1 HeZapod Assembly Guide

To assemble the hexapod, we first assemble the legs with their idle femur links (ie do not connect the shafts of the servos yet). Once all six(6) legs are assembled, the servos may be inserted into their appropriate parts (CoxaV2.stl and Tibia-V2.stl). At this point, the servos should be connected to the servo controller (SSC-32 for the purpose of this guide) and set to their center position (1500ms). The servo side femur link (FemurHornSide.stl) should then be installed onto the servo horns such that the femur is horizontal and the tibia is at a right angle (vertical).

Once the legs have been assembled, we assemble the upper and lower chassis parts. The coxa servos may be attached to the upper chassis (FrameUpper.stl) via the coxa servo mounts (CoxaServoMount.stl). The coxa idle bearings should then be attached to the lower chassis part (FrameLower.stl) .

There are two possible ways to assemble the HeZapod. One is with all legs identical (so the left side legs face the opposite direction the right side), the other is with three legs the mirror image of the opposite side – so all legs face towards the front (or back) of the HeZapod. I find the antisymmetry aesthetically pleasing for some reason, so I have assembled it in the former. If however you would like to assemble it in the latter then you will need to print *MIRROR* parts where instructed.

1.1 Preparing parts:

1.1.1 Coxa Idler Bearings:

Six coxa idlers must be assembled, for each assembly you will require;

- 1 x CoxaBearingMount.stl
- 1 x BearingOuter-15mmID.stl
- 1 x BearingTop-2_5mm.stl
- 13 x 1/8” bearing balls
- 1 x M2x10 bolt
- 1 x M2 nut

When printing the CoxaBearingMount piece, you do not tend to need any support material for the nut trap. Just clean out any sagging filament that may be in the nut trap with an exacto knife and push the M2 nut in. As seen in Figure 1 below.

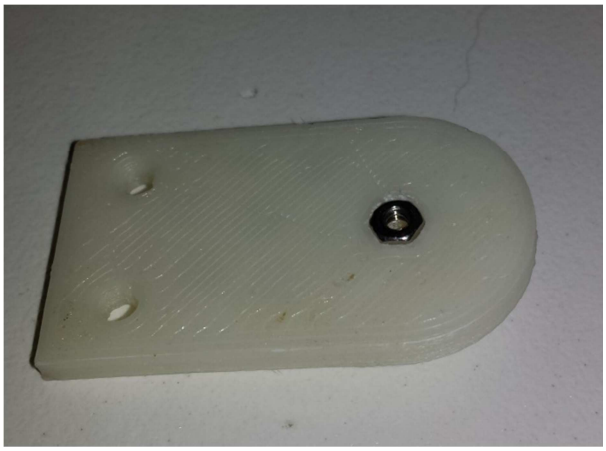

Figure 1 – Insert M2 nut into CoxaBearingMount nut trap

Before you perform this step, you may want to grab your knife and run it around the inner diameter of the outer piece to remove any imperfections. Flip the CoxaBearingMount over, place the BearingOuter-15mmID piece over the raised area of CoxaBearingMount and put 13 1/8" bearing balls in the middle (you may want to go for 12 or 14 balls, depending on what fits better; the tolerance of your printer and how much the print shrinks can effect this). Slightly lift the outer ring and guide the balls into the groove. Just don't lift the outer ring too high or the balls will fall out the bottom and the universe will implode. I found it easier to screw the M2 bolt through the BearingTop first; then secure the bearings down.

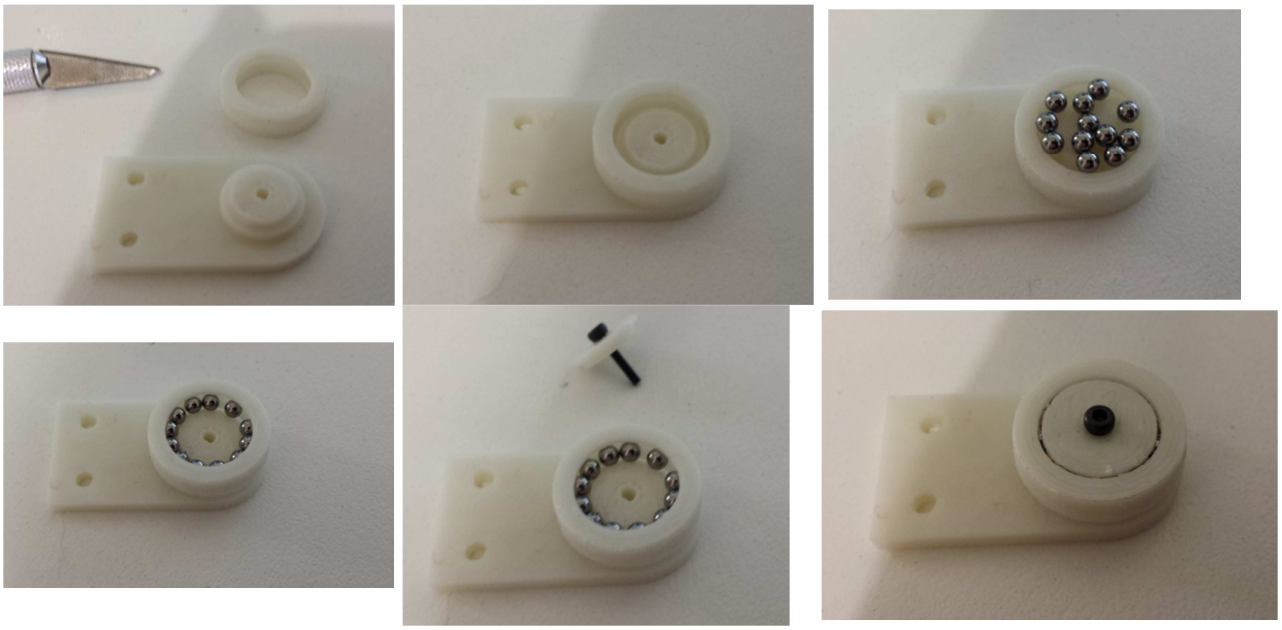

Figure 2 – Assembling the Coxa Idler Bearing

Perform this 6 times to prepare all 6 coxa idler bearing assemblies.

NOTE: There are two different BearingTop pieces. The 2.5mm high ones are used for the coxa bearing assembly, the 3.5mm high ones are used for the Tibia Idler link assembly. Seen in Figure 3 below.

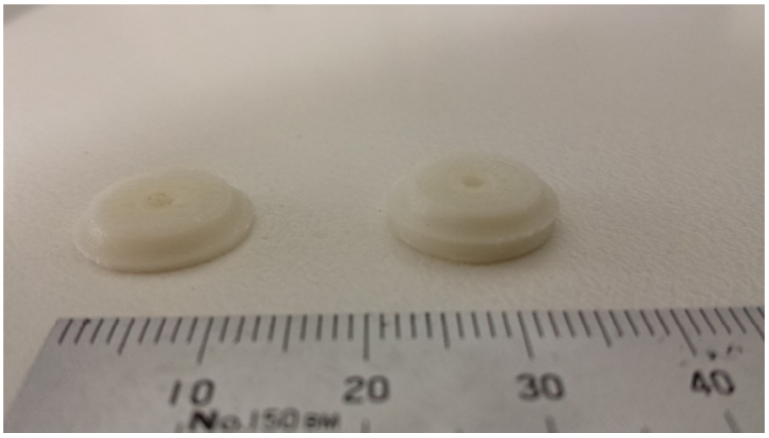

Figure 3 – There are two different BearingTop pieces

1.1.2 Femur Idler Link:

Six femur idlers must be assembled. If you are building a hexapod with mirrored legs then you will need to build three of these six with mirrored parts; for each assembly you will require;

- 1 x FemurBearingSide.stl
- 2 x BearingTop-3_5mm.stl
- 2 x TibiaBearing.stl OR TibiaBearing-MIRROR.stl if you are building a mirror leg.
- 2 x M2x10 bolt
- 2 x M2 nut

The femur idler link is assembled exactly the same as the coxa idler assembly. However the outer bearing pieces are integrated directly into the tibia link. Ensure that you assemble it with the mount on the same side of the link, as shown: (TibiaIdler1, TibiaIdler2)

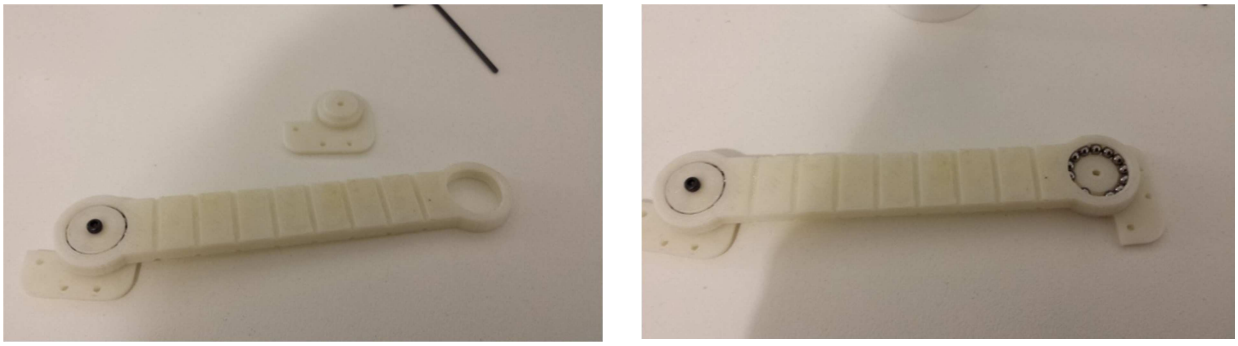

Figure 4 –Assemble the bearings in the Femur Idler link the same as in the Coxa Idler.

NOTE: There are two different BearingTop pieces. The 2.5mm high ones are used for the coxa bearing assembly, the 3.5mm high ones are used for the Tibia Idler link assembly. Seen in Figure 3 above.

1.1.3 Attach horns to Femur link and to Coxa

Attaching the horns is a pain. I am just using plastic horns. You may be using metal horns that are already threaded. I am jealous. There are four holes in each of the 3D printed parts to attach the horns. You can just use two screws per horn – it is totally sufficient.

What you will need (for two bolts per horn);

- 6 x FemurHornSide.stl
- 6 x CoxaV2.stl or replace 3 with CoxaV2-MIRROR.stl if assembling mirrored legs.
- 18 x Servo Horns
- 36 x M2x6.5 bolts. I could not find any M2 bolts this length. I had to cut M2x10. There is clearance enough to cut them between about 6-8mm long. JUST MAKE SURE YOU PUT A NUT ON THEM BEFORE YOU CUT THEM.
- 36 x M2 nut
- Some locktight
- Patience

The first step is to drill out the holes on the horns. Grab a drill bit slightly smaller than the M2 bolts and drill out some holes on the horn. Line the horn up to the 3D printed part to see what holes they line up with. If you just use two bolts per horn make sure you use holes on opposite sides.

Next cut your bolts and go ahead and bolt on each horn. Apply lock tight generously or else they WILL come loose. The best way to cut them is to first put on a nut, mark the position where you want to cut and then lock the head of the bolt in a vice (not too night) and cut the bolt with a fine hacksaw. If it is a bad cut then you may have to improvise with a file.

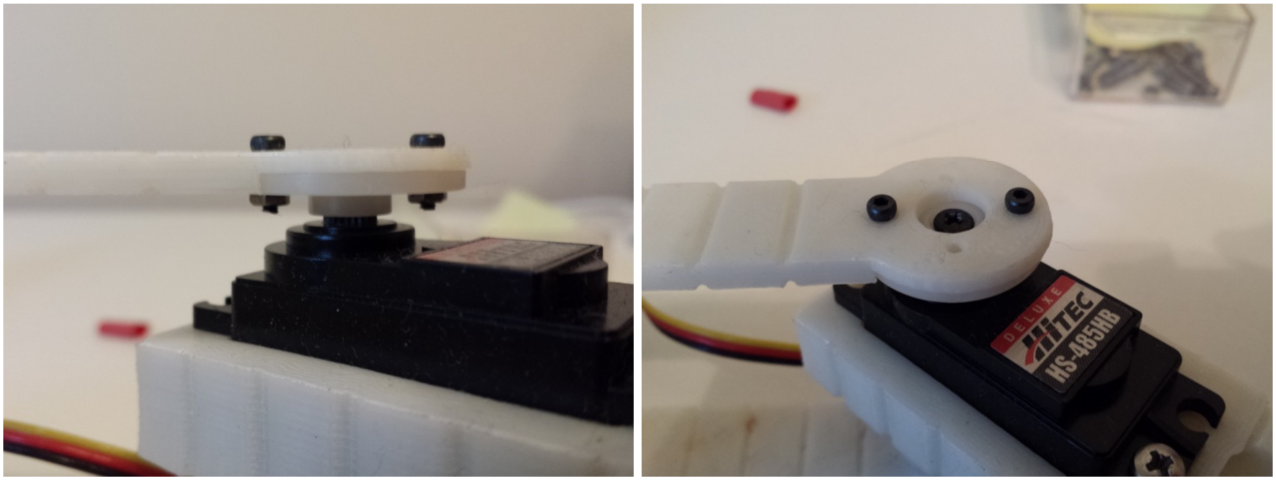

Figure 5 – Servo horns attached using two M2x6.5 bolts per horn and generous application of locktight.

1.1.4 Coxa Servo Assembly

Six of the servos will require the CoxaServoMount to be installed so they can function as the Coxa servos. The CoxaServoMount part has four holes to secure the servos using 4 M3 bolts each. Just using two bolts is fine, that is what I have done. Each of the six coxa servo assemblies will require;

(Using only two bolts per assembly)

- 1 x Hitec HS-485 servo
- 1 x CoxaServoMount.stl
- 2 x M3x9 bolts (longer is fine)
- 2 x M2 nuts

Slide the CoxaServoMount part over the servo, being careful not to pinch the wires in the process. It should oriented such that the ridge is on the opposite end of the servo to the spline and the nut traps are facing down (away from the spline). Now, simply insert M3 nuts into the nut traps and secure the servo in place using M3 bolts. If you are only using two of the holes as I have then be sure to select holes at diagonals.

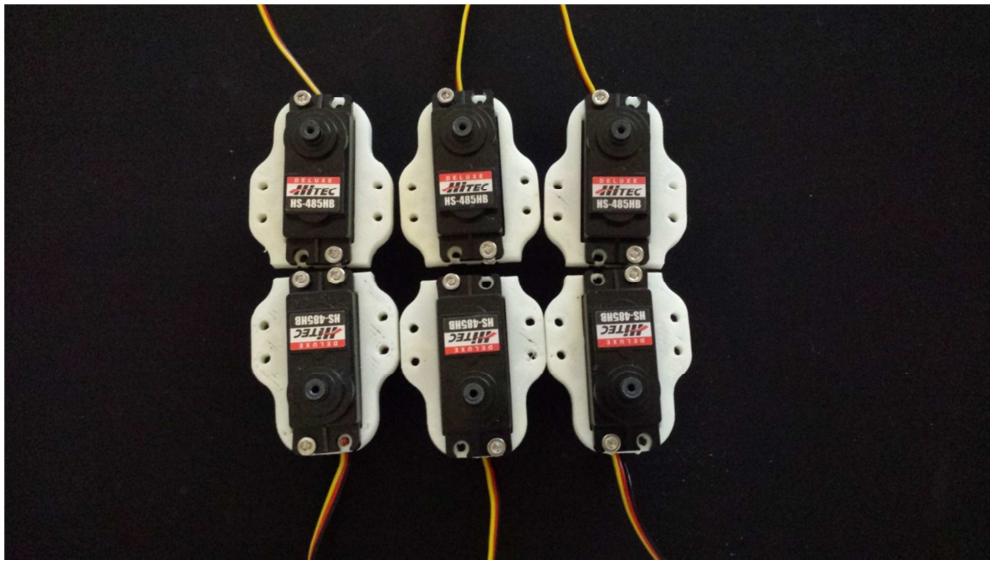

Figure 6 – Coxa Servo Assemblies

1.1.5 Preparing the Lower Chassis

The lower chassis will link all of the Coxa bearings together and hold the SSC-32 servo sequencer. For this assembly you will need;

- 1 x ChassisLowerV2.stl
- 1 x LynxMotion SSC-32 Servo Sequencer
- 4 x M3x9 Bolts (longer is OK)
- 4 x M3 nuts

As with most screw holes in this design, these holes are printed exactly 3mm, so the first time you put a bolt through, it will create a thread. I would advise to go ahead and put a bolt thorough to thread all of the holes in the lower chassis as it will make like easier later. There are four holes that should line up to the SSC-32 mounting holes. Using 4 (or only 2 if you wish) M3 bolts go ahead and attach the SSC-32 to the top of the lower chassis. The top can be identified as it has some spacers for the board to sit on. If you are using longer screws, make sure you put them through from the bottom otherwise the excess length may scrape on the ground when the HeZapod is walking low. Hindsight informs me I shold have designed in a little wire trap to ensure the power lines do not move around during operation. Maybe in the next version. I am just using cable ties for now.

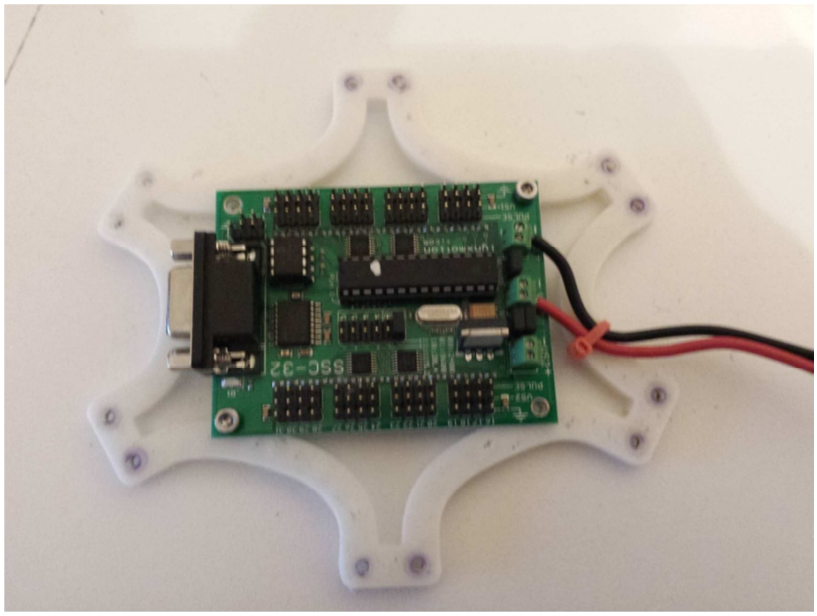

Figure 7 – ChassisLowerV2 with SSC-32 attached and holes pre-threaded.

1.2 Assembling the HeZapod

1.2.1 Assembling the legs

There are six legs to assemble. To assemble each one you will need the following;

- 1 x Femur Idler Link Assembly (1.1.2, pp3)
- 1 x FemurHornSide.stl (with horns attached as in 1.1.3, pp3)
- 1 x Tibia-V2.stl OR Tibia-V2-MIRROR.stl if assembling a mirror leg.
- 1 x CoxaV2.stl OR CoxaV2-MIRROR.stl if assembling a mirror leg (with horns attached as in 1.1.3, pp3)
- 6 x M2x10 bolts
- 6 x M2 nuts
- 2 x Hitec HS-485 servos
- 1 x Coxa Servo Assembly (1.1.4, pp4)
- 8 x M3x16 bolts (or just 4 if you want to secure each servo with 2 bolts each). You can use longer bolts too – there is nothing that they will run into aside from one of the holes that you can only use up to around 20mm bolts.
- 8 x M3 nuts (or just 4)

1.2.1.1 Install Femur Idler Link Assembly

Before installing the motors, we must attach the Femur Idler Link that connect the CoxaV2 and the Tibia-V2 parts. The motors will block access to the nut traps for the idler links. Locate the nut traps (Figure 8 below) and slide some M2 nuts in. These pieces are all printed without support material so you will likely need to get in there with your knife and clean up the first layer that has sagged. You will notice these three holes lines up with three holes from the bearings on the Femur Idler Link Assembly. Coincidence? No.

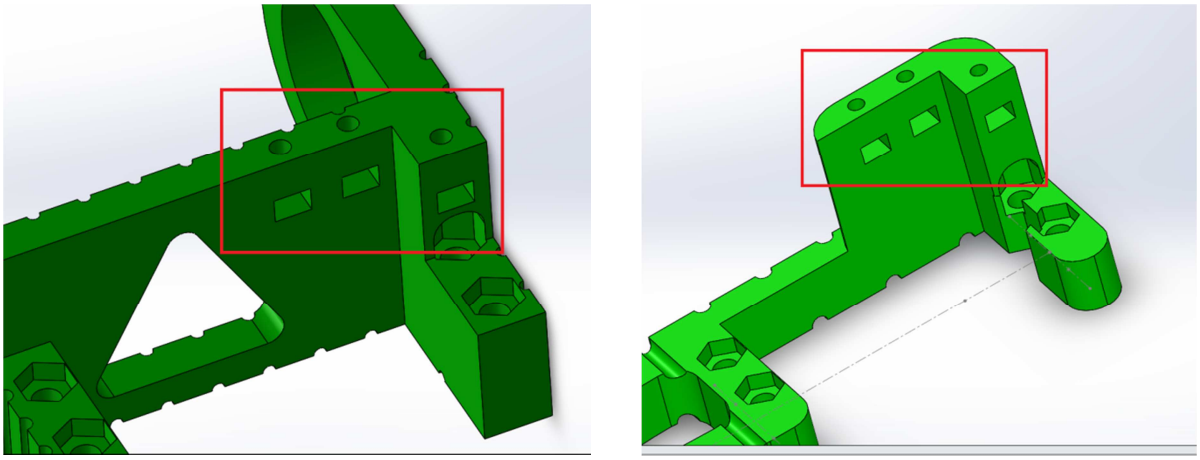

Figure 8 – M2 nut traps on the CoxaV2 and Tibia-V2 parts.

Once you have connected the Femur Idler Link Assembly to both the CoxaV2 piece and Femur-V2 pieces (see in Figure 9 below) you are ready to install the servos. Of course use mirrored parts with mirrored parts where appropriate.

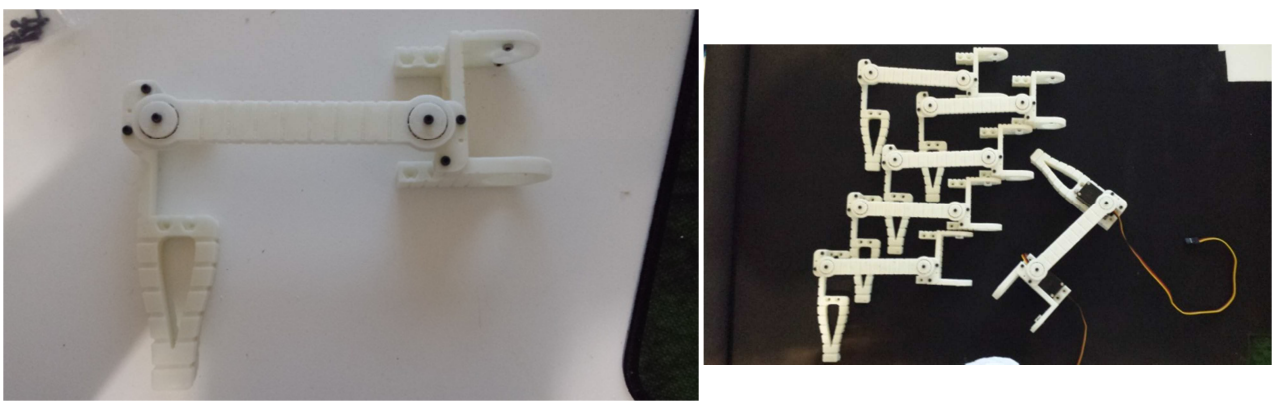

Figure 9 – Attach Femur Idler Link assemblies to CoxaV2 and Femur-V2 pieces.

1.2.1.2 Install Tibia and Femur Servos

Servos should be oriented such that the rotational axis of the servos and the idler bearings are collinear. They will fit both ways so make sure you do not install them backwards. Locate the M3 nut traps on both the CoxaV2 and Femur-V2 pieces (Figure 10), populate them with nuts and secure the servos in place (Figure 11). If you are only using two bolts per servo ensure to locate your bolts diagonal to each other.

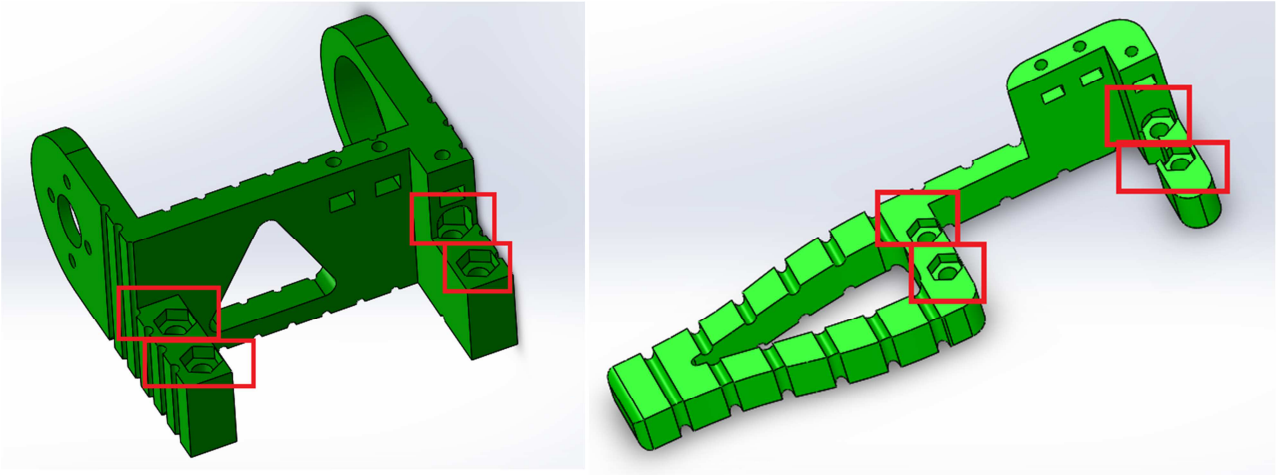

Figure 10 – Coxa M3 nut traps (left) and Femur M3 nut traps (right)

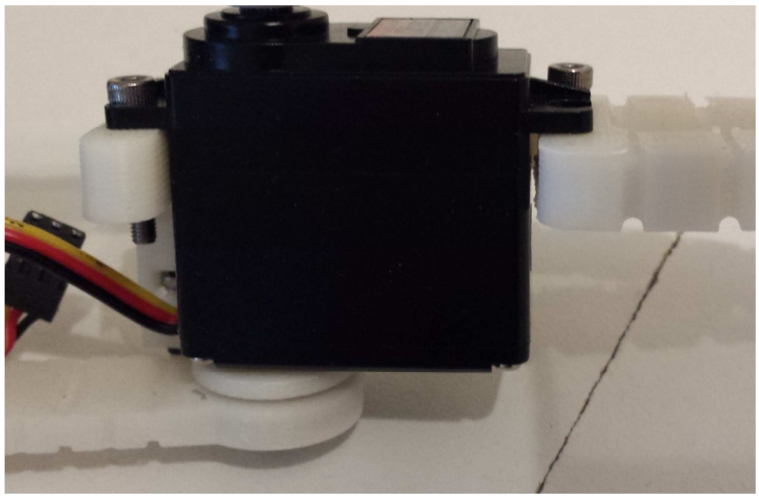

Figure 11 – Servo Installed in Tibia.

1.2.1.3 Homing Servos and attaching FemurHornSide

Now, to install the FemurHornSide links to the servos via the horns, you will first need to connect the servos to your electronics (SSC-32 in the case of this tutorial) and send them to their center position (1500ms pulse width). I am using the windows interface LynxTerm from lynxmotion and a little FTDI USB to serial converter from sparkfun (Figure 12 below). Simply hit the *'All=1500'* button to send all legs to 1500 (Figure 13). You can now install the Femur links such that they are horizontal from the Coxa and at a 90 degree angle from the Tibia, see Figure 14 below. Note that since the servo spline has a discrete number of teeth, there are only a discrete number of angles that you can attach the horn. Hence you will not be able to get them perfectly horizontal and vertical. This is ok, we will do some calibration later.

Fix the horns down with the horn screws.

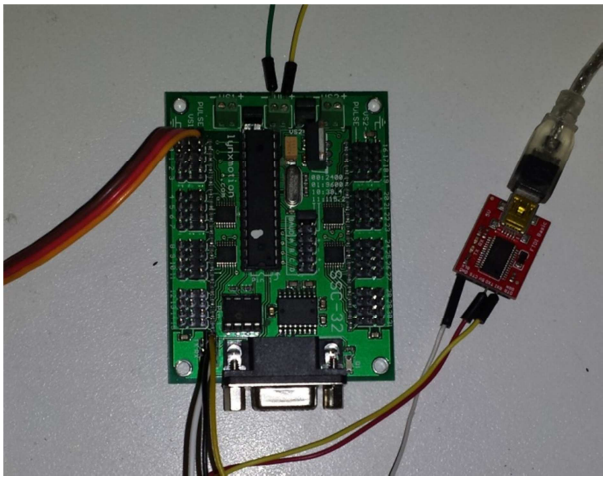

Figure 12 – Sparkfun FTDI connected to SSC-32 servo sequencer.

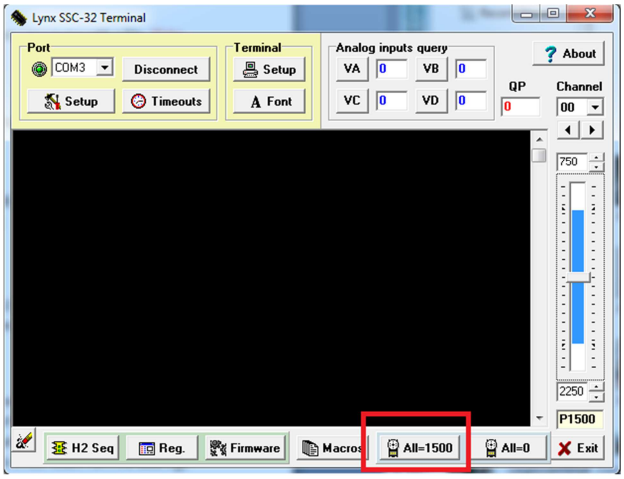

Figure 13 – Lynxterm software. Can simply hit All=1500 to send all servos to 1500.

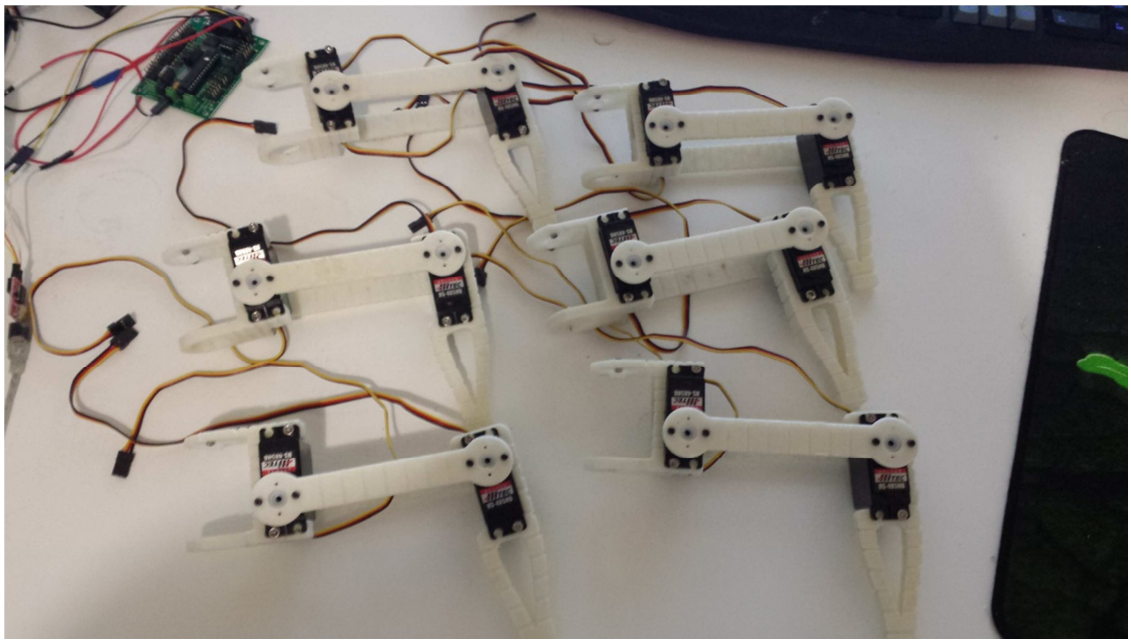

Figure 14 – FemurHornSide attached to servos via the horns. Servos were set to their home position first.

1.2.1.1 Install Coxa Servo Assemblies

Lastly, we want to install the Coxa Servo Assemblies into the legs. These servos will need to be homed in the same manner as the other servos from 1.2.1.3 (pp8). Then attach the horn such that the long dimension of the servo is parallel with the direction of the leg. Secure it in place with the servo horn screw and the leg is complete!

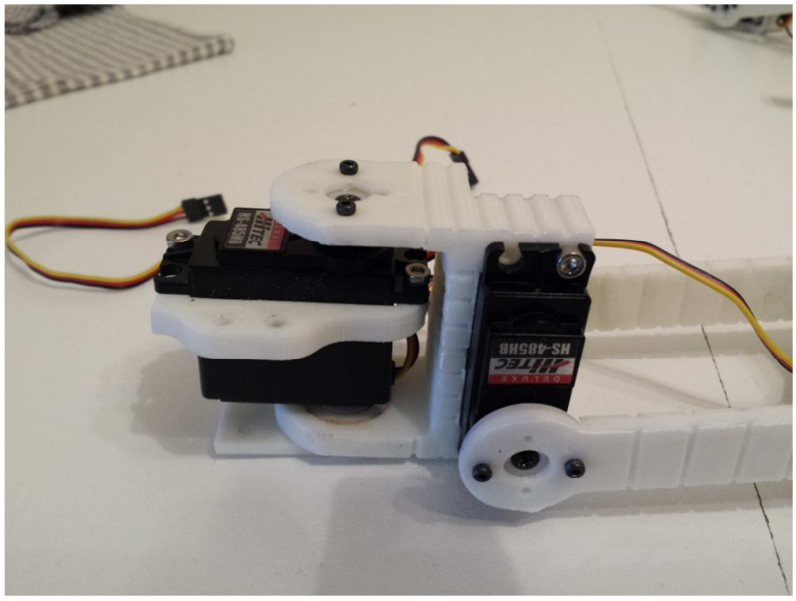

Figure 15 – Coxa Servo Assembly installed to leg.

1.2.2 Putting it all Together

You can really attach it all together in any order you like. I like to attach all of the legs to the lower chassis first then attach the upper chassis, so that is what I will explain here. But Feel free to do it however you like.