Fab Lab Instruction Guide

Midwest Digital Fabrication Partnership
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Fox Valley Technical College, University of Wisconsin-Stout,
Century College and Lorain County Community College

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Be the

Combustion

of a

"Creative Explosion"

This publication is compiled from many resources listed in the appendix and is meant to assist in the creation or operation of a Fab Lab.

This guide has presented the basic, very preliminary edition of the guide. It is hoped that the presented guide, even in its primitive form, will be useful to persons needing to develop and apply proven Fab Lab techniques. Of course, the Midwest Digital Fabrication Project participants itself needs fuller processing through all the updated equipment and techniques. Users and reviewers of this first draft can facilitate the MDFP's further development and validation of the by sending in their criticisms and suggestions. All such input will be appreciated and considered in the further development of the guide. The ultimate test of the guide will be its impact on helping academics not to develop and employ outstanding, life-changing and community Fab Labs.

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Software Tools

Linux

Linux is a generic term referring to Unix-like computer operating systems based on the Linux kernel. Its development is an example of free and open source software collaboration; typically all the underlying source code can be used, freely modified, and redistributed by anyone.

Linux is predominantly known for its use in servers, although it is installed on a wide variety of computer hardware, ranging from embedded devices and mobile phones to supercomputers. Linux distributions, installed on both desktop and laptop computers, have become increasingly commonplace in recent years, owing largely to the popular Ubuntu distribution and to the emergence of net books.

Ubuntu

Ubuntu is a free Debian-derived computer operating system based on Linux. Ubuntu's goals include providing an up-to-date, stable operating system for the average user, with a strong focus on usability and ease-of-installation. Ubuntu has been selected by readers of desktoplinux.com as the most popular Linux distribution for the desktop, claiming approximately 30% of their desktop installations in both 2006 and 2007.

http://www.ubuntu.com/

Linux Installation Instructions

First take stuff out of boxes and set up computer.

Then be sure you are connected to the internet. Set up internal Windows settings for your computer. Try to set up the computer such that you have a user's world and an administrator's world. Will save headaches in the future. You will likely get a EULA tool bar screen that you can't navigate around or close in any normal manner. Look at the bottom of the computer screen at the EULA Toolbar menu tab, click on it, and select "Close Group". It should go away and not bother you anymore.

Insert the Ubuntu 7.10 (Gutsy Gibbon) CD into the CD/DVD drive. Quit /Restart your computer.

As the computer shuts down and before it boots up again, hold down F12 for the boot menu. When it comes up, choose CD/Rom Drive. Hit "Enter".

The screen will reset, there will likely be some plain text on the monitor. Wait until the Ubuntu install screen comes up. You will have several choices as to how to install Ubuntu—you want to choose the first item at the top of the list, Start or Install Ubuntu. Hit "Enter". The computer will take a while to boot up in Ubuntu.

When you get the Ubuntu desktop screen there will be an install icon on the desktop. Double click the icon. It will take you through a series of set up questions like what language, what time zone, user name, password, etc. Answer as appropriate. We always suggest that in order to make all computers everywhere accessible to everyone that you establish the user name "Fab" AND the password "Fab". You may later want to go and set up a different user account for your everyday users or for the administrator, but for now just use "Fab" and "Fab".

A few screens into the install process you will be asked how you want to install—as in do you want Ubuntu to be the only operating system or if you want to partition the drive such that whatever else is on the computer can remain there. We suggest that you set these up as Dual Boot computers. That is, Windows XP on one partition and Ubuntu OS on the other partition. So choose to partition the drive. Ubuntu automatically cuts the drive space in half and so will offer you the option of splitting the drive 50-50%. Say "Yes" unless you have special needs for three operating systems or need more Windows space or whatever.

It will ask you very scarily… "Do you really want to do this?" Be brave, say "yes". Then it will take some time for the partitioning to happen. Once the process is complete it will ask you to restart the computer. Please restart the computer. (Remember your user ID and Password are "Fab" and "Fab"). You will notice that the CD/DVD drive will eject the Ubuntu live disk, and you will see a boot up choice list on the screen. The choices are between different operating systems, Windows being at the bottom of the list. (If you want to boot into Windows, you have to very quickly scroll to the bottom of the list to "Windows" and hit "enter".) If you do nothing, the computer will automatically boot up in the appropriate Ubuntu OS (the first one on the list.)

Now you're in, and it's time to load all the Fab software onto your computer. First we need up upgrade and update all the Ubuntu standard software and programs.

At the top of your desktop in the menu bar, click and hold on:

Applications

Accessories

Terminal

This will open a terminal window for you. You will see a fab@fab-desktop:~$ prompt. The name reflects whatever name you used to set up the computer. Here you are going directly into the heart of the computer and you will ask it to update programs and upgrade them as well. At the prompt type:

sudo apt-get update

You will be prompted for your password:

fab

("sudo" is the term that makes you the "root" user or administrator. If you tried to type "apt-get update" without the "sudo", you would not be allowed to perform this task.)

Now the computer will update all the programs via the internet. This shouldn't take long.

When it has completed the upgrade you will get the fab prompt again. Now type:

sudo apt-get upgrade

This process will likely take a lot longer and you will be asked questions during the process, the most common being "this programs needs X amount of space, do you want to continue?" You say "yes". In most cases you want to take the default option to the questions. But be sure to read every question to insure its loading what you want and how you want it.

Once the upgrade process is complete, you'll need to restart the computer again.

Dual Boot

This is for helping people get Ubuntu Linux installed and set up in a 'dual boot' configuration with their existing operating system. 'Dual boot' means the computer will have two operating systems in it and you can choose which one you want to use each time the computer is booting up. This website contains six different

illustrated examples of how to install Ubuntu Linux, plus several pages of related information that may be useful before and after the installation.

Linux operating systems have become much more user friendly in the last few years. Ubuntu Linux is easy to use and quite fast, and is now by far the most popular Linux. Linux operating systems are immune to viruses and all kinds of malware because they are designed and built properly from the ground up.
Installing Ubuntu after Windows

It is much easier to install Windows and then Ubuntu, so if Windows isn't already installed, install it first. If you leave space for Ubuntu at this step you don't have to resize your NTFS partition later saving a bit of time.

Backing Up Your Data and Operating System

Although this may seem obvious, do backup your important data files to another media before attempting a dual boot install. Many backup solutions exist for Windows users, but the easiest one may be to just plug in a USB flash drive or other external storage with enough space on it, or create as many CDs or DVDs with copies of your data as required. (Maybe you can borrow a USB hard drive from a friend if you don't have one.)

Have your recovery CD or DVD handy - Most systems which are delivered with Windows already installed also come with some sort of recovery or re-installation disk. There is a recent tendency for companies to try to save money and not ship such a disk. Instead, they provide you a hidden partition on which there is a recovery tool and an image of the pre-installed system.

If you are buying a new computer and intend on dual booting, perhaps it would be a good idea to inquire if you can get a Windows install or recovery media (CD or DVD), if one is not provided by default. The only solution is to telephone your vendor and ask for a proper CD or DVD, which you are normally entitled to.

There is no mention in the Windows End User License Agreement (EULA) of the partitioning of the hard drive(s) being against it. Just because the tool they provide for system restore is not adequate does not mean you are prohibited from using another tool.

According to the Windows EULA, you are entitled to a backup copy of your OS. While your vendor is not really obliged to provide you with one, having such

image tools pre-installed on your computer in no way prohibits you from obtaining a proper backup of your installation CD. You can remove the restore-image tools from your computer at any time, although Ubuntu can happily be installed alongside them and keep them intact.

The problem with that is if your partition table becomes corrupt, or if you have hardware problem with your disk, recovery from an internal partition is not an option.

Example request for Windows OS CD / DVD recovery media:

"I am about to install Ubuntu Linux and that will change my partition table. I was not given an OS install disk with my system, but a system restore program which is on a hidden partition. If, for some reason, the PC restore tool is no longer able to find the image partition, I would not be able to restore my system. The system restore tools that came with my system are not adequate for my needs. I need an operating system disk. Would you send me one?"

Getting Recovery Media

- Dell Operating System (OS) Recovery CD Creation and Manual Operating System Reinstall
- Other related links and information for Dell owners
- How can I get a Product Recovery CD or DVD? - for Lenovo owners
- Someone's experience getting recovery CDs from IBM for a Thinkpad
- Obtaining a Windows Recovery CD or DVD set - for HP and Compaq Desktop PCs owners

Beginning Ubuntu Installation

1. Boot into Windows or using an Ubuntu Live CD and backup any valuable documents/photos etc. onto removable media such as CD-R/DVD-R.
2. Run the Windows defragmentation tool on C: (My Computer, Right click on drive, Properties, Tools, Defragment Now)
3. Download and burn, or order a CD
    - Download Ubuntu iso from List of Download Mirrors and create the

Ubuntu CD : https://help.ubuntu.com/community/BurningIsoHowto

- Or Order Ubuntu CDs (currently free!, please use judiciously)

4. Once you have the CD, insert it into your CD-ROM drive and reboot your PC.
    - If the computer does not boot from the CD (eg. Windows starts again instead), check your BIOS settings and fix as appropriate.
5. If successfully booted from CD, the Ubuntu logo will be displayed on the screen. Press Enter to continue.
6. Follow the prompts until you are asked this question: "How do you want to partition the disk?".

Resizing partitions with Windows Vista

Windows Vista can shrink its own partition without the need to use third-party software. See this link. If you are running Windows Vista, shrink down your partition through that method, and then boot Ubuntu. The Ubuntu installer will use the free space you created.

Resizing Partitions Using the Ubuntu Installer

Automatic partitioning

1. Choose the First Option (It should be something like: "Resize IDE1 master, partition #1 (hda1) and use freed space").
2. Specify the size of the new partition as a percentage of your entire hard disk.
3. Click on "Forward".
4. continue to Finishing Ubuntu Installation

Manual partitioning

1. Choose "Manually edit partition table"
    - Listed will be your current partitions
2. Select the partition you want to resize and press Enter.

3. Select "Size:" press Enter.
4. Select yes, press Enter.
5. Type in a new size in Gigabytes for your partition, it's recommended you free up AT LEAST 10 GB of free space for your Ubuntu install. Press Enter when happy with your changes. It may take some time to apply the changes.
6. Create a swap partition of at least your amount of RAM (if you don't know, 2000 MB is a good value).
7. Create a partition for your Ubuntu installation, at least 10 GB.
8. Select "Finish partitioning and write changes to disk".

Finishing Ubuntu Installation

1. Finish installing your Ubuntu system.
2. On reboot, remove your Ubuntu cdrom from the cdrom drive, you should be presented with a list of operating systems to boot. Ubuntu should have automatically detected your Windows installation and added an option to boot it on this screen.

Disadvantage of Installing Ubuntu after Windows

This is an optional tip for advanced users to make Ubuntu faster. The rotating hard drive does not have the same performance over all cylinders. The speed of the disk relative to the head is larger at the disk outer edge than near the center of the disk. Therefore rotating disks may have read/write rate 60 MB/sec at the cylinders with lowest numbers (near the outer edge), but only 30-40 MB/sec at cylinders with highest numbers (near the center). So if you just shrink Windows partition and then install Ubuntu, you end up with Windows on the fast side the disk and Ubuntu on the slow side. For faster Ubuntu, install Ubuntu first, and then install Windows. Note that sometimes Windows refuses to be installed anywhere but in the disk partition 1. In such a case, during Ubuntu installation, create your Ubuntu partitions 2,3, and perhaps 4 at low numbered cylinders, and leave unused partition 1 and some amount of high numbered cylinders for Windows. During Windows installation, Windows will set up partition 1 in the slow high numbered cylinders.

Master Boot Record and Boot Manager

GNU/GRUB is the boot manager installed in Ubuntu by default. If you use the Alternate CD you can choose Lilo instead. GRUB and Lilo are both good Open Source boot managers so the main parts of the boot loaders are installed inside Ubuntu. This means Ubuntu is independent and avoids any need for writing to other operating systems. To accomplish this, the only thing in your computer outside of Ubuntu that needs to be changed is a small code in the MBR (Master Boot Record) of the first hard disk. The MBR code is changed to point to the boot loader in Ubuntu. You will be presented with a list of operating systems and you can choose one to boot. If you do nothing Ubuntu will boot after a ten second countdown. If you select Windows then GRUB or Lilo will chain load Windows for you at the Windows boot sector, which is the first sector of the Windows partition.

If you have a problem with changing the MBR code, you might prefer to just install the code for pointing to GRUB to the first sector of your Ubuntu partition instead. If you do that during the Ubuntu installation process, then Ubuntu won't boot until you configure some other boot manager to point to Ubuntu's boot sector. Windows Vista no longer utilizes boot.ini, ntdetect.com, and ntldr when booting. Instead, Vista stores all data for its new boot manager in a boot folder. Windows Vista ships with an command line utility called bcdedit.exe, which requires administrator credentials to use. You may want to read http://go.microsoft.com/fwlink/?LinkId=112156 about it.

Using a command line utility always has its learning curve, so a more productive and better job can be done with a free utility called EasyBCD, developed and mastered in during the times of Vista Beta already. EasyBCD is user friendly and many Vista users highly recommend EasyBCD.

Installing Windows after Ubuntu

Normally when Windows is installed after Ubuntu the master boot record will be overwritten. This means that you would have to boot off a LiveCD and re-install grub. However, here is an alternative method:

1. Create an NTFS partition for windows (using fdisk or whatever tool you are familiar with)
2. Backup the boot sector e.g. dd if=/dev/hda of=/mbr.bin bs=512 count=1
3. Install windows

4. Boot into a LiveCD
5. Mount your root partition in the LiveCD
6. Restore the boot sector e.g. dd if=/media/hda/mbr.bin of=/dev/hda bs=512 count=1
7. Restart and Ubuntu will boot
8. Setup grub to boot windows

Recovering GRUB after reinstalling Windows

As above, when Windows is reinstalled, the master boot record will be overwritten. This can be avoided by backing up the boot sector, by following the instructions from step 2 in the above section 'Installing Windows After Ubuntu'. An alternative method, which has the advantage of not requiring forward planning, is to use the Ubuntu LiveCD to reinstall the GRUB boot sector, here are step-by-step instructions, to be run after Windows has been reinstalled:

1. Boot into a LiveCD
2. Open a terminal
3. Open the GRUB Command line utility by typing

   sudo grub
4. Tell GRUB where your Ubuntu partition is by entering

   root (hdA,B)

Where 'A' is the hard-drive number, starting at 0, and 'B' is the partition number, starting at 0. For example, if Ubuntu was installed on the second partition of the first hard-drive, the command should be

   root (hd0,1)

5. Tell GRUB which drive to put the boot sector on

   setup (hd0)

(Replacing 0, as above, if a drive other than the first is used as the boot device)

6. Leave the GRUB Command line

   quit

and reboot

Issues with Windows XP and NTFS

The Ubuntu installer has included support for resizing NTFS partitions since Ubuntu 5.10 (Breezy Badger) was released way back in 2005. Very few problems have been reported relative to the huge number of times that the installer has been used. If you tried the above procedure and have had no luck, it might be that there is a pre-existing problem either in the file system, in the partition table or the hard disk.

First you should try running CHKDSK before trying again to resize the partition, and if you are using the Alternate CD, defragging might help. It is recommended that you run CHKDSK once again after resizing your NTFS partition.

Also, try the following alternative methods:

Using QtParted from the System Rescue CD

1. Boot into Windows and backup any valuable documents/photos etc onto removable media such as CD-R/DVD-R.
2. Run the Windows disk check tool (Error-checking) on C: a couple of times (the results can be seen in the Administrative Tools > Event Viewer > Application under a "Winlogon" entry).
3. Run the Windows defragmentation tool on C:
4. Download the System Rescue CD ISO image (100 MB; has several very useful software tools).
5. Burn the ISO image to a CD.
6. Boot from the CD and hit Enter when you see the message "Boot:".
7. When you get a command prompt, enter:

   run_qtparted

1. Select your disk on the graphical screen (most likely /dev/hda).
2. Select your NTFS partition to be resized (most likely /dev/hda1).
3. Right click with the mouse and choose Resize.

4. Set the new partition size.
5. Commit your changes in the File -> Commit menu. If your keyboard and mouse stop responding during resizing then please just be patient.
6. Once your changes are saved, remove the System Rescue CD and insert your Ubuntu installation CD.
7. Reboot and install Ubuntu into the free space.

Using GParted from UNetbootin-PartedMagic

Another approach to resizing partitions, which does not require a CD, is to load PartedMagic from Windows via the UNetbootin PartedMagic Loader:

1. Download and install the Windows (.exe) file, then reboot.
2. Select the UNetbootin-partedmagic entry after rebooting, and wait as PartedMagic boots up.
3. Start the partition manager by clicking the GParted icon on the the panel.
4. Select your disk (probably /dev/sda) via the drop-down menu on the top-right corner of the interface.
5. Right-click the NTFS partition to be resized (probably /dev/sda1), and select the "resize" option.
6. Drag the slider to specify the new size the NTFS partition should be resized to, then press OK.
7. Press the "Apply" button to resize the disk, then reboot once done.
8. Upon the next Windows boot, click OK when prompted to remove UNetbootin-partedmagic to remove its boot menu entry.

Now, what software do you load?

It's listed and linked on the webpage that we call the Fab Shoebox.

http://fab.cba.mit.edu/fab

There are several methods you can use to load the software on your computer. They are:

1. via terminal (apt program)

2. Via Ubuntu Synaptic Package Manager (related to method 1—but this a user friendlier GUI).

3. via Fabuntu (http://fabuntu.org) --the online installer created by Ed Baafi at SETC Fab Lab.

4. via a script written by CBA grad students Amon Millner and Amy Sun.

As the last two ways are entirely dependent on what version of Ubuntu you have loaded and what development has happened on the Fab Shoe Box page recently, you might find in two months that both methods 3&4 don't work for you. In that case please do learn methods 1 &2 thoroughly, such that you can fall back on them when Fabuntu and the script become outdated.

Here are the methods described in some detail:

METHOD 1 Via terminal (apt program) This method is the most rudimentary method and uses a terminal window and the APT program. (Stands for Advanced Packaging Tool) People who are Linux savvy really prefer this method as it is straightforward and easy. Read about it at:

http://www.debian.org/doc/manuals/apt-howto/index.en.html

For those of you who are less Linux savvy, less adventurous, and aren't computer geeks yet , try one of the other methods—but be sure to familiarize yourself with this method as a fall back.

At the top of your desktop in the menu bar, click and hold on:

Applications

Accessories

Terminal

This will open a terminal window for you. You will see a fab@fab-desktop:~$ prompt.

STEP A: At the prompt type:

sudo apt-get install blender

Computer will ask you for your password:

fab

Then it will load the software, ask you if it's OK to use the needed space for loading it—you say "Y" for yes.

Then it loads.

Be aware that once you download the EAGLE installation package and run it, you will be asked about Eagle freeware. ** The question will pop up "do you want to run this as a license or freeware?" YOU REALLY WANT TO CLICK ON 'Run as Freeware". The Eagle installer will then ask you if you want to create an Eagle directory. SAY YES!

(**We've recently found a conflict between Eagle and the desktop appearance settings in Ubuntu. Eagle screens are illegible with the default desktop appearance preferences. Before you load Eagle, go to:

System

Preferences

Appearance

You will get a window with several choices and menu tabs. Click on the tab for "Visual Effects". Choose NONE. Then close the window and return to the downloading task at hand.)

Continue the "apt-get" process for each package needed. We suggest that for programming software you add to the fab shoebox list the package "sci.py", which is related to num.py. Be sure to load num.py first! It may be that there are other packages missing for the sci.py installation. When we loaded we found we needed several others that aren't listed on the shoebox: gcc, g77, python-dev, atlas3-base-dev, g++ , in which case you just type:

sudo apt-get install gcc g77 python-dev atlas3-base-dev g++

pwd: fab

And everything you need will load. You will probably be asked ask to put your Ubuntu Gutsy disk back in the CD/DVD drive, please do so and hit Enter.

After you have loaded all the programming software, then test sci.py to be sure it works. In terminal window type:

python

You will see what version of python is on your computer and you will get at prompt that looks like:

>>>

at the prompt type:

>>> import scipy

>>>scipy.test(level=1)

If you are successful you will see a lot of test lines run by on the screen. Horrah!

STEP B: Apt-get won't always be able to find the packages you want. For example TclSpice is one. TclSpice is no longer supported and updated so we've found that the package "ngspice" is probably better. Go to ngspice.sourceforge.net and download to your desktop the Linux version of the ngspice software package. (version 17 under the ng-spice-rework section. Click on "view older releases from the ng-spice-rework package. Then click on "17—platform independent". You will download a .tar.gz file to your desktop.)

Before installing ngspice, lets install:

autoconf

automake

libtool

in the ususal way using apt-get install.

Now go back to your terminal window and type:

cd Desktop

You will now be in the Desktop directory. Create an empty folder and drag the ngspice file into that folder. Change directories such that you are in the empty folder (which now has the ngspice tar file in it.) At the prompt type:

cd foldername (ngspice or whatever you named it)

At the new prompt type:

tar xvfz ng-spice-rework-17.tar.gz

(if by chance you download just a tar file, then type:

tar xvf ng-spice-rework-17.tar)

Now you go into the unpacked ngspice folder:

cd ng-spice-rework-17

Next you want to list the files so you can see them. At the prompt type:

ls

This will show you all the files, in the directory. One is called install. At the prompt type:

cat INSTALL

It will load a text file that tells you everything you need to know to install the program. In this case you will need to type:

./autogen.sh

Run that then type

. /configure – enable-maintainer-mode

Run that then type

make

Run that then type

sudo make install

And it will do its thing for you. To test if you did this correctly type: ngspice. You should get some text telling you what version of ngspice you are running. If for some reason you can't do the last few steps above it probably means you are missing a library—try

sudo apt-get libxaw7-dev

Then execute the above strings of code and that should work.

Now try loading the program gavrasm: again you're going to download a file to your desktop. Click on the gavrasm link on the fab shoebox webpage to find the package. You'll want to download the Linux version.

You'll need to "sudo apt-get install build-essential" first. Then install gavrasm by double clicking on the file on your desktop-- the download manager window will open—select the gavrasm file and the instr.ams file and extract them(in the menu bar above is the "extract" button.) Now look in your folder and you will see the gavrasm icon and the instr.asm file. Good work. Now move them to /usr/local/bin—you should have the file on the desktop and be in the Desktop directory.

sudo mv gavrasm /usr/local/bin

pwd: fab

sudo mv instr.asm usr/local/bin

pwd: fab

Then type:

cd /usr/local/bin

ls

(you should see gavrasm and instr.asm in the directory /usr/local/bin now-if so type:

sudo chmod 755 gavrasm

Next install gcc avr-libc:

Sudo apt-get install gcc avr-libc

Pwd:

fab

We've recently found that "pySerial" (python serial) can cause troubles in installation. Use the Synaptic Package Manager method for python serial. (see

Method 2 below) The package is called "python-serial". To test whether or not it's loaded correctly

In terminal window type:

python

You will see what version of python is on your computer and you will get at prompt that looks like:

>>>

At the prompt type:

>>> Import serial

>>>ser=serial.Serial(1)

>>>ser.write("hi")

If you get no text or error messages back, you have been successful. Hoorah!

Now you should have everything you need installed for graphics and programming.

Now let's load the MIT cad.py and cam.py packages.

At top of the fab shoebox right click on cad.py and on cad.cfg to download to desktop.

Move to the desktop directory:

cd Desktop

And now move the two files into /usr/local/bin:

sudo mv cad.py /usr/local/bin

pwd: fab

sudo mv cad.cfg /usr/local/bin

pwd:fab

Go to /usr/local/bin directory"

cd /usr/local/bin

Give permission for everyone to use cad.py:

Sudo chmod 755 cad.py

We have found that you need to change one of the lines of code in the program to allow the laser cutter time to load large files. So at the prompt type:

sudo gedit cad.cfg

An editable file will open. Replace in the next to the last line "sleep 1" with "sleep 15". Now save the file and close it. It might tell you there is no backup. That's OK. Just go ahead and save it.

Dowload the cad shell script "cad":

Right click on file

Select : copy link location

Go to /usr/local/bin directory:

cd /usr/local/bin

Type:

sudo wget

(Then paste in the link and hit enter)

Now permissions:

sudo chmod 755 cad

Now go to the bottom of the fab shoebox page and right click on cam.py to download to desktop.

And now move the file into /usr/local/bin:

sudo mv cam.py /usr/local/bin

pwd: fab

Get the cam shell script "cam" as well while in /usr/local/bin directory

Right click on file

Select: copy link location

Go to /usr/local/bin directory:

cd /usr/local/bin

Type:

Sudo wget

(then past in the link and hit enter)

Now permissions:

sudo chmod 755 cam

Whew! Done! You are just about ready to fab. Now you need to network printers, another tutorial for later…

METHOD 2 Ubuntu's Synaptic Package Manager:

Read instructions which are very good at:

http://www.debianadmin.com/simple-package-management-with-synaptic-package-manager-in-ubuntu.html

On top menu bar click and hold:

System

Administration

Synaptic Package Manager

Computer will ask for your password (fab)

The GUI will pop up. On the GUI menu bar, click and hold:

Settings

Repositories

A window entitled software sources will pop up, click on the Ubuntu tab.

Be sure all the boxes are checked and select the closest server for download. If

you don't want all these options just be sure the Universe Repositories is checked off at a minimum.

Now click on Internet Updates tab

Check the three top boxes and be sure to click on check for updates in a time frame that makes sense for you. The three remaining tabs aren't really important for us at this time. But do read about them at the above link if you are interested in downloading new and proprietary software as these tabs will allow you to do so.

Now click on Close.

A screen that tells you that the repositories are changed will pop up. You need to click on the "reload" button to insure that the changes are accepted by the computer.

Now you can return to the SPM and load desired software. In the left column/window you will find general descriptions of repositories and on the right upper window you will find the specific programs listed. You need to select the repository category of the program and then find the specific program and RIGHT click on the box next to it identify it for installation. Another window will pop up telling you what supporting packages need to be loaded in order to load the desired software—do "mark" all those packages as well. Mark all your desired software packages, and go up to the SPM menu bar and select APPLY. A screen pops up that shows you everything you asked to be installed so that you can review it one last time, and then you click on the "apply" button. You will see a task bar that shows you the progress of your installations. It may take some time to load all the packages you have selected. When complete a window acknowledging changes will pop up. Hit "CLOSE". Now you're done!

FYI: You can use the SPM to upgrade and to remove software as well.

There will be packages that you can't find using the Synaptic Pacakage Manager. In which case go back to Method 1 and apt-get the ones you can't find.

METHOD 3 Via Fabuntu (http://fabuntu.org)

Here's a quick and easy way to load everything in one relatively painless pass. The catch is that in a few months when the Ubuntu version is updated AND some of the MIT fab software is updated this will no longer work completely—that is, until

Ed and Amon out of the kindness of their hearts update it again. So fabuntu is a static moment in time. As long as you have the same version of Ubuntu (at this moment version 7.10) and the fab shoe box page hasn't changed significantly, you can still use the fabuntu download. Please see the Fab Forum page: http://fab.cba.mit.edu/central/?q=forums/fab_deb/175

Be aware that once you download this installation package and run it, you will be asked about Eagle freeware. The question will pop up "do you want to run this as a license or freeware?" YOU REALLY WANT TO CLICK ON 'Run as Freeware". The eagle installer will then ask you if you want to create an Eagle directory. SAY YES!

(**We've recently found a conflict between Eagle and the desktop appearance settings in Ubuntu. Eagle screens are illegible with the default desktop appearance preferences. Before you load Eagle, go to:

System

Preferences

Appearance

You will get a window with several choices and menu tabs. Click on the tab for "Visual Effects". Choose NONE. Then close the window and return to the downloading task at hand.)

Most of the rest of the installation happens automatically without input required on your part.

4. via a script written by CBA grad students Amon Millner and Amy Sun.

This tool can be used for both individual computer download/installations and for networked lab environments. The default setting is for individual station downloads.

Very similar to METHOD 3 above, this time open a terminal window

At the top of your desktop in the menu bar, click and hold on:

Applications

Accessories

Terminal

This will open a terminal window for you. You will see a fab@fab-desktop:~$ prompt. The name reflects whatever name you used to set up the computer. Here you are going directly into the heart of the computer and you will ask it to update programs and upgrade them as well. At the prompt type:

Wget

http://fab.cba.mit.edu/content/tools/attic/howto/install/fabauto-2.sh

The program "fabauto.sh" will be deposited on your Desktop. Then run it. In your terminal window (in Desktop directory) type:

sh fabauto-2.sh

This generic tool installer has the network drive stuff commented out so the networked parts won't run unless a person uncomments that code.

There is some permission that you will have to set regardless of which method you use to install the fab shoe box software. To do so, you need to go to the internal folder for the MIT fab software: /usr/local/bin. Whenever you run into a permission problem:

At the prompt type:

cd usr/local/bin (this means change director to the /usr/local/bin directory)

then find the program there that you need to change. For example: cam.py needs permissions. To view permissions that currently exist at the prompt type:

ls -l file

This will show you the state of permissions in the file. Now type:

sudo chmod 777 cam.py

Computer will ask for password.

fab

chmod 777 gives anyone permission to read , write and execute with/to this file/application. IF you want to limit permissions to read and execute, or read and write, use "chmod 755". That's what I've done above. Here is the wikipedia cheat sheet on how to use "chmod":

http://en.wikipedia.org/wiki/Chmod

REMEMBER:

Be aware that once you download the EAGLE installation package and run it, you will be asked about Eagle freeware. The question will pop up "do you want to run this as a license or freeware?" YOU REALLY WANT TO CLICK ON 'Run as Freeware". The eagle installer will then ask you if you want to create an Eagle directory. SAY YES!

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Preferences

Appearance

You will get a window with several choices and menu tabs. Click on the tab for "Visual Effects". Choose NONE. Then close the window and return to the downloading task at hand.)

Most of the rest of the installation happens automatically without input required on your part.

Python Programming Language

Python is a dynamic object-oriented programming language that can be used for many kinds of software development. It offers strong support for integration with other languages and tools, comes with extensive standard libraries, and can be learned in a few days. Many Python programmers report substantial productivity gains and feel the language encourages the development of higher quality, more

maintainable code.

Python runs on Windows, Linux/Unix, Mac OS X, OS/2, Amiga, Palm Handhelds, and Nokia mobile phones. Python has also been ported to the Java and .NET virtual machines.

CAD

Computer-aided design (CAD) is the use of computer technology for the design of objects, real or virtual. The design of geometric models for object shapes, in particular, is often called computer-aided geometric design (CAGD).

However CAD often involves more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD often must convey also symbolic information such as materials, processes, dimensions, and tolerances, according to application-specific conventions.

CAD may be used to design curves and figures in two-dimensional ("2D") space; or curves, surfaces, or solids in three-dimensional ("3D") objects.

CAD is an important industrial art extensively used in many applications, including automotive, shipbuilding, and aerospace industries, industrial and architectural design, prosthetics, and many more. CAD is also widely used to produce computer animation for special effects in movies, advertising, technical manuals. The modern ubiquity and power of computers means that even perfume bottles and shampoo dispensers are designed using techniques unheard of by shipbuilders of 1960s. Because of its enormous economic importance, CAD has been a major driving force for research in computational geometry, computer graphics (both hardware and software), and discrete differential geometry.

CAD.PY

PythonCAD is a CAD package written, surprisingly enough, in Python. The PythonCAD project aims to produce a scriptable, open-source, easy to use CAD package for Linux, the various flavors of BSD Unix, commercial Unix, and other platforms to which someone who is interested ports the program. Work began on PythonCAD in July, 2002, and the first public release was on December 21, 2002.

PythonCAD requires a few bits of software to be up and running on your machine before it will work. You need to have Python 2.2 or newer installed with the zlib module, gtk-2.0, and pygtk-2.0. The code uses features introduced in Python

2.2, so earlier versions will not work, and the GTK/PyGTK code requirements are equally strict, as code for the pygtk-2.0 module do not work with the earlier release. If you want things to work with gtk-1.2 and the older PyGTK, you will have to do some coding.

Installation procedure for cad.py on a particularly uncooperative linux machine

Needed-python (of course).

numpy:
download from http://numpy.scipy.org/
run: python setup.py install

scipy:
(scipy installation somewhat painful... theoretically supposed to just work when you do 'python setup.py install', but instead had build errors, which had to do with sse2 instruction set (see the post to scipy-user mailing list at the bottom of the page).

Tkinter:
My python refused to recognize the Tkinter module. This is because it was built without having access to tcl & tk. So I got tcl/tk and built python all over again, starting from scratch (I downloaded python -- my previous version had come with fedora).

yum install tcl tk tcl-devel tk-devel

Image:
Installed python Imaging library from http://www.pythonware.com/products/pil/

Appendix I: Build problems with SciPy

Date: Mon, 1 Oct 2007 21:26:34 -0400
From: "Steve Leibman"
Subject: [SciPy-user] How to get past the dfftpack build error "suffix
or operands invalid for `movd'"

To: scipy-user@scipy.org
Message-ID:
<d13973a60710011826k35582766qd92113b48bcbe8ae@mail.gmail.com>
Content-Type: text/plain; charset=ISO-8859-1

While attempting to build scipy on an Intel core 2 duo box with fedora core 5, I ran into a problem during the compilation of dfftpack.
I saw a few other people post this complaint to various lists, but no published solutions, so this email is intended to show the workaround that worked for me. I have not tried to reproduce it in a standalone copy of fftpack from netlib, though presumably the bug is somewhere in there.

The symptoms:
==========
/tmp/ccCnF9WU.s: Assembler messages:
/tmp/ccCnF9WU.s:599: Error: suffix or operands invalid for `movd'
/tmp/ccCnF9WU.s:2982: Error: suffix or operands invalid for `movd'
/tmp/ccCnF9WU.s: Assembler messages:
/tmp/ccCnF9WU.s:599: Error: suffix or operands invalid for `movd'
/tmp/ccCnF9WU.s:2982: Error: suffix or operands invalid for `movd'
error: Command "/usr/bin/g77 -g -Wall -fno-second-underscore -fPIC -O2 -funroll-loops -march=pentium3 -mmmx -msse2 -msse -f omit-frame-pointer -malign-double -c -c Lib/fftpack/dfftpack/zfftf1.f -o build/temp.linux-i686-2.4/Lib/fftpack/dfftpack/zfftf1.o" failed with exit status 1

The solution:
==========
The real solution is to figure out why the generated assembly has a screwy instruction in it.

In the meantime... despite the fact that my machine supports the sse2 instructions, I was able to work around the issue by getting rid of the -msse2 flag on the compile line in order to make it work (if you have this problem, run the g77 compile line both with and without "-msse2", to see whether this solution will work for you). The problem is that there's no convenient way to forcefully remove the

"-msse2" option... it isn't written into anything civilized like a Makefile. Instead, I temporarily modified my python numpy installation, changing the _has_sse2 () function in site-packages/numpy/distutils/cpuinfo.py, such that it always returns False. Pretty nasty, but it worked for me.

--
Steve Leibman
sleibman@gmail.com

AVRDUDE

AVR Downloader/UploaDEr

- For the latest AVRDUDE version, see here: savannah.nongnu.org/projects/avrdude
- For the latest project information, see the AVRDUDE project at savannah.nongnu.org.

AVRDUDE is a full featured FreeBSD UNIX program for programming Atmel's AVR CPU's. It can program the Flash and EEPROM, and where supported by the serial programming protocol, it can program fuse and lock bits. AVRDUDE also supplies a direct instruction mode allowing one to issue any programming instruction to the AVR chip regardless of whether AVRDUDE implements that specific feature of a particular chip.

AVRDUDE can be used effectively via the command line to read or write all chip memory types (eeprom, flash, fuse bits, lock bits, signature bytes) or via an interactive (terminal) mode. Using AVRDUDE from the command line works well for programming the entire memory of the chip from the contents of a file while interactive mode is useful for exploring memory contents, modifying individual bytes of eeprom, programming fuse/lock bits, etc.

EAGLE

The EAGLE Layout Editor is an easy to use, yet powerful tool for designing printed circuit boards (PCBs). The name EAGLE is an acronym, which stands for

Easily Applicable Graphical Layout Editor

The EAGLE Light Edition can be used for free.

Limitations

The following limitations apply to the EAGLE Light Edition in general:

- The useable board area is limited to 100 x 80 mm (4 x 3.2 inches).
- Only two signal layers can be used (Top and Bottom).
- The schematic editor can only create one sheet.

Apart from these three limitations the EAGLE Light Edition can do anything the Professional Edition can do. You can even load, view and print drawings that exceed these limits!

The Freeware version of EAGLE Light has these limitations:

- Support is only available via email or through our forum (no fax or phone support).
- Use is limited to non-profit applications or evaluation purposes.

Follow these steps to install the free EAGLE Light Edition on your system:

- Go to the Download area and get the file that contains the EAGLE program installation data for your language (English or German) and your operating system (Linux, Windows or Mac).
- Install the file you have downloaded onto your system.
- When you first start EAGLE, you will be asked whether you have a personalized license disk, or whether you want to run EAGLE as Freeware. To use the Freeware license select the “Run as freeware” button.

Be aware that once you download the EAGLE installation package and run it, you will be asked about Eagle freeware. ** The question will pop up “do you want to run this as a license or freeware?” YOU REALLY WANT TO CLICK ON ‘Run as Freeware”. The Eagle installer will then ask you if you want to create an Eagle directory. SAY YES!

- (**We’ve recently found a conflict between Eagle and the desktop appearance settings in Ubuntu. Eagle screens are illegible with the default desktop appearance preferences. Before you load Eagle, go to:

System

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Appearance

You will get a window with several choices and menu tabs. Click on the tab for “Visual Effects”. Choose NONE. Then close the window and return to the downloading task at hand.)

RHINO 3D

Rhinoceros (Rhino) is a stand-alone, commercial NURBS-based 3-D modeling tool, developed by Robert McNeel & Associates. The software is commonly used for industrial design, architecture, marine design, jewelry design, automotive design, CAD / CAM, rapid prototyping, reverse engineering as well as the multimedia and graphic design industries.

Rhino specializes in free-form NURBS modeling. Plug-ins developed includes Flamingo (raytrace rendering), Penguin (non-photorealistic rendering), Bongo (animation), and Brazil (advanced rendering). Over 100 third-party plugins are also available. Like many modeling applications, Rhino also features a scripting language based on the Visual Basic language, and an SDK that allows reading and writing Rhino files directly.

Rhino’s increasing popularity is based on its diversity, multi-disciplinary functions, low learning-curve, relatively low cost, and its ability to import and export over 30 file formats, which allows Rhino to act as a ‘converter’ tool between programs in a design workflow.

http://www.rhino3d.com/download.htm

GAVRASM

GAVRASM, A command line assembler for all AT90S-, ATtiny- and ATmega types of microcontrollers of ATMEL, with many extended and new features.

The Assembler translates assembly source code into object code. The generated object code can be used as input to a simulator or an emulator such as the Atmel AVR In-Circuit Emulator. The Assembler also generates a PROMable code and an optional EEPROM file which can be programmed directly into the program memory and EEPROM memory of an AVR microcontroller.The Assembler generates fixed code allocations, consequently no linking is necessary.

THE GIMP

The GNU Image Manipulation Program (GIMP) is a free software raster graphics editor. The GIMP product vision sees GIMP as a high end program for the editing and creation of Original Images, icons, graphical elements of web pages and art for user interface elements. The product vision also sees GIMP as a platform for the development of cutting edge scientific image processing algorithms.

CAD / CAM

Computer-aided technologies (sometimes abbreviated as CAx), is a broad term describing the use of computer technology to aid in the design, analysis, and manufacture of products.

Advanced CAx tools merge many different aspects of the product lifecycle management (PLM), including design, analysis using finite element analysis (FEA), manufacturing, production planning, product testing using virtual lab models and visualization, product documentation, product support, etc. CAx encompasses a broad range of tools, both those commercially available and those which are proprietary to the engineering firm.

The term CAD/CAM (computer-aided design and computer-aided manufacturing) is also often used in the context of a software tool covering a number of engineering functions.

cad.py

PythonCAD is a CAD package written, surprisingly enough, in Python. The PythonCAD project aims to produce a scriptable, open-source, easy to use CAD package for Linux, the various flavors of BSD Unix, commercial UNIX, and other platforms to which someone who is interested ports the program. Work began on PythonCAD in July, 2002, and the first public release was on December 21, 2002.

Inkscape

An Open Source vector graphics editor, with capabilities similar to Illustrator, CorelDraw or Xara X uses the W3C standard Scalable Vector Graphics (SVG) file format.

Inkscape supports many advanced SVG features (markers, clones, alpha blending, etc.) and great care is taken in designing a streamlined interface. It is very easy

to edit nodes, perform complex path operations, trace bitmaps and much more. We also aim to maintain a thriving user and developer community by using open, community-oriented development.

oodraw

OpenOffice.org Draw is a vector graphics editor and is part of the OpenOffice.org office suite. It features "connectors" between shapes, which are available in a range of line styles and facilitate building drawings such as flowchart. It also includes many features found in desktop publishing software. Draw is similar to Microsoft Publisher.

OpenOffice.org users can also install the Open Clip Art Library, which adds a huge gallery of flags, logos, icons and banners for general presentation and drawing projects. In particular, Linux distributions Debian and Ubuntu have provided ready-to-use openclipart packages for easy download and install from their online software repositories.

Released under the terms of the GNU Lesser General Public Licence, Draw is free software.

QCad

QCad is a computer-aided design (CAD) software package for 2D design and drafting. It is available for Linux, Mac OS X, Unix and Microsoft Windows. The QCad Community Edition, which lacks functionality present in the full version, is released under the GNU General Public License and is not (officially) available for Windows, though unofficial builds do exist. Precompiled packages are available for some Linux platforms, such as Debian, via the distribution's package manager.

QCad is developed by RibbonSoft. Development on QCad began in October 1999, starting with code from CAM Expert. QCad 2, designed to "make QCad more productive, more user friendly, more flexible and increase its compatibility with other products" began development in May 2002.

Much of the interface and concepts behind use are the same of those of AutoCAD.

QCad uses the AutoCAD DXF file format internally and to save and import files.

Tux Paint

Tux Paint is a free, award-winning drawing program for children ages 3 to 12 (for example, preschool and K-6). It combines an easy-to-use interface, fun sound effects, and an encouraging cartoon mascot who guides children as they use the program.

Kids are presented with a blank canvas and a variety of drawing tools to help them be creative.

http://www.tuxpaint.org/download/

K-3D

K-3D is free-as-in-freedom 3D modeling and animation software. It features a plugin-oriented procedural engine for all of its content, making K-3D a very versatile and powerful package.
K-3D excels at polygonal modeling, and includes basic tools for NURBS, patches, curves and animation.

SketchUp

Google SketchUp is software that you can use to create 3D models of anything you like.

Most people get rolling with SketchUp in just a few minutes. Dozens of video tutorials, an extensive Help Center and a worldwide user community mean that anyone who wants to make 3D models with SketchUp, can. Check out our training videos »

Model anything you can imagine.

Redecorate your living room. Design a new piece of furniture. Model your city for Google Earth. Create a skate park for your hometown, then export an animation and share it on YouTube. There's no limit to what you can create with SketchUp.

Get models online for free.

You can build models from scratch, or you can download what you need. People all over the world share what they've made on the Google 3D Warehouse. It's a huge, searchable repository of models, and it's free.

http://sketchup.google.com/download/

Tkinter

The Tkinter module ("Tk interface") is the standard Python interface to the Tk GUI toolkit from Scriptics (formerly developed by Sun Labs).

Both Tk and Tkinter are available on most UNIX platforms, as well as on Windows and Macintosh systems. Starting with the 8.0 release, Tk offers native look and feel on all platforms.

Tkinter consists of a number of modules. The Tk interface is located in a binary module named tkinter (this was tkinter in earlier versions). This module contains the low-level interface to Tk, and should never be used directly by application programmers. It is usually a shared library (or DLL), but might in some cases be statically linked with the Python interpreter.

In addition to the Tk interface module, Tkinter includes a number of Python modules. The two most important modules are the Tkinter module itself, and a module called Tkconstants. The former automatically imports the latter, so to use Tkinter, all you need to do is to import one module:

Numpy

NumPy is the fundamental package needed for scientific computing with Python. It contains:

- a powerful N-dimensional array object
- sophisticated broadcasting functions
- basic linear algebra functions
- basic Fourier transforms
- sophisticated random number capabilities
- tools for integrating Fortran code
- tools for integrating C/C++ code

Besides its obvious scientific uses, NumPy can also be used as an efficient multi-dimensional container of generic data. Arbitrary data-types can be defined.
This allows NumPy to seamlessly and speedily integrate with a wide variety of databases.

Matplotlib

Matplotlib is a plotting library for the Python programming language and its NumPy numerical mathematics extension. It provides a "pylab" API designed to closely resemble that of MATLAB, thereby making it easy to learn for experienced MATLAB users. Matplotlib is written and maintained primarily by John Hunter, and is distributed under a BSD-style license.

The "pylab" interface is procedural and based on a state machine, like OpenGL. There is also an OOP interface which is documented in the API Docs which allows matplotlib plots to be embedded into applications using generic GUI toolkits, like wxPython, Qt or GTK.

Currently, Matplotlib only has support for Python versions up to 2.5.

PIL

The Python Imaging Library (PIL) adds image processing capabilities to your Python interpreter. This library supports many file formats, and provides powerful image processing and graphics capabilities.

Pygame

Pygame is a cross-platform set of Python modules designed for writing video games. It includes computer graphics and sound libraries designed to be used with the Python programming language. It is built over the Simple DirectMedia Layer (SDL) library, with the intention of allowing rapid development.

Ngspice

Ngspice is a mixed-level/mixed-signal circuit simulator. Its code is based on three open source software packages: Spice3f5, Cider1b1 and Xspice.

- Spice3 does not need any introduction, is the most popular circuit simulator. In over 30 years of its life Spice3 has become a de-facto standard for simulating circuits.
- Cider couples Spice3f5 circuit level simulator to DSIM device simulator to provide greater simulation accuracy of critical devices. DSIM devices are described in terms of their structures and materials.

- Xspice is an extension to Spice3C1 that provides code modeling support and simulation of digital components through an embedded event driven algorithm.

http://ngspice.sourceforge.net/

CorelDraw X3

CorelDraw X3 is the Windows program most often used to communicate with the various machines in the Fab Lab [especially the Epilog Laser Cutter and the Roland Vinyl Cutter]. The following explains how to prepare the various types of files for use in Corel.

What programs can I convert?

This following will cover converting AutoCAD, Pro/Engineer Wildfire 4, and Inkscape.

AutoCAD

While in AutoCAD, do the following:

1) Create a rectangle around the geometry to be cut with the lower left hand corner at 0, 0.
2) In Layer Manager:
   a) Turn off all layers that will not be used during the cutting process (dims, notes, etc.), they should be marked "Do Not Plot"
   b) Change all the geometry to be [vector] cut to the same color.
   c) Change all the geometry to be [vector] cut to line weight 0.001 (AutoCAD will display this as 0.00)
   d) Change all geometry to be [raster] engraved to the same color (different than the color you chose for the [vector] cuts).
3) Save the file on a flash drive as an AutoCAD 2004 DXF file for compatibility with CorelDraw X3.

Once in CorelDraw:

Open a blank document and choose File Import, then select the appropriate file from your flash drive. When you are importing you DXF file make sure that "Auto-Reduce Nodes" is enabled. A window will pop up during import; make sure the box

next to "Auto-Reduce Nodes" is checked before proceeding.
Clean up the file by selected all your objects and ungrouping them [Arrange Ungroup or Ctrl + u], then select only the border and delete it.
After you have sent your file to the Laser Cutter, save a copy of the Corel file you used onto your flash drive for future reference.

Pro/Engineer Wildfire 4.0

While in Pro/Engineer do the following:

a) Create a Two Dimensional view of the model by creating a new drawing.
b) Hide the axes, datum planes, origins, and spin center [make sure their buttons at the top of the window are deselected].
c) File|New|Drawing – give your drawing a name.
d) Make sure "use default template" is checked.
e) Select c_drawing as drawing template then click OK.
f) A 3-view drawing will appear, delete the two views that do not show the desired profile [click the view to be removed then press the delete key].
g) At the bottom of the drawing frame should be SCALE in gray; double click it.
h) In the text field at the bottom of the window type 1 to change the scale to 1:1 and click the check mark or press enter.
i) Now "Save a Copy" (Under the File Menu) of the drawing as a DXF files to your flash drive. Type in whatever name you like for the file. A dialog box appears – change the DXF version from 2007 to 2004 and then click OK.
j) Pro E creates 3 files; you only need the ".dxf" file. Windows may not show the extension so you can right click and check Properties to see what type of file it is. Copy the correct file to your flash drive.

Once in Corel:

Open a blank document and choose File|Import, then select the appropriate file from your flash drive. When you are importing you DXF file make sure that "Auto-Reduce Nodes" is enabled. A window will pop up during import; make sure the box next to "Auto-Reduce Nodes" is checked before proceeding.
Clean up the file by selected all your objects and ungrouping them [Arrange|Ungroup or Ctrl+u], then select only the border and delete it.
After you have sent your file to the Laser Cutter, save a copy of the Corel file you used onto your flash drive for future reference.

Inkscape

For the dimensions you see in Inkscape to remain accurate when transferred to Corel you will do the following:

a) Remove the line/Stroke from your objects. In the lower left hand corner of the window double click the color box next to "Stroke:" A frame with the Fill and Stroke options will open. Click the tab that says "Stroke paint" and select the black X on the left to remove the outline from the objects you have selected.
b) In order to see the objects they must be filled. Click the Fill tab (next to Stroke). Select solid colors to fill each of the objects. You can use the Object|Raise/Lower to see if objects overlap.
c) File|Save the original file [as an Inkscape SVG] then File|Save a Copy on your flash drive as an EPS file [select it from the dropdown box in the lower right corner].

Once in Corel:

Open a blank document and choose File|Import, then select the appropriate file from your flash drive.
Select all your objects and ungroup them [Arrange|Ungroup or Ctrl+u]. In order to vector cut your objects you will need to select each one, change the Stroke width to "Hairline", and remove the fill (otherwise it will get rastered).
After you have sent your file to the Laser Cutter, save a copy of the Corel file you used onto your flash drive for future reference.

Final notes

Once your files are ready in CorelDRAW reference the tutorial for the machine you will be using.
Other questions can be answered by Lab Assistants in the Fab Lab network

STL Files

What does this tutorial cover?
How to export a stereo lithography file from ProEngineer to use on the ZCorp 3D printer
The Steps
1. Open your finished model and go File->Save a Copy
2. In the "Save a Copy" dialog box, select "STL (*.stl)" from the "Type" menu and then write a name in the "New Name" box right above that.

3. In the "Export STL" dialog click "Okay" [the default settings should be fine].
4. After the export is complete your model will have the triangulated mesh for the Stereo Lithography highlighted in green.

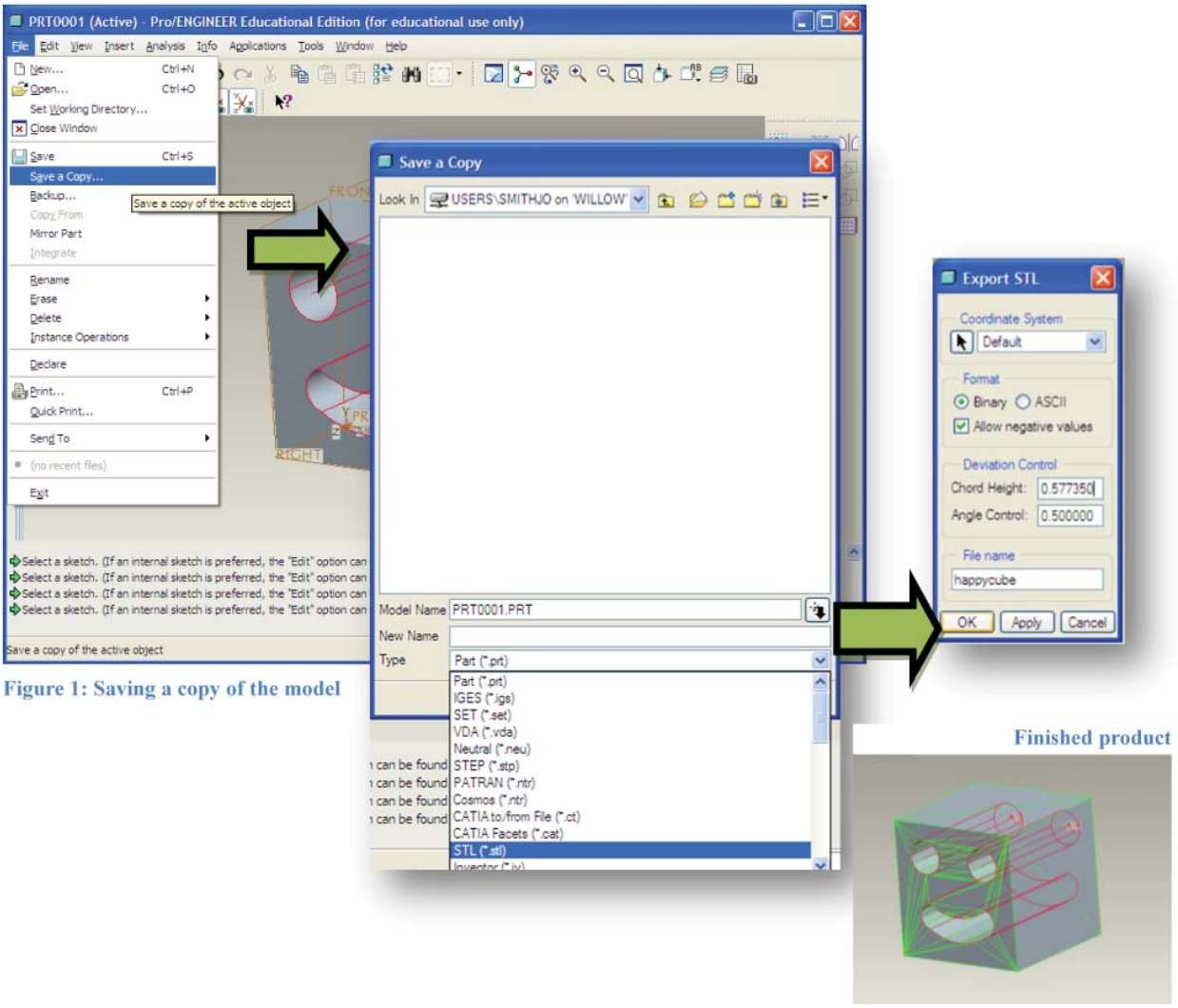

Figure 1: Saving a copy of the model

CAD/CAM is a python program that runs on the Linux Operating System. CAD/CAM can be used to design 2d shapes or 3d objects that can be prototyped using many different methods and machines in the Fab Lab. Below, are application examples for using CAD/CAM as well as tricks and tips for using this software.

Applications

Modela Mini Mill
Roland Vinyl Cutter

Tricks and Tips

Killing/Restarting CAD/CAM without restarting Linux

and, do you know a key command to kill cad.py while it's sending data to the Modella? So I don't need to reboot the whole system.

All you need to do is kill the processes that you are sending to the Modella you don't even need to kill cad.py, so you don't have to re-contour.

First, find the processes sending to the Modella. These processes are something like cat something.rml > /dev/ttyS0, you can find them by % ps aux | grep rml

You should see 2 or 3 processes listed, one of which is the "grep" command you used to search for the process. Look at the process number, and kill them all, e.g.: % kill 1234 5678 (But with the correct process numbers).

Next, be sure to clear the modela's buffer by pressing the up and down buttons simultaneously. The green light on the modela should flash for a couple of seconds then stop. If it doesn't stop flashing, this indicates that the computer is still sending. Repeat the above steps until the light stops flashing.

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Operation And Safety

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Polycom

Starting…

Make sure the Polycom is on.
[The outline of the power button should be glowing green; if it's blue, and then press it once to turn it on. Make sure the view screen is on [this should be fairly obvious].
Connecting to a remote site

Press the Mute button (it's the orange oval button with a picture of microphone with a slash through it). This is so you will not be transmitting sound to the site you are connecting too (for example, MIT classes prefer not to be disturbed by noise from the remote sites). If will be directly conferencing with another site you can skip this step.

Use the down arrow to choose the Directory. Choose Fox Valley, LCCC, or MIT. [You can choose others if you would like as well.] If you choose Fox Valley or LCCC you should be looking at their respective Fab Labs. If you choose MIT, you will need to press the 'far' button *it's to the right of the volume controls+ and then uses the arrow keys [up or down] to choose [right arrow] the correct class.

When you are finished – end the call. You can press the red telephone button on the upper right of the remote to do this.

Other notes:

If you would prefer to stop sending our video to other sites you can press the purple button on the lower left of the remote. Setting down the remote will also stop our camera from transmitting. You can control the camera at Fox Valley by pressing the far button then using the arrow keys and zoom keys. If you need further assistance, Polycom has a great manual:

http//:www.polycom.com/global/documents/support/user/products

VSX Series Remote Control

Laser Engraver

Epilog Helix [45W Laser Cutter] Please refer to the manufactures operational manual for more indepth information.

What does this machine do?

A laser cutter uses a concentrated beam of energy to cut or raster a flat material. In our case that material is usually cardboard for the first run and then some type of acrylic for the final piece.

Safety

- NEVER operate the machine unattended.
- Always use the air assist and exhaust while running the machine.
- Do not set anything on top of the machine.

Never cut any material containing PVC or vinyl. Cutting these will produce a corrosive gas that will destroy the machine and could seriously hurt you. If you are not sure about your material ask the Fab Lab assistant before proceeding.

Do not open the machine while it is running. If you need to stop the laser, press the red 'STOP' button.

If for some reason the material being cut catches on fire it must be extinguished immediately. Press the STOP button, lift the lid, and quickly blow out the flame. Get the attention of the instructor or lab assistant right away. In case of serious flames use the fire extinguisher located between the entrance to the Fab Lab and the sink to put out the fire.

Beginning

Power on the computer (allow Windows to start up if you will be using Corel or Adobe; if you will be printing using CAD.py then switch to Ubuntu while booting up the computer).

Import and format file in Corel

Prepare your part for import into Corel before you sit down at the machine. [See "How to Get Ready for Corel" document in D2L for more information.]
Once at the machine, login as "Student", then double-click the Corel X3 icon on the desktop.
Open your file if you created it in Corel. Import your file if you created it

something else (and then saved it to a compatible SVG, EPS, or DXF). [Reminder: when importing DXF files you must have the "Auto-Reduce Nodes" check box enabled.]

If you imported your file you may need to select all [Ctrl-a] and then ungroup [Ctrl-u or Arrange Ungroup] so that you can select individual objects.

Vector cutting: Select the lines [objects] you want to the laser to cut completely through the material. Make sure the line thickness of these objects is set to 'Hairline'. [You can do this by double-clicking the Pen icon in the lower right or checking the description next to the Pen icon in the Property Bar.] If you are using a program other than Corel set the line thickness to 0.001 inches [0.025mm].

Rastering (engraving): Any lines that are wider than Hairline width [or greater than 0.007 inches] and any images or text will be engraved onto the surface of your material. Any filled in shapes will also be engraved, so for the sake of time it is helpful to keep shaded areas to a minimum.

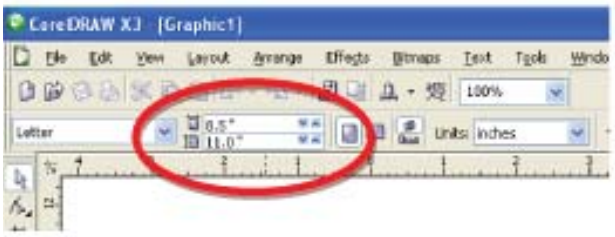
Select and set material

For your first run of any part do a practice cut on cardboard. For your final product we have a supply of acrylic that cuts well and leaves a professional finish. Position your material in the back left corner of the machine (the origin) and close the lid.

Arrange Parts

Measure your material using the rulers along the top and left side of the machine. Change the paper size of your drawing to match the measurements of your material. You can do this by deselecting all the objects and then changing the size in the Property Bar. [see image below] Also, make sure the Units are in inches.

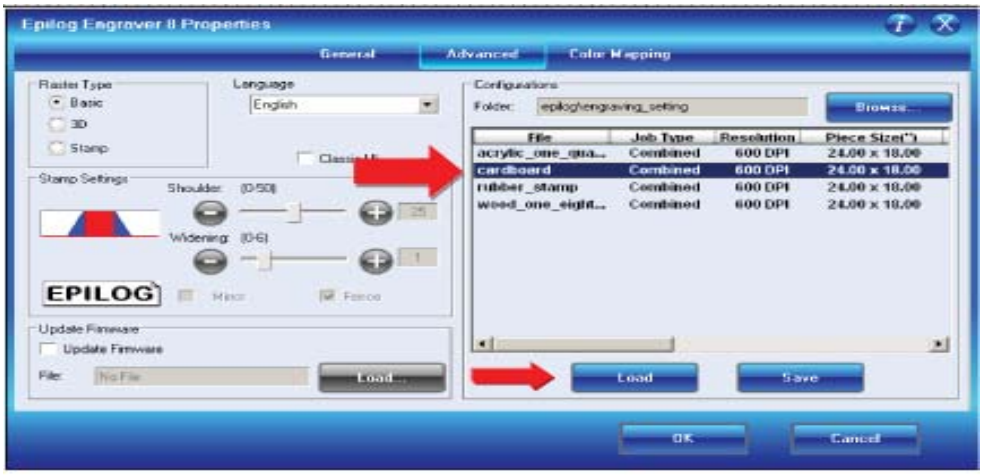
Now, arrange the objects you will be cutting within the paper (page) outline – this insures your pieces will fit on the material. It is good practice to place your pieces reasonably close together in order to conserve material, however make sure that none of the pieces overlap. Sometimes it helps to rotate a piece or two.

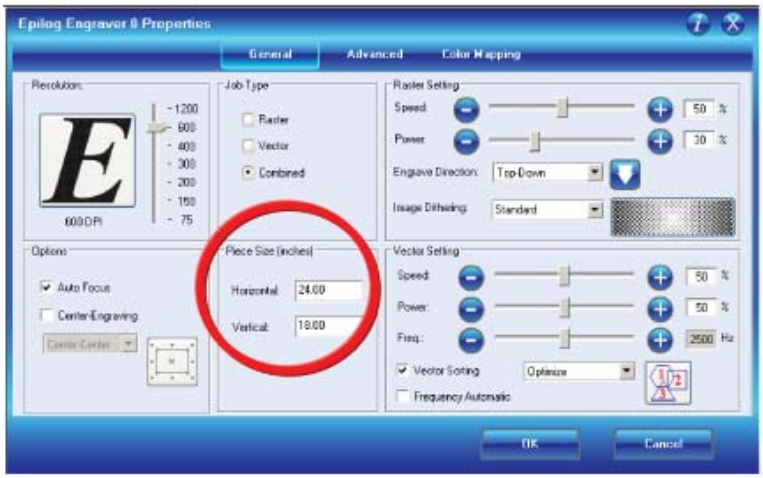


'Printing' [a.k.a. laser engraving/cutting]

Go to File Print Setup. Select the Epilog Engraver 8 and then click the 'Properties' button. Select the 'Advanced' Tab [see illustration on the next page] along the top of the window and then select your material from the list in the box on the right. Then click 'Load' below the box. [If your material is not listed click the big blue "Browse…" button, choose 'All materials', then click Open.]

Click the 'General' tab. set the Piece Size to the dimensions of the material you placed in the machine. If you are only cutting all the way through your material you may select the "Vector" setting [only lines of thickness 0.001 and Hairline will be cut]; if you only want to engrave your image you can choose the "Raster" setting.





Finally – the Laser

If it is your first time cutting this material then get a lab assistant to look over your settings prior to sending them to the laser. Then:

1. Turn on the Epilog by flipping the switch in on the left side of the machine [back bottom corner]. If Windows tries to tell you it has 'found' a new printer ignore close these boxes.

2. Turn on the air assist by turning the lever counterclockwise from the 'left' to the 'down' position. You should hear the air pressure being released into the system.

3. Turn on the exhaust fan [it's the lighter switch on the wall near the air line.

4. Send your job to the printer. [File Print, if issues surface, correct them before proceeding. It is good practice to look at a Print Preview as well before sending it to the Laser.]

5. Once your file is in the Epilog, press the green "GO" button. DO NOT LEAVE THE MACHINE while it is cutting. If your material is set on fire press the "STOP" button immediately, lift the lid and quickly blow out the flame if possible. Call over a Lab Assistant as soon as possible for help.

6. After you file is finishing cutting wait another minute to allow the exhaust to clear some most of the fumes from the lased material. Then lift the lid and remove all of your material (even the pieces that you will later discard). Close the lid.

Clean up

After clearing all of your material from the laser, close the lid, and then turn off the air assist, the exhaust fan, and the Epilog Helix (in that order). Close your programs and remove any files you transferred to the hard drive for your project.

Other Notes

More information about the Epilog Helix Laser Engraver can be found on the Fab Lab D2L site as well as at www.epiloglaser.com. For specific instructions about how to prepare different file formats for import into Corel see "How to Get Ready for Corel" document in D2L. If you will be using the Linux printing program 'cad.py' then try the MIT Fab Lab website for help.

WARNING

The laser cutter is a potentially dangerous machine. It is very easy to start fires with the laser cutter; Stanford apparently lost part of a building to an unsupervised machine. The laser cutter can also produce dangerous fumes (e.g., chlorine) if used with improper materials.

People must receive training prior to use of the laser cutter. The cutter must also remain under constant supervision while in use. This document is very partial, and does not constitute training. Please contact shop-admin@cba.mit.edu for further information.

Particular warnings:

Never cut PVC, or other chlorinated plastics (Lexan and PC boards are also strongly discouraged). PVC in particular will give off chlorine gas, which is not only highly corrosive to the machine, but also dangerous for any nearby people.

Constant machine supervision really is a must. E.g., with our own machine, in the middle of a cut, I observed the laser begin etching the internal walls of the machine, and igniting the rubber rollers of the laser cutter head. It turned out that a primary mirror had fallen off, and the 100 watt laser beam was reflecting off the skewed and moving mirror. Had the machine not been under supervision, this might have resulted in a serious fire. We've repaired this problem, but -- others of its ilk may well appear in time.

The machine also has known firmware bugs which can and do cause random cuts.

There are ways to ameliorate this problem, but -- again, constant monitoring is very important.

General capability: Our 100 watt laser cutter can cut acrylic, wood, paper, foam core, among other materials. It can also etch vector (line/arc) and raster (image) engravings into these materials, as well as glass, stone, slate, etc. Our laser cutter cannot cut metal.

Varied cutting speeds, power levels, and pulses per inch (PPI) allow some modulation of this etching, making some limited forms of three-dimensional relief plausible. At heart, though, the laser cutter is a 2D cutting and etching tool, with the third dimension achievable through the stacking or assembly of multiple laser-cut elements or layers.

General cutting procedure follows. Higher-level notes on cutter use follow later in the document (added 6/1/1999).

Laser Software

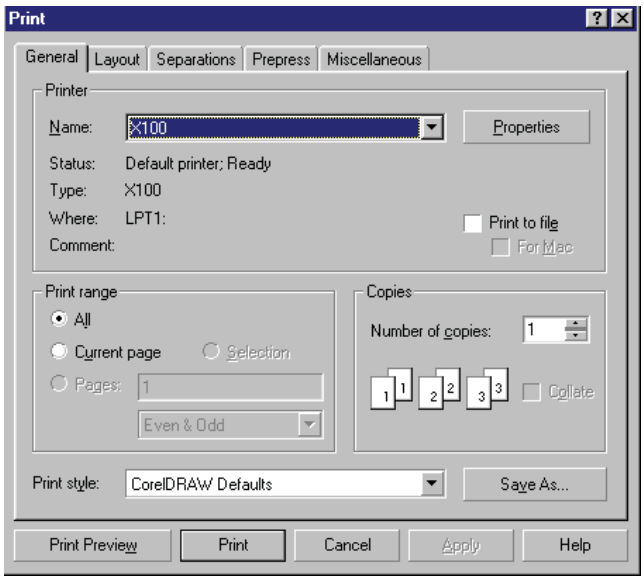
Printing to the laser cutter is currently done through the CorelDRAW software installed on the machine (the special printer driver "X100" drives the cutter). Corel Draw can import 2D DXF files; PostScript files; general pixmaps; among others.

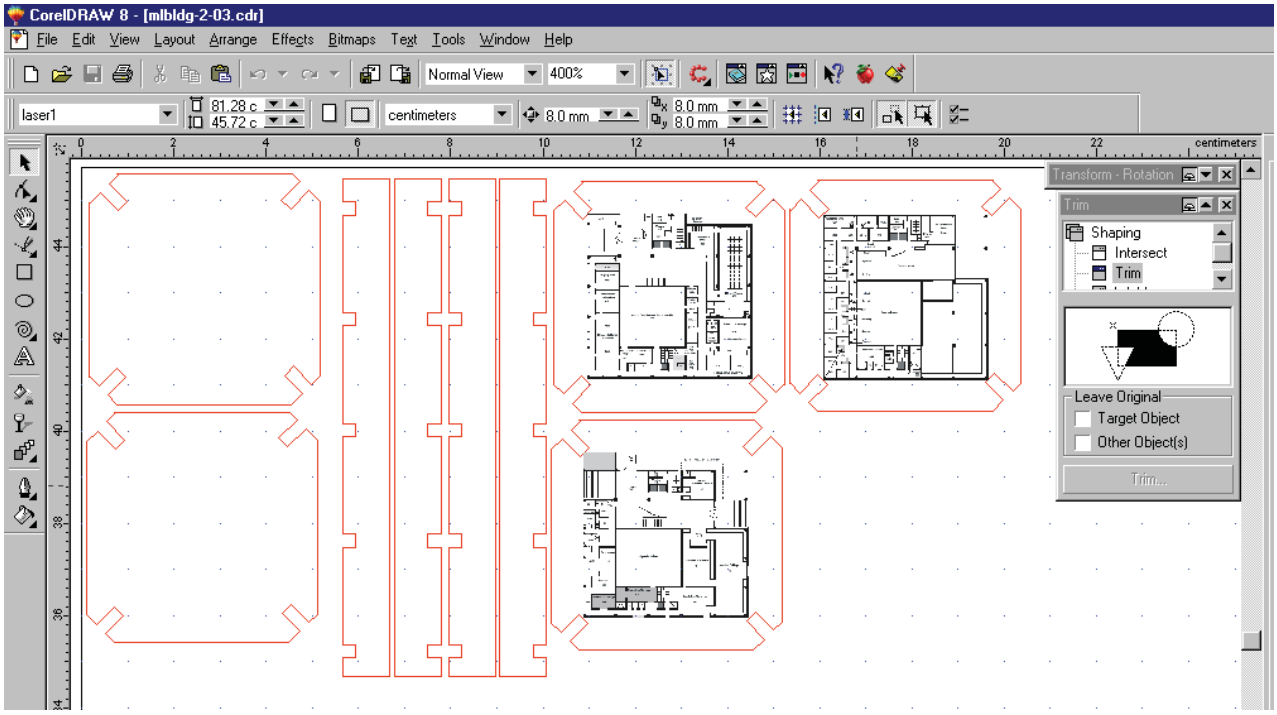
The CorelDraw driver maps graphical lines and arcs to laser cuts. Lines should be set to minimum width (.004") to be preserved as "vector" cuts (lines/arcs). Wider lines will be automatically rasterized, i.e. composed from a series of pixel-like laser burns -- much slower, and of somewhat poorer-quality finish.

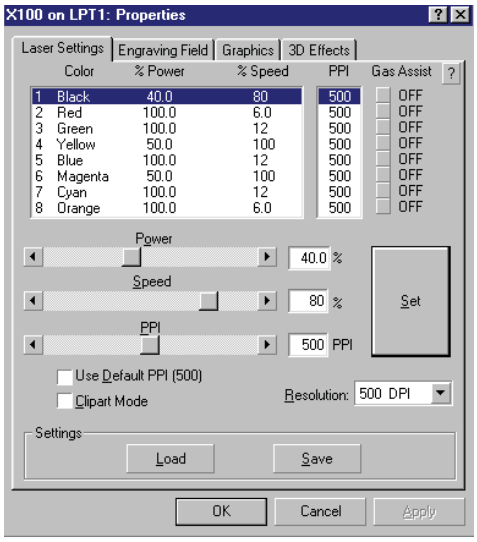
Line colors are mapped to different laser speeds, powers, and PPI by the CorelDraw laser cutter driver. It's probably best to stick to the "black" color for starters. Alternately, for parts involving both imaging and cuts, I've tended to use black for the raster image, and red for cuts (as these involve different power levels). Make sure you select Pantone> Red: the normal red sometimes gets interpreted as orange, with unpredictable results. To select an ink color, click on the fountain-pen icon in the toolbar, and select the color-wheel icon from the fly out. Then click on the third icon in the dialog box, for Pantone colors. Type the name of the color (e.g. Red) in the text box. The program will change this to the appropriate name (e.g. PANTONE Red 032CV).

Once you've executed the CAD design of your laser cut part, you can begin the production process by transferring your file to the laser cutter PC (either via the net or floppy disk). Load or import your drawing into CorelDraw. Change the paper size to the dimensions of the laser cutter bed. To do this, select "Layout... Page setup", and select the page size to be "laser1".

An example screen-shot of Brygg's Media Lab model follows:







Before we can print, we need to verify the cut power/speed settings. Go to "Properties" on the print popup. We need to verify two numbers in particular for each drawing color: power and speed. Some settings which have been found to work are compiled below.

The laser cutter print-properties menu looks like:

To configure these settings, click on the color you'd like to modify. Then, change the power/speed levels by pulling the sliders or typing directly into the screen. Most folks may wish to choose acrylic for their laser cutter assignment (so far as raw materials are available). Small quantities of translucent quarter-inch acrylic stock should be available near the laser cutter. The paper film on top and bottom of the acrylic should be peeled off to minimize chance of flaming.

Stock

The laser cutter stock situation is evolving. While acrylic scraps and corrugated cardboard are often available near the cutter, individual users are basically responsible for purchasing their own stock (and replenishing existing stock that they use). Please be respectful of stock purchased by others, especially of thick and colored acrylic stock (which can be expensive.).

I strongly encourage people to do early cutting runs in corrugated cardboard. It's cheap, structurally robust (for medium-sized pieces), easy to mark on with a pen and hack with a knife, and environmentally sound. Note that when laser-cut, corrugated cardboard is quite sharp.

For final cuts, 1/8" clear or tinted acrylic is the norm. 1/8" or 3/16" cherry wood (available from Pearl in the modeling section) also behaves fairly nicely.

J. Freeman, Inc 65 Tenean St. Dorchester, MA 02122 phone: 800-841-9442) is the standard local supply for acrylic. McMaster-Carr is a fairly good mail-order source; search for "acrylic." Canal Street in NYC is rumored to abound with great supply shops, too.

At J. Freeman if you're really stocking up, you're best off to purchase 4'x8' sheets; the back room cut these down to size. Given the 18"x32" bed size of our cutter, Ron has suggested we use 16"x32" tiles, this produces 9 tiles.

To give some ballpark cost numbers, here are some recent prices from J. Freeman. Please note that the prices do fluctuate. Again, "sheets" are 4'x8', where "tiles" are 16"x32" (tile costs = sheet costs / 9).

Clear cast acrylic
1/8": $57/sheet ($6.30/tile)
1/4": $88/sheet ($9.80/tile)

Clear cast P95 ("frosted"; very nice material)
1/8": $84/sheet ($9.30/tile)
1/4": $110/sheet ($12.20/tile)

Black acrylic (P95-like material is also available, and is quite nice)
1/8": $52 ($5.80/tile)
1/4": $99 ($11.00/tile)

White, tinted, mirrored, etc. acrylic is also available. Thicker (e.g., 3/8") acrylic can be cut multi-pass, and thinner (e.g., 1/16" and 1/32") acrylics are also available. Note that tinted acrylics in particular (and thick acrylics as well) often run triple the above prices.

Many other nice laser-cuttable materials exist. E.g., I'm working on getting some Corian from Art Specialties (800-724-1002), which is really beautiful material often used in countertops (~1/3 acrylic, ~2/3 mineral).

Note that acrylic, cardboard, and wood are all readily flammable (especially acrylic and cardboard). Acrylic also gives off noxious fumes. And again, PVC (which appears in many forms, including a foamed form) and some other materials are highly toxic. In short, if you're not sure of the material, ask! And if you notice strange green gases, etc. coming from your cut, shut off the laser cutter immediately, and do not continue cutting without advice from experienced building

folks (like Saul Griffith).

Please let acrylic cuts sit for 30 seconds in the laser cutter bed before opening -- more, if heavy etching or cutting has been done, especially of thick acrylic (e.g., 1/4”).

Cleaning of the lens

The lens should be removed from the machine (with the three thumbscrews) and checked for material accumulation at the beginning of each cutting session. If the lens is dirty (with “removable” grit; some is permanently impacted), it should be cleaned with a clean cue-tip and one or two drops of cleaning fluid. Please ask for training with this, if you’re not overly familiar.

The laser cutter lens accumulates material residue as a normal part of laser cutter use. When “dirty cuts” are performed, or burning occurs, the lens gets dirty at a much faster rate. When the cutter is used with a dirty lens, particles can ignite and destroy the lens. We’ve lost 4-6 lenses this way. Lenses are >$200 a piece, so it’s important to be careful about this.

Focus

The laser cutter must be focused before use. This is done using the plastic focus tool, and the Z adjustments of the laser cutter. Please request training from a knowledgeable user. If not properly focused, the laser cutter won’t properly cut. This not only results in a poorly cut part, but also produces lots of extra material residue and gas, which is especially problematic with acrylic and other plastics.

Registration of origin

The laser cutter origin (the top-left of the cut) is configurable through the laser cutter menus. The origin is frequently moved during typical cutting sessions, to best utilize the remaining material from a piece of stock. Be sure to check the origin before beginning your cut, as the system retains origin settings from previous runs -- even if the machine has been powered off in the interim.

As a part of registration, it’s good to do a draft unpowered cut (described below). Otherwise, especially with our current cutting table, it’s possible to cut the ruler-borders of the cutter itself, which is to be avoided.

Draft cuts and cutting firmware bugs

It's best to do a "draft" or "air" cut with the cutter before executing an actual cut (e.g., a cut with the red tracer beam, rather than the powered cutting beam). This allows you to make sure the cutter is behaving as you expect (and allows you to identify occasional firmware glitches).

To do an air cut, start the cut with the laser cutter lid raised (taking care not to interfere with the moving head). The red tracer laser should allow viewing of the beam path. Note that the water chiller should be left on at all times, to avoid damaging the machine (we used to turn off the water chiller to produce draft cuts, which is apparently hard on the machine).

It's important to note that the laser cutter has known firmware bugs. In particular, shapes that begin with (or consist of) only a few straight lines/rectangles often result in a bug where the laser cutter ignores/screws up the registered origin. If this happens, (a) change the order of cuts within Corel (described below), or (b) add a very small filled circle somewhere within the cut pattern. Fills are treated as bitmaps, and bitmaps are always printed before vector cuts.

Fixturing and order of cuts

Light materials (e.g., cardboard, thin plastic, paper, and vellum) generally need to be taped down to the laser cutter bed with masking tape. Otherwise, vibration and the air displacement of the moving cutter head will move materials during cutting.

The order of cutting is an important parameter. When the outer border of a part is cut, the piece will often "fall out" of the stock material (if only by a fraction of a millimeter). The part will often slightly skew rotationally as well. If further cuts interior to the part are made, they'll often be improperly registered.

To change the order of cutting, right-click on the part in Corel, and use the "order" submenu to make the changes. Pieces sent to the "back" will cut first; pieces sent to the "front" will cut last. The outside border of parts should generally be sent to the front. However, it should be noted that this has the annoying affect of making interior drawings hard to select (as the part frame "occludes" these inner features). If you have problems, talk to an experienced user.

Beam width

It's worth noting that the laser cutter beam has a finite width, which changes both

as a function of the material, and as a product of its depth within the material. The cut width will be wider at the upper surface than at deeper locations within the material. This can significantly influence the fitting of laser-cut parts, especially for press-fit joins.

Material	Power	Speed
1/8” Acrylic: vector cut (single pass)	50	2
1/8” Acrylic: raster etch	30	70
1/8” Cherry: cut (three passes)	80, 80, 80	8,12,12
1/8” Cherry: raster	20	20
Corrugated cardboard (1/8”)	80	16

Settings

Some example settings getting such numbers “right,” and adjusting them for new materials, reminds me a bit of cooking. I’m constantly guestimating numbers, trying them out, adjusting them, etc. The laser cutter manual also has suggested settings for many materials.

Vinyl Cutter

Roland Camm-1 Servo GX-24 [Vinyl Cutter] Please refer to the manufactures operational manual for more indepth information.

What does this machine do?
A vinyl cutter uses a precision controlled knife to cut out shapes and lettering in vinyl. It can also be used to cut circuit paths in thin copper sheeting.

Safety

- NEVER operate the machine unattended.
- Do not set anything on top of the machine.
- Do not reach near the knife when it is cutting.

Beginning

Power on the computer (allow Windows to start up if you will be using Corel or Adobe; if you will be printing using CAD.py then switch to Ubuntu while booting up the computer).

Import and format file in Corel

Prepare your part for import into Corel before you sit down at the machine. [See "How to Get Ready for Corel" document in D2L for more information.] Once at the machine, login as "Student", then double-click the Corel X3 icon on the desktop.

Open your file if you created it in Corel. Import your file if you created it something else (and then saved it to a compatible SVG, EPS, or DXF). [Reminder: when importing DXF files you must have the "Auto-Reduce Nodes" check box enabled.]

If you imported your file you may need to select all [Ctrl-a] and then ungroup [Ctrl-u or Arrange□Ungroup] so that you can select individual objects.

Cutting: There are two ways to tell the vinyl cutter what to cut, choose ONLY one:

1) Select the lines [objects] you want to the laser to cut completely through the material. Make sure the line thickness of these objects is set to 'Hairline'. [You can do this by double-clicking the Pen icon in the lower right or checking the description next to the Pen icon in the Property Bar.] If you are using a program other than Corel set the line thickness to 0.001 inches [0.025mm].

2) Leave all your shapes filled with a color and with Stroke set to “None”. The machine will assume you want to cut the outline.

If your objects have both a Fill color and the Stroke set to hairline, it will cut your shapes twice which often results in bunching up the vinyl and/or ruining your work.

Select and set material

Choose what color vinyl you will use and load the roll [or the piece]. To load a piece, push down the lever on the back left of the machine to release the material rollers. The blade carriage should be all the way to the right of the cutting area. Insert the material squarely into the machine, align the right edge with one of the three, dark, one-inch indicators, and check to make cure the left edge of your material is within the longer left indicator section. Lift the lever back into position to secure the piece. On the machine use the down arrow to select ‘Roll’ or ‘Piece’ and press Enter.

Setting up the cut

Go to File Print Setup, choose the Roland, and then click ‘Properties’. Click the “Get from machine” button. Select ‘OK’ and then ‘OK’. Change the paper size of your drawing to match the measurements of your material. You can do this by deselecting all the objects and then changing the size in the Property Bar. You will need to change the units to millimeters when changing the paper size, since that is the units the machine will display. Reminder: If you are using a roll of vinyl set the vertical length to 1600mm.

Now, arrange the objects you will be cutting within the paper (page) outline – this insures your pieces will fit on the material. It is good practice to place your pieces close to the bottom of the print area in order to conserve material. Make sure no pieces are overlapping.

‘Printing’ [a.k.a. cutting]

Select File□Print, and if there are no Issues, click Print.

Once the piece is cut, hold down the right arrow key to return the blade to the rightmost position. Release the material by pushing the lever back. If it is a part of a roll, extend the material to the cutting slot near the front of the machine and use a razor blade to cut across. Make sure to insert the blade into the slot, keep your fingers away from the cutting path, and keep the material taut while cutting.

Clean up

Close your programs and remove any files you transferred to the hard drive for your project. Return the roll of vinyl to the shelves above the machine.

Next steps

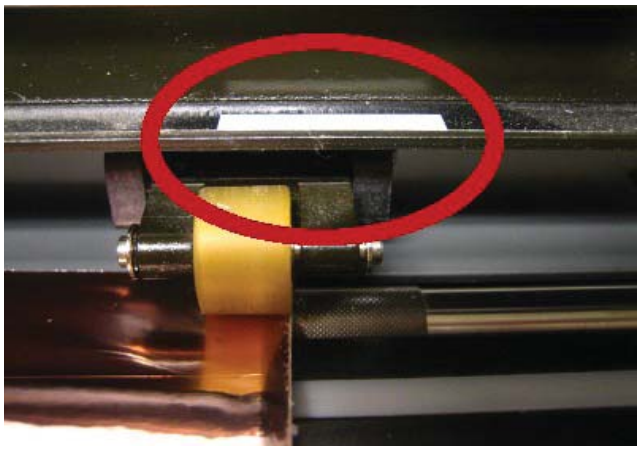
A good video on how to apply cut vinyl is located near the machine. You can also ask a Lab Assistant to show you the basics.

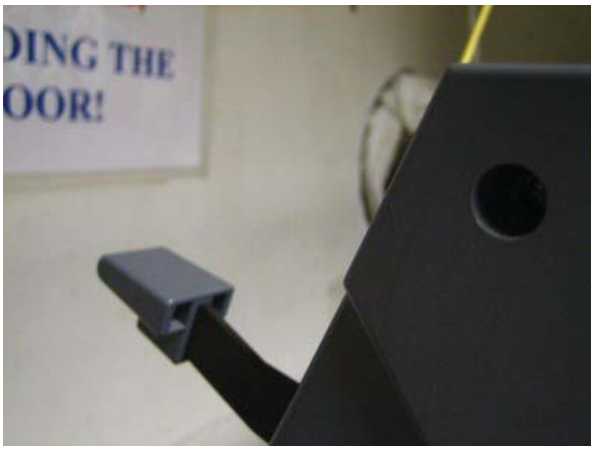
More information about the Roland CAMM-1 Vinyl Cutter can be found on the Fab Lab D2L site. For specific instructions about how to prepare different file formats for import into Corel see "How to Get Ready for Corel" document in D2L. If you will be using the Linux printing program 'cad.py' then try the MIT Fab Lab website for help.

For Tricks and Tips after learning the basics try Here.

Loading your Material

Cut off a large piece of material from the roll. This works better than feeding directly from the roll.



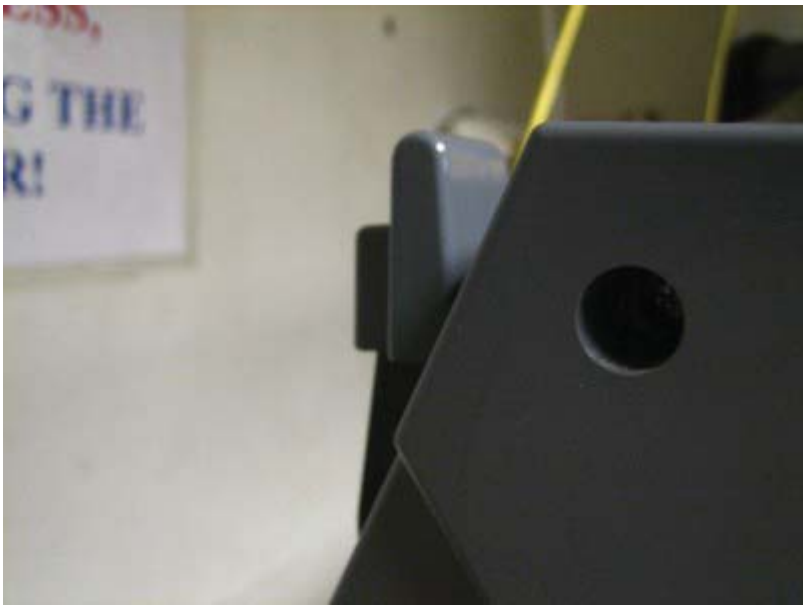


Lift the rollers using the lever to the back left of the machine.

Notice the white markings along the cutting area of the machine. Move the rollers by hand to where you will place the edges of your piece. If the blade is in the way move it to the right. Make sure the rollers coincide with the white markings so that they can catch the moving ridges.

Then put your piece under the rollers and use the lever to put the rollers down, holding the piece in place.

Now there will probably be a message about sheet unloaded. Select “piece”. The machine will measure the width and length of your piece.



Use the arrow keys to get to where you want your origin to be (the origin will be the bottom left corner of the cam.py window). Press and hold the origin button until the message appears in the display that origin is set.

It might be necessary to prop up the cutter, if your copper piece is longer than 12” as it needs to remain bent (it does not flatten out completely when taken off the roll) otherwise it will crumple.

Sending the File

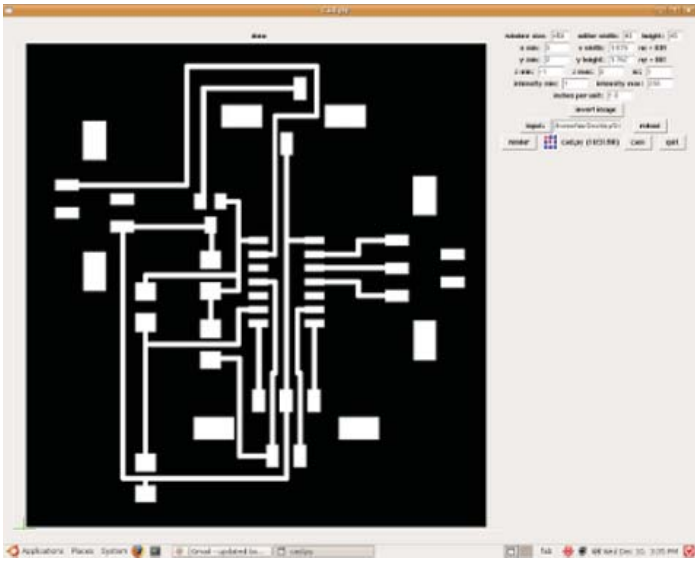
Method One - cad.py file

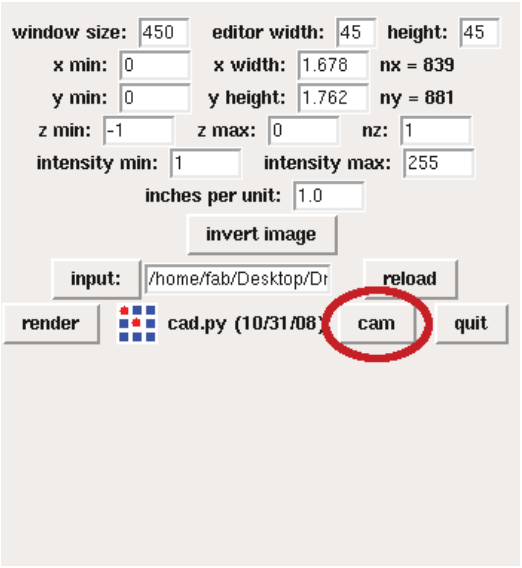
Open a shell and type “cad”. You can make any shape in cad.py you want to cut out.

Next, select the right output device and do 1 contour. Set the desired force and velocity.

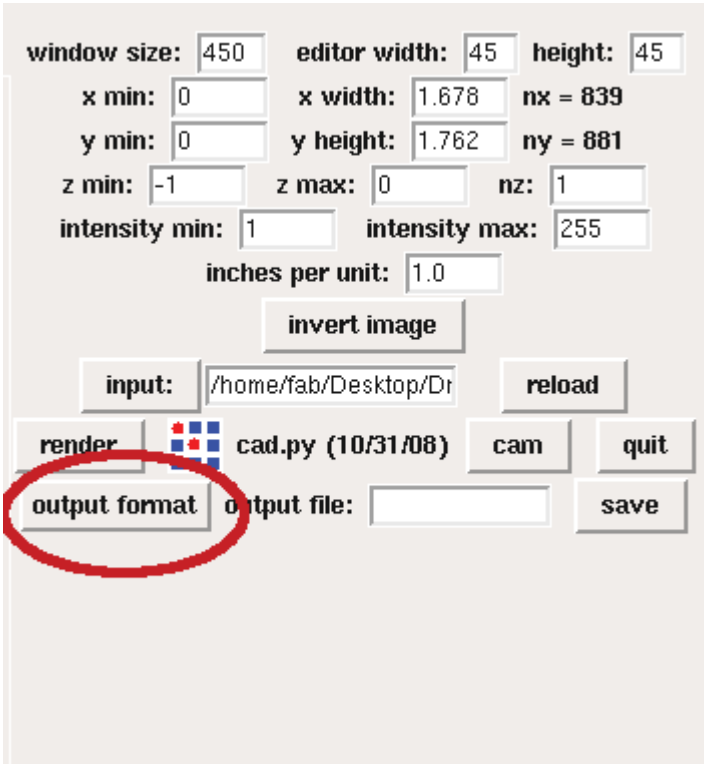
Method Two - png file

Open cad.py - Open a shell and type “cad” or open it from the desktop icon. Your first screen will look something like this. Click the “cam” button.

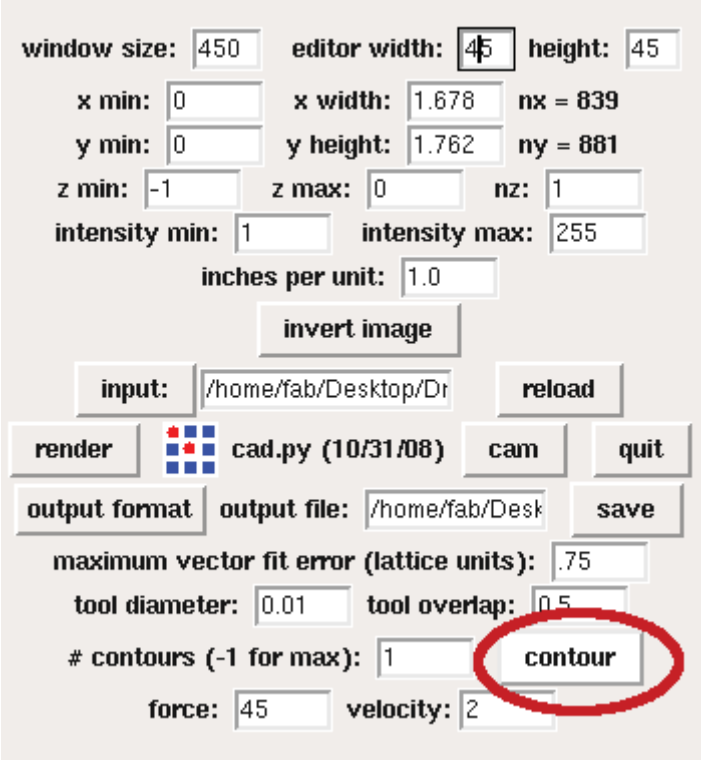




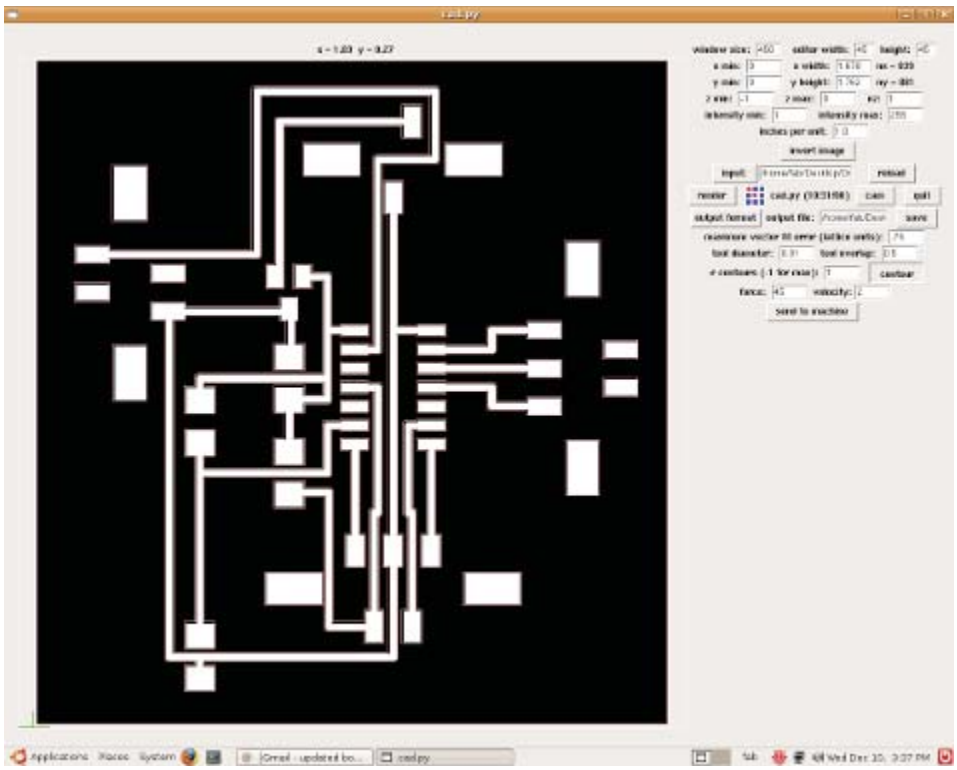
Click on "output format" and select "cam" from the drop down menu.

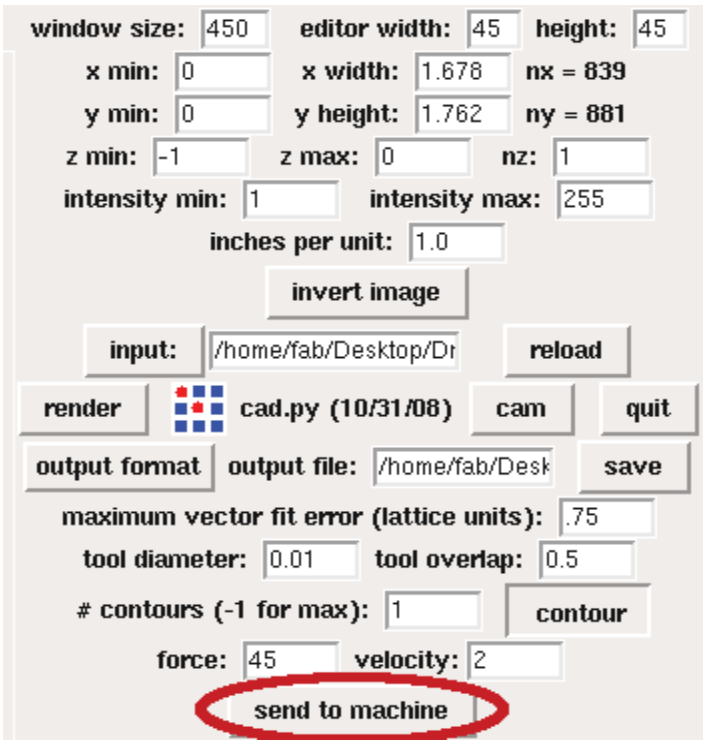


Next, click "contour". Set the desired force and velocity - most likely you will use the settings preselected by cad.py (force = 45, velocity = 2).



Wait a moment for cad.py to contour your png image. When it's done, you will see a "send to machine" button. Click there and the vinyl cutter will begin on your cutting job.





Force and Velocity

- When you begin to use the vinyl cutter, the source of greatest potential frustration will probably be finding the proper settings for the force and velocity of the blade. Don't worry, you can do it, but take your time - note that most likely you will use the settings preselected by cad.py (force = 45, velocity = 2).

- I have found that the far more important of these two variables is force. The hardware force slider and force settings in cad.py need to be adjusted together.

- If you cannot separate your material from its backing, then your force is too low. If your piece is mangled, then your force is probably too high (or the blade might be dull). What you want to see is slight lifting of the material around corners.

- I have found that the force value must be within about 2 or 3 units. Fortunately, you can tell when the force is too high or too low, so the narrowing process is straightforward. If anyone finds good values for new materials, please leave a note on the Desktop.

- If it turns out that the blade is in fact dull, you can get another one from John or Professor Gershenfeld.

If you want to cut a circuit board with the vinyl cutter, see the tutorial in the processes section of the MIT website.

Roland Modella Mill

Guide to Making a Circuit Board Using the Roland Modela Mill-Please refer to the manufactures operational manual for more indepth information.

About the programs being used:

Eagle is a commercial program that allows you to create electrical schematics on your computer, and also design the physical circuit boards. Eagle has a freeware version for noncommercial use, which is the one being used in this tutorial. There is a version for both Windows and Linux.

For this tutorial, the Windows version will be used.

CAD.PY is a free program that can only be run on Ubuntu. It is what actually sends your data to the Modela mill to be cut.

GIMP is a free program that allows you to edit images.

This guide will cover only the basics. It will allow you to "hit the ground running" and get your hands dirty as soon as possible. If you want to exploit more advanced features, Eagle comes with a free tutorial and a manual in PDF format. You can find these in the same directory that the Eagle program resides.

Build your schematic in Eagle

1. Starting Eagle

Open Eagle. Go to File > New > Schematic (see below)

2. Adding a frame

You will now be at the Schematic window.

You must now "Add" a frame. Click on the Add button on the toolbar at the left of the window. Go to the "search" feature on the bottom of the window, and type in "frame" and press Enter. The list on the left is the results of the search. Select "LETTER_L" in the list and click "OK"

3. Dropping frame

The Add window will close, and you will be back at the Schematic window. The frame will be "attached" to the mouse, and in bright red. Bring the bottom edge

of the frame to the origin (the dotted cross on the lower-left) of the Schematic window and left-click to "drop" it. Once "dropped," the frame will turn to a light ruby color (see below). There will be another frame "attached" to the mouse once again. To tell Eagle that you are done placing your frame(s), press the Stop button at the top of the window. Your mouse will now be normal again.

You can now press, Alt+F2 to show the whole frame (schematic), and you and can move the screen around by "dragging" it around with the middle mouse button. You can zoom in and out using the scroll on the mouse.

Important: You must use the Stop button when you are done doing ANY operation in Eagle. Such as Delete, Add Change, etc... E.g. If you don't press Stop after deleting a component, and then click another component you want to edit, it will DELETE it, because you haven't told Eagle to stop the Delete operation.

4. You are now ready to build your schematic.

Use the Add button to add a component. You can search for your part (see step 2) or browse through the list on the left. Components are organized into "libraries," and you can browse through the libraries to find your component(s).

PACKAGE: In the Add window, it tells you the name of the components, as well as their package (a package is the "foot print" of the component). There are a lot of packages, so look carefully for the ones you will be using when you build your board.

Note: You can also change the package after placing the components by right-clicking them and clicking on "Package" in the pop-up menu. If you need to clear your search term (so you can hand-browse through all the libraries), clear the search field and press Enter. Once you find your component, select it and click "OK" or double click the component. Your component will now be "attached" to your mouse. You can "drop" as many of them as you like (left-mouse). Eagle will automatically name each component.

Note: "Dropped" components are a light ruby color and components still "attached" to the mouse are a bright red color. Here, I have used NPN transistors with a SOT-23 package (which is surface-mount):

And then I added LEDs with a 1206 (surface-mount) package:

DO NOT CLICK THE DROP BUTTON – THIS WILL REMOVE YOUR LIBRARY OF

COMPONENTS FROM THE LIST

After placing each component, make sure you press the Stop button.

With the components (with their correct packages) on the schematic (I have zoomed in):

5. Connecting components

Now you have to connect the components. In Eagle, you have to use what is called a "Net" to wire your components together. Eagle has a "Wire" operation, which you DO NOT USE if you want to physically wire your components. You must use the "Net." To add a Net, click on the Net button near the bottom of the toolbar on the left. You then connect each pin of the components according to your design. To complete the circuit, I have added a surface-mount (SMD) button (search for "10-XX") and 4 SMD resistors (search for "R-EU_M1206") and a jumper (to get power to the board). I then connected the pins accordingly using the Net tool.

Setting values

I then set the value of each component by right-clicking on them, and clicking the Value. Then I entered the value in the dialog box that popped up (separately for each component). Press Stop once you are done setting the values. Below is what the Value's dialog box looks like. Here I have used 680 ohms for the resistors, but you may use whatever you want.

Rotating symbols

If you want to rotate the symbol BEFORE you drop it, simply right-click and it will rotate 90 degrees (it will stay "attached" to the mouse). If the component is already dropped, make sure all other operations are stopped (by clicking the Stop button), right click the component, and click "rotate" from the pop-up menu.

In theory, this circuit should turn on both LEDs when the S1 button is pressed. +6 volts goes to pin-1 on JP1 and GND to pin-2 on JP1. Make sure you have saved your schematic in a place that is not in the Eagle program directory. As you do not have permission when logged in as student to save to this location, you will be getting constant errors when making your board. A good place is your thumb drive.

Important: Do not change the grid size of the schematic. This is because the

libraries have been defined to use the default 0.1 inch grid. Otherwise you will run into problems with pin connections no longer being able to connect (even though they will look like they are connected).

Output to Board (in Eagle), set component places, and auto-route

Get board information from schematic

Now that your schematic is done (and you chose the correct package for each component), you can now use Eagle to build the physical board that you want to cut. At the schematic window, click the Board button on the top toolbar (it will be on the left of the toolbar). If a dialog pops up asking this: (The black line will say where your schematic file is saved) then click "Yes." This will create a .brd (board) file in the same directory as your schematic. A new window will pop up with a black frame, and all your components on the outer, bottom left of it:

Notice how each component is represented by its physical footprint (package) instead of the symbols used in the schematic. If you look a bit closer, you will notice tiny lines connecting all the pins together respective of the schematic you drew earlier (see picture on previous page). This jumble of lines is called a "ratsnest," and each line is called an "air wire" and connects to the pins that are defined in the schematic.

Place components

Now you have to move the components to where you want them on your board. Remember that the smaller the board, the better. Keep in mind that the Modela mill takes about 30-minutes to create a 1" x 1" board.

To move a component, right-click the component and click Move. The component will now be "attached" to the mouse, and you can move it anywhere inside the black box on the right. Since Eagle is now in the Move operation you can now left-click on each component, and move them to where ever you want. Once you are done moving, press the Stop button (press the Stop button when you are done doing anything).

Rotating parts is the same process as in the schematic. Simply right-click while the component is attached to the mouse. When placing the components, try and keep the air wires from intersecting as much as possible. Sometimes rotating a part can help "untangle" the air wires. To have Eagle re-render the air wires to be

the shortest distance possible to the next connection, click on the Ratsnest button near the bottom of the toolbar on the left. This can be useful while experimenting with the placement of parts. E.g. you can move your parts, click on Ratsnest, and if you're not happy with it, move the parts and click Rats nest again. Repeat that process until you are happy with it. It is a bit of trial and error.

Remember that you have only one layer to work with (can't route anything beneath the board), so arrange the components in a way you think will allow all the wires to be routed on the top. You don't have to think it over too much, as the auto-router is very clever in finding paths for the wires. Note: If anything appears in blue that means it is on the bottom layer of the board. Be sure to fix this if it happens.

Auto-routing

Now that you have your components where you want them, save your board by going to File > Save. Save it in the same directory as your schematic file. You can name the board whatever you like.

Before auto-routing, you will want to save at this step because Eagle can't undo an "auto-route."

It is easiest to trial-and-error with the auto-router, and keeps re-opening your saved board file to start over. This is called a save/revert process. If you jumped the gun and auto-routed before saving, you can manually undo the traces that the auto-router laid. You have to use the "Ripup" operation, which will be discussed later. Go to the Tools menu and click Auto.

On the dialog box that pops up, go to the General tab on the top. To the left there is a frame titled "Preferred Directions." Set the "16 Bottom" to "N/A" by selecting it from the drop-down list. This will tell Eagle to only route on the top layer of the board. For the "1 Top" menu, if you don't like the way it routed the wires, you can try another option from the drop-down menu. "-" and "|" are the good ones to use. For starters, select "-".

Now click "OK". Eagle will now auto-route the Because the end mill bits are of a 1/64 inch diameter, which are very small, it's not small enough to engrave between very close copper traces (A trace is the "wire" that is laid on the circuit board).

In the board above, there are 3 areas to be concerned about, and should be corrected because of this. There is also that weird angled trace on the left that we can manually re-route to look a bit cleaner. Even if yours auto-routed differently than the above picture, you still have to check for these problems.

Fixing layout problems

The problems are this: the copper traces are too close together for the Modela mill (end mill bit isn't small enough). We can fix the problems in Eagle. However, problem 1 requires us to edit it in GIMP (after exporting the board as a .PNG image file).

Right click on the vertical line that is in problem 2. Click Move. You can now move the traces to where ever you need them. In this case, I just moved in over to the right a little bit. Do the same with problem 3, but move it to left. If your board layout is different then where I'm moving the traces, it doesn't matter – what matters is that you move any traces on your board that appear too close together.

Now I want to neaten up that weird-angled trace on the left of the board (going from R1 to R2). For this, we use the "Ripup" command. This command will allow you to "rip up" the trace, and give you back an air wire. From there, you can route your own trace where ever you want. Right click on the line, and click Ripup in the pop-up menu.

Now that you are in Ripup mode, you can just left-click on the lines you want to rip up. Click Stop. Now you have to run your own, custom trace. You do this by right-clicking on the air wire, and going to Route.

You can now drag the mouse to where you want the trace to lie, and left-click to set the trace. Note: you can change the angle the trace makes while you route by right-clicking the mouse. After re-routing those traces, I also moved the trace to be a little closer to the rest of the circuit: Because it takes longer to cut out a board when more copper has to be removed, we will make all of the traces on the board a bit bigger. This will reduce the time to make a board. Click on the Change button on the toolbar to the left. It will be near the top. Go down and click on Width and click 0.016.

You can now click on each trace, and their width will increase slightly. If a trace gets too close to another trace, or a pad (the green round things) then do not increase the size of that trace.

Export Board as a PNG file.

Hide unneeded layers

We can't output the board as it is shown in Eagle right now. This is because it will export all the package lines, etc, which CAD.PY will consider cutting data. So, to remove all the unnecessary lines on our board, click on the Display icon in the toolbar on the left (it will be near the top). Zoomed in, you will now see this (or something similar if your board routed differently).

A dialog box will pop up; these are the layers that Eagle can show/hide. The blue on the left of the option (highlighted number) means that particular layer is visible. We want to hide everything except for "Top", "Pads" and "Dimension". This is easily accomplished by clicking the "None" button on the lower-right of the display dialog. Now left-click the number next to the layers "Top", "Pads" and "Dimension" to make those layers visible (the number will be highlighted in blue again) Click "OK"

You will now want to bring the black frame that surrounds the board layout to be closer to the components and traces. Resize it to be the size you want the board to be when it's cut out. This can be done by right-clicking on the black line, and clicking on Move. Left-click does drop the line. Do this to all 4 lines. Once the frame has been resized, go back to the Display dialog and set the "Dimension" to be hidden (not highlighted in blue).

We now will export this as an image file (Monochrome PNG @ 500 DPI) Go to File > Export... On the menu that pops up, click Image. Eagle has now outputted your board as a .PNG image file that is black and white, with a resolution of 500 DPI (500 DPI is required for CAD.PY). Save the file to the Share Drive D: so you can access it in Ubuntu (you can also save it on your thumb drive). You can name it whatever you like. Set the Monochrome option, and set the DPI to 500. Press OK once everything has been set.

Editing in GIMP

We have to now fix the problem in circle 1 from earlier (page 13). You have to remove some of the padding for the transistor in circle 1 from the inside (since there is a trace going under the transistor and between its pads). If you had set the board layout background to be black, then your traces will be white and everything else will be black. In that case, you want to remove the padding the

same way that will be described now, but instead use black when filling with the Bucket tool. If you want to remove a trace in GIMP, simply replace the black line with white using rectangle select tool and filling it in with white. To add a trace, use the rectangle select tool to make a trace the size you want, and then fill it with black. You can also add text, or use any other tool GIMP has to offer to modify your board.

Because CAD.PY cuts out everything that is black, we want to invert the colors so the traces are white, and everything we want to be cut away is black. If your traces are black, then Goto Colors > Value Invert. If your board layout background was black (and thus your traces are white) then you DO NOT invert the colors. Once you have fixed all the problems in GIMP, save it in a place that can be accessed in Ubuntu (Share drive D: or your thumb drive). If you save as..., make sure it saves it in the same file type and resolution with 0 compressions (a dialog box pops up asking about these settings). If you simply click "Save" then the original settings are retained, and nothing else is required.

The easiest way in GIMP to do this is to take the selection tool, and make a small rectangle in the spot you want to "delete." In this case, you are removing some of the square pad. Then you Fill that selection with white color using the Bucket tool. I have removed about 1/3 of the padding from the inside. This should be enough for the Modela to cut around.
If not enough is removed, you will see by the cutting paths in CAD.PY, in which case you can edit it again in GIMP and remove a tiny bit more of the pads.

Import into CAD.PY on the Ubuntu operating system.

1. Start the computer into Ubuntu. Copy your image of your board to the desktop. Now double-click on CAD.PY on the desktop, and when a dialog box pops up, click on "Run". Make sure your file is in the same directory as CAD.PY (desktop).

2. Before contouring, set the x min and y min to values that will fit onto your board (or around part of the board that has already been cut out), and check that your settings are the same that are listed on the bottom of this page. This can be checked by entering an estimate into the x and y boxes on the bottom of CAD. PY, and clicking "move". Once you have found the x, y min values that work, enter them into the x min and y min boxes on the top of CAD.PY.

If you have already contoured before setting the x min and y min, then reload your image, set the x, y min values, as well as z values, and then contour. If you

contour before setting the x and y min values, CAD.PY will use the values that where there when the image was contoured.

Settings:

When milling the circuit:

- set the z min to -0.005 and z max to 0.05
- set the xy speed to 4, z speed to 4
- set tool diameter to 0.0156
- set # contours to -1

When cutting OUT the circuit from the copper board:
Note: you need to import the outline of the board, not the board itself.

- set z min to -0.065 and z max to 0.05
- set the xy speed to 0.5, z speed to 0.5
- set tool diameter to 0.0312
- set # contours to 1.

Click on the Input button and open your image file from the desktop. Now that your file is imported, click the "cam" button. Now click the "output format" button and click the .rml (Modela) option in the menu that pops up.

3. Setting up the Modela mill, Please reference the article "Preparing the Modela Mill and circuit board for cutting." Please note that on this article that whenever you adjust the spindle height, the front cover must be on. It will be awkward, but you have to drop the end mill and tighten the set screws with the front cover on. This is best accomplished if you carefully move your arm around the front cover (in the article, the interlock safety switch has been defeated). Here is what CAD.PY will look like if you are using a new copper board (x min and y min are set to .25). This is assuming the copper board has its lower-left side be flush with the lower left side of the sacrificial white layer on the Modela.

If your board is in a different position, or you have to avoid a part of the board that has already been milled or cut out, then your x min and y min values will be different.

4. Contour

To check to make sure the Modela can cut between everything, contour once, and check to see if the pink lines (milling path) goes between all the traces. If it doesn't, then you have to edit that part in gimp or in Eagle (depending on the

problem) and make the distance between the traces bigger. Use the settings from page 22 (the first page of Procedure 4) for milling the circuit. Press the “contour” button. After a couple of minutes, you will get something like this (the pink lines are the milling path of the Modela mill).

ShopBot

Your ShopBot was configured to run either a router or a spindle-Please refer to the manufactures operational manual for more indepth information.

Spindle/VFD - The power to the VFD should be wired by a licensed electrician familiar with industrial equipment.
Router–110v Heavy duty extension cord with power-on light indicator recommended.

Leveling

ShopBot Buddies are meant to be mobile so that they can be readily reconfigured for a shops needs or to get them out of the way when not in use. However, they should always be leveled before use to make sure that there is no distortion or unexpected binding in the motion of any of the axes.

Adjusting the Rollers

Roller height is preset at the factory. If they need to be adjusted, set the height so that they are level and just touching the bottom of the deck. Make any adjustments you need to make to the rollers for a particular project before you surface/flatten your work surface or material.

Adjust the rollers by moving the height of the bolts at each end of the roller axle. Make sure to lock in the height with the nut when you get the height right.
Stopping the ShopBot

Using the PRS alpha E-STOP

You must be running ShopBot Control Software 3.5.x or higher for these instructions to apply. Go to www.shopbottools.com to download the latest control software.

Once it is properly attached, hitting the E-Stop Switch will instantly stop the movement of your X, Y and Z gantries. The power to the spindle/router, motors, and the rest of your tool will be cut off.

After you have activated the E-Stop Switch, to go back to work you will need to Release the red button on the E-Stop by rotating it

Press the RESET button on the PRS alpha Control Box to send power to the

spindle/router and motors on your tool.

Clear the message box in the control software by pressing “Quit”.

Re-zero the tool to make sure its location is correct because the motors were turned off

You can return to the location in the file you were cutting and continue from there by using the [FG] Command to start the file in the Go To mode.

Use 3-Button Pendant

Place the 3-Button Pendant in a convenient spot for you to operate your machine. Both the Reset button and the Start button for your Spindle/router are now located on the 3-Button Pendant, not on the PRS alpha Control Box. The E-Stop button on your 3-Button Pendant and the separate E-Stop Switch function alike

Using the PRS standard Remote Stop Switch

You must be running ShopBot Control Software 3.5.x or higher for these instructions to apply. Go to www.shopbottools.com to download the latest control software.

Once it is properly attached, hitting the Remote-Stop Switch will instantly stop the movement of your X, Y and Z gantries. Because the spindle/router is connected independently to power, the Remote Stop Switch will not turn off the spindle/router.

After you have activated the Remote Stop Switch, to go back to work you will need to Release the red button on the E-Stop by rotating it

Clear the message box in the control software by pressing “Quit”.

Re-zero the tool to make sure its location is correct because the motors were turned off

You can return to the location in the file you were cutting and continue from there by using the [FG] Command to start the file in the Go To mode.

Stopping with the Space-Bar or “S” key

In a non-emergency situation, you might want to stop the movement of the carriages without cutting power to the motors. This can be done by hitting the SPACE BAR or the “S” top key. This will stop the movement of all three axes. If the

tool is moving slower than 3”/sec, the router bit will stay in its current position. If the tool is going faster than 3”/sec, the movement speed of the X and Y axes will be ramped down, and the cutter will be pulled up and out of the material. The spindle/router will be not shut down.

In both cases, the computer will display a message screen to prompt you for what to do next.

The presence of a Remote Stop Switch does not alter the need to good safety procedures for operating your ShopBot. You should always stand clear of the tool when it is in movement, preferably positioning yourself near the computer controlling the operation. A Personal Robotic Tool can be a very safe power tool as long as all safety procedures are followed. Take a Test Spin

Next we’ll go for a quick trial spin with your tool and do a few tests to make sure things are working as they should be. Then you’ll be ready to start putting your ShopBot to work!

Run Your ShopBot now and Check out some of its Basic Functions.

Turn on the Control Box

If your tool is a PRS alpha, also hit the blue “Reset” button on the box to activate the safety relay systems). Your first moves will just be ‘air’ cuts so there is no need to have a bit in the router/spindle.

Start the ShopBot Control Software

The icon to start the Control Software is labeled “ShopBot 3” and should show up on your Windows Desktop. Double click it to start the software. The first time you run the software, you will be prompted to select your tool type from a list. If you get it wrong, you can correct later with Utilities > Reset.

As the ShopBot Control Software starts, it tries to find your ShopBot and establish a connection. If you have run the software in Preview Mode previously, just click the ‘Move’ Switch on the Red Panel to switch out of the Preview Mode and into Move/Cut Mode and start the connection process.

If a connection to a ShopBot Tool cannot be established, a yellow screen will come up with suggestions for you to try. Choose “Try to Connect on Another Port” and hit OK. Then click the button to ‘Automatically Find’ your ShopBot. When the

correct port is located, click OK. The connection will be established and the port will be remembered for future starts.
If you have a problem, there is information in the README file on establishing connections and also in the Troubleshooting section under Help in the Software.

Control Console and Position Windows

Once you are connected, the ShopBot Control Software will bring up two windows. The red one is the Locations Display for your tool. The toggle switch on the left indicates whether the tool is in Move or Cut Mode. The second screen is the Control Console where you enter Commands to tell your ShopBot what you would like it to do.

You can use the keyboard or mouse to select commands from the Main Menu bar, or you can enter two letter ShopBot Commands into the Command Box in the Control Console.

First, make sure that the Distance Switch on the red panel is set to 'Absolute' (Up).

Set the current location to zero by typing the ShopBot Command Z3 at the keyboard. The Location Display should now show 0 in all axes. Z3 is an example of a ShopBot Command and is usually indicated with brackets, for example, [Z3]. With ShopBot Commands you only need to type the two letters in the appropriate space. There are drop-down menus that remind you of the meaning of these Commands letters. This is fun, so relax and enjoy.

Now we'll try a few moves. Before carrying out any of these instructions, make sure that the area is clear for the Power Stick to move. And remember, YOU CAN STOP ANY MOVE BY HITTING THE SPACE BAR!
Try a 1" Z plunge.

Use: [MZ] … first type 'MZ' as the Command, then put '-1' in for the parameter. Remember, negative numbers move the Z axis down; plunge. Then hit ENTER.

You should hear a few seconds of warning beeps, and then the Z-axis should start plunging down. It should stop after moving 1" down. You should see the tool move, and the new location should show on the Location Display.

Now, go another inch down ... you need to use an [MZ] -2 because you'll be moving 1" further down to the location -2.00. Then, return to your starting point

at a faster (jog) speed with: [JZ] 0. This should give you a feel for how the Z-axis works.

Now check out the Y axis in a similar fashion.

Let's go 3" in the positive direction on the Y-axis.

Use: [MY] 3. Your tool should have gone exactly 3" back (away from you on the Y-axis as you are facing the tool from the front) and the computer display should indicate a Y location of 3.00.

Then use [JY] to bring it back

And give the X-axis a try using [MX]. The table/Power Stick should move.

The 'Keypad' Control

If all has gone well, it's time to try the Keypad Control which is a more convenient way to move your tool from the Control Console when it is not running a file.

Hit 'K' which is the shortcut to Keypad Control (full command = [SK]). You should see a new screen displaying a number of arrow key buttons. You can move your mouse over any of the items on the Keypad to get an explanation of what they do. But basically, you can click on keys to move your tool, or you can use the equivalent arrow key on your computer keyboard.

Try driving your tool around with the arrow keys. Use the ESC key when you are ready to close the Keypad.

If you want to Zero the X and Y axes in another location, use the Keypad control to move the tool to that location, escape from the Keypad control, and use the Z2 command to re-zero.

If all has worked well so far, jog back to the starting point using both axes. Use: [J2] 0, 0. Your tool should move rapidly back to where you last zeroed it.

Try a Circle

To try a circle, use the Keypad (remember 'K') to move the tool out to the middle of the table, then ESC to close it.
Now, does a 6" circle using the built-in circle command: [CC] 6 (The 6 is the only parameter you will need to provide on the 'Fill-In Sheet' that comes up). Your

ShopBot should execute a smooth 6” circle.
Note that the speeds of the motors change as the tool moves through the circle. The motor speed changes in order to maintain a constant vectored speed at the cutter.

Do an ‘Air Cut’ of a ShopBot Part File

Now let’s try running a Part File (a file containing cutting instructions or ‘tool paths’). We will do an ‘air cut’, which means to run it in the air above the cutting bed without the router or spindle running.

First go back to 0, 0 with a [J2] Command.
Use: [FP; ‘File ‘Part], then use the arrow keys to scroll to the file called “S_ SBLOGO.SBP” and hit ENTER (If you aren’t in the c:\SbParts folder, you will need to browse to it). All the files which start ‘S_’ are sample files of one sort or another … you will probably find them interesting and helpful. Use the [‘File ‘Edit] Command to check out what’s in them.

We’ll ignore the parameter settings on the fill-in sheet for the moment ... just hit ENTER twice again to start air-cutting the file.

This file cuts the ShopBot logo (normally you would use a ‘V’ bit). It can be cut it in all different sizes using the proportion feature in the [FP] Command. Note that the underline portion of the logo cuts first, followed by the letters. The file ends with a couple of 3D moves to carve the shape of the flying wood chips in our logo.

Test the Proximity (Limit) Switches on the Buddy

You can test the “Limit” Function of the proximity switches with the Keypad. First use the [VN] Command to turn on the proximity switches. Now hold down the arrow key on the Keypad to drive into the switch. Your tool should stop. Release the arrow key. Depressing the arrow key on the Keypad again will override all proximity switches so you can drive off the switch in either direction. All proximity switch function is off until you release the arrow key so if you choose to move in the opposite direction toward the other end of the table, the tool will run past the proximity switch and hit the hard stop. When you release the arrow key, the proximity switches will again function to stop motion.

You can tell whether the proximity switches are on or off by looking at input 2 & 3 indicator lights in the red Position window of the ShopBot Control Software.

Red X = proximity switch is disabled
Yellow with green dot in center of input 2 and 3 = good
Solid yellow = over target

All Power Sticks are fitted with proximity switch targets so that you can use the [C3] Command to zero the X- and Y-axes (or click the 'XY Zeroing' icon in the toolbar).

Surfacing Your Table

One of the first things you'll want to do after getting your ShopBot together and running is to smooth your work surface. Here are a set of general procedures for surfacing your table. There are several ShopBot Commands you will learn about in the process …

You will want to make sure that you followed the instructions to square up your Z-axis before you start. The smoothness of the surfacing you do will depend on the Z-axis being perpendicular to the table. However, don't be too disappointed if your surface has distinct tooling marks. After you've finished this surfacing, you will actually be able to adjust the Z-axis with even more precision because you will have a tool-defined, flat plane to measure against. The larger diameter the cutter that you use for surfacing, the less time it will take. But a wider cutter makes it more likely that you will have tooling ridges from the process and increases the load on your router. A .75"- 1.25" diameter bit will probably work well.
This little project is going to generate a lot of sawdust. We'd recommend you get your dust collector hooked up and running before starting the actual cutting.

The instructions use values appropriate for a table that is exactly 96" X 48". If your ShopBot is a different size, the table surface slightly larger or smaller, or you are working in mm, just replace the '96' and '48' with appropriate dimensions for your table (for example '32' and '24' for a BT). NOTE: If you are using a router bit that does not have a blade for plunging, you need to plunge to the cutting depth outside of the material, and move into the material. The instructions will give you suggestions on how to do this.

By this point you should have the table surface material mounted on your ShopBot. You should have attached the support board to the table with the carriage bolts (recessed) included in the table hardware. Now, attach a sacrificial board to the underlying support board by countersinking drywall screws. If you

can find them, plastic screws countersunk are a good option. If there are warps in the sacrificial board, check to be sure that all the screws are tight.

The table surfacing routine will use the Cut Rectangle [CR] Command (with pocketing) in the ShopBot Software to run a surfacing bit over the entire surface of the sacrificial board.
Remember: The [Esc] key will back you out of a command that you don't want. Hitting the Spacebar or the "S" key (and Remote Stop on a PRS standard) will stop the movement of the carriages without shutting down power to the router or spindle. The E-Stop on a PRS alpha will stop movement of the carriages AND shut down power to the spindle/router.

Steps for surfacing your table …

What	How
Set the diameter for the bit you are using	**[VC]** (Value Cutter)
Move the router bit to the starting point for the X and Y axes at the **lower left corner** of the table.	Call up the keyboard control **[SK]** (Set Keyboard or just **K**). Use your keyboard arrow keys to move the router into the lower left hand corner of the table (think of the little man). Carefully line up the center of the bit with the corner of the table. *Note: if you are using a bit with no plunge capabilities, move the bit to slightly beyond the material so that the bit plunges outside the material, and moves into the material to cut.*
Make that point 0,0 for the X and Y axes	**[Z2]** (Zero 2D)
Lower the router bit onto the surface of the board	Call up the keyboard control **[SK]** or **[K].** Use the Page Up and Page Down keys to raise and lower the Z-axis/ router … move the bit down until it would just touch the table. **Esc**ape out of Keyboard Control
Set the surface as 0 for the Z-axis	**[ZZ]** (Zero the Z)
Raise the bit so that it is about ¼" off the surface of the table	Call up the keyboard control **[SK]** or **[K].** Use the Page Up and Page Down keys to raise and lower the Z-axis/ router. [**Esc**ape]
Send the router across the table diagonally. Watch carefully for the low point on the surface of the board.	**[M2] 96, 48** to Move in 2 Dimensions (the X & Y) to the point that is 96" along the X axis and 48" along the Y axis. If your tool is not a 96x48, use the correct dimensions. Hit Enter to initiate the move. The router should glide along a diagonal line and end up at the upper right corner of the table board. **NOTE: the space after the M2 and the COMMA are very important.**

Send the router to the lower right corner of the table.	**[M2] 96, 0** to Move 2 Dimensions (the X & Y) to the point that is 96" along the X axis and 0" along the Y axis [hit Enter to move]
Send the router across the other diagonal. Watch carefully for the low point on the surface of the board.	**[M2] 0, 48** to Move 2 Dimensions (the X & Y) to the point that is 0" along the X axis and 48" along the Y axis **[Enter].** The router should glide along a diagonal line and end up at the upper left corner of the table board.
Move the router to what looks like the lowest area of the table surface.	Again call up the keyboard arrow key controls **[SK]** or **[K]** to move to the lowest point.
Lower the Z to that point.	**[K]** and Page Down. **Read the Z location on the screen** on the ShopBot Position screen (red)… it should be a negative number if this point is lower than your original start point.
Zero the Z-axis to reflect this new lowest point	**[ZZ]**
Raise the Z and Jog Home to 0,0	**[JH]** This command automatically pulls the Z up and moves you at jog speed back to the home location in X and Y.
Now you are ready to try the diagonals with the router on to see if the cutting head is at the right height to remove a small bit of material from the entire surface	TURN ON THE ROUTER/SPINDLE For PSRalpah Ctrl-1 to Activate; then hit Start Button.
[MZ] 0 to Move the Z to 0.	
[M2] 96, 48 [Enter] will Send router across diagonal to the point 96, 48 (You may have to add an inch to the length or width if you plunge outside the material.)	
If the cutter removes a bit of material from all across the diagonal, you are at the right Z height. If not, lower the Z	
slightly and return to 0,0 **[M2 0,0]** You should confirm your final height by cutting the other diagonal … you've done this before, right ?	
Go back to home after getting the depth set with diagonal passes	

Now, you are ready to surface the table.

NOTE: You may want to try this up in the air first before you really cut the surface, (you can do a few passes to make sure all is going right, then stop the action with the space bar, jog home **[JH],** and start over … you can also try this in Preview Mode first)	**[CR]** for Cut Rectangle.
Fill in the blanks on the parameter sheet:	

Length x **96**, length y **48**, **T** (for True),	Use dimensions for your tool if not a 96x48.
1 (direction of cut=clockwise), Start*** 4,**	***set to 4 to start in bottom left**
Plunge per pass (set depth slightly below predetermined lowest point on table to be surfaced, say **-.025**), Reps **1,**	
Use the tab keys to move between rows of options, set Pocket function by marking box [X] with the spacebar. Set "Z Plunge Offset 0" by checking box with spacebar. Accept [**Enter**] then [**Enter**] again to run it.	YOU'RE OFF AND RUNNING ….

Decks for the Power Stick

The deck is the first level of support for your work surface. If your Buddy came with a standard size Power Stick (24" nominal work area; 48" stick) we've put a plywood deck on it to get you started. As you begin to use your tool, you will develop an idea about the type, size, and shape of deck that best suits your work.

Typically, you will attach an additional sacrificial sheet of material (also called a spoil board) to the deck, or you may attach a plenum for a vacuum hold-down system. The t-track slots in the Power Stick provide a convenient system for securing the deck to the Power Stick. We've used bolts and t-nuts to attach the "starter" deck, but you can also use clamps in the slots.

Suggested Materials for Future Decks

½" or ¾" Plywood Always a good choice - 2 laminated pieces of ½" is particularly stable

¾" MDF or LDF Not as stable but may work well for many applications particularly when you are not using a full size deck

½" or ¾" Phenolic

½" Aluminum Plate

For a Vacuum Plenum
(2nd layer, only used if installing a vacuum hold-down system):

¾" extruded sheet PVC

¾" MDF (must be sealed after machining)

¾" Phenolic

¾” Polyethylene

For the Top Layer (sacrificial or spoil board)

¾” LDF

Sizing Your Deck

Your deck can be sized for the projects you will be doing. It can be as narrow or wide as convenient; however, you will probably want the deck an inch or two wider than the Power Stick to keep debris from accumulating on the tracks. Keeping the deck about 3” wider than projects will improve dust collection by providing an extended surface at the edges for the dust skirt to work.

We recommend that the length of the deck be extended to within about 6” of the Power Stick at each end. Keeping the deck long is a SAFETY measure. It avoids creating a pinch point behind the front and back rollers under the deck.

Attaching the Spoil Board Material to Your “Starter” Deck

You can screw, glue, or clamp the sacrificial spoil board surface on your deck. But to keep it simple, let’s say you are using ¾” MDF. Screw it on with drywall screws from under the deck. Make sure you completely sink the heads of the screws so that they do not bump on the rollers. You can take the deck off and turn it over on the spoil board to hold it while you are attaching it, or you can leave the deck on and have someone press down from above while you drive the screws in. For many types of projects, after you’ve installed a spoil board you will want to surface it flat before beginning work. See “Surfacing your Table”. Use a surfacing bit such as the one included in the ShopBot Starter Bit Kit. Also, see the next section on adjusting rollers before doing your surfacing.

Adjusting the Rollers

Roller height is preset at the factory. If they need to be adjusted, set the height so that they are level and just touching the bottom of the deck. Make any adjustments you need to make to the rollers for a particular project before you surface/flatten your work surface or material.

Adjust the rollers by moving the height of the bolts at each end of the roller axle. Make sure to lock in the height with the nut when you get the height right.

Working with Longer Power Sticks

Power Sticks of varied lengths add great versatility to what you can accomplish with your Buddy. The moving work bed on a CNC tool allows you to cut, drill, and machine projects of much greater length than the standard bed size of your tool. The work area of your Buddy can be lengthened with a longer Power Stick. One or more Power Sticks can also be used as multiple work fixtures that can be readily swapped in and out of your tool. And, you will be able to quickly switch back to using your standard length Power Stick at any time.

Longer Power Sticks are installed and used similarly to the standard Power Stick. But, there are some additional things to think about due to the length of the stick.

PLEASE NOTE THIS SAFETY ISSUE! Your tool now moves in and out over a much longer distance. The Power Stick can move very quickly. Make sure that you have adequate clearance around the tool so that no one is likely to come into contact with the moving PowerStick and that they cannot be cornered by it.

A Power Stick over about 6’ will typically need some sort of out-feed support. ShopBot offers an Out-Feed System for Buddies with Power Sticks that includes 4 configurable, 4-ft long out-feed rollers -- 2 on each side of the Buddy tool. However, there are many other out-feed support solutions that should suffice for Power Stick work. These include using adjustable-stand, shop rollers, or fabricating special-purpose feed systems.

Note that even though the Power Stick seems quite rigid, pressure on a long, unsupported stick can cause the work surface to bow and affect cutting.

Part and Material Hold-Down

Holding material down to keep it from moving on the table during cutting and to keep it flat will be a challenge with PowerSticks just as it is with standard gantry tools … perhaps more of a challenge. As with traditional CNC, vacuum hold-down is one option. However, the space for vacuum under the PowerStick table is limited and the weight must be kept low.

Spring-loaded hold-down wheels also offer a useful method for material holding with PowerSticks. Support for such hold-downs can be positioned across the table sides at each end of the Buddy frame, and then spring-loaded wheels might be swung down from the support. Wheel pressure can also be applied with other methods and may be directed around the cutting area itself or the edges of the material being machined. We believe that new uses of the Buddy such

as in construction will promote development of additional clamping methods, particularly in the area of semi-automatic clamping, fixturing,

Tempering Expectations for Power Sticks with a Little Realism

The Buddy with Power Stick is a whole new concept for flexible CNC. We have a number of applications in mind for this new flexibility but we believe that even more interesting applications will arise as Shop Botters begin to put these tools to use and develop creative new approaches and techniques in their use. That means we can give you some ideas about where to start and issues that may arise, but also realize that you are an early adopter of a new type of CNC tool having new and un-explored opportunities and possibilities -- and there's a lot still to be worked out.

It is true that some pretty big material can now be cut on little tools with PowerSticks, and that a small tool can now be used for a big job. But a PowerStick will not replace a table and gantry tool for intense commercial applications such as cabinet production from full sheets. A PowerStick does not offer the same rigidity or perfect flatness afforded by a gantry CNC router for cutting full sheets of plywood. Additionally, it does not offer the space for installing an industrial vacuum hold-down system in the way that a gantry table offers. A PowerStick tool will require almost twice as much floor space during the cutting of a large project because the entire panel must move to each side of the Buddy for full cutting.

When deck material, sacrificial spoilboard, and project material are added to a PowerStick, the X-axis can become heavy. This will place a large load on the X-axis motor. Particularly with PRSstandard Buddies, be careful to avoid pushing the PowerStick beyond the motors' capabilities and causing it to miss steps. Although this is less of a problem with the more powerful PRSalpha Buddies, be aware that when large loads are placed on the X-axis, mechanicals and speeds should be adjusted downward accordingly. In any case, please note that it is dangerous to move the tables too quickly as persons standing around the tool may not be expecting the table to move towards them at a high rate.

- Try pressing in and then pulling out red "Emergency stop" button. As

General Safety Considerations

SHOP RULES

- Make sure you understand and respect each property of a material before use. For example, if waxing and molding, do not pour hot wax down any drain; it will clog the drain.
- Wear safety glasses and gloves when using machines or materials that require such safety equipment. If you are unsure if a machine requires safety equipment, check with a supervisor.
- Wear close-toed shoes at all times in the Fab Lab. No sandals or heels.
- Be sure to allow enough work space for anyone using the machines. Do not crowd around any machine unless under the supervision of an advisor.
- Be alert. Machines can get very hot from normal use.
- Never leave any machine unattended at any time.
- Respect the machines when using them. They are expensive equipment.
- Clean up! Any mess you leave is a direct imposition on someone else who is forced to clean up after you.
- Vacuum your work areas, and wipe down machine tools after use.
- Put away used materials in the designated storage areas.
- Put away tools and safety glasses after use.
- Only authorized users are permitted to use power tools in the shop. Make sure you check if you are authorized before using a power tool.
- Do not use power tools alone, or if you feel tired.
- No tools whatsoever are to leave the shop.
- Think! Make sure you know how machines can hurt you, and how you can hurt them, before you touch them.
- Do not install software or change the configuration of the shop computers without approval.

- Report missing supplies, broken machines, or accidents right away: it's far worse for them to be discovered later.
- The shop functions as a collectively-supported resource; ask yourself how you can improve it as well as use it.
- Use of the shop is a privilege, which can be revoked for any infractions of any of these rules.

Fab Lab Resources

Fab Lab FAQ's

Fab Labs provide widespread access to modern means for invention. They began as an outreach project from MIT's Center for Bits and Atoms (CBA). CBA assembled millions of dollars in machines for research in digital fabrication, ultimately aiming at developing programmable molecular assemblers that will be able to make almost anything. Fab Labs fall between these extremes, comprising roughly fifty thousand dollars in equipment and materials that can be used today to do what will be possible with tomorrow's personal fabricators.

Fab Labs have spread from inner-city Boston to rural India, from South Africa to the North of Norway. Activities in Fab Labs range from technological empowerment to peer-to-peer project-based technical training to local problem-solving to small-scale high-tech business incubation to grass-roots research. Projects being developed and produced in Fab Labs include solar and wind-powered turbines, thin-client computers and wireless data networks, analytical instrumentation for agriculture and healthcare, custom housing, and rapid-prototyping of rapid-prototyping machines.

Fab Labs share core capabilities, so that people and projects can be shared across them. This currently includes:

- A computer-controlled laser cutter, for press-fit assembly of 3D structures from 2D parts
- A larger (4'x8') numerically-controlled milling machine, for making furniture-(and house-) sized parts

- A sign cutter, to produce printing masks, flexible circuits, and antennas
- A precision (micron resolution) milling machine to make three-dimensional molds and surface-mount circuit boards
- Programming tools for low-cost high-speed embedded processors

These works with components and materials optimized for use in the field, and are controlled with custom software for integrated design, manufacturing, and project management. This inventory is continuously evolving, towards the goal of a Fab Lab being able to make a Fab Lab.

Curriculum Overview

Because Digital Fabrication Laboratories are new in the United States and were developed by a research institution, no formal curriculum plans or models exist to help guide educators leverage these capabilities in their curriculum. The MDFP project has provided a solution by developing a Digital Fabrication STEM Curriculum Guide. MDFP partners has applied and validated this model during the integration of Digital Fabrication Laboratories into their STEM-related courses and programs (see Objective 2).

Each partner institution has utilized the Worldwide Instructional Design Systems (WIDS) software tools when designing and developing curriculum and instructional materials. This system was developed by Fox Valley Technical College and its Wisconsin Technical College System (WTCS) partners. The Digital Fabrication Curriculum Integration Plan and Guide will be anchored on this competency-based system.

Curriculum Objectives

These objectives have been accomplished through the following activities:

Conducted a formal project planning workshop with key MDFP personnel based on Project Management Institute (PMI) processes

Conducted a formal curriculum development workshop with key MDFP personnel based on WIDS processes and best practices

Evaluated the feasibility of applying special learning technologies such as Learning Management Systems and Learning Objects from Wisc-Online to Digital Fabrication learning experiences

Sample MIT Projects

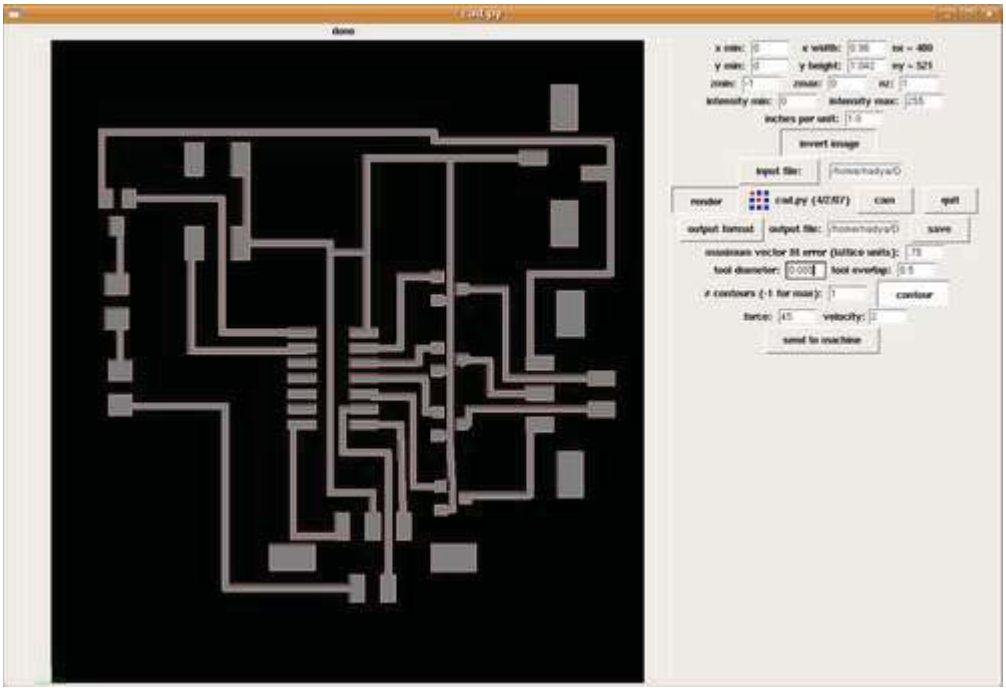
How to make flexible vinyl cut circuits

Design constrains for the circuit

The circuits that you can cut on the Roland are limited by the width of the pen knife. As a rule of thumb, anything that you can cut with a lot of time and effort with an x-acto can be cut by the Roland, but if there are things that are too small for that they will probably also be too small for the vinyl cutter.

To use the cad.py software that goes with a lot of the FabLab machines, save your circuit as a .png. If you're using Eagle as your design software, you can output the layers that you want to use as a monochrome image, and use a 500 dpi to make sure you get enough resolution to contour the part. You can also use this design constraint file in Eagle to make sure your traces aren't too close together.

Use the .png as your input, and after clicking the cam button select .camm (for the roland) as your output.

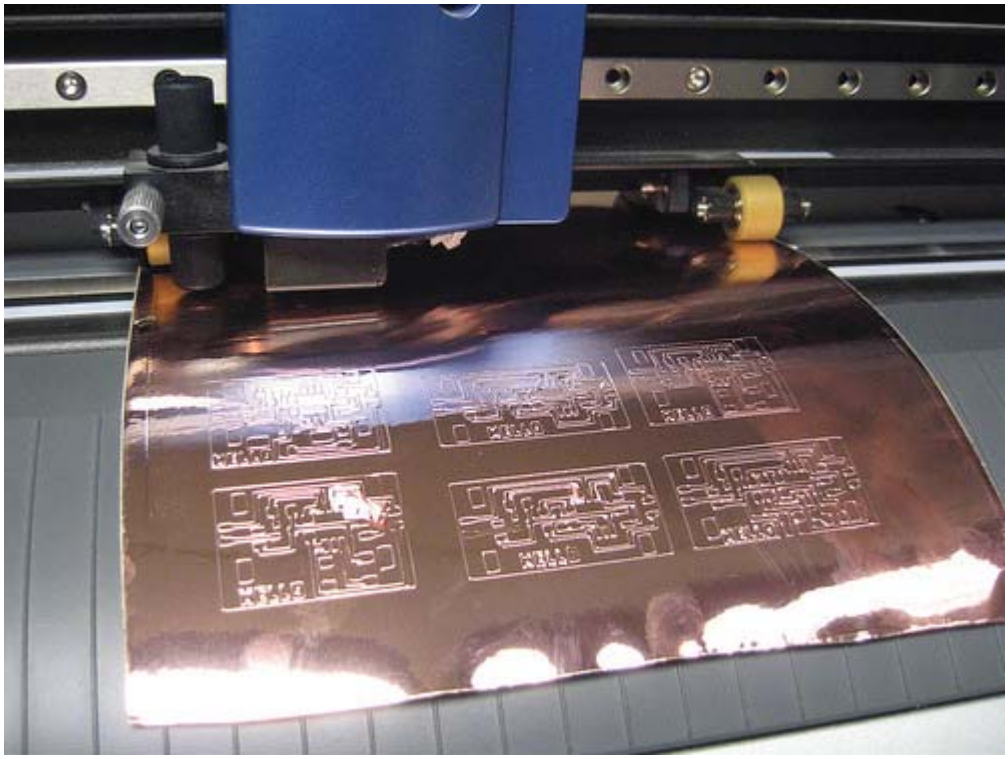


For the vinylcutter you only need one contour, check all of the contour lines to make sure that none of your paths are being skipped. If the contouring is sticking two of your parts together, you can down the tool diameter to something untrue as a hack-- the tool really is 0.01, but changing it to for instance 0.005 will probably

keep the integrity of your circuit even if all the parts might be a bit smaller than you called for. Similarly, if your circuit has a lot of spacing, you can make your circuit wider by pretending that the tool is wider than it really is.

Cutting the circuit

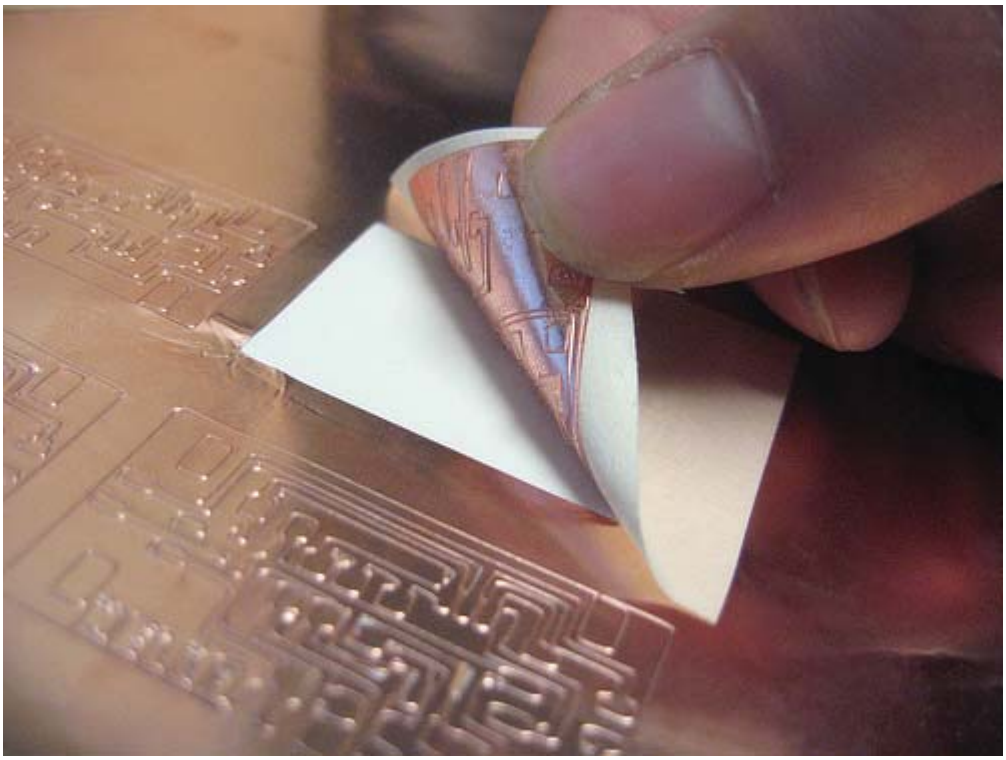
You want enough force in your circuit to cut through the copper, but not through the backing. If you use too much force, the traces will also be dragged up with the cutting. I have found that setting the pen force to approximately 45 when the knife is sticking out about 1mm is pretty good, although this varies. While cutting the circuit and watching the vinyl cutter, you can dynamically adjust the pen force with the slider located on the right control panel of the machine. Adjusting the pen force to be lighter for smaller traces and heavier for larger ones tends to work pretty well.



Moving your circuit onto a base

It is necessary to maintain all of the relative positioning in the circuit itself. So the basic idea for making the circuit is to lift all of the cut copper out with pieces of masking tape, then to place them on your circuit substrate, and finally to weed out the excess copper. When putting on the masking tape, try not to press too hard as to set the pressure-set adhesive.

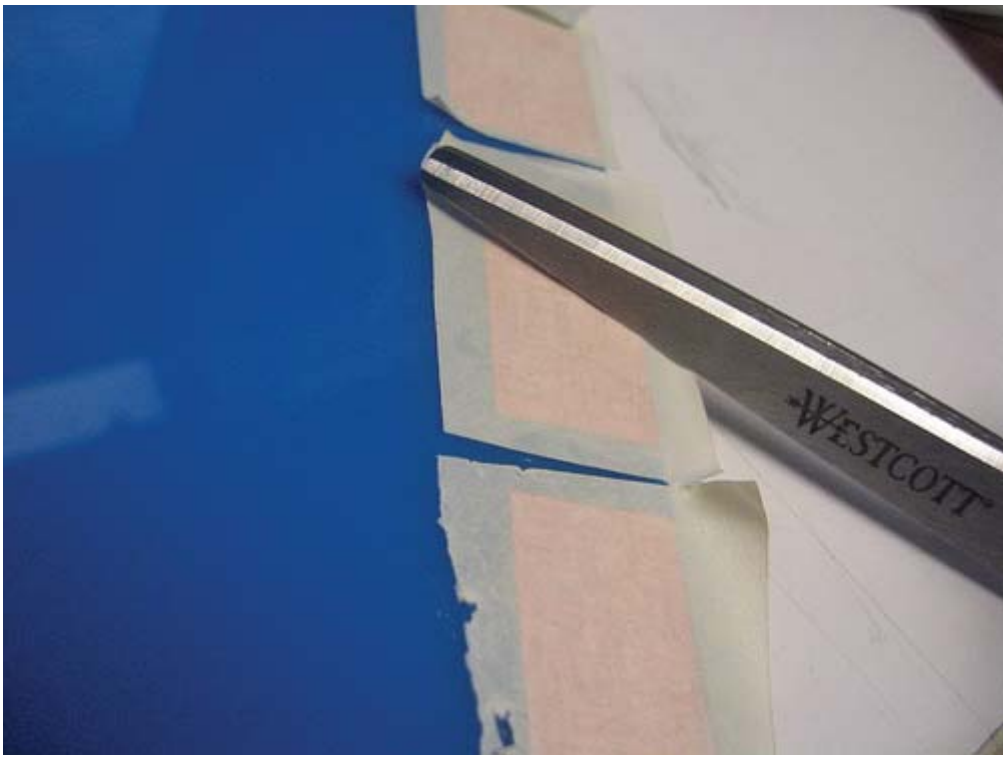
When you lift the circuit off, it is best to lift the circuit at a more obtuse angle to minimize the amount of traces accidentally left behind.



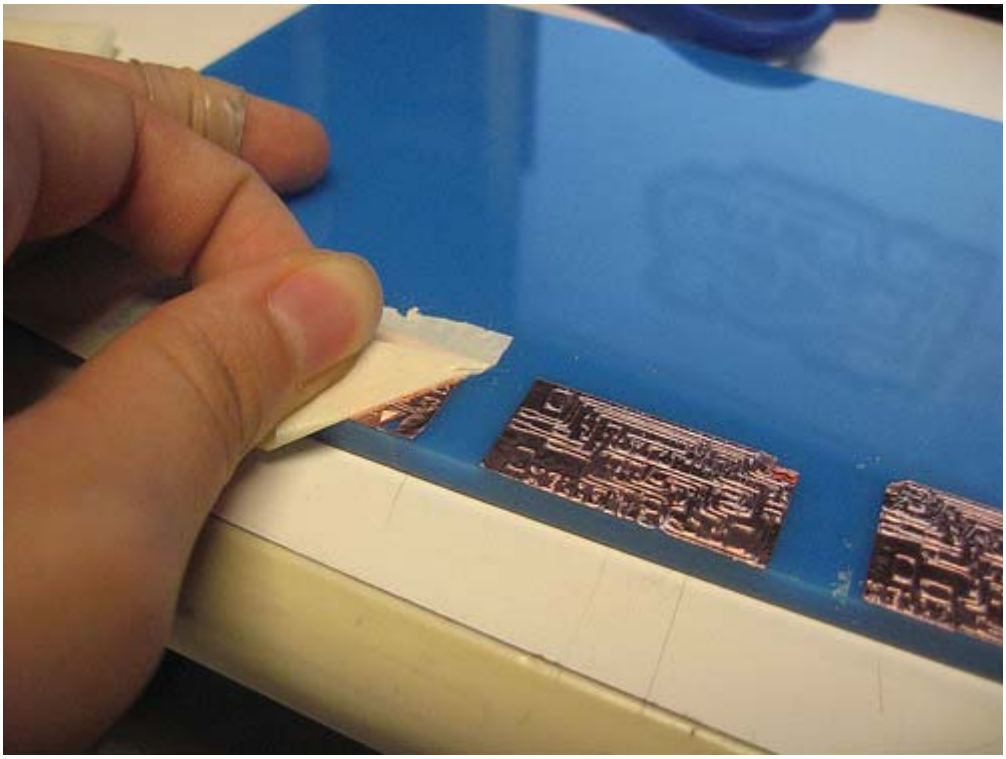
The circuits can be placed on any more or less heat-resistant surface. This can be glass, acrylic, wood or even cardboard or fabric. The surface will get hot when you solder on your components, but if you can solder quickly you can have some pretty sensitive surfaces as a base.

Fixing your circuit to the base

The 3M 1126 conductive adhesive tape is pressure-set, which means that it sticks once you press it. To make the circuits stick to your base, you need to push the copper all over as much as you can. I keep the masking tape on the circuit to protect it while rubbing all over it with the flat side of a pair of scissors or a ruler.

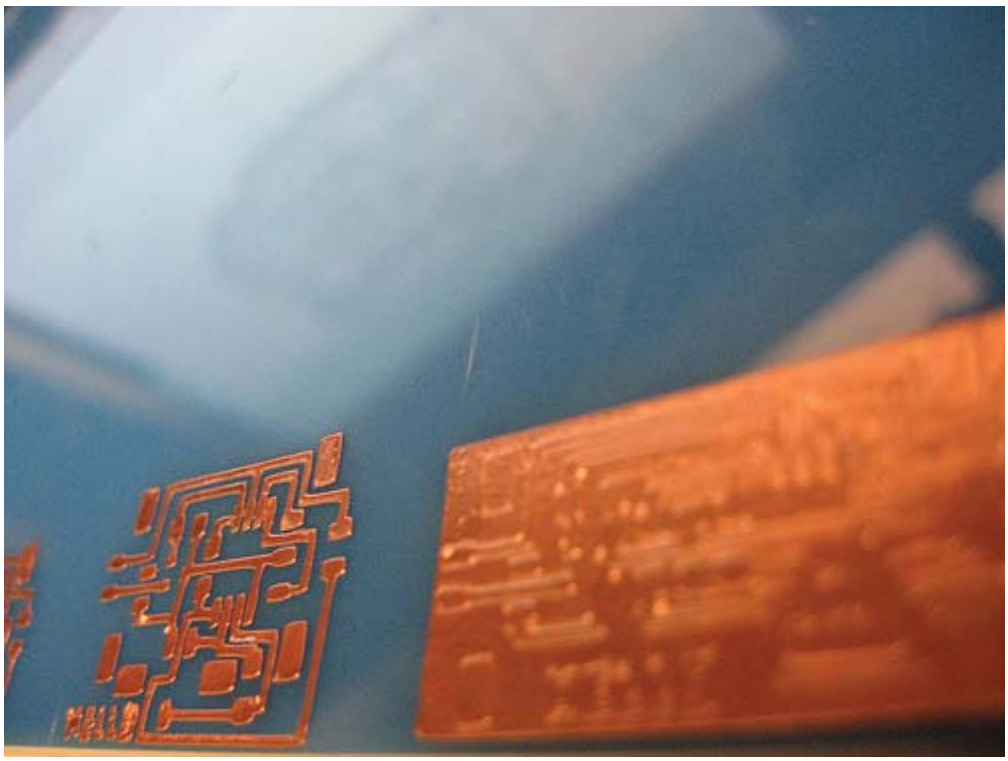


Then you will want to remove the protective masking tape, which you can do by peeling it off at as sharp an angle as possible, as not to rip up any of the traces. If the copper is lifting as you peel off the masking tape, push the masking tape back down and try to rub over the lifting area some more.

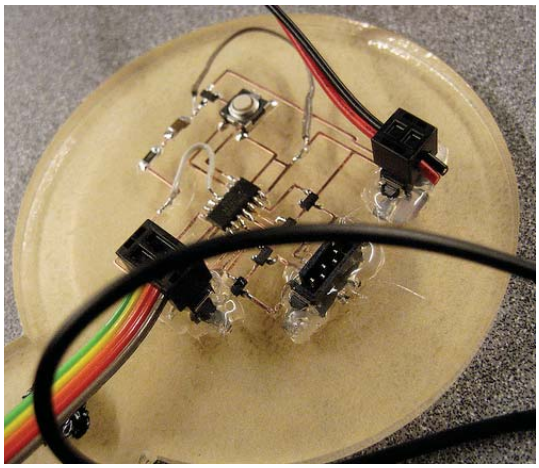


Weeding the circuit

Now you need to tweeze all of the excess copper out of the circuit. Again, you want to peel the copper off at as sharp an angle as possible, so that you leave the rest of the copper that forms the circuit exactly in place. It is easiest to not try to keep the excess as one piece of copper, but to cut it away as often as possible.



Soldering the circuit



Soldering is the same as soldering on any other PCB. However, while soldering you might find that some of your traces are looser than need be. Fix these by adding extra pressure to the trace.

Extra tips to cut fine detail, try setting the force down to 10 but run your job from the same origin several times.

once the board is weeded and mounted on the acrylic, use the soldering iron on critical parts without solder as this will slightly melt the acrylic to make your traces more durable in these locations.

Important! Use plenty of hot glue around MTA connectors or they will rip up your traces when you unplug cables!

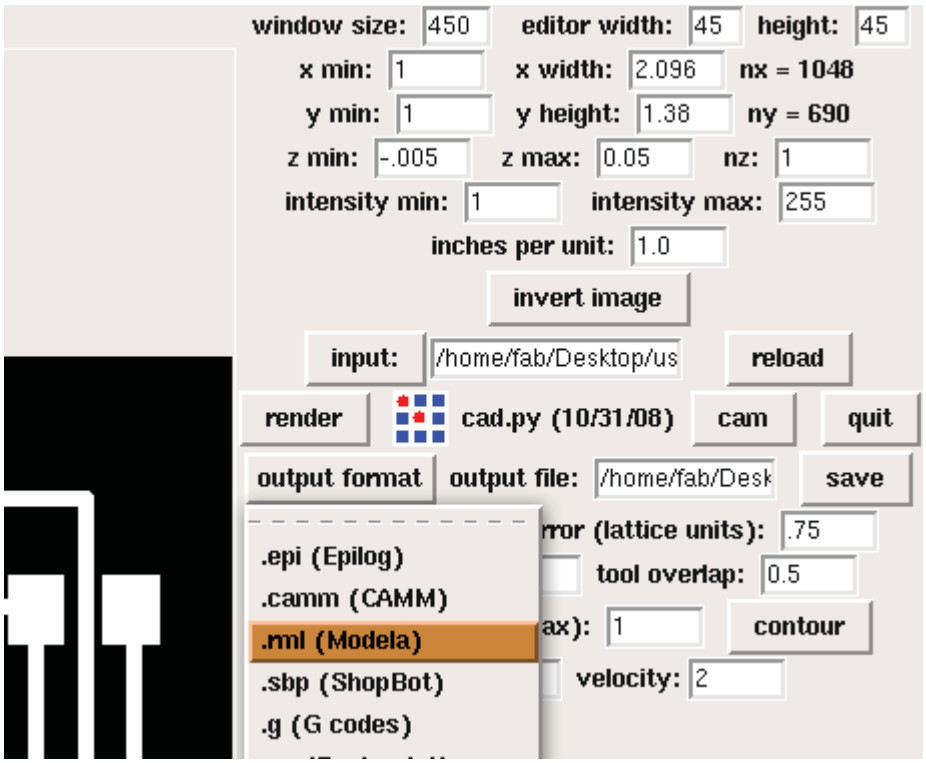
How to make circuits on the Modela milling machine

Starting out

The modela is a nice little milling machine that cranks out most of the circuits you will need for HTMAA. To be able to mill on it, you need to have FR1 which is a paper based copper plate. You cannot mill the fiberglass copper plates on the modela as it will break your bit and the dust it will create is irritant. The FR1 is more than the fiberglass, which is more green, and the FR1 is in stock in 016 in 2x3 inch and 4x6 inch pieces.

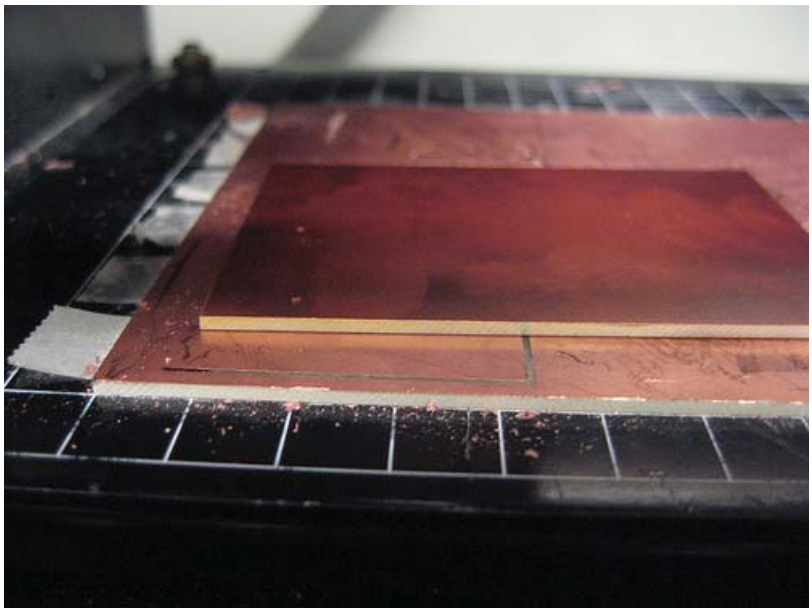
Where do you get the circuit?

You can either use a b/w .png with 500 resolution, which can be output by eagle, or a .cad file written for cad.py. If you are using a .png, the traces should be white and the background should be black. Do not make the edges of your board too wide, as it will just be more work for the modela to mill those out. If you need help designing the board, check out the PCB design page.



This tutorial is mainly for using your own .pngs. The .cad files for the hello boards will already have z min and max specified, you do not need to do that.

Fixing your board to the Modela



First make sure you have a sacrificial board underneath the board that you are milling. When you drill out the PCB you are making, you might go further than the actual thickness of the board. Attach the sacrificial board and the board you are milling out to the modela with double sided tape. Make sure the tape is not overlapping in any way as to not make the base for your board uneven.

Settings

The z min is how far down the bit is going to travel. When milling out the traces, this should be set to -0.005. The z max is how high the bit will go up when traversing between the drilling parts. This should be set to 0.05, or even 0.1 if you think that your piece might be more curved than usual. When you are actually milling out the whole board you can set the z min to -0.065.

The x and y min you can set depending on where you have placed the board you want to be milling on. The units are in inches measured from the front left corner of the modela when you are facing it.

Bits

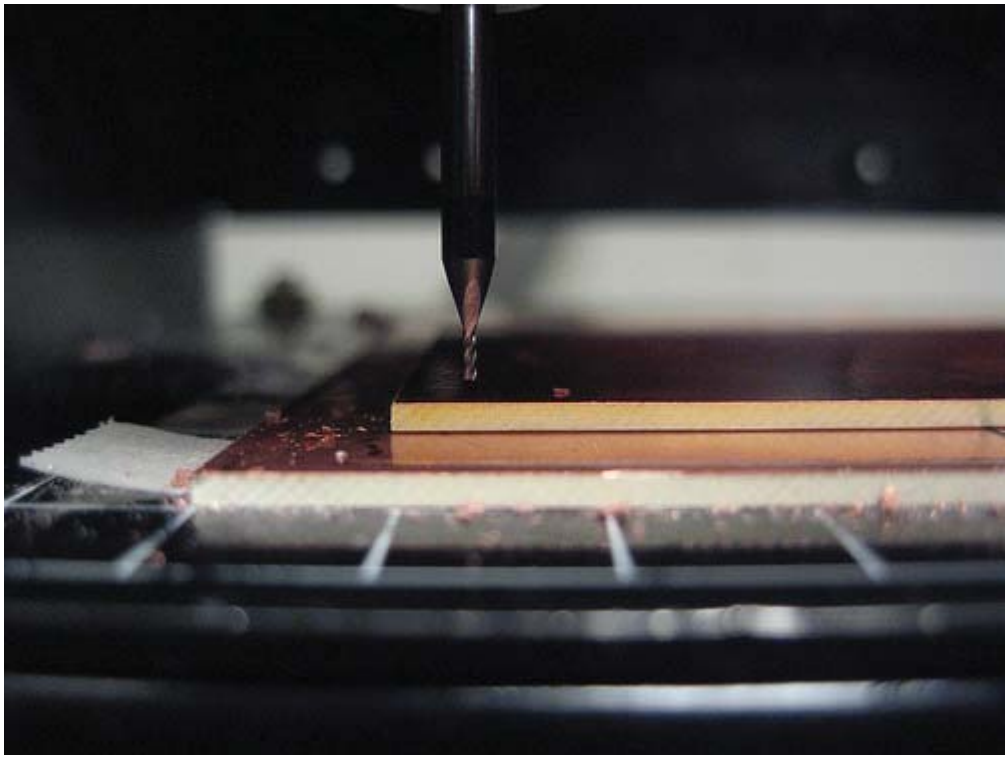
Picking a bit

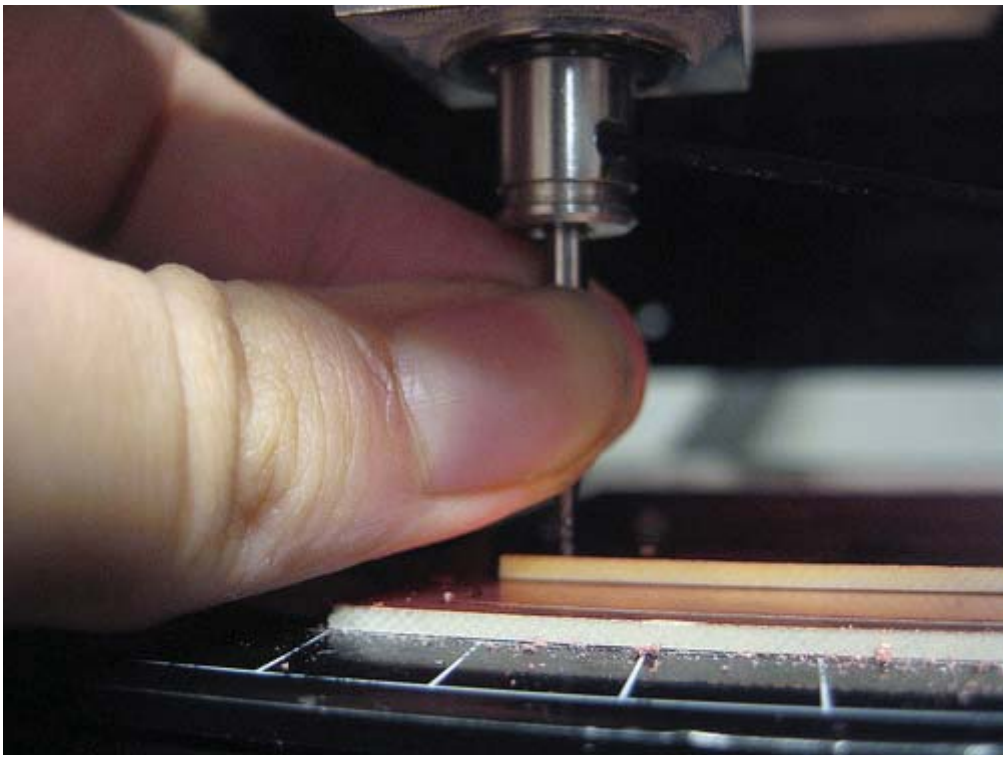
To mill out the traces of a circuit board you will generally want to use a 1/64th n-mill, but if you have a particularly rough circuit you might be able to get away with 1/32nd. Contour your board once with the tool diameter set to either 1/64 or 1/32 and check if all the pieces are milled correctly. If 1/32 is ok, contour as many

times as you want with that, otherwise contour with 1/64th.

Putting the bit in

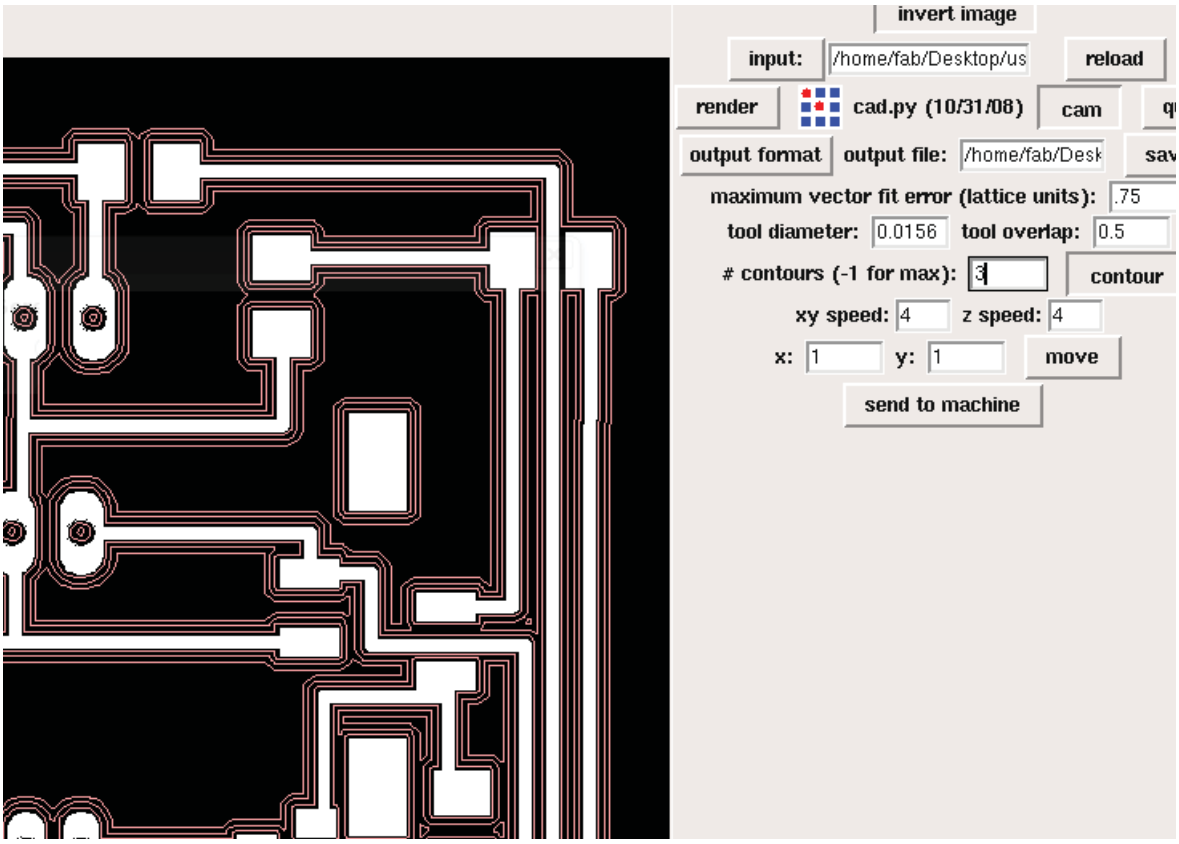
When you put the bit into the modela, you don’t have to tighten the set screws all that much. Snug is fine. Then lower the bit as close as you can get to your copper plate but without touching it by keeping the down button pressed. If you only press the button once, the head will move the bit down exactly 7 mills.





Once you have the bit as close to the copper, loosen the set screws again and push the bit all the way onto the copper. You should hear a small tick. Then tighten the screws again. You have now set the z origin.

Sending the job for the traces



Now that your z origin is set and your path is calculated, you can send the job to the modela. If for some reason cad.py hung after calculating the toolpath, you can still send the .rml file that cad.py outputted by means of the following shell command: cat /out.rml/ > /dev/ttyS0/ where out.rml is the path to your file and /dev/ttyS0 is the port that the modela is hooked up to.

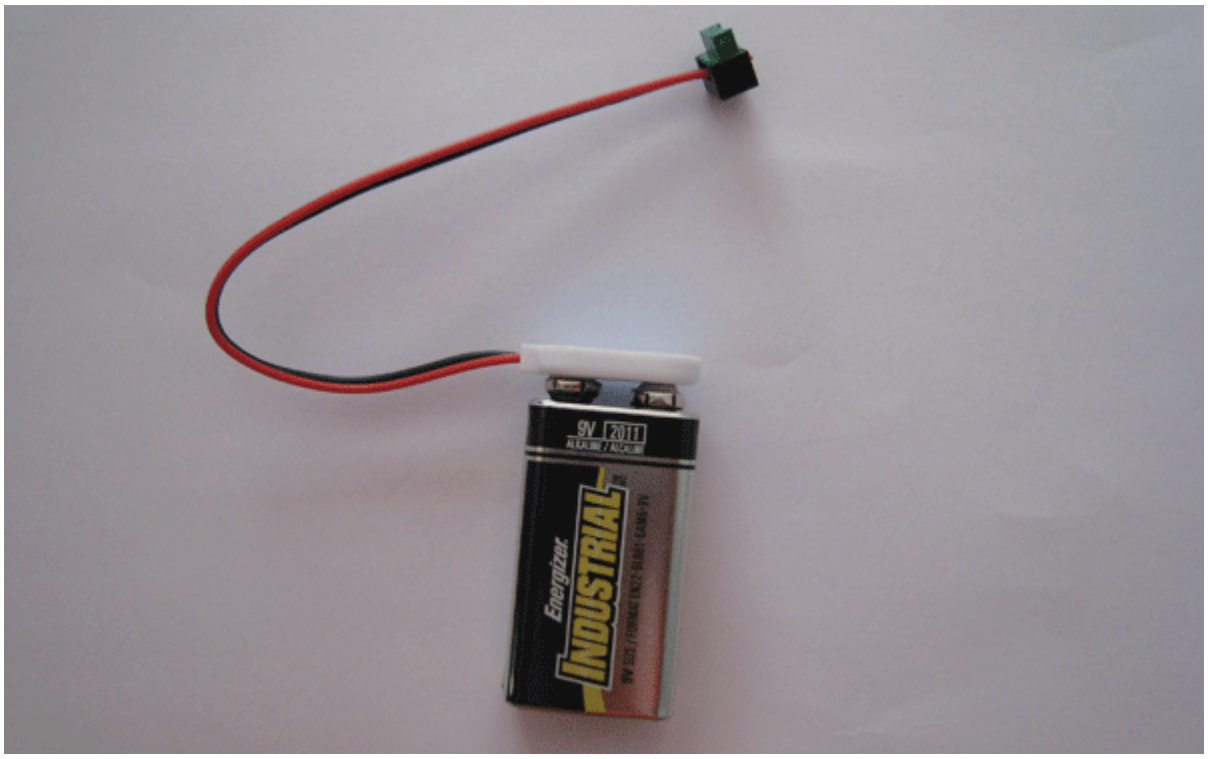
Sending the job to cut out the board

This is the same as sending a job for the traces, only you have to use the 1/32 bit, contour once and set the z-min to -0.065.

Step 1:

Create an external power supply for the board, using the 4-pin AMP connector that would normally go straight to the DB-9 serial connector. This isn't really a necessary part of the USB conversion, but it is convenient, allowing us to program the board with just one connection to the computer (instead of having a connection for power in addition to the connection for programming). Since all of the boards described on this website already have a voltage limiter, it is sufficient to just directly hook up a 9-volt battery. Many of these boards do not have a

mechanism to protect against reverse polarity, so be sure to hook up the cable correctly. The correct pins for power and ground are labeled on all of the hello-world series of boards.



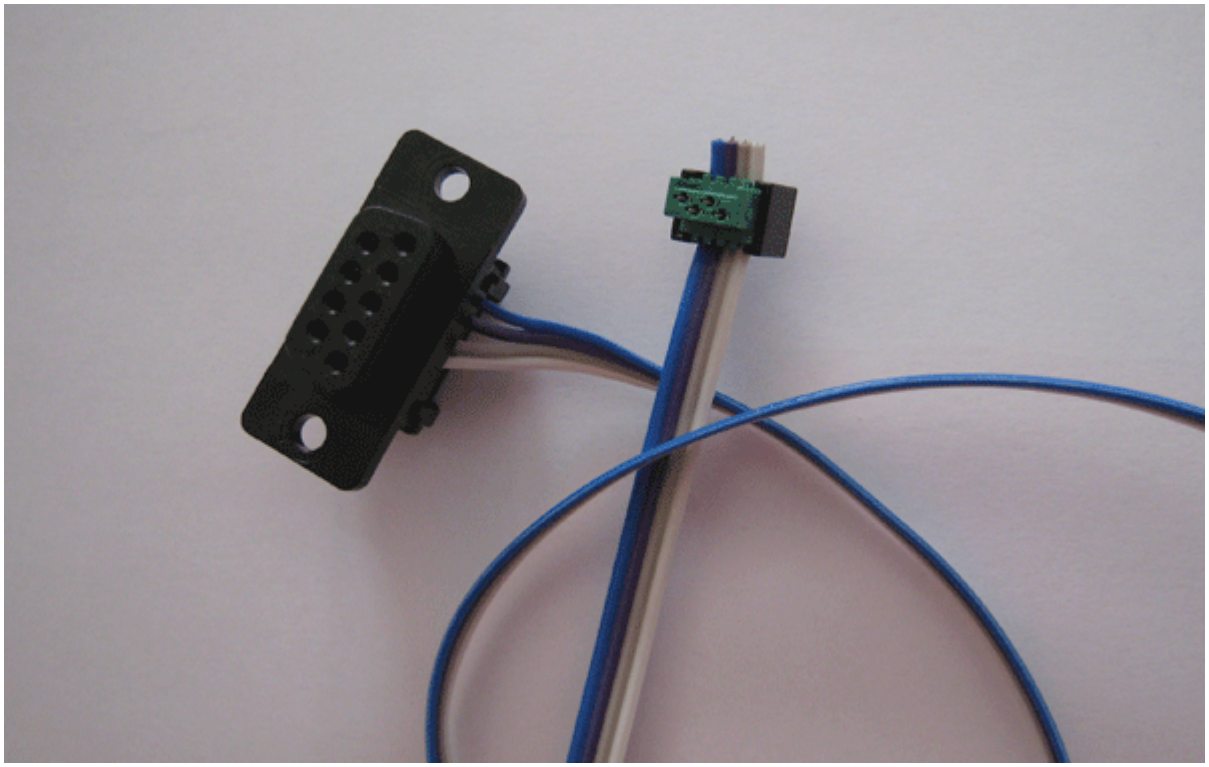
Step 2:
Create a cable to connect from the 4-pin AMP connector to a DB-9 female serial connector. The appropriate pin combination is shown here (careful while reading this diagram... the wires in a ribbon cable are not numbered. All the numbers refer to pins on one or the other of the connectors. If you do it right, this particular cable does not require any wires to cross over each other):

serial AMP MTA plug <-> DB9F cable (wire side view):

```
   Tx GND
|  2   1 |
 3   4
 Rx DTR

plug      3   2   4   1
    DCD  Rx  Tx DTR GND
      DSR RTS CTS  RI
DB9   1   2   3   4   5
```

DB9 6 7 8 9



Step 3:

Create a cable that directly connects one 5-pin AMP connector to another. Both connectors should be oriented in the same direction (notice in the picture, if you look at the connectors with the space for the MTA tab towards the top of the page, the white wire is on the right side for both).

Step 4:

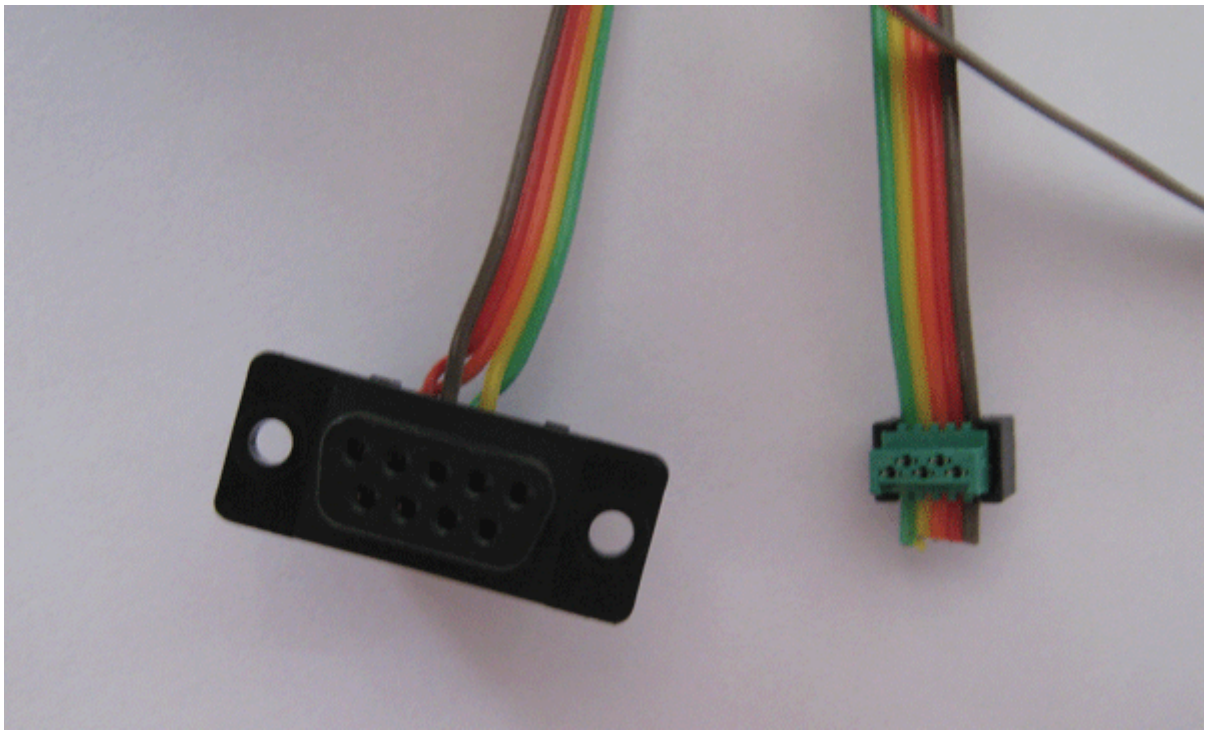
Create a connector from a 5-pin AMP to a DB-9 female. This will be our programming cable. The appropriate wiring diagram is:

in-circuit programming AMP MTA plug <-> DB9F
serial (dasa) cable (wire side view):

```
          ^
          | cable direction
    3     5     8
| MOSI (3)  GND (2)  MISO (1) |
  -RESET (4)  SCK (5)
```

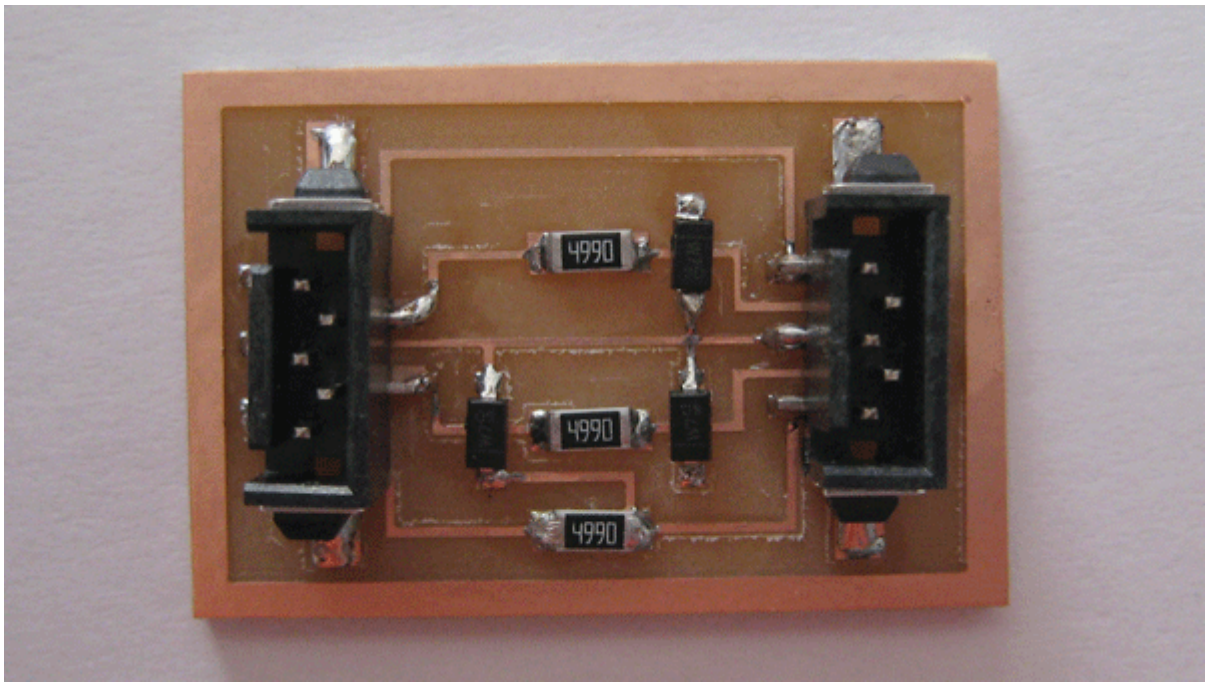
7 4

plug 4 3 1 5 2
DCD Rx Tx DTR GND
DSR RTS CTS RI
DB9 1 2 3 4 5
DB9 6 7 8 9



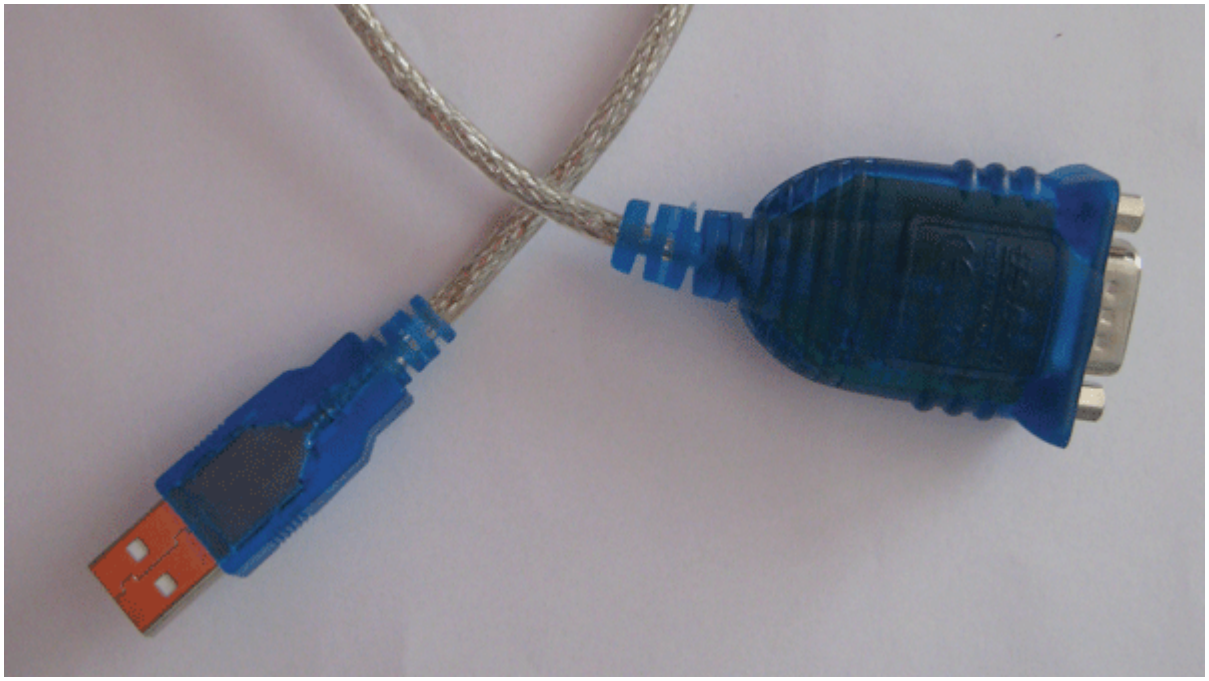
Step 5:

Create a board that will act as a serial programming voltage limiter. The cad.py specification is here



Step 6:

Get a USB to DB-9 male converter cable

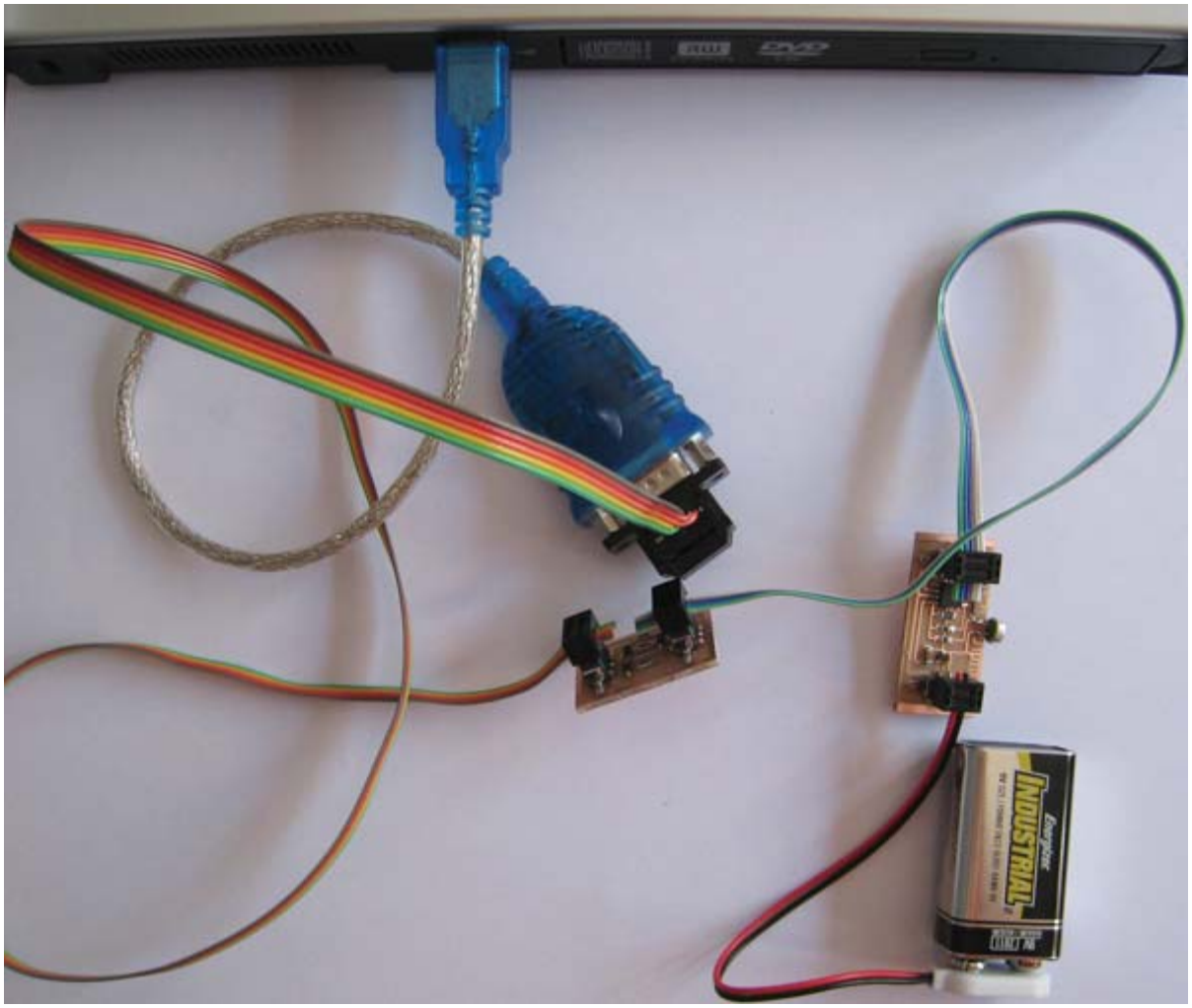


Step 7:

Program your microcontroller. In the photo here, we are using the battery as an external power supply (connected to the 4-pin AMP/MTA connector) and

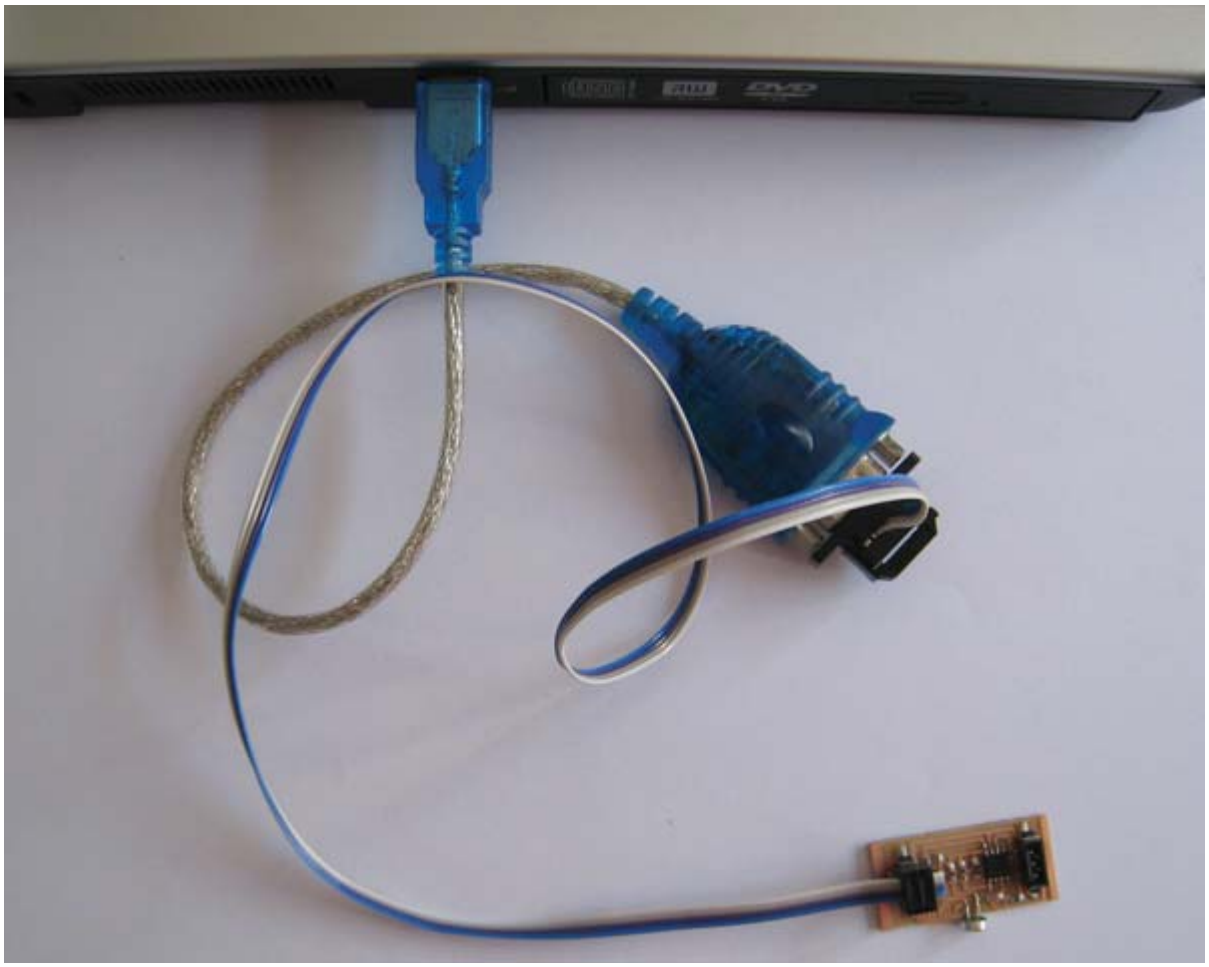
programming using serial over USB. If using avrdude, you need to tell the program which port to use (-P /dev/ttyUSB0), as well as what type of connection you have (-c dasa):

avrdude -p t45 -P /dev/ttyUSB0
-c dasa -U flash:w:file.hex



Step 8:

Send data to the computer. In the photo here, our board has a microphone picking up audio signals, and is sending the data to the USB port on the laptop computer.



…Safety First!…Safety First!…Saf

Equipment:	Epilog Laser Legend 24tt

Really Good Things to do:

- Press the "STOP" button if anything goes wrong
- Turn the fan on before you begin cutting
- Position materials with care in the upper left corner of the platform in the machine
- Wait thirty (30) seconds before opening the cover, after a job is done
- Turn off the machine when you are done
- Make sure the water bottle is by the machine in case there is a small fire in the cardboard
- Use the right power and speed settings for cardboard, plastic or other materials

Really Dangerous Things (things not to do):

- Cutting material that could give off dangerous fumes – ask before you use a new material
- Cutting material that could catch on fire
- Don't start the machine cutting something and then walk away – it's really dangerous if no one is watching!

Other Things That Could Create Problems:

- Don't open the cover while the machine is running – it stops cutting
- Trying to cut metal with the laser cutter
- Cutting something with an uneven surface that trips the cutter off its track

First!…Safety First!…Safety First!

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