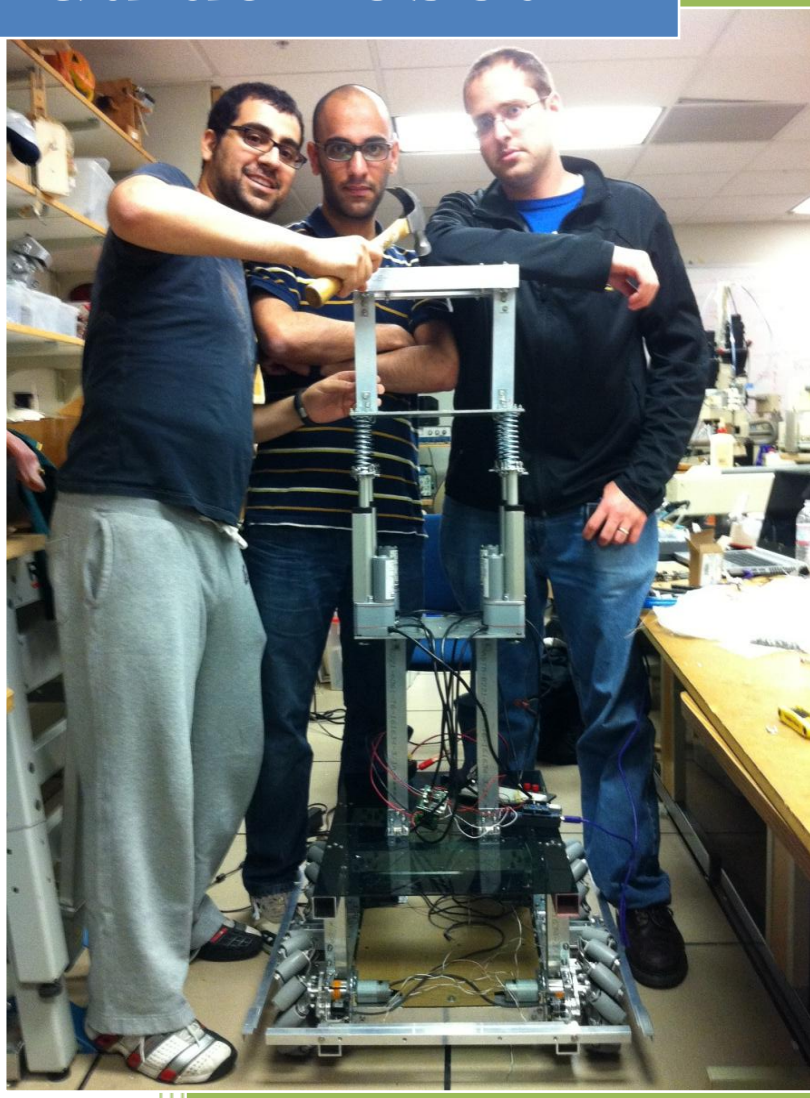
Spring - 2012

Advanced Embedded System

PSU Guide Robot



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PSU Guide Robot: Mecanum Platform II

I. Introduction

This is the second term of working on PSU_GUIDE robot. In the winter term we finished the lower part of the base. The lower part was including the Aluminum structure, Mecanum wheels, Dc-motors, P60 gears and an Arduino mega as a simple microcontroller for demo purposes. This term, we started working on the upper part of the base which is including the Aluminum structure, DC-motor controller, batteries, battery charger, Encoders, Ultrasonic sensors and Bumpers. Then, after finishing working on the upper part we finished the whole base. The body (legs, waist and the upper part that holding the arms and the head) is integrated to the base. That means the robot is ready to mount the head and arms to it.

For demonstration, we will use Arduino Mega to get the input from the sonars and the bumpers then drive the base and waist. We are going to write a simple code to show that everything is working properly.

II. Robot Design

According to our design in the google SketchUp in figure 1, the base consists of all parts mentioned in the introduction. There is a little different between the real robot and the designed one. The stepper motor part is not yet in the real robot which add one more degree of freedom that allow the robot to rotate around the z-axis.

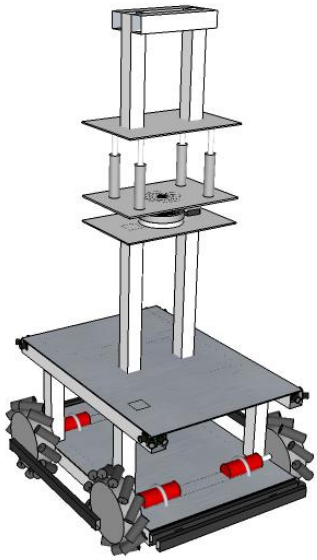


Figure 1: PSU Guide Robot.

III. Construction Parts

All the parts that we bought during working on this project were from Parkrose hardware

A. Aluminum Bars

The Aluminum bars that used in building the upper part of the base is square shape 1.5”X1.5” and a thickness of 0.065” which weighs .45lb per foot. The other square shape is .5”X.5” and thickness of 0.065” which weighs 0.13lb per foot. The last piece was L shape 0.75”X0.75” and a thickness of 0.125” which weighs 0.205lb per foot. As shown in figure 2.

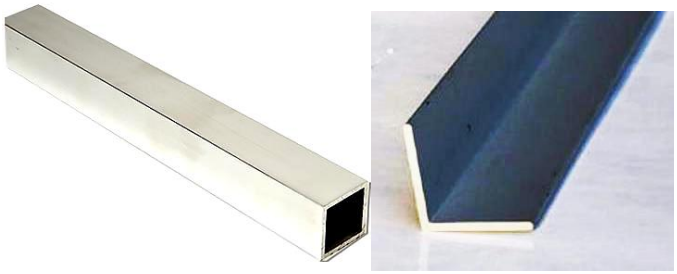


Figure 2: Square/L shape Aluminum bars.

B. Bolts

There are two types of bolts. One of them is stainless steel socket screws 2” length and 3/16” in width and a bolts of 3/4” length 3/16 width. There couple bolts which are used in small quantity (1” length 1/16 width, 1/4” length 1/16 width). It is shown in figure 3. The 2” bolts are 24 teeth, as there are 32 teeth and 24 teeth.

Figure 3: Socket screw bolts.

D. Nuts

The lock nuts (figure 4) are nylon which will tighten the bolts strongly. It is 3/16” in width to support the available bolts and there are 100 nuts.

Figure 4: Nylon nut.

E. Brackets

This time we used only four kind of bracket. They are 1-1/2”X1-1/2” with 6-holes L bracket (brace), 1-1/2"X5/8" with 4-holes L bracket, 1"X1/2" with 2-holes L bracket and the 4"X4" T-shaped bracket with 5-holes. We have to do little modification to these brackets to make them more suitable with the robot design. All brackets are shown in figure 5.

Figure 5: Brackets

F. Washers

There are many washers used in this robot to hold the bolts while they are attached to the brackets.

Figure 6: Flat washer.

G. Spacer

Spacers are used to build the bumpers as we will talk about them in detail in the bumpers part of this report.

Figure 7: Aluminum spacer:

IV. Base Parts

A. DC-motor controller

Basic Micro's RoboClaw motor controller can control a pair of brushed DC motors using serial, RC, or analog inputs. Integrated dual quadrature decoders make it easy to create a closed-loop speed control system. This version can supply a continuous 15 A per channel (30 A peak) [1]. Figure 8 shows a picture of this micro controller. In this robot, two of these motor controllers are used to control four DC motors. See appendix A for more information about these motor controller. http://www.pololu.com/catalog/product/1496 support all the documentations required to work in this motor controller as well as the libraries or codes related to that purpose.

Figure 8: RoboClaw 2x15A.

B. Encoder

This encoder sends a 200 pulse per rotation. Using this encoder allows us to know the direction and the speed which allows adding a closed loop feedback controller. The encoder is shown in figure 9. Appendix B has more information about these encoders.

Figure 9: Encoder.

Features [2]:

- Resolution: 200 Pulse/Rotation
- Input Voltage: 5 - 12VDC
- Maximum Rotating Speed: 5000rpm
- Allowable Radial Load: 5N
- Allowable Axial Load: 3N
- Cable Length: 50cm
- Shaft Diameter: 4mm

C. Gears

A Tetrix gears are used in this design. Tetrix gears are expensive as they cost $ 17-19. I found another source of gears which are cheaper. http://www.servocity.com/index.html this website is a good resource to find motor accessories like gears, hubs and bearing … Etc. In order to use these gears, the bore of the 3” diameter had to be come 0.5”, so we made them bigger by using a 0.5” drill bit. After that we used one of the holes that surrounding the bore with the mechanical key. Using the mechanical key is to attach the gear to the bane bot gear shaft. Figure 10 shown the gears and how they are attached to the encoder as well as the gear shaft.

Figure 10: gears to attach the encoder to the gear shaft.

D. Ultrasonic sensors

In our design a 12 ultrasonic sensors are used in this design. Figure 11 shows how these ultrasonic sensors are attached to this robot. This LV-MaxSonar-EZ0 (shown in figure 12) is [3]:

- 42kHz Ultrasonic sensor measures distance to objects
- RoHS Compliant
- Read from all 3 sensor outputs: Analog Voltage, Serial, Pulse Width
- Virtually no sensor dead zone, objects closer than 6 inches range as 6 inches
- Resolution of 1 inch
- Maximum Range of 254 inches (645 cm)
- Operates from 2.5-5.5V
- Low 2.0mA average current requirement
- 20Hz reading rate
- Small, lightweight module
- Designed for easy integration into your project or product
- Widest beam of the LV-MaxSonar-EZ sensors
- Great for people detection applications

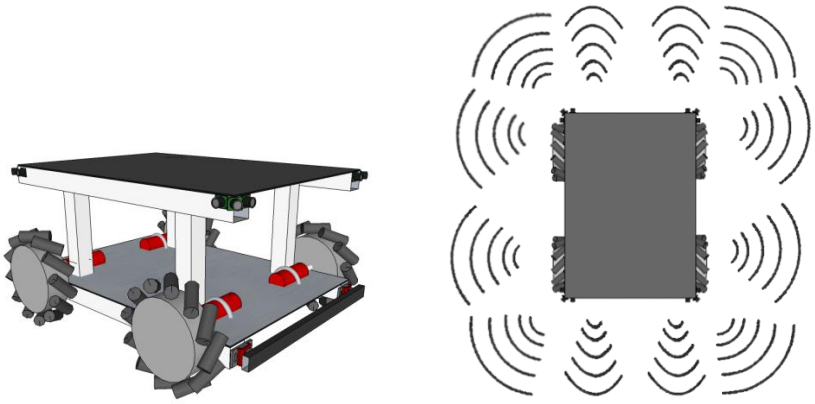


Figure 11: Sensores distribution on the robot.

Figure 12: LV-MaxSonar-EZ0.

For more information see appendix C.

E. Batteries

A four LiFeMnPO4/60AH are used in this robot. There are many reasons of using these batteries. Reading the specifications will give an idea about these reasons. Figure 13 shows the battery pack. All the charts and the instruction manual are found in appendix D.

Figure 13: LiFeMnPO4/60AH Battery pack.

Specifications [4]

- Nominal Voltage: 12.8V (4X 3.2 V)
- Nominal Capacity: 60 Ah
- LiFeMnPO4 chemistry
- Operation Voltage Range: 11.2 to 14.4V
- Weight: 9.2 kg or 20.3 lbs
- Dimension: 125X280X180 mm or 4.9X11X7.1 in
- Max Charging Current: 3C
- Max Discharge Current: 3C (continuous) / 10C (pulsed)
- Cycle Life : >1500 (80%DOD)

- Operating Temperature: -20 to 65 C or -4 to 149 F

- Self Discharge Rate: <3% monthly

F. BMS

Using battery management system is important because we are using a battery pack of 4 cells. The cells are exposed to different temperature as they worked. This difference in temperature as well as the differences in the chemical component as they are not perfect will make the voltage different from cell to cell by time. Using the BMS will protect the cells from overcharge/overdischarge, over current drown as well as keep cells having the same voltage. In appendix E, the BMS specification and user manual are found.

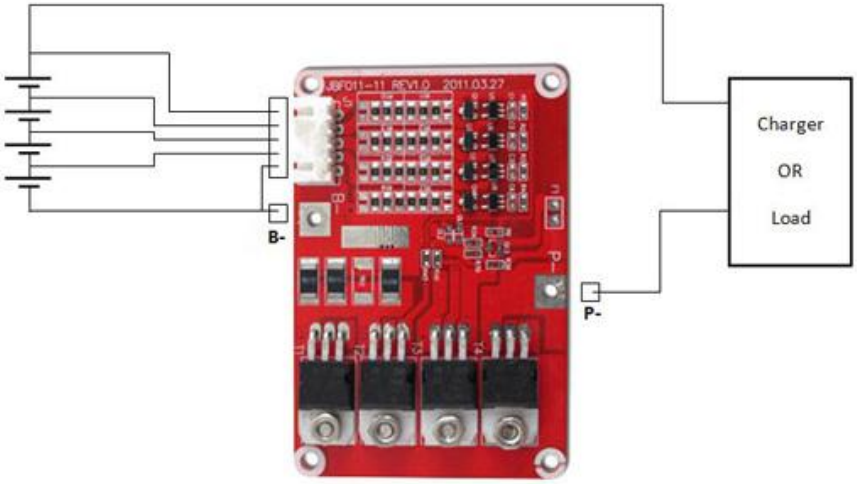


Figure 14: BMS.

G. Charger

The charger that we used has Over Voltage Protection, Short Circuit Protection and Output Reverse Protection. This charger is a special charger for the lithium ion batteries (charger is shown in figure 15). It can support a 10 Amp which means the charging time is 6 hours. (Charging Time= (1.41 * Ah rate of the pack) / 10A charge current) this formula shows that the time is a bit longer as there are two stages of charging. The first one is when the current is constant and the voltage is increased. In the other hand, after this stage, is the stage when the charger start holding the voltage and start decreasing the current till it reaches zero. For more detail see appendix F.

Figure 15: Charger.

H. Bumpers

There is one more thing have been added in this term which is the bumpers. The bumpers are important to our robot as there still a dead zone which can't be recognized as obstacle by the Kinect or ultrasonic sensors. The main goal is to not use these bumpers because we should have an efficient system which able to detect the obstacle and not to crash on them. The bumpers are used for an emergency stop in a case there are no inputs from the other sensors. Tow micro-switches are used in each bumper. Springs as well as spacers are used to protect the micro-switches from being damaged during operation. Each micro-switch is simply operated as they work

either normally open or normally closed. For instance, when it hit something it will simply turned off the input from +5 to the analog/digital input in the Arduino board. Figure 16 shows the bumpers.

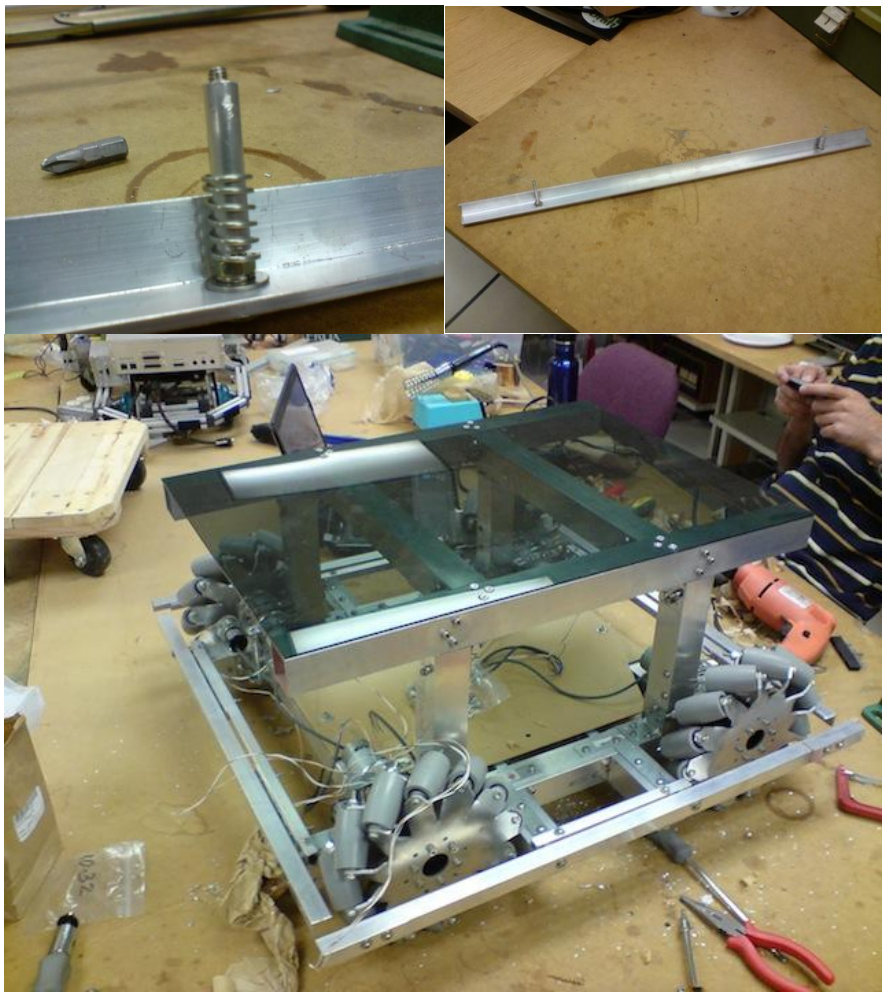


Figure 16: Bumpers.

V. Prices

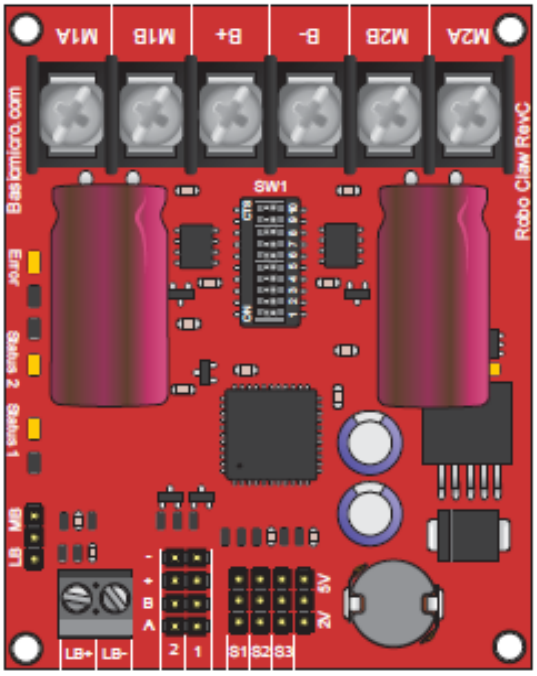
Item	Quantity	Price $
Hardware stuffs	-----	201.26
Plastic shield	2	34.32
DC-motor controller	2	179.9
Encoder	4	169.95
Micro switch	10	20.92
Battery Management system board	1	38.41
Gears	2	16.43
Batter pack of 4 cells	1	410.26
Aluminum Bars	----	91.47
Total		1,162.92

Appendix A [1]

B0097 - RoboClaw 2 Channel 15A Motor Controller **Data Sheet**

Feature Overview:

- 2 Channel at 15Amp, Peak 30Amp
- Battery Elimination Circuit (BEC)
- Switching Mode BEC
- Hobby RC Radio Compatible
- Serial Mode
- TTL Input
- Analog Mode
- 2 Channel Quadrature Decoding
- Thermal Protection
- Lithium Cut Off
- Packet Serial
- High Speed Direction Switching
- Flip Over Switch
- Over Current Protection
- Regenerative Braking



Basic Description
The RoboClaw 2X15 Amp is an extremely efficient, versatile, dual channel synchronous regenerative motor controller. It supports dual quadrature encoders and can supply two brushed DC motors with 15 Amps continuous and 30 Amp peak.

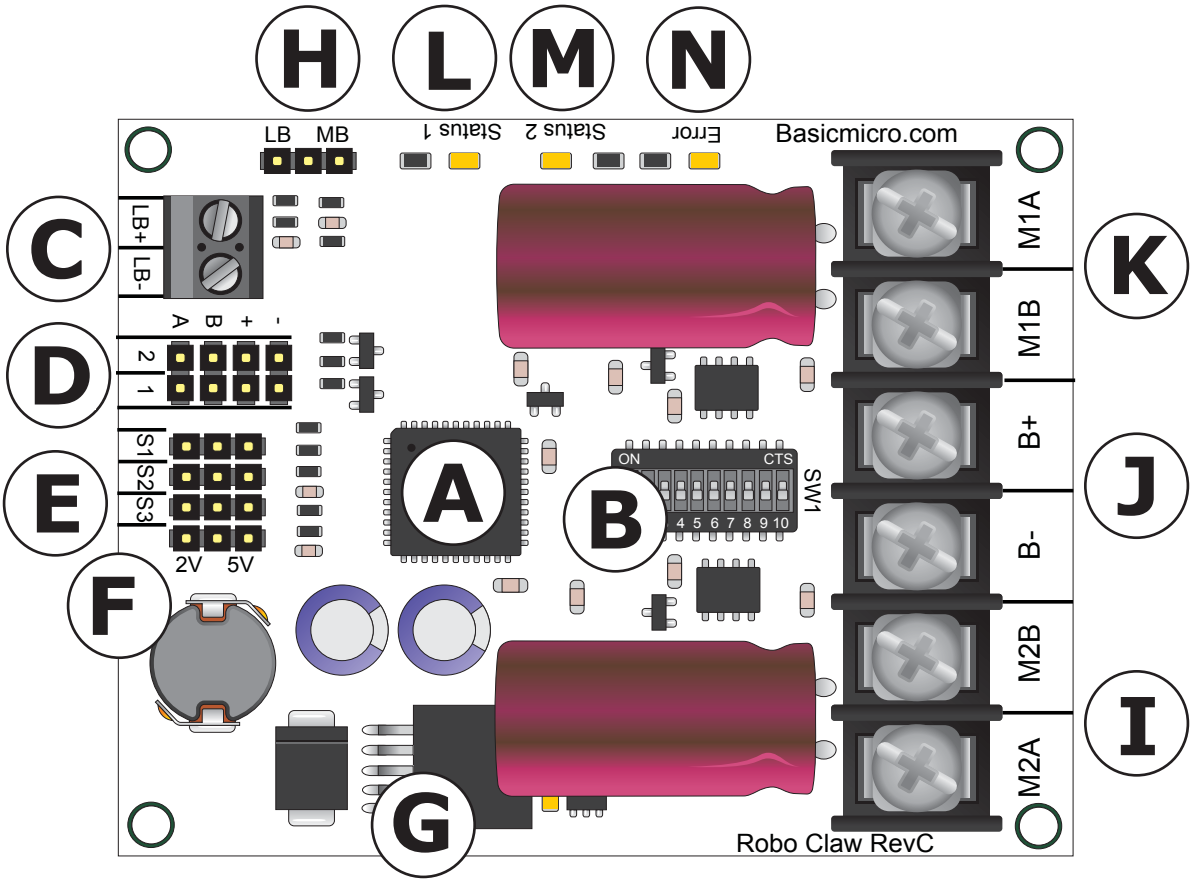
With dual quadrature decoding you get greater control over speed and velocity. Automatically maintain a speed even if load increases. RoboClaw also has a built in PID routine for use with an external control system.

RoboClaw is easy to control with several built in modes. It can be controlled from a standard RC receiver/transmitter, serial device, microcontroller or an analog source, such as a potentiometer based joystick. RoboClaw is equipped with screw terminal for fast connect and disconnect. All modes are set by the onboard dip switches making setup a snap!

Optical Encoders
RoboClaw features dual channel quadrature decoding. RoboClaw gives you the ability to create a closed loop system. Now you can know a motors speed and direction giving you greater control over DC motors systems.

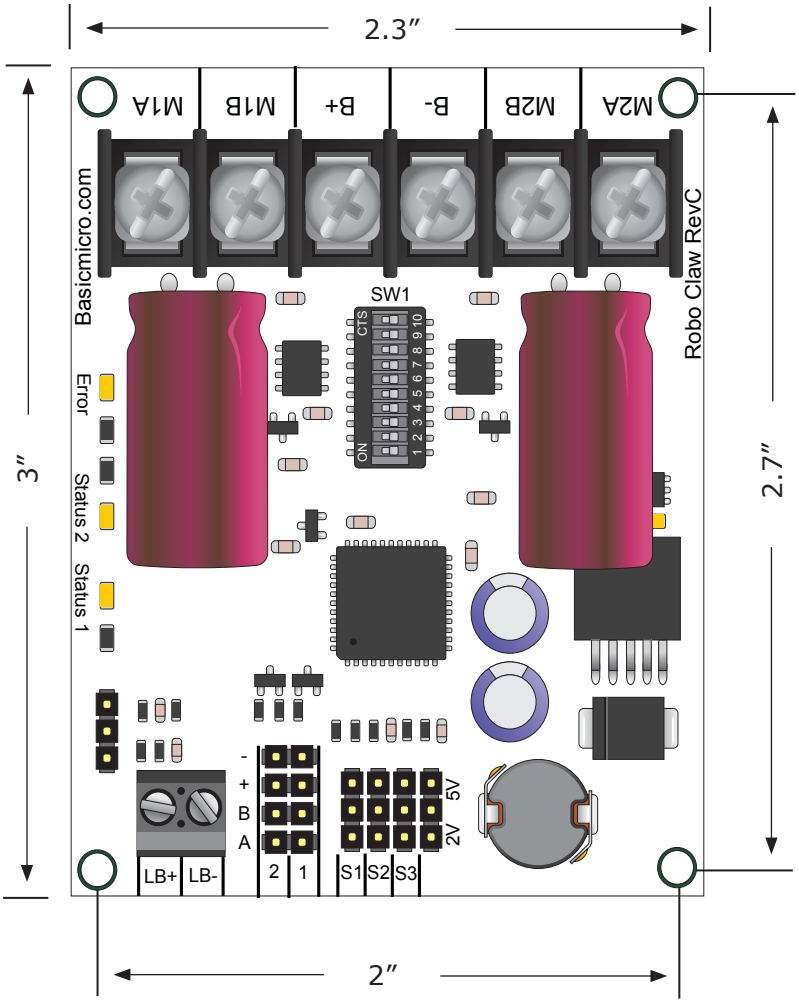
Power System
The RoboClaw is equipped with synchronous regenerative motor drivers. This means your battery is recharged when slowing down, braking or reversing. In addition a switching mode BEC is included. It can supply a useful current of up to 3Amps. The BEC is meant to provide power to a microcontroller or RC receiver.

Hardware Overview:



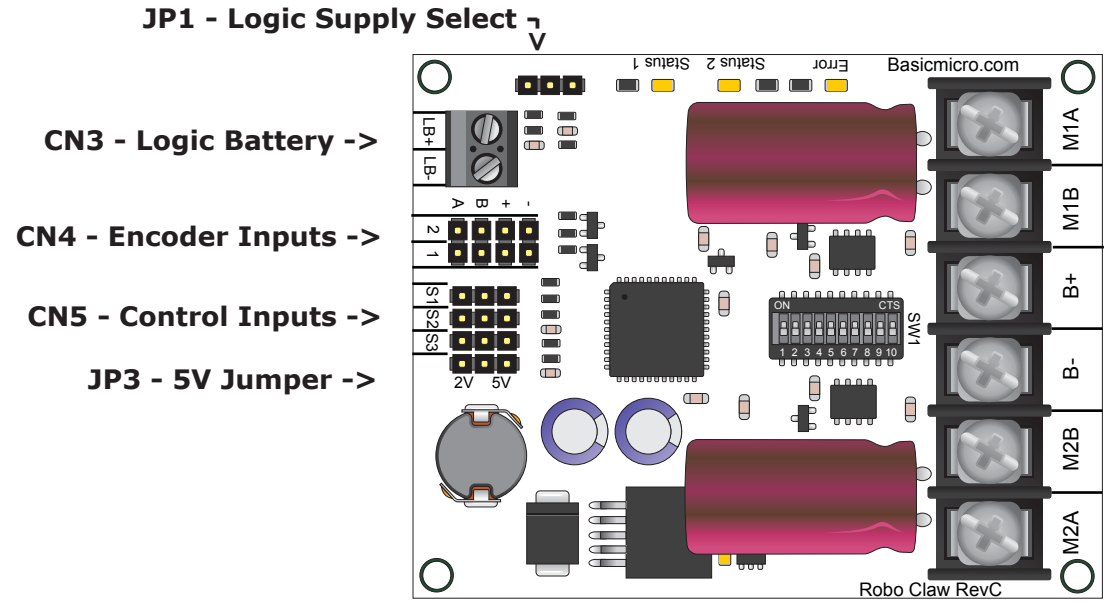
A: Microcontroller
B: DIP Switch
C: Logic Battery 3.5mm Screw Terminals
D: Encoder Input Header
E: Input Control Headers
F: VCC on Input Control Header Disable Jumper
G: Logic Voltage Regulator
H: Logic Voltage Source Selection Header
I: DC Motor Channel 2 Screw Terminals
J: Main Battery Input Screw Terminals
K: DC Motor Channel 1 Screw Terminals
L: Status LED 1
M: Status LED 2
N: Error LED

Dimensions:



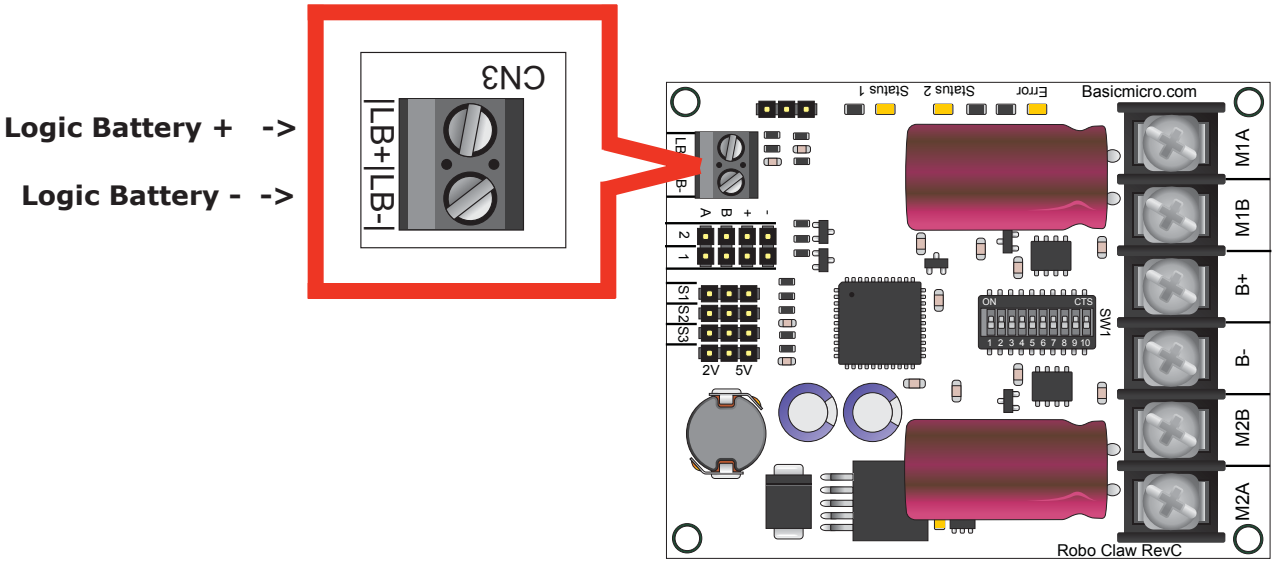
Board Edge: 2.3”W X 3”L
Hole Pattern: 0.125D, 2”W x 2.7”H

Header Overview

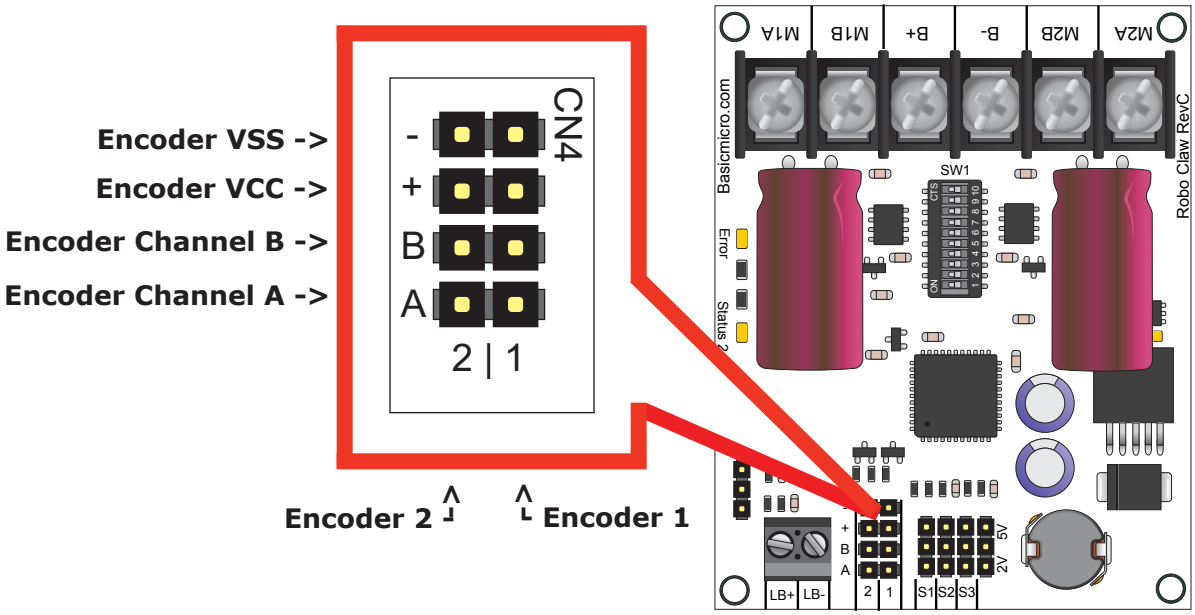


Logic Battery Screw Terminals

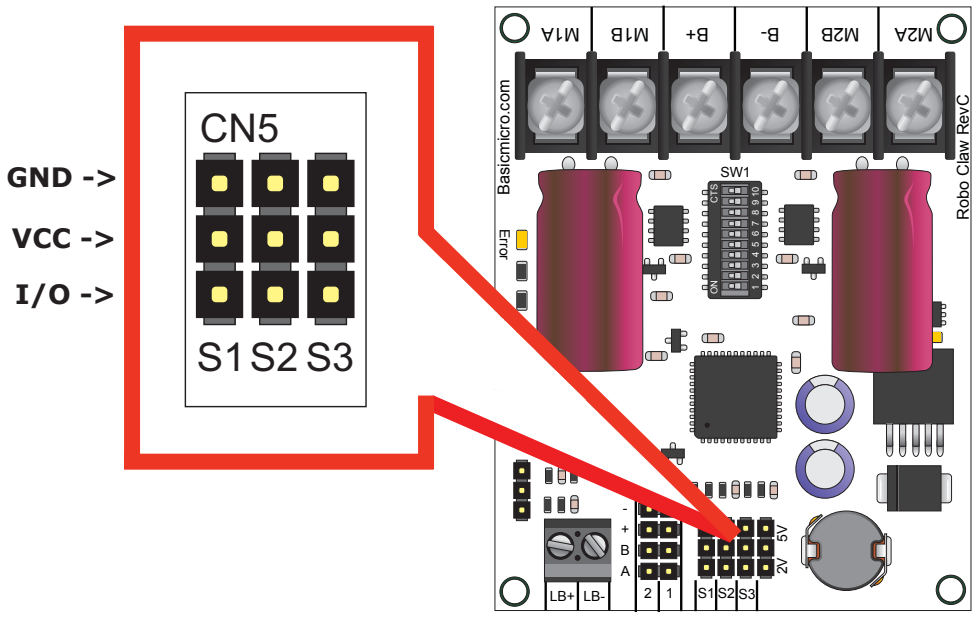
The logic circuits can be powered from the main battery or a secondary battery wired to CN3. JP1 controls what source powers the logic circuits. The maximum input voltage for the logic supply is 30VDC.



Encoder Inputs
This header is setup for dual quadrature encoders. A and B are the inputs from the encoders. The header also supplies 5VDC to power the encoders. 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. Which will affect the operation of Robo Claw. Refer to the data sheet of the encoder you are using for channel direction.

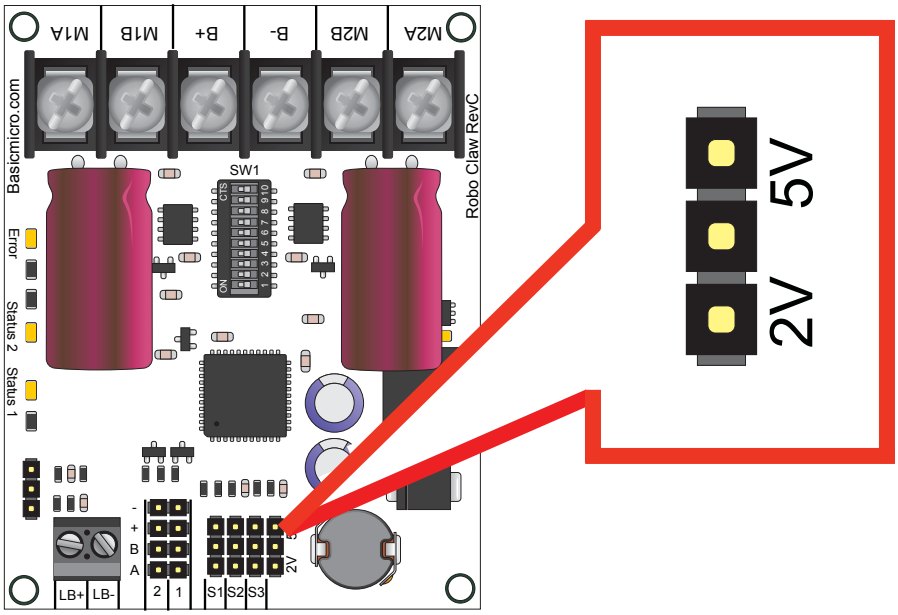


Control Inputs
S1, S2 and S3 are setup for standard servo style headers GND, +5V and I/O. S1 and S2 are the control inputs for serial, analog and RC modes. S3 used as a flip switch input when in RC or Analog modes. In serial mode S3 becomes a emergency stop.



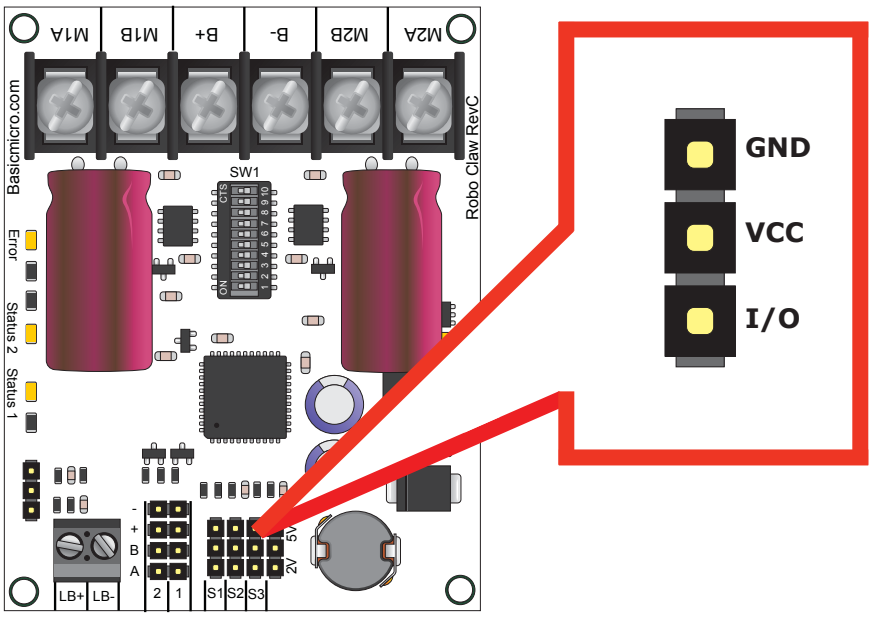
BEC Jumper

VCC on control input headers S1,S2 and S3 can be turned off, on or 2V by the jumper near S3 on CN5. Removing the BEC jumper disables VCC on S1, S2 and S3 headers. In some systems the RC receiver may have its own supply and will conflict with the RoboClaw logic supply.



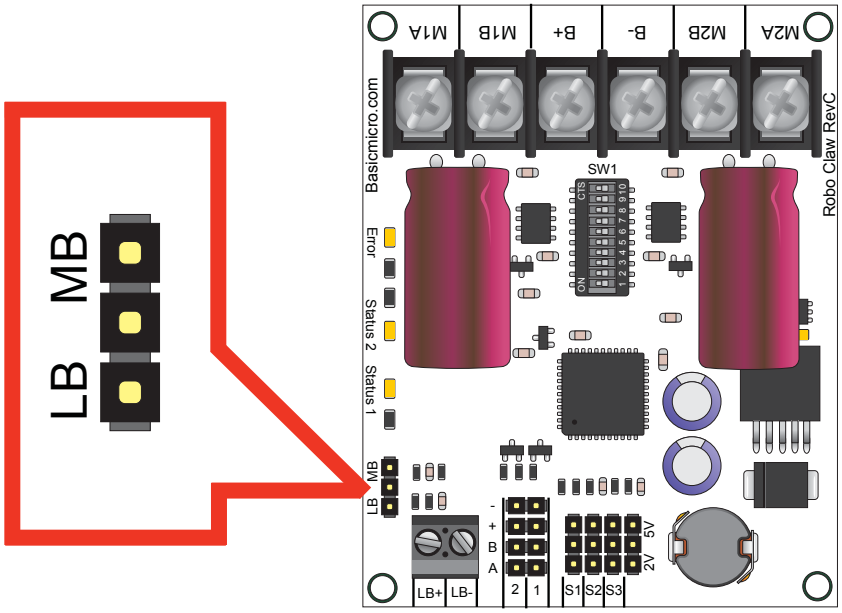
Emergency Stop

In serial mode S3 becomes the emergency stop. S3 is active low. It is internally pulled up so it will not accidentally trip.



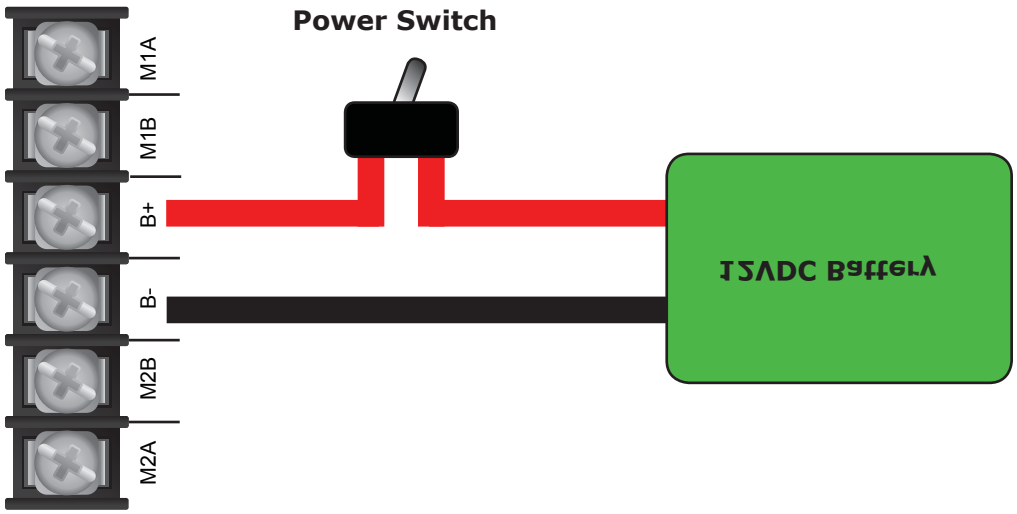
Logic Supply Select

The RoboClaw logic requires 5VDC which is provided from the on board regulator. The regulator source input is set with the logic supply jumper. Set to LB for a separate logic battery or MB for the main battery as the source.



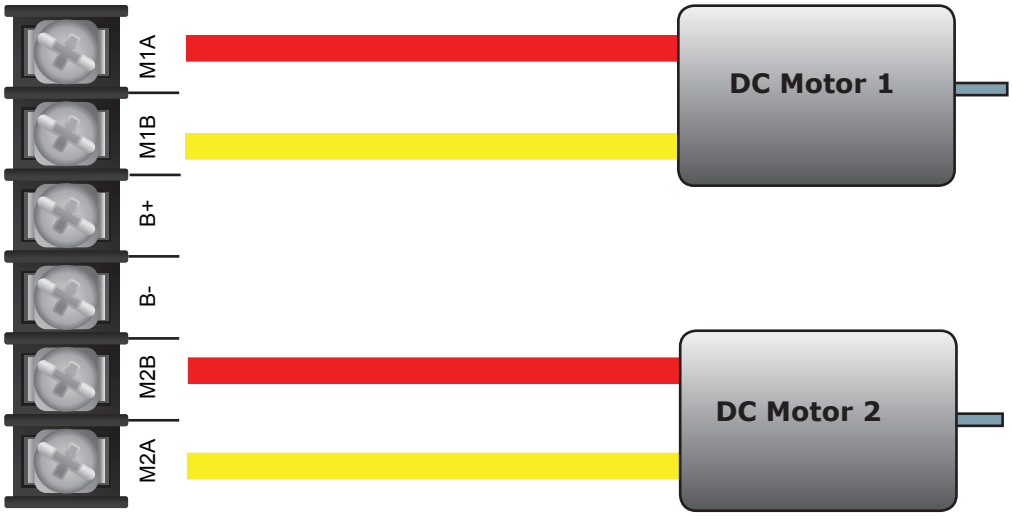
Main Battery Screw Terminals

The main battery connections are marked with a B- and B+ on the main screw terminal. B+ is the positive side of the battery typically marked with a red wire. The B- is the negative side of the battery and typically marked with a black wire. When connecting the main battery its a good practice to use a switch to turn the main power on and off. When placing a switch in between the RoboClaw and main battery you must use a switch with the proper current rating. Since the RoboClaw can draw up to 30Amps peak you should use a switch rated for at least 40Amps. The main battery can be 6V to 30V DC.



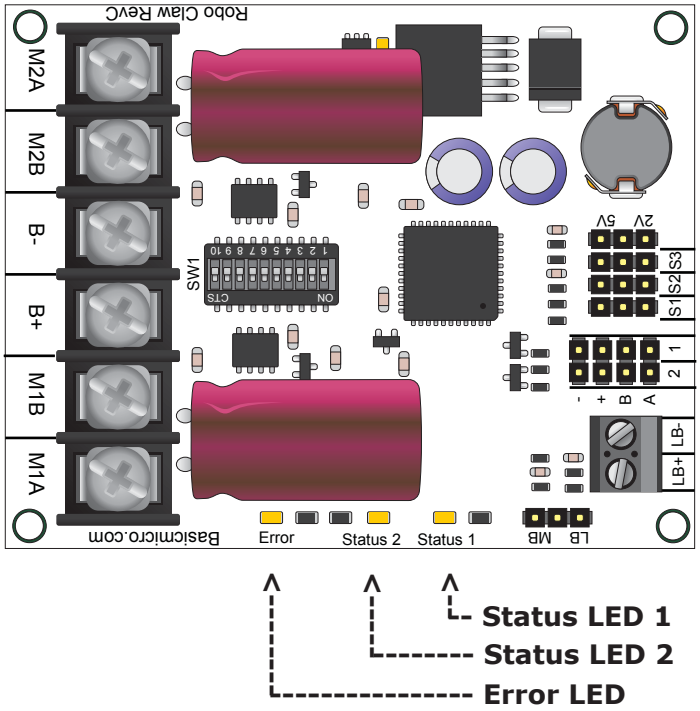
Motor Screw Terminals

The motor screw terminals are marked with M1A / M1B for channel 1 and M2A / M2B for channel 2. There is no specific polarities for the motors. However if you want both motors turning in the same direction on a 4 wheeled robot you need to reverse one of the motors as shown below:



Status and Error LEDs

The RoboClaw has 3 main LEDs. 2 Status LEDs and 1 Error LED. When Robo Claw is first powered up all 3 LED should blink several times briefly to indicate all 3 LEDs are functional. The status LEDs will indicate a status based on what mode RoboClaw is set to.



Analog Mode

Status LED 1 = On continuous.
Status LED 2 = On when motor(s) active.

RC Mode

Status LED 1 = On continuous, blink when pulse received.
Status LED 2 = On when motor(s) active.

Serial Modes

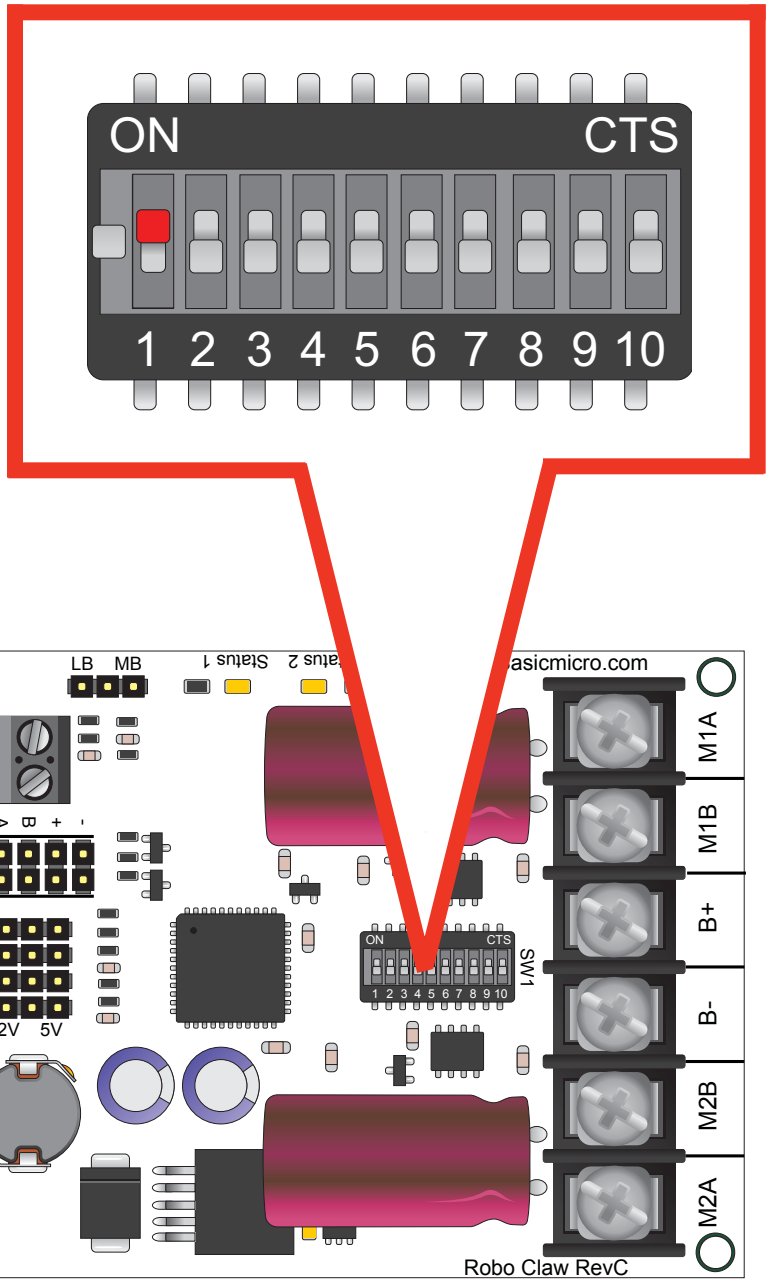
Status LED 1 = On continuous, blink on serial receive.
Status LED 2 = On when motor(s) active.

Errors

Over Current	= Error LED on solid. Status 1 or 2 indicates which motor.
Over Heat	= Error LED blinking once with a long pause.
Main Batt Low	= Error LED blinking twice with a long pause.
Main Batt High	= Error LED on fast flicker until condition is cleared.
Logic Batt Low	= Error LED blinking three times with a long pause.
Logic Batt High	= Error LED blinking four times with a long pause.

DIP Switch Overview

The dip switch on RoboClaw is used to set its operating modes and the many options. The switch is marked with an ON label at its top. The switches are also labeled from left to right starting with switch 1 and ending with switch 10. When a dip switch is moved toward the label ON it is considered ON. When the switch is facing away from the ON label it is considered off. Be careful to ensure the switch is not floating in between and is firmly OFF or ON. See illustration below. The red switch (SW1) is in the ON position. The grey colored switches are in the OFF position.



Low Voltage Cutoff

RoboClaw has a built in low voltage protection. This has two main purposed. To protect RoboClaw from running erratically when the main battery level gets to low and protect a Lithium battery from being damaged.

Voltage	SW8	SW9	SW10
Not Monitored	OFF	OFF	OFF
Lead Acid - Auto	ON	OFF	OFF
2- Cell (6V Cutoff)	OFF	ON	OFF
3- Cell (9V Cutoff)	ON	ON	OFF
4- Cell (12V Cutoff)	OFF	OFF	ON
5- Cell (15V Cutoff)	ON	OFF	ON
6- Cell (18V Cutoff)	OFF	ON	ON
7- Cell (21V Cutoff)	ON	ON	ON

RoboClaw Modes
There are 4 modes. Each with a specific way to control RoboClaw. The following list explain each mode and the ideal application.

Mode 1 - RC Input
With RC input mode RoboClaw can be controlled from any hobby RC radio system. RC input mode also allows low powered microcontroller such as a Basic Stamp or Nano to control RoboClaw. RoboClaw expects servo pulse inputs to control the direction and speed. Very similar to how a regular servo is controlled. RC mode can not use encoders.

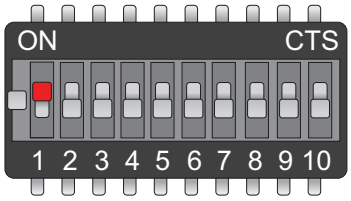
Mode 2 - Analog
Analog mode uses an analog signal from 0V to 5V to control the speed and direction of each motor. RoboClaw can be controlled using a potentiometer or filtered PWM from a microcontroller. Analog mode is ideal for interfacing RoboClaw joystick positioning systems or other non microcontroller interfacing hardware. Analog mode can not use encoders.

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

Mode 4 - Packet Serial
In packet serial mode RoboClaw expects TTL level RS-232 serial data to control direction and speed of each motor. Packet serial is typically used to control RoboClaw from a microcontroller or PC. If using a PC a MAX232 type circuit must be used since RoboClaw only works with TTL level input. In packet serial mode each RoboClaw is assigned an address using the dip switches. There are 8 addresses available. This means up to 8 RoboClaws can be on the same serial port. When using the quadrature decoding feature of RoboClaw packet serial is required since it is a two way communications format. This allows RoboClaw to transmit information about the encoders position and speed.

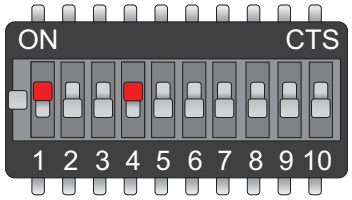
RC Input

Mode 1 - RC Input
For RC mode set SW1 = ON. 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. There are 4 options in RC Input mode. These options are set with SW4, SW5, SW6 and SW7.



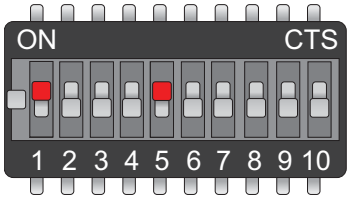
Switch 4 - Mixing Mode
SW4 = ON: Turns mixing mode ON. S1 controls forward and reverse. S2 controls steering. Control will be like a car.

SW4 = OFF: Turns mixing mode OFF. S1 controls motor 1 speed and direction. S2 controls motor 2 speed and direction. Control will be like a tank.



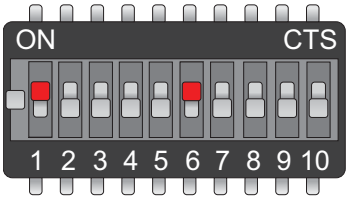
Switch 5 - Exponential Mode
SW5 = ON: Turns exponential mode ON. Exponential response softens the center control position. This mode is ideal with tank style robots.

SW5 = OFF: Turns exponential mode OFF. Motor response will be linear and directly proportional to the control input. Ideal for 4 wheel style robots.



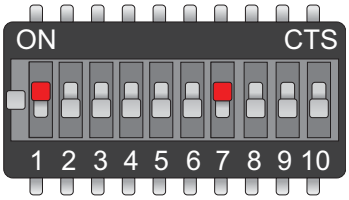
Switch 6 - MCU or RC Control
SW6 = ON: Turns MCU control mode ON. RoboClaw will continue to execute last pulse received until new pulse received. Signal lost fail safe and auto calibration are off in this mode.

SW6 = OFF: Turns RC control mode ON. RoboClaw will calibrate the center and end points automatically to maximize stick throw. This mode includes a fail safe. If control input is lost, RoboClaw will shut down.



Switch 7 - Flip Switch Input
SW7 = ON: Flip switch input requires servo pulse. Pulse greater than 1.5ms will reverse steering control. The flip switch is typically used in robot combats to automatically reverse the controls if a robot is flipped over.

SW7 = OFF: Flip switch input expects TTL control signal. 0V for flipped and 5V for normal.



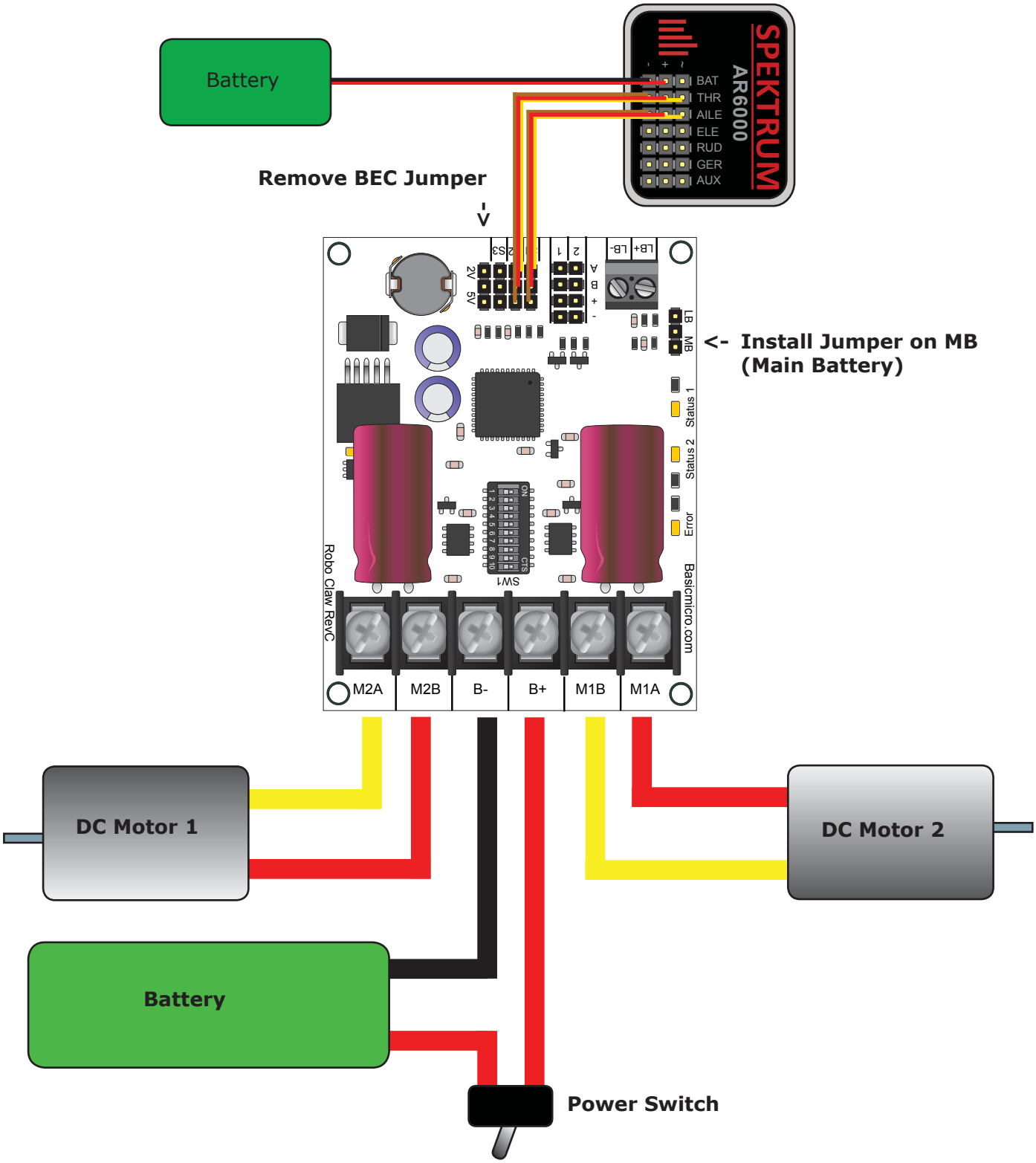
Servo Pulse Ranges

The RoboClaw expects RC servo pulses on S1 and S2 to drive the motors when the dip switches are set for RC mode. The center points are calibrated at start up. 1000us is the default for full reverse and 2000us is the default for full forward. The RoboClaw will auto calibrate these ranges on the fly. If a pulse smaller than 1000us or larger than 2000us is detected the new pulses will be set as the new range.

Pulse	Function
1000us	Full Reverse
2000us	Full Forward

RC Wiring Example

Connect the RoboClaw as shown below. Set switches SW1 and SW4 to ON. Make sure you center the control sticks and turn the radio on first, then the receiver, then RoboClaw. It will take RoboClaw about 1 second to calibrate the neutral position.



RC Control - Arduino Example

The example will drive a 2 motor 4 wheel robot in reverse, stop, forward, left turn and then right turn. The program was written and tested with a Arduino Uno and P5 connected to S1, P6 connected to S2. Set switches SW1, SW4, SW5 and SW6 to ON.

```
//Basic Micro Robo Claw RC Mode. Control Robo Claw
//with servo pulses from a microcontroller.
//Switch settings: SW1=ON, SW4=ON, SW5=ON and SW6=ON


#include <Servo.h>

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

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

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


void loop()
{
  myservo1.writeMicroseconds(1500);  //Stop
  myservo2.writeMicroseconds(1500);  //Stop
  delay(2000);

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

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

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

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

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

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

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

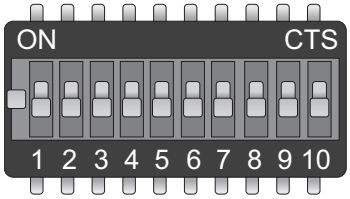
RC Control - BasicATOM Pro Example

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 BasicATOM Pro and P0 connected to S1, P1 connected to S2. Set switches SW1, SW4, SW5 and SW6 to ON.

```
;Basic Micro Robo Claw RC Mode. Control Robo Claw
;with servo pulses from a microcontroller.
;Switch settings: SW1=ON, SW4=ON, SW5=ON and SW6=ON

Main
     pulsout P15,(1500*2)    ; stop
     pulsout P14,(1500*2)    ; stop
     pause 2000

     pulsout P15,(500*2)     ; full backward
     pause 1000

     pulsout P15,(1500*2)    ; stop
     pause 2000

     pulsout P15,(2500*2)    ; full forward
     pause 1000

     pulsout P15,(1500*2)    ; stop
     pause 2000

     pulsout P14,(500*2)     ; left turn
     pause 1000

     pulsout P14,(1500*2)    ; stop
     pause 2000

     pulsout P14,(2500*2)    ; right turn
     pause 1000

goto main
```

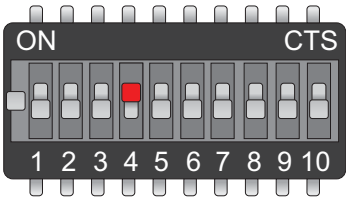
Analog Input

Mode 2 - Analog Input
For Analog mode set SW1,SW2 and SW3 = OFF. In this mode S1 and S2 are set as analog inputs. Voltages of 0V = Full reverse, 1V = Stop and 2V = Full forward. You can use linear potentiometers of 1K to 100K to control RoboClaw. Or you can use a PWM signal to control RoboClaw in analog mode. If using a PWM signal to control RoboClaw you will need a simple filter circuit to clean up the pulse. If using a potentiometer set the BEC header to 2V.



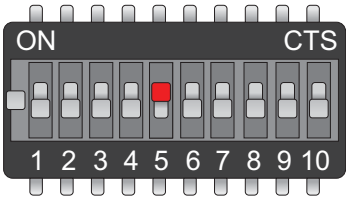
Switch 4 - Mixing Mode
SW4 = ON: Turns mixing mode ON. One channel input to control forward and reverse. Second channel input for steering control. Control will be like a car.

SW4 = OFF: Turns mixing mode OFF. One channel controls one motor speed and direction. Second channel controls the other motor speed and direction. Control will be like a tank.



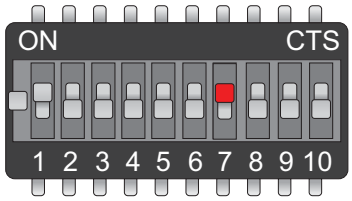
Switch 5 - Exponential Mode
SW5 = ON: Turns exponential mode ON. Exponential response softens the center control position. This mode is ideal with tank style robots.

SW5 = OFF: Turns exponential mode OFF. Motor response will be linear and directly proportional to the control input. Ideal for 4 wheel style robots.



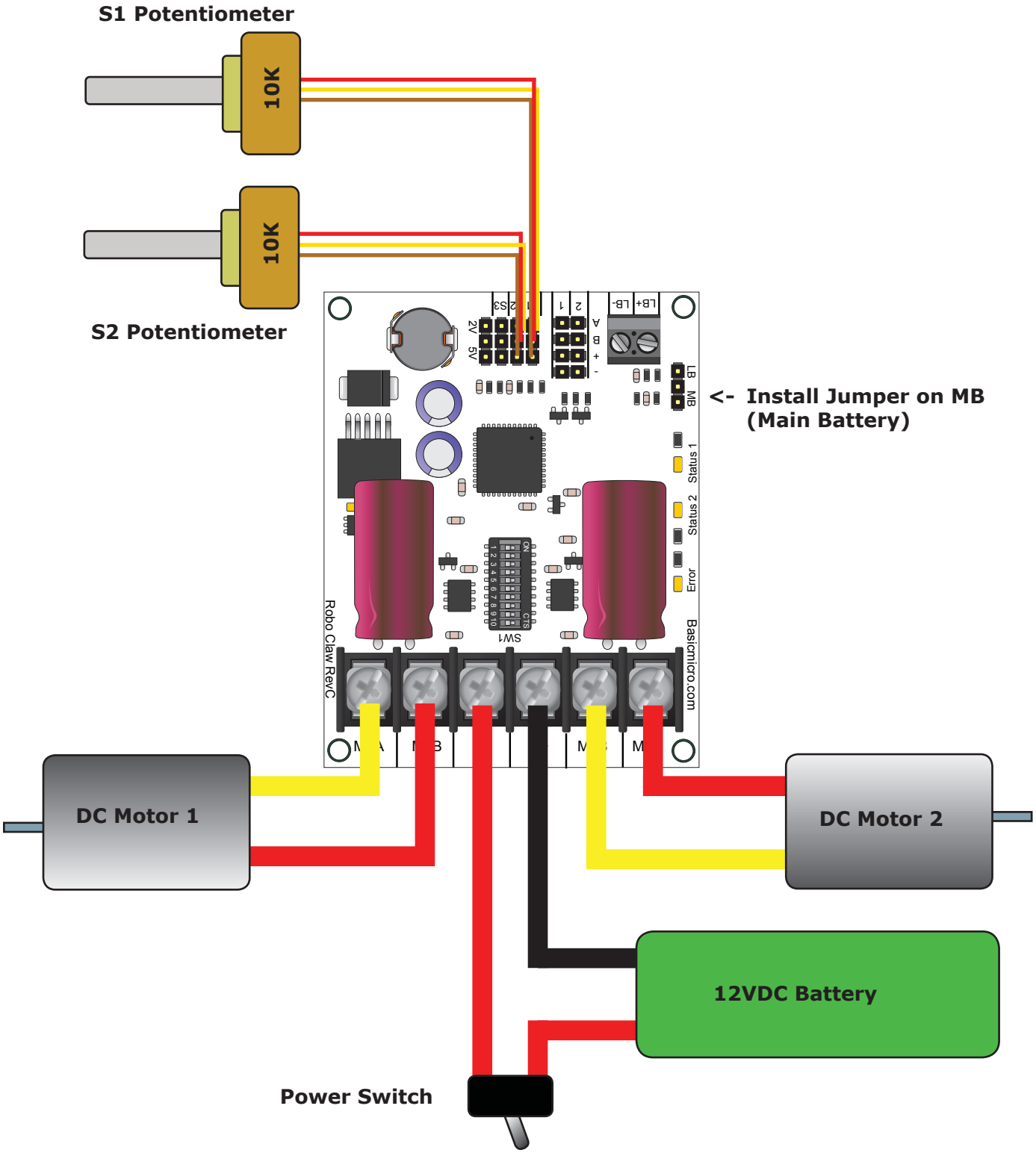
Switch 7 - Flip Switch
SW7 = ON: Turns the flip switch input S3 on. The flip switch signal is a TTL driven signal. 0V is active and 5V is not active. When the flip switch signal is active all inputs to RoboClaw are reversed.

SW7 = OFF: Turns flip switch input S3 off.



Analog Wiring Example

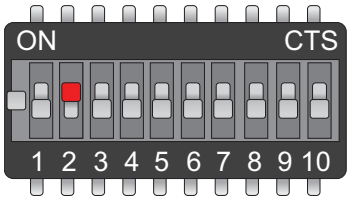
Connect the RoboClaw as shown below using two potentiometers. Install BEC 2V jumper and set switch SW4 to ON (Mixing Mode). You can also use the wire example with SW4 OFF. Center the potentiometers before applying power or the attached motors will start moving. S1 potentiometer in mix mode (SW4) will control forward and reverse. S2 potentiometer in mix mode (SW4) will control turning (LEFT / RIGHT).



Simple Serial

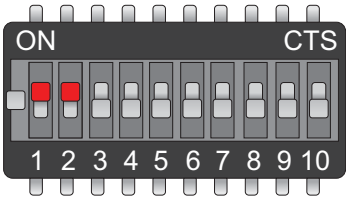
Mode 3 - Simple Serial

Simple Serial mode set SW1 = OFF, SW2 = ON and SW3 = OFF. In this mode S1 accepts TTL level byte commands. RoboClaw is receive only and uses 8N1 format which is 8 bits, no parity bits and 1 stop bit. If your using a microcontroller you can interface directly to RoboClaw. If your using a PC a level shifting circuit is required (MAX232). The baud rate is set by the dip switches.



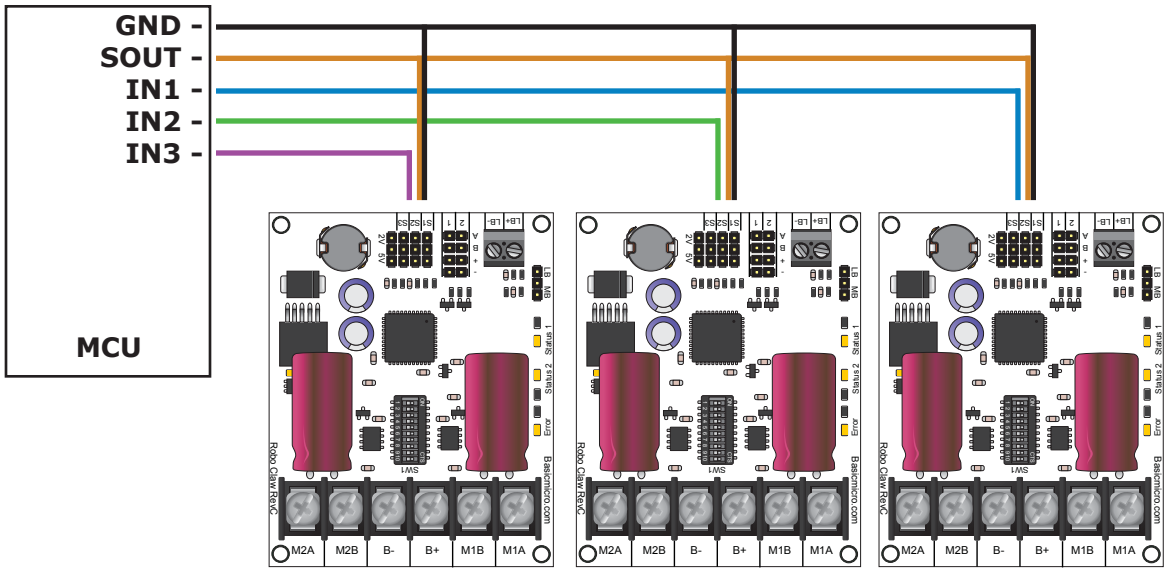
Switch 1 - Slave Select

SW1 = ON: Turns slave select ON. 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 commands. Set S2 low (0V) and RoboClaws will ignore all sent commands.



Simple Serial Slave

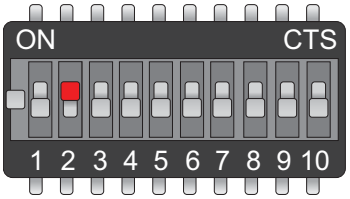
Setting up the RoboClaw for serial slave is straight forward. Make sure all RoboClaws share a common signal ground (GND) shown by the black wire. P0 (Brown line) is connected to S1 of all 3 RoboClaws which is the serial in of the RoboClaw. P1, P2 and P3 are connected to S2. Only one MCU pin is connected to each RoboClaws S2 pin. To enable RoboClaw hold S2 high otherwise any commands sent is ignored.



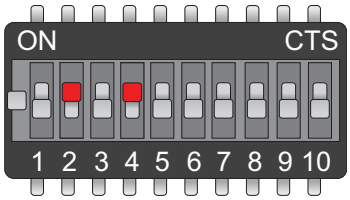
Baud Rate
RoboClaw supports 4 baud rates in serial mode. The baud rate is selected by setting switch 4 and 5.

Baud Rate	SW4	SW5
2400	OFF	OFF
9600	ON	OFF
19200	OFF	ON
38400	ON	ON

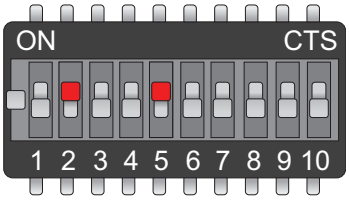
2400 Baud



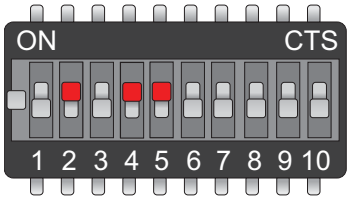
9600 Baud



19200 Baud



38400 Baud

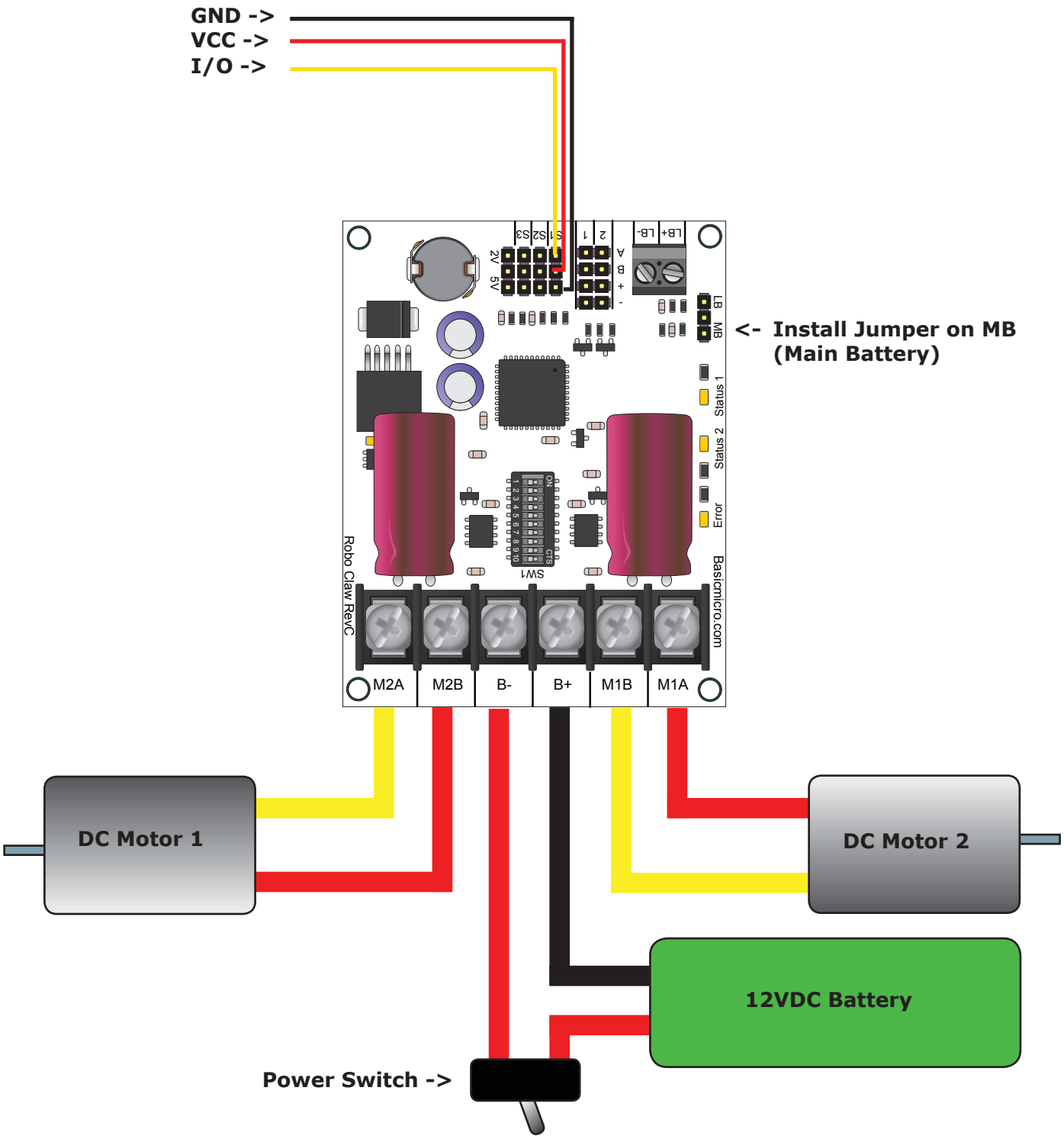


Simple Serial Command Syntax
The RoboClaw simple serial is setup to control both motors with one byte sized command character. Since a byte can be anything from 0 to 255 the control of each motor is split. 1 to 127 controls channel 1 and 128 to 255 controls channel 2. Command character 0 will shut down both channels. Any characters in between will control speed, direction of each 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

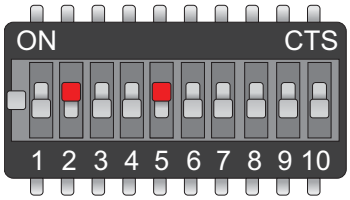
Simple Serial Wiring Example

In simple serial mode the RoboClaw can only receive serial data. Use the below wiring diagrahm with the following code examples. Make sure you install the BEC jumper to 5V if powering the MCU from RoboClaw.



Simple Serial - Arduino Example

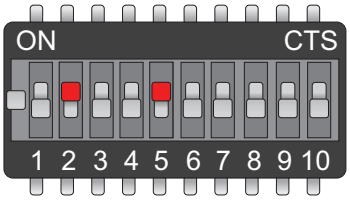
The following example will start both channels in reverse, stop, then full speed forward. The program was written and tested with a Arduino Uno and Pin 5 connected to S1. Set switch SW2 and SW5 to ON.




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

#include "BMSerial.h"

BMSerial mySerial(5,6);

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

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

Simple Serial - BasicATOM Pro Example

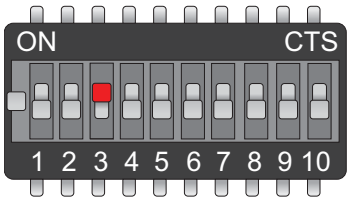
The following example will start both channels in reverse, stop, then full speed forward. The program was written and tested with a BasicATOM Pro and P0 connected to S1. Set switch SW2 and SW5 to ON.




```
;Basic Micro Robo Claw Simple Serial Test
;Switch settings: SW2=ON and SW5=ON
;Make sure BAP and Robo Claw share common GND!

Main
     Serout P15, i19200, [0] ;Full stop both channels
     Pause 500
     Serout P15, i19200, [96,224] ;Foward slowly
     Pause 3000
     Serout P15, i19200, [127,255] ;Foward fast
     Pause 3000

     Serout P15, i19200, [64,192] ;Full stop both channels
     Pause 500
     Serout P15, i19200, [32,160] ;Reverse slowly
     Pause 3000
     Serout P15, i19200, [1,128] ;Reverse fast
     Pause 3000
Goto Main
```

Packet Serial

Mode 4 - Packet Serial
Packet serial mode set SW3 = ON and then selected address. See table below. Packet serial is used to communicate more sophisticated instructions to RoboClaw. RoboClaw can send or receive serial data in packet mode. The basic command structures consists of address byte, command byte, data bytes and a checksum. The amount of data each command will send or receive can vary. In packet mode the RoboClaw serial commands are buffered for more complex functionality.



Baud Rate
Packet serial supports the same baud rate modes as simple serial and uses the same RS232 8N1 format. The following table defines the available baud rates and their respective switch settings.

Baud Rate	SW4	SW5
2400	OFF	OFF
9600	ON	OFF
19200	OFF	ON
38400	ON	ON

Address
When using packet serial each RoboClaw must be assigned a unique address. With up to 8 addresses available you can have up to 8 RoboClaws bussed on the same RS232 port. The following table defines the addresses and their respective switch settings.

Address	SW1	SW6	SW7
128 (0x80)	OFF	OFF	OFF
129 (0x81)	OFF	ON	OFF
130 (0x82)	OFF	OFF	ON
131 (0x83)	OFF	ON	ON
132 (0x84)	ON	OFF	OFF
133 (0x85)	ON	ON	OFF
134 (0x86)	ON	OFF	ON
135 (0x87)	ON	ON	ON

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

Address + Command + Data = Checksum

To mask the 8th bit you use can a simple math expression called AND as shown below:

```
Serout P15, i19200, [128, 0, 127, (255 & 0X7F)]
```

The hexadecimal value 0X7F is used to mask the 8th bit. You can also use a binary value of 01111111 as shown below:

```
Serout P15, i19200, [128, 0, 127, (255 & %01111111)]
```

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

Address, Command, ByteValue, Checksum

0 - Drive Forward M1
Drive motor 1 forward. Valid data range is 0 - 127. A value of 127 = full speed forward, 64 = about half speed forward and 0 = full stop. Example with RoboClaw address set to 128:

```
Serout P15, i19200, [128, 0, 127, (255 & 0X7F)] ;M1 full speed forward
```

1 - Drive Backwards M1
Drive motor 1 backwards. Valid data range is 0 - 127. A value of 127 full speed backwards, 64 = about half speed backward and 0 = full stop. Example with RoboClaw address set to 128:

```
Serout P15, i19200, [128, 1, 127, (256 & 0X7F)] ;M1 full speed forward
```

2 - Set Minimum Main Voltage
Sets main battery (B- / B+) minimum voltage level. If the battery voltages drops below the set voltage level RoboClaw will shut down. The value is cleared at start up and must set after each power up. The voltage is set in .2 volt increments. A value of 0 sets the minimum value allowed which is 6V. The valid data range is 0 - 120 (6V - 30V). The formula for calculating the voltage is: (Desired Volts - 6) x 5 = Value. Examples of valid values are 6V = 0, 8V = 10 and 11V = 25. Example with RoboClaw address set to 128:

```
Serout P15, i19200, [128, 2, 25, (165 & 0X7F)]
```

3 - Set Maximum Main Voltage
Sets main battery (B- / B+) maximum voltage level. The valid data range is 0 - 154 (0V - 30V). If you are using a battery of any type you can ignore this setting. During regenerative breaking a back voltage is applied to charge the battery. When using an ATX type power supply if it senses anything over 16V it will shut down. By setting the maximum voltage level, RoboClaw before exceeding it will go into hard breaking mode until the voltage drops below the maximum value set. The formula for calculating the voltage is: Desired Volts x 5.12 = Value. Examples of valid values are 12V = 62, 16V = 82 and 24V = 123. Example with RoboClaw address set to 128:

```
Serout P15, i19200, [128, 3, 82, (213 & 0X7F)]
```

4 - Drive Forward M2
Drive motor 2 forward. Valid data range is 0 - 127. A value of 127 full speed forward, 64 = about half speed forward and 0 = full stop. Example with RoboClaw address set to 128:

```
Serout P15, i19200, [128, 4, 127, (259 & 0X7F)] ;M2 full speed forward
```

5 - Drive Backwards M2
Drive motor 2 backwards. Valid data range is 0 - 127. A value of 127 full speed backwards, 64 = about half speed backward and 0 = full stop. Example with RoboClaw address set to 128:

```
Serout P15, i19200, [128, 5, 127, (260 & 0X7F)] ;M2 full speed forward
```

6 - Drive M1 (7 Bit)
Drive motor 1 forward and reverse. Valid data range is 0 - 127. A value of 0 = full speed reverse, 64 = stop and 127 = full speed forward. Example with RoboClaw address set to 128:

```
Serout P15, i19200, [128, 6, 96, (230 & 0X7F)] ;M1 half speed forward
```

7 - Drive M2 (7 Bit)
Drive motor 2 forward and reverse. Valid data range is 0 - 127. A value of 0 = full speed reverse, 64 = stop and 127 = full speed forward. Example with RoboClaw address set to 128:

```
Serout P15, i19200, [128, 7, 32, (167 & 0X7F)] ;M2 half speed reverse
```

Commands 8 - 13 Mix Mode Commands
The following commands are mix mode commands and used to control speed and turn. Before a command is executed valid drive and turn data is required. You only need to send both data packets once. After receiving both valid drive and turn data RoboClaw will begin to operate. At this point you only need to update turn or drive data.

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

```
Serout P15, i19200, [128, 8, 127, (263 & 0x7F)] ;full speed forward
```

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

```
Serout P15, i19200, [128, 9, 127, (264 & 0x7F)] ;full speed reverse
```

10 - Turn right
Turn right in mix mode. Valid data range is 0 - 127. A value of 0 = stop turn and 127 = full speed turn. Example with RoboClaw address set to 128:

```
Serout P15, i19200, [128, 10, 127, (265 & 0x7F1)] ;full speed right turn
```

11 - Turn left
Turn left in mix mode. Valid data range is 0 - 127. A value of 0 = stop turn and 127 = full speed turn. Example with RoboClaw address set to 128:

```
Serout P15, i19200, [128, 11, 127, (266 & 0x7F)] ;full speed left turn
```

12 - Drive Forward or Backward (7 Bit)
Drive forward or backwards. Valid data range is 0 - 127. A value of 0 = full backward, 64 = stop and 127 = full forward. Example with RoboClaw address set to 128:

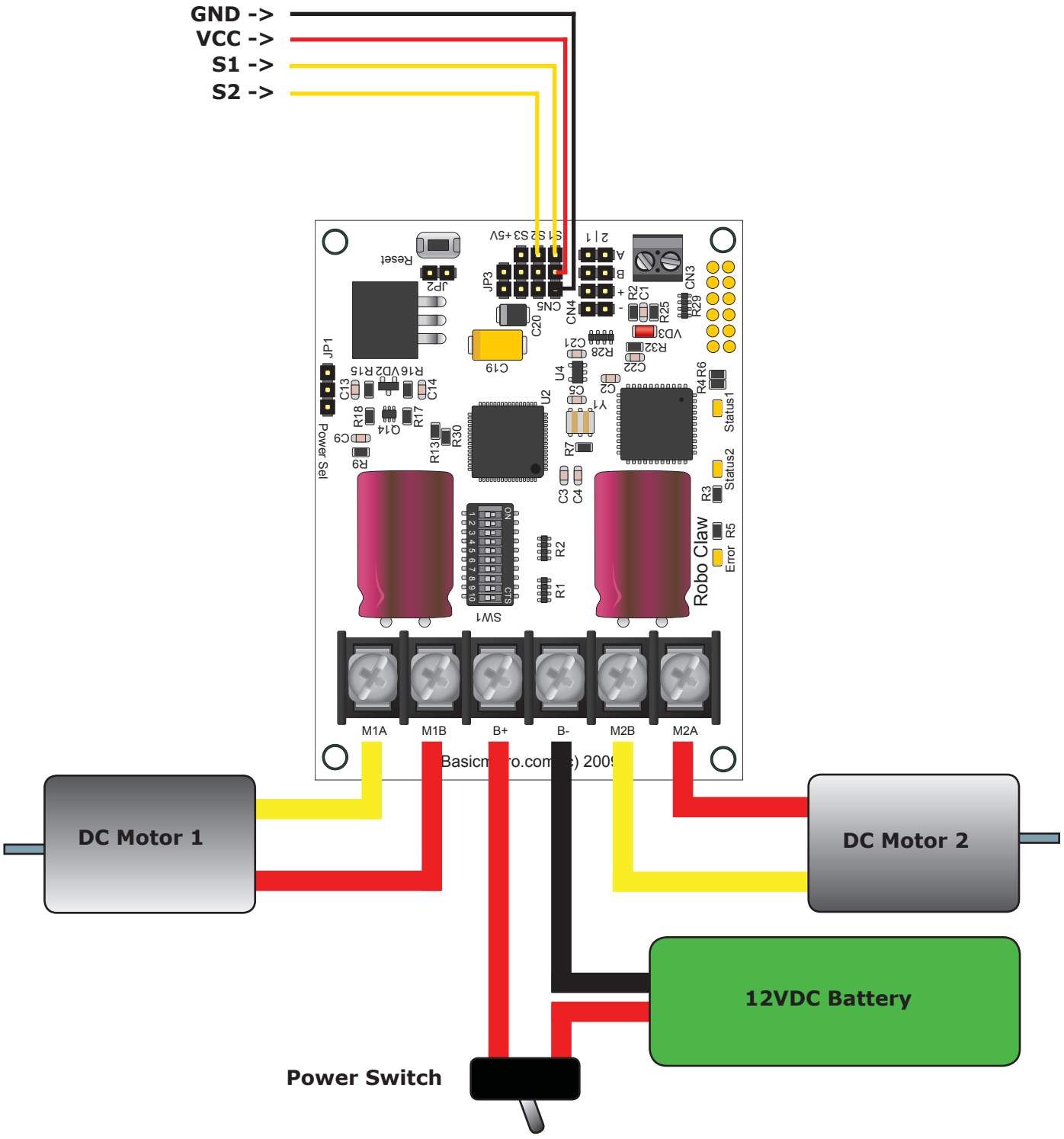
```
Serout P15, i19200, [128, 12, 96, (236 & 0x7F)] ;medium speed forward
```

13 - Turn Left or Right (7 Bit)
Turn left or right. Valid data range is 0 - 127. A value of 0 = full left, 0 = stop turn and 127 = full right. Example with RoboClaw address set to 128:

```
Serout P15, i19200, [128, 13, 0, (141 & 0x7F)] ;full speed turn left
```

Packet Serial Wiring

In packet mode the RoboClaw can transmit and receive serial data. RoboClaw is transmitting return data a processor with a hardware serial port is required.



Packet Serial - Arduino Example

The example will start the motor channels independently. Then start turns with mix mode commands. The program was written and tested with a Arduno Uno and P5 connected to S1. Set switch SW3 and SW5 to ON.

```
//Basic Micro Robo Claw Packet Serial Test Commands 0 to 13.
//Switch settings: SW3=ON and SW5=ON.

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

#define address 0x80

RoboClaw roboclaw(5,6);

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

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

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

  delay(10000);

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

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

  delay(10000);
}
```

Packet Serial - BasicATOM Pro Example

The example will start the motor channels independently. Then start turns with mix mode commands. The program was written and tested with a BasicATOM Pro and P15 connected to S1. Set switch SW3 and SW5 to ON.

```
;Basic Micro Robo Claw Packet Serial Test Commands 0 to 13.
;Switch settings: SW3=ON and SW5=ON.

Main
     Pause 2000
     Serout P15, i19200, [128, 0, 127, (255 & 0x7F)];M1 full speed forward
     Serout P15, i19200, [128, 4, 127, (259 & 0x7F)];M2 full speed forward

     Pause 1000
     Serout P15, i19200, [128, 0, 0, (128 & 0x7F)];M1 stop
     Serout P15, i19200, [128, 4, 0, (132 & 0x7F)];M2 stop

     Pause 1000
     Serout P15, i19200, [128, 1, 127, (256 & 0x7F)];M1 full speed backwards
     Serout P15, i19200, [128, 5, 127, (260 & 0x7F)];M1 full speed backwards

     Pause 1000
     Serout P15, i19200, [128, 0, 0, (128 & 0x7F)];M1 stop
     Serout P15, i19200, [128, 4, 0, (132 & 0x7F)];M2 stop

     Pause 1000
     Serout P15, i19200, [128, 10, 127, (265 & 0x7F)];Mix mode right full speed

     Pause 1000
     Serout P15, i19200, [128, 10, 0, (138 & 0x7F)];Mix mode stop

     Pause 1000
     Serout P15, i19200, [128, 11, 127, (266 & 0x7F)];Mix mode left full speed

     Pause 1000
     Serout P15, i19200, [128, 11, 0, (139 & 0x7F)];Mix mode stop
Goto Main
```

Battery and Version Information

21 - Read Firmware Version

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

```
Sent: [Address, CMD]
Received: ["RoboClaw 10.2A v1.3.9, Checksum]
```

The command will return up to 32 bytes. The return string includes the product name and firmware version. The return string is terminated with a null (0) character. This is done so the version information can be read from a standard PC terminal window.

```
hserout [128, 21] ;read firmware version
hserin [Str VersionByte\32\0, Checksum]
```

24 - Read Main Battery Voltage Level

Read the main battery voltage level connected to B+ and B- terminals. The voltage is returned in 10ths of a volt. Command syntax:

```
Sent: [Address, CMD]
Received: [Value.Byte1, Value.Byte0, Checksum]
```

The command will return 3 bytes. Byte 1 and 2 make up a word variable which is received MSB first and is 10th of a volt. A returned value of 300 would equal 30V. Byte 3 is the checksum. It is calculated the same way as sending a command and can be used to validate the data. The following example will read the main battery voltage with RoboClaw address set to 128.

```
hserout [128, 24] ;read main battery voltage
hserin [Value.Byte1, Value.Byte0, Checksum]
```

25 - Read Logic Battery Voltage Level

Read a logic battery voltage level connected to LB+ and LB- terminals. The voltage is returned in 10ths of a volt. Command syntax:

```
Sent: [Address, CMD]
Received: [Value.Byte1, Value.Byte0, Checksum]
```

The command will return 3 bytes. Byte 1 and 2 make up a word variable which is received MSB first and is 10th of a volt. A returned value of 50 would equal 5V. Byte 3 is the checksum. It is calculated the same way as sending a command and can be used to validate the data. The following example will read the main battery voltage with RoboClaw address set to 128.

```
hserout [128, 25] ;read logic battery voltage
hserin [Value.Byte1, Value.Byte0, Checksum]
```

26 - Set Minimum Logic Voltage Level
Sets logic input (LB- / LB+) minimum voltage level. If the battery voltages drops below the set voltage level RoboClaw will shut down. The value is cleared at start up and must set after each power up. The voltage is set in .2 volt increments. A value of 0 sets the minimum value allowed which is 3V. The valid data range is 0 - 120 (6V - 28V). The formula for calculating the voltage is: (Desired Volts - 6) x 5 = Value. Examples of valid values are 3V = 0, 8V = 10 and 11V = 25. RoboClaw example with address set to 128:

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

27 - Set Maximum Logic Voltage Level
Sets logic input (LB- / LB+) maximum voltage level. The valid data range is 0 - 144 (0V - 28V). By setting the maximum voltage level RoboClaw will go into shut down and requires a hard reset to recovers. The formula for calculating the voltage is: Desired Volts x 5.12 = Value. Examples of valid values are 12V = 62, 16V = 82 and 24V = 123. RoboClaw example with address set to 128:

```
hserout [128, 27, 82, (213 & 0X7F)]
```

Main Battery Voltage Levels
The main battery levels are set in a similar way as the logic battery. See command 2 and 3 for details.

Quadrature Decoding

Quadrature Decoding
Handling the quadrature encoders is done using packet serial. All the switch settings still apply in to enabling packet serial and setting the desired baud rates. See Mode - Packet Serial. The following commands deal specifically with the dual quadrature decoders built into RoboClaw.

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

Address + Command + Data = Checksum

To mask the 8th bit you use can a simple math expression called AND as shown below:

```
Serout P15, i19200, [128, 0, 127, (255 & 0X7F)]
```

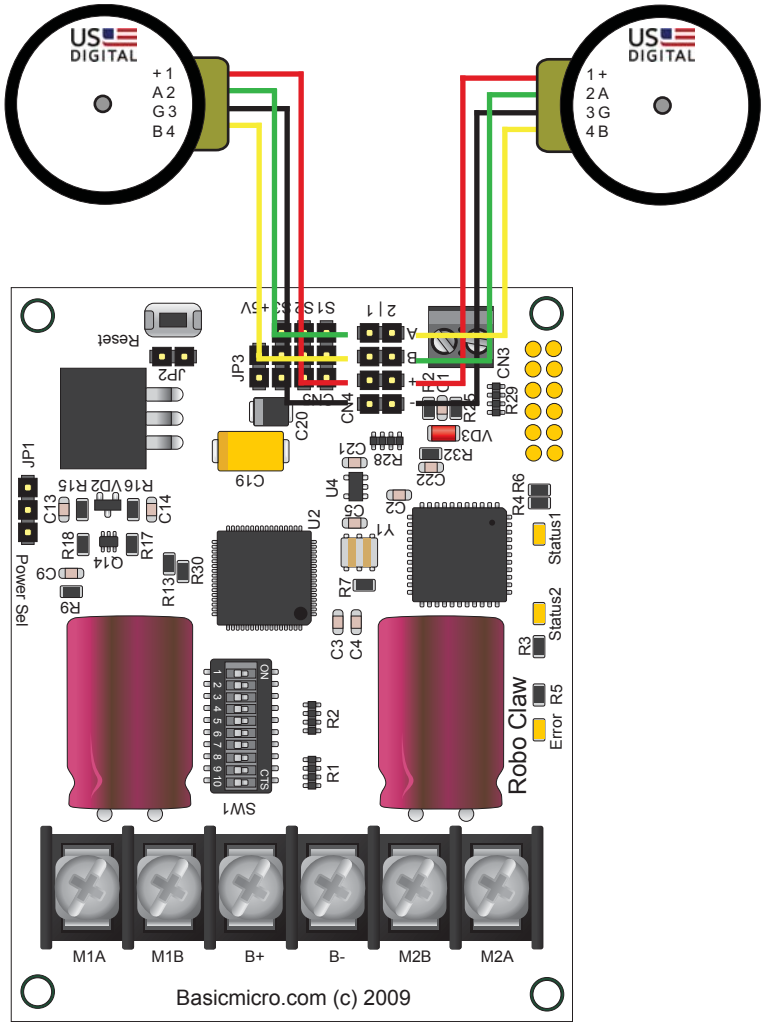
The hexadecimal value 0X7F is used to mask the 8th bit. You can also use a binary value of 01111111 as shown below:

```
Serout P15, i19200, [128, 0, 127, (255 & %01111111)]
```

Quadrature Encoder Wiring

RoboClaw can read two quadrature encoders. The encoders are connected to RoboClaw using CN4. Both GND and 5 volts are present on the header to power the encoders.

In a two motor robot configuration one motor will spin clock wise (CW) while the other motor will spin counter clock wise (CCW). The A and B inputs for one of the two encoders must be reversed as shown. If either encoder is connected wrong one will count up and the other down this will cause commands like mix drive forward to not work properly.



Commands 16 - 20 Reading Quadrature Encoders

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

Command	Description
16	Read Quadrature Encoder Register for M1.
17	Read Quadrature Encoder Register for M2.
18	Read M1 Speed in Pulses Per Second.
19	Read M2 Speed in Pulses Per Second.
20	Resets Quadrature Encoder Registers for M1 and M2.

16 - Read Quadrature Encoder Register M1

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

```
Sent: [Address, CMD]
Received: [Value1.Byte3, Value1.Byte2, Value1.Byte1, Value1.Byte0, Value2,
Checksum]
```

The command will return 6 bytes. Byte 1,2,3 and 4 make up a long variable which is received MSB first and represents the current count which can be any value from 0 - 4,294,967,295. Each pulse from the quadrature encoder will increment or decrement the counter depending on the direction of rotation.

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

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

Byte 6 is the checksum. It is calculated the same way as sending a command. It can be used to validate the resulting data. The following example will read M1 counter register, status byte and checksum value with RoboClaw address set to 128.

```
hserout [128, 16] ;read command for M1 encoder
hserin [Value1.Byte3, Value1.Byte2, Value1.Byte1, Value1.Byte0, Value2, Checksum]
```

17 - Read Quadrature Encoder Register M2

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

```
Sent: [Address, CMD]
Received: [Value1.Byte3, Value1.Byte2, Value1.Byte1, Value1.Byte0, Value2, Checksum]
```

The command will return 6 bytes. Byte 1,2,3 and 4 make up a long variable which is received MSB first and represents the current count which can be any value from 0 - 4,294,967,295. Each pulse from the quadrature encoder will increment or decrement the counter depending on the direction of rotation.

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

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

Byte 6 is the checksum. It is calculated the same way as sending a command. It can be used to validate the resulting data. The following example will read M1 counter register, status byte and checksum value with RoboClaw address set to 128.

```
hserout [128, 17] ;read command for M2 encoder
hserin [Value1.Byte3, Value1.Byte2, Value1.Byte1, Value1.Byte0, Value2, Checksum]
```

18 - Read Speed M1

Read M1 counter speed. Returned value is in pulses per second. RoboClaw keeps track of how many pulses received per second for both decoder channels. Since CMD 18 is a read command it does not require a checksum to be sent. However a checksum value will be returned from RoboClaw and can be used to validate the data. Command syntax:

```
Sent: [Address, CMD]
Received: [Value1.Byte3, Value1.Byte2, Value1.Byte1, Value1.Byte0, Value2, Checksum]
```

The command will return 6 bytes. Byte 1,2,3 and 4 make up a long variable which is received MSB first and is the current ticks per second which can be any value from 0 - 4,294,967,295. Byte 5 is the direction (0 – forward, 1 - backward). Byte 6 is the checksum. It is calculated the same way as sending a command and can be used to validate the data. The following example will read M1 pulse per second and direction with RoboClaw address set to 128.

```
hserout [128, 18] ;read command for M1 encoder
hserin [Value1.Byte3, Value1.Byte2, Value1.Byte1, Value1.Byte0, Value2, Checksum]
```

19 - Read Speed M2

Read M2 counter speed. Returned value is in pulses per second. RoboClaw keeps track of how many pulses received per second for both decoder channels. Since CMD 19 is a read command it does not require a checksum to be sent. However a checksum value will be returned from RoboClaw and can be used to validate the data. Command syntax:

```
Sent: [Address, CMD]
Received: [Value1.Byte3, Value1.Byte2, Value1.Byte1, Value1.Byte0, Value2, Checksum]
```

The command will return 6 bytes. Byte 1,2,3 and 4 make up a long variable which is received MSB first and is the current ticks per second which can be any value from 0 - 4,294,967,295. Byte 5 is the direction (0 – forward, 1 - backward). Byte 6 is the checksum. It is calculated the same way as sending a command and can be used to validate the data. The following example will read M2 pulse per second and direction with RoboClaw address set to 128.

```
hserout [128, 19] ;read command for M2 encoder
hserin [Value1.Byte3, Value1.Byte2, Value1.Byte1, Value1.Byte0, Value2, Checksum]
```

20 - Reset Quadrature Encoder Counters

Will reset both quadrature decoder counters to zero. Since CMD 20 is a write command a checksum value is required. Command syntax and example:

```
hserout [128, 20, (148 & %01111111)]; resets encoder registers
```

Commands 28 - 48 Motor Control by Quadrature Encoders
The following commands are used to control motor speeds, acceleration and distance using the quadrature encoders. All speeds are given in quad pulses per second (QPPS) unless otherwise stated. Quadrature encoders of different types and manufactures can be used. However many have different resolutions and maximum speeds at which they operate. So each quadrature encoder will produce a different range of pulses per second.

Command	Description
28	Set PID Constants for M1.
29	Set PID Constants for M2.
30	Read Current M1 Speed Resolution 125th of a Second.
31	Read Current M2 Speed Resolution 125th of a Second.
32	Drive M1 With Signed Duty Cycle.
33	Drive M2 With Signed Duty Cycle.
34	Mix Mode Drive M1 / M2 With Signed Duty Cycle.
35	Drive M1 With Signed Speed.
36	Drive M2 With Signed Speed.
37	Mix Mode Drive M1 / M2 With Signed Speed.
38	Drive M1 With Signed Speed And Acceleration.
39	Drive M2 With Signed Speed And Acceleration.
40	Mix Mode Drive M1 / M2 With Speed And Acceleration.
41	Drive M1 With Signed Speed And Distance. Buffered.
42	Drive M2 With Signed Speed And Distance. Buffered.
43	Mix Mode Drive M1 / M2 With Speed And Distance. Buffered.
44	Drive M1 With Signed Speed, Acceleration and Distance. Buffered.
45	Drive M2 With Signed Speed, Acceleration and Distance. Buffered.
46	Mix Mode Drive M1 / M2 With Speed, Acceleration And Distance. Buffered.
47	Read Buffer Length.
48	Set PWM Resolution.

28 - Set PID Constants M1

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

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

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

```
Sent: [Address, CMD, D(4 bytes), P(4 bytes), I(4 bytes), QPPS(4 byte), Checksum]
```

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

29 - Set PID Constants M2

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

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

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

```
Sent: [Address, CMD, D(4 bytes), P(4 bytes), I(4 bytes), QPPS(4 byte), Checksum]
```

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

30 - Read Current Speed M1
Read the current pulse per 125th of a second. This is a high resolution version of command 18 and 19. Command 30 can be used to make a independent PID routine. The resolution of the command is required to create a PID routine using any microcontroller or PC used to drive RoboClaw. The command syntax:

```
Sent: [Address, CMD]
Received: [Value1.Byte3, Value1.Byte2, Value1.Byte1, Value1.Byte0, Value2, Checksum]
```

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

31 - Read Current Speed M2
Read the current pulse per 125th of a second. This is a high resolution version of command 18 and 19. Command 31 can be used to make a independent PID routine. The resolution of the command is required to create a PID routine using any microcontroller or PC used to drive RoboClaw. The command syntax:

```
Sent: [Address, CMD]
Received: [Value1.Byte3, Value1.Byte2, Value1.Byte1, Value1.Byte0, Value2, Checksum]
```

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

32 - Drive M1 With Signed Duty Cycle
Drive M1 using a duty cycle value. The default PWM is 8bit resolution. The default value can be changed see CMD 48. The duty cycle is used to control the speed of the motor without a quadrature encoder. A value used to drive one motor at 50% will be differ from one motor to the next. The command syntax:

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

The duty value is signed and the default range is 8bits. The default PWM resolution can be changed for more range. To change the resolution see command 48.

33 - Drive M2 With Signed Duty Cycle
Drive M2 using a duty cycle value. The default PWM is 8bit resolution. The default value can be changed see CMD 48. The duty cycle is used to control the speed of the motor without a quadrature encoder. A value used to drive one motor at 50% will be differ from one motor to the next. The command syntax:

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

The duty value is signed and the default range is 8bits. The default PWM resolution can be changed for more range. To change the resolution see command 48.

34 - Mix Mode Drive M1 / M2 With Signed Duty Cycle

Drive both M1 and M2 using a duty cycle value. The default PWM is 8bit resolution. The default value can be changed see CMD 48. The duty cycle is used to control the speed of the motor without a quadrature encoder. A value used to drive one motor at 50% will be differ from one motor to the next. The command syntax:

```
Sent: [Address, CMD, DutyM1(2 Bytes), DutyM2(2 Bytes), Checksum]
```

The duty value is signed and the default range is 8bits. The default PWM resolution can be changed for more range. To change the resolution see command 48.

35 - Drive M1 With Signed Speed

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

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

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

36 - Drive M2 With Signed Speed

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

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

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

37 - Mix Mode Drive M1 / M2 With Signed Speed

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

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

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

38 - Drive M1 With Signed Speed And Acceleration

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

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

4 Bytes (long) are used to express the pulses per second. Quadrature encoders send 4 pulses per tick. So 1000 ticks would be counted as 4000 pulses. The acceleration is measured in speed per second. An acceleration value of 12,000 QPPS with a speed of 12,000 QPPS would accelerate a motor from 0 to 12,000 QPPS in 1 second. Another example would be an acceleration value of 24,000 QPPS and a speed value of 12,000 QPPS would accelerate the motor to 12,000 QPPS in 0.5 seconds.

39 - Drive M2 With Signed Speed And Acceleration

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

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

4 Bytes (long) are used to express the pulses per second. Quadrature encoders send 4 pulses per tick. So 1000 ticks would be counted as 4000 pulses. The acceleration is measured in speed per second. An acceleration value of 12,000 QPPS with a speed of 12,000 QPPS would accelerate a motor from 0 to 12,000 QPPS in 1 second. Another example would be an acceleration value of 24,000 QPPS and a speed value of 12,000 QPPS would accelerate the motor to 12,000 QPPS in 0.5 seconds.

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

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

4 Bytes (long) are used to express the pulses per second. Quadrature encoders send 4 pulses per tick. So 1000 ticks would be counted as 4000 pulses. The acceleration is measured in speed per second. An acceleration value of 12,000 QPPS with a speed of 12,000 QPPS would accelerate a motor from 0 to 12,000 QPPS in 1 second. Another example would be an acceleration value of 24,000 QPPS and a speed value of 12,000 QPPS would accelerate the motor to 12,000 QPPS in 0.5 seconds.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

47 - Read Buffer Length

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

```
Sent: [Address, CMD]
Received: [BufferM1(1 Bytes), BufferM2(1 Bytes), Checksum]
```

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

Reading Quadrature Encoder - Arduino Example
The example was tested with an Arduino Uno. RoboClaw was connected as shown in both 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.

```
//Basic Micro Robo Claw Packet Serial Mode.
//Switch settings: SW3=ON, SW4=ON, SW5=ON

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

#define address 0x80

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

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

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

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

void loop() {
  uint8_t status;
  bool valid;

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

  delay(100);
}
```

Speed Controlled by Quadrature Encoders - Arduino Example
The following example was written using an BasicATOM Pro. RoboClaw was connected as shown in both 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.

```
//Basic Micro Robo Claw Packet Serial Mode.
//Switch settings: SW3=ON, SW4=ON, SW5=ON

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

#define address 0x80


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

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

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

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

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

  uint32_t enc1= roboclaw.ReadEncM1(address, &status, &valid);
  if(valid){
    terminal.print("Encoder1:");
    terminal.print(enc1,DEC);
    terminal.print(" ");
    terminal.print(status,HEX);
    terminal.print(" ");
  }
  uint32_t enc2 = roboclaw.ReadEncM2(address, &status, &valid);
  if(valid){
    terminal.print("Encoder2:");
    terminal.print(enc2,DEC);
    terminal.print(" ");
    terminal.print(status,HEX);
    terminal.print(" ");
  }
```

```
  uint32_t speed1 = roboclaw.ReadSpeedM1(address, &status, &valid);
  if(valid){
    terminal.print("Speed1:");
    terminal.print(speed1,DEC);
    terminal.print(" ");
  }
  uint32_t speed2 = roboclaw.ReadSpeedM2(address, &status, &valid);
  if(valid){
    terminal.print("Speed2:");
    terminal.print(speed2,DEC);
    terminal.print(" ");
  }
  terminal.println();
}

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

}
```

Reading Quadrature Encoder - BasicATOM Pro Example
The example was tested with a BasicATOM Pro. RoboClaw was connected as shown in both 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 the Basic Micro Studio 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.

```
Encoder1 Var Long
Encoder2 Var Long
Status Var Byte
CRC Var Byte

ENABLEHSERIAL       ;used on AtomPro24 and AtomPro28. AtomPro40 and ARC-32 use EnableHSerial2

SetHSerial H38400,H8DATABITS,HNOPARITY,H1STOPBITS

Pause 250

Hserout [128, 20, (148 & 0x7F)]; Resets encoder registers

Main
      Pause 100

ReadEncoderM1
      Hserout [128, 16]
      Hserin [Encoder1.byte3, Encoder1.Byte2, Encoder1.Byte1, Encoder1.Byte0, Status, crc]
      Serout s_out, i38400, [0,"Encoder1: ", SDEC Encoder1, 13, "Status Byte: ", BIN Status]

ReadSpeedM1
      Hserout [128, 18]
      Hserin [Encoder1.byte3, Encoder1.Byte2, Encoder1.Byte1, Encoder1.Byte0, Status, crc]
      Serout s_out, i38400, [13, 13, "Speed: ", DEC Encoder1, 13, "Direction: ", DEC Status]

ReadEncoderM2
      Hserout [128, 17]
      Hserin [Encoder2.byte3, Encoder2.Byte2, Encoder2.Byte1, Encoder2.Byte0, Status, crc]
      Serout s_out, i38400, [13, 13, "Encoder2: ", SDEC Encoder2, 13, "Status Byte: ", BIN Status]

ReadSpeedM2
      Hserout [128, 19]
      Hserin [Encoder2.byte3, Encoder2.Byte2, Encoder2.Byte1, Encoder2.Byte0, Status, crc]
      Serout s_out, i38400, [13, 13, "Speed: ", DEC Encoder2, 13, "Direction: ", DEC Status]

Goto Main
```

Speed Controlled by Quadrature Encoders - BasicATOM Pro Example

The following example was written using an BasicATOM Pro. RoboClaw was connected as shown in both 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.

```
CMD     var byte
Speed   var long
Speed2  var long
CRC     var byte
Address con 128

ENABLEHSERIAL   ;used on AtomPro24 and AtomPro28. AtomPro40 and ARC-32 use EnableHSerial2
SetHSerial H38400,H8DATABITS,HNOPARITY,H1STOPBITS

Mixed_Forward
       CMD=37
       Speed=12000
       Speed2=12000
       CRC = (address + cmd + speed.byte3 + speed.byte2 + speed.byte1 + speed.byte0 + |
                          speed2.byte3 + speed2.byte2 + speed2.byte1 + speed2.byte0)&0x7F
       hserout [address,cmd,speed.byte3,speed.byte2,speed.byte1,speed.byte0, |
                          speed2.byte3,speed2.byte2,speed2.byte1,speed2.byte0,crc]
       pause 4000

Mixed_Backward
       CMD=37
       Speed=-12000
       Speed2=-12000
       CRC = (address + cmd + speed.byte3 + speed.byte2 + speed.byte1 + speed.byte0 + |
                          speed2.byte3 + speed2.byte2 + speed2.byte1 + speed2.byte0)&0x7F
       hserout [address,cmd,speed.byte3,speed.byte2,speed.byte1,speed.byte0, |
                          speed2.byte3,speed2.byte2,speed2.byte1,speed2.byte0,crc]
       pause 4000

Mixed_Left
       CMD=37
       Speed=-12000
       Speed2=12000
       CRC = (address + cmd + speed.byte3 + speed.byte2 + speed.byte1 + speed.byte0 + |
                          speed2.byte3 + speed2.byte2 + speed2.byte1 + speed2.byte0)&0x7F
       hserout [address,cmd,speed.byte3,speed.byte2,speed.byte1,speed.byte0, |
                          speed2.byte3,speed2.byte2,speed2.byte1,speed2.byte0,crc]
       pause 4000

Mixed_Right
       CMD=37
       Speed=12000
       Speed2=-12000
       CRC = (address + cmd + speed.byte3 + speed.byte2 + speed.byte1 + speed.byte0 + |
                          speed2.byte3 + speed2.byte2 + speed2.byte1 + speed2.byte0)&0x7F
       hserout [address,cmd,speed.byte3,speed.byte2,speed.byte1,speed.byte0, |
                          speed2.byte3,speed2.byte2,speed2.byte1,speed2.byte0,crc]
       pause 4000

Mixed_Stop
       CMD=37
       Speed=0
       Speed2=0
       CRC = (address + cmd + speed.byte3 + speed.byte2 + speed.byte1 + speed.byte0 + |
                          speed2.byte3 + speed2.byte2 + speed2.byte1 + speed2.byte0)&0x7F
       hserout [address,cmd,speed.byte3,speed.byte2,speed.byte1,speed.byte0, |
                          speed2.byte3,speed2.byte2,speed2.byte1,speed2.byte0,crc]

       stop
```

Electrical Characteristics

Characteristic	Rating	Min	Typ	Max
Pulse Per Second	PPS	0		8,000,000
Main Battery (B+ / B-)	VDC	6	24	30
Logic Battery (LB+ / LB-)	VDC	6	12	30
External Current Draw (BEC)	A			3A
Logic Circuit	mA		90	
Motor Current Per Channel	A		15	30
I/O Voltages	VDC	0		5
I/O Logic	TTL			5
Tempature Range	C	-40		+125

Warranty

Basic Micro warranties its products against defects in material and workmanship for a period of 90 days. If a defect is discovered, Basic Micro will, at our discretion, repair, replace, or refund the purchase price of the product in question. Contact us at support@basicmicro.com. No returns will be accepted without the proper authorization.

Copyrights and Trademarks

Disclaimer

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Contacts

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

Discussion List

A web based discussion board is maintained at http://www.basicmicro.com**.**

Technical Support

Technical support is made available by sending an email to support@basicmicro.com. All email will be answered within 48 hours. All general syntax and programming questions, unless deemed to be a software issue, will be referred to the on-line discussion forums.

Appendix B [2]

YUMO

旋转编码器
ROTARY ENCODERS

增量型旋转编码器

增量型 外径φ25 型号：A6A2
INCREMENTAL ROTARY ENCODERS,OUTSIDE DIAM φ25 MODEL：A6A2
替代型号SUBSTITUTE：E6A2

型号 小型编码器MINITYPE ENCODERS

A6A2 – CWZ 6C

- A6A2：设计顺序 Sequence Number；外径φ25 outsidediam diam φ25
- CWZ：
  - S:单相输出 singleness Output "A"
  - W:多相输出 AB90° Phase Difference
  - Z：带复位相输出 + Zero Signal
- 6C：
  - 1：DC5V
  - 3：DC5～12V
  - 5：DC12～24V
  - 6：DC5～24V
  - B：PNP开路输出PNP open collector Output
  - C：NPN开路输出Open collector NPN output
  - E：电压（NPN）输出Voltage output
  - Gh：互补输出 NPN Push Pull output
  - EH：电压（PNP）输出PNP Voltage output
- •绝对式编码器
- •增量式编码器

■种类Ordering Information

◆本体ABSOLUTE ROTARY ENCODERS

输出相 Output Mode	电源电压 Supply Voltage	输出状态 Output Configuration	替代型号 Substitute	分辨率（脉冲/旋转）Resolution(p/r)
A相	DC 5~12V	电压输出 Voltage output	型号A6A2-CS3E	10 60 100 200 300 360 / 500
		NPN开路集电极输出 Open collector NPN output	型号A6A2-CS3C	10 60 100 200 300 360 / 500
	DC12~24V		型号A6A2-CS5C	10 60 100 200 300 360 / 500
A相、B相	DC 5~12V	电压输出 Voltage output	○型号A6A2-CW3E	100 200 360 / 500
		NPN开路集电极输出 Open collector NPN output	○型号A6A2-CW3C	100 200 360 / 500
	DC12~24V		○型号A6A2-CW5C	100 200 360 / 500
A相、B相 Z相	DC 5~12V	电压输出 Voltage output	○型号A6A2-CWZ3E	100 200 360 / 500
		NPN开路集电极输出 Open collector NPN output	○型号A6A2-CWZ3C	100 200 300 / 500
	DC12~24V		○型号A6A2-CWZ5C	100 200 360 / 500

注：订购时，除型号之外，还一定要指定"分辨率"。
分辨率为标准在库，无记号的为接收订货生产。

●适应定位的需要。
带原点输出(Z相)型出现在生产线上。
●也实现了更高精度的测长等。
●追加了外径φ25，分辨率500P/R的系列。

增量型旋转编码器

增量型　外径φ25 型号：A6A2
INCREMENTAL ROTARY ENCODERS,OUTSIDE DIAM φ25 MODEL：A6A2
替代型号SUBSTITUTE：E6A2

外径：φ25　型号：A6A2　替代型号：E6A2

Miniature Rotary Encoder for
Positioning in Space-Confined Areas

- Wide variety of supply voltages and output forms to match input devices
- Models with zero index function ideal for positioning applications
- High resolution models (300 or 360 pulses per revolution) substantially improve measuring accuracy
- High response frequency and noise immunity make encoders ideal for factory automation applications

■额定/性能SPECIFICATIONS

型号MODEL / 项目ITEM	型号A6A2-CS3E	型号A6A2-CS3C	型号A6A2-CS5C	型号A6A2-CW3E	型号A6A2-CW3C	型号A6A2-CW5C	型号A6A2-CWZ3E	型号A6A2-CWZ3C	型号A6A2-CWZ5C
电源电压 Powersupplyvoltage	DC5V-5%~12V+10% 脉动(p-p)5%以下		DC12V-10%~24V+15% 脉动(p-p)5%以下	DC5V-5%~12V+10% 脉动(p-p)5%以下		DC12V-10%~24V+15% 脉动(p-p)5%以下	DC5V-5%~12V+10% 脉动(p-p)5%以下		DC12V-10%~24V+15% 脉动(p-p)5%以下
消耗电流 Currentconsumption	30mA以下max	20mA以下max		30mA以下max	20mA以下max		50mA以下max	30mA以下max	
分辨率(脉冲/旋转) Resolution (See Note 1)	10、20、60、100、200、300、360、500			10、200、360、500					
输出相 Output phases	A相			A相、B相			A相、B相、Z相		
输出状态 Output form	电压输出 Voltage output	开路集电极输出 Open collector output		电压输出 Voltage output	开路集电极输出 Open collector output		电压输出 Voltage output	开路集电极输出 Open collector output	
输出容量 Output capacity	输出电阻：2kΩ Output resistance：2kΩ 输出电流：20mA以下 Sink current：20mA max 残留电压：0.4V以下 Residual voltage：0.4V max (输出电流)20mA时	外加电压：DC30V以下 Applied voltage：30VDC max 同步电流：30mA以下 Sink current：30mA max 残留电压：0.4V以下 (同步电流30mA以下) Residual voltage：0.4V max		输出电阻：2kΩ Output resistance：2kΩ 输出电流：20mA以下 Sink current：20mA max 残留电压：0.4V以下 Residual voltage：0.4V max (输出电流)20mA时	外加电压：DC30V以下 Applied voltage：30VDC max 同步电流：30mA以下 Sink current：30mA max 残留电压：0.4V以下 (同步电流30mA以下) Residual voltage：0.4V max		输出电阻：2kΩ Output resistance：2kΩ 输出电流：20mA以下 Sink current：20mA max 残留电压：0.4V以下 Residual voltage：0.4V max (输出电流)20mA时	外加电压：DC30V以下 Applied voltage：30VDC max 同步电流：30mA以下 Sink current：30mA max 残留电压：0.4V以下 (同步电流30mA以下) Residual voltage：0.4V max	
最高应答频率 Maximum response frequency	30kHz								
输出相位差 Phase difference of output	A相、B相差　90°±45°								
输出占空比 output wavefrom percentage	50±25%								
输出上升、下降时间 Output rise and fall times	1.0μs以下max 导线cable 500m,同步电流10mA (at sink current of 10mA with 2m cable)	1.0μs以下，导线长500mm，控制输出电压5V，负荷电阻1KΩ 1.0μs max. (at control output voltage of 5V and load resistance of 1kΩ with 2m cable)		1.0μs以下max 导线cable 500m,同步电流10mA (at sink current of 10mA with 2m cable)	1.0μs以下，导线长500mm，控制输出电压5V，负荷电阻1KΩ 1.0μs max. (at control output voltage of 5V and load resistance of 1kΩ with 2m cable)		1.0μs以下max 导线cable 500m,同步电流10mA (at sink current of 10mA with 2m cable)	1.0μs以下，导线长500mm，控制输出电压5V，负荷电阻1KΩ 1.0μs max. (at control output voltage of 5V and load resistance of 1kΩ with 2m cable)	

*1.电的最高应答转速由分辨率以及最高应答频率决定。

$$\text{电的最高应答频率转速(r/min)} = \frac{\text{最高响应频率}}{\text{分辨率}} \times 60$$

因此，如果旋转超过最高响应转速，则电气上无法追踪信号。

*2.对水、油没有保护作用。

*3.接通电源时，会流过约9A的冲流。(时间约0.3ms)

Note:

♦The maximum electrical response revolution is determined by the resolution and maximum response frequency as follows:

♦Maximum electrical response frequency (rpm)
= Maximum response frequency ÷ resolution x 60

♦This means that the A6B2 encoder will not operate electrically if its shaft speed exceeds the maximum electrical response revolution.

增量型旋转编码器

增量型　外径Φ25 型号：A6A2
INCREMENTAL ROTARY ENCODERS,OUTSIDE DIAM Φ25 MODEL：A6A2
替代型号SUBSTITUTE：E6A2

外径：Φ25　型号：A6A2　替代型号：E6A2

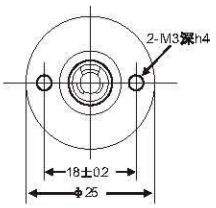
■额定/性能SPECIFICATIONS

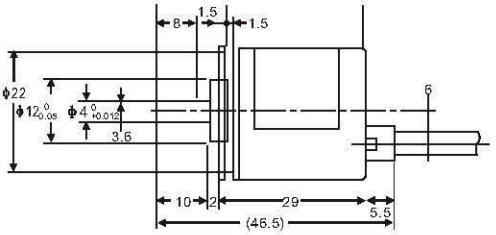
机械性能　参数 Mechanical Spec		
起动转矩　Startion Torque		1mN・m以下max
惯性力矩Moment of Inertia		1×10^{-7} kg・m^2以下max
允许容力 Shaft loading	倾向Radial	10N
	推力Thrust	5N
允许安装精度　Mounting Tolerance		侧面误差 Raclial:0.03mm TIR Max;　正向误差 Axial：0.2mm Max;　角度误差Shaft Runout：0.1°Max
轴最大负荷　Allowable Shaft Load		径向Radial ：5N，轴向　Axial ：3N
允许最高转速Maxirnun Rotating Speed		5000rpm
环境温度 Operating Temp Range		工作时:-10 ~ +55℃　保存时：-25 ~ +80℃ (不结冰)
环境湿度Humidity		工作时、保存时：各35 ~ 85%RH(不结露)
绝缘电阻 Insulation resistance		20MΩ以上(DC500V摇表)充电部整体与外壳间
耐电压 Dielectric strength		AC500V　50/50Hx　1min　充电部整体与外壳间　　充电部整体与外壳间
振动(耐久)Vibration resistance		10~55Hz　上下振幅1.5mm　X、Y、Z各方向
冲击(耐久)Shock resistance		500m/s² 3次 X、Y、Z各方向　3次
保护结构　Degree of protection		IEC规格　Ip50
连接方式　Connection		导线引出型(标准导线长cable length：500mm)
质量　Weight		约60g
附件　Accessories		耦合器、伺服装置用安装配件(附于型号E6A2-CW2□)、六角扳手，使用说明书

■ 外形尺寸Dimensions　(单位Unit：mm)

◆ 本体

型号model:A6A2





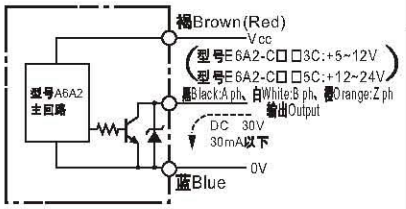
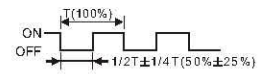
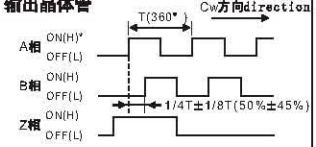
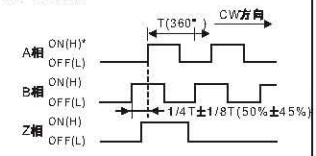
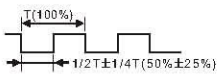
*PVC绝缘圆形导线Φ4.5芯(导体截面积：0.15mm²、绝缘体直径：Φ0.9mm)标准500mm长
Output cable (shielded) O.D.: 4 dia.
Standard length: 50 cm (1.64 ft

增量型旋转编码器

增量型　外径Φ25　型号：A6A2
INCREMENTAL ROTARY ENCODERS,OUTSIDE DIAM Φ25 MODEL：A6A2
替代型号SUBSTITUTE：E6A2

外径：Φ25　型号：A6A2　替代型号：E6A2

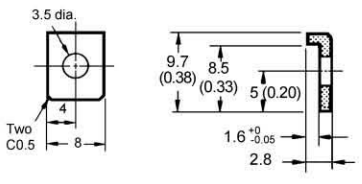
■输出段回路图OUTPUT CIRCUIT DIAGRAMS

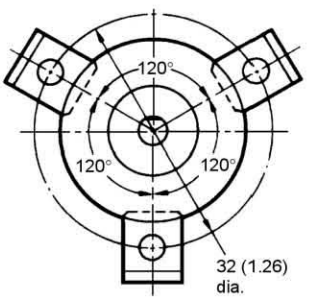
型号 MODEL	输出回路 Output diagram	输出方式 Output wave	连接 Wire Code Code
型号A6A2-CS3C 型号A6A2-CS5C		输出晶体管Output transistor 	线色Wire color / 内容Signal 褐Brown — +VCC 黑 Black — A相ph 白White — B相ph 橙Orange — Z相ph 蓝Blue — 0V 注：1.单型(型号A6A2-CS□□)中，白和橙色无输出。(未连接) 2.换向型(型号A6A2-CW□□)中，橙色无输出。(未连接) 3.电压输出型中，可吸收20mA的电流。 注1* (H)(L)表示电压输出型的状态。 2.顺时针(CW)旋转时，A相比B相，超前1/4T±18T相位，而逆时针(CCW)旋转时，A相比B相滞后1/4T±18T相位。 Note: 1. The white (green) and orange (yellow) lines of the single type (E6A2-CS) do not output signals (no connection). 2. The orange (yellow) line of the reversible type (E6A2-CW) does not output signal (no connection). 3. The voltage output type is capable of sinking a maximum of 20 mA. Note: 1. *(H) and (L) indicate the output levels of the voltage output type. 2. Output A leads B by 1/4T ±1/8T when the shaft revolves clockwise. Output Alags behind B by 1/4T ±1/8T when the shaft revolves counterclockwise.
型号A6A2-CW3C 型号A6A2-CW5C	旋转方向：CW Direction of rotation: CW (从轴方向观察为右转) Clockwise as viewed from the shaft 输出晶体管 		
型号A6A2-CWZ3C 型号A6A2-CWZ5C			
型号A6A2-CW3E	褐Brown Vcc(+5~12V) 2kW 型号 A6A2 主回路 黑Black:A ph、白White:B ph 输出Output 20mA以下 0V 蓝Blue	旋转方向：CCW Direction of rotation: CCW (从轴方向观察为右转) Counterclockwise as viewed from the shaft 输出晶体管 	
型号A6A2-CWZ3E			
型号A6A2-CS3E		输出晶体管 	

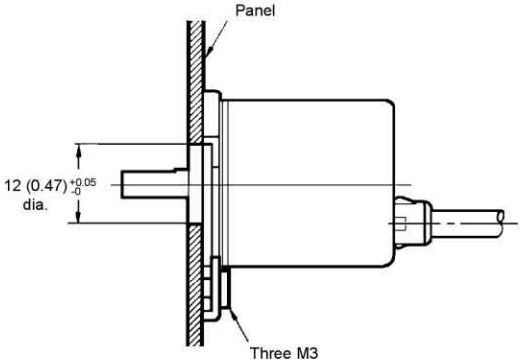
■ 安装尺寸 Installation Dimension　(单位Unit：mm)

Dimensions with Encoder

Mounting Bracket E69-1
supplied with A6A2-CWZ encoders



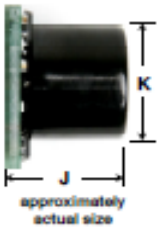


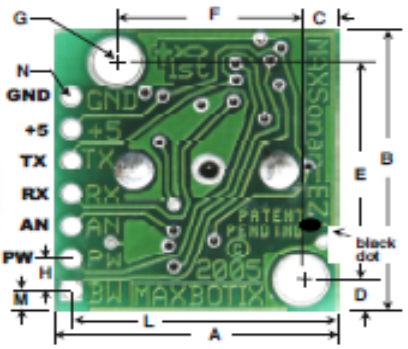


Appendix C [3]

LV-MaxSonar®-EZ0™ High Performance Sonar Range Finder

With 2.5V - 5.5V power the LV-MaxSonar®-EZ0™ provides very short to long-range detection and ranging, in an incredibly small package. The LV-MaxSonar®-EZ0™ detects objects from 0-inches to 254-inches (6.45-meters) and provides sonar range information from 6-inches out to 254-inches with 1-inch resolution. Objects from 0-inches to 6-inches typically range as 6-inches. The interface output formats included are pulse width output, analog voltage output, and serial digital output.





A	0.785"	19.9 mm	H	0.100"	2.54 mm
B	0.870"	22.1 mm	J	0.610"	15.5 mm
C	0.100"	2.54 mm	K	0.645"	16.4 mm
D	0.100"	2.54 mm	L	0.735"	18.7 mm
E	0.670"	17.0 mm	M	0.065"	1.7 mm
F	0.510"	12.6 mm	N	0.038" dia.	1.0 mm dia.
G	0.124" dia.	3.1 mm dia.	weight, 4.3 grams		

values are nominal

Features

- Continuously variable gain for beam control and side lobe suppression
- Object detection includes zero range objects
- 2.5V to 5.5V supply with 2mA typical current draw
- Readings can occur up to every 50mS, (20-Hz rate)
- Free run operation can continually measure and output range information
- Triggered operation provides the range reading as desired
- All interfaces are active simultaneously
- Serial, 0 to Vcc, 9600Baud, 81N
- Analog, (Vcc/512) / inch
- Pulse width, (147uS/inch)
- Learns ringdown pattern when commanded to start ranging
- Designed for protected indoor environments
- Sensor operates at 42KHz
- High output square wave sensor drive (double Vcc)

Benefits

- Very low cost sonar ranger
- Reliable and stable range data
- Sensor dead zone virtually gone
- Lowest power ranger
- Quality beam characteristics
- Mounting holes provided on the circuit board
- Very low power ranger, excellent for multiple sensor or battery based systems
- Can be triggered externally or internally
- Sensor reports the range reading directly, frees up user processor
- Fast measurement cycle
- User can choose any of the three sensor outputs

Beam Characteristics

The LV-MaxSonar®-EZ0™ has the most sensitivity of the LV-MaxSonar®-EZ™ product line, yielding a controlled wide beam with high sensitivity. Sample results for measured beam patterns are shown below on a 12-inch grid. The detection pattern is shown for;

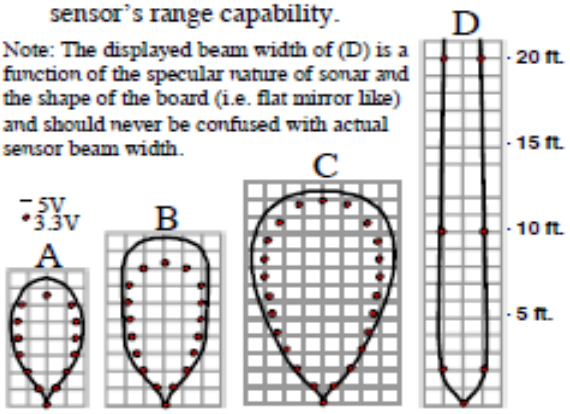
(A) 0.25-inch diameter dowel, note the narrow beam for close small objects,

(B) 1-inch diameter dowel, note the long narrow detection pattern,

(C) 3.25-inch diameter rod, note the long controlled detection pattern,

(D) 11-inch wide board moved left to right with the board parallel to the front sensor face and the sensor stationary. This shows the sensor's range capability.

Note: The displayed beam width of (D) is a function of the specular nature of sonar and the shape of the board (i.e. flat mirror like) and should never be confused with actual sensor beam width.



beam characteristics are approximate

LV-MaxSonar®-EZ0™ Pin Out

GND – Return for the DC power supply. GND (& Vcc) must be ripple and noise free for best operation.

+5V – Vcc – Operates on 2.5V - 5.5V. Recommended current capability of 3mA for 5V, and 2mA for 3V.

TX – When the *BW is open or held low, the TX output delivers asynchronous serial with an RS232 format, except voltages are 0-Vcc. The output is an ASCII capital "R", followed by three ASCII character digits representing the range in inches up to a maximum of 255, followed by a carriage return (ASCII 13). The baud rate is 9600, 8 bits, no parity, with one stop bit. Although the voltage of 0-Vcc is outside the RS232 standard, most RS232 devices have sufficient margin to read 0-Vcc serial data. If standard voltage level RS232 is desired, invert, and connect an RS232 converter such as a MAX232. When BW pin is held high the TX output sends a single pulse, suitable for low noise chaining. (no serial data).

RX – This pin is internally pulled high. The EZ0™ will continually measure range and output if RX data is left unconnected or held high. If held low, the EZ0™ will stop ranging. Bring high for 20uS or more to command a range reading.

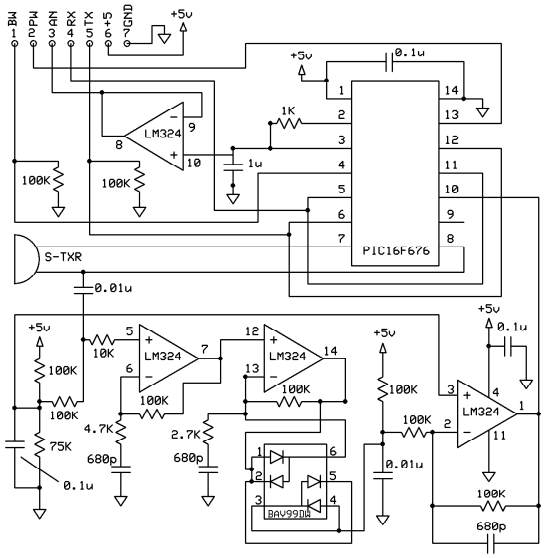
AN – Outputs analog voltage with a scaling factor of (Vcc/512) per inch. A supply of 5V yields ~9.8mV/in. and 3.3V yields ~6.4mV/in. The output is buffered and corresponds to the most recent range data.

PW – This pin outputs a pulse width representation of range. The distance can be calculated using the scale factor of 147uS per inch.

BW – *Leave open or hold low for serial output on the TX output. When BW pin is held high, the TX output sends a pulse (instead of serial data), suitable for low noise chaining.

LV-MaxSonar®-EZ0™ Circuit

The LV-MaxSonar®-EZ0™ sensor functions using active components consisting of an LM324, a diode array, a PIC16F676, together with a variety of passive components.



LV-MaxSonar®-EZ0™ Timing Description

250mS after power-up, the LV-MaxSonar®-EZ0™ is ready to accept the RX command. If the RX pin is left open or held high, the sensor will first run a calibration cycle (49mS), and then it will take a range reading (49mS). After the power up delay, the first reading will take an additional ~100mS. Subsequent readings will take 49mS. The LV-MaxSonar®-EZ0™ checks the RX pin at the end of every cycle. Range data can be acquired once every 49mS.

Each 49mS period starts by the RX being high or open, after which the LV-MaxSonar®-EZ0™ sends thirteen 42KHz waves, after which the pulse width pin (PW) is set high. When a target is detected the PW pin is pulled low. The PW pin is high for up to 37.5mS if no target is detected. The remainder of the 49mS time (less 4.7mS) is spent adjusting the analog voltage to the correct level. When a long distance is measured immediately after a short distance reading, the analog voltage may not reach the exact level within one read cycle. During the last 4.7mS, the serial data is sent. The LV-MaxSonar®-EZ0™ timing is factory calibrated to one percent at five volts, and in use is better than two percent. In addition, operation at 3.3V typically causes the objects range, to be reported, one to two percent further than actual.

LV-MaxSonar®-EZ0™ General Power-Up Instruction

Each time after the LV-MaxSonar®-EZ0™ is powered up, it will calibrate during its first read cycle. The sensor uses this stored information to range a close object. It is important that objects not be close to the sensor during this calibration cycle. The best sensitivity is obtained when it is clear for fourteen inches, but good results are common when clear for at least seven inches. If an object is too close during the calibration cycle, the sensor may then ignore objects at that distance.

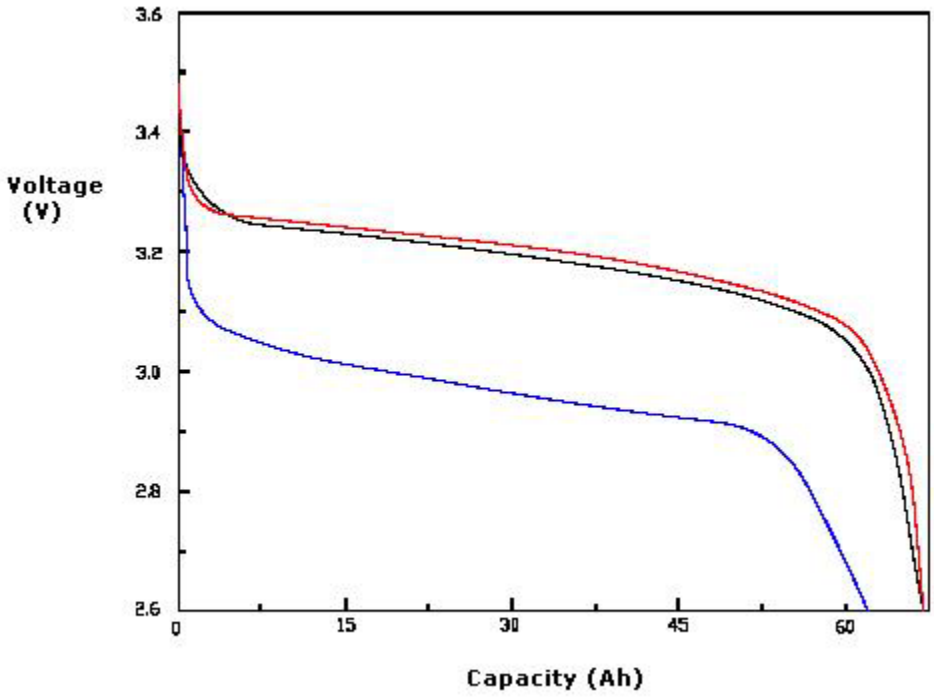
The LV-MaxSonar®-EZ0™ does not use the calibration data to temperature compensate for range, but instead to compensate for the sensor ringdown pattern. If the temperature, humidity, or applied voltage changes during operation, the sensor may require recalibration to reacquire the ringdown pattern. Unless recalibrated, if the temperature increases, the sensor is more likely to have false close readings. If the temperature decreases, the sensor is more likely to have reduced up close sensitivity. To recalibrate the LV-MaxSonar®-EZ0™, cycle power, then command a read cycle.

Email: info@maxbotix.com
Web: www.maxbotix.com

Appendix D [5]

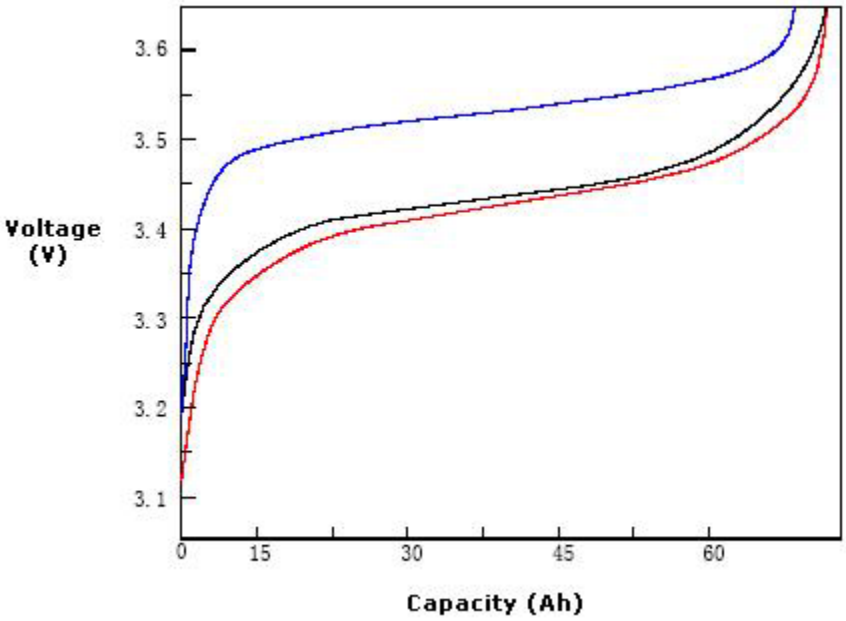
Nominal Capacity	60Ah	Working Voltage	Single cell charging：3.8V
			Battery pack charging：3.65V
			Single cell charging：2.5V
			Battery pack discharging：2.8V
Max. Charging Current	≤3C	Max. Discharging Current	Continuous Current：≤3C
			Impulse Current：≤10C
Standard Charging Current	0.3~0.8C	Best Charging Current	0.5C
Internal Resistance	≤2.0mΩ	Cycle Life	Single cell ≥2000 times（80%DOD）
			Battery pack≥1500 times（80%DOD）
Temp. resistance of Shell	≤135℃	Working Temperature	Charging：＞0℃
			Discharging：-20℃-65℃
Self Discharge rate（month）	≤3%	Cell Weight	2.5kg±100g
Energy Density	85~100Wh/kg	Power Density	＞800w/kg
Dimension	126mm*65mm*180mm		

Discharge Curve



Note: Red = 0.5C rate, Black = 1.0C rate, Blue = 3.0C rate

Charging Curve



Note: Red = 0.5C rate, Black = 1.0C rate, Blue = 3.0C rate

SPECIFICATION OF GBS-LFP20AH

Nominal Capacity	20Ah	Working Voltage	Single cell charging：3.8V
			Battery pack charging：3.6V
			Single cell charging：2.5V
			Battery pack discharging：2.8V
Max. Charging Current	≤3C	Max. Discharging Current	Continuous Current：≤3C
			Impulse Current：≤10C
Standard Charging Current	0.3~0.8C	Best Charging Current	0.5C
Internal Resistance	≤2.5mΩ	Cycle Life	Single cell ≥1500 times（80%DOD）
			Battery pack≥1200 times（80%DOD）
Temp. resistance of Shell	≤135℃	Working Temperature	Charging：＞0℃
			Discharging：-20℃-65℃
Self Discharge rate (month)	≤3%	Cell Weight	0.75kg±100g
Energy Density	85~100Wh/kg	Power Density	＞800w/kg
Single Cell Dimension	71mm*42mm*152mm		

Appendix E [6]

Tenergy Corporation
436 Kato Terrace
Fremont, CA 94539
Tel: 510.687-0388 Fax: 510.687.0328
www.TenergyBattery.com email: sales@tenergybattery.com

Contents

1 Outline

This specification applies to 4-serial-cell LiFePO4 Battery Protection Circuit Module designed and manufactured by TENERGY CORPORATION.

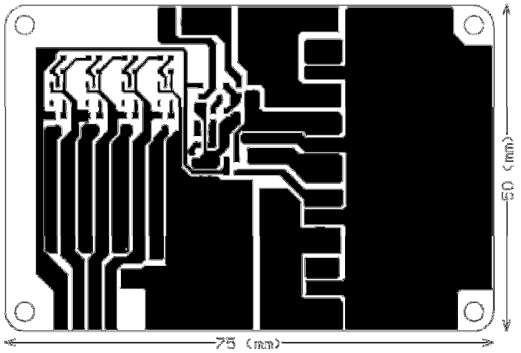
2 Electrical characteristics

Unless specified otherwise: Temp.= 25℃

Item	Content	Criterion	Remarks
Application	Battery Type	**LiFePO4** Battery	
	Battery Cell	4 Cells	
Charge Parameters	Input charging voltage	14.6±0.3V	
	Input charging current	20A	
Discharge Parameters	Continuous discharge current	20A	
Charge Protection	Over charge detection voltage(Cell)	3.900±0.025V	
	Over charge release voltage(Cell)	3.800±0.050V	
Discharge protection	Over discharge detection voltage (Cell)	2.000±0.050V	
	Over discharge release voltage (Cell)	2.300±0.100V	
	Over discharge detection current	33±5A	
Balance	Balance open voltage(Cell)	3.600±0.025V	
	Balance release voltage(Cell)	3.600±0.050V	
	Balance current(Cell)	65±5mA	
Short Circuit Protection	Short Circuit protection	Have	
	Detection delay time	300-5000uS	
	Recovery condition	Disconnect load	
Internal resistance	Main loop electrify resistance	≤20mΩ	
Current Consumption	Current consume in normal operation	≤50μA	
PCB Dimension(L*W*T)	75*50*1.6mm		

Tenergy Corporation
436 Kato Terrace
Fremont, CA 94539
Tel: 510.687-0388 Fax: 510.687.0328
www.TenergyBattery.com email: sales@tenergybattery.com

3、PCB Layout



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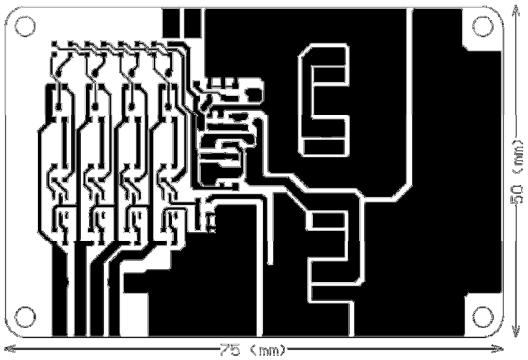

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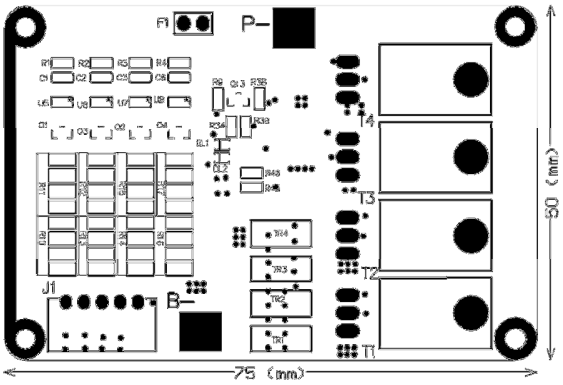
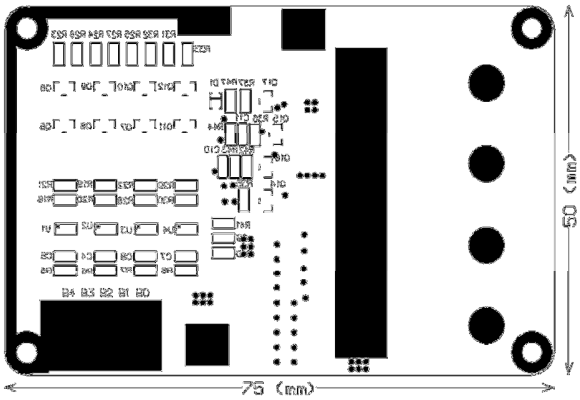


Top Overlay



Bottom Overlay

Terminals:

1. B4: Connect to the forth battery's positive terminal
2. B3: Connect to the third battery's positive terminal
3. B2: Connect to the second battery's positive terminal
4. B1: Connect to the first battery's positive terminal
5. B0: Connect to the first battery's negative terminal
6. B-: Connect to the first battery's negative terminal
7. P-: Connect to the battery's output or the charger's negative terminal

Appendix F [7]

Features:

- Intelligent charger designed for 4 cell LiFePO4 battery packs.
- CPU control and pulse width modulation (PWM) technology, charging current and output voltage is controlled accurately to ensure fully-charged and avoid over-charging.
- Built-in cooling fan to ensure charger long service life.
- Safety protection:
    - Over Voltage Protection
    - Short Circuit Protection
    - Output Reverse Protection
- Charging time:
    - Charging Time= (1.41 * Ah rate of the pack) / 10A charge current
- Built-in IC to cut-off power automatically when battery is fully charged.
- LED indicators:
    - LED 1 = Red = Power On
    - LED 2 = Red = Charging
    - LED 3 = Green = Fully Charged

User Instructions:

- Check the output plug of this charger and make sure it is not loose.
- Before charging, please connect the charger's alligator clips to battery first: the "red" clip connects to the POSITIVE pole and the "black" connects to the NEGATIVE pole. After, connect the input power plug to the indoor power supply.
- The charger applies the intelligent charging method of constant current and constant voltage. The charger will automatically shut off when battery is fully charged. Unplug the input power supply then disconnect the output clips.
- When charger is not in use or finished charging, be sure to unplug input power supply.
- Indictor LED instruction:
    - "Charging" indicator shows "red" under normal charging state. It turns into "Green" when the battery is fully charged, the battery can be put into use at this time.
    - The charging voltage of this charger is 12V, and shut-off current is 1A. It can only be operated when connect with not fully charged battery.

Includes:

- Battery Charger
- Power Cable
- Manual

Technical Specifications:

Item	4 Cell 14.6V (12.8V Nominal) 10A Charger
Model	TN1210JL
Max Output Power	240W
Output Voltage	14.6V ±0.02Vdc
Output Current	10A
Rated Input Voltage	110Vac
Input Voltage	AC90-135V
Constant Voltage	14.6V±0.2V
AC Input Voltage Frequency	50¿60 Hz
Constant Current	10A±1A
Constant Voltage	14.6 Vdc, 10A ¿
Shut-off Current	1A
Power Efficiency	¿90% (Vin=110Vac, rated load)
Over Voltage Protection	YES
Software Over Voltage Protection	The charger software limits the maximum output voltage to a level suitable for the connected battery system
Thermal Protection	N/A
Current Limiting Protection	YES (At CC Mode)
Reverse Polarity Protection	When output wires are reversely connected to the battery the charger will not operate and will work normally when DC wires are correctly connected
Electric Strength Test Input-Output	1500Vac/10mA/1 min (No Breakdown)

Isolation Resistance Input-ground	¿10m¿@500Vdc
Isolation Resistance Output-ground	¿10m¿@500Vdc
Leakage Current	<3.5mA
Safety	CE/UL Compliant
High Temperature Ambient Operating	+40°C
Low Temperature	-10°C
High Temperature Storage	+70°C (Normal after recovery under normal temperature for 2 hours)
Low Temperature Storage	+40°C (Normal after recovery under normal temperature for 2 hours)
Random Vibration	20Hz to 2000Hz 3 Grms 20 hours per axis
Repetitive Shock	40g peak 3 orthogonal axes, 3+ and 3- in each axis, 11ms pulse width
Thermal Shock	-35°C to 75°C, <3min transition, 2.5 hours dwell, 200 cycle
Drop Test	BS EN60068-2-32:1993 TEST ED: free fall appendix B
AC Wire Length	1.5 m length
DC Wire Length	1.5 m length
Dimensions	173mmX88mmX62mm (L*W*H)
Net Weight	1.0Kg
Output Connector Type	XLR Connector
Casing	Aluminum

The charger has been calibrated to take account of the voltage drop in the DC output cables during operation, to prevent the possibility of over or under charging of the battery it is recommended the DC output cables are connected directly to the battery without modification.

Warning:

- *Only for use with LiFePO4 4 cell battery pack (If used with battery pack of less cells will cause damage to battery and possible personal injury may occur).*
- *Unplug charger after use.*
- *To prevent electrical shock, DO NOT remove casing*
- *Be careful of high-voltage inside charger. If failure happens, please contact us. Users and non-professional technicians are prohibited to open the charger!*
- *Keep charger out of children's reach.*
- *The charger and battery belongs in indoor environment with good ventilation and good cooling system, Do not expose to humid, high temperature, flammable, explosive gas environments.*
- *Do not bring charger along during transportation to prevent shock damage!*
- *Read the instructions carefully before using.*
- *Damage caused by improper use is not covered by warranty.*

VI. References

[1] http://www.pololu.com/catalog/product/1496

[2] http://www.sparkfun.com/products/10932

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[6] http://www.all-battery.com/ProtectionCircuitModulefor4CellsLiFePO4BatteryPack15A_33A-32105.aspx

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