Development of a High-Resolution Position Sensor Using Radar

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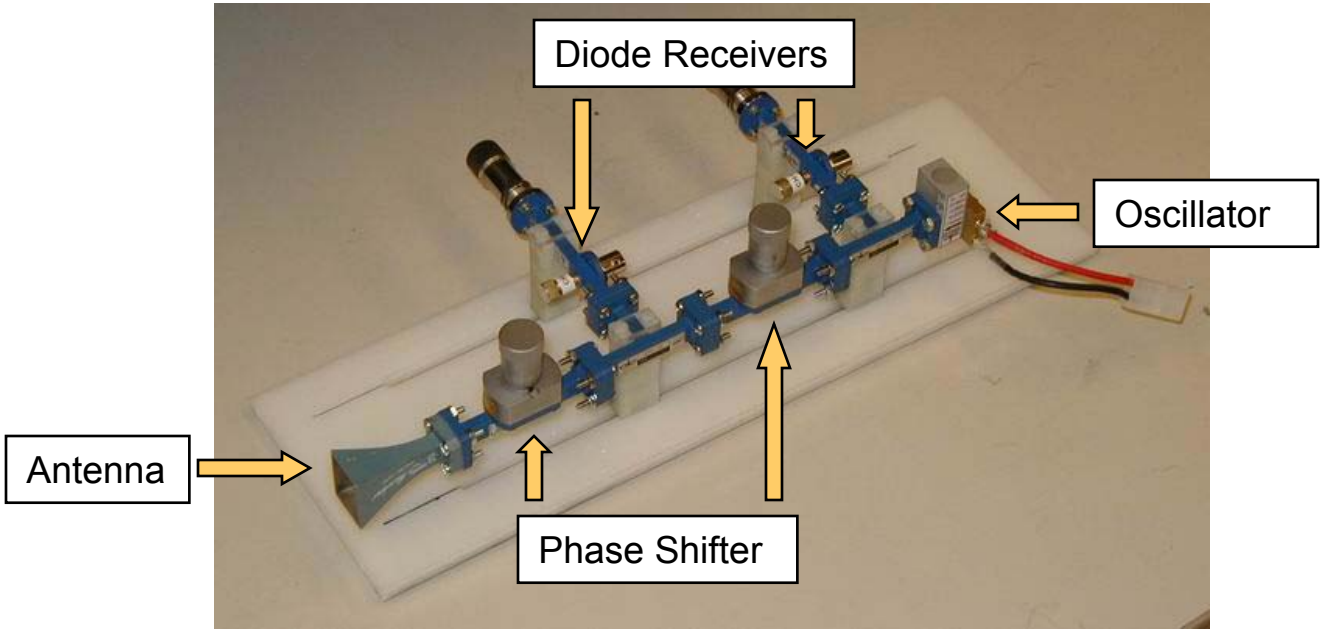
Why We Use Radar?

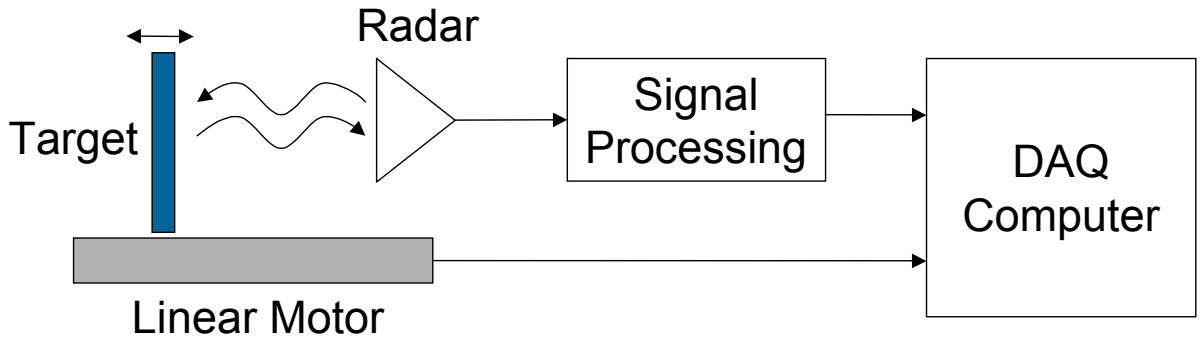
- Capacitive/Inductive : Limited to short-range (mm)
- Optical (Laser Interferometer) : Expensive, Fail in hostile environment, e.g. smoke, dust, debris
- Radar is a good candidate for:
  - Non-contact
  - Long-range
  - Applicable in Hostile Environment
  - Can see through Non-metallic Material
  - Low cost

CW Radar Components

- Main Components of CW Radar
  - **Oscillator**: Generate radar wave
  - **Antenna**: Transmit and receive radar wave to and from targets
  - **Diode Receivers**: Convert radar wave into electrical signal
  - **Phase shifters**: Adjust phase difference between *Inphase* (I) and *Quadrature* (Q) channel

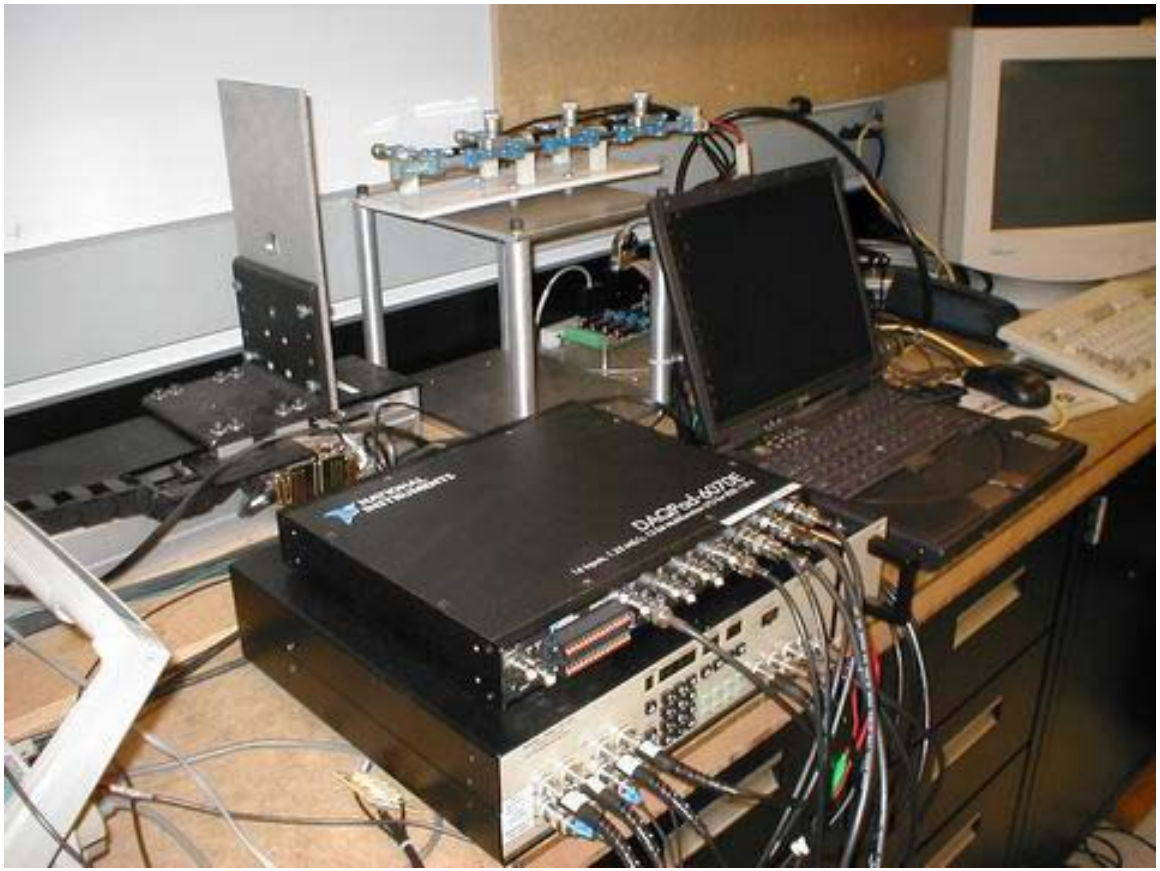


Experimental Validation



- Aerotech linear motor
  - 1 μm resolution
- Signal Processing
  - Nulling
  - Amplifying
  - Low-pass Filtering
- Data Acquisition (DAQ)
  - Acquire radar signals and encoder pulses simultaneously
  - Process encoder pulses into reference displacement
  - Convert radar signals into displacement
  - Compare displacement from radar sensor and encoder

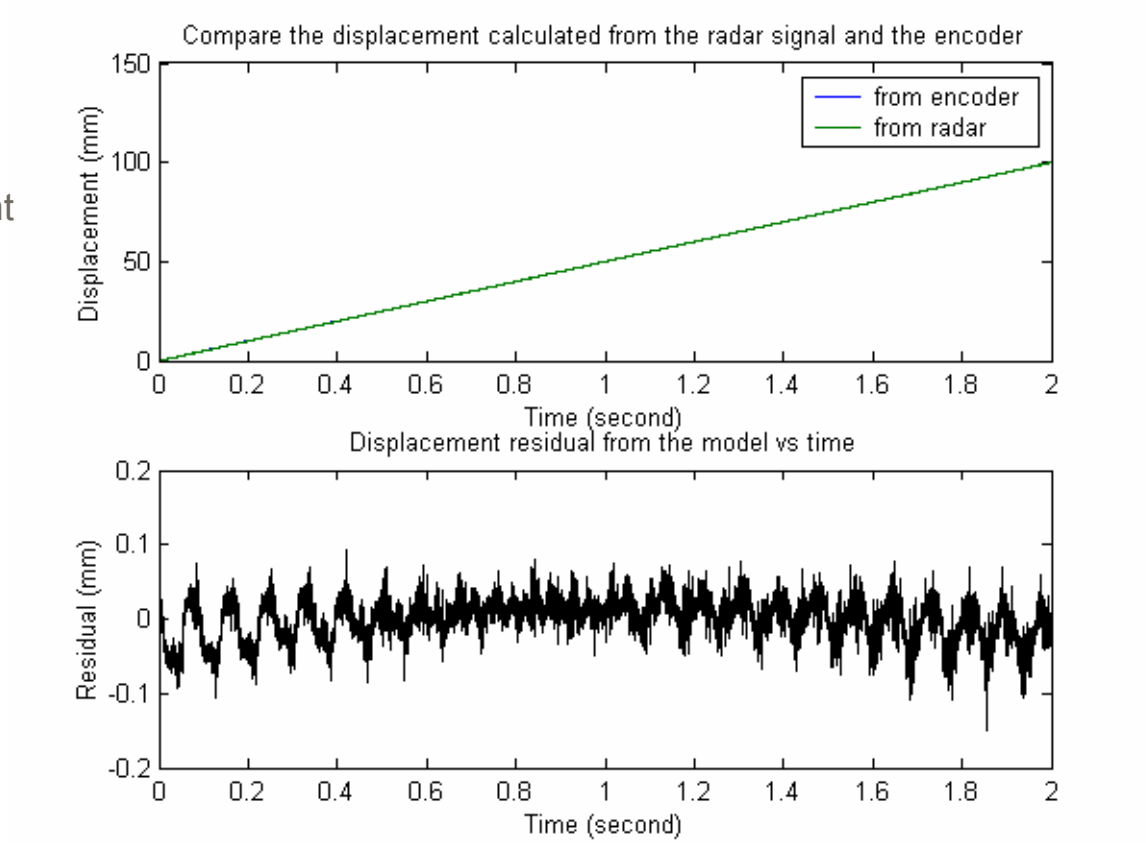
Instrumentation



Experiment Result

Displacement

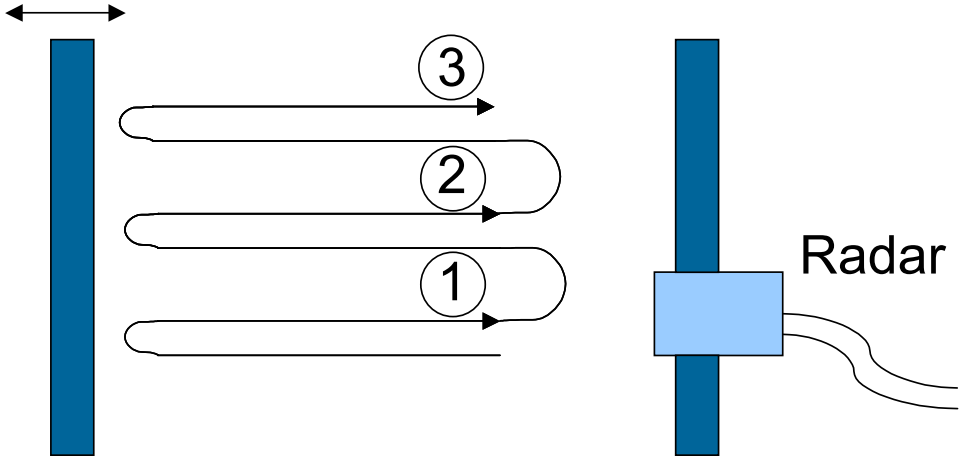
Residual



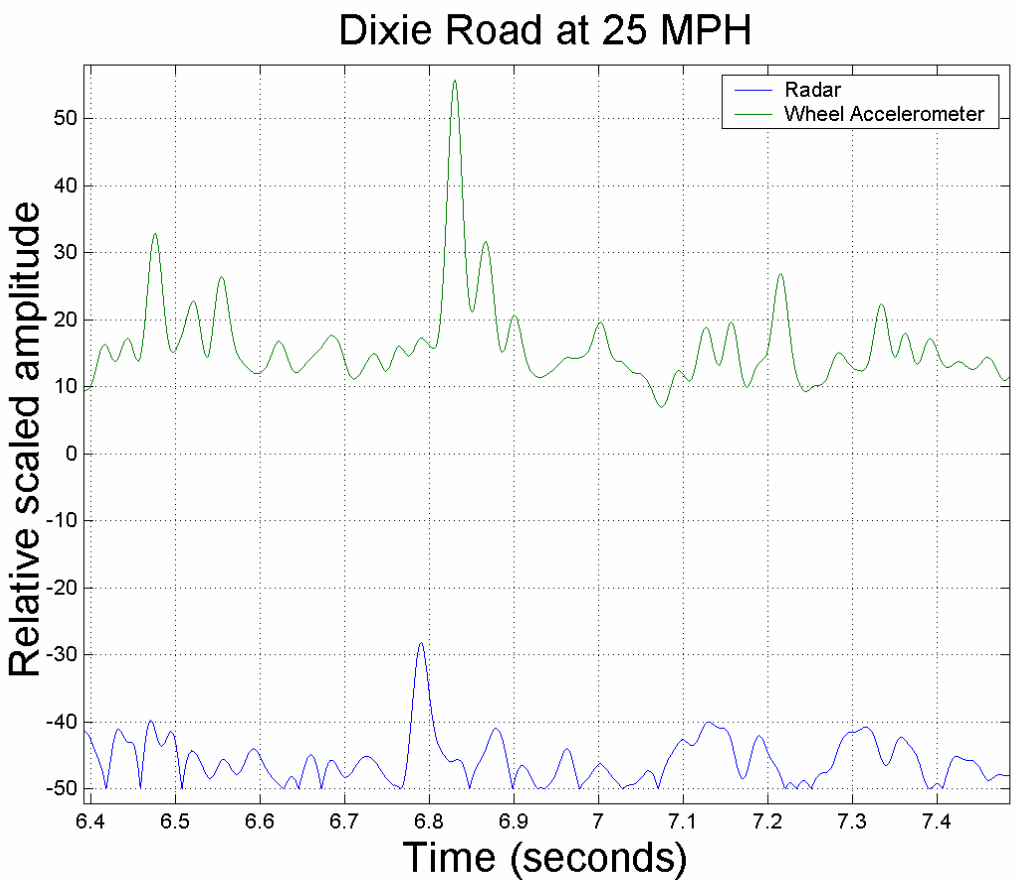
- For large displacement (100 mm), the radar sensor demonstrate good tracking ability
- Error is within 0.2 mm or 0.2% linearity error

Accuracy/Repeatability Improvement

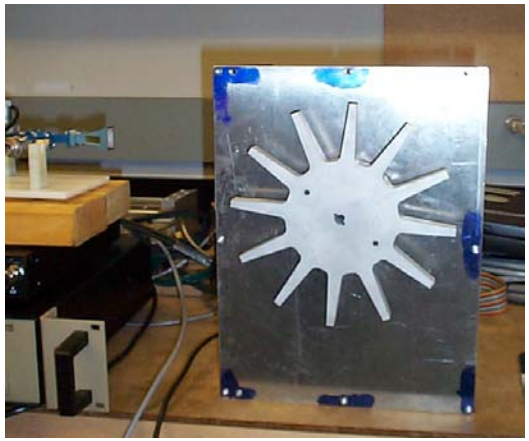
- Increase Repeatability
  - Adding more channels : ~50% Improvement
- Increase Accuracy
  - Multipath Modeling
  - Multipath Cancellation
  - Hardware Design

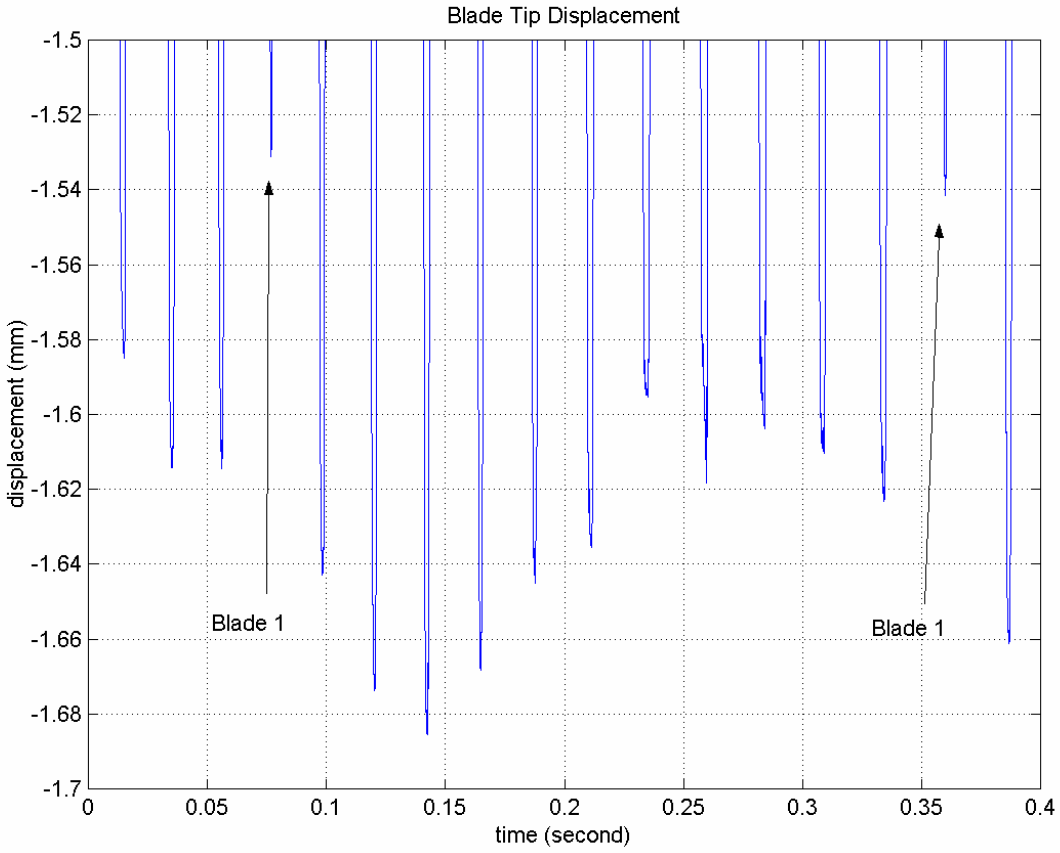


Terrain Sensing Application

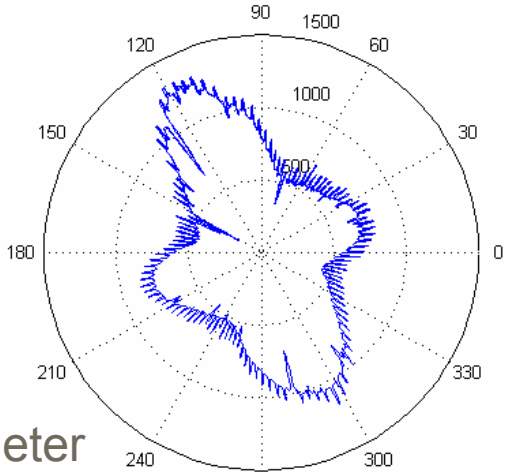


Turbine Blade Sensing Application

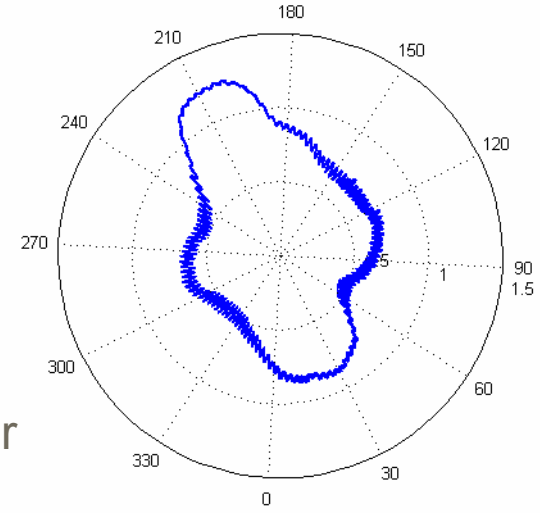




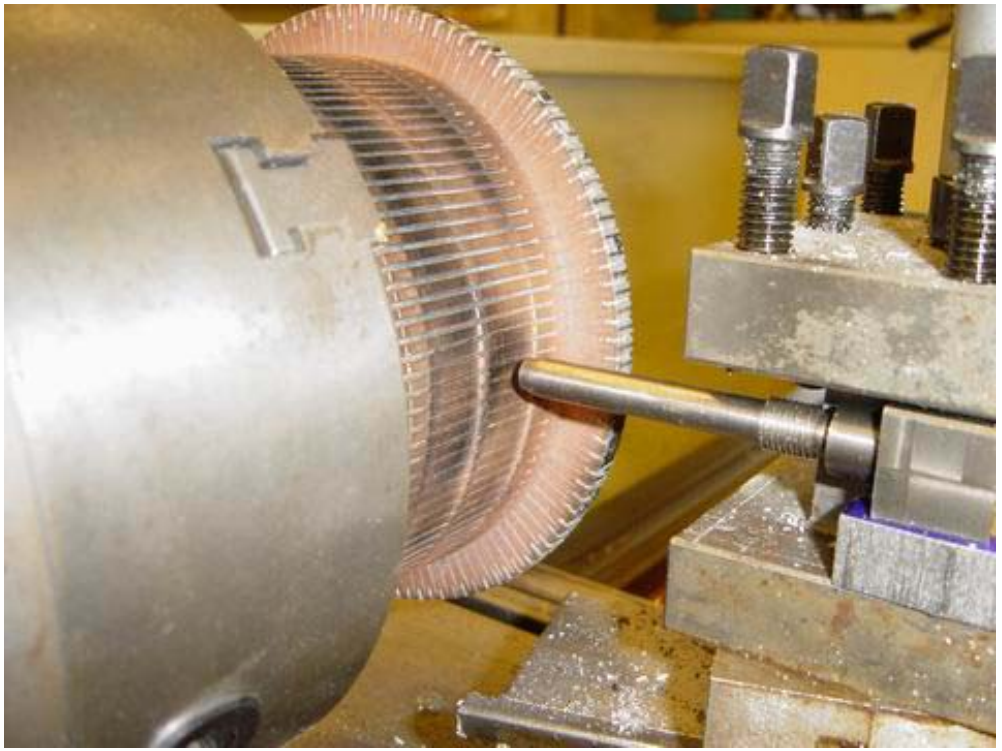
Commutator Profiling



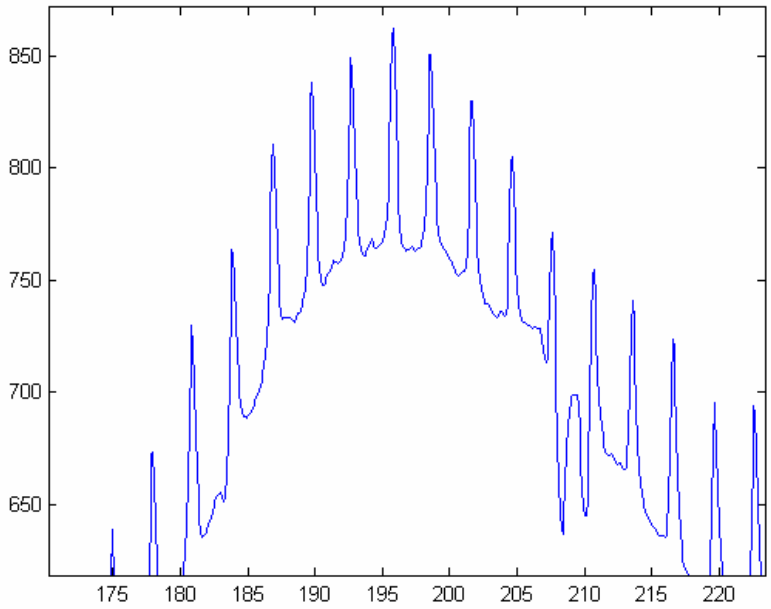
Profilometer



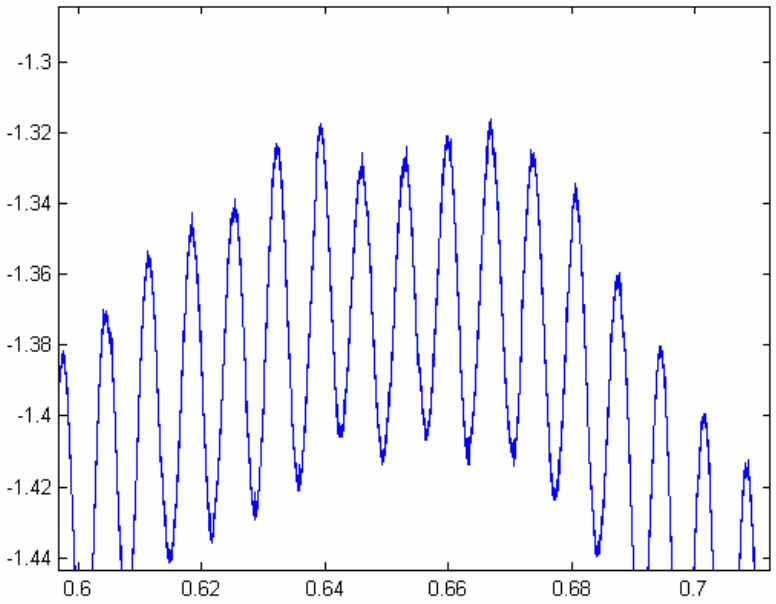
Radar



Zoomed Bar Profile



Profilometer



Radar

Question ?