How to use the pendulum apparatus

Updated August 2024. The currently recommended/supported version of Matlab is 2023b.

Turn on the computer, turn on the ECP control box (the box under the bench), and log in to the computer. Ensure that the toggle switch for the axis 3 brake on the ECP control box is switched on. **If the third axis is not level, turn off the brake before adjusting**. This will reduce the wear on the brake and keep the gyroscopes in service for longer.

Before running anything, take a moment to think about safe operation of the system; check that there is nothing that can be hit by the pendulum when it is swinging (especially the computer monitor and anything on the work bench near the gyroscope base) and check that the screws on the mass and pendulum pivot are secure.

Install the controller personality file and reset the controller. Do this whenever you log onto the computer, and after switching the ECP control box on.

> 1) Close Matlab if open.
>
> 2) Start the ECP USR-MV application as administrator. You can find this in the windows start menu, on the taskbar, as a desktop shortcut, or at C:\Program Files (x86)\ECP Systems_MV\mv\E2Usr32.exe. Right-click and select 'Run as administrator'.
>
> 3) From the top bar select Utility/Reset Controller.
>
> 4) From the top bar select Utility/Download Controller Personality File
>
> 5) Select "m750_rtwt_3.pmc" from 'C:\ECP Personality Files'
>
> 6) Press Open. Wait for the status bar to complete.
>
> 7) Close the ECP program.
>
> 8) Matlab can now be opened. Use Matlab R2023b.

Download plant_block.slx and Resetmdl.slx from Blackboard if you have not done so yet. The plant_block.slx is the file you will use to start building the pendulum controller. Resetmdl.slx is used to reset the encoder counts every time the controller is run.

Where should I save my files? It is best to save your files on the local drive (for example, C:\Users\<your username>), as they build faster when saved on the machine's hard drive instead of the network drive. However, you must take responsibility to move them to the network drive or your own storage medium, so that the files will still be accessible if you work on another computer.

You do not have to work in the ECP folder on the C drive, as this should automatically be in your Matlab path.

> 1) Make a new folder in C:\Users\<your username> and make this your working directory (current folder) in Matlab.
>
> 2) Move your resetmdl.slx and plant_block.slx files into this folder.
>
> 3) At the end of your session, save your work to the network drive or your own flash drive and remove it from the desktop. Otherwise you may not be able to access your files if you work on a different machine next time.

Running on a new machine for the first time, or my machine isn't doing anything?

The machines are configured to send data to the PCI card over a defined address. Some computers are defined for different addresses, but this is an easy fix.

> 1) Open the Device Manager (Control panel -> System -> Device manager on the tab on the left, or press the windows key and start typing 'device manager').
>
> 2) Go to Motion Controllers -> PMAC PCI Motion Control Card.
>
> 3) Under the Resources tab, there will be an I/O Range listed for the card address. Take note of the start value of this range, e.g., C000 or D000.
>
> 4) In Simulink, double click the blue plant AND the blue plantReset boxes (in plant_block.slx and resetmdl.slx).
>
> 5) Take note of the value in the "Base I/O Address" field and modify it to match the value obtained from device manager. For example, mine says D000-D0FF, so I need to make sure all my plants are on address '0xD000'.

Now you are ready to start running a program on the apparatus. Do the reset first. (This is a good habit to get into, as it will zero all encoder positions and you should do it every time you run the plant block).

> 1) Open resetmdl.slx.
>
> 2) Ensure the ECP controller is turned on (the box under the bench).
>
> 3) Go to the 'DESKTOP REAL-TIME' tab and click 'Run in Real Time' (the green play button in the top menu). This will build the model, deploy it to the hardware, and then run it. The 0 in the 'ENC 1 Pos' box should turn into a 1 and the computer will beep if sound is on.
>
> 4) Do not move the pendulum, as you have just defined all angles to 0.

Plant model outputs: In the plant_model.slx, multiply 'encoder ticks' signals by these to get radians.

> • theta_flywheel * 1/(1061*32)
>
> • theta_gimbal * 1/(3883*32)
>
> • theta_pendulum * 1/(2608*32)
>
> • theta_table * 1/(2546*32)

Plant model inputs: As per the ECP RTWT User manual (page 18), the motor input to the plant model is a 16-bit number where 32767 is the equivalent of maximum positive torque command and 32768 is the equivalent of the maximum negative torque command.

Troubleshooting

> • If the 'ECP USR-MV' application prompts 'Controller not found. Would you like to set up communications?', close the application and run again as administrator.
>
> • Make sure that the axis 3 (the fixed gimbal axis) is oriented so that the limit switches are on the bottom.
>
> • If the flywheel is running too fast, close Matlab and follow the steps to reset the ECP controller and download the personality file again.

• The position of the mass on the pendulum will affect the dynamics of your system and how your controller works. Consider measuring this so it is consistent when you use it. Always ensure that the mass and the rod screws are securely fastened when using the system.

• "C:\ECP\m750" or "C:\ECP\Model210" should already be in the Matlab path by default, but if nothing works you may want to check the path.

      1) In the Home toolbar, click 'Set Path'.

      2) Click 'Add Folder' and find 'C:\ECP\m750' and click 'Select Folder'.

      3) In the Set Path dialog box, click 'Save' and 'Close'.