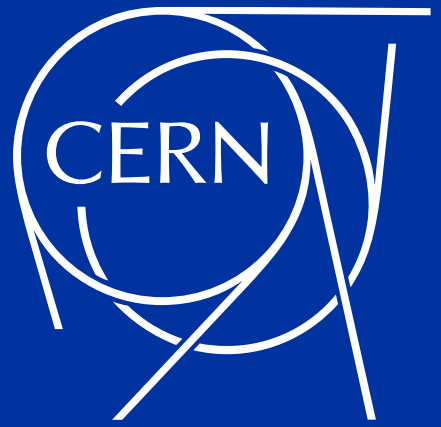


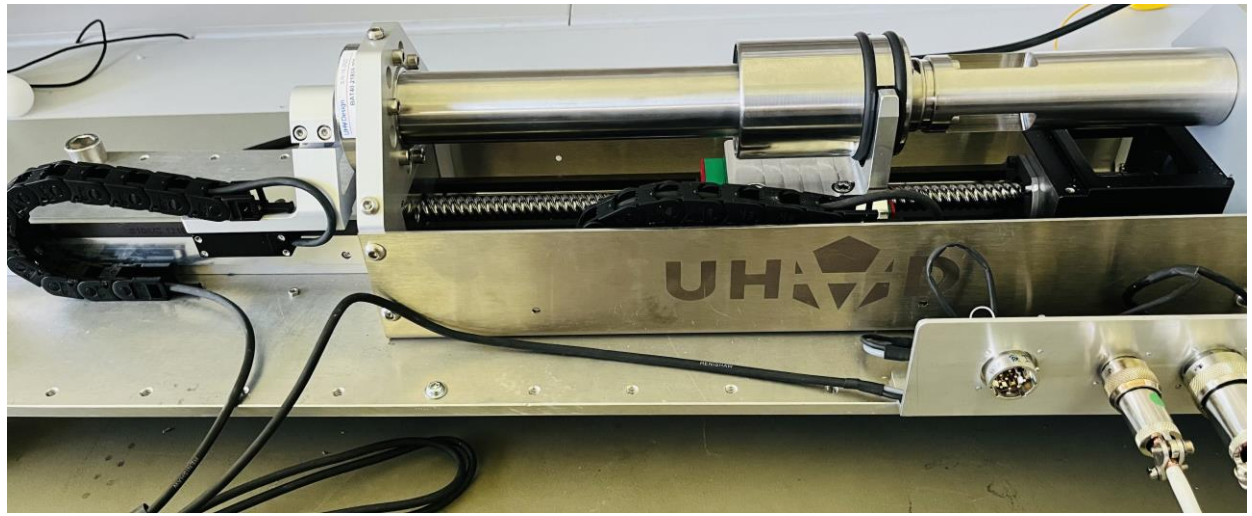
Magnetically Coupled Actuator Scan Analysis and System Modelling

Vishnu Varadan

02.05.2023

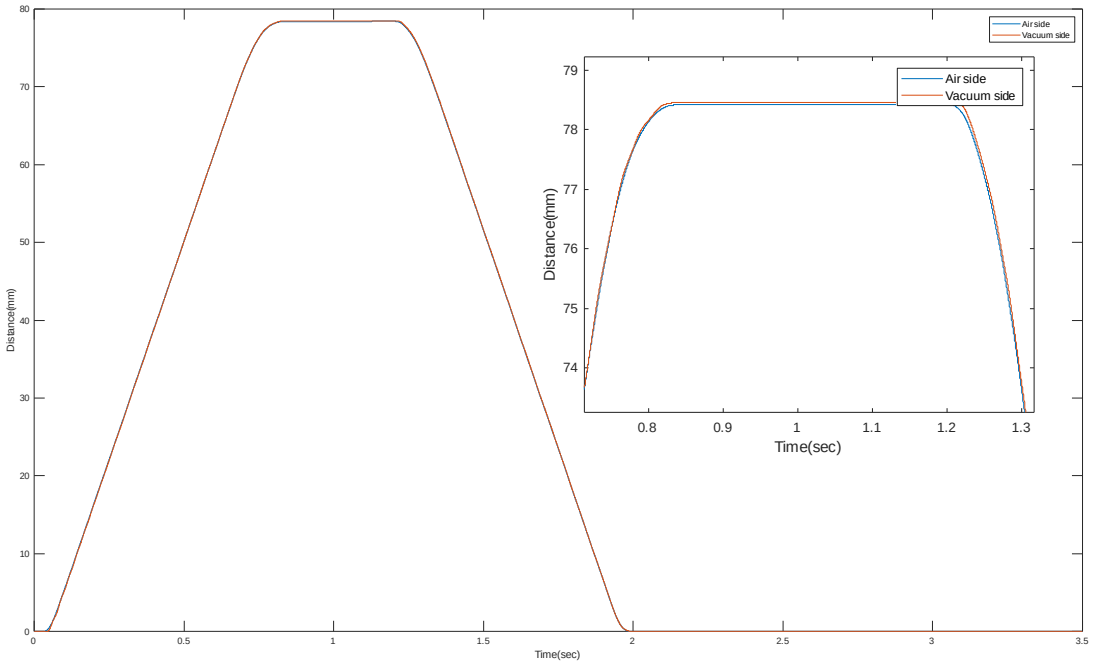
Goals

- Operate at different speeds and obtain corresponding measurements
- Study the reproducibility of encoder measurements
- Understand the relationship between the Air Side Displacement and Vacuum Side Displacement
- Identify the resonant frequency to minimize vibrations

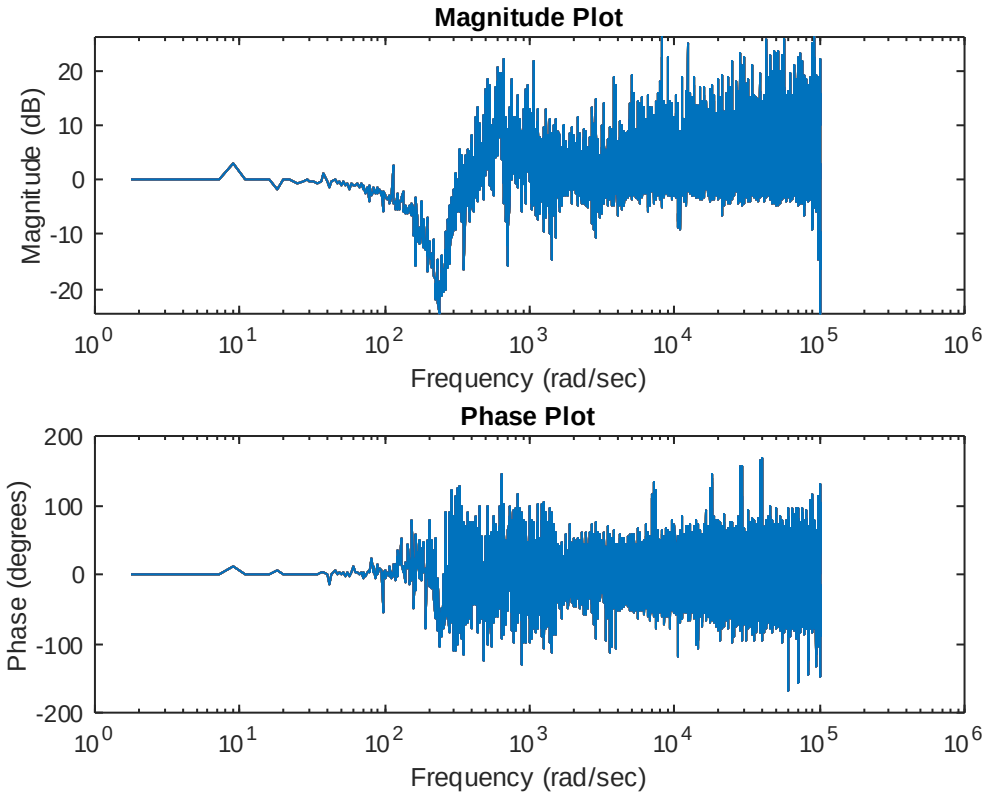


Data Collection

- Worked fine for 4 speeds: 0.1 m/sec, 0.2 m/sec, 0.5 m/sec and 0.75 m/sec – Collected data for 15 runs each
- While setting the speed to 1 m/sec, the vacuum side encoder gives invalid data. Tried repositioning but did not work

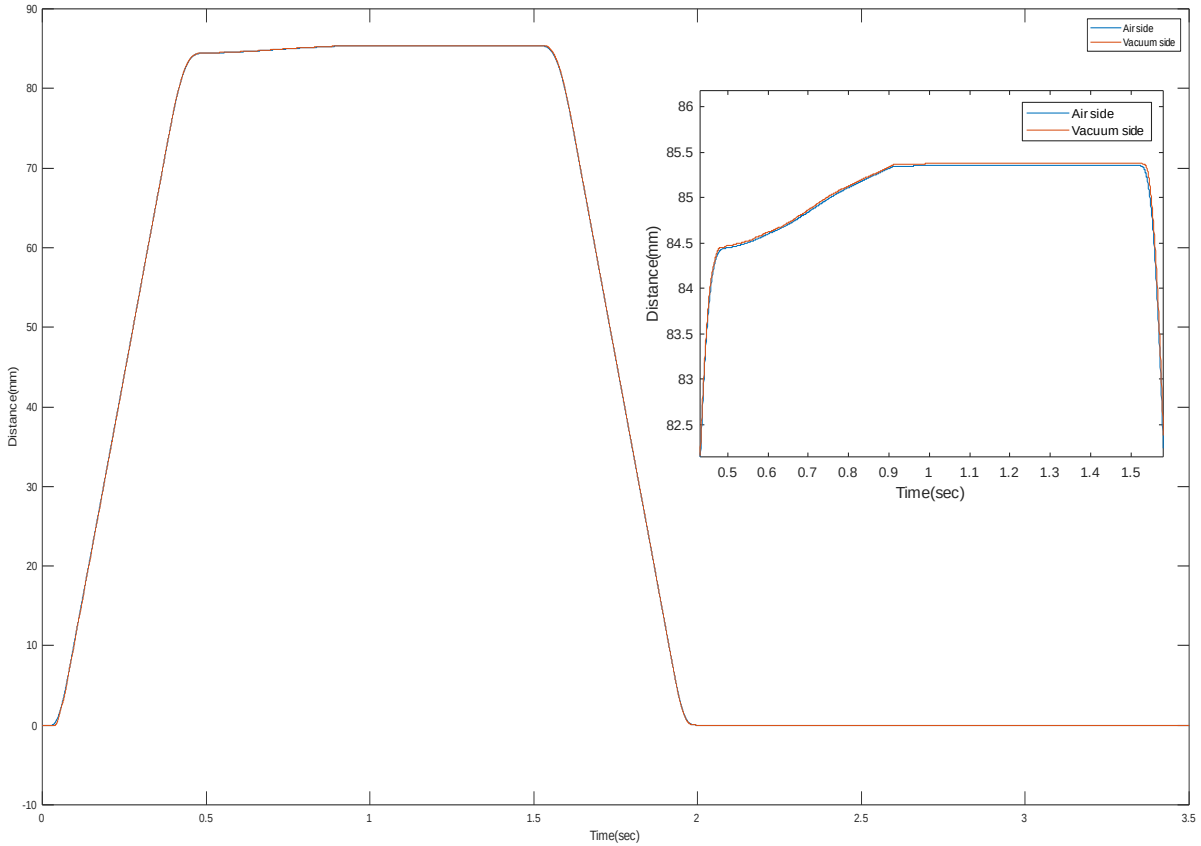


One sample run for 0.1 m/sec

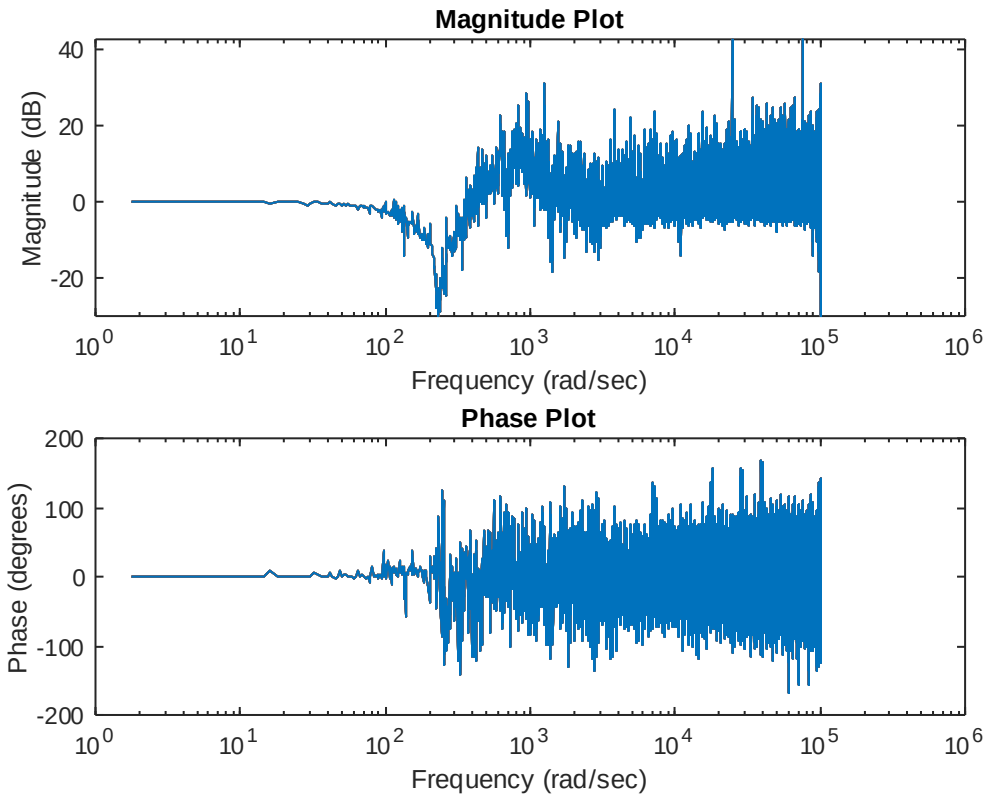


Bode Plot from mean of 15 runs

Data Collection

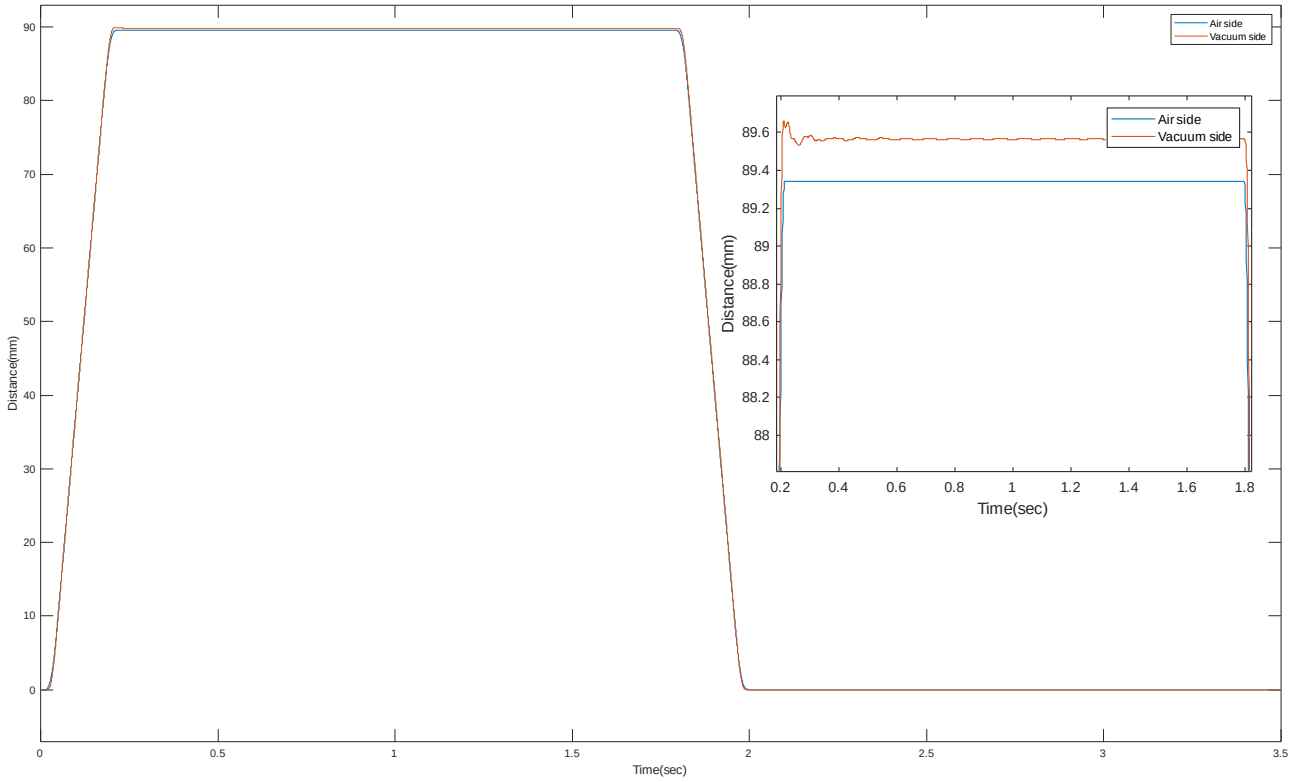


One sample run for 0.2 m/sec

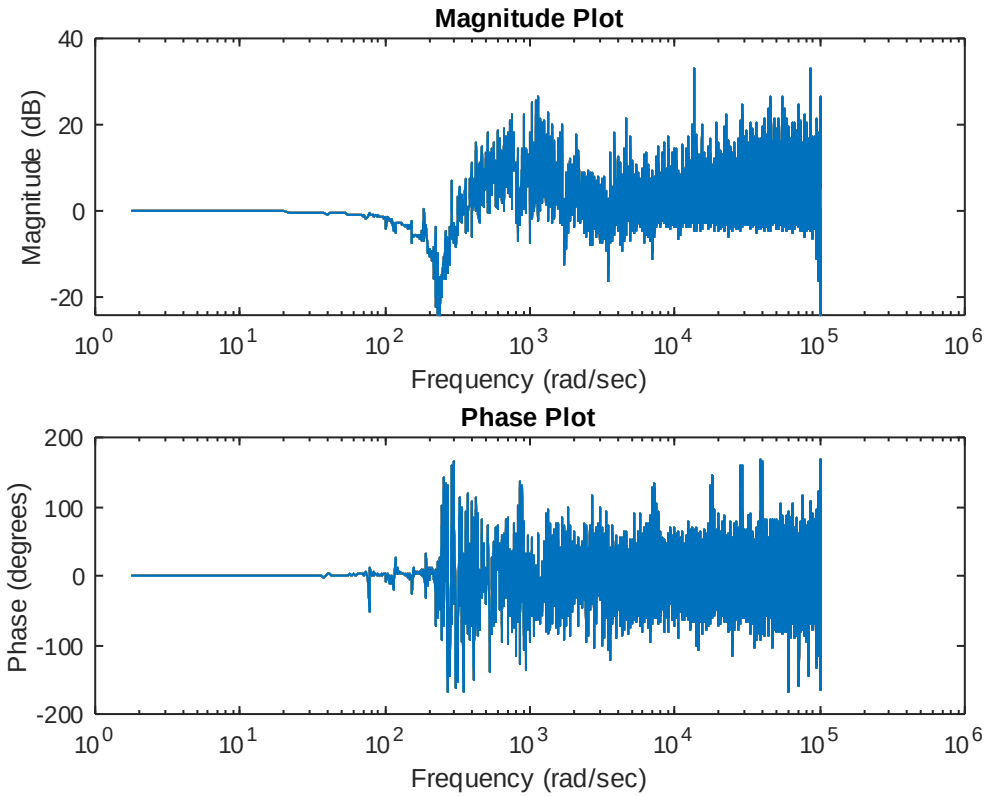


Bode Plot from mean of 15 runs

Data Collection

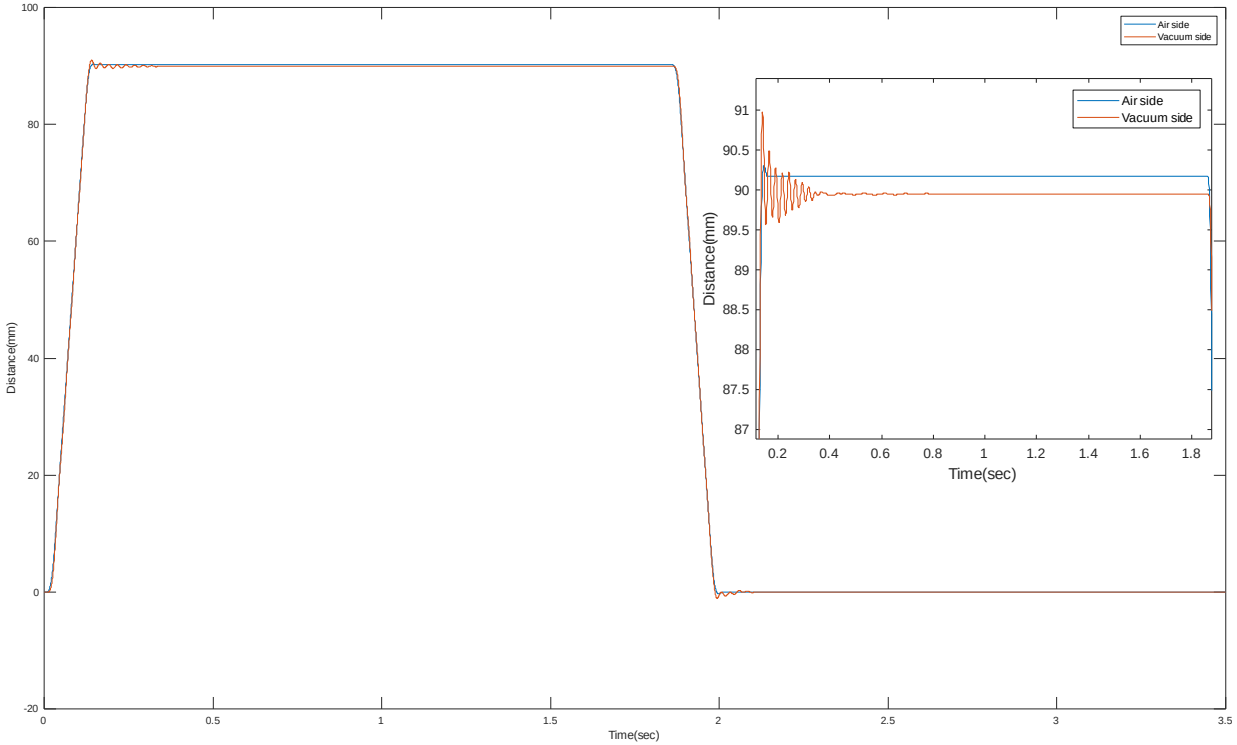


One sample run for 0.5 m/sec

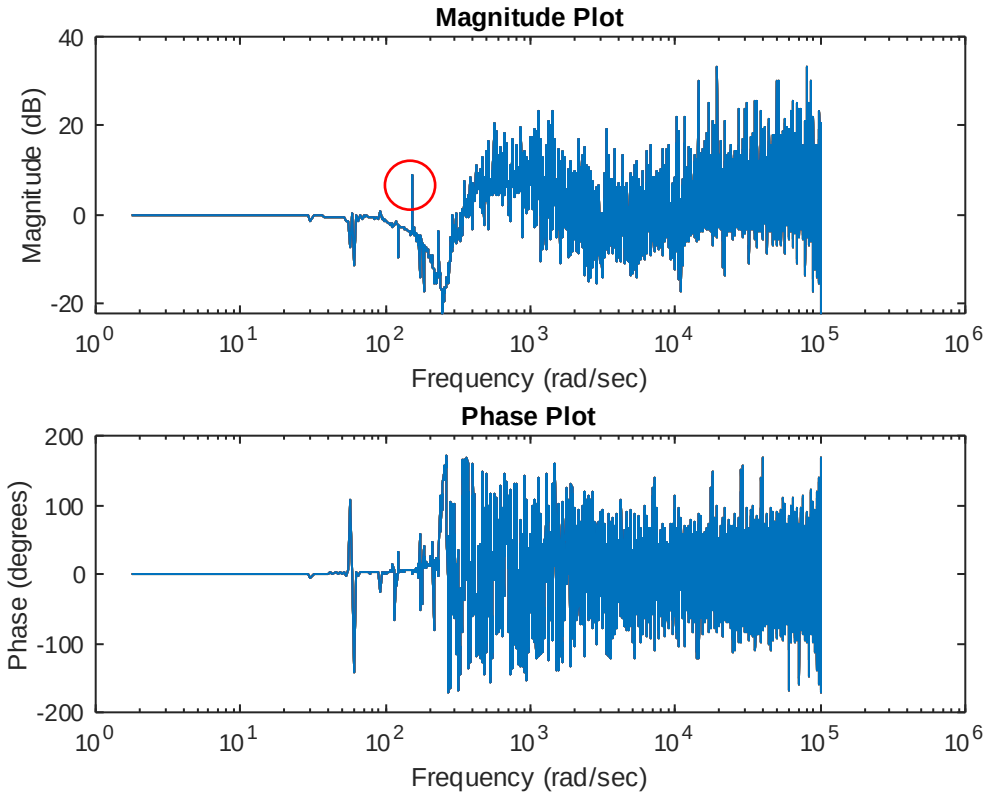


Bode Plot from mean of 15 runs

Data Collection

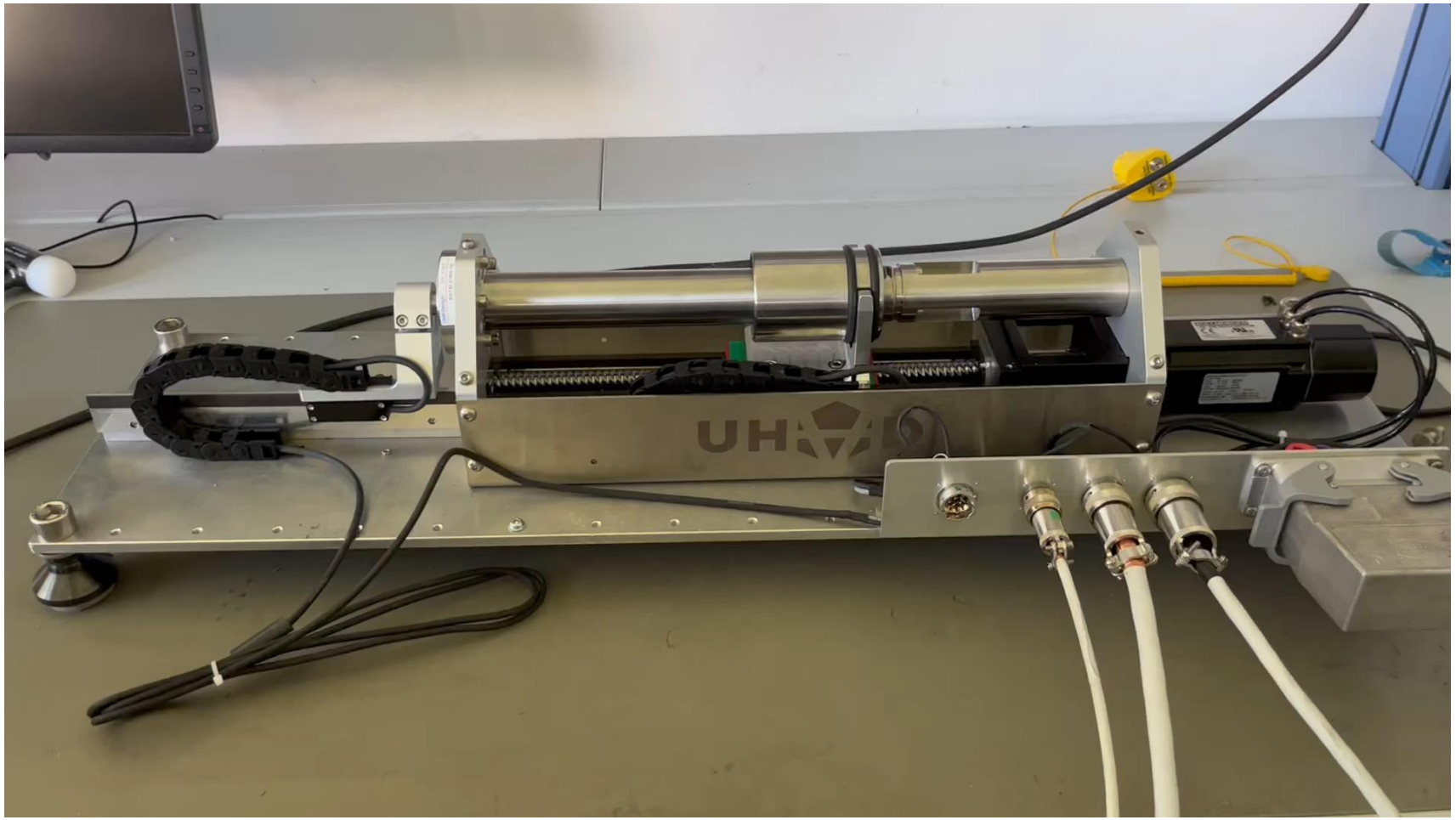


One sample run for 0.75 m/sec

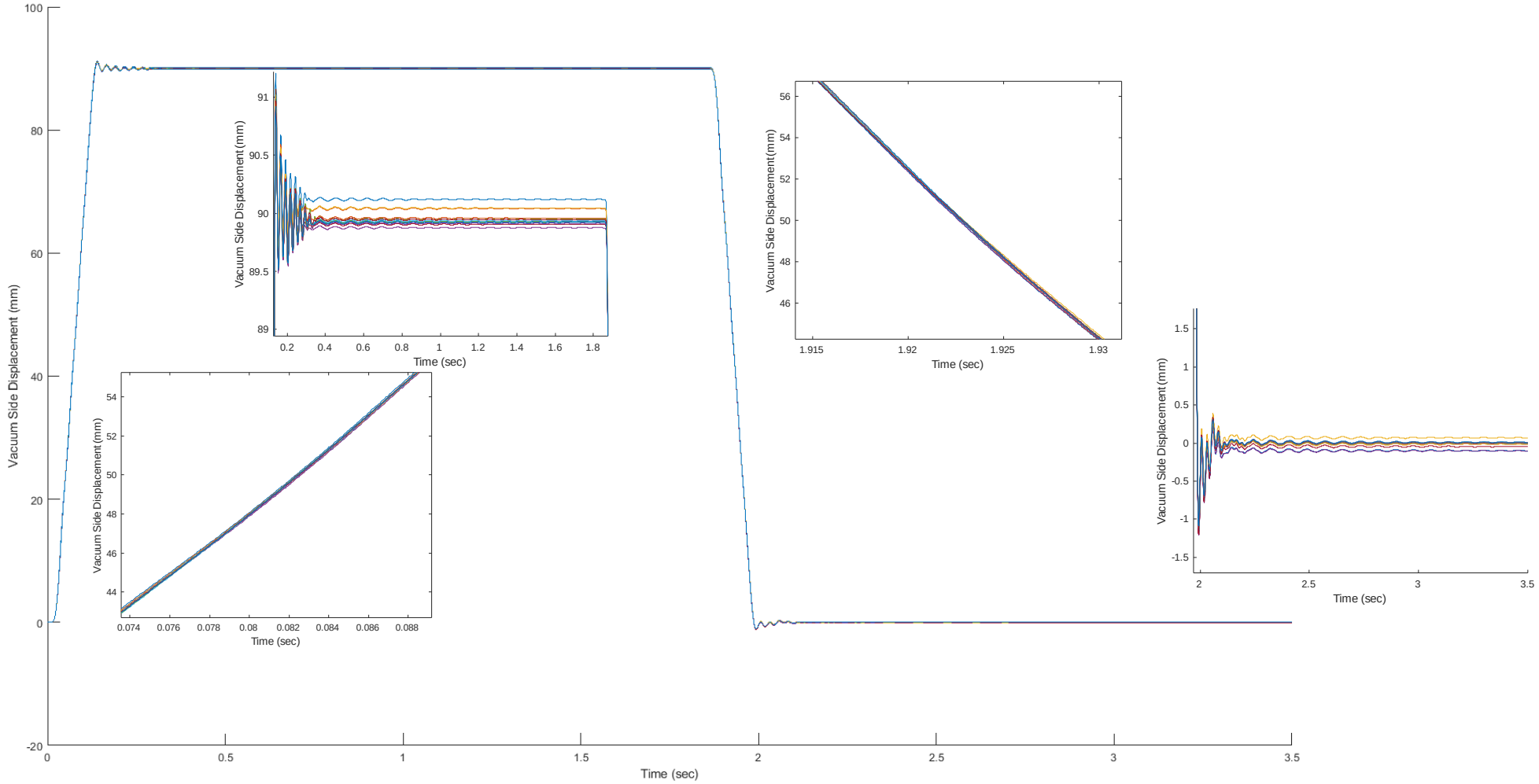


Bode Plot from mean of 15 runs

Motion at 1 m/s



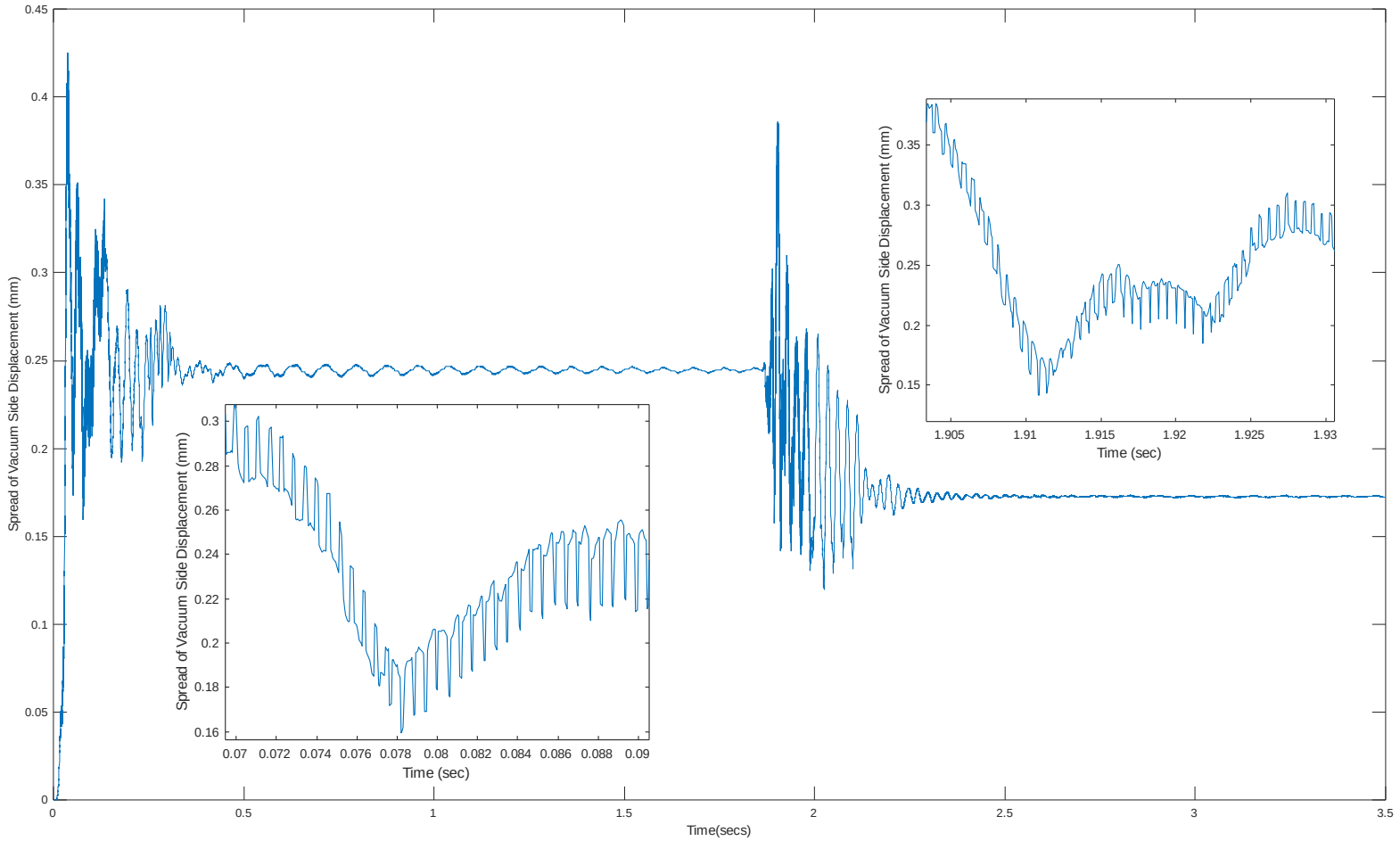
Reproducibility Analysis

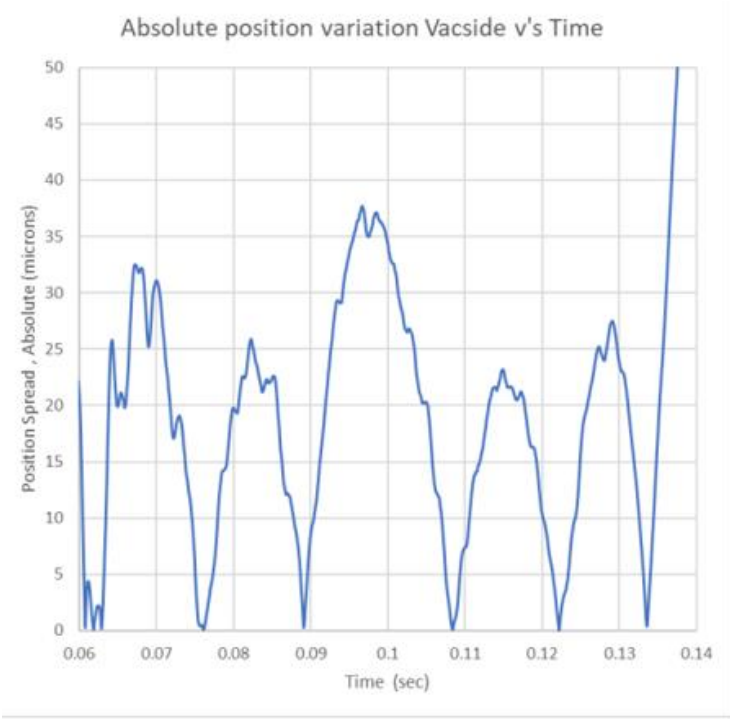


Vacuum Side Displacements
From data collected at 0.75 m/sec over 15 runs

Reproducibility Analysis

Max(Vacuum Side Displacement) - Min (Vacuum Side Displacement)





Absolute positional variation over 5 cycles during ~1m/sec phase

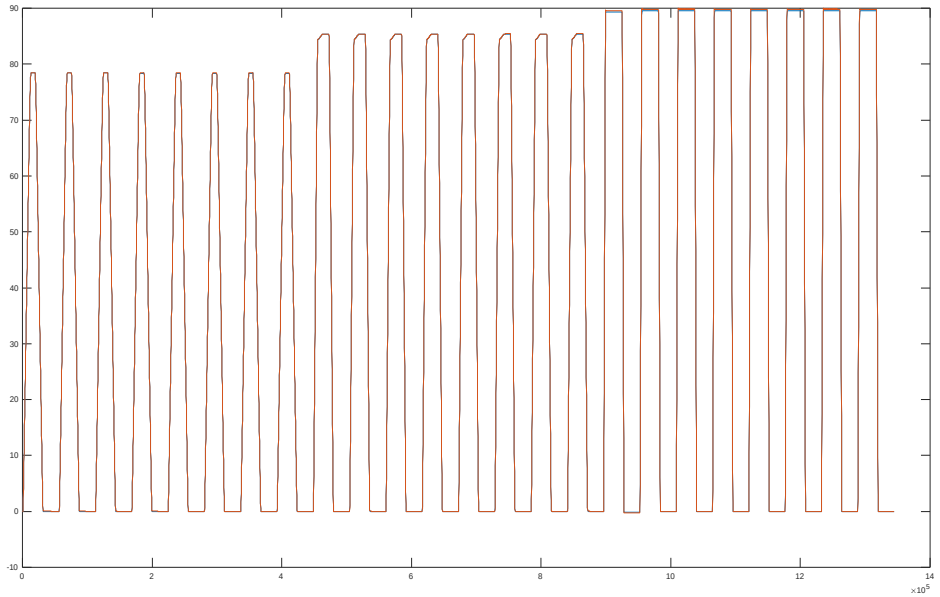
From NPL and UHVD

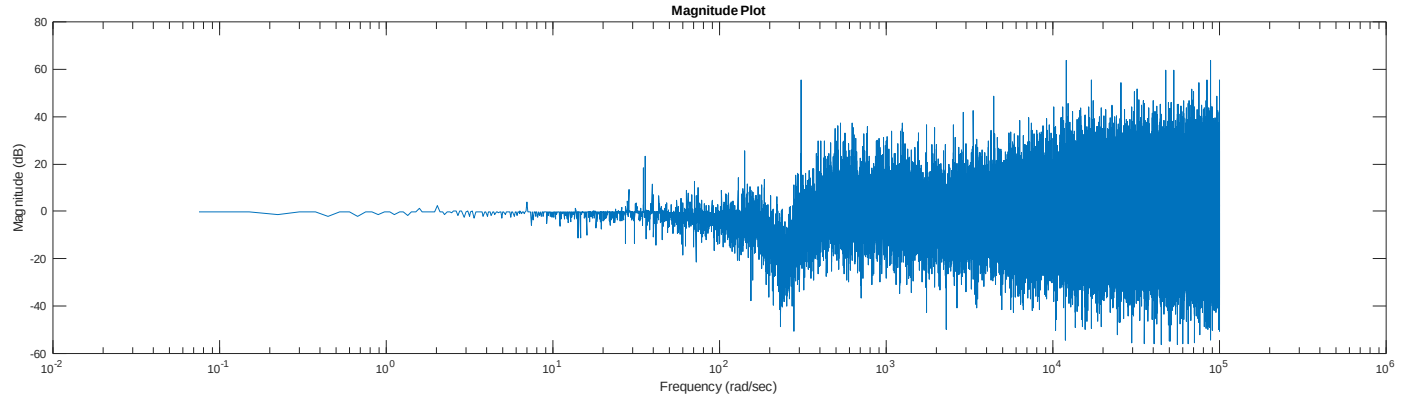
From data collected at 0.75 m/sec over 15 runs, Mean = 212.6 microns

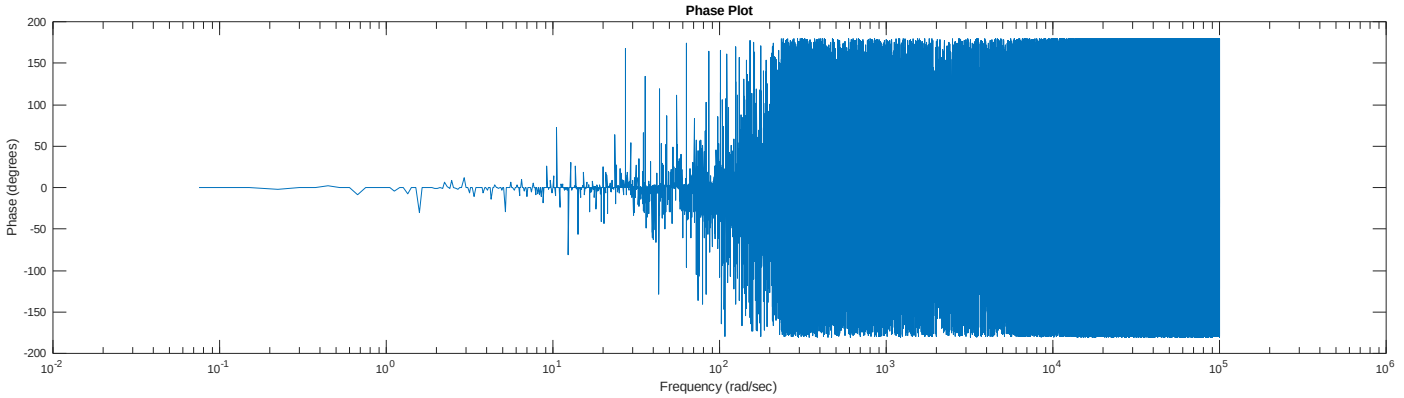
System Identification

- Combined data from all speeds and used it for identification
- For ARX Identification split into 80% for identification and 20% for validation

Data used for identification

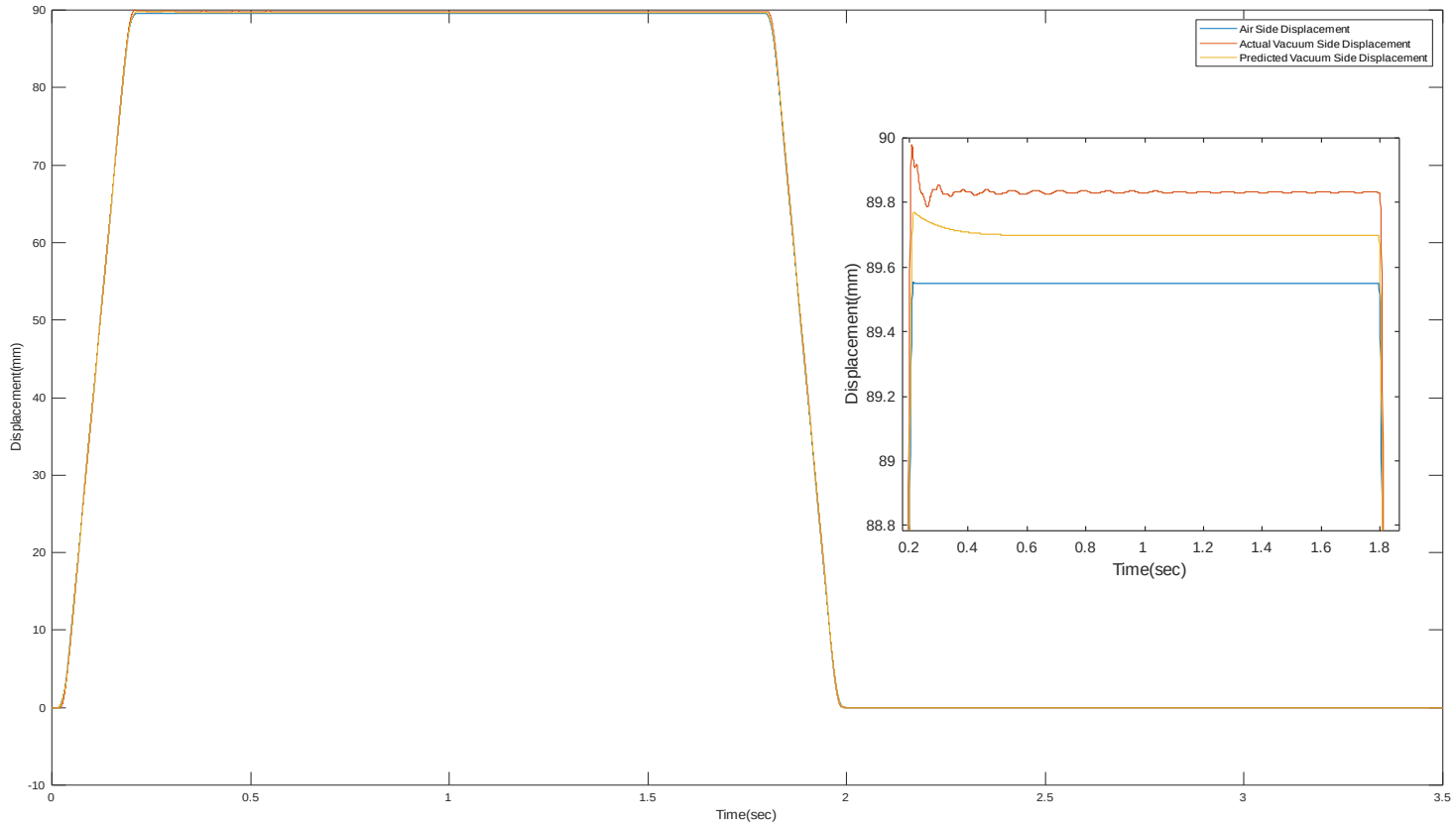


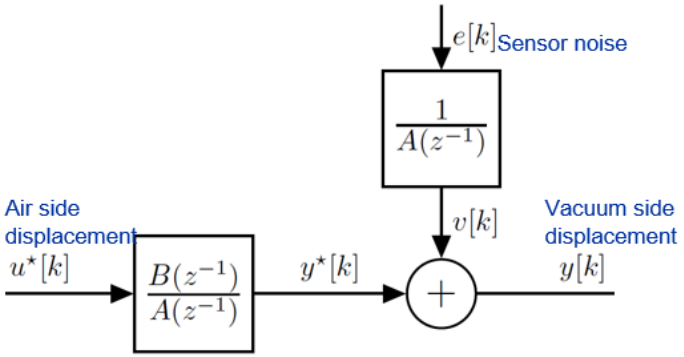




ARX Identification

- Tried out 45 different model structures until order 10
- Evaluated the models using the validation data and the structure (9,7) had the lowest MSE



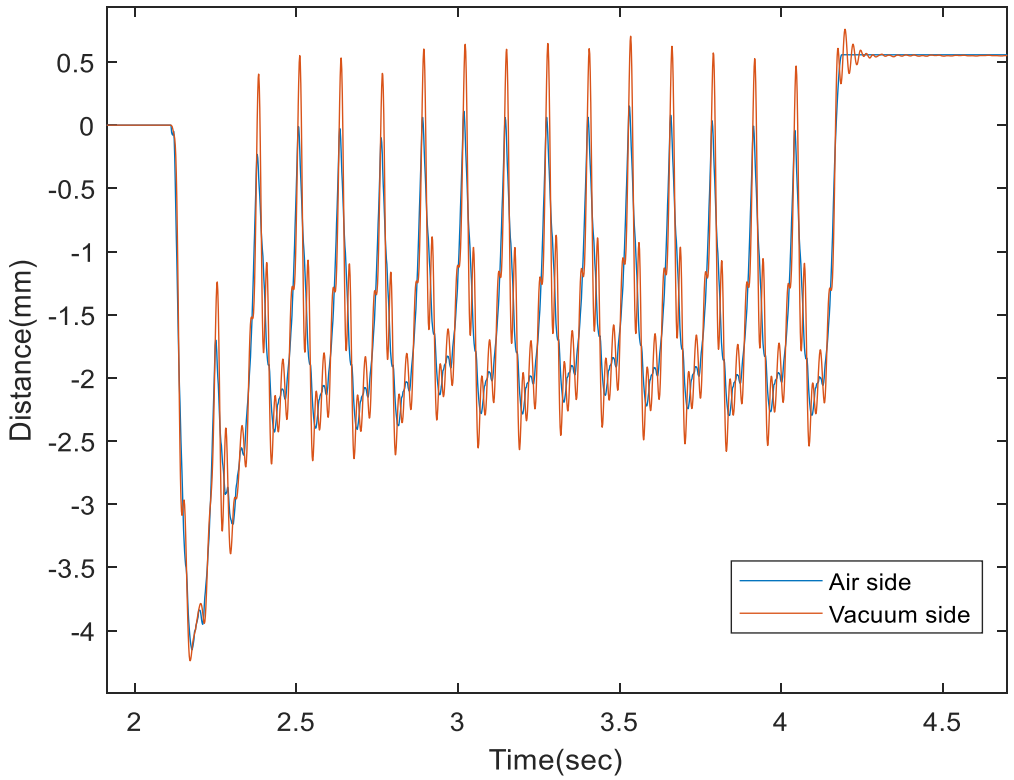


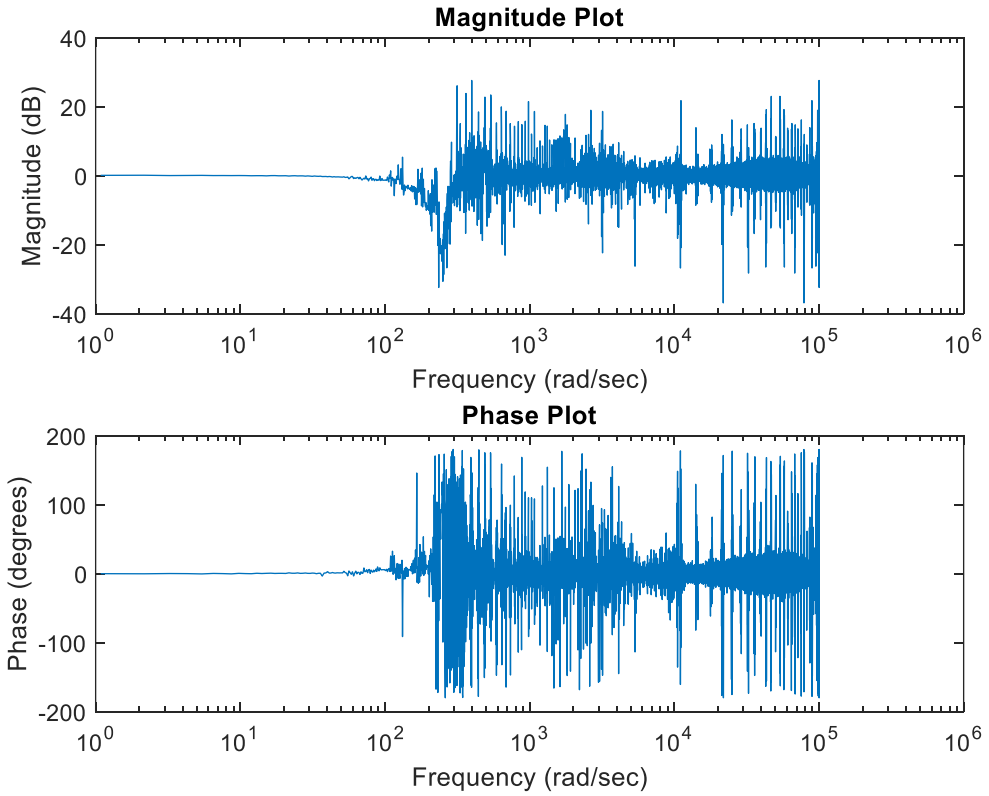
ARX Model Structure

System Identification

- PRBS Input on the current for identification

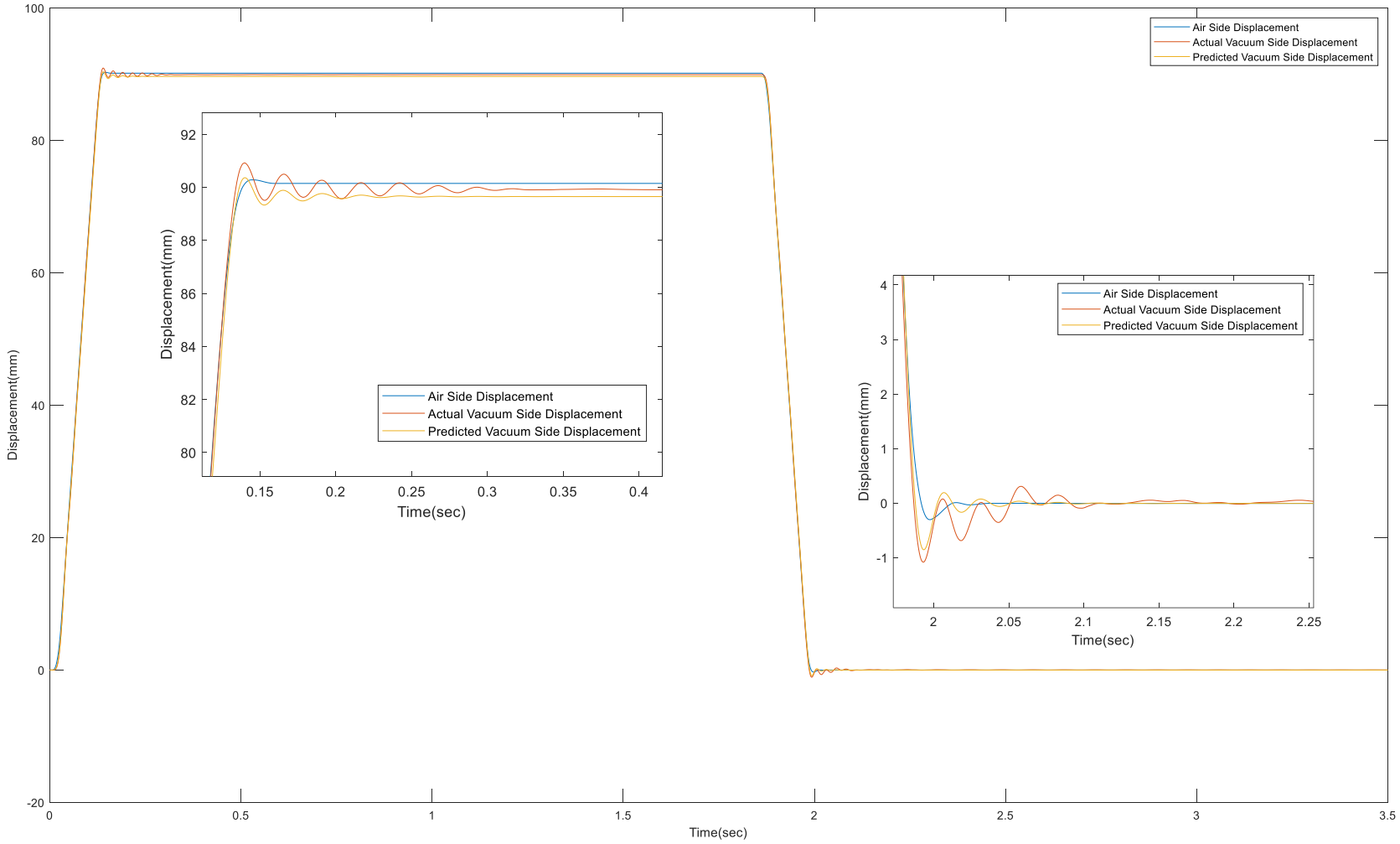
Data used for identification





ARX Identification

- Evaluated the models using the validation data and the structure (6,5) had the lowest MSE



Outlook

- Goal: Operate at different speeds and obtain corresponding measurements

  Next Step: Would need help to fix the Vacuum side encoder to obtain reliable measurements at 1 m/s

- Goal: Study the reproducibility of encoder measurements

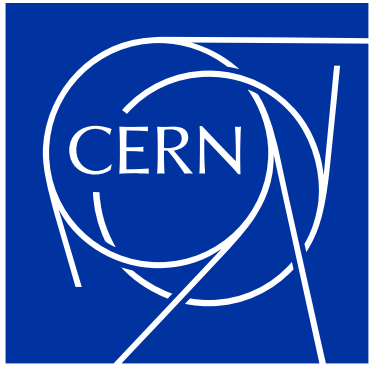
  Next Step : Preliminary studies indicate a higher spread; Design trajectories that ensure reproducibility

- Goal: Understand the relationship between the Air Side Displacement and Vacuum Side Displacement

  Next Step : Trying out using a larger dataset and validation data

- Goal: Identify the resonant frequency to minimize vibrations

  Next Step: Run experiments using signals at the specific frequency range



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