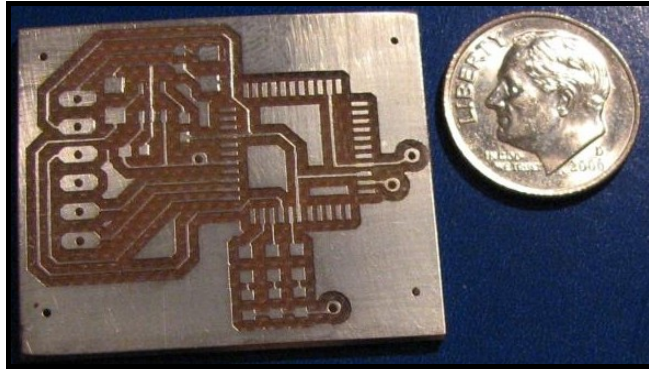


An Example Home-Made CNC Machine for Fine-Pitch PCB Manufacture

The person that runs the Mill PCBs site and forum (<http://www.millpcbs.com>) has put up an impressive demonstration of fine-pitch PCB manufacturing using a home-made CNC machine.

I'll take the liberty of including an example of his results from the Mill PCBs site:

Here is an example of possible work, 0603 smds, VQ44 smd, SOT23-5, 10 and 12 mil traces.



In his post at <http://www.millpcbs.com/phpbb3/viewtopic.php?f=8&t=10>, the Administrator of the Mill PCB forum lists his CNC setup as:

“Fireball M90 machine, Halo controller with linear power supply, Paul Jones spindle (www.cnconabudget.com). Z axis is Nema23 single stack, nema 23 single stack on the table axis, nema23 double stack on the other axis. Use Mach3 for control. Most of the routing is done with a Drewtronics 90, 60, or 45 degree bit depends on trace width needed. Also periodically use a Think N Tinker mechanical etching bit or the same angles, but have come to prefer the Drewtronics bits as less expensive, more durable, and provide as good of cut as I need.”

Well, as a person new to this subject I found this description to be lacking in detail if not down-right cryptic. Just what are these parts, how much do they cost and where can you buy them? I decided to let Google reverse-engineer the machine and provide the missing detail. What follows is what it found.

The items shown may not match the description above exactly, but I feel they are close enough to provide the reader for a feel for what's involved and approximately what it will cost to duplicate something like the Mill PCBs machine. Please note, we do not include any software other than the stepper motor interface controller. All prices are estimated in U.S. Dollars and do not include any taxes, shipping, or handling charges. Also not included in the price estimate are miscellaneous hardware such as cables, etc. and consumables other than a small hand-full of cutting bits. Otherwise, I hope everything needed is shown – remember, I'm no expert in this subject, that's why I'm writing this. Let me know if you see any glaring errors or omissions.

- **Fireball M90 Machine**

Well, I wasn't readily able to find a Fireball M90, but I was able to easily find a Fireball V90. It seems this is the CNC table only, no motors, controller, spindle, power supply etc.

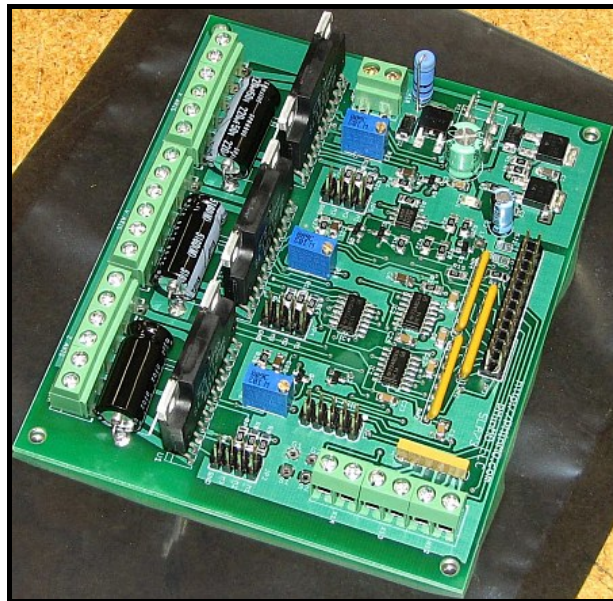
Fireball V90 CNC Machine... \$550 USD
<http://www.fireballcnc.com/>
<http://groups.yahoo.com/group/Fireballcnc/>



- **Halo Controller**

The Halo controller is a 3-axis uni-polar stepper-motor driver board. It comes pre-assembled and is built to order from the folks at PMinMO (see below). There was no price listed, you have to Email them. However looking at the board and knowing what things like this cost, I would conservatively estimate this board costs around \$150 USD each.

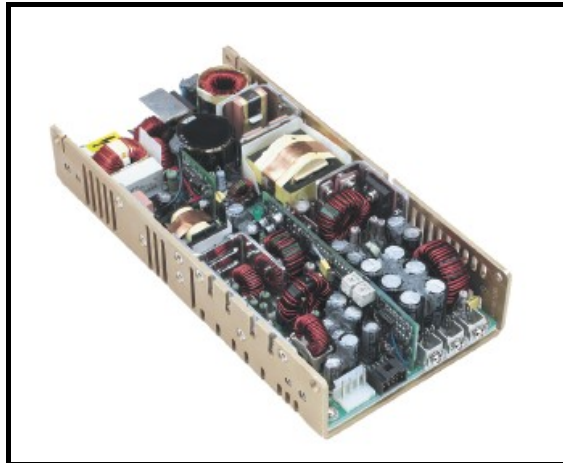
Halo Controller (Made to Order)... \$150 USD est.
All in one three axis unipolar controller.
<http://pminmo.com/PMinMOWiki/index.php5?title=Halo>
info@PMinMO.com



- **Linear Power Supply**

There isn't much information about the supply used in the Mill PCBs machine, but from experience and information given about the stepper motors used, it is likely each of three steppers is rated for 3.6VDC at 3A. It is stated that a linear supply is used, and this is good practice when driving steppers. A quick look at a couple of electronic supply houses found a decent linear supply that supplies 3.3VDC at 15A. The retail price for the supply is given below; but I'm pretty sure a quick search on ebaY would yield a cheaper and perhaps better alternative. But I'll stick with the retail supply for now.

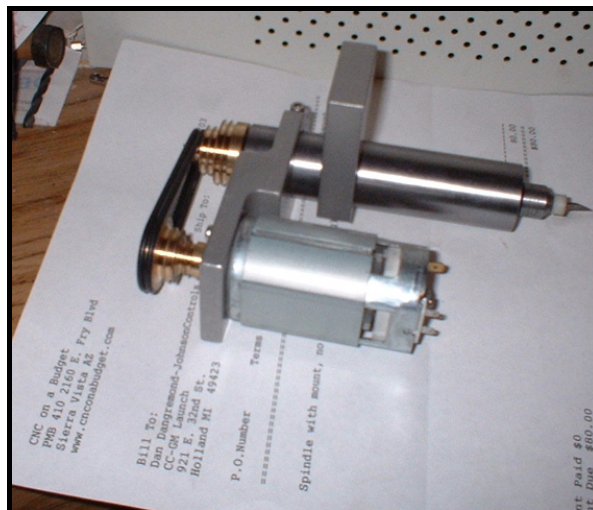
Linear Power Supply, 3.3V/15A... \$223.31 USD
Emmerson Network Power P/N NTQ165
www.digikey.com P/N 454-1240-ND



- **Spindle**

The spindle is the part that does the actual cutting. We were able to find a spindle manufactured by Paul Jones. It seems that Paul Jones has sold spindles of various types as the design has evolved. Below is the latest example.

Paul Jones Spindle... \$70 USD
<http://www.cnconabudget.com/>



- **Stepper Motors**

It is stated that the Mill PCBs machine uses NEMA 23 steppers. NEMA 23 is a standardized size descriptor. The description of the Halo stepper-controller confirms these are uni-polar motors. One could assume from the description of the motors that the Z or vertical axis and one horizontal axis (probably the shorter axis) is driven by motors with a single winding stack and presumably a 1.8 degree step size. The other horizontal axis (presumably the longer axis) is driven by a higher resolution motor with two winding stacks. In either case, NEMA 23 motors are quite common and readily available new and used via the Internet. We use a retail example below, we don't know if the motor offered is new or used, but I wouldn't have a problem with either case, these steppers are quite robust. Once again, this is a prime candidate for an ebaY search.

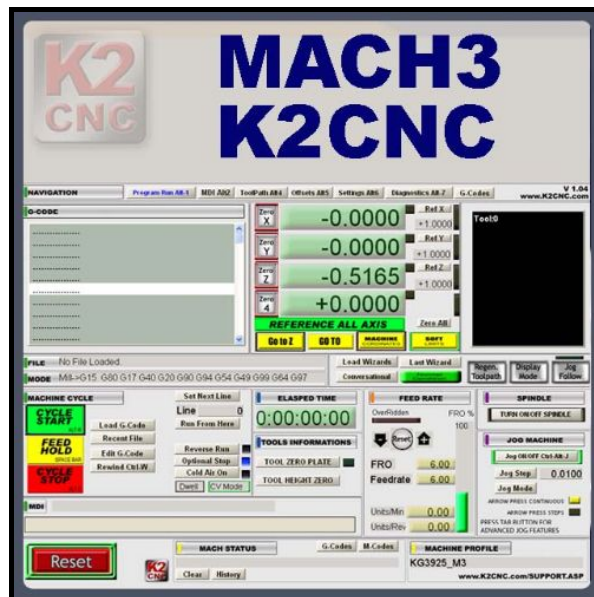
Z-axis stepper is NEMA 23 single stack... \$35
Short table axis NEMA 23 single stack... \$35.
Long table axis NEMA 23 double stack... \$40 est.
<http://webtronics.stores.yahoo.net/stmo52.html>



- **Control Software**

For control software, It seems a favorite amongst the home-brew CNC crowd is Mach 3. From what I can tell, the software interfaces with the controller card via the PC's LPT port.

Mach 3 K2CNC Control Software... \$199
<http://www.k2cnc.com/proddetail.asp?prod=Mach>



- **Cutting Bits**

There's not a lot to be said about the cutting bits except for the fact that I could only find 60 degree bits while the description of the machine mentions the availability of 90 and 45 degree bits as well.

Drewtronics 90, 60, 45 degree bit... \$12 ea., 10X=\$100+\$5S&H
<http://www.drewtronics.net/>



- **Conclusion**

Let's wrap all this up into a spreadsheet and see what the total is:

Home-Made PCB CNC Machine, Itemized Parts List					
Item	Description	Qty	Price		USD
			Unit		Ext
1	CNC Table	1	\$	550	\$ 550
2	Stepper Controller	1	\$	150	\$ 150
3	3.3VDC/15A Linear Power Supply	1	\$	225	\$ 225
4	Spindle with motor.	1	\$	70	\$ 70
5	Single Stack Unipolar NEMA 23 Stepper Motor	2	\$	35	\$ 70
6	Double Stack Unipolar NEMA 23 Stepper Motor	1	\$	40	\$ 40
7	Motor Controller Control Software	1	\$	199	\$ 199
8	Cutting Bits	5	\$	12	\$ 60
9	Total				\$ 1,364

\$1,364 USD, Hmmm.... I bet you could knock a couple of hundred Dollars off this with ebaY etc. But still, it's way over \$1,000 USD. I've seen complete retail machines for a bit over \$2,000 that claim to have this fine-pitch PCB manufacturing capability. Also keep in-mind; I've not included software other than the motor control interface software. Also not included is shipping, handling, shipping, taxes, miscellaneous hardware such as cables, etc. and consumables, other than a small hand-full of cutting bits.