BARC V4.0 Documentation

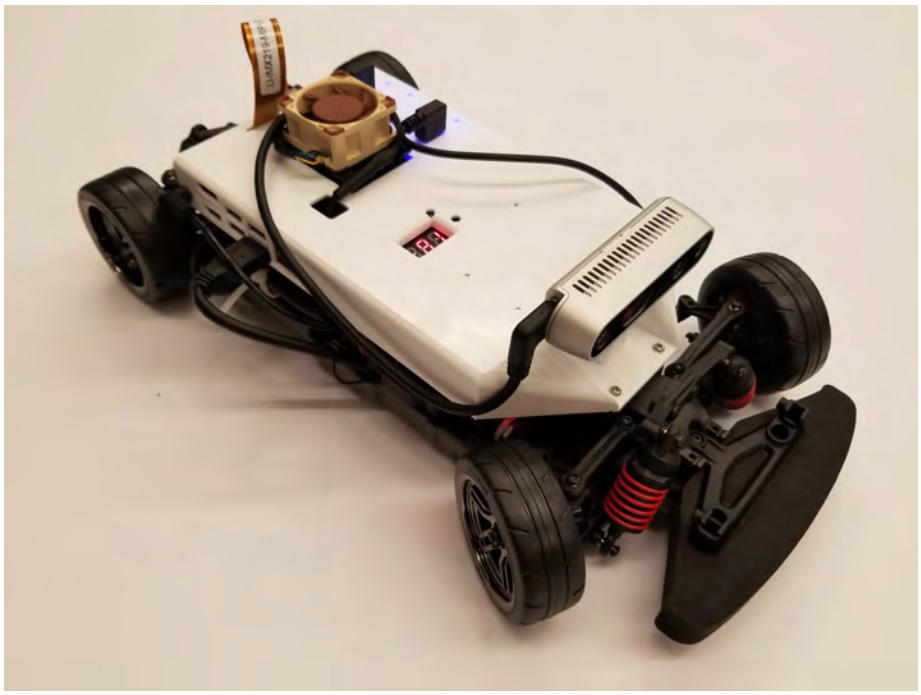


Figure 1: BARC v4.0

To assemble the BARC V4.0 platform please use the following assembly instructions. At the end of the document hardware choice and software implementation will be discussed.

Website: http://www.barc-project.com/

Github: https://github.com/MPC-Berkeley/barc

Task 1 Debugging the BARC platform

The BARC platform is a complicated system that requires all components to be working to be a reliable system. Here some of the solutions to common issues will be listed for easy fixing. If you are trying to assemble the car proceed to **Preparing the Traxxas 4-Tec**.

To debug the BARC car first verify that all physical hardware is present, undamaged, properly secured, plugged in, and working.

Common Arduino DUE Issues for Serial Port issues:

- Confirm that the DUE is plugged into the programming port (not the native port.
- Confirm that the serial port /dev/ttyACM0 is used. (Not /dev/ttyUSB0)

- In Ubuntu add "sudo chmod a+rw /dev/ttyACM0" to bash.rc file.
- Confirm that the BARC car and Arduino Code are both operating at the same baud rate. (115200)
- Attempt reflashing the Arduino DUE to fix any corrupt code on the Arduino.
- Unplug arduino into windows or macosx computer and open Arduino IDE to ensure that the Arduino is properly working. Open Serial monitor and check output.

Common Hardware Issues:

- Jetson Nano or Xavier losing power mid operation: Low LiPo Battery Voltage ¿ charge the battery!
- Jetson Nano not starting. Ensure that the power jumper is properly installed on the car (See Figure 17).

Task 2 Preparing the Traxxas 4-Tec

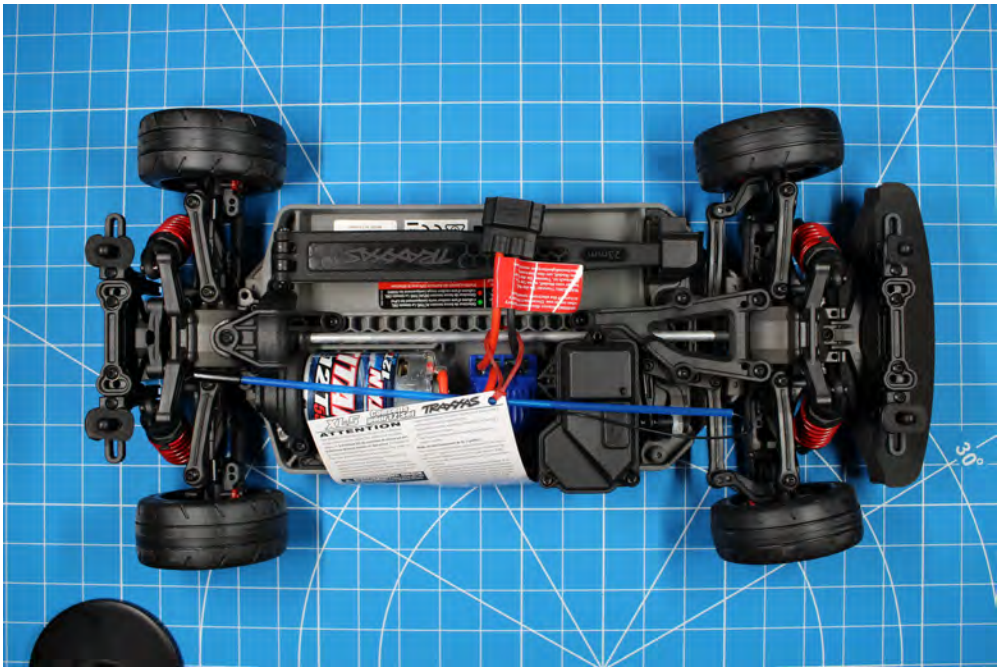


Figure 2: Stock Traxxas 4-tec removed from box.

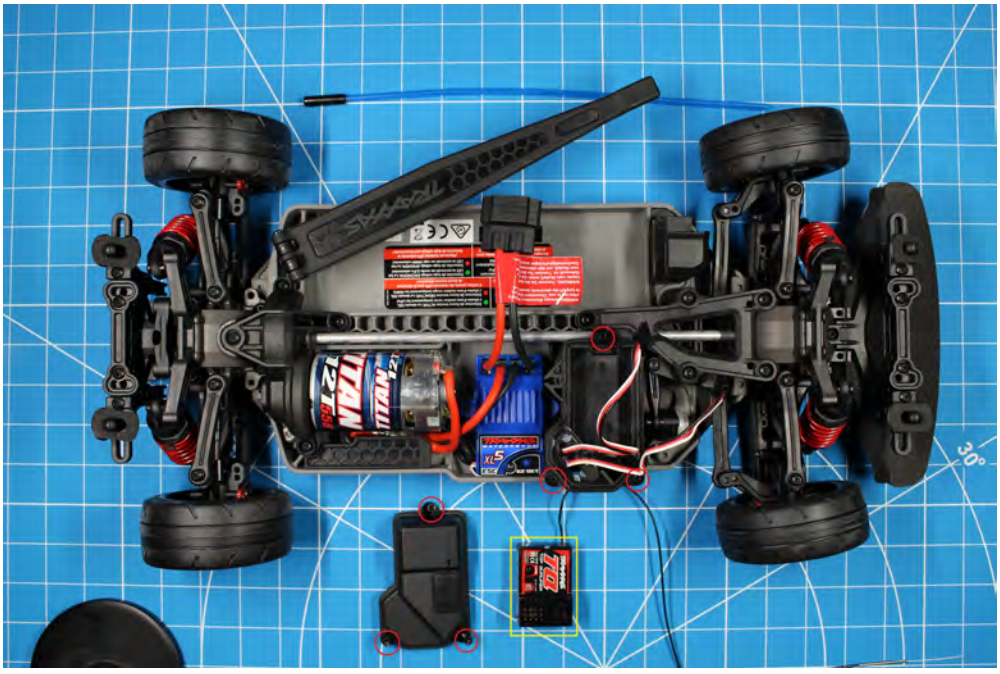


Figure 3: Receiver (boxed in yellow) removed from stock location. 3xM2.5x8 screws (circled in red).

To prepare the Traxxas 4-Tec (See Figure 2) the receiver must be removed and relocated to a position that has minimal WiFi interference. To remove the receiver 3xM2.5x8 screws (circled in red) must be removed with a 2mm hex driver. The receiver is attached with double sided tape and can be pry-ed off with a flat-head screwdriver. (See Figure 3)

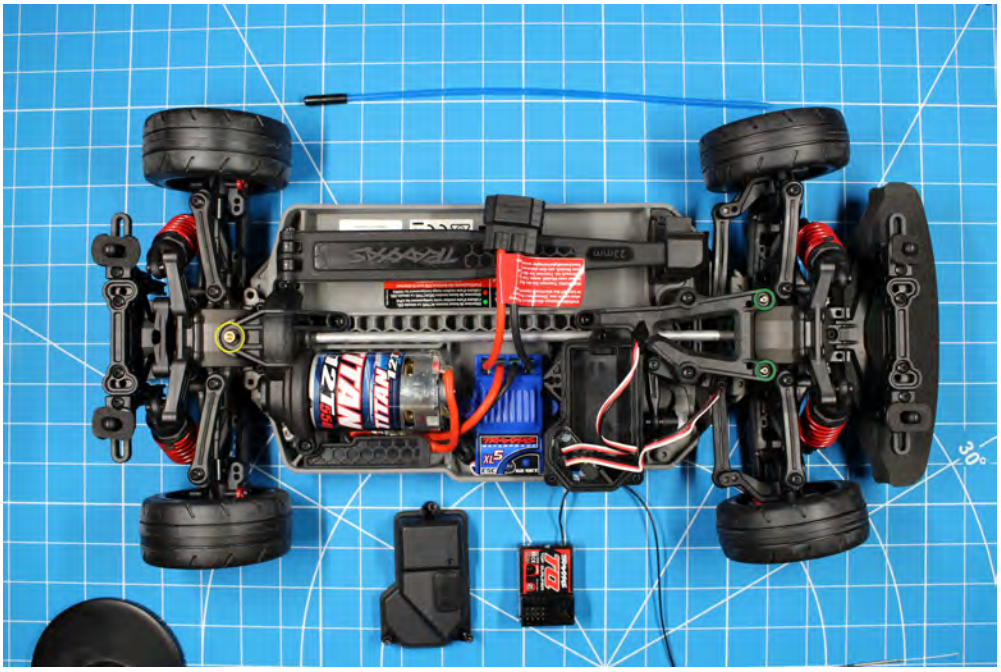


Figure 4: m3x6x6mm F to M stand off (circled in yellow). m3x10mm set screw (circled in green).

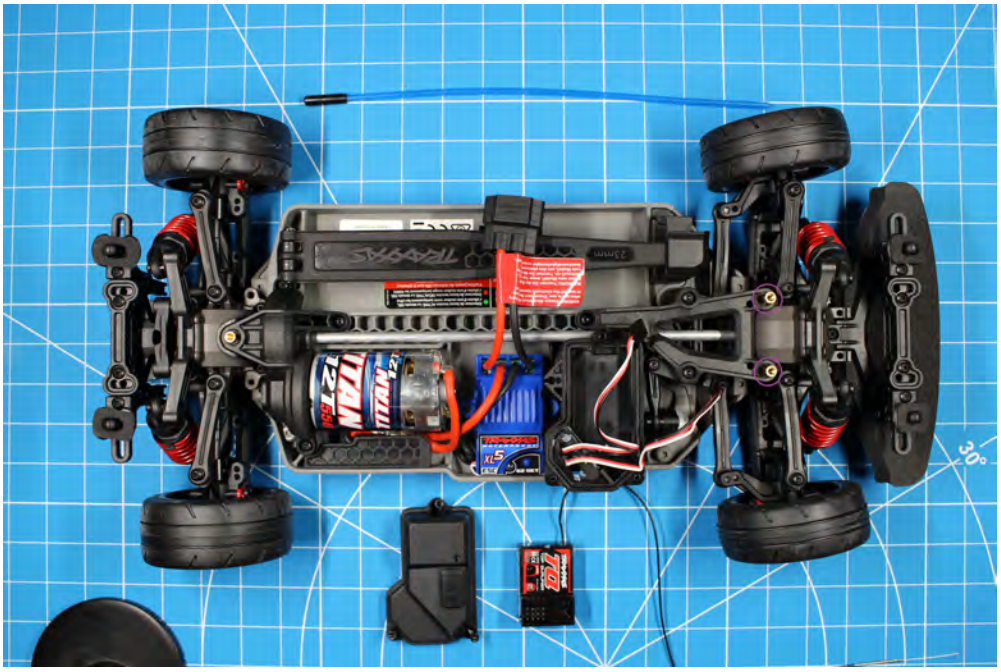


Figure 5: m3x8mm F to F stand off (circled in purple) screwed into m3x10mm set screw.

Remove the screws in the location of the Yellow and green circles in Figure 4. Install a m3x6x6mm F to M stand off in the yellow circle location. Install two m3x10mm set screws in the two green circle locations. Do not screw the set screw all the way down and leave 2 to 3mm of the set screw sticking out. Next using two m3x8mm F to F stand offs install on the m3x10 set screw (See Figure 5).

Task 3 DC to DC Step Down Installation



Figure 6: Cutting the "smaller" barrel jack from the AC to DC wall adapter.



Figure 7: 5.1mmx2.1mm barrel jack cut to 30cm length. "smaller" barrel jack cut to 15cm length.



Figure 8: Splicing the XT60 Power Splitter.

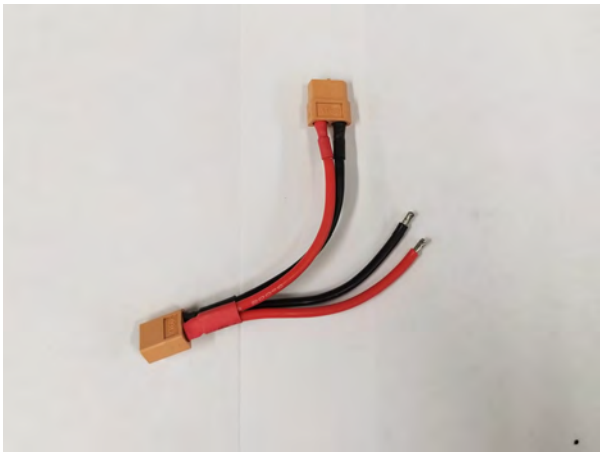


Figure 9: XT60 male to XT60 female and two stripped wires.

This requires two Barrel Jacks to be cut (See Figure 7) for the 5.5x2.1mm barrel jack 30cm and 15cm for the "smaller" barrel jack. The "smaller" barrel jack connector can be cut from the included AC to DC converter with the USB splitter (See Figure 6). Modify the 2 female to 1 male XT60 connector by splicing one of the female XT60 connectors off (See Figure 8). This will be inserted into the DC to DC step down input.

Solder the two barrel jack wires together so that they stay in the DC to DC step down.

Install the modified XT60 splitter cable and barrel jack connectors into the DC to DC step down by using a flat head screw driver and unscrewing the terminal blocks, inserting the wires into the appropriate terminals, then screwing the terminal blocks down again (See Figure 12).

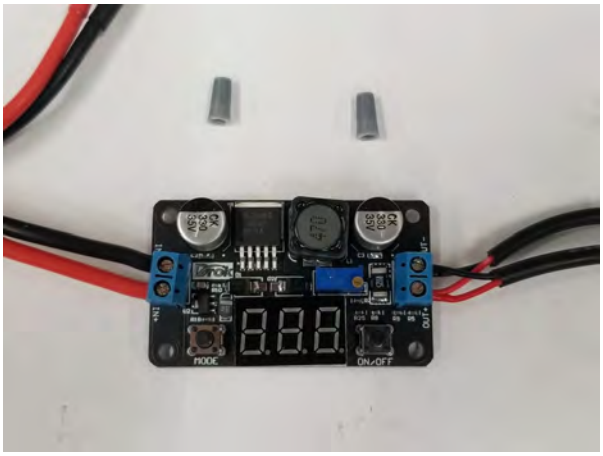


Figure 10: XT60 splitter and barrel jack connectors wired to step down.

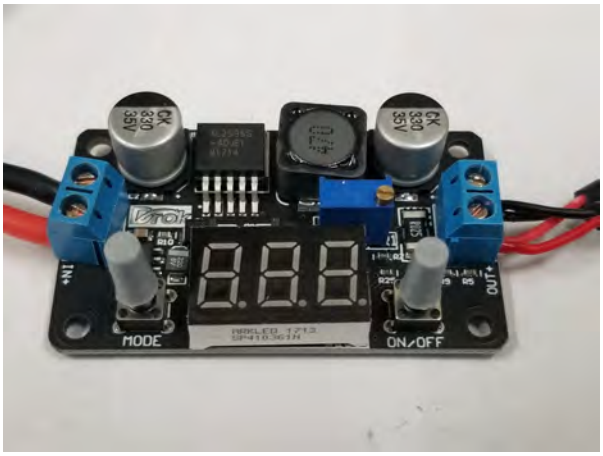


Figure 11: 3D printed buttons installed on DC to DC step down.



Figure 12: Step down plugged into LiPo battery.

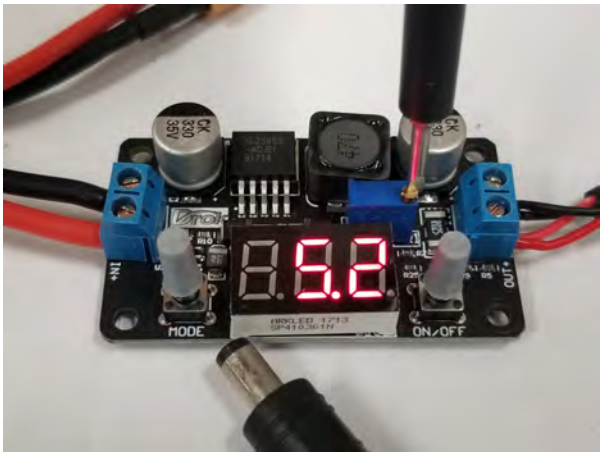


Figure 13: Voltage adjusted to 5.2Volts using potentiometer.

Install the two shorter 3D printed button extensions (See Figure 10) to the DC to DC step down by pushing them into place. They should fit with no modification to the Step Down (See Figure 11).

To ensure the correct voltage is sent to the Nvidia Jetson Nano, install a battery to the DC to DC step down with nothing else attached (See Figure 12). There are two buttons on the step down converter (See Figure 11). The right button turns the power on and off. The left button toggles between three different modes in the following order: **Current through Step Down, Input Voltage, Output Voltage**. You will now lower the voltage of the DC to DC step down by turning the potentiometer counter-clockwise on the Step down converter till the display readout for output voltage is roughly 5 volts (See Figure 13). If the voltage is too low to power the Nvidia Jetson Nano the voltage can be incrementally increased once the car is fully assembled.

Task 4 Installing Components to 3D printed Shell

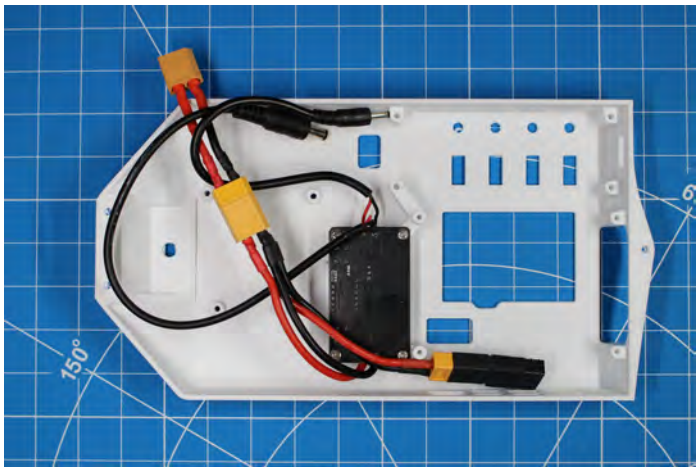


Figure 14: Installing the DC to DC Step Down into the 3D printed shell.

Install step down into the 3D printed shell by inverting it and using 4 m3x6 Phillips button head screws (See Figure 14).

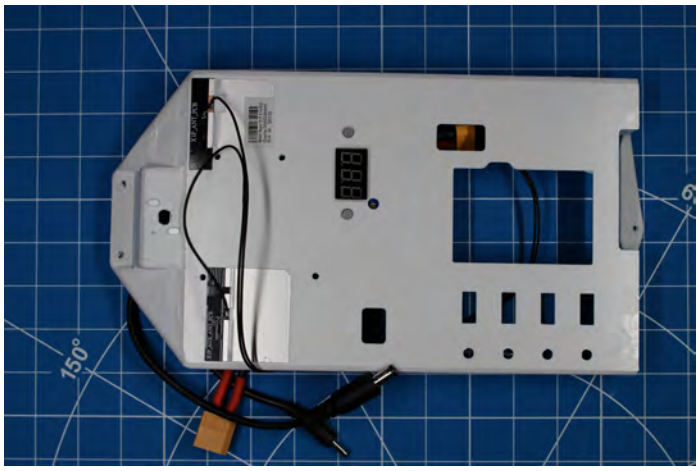


Figure 15: Install WiFi antennas to 3D printed shell.

Remove backing tape on WiFi antennas and install to the top of the 3D printed shell. (these can be mounted anywhere you desire for best WiFi reception. (See Figure 15). On the Nvidia Jetson Nano Install the Jumper cable to be able to use the barrel jack power (See Figure 17). The Nvidia Jetson Nano will not power on with out this jumper.

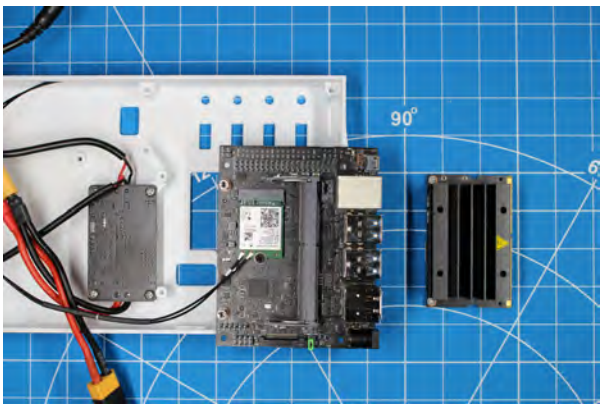


Figure 16: Attach Wifi Antennas to AX200 WiFi chip.

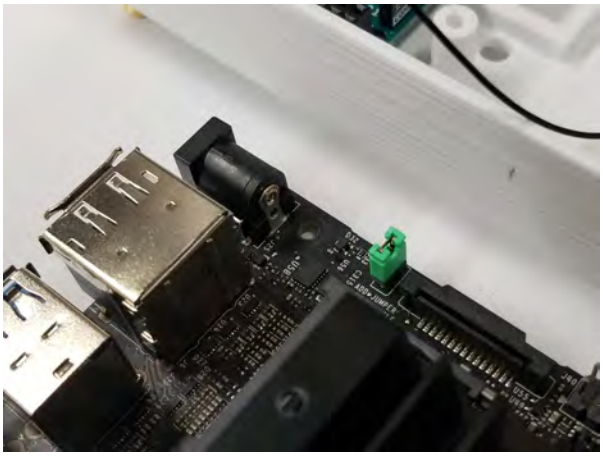


Figure 17: Jumper to use barrel jack.

Remove the Nvidia Jetson Nano heat sink for access to the WiFi card. Attach WiFi antennas to WiFi card. Pass through the cables through one of the chassis holes. (See Figure 16). (optional) to install a Noctua 40mm Fan use 4 M3x6mm screws to install the fan (See Figure 18). Reinstall Jetson Nano heat sink (See Figure 19). Pass the Jetson Nano Fan through the large rectangular hole (See Figure 20). Install the SD card in the Jetson Nano (See Figure 21). Install four M2.5x6mm Screws for the Jetson Nano (See Figure 22). Plug in fan cable to header on Jetson Nano (See Figure 23).

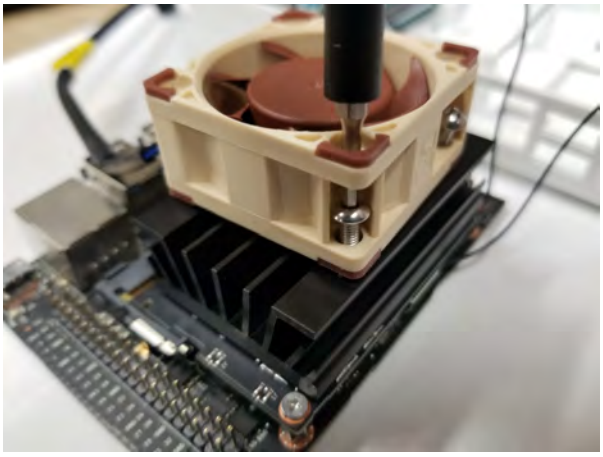


Figure 18: Install the Noctua 40mm Fan using 4 M3x6mm screws. Be sure the cable is facing the I/O of the Jetson Nano.

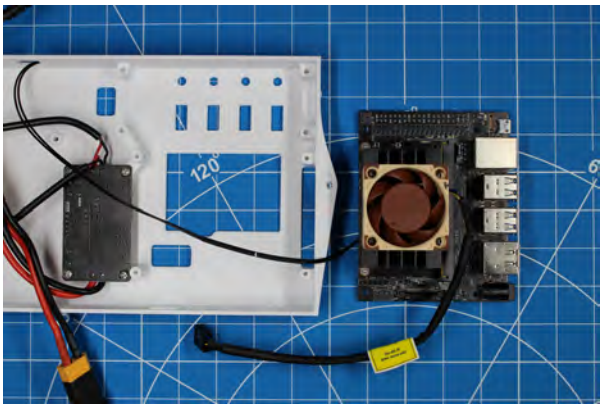


Figure 19: Reinstall Nvidia Jetson Nano heat sink.

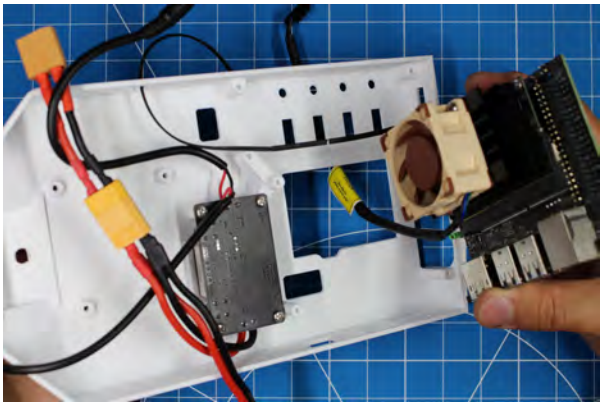


Figure 20: Pass the Jetson Nano Fan through the hole.

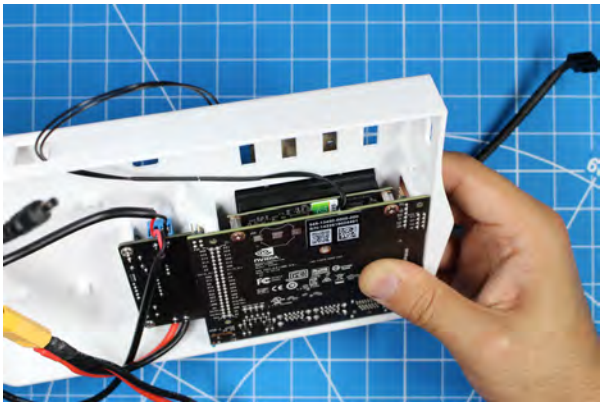


Figure 21: Install Ubuntu pre-loaded SD Card into Jetson Nano.

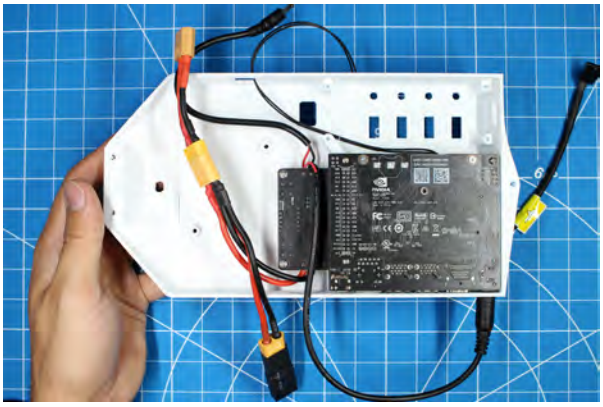


Figure 22: Install 4x M2.5x6mm Screws for the Jetson Nano.

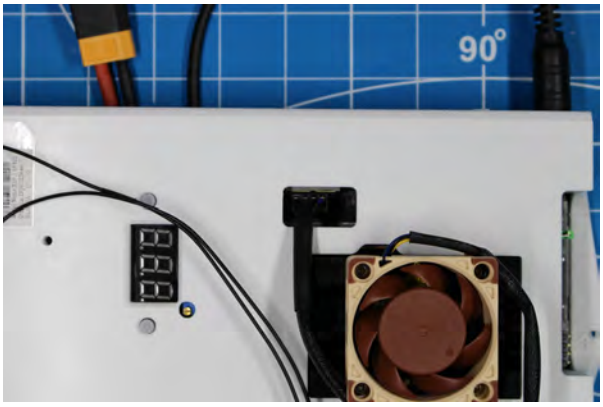


Figure 23: Plug Fan into fan header on Jetson Nano through Fan cable hole.

Install the Arduino Due into the 3D printed shell with 4 M3x6mm screws (See Figure 24). It is easier to plug in the USB cables first before screwing the Arduino in. This Arduino mounting can be used for the following Arduinos: Arduino Mega, Arduino UNO, Arduino Nano with Sensor Breakout Shield.

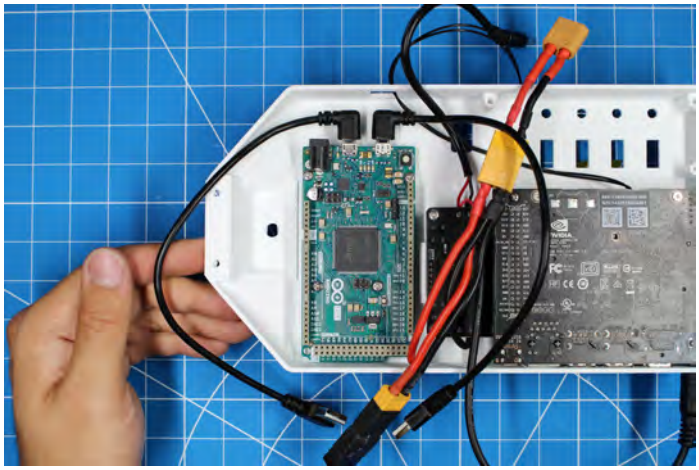


Figure 24: Arduino Due installed in shell with 4 M3x6mm screws.

Install the USB Splitter into the 3D printed shell with 4 M3x6mm screws (See Figure 24). It is easier to plug in the external power for the USB splitter before installing. Organize the cables for easy installation.

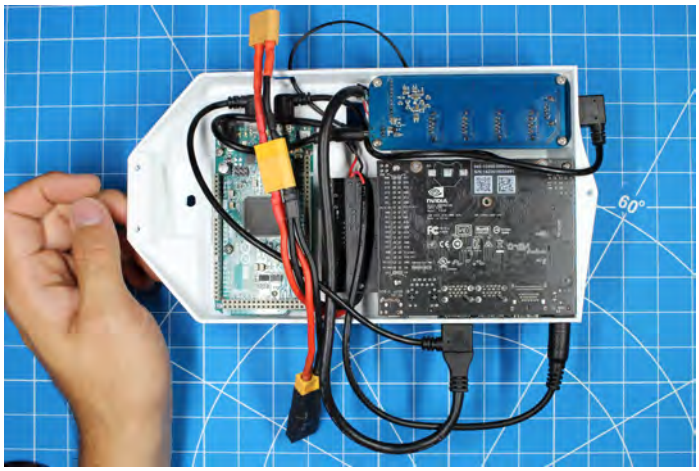


Figure 25: USB Splitter installed in shell with 4 M3x6mm screws.

Install either a single Intel Real sense D435i or Dual Intel Real Sense D435i and T265 with 3D printed bracket (See Figure 26). Need 4x M3x6mm and 1x 1/4-20x 2.25" screws for Dual Cameras or, 1x 1/4-20x 2.25" screws for single camera. Install Single 1/4-20x 2.25" screw from the inside of the shell (See Figure 27).

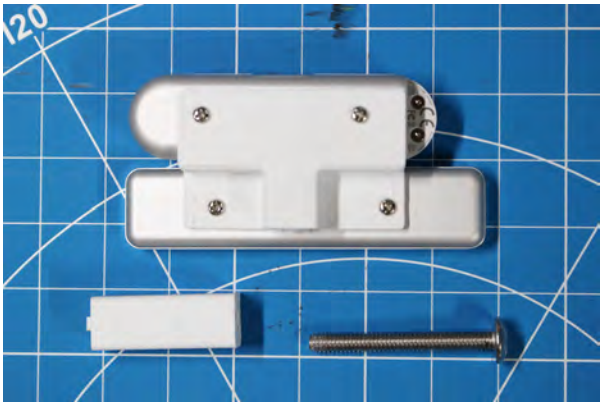


Figure 26: Install 4x M3x6mm Screws for the Intel Real Sense Cameras.



Figure 27: 1x 1/4-20x 2.25" Screw for mounting to chassis. Pass screw through bottom of chassis.

Task 5 (REQUIRED) Receiver Modification

To allow for the Jetson Nano to take control of the Traxxas 4-Tec a modification must be made to the Receiver of the car to tell the Arduino the state of the receiver. The two states of the receiver are the following: If the paired controller is within range of the receiver or not. This also allows the controller to act as an override for a "rogue" BARC car.

- **1x** Sacrificial Jumper cable
- **2x** Jumper cables (preferably long)
- **4x** 1 Latest Gen Traxxas Receiver (included with Traxxas 4-Tec)

First cut the stickers on side of receiver (See Figure 28). Unclip the clips on one side of receiver to open the clam shell of the receiver (See Figure 29). Remove the PCB from the clam shell (See Figure 30). Solder the jumper to the blank solder pad on the back of the receiver PCB. Ensure to use flux to prevent burning the PCB (See Figure 31). Enlarge the hole for the antenna cable to allow clearance for the additional jumper cable to pass through (See Figure 32). Close the clam shell back together. There should be an audible snap. Ensure that no wires are pinched (See Figure 33). The receiver can be mounted to any location on the chassis (preferably away from any WiFi antennas). Attach a jumper extension to plug the receiver state cable into pin 30 on the Arduino DUE. Using female to male jumper cables plug ground of the receiver to one of the grounds on the Arduino DUE, plug the 5volts from the Arduino DUE to the middle row of the receiver pins to supply power to the receiver.



Figure 28: Cut stickers on side of receiver.

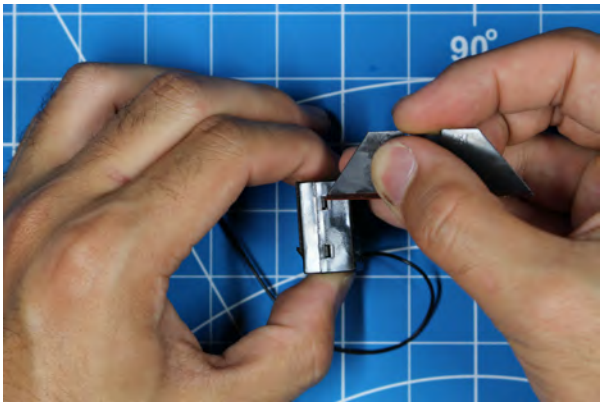


Figure 29: Unclip clips on one side of receiver to open clam shell.

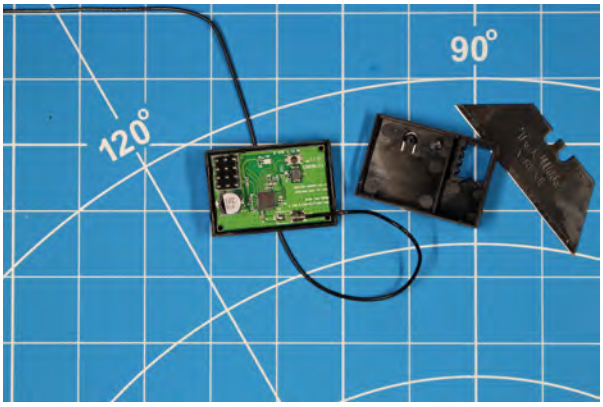


Figure 30: Inside of receiver box. Remove the PCB from the clam shell.

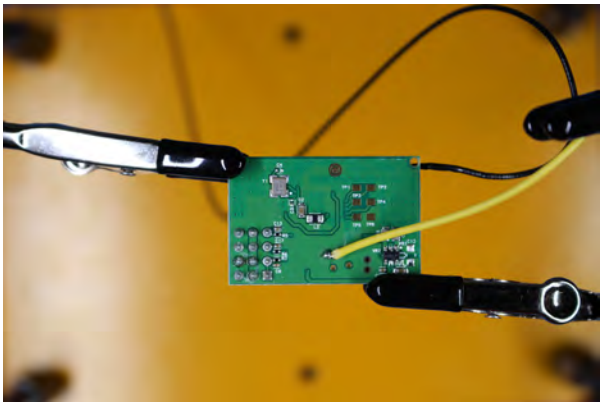


Figure 31: Solder the jumper to the blank solder pad on the back of the receiver PCB. Ensure to use flux to prevent burning the PCB.

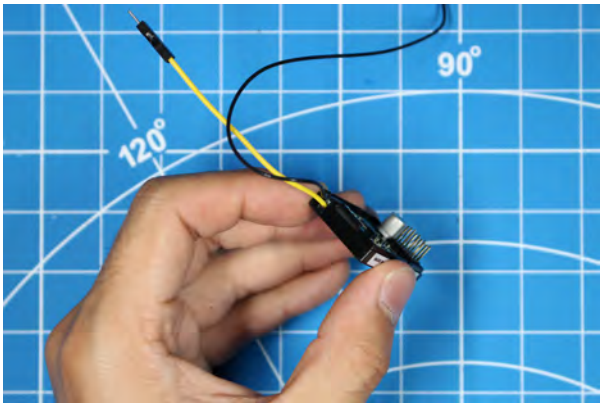


Figure 32: Enlarge the hole for the antenna cable to allow clearance for the additional jumper cable to pass through.

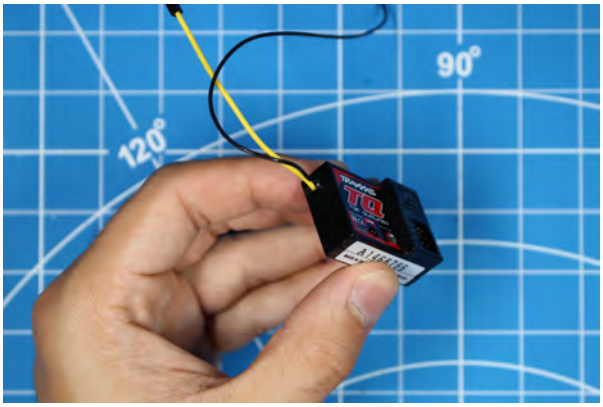


Figure 33: Close the clam shell back together. There should be an audible snap. Ensure that no wires are pinched.

Task 6 (REQUIRED) PWM output harness

- **2x** Female to Male PWM servo extension cable 3 to 6 inches (See Figure 34).
- Male pin headers
- Assorted heat shrink tubing

Cut off the Male connector on the Female to Male PWM servo extension cable. Strip the wire to solder the cables. Solder the red cables together to power the servo motor from the ESC (See Figure 35). Solder the two grounds together to the header for ground on the Arduino Due, bottom purple circle (See Figure 36). Solder the white signal cables to Arduino DUE output pins 4 and 5, top purple circle (See Figure 36).

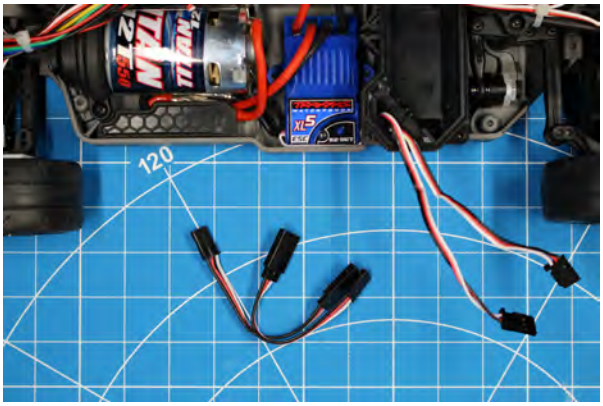


Figure 34: Two Female to Male PWM servo cables.

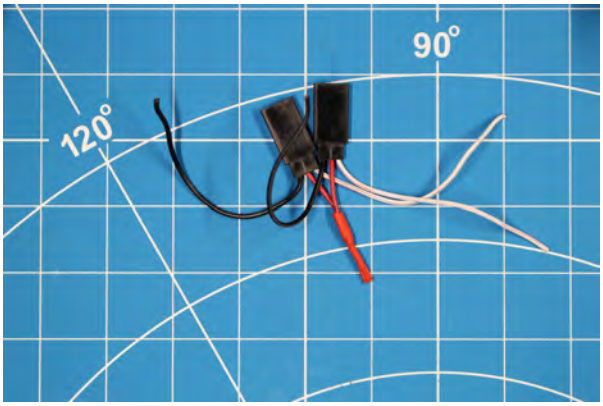


Figure 35: PWM cables soldered with heat shrink applied.

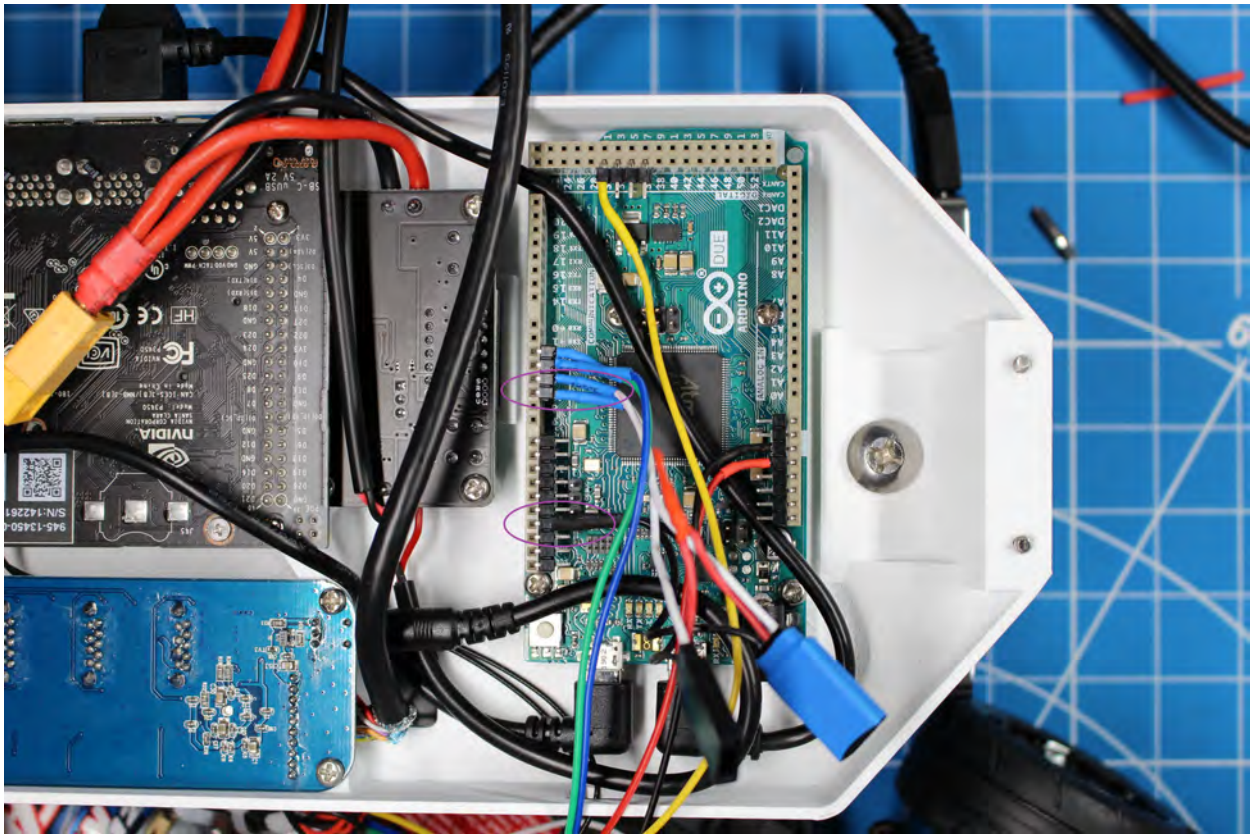


Figure 36: PWM output harness soldered to headers plugged into Arduino DUE.

Task 7 Arduino Wiring Schematic

Arduino Pin	Connection
2	CHANNEL1 IN PIN
3	CHANNEL2 IN PIN
4	CHANNEL1 OUT PIN
5	CHANNEL2 OUT PIN
22	FL IN PIN
24	FR IN PIN
26	BL IN PIN
28	BR IN PIN
30	RECEIVER STATE PIN
32	PHASE A servo
34	PHASE B servo
36	PHASE C servo

Task 8 (OPTIONAL) Wheel Encoder Assembly

To assemble the BARC wheel encoders the following materials are required (See Figure 37).

- **4x** SparkFun Digital QRE 1113R IR Sensor Breakout Boards
- **4x** Female to Female PWM servo cable 9 inch
- **4x** Female to male PWM servo cable 9 inch
- **4x** M2x5mm Screws
- **2x** Left Side Encoder Mount
- **2x** Right Side Encoder Mount
- Male pin headers
- Assorted heat shrink tubing

This modification utilizes the fake "brake rotors" on the Traxxas 4-Tec. These are modified into encoder disks using IR reflective tape and a sharpie. This is used to trigger the Arduino interrupts and sending the data over serial to the Jetson Nano.

For single wheel encoder application install on the front left. Note: The front and rear "brake rotors" are different sizes so do the rear first them the front.

Cut one end off of the 4x Female to Female PWM servo cable and maximize the length of the cable (See Figure 38). Solder the cut Female to Female servo cable to the Digital QRE 1113R IR sensor. Be sure to have the correct order of cables (See Figure 39). Remove the wheel using a 7mm hex. Remove the "brake caliper" using a 2.00mm hex. The "brake rotor" should clip off (See Figure 40). Recommend doing one wheel at a time to ensure not mixing up the wheels or "brake rotors".

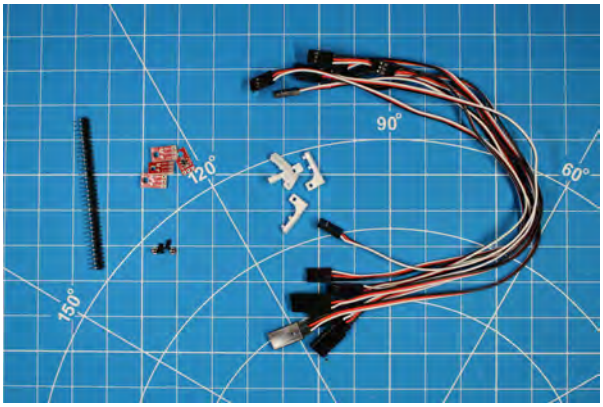


Figure 37: Required materials for 4 wheel encoders.

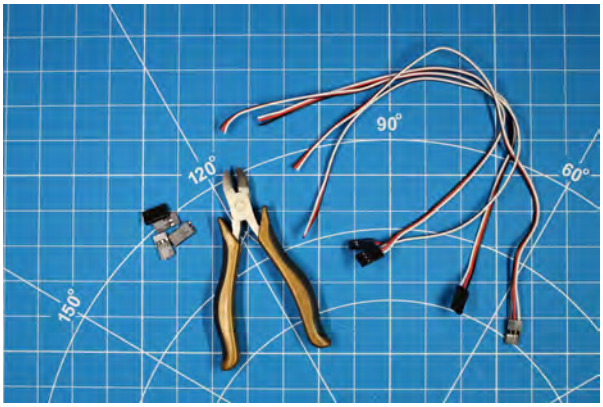


Figure 38: Cut one end off of the Female to Female PWM servo cable. (maximize length)

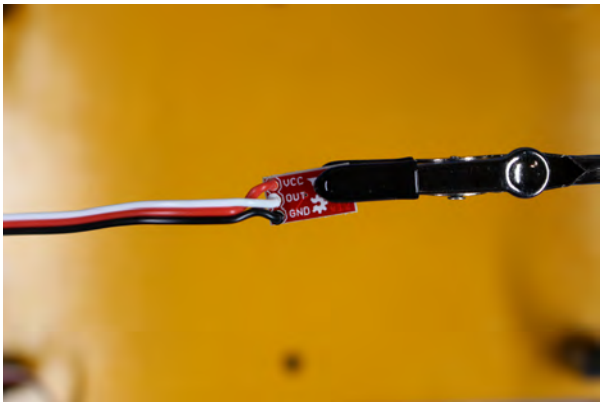


Figure 39: Solder the cut Female to Female servo cable to the QRE D1113R IR sensor. Be sure to have the correct order of cables.

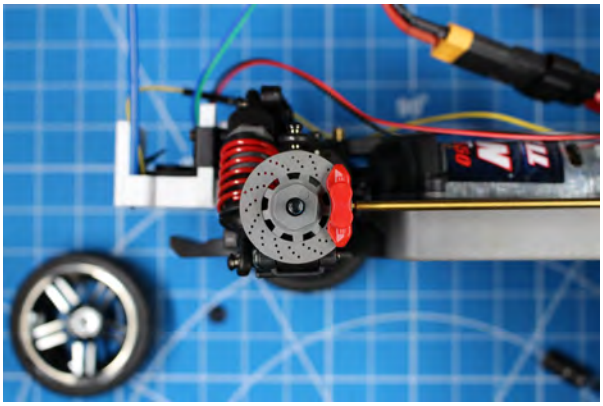
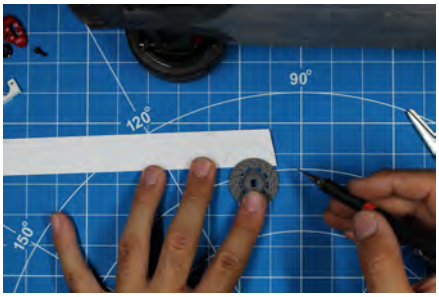
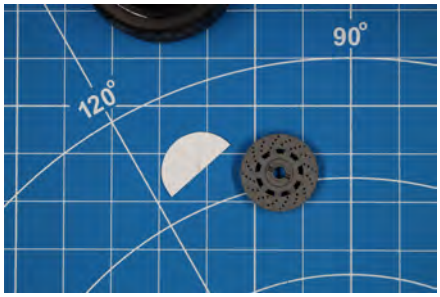


Figure 40: Remove the wheel using a 7mm hex. Remove the "brake caliper" using a 2.00mm hex. The "brake rotor" should clip off.

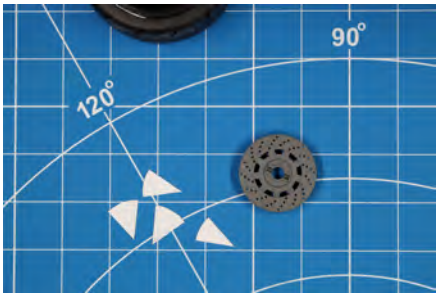
Follow the following figure to modify the wheel encoder disks (See Figure 41).



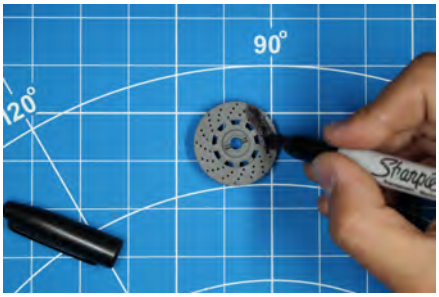
(a) Mark a half circle on the back on the IR tape using the "brake rotor".



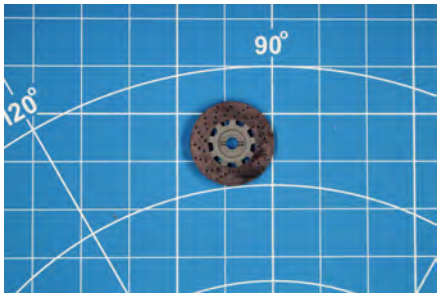
(b) Cut out half circle from IR tape.



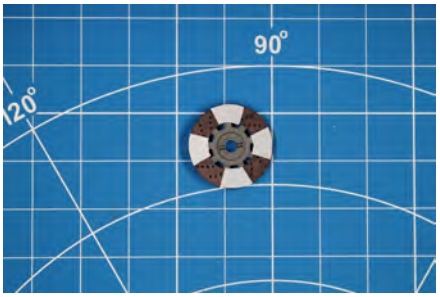
(c) Cut the half circle into fourths.



(d) Using a sharpie color the back of the "brake rotor" black.



(e) Colored "brake rotor".



(f) Peel and install pieces of IR tape to the back of the "brake rotor".

Figure 41: Traxxas 4-Tec Wheel Encoder disk using "brake rotor" modification. Note: The front and rear "brake rotors" are different sizes so do the rear first them the front.

Install the 3D printed IR sensor mount using the screw to hold the caliper in place (See Figure 42). Secure the IR sensor using a M2x5mm screw to the 3D printed mount (See Figure 43). By choosing the mirrored 3D printed bracket the distance between the Encoder Disk and IR sensor can be adjusted.

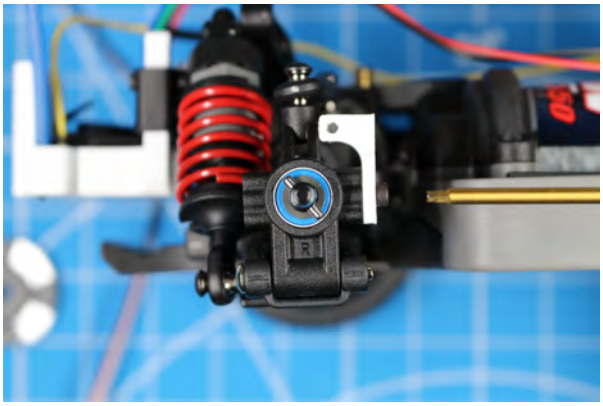


Figure 42: Install the 3D printed IR sensor mount using the screw to hold the caliper in place.

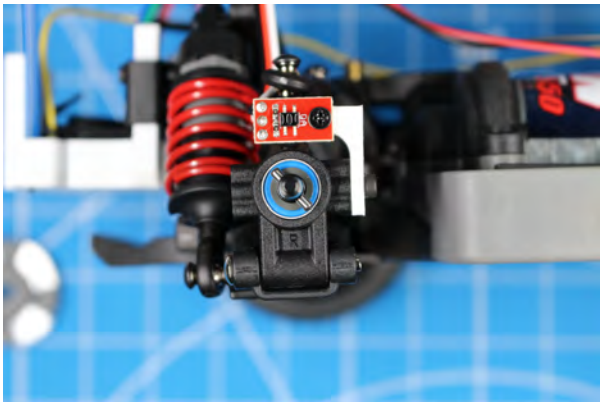
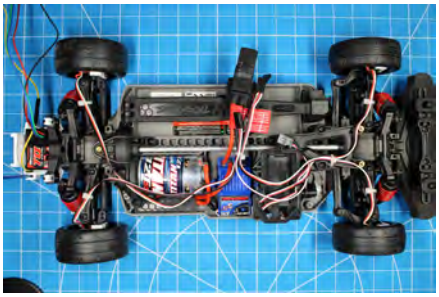
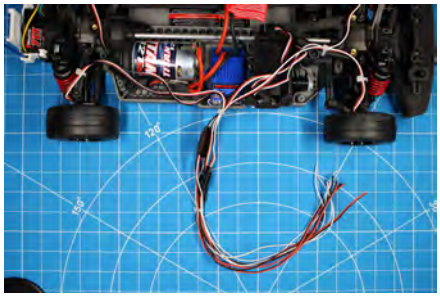


Figure 43: Secure the IR sensor using a M2x5mm screw to the 3D printed mount.

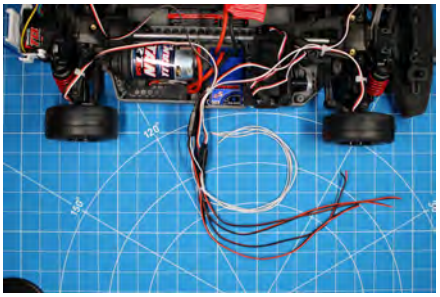
To assemble the wiring harness for the wheel encoders (See Figure 44).



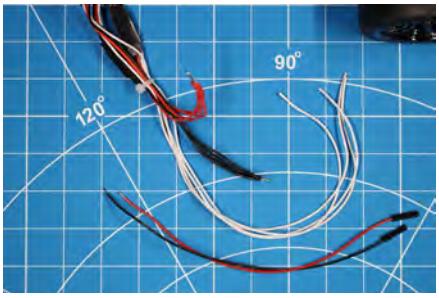
(a) Using zip ties, secure the IR sensor cables. Ensure adequate slack is present for suspension travel. Bundle the cables to the center of the vehicle.



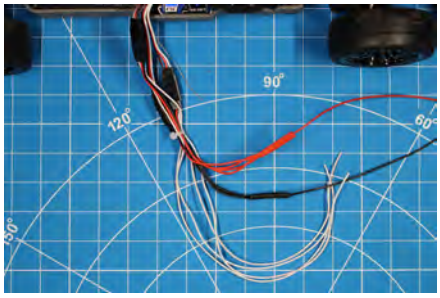
(b) Attach female to male connectors to IR sensor cables. (label the white cables to keep track of the IR sensor locations. Ground and power do not matter.)



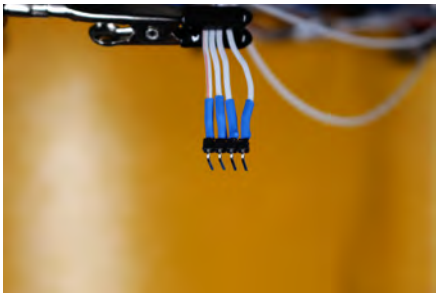
(c) Separate the white signal cable and bundle the grounds and power cables (black and red).



(d) Splice and solder the grounds and power cables. Splice two jumper wires to attach to the power and ground cables.



(e) Solder and apply heat shrink to the ground and power cable.



(f) Solder the white cables to headers to attach to the Arduino DUE. Wire order from right to left ¿ Front Left, Front Right, Rear Left, Rear Right.

Figure 44: Traxxas 4-Tec Wheel Encoder disk using "brake rotor" modification. Note: The front and rear "brake rotors" are different sizes so do the rear first them the front.

Wheel encoder wire harness ground and power soldered to ground and 5v respectively on the Arduino DUE headers (See Figure 45). Wheel encoder signal cables attached to pins 22, 24, 26, and 28.

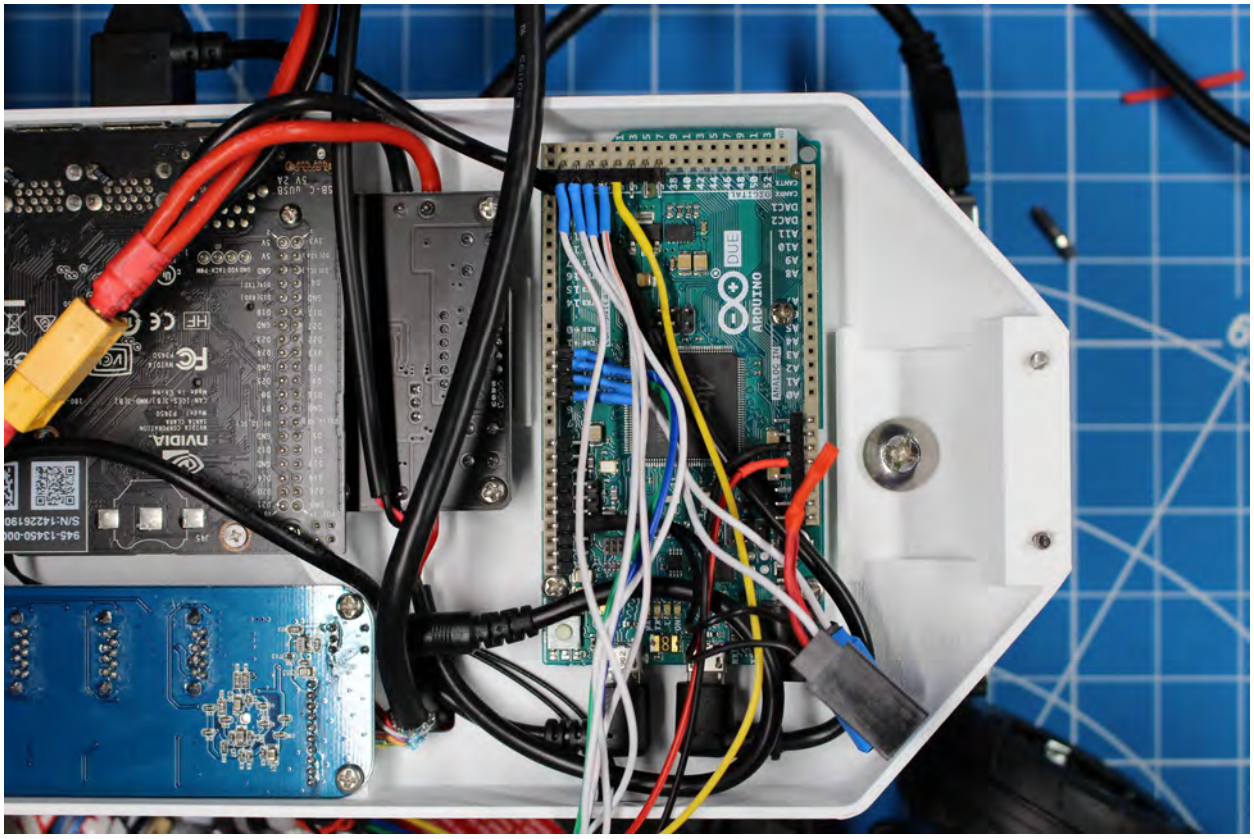


Figure 45: Wheel encoder wire harness ground and power soldered to ground and 5v respectively on the Arduino DUE headers.

Task 9 (OPTIONAL) Servo Position Encoder Modification

To assemble the BARC servo position encoder modification the following materials are required.

- **1x** Savox SB-2263MG-Be High Speed, Brushless Motor, Metal Gear, Low Profile Digital Servo, Black Edition (0.076/138.9)
- Assorted color 28 AWG wire
- **4x** Female to male PWM servo cable 9 inch
- **1x** TEAM LOSI RACING Servo Horn, 25T, Aluminum: 22, TLR1557
- **2x** Servo Mount (cut the receiver box off the one included with the Traxxas 4-Tec or replace with standard RC servo mount)
- Male pin headers
- Assorted heat shrink tubing

Its a bit wordy to explain in text so instead please watch this video for assembly instructions:

https://www.youtube.com/watch?v=xVmNpQ9DWWw

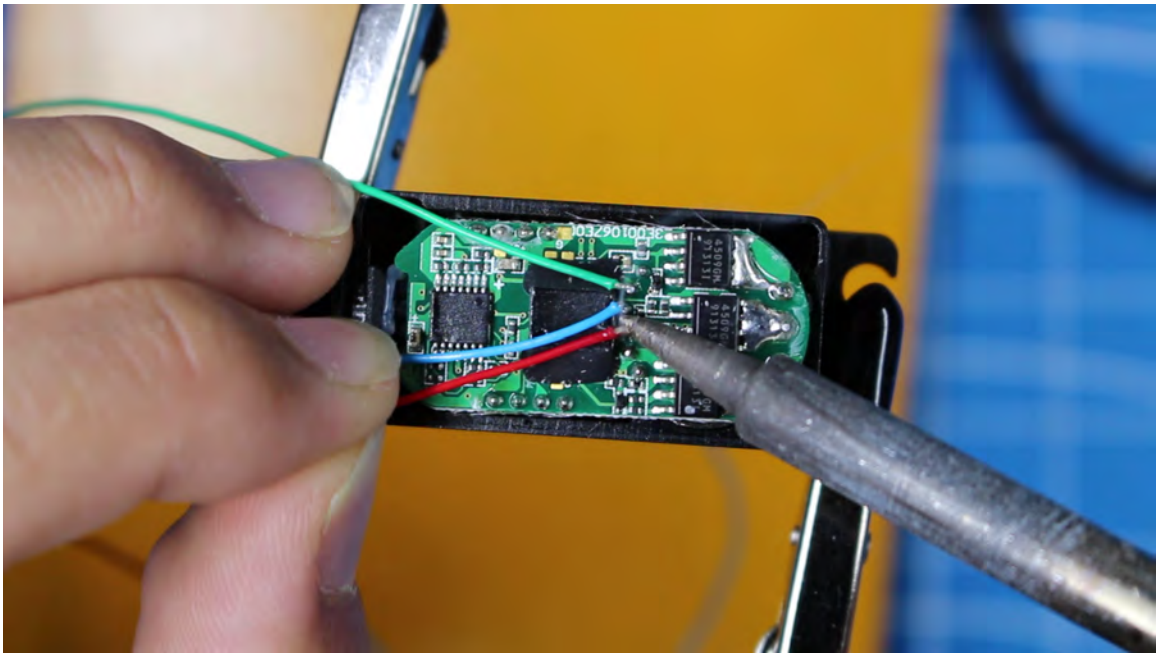


Figure 46: Wires soldered to servo for position feedback.

Listing 1: Arduino IDE code for position feedback

```
#define PHASE_A_servo 32
#define PHASE_B_servo 34
#define PHASE_C_servo 36

int encoder_servo_state_A = 0;
int encoder_servo_state_B = 0;
int encoder_servo_state_C = 0;

int direction_servo = 0;
float servo_angle = 0;
int enc_count = 0;

void setup() {

  Serial.begin(115200);

  pinMode(PHASE_A_servo, INPUT_PULLUP);
  pinMode(PHASE_B_servo, INPUT_PULLUP);
  pinMode(PHASE_C_servo, INPUT_PULLUP);

  attachInterrupt(PHASE_A_servo, calc_A_servo, CHANGE);
  attachInterrupt(PHASE_B_servo, calc_B_servo, CHANGE);
  attachInterrupt(PHASE_C_servo, calc_C_servo, CHANGE);

}
```

```
void loop() {

  servo_angle = enc_count*0.3515625;
  Serial.println();
  Serial.print(servo_angle);
  Serial.print(" , ");
  Serial.print(enc_count);
  Serial.print(" , ");
  Serial.print(encoder_servo_state_A);
  Serial.print(" , ");
  Serial.print(encoder_servo_state_B);
  Serial.print(" , ");
  Serial.print(encoder_servo_state_C);

}

void readServoEncoder() {
  encoder_servo_state_A = digitalRead(PHASE_A_servo);
  encoder_servo_state_B = digitalRead(PHASE_B_servo);
  encoder_servo_state_C = digitalRead(PHASE_C_servo);
}

void calc_A_servo() {
  readServoEncoder();
  if (encoder_servo_state_A + encoder_servo_state_B + encoder_servo_state_C == 2) {
    if (encoder_servo_state_B == HIGH) {
      direction_servo = -1;
    } else {
      direction_servo = 1;
    }
  } else {
    if (encoder_servo_state_B == HIGH) {
      direction_servo = 1;
    } else {
      direction_servo = -1;
    }
  }
  enc_count += direction_servo;
}

void calc_B_servo() {
  readServoEncoder();
  if (encoder_servo_state_A + encoder_servo_state_B + encoder_servo_state_C == 2) {
    if (encoder_servo_state_A == HIGH) {
      direction_servo = 1;
    } else {
      direction_servo = -1;
    }
  } else {
    if (encoder_servo_state_A == HIGH) {
      direction_servo = -1;
    } else {
      direction_servo = 1;
    }
  }
  enc_count += direction_servo;
}

void calc_C_servo() {
```

```
  readServoEncoder();
  if (encoder_servo_state_A + encoder_servo_state_B + encoder_servo_state_C == 2) {
    if (encoder_servo_state_A == HIGH) {
      direction_servo = -1;
    } else {
      direction_servo = 1;
    }
  } else {
    if (encoder_servo_state_A == HIGH) {
      direction_servo = 1;
    } else {
      direction_servo = -1;
    }
  }
  enc_count += direction_servo;
}
```

Task 10 (OPTIONAL) Change Power Plug on Traxxas ESC

Changing the power plug allows for lower resistance which allows for better transmission of power to the components. May allow for easier charging and after market battery options.

- **1x** Male Power Connector (i.e. XT60, DEANs, EC3, etc)
- Assorted heat shrink tubing

To change the power plug on the Traxxas ESC first pull the connector out and de-solder the original connector or cut the original connector off (See Figure 47). Solder the new Male connector onto the ESC ensuring the correct polarity (See Figure 48).

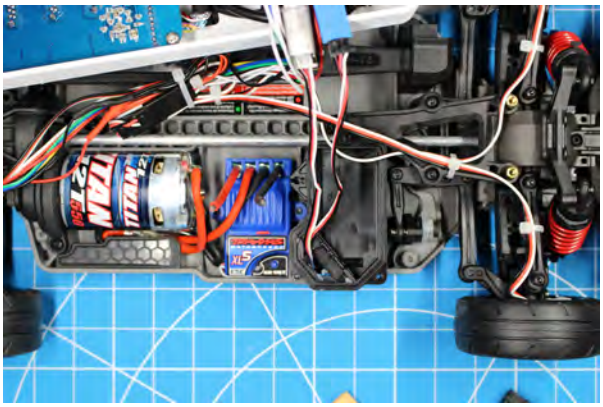


Figure 47: Original connector cut off from ESC.

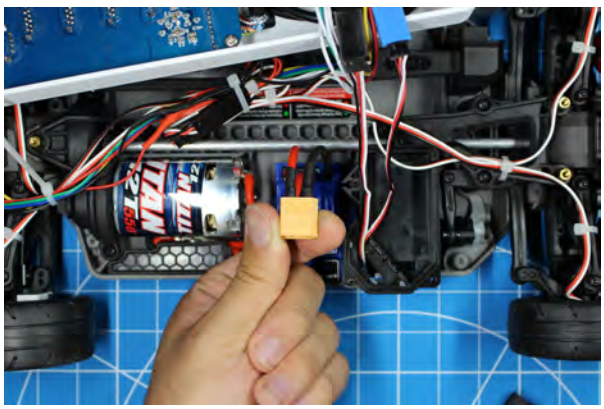


Figure 48: New connector soldered with heat shrink applied.

Task 11 Bill of Materials

Main Hardware:

- Traxxas 4Tec
- Intel RealSense D435i
- Nvidia Jetson Nano
- Arduino Due
- IPX Sticker WiFi Antennas
- Intel AX200 WiFi m.2 Card
- USB Splitter Board
- Drok 3A Step Down

Fasteners

- **19x** m3x6 Phillips button head screw
- **4x** m2.5x6 Phillips button head screw
- **2x** m3x8 Female to Female Standoff
- **2x** m3x20 Setscrew
- **1x** m3x4+6 Female to Male Standoff
- **1x** 1/4x20x2 inch Screw

Cables

- **2x** Servo Extension 3 inch
- **1x** XT60 Splitter One Male to Two Female
- **1x** Right angle 5.1x2.1mm Barrel Jack Connector
- **2x** Invertable Right angle USB A to Micro USB
- **1x** Right angle USB C to A 9 inch
- **20x** Jumper Wire Female to Male

Wheel Encoders

- **4x** Analog QRE1113 SparkFun Line Sensor Breakout Board
- **4x** Male to Female Servo Extension Cables
- **4x** Servo Cable 9 inch
- Black Sharpie
- Reflective Tape

Servo Position Encoder

- **3x** 3 Different colored 30AWG wire
- **3x** Pin headers

Optional Hardware:

- Noctua 40mmx20mm 5 Volt fan
- MiPi Camera
- Intel RealSense T265

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40 Remove the wheel using a 7mm hex. Remove the "brake caliper" using a 2.00mm hex. The "brake rotor" should clip off. 16

41 Traxxas 4-Tec Wheel Encoder disk using "brake rotor" modification. Note: The front and rear "brake rotors" are different sizes so do the rear first them the front. 16

42 Install the 3D printed IR sensor mount using the screw to hold the caliper in place. 17

43 Secure the IR sensor using a M2x5mm screw to the 3D printed mount. 17

44 Traxxas 4-Tec Wheel Encoder disk using "brake rotor" modification. Note: The front and rear "brake rotors" are different sizes so do the rear first them the front. 17

45 Wheel encoder wire harness ground and power soldered to ground and 5v respectively on the Arduino DUE headers. 18

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