MOTION CONTROL

RoboClaw Series
Brushed DC Motor Controllers

RoboClaw 2x5A
RoboClaw 2x15A
RoboClaw 2x30A
RoboClaw 2x45A
RoboClaw 2x45A ST
RoboClaw 2x60A
Roboclaw 2x60HV

User Manual

Firmware 4.1.11 and Newer
Hardware V3, V4 and V5
User Manual Revision 5

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	Description
4.1.11	1. Manual home setting available on S4 and S5. User must send movement commands to motor. Motor will stop automatically when the home signal triggers and the encoder count for that motor will be reset 2. Fixed unsigned value underflow in analog filter function 3. Changed E-Stop to OR instead of AND when using multiple E-Stop inputs. Note that if any E-Stop is set as latching all E-Stops will be latching 4. Added enocder channel swap setting(eg Enc2 to Motor1 and Enc 1 to Motor 2 etc). 5. Added Home Signal States to status word. See GetStatus command 6. Changed communications checksum in packet serial to CRC-CCITT(CRC16 xmodem).
4.1.10	1. Added reset to default button option on power up(hold SET while powering on unit) 2. Added new options for S3, S4 and S5.
4.1.9	1. Added hysteresis to voltage protection
4.1.8	1, Added motor breaking on maximum overvoltage error 2. Added user overvoltage setting 3. Added user undervoltage setting 4. Added Sign Magnitude Drive option(not availble on Roboclaw 2x60A v4.2 and older 5. Changed overcurrent error to overcurrent warning. Overcurrent limit is controlled by temperature
4.1.7	1. Adjusted overcurrent temperature range calculation 2. Added button swap option
4.1.6	1. Changed timer counter to volatile
4.1.5	1. Reversed RC motor channels to match signal input channels 2. Changed read back delay to use timer instead of isntruction cycle count delay

Revision	Description
4.1.4	1. fixed speed control using RC input(eg velocity control using encoders with RC/Analog inputs) 2. Removes Set/GetDither commands 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 2. Fixed battery cutoff settings 3. Fixed battery auto cell count detect 4. Config settings now must be saved using WriteNVM 5. USB interface is locked to packet serial mode now. Standard serial is only available on TTL Serial pins. 6. Fixed checksum calculation on re-set encoder commands
4.1.1	1. Added timeouts on USB while loops. 2. Changed current offset calibration for better accuracy
4.1.0	1. Added new error/warning code. GetErrorStatus command now returns 16bits of data 2. Fixed encoder re-set command to support values larger then 65535
4.0.9	1. Removed max current error 2. Add maxcurrent chopper 3. Add temperature max current ramp down

Precautions

There are several important precautions that should be followed to avoid damage to the RoboClaw and connected systems.

1. Disconnecting the negative power terminal is not the proper way to shut down a motor controller. If any I/O are connected to the RoboClaw a ground loop through the attached I/O pins will result. Which can cause damaged to the RoboClaw and any attached devices. To shut down a motor controller the positive power connections should be removed first after the motors have stopped moving.

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

3. Powering off in an emergency, a properly sized switch and/or contactor should be used. Also because the power may be disconnected at any time there should be a path for regeneration energy to get back to the battery even after the power has been disconnected. Use a power diode with proper ratings to provide a path across the switch/contactor.

4. Depending on the model of RoboClaw there is a minimum power requirement of at least 6V. Under heavy loads, if the logic battery and main battery are combined, brownouts can happen. This can cause erratic behavior from RoboClaw. If this is the case a seperate logic battery should be used to power the logic.

Motor Selection

When selecting RoboClaw for a motor several factors should 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. Choose a Roboclaw model that can support the stall current of the motor to insure you can drive the motor properly without damage to the Roboclaw.

Stall Current

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

Running Current

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

Wire Lengths

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

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 is recommended as the main power source for RoboClaw. Some linear power supplies can also be used without additional hardware if they have built in voltage clamps. Most Linear and Switching power supplies are not capable of handling the regeneration energy generated by DC motors. The regeneration creates voltage spikes which most power sipplies are not designed to handle. Switching power supplies will momentarily reduce voltage and or shut down, causing brown outs which will leave RoboClaw in an unsafe state. The Roboclaws minimum and maximum voltage levels can be set to prevent some of these voltage spikes, however this will cause the motors to brake when slowing down too quickly in an attempt to reduce the over voltage spikes. This will also limit power output when accelerating motors or when the load changes to prevent undervoltage condition.

Optical Encoders

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

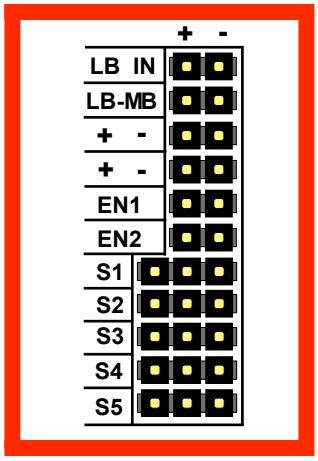
Easy to use Libraries

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

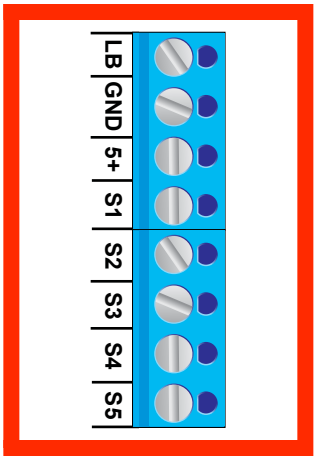
Header Overview

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.

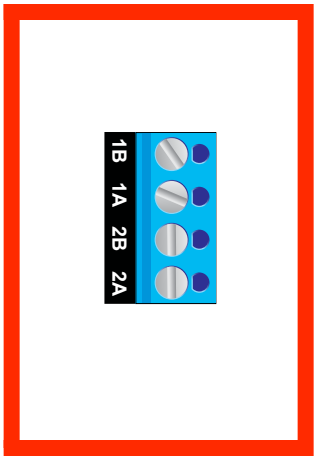
Pin Headers



Screw Terminals



Screw Terminal Encoder



Logic Battery (LB IN)

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

BEC Source (LB-MB)

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

Encoder Power (+ -)

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

Encoder Inputs (EN1 / EN2 - 1B / 1A / 2B / 2A)

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

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

Control Inputs (S1 / S2 / S3 / S4 /S5)

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

Main Battery Screw Terminals

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

Do not install the power wires reversed. The Roboclaw will be permenantly damaged.

Disconnect

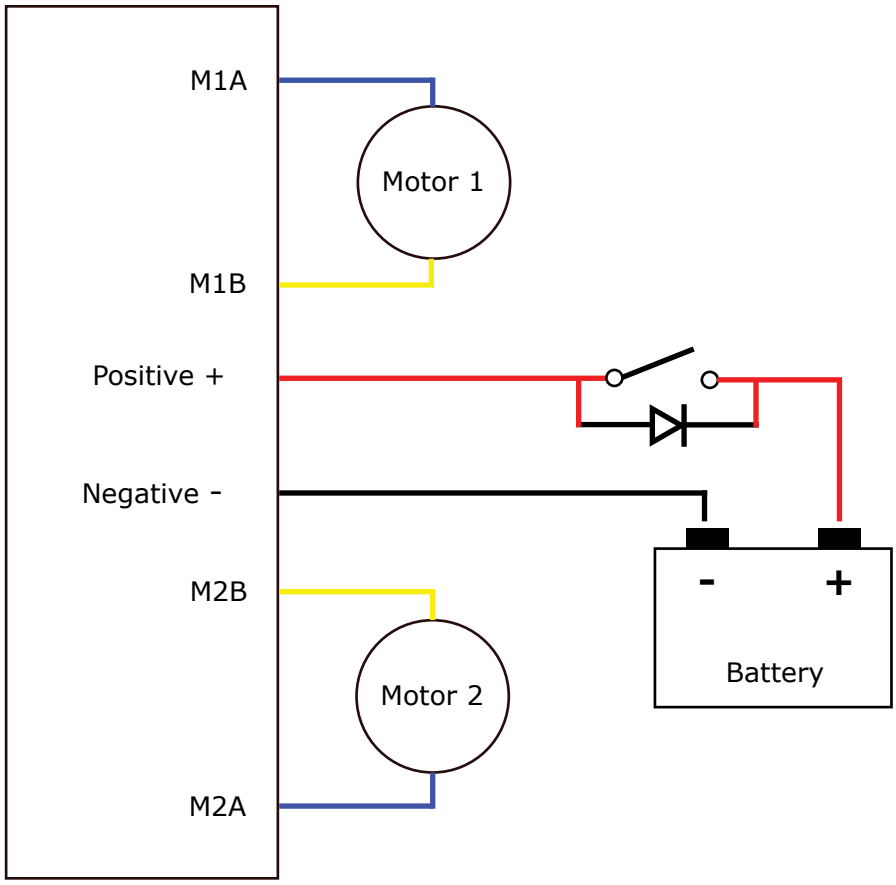
The main battery should have a disconnect in case of a run away situation and power needs to be cut. The switch must be rated to handle the maximum current and voltage from the battery. This will vary depending on the type of motors and or power source you are using. A typically solution would be an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

Motor Screw Terminals

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

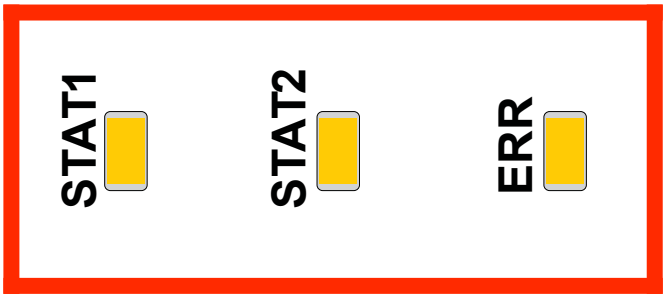
Basic Wiring

The wiring diagrahm below illustrates the basic battery and motor connections for RoboClaw. M1A and M1B is motor channel 1 with M2A and M2B as motor channel 2.



Status and Error LEDs

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



Error and Warning States

When an error occurs both motor channel outputs will be disabled and RoboClaw will stop any further actions until the unit is reset, or in the case of non-latching E-Stops, the error state is cleared. When warnings occur both motor channel outputs will be controlled automatically depending on the warning condition(s).

Condition	Type	LED Status	
E-Stop	Error	All three LEDs lit.	Motors are stopped by braking.
Over 85c Temperature	Warning	Error LED lit while condition is active.	Motor current limit is recalculated based on temperature.
Over 100c Temperature	Error	Error LED blinks once with short delay. Other LEDs off.	Motors freewheel while condition exist.
Over Current	Warning	Error LED lit while condition is active.	Motor power is automatically limited.
Driver Fault	Error	Error LED blinking twice. STAT1 or STAT2 indicates channel.	Motors freewheel. RoboClaw has detected damage.
Logic Battery High	Error	Error LED blinking three times.	Motors freewheel until RoboClaw is reset.
Logic Battery Low	Error	Error LED blinking four times.	Motors freewheel until RoboClaw is reset.
Main Battery High	Error	Error LED blinking five times.	Motors are stopped by braking until RoboClaw is reset.
Main Battery High	Warning	Error LED lit while condition is active.	Motors are stopped by braking while condition exist.
Main Battery Low	Warning	Error LED lit while condition is active.	Motors freewheel while condition exist.
M1 or M2 Home	Warning	Error LED lit while condition is active.	Motor is stopped and encoder is reset to 0

Firmware Update LED State

If all three LEDs begin to cycle on and off after powering on, the Roboclaw has been set to install new firmware. Use IonMotion on a Windows PC to install the new firmware to clear this state.

Automatic Battery Detection on Startup

If the automatic battery detection mode is enabled the Stat2 LED will blink to indicate the detected battery type. Each blink indicates the number of LIPO cells detected. If automatic detection is used the number of cells detected should be confirmed on power up before running the unit.

Undercharged or overcharged batteries can cause invalid autodetection.

RoboClaw Modes

There are 4 main modes with variations totaling 14 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.

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

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 microcontrollers such as a Basic Stamp to control RoboClaw. RoboClaw expects servo pulse inputs to control the direction and speed. Very similar to how a regular servo is controlled. RC mode can use encoders if properly setup(See Encoder section).

2. Analog Mode 3 & 4 - Analog mode uses an analog signal from 0V to 2V to control the speed and direction of each motor. RoboClaw can be controlled using a potentiometer or filtered PWM from a microcontroller. Analog mode is ideal for interfacing RoboClaw with joystick positioning systems or other non microcontroller interfacing hardware. Analog mode can use encoders if properly setup(See Encoder section).

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 or an equivilent level converter circuit must be used since RoboClaw only works with TTL level inputs. 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. Encoders are not supported with Standard Serial mode.

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 or an equivilent level converter circuit must be used since RoboClaw only works with TTL level input. In packet serial mode each RoboClaw is assigned a unique address. There are 8 addresses available. This means up to 8 RoboClaws can be on the same serial port. Encoders are support in Packet Serial mode(See Encoder section).

5. USB Control - USB can be connected in any mode. When the Roboclaw is not in packet serial mode USB packet serial commands can be used to read status information and/or set configuration settings, however motor movement commands will not function. When in packet serial mode if another device, for example an Arduino, is connected to the S1 and S2 pins and sending commands to the Roboclaw both those commands and USB packet serial commands will execute.

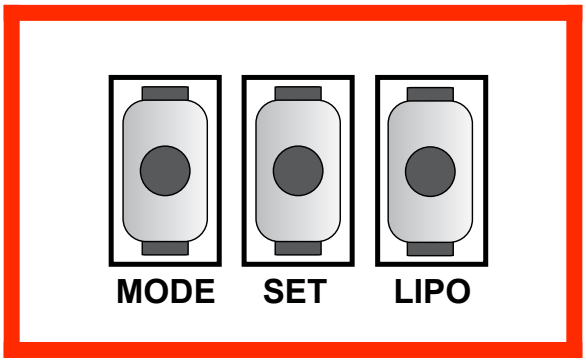
Configuring RoboClaw Modes

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

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 setting. 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
5	57600bps
6	115200bps
7	230400bps
8	460800bps

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)

Manual Voltage Settings

The minimum and maximum voltage can be set using the IonMotion software or packet serial commands. Values can be set to any value between the boards minimum and maximum voltage limits. This is useful when using a power supply. A minimum voltage just below the power supply voltage (2 to 3v below) will prevent the power supply voltage from dipping too low under heavy load. A maximum voltage set just above the power supply voltage(2 to 3v above) will help protect the power supply and RoboClaw from regenerative voltage spikes if an external voltage clamp circuit is not being used.

USB CONTROL

RoboClaw and USB Power

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

RoboClaw USB Connection

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

USB Comport and Baudrate

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

Unlike a real comport the USB CDC Virtual Comport does not need a baud rate to be set correctly. It will always communicate at the fastest speed the master and slave device can reach. This will typically be around 1mb/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 direction and speed of motor 2.

RC Mode With Mixing

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

Using RC Mode with feedback for velocity/position control

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

RC Mode Options

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

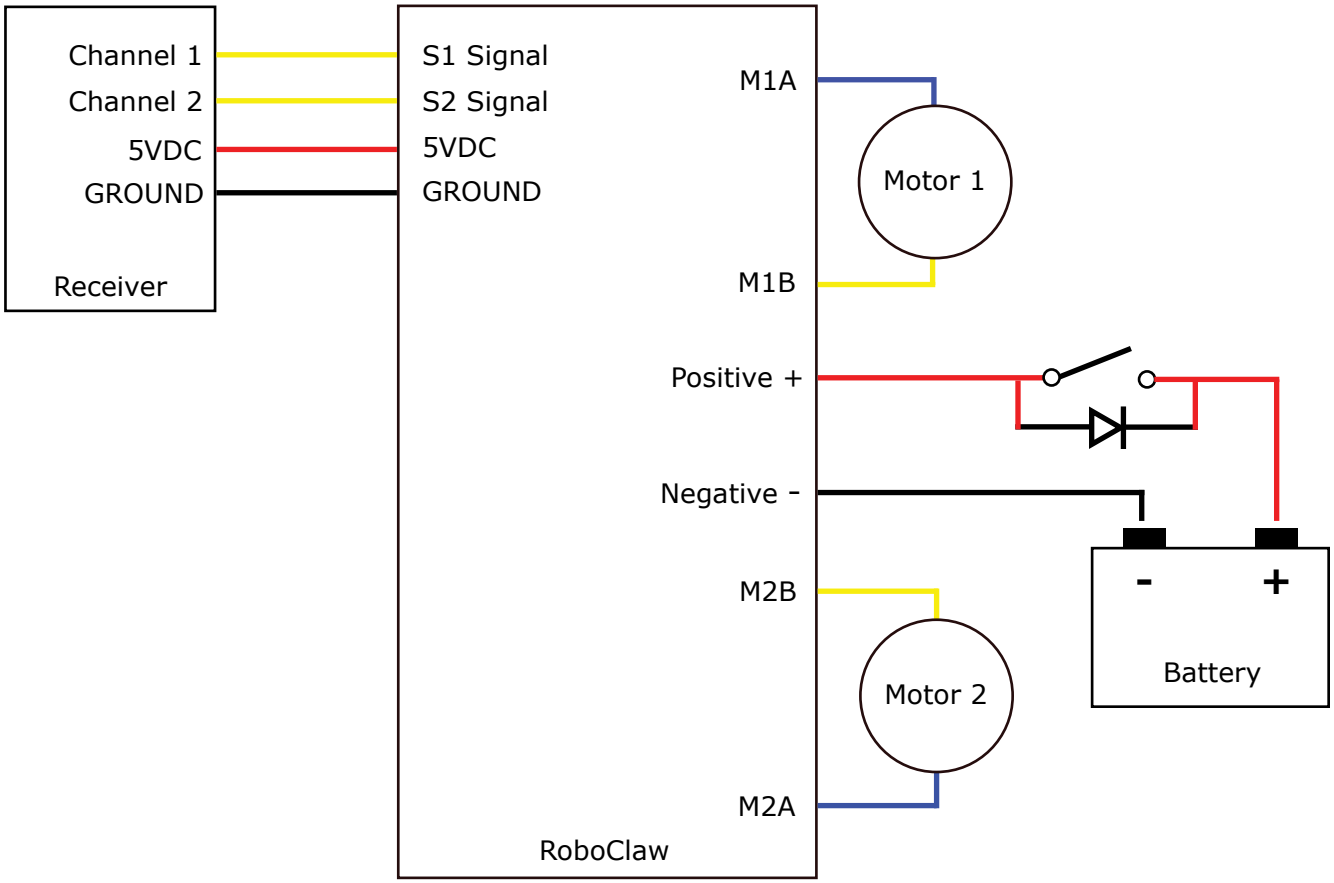
Pulse Ranges

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

Pulse	Function
1250us	Full Reverse
1750us	Full Forward

RC Wiring Example

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



RC Control - Arduino Example

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

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

#include <Servo.h>

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

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

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

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

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

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

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

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

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

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

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

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

ANALOG 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. The voltage range is 0V = Full reverse, 1V = Stop and 2V = Full forward.

Analog Mode With Mixing

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

Using Analog Mode with feedback for velocity/position control

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

Analog Mode Options

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1	TTL Flip Switch	Flip switch triggered by low signal.
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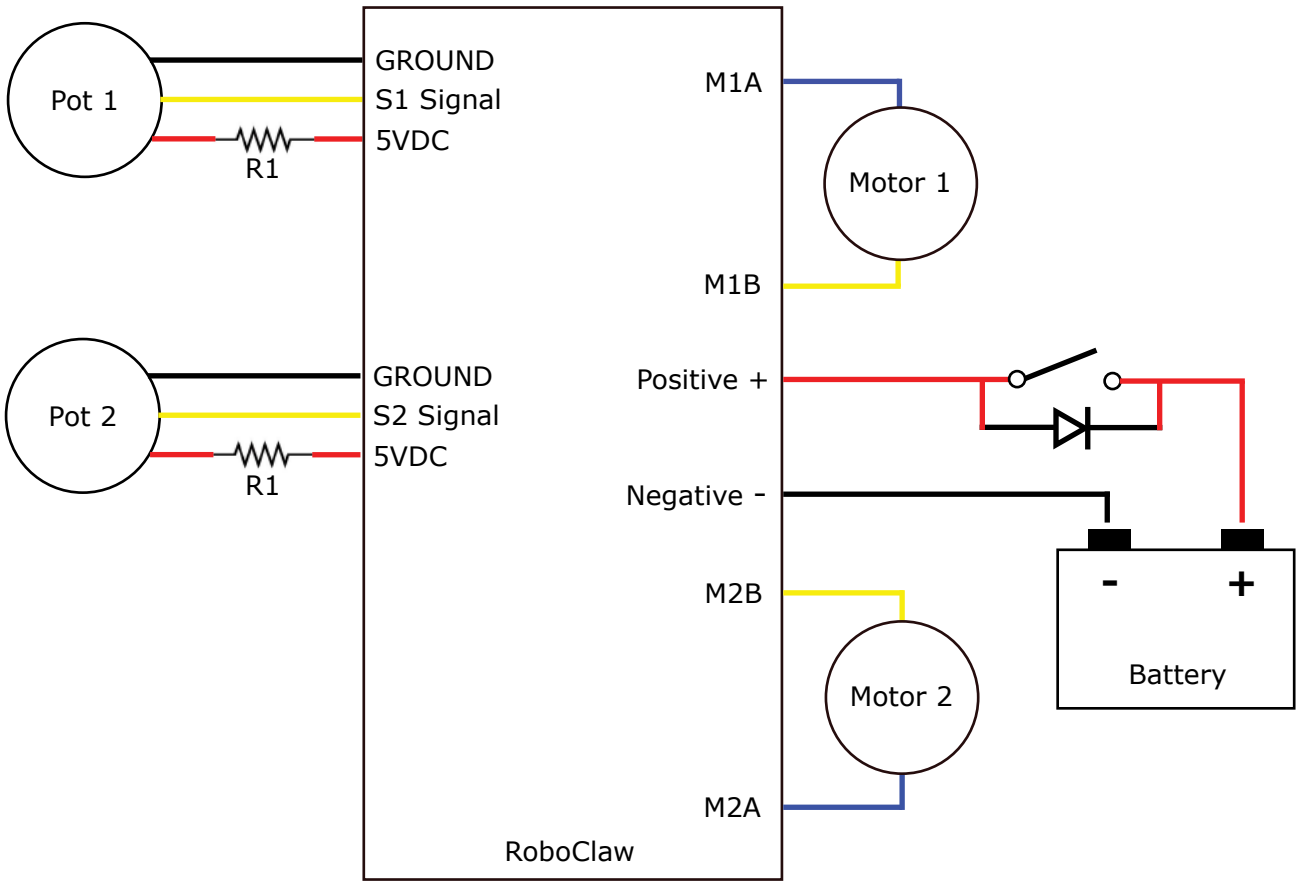
6	RC Flip and Exponential Enabled	Same as mode 2 with flip switch triggered by RC signal.
7	RC Flip and MCU Enabled	Same as mode 3 with flip switch triggered by RC signal.
8	RC Flip and Exponential and MCU Enabled	Same as mode 4 with flip switch triggered by RC signal.

Analog Wiring Example

RoboClaw uses a high speed 12 bit analog converter. Its range is 0 to 2V. The analog pins are protected and 5V tolerant. The potentiometer range will be limited if 5V is utilized as the reference voltage. A simple resistor divider circuit can be used to reduce the on board 5V to 2V for use with a potentiometer(POT). See the below schematic. The POT acts as one half of the resistor divider. If using a 5k potentiometer R1 = 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. The S1 potentiometer will control the motor 1 direction and speed. The S2 potentiometer will control the 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 (eg: Max232) is required. The baud rate can be changed using the SET button once a serial mode has been selected.

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

Serial Mode Baud Rates

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

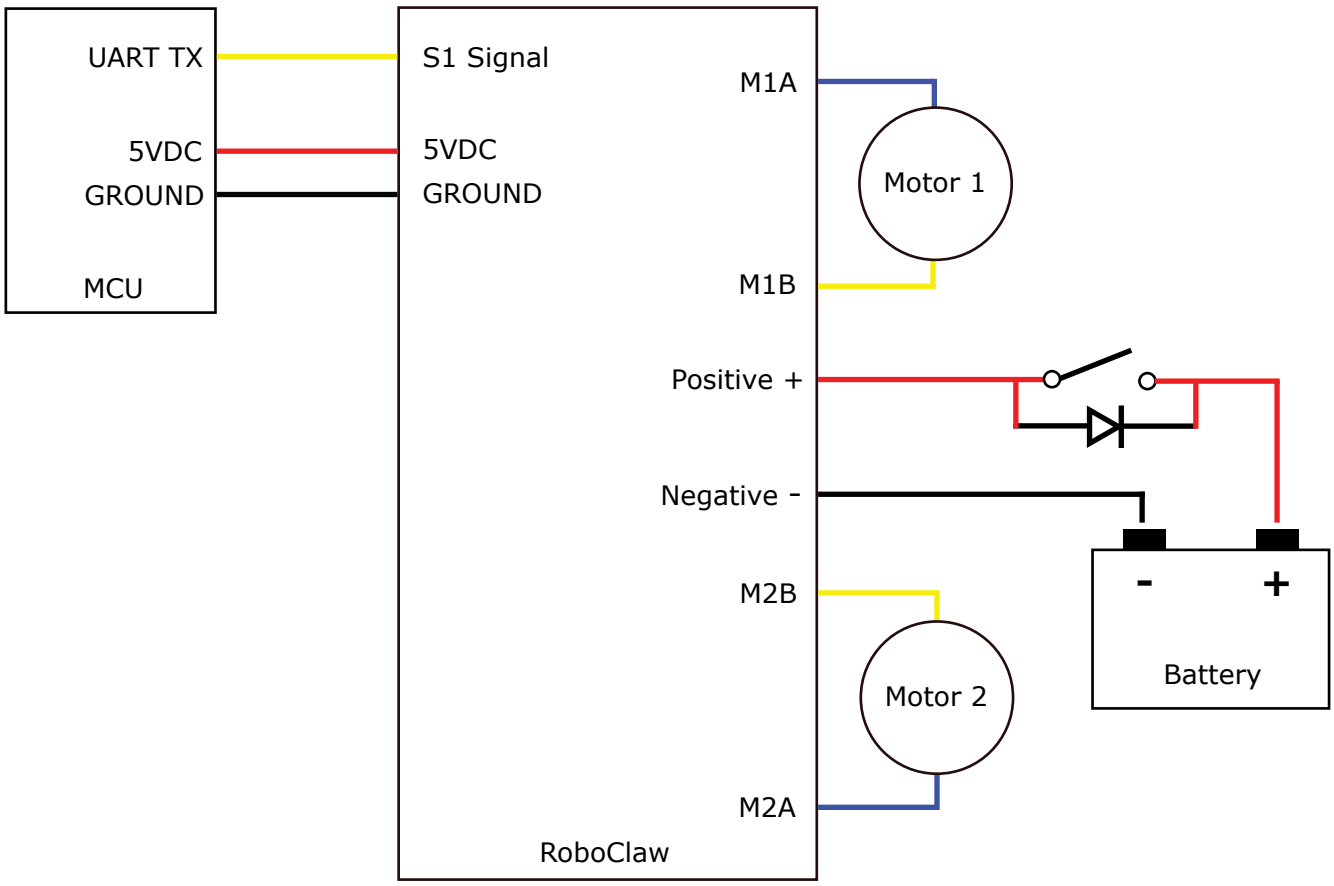
Standard Serial Command Syntax

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

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

Standard Serial Wiring Example

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

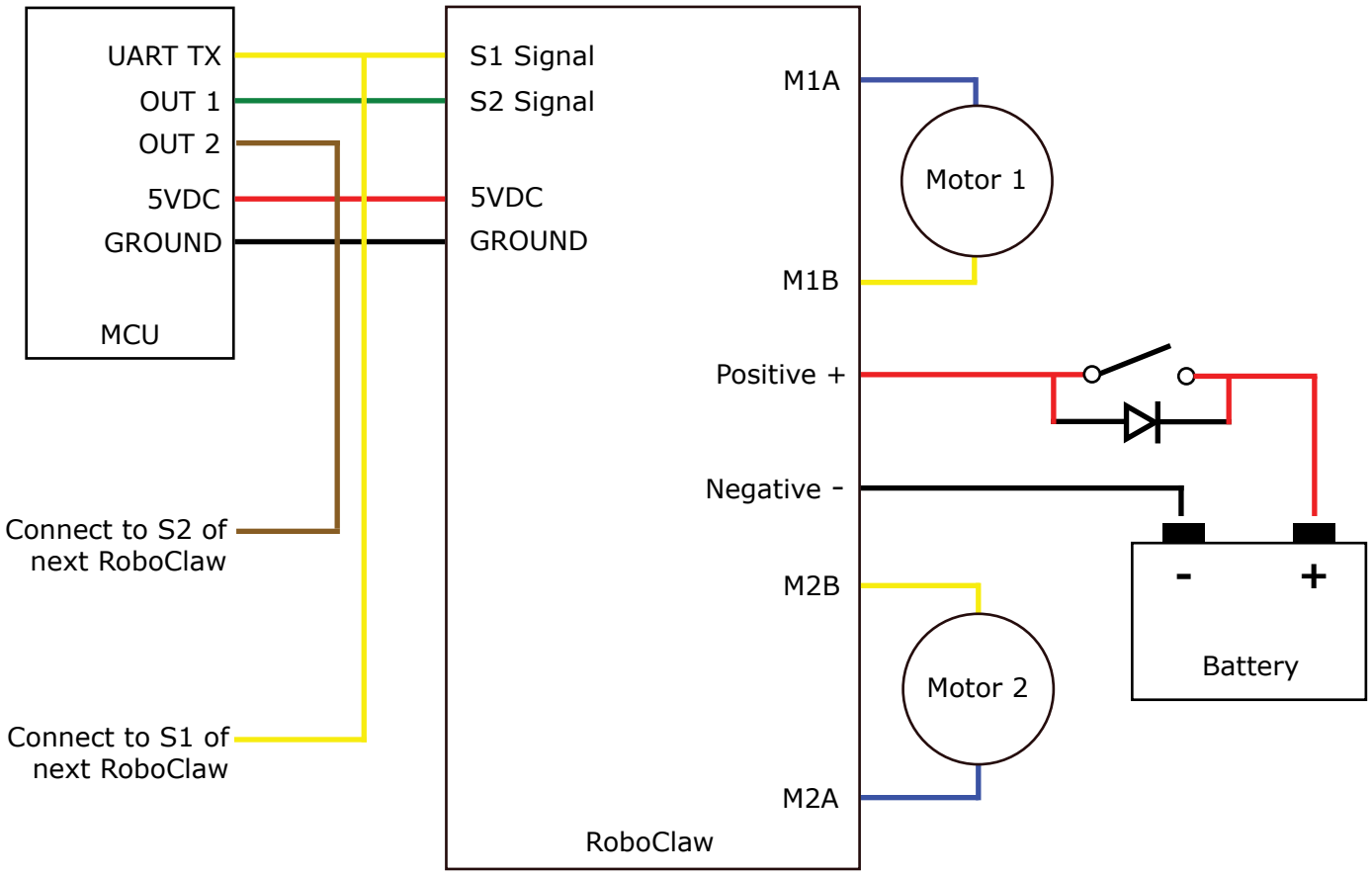


Standard Serial Mode With Slave Select

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

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

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



Standard Serial - Arduino Example

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

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

BMSerial mySerial(10,11);

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

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

PACKET SERIAL

Packet Serial Mode

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

Address

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

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

Packet Modes

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

Packet Serial Baud Rate

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

Serial Mode Options

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

Packet Timeout

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

Packet Acknowledgement

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

CRC16 Checksum Calculation

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

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

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

CRC16 Checksum Calculation for Received data

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

Easy to use Libraries

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

Handling values larger than a byte

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

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

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

The same applies to 16bit values:

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

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

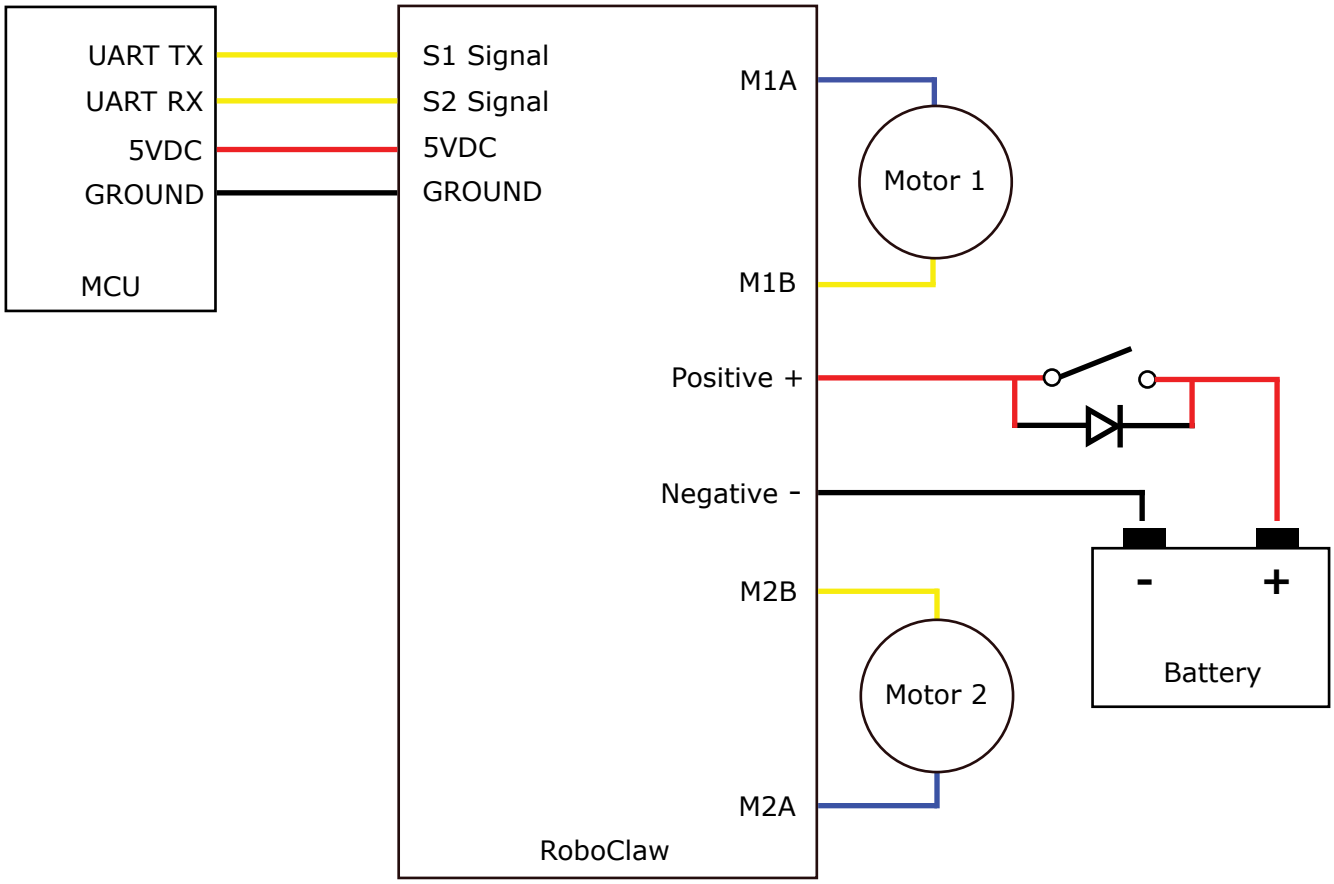
```
unsigned long MyLongValue = byte3<<24 | byte2<<16 | byte1<<8 | byte0;

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

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

Packet Serial Wiring

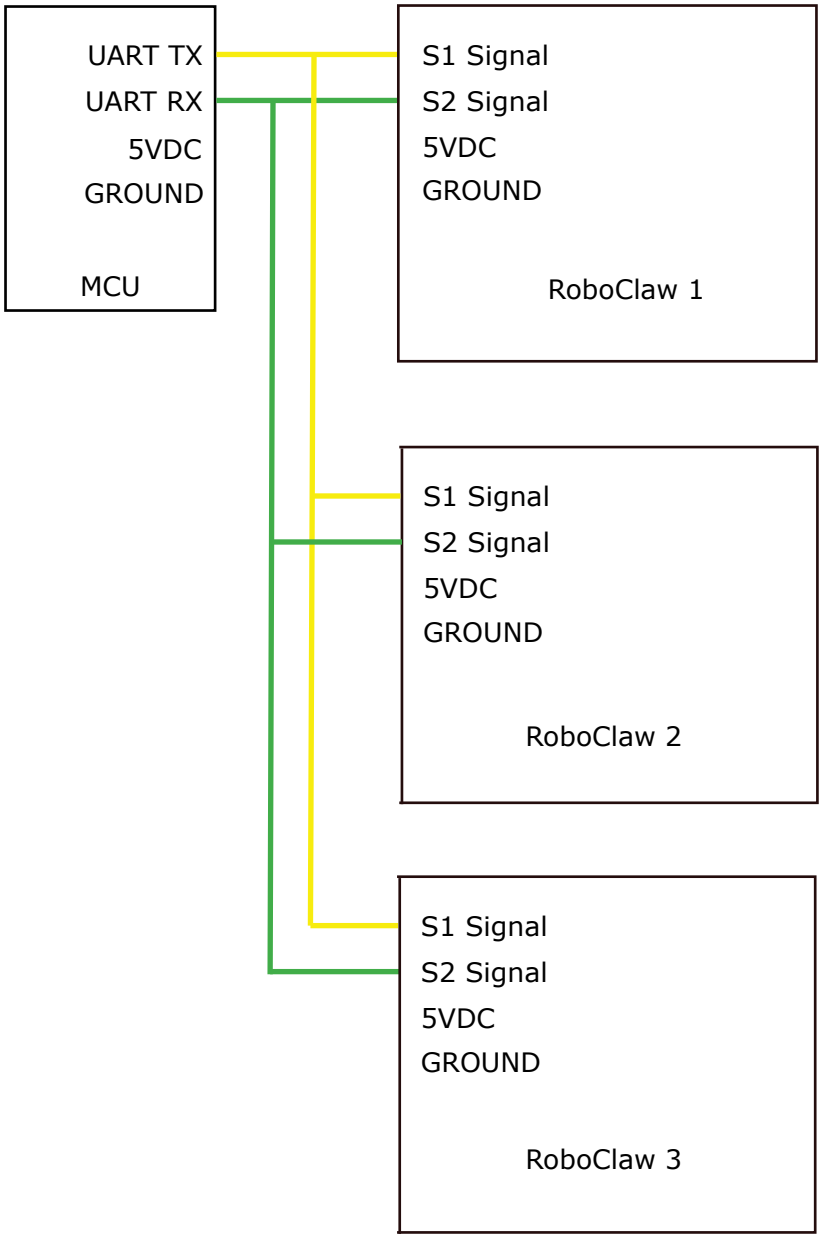
In packet serial mode the RoboClaw can transmit and receive serial data. A microcontroller with a UART is recommended. The UART will buffer the data received from RoboClaw. When a request for data is made to RoboClaw the return data will have at least a 1ms delay after the command is received if the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

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



Multi-Unit Packet Serial Wiring

In packet serial mode up to eight Roboclaw units can be controlled from a single serial port. The wiring diaghram below illustrates how this is done. Each Roboclaw must have multi-unit mode enabled and have a unique packet serial address set(see General Settings in IonMotion). Wire the S1 and S2 pins directly to the MCU TX and RX pins. Install a pullup resistor on the MCU RX pin.



Commands 0 - 7 Compatibility Commands

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

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

0 - Drive Forward M1

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

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

1 - Drive Backwards M1

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

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

2 - Set Minimum Main Voltage

Note: This command is included for backwards compatibility. We recommend you use command 57 instead.

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

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

3 - Set Maximum Main Voltage

Note: This command is included for backwards compatibility. We recommend you use command 57 instead.

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

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

4 - Drive Forward M2

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

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

5 - Drive Backwards M2

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

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

6 - Drive M1 (7 Bit)

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

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

7 - Drive M2 (7 Bit)

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

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

Commands 8 - 13 Mixed Mode Compatibility Commands

The following commands are mix mode compatibility commands used to control speed and turn using differential steering. 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 the motors. At this point you only need to update turn or drive data as needed.

8 - Drive Forward

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

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

9 - Drive Backwards

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

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

10 - Turn right

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

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

11 - Turn left

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

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

12 - Drive Forward or Backward (7 Bit)

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

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

13 - Turn Left or Right (7 Bit)

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

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

Packet Serial - Arduino Example

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

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

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

//Roboclaw Address
#define address 0x80

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

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

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

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

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

```
  roboclaw.TurnLeftMixed(address, 0);  //stop turn
  roboclaw.BackwardMixed(address, 127);  //half speed backward
  delay(2000);
  roboclaw.TurnRightMixed(address, 64);  //half speed turn right
  delay(2000);
  roboclaw.TurnLeftMixed(address, 64);  //half speed turn left
  delay(2000);

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

ADVANCED PACKET SERIAL

Version, Status, and Settings Commands

The following commands are used to read board status, version information and set/read 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
48	Read Motor PWMs
49	Read Motor Currents
57	Set Main Battery Voltages
58	Set Logic Battery Voltages
59	Read Main Battery Voltage Settings
60	Read Logic Battery Voltage Settings
74	Set S3,S4 and S5 Modes
75	Read S3,S4 and S5 Modes
76	Set DeadBand for RC/Analog controls
77	Read DeadBand for RC/Analog controls
80	Restore Defaults
82	Read Temperature
83	Read Temperature 2
90	Read Status
91	Read Encoder Modes
92	Set Motor 1 Encoder Mode
93	Set Motor 2 Encoder Mode
94	Write Settings to EEPROM
95	Read Settings from EEPROM
98	Set Standard Config Settings
99	Read Standard Config Settings
133	Set M1 Max Current
134	Set M2 Max Current
135	Read M1 Max Current
136	Read M2 Max Current
148	Set PWM Mode
149	Read PWM Mode

21 - Read Firmware Version

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

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

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

24 - Read Main Battery Voltage Level

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

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

25 - Read Logic Battery Voltage Level

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

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

26 - Set Minimum Logic Voltage Level

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

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

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

27 - Set Maximum Logic Voltage Level

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

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

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

48 - Read Motor PWM values

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

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

49 - Read Motor Currents

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

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

57 - Set Main Battery Voltages

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

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

58 - Set Logic Battery Voltages

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

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

59 - Read Main Battery Voltage Settings

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

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

60 - Read Logic Battery Voltage Settings

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

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

74 - Set S3, S4 and S5 Modes

Set modes for S3,S4 and S5.

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

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

Mode Description:

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

75 - Get S3, S4 amd S5 Modes

Read mode settings for S3,S4 and S5. See command 74 for mode descriptions

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

76 - Set DeadBand for RC/Analog controls

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

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

77 - Read DeadBand for RC/Analog controls

Read DeadBand settings in 10ths of a percent.

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

80 - Restore Defaults

Reset Settings to factory defaults.

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

82 - Read Temperature

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

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

83 - Read Temperature 2

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

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

90 - Read Status

Read the current unit status.

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

Status Bit Mask

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

91 - Read Encoder Mode

Read the encoder mode for both motors.

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

Encoder Mode bits

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

92 - Set Motor 1 Encoder Mode

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

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

93 - Set Motor 2 Encoder Mode

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

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

94 - Write Settings to EEPROM

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

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

95 - Read Settings from EEPROM

Read all settings from non-volatile memory.

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

98 - Set Standard Config Settings

Set config bits for standard settings.

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

Config Bit Masks

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

99 - Read Standard Config Settings

Read config bits for standard settings See Command 98.

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

134 - Set M1 Max Current Limit

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

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

135 - Set M2 Max Current Limit

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

```
Send: [Address, 135, MaxCurrent(2 bytes), 0, 0, CRC(2 bytes)]
Receive: [0xFF]
```

136 - Read M1 Max Current Limit

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

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

137 - Read M2 Max Current Limit

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

```
Send: [Address, 137]
Receive: [MaxCurrent(2 bytes), MinCurrent(2 bytes), CRC(2 bytes)]
```

148 - Set PWM Mode

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

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

149 - Read PWM Mode

Read PWM Drive mode. See Command 148.

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

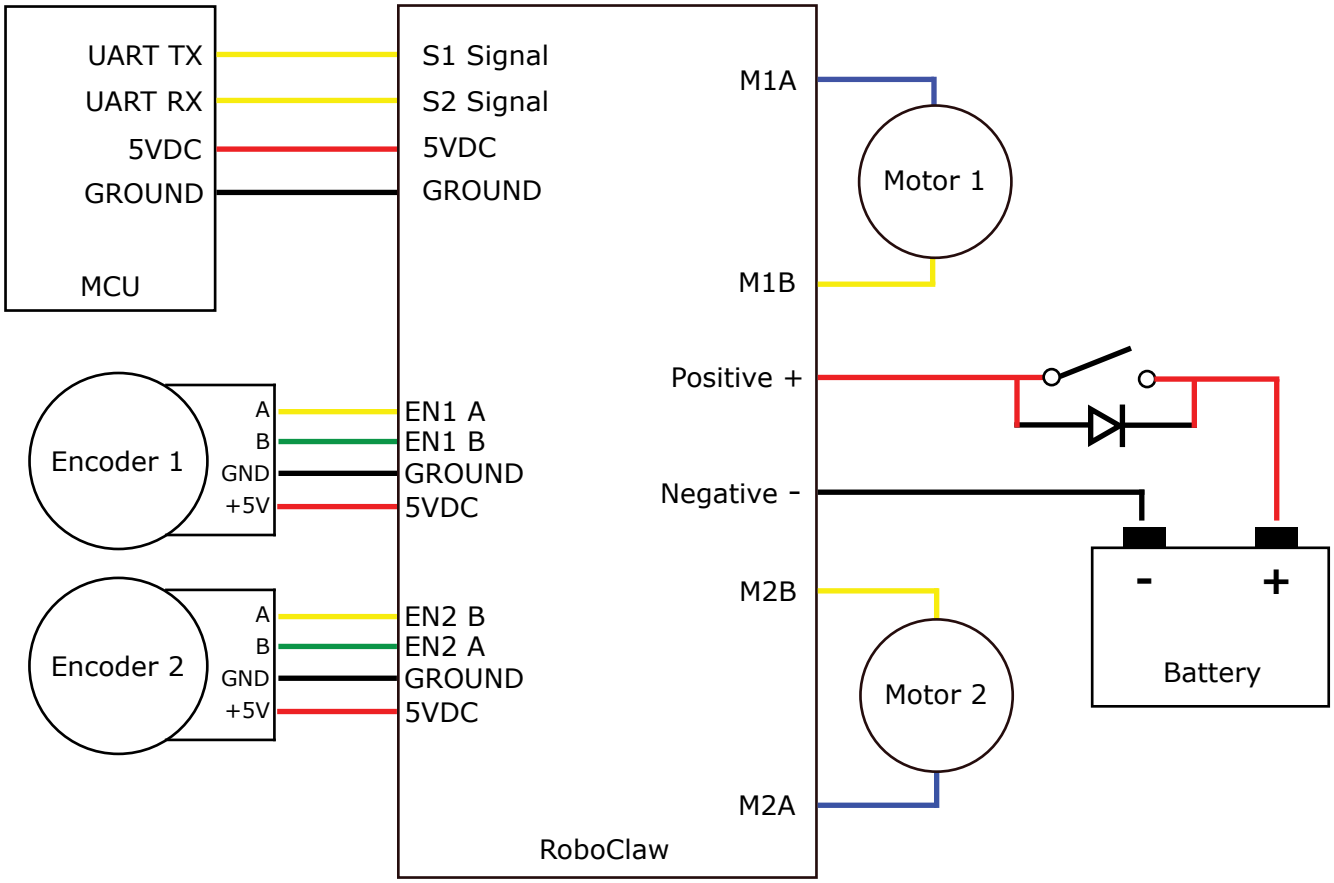
ENCODERS

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 for each encoder.

In a robot with two motor configurations 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.

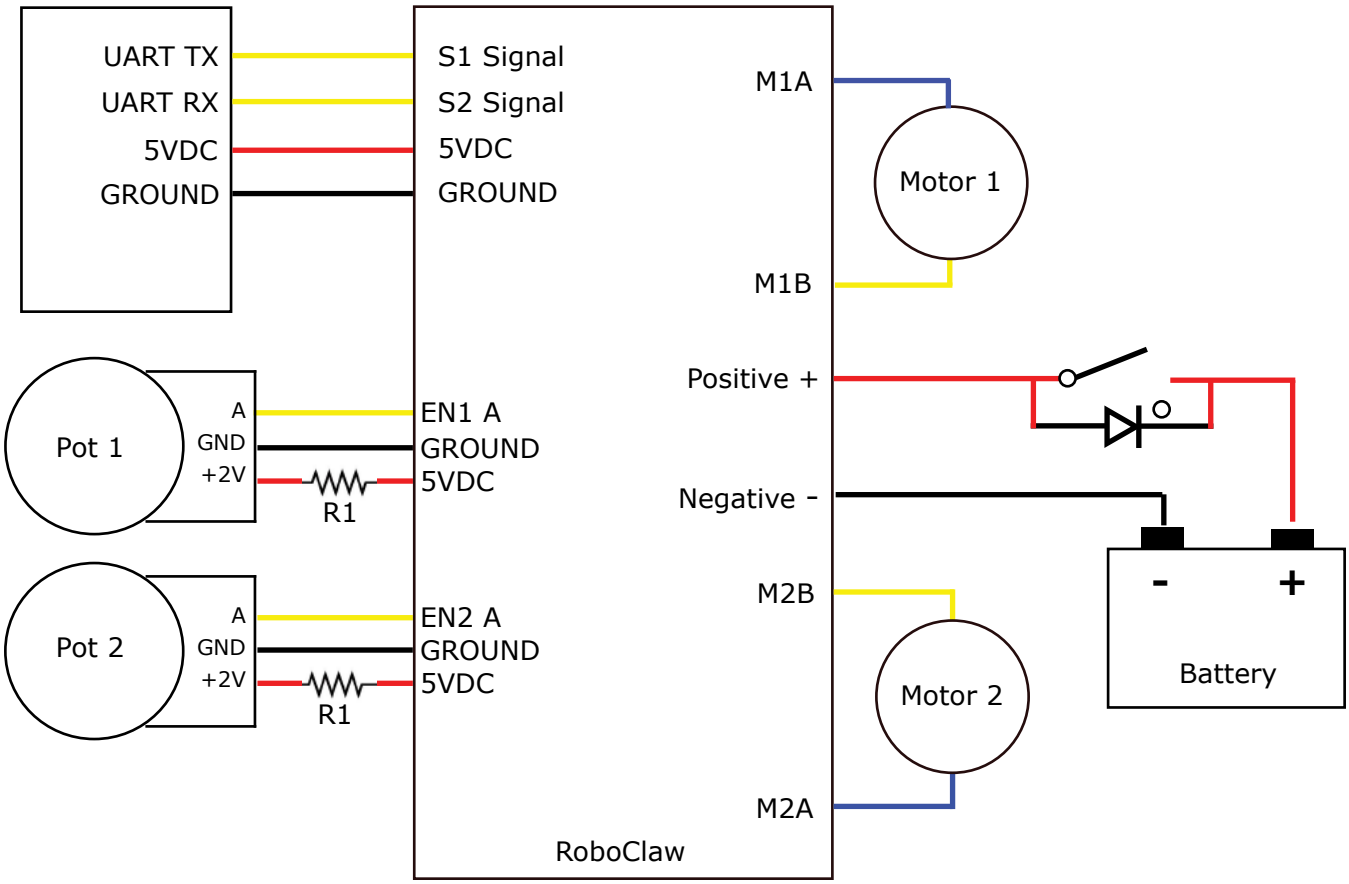
The diagram below shows the main battery as the only power source. Make sure the LB jumper is set correctly. The 5VDC shown connected is only required if your MCU needs a power source. This is the BEC feature of RoboClaw. If the MCU has its own power source do not the 5VDC.



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 connect 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. To do this go to the PWM Settings screen in IonMotion. Slide the motor slider up to start moving the motor forward. Check the encoder is increasing in value. If it is not either reverse the motor wires or the encoder wires.

If you are using autotune for Position control you must first set the motors QPPS value. Unlike Velocity autotune the QPPS value will not be automatically measured. This is because most position control systems have a limited range of movement. Once you have manually set the motors QPPS value(eg the maximum speed the motor can run at) you can continue with Position autotuning.

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 but still requires the QPPS be manually set for the motor before starting. Autotune functions usually return reasonable values but in most cases you will still need to manually adjust them for optimum performance.

If the motor or encoder are wired incorrectly, the autotune function can lock up and RoboClaw will become unresponsive. Correcting the wiring problem and reset RoboClaw to continue.

Encoder Commands

The following commands are used with the encoder(quadrature and absolute) hardware.

Command	Description
16	Read Encoder Count/Value for M1.
17	Read Encoder Count/Value for M2.
18	Read M1 Speed in Encoder Counts Per Second.
19	Read M2 Speed in Encoder Counts Per Second.
20	Resets Encoder Registers for M1 and M2(Quadrature only).
22	Set Encoder 1 Register(Quadrature only).
23	Set Encoder 2 Register(Quadrature only).

16 - Read Encoder Count/Value M1

Read M1 encoder count/position.

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

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

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

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

17 - Read Quadrature Encoder Count/Value M2

Read M2 encoder count/position.

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

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

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

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

18 - Read Encoder Speed M1

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

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

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

19 - Read Encoder Speed M2

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

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

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

20 - Reset Quadrature Encoder Counters

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

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

22 - Set Quadrature Encoder 1 Value

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

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

23 - Set Quadrature Encoder 2 Value

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

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

Advanced Motor Control

The following commands are used to control motor speeds, acceleration distance and position using encoders.

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

28 - Set Velocity PID Constants M1

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

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

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

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

29 - Set Velocity PID Constants M2

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

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

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

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

30 - Read Raw Speed M1

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

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

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

31 - Read Raw Speed M2

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

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

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

32 - Drive M1 With Signed Duty Cycle

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

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

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

33 - Drive M2 With Signed Duty Cycle

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

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

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

34 - Drive M1 / M2 With Signed Duty Cycle

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

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

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

35 - Drive M1 With Signed Speed

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

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

36 - Drive M2 With Signed Speed

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

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

37 - Drive M1 / M2 With Signed Speed

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

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

38 - Drive M1 With Signed Speed And Acceleration

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

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

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

39 - Drive M2 With Signed Speed And Acceleration

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

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

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

40 - Drive M1 / M2 With Signed Speed And Acceleration

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

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

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

41 - Buffered M1 Drive With Signed Speed And Distance

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

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

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

42 - Buffered M2 Drive With Signed Speed And Distance

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

47 - Read Buffer Length

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

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

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

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

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

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

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

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

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

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

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

52 - Drive M1 With Signed Duty And Acceleration

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

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

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

53 - Drive M2 With Signed Duty And Acceleration

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

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

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

54 - Drive M1 / M2 With Signed Duty And Acceleration

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

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

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

55 - Read Motor 1 Velocity PID and QPPS Settings

Read the PID and QPPS Settings.

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

56 - Read Motor 2 Velocity PID and QPPS Settings

Read the PID and QPPS Settings.

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

61 - Set Motor 1 Position PID Constants

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

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

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

62 - Set Motor 2 Position PID Constants

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

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

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

63 - Read Motor 1 Position PID Constants

Read the Position PID Settings.

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

64 - Read Motor 2 Position PID Constants

Read the Position PID Settings.

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

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

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

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

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

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

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

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

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

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

68 - Set M1 Default Duty Acceleration

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

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

69 - Set M2 Default Duty Acceleration

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

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

Reading Quadrature Encoder - Arduino Example

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

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

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

//Roboclaw Address
#define address 0x80

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

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

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

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

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

  terminal.print("Encoder1:");
  if(valid1){
    terminal.print(enc1,HEX);
    terminal.print(" ");
    terminal.print(status1,HEX);
    terminal.print(" ");
  }
  else{
    terminal.print("invalid ");
  }
  terminal.print("Encoder2:");
  if(valid2){
    terminal.print(enc2,HEX);
    terminal.print(" ");
    terminal.print(status2,HEX);
    terminal.print(" ");
  }
  else{
    terminal.print("invalid ");
  }
  terminal.print("Speed1:");
```

```
  if(valid3){
    terminal.print(speed1,HEX);
    terminal.print(" ");
  }
  else{
    terminal.print("invalid ");
  }
  terminal.print("Speed2:");
  if(valid4){
    terminal.print(speed2,HEX);
    terminal.print(" ");
  }
  else{
    terminal.print("invalid ");
  }
  terminal.println();

  delay(100);
}
```

Speed Controlled by Quadrature Encoders - Arduino Example

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

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

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

#define SPEED 12000
#define SPEED2 12000

//Roboclaw Address
#define address 0x80

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

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

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

long speed;
long speed2;

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

  speed = SPEED;
  speed2 = SPEED2;

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

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

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

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

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

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

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

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

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

RoboClaw Electrical Specifications

Characteristic	Model	Rating	Min	Typ	Max
Pulse Per Second	All	QPPS	0		19,660800
Logic Battery	All	VDC	6	12	34
Main Battery	2x5A	VDC	6		34
	2x15A	VDC	6		34
	2x30A	VDC	6		34
	2x45A	VDC	6		34
	2x60A	VDC	6		34
	2x60A HV	VDC	10.5		60
Maximum External Current Draw (BEC)	2x5A	mA			200
	2x15A	A			3
	2x30A	A			3
	2x45A	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]
	2x45A			45[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: Peak current is automatically reduced to the typical current limit as temperature approaches 85C.

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.

Warranty

Ion Motion Control warranties its products against defects in material and workmanship for a period of 1 year. If a defect is discovered, IonMC will, at our discretion, repair, replace, or refund the purchase price of the product in question. Contact us at support@ionmc.com. No returns will be accepted without the proper authorization.

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Contacts

Email: sales@ionmc.com
Tech support: support@ionmc.com
Web: http://www.ionmc.com

Discussion List

A web based discussion board is maintained at http://forums.ionmc.com**.**

Technical Support

Technical support is available by sending an email to support@ionmc.com, by opening a support ticket on the Ion Motion Control website or by calling 800-535-8161 during normal operating hours. All email will be answered within 48 hours.