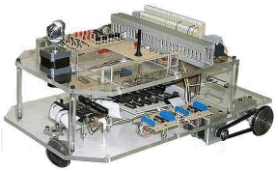


Lab 4 – Simulink (Waijung) programming. Calibration, Dynamics modeling, Filtering

GENERAL

Lab 4 will cover these topics:

(i) Simulink based embedded programming (Waijung™)
(ii) Discrete time, filtering, transformation
(iii) Input and output, (Input capture, timer), UART based I/O
(iv) State Machine
(v) Interfacing Matlab (user interface)

To unify the terminology, consider Fig.1 below

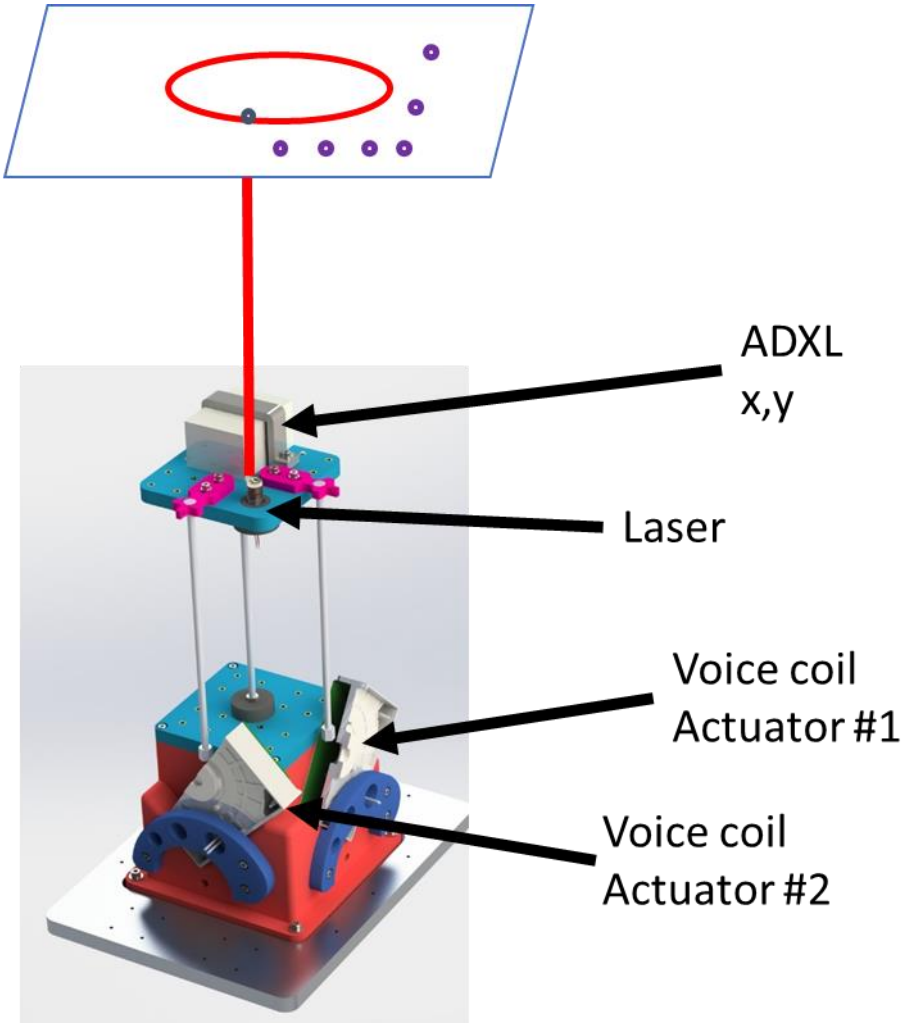
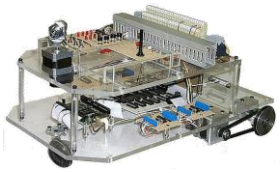


Figure 1. Lab system, showing main components and the laser illuminating the ceiling



ASSIGNMENTS

The laboratory consists of modifying example Simulink programs, writing Matlab programs to communicate with the Microcontroller (Nucleo 446ze) and analyzing the data.

Assignment number 1

- Based on the example Manual_UART_xy_wiggler.zip
  - Compile **uart_xy_wiggler.slx** (Simulink) – see lecture for explanation
  - Write a GUI program (see **go_set_xy.m** , **set_vx_vy.m**) to control the voice coil motors

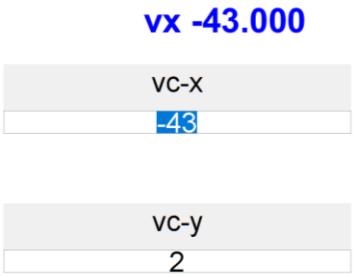


Figure 2. The **gui** created by go_Set_xy.m – entering values sends them to the NUCLEO

  - Record values of the PWM levels (-100:100) vx,vy needed to move the Laser beam on the grid that is placed on the ceiling (see below)

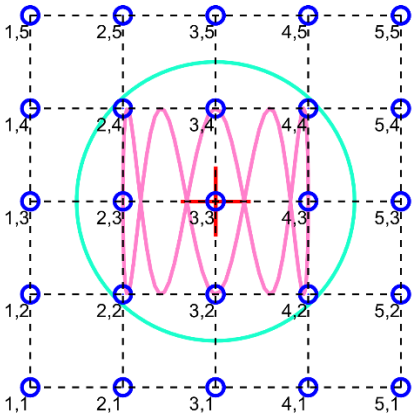
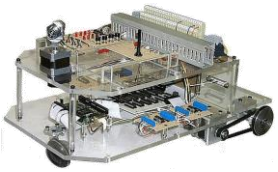


Figure 3. grid points needed for the calibration part

  - Fit a model (see lecture) that calibrates the relations between the values sent to the voice-coils vx,vy and the actual position. Make use of the model to located the Laser beam on any desired point in the x,y plane (ceiling). The model compensates for the distortions caused by the mechanical and electrical systems

⇨ Write a Matlab script that moves the Laser beam along the green circle (see above) SLOWLY (0.1 revolutions per second)



Assignment number 2a

- Based on the example record_steps_wiggler_adxl.zip
  - Compile **ADXL_recorder_fast1.slx** (Simulink) – see lecture for explanation
  - Run **test_recorder_adxl.m** and examine the code and the results

⇨ Replace the square wave generators in this example with variables modifiable via the UART. Note that once the PWM values sent to either voice coil is modified abruptly, the laser beam oscillates until it settles at a fixed position

⇨ Add a s-curve filter to eliminate the oscillations of the laser beam while settling after a reasonably fast time

⇨ → record data, show in the report and analyze

Assignment number 2b

⇨ Modify the inputs such that voice-coil #1 receives a voltage of $PWM_x = A_x \cos(\omega t)$, while voice-coil #2 $PWM_y = A_y \sin(5\omega t)$

These inputs should trace the Lissajous curve shown in purple on the ceiling plot.

Use the UART to modify from Matlab A_x and A_y

where $\omega = 2\pi f$ with $f = 0.1, 0.5, 1 Hz$

➔ Discuss the results (the report should show plots too)

⇨ Add an Input controlling the Laser (see lesson 11) illumination PWM as $PWM_{LASER} = (90 + A_{Laser})\cos(\omega t)$ while moving as shown above

Assignment number 2c

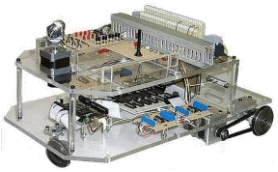
⇨ Modify the inputs such that voice-coil #1 receives a voltage of

$PWM_x = A_{x,c} \cos(\omega t) + A_{x,s} \sin(\omega t)$,

$PWM_y = A_{y,c} \cos(5\omega t) + A_{y,s} \sin(5\omega t)$

⇨ Make $A_{x,c}, A_{x,s}$, $A_{y,c}, A_{y,s}$ modifiable via Matlab/UART

⇨ Change these values manually until the purple Lissajous curve is well approximated.



Assignment number 3

- Based on the example wiggler_frf.zip
  - Compile **wiggler_frf_adxl.slx** (Simulink) – see lecture for explanation
  - Try test_frf_wiggler_adxl_full.m to measure the frequency response between the 2 voice coil actuators and the ADXL (both channels)

⇨ Find the first resonance frequency of the system (around 4Hz) by inspecting the obtained frequency response. (visual inspection of the data, plotted in Matlab)

⇨ Drive the system with a single sine-wave (Voice-coil x) at the resonance frequency and examine the result (cell-phone video may be included in the report)

⇨ Drive the system with a single sine-wave (Voice-coil y) at the resonance frequency and examine the result (cell-phone video may be included in the report)

⇨ Find the two sinusoidal excitation s fed to the voice coils, needed to make the laser beam oscillate at the resonance (PWM ~=40%) along the x direction (following a straight line, not an ellipse) and repeat for the y axis. In order to obtain this, you have to change the Simulink program and try different values for the sine and cosine amplitudes and phases.