Novel wireless sensing and identification technique for Battery-less sensors

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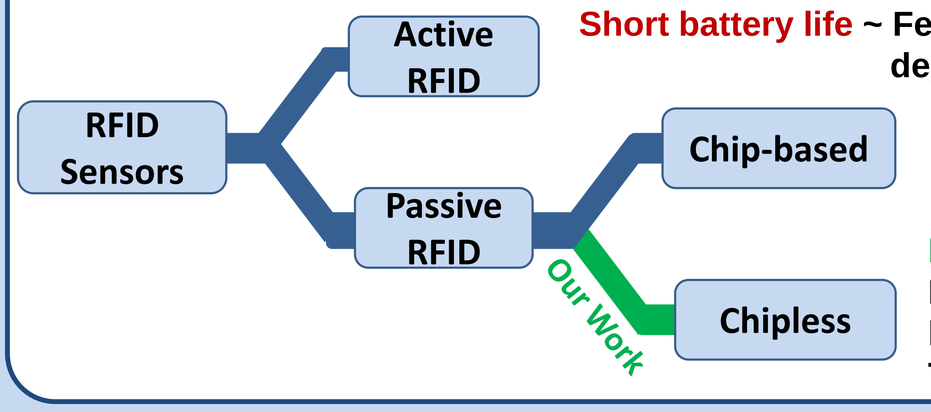
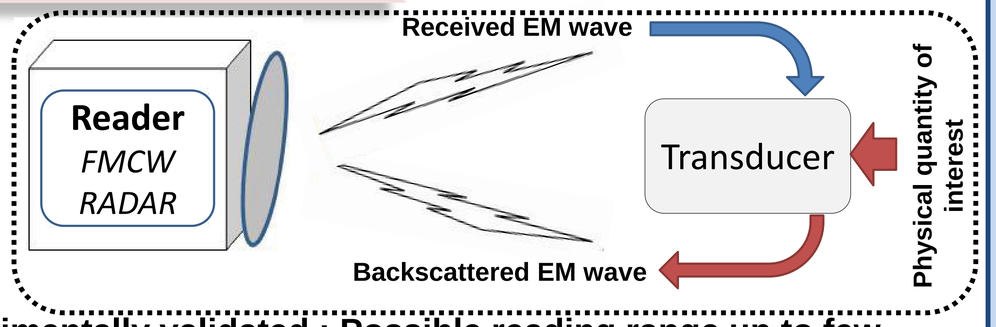
Introduction



Short battery life ~ Few months to few years depending on the use

Short Range (3 to 10 meters)
Due to the required IC activating power

No battery ; No integrated circuit
Reading range of 30 meters experimentally validated ; Possible reading range up to few hundred meters. Long sensor life ; Good measurement resolution and sensibility ; Temperature, Gas, Pressure sensors



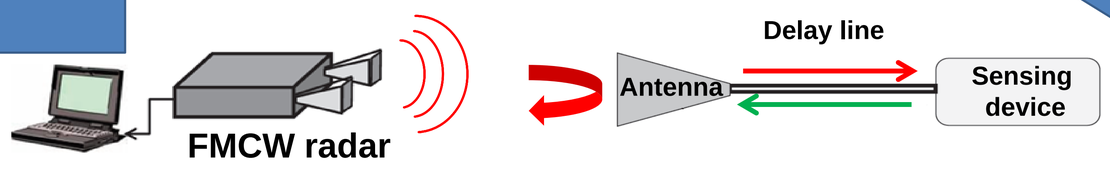
Principle

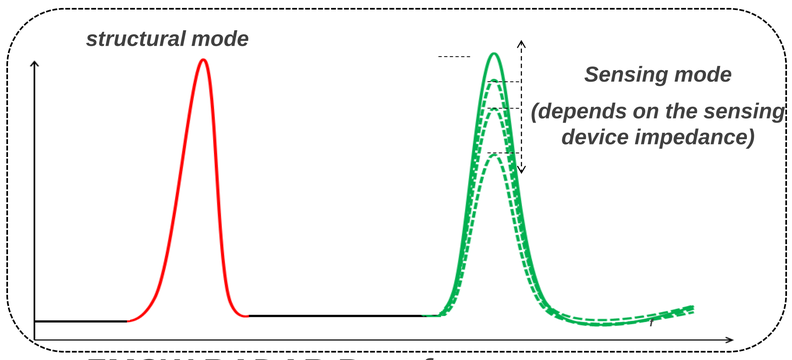
Based on *theory of backscattered field from a loaded antenna* (Used in RFID systems): The echo of the loaded antenna varies with the load impedance

A time domain reader (FMCW radar):
Allows separating two echoes from two different distances

This novel method combines

A millimetric frequencies design:
Allows a spatial resolution of few centimeters



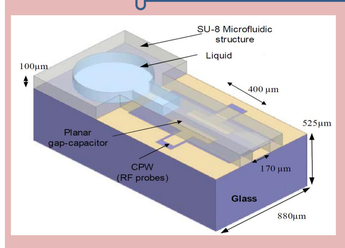


A delay line between the antenna and the load (sensing device):
Allows separating of the echo from the antenna and the echo from the sensing device.

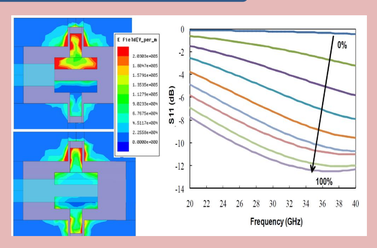
Electromagnetic transducers:
allows converting the variation of the physical quantity of interest to a specific variation of the load impedance

Examples of Passive Sensing

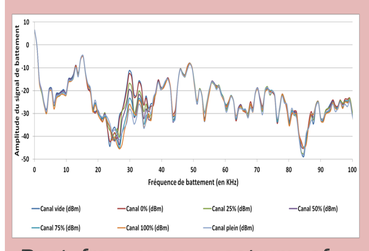
Temperature[1]



The transducer is based on a planar capacitor where the displacement due to dilatation of the fluid in the micro fluidic channel changes the permittivity of the medium between the two electrodes of the capacitor.

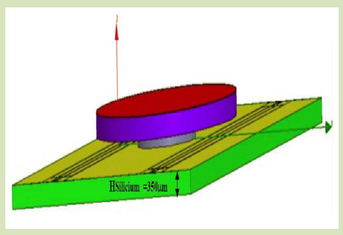


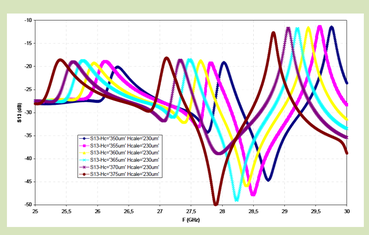
the water inside the channel favors the power transmission between the two capacitor electrodes.



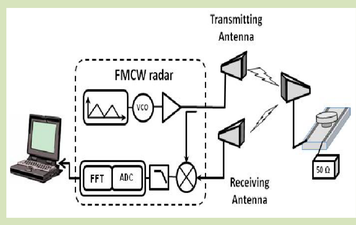
Beat frequency spectrum of the radar interrogation showing the variation of the sensing mode versus temperature.

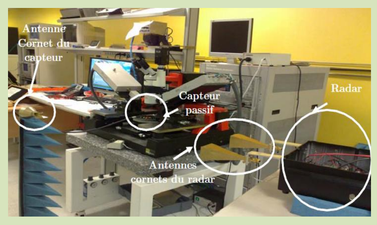
Gas detection[2]





A dielectric resonator is built using TiO2. The permittivity of this dielectric medium changes with the gas concentration

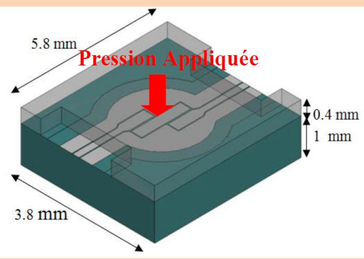


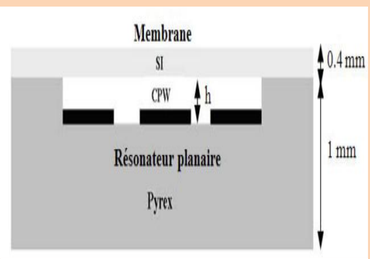


The experimental set-up allows the detection of the contamination of the sensor due to liquid (ethanol and isopropanol here)

	Not contaminated sensor	Contaminated sensor 1	Contaminated sensor 2
Sensing mode level of open loaded antenna (reference)	*-10*	*-12*	*-15*
Sensing mode level (dBm)	*-35*	*-19*	*-33*

Pressure[3]

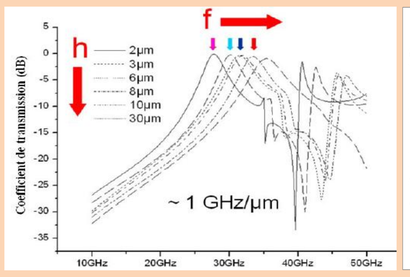


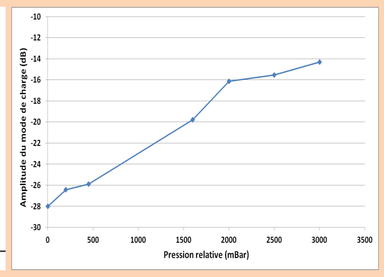


Pressure Sensor

Resonant frequency of the Coplanar resonator varies with the pressure applied on the membrane of the resonant cavity

Sensing mode In wireless interrogation changes with Pressure





[1] S. Bouaziz, *et al.*, « Novel Microfluidic Structure for Temperature Wireless Passive Sensing Using Radar InterrogationTechnique at Ka-band», IEEE *Antenna and Wireless Propagation Letters, 2012.*

[2] H. Hallil, *et al.*, "Feasibility of passive gas sensor based on Whispering Gallery Modes and its Radar interrogation: theoretical and experimental investigations" Sensors & Transducers, Vol.116, N°5, pp.38-48, Mai 2010

[3] M. M. Jatlaoui *et al.* « New Electromagnetic Transduction Micro-sensor Concept For Passive Wireless Pressure Monitoring Application », The 15th Conference on Solid-State Sensors, Actuators & Microsystems, Transducers 2009

Conclusion

8 years of research and development of a novel wireless batteryless and chipless sensing technique allow us to achieve the following goals:

- ✓ **Establishing a rigorous analytical description of the loaded antenna echo with an FMCW radar interrogation**
- ✓ **Fabrication and characterization of different types of sensing devices operating at millimeter waves with an extremely compact size (few mm²) this for different physical quantities : Pressure, MEMS T°, stress, Gas, nuclear radiation**
- ✓ **Experimental validation of the long reading range (up to 30 meters)**
- ✓ **Novel identification method for the passive chipless sensors based on delay lines technique.**