RFID Reader Frontends for a Dual-Frequency (13 MHz and 868 MHz) Rapid Prototyping Environment

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Outline

- Reader – Tag Communication
- Analog Frontends for Rapid Prototyping Environments
- HF-Frontend
- UHF-Frontend
Reader – Tag Communication

- Tag is powered by the reader
- Energy transfer from reader to tag during the entire communication
- Energy transfer happens at the carrier frequency of the data signal
- Cross talk from transmitter to receiver at the reader
Analog Frontends for a Rapid Prototyping Environment

- As much functionality as possible should be realized by the digital baseband
- Frequency conversion, filtering and amplification are the tasks of the RF-frontend
HF-Frontend: Requirements

- Frequency: 13.56MHz
- Communication range: a few centimeters
- Inductive coupling between reader and tag
- Load modulation
- HF-power of 1 W
- Interface with the DSP-hardware
  - frequency: 13.56MHz
  - power levels: determined by ADCs and DACs
- Carrier to sideband ratio improvement
HF-Frontend: Carrier Suppression Principle
HF-Frontend with Tag-Emulator
HF-Frontend: Verification

- Laboratory setup with tag-emulator
- Optimal tuning
- Modulation signal enhanced by 34 dB
Measurement with Commercial Tag

Distance between tag and transmit coil $d = 24\,\text{mm}$
Magnetic field at tag position (without Tag) $H = 2.4\,\text{A/m}$

Transmit coil voltage

Carrier-suppressed output voltage of the HF-Frontend
UHF-Frontend

- Requirements
- Rx/Tx crosstalk
  - Antenna configurations
  - Active Rx/Tx decoupling
- Frontend concept
- Verification measurement
Requirements

• Frequency: 865MHz - 868MHz
• Communication range: up to 10m
• 2 Watt linear output power
• Interface with the DSP-hardware
  • frequency: 867MHz not directly possible → frequency conversion necessary
  • power level: determined by ADCs and DACs
• Carrier to sideband ratio improvement (carrier suppression)
Separate Rx/Tx Antenna

Rx/Tx isolation: 30 to 40 dB

two antennas

Rx/Tx isolation depends on:
- antenna spacing
- antenna radiation pattern

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Single Rx/Tx Antenna

Rx/Tx isolation: 20 to 30 dB
single antenna

Rx/Tx isolation depends on:
- circulator
- return loss of antenna

circulator insertion loss: 0.4 – 1 dB
Active Rx/Tx Decoupling

-27dBm   Coupler
       ↓
     I-CTRL
       ↓
   Q-CTRL
       ↓
   Vector Modulator
       ↓
   Amp.
       ↓
Rx      Coupler
       ↓
+13dBm

Tx (+33dBm)

S21

coupling 20dB

Christian Doppler Laboratory for Design Methodology of Signal Processing Algorithms
UHF Transmitter
Measurement Setup

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Scenario: Corridor 5th Floor

Power amplifier: $P_{out} = 33.4$ dBm
Losses (cable, coupler..): 2.75 dB
Antenna gain: $\sim 5$ dBi ($\sim 2.85$ dBi)
Transmit power: $\sim 33$ dBm ERP
Received Tag Answer

Screenshot at maximum communication range of ~11m
Summary

- Frontends for Rapid Prototyping
- Current implementations for RFID
  - HF-Frontend
    - Rx/Tx decoupling
      (34 dB carrier suppression achieved)
    - Measurements
  - UHF-Frontend
    - Rx/Tx decoupling
      (antenna configuration, vector modulator)
    - Concept and verification
      (∼11m comunication distance achieved)
Thank you!