Optimizing RFID Product Tagging by Measurements and Tests Using the NI PXI Platform

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Agenda

- Company Introduction
- CISC RFID Measurement and Evaluation Test System
- Modular HW Platform and Configurations
- Example of MeETS Measurement Results
- Summary
CISC Semiconductor is...

...independent
CISC was founded in 1999 and is a 100% private owned company

...experienced
CISC Semiconductor is managed by an international team of highest skilled experts & working with RFID since the first hour

...for the whole industry
supporting industries that develop embedded microelectronic systems with extremely short Time-To-Market cycles

Head office at Lake Woerthersee
Lakeside B07, Klagenfurt, Austria
CISC Business Units

CISC Semiconductor focus on system design, modeling, simulation, verification and optimization of heterogeneous embedded microelectronic systems.

**AT**
- Automotive
  - Power Train
  - Safety Systems
  - Body electronics
  - Transceiver
    - LIN
    - CAN
    - FlexRay
  - Smart Sensors
  - Info & Entertainment

**RF**
- RFID+RFComm
  - Inductive Systems
    - LF (125 kHz)
    - HF (13.56 MHz)
  - Propagative Systems
    - UHF
    - 2.45 GHz
  - Propagative Systems
  - RFID Product Design
  - RFID System Design
  - Simulations/Emulations
  - Measurement Tools
  - Int. Standardization

**TM**
- Tools+Methodology
  - Tools
    - SyAD®
    - TecPET
    - Model Libraries
  - Methodology
    - Mixed Signal / Mixed Domain Design Methods
    - Embedded system simulation
    - Design Centering / Yield Optimization
CISC RF: Core competences

- **RFID system simulation+emulation**
  - RFID system modeling
  - RF system communication link modeling
  - Protocol evaluation
  - Identification software optimization
  - RFID System application evaluations

- **RFID system design**
  - Readers
  - Tag ASIC
  - Tags, Labels
  - Application Setups

- **RFID measurement products**
  - Applications
  - Conformance
  - Performance
CISC RF

- Team of RFID professionals with long-term, international reputation
- Performance improver of RFID products and systems in many projects through our solutions.
- Knows what to measure on RFID systems and products in order to evaluate the performance and we know what wheels to twist in order to maximize it
- Provider of RFID simulation and measurement tools
- Leading organization in RFID Standardization
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Challenges in RFID

• HF cards:
  ▪ Stacking
  ▪ Read range
  ▪ Strength of response (sidebands)

• UHF tags:
  ▪ Tags applied on products
  ▪ Interference of multiple readers
  ▪ Read range
  ▪ Closely coupled tags (proximity)

• Readers and Reader Systems
  ▪ Command set and RF compliance
  ▪ Sensitivity
  ▪ Dense reader environments
  ▪ Unwanted reads, tag collisions
### RF effects of common materials in UHF

<table>
<thead>
<tr>
<th>Material</th>
<th>RF Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardboard</td>
<td>- Absorption (moisture)</td>
</tr>
<tr>
<td></td>
<td>- Detuning (dielectric)</td>
</tr>
<tr>
<td>Conductive liquids</td>
<td>- Absorption</td>
</tr>
<tr>
<td>(e.g. shampoo)</td>
<td>- Detuning</td>
</tr>
<tr>
<td>Plastics</td>
<td>- Absorption</td>
</tr>
<tr>
<td>Metals</td>
<td>- Detuning</td>
</tr>
<tr>
<td>Cans</td>
<td>- Reflection</td>
</tr>
<tr>
<td>Groups of cans</td>
<td>- Complex effects (lenses, filters)</td>
</tr>
<tr>
<td>Human body</td>
<td>- Absorption</td>
</tr>
<tr>
<td>Animals</td>
<td>- Detuning</td>
</tr>
<tr>
<td></td>
<td>- Reflection</td>
</tr>
</tbody>
</table>
CISC RFID MeETS
Performance and Conformance Tests

NEED
- Products fulfilling conformance requirements
- Product fulfilling customer performance requirements
- Best suitable product for the application (e.g. applied tags)

SOLUTION
- Performance and conformance tests
- Data sheet based on performance tests

BENEFIT
- Confirmed recommendation for best product
- Fast, reliable product data sheets

- UHF band (860 – 960 MHz)
- HF band (13.56 MHz)
- Modular, based on industrial standard of NI PXI and Labview
Test Capabilities

• RFID Tests & Measurements
  ▪ Conformance
  ▪ Performance
  ▪ Interoperability

• Reader Emulator
  ▪ Tag Test

• Sniffer Test
  ▪ Tag and Reader Test

• Tag Emulator
  ▪ Reader Test
RFID Protocols Available in MeETS

- **13.56 MHz (HF)**
  - ISO 14443 Type A
  - ISO 14443 Type B
  - ISO 15693
  - ISO 18000-3 Mode 1
  - ISO 18000-3 Mode 2
  - ISO 18092 NFC
  - EPCglobal HF Class-1 Generation 2

- **860 – 960 MHz (UHF)**
  - ISO 18000-6 Type A
  - ISO 18000-6 Type B
  - ISO 18000-6 Type C / EPCglobal UHF Class-1 Gen-2
  - EPC Class 1 Generation 2

- **2.45 GHz (Microwave)**
  - ISO 18000-4 Mode 1

- **125 kHz - 2.7 GHz Customized Protocol**
UHF RFID Performance Testing

- 860 - 960 MHz
- Accuracy
- Reproducibility
- Automation
- Compliance
- Quality

MeETS UHF RFID test setup installed at the European EPC Competence Center
MeETS UHF Tag Performance Tester

- Fully automated SW for complete characterization of UHF tag performance

![Image of MeETS UHF Tag Performance Tester interface]

**Test cases**
- Read & backscatter range
- Orientation tolerance
- Frequency tolerance
- Interference tolerance
- Write Range & Time
- Tag Proximity

**Tag characteristic**
- Frequency sweep 800MHz – 1 GHz
- Power sweep
- Response evaluation

**Report generator**
- In Microsoft Word format
MeETS UHF Tag Conformance Tester

- Detailed analysis of tag conformance
- UHF reader emulator

**Free-defined reader command**
- All standard commands
- Selection of command type
- Define data content
- Modulation type and index
- Pulse width, transition edges
- Timing

**Response analysis**
- Memory content, bit stream
- Protocol state transition
- Link frequency/Data rate

**RF Signal Analysis**
- Frequency Spectrum, JTFA
- Waveform Graph
- Response timing analysis
HF RFID Performance and Conformance Testing

- 13.56 MHz
- 5 mA/m to 5 A/m
- Feedback H-field measurement
- Self-calibration
- ISO compliant
  - ISO 18047-3
  - ISO 10373-6
  - ISO 10373-7
MeETS HF Tag Performance and Conformance Test System

- HF (13.56 MHz) Tag Evaluations

Reporting and Test logs

Compliance Test
- RF and analog
- Command set

Performance Test
- Resonance frequency measurement
- Sideband levels
- Load modulation
- Operating field vs. Modulation index
MeETS Reader Conformance Test System

- Measurement and Tests of RFID Readers
- Tag emulator and Sniffer
- UHF and HF

Communication analysis
- Decoded message
- Turnaround time measurement

Free-defined tag response
- Tag emulation with user defined response parameters
- Triggering on reader command

RF Signal Analysis
- Timing
- Spectrum
- Protocol
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PXI – One Platform for all RFID tests
## PXIe 5641R/PCI 5640R

### FPGA-Based RF Transceiver

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range</td>
<td>250 kHz to 80 MHz</td>
</tr>
<tr>
<td>Real-time bandwidth</td>
<td>20 MHz</td>
</tr>
<tr>
<td>Input</td>
<td>2 channels, 100 MS/s, 14 bits</td>
</tr>
<tr>
<td>Output</td>
<td>2 channels, 200 MS/s, 14 bits</td>
</tr>
<tr>
<td>FPGA</td>
<td>Xilinx Virtex-II Pro / Virtex-5</td>
</tr>
<tr>
<td>Data streaming</td>
<td>4 DMA channels</td>
</tr>
</tbody>
</table>
**PXI 5600 and PXI 5610**

- **2.7 GHz RF Downconverter**
  - Frequency range 9 kHz to 2.7 GHz
  - Real-time bandwidth 20 MHz
  - Input signal range -130 dBm to +30 dBm
  - Absolute accuracy ±1 dB, typical

- **2.7 GHz RF Upconverter**
  - Frequency range 250 kHz to 2.7 GHz
  - Real-time bandwidth 20 MHz
  - Output signal range -145 dBm to +10 dBm
  - Absolute accuracy ±1 dB, typical
CISC PXI Carrier Cancellation System

- For high quality UHF systems
- Suppresses unwanted coupling between transmitter and receiver
- Increases receiver sensitivity
- Improves signal-to-noise ratio
- Weak signals become better detectable
CISC PXI Carrier Cancellation System

Reader command

Tag response

With CISC PXI CCS

Without CISC PXI CCS
CISC Impedance Converter

- For high precision HF test systems
- 2 inputs, 2 outputs HF preamplifier
- Interface between the HF antenna assembly and the RF transceiver
- Special probe cables with low capacitance
- SW controllable gain
- 1 M ohm inputs
- 50 ohm outputs
RF Frontend

**UHF Test Antenna**
- 800 MHz – 1 GHz
- Narrow beam
- Flat gain

**HF Test Assembly**
- 13.56 MHz
- ISO compliant
  - ISO 10373-6
  - ISO 10373-7
  - ISO 18047-3
Hardware configuration for HF tests

- HF (13.56 MHz) Tag Evaluations
  - PCI 5640R
  - Power amplifier
  - HF antenna setup
  - Impedance Converter
  - PC with Labview and MeETS SW
PXI Hardware configuration for UHF tests

- UHF (860-960 MHz) tag evaluations
  - Upconverter PXI 5610
  - Downconverter PXI 5600
  - RF transceiver PXIe 5641R
  - PXI Carrier Cancellation System
  - PXIe controller and chassis
  - Labview and MeETS SW
  - RF power amplifier
  - Antennas
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Tag test procedure

• Reader independent test
  ▪ Use reference reader (close to ideal = no tag response missed)

• Attach tag to a product or reference material

• Test tag performance over the whole range of UHF frequencies allocated for RFID

• Test tag performance over the whole range of power levels
Frequency dependent sensitivity

- Effects of various materials on read range

![Graph showing material dependency of read range](image-url)
Orientation degradation of tag sensitivity

Orientation Dependency of Sensitivity of a dipole tag

Orientation Dependency of Sensitivity of an omni-directional tag
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RFID Measurement & Test Summary

- **Solution for**
  - Readers
  - Tags, Labels
  - ASICs
  - Operating setups

- **Systems**
  - LF
  - HF
  - UHF

- **Tests**
  - Conformance
  - Performance
  - Interoperability

- **CISC Products**
  - High performance
    - accuracy configurable
    - NI-based
  - Standalone rugged
    - portable
Get the ID with CISC RFID products!
v.derbek@cisc.at

www.CISC.at/meets