

Assembly instructions for the Blue Bell Design Co-Processor board
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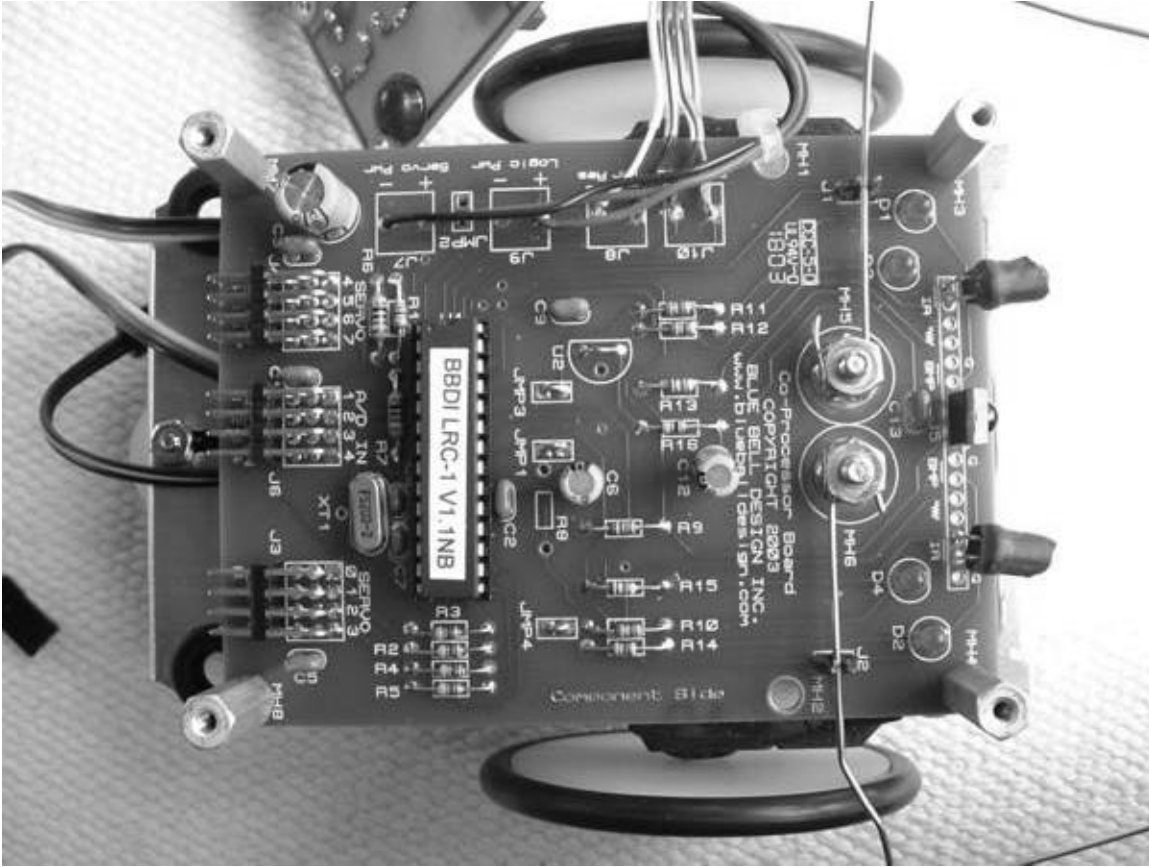
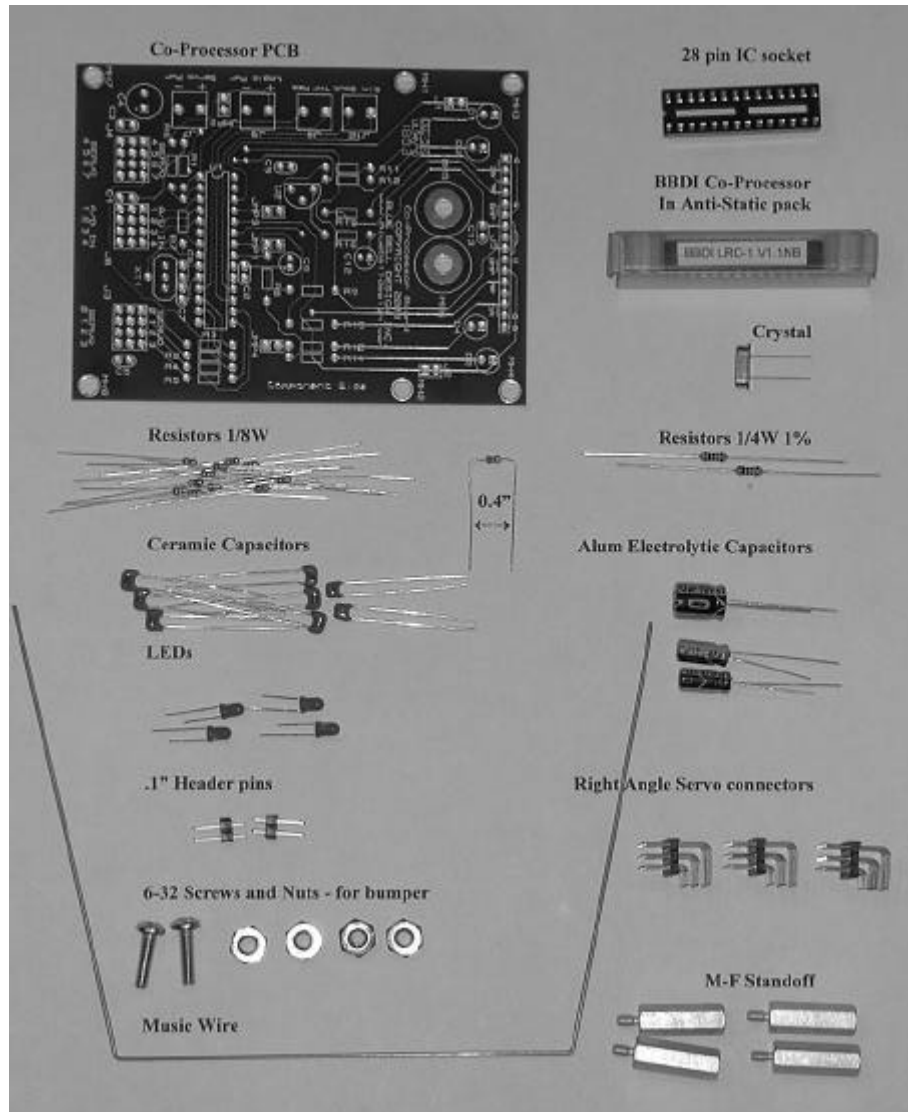


Photo 1 – Co-Processor Board mounted on a Parallax BoE-Bot
For the image in color see http://www.bluebelldesign.com/BoE_Bot_Big3.htm.
Jumpers are set for 9600 Baud, IRPD display, external voltage regulator, and separate logic and servo supplies. Shown with optional IRPD vision parts installed.

Thank you for buying our Co-Processor board (PCB). If you need to contact us you can through our website at www.bluebelldesign.com. That is also the place to go for lots more information on the PCB and our Co-Processor.

This board does require soldering! If you don't already know how to solder, there are various sites on the Internet to help you learn. You should also practice a bit before starting on the PCB. Because the parts are well spaced out and the parts are all top quality, this project is actually reasonable for a relative beginner to handle.

We recommend you read the instructions completely through before starting. Then check and identify the parts. Finally, go back and start to actually build your board. It is better to clarify any confusion as to which part is which before you have soldered it on to the board. **In any case, keep the Co-Processor in its static protective packaging until you are ready to install it.**



Legal Disclaimer

Electronic assembly can be dangerous. There are sharp edges, lead is used in the solder for assembly and plating, and, a soldering iron gets very hot. In general, **be careful!** Never put anything with lead in or on it into anyone's mouth.

If you're under 18, make sure your parents know what you're doing. If you are very young, have an adult supervise or help.

No guarantee is made for any fitness of purpose or function. **This product is not designed for use in any applications where the life or health of anything living depends on it.**

Items shipped with your kit:

Reference	Quantity	Description
	1	Co-Processor Board Manual (This manual)
	1	Co-Processor PCB
	1	28 pin 0.3" IC socket
R1,R8,R9	3	10K Resistor 1/8W 5% (Brown, Black, Orange, Gold)
R2,R3,R4,R5	4	470 ohm Resistor 1/8W 5% (Yellow, Violet, Brown, Gold)
R6,R7	2	20.0K Resistor 1/4W 1% (Red, Black, Black, Red, Brown)
R10,R11,R12,R14	4	2.2K Resistor 1/8W 5% (Red, Red, Red, Gold)
R13,R15	2	1K Resistor 1/8W 5% (Brown, Black, Red, Gold)
R16	1	47 ohm Resistor 1/8W 5% (Yellow, Violet, Black, Gold)
C1,C2,C3,C5,C9,C13	6	Ceramic Capacitor 0.1uF - 0.1" LS (marked 104 or .1M)
C4	1	470uF/10V Alum Electrolytic Capacitor 0.1" LS
C6,C12	2	47uF/10V Alum Electrolytic Capacitor 2mm LS
C7,C8	2	Ceramic Cap 22pF - LS = 2.5mm (marked 22J)
D1,D2,D3,D4	4	Red LED
J1,J2	2	.1" Header pins
J3,J4,J6	3	Right Angle Servo connector
XT1	1	Crystal, 20 MHz
U1	1	BBDI Co-Processor – Static Sensitive!
	2	Pan Head Screw 6-32 X 1/2" - for bumper
	4	Nut 6-32 - for bumper
	1	.039" Music Wire x 12" long
	4	"4-40 X 3/4"" Al M-F Standoff"

The next step is to decide what your application will need. The board has several options for you to choose from so let's start there.

1. The Baud rate between the main controller (Stamp?) and the Co-Processor is determined by the state of pin 21. If a wire is soldered between the pins of JMP1, pin 21 gets grounded so the baud rate is 9600. If pin 21 is pulled up to +5 volts, the Baud rate is 2400. This can be accomplished by either installing R8 or just using a wire to jumper across where it will be. The BS2 has been tested and will work at 9600 Baud so you might as well use that setting for best performance.
2. Servo channels 6 and 7 can optionally be used to indicate if the internal IR Proximity Detection (IRPD) vision system "sees" anything. This is very handy while debugging your programs or just for the fun of being able to see what the robot is getting as inputs. The PCB has the wiring from those servo outputs to

LEDs D3 and D4 through Jumper positions JMP3 and JMP4. R10 and R11 provide current limiting for the LEDs.

- a. If you want to use Servo channels 6 and 7 as servo drivers, you can still use LEDs D3 and D4 for general-purpose display. Connect the drive signals to the JMP3 and JMP4 connections closest to the R10 and R11. This will allow you to display outputs from the main controller. A high signal (+5 V) turns the LEDs on.
- b. If you want to use servo channels 6 and 7 as IRPD indicator drivers, you connect across the pins of JMP3 and JMP4. This configuration is shown on Photo 1.
Even if D3 and D4 are connected as vision indicators, servo channels 6 and 7 can still be used as general-purpose servo drivers. The LEDs will have a faint glow due to the 1-2 ms servo drive signal but nothing will be harmed and the servos will work fine.

3. Do you need a bumper? The PCB is laid out for a bumper and indicator LEDs (D1 and D2). J1 and J2 are the sensing points for each side. When they are grounded, the bumper is considered “hit” on the respective side. J1 and J2 are normally pulled high by the combination of R12 and D1 on the left and R14 and D2 on the right. J1 and J2 are already connected to the Co-Processor bumper input pins on the PCB.

- a. A piece of formed 0.039” (1mm) “piano” wire makes a good bumper. It can be mounted and grounded using 6-32 screws through MH5 and MH6. The bumper wire threads through J1 and J2 and is bent and adjusted so that normally it does not contact any of the pins. When the bumper wire contacts something, it touches J1 or J2. The LED(s) corresponding to the side(s) hit lights up and the Co-Processor is given the signal. Photo 1 shows the bumper installed. If the bumper is to be installed separately from the PCB, you can just wire from J1 and J2 to ground through the external bumper switches for each side. The connections are also available on pins 5,6 and 10,11 of J5 for external bumpers. 2 Pin headers on those sections of J5 can be used to make disassembly easier than using J1 and J2. A 12” piece of music wire is provided for your bumper but you can buy more at most hobby stores for a custom bumper if you want one.
- b. If you don’t want the bumper, you can still use D1 and D2 LEDs for general use. Just skip the bumper wire. Grounding J1 will light up D1 and grounding J2 will light up D2. High inputs to J1 or J2 will leave the LEDs off. This is the reverse of D3 and D4 but was wired this way to have the bumper wire be at ground. J1 and J2 still being wired to the Co-Processor bumper inputs will not be a problem because you can ignore the bumper inputs via software control and they will not be floating. You could use any general output to drive D1 and D2 but a convenient pair are servo channels 4 and 5. Just wire from J4 (servo output connector) to J1 and J2. Photo 2 below shows the LEDs driven that way. In that case there was no

need to put in J4 because all 4 servo outputs were used to drive indicator LEDs.

- c. Even if you don't want a bumper or D1 and D2 as indicators, you should install R12 and R14 and jumper the holes for D1 and D2. That will put pull-ups on the Co-Processor bumper inputs. Even though they aren't being used, it is always good practice not to leave the processor inputs floating.

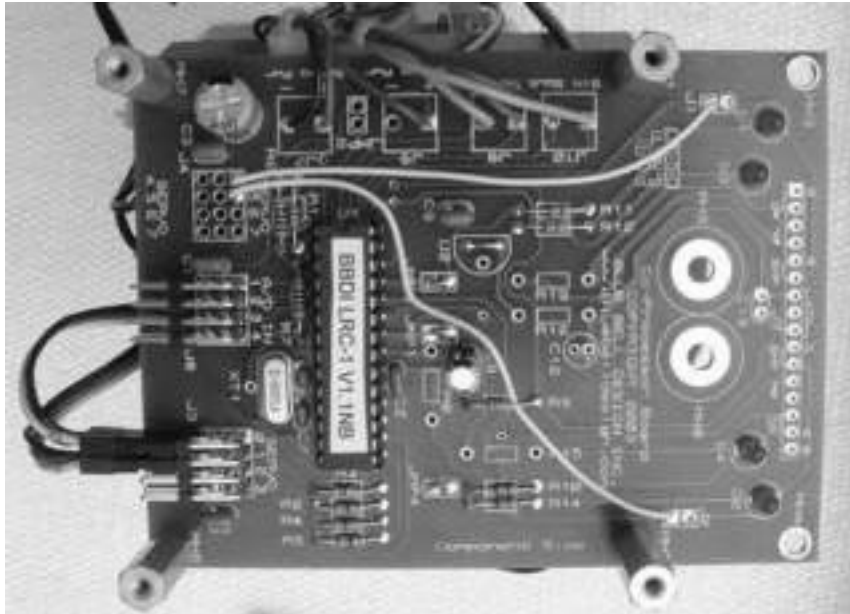


Photo 2 – Co-Processor Board (without vision components or J4) mounted on a Parallax Toddler. Wires were added to drive the bumper LEDs from servo channels 4 and 5.

For a higher resolution color image in see

http://www.bluebelldesign.com/Toddler_CoP_Big2.htm.

4. IRPD vision is included on the Co-Processor and PCB. It allows some choices too. Either way, R9 should be installed so the sensor input isn't floating.
 - a. If you want vision - R16, C12, C13 power the IR sensor and R13 and R15 current limit the IR LEDs. You'll also need to add IR LEDs and an IR sensor. They aren't included with the kit but the parts that came with your BoE-Bot are fine. If you don't have them, a package of IRPD parts is also available from Blue Bell Design Inc. Photo 1 shows the vision. If the PCB is enclosed in an outer body, the IR LEDs and IR sensor can be mounted off-board and wired back to the PCB. This approach could also be used if it is not convenient to mount the "front" of the PCB forward in your robot.
 - b. Even if you don't want IRPD vision, you should still at least install R9 to pull up the Co-Processor vision input. In any case you can install R13,

R15, R16, C12 and C13. They are supplied in the kit and cause no problem if installed. That way, in the future, you are ready to just add the sensor and IR LEDs if you want to add vision.

5. There is a place for a built in 5 volt regulator (U2) on the PCB. Since most controllers like Parallax BoE-Bots and Toddlers already have the built in regulators, one is not provided in the kit. In case your application does need a local regulator, the schematic and layout are set up for an LP2950-5.

Now we are ready to build the board. A PCB has two sides. The top, called the component side is the side the part bodies are on. It also has the white markings (called the silk screen) to show where the parts go and their orientations. The other side, the solder side, is the side you solder on. Both sides are labeled on the edge of the artwork.

Some parts are polarized. That means you have to put the pins into certain PCB holes only. LEDs, ICs, and Electrolytic capacitors are all polarized. On parts that aren't polarized, you can put either lead into either hole on the PCB. Resistors, ceramic capacitors and crystals aren't polarized.

Resistors are tubular and have a wire coming out each end. They are marked with color bands to indicate their value and tolerance. When describing a resistor we will give both the value and color bands for your convenience. Pre-bend the resistor leads so the spacing is 0.4" between the leads. This makes it easy to insert the resistor into the holes for soldering. Bend the leads out a bit after they are through the holes so the resistor stays in place for soldering. Cut the leads off after soldering. The cut off lead ends make good jumper wires for JMP1-JMP4 so save a few. The instructions will just say insert a resistor but it means to pre-bend, insert, solder and clip the wires. Resistors are not polarized.

1. Insert 10K Resistors (Brown, Black, Orange, Gold) into R1 and R9 positions.
2. If you want to operate at 2400 baud, insert a 10K Resistor (Brown, Black, Orange, Gold) into the R8 position. Otherwise, to operate at 9600 baud, use a piece of bare wire or resistor lead to short across the pads of JMP1. Trim any excess lead length.
3. Insert 470 ohm Resistors (Yellow, Violet, Brown, Gold) into R2, R3, R4, and R5 positions.
4. Insert 20.0K Resistors 1% (Red, Black, Black, Red, Brown) into R6 and R7 positions.
5. Insert 2.2K Resistors (Red, Red, Red, Gold) into R10, R11, R12 and R14 positions.
6. Insert 1K Resistors (Brown, Black, Red, Gold) into R13 and R15 positions.

7. Insert 47 ohm Resistor (Yellow, Violet, Black, Gold) into R16 position.
8. Insert and solder the 28-pin socket into the PCB in the position marked U1. Make sure to match the notched side of the socket to the notch on the silk-screened pattern.
9. The Crystal is a small metal can with 2 leads coming out of one side. The leads aren't polarized. Insert, solder and trim the crystal into the XT1 position. BE CAREFUL, crystals don't like physical shock or too much heat. Use some paper for a shim to space the crystal slightly away from the PCB during soldering. When the solder joints are cool, remove the paper.
10. Two values of ceramic capacitor are provided. Both are in small blue plastic coated packages with 2 leads coming out the side.
 - a. Locate the two 22 pf capacitors (they are marked 22J) and solder them into the positions for C7 and C8 next to the crystal. Trim the leads.
 - b. Install the 0.1 mf capacitors (they are marked 104 or .1M) and solder them into the positions for C1, C2, C3, C5, C9, and C13. Trim the leads.
11. Aluminum Electrolytic Capacitors are polarized. The case has a large black band along one side to signify the negative lead. It is also the shorter of the two leads. The longer positive lead goes into the hole with the square pad that has a "+" beside it.
 - a. Install the 470uF/10V Alum Electrolytic Capacitor into the C4 position. Solder it and trim the leads.
 - b. Install the 47uF/10V Alum Electrolytic Capacitors into the C6 and C12 positions. Solder them and trim the leads.
12. LEDs are polarized. If the leads are different lengths, the shorter lead goes into the square pad. If they are the same length, look through the red body of the LED. One lead has a large triangular structure inside the case. The other has a much smaller lead assembly. The lead with the large triangular structure is the side that goes into the square pad. Install Red LEDs into the D1, D2, D3 and D4 positions. Solder them and trim the leads.
13. Place the header pins into J1 and J2. The shorter length post gets soldered into the PCB. When soldering, be careful not to touch the pin being soldered! One technique is
 - a. Have the solder standing in the air pointing toward you.
 - b. Hold the PCB with one hand while holding a pin with one fingertip of that same hand.
 - c. With the soldering iron in the other hand, touch the iron to the pin NOT being held. Quickly move the PCB and soldering iron over to touch the solder.
 - d. This sounds awkward but it is a useful technique to learn. You can then solder the second pin normally. When soldering these pins, move quickly

as the plastic melts easily.

14. The Right Angle Servo connectors are soldered similarly to the header pins. They may be aligned by first soldering a single pin closest to the PCB while holding the outer pins. Once the connector is aligned, you can solder the other pins normally.
15. Pick at most one of the steps below. Make sure you don't wire across JMP3 or JMP4 and also connect it to another output. That will cause the outputs to "fight" and may damage one or both of the outputs fighting.
 - a. If you want to use D3 and D4 to display the IRPD status, use a piece of bare wire or resistor lead to short across the pads of JMP3 and JMP4. Trim any excess lead length.
 - b. If, instead, you want general-purpose LED displays and to drive servos from channels 6 and 7, you can attach the D3 LED drive signal to JMP3 on the pad closest to R11. Leave the other pad of JMP3 open. Likewise, attach the D4 LED drive signal to JMP4 on the pad closest to R10. Again, leave the other pad of JMP4 open.
16. If you are using the on-board IRPD vision –
 - a. Pin one of J5 has a square pad.
 - b. Solder the sensor to pins 7 → 9 of J5. The "bead" faces away from the PCB.
 - c. See the photo for lead forming on the IR LEDs. Note that they bend differently. They are a mirror image of each other.
 - d. Solder an IR LED between pin 1 (shorter lead - large triangular structure inside the case) and pin 2 (longer lead) of J5. See the photo for lead forming on the IR LEDs
 - e. Solder an IR LED between pin 14 (longer lead) and pin 15 (shorter lead - large triangular structure inside the case) of J5.
 - f. Bend the LEDs so they point forward and slightly out to each side.
17. There is a place for a built in 5 volt regulator (U2) on the PCB. Since most controllers already have the built in regulators, one is not provided in the kit. Parallax BoE-Bots and Toddlers are just two examples of controller boards that already have on-board regulators.
 - a. If you don't need the built in 5 volt regulator, short the input to the output connections for the on-board regulator (U2). (Those are the 2 pads that are closest to the outside of the PCB.) The +5 regulated input to the PCB is then connected to J9+. Ground is available at J9- or J7-. Servo power is then brought in through J7. Photo 1 shows an example of the shorted regulator.
 - b. In case your application does need a local regulator, the schematic and layout are set up for an LP2950-5. If U2 is to be powered from the same power supply as the servo supply, you can jumper JMP2 and you only

have to connect the servo power to J7.

18. Inspect your assembly job and the solder joints. Make sure there are no solder splashes or bridging between the pads.
19. **The Co-Processor is static sensitive!** - Electrostatic discharges from touching the leads can generate thousands of volts. That is enough to damage it. **Don't take the Co-Processor out of its static protective packaging until you are ready to assemble it into the PCB.** When touching the Co-Processor, keep yourself and the worktop grounded. You can use a wrist strap or be touching earth ground while touching the pins.

Carefully plug the Co-Processor chip into the 28-pin socket. Make sure to match the package notch to the socket and PCB notches. (They all should point toward J7.) Make sure all of the leads are plugged into the socket contacts.

The Co-Processor pins are usually spread too far apart to fit into the socket. An easy way to squeeze them together is to insert the pins on one side of the chip halfway, then while holding the chip by the ends, apply gentle pressure to simultaneously bend the all legs that are already plugged in.

20. To add a bumper, see photo 1. Then –
 - a. Put a 6-32 screw through MH5. Put the screw head on the solder side of the PCB. Secure it with a 6-32 nut on the component side. Loosely add another 6-32 nut to be used to clamp down the bumper.
 - b. Do the same for MH6.
 - c. Form the music wire to the shape you want for the bumper. Notice that J1 and J2 are not in a straight line. This is to allow for the correct wrap direction around the 6-32 mounting screws. Bend the bumper to clear any obstacles. The bumper is shipped partially pre-bent to facilitate shipping. The bend gives a 4" front section, just right for a BoE-Bot.
 - d. **DO NOT USE YOUR PRECISION ELECTRONIC CUTTERS TO CUT MUSIC WIRE!** It is very hard and could destroy your cutters. If you need to, a better way to cut music wire is with a "Dremel tool" and cut-off wheel. You can also nick the wire with a file and bend it back and forth with two pairs of pliers until it breaks at the nick.
21. Mount the PCB onto your project.
 - a. If you have a Parallax BoE-Bot, unscrew the 4 screws holding the Board of Education and place the Co-Processor board where the BoE was. Instead of replacing the 4-40 screws, use the Male side of the Male-Female spacers supplied with the kit to attach the Co-Processor board to the robot base. Now put the BoE on top of the M-F spacers and use the 4-40 screws to attach it.
 - b. The same procedure is followed with a Toddler except MH1 and MH2 are used instead of MH3 and MH4. The LED part of the PCB stick out

beyond the Toddler PCB. That makes it easy to see the LEDs and the IRPD on the Toddler board still works fine.

- c. You can also just use the 4 standoffs to mount the PCB on your project.

22. Wiring the PCB into your project.

- a. On a BoE-Bot or Toddler, the easiest way to connect to servo power is wiring the “+” and “-“ power pins of a servo connector to J7. The “+” servo connection is the center pin. The “-“ pin is the one where the black or brown servo wire goes when a servo is plugged in. Instructions for making a servo connector are shown near the end of the Nuts & Volts Stamp Column #8. (Rotary Encoders Provide Friendly Spin and Grin Interface). Articles are available on the Parallax website at http://www.parallax.com/html_pages/downloads/nvcolumns/Nuts_Volts_Download_V1.asp. (If you cut and paste this address, watch for line wrap.) In any case, this is a very useful technique to know for robotics.
- b. On a Toddler, if servo power (J7) is connected to the servo ports (X6 or X7), the separately switched power to the servos will stay separate. The Toddler servo power wiring to X6 is shown on our website at http://www.bluebelldesign.com/Toddler_CoP_Big3.htm.
- c. When an on-board regulator is not used, the Vdd (+5) connection is easily done with a wire from J9+ to a Vdd connector on the controller board.
- d. The four signal connections to J8 and J10 just wire to the controller board. The exact I/O pin assignment changes depending on the project so look at the code for your application.
- e. If you don't want to solder to the PCB connections, J7-J10 layouts will accept 0.2” center-to-center screw terminals (not provided in kit).

Note: The reset circuit on many microcontroller boards is not very robust. They do normally work in a standalone configuration. Our Co-Processor PCB has extra filtering for better noise performance. This can cause the reset circuit to stop working because of the slower rise time of the power supply. The simplest solution is to press the reset switch while turning on the power. If that is not acceptable, a more robust reset can be added to the controller board. Look on our website at the schematic for our Libby controller to get one possible solution.

Congratulations! The kit is complete but now you are just starting. There are lots of things you can do with your new Co-Processor PCB. It gives you back your controller for new things to add. The A/Ds are excellent for sensors. The ramping servo controllers do wonders for animatronics or walker robots. If you are using a Basic Stamp® from Parallax, don't forget the timers, they can give a tremendous boost to the Stamp's compute power. Periodically check our website (www.bluebelldesign.com) for some ideas. If you find some fun new application, tell us about it.