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109 Woods of Arden Road

Staten Island NY 10312

718.966.3694 Tel.

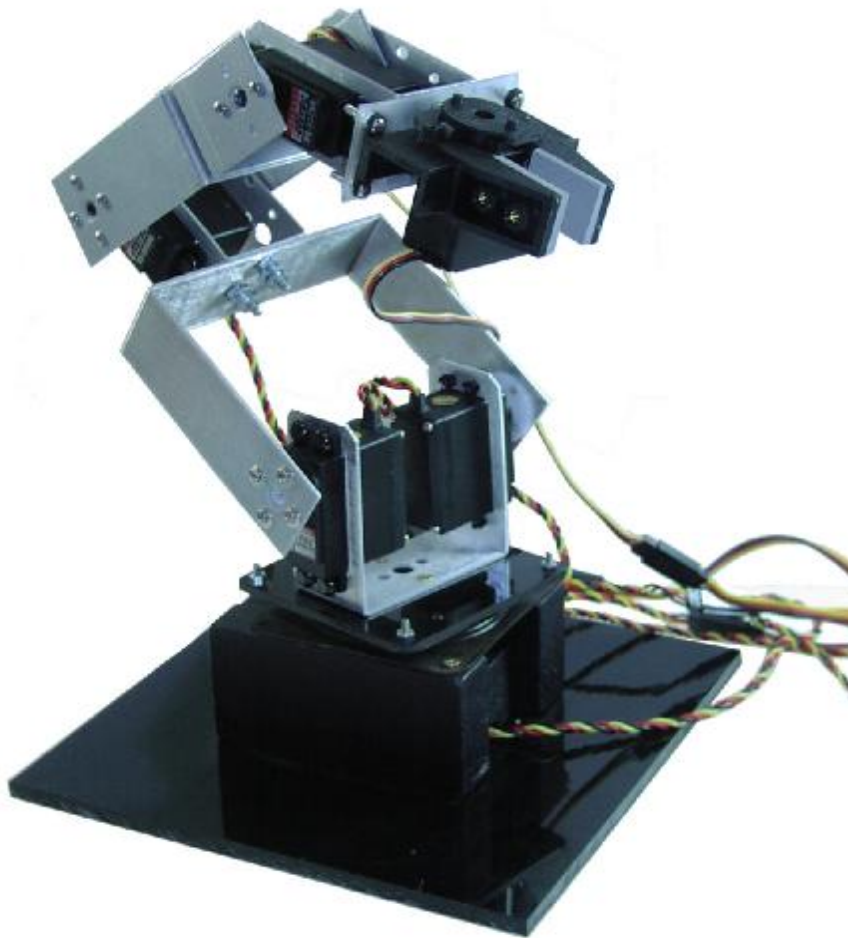
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## **Servobotics**

### **RA-02 Robotic Arm & Controller**

*Manual & User's Guide*



## Important Safety Warning

This kit is not intended for young children! Assembly of this kit requires high-temperature soldering and the use of sharp edged components and cutting tools. Some included components may become hot, leak, or explode if used improperly. Images strongly recommends that you wear safety glasses when building or working with **any** electronic equipment. Children should use this kit only under adult supervision.

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Tell us what we did well, what we could improve, what you would like to see in the future, or anything else you would like to say!

# Building the SMC-05 Five Servomotor Controller



## Parts List

The following components are in the SMC-05 servo controller kit. Make sure to verify that all components are included, and that you know which component is which. For each component, the reference number, description, and quantity are indicated.

Quan.	Ref	Part Description
21	R1-R10	10 K resistors (brown, black, orange, gold)
	R12 - R20	
1	R11	4.7 K ohm resistor (yellow, purple, red, gold)
2		330 ohm resistors (orange, orange, brown, gold)
1		3.3K resistor (orange, orange, red, gold)
3	C1, C3 & C2	4700 uF, 10 V electrolytic capacitors
2		22 pF capacitors
1		16 MHz crystal
1	D1	1N751 5.1 zener diode
1	D2	Red miniature LED
5	D3	1N5402 diodes
1	D4	1N4007 diodes
1	Q1	LM084 -5VDC voltage regulator
1	Q2	2N3904 transistor
1	P1	DB-9 female right-angle PC-mount socket
1	PJ-01	DC power jack
1		28-pin thin IC socket
1	16F873	PIC16F873 microcontroller, pre-programmed
3	SW 15	PC-mounted switches
5		SPDT on-off-on three-position switch
1	SW 03	Pushbutton switch
5	SMH-03	3-pin headers
1		PC Board
1	Bat-05	9V Battery Clips
1	Bat-06	9V Battery Clips





### Construction of the Servo Motor Controller

All components are mounted on the topside of the PC board with the white silkscreen labels.

Begin construction by soldering the twenty-one 10K resistors (color bands: brown, black, orange, gold) in the positions marked R1 to R10, R12 to R20 and the resistor labeled 10K on the PCB, see figure 1. Mount and solder resistor R11 which is the 4.7K resistor, (yellow, purple, red, gold). Next mount and solder the two 330-ohm resistors (orange, orange, brown, gold) label 330 on the PCB and the 3.3K resistor (orange, orange, red, gold), labeled 3.3K.



FIGURE 1



FIGURE 2

Install the 28-pin socket for the PIC16F873, match the orientation of the notch on the socket to the silk screen image printed on the board. Next install the LED, matching polarity to the board (the long lead of the LED is positive), see figure 2.

Mount and solder the 16 MHz crystal in the space marked 16 MHz XTAL. Then install the two small 22 pF capacitors below the crystal. Mount and solder the 5.1 volt zener diode (marked on the board as "5.1"), making sure the black band is orientated as on the board. Next mount and solder D3, a 1N5402 diode, again making sure the band matches up with the board. Install the other four 1N5402 diodes as above.

Install the three PC-mounted switches. The power switch is labeled "On Off". The second switch, to choose between PC or MAN (manual mode), see silk screen on pc board. The third PC switch is labeled Fast/Slow by the DB-9 right angle connector. Install the power jack on the top-right corner of the board. The jack should be pointing to the right. See figure 3.



FIGURE 3



Install the five three-pin headers that connect to the servomotors. The five headers for the servomotors are labeled 1 through 5, the symbols "s + -" above the three position headers mean signal, positive +5V and ground.

Install Q2, the 2N3904, aligning the flat side as shown on the board. Install the pushbutton in the spot marked "Save." This button allows you to set the starting position of the servomotors in manual mode. Now install the female DB-9 connector. See Figure 4



FIGURE 4

Mount and solder the 9V battery clip near C2, the positive wire is red and the black wire is negative, see figure 5. The 9V battery clip is optional. It allows a fast power supply for quick no-load to low-load servomotor testing and work. Next install Q1, the LM1084 voltage regulator, lining up the flange with the mark on the board. With extended use, this regulator can start to get hot. We recommend purchasing a heat sink to prevent overheating. To properly mount the heat sink to the voltage regulator it is important to push the regulator leads through the pcb holes until the regulator sits flush on the PC board. This allows the heat sink to rest properly on the PC board. Secure the heat sink to the regulator with a 4-40 screw and nut. See figure 5B.

FIGURE 5



FIGURE 5B



Now install the five SPDT switches that control the servomotors. Mount and solder the three electrolytic capacitors. C1, C2 and C3 are the large 4700 uF, 10V electrolytic capacitors. Make sure when you install them that the polarity of each is aligned as marked on the board. The longer lead is positive, and the negative lead is marked on the side of the capacitor. Mount and solder D4, the 1N4007 diode, making sure the band on the diode matches to the band on the silk screen. Finally, insert the pre-programmed PIC16F873 into the socket, lining up the notch on the chip with the one on the board and the socket. Construction is now complete. See figure 6.



FIGURE 6

**Use:**

**Manual Mode:**

To begin, place each 3-position toggle switches in their center neutral position. Push the PC/Manual Mode switch to MAN. Connect the servomotors to the three position header(s). Making sure the signal lead is aligned with the header pin labeled "S".

Turn on power. Each numbered three-position toggle switch will control the corresponding numbered servomotor. The center position of each switch is the servomotor neutral position. In the neutral position, the servomotor is maintained in its current position.

Moving a toggle switch in the "up" position rotates the servomotor shaft in a clockwise (CW) rotation for as long as the switch is held in the up position. Returning the switch to the neutral position stops the rotation, and holds the servomotor in its new position.

Moving a toggle switch in the "down" position rotates the servomotor shaft in the counterclockwise (CCW) rotation for as long as the switch is held in the "down" position. Returning the switch to the neutral position stops the rotation, and holds the servomotor in its new position.

**Speed Position:**

The speed switch controls the speed of the servomotor movement; Fast or Slow. When operating robotics manually, like the RA-01 robotic arm, the slow speed is typically needed to maintain precise movement control.

**Save Button:**

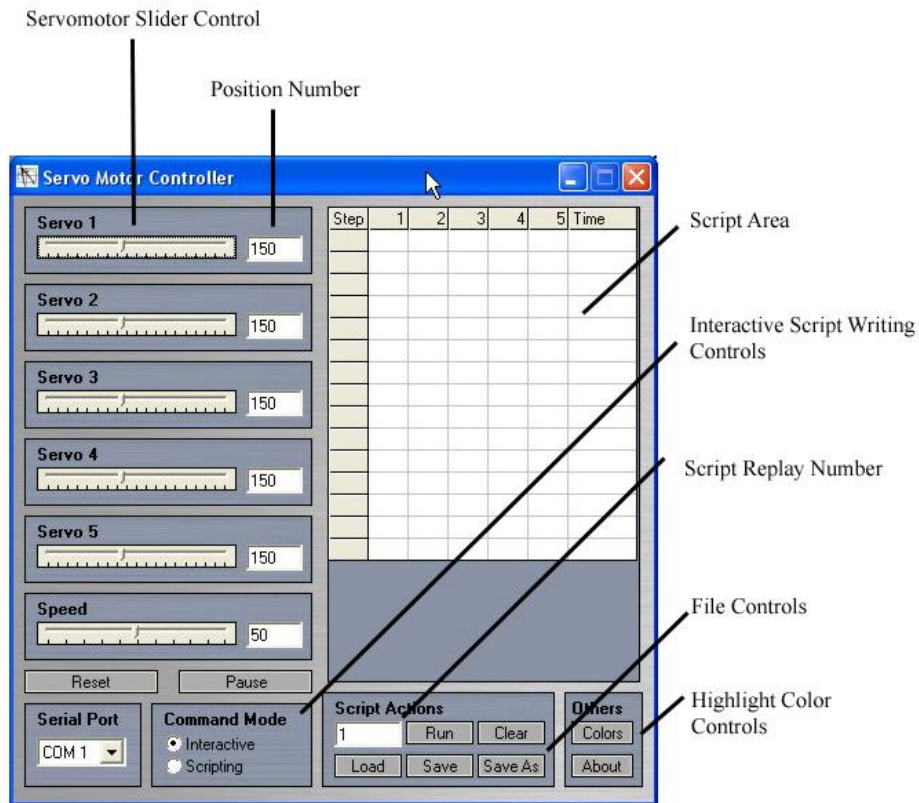
You can "save" the five servomotors current position by pressing the "save" button. The positions saved will be the position the servomotors will go to upon startup.

**PC Mode:**

Install Windows Servomotor program on your computer.

Push the PC/Manual Mode switch to PC. Connect the hobby servomotors to the three position headers as described in the manual mode. Connect the DB9 cable to an open serial port on the PC. Or to USB serial adapter. Connect the opposite end to the DB9 connector on the servomotor control board.

Start Windows program. Select the serial port the servomotor board is connected to. Turn on the power to the servomotor board.



Turn on power to the servomotor controller board.

### **Interactive Mode**

The numbered Servomotor Slider control will control and position its corresponding numbered servomotor interactively. If the servomotor doesn't move, check to see if you have the correct COM port selected. The program will only display the COM ports it has detected on the computer in the pull down menu.

Instead of using the Slider control one may type a number into a text box, select the text box, enter a number into the box then hit the tab key. The tab key enters the number.

### **Speed Slider Control**

The Speed Slider control works in both interactive, scripting and when re-playing scripts. The slider control determines the speed of the servomotors movements.

### **Script Writing:**

To write scripts for automation and animatronics control of the five servomotors, select the Scripting Option. With the Scripting option selected, each servomotor action perform using the Servomotor Slider Control, will be performed by the servomotor and written as a step into the script writing area. Instead of using the slider control one may also type numbers into the "Position Number" textbox . To enter number into the text box hit the TAB key. The Tab key enters the number, which cause the servomotor to react and the action to be written into the script.

Timed pauses may also be written into the script using the pause button. Click once to start the pause, and then click a second time to end the pause.

### **Playback:**

Scripts can be re-play thousands of times. Enter the number of iteration you want the script to be performed in the "Script Replay Number" textbox. Each time the script is play, the number in the textbox will be decreased by one.

During Playback, the step being performed is highlighted. The color of the highlight may be changed using the Color Highlight Control button. Save the change before exiting the pop-up control.

### **Script File Handling:**

Scripts files may be saved, loaded and played and replayed. Once loaded into the program a script file may be appended. You can add additional steps to the file by choosing the "Scripting" option and performing additional servomotor movements.

### **Program Updates:**

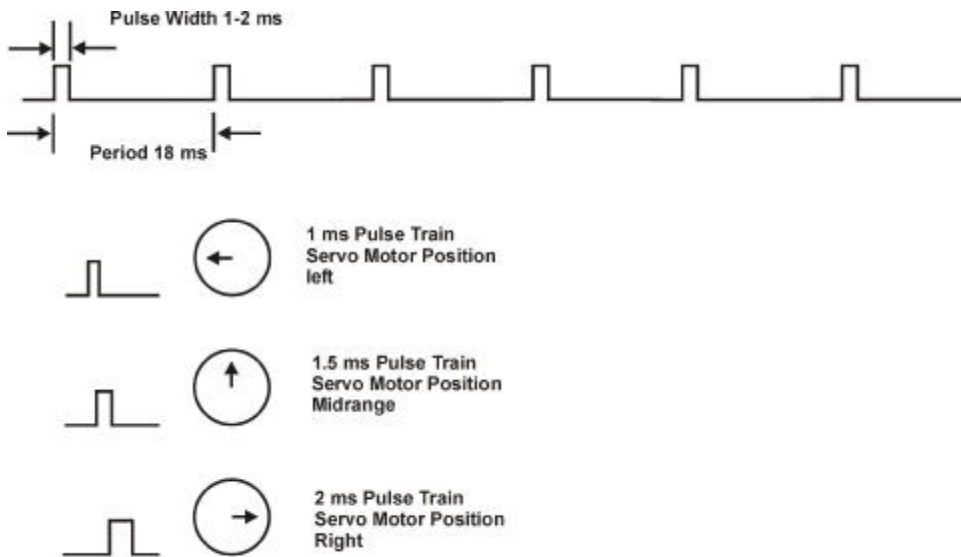
<http://www.imagesco.com/catalog/servobds/servoboard.html>

### Servo Motors

Primarily, servomotors are geared dc motors with a positional feedback control that allows the rotor (shaft) to be positioned accurately. The specification state that the shaft can be positioned through a minimum of 90 degrees (+/- 45'). In reality we can extend the range closer to 180 degrees (+/- 90') by adjusting the positional control signal beyond the standard parameters.

There are three leads to a servo motor. Two leads are for power; +5V and ground. The third lead feeds a positional control signal to the motor. The position control signal is a single variable width pulse. The pulse can be varied from 1 to 2 ms. The width of the pulse controls the position of the servo motor shaft.

A 1-ms pulse rotates the shaft to the extreme counterclockwise (CCW) position (-45'). A 1.5-ms pulse places the shaft in a neutral midpoint position (0'). A 2-ms pulse rotates the shaft to the extreme clockwise (CW) position (+45'). The pulse width signal is sent to the servomotor approximately 50 times per second (50Hz). Figure below illustrates the relationship of pulse width to servomotor position.



### Programming the SMC-05 Servo Motor Controller Board

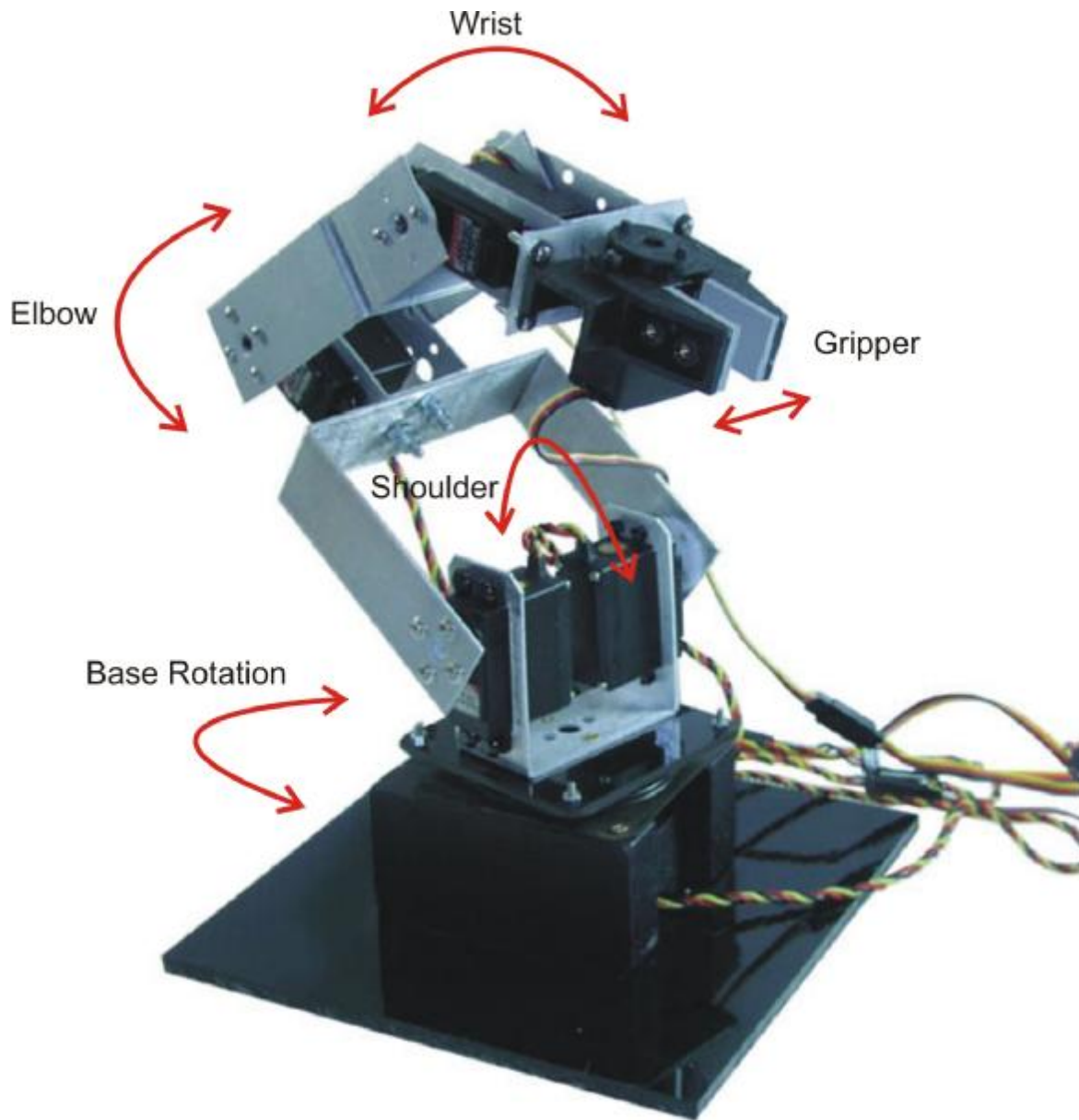
In the event you need to write your own program to control the SMC-05 the information provided here will be invaluable. The SMC-05 receives serial data using a standard protocol from the PC (19200, N,8,1).

The computer continually sends position control data. The data stream begins with a qualifying number 7 followed by the numerical servo motor position for the five servomotors in sequence starting with servomotor 1. The numerical position control number can be any number between 75 and 255.

This number represents the pulse width provided to the servo motor from .75 millisecond to 2.55 millisecond. So if you were to send a serial signal to center all servomotors, the number sent would appear like this 7, 150,150,150,150,150.

To move servomotor # 3 to the extreme CW position 7, 150,150,255,150,150. The serial data is constantly being sent to the servo motor controller board, approx 20X a second.

## Part 2: Construction of the Robotic Arm



Before starting construction on the robotic arm the 5 servo motor controller SMC-05 should be built first. You will use the controller to align the servomotors during construction. Before we begin construction, let's first assemble a servo motor bracket and understand its function before assembling them into a robotic arm.

### Basic Servomotor Bracket Assembly

This robotic arm uses six HI-TEC servomotors, they are; (3) HS-645MG, (2) HS-422, and (1) HS-322 HD servomotors. The HS-645 MG servomotor has about three times more torque than the HS-322 HD's and is used in the second position and third positions up from the bottom (or base) servomotor on the robotic arm. These servomotor position requires the most torque in order to lift the arm and any object the arm is holding.

Before we begin assembling the brackets to create the robotic arm we will put one servomotor bracket together to gain a general understanding of its assembly. These servomotor brackets may be used to create any number of robotic projects, such as robotic walkers, Golfer-bot, inch worm bot, and many more, visit our website at <http://www.imagesco.com> for more ideas and uses for the servo motor bracket. The servomotor brackets are compatible with the following types of servomotors:

**Compatible with the following HiTec servo motors:**

HS-311, HS-322, HS-325, HS-422, HS-425BB, HS-475, HS-525BB, HS-525MG, HS-545BB, HS-625MG, HS-635HB, HS-645MG, HS-925MG, HS-945MG, HS-5475HB, HS,5625, HS-5925MG, HS-5945MG, HS-5955TG, HSR-5995TG, HSC-5996TG, HSC-5997TG, HSC-5998TG, HS-6635HB, HS-6965HB, HS-6975HB, HS-6985HB

**Compatible with the following Futaba servo motors:**

S-148, S-3001, S-3003, S-3004, S-3005, S-3010, S-9001, S-9202, S-9206, S-9402, S-9405

The servomotor bracket components are shown in figure 1.

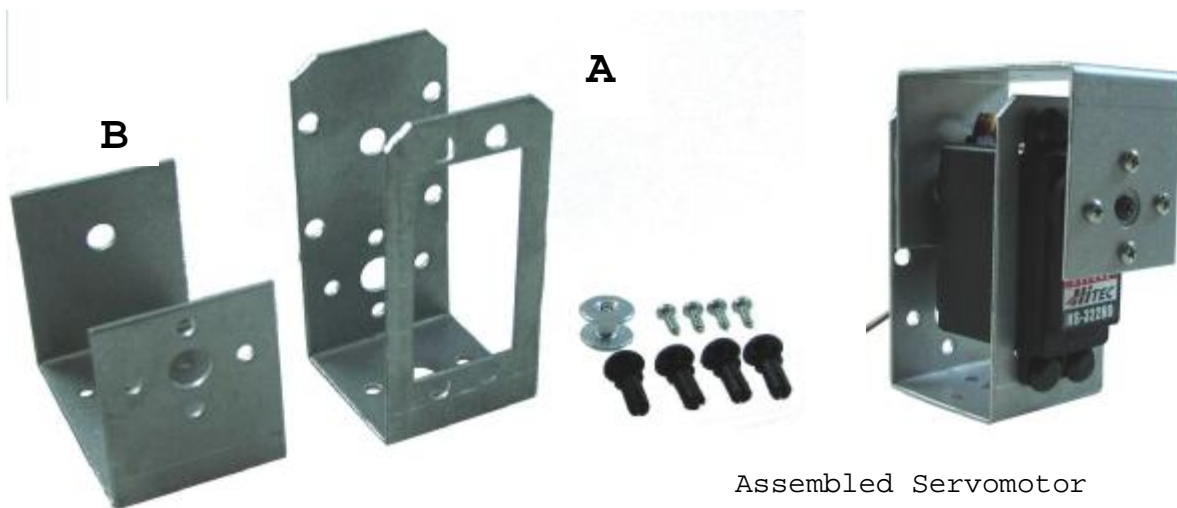
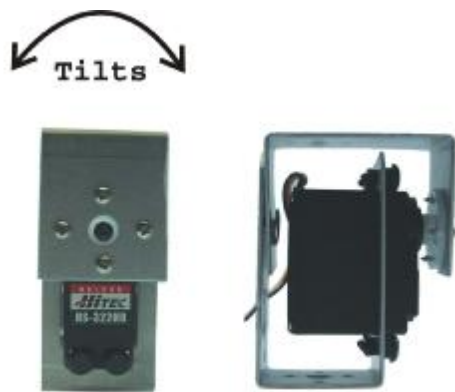


FIGURE 1

The servomotor bracket components are shown in figure 1. Each of the aluminum U brackets that make up the assembly has multiple holes for connecting a standard Hi-Tec or Futaba servomotor as well as bottom and top holes for connecting U brackets and assemblies to one another.

The servomotor horn holes in Part B are compatible with Hi-Tec the round horn standard included with Hi-Tec servomotors, see compatibility list below. These brackets may also be used with similar size Futaba servomotors, see compatibility list below, but you need to match a suitable horn to attach to part B.

Each servomotor bracket assembly consists of the following components: two aluminum U brackets, labeled A and B, (1) binding head post screw, (4) plastic pop rivets and four sheet metal screw for mounting a servomotor horn. When assembled with a compatible servomotor, the bracket becomes a modular motion controlled component that may be attached to other brackets and components.

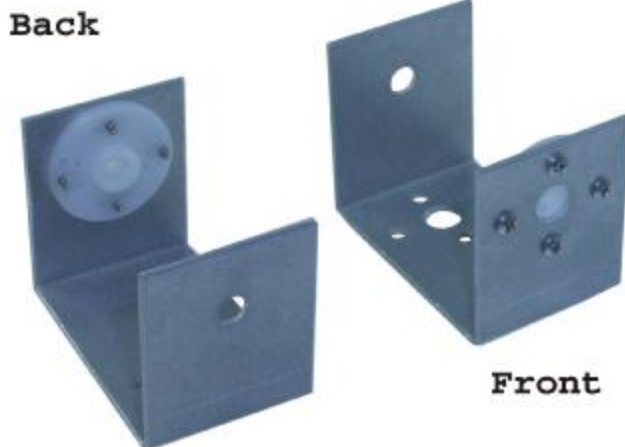


Front View Side View  
FIGURE 2

The servomotor bracket allows the top and bottom components to swivel along the axis of the servomotor's shaft, see figure 2.

#### Assembly

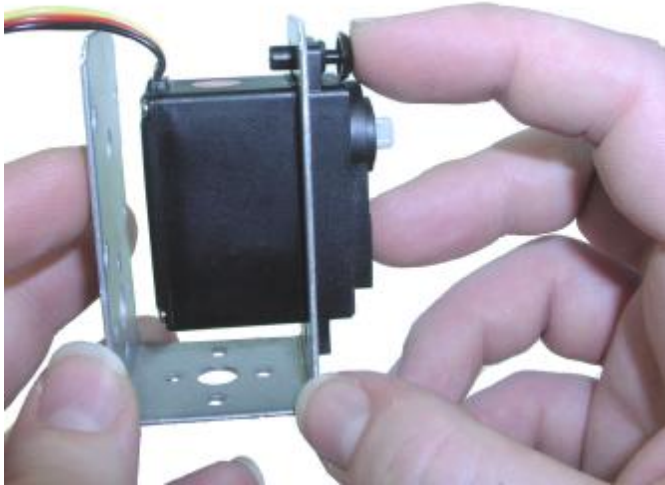
Remove the existing horn that is on the servomotor by unscrewing the center screw on the horn/servomotor. Place the center screw to the side, you will need it later. Attach the servomotor horn to part B, see figure 3, using the four #2-1/4", sheet metal screws.



Back Front  
FIGURE 3

Next, attach the servomotor to Bracket A. Using the four pop rivets.

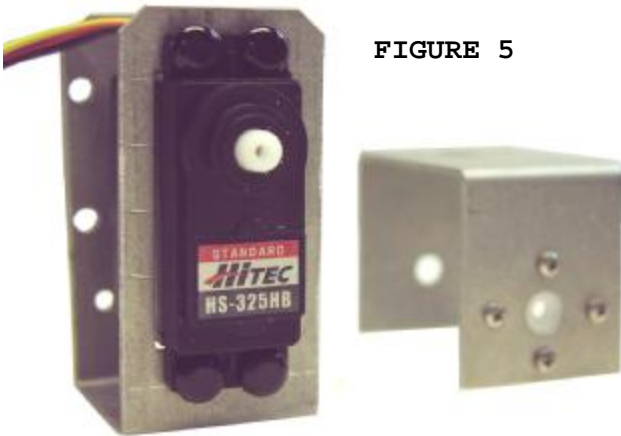
**FIGURE 4**



Place servomotor into part A. Align servo motor holes with the holes in part A. Place pop-riev into aligned holes. Press pop rivet into aligned holes. This expands the back of the pop rivet locking it into place. Place pop rivets in the three remaining holes see figure 5.

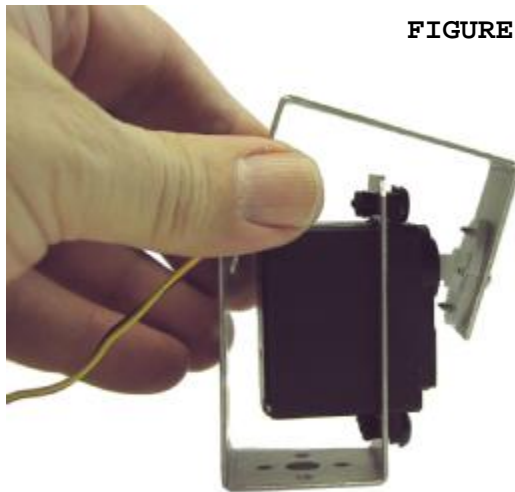
Once the servomotor is attached we can add part B to the assembly, see figure 5 .

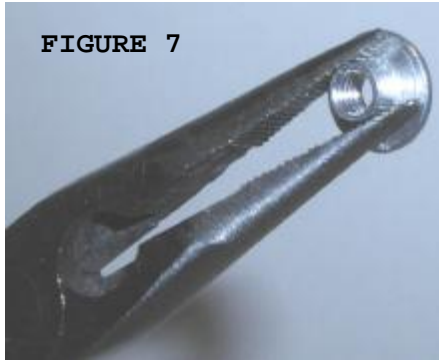
**FIGURE 5**



Center the servomotor. After the servomotor is in its center position attach part B, see figure 6. Now we need to add the back pivot that consists of a binding head screw and post.

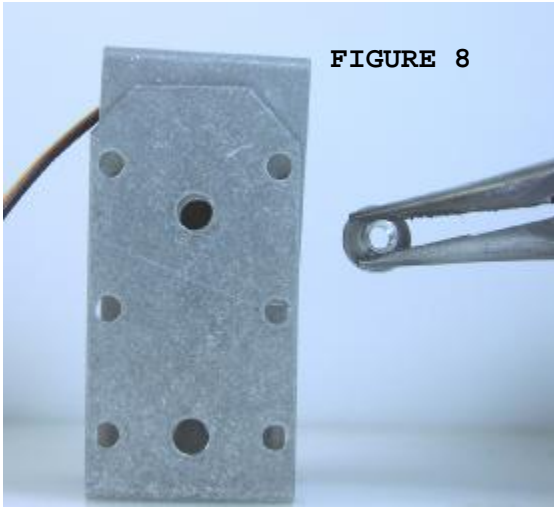
**FIGURE 6**



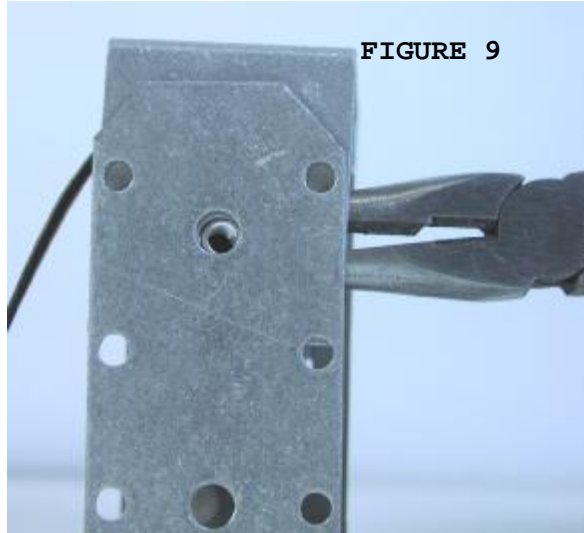


**FIGURE 7**

Grab Binding post with a needle nose pliers. See figure 7. Use needle nose pliers to position binding post behind the servomotor so that the hole of the binding post is aligned with the holes of parts A and B, see figures 8 and 9.



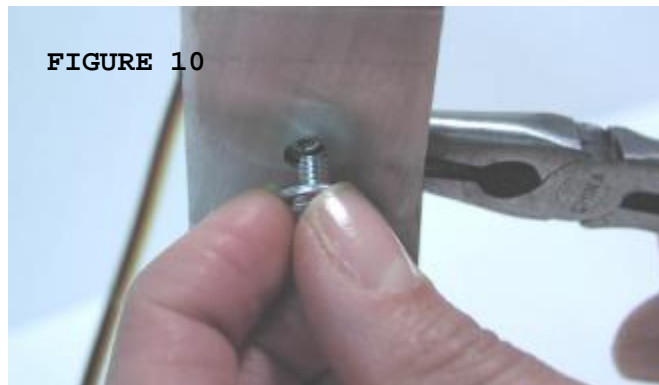
**FIGURE 8**



**FIGURE 9**

With the holes so aligned, place binding head screw through the holes of parts A and B and start screwing it into the binding post, see figure 9.

Once you have the screw started, push the binding head post through the holes. You may want to use a small flat head screwdriver. Then finish by screwing the screw all the way in, see figures 10, 11 and 12.

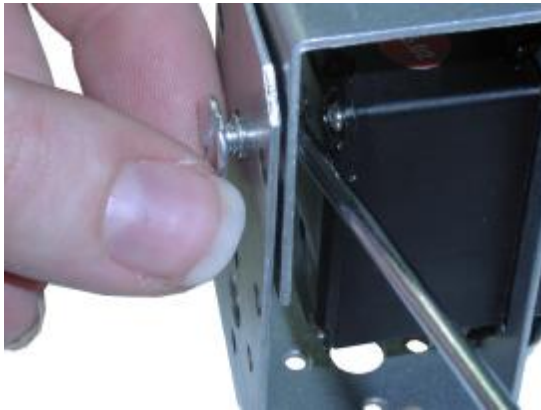


**FIGURE 10**

Finally secure the horn/top bracket to the servomotor, using the center black servomotor screw. This completes construction of the servomotor bracket. For ideas on using the servomotor brackets to build other robotic projects visit:

<http://www.imagesco.com>.

**FIGURE 11**

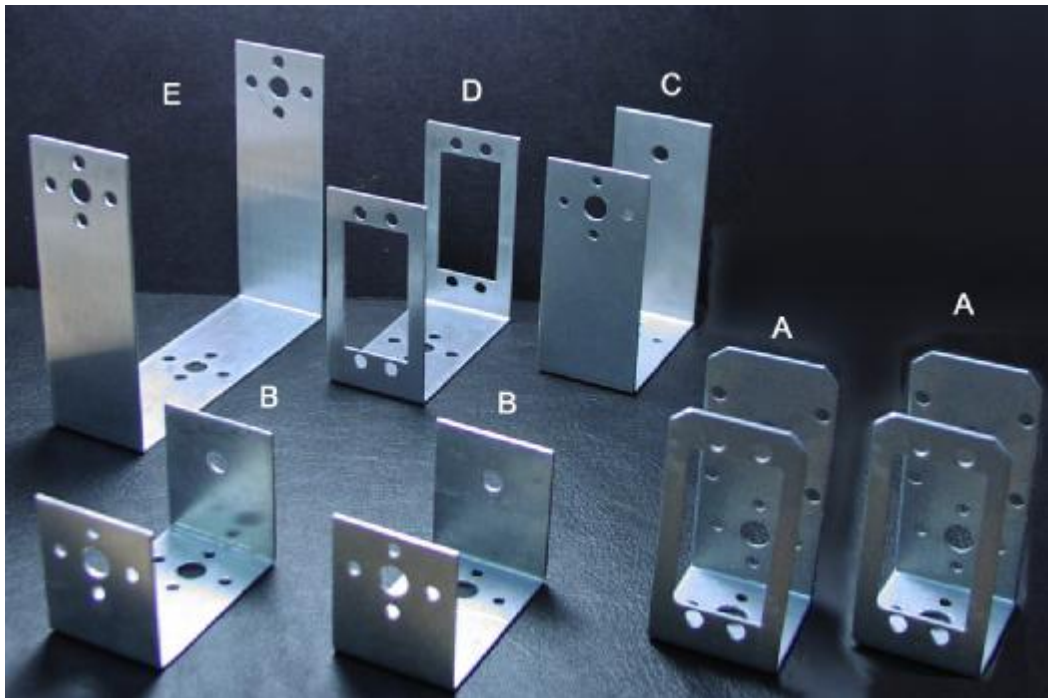


**FIGURE 12**



### **Assembling Multiple Servomotor Assemblies**

When using multiple servomotor bracket assemblies for complex projects it is essential to pre-plan how the servomotors and brackets will be connected together. In many cases, when connecting two or more servomotors assemblies together the connecting brackets of the joints need to be pre-assembled.



**FIGURE 13**

This project is no exception. The brackets may be orientated to one another in a number of ways, depending upon your design. The brackets to make the robotic arm, are shown in figure 13,

**Important:**

When assembling the servomotors inside the brackets, make sure you position the servomotor to its centered position, before securing the "B" portion of the bracket. This will insure that the robotic arm will be in it's proper position upon start up. The SMC-05 automatically positions all the servomotors in their center position upon start up. Use the SMC-05 controller to center every servomotor during the robotic arm construction.

**Gripper Assembly**

Aside from the servomotor brackets we need one other specialized component, a robotic arm gripper, see figure 13. In our configuration this gripper requires one HS-322 servomotor to open and close the gripper fingers. The gripper fingers can accommodate objects up to about 1.0 inches (25mm).

FIGURE 14

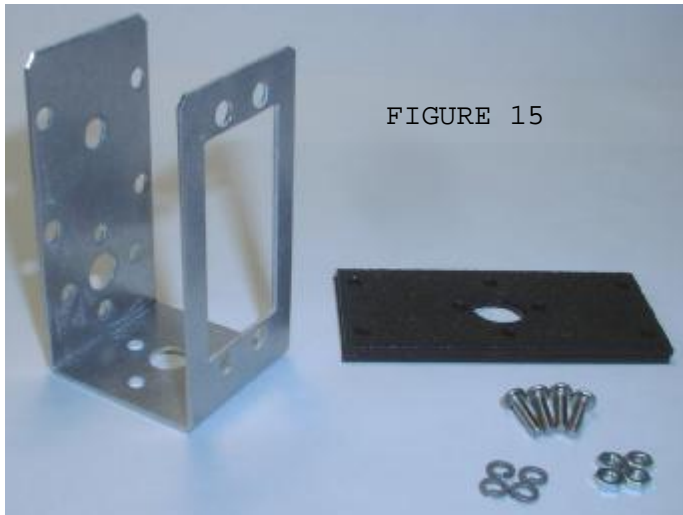


FIGURE 15



FIGURE 16

Begin the gripper assembly by attaching the gripper plate to the base of an A bracket using four 3-48 x 3/8" long machine screws, nuts and lock washers as shown in figure 15. If your gripper plate is 1/16 of an inch thick, you will need to stack two gripper plates together. Other kits will have a single gripper plate that is 1/8" of an inch thick, so will only require a single plate.

FIGURE 17



Next we attach the gripper to the plastic gripper plate using (4) 3-48 x 3/8" long machine screws, nuts and lock washers as shown in figure 17.

Next we want to attach the HS322 servo motor to the plastic gripper, see figure 18.

Figure 19 shows how the HS-322 servomotor is attached to the gripper. Remove the servomotor

horn from the servomotor, if you haven't already and put the horn screw to the side we will need it. Next, we need to center the servomotor using the five servomotor controller. Plug the servomotor

FIGURE 18

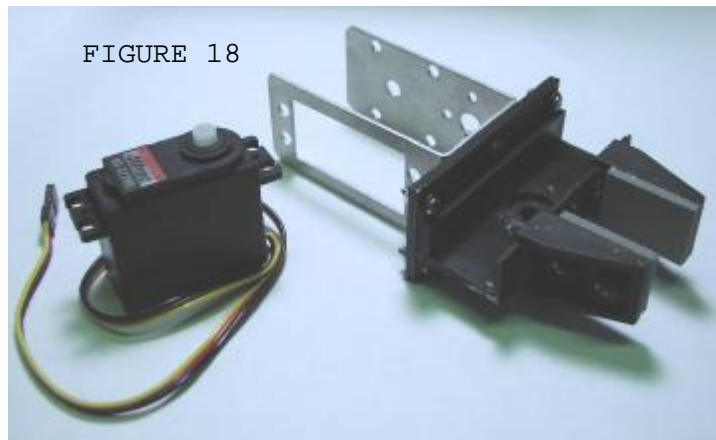


FIGURE 19



## Finger Servo

motor inside the gripper. Replace the horn screw removed earlier and tighten the servomotor horn screw, locking the gripper, see figure 20. Turn off the power to the servomotor.

into number 5 servomotor header on the SMC-05 PC board. Make sure all the servomotor control switches are in the center "Off" position and apply power. The starting position on all five servomotors is center. With power applied to the SMC-05, any servomotor attached to the board will move to its center position. Next position the gripper fingers in mid-position. Keeping the power applied place the servo-

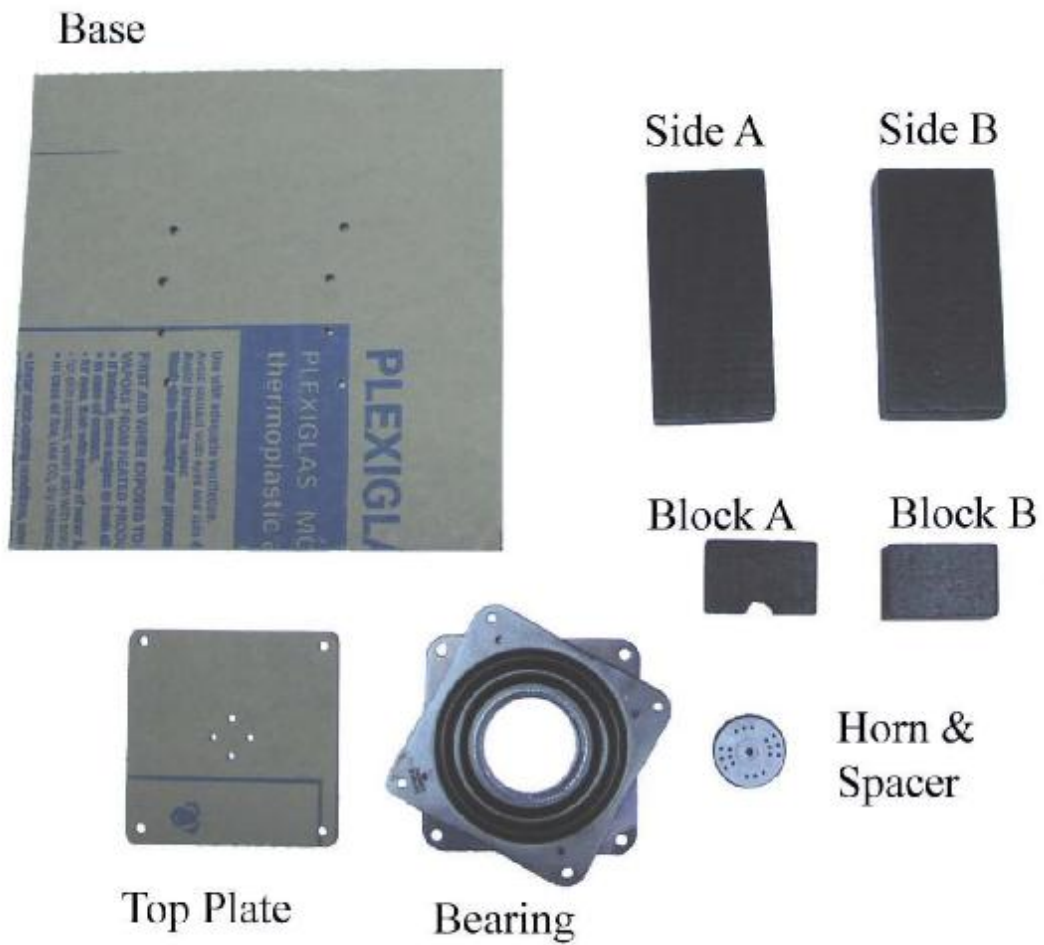


FIGURE 20

## Building The Robotic Arm Base

Figure 21 shows the nine components needed to build the robotic base as supplied in the kit.

FIGURE 20



We begin construction of the base, by putting the base plate assembly together. The top of the servomotor horn should be sanded flat to remove the small lip around the center. Then the servomotor horn is attached to the wood space using two #2 x 1/4" screws, see figure 22 and 23. (Note- On rare occasion one might need to add one or two washers between the wood block and servomotor horn-If the servomotor horn does not reach the shaft of the base servomotor.)



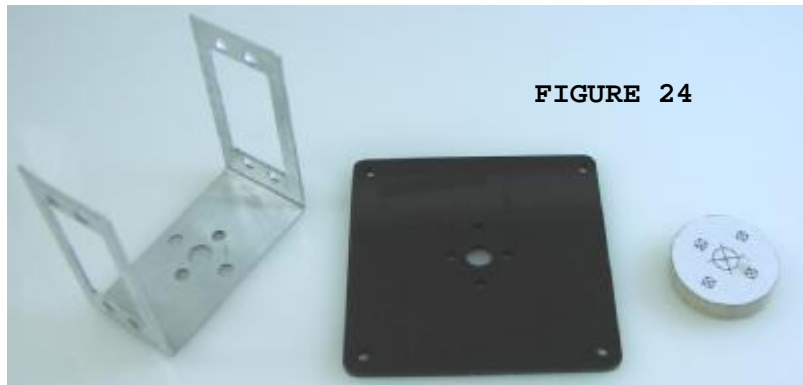
**FIGURE 23**



Next assemble the top plate assembly that consists of the top plate, spacer assembly and the D servomotor bracket.

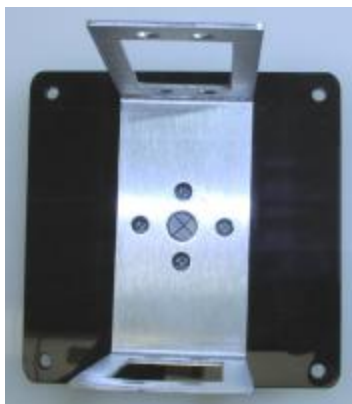
The D bracket is positioned on top of the top plate. Align the four holes of the top plate and bracket D.

Next place the spacer assembly (fig 23) on the bottom of the top place, wood side touching the top plate, The spacer has template holes that will align with the holes in the bracket and top plate, see figure 24. Secure the components together using the four #2-3/8" screws and flat washers, see figures 25, and 26.

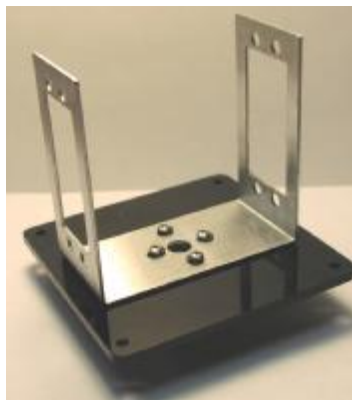


**FIGURE 24**

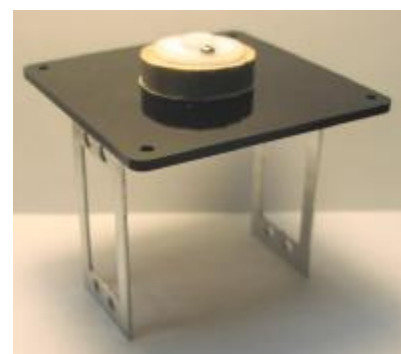
**FIGURE 24**



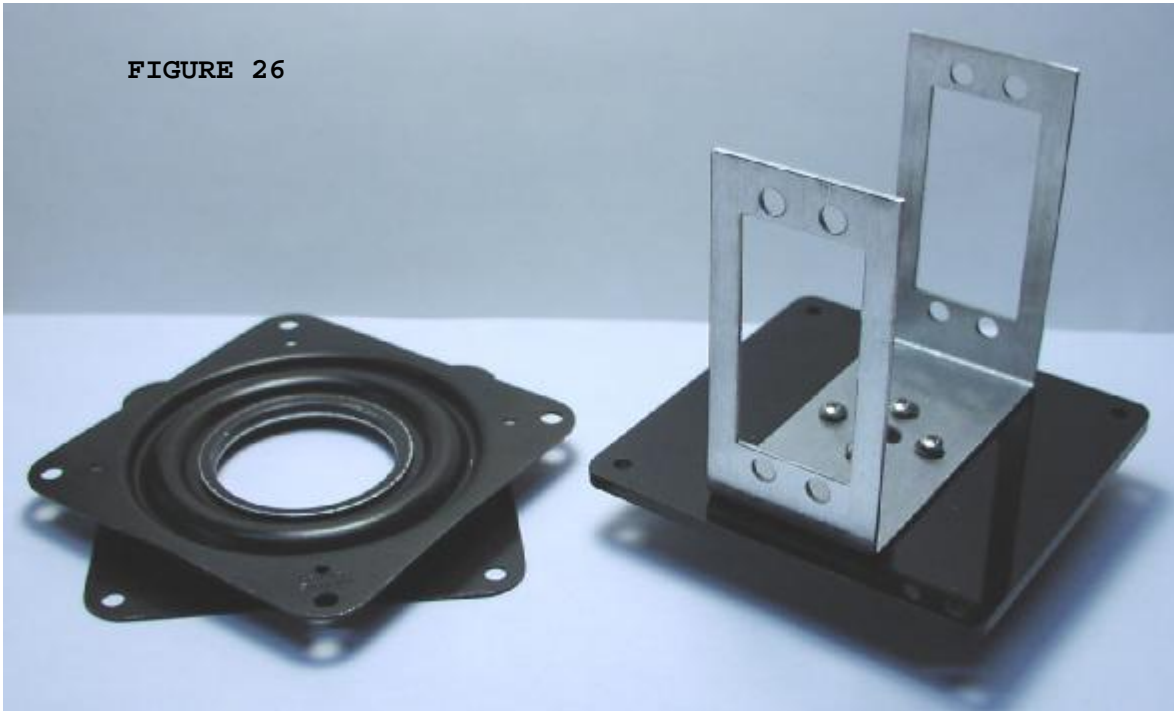
**FIGURE 25**



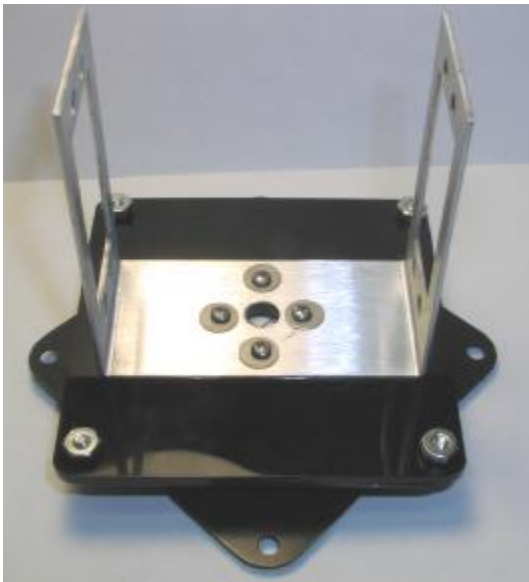
**FIGURE 25**



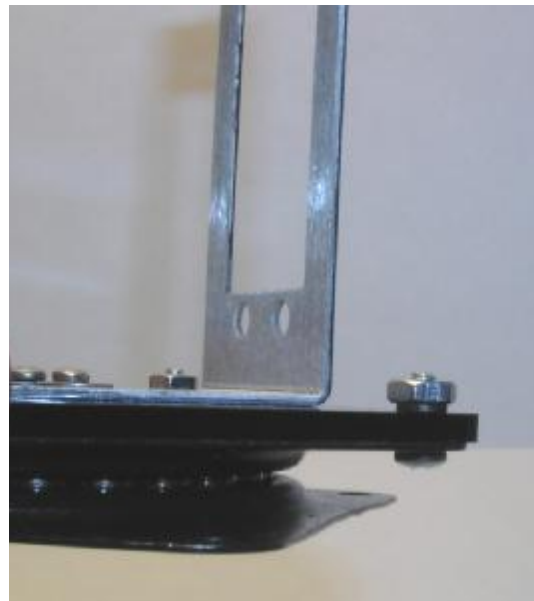
**FIGURE 26**



Secure the top plate assembly to the 3" square bearing using four 4-40 x 5/16" machine screws, nuts and #4 split lock washers as shown in figure 26, 27 and 28. Make sure the screw head, nut and lock washer is orientated as shown in the close up, figure 27. Doing so will insure that the assembly can turn freely on the bearing. Place this bearing plate assembly to the side while we construct the base.



**FIGURE 26**



**FIGURE 27**

The 7" square base, see figure 28, has eight pre-drilled holes for the side blocks A and B and for the servo motor blocks A and B. .

**Base Plate 7" x 7"**  
**1/4" thick -- Black acrylic**

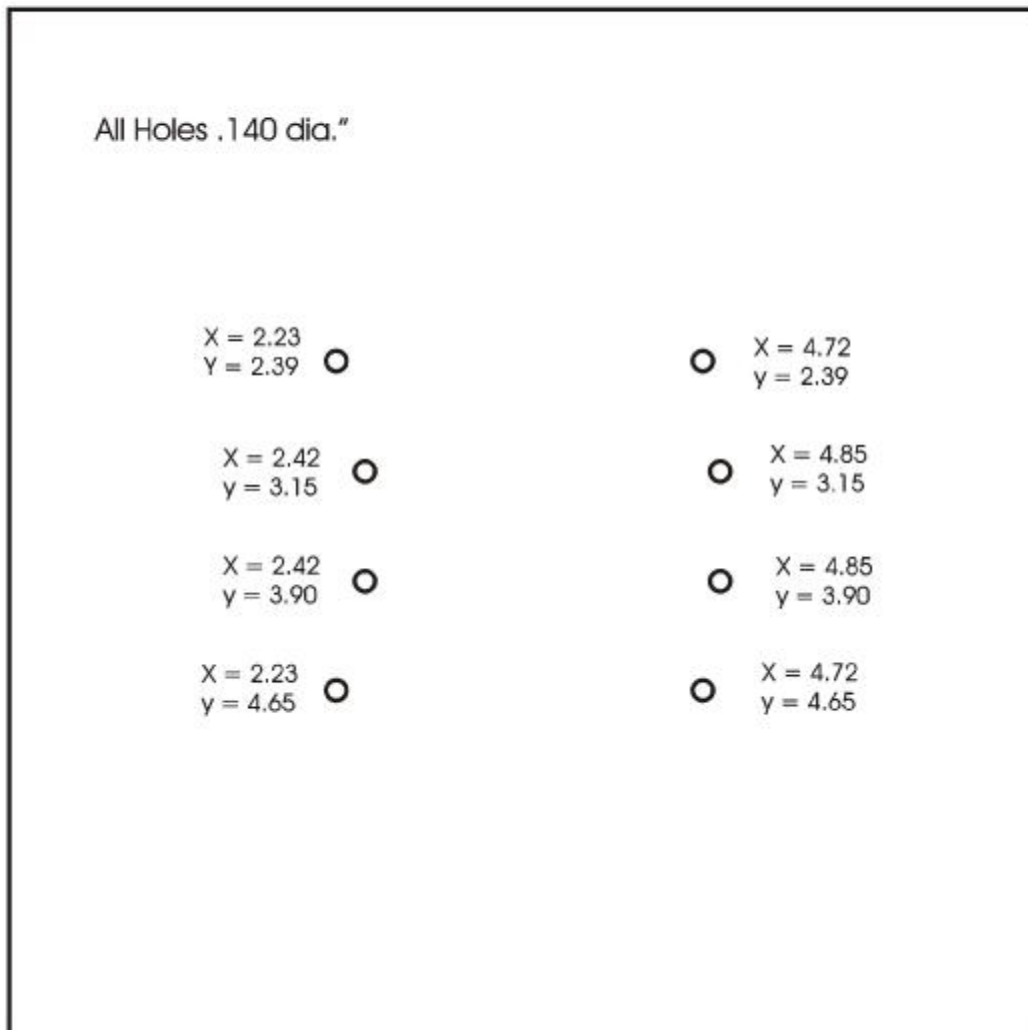


FIGURE 28

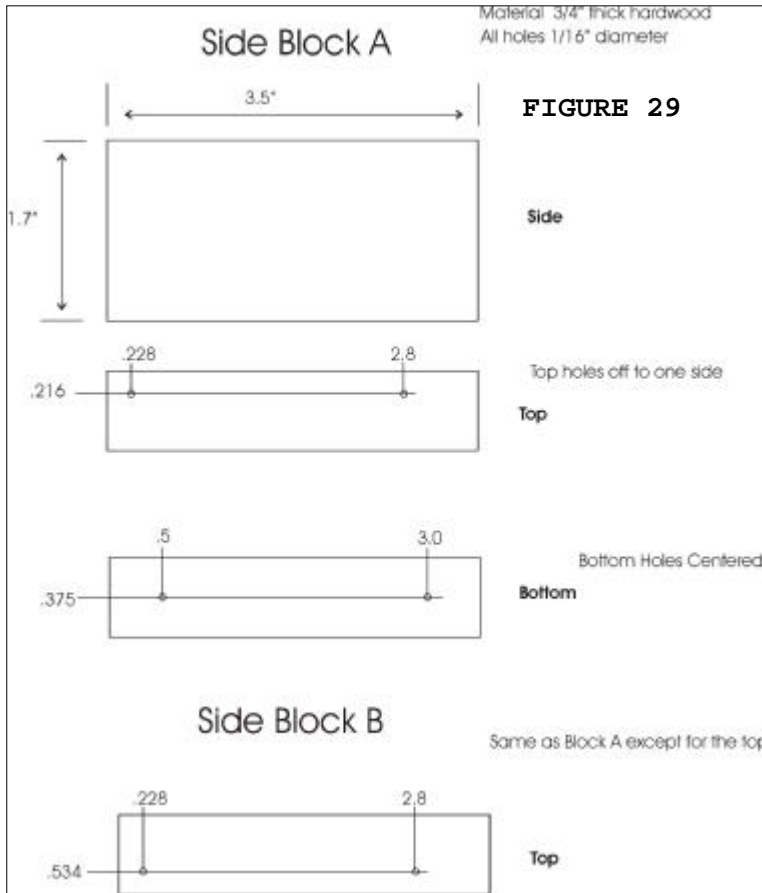
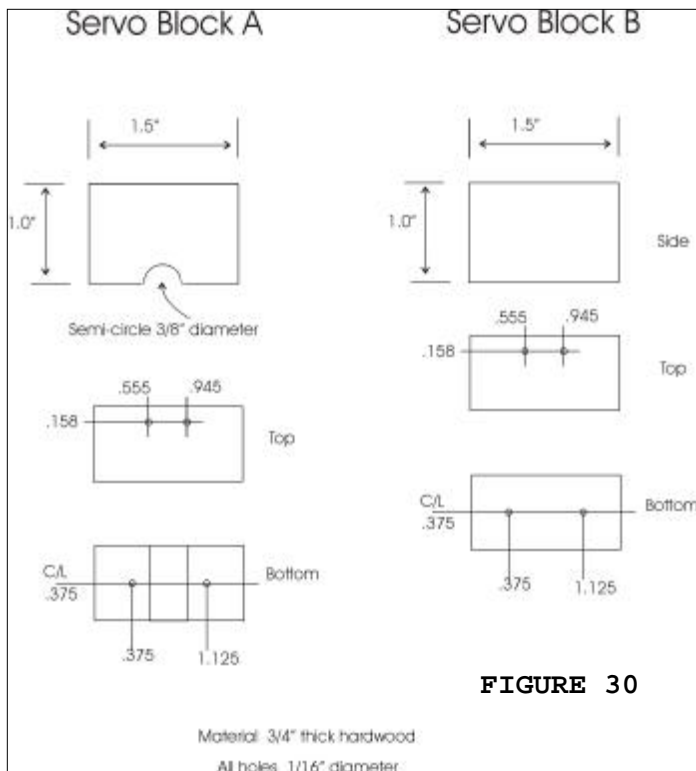
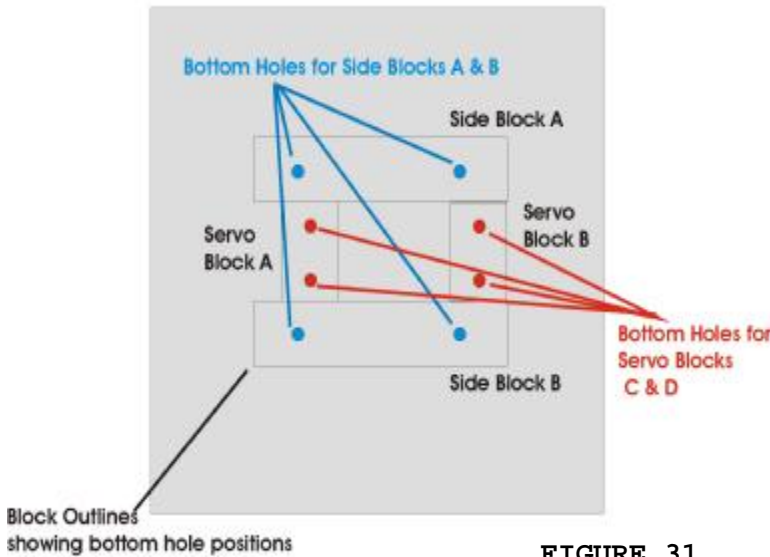


Figure 29 a mechanical drawing of side blocks A and B. The pre-drilled bottom holes on these two block are centered. The top pre-drilled holes are off to one side.



The same is true for the servo blocks A and B, see figure 30. The bottom holes are centered and the top holes are off to one side.

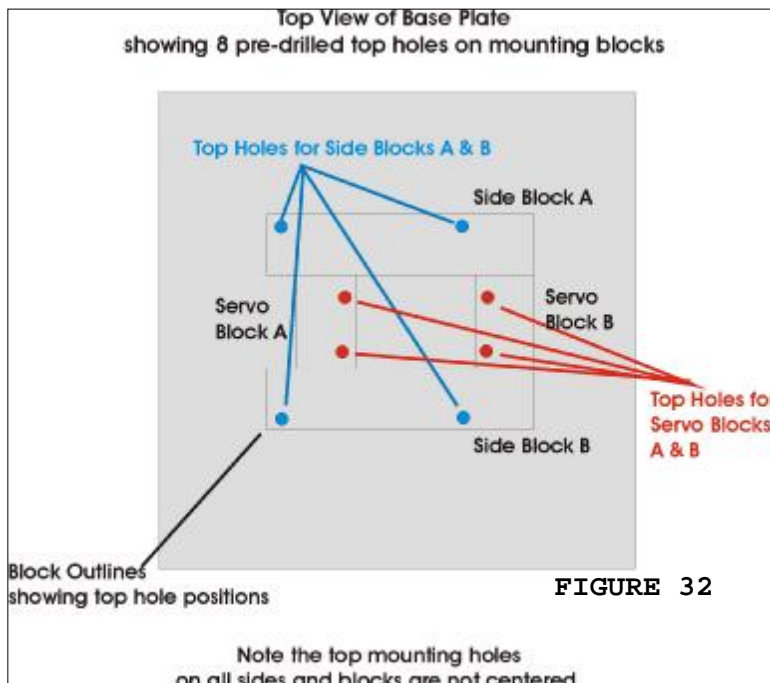
Top View of Base Plate  
 showing 8 pre-drilled bottom holes for mounting blocks



Side blocks A and B are secured to the base using four #4 - 3/4" wood screws, see figure 31. The bottom holes are aligned as shown in figure 32.

FIGURE 31

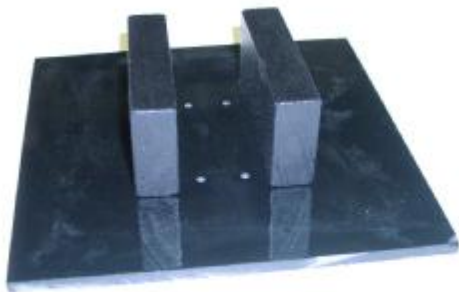
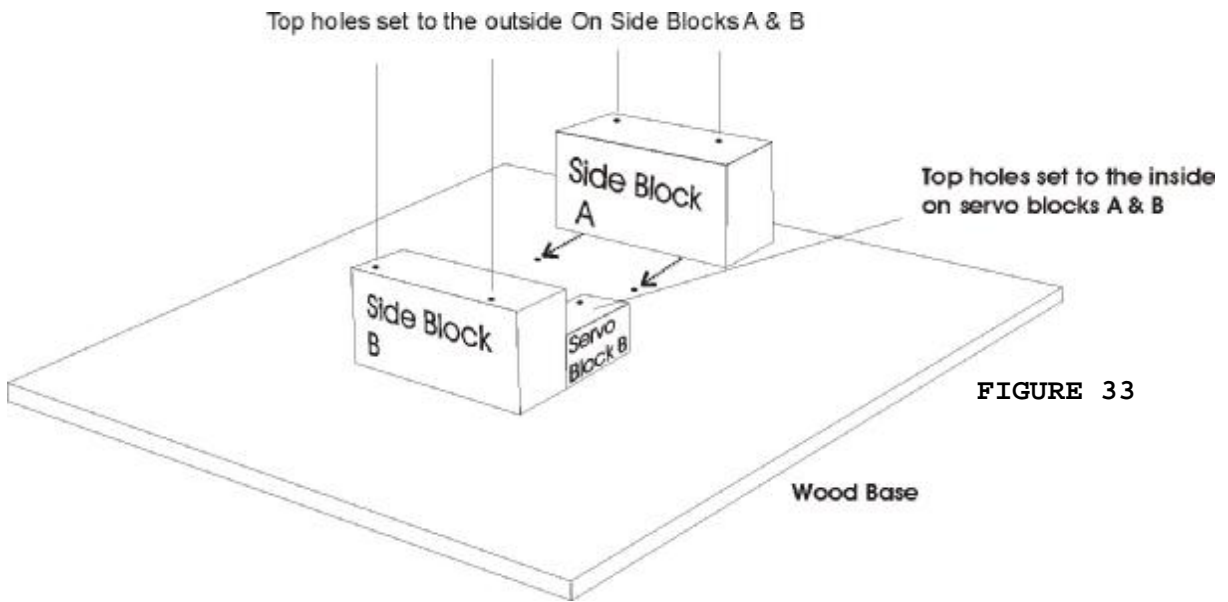
Note the bottom mounting holes on all sides and blocks are centered.



The top holes of side blocks A and B are set to the outside, see figures 32 and figure 33. When the holes are properly aligned secure the sides to the base using the four #4 - 3/4" wood screws.

FIGURE 32

Note the top mounting holes on all sides and blocks are not centered.



At this point the base should appear as in figure 34.

FIGURE 34

Next we secure servo block B to the base. Taking care to align the bottom holes so that the top holes are closest to the center of the 7" base, see figure 32. The base should now appear as shown in figure 35. Do not tighten down Servo Block B, leave it a little loose. This will help when securing the servomotor.

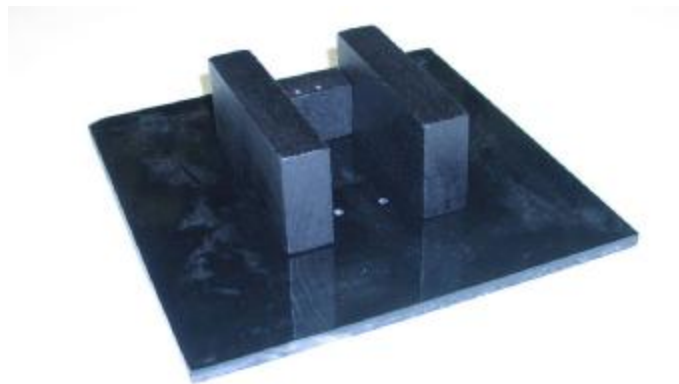


FIGURE 35

**FIGURE 36**



Now place the HS-422 servomotor inside the base. Place servo block A so that the servomotor wires pass through the bottom arch, see figure 36, keeping the top holes facing toward the center of the base. Secure servo blocks A to the base using two #4-3/4" wood screws. Do Not tighten servo block A to the base leave it loose. Next secure the HS-422 servo motor to servo

blocks A and B using (4) #4 x 1/2" brass wood screws. Once the servomotor is attached, gently tighten down both servo motor blocks A and B to the base. DO NOT OVERTIGHTEN SCREWS.

**FIGURE 37**



Next we will attach the top bearing plate to the base, see figure 37 bottom view. The horn on the bottom of the top bearing plate assembly will be aligned and fit into the shaft of the base HS-422 servomotor. Position the servomotor to mid position using the SMC-05 servomotor controller. Place the bearing plate assembly on top of the base. Making sure to align the bottom horn to the servomotor. Secure the bearing to the base using four; #4-3/8" brass wood screws, see figure 38.

**FIGURE 38**

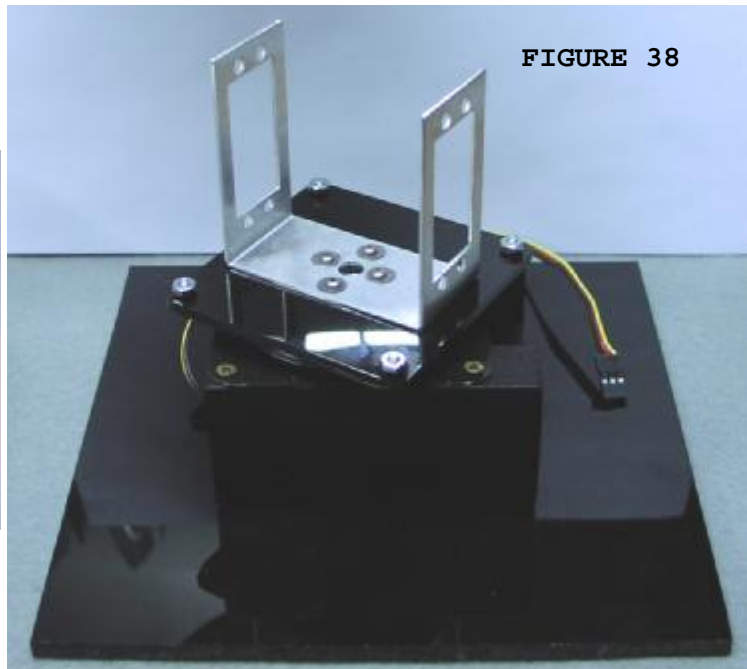




FIGURE 39



FIGURE 40

The next step, remove servo motor horns from two HS-645 servo motors see figure 39. Save the servo motor screws and washers for later. Then attach two HS-645 Hi-Tec servo motors to servo motor bracket D using (8) plastic pop rivets, see figure 40.

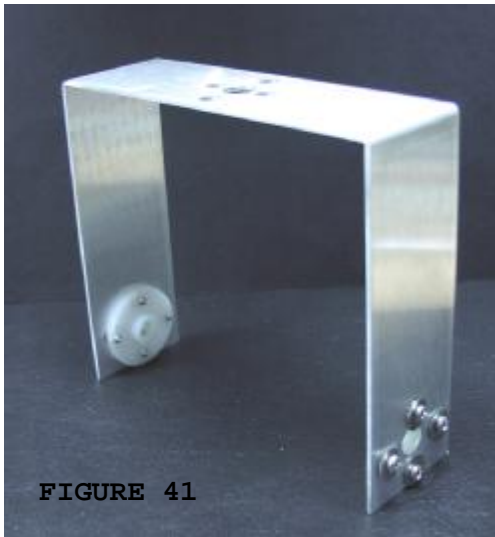
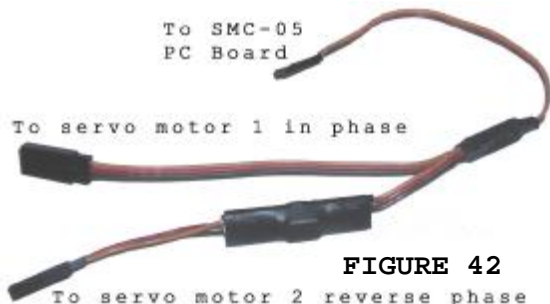


FIGURE 41



FIGURE 41

Attach the two servo motor horns removed from the servo motors in the last step and attach them to bracket E. Attach the horns to the bracket using (8) #2 x 1/4" long and (8) flat washers as shown in figure 41 and 42. **VERY IMPORTANT: Do not tighten the servo motor horns to the E bracket. Leave them loose so that they can move and rotate freely within the confines of the screw holes. This is important and is necessary to properly attach this bracket to the servo motors in the next step.**



**FIGURE 42**

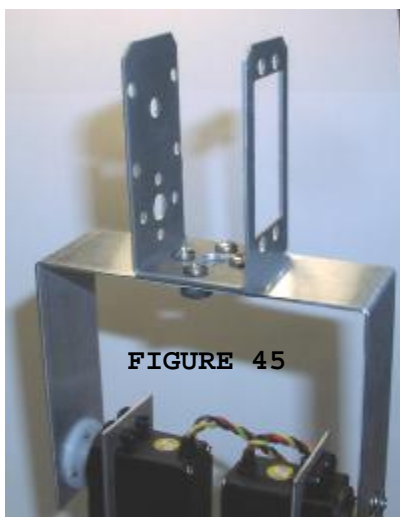
Servo motor reverser, see figure 42, has a standard "J" connector. Fits inline between servo motor controller board and "Y" connector to two servo motors. When installed one servo motor will move in the opposite direction of the other. When installed to the two servomotors in the "D" bracket, will keep servo motors working in unison. Before attaching bracket E to the servo motors on bracket D set the servo motors to their center position using the SMC-05 servo motor controller and the servomotor reverser. Attach the servo motor reverser to the number "2" servo motor header on the PC board. Then attach the opposite ends of the reverser to the HS-645 servo motors on the "D" bracket. Apply power to the SMC-05. This will center the servo motors. Next attach the "E" bracket to the "D" bracket servo motors. Insert the servo motor horns on the "E" bracket onto the shafts of the "D" bracket servomotors.



**FIGURE 43**



**FIGURE 44**



**FIGURE 45**

Next place the center servo motor screws, see figure 39, that will lock the servo motor horns to the servo motors.

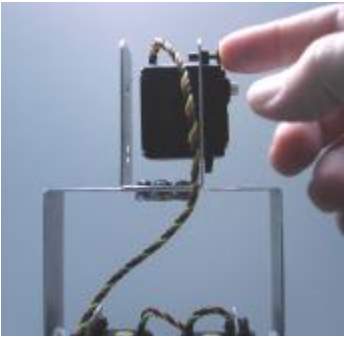
Next, attach an "A" bracket to the top of the "E" bracket using (4) 3-48 x 3/8 long machine screws with #4 split lock washers and nuts, see figures 45 and 46.

The servo motor horns should still be only loosely attached to the "E" bracket. The "E" bracket should be loosed enough to move back and forth slight as shown in figures 43 and 44. The reason that this is necessary is so that we can tighten the "E" bracket on to the servo motors without having the two "D" bracket servo motors fight against one another. At this point, keep the power applied to the servo motors and gently tighten the (8) #2 screws holding the servo motor horns to the "E" bracket. Next place the center servo motor screws, see figure



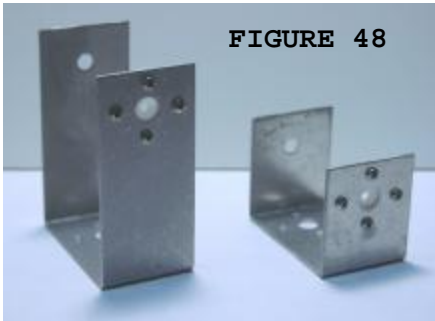
**FIGURE 46**

**FIGURE 47**



Attach a Hi-Tec HS-645 servo motor to the "A" bracket, secured to the "E" bracket, see figure 47, using four plastic pop rivets.

**FIGURE 48**



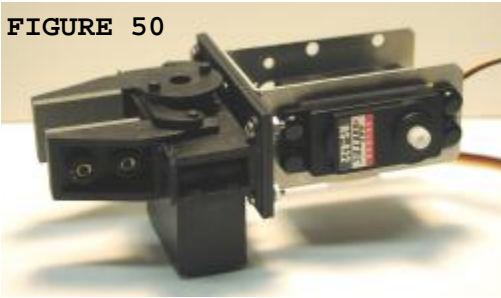
Next attach round servo motor horns to "B" and "C" brackets, see figure 48

**FIGURE 49**



Attach the "B" and "C" brackets together using (4) 3-48 x 1/4" long machine screw with split lock washers and nut, see figure 49.

**FIGURE 50**

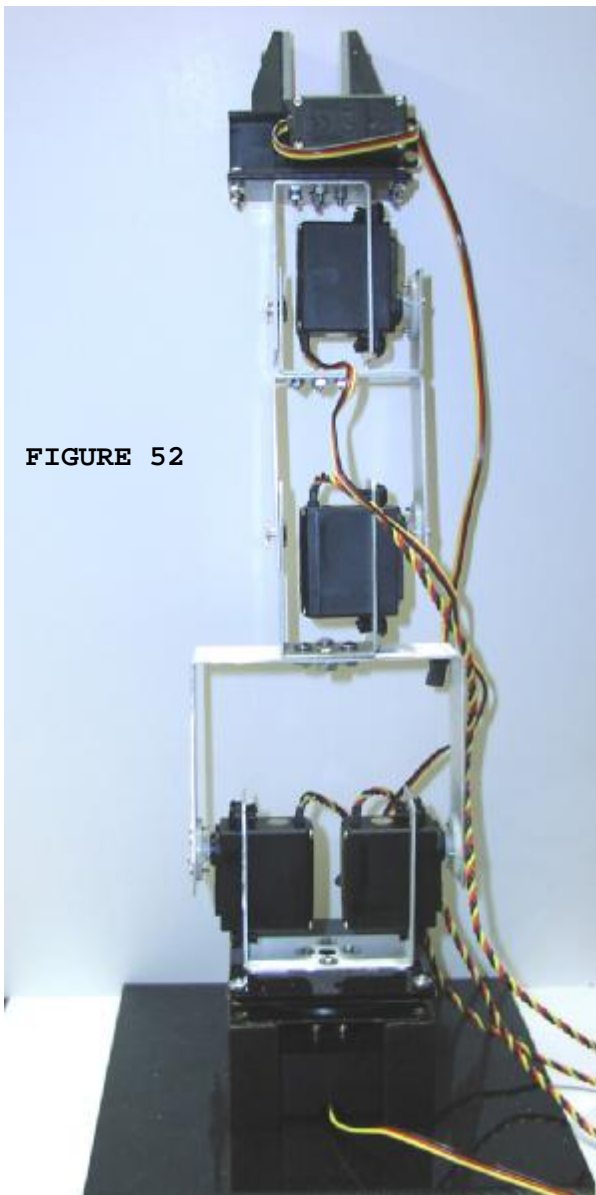


Attach "BC" assembly, figure 49, to gripper assembly, figure 50. Align servomotor horn on "BC" assembly, to servomotor shaft on gripper assembly and attach. Center gripper servomotor before attaching. Next place binding head post and screw in back of brackets as shown in figures 7 through 12, see figure 51.

**FIGURE 51**

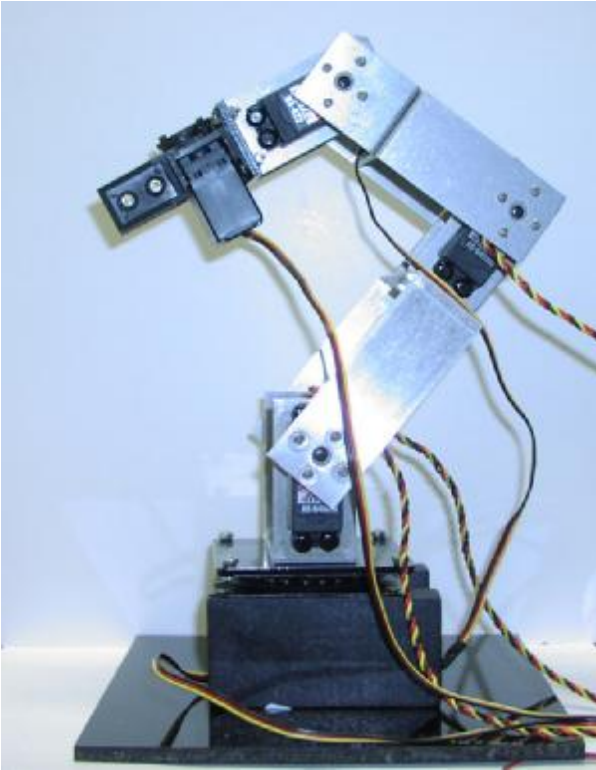


**FIGURE 52**



Attach gripper assembly, figure 51 to the HS-645 servomotor on the "E" bracket, figure 45. Center the HS-645 servo motor before attaching the servo motor horn on the gripper assembly to the HS-645 shaft. Next attach binding head post and screw and shown in figures 7 through 12 to back of servo motor brackets, see figure 52.

## Connection to Five-Servomotor Controller



There are five servo motor extensions; (2) 12 inch long and (3) 6 inch long. The two longer extension are used on the top two servo motors. The balance on the bottom servo motors.

To wire the robotic arm's servo motors to the controller attach 6" extensions to SMC-05 servo motor headers numbered 1,2 and 3. Next attach 12" extensions to servo motor headers 4 and 5.

Starting with the bottom in the base servomotor (HS-422), we work our way up the robotic arm consecutively. So connect base servomotor to servo motor position 1's extension cable. Next attach servo motor reverser to position 2's cable. Attach the two HS-645 "D" bracket shoulder servo motors to the other ends of the reverser. Elbow (HS-645) gets connected to position 3's cable. Wrist servomotor (HS-422) connects to position 4's cable. And the top gripper servo motor (HS-322) connects to position 5's cable.

Apply power to the servomotor controller board. The servomotor controller may be operated from a standard 9 volt battery. The battery is okay for low power applications like centering the servo motors. To operate the robotic arm you need more power than what can be supplied from the 9V transistor battery, so use the AC adapter

The servomotor controller has two operating modes; manual mode and a Windows PC computer control. As shown in part 1

### Fast - Slow Speed Selection

On the servomotor controller board there is a jumper you can set to fast or slow mode. Set the jumper to slow mode. In fast mode the robotic arm will move too quickly for precise control.

## **Save Servo Motors Position**

You can "save" the five servomotors current position by pressing the "save" button. The saved position will be the position the servomotors will go to when the five-servo motor controller is turned on.

### **Finishing Up:**

After you have successfully tested the robotic arm, its time to finish the project. Use wire ties to hold the servomotor cables to the body of the robotic arm. Be sure to leave enough slack in the wires so that the robotic arm can move through its full range unimpeded.

### **Going Further**

As the robotic arm stands here are the general specifications:

<b>Five Axis of Motion:</b>	<b>Approximate Range of Motion</b>
Base Rotation	160 degrees
Shoulder moving range	160 degrees
Elbow moving Range	160 degrees
Wrist Range	160 degrees
Gripper Open & Close	32mm ( 1.25")
Lifting capacity	12.0 oz.
Height	15.5"
Reach	12"

Part #	Qty
SMC-05	1
SMR-01	1
HS-645MG	3
HS-425BB	2
HS-322HD	1
Bracket-A	2
Bracket-B	1
Bracket-C	1
Bracket-D	1
Bracket-E	1
SG-01	1
SXT-6	3
SXT-12	2
GBP-01	2
P-Base-RA	1
TP-01	1
BG-01	1
SB-A	1
SB-B	1
SDB-A	1
SDB-B	1
Spacer	1
L-Washer	24
#4Washer	14
#2x1/4-SS-Screw	20
BP-3/16	2
#4x3/8-BWS-Screw	5
#4 x3/4-SS-Screw	10
440-5/16-Z-Screw	5
#2x3/8-SS-Screw	5
#4x1/2-BW-Screw	5
Rivet-1/2	18
HN-440-ZP	5
348x1/4-Z-Screw	14
348x3/8-Z-Screw	5
HN-348-Z	20
Bumps-02	4