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
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
Radar – 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

- 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