

EMC ON A SMALL MILL

OR
AN OVERVIEW OF A CNC CONTROLLED MILL
OR
HOW TO CONVERT A MILL TO CNC CONTROL

EMC2,
A FREE AND POWERFUL MACHINE CONTROLLER

OVERVIEW

- ☐ SMALL MILL CONVERSION
- ☐ THE MILL AND IT'S CONTROL
- ☐ THE HARDWARE AND SOFTWARE
- ☐ CONTROL SOFTWARE - WHERE DOES IT FIT IN?
- ☐ HOW TO USE IT

MY BACKGROUND (OR LACK THEREOF)

- ☐ COMPLETELY OUTSIDE OF CNC, MACHINE CONTROL, OR METALWORKING. NO MACHINING BACKGROUND AT ALL.
- ☐ ENGINEERING BACKGROUND IN IP NETWORK PROTOCOLS AND WIDE AREA NETWORK DESIGN ...NO HELP THERE!
- ☐ I HAVE DONE SOME WOOD WORKING
- ☐ I AM INTERESTED IN ROBOTICS (MACHINE CONTROL)
- ☐ BASICALLY, IF I CAN DO IT...SO CAN YOU!



MY EMCO FI CNC

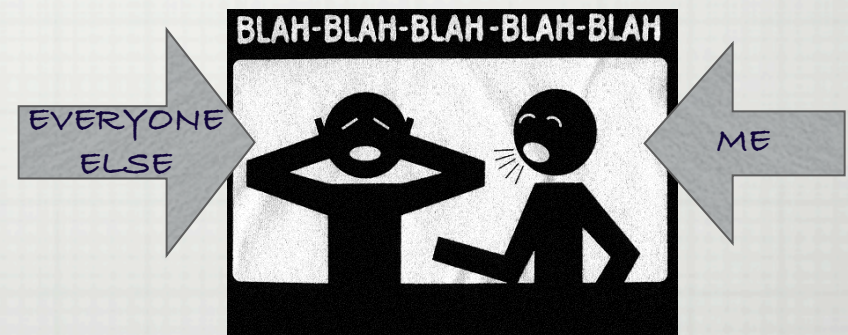
R & D

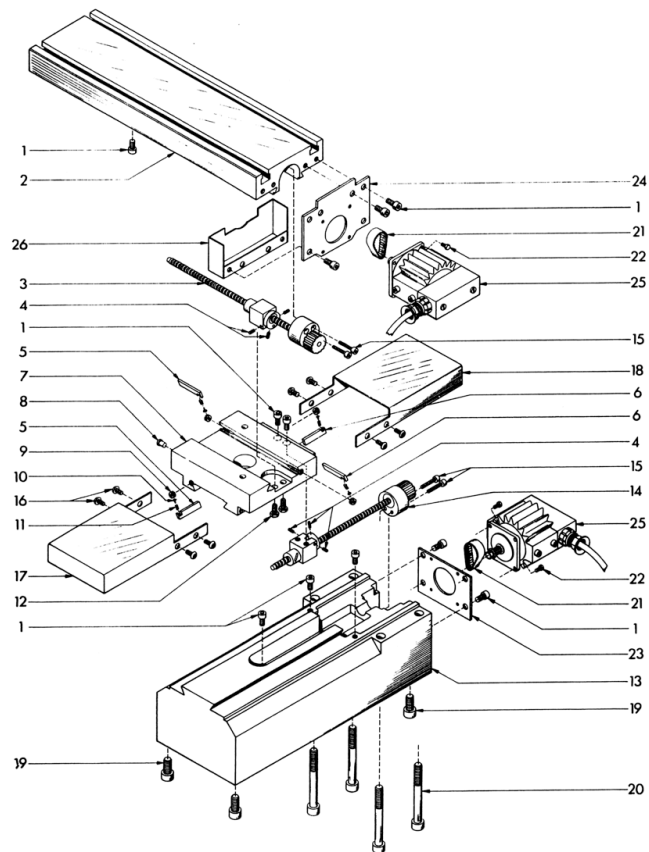


EMCO F1 MILL

Advanced search
Language tools

Google Search I'm Feeling Lucky

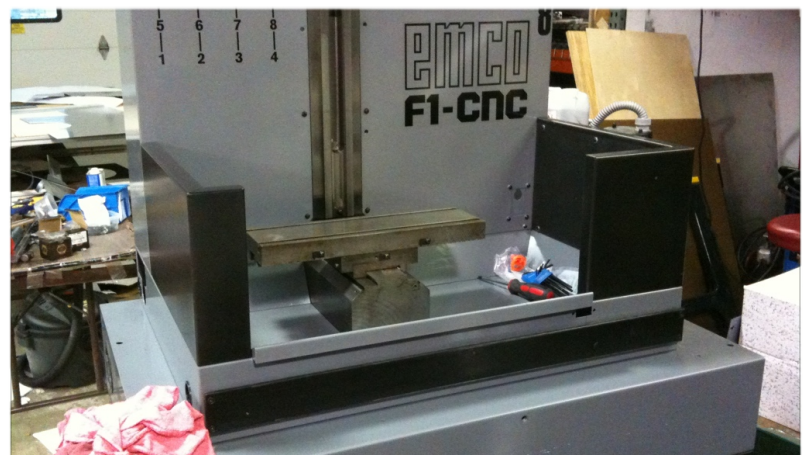
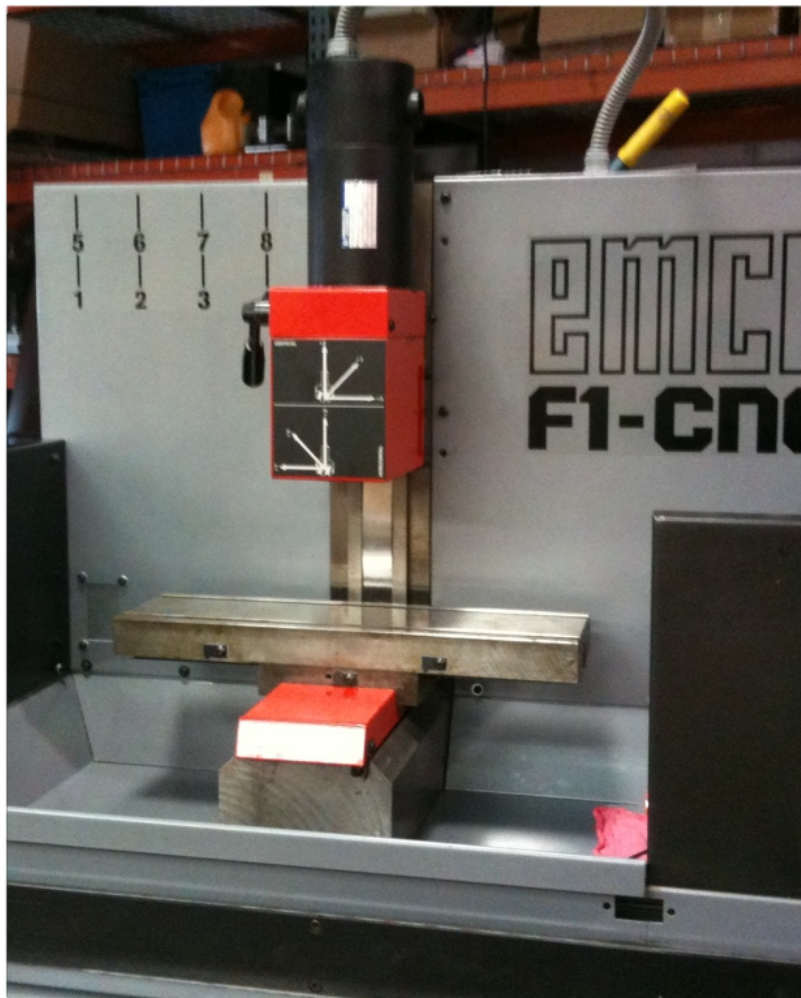




EMCO F1 CNC

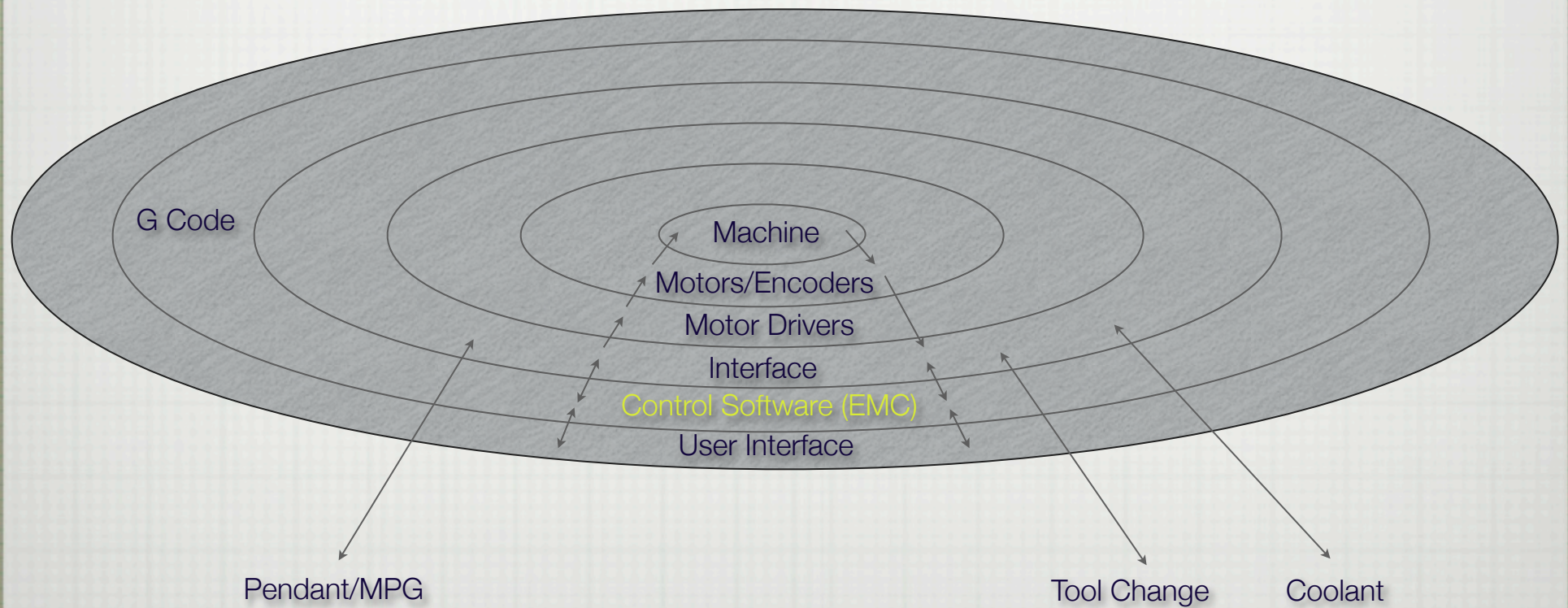
Pos.	Ref. No.	DIN	Benennung	Description
1-15	FIA 030 000		Gruppe Kreuzschlitten	Cross slide compl.
1	ZSR 12 0612	M6x12 DIN 912-6.9	Zylinderschraube	Socket head screw
2	FIA 030 030		Frästisch	Milling table
3+4	FIA 031 001		X-Spindel komplett	X-spindle complete
4	ZST 51 0408	M4x8 DIN 551-5.8	Gewindestift	Set screw
5	FIA 020 050		Keilleiste kurz links	Taper gib short left
5	FIA 020 060		Keilleiste lang links	Taper gib long left
6	FIA 020 110		Keilleiste kurz rechts	Taper gib short right
6	FIA 020 120		Keilleiste lang rechts	Taper gib long right
7	FIA 030 020		Kreuzschlitten	Cross slide
8	ZNP 01 2000	A2	Schmiernippel	Grease nipple
9	FIA 020 070		Stellschraube	Adjusting screw
10	ZNA 76 0204	2x4 DIN 1476-4.6	Kerbnagel	Rivet
11	ZFD 02 4061		Druckfeder	Compression spring
12	ZSR 33 0616	M6x12 DIN 933-5.6	Sechskantschraube	Hexagon head screw
13	FIA 030 010		Socket	Base
14+4	FIA 032 001		Y-Spindel komplett	Y-spindle complete
15	ZSR 12 0525	M5x25 DIN 912-6.9	Zylinderschraube	Socket head screw
16	ZSR 88 0610	M6x10 - 10.9	Linse	Filter head screw
17	FIA 000 010		Schutzblech 1	Cover sheet 1
18	FIA 000 020		Schutzblech 2	Cover sheet 2
19	ZSR 12 1020	M10x20 DIN 912-8.8	Zylinderschraube	Socket head screw
20	ZSR 12 1090	M10x90 DIN 912-10.9	Zylinderschraube	Socket head screw
21	ZRM 73 4805	MXL 48 050	Zahnriemen	Timing belt
22	ZSR 33 0408	M4x8 DIN 933-5.6	Sechskantschraube	Hexagon head screw
23	FIA 000 160		Motorplatte Y	Motor plate Y
24	FIA 000 150		Motorplatte X	Motor plate X
25	FIA 103 000		Schrittmotor	Step motor
26	FIA 000 140		Riemenschutz	Belt cover

THESE ARE HELPFUL!



A COUPLE WEEKS LATER

CNC MACHINE CONTROL



DECISIONS DECISIONS

- COMPUTER, WIRING,
POWER SUPPLIES,
CONNECTORS,
SWITCHES,
ENCLOSURE,
CONTROLLERS,
BREAKOUT BOARD,
STEPPERS, SERVOS
AND ENCODERS, OH
MY!



DECIDE ON...

- ☐ CONTROL SOFTWARE (EMC2, MACH3)
- ☐ PC HARDWARE (BUILD, BUY)
- ☐ MOTORS FOR AXIS, SPINDLE (STEPPERS, SERVOS)
- ☐ MOTOR CONTROLLERS
- ☐ INTERFACE (B.O.B., GPIO)
- ☐ ACCESSORIES, WIRING/CABLING

CONTROL SOFTWARE

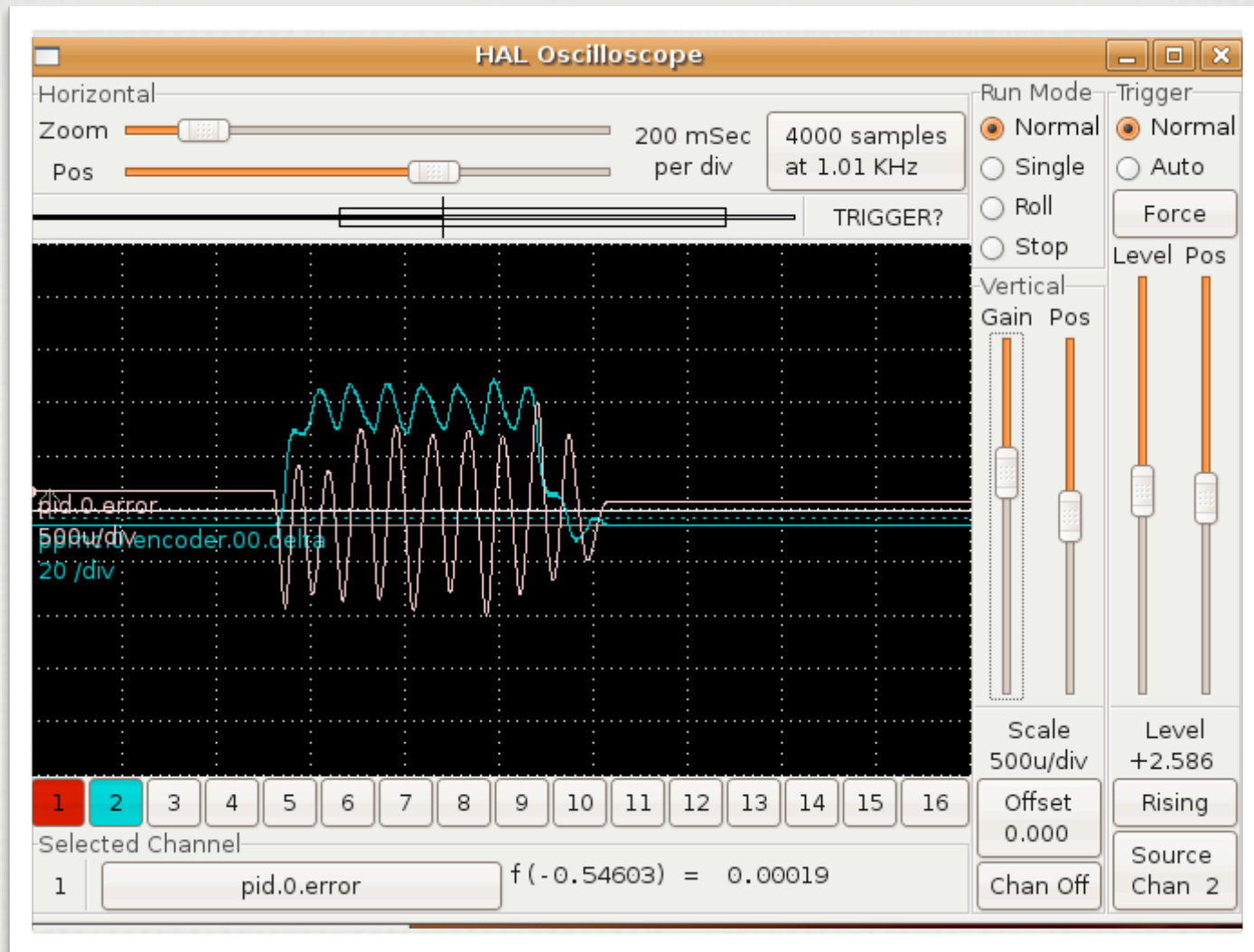
- ☐ EMC - OPEN SOURCE, LOCAL RESOURCES
- ☐ RUNS ON LTS VERSION OF UBUNTU (LINUX)
- ☐ LIVECD (OR SOURCE)
- ☐ SUPPORT COMMUNITY (FORUMS, MAILING LIST, IRC)
- ☐ WWW.LINUXCNC.ORG



EMC CAPABILITIES

- ☐ G-CODE: RS-274NGC
- ☐ REAL-TIME MOTION PLANNING SYSTEM
- ☐ PLC (LADDER LOGIC) AND HAL
- ☐ 9 AXES, SUPPORTS UNUSUAL KINEMATICS
- ☐ CONTROLS TRUE SERVOS WITH EMC CLOSING THE LOOP
- ☐ CUTTER RADIUS/LENGTH COMP., LATHE THREADING,
RIGID TAPPING





POWERFUL ANALYSIS/TUNING/DEBUG TOOLS



EMC2 Stepper Mill Configuration

X Axis Configuration

Motor steps per revolution:

200.0

Test this axis

Driver Microstepping

2.0

Pulley teeth (Motor:Leadscrew):

1.0

:

1.0

Leadscrew Pitch:

20.0

rev / in

Maximum Velocity:

1.0

in / s

Maximum Acceleration:

30.0

in / s²

Home location:

0.0

Table travel:

0.0

to

8.0

Home Switch location:

0.0

Home Search velocity:

0.05

Home Latch direction:

Same

Time to accelerate to max speed:

0.0333s

Distance to accelerate to max speed:

0.0167in

Pulse rate at max speed:

8000.0Hz

Axis SCALE

8000.0

Cancel

Back

Forward

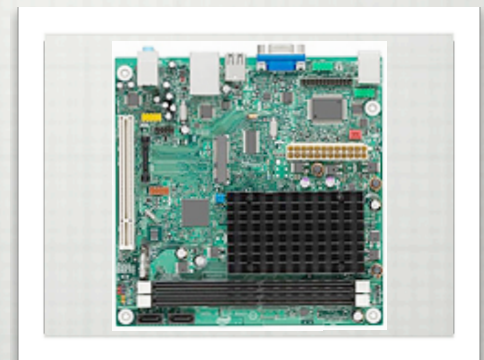
STEPCONF, A STEPPER MOTOR CONFIGURATION WIZARD

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PC HARDWARE

- ☐ BUILD (MINI-BOX MOTHERBOARDS), BUY (DELL, ETC)
- ☐ EMC WANTS LOW LATENCY HARDWARE

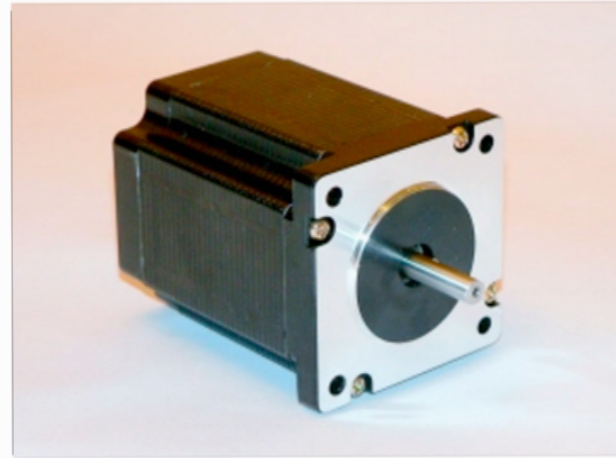


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- ☐ ACCESSORIES, WIRING/CABLING

MOTORS

- ☐ STEPPERS, USUALLY CHEAPER (ENCODERS - NOT TYPICAL)
- ☐ SERVOS, MORE TORQUE, ENCODERS

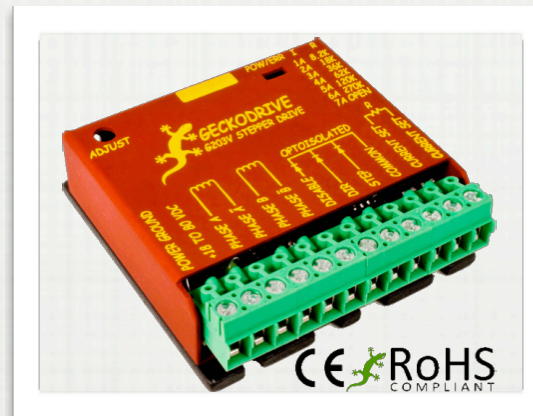


DECIDE ON...

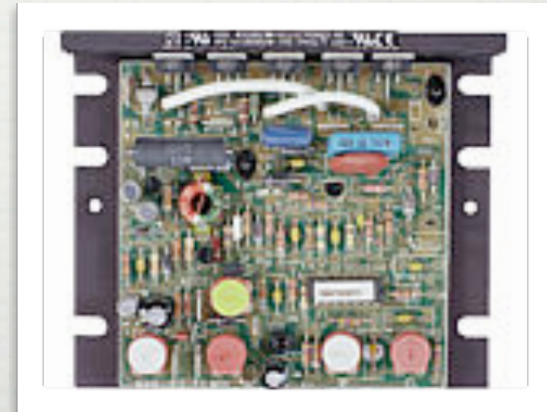
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MOTOR CONTROLLERS

- ☐ STEPPER/SERVOS -
GECKO, PMDX,
GRANITE, OTHERS



- ☐ SPINDLE MOTOR - KBIC,
MINARIK

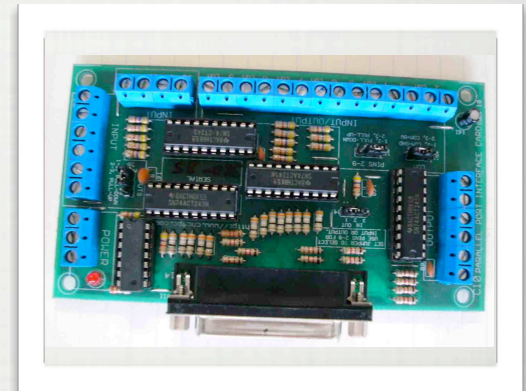
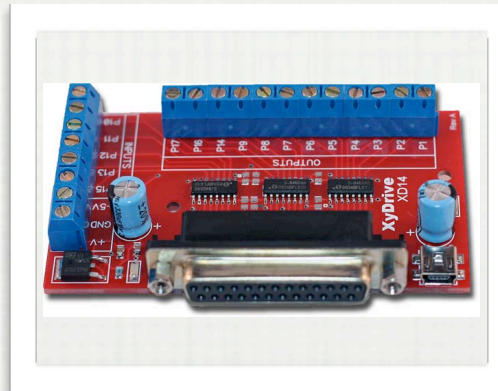


DECIDE ON...

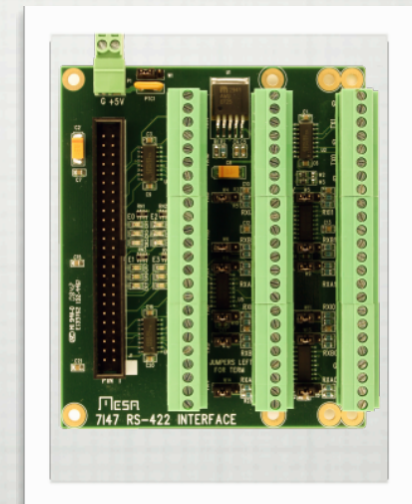
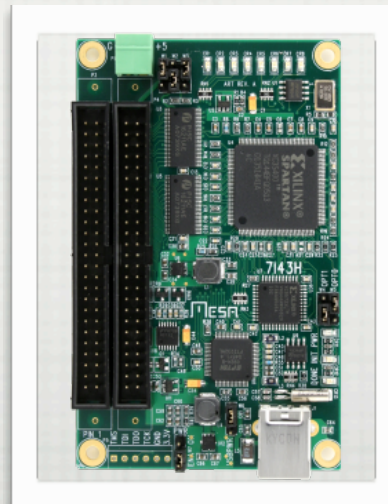
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- ☐ ACCESSORIES, WIRING/CABLING

INTERFACE

- ☐ B.O.B - BREAKOUT BOARD - PARALLEL PORT PINS



- ☐ MESA ELECTRONICS
FPGA, FIRMWARE



DECIDE ON...

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- ☐ INTERFACE (B.O.B., GPIO)
- ☐ ACCESSORIES, WIRING/CABLING

NEXT STEPS

- ☐ MAKE A LIST OF ALL STUFF TO GET
- ☐ CAN LOOK AT PRE-BUILT CONTROLLERS (LIKE CAMPBELL), OTHER CONVERSIONS, FOR IDEAS
- ☐ THEN...

2	Description	QTY	Price
3	EMCO F1	1	\$1,200.00
4	RS23-370 Steppers	4	\$186.00
5	Gecko G203V	4	\$387.00
6	KB Elec. KBPB-125	1	\$100.00
7	KB Resistor #9842	1	\$1.00
8	Fan	1	\$16.58
9	Fan power cord	1	\$1.78
10	Fan guard/filter	1	\$2.35
11	circuit breaker	1	\$7.50
12	Switches (pair)	1	\$9.50
13	EPO Switch	1	\$12.25
14	Power supply board	1	\$90.00
15	Transformer	1	\$90.00
16	Parallel port cable	1	\$7.44
17	Ribbon cable	1	\$8.95
18	Mesa card cable	2	\$11.40
19	Computer On/Off	1	\$6.25
20	PC	1	\$175.50
21	Monitor	1	\$100.00
22	Keyboard	1	\$10.00
23	Joystick	1	\$6.99
24	118k resistor for Gecko	3	\$0.53
25	Mesa 7i43 FPGA Bd	1	\$99.00
26	Mesa 7i42	1	\$45.00
27	Mesa 7i47	1	\$69.00
28	Encoders	3	\$89.85
29	Encoder Cables	3	\$21.45
30	Relays (SSR)	2	\$27.98
31	Cable (18/4)	1	\$137.50
32	Conduit/Fittings	1	\$43.00
33			\$2,963.80

MATERIALS



...



...

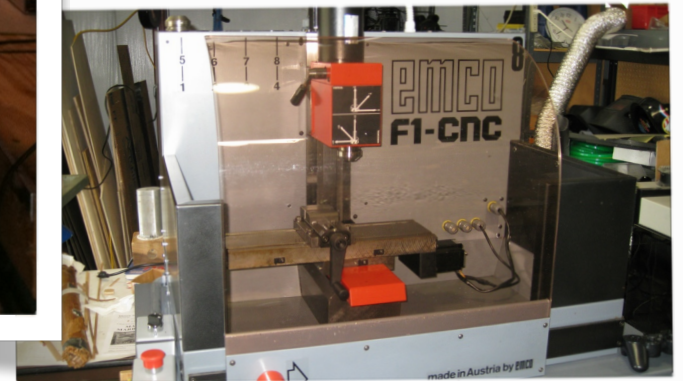
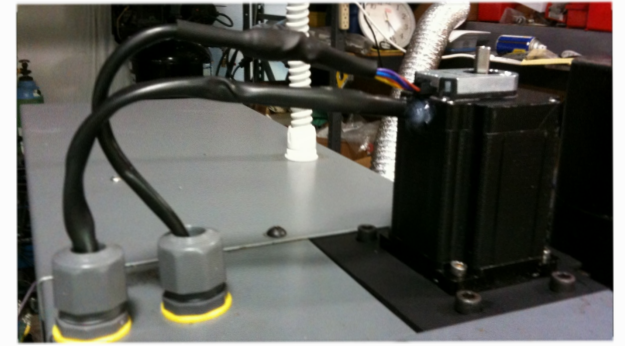
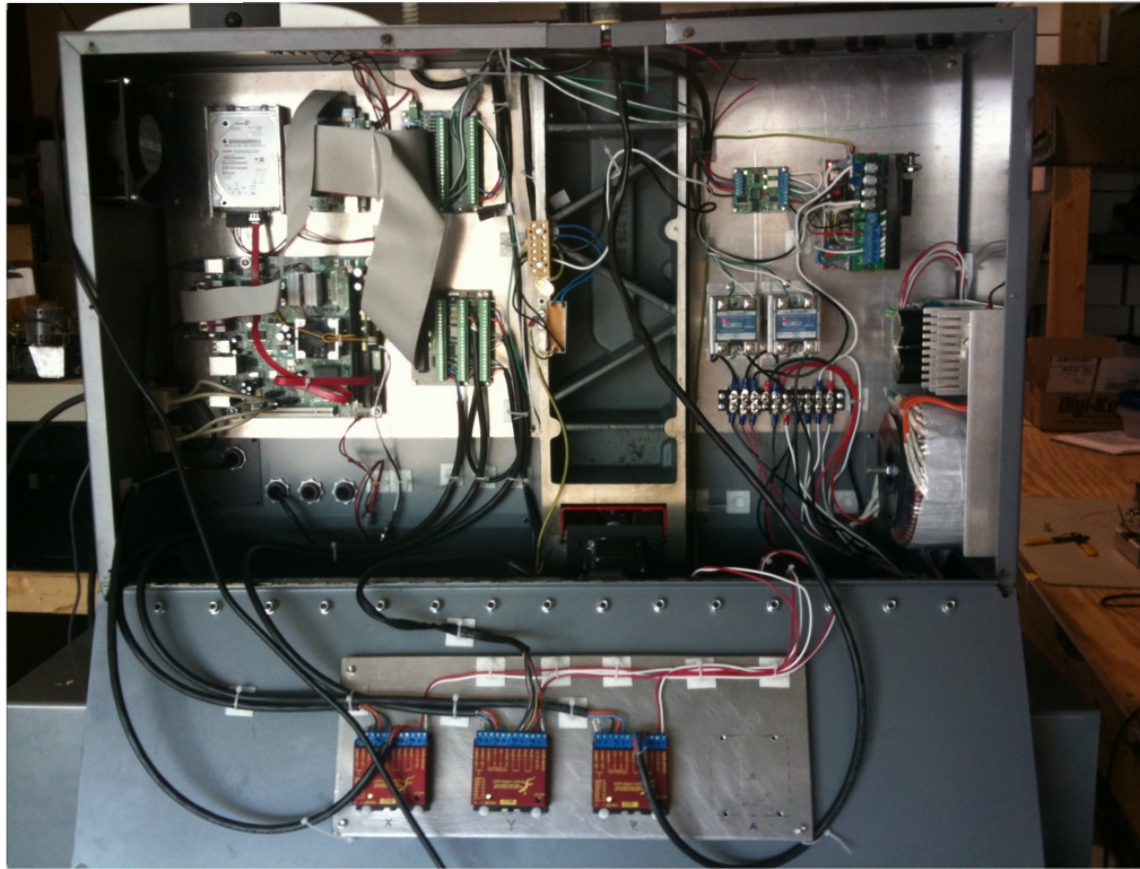


NO EXIT

© Andy Singer

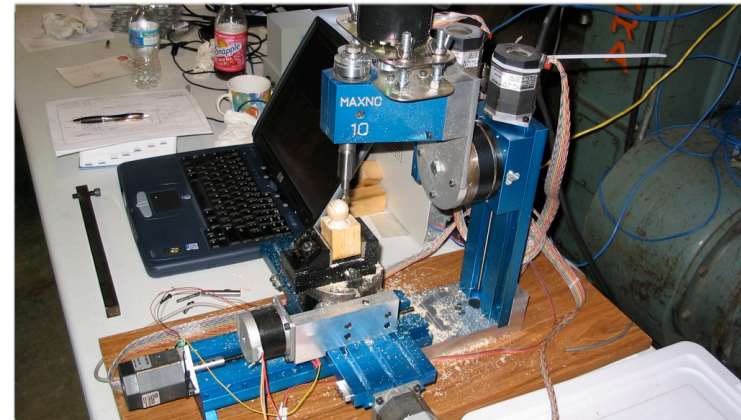
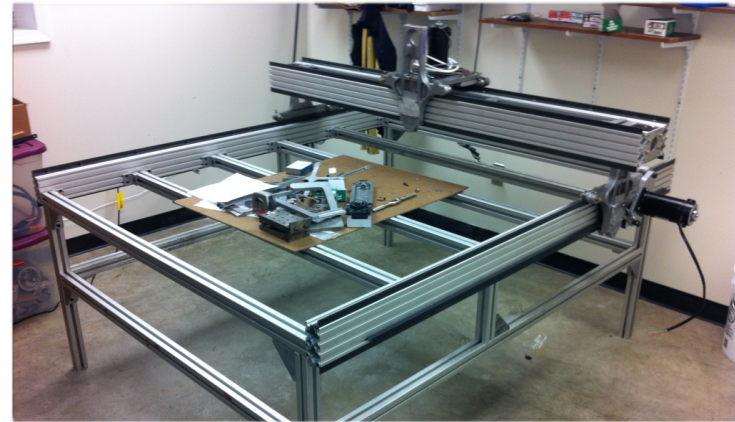


...AND A LITTLE WORK...

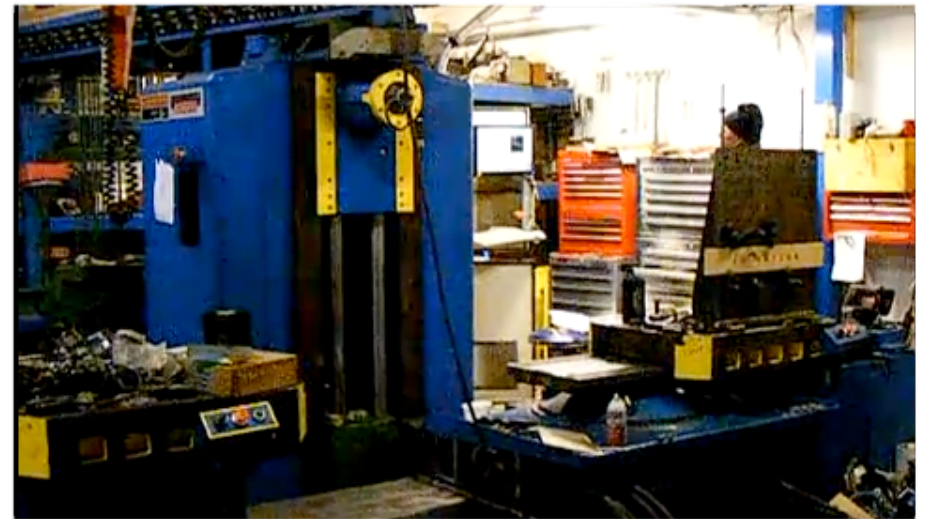


SEVERAL MONTHS LATER

OH, AND YOU NEED A MACHINE



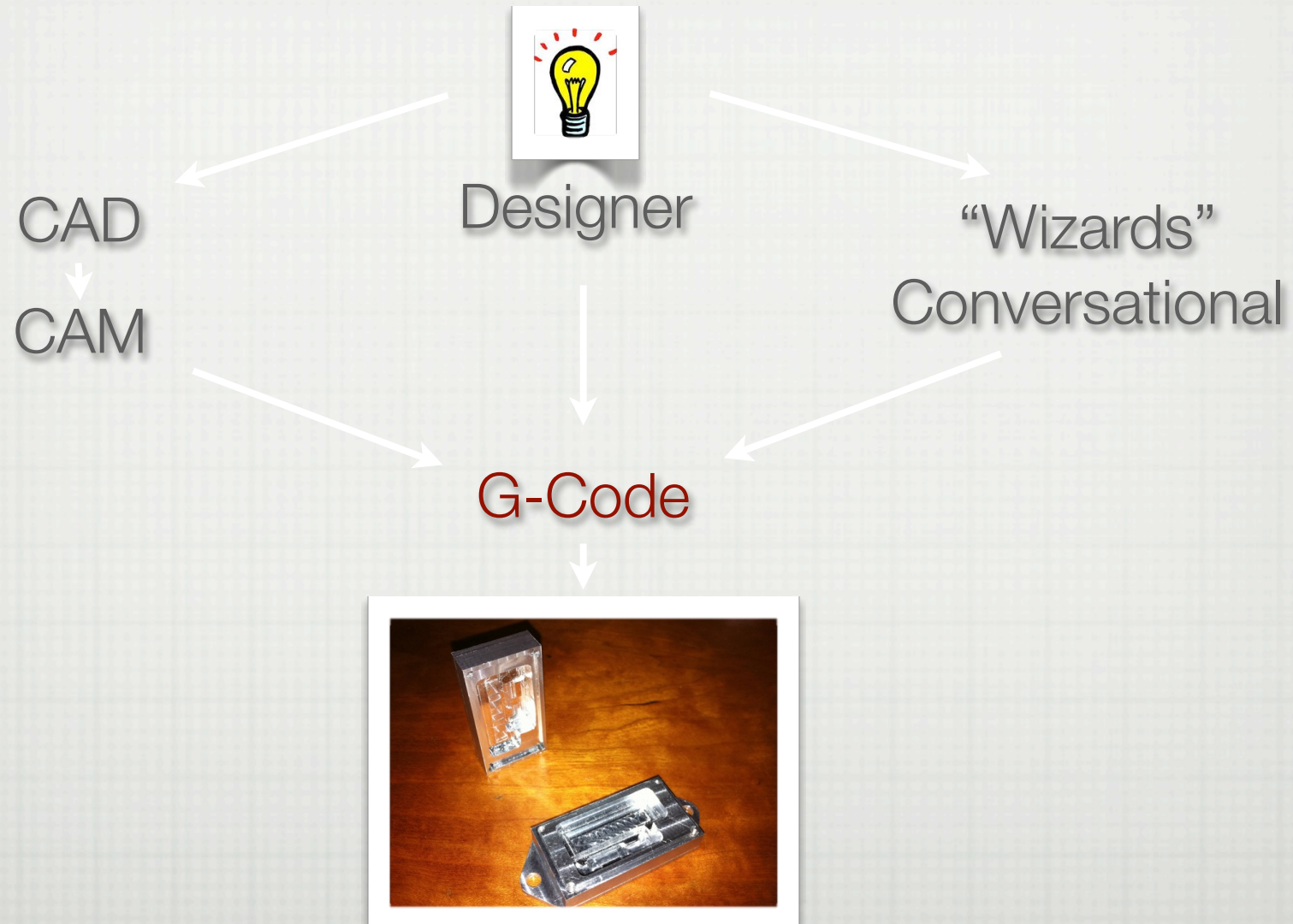
- TYPICAL SMALL SYSTEM
 - BRIDGEPORT OR SMALLER (OFTEN W/ STEPPERS)



OH, THE MACHINE!

WHAT ARE YOU GOING TO
USE THAT FOR?

MAKING SOMETHING



G-CODE

- ☐ G CODE COMMANDS ARE INTERPRETED BY THE CONTROLLER WHICH THEN SENDS SIGNALS TO MOVE MOTORS, ACTUATE RELAYS OR SOLENOIDS, ETC
- ☐ G CODE IS A CNC PROGRAMMING LANGUAGE
- ☐ EMC IMPLEMENTS RS274NGC
- ☐ HAS VARIABLES, SUBROUTINES, IF STATEMENTS, LOOPS

WAYS TO GENERATE G CODE

- ☐ WRITE IT
- ☐ RUN A WIZARD (CONVERSATIONAL PROGRAMMING)
- ☐ USE A CAM PROGRAM (USING A CAD DRAWING)

G CODE PROGRAM

□ SIMPLE AS:

```
N4 G17 G20 G40 G49
N5 G80 G90
N6 (FEATURE FACE)
N7 G0 G53 Z0.
N8 (MSG,LOAD1.575 ENDMILL ROUGH)
N9 T30 M06
N10 S2500 M3
N11 G54 X-2.3 Y-.315
N12 G43 H30 Z1.25
N13 Z.6
N14 G1 Z.4553 F10.
N15 X1.9125
N16 G0 Z.6
N17 X-.9125 Y.1575
N18 G1 Z.4553 F10.
N19 X2.4125
N20 G0 Z.6
N21 X-2.3 Y-.315
N22 Z.5553
(JOB 1 FACING)
(FEATURE FACE)
N23 G1 Z.4107 F10.
N24 X1.9125
N25 G0 Z.6
N26 X-.9125 Y.1575
N27 G1 Z.4107 F10.
N28 X2.4125
N29 G0 Z.6
N30 X-2.3 Y-.315
N31 Z.5107
(JOB 1 FACING)
(FEATURE FACE)
N32 G1 Z.366 F10.
N33 X1.9125
N34 G0 Z.6
N35 X-.9125 Y.1575
N36 G1 Z.366 F10.
N37 X2.4125
N38 G0 Z1.25
(JOB 1 FACING)
```

□ OR LIKE A PROG. LANG.

```
#<ledgeWidth>=0.050
#<ledgeDepth>=-0.050
#<ledgeRad>=0.065 (a bit more than 1/16" radius=0.0625, -> 1/8" dia.)
(ledge around top, fits into top part, cut with 3/8 tool)
g0 x-0.25 y0 (initial position, for lead in w/cutter comp)
g0 z#<zSafe>
#<first>=1
#<lz>=0 (start at top of part)
#<x1>=[#<x>+#<ledgeWidth>]
#<x2>=[#<x>+#<ledgeWidth>+#<ledgeRad>]
#<x3>=[#<x>+#<xLen>-#<ledgeWidth>-#<ledgeRad>]
#<x4>=[#<x>+#<xLen>-#<ledgeWidth>]

#<y1>=[#<y>+#<ledgeWidth>]
#<y2>=[#<y>+#<ledgeWidth>+#<ledgeRad>]
#<y3>=[#<y>+#<yLen>-#<ledgeWidth>-#<ledgeRad>]
#<y4>=[#<y>+#<yLen>-#<ledgeWidth>]

o15 while [#<lz> GT #<ledgeDepth>]
  (adjust depth per pass)
  #<lz>=[#<lz> - #<doc4>]
  o16 if [#<lz> LT #<ledgeDepth>]
    #<lz>=#<ledgeDepth>
  o16 endif
  (depth now correct)
  o17 if [#<first> EQ 1]
    g1 z#<lz> (drop down)
    g1 g42 x#<x1> y#<y1> (note radius compensation on!)
    g1 x#<x2>
    #<first>=0
  o17 else
    g1 z#<lz> (drop down)
  o17 endif

  (now do one loop around)
  g1 x#<x3>
  g3 x#<x4> y#<y2> i0 j#<ledgeRad>
  g1 y#<y3>
  g3 x#<x3> y#<y4> i[0-#<ledgeRad>] j0
  g1 x#<x2>
  g3 x#<x1> y#<y3> i0 j[0-#<ledgeRad>]
  g1 y#<y2>
  g3 x#<x2> y#<y1> i#<ledgeRad> j0

o15 endwhile

g0 z#<zSafe>
g40 (radius compensation off)
```


WIZARDS -COUNTERBORE

Applications Places System ? counterbore.py - AXIS 2.4.6 on EMCO Thu Apr 7, 12:13 PM tom

File Machine View Help

Manual Control [F3] MDI [F5]

Axis: X Y Z

Continuous

Home All Touch Off

Spindle: Stop

Brake

Coolant: Flood

Feed Override: 100%

Spindle Override: 100%

Jog Speed: 15 in/min

Max Velocity: 120 in/min

1: (SHCS Counterbore, Diameter = 0.8125, Depth = 0.5000)
2: (Number of Cuts 4, Depth of Cut 0.1250)
3: (Tool Diameter = 0.5000)
4: (Spiral Down to Depth of each Pass and Spiral Out)
5: F10.0 S1800
6: (Hole Center X1.0000 Y1.0000)
7: G0 Z0.2500
8: G0 X1.0000 Y0.8438
9: G1 Z0.1000

ON No tool Position:

Preview DRO

X: -0.1383
Y: 0.0000
Z: -0.0000
Vel: 0.00

Work Light On/Off

Spindle Speed 0.0

Counterbore 1.3

File Edit Help

Socket Head Cap Screw Counterbore G-Code Generator

Number SHCS	Fraction SHCS	Metric SHCS	Clearance Height Z	X Center	Y Center	G-Code
<input type="radio"/> 0	<input type="radio"/> 1/4	<input type="radio"/> M1.6	0.2500			(SHCS Counterbore, Diameter = 0.8125, Depth = 0.5000)
<input type="radio"/> 1	<input type="radio"/> 5/16	<input type="radio"/> M2	Material Top Z	X & Y List		(Number of Cuts 4, Depth of Cut 0.1250)
<input type="radio"/> 2	<input type="radio"/> 3/8	<input type="radio"/> M2.5	0.000	X1.0000	Y1.0000	(Tool Diameter = 0.5000)
<input type="radio"/> 3	<input type="radio"/> 7/16	<input type="radio"/> M3	Start Height Z			(Spiral Down to Depth of each Pass and Spiral Out)
<input type="radio"/> 4	<input type="radio"/> 1/2	<input type="radio"/> M4	0.1000			F10.0 S2000
<input type="radio"/> 5	<input type="radio"/> 9/16	<input type="radio"/> M5	Tool Diameter			(Hole Center X1.0000 Y1.0000)
<input type="radio"/> 6	<input type="radio"/> 5/8	<input type="radio"/> M6	.5			G0 Z0.2500
<input type="radio"/> 8	<input type="radio"/> 3/4	<input type="radio"/> M8	Spindle RPM			G0 X1.0000 Y0.8438
<input type="radio"/> 10	<input type="radio"/> 7/8	<input type="radio"/> M10	2000			G1 Z0.1000
<input type="radio"/> 12	<input type="radio"/> 1	<input type="radio"/> M12	Feed Rate			(spiral down)
	<input type="radio"/> 1-1/8	<input type="radio"/> M14	10.0			G3 X1.0000 Y0.8438 Z-0.1250 J0.1562
	<input type="radio"/> 1-1/2	<input type="radio"/> M16	Depth each Pass			G3 X1.0000 Y0.8438 Z-0.2500 J0.1562
	<input type="radio"/> 1-3/4	<input type="radio"/> M18	.125			G3 X1.0000 Y0.8438 Z-0.3750 J0.1562
	<input type="radio"/> 2	<input type="radio"/> M20	Stepover %			G3 X1.0000 Y0.8438 Z-0.5000 J0.1562
		<input type="radio"/> M24	33			(clean up hole)
		<input type="radio"/> M30	Spiral Depth			G3 X1.0000 Y0.8438 J0.1562
		<input type="radio"/> M36	.1			G1 X1.0000 Y1.0000
		<input type="radio"/> M42	<input checked="" type="checkbox"/> Insert EOF			G0 Z0.2500 M5
		<input type="radio"/> M48				M2

Hole Diameter 2.000

Hole Depth 1.250

Cut Direction

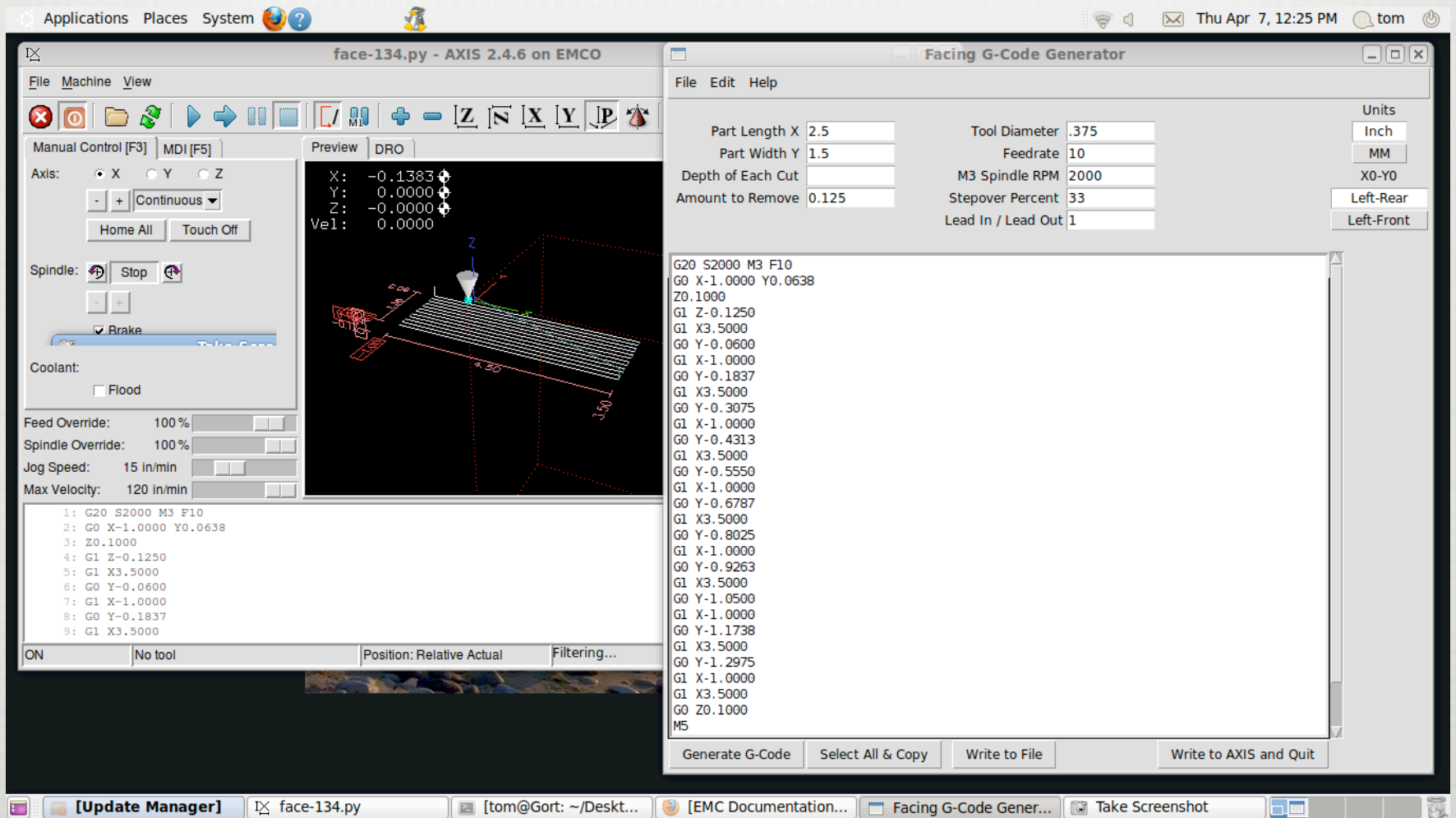
☒ Climb

☐ Conventional

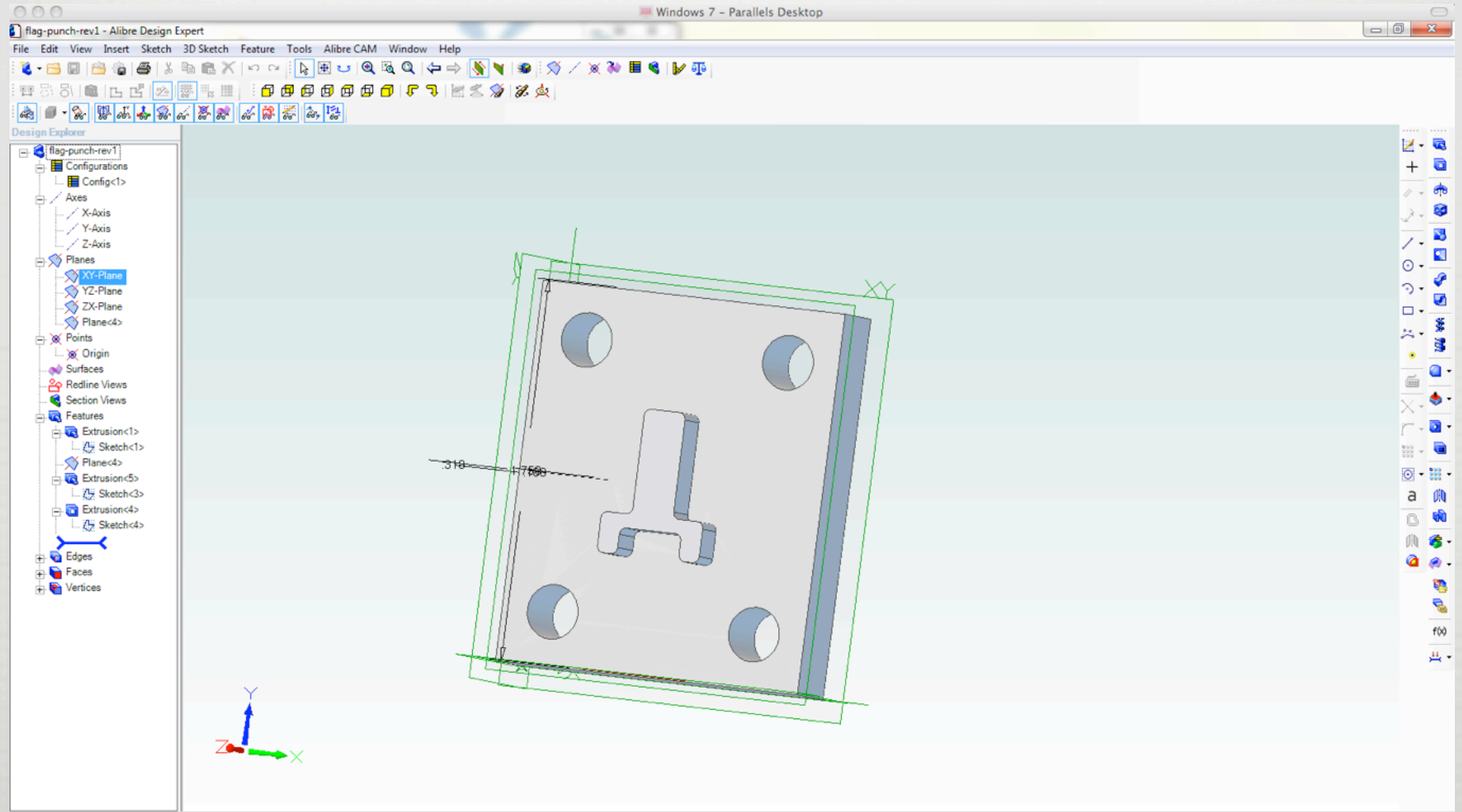
Generate To AXIS Clear G Code Window Cancel

[Update Manager] counterbore.py Counterbore 1.3

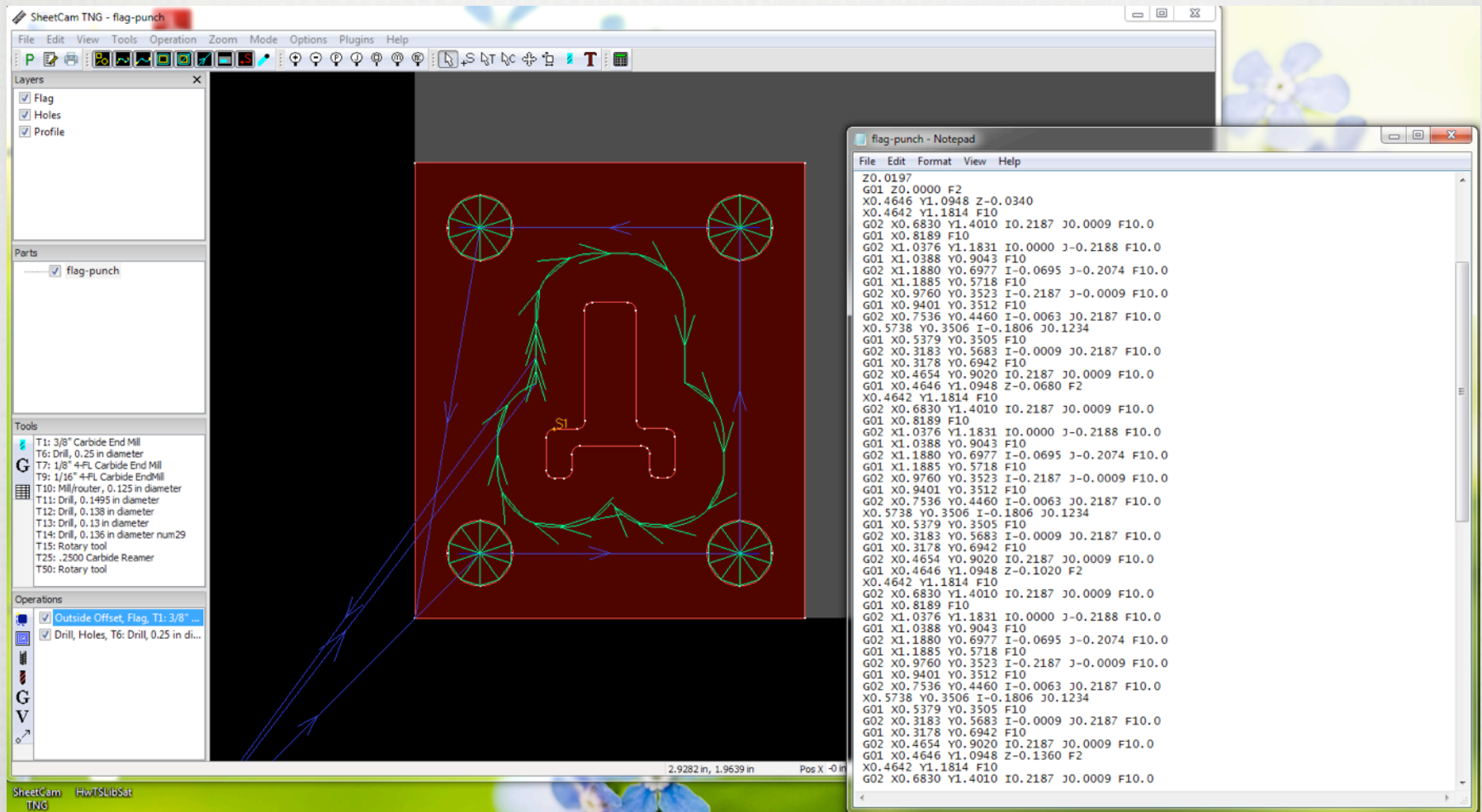
WIZARDS - FACING



CAD



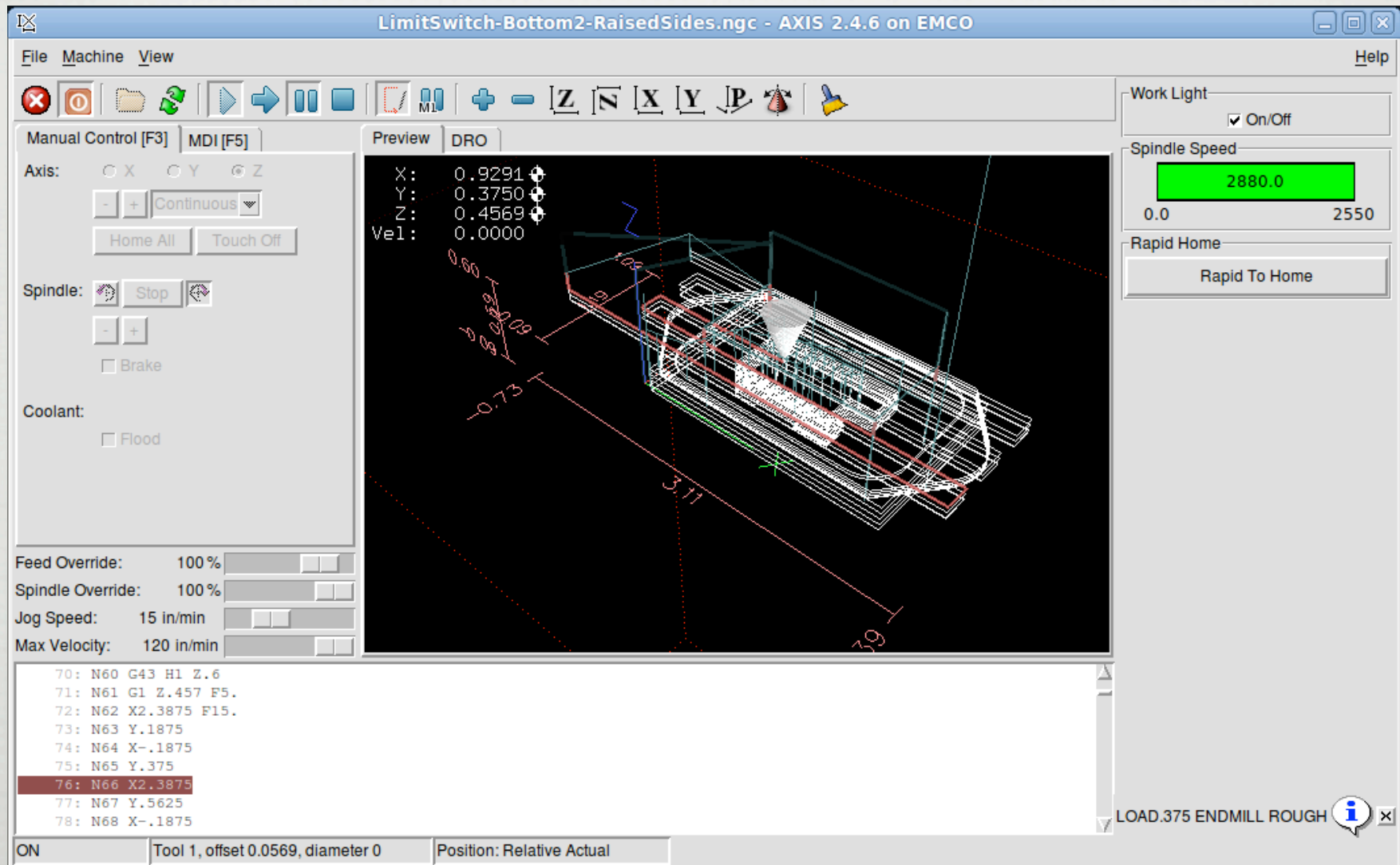
CAM



OPERATION

- ☐ SELECT MACHINE CONFIGURATION TO START EMC
- ☐ LOAD G-CODE FILE IN AXIS (OR OTHER UI)
- ☐ E-STOP OFF
- ☐ HOME/TOUCH OFF
- ☐ RUN PROGRAM

AXIS USER INTERFACE



POOR MAN'S MPG



```
# now process axes
loadrt sum2 count=2 # one instance for each axis you need to reverse, also check
sum2 loaded (will show up under functions in machine->show hal configuration?)
addf sum2.0 servo-thread # in my case I needed to reverse the Y and Z axis
addf sum2.1 servo-thread

# x is fine, no need to reverse
net joy-x-jog halui.jog.0.analog <= input.0.abs-x-position

# if no need to reverse, use the following line:
#net joy-y-jog halui.jog.1.analog <= input.0.abs-y-position
# if needed, reverse the analog so the axis will go in the expected direction
setp sum2.0.gain0 -1
net reverse-y sum2.0.in0 <= input.0.abs-y-position
net joy-y-jog halui.jog.1.analog <= sum2.0.out

# same need to reverse z axis
#net joy-z-jog halui.jog.2.analog <= input.0.abs-rz-position
setp sum2.1.gain0 -1
net reverse-z sum2.1.in0 <= input.0.abs-rz-position
net joy-z-jog halui.jog.2.analog <= sum2.1.out

# a (rotation) axis
#net joy-a-jog halui.jog.3.analog <= input.0.abs-a-position

# set up e-stop--larger right button marked "2" facing away from operator
net joy-estop halui.estop.activate <= input.0.btn-pinkie

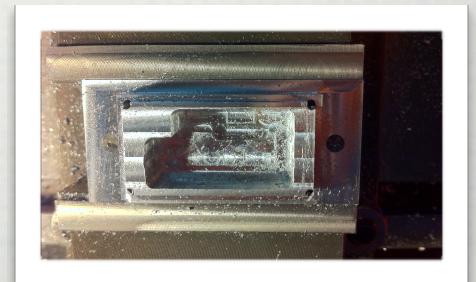
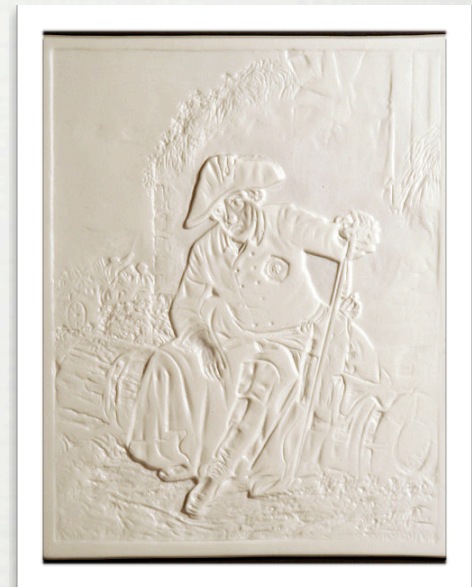
# spindle on, increase, off
# spindle on is "start" button
net joy-spindle-on halui.spindle.start <= input.0.btn-base4
# spindle increase is button "1" on right
net joy-spindle-increase halui.spindle.increase <= input.0.btn-base2
# spindle decrease is button "1" on left
net joy-spindle-decrease halui.spindle.decrease <= input.0.btn-base
# spindle stop is button "select"
net joy-spindle-stop halui.spindle.stop <= input.0.btn-base3

#AXIS display of Spindle speed
#linksp spindle-vel-fb pyvcp.spindle-speed
linksp spindle-vel-cmd pyvcp.spindle-speed

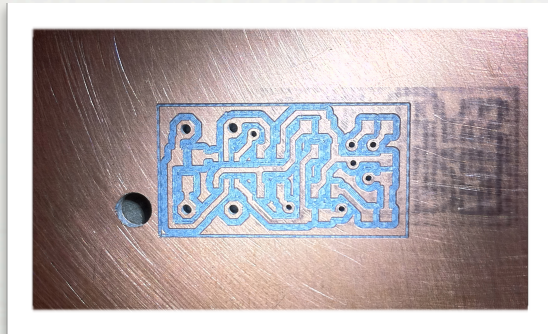
#AXIS display of Work Light Control
linksp worklight-ctl pyvcp.worklight
```

A MACHINE WITH EMC2 CAN....

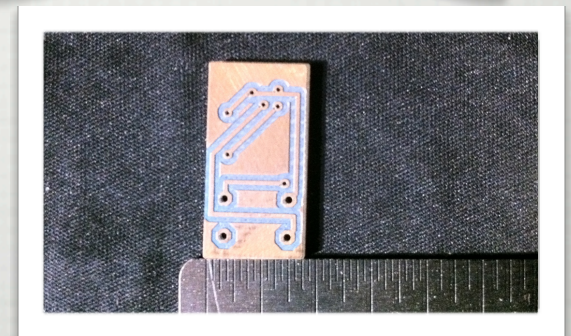
☐ MAKE PARTS



A MACHINE WITH EMC2 CAN....

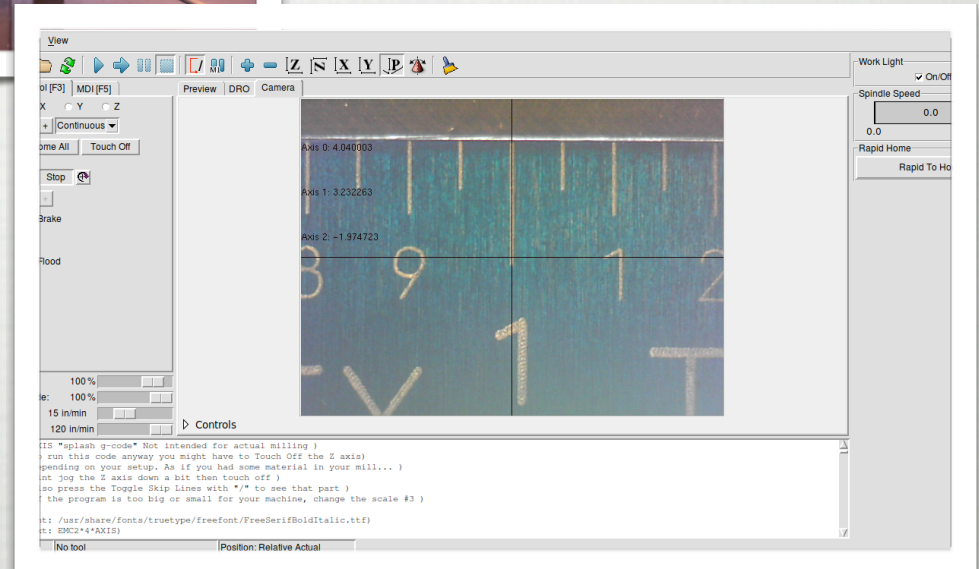
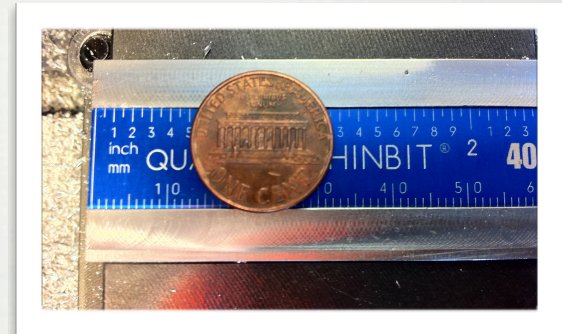
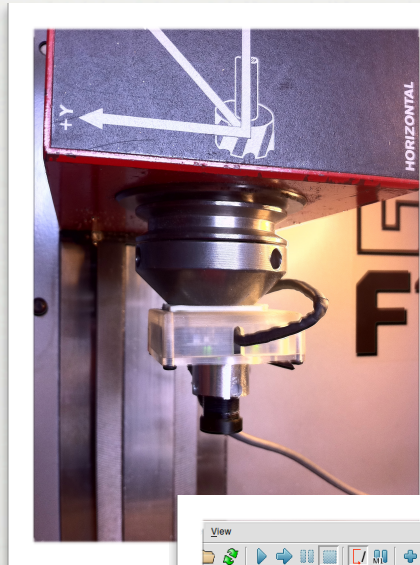


☐ ETCH CIRCUIT BOARDS



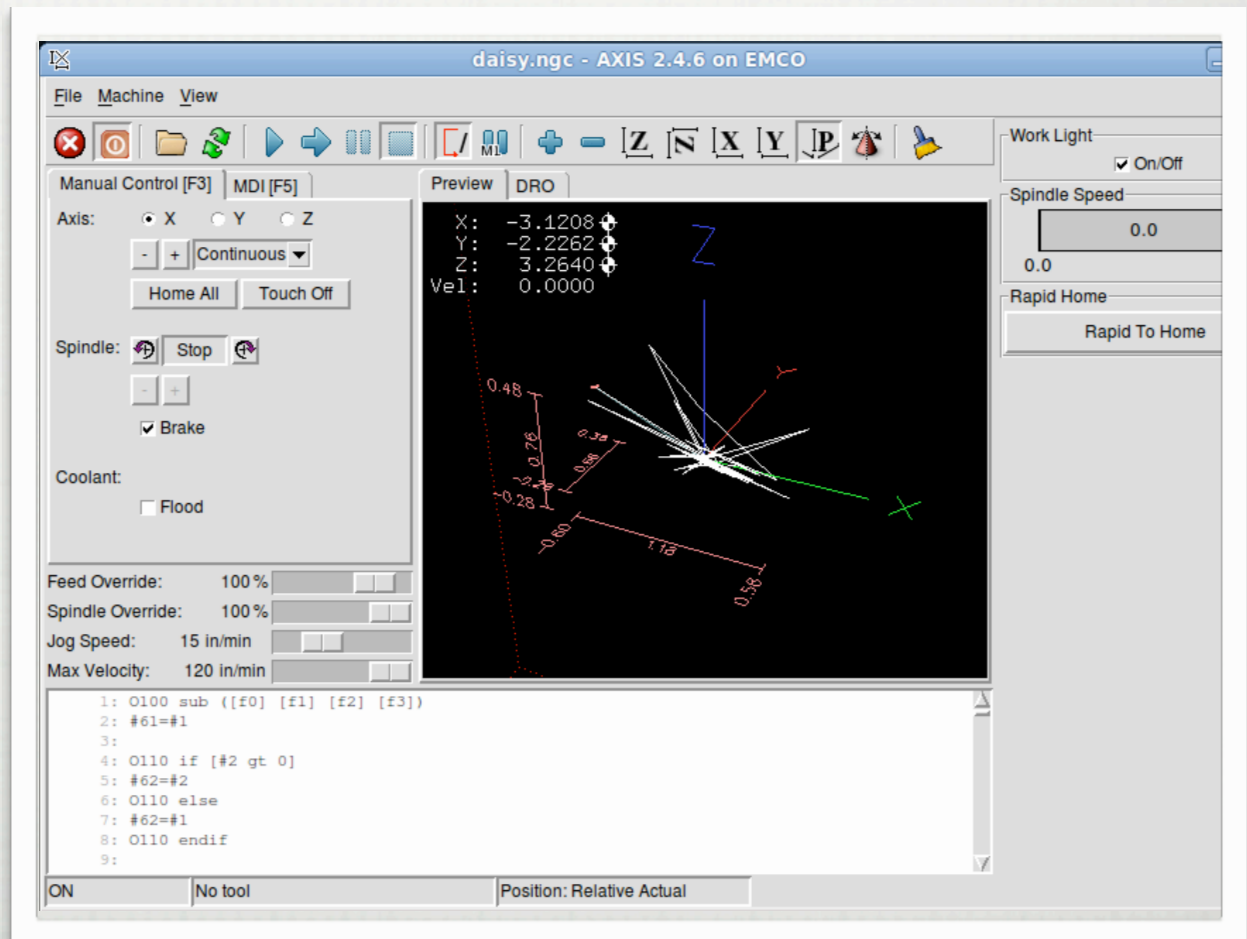
A MACHINE WITH EMC2 CAN....

☐ INSPECT OBJECTS



A MACHINE WITH EMC2 CAN....

☐ PLAY MUSIC ??

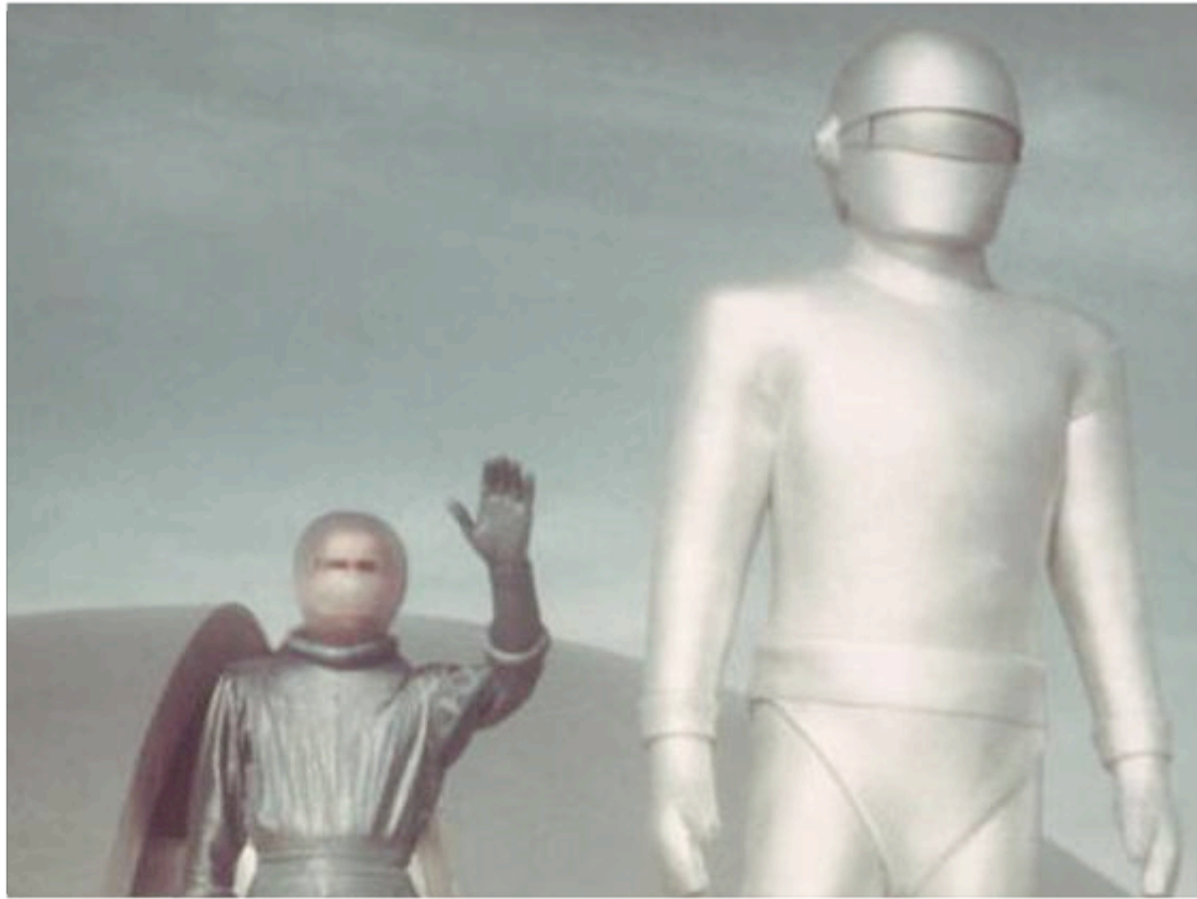


LEARN MORE

- ☐ DIGITAL MACHINIST CNC WORKSHOP, JUNE 12-24TH @ WASHTENAW COMMUNITY COLLEGE - LOOK ON DIGITAL MACHINIST WEB SITE FOR MORE INFO
- ☐ YOUR LOCAL MAKER SPACE
AA: [HTTP://WWW.MAKER-WORKS.COM/](http://www.maker-works.com/) - NOW
DTW: [HTTP://TECHSHOP.WS/](http://techshop.ws/) - THIS SUMMER
- ☐ PUBLICATIONS (DIGITAL MACHINIST, HOME SHOP MACHINIST, ETC)

REFERENCES

- ☐ EMC - [HTTP://WWW.LINUXCNC.ORG](http://www.linuxcnc.org)
- ☐ DIGITAL MACHINIST - [HTTP://WWW.DIGITALMACHINIST.NET](http://www.digitalmachinist.net)
- ☐ G CODE - [HTTP://LINUXCNC.ORG/HANDBOOK/RS274NGC_3/RS274NGC_3TOC.HTML](http://linuxcnc.org/handbook/rs274ngc_3/rs274ngc_3toc.html)
- ☐ MESA ELECTRONICS - [HTTP://WWW.MESANET.COM/](http://www.mesanet.com/)
- ☐ BOB CAMPBELL DESIGNS - [HTTP://CAMPBELLDESIGNS.NET/](http://campbelldesigns.net/)
- ☐ KB ELECTRONICS - [HTTP://WWW.KBELECTRONICS.COM](http://www.kbelectronics.com)
- ☐ GECKO MOTOR CONTROLS - [HTTP://WWW.GECKODRIVE.COM/](http://www.geckodrive.com/)
- ☐ CNC4PC CONTROLS - [HTTP://WWW.CNC4PC.COM/](http://www.cnc4pc.com/)
- ☐ ALIBRE DESIGN - [HTTP://WWW.ALIBRE.COM/](http://www.alibre.com/)
- ☐ SHEETCAM - [HTTP://WWW.SHEETCAM.COM/](http://www.sheetcam.com/)



THE END
