Hitec HS-422 Servo Modification

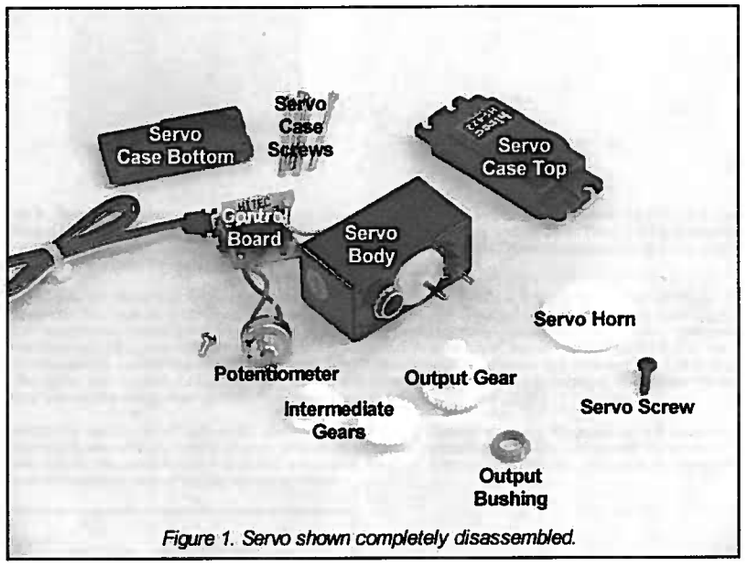
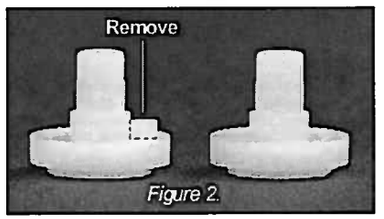


Figure 1. Servo shown completely disassembled.

Step 1, Disassemble the servo as illustrated above. Be sure to keep the small parts in a safe place, away from small children.

Step 2, Remove the mechanical stop from the gear as shown in Figure 2.



Caution, wear eye protection for this step. Use a wood backer as illustrated in Figure 3 and Figure 4. A 1/2 wide, square, Exacto blade (#18) works well. First make a short (vertical) cut, then make the long (horizontal) cut.

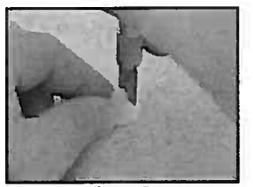


Figure 3.

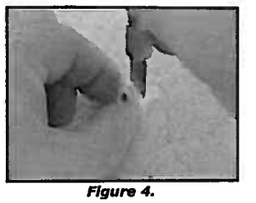


Figure 4.

A file or fine tooth saw may also be used, as shown in Figure 5 and Figure 6. Use whatever method you are most comfortable with to remove the plastic stop from the gear.

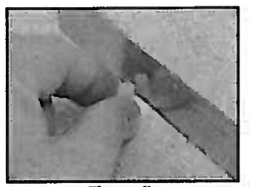


Figure 5.

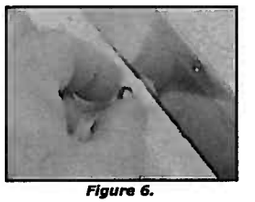


Figure 6.

Step 3, Next we need to bring the potentiometer outside of the housing. This allows the precise adjustment of the servos stop value. I use a pair of needle-nose pliers to remove a small section of the case to allow the wires to exit. Just give the pliers a twist and the plastic will come out easily. Figure 7 illustrates the procedure.

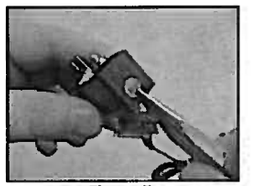


Figure 7.

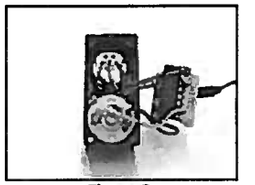
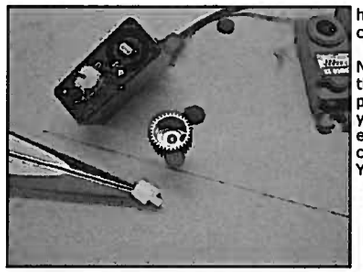


Figure 8.

Step 4, A nice feature of the Hitec servo modification is the ability to reverse the wires to the motor. The motor is the large round object with the brown and orange wires going to it as shown in Figure 8. When done to one of the servos the relationship of left and right servos are the same. For example an increase in pulse length on both sides will result in forward motion. Reverse the motor leads on one of the servos and mark it as the "left" servo.

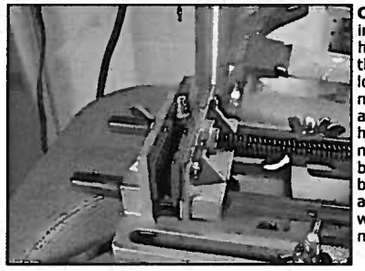


here. Give it a yank and Voila!, you have a continuous rotation servo.

Note that, before reassembly, you will want to plug the servo in and turn on the transmitter and get the pot positioned so that the servo doesn't rotate. Or you could do what I did; forget about it, reassemble everything, plug it in and find that you have a *true* continuous rotation servo since it will not stop! Yaaaah! *Minolta G500 digital*

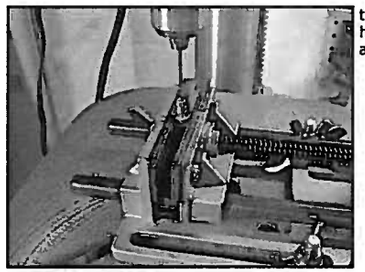
From the point of view of modifying the servo to Continuous Rotation, at this point you'd be done. This servo will rotate through 360 degrees with no problem. In my pan design, I want to mount a small gear on this output shaft. To do this, I need to thread the output gear to a 4-40 thread so I can attach a shoulder bolt (from Small Parts Inc.) on which will go the small gear. Since I have this servo apart already, I might as well thread the thing.

Preparing to Tap the Output Gear To thread this gear I am going to use a 4-40 tap. As you can see by where the screwdriver is artfully laid in the photo, this will require drilling a hole using a #43 drill bit. You aren't going to find this bit in your drill bit set from Target; it is one of a sequence of precisely-sized bits and I buy mine one at a time, as needed, from the hardware store. You can see the packaging for it lying in the photo. The black metal thing is useful for checking threads on fasteners you are unsure of and also has the clearance and tap bit sizes. I neglected to lay the tap down in this artistic tableau. *Minolta G500 digital*

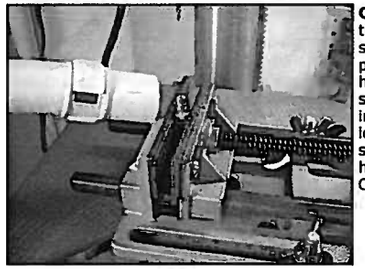


Carefully Position the Workpiece The hole to tap into needs to be precisely positioned. This isn't too hard with the drill press. Here the gear is clamped in the drill press vise, the drill press table has been locked, the vise lightly tightened down and I am moving the vise the last few, what, thousandths?, of an inch into place. The hammer, gently employed, helps greatly in making these final positioning moves. Note that my drill press, seen vaguely in the background here, is pretty burly. I owned this long before I tried KAP. If you don't own a drill press already, I'd recommend it, but if it's mostly for light work like this I'd buy a smaller, cheaper benchtop model. *Minolta G500 digital*

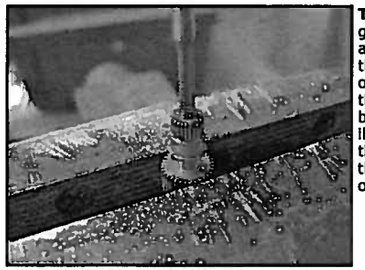
Drilling the Hole to tap out With the workpiece positioned and clamped into place, you can drill the hole. The drill press is set to its slowest speed (460 rpm in my case) for drilling metal. You can also set



the depth so it will only drill to a certain depth, and I have done that here. In this photo the drilling is actually occurring. *Minolta G500 digital*



Cleaning Things Up It's a good idea to keep things tidy. Here I vaccuum up the mess while things are still clamped down. When working around small parts it's good to be careful with the vac. While I have never sucked up, say, all the output gears for a servo or a bunch of 4-40 hardware, I did inadvertenly vacuum up a screwdriver which became lodged in the first bend of the vacuum pipe. I had to saw off several inches of vacuum hose to get it out, hence the stubby hose-end here. Be Clean but Be Careful. *Minolta G500 digital*



Tapping the Output Gear I clamped the output gear in the vise, mounted the tap in the tap handle, and tapped out the gear, cutting a set of 4-40 threads in the gear. There are threads in these output gears already, but good luck finding what they are. The local hobby shop thought they might be 2.6mm metric threads but apparently it's all very ill-documented. You probably aren't going to find these fasteners and hardware anywhere. The 4-40 thread, by contrast, is bigger and gives me some options. *Minolta G500 digital*

The Shoulder Bolt The option I went with was a 4-40 shoulder bolt from Small Parts, Inc. Early on, when I was first acquiring parts for the very first rig, the one I didn't actually complete, I ordered a bunch of interesting hardware from Small Parts Inc. Included in the order were these shoulder bolts. The shoulder happens to match well with some aluminum gears available from hobby stores and it is these that I have chosen for my pan mechanism. *Minolta G500 digital*

Step 9

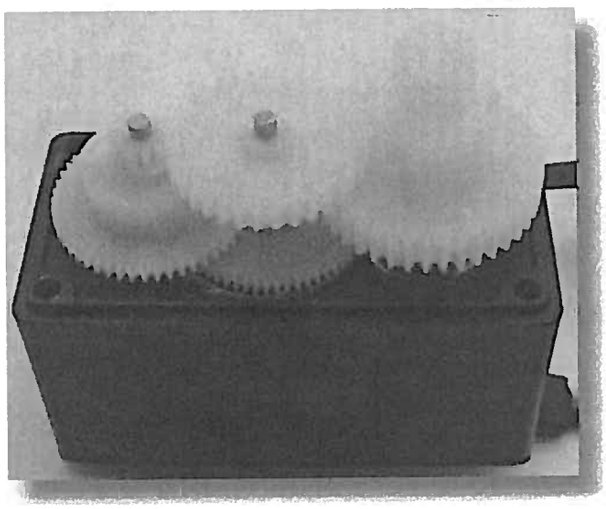
A: Place the main shaft back in place.

B: Place the intermediate gear back in place.

C: Place the nylon bushing on the shaft.

D: Replace the servo top.

E: Reattach the 4 rear screws.



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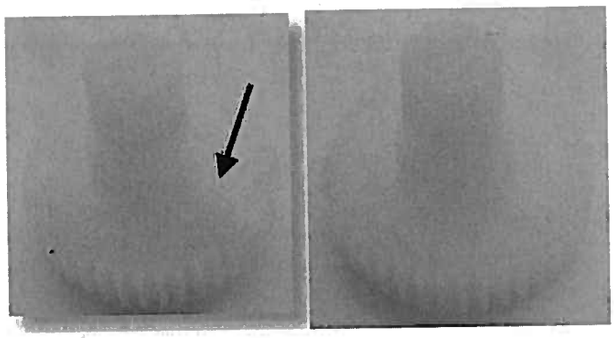
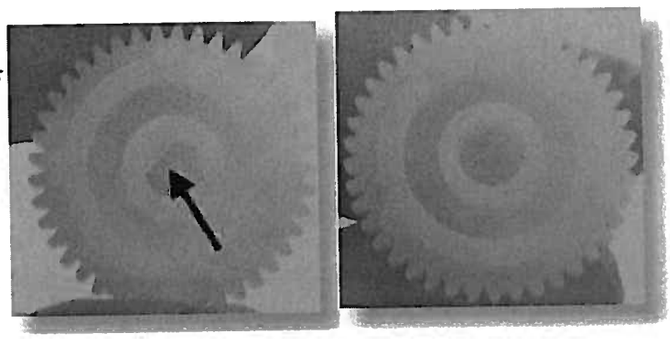


Step 7

The hole under the main shaft must be rounded and enlarged. This is what comes in contact with the potentiometer.

Use a 9/64" drill bit held with your hand or pliers and insert it into the hole and ream out the slots. Once you have rounded the hole use a 5/32" bit to enlarge the hole.



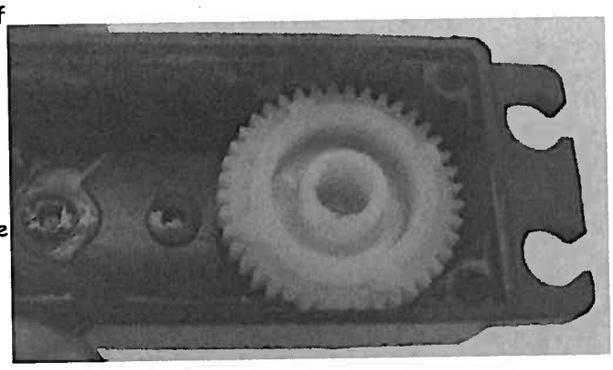
Warning !! do not use a drill. You will not be able to hold the shaft in place and will cause damage if you try.

Tip

If you insert the drill bit into a drill (no power) it make it easier to turn the bit.

Step 8

Insert the shaft into the top of the servo case as shown and test that you can rotate the shaft completely.



Tip

Assemble the servo without the intermediate gear and rotate the main shaft by hand. It should rotate freely with out catching. Also examine the potentiometer shaft and make sure it did not move.

Modifying a Servo

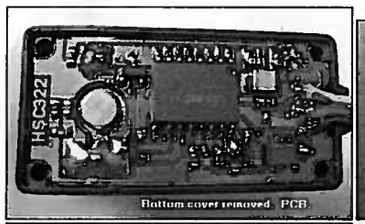
by Tony van Roon

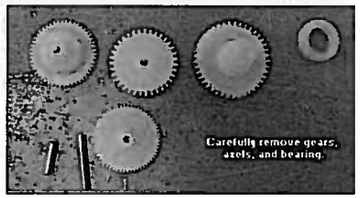
Project Background Info:

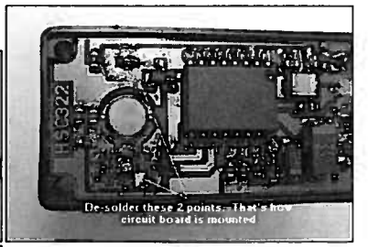
I was in need to modify four expensive JR-DS8231 Ultra Digital servos to rotate 360° instead of the standard 130° or something. The mods were required so they could be used with a tethered blimp. The infra-red and night vision camera equipment is mounted underneath the blimp on a special frabicated aluminum cage and is radio controlled (R/C). I choose a digital 10-channel radio transmitter merely for the needed channels and reliability of JR products.
The project was handed to me by our local "Land Resources" department, for my extensive experience with all sorts of radio control systems and products.

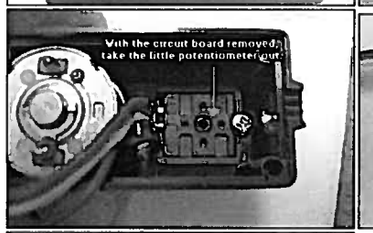
Since modifying the digital servos was not gone work, I opted for four cheapie analog servos, Hobbyco C60 (made by HiTec). The little pot inside the servo is 5K and so has to be replaced with 2.5K resistors each. Since 2.5K is not standard stock, I opted for 2.4K resistors. Worked out fine. (I thought maybe publishing my findings could possibly assist in helping someone else obtain the same goals). Check the pictures at the bottom of the page for the modification sequence. I soldered a couple days later two small ceramic capacitors (0.01uF) over the servo motor power connections to eliminate 'servo-creep' on a Futaba servo. Worked fine. See picture 16-a down below.
Also, remove the notch (or stopper) from the gear with the bearing. Snip it off with a cutting plier and then use an exacto knife to clean up the rest.

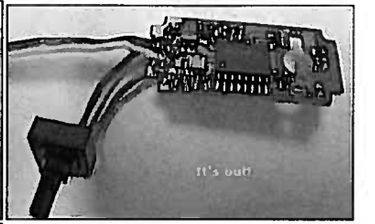
Underneath this blimp is a system with 2 infra-red cameras which takes a variety of pictures from the soil at different locations. The different colors of the soil in the pictures are then analyzed in regards to soil looseness, clay, (hot)rock, type, etc. The system which houses these cameras had to extremely safe. The 2 cameras alone are expensive at a cost of $35K each and weigh almost 4 pounds each plus the battery packs and R/C equipment and weight of the aluminum frame (cage) itself. Total weight to be carried by the blimp, at one time, was about 15 pounds (Can). Cameras can be switched with Infra-red cameras or night vision, etc.

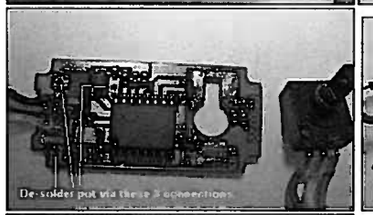


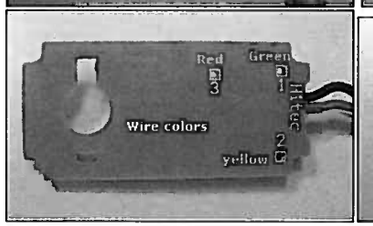












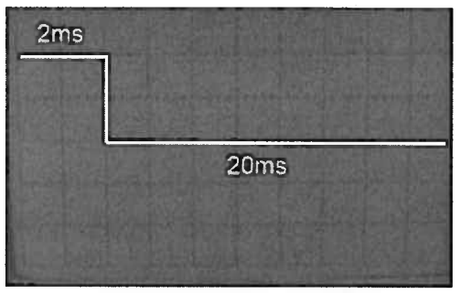


Figure 1

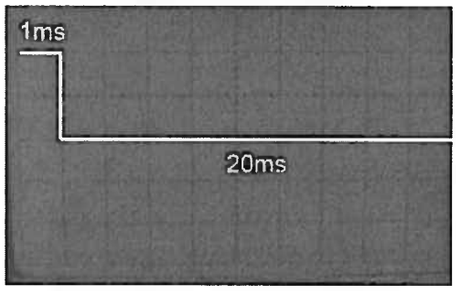


Figure 2

I say generally because I found that the range can be any where from .2ms to 3ms depending on the servo manufacture and model. Again generally when the pulse width is 1.5ms the servo will reach the half way point in its swing.

There is a small potentiometer inside the servo that rotates with the main shaft. This is what tells the electronics in the servo where it is at any given time. When we convert a servo to free running mode we disconnect the potentiometer from the shaft and set it at its center position. We also remove any mechanical stops that may keep the servo from turning completely around.

Once the servo can rotate freely we can find the center spot by slowly adjusting the pulse width. I call this the neutral position. Now by adjusting the pulse width greater than the neutral position we can move the shaft in one direction. By adjusting the pulse width less than the neutral position we can move the shaft in the opposite direction.

Most servos were designed so that when it gets closer to its allocated position it slows down. This will allow us to adjust the speed of the shaft by varying the amount that deviates from the neutral position.

Modifying the Servo

Note that the following modifications will void your servo warranty.

There are two ways to convert this servo. You can open up the servo and disconnect and remove the potentiometer. You then must solder two 2.2 resistors in place. Even after all that you need to take the poteniomiter apart and remove some detents. I feel this is too much work and can be very error prone.

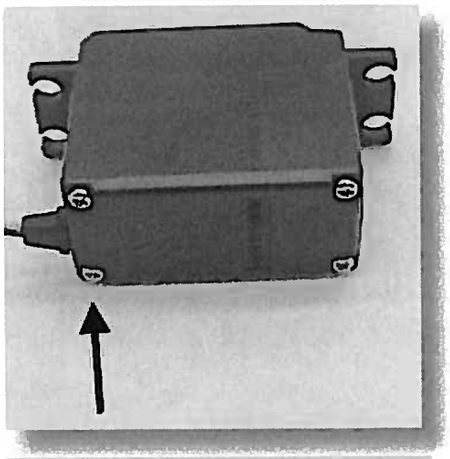
In the following steps we will work only on the main shaft. You never have to open up the guts of the servo. Also By purchasing a new gear set you can restore the servo back to normal operation if you decide to do so later.

Step 1

Remove the 4 screws on the back of the servo.

Note that its not necessary to remove the back of the servo.

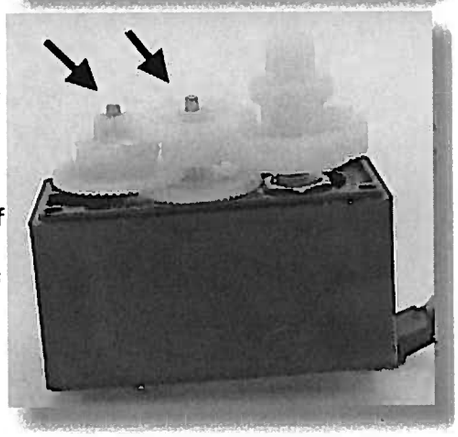
Remove any servo wheels or arms that may be attached to the main shaft.



Step 2

Remove the top of the servo by lifting.

Note that the two pins shown may stay attached to the top of the servo. If they do remove them and insert into position as shown.

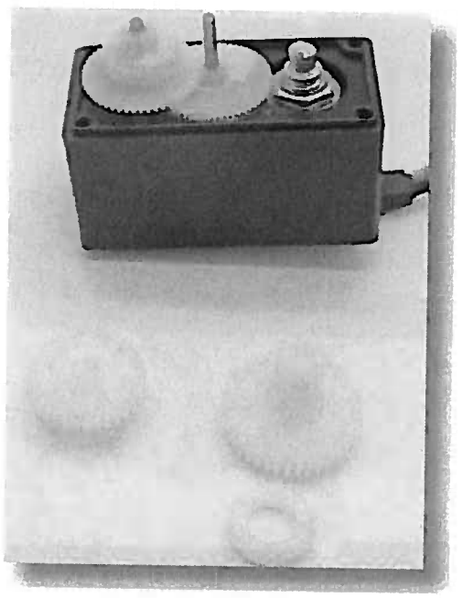


Step 3

A: Remove the intermediate gear by just lifting.

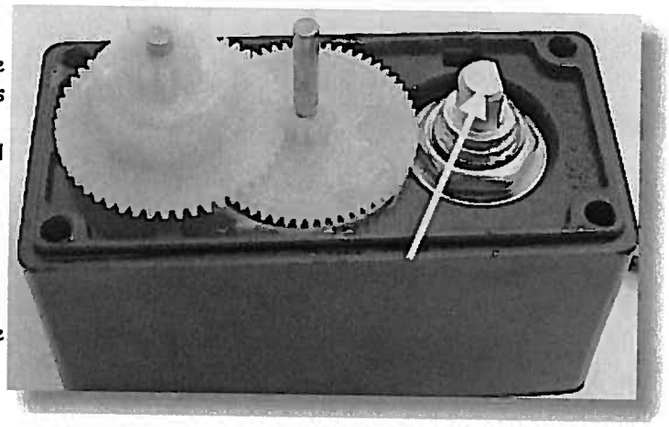
B: Remove the main shaft by lifting.

The main shaft also has a nylon bushing. Remove it from the main shaft.



Step 4

With your fingers or some small pliers place the potentiometer shaft into the center position.



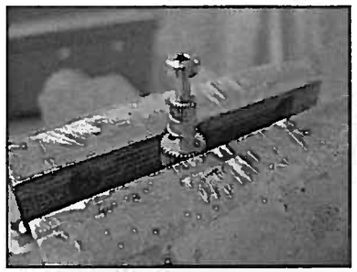
The position shown seems to be the center pos on all the servos that I have converted. Just rotate it to the left detent and right detent to make sure.

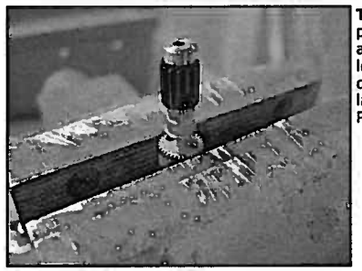
Place a very small amount of super glue around the potentiometer shaft where the shaft comes in contact with the mounting screw.

Be very careful not to get any flue on the other gears as this will ruin them. Let the glue dry.

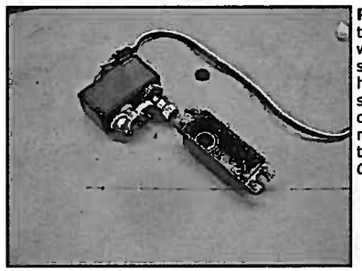
Step 5

There is a small stop that must be removed from the main shaft. I found that using small wire cutters and then cleaning up with and exact knife works the best.



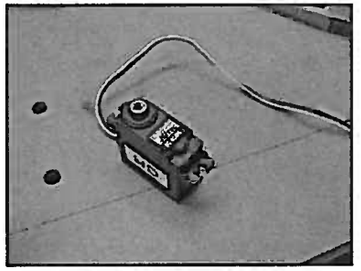


The Shoulder Bolt with Pan Gear Here the small pan gear is in place. It slides onto the shoulder and a small set screw tightens against the shaft and locks it in place. In my pan mechanishm, this small, continuously-rotating gear will "crawl" around a larger gear attached to the suspension bolt (and Picavet Cross) of the rig. *Minolta G500 digital*



Putting It Back Together Here I am reassembling the servo. You can see the inside of the front cover with the ball bearing insert in it. I like this on a servo that is going to be in constant use or which has to bear weight. On this digital rig, I used the same servo model for the tilt servo (unmodifed, of course). On the Contax G1 rig, where the camera is much heavier, I used a beffier HiTec HS-225MG with two bearings, metal gears and more torque. *Minolta G500 digital*

The Modified Servo All Done Here the servo is all reassembled and I have marked it with a "CR" for Continuous Rotation. The output shaft is threaded (although I have removed my shoulder bolt and gear) and ready for mounting on my pan structure, but that's a different project, one of many little time-consumers involved in a KAP rig and is covered in a separate page (which can be found on my Pan Mechanism Page. *Minolta G500 digital*



I didn't time this procedure, but the Continuous Rotation modification is actually pretty quick. Once you figure out that all you have to do is rip out that plastic sleeve, this goes really fast. The threading of the gear takes some more time and involves the extra runs to the hardware store if you don't already own the drill bit, tap or tap handle.

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by Matthew Cole, Saint Paul, Minnesota email me

Figure 9.

Step 5, Gently push the control board back in place. Replace the nylon gears into position starting with the middle one. When all of the gears are in place install the servo case top and bottom. They should fit together squarely with little effort. Finally replace the four long servo case screws. Your servos should look like Figure 9, and are now ready for installation into the robot body.

Step 6A, To use the servo with a microcontroller, program it to generate a 1.5mS pulse every 10mS. A program for the First Step (BS1) can be found here. A program for the Next Step (BS2) can be found here. When you run the program the servo should immediately begin rotating. Adjust the potentiometer until the servo stops rotating. Now altering the pulse value will result in rotation of the servos output shaft. For the right side servos, shortening the on time below 1.5mS results in CCW rotation. The farther from 1.5mS you go the faster the rotation. Lengthening the time more than 1.5mS results in CW rotation. The farther from 1.5mS you go the faster the rotation. The legal range is 1.0mS to 2.0mS.

Step 6B, To use the servo with an RC system, connect it to a receiver as usual. When you power it up the servo should immediately begin rotating. Adjust the stick and trimmers on the RC transmitter for center of throw. Adjust the potentiometer until the servo stops rotating. Now moving the stick will result in changing the speed and direction of the servos output shaft.

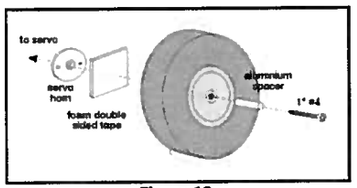

Figure 10.

Step 7, Attaching a 3" wheel to a servo is not that difficult. Remove the servo horn screw, but leave the round servo horn in place. Attach a small section of foam double sided tape to the servo horn then push the wheel onto the tape, aligning the center hole to the servos. Install a 1" #4 self tapping screw into the wheel / servo combo, and drive till tight. Other wheels will require different methods.

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Modifying the HS-322HD Servo

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Hitech HS-322 Heavy Duty Servo

Modifying aircraft servos for continuous rotation is a common and well-documented hack to create an easy-to-interface and inexpensive gearmotor. The steps required to perform the modification can differ between manufacturers.

The following instructions tell how to modify the Hitech HS-322HD for continuous rotation. This servo has very smooth operation and long life so it makes a very nice robot motor. While these instructions are specifically for the Hitech HS-322HD it may be possible to modify other Hitec servo models using this same procedure. It takes a bit more work to modify these servos when compared to other servo brands but when compared to older Hitec servo models, modifying the HS-322HD is much easier.

Tools you will need:

- small phillips screwdriver
- small flathead screwdriver
- small diagonal cutters
- tiny hand saw or other plastic cutting device
- drill and 11/64 inch bit

Below are the steps we take to modify the Hitech HS-322HD servos. The square boxes allow you to print this article and check off each step as you proceed from start to finish.

☐ Step 1

Remove the single black screw holding the round white servo horn. Make sure you get a good grip on both the horn and servo case when removing the screw. The screw can be pretty tight in a new servo. Once the screw is removed, pull the servo horn off. It may also have a snug fit so it may take some force to remove it after the screw has been taken out. Sometimes rocking the servo horn a bit can help.

☐ Step 2

Remove the four screws from the bottom of the servo. These screws are quite long reaching the entire height of the servo. Take care as these screws can be stripped easily.

☐ Step 3

Now, carefully remove the cover of the servo. The geartrain will be exposed and don't be surprised if some of the gears fall out. There may be a lot of grease on the gears so avoid getting dust on them. Find a clean safe place in your work area (perhaps a small bin) and set aside the servo lid, servo horn, black screw, four long screws, and the gears. The last gear will be in the middle and you can rock the post it sits on back and forth slightly while pulling to remove both the post and the gear.

☐ Step 4

Locate the tiny black knob attached to the potentiometer. It's made of plastic and rotates easily through 180 degrees. With the tiny hand saw (the smaller the better) or other plastic cutting device, saw off this knob. It is very important to make a clean cut as close as possible to the servo case.

NOTE:	You can try to pop the motor and circuit board out of the case in order to get at the potentiometer, but they're usually stuck in there very securely with adhesive. Applying any force to the motor in an effort to pop it out could damage the motor and destroy your servo.

☐ Step 5

You'll need a controller (we use a BrainStem GP 1.0 module) that outputs a 1.5ms centering pulse and supplies power to the servo. Plug in the servo. The motor will probably be spinning. Adjust the potentiometer (whose knob you just removed) with a small screwdriver until it stops rotating. As an optional next step, you can put a tiny bit of glue on the pot to hold it in that centered position.

☐ Step 6

The biggest gear, the one with the output shaft and splines, has a small plastic stop on it. Using diagonal cutters, a tiny saw, or some other tool, remove this plastic stop to allow this gear to rotate continously.

☐ Step 7

Look on the bottom of the big gear. You'll see the rectangular hole that fit over the potentiometer knob. Use the drill and 11/64" bit to widen that hole and make it a little bit deeper. It needs to be rounded out so no part of it will touch the sawed-down pot. Be careful not to remove too much material since that will weaken the output shaft. Test the fit of the big gear and make sure it spins freely when seated over the potentiometer. It should not move the potentiometer. If it does, drill the hole a little deeper.

☐ Step 8

If you have a servo ball-bearing, you can replace the plastic donut bearing on the output shaft with it. The ball bearings don't have a top or a bottom and can be installed either way. The fit is tight so it may take a bit of pressure to get the bearing to seat down on the gear. Once you get it aligned, it will typically snap down in place.

☐ Step 9

Make sure the gears are aligned properly and re-install the top of the servo and the 4 long screws to hold the servo together.

☐ Step 10

The servo is done! Test it out to make sure it spins freely and can be run in both directions. If there are problems, try verifying the input to the servo with another servo before taking it apart again. You may want to re-install the white round servo horn depending on your intended use.