

User Manual

Introduction

OpenPnP is an Open Source SMT pick and place system designed and built with the hobbyist in mind but with the features and power to run commercial pick and place operations. It's goal is to bring pick and place to the desktop of anyone who needs to make more than a few of something.

OpenPnP is made up of three components. The hardware, the firmware and the software. This User Manual focuses only on the software. To get information about the hardware and firmware please visit <http://openpnp.org>.

The purpose of this manual is to help you get the software up and running, and to teach you how to configure and operate it.

Quick Start

If you are brand new to OpenPnP have a look at the [Quick Start](#) guide to quickly get up and running and comfortable with the software. Once you are done there it will guide you back here to get into the details.

Installation

Prerequisites

OpenPnP runs on the Java platform and requires the Java runtime version 7 or higher to run. You can download the latest version of Java from <http://java.com/getjava>.

OpenPnP is designed to run on Mac, Windows and Linux. Other platforms may be supported due to the nature of Java, but they are not recommended. OpenPnP is written and tested on Mac and used regularly on Windows. These two platforms are recommended for the best compatibility.

Download

Visit <http://openpnp.org/downloads> to find out how to download the latest snapshot or release of OpenPnP.

Install and Run

If you are using one of the binary installers from the website, just run the installer and follow the instructions. After installation you can run OpenPnP from your operating system's applications list, i.e. Start Menu, Applications folder, etc.

If you are using an archive version of OpenPnP, unzip the software into a directory of your choosing. Typically this would be the same place you keep your other applications. Inside the folder you unzipped OpenPnP to there is an `openpnp.sh` and `openpnp.bat` script. These should work for Windows, Mac and Linux. For Mac and Linux, run `openpnp.sh` and for Windows run `openpnp.bat`. After a short wait you should see the OpenPnP Main Window. If something goes wrong, visit the Troubleshooting section of this document for help.

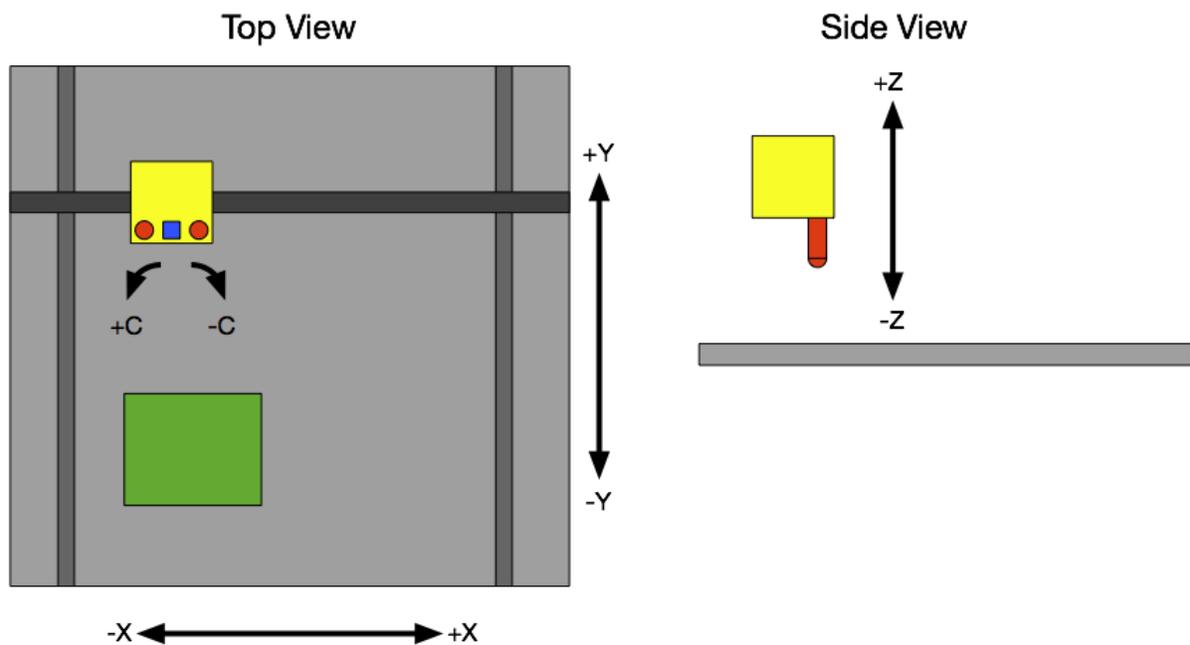
Coordinate System

OpenPnP uses the right handed coordinate system which is also used in physics, math, 3D graphics and many CAD packages.

For a more formal definition of this coordinate system see the [Wikipedia Page](#).

In this coordinate system we are standing above the machine, looking down at it.

The X axis moves right and left. Right is positive. The Y axis moves forward and back. Forward is positive. The Z axis moves up and down. Up is positive. The C, or rotation, axis rotates clockwise and counter-clockwise. Counter-clockwise is positive.



The units for the X, Y and Z axes are set in the GUI, the default is Millimeters. The units for the C axis is degrees, OpenPnP measures rotation in degrees and treats them like Millimeters from the perspective of the controller.

The User Interface

OpenPnP is primarily a single window interface, broken up into multiple sections. Those sections will be explained in detail below.

The Main Window

The screenshot displays the OpenPnP software interface with several key components:

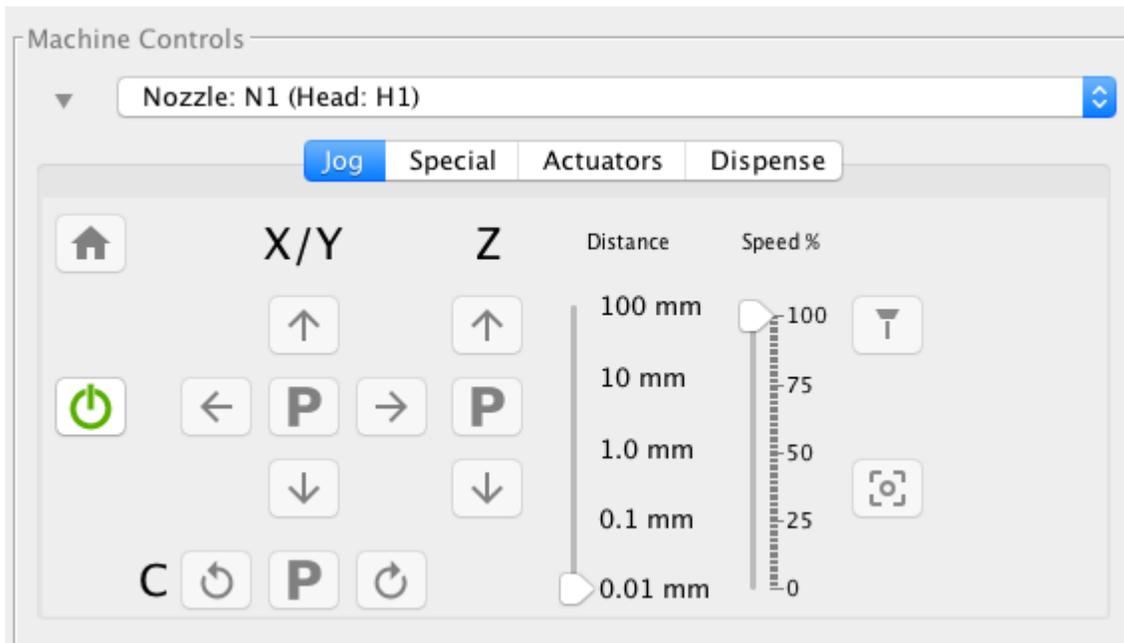
- Camera View:** A large black area on the left showing a camera feed with a red crosshair and a label 'FID1'.
- Jog Controls:** A panel at the bottom left with directional buttons (up, down, left, right) and a speed slider, labeled 'Jog Controls'.
- Boards Table:** A table at the top right listing board details. A red box labeled 'Tabs' points to the menu bar above it.
- Pick and Place Table:** A table in the center-right showing part details and status. A red box labeled 'Digital Read Outs (DROs)' points to the status bar at the bottom right.

Board	Width	Length	Side	X	Y	Z	Rot.	Enabled?	Check Fids?
pnp-test.bo...	37.000	0.000	Top	3.995	4.413	0.000	0.008	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
pnp-test.bo...	37.000	0.000	Top	5.139	62.744	0.000	-19.947	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
pnp-test.bo...	37.000	0.000	Bottom	64.490	7.248	0.000	0.605	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
pnp-test.bo...	37.000	0.000	Bottom	84.336	46.650	0.000	36.609	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
pnp-test.bo...	37.000	0.000	Bottom	59.177	120.839	0.000	-28.179	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
pnp-test.bo...	37.000	0.000	Top	155.018	151.332	0.000	157.093	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
pnp-test.bo...	37.000	0.000	Bottom	183.955	146.597	0.000	-140.607	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
pnp-test.bo...	37.000	0.000	Top	38.020	100.912	0.000	76.646	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Id	Part	Side	X	Y	Rot.	Type	Status	Check Fids
R1	R0805-1K	Top	31.000	6.000	0.000	Place	Ready	<input type="checkbox"/>
R2	R0805-1K	Top	6.000	22.000	0.000	Place	Ready	<input type="checkbox"/>
R9	R0201-1K	K	12.000	22.000	315.000	Ignore	Ready	<input type="checkbox"/>
R6	R0402-1K	Top	6.000	17.000	270.000	Ignore	Ready	<input type="checkbox"/>
R5	R0402-1K	Top	25.000	22.000	45.000	Place	Ready	<input type="checkbox"/>
R4	R0402-1K	Top	31.000	22.000	0.000	Ignore	Ready	<input type="checkbox"/>
R10	R0603-1K	Top	31.000	17.000	90.000	Ignore	Ready	<input type="checkbox"/>
R12	R0603-1K	Top	6.000	11.000	270.000	Place	Ready	<input type="checkbox"/>
R11	R0603-1K	Top	12.000	6.000	315.000	Ignore	Ready	<input type="checkbox"/>
FID1	FIDUCIAL-1X2...	Top	2.000	2.000	0.000	Fiducial	Ready	<input type="checkbox"/>
FID2	FIDUCIAL-1X2...	Top	34.500	26.500	0.000	Fiducial	Ready	<input type="checkbox"/>
FID3	FIDUCIAL-1X2...	Top	34.500	2.000	0.000	Fiducial	Ready	<input type="checkbox"/>
R2	R0805-1K	Top	31.000	11.000	90.000	Ignore	Ready	<input type="checkbox"/>
R15	R0805-1K	Top	25.000	6.000	45.000	Ignore	Ready	<input type="checkbox"/>
R16	R0805-1K	Bottom	6.000	6.000	0.000	Place	Ready	<input type="checkbox"/>
R17	R0201-1K	Bottom	31.000	22.000	0.000	Place	Ready	<input type="checkbox"/>
R18	R0402-1K	Bottom	25.000	22.000	315.000	Ignore	Ready	<input type="checkbox"/>
R19	R0402-1K	Bottom	31.000	22.000	270.000	Ignore	Ready	<input type="checkbox"/>
R20	R0402-1K	Bottom	12.000	22.000	45.000	Ignore	Ready	<input type="checkbox"/>
R21	R0603-1K	Bottom	6.000	22.000	0.000	Place	Ready	<input type="checkbox"/>
R22	R0603-1K	Bottom	6.000	17.000	90.000	Ignore	Ready	<input type="checkbox"/>
FID4	FIDUCIAL-1X2...	Bottom	31.000	11.000	270.000	Place	Ready	<input type="checkbox"/>
FID5	FIDUCIAL-1X2...	Bottom	31.000	11.000	270.000	Ignore	Ready	<input type="checkbox"/>
FID6	FIDUCIAL-1X2...	Bottom	0	0	0	Fiducial	Ready	<input type="checkbox"/>
			0	0	0	Fiducial	Ready	<input type="checkbox"/>
			0	0	0	Fiducial	Ready	<input type="checkbox"/>
			0	0	0	Fiducial	Ready	<input type="checkbox"/>

X:0.000 Y:0.000 Z:0.000 C:0.000

Machine Controls



The Machine Controls are your interface to interacting with the machine. From here you can:

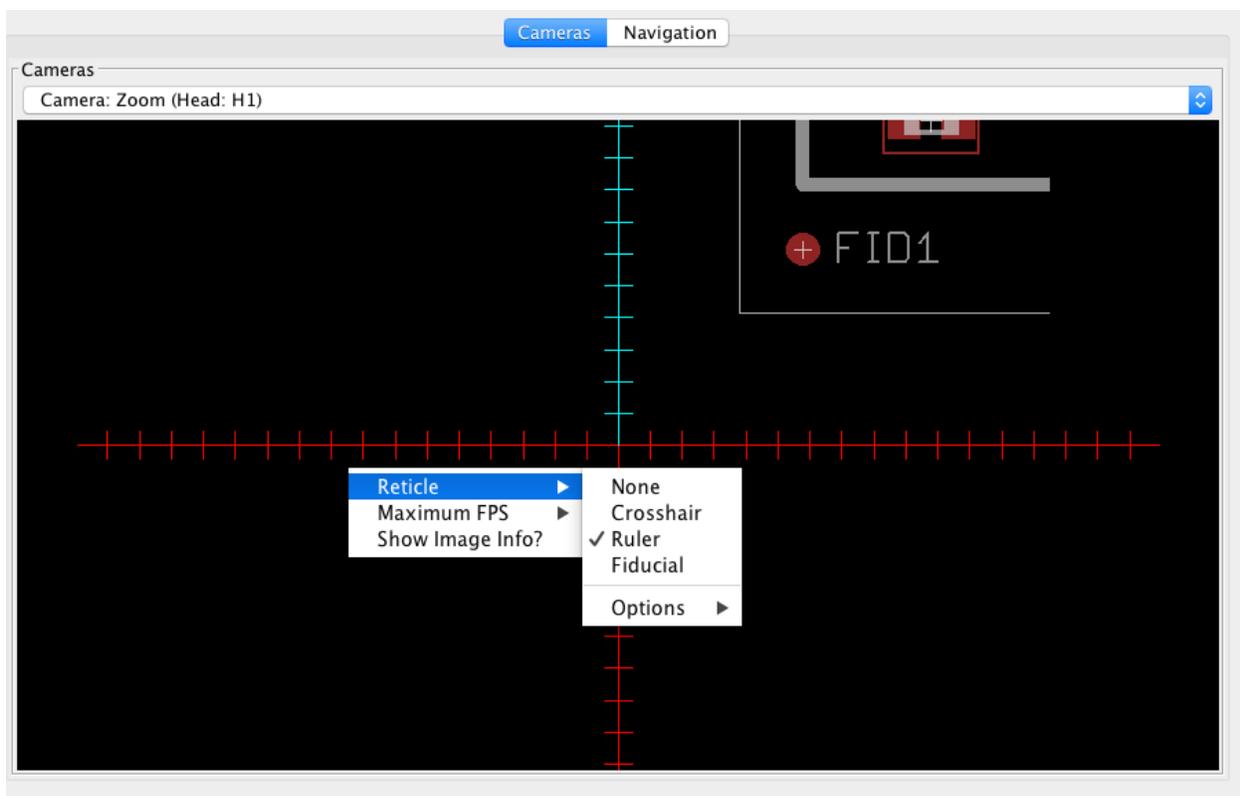
- Turn the machine on and off with the power button .
- Select the nozzle that you'd like to use for setup operations.
- Jog the currently selected nozzle with the jog buttons.
- Use the Distance slider to change how far the machine moves with each jog.
- Use the Speed slider to change how fast movements happen.
- Use the Special, Actuators and Dispense tabs to trigger more advanced actions.
- Press the Park buttons to move either the X/Y axes, the Z axis or the C axis to the Park location defined on your head.
- Press the Home button to perform a homing operation. You should do this each time you start your machine.

Digital Read Outs (DROs)

X:0.000 Y:0.000 Z:0.000 C:0.000

The DROs show the current position of the selected nozzle in your preferred units. You can click the DROs to set them to relative mode which will zero them out and turn them blue. You can use this to measure distances; the DROs will show the distance from where you first clicked them. Click again to go back to normal mode.

The Camera Panel



The Camera Panel is where images from your cameras will show. You can select the currently visible camera from the dropdown, or select to show All Cameras or None. When multiple cameras are shown they are broken up into multiple Camera Views.

You can right click in each Camera View to set options specific to that camera. Most importantly, you can choose your Reticle here. The Reticle is an overlay on the camera

view to help with targeting. You should start with the Crosshair Reticle and try out some of the other options to see what you prefer.

You can also hold down Shift and click the Left Mouse Button in a Camera View to move the nozzle to that location. This is called Camera Jogging.

The Tabs

The screenshot displays two panels from a PCB manufacturing software interface. The top panel, titled 'Boards', has tabs for 'Job', 'Parts', 'Packages', 'Feeders', 'Machine Setup', and 'Log'. It contains a toolbar with icons for navigation and a table listing board parameters. The bottom panel, titled 'Pick and Place', has tabs for 'Pick and Place' and 'Solder Paste'. It contains a toolbar with icons for adding and deleting parts and a table listing individual components with their properties and status.

Boards Panel Table:

Board	Width	Height	Side	X	Y	Z	ø	Enabled?	Check Fids?
pnp-test.b...	37.000	0.000	Top	3.995	4.413	0.000	0.008	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
pnp-test.b...	37.000	0.000	Top	5.139	62.744	0.000	-19.947	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
pnp-test.b...	37.000	0.000	Bottom	64.490	7.248	0.000	0.605	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
pnp-test.b...	37.000	0.000	Bottom	84.336	46.650	0.000	36.609	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
pnp-test.b...	37.000	0.000	Bottom	59.177	120.839	0.000	-28.179	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
pnp-test.b...	37.000	0.000	Top	155.018	151.332	0.000	157.093	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
pnp-test.b...	37.000	0.000	Bottom	183.955	146.597	0.000	-140.607	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
pnp-test.b...	37.000	0.000	Top	38.020	100.912	0.000	76.646	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Pick and Place Panel Table:

Id	Part	Side	X	Y	ø	Type	Status	Glue	Check Fids
R1	R0805-1K	Top	31.000	6.000	0.000	Place	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R8	R0201-1K	Top	6.000	22.000	0.000	Place	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R7	R0201-1K	Top	12.000	22.000	315.000	Ignore	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R9	R0201-1K	Top	6.000	17.000	270.000	Ignore	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R6	R0402-1K	Top	25.000	22.000	45.000	Place	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R5	R0402-1K	Top	31.000	22.000	0.000	Ignore	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R4	R0402-1K	Top	31.000	17.000	90.000	Ignore	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R10	R0603-1K	Top	6.000	11.000	270.000	Place	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R12	R0603-1K	Top	12.000	6.000	315.000	Ignore	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R11	R0603-1K	Top	6.000	6.000	0.000	Ignore	Ready	<input type="checkbox"/>	<input type="checkbox"/>
FID1	FIDUCIAL-...	Top	2.000	2.000	0.000	Fiducial	Ready	<input type="checkbox"/>	<input type="checkbox"/>
FID2	FIDUCIAL-...	Top	34.500	26.500	0.000	Fiducial	Ready	<input type="checkbox"/>	<input type="checkbox"/>
FID3	FIDUCIAL-...	Top	34.500	2.000	0.000	Fiducial	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R2	R0805-1K	Top	31.000	11.000	90.000	Ignore	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R3	R0805-1K	Top	25.000	6.000	45.000	Ignore	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R13	R0805-1K	Bottom	6.000	6.000	0.000	Place	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R14	R0201-1K	Bottom	31.000	22.000	0.000	Place	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R15	R0201-1K	Bottom	25.000	22.000	315.000	Ignore	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R16	R0201-1K	Bottom	31.000	17.000	270.000	Ignore	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R17	R0402-1K	Bottom	12.000	22.000	45.000	Ignore	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R18	R0402-1K	Bottom	6.000	22.000	0.000	Place	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R19	R0402-1K	Bottom	6.000	17.000	90.000	Ignore	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R20	R0603-1K	Bottom	31.000	11.000	270.000	Place	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R21	R0603-1K	Bottom	25.000	6.000	315.000	Ignore	Ready	<input type="checkbox"/>	<input type="checkbox"/>
R22	R0603-1K	Bottom	31.000	6.000	0.000	Ignore	Ready	<input type="checkbox"/>	<input type="checkbox"/>
FID4	FIDUCIAL-...	Bottom	34.500	2.000	0.000	Fiducial	Ready	<input type="checkbox"/>	<input type="checkbox"/>

The tabs at the right of the window are where all configuration and job setup takes place. These tabs are covered in more detail elsewhere, but here is a brief overview:

- Job: Job setup and control.
- Parts: Create new parts, setup bottom vision, pick parts for testing.
- Packages: Create packages, setup footprints. Important for [Fiducials](#).
- Feeders: Setup feeders, specify parts to feed.
- Machine Setup: Configure every aspect of the machine's hardware and setup.
- Log: Shows log output from the system and lets you choose what to show.

Location Buttons



The Location Buttons are used in many places throughout OpenPnP. It's good to get familiar with these buttons and their functions as you will see them everywhere.

From the left, the buttons are:

- Capture Camera Location : Used to capture the location the camera is currently looking at. Will typically be used to fill in the X, Y, Z and Rotation fields of an associated value.
- Capture Nozzle Location : Same the above, but captures the nozzle location.
- Move Camera to Location : Move the camera to a given location. Usually to the location identified by associated fields.
- Move Nozzle to Location : Save as above, but moves the nozzle.

You'll often see these buttons grouped together with a set of fields, like this:



The buttons control the fields and respond to the values in them. You'll also see the buttons used individually where applicable, like in the Job tab. Here the buttons are used in context with the selected board to capture the board location or move to it.

Finally, note the color and the icon of the buttons. These colors and icons are used throughout the system to mean the same thing. Red icons are a warning - clicking it

may make something bad happen. In this case it will make the machine move, so make sure you are clear of it. Blue icons mean capture - blue is used to indicate that clicking this button will capture a value into a field.

Keyboard Shortcuts

There are a few important keyboard shortcuts that are critical to know to use OpenPnP. They are:

- Ctrl+H: Home the machine.
- Ctrl+Arrow Key: Jog the currently selected Nozzle in X and Y. Up and Down arrows jog in Y and Left and Right arrows jog in X.
- Ctrl+/, Ctrl+' : Jog the currently selected Nozzle down and up in Z.
- Ctrl+<, Ctrl+>: Rotate the currently selected Nozzle counter-clockwise and clockwise.
- Ctrl+Plus, Ctrl+Minus: Change the jog distance slider. This changes how far each jog key will move the Nozzle.
- Shift+Left Mouse Click: Hold Shift and left click the mouse anywhere in the camera view to move the camera to that position.
- Ctrl-Shift-R: Starts a job
- Ctrl-Shift-S: Steps through the job
- Ctrl-Shift-A: Stops the job
- Ctrl-Shift-P: Parks head (Z retract then XY park)
- Ctrl-Shift-L: Parks Z axis only
- Ctrl-Shift-Z: Moves head to safe Z
- Ctrl-Shift-D: Discard component
- Ctrl-Shift-F1: 0.01mm / 0.001" jog increment
- Ctrl-Shift-F2: 0.1mm / 0.01" jog increment
- Ctrl-Shift-F3: 1mm / 0.1" jog increment
- Ctrl-Shift-F4: 10mm / 1" jog increment
- Ctrl-Shift-F5: 100mm / 10" jog increment

The below shortcuts are bound to your system command modifier key. On Windows and Linux this is Ctrl, and on Mac it's Cmd:

- Modifier+O: Open a Job.
- Modifier+N: New Job.
- Modifier+S: Save Job.
- Modifier+E: Enable/Disable Machine (Power Button).
- Modifier+` : Home.

Configuration and Operation

Packages

The only thing you need to configure in packages is the pads for fiducials. Normal parts / packages don't need any of the footprint data set. They may in the future, but it will likely always be optional.

eg. the Body Height field in the Footprint tab is not used at all currently. You can leave it blank.

Feeders

Feeder locations are simple locations. In general no math is applied. The location you set is where the nozzle will go to pick. The part height is not used here.

Parts

Part height is simply the height of the part as measured, typically with calipers or from a data sheet. Part height should only need to be measured and set once per part. A Part should represent an actual physical SKU. If you have a 47uF cap that is 6mm high and one that is 4mm high, those are different parts.

Parts refer to a feeder from which they are picked and a package. The package is currently only used for fiducials.

Boards

Boards tell OpenPnP which parts to place and where to place them. Boards are stored in files with the extension `.board.xml`. A Board contains a list of Placements. A Placement tells OpenPnP which part to place at what coordinates and rotation.

Board files are independent from any user or machine. You can share Board files for a given PCB design and use the file to build that particular PCB.

You will typically create a new Board file by [importing data from your CAD software](#) such as Eagle or KiCAD. Once you've created a Board file for a design there's no need to change it unless the design changes.

PCB locations represent the 0,0,0 origin of the top of the PCB. This tells the machine where to find 0,0,0 on the board and it performs the math needed to find the individual placements from there. Part height is added when placing a part so that the needle stops at "part height" above the board.

Jobs

Job files tell OpenPnP where to find one or more Boards on the machine. A Job might consist of a single Board or of many of the same or even different Boards. Each line in a Job tells OpenPnP where to find one particular Board using machine coordinates. When you run the Job OpenPnP will process all of the Placements for each Board in the Job.

You can also set up panels of PCBs using the [Panelization](#) feature.

Understanding Z

A common source of confusion is how OpenPnP uses the various Z values and Part heights throughout the system. In simplest terms:

- Parts are picked from feeders at the Z value specified on the feeder. Every feeder type has a Z value you can set, and this is where the nozzle will be lowered to before picking.
- Every board in a job has a location which includes a Z value. The Z value is the top of the board.
- Every part has an associated height value. The height value is added to the board's Z value when placing.

Your First Job

This is a brief explanation of how to setup and run your first job. For details on any step you can refer to other parts of this page, but be warned that it hasn't all been documented yet. This is meant to serve as a jumping off point.

1. Define packages used in the PCB in the Packages tab.
2. Define parts used in the PCB in the Parts tab. Reference the previously created Packages.
3. Setup feeders in the Feeders tab for each unique Part being used in the job.

4. Create a new board by pressing  in the Job tab and add Placements to it for each Placement in the PCB.
5. Set the position of the board in the Job tab. You can use capture camera  to align it to the corner, use fiducial locate  to find it automatically or use the two placement manual process .

For additional information on using fiducials, see [Fiducials](#).

6. You'll need to set the Z position of the board, too. Touch the nozzle tip to the board and use capture nozzle  to set it.
 7. Run the job by clicking Start .
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Advanced Topics

Scripting

See [Scripting](#) for information about OpenPnP's built in scripting engine, which can be used to add new functionality to OpenPnP without changing the source code.

Configuration Files

Configuration files are located in your home directory, under a subdirectory called `.openpnp`.

- On Mac this will typically be `/Users/[username]/.openpnp`.
- On Windows 2000, XP and 2003 it will be `C:\Documents and Settings\[username]\.openpnp`.
- On Windows Vista and above it's `C:\Users\[username]\.openpnp`.

Configuration files are in XML format and can be edited by hand in a text editor. You should shutdown OpenPnP before editing files by hand as OpenPnP will rewrite the configuration files on exit.

There are three primary configuration files. They are:

1. `machine.xml`: Contains the primary configuration for the entire system, including information about the machine, cameras, feeders, nozzles, etc.
2. `parts.xml`: A portable parts database. As you define parts (components) in OpenPnP they are stored here.
3. `packages.xml`: A portable packages database. Component package information including shape and dimensions are stored here.