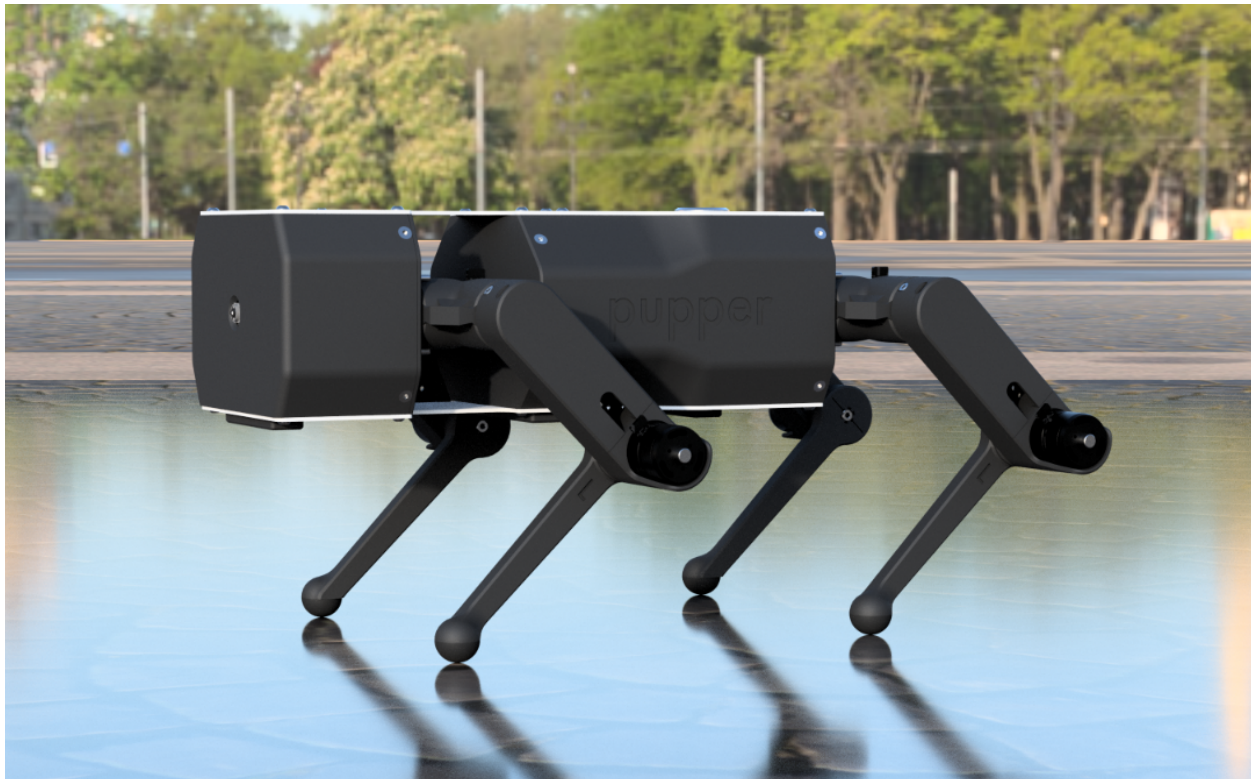


# Stanford Pupper 2.1

Assembly and Operation



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# Overview

## Mechanical Design

- [Fusion 360 CAD](#)
  - Outdated, need to upload latest files

## Bill of Materials

- [Pupper V2.1 BOM](#)
- Costs about \$2k to build

## Part files

- [DJI Pupper](#) -> DJI Pupper STLs
  - Outdated, need to upload latest files
  - A readme is included in this folder for printing instructions
- [DJI Pupper](#) -> PCB Production Files
  - Outdated, need to upload latest files
  - A readme is included in this folder for fabrication instructions
  - Videos for purchasing the pcbs
    - Teensy shield: <https://www.youtube.com/watch?v=Jm57xkEqToU>
    - Bottom PCB: [https://www.youtube.com/watch?v=D\\_1yNNPYND0](https://www.youtube.com/watch?v=D_1yNNPYND0)
    - Top PCB: <https://youtu.be/Av4CbTJec8I>

## Software

- Laptop code: <https://github.com/stanfordroboticsclub/StanfordQuadruped/tree/dji>
- Laptop joystick emulator:  
<https://github.com/stanfordroboticsclub/PupperKeyboardController>
- Teensy code: <https://github.com/Nate711/DJIPupperTests/tree/master>

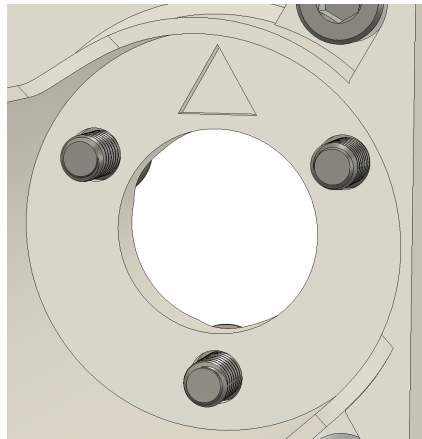
# Assembly

Important: Read before starting

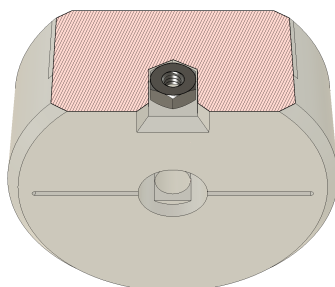
- Parts that differ between the left and right side are correspondingly embossed with an L or R.



- The embossed triangles indicate the correct direction of the motor wires.



- The following image shows a cross-section of a correctly-inserted hex nut. Note that the flats of the nut are parallel to the pocket walls.



- Apply Loctite Blue 242 to all M3x6 flat-head cap screws used to mount the motors. This is mandatory, as otherwise these screws will quickly loosen from repeated foot-ground impacts.
- Melt the cut ends of the cable sleeving to prevent them from unravelling.

## Electronics

### 1. Wiring the bottom PCB

1. Solder the XT-60 leads.
2. Mount the Teensy to the bottom PCB in the indicated orientation.
3. Insert the ends of the power switch wires into the screw terminals on the bottom PCB. There are labels on the PCB indicating which color wire goes where.

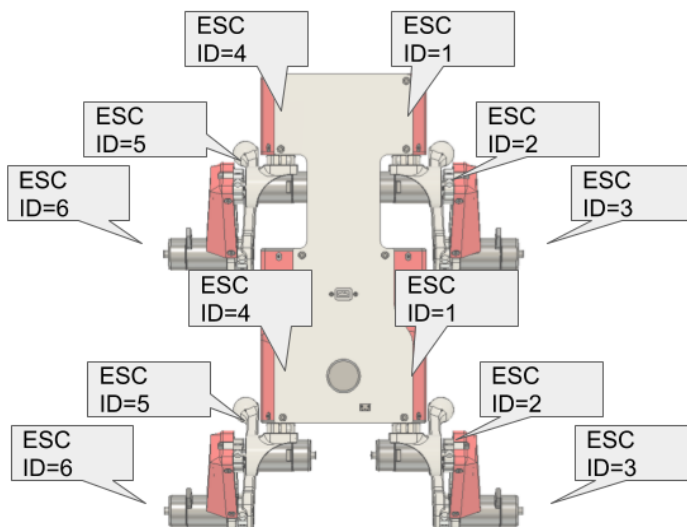
### 2. Set motor controller IDs

Each C610 motor controller needs an ID number so that it knows which motor commands to listen to. The front and back motor controllers are on separate CAN networks so their IDs can overlap, but on each network, each controller must have a unique ID.

Review the diagram below to see which motor controllers have what ID.

#### Setting the ID

1. Press the C610 button once to tell it to enter ID-setting mode
2. Without pausing (aka within 1s), press the button additional times, with the number of presses indicating the ID. For example, press it once to put it into ID-setting mode, then press the button 6 more times to assign it the ID number 6. After each of the presses after the first press to change the mode, you should see the blue light flash.
3. The C610 will now reboot and the number of green flashes indicates the ID. After the flashing sequence is complete, it'll wait a little and repeat the sequence.



### 3. Calibrate motors

Whenever you connect the C610 motor controller to a motor (the M2006), the pairing must be calibrated. Before calibrating, check that the motor is free to move. This often means taking off the attached legs.

Steps

1. Long-press the C610 button to enter calibration mode, release once it starts beeping
2. The motor will now slowly turn to calibrate itself
3. The controller will reboot once finished

### 4. Remove ferrite rings from motor controllers

The ferrite rings are the black plastic cylinders attached to the power cables. You can remove them by lifting the small tabs on the side of the plastic housing.

## Subassemblies

### 1. Lower Leg L/R

Quantity to assemble: 4

Parts:	Qty.	Descr.	ID
	(1)	M2.5 hex nut	91828A113
	(1)	Rubber foot	9541K82

3D-printed parts:

(1) Lower leg L/R

Instructions: [Lower Leg L\\_R - All Steps.mp4](#)

### 2. Upper Leg

Quantity to assemble: 4

Parts:	Qty.	Descr.	ID
	(3)	M3x6 flat-head cap screw	92125A126
	(4)	M3x16 dowel pin	91585A379
	(1)	M2.5 hex nut	91828A113
	(1)	Motor	DJI M2006
	(1)	Motor driver	DJI C610
	(1)	Cable sleeving, 20cm length	

3D-printed parts:

(1) Upper leg

(1) Upper leg cover

Instructions: [Upper Leg - All Steps.mp4](#)

### 3. Hip L/R

Quantity to assemble: 4

Parts:	Qty.	Descr.	ID
	(3)	M3x6 flat-head cap screw	92125A126
	(1)	M2.5 hex nut	91828A113
	(4)	Motor	DJI M2006
	(2)	Cable sleeving, 15cm length	
	(4)	Zip-tie	

3D-printed parts:

(1) Hip L/R

Instructions: [Hip L\\_R - All Steps.mp4](#)

### 4. Motor Bulkhead

Quantity to assemble: 2

Parts:	Qty.	Descr.	ID
--------	------	--------	----



- |     |                          |           |
|-----|--------------------------|-----------|
| (6) | M3x6 flat-head cap screw | 92125A126 |
| (4) | M3x16 dowel pin          | 91585A379 |
| (2) | Motor                    | DJI M2006 |
| (2) | Motor driver             | DJI C610  |

3D-printed parts:

- (1) Motor bulkhead

Instructions: [Motor Bulkhead - All Steps.mp4](#)

## Assemblies

### 1. Leg L/R

Quantity to assemble: 4 (2 L, 2 R)

Parts:	Qty.	Descr.	ID
	(8)	M2.5x16 shoulder screw	90265A420

Subassemblies:

- (1) Lower Leg L/R
- (1) Upper Leg
- (1) Hip L/R

Instructions: **Todo: add video**

### 2. Bulkhead Module

Quantity to assemble: 2

Parts:	Qty.	Descr.	ID
	(2)	M2.5x16 shoulder screw	90265A420
	(4)	Zip-tie	

Subassemblies:

- (1) Leg L
- (1) Leg R

Instructions: **Todo: add video**

### 3. Pupper

Quantity to assemble: 1

Parts:	Qty.	Descr.	ID
	(16)	M3x6 button-head cap screw	92125A126
	(12)	M3x6 flat-head cap screw	92125A126
	(1)	Top PCB	
	(1)	Bottom PCB	

3D-printed parts:

- (1) Electronics bulkhead
- (1) Front cover
- (2) Side cover L/R
- (1) Bottom PCB cover A
- (2) Bottom PCB cover B

Subassemblies:

- (2) Bulkhead Module

Instructions: **Todo: add video**

# Software Installation

## 1. Requirements

- a. Mac or Linux machine. Windows instructions are experimental.
- b. MicroSD card reader
- c. USB-C data cable

## 2. Teensy

- a. Clone <https://github.com/Nate711/DJIPupperTests.git>

```
git clone https://github.com/Nate711/DJIPupperTests.git
```

- b. Cd that directory

```
cd DJIPupperTests
```

- c. Update the submodules:

```
git submodule update --init
```

- d. Install VSCode and the Platformio VSCode extension

- e. This video shows the next few steps:

<https://knowledge.autodesk.com/community/screencast/cbf5a477-08e8-4b54-aa1b-aeffc3e5aa3d>

- f. Install "ArduinoJson" by Benoit Blanchon and "BasicLinearAlgebra" by Tom Stewart

- g. Linux only

- i. Download the following file:

<https://www.pjrc.com/teensy/00-teensy.rules> and put it under  
`/etc/udev/rules.d/`

- ii. Reload udev rules.

```
sudo udevadm control --reload-rules && udevadm trigger
```

- h. Use platformio to upload the code (click upload)

- i. When the firmware is uploaded correctly, the teensy will flash over 5 seconds and then start printing debug information over the usb serial cable.

## 3. Raspberry Pi

- a. Download [Balena Etcher](#)

- b. Get a system image. There are two options for this:

- i. Download a prebuilt image

**Todo: add link**

- ii. Build the image yourself

**Todo: add instructions**

- c. Select the image in Etcher and flash it to the MicroSD card.

- d. Insert the MicroSD card into the Pi. To test that it works, boot up the Pi and SSH in over the USB-C port using the default credentials.

# Operation

## 1. Startup

- 1.1. Plug in the battery alarm (if using one).
- 1.2. Place the robot on a flat, level surface. Position the legs as shown.



- 1.3. Move the left thumbstick on the transmitter to its bottom position.
- 1.4. Turn on the transmitter by holding its power button for 5 seconds.
- 1.5. Turn on the robot by pressing its power button. It will immediately begin the homing sequence.
- 1.6. Wait 20 seconds for the Raspberry Pi to boot up.
- 1.7. The robot is now ready to receive control inputs.

## 2. Controls

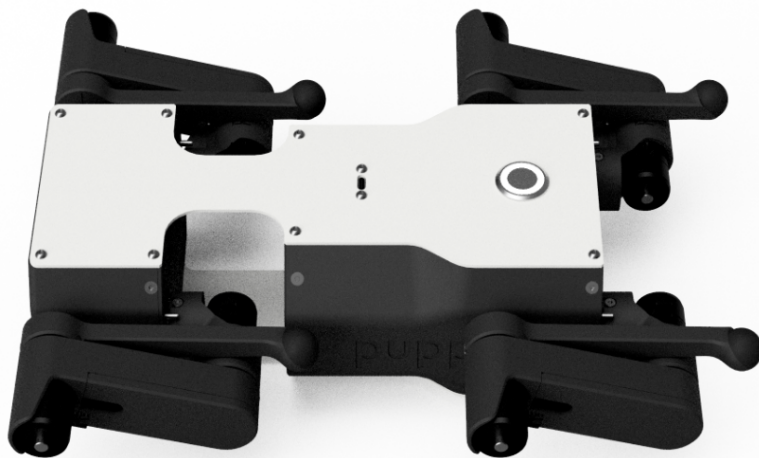
Transmitter Input	Function
Left thumbstick	Yaw rotation
Right thumbstick	Translation
Left 2-position switch	Activates and deactivates the motors (can be used as an emergency stop)
Right 2-position switch	Switches between standing and locomoting
Left 3-position switch	N/A
Right 3-position switch	Switches between trotting and static gait (flip the switch all the way)

### 3. Shutdown

- 3.1. Turn off the robot by pressing its power button.
- 3.2. Turn off the transmitter by holding its power button for 5 seconds.
- 3.3. Unplug the battery alarm (if using one).

### 4. Storage

- 4.1. Position the legs as shown.



- 4.2. Place the robot in the carrying case with its camera facing to the left.
- 4.3. Place the transmitter in the carrying case with its thumbsticks facing away from the robot.

### 5. Charging

- 5.1. Remove the left side cover.
- 5.2. Unplug the battery's XT-60 and JST-XH connectors.
- 5.3. Charge the battery with a 6S lithium-ion balance charger.

More information here:

<https://github.com/stanfordroboticsclub/StanfordQuadruped/blob/dji/README.md>

## Troubleshooting

Check the C610 manual

Contains info about LED flash sequences etc:

<https://drive.google.com/file/d/1L8oGLUjuZ96MB90XeFtk1E01sL-Uh4BW/view?usp=sharing>

Or the M2006 manual:

<https://drive.google.com/file/d/1L8oGLUjuZ96MB90XeFtk1E01sL-Uh4BW/view?usp=sharing>

# Reference

## Actuator Numbering

