PASSIVE WIRELESS SENSOR SYSTEM FOR STRUCTURAL HEALTH MONITORING

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Industry needs Sensors

Structural Health Monitoring :

- Detecting and locating damages
- Identifying damage types & severity

Condition Based Maintenance:

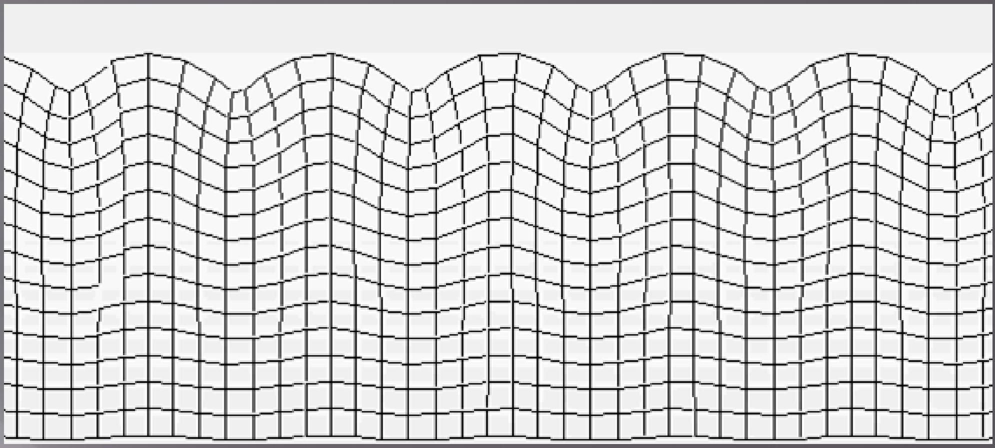
- Improve system reliability
- Maximize equipment availability
- Decrease maintenance costs
- Reduce human error

Solution: Wireless SAW Sensors

- Surface Acoustic Wave (SAW) technology
- Wireless systems for measurement of strain, torque, and temperature
- Differentiate between the effect of strain/torque and temperature

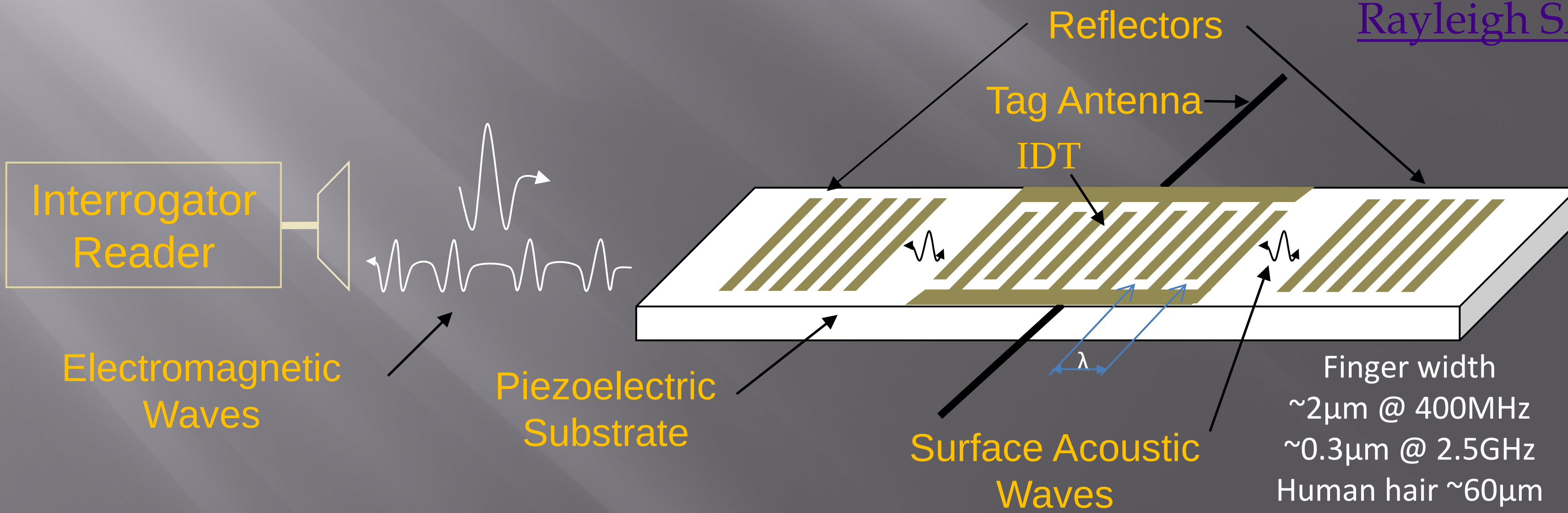
What is a typical SAW Device?

A solid state device - Converts electrical energy into a mechanical wave on a piezoelectric crystal substrate, and vise versa.



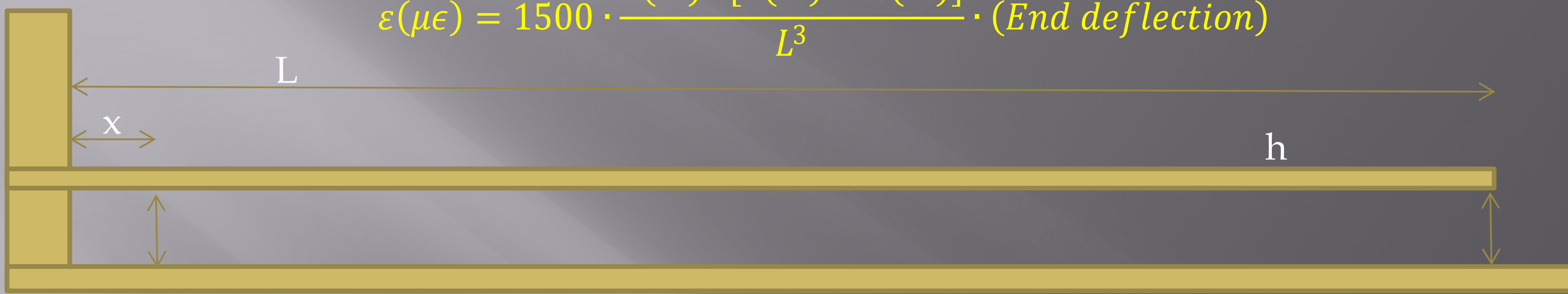
$$\tau = \frac{2 \cdot L}{v}; \; f_c = \frac{1}{\tau} = \frac{v}{2 \cdot L}$$

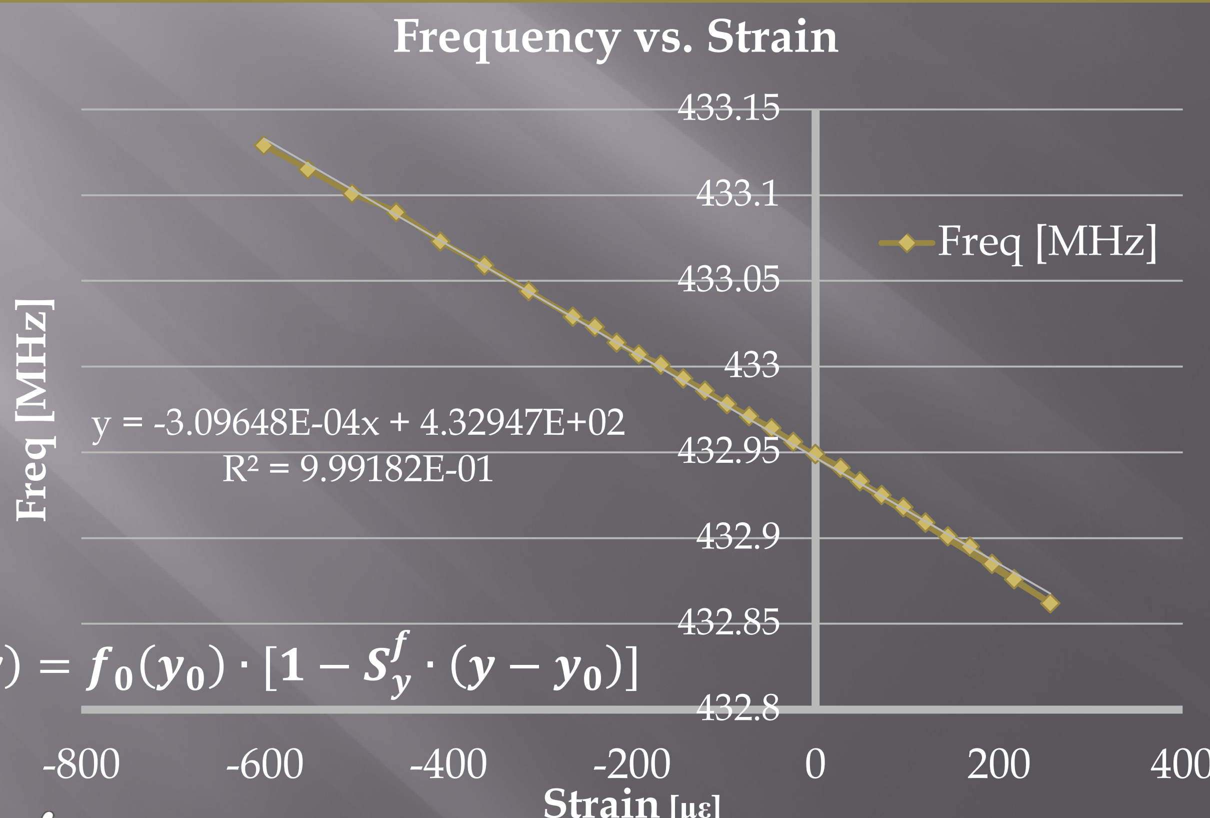
[Rayleigh SAW]



Experimental SAW Strain Sensor Assembly

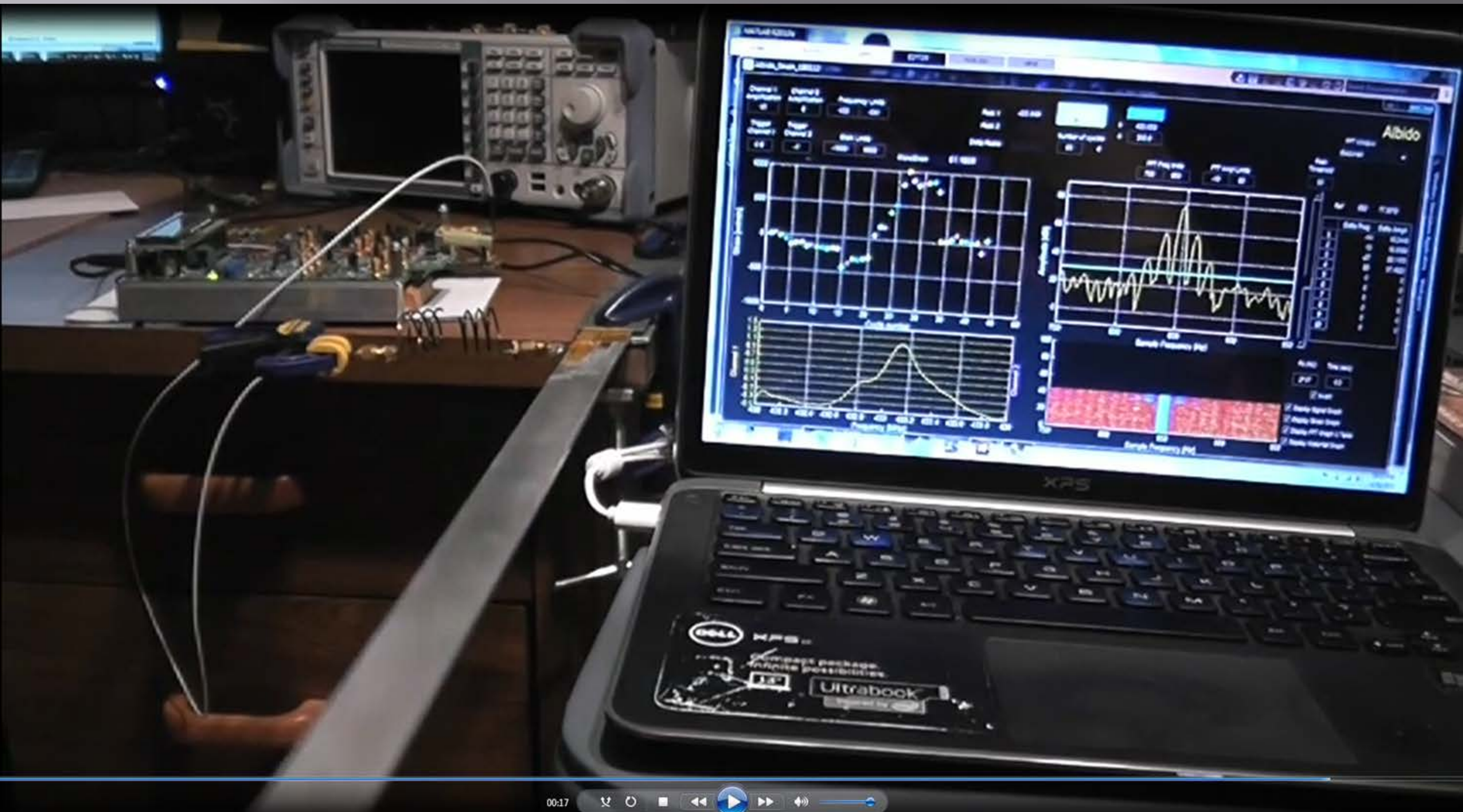
$$\varepsilon(\mu\epsilon) = 1500 \cdot \frac{h(m) \cdot [L(m) - x(m)]}{L^3} \cdot (End\ deflection)$$





$$f_0(y) = f_0(y_0) \cdot [1 - S_y^f \cdot (y - y_0)]$$

SAW Strain Sensor – Dynamic



[SAW Strain Sensor - Dynamic]

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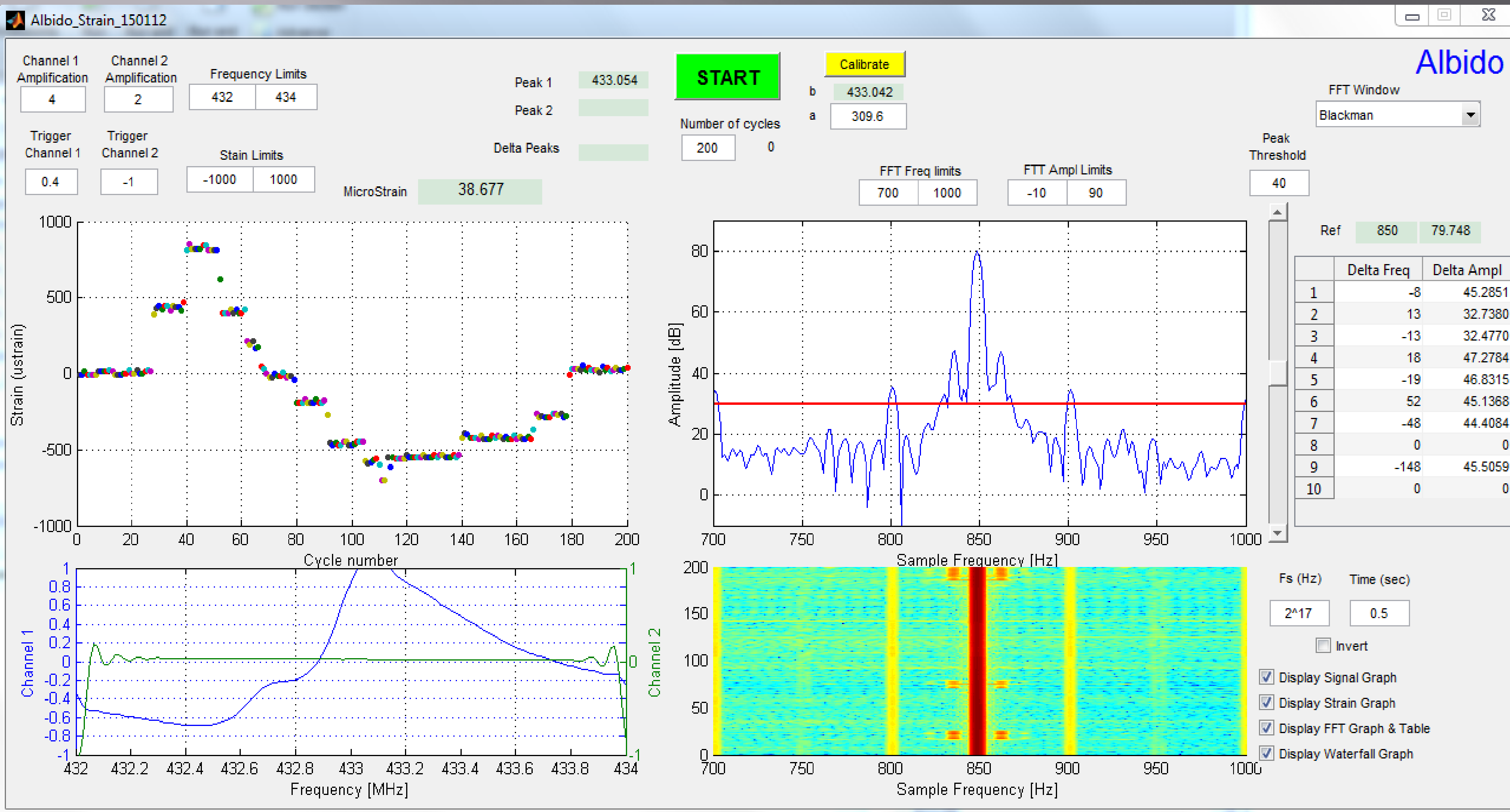
Perform validation Experiment
SAW Strain Sensor – Static and Dynamic



Slow change response

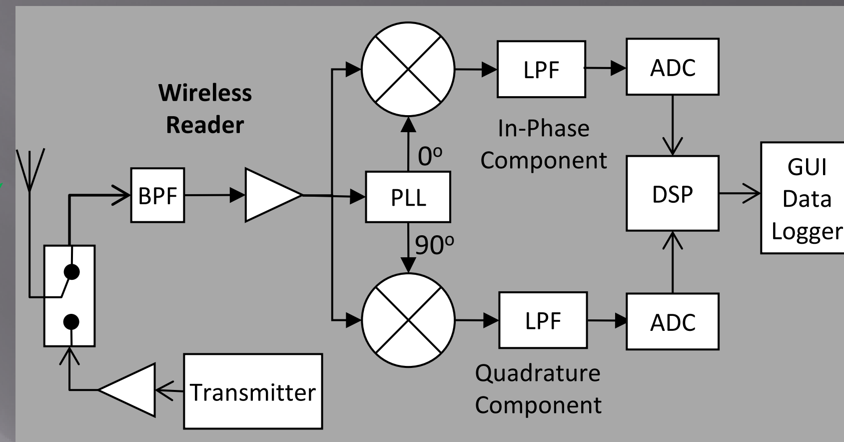
Free vibration response

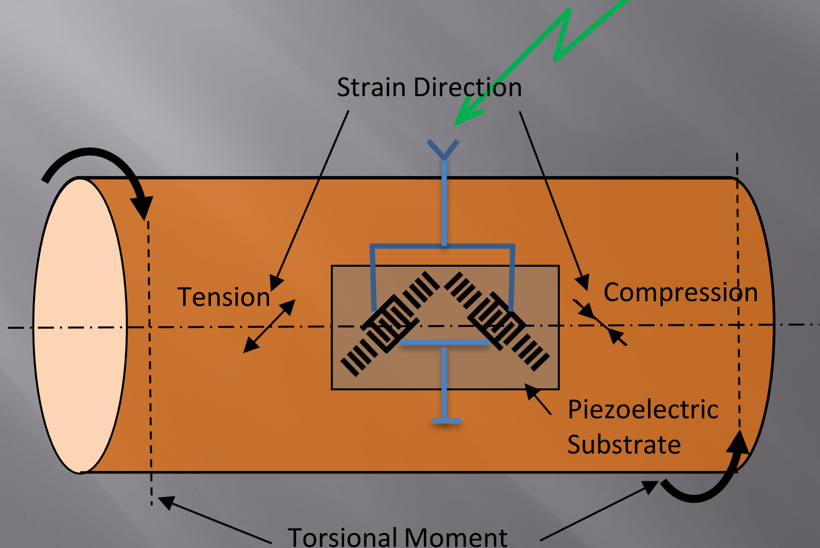
SAW based Torque Sensor and Wireless Reader

<u>Measure:</u>

- Static & dynamic strain/torque
- Rate-of-change of strain/torque

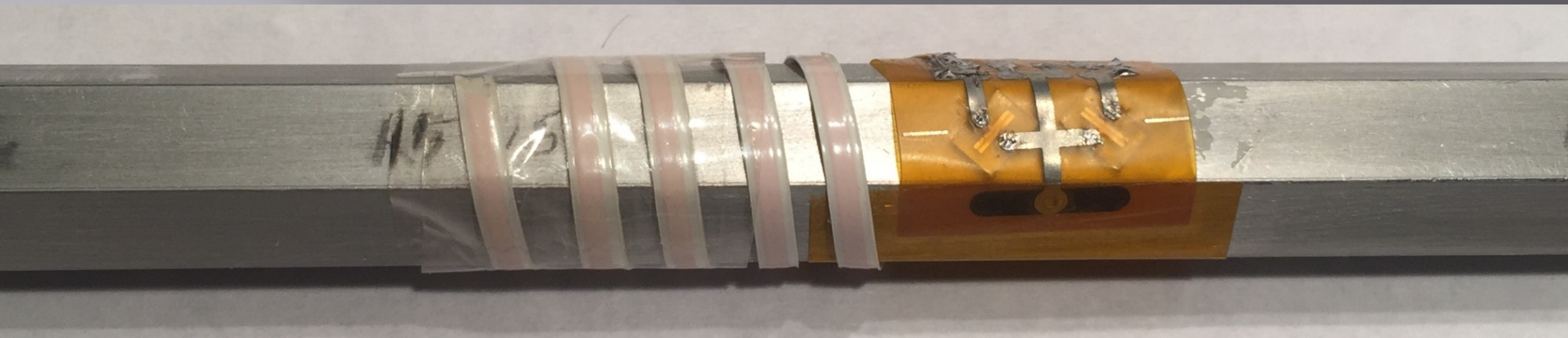
<u>Minimum post-processing required</u>

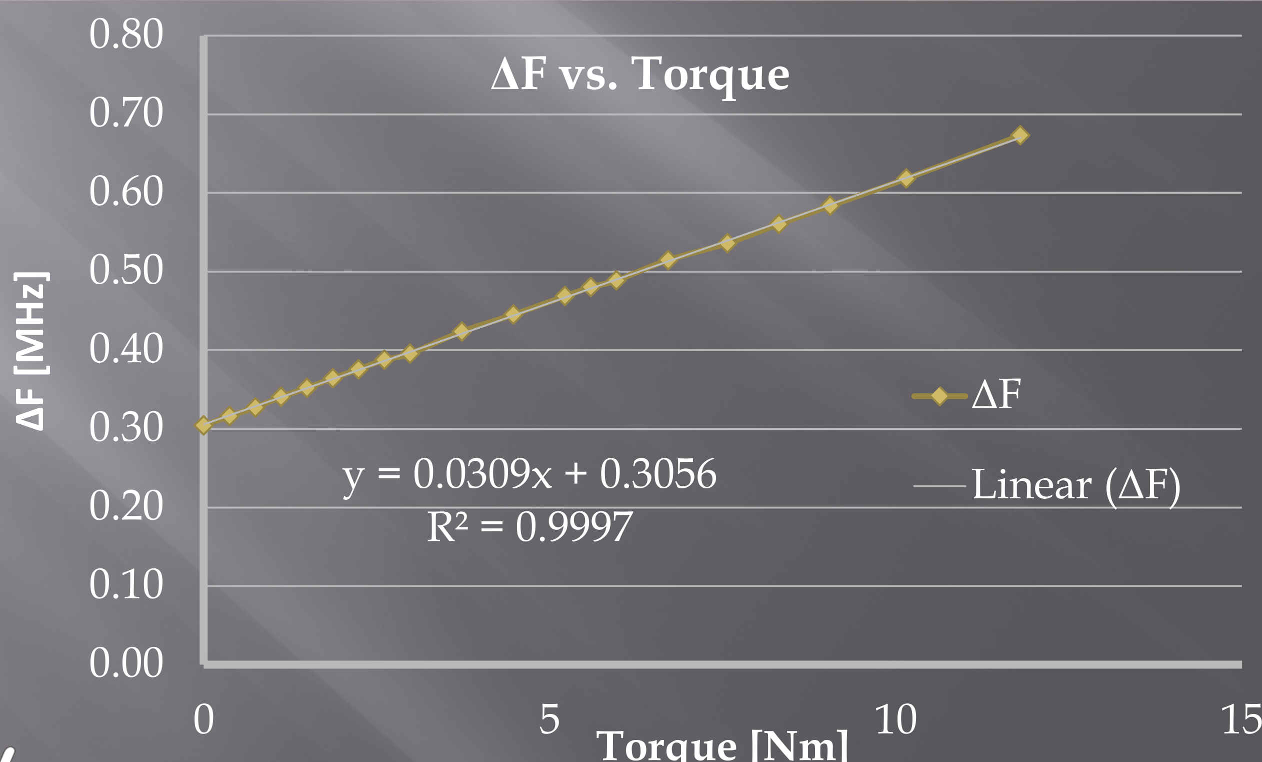




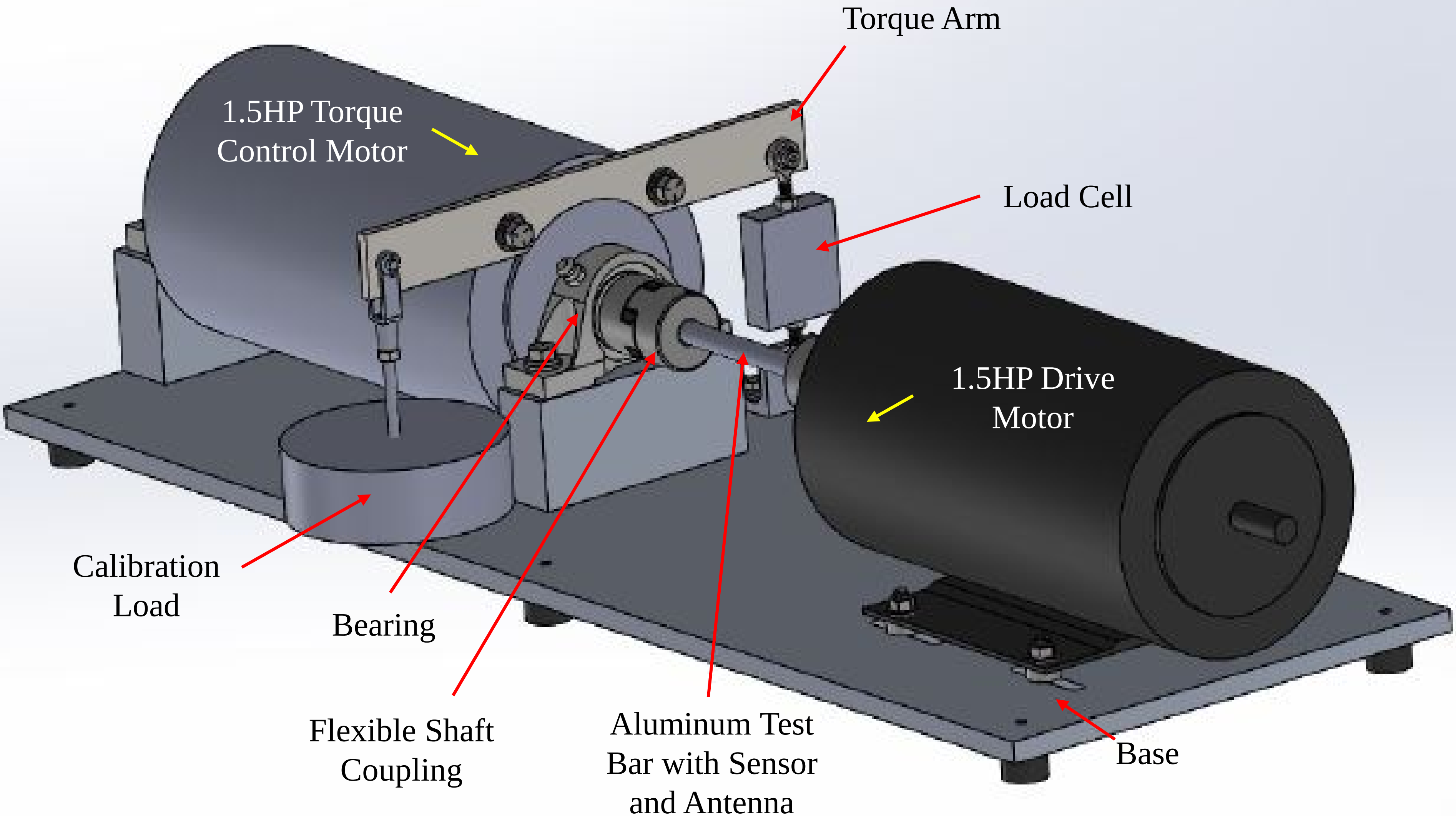
$$\Delta F(MHz) = a \cdot Torque(Nm) + b$$

Frequency Response (Torque Sensor)

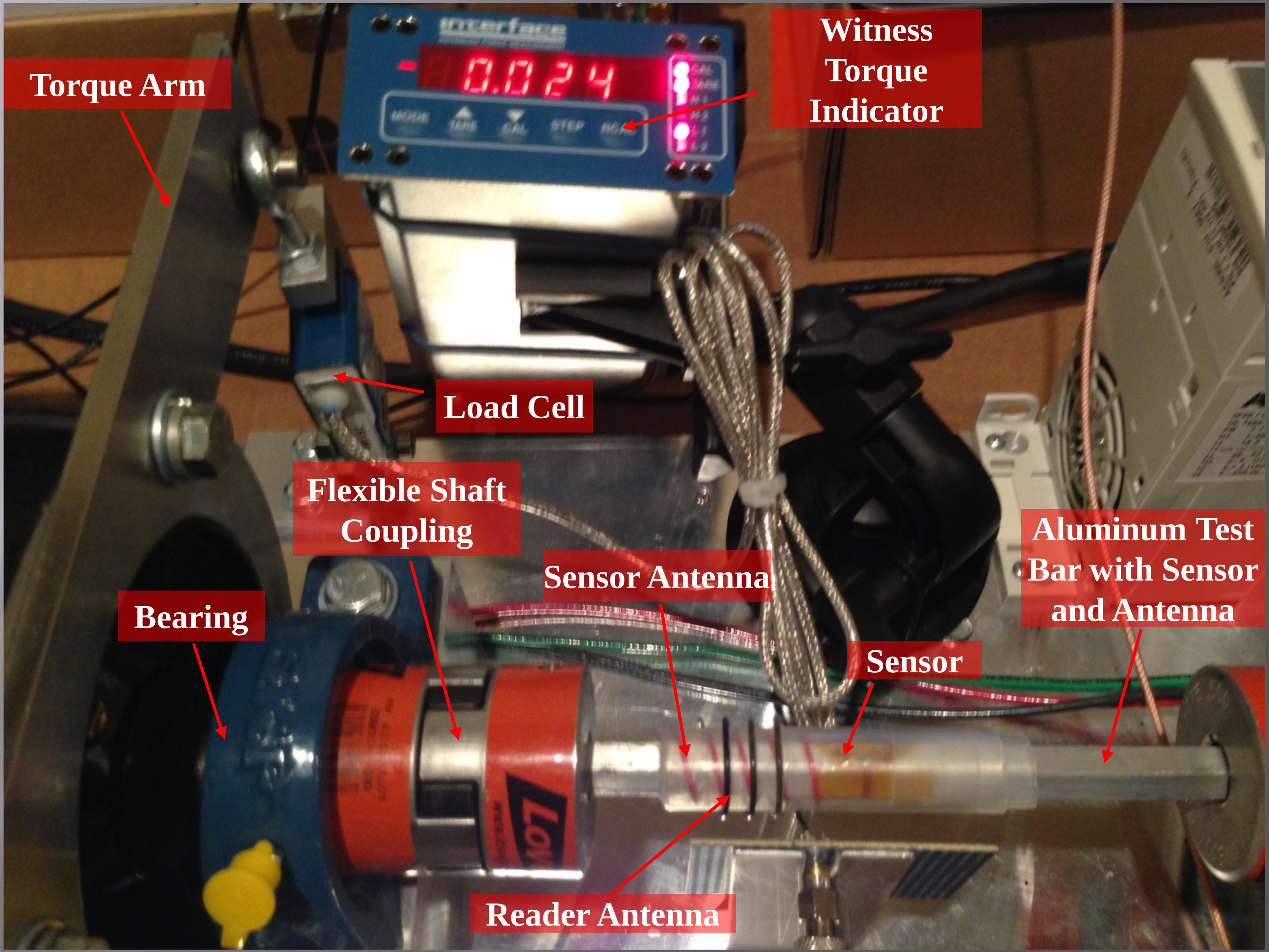




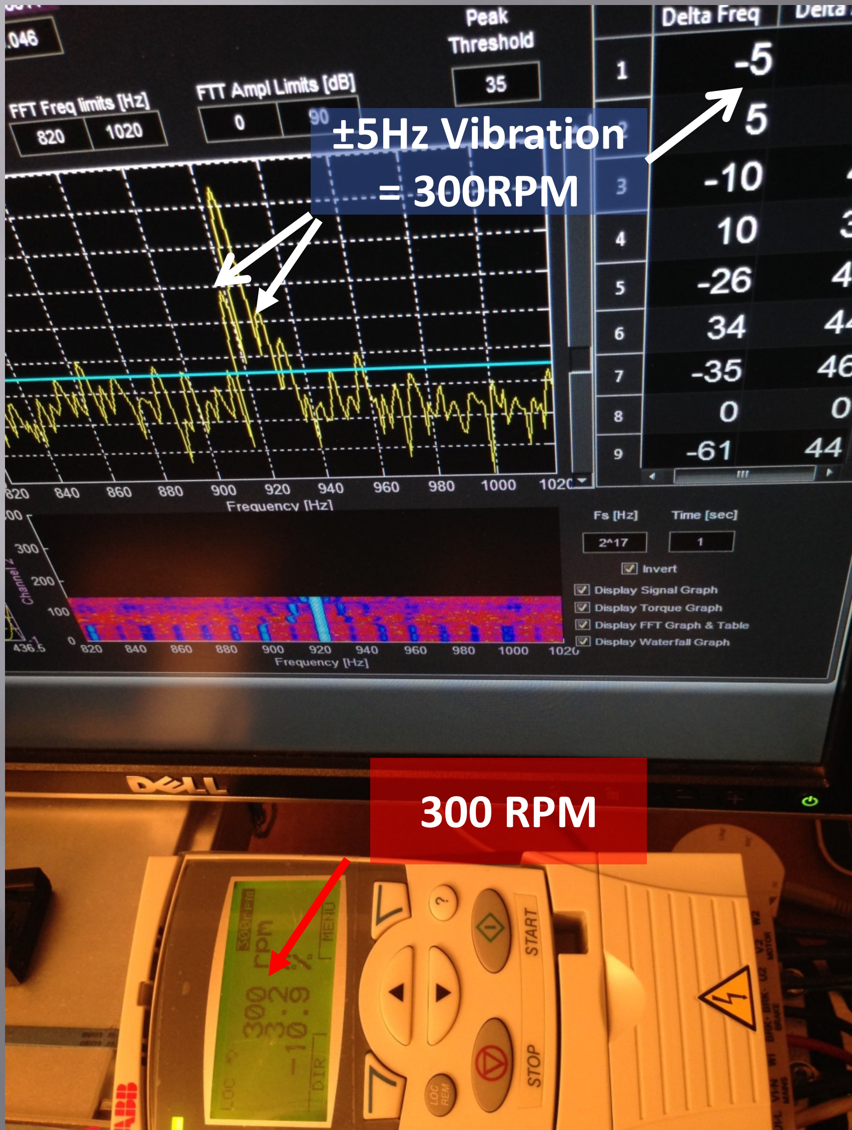
Test Rig Design for Dynamic Experiments

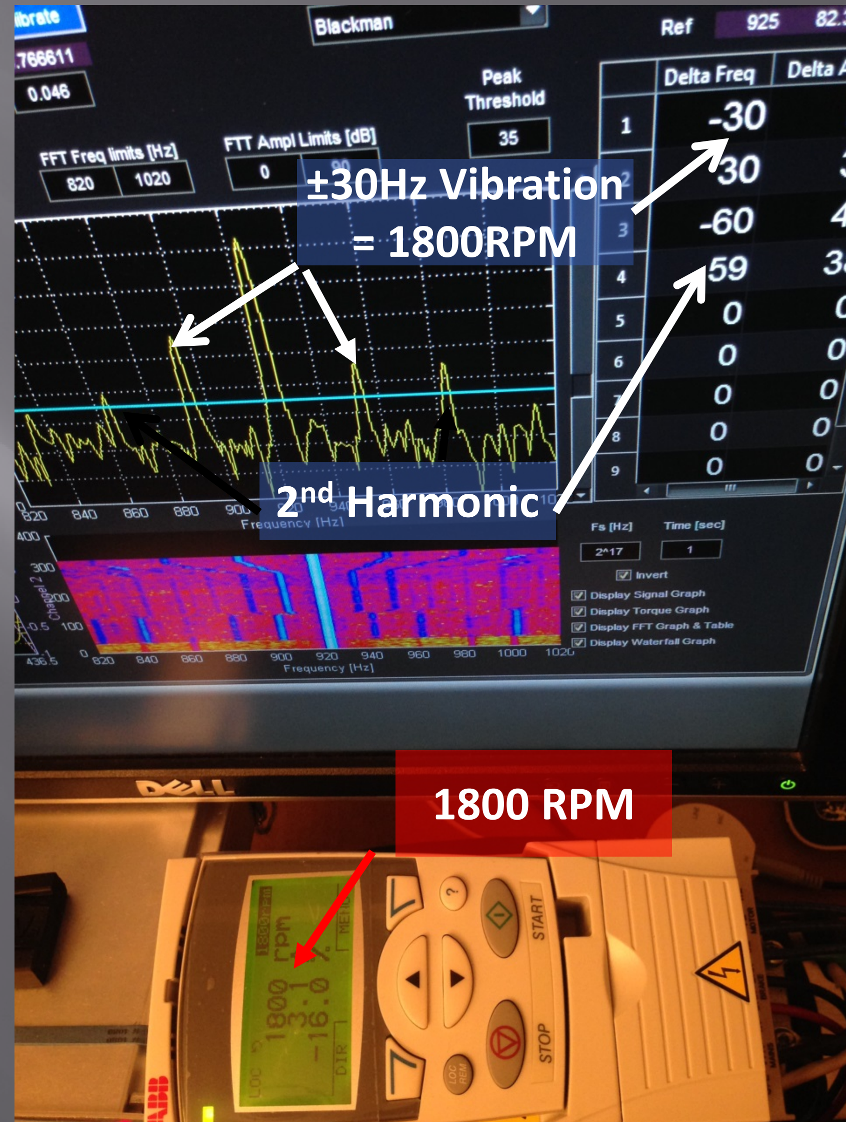


Torque Dynamic Test Bench

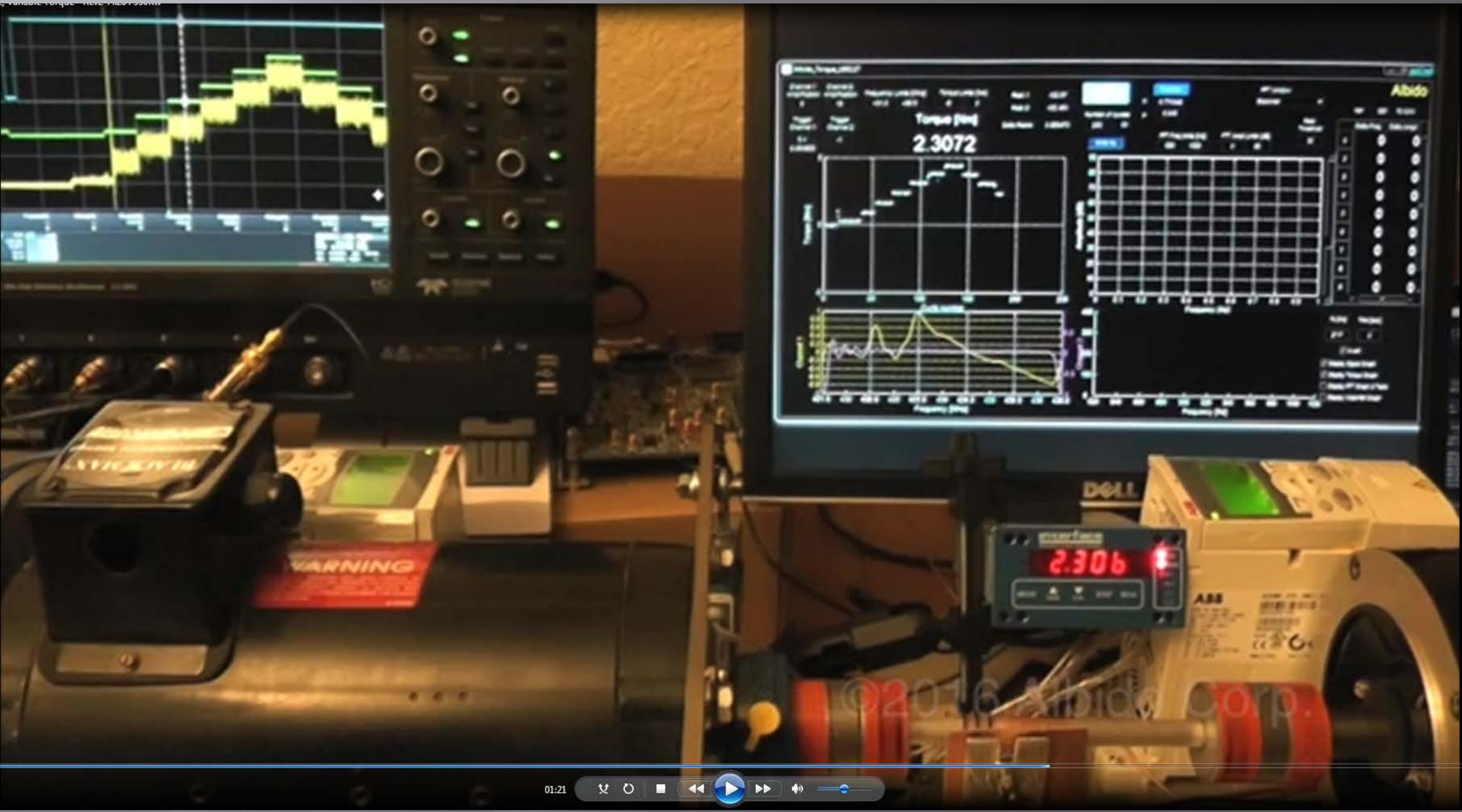


Sensor Dynamic Response and Analysis



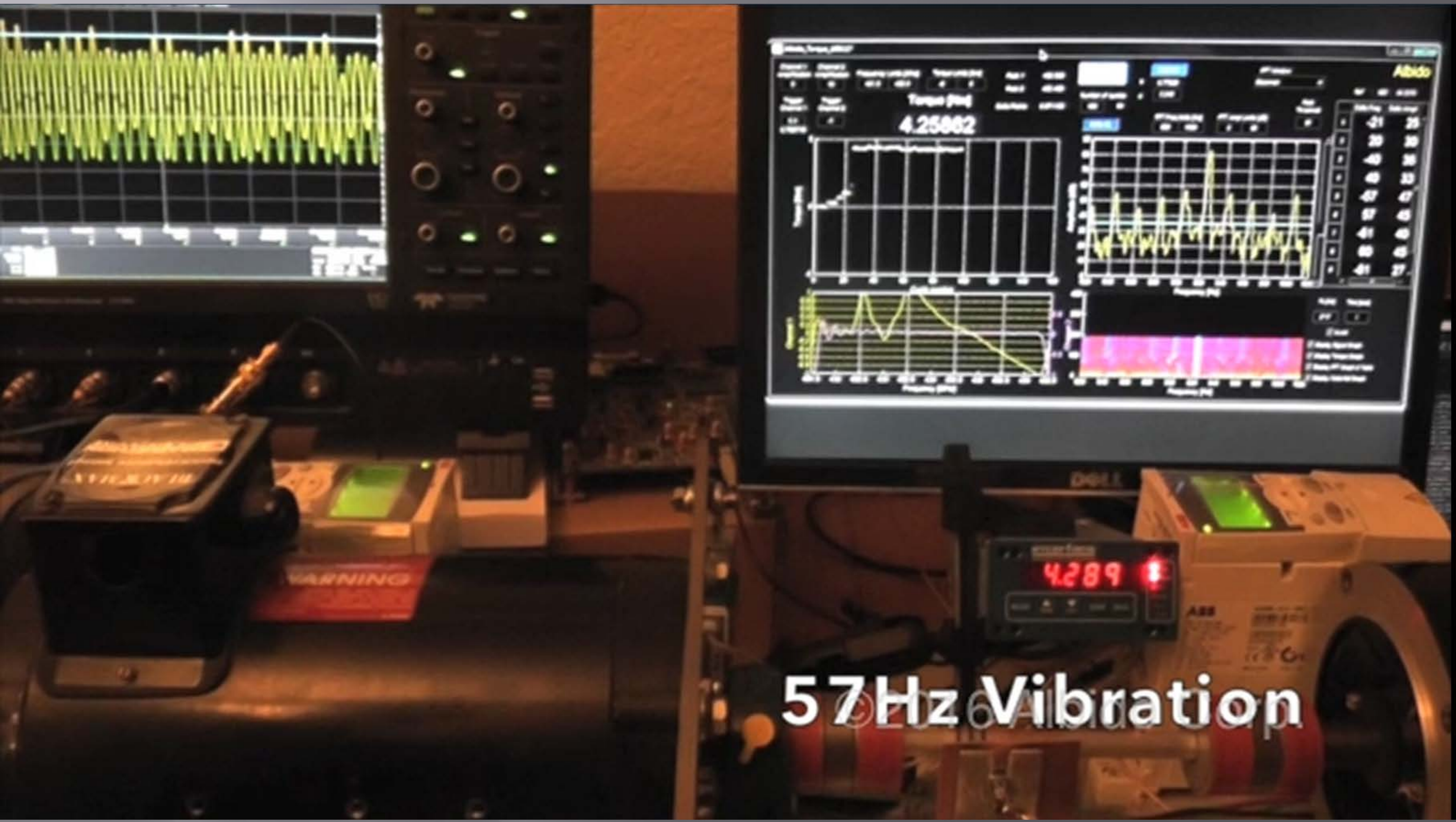


Dynamic, Variable Torque



Dynamic, Variable Torque

Variable Speed, Vibrations



[Variable Speed, Vibrations]

Performance Specifications

Feature	Advantage	Benefit
Wireless sensor Low radiofrequency (RF) power (<10mW)	No wires between sensors and reader. No slip rings and brushes.	Install on moving parts. Retrofittable. Low EMI.
Passive, very light, small, and thin.	Do not load/disturb the dynamics of the moving parts.	No or very low maintenance.
Simple, reliable, scalable, sensitive (<1 μstrain, <0.1 ^{o}C)	Adaptable to a large variety of applications.	The overdesign margin can be reduced; CBM.
Temperature compensation (US8,258,674)	Provides accurate and precise measurements.	Can operate in extreme environments, from cryogenic to 1000^{o}C.
System high data rate (up to 100 kbs)	Can be used for directly measuring the rate-of-change of strain/torque and vibrations.	Real time analysis.

Summary

- Albido a demonstrated a fully functional prototype system capable of measuring high-bandwidth strain and torque of rotating machinery, particularly for CBM and SHM applications
- The system uses wireless, true passive sensors based on SAW technology
- The system employs a new method for compensating the errors induced in the SAW strain sensor by large temperature variations
- Sensors are small and lightweight → stationary or moving structures
- The product includes Sensors, Reader, and Software

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Thank You!

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