

QDrone2

System Hardware User Manual

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This equipment is designed to be used for educational and research purposes and is not intended for use by the public. The user is responsible to ensure that the equipment will be used by technically qualified personnel only. While the end-effector board provides connections for external user devices, users are responsible for certifying any modifications or additions they make to the default configuration.

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A. Hardware Components

The main components for the QDrone2 are listed in Table 1.

ID	Component	ID	Component
1	Intel RealSense D435	12	LCD display
2	Right CSI camera	13	ESC Enable
3	Rear CSI camera	14	Programable LEDs
4	Left CSI camera	15	USB3 Port
5	Downward Greyscale camera	16	Micro USB2 Port
6	WiFi 802.11 a/b/g/n/ac with dual antennas	17	NVIDIA Jetson Xavier NX
7	Expandable I/O	18	Brother Hobby Brushless motors
8	Micro-HDMI Port	19	Optical Flow Camera
9	Power Button	20	Height Sensor
10	XT-60 battery connector	21	15x1mm FPC RPi Connector
11	LiPo battery compartment		

Table 1. QDrone2 Components

i. Nvidia Jetson Xavier NX

The QDrone2 is powered by a NVIDIA Jetson Xavier NX with 358 CUDA® Cores and an NVIDIA Volta™ GPU architecture. It also features a 6-Core NVIDIA Carmel ARM® 64-Bit CPU. More information on this board can be found [here](#).

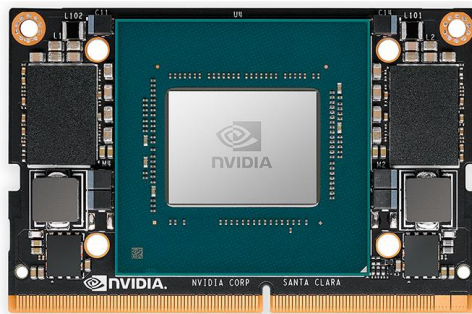


Figure 2. NVIDIA Jetson TX2 Processor

The board includes 16 GB of storage via an eMMC and 8 GB of 128-bit LPDDR4X 1866 MHz 59.7 GB/s memory. Ubuntu 20.04LTS is installed in the 128GB SD card provided.

ii. Intel RealSense D435 Camera

The QDrone2 comes equipped with an Intel RealSense D435 RGB-D camera. It includes an IR projector and two IR imagers, making this unit a stereo tracking solution. The camera can provide RGB, Infrared (left and right) and depth streams of data at frame rates and resolutions summarized in Table 3, as well as at fields of view in Table 4. More information can be found [here](#).



Figure 4. Intel RealSense D435 RGBD camera

RGB		Infrared		Depth	
Resolution	Max. Frame Rate	Resolution	Max. Frame Rate	Resolution	Max. Frame Rate
1920 x 1080	30	1280 x 800	30	1280 x 720	30
1280 x 720	30	1280 x 720	30	848 x 480	90
960 x 540	60	848 x 480	90	848 x 100	100
848 x 480	60	848 x 100	100	640 x 480	90
640 x 480	60	640 x 480	90	640 x 360	90
640 x 360	60	640 x 360	90	480 x 270	90
424 x 240	60	480 x 270	90	424 x 240	90
320 x 240	60	424 x 240	90	256 x 144	90
320 x 180	60	256 x 144	90	n/a	n/a

Table 3: Intel RealSense resolutions and frame rates

Camera	Horizontal	Vertical	Diagonal
RGB	$69.4^{\circ} \pm 3^{\circ}$	$42.5^{\circ} \pm 3^{\circ}$	$77^{\circ} \pm 3^{\circ}$
Depth	$87^{\circ} \pm 3^{\circ}$	$58^{\circ} \pm 1^{\circ}$	$95^{\circ} \pm 3^{\circ}$

Table 4. Intel RealSense D435 field of view

iii. CSI Camera Suite

The QDrone2 provides 3 CSI cameras along with the Intel RealSense to give a complete 360° view (Figure 5a). Each camera has a wide-angle lens providing up to 160° Horizontal-FOV (field of view) and 120° Vertical-FOV. The corresponding blind-spots have been shown below in Figure 5b.

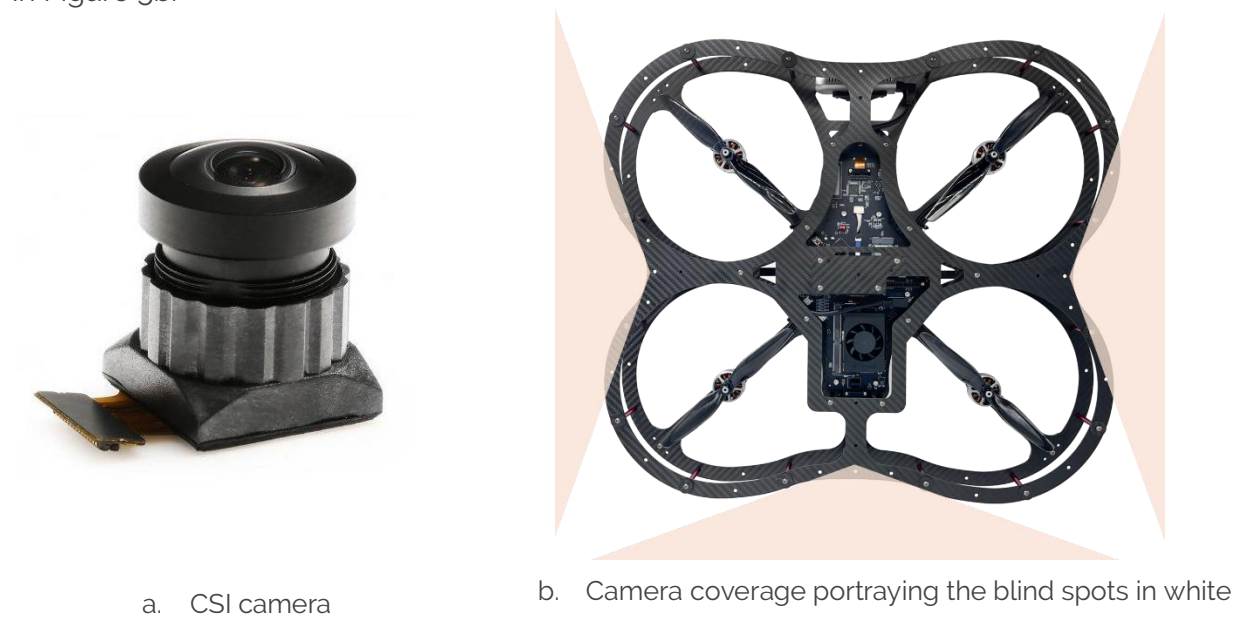


Figure 5. CSI cameras with wide angle lenses and field of view via their placement.

These cameras are indexed in Simulink, Python and C/C++ using the camera IDs as presented in Table 5. The frame resolutions, frame rates and corresponding FOV are documented in Table 6.

Camera	ID
Right	0
Rear	1
Left	2

Table 5. Camera indexing IDs

Resolution	Max Frame Rate (FPS)	Horizontal FOV	Vertical FOV
3280 x 2464	21 Hz	160°	120°
1640 x 1232	80 Hz	160°	120°
820 x 616	80 Hz	160°	120°
1640 x 820	120 Hz	160°	80°
820 x 410	120 Hz	160	80°

Table 6. Achievable frame rates for CSI cameras

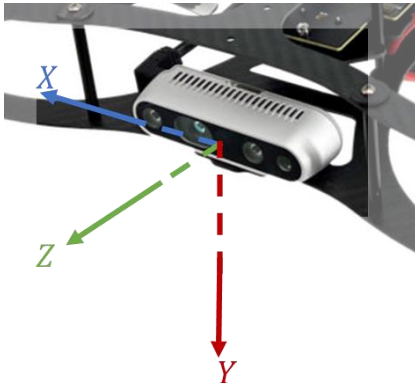
The extrinsic matrices of the four CSI cameras have been provided below. The intrinsic matrices have not been provided, as they vary with resolution. Each extrinsic matrix transforms a 3D world coordinate expressed in the body frame $\{B\}$, into a 3D world coordinate expressed in the camera frame of reference $\{C\}$. Facing any camera, the z axis of the camera points straight outwards, the x axis points towards the right, and the y axis points downwards, as shown in Figure 6a. Note that this is a left-handed reference frame. The body frame's x axis points longitudinally forwards, the z axis points upwards, and the y axis points towards the left side of the vehicle, as shown in Figure 6b. As a result, the rotation matrix part of each extrinsic matrix has a determinant of -1 .

$$\epsilon_{T_{B_{front}}} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0.087 \\ 1 & 0 & 0 & -0.190 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\epsilon_{T_{B_{rear}}} = \begin{bmatrix} 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0.087 \\ -1 & 0 & 0 & -0.145 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\epsilon_{T_{B_{right}}} = \begin{bmatrix} 1 & 0 & 0 & 0.026 \\ 0 & 0 & -1 & 0.087 \\ 0 & -1 & 0 & -0.052 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\epsilon_{T_{B_{left}}} = \begin{bmatrix} -1 & 0 & 0 & -0.026 \\ 0 & 0 & -1 & 0.087 \\ 0 & 1 & 0 & -0.045 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$



a. Camera frame $\{C\}$ b. Body frame $\{B\}$
 Figure 6. Camera and body reference frames used in the extrinsic matrices

As an example, a point located on the floor 1m ahead of the QCar is expressed in body frame as

$${}^Bx = [1 \ 0 \ 0]^T$$

This point can be expressed in the front CSI camera's coordinates as,

$${}^Cx = {}^C T_{B_{front}} \begin{bmatrix} {}^Bx \\ 1 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0.087 \\ 1 & 0 & 0 & -0.190 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 0.087 \\ 0.810 \\ 1 \end{bmatrix}$$

The point is then ${}^Cx = [0 \ 0.087 \ 0.810]^T$.

iv. Brother Hobby Motors

The QDrone2 comes equipped with 4 Brother Hobby 2806.5-1300Kv brushless motors. Onboard motor command modulation is done from the microcontroller to prevent overheating from damaging the ESC or the onboard PCB.

When sending a 100% duty cycle command the onboard modulation will send a command signal with the following characteristics:

- A 1s burst at 80% duty cycle followed by a 5s continuous signal at 70%

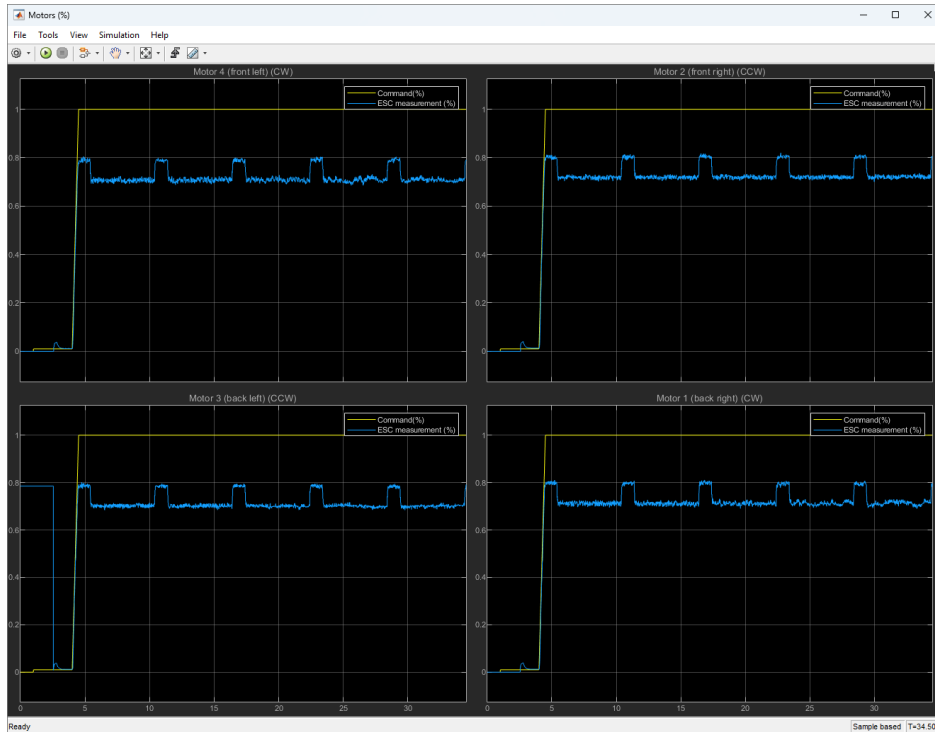


Figure 7. Firmware throttle limits applied to a continuous 100% duty cycle command.

Symbol	Description	Value
K_V	Motor speed constant	1300 RPM/V

Table 7: Brother Hobby motor thrust constant.

v. Height Sensor

The QDrone2 comes with a VL53L1X Time of Flight optical distance sensor for measuring the distance of a surface to the underside of the QDrone2. Distance measurements can be performed in the three following modes:

Description	Value	Max Sampling Rate
Short	1.3 m	50Hz
Medium	3.0m	30Hz
Long	4.0m	30Hz

Table 8: VL53L1x max distance parameters.

For more information on the VL53L1x module you can click [here](#).

vi. Battery

QDrone2 uses a 4S (4-cell 15.6 Volts) 3700 mAh capacity lithium polymer (LiPo) battery (Figure 8a) with a female XT-60 connector. More information on the provided battery is summarized in Table 9. The battery can be charged using the provided EV-Peak E4 charger (Figure 7b). Under-voltage protection ensures that the QCar automatically shuts down when the battery voltage drops below 10.0V. If the battery voltage drops below 10.5V, a 'LOW BAT' warning message is displayed on the LCD. For more information, see the [User Manual - Power](#) document.



a. LiPo 4s 3700mAh with balancer cable (5 wire connector) and XT60 female connector



b. EV-Peak E4 charger

Figure 7. LiPo battery and charger provided with the QCar

#	Item	Value
1	Cells	4S (4 cells in series)
2	Battery capacity	3700 mAh
3	Minimum continuous discharge rating	45 C
4	Connector on battery side	XT60 (Female)
5	Maximum voltage per cell	4.2 V
6	Nominal voltage per cell	3.7 V
7	Minimum voltage per cell	3.5 V
8	Battery weight	372 grams
9	Battery dimensions (LxWxH)	136 mm x 41 mm x 27 mm

Table 9. LiPo battery characteristics



Caution: Before using any batteries, chargers/balancers, or power supplies, users must first read the manuals packaged with their equipment. Quanser supplies these guidelines for charging batteries but it is the users' responsibility to ensure they are operating their equipment safely and correctly. Quanser is not responsible for any damages resulting from use of batteries, power supplies, chargers, or balancers.



Caution: Prior to using the QDrone2, visually check the battery for bloating or damage. If the battery exhibits bloating **DO NOT USE** it. Visual bloating of the battery is dangerous - discard it in accordance with your country's relevant recycling and disposal laws



Caution: A battery voltage below 14V increases the risk of uneven charge between the four cells. If you experience issues charging a battery that is consistently below 14V, discard it in accordance with your country's relevant recycling and disposal laws



Caution: Charge and store LiPo batteries in a location where a battery fire or explosion (including smoke hazard) will not endanger life or property. Do not charge LiPo batteries near flammable materials, liquids or objects.

Note: Use and store battery in a dry environment.



Caution: Do not charge the battery under direct sunlight.



Caution: Do not charge the battery when it feels hot. If it does, you should place it in a metal container and observe signs of swelling or heating for at least 30 minutes.

Ensure that the metal container doesn't short the leads of the battery, which may cause a fire!



Caution: Always be present when charging batteries and do not leave batteries connected to the chargers or the QDrone2 overnight.



Caution: Keep LiPo batteries away from children and animals.





Caution: Never charge a LiPo battery that has been punctured or damaged in a crash. After a crash, inspect the battery pack for signs of damage. Protect your LiPo batteries from accidental damage during storage and transportation. Do not put battery packs in pockets or bags where they can short circuit or can come into contact with sharp or metallic objects.

Note: If you require additional batteries, please contact Quanser. If you are using batteries not supplied by Quanser, ensure that the connection and polarity match.



Caution: A LiPo battery fire is a chemical fire. Have a suitable fire extinguisher (class D/for electrical fires) near the charging area. Do not try to extinguish electrical battery fires with water.

 **Caution:** Protect your LiPo batteries from accidental damage during storage and transportation. Do not put battery packs in pockets or bags where they can short circuit or can come into contact with sharp or metallic objects.

 **Caution:** If your LiPo battery is subjected to a shock (such as a crash) you should place it in a metal container and observe signs of swelling or heating for at least 30 minutes.

Ensure that the metal container doesn't short the leads of the battery, which may cause a fire!

 **Caution:** Do NOT attempt to disassemble, modify, or repair the LiPo battery.

Note: Consider how you would deal with a LiPo battery fire/explosion as part of your normal fire safety and evacuation planning.

Note: When discarding a LiPo battery, discard it in accordance with your country's relevant recycling and disposal laws.

Note: Monitor charging LiPo batteries for signs of overheating

The battery's performance has been summarized in Table 9 below.

Condition	Battery Life
Hover Flight (no payload)	8 min 30 s

Table 9. Battery performance at hover

vii. IMU

The platform includes 2 6-axis IMU. The specifications are summarized in Table 10 below and all data is provided in the body frame shown in Figure 6b.

Sensor	Description
Accelerometer	16-bit with configuration range $\pm 2g$ to $\pm 16g$
Gyroscope	Configurable range from $\pm 125^\circ/s$ to $\pm 2000^\circ/s$

Table 10. IMU specifications for QDrone2

vii. Dimensions

The QCar is based on a 1/10th scale platform (i.e., Traxxas 4-Tec 2.0). Its dimensions have been summarized in 11. The wheelbase and track are shown in Figure 8.

Item	Value
Length	
Width	
Height	

Table 11. QDrone2 dimensions

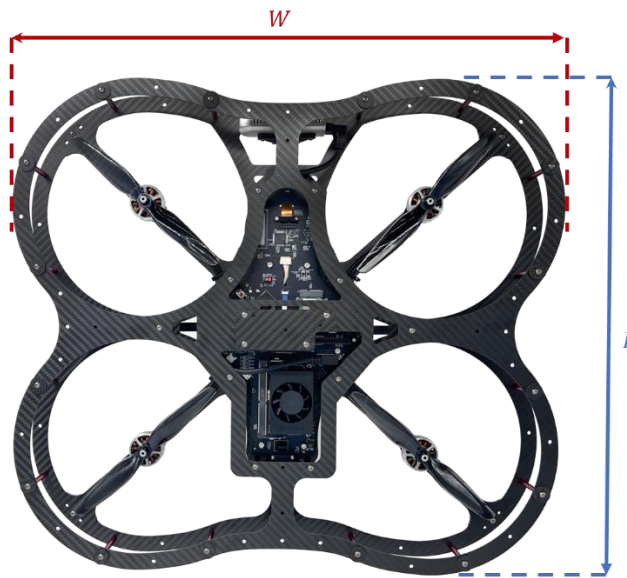


Figure 8. QDrone2 dimensions top view

ix. PCB and integrated Data Acquisition (DAQ)

The QDrone2 PCB is equipped with a wide array of components to support expanded I/O capabilities. These components are summarized in Table 12 and displayed in Figure 9. These I/O include:

1. 6 PWM output channels: Four PWM output channel to command the Brother Hobby motor plus two additional PWM outputs for ESCs or servos. Standard PWM, RC, OneShot, Multishot and DShot are all supported. *
2. One unipolar user analog input channels, 12-bit, +3.3V*
3. 6 reconfigurable digital I/O*
4. 2 LEDs (intensity cannot be controlled)
5. 2 6-axis IMU with temperature information

- 6. 4 Dedicated encoder channels with 24-bit counters (in quadrature mode)
- 7. 2 general purpose 1.8V high-speed serial ports (up to 4 Mbaud) *
- 8. 1 high-speed 1.8V SPI port with 2 chip selects (up to 25 MHz) *
- 9. 1 high-speed 1.8V SPI port with 1 chip select (up to 25 MHz) *
- 10. 2 3.3V I2C ports (up to 1 MHz) *

* See figure 10 for pin diagram

ID	Description	ID	Description
1	User LEDs*	8	Nvidia Jetson Xavier NX*
2	J3 (User analog, digital, PWM and encoders) *	9	Programmable LCD*
3	ESC PWM Connector*	10	ESC Enable Switch*
4	WiFi Module*	11	Power Button*
5	J12 (User digital, I2C, SPI and UART)*	12	RPi camera connector*
6	USB3 Port*	13	Micro USB2 debug port*
7	J15 Power Connector*	14	Micro-HDMI Port*

Table 12. QCar PCB components (* See Figure 10 for pin diagram)

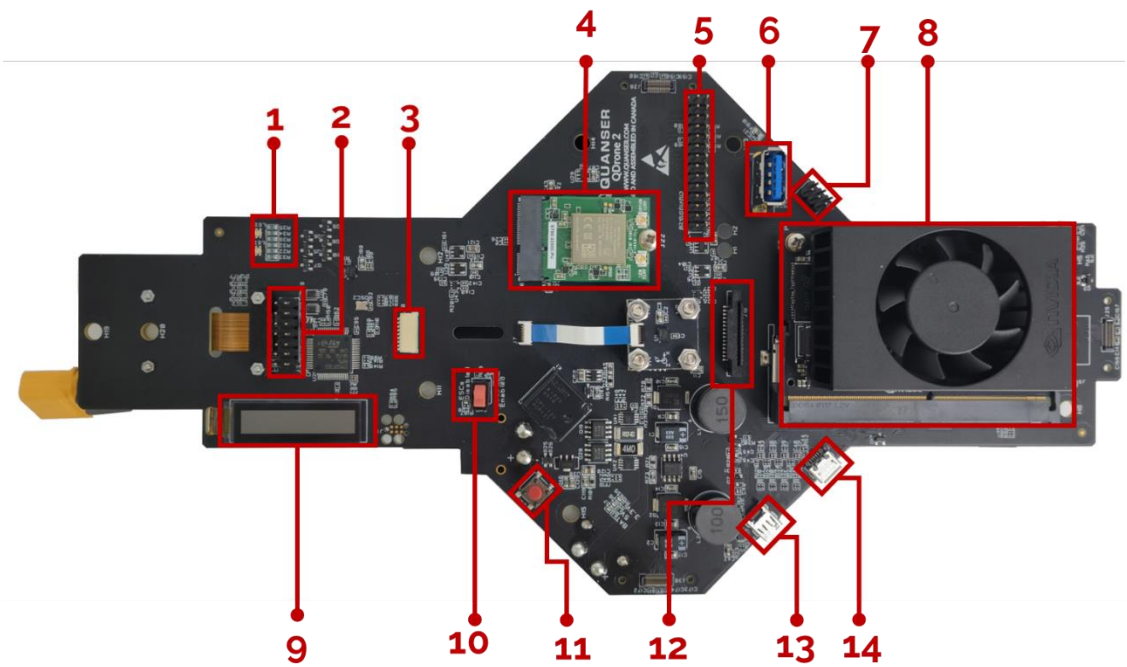


Figure 9. QDrone2 PCB components

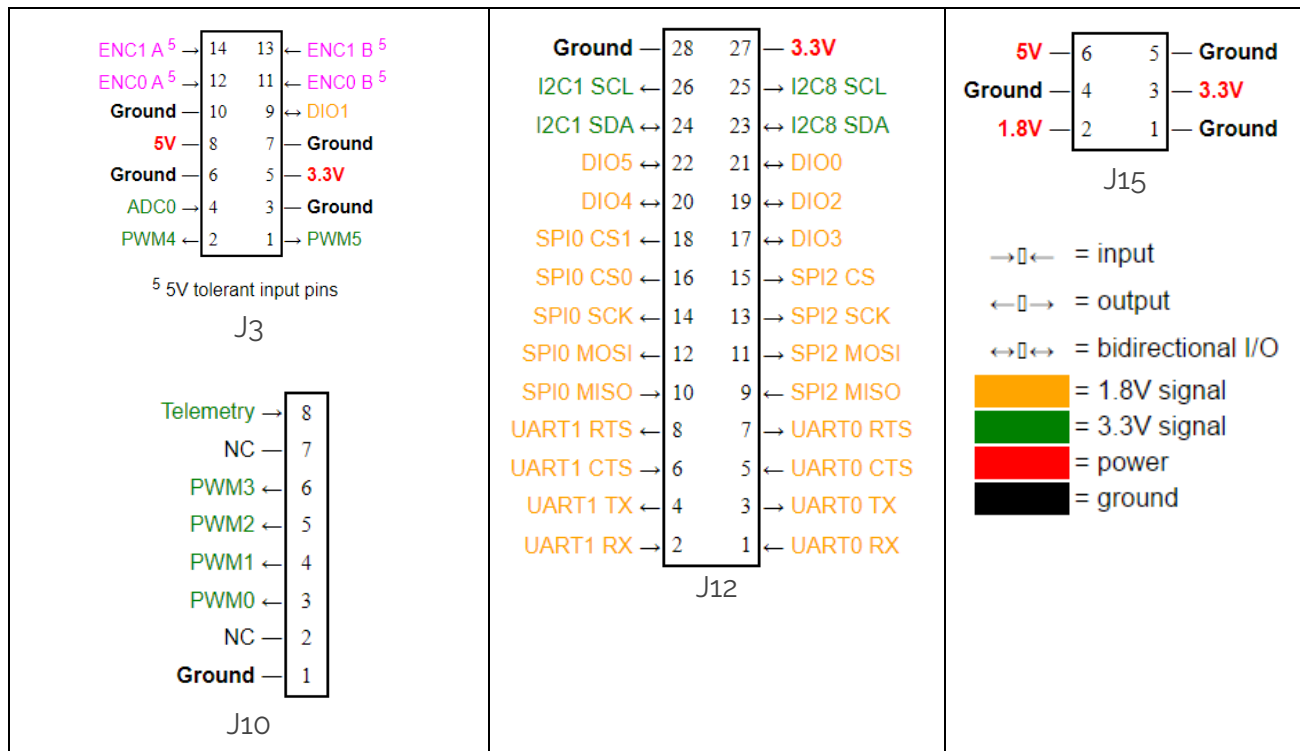


Figure 10. Pin I/O diagram (max current - 5A for 5V pins, 5A for 3.3 V pins, 0.2A for 1.8V pins)

B. Environmental

The QCar is designed to function under the following environmental conditions:

- Standard rating
- Indoor use only
- Temperature 5°C to 40°C
- Altitude up to 2000 m
- Maximum relative humidity of 80% up to 31°C decreasing linearly to 50% relative humidity at 40°C
- Pollution Degree 2
- Mains supply voltage fluctuations up to 10% of nominal voltage
- Maximum transient overvoltage 2500 V
- Marked degree of protection to IEC 60529: Ordinary Equipment (IPX0)

C. Electrical Considerations



**ESD
warning**

The QCar internal components are sensitive to electrostatic discharge. Before handling the QCar, ensure that you have been properly grounded.

**Caution**

Maximum recommended total current draw from the power pins on user headers is

- 5 Amps for 5V
- 5 Amps for 3.3V
- 0.2 Amps for 1.8V

**Caution**

Do not have conductive material touch either the top or bottom surface of the PCB as it can short the LiPo battery, cause sparks and damage the electronics.

**Caution**

Do not remove the Jetson TX2 fan connector or obstruct the fan as it may cause overheating and damage the TX2.

**Caution**

The QCar is not waterproof.



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