Implementation and Wireless Readout of Passive UHF RFID Strain Sensor Tags based on Electro-Textile Antennas

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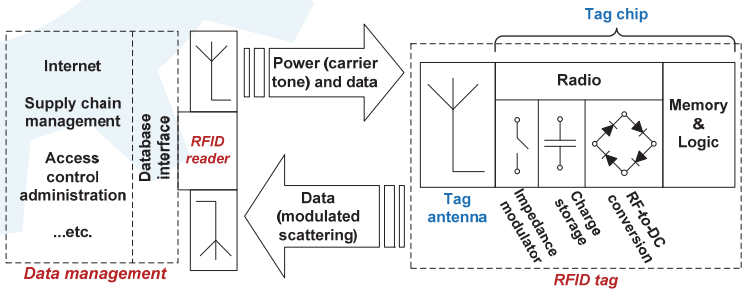
I. Passive UHF RFID Sensors Tags

- Digitally modulated scattering provides the means for the wireless communication with remotely-powered passive UHF tags at distances reaching 25 m
- Passive tags are promising candidates as battery-free sensing platforms and digital entities in the Internet of Things



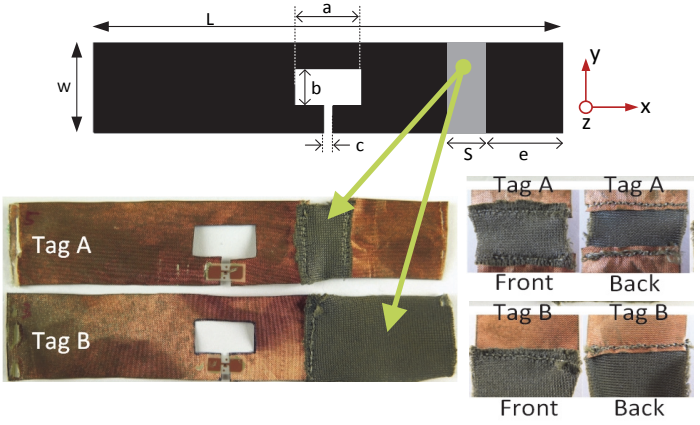
Communication distance is limited by the power delivery to the tag chip:

$$d_{tag} = \frac{\lambda}{4\pi}\sqrt{\frac{\tau D_{tag} e_{r,tag} \mathrm{EIRP}}{P_{ic0}}}; \quad \tau = \frac{4\,\mathrm{Re}(Z_{tag})\mathrm{Re}(Z_{ic})}{|Z_{tag}+Z_{ic}|^2},$$

- A passive RFID tag can be turned into a sensor by using an antenna which is sensitive toward a parameter of interest
→ **Antenna self-sensing**
- Challenges: realization and how to maintain high communication range if the antenna gets detuned by an environmental change

II. Textile Strain Sensor Tag: Implementation

- Metal-coated fabrics are a popular choice in wearable antennas
→ Conformal, light-weight, touch and feel of regular fabrics
- By inserting a section of stretchable fabric in a textile dipole antenna, we achieve a strain-sensitive RFID tag



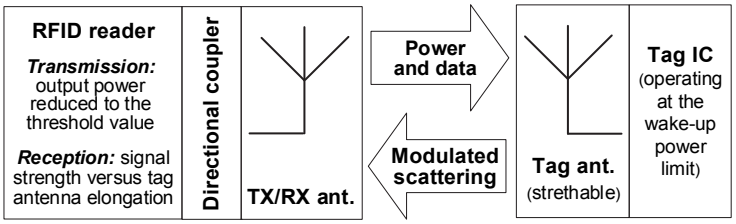
- Non-stretchable copper fabric: sheet resistance = 0.4 Ω/Sq
- Stretchable silver fabric: sheet resistance = 1.25 Ω/Sq
- Fabrics are sewn together using metal-coated thread
→ **Electrical and mechanical connection**
- RFID IC (wake-up power: 15.8 μW = −18 dBm) was attached to copper fabric using conductive epoxy

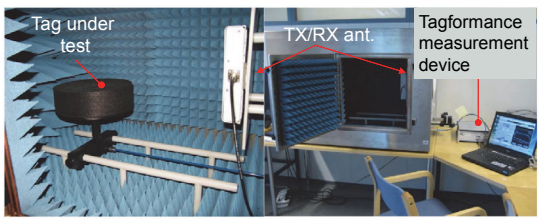
III. Textile Strain Sensor Tag: Readout and Sensor's Response

- Elongation of the antenna changes its impedance and gain
→ Power of the modulated backscattered signal varies
→ Tag read range varies

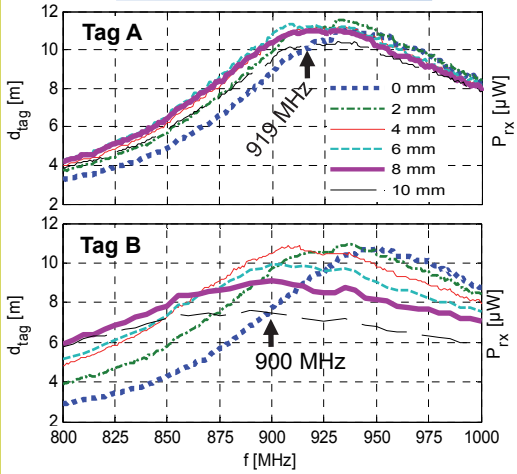
Backscattered signal power at the receiver:

$$P_{rx} = \frac{1}{4}|\rho_1 - \rho_2|^2\left(\frac{\lambda}{4\pi d}\right)^4 G^2 G_{read}^2 P_{tx}; \quad \rho_k = \frac{Z_{ic,k} - Z_a^*}{Z_{ic,k} + Z_a}; \quad k = 1,2$$

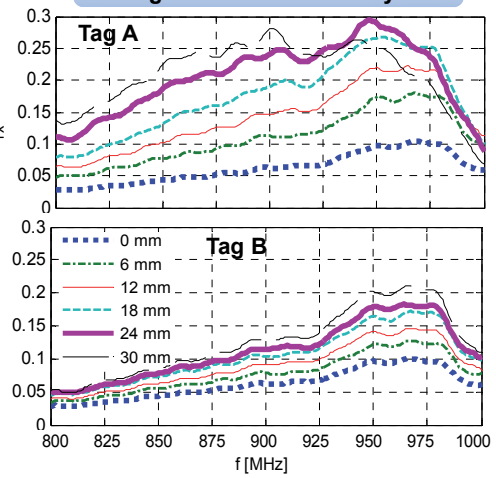




Optimal readout frequency?



P_{rx} at the at the wake-up limit of the tag IC in a monostatic system



Sensor's response