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Finnish Metals and Engineering Competence Cluster

EFFIMA program

Zero Power Sensor Network

ZERO POWER SENSOR

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Passive Wireless Sensor Network

Goal: Demonstrate **Intermodulation Communication Principle** to enable:

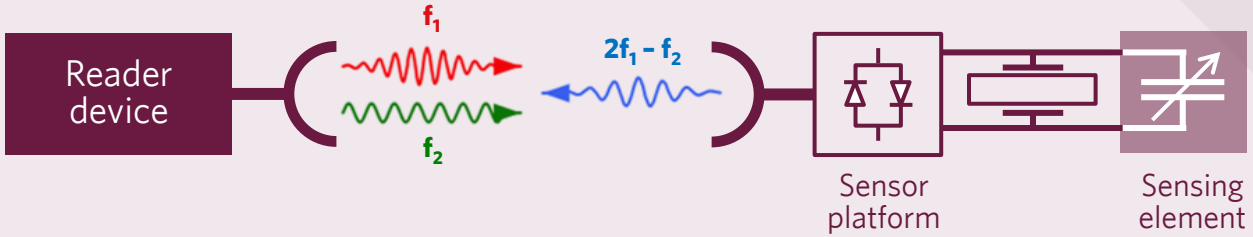
- Long range passive wireless sensing
- Generic sensor interface for capacitive, resistive or inductive sensors
- Interrogation of multiple sensors each having own ID

Passive wireless low power sensor networks will enable new machines and systems with significantly reduced life-cycle costs through energy saving, enhanced control of machines and systems, and lower amount of required maintenance.

Intermodulation Communication Principle in action

Sensor is illuminated at two closely located frequencies (f_1 and f_2)

Sensor replies the sensor data at an intermodulation frequency ($2f_1 - f_2$)



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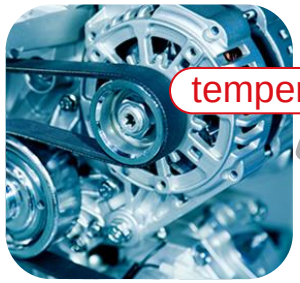
Application: Intelligent Machines

- **Network of** passive **wireless sensors**
- **Readable from long** distances
- **Complying with the** regulations

strain



temperature

state

Examples of variables measured from industrial machinery

torque

vibrations

pressure

Zero Power Sensor Network provides a novel and low-cost solution to implement **Industrial Intelligence.**

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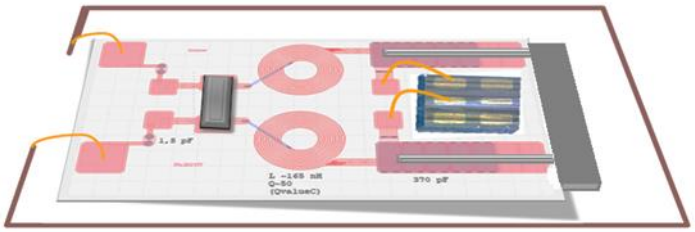
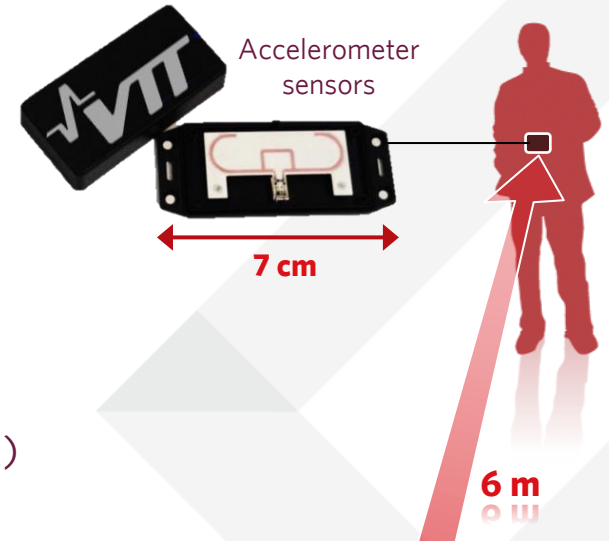
The Concept Demonstrated

- Long range passive wireless sensing was achieved with different sensing applications based on capacitive sensors: accelerometer/inclinometer, dynamic strain measurements and binary state machine.
- Numerical evaluation tools were coded for optimizing the measurement accuracy.
- Frequency Division Multiplexing Access (FDMA) concept was demonstrated with 10 tags each having its own ID.



Procedures to optimize the design of the sensor tags were developed and an integrated passive wireless sensor tag was realized.



Portable reader was developed for the UHF band.

Reading distances exceeding 6 meters were demonstrated at the UHF band.

Novel Research Results with Impact

Patent Application

- **Non-linear resonating sensor and a method** – Finnish patent application nr FI20105330, its amended continuation PCT-application PCT/FI2011/050263 and US provisional application US61/468588.

Scientific Publications

- **On Optimization and Read-out Resolution of the Zero Power Sensor**
  J. Song – Master's thesis, 2012.
- **Passive wireless sensor platform utilizing a mechanical resonator**
  V. Viikari, J. Song, and H. Seppä – *IEEE Sensors Journal, Vol. 13, No. 4, pp. 1180 – 1186, April. 2013.*
- **Optimization of Wireless Sensors Based on Intermodulation Communication**
  J. Song, V. Viikari, N. Pesonen, I. Marttila, and H. Seppä – *IEEE Transactions on Microwave Theory and Techniques, Vol. 61, No. 9, pp 3446-3452, Sep. 2013.*
- **On the Use of the Intermodulation Communication Towards Zero Power Sensor Nodes**
  J. Song, N. Pesonen, V. Viikari – *presented at the European microwave week conference, October 2013.*
- **Maximum Likelihood Estimation for Passive Wireless Intermodulation Communication Sensors**
  J. Song, J. Salmi, V. Viikari, and N. Pesonen – *submitted to the IEEE Sensor Journal.*
- **Realizing Frequency Division Multiple Access with Passive Wireless Intermodulation Communication Sensors**
  J. Song, N. Pesonen, V. Viikari, and H. Seppä – *to be submitted to the IEEE Sensor Journal.*
- **Long range passive wireless MEMS-based accelerometer sensor utilizing the intermodulation communication principle**
  J. Song, N. Pesonen, V. Viikari – *to be submitted to the International Wireless Symposium, Xi'an, China, 2014.*

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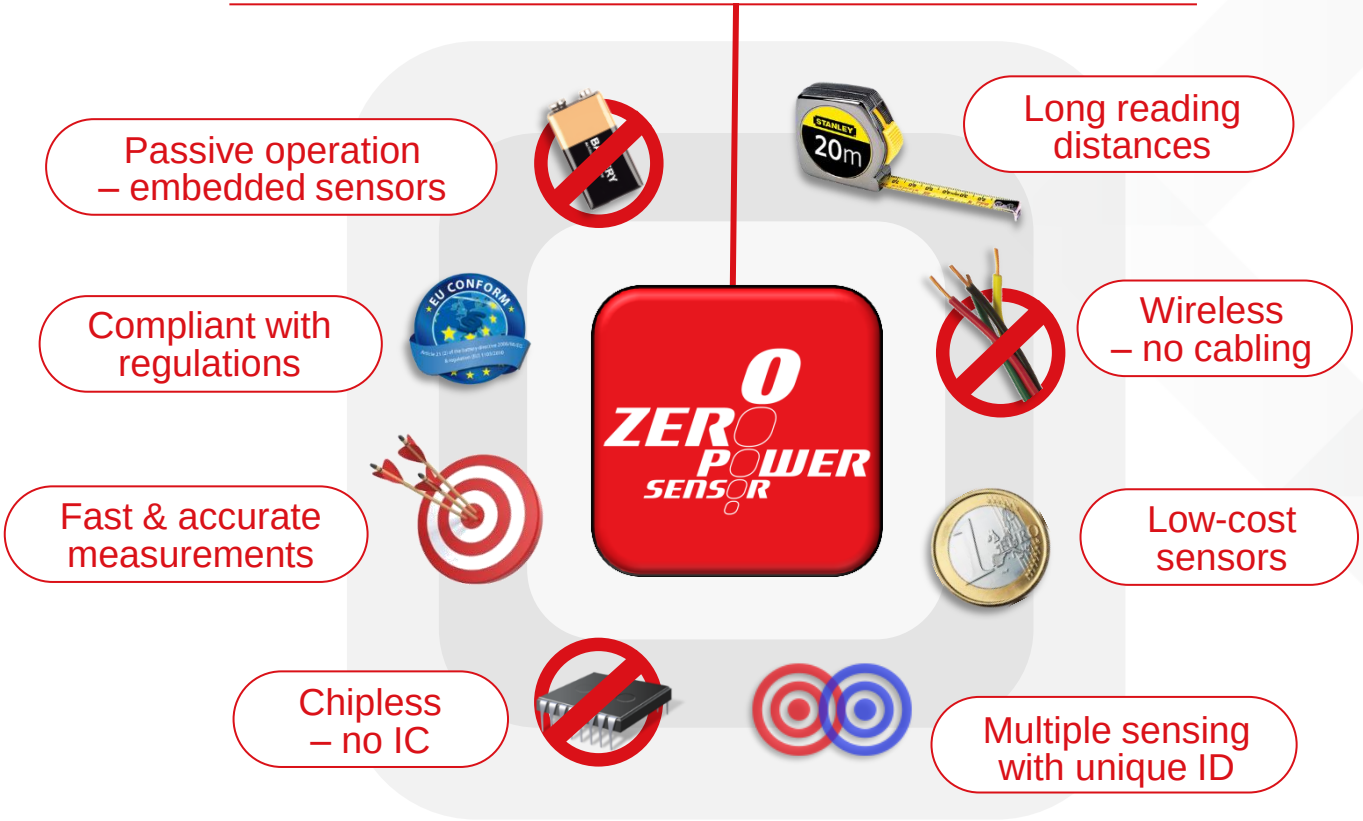
The Competitive Edge

The long reading distances can revolutionize passive wireless sensing paradigms.



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Infinite Possibilities

In co-operation

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