1. Hardware Requirements
    a. Laser & Linear Stage
        i.
    b. NCBox-189 CNC machine controller
        i. The NCBOX-189 is a very small footprint x86 computer (Vortex86MX+ Processor) which can be used for a CNC controller
        ii. Features:
            1. BIOS: AMI BIOS
            2. Memory: 1GB DDR 2 on board
            3. Power Input: DC 8V-24V
        iii. User Manual: http://www.robotshop.com/media/files/pdf/rb-boa-17-manual.pdf
    c. 6 Axis Stepper Motor Controller CNC Kit - Digital Dream Multiple input Mach3 Card (Version 2.1)
        i. User Manual: http://www.soonwell.com/ebay_file/App_pic/123456
    d. PCI-E to Parallel LPT Port and Serial Port
        i. One 25 pin DB25 standard ECP/EPP/SPP parallel port
        ii. One standard RS232 9 pin serial ports
        iii. Works with CNC software such as Mach2/3, POS, LPT printer, ID reader, wiggler, ByteBlaster programmer etc
        iv. Supports Windows XP, 7/8, Mac, Linux
        v. Download Driver
2. Latency Test
    a. What Latency-Test does and how to use it?
        i. latency-test sets up and runs one or two real-time threads. By default these threads are a fast thread with a 25.0us period and a slow thread with a 1.0ms period. This default setup mimics a common configuration pattern for LinuxCNC. The two threads are referred to as the base thread and the servo thread, respectively.
        ii. Latency-test comes with LinuxCNC, you can run it with 'latency-test' from the prompt. Let the test run for at least 15 minutes (it has been suggested that the longer the better let it run for a day or overnight for instance) while you run glxgears or a similar application to stress the cpu. Move around windows, surf the web, copy files, play music etc.
    b. So, what do the results mean?
        i. If your "Max Jitter" number is less than about 15-20 microseconds (15000-20000 nanoseconds), the computer should give very nice results with software stepping.
        ii. If the Max Jitter is more like 30-50 microseconds, you can still get good results, but your maximum step rate might be a little disappointing, especially if you use microstepping or have very fine pitch leadscrews.
        iii. If the numbers are 100 uS or more (100,000 nanoseconds), then the PC is not a good candidate for software stepping. Numbers over 1

millisecond (1,000,000 nanoseconds) mean the PC is not a good candidate for LinuxCNC, regardless of whether you use software stepping or not.

c. (blank)

3. Installing LinuxCNC - Installing to Ubuntu 10.04 or 8.04 from source
    a. Preparation
        i. On "Stock" Ubuntu

        First enable the universe repository (to find needed packages not in the Canonical repository) if it isn't already. This can be done in the Ubuntu GUI by clicking System>Administration>Software Sources from the menu bar and ticking "Community-maintained Open Source software (universe)" in the Ubuntu Software tab if it isn't already. The same tab can be reached by clicking Settings>Repositories in the menu bar of the Synaptic Package Manager (which can be started from the command line by typing "sudo synaptic".)

        You need to add the LinuxCNC repository to the apt sources list if it hasn't been already. This also can be done in the Ubuntu GUI by clicking System>Administration>Software Sources from the menu bar or clicking Settings>Repositories in the menu bar of the Synaptic Package Manager. In the list presented in the Other Software tab, look for the following entries to be present and ticked

        -for Ubuntu 10.04 (Lucid Lynx)

        http://www.linuxcnc.org/ lucid base linuxcnc2.5

        http://www.linuxcnc.org/ lucid base linuxcnc2.5 (Source Code)

        -for Ubuntu 8.04 (Hardy Heron)

        http://www.linuxcnc.org/ hardy base linuxcnc2.5

        http://www.linuxcnc.org/ hardy base linuxcnc2.5 (Source Code)

        If these entries are not present, then use the +Add... function to add the following two lines one at a time

        -for Ubuntu 10.04 (Lucid Lynx)

        deb http://www.linuxcnc.org/ lucid base linuxcnc2.5

        deb-src http://www.linuxcnc.org/ lucid base linuxcnc2.5

        -for Ubuntu 8.04 (Hardy Heron)

        deb http://www.linuxcnc.org/ hardy base linuxcnc2.5

        deb-src http://www.linuxcnc.org/ hardy base linuxcnc2.5

        ii. On Ubuntu with LinuxCNC package already installed

        Use apt-get to install additional packages required to rebuild LinuxCNC from source:

        ```
        sudo apt-get install libpth-dev
        sudo apt-get build-dep linuxcnc
        ```

    b. Getting the source with git
        i. If it is not installed yet, you will need to install git first:

        ```
        sudo apt-get install git-core gitk git-gui
        ```

Once you have installed git, you will use it to create a local copy (a "clone") of the LinuxCNC source-files project from the git server

```
git clone git://git.linuxcnc.org/git/linuxcnc.git linuxcnc-dev
```

c. Getting the latest updates with git
   i. you can get the latest updates using

```
git pull
```

   If you have made changes locally, then before doing this step you must "git commit" or "git stash" them. For more information, see Git.

d. Resolving outstanding build dependencies
   i. If the computer is missing some build dependencies (packages needed for a compile, or documentation build), then the next step (build) may fail during the './configure ..' run.
   If this happens, or even just to forestall it happening, proceed as follows in the directory created by the git clone command:

```
cd debian
./configure -a (if installing simulator use "./configure sim" instead)
cd ..
dpkg-checkbuilddeps
```

   Then "apt-get install" each of the missing build dependencies, and your configure should work (the configure script in the ./src directory this time, not in the ./debian directory). If installing simulator - don't apt-get install the rtai-modules-x.x.... package.
   If you're building the current master (2.6pre) you need an additional dependency

```
sudo apt-get install libboost-python-dev
```

e. Building LinuxCNC
   i. (Realtime)
   If you have already installed LinuxCNC from the Live-CD do not use --prefix/make install. make with no options will default to the 'run in place' method.

   Run these commands in the directory created by git above (e.g., linuxcnc-dev):

```
cd src
./autogen.sh
./configure
make
make install-menus
sudo make setuid
```

   the make command may take several minutes to complete.

4.

HAL - Hardware Abstraction Layer

1. Introduction
    a. HAL was originally designed to make it easier to configure LinuxCNC for a wide variety of hardware devices. Any system (including a CNC machine), consists of interconnected components. For the CNC machine, those components might be the main controller, servo amps or stepper drives, motors, encoders, limit switches, pushbutton pendants, perhaps a VFD for the spindle drive, a PLC to run a toolchanger, etc. The machine builder must select, mount and wire these pieces together to make a complete system.

visualizing hal nets with graphviz

I'm learning some python and I needed a quick hack to get a visual map on hal nets, so I made this little python script that reads input from "halcmd show" and outputs a graphviz file. Maybe you will find it useful.

You need to:
1) install graphviz, using "sudo apt-get install graphviz"
2) download the hal_sigs_graphviz.py attachment in a directory of your choice.
3) make a shell script inside the same dir, with the following lines in it and run it:

```
halcmd -s show pin | grep "==" > pin.out
halcmd -s show sig | grep -v "^$" > sig.out
python hal_sigs_graphviz.py > gv.in
dot -Tpng gv.in > gv.png
```

Attached is an example of what I get when running it with my (stepconf generated) hal configuration I use on my first cnc router. Tables are components and circles are nets.

I will probably add more features like colors and some fine tuning on how graphviz outputs the image, when I find some time to learn more about this excellent application. But it's probably good enough for a quick visualization as it is now.

Forum does not let me attach a .py file, so I renamed it as .txt. You need to rename it back as a .py

I also had to resize the image file. **File Attachment:** hal_sigs_graphviz.txt

Kinematics

- Coordinate Systems
  - http://linuxcnc.org/docs/devel/html/gcode/coordinates.html
  - http://wiki.linuxcnc.org/cgi-bin/wiki.pl?CoordinateSystems
- Cartesian (“Part”) coordinate
  - X, Y, Z and A, B, C ("pitch", "yaw", and "roll")
  - It describe the orientation of the tool in three dimensional space.
- Machine coordinate (robot configuration)
  - [Lx, Ly, Lz, θa, θb]
    3 linear motion provided by the linear stage + 2 rotary motion provided by the rotary table

- It describes the state of the machine. If a machine only has three motors, then the machine coordinates only consist of three numbers.
- Machine coordinates have upper and lower limits that cannot be exceeded.

.Ini Configuration

- INI File Components
  - comments
  - sections
  - variables
- Sections
  - *[EMC]* general information
  - *[DISPLAY]* settings related to the graphical user interface
  - *[FILTER]* settings input filter programs
  - *[RS274NGC]* settings used by the g-code interpreter
  - *[EMCMOT]* settings used by the real time motion controller
  - *[TASK]* settings used by the task controller
  - *[HAL]* specifies .hal files
  - *[HALUI]* MDI commands used by HALUI
  - *[APPLICATIONS]* Other applications to be started by LinuxCNC
  - *[TRAJ]* additional settings used by the real time motion controller
  - *[AXIS_n]* individual axis variables
  - *[EMCIO]* settings used by the I/O Controller
- Variables

GUI Design

- Laser Power
  - Display
  - Parameters
    - Cutting material
    - Thickness
    - Manual set
  - Hardware
    - C-Axis Pulse

        - C-Axis Dir
    - Hal
        - Set up Hal pins
    - Control
        - PWM (0-5V)
            - Calibration\
    - Reference
        - Python Virtual Control Panel http://linuxcnc.org/docs/2.7/html/gui/pyvcp.html
        - PyVCP Examples http://linuxcnc.org/docs/2.7/html/gui/pyvcp-examples.html
        - Glade Virtual Control Panel http://linuxcnc.org/docs/2.7/html/gui/gladevcp.html
        - Gscreen http://linuxcnc.org/docs/2.7/html/gui/gscreen.html

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