# Torsional/Lateral Rotordynamics Software with Variable Frequency Drives and Motor Eccentric Force Prediction

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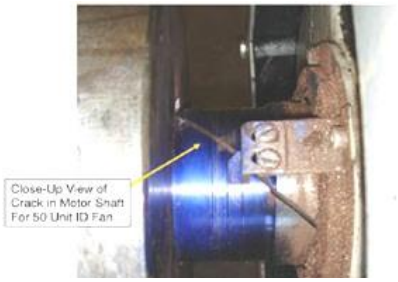
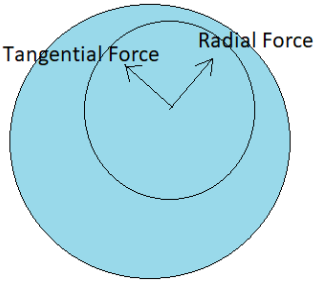



## INTRODUCTION AND JUSTIFICATION

### VFD-Motor Machinery Train Software:

- VFD-motor drive may cause shear failure of rotating machinery.
- Primary reason for failure is rich harmonic spectrum of the motor torque.
- VFD-Motor Machinery Train Software (VFD Torsional) provides the feature of simultaneously solving VFDs, motors, and mechanical gear trains with various open and closed loop control techniques.




### Motor FEM Software:

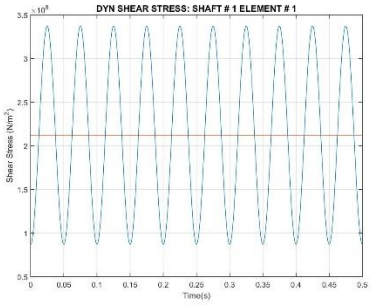
- Electric motors may have static eccentricity due to operating conditions.
- Static eccentricity results in unbalanced eccentric shaft forces in the radial and tangential directions.
- Eccentric shaft forces may result in an instability problem.
- Motor-FEM Software provides the feature of electromagnetic FEA of motors to calculate eccentric shaft forces.

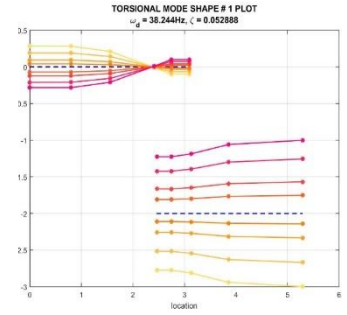
## STATUS OF CURRENT WORK

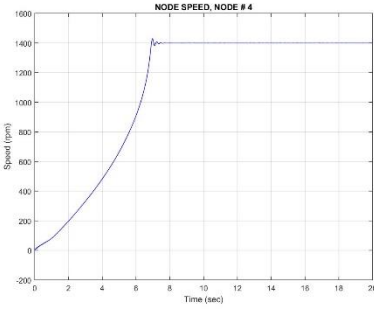
Excel GUI based software. Does not need MATLAB/ANSYS etc.

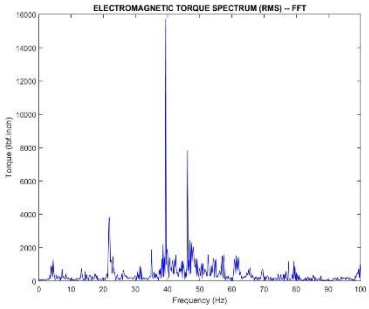
### VFD Software

- Synchronous/Induction Motor Open/Closed Loop Simulations.
- Both steady-state and transient life-prediction and vibration response of mechanical systems with the pure torsional/coupled lateral-torsional model with user-defined/motor torque. Mechanical train may consist of shafts, couplings, gears, etc. Gears could be rigid/flexible with/without backlash and impact damping.



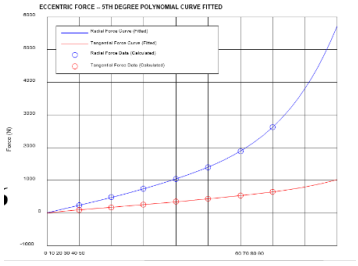



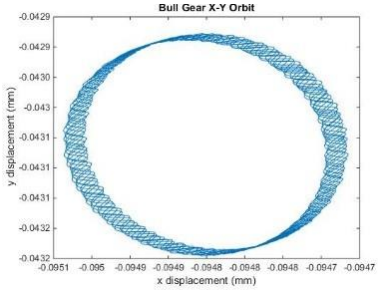




### Motor MEC Software

- Radial and tangential magnetic forces and stiffness calculated using Maxwell stress tensor method.
- Bounded limit cycle with mass unbalance included. Combination of the synchronous whirling due to mass unbalance and the whirling limit cycle due to the motor radial and tangential forces.

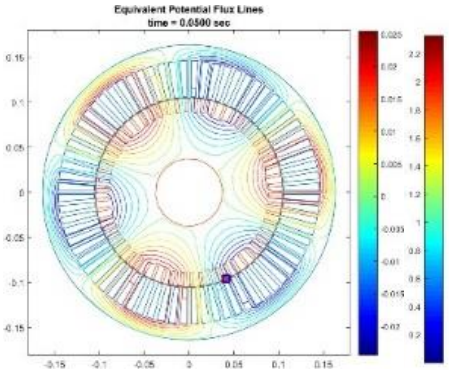


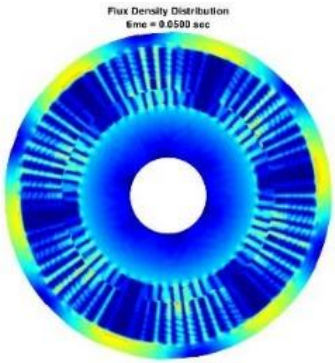




### Motor FEM Software

- Linear and Non-linear Electromagnetic FEM of induction and synchronous motors to calculate motor force.

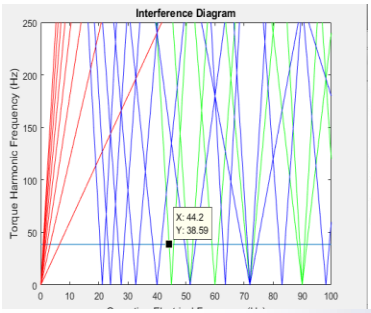
- Simulate motor eccentric fault condition to calculate radial and tangential force.

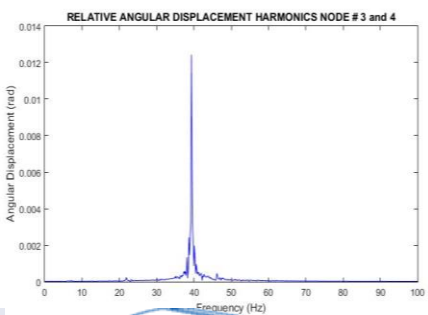



**Case Study:** Southwest Research Institute Motor-Compressor Model

- Theoretical validation of mode shapes and natural frequencies.
- Verification of presence of torque and shear stress harmonic around fundamental natural frequency during open loop control.

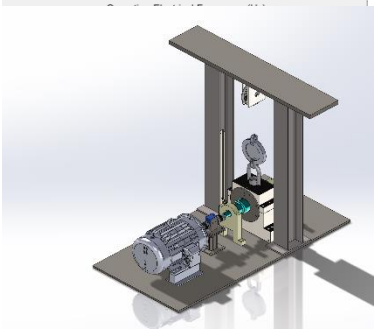


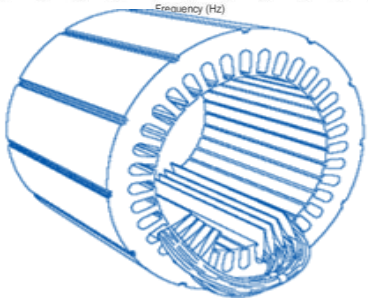




## PROPOSED WORK

### Experimentation

- Experimental study of VFD-motor torque signal using an in-house test rig.



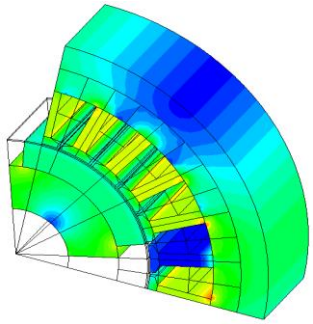


### VFD Software: Mechanical System

- Frequency Sweep test: Steady State
- Other methods to incorporate effect of mean shear stress in pure torsional loading.
- Include other life prediction methods - nominal mean stress theory and residual mean stress theory.
- Nonlinear coupling (Holset). Gear teeth fatigue prediction. Planetary gear system.

### VFD Software: Electrical System

- Calculation of steady-state motor torque and vibration response with ideal voltage input.
- Other PWM generation technique and PWM Interleaving for eliminating Current Harmonics.
- Other closed loop motor control methods such as Sensor-less Vector Control.
- Simulation of Electrical fault such as 2-phase/3-phase short circuit analysis and voltage imbalance analysis.
- User defined initial condition for both electrical and mechanical systems.
- Include generic motor parameters for different HP rating.



### Motor FEM Software

- Evaluate motor equivalent circuit parameter
- Extend Source Options: Line-Line Voltage Source; Current Source and External Circuit.
- Extend windings types: multiple layers with delta connection/star with neutral connection.
- Add material database for back iron and conductors and other slot shape options.
- Add other types of motors: reluctance/hysteresis synchronous motor and wound rotor induction motor.
- Develop 3D FEM magnetic field modeler with option to import CAD file.

## BUDGET FOR 2018-2019

- 1 MS student ($2,200/mo. Salary + $400/mo. insurance) × 12 months, Tuition and fees $13,000, computer, equipment, software license and supplies $5,800, Total Cost: $ 50,000