A novel microwave reflector-antenna as a resonant wireless passive mechanical sensor

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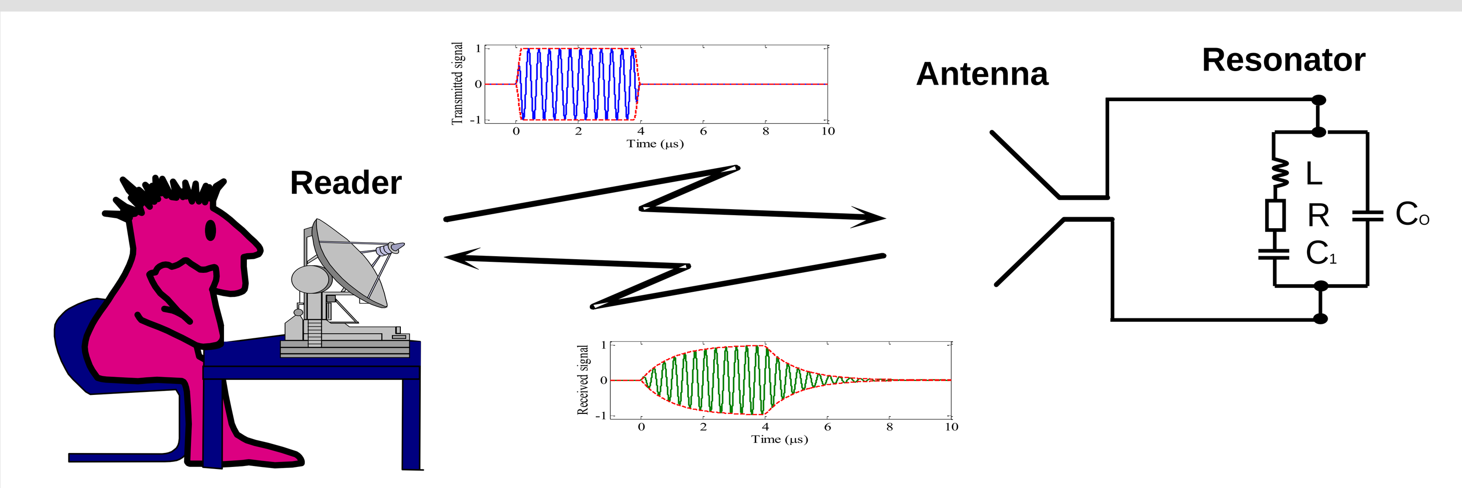
Motivation

- Ubiquitous sensing for the internet of things.
- Monitoring in harsh environments.
- Chipless design gives high temperature compatibility.
- Frequency shift sensing using high-Q resonator.
- Integrated antenna + sensor concept.
- Low complexity, low cost.

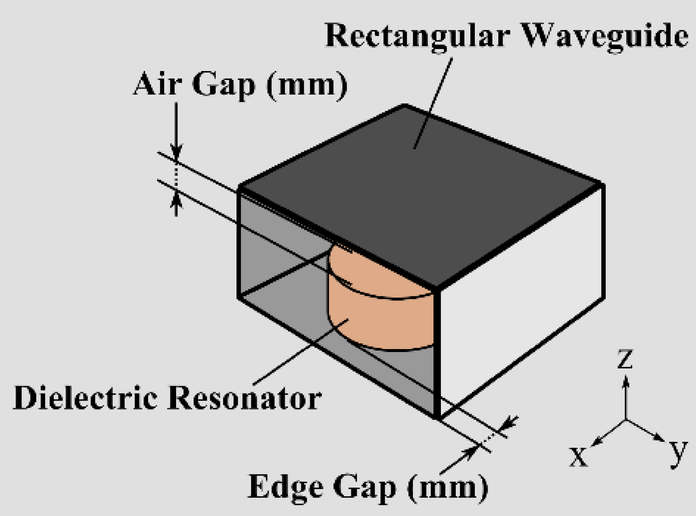
Wireless measurement scheme

- Frequency shift measurement due to physical variable.
- Burst signal from interrogation unit excites the resonator.
- The decaying response is analyzed.



Sensor design

- Dielectric resonator ($TE_{01\delta}$ mode) in evanescent open ended waveguide.
- Frequency perturbation modelled as PPDR.



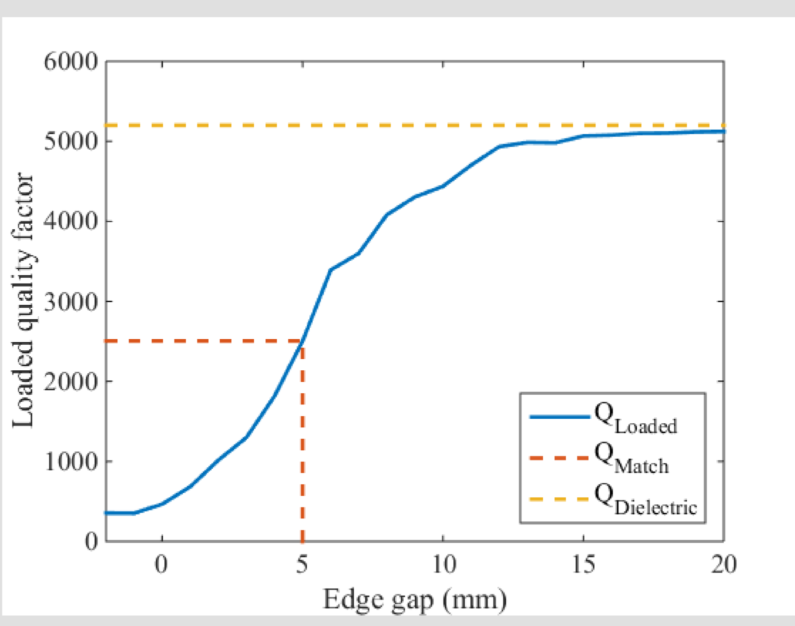


Figure 1: Radiation and dielectric Q matching from simulation.

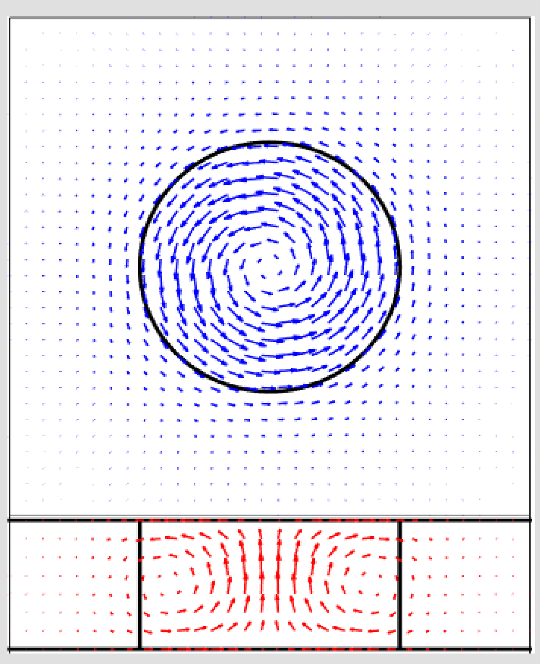


Figure 2: E and H field plots of the $TE_{01\delta}$ mode.

- Maximum coupling is achieved when $Q_{rad} = Q_{other}$.

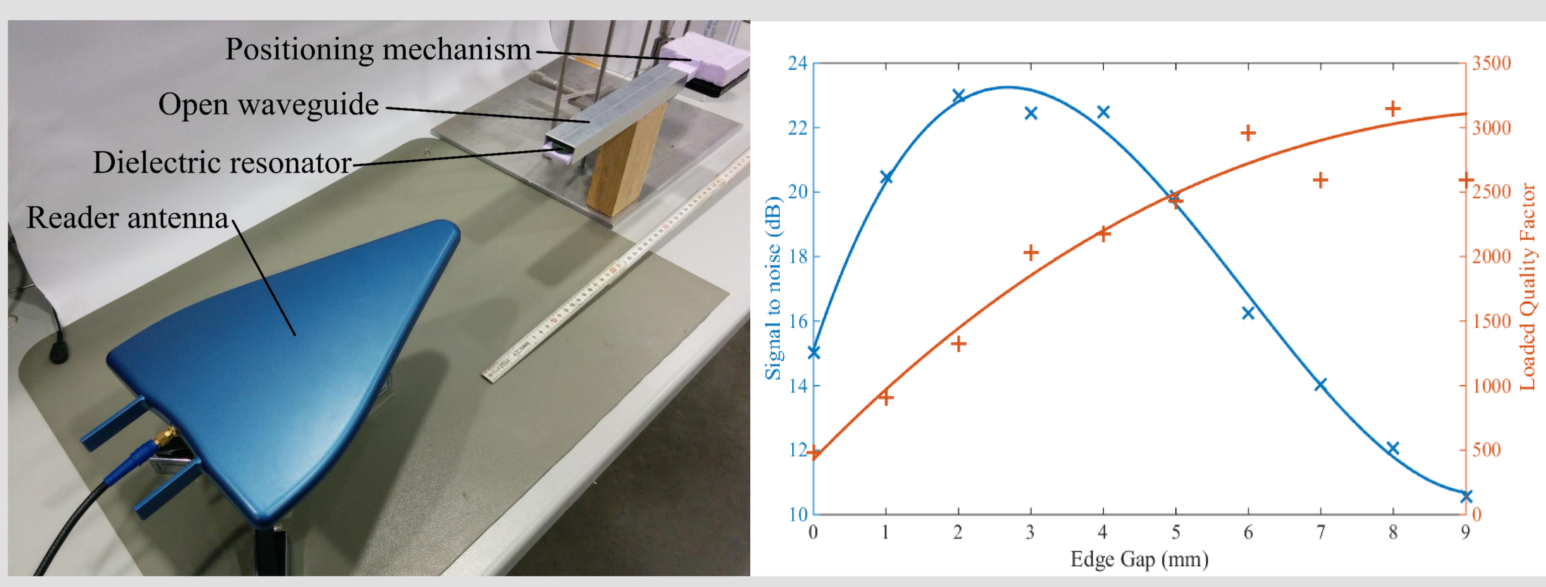


Figure 3: Experimental determination of the maximum SNR 'edge gap'.

Force sensing mechanism

- Perturbation of the evanescent field of the resonator is caused by relative motion of a conductor.

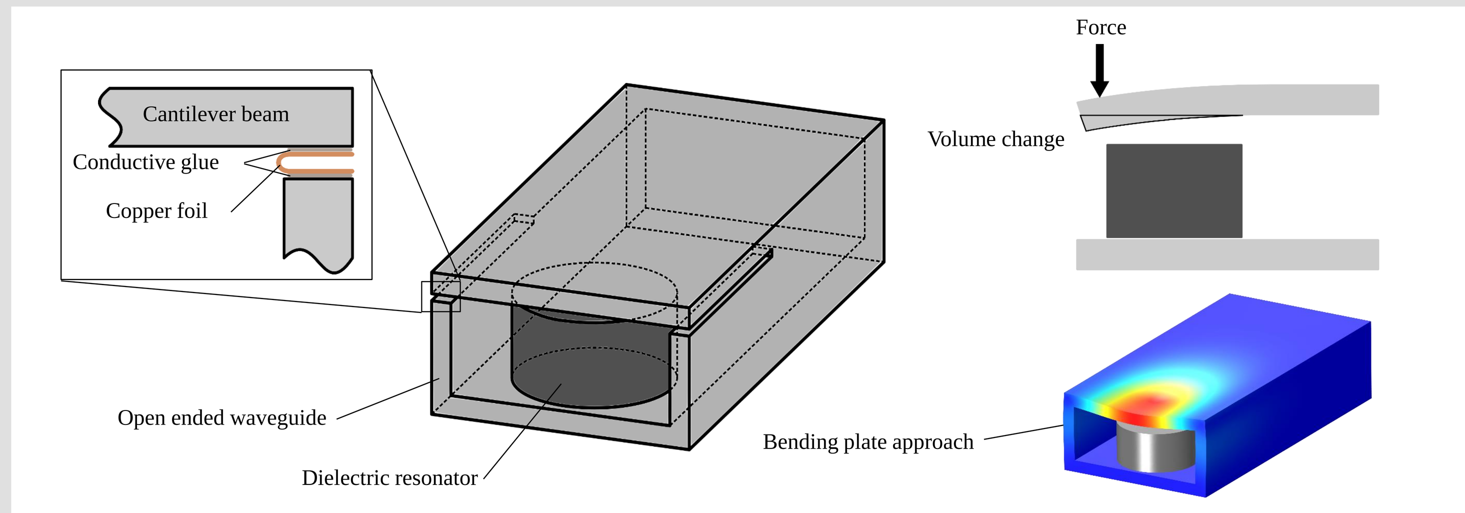


Figure 4: A modified waveguide with slits (left) to allow a cantilever behavior (top right). An uncut bending plate design (bottom right) .

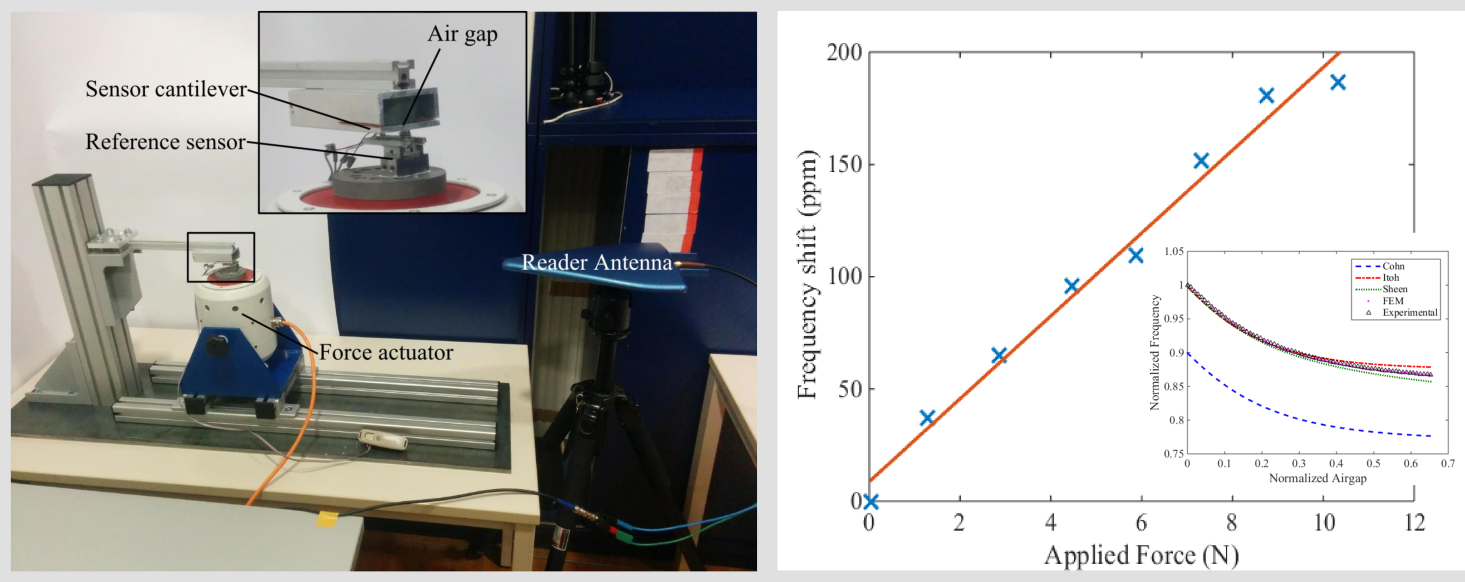


Figure 5: Experimental sensor characterization setup(left). Force-frequency shift transfer function @ 2.46 GHz (right). Theoretical PPDR frequency perturbation action (right insert).

Far field characterization

- 2 dBi gain as an antenna.
- < 1 ppm frequency tracking resolution @ 30 cm, 2.45 GHz.
- Up to 5 m range with 5 dBi interrogation antenna.

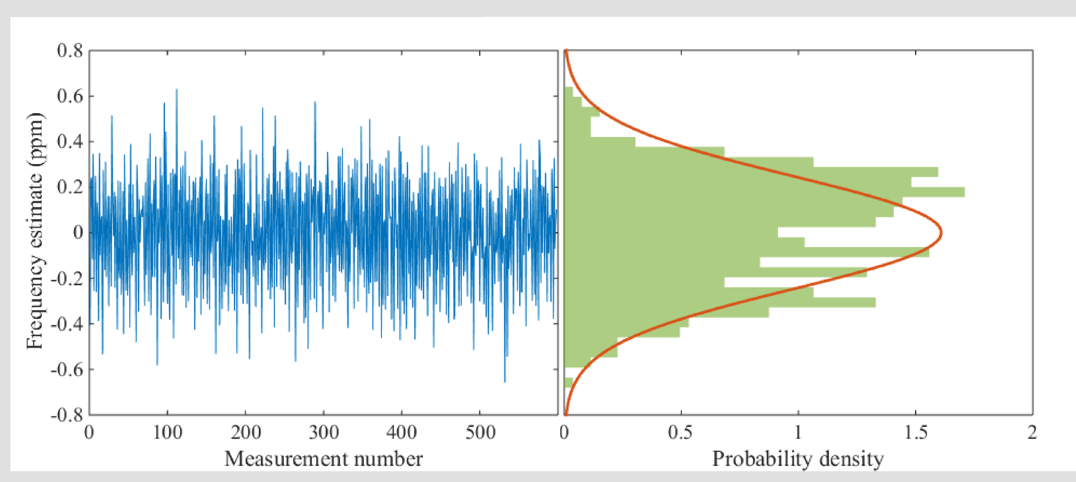


Figure 6: Frequency measurement @ 1k samp/sec with spread probability (right).

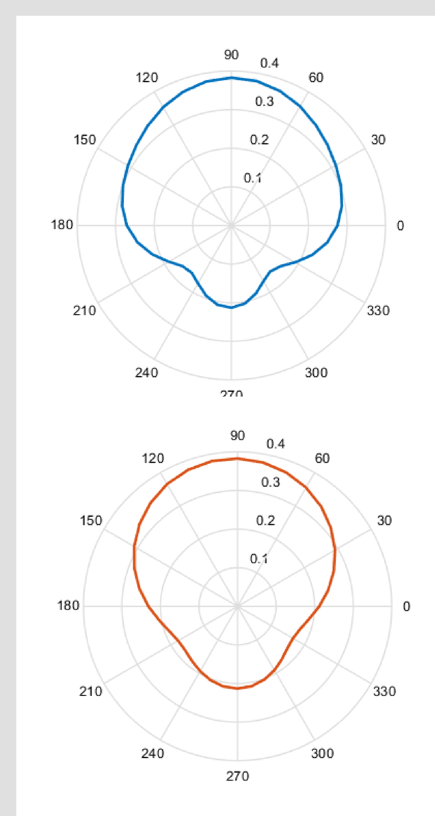


Figure 7: Horizontal (top) and vertical (bottom) radiation profiles.

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- Theodor Rinas for the force characterization rig.

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