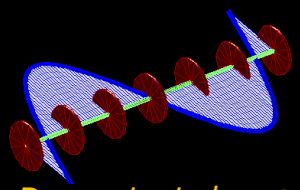

Dynamics Laboratory

EXPERIMENTAL AND SIMULATED DYNAMICS OF A TURBO-JET ROTOR LABORATORY SIMULATOR

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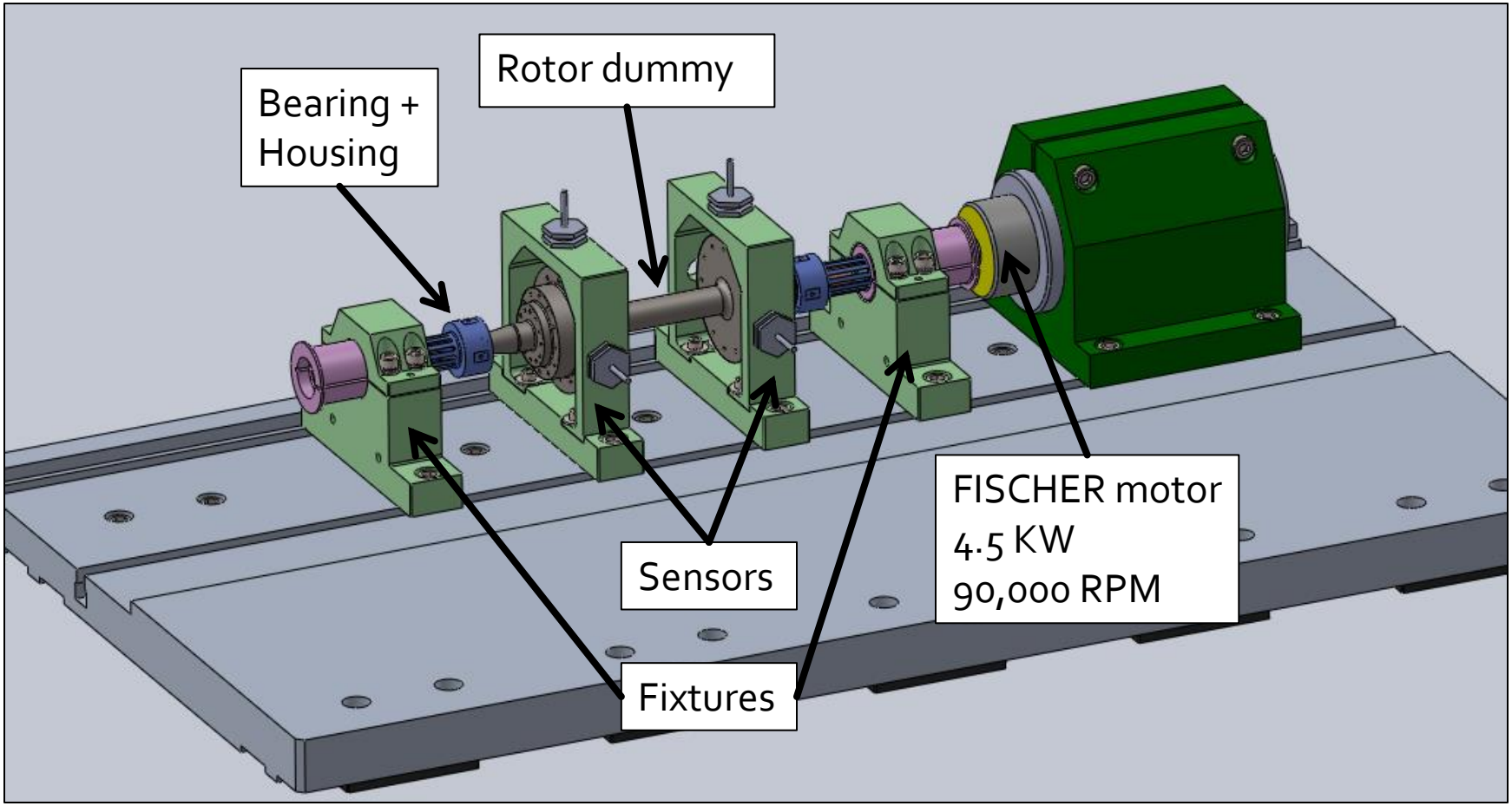
Dynamics Laboratory
Mechanical Engineering
Technion - Israel Institute of Technology

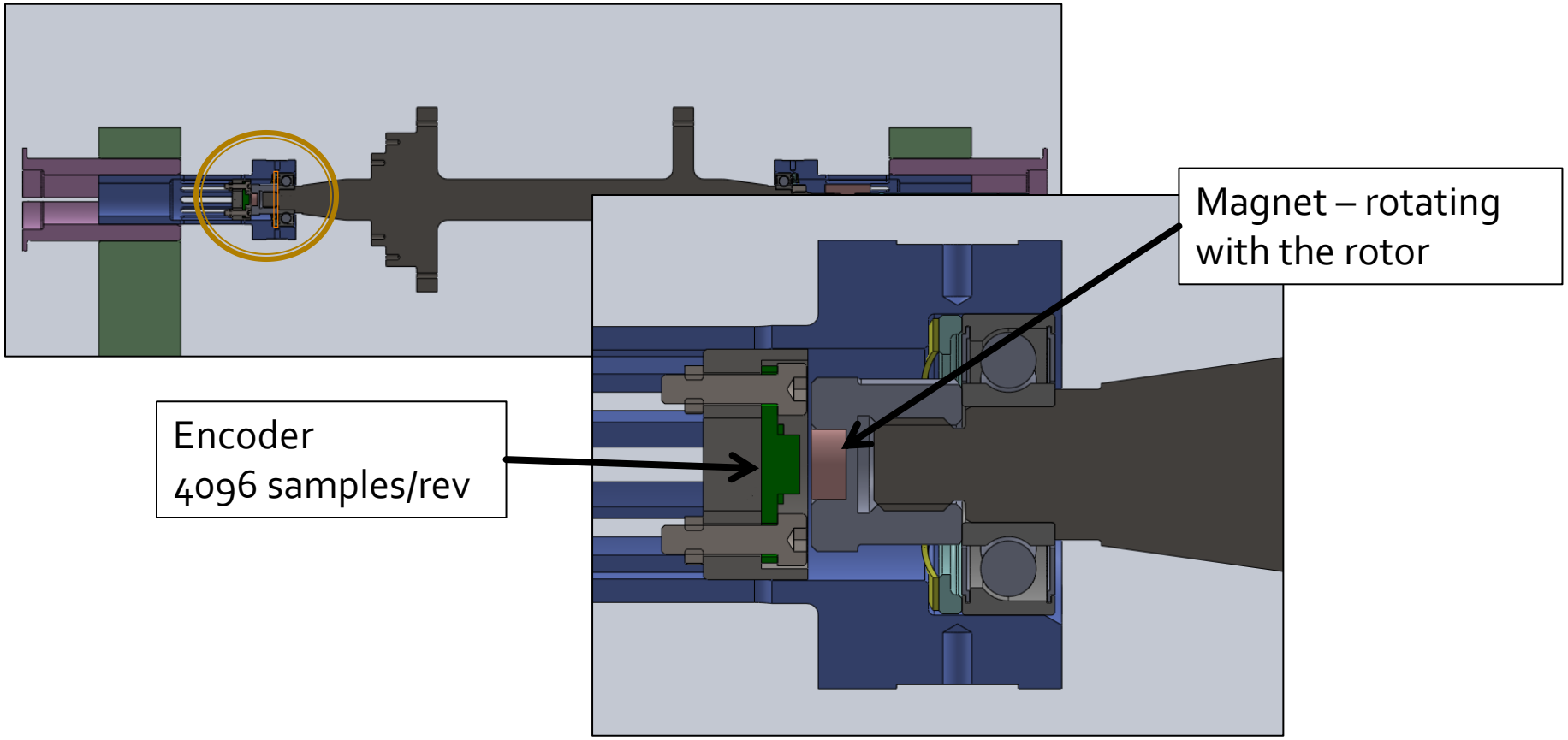
Dynamics Laboratory

LABORATORY SIMULATOR



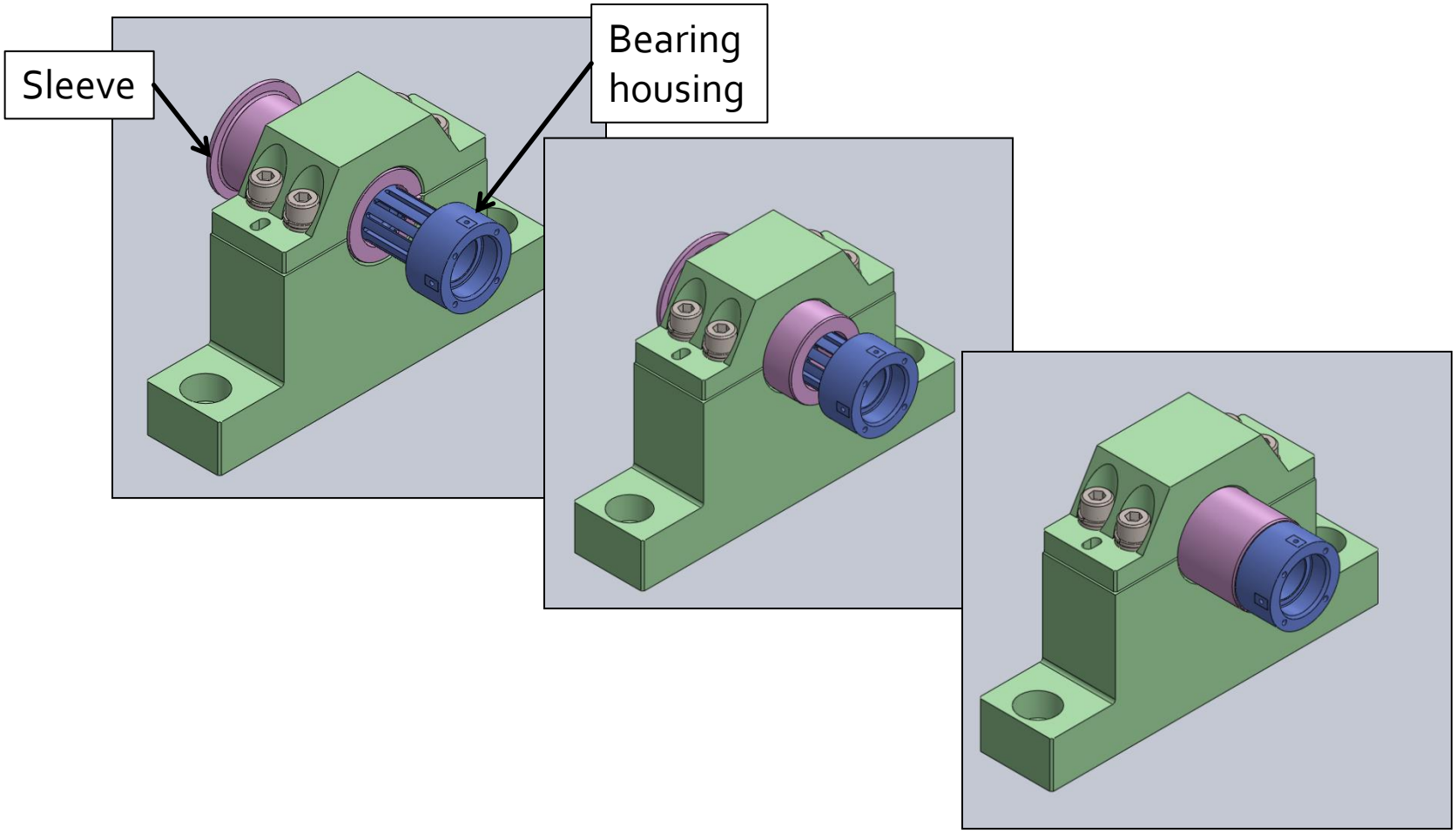
Speed control

- Magnetic encoder

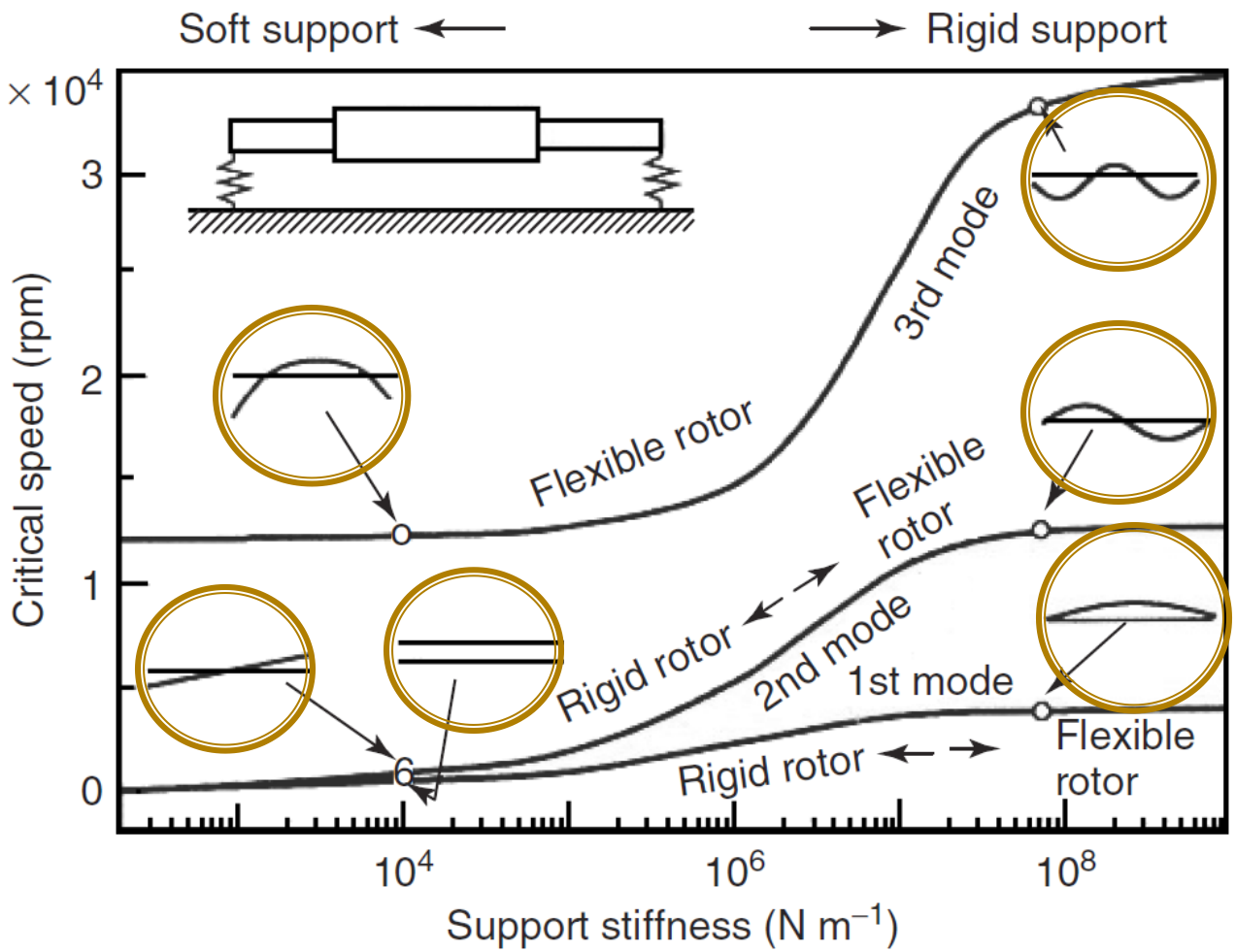


Changing support's stiffness

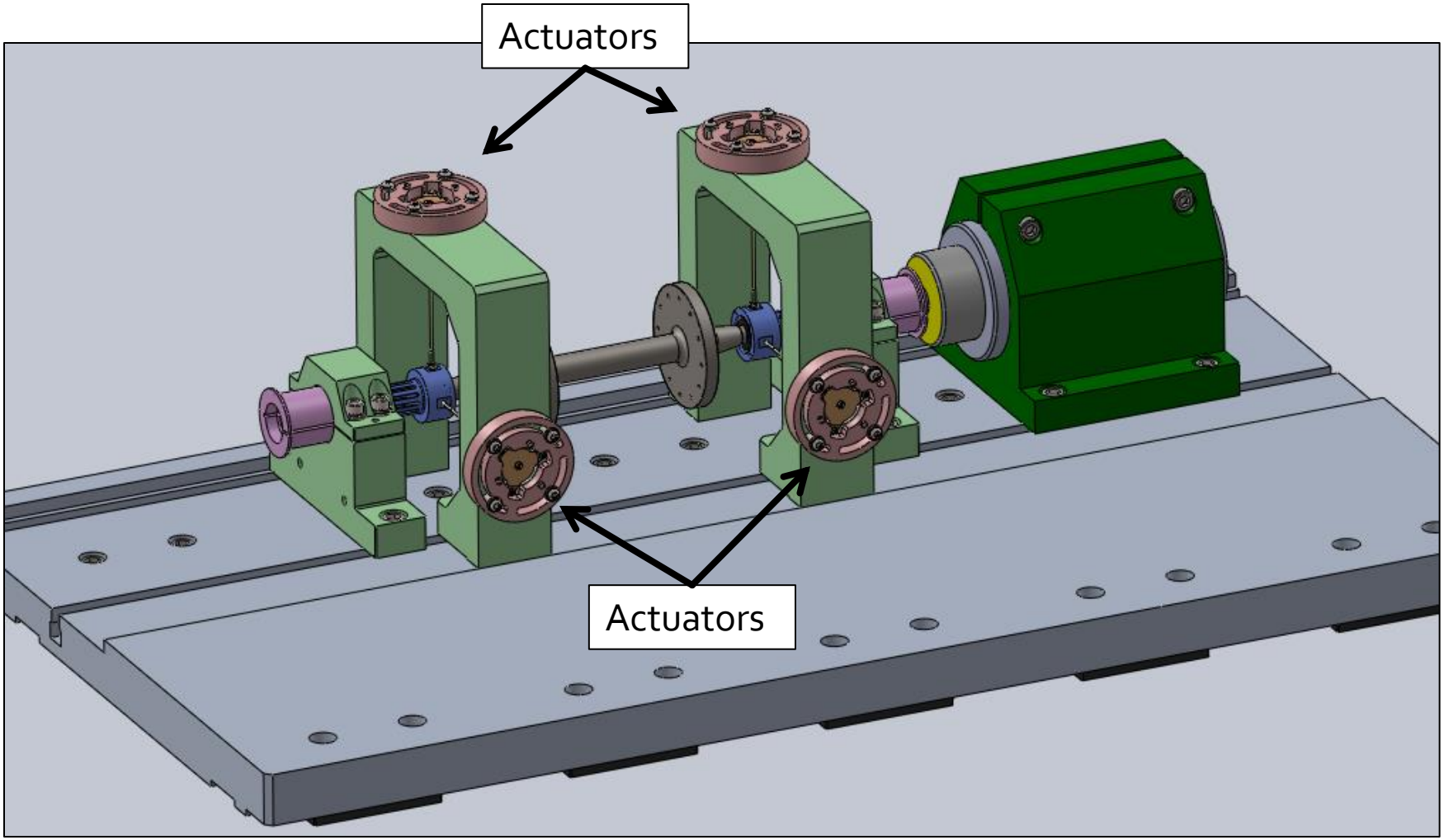
- **Varying support's stiffness using adjustable spring element**



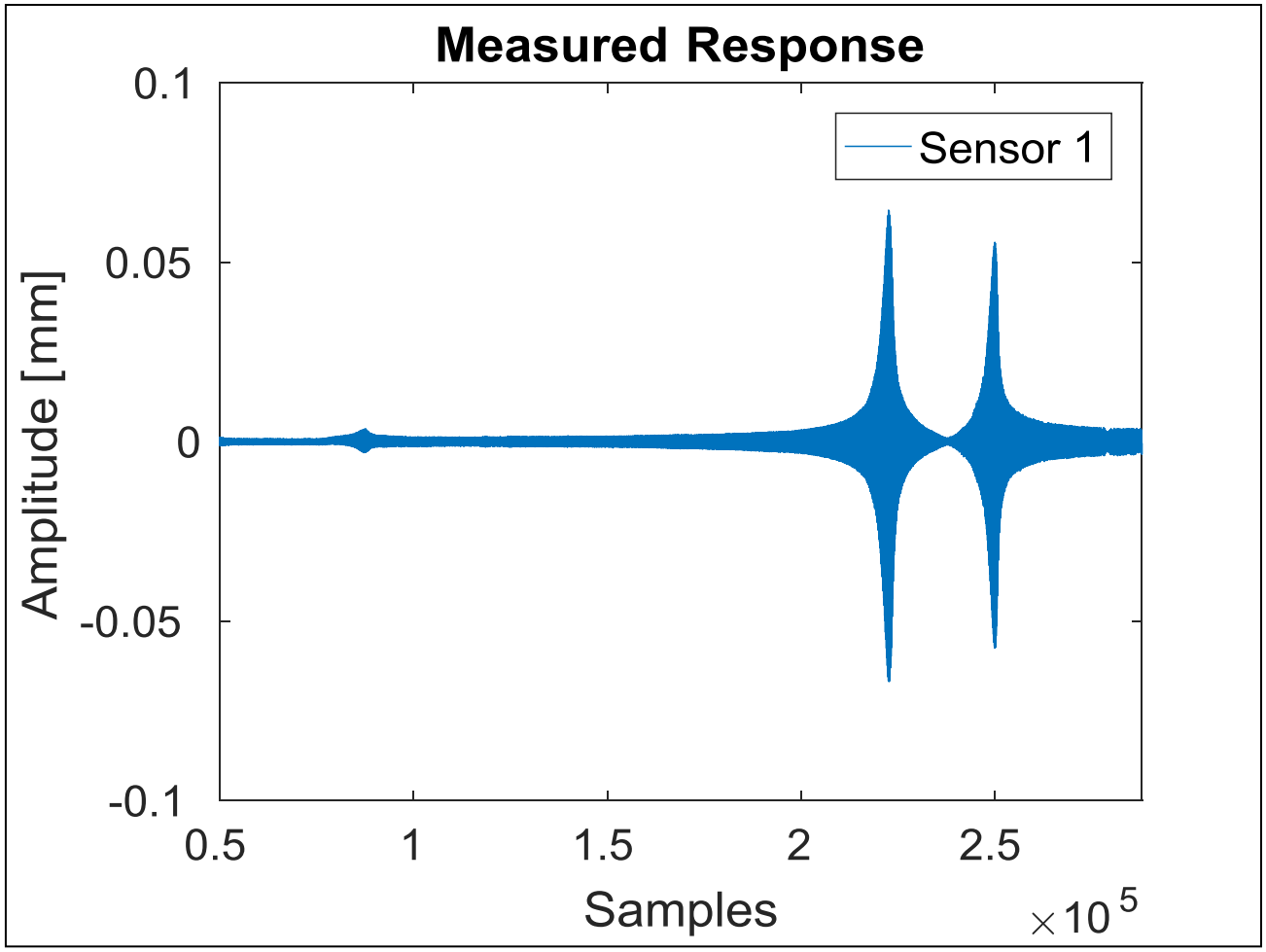
Rotor Modes


Soft support
Rigid support
× 10^4
3
2
1
0
Critical speed (rpm)
3rd mode
Flexible rotor
Flexible rotor
Rigid rotor
2nd mode
1st mode
Rigid rotor
Flexible rotor
6
10^4
10^6
10^8
Support stiffness (N m^−1)

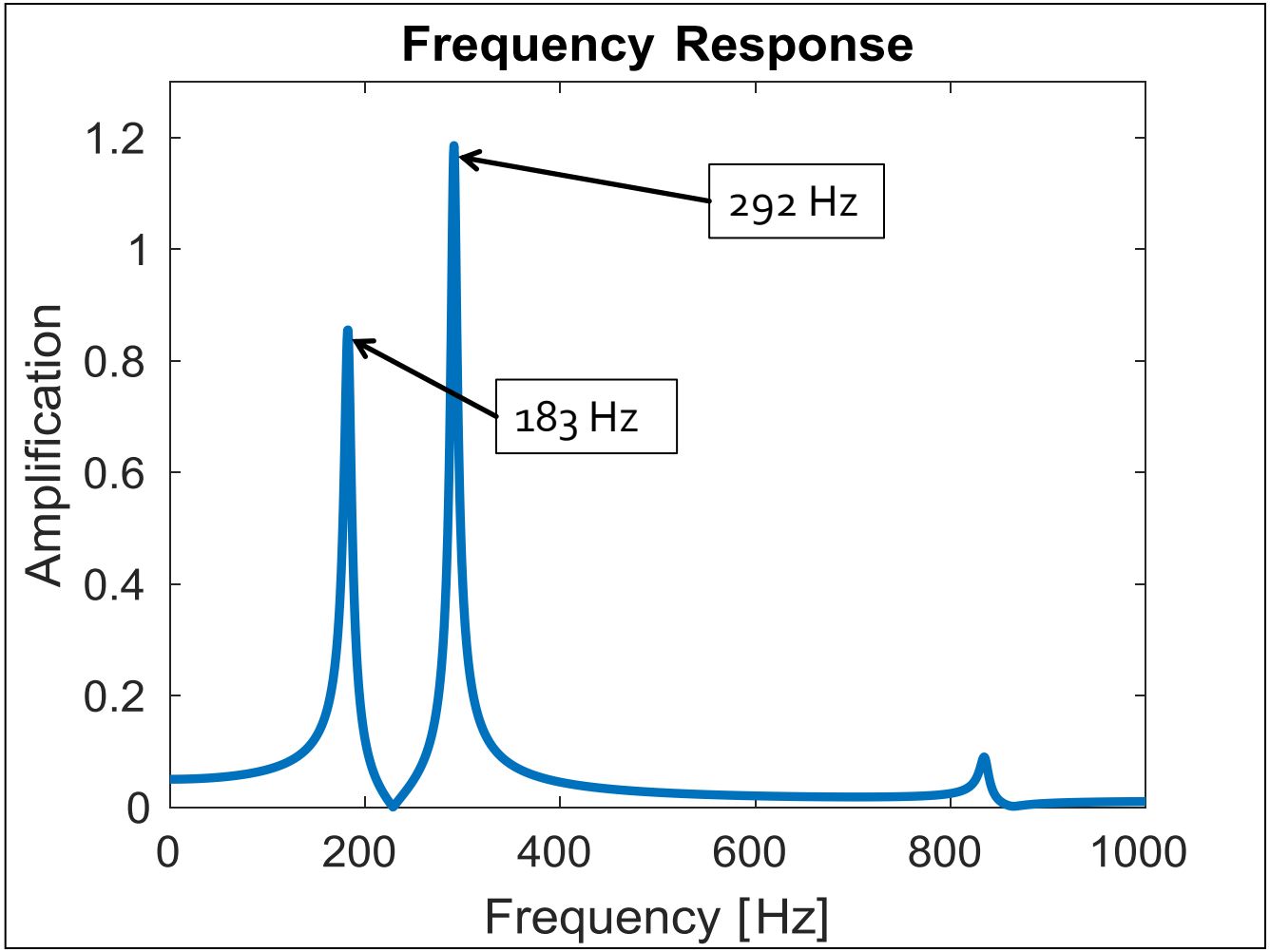
Voice Coil Actuators



Non rotating excitation

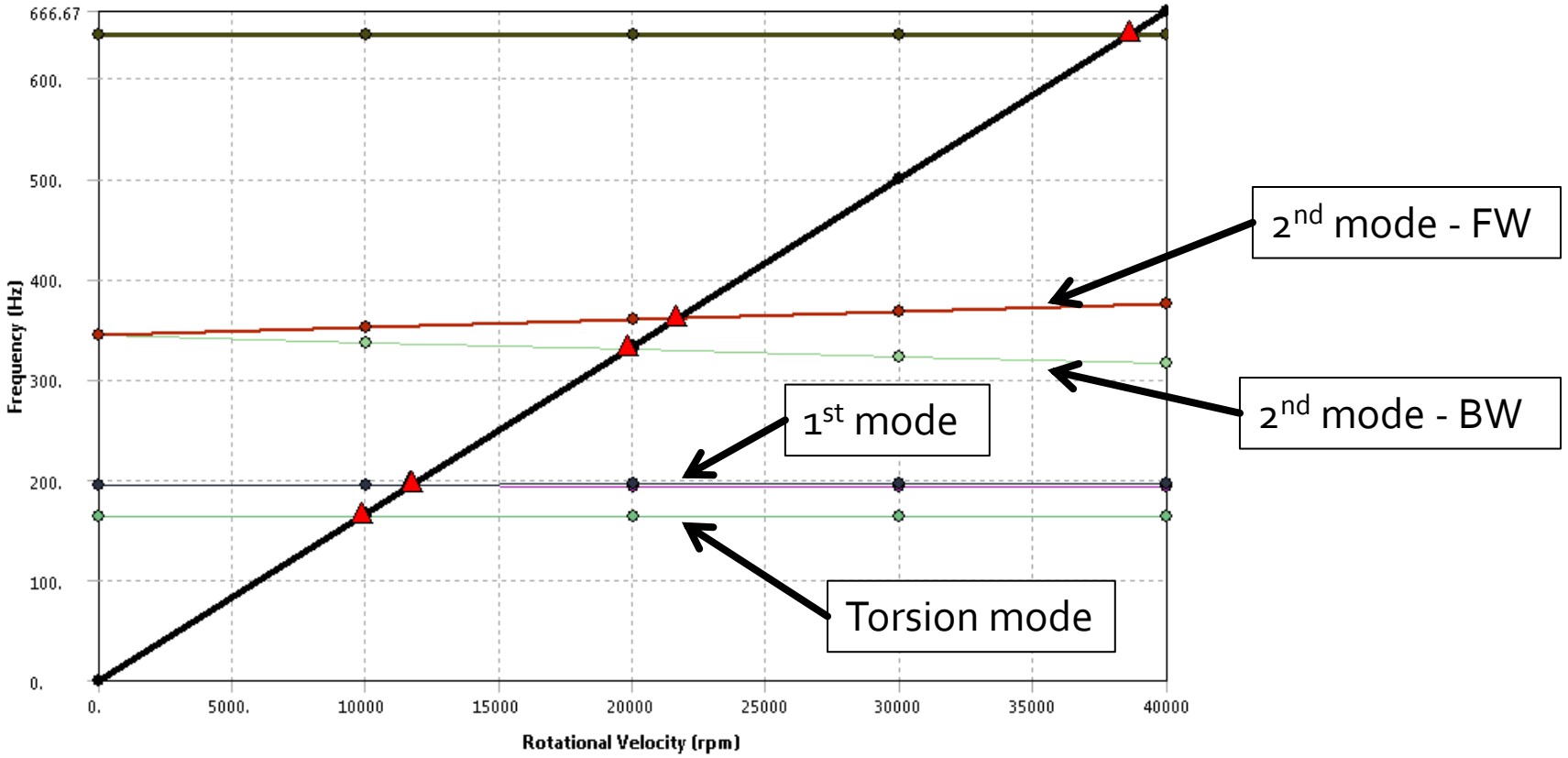


Non rotating excitation



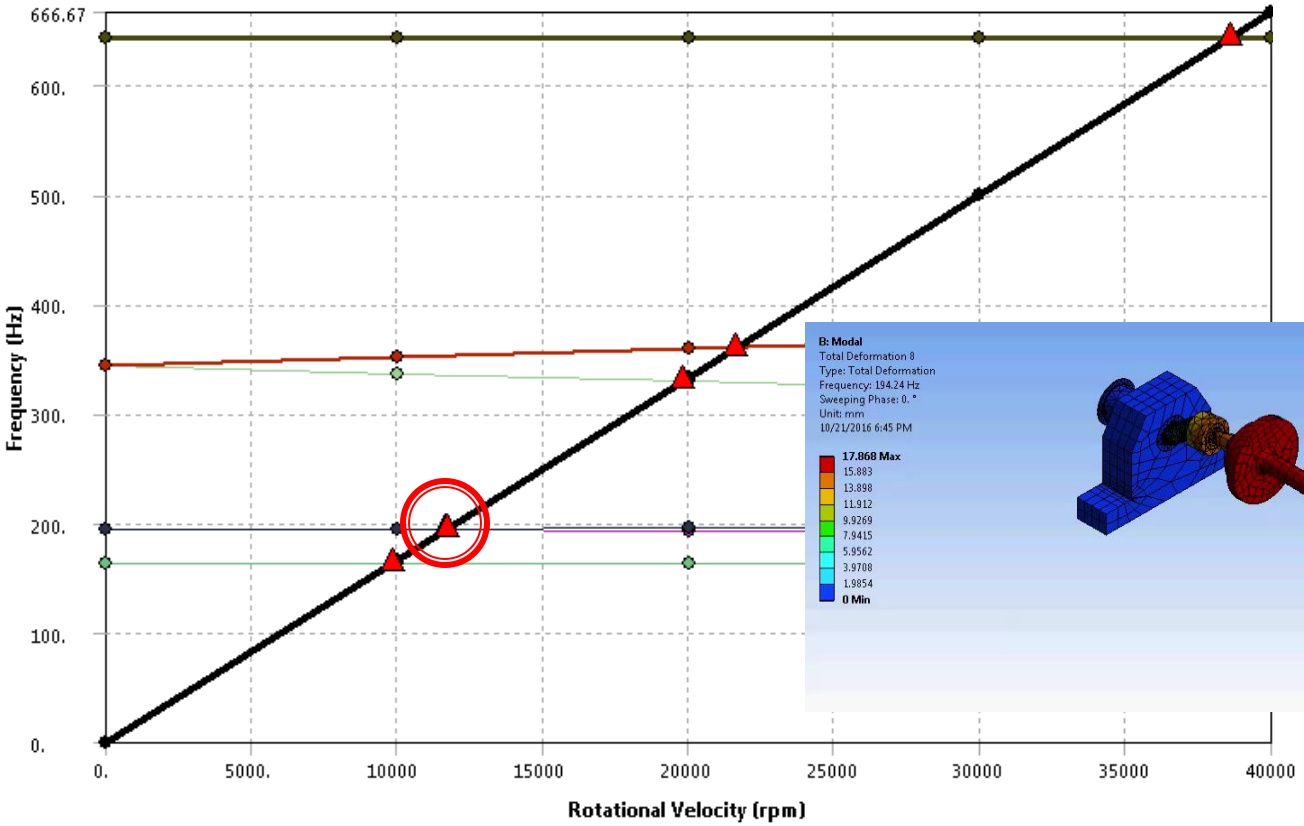
FE Analysis

- Campbell diagram – Soft support



FE Analysis

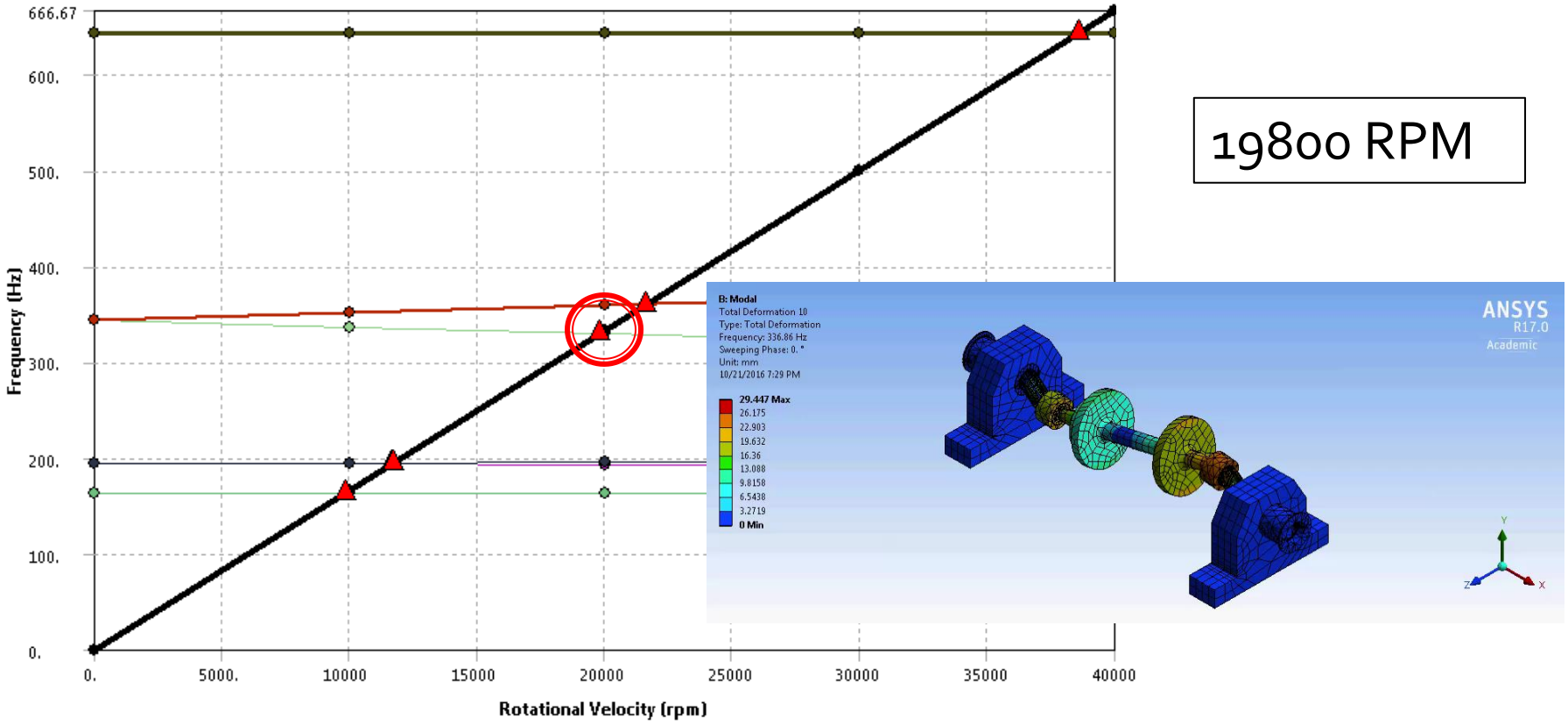
- 1st Critical speed - Rigid body mode



11600 RPM

FE Analysis

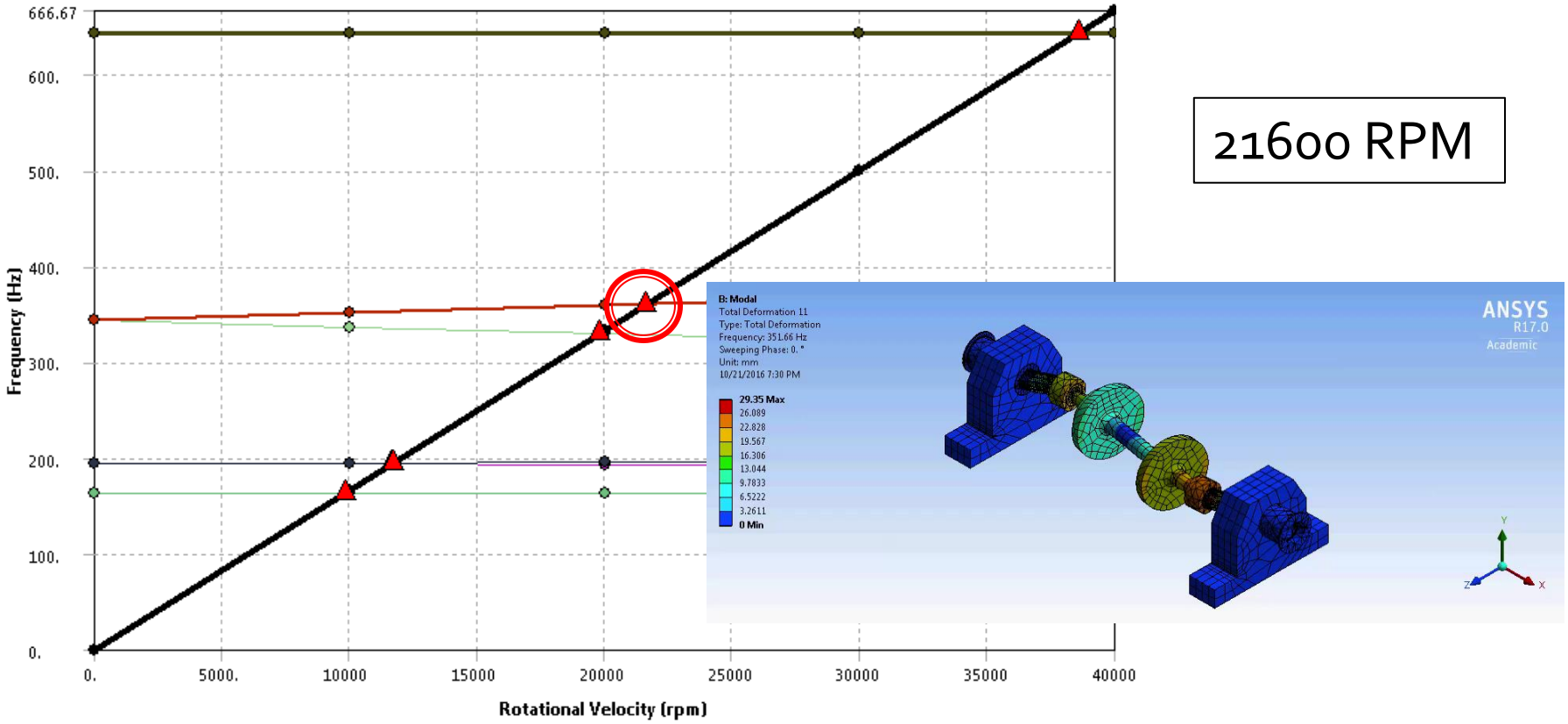
- 2rd Critical speed - Rigid body mode BW



19800 RPM

FE Analysis

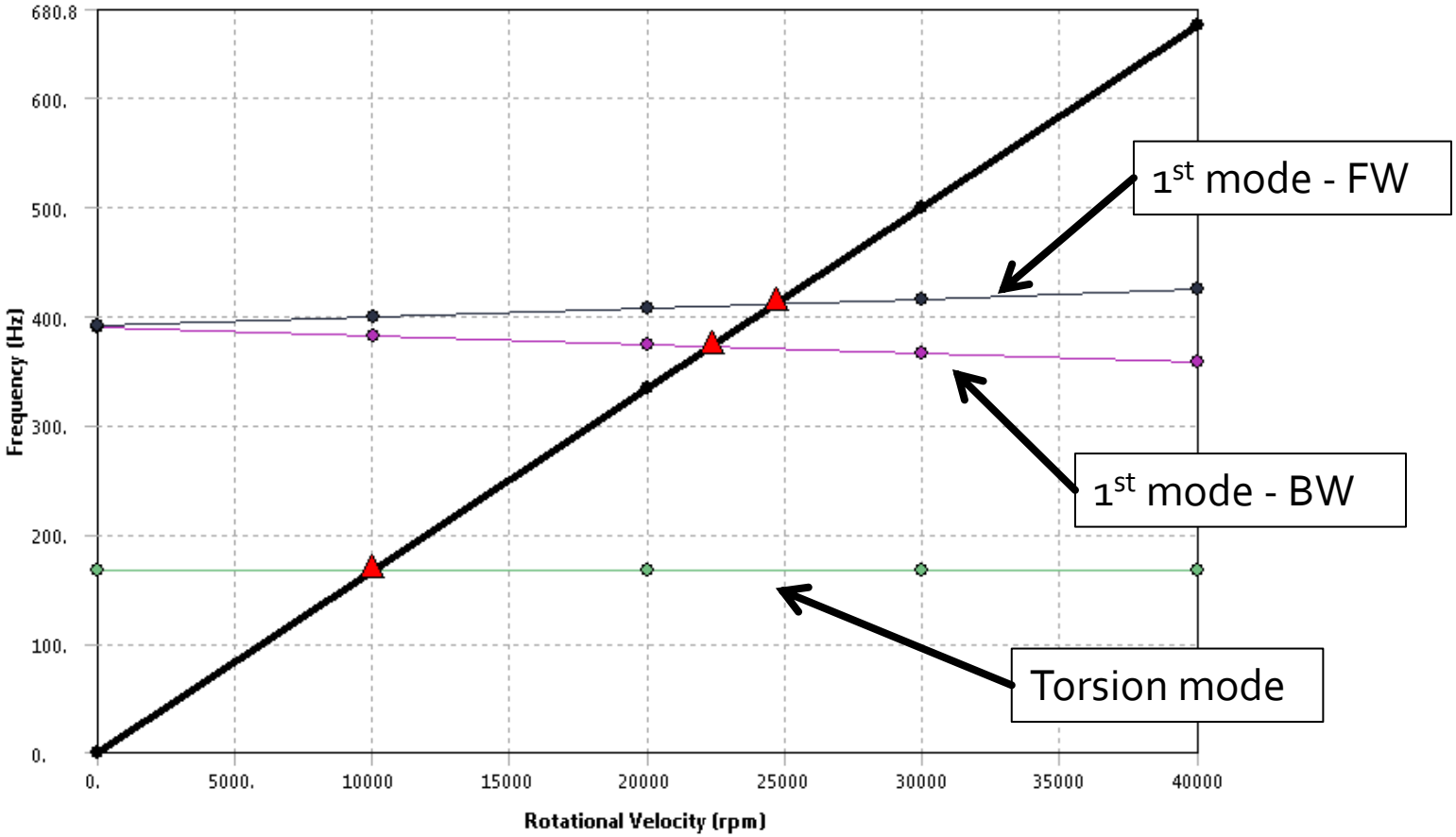
- 2rd Critical speed - Rigid body mode FW



21600 RPM

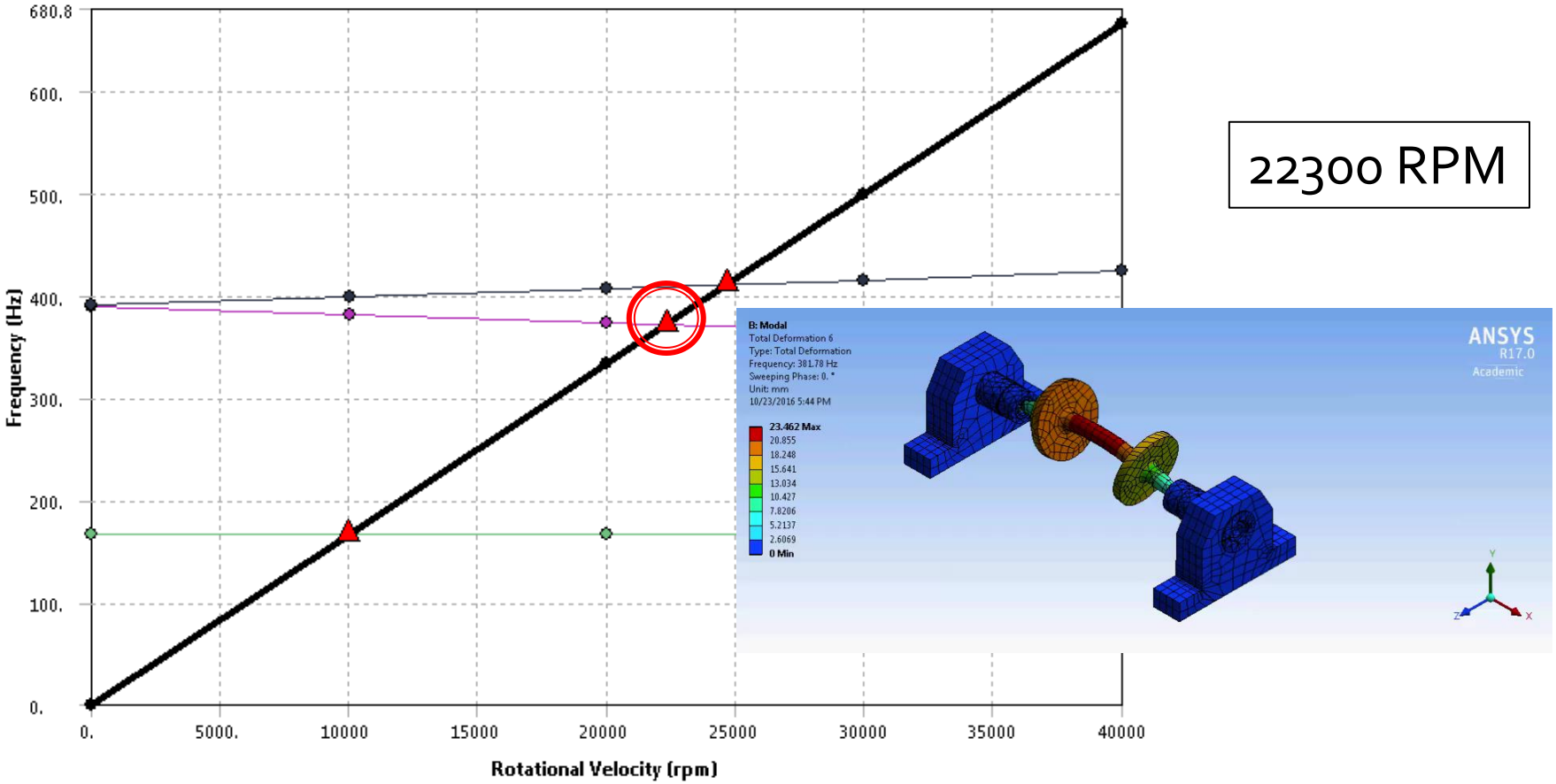
FE Analysis

- Campbell diagram – Stiff support



FE Analysis

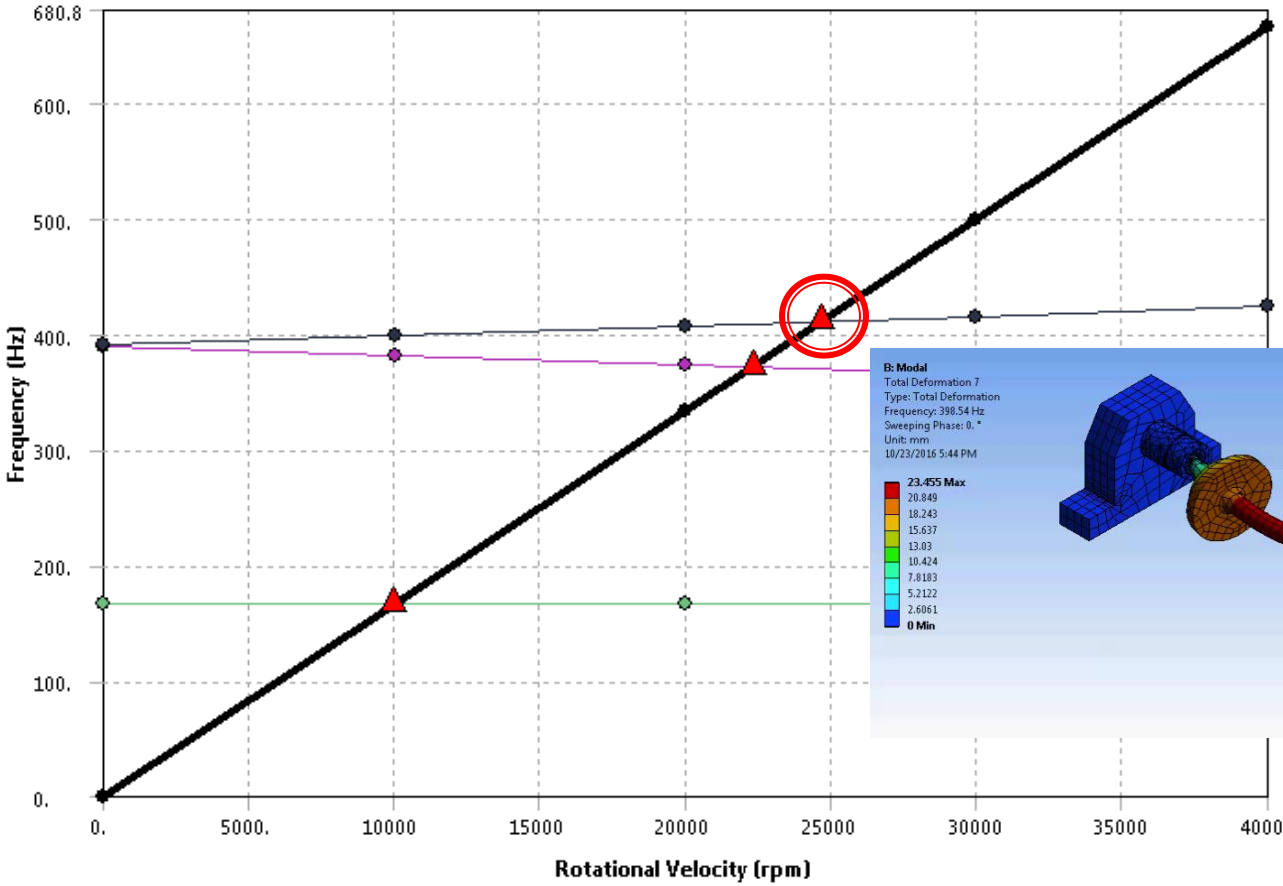
- 1st Critical speed – Bending mode BW

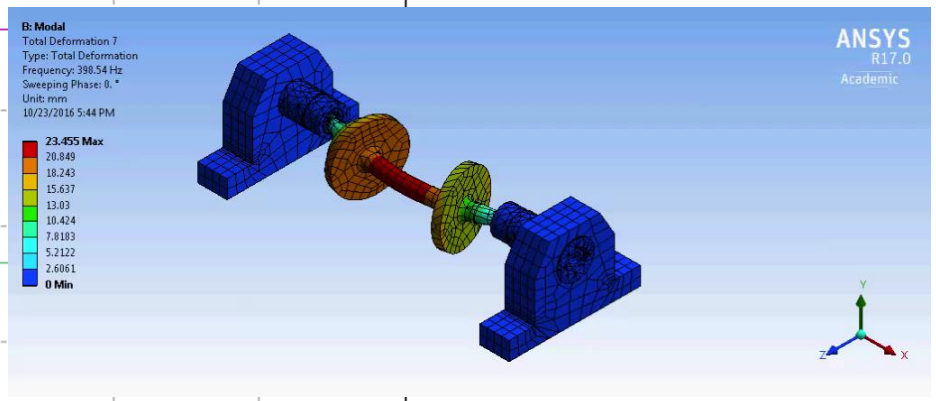


22300 RPM

FE Analysis

- 1st Critical speed – Bending mode FW

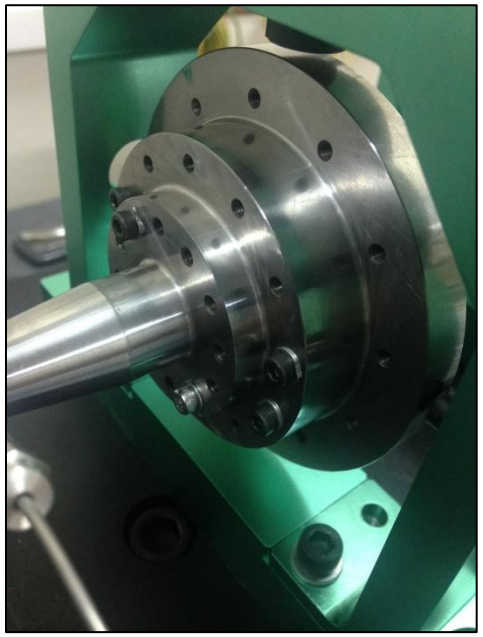




24700 RPM

Balancing

- Influence Coefficients method

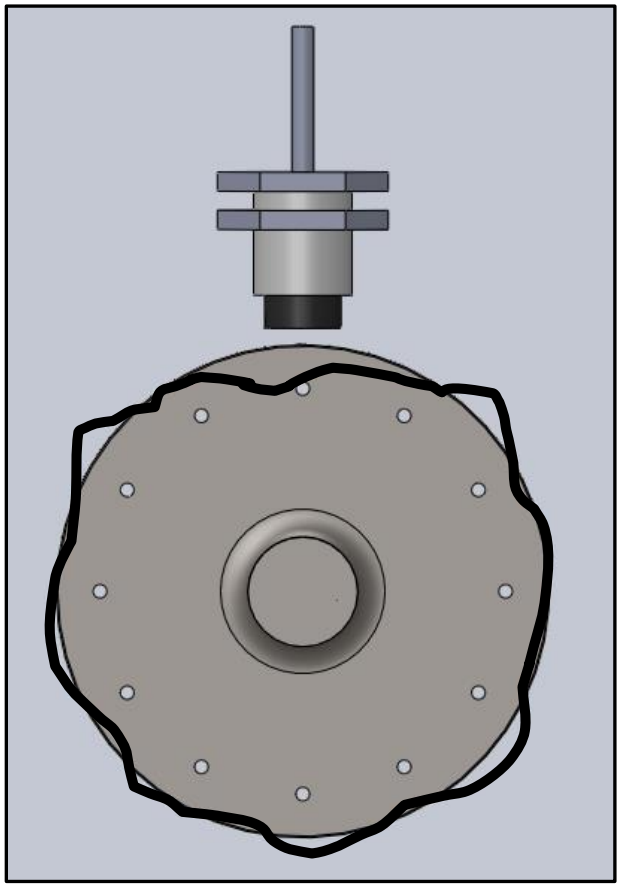


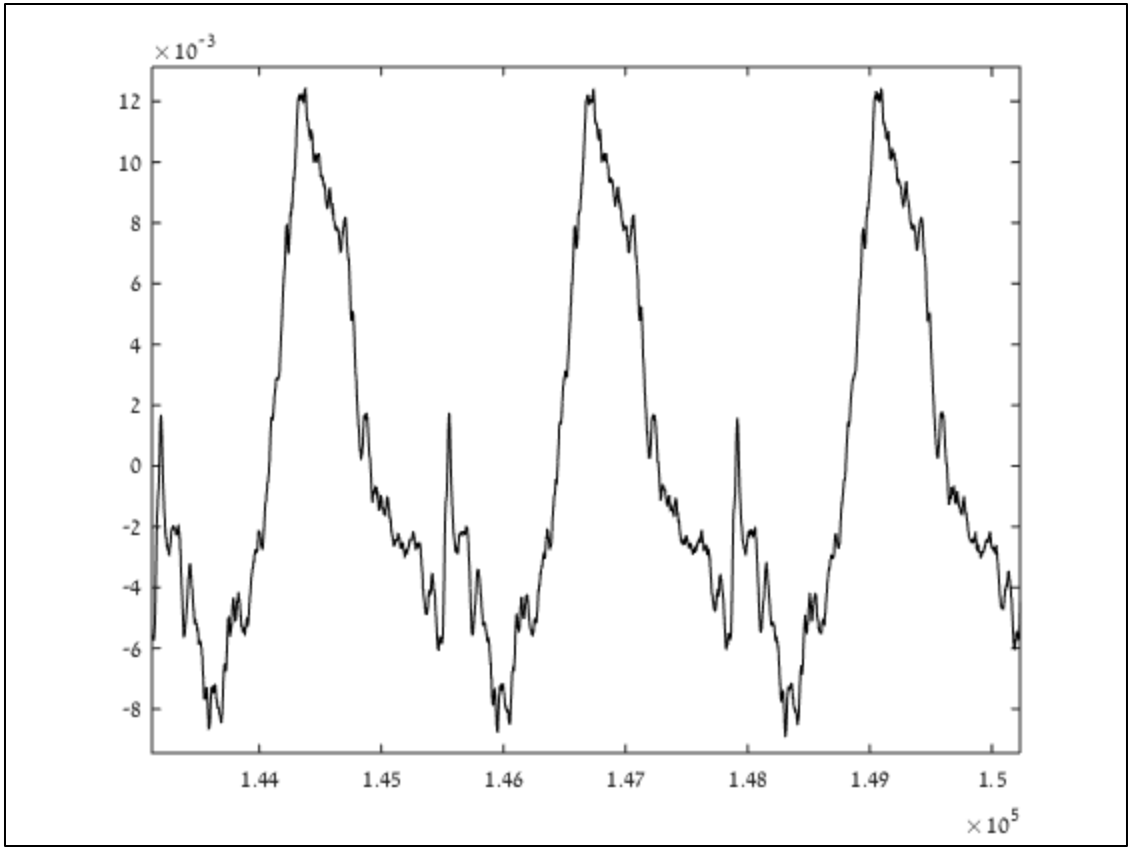
Dynamic Response = Unbalance X Influence Coefficients

Dynamic Response + Δ Dynamic Response = Unbalance + Δ Unbalance X Influence Coefficients

Balancing

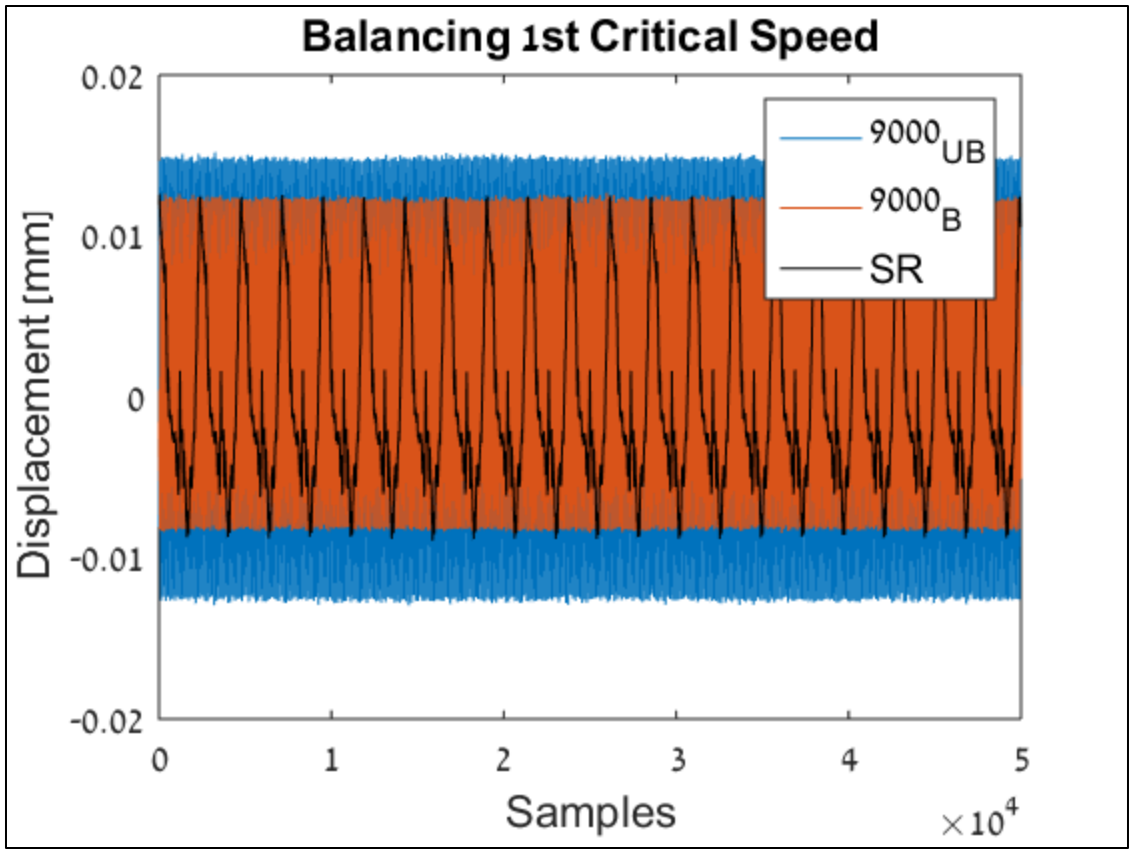
- Static Runout at 500 RPM





Balancing

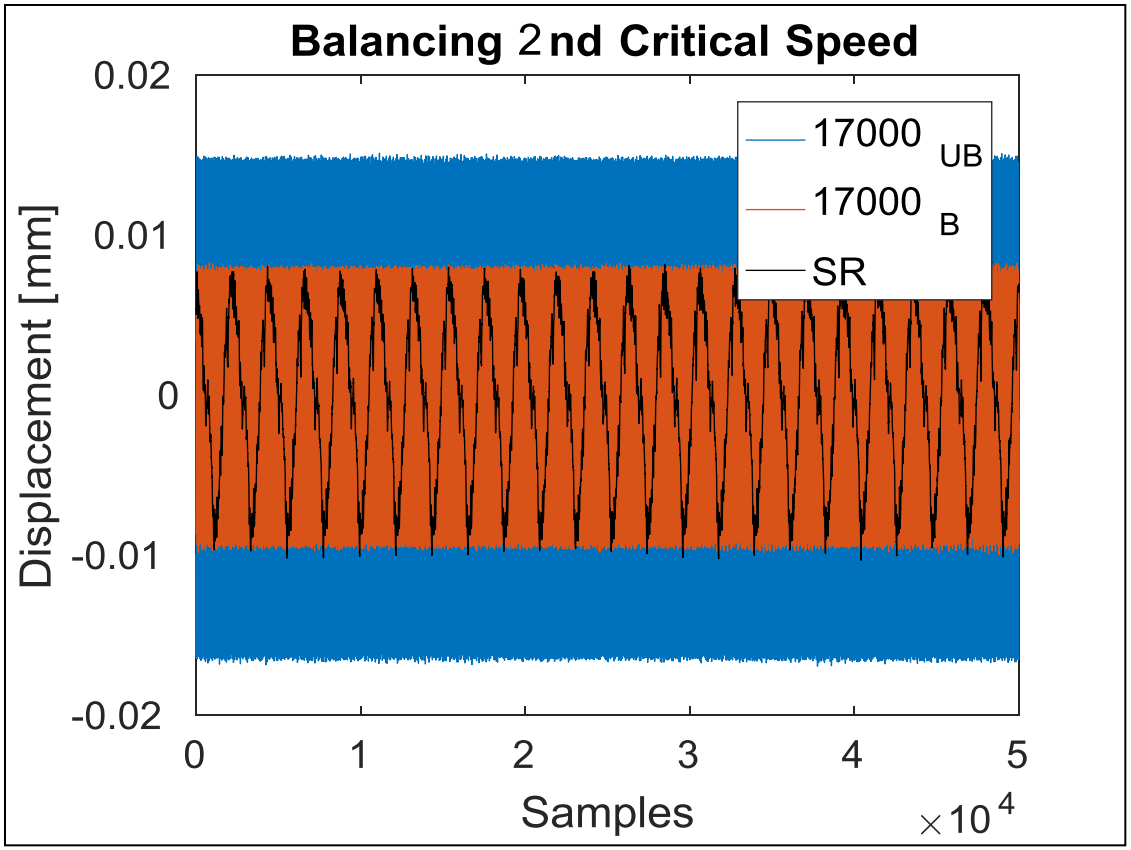
- Balancing 1st critical speed at 9 kRPM



Unbalanced
Balanced
Static runout

Balancing

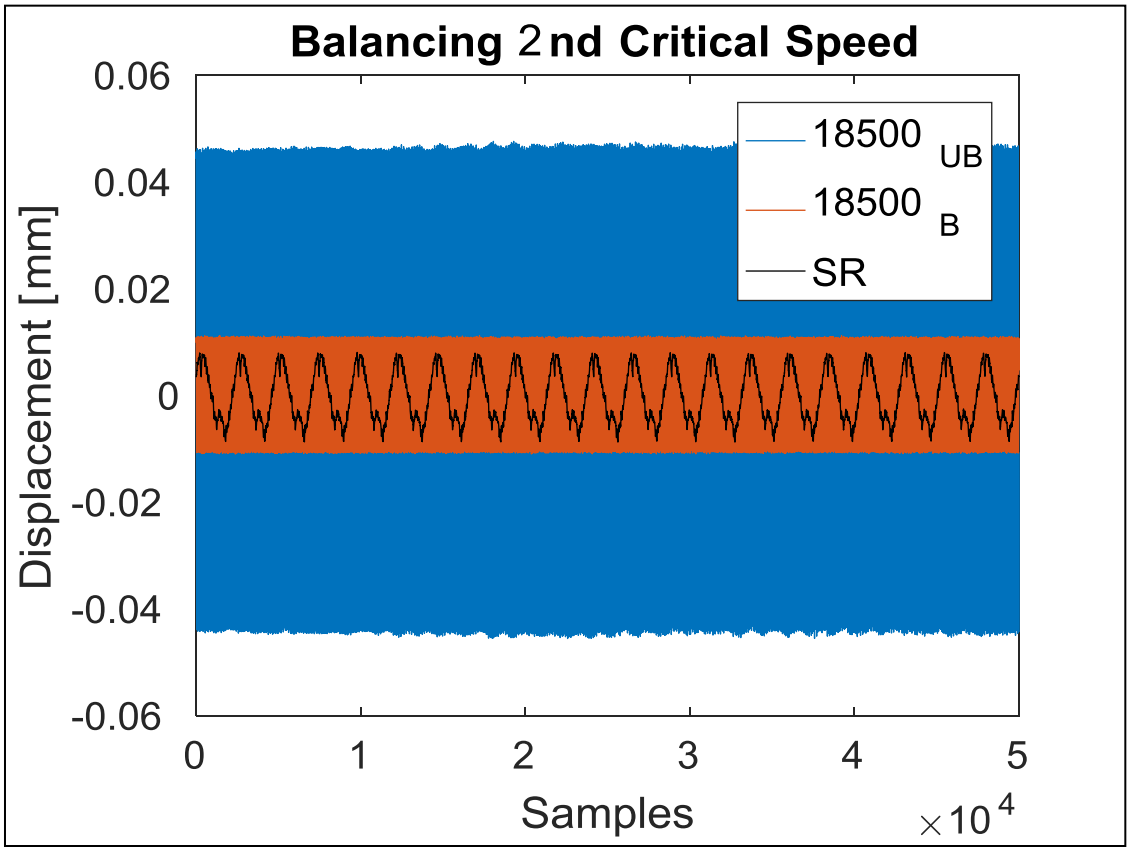
- Balancing 2nd critical speed at 17 kRPM



Unbalanced
Balanced
Static runout

Balancing

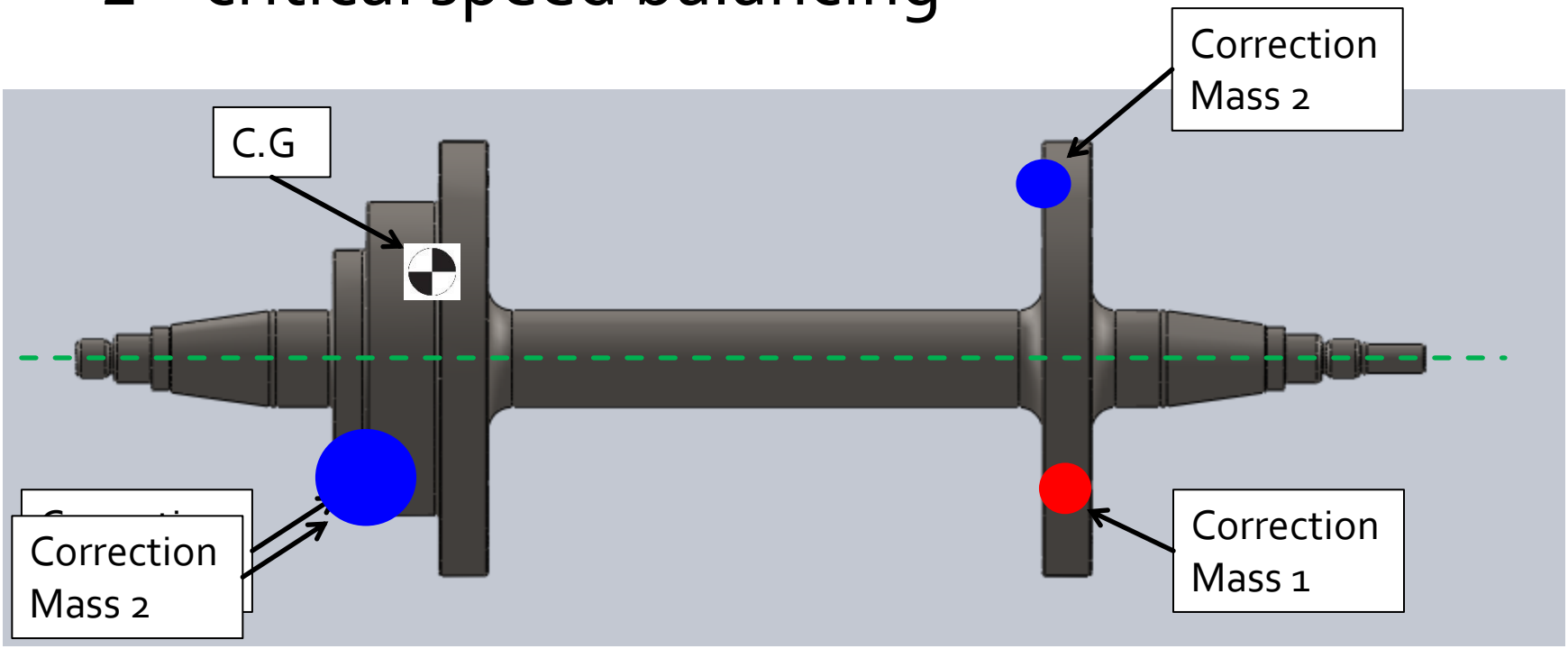
- Balancing 2nd critical speed at 18.5 kRPM



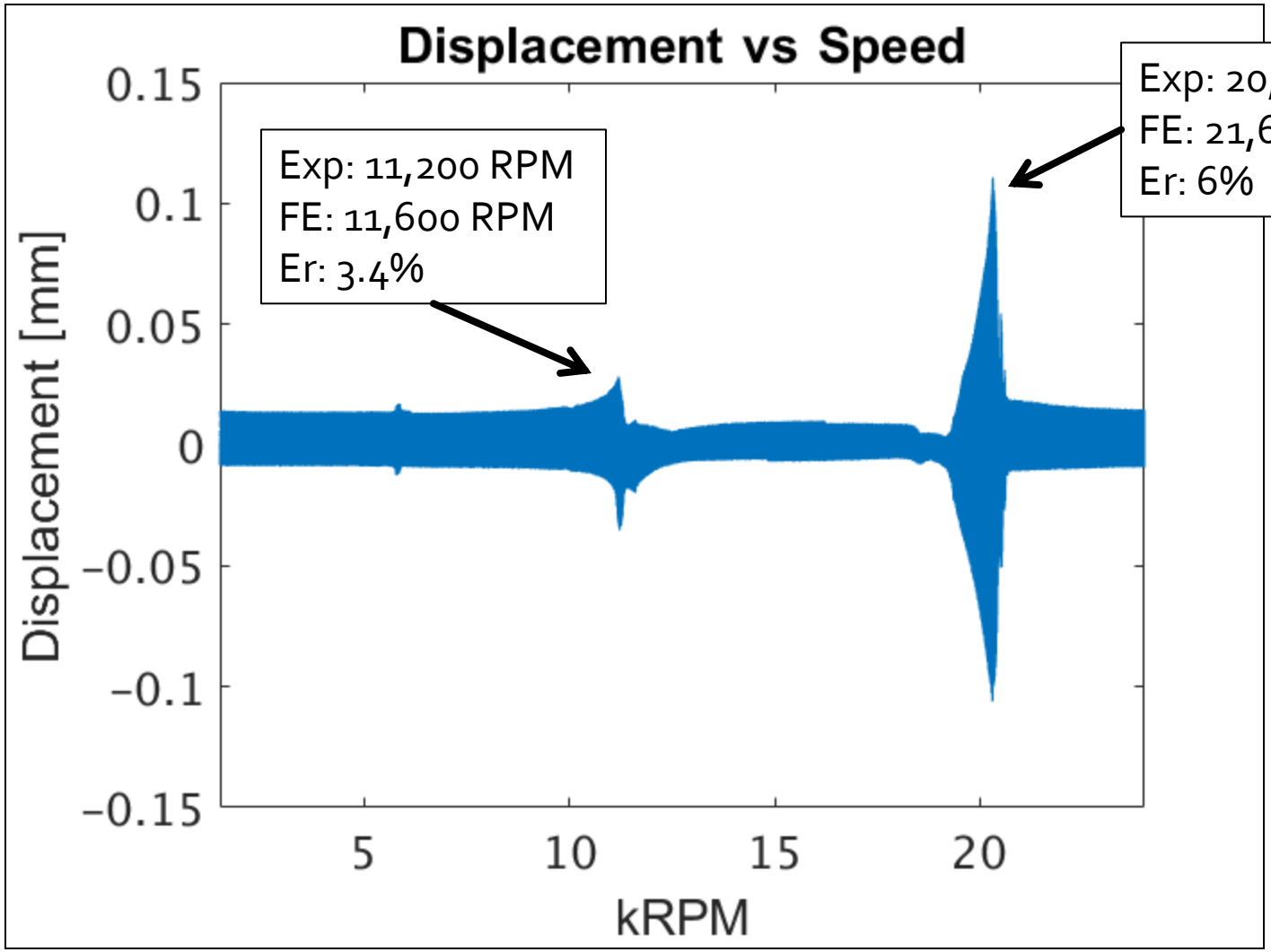
Unbalanced
Balanced
Static runout

Balancing

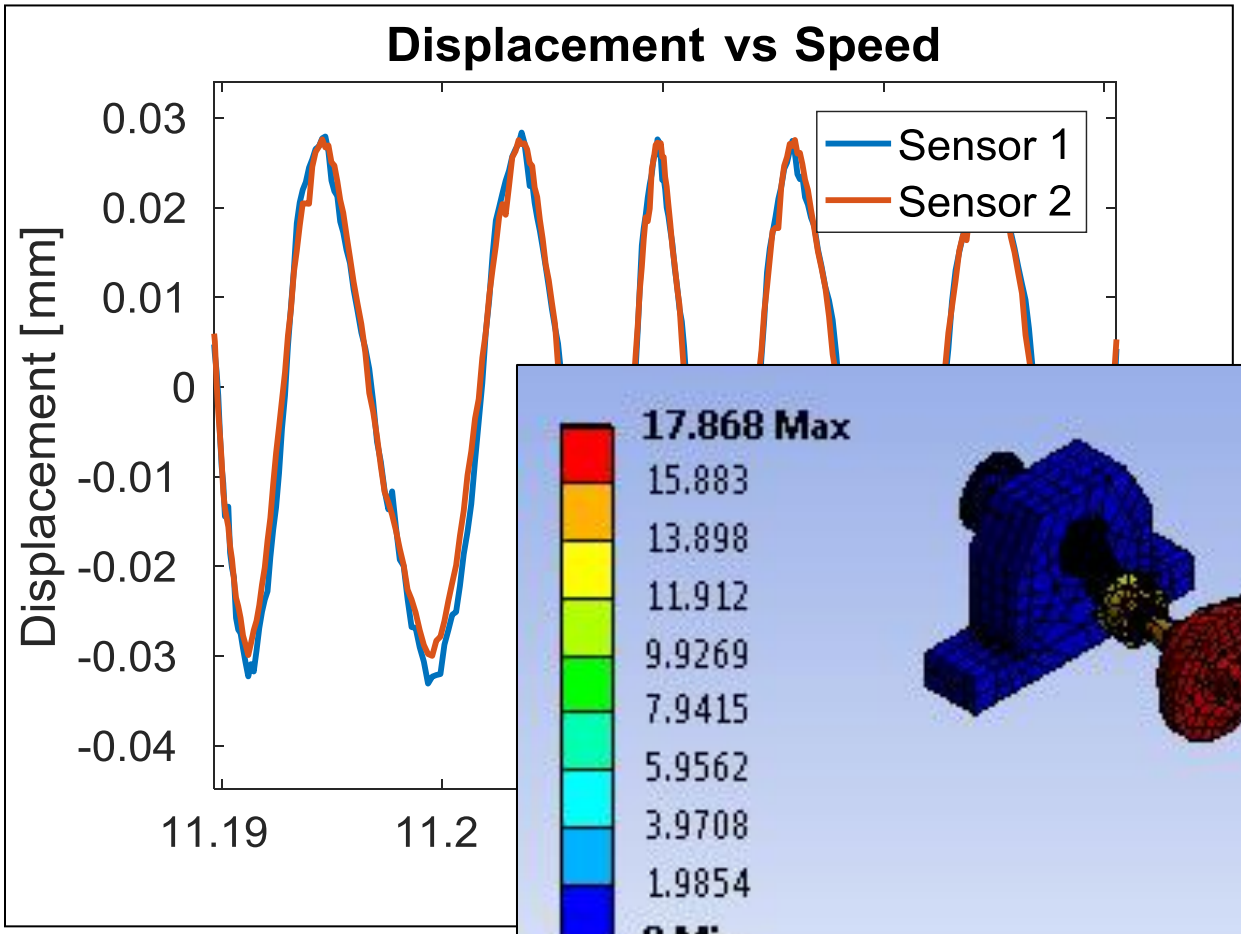
- 2nd critical speed balancing



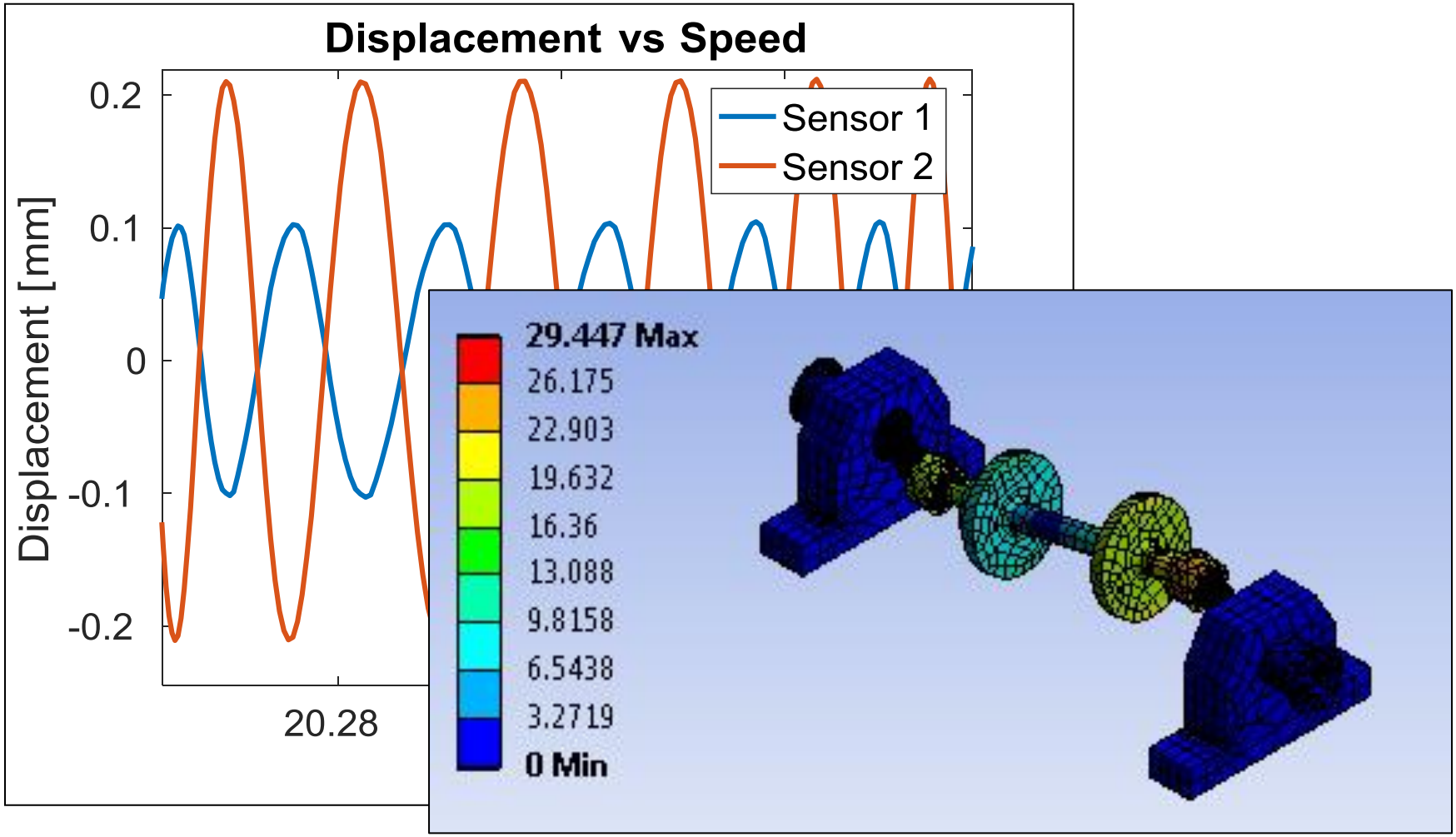
Transient measurements



Transient measurements



Transient measurements



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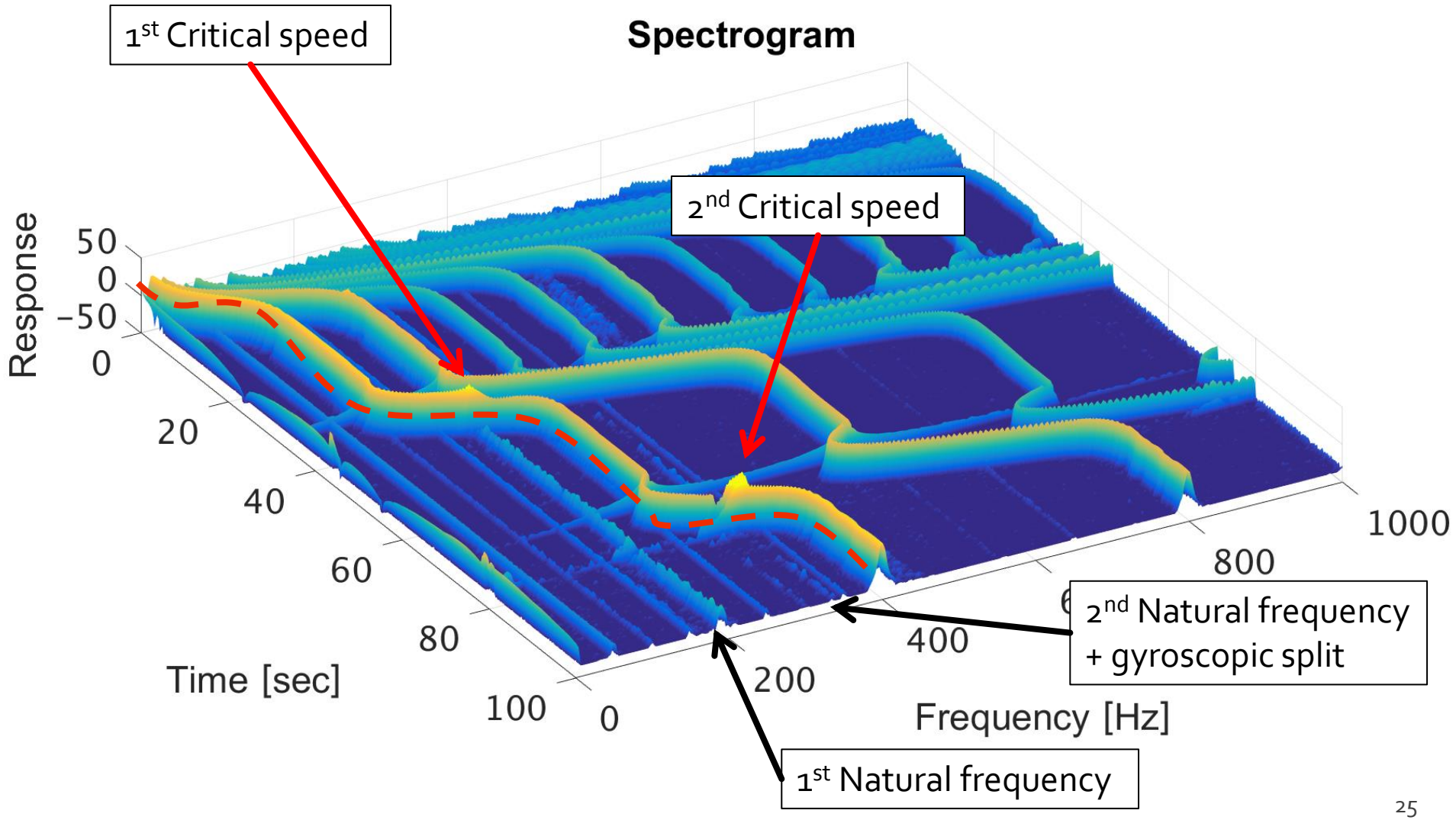
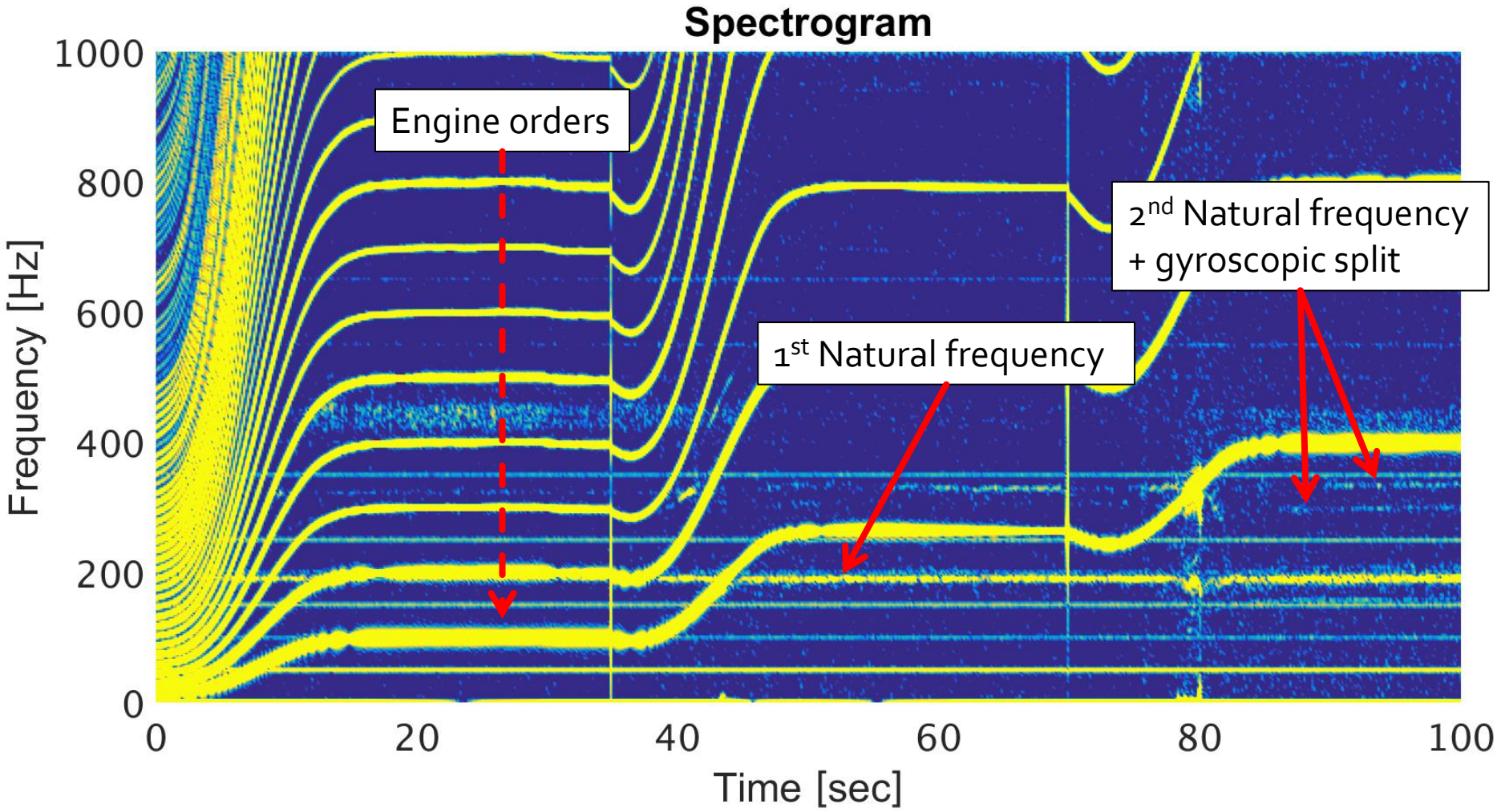
Transient measurements

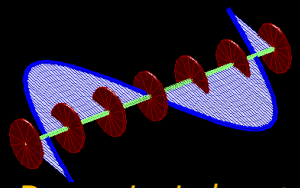


Transient measurements



Summary

- Full rotor-dynamics simulation with laboratory test rig
- FE analysis of modes, critical speeds and gyroscopic effect
- Balancing according to Influence Coefficient method
- Signal processing and comparison to simulations



Future plans

- Transient measurements with stiff supports.
- Implementing Voice Coil actuators to simulate squeeze-film dampers.
- Reconcile finite element models with experiments
- Investigating the method of balancing fast rotors while rotating at low speeds

Questions