“Fundamentals about RFID in contactless ISO-cards”

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Content

Base Technologies

- Working principle / physics behind
- Applications
- Available antenna & inlay technology
- Common silicon suppliers & silicon types
RFID Technologies in ISO Cards

**Base Technologies**

- **Pure Contactless**
  - Only RF interface
  - Transit
  - Access Control
  - Closed Loop Payment
  - Open Loop Payment
  - eID / eDL

- **Hybrid Technologies**
  - Combination of
    - c'less & dual interface
    - c'less & c'less
    - RF powered components
  - Combination of:
    - Access Control
    - Crowed Tracking
    - Closed loop payment
    - Open loop payment

- **Dual Interface**
  - RF Interface
  - Contact Interface
  - Open Loop Payment
  - Transit
  - Access Control
  - eID

**Predominant Application Fields**
Pure Contactless / Single Transponder Solutions
RF Frequencies in ISO Cards

<table>
<thead>
<tr>
<th>frequency (Hz)</th>
<th>LF</th>
<th>HF</th>
<th>UHF</th>
</tr>
</thead>
<tbody>
<tr>
<td>card operating frequencies</td>
<td>125 KHz</td>
<td>13.56 MHz</td>
<td>860-960 MHz</td>
</tr>
<tr>
<td>commercial market launch</td>
<td>1980</td>
<td>1990</td>
<td>2007</td>
</tr>
<tr>
<td>units per year</td>
<td>200mio.</td>
<td>1000mio.</td>
<td>50mio.</td>
</tr>
</tbody>
</table>

volume trend
125 KHz – Low Frequency (LF)

- basics about LF antennas
  - inductive coupling
  - 200-300 turn copper wire coil

- common application
  - enterprise Access Control
  - …but no WW standard for data transmission
    - (all proprietary solutions)
antenna & PRELAM® technology

- only wire wound antenna / air-coil
- PRELAM® mainly PVC
- Typical PRELAM® thickness 400 micron (allowing 60% / 40% PVC/PET card structure for composite cards) no thinner PRELAM® possible, due to quite thick wire wound antenna)
common IC suppliers

- Atmel *(former Temic)*
  (T5577 – read/write)

- EM Microelectronics
  (EM 4200 – read-only // EM4450 – read/write)

- NXP
  (Hitag-1 / Hitag-2 / Hitag-S)
13.56 MHz – High Frequency (HF)

- basics about HF antennas

  - inductive coupling
  
  4 – 7 turn coil

- common application

  - transit / automatic fare collection (AFC)
  - payment, open & closed loop
  - eGovernment (eID / ePP / eDL…)
  - corporate access control
  - hotel, leisure & entertainment

- world-wide standards:

  - ISO 14443
  - ISO 15693
antenna & PRELAM® technology

- **wire wound antenna / air-coil**
  - high durability (++)
  - limited possibilities for antenna tuning (--) few

- **wire embedded antenna**
  - high durability (CU wire (flexibility) / no bridge) (++)
  - precise antenna tuning via length & pitch (++)
  - high flexibility design / format changes (++)
  - low impact on card surface (++)
  - available on most substrates (PVC / PET-G / PC) (++)
  - Typical PRELAM® thickness (module) 400 micro with migration towards 310 micron
13.56 MHz – High Frequency

- **etched antenna (subtractive technology)**
  - only on PET substrate → adhesion challenges (--)  
  - “bridge” as potential failure cause (--)  
  - antenna tuning on batch level complicate (--)  
  - antenna traces visible in card-print (--)  
  - no module visibility (++)  
  - lead time & set-up cost for customized formats (--)  
  - low cost in high volume (++)  
  - very thin inlay possible (direct die attach) (++)

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“bridge”, required for etched, printed & additive HF antennas
13.56 MHz – High Frequency

- **printed antenna**
  - high flexibility on substrate type (++)
    (even paper possible !)
  - very thin PRELAM® possible (direct die attach) (++)
  - no module visibility (++)
  - high cost due to silver paste (-)
  - antenna tuning on batch level complicate (-)
  - “bridge” as potential failure cause (-)
  - durability of antenna tracks (-)

- **additive antenna (additive / galvanic technology)**
  - high investment & set-up cost (-)
  - high flexibility on substrate type (++)
  - good RF-performance = low production UPH (-)
  - “bridge” as potential failure cause (-)
  - antenna tuning on batch level complicate (-)
  - no module visibility (++)
  - theoretically low cost per unit in (very) high volume (++)
  - very thin PRELAM® possible (direct die attach) (++)
common IC suppliers

- **payment “closed loop”:**
  - Sony (Felica), NXP (Mifare- & SmartMX-Family)
  - Infineon (SLE77- / SLE78-Family)

- **payment “open loop”:**
  - Infineon (SLE77- / SLE78-Family), NXP (SmartMX-Family)
  - Samsung (S3), ST (ST 23,31), Inside (MicroPass)

- **transit / automatic fare collection:**
  - NXP (Mifare- & SmartMX-Family), Sony (Felica), ST (Calypso),
  - Infineon (SLE66- / SLE77- / SLE78- / CIPURSE-Family)

- **access control:**
  - NXP (Mifare-Family), Inside (PicoPass),
  - Legic (prime / advant-family)

- **eID (ISO card):**
  - NXP (SmartMX-Family), Infineon (SLE77- / SLE78-Family)
  - ST (ST23- / ST31-Family)
basics about UHF antennas

common application
- government ID
- toll collection
- parking
- access in leisure & entertainment
- crowd control
- future: secure access??

but no WW harmonized frequency:
- USA: 915 MHz (4W EIRP)
- EU: 869 MHz (0,5W / 2W ERP)
- Japan: 950-962 MHz
868–960 MHz – Ultra High Frequency (UHF)

- antenna & inlay technology
  - etched Al antenna - “solid” PET inlay
    - low cost (++)
    - only on PET substrate (- -)
    - lamination challenges due to PET substrate (- -)
    - logistics / lead times for customized formats (- -)
    - antenna traces in print (- -)
  - etched Al antenna - PET inlets
    - low cost (++)
    - fair lamination properties with small antennas (++)
    - easier logistics compared to “solid” PET inlay (++)
    - antenna traces in print (- -)
  - printed antenna
    - flexible on substrates (PVC, PC, PET-G)
      → mono-block structure (++)
    - high cost due to silver paste (- -)
    - no antenna traces in print (++)
### 868–960 MHz – Ultra High Frequency

- **additive antenna**
  - High set-up cost (---)
  - Different substrates (++)
  - Logistics / lead times for customized formats (---)
  - In high volume competitive to etched antennas (++)
  - Antenna traces in print (---)

- **wire embedded antenna**
  - Relatively high cost (---)
  - Antenna-design limitation (---)
  - Different substrates (PVC, PC, Teslin, PET-G) (++)
  - No traces in print (++)
  - Short lead times for customized formats (++)
common IC suppliers

- Impinj (Monza family)
- NXP (UCODE family; new: UCODE DNA → secure UHF!)
- Alien (Higgs family)
Dual Interface Technology *(13.56 MHz only!)*
High volume process
Available via most major vendors
No supply chain restrictions
Good electrical performance

Electrical interconnection
- Conductive tape (ACF)
- Conductive paste
- Conductive polymer

Aging of interconnection & potential loss of RF interface
Challenging process control
Electrical / mechanical connection
  - TC bonding
  - Soldering

Low cost on equipment side
- Very good RF performance
- High electrical reliability
- High quality optical card appearance

Challenging implementation into card manufacturing process
- Requires good yield control on card manufacturing side
AUTOMATED SOLDERING PROCESS

- Electrical / mechanical connection
  - Laser soldering
  - Hot soldering
- High electrical reliability
- Very good RF performance
- High investment for equipment
- Relatively slow process
INDUCTIVE COUPLING TECHNOLOGY (CoM)

- Inductive coupling

- Low cost on equipment side
- Easy to implement by every card manufacturer
- High electrical reliability
- Cost & time savings in approval process (TA/LOA)
- High throughput & easy scalable

- Reduced RF performance
- Card durability (delamination) *
- Restricted art work / card design *
- Restricted supply chain (IP & business models)

* Depending on inlay / antenna technology

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COMMON ICs FOR DUAL INTERFACE APPLICATIONS

- **Infineon:**
  SLE77 / SLE78-Family (Solid Flash)

- **NPX:**
  SmartMX P5- / P60-Family (EEPROM; Flash-version coming)

- **STM:**
  ST21- / ST31-Family (EEPROM; Flash version coming)

- **SAMSUNG:**
  S3CT9KW (EEPROM)

- **Inside Secure:**
  Micropass 6323/6303 (EEPROM)
Hybrid Technologies (multiple ICs)
Migration of legacy access control systems from LF to HF

Common inlay technologies:
- HF wire embedding / LF coil-winding
- HF coil winding / LF coil winding
- HF wire embedding / HF wire embedding
High end access control – logical & physical (migration) (i.e. FIPS 201 CACC)

Common inlay technologies:
- HF wire-embedding / LF “air-coil”
- combination of 2 technologies in 1 Card
  (e.g. employee ID card for access payment, etc.)

- even combinations on one antenna possible!
  further technologies (contact module embedding / 4-line embossing) possible!
- Future market for hotel, leisure & entertainment
  (i.e. tracking & payment; tracking & access; gated-access & building access)

- Common inlay technologies:
  - HF wire embedding / UHF printed or etched
  - HF “air-coil” / UHF printed or etched

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HF / UHF “combo-card”
*(today)*

HF / UHF dual-frequency IC (e.g. EM4423)
*(tomorrow)*
Powered Components
13.56 MHz (HF) & 13.56 MHz powered components

Dual-Interface with Dynamic-CVV

Dual-Interface with RF-powered LED
Thank you very much!

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