ION MOTION CONTROL

RoboClaw Series Brushed DC Motor Controllers

RoboClaw Solo
RoboClaw 2x5A
RoboClaw 2x7A
RoboClaw 2x15A
RoboClaw 2x30A
RoboClaw 2x45A
RoboClaw 2x45A ST
RoboClaw 2x60A
Roboclaw 2x60HV
Roboclaw 2x120A
Roboclaw 2x160A
Roboclaw 2x200A

User Manual

Firmware 4.1.20 and Newer
Hardware V3, V4, V5 and V6
User Manual Revision 5.6

Contents

Firmware History

RoboClaw is an actively maintained product. New firmware features will be available from time to time. The table below outlines key revisions that could affect the version of RoboClaw you currently own.

Revision	Description
4.1.20	• Added Default Deceleration setting • Added Forward/Reverse Limit support • Added Forward Limit/Reverse Home support • Fixed power up Home switch state(now reads the initial state if HOME/Manual Home is enabeld • Home/Limit switch now supports on the fly changes • Fixed short PWM glitch on power up • Resets internal position counter when encoder is reset(fixes position movement glitches after Encoder Reset) • Fixed sign magnitude on HV units
4.1.19	• Adjusted deadtime on MC5,7,15,30,60
4.1.18	• Fixed invalid conditional in MC120-160 A/D sample timer • Fixed Set/Zero Encoders • Added RC Encoder Mode selection Option using RC/TTL signal on S3
4.1.17	• Adjusted RC/Analog deadband filtering • Changed A/D sampling to prevent PWM noise • Added GetDefaultAccel commands • Changed RC/Analog w/ Encoder modes to use DefaultAccel for Accel/Deccel • Added MC60A V5 • Added MC160A • Removed Sign Magnitude mode on HV models(cant do noise free A/D sampling in Sign Magnitude mode on HV boards) • Fixed power on zero position movement in RC w/ Encoder mode.
4.1.16	• Adjusted RC/Analog controlled Velocity and Position Control functions. • Fixed Sync Motor option in Position Settings window.

Warnings

There are several warnings that should be noted before getting started. Damage can easily result by not properly wiring RoboClaw. Harm can also result by not properly planning emergency situations. Any time mechanical movement is involved the potential for harm is present. The following information can help avoid damage to RoboClaw, connected devices and help reduce the potential for harm or bodily injury.

⚠ ***Disconnecting the negative power terminal is not the proper way to shut down a motor controller. Any connected I/O to RoboClaw will create a ground loop and cause damage to RoboClaw and attached devices.***

⚠ ***Brushed DC motors are generators when spun. A robot being pushed or coasting can create enough voltage to power RoboClaws logic intermittenly creating an unsafe state. Always stop the motors before powering down RoboClaw.***

⚠ ***RoboClaw has a minimum power requirement. Under heavy loads, without a logic battery and, brownouts can happen. This will cause erratic behavior. A logic battery should be used in these situations.***

⚠ ***Never reverse the main battery wires Roboclaw will be permenantly damaged.***

⚠ ***Never disconnect the motors from RoboClaw when under power. Damage will result.***

Introduction

Motor Selection

When selecting a motor controller several factors should be considered. All DC brushed motors will have two current ratings, maximum stall current and continuous current. The most important rating is the stall current. Choose a model that can support the stall current of the motor selected to insure the motor can be driven properly without damage to the motor controller.

Stall Current

A motor at rest is in a stall condition. This means during start up the motors stall current will be reached. The loading of the motor will determine how long maximum stall current is required. A motor that is required to start and stop or change directions rapidly but with light load will still require maximum stall current often.

Running Current

The continuous current rating of a motor is the maximum current the motor can run without overheating and eventually failing. The average running current of the motor should not excede the continuous current rating of the motor.

Shut Down

To shut down a motor controller the positive power connections should be removed first after the motors have stopped moving. Powering off in an emergency, a properly sized switch or contactor can be used. A path to ground for regeneration energy to return to the battery should always be provided. This can be accomplish by using a power diode with proper ratings to provide a path across the switch or contactor when in an open circuit state.

Run Away

During development of your project caution should be taken to avoid run away conditions. The wheels of a robot should not be in contact with any surface until all development is complete. If the motor is embedded, ensure you have a safe and easy method to remove power from RoboClaw as a fail safe.

Wire Lengths

Wire lengths to the motors and from the battery should be kept as short as possible. Longer wires will create increased inductance which will produce undesirable effects such as electrical noise or increased current and voltage ripple. The power supply/battery wires must be as short as possible. They should also be sized appropriately for the amout of current being drawn. Increased inductance in the power source wires will increase the ripple current/voltage at the RoboClaw which can damage the filter caps on the board or even causing voltage spikes over the rated voltage of the Roboclaw, leading to board failure.

Power Sources

A battery is recommended as the main power source for the motor controller. Some power supplies can also be used without additional hardware if they have built in voltage clamps or if used with very low current motors. Most Linear and Switching power supplies are not capable of handling the regeneration energy generated by DC motors. Switching power supplies will momentarily reduce voltage and/or shut down, causing brown outs which will leave the controller in an unsafe state. The MCPs minimum and maximum voltage levels can be set to prevent some of these voltage spikes, however this will cause the motors to brake when slowing down in an attempt to reduce the over voltage spikes. This will also limit power output when accelerating motors or when the load changes to prevent undervoltage conditions. Voltage clamp solutions may be required for higher power motors when using power supplies.

Logic Power

When powering external devices from RoboClaw ensure the maximum BEC output rating is not exceeded. This can cause RoboClaw to suffer logic brown out which will cause erratic behavior. Some low quality encoders can cause excessive noise being put on the +5VDC rail of the RoboClaw. This excessive noise will cause unpredictable behavior.

Encoders

RoboClaw features dual channel quadrature/absolute decoding. When wiring encoders make sure the direction of spin is correct to the motor direction. Incorrect encoder connections can cause a run away state. Refer to the encoder section of this user manual for proper setup.

Getting Started

Initial Setup

RoboClaw offers several methods of control. Each control scheme has several configuration options. The following is quick start guide which will cover the basic initialization of RoboClaw. Most control schemes require very little configuration. The control options are covered in detail in this manual. The following is a basic setup procedure.

1. Read the Introduction and Hardware Overview sections of this manual. It is important to ensure the RoboClaw model chosen is rated to drive the selected motors. RoboClaw must be paired by the motor stall current ratings. Not running current.

2. Before configuring RoboClaw. Make sure a reliable power source is available such as a fully charged battery. See Wiring section of this manual for proper wiring instructions.

3. The RoboClaw main modes can be configured using Ion Studio or on-board buttons. Ion Studio is the preferred method of configuration with additional options not available using the on-board buttons. However these additional options are not critical to RoboClaw's operation. This manual covers both configuration methods.

4. Once the configuration is complete see Wiring section of this manual. The basic wiring diagram should only be used for basic for testing purposes. The Safety Wiring diagram is recommended for safe and reliable operation.

Encoder Setup

RoboClaw supports several encoder types. All encoders require tunning to properly pair with the selected motors. The auto tune function can automatically tune for most all combinations. However some manual adjustment maybe required. The final auto tune settings can be adjusted for optimal performance.

1. Once Initial Setup is complete. Attached an encoder to your motor and wire as shown in the encoder section of this manual. Make sure the encoder can be powered from a 5VDC power source.

2. After the encoder is wired double check the wiring. Then proceed to the auto tune function in the Encoder section of this manual.

3. Auto tune will work in most all cases. Some manual tweaks may be necessary. If additional assistance is required contact support at support@ionmc.com

Hardware Overview

I/O

RoboClaw's I/O is setup to interface to both 5V and 3.3V logic. This is accomplished by internally current limiting and clipping any voltages over 3.3V. RoboClaw outputs 3.3V which will work with any 5V or 3.3V logic. This is also done to protect the I/O from damage.

Headers

RoboClaw's share the same header and screw terminal pinouts accross models in this user manual. The main control I/O are arranged for easy connectivity to control devices such as R/C controllers. The headers are also arranged to provide easy access to ground and power for supplying power to external controllers. see the specific model of RoboClaw's data sheet for pinout details.

Control Inputs

S1, S2, S3, S4 and S5 are setup for standard servo style headers I/O(except on ST models), +5V and GND. S1 and S2 are the control inputs for serial, analog and RC modes. S3 can be used as a flip switch input when in RC or Analog modes. In serial mode S3, S4 and S5 can be used as emergency stop inputs or as voltage clamp control outputs. When set as E-Stop inputs they are active when pulled low and have internal pullups so they will not accidentally trip when left floating. S4 and S5 can also optionally be used as home signal inputs. The pins closest to the board edge are the I/0s, center pin is the +5V and the inside pins are ground. Some RC receivers have their own supply and will conflict with the RoboClaw’s 5v logic supply. It may be necessary to remove the +5V pin from the RC receivers cable in those cases.

Encoder Inputs

EN1 and EN2 are the inputs from the encoders on pin header versions of RoboClaw. 1B, 1A, 2B and 2A are the encoders inputs on screw terminal versions of RoboClaw. Channel A of both EN1 and EN2 are located at the board edge on the pin header. Channel B pins are located near the heatsink on the pin header. The A and B channels are labeled appropriately on screw terminal versions.

When connecting the encoder make sure the leading channel for the direction of rotation is connected to A. If one encoder is backwards to the other you will have one internal counter counting up and the other counting down. Refer to the data sheet of the encoder you are using for channel direction. Which encoder is used on which motor can be swapped via a software setting.

Logic Battery (LB IN)

The logic side of RoboClaw can be powered from a secondary battery wired to LB IN. The positive (**+**) terminal is located at the board edge and ground (**-**) is the inside pin closest to the heatsink. Remove the LB-MB jumper if a secondary battery for logic will be used.

BEC Source (LB-MB)

RoboClaw logic requires 5VDC which is provided from the on board BEC circuit. The BEC source input is set with the LB-MB jumper. Install a jumper on the 2 pins labeled LB-MB to use the main battery as the BEC power source. Remove this jumper if using a separate logic battery. On models without this jumper the power source is selected automatically.

Encoder Power (+ -)

The pins labeled + and - are the source power pins for encoders. The positive (+) is located at the board edge and supplies +5VDC. The ground (-) pin is near the heatsink. On ST models all power must come from the single 5v screw terminal and the single GND screw terminal

Main Battery Screw Terminals

The main power input can be from 6VDC to 34VDC on a standard RoboClaw and 10.5VDC to 60VDC on an HV (High Voltage) RoboClaw. The connections are marked **+** and **-** on the main screw terminal. The plus (**+**) symbol marks the positive terminal and the negative (**-**) marks the negative terminal. The main battery wires should be as short as possible.

Do not reverse main battery wires. Roboclaw will be permenantly damaged.

Main Battery Disconnect

The main battery should have a disconnect in case of a run away situation and power needs to be cut. The switch must be rated to handle the maximum current and voltage from the battery. This will vary depending on the type of motors and or power source you are using. A typically solution would be an inexpensive contactor which can be sourced from sites like Ebay. A power diode rated for the maximum current the battery will deliver should be placed across the switch/contactor to provide a path back to the battery when disconnected while the motors are spinning. The diode will provice a path back to the battery for regenerative power even if the switch is opened.

Motor Screw Terminals

The motor screw terminals are marked with M1A / M1B for channel 1 and M2A / M2B for channel 2. For both motors to turn in the same direction the wiring of one motor should be reversed from the other in a typical differential drive robot. The motor and battery wires should be as short as possible. Long wires can increase the inductance and therefore increase potentially harmful voltage spikes.

Easy to use Libraries

Source code and Libraries are available on the Ion Motion Control website. Libraries are available for Arduino(C++), C# on Windows(.NET) or Linux(Mono) and Python(Raspberry Pi, Linux, OSX, etc).

Ion Studio Overview

Ion Studio

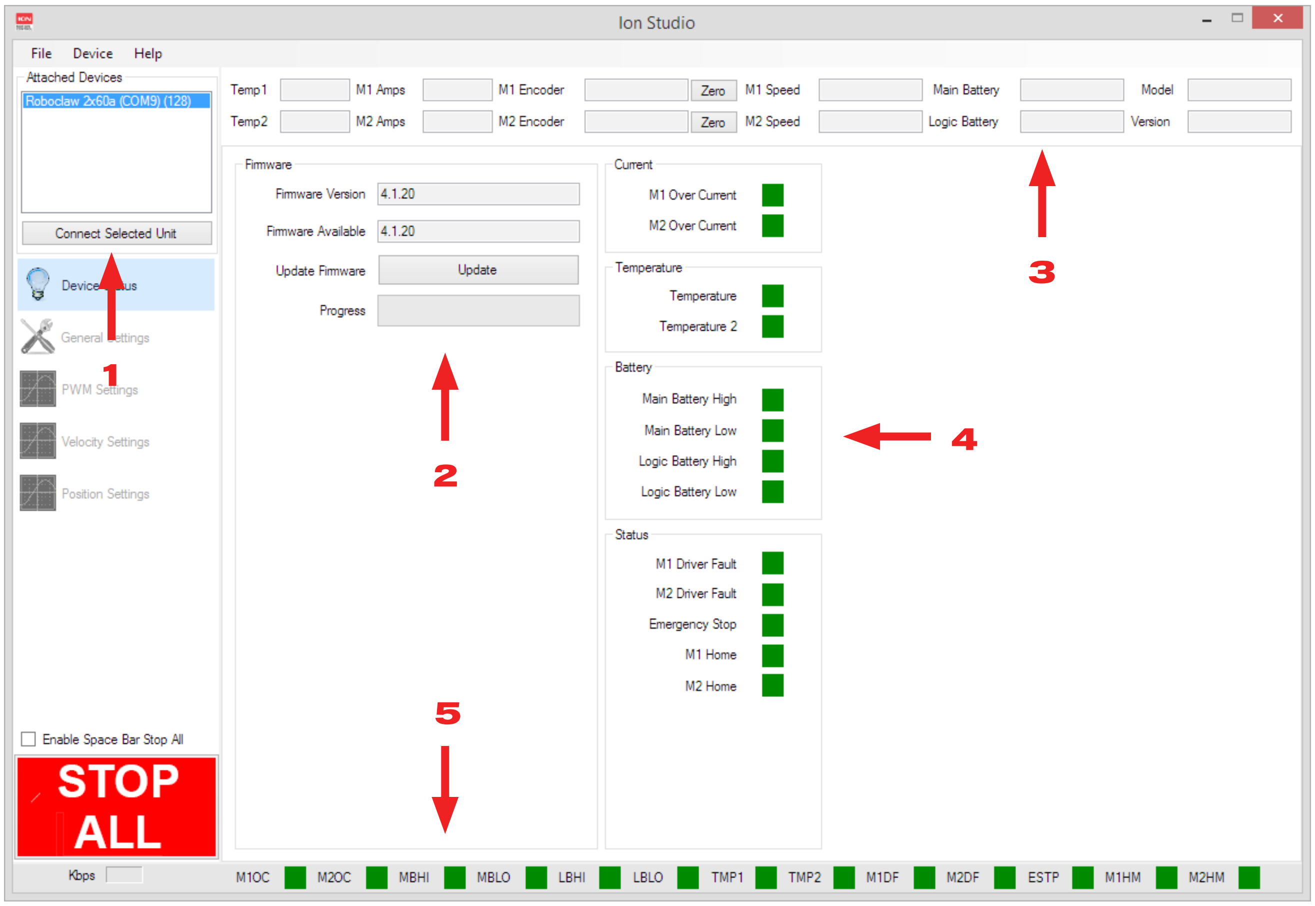
The Ion Studio software suite is design to configure, monitor and maintain RoboClaw. It's used to configure all the available RoboClaw modes and options. Ion Studio can be used to monitor and control RoboClaw. It can be download from http://www.ionmc.com. Once installed, each time Ion Studio is ran it will check for the latest version online.

Connection

This is the first screen shown when first running Ion Studio. From this screen you can select a detected RoboClaw and connect (1). More than one RoboClaw can be connected at a time. Box (1) is where the desired RoboClaw is selected.

After the RoboClaw is detected and it's firmware version is checked (2). If a newer firmware version is available it can be updated by clicking the Update Firmware button (2).

Fields (3,4,5) display current values and status. The feilds at the top of the screen (3) show the current value in each monitored parameter and are updated live once a RoboClaw is connected. Status indicators (4,5) indicate the current condition of the named monitor parameter. Green indicates operationing within the defined parameter. Yellow indicates a warning. Red indicates a fault.



Attached Devices: Roboclaw 2x60a (COM9) (128)

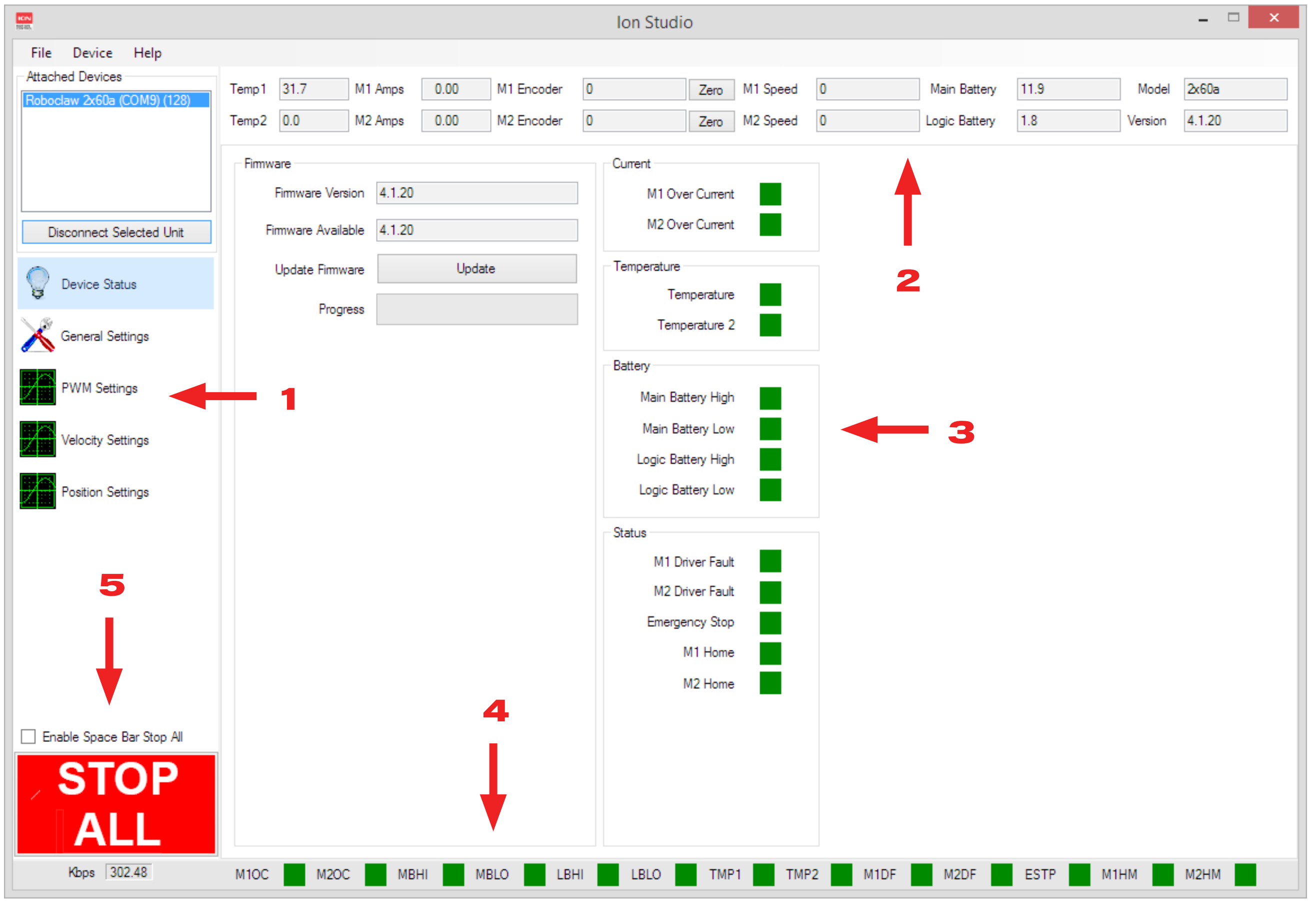
Firmware Version: 4.1.20

Firmware Available: 4.1.20

Device Status

Once a RoboClaw is connected, the connection screen becomes active (1) and is now the Device Status screen. All status indicators (3,4) and monitored parameter feilds (2) will update to reflect the current status and values of the connected RoboClaw.

When an RoboClaw is connected the Stop All (5) button becomes active. There is a small check box to activate the Stop All function by using the space bar on the keyboard. This is safety feature and is the quickest method to stop all motor movements when using Ion Studio.



Attached Devices: Roboclaw 2x60a (COM9) (128)

Temp1	31.7	M1 Amps	0.00	M1 Encoder	0	M1 Speed	0	Main Battery	11.9	Model	2x60a
Temp2	0.0	M2 Amps	0.00	M2 Encoder	0	M2 Speed	0	Logic Battery	1.8	Version	4.1.20

Firmware
Firmware Version: 4.1.20
Firmware Available: 4.1.20
Update Firmware
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 🟩

Kbps 302.48

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

Device Status Screen Layout

Label	Function	Description
1	Window Selection	Used to select which settings or testing screen is currently displayed.
2	Monitored Parameters	Displays continuously updated status parameters.
3	Status Indicators	Displays current warnings and faults.
4	Status Indicators	Displays abbreviated status of warnings and faults. Visible at all times.
5	Stop All	Stops all motion. Can activate from keyboard space bar.

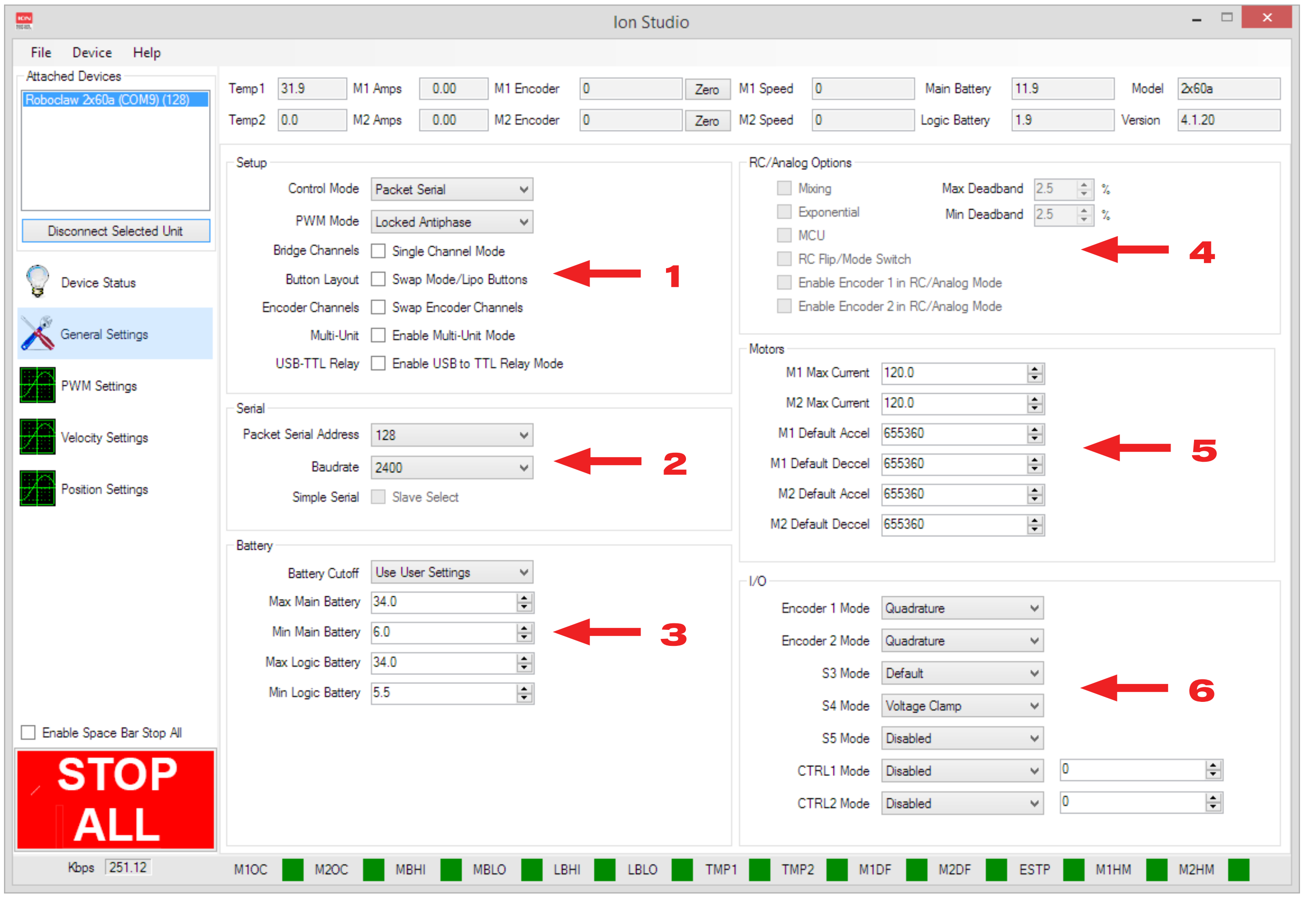
Status Indicator (4)

The status indicators shown at the bottom of the screen are an abbreviated duplication of the main status indicators shown on the device status screen.

Label	Description
M1OC	Motor 1 over current.
M2OC	Motor 2 over current.
MBHI	Main battery over voltage.
MBLO	Main battery under voltage.
LBHI	Logic battery over voltage.
LBLO	Logic battery under voltage.
TMP1	Temperature 1
TMP2	Optional temperature 2 on some RoboClaw models.
M1DF	Motor driver 1 fault.
M2DF	Motor driver 2 fault.
ESTP	Emergency stop. When active.
M1HM	Motor 1 homed or limit switch active. When option in use.
M2HM	Motor 2 homed or limit switch active. When option in use.

General Settings

The general settings screen can be used to configure RoboClaw. This includes modes, mode options and monitored parameters. For detailed explanations see the Configuration with Ion Studio section of this manual.



Temp1 31.9 | M1 Amps 0.00 | M1 Encoder 0 | M1 Speed 0 | Main Battery 11.9 | Model 2x60a
Temp2 0.0 | M2 Amps 0.00 | M2 Encoder 0 | M2 Speed 0 | Logic Battery 1.9 | Version 4.1.20

Setup
- Control Mode: Packet Serial
- PWM Mode: Locked Antiphase
- 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: 2400
- Simple Serial: ☐ Slave Select

Battery
- Battery Cutoff: Use User Settings
- Max Main Battery: 34.0
- Min Main Battery: 6.0
- Max Logic Battery: 34.0
- 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: 120.0
- M2 Max Current: 120.0
- M1 Default Accel: 655360
- M1 Default Deccel: 655360
- M2 Default Accel: 655360
- M2 Default Deccel: 655360

I/O
- Encoder 1 Mode: Quadrature
- Encoder 2 Mode: Quadrature
- S3 Mode: Default
- S4 Mode: Voltage Clamp
- S5 Mode: Disabled
- CTRL1 Mode: Disabled 0
- CTRL2 Mode: Disabled 0

Kbps 251.12 | M1OC 🟩 | M2OC 🟩 | MBHI 🟩 | MBLO 🟩 | LBHI 🟩 | LBLO 🟩 | TMP1 🟩 | TMP2 🟩 | M1DF 🟩 | M2DF 🟩 | ESTP 🟩 | M1HM 🟩 | M2HM 🟩

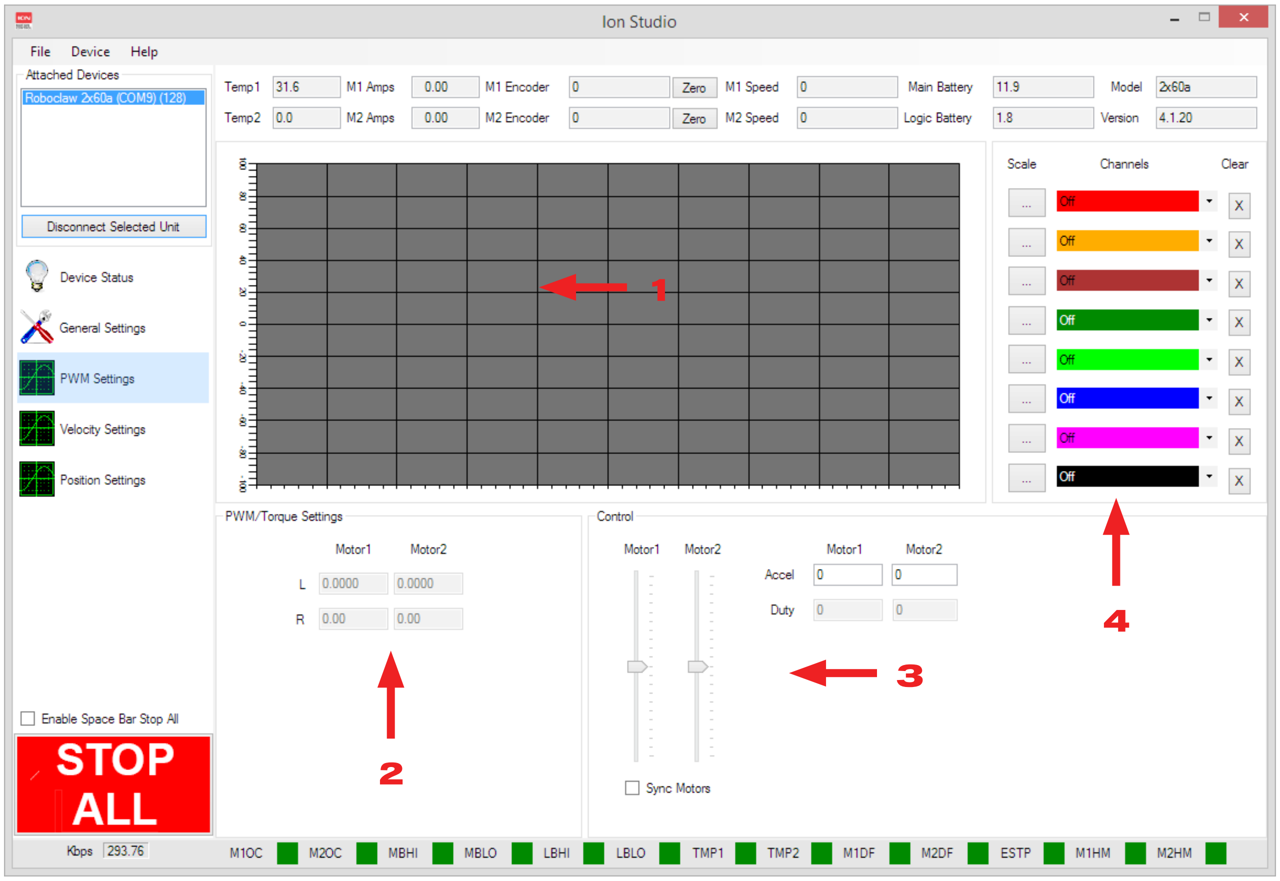
Configuration Options

Each control mode will have several configuration options. Some options will appear grayed out to indicate the option is not available for the selected mode. All setting changes will need to be saved and the RoboClaw reset in order to take. Select Save Settings under File in the menu bar.

Label	Function	Description
1	Setup	Main confirguration options and main control mode selection drop down.
2	Serial	Settings for serial modes. Set packet address, baudrate and slave select.
3	Battery	Voltage setting options for main battery and logic batteries.
4	RC/Analog Options	Configure RC and Ananlog control options.
5	Motors	Motor current, accel and deccel settings.
6	I/O	Set encoder input type. Set S3, S4 and S5 configuration options. Enabling output pins on certain models of RoboClaw.

PWM Settings

The PWM settings screen is used to control RoboClaw for testing. Slider are provided to control each motor channel. This screen can also be used to determine the QPPS of attached encoders.



Temp1 31.6 | M1 Amps 0.00 | M1 Encoder 0 | M1 Speed 0 | Main Battery 11.9 | Model 2x60a
Temp2 0.0 | M2 Amps 0.00 | M2 Encoder 0 | M2 Speed 0 | Logic Battery 1.8 | Version 4.1.20

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

PWM/Torque Settings: Motor1 L 0.0000, R 0.00; Motor2 L 0.0000, R 0.00

Control: Accel Motor1 0, Motor2 0; Duty Motor1 0, Motor2 0

Kbps 293.76

(1) Graph

Function	Description
Grid	Displays channel data with 100mS update rate and one second horizontal divisions.

(2) PWM/Torque Settings

Function	Description
L	MCP only. Motor Inductance in Henries.
R	MCP only. Motor resistance in Ohms.

(3) Control

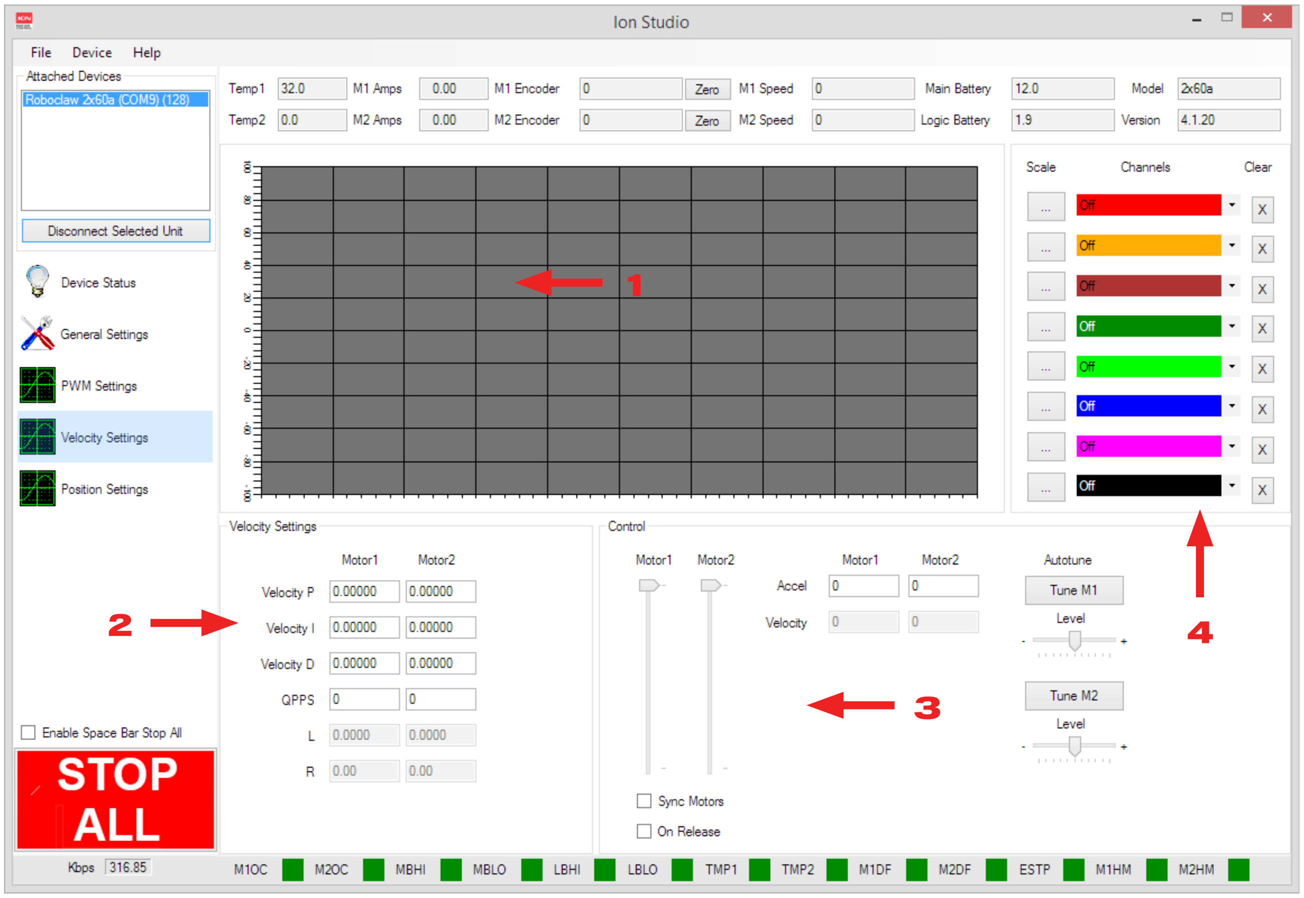
Function	Description
Motor 1	Controls motor 1 duty percentage forward and reverse.
Motor 2	Controls motor 2 duty percentage forward and reverse.
Sync Motors	Synchronises Motor 1 and Motor 2 Sliders.
Accel	Acceleration rate used when moving the sliders.
Duty	Displays the numberic value of the motor slider in 10ths of a Percent (0 to +/-1000).

(4) Graph Channels

Function	Description
Scale	Sets vertical scale to fit the range of the specified Channel.
Channels	Select data to display on the channel. The channel is graphed in the color shown. Channel options: • M1 or M2 Setpoint - User input for channel • M1 or M2 PWM - Motor PWM output • M1 or M2 Velocity - Motors Encoder Velocity • M1 or M2 Position - Motors Encoder Position • M1 or M2 Current - Motor running current • Temperature • Main Battery Voltage • Logic Battery Voltage
Clear	Clears channels graphed line.

Velocity Settings

The Velocity settings screen is used to set the encoder and PID settings for speed control. The screen is also used for testing and plotting.



Roboclaw 2x60a (COM9) (128)

Temp1 32.0 | M1 Amps 0.00 | M1 Encoder 0 | M1 Speed 0 | Main Battery 12.0 | Model 2x60a

Temp2 0.0 | M2 Amps 0.00 | M2 Encoder 0 | M2 Speed 0 | Logic Battery 1.9 | Version 4.1.20

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

	Motor1	Motor2
Velocity P	0.00000	0.00000
Velocity I	0.00000	0.00000
Velocity D	0.00000	0.00000
QPPS	0	0
L	0.0000	0.0000
R	0.00	0.00

	Motor1	Motor2
Accel	0	0
Velocity	0	0

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

Kbps 316.85

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

(1) Graph

Function	Description
Grid	Displays channel data with 100mS update rate and one second horizontal divisions.

(2) Velocity Settings

Function	Description
Velocity P	Proportional setting for PID.
Velocity I	Integral setting for PID.
Velocity D	Differential setting for PID.
QPPS	Maximum speed of motor using encoder counts per second.
L	MCP only. Motor Inductance in Henries.
R	MCP only. Motor resistance in Ohms.

(3) Control

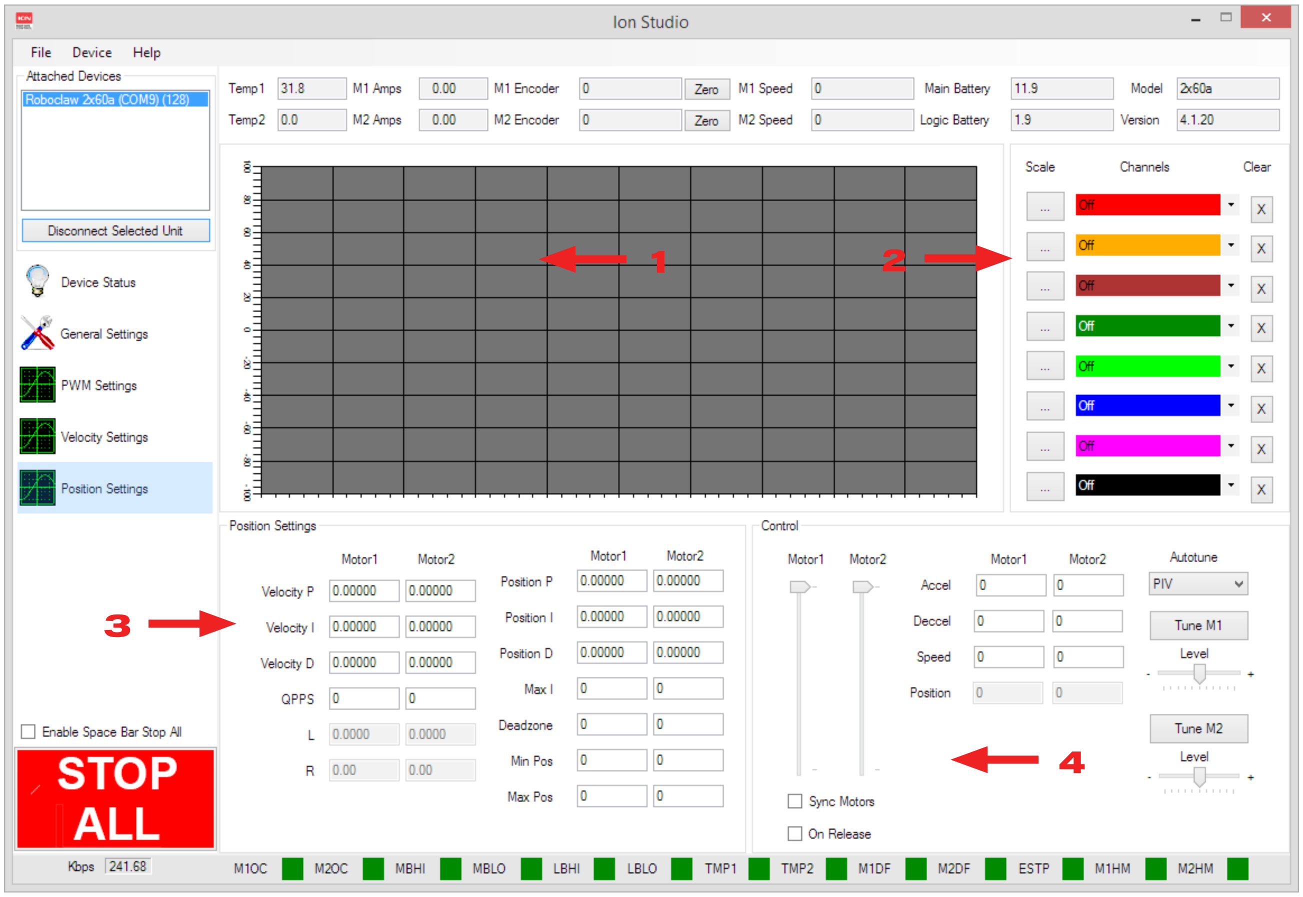
Function	Description
Motor 1	Motor 1 velocity control (0 to +/- maximum motor speed).
Motor 2	Motor 2 velocity control (0 to +/- maximum motor speed).
Sync Motors	Synchronises Motor 1 and Motor 2 Sliders.
On Release	Will not update new speed until the slider is released.
Accel	Acceleration rate used when moving the sliders.
Velocity	Shows the numeric value for the sliders current position.
Tune M1	Start motor 1 velocity auto tune.
Level	Adjust auto tune 1 values agressiveness. Sllide left for softer control.
Tune M2	Start motor 2 velocity auto tune.
Level	Adjust auto tune 2 values agressiveness. Sllide left for softer control.

(4) Graph Channels

Function	Description
Scale	Sets vertical scale to fit the range of the specified Channel.
Channels	Select data to display on the channel. The channel is graphed in the color shown. Channel options: • M1 or M2 Setpoint - User input for channel • M1 or M2 PWM - Motor PWM output • M1 or M2 Velocity - Motors Encoder Velocity • M1 or M2 Position - Motors Encoder Position • M1 or M2 Current - Motor running current • Temperature • Main Battery Voltage • Logic Battery Voltage
Clear	Clears channels graphed line.

Position Settings

The Position settings screen is used to set the encoder and PID settings for position control. The screen is also used for testing and plotting.



Roboclaw 2x60a (COM9) (128)

Temp1	31.8	M1 Amps	0.00	M1 Encoder	0	M1 Speed	0	Main Battery	11.9	Model	2x60a
Temp2	0.0	M2 Amps	0.00	M2 Encoder	0	M2 Speed	0	Logic Battery	1.9	Version	4.1.20

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

Position Settings

	Motor1	Motor2
Velocity P	0.00000	0.00000
Velocity I	0.00000	0.00000
Velocity D	0.00000	0.00000
QPPS	0	0
L	0.0000	0.0000
R	0.00	0.00

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

Control

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

Sync Motors ☐
On Release ☐

Autotune: PIV

Kbps 241.68

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

(1) Graph

Function	Description
Grid	Displays channel data with 100mS update rate and one second horizontal divisions.

(2) Graph Channels

Function	Description
Scale	Sets vertical scale to fit the range of the specified Channel.
Channels	Select data to display on the channel. The channel is graphed in the color shown. Channel options: • M1 or M2 Setpoint - User input for channel • M1 or M2 PWM - Motor PWM output • M1 or M2 Velocity - Motors Encoder Velocity • M1 or M2 Position - Motors Encoder Position • M1 or M2 Current - Motor running current • Temperature • Main Battery Voltage • Logic Battery Voltage
Clear	Clears channels graphed line.

(3) Position Settings

Function	Description
Velocity P	Proportional setting for velocity PID.
Velocity I	Integral setting for velocity PID.
Velocity D	Differential setting for velocity PID.
QPPS	Maximum speed of motor using encoder counts per second.
L	MCP only. Motor Inductance in Henries.
R	MCP only. Motor resistance in Ohms.
Position P	Proportional setting for position PID.
Position I	Integral setting for position PID.
Position D	Differential setting for position PID.
Max I	Maximum integral windup limit.
Deadzone	Zero position deadzone. Increases the "stopped" range.
Min Pos	Minimum encoder position.
Max Pos	Maximum encoder position.

(4) Control

Function	Description
Motor 1	Motor 1 velocity control (0 to +/- maximum motor speed).
Motor 2	Motor 2 velocity control (0 to +/- maximum motor speed).
Sync Motors	Synchronises Motor 1 and Motor 2 Sliders.
On Release	Will not update new speed until the slider is released.
Accel	Acceleration rate used when moving the sliders.
Deccel	Decceleration rate used when moving the sliders.
Speed	Speed to use with slide move.
Position	Numeric value of slider motor position.
Autotune	Method used. PD = Proportional and Differential. PID = Proportional Differential and Integral. PIV = Cascaded Velocity PD + Position P.
Tune M1	Start motor 1 velocity auto tune.
Level	Adjust auto tune 1 values agressiveness. Sllide left for softer control.
Tune M2	Start motor 2 velocity auto tune.
Level	Adjust auto tune 2 values agressiveness. Sllide left for softer control.

Firmware Updates

Ion Studio Setup

Download and install the Ion Studio application. Win7 or newer is required. When opening Ion Studio it will check for a newer version of it's self. It will then search for the USB RoboClaw Windows Driver to verify installation. If the USB driver is not found Ion Studio will install it.

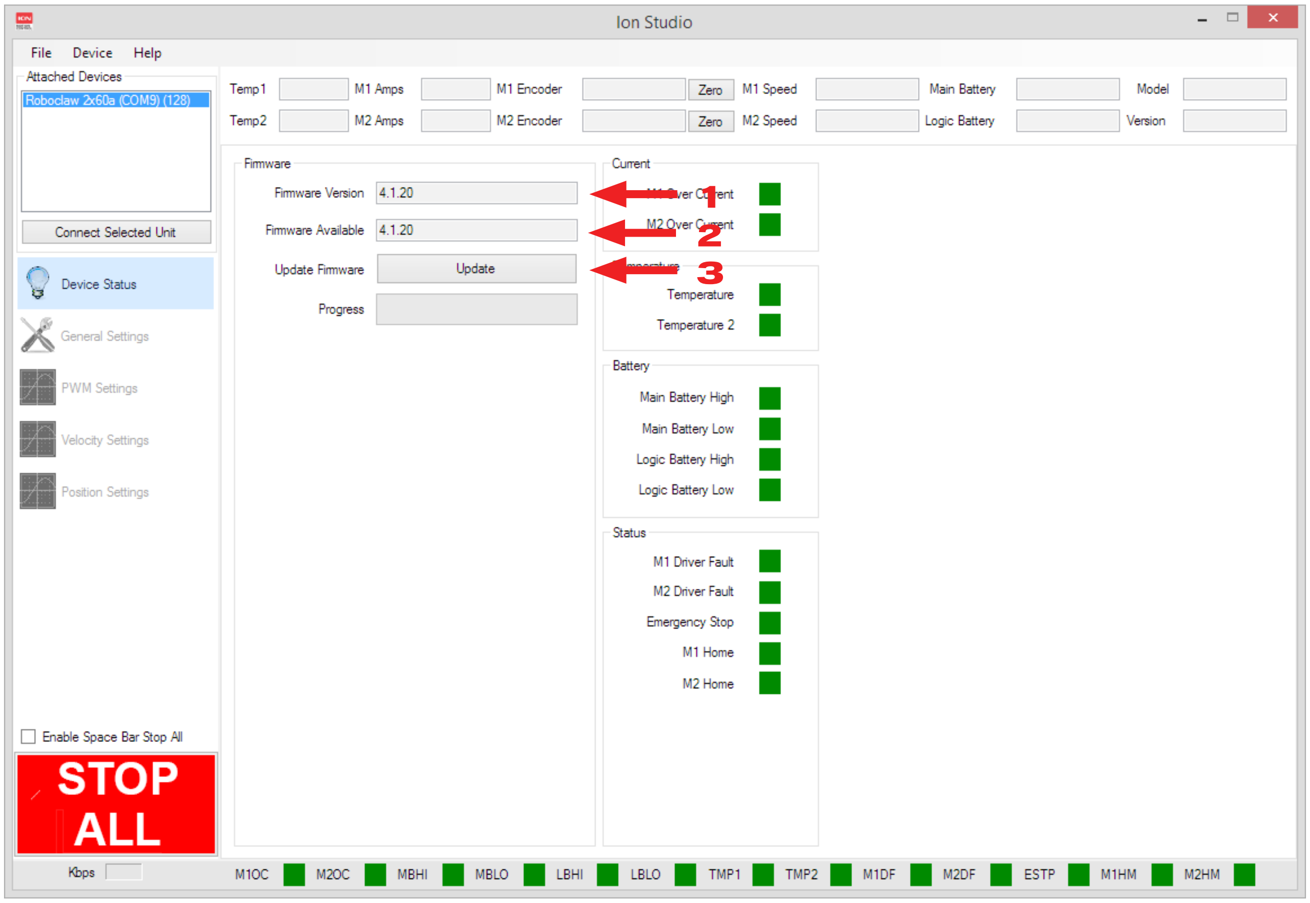
1. Open the Ion Studio application.

2. Apply a reliable power source such as a fully charge battery to power RoboClaw.

3. Connect the powered RoboClaw to a USB port on your computer with Ion Studio already open.

Firmware Update

Once Ion Studio detects RoboClaw it will display the current firmware version in the Firmware Version field (1). Each time Ion Studio is started it will check for a new version of its self which will always include new firmware. If an update is required Ion Studio will download the latest version and display it in the firmware available field (2).



Roboclaw 2x60a (COM9) (128)

Firmware Version 4.1.20

Firmware Available 4.1.20

1. When a new version of firmware is shown click the update button (3) to start the process.

2. Ion Studio will begin to update the firmware. While the firmware update is in progress the onboard LEDs will begin to flash. The onboard flash memory will first be erased. It is important power is not lost during this process or the motor controller will no longer function. There is no recovery if power fails during the erase process.

3. Once the firmware update is complete the motor controller will reset. Click the "Connect Selected Unit" button to re-connect.

Control Modes

Setup

RoboClaw has several fucntional control modes. There are two methods to configure these modes. Using the built-in buttons or Ion Studio. This manaul covers both methods of configuration. Ion Studio offers greater options for each mode and can be easier to configure the RoboClaw in several situations. However the built-in buttons are more than adequate in most all modes. Refer to the configuration section of this manual for mode setup instructions using Ion Studio or the built-in buttons.

There are 4 main modes with several variations. Each mode enables RoboClaw to be controlled in a very specific way. The following list explains each mode and the ideal application.

USB Control

USB can be used in any mode. When RoboClaw is in packet serial mode and another device, such as an Arduino, is connected commands from the USB and Arduino will be executed and can potential over ride one another. However if Roboclaw is not in packet serial mode, motor movement commands will not function. USB packet serial commands can then only be used to read status information and set configuration settings.

RC

Using RC mode RoboClaw can be controlled from any hobby RC radio system. RC input mode also allows low powered microcontrollers such as a Basic Stamp to control RoboClaw. RoboClaw expects servo pulse inputs to control the direction and speed. Very similar to how a regular servo is controlled. RC mode can use encoders if properly setup(See Encoder section).

Analog

Analog mode uses an analog signal from 0V to 2V to control the speed and direction of each motor. RoboClaw can be controlled using a potentiometer or filtered PWM from a microcontroller. Analog mode is ideal for interfacing RoboClaw with joystick positioning systems or other non microcontroller interfacing hardware. Analog mode can use encoders if properly setup(See Encoder section).

Simple Serial

In simple serial mode RoboClaw expects TTL level RS-232 serial data to control direction and speed of each motor. Simple serial is typically used to control RoboClaw from a microcontroller or PC. If using a PC, a MAX232 or an equivilent level converter circuit must be used since RoboClaw only works with TTL level inputs. Simple serial includes a slave select mode which allows multiple RoboClaws to be controlled from a signal RS-232 port (PC or microcontroller). Simple serial is a one way format, RoboClaw can only receive data. Encoders are not supported in Simple Serial mode.

Packet Serial

In packet serial mode RoboClaw expects TTL level RS-232 serial data to control direction and speed of each motor. Packet serial is typically used to control RoboClaw from a microcontroller or PC. If using a PC a MAX232 or an equivilent level converter circuit must be used since RoboClaw only works with TTL level input. In packet serial mode each RoboClaw is assigned a unique address. There are 8 addresses available. This means up to 8 RoboClaws can be on the same serial port. Encoders are support in Packet Serial mode(See Encoder section).

Configuration Using Ion Studio

Mode Setup

Download and install the Ion Studio application from http://www.ionmc.com. A PC with Windows 7 or newer is required. Ion Studio will check for a newer version each time it is ran. It will then search for the USB RoboClaw Windows Driver to verify installation. If the USB driver is not found Ion Studio will install it.

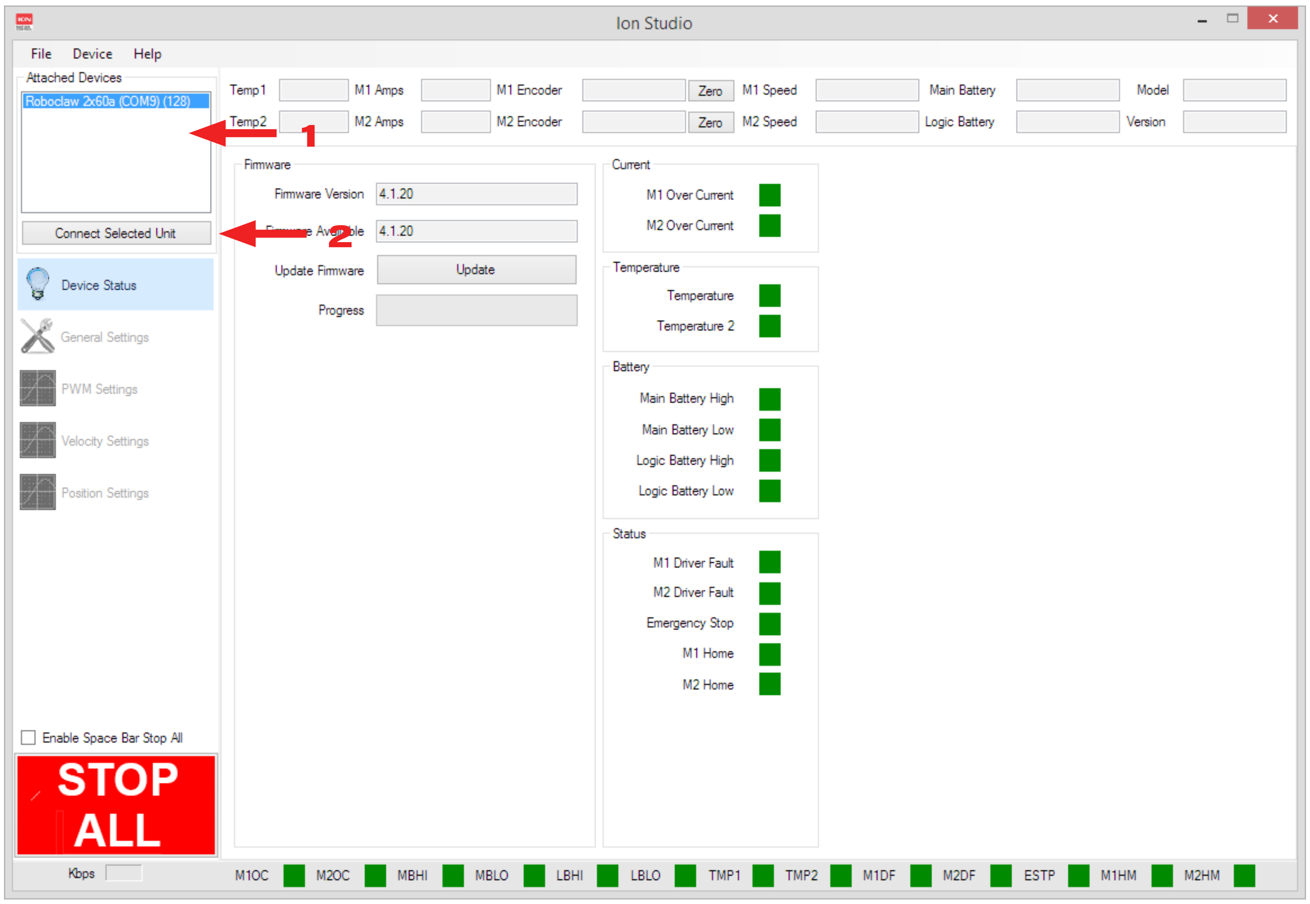
1. Open the Ion Studio application.

2. Apply a reliable power source such as a fully charge battery to power up RoboClaw.

3. Connect the powered RoboClaw to a USB port on your computer with Ion Studio already open. The RoboClaw USB driver may need to be installed Ion Studio will automatically handling installing the required driver.

4. When RoboClaw is detected, it will appear in the Attached Device window (1).

5. Once RoboClaw appears in the Attached Device window (1), click the connect button (2).



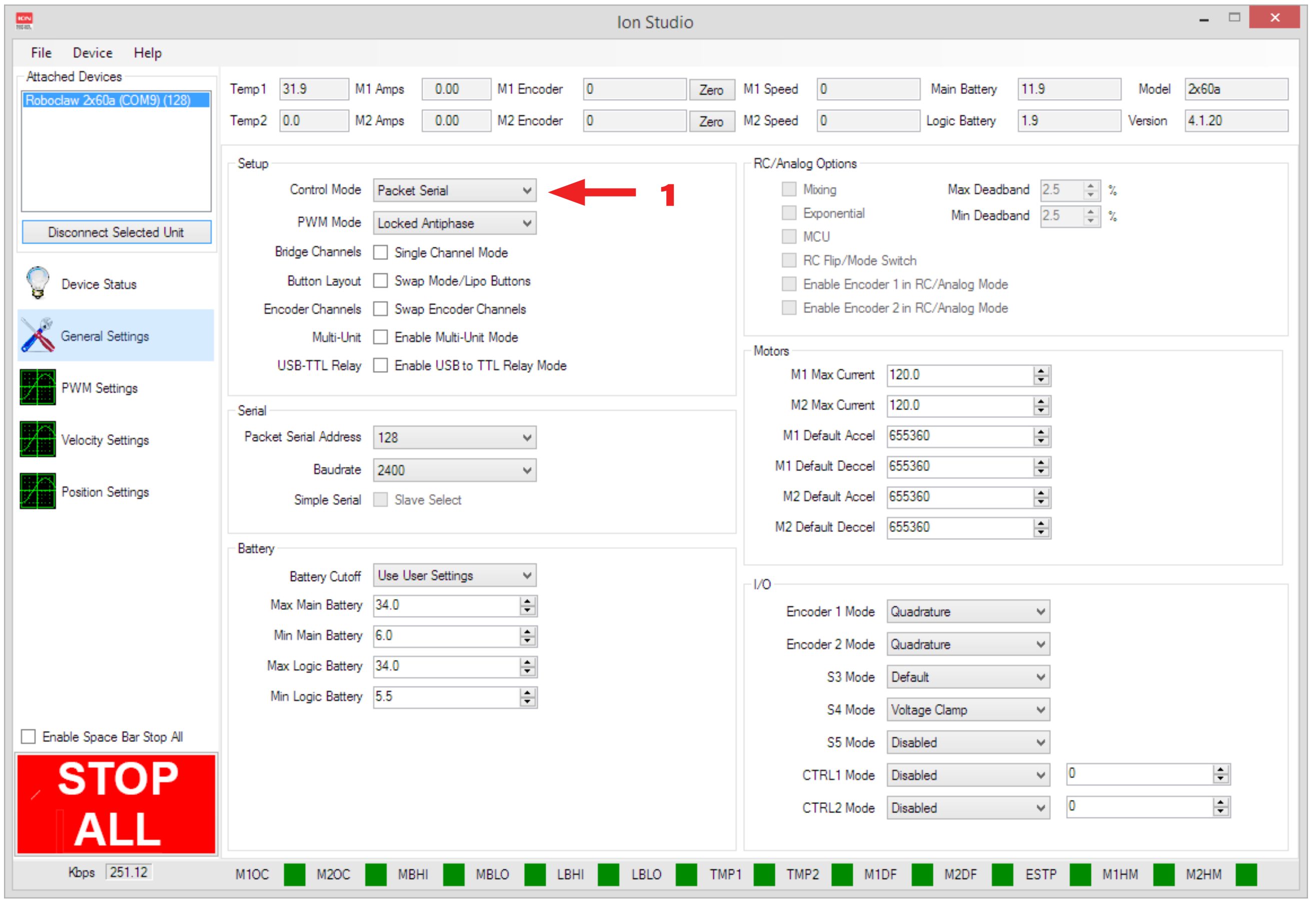
Attached Devices: Roboclaw 2x60a (COM9) (128)

Firmware Version: 4.1.20

Firmware Available: 4.1.20

Control Mode Setup

Select the Control Mode drop down (1). There are 4 main modes. See the Control Modes section of this manual for a detailed explanation of each available mode.



Roboclaw 2x60a (COM9) (128)

Temp1 31.9 | M1 Amps 0.00 | M1 Encoder 0 | M1 Speed 0 | Main Battery 11.9 | Model 2x60a
Temp2 0.0 | M2 Amps 0.00 | M2 Encoder 0 | M2 Speed 0 | Logic Battery 1.9 | Version 4.1.20

Setup
- Control Mode: Packet Serial
- PWM Mode: Locked Antiphase
- 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: 2400
- Simple Serial: ☐ Slave Select

Battery
- Battery Cutoff: Use User Settings
- Max Main Battery: 34.0
- Min Main Battery: 6.0
- Max Logic Battery: 34.0
- 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: 120.0
- M2 Max Current: 120.0
- M1 Default Accel: 655360
- M1 Default Deccel: 655360
- M2 Default Accel: 655360
- M2 Default Deccel: 655360

I/O
- Encoder 1 Mode: Quadrature
- Encoder 2 Mode: Quadrature
- S3 Mode: Default
- S4 Mode: Voltage Clamp
- S5 Mode: Disabled
- CTRL1 Mode: Disabled 0
- CTRL2 Mode: Disabled 0

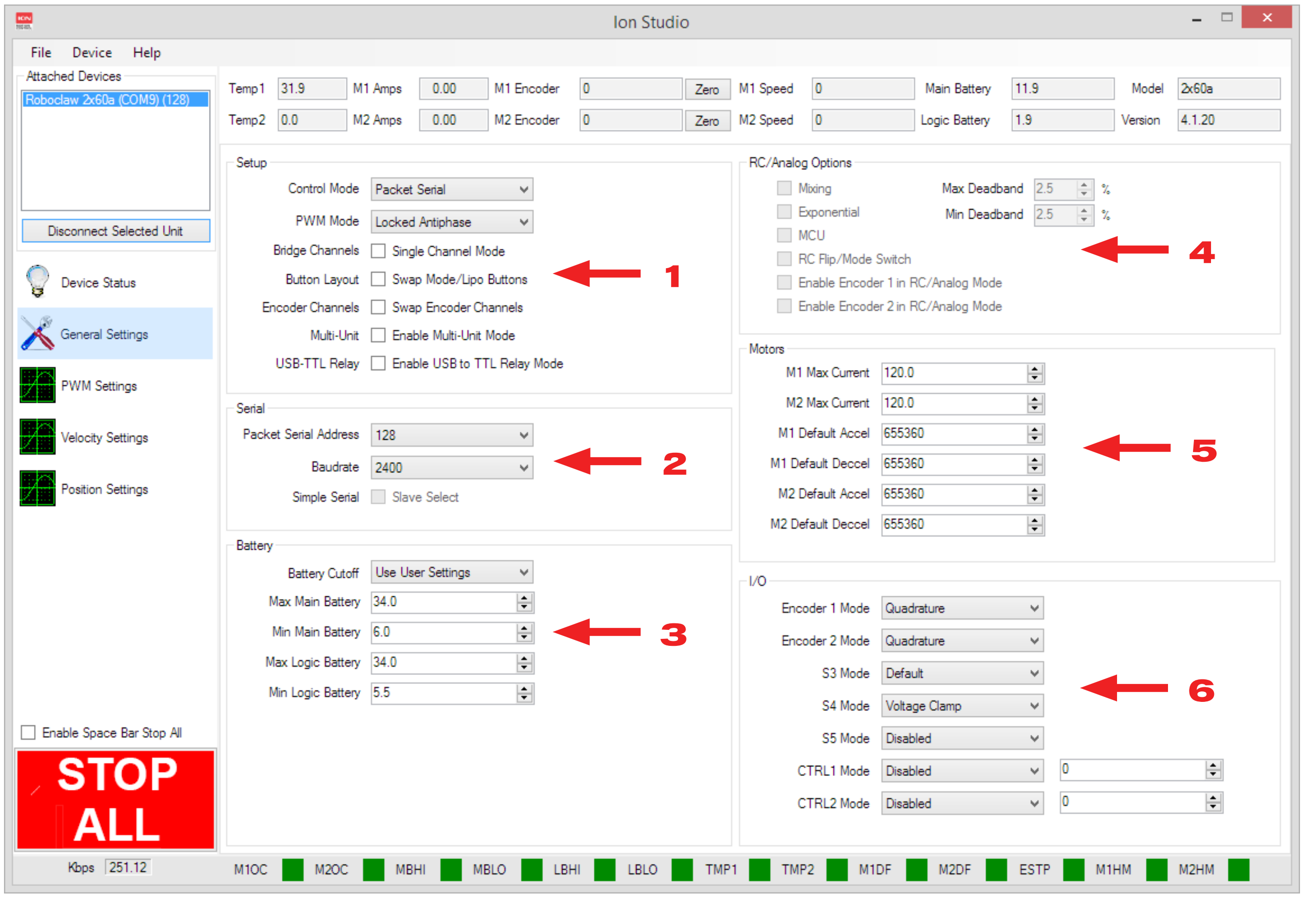
☐ Enable Space Bar Stop All

Kbps 251.12

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

Control Mode Options

The general settings screen is used to configure RoboClaw. Each control mode will have several configuration options. Grayed out options are not available for the selected mode. Once all settings are configured they must be saved to RoboClaw. This is done by selecting Save Settings from the File menu in the menu bar.



Attached Devices: Roboclaw 2x60a (COM9) (128)

Temp1	31.9	M1 Amps	0.00	M1 Encoder	0	M1 Speed	0	Main Battery	11.9	Model	2x60a
Temp2	0.0	M2 Amps	0.00	M2 Encoder	0	M2 Speed	0	Logic Battery	1.9	Version	4.1.20

Setup
- Control Mode: Packet Serial
- PWM Mode: Locked Antiphase
- 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: 2400
- Simple Serial: [ ] Slave Select

Battery
- Battery Cutoff: Use User Settings
- Max Main Battery: 34.0
- Min Main Battery: 6.0
- Max Logic Battery: 34.0
- 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: 120.0
- M2 Max Current: 120.0
- M1 Default Accel: 655360
- M1 Default Deccel: 655360
- M2 Default Accel: 655360
- M2 Default Deccel: 655360

I/O
- Encoder 1 Mode: Quadrature
- Encoder 2 Mode: Quadrature
- S3 Mode: Default
- S4 Mode: Voltage Clamp
- S5 Mode: Disabled
- CTRL1 Mode: Disabled, 0
- CTRL2 Mode: Disabled, 0

[ ] Enable Space Bar Stop All

Kbps 251.12

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

(1) Setup

Main drop down for setting the control modes and confirguration options.

Function	Description
Control Mode	Drop down to set main control mode. Some options may grey out if not available in the selected mode.
PWM Mode	Drop down to set the main MOSFET driving scheme. This option should never be change but in rare circumstances.
Bridge Channels	Used to bridge motor channe 1 and 2. This option must be set before physically bridging the channels. Or damage will result.
Button Layout	Swaps Mode and LIPO button interface. Only affects hardware V5 and RoboClaw 2x15, 2x30 and 2x45.
Encoder Channels	This option will swap encoder channels. Pair encoder 1 to motor channel 2 and encoder 2 to motor channel 1.
Mulit-Unit	Sets S2 pin to open drain. Allows multiple Roboclaws to be controlled from a single serial port.
USB-TTL Relay	Enables RoboClaw to pass data from USB through S1 (RX) and S2 (TX). Allows several RoboClaws to be networked from one USB connection. All connected RoboClaw's baud rates must be set to the same.

(2) Serial

Settings for serial modes. Set packet address, baudrate and slave select.

Function	Description
Packet Serial Address	Sets RoboClaw address for packet serial mode. Allows multiple Roboclaws to be controlled from a single Serial port.
Baudrate	Sets the baudrate in all serial modes.
Simple Serial	Sets simple serial mode with slave select. Set pin S2 high to enable the attached RoboClaw. Pull S2 low and all commands will be ignored.

(3) Battery
Main and logic battery voltage settings. Sets cut off and protection limits.

Function	Description
Battery Cut Off	Sets main battery cut off based on LiPo cell count. Can also be set to auto detect or User Settings for manual configuration. Auto detect requires a properly charged battery. User Settings allows editing of the voltage values manually. See Battery Settings.
Max Main Battery	Sets main battery maximum voltage. If the main battery voltage goes above the set maximum value running motors will go into brake mode.
Min Main Battery	Sets main battery minimum voltage. If the main battery voltage falls below the set minimum value running motors will go into freewheel.
Max Logic Battery	Sets logic battery maximum voltage. If logic battery voltage goes above the maximum set value RoboClaw will shut down until the voltage is corrected and a reset.
Min Logic Battery	Sets logic battery minimum voltage. If logic battery voltage goes below the minimum set value RoboClaw will shut down until the voltage is corrected and a reset.

(4) RC/Analog Options
Configure RC and Ananlog control options. Set control type in RC and Analog modes.

Function	Description
Mixing	Mixes S1 and S2 inputs for control of a differentially steered robot. S1 controls direction (forward / reverse) and speed. S2 controls turning left or right with speed. Simliar to how a RC car would be controlled. Turn this mode off for tank style control.
Exponential	Enable increased control range at slow speed.
MCU	Disables auto calibrate. Allows slow MCU to send R/C pulses at lower than normal R/C rates.
RC Flip/Mode Switch	R/C pulse switched. Use radio channel to toggle and change all motor direction. Used when a robot is flipped upside down to reverse steering control.
Enable Encoder 1 in RC/ AnalogMode	Enables encoder 1 to be used in RC or Analog mode. Will control motor by speed or position depending on which PID control is set. The range of speed is mapped to the RC control using the QPPS value as the maximum speed. The position range is controlled by maximum and minimum position settings.
Enable Encoder 2 in RC/ AnalogMode	Enables encoder 1 to be used in RC or Analog mode. Will control motor by speed or position depending on which PID control is set. The range of speed is mapped to the RC control using the QPPS value as the maximum speed. The position range is controlled by maximum and minimum position settings.
Max Deadband	Sets maximum range of control signal seen as 0 (Stopped).
Min Deadband	Sets minimum range of control signal seen as 0 (Stopped).

(5) Motors

Motor current limit settings. The accel and deccel settings apply to RC, Analog and commands with no Accel and Deccel arugements.

Function	Description
M1 Max Current	Sets maximum motor current for channel 1. Can not exceed RoboClaw rated peak current.
M2 Max Current	Sets maximum motor current for channel 2. Can not exceed RoboClaw rated peak current.
M1 Default Accel	Sets the ramp rate of acceleration for motor channel 1. A value of 1 to 655,360 can be used. Value of 0 sets the internal default for Accel and Deccel. Value of 655,360 equals 100mS full forward to reverse ramping rate.
M1 Default Deccel	Sets the ramp rate of decceleration for motor channel 1. A value of 1 to 655,360 can be used. Value of 0 sets the internal default for Accel and Deccel. Value of 655,360 equals 100mS full forward to reverse ramping rate.
M2 Default Accel	Sets the ramp rate of acceleration for motor channel 2. A value of 1 to 655,360 can be used. Value of 0 sets the internal default for Accel and Deccel. Value of 655,360 equals 100mS full forward to reverse ramping rate.
M2 Default Deccel	Sets the ramp rate of decceleration for motor channel 2. A value of 1 to 655,360 can be used. Value of 0 sets the internal default for Accel and Deccel. Value of 655,360 equals 100mS full forward to reverse ramping rate.

(6) I/O

Set encoder input type. Set S3, S4 and S5 configuration options. Enabling output pins on certain models of RoboClaw. Set limit, homing, voltage clamp, E-stop options.

Function	Description
Encoder 1 Mode	Sets encoder type for encoder 1.
Encoder 2 Mode	Sets encoder type for encoder 2.
S3 Mode	Sets the default function for S3.
S4 Mode	Sets the default function for S4.
S5 Mode	Sets the default function for S5.
CTRL1 Mode	Enables output pins on certain models of RoboClaw. A value of 0 to 65535 can be used to set the pin's default PWM output. Value can be changed by commands during run time.
CTRL2 Mode	Enables output pins on certain models of RoboClaw. A value of 0 to 65535 can be used to set the pin's default PWM output. Value can be changed by commands during run time.

Configuration with Buttons

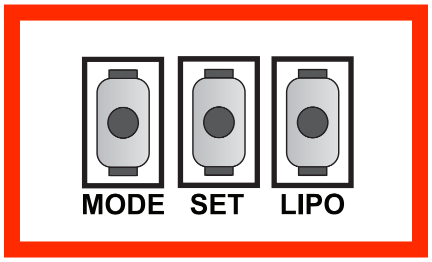
Mode Setup

The 3 buttons on RoboClaw are used to set the different configuration options. The MODE button sets the interface method such as Serial or RC modes. The SET button is used to configure the options for the mode. The LIPO button doubles as a save button and configuring the low battery voltage cut out function of RoboClaw. To set the desired mode follow the steps below.

1. Press and release the MODE button to enter mode setup. The STAT2 LED will begin to blink out the current mode. Each blink is a half second with a long pause at the end of the count. Five blinks with a long pause equals mode 5 and so on.

2. Press SET to increment to the next mode. Press MODE to decrement to the previous mode.

3. Press and release the LIPO button to save this mode to memory.



Modes

Mode	Function	Description
1	R/C mode	Control with standard R/C pulses from a R/C radio or MCU. Controls a robot like a tank. S1 controls motor 1 forward or reverse and S2 controls motor 2 forward or reverse.
2	R/C mode with mixing	Same as Mode 1 with mixing enabled. Channels are mixed for differentially steered robots (R/C Car). S1 controls forward or reverse and S2 controls left or right.
3	Analog mode	Control using analog voltage from 0V to 2V. S1 controls motor 1 and S2 controls motor 2.
4	Analog mode with mixing	Same as Mode 3 with mixing enabled. Channels are mixed for differentially steered robots (R/C Car). S1 controls forward or reverse and S2 controls left or right.
5	Standard Serial	Use standard serial communications for control.
6	Standard Serial with slave pin	Same as Mode 5 with a select pin. Used for networking. RoboClaw will ignore commands until pin goes high.
7	Packet Serial Mode - Address 0x80	Control using packet serial mode with a specific address for networking several motor controllers together.
8	Packet Serial Mode - Address 0x81	
9	Packet Serial Mode - Address 0x82	
10	Packet Serial Mode - Address 0x83	
11	Packet Serial Mode - Address 0x84	
12	Packet Serial Mode - Address 0x85	
13	Packet Serial Mode - Address 0x86	
14	Packet Serial Mode - Address 0x87	

Mode Options

Each mode will have several possible configuration settings. The settings need to be setup after the initial mode is selected. Follow the steps below.

1. After the desired mode is set and saved press and release the SET button for options setup. The STAT2 LED will begin to blink out the current option setting.
2. Press SET to increment to the next option. Press MODE to decrement to the previous option.
3. Once the desired option is selected press and release the LIPO button to save the option to memory.

RC and Analog Mode Options

Option	Function	Description
1	TTL Flip Switch	Logic level switch. Toggle to change all motor direction. Used when a robot is flipped upside down to reverse steering control.
2	TTL Flip and Exponential Enabled	Option 1 combined with increased control range at slow speed.
3	TTL Flip and MCU Enabled	Disables auto calibrate. Allows slow MCU to send R/C pulses at lower than normal R/C rates.
4	TTL Flip and Exp and MCU Enabled	Option 2 and 3 combined.
5	RC Flip Switch	R/C pulse switched. Use radio channel to toggle and change all motor direction. Used when a robot is flipped upside down to reverse steering control.
6	RC Flip and Exponential Enabled	Option 5 combined with increased control range at slow speed.
7	RC Flip and MCU Enabled	Disables auto calibrate and auto stop due to R/C signal loss. Allows slow MCU to send R/C pulses at lower than normal R/C rates.
8	RC Flip and Exponential and MCU Enabled	Option 6 and 7 combined.

Standard Serial and Packet Serial Mode Options

Option	Baud Rate	Description
1	2400bps	Standard RS-232 serial data rate.
2	9600bps	Standard RS-232 serial data rate.
3	19200bps	Standard RS-232 serial data rate.
4	38400bps	Standard RS-232 serial data rate.
5	57600bps	Standard RS-232 serial data rate.
6	115200bps	Standard RS-232 serial data rate.
7	230400bps	Standard RS-232 serial data rate.
8	460800bps	Standard RS-232 serial data rate.

Battery Cut Off Settings

The RoboClaw is able to protect the main battery by utilizing a battery voltage cut off. The cut off voltage will vary depending on the size of battery used. The table below shows the battery option setting with the type of battery it will protect and at what voltage the cutoff will kick in. The battery settings can be set by following the steps below.

1. Press and release the LIPO button. The STAT2 LED will begin to blink out the current setting.
2. Press SET to increment to the next setting. Press MODE to decrement to the previous setting.
3. Once the desired setting is selected press and release the LIPO button to save this setting to memory.

Battery Options

Option	Setting	Description
1	Disabled	6VDC is the default cut off when disabled.
2	Auto Detect	Battery must not be overcharged or undercharge! See Battery Settings.
3	3 Cell	9VDC is the cut off voltage.
4	4 Cell	12VDC is the cut off voltage.
5	5 Cell	15VDC is the cut off voltage.
6	6 Cell	18VDC is the cut off voltage.
7	7 Cell	21VDC is the cut off voltage.
8	8 Cell	24VDC is the cut off voltage.

Battery Settings

Automatic Battery Detection on Startup

Auto detect will sample the main battery voltage on power up or after a reset. All Lipo batteries, depending on cell count will have a minimum and maximum safe voltage range. The attached battery must be within this acceptable voltage range to be correctly detected. Undercharged or overcharged batteries will cause false readings and RoboClaw will not properly protect the battery. If the automatic battery detection mode is enabled using the on-board buttons, the Stat2 LED will blink to indicate the battery cell count that was detected. Each blink indicates the number of LIPO cells detected. When automatic battery detection is used the number of cells detected should be confirmed on power up.

Undercharged or overcharged batteries can cause an incorrect auto detection voltage.

Manual Voltage Settings

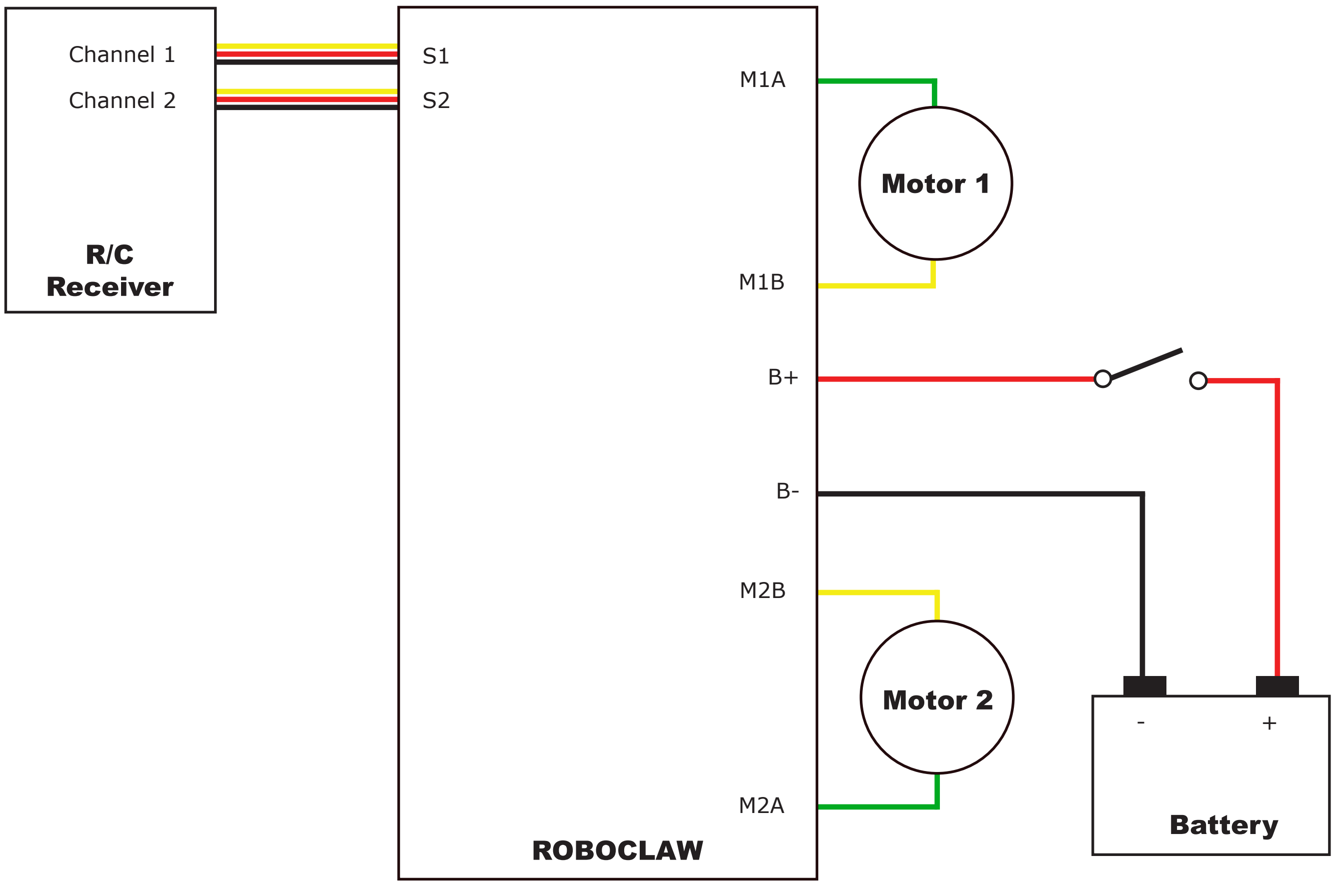
The minimum and maximum voltage can be set using the Ion Studio application or packet serial commands. Values can be set to any value between the boards minimum and maximum voltage limits. This feature can be useful when using a power supply to power RoboClaw. A minimum voltage just below the power supply voltage of 2VDC will prevent the power supply voltage from dipping too low under heavy load. A maximum voltage set to just above the power supply voltage 2VDC will help protect the power supply from regenerative voltage spikes if an external voltage clamp circuit is not being used. However when the minimum or maximum voltages are reached RoboClaw will go into either braking or freewheel mode. This feature will only help to protect a power supply not correct regenerative voltages issues. A voltage clamping circuit is required to correct any regenerative voltage issues when a power supply is used as the main power source. See Voltage Clamping.

Wiring

Basic Wiring

The MCP has many control modes and each mode may have unique wiring requirments to ensure safe and reliable operation. The diagram below illustrates a very basic wiring configuration used in a small motor system where safety concerns are minimal. This is the most basic wiring configuration possible. Any wiring of RoboClaw should include a main battery shut off switch, even when safety concerns are minimal. Never underestimate a motorized system in an uncontrolled condition.

In addition, RoboClaw is a regenerative motor controller. If the motors are moved when the system is off, it could cause potential erratic behavior due to the regenerative voltages powering the system. A return path to the battery should always be supplied if the system can move when main power is disconnected or a fuse is blown.



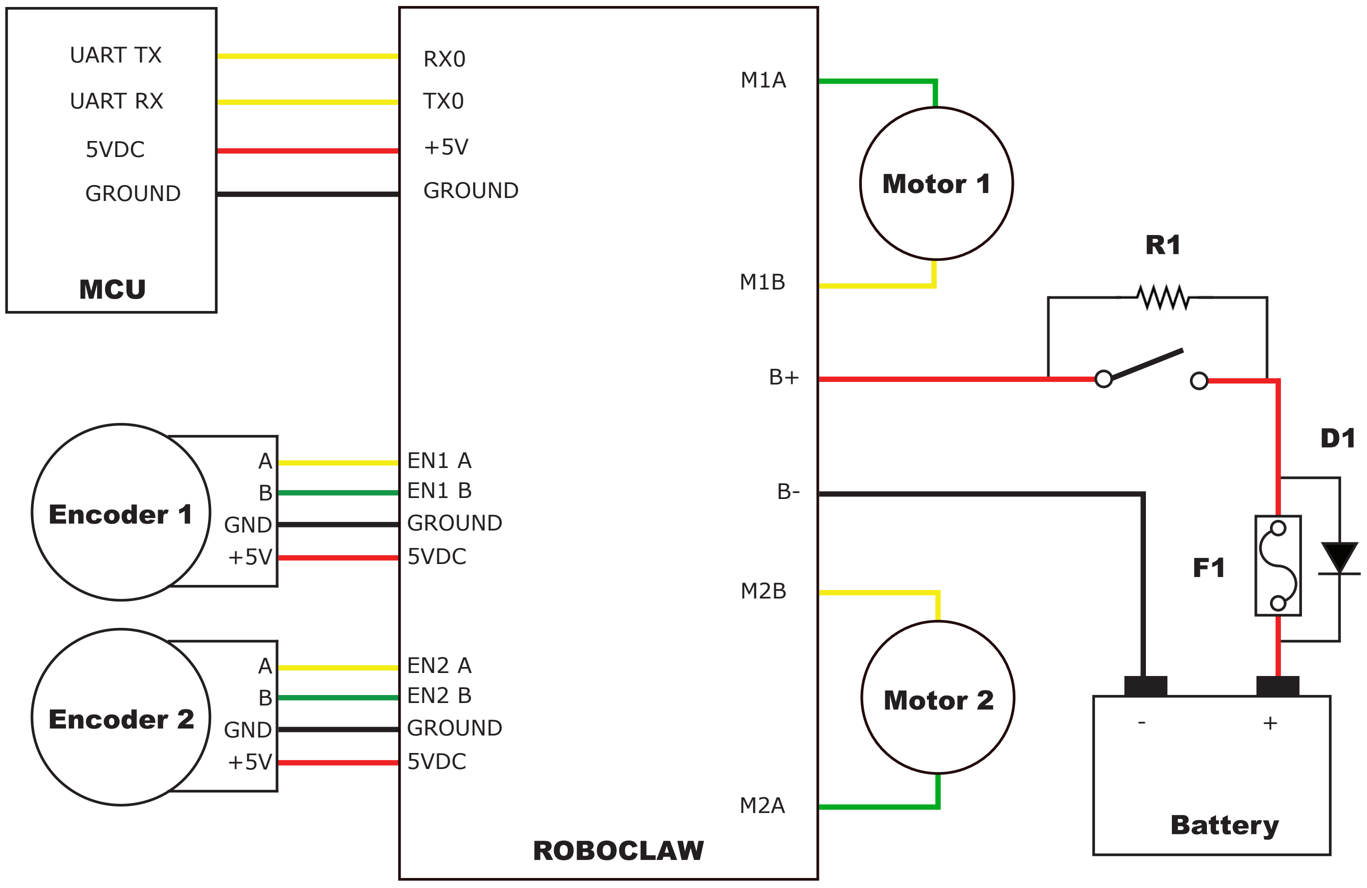
Never disconnect the negative battery lead before disconnecting the positive!

Safety Wiring

In all system with movement, safety is a concern. The wiring diagram below illustrates a properly wired system with several safety features. An external main power cut off is required for safety. When the RoboClaw is switched off or the fuse is blown, a high current diode (D1) is required to create a return path to the battery for any regenerative voltages. The use of a pre-charge resistor (R1) is required to avoid high inrush currents and arcing. A pre-charge resistor (R1) should be 1K, 1/2Watt for a 60VDC motor controller which will give a pre-charge time of about 15 seconds. A lower resistances can be used with lower voltages to decrease the pre-charge time.

Encoder Wiring

A wide range of sensors are supported including quadrature encoders, absolute encoders, potentiometers and hall effect sensors for closed loop operation. The encoder pins are not exclusive to supporting encoders and have several functions available. See Encoder section of this manual for additional information.

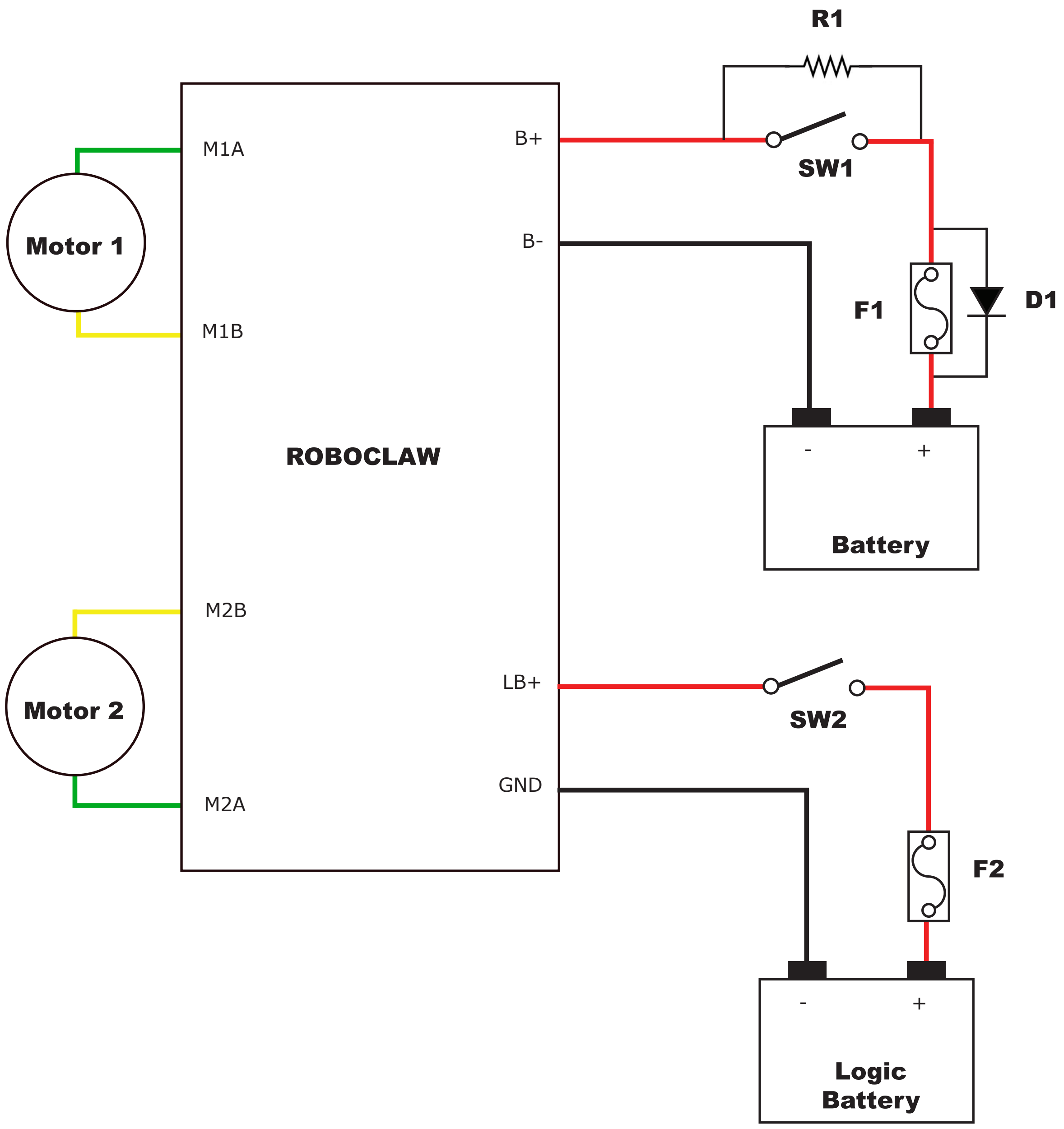


Logic Battery Wiring

An optional logic battery is supported. Under heavy loads the main power can suffer voltage drops, causing potential logic brown outs which may result in uncontrolled behavior. A separate power source for the motor controllers logic circuits, can remedy potential problems from main power voltage drops. The logic battery maximum input voltage is 34VDC with a minimum input voltage of 6VDC. The 5V regulated user output is supplied by the secondary logic battery if supplied. The mAh of the logic battery should be determined based on the load of attached devices powered by the regulated 5V user output.

Logic Battery Jumper

A logic battery is used in the configurtion below. Some models of RoboClaw have a jumper to set the logic battery. On models where the LB-MB header is present the jumper must be removed when a logic battery is used. If the header for LB-MB is not present, then the RoboClaw will automatically set the logic battery power source.

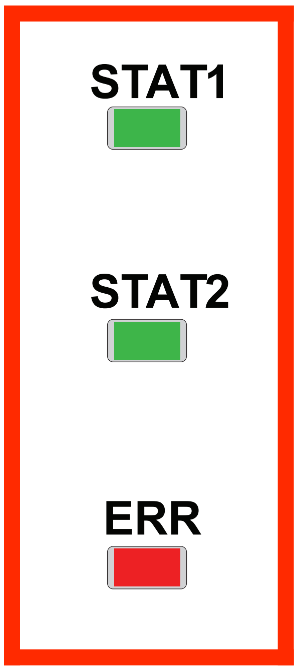


LED Indicators

Status and Error LEDs

RoboClaw includes 3 LEDs to indicate status. Two green status LEDs labeled STAT1 and STAT2 and one red error LED labeled ERR. When the motor controller is first powered on all 3 LEDs should blink briefly to indicate all LEDs are functional.

The LEDs will behave differently depending on the mode. During normal operation the status 1 LED will remain on continuously or blink when data is received in RC Mode or Serial Modes. The status 2 LED will light when either drive stage is active.



Message Types

There are 3 types of message RoboClaw can indicate. The first type is a fault. When a fault occurs, both motor channel outputs will be disabled and RoboClaw will stop any further actions until the unit is reset, or in the case of non-latching E-Stops, the fault state is cleared. The second message type is a warning. When a warnings occurs both motor channel outputs will be controlled automatically depending on the warning condition. As an example if an over temperature of 85c is reach RoboClaw will reduce the maximum allowed current until a safe temperature is reached. The final message type is a notice. Currently there is only one notice indicated.

LED Blink Sequences

When a warning or fault occurs RoboClaw will use the LEDs to blink a sequence. The below table details each sequence and the cause.

LED Status	Condition	Type	Description
All three LEDs lit.	E-Stop	Fault	Motors are stopped by braking.
Error LED lit while condition is active.	Over 85c Temperature	Warning	Motor current limit is recalculated based on temperature.
Error LED blinks once with short delay. Other LEDs off.	Over 100c Temperature	Fault	Motors freewheel while condition exist.
Error LED lit while condition is active.	Over Current	Warning	Motor power is automatically limited.
Error LED blinking twice. STAT1 or STAT2 indicates channel.	Driver Fault	Fault	Motors freewheel. Damage detected.
Error LED blinking three times.	Logic Battery High	Fault	Motors freewheel until reset.
Error LED blinking four times.	Logic Battery Low	Fault	Motors freewheel until reset.
Error LED blinking five times.	Main Battery High	Fault	Motors are stopped by braking until reset.
Error LED lit while condition is active.	Main Battery High	Warning	Motors are stopped by braking while condition exist.
Error LED lit while condition is active.	Main Battery Low	Warning	Motors freewheel while condition exist.
Error LED lit while condition is active.	M1 or M2 Home	Warning	Motor is stopped and encoder is reset to 0
All 3 LED cycle on and off in sequence after power up.	RoboClaw is waiting for new firmware.	Notice	RoboClaw is in boot mode. Use IonMotion PC setup utility to clear.

Inputs

S3, S4 and S5 Setup

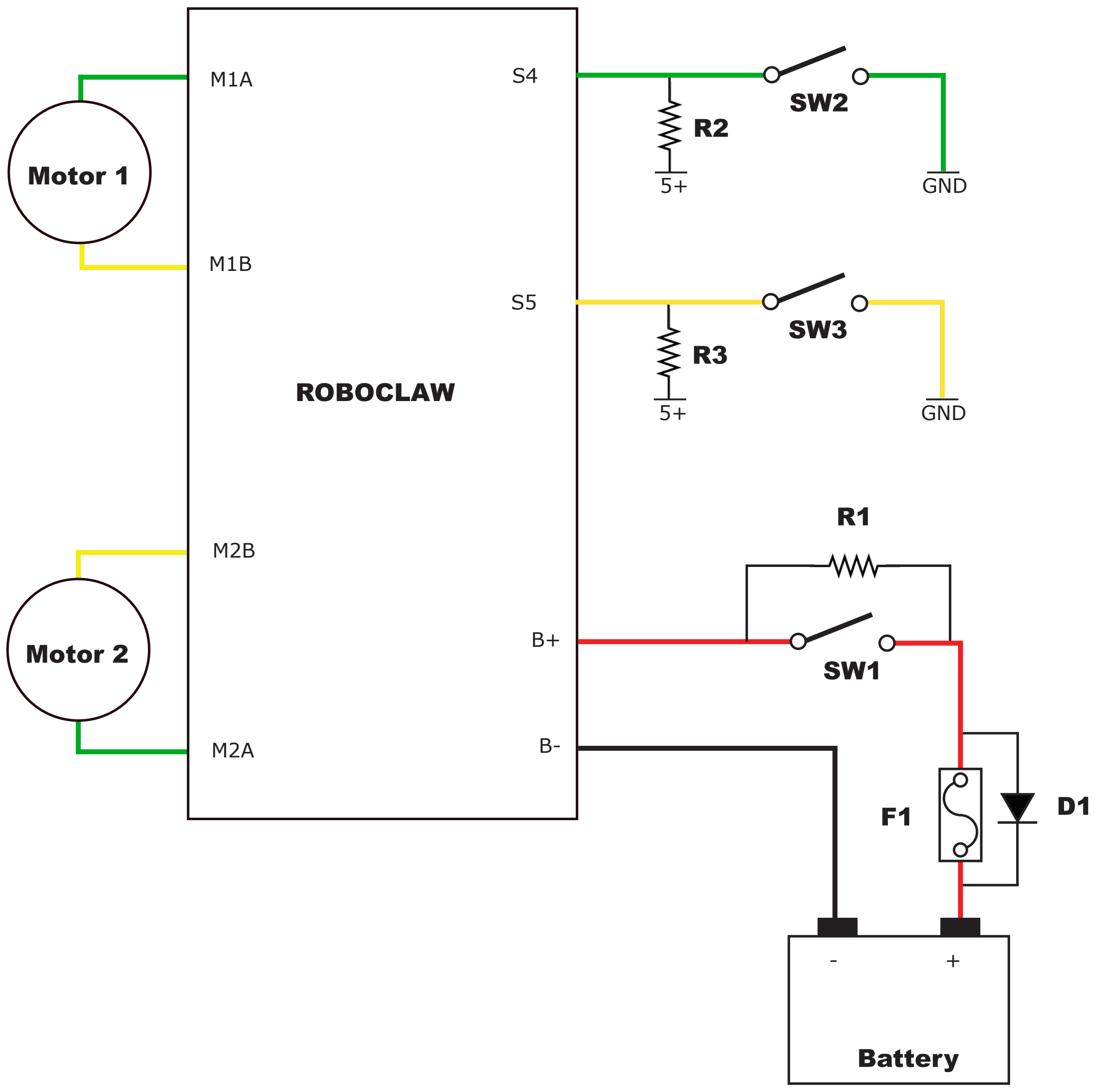
RoboClaw S3, S4 and S5 inputs support the use of home switches, limit switches, Voltage Clamping and E-Stops. A limit switch is used to detect the travel limits. Travel limits are typically used on a linear slide to detect when the assembly has reached the end of travel. A home switch is used to create a known start position. In some situations both may be required.

Open Ion Studio and select the S3, S4 or S5 options drop down. There are several options to choose from. Each option is explained below. After setting S3, S4 and S5 options save the settings before exiting Ion Studio.

Option	Description
Disable	Disables S4 and S5. Set by default.
E-Stop(Latching)	All stop until RoboClaw is reset.
E-Stop	All stop until switch released.
Voltage Clamp	Used to control a voltage clamp circuit. Dumps the regenerative voltages. For use with power supplies.
Motor Home(Auto)	Moves motor in reverse rotation until switch tripped.
Motor Home(User)	User controls direction of motor to reach switch.
Limit(Forward)	Motor moves forward rotation until switch tripped.
Limit(Reverse)	Motor moves in reverse rotation until switch tripped.

Limit / Home / E-Stop Wiring

S4 controls motor channel 1 and S5 controls motor channel 2. A pull-up resistor to 5VDC or 3.3VDC should be used if wire lengths exceed 6" (150mm). The circuit below shows a NO (normally open) style switch. Connect the NO to S4 or S5 and the COM end to a power ground shared with RoboClaw.



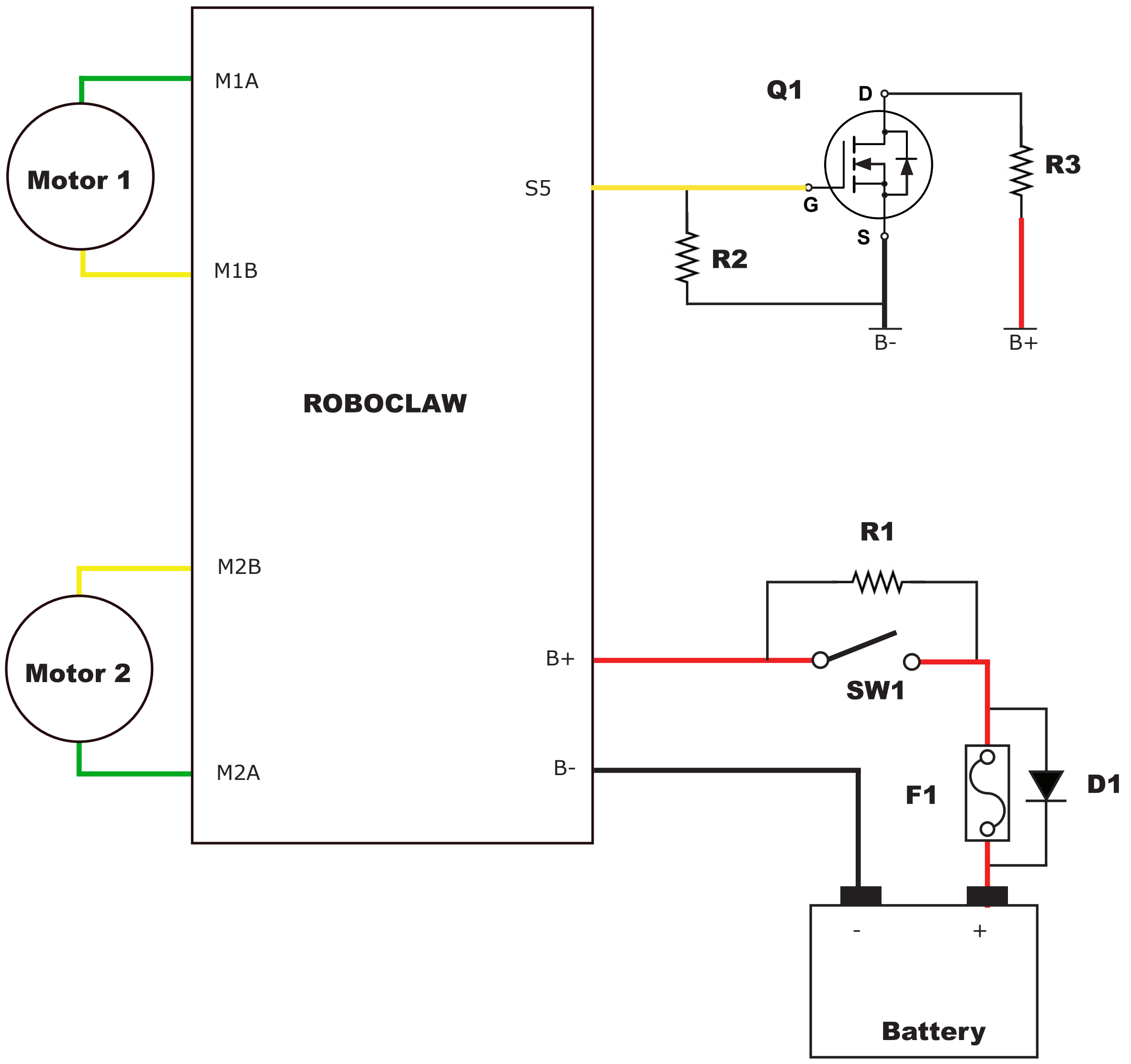
Regenerative Voltage Clamping

Voltage Clamp

When using power supplies regenerative voltage spikes will need to be dissipated. This can be done with a simple circuit shown below and using a V-Clamp pin to activate it. A solid state switch (Q1) and large wattage resistor (R3) are required. The regenerative voltage will be dissipated as heat. An example of a large resistor would be in the range of 10 Ohms at 50 watts for small motors and down to 1 Ohms or lower for larger motors. 50 watts will likely cover most situation smaller wattage resistor may work.

Voltage Clamp Circuit

Wire the circuit as shown below. Q1 should be a 3V logic level MOSFET. An example would be FQP30N06L. Which is rated to a maximum voltage of 60VDC. You may need to change the MOSFET used based on the application. R2 (10K) will keep the MOSFET off when not in use. R3 will need to be adjusted based on the initial test results. Start with a 10 Ohms 50 Watt. If after testing the voltage spike is still too great reduce the resistor to a 5 Ohms and so on.



Voltage Clamp Setup and Testing

Open Ion Studio and set S5 to the Voltage Clamp option in the drop down and save the setting before exiting the application (see user manual).

The circuit shown will need to be tuned for each application to properly dissipate the regenerative voltages. Testing should consist of a running the motor up to 25% of its speed and then quickly slowing down without braking or e-stop while checking the voltage spike. Repeat, by increasing the speed and power by 5% and checking the voltage spikes again. Repeat this process until 100% power is achieved without a major spike or until the voltage clamp is not dissipating the voltage spikes. If over voltages are not completely clamped, either a lower Ohm resistor is required or additional capacitance is required. Add a capacitor of 5000uF to 10000uF or more across B+ and B-.

Bridge Mode

Bridging Channels

RoboClaws dual channels can be bridge to run as one channel, effectively doubling its current capability for one motor. RoboClaw will be damaged if it is not set to bridged channel mode before wiring.

Download and install Ion Studio application. Connect the motor controller to the computer using an available USB port. Run Ion Studio and in general settings check the option to "Bridge Channels". Then click “Save Settings” in the device menu at the top of the window.

When operating in bridged channel mode the total peak current output is combined from both channels. The peak current run time is dependant on heat build up. Adequate cooling must be maintained.

Bridged Channel Wiring

When bridged channel mode is active the internal driver scheme for the output stage is modified. The output leads must be wired correctly or damage will result. Each RoboClaw varies on the correct wiring. See each models data sheet for wiring schematic.

Bridged Motor Control

When RoboClaw is set to bridged mode all motor control commands for M1 will control the attached motor. All commands for M2 will be ignored. In RC and Analog modes S1 will control the motor and S2 will be ignored.

USB Control

USB Connection

When RoboClaw is connected, it will automatically detect it has been connected to a powered USB master and will enable USB communications. USB can be connected in any mode. When the Roboclaw is not in packet serial mode USB packet serial commands can be used to read status information and set configuration settings, however motor movement commands will not function. When in packet serial mode if another device such as an Arduino is connected to S1 and S2 pins and sending commands to the RoboClaw, both those commands and USB packet serial commands will execute.

USB Power

The USB RoboClaw is self powered. This means it receives no power from the USB cable. The USB RoboClaw must be externally powered to function.

USB Comport and Baudrate

The RoboClaw will be detected as a CDC Virtual Comport. When connected to a Windows PC a driver must be installed. The driver is available for download from our website. On Linux or OSX the RoboClaw will be automatically detected as a virtual comport and an appropriate driver will be automatically loaded.

Unlike a real comport the USB CDC Virtual Comport does not need a baud rate to be set. It will always communicate at the fastest speed the master and slave device can reach. This will typically be around 1mb/s.

RC Control

RC Mode

RC mode is typically used when controlling RoboClaw from a hobby RC radio. This mode can also be used to simplify driving RoboClaw from a microcontroller using servo pulses. In this mode S1 controls the direction and speed of motor 1 and S2 controls the direction and speed of motor 2.

RC Mode With Mixing

This mode is the same as RC mode with the exception of how S1 and S2 controls the attached motors. When used with a differentially steered robot, mixing mode allows S1 to control the speed forward and backward and S2 to control steering left and right.

RC Mode with feedback for velocity or position control

RC Mode can be used with encoders. Velocity and/or Position PID constants must be calibrated for proper operation first. Once calibrated values have been set and saved into Roboclaws eeprom memory, encoder support using velocity or position PID control can be enabled. Use Ion Studio control software or Packet Serial commands, enable encoders for RC/Analog modes (See Configuration Using Ion Studio).

RC Mode Options

Option	Function	Description
1	TTL Flip Switch	Flip switch triggered by low signal.
2	TTL Flip and Exponential Enabled	Softens the center control position. This mode is ideal with tank style robots. Making it easier to control from an RC radio. Flip switch triggered by low signal.
3	TTL Flip and MCU Enabled	Continues to execute last pulse received until new pulse received. Disables Signal loss fail safe and auto calibration. Flip switch triggered by low signal.
4	TTL Flip and Exponential and MCU Enabled	Enables both options. Flip switch triggered by low signal.
5	RC Flip Switch Enabled	Same as mode 1 with flip switch triggered by RC signal.
6	RC Flip and Exponential Enabled	Same as mode 2 with flip switch triggered by RC signal.
7	RC Flip and MCU Enabled	Same as mode 3 with flip switch triggered by RC signal.
8	RC Flip and Exponential and MCU Enabled	Same as mode 4 with flip switch triggered by RC signal.

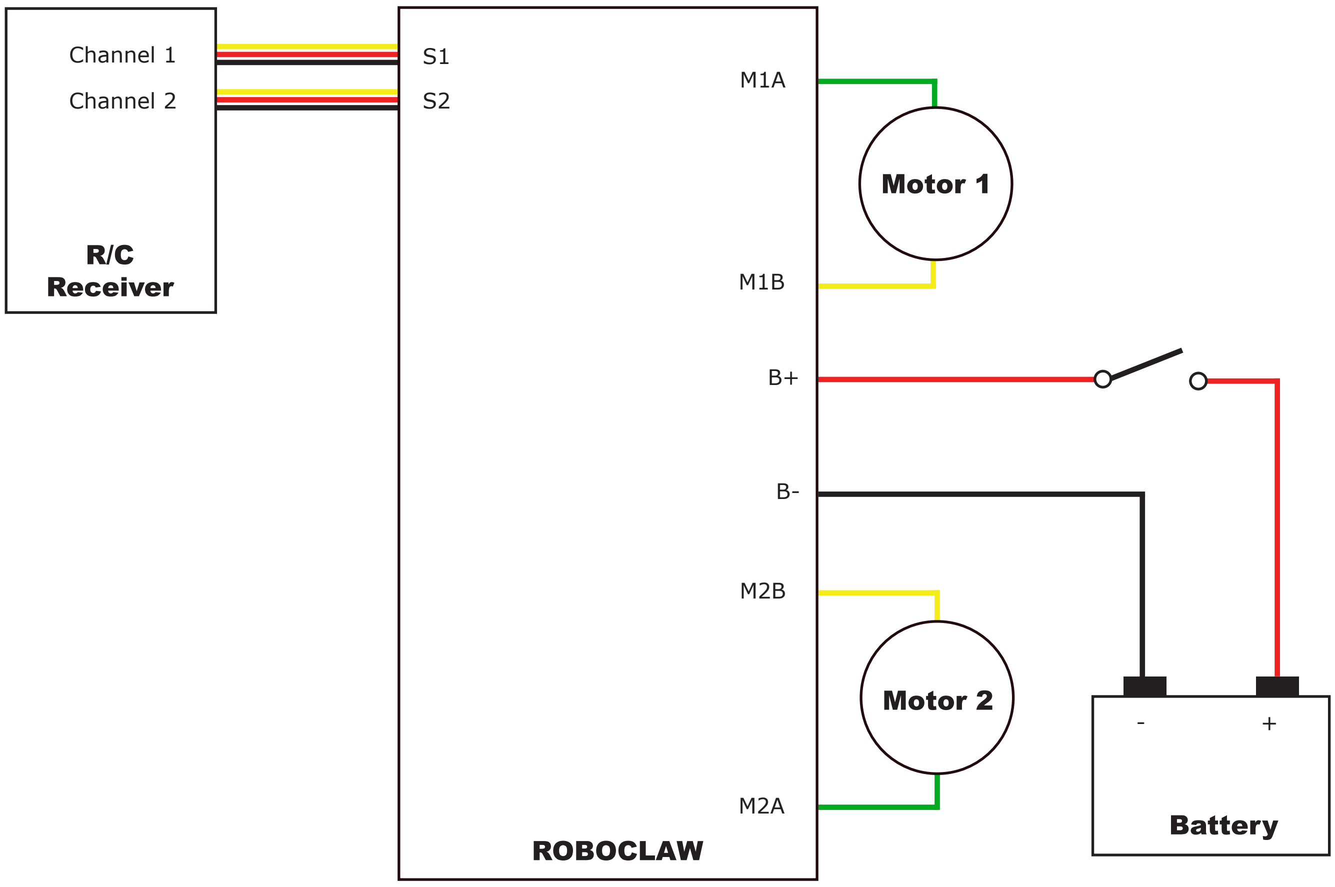
Pulse Ranges

The RoboClaw expects RC pulses on S1 and S2 to drive the motors when the mode is set to RC mode. The center points are calibrated at start up(unless disabled by enabling MCU mode). 1250us is the default for full reverse and 1750us is the default for full forward. The RoboClaw will auto calibrate these ranges on the fly unless auto-calibration is disabled. If a pulse smaller than 1250us or larger than 1750us is detected the new pulse range will be set as the maximum.

Pulse	MCU Mode Enabled	MCU Mode Diabled
Stopped	1520μs	Start Up Auto Calibration
Full Reverse	1120μs	+400μs
Full Forward	1920μs	-400μs

RC Wiring Example

Connect the RoboClaw as shown below. Set mode 1 with option 1. Before powering up, center the control sticks on the radio transmitter, turn the radio on first, then the receiver, then RoboClaw. It will take RoboClaw about 1 second to calibrate the neutral positions of the RC controller. After RC pulses start to be received and calibration is complete the Stat1 LED will begin to flash indicating signals from the RC receiver are being received.



RC Control - Arduino Example

The example will drive a 2 motor 4 wheel robot in reverse, stop, forward, left turn and then right turn. The program was written and tested with a Arduino Uno and P5 connected to S1, P6 connected to S2. Set mode 2 with option 4.

```
//RoboClaw RC Mode
//Control RoboClaw with servo pulses from a microcontroller.
//Mode settings: Mode 2(RC mixed mode) with Option 4(MCU with Exponential).

#include <Servo.h>

#define MIN 1250
#define MAX 1750
#define STOP 1500

Servo myservo1;  // create servo object to control a RoboClaw channel
Servo myservo2;  // create servo object to control a RoboClaw channel

int pos = 0;    // variable to store the servo position

void setup()
{
  myservo1.attach(5);  // attaches the RC signal on pin 5 to the servo object
  myservo2.attach(6);  // attaches the RC signal on pin 6 to the servo object
}

void loop()
{
  myservo1.writeMicroseconds(STOP);  //Stop
  myservo2.writeMicroseconds(STOP);  //Stop
  delay(2000);

  myservo1.writeMicroseconds(MIN);  //full forward
  delay(1000);

  myservo1.writeMicroseconds(STOP);  //stop
  delay(2000);

  myservo1.writeMicroseconds(MAX);  //full reverse
  delay(1000);

  myservo1.writeMicroseconds(STOP);  //Stop
  delay(2000);

  myservo2.writeMicroseconds(MIN);  //full turn left
  delay(1000);

  myservo2.writeMicroseconds(STOP);  //Stop
  delay(2000);

  myservo2.writeMicroseconds(MAX);  //full turn right
  delay(1000);
}
```

Analog Control

Analog Mode

Analog mode is used when controlling RoboClaw from a potentiometer or a filtered PWM signal. In this mode S1 and S2 are set as analog inputs. The voltage range is 0V = Full reverse, 1V = Stop and 2V = Full forward.

Analog Mode With Mixing

This mode is the same as Analog mode with the exception of how S1 and S2 control the attached motors. When used with a differentially steered robot, mixing mode allows S1 to control the speed forward and backward and S2 to control steering left and right.

Analog Mode with feedback for velocity or position control

Analog Mode can be used with encoders. Velocity and/or Position PID constants must be calibrated for proper operation. Once calibrated values have been set and saved into Roboclaws eeprom, encoder support using velocity or position PID control can be enabled. Use Ion Studio control software or PacketSerial commands to enable encoders for RC/Analog modes (see Configuration Using Ion Studio).

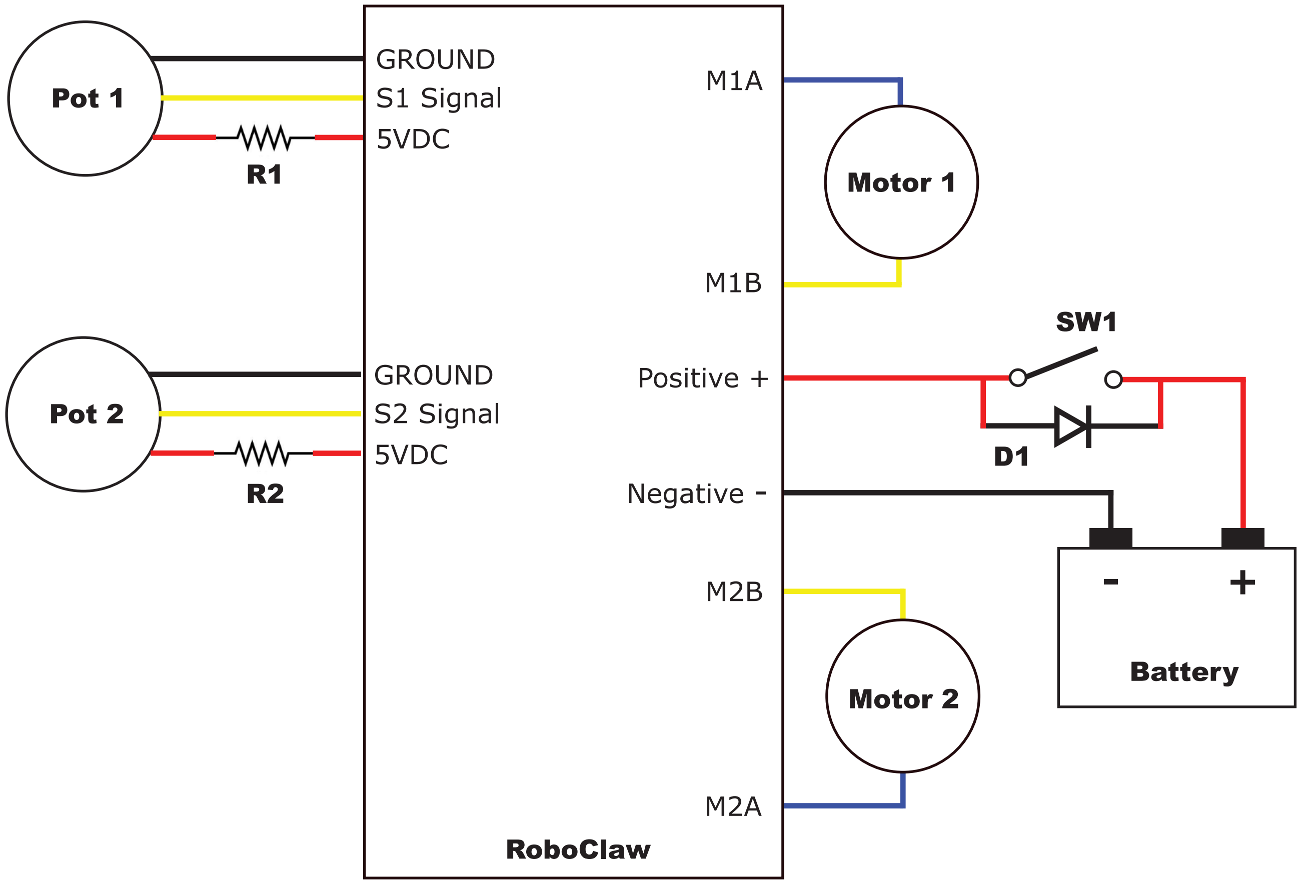
Analog Mode Options

Option	Function	Description
1	TTL Flip Switch	Flip switch triggered by low signal.
2	TTL Flip and Exponential Enabled	Softens the center control position. This mode is ideal with tank style robots. Making it easier to control from an RC radio. Flip switch triggered by low signal.
3	TTL FLip and MCU Enabled	Continues to execute last pulse received until new pulse received. Disables Signal loss fail safe and auto calibration. Flip switch triggered by low signal.
4	TTL FLip and Exponential and MCU Enabled	Enables both options. Flip switch triggered by low signal.
5	RC Flip Switch Enabled	Same as mode 1 with flip switch triggered by RC signal.
6	RC Flip and Exponential Enabled	Same as mode 2 with flip switch triggered by RC signal.
7	RC Flip and MCU Enabled	Same as mode 3 with flip switch triggered by RC signal.
8	RC Flip and Exponential and MCU Enabled	Same as mode 4 with flip switch triggered by RC signal.

Analog Wiring Example

RoboClaw uses a high speed 12 bit analog converter. Its range is 0 to 2V. The analog pins are protected and 5V tolerant. The potentiometer range will be limited if 5V is utilized as the reference voltage. A simple resistor divider circuit can be used to reduce the on board 5V to 2V for use with a potentiometer(POT). See the below schematic. The POT acts as one half of the resistor divider. If using a 5k potentiometer R1 / R2 = 7.5k, If using a 10k potentiometer R1 / R2 = 15k and if using a 20k potentiometer R1 / R2 = 30k.

Set mode 3 with option 1. Center the potentiometers before applying power. The S1 potentiometer will control the motor 1 direction and speed. The S2 potentiometer will control the motor 2 direction and speed.



Stand Serial Control

Standard Serial Mode

In this mode S1 accepts TTL level byte commands. Standard serial mode is one way serial data. RoboClaw can receive only. A standard 8N1 format is used. Which is 8 bits, no parity bits and 1 stop bit. If you are using a microcontroller you can interface directly to RoboClaw. If you are using a PC a level shifting circuit (eg: Max232) is required. The baud rate can be changed using the SET button once a serial mode has been selected.

Standard Serial communications has no error correction. It is recommended to use Packet Serial mode instead for more reliable communications.

Serial Mode Baud Rates

Option	Description
1	2400
2	9600
3	19200
4	38400
5	57600
6	115200
7	230400
8	460800

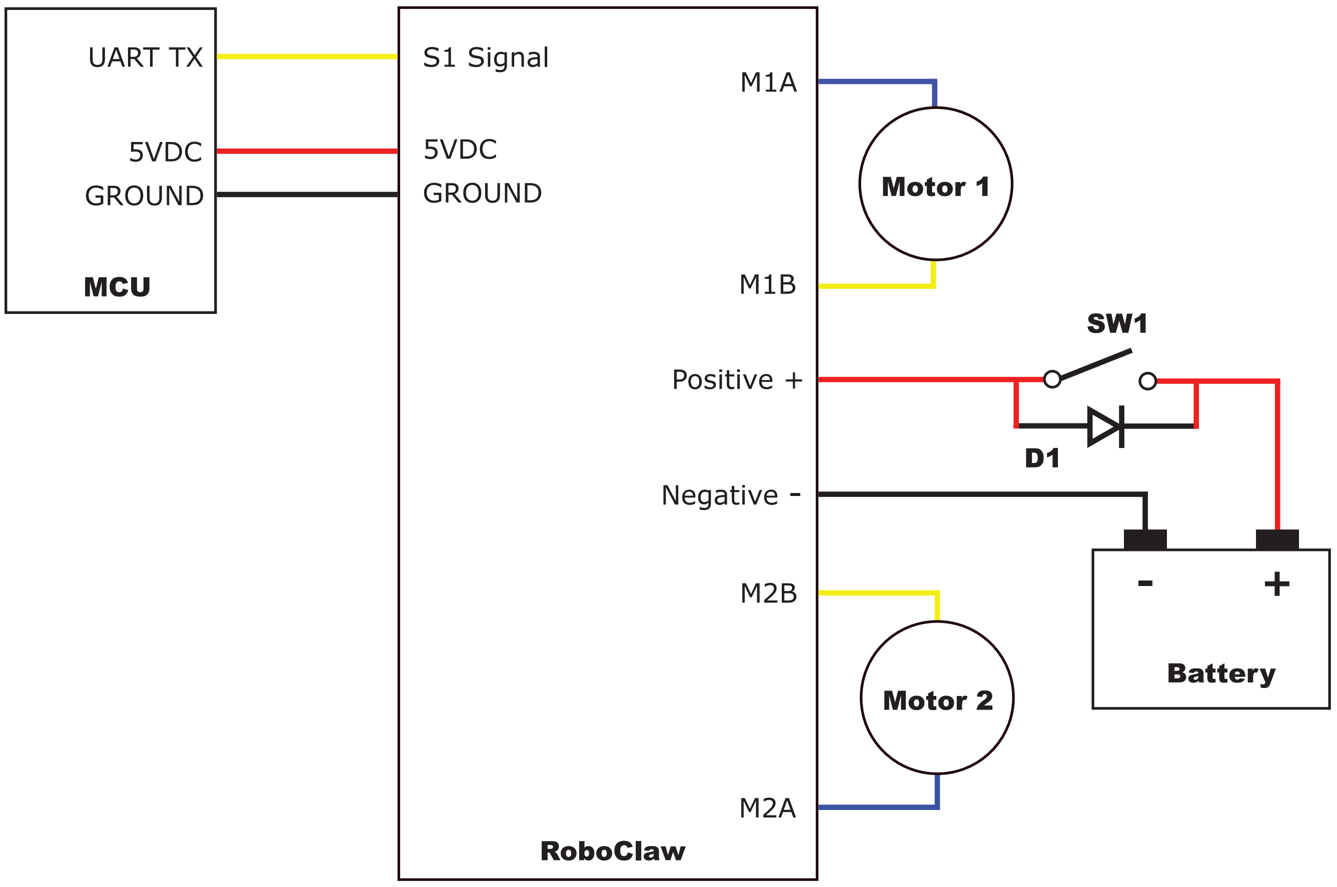
Standard Serial Command Syntax

The RoboClaw standard serial is setup to control both motors with one byte sized command character. Since a byte can be any value from 0 to 255(or -128 to 127) the control of each motor is split. 1 to 127 controls channel 1 and 128 to 255(or -1 to -127) controls channel 2. Command value 0 will stop both channels. Any other values will control speed and direction of the specific channel.

Character	Function
0	Shuts Down Channel 1 and 2
1	Channel 1 - Full Reverse
64	Channel 1 - Stop
127	Channel 1 - Full Forward
128	Channel 2 - Full Reverse
192	Channel 2 - Stop
255	Channel 2 - Full Forward

Standard Serial Wiring Example

In standard serial mode the RoboClaw can only receive serial data. The below wiring diagram illustrates a basic setup of RoboClaw for use with standard serial. The diagram below shows the main battery as the only power source. Make sure the LB jumper is set correctly. The 5VDC shown connected is only required if your MCU needs a power source. This is the BEC feature of RoboClaw. If the MCU has its own power source do not the 5VDC.

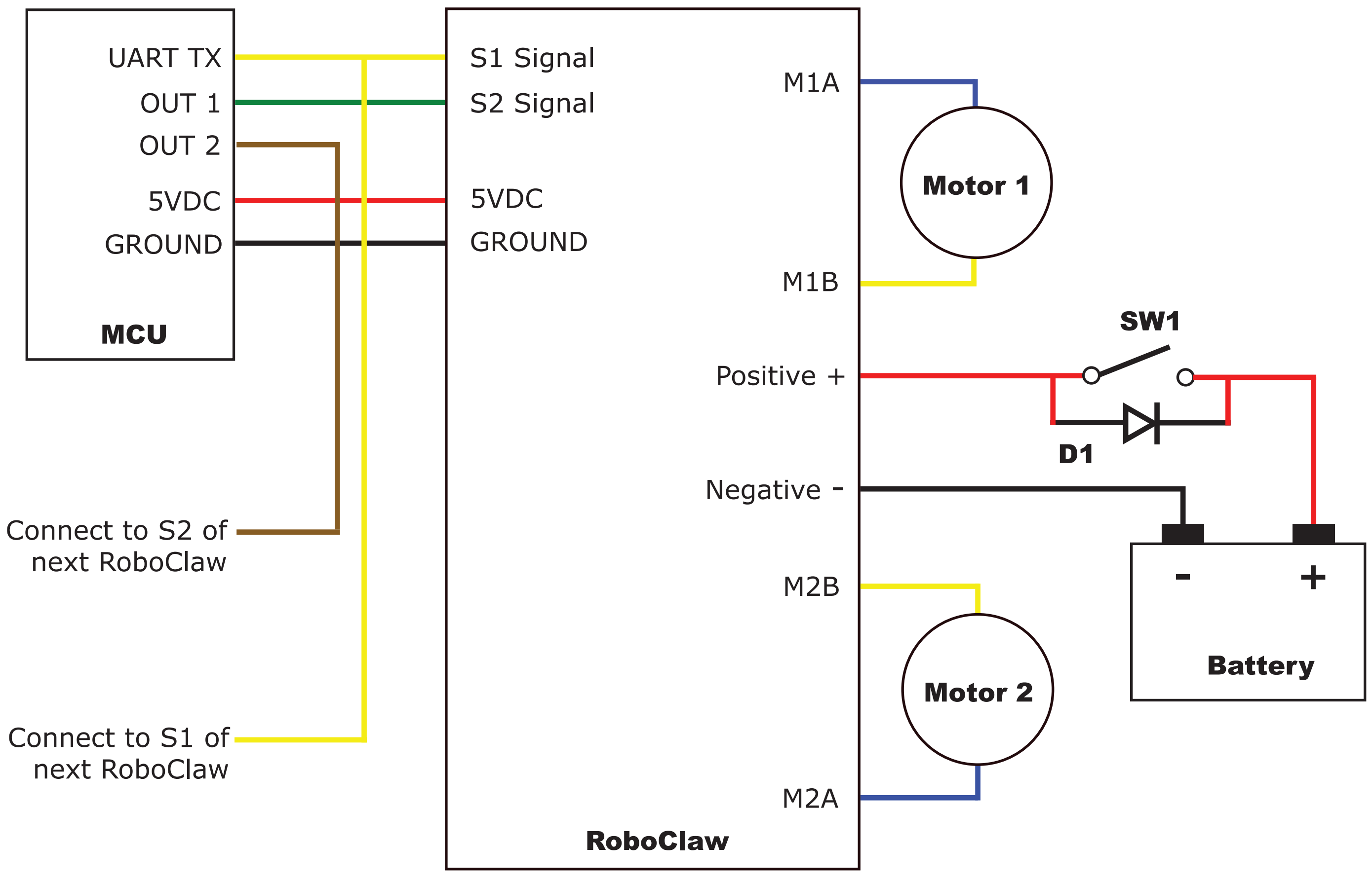


Standard Serial Mode With Slave Select

Slave select is used when more than one RoboClaw is on the same serial bus. When slave select is set to ON the S2 pin becomes the select pin. Set S2 high (5V) and RoboClaw will execute the next set of commands sent to S1 pin. Set S2 low (0V) and RoboClaw will ignore all received commands.

Any RoboClaw connected to a bus must share a common signal ground (GND) shown by the black wire. The S1 pin of RoboClaw is the serial receive pin and should be connected to the transmit pin of the MCU. All RoboClaw's S1 pins will be connected to the same MCU transmit pin. Each RoboClaw S2 pin should be connected to a unique I/O pin on the MCU. S2 is used as the control pin to activate the attached RoboClaw. To enable a RoboClaw hold its S2 pin high otherwise any commands sent are ignored.

The diagram below shows the main battery as the only power source. Make sure the LB jumper is set correctly. The 5VDC shown connected is only required if your MCU needs a power source. This is the BEC feature of RoboClaw. If the MCU has its own power source do not connect the 5VDC.



Standard Serial - Arduino Example

The following example will start both channels in reverse, stop, forward, stop, turn left, stop turn right stop. The program was written and tested with a Arduino Uno and Pin 11 connected to S1 and pin 10 connected to S2.

```
//Roboclaw simple serial example.  Set mode to 5.  Option to 4(38400 bps)
#include "BMSerial.h"

BMSerial mySerial(10,11);

void setup() {
  mySerial.begin(38400);
}

void loop() {
  mySerial.write(1);
  mySerial.write(-127);
  delay(2000);
  mySerial.write(64);
  delay(1000);
  mySerial.write(127);
  mySerial.write(-1);
  delay(2000);
  mySerial.write(-64);
  delay(1000);
  mySerial.write(1);
  mySerial.write(-1);
  delay(2000);
  mySerial.write(0);
  delay(1000);
  mySerial.write(127);
  mySerial.write(-127);
  delay(2000);
  mySerial.write(0);
  delay(1000);
}
```

Packet Serial

Packet Serial Mode

Packet serial is a buffered bidirectional serial mode. More sophisticated instructions can be sent to RoboClaw. The basic command structures consist of an address byte, command byte, data bytes and a CRC16 16bit checksum. The amount of data each command will send or receive can vary.

Address

Packet serial requires a unique address when used with TTL serial pins(S1 and S2). With up to 8 addresses available you can have up to 8 RoboClaws bussed on the same RS232 port when properly wired. There are 8 packet modes 7 to 14. Each mode has a unique address. The address is selected by setting the desired packet mode using the MODE button.

NOTE: When using packet serial commands via the USB connection the address byte can be any value from 0x80 to 0x87 since each USB connection is already unique.

Packet Modes

Mode	Description
7	Packet Serial Mode - Address 0x80 (128)
8	Packet Serial Mode - Address 0x81 (129)
9	Packet Serial Mode - Address 0x82 (130)
10	Packet Serial Mode - Address 0x83 (131)
11	Packet Serial Mode - Address 0x84 (132)
12	Packet Serial Mode - Address 0x85 (133)
13	Packet Serial Mode - Address 0x86 (134)
14	Packet Serial Mode - Address 0x87 (135)

Packet Serial Baud Rate

When in serial mode or packet serial mode the baud rate can be changed to one of four different settings in the table below. These are set using the SET button as covered in Mode Options.

Serial Mode Options

Option	Description
1	2400
2	9600
3	19200
4	38400
5	57600
6	115200
7	230400
8	460800

Packet Timeout

When sending a packet to RoboClaw, if there is a delay longer than 10ms between bytes being received in a packet, RoboClaw will discard the entire packet. This will allow the packet buffer to be cleared by simply adding a minimum 10ms delay before sending a new packet command in the case of a communications error. This can usually be accomodated by having a 10ms timeout when waiting for a reply from the RoboClaw. If the reply times out the packet buffer will have been cleared automatically.

Packet Acknowledgement

RoboClaw will send an acknowledgment byte on write only packet commands that are valid. The value sent back is 0xFF. If the packet was not valid for any reason no acknowledgement will be sent back.

CRC16 Checksum Calculation

Roboclaw uses a CRC(Cyclic Redundancy Check) to validate each packet it receives. This is more complex than a simple checksum but prevents errors that could otherwise cause unexpected actions to execute on the Roboclaw.

The CRC can be calculated using the following code(example in C):

```
//Calculates CRC16 of nBytes of data in byte array message
unsigned int crc16(unsigned char *packet, int nBytes) {
    for (int byte = 0; byte < nBytes; byte++) {
        crc = crc ^ ((unsigned int)packet[byte] << 8);
        for (unsigned char bit = 0; bit < 8; bit++) {
            if (crc & 0x8000) {
                crc = (crc << 1) ^ 0x1021;
            } else {
                crc = crc << 1;
            }
        }
    }
    return crc;
}
```

CRC16 Checksum Calculation for Received data

The CRC16 calculation can also be used to validate received data from the Roboclaw. The CRC16 value should be calculated using the sent Address and Command byte as well as all the data received back from the Roboclaw except the two CRC16 bytes. The value calculated will match the CRC16 sent by the Roboclaw if there are no errors in the data sent or received.

Easy to use Libraries

Source code and Libraries are available on the Ion Motion Control website that already handle the complexities of using packet serial with the Roboclaw. Libraries are available for Arduino(C++), C# on Windows(.NET) or Linux(Mono) and Python(Raspberry Pi, Linux, OSX, etc).

Handling values larger than a byte

Many Packet Serial commands require values larger than a byte can hold. In order to send or receive those values they need to be broken up into 2 or more bytes. There are two ways this can be done, high byte first or low byte first. Roboclaw expects the high byte first. All command arguments and values are either single bytes, words (2 bytes) or longs (4 bytes). All arguments and values are integers (signed or unsigned). No floating point values (numbers with decimal places) are used in Packet Serial commands.

To convert a 32bit value into 4 bytes you just need to shift the bits around:

```
unsigned char byte3 = MyLongValue>>24;  //High byte
unsigned char byte2 = MyLongValue>>16;
unsigned char byte1 = MyLongValue>>8;
unsigned char byte0 = MyLongValue;             //Low byte
```

The same applies to 16bit values:

```
unsigned char byte1 = MyWordValue>>8;   //High byte
unsigned char byte0 = MyWordValue;             //Low byte
```

The oposite can also be done. Convert several bytes into a 16bit or 32bit value:

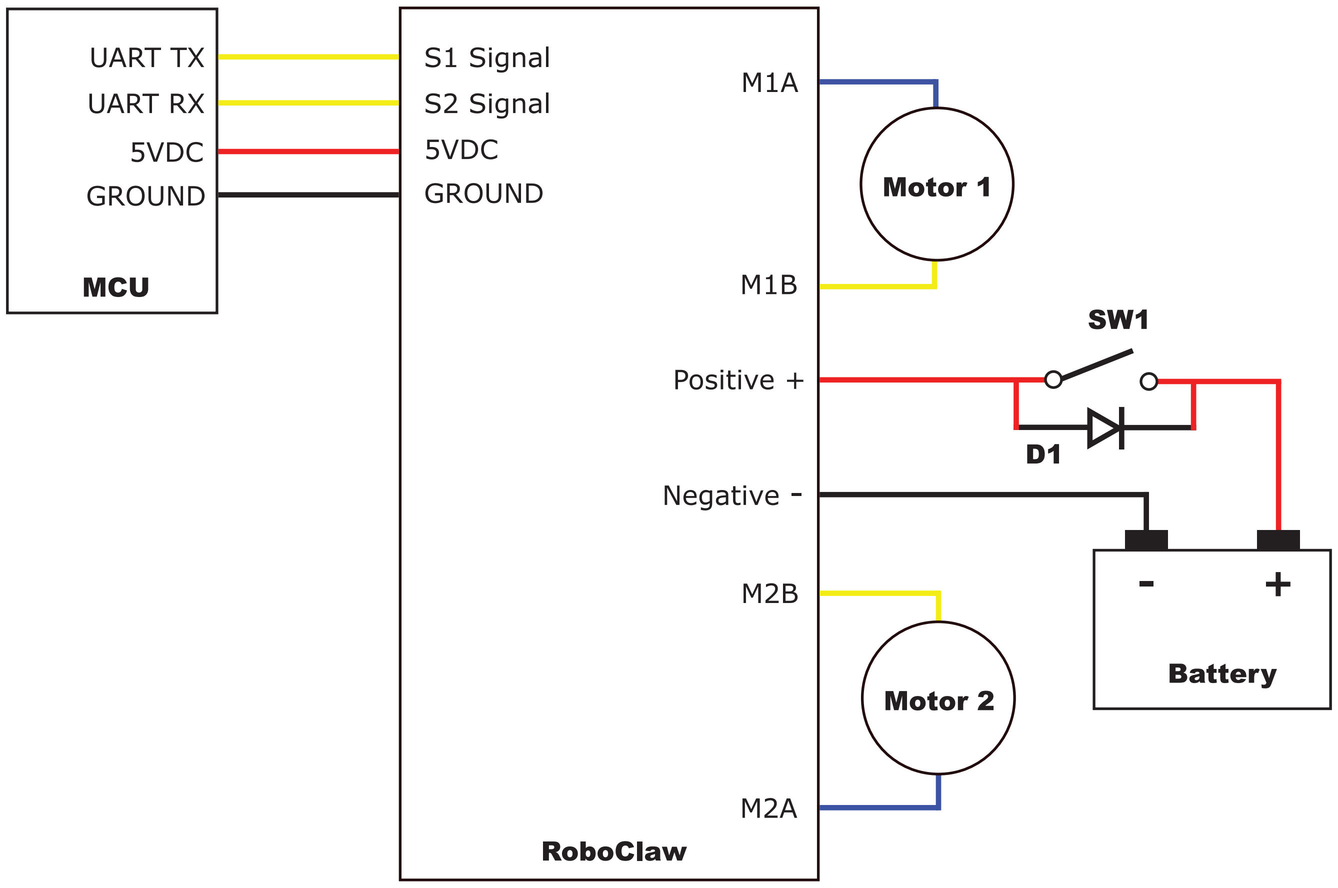
```
unsigned long MyLongValue = byte3<<24 | byte2<<16 | byte1<<8 | byte0;

unsigned int MyWordValue = byte1<<8 | byte0;
```

Packet Serial commands, when a value must be broken into multiple bytes or combined from multple bytes it will be indicated either by (2 bytes) or (4 bytes).

Packet Serial Wiring

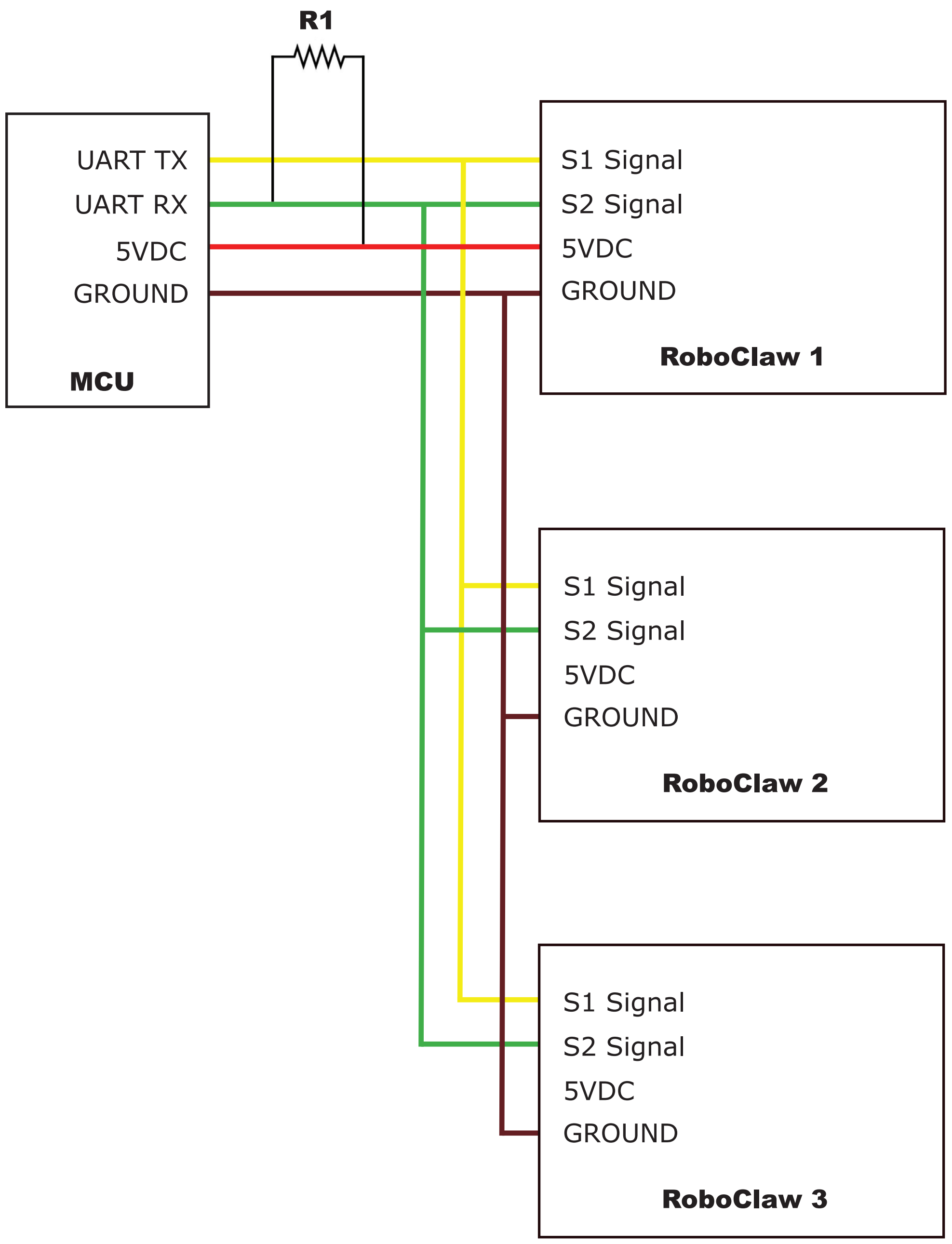
In packet serial mode the RoboClaw can transmit and receive serial data. A microcontroller with a UART is recommended. The UART will buffer the data received from RoboClaw. When a request for data is made to RoboClaw the return data will have at least a 1ms delay after the command is received if the baud rate is set at or below 38400. This will allow slower processors and processors without UARTs to communicate with RoboClaw.

The diagram below shows the main battery as the only power source. Make sure the LB jumper is set correctly. The 5VDC shown connected is only required if your MCU needs a power source. This is the BEC feature of RoboClaw. If the MCU has its own power source do not connect the 5VDC.



Multi-Unit Packet Serial Wiring

In packet serial mode up to eight Roboclaw units can be controlled from a single serial port. The wiring diagram below illustrates how this is done. Each Roboclaw must have multi-unit mode enabled and have a unique packet serial address set. This can be configured using Ion studio. Wire the S1 and S2 pins directly to the MCU TX and RX pins. Install a pull-up resistor (R1) on the MCU RX pin. A 1K to 4.7K resistor value is recommended.



Commands 0 - 7 Compatibility Commands

The following commands are used in packet serial mode. The command syntax is the same for commands 0 thru 7:

```
Send: Address, Command, ByteValue, CRC16
Receive: [0xFF]
```

Command	Description
0	Drive Forward Motor 1
1	Drive Backwards Motor 1
2	Set Main Voltage Minimum
3	Set Main Voltage Maximum
4	Drive Forward Motor 2
5	Drive Backwards Motor 2
6	Drive Motor 1 (7 Bit)
7	Drive Motor 2 (7 Bit)
8	Drive Forward Mixed Mode
9	Drive Backwards Mixed Mode
10	Turn Right Mixed Mode
11	Turn Left Mixed Mode
12	Drive Forward or Backward (7 bit)
13	Turn Left or Right (7 Bit)

0 - Drive Forward M1

Drive motor 1 forward. Valid data range is 0 - 127. A value of 127 = full speed forward, 64 = about half speed forward and 0 = full stop.

```
Send: [Address, 0, Value, CRC(2 bytes)]
Receive: [0xFF]
```

1 - Drive Backwards M1

Drive motor 1 backwards. Valid data range is 0 - 127. A value of 127 full speed backwards, 64 = about half speed backward and 0 = full stop.

```
Send: [Address, 1, Value, CRC(2 bytes)]
Receive: [0xFF]
```

2 - Set Minimum Main Voltage (Command 57 Preferred)

Sets main battery (B- / B+) minimum voltage level. If the battery voltages drops below the set voltage level RoboClaw will stop driving the motors. The voltage is set in .2 volt increments. A value of 0 sets the minimum value allowed which is 6V. The valid data range is 0 - 140 (6V - 34V). The formula for calculating the voltage is: (Desired Volts - 6) x 5 = Value. Examples of valid values are 6V = 0, 8V = 10 and 11V = 25.

```
Send: [Address, 2, Value, CRC(2 bytes)]
Receive: [0xFF]
```

3 - Set Maximum Main Voltage (Command 57 Preferred)

Sets main battery (B- / B+) maximum voltage level. The valid data range is 30 - 175 (6V - 34V). During regenerative breaking a back voltage is applied to charge the battery. When using a power supply, by setting the maximum voltage level, RoboClaw will, before exceeding it, go into hard braking mode until the voltage drops below the maximum value set. This will prevent overvoltage conditions when using power supplies. The formula for calculating the voltage is: Desired Volts x 5.12 = Value. Examples of valid values are 12V = 62, 16V = 82 and 24V = 123.

```
Send: [Address, 3, Value, CRC(2 bytes)]
Receive: [0xFF]
```

4 - Drive Forward M2

Drive motor 2 forward. Valid data range is 0 - 127. A value of 127 full speed forward, 64 = about half speed forward and 0 = full stop.

```
Send: [Address, 4, Value, CRC(2 bytes)]
Receive: [0xFF]
```

5 - Drive Backwards M2

Drive motor 2 backwards. Valid data range is 0 - 127. A value of 127 full speed backwards, 64 = about half speed backward and 0 = full stop.

```
Send: [Address, 5, Value, CRC(2 bytes)]
Receive: [0xFF]
```

6 - Drive M1 (7 Bit)

Drive motor 1 forward or reverse. Valid data range is 0 - 127. A value of 0 = full speed reverse, 64 = stop and 127 = full speed forward.

```
Send: [Address, 6, Value, CRC(2 bytes)]
Receive: [0xFF]
```

7 - Drive M2 (7 Bit)

Drive motor 2 forward or reverse. Valid data range is 0 - 127. A value of 0 = full speed reverse, 64 = stop and 127 = full speed forward.

```
Send: [Address, 7, Value, CRC(2 bytes)]
Receive: [0xFF]
```

Commands 8 - 13 Mixed Mode Compatibility Commands

The following commands are mix mode commands used to control speed and turn for differential steering. Before a command is executed, both valid drive and turn data packets are required Once RoboClaw begins to operate the motors turn and speed can be updated independently.

8 - Drive Forward

Drive forward in mix mode. Valid data range is 0 - 127. A value of 0 = full stop and 127 = full forward.

```
Send: [Address, 8, Value, CRC(2 bytes)]
Receive: [0xFF]
```

9 - Drive Backwards

Drive backwards in mix mode. Valid data range is 0 - 127. A value of 0 = full stop and 127 = full reverse.

```
Send: [Address, 9, Value, CRC(2 bytes)]
Receive: [0xFF]
```

10 - Turn right

Turn right in mix mode. Valid data range is 0 - 127. A value of 0 = stop turn and 127 = full speed turn.

```
Send: [Address, 10, Value, CRC(2 bytes)]
Receive: [0xFF]
```

11 - Turn left

Turn left in mix mode. Valid data range is 0 - 127. A value of 0 = stop turn and 127 = full speed turn.

```
Send: [Address, 11, Value, CRC(2 bytes)]
Receive: [0xFF]
```

12 - Drive Forward or Backward (7 Bit)

Drive forward or backwards. Valid data range is 0 - 127. A value of 0 = full backward, 64 = stop and 127 = full forward.

```
Send: [Address, 12, Value, CRC(2 bytes)]
Receive: [0xFF]
```

13 - Turn Left or Right (7 Bit)

Turn left or right. Valid data range is 0 - 127. A value of 0 = full left, 0 = stop turn and 127 = full right.

```
Send: [Address, 13, Value, CRC(2 bytes)]
Receive: [0xFF]
```

Packet Serial - Arduino Example

The example will start the motor channels independently. Then start turns with mix mode commands. The program was written and tested with an Arduno Uno with P11 connected to S1 and P10 connected to S2. Set mode 7 and option 4. Additional example programs can be downloaded from Ionmc.com.

```
//Set mode to 7(packet serial address 0x80) and option to 4(38400)

//Includes required to use Roboclaw library
#include "BMSerial.h"
#include "RoboClaw.h"

//Roboclaw Address
#define address 0x80

//Setup communcaitions with roboclaw. Use pins 10 and 11 with 10ms timeout
RoboClaw roboclaw(10,11,10000);

void setup() {
  //Communciate with roboclaw at 38400bps
  roboclaw.begin(38400);
  roboclaw.ForwardMixed(address, 0);
  roboclaw.TurnRightMixed(address, 0);
}

void loop() {
  //Using independant motor Forward and Backward commands
  roboclaw.ForwardM1(address,64); //start Motor1 forward at half speed
  roboclaw.BackwardM2(address,64); //start Motor2 backward at half speed
  delay(2000);
  roboclaw.BackwardM1(address,64);
  roboclaw.ForwardM2(address,64);
  delay(2000);
  roboclaw.BackwardM1(address,0);
  roboclaw.ForwardM2(address,0);
  delay(2000);

  //Using independant motor combined forward/backward commands
  roboclaw.ForwardBackwardM1(address,96); //start Motor1 forward at half speed
  roboclaw.ForwardBackwardM2(address,32); //start Motor2 backward at half speed
  delay(2000);
  roboclaw.ForwardBackwardM1(address,32);
  roboclaw.ForwardBackwardM2(address,96);
  delay(2000);
  roboclaw.ForwardM1(address,0); //stop
  roboclaw.BackwardM2(address,0); //stop
  delay(2000);

  //Using Mixed commands
  roboclaw.ForwardMixed(address, 127);  //full speed forward
  roboclaw.TurnRightMixed(address, 0);  //no turn
  delay(2000);
  roboclaw.TurnRightMixed(address, 64);  //half speed turn right
  delay(2000);
  roboclaw.TurnLeftMixed(address, 64);  //half speed turn left
  delay(2000);
  roboclaw.TurnLeftMixed(address, 0);  //stop turn
  roboclaw.BackwardMixed(address, 127);  //half speed backward
  delay(2000);
  roboclaw.TurnRightMixed(address, 64);  //half speed turn right
  delay(2000);
  roboclaw.TurnLeftMixed(address, 64);  //half speed turn left
  delay(2000);

  roboclaw.ForwardMixed(address, 0);    //stop going backward
  roboclaw.TurnRightMixed(address, 64);  //half speed right turn
  delay(2000);
  roboclaw.TurnLeftMixed(address, 64);  //half speed left turn
  delay(2000);
  roboclaw.TurnRightMixed(address, 0);  //stop turn(full stop)
  delay(2000);
}
```

Advance Packet Serial

Commands

The following commands are used to read RoboClaw status information, version information and to set or read configuration values. All commands sent to RoboClaw need to be signed with a CRC16 (Cyclic Redundancy Check of 2 bytes) to validate each packet it received. This is more complex than a simple checksum but prevents errors that could otherwise cause unexpected actions to execute on the Roboclaw. See Packet Serial section of this manual for an explanation on how to create the CRC16 values.

Command	Description
21	Read Firmware Version
24	Read Main Battery Voltage
25	Read Logic Battery Voltage
26	Set Minimum Logic Voltage Level
27	Set Maximum Logic Voltage Level
48	Read Motor PWMs
49	Read Motor Currents
57	Set Main Battery Voltages
58	Set Logic Battery Voltages
59	Read Main Battery Voltage Settings
60	Read Logic Battery Voltage Settings
68	Set default duty cycle acceleration for M1
69	Set default duty cycle acceleration for M2
74	Set S3,S4 and S5 Modes
75	Read S3,S4 and S5 Modes
76	Set DeadBand for RC/Analog controls
77	Read DeadBand for RC/Analog controls
80	Restore Defaults
81	Read Default Duty Cycle Accelerations
82	Read Temperature
83	Read Temperature 2
90	Read Status
91	Read Encoder Modes
92	Set Motor 1 Encoder Mode
93	Set Motor 2 Encoder Mode
94	Write Settings to EEPROM
95	Read Settings from EEPROM
98	Set Standard Config Settings
99	Read Standard Config Settings
100	Set CTRL Modes
101	Read CTRL Modes
102	Set CTRL1
103	Set CTRL2

Command	Description
104	Read CTRLs
133	Set M1 Maximum Current
134	Set M2 Maximum Current
135	Read M1 Maximum Current
136	Read M2 Maximum Current
148	Set PWM Mode
149	Read PWM Mode

21 - Read Firmware Version

Read RoboClaw firmware version. Returns up to 48 bytes(depending on the Roboclaw model) and is terminated by a line feed character and a null character.

```
Send: [Address, 21]
Receive: ["RoboClaw 10.2A v4.1.11",10,0, CRC(2 bytes)]
```

The command will return up to 48 bytes. The return string includes the product name and firmware version. The return string is terminated with a line feed (10) and null (0) character.

24 - Read Main Battery Voltage Level

Read the main battery voltage level connected to B+ and B- terminals. The voltage is returned in 10ths of a volt(eg 300 = 30v).

```
Send: [Address, 24]
Receive: [Value(2 bytes), CRC(2 bytes)]
```

25 - Read Logic Battery Voltage Level

Read a logic battery voltage level connected to LB+ and LB- terminals. The voltage is returned in 10ths of a volt(eg 50 = 5v).

```
Send: [Address, 25]
Receive: [Value.Byte1, Value.Byte0, CRC(2 bytes)]
```

26 - Set Minimum Logic Voltage Level

Note: This command is included for backwards compatibility. We recommend you use command 58 instead.

Sets logic input (LB- / LB+) minimum voltage level. RoboClaw will shut down with an error if the voltage is below this level. The voltage is set in .2 volt increments. A value of 0 sets the minimum value allowed which is 6V. The valid data range is 0 - 140 (6V - 34V). The formula for calculating the voltage is: (Desired Volts - 6) x 5 = Value. Examples of valid values are 6V = 0, 8V = 10 and 11V = 25.

```
Send: [Address, 26, Value, CRC(2 bytes)]
Receive: [0xFF]
```

27 - Set Maximum Logic Voltage Level

Note: This command is included for backwards compatibility. We recommend you use command 58 instead.

Sets logic input (LB- / LB+) maximum voltage level. The valid data range is 30 - 175 (6V - 34V). RoboClaw will shutdown with an error if the voltage is above this level. The formula for calculating the voltage is: Desired Volts x 5.12 = Value. Examples of valid values are 12V = 62, 16V = 82 and 24V = 123.

```
Send: [Address, 27, Value, CRC(2 bytes)]
Receive: [0xFF]
```

48 - Read Motor PWM values

Read the current PWM output values for the motor channels. The values returned are +/-32767. The duty cycle percent is calculated by dividing the Value by 327.67.

```
Send: [Address, 48]
Receive: [M1 PWM(2 bytes), M2 PWM(2 bytes), CRC(2 bytes)]
```

49 - Read Motor Currents

Read the current draw from each motor in 10ma increments. The amps value is calculated by dividing the value by 100.

```
Send: [Address, 49]
Receive: [M1 Current(2 bytes), M2 Currrent(2 bytes), CRC(2 bytes)]
```

57 - Set Main Battery Voltages

Set the Main Battery Voltage cutoffs, Min and Max. Min and Max voltages are in 10th of a volt increments. Multiply the voltage to set by 10.

```
Send: [Address, 57, Min(2 bytes), Max(2bytes, CRC(2 bytes)]
Receive: [0xFF]
```

58 - Set Logic Battery Voltages

Set the Logic Battery Voltages cutoffs, Min and Max. Min and Max voltages are in 10th of a volt increments. Multiply the voltage to set by 10.

```
Send: [Address, 58, Min(2 bytes), Max(2bytes, CRC(2 bytes)]
Receive: [0xFF]
```

59 - Read Main Battery Voltage Settings

Read the Main Battery Voltage Settings. The voltage is calculated by dividing the value by 10

```
Send: [Address, 59]
Receive: [Min(2 bytes), Max(2 bytes), CRC(2 bytes)]
```

60 - Read Logic Battery Voltage Settings

Read the Logic Battery Voltage Settings. The voltage is calculated by dividing the value by 10

```
Send: [Address, 60]
Receive: [Min(2 bytes), Max(2 bytes), CRC(2 bytes)]
```

68 - Set M1 Default Duty Acceleration

Set the default acceleration for M1 when using duty cycle commands(Cmds 32,33 and 34) or when using Standard Serial, RC and Analog PWM modes.

```
        Send: [Address, 68, Accel(4 bytes), CRC(2 bytes)]
Receive: [0xFF]
```

69 - Set M2 Default Duty Acceleration

Set the default acceleration for M2 when using duty cycle commands(Cmds 32,33 and 34) or when using Standard Serial, RC and Analog PWM modes.

```
        Send: [Address, 69, Accel(4 bytes), CRC(2 bytes)]
Receive: [0xFF]
```

74 - Set S3, S4 and S5 Modes

Set modes for S3,S4 and S5.

```
Send: [Address, 74, S3mode, S4mode, S5mode, CRC(2 bytes)]
Receive: [0xFF]
```

Mode	S3mode	S4mode	S5mode
0	Default	Disabled	Disabled
1	E-Stop(latching)	E-Stop(latching)	E-Stop(latching)
2	E-Stop	E-Stop	E-Stop
3	Voltage Clamp	Voltage Clamp	Voltage Clamp
4		M1 Home	M2 Home

Mode Description
Disabled: pin is inactive.
Default: Flip switch if in RC/Analog mode or E-Stop(latching) in Serial modes.
E-Stop(Latching): causes the Roboclaw to shutdown until the unit is power cycled.
E-Stop: Holds the Roboclaw in shutdown until the E-Stop signal is cleared.
Voltage Clamp: Sets the signal pin as an output to drive an external voltage clamp circuit
Home(M1 & M2): will trigger the specific motor to stop and the encoder count to reset to 0.

75 - Get S3, S4 amd S5 Modes
Read mode settings for S3,S4 and S5. See command 74 for mode descriptions

```
Send: [Address, 75]
Receive: [S3mode, S4mode, S5mode, CRC(2 bytes)]
```

76 - Set DeadBand for RC/Analog controls
Set RC/Analog mode control deadband percentage in 10ths of a percent. Default value is 25(2.5%). Minimum value is 0(no DeadBand), Maximum value is 250(25%).

```
Send: [Address, 76, Reverse, Forward, CRC(2 bytes)]
Receive: [0xFF]
```

77 - Read DeadBand for RC/Analog controls
Read DeadBand settings in 10ths of a percent.

```
Send: [Address, 77]
Receive: [Reverse, SForward, CRC(2 bytes)]
```

80 - Restore Defaults
Reset Settings to factory defaults.

```
Send: [Address, 80]
Receive: [0xFF]
```

81 - Read Default Duty Acceleration Settings
Read M1 and M2 Duty Cycle Acceleration Settings.

```
Send: [Address, 81]
Receive: [M1Accel(4 bytes), M2Accel(4 bytes), CRC(2 bytes)]
```

82 - Read Temperature
Read the board temperature. Value returned is in 10ths of degrees.

```
Send: [Address, 82]
Receive: [Temperature(2 bytes), CRC(2 bytes)]
```

83 - Read Temperature 2
Read the second board temperature(only on supported units). Value returned is in 10ths of degrees.

```
Send: [Address, 83]
Receive: [Temperature(2 bytes), CRC(2 bytes)]
```

90 - Read Status

Read the current unit status.

```
Send: [Address, 90]
Receive: [Status, CRC(2 bytes)]
```

Function	Status Bit Mask
Normal	0x0000
M1 OverCurrent Warning	0x0001
M2 OverCurrent Warning	0x0002
E-Stop	0x0004
Temperature Error	0x0008
Temperature2 Error	0x0010
Main Battery High Error	0x0020
Logic Battery High Error	0x0040
Logic Battery Low Error	0x0080
M1 Driver Fault	0x0100
M2 Driver Fault	0x0200
Main Battery High Warning	0x0400
Main Battery Low Warning	0x0800
Termperature Warning	0x1000
Temperature2 Warning	0x2000
M1 Home	0x4000
M2 Home	0x8000

91 - Read Encoder Mode

Read the encoder mode for both motors.

```
Send: [Address, 91]
Receive: [Enc1Mode, Enc2Mode, CRC(2 bytes)]
```

Encoder Mode bits

Bit 7	Enable RC/Analog Encoder support
Bit 6-1	N/A
Bit 0	Quadrature(0)/Absolute(1)

92 - Set Motor 1 Encoder Mode

Set the Encoder Mode for motor 1. See command 91.

```
Send: [Address, 92, Mode, CRC(2 bytes)]
Receive: [0xFF]
```

93 - Set Motor 2 Encoder Mode

Set the Encoder Mode for motor 2. See command 91.

```
Send: [Address, 93, Mode, CRC(2 bytes)]
Receive: [0xFF]
```

94 - Write Settings to EEPROM

Writes all settings to non-volatile memory. Values will be loaded after each power up.

```
Send: [Address, 94]
Receive: [0xFF]
```

95 - Read Settings from EEPROM

Read all settings from non-volatile memory.

```
Send: [Address, 95]
Receive: [Enc1Mode, Enc2Mode, CRC(2 bytes)]
```

98 - Set Standard Config Settings

Set config bits for standard settings.

```
Send: [Address, 98, Config(2 bytes), CRC(2 bytes)]
Receive: [0xFF]
```

Function	Config Bit Mask
RC Mode	0x0000
Analog Mode	0x0001
Simple Serial Mode	0x0002
Packet Serial Mode	0x0003
Battery Mode Off	0x0000
Battery Mode Auto	0x0004
Battery Mode 2 Cell	0x0008
Battery Mode 3 Cell	0x000C
Battery Mode 4 Cell	0x0010
Battery Mode 5 Cell	0x0014
Battery Mode 6 Cell	0x0018
Battery Mode 7 Cell	0x001C
Mixing	0x0020
Exponential	0x0040
MCU	0x0080
BaudRate 2400	0x0000
BaudRate 9600	0x0020
BaudRate 19200	0x0040
BaudRate 38400	0x0060
BaudRate 57600	0x0080
BaudRate 115200	0x00A0
BaudRate 230400	0x00C0
BaudRate 460800	0x00E0
FlipSwitch	0x0100
Packet Address 0x80	0x0000
Packet Address 0x81	0x0100
Packet Address 0x82	0x0200
Packet Address 0x83	0x0300
Packet Address 0x84	0x0400
Packet Address 0x85	0x0500
Packet Address 0x86	0x0600
Packet Address 0x87	0x0700
Slave Mode	0x0800
Relay Mode	0X1000
Swap Encoders	0x2000
Swap Buttons	0x4000
Multi-Unit Mode	0x8000

99 - Read Standard Config Settings

Read config bits for standard settings See Command 98.

```
Send: [Address, 99]
Receive: [Config(2 bytes), CRC(2 bytes)]
```

100 - Set CTRL Modes

Set CTRL modes of CTRL1 and CTRL2 output pins(available on select models).

```
Send: [Address, 20, CRC(2 bytes)]
Receive: [0xFF]
```

On select models of Roboclaw, two Open drain, high current output drivers are available, CTRL1 and CTRL2.

Mode	Function
0	Disable
1	User
2	Voltage Clamp
3	Brake

User Mode - The output level can be controlled by setting a value from 0(0%) to 65535(100%). A variable frequency PWM is generated at the specified percentage.

Voltage Clamp Mode - The CTRL output will activate when an over voltage is detected and released when the overvoltage disipates. Adding an external load dump resistor from the CTRL pin to B+ will allow the Roboclaw to disipate over voltage energy automatically(up to the 3amp limit of the CTRL pin).

Brake Mode - The CTRL pin can be used to activate an external brake(CTRL1 for Motor 1 brake and CTRL2 for Motor 2 brake). The signal will activate when the motor is stopped(eg 0 PWM). Note acceleration/default_acceleration settings should be set appropriately to allow the motor to slow down before the brake is activated.

101 - Read CTRL Modes

Read CTRL modes of CTRL1 and CTRL2 output pins(available on select models).

```
Send: [Address, 101]
Receive: [CTRL1Mode(1 bytes), CTRL2Mode(1 bytes), CRC(2 bytes)]
```

Reads CTRL1 and CTRL2 mode setting. See 100 - Set CTRL Modes for valid values.

102 - Set CTRL1
Set CTRL1 output value(available on select models)

```
Send: [Address, 102, Value(2 bytes), CRC(2 bytes)]
Receive: [0xFF]
```

Set the output state value of CTRL1. See 100 - Set CTRL Modes for valid values.

103 - Set CTRL2
Set CTRL2 output value(available on select models)

```
Send: [Address, 103, Value(2 bytes), CRC(2 bytes)]
Receive: [0xFF]
```

Set the output state value of CTRL2. See 100 - Set CTRL Modes for valid values.

104 - Read CTRL Settings
Read CTRL1 and CTRL2 output values(available on select models)

```
Send: [Address, 104]
Receive: [CTRL1(2 bytes), CTRL2(2 bytes), CRC(2 bytes)]
```

Reads currently set values for CTRL Settings. See 100 - Set CTRL Modes for valid values.

133 - Set M1 Max Current Limit
Set Motor 1 Maximum Current Limit. Current value is in 10ma units. To calculate multiply current limit by 100.

```
Send: [Address, 134, MaxCurrent(4 bytes), 0, 0, 0, 0, CRC(2 bytes)]
Receive: [0xFF]
```

134 - Set M2 Max Current Limit
Set Motor 2 Maximum Current Limit. Current value is in 10ma units. To calculate multiply current limit by 100.

```
Send: [Address, 134, MaxCurrent(4 bytes), 0, 0, 0, 0, CRC(2 bytes)]
Receive: [0xFF]
```

135 - Read M1 Max Current Limit
Read Motor 1 Maximum Current Limit. Current value is in 10ma units. To calculate divide value by 100. MinCurrent is always 0.

```
Send: [Address, 135]
Receive: [MaxCurrent(4 bytes), MinCurrent(4 bytes), CRC(2 bytes)]
```

136 - Read M2 Max Current Limit
Read Motor 2 Maximum Current Limit. Current value is in 10ma units. To calculate divide value by 100. MinCurrent is always 0.

```
Send: [Address, 136]
Receive: [MaxCurrent(4 bytes), MinCurrent(4 bytes), CRC(2 bytes)]
```

148 - Set PWM Mode
Set PWM Drive mode. Locked Antiphase(0) or Sign Magnitude(1).

```
Send: [Address, 148, Mode, CRC(2 bytes)]
Receive: [0xFF]
```

149 - Read PWM Mode
Read PWM Drive mode. See Command 148.

```
Send: [Address, 149]
Receive: [PWMMode, CRC(2 bytes)]
```

Encoders

Cloose Loop Modes

RoboClaw supports a wide range of encoders for close loop modes. Encoders are used in velocity, position or a cascaded velocity with position control mode. This manual mainly deals with Quadrature and Absolute encoders. However additional types of encoders are supported.

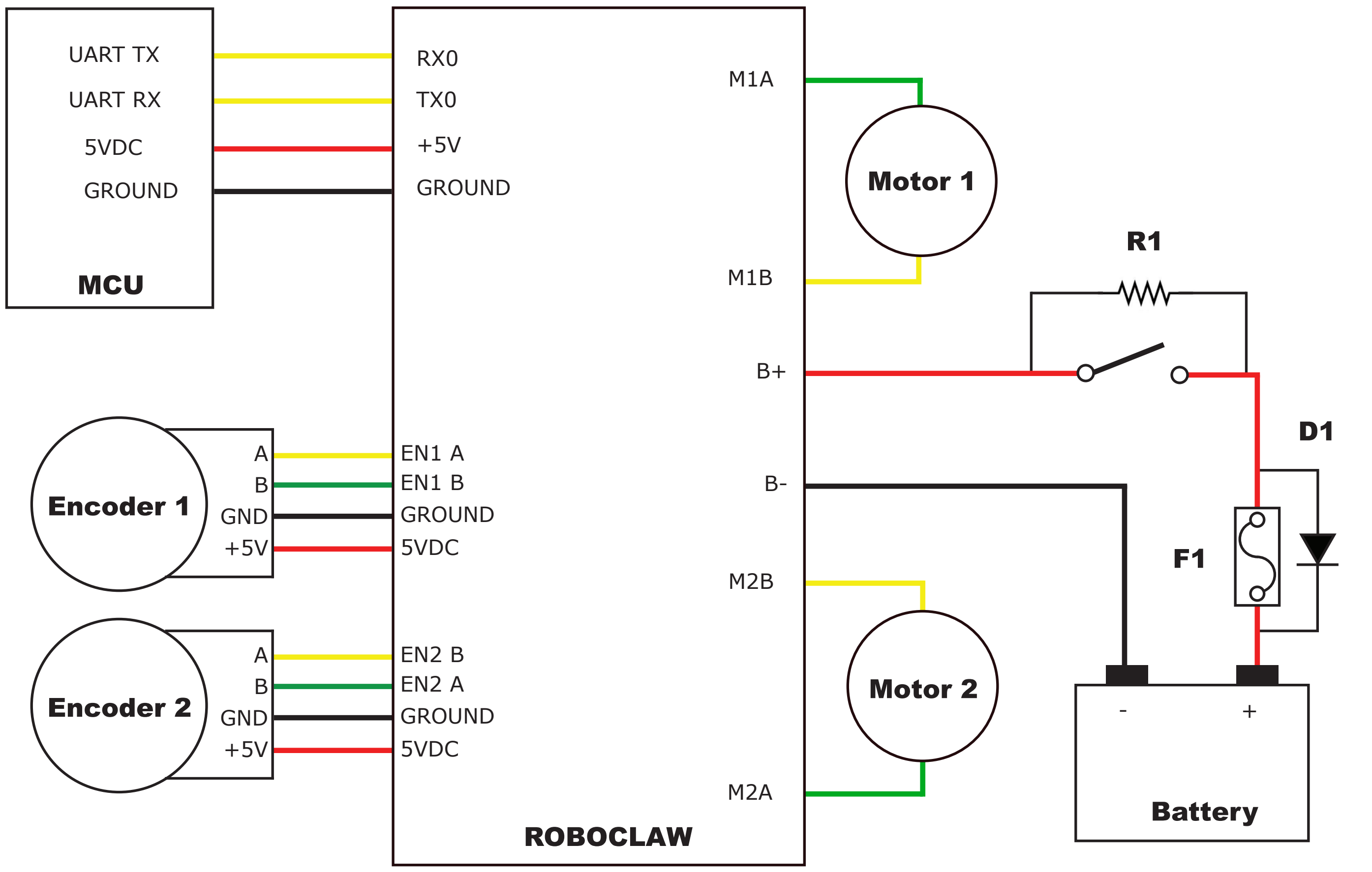
Encoder Tunning

All encoders will require tuning to properly function. Ion Studio incorperates an Auto Tune function which can automatically tune the PID and editable fields for manual tuning of the PID. Encoders can also be tunned using Advance Control Commands which can be sent by a MCU or other control devices.

Quadrature Encoders Wiring

RoboClaw is capable of reading two quadrature encoders, one for each motor channel. The main header provides two +5VDC connections with dual A and B input signals for each encoder.

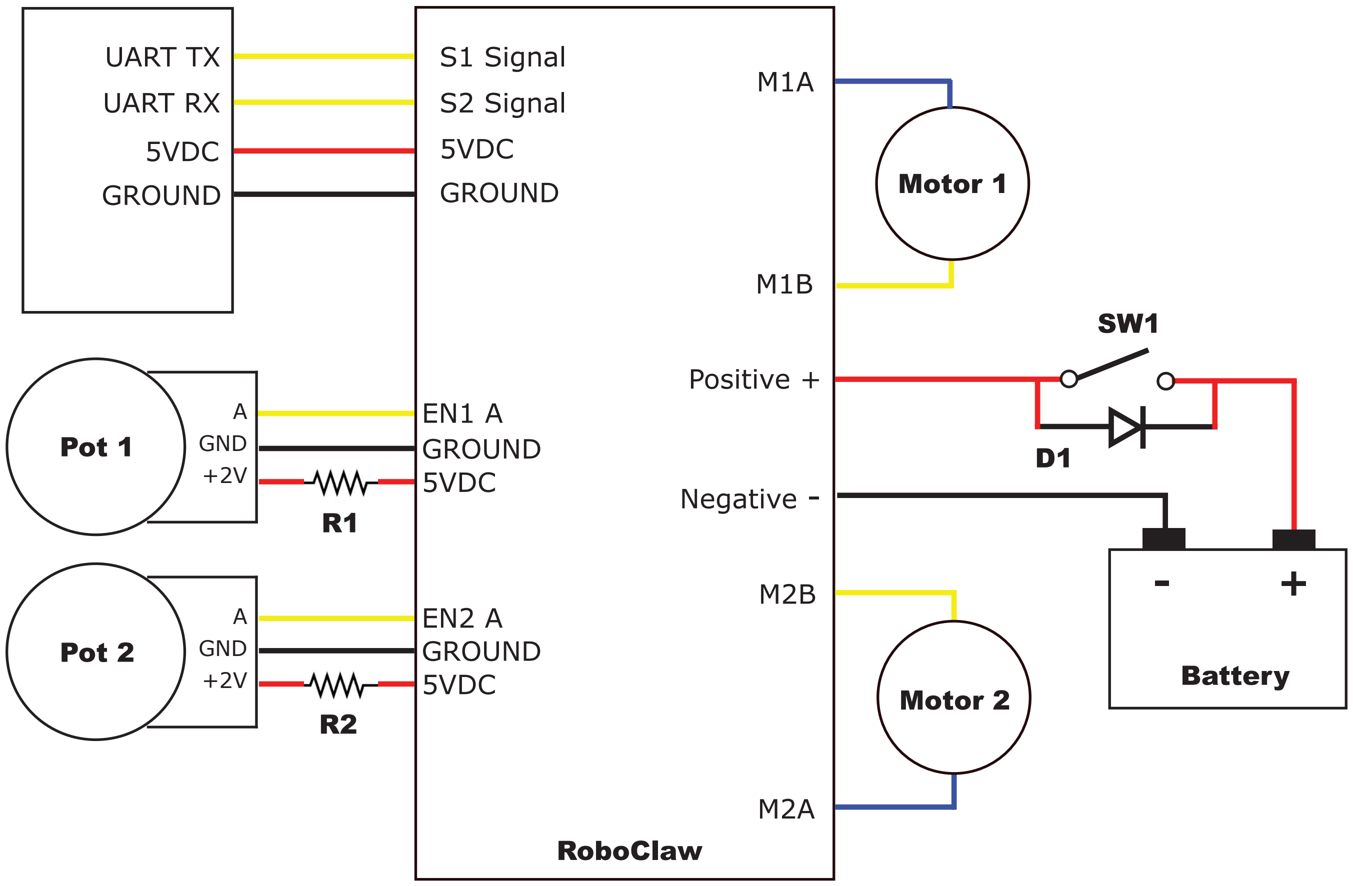
Quadrature encoders are directional. In a simple two motor robot, one motor will spin clock wise (CW) and the other motor will spin counter clock wise (CCW). The A and B inputs for one of the encoders must be reversed to allow both encoders to count up when the robot is moving forward. If both encoder are connected with leading edge pulse to channel A one will count up and the other down. This will cause commands like Mix Drive Forward to not work as expected. All motor and encoder combinations will need to be tuned.



Absolute Encoder Wiring

RoboClaw is capable of reading absolute encoders that output an analog voltage. Like the Analog input modes for controlling the motors, the absolute encoder voltage must be between 0v and 2v. If using standard potentiometers as absolute encoders the 5v from the RoboClaw can be divided down to 2v at the potentiometer by adding a resistor from the 5v line on the RoboClaw to the potentiometer. For a 5k pot R1 / R2 = 7.5k, for a 10k pot R1 / R2 = 15k and for a 20k pot R1 / R2 = 30k.

The diagram below shows the main battery as the only power source. Make sure the LB jumper is installed. The 5VDC shown connected is only required if your MCU needs a power source. This is the BEC feature of RoboClaw. If the MCU has its own power source do not connect the 5VDC.



Encoder Tuning

To control motor speed and or position with an encoder the PID must be calibrated for the specific motor and encoder being used. Using Ion Studio the PID can be tuned manually or by the auto tune fucntion. Once the encoders are tuned the settings can be saved to the onboard eeprom and will be loaded each time the unit powers up.

The Ion Studio window for Velocity Settings will auto tune for velocity. The window for Position Settings can tune a simple PD position controller, a PID position controller or a cascaded Position with Velocity controller(PIV). The cascaded tune will determine both the velocity and position values for the motor but still requires the QPPS be manually set for the motor before starting. Auto tune functions usually return reasonable values but manually adjustments may be required for optimum performance.

Auto Tuning

Ion Studio provides the option to auto tune velocity and position control. To use the auto tune option make sure the encoder and motor are running in the desired direction and the basic PWM control of the motor works as expected. It is recommend to ensure the motor and encoder combination are functioning properly before using the auto tune feature.

1. Go to the PWM Settings screen in Ion Studio.

2. Slide the motor slider up to start moving the motor forward. Check the encoder is increasing in value. If it is not either reverse the motor wires or the encoder wires. The recheck.

Before using auto tune you must first set the motors and encoders maximum speed. For the purpose of auto tune the maximum quadrature pulse per second (QPPS) is the maximum speed the motor and encoder can acheive. When using an absolute encoder the QPPS will be the maximum rotational speed of the absolute encoder. Check the encoders data sheet to ensure the maximum rotational speed is not exceeded. Auto tune for position control can not automatically measure the maximum QPPS due to most position control systems having a limited range of movement.

3. To determine the maximum QPPS value, use the PWM settings screen to run the motor and encoder at 100% duty by moving the slider bar full up or down. Record the value from M1 Speed or M2 Speed fields at the top of the window. This is your maximum QPPS speed. If the motor can not be ran at full speed due to physical constraints, then an estimated maximum speed in encoder counts is required.

4. Enter the QPPS speed obtained from step 3 into the QPPS fields under settings. Ensure the correct QPPS is entered for the corresponding motor channel. Two identical motors and encoders may not function exactly the same so the maximum QPPS may vary.

5. To start auto tune click the auto tune button for the motor channel that is will be tuned first. The auto tune function will try to determine the best settings for that motor channel.

If the motor or encoder are wired incorrectly, the auto tune function can lock up and the motor controller will become unresponsive. Correct the wiring problem and reset the motor controller to continue.

Manual Velocity Calibration Procedure

1. Determine the quadrature pulses per second(QPPS) value for your motor. The simplest method to do this is to run the Motor at 100% duty using Ion Studio and read back the speed value from the encoder attached to the motor. If you are unable to run the motor like this due to physical constraints you will need to estimate the maximum speed in encoder counts the motor can produce.

2. Set the initial P,I and D values in the Velocity control window to 1,0 and 0. Try moving the motor using the slider controls in IonMotion. If the motor does not move it may not be wired correctly or the P value needs to be increased. If the motor immediately runs at max speed when you change the slider position you probably have the motor or encoder wires reversed. The motor is trying to go at the speed specified but the encoder reading is coming back in the opposite direction so the motor increases power until it eventually hits 100% power. Reverse the encoder or motor wires(not both) and test again.

3. Once the motor has some semblance of control you can set a moderate speed. Then start increasing the P value until the speed reading is near the set value. If the motor feels like it is vibrating at higher P values you should reduce the P value to about 2/3rds that value. Move on to the I setting.

4. Start increasing the I setting. You will usually want to increase this value by .1 increments. The I value helps the motor reach the exact speed specified. Too high an I value will also cause the motor to feel rough/vibrate. This is because the motor will over shoot the set speed and then the controller will reduce power to get the speed back down which will also under shoot and this will continue oscillating back and forth form too fast to too slow, causing a vibration in the motor.

5. Once P and I are set reasonably well usually you will leave D = 0. D is only required if you are unable to get reasonable speed control out of the motor using just P and I. D will help dampen P and I over shoot allowing higher P and I values, but D also increases noise in the calculation which can cause oscillations in the speed as well.

Manual Position Calibration Procedure

1. Position mode requires the Velocity mode QPPS value be set as described above. For simple Position control you can set Velocity P, I and D all to 0.

2. Set the Position I and D settings to 0. Set the P setting to 2000 as a reasonable starting point. To test the motor you must also set the Speed argument to some value. We recommend setting it to the same value as the QPPS setting(eg maximum motor speed). Set the minimum and maximum position values to safe numbers. If your motor has no dead stops this can be +-2 billion. If your motor has specific dead stops(like on a linear actuator) you will need to manually move the motor to its dead stops to determine these numbers. Leave some margin infront of each deadstop. Note that when using quadrature encoders you will need to home your motor on every power up since the quadrature readings are all relative to the starting position unless you set/reset the encoder values.

3. At this point the motor should move in the appropriate direction and stop, not necessarily close to the set position when you move the slider. Increase the P setting until the position is over shooting some each time you change the position slider. Now start increasing the D setting(leave I at 0). Increasing D will add dampening to the movement when getting close to the set position. This will help prevent the over shoot. D will usually be anywhere from 5 to 20 times larger than P but not always. Continue increasing P and D until the motor is working reasonably well. Once it is you have tuned a simple PD system.

4. Once your position control is acting relatively smoothly and coming close to the set position you can think about adjusting the I setting. Adding I will help reach the exact set point specified but in most motor systems there is enough slop in the gears that instead you will end up causing an oscillation around the specified position. This is called hunting. The I setting causes this when there is any slop in the motor/encoder/gear train. You can compensate some for this by adding deadzone. Deadzone is the area around the specified position the controller will consider to be equal to the position specified.

5. One more setting must be adjusted in order to use the I setting. The Imax value sets the maximum wind up allowed for the I setting calculation. Increasing Imax will allow I to affect a larger amount of the movement of the motor but will also allow the system to oscillate if used with a badly tuned I and/or set too high.

Encoder Commands

The following commands are used with the encoders both quadrature and absolute. The Encoder Commands are used to read the register values for both encoder channels.

Command	Description
16	Read Encoder Count/Value for M1.
17	Read Encoder Count/Value for M2.
18	Read M1 Speed in Encoder Counts Per Second.
19	Read M2 Speed in Encoder Counts Per Second.
20	Resets Encoder Registers for M1 and M2(Quadrature only).
22	Set Encoder 1 Register(Quadrature only).
23	Set Encoder 2 Register(Quadrature only).
30	Read Current M1 Raw Speed
31	Read Current M2 Raw Speed
78	Read Encoders Counts
79	Read Motor Speeds

16 - Read Encoder Count/Value M1

Read M1 encoder count/position.

```
Send: [Address, 16]
Receive: [Enc1(4 bytes), Status, CRC(2 bytes)]
```

Quadrature encoders have a range of 0 to 4,294,967,295. Absolute encoder values are converted from an analog voltage into a value from 0 to 2047 for the full 2v range.

The status byte tracks counter underflow, direction and overflow. The byte value represents:

Bit0 - Counter Underflow (1= Underflow Occurred, Clear After Reading)
Bit1 - Direction (0 = Forward, 1 = Backwards)
Bit2 - Counter Overflow (1= Underflow Occurred, Clear After Reading)
Bit3 - Reserved
Bit4 - Reserved
Bit5 - Reserved
Bit6 - Reserved
Bit7 - Reserved

17 - Read Quadrature Encoder Count/Value M2

Read M2 encoder count/position.

```
Send: [Address, 17]
Receive: [EncCnt(4 bytes), Status, CRC(2 bytes)]
```

Quadrature encoders have a range of 0 to 4,294,967,295. Absolute encoder values are converted from an analog voltage into a value from 0 to 2047 for the full 2v range.

The Status byte tracks counter underflow, direction and overflow. The byte value represents:

Bit0 - Counter Underflow (1= Underflow Occurred, Cleared After Reading)
Bit1 - Direction (0 = Forward, 1 = Backwards)
Bit2 - Counter Overflow (1= Underflow Occurred, Cleared After Reading)
Bit3 - Reserved
Bit4 - Reserved
Bit5 - Reserved
Bit6 - Reserved
Bit7 - Reserved

18 - Read Encoder Speed M1

Read M1 counter speed. Returned value is in pulses per second. RoboClaw keeps track of how many pulses received per second for both encoder channels.

```
Send: [Address, 18]
Receive: [Speed(4 bytes), Status, CRC(2 bytes)]
```

Status indicates the direction (0 – forward, 1 - backward).

19 - Read Encoder Speed M2

Read M2 counter speed. Returned value is in pulses per second. RoboClaw keeps track of how many pulses received per second for both encoder channels.

```
Send: [Address, 19]
Receive: [Speed(4 bytes), Status, CRC(2 bytes)]
```

Status indicates the direction (0 – forward, 1 - backward).

20 - Reset Quadrature Encoder Counters

Will reset both quadrature decoder counters to zero. This command applies to quadrature encoders only.

```
Send: [Address, 20, CRC(2 bytes)]
Receive: [0xFF]
```

22 - Set Quadrature Encoder 1 Value

Set the value of the Encoder 1 register. Useful when homing motor 1. This command applies to quadrature encoders only.

```
Send: [Address, 22, Value(4 bytes), CRC(2 bytes)]
Receive: [0xFF]
```

23 - Set Quadrature Encoder 2 Value

Set the value of the Encoder 2 register. Useful when homing motor 2. This command applies to quadrature encoders only.

```
Send: [Address, 23, Value(4 bytes), CRC(2 bytes)]
Receive: [0xFF]
```

30 - Read Raw Speed M1

Read the pulses counted in that last 300th of a second. This is an unfiltered version of command 18. Command 30 can be used to make a independent PID routine. Value returned is in encoder counts per second.

```
Send: [Address, 30]
Receive: [Speed(4 bytes), Status, CRC(2 bytes)]
```

The Status byte is direction (0 – forward, 1 - backward).

31 - Read Raw Speed M2

Read the pulses counted in that last 300th of a second. This is an unfiltered version of command 19. Command 31 can be used to make a independent PID routine. Value returned is in encoder counts per second.

```
Send: [Address, 31]
Receive: [Speed(4 bytes), Status, CRC(2 bytes)]
```

The Status byte is direction (0 – forward, 1 - backward).

78 - Read Encoder Counters

Read M1 and M2 encoder counters. Quadrature encoders have a range of 0 to 4,294,967,295. Absolute encoder values are converted from an analog voltage into a value from 0 to 2047 for the full 2V analog range.

```
Send: [Address, 78]
Receive: [Enc1(4 bytes), Enc2(4 bytes), CRC(2 bytes)]
```

79 - Read ISpeeds Counters

Read M1 and M2 instantaneous speeds. Returns the speed in encoder counts per second for the last 300th of a second for both encoder channels.

```
Send: [Address, 79]
Receive: [ISpeed1(4 bytes), ISpeed2(4 bytes), CRC(2 bytes)]
```

Advance Motor Control

Advanced Motor Control Commands

The following commands are used to control motor speeds, acceleration distance and position using encoders. The PID can also be manually adjusted using Advance Motor Control Commands.

Command	Description
28	Set Velocity PID Constants for M1.
29	Set Velocity PID Constants for M2.
32	Drive M1 With Signed Duty Cycle. (Encoders not required)
33	Drive M2 With Signed Duty Cycle. (Encoders not required)
34	Drive M1 / M2 With Signed Duty Cycle. (Encoders not required)
35	Drive M1 With Signed Speed.
36	Drive M2 With Signed Speed.
37	Drive M1 / M2 With Signed Speed.
38	Drive M1 With Signed Speed And Acceleration.
39	Drive M2 With Signed Speed And Acceleration.
40	Drive M1 / M2 With Signed Speed And Acceleration.
41	Drive M1 With Signed Speed And Distance. Buffered.
42	Drive M2 With Signed Speed And Distance. Buffered.
43	Drive M1 / M2 With Signed Speed And Distance. Buffered.
44	Drive M1 With Signed Speed, Acceleration and Distance. Buffered.
45	Drive M2 With Signed Speed, Acceleration and Distance. Buffered.
46	Drive M1 / M2 With Signed Speed, Acceleration And Distance. Buffered.
47	Read Buffer Length.
50	Drive M1 / M2 With Individual Signed Speed and Acceleration
51	Drive M1 / M2 With Individual Signed Speed, Accel and Distance
52	Drive M1 With Signed Duty and Accel. (Encoders not required)
53	Drive M2 With Signed Duty and Accel. (Encoders not required)
54	Drive M1 / M2 With Signed Duty and Accel. (Encoders not required)
55	Read Motor 1 Velocity PID Constants
56	Read Motor 2 Velocity PID Constants
61	Set Position PID Constants for M1.
62	Set Position PID Constants for M2
63	Read Motor 1 Position PID Constants
64	Read Motor 2 Position PID Constants
65	Drive M1 with Speed, Accel, Deccel and Position
66	Drive M2 with Speed, Accel, Deccel and Position
67	Drive M1 / M2 with Speed, Accel, Deccel and Position
68	Set default duty cycle acceleration for M1
69	Set default duty cycle acceleration for M2

28 - Set Velocity PID Constants M1

Several motor and quadrature combinations can be used with RoboClaw. In some cases the default PID values will need to be tuned for the systems being driven. This gives greater flexibility in what motor and encoder combinations can be used. The RoboClaw PID system consist of four constants starting with QPPS, P = Proportional, I= Integral and D= Derivative. The defaults values are:

```
QPPS = 44000
P = 0x00010000
I = 0x00008000
D = 0x00004000
```

QPPS is the speed of the encoder when the motor is at 100% power. P, I, D are the default values used after a reset. Command syntax:

```
Send: [Address, 28, D(4 bytes), P(4 bytes), I(4 bytes), QPPS(4 byte), CRC(2 bytes)]
Receive: [0xFF]
```

29 - Set Velocity PID Constants M2

Several motor and quadrature combinations can be used with RoboClaw. In some cases the default PID values will need to be tuned for the systems being driven. This gives greater flexibility in what motor and encoder combinations can be used. The RoboClaw PID system consist of four constants starting with QPPS, P = Proportional, I= Integral and D= Derivative. The defaults values are:

```
QPPS = 44000
P = 0x00010000
I = 0x00008000
D = 0x00004000
```

QPPS is the speed of the encoder when the motor is at 100% power. P, I, D are the default values used after a reset. Command syntax:

```
Send: [Address, 29, D(4 bytes), P(4 bytes), I(4 bytes), QPPS(4 byte), CRC(2 bytes)]Re-
ceive: [0xFF]
```

32 - Drive M1 With Signed Duty Cycle

Drive M1 using a duty cycle value. The duty cycle is used to control the speed of the motor without a quadrature encoder.

```
Send: [Address, 32, Duty(2 Bytes), CRC(2 bytes)]
Receive: [0xFF]
```

The duty value is signed and the range is -32767 to +32767 (eg. +-100% duty).

33 - Drive M2 With Signed Duty Cycle

Drive M2 using a duty cycle value. The duty cycle is used to control the speed of the motor without a quadrature encoder. The command syntax:

```
Send: [Address, 33, Duty(2 Bytes), CRC(2 bytes)]
Receive: [0xFF]
```

The duty value is signed and the range is -32768 to +32767 (eg. +-100% duty).

34 - Drive M1 / M2 With Signed Duty Cycle

Drive both M1 and M2 using a duty cycle value. The duty cycle is used to control the speed of the motor without a quadrature encoder. The command syntax:

```
Send: [Address, 34, DutyM1(2 Bytes), DutyM2(2 Bytes), CRC(2 bytes)]
Receive: [0xFF]
```

The duty value is signed and the range is -32768 to +32767 (eg. +-100% duty).

35 - Drive M1 With Signed Speed

Drive M1 using a speed value. The sign indicates which direction the motor will turn. This command is used to drive the motor by quad pulses per second. Different quadrature encoders will have different rates at which they generate the incoming pulses. The values used will differ from one encoder to another. Once a value is sent the motor will begin to accelerate as fast as possible until the defined rate is reached.

```
Send: [Address, 35, Speed(4 Bytes), CRC(2 bytes)]
Receive: [0xFF]
```

36 - Drive M2 With Signed Speed

Drive M2 with a speed value. The sign indicates which direction the motor will turn. This command is used to drive the motor by quad pulses per second. Different quadrature encoders will have different rates at which they generate the incoming pulses. The values used will differ from one encoder to another. Once a value is sent, the motor will begin to accelerate as fast as possible until the rate defined is reached.

```
Send: [Address, 36, Speed(4 Bytes), CRC(2 bytes)]
Receive: [0xFF]
```

37 - Drive M1 / M2 With Signed Speed

Drive M1 and M2 in the same command using a signed speed value. The sign indicates which direction the motor will turn. This command is used to drive both motors by quad pulses per second. Different quadrature encoders will have different rates at which they generate the incoming pulses. The values used will differ from one encoder to another. Once a value is sent the motor will begin to accelerate as fast as possible until the rate defined is reached.

```
Send: [Address, 37, SpeedM1(4 Bytes), SpeedM2(4 Bytes), CRC(2 bytes)]
Receive: [0xFF]
```

38 - Drive M1 With Signed Speed And Acceleration

Drive M1 with a signed speed and acceleration value. The sign indicates which direction the motor will run. The acceleration values are not signed. This command is used to drive the motor by quad pulses per second and using an acceleration value for ramping. Different quadrature encoders will have different rates at which they generate the incoming pulses. The values used will differ from one encoder to another. Once a value is sent the motor will begin to accelerate incrementally until the rate defined is reached.

```
Send: [Address, 38, Accel(4 Bytes), Speed(4 Bytes), CRC(2 bytes)]
Receive: [0xFF]
```

The acceleration is measured in speed increase per second. An acceleration value of 12,000 QPPS with a speed of 12,000 QPPS would accelerate a motor from 0 to 12,000 QPPS in 1 second. Another example would be an acceleration value of 24,000 QPPS and a speed value of 12,000 QPPS would accelerate the motor to 12,000 QPPS in 0.5 seconds.

39 - Drive M2 With Signed Speed And Acceleration

Drive M2 with a signed speed and acceleration value. The sign indicates which direction the motor will run. The acceleration value is not signed. This command is used to drive the motor by quad pulses per second and using an acceleration value for ramping. Different quadrature encoders will have different rates at which they generate the incoming pulses. The values used will differ from one encoder to another. Once a value is sent the motor will begin to accelerate incrementally until the rate defined is reached.

```
Send: [Address, 39, Accel(4 Bytes), Speed(4 Bytes), CRC(2 bytes)]
Receive: [0xFF]
```

The acceleration is measured in speed increase per second. An acceleration value of 12,000 QPPS with a speed of 12,000 QPPS would accelerate a motor from 0 to 12,000 QPPS in 1 second. Another example would be an acceleration value of 24,000 QPPS and a speed value of 12,000 QPPS would accelerate the motor to 12,000 QPPS in 0.5 seconds.

40 - Drive M1 / M2 With Signed Speed And Acceleration

Drive M1 and M2 in the same command using one value for acceleration and two signed speed values for each motor. The sign indicates which direction the motor will run. The acceleration value is not signed. The motors are sync during acceleration. This command is used to drive the motor by quad pulses per second and using an acceleration value for ramping. Different quadrature encoders will have different rates at which they generate the incoming pulses. The values used will differ from one encoder to another. Once a value is sent the motor will begin to accelerate incrementally until the rate defined is reached.

```
Send: [Address, 40, Accel(4 Bytes), SpeedM1(4 Bytes), SpeedM2(4 Bytes), CRC(2 bytes)]
Receive: [0xFF]
```

The acceleration is measured in speed increase per second. An acceleration value of 12,000 QPPS with a speed of 12,000 QPPS would accelerate a motor from 0 to 12,000 QPPS in 1 second. Another example would be an acceleration value of 24,000 QPPS and a speed value of 12,000 QPPS would accelerate the motor to 12,000 QPPS in 0.5 seconds.

41 - Buffered M1 Drive With Signed Speed And Distance

Drive M1 with a signed speed and distance value. The sign indicates which direction the motor will run. The distance value is not signed. This command is buffered. This command is used to control the top speed and total distance traveled by the motor. Each motor channel M1 and M2 have separate buffers. This command will execute immediately if no other command for that channel is executing, otherwise the command will be buffered in the order it was sent. Any buffered or executing command can be stopped when a new command is issued by setting the Buffer argument. All values used are in quad pulses per second.

```
Send: [Address, 41, Speed(4 Bytes), Distance(4 Bytes), Buffer, CRC(2 bytes)]
Receive: [0xFF]
```

The Buffer argument can be set to a 1 or 0. If a value of 0 is used the command will be buffered and executed in the order sent. If a value of 1 is used the current running command is stopped, any other commands in the buffer are deleted and the new command is executed.

42 - Buffered M2 Drive With Signed Speed And Distance

Drive M2 with a speed and distance value. The sign indicates which direction the motor will run. The distance value is not signed. This command is buffered. Each motor channel M1 and M2 have separate buffers. This command will execute immediately if no other command for that channel is executing, otherwise the command will be buffered in the order it was sent. Any buffered or executing command can be stopped when a new command is issued by setting the Buffer argument. All values used are in quad pulses per second.

```
Send: [Address, 42, Speed(4 Bytes), Distance(4 Bytes), Buffer, CRC(2 bytes)]
Receive: [0xFF]
```

The Buffer argument can be set to a 1 or 0. If a value of 0 is used the command will be buffered and executed in the order sent. If a value of 1 is used the current running command is stopped, any other commands in the buffer are deleted and the new command is executed.

43 - Buffered Drive M1 / M2 With Signed Speed And Distance

Drive M1 and M2 with a speed and distance value. The sign indicates which direction the motor will run. The distance value is not signed. This command is buffered. Each motor channel M1 and M2 have separate buffers. This command will execute immediately if no other command for that channel is executing, otherwise the command will be buffered in the order it was sent. Any buffered or executing command can be stopped when a new command is issued by setting the Buffer argument. All values used are in quad pulses per second.

```
Send: [Address, 43, SpeedM1(4 Bytes), DistanceM1(4 Bytes),
              SpeedM2(4 Bytes), DistanceM2(4 Bytes), Buffer, CRC(2 bytes)]
Receive: [0xFF]
```

The Buffer argument can be set to a 1 or 0. If a value of 0 is used the command will be buffered and executed in the order sent. If a value of 1 is used the current running command is stopped, any other commands in the buffer are deleted and the new command is executed.

44 - Buffered M1 Drive With Signed Speed, Accel And Distance

Drive M1 with a speed, acceleration and distance value. The sign indicates which direction the motor will run. The acceleration and distance values are not signed. This command is used to control the motors top speed, total distanced traveled and at what incremental acceleration value to use until the top speed is reached. Each motor channel M1 and M2 have separate buffers. This command will execute immediately if no other command for that channel is executing, otherwise the command will be buffered in the order it was sent. Any buffered or executing command can be stopped when a new command is issued by setting the Buffer argument. All values used are in quad pulses per second.

```
Send: [Address, 44, Accel(4 bytes), Speed(4 Bytes), Distance(4 Bytes),
              Buffer, CRC(2 bytes)]
Receive: [0xFF]
```

The Buffer argument can be set to a 1 or 0. If a value of 0 is used the command will be buffered and executed in the order sent. If a value of 1 is used the current running command is stopped, any other commands in the buffer are deleted and the new command is executed.

45 - Buffered M2 Drive With Signed Speed, Accel And Distance

Drive M2 with a speed, acceleration and distance value. The sign indicates which direction the motor will run. The acceleration and distance values are not signed. This command is used to control the motors top speed, total distanced traveled and at what incremental acceleration value to use until the top speed is reached. Each motor channel M1 and M2 have separate buffers. This command will execute immediately if no other command for that channel is executing, otherwise the command will be buffered in the order it was sent. Any buffered or executing command can be stopped when a new command is issued by setting the Buffer argument. All values used are in quad pulses per second.

```
Send: [Address, 45, Accel(4 bytes), Speed(4 Bytes), Distance(4 Bytes),
          Buffer, CRC(2 bytes)]
Receive: [0xFF]
```

The Buffer argument can be set to a 1 or 0. If a value of 0 is used the command will be buffered and executed in the order sent. If a value of 1 is used the current running command is stopped, any other commands in the buffer are deleted and the new command is executed.

46 - Buffered Drive M1 / M2 With Signed Speed, Accel And Distance

Drive M1 and M2 with a speed, acceleration and distance value. The sign indicates which direction the motor will run. The acceleration and distance values are not signed. This command is used to control both motors top speed, total distanced traveled and at what incremental acceleration value to use until the top speed is reached. Each motor channel M1 and M2 have separate buffers. This command will execute immediately if no other command for that channel is executing, otherwise the command will be buffered in the order it was sent. Any buffered or executing command can be stopped when a new command is issued by setting the Buffer argument. All values used are in quad pulses per second.

```
Send: [Address, 46, Accel(4 Bytes), SpeedM1(4 Bytes), DistanceM1(4 Bytes),
      SpeedM2(4 bytes), DistanceM2(4 Bytes), Buffer, CRC(2 bytes)]
Receive: [0xFF]
```

The Buffer argument can be set to a 1 or 0. If a value of 0 is used the command will be buffered and executed in the order sent. If a value of 1 is used the current running command is stopped, any other commands in the buffer are deleted and the new command is executed.

47 - Read Buffer Length

Read both motor M1 and M2 buffer lengths. This command can be used to determine how many commands are waiting to execute.

```
Send: [Address, 47]
Receive: [BufferM1, BufferM2, CRC(2 bytes)]
```

The return values represent how many commands per buffer are waiting to be executed. The maximum buffer size per motor is 64 commands(0x3F). A return value of 0x80(128) indicates the buffer is empty. A return value of 0 indiciates the last command sent is executing. A value of 0x80 indicates the last command buffered has finished.

50 - Drive M1 / M2 With Signed Speed And Individual Acceleration

Drive M1 and M2 in the same command using one value for acceleration and two signed speed values for each motor. The sign indicates which direction the motor will run. The acceleration value is not signed. The motors are sync during acceleration. This command is used to drive the motor by quad pulses per second and using an acceleration value for ramping. Different quadrature encoders will have different rates at which they generate the incoming pulses. The values used will differ from one encoder to another. Once a value is sent the motor will begin to accelerate incrementally until the rate defined is reached.

```
Send: [Address, 50, AccelM1(4 Bytes), SpeedM1(4 Bytes), AccelM2(4 Bytes),
             SpeedM2(4 Bytes), CRC(2 bytes)]
Receive: [0xFF]
```

The acceleration is measured in speed increase per second. An acceleration value of 12,000 QPPS with a speed of 12,000 QPPS would accelerate a motor from 0 to 12,000 QPPS in 1 second. Another example would be an acceleration value of 24,000 QPPS and a speed value of 12,000 QPPS would accelerate the motor to 12,000 QPPS in 0.5 seconds.

51 - Buffered Drive M1 / M2 With Signed Speed, Individual Accel And Distance

Drive M1 and M2 with a speed, acceleration and distance value. The sign indicates which direction the motor will run. The acceleration and distance values are not signed. This command is used to control both motors top speed, total distanced traveled and at what incremental acceleration value to use until the top speed is reached. Each motor channel M1 and M2 have separate buffers. This command will execute immediately if no other command for that channel is executing, otherwise the command will be buffered in the order it was sent. Any buffered or executing command can be stopped when a new command is issued by setting the Buffer argument. All values used are in quad pulses per second.

```
Send: [Address, 51, AccelM1(4 Bytes), SpeedM1(4 Bytes), DistanceM1(4 Bytes),
AccelM2(4 Bytes), SpeedM2(4 bytes), DistanceM2(4 Bytes), Buffer, CRC(2 bytes)]
Receive: [0xFF]
```

The Buffer argument can be set to a 1 or 0. If a value of 0 is used the command will be buffered and executed in the order sent. If a value of 1 is used the current running command is stopped, any other commands in the buffer are deleted and the new command is executed.

52 - Drive M1 With Signed Duty And Acceleration

Drive M1 with a signed duty and acceleration value. The sign indicates which direction the motor will run. The acceleration values are not signed. This command is used to drive the motor by PWM and using an acceleration value for ramping. Accel is the rate per second at which the duty changes from the current duty to the specified duty.

```
Send: [Address, 52, Duty(2 bytes), Accel(2 Bytes), CRC(2 bytes)]
Receive: [0xFF]
```

The duty value is signed and the range is -32768 to +32767(eg. +-100% duty). The accel value range is 0 to 655359(eg maximum acceleration rate is -100% to 100% in 100ms).

53 - Drive M2 With Signed Duty And Acceleration

Drive M1 with a signed duty and acceleration value. The sign indicates which direction the motor will run. The acceleration values are not signed. This command is used to drive the motor by PWM and using an acceleration value for ramping. Accel is the rate at which the duty changes from the current duty to the specified dury.

```
Send: [Address, 53, Duty(2 bytes), Accel(2 Bytes), CRC(2 bytes)]
Receive: [0xFF]
```

The duty value is signed and the range is -32768 to +32767 (eg. +-100% duty). The accel value range is 0 to 655359 (eg maximum acceleration rate is -100% to 100% in 100ms).

54 - Drive M1 / M2 With Signed Duty And Acceleration

Drive M1 and M2 in the same command using acceleration and duty values for each motor. The sign indicates which direction the motor will run. The acceleration value is not signed. This command is used to drive the motor by PWM using an acceleration value for ramping. The command syntax:

```
Send: [Address, CMD, DutyM1(2 bytes), AccelM1(4 Bytes), DutyM2(2 bytes),
        AccelM1(4 bytes), CRC(2 bytes)]
Receive: [0xFF]
```

The duty value is signed and the range is -32768 to +32767 (eg. +-100% duty). The accel value range is 0 to 655359 (eg maximum acceleration rate is -100% to 100% in 100ms).

55 - Read Motor 1 Velocity PID and QPPS Settings

Read the PID and QPPS Settings.

```
Send: [Address, 55]
Receive: [P(4 bytes), I(4 bytes), D(4 bytes), QPPS(4 byte), CRC(2 bytes)]
```

56 - Read Motor 2 Velocity PID and QPPS Settings

Read the PID and QPPS Settings.

```
Send: [Address, 56]
Receive: [P(4 bytes), I(4 bytes), D(4 bytes), QPPS(4 byte), CRC(2 bytes)]
```

61 - Set Motor 1 Position PID Constants

The RoboClaw Position PID system consist of seven constants starting with P = Proportional, I= Integral and D= Derivative, MaxI = Maximum Integral windup, Deadzone in encoder counts, MinPos = Minimum Position and MaxPos = Maximum Position. The defaults values are all zero.

```
Send: [Address, 61, D(4 bytes), P(4 bytes), I(4 bytes), MaxI(4 bytes),
        Deadzone(4 bytes), MinPos(4 bytes), MaxPos(4 bytes), CRC(2 bytes)]
Receive: [0xFF]
```

Position constants are used only with the Position commands, 65,66 and 67 or when encoders are enabled in RC/Analog modes.

62 - Set Motor 2 Position PID Constants

The RoboClaw Position PID system consist of seven constants starting with P = Proportional, I= Integral and D= Derivative, MaxI = Maximum Integral windup, Deadzone in encoder counts, MinPos = Minimum Position and MaxPos = Maximum Position. The defaults values are all zero.

```
Send: [Address, 62, D(4 bytes), P(4 bytes), I(4 bytes), MaxI(4 bytes),
      Deadzone(4 bytes), MinPos(4 bytes), MaxPos(4 bytes), CRC(2 bytes)]
Receive: [0xFF]
```

Position constants are used only with the Position commands, 65,66 and 67 or when encoders are enabled in RC/Analog modes.

63 - Read Motor 1 Position PID Constants

Read the Position PID Settings.

```
Send: [Address, 63]
Receive: [P(4 bytes), I(4 bytes), D(4 bytes), MaxI(4 byte), Deadzone(4 byte),
            MinPos(4 byte), MaxPos(4 byte), CRC(2 bytes)]
```

64 - Read Motor 2 Position PID Constants

Read the Position PID Settings.

```
Send: [Address, 64]
Receive: [P(4 bytes), I(4 bytes), D(4 bytes), MaxI(4 byte), Deadzone(4 byte),
            MinPos(4 byte), MaxPos(4 byte), CRC(2 bytes)]
```

65 - Buffered Drive M1 with signed Speed, Accel, Deccel and Position

Move M1 position from the current position to the specified new position and hold the new position. Accel sets the acceleration value and deccel the decceleration value. QSpeed sets the speed in quadrature pulses the motor will run at after acceleration and before decceleration.

```
Send: [Address, 65, Accel(4 bytes), Speed(4 Bytes), Deccel(4 bytes),
            Position(4 Bytes), Buffer, CRC(2 bytes)]
Receive: [0xFF]
```

66 - Buffered Drive M2 with signed Speed, Accel, Deccel and Position

Move M2 position from the current position to the specified new position and hold the new position. Accel sets the acceleration value and deccel the decceleration value. QSpeed sets the speed in quadrature pulses the motor will run at after acceleration and before decceleration.

```
Send: [Address, 66, Accel(4 bytes), Speed(4 Bytes), Deccel(4 bytes),
            Position(4 Bytes), Buffer, CRC(2 bytes)]
Receive: [0xFF]
```

67 - Buffered Drive M1 & M2 with signed Speed, Accel, Deccel and Position

Move M1 & M2 positions from their current positions to the specified new positions and hold the new positions. Accel sets the acceleration value and deccel the decceleration value. QSpeed sets the speed in quadrature pulses the motor will run at after acceleration and before decceleration.

```
Send: [Address, 67, AccelM1(4 bytes), SpeedM1(4 Bytes), DeccelM1(4 bytes),
             PositionM1(4 Bytes), AccelM2(4 bytes), SpeedM2(4 Bytes), DeccelM2(4 bytes),
                   PositionM2(4 Bytes), Buffer, CRC(2 bytes)]
Receive: [0xFF]
```

Reading Quadrature Encoder - Arduino Example

The example was tested with an Arduino Uno using packet serial wiring and quadrature encoder wiring diagrams. The example will read the speed, total ticks and direction of each encoder. Connect to the program using a terminal window set to 38400 baud. The program will display the values of each encoders current count along with each encoder status bit in binary and the direction bit. As the encoder is turned it will update the screen. Additional example programs can be downloaded from Ionmc.com.

```
//Set mode to 7(packet serial address 0x80) and option 4(38400)

//Includes required to use Roboclaw library
#include "BMSerial.h"
#include "RoboClaw.h"

//Roboclaw Address
#define address 0x80

//Definte terminal for display. Use hardware serial pins 0 and 1
BMSerial terminal(0,1);

//Setup communcaitions with roboclaw. Use pins 10 and 11 with 10ms timeout
RoboClaw roboclaw(10,11,10000);

void setup() {
  //Open terminal and roboclaw at 38400bps
  terminal.begin(57600);
  roboclaw.begin(38400);
}

void loop() {
  uint8_t status1,status2,status3,status4;
  bool valid1,valid2,valid3,valid4;

  //Read all the data from Roboclaw before displaying on terminal window
  //This prevents the hardware serial interrupt from interfering with
  //reading data using software serial.
  int32_t enc1= roboclaw.ReadEncM1(address, &status1, &valid1);
  int32_t enc2 = roboclaw.ReadEncM2(address, &status2, &valid2);
  int32_t speed1 = roboclaw.ReadSpeedM1(address, &status3, &valid3);
  int32_t speed2 = roboclaw.ReadSpeedM2(address, &status4, &valid4);

  terminal.print("Encoder1:");
  if(valid1){
    terminal.print(enc1,HEX);
    terminal.print(" ");
    terminal.print(status1,HEX);
    terminal.print(" ");
  }
  else{
    terminal.print("invalid ");
  }
  terminal.print("Encoder2:");
  if(valid2){
    terminal.print(enc2,HEX);
    terminal.print(" ");
    terminal.print(status2,HEX);
    terminal.print(" ");
  }
  else{
    terminal.print("invalid ");
  }
  terminal.print("Speed1:");
  if(valid3){
    terminal.print(speed1,HEX);
    terminal.print(" ");
  }
  else{
    terminal.print("invalid ");
  }
  terminal.print("Speed2:");
  if(valid4){
    terminal.print(speed2,HEX);
    terminal.print(" ");
  }
  else{
    terminal.print("invalid ");
  }
  terminal.println();

  delay(100);
}
```

Speed Controlled by Quadrature Encoders - Arduino Example

The following example was written using an Arduino UNO using packet serial wiring and quadrature encoder wiring diagrams. The example will command a 4wheel robot to move forward, backward, right turn and left turn slowly. You can change the speed by adjusting the value of Speed and Speed2 variables. Additional example programs can be downloaded from Ionmc.com.

```
//Set mode 7(packet serial address 0x80) and mode 4(38400)

//Includes required to use Roboclaw library
#include "BMSerial.h"
#include "RoboClaw.h"

#define SPEED 12000
#define SPEED2 12000

//Roboclaw Address
#define address 0x80

//Velocity PID coefficients
#define Kp 1.0
#define Ki 0.5
#define Kd 0.25
#define qpps 44000

//Definte terminal for display. Use hardware serial pins 0 and 1
BMSerial terminal(0,1);

//Setup communcaitions with roboclaw. Use pins 10 and 11 with 10ms timeout
RoboClaw roboclaw(10,11,10000);

long speed;
long speed2;

void setup() {
  //Open terminal and roboclaw serial ports
  terminal.begin(57600);
  roboclaw.begin(38400);

  speed = SPEED;
  speed2 = SPEED2;

  //Set PID Coefficients
  roboclaw.SetM1VelocityPID(address,Kd,Kp,Ki,qpps);
  roboclaw.SetM2VelocityPID(address,Kd,Kp,Ki,qpps);
}
```

```
void displayspeed(void)
{
  uint8_t status1,status2,status3,status4;
  bool valid1,valid2,valid3,valid4;

  int32_t enc1= roboclaw.ReadEncM1(address, &status1, &valid1);
  int32_t enc2 = roboclaw.ReadEncM2(address, &status2, &valid2);
  int32_t speed1 = roboclaw.ReadSpeedM1(address, &status3, &valid3);
  int32_t speed2 = roboclaw.ReadSpeedM2(address, &status4, &valid4);
  terminal.print("Encoder1:");
  if(valid1){
    terminal.print(enc1,DEC);
    terminal.print(" ");
    terminal.print(status1,HEX);
    terminal.print(" ");
  }
  else{
    terminal.print("invalid ");
  }
  terminal.print("Encoder2:");
  if(valid2){
    terminal.print(enc2,DEC);
    terminal.print(" ");
    terminal.print(status2,HEX);
    terminal.print(" ");
  }
  else{
    terminal.print("invalid ");
  }
  terminal.print("Speed1:");
  if(valid3){
    terminal.print(speed1,DEC);
    terminal.print(" ");
  }
  else{
    terminal.print("invalid ");
  }
  terminal.print("Speed2:");
  if(valid4){
    terminal.print(speed2,DEC);
    terminal.print(" ");
  }
  else{
    terminal.print("invalid ");
  }
  terminal.println();
}
```

```
void loop() {
  roboclaw.SpeedM1(address,speed);
  roboclaw.SpeedM2(address,speed);
  for(uint8_t i = 0;i<100;i++){
    displayspeed();
    delay(10);
  }

  roboclaw.SpeedM1(address,-speed);
  roboclaw.SpeedM2(address,-speed);
  for(uint8_t i = 0;i<100;i++){
    displayspeed();
    delay(10);
  }

  roboclaw.SpeedM1(address,0);
  roboclaw.SpeedM2(address,0);
  delay(2000);

  roboclaw.SpeedM1(address,speed2);
  roboclaw.SpeedM2(address,-speed2);
  for(uint8_t i = 0;i<100;i++){
    displayspeed();
    delay(10);
  }

  roboclaw.SpeedM1(address,-speed2);
  roboclaw.SpeedM2(address,speed2);
  for(uint8_t i = 0;i<100;i++){
    displayspeed();
    delay(10);
  }

  roboclaw.SpeedM1(address,0);
  roboclaw.SpeedM2(address,0);
  delay(2000);
}
```

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Technical Support

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