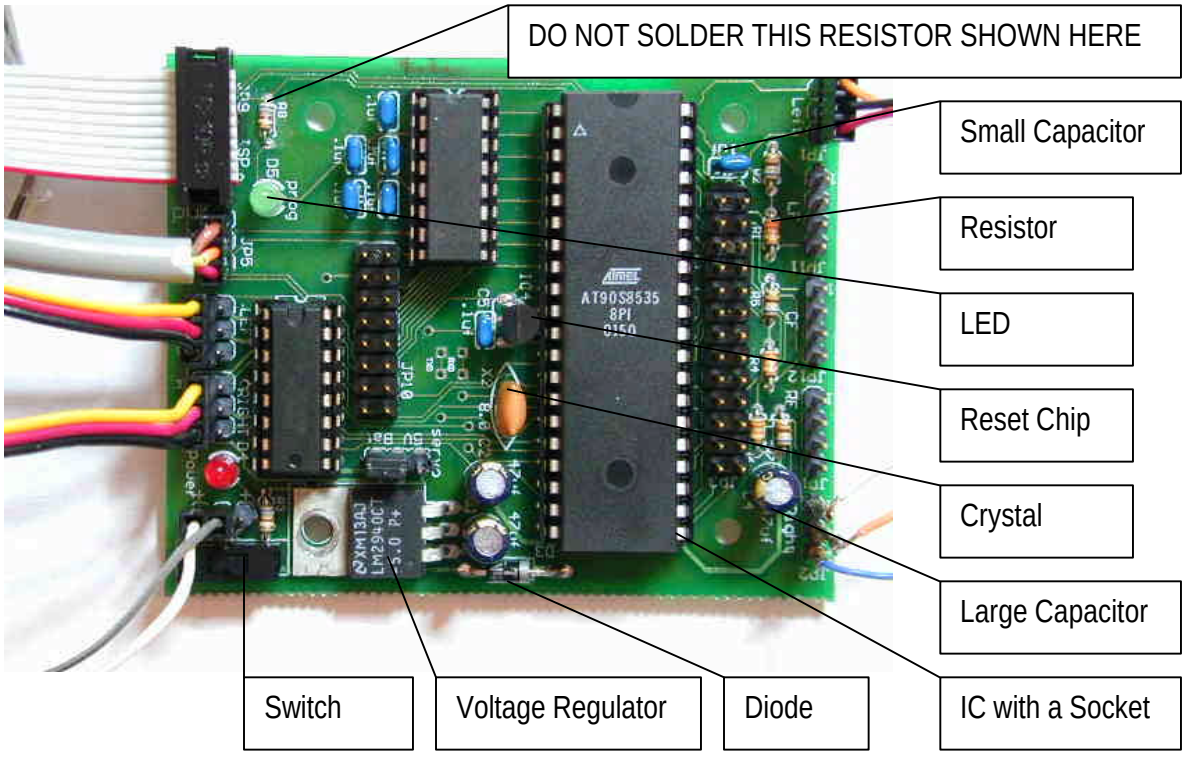
Building the Mini Sumo: (Revised)



1. The Circuit Board Soldering Work (step by step):

1.1. Small Capacitors (7 included):

- They are blue in the example above. Some kits may contain orange ones of similar shape and size.
- Stick the 2 leads through the 2 holes marked ".1uf". The orientation does not matter.
- Push all of the way though the hole. They should rest firmly.
- Bend the leads under the board if necessary to keep them from falling out.
- Cut the excess leads after soldering them in place.

1.2. Resistors (8 included):

- There are 2 types of resistors in this kit:

Orange, orange, orange: 33k ohm resistors (goes into the holes marked "20k").

Blue, gray, brown: 680 ohm resistors (goes into the holes marked "560" or "680").

- Bend the leads of the resistors and stick them in the appropriate places. The orientation does not matter.
- As with the capacitors, Push all of the way through until the resistor sits on the board. Pull the leads underneath or push the resistor from above to get it in place.
- Bend the resistor leads under the board to hold them securely in place for soldering.
- Cut the excess leads after soldering them in place.
- DO NOT SOLDER THE 680 OHM RESISTOR ON THE TOP LEFT CORNER (SHOWN ON THE IMAGE ABOVE).

1.3. Diode (1 included):

Soldering Tips:

- Turn the board over and rest it on a level surface.
- To solder, heat the soldering iron (obviously) until it starts to melt solder.
- With the tip of the iron, touch the printed metal on the board and the leads sticking out of the hole at the same time. Hold for about 2-3 seconds
- Touch the printed metal on the board with the tip of a string of solder. The solder should melt on to the board and the lead. If it does not, try again after cleaning the tip of the iron with a wet sponge.
- The soldered should lay concave and thinly from the pad to the lead.

- Bend the leads of the diode to fit through the hole (as in the image above). Make sure the diode is oriented such that the silver band on the diode is towards of the direction of the arrow on the board. 

- Cut the excess leads after soldering.

1.4. IC sockets (3 included):

- Place the sockets so that the notches on the sockets match the notches on the board. 

- *The two smaller sockets are the exact same.
- When soldering the sockets, first solder only the two corner pins and check to make sure it is sitting all of the way down on the board.
- Do not bend the leads.
- Solder the rest of the pins.
- Do not cut the leads after soldering.

1.5. LEDs:

- The LEDs have a long and short lead. Orient the LEDs so that the shorter lead is towards the nearest edge of the board.
- Cut the excess leads after soldering.

1.6. Voltage regulator (1 included):

- Locate the piece of tape on the board. Do not remove it. The voltage regulator will sit on top of it.
- Bend the 3 leads of the voltage regulator down 90 degrees on the center part of the fat section of its leads.
- Position it as shown on the image. Make sure it sits flat on the board and the large circuit board hole matches with the mounting hole of the voltage regulator.
- Solder in place.
- Cut the excess leads after soldering.

1.7. Switch (1 included):

- The orientation of the switch does not matter
- A good technique for soldering the switch is to hold the switch in place, flip the board over, and to rub a little solder coated iron tip over the leads. The solder should melt off and secure the switch in place. More solder will likely be needed, but this is just to hold it in place.
- Do not bent the leads of the switch (although doing so will not damage it).
- Cut the leads after soldering if they appear to be too long.

Crystal and reset chip (1 each included):

- Orient them as printed on the board. The crystal orientation is difficult to see: the side that has writing faces away from the CPU.
- It is not necessary to bent the crystal leads.
- Cut the leads after soldering if they appear to be too long.

1.8. Headers (3 2-row headers and 6 1-row headers included):

- Solder all of the headers as marked on the board except for the 16 and 25 pin ones as they are neither needed nor included in the kit.
- Also, there is a group of 1 row headers to one end of the board, and in the center, a position for soldering 3 4-pin headers. Do not solder the center 4 pin header in. There are only 2 4-pin headers provided.

Tip: For 1-row headers, start by soldering one pin of the header to the board. This way, it is easy to fix if the headers are tilted in the soldering process.

- To fix a tilted header, flip the board over and the hold it straight up. Heat the solder under the header. If only one pin is soldered, the header should pop into place just by the force of gravity. However, if more than one pin is soldered, take the following steps:

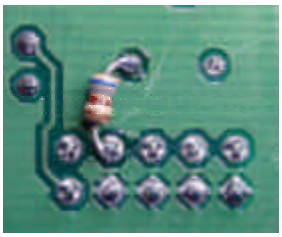
1. Flip the board over and push against the headers towards the correct alignment. DO NOT USE YOUR FINGER (OR ANY OTHER BODY PART) AS THE HEADER WILL HEAT UP VERY QUICKLY.
2. While pushing, melt all of the solder underneath in a quick motion to heat all of the joints. This is a relatively slow process.

- DO NOT TRY TO CUT THE LEADS AFTER SOLDERING.

1.9. Large Capacitors (3 included):

- The large capacitors have a vertical gold band on one side. Orient this toward the side marked "-".

1.10. The one remaining resistor:



- This resistor is soldered on the other side of the board:

Tip: Cut one lead short (about 2mm) and stick the long lead it through the resistor hole and solder. Then bend the short lead of the resistor towards the pin and solder.

- Cut the excess leads after soldering.

1.11. Inspection:

- Check each solder pad and make sure they have a "wet" and shiny look. Go back and reheat the areas that do not.
- Check for excessive solder, which may have resulted in pins and pads connecting. Remove any bridging with a clean soldering iron.
- Carefully try moving all of the parts. If something rocks or otherwise doesn't seem to be secure, resolder the part in.
- Plug a 6 volt power supply to the 3 pin connector next to the switch (the edges positive and the center ground). Turn the switch on (to the left position on the image above). The red LED should light.

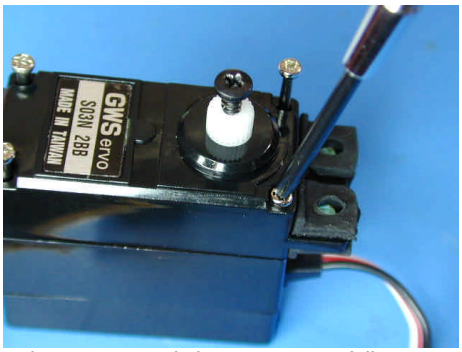
1.12. Board Testing:

- Plug the appropriate ICs into their sockets. Make sure the notches on the ICs match those on the board and the sockets. The Legs may have to be bent in before they will fit into the sockets. Lay the static sensitive bags flat on the table and carefully push the IC legs against it.
- Plug the programming cable in the 10 pin header (cable facing away from the board). With the power plugged in, load the program called "flash.bas" from samples. The green LED should flash.

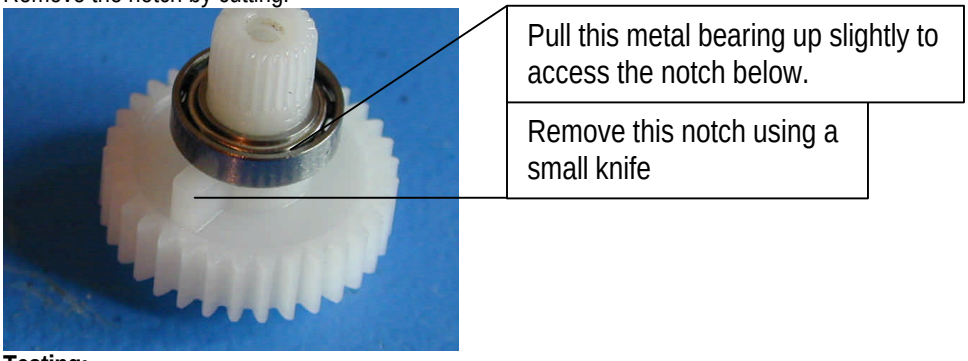
2. Servo Hacking:

2.1. The Notch:

- Remove the black screw holding the white disk on to the servo and pull the disk out.
- Remove the 4 silver screws on each corner.



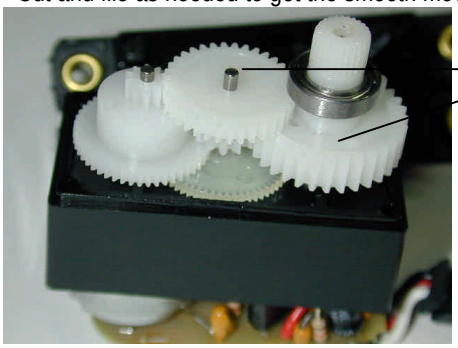
- The servo case is in 3 parts. Carefully remove the top cover from the bottom 2 pieces. The top cover will have 2 gears stuck inside. One of them should slide out easily. Pull on the other one to remove from the cover.
- The gear will have a small notch. Lift the metal bearing slightly and slide a knife underneath on top of the notch. Remove the notch by cutting.



Testing:

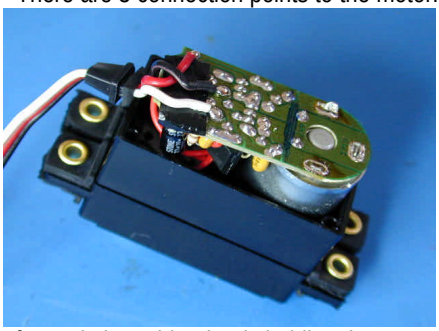
- Reassemble the gear box and make sure it spins freely. You may need to put the white disk back in in order to spin the servo.

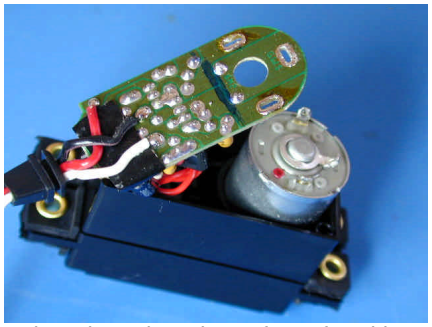
- Cut and file as needed to get the smooth movement.



2.2. Removing the Electronics:

- Take all of the gears and gear shafts out and put them in some secure container.
- Carefully remove the bottom cover to expose the motor and the electronics.
- Remove the motor and the electronics from the middle section of the plastic container by pulling down gently.
- There are 3 connection points to the motor. Solder them off to remove the electronics board leaving just the motor.





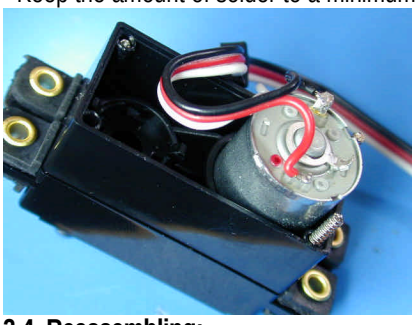
Tip: Melt the solder that is holding the motor and gently tap it on the surface of a table to use the momentum to fling some solder off. Also, as the solder starts to come off, stick a thin flat head screw driver in between the motor and the electronics board to start prying it off while melting the remaining solder.

Note: Some servos will have wires soldered to the motors instead of an electronics board. In this case, melt the solder off while pulling on the wires to disconnect them.

- There are 3 red wires running from the mini-board to a potentiometer in the middle casing. Cut these wires.

2.3. Connecting the Motor:

- There is a red, white and black wire connecting the electronics board to a connector outside of the servo. Cut these wires off of the board.
- Strip the red and the black wires about 1/8"
- Solder the red wire to the terminal on the motor with a red dot. Solder the black to the terminal on the other side. The middle terminal is just a support and can be removed.
- Keep the amount of solder to a minimum. The bottom casing may not fit if the soldered joint is too big.



2.4. Reassembling:

- Stick the motor back in its case in any orientation that will suit the wiring.
- Put all of the gears back in place and put the top cover on. Then put the bottom cover on and screw the 4 silver screws back in place.

3. Sensor Connectors:

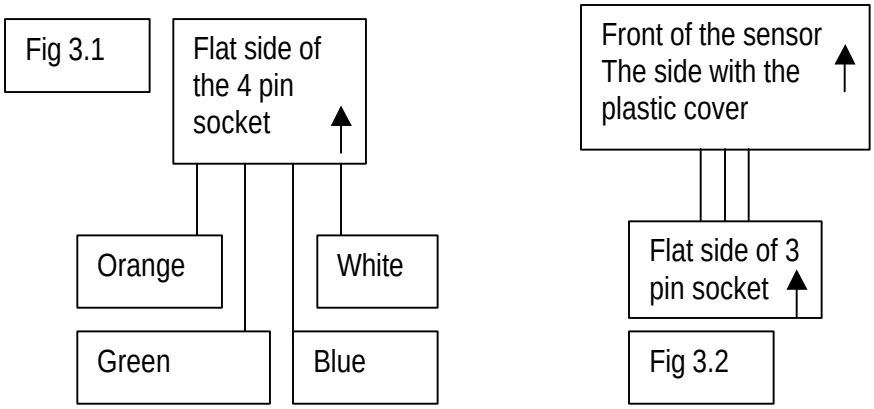
3.1. The Floor Sensors (2 included):

- The wires on the floor sensors should be at least 5" long from the tip to where it sticks out of the sensor mount. If you would like to account for the possibility of screwing up, or just want to leave some lee way, cut the wires at 6". Save the rest for later use.
- Strip each of the 4 wires about 1/8" and solder each to a connector.

Tip: There are 2 places where the sockets are crimped: The very edge with the 2 triangular flaps and the middle with 2 rectangular flaps. Ideally, the rubber coating on the wires should go up as far as the 2 triangular flaps and the wire itself as far as the 2 middle rectangular flaps. DO NOT LET THE WIRE GO FURTHER INTO THE SOCKET AS IT WILL CAUSE JAMMING WHEN THE CONNECTOR IS PLUGGED INTO THE HEADER.

- Crimp the sockets using the crimping tool.

After all 4 are done, insert them into the 4 pin socket as shown in Fig 3.1.



3.2. The Distance Sensors (2 included):

- Cut 3 pieces of wire 3" long each (use the wires cut from the floor sensors). Find the white connector for the distance sensor and lay it flat on a table with bladed side up. Take a piece of unstripped wire and jam it in between one of the 3 bladed grooves using a flat head screw driver. Be careful not to cut the wire or smash the blades with the screw driver. Repeat the step for the 2 other grooves using different color wire.
- Strip the other ends of the 3 wires about 1/8". Repeat the steps in 5.1 for soldering crimp sockets on to the wire and insert the 3 crimp sockets into a 3 pin socket.
- Plug the white connector into the sensor.
- The 3 wires should hook up as shown in Fig 3.2

4. Main Chassis Assembly:

4.1. The Stands (4 included):

- Position the stands so that the 2 holes on the side are closer to the bottom, and are also aligned closer to the edges of the chassis (See fig 4.1). The other side is symmetrical to this.

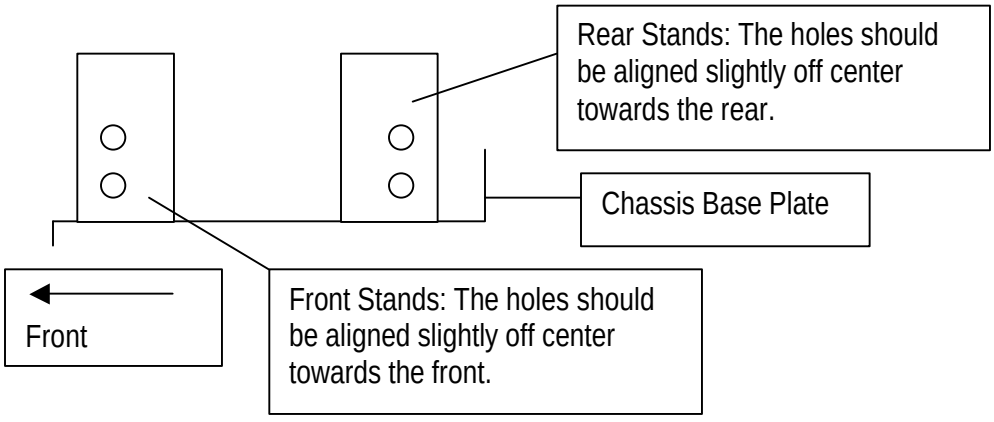
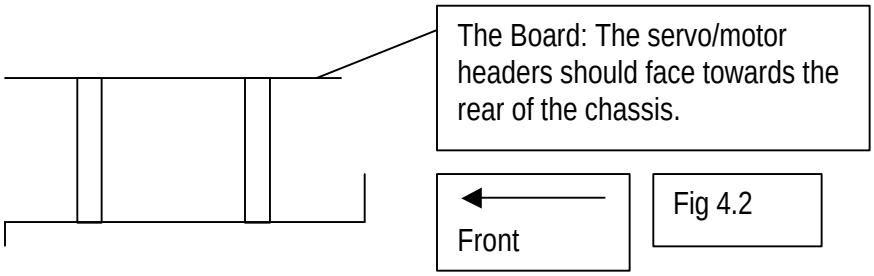


Fig 4.1 (the stands exaggerated to show detail)

- Attach the stands to the base plate using 1/4" 4-40 screws

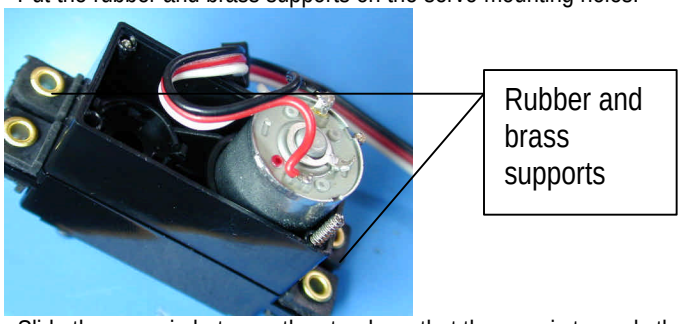
4.2. The Board:

- Attach the electronics board on top of the stands using 1/4" 4-40 screws. The holes should match up.
- *One of the screws on the rear should go through the voltage regulator.

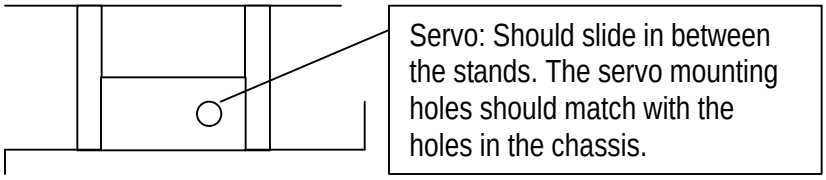


4.3. The Servos:

- Put the rubber and brass supports on the servo mounting holes.



- Slide the servo in between the stands so that the gear is towards the rear of the chassis.



- Using the servo mounting screws, mount the servo to the stand ONLY THROUGH THE TOP HOLES. Use the plastic washers supplied as needed.

4.4. The Scoop:

- The scoop mounts to the front of the chassis using 1/4" 4-40 screws and nuts.
- The floor sensors mount underneath the scoop on the 2 side holes using 3/8" 4-40 screws and nuts.
- The floor sensors hook up to the 4 pin headers in the front of the chassis.

4.5. The Mounting the Distance Sensors:

- The mounting location of these sensors is completely optional and should be chosen based on the CPU program.
- The distance sensors hook up to the 3 pin headers on the front of the chassis.

4.6. Mount the Wheels:

- The wheels mount directly on to the servo with the servo screw.

4.7. Battery pack:

- The 2-Battery pack sits in the back of the chassis behind the stands. The 4-battery pack can be attached to the bottom using Velcro (included).
- Connect the negative of one battery pack to the positive of the other. Strip (if needed) the ends of the 2 free wires.
- Repeat steps in 5.1 to attach crimp sockets onto the wires and plug them into a 3 pin socket (the negative terminal in the middle and the positive on either side.
- The power plugs into the 3 pin header marked "power" (obviously) next to the switch (in either orientation).

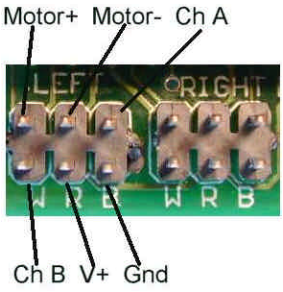
Items List:

Item	Amount	Description	Item	Amount	Description
1	1	ARC PCB	19	1	2x5 .1" pin header
2	1	AT90S8535-8PC	20	4	1x3 .1" pin socket
3	1	ZTT-8.0 Ceramic Resonator	21	2	1x4 .1" pin socket
4	1	Microchip Reset Chip 4.5v	22	20	Crimp sockets
5	1	LM2940CT-5.0 TO220 case	23	1	TI 754410 Dual H-Bridge
6	1	Diode, 1A	24	1	DB25 Solder Cup male
7	3	47uf 20v Electrolytic	25	1	DB9 Solder Cup Female
8	7	.1 uf ceramic Z7T .1"	26	1	XXX232A RS232 Driver
9	3	33K 1/8 wt carbon film	27	3'	22ga 3 conductor cable
10	5	680 1/8 wt carbon film	28	1	10 pin IDC socket
11	1	LED red	29	3'	10 conductor ribbon cable
12	1	LED green	30	1	.1" shorting jumper
13	2	16 pin low profile DIP socket	31	1	Chassis Kit (base and scoop)
14	1	40 pin low profile DIP socket	32	2	Sharp GP2D12 Distance Measuring Sensor
15	1	Switch, SPDT, PCB mount	33	1	Injection Molded Wheels
16	5	1x3 .1" pin header	34	2	High-torque ball-bearing servo motor
17	3	1x4 .1" pin headers	35	2	Fairchild QRB1133 IR Photo reflector
18	2	2x3 .1" pin header			

5. Hooking Everything up:

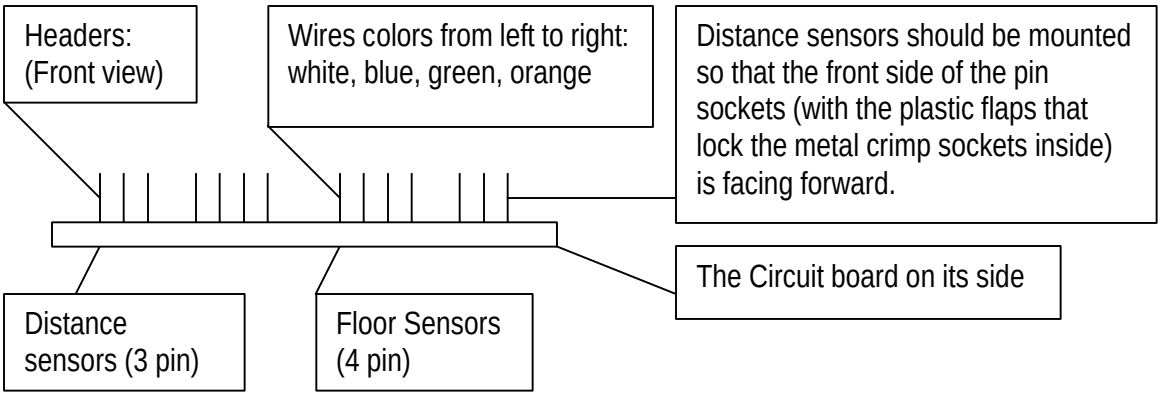
5.1. The servos:

- The Servos hook up to the 3x2 pin headers. Orient the socket so that the red wire goes to "Motor-" and the black goes to "Motor+". The white wire does nothing.
- The left and right servos mount the same way, but make sure the right servo goes to the headers marked "RIGHT" and the left one to "LEFT".



5.2. The Sensors:

- The 3x1 and the 4x1 pin headers on the other side of the board are where the sensors mount. Refer to the diagram below for mounting sensors: The left and right sensors are mounted identically (not symmetrically).



5. Programming:

5.1. The Analog to Digital Converter (ADC):

Sample program: This program collects information from sensors and displays them on the (PC) screen using BASCOM's terminal emulator.

```
$regfile = "8535def.dat"
$crystal = 8000000
$baud = 19200
```

Defines the chip and the crystal used.

```
Config Adc = Single , Prescaler = Auto
Start Adc
```

Activates the ADC

```
Const Leftsharp = 0
Const Leftfloor = 1
Const Rightfloor = 3
Const Rightsharp = 7
```

Giving names to ADC channels to make life easier

```
Do

Waitms 100

Print Getadc(rightsharp) ; " " ; Getadc(leftsharp) ; " " ;
Getadc(rightfloor) ; " " ; Getadc(leftfloor)
Loop
```

The Getadc command collects sensor information. The print command prints this information on the terminal emulator screen. The entire routine is in a never ending loop that repeats every 100 milliseconds.

5.2. The PWM:

- Sample Program: This program spins the 2 wheels forward:

```
Config Timer1 = Pwm , Pwm = 9 , Compare A Pwm = Clear Down , Compare B Pwm = Clear Down , Prescale = 1
```

Timer1 function is set to PWM mode

```
Config Pinc.3 = Output                  ' Left Servo output
Config Pinc.4 = Output                  ' right servo output
```

Configuring the motor direction control pins as output

```
Portc.4 = 0
Portc.3 = 0
```

Setting the motor direction to "normal" (1 = inverse)

```
Pwm1b = 255
Pwm1a = 255
```

The numbers control the speed of the motor. 0 = stop, 255 = max.

- Sample Program: This program spins the 2 wheels backward:

```
Config Timer1 = Pwm , Pwm = 9 , Compare A Pwm = Clear Down , Compare B
Pwm = Clear Down , Prescale = 1

Config Pinc.3 = Output                    ' Left Servo output
Config Pinc.4 = Output                    ' right servo output

Portc.4 = 1
Portc.3 = 1
```

Setting the motor direction to "inverse" (0 = normal)

```
    Tccr1a.com1b0 = 1
    Tccr1a.com1a0 = 1
```

Timer/counter control register is used as the second half of the motor direction control. Setting both to 1 will reverse the motor direction.

```
Pwm1b = 255
Pwm1a = 255
```

5.3. The Mini Sumo code:

- The basics:

- The mini sumo code combines both the ADC input and the PWM output. The main routine is a never ending loop (do loop) of sensors that check the surroundings approximately every 20 milliseconds. When the sensors detect something (i.e. an If statement of whether an ADC value of a sensor is greater than some set constant), the Goto/Gosub statement activates another function outside of the loop that controls the PWM output.

Sample code available.