

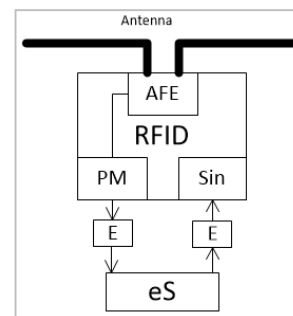
RFID Sensor Systems Embedded in Concrete – Systematical Investigation of the Transmission Characteristics

M. Bartholmai, S. Johann, M. Kammermeier, M. Mueller, C. Strangfeld

Introduction

- Bridges as typical example: old structures, increasing traffic volume
- Demand for monitoring of steel reinforced concrete components

→ Long-term, completely embedded RFID sensor systems
→ Systematical investigation of the transmission characteristics



- AFE: Analog front end
- PM: Power management
- E: Electronic interface
- eS: external Sensors
- Sin: Signal input

System Design and Operation principle

- Passive RFID systems using low energy components, no battery
- Energy supply via electromagnetic field from external reader
- Sensors for temperature, humidity, and indication of corrosion
- Similar HF (13.56 MHz) and UHF (868 MHz) RFID systems
- HF RFID: sensor signal is communicated via load modulation
- UHF RFID: sensor signal is communicated via backscattering

RFID sensor system scheme



RFID sensor system (UHF left, HF right)

Investigation Method and Set-up

- Test specimen with RFID systems featuring different installation depths, different concrete types, varying moisture contents
- Investigation of transmission with HF and UHF analysis tools
- At constant frequency, an excitation signal is sent with increasing transmission power from 0 to 29 dBm
- Once a backscattered signal from the RFID system can be received, the transmitted power is recorded
- The transmitted power represents the minimal power transmitted by the reader device, which is required to receive a response signal
- Sequentially repetition of this routine at stepwise varied frequencies (0.01 MHz steps)

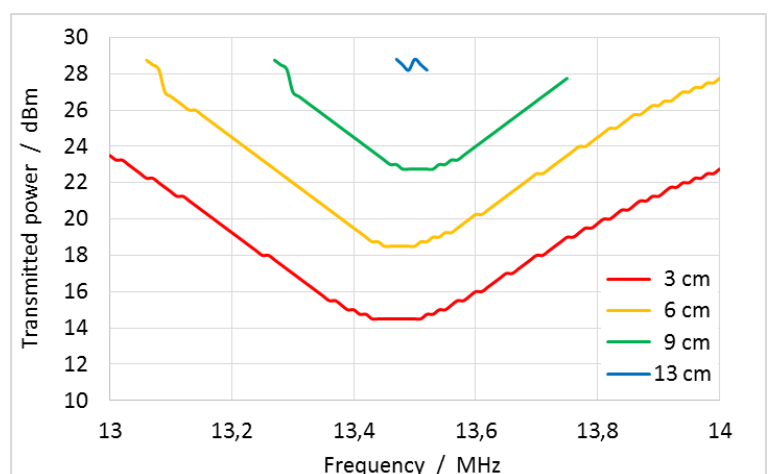


Test specimen with RFID systems before filling with concrete

Results

HF measurement results

- Results are well reproducible; exemplary standard deviation of 0.27 for 16 measurements at 13.29 MHz
- Similar installation depths at different specimen show similar results
- A roughly linear relation can be recognized between installation depth and transmitted power



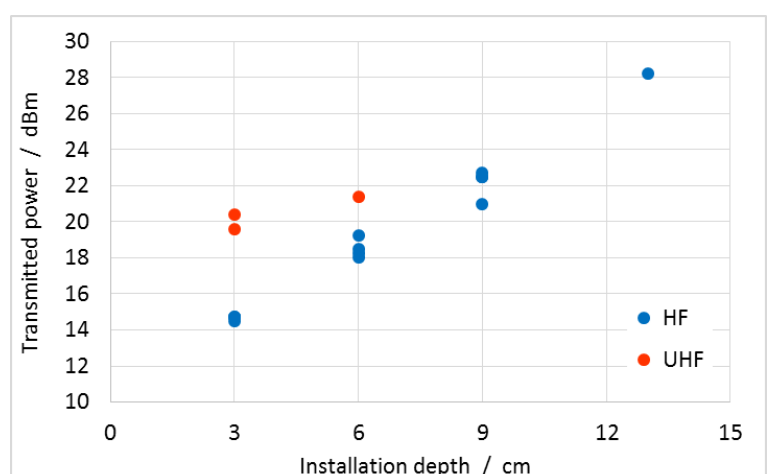
Exemplary results of HF measurements for RFID systems at different installation depth

UHF measurements

- Strong dependency from orientation of the antenna and positioning of the reader device
- Results have to be interpreted carefully

Conclusions and Outlook

- Investigation method is suitable and provides promising results, particularly for HF RFID systems
- UHF RFID systems must be optimized regarding antenna design, orientation, and ambient influences on the transmission
- Further specimen will be assembled and further tests performed



Comparison between results of HF and UHF measurements