



Microwave/Radar Position Sensing

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Background – Position Sensors



❖ Common Sensors Technologies

- Piezo-Electric Based**
 - ◆ Accelerometer
 - ◆ Acoustic Emission
 - ◆ Sound/Microphone
 - ◆ Force/Torque Sensing
- Eddy Current**
 - ◆ Proximity Probes
- Laser/Optical**
 - ◆ Interferometer
 - ◆ Triangulation
 - ◆ Encoder
- Magnetic**
 - ◆ LVDT
 - ◆ Magnetostrictive

Radar- Traditional Uses



❖ Traditionally Used for Doppler Effect



- ❖ Radar Carrier Waves Modulated based on speed of the moving object.**
- ❖ Used as a means of detection in: advanced burglar alarms, automatic door openers, backup sensors**

Radar – New Developments



❖ **GTRI / Sensors and Electromagnetic Applications Laboratory**

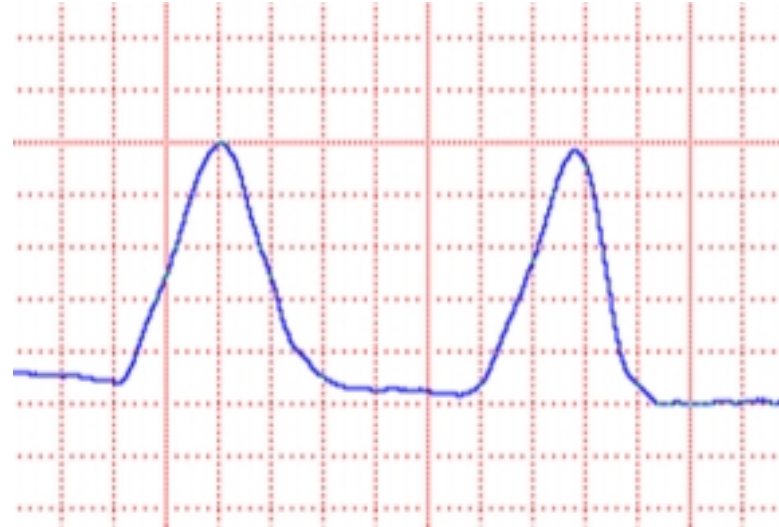
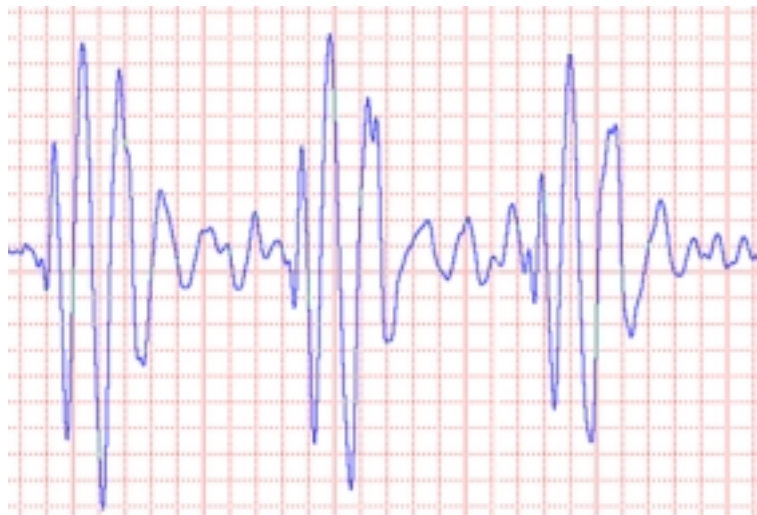
- History of Government Projects in Radar
- Expertise:
 - ◆ Airborne Early Warning Systems
 - ◆ Synthetic Aperture Radar
 - ◆ Air Traffic Control
 - ◆ Radar Personnel Detection



Radar – New Developments



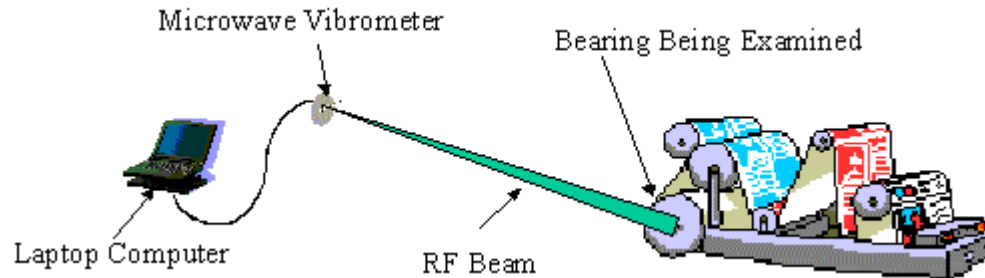
- ❖ **DARPA funded project for Vital Signs Monitoring**
- ❖ **Detection of Heart Beat and Breathing**
- ❖ **Applications: Law Enforcement, Target Interdiction**



Radars – New Developments

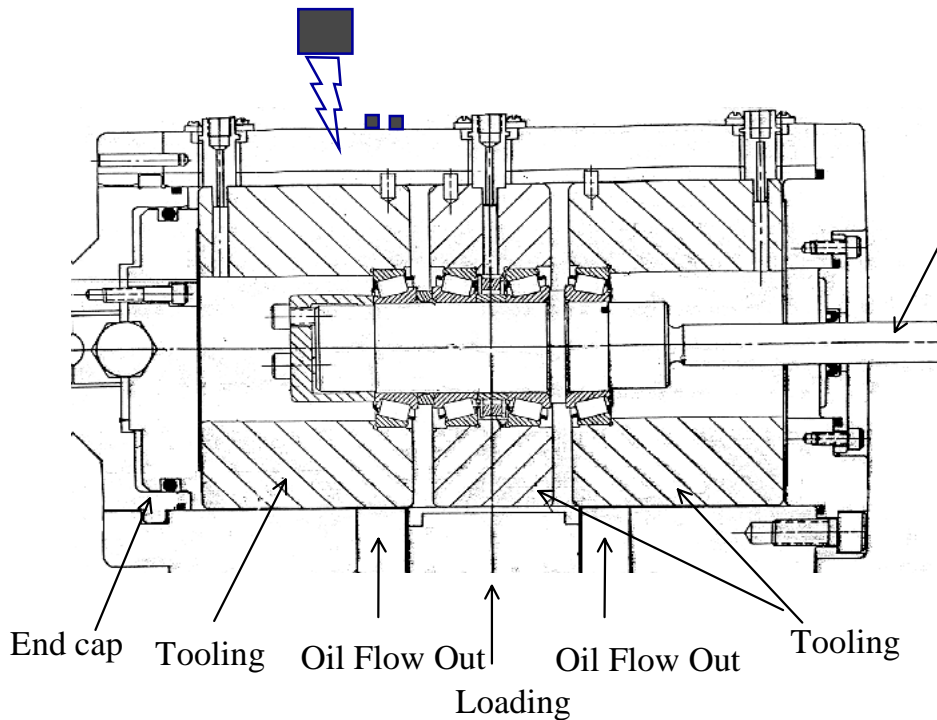


❖ Applications to Machine Vibration

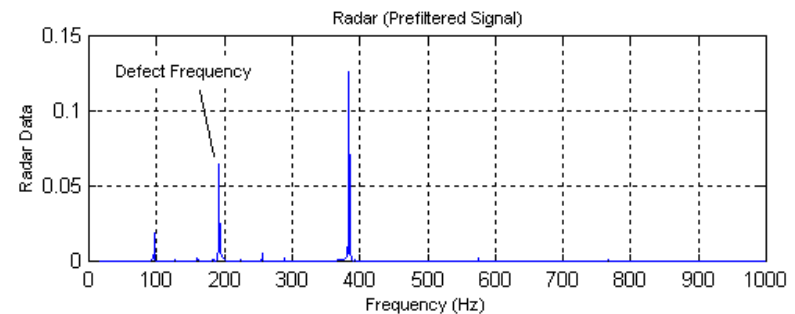
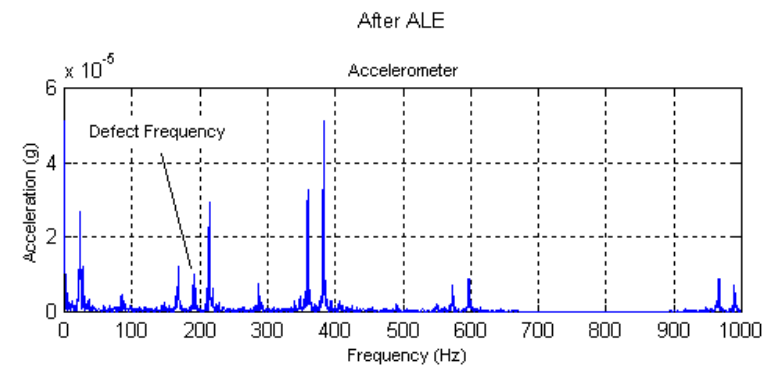


- ❖ Measure Vibration Non-Contact
- ❖ Similar to Laser Systems, but inexpensive

Initial Test Results

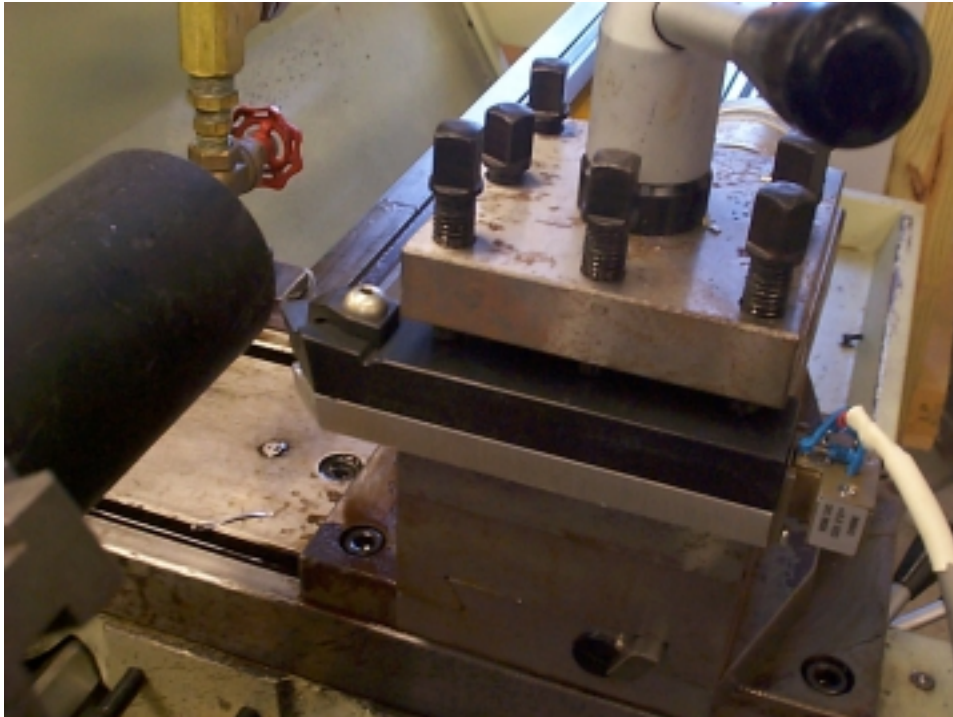


- Frequency Peak is The frequency of a roller hitting a crack



- Application in handheld vibration detection

Other Test Results



- ❖ **Real-Time Runout Measurement**
- ❖ **Modified Tool successfully measured runout**

Radar Other Features

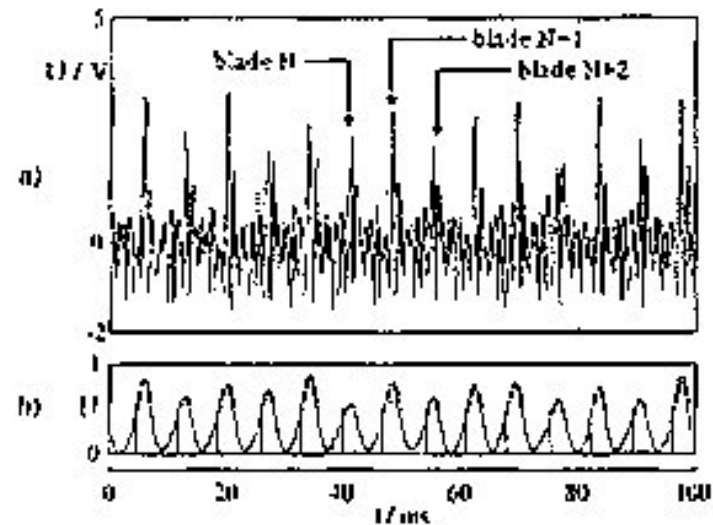


- ❖ **Many Materials are Transparent to Radar**
 - All Plastics are Transparent
 - All Ceramics are Transparent
 - Some Liquids are Transparent (Frequency Dependent)
- ❖ **Robust Operating Environment**
 - Much Design in Radar for Military Applications
 - Good for Rough Industrial Environments
 - ◆ “Sees” through dust
 - ◆ Very Little Effect from Electromagnetic fields: e.g. transformers, motors, etc...
- ❖ **Waveguide Principles**
 - Metallic Channels can be put into a system to act as a “pipe” for signals, similar to a fiber-optic.

Other Applications -- Turbine



❖ Turbine Performance Monitoring



Measured pulse sequence during turbine rotation.
a) raw signal, b) filtered and smoothed signal.

- ❖ RADAR has already been used successfully by Siemens Westinghouse for Torsional Vibration Measurement
- ❖ Used in Blade Pass Detection, not blade measurement
- ❖ Proof of Waveguide Concept to Bring Sensing to Combustion Cells

Other Possible Applications

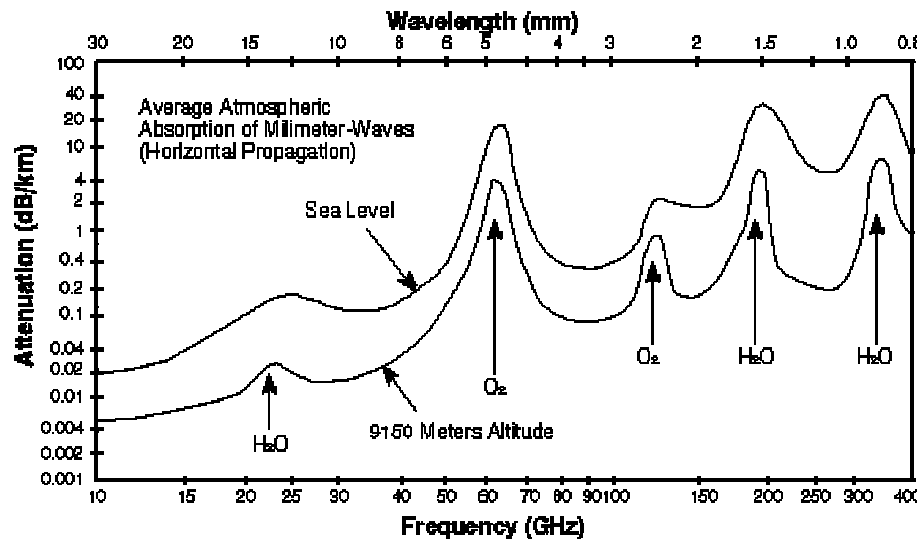


- ❖ **Early warning system for coronary heart disease– better than EKG, worse than ultrasound**
- ❖ **Motion sensing of drivers in car crashes for airbag deployment**
- ❖ **Vibration of Metallic parts in combustion**
- ❖ **Precision Terrain sensing in automotive applications**
- ❖ **Vibration measurement for active noise control**

Areas of Research



❖ Cutting Fluid Environments



- ❖ Water Absorption issues well understood from development of all weather radar
- ❖ Apply Range-Gate Techniques to reject noise clutter

Where are we now...



- ❖ **Level of Precision:**
 - 0.001” at a range of ½-1”
 - Lower, but unquantified precision at larger distances
 - ◆ E.g. heartbeat measurement capable at 20-30 ft.
- ❖ **Possible NSF funding beginning January 2001**
- ❖ **Currently not funded by industrial sponsors at this time.**

Future Plans



- ❖ **Complete Feasibility Study over Range of Operational Conditions**
 - Frequency Response
 - Precision
- ❖ **File Patents**

Conclusion



- ❖ **Proven Feasibility of Vibration measurement non-contact**
- ❖ **Robust sensor for factory environments**
- ❖ **Waveguide capability to direct beam to desired location**
- ❖ **Ability to “see” through many materials**