Dual Bay CNC Plywood Router

Sean Munson

Team members: Matt Hill, Bret Richmond, Jeff Satwicz
Executive Summary

The Dual Bay three-axis CNC Plywood Router makes it possible for wooden boat companies to cut wood panels in sequence without stopping the router bit. Work-piece clamps and datum surfaces ensure a single operator the ability to keep up with the router, while a dust collection system that integrates with the factory’s own systems helps keep the work environment clean. All components were designed or selected for a maximal lifetime of high precision operation.

Implementation of the CNC Router

Structure

The structure is divided into primary segments – the machining carriage that moves in the x-axis and contains the components for movement in the y- and z-axes, as well as the table which supports the plywood and carriage.

The table is a post-and-lintel structure, designed to maximize stiffness, which is required in order to achieve the specified precision for the router. The table measures 9 x 9.5 x 4' and supports an 8’ x 8’ x 3/4” work surface. In addition to steel tubing at the perimeter of the table, two crossbeams are added to increase rigidity and to support the work surface. The table sits on ten eight inch by eight inch legs; each of which has four leveling feet.

The carriage sits above the table and it attached at four points: twice at the ball nuts that control movement in the x-axis and twice on Bishop Wisecarver Utilitrack rails running parallel to the ball screws. The load of the carriage is well below the maximum rating of the screws and Utilitrack system. Alternative designs that would have required a cantilevered carriage were avoided.
because of concerns about stiffness and ability to support the structure.

The carriage is also a post and lintel structure, fabricated of steel tubing and gusseted as necessary to ensure stiffness. The z-axis control and router head hang from the carriage, attached using one Bishop Wisecarver cart and also at a ballnut. Torque is minimized by placing the majority of the z-axis’s mass under the carriage and mounting the ballscrew-ballnut joint off-axis to improve rotational restraint.

**Materials**

Steel was the most commonly used material in the router, primarily for stiffness, and is found in both the machined parts and a number of the COTS parts such as the Nook ball screws and the Bishop WiseCarver rails. Steel also offers numerous advantages over aluminum for construction, in terms of hardness, ease of welding, and cost. Steel’s primary disadvantage – weight – was actually advantageous in this industrial application.

**Fasteners and Joints**

A mix of butt and miter joints were used. The majority joints were welded, including essentially all structural joints. Welded joints resist vibration the resulting gradual decay in tolerances that can be found when using fasteners, a key strength in this high-use, industrial tool, and so the advantages justify the cost.

Components that were determined to possibly require replacement – the servo motors, the router, Utilitrack rails, limit switches, and work surface – were mounted with fasteners that could be quickly changed in order to minimize downtime when replacement becomes necessary. Standard hex head bolts and socket head cap screws were used throughout the machine, with a goal of minimizing the number of different tools required for assembly or maintenance. The design of a few COTS components did not permit the use of washers, but in general, washers and lock-washers were used through the router’s construction. To ensure the security of the fasteners, anywhere that the depth of a component would have been insufficient to ensure at least two diameters of threading (such as on some of the tubing), a plate was welded on and then used to tap into.

**Drive Train and Power Transmission**

Each axis requires at least one actuator. The x- and y-axes use identical servo motors with integrated encoders. Two are used on the x-axis and one on the y-axis. These motors are coupled directly to the shafts of the ball screws using a COTS coupling, requiring no gearing. As the ball screws turn, the force a ballnut – rotationally restrained by the component it drives – to move along the length of the screw. The entire assembly, including ball screw, ballnut, EZMount bearings, and shaft for attachment, is purchased as a unit from Nook Industries to ensure compatibility and performance.

For the z-axis, a Nook CCHD-5368 linear actuator controls movement.
Shafts and Bearings
In order to ensure the required tolerances are met, all shafts and bearings must be properly aligned. On the y-axis, this challenge is largely addressed by mounting the ball screw and the rail to the same piece of structural tubing. On the x-axis, the ball screws are mounted in slotted brackets to permit alignment.

The Nook ball screws have a reputation for performance in industrial settings, as do the Bishop Wisecarver rails, which were selected in part because they are self-clearing and operate within tolerance even with significant sawdust accumulation.

Areas of Responsibility
Top level design was completed as a group; subsystems then became individuals’ responsibilities.

- Matt Hill: Router work surface, x-axis drive systems, and interface with carriage
- Sean Munson: Carriage, y-axis systems, x- and y- drive component selection, and interface with x-axis drive and z-axis unit
- Bret Richmond: Table structure and clamping systems
- Jeff Satwicz: Z-axis Unit
# CNC Router Project

## Project Costing

### Labor

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**Total Labor** $ 4,040.00

**Labor + Overhead** $ 4,848.00

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**Total Materials** $15,234.16

**Projected Cost** $20,082.16

**PC and G&A Fee** -

**Total Project Cost** $20,082.16
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<tr>
<td>10</td>
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<td>1/2&quot; FLAT WASHER</td>
<td>1</td>
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<td>11</td>
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<td>13</td>
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<td>SRC'S 1/4&quot;-20 X 1&quot;</td>
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<td>14</td>
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<td>3/8&quot; FLAT WASHER</td>
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<td>15</td>
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<tr>
<td>16</td>
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<td>SRC'S 3/8&quot;-16 X 1.5&quot;</td>
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<td>18</td>
<td>PB-4-01</td>
<td>Z AXIS POST</td>
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<td>19</td>
<td>PB-4-02</td>
<td>NOOK TO Z POST</td>
<td>1</td>
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<td>PB-4-03</td>
<td>NOOK TO Z POST GUSSET</td>
<td>1</td>
</tr>
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<td>21</td>
<td>PB-4-04</td>
<td>ROUTER GRIP FLEXURE</td>
<td>2</td>
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<td>22</td>
<td>PB-4-05</td>
<td>CART TO ROUTER PLATE</td>
<td>1</td>
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<td>23</td>
<td>PB-4-06</td>
<td>NOOK TO ROUTER PLATE</td>
<td>1</td>
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<td>24</td>
<td>PB-4-07</td>
<td>NOOK TO ROUTER PLATE ATTACHMENT</td>
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<td>25</td>
<td>PB-4-08</td>
<td>POST-BALLNUT</td>
<td>1</td>
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<td>26</td>
<td>PB-4-09</td>
<td>POST TO XY CART</td>
<td>1</td>
</tr>
<tr>
<td>27</td>
<td>PB-4-10</td>
<td>VACUUM HOSE MOUNT</td>
<td>1</td>
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<tr>
<td>28</td>
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<td>VACUUM HOSE MOUNT</td>
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</table>

ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5 -1994

TO TOLERANCES UNLESS OTHERWISE SPECIFIED:

XX ± .03  <±.5°
XXX ± .01
X.XXX ± .005 125°

REMOVE ALL BURRS AND SHARP EDGES .015" R OR CHAMFER MAX
WELD SUPPORTS TO Z AXIS POST

Z-AXIS POST

ITEM NO. Number DESCRIPTION ZPost/QTY.
1 LINEAR BEARING 1
2 LINEAR BEARING CART 1
3 NOOK LINEAR ACTUATOR 1
4 COTTER PIN 1
5 SPRING 1
6 1" FLAT WASHER 1
7 1/2" CLEVIS PIN 1
8 1/2" FLAT WASHER 1
9 1/4" FLAT WASHER 1
10 3/8" FLAT WASHER 4
11 SHCS 3/8"-16 X 1" 8
12 SHCS 1/4"-20 X 1" 5
13 PB-4-01 Z AXIS POST 1
14 PB-4-02 NOOK TO Z POST 1
15 PB-4-03 NOOK TO Z POST GUSSET 1
16 PB-4-08 ZPOST BALLNUT 1
17 PB-4-09 ZPOST TO XY CART 1
<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>Number</th>
<th>DESCRIPTION</th>
<th>Carriage/QTY.</th>
</tr>
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<tbody>
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<td>SHOP VAC HOSE</td>
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<td>2</td>
<td>LINEAR BEARING CART XY</td>
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</tr>
<tr>
<td>3</td>
<td>COTTER PIN</td>
<td>1</td>
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<td>4</td>
<td>DEWALT ROUTER</td>
<td>1</td>
<td></td>
</tr>
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<td>5</td>
<td>SPRING</td>
<td>1</td>
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</tr>
<tr>
<td>6</td>
<td>1&quot; FLAT WASHER</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1/2&quot; CLEVIS PIN</td>
<td>1</td>
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</tr>
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<td>8</td>
<td>1/2&quot; FLAT WASHER</td>
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<td>9</td>
<td>1/4&quot; FLAT WASHER</td>
<td>2</td>
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<tr>
<td>10</td>
<td>3/8&quot; FLAT WASHER</td>
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<td>3/8&quot; LOCK WASHER</td>
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<td>SHCS 3/8&quot;-16 X 1&quot;</td>
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<td>13</td>
<td>SHCS 3/8&quot;-16 X 1.5&quot;</td>
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<td>PB-4-04 ROUTER GRIP FLEXURE</td>
<td>2</td>
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<td>15</td>
<td>PB-4-05 CART TO ROUTER PLATE</td>
<td>1</td>
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<td>16</td>
<td>PB-4-06 NOOK TO ROUTER PLATE</td>
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</tr>
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<td>17</td>
<td>PB-4-07 NOOK TO ROUTER PLATE ATTACHMENT</td>
<td>2</td>
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<td>18</td>
<td>PB-4-10 VACUUM HOSE MOUNT</td>
<td>1</td>
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</tr>
</tbody>
</table>
NOTES, UNLESS OTHERWISE SPECIFIED

1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 2" X 4" X 1/8" RECTANGULAR TUBING

ALL DIMENSIONS ARE IN INCHES - INTERPRET DRAWING PER ASME Y14.5-1994

REMOVE ALL BURRS AND SHARP EDGES. 0.015 R OR CHAMFER MAX.

TOLERANCES UNLESS OTHERWISE SPECIFIED:

X.X  .03
X.XX  .01
X.XXX  .005
± .5°

APPROVED DATE

PREP BY J. SATWICK
CHECKED
RESP ENG
MECH ENG
QUAL ENG

SCALE 1:8
WT 10.3049
SHEET 1 OF 1

Z-AXIS POST
1020 CARBON STEEL
2"X4"X0.065" RECT TUBE

C  PB-4-01  -

125°
NOTES, UNLESS OTHERWISE SPECIFIED:

1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 1" X 1" X 0.065" SQUARE TUBE

ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5 - 1994

REMOVE ALL BURRS AND SHARP EDGES. 0.15 R OR CHAMFER MAX

TOLERANCES UNLESS OTHERWISE SPECIFIED:

XX ± .03  ± 5°
XXX ± .01
X.XXX ± .005  125°

NOTES, UNLESS OTHERWISE SPECIFIED:

1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 1" X 1" X 0.065" SQUARE TUBE
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 1" X 1" X 0.065" SQUARE TUBING

NOTES, UNLESS OTHERWISE SPECIFIED

1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 1" X 1" X 0.065" SQUARE TUBING
NOTES, UNLESS OTHERWISE SPECIFIED

1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: ¼ PLATE

ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5 - 1994

TOLERANCES UNLESS OTHERWISE SPECIFIED:
XX ± .03  ± 5°
XXX ± .01
X.XXX ± .005  125°

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: ¾" PLATE
NOTES UNLESS OTHERWISE SPECIFIED:

1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: ¾" PLATE

ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5-1994

REMOVE ALL BURRS AND SHARP EDGES. 0.015 R OR CHAMFER MAX

TOLERANCES UNLESS OTHERWISE SPECIFIED:

XX ± 0.03
XXX ± 0.01
X.XXX ± 0.005

± 5°

125°

SCALE: 1:2
WT: 11.0663
SHEET 1 OF 1

NOOK TO ROUTER PLATE
Alloy Steel
0.75" PLATE

APPROVED DATE
PREP BY
CHECKED
RESP ENG
MFG ENG
QUAL ENG
SIZE
SCALE
FSCM NO.
PART NO.
WT
PART REV
SHEET
NO.

PB-4-06
1.25" R OR CHAMFER MAX

(CRITICAL DIMENSION)
ALL DIMENSIONS ARE IN INCHES - INTERPRET DRAWING PER ASME Y14.5 - 1994

1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: ¾" PLATE

NOTES, UNLESS OTHERWISE SPECIFIED:
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: ¾" PLATE

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

APPROVED DATE
PREP BY     CHECKED     RESP ENG     MFG ENG     QUAL ENG
J. SATWICZ  12.9.2004

PB-4-07

NOOK TO ROUTER PLATE ATTACHMENT
Alloy Steel
0.75" PLATE

SCALE 1:1  WT 1.1900  SHEET 1 OF 2
NOTES, UNLESS OTHERWISE SPECIFIED:
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 0.125" SHEET

ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5-1994

REMOVE ALL BURRS AND SHARP EDGES. 0.15 R OR CHAMFER MAX

NOTES, UNLESS OTHERWISE SPECIFIED
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 0.125" SHEET

ZPOST-BALLNUT
Alloy Steel
0.125" SHEET
NOTES, UNLESS OTHERWISE SPECIFIED

1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: ¾" PLATE

ALL DIMENSIONS ARE IN INCHES - INTERPRET DRAWING PER ASME Y14.5 - 1994

REMOVE ALL BURRS AND SHARP EDGES. 015 R OR CHAMFER MAX

MATERIAL: PLAIN CARBON STEEL
STOCK SIZE: ¾" PLATE
2.500
2X .281 .750
120.00°
119°
2.604
5.948
6.472
10.575
9.825
0
1.354
1.604
3.604
3.854
6.104
10.527
1.364
1.604
3.604
3.854
6.104
7.952
3X 7.452
6.702
6.452
4.019
120.00°
10.575
9.825
4.019
6.452
7.452
3.702
0
0
2.604
5.948
2X Ø .281 ¥ .750
10.575
2X Ø .281 ¥ .750
2X Ø .281 ¥ .750
10.575
2X Ø .281 ¥ .750

ALL DIMENSIONS ARE IN INCHES - INTERPRET DRAWING PER ASME Y14.5 - 1994

TO CONVENIENCE UNLESS OTHERWISE SPECIFIED:
XX ± .03
XXX ± .01
X.XXX ± .005

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

VACUUM HOSE MOUNT
Alloy Steel
0.075" SHEET

MATERIAL: PLAIN CARBON STEEL
STOCK SIZE: 0.075" SHEET (14 GAUGE)
**ITEM NO. PART NUMBER DESCRIPTION QTY.**

1. WorkSurface  WORK SURFACE  2
2. JoiningDatum  REAR DATUM SURFACE  1
3. SideDatum  Side Datum Surface for Plywood Router  2
4. L2x2x0.25x92 ANGLE IRON MOUNTING BRACKET  4
5. SPC 100P  Carr Lane Small Side Clamps  4
6. HX-SHCS 0.19-24x1x1-N SHCS 10-24x1.00 - Clamps  16
7. HX-SHCS 0.25-20x0.75x0.75-N SHCS 0.25"-20x0.75 - Slotted Bracket  36
8. HX-SHCS 0.25-20x1.25x1.25-N SHCS 0.25-20x1.25 - Datum Surfaces  76
9. FW 0.25  0.25" Regular Flat Washer  76
10. FW 0.25  0.25" Wide flat washer for slotted bracket  36
11. LW 0.25  0.25" Regular Lock Washer  112

**REMOVE ALL BURRS AND SHARP EDGES**

**SCALE**

**APPROVED** 12/13/04

**PREP BY**

**CHECKED**

**RESP ENG**

**ALL DIMENSIONS ARE IN INCHES - INTERPRET DRAWING PER ASME Y14.5-1994**

**TOLERANCES UNLESS OTHERWISE SPECIFIED:**

± 0.5°

± 0.03

± 0.01

± 0.005
NOTES, UNLESS OTHERWISE SPECIFIED
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 108"X57"X0.75"

ALL DIMENSIONS ARE IN INCHES- INTERPRET DRAWING PER ASME Y14.5 -1994
TOLERANCES UNLESS OTHERWISE SPECIFIED:
XX ± .03 ± .05°
XXX ± .01
X.XXX ± .005

WORK SURFACE

REV. 1

PB-3-01

1300.7560

1:16

1 OF 2
NOTES, UNLESS OTHERWISE SPECIFIED
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 108" x 8" x 0.5" PLATE

ALL DIMENSIONS ARE IN INCHES - INTERPRET DRAWING PER ASME Y14.5 - 1994

REMOVE ALL BURRS AND SHARP EDGES. 0.015 R OR CHAMFER MAX

TOLERANCES UNLESS OTHERWISE SPECIFIED:
XX ± .03
XXX ± .01
X.XXX ± .005

45.00°
NOTES UNLESS OTHERWISE SPECIFIED

1. MATERIAL: PLAIN CARBON STEEL

2. STOCK SIZE: 4"x53.5"x0.5" Bar Stock

ALL DIMENSIONS ARE IN INCHES - INTERPRET DRAWING PER ASME Y14.5 -1994

REMOVE ALL BURRS AND SHARP EDGES. 0.015 R OR CHAMFER MAX.

X.X ± .03  ± 5°
XXX ± .01
X.XXX ± .005  ± 125°

NOTES, UNLESS OTHERWISE SPECIFIED

1. MATERIAL: PLAIN CARBON STEEL

2. STOCK SIZE: 4"x53.5"x0.5" Bar Stock
1. MATERIAL: PLAIN CARBON STEEL
2. SIDE SIZE: 7"x7"x0.50" Plate

Chamfer All Edges 0.0625" Front, back

45.00°

ALL DIMENSIONS ARE IN INCHES - INTERPRET DRAWING PER ASME Y14.5 - 1994

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

NOTES, UNLESS OTHERWISE SPECIFIED
1. MATERIAL: PLAIN CARBON STEEL
2. SIDE SIZE: 7"x7"x0.50" Plate
NOTES, UNLESS OTHERWISE SPECIFIED:
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 2" X 2" X ¼" Angle Iron

ALL DIMENSIONS ARE IN INCHES: INTERPRET DRAWING PER ASME Y14.5-1994

TO LE RANCES UNLESS OTHER WISE SPECIFIED:
XX ± .03  ± 5°
XXX ± .01
X.XXX ± .005  125°

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

NOTE: CRITICAL DIMENSION

MATT HILL 12/13/04

ANGLE IRON MOUNTING BRACKET

PB-3-05

23.9886

1  OF  2
NOTE: All holes 3/8"-16 THRU. Hole spacing is 9.843 in, which is equivalent to 250mm.

MATERIAL: PLAIN CARBON STEEL

DETAIL A
SCALE 1:1

DETAIL B
SCALE 1:1

ALL DIMENSIONS ARE IN INCHES - INTERPRET DRAWING PER ASME Y14.5-1994

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

TOOL RACES UNLESS OTHERWISE SPECIFIED:
XX ± .03  ± 5°
XXX ± .01
X.XXX ± .005  125°

= (CRITICAL DIMENSION)

ALL DIMENSIONS ARE IN INCHES - INTERPRET DRAWING PER ASME Y14.5-1994

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

TOOL RACES UNLESS OTHERWISE SPECIFIED:
XX ± .03  ± 5°
XXX ± .01
X.XXX ± .005  125°

= (CRITICAL DIMENSION)
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 3/16" STEEL PLATE

NOTES UNLESS OTHERWISE SPECIFIED:

1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 3/16" STEEL PLATE

ALL DIMENSIONS ARE IN INCHES - INTERPRET DRAWING PER ASME Y14.5-1994

TO BE INCLUDE UNLESS OTHERWISE SPECIFIED:

XX ± .03 ∆ ± 5°
XXX ± .01
X.XXX ± .005 125°

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

60.000°
MATERIAL: PLAIN CARBON STEEL

X-Y SERVO MOUNTING BRACKET

ALL DIMENSIONS ARE IN INCHES - INTERPRET DRAWING PER ASME Y14.5-1994

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

TO TOLERANCES UNLESS OTHERWISE SPECIFIED:

± .03 ± 5°

± .01

± .005 125°

Franklin W. Olin College of Engineering

APPROVED DATE
PREP BY MATTHEW 12/13/04
CHECKED
MFG ENG
RESP ENG
QUAL ENG
SCALE 1:1

PART NO. PB-3-07 SHEET 1 OF 2

WT 2.1498

FSCM NO. PART REV
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 8 X .25 SQUARE TUBING

ALL DIMENSIONS ARE IN INCHES - INTERPRET DRAWING PER ASME Y14.5 - 1994

REMOVE ALL BURRS AND SHARP EDGES

.015 R OR CHAMFER MAX

TOLERANCES UNLESS OTHERWISE SPECIFIED:
XX ± .03 ± .5°
XXX ± .01
X.XXX ± .005

125

± .5°

APPROVED DATE
PREP BY
CHECKED
RESP ENG
MFG ENG
QUAL ENG
SIZE

SCALE: 1:3

DOC REV
FSCM NO. PART NO.
WT
PART REV
SHEET
OF

TABLE POST
CNC ROUTER TABLE

Franklin W. Olin College of Engineering

B. RICHMOND 12/10/04

PART NO.
PB-2-01

REV ZONE DESCRIPTION APPROVED DATE
- INITIAL RELEASE
NOTES, UNLESS OTHERWISE SPECIFIED

1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 8 X .25 SQUARE TUBING
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 4 X 8 X .25 RECTANGULAR TUBING

ALL DIMENSIONS ARE IN INCHES - INTERPRET DRAWING PER ASME Y14.5-1994

TOLERANCES UNLESS OTHERWISE SPECIFIED:
XX ± .03 ± 5°
XXX ± .01
X.XXX ± .005 125

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

CNC ROUTER TABLE

TOL. LATERAL MEMBER

PREP BY B. RICHMOND 12/10/04

NOTES, UNLESS OTHERWISE SPECIFIED
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 4 X 8 X .25 RECTANGULAR TUBING
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 4 X 8 X .25 RECTANGULAR TUBING

ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5 - 1994

TO LEARANCES UNLESS OTHERWISE SPECIFIED:

XX ± .03 ± 5°
XXX ± .01
X.XXX ± .005 125°

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

MFG ENG
QUAL ENG
SIZE
FSCM NO.
PART NO.
WT
PART REV
SHEET
OF

TOP CROSS MEMBER
CNC ROUTER TABLE

DOC REV = (CRITICAL DIMENSION)
ALL DIMENSIONS ARE IN INCHES - INTERPRET DRAWING PER ASME Y14.5 - 1994

NO TOLERANCES UNLESS OTHERWISE SPECIFIED:

XX ± .03  ± 5°
XXX ± .01
X.XXX ± .005

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 4 X .25 SQUARE TUBING

MFG ENG
QUAL ENG
RESP ENG
CHECKED
PREP BY
B. RICHMOND 12/10/04

PB-2-04
93.0459
1
1

[Table of Specifications]

[Diagram of Cross Member]
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: .25 PLATE

ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5-1994

TOLERANCES UNLESS OTHERWISE SPECIFIED:

XX ± .03
XXX ± .01
X.XXX ± .005

125° ± .5°

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX.

GUSSET
CNC ROUTER TABLE

PREP BY: B. RICHMOND 12/13/04
CHECKED
REV ENG
RFQ ENG
DUAL ENG

REV ZONE DESCRIPTION APPROVED DATE
- INITIAL RELEASE

NOTES, UNLESS OTHERWISE SPECIFIED

1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: .25 PLATE
FOOTPLATE
CNC ROUTER TABLE

1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: .75 PLATE

ALL DIMENSIONS ARE IN INCHES- INTERPRET DRAWING PER ASME Y14.5-1994

TO LEVANCES UNLESS OTHERWISE SPECIFIED:
XX ± .03 ± 5°
XXX ± .01
X.XXX ± .005 125°

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

063 X 45° TYP

4X Ø .531 THRU

2X .750
2X 9.750
10.500

SCALE 1:2
DOC REV.
PART NO.
PB-2-06
WT 23.0579
SHEET 1 OF 1

APPROVED DATE
PREP BY
CHECKED
RESP ENG
MFG ENG
QUAL  ENG
SIZE
FSCM NO.
PART REV
NOTE, UNLESS OTHERWISE SPECIFIED

- CRITICAL DIMENSION

REV ZONE DESCRIPTION APPROVED DATE
- INITIAL RELEASE

NOTES, UNLESS OTHERWISE SPECIFIED
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: .75 PLATE
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 0.5 PLATE

ALL DIMENSIONS ARE IN INCHES - INTERPRET DRAWING PER ASME Y14.5 - 1994

REMOVE ALL BURRS AND SHARP EDGES. 0.015 R OR CHAMFER MAX

BALLSCREW TABLE MOUNT
VERTICAL SLOTS
CNC ROUTER TABLE

B. RICHMOND
12/13/04
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 4 X .75 BAR

ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5 -1994

TOificate UNLESS OTHERWISE SPECIFIED:
XX ± .03 ± .5°
XXX ± .01
X.XXX ± .005

REMOVE ALL BURRS AND SHARP EDGES .012 R OR CHAMFER MAX

Franklin W. Olin College of Engineering

Y-AXIS TR A C K M O U N T PL A T E
CNC ROUTER TABLE

PB-2-09
NOTES:
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 0.125 SHEET METAL

ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5 -1994

TOLERANCES UNLESS OTHERWISE SPECIFIED:
XX ± .03
XXX ± .01
X.XXX ± .005

REMOVE ALL BURRS AND SHARP EDGES
.015 R OR CHAMFER MAX

REV. ZONE DESCRIPTION
APPROVED DATE

PREP BY: B. RICHMOND 12/13/04

QUAL ENG
MFG ENG
RESP ENG
DUAL ENG

SHEET 1 OF 1
SCALE 1:1
PART NO. PB-2-10
WT 0.4281
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: .75 ROUND BAR

ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5-1994

TOLERANCES UNLESS OTHERWISE SPECIFIED:

XX ± .03
XXX ± .01
X.XXX ± .005

± .5°

0.015 R OR CHAMFER MAX

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

PART NO. PB-2-11

SHEET 1 OF 2

SCALE 2:1

WT 0.1627
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 0.125 SHEET METAL

ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5-1994

TO BE USED UNLESS OTHERWISE SPECIFIED:

- MATERIAL: PLAIN CARBON STEEL
- STOCK SIZE: 0.125 SHEET METAL

TOLERANCES UNLESS OTHERWISE SPECIFIED:
- XX ± .03
- XXX ± .01
- X.XXX ± .005

± .5°

REMOTE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX
1. MATERIAL: PLAIN CARBON STEEL
2. STOCK SIZE: 0.125 SHEET METAL

All dimensions are in inches. Interpret drawing per ASME Y14.5 -1994.

TOLERANCES UNLESS OTHERWISE SPECIFIED:
- XX ± .03 ± 5°
- XXX ± .01
- XXXX ± .005 125°

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX.

All dimensions are in inches. Interpret drawing per ASME Y14.5 -1994.

TOLERANCES UNLESS OTHERWISE SPECIFIED:
- XX ± .03 ± 5°
- XXX ± .01
- XXXX ± .005 125°

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX.

All dimensions are in inches. Interpret drawing per ASME Y14.5 -1994.

TOLERANCES UNLESS OTHERWISE SPECIFIED:
- XX ± .03 ± 5°
- XXX ± .01
- XXXX ± .005 125°

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX.

All dimensions are in inches. Interpret drawing per ASME Y14.5 -1994.

TOLERANCES UNLESS OTHERWISE SPECIFIED:
- XX ± .03 ± 5°
- XXX ± .01
- XXXX ± .005 125°

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX.
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<th>ITEM NO.</th>
<th>PART NUMBER</th>
<th>DESCRIPTION</th>
<th>QTY.</th>
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<td>PB-2-01</td>
<td>TABLE POST</td>
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<td>PB-2-02</td>
<td>TOP LATERAL MEMBER</td>
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<td>PB-2-03</td>
<td>TOP CROSS MEMBER</td>
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<td>PB-2-06</td>
<td>FOOT PLATE</td>
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<td>Y-AXIS TRACK MOUNT PLATE</td>
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<td>10</td>
<td>PB-3-04</td>
<td>SCREW MOUNTING PLATE GUSSET</td>
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<td>CLAMP ASSEMBLY</td>
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<td>CL-8-SLF</td>
<td>1/2-13 STUD LEVELING FOOT</td>
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<td>13</td>
<td>MM91251A624</td>
<td>3/8-16 X 1 1/4SHCS</td>
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<td>14</td>
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<td>1/2-13 HEX NUT</td>
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<td>BWC-UTCTPA3-3165-55</td>
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</table>

**NOTE:**
- All dimensions are in inches. Interpret drawing per ASME Y14.5-1994.
- Remove all burrs and sharp edges. 0.125 X 45° or chamfer max.
- ±0.03
- ± 0.01
- ±0.005

**APPROVED:**
- PREP BY: B. Richmond 12/13/04
- CHECKED: 12/13/04
- MFG ENG
- QUAL ENG
- SIZE
- SCALE 1:16
- FSCM NO. PXA-3-3165-55
- PART NO. PB-A-2-01
- PART REV.
- DOC REV.
- SHEET 1 OF 1

**TABLE STRUCTURE**
- CNC ROUTER TABLE
- Franklin W. Olin College of Engineering
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<td>1/4-20 X 4 SQUARE NECK CARRIAGE BOLT</td>
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ALL DIMENSIONS ARE IN INCHES - INTERPRET DRAWING PER ASME Y14.5 - 1994

TO TOLERANCES UNLESS OTHERWISE SPECIFIED:

- XX ± .03
- XXX ± .01
- X.XXX ± .005
- ± .5°
- \( \pm 5' \)

REMOVE ALL BURRS AND SHARP EDGES.015 R OR CHAMFER MAX
### Table of Parts

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### Notes

- All dimensions are in inches, interpret drawing per ASME Y14.5-1994
- Tolerances unless otherwise specified:
  - XX ± 0.03
  - XXX ± 0.01
  - XXXX ± 0.005
- ± 0.5°
- All edges are rounded at 0.015 max with 0.015 R or chamfer.
- Remove all burrs and sharp edges with 0.015 R or chamfer max.

### Detail B
- Opposite Side Symmetric

### Detail A
- SCALE 1 : 4
ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5-1994

TO LEAKANCES UNLESS OTHERWISE SPECIFIED:

XX ± .03  ± .5°
XXX ± .01
X.XXX ± .005

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

TOP PLATE XAXIS G RIPS
Plain Carbon Steel
3/8" STOCK

DOC REV = (CRITICAL DIMENSION)
ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5-1994

TO LEAVES UNLESS OTHERWISE SPECIFIED:
XX ± .03 \( \pm 5^\circ \)
XXX ± .01
X.XXX ± .005 \( 125^\circ \)

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

BALL SCREW MOUNTING BLOCK
Alloy Steel
3/4" STOCK

SEAN MUNSON
12.11.2004

DOC REV = (CRITICAL DIMENSION)
ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5-1994

TO ERANCES UNLESS OTHERWISE SPECIFIED:

XX ± .03 ± .5°
XXX ± .01
X.XXX ± .005

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

CARTBOX INSERT
Alloy Steel
1/2" STOCK

SEAN MUNSON
12.11.2004
ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5-1994

REMOVE ALL BURRS AND SHARP EDGES. (.015 R OR CHAMFER MAX)

TOLERANCES UNLESS OTHERWISE SPECIFIED:

XX ± .03  ± .5°
XXX ± .01  125°
X.XXX ± .005

SEAN MUNSON  12.13.2004

X-AXIS CARRIAGE BOX SIDE
Alloy Steel
1/2" STOCK
ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5 - 1994

TO ERRANCES UNLESS OTHERWISE SPECIFIED:
XX ± .03  ± .5°
XXX ± .01
X.XXX ± .005

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

END PLATE X AXIS
Plain Carbon Steel
1/4" STOCK
All dimensions are in inches. Interpret drawing per ASME Y14.5-1994.

Remove all burrs and sharp edges. .015 R or chamfer max.

Tolerances unless otherwise specified:

XX ± .03
XXX ± .01
X.XXX ± .005

± .5°

CARRIAGE HOLDER TOP/BOT
Alloy Steel
1/2" STOCK

APPROVED DATE
PREP BY SEAN HUNSDON 12.13.2004
CHECKED
RESP ENG
MFG ENG
QUAL ENG
SIZE SCALE: 1:1.5
PART NO. PB-1-10
DOC REV
ALL DIMENSIONS ARE IN INCHES - INTERPRET DRAWING PER ASME Y14.5-1994

REMOVE ALL BURRS AND SHARP EDGES. 0.015 R OR CHAMFER MAX

TOLERANCES UNLESS OTHERWISE SPECIFIED:
XX ± .03  ± .05°
XXX ± .01
X.XXX ± .005  ± .025

1/2" STOCK

GUSSET FOR UPRIGHTS
Plain Carbon Steel

1/2" STOCK

SEAN MUNSON 12/13/2004

DOC REV = (CRITICAL DIMENSION)
ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5-1994

REMOVE ALL BURRS AND SHARP EDGES. .015 R OR CHAMFER MAX

GRIFF INSERT
Plain Carbon Steel
3/8 STOCK

± .01
± .03
± .005
125°
10.000
13.333

53.13°

ALL DIMENSIONS ARE IN INCHES - INTERPRET
DRAWING PER ASME Y14.5 - 1994

REMOVE ALL BURRS AND SHARP EDGES.015 R OR CHAMFER MAX

TOLERANCES UNLESS OTHERWISE SPECIFIED:
XX ± .03  ± .5°
XXX ± .01
X.XXX ± .005  ± .25°

UPRIGHT BOTTOM SUPPORT
Cast Carbon Steel
10x12x3/8 TUBING

FRANKLIN W. OLIN
College of Engineering

C | PB-1-07

SEAN MUNSON 12.13.2004

DOC REV = (CRITICAL DIMENSION)
ALL DIMENSIONS ARE IN INCHES- INTERPRET DRAWING PER ASME Y14.5-1994

TOLERANCES UNLESS OTHERWISE SPECIFIED:

XX ± .03
XXX ± .01
X.XXX ± .005

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

NOTES, UNLESS OTHERWISE SPECIFIED:
1. ONLY MODIFIED DIMENSIONS INDICATED
2. HOLES #10-32 TAPPED
1. Only modified dimensions indicated.

All dimensions are in inches. Interpret drawing per ASME Y14.5-1994.

Tolerances unless otherwise specified:
- XX ± .03
- XXX ± .01
- XXXX ± .005

All burrs and sharp edges .015 R or chamfer max.

Approved date: SEAN MUNSON 12.11.2004

UPRIG HT TUBING
CAST CARBON STEEL
STOCK 8"x8"x1/4"

DOC REV = (CRITICAL DIMENSION)
NOTES UNLESS OTHERWISE SPECIFIED:

1. HOLES 0.660 DIA THRU

ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5-1994

TOLERANCES UNLESS OTHERWISE SPECIFIED:

XX ± .03
XXX ± .01
X.XXX ± .005

125° ± .5°

REMOVE ALL BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

1. HOLES 0.660 DIA THRU
ALL DIMENSIONS ARE IN INCHES. INTERPRET DRAWING PER ASME Y14.5-1994

REMOVED BURRS AND SHARP EDGES .015 R OR CHAMFER MAX

TOOLANCES UNLESS OTHERWISE SPECIFIED:
XX ± .03  \( \pm .5^\circ \)
XXX ± .01
X.XXX ± .005  \( \pm .125 \)

APPROVED DATE
PREP BY
CHECKED
RESP ENG
RFPC ENG
QUAL ENG
SIZE
XAXIS-BALLNUT-MOUNT
Alloy Steel
0.125" SHEET

FSCM NO. PART NO. WT
PB-1-02 1.8179
PART REV
DOC REV
SHEET
1. HOLES 3/8-16 TAPPED