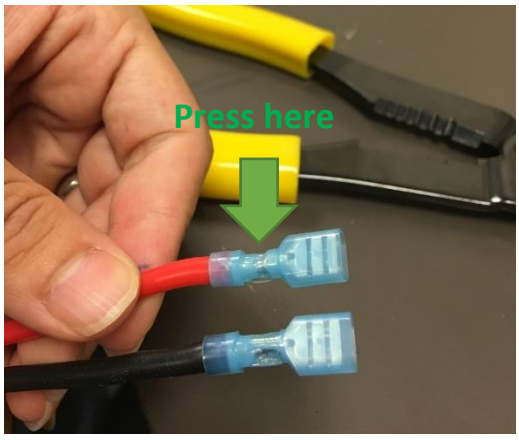


Figure 19 - The connectors should be secure and tight

The connection to the crimp should be secure and will not fall off if you pull it. Repeat this step for the thick black wire as well.

Figure 20 - Attaching female connector to the battery side wires

Detatch the red wire from the Motor driver positive terminal and perform the previous steps to add a femal crimp to it as well. You should now have used all 3 of the female crimps you were given.

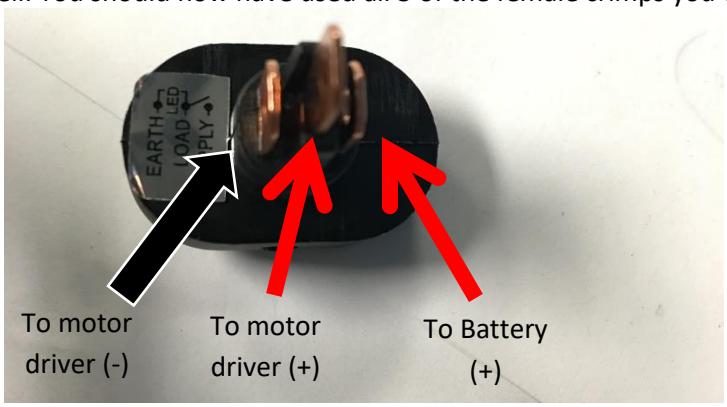


Figure 21 - How to plugging wires into the switch

The above figure shows how to plug the wires into the switch.

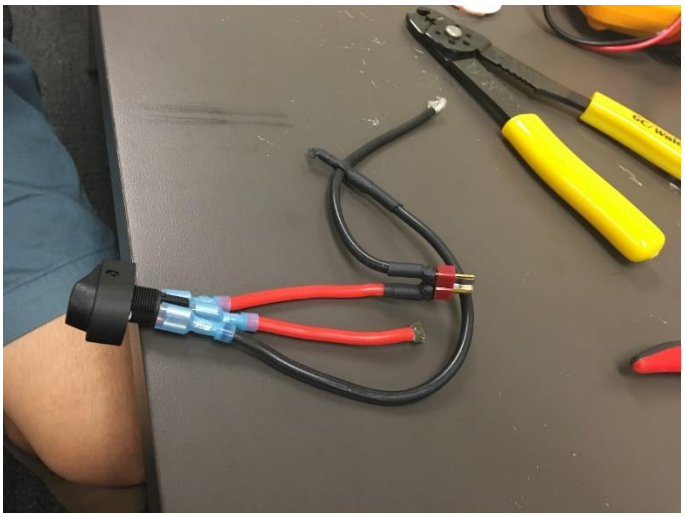


Figure 22 - Plugged wires into the switch

It is time to plug in the wires to the switch. They should be fully plugged in.

Then, we will take the other end of the black wire that you previously put a crimp on. Strip the end of this wire about 1/2” and insert it into the negative (-) terminal of the motor driver.

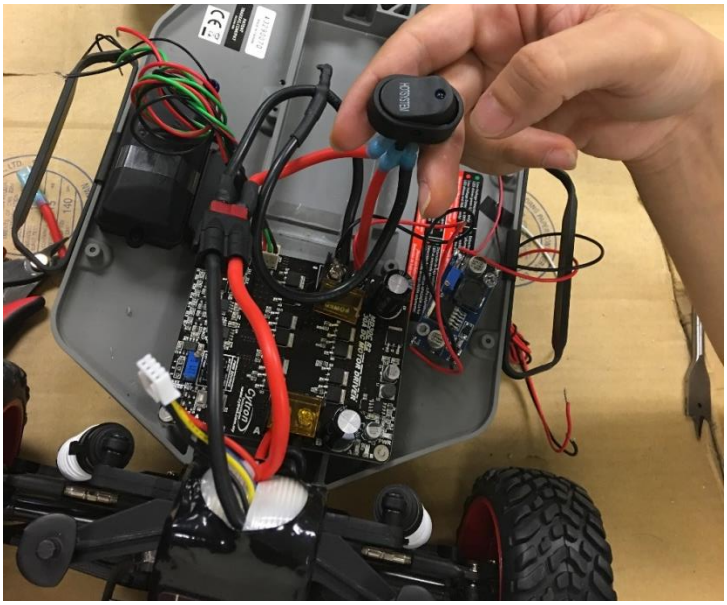
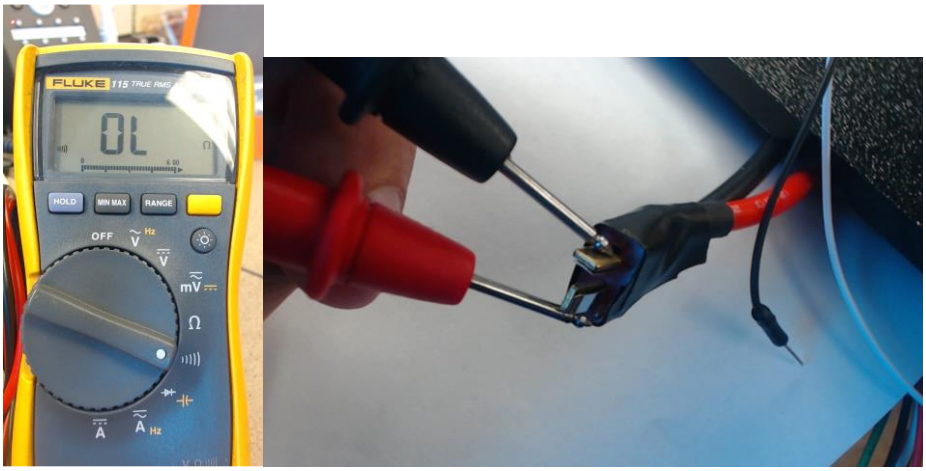


Figure 24 - Final version

The final wiring should look something like Figure 24. Turn the switch off (depress the side that says “HOTSYSTEM”), and test the system using a multimeter.

Set the multimeter to continuity check and place the probes on both sides of the battery connector terminals. If it beeps, there is a short circuit in the system, and you should re-check your wiring before connecting the battery.

Next, turn the switch on and repeat the continuity test. If it beeps, there is a short in the system, and you should re-check your wiring before connecting the battery.



Any changes to electrical wiring can introduce short circuits to the system. If a power supply is connected to a circuit with a short, you can damage your battery, electronics, and possibly even start a fire. Damaged batteries can explode, causing fires and injuries.

You should always disconnect the battery when making circuit changes, and perform a continuity test on the power supply rails (both at the battery and after the regulator) before connecting power.

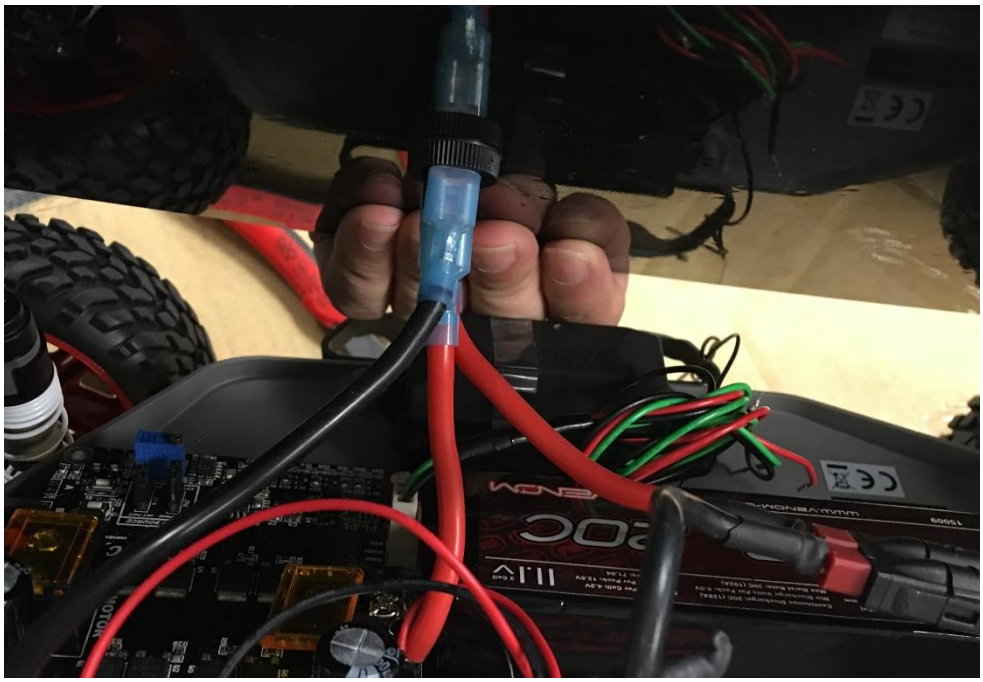


Figure 25 - How to install the switch on the top plate

Take the wires off so we can install the switch permanently into the top plate. Take the switch and remove the black plastic screw. Place the switch on the plate where you were drilled it before and press it down so it fits in. Now turn the black plastic screw from bottom and make sure it's firmly secured. You can place the wires back on according to the diagram.

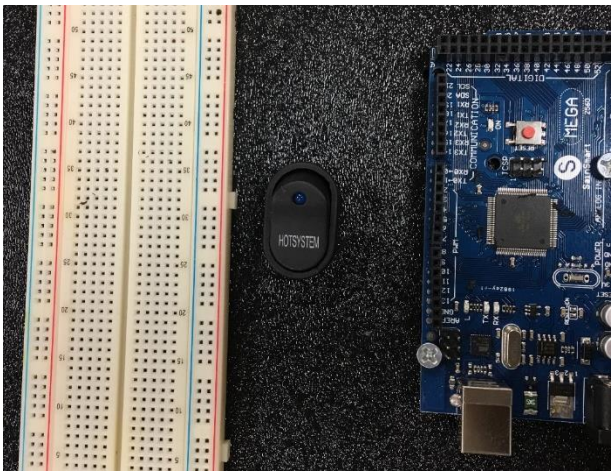


Figure 26 – The installed Switch on the top plate

At last, it should look like the above picture.

Part 2: Testing the Motor driver

Using the screw driver with a flat head and turn the screw on top the blue potentiometer indicated in yellow in Figure 2 about 20 turns counter-clockwise. This will lower the duty cycle of the output to the motors and consequently, lower the speed. Once you turned the screw 20 times, flip the switch to engage power, and you can press the button labeled "A" **while you are safely holding the back of the car high so that the tires are not touching anything**. You should see the wheels move in the forward direction. The button "B" should move it in the backwards direction. Buttons "A" and "B" are indicated in Figure 2 with a green circle.

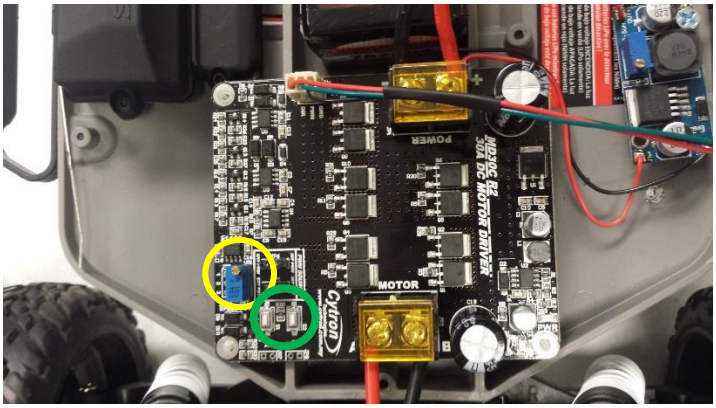


Figure 2 – test buttons and potentiometer indicated on the Motor driver

After you are done with this test, ensure that you have unplugged the battery.

Part 4: Tuning the voltage of the Voltage Converter

Use a digital multi-meter to measure the output of the voltage converter (+ and – terminals). Plug the battery back in. The voltage should be between 12v and 3v. Adjust the potentiometer screw on the converter until you get it to read 5.1 V.

Part 3: Connecting the Voltage converter

Next, connect the power terminal of the motor driver to the input terminals of the voltage converter as depicted in Figure 4. The red wire should be connected to positive terminal (+) and the black wire should be connected to the negative terminal (-). Make sure you have unplugged the battery before attempting this.

Use one of the short screws included in your kit to secure the voltage converter if it's not.

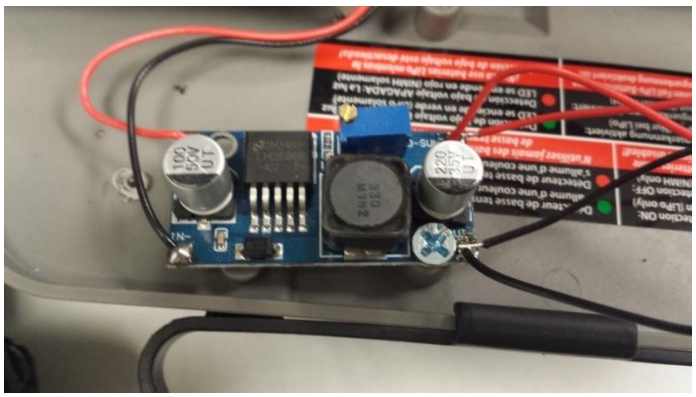


Figure 4 – Connection of voltage converter

Part 5: Connecting Power to the FRDM-KL46Z (test voltage, run LED blink)

Connect the voltage converter positive (+) output terminal to FRDM-KL46Z *Vin* pin (Noted as P5-9V on the diagram below) and negative (-) output terminal a *GND* pin. See Figure 5.

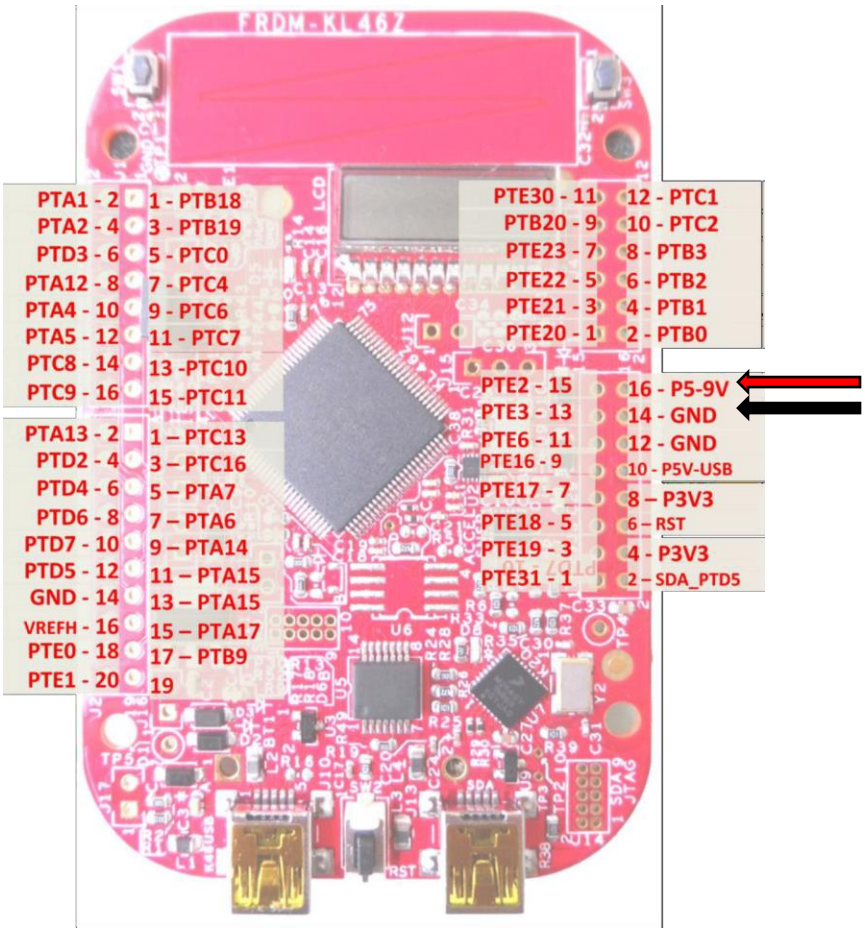


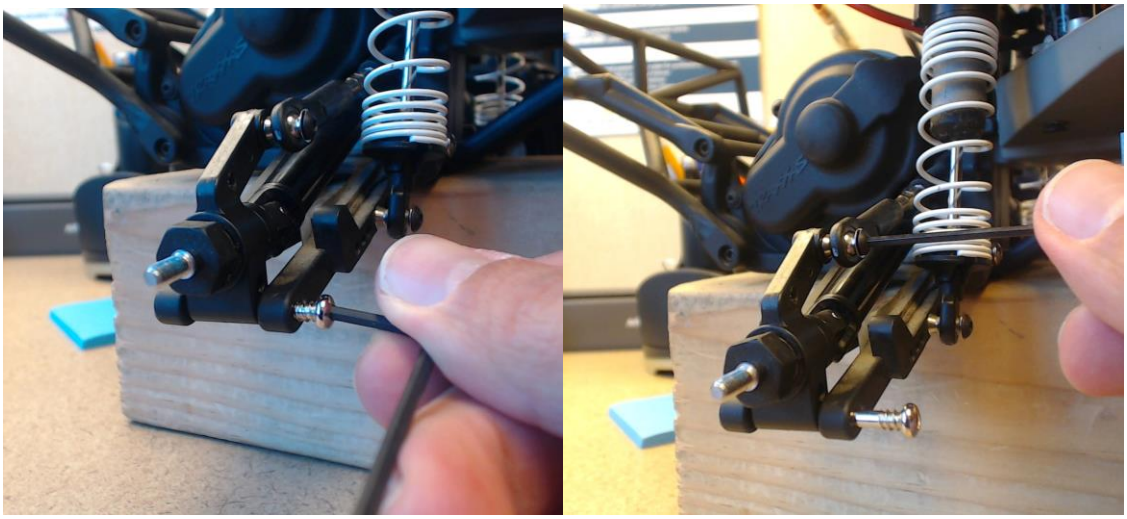
Figure 5 – Powering up the FRDM board to the circuit

With the FRDM plugged in, re-attach the battery. The power LED on the FRDM board will turn on. Upload the blink example program and make sure the program is uploaded successfully.

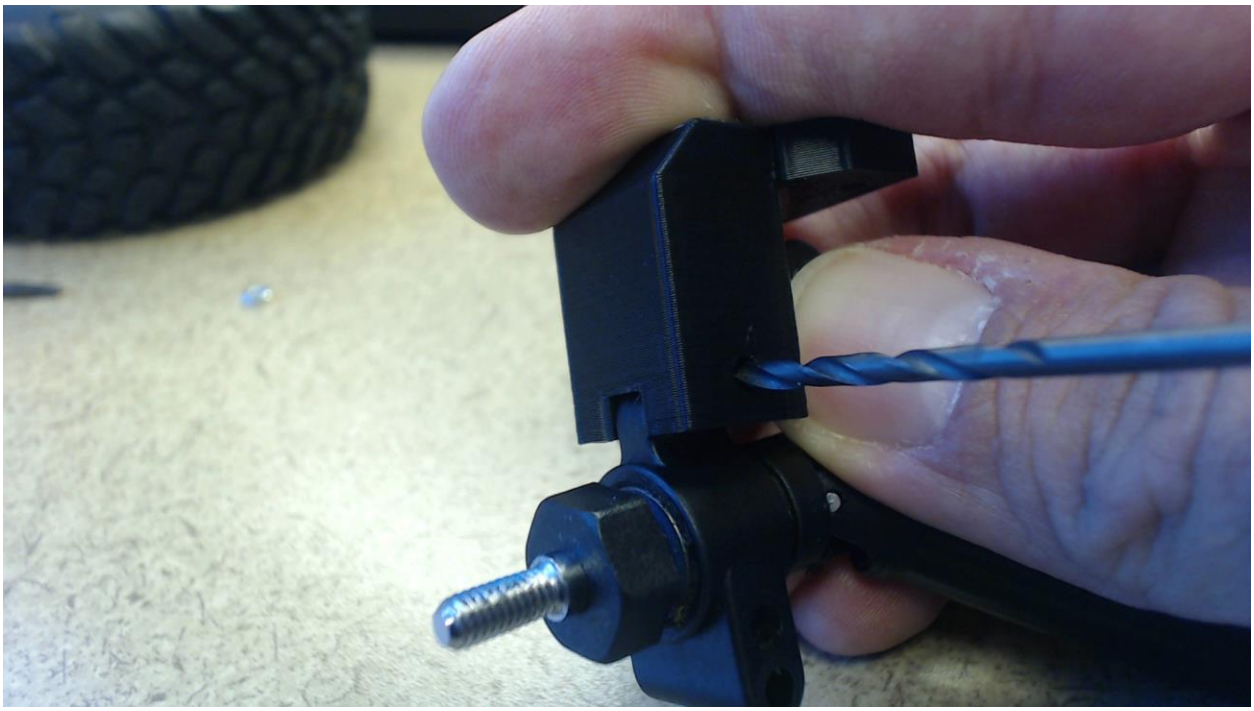
Part 7: Mounting wheel encoder

Remove one of the back drive wheels by removing the hub nut. You should be able to hold the nut with pliers, and unscrew it by turning the wheel.

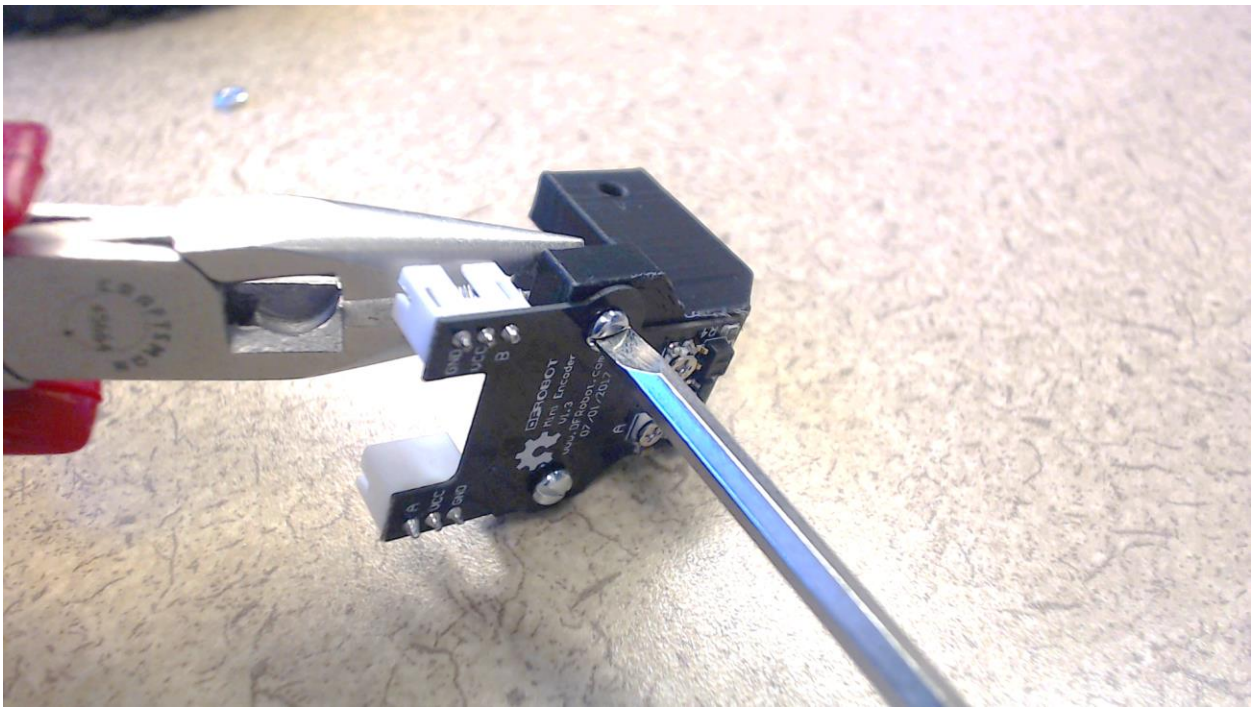
Next, remove the screws for the wheel mount.



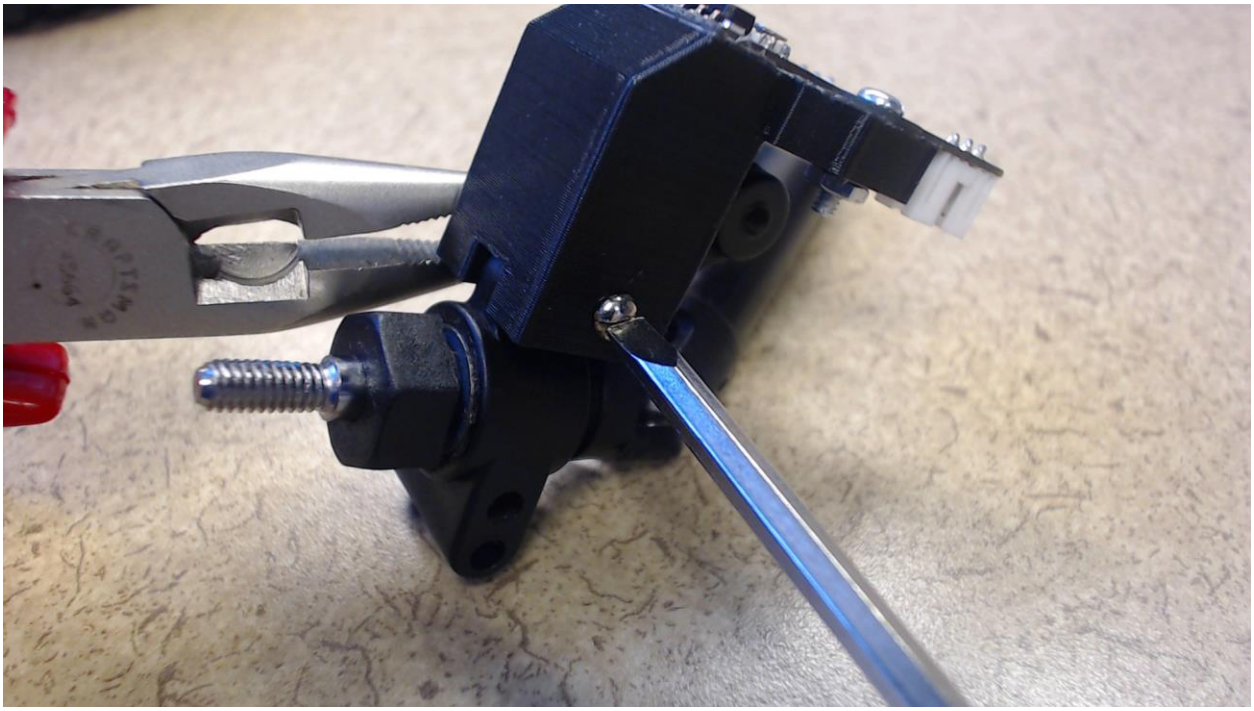
Align the encoder mount so that the front face of the mount is flush with the front of the angle arm, then use a 1/16” drill bit to mark the hole. Drill a hole here.



Next, mount the encoder sensor to the encoder mount using short M2 screws and nuts:



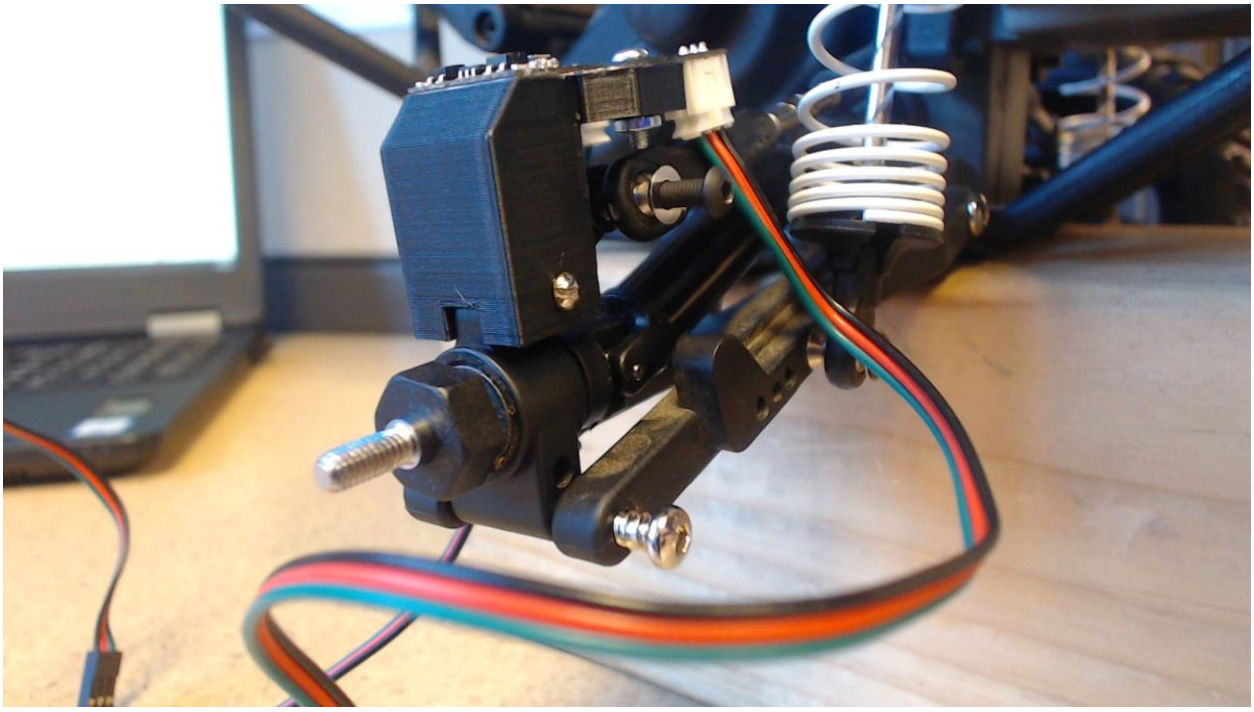
Mount the encoder to the wheel bracket using a long M3 screw and nut:



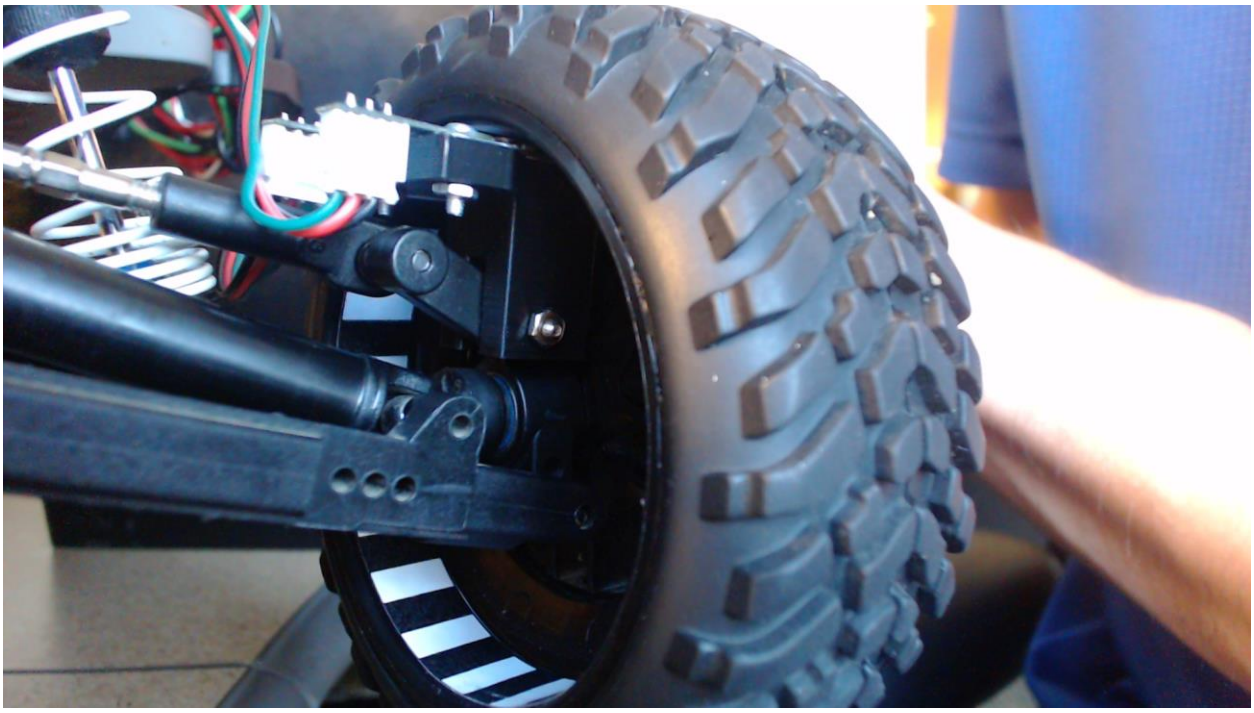
It is OK if the encoder is a little forward, and if it wiggles a little, but it should not be able to tip too far forward.

Using a wet paper towel, clean and dry the inside hub of the wheel. Using a glue stick, paste the encoder strip to the inner hub:

Connect the provided cables to the encoder, and re-mount the wheel bracket:



Re-attach the wheel and make sure that the encoder does not rub on the inside rim, but it should be very close:



We won't need the encoder wires right now, so tie them up so they do not interfere with the drive train.

Part 8: Configuring the Motor driver for PWM Control

On the Motor driver there are 2 jumpers that need to be moved to configure it for external PWM Control. Please refer to the Cytron MD30C H-bridge manual (in References on Canvas) for how to set them to external PWM control.

Part 9: Soldering a Longer Wire to Servo

Split the white wire of the blue servo motor from the red and black ones. Solder an 18-inch-long piece of white wire to the end of the white wire attached to the servo. Use a 1-inch-long piece of heat shrink tubing to cover it and heat it with the heat gun to shrink it:

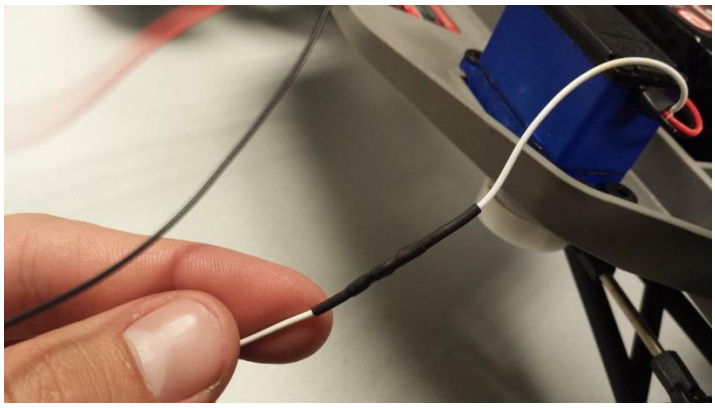


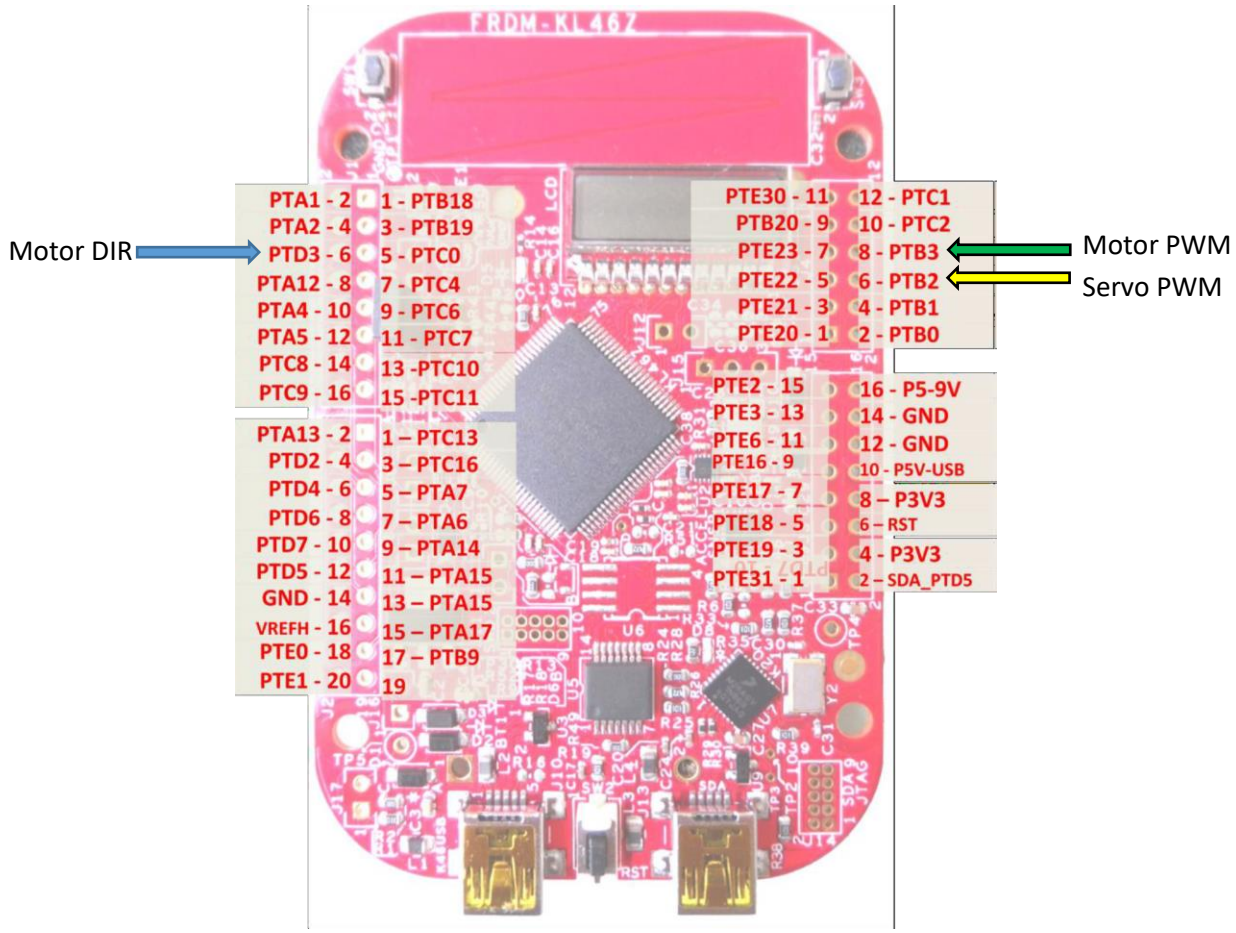
Figure 27 - Soldering the wires of the servo motor

Take the other 2 wires of the servo (the red and black wires) and strip a quarter inch off the ends of both. Solder the red wire to the other red wire from voltage converter positive (+) output terminal. Solder the black wire to the negative (-) output terminal of voltage converter. If you are using a voltage converter which need soldering, solder the new black and red wire to the voltage converter negative and positive output respectively.

Part 10: Connecting the Servo & Motor Controller

Connect the servo wire to pin PTB2 of the FRDM-KL46Z.

Connect the PWM and DIR pins of motor driver to pin PTB3 and PTD3, respectively.



Part 11: Controlling the Servo

The servo can now be controlled by TPM2, Channel 0. Write a test program to configure the pin and TPM2 for PWM servo control. The test should turn all the way to the left for 1 second, go to the middle for 1 second, turn all the way to the right for 1 second, then back to middle for 1 second, then repeat.

Part 12: Controlling the Motor

The motor speed can now be controlled by TPM2, Channel 1, and the motor direction controlled by PTD3. Write a test program to configure these pin and TPM2 for PWM motor control.

Note that the motor is very strong, and PWM should never be higher than 20% duty cycle.

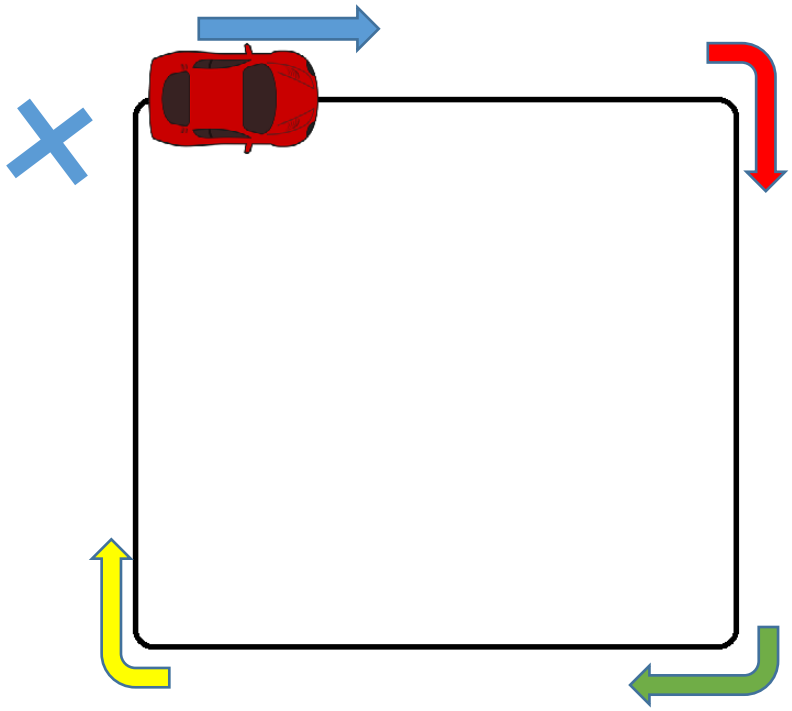
Also note that both the motor and servo will need to operate independently, but they use the same timer module. You will need to find a PWM frequency that works well for both.

Your motor test program should start in the "STOP" state, then slowly ramp up to full speed forward (20% duty cycle), then slowly ramp down to stop, pause for 1 second, then ramp up to full speed reverse (20% duty cycle), then ramp down to stop again.

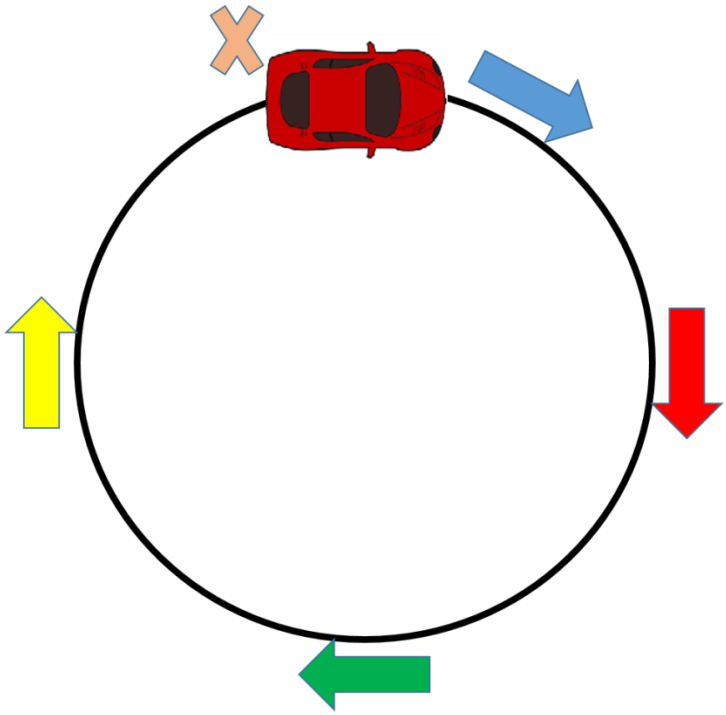
Part 13: Driving the car

On the demo day, you will be asked to drive the car in a square and a circle path.

1. The square will look like the diagram below. You will start at the X position. Begin driving in the direction of the blue arrow, following the track to the red arrow. At the red arrow, turn as sharp as possible until your car has turned 90 degrees to point at the green arrow. Then, continue straight. Repeat the same thing when you reach the other arrows (green and yellow). The car should finish at the x position in the same orientation it began. You should have completed 4 90 degree turns. The purpose of this exercise is to test the steering ability of your car which is controlled by the servo motor.



2. For circle tracking, the track will look like the diagram below. You will start from the position X, begin driving in the direction of the blue arrow, following the track to the red, green and yellow arrows, then over the X point again. In this section, you should be able to apply two different speeds on your car and follow the same circle. You should apply 10% and 20% duty cycle to drive the car with two different speeds. The radius of the circle is arbitrary and you can assume your own radius and in each speed you should drive the car for one circle (no more and no less).



HINT: For extra accuracy, use the wheel encoder to count steps and distance. The schematic for the wheel encoders is provided in the reference folder on the course website. Connect the encoder data lines to PTD3, and PTA12, and also connect power and ground. The encoder stripes have 38 transitions (19 black to white, 19 white to black), and the wheels are approx. 11cm in diameter.

Demo location:

Demo location is somewhere between BYAC & BYOH as indicated in the following image.

Submission:

Export your 2 projects, Drive in a Circle, and Drive in a Square. Submit these 4 files:

1. CSE325_driveCircle.zip
2. CSE325_driveSquare.zip
3. Members.txt
4. Integrity.txt

All files should be zipped into a single file named CSE325 _Project2.zip and be uploaded to the course website before the due date.

Students will show their finished cars to the TA. Students will then drive the square and circle path on the demo day. TAs will check your robot to ensure it was assembled

correctly, watch the driving test to determine your code works, and will ask some questions from all members.

Submit on time. Late submissions will be awarded 0 points.

How the project is graded:

On the demo day, groups are called to present the demo and show their code. The TA will ask you to drive your car in a square and a circle track respectively, and checks the functionality of your code. The TA may also ask you some questions about how the application works, what will happen if you change some things, and will ask questions about your understanding of the program used in this project.

Note that: Even if you have worked on one aspect of the program, you need to be able to answer questions about any and every aspect of the application.

Grading rubric:

The grading rubric is as follows:

Points	Description
40	Car assembly is complete, all drive motor and steering tested and functional.
20	Car can drive in an arbitrary square.
20	Car can drive in an arbitrary circle.
20	All group members can answer questions asked by the TA about the project program and configurations or change a part of the Arduino program.
-20	If any value for actuators (motors) is written more than one time.
	If you do not upload your code up to the deadline, you will be graded 0.