ION MOTION CONTROL

# RoboClaw Series Brushed DC Motor Controllers

RoboClaw 2x5A
RoboClaw 2x15A
RoboClaw 2x30A
RoboClaw 2x60A

## User Manual

Firmware 4.1.4 and Newer
Hardware V4 and Newer
User Manual Revision 4

## RoboClaw Revision 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 | Date | Description |
|---|---|---|
| 4.1.4 | | 1. fixed speed control using RC input(eg velocity control using encoders with RC/Analog inputs)<br><br>2. Removes Set/GetDither commands<br><br>3. Changed PWM Duty commands to use +-15bit values(-32768 ti 32767) for duty(-100% ti +100) and changed duty cycle acceleration argument to use same scaling. |
| 4.1.3 | | 1. USB detach/re-attach code changed |
| 4.1.2 | | 1. Changed battery voltages to signed calculation<br><br>2. Fixed battery cutoff settings<br><br>3. Fixed battery auto cell count detect<br><br>4. Config settings now must be saved using WriteNVM<br><br>5. USB interface is locked to packet serial mode now. Standard serial is only available on TTL Serial pins.<br><br>6. Fixed checksum calculation on re-set encoder commands |
| 4.1.1 | | 1. Added timeouts on USB while loops.<br><br>2. Changed current offset calibration for better accuracy |
| 4.1.0 | | 1. Added new error/warning code. GetErrorStatus command now returns 16bits of data<br><br>2. Fixed encoder re-set command to support values larger then 65535 |
| 4.0.9 | | 1. Removed max current error<br><br>2. Add maxcurrent chopper<br><br>3. Add temperature max current ramp down |

## Precautions

There are several important precautions that should be followed when dealing with RoboClaw or damage will result. The following list should be observed when dealing with any motion control systems.

**1.** Disconnecting the negative power terminal is not the proper way to shut down a motor controller. If I/O are connected it can easily result in a ground loop through the attached I/O pins. This can cause damaged to RoboClaw and or any attached devices. To shut down a motor controller the positive power connections should be removed.

**2.** A DC brushed motor will work like a generator when spun. As an example a robot being pushed or when turned off with forward momentum can create enough voltage to power RoboClaws logic in some cases which will create an unsafe state. Always stop the motors before powering down RoboClaw.

**3.** RoboClaw has minimum power requirements of at least 6V. Under heavy loads, if the logic battery and main battery are combined, power drops can and will happen. This can cause erratic behavior from RoboClaw.

## Motor Selection

When pairing RoboClaw to a motor several key factors must be considered. All brushed DC motors will have two amperage ratings which are maximum stall current and running current. The most important rating is the stall current. This rating can determine what RoboClaw model should be used.

## Stall Current

A motor at rest is in a stall state. Which means during start up the motors stall current will be reached. The loaded 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. Pairing RoboClaw by using its peak current to handle these situations is not advised. This will only result in erratic behavior and possible damage to RoboClaw. In some applications RoboClaw can be paired using its peak current. This should only be considered in situations where the motor is under very light load and not expect to start, stop or change directions rapidly.

## Running Current

Brushed DC motor will have two current ratings, continuous and stall ameperage. The continuous current rating is the maximum current the motor can run at without overheating. The stall current is the amount of amperage the motor requires on start up and likely under a heavy load or during a high speed direction change. To properly pair a motor controller to a given brushed DC motor you will need both of these values.

## Wire Lengths

Wire lengths to the motors and from the battery should be keep as short as possible. Longer wires will create increased inductance which will produce undesirable effects such as electrical noise or increase ripple current. 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 at the RoboClaw which can damage the filter caps on the board leading to board failure.

### 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.

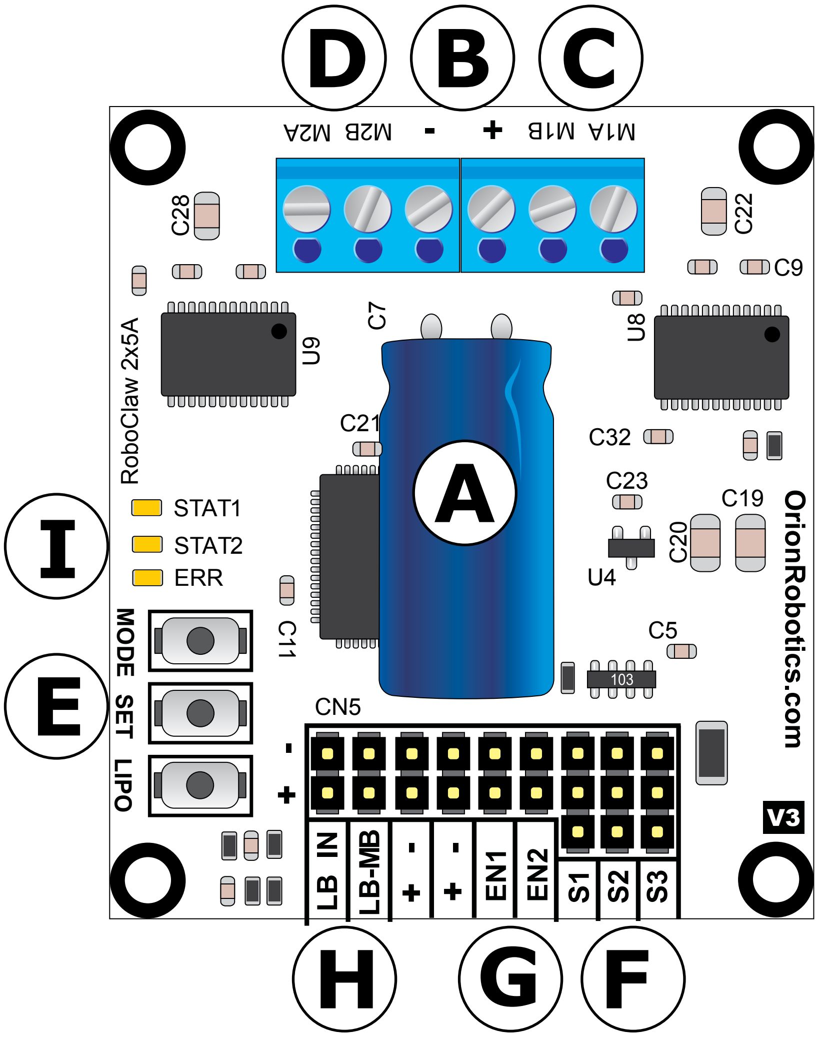
### Power Sources

A battery or linear power supply is recommended as the main power source for RoboClaw. Switching power supplies are suitable in some cases however  regeneration caused by RoboClaw will cause most switching power supplies to behave erratically. The regeneration creates voltage spikes because the switching power supplies are not designed to take the regenerative power. Most switching power supply will momentarily reduce voltage and or limit current, effectively causing brown outs which will leave RoboClaw in an unsafe state.

### Optical Encoders

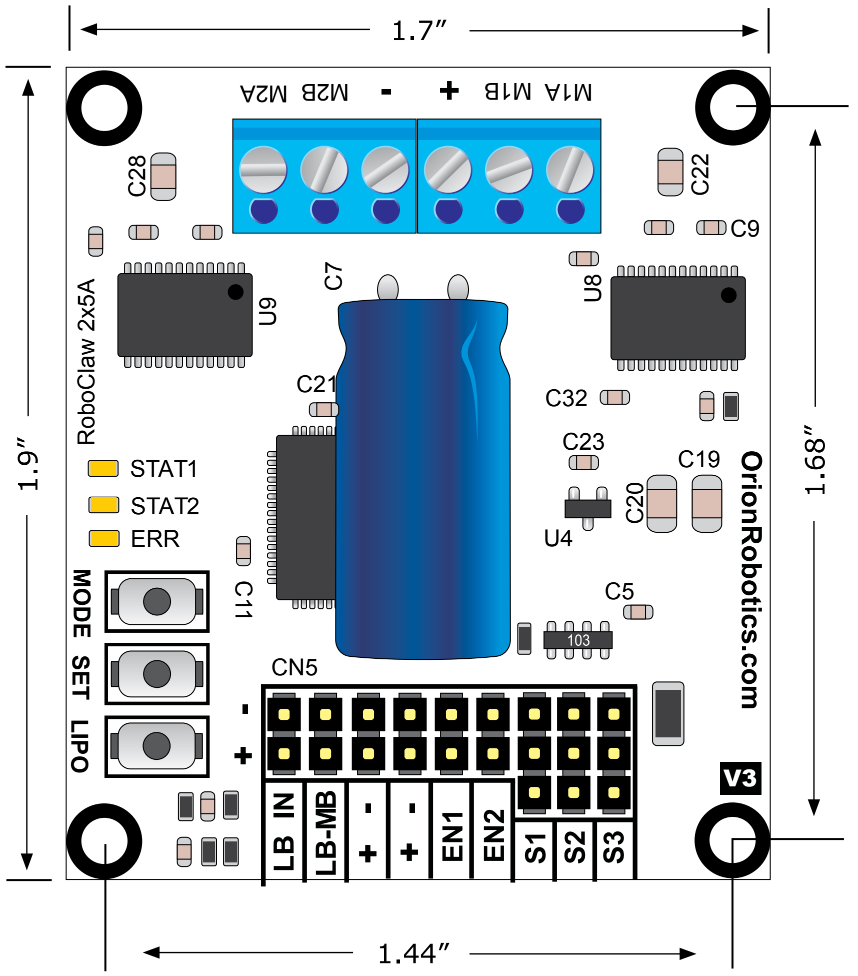
RoboClaw features dual channel quadrature decoding. When wiring encoders make sure the direction of spin is correct to the motor direction. The RoboClaw internal counters increments or decrement based on the inputs A and B. By reversing A and B signals the encoder counter will reverse the count. Incorrect encoder connection can cause a run away state. Referring to the encoder section of this user manual for proper setup.

## RoboClaw 2x5A Hardware Overview



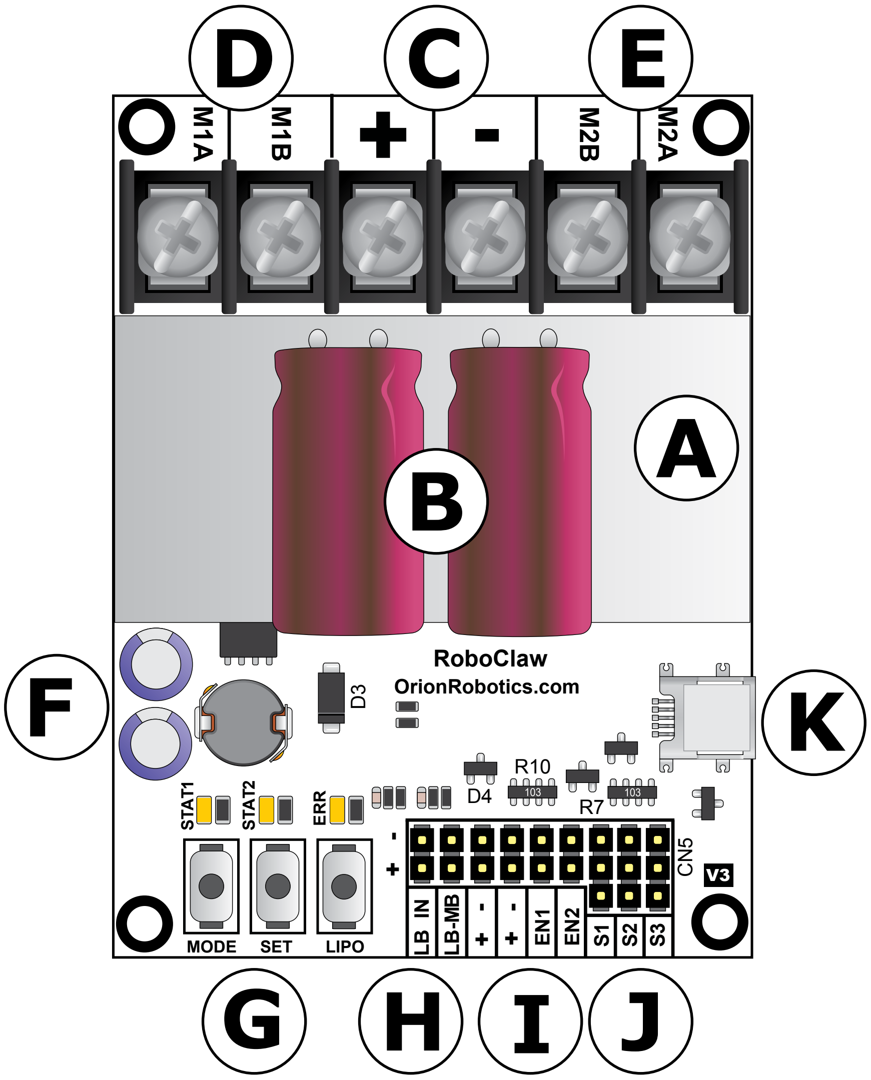
**A:** Power Stabilizer
**B:** Main Battery Input
**C:** Motor Channel 1
**D:** Motor Channel 2
**E:** Setup Buttons
**F:** Control Inputs
**G:** Encoder Inputs
**H:** Logic Voltage Source/Selection Header
**I:** Status and Error LED Indicators

## RoboClaw 2x5A Dimensions



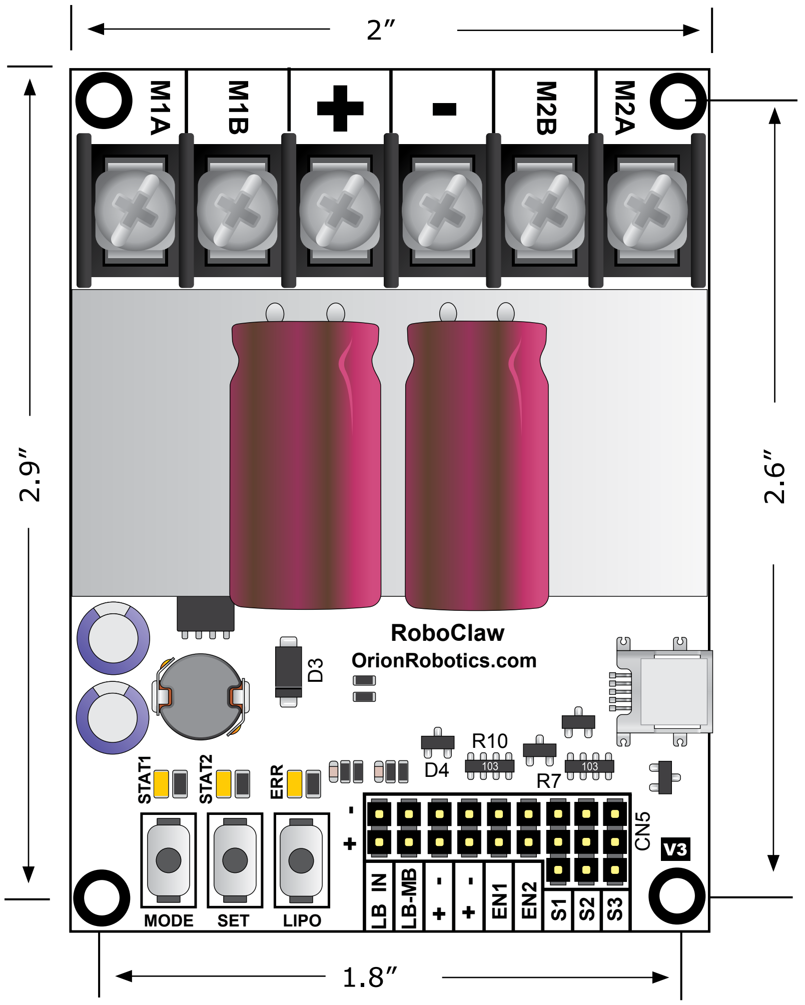
**Board Edge:** 1.7"W X 1.9"L
**Hole Pattern:** 0.125D, 1.44"W x 1.68"H

## RoboClaw 2x15A and 2x30A Hardware Overview



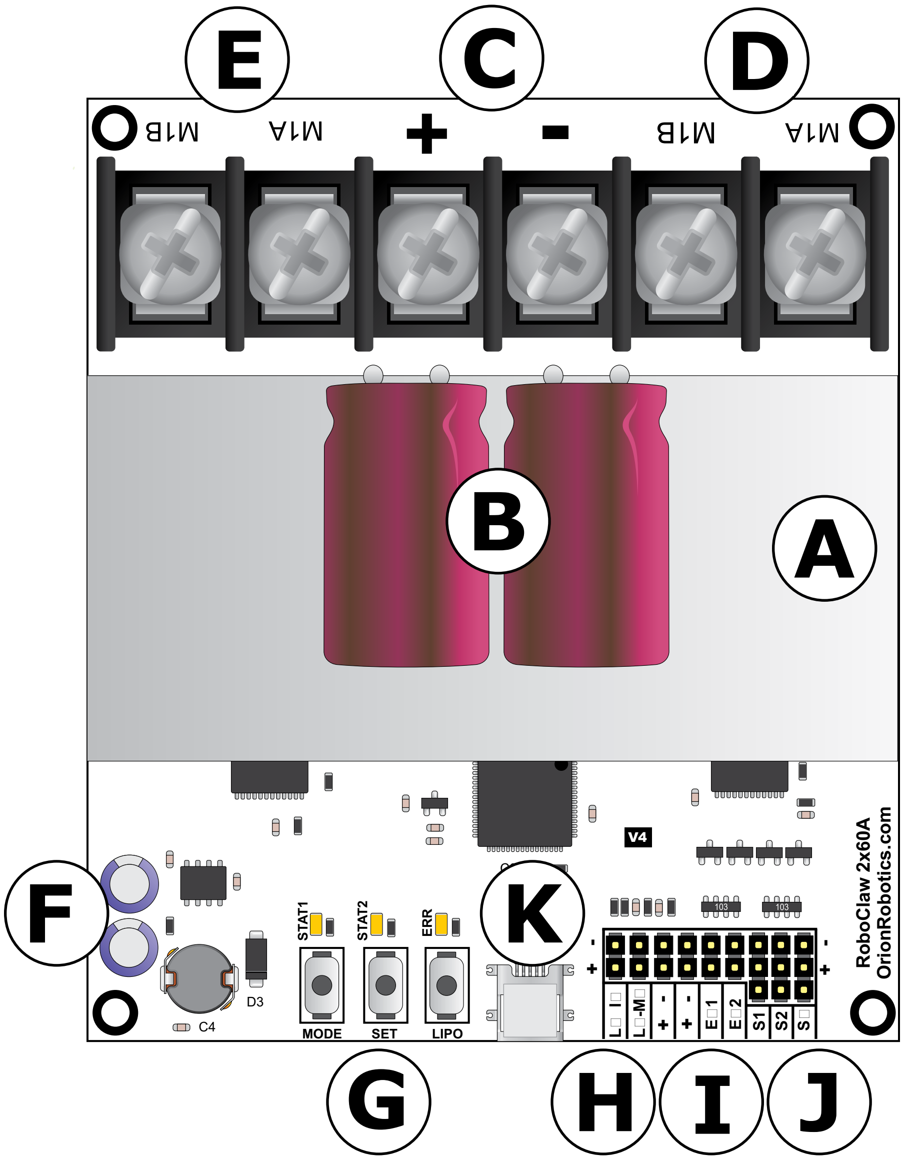
**A:** Heat Sink
**B:** Power Stabilizers
**C:** Main Battery Input
**D:** Motor Channel 1
**E:** Motor Channel 2
**F:** BEC 3A Circuit
**G:** Setup Buttons
**H:** Logic Voltage Source/Selection Header
**I:** Encoder Inputs
**J:** Controller Inputs
**K:** USB Connector - MiniB (Optional)

## RoboClaw 2x15A and 2x30A Dimensions



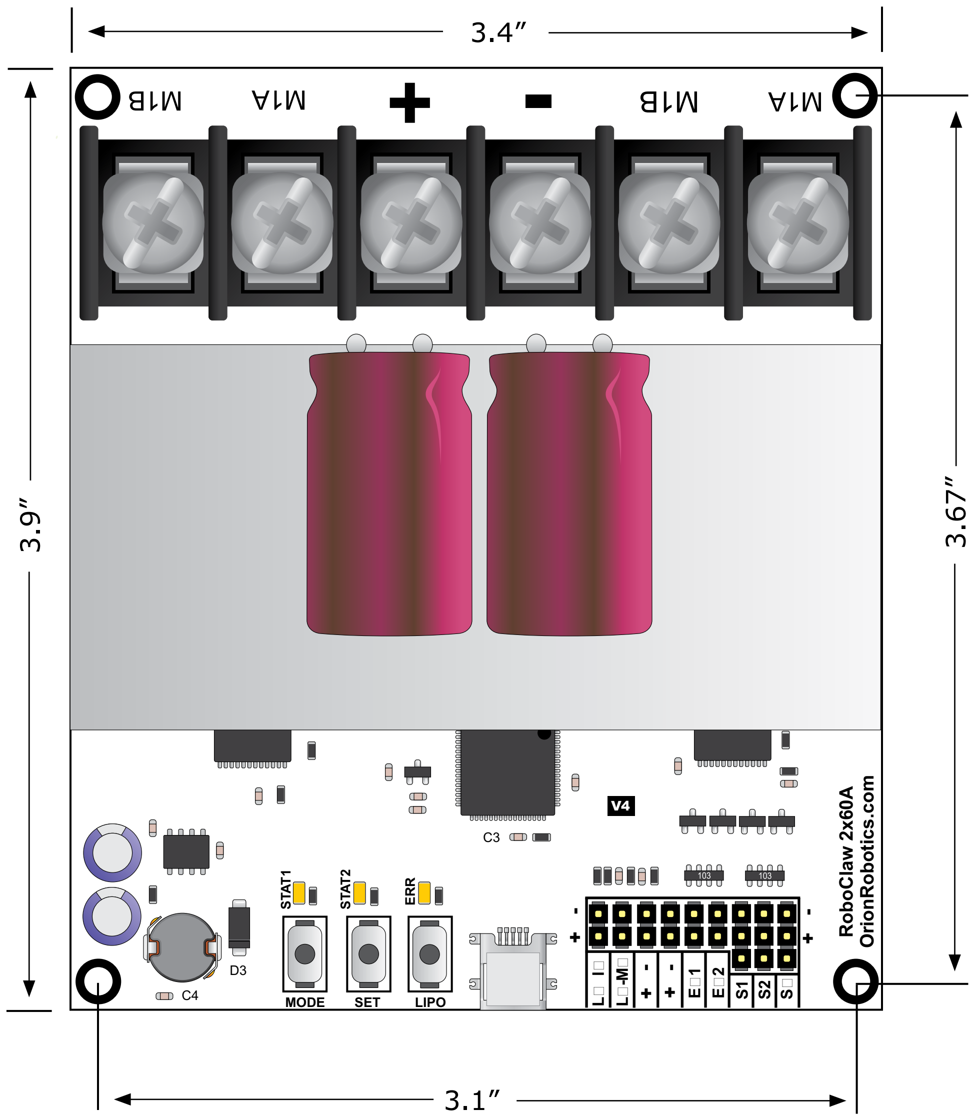
**Board Edge:** 2″W X 2.9″L
**Hole Pattern:** 0.125D, 1.8″W x 2.6″H

## RoboClaw 2x60A and HV 2x60A Hardware Overview



**A:** Heat Sink
**B:** Power Stabilizers
**C:** Main Battery Input
**D:** Motor Channel 1
**E:** Motor Channel 2
**F:** BEC 3A Circuit
**G:** Setup Buttons
**H:** Logic Voltage Source/Selection Header
**I:** Encoder Inputs
**J:** Controller Inputs
**K:** USB Connector - MiniB (Optional)

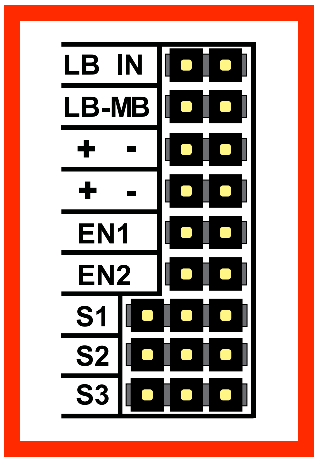
## RoboClaw 2x60A and HV 2x60A Dimensions



**Board Edge:** 3.4″W X 3.9″L
**Hole Pattern:** 0.125D, 3.1″W x 3.67″H

## Header Overview

They same header layout is shared for each of the RoboClaw models covered in this user manual. The main control I/O are arranged for easy connectivity to control devices such as RC controllers. The headers are also arranged to provide easy access to ground and power for supplying power to external controllers.



## 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 closes 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.

## 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.

## Encoder Inputs (EN1 / EN2)

EN1 and EN2 are the inputs from the encoders. Channel A of both EN1 and EN2 are located at the board edge. Channel B pins are located near the heatsink. 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.

## Control Inputs (S1 / S2 / S3)

S1, S2 and S3 are setup for standard servo style headers I/O, +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 becomes an emergency stop. S3 is active when pulled low. It is internally pull up so it will not accidentally trip when left floating. 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 logic supply. It may be necessary to remove the +5V pin from the RC receivers cable in those cases.

### Main Battery Screw Terminals

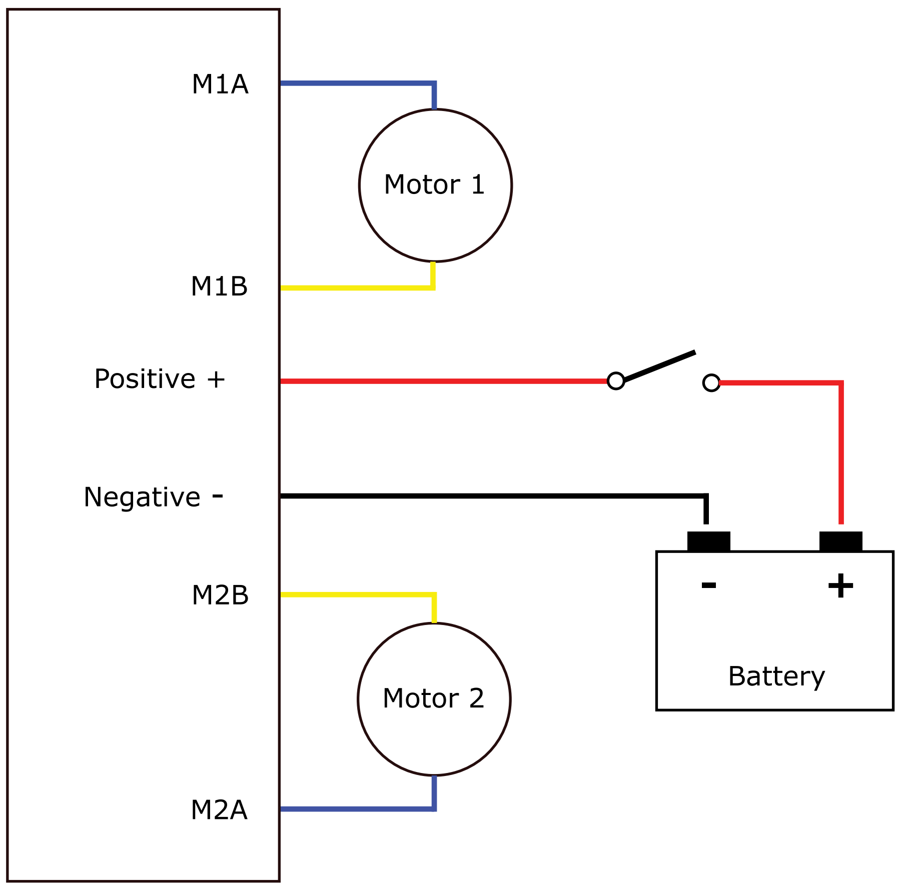
The main power input can be from 6VDC to 34VDC on a standard RoboClaw and 10.5VDC to 60VDC for the HV (High Voltage) RoboClaw. The connections are marked **+** and **-** on the main screw terminal. **+** is the positive terminal and **-** is the negative terminal. The main battery wires should be short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

### 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 source from sites like Ebay.

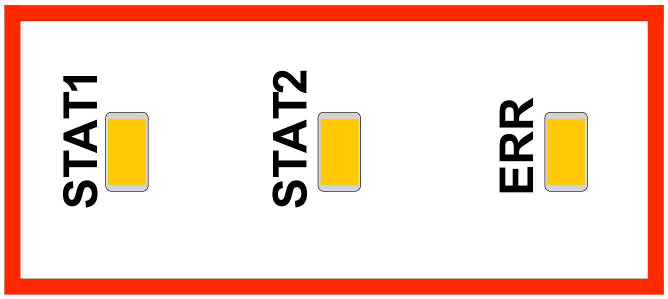
### Motor Screw Terminals

The motor screw terminals are marked with M1A / M1B for channel 1 and M2A / M2B for channel 2. There is no specific polarities for the motors. For both motors to turn in the same direction the wiring of one motor should be reversed from the other. The motor/battery wires should be as short as possible. Long wires can increase the inductance and therefore increase potential harmful voltage spikes.



## Status and Error LEDs

The RoboClaw has three LEDs. Two status LEDs marked STAT1 and STAT2. An error LED marked ERR. When RoboClaw is first powered up all 3 LEDs should blink briefly to indicate all 3 LEDs are functional. LEDs will behave differently depending on the mode RoboClaw is set to. During normal operation status 1 LED will remain lite continuously or blink when data is received in RC Mode or Serial Modes. Status 2 LED will light when the drive stage is active.



## Error and Warning States

When an error occurs both motor channel outputs will be disabled and RoboClaw will stop any further actions until the error state is cleared. When a warnings occurs both motor channel outputs will continue to function and the RoboClaw will continue to operate.

| State | Type | Description |
|---|---|---|
| E-Stop | Error | All three LEDs solid. |
| Over Temperature | Error | Error LED blinking once with one second delay. Other LEDs off. |
| Driver Fault | Error | Error LED blinking once. STAT1 or STAT2 indicates channel. |
| Main Battery Low | Error | Error LED blinking twice. |
| Logic Battery High | Error | Error LED blinking three times. |
| Logic Battery Low | Error | Error LED blinking four times. |
| Main Batt Board Limit | Error | Error LED blinking five times. |
| Max Current | Warning | Error LED solid. STAT1 or STAT2 quick blinking indicates channel. |
| Max Temperature | Warning | Error LED solid (Maximum current limit is also reduced). |
| Main Batt User Limit | Warning | Error LED solid. |

## RoboClaw Modes

There are 4 main modes with variations totaling 14 or 15 modes in all.  Each mode enables RoboClaw to be controlled in a very specific way. The following list explains each mode and the ideal application.

**1. RC Mode 1 & 2** - With RC mode RoboClaw can be controlled from any hobby RC radio system. RC input mode also allows low powered microcontroller such as a Basic Stamp or Nano 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.

**2. Analog Mode 3 & 4** - Analog mode uses an analog signal from 0V to 5V 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 joystick positioning systems or other non microcontroller interfacing hardware. Analog mode can use encoders.

**3. Standard Serial Mode 5 & 6** - In standard serial mode RoboClaw expects TTL level RS-232 serial data to control direction and speed of each motor. Standard serial is typically used to control RoboClaw from a microcontroller or PC. If using a PC a MAX232 type circuit must be used since RoboClaw only works with TTL level input. Standard serial includes a slave select mode which allows multiple RoboClaws to be controlled from a signal RS-232 port (PC or microcontroller). Standard serial is a one way format, RoboClaw only receives data.

**4. Packet Serial Mode 7 through 14** - 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 type circuit must be used since RoboClaw only works with TTL level input. In packet serial mode each RoboClaw is assigned an address using the dip switches. There are 8 addresses available. This means up to 8 RoboClaws can be on the same serial port. When using the quadrature decoding feature of RoboClaw packet serial is required since it is a two way communications format. This allows RoboClaw to transmit information about the encoders position and speed.

**5. USB Mode 15** - In USB mode the RoboClaw’s USB port acts as a CDC Virtual Comport in Packet Serial mode with packet address 128.  There are two ways to activate the USB mode. Power up a USB RoboClaw while it is attached to an active USB cable, or set it to mode 15. If the USB host connected to RoboClaw will be powered up at the same time as RoboClaw, mode 15 should be set.

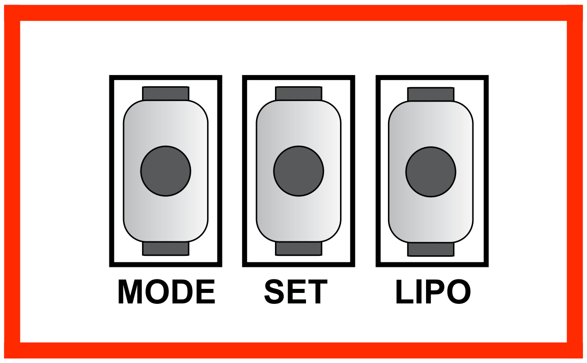
## Configuring RoboClaw Modes

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 | Description |
|---|---|
| **1** | RC mode |
| **2** | RC mode with mixing |
| **3** | Analog mode |
| **4** | Analog mode with mixing |
| **5** | Standard Serial |
| **6** | Standard Serial with slave pin |
| **7** | Packet Serial Mode - Address 0x80 |
| **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 |
| **15** | USB Mode Packet Serial - Address 0x80 |

## Mode Options

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. Press SET to increment to the next option. Press MODE to decrement to the previous option. Once the desired option is selected press and release the LIPO button to save the option to memory.

### *RC and Analog Mode Options*

| Option | Description |
|---|---|
| **1** | TTL Flip Switch |
| **2** | TTL Flip and Exponential Enabled |
| **3** | TTL Flip and MCU Enabled |
| **4** | TTL Flip and Exp and MCU Enabled |
| **5** | RC Flip Switch |
| **6** | RC Flip and Exponential Enabled |
| **7** | RC Flip and MCU Enabled |
| **8** | RC Flip and Exponential and MCU Enabled |

### *Standard Serial and Packet Serial Mode Options*

| Option | Description |
|---|---|
| **1** | 2400bps |
| **2** | 9600bps |
| **3** | 19200bps |
| **4** | 38400bps |

## Battery Cut Off Settings

The battery settings can be set by pressing and releasing the LIPO button. The STAT2 LED will begin to blink out the current setting. Press SET to increment to the next setting. Press MODE to decrement to the previous setting. Once the desired setting is selected press and release the LIPO button to save this setting to memory.

### *Battery Options*

| Option | Description |
|---|---|
| **1** | Disabled |
| **2** | Auto Detect |
| **3** | 2 Cell(6v Cutoff) |
| **4** | 3 Cell(9v Cutoff) |
| **5** | 4 Cell(12v Cutoff) |
| **6** | 5 Cell(15v Cutoff) |
| **7** | 6 Cell(18v Cutoff) |
| **8** | 7 Cell(21v Cutoff) |

# USB CONTROL

### USB RoboClaw Power

The USB RoboClaw is self powered. Which means it is not powered from the USB cable. The USB RoboClaw must be externally powered to function correctly.

### USB RoboClaw Connection

The USB RoboClaw should have its USB cable connected before powering it up unless USB mode is specifically set (mode 15). If the master controller (the PC) is powered up the USB RoboClaw will automatically detect it is connected to a powered USB master and will enter USB mode. In some cases it may be necessairy to set USB mode manually by setting RoboClaw to mode 15.

### USB Comport and baudrate

The USB 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. On Linux or OSX the RoboClaw will be automatically detected as a virtual comport and an appropriate driver will automatically be 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 1mbit/s.

# RC MODE

## 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 speed and direction of motor 2. This drive method is similar to how a tank is controlled.

## Using RC Mode with feedback for velocity/position control

RC Mode can be used with encoders.  Use IonMotion control software to enable encoders for RC/Analog modes in General Settings. Packet Serial commands can also be used to enable this option. 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.

## RC Mode With Mixing

This mode is the same as RC mode with the exception of how S1 and S2 control the attached motors. S1 controls speed and direction of both motors 1 and 2. S2 controls steering by slowing one of the motors. This drive method is similar to how a car would be controlled.

***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. |

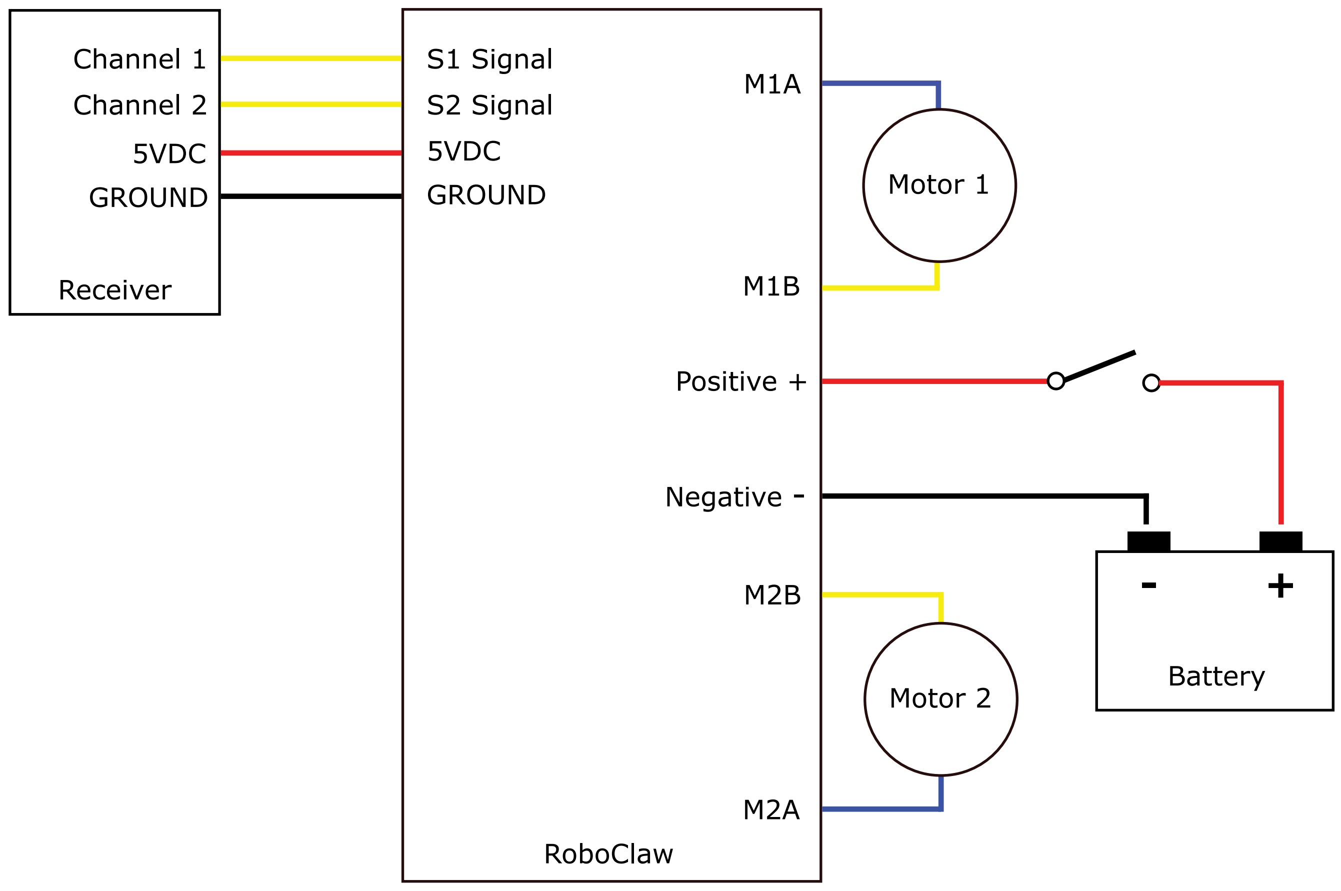
### Pulse Ranges

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. 1000us is the default for full reverse and 2000us 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 1000us or larger than 2000us is detected the new pulses will be set as the new ranges.

| Pulse | Function |
|---|---|
| **1000us** | Full Reverse |
| **2000us** | Full Forward |

### RC Wiring Example

Connect the RoboClaw as shown below. Set mode 1 with option 1. The configuration below uses a separate logic battery so remove the MB-LB jumper. 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 position.



## 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.

```
//Basic Micro RoboClaw RC Mode. Control RoboClaw
//with servo pulses from a microcontroller.
//Mode settings: Mode 2 with Option 4.


#include <Servo.h>

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(1500);  //Stop
  myservo2.writeMicroseconds(1500);  //Stop
  delay(2000);

  myservo1.writeMicroseconds(1250);  //full forward
  delay(1000);

  myservo1.writeMicroseconds(1500);  //stop
  delay(2000);

  myservo1.writeMicroseconds(1750);  //full reverse
  delay(1000);

  myservo1.writeMicroseconds(1500);  //Stop
  delay(2000);

  myservo2.writeMicroseconds(1250);  //full forward
  delay(1000);

  myservo2.writeMicroseconds(1500);  //Stop
  delay(2000);

  myservo2.writeMicroseconds(1750);  //full reverse
  delay(1000);
}
```

# ANALOG MODE

## 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. Voltage range is 0V = Full reverse, 1V = Stop and 2V = Full forward.

## Using Analog Mode with feedback for velocity/position control

Analog Mode can be used with encoders.  Use IonMotion control software to enable encoders for RC/Analog modes in General Settings. Packet Serial commands can also be used to enable this option. 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.

## Analog Mode With Mixing

This mode is the same as Analog mode with the exception of how S1 and S2 control the attached motors. S1 controls speed and direction of both motors 1 and 2. S2 controls steering by slowing one of the motors. This drive method is similar to how a car would be controlled.

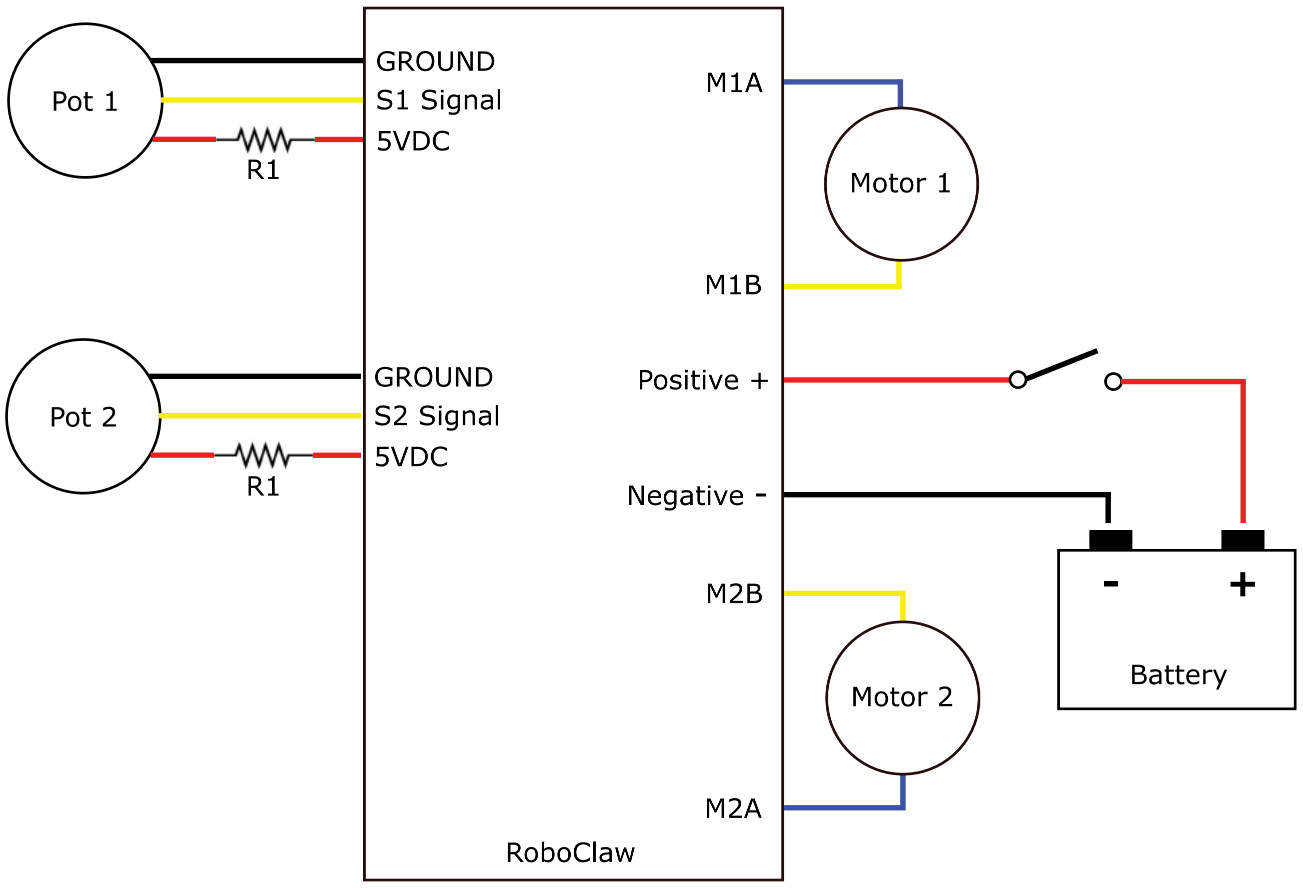
### Analog Mode Options

| 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 use a high speed 12 bit analog converter. Its range is 0 to 2V. The analog pins are protect and 5V can be applied without damage. 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. See the below schematic. The POT acts as one half of the resistor divider. If using a 5k potentiometer R1 = 7.5k, If using a 10k potentiometer R1 = 15k and if using a 20k potentiometer R1 = 30k.

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



# STANDARD SERIAL

## 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 (See Max232) is required. The baud rate can be changed using the SET button once a serial mode has been selected.

### *Serial Mode Baud Rates*

| Option | Description |
|---|---|
| **1** | 2400 |
| **2** | 9600 |
| **3** | 19200 |
| **4** | 38400 |

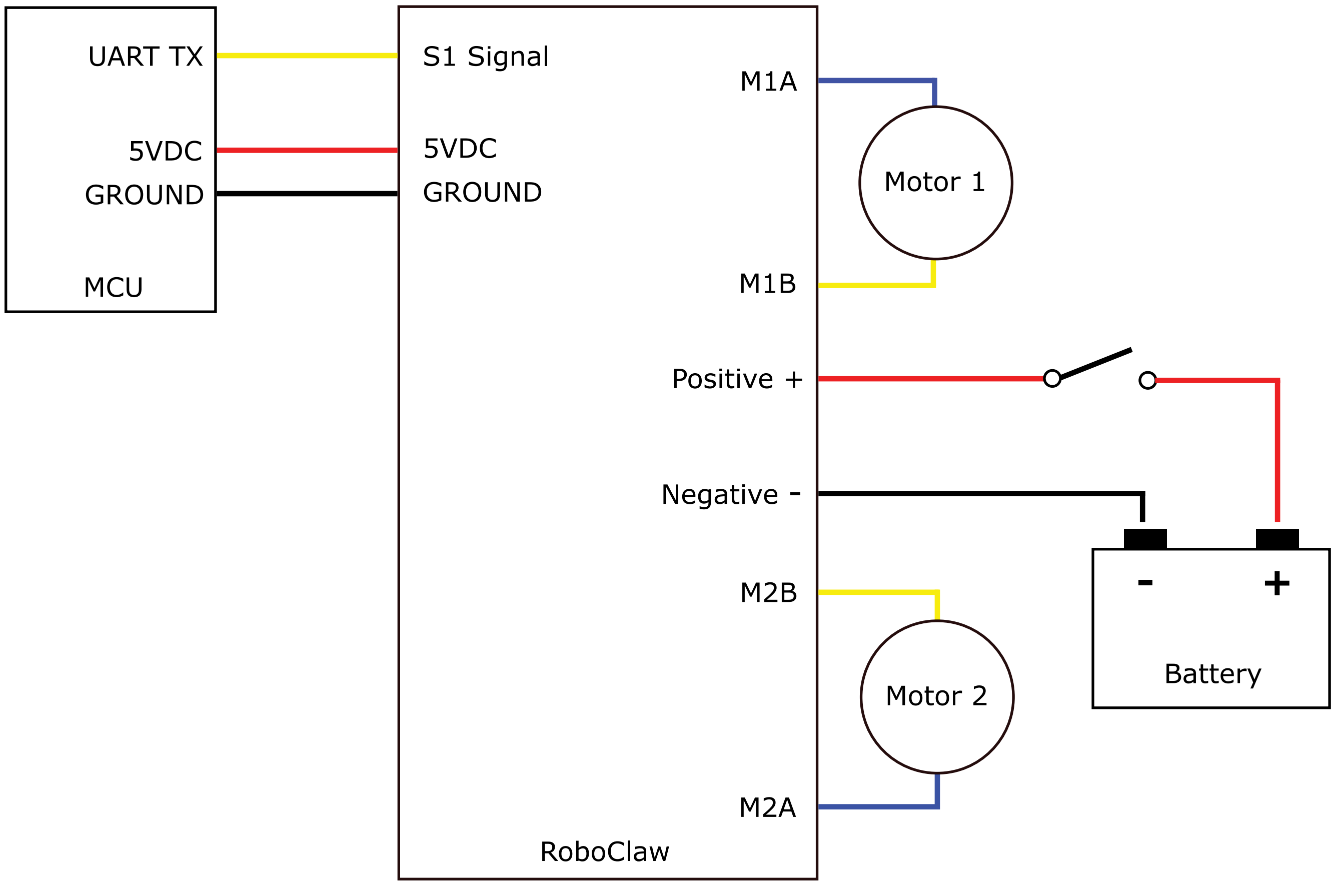
## Standard Serial Command Syntax

The RoboClaw standard serial is setup to control both motors with one byte sized command character. Since a byte can be anything from 0 to 255 the control of each motor is split. 1 to 127 controls channel 1 and 128 to 255 controls channel 2. Command character 0 will shut down 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.

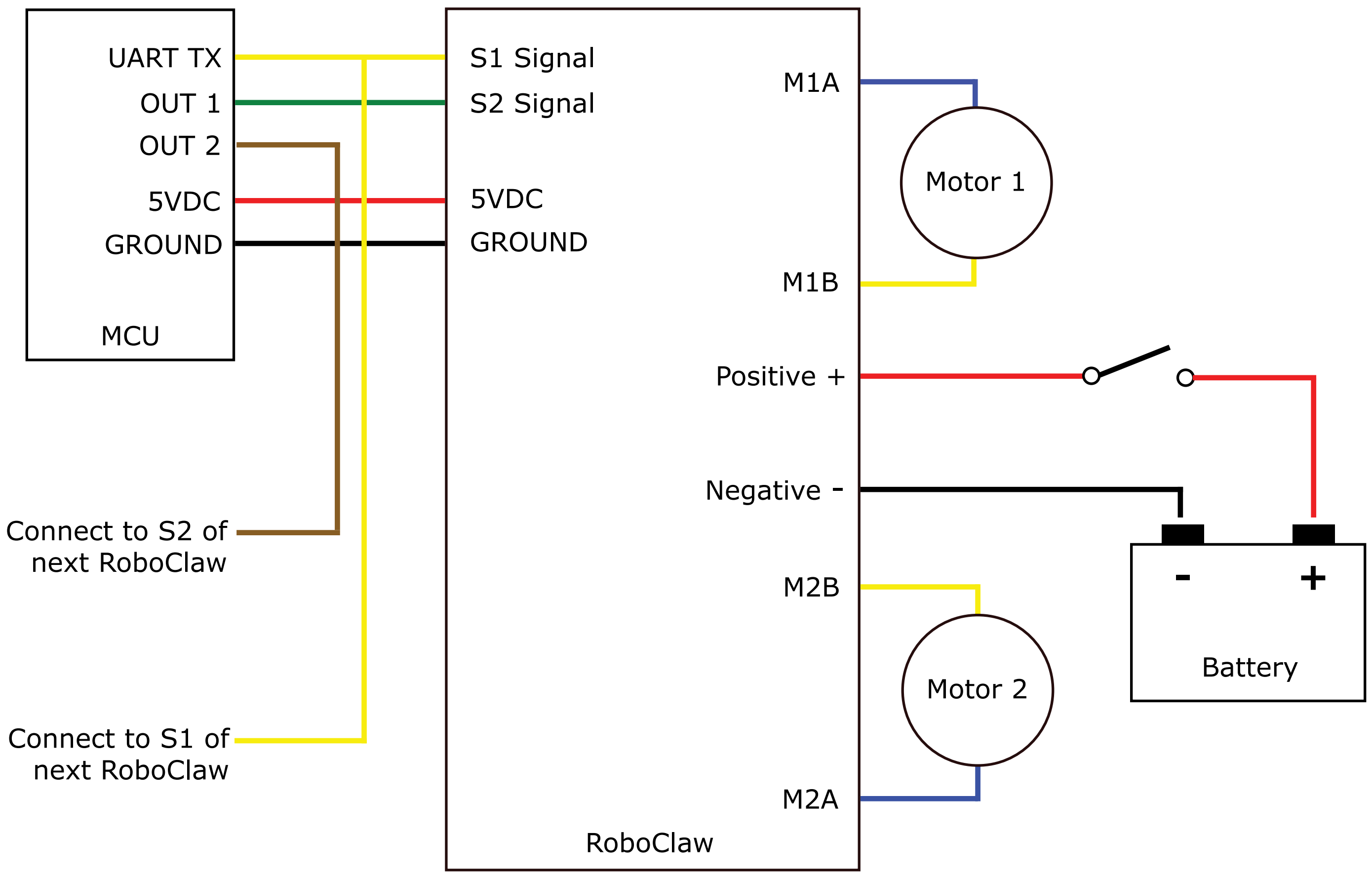


## Standard Serial Mode With Slave Select

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 the 5VDC.



### Standard Serial - Arduino Example

The following example will start both channels in reverse, then full speed forward. The program was written and tested with a Arduino Uno and Pin 5 connected to S1. Set mode 5 and option 3.

```
//RoboClaw Standard Serial Test
//Switch settings: SW2=ON and SW5=ON
//Make sure Arduino and Robo Claw share common GND!

#include "BMSerial.h"

BMSerial mySerial(5,6);

void setup() {
  mySerial.begin(19200);
}

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

# 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 consists of an address byte, command byte, data bytes and a checksum. The amount of data each command will send or receive can vary.

## Address

Packet serial requires a unique address. With up to 8 addresses available you can have up to 8 RoboClaws bussed on the same RS232 port. 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.

### 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 |

## Checksum Calculation

All packet serial commands use a 7 bit checksum to prevent corrupt commands from being executed. Since the RoboClaw expects a 7bit value the 8th bit is masked. The checksum is calculated as follows:

Checksum = (Address + Command + Data bytes) & 0x7F

When calculating the checksum all data bytes sent or received must be added together. The hexadecimal value 0X7F is used to mask the 8th bit.

## 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.

## Packet Acknowledgement

If you set the 8th bit of the checksum byte to one RoboClaw will send an acknowledgment byte back on write only packet commands that were properly received and were valid commands.

Checksum = (Address + Command + Data bytes) & 0x7F | 0x80

The value sent back is 0xFF. if the packet was not valid for any reason no acknowledgement will be sent back.

## Commands 0 - 7 Compatibility Commands

The following commands are the standard set of commands used with packet mode. The command syntax is the same for commands 0 to 7:

*Address, Command, ByteValue, Checksum*

### 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. Example with RoboClaw address set to 128:

```
Send: 128, 0, 127, ((128+0+127) & 0X7F)
```

### 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. Example with RoboClaw address set to 128:

```
Send: 128, 1, 127, ((128+0+127) & 0X7F)
```

### 2 - Set Minimum Main Voltage

Sets main battery (B- / B+) minimum voltage level. If the battery voltages drops below the set voltage level RoboClaw will shut down. The value is cleared at start up and must set after each power up. 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 - 120 (6V - 30V). 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. Example with RoboClaw address set to 128:

```
Send: 128, 2, 25, ((128+2+25) & 0X7F)
```

### 3 - Set Maximum Main Voltage

Sets main battery (B- / B+) maximum voltage level. The valid data range is 0 - 154 (0V - 30V). If you are using a battery of any type you can ignore this setting. During regenerative breaking a back voltage is applied to charge the battery. When using an ATX type power supply if it senses anything over 16V it will shut down. By setting the maximum voltage level, RoboClaw before exceeding it will go into hard breaking mode until the voltage drops below the maximum value set. 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. Example with RoboClaw address set to 128:

```
Send: 128, 3, 82, ((128+3+82) & 0X7F)
```

### 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. Example with RoboClaw address set to 128:

```
Send: 128, 4, 127, ((128+4+127) & 0X7F)]
```

### 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. Example with RoboClaw address set to 128:

```
Send: 128, 5, 127, ((128+5+127) & 0X7F)
```

### 6 - Drive M1 (7 Bit)

Drive motor 1 forward and reverse. Valid data range is 0 - 127. A value of 0 =  full speed reverse, 64 = stop and 127 = full speed forward. Example with RoboClaw address set to 128:

```
Send: 128, 6, 96, ((128+6+96) & 0X7F)
```

### 7 - Drive M2 (7 Bit)

Drive motor 2 forward and reverse. Valid data range is 0 - 127. A value of 0 =  full speed reverse, 64 = stop and 127 = full speed forward. Example with RoboClaw address set to 128:

```
Send: 128, 7, 32, ((128+7+32) & 0X7F)
```

## Commands 8 - 13 Mix Mode Compatibility Commands

The following commands are mix mode commands and used to control speed and turn. Before a command is executed valid drive and turn data is required. You only need to send both data packets once. After receiving both valid drive and turn data RoboClaw will begin to operate. At this point you only need to update turn or drive data.

### 8 - Drive Forward

Drive forward in mix mode. Valid data range is 0 - 127. A value of 0 = full stop and 127 = full forward. Example with RoboClaw address set to 128:

```
Send: 128, 8, 127, ((128+8+127) & 0x7F)
```

### 9 - Drive Backwards

Drive backwards in mix mode. Valid data range is 0 - 127. A value of 0 = full stop and 127 = full reverse. Example with RoboClaw address set to 128:

```
Send: 128, 9, 127, ((128+9+127) & 0x7F)
```

### 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. Example with RoboClaw address set to 128:

```
Send: 128, 10, 127, ((128+10+127) & 0x7F1)
```

### 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. Example with RoboClaw address set to 128:

```
Send: 128, 11, 127, ((128+11+127) & 0x7F)
```

### 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. Example with RoboClaw address set to 128:

```
Send: 128, 12, 96, ((128+12=96) & 0x7F)
```

### 13 - Turn Left or Right (7 Bit)

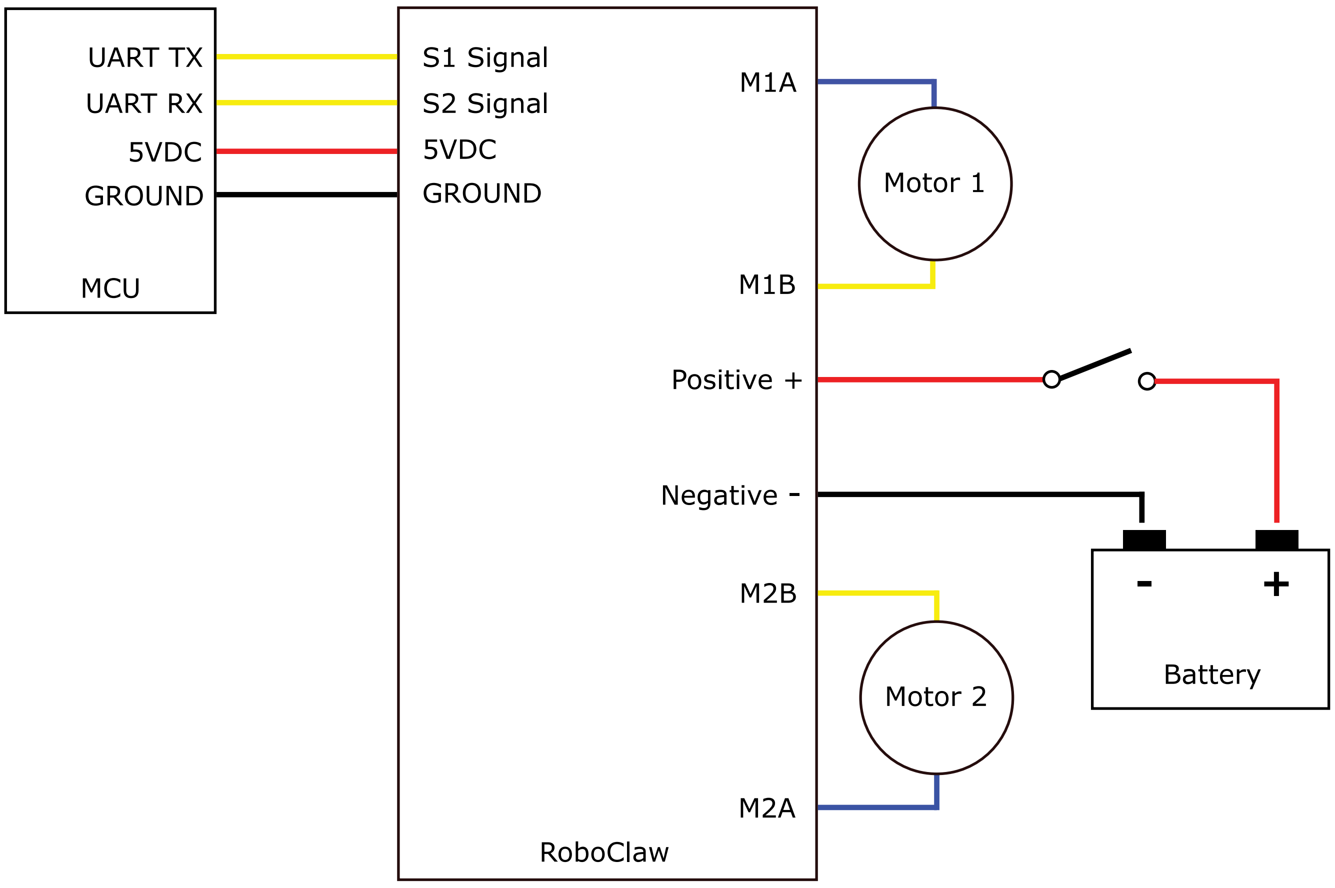
Turn left or right. Valid data range is 0 - 127. A value of 0 = full left, 0 = stop turn and 127 = full right. Example with RoboClaw address set to 128:

```
Send: 128, 13, 0, ((128+13=0) & 0x7F)
```

## Packet Serial Wiring

In packet 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 always have at least a 1ms delay after the command is received. 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 the 5VDC.



## 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 a Arduino Uno and P5 connected to S1. Set mode 7 and option 3.

```
//RoboClaw Packet Serial Test Commands 0 to 13.
//Switch settings: SW3=ON and SW5=ON.

#include “BMSerial.h”
#include “RoboClaw.h”

#define address 0x80

RoboClaw roboclaw(5,6,10000);

void setup() {
  roboclaw.begin(19200);
}

void loop() {
  roboclaw.ForwardM1(address,64);  //Cmd 0
  roboclaw.BackwardM2(address,64); //Cmd 5
  delay(2000);
  roboclaw.BackwardM1(address,64); //Cmd 1
  roboclaw.ForwardM2(address,64);  //Cmd 6
  delay(2000);
  roboclaw.ForwardBackwardM1(address,96);      //Cmd 6
  roboclaw.ForwardBackwardM2(address,32);      //Cmd 7
  delay(2000);
  roboclaw.ForwardBackwardM1(address,32);      //Cmd 6
  roboclaw.ForwardBackwardM2(address,96);      //Cmd 7
  delay(2000);

  //stop motors
  roboclaw.ForwardBackwardM1(address,0);
  roboclaw.ForwardBackwardM2(address,0);

  delay(10000);

  roboclaw.ForwardMixed(address, 64);    //Cmd 8
  delay(2000);
  roboclaw.BackwardMixed(address, 64);   //Cmd 9
  delay(2000);
  roboclaw.TurnRightMixed(address, 64);  //Cmd 10
  delay(2000);
  roboclaw.TurnLeftMixed(address, 64);         //Cmd 11
  delay(2000);
  roboclaw.ForwardBackwardMixed(address, 32);  //Cmd 12
  delay(2000);
  roboclaw.ForwardBackwardMixed(address, 96);  //Cmd 12
  delay(2000);
  roboclaw.LeftRightMixed(address, 32);  //Cmd 13
  delay(2000);
  roboclaw.LeftRightMixed(address, 96);  //Cmd 13
  delay(2000);

  //stop motors
  roboclaw.ForwardMixed(address, 0);

  delay(10000);
}
```

# ADVANCED PACKET SERIAL

## Version, Status, and Settings Commands

The following commands are used to read board status, version information and set configuration 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 |
| 49 | Read Motor Currents |
| 55 | Read Motor 1 Velocity PID Constants |
| 56 | Read Motor 2 Velocity PID Constants |
| 57 | Set Main Battery Voltages |
| 58 | Set Logic Battery Voltages |
| 59 | Read Main Battery Voltage Settings |
| 60 | Read Logic Battery Voltage Settings |
| 63 | Read Motor 1 Position PID Constants |
| 64 | Read Motor 2 Position PID Constants |
| 82 | Read Temperature |
| 83 | Read Temperature 2 |
| 90 | Read Error Status |
| 91 | Read Encoder Mode |
| 92 | Set Motor 1 Encoder Mode |
| 93 | Set Motor 2 Encoder Mode |
| 94 | Write Settings to EEPROM |

### 21 - Read Firmware Version

Read RoboClaw firmware version. Returns up to 32 bytes and is terminated by a null character. Command syntax:

```
Send: [Address, 21]
Receive: [“RoboClaw 10.2A v1.3.9, Checksum]
```

The command will return up to 32 bytes. The return string includes the product name and firmware version. The return string is terminated with a 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. Command syntax:

```
Send: [Address, 24]
Receive: [Value.Byte1, Value.Byte0, Checksum]
```

The command will return 3 bytes. Byte 1 and 2 make up a word variable which is received MSB first and is 10th of a volt. A returned value of 300 would equal 30V. Byte 3 is the checksum. It is calculated the same way as sending a command and can be used to validate the data.

### 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. Command syntax:

```
Send: [Address, 25]
Receive: [Value.Byte1, Value.Byte0, Checksum]
```

The command will return 3 bytes. Byte 1 and 2 make up a word variable which is received MSB first and is 10th of a volt. A returned value of 50 would equal 5V. Byte 3 is the checksum. It is calculated the same way as sending a command and can be used to validate the data.

### 26 - Set Minimum Logic Voltage Level

Sets logic input (LB- / LB+) minimum voltage level. If the battery voltages drops below the set voltage level RoboClaw will shut down. The value is cleared at start up and must set after each power up. The voltage is set in .2 volt increments. A value of 0 sets the minimum value allowed which is 3V. The valid data range is 0 - 120 (6V - 28V). The formula for calculating the voltage is: (Desired Volts - 6) x 5 = Value. Examples of valid values are 3V = 0, 8V = 10 and 11V = 25.

```
Send: [128, 26, 0, (154 & 0X7F)]
```

### 27 - Set Maximum Logic Voltage Level

Sets logic input (LB- / LB+) maximum voltage level. The valid data range is 0 - 144 (0V - 28V). By setting the maximum voltage level RoboClaw will go into shut down and requires a hard reset to recovers. 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: [128, 27, 82, (213 & 0X7F)]
```

### 49 - Read Motor Currents

Read the current draw from each motor in 10ma increments. Command syntax:

```
Send: [Address, 49]
Receive: [M1Cur.Byte1, M1Cur.Byte0, M2Cur.Byte1, M2Cur.Byte0, Checksum]
```

The command will return 5 bytes. Bytes 1 and 2 combine to represent the current in 10ma increments of motor1. Bytes 3 and 4 combine to represent the current in 10ma increments of motor2 . Byte 5 is the checksum.

### 55 - Read Motor 1 P, I, D and QPPS Settings

Read the PID and QPPS Settings. Command syntax:

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

### 56 - Read Motor 2 P, I, D and QPPS Settings

Read the PID and QPPS Settings. Command syntax:

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

## 57 - Set Main Battery Voltages

Set the Main Battery Voltages cutoffs, Min and Max. Command syntax:

```
Send: [Address, 57, Min(2 bytes), Max(2bytes, Checksum]
```

## 58 - Set Logic Battery Voltages

Set the Logic Battery Voltages cutoffs, Min and Max. Command syntax:

```
Send: [Address, 58, Min(2 bytes), Max(2bytes, Checksum]
```

## 59 - Read Main Battery Voltage Settings

Read the Main Battery Voltage Settings. Command syntax:

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

## 60 - Read Logic Battery Voltage Settings

Read the Main Battery Voltage Settings. Command syntax:

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

## 63 - Read Motor 1 Position P, I, D Constants

Read the Position PID Settings. Command syntax:

```
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), Checksum]
```

## 64 - Read Motor 2 Position P, I, D Constants

Read the Position PID Settings. Command syntax:

```
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), Checksum]
```

## 82 - Read Temperature

Read the board temperature. Value returned is in 0.1 degree increments. Command syntax:

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

## 83 - Read Temperature 2

Read the second board temperature(on supported units). Value returned is in 0.1 degree increments. Command syntax:

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

## 90 - Read Error Status

Read the current error status. Command syntax:

```
Send: [Address, 90]
Receive: [Error, Checksum]
```

**Error Mask**

| | |
|---|---|
| Normal | 0x00 |
| M1 OverCurrent | 0x01 |
| M2 OverCurrent | 0x02 |
| E-Stop | 0x04 |
| Temperature | 0x08 |
| Main Battery High | 0x10 |
| Main Battery Low | 0x20 |
| Logic Battery High | 0x40 |
| Logic Battery Low | 0x80 |

## 91 - Read Encoder Mode

Read the encoder mode for both motors. Command syntax:

```
Send: [Address, 91]
Receive: [Mode1, Mode2, Checksum]
```

## 92 - Set Motor 1 Encoder Mode

Set the Encoder Mode for motor 1. Command syntax:

```
Send: [Address, 92, Mode, Checksum]
```

## 93 - Set Motor 2 Encoder Mode

Set the Encoder Mode for motor 1. Command syntax:

```
Send: [Address, 93, Mode, Checksum]
```

**Encoder Mode bits**

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

## 94 - Write Settings to EEPROM

Writes all settings to non-volatile memory. Command syntax:

```
Send: [Address, 94]
Receive: [Checksum]
```

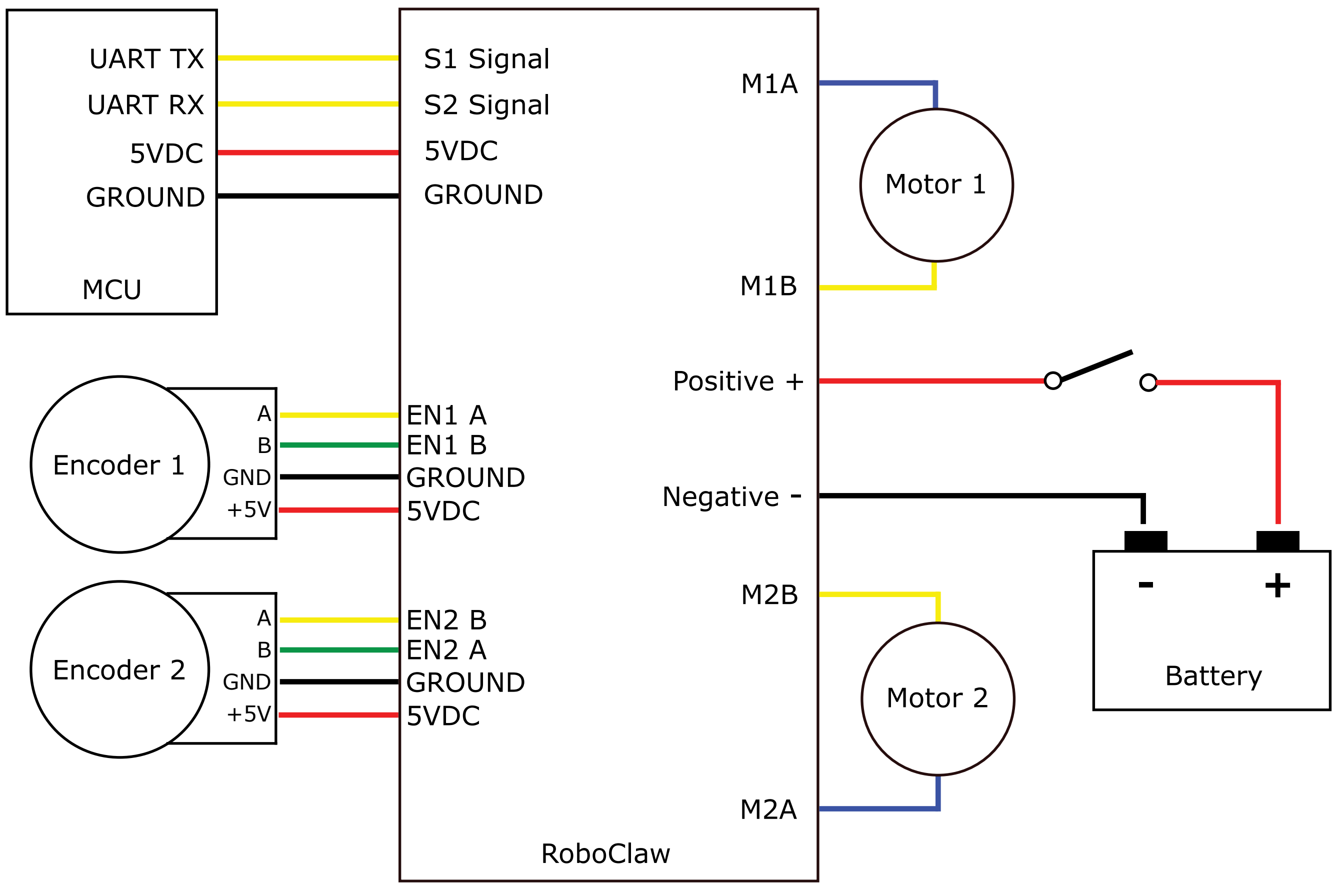
# ENCODERS

## Quadrature Encoder Wiring

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

In a robot with two motors configuration one motor will spin clock wise (CW) while the other motor will spin counter clock wise (CCW). The A and B inputs for one of the encoders must be reversed as shown. 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.

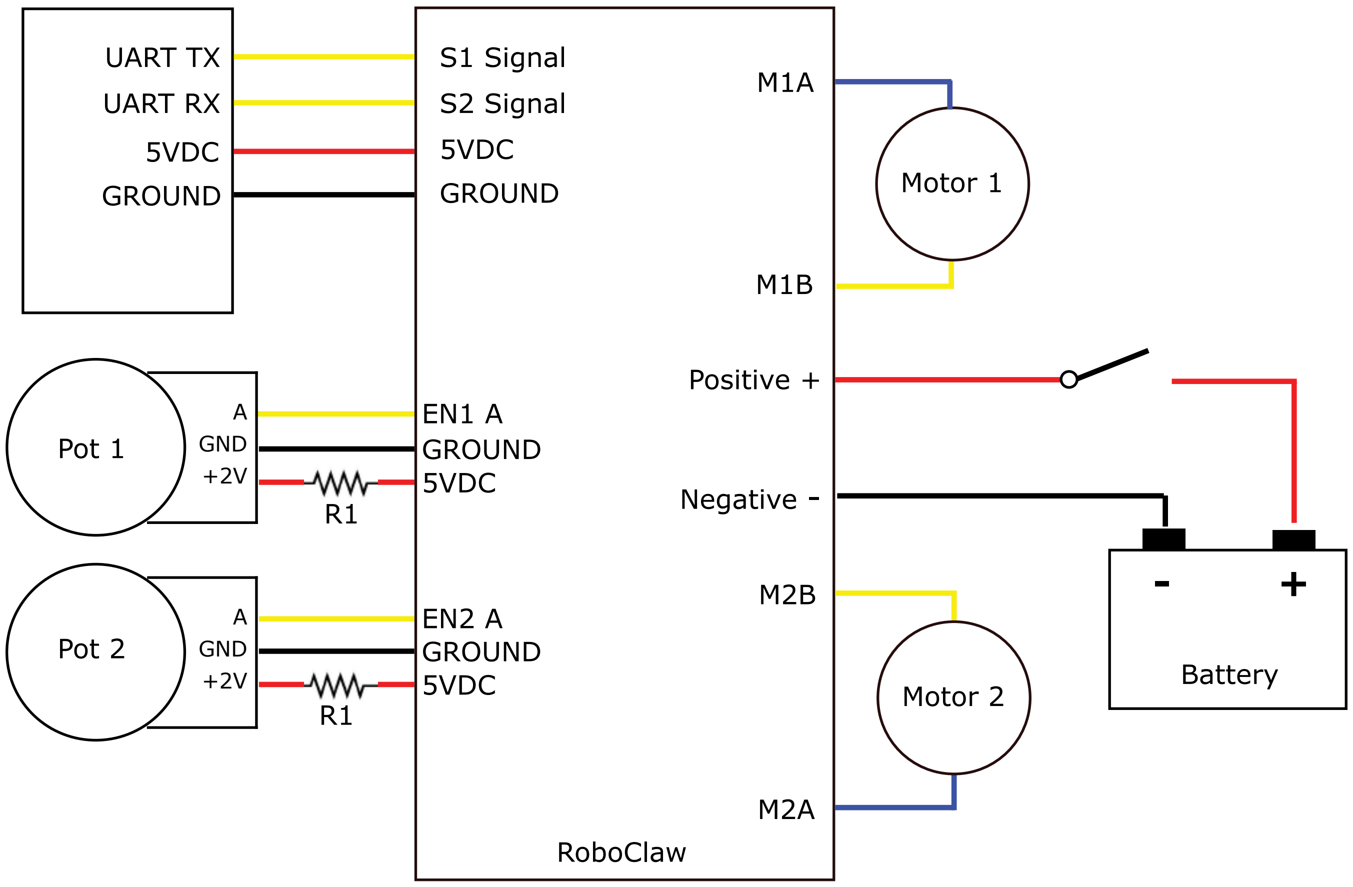
The diagram below shows the main battery as the only power source. Make sure the LB jumper is set correctly. The 5VDC shown connected is only required if your MCU needs a power source. This is the BEC feature of RoboClaw. If the MCU has its own power source do not the 5VDC.



## 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 = 7.5k, for a 10k pot R1 = 15k and for a 20k pot R1 = 30k.

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.



## Encoder/Motor Calibration for Velocity/Position Control

To control motors speed and/or position with encoders correctly the Roboclaw must have its settings calibrated for the specific motors/encoders being used. The IonMotion software makes calibrating manually easy and also offers an autotune function for both velocity and position control modes.

Once the calibration settings for the specific mode you will be using(velocity, position or a cascaded velocity/position control) are set and working correctly within the IonMotion software the settings can be saved to the RoboClaw eeprom and will be loaded each time the unit powers up.

## Velocity Manual 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 IonMotion 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.

## Position Manual 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.

**Auto tuning**

IonMotion includes the option to autotune velocity and or position values. To use these options you should first make sure your encoder and motor are running in the correct direction and that basic PWM control of the motor works as expected. Then just click the autotune button for the motor you want to tune. The autotune function will try to determine the best settings for the motor. In the Velocity settings window it will autotune for velocity. In the Position Settings window you have the option to tune a simple PD position controller, a PID position controller or a cascaded Position/Velocity controller(PIV). The cascaded tune will determine both the velocity and position values for the motor. Autotune functions usually return reasonable values but in most cases you will still need to manually adjust them for optimum performance.

## Encoder Commands

The following commands are used in dealing with the quadrature decoding counter registers. The quadrature decoder is a simple counter that counts the incoming pulses, tracks the direction and speed of each pulse. There are two registers one each for M1 and M2. (Note: A microcontroller with a hardware UART is recommended for use with packet serial modes).

| Command | Description |
|---|---|
| **16** | Read Encoder Register for M1. |
| **17** | Read Encoder Register 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). |

## 16 - Read Encoder Register M1

Read decoder M1 counter. Since CMD 16 is a read command it does not require a checksum. However a checksum value will be returned from RoboClaw and can be used to validate the data. Command syntax:

```
Send: [Address, CMD]
Receive: [Value1.Byte3, Value1.Byte2, Value1.Byte1, Value1.Byte0, Value2,
Checksum]
```

The command will return 6 bytes. Byte 1,2,3 and 4 make up a long variable which is received MSB first and represents the current count which can be any value from 0 - 4,294,967,295. With quadrature encoders each pulse edge will increment or decrement the counter depending on the direction of rotation. Absolute encoder values are converted from an analog voltage into a value from 0 to 2047 for the full 2v range.

Byte 5 is the status byte for M1 decoder. It tracks counter underflow, direction, overflow and if the encoder is operational. 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

Byte 6 is the checksum. It is calculated the same way as sending a command, Sum all the values sent and received except the checksum and mask the 8th bit.

### 17 - Read Quadrature Encoder Register M2

Read decoder M2 counter. Since CMD 16 is a read command it does not require a checksum. However a checksum value will be returned from RoboClaw and can be used to validate the data. Command syntax:

```
Send: [Address, CMD]
Receive: [Value1.Byte3, Value1.Byte2, Value1.Byte1, Value1.Byte0, Value2, Checksum]
```

The command will return 6 bytes. Byte 1,2,3 and 4 make up a long variable which is received MSB first and represents the current count which can be any value from 0 - 4,294,967,295. With quadrature encoders each pulse edge will increment or decrement the counter depending on the direction of rotation. Absolute encoder values are converted from an analog voltage into a value from 0 to 2047 for the full 2v range.

Byte 5 is the status byte for M1 decoder. It tracks counter underflow, direction, overflow and if the encoder is operational. 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

Byte 6 is the checksum.

### 18 - Read 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 decoder channels. Since CMD 18 is a read command it does not require a checksum to be sent. However a checksum value will be returned from RoboClaw and can be used to validate the data. Command syntax:

```
Send: [Address, CMD]
Receive: [Value1.Byte3, Value1.Byte2, Value1.Byte1, Value1.Byte0, Value2, Checksum]
```

The command will return 6 bytes. Byte 1,2,3 and 4 make up a long variable which is received MSB first and is the current count change per second which can be any value from 0 - 4,294,967,295. Byte 5 is the direction (0 – forward, 1 - backward). Byte 6 is the checksum.

### 19 - Read 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 decoder channels. Since CMD 19 is a read command it does not require a checksum to be sent. However a checksum value will be returned from RoboClaw and can be used to validate the data. Command syntax:

```
Send: [Address, CMD]
Receive: [Value1.Byte3, Value1.Byte2, Value1.Byte1, Value1.Byte0, Value2, Checksum]
```

The command will return 6 bytes. Byte 1,2,3 and 4 make up a long variable which is received MSB first and is the current count change per second which can be any value from 0 - 4,294,967,295. Byte 5 is the direction (0 – forward, 1 - backward). Byte 6 is the checksum.

### 20 - Reset Quadrature Encoder Counters

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

```
Send: [128, 20, ((128+20) & 0x7F)]
```

### 22 - Set Encoder 1 Register 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), Checksum]
```

### 23 - Set Encoder 2 Register 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), Checksum]
```

The following commands are used to control motor speeds, acceleration and distance using the quadrature encoders. All speeds are given in quad pulses per second (QPPS) unless otherwise stated. Quadrature encoders of different types and manufactures can be used. However many have different resolutions and maximum speeds at which they operate. So each quadrature encoder will produce a different range of pulses per second.

| Command | Description |
|---|---|
| **28** | Set PID Constants for M1. |
| **29** | Set PID Constants for M2. |
| **30** | Read Current M1 Speed Resolution 125th of a Second. |
| **31** | Read Current M2 Speed Resolution 125th of a Second. |
| **32** | Drive M1 With Signed Duty Cycle. (Encoders not required) |
| **33** | Drive M2 With Signed Duty Cycle. (Encoders not required) |
| **34** | Mix Mode Drive M1 / M2 With Signed Duty Cycle. (Encoders not required) |
| **35** | Drive M1 With Signed Speed. |
| **36** | Drive M2 With Signed Speed. |
| **37** | Mix Mode Drive M1 / M2 With Signed Speed. |
| **38** | Drive M1 With Signed Speed And Acceleration. |
| **39** | Drive M2 With Signed Speed And Acceleration. |
| **40** | Mix Mode Drive M1 / M2 With Speed And Acceleration. |
| **41** | Drive M1 With Signed Speed And Distance. Buffered. |
| **42** | Drive M2 With Signed Speed And Distance. Buffered. |
| **43** | Mix Mode Drive M1 / M2 With 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** | Mix Mode Drive M1 / M2 With Speed, Acceleration And Distance. Buffered. |
| **47** | Read Buffer Length. |
| **50** | Mix Drive M1 / M2 With Individual Speed and Acceleration |
| **51** | Mix Drive M1 / M2 With Individual Speed, Accel and Distance |
| **52** | Drive M1 With Duty and Accel. (Encoders not required) |
| **53** | Drive M2 With Duty and Accel. (Encoders not required) |
| **54** | Mix Drive M1 / M2 With Duty and Accel. (Encoders not required) |
| **61** | Set Position PID Constants for M1. |
| **62** | Set Position PID Constants for M2 |
| **65** | Drive M1 with signed Speed, Accel, Deccel and Position |
| **66** | Drive M2 with signed Speed, Accel, Deccel and Position |
| **67** | Drive M1 & M2 with signed Speed, Accel, Deccel and Position |
| **68** | Set default duty cycle acceleration for M1 |
| **69** | Set default duty cycle acceleration for M2 |

### 28 - Set 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), Checksum]
```

Each value is made up of 4 bytes for a long. To write the registers a checksum value is used. This prevents an accidental write.

### 29 - Set 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), Checksum]
```

Each value is made up of 4 bytes for a long. To write the registers a checksum value is used. This prevents an accidental write.

### 30 - Read Current Speed M1

Read the current pulse per 125th of a second. This is a high resolution version of command 18 and 19. Command 30 can be used to make a independent PID routine. The resolution of the command is required to create a PID routine using any microcontroller or PC used to drive RoboClaw. The command syntax:

```
Send: [Address, CMD]
Receive: [Value1.Byte3, Value1.Byte2, Value1.Byte1, Value1.Byte0, Value2, Checksum]
```

The command will return 5 bytes, MSB sent first for a long. The first 4 bytes are a 32 byte value (long) that repersent the speed. The 5th byte (Value2) is direction (0 – forward, 1 - backward). is A checksum is returned in order to validate the data returned.

### 31 - Read Current Speed M2

Read the current pulse per 125th of a second. This is a high resolution version of command 18 and 19. Command 31 can be used to make a independent PID routine. The resolution of the command is required to create a PID routine using any microcontroller or PC used to drive RoboClaw. The command syntax:

```
Send: [Address, CMD]
Receive: [Value1.Byte3, Value1.Byte2, Value1.Byte1, Value1.Byte0, Value2, Checksum]
```

The command will return 5 bytes, MSB sent first for a long. The first 4 bytes are a 32 byte value (long) that repersent the speed. The 5th byte (Value2) is direction (0 – forward, 1 - backward). is A checksum is returned in order to validate the data returned.

### 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. The command syntax:

```
Send: [Address, CMD, Duty(2 Bytes), Checksum]
```

The duty value is signed and the range is -32768 to +32767.

### 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, CMD, Duty(2 Bytes), Checksum]
```

The duty value is signed and the range is -32768 to +32767.

### 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, CMD, DutyM1(2 Bytes), DutyM2(2 Bytes), Checksum]
```

The duty value is signed and the range is -32768 to +32767.

### 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. The command syntax:

```
Send: [Address, CMD, Qspeed(4 Bytes), Checksum]
```

4 Bytes (long) are used to express the pulses per second. Quadrature encoders send 4 pulses per tick. So 1000 ticks would be counted as 4000 pulses.

### 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. The command syntax:

```
Send: [Address, CMD, Qspeed(4 Bytes), Checksum]
```

4 Bytes (long) are used to expressed the pulses per second. Quadrature encoders send 4 pulses per tick. So 1000 ticks would be counted as 4000 pulses.

### 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. The command syntax:

```
Send: [Address, CMD, QspeedM1(4 Bytes), QspeedM2(4 Bytes), Checksum]
```

4 Bytes (long) are used to express the pulses per second. Quadrature encoders send 4 pulses per tick. So 1000 ticks would be counted as 4000 pulses.

### 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. The command syntax:

```
Send: [Address, CMD, Accel(4 Bytes), Qspeed(4 Bytes), Checksum]
```

4 Bytes (long) are used to express the pulses per second. Quadrature encoders send 4 pulses per tick. So 1000 ticks would be counted as 4000 pulses. The acceleration is measured in speed 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. The command syntax:

```
Send: [Address, CMD, Accel(4 Bytes), Qspeed(4 Bytes), Checksum]
```

4 Bytes (long) are used to express the pulses per second. Quadrature encoders send 4 pulses per tick. So 1000 ticks would be counted as 4000 pulses. The acceleration is measured in speed 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. The command syntax:

```
Send: [Address, CMD, Accel(4 Bytes), QspeedM1(4 Bytes), QspeedM2(4 Bytes), Checksum]
```

4 Bytes (long) are used to express the pulses per second. Quadrature encoders send 4 pulses per tick. So 1000 ticks would be counted as 4000 pulses. The acceleration is measured in speed 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. The command syntax:

```
Send: [Address, CMD, QSpeed(4 Bytes), Distance(4 Bytes), Buffer(1 Byte), Checksum]
```

4 Bytes(long) are used to express the pulses per second.  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. The command syntax:

```
Send: [Address, CMD, QSpeed(4 Bytes), Distance(4 Bytes), Buffer(1 Byte), Checksum]
```

4 Bytes(long) are used to express the pulses per second.  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. The command syntax:

```
Send: [Address, CMD, QSpeedM1(4 Bytes), DistanceM1(4 Bytes),
        QSpeedM2(4 Bytes), DistanceM2(4 Bytes), Buffer(1 Byte), Checksum]
```

4 Bytes(long) are used to express the pulses per second. 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. The command syntax:

```
Send: [Address, CMD, Accel(4 bytes), QSpeed(4 Bytes), Distance(4 Bytes),
        Buffer(1 Byte), Checksum]
```

4 Bytes(long) are used to express the pulses per second. 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. The command syntax:

```
Send: [Address, CMD, Accel(4 bytes), QSpeed(4 Bytes), Distance(4 Bytes),
        Buffer(1 Byte), Checksum]
```

4 Bytes(long) are used to express the pulses per second. 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 - 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. The command syntax:

```
Send: [Address, CMD, Accel(4 Bytes), QSpeedM1(4 Bytes), DistanceM1(4 Bytes),
QSpeedM2(4 bytes), DistanceM2(4 Bytes), Buffer(1 Byte), Checksum]
```

4 Bytes(long) are used to express the pulses per second.  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, CMD]
Receive: [BufferM1(1 Bytes), BufferM2(1 Bytes), Checksum]
```

The return values represent how many commands per buffer are waiting to be executed. The maximum buffer size per motor is 31 commands. 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 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. The command syntax:

```
Send: [Address, CMD, AccelM1(4 Bytes), QspeedM1(4 Bytes), AccelM2(4 Bytes), QspeedM2(4
Bytes), Checksum]
```

4 Bytes (long) are used to express the pulses per second. Quadrature encoders send 4 pulses per tick. So 1000 ticks would be counted as 4000 pulses. The acceleration is measured in speed 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 - Drive M1 / M2 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. The command syntax:

```
Send: [Address, CMD, AccelM1(4 Bytes), QSpeedM1(4 Bytes), DistanceM1(4 Bytes),  Ac-
celM2(4 Bytes), QSpeedM2(4 bytes), DistanceM2(4 Bytes), Buffer(1 Byte), Checksum]
```

4 Bytes(long) are used to express the pulses per second. 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. The command syntax:

```
Send: [Address, CMD, Duty(2 bytes), Accel(2 Bytes), Checksum]
```

The duty value is signed and the range is -32768 to +32767. The accel value range is 0 to 655359.

### 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. The command syntax:

```
Send: [Address, CMD, Duty(2 bytes), Accel(2 Bytes), Checksum]
```

The duty value is signed and the range is -32768 to +32767. The accel value range is 0 to 655359.

### 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), Checksum]
```

The duty value is signed and the range is -32768 to +32767. The accel value range is 0 to 655359.

## 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, CMD, P(4 bytes), I(4 bytes), D(4 bytes), MaxI(4 bytes), Deadzone(4
bytes), MinPos(4 bytes), MaxPos(4 bytes)
```

Position constants are used only with the Position commands, 65,66 and 67 and RC or Analog mode when in absolute mode with encoders or potentiometers.

## 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, CMD, P(4 bytes), I(4 bytes), D(4 bytes), MaxI(4 bytes), Deadzone(4
bytes), MinPos(4 bytes), MaxPos(4 bytes)
```

Position constants are used only with the Position commands, 65,66 and 67 and RC or Analog mode when in absolute mode with encoders or potentiometers.

## 65 - 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. The command syntax:

```
Send: [Address, CMD, Accel(4 bytes), QSpeed(4 Bytes), Deccel(4 bytes), Position(4
Bytes), Buffer(1 Byte), Checksum]
```

## 66 - 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. The command syntax:

```
Send: [Address, CMD, Accel1(4 bytes), QSpeed1(4 Bytes), Deccel1(4 bytes), Position1(4
Bytes), Accel2(4 bytes), QSpeed2(4 Bytes), Deccel2(4 bytes), Position2(4 Bytes), Buf-
fer(1 Byte), Checksum]
```

## 67 - 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. The command syntax:

```
Send: [Address, CMD, Accel(4 bytes), QSpeed(4 Bytes), Deccel(4 bytes), Position(4
Bytes),Buffer(1 Byte), Checksum]
```

### 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. The command syntax:

```
Send: [Address, CMD, Accel(4 bytes), Checksum]
```

### 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. The command syntax:

```
Send: [Address, CMD, Accel(4 bytes), Checksum]
```

### 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.

```
//RoboClaw Packet Serial Mode.
//Switch settings: SW3=ON, SW4=ON, SW5=ON

#include "BMSerial.h"
#include "RoboClaw.h"

#define address 0x80

#define Kp 0x00010000
#define Ki 0x00008000
#define Kd 0x00004000
#define qpps 44000

BMSerial terminal(0,1);
RoboClaw roboclaw(5,6,10000);

void setup() {
  terminal.begin(38400);
  roboclaw.begin(38400);

  roboclaw.SetM1Constants(address,Kd,Kp,Ki,qpps);
  roboclaw.SetM2Constants(address,Kd,Kp,Ki,qpps);
}

void loop() {
  uint8_t status;
  bool valid;

  uint32_t enc1= roboclaw.ReadEncM1(address, &status, &valid);
  if(valid){
    terminal.print("Encoder1:");
    terminal.print(enc1,HEX);
    terminal.print(" ");
    terminal.print(status,HEX);
    terminal.print(" ");
  }
  uint32_t enc2 = roboclaw.ReadEncM2(address, &status, &valid);
  if(valid){
    terminal.print("Encoder2:");
    terminal.print(enc2,HEX);
    terminal.print(" ");
    terminal.print(status,HEX);
    terminal.print(" ");
  }
  uint32_t speed1 = roboclaw.ReadSpeedM1(address, &status, &valid);
  if(valid){
    terminal.print("Speed1:");
    terminal.print(speed1,HEX);
    terminal.print(" ");
  }
  uint32_t speed2 = roboclaw.ReadSpeedM2(address, &status, &valid);
  if(valid){
    terminal.print("Speed2:");
    terminal.print(speed2,HEX);
    terminal.print(" ");
  }
  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.

```
//RoboClaw Packet Serial Mode.
//Switch settings: SW3=ON, SW4=ON, SW5=ON

#include “BMSerial.h”
#include “RoboClaw.h”

#define address 0x80


#define Kp 0x00010000
#define Ki 0x00008000
#define Kd 0x00004000
#define qpps 44000

BMSerial terminal(0,1);
RoboClaw roboclaw(5,6,10000);

void setup() {
  terminal.begin(38400);
  roboclaw.begin(38400);

  roboclaw.SetM1Constants(address,Kd,Kp,Ki,qpps);
  roboclaw.SetM2Constants(address,Kd,Kp,Ki,qpps);
}

void displayspeed(void)
{
  uint8_t status;
  bool valid;

  uint32_t enc1= roboclaw.ReadEncM1(address, &status, &valid);
  if(valid){
    terminal.print(“Encoder1:”);
    terminal.print(enc1,DEC);
    terminal.print(“ “);
    terminal.print(status,HEX);
    terminal.print(“ “);
  }
  uint32_t enc2 = roboclaw.ReadEncM2(address, &status, &valid);
  if(valid){
    terminal.print(“Encoder2:”);
    terminal.print(enc2,DEC);
    terminal.print(“ “);
    terminal.print(status,HEX);
    terminal.print(“ “);
  }
uint32_t speed1 = roboclaw.ReadSpeedM1(address, &status, &valid);
  if(valid){
    terminal.print("Speed1:");
    terminal.print(speed1,DEC);
    terminal.print(" ");
  }
  uint32_t speed2 = roboclaw.ReadSpeedM2(address, &status, &valid);
  if(valid){
    terminal.print("Speed2:");
    terminal.print(speed2,DEC);
    terminal.print(" ");
  }
  terminal.println();
}

void loop() {
  roboclaw.SpeedAccelDistanceM1(address,12000,12000,48000);
  uint8_t depth1,depth2;
  do{
    displayspeed();
    roboclaw.ReadBuffers(address,depth1,depth2);
  }while(depth1);
  roboclaw.SpeedAccelDistanceM1(address,12000,-12000,48000);
  do{
    displayspeed();
    roboclaw.ReadBuffers(address,depth1,depth2);
  }while(depth1);

}
```

## RoboClaw Electrical Specifications

| Characteristic | Model | Rating | Min | Typ | Max |
|---|---|---|---|---|---|
| Pulse Per Second | All | PPS | 0 | | 8,000,000 |
| Logic Battery | All | VDC | 6 | 12 | 34 |
| Main Battery | 2x5A | VDC | 6 | | 34 |
| | 2x15A | VDC | 6 | | 34 |
| | 2x30A | VDC | 6 | | 34 |
| | 2x60A | VDC | 6 | | 34 |
| | 2x60A HV | VDC | 10.5 | | 60 |
| External Current Draw (BEC) | 2x5A | mA | | | 200 |
| | 2x15A | A | | | 3 |
| | 2x30A | A | | | 3 |
| | 2x60A | A | | | 3 |
| | 2x60A HV | mA | | | 200 |
| Motor Current Per Channel | 2x5A | A | | 5[2] | 10[1] |
| | 2x15A | | | 15[2] | 30[1] |
| | 2x30A | | | 30[2] | 60[1] |
| | 2x60A | | | 60[2] | 120[1] |
| | 2x60A HV | | | 60[2] | 120[1] |
| Logic Circuit | All | mA | | 30 | |
| I/O Input | All | VDC | 0 | | 5 |
| I/O Output | All | VDC | 0 | | 3.3 |
| Analog Voltage Range | All | VDC | 0 | | 2 |
| Tempature Range | All | C | -40 | 40 | +100 |

**Note 1:** Maximum current is automatically reduced to the rated current limit within 2.5 seconds

**Note 2:** Current is limited by maximum temperature. Starting at 85c, the current limit is reduced on a slope with a maximum temperature of 100c, which will reduce the current to 0 amps.

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