HexRod / QuadRod Assembly Manual

Kit Assembly, Tuning and Example Programs

VERSION 1.1

Author – Alex Dirks

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Preface

The HexRod QuadRod robots are an original design from Alex Dirks of CrustCrawler (www.crustcrawler.com). The HexRod QuadRod is an advanced robotic kit consisting of a heavy duty, walking platform.

The applications CrustCrawler provides on our HexRod / QuadRod web pages are project-oriented. Experience programming the BASIC Stamp is helpful, but if you need more help in this regard you can find plenty of robotic programming resources on the CrustCrawler and Parallax web site. All of the sensors we sell include BASIC Stamp program examples which you could readily adapt to the HexRod and HexRod / QuadRod robotic kits.

Putting the hardware together also requires some skill with hand tools. If you are not semi-skilled with common hand tools we recommend you return the kit prior to assembly unless you have some patience.

But, the CrustCrawler team assures you that when you can successfully complete the HexRod / QuadRod robotic kits you're in for an exciting series of robotic projects that you will find highly rewarding. Our office staff has customized the HexRod / QuadRod kits by adding, cameras, ultrasonic sensors and infrared detectors.

Chapter #1: Preparing to Assemble the HexRod / QuadRod

1

REQUIRED TOOLS

The following tools will be required to build your HexRod / QuadRod:

- Phillips screwdriver
- Drill
- 1/8" drill bit
- Small adjustable crescent wrench or socket set
- Wire cutters
- A small amount of white grease or equivalent

QUADROD FULL KIT INVENTORY

The QuadRod full kit contains the following components:

Electronics:

- (1) BASIC Stamp 2 Module
- (1) USB Board of Education (BOE)
- (8) HiTec HS-322 HD Servos
- (1) USB Cable
- (1) USB Parallax servo controller
- (4) 6" servo extensions

Aluminum Parts:

- (1) Channel
- (4) Servo Holders
- (4) Leg Actuators
- (4) Leg Actuator Supports
- (4) Front Legs
- (4) Rear Legs
- (4) Servo Brackets
- (4) Circuit board brackets

Nuts, Bolts, Washers and Screws

- (8) #2 lock nuts
- (20) #4 -1/4" screws
- (8) #4 -3/8" screws
- (4) #4 - 7/16" screws
- (6) #4 - ½" screws
- (6) #4 - ¼" nylon spacers
- (30) #4 – nuts

- (10) #4 lock nuts
- (2) #4 1.50” Screws
- (4) #4 Washers
- (30) #4 – lock washers
- (16) #6 –3/8” screws
- (16) #6 lock washers
- (16) #6 nuts
- (4) #8 -1.50” screws
- (4) #8 lock nuts
- (8) #8 washers
- (4) #8 -9/16” nylon spacers
- (4) #8 -7/16” nylon spacers
- (8) ¼” SAE flat washers

Miscellaneous

- HexRod / QuadRod Manual
- (4)- 2/56 threaded rods
- (4) rubber feet
- (8) dog bones
- (8) ball links
- (12) cable ties

HEXROD FULL KIT INVENTORY

The HexRod full kit contains the following components:

Electronics:

- (1) BASIC Stamp 2 Module
- (1) USB Board of Education (BOE)
- (12) HiTec HS-322 HD Servos
- (1) USB Cable
- (1) USB Parallax servo controller
- (4) 6” servo wire extensions

Aluminum Parts:

- (1) Channel
- (6) Servo Holders
- (6) Leg Actuators
- (6) Leg Actuator Supports
- (6) Front Legs
- (6) Rear Legs
- (6) Servo Brackets
- (4) Circuit board brackets

Nuts, Bolts, Washers and Screws

- (12) #2 lock nuts
- (28) #4 -1/4" screws
- (12) #4 -3/8" screws
- (6) #4 - 7/16" screws
- (6) #4 - ½" screws
- (6) #4 - ¼" nylon spacers
- (40) #4 – nuts
- (15) #4 lock nuts
- (40) #4 – lock washers
- (3) #4 1.50" Screws
- (6) #4 Washers
- (24) #6 –3/8" screws
- (24) #6 lock washers
- (24) #6 nuts
- (6) #8 -1.50" screws
- (6) #8 lock nuts
- (12) #8 washers
- (6) #8 -9/16" nylon spacers
- (6) #8 -7/16" nylon spacers
- (12) ¼" SAE flat washers

Miscellaneous

- HexRod / HexRod / QuadRod Manual
- (6)- 2/56 threaded rods
- (6) rubber feet
- (12) dog bones
- (12) ball links
- (12) cable ties

Source Code from the CrustCrawler Web Site (www.crustcrawler.com)

HexRod/ QuadRod Source Code

The CrustCrawler web site HexRod / QuadRod page contains sample BS2-IC source code, this installation guide and additional pictures of the HexRod / QuadRod to aid you during the construction process. Additionally, we frequently post additional applications for our products on the web site.

Projects and Accessories are available from the Parallax Web Site (www.parallax.com) and the CrustCrawler web sites (www.CrustCrawler.com)

HexRod / QuadRod Projects / Accessories

Projects that include updated code, electronics and hardware accessories are always being added to the Crustcrawler and Parallax web sites. Check with our site often for the latest updates.

ADDITIONAL PARTS YOU NEED TO SUPPLY

Like other hobby kits, completing the HexRod / QuadRod kits requires additional parts that you will need to supply. CrustCrawler carries all of the assessors best suited for the HexRod and QuadRod kits.

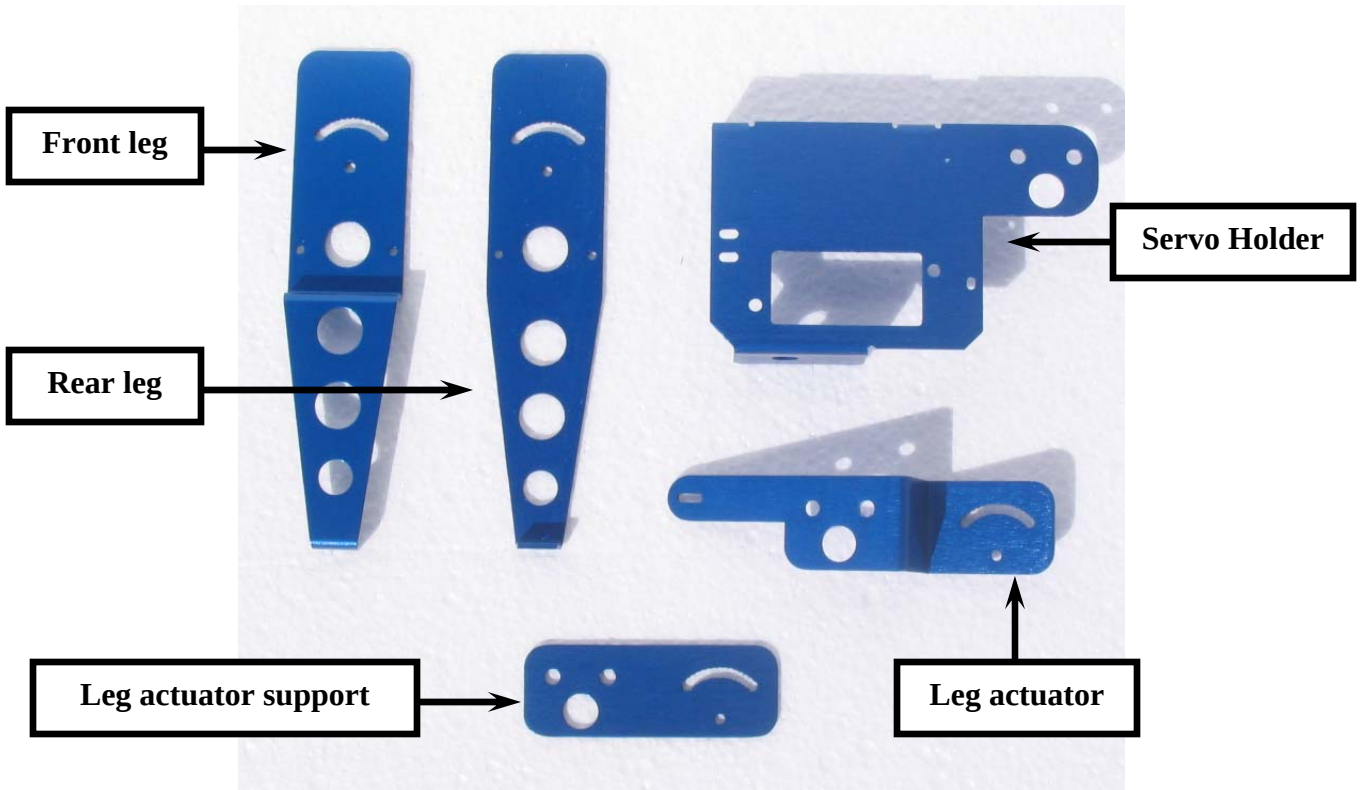
- 5 – 7.2v NiMH or NiCd six-cell rechargeable battery for servo power. This is a standard 1800 mAH to 3300 mAH battery pack, commonly used in R/C cars. CrustCrawler has an excellent, deep cycle, 3300 series NiMH battery pack which has been selected just for our line of walking robotic kits.
- AC/DC Digital Peak Charger for the 5 V NiCd/NiMH battery. CrustCrawler carries an excellent charger from Hi-Tec. Refer to our web site for details.
- Zip-ties of the smaller sizes are very useful for securing wires in a tidy fashion. Approximate cost is probably a few dollars. Available from any hardware store. (12) Zip ties have been included in your kit.
- Robot sensors The HexRod / QuadRod is a platform and the opportunities for sensor integration are endless. Selecting the appropriate sensor is left up to you, our customer. The S2 and S3 sensors will bolt right onto the HexRod and QuadRod kits.

Chapter #2: Pre-Assembly Tips

PAY ATTENTION TO DETAILS

- Work in a well lit, clean environment with lots of workspace
- Organize your nuts, bolts and screws so that you have each specific size of lock-nuts, screws, washers in the same group and are easily within reach.
- Take your time! The HexRod / QuadRod kit is a precision made product and requires all parts to be assembled in the *exact* order as described in this installation manual.
- The average time to construct a kit is between 3 – 4 hrs.
- Always note the **orientation** and **direction** of screws and aluminum parts and which **side** of your HexRod / QuadRod you are constructing! It absolutely makes a difference! Although some parts may look identical there are "left" and "right" hand parts.

PARTS IDENTIFICATION



PREPARING THE SERVOS

- Remove the aluminum body parts from their protective bags and lay them loosely in their respective groups on your work surface.
- Gather all of your servos and remove the servo horn and screw, setting them aside in a safe place.
- Remove the riser tabs from both sides of (4) of the servos for the Quad Rod or (6) of the servos for the HexRod kits as shown below. The removal of this plastic riser will allow the servo to sit flush against the servo holder. These servos will be installed in the next few steps of the construction process.

Chapter #3: HexRod / QuadRod Leg Assembly

Figure 2: Mounting Servos

1. Using (2) #6 - 3/8” screws lock washers and nuts, install the horizontal servo (the servos with the riser tabs intact) to the top of the servo holder as shown in figure 2. The servo gear head should always be orientated towards the straight end of the servo holder.

2. Using (2) #6 - 3/8” screws and lock washers and nuts, install the vertical servo (he servo with the riser removed earlier) to the servo holder as shown in figure 3. Complete steps 1 and 2 for the remaining servos in your kit.

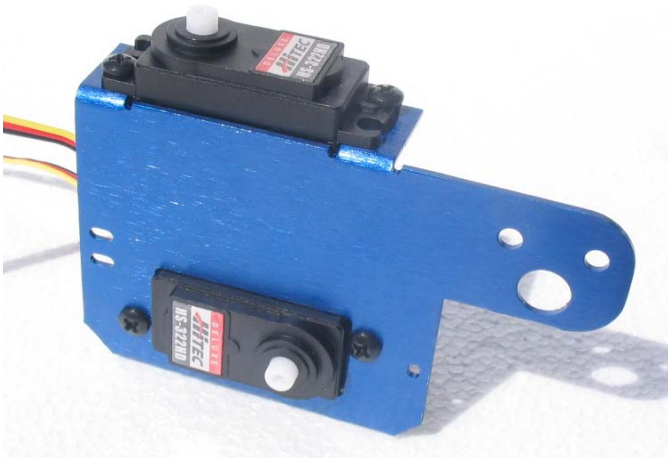


Figure 3: Servo Orientation

3. Secure the (2) servo wires with a tie wrap as shown in figure 4. Ensure that the servo wires are not being pulled by the tie wrap when tightened.

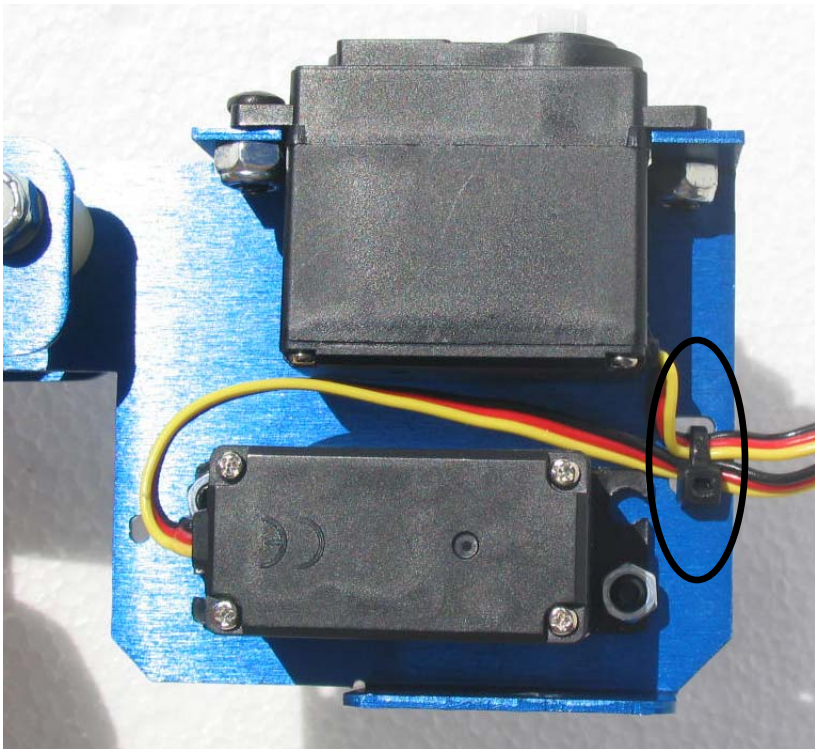


Figure 4

4. Using a #2 lock nut, install the ball link to the leg actuator as shown in figure 4. Place the ball link towards the curved end of the leg actuator leaving about 1/16” of space in the slot.

Figure 4

5. Using (1) #8- 1.50” screw, (2) washers, (1) lock nut, (1) 7/16” nylon spacer and (1) 9/16” nylon spacer, install the leg actuator and leg actuator support to the servo holder as shown in figure 5 and figure 6.

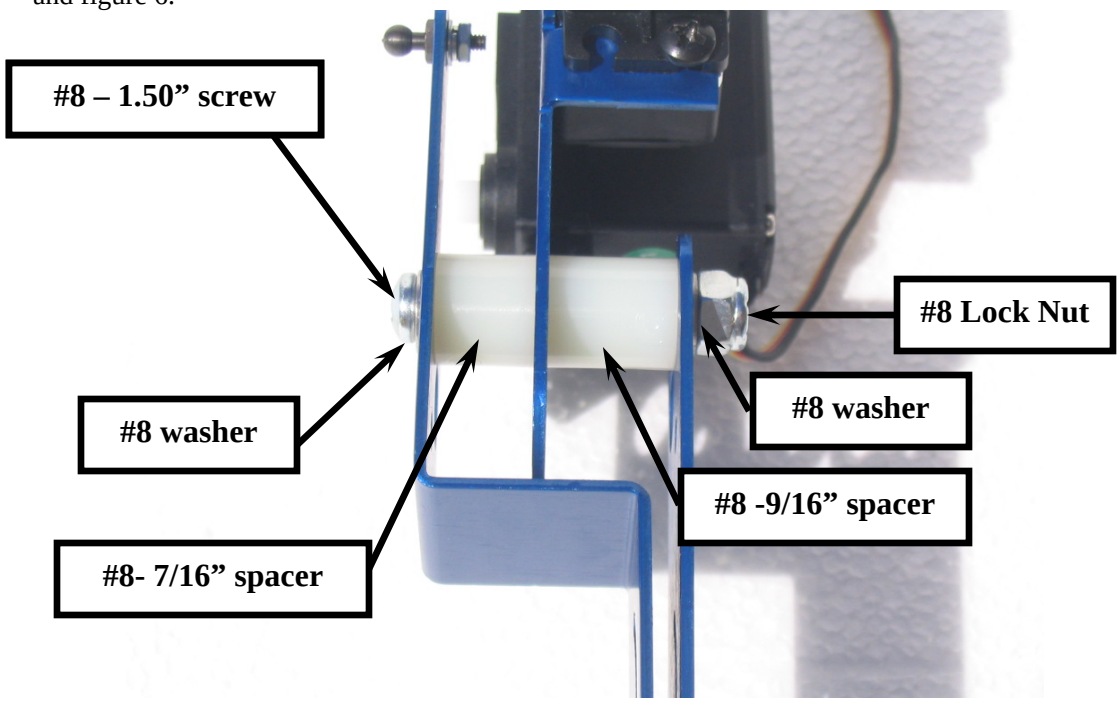


Figure 5

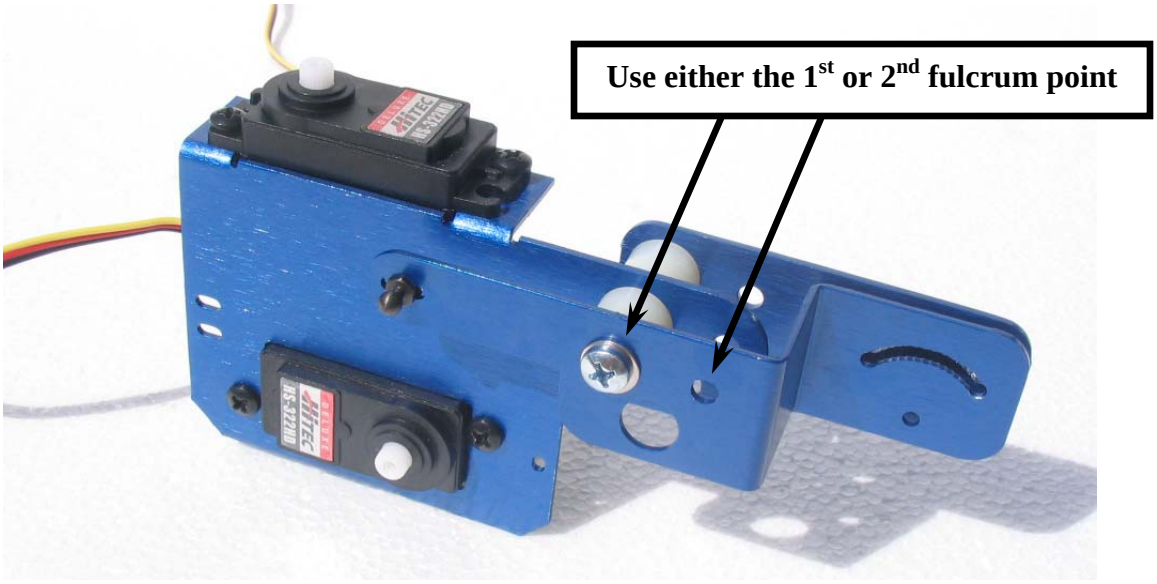


Figure 6

6. Use the close-up diagram in Figure 6 for the complete assembly sequence. Tighten the #8 screw just enough so that the assembly will remain upright as shown in figure 6. This assembly will be loosened later in the construction process to ensure proper leg movement.

Note: There are (2) fulcrum points to choose from depending on the payload capacity and leg lift clearance that you require. The hole that is closest to the servo holder is for optimum leg lift and ground clearance when the HexRod of QuadRod is walking. The second fulcrum point (located farthest from the servo holder)is used for heavier payload capacities of over 6 pounds.

7. Using (1) #4- 7/16” screw, lock washer and nut, install the rubber bumper to the front and rear leg assembly as shown in figure 7. Ensure that the back leg is placed on top of the front leg before inserting the #4 – 7/16” screw.

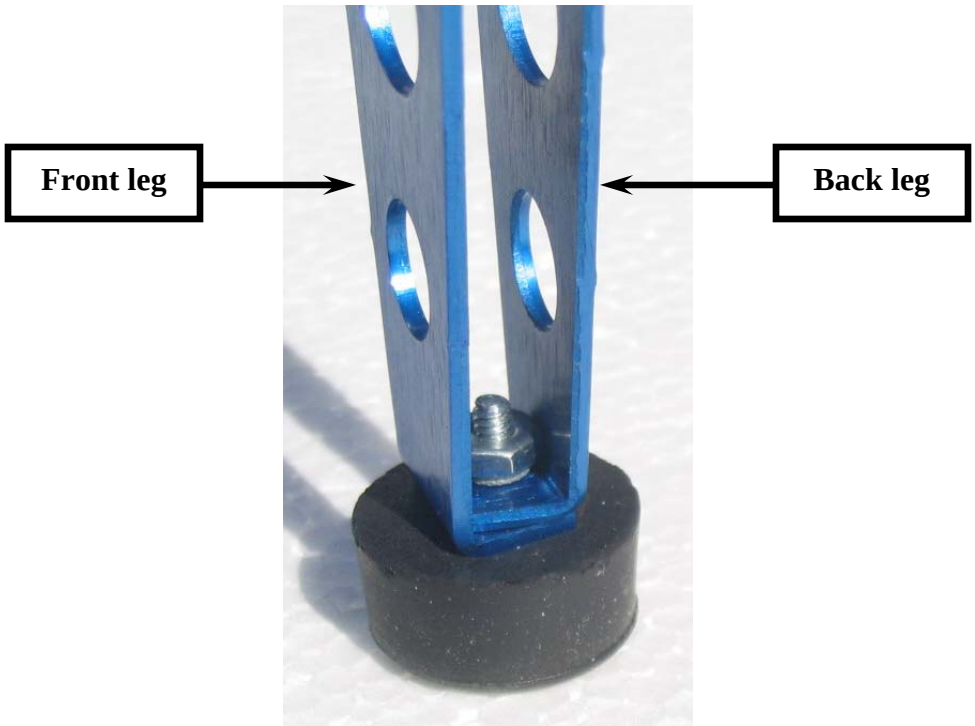


Figure 7

8. Using (1) #4 – 3/8” screw and lock nut, install the leg assembly to the leg actuator assembly as shown in figure 8. Ensure that the front leg is oriented towards the front of the assembly. Ensure that the leg assembly is perpendicular with the leg actuator assembly before tightening the #4 lock nut.

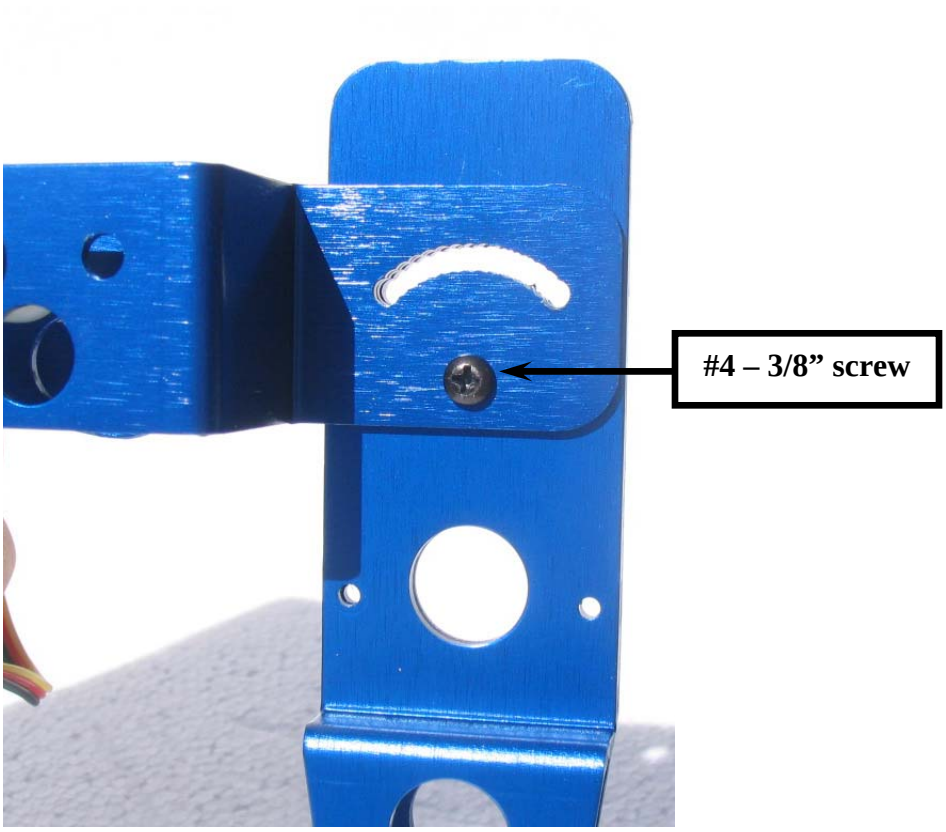


Figure 8

- The completed assembly.

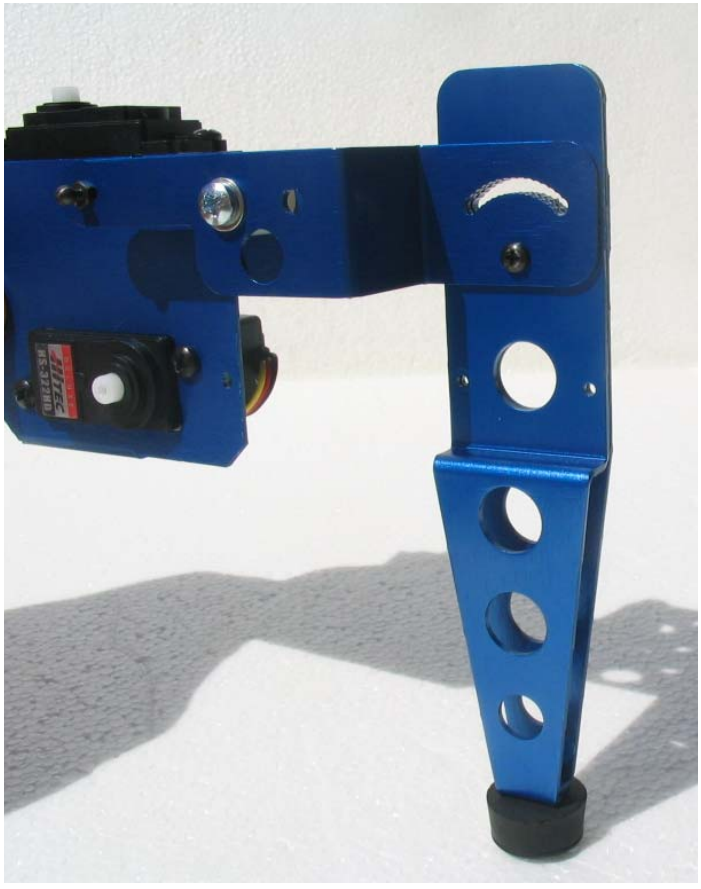


Figure 9 – Completed Assembly

9. Using a 1/8" drill bit, drill out the 2nd hole of the straight servo horn as shown in figure 9. To make drilling easier, place the servo horn onto a servo before drilling.

10. Using (1) #2- lock nut, install the ball link to the servo arm as shown in figure 10.

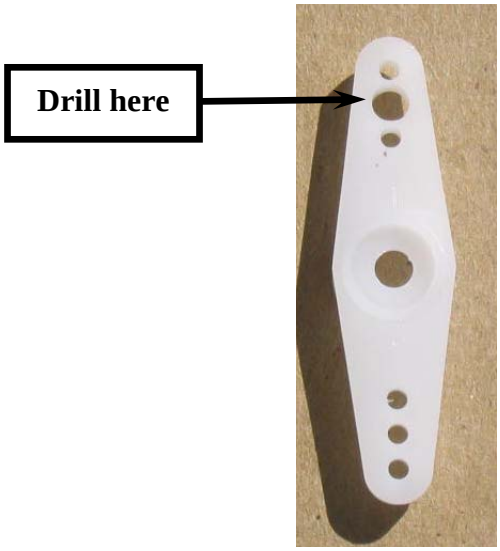


Figure 9

Figure 10

11. Place the servo horn onto the vertical leg lift servo and rotate the servo horn in the counter clockwise direction until it stops for the right hand servo holder and clockwise for the left hand servo holder

12. Remove the servo horn and place it back onto the servo spindle in the 11 o'clock position for the right hand servo holder and the 1 o'clock for the left hand servo holder as shown in figure 11a and 11b. When completed, secure the servo with the servo horn screw.

Figure 11a – Right hand servo holder

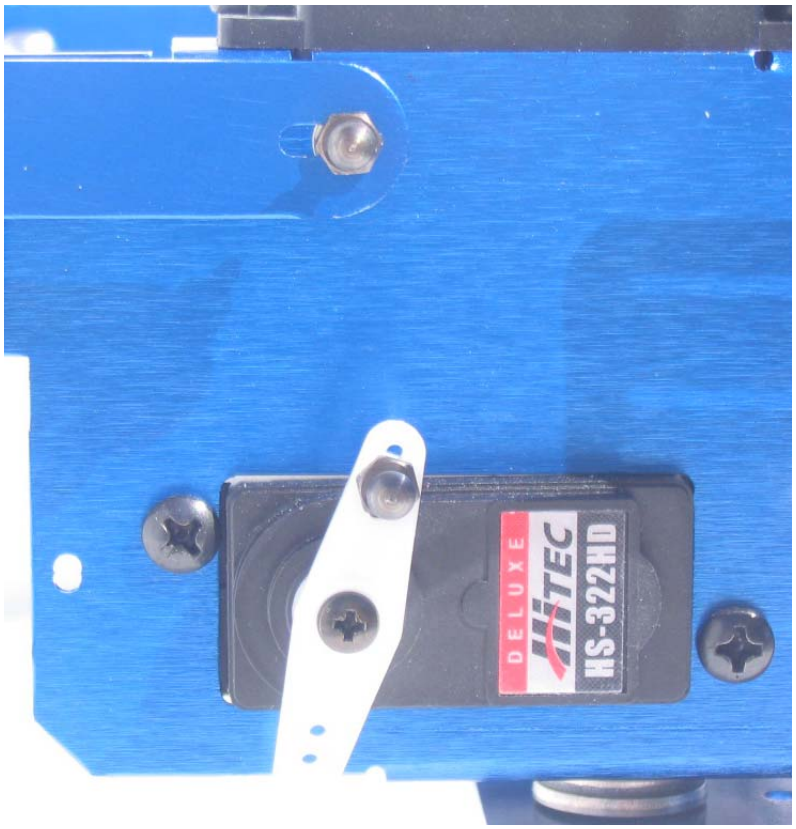


Figure 11b – Left hand servo holder

13. Join the 2 dog bones by threading the 2/56” threaded rod into each end of the dog-bones. Start threading one dog bone for a few turns onto the threaded rod and then install the other dog bone and turn them together in opposite directions (Figure 12). Repeat this step for all of the legs in your kit.

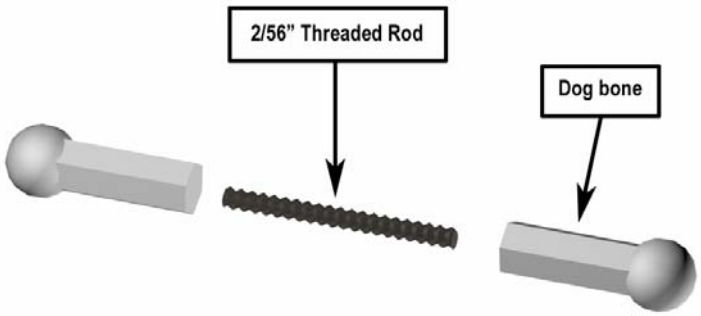


Figure 12: Dog Bone Assembly

	Tip: If turning the threaded rod onto the dog bone is difficult by hand, place the 2/56” threaded rod into a padded vise and use an adjustable wrench to turn the dog-bone onto the threaded rod.

Figure 13: Completed Dog Bone Assembly

14. Install the dog bone assembly to the ball joints as shown in figure 14. Do not press on the center of the dog bone assembly when installing the dog bone assembly or the 2/26" threaded rod will bend. Simply press on the ends of the round, ball joint housing. Also, support the leg actuator with your fingers when installing the dog bone assembly or you could bend the leg actuator as well.

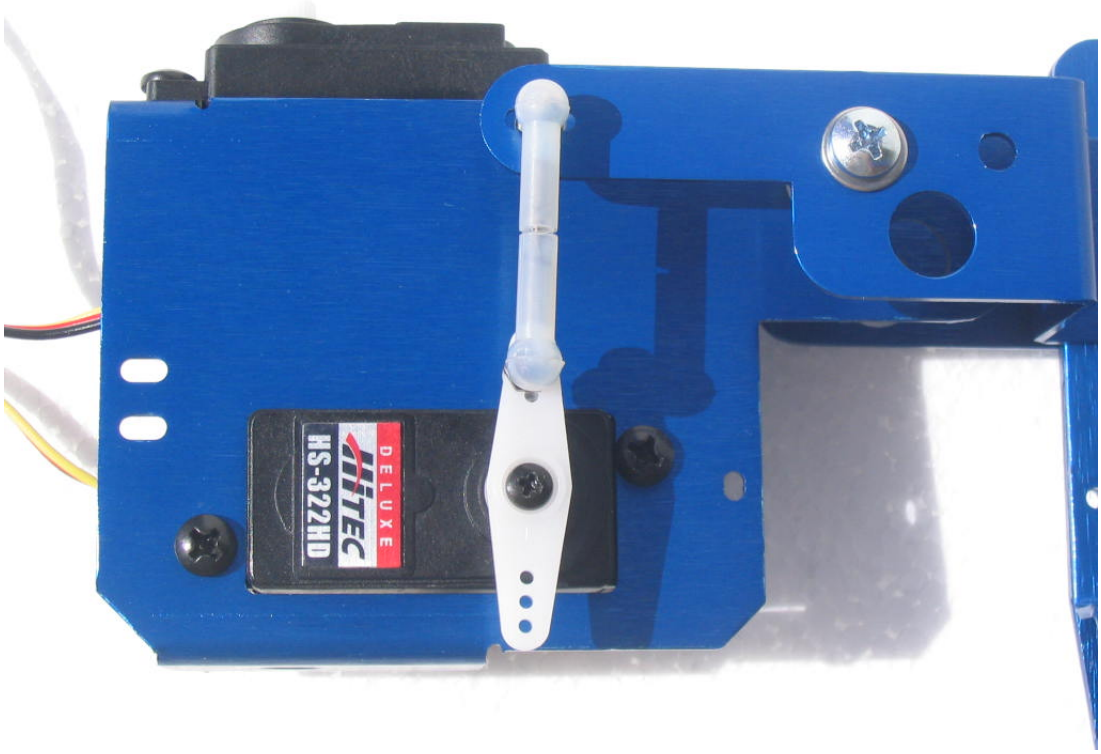


Figure 14

- The leg assembly is now complete. Repeat steps 1 – 14 for the remaining legs in your kit.

Chapter #4: HexRod / QuadRod Body Assembly

15. Using a 1/8” drill bit, drill out the holes of (6) of the servo horns for the HexRod or (4) for the QuadRod as shown in figure 15.

Tip: Drill the holes with the servo arm still mounted on the servo. After completing the holes, remove the round servo arm and temporarily place the servo screw back onto the servo.

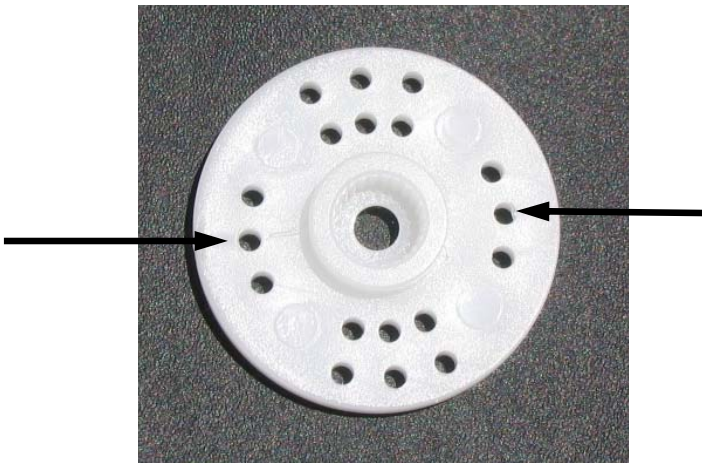


Figure 15

16. Using (2) #4- ¼” screws, lock washers and nuts, install the servo horn to the servo bracket as shown in figure 16.

Figure 16

17. Using (2) #4-1/4” screws, lock washers and nuts, install the servo bracket to the 2 holes located near the top of the channel as shown in figure 17a. Ensure that servo bracket is installed evenly with the top of the channel before tightening the screws firmly.

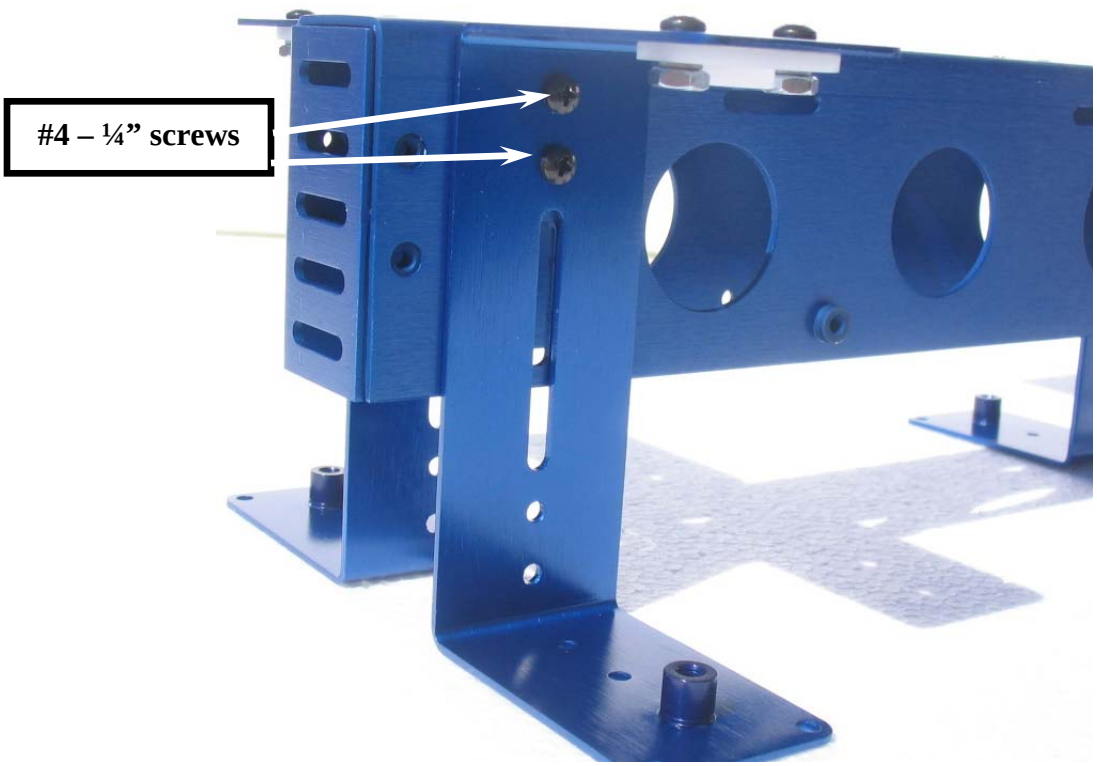


Figure 17a

18. Using (1) #4 – 1.5” screw, (2) washers and a lock nut, secure the (2) servo brackets using the upper hole of the (2) holes as shown in figure 17b. Tighten the lock nut just enough so that it is up against the channel but loose enough so it can be turned by hand. Ensure that the screw does not bend the servo brackets.

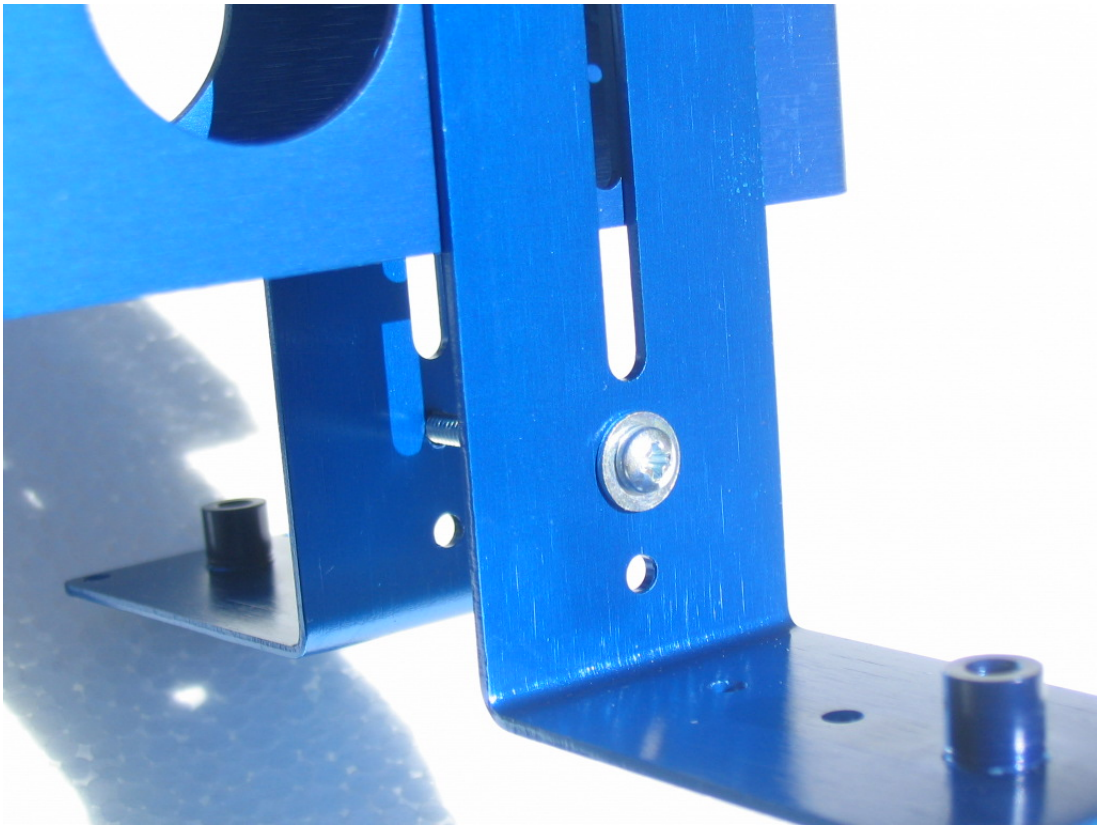


Figure 17b

19. Repeat steps 15 – 18 for the rest of the servo brackets in your kit.

20. Install (2) ¼” SAE flat washers to the pem spacer located at the bottom of the servo bracket as shown in figure 18 . The first washer should be installed flat side up and the second washer should be installed flat side down. Lightly grease the top washer.

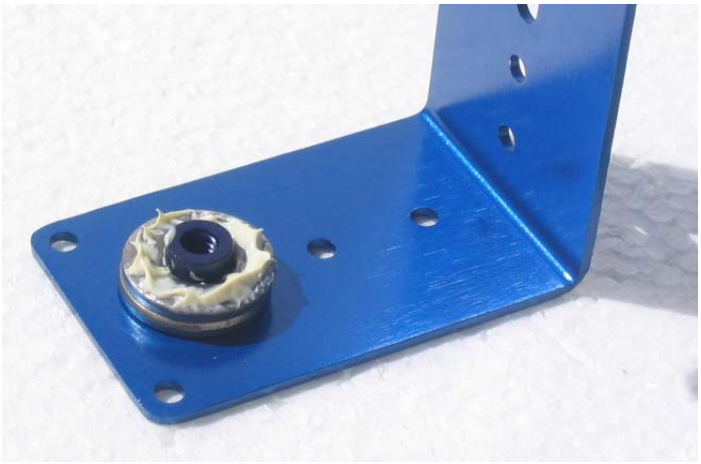


Figure 18

21. Install the completed leg assembly to the servo bracket by first placing the hole located at the bottom of the servo bracket onto the edge of the pem spacer and then gently lifting the top of the servo bracket to place the horizontal servo's spindle into the servo horn as shown in figure 19.

22. Before securing the leg assembly to the servo bracket with the servo horn screw, be sure that the horizontal servo can rotate 90 degrees forward and backward from its perpendicular position with the channel or body of the robot. If the rotation is un-even, simply lift up on the servo bracket to release the servo spindle from the servo horn and rotate the assembly forward or backward before re-installing the servo horn back onto the servo spindle.

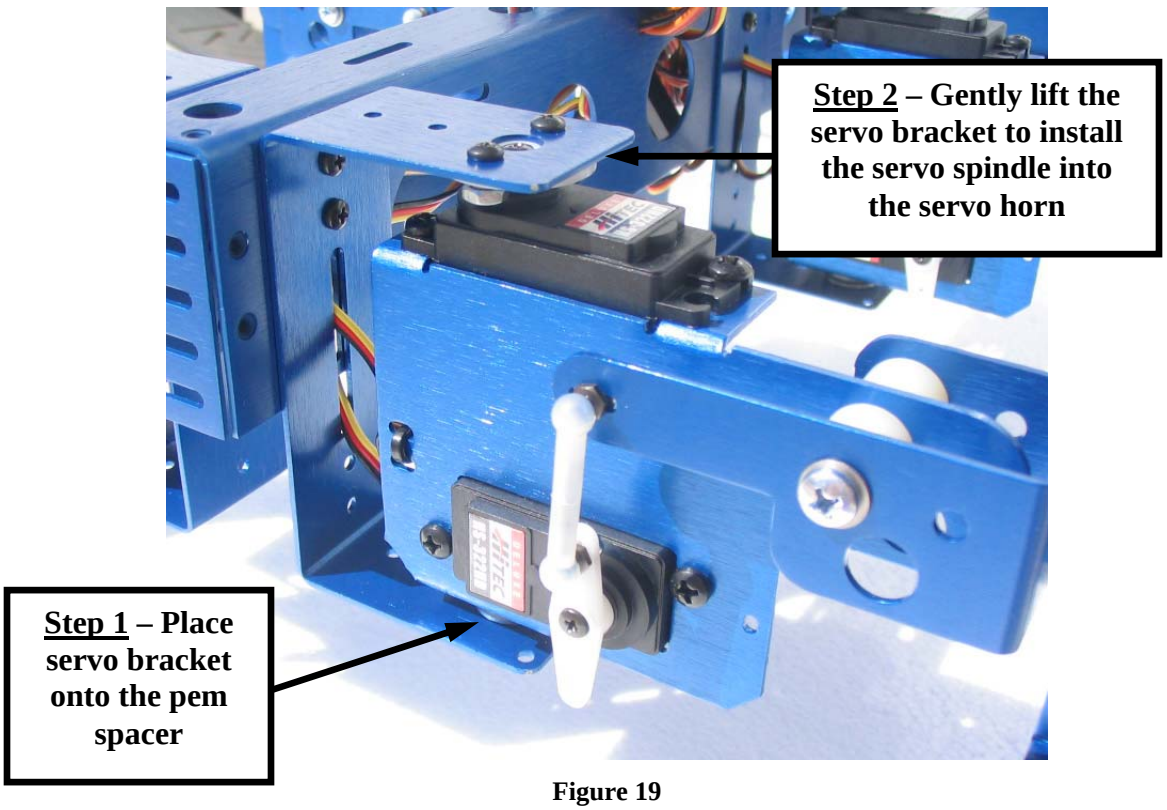


Figure 19

- **Note:** Install the "right hand" legs (figure 19) to the side of the channel that has the pem nut protruding out from the side of the lower part of the channel body. All of the left hand legs are located on the non-pemmed side of the channel.

- Repeat steps 20 thru 22 for the remaining legs in your kit.

- Loosen the #8 lock nut on the #8, 1.50” screw for each leg in your kit (figure 19b). Loosen the nut just enough so that the leg can move freely but not too much so that the legs nylon spacers are “loose” and the leg hardware displays a “rattle” when moved.

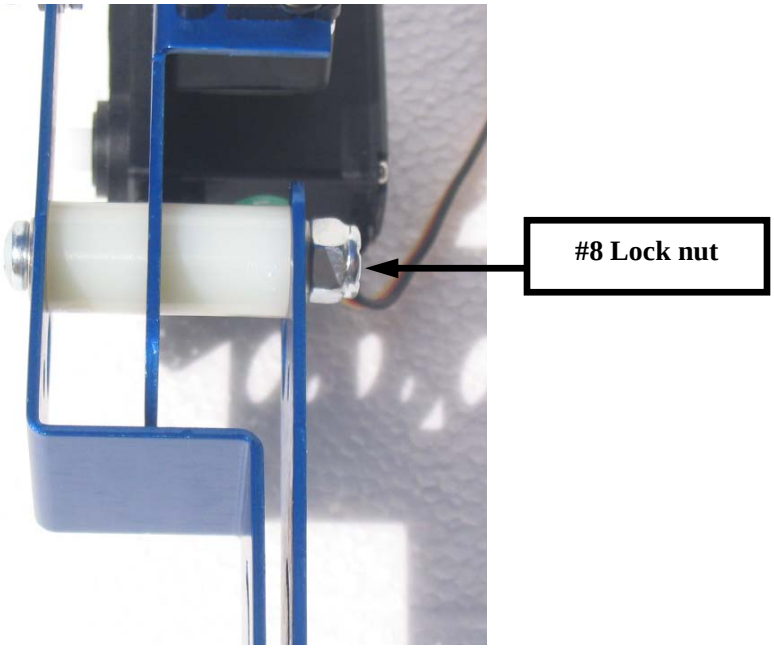


Figure 19B

Chapter #5: HexRod / QuadRod Electronics Installation

23. Using (4) #4-1/4” screws, lock washers and nuts, install the circuit board holder brackets to the slots located near the top of the channel as shown in figure 20. Be sure to note that one side of the bracket is longer than the other and to use the correct size to match the size of the microcontroller board that you will be installing. Mount the circuit board holder brackets flush with the top of the channel to make leveling all of the brackets easier.

- **Note 1:** The Parallax BOE installs to the shorter side of the bracket

- **Note 2:** Install your circuit board holder brackets to the rear of the robot for either the HexRod or QuadRod kits as shown in figure 20.

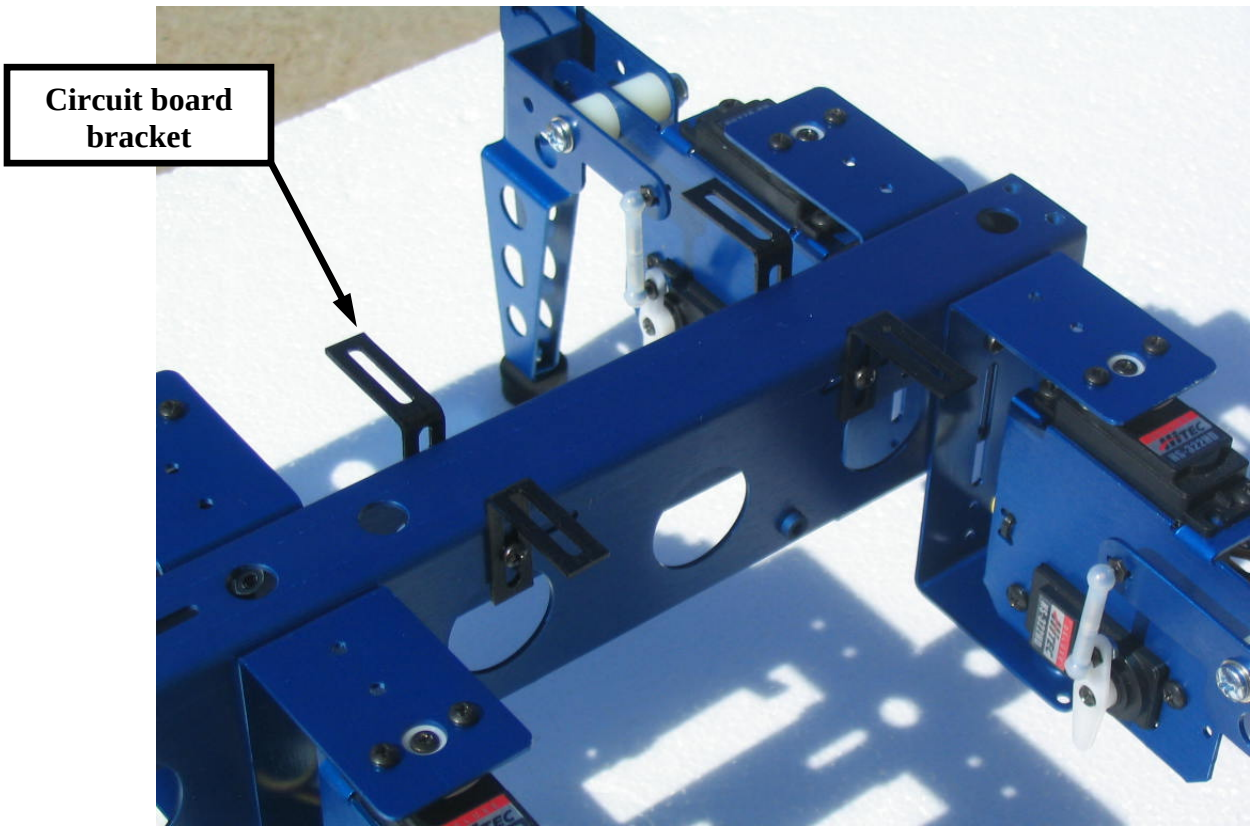


Figure 20

24. Using (4) ½” screws, ¼” nylon spacers, lock washers and nuts, install the Parallax BOE (full kit only) to the circuit board brackets as shown in figure 21. Do not tighten the screws until they are all installed and the Parallax BOE is mounted evenly on the circuit board holders.

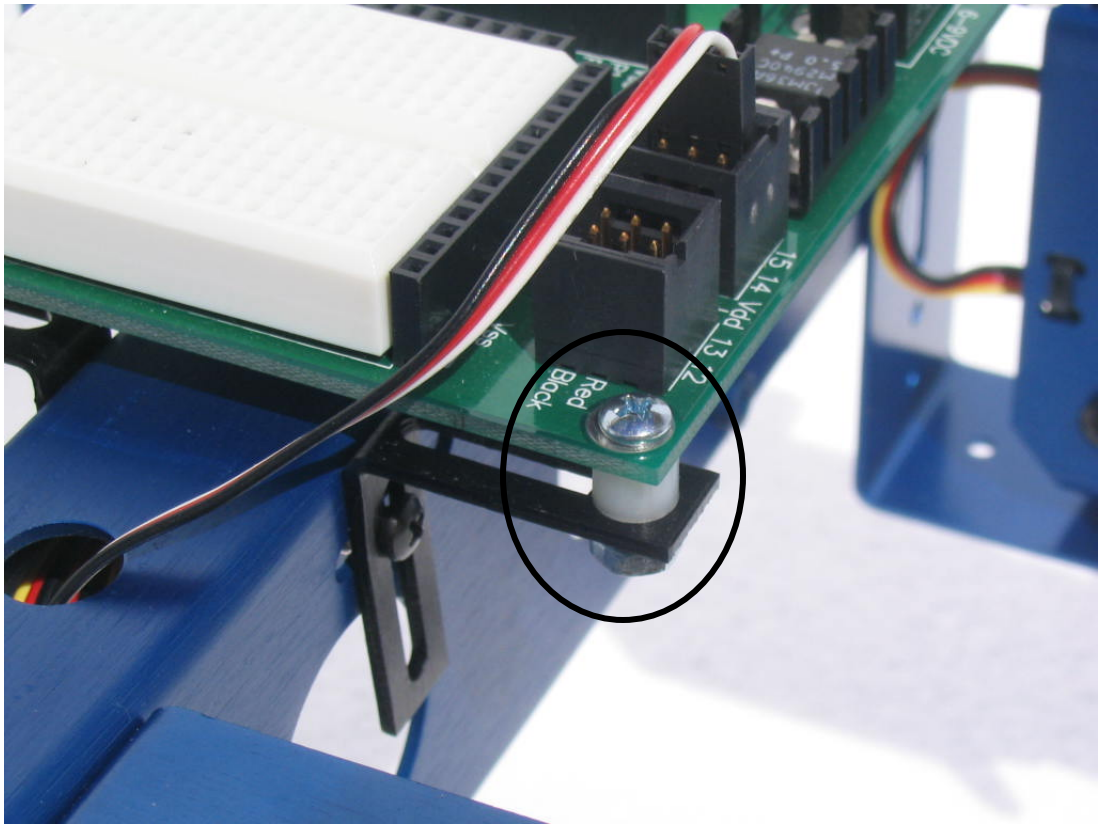


Figure 21

25. Using (2) #4 - ½" screws, ¼" nylon spacers, lock washers and nuts, install the Parallax PSC controller to the slots located at the top, front half of the Channel.

    - For the HexRod, use the 2 slots located just in front of the center legs (figure 22).
    - For the QuadRod, use the slots located just behind the front legs or the slots located in front of the Parallax BOE (figure 23).
    - Servo wire connections to the PSC is illustrated on page 33.

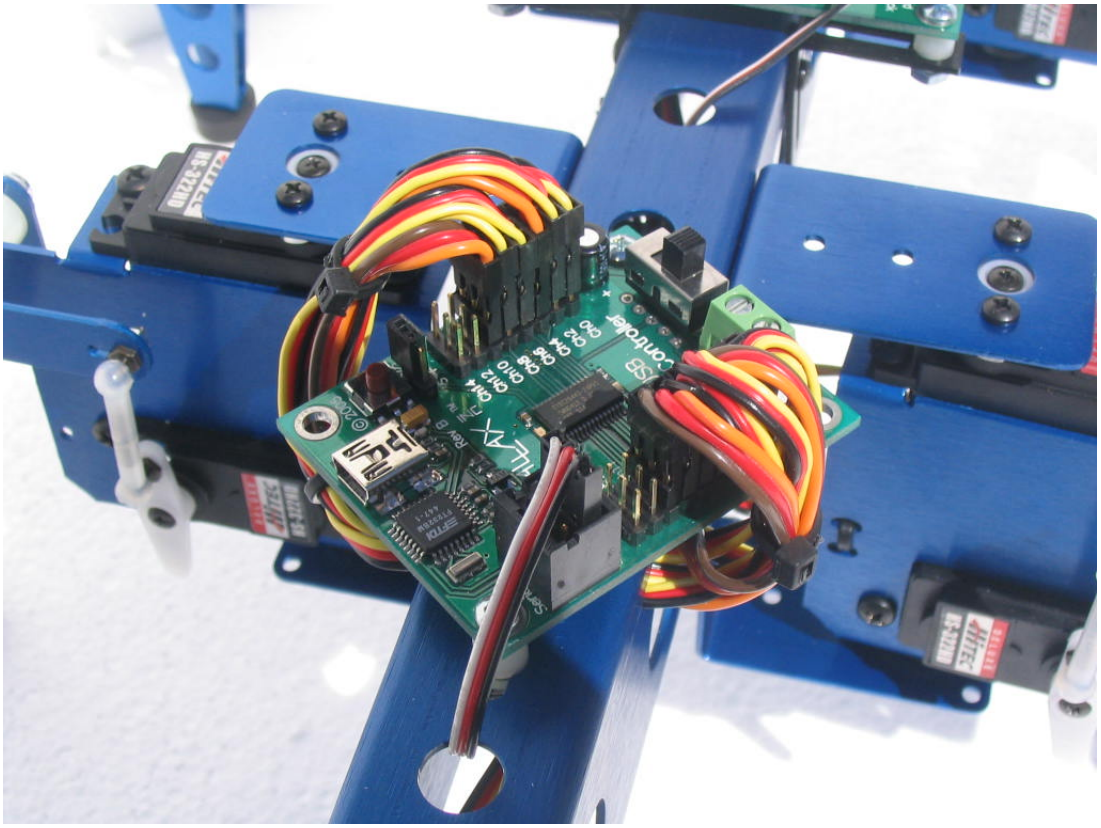


Figure 22 – HexRod PSC installation

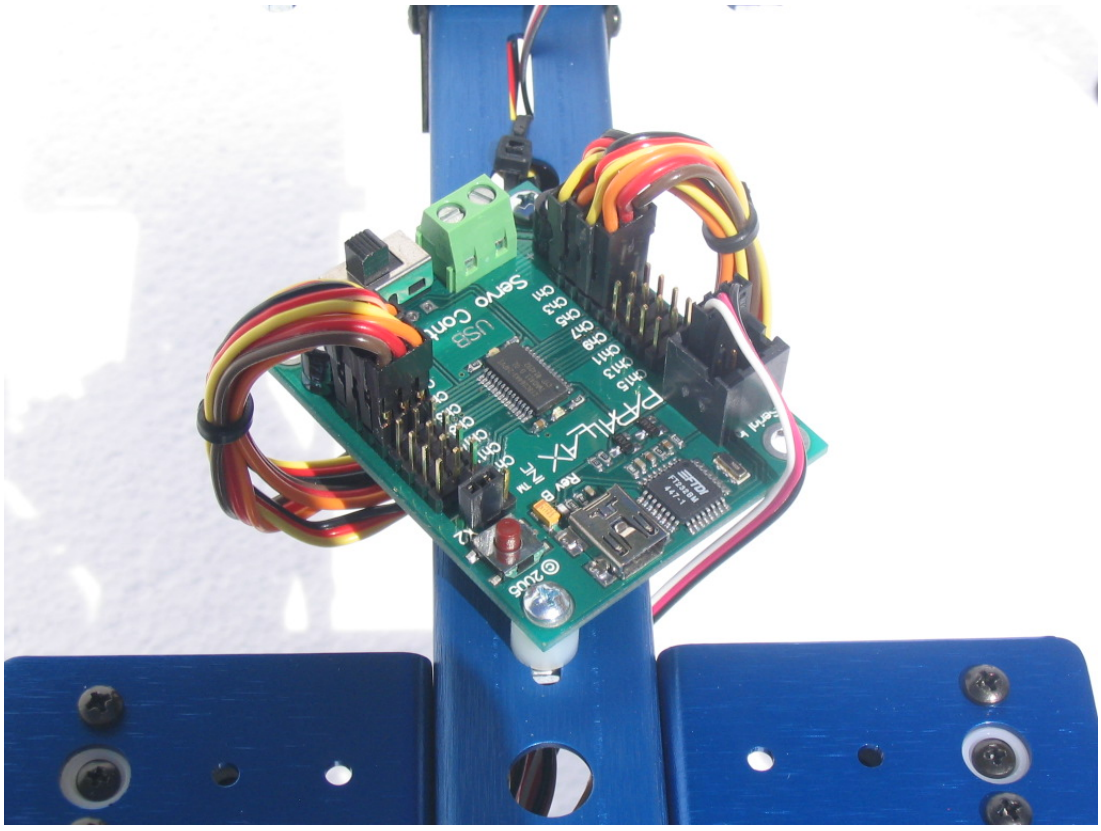


Figure 23 – QuadRod PSC installation

26. Using figure 24 and 25, route the servo wires to the Parallax servo controller one leg at a time. Use figure 26 for the HexRod PSC connections or figure 27 for the QuadRod PSC connections.

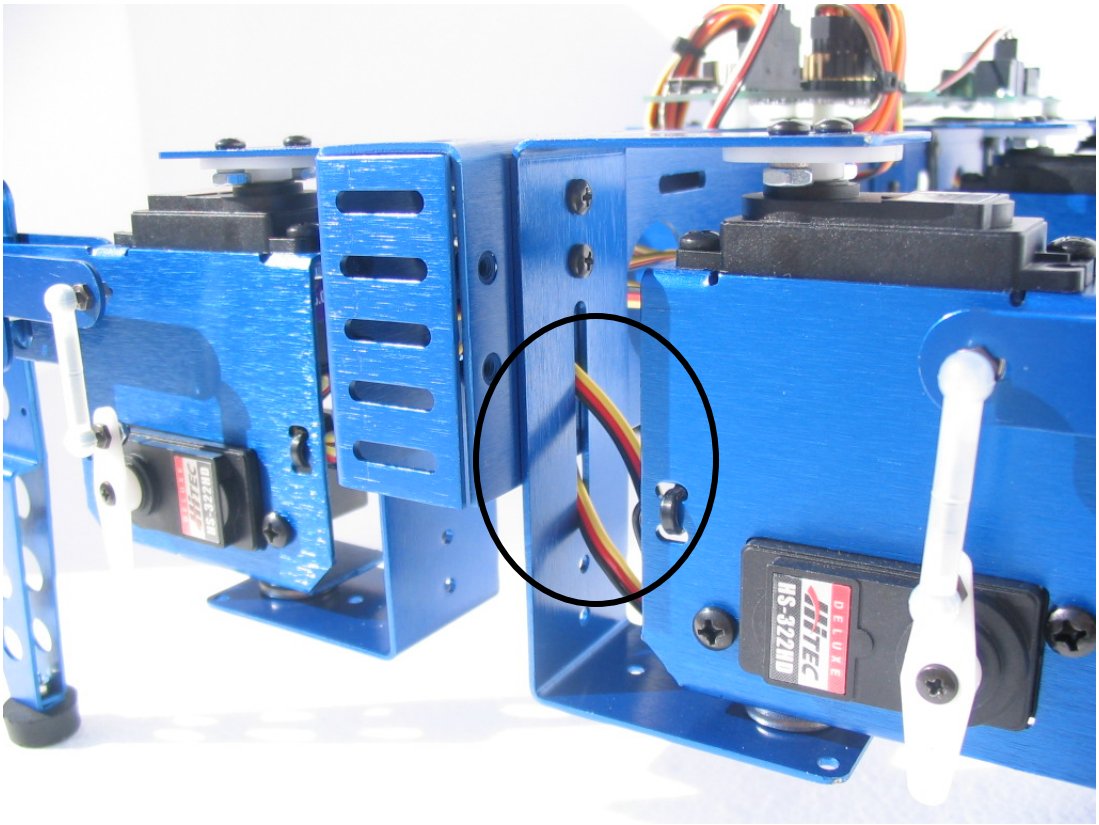


Figure 24 –Servo wire routing

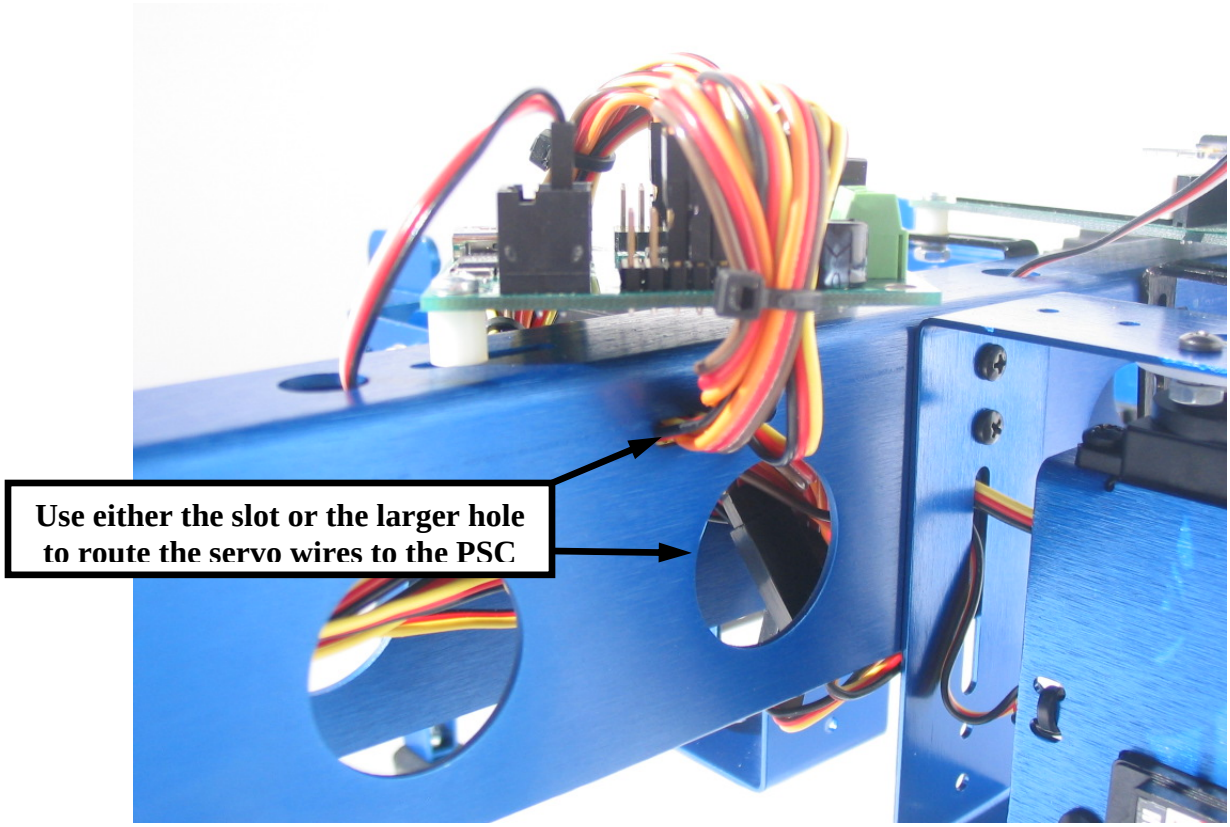


Figure 25 – Servo wire routing

HEXROD PSC CONNECTIONS

Note: H = Horizontal servo, V= Vertical servo

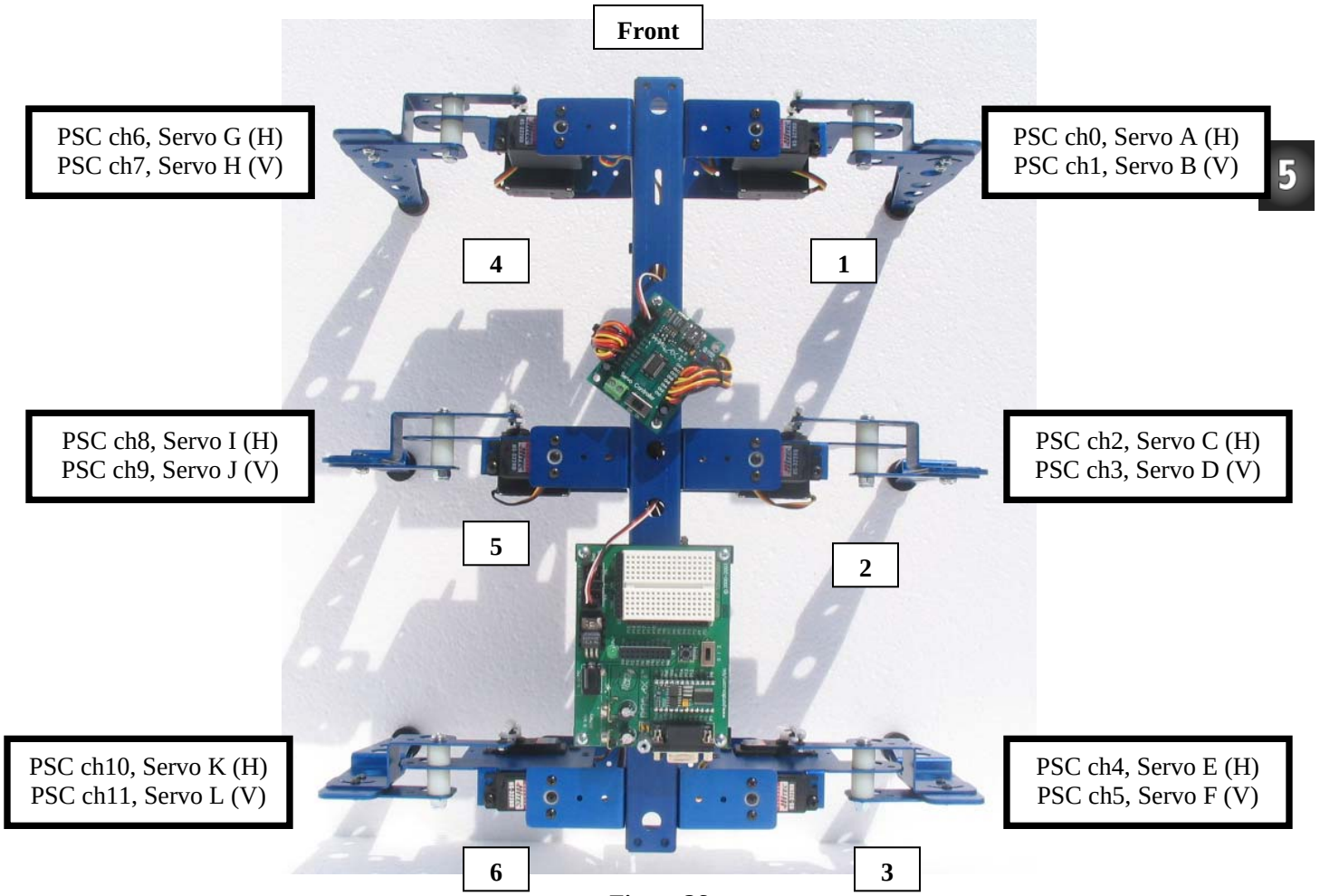


Figure 26

Refer to your PSC documentation for proper operation and connections of the Parallax Servo Controller to the Parallax Board of Education as well as refer to figure 26b.

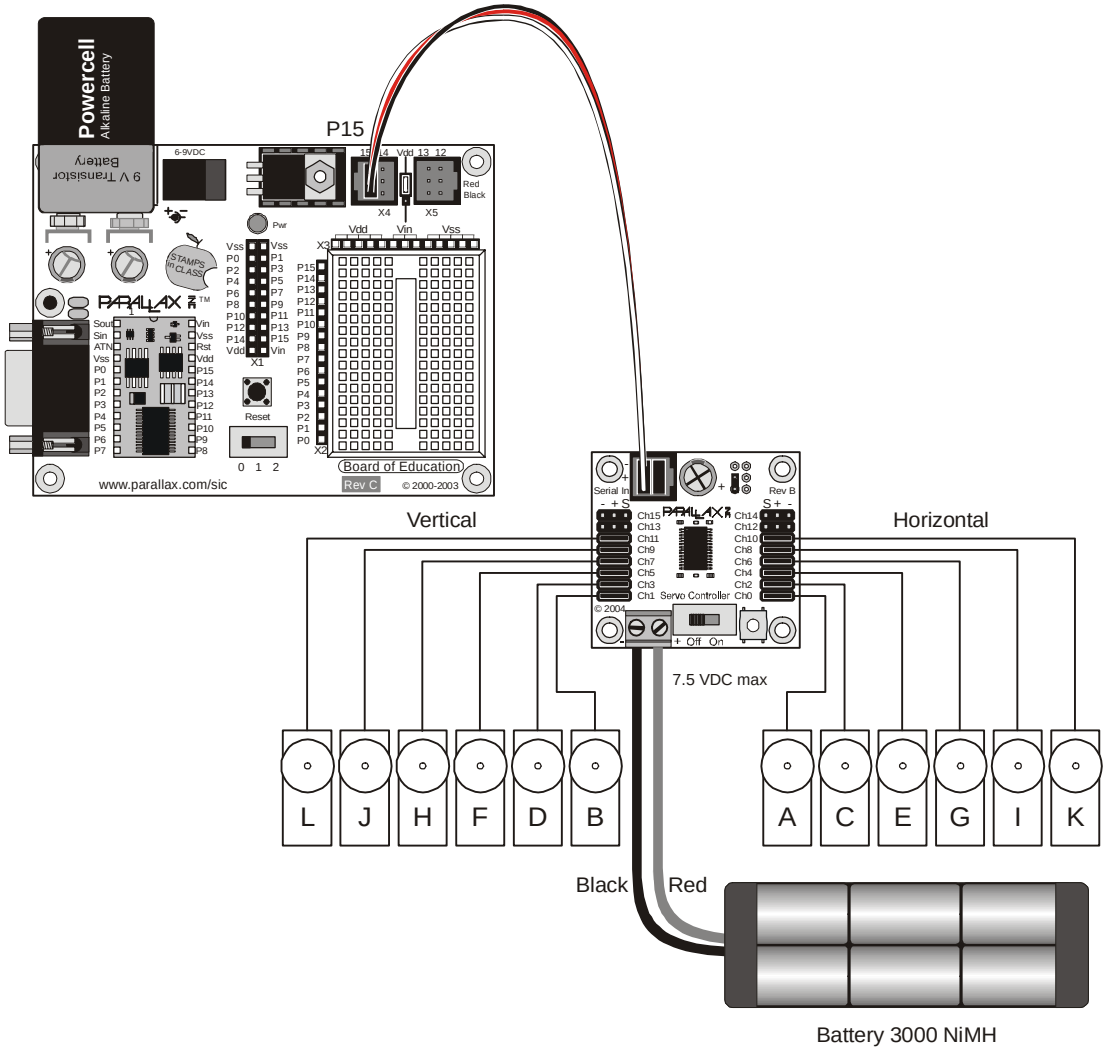


Figure 26b – HexRod- Board of Education to Parallax Servo controller connections

QUADROD PSC CONNECTIONS

Note: H = Horizontal servo, V= Vertical servo

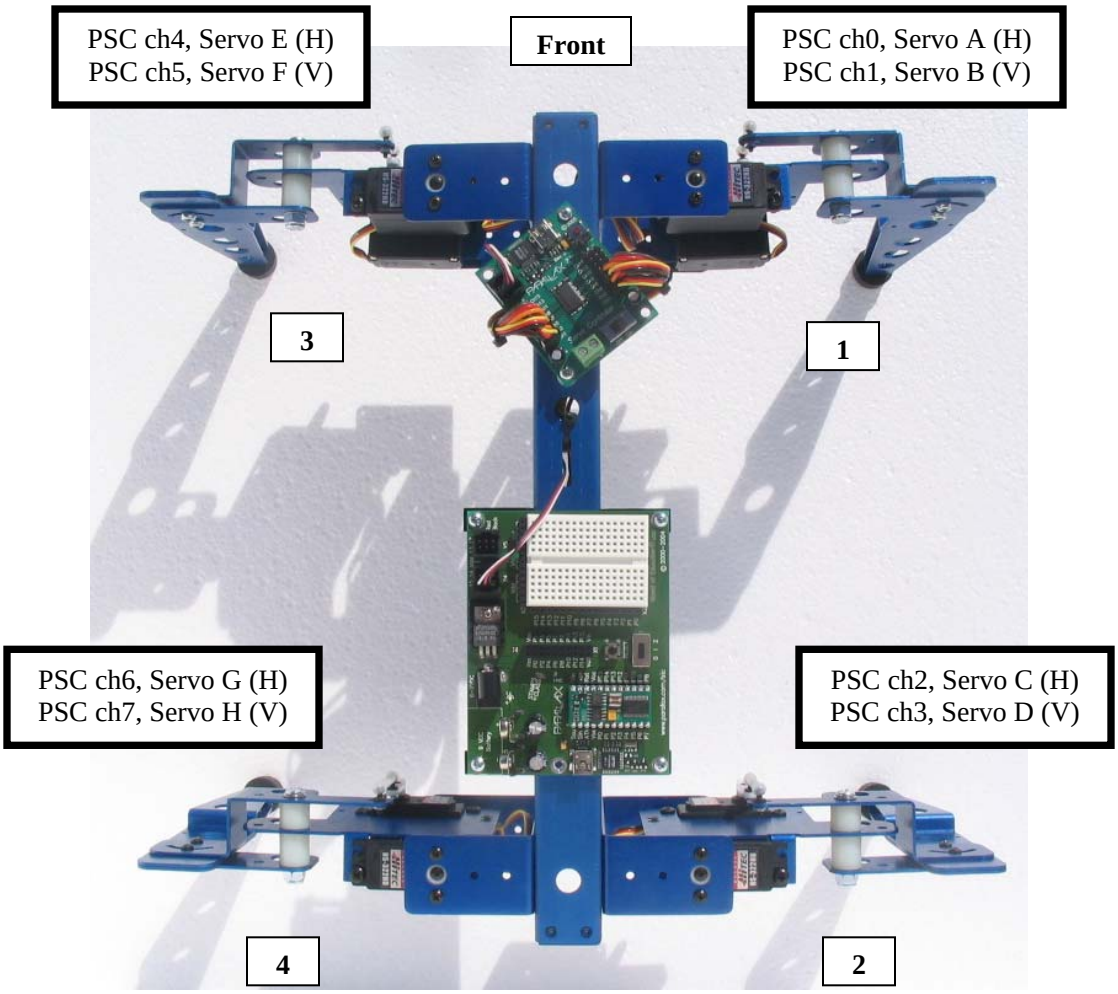


Figure 27

- Refer to your PSC documentation for proper operation and connections of the Parallax Servo Controller to the Parallax Board of Education. Also, refer to

1.

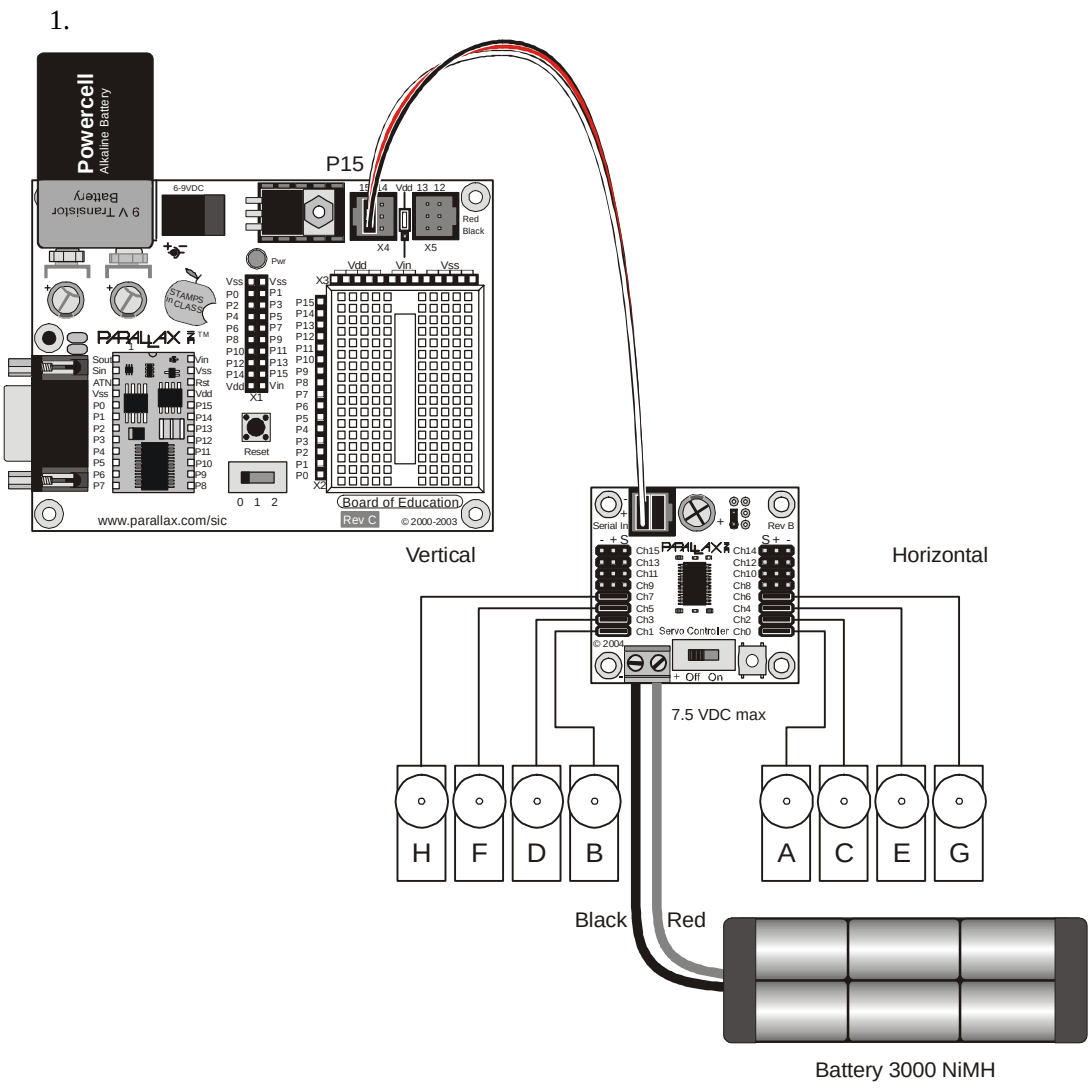


Figure 27B – QuadRod Board of Education to Parallax Servo controller connections

Using (1) #4 – 3/8” screw and lock nut, secure the leg assemblies as shown in figure 28. Ensure that the leg assemblies are perpendicular to the leg actuator assembly before tightening the #4 screw. Perform this step for each leg in your kit.

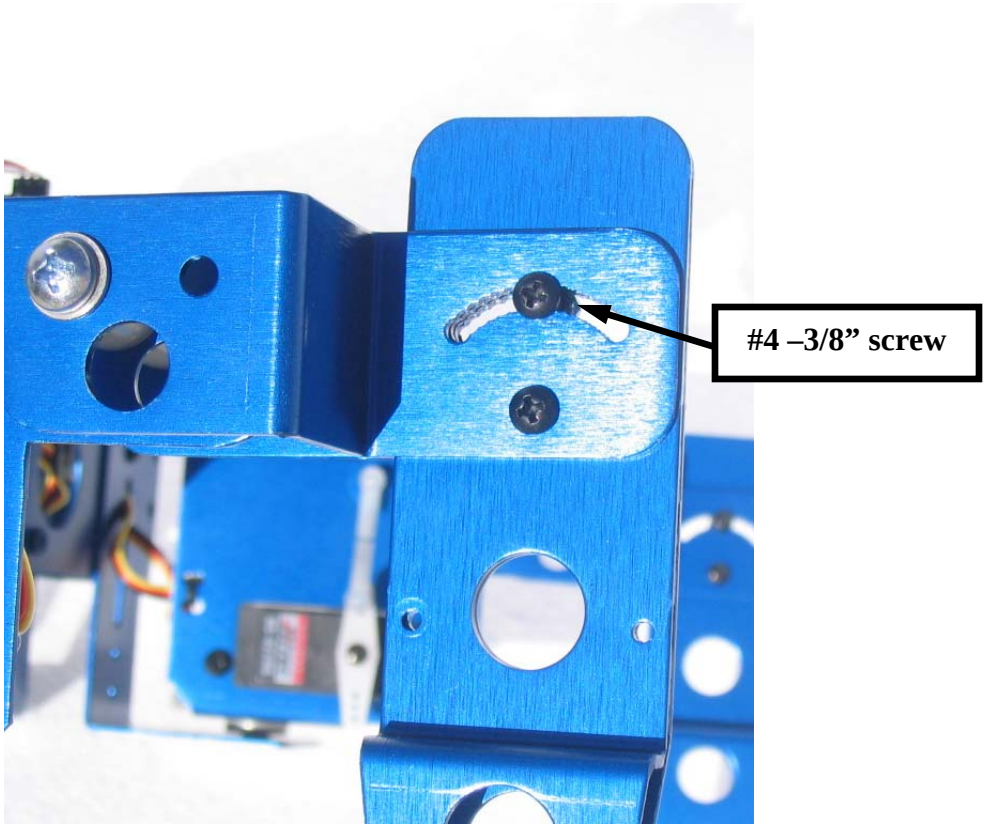
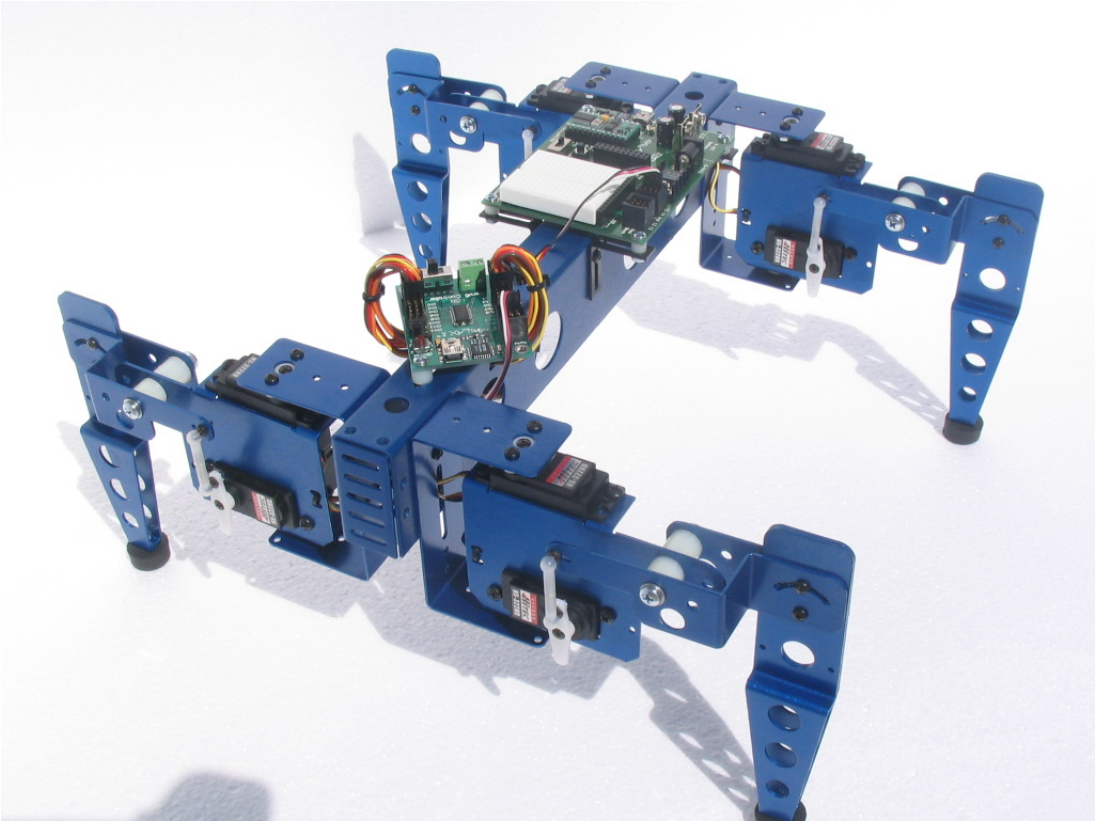


Figure 28

Chapter #6 Programming

Congratulations on completing the assembly of your HexRod / QuadRod kit. The next step to ensure the proper operation of your HexRod / QuadRod kit is to ensure that the horizontal and vertical servos are physically installed in their proper rotational positions for walking. Failure to physically and programmatically check and adjust the vertical and horizontal servos can result in the HexRod / QuadRod from walking correctly.

- Log on to www.crustcrawler.com and download the "Tune Legs" program from the HexRod or QuadRod product page. Be sure to read the comments section of the code to ensure you understand the program and what it is supposed to accomplish. When the "Tune Legs" program is executed successfully and the legs are physically adjusted (where required) the vertical servo horns should be pointing straight up and down (legs lowered) and the horizontal servos should have the legs perpendicular to the body of the HexRod / QuadRod.



- After the HexRod / QuadRod's legs have been physically adjusted with the "Tune Legs" program, any of our walking and control programs can be downloaded from the crustcrawler website and run successfully.