RFID in Metallic Environment

A Technological Gap to be closed

Dipl.-Ing. Josef Bernhard
Dipl.-Ing. Thomas Leipold
Dr.rer.pol. Dipl.-Ing. Alexander Pflaum
Dipl.-Ing. Rainer Wansch

Fraunhofer Institut für Integrierte Schaltungen IIS
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Overview

- Tags on Metal Surface
  - Requirements from a MRO perspective
  - How to deal with the problem of metal surface
  - An UHF-Tag solution
- Tags inside Metal objects
  - Challenges and Approaches
  - A HF-Tag solution

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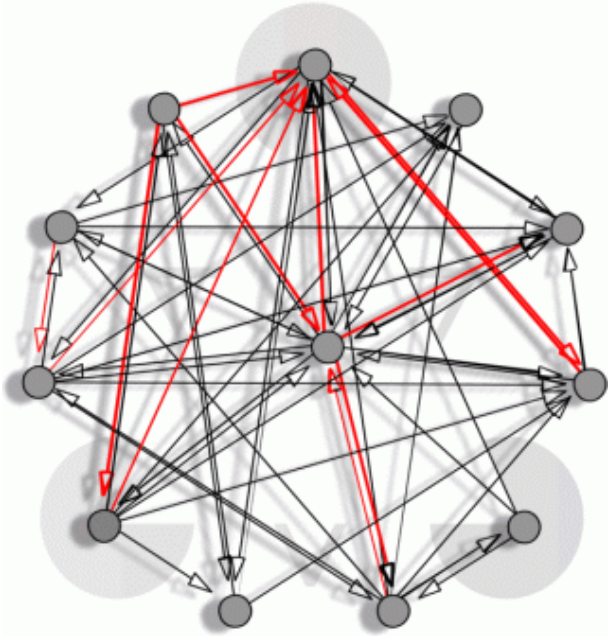
Ultra-high Complexity of Networks & Processes in the Field of Maintenance-, Repair- and Overhaul-Services



- Global organizational structure within the MRO network with many partners and service providers.
- Complex logistic network with many different service providers for bulk & break, storage and transport.
- Complex flows of spares within the whole network during life cycle.
- Sometimes even higher complexity of processes due to hierarchical structure of spare parts.
- Complex structure of worldwide information system which supports the life cycle processes.
- Extremely high requirements for RFID-based MRO information systems (especially the tag).

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MRO in the Aviation Industry as an Example – Requirements concerning the finished Tag

Source: LHT

- Passive tag with reading range of more than 1,5 m on metal surfaces under operation conditions.
- Resistance against chemical substances used during operation, repair and overhaul processes.
- Resistance against mechanical shock, non-flammability (DO 160 requirements) and 20 years life cycle.
- Temperature range between -60° and +150° (due to operation conditions and MRO-processes).
- Small dimensions due to different types of items to be tagged, flexibility if possible (rounded surfaces).
- Standard compatibility (ISO18000-6C, ATA Spec 2000) with high memory capacity (280 Bit up to 64 kBit)

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Results of a comparison between Requirements and existing Products: Technological Gaps and Challenges

Source: LHT

- Actually there is no existing tag product which meets all requirements, but:
  - Resistance against chemical substances and DO 160 requirements are not really a problem.
  - Even temperature range and life cycle are not critical from a technological point of view.
  - Chips with the necessary storage compatibility will be available before end of 2007
- Preconditions for construction of a tag which meets requirements will be given on short term
- Challenge: Small dimensions combined with metal surfaces, long read range (and high storage microchips) are the real problem.

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Tags on Metal surfaces

The Problem:

- At LF and HF (< 13,56 MHz) the inductive coupled antenna system causes eddy currents in the metal surface reducing the coupling factor
- At UHF and Microwave Frequencies the metal surface detunes the antenna

Possible solutions:

- Keeping a certain distance between tag and metal surrounding (Filling the gap with special material can reduce the necessary distance)
- Taking the metal surface into account when designing the antenna (UHF)

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Materials

Figure: LIQUALLOY™ Magnetic sheets (ALPS)

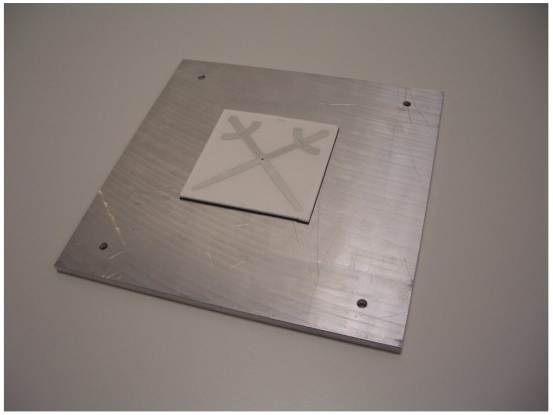

Figure: UHF Tag with Emerson&Cuming absorbing material

- New Materials with nanostructures, which are placed between RFID Tag and the metal surface can improve the tag performance
- Foils for different frequencies are already offered from different manufactures like ALPS and Emerson & Cuming
- The thickness of the foils is between 0,1 mm and 3 mm
- 50-60% of the normal read range of the tag can be reached

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UHF RFID Antenna Design

The Design Goals:

- Smallest size possible with acceptable read range
- High bandwidth from 860-960 MHz for worldwide use

The Solution

- Planar Inverted F-Antenna (PIFA) with a size of 45mmx14mmx3mm
- Foldable design based on semi-flexible PCB
- Also possible to manufactures as molded device

The Results:

- Read range on metal: more than 1 m with a first prototype version

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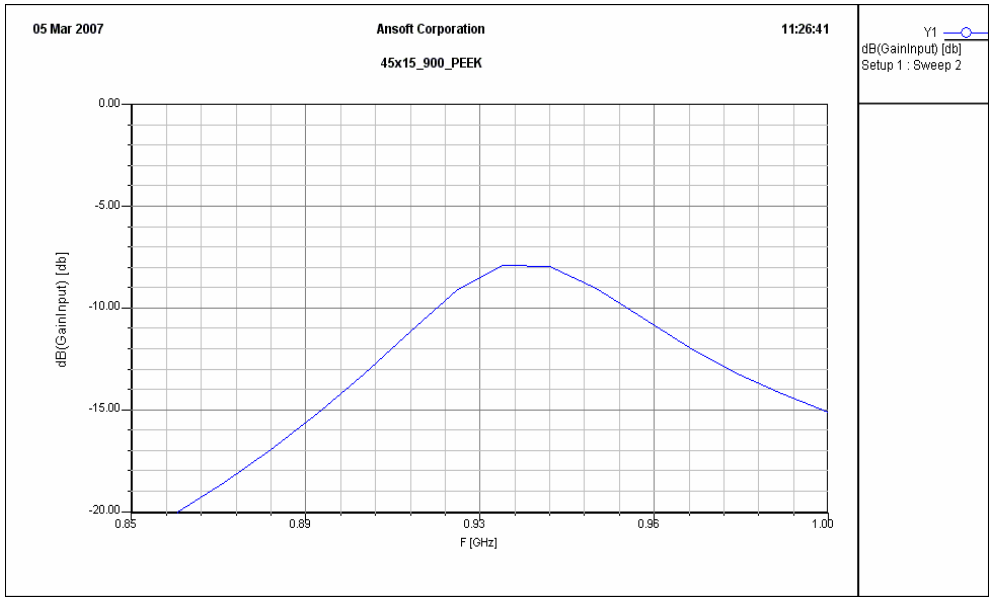
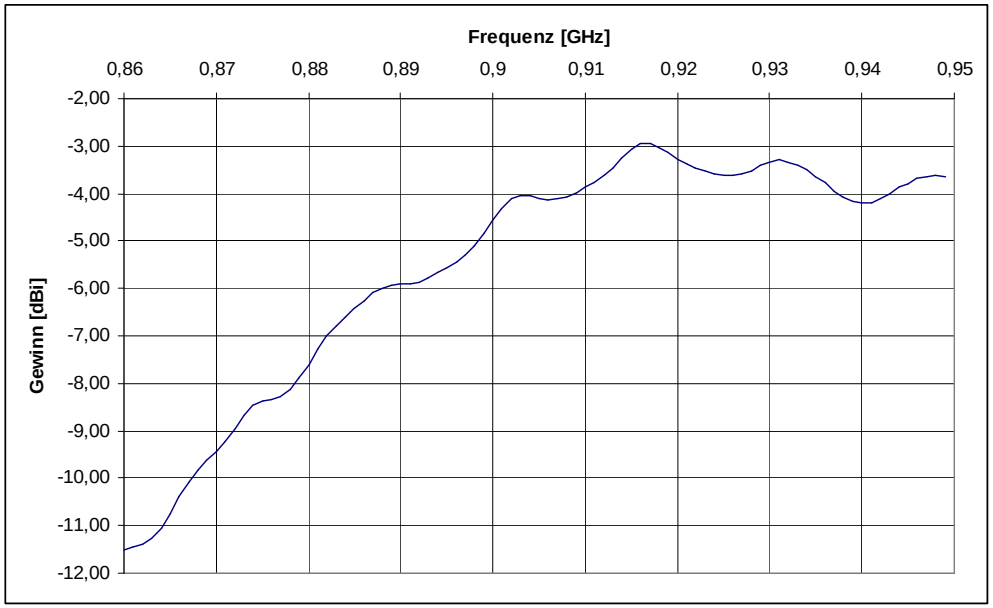
UHF RFID Antenna

Simulated gain vs. Measured gain
simulated gain is slightly lower than measured gain





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Tags Inside Metal

Possible Applications

- Incorperating of the tag into a metal part for counterfeits detection
- Wireless data and energy interface to a sensor/actor system inside the metal part

The challenge

- Penetration of the electromagnetic field through into the metal component
- Necessary mechanical reconstruction should not affect the stability of the component

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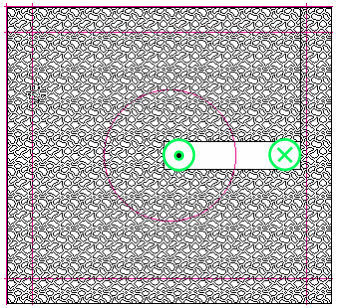
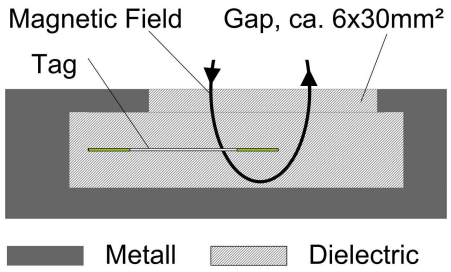
Design Considerations for an inductive coupled solution



$-d/dt \int_A B \, dA = 0$

A: Area of the opening, B: magnetic field



- A nonmetallic path from tag antenna to the surface is necessary, which can be filled with dielectric or permeable material (needs opening in the surface)
- A cavity containing the tag inside the part has to provide sufficient clearance to the surrounding metal
- The magnetic field should enter and leave the object through one opening in the surface

The Design Goal:

- The opening in the surface should be as small as possible to prevent the tag from being taken out
- realize a good coupling factor of the antenna system

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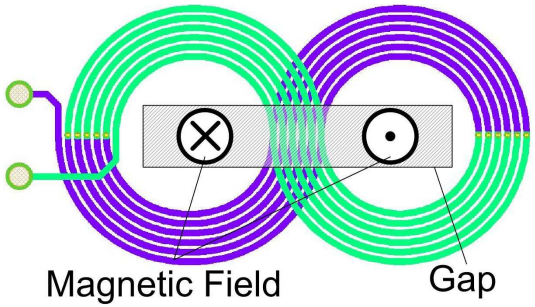
Optimized Antenna design



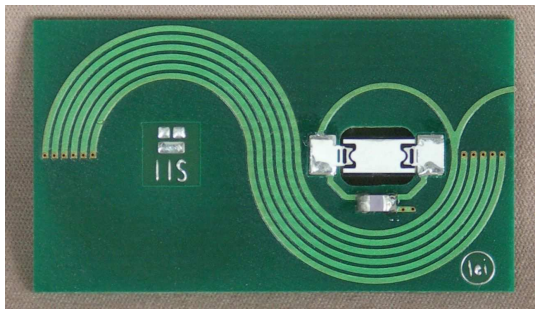


Figure: 8-shaped Tag antenna with a Infineon my-ID Chip

- To increase the efficiency the tag antenna has been optimized leading to an 8-shaped antenna
- With this design the magnetic flux passes the antenna twice in opposite directions
- The design can easily be realised on a two sided printed circuit board
- With this antenna a power transmission of app. 50 mW can be achieved from a 3 Watt Reader

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The INGUSS Project

- This projects aims to integrate electronics with sensors and actors into aluminium die cast components in order to realize intelligent mechanical parts
- Data and energy transfer will be realized via inductive coupled 13,56 MHz RFID interface

Challenges:

- Physical conditions of the die cast process:
  - Pressure of about 1000 bar
  - Temperatures of 750°C for aluminium

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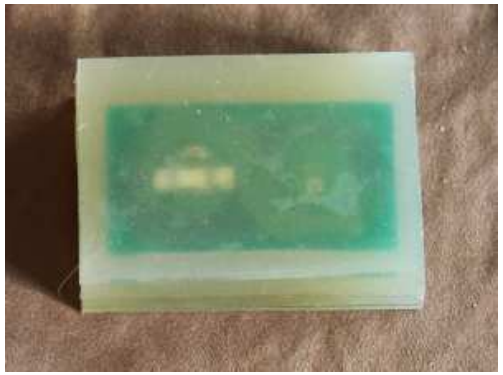
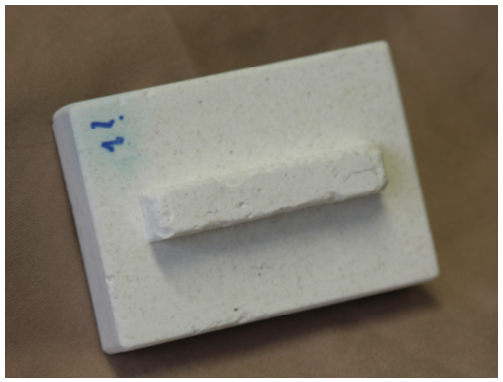
Results from the current „die cast“ Tags





- standard ISO15693 transponder inlays as well as ones with an 8-shaped antenna have been integrated into die cast components so far
- All have been implemented into a special coating for
  - Protection against thermal and mechanical damage
  - Forming a cavity inside metal as a clearance between the tag and the metal surrounding
  - Forming the opening into the metal surface
- Good reading perfomance can be achieved: with a handheld reader the tag can be read out over a distance of a few centimeters

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Summary

- Requirements from a MRO perspective show a strong demand for tags in metallic environment
- Some examples of improving RFID tag performance in an metallic Environment have been given
  - Industry offers new materials for HF and UHF Band to delimit the metal influence
  - Improvements can already be achieved by considering the metal environment when designing the antenna

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