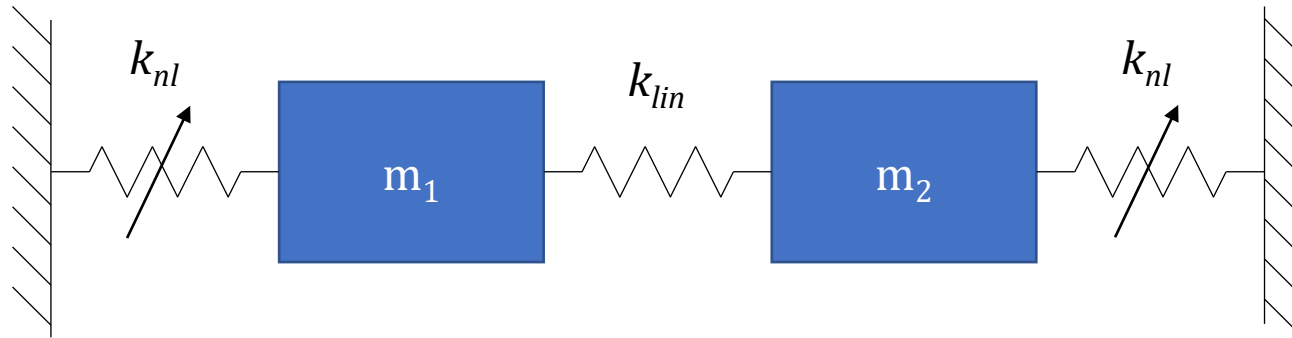


RMS AND PSD PLOTS FOR 2DOF SYSTEM

Problem Setup

We have a 2DOF system as diagramed here.



k_{nl} is the bilinear stiffness. Most results here assume the stiffer side of the bilinearity occurs on the extension of the spring.

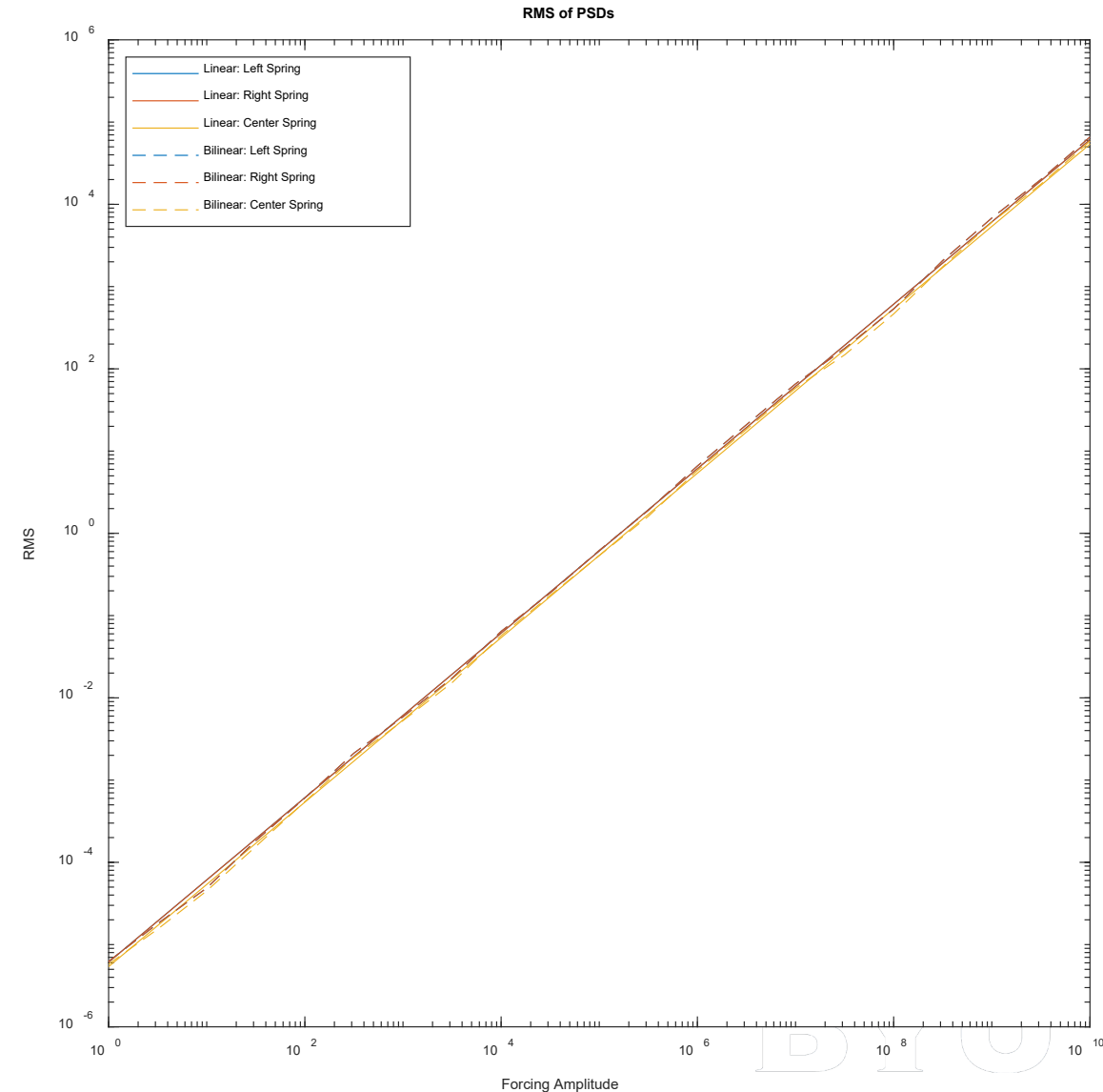
Calculation Assumptions

- Damping is mass proportional with $\zeta_1 = \zeta_2 = 0.00088$.
- $\omega_1 = 100$ Hz
- $\omega_2 = 200$ Hz
- $c = 0$
- $\alpha = 10$

Failure: RMS of Spring Displacements

The RMS values of the spring displacements when the bilinear system is subject to random forcing on each mass is shown here.

The bilinear RMS values fluctuate above and below the linear values, but they retain the same trend. The errors retain the general order of magnitude difference as well.

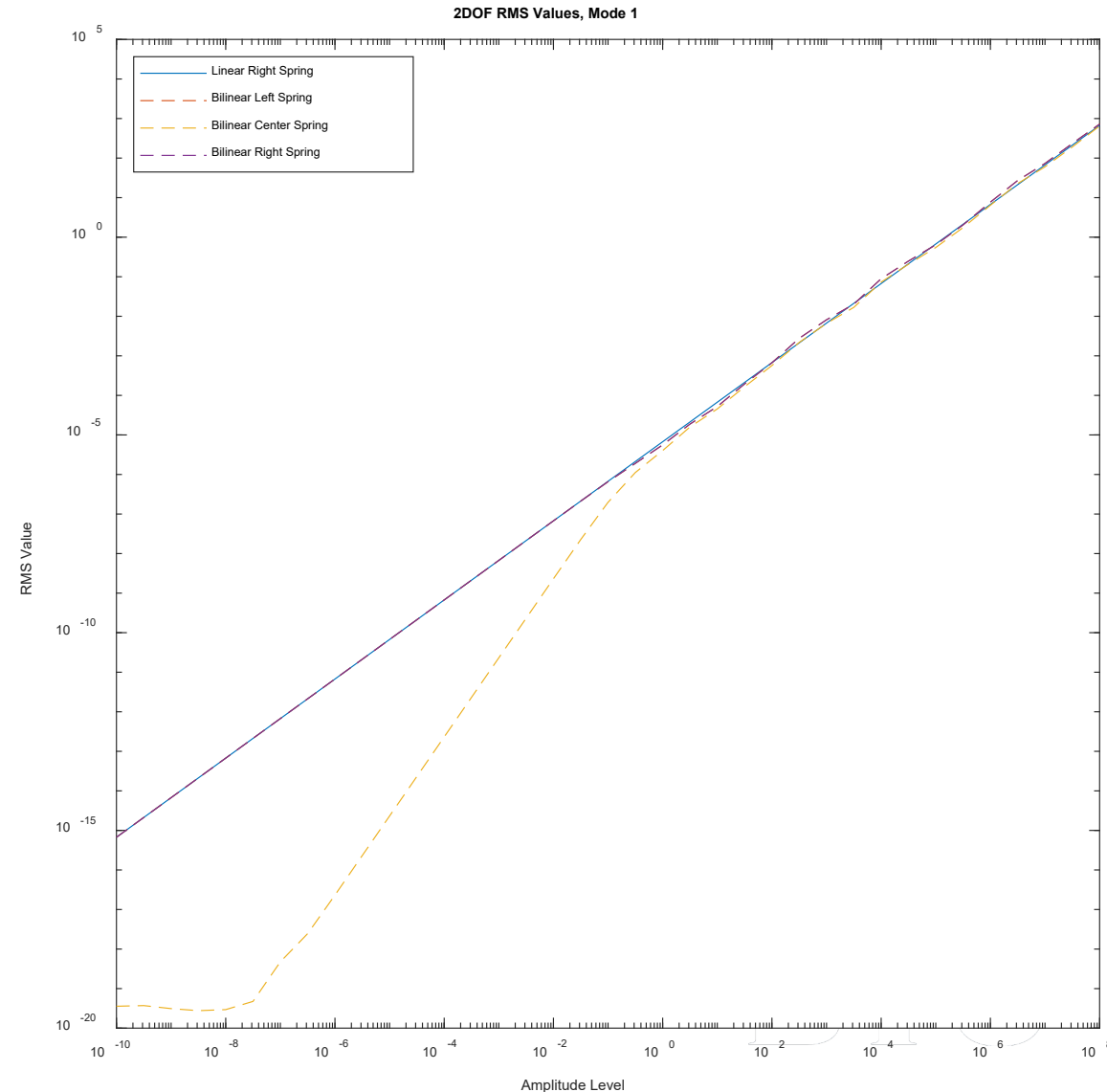


Failure: RMS of Spring Displacements

If the forcing is instead along modal coordinates then some differences appear.

This plot shows the displacement RMS for each spring with mode 1 forcing. The linear RMS for the center spring is not shown because it is zero.

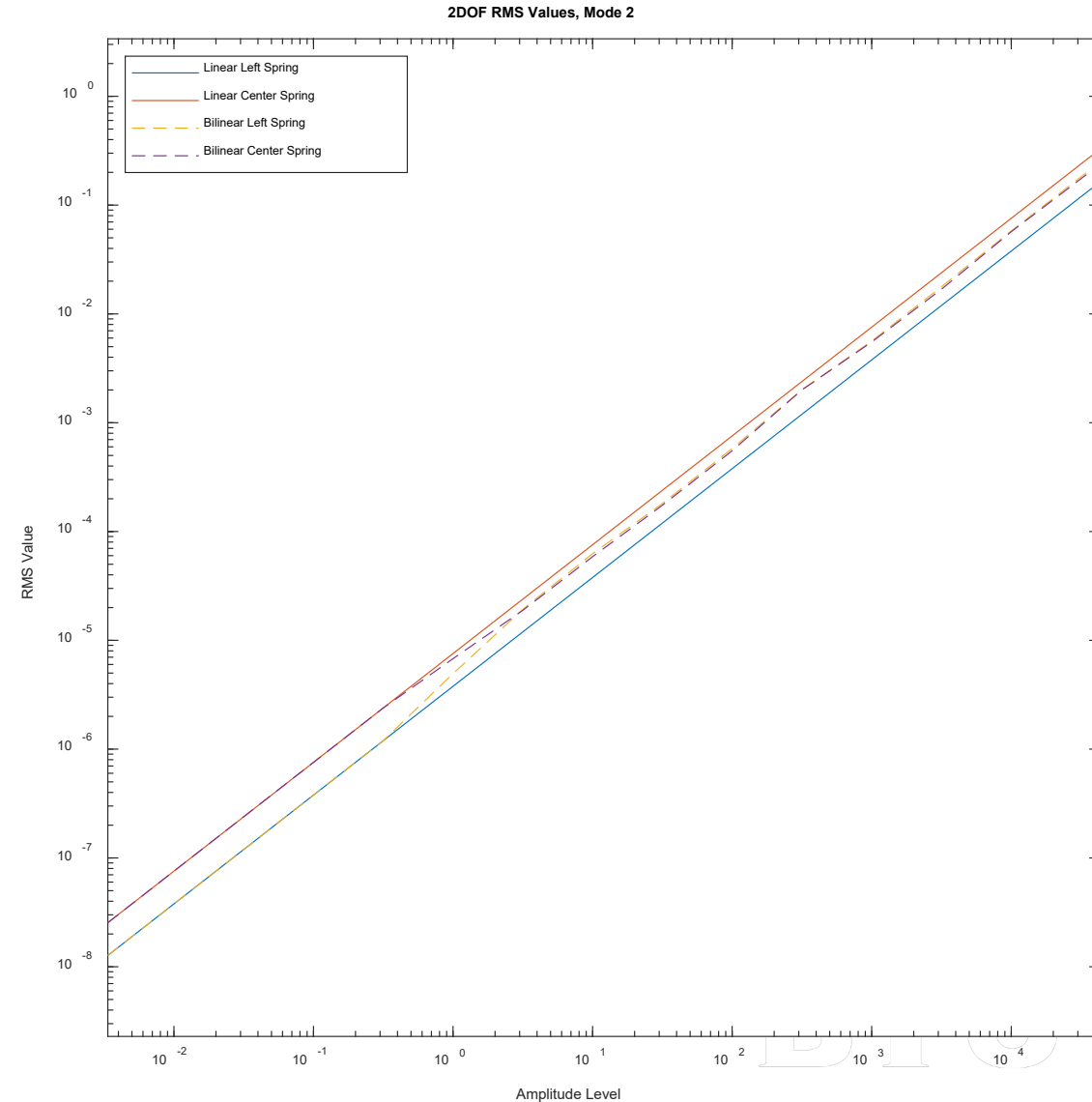
The center spring in the bilinear system starts with smaller values, but it rises to the level of the other springs.



Failure: RMS of Spring Displacements

Here the RMS value for mode 2 forcing are shown.

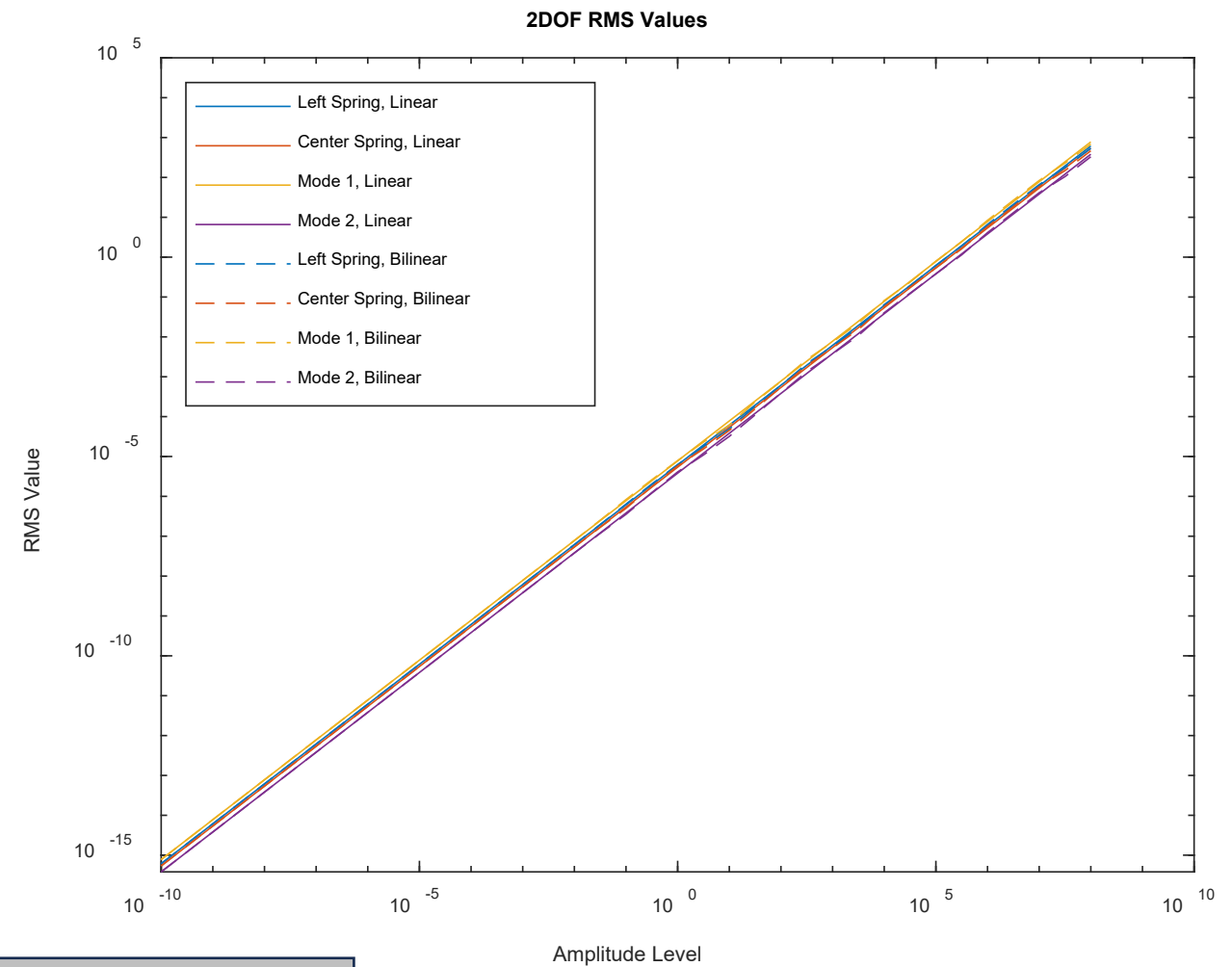
The linear case always shows the middle spring having the largest value. In the bilinear case, these two springs adjust to where they have roughly the same value, with some fluctuation.



Linear Systems

- If forced in mode shape, the response is in that mode shape.
- Each mode shape can be driven at any frequency.
- Random forcing at a given frequency can result in a response around the modal frequencies based which modal forcing FRF has the largest value.
- Do not depend on amplitude.

RMS Values



DOF

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

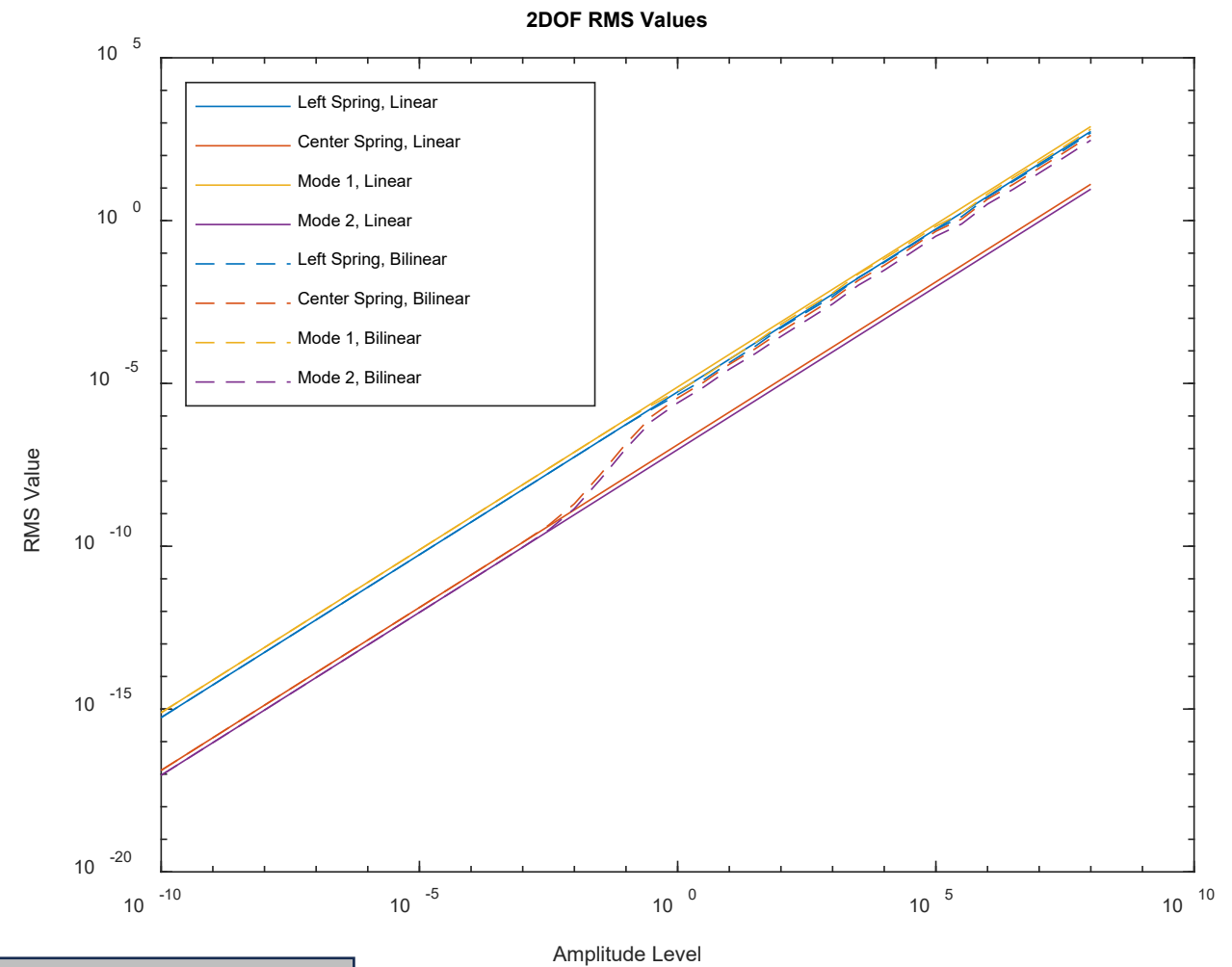
90-110

150-250

190-210

BYU

RMS Values



DOF

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

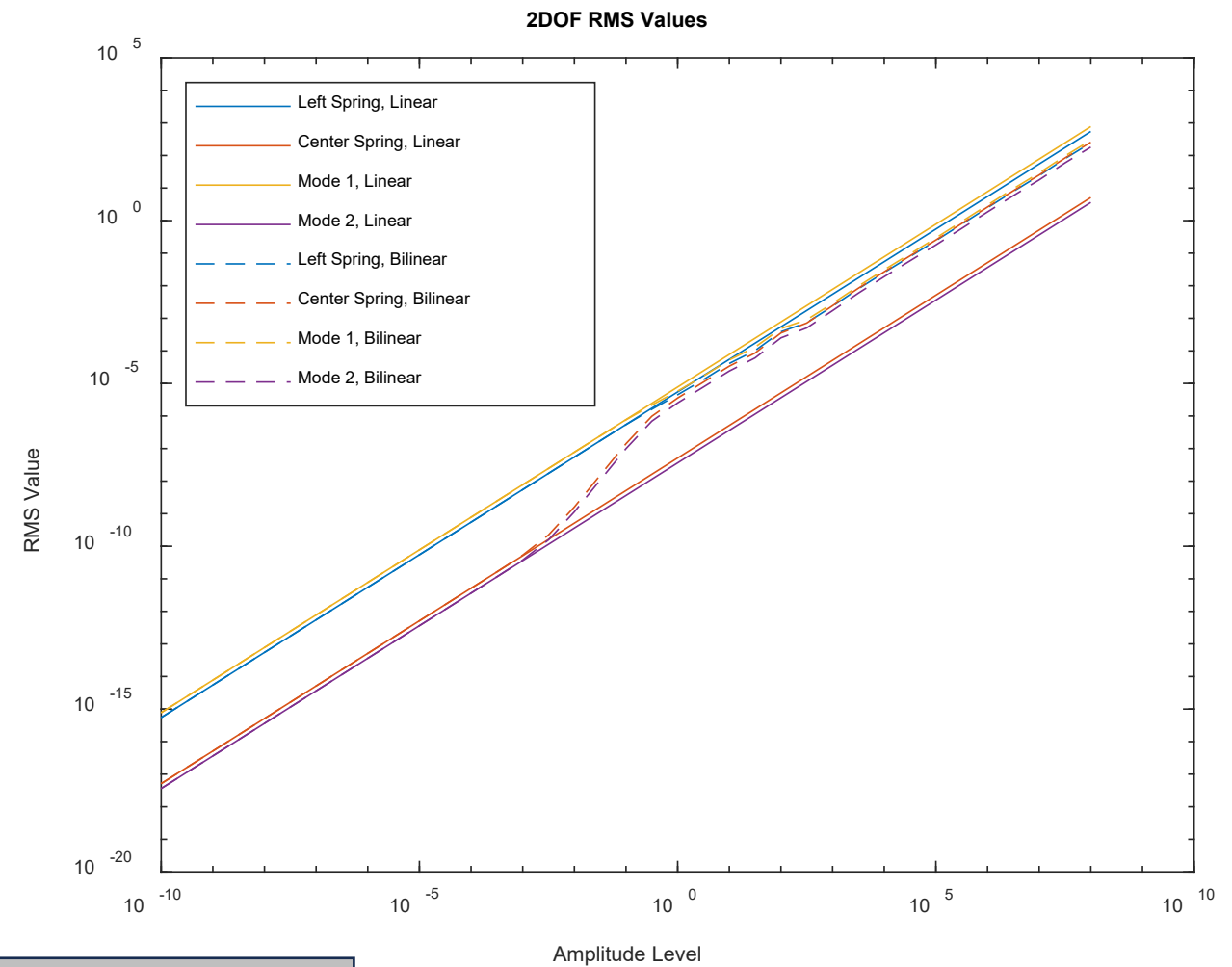
90-110

150-250

190-210

BYU

RMS Values



DOF

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

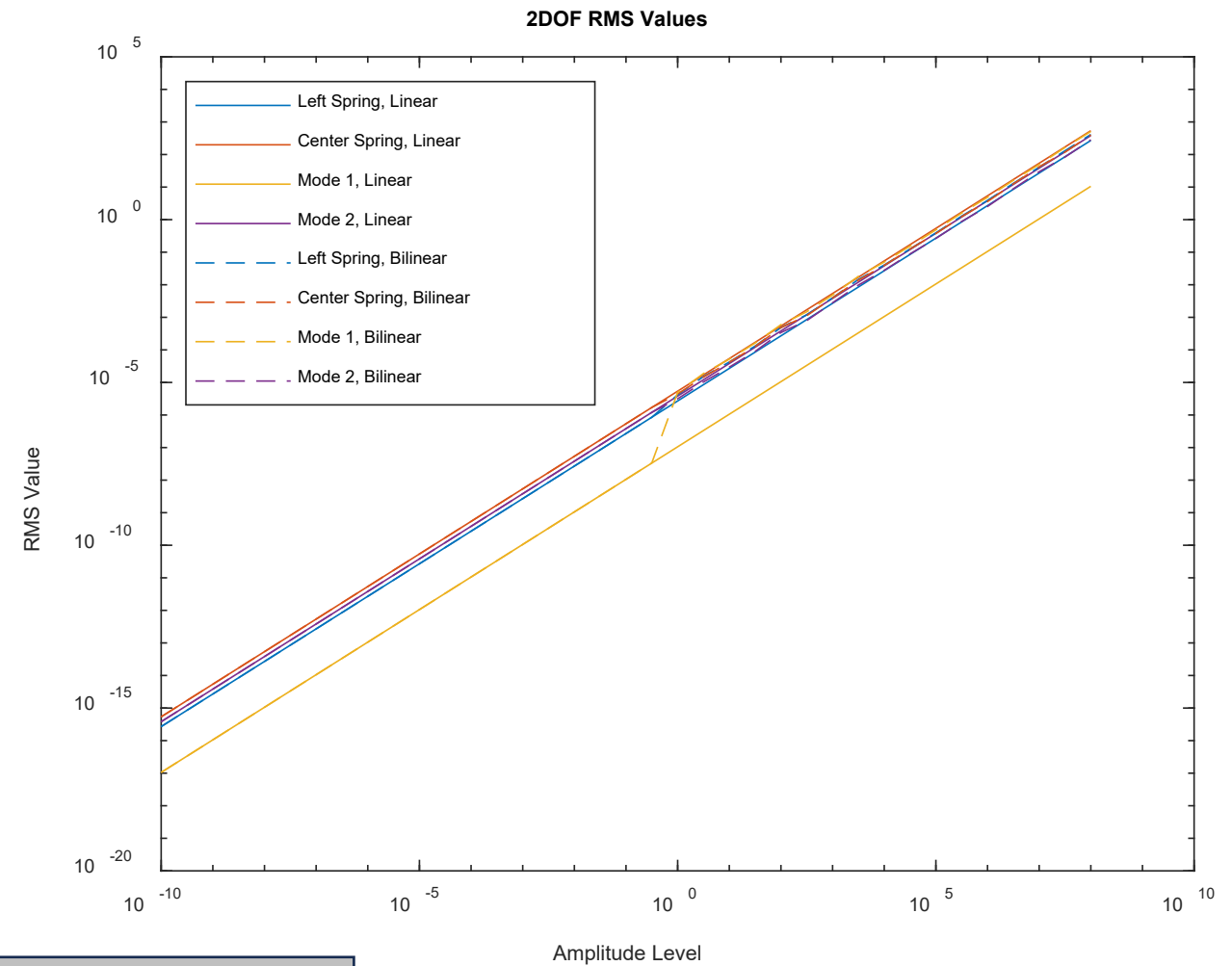
90-110

150-250

190-210

BYU

RMS Values



DOF

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

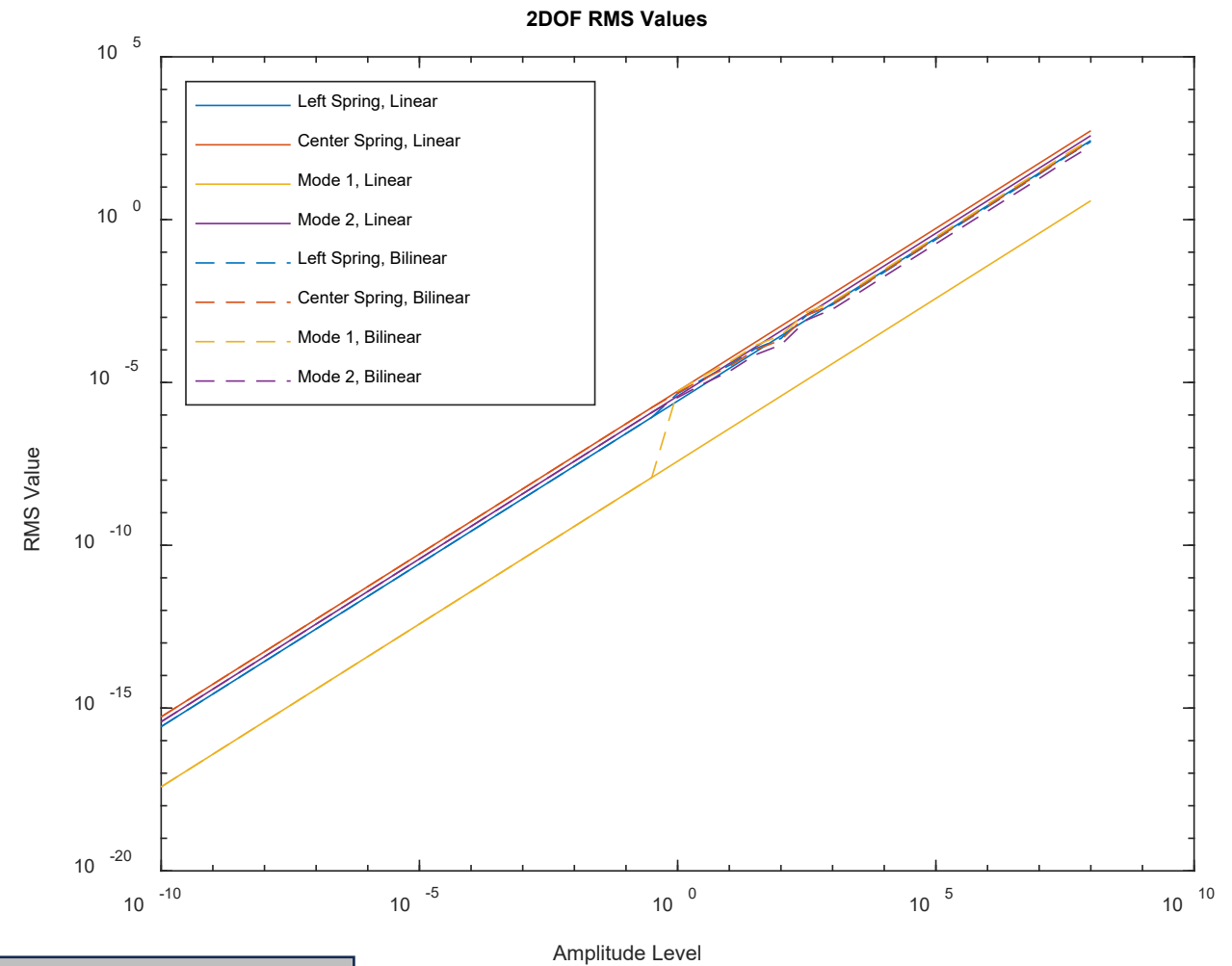
90-110

150-250

190-210

BYU

RMS Values



DOF

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

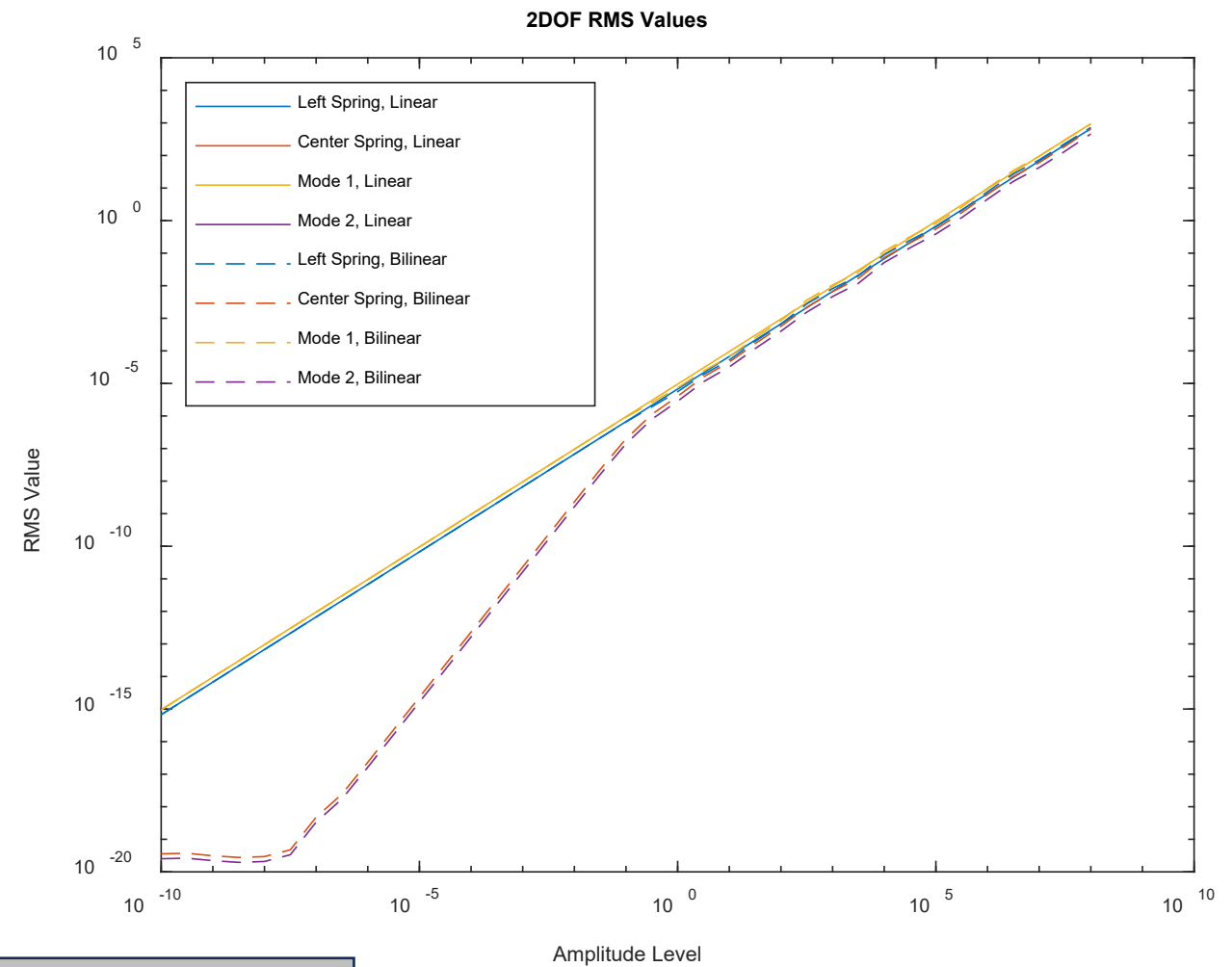
90-110

150-250

190-210

BYU

RMS Values



DOF

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

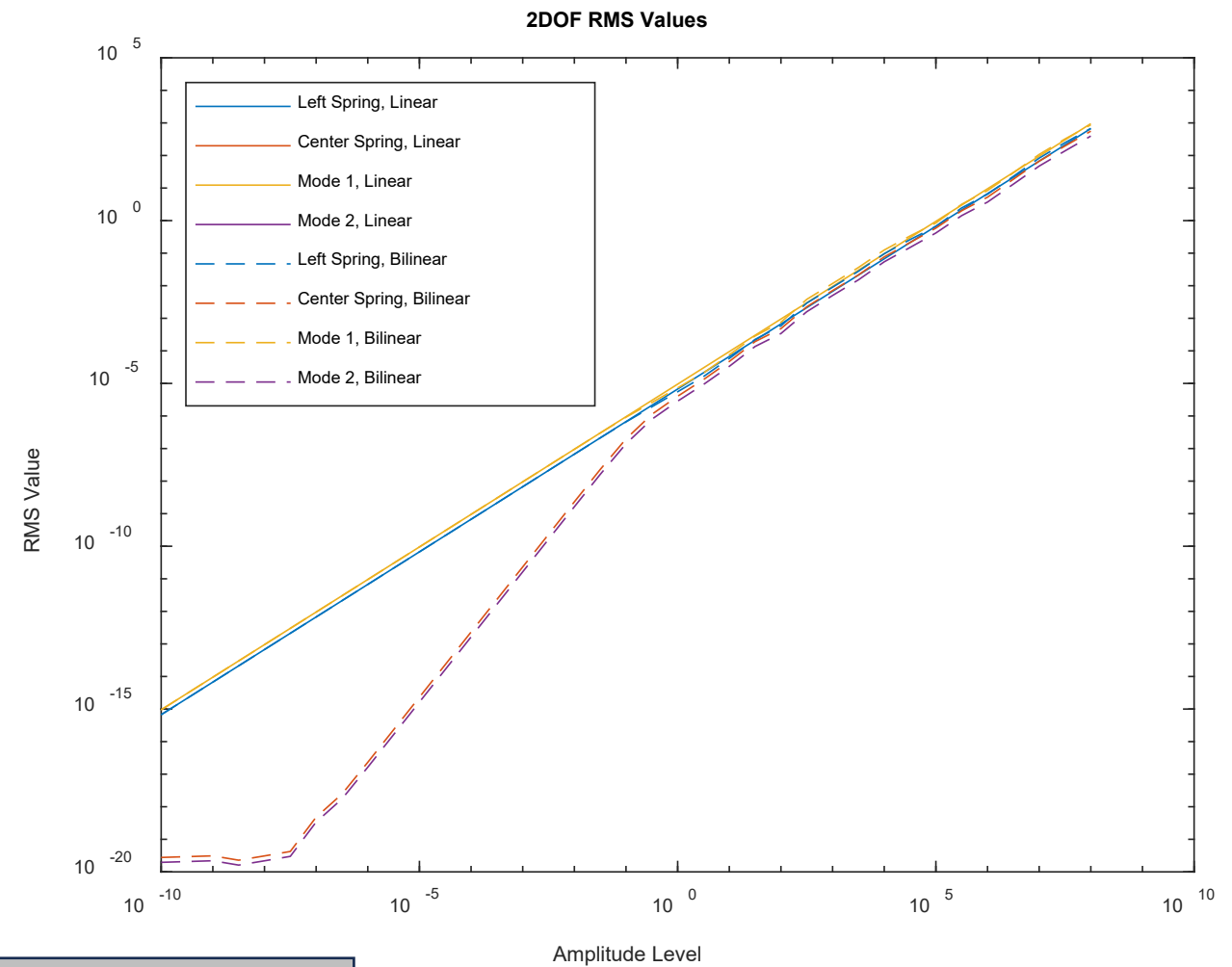
90-110

150-250

190-210

BYU

RMS Values



DOF

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

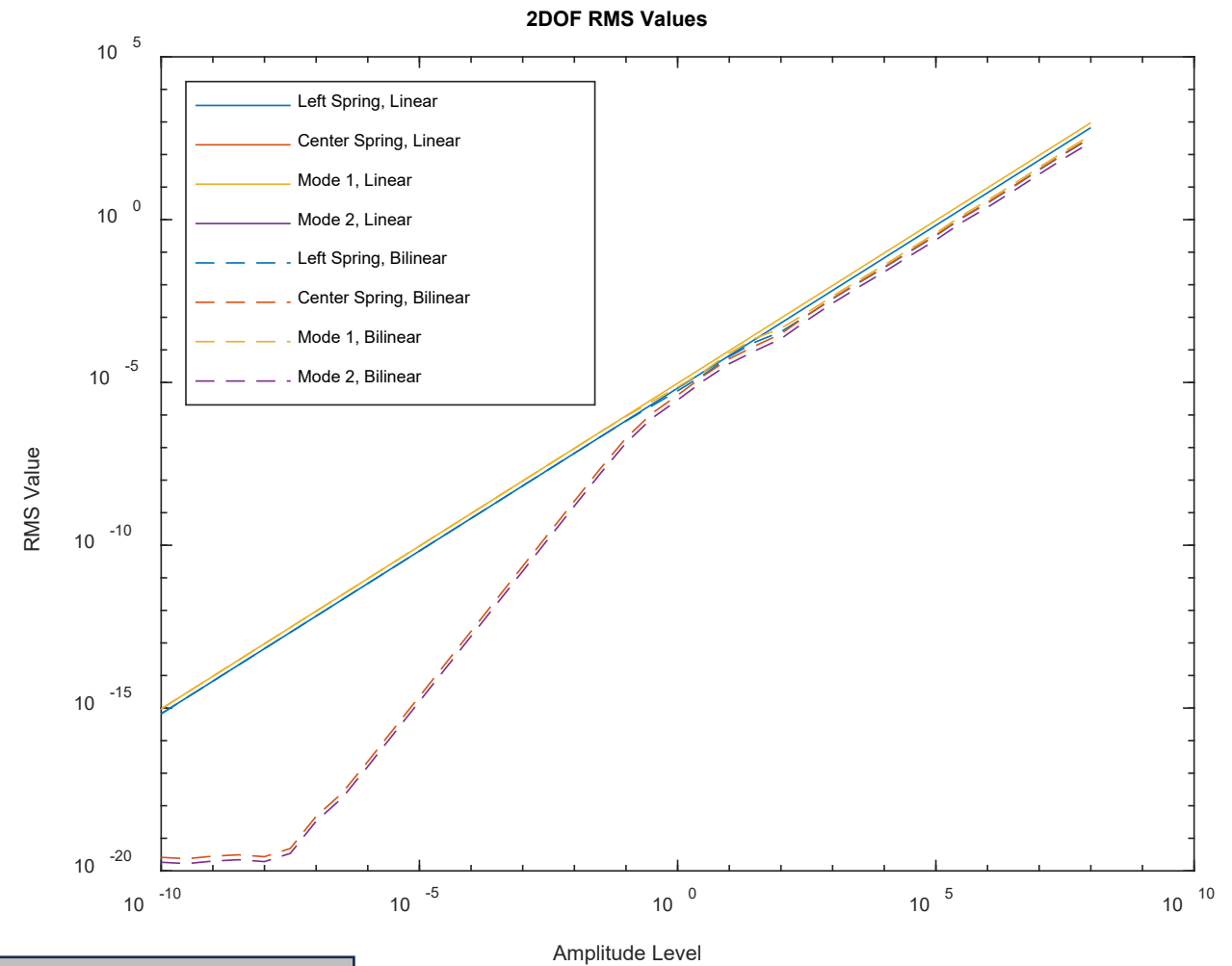
90-110

150-250

190-210

BYU

RMS Values



DOF

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

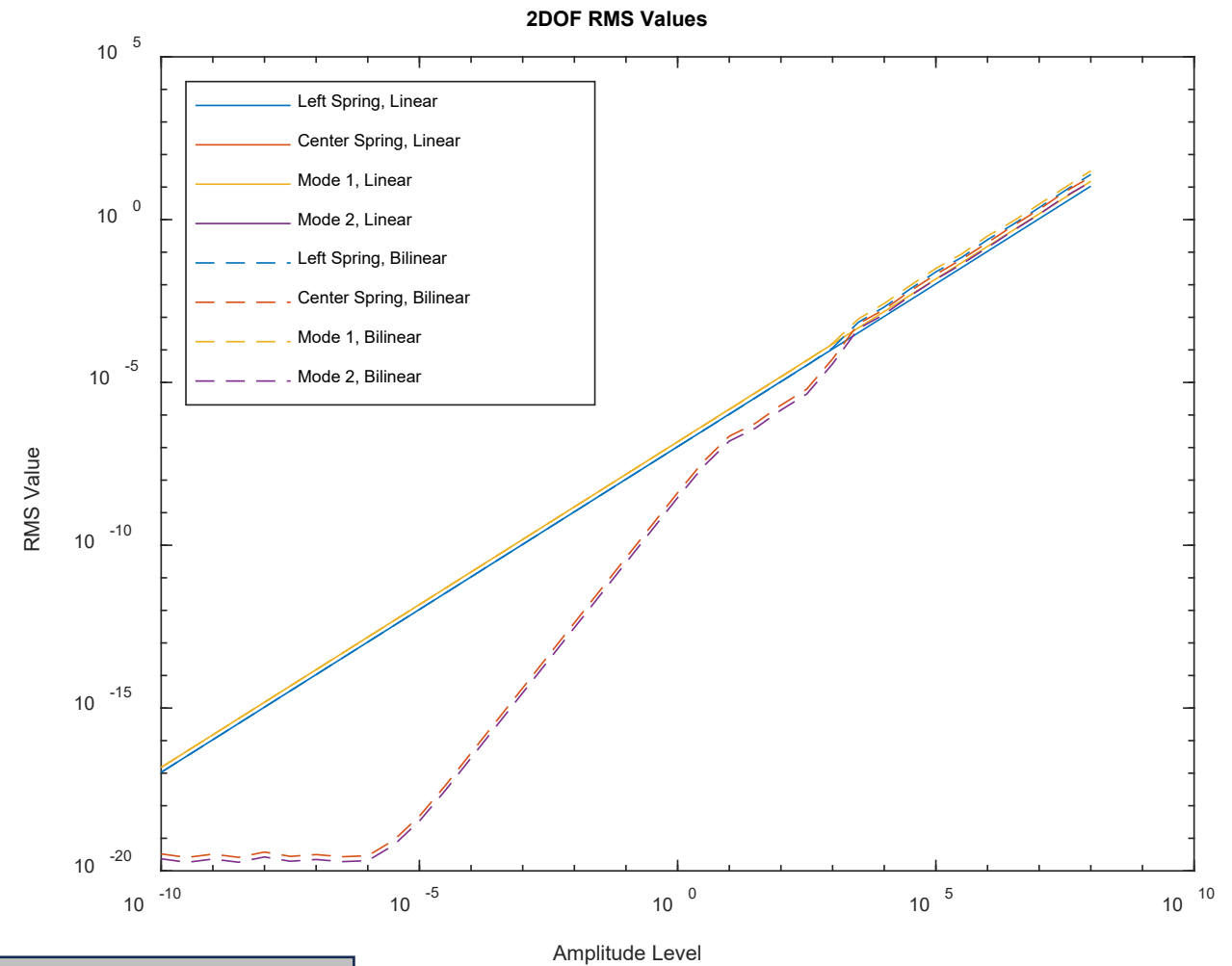
90-110

150-250

190-210

BYU

RMS Values



DOF

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

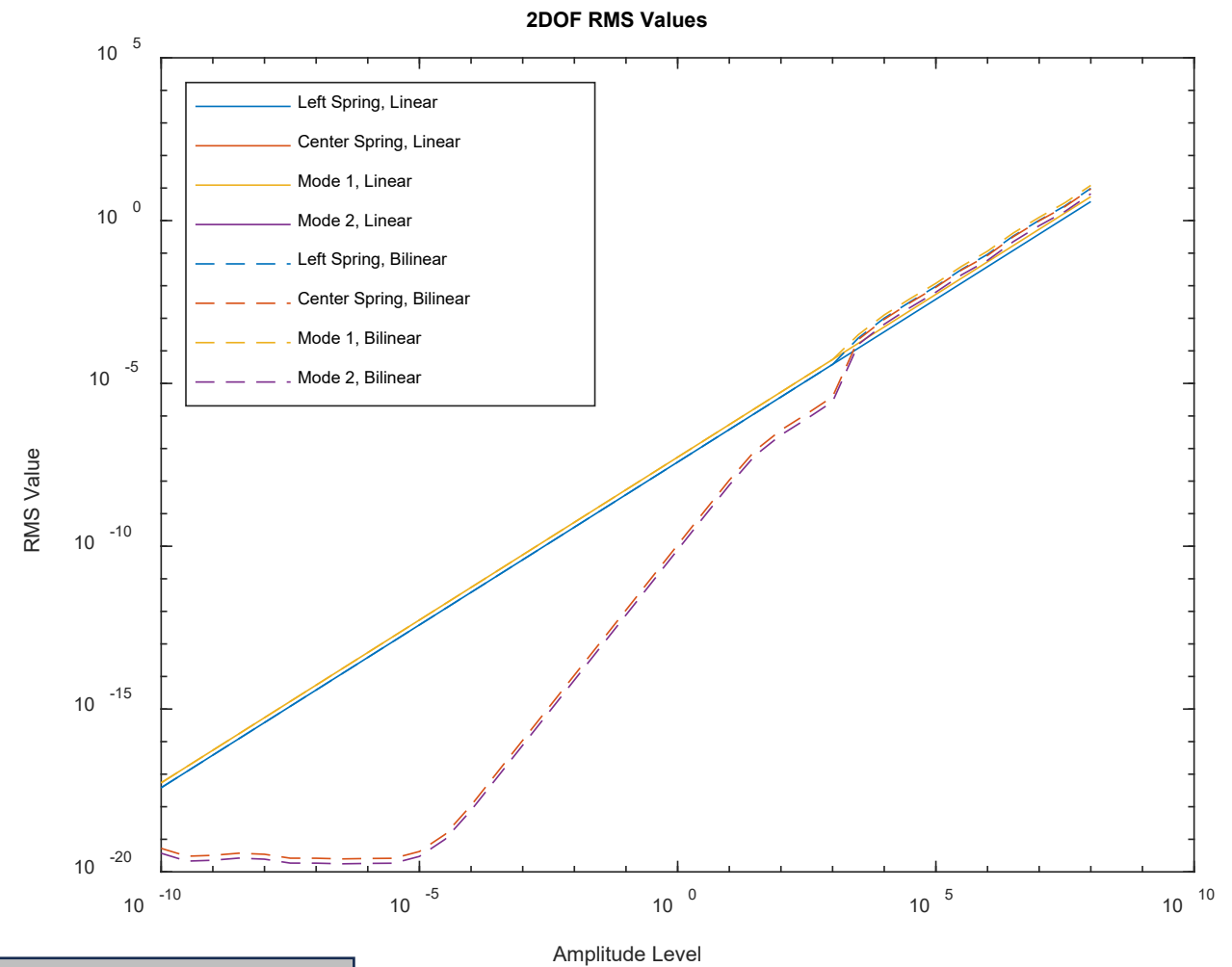
90-110

150-250

190-210

BYU

RMS Values



DOF

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

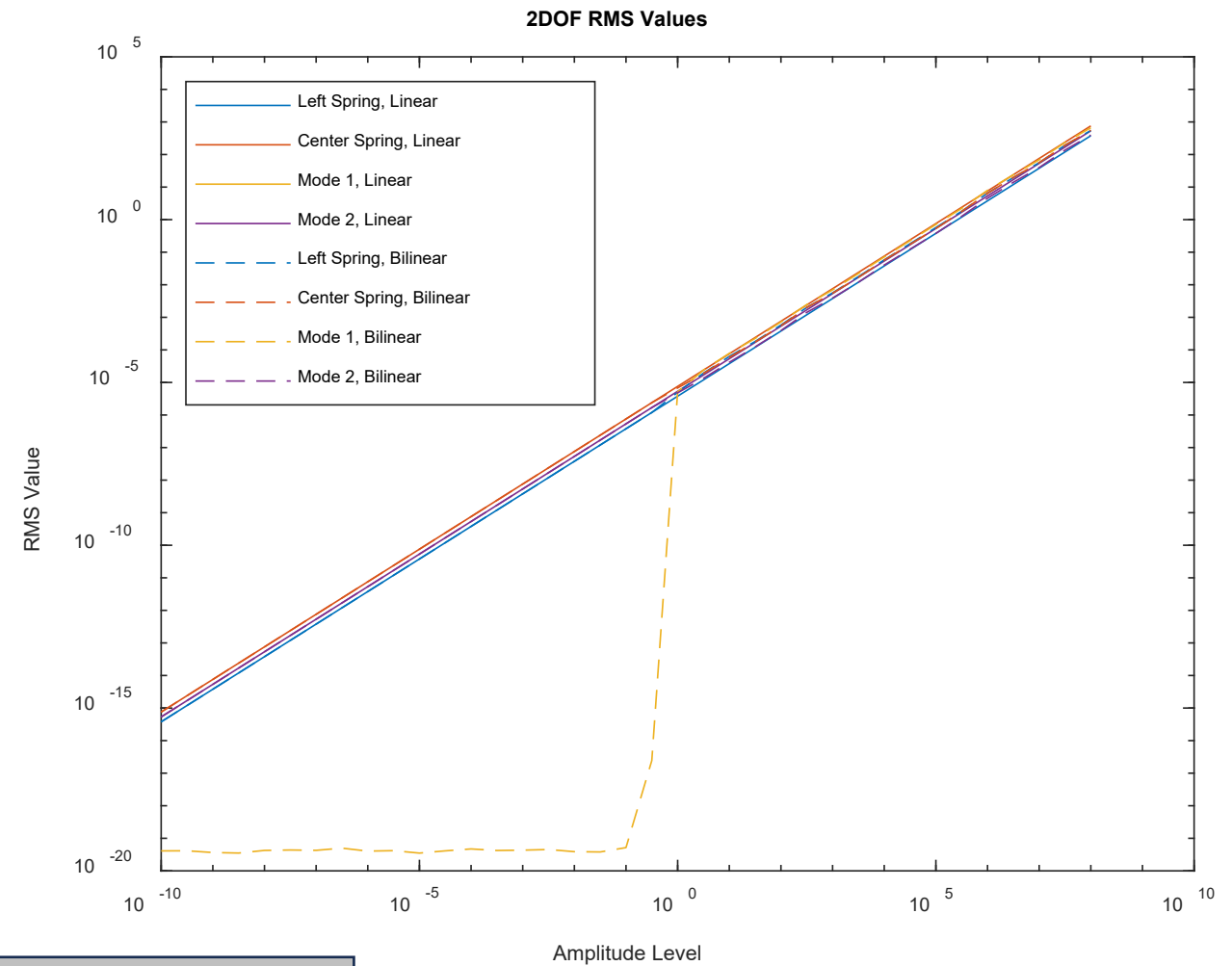
90-110

150-250

190-210

BYU

RMS Values



DOF

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

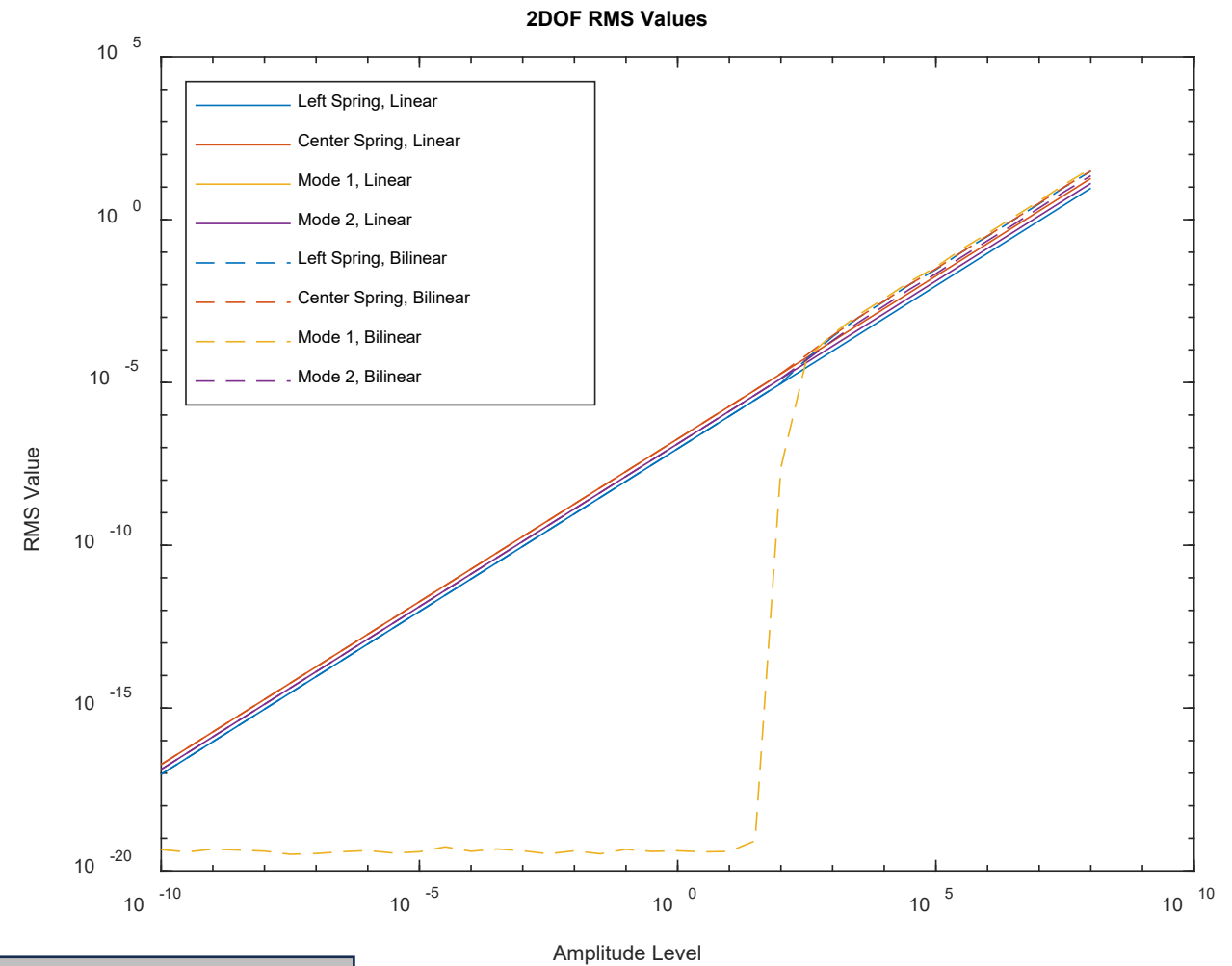
90-110

150-250

190-210

BYU

RMS Values



DOF

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

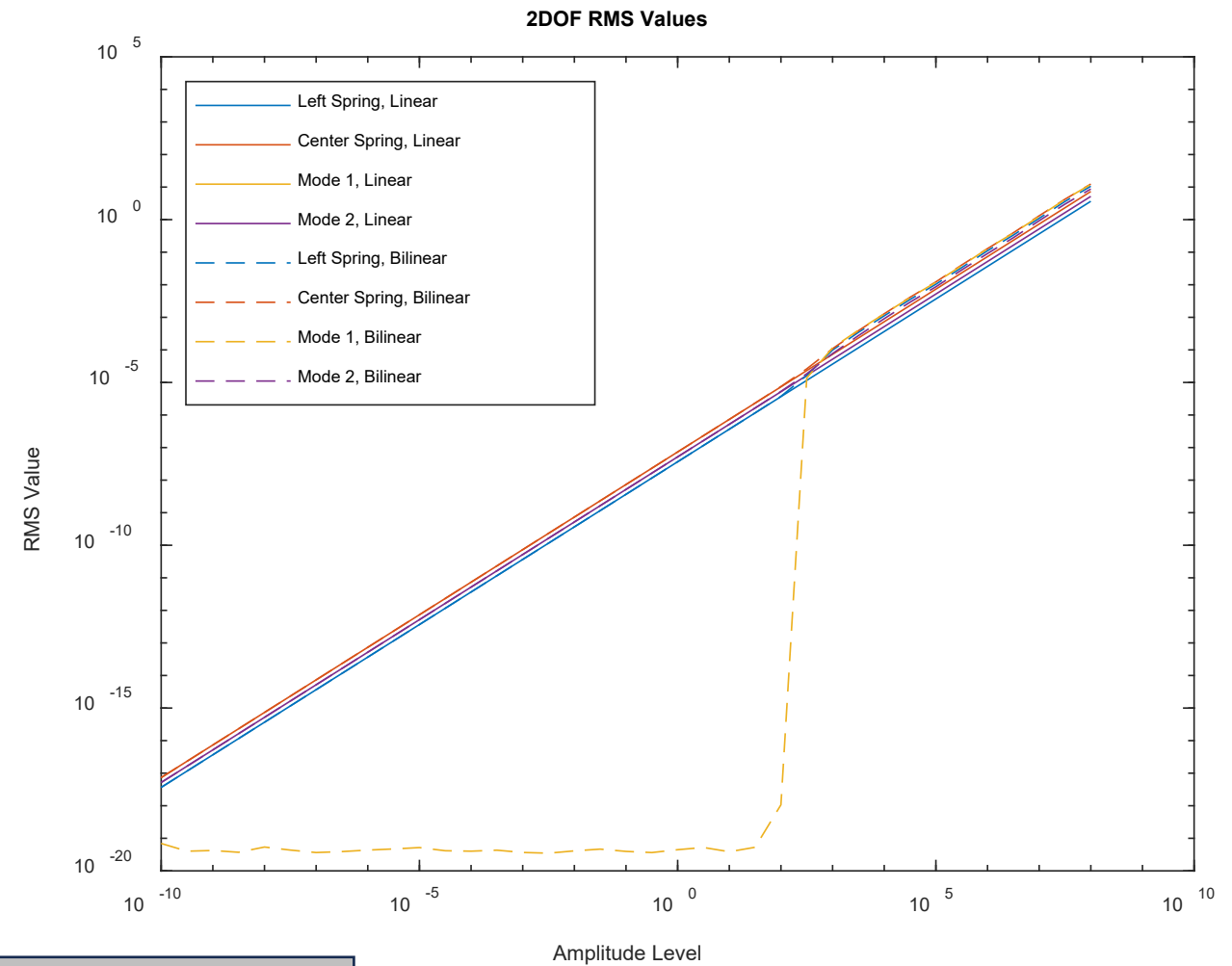
90-110

150-250

190-210

BYU

RMS Values



DOF

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

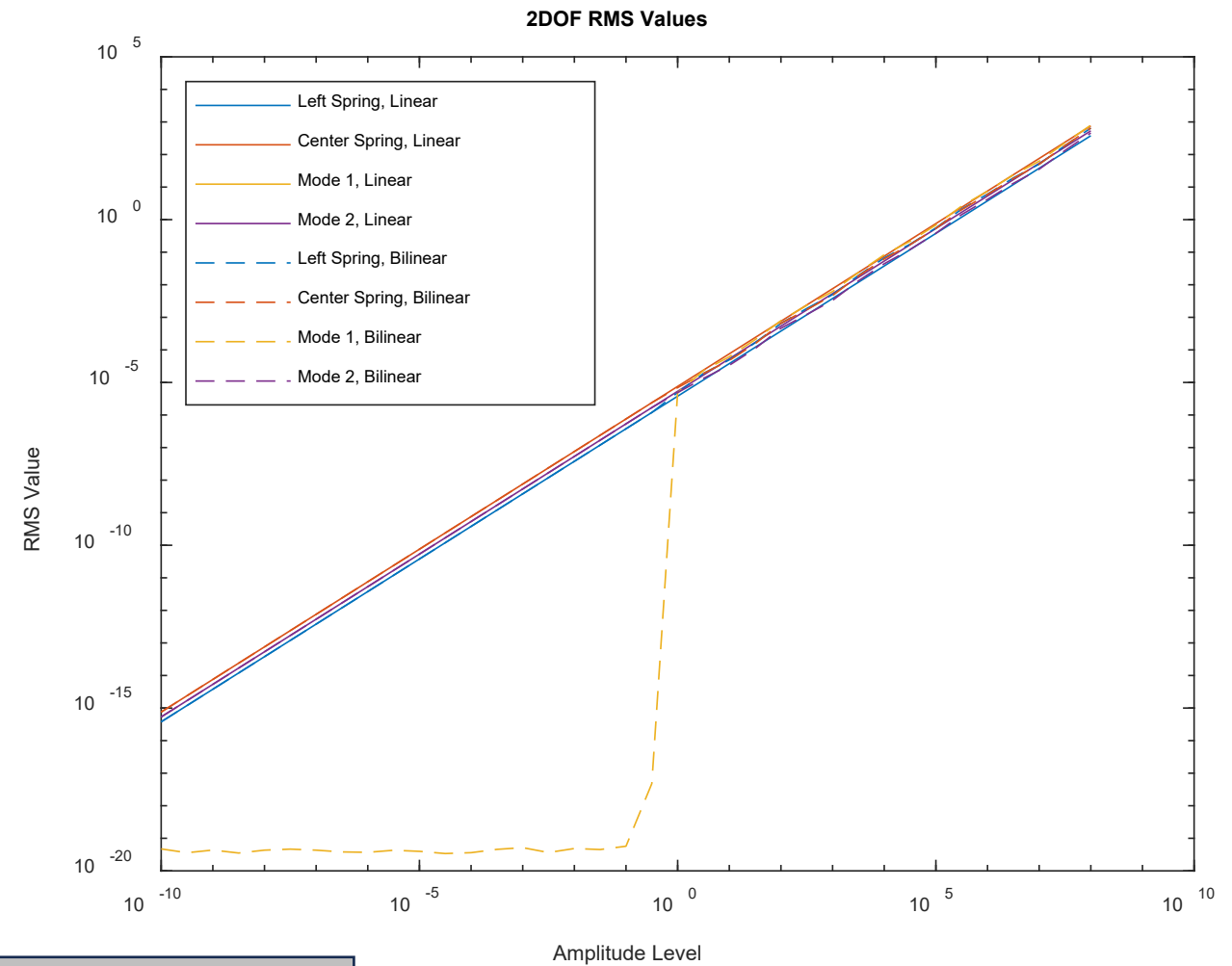
90-110

150-250

190-210

BYU

RMS Values



DOF

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

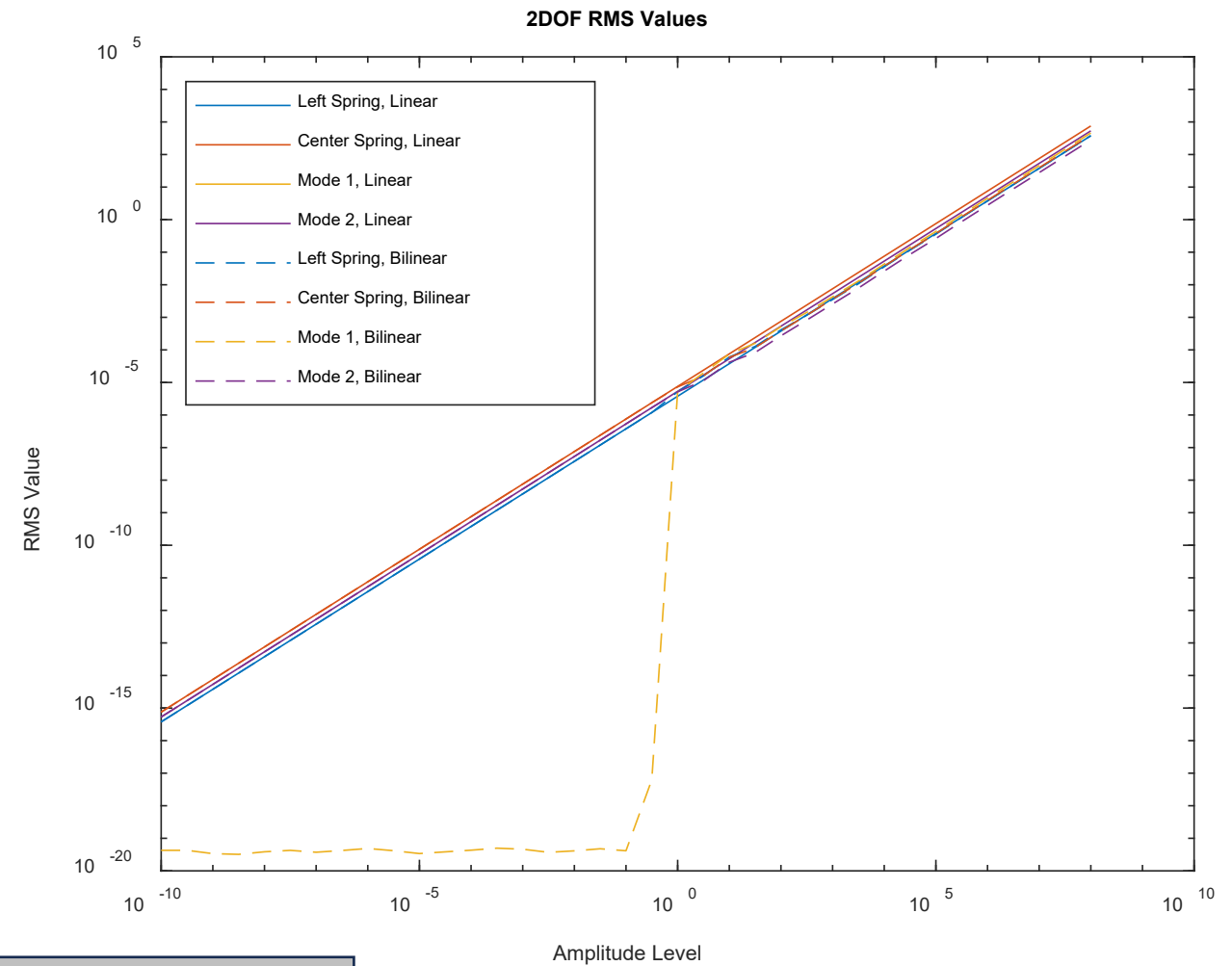
90-110

150-250

190-210

BYU

RMS Values



DOF

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

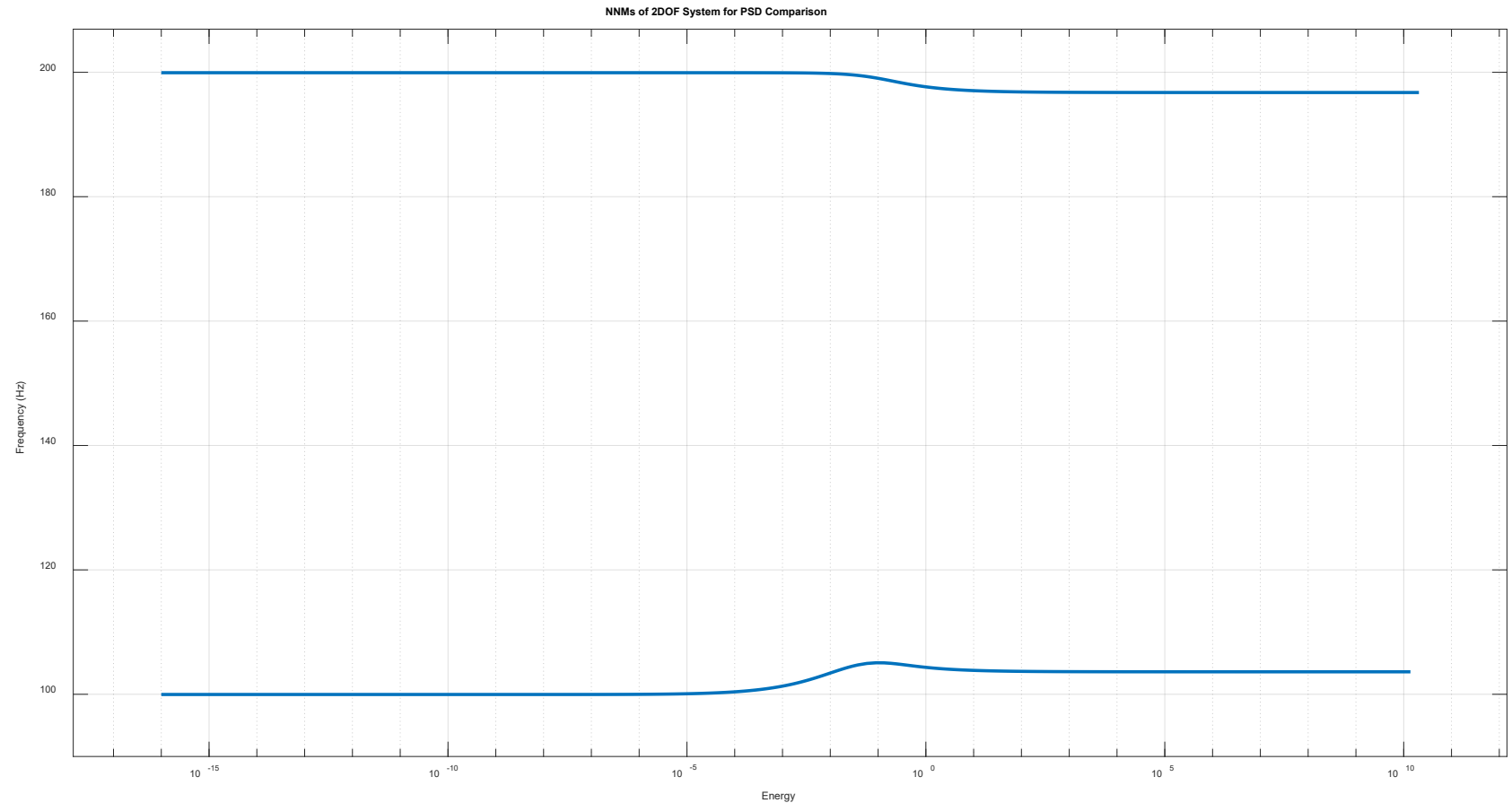
150-250

190-210

BYU

NNMs

- These NNMs show at what amplitudes the modes start changing their natural frequencies.



PSD Plot Variables

The following are the variables that are varied in the following slides:

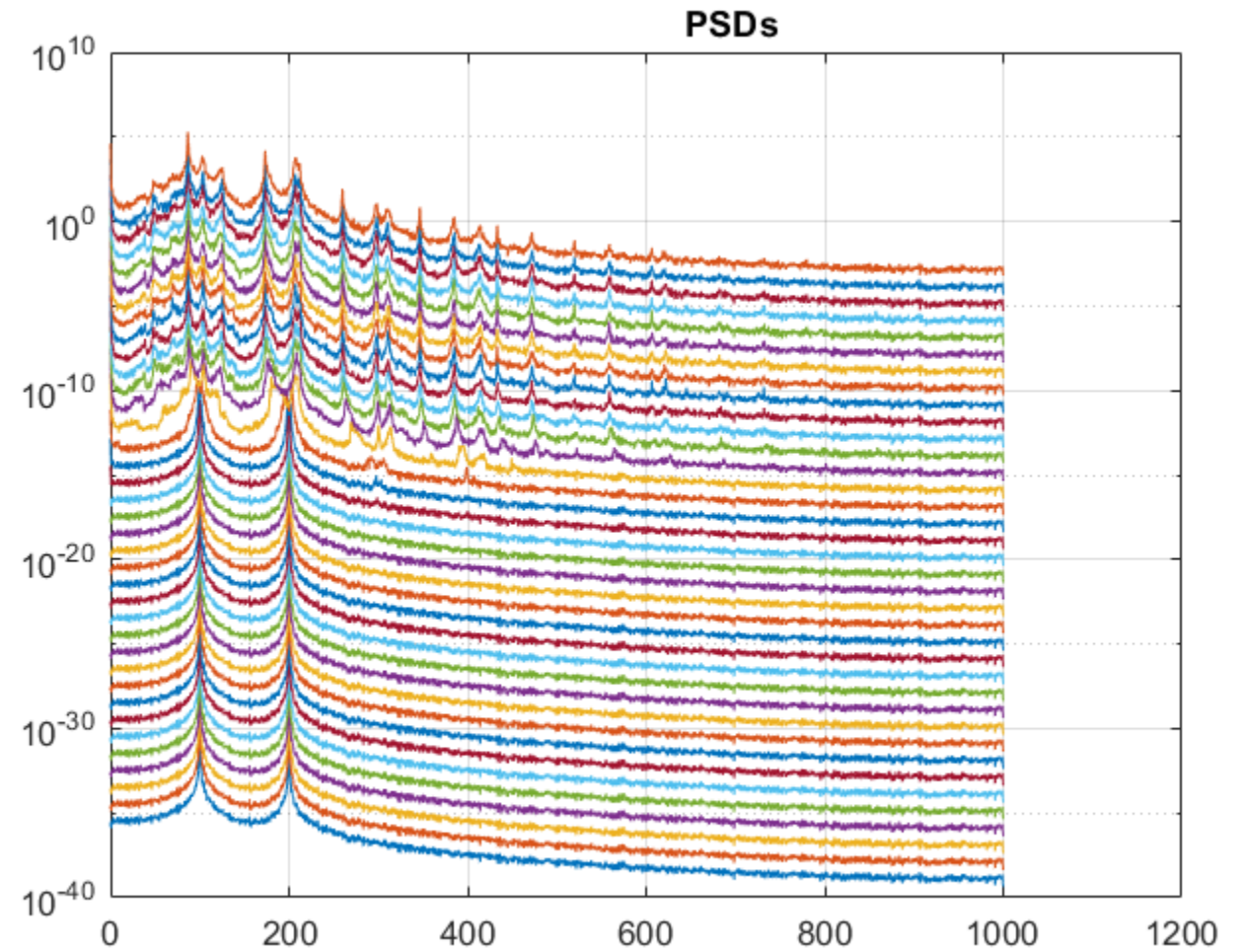
Variable Name	Possible Values
Forcing Type/Shape	Random, Mode 1, Mode 2,
Coordinates analyzed (deflections)	Left spring, center spring, mode 1, mode 2,
Amplitude Range	10^{-10} - 10^8 ,
Band limited forcing (Hz)	None, 50-150, 90-110, 150-250, 190-210,

PSDs

Left spring deflection

Random forcing

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

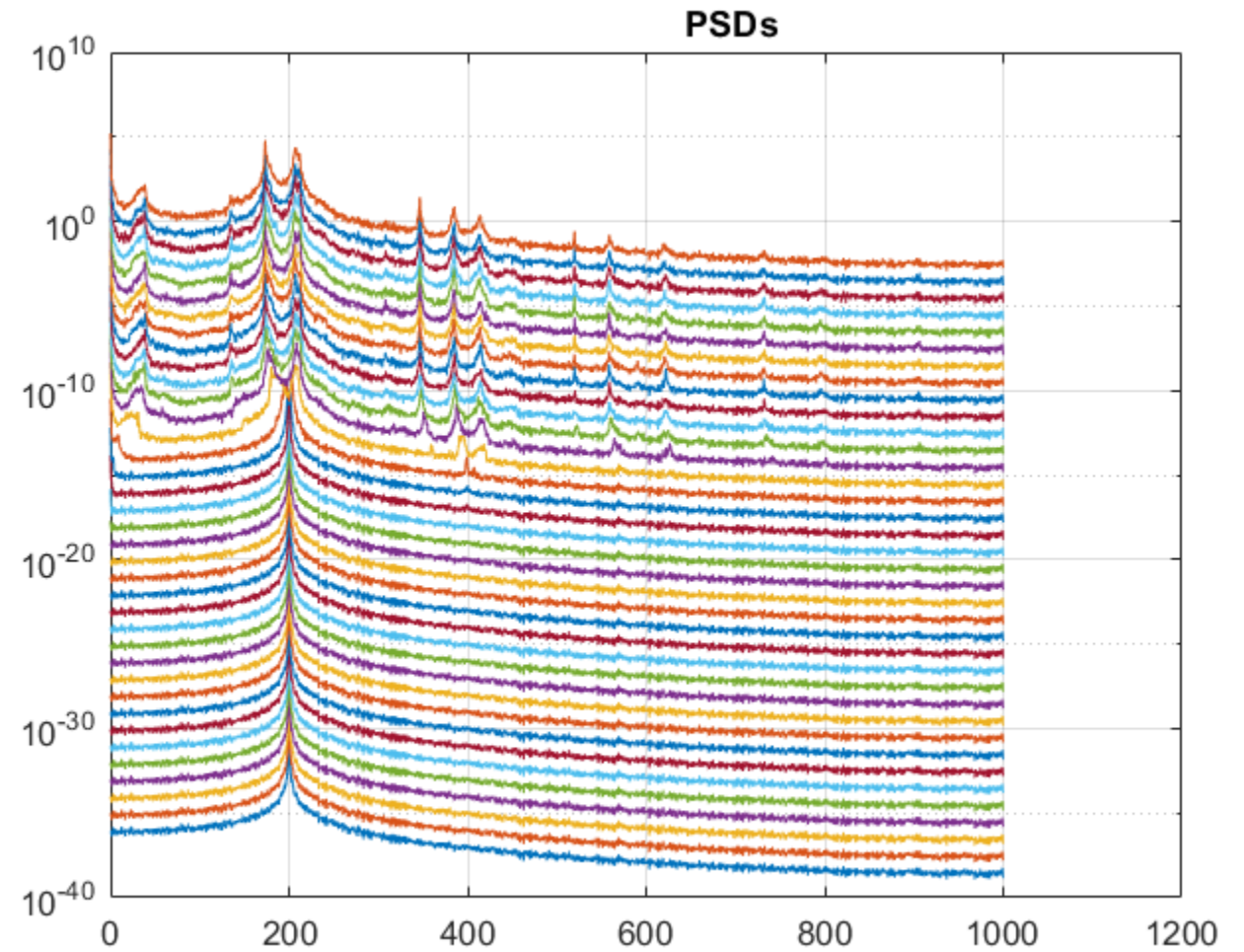
190-210

PSDs

Center spring deflection

Random forcing

Amplitude Range: $10^{-10} - 10^8$



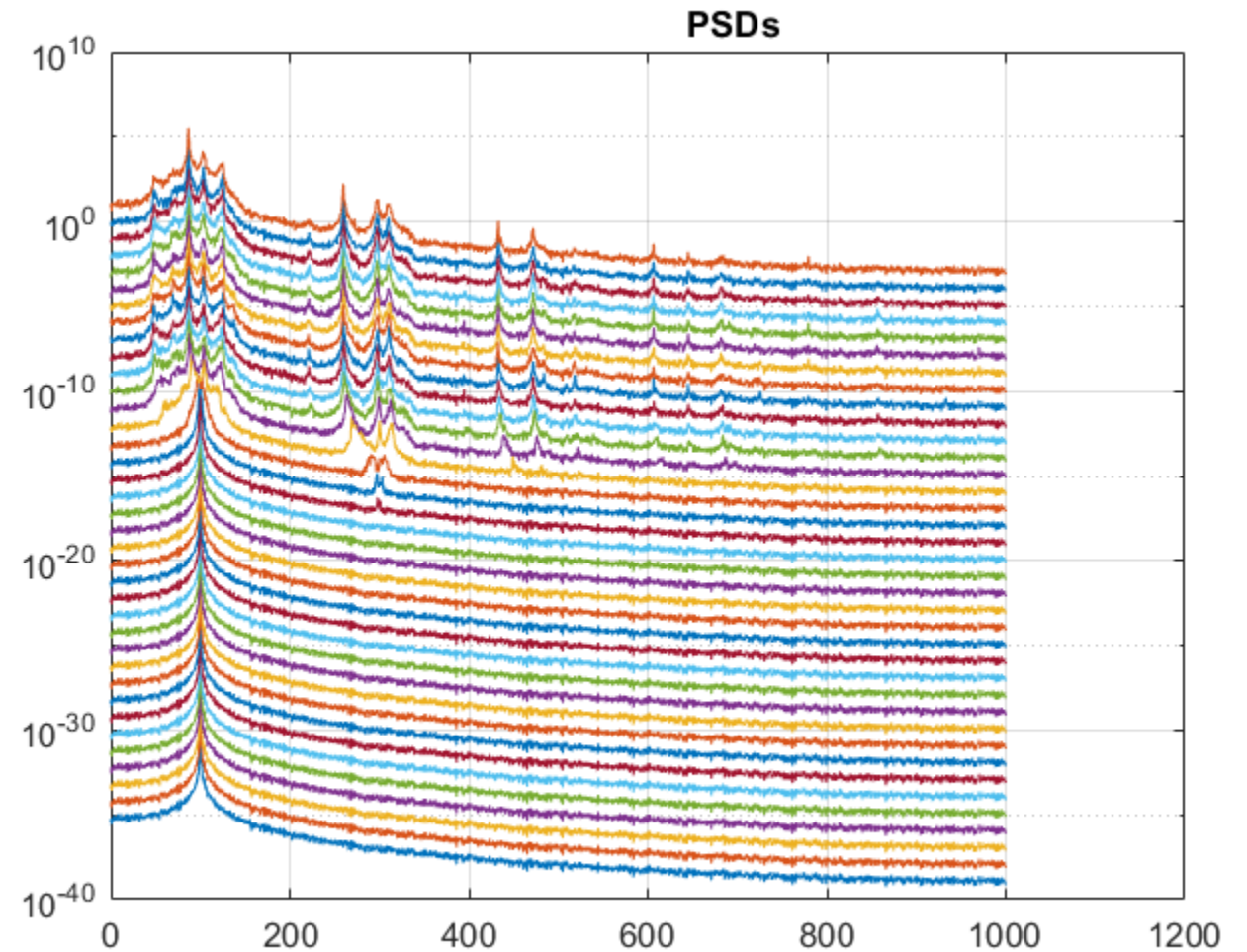
DOF	Left	Center	Mode 1	Mode 2	
Forcing	Random	Mode 1	Mode 2		
Bandlimiting	None	50-150	90-110	150-250	190-210

PSDs

Mode 1 deflection

Random forcing

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

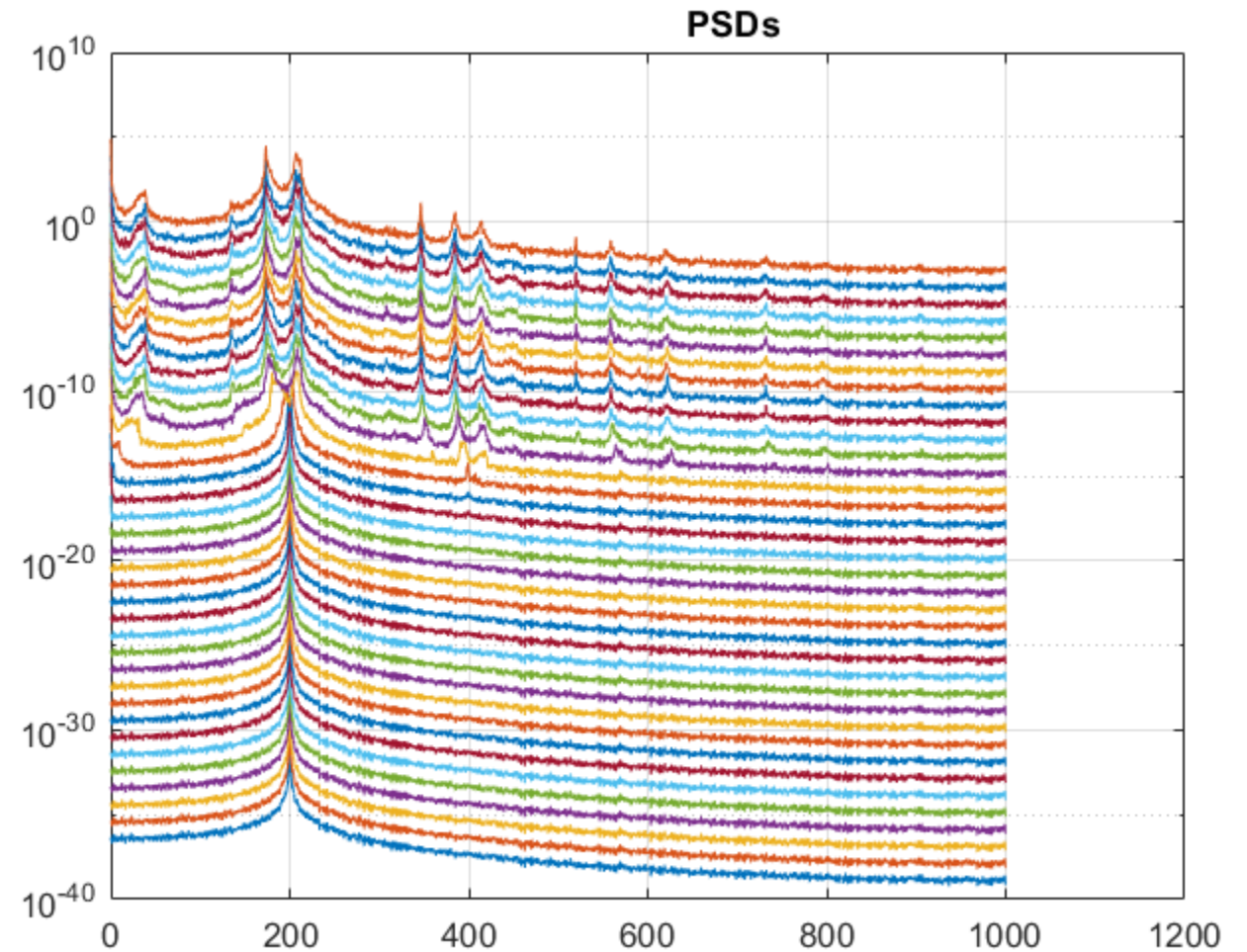
190-210

PSDs

Mode 2 deflection

Random forcing

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

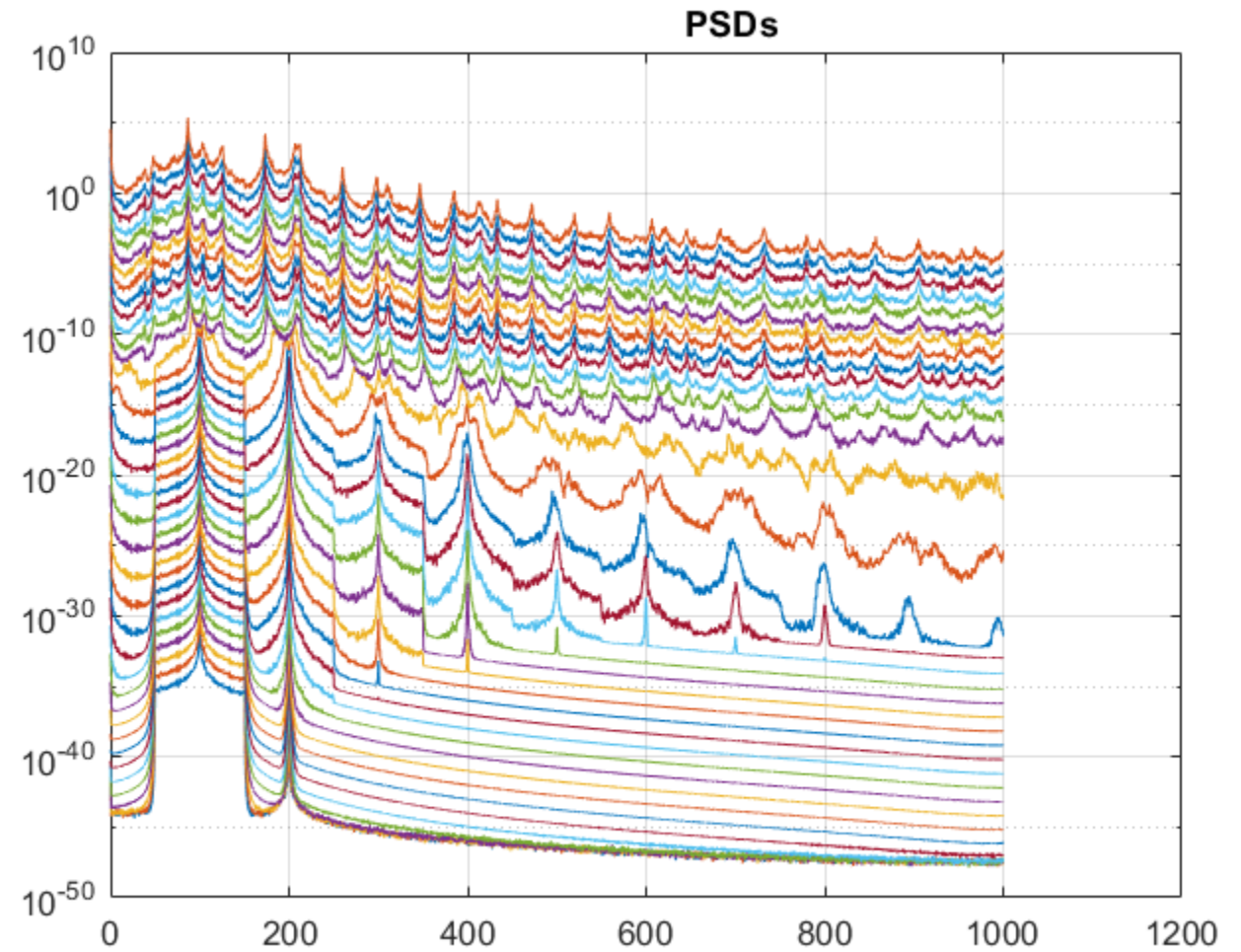
190-210

PSDs

Left spring deflection

Band limited random forcing
(50-150 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

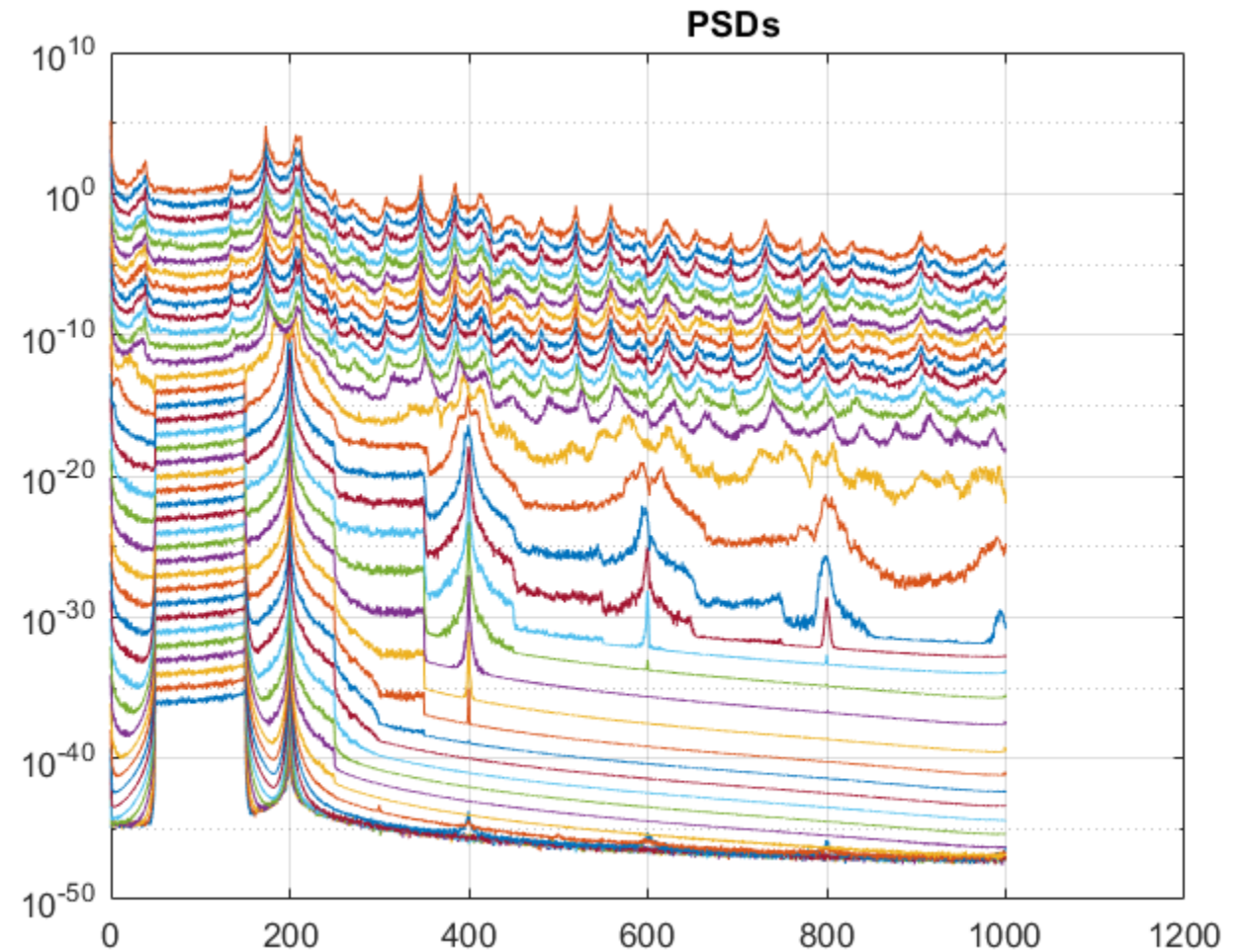
190-210

PSDs

Center spring deflection

Band limited random forcing
(50-150 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

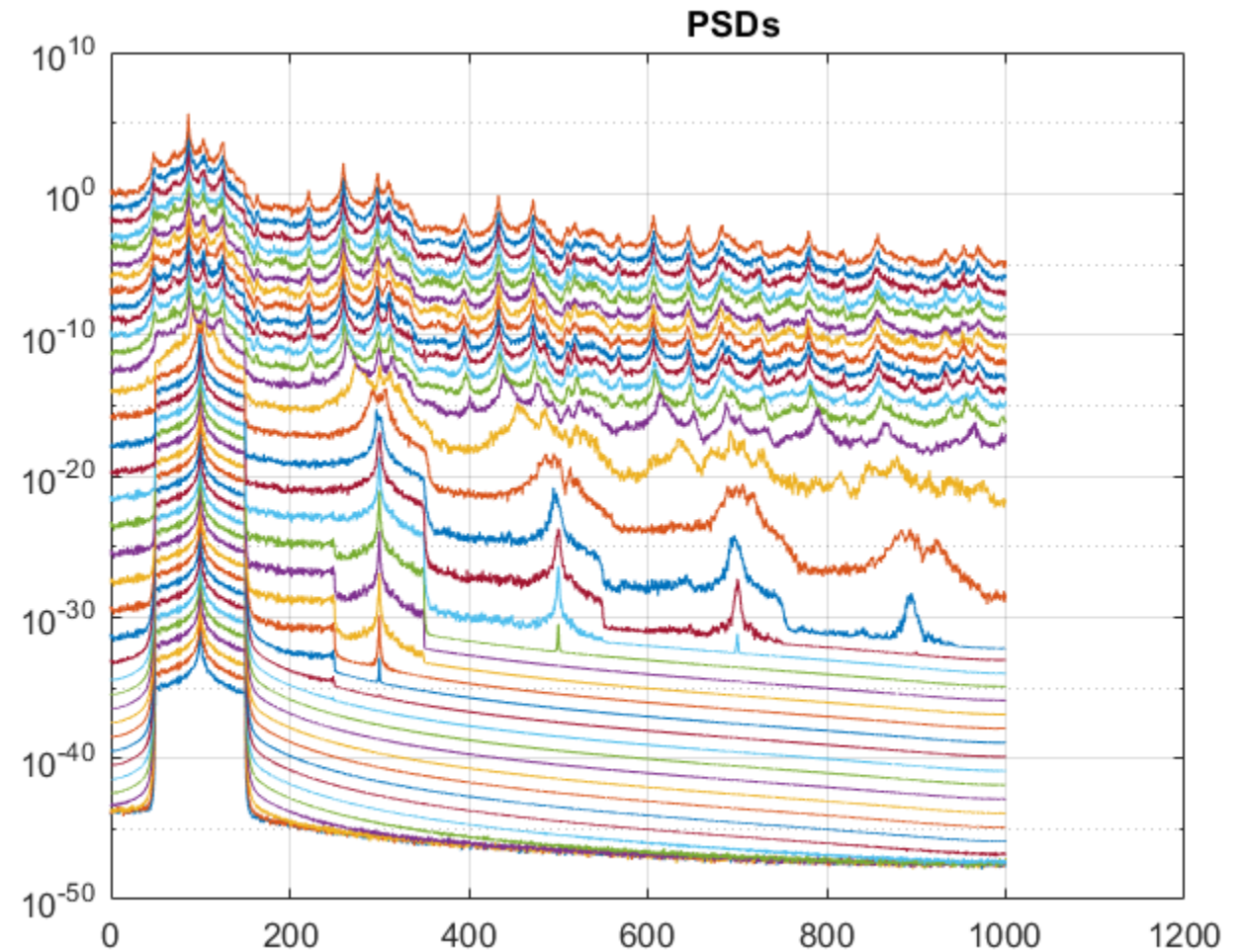
190-210

PSDs

Mode 1 deflection

Band limited random forcing
(50-150 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

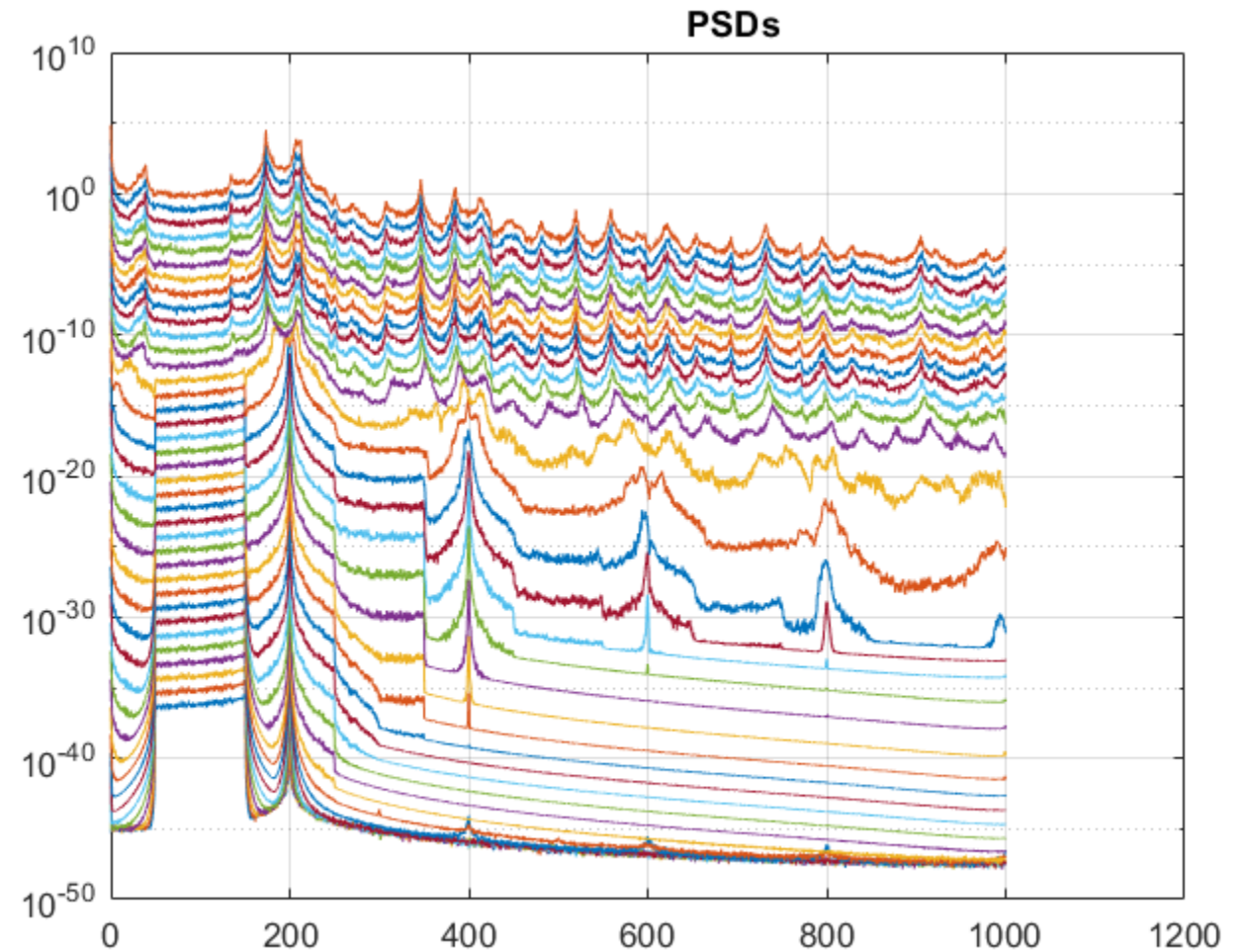
190-210

PSDs

Mode 2 deflection

Band limited random forcing
(50-150 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

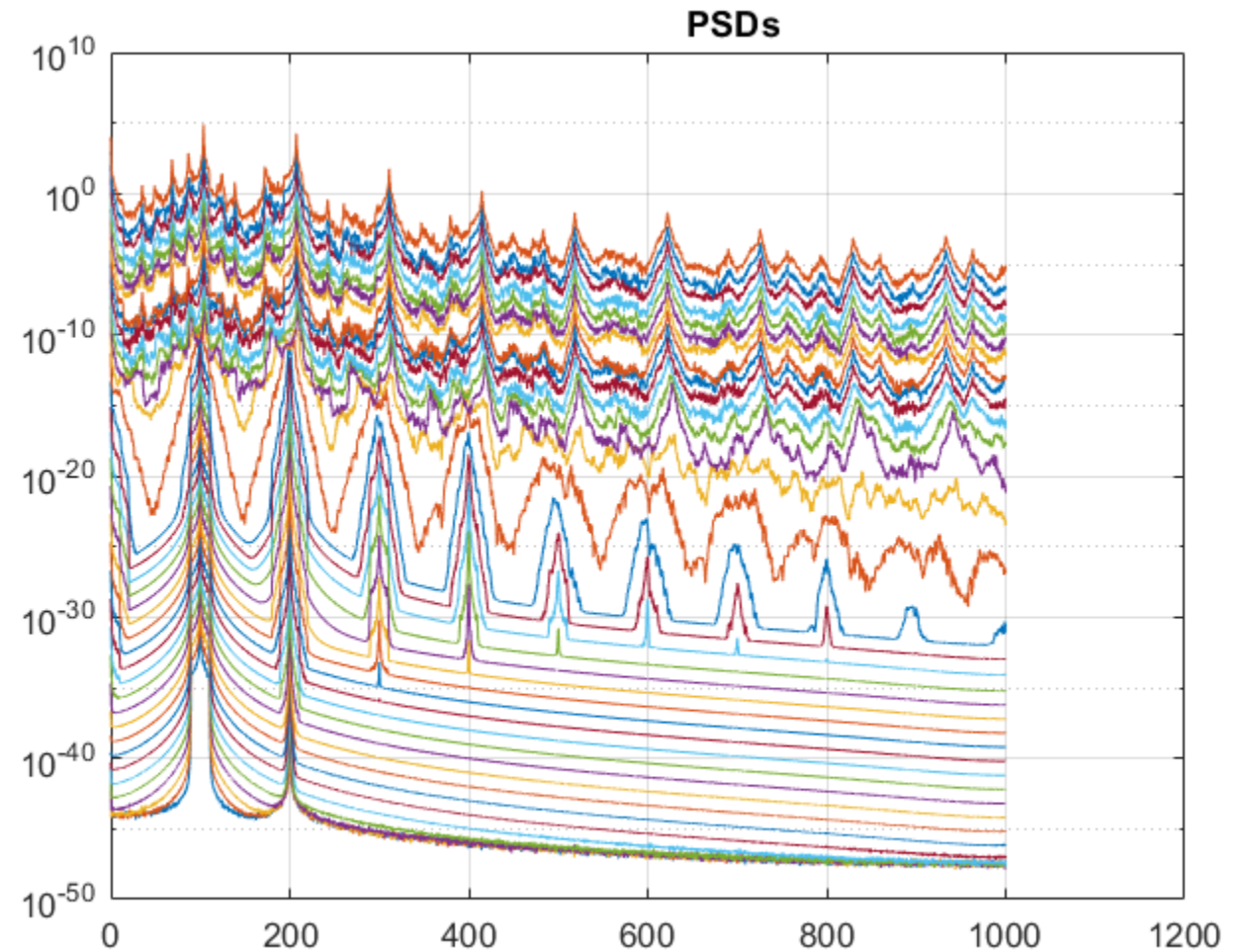
190-210

PSDs

Left spring deflection

Band limited random forcing
(90-110 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

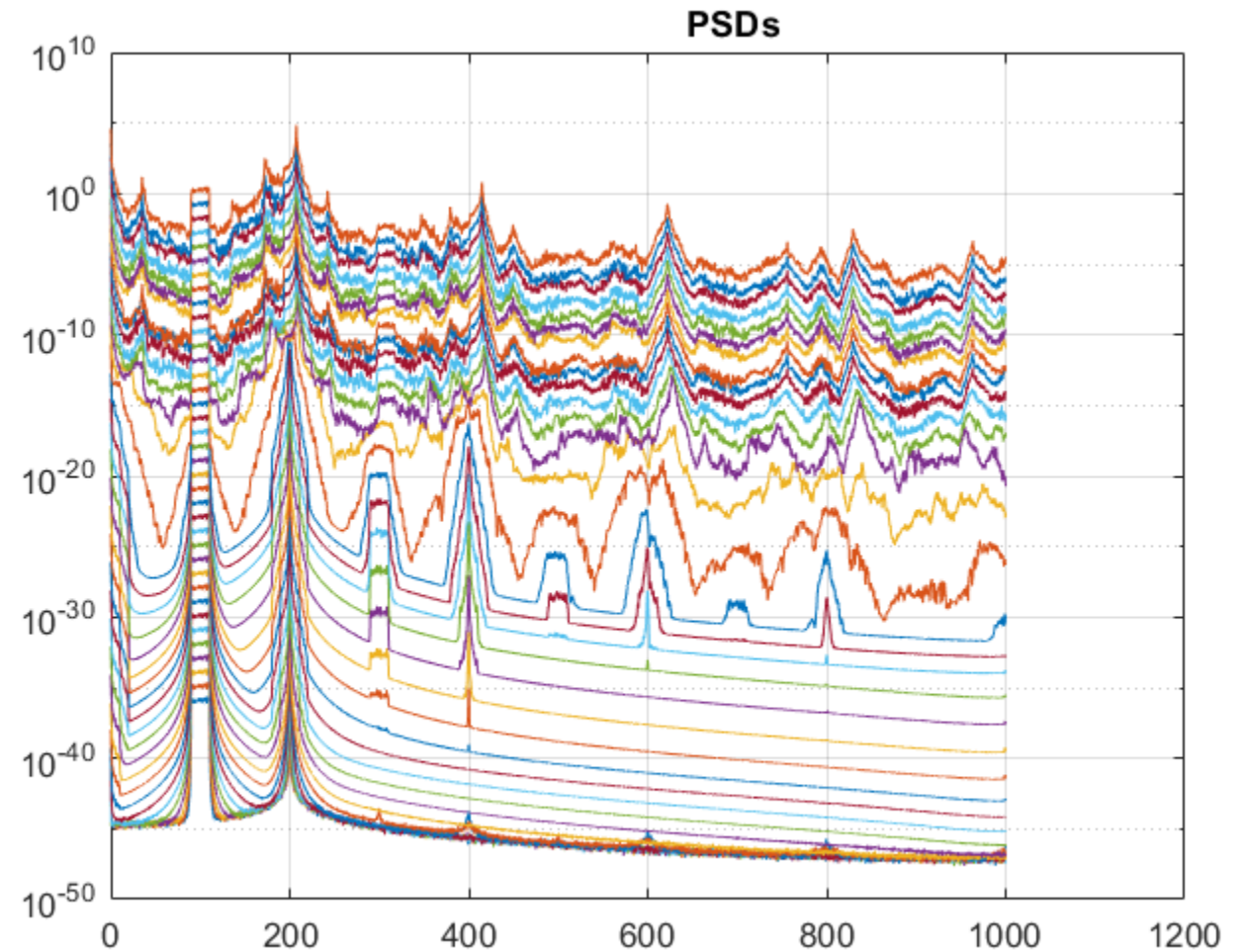
190-210

PSDs

Center spring deflection

Band limited random forcing
(90-110 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

190-210

PSDs

Mode 1 deflection

Band limited random forcing
(90-110 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

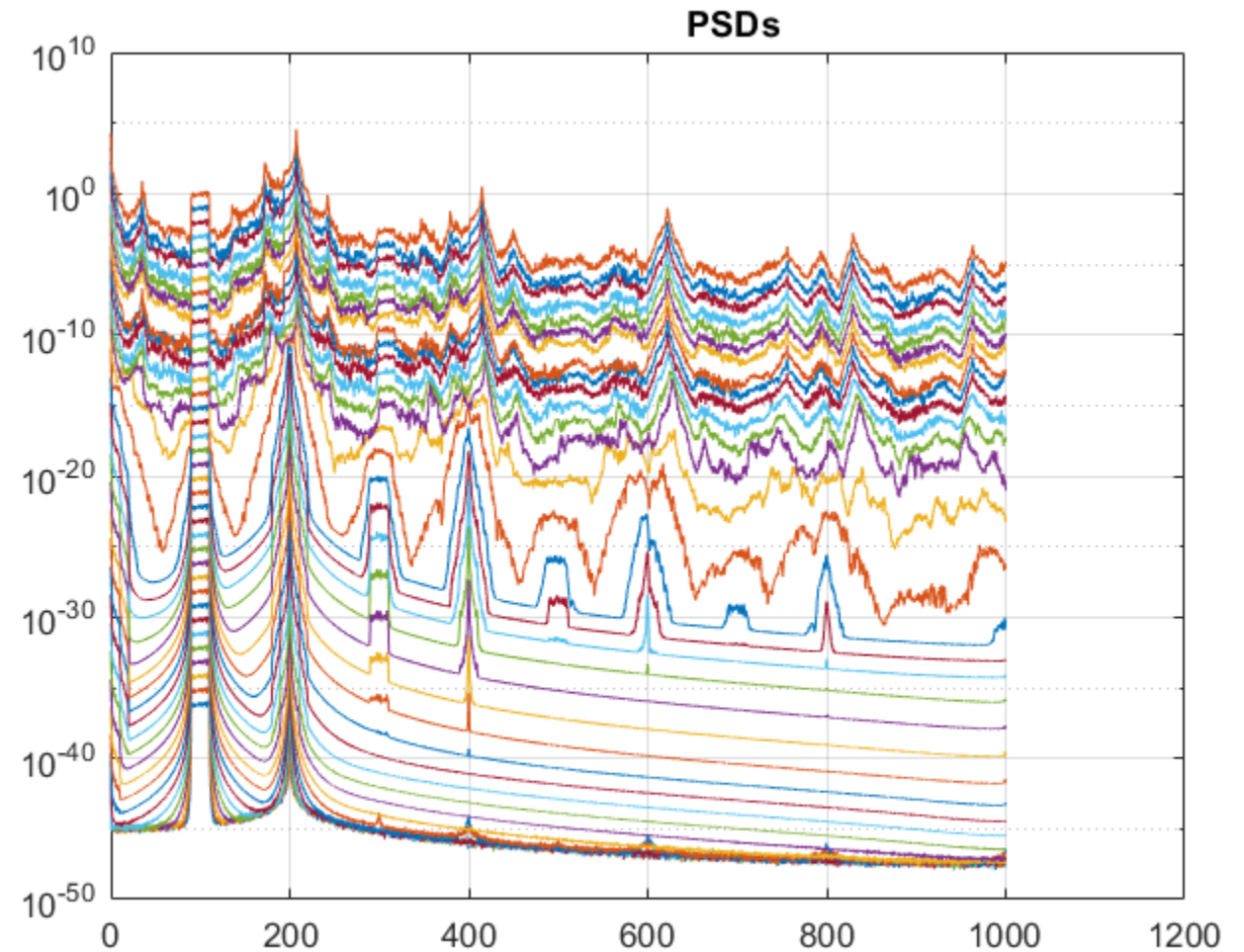
190-210

PSDs

Mode 2 deflection

Band limited random forcing
(90-110 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

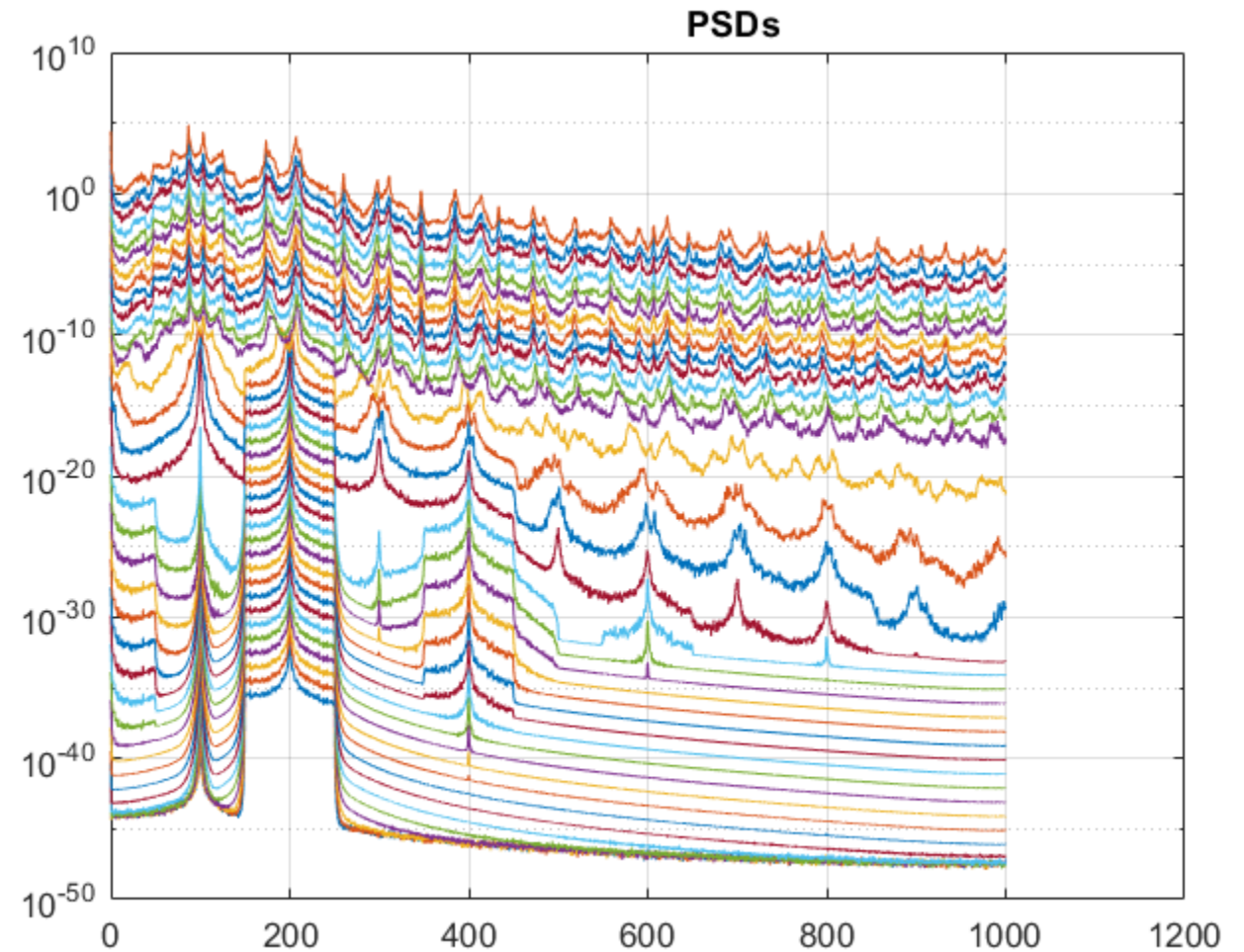
190-210

PSDs

Left spring deflection

Band limited random forcing
(150-250 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

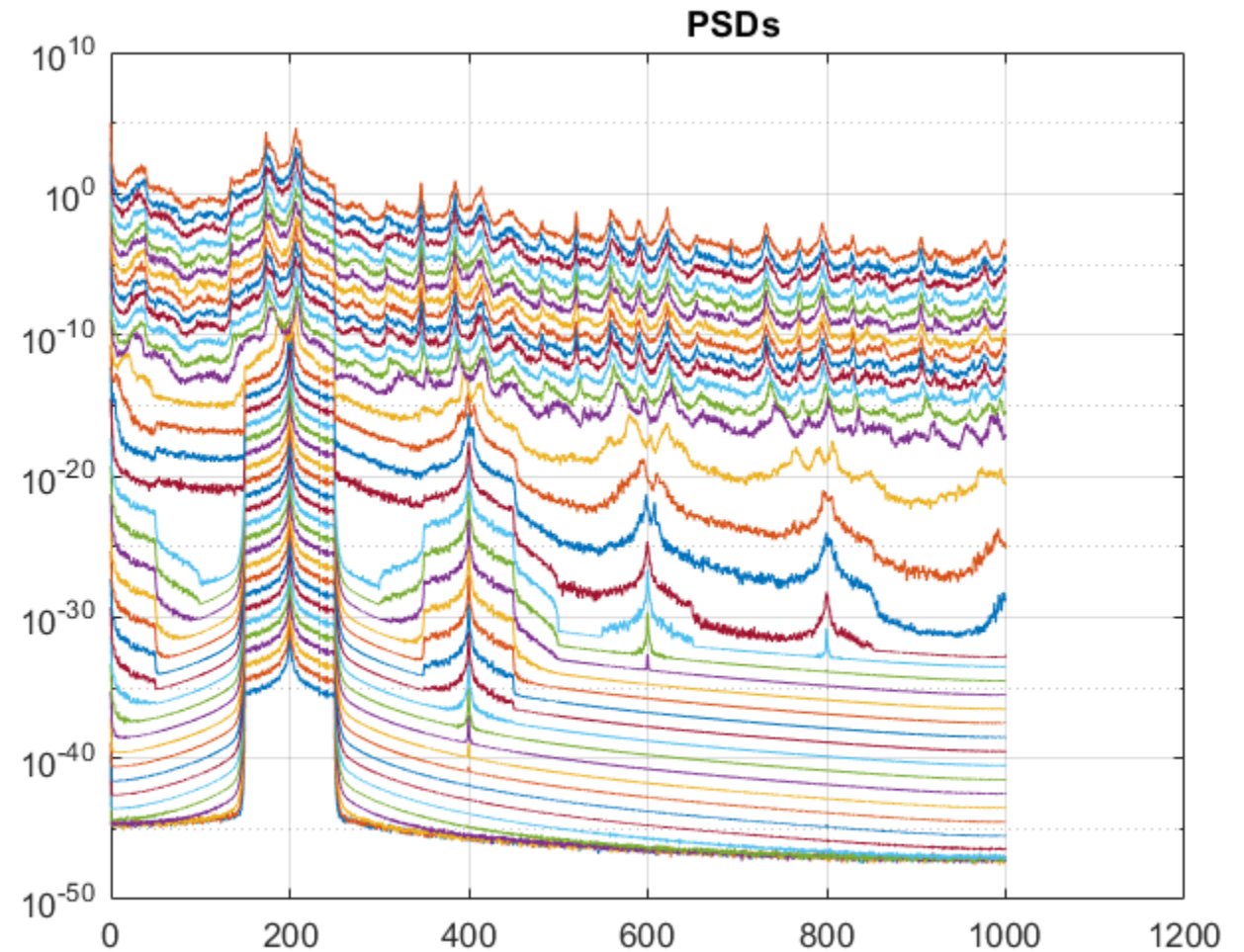
190-210

PSDs

Center spring deflection

Band limited random forcing
(150-250 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

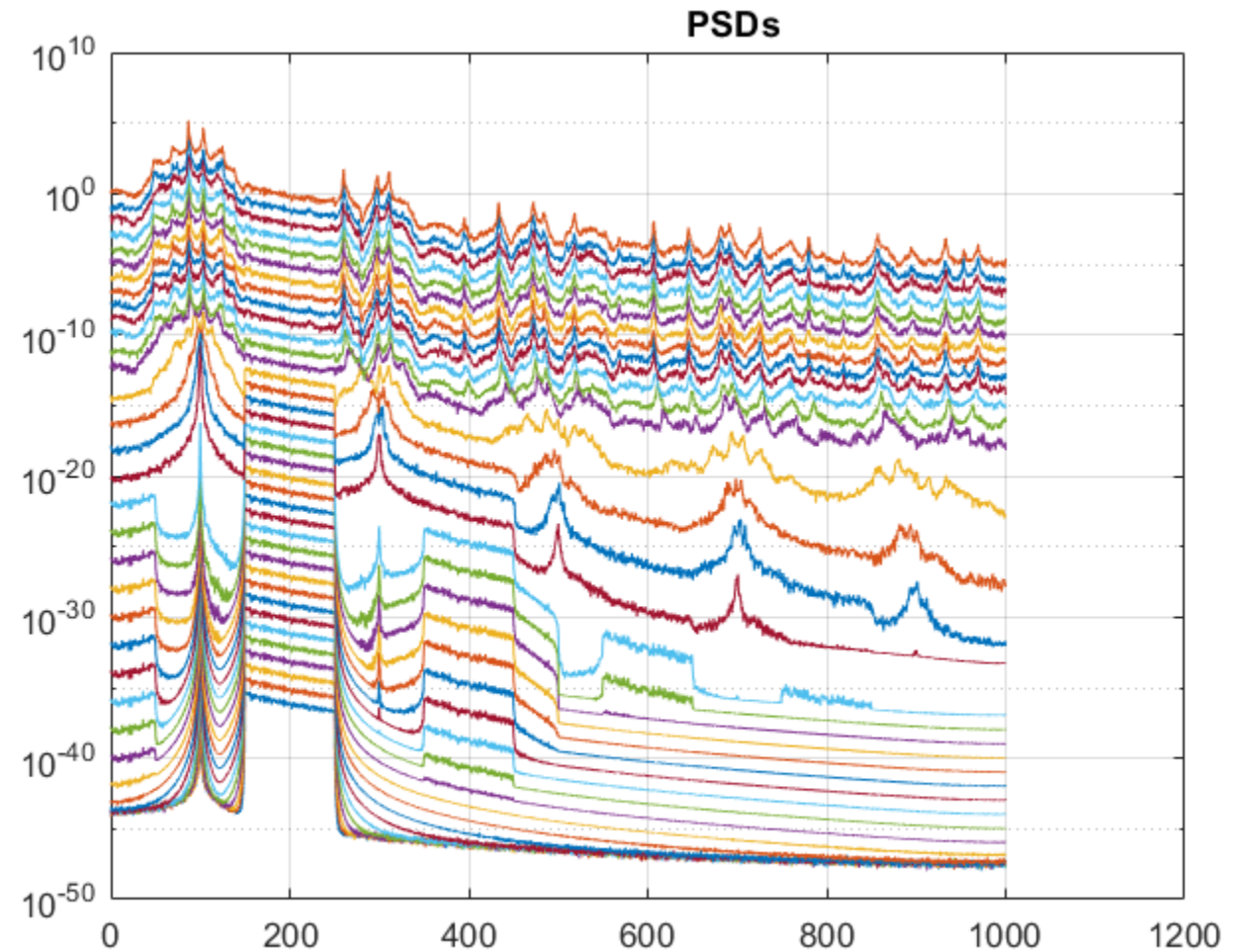
190-210

PSDs

Mode 1 deflection

Band limited random forcing
(150-250 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

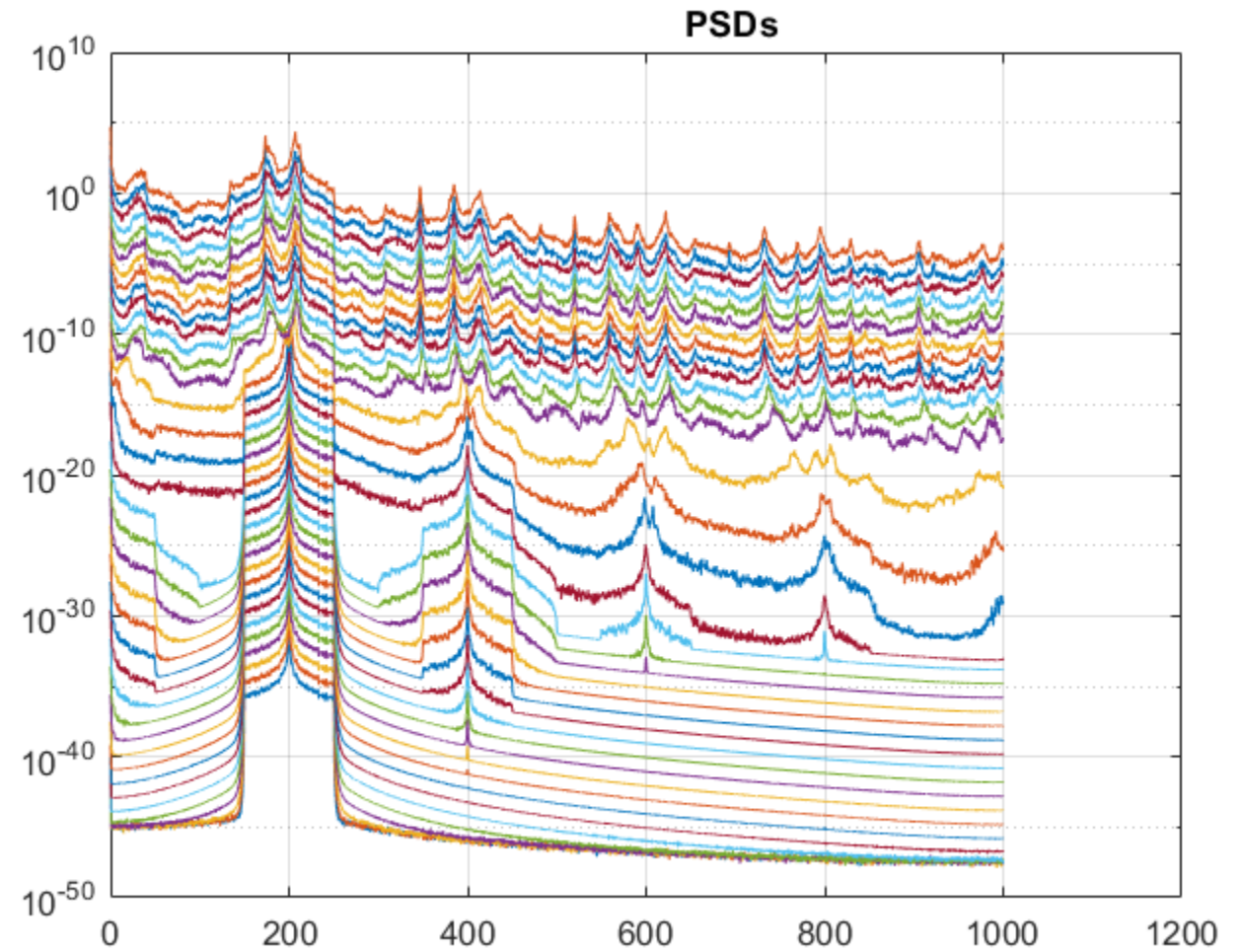
190-210

PSDs

Mode 2 deflection

Band limited random forcing
(150-250 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

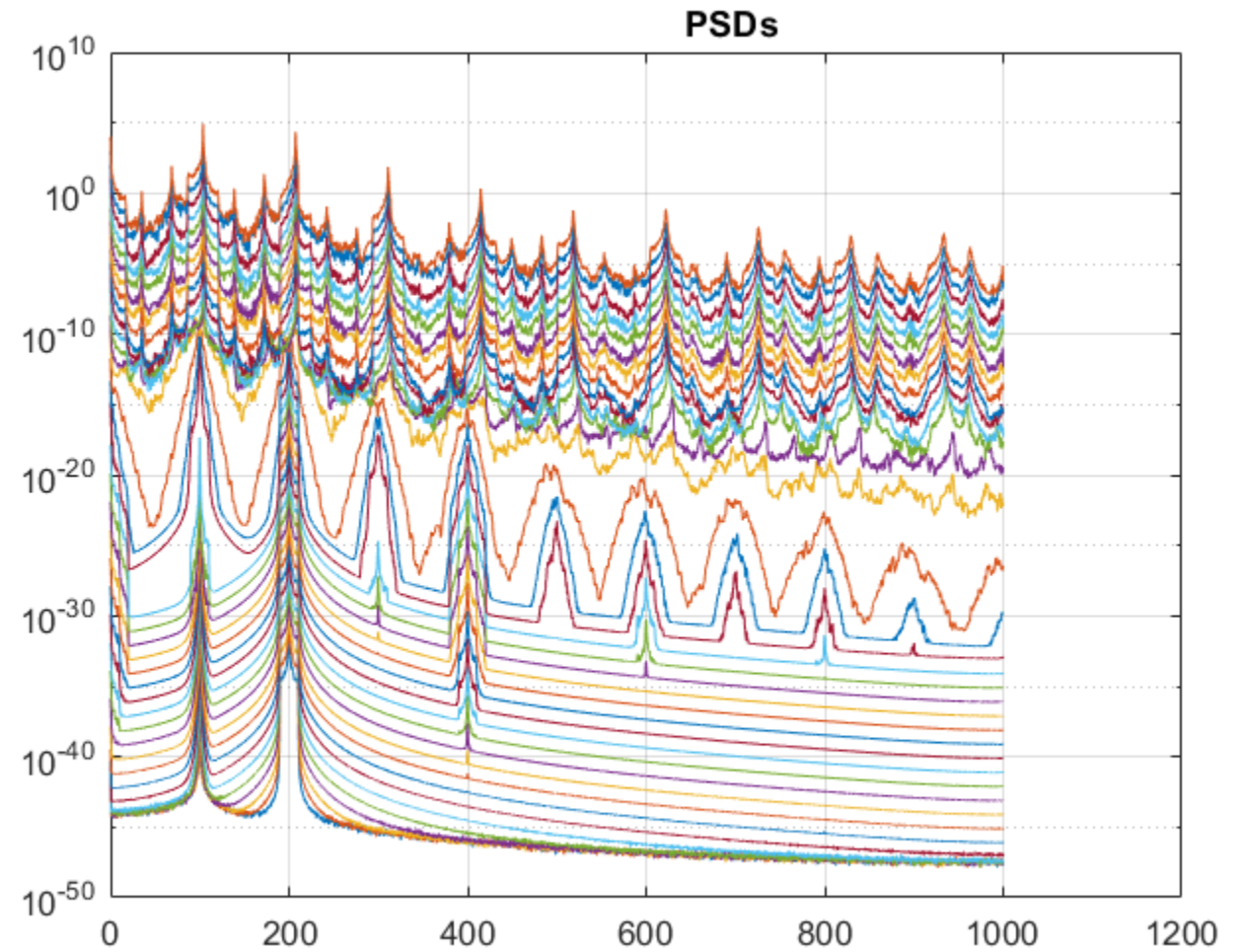
190-210

PSDs

Left spring deflection

Band limited random forcing
(190-210 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

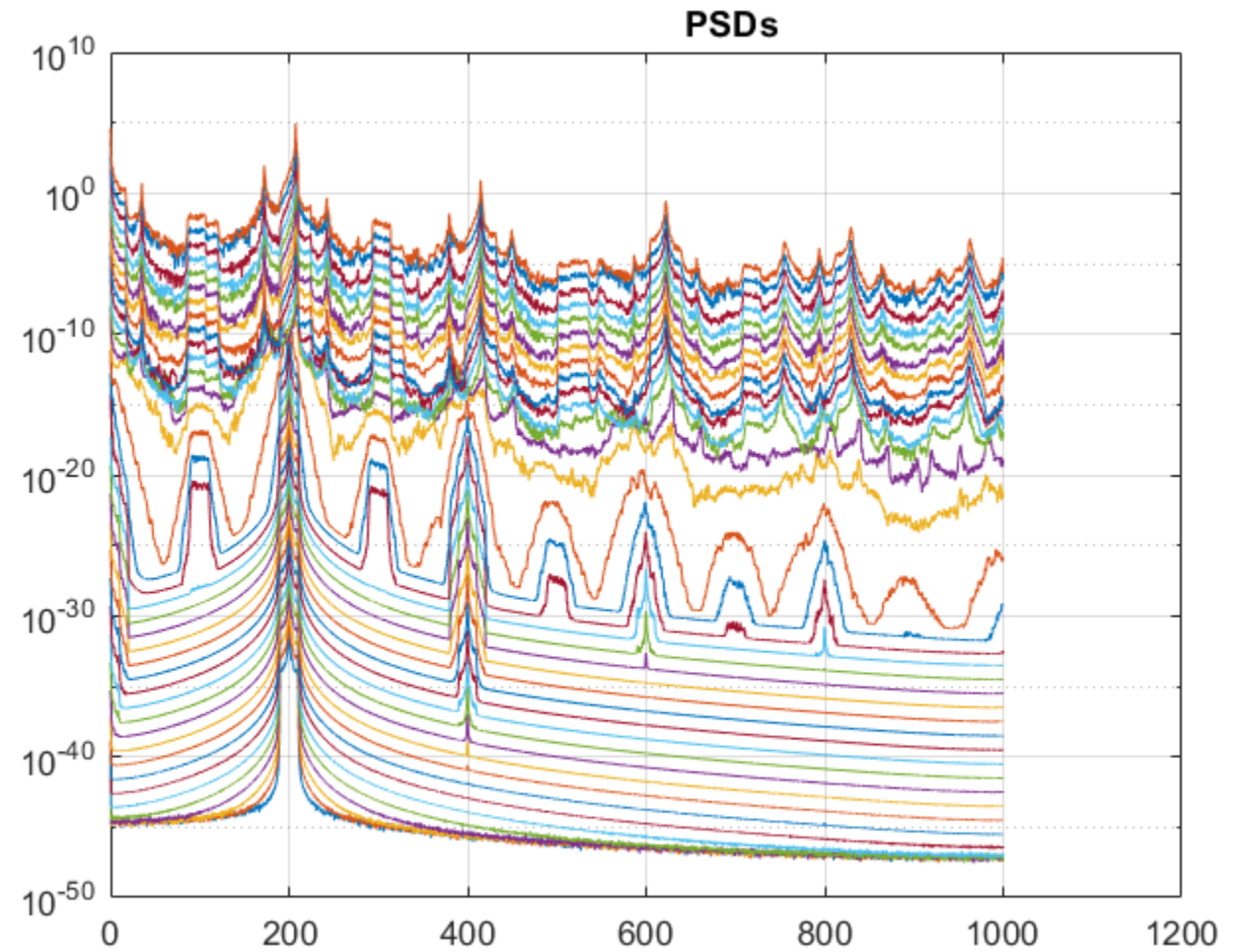
190-210

PSDs

Center spring deflection

Band limited random forcing
(190-210 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

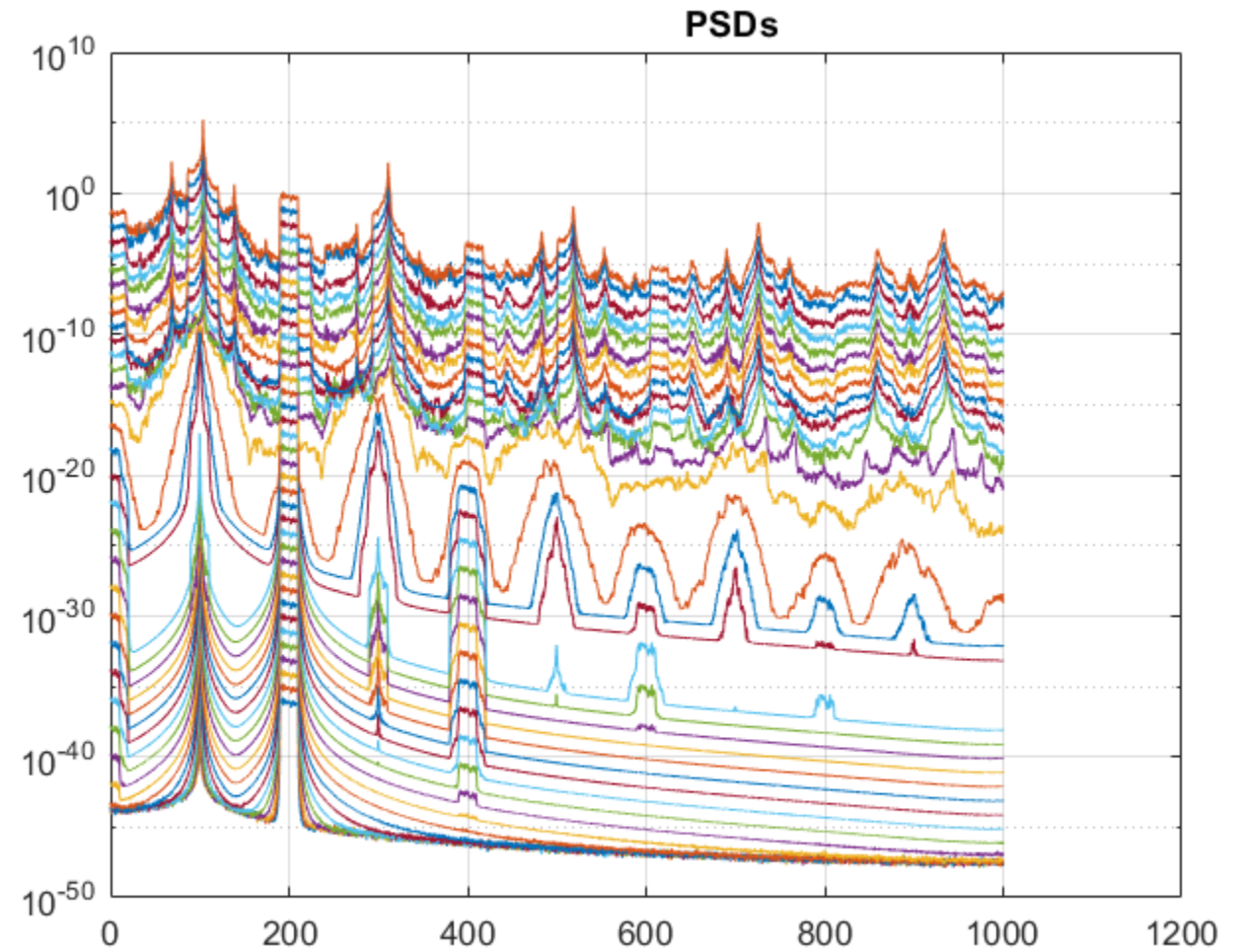
190-210

PSDs

Mode 1 deflection

Band limited random forcing
(190-210 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

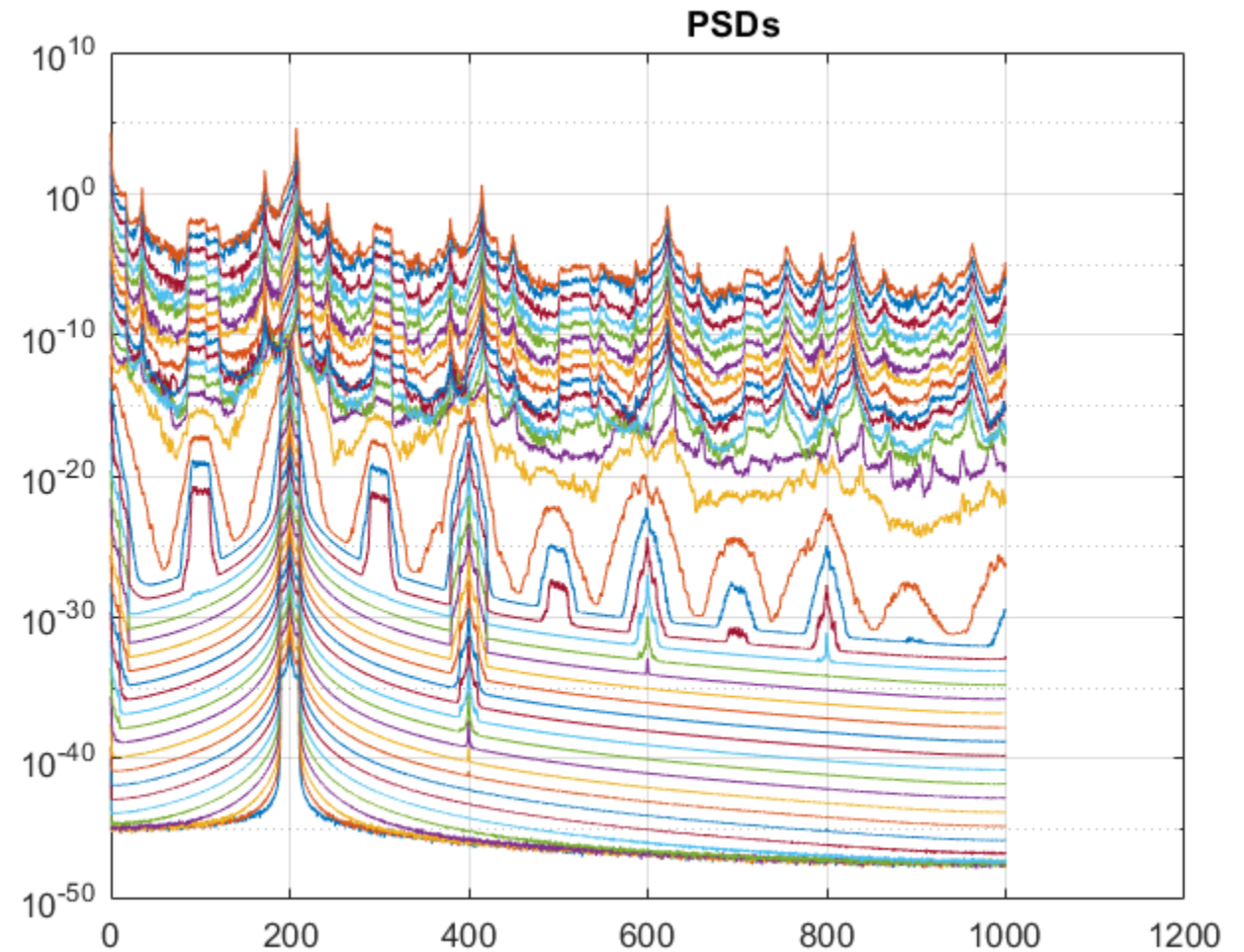
190-210

PSDs

Mode 2 deflection

Band limited random forcing
(190-210 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

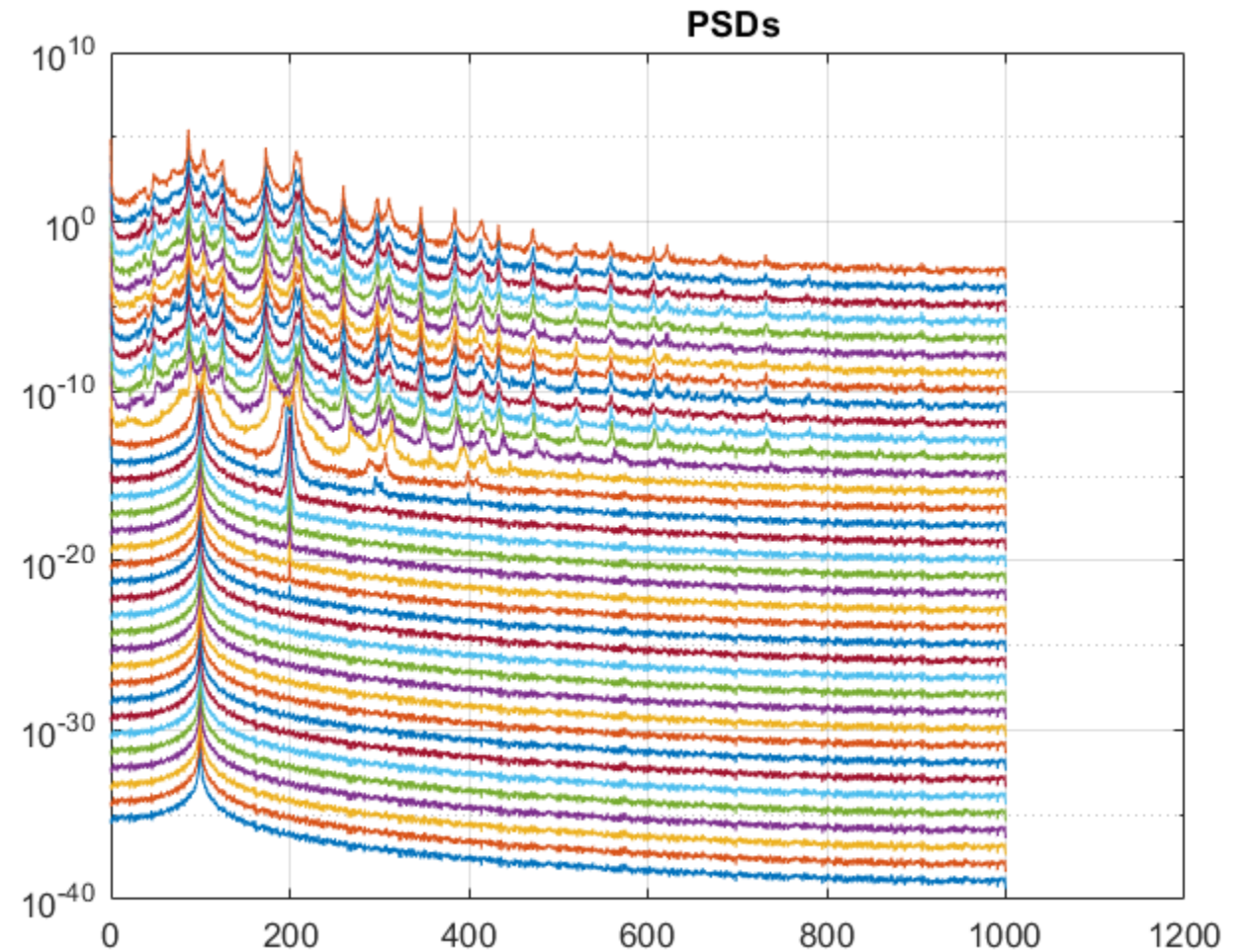
190-210

PSDs

Left spring deflection

Mode 1 forcing

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

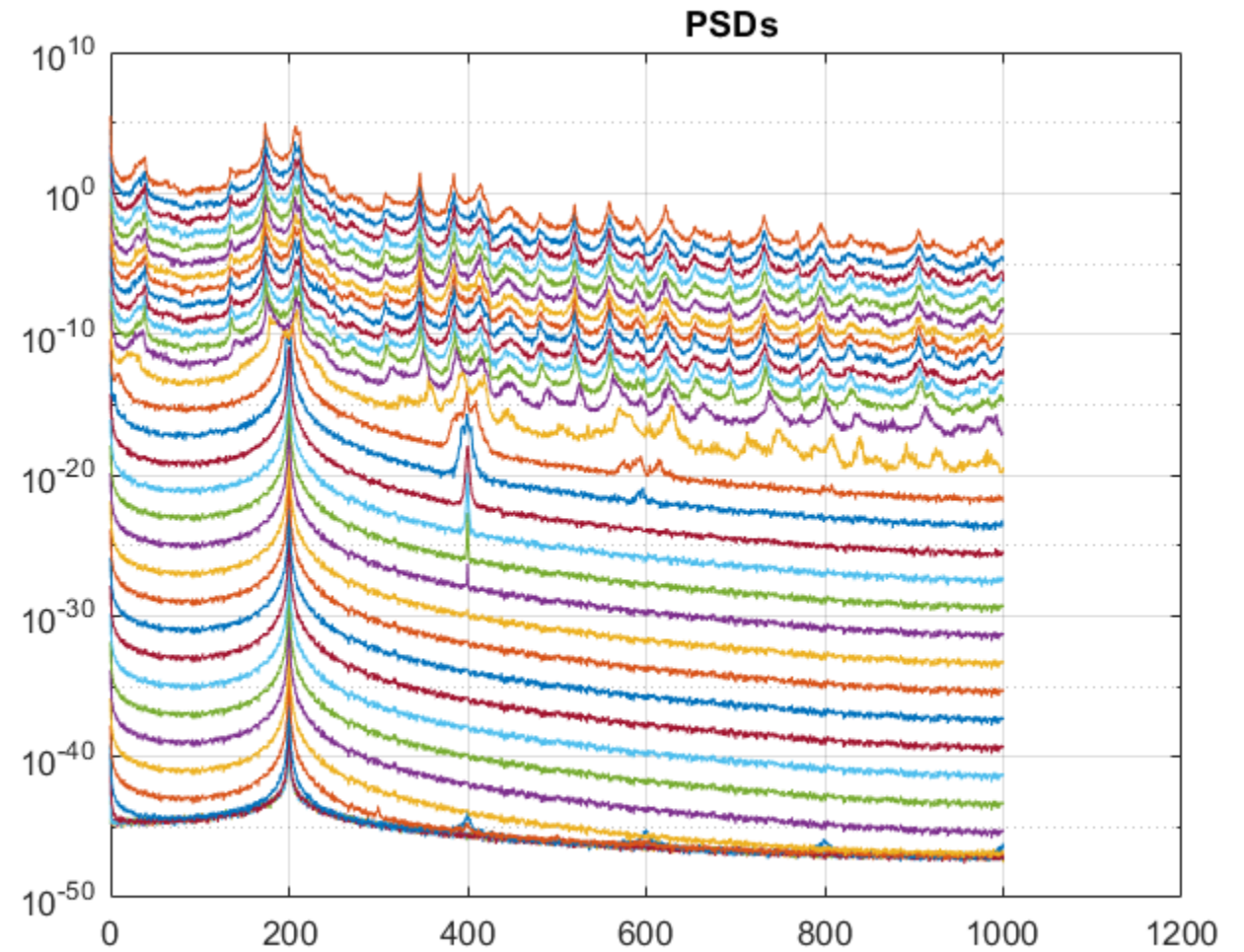
190-210

PSDs

Center spring deflection

Mode 1 forcing

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

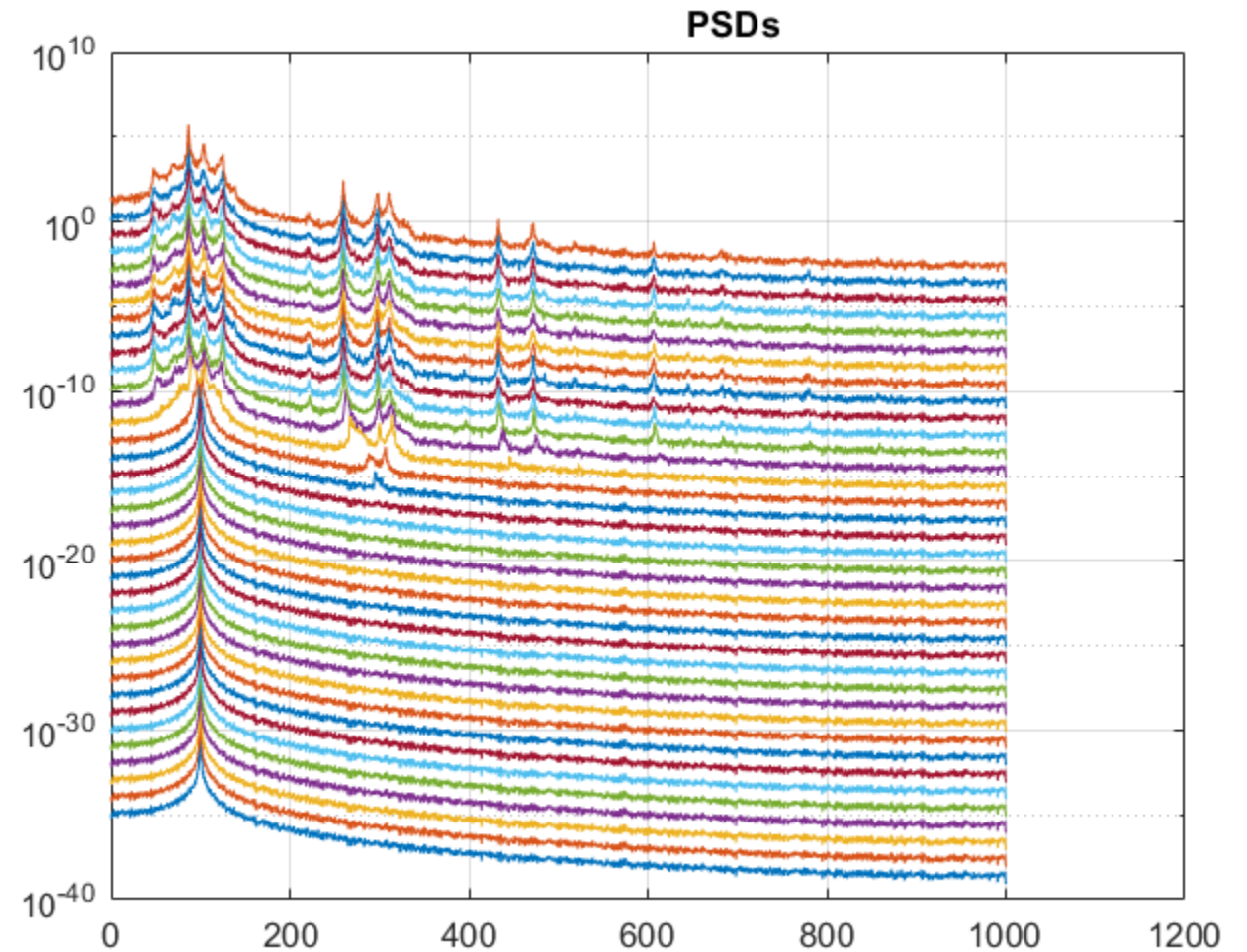
190-210

PSDs

Mode 1 deflection

Mode 1 forcing

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

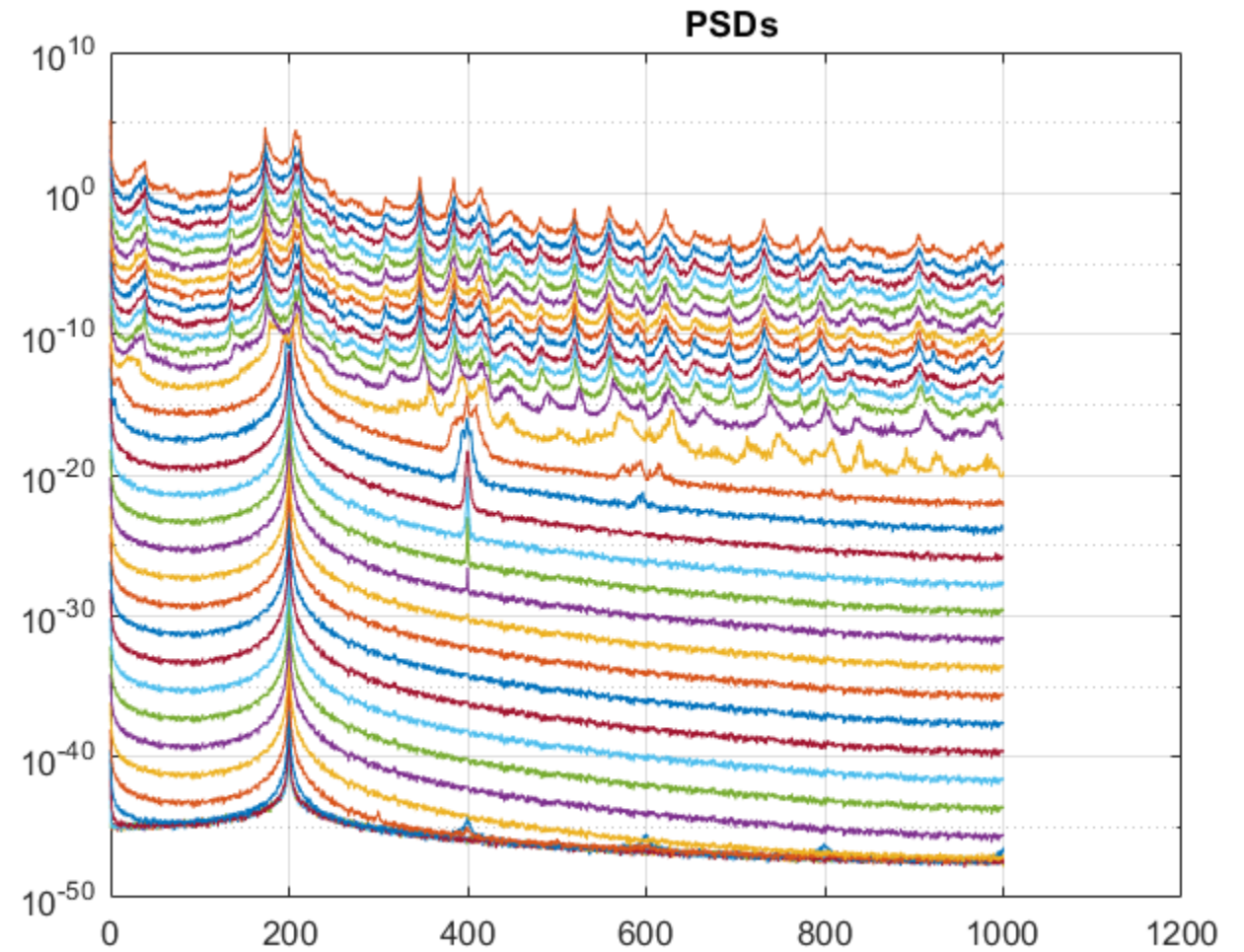
190-210

PSDs

Mode 2 deflection

Mode 1 forcing

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

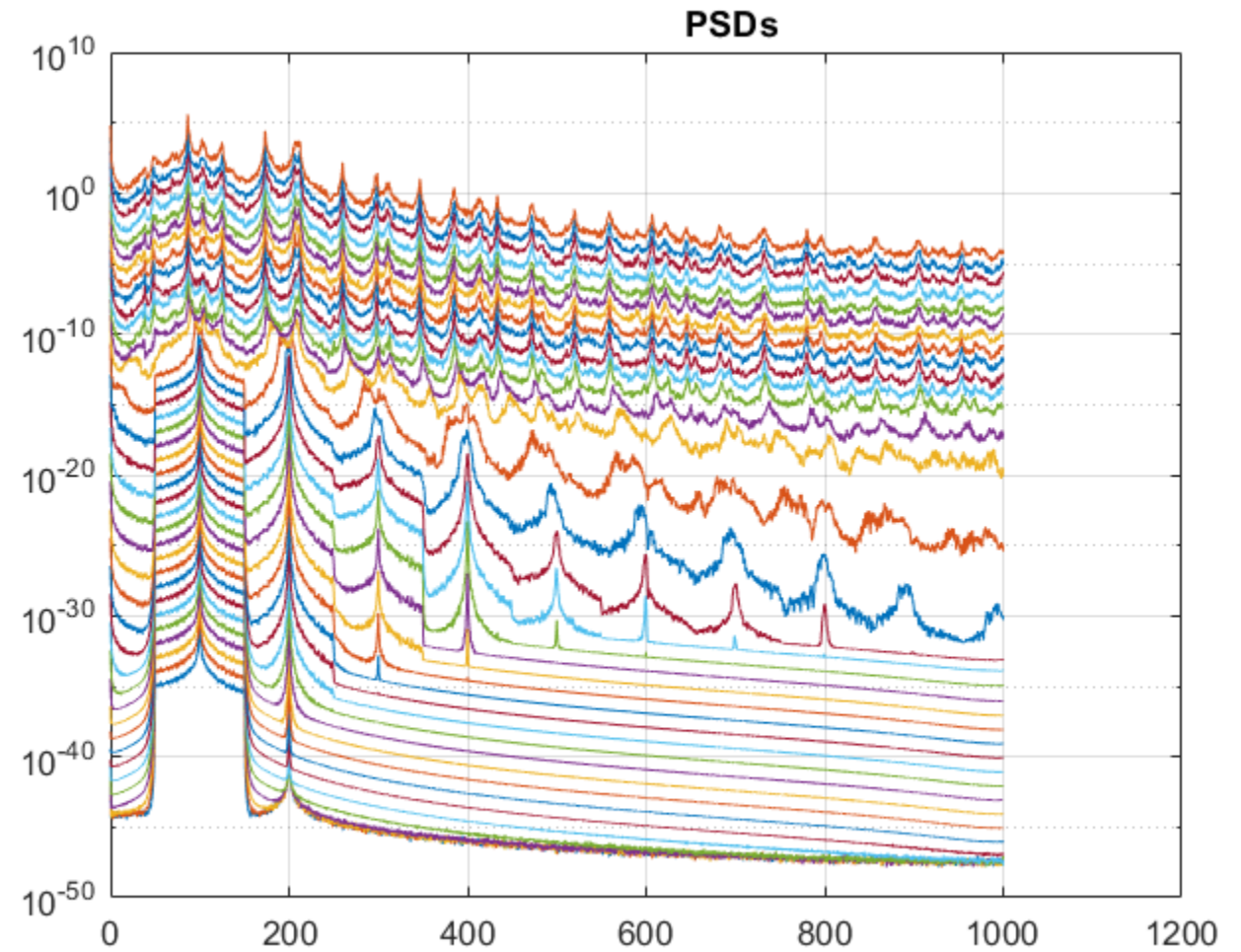
190-210

PSDs

Left spring deflection

Band limited mode 1 forcing
(50-150 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

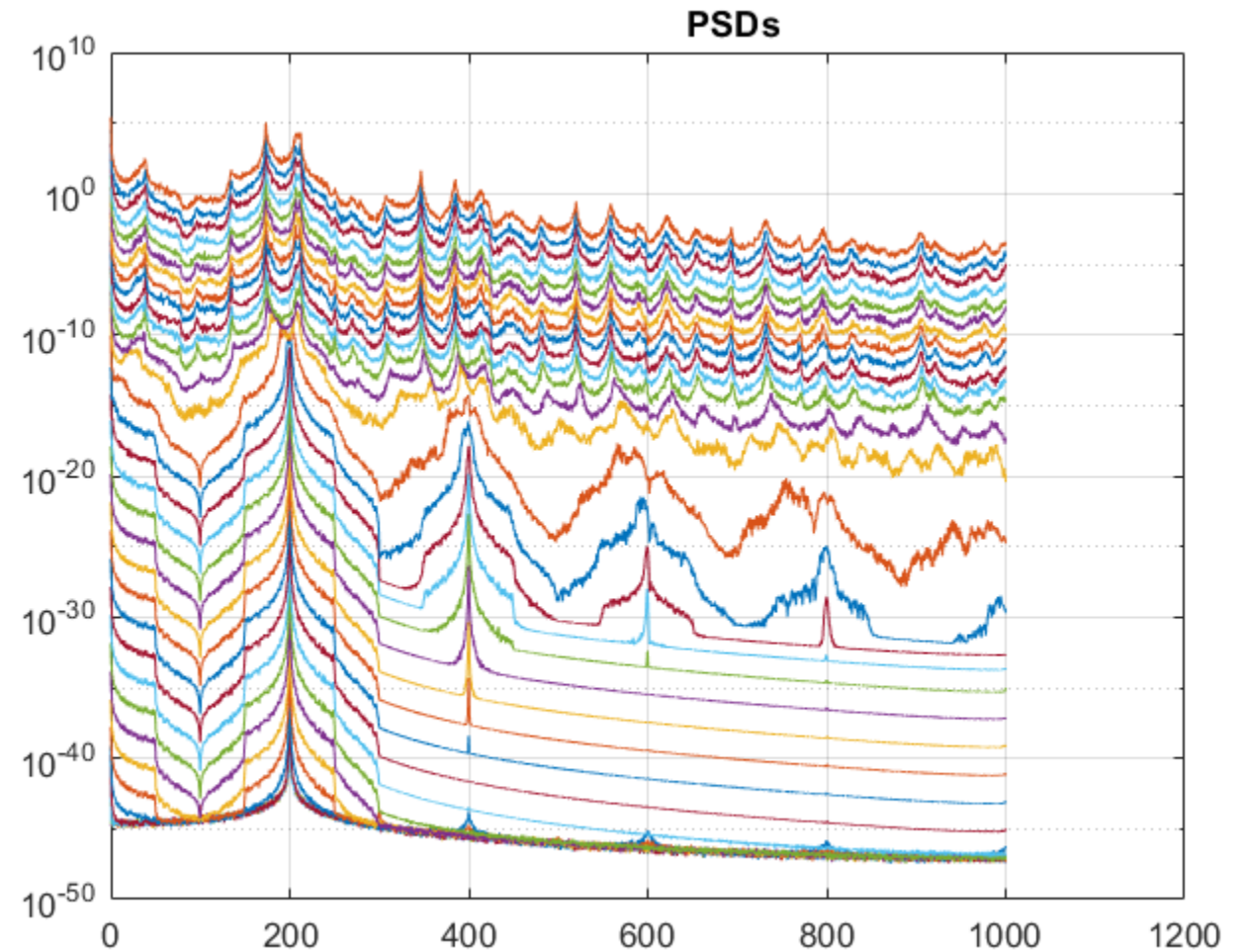
190-210

PSDs

Center spring deflection

Band limited mode 1 forcing
(50-150 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

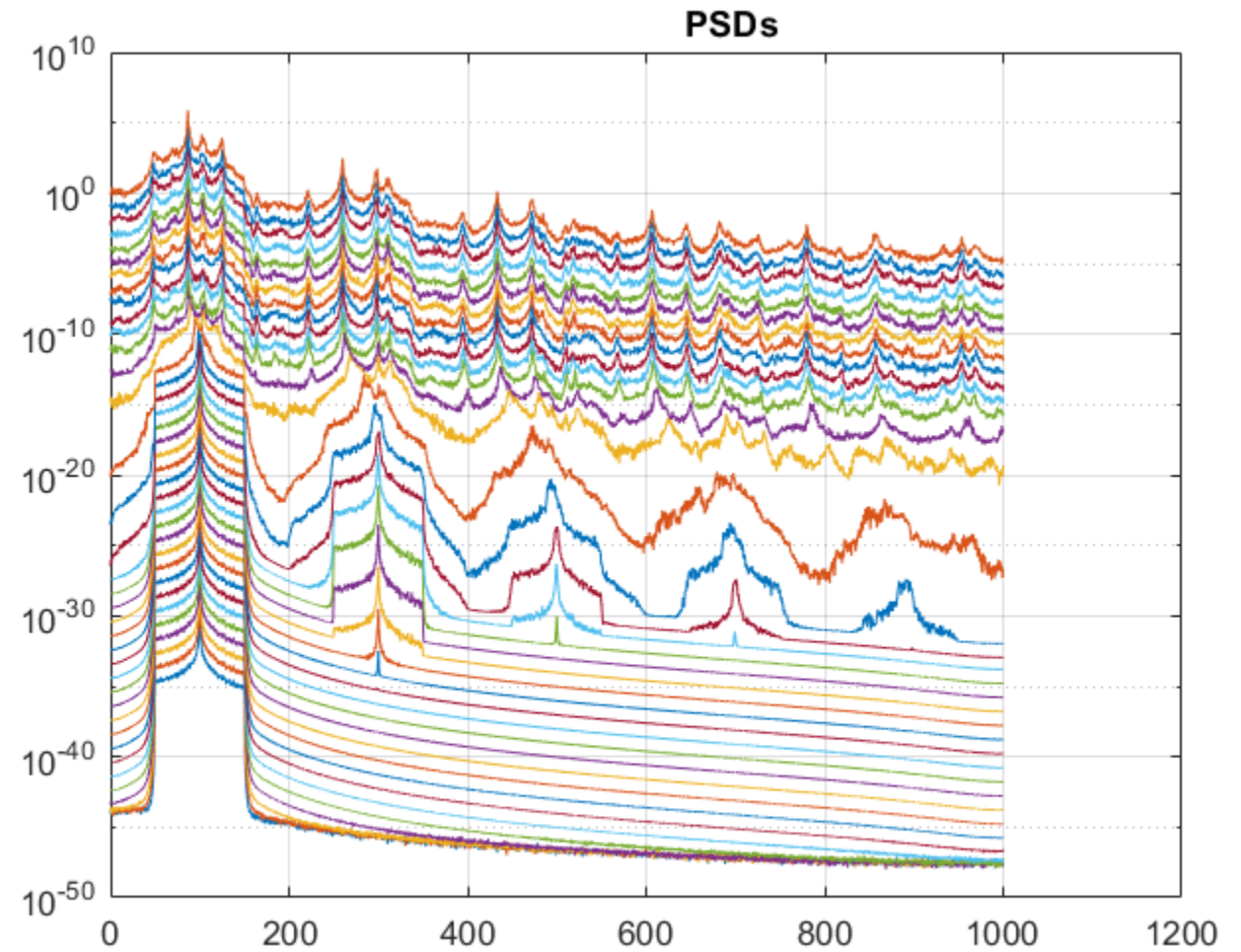
190-210

PSDs

Mode 1 deflection

Band limited mode 1 forcing
(50-150 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

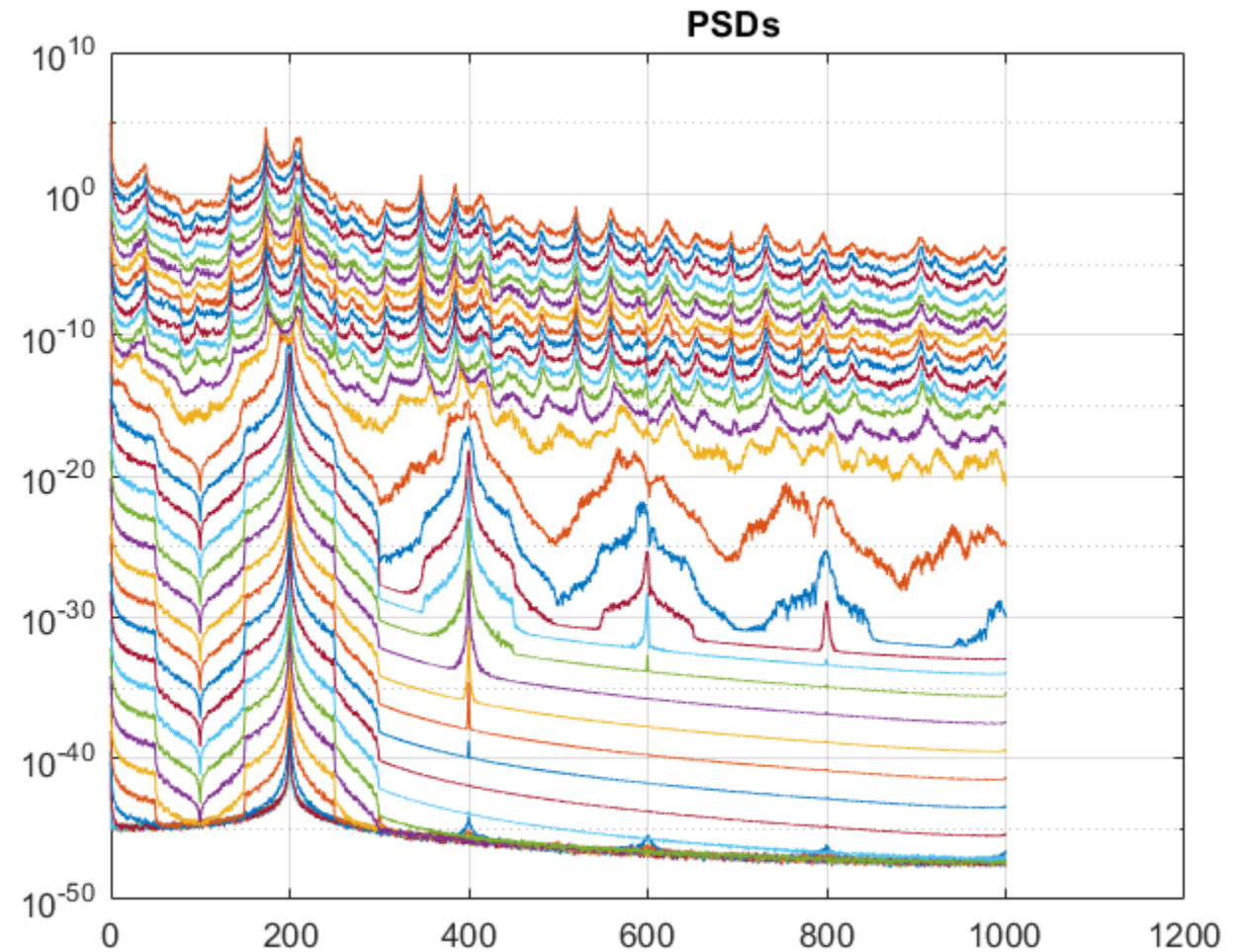
190-210

PSDs

Mode 2 deflection

Band limited mode 1 forcing
(50-150 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

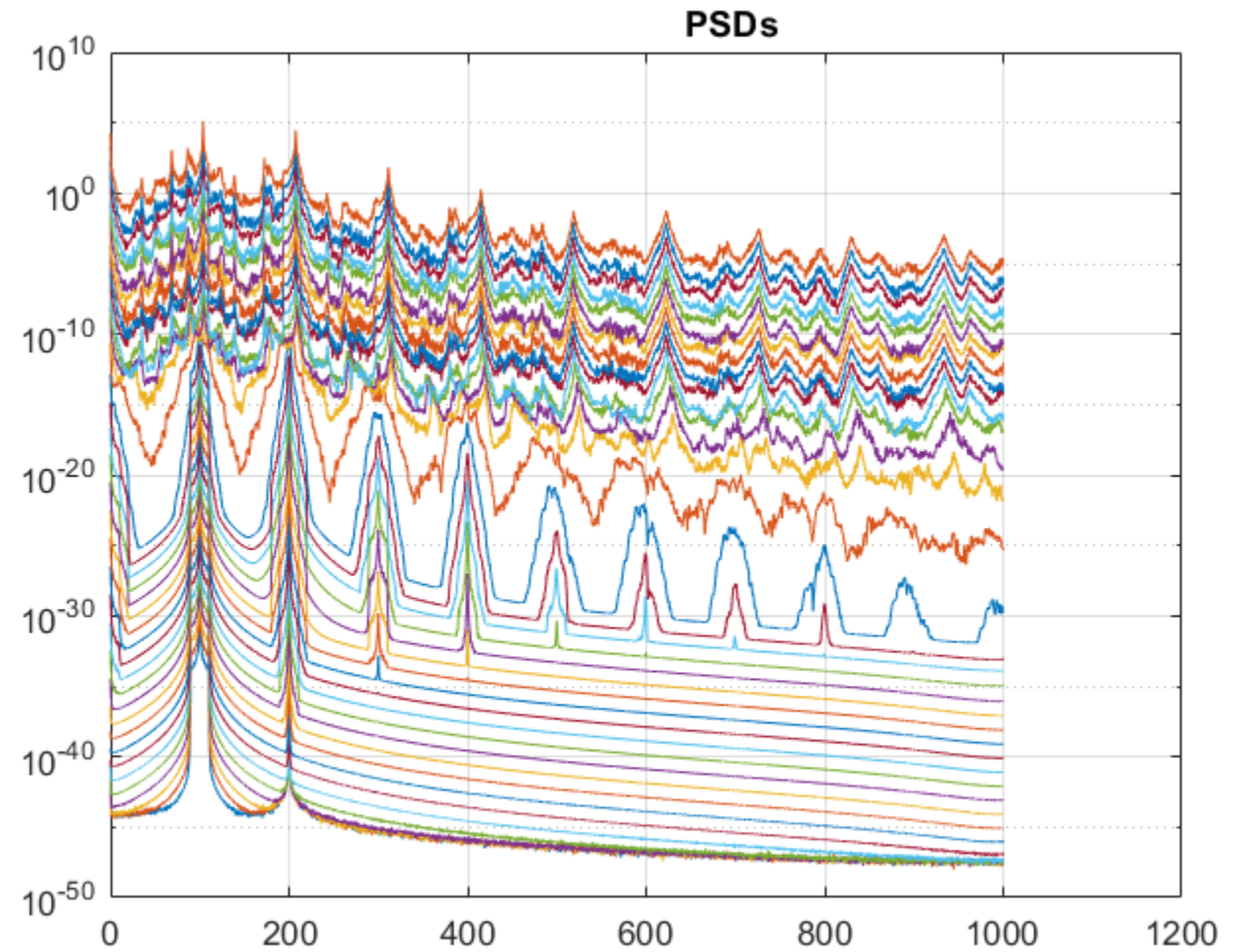
190-210

PSDs

Left spring deflection

Band limited mode 1 forcing
(90-110 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

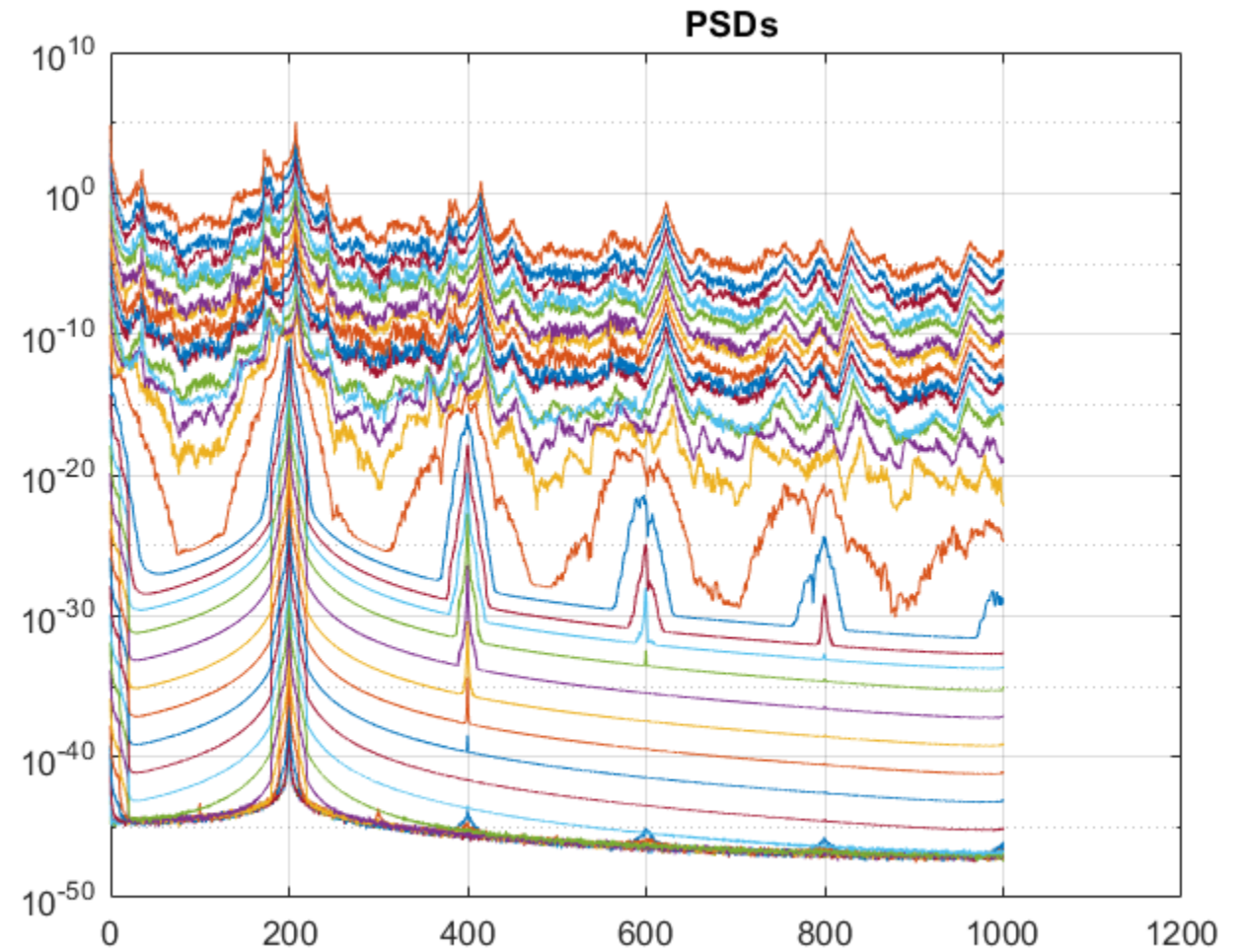
190-210

PSDs

Center spring deflection

Band limited mode 1 forcing
(90-110 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

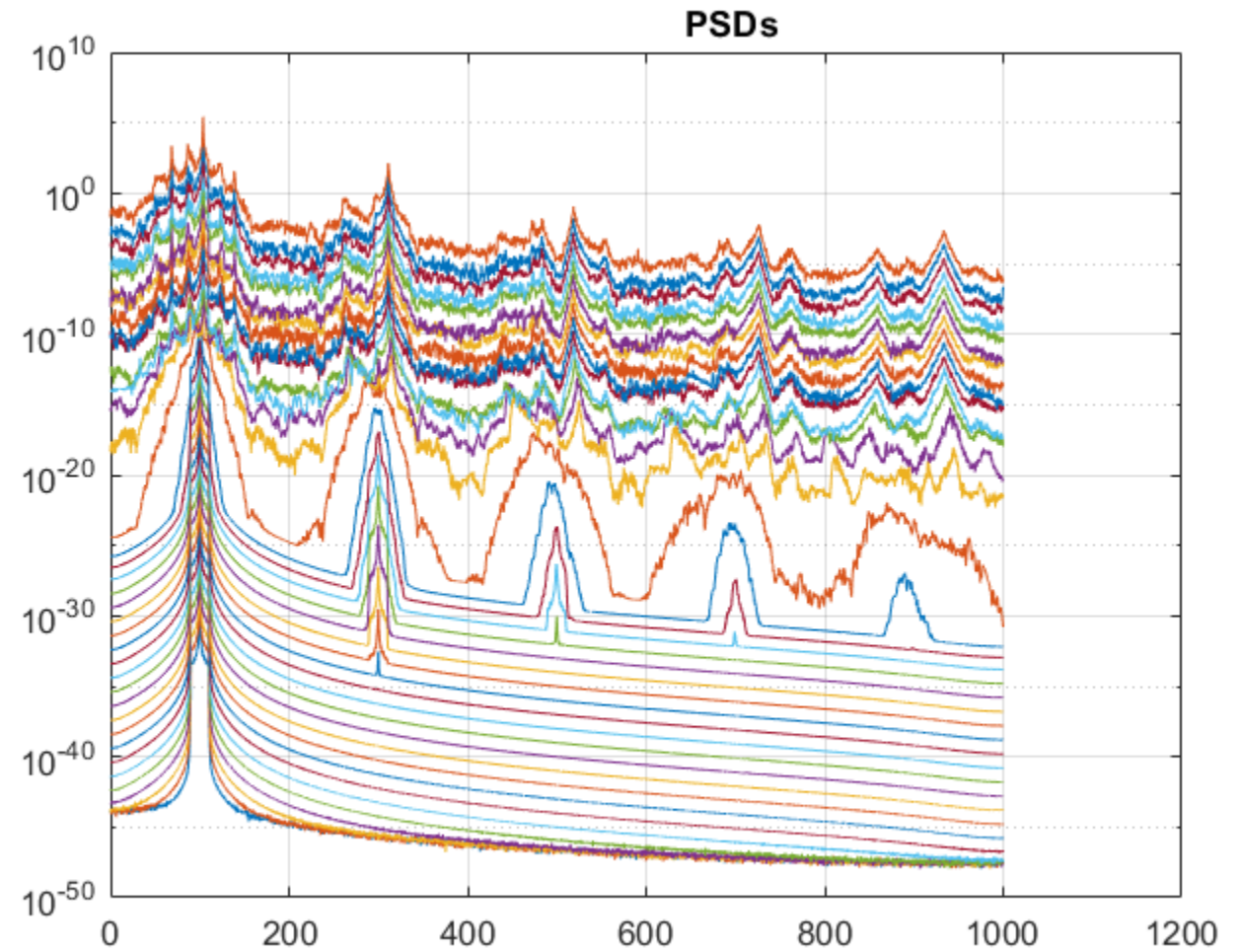
190-210

PSDs

Mode 1 deflection

Band limited mode 1 forcing
(90-110 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

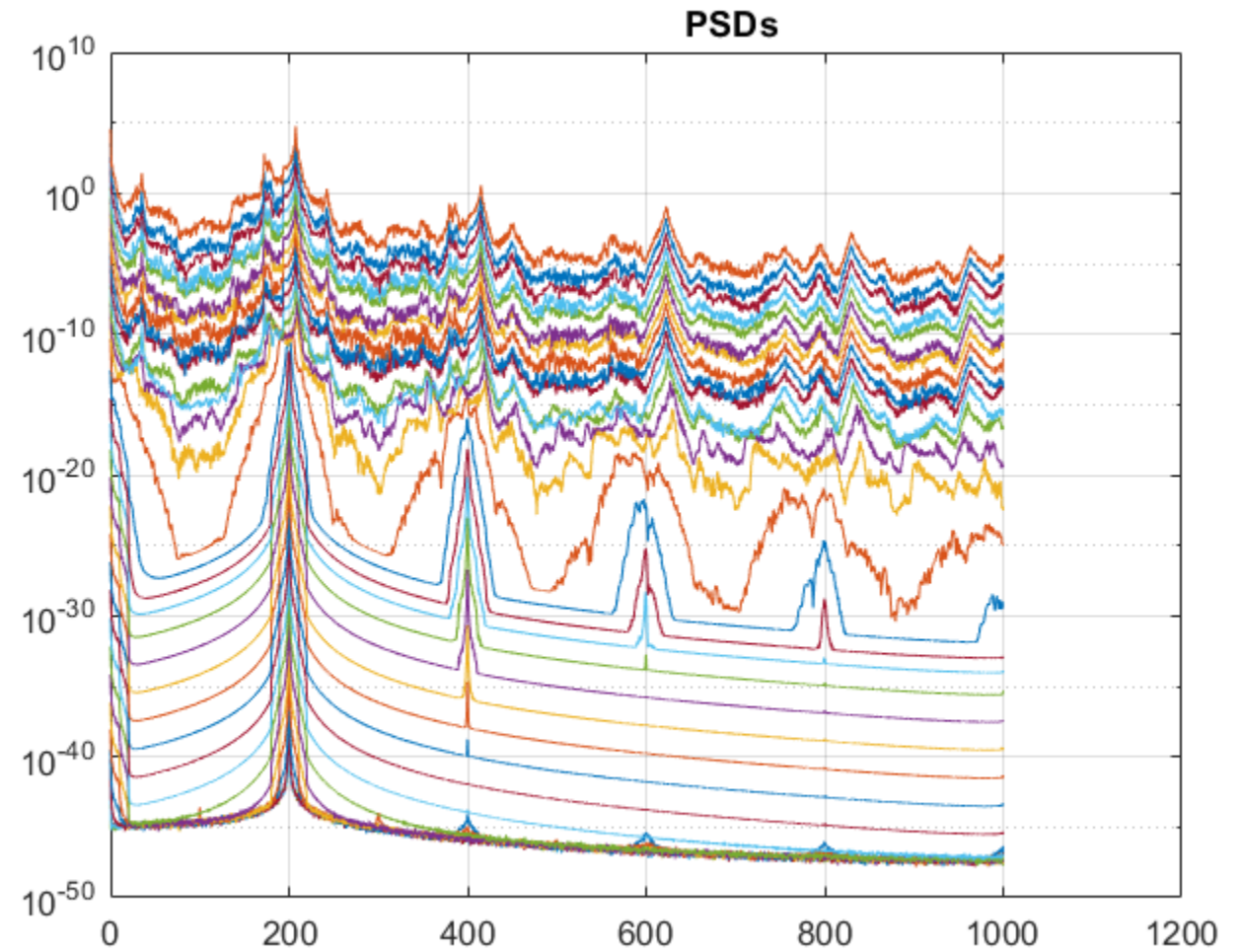
190-210

PSDs

Mode 2 deflection

Band limited mode 1 forcing
(90-110 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

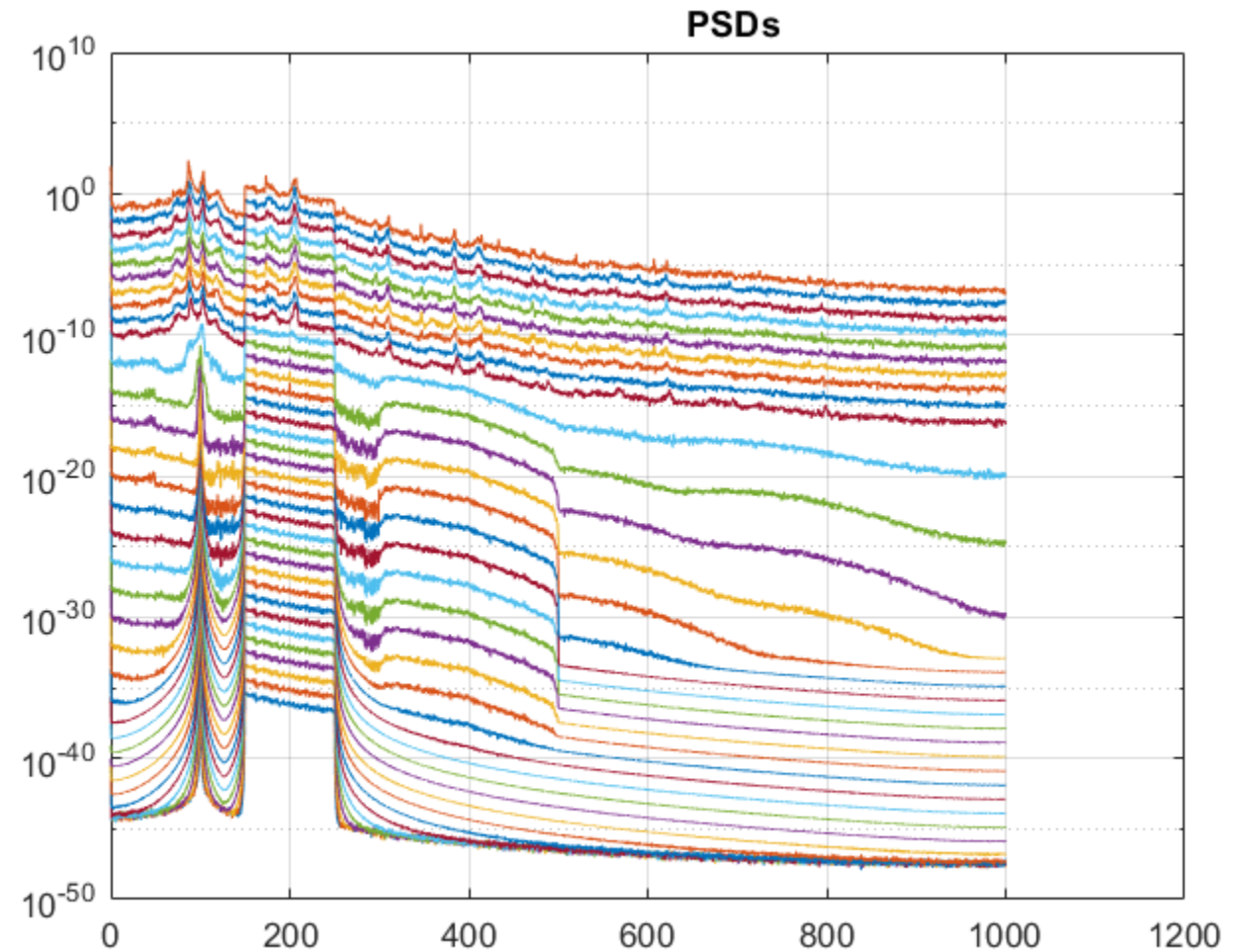
190-210

PSDs

Left spring deflection

Band limited mode 1 forcing
(150-250 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

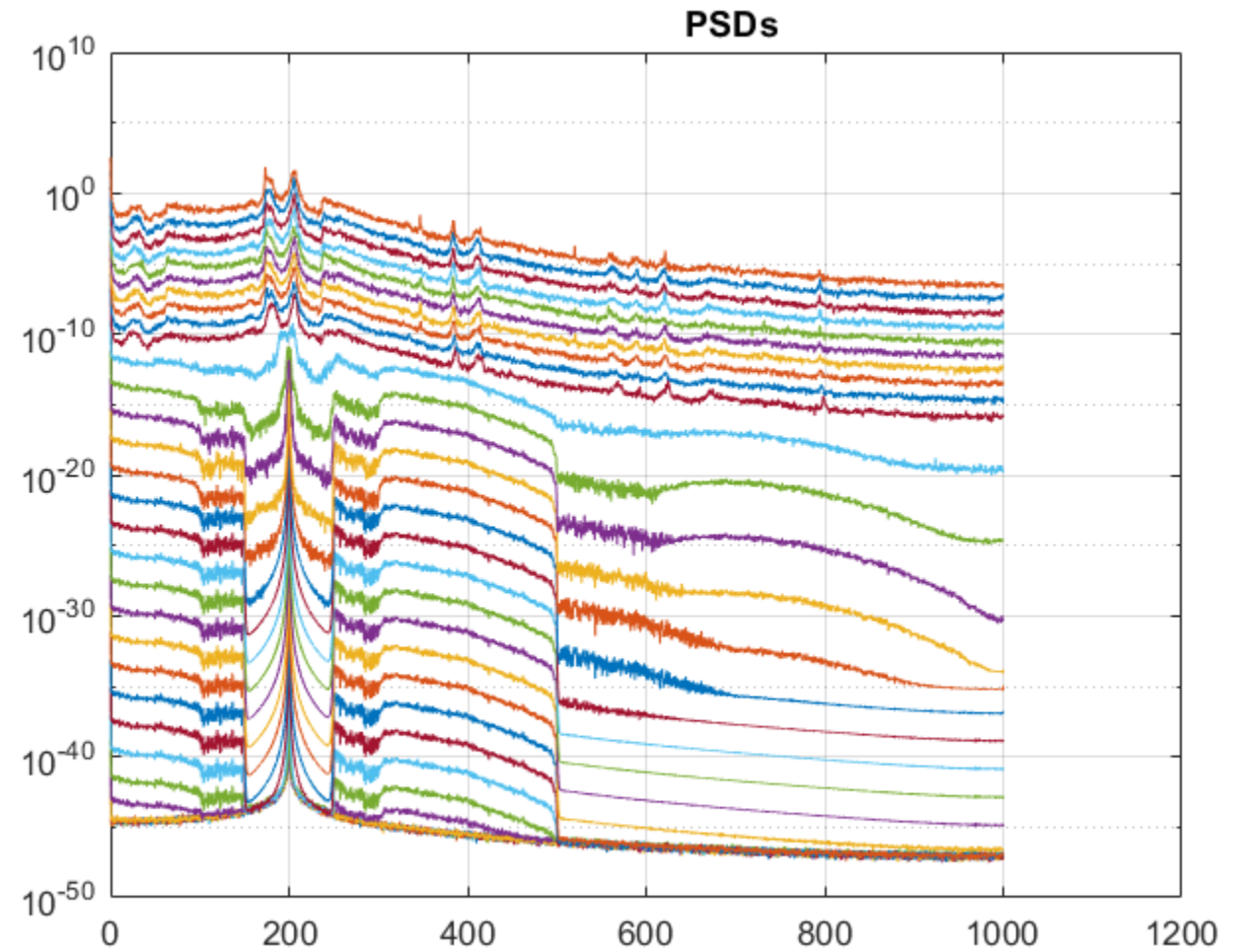
190-210

PSDs

Center spring deflection

Band limited mode 1 forcing
(150-250 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

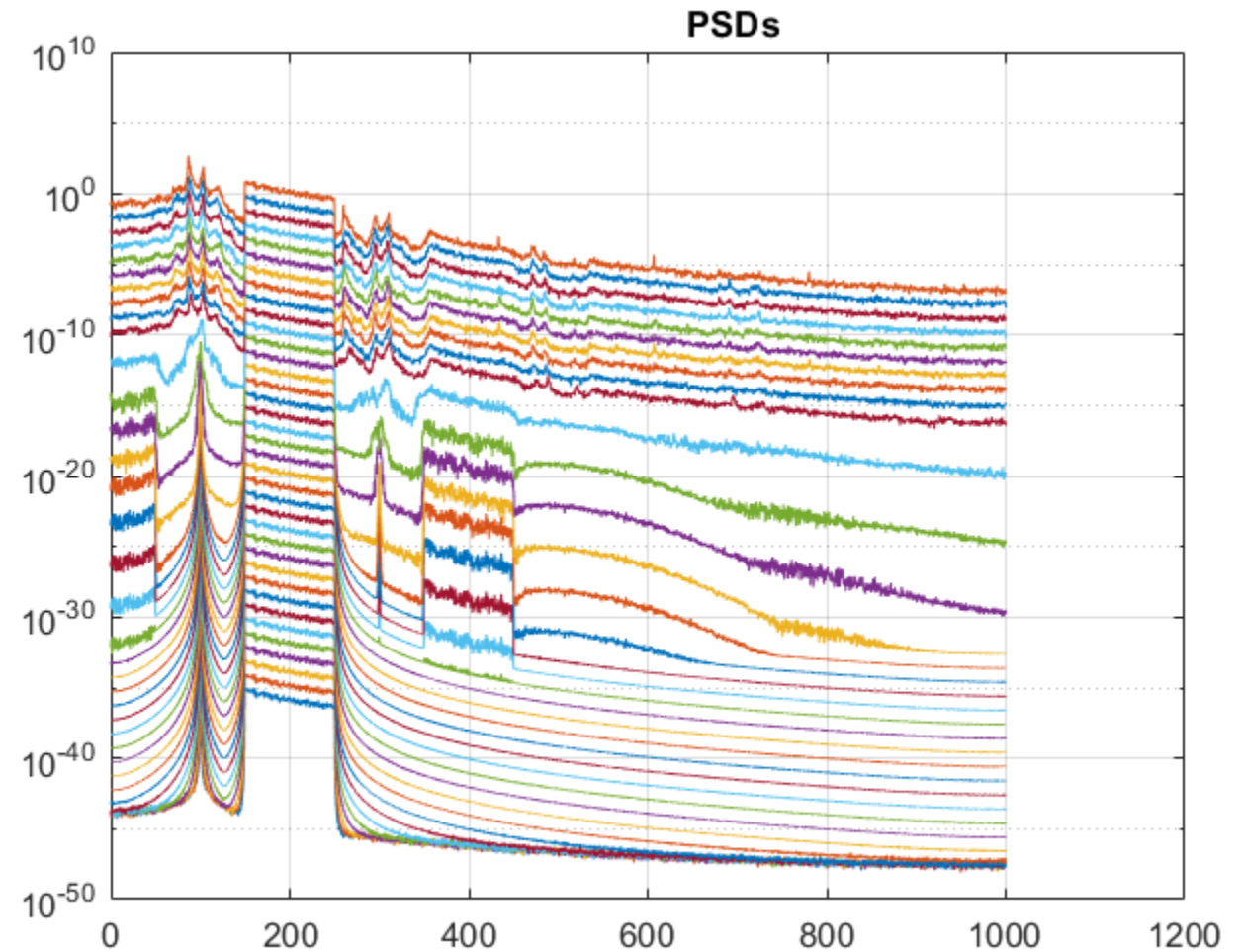
190-210

PSDs

Mode 1 deflection

Band limited mode 1 forcing
(150-250 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

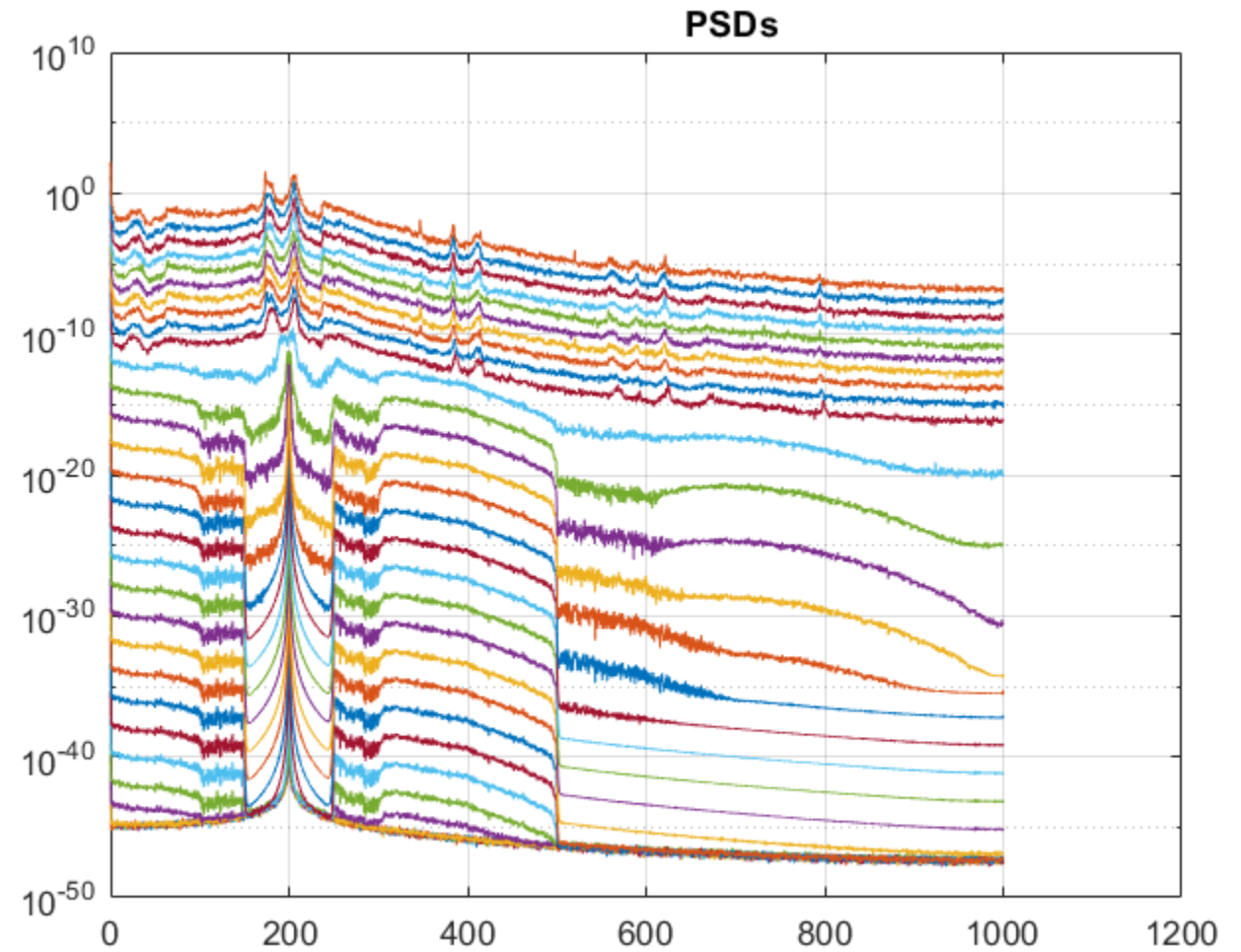
190-210

PSDs

Mode 2 deflection

Band limited mode 1 forcing
(150-250 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

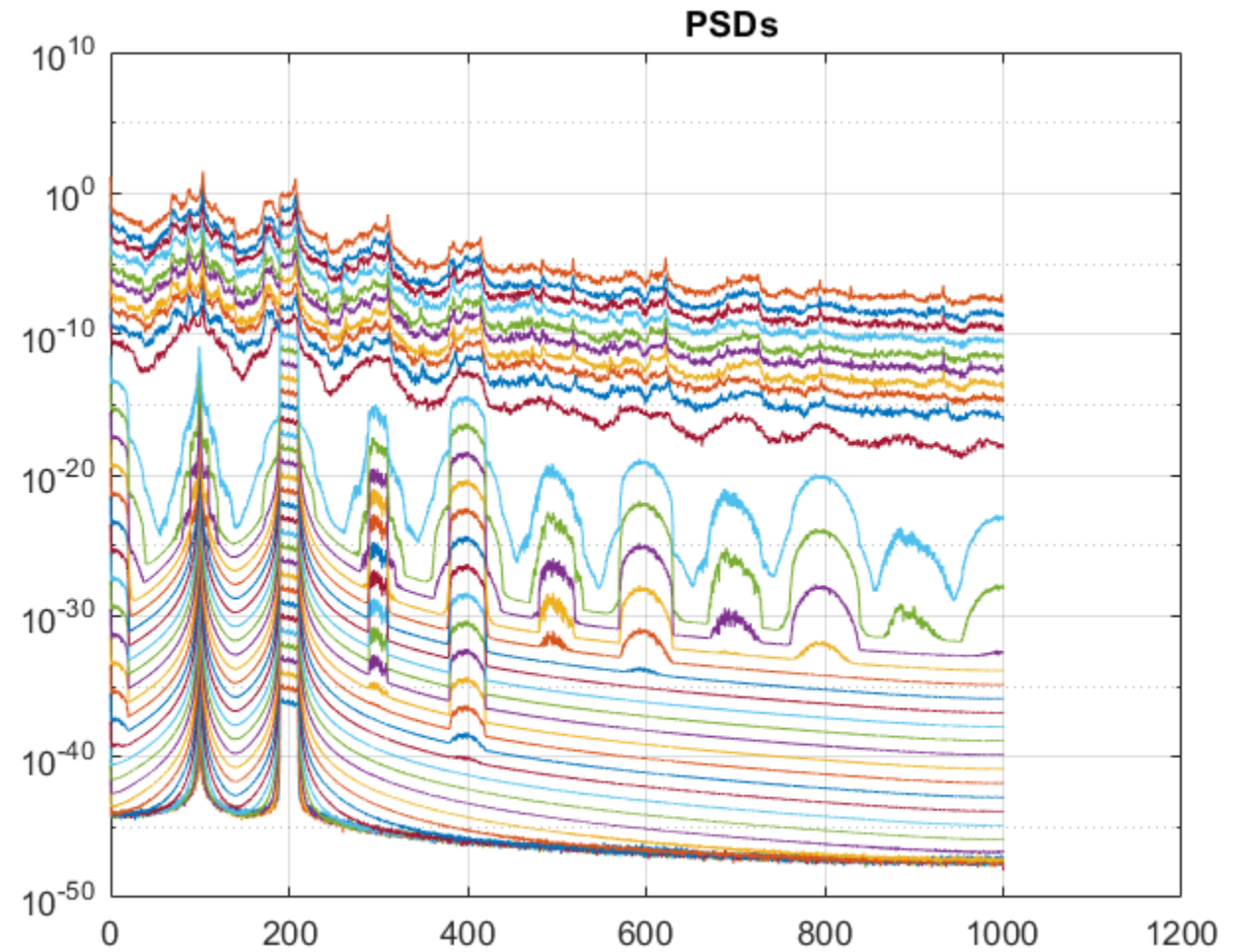
190-210

PSDs

Left spring deflection

Band limited mode 1 forcing
(190-210 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

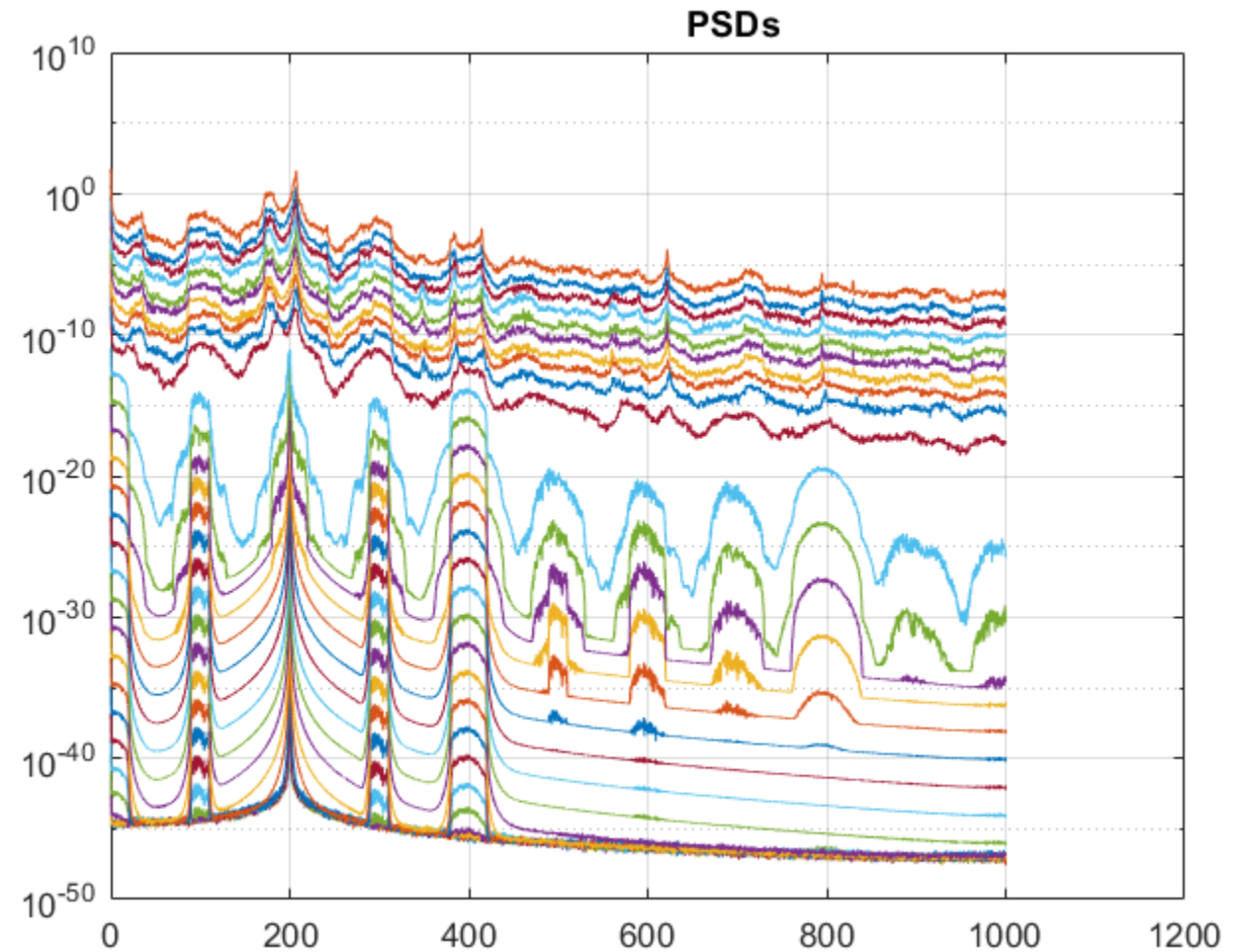
190-210

PSDs

Center spring deflection

Band limited mode 1 forcing
(190-210 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

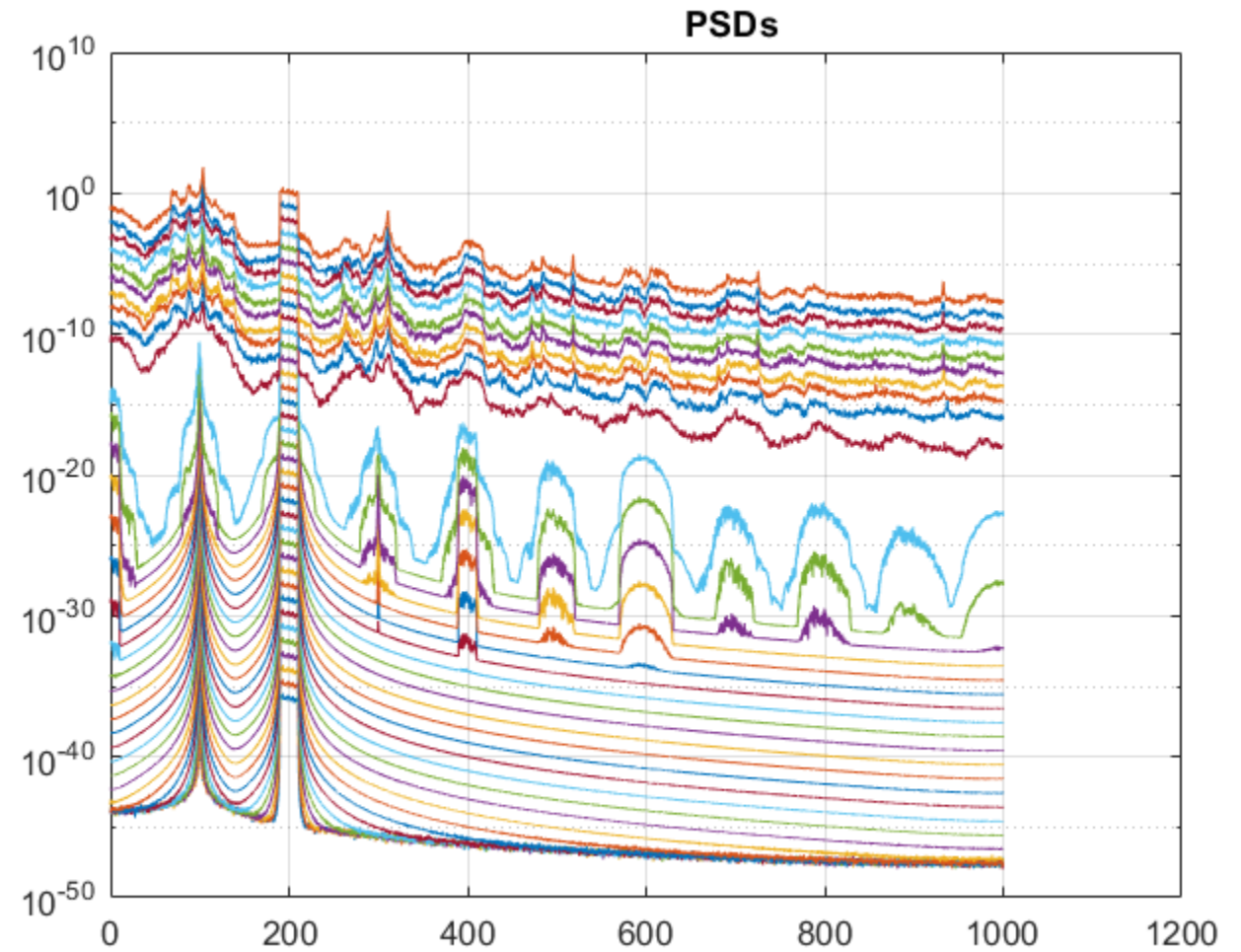
190-210

PSDs

Mode 1 deflection

Band limited mode 1 forcing
(190-210 Hz)

Amplitude Range: 10^{-10} – 10^8



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

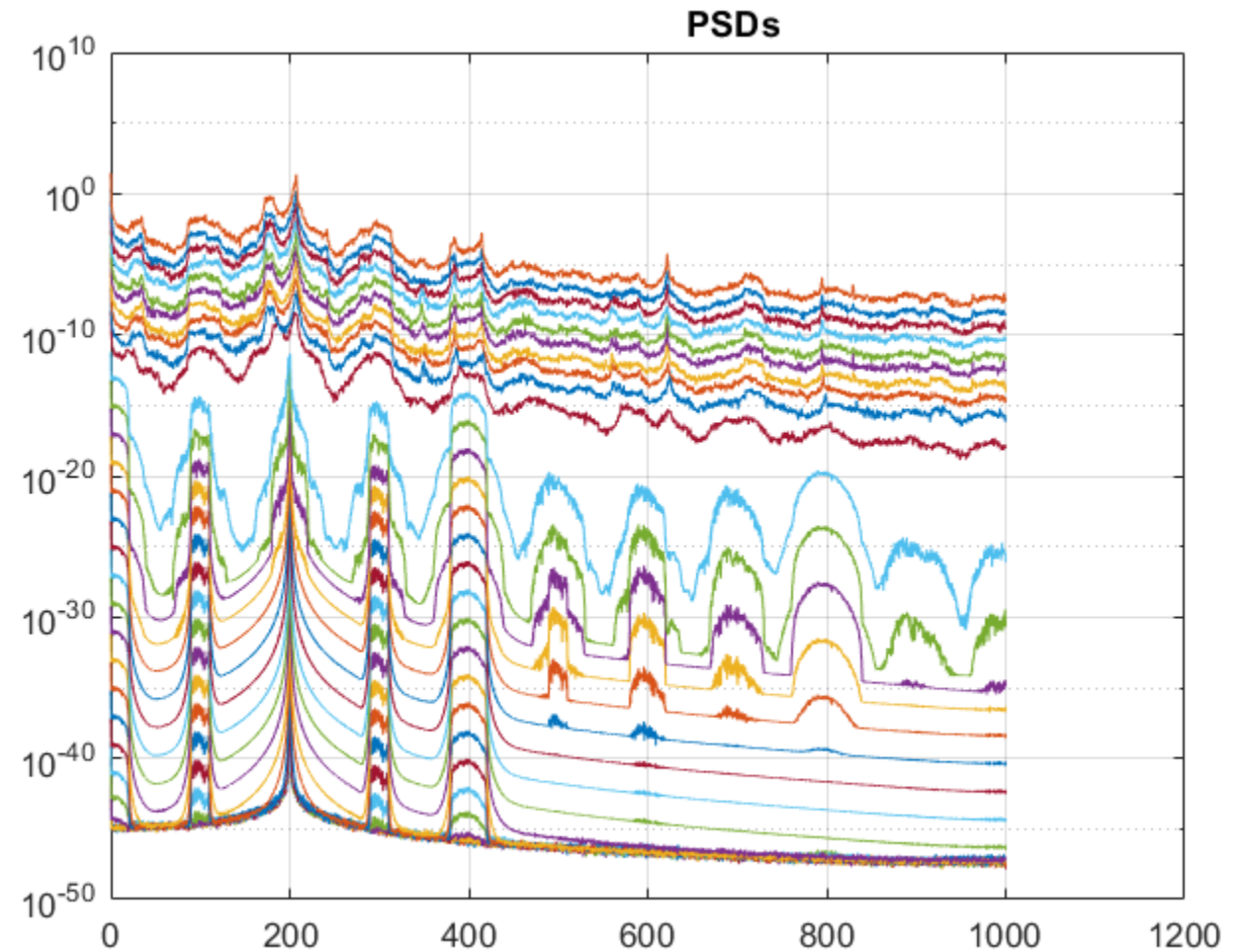
190-210

PSDs

Mode 2 deflection

Band limited mode 1 forcing
(190-210 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

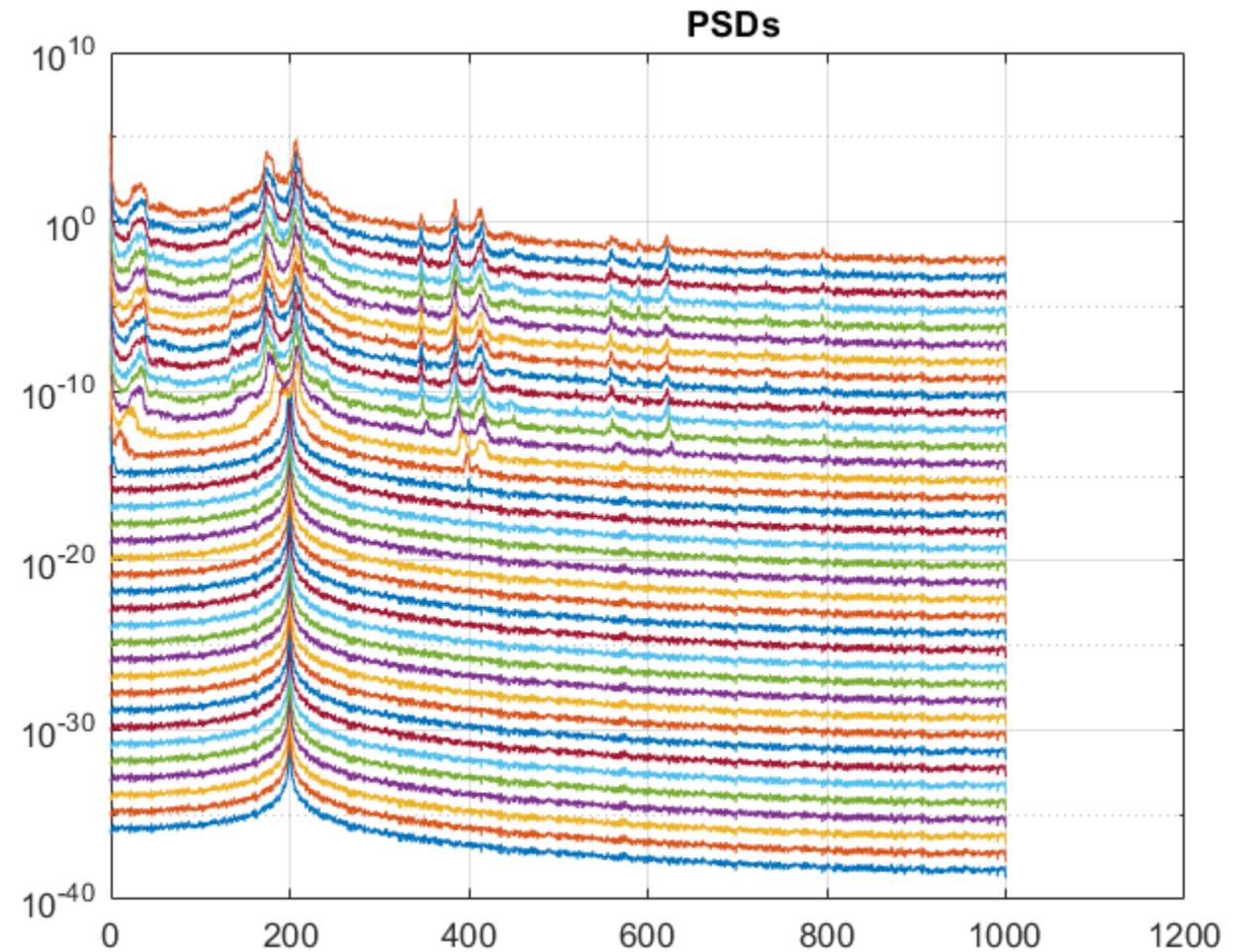
190-210

PSDs

Left spring deflection

Mode 2 forcing

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

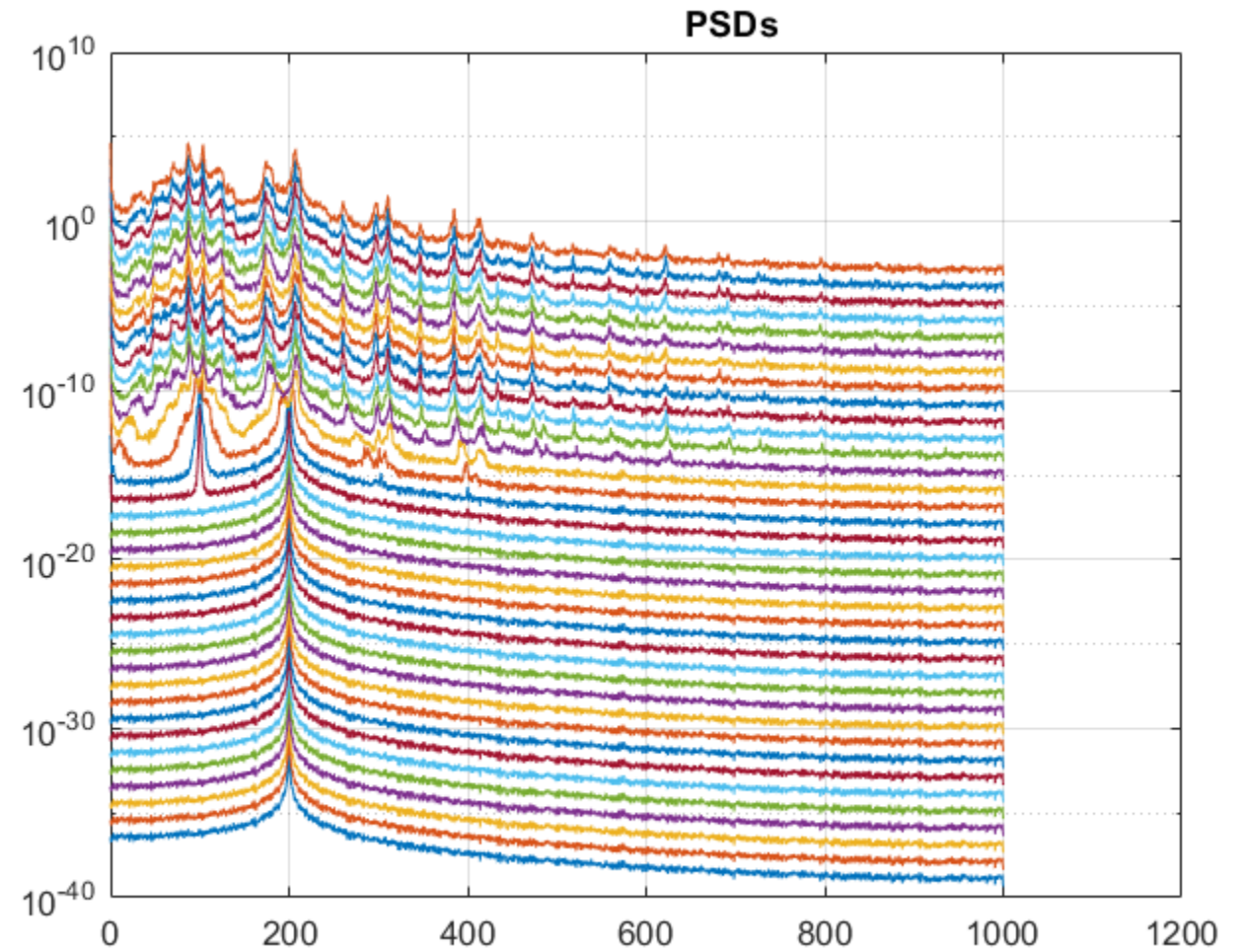
190-210

PSDs

Center spring deflection

Mode 2 forcing

Amplitude Range: 10^{-10} – 10^8



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

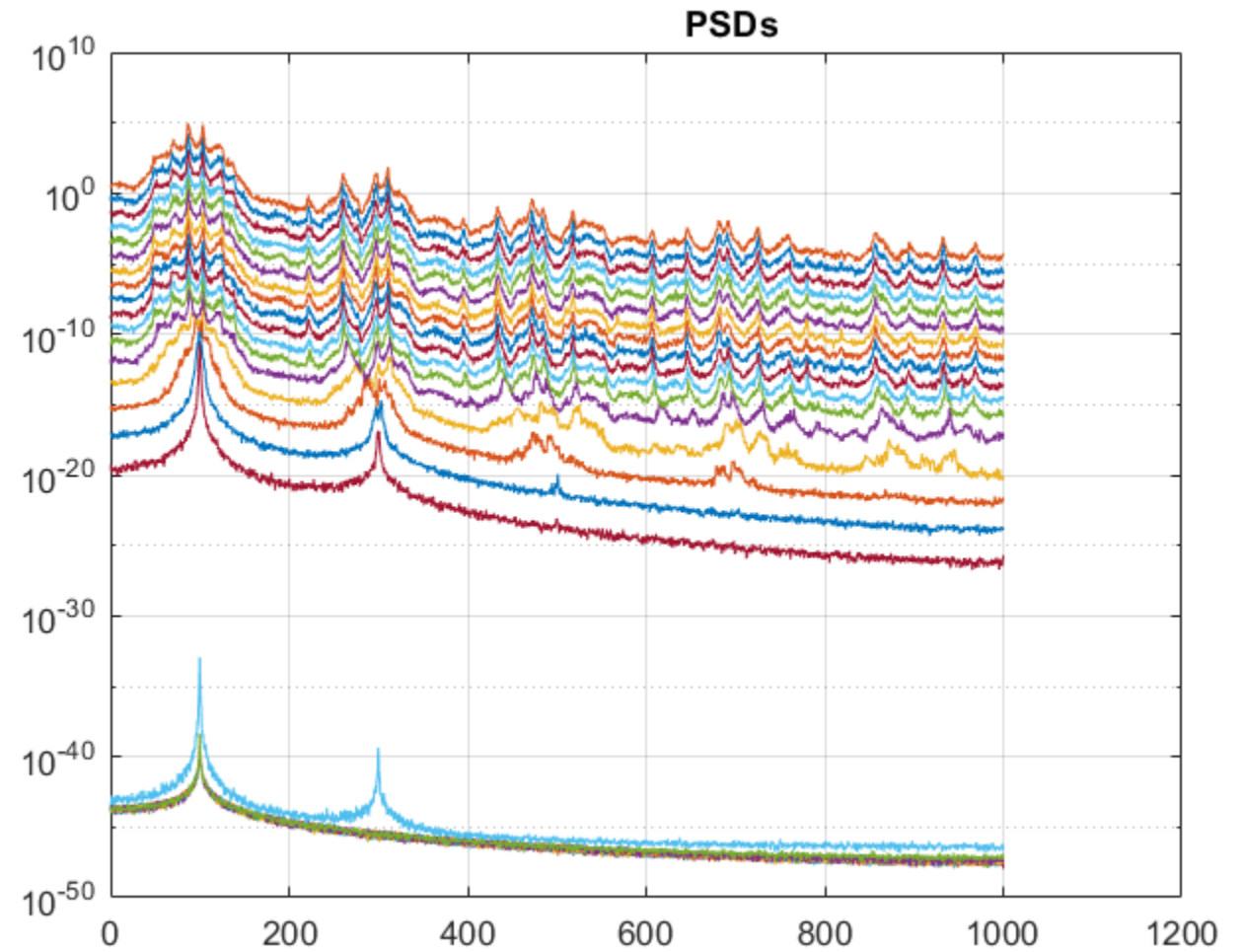
190-210

PSDs

Mode 1 deflection

Mode 2 forcing

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

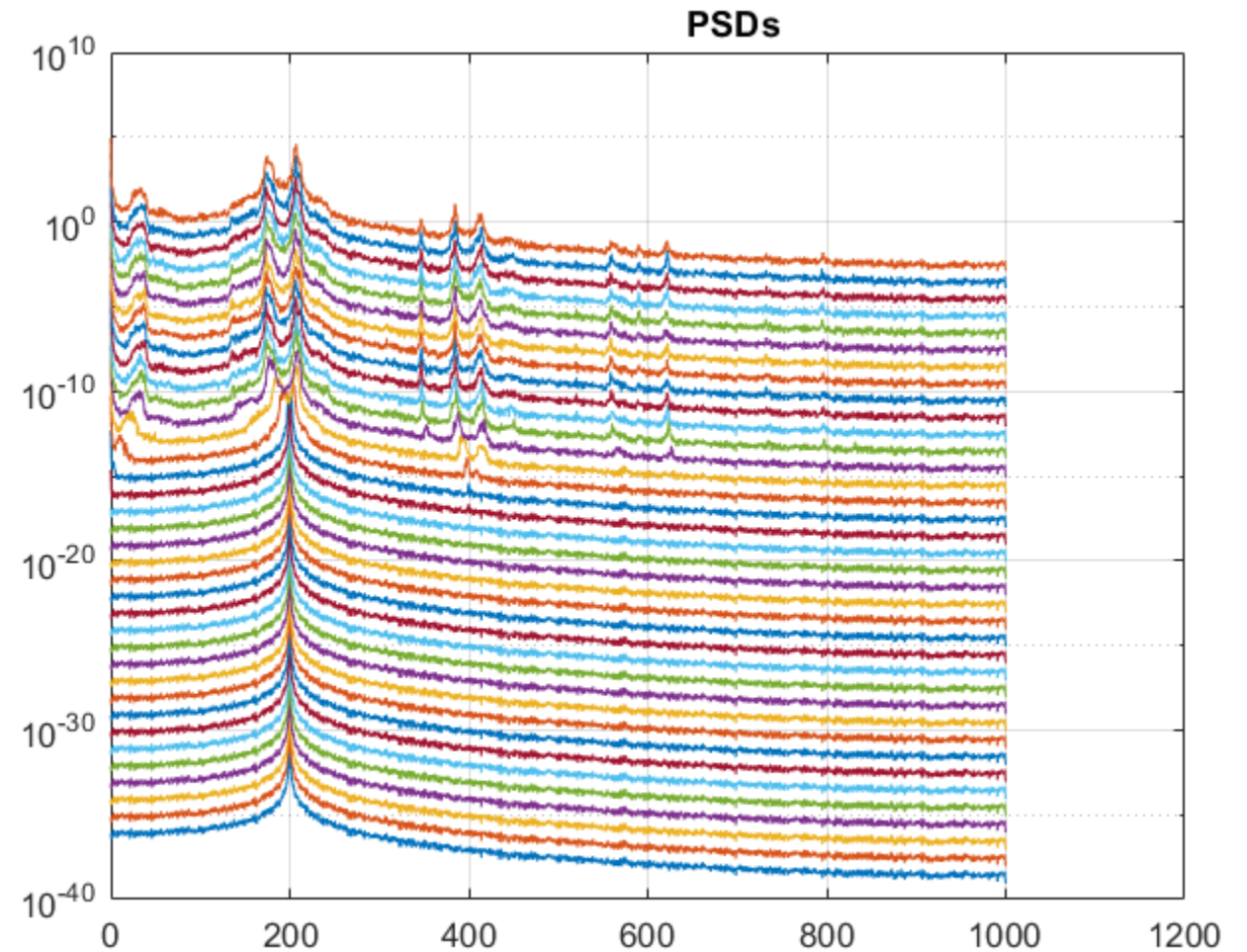
190-210

PSDs

Mode 2 deflection

Mode 2 forcing

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

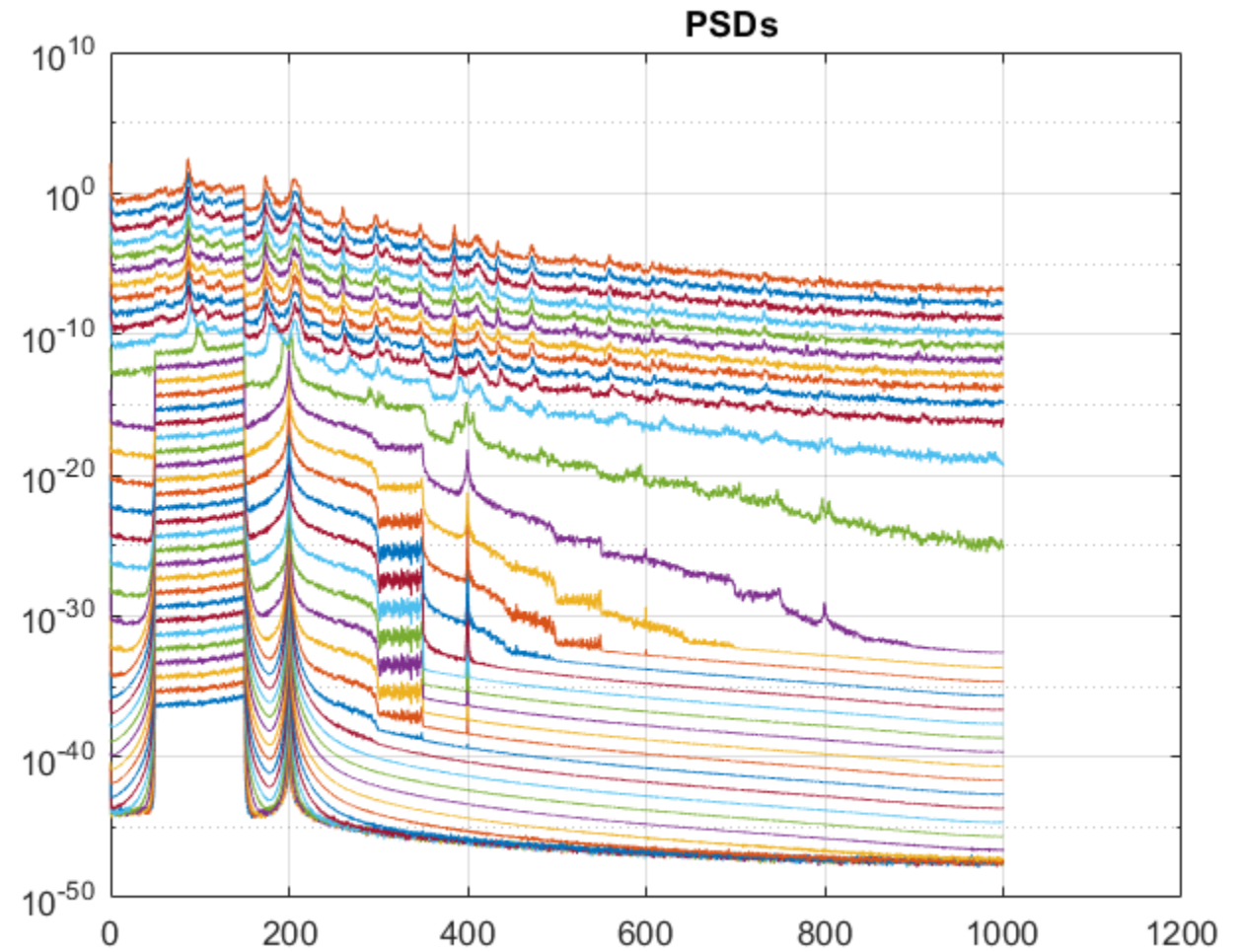
190-210

PSDs

Left spring deflection

Band limited mode 2 forcing
(50-150 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

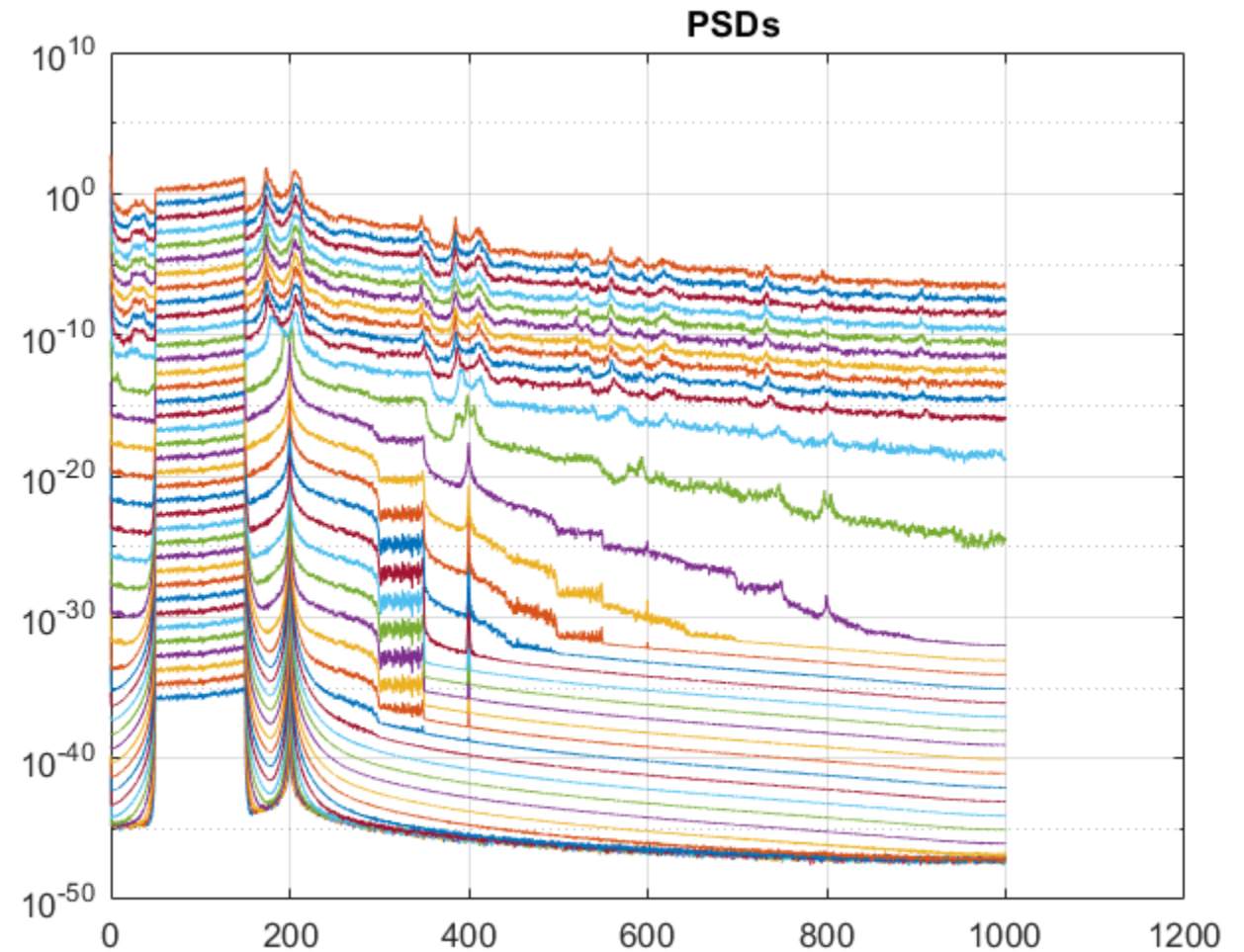
190-210

PSDs

Center spring deflection

Band limited mode 2 forcing
(50-150 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

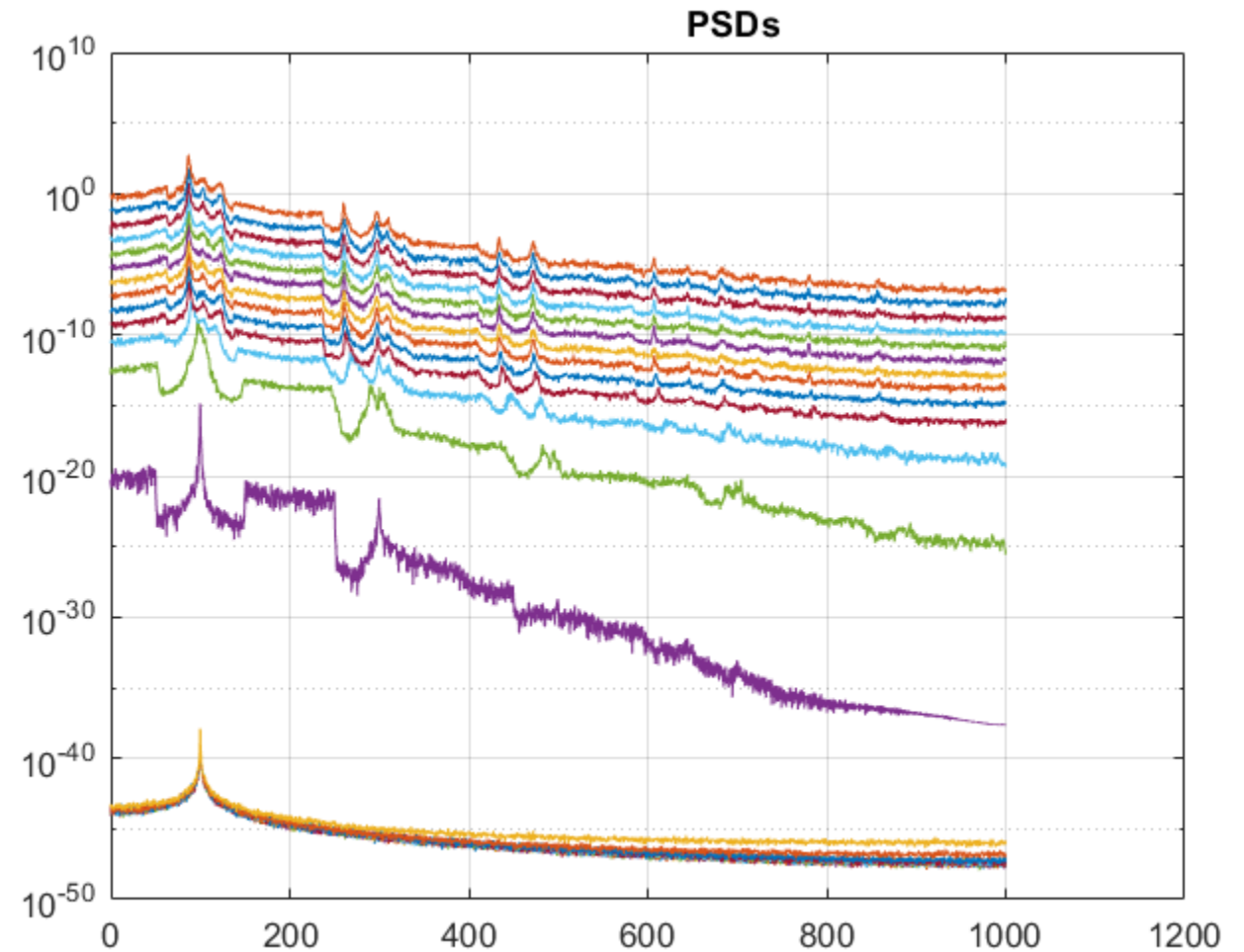
190-210

PSDs

Mode 1 deflection

Band limited mode 2 forcing
(50-150 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

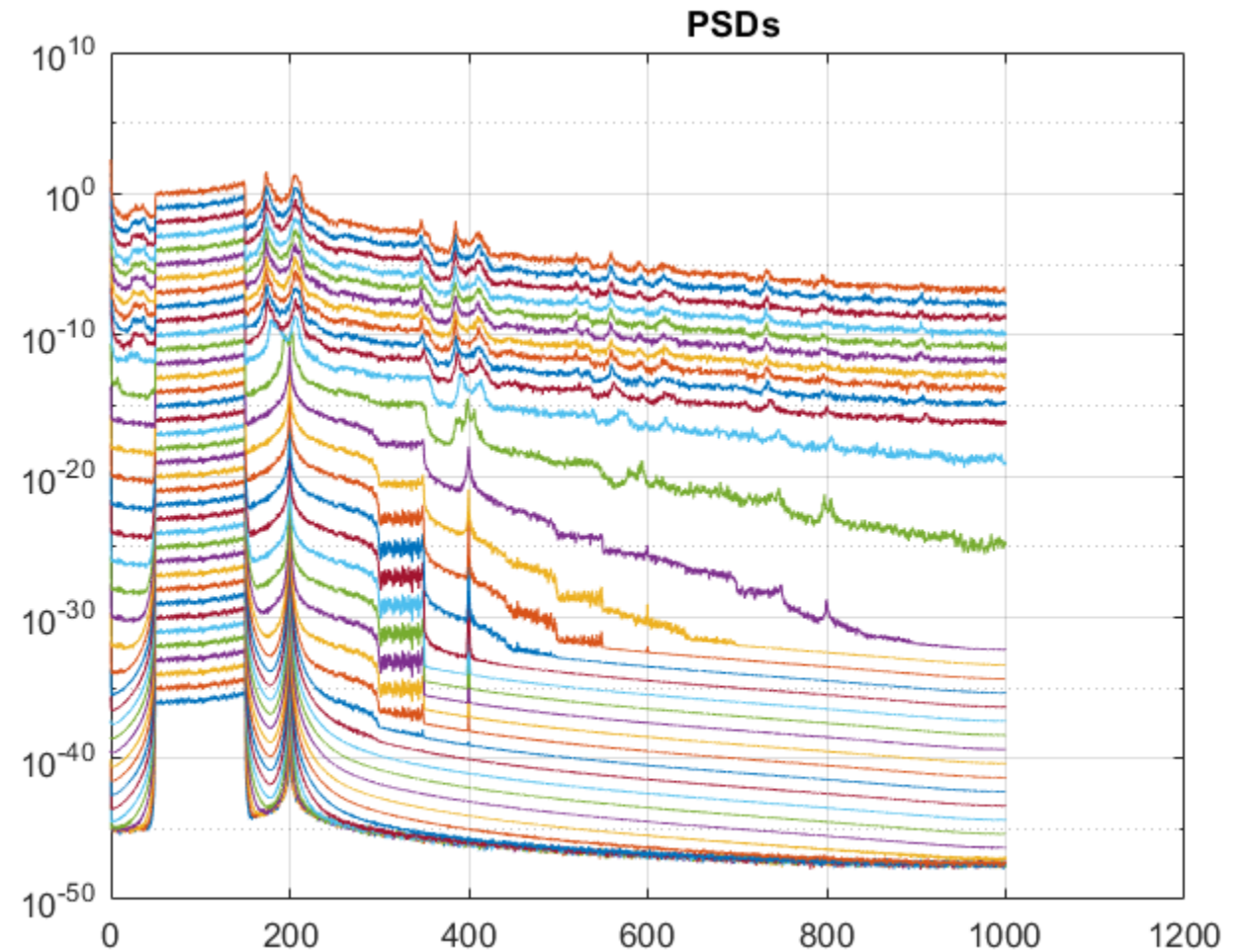
190-210

PSDs

Mode 2 deflection

Band limited mode 2 forcing
(50-150 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

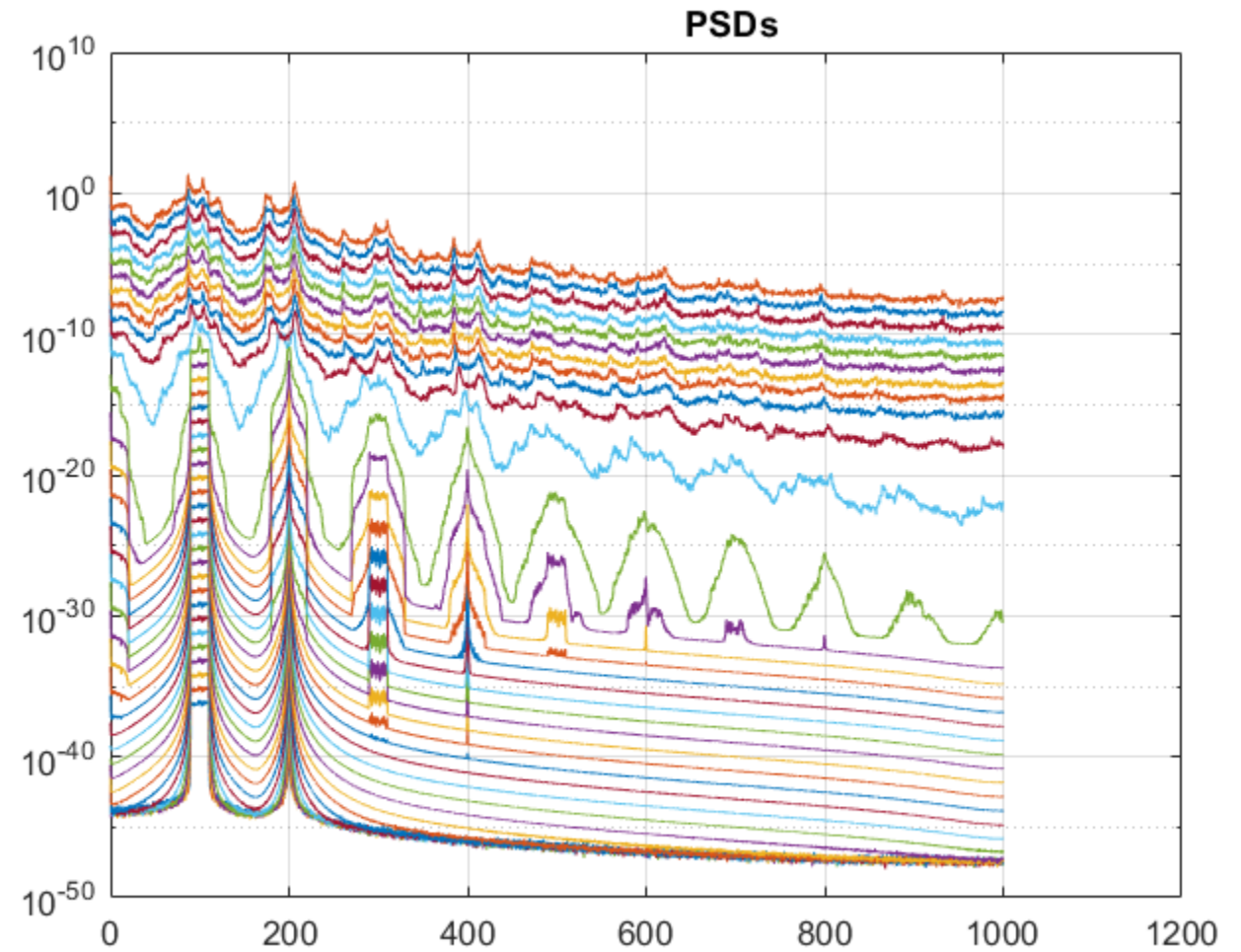
190-210

PSDs

Left spring deflection

Band limited mode 2 forcing
(90-110 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

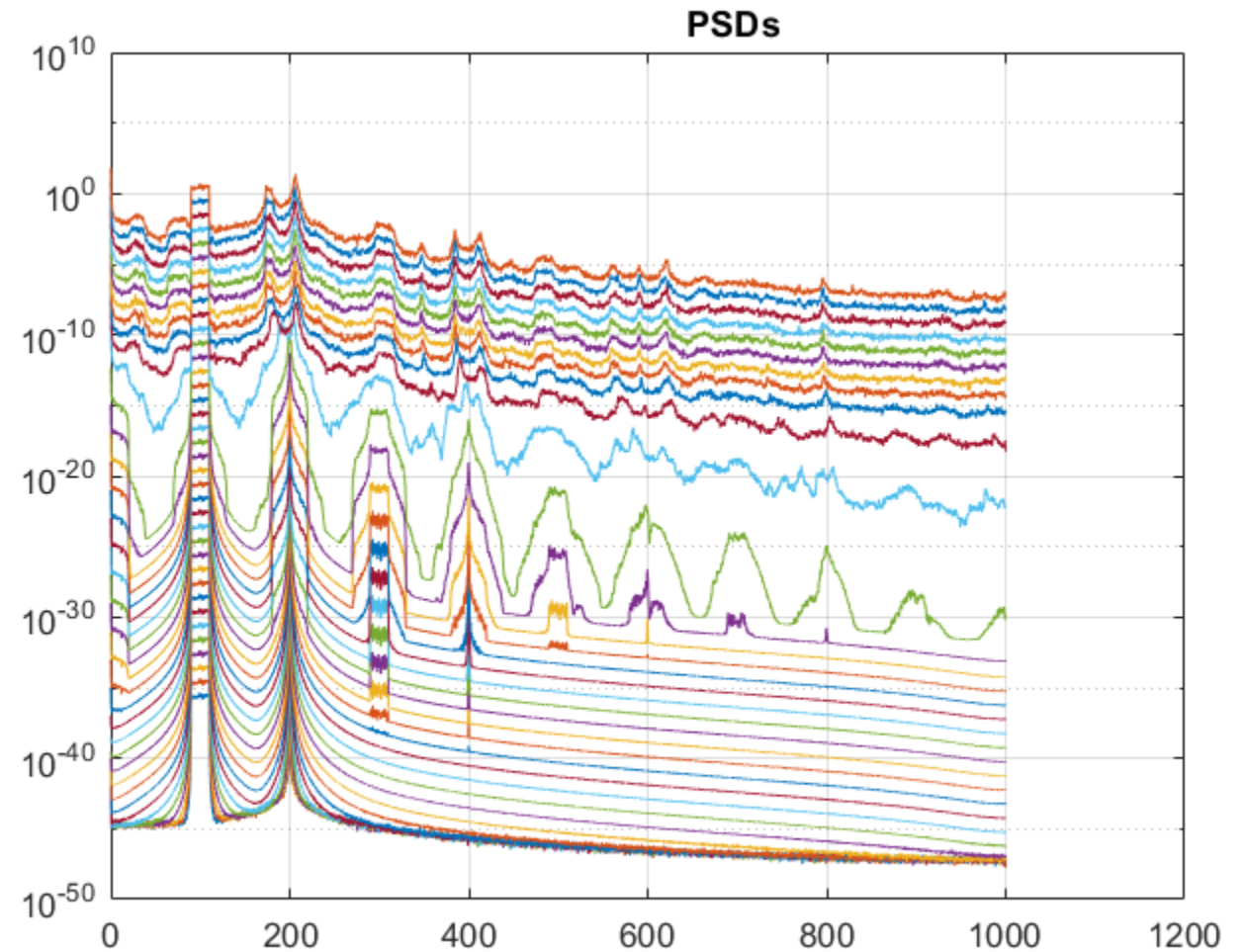
190-210

PSDs

Center spring deflection

Band limited mode 2 forcing
(90-110 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

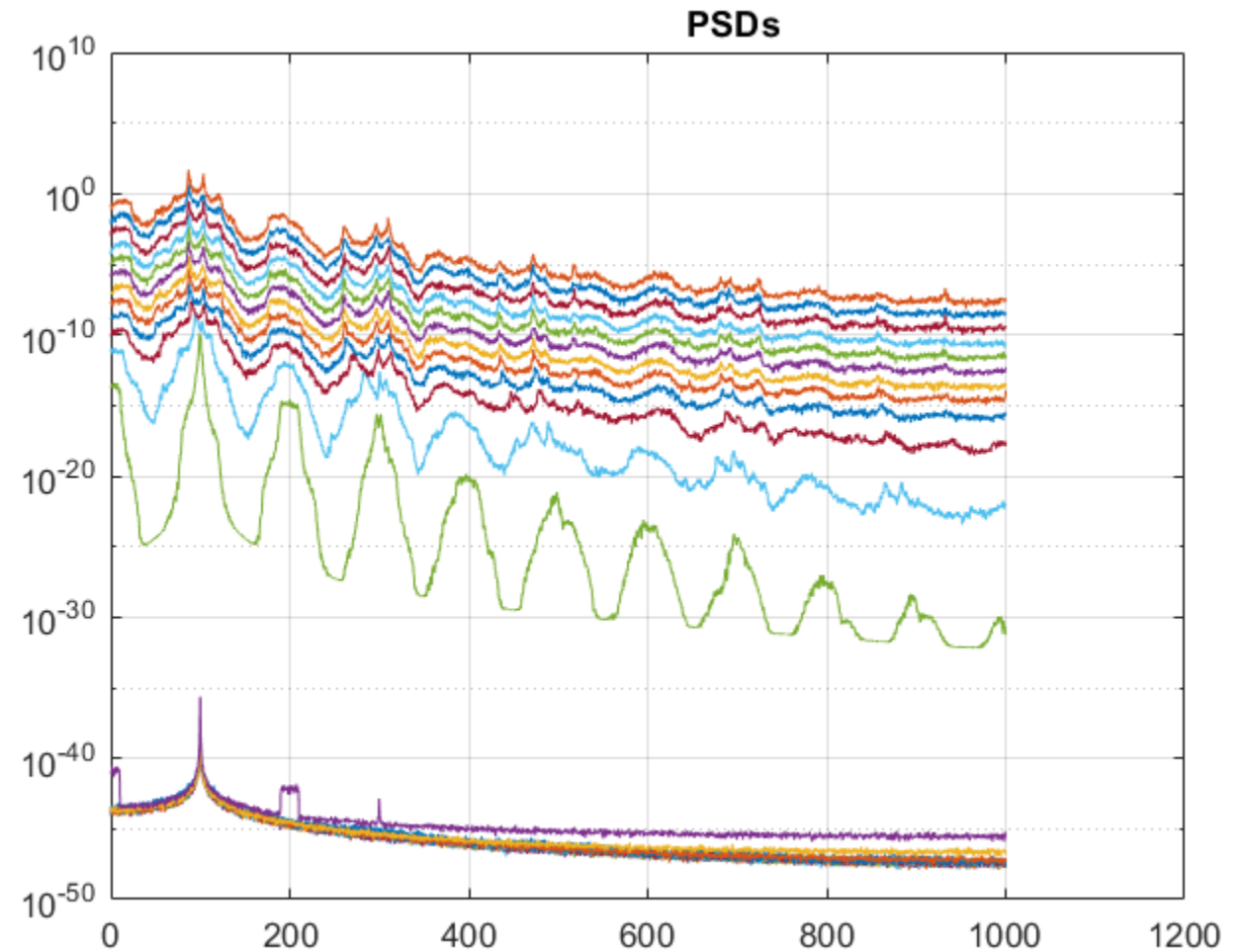
190-210

PSDs

Mode 1 deflection

Band limited mode 2 forcing
(90-110 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

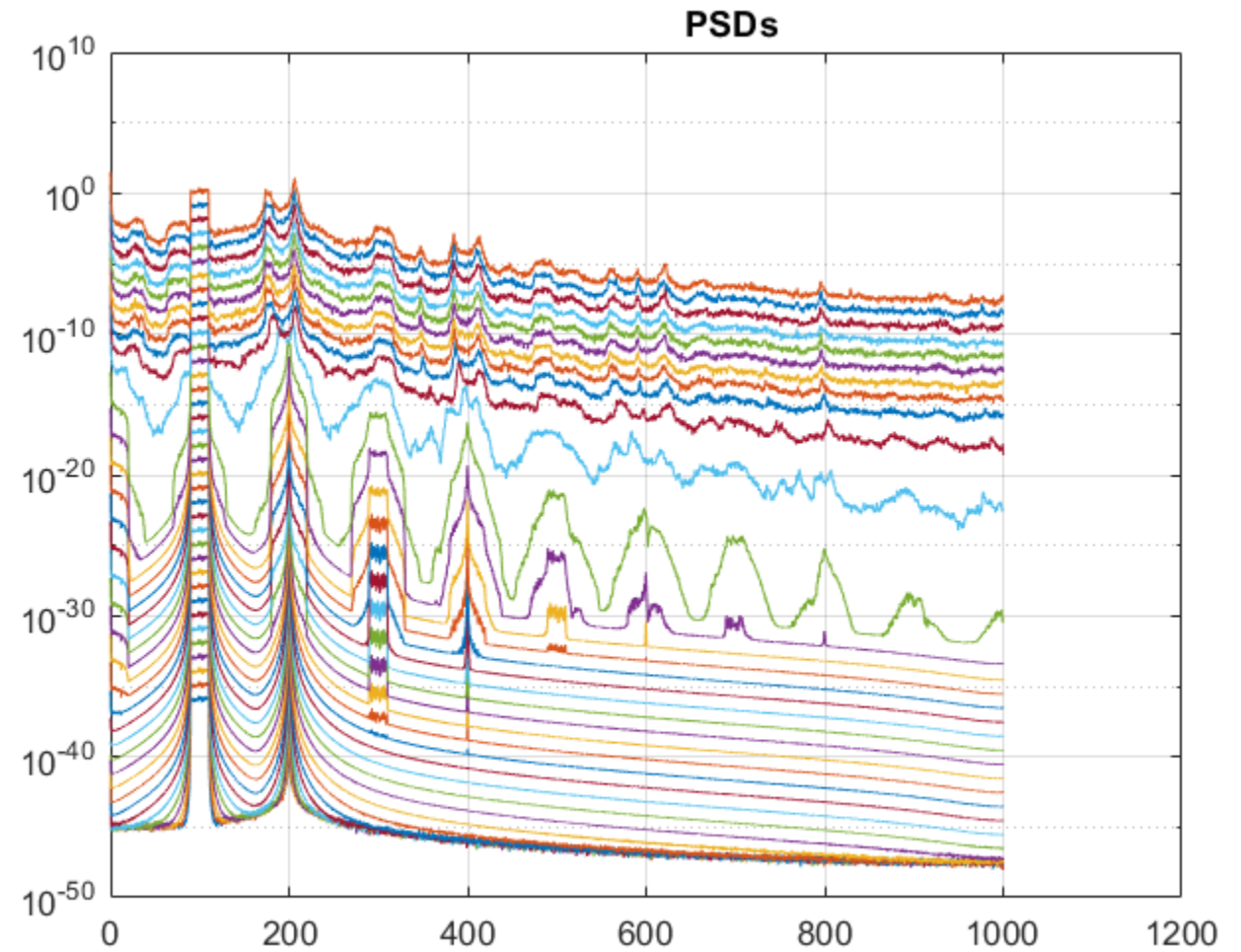
190-210

PSDs

Mode 2 deflection

Band limited mode 2 forcing
(90-110 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

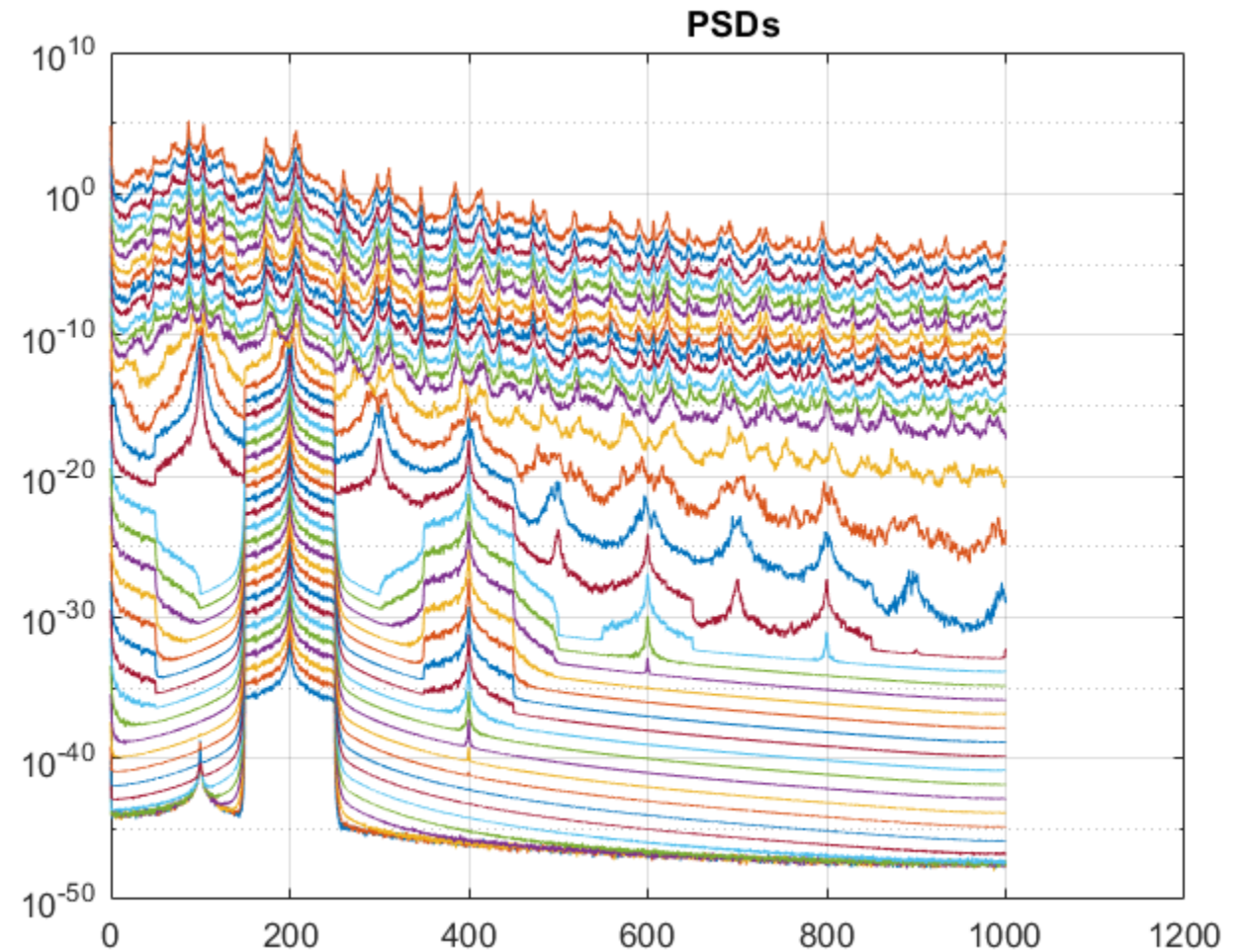
190-210

PSDs

Left spring deflection

Band limited mode 2 forcing
(150-250 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

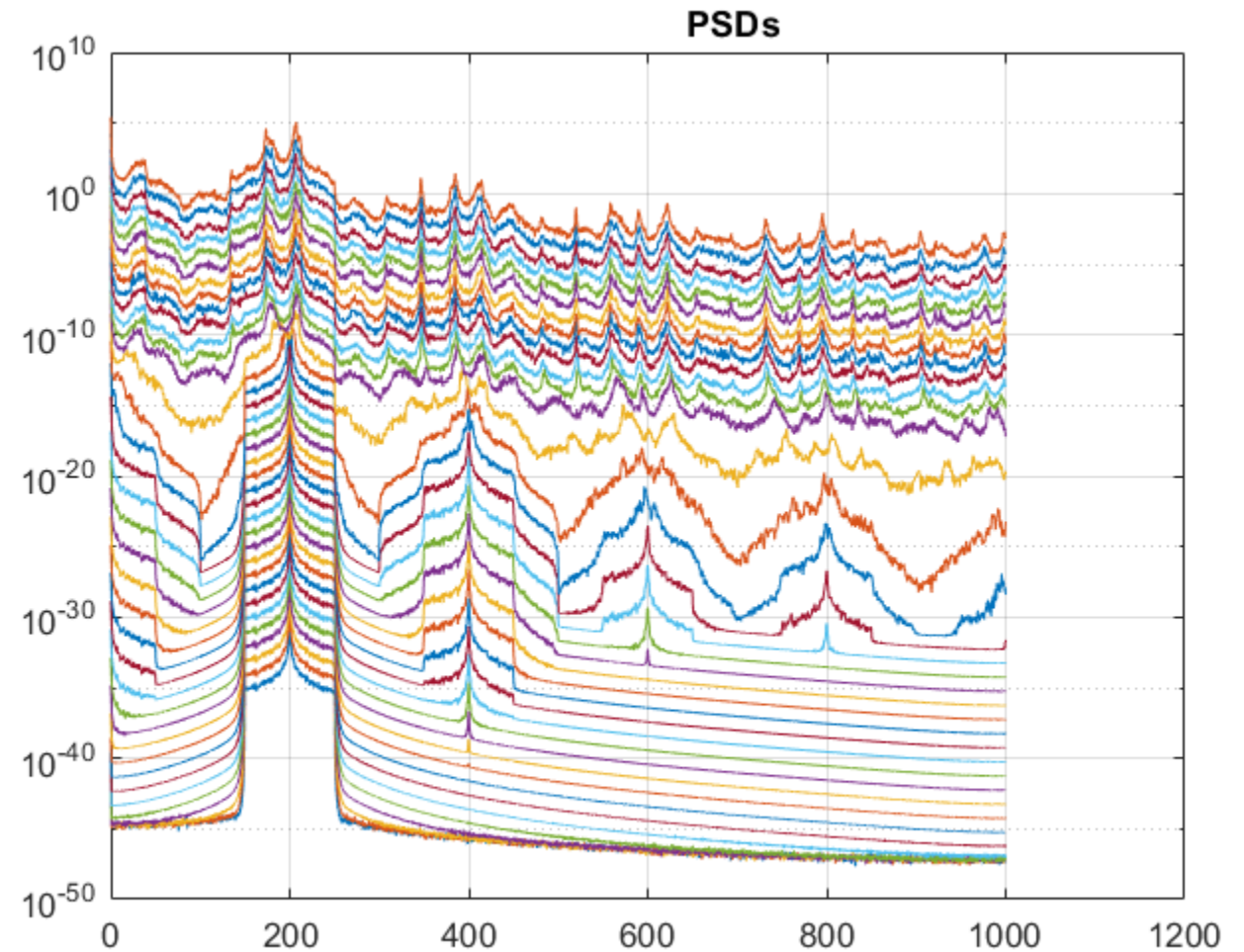
190-210

PSDs

Center spring deflection

Band limited mode 2 forcing
(150-250 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

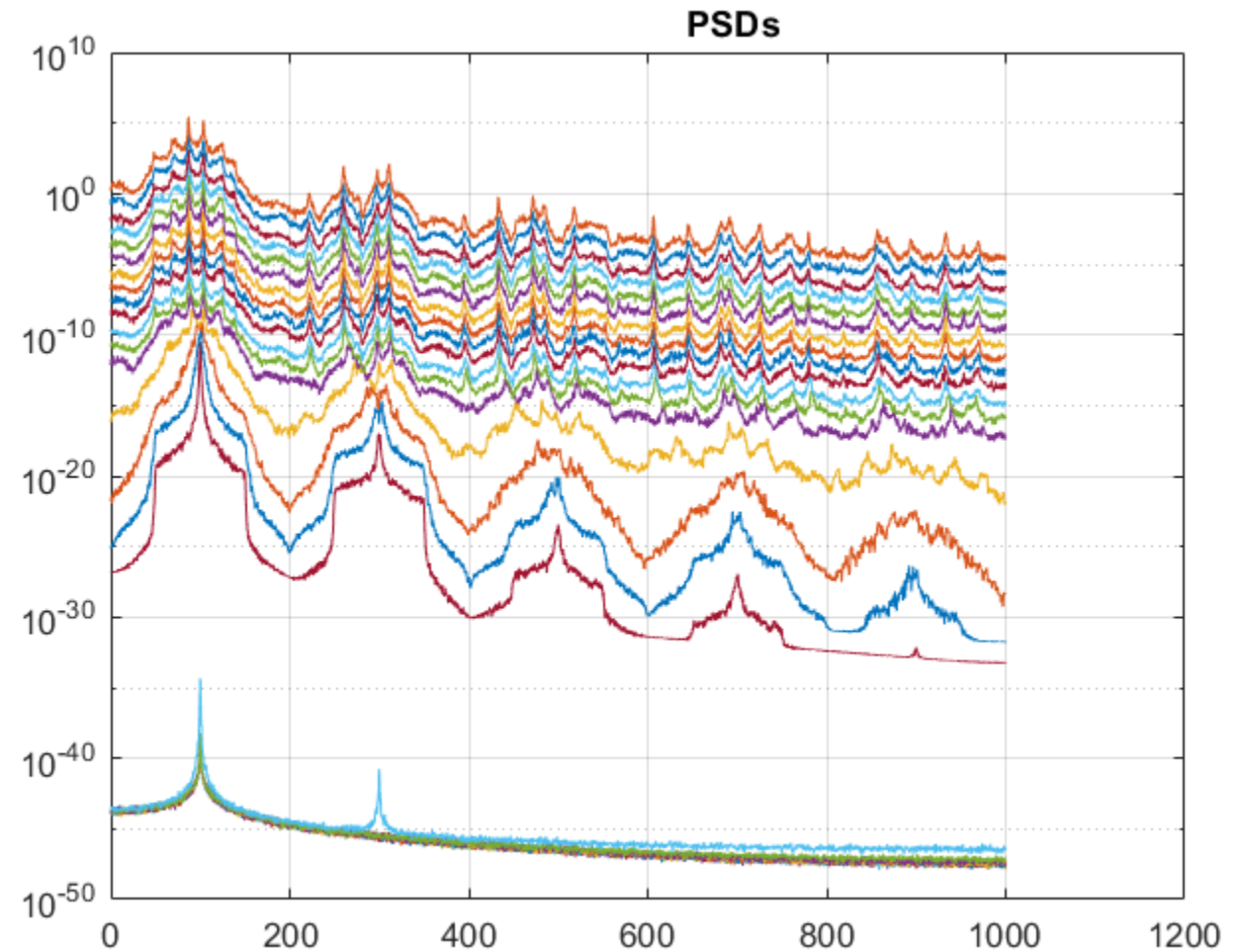
190-210

PSDs

Mode 1 deflection

Band limited mode 2 forcing
(150-250 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

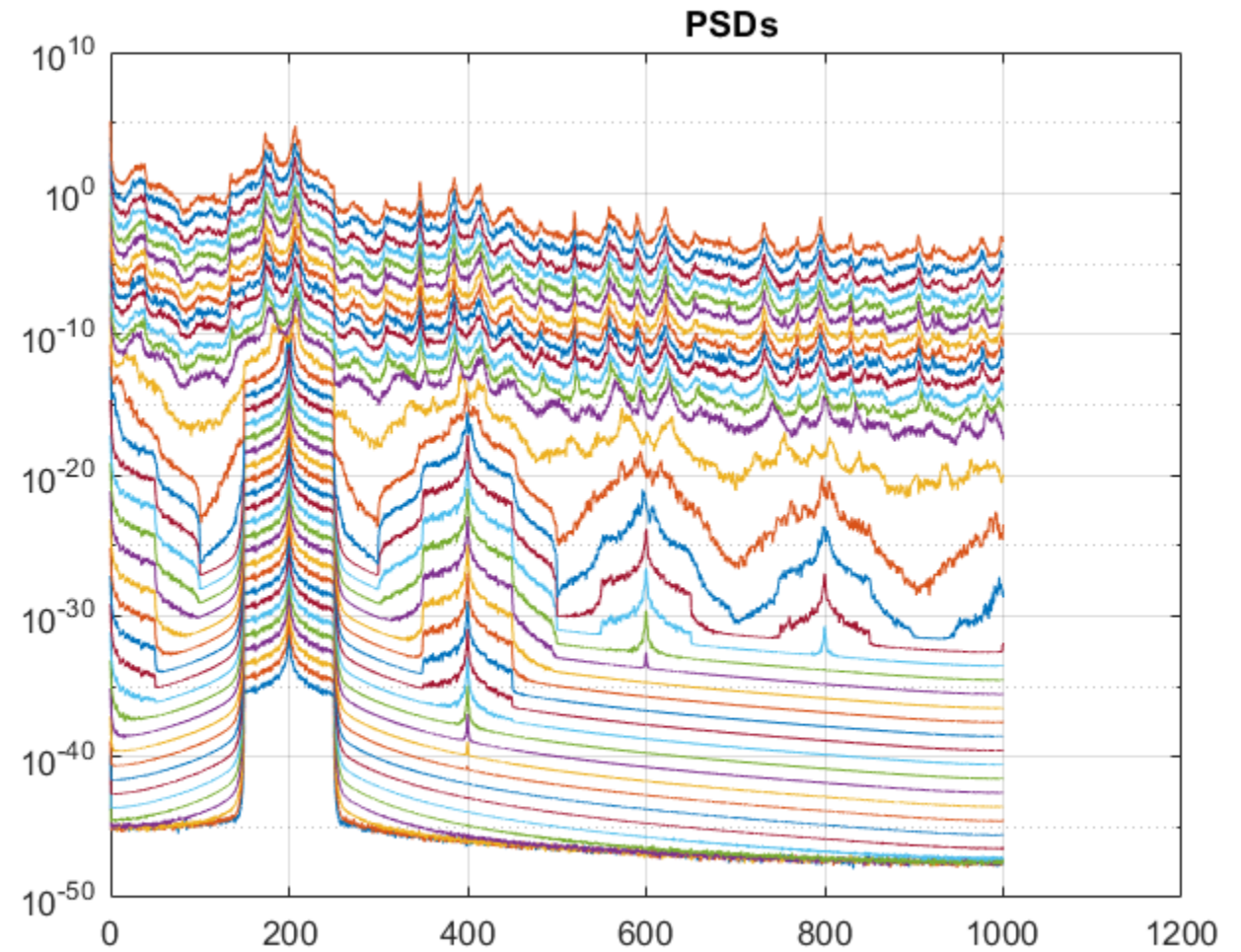
190-210

PSDs

Mode 2 deflection

Band limited mode 2 forcing
(150-250 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

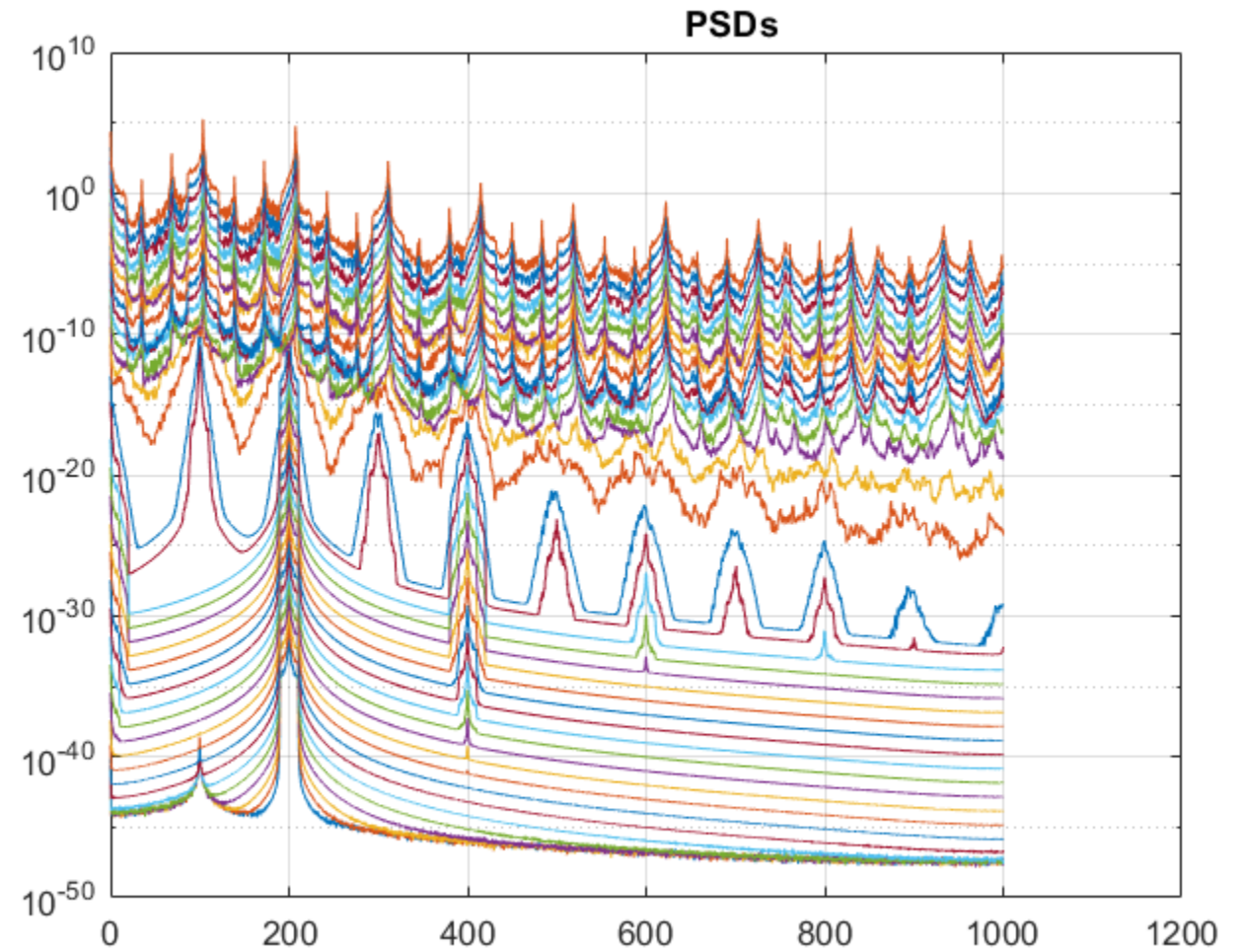
190-210

PSDs

Left spring deflection

Band limited mode 2 forcing
(190-210 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

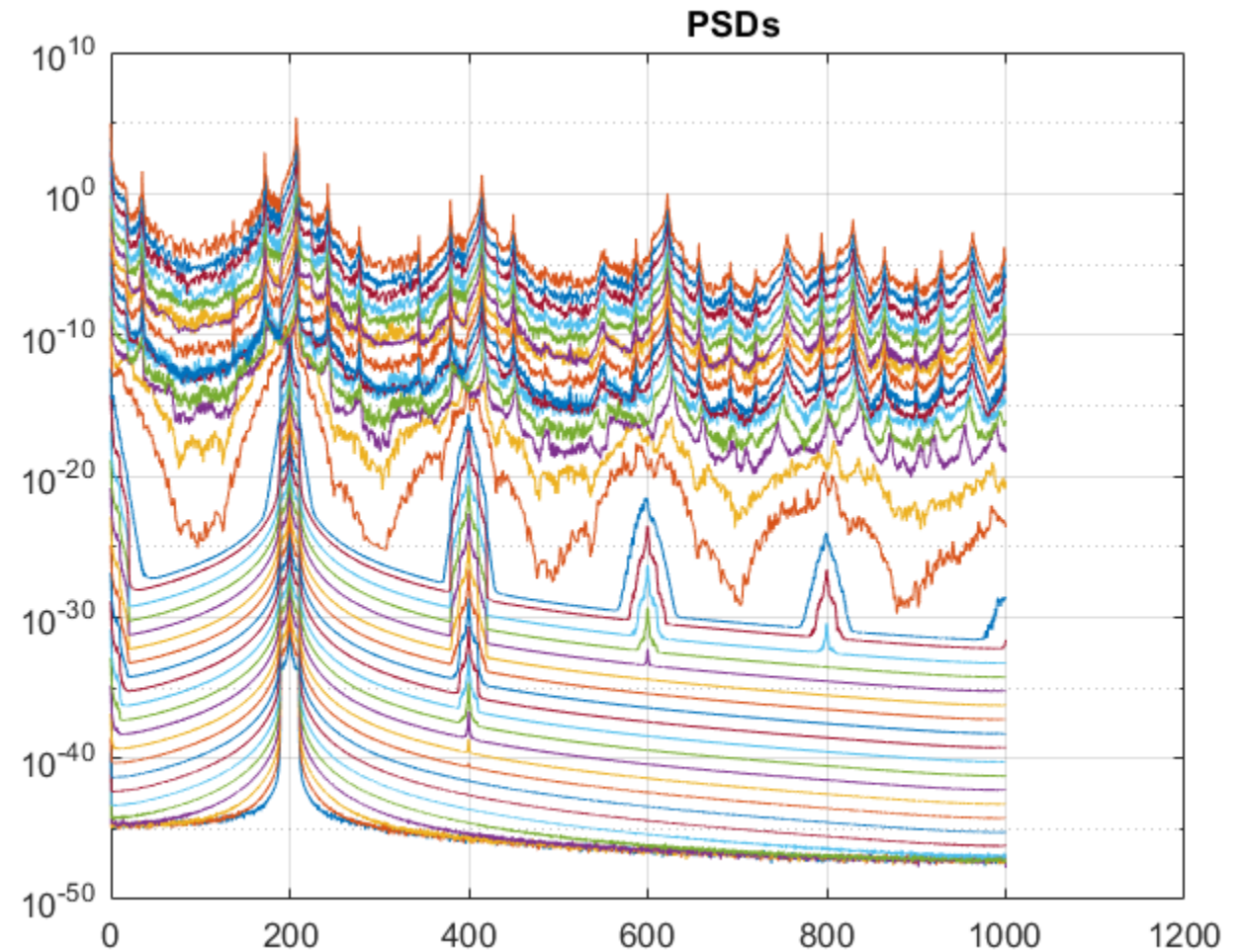
190-210

PSDs

Center spring deflection

Band limited mode 2 forcing
(190-210 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

190-210

PSDs

Mode 1 deflection

Band limited mode 2 forcing
(190-210 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

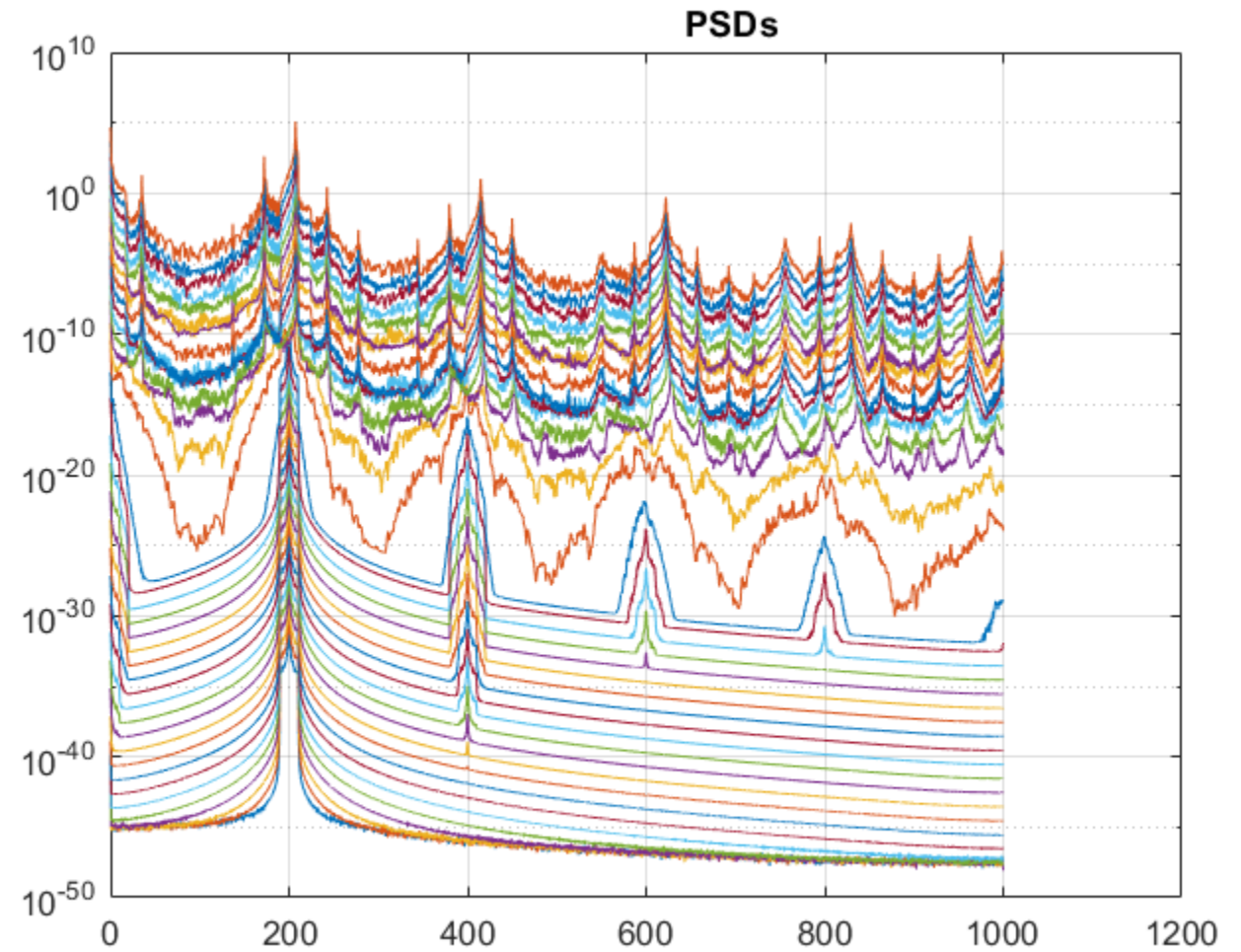
190-210

PSDs

Mode 2 deflection

Band limited mode 2 forcing
(190-210 Hz)

Amplitude Range: $10^{-10} - 10^8$



DOF

Left

Center

Mode 1

Mode 2

Forcing

Random

Mode 1

Mode 2

Bandlimiting

None

50-150

90-110

150-250

190-210