Motor & Drive Systems 2018

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# Dual Rotor LSPM Motor

MOTOR GENERATOR TECHNOLOGY

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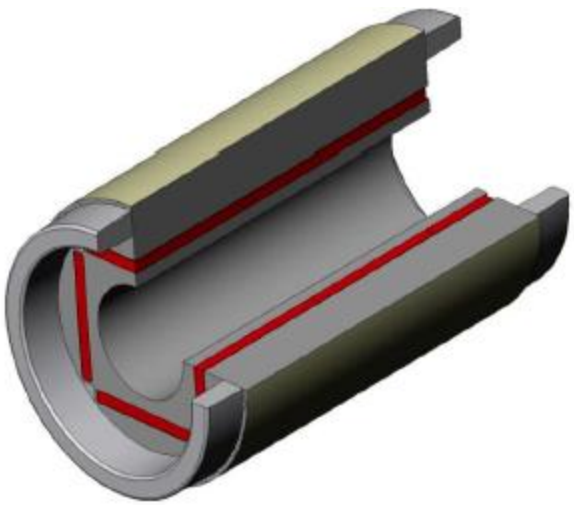
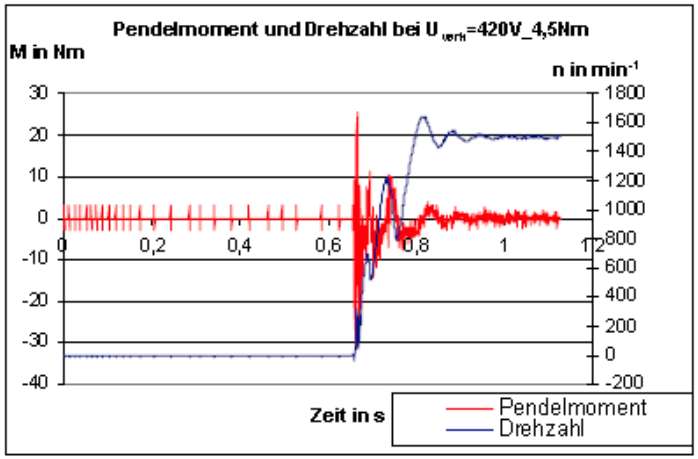
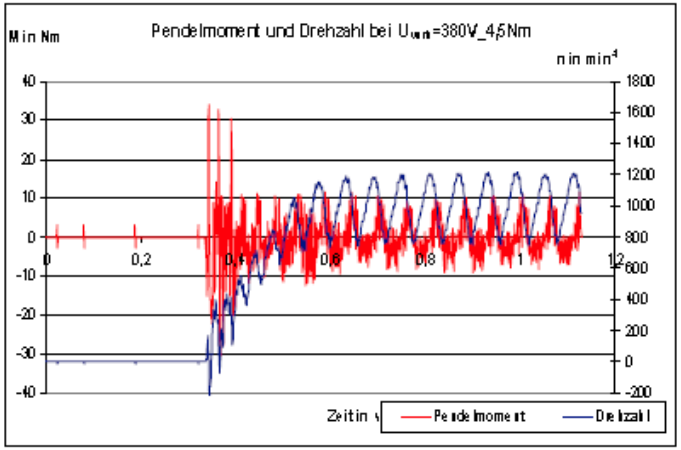
# Traditional LSPM Design Limitations

- Inability to synchronize load with high inertia. According to some the maximum load inertia for LSPM is between 25 to 30 times the motor rotor own inertia
- The initial “kick” torque is quite violent, and often can cause damage in the coupled load or coupling itself

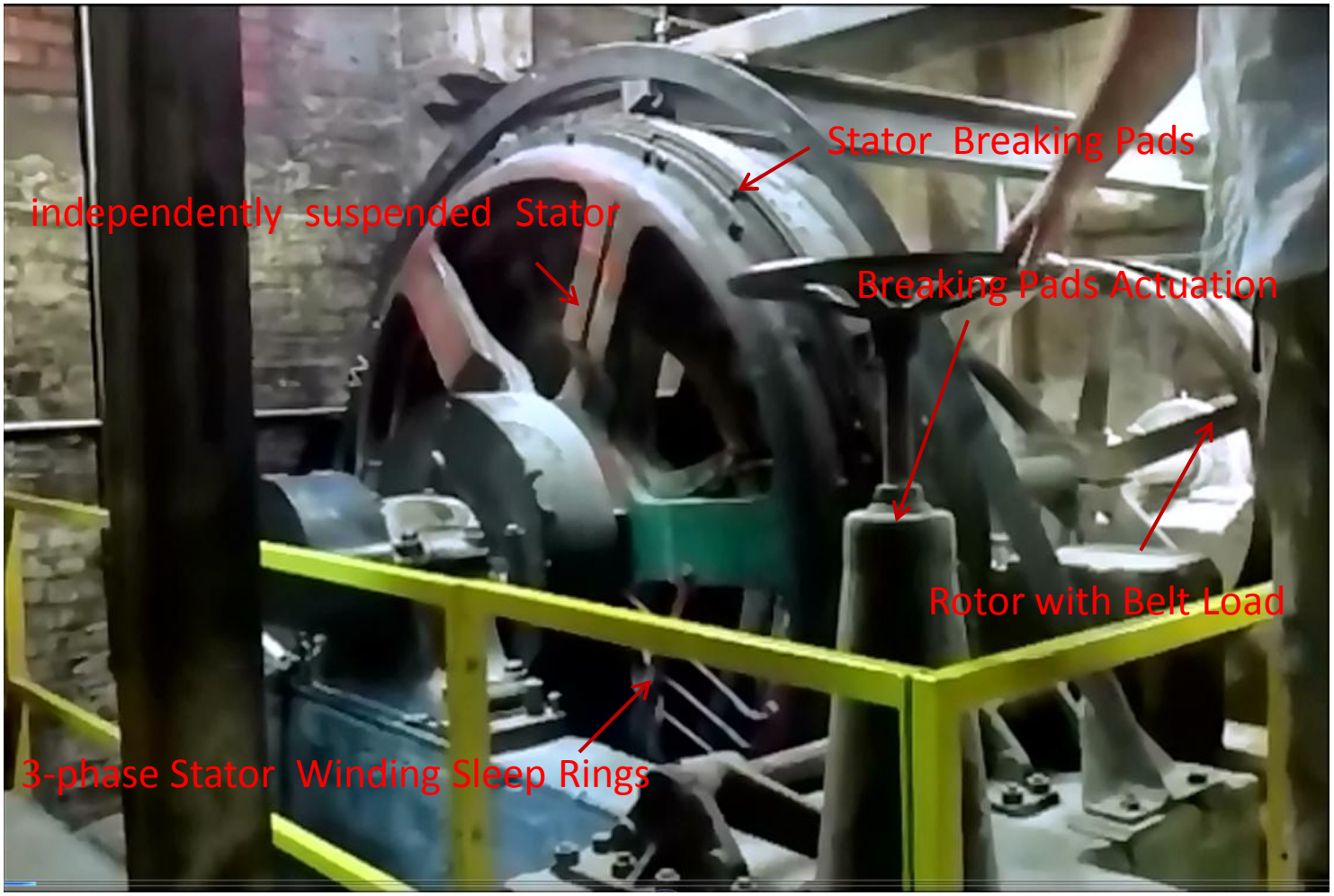




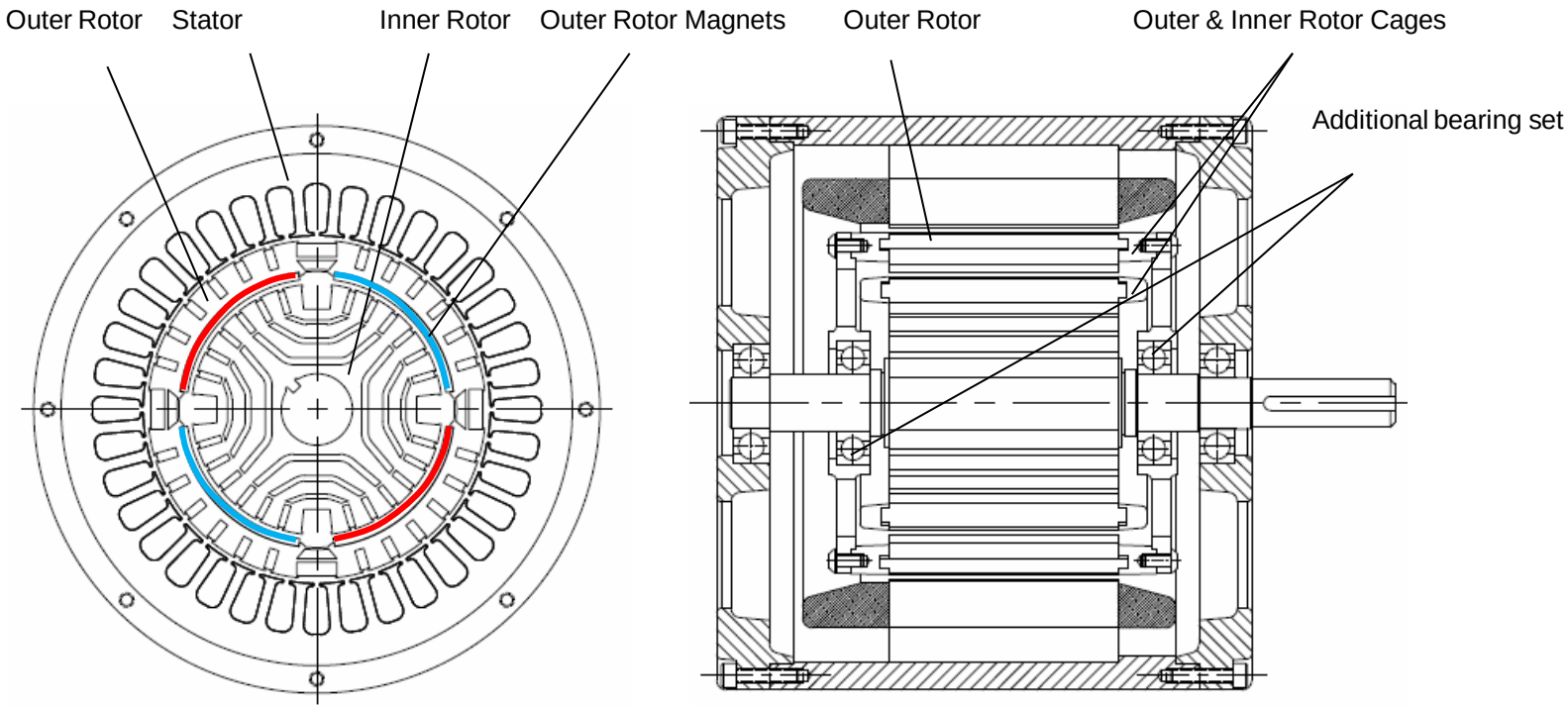

* Dr. Doppelbauer, EEMODs’2013

# Electomechanical Synchronous motor start



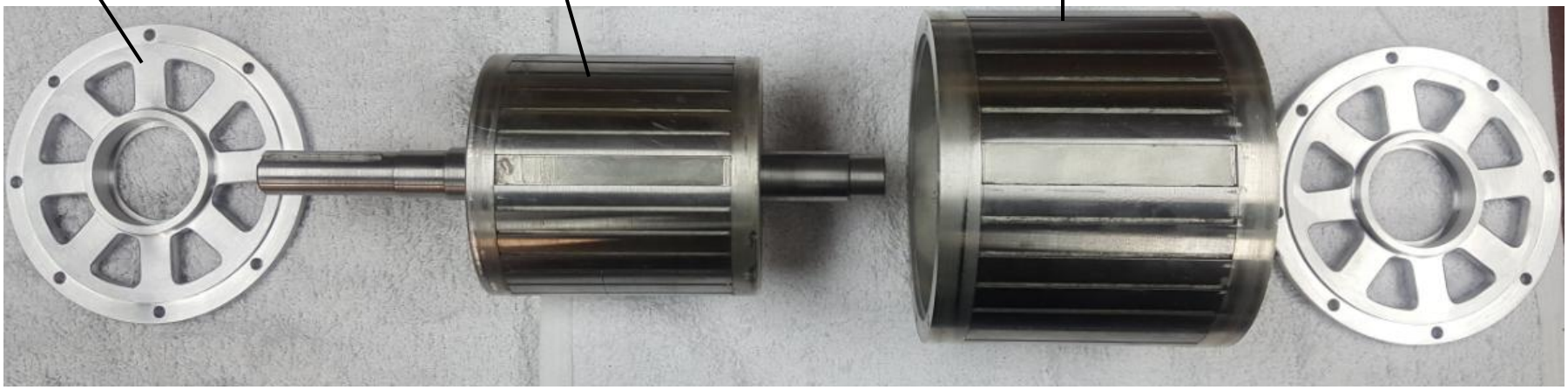

- This motor runs the main line shaft of a flour mill. Motor is 85 - 90 years old

# Dual Rotor LSPM Construction



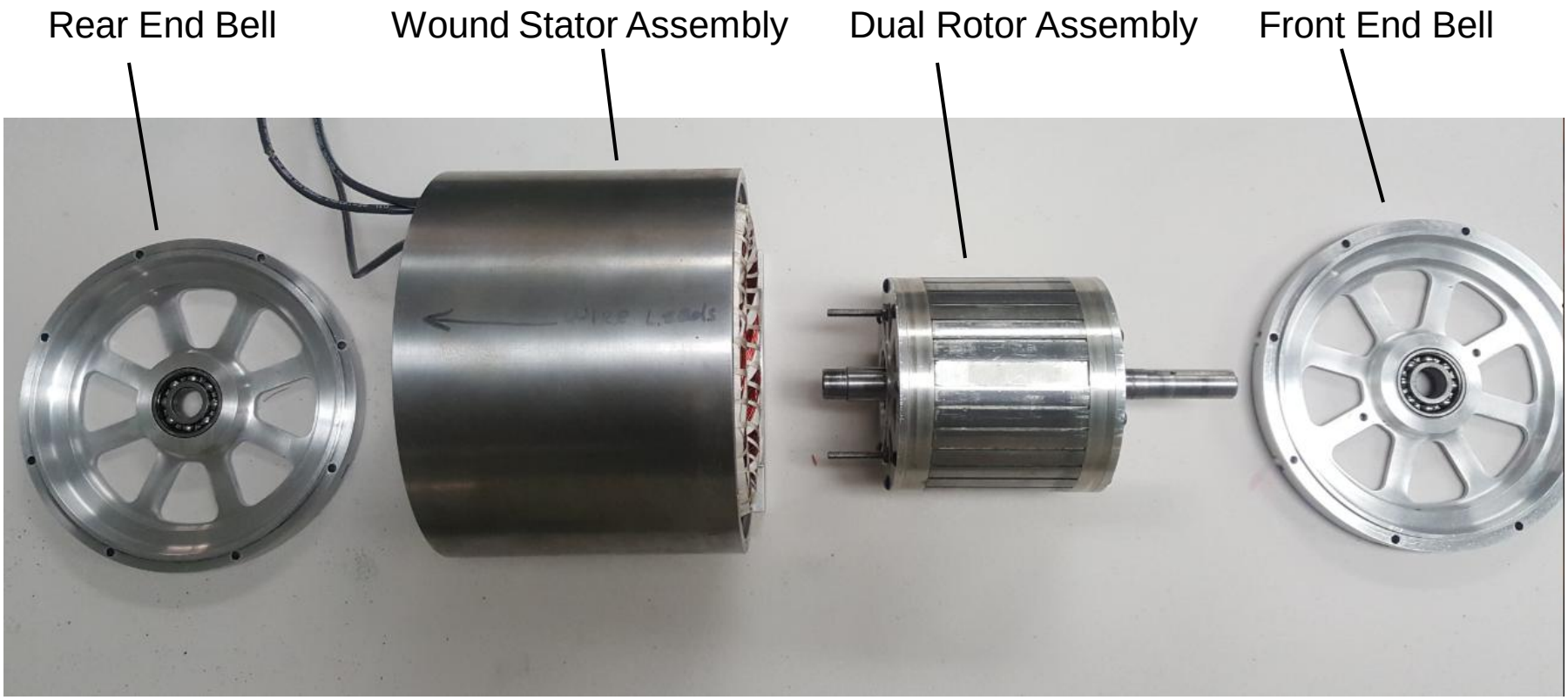

- Outer Rotor is not coupled to the load and its inertia
- Inner Rotor is coupled with load and in its inertial through a EM “Torque Converter”
- Magnets are attached to the ID of the Outer Rotor

# Dual Rotor LSPM Construction



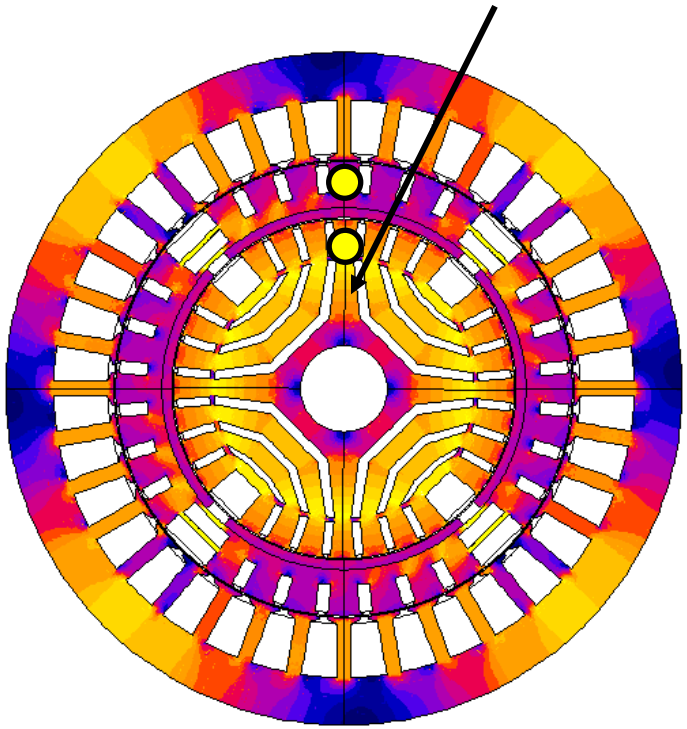
Dual Rotor LSPM Rotor Assembly

# Dual Rotor LSPM major Components



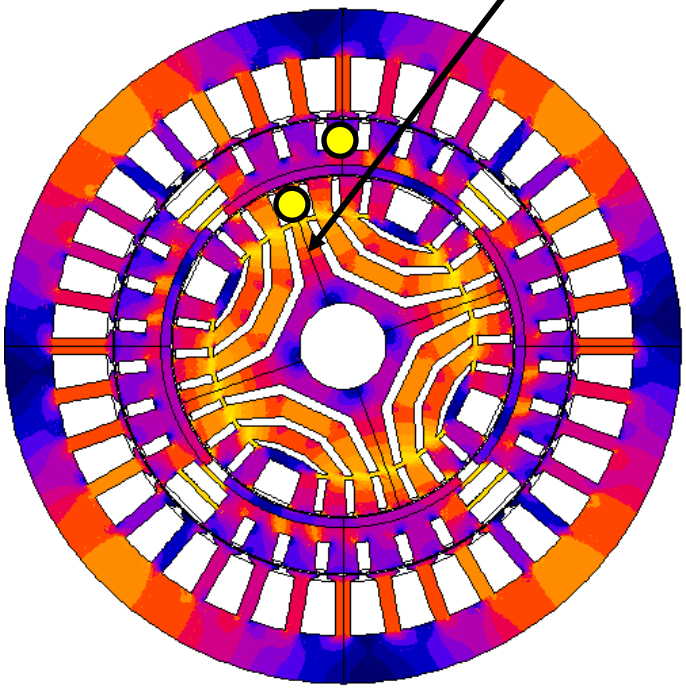
# Dual Rotor LSPM Flux Distribution

Magnet aligned with Inner rotor d-axis



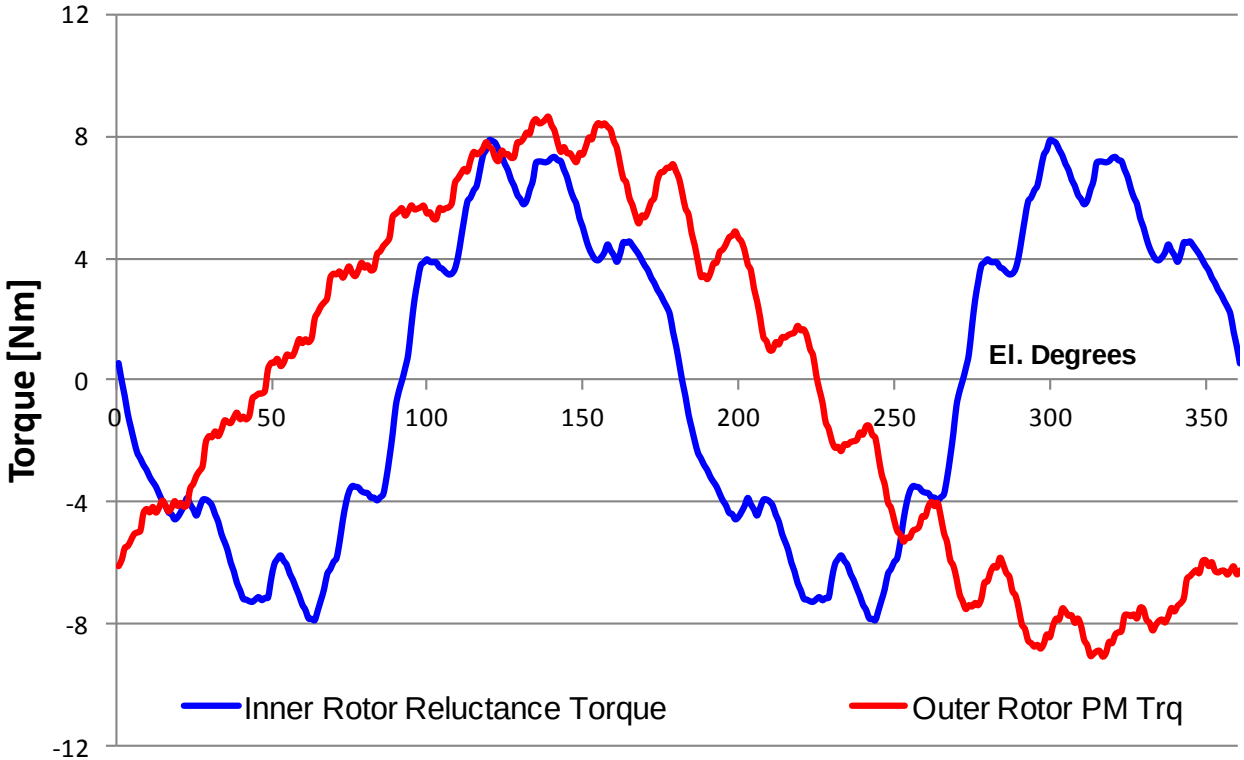
NO-Load Field

Outer rotor Magnets misalignment with Inner Rotor d-axis

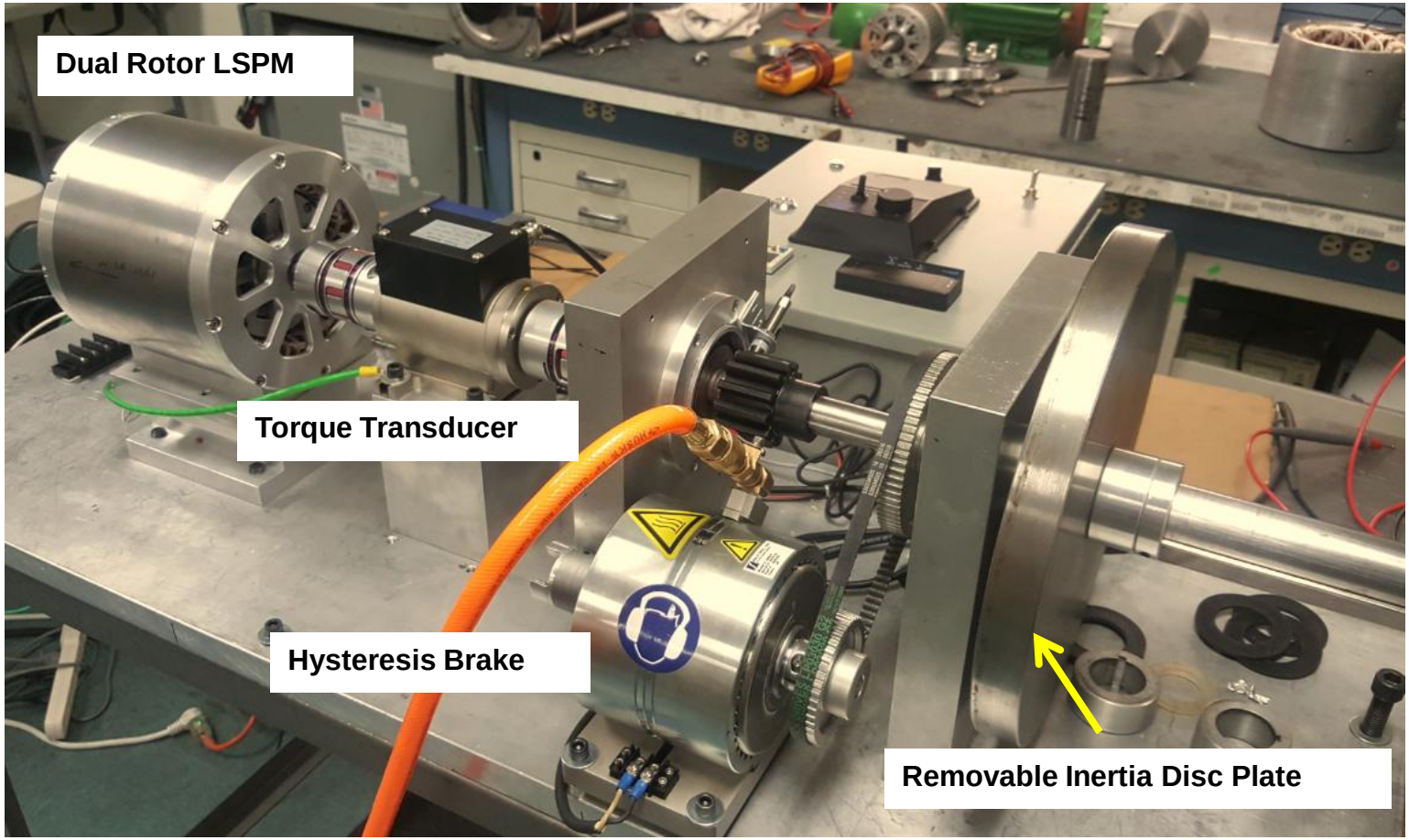


Under Load

# Dual Rotor LSPM Synchronous Torques



# Dual Rotor LSPM Test Bench



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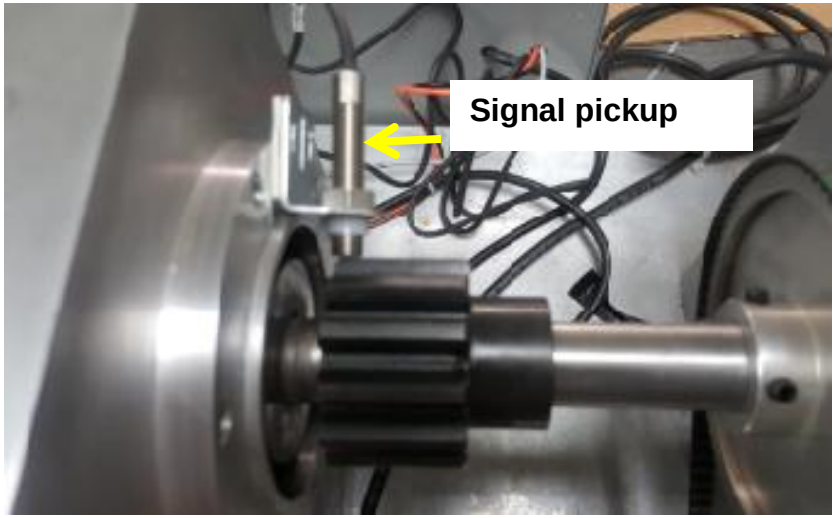
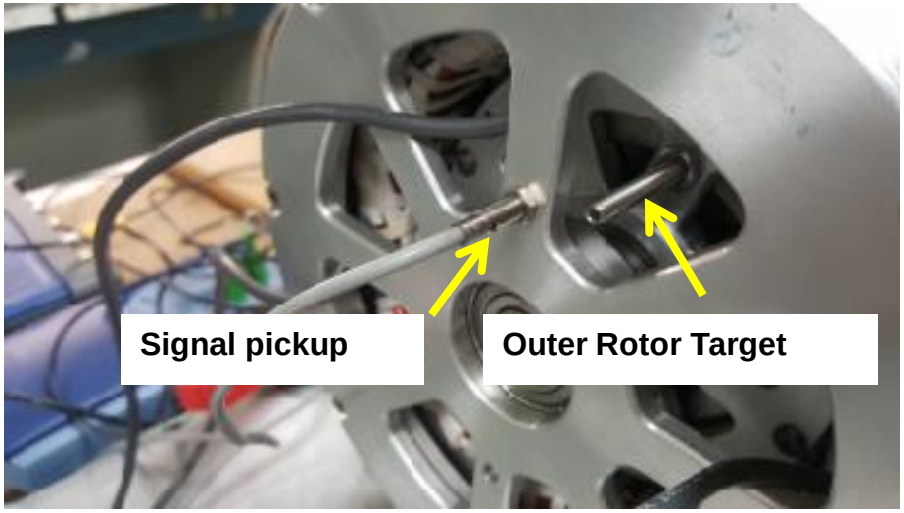
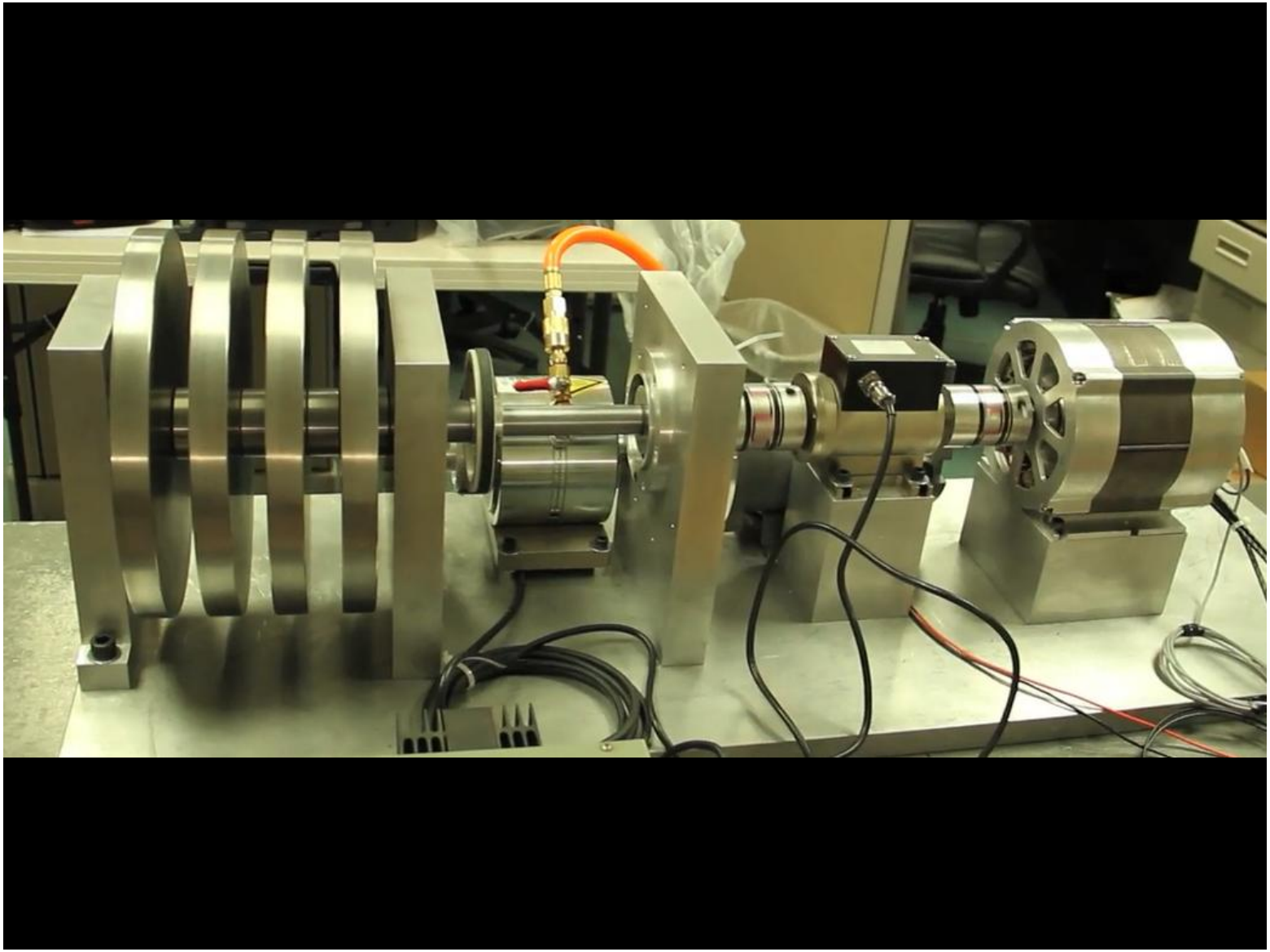


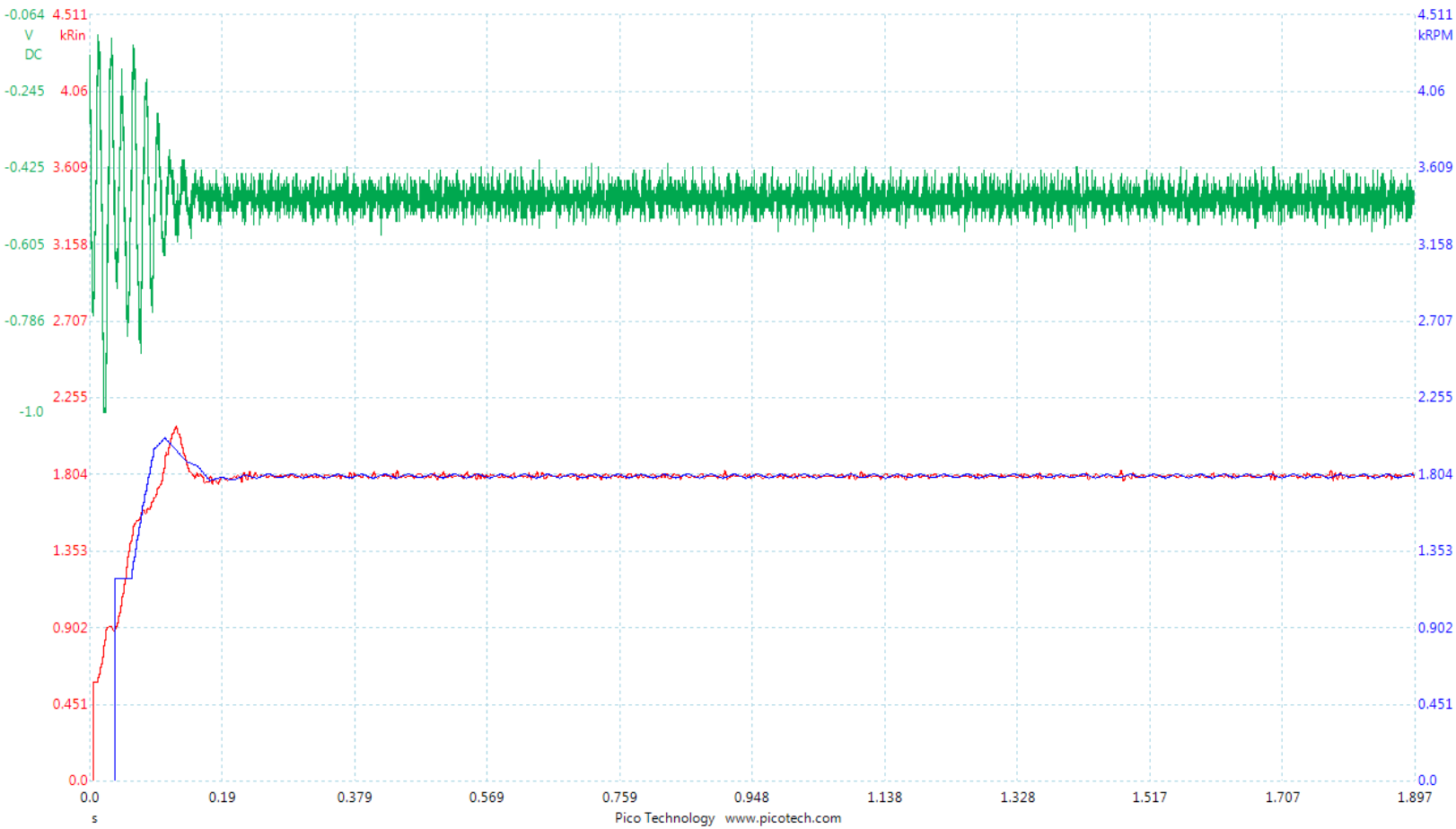




- Rotor Speeds measurements during motor startup

# Dual Rotor LSPM Startup Demo

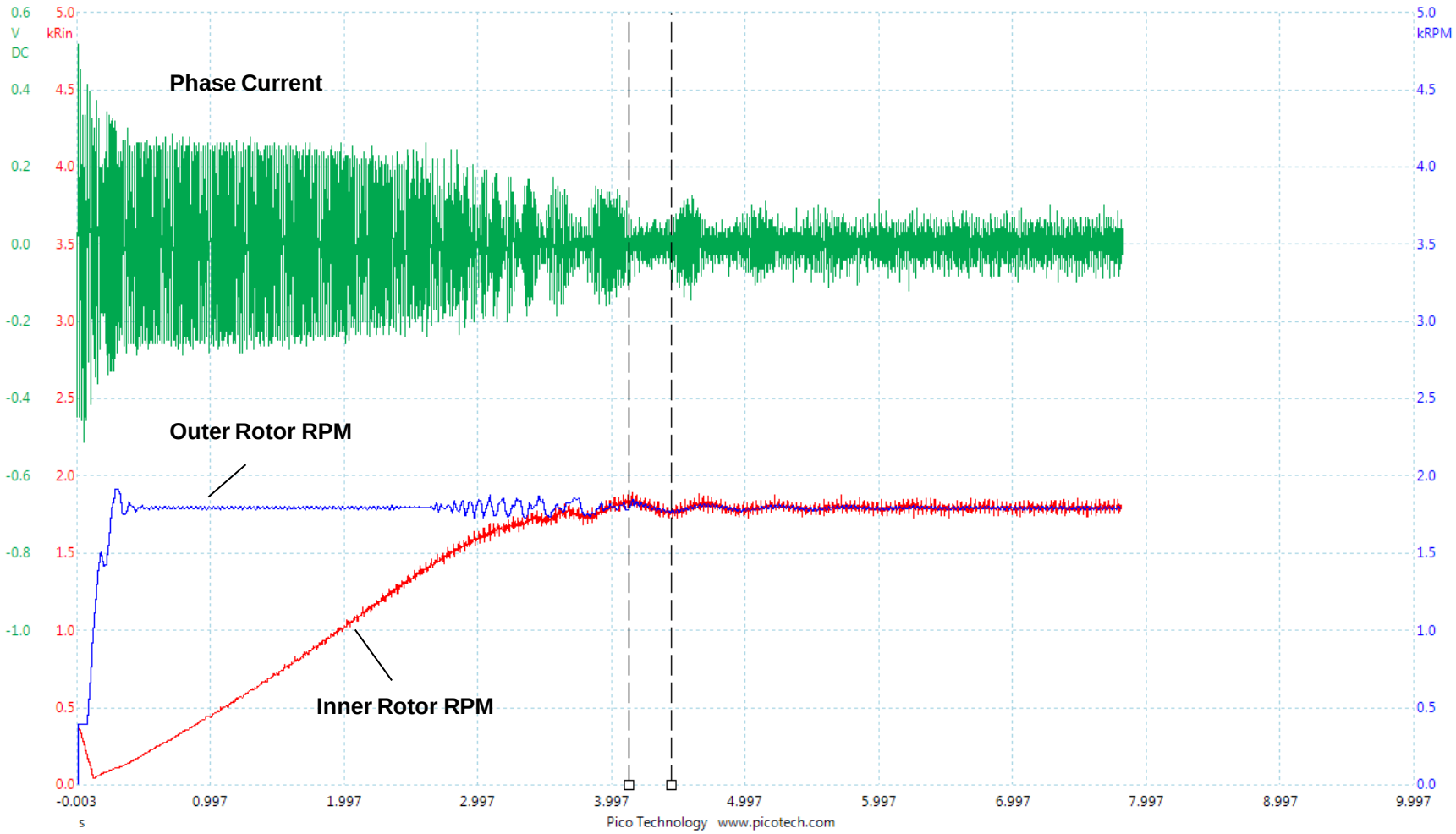


# No-Load Startup Test of Dual Rotor LSPM



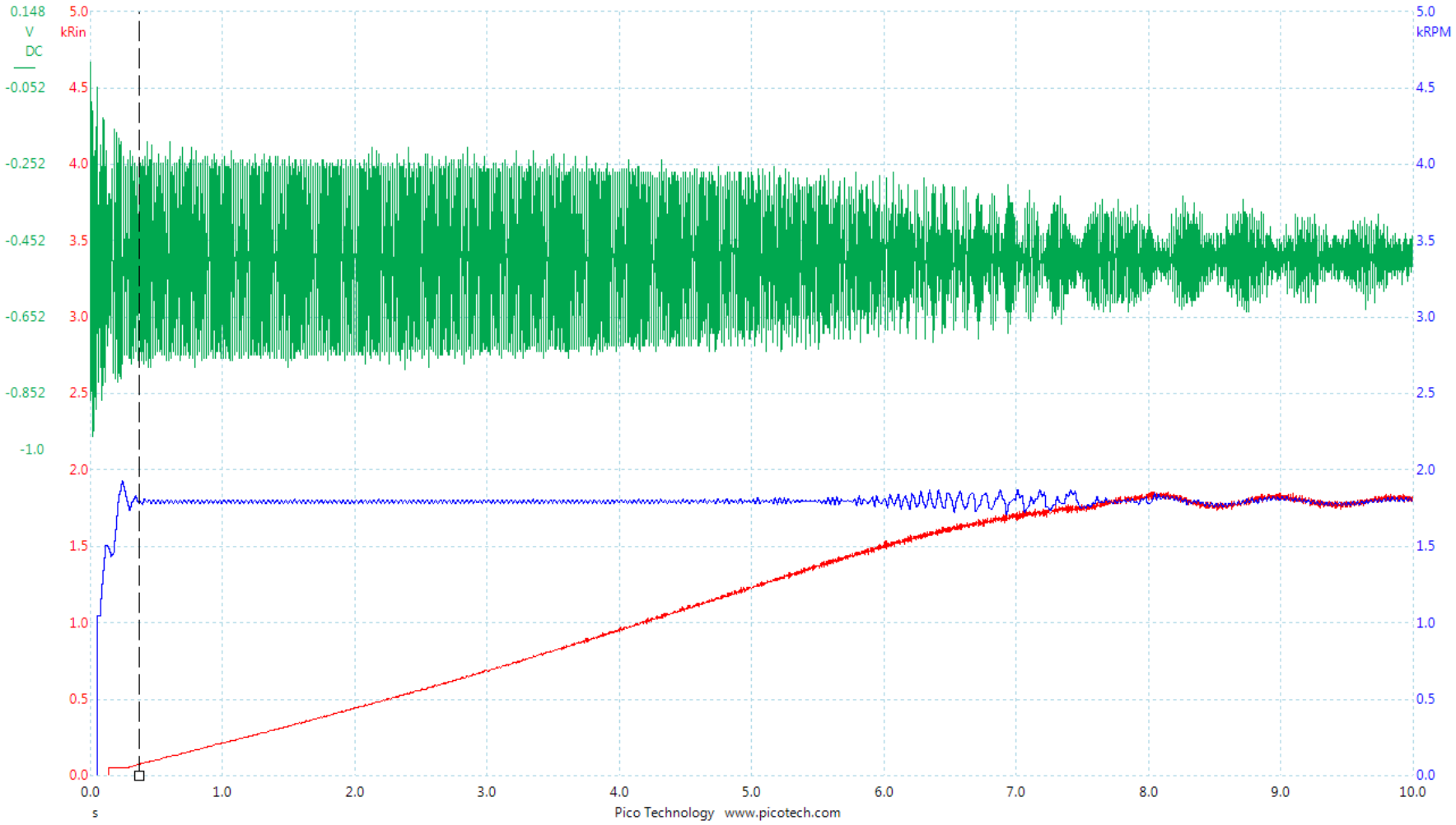

Outer Rotor RPM — Inner Rotor RPM — Phase Current

# Startup Test of Dual Rotor LSPM



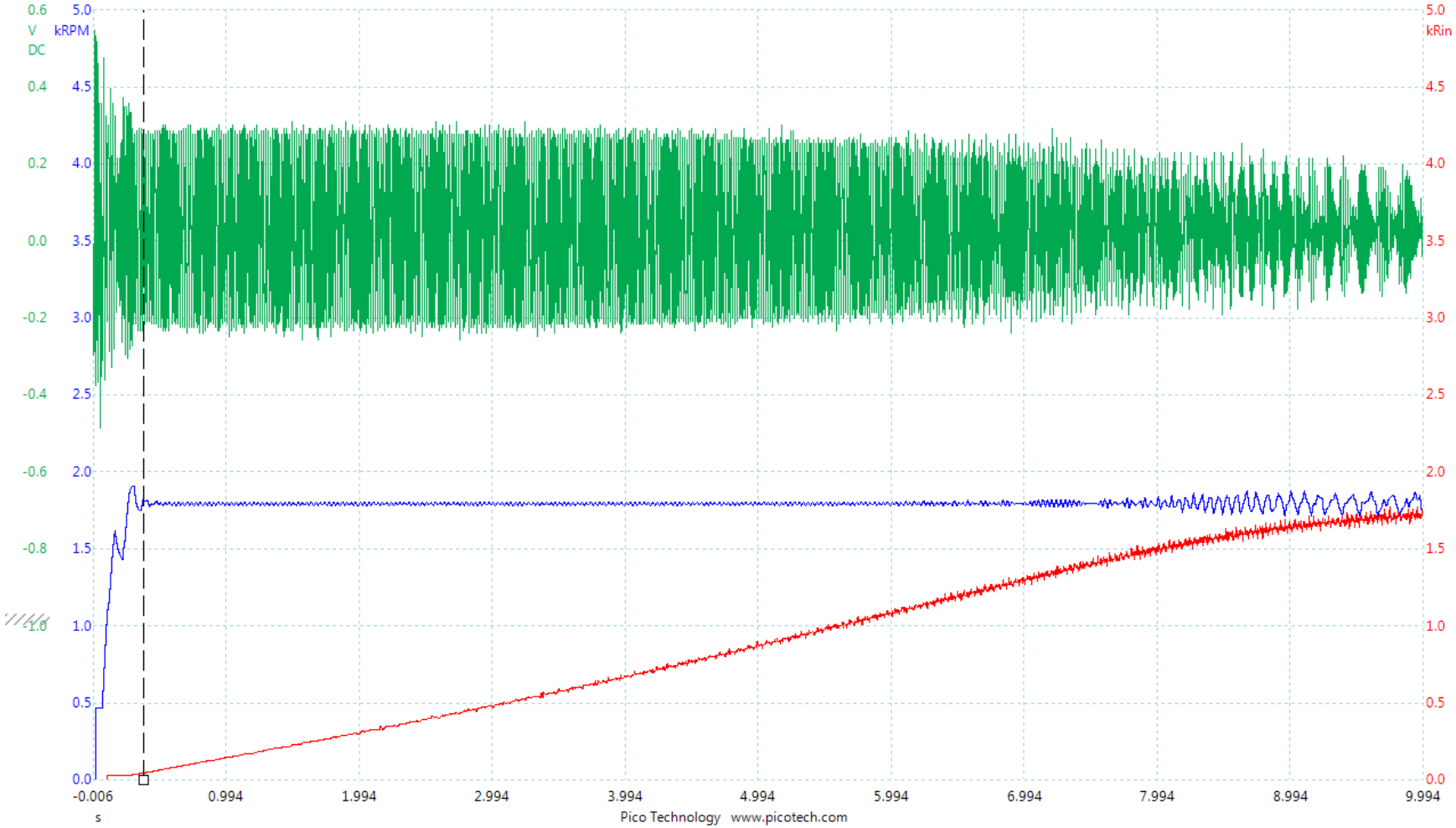

- 1hp Load Torque & 1 Disc Dynamic Load (~27 x motor inner rotor inertia)

# Startup Test of Dual Rotor LSPM



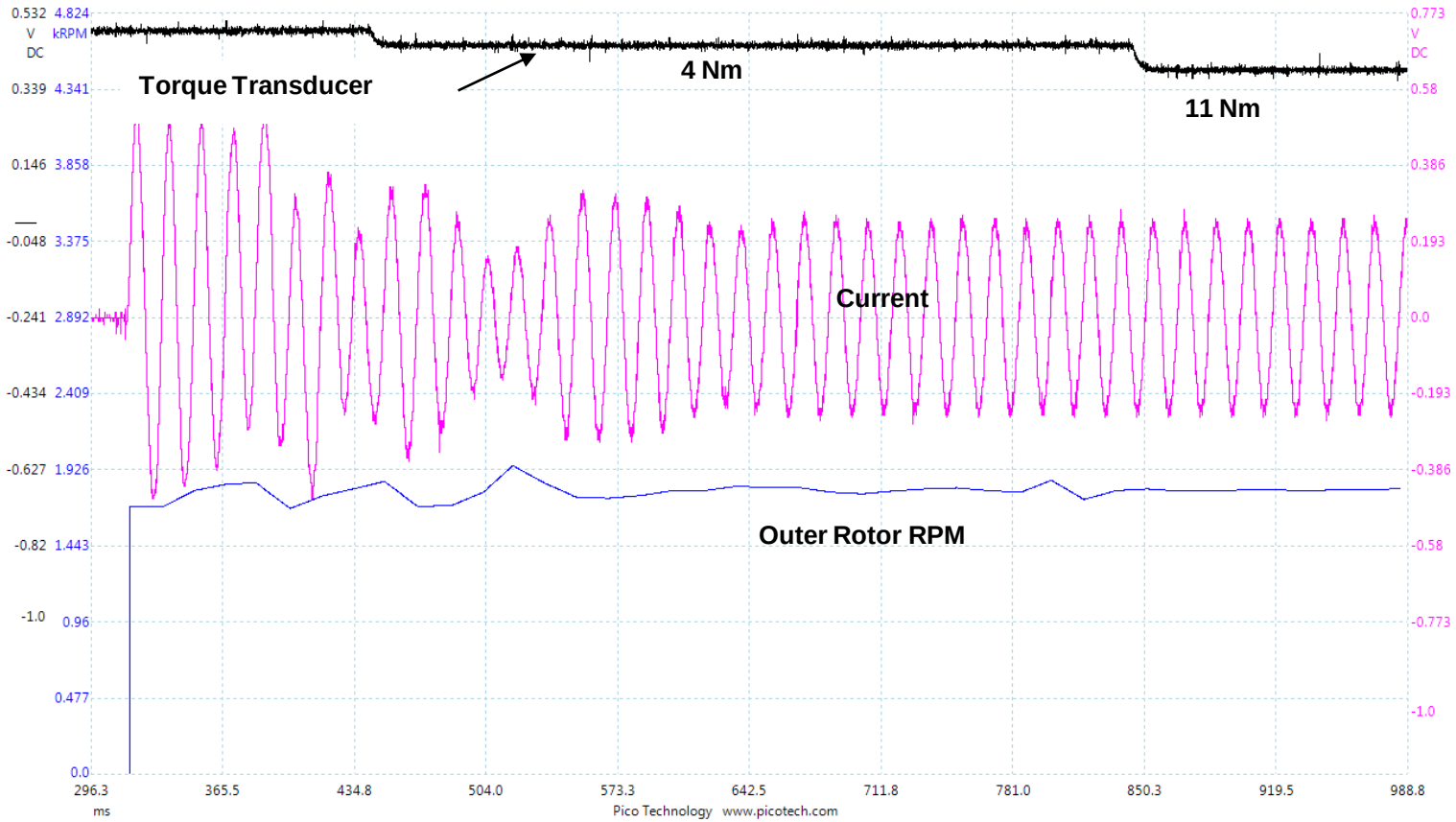

- 0hp Load Torque + 3.5 Discs Dynamic Load (~94 x motor inner rotor inertia)

# Startup Test of Dual Rotor LSPM



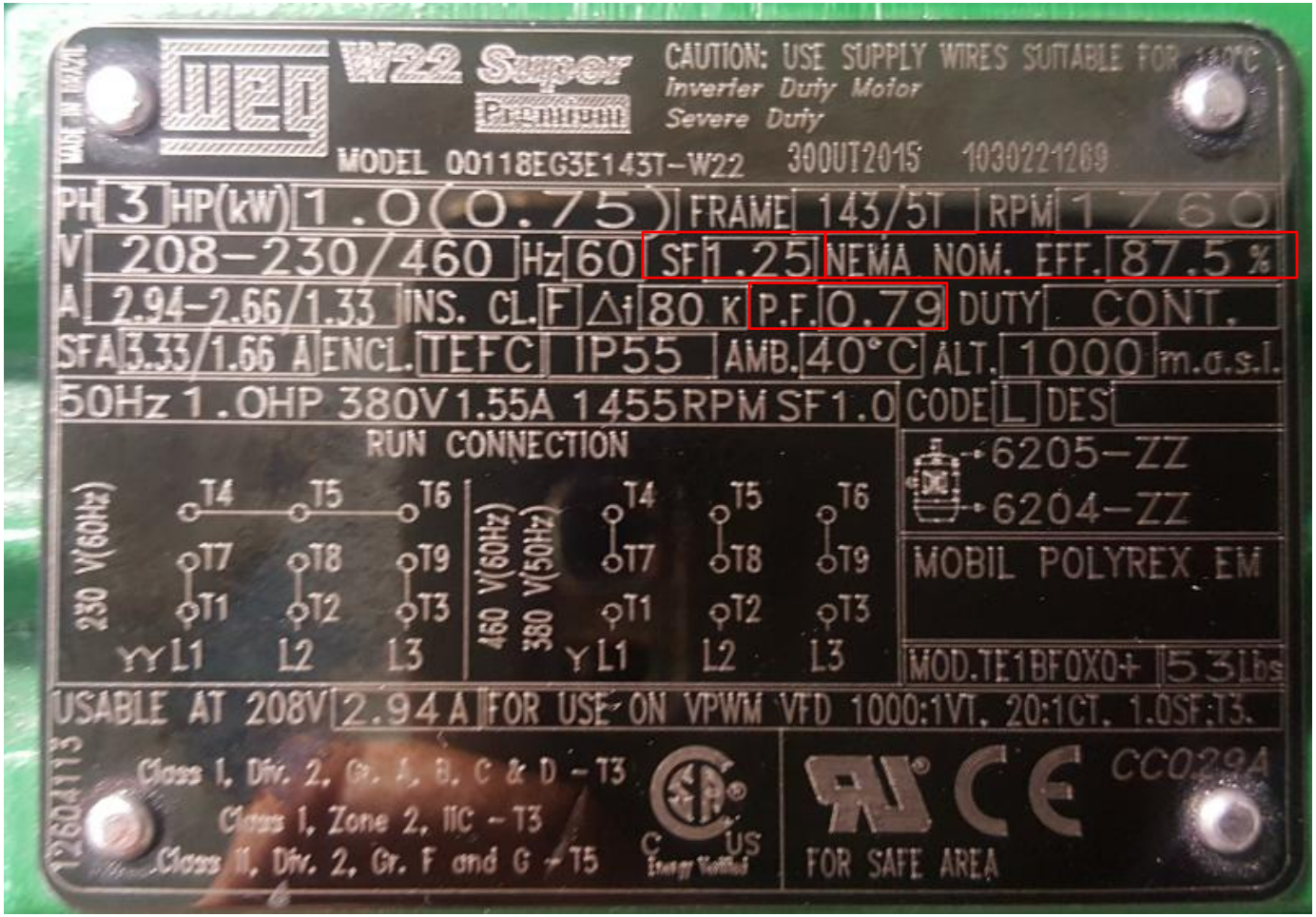

- 1hp Load Torque & 3.5 Discs Dynamic Load (~94 x motor inner rotor inertia)

# Locked Rotor Test




- Locked Rotor Torque rises to its maximum gradually
- Outer Rotor reaches synchronous RPM in about 0.17sec (10 el. Cycles) and would help machine cooling during stall

# IE4 ACIM Comparison




- IE4 ACIM 0.75kW Rated Efficiency is 87.5% @ PF 0.79

# Load Test of Dual Rotor LSPM

| DR-LSPM Operating point | Load Torque | Line to Line Voltage | Phase Current | Power Factor | RPM | Input Power | Output Power | Efficiency |
|---|---|---|---|---|---|---|---|---|
| | Nm | Vrms | Arms | PF | rpm | W | W | % |
| LSPM @ No load | 0 | 221 | 0.25 | 0.40 | 1800 | 38.9 | 0.0 | **0.0** |
| LSPM @ 3/4hp | 2.97 | 221 | 1.61 | 0.98 | 1800 | 607.8 | 559.9 | **92.1** |
| LSPM @ 1hp | 3.96 | 221 | 2.06 | 0.99 | 1800 | 800.3 | 746.5 | **93.3** |
| LSPM @ 1.25 hp | 4.95 | 221 | 2.62 | 0.99 | 1800 | 1002.6 | 933.1 | **93.1** |

- Rated power Efficiency Improved by 5.8% vs. IE4 ACIM
- Rated Power PF improved by 20%

# Dual Rotor LSPM Active Materials vs. IE4 ACIM

| Active Material Factors | OD | L | D^2L | Copper | | Eff | Rotor Total Weight | Stator Lam Weight |
|---|---|---|---|---|---|---|---|---|
| Units | inch | inch | inch^3 | kg | % | % | kg | kg |
| WEG IE4 ACIM | 5.515 | 4.63 | 141 | 1.72 | 100% | 87.5% | 5.08 | 5.8 |
| DR-LSPM | 6.9 | 3 | 143 | 2.67 | 155% | 93.3% | 5.61 | 4.746 |
| DR-LSPM* | 6.9 | 3 | 143 | 1.72 | 100% | 92.4% | 5.61 | 4.746 |

* Analytical estimate for the same weight of winding copper

- D^2L of DR-LSPM does match IE4 ACIM
- DR-LSPM winding has 55% more copper, but it does deliver 5.8% Efficiency improvement !
- For the same copper weight DR-LSPM would loose only ~0.9% of efficiency (to 92.4%)
- More objective analysis will be available as we design more DR-LSPM motors

# Conclusions

- New Dual Rotor LSPM has been presented. This new type LSPM is able to overcome some major problems with use of line-start motors for general industrial applications
- The starting LSPM torque “kick” and load inertia limitation have been practically eliminated. These improvements can widen up the range of use LSPM for IE4, IE5 applications, beyond traditionally accepted power & load inertia range
- Dual Rotor LSPM active material requirements are similar to IE4 ACIM, and fairly similar cost in production