CISC RFID Measurement & Evaluation Test System

Tag Test System for EPCglobal HF Class 1 Generation 2

DATASHEET

CONFIDENTIAL

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## 1 OVERVIEW

The CISC RFID Measurement & Evaluation Test System (MeETS) is a solution for testing radio frequency identification (RFID) devices by using National Instruments RF hardware modules and LabVIEW. This system supports various RFID communication standards on both high frequency (HF) and ultra-high frequency (UHF) bands. Figure 1 shows the MeETS in overview.

![Block Diagram of CISC RFID Measurement & Evaluation Test System](image)

**Figure 1: Block Diagram of CISC RFID Measurement & Evaluation Test System**

The MeETS Tag Test System for EPCglobal HF Class 1 Generation 2 is based on the National Instruments FPGA-based RF Transceiver PCI-5640R only (no PXI system required) and the LabVIEW development environment.

During the conformance test, engineers can download standard or customized commands and parameters from the host controller to the RF modules. Using the RF modules, the tester converts the baseband signal to the RF signal and transmits it to the RFID UUT via cable or air interface.

The software of the MeETS Tag Test System for EPCglobal HF Class 1 Generation 2 is provided as a LabVIEW-based test suite with an easy to use Test Panel and a set of API Test Toolkit. RFID product developers, certification labs, and protocol conformance test groups can execute predefined tests in the Test Panel and create advanced or customized tests with the Test Toolkit. They also can use the Test Toolkit to create test sequences and integrate with test management software such as NI Test Stand for manufacturing test or protocol conformance.
Tag Test System for EPCglobal HF Class 1 Generation 2

Table 1: Overview of the Supported Protocol Features

<table>
<thead>
<tr>
<th>Standard</th>
<th>EPCglobal HF Class 1 Generation 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency Range</strong></td>
<td>Test system: 10 MHz – 20 MHz</td>
</tr>
<tr>
<td></td>
<td>Protocol requirement: 13.56 MHz</td>
</tr>
<tr>
<td><strong>Signaling</strong></td>
<td></td>
</tr>
<tr>
<td>Interrogator to Tag</td>
<td>Coding: PIE; Modulation: DSB-ASK</td>
</tr>
<tr>
<td>Tag to Interrogator</td>
<td>Coding: FM0, Miller8, Manchester2,4; Modulation: ASK</td>
</tr>
<tr>
<td><strong>Command Encoding</strong></td>
<td>Select, Query, QueryRep, QueryAdjust, ACK, NAK, Req_RN, Read, Write, Kill, Lock, Access, BlockWrite, BlockErase, Reserved or Custom Commands</td>
</tr>
<tr>
<td><strong>Response Decoding</strong></td>
<td>RN16, PC, EPC, CRC16, Other Information</td>
</tr>
</tbody>
</table>

1.1 Test Items and Functions

Table 2: Overview – Test Items

<table>
<thead>
<tr>
<th>Physical Layer</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Domain</td>
<td>Frequency Range</td>
</tr>
<tr>
<td></td>
<td>Frame Spectrum Analysis</td>
</tr>
<tr>
<td></td>
<td>JTFA Analysis</td>
</tr>
<tr>
<td>Time Domain</td>
<td>Transmission Rise / Fall Time</td>
</tr>
<tr>
<td></td>
<td>Transmission Pulse Width / Duty Cycle</td>
</tr>
<tr>
<td></td>
<td>Turn-around Time (T1, T2, T3, T4)</td>
</tr>
<tr>
<td></td>
<td>Frame Signal Extraction</td>
</tr>
<tr>
<td>Power &amp; Envelope</td>
<td>Modulation Depth</td>
</tr>
<tr>
<td></td>
<td>Transmission Ripple</td>
</tr>
<tr>
<td></td>
<td>Power of Load Modulation</td>
</tr>
<tr>
<td></td>
<td>Time Waveform Analysis</td>
</tr>
<tr>
<td>Protocol Layer</td>
<td>Memory Content</td>
</tr>
<tr>
<td></td>
<td>Protocol State Transition</td>
</tr>
<tr>
<td></td>
<td>Link Frequency / Data Rate</td>
</tr>
<tr>
<td></td>
<td>Bit Length</td>
</tr>
<tr>
<td></td>
<td>Other Protocol Parameters (Preamble, Frame Sync, ...)</td>
</tr>
<tr>
<td></td>
<td>Bit Stream, Decoded Message</td>
</tr>
<tr>
<td>Automated Tests Layer</td>
<td>Full Interrogation, all Mandatory, Optional, Custom Commands</td>
</tr>
</tbody>
</table>

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1.2 Required Hardware

- NI PCI-5640R IF RIO
- GPIB-USB interface
- ISO/IEC 18047-3 / ISO/IEC 10373-7 HF Test Interrogator Assembly
- External HF power amplifier remote controlled
- Interface module for NI-PXI/PCI564R system and ISO 10373-6 and ISO 18047-3 / ISO 10373-7 HF Test Interrogator Assembly

1.3 Required Software

- LabVIEW FDS 8.2
- NI Spectral Measurements Toolkit 2.1
- NI Advance Signal Process Toolset 7.5
2 COMPONENTS

Figure 2: Schematic diagram of the HF test system

2.1 NI PCI-5640R IF RIO

The NI PCI-5640R is a 2 Inputs and 2 Outputs IF Transceiver with FPGA. In the RFID HF test system it is used for sending, receiving and processing signals, executing the protocol state machine, real-time analysis, and synchronized control of the external RF measurement devices.

2.2 External HF power amplifier remote controlled

The HF power amplifier amplifies the RF output signal of the 5640R to generate required input power of the transmit antenna.
2.3 GPIB-USB interface

The GPIB-USB interface is used to dynamically control the external HF power amplifier gain by the test software from LabVIEW in order to optimize the resolution of the output signal and the gain distribution on the two amplification stages.

2.4 HF Test Interrogator Assembly

The antenna assembly is provided according the specification of ISO/IEC 18047-3 / ISO/IEC 10373-7. The 50 Ohm input is connected to the RF power amplifier. The high-ohmic outputs of the compensation circuit and of the calibration coil are connected to the high-ohmic inputs of the Interface module.

The maximum achievable field strength is 5 A/m.

2.5 Interface module

The Interface module provides an active matched interface between the NI PCI5640R and the HF Test Interrogator Assembly. Furthermore, it includes a LabVIEW-controlled preamplifier of the antenna output signals.

3 SPECIFICATIONS

3.1 Protocol implementation

The following items show briefly the implemented protocol functions.

3.1.1 Physical layer

- Interrogator to Tag: DSB-ASK using PIE.
- Tag to Interrogator: Manchester-, FM0-, and Miller-modulated subcarrier.
- PJM mode is NOT implemented.

3.1.2 Tag-identification layer

- Select
- Inventory
- Access
3.1.3 Signaling

The following parameters are definable within specified limits.

Table 3: Parameters Specification

<table>
<thead>
<tr>
<th>Subject</th>
<th>Protocol requirement</th>
<th>MeETS specification</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center Frequency</td>
<td>13.56</td>
<td>10 – 20</td>
<td>MHz</td>
</tr>
<tr>
<td>Frequency Accuracy</td>
<td>1.0</td>
<td>1.0</td>
<td>ppm</td>
</tr>
<tr>
<td>Interrogator Modulation</td>
<td>DSB-ASK / PJM</td>
<td>DSB-ASK</td>
<td></td>
</tr>
<tr>
<td>DSB-ASK Modulation Index</td>
<td>10 – 30</td>
<td>0 - 90(^1)</td>
<td>%</td>
</tr>
<tr>
<td>Modulation Index Accuracy</td>
<td>1</td>
<td>1</td>
<td>%</td>
</tr>
<tr>
<td>Field Strength</td>
<td>Not defined</td>
<td>30 – 5000</td>
<td>mA/m</td>
</tr>
<tr>
<td>Field Strength Accuracy</td>
<td>1</td>
<td>1</td>
<td>%</td>
</tr>
<tr>
<td>DSB-ASK Rise Time</td>
<td>0 – 4.5</td>
<td>1 – 5</td>
<td>µs</td>
</tr>
<tr>
<td>DSB-ASK Fall Time</td>
<td>0 – 4.5</td>
<td>1 – 5</td>
<td>µs</td>
</tr>
<tr>
<td>Command Encoding</td>
<td>PIE</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Response Decoding</td>
<td>FM0: 424 and 848 kbit/s</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manchester-modulated subcarrier (2 sub-carrier pulse Manchester: 106 and 212 kbit/s)</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manchester-modulated subcarrier (4 sub-carrier pulse Manchester: 53 and 106 kbit/s)</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Miller-modulated subcarrier (8 sub-carrier pulse Miller: 53 and 106 kbit/s)</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Tari</td>
<td>8 – 25</td>
<td>5 – 30</td>
<td>µs</td>
</tr>
<tr>
<td>T2</td>
<td>151 - 1208</td>
<td>150 - 5000</td>
<td>µs</td>
</tr>
</tbody>
</table>

\(^1\) Minimum B-value of modulation index (Lo pulse) is 10 mA/m
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<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>T3</td>
<td>Ts of tag (min)</td>
<td>150</td>
<td>5000</td>
</tr>
<tr>
<td>T4</td>
<td>T_{1Typ} + T_{3Min} (min)</td>
<td>150</td>
<td>5000</td>
</tr>
<tr>
<td>Delimiter</td>
<td></td>
<td>9.44</td>
<td>5 - 30</td>
</tr>
<tr>
<td>RTcal</td>
<td></td>
<td>2.5 – 3.0</td>
<td>1.0 – 5.0</td>
</tr>
<tr>
<td>TRcal Dummy</td>
<td></td>
<td>1.1 – 3.0</td>
<td>0.0 – 5.0</td>
</tr>
<tr>
<td>DSB-ASK Pulse Width</td>
<td></td>
<td>4 µs – 9.44 µs</td>
<td>(0 – 1)*Tari</td>
</tr>
</tbody>
</table>

3.1.4 Commands

The following commands are implemented and editable for error injection. The creation of invalid command is possible. Custom commands are allowed and the creation of these is easily possible. Appending invalid CRC 5 or CRC 16 is possible.

- Query
- QueryRep
- QueryAdjust
- ACK (in ASK mode)
- Select
- NAK
- Req_RN
- Read
- Write
- Kill
- Lock
- Custom Commands

Optional Commands are supported:

- Access
- BlockWrite
- BlockErase
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3.1.4.1 Custom Commands

For custom commands the following parameters are parameterized freely according the limits specified in 3.1.3.

- Delimiter width
- Pulse width
- Tari width
- Data-1 width
- RTcal width
- TRcal width
- CRC16 yes/no - correct/false/specifed
- CRC5 yes/no - correct/false/specifed
- TX length (number of data bits)

Custom commands can occur as defined in EPCglobal HF EPC V2 or as initial command.

3.1.4.2 Transparent Commands

The transparent command is used to realize error injection into mandatory and optional commands. The user is allowed to modify and define bit content (number of bits and values) of any existing command.

3.2 Measurements and analysis capabilities

A number of analyzes is applied on the forward and return data. Furthermore, the sampled forward and return signal is available for further processing. In the following sections the implemented analyze methods are listed.

3.2.1 Frequency Domain

- Frequency Range: presented in a graph (spectrum).
- Frequency Accuracy/Drift (Return Link Frequency Accuracy): presented in a graph (spectrum).
- Frame Spectrum Analysis
- Joint Time Frequency Analysis
3.2.2 Time Domain

- Transmission Rise / Fall Time: presented in a graph, with cursors and showing the current time in an indicator field.
- Transmission Pulse Width / Duty Cycle: presented in a graph, with cursors and showing the current time in an indicator field.
- Turn-around Time: presented in an indicator field.
- Frame Signal Extraction, Frame Delay time, Frame Duration

3.2.3 Power and Envelope

- Time Waveform Analysis
- Modulation Depth
- Transmission Ripple: presented in a graph.
- Time Waveform Analysis: presented in a graph.

3.2.4 Protocol

- Timing analysis (T1, T2, T3, T4): presented as indicator fields
- Response decoding: viewable in the message area.
- Memory Content: viewable in the message area.
- Protocol State Transition: viewable in the message area.
- Data Rate: presented as an indicator field.
- Bit (Etu, Tari...) Length: as an indicator field.
- Other Protocol Parameters (Preamble, SOF, EOF...): presented as indicator fields.
- Bit Stream, Decoded Message: viewable in the message area.

3.2.5 Automated Tests

- Resonance frequency measurement (tag turn on field over frequency)
- Minimum operation field measurement (modulation index over H-field)
- Sideband levels measurement (sideband levels over H-field)
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- Existence of backscatter modulation over field strength (tag response over H-field and frequency)
- Tag reset time measurement

3.2.6 Scripting

The application is provided with basic scripting (commands sequences, power levels, modulation index). Further customization is possible in LabVIEW environment.

4 USER INTERFACE

The user interface is provided as GUI and as a VI library toolkit.

The graphical user interface provides a number of functionalities, such as hardware configuration and calibration, measurement accuracy settings, parameters settings, status indicators, graphs and analyses functions. The GUI is organized in five main panes:

- System Functionality Pane (SFP) – HW configuration, measurement settings, commands and protocol parameters settings, RF output settings, calibration, scope display, basic message and timing analysis
- Measurements Pane – Parameters settings of automated tests, calibration results, recent status of RF HW outputs
- Tag Analysis Pane – Detailed analysis of tag response such as time waveform, frequency spectrum, sideband levels, frequency shift, occupied bandwidth, IQ diagram
- Pulse Mode Pane – Definition of parameters of a custom command in pulse mode on logic level (edge times, pulses duration)
- Advanced Settings Pane – Waveform modulation and timing settings, turnaround time settings, CRC settings, channel specification, digital interface settings, signal analyses controls

Figure 3 and Figure 4 show the screenshots of the SFP and the Measurement Pane.
4.1.1 Test Panel

Figure 3: System Functionality Pane (SFP)
Figure 4: Measurements Pane
5 DISCLAIMER

Document status

<table>
<thead>
<tr>
<th>Objective specification</th>
<th>This data sheet contains target or goal specifications for product development.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary specification</td>
<td>This data sheet contains preliminary data; supplementary data may be published later.</td>
</tr>
<tr>
<td>Product specification</td>
<td>This data sheet contains final product specifications.</td>
</tr>
</tbody>
</table>

Limiting values

Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics section of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

Application information and User Manuals

Where application or use information is given, it is advisory and does not form part of the specification.

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. CISC Semiconductor Design+Consulting GmbH customers using or selling these products for use in such applications do so on their own risk and agree to fully indemnify CISC Semiconductor Design+Consulting GmbH for any damages resulting from such improper use or sale.

6 REVISION HISTORY

Table 4: Revision History

<table>
<thead>
<tr>
<th>REVISION</th>
<th>DATE</th>
<th>PAGE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.7.2008</td>
<td></td>
<td>Initial version.</td>
</tr>
<tr>
<td>1.1</td>
<td>3.11.2008</td>
<td></td>
<td>Update protocol name</td>
</tr>
</tbody>
</table>
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NOTES
About CISC Semiconductor

CISC Semiconductor Design+Consulting GmbH is a design and consulting service company for industries developing embedded microelectronic systems with extremely short Time-To-Market cycles. Our core competences are: System design, modeling, simulation, verification and optimization of heterogeneous embedded microelectronic systems with a particular focus on Automotive and RFID systems. Our customers are coming from Semiconductor, Automotive, and RFID industry.

The company was founded in 1999 and is 100% private owned. CISC is managed by an international team of highest skilled experts. Our main office is situated in Klagenfurt, Austria (close to well known Wörthersee) at the heart of the Alpe-Adria-Region. We are proud to be able to conduct our international business from this part of the world and also enjoy our life with our families and friends within this beautiful nature.

Being an independent company CISC furthermore is able to provide non CAD/CAE market driven technology for individual customer solutions. CISC offers commercial tools and techniques for simulation based system development of embedded microelectronic systems including RFID systems.