ZenseTag

RFID assisted Twin-Tag Single Antenna COTS Sensor Interface

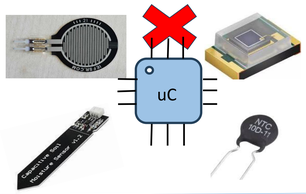
Nagarjun Bhat, Agrim Gupta, Ishan Bansal, Harine Govindarajan, Dinesh Bharadia

UC San Diego
Electrical and Computer Engineering
JACOBS SCHOOL OF ENGINEERING

WCSNG
Wireless Communications Sensing and Networking

Current Sensor Interfaces

No universal interface for sensing!



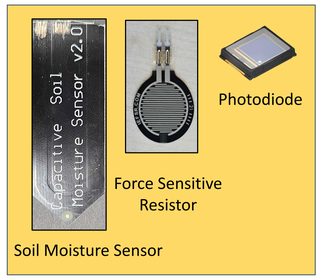
Sensor interfaces are bulky, rigid, complex and need batteries

Current radio infrastructure does not support battery-free sensing!

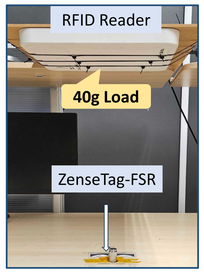
Passive sensing needs SDRs and custom waveforms.

Sensor interfaces are still archaic, bulky, power hungry and non-compliant with existing radios

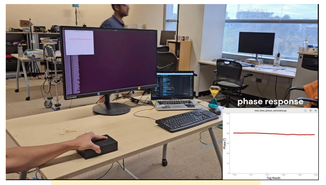
ZenseTag



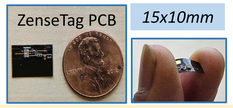
Direct-to-RF COTS Sensor Interface



Batteryless, Commercial RFID Compatible



Robust and Realtime

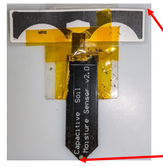


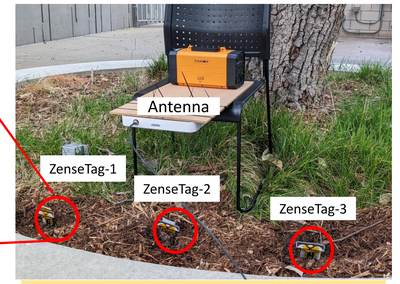
Compact, Flexible form-factor

ZenseTag enables a Direct-to-RF interface with commercial antennas using a compact twin-tag-single antenna architecture.

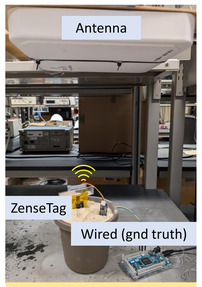
Applications of ZenseTag

Application 1: Soil Moisture Sensor



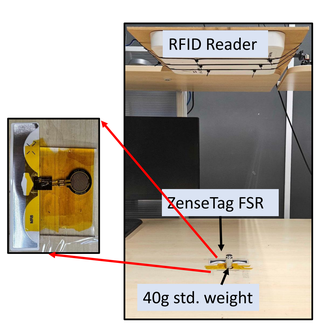


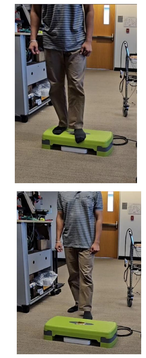
Outdoor measurement

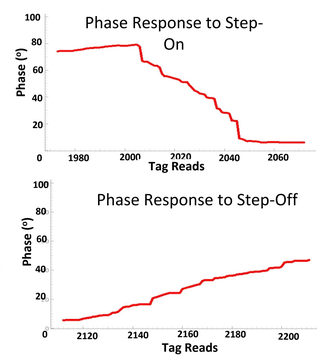


Indoor measurement

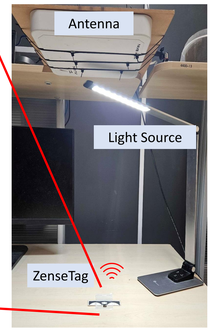
Application 2: Contact force sensor

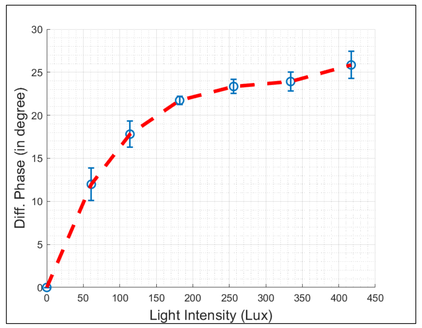






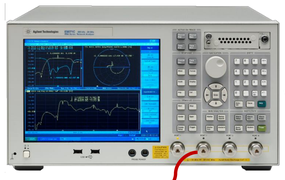
Application 3: Light Sensor

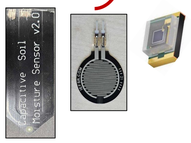




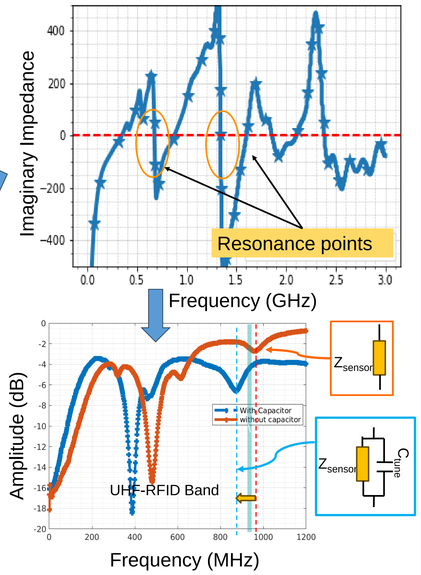
Direct-to-RF Sensor Interface

Vector Network Analyzer



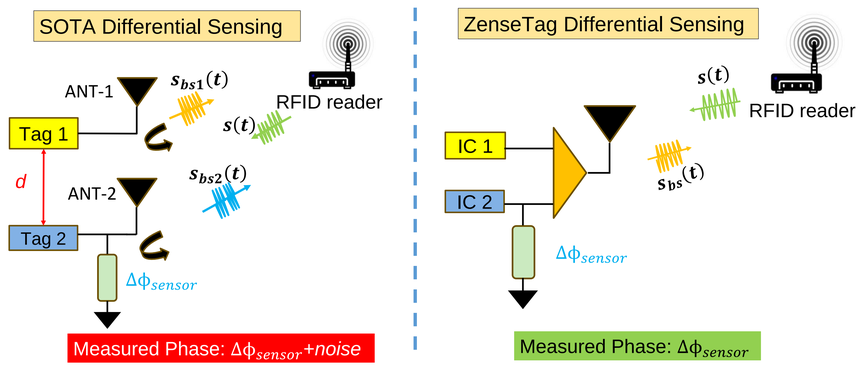


Profile Sensor Impedance Z_{sense}(freq)



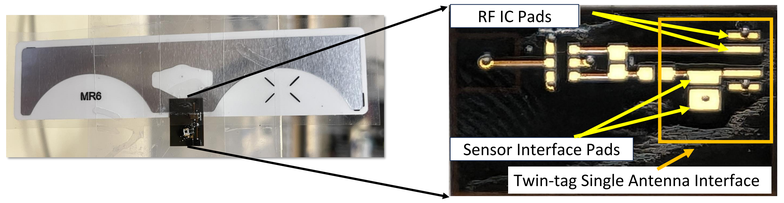
ZenseTag enables direct-to-RF-interface by leveraging the resonance of COTS sensors

Twin-Tag-Single Antenna Interface



Measured Phase: $\Delta\phi_{sensor}$+*noise*

Measured Phase: $\Delta\phi_{sensor}$

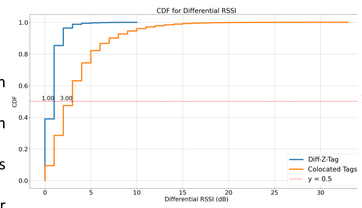


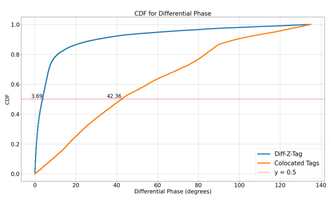
ZenseTag enables robust differential sensing

Results

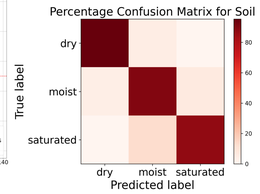
ZenseTag achieves:

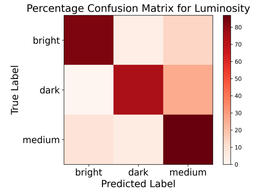
- **Over 93%** accuracy in soil moisture classification (Dry/Moist/Saturated) with three sensors outdoors
- Detects loads as **small as 10g (0.1N)** and can sense human stepping force in real-time.
- Achieves **85% accuracy** in classifying three brightness levels with a photodiode.
- Median phase error below 4°—8x improvement over previous RFID methods.
- Compact, flexible 150mm² PCB





ZenseTag enables ***Robust*** sensing in multipath





ZenseTag can sense various stimuli accurately

Summary

ZenseTag is a novel RFID-assisted sensing platform that interfaces commercial off-the-shelf (COTS) sensors to affordable, flexible RFID stickers. By utilizing a direct-to-RF interface, it optimally couples sensors with RFID tags. It uses a twin-tag single antenna interface to enable robust readout even in dynamic environments..