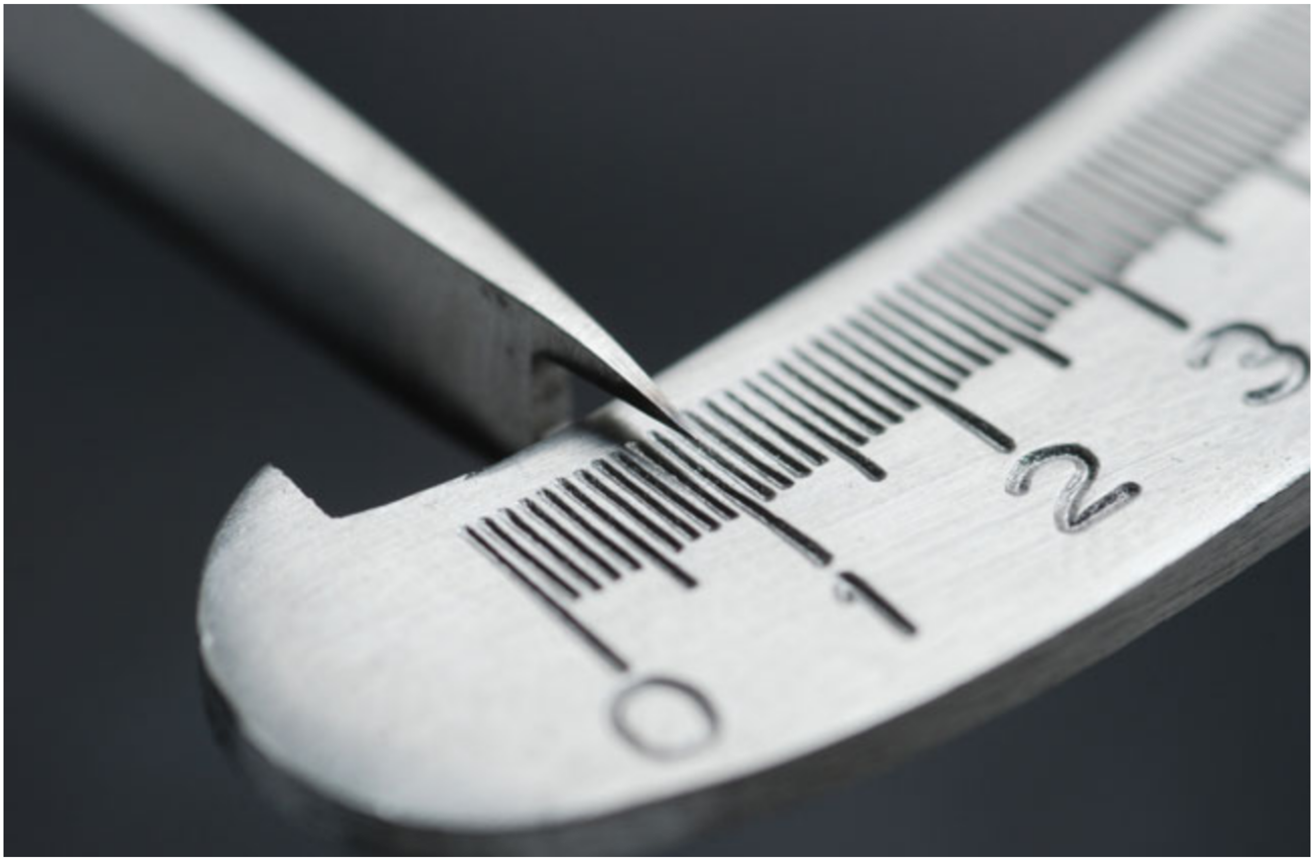


Open Source Rover: Calibration

Author: Eric Junkins

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement by the United States Government or the Jet Propulsion Laboratory, California Institute of Technology.

Contents

1 Calibration

In order for the motors to all work correctly to drive the rover we must calibrate the motors and encoders. We will use a program called Ion Studio to assist with this, which can be found at

- http://www.ionmc.com/downloads

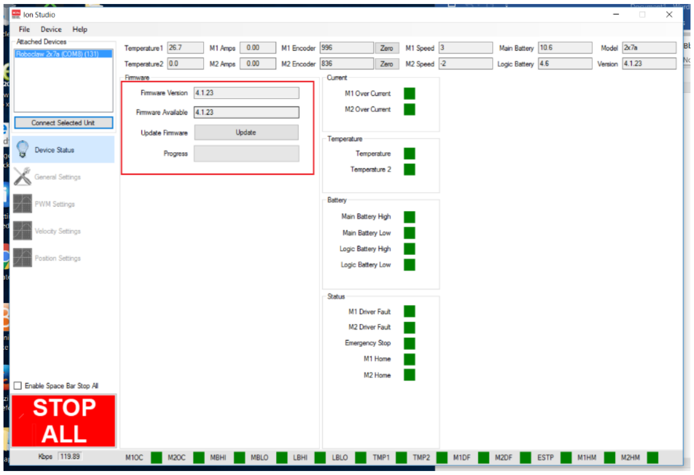
One at a time we will go through and check the encoders, motors, and perform the calibration on each of the motors. As you go to spin the drive motors make sure either the robot is fully hanging such that every drive wheel is not in contact with the ground, or you elevate each drive wheel as you attempt to spin that wheel.

1.1 RoboClaw Setup

1. Connect to the RoboClaw via USB-micro USB cable

2. Open Ion Studio

3. If necessary update the RoboClaw Firmware



Attached Devices: Roboclaw 2x7a (COM8) (131)

Temperature1: 26.7
Temperature2: 0.0
M1 Amps: 0.00
M2 Amps: 0.00
M1 Encoder: 996
M2 Encoder: 836
M1 Speed: 3
M2 Speed: -2
Main Battery: 10.6
Logic Battery: 4.6
Model: 2x7a
Version: 4.1.23

Firmware
Firmware Version: 4.1.23
Firmware Available: 4.1.23
Update Firmware: Update
Progress:

Current
M1 Over Current 🟩
M2 Over Current 🟩

Temperature
Temperature 🟩
Temperature 2 🟩

Battery
Main Battery High 🟩
Main Battery Low 🟩
Logic Battery High 🟩
Logic Battery Low 🟩

Status
M1 Driver Fault 🟩
M2 Driver Fault 🟩
Emergency Stop 🟩
M1 Home 🟩
M2 Home 🟩

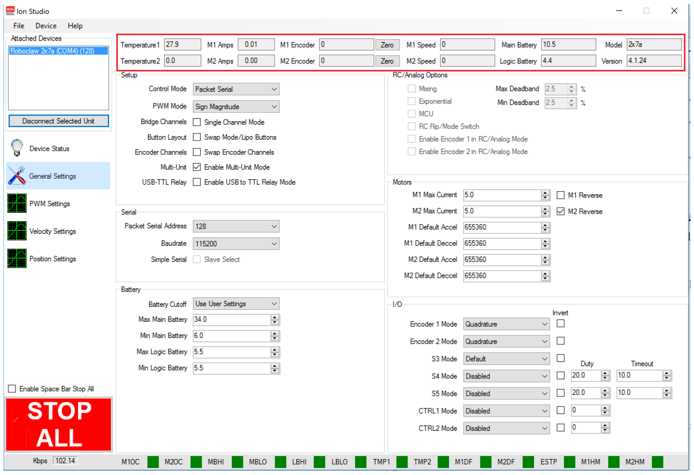
□ Enable Space Bar Stop All

Kbps 119.89 M1OC 🟩 M2OC 🟩 MBHI 🟩 MBLO 🟩 LBHI 🟩 LBLO 🟩 TMP1 🟩 TMP2 🟩 M1DF 🟩 M2DF 🟩 ESTP 🟩 M1HM 🟩 M2HM 🟩

Figure 1: Ion Studio Firmware Update

4. Select Connect Selected Unit in the upper left box

5. Verify that all the motor control parameters are roughly nominal:



Attached Devices: Roboclaw 2x7a (COM4) (128)

Temperature1: 27.9
Temperature2: 0.0
M1 Amps: 0.01
M2 Amps: 0.00
M1 Encoder: 0
M2 Encoder: 0
M1 Speed: 0
M2 Speed: 0
Main Battery: 10.5
Logic Battery: 4.4
Model: 2x7a
Version: 4.1.24

Setup
Control Mode: Packet Serial
PWM Mode: Sign Magnitude
Bridge Channels: □ Single Channel Mode
Button Layout: □ Swap Mode/Lipo Buttons
Encoder Channels: □ Swap Encoder Channels
Multi-Unit: ☑ Enable Multi-Unit Mode
USB-TTL Relay: □ Enable USB to TTL Relay Mode

Serial
Packet Serial Address: 128
Baudrate: 115200
Simple Serial: □ Slave Select

Battery
Battery Cutoff: Use User Settings
Max Main Battery: 34.0
Min Main Battery: 6.0
Max Logic Battery: 5.5
Min Logic Battery: 5.5

RC/Analog Options
□ Mixing
□ Exponential
□ MCU
□ RC Flip/Mode Switch
□ Enable Encoder 1 in RC/Analog Mode
□ Enable Encoder 2 in RC/Analog Mode
Max Deadband: 2.5 %
Min Deadband: 2.5 %

Motors
M1 Max Current: 5.0 □ M1 Reverse
M2 Max Current: 5.0 ☑ M2 Reverse
M1 Default Accel: 655360
M1 Default Deccel: 655360
M2 Default Accel: 655360
M2 Default Deccel: 655360

I/O

Mode	Setting	Invert	Duty	Timeout
Encoder 1 Mode	Quadrature	□		
Encoder 2 Mode	Quadrature	□		
S3 Mode	Default	□		
S4 Mode	Disabled	□	20.0	10.0
S5 Mode	Disabled	□	20.0	10.0
CTRL1 Mode	Disabled	□	0	
CTRL2 Mode	Disabled	□	0	

□ Enable Space Bar Stop All

Kbps 102.14 M1OC 🟩 M2OC 🟩 MBHI 🟩 MBLO 🟩 LBHI 🟩 LBLO 🟩 TMP1 🟩 TMP2 🟩 M1DF 🟩 M2DF 🟩 ESTP 🟩 M1HM 🟩 M2HM 🟩

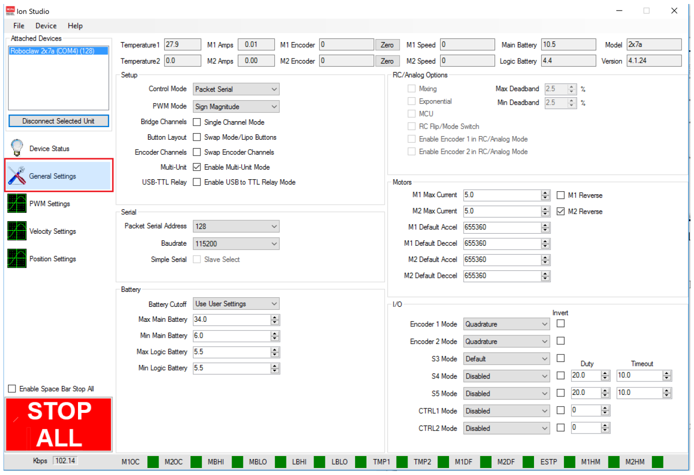
Figure 2

- **Temperature1:** 30
- **M1/M2 Amps:** 0.01
- **M1/M2 Encoder:** 0
- **M1/M2 Speed:** 0
- **Main Battery:** Between 11.5-16.7V

- **Logic Battery:** 5V
- **Model:** 2x7a

As you perform the calibration and testing in this doc make sure to monitor these settings and make sure they are changing roughly with how you expect they should, for instance the temperature going much higher than 35 would denote something is going wrong, or if you are pulling a large amount of current you might have a short in the wiring.

6. Under the General Settings Tab you'll need to change the following settings for each RoboClaw:



Attached Devices: Roboclaw 2x7a (COM4) (128)

Temperature1 27.9 M1 Amps 0.01 M1 Encoder 0 M1 Speed 0 Main Battery 10.5 Model 2x7a
Temperature2 0.0 M2 Amps 0.00 M2 Encoder 0 M2 Speed 0 Logic Battery 4.4 Version 4.1.24

Setup
Control Mode: Packet Serial
PWM Mode: Sign Magnitude
Bridge Channels: □ Single Channel Mode
Button Layout: □ Swap Mode/Lipo Buttons
Encoder Channels: □ Swap Encoder Channels
Multi-Unit: ☑ Enable Multi-Unit Mode
USB-TTL Relay: □ Enable USB to TTL Relay Mode

Serial
Packet Serial Address: 128
Baudrate: 115200
Simple Serial: □ Slave Select

Battery
Battery Cutoff: Use User Settings
Max Main Battery: 34.0
Min Main Battery: 6.0
Max Logic Battery: 5.5
Min Logic Battery: 5.5

RC/Analog Options
□ Mixing Max Deadband 2.5 %
□ Exponential Min Deadband 2.5 %
□ MCU
□ RC Flip/Mode Switch
□ Enable Encoder 1 in RC/Analog Mode
□ Enable Encoder 2 in RC/Analog Mode

Motors
M1 Max Current: 5.0 □ M1 Reverse
M2 Max Current: 5.0 ☑ M2 Reverse
M1 Default Accel: 655360
M1 Default Deccel: 655360
M2 Default Accel: 655360
M2 Default Deccel: 655360

I/O

	Mode	Invert	Duty	Timeout
Encoder 1 Mode	Quadrature	□		
Encoder 2 Mode	Quadrature	□		
S3 Mode	Default	□		
S4 Mode	Disabled	□	20.0	10.0
S5 Mode	Disabled	□	20.0	10.0
CTRL1 Mode	Disabled	□	0	
CTRL2 Mode	Disabled	□	0	

□ Enable Space Bar Stop All

Kbps 102.14

Figure 3

(a) **Setup**:

i. Control Mode: Packet Serial

ii. Multi-Unit: Check Enable Multi-Unit Mode

(b) **Serial**:

i. Set the addressed to 128,129,130,131,132 for each respective RoboClaw

ii. Baudrate: 115200

(c) **Battery**:

      i. Max Main Batter: 17.5V
      ii. Min Main Batter: 11.5V
      iii. Max Logic Battery: 5.5V
      iv. Min Logic Battery: 4.5V

   (d) **Motors**:
      i. M1 Max Current: 3.0A
      ii. M2 Max Current: 3.0 A

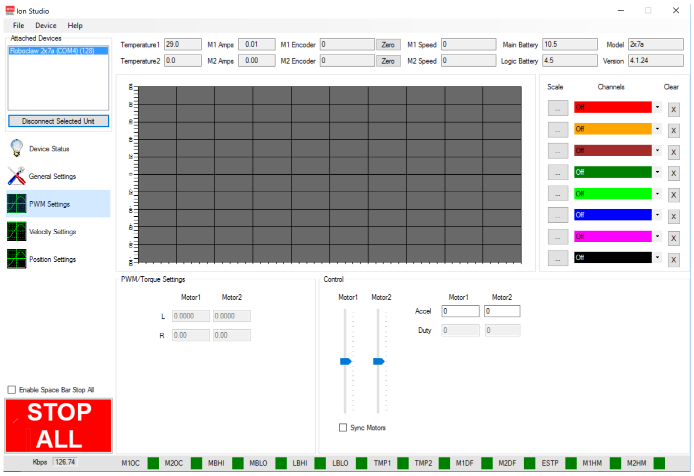
   (e) **I/O**:
      i. Encoder 1 Mode: For addressed 128,129,130 Quadrature, for addresses 131 and 132 Absolute
      ii. Encoder 2 Mode: For addressed 128,129,130 Quadrature, for addresses 131 and 132 Absolute

After changing these settings make sure to save them! Go to *Device* − > *Save Settings*

1.2 Drive Motor Calibration

7. Perform the following for the **RoboClaw addresses 128,129, and 130**

   (a) Go to the PWM settings tab



Attached Devices: Roboclaw 2x7a (COM4) (128)

Temperature1	29.0	M1 Amps	0.01	M1 Encoder	0	M1 Speed	0	Main Battery	10.5	Model	2x7a
Temperature2	0.0	M2 Amps	0.00	M2 Encoder	0	M2 Speed	0	Logic Battery	4.5	Version	4.1.24

Channels: Off, Off, Off, Off, Off, Off, Off, Off

PWM/Torque Settings

	Motor1	Motor2
L	0.0000	0.0000
R	0.00	0.00

Control

	Motor1	Motor2
Accel	0	0
Duty	0	0

□ Sync Motors

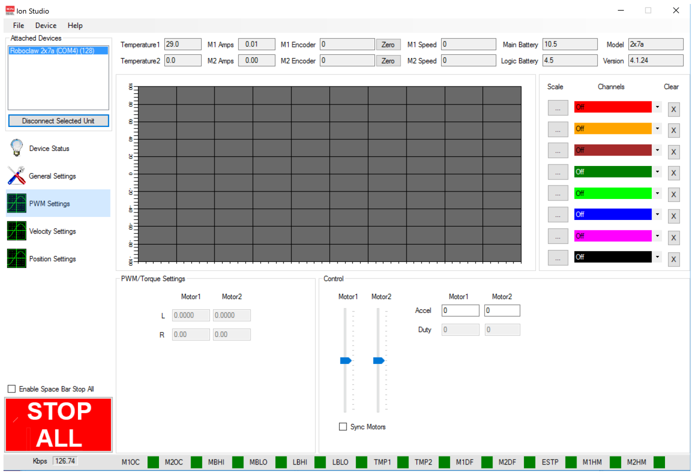
□ Enable Space Bar Stop All

Kbps 126.74

M1OC 🟩 M2OC 🟩 MBHI 🟩 MBLO 🟩 LBHI 🟩 LBLO 🟩 TMP1 🟩 TMP2 🟩 M1DF 🟩 M2DF 🟩 ESTP 🟩 M1HM 🟩 M2HM 🟩

Figure 4

(b) Under the control pane slowly move the slider bar up for M1.



Attached Devices: Roboclaw 2x7a (COM4) (128)

Temperature1	29.0	M1 Amps	0.01	M1 Encoder	0	M1 Speed	0	Main Battery	10.5	Model	2x7a
Temperature2	0.0	M2 Amps	0.00	M2 Encoder	0	M2 Speed	0	Logic Battery	4.5	Version	4.1.24

Channels: Off, Off, Off, Off, Off, Off, Off, Off

PWM/Torque Settings

	Motor1	Motor2
L	0.0000	0.0000
R	0.00	0.00

Control

	Motor1	Motor2
Accel	0	0
Duty	0	0

□ Sync Motors

□ Enable Space Bar Stop All

Kbps 126.74

M1OC 🟩 M2OC 🟩 MBHI 🟩 MBLO 🟩 LBHI 🟩 LBLO 🟩 TMP1 🟩 TMP2 🟩 M1DF 🟩 M2DF 🟩 ESTP 🟩 M1HM 🟩 M2HM 🟩

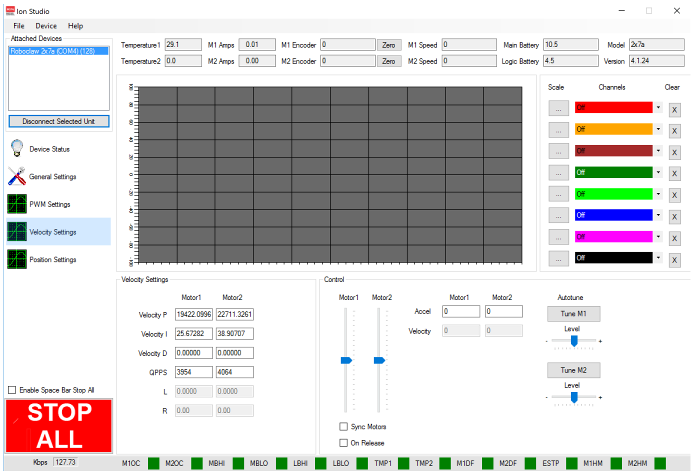
Figure 5

Verify that when the forward signal is sent to the motor that the wheel spins in the direction that would move the rover as a whole forward (note this is different clockwise vs counterclockwise based on which wheel you are testing). If the wheel moves backwards with respect to the rover direction than switch the motor leads coming from the motor controller, which are M1A and M1B.

(c) Now as you drive M1 motor forward (which now corresponds to the rover moving forward) verify that M1 Encoder value increases [1]. If it is decreasing then you have to switch the A and B channels of the encoder signals. These are the EN1 +/- pins on the header pins.

(d) Repeat 7b and 7c for M2 motor.

8. If once both motors are spinning the correct direction and encoders respond accordingly when commanded through PWM signal tab move then go to the *Velocity Settings* tab.



Temperature1 29.1
Temperature2 0.0
M1 Amps 0.01
M2 Amps 0.00
M1 Encoder 0
M2 Encoder 0
M1 Speed 0
M2 Speed 0
Main Battery 10.5
Logic Battery 4.5
Model 2x7a
Version 4.1.24

Velocity Settings

	Motor1	Motor2
Velocity P	19422.0996	22711.3261
Velocity I	25.67282	38.90707
Velocity D	0.00000	0.00000
QPPS	3954	4064
L	0.0000	0.0000
R	0.00	0.00

	Motor1	Motor2
Accel	0	0
Velocity	0	0

□ Sync Motors
□ On Release

Kbps 127.73

Figure 6

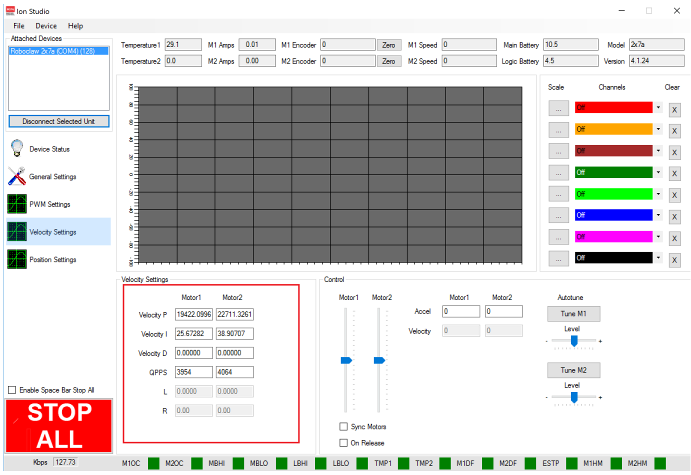
Here we'll be tuning the motor settings. This needs to be done to have fluid control of the motor, and needs to be done for each individual motor as they will all differ slightly out of the box, so each will be individually tuned. For more information on motor PID controls and what they do you can visit:

- https://medium.com/pollenrobotics/an-introduction-to-pid-control-with-dc-motor-1fa3b26ec661
- https://www.elprocus.com/the-working-of-a-pid-controller/

(a) Begin by entering in the QPPS (quadrature pulses per second), or the maximum number of encoder ticks per second. To figure this out drive the motor at max in

[1] If you get no reading values for the encoder re-check your wiring and connections

the PWM setting and look at the speed.



Temperature1 29.1 | M1 Amps 0.01 | M1 Encoder 0 | M1 Speed 0 | Main Battery 10.5 | Model 2x7a

Temperature2 0.0 | M2 Amps 0.00 | M2 Encoder 0 | M2 Speed 0 | Logic Battery 4.5 | Version 4.1.24

Velocity Settings

	Motor1	Motor2
Velocity P	19422.0996	22711.3261
Velocity I	25.67282	38.90707
Velocity D	0.00000	0.00000
QPPS	3954	4064
L	0.0000	0.0000
R	0.00	0.00

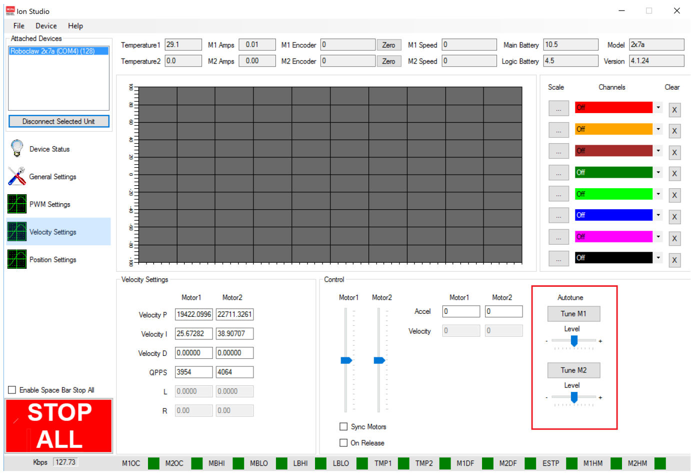
Control

	Motor1	Motor2
Accel	0	0
Velocity	0	0

Kbps 127.73

Figure 7

(b) Now hit the Tune M1 button. This will populate the *Velocity P I D* variables on the side. Repeat this step for M2 motor as well.



Temperature1 29.1 | M1 Amps 0.01 | M1 Encoder 0 | M1 Speed 0 | Main Battery 10.5 | Model 2x7a

Temperature2 0.0 | M2 Amps 0.00 | M2 Encoder 0 | M2 Speed 0 | Logic Battery 4.5 | Version 4.1.24

Velocity Settings

	Motor1	Motor2
Velocity P	19422.0996	22711.3261
Velocity I	25.67282	38.90707
Velocity D	0.00000	0.00000
QPPS	3954	4064
L	0.0000	0.0000
R	0.00	0.00

Control

	Motor1	Motor2
Accel	0	0
Velocity	0	0

Kbps 127.73

Figure 8

(c) Once both motors are tuned from this motor controller go to *Device* $->$ *Save Settings* and then exit. Repeat all of steps 6 and 8 for the other drive motors.

1.3 Corner Motor Calibration

9. Perform the following for the **RoboClaw addresses 131 and 132**

(a) Perform step 6 for the Corner motors, making sure to set the encoder type to absolute.

(b) Go to the *PWM Settings* tab and slowly drive the M1 corner forward. Verify that the encoder value goes up. If it does not switch the motor wire leads at M1A and M1B. [2]

(c) Repeat 9b for M2 motor

(d) You'll might need to set the absolute encoder zero point in a different location. In order to avoid clipping[3] of the range of the encoder we'll set the mid-point of the absolute encoder to be the middle of the turning arc.

   i. Navigate to the *PWM Settings* tab to move the corner to its' "zero" position, which is where the wheel is directly forward.

   ii. Unscrew the small gear at the bottom of the absolute encoder

   iii. Once the absolute encoder shaft is uncoupled to the robot spin the encoder until you determine the max value. This should be somewhere in the range of 1400-1800 ish[4].

   iv. Spin the encoder until it is reading values of roughly half the max value and reattach the gear, coupling it back to the rover.

(e) For each motor M1 and M2 get what is now the new min and max encoder values. Using the *PWM Settings* tab move the motors until they run into the physical hard stops. Record the min and max values for each, but for the min values add about 15 and the max subtract about 15[5]

(f) Perform the Velocity tuning for each of the corners similar to the drive motors.

[2] As opposed to the drive motors the corners use absolute encoders that are defined in one direction only, so you cannot switch the direction of the encoder

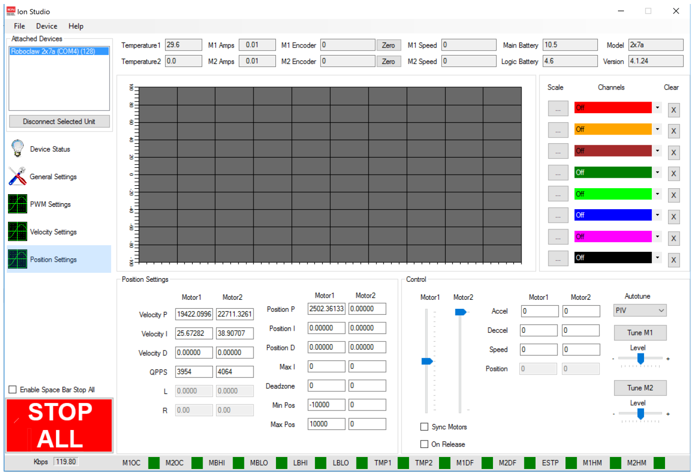
[3] Clipping would be where you go past the 360 deg mark on the encoder and it starts again at 0

[4] If you are getting values of close to 2000 and then it is staying above 2000 and not resetting to 0 while spinning it means the Voltage divider board is not working properly. Check to make sure you didn't put the resistors in backwards

[5] This is to avoid driving into the hard stop, we'll impose a software 'soft stop'.

You will have to estimate the QPPS value for the corners as you cannot spin them at fully speed without running into the physical hard stop very quickly.

(g) Navigate to the *Position Settings* tab.



Ion Studio — Attached Devices: Roboclaw 2x7a (COM4) (128)

Temperature1	29.6	M1 Amps	0.01	M1 Encoder	0	M1 Speed	0	Main Battery	10.5	Model	2x7a
Temperature2	0.0	M2 Amps	0.01	M2 Encoder	0	M2 Speed	0	Logic Battery	4.6	Version	4.1.24

Position Settings

	Motor1	Motor2		Motor1	Motor2
Velocity P	19422.0996	22711.3261	Position P	2502.36133	0.00000
Velocity I	25.67282	38.90707	Position I	0.00000	0.00000
Velocity D	0.00000	0.00000	Position D	0.00000	0.00000
QPPS	3954	4064	Max I	0	0
L	0.0000	0.0000	Deadzone	0	0
R	0.00	0.00	Min Pos	-10000	0
			Max Pos	10000	0

Control

	Motor1	Motor2
Accel	0	0
Deccel	0	0
Speed	0	0
Position	0	0

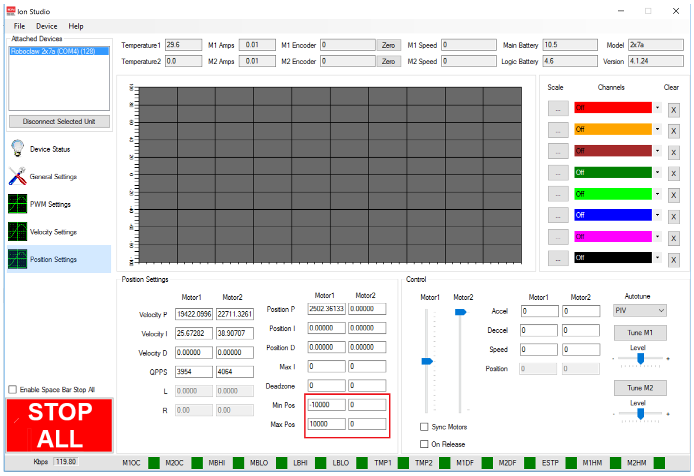
Autotune: PIV

□ Sync Motors
□ On Release
□ Enable Space Bar Stop All

Kbps 119.80

Figure 9

(h) Enter in your Min and Max values for each M1 and M2 motor



Ion Studio — Attached Devices: Roboclaw 2x7a (COM4) (128)

Temperature1	29.6	M1 Amps	0.01	M1 Encoder	0	M1 Speed	0	Main Battery	10.5	Model	2x7a
Temperature2	0.0	M2 Amps	0.01	M2 Encoder	0	M2 Speed	0	Logic Battery	4.6	Version	4.1.24

Position Settings

	Motor1	Motor2		Motor1	Motor2
Velocity P	19422.0996	22711.3261	Position P	2502.36133	0.00000
Velocity I	25.67282	38.90707	Position I	0.00000	0.00000
Velocity D	0.00000	0.00000	Position D	0.00000	0.00000
QPPS	3954	4064	Max I	0	0
L	0.0000	0.0000	Deadzone	0	0
R	0.00	0.00	Min Pos	-10000	0
			Max Pos	10000	0

Control

	Motor1	Motor2
Accel	0	0
Deccel	0	0
Speed	0	0
Position	0	0

Autotune: PIV

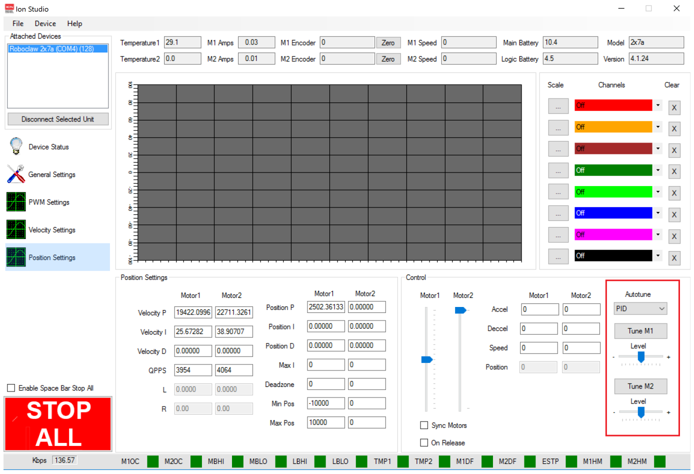
□ Sync Motors
□ On Release
□ Enable Space Bar Stop All

Kbps 119.80

Figure 10

(i) Change the Autotune type to **PID** and then tune the M1 and M2 motors[6].

[6] We've found this is more successful if you tune them with the wheels down on a smooth surface, but supporting the weight of the robot during tuning



Temperature1	29.1	M1 Amps	0.03	M1 Encoder	0	M1 Speed	0	Main Battery	10.4	Model	2x7a
Temperature2	0.0	M2 Amps	0.01	M2 Encoder	0	M2 Speed	0	Logic Battery	4.5	Version	4.1.24

Position Settings

	Motor1	Motor2
Velocity P	19422.0996	22711.3261
Velocity I	25.67282	38.90707
Velocity D	0.00000	0.00000
QPPS	3954	4064
L	0.0000	0.0000
R	0.00	0.00

	Motor1	Motor2
Position P	2502.36133	0.00000
Position I	0.00000	0.00000
Position D	0.00000	0.00000
Max I	0	0
Deadzone	0	0
Min Pos	-10000	0
Max Pos	10000	0

Control

	Motor1	Motor2
Accel	0	0
Deccel	0	0
Speed	0	0
Position	0	0

□ Sync Motors
□ On Release

Autotune: PID

□ Enable Space Bar Stop All

Kbps 136.57

Figure 11

(j) To test this now using the Controls for M1 and M2 move them to their middle positions (halfway between min and max) and verify that the wheels all should point entirely straight forward now. If they do not re-check the min and max values, and ensure that no signal clipping is happening on the encoders.

(k) Repeat Step 9 for the remaining corner motors