RFID standards
ISO14443, ISO15693 and EPCGlobal

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General overview

There are a multitude of standards for contactless ICs:

- ISO14443 for proximity contactless cards
- ISO15693 for vicinity contactless cards
- ISO18000 set of standards for RFIDs
- EPCglobal Class 1 Gen 2 (=18000-6C)
Common terms & definitions

- **PCD**: Proximity Coupling Device (≈ reader)
- **PICC**: Proximity IC Card (≈ tag)
- Similarly **VCD** and **VICC** for Vicinity reader/tag
- **Interrogator**: stands for “reader” in EPCglobal standard
- **UID**: Unique ID
- **Carrier**: Base signal (e.g. 13.56Mhz). Reader modifies this signal to send data.
- **Subcarrier**: Signal on top of the base signal. Tag generates this signal to send data.
General background

- Anticollision is needed due to TDMA. Note: FDMA and SDMA are too expensive
- The reader *always* starts all data transfer. So if tag wants to send something, it needs to be queried first. E.g.: “Do you have something to send?” - “Yes, here you go”
- Anticollision is to select one tag. All further commands will be executed by this one tag
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General background

- Proximity card $\rightarrow \approx 10\text{cm max range}$
- Usually uses the 7810 ID-1 card form factor (i.e. credit card)
- Quite a lot of power on card
- Used in transportation systems, building access, Visa paypass
- Sometimes integrates the 7816-* (i.e. smart card) standards
Radio interface - Type A

PCD→PICC:
- Carrier: 13.56Mhz
- Modulation ASK 100%
- Coding: Modified Miller
- Bandwidth: 106kbit/s → 847kbit/s

PICC→PCD:
- Load modulation
- Subcarrier: $f_c/16 \rightarrow f_c/128$
- Coding: OOK, Manchester
- Bandwidth: 106kbit/s → 847kbit/s
Radio interface - Type B

PCD→PICC:
- Carrier: 13.56Mhz
- Modulation: ASK 10%
- Coding: NRZ
- Bandwidth: 106kbit/s → 847kbit/s

PICC→PCD:
- Load modulation
- Subcarrier: $f_c/16 \rightarrow f_c/128$
- Coding: BPSK, NRZ-L
- Bandwidth: 106kbit/s → 847kbit/s
Anticollision - Type A

1. Reader issues SELECT command with 0 known bits
2. All tags respond with their UID
3. Tags clash at bit position $C$
4. Reader decides to explore $C + 1 = 0$ or $C + 1 = 1$
5. Reader issues SELECT command with $C + 1$ bits
6. Goto 3
7. If no clash: Issue SELECT with full UID of tag
Anticollision - Type B

1. Reader issues REQB with $S$ slots
2. All tags pick a slot randomly
3. Reader issues SLOT-MARKER commands to mark the slots
4. Tag sends ATQB with PUPI inside
5. Reader sends ATTRIB (to select it) or HLTB (to halt it)
6. If tags clashed, reader starts again with more slots
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General background

- Vicinity card → ≈ 1-1.5m max range
- Usually uses the 7810 ID-1 card form factor (i.e. credit card)
- Has much less power so less powerful CPU
- Usually only has some RAM and memory manipulation commands
Radio interface

VCD→VICC:
- Carrier: 13.56Mhz
- Modulation: ASK 10% or 100% (VICC knows both)
- Coding: PPM, “1 out of 4” or “1 out of 256”
- Bandwidth: 26.48 kbits/s or 1.65kbit/s

VICC→VCD:
- Subcarrier: Single: $f_c/32$
  - Single: $f_c/32$
  - Dual: $f_c/28, f_c/32$
- Coding:
  - One subcarrier: $(\text{subcarr})(\text{unmodulated time})=0$, reverse=1
  - Two subcarrier: $(\text{subcarr1})(\text{subcarr2})=0$, reverse=1
- Bandwidth:
  - Low: $\approx 6.6kbit/s$
  - High: $\approx 26kbit/s$
Anticollision

1. Reader issues inventory request with $S$ slots
2. Tag sends its inventory response with UID
3. Reader issues EOF to signal next slot

Two different modes after anticollision:
- **Addressed**: 1) Select 2) Issue commands
- **Non-addressed**: Each command must be individually addressed (i.e. contain the UID)
ISO 15693 physical layer

VICC→VCD:
- **Subcarrier:**
  - Single: \( f_c/32 \)
  - Dual: \( f_c/28, f_c/32 \)
- **Coding:**
  - One subcarrier: (subcarr)(unmodulated time)=0, reverse=1
  - Two subcarrier: (subcarr1)(subcarr2)=0, reverse=1
- **Bandwidth:**
  - Low: \( \approx 6.6\text{kbit/s} \)
  - High: \( \approx 26\text{kbit/s} \)
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General background

- Most recent standard, to be on all goods
- Works up to a couple of meters
- Very sophisticated inventorying, session management, outlier singulation, etc.
- Multiple physical standards supported (probably to get around IP)
EPC physical layer

Interrogator→tag:
- Carrier: 860-960Mhz (depending on local regulations)
- EU: 865.5-867.6Mhz, US: 902-928Mhz, divided into channels (200kHz, 500kHz) – yes, FDMA is possible!
- Modulation: ASK (DSB-ASK, SSB-ASK, PR-ASK – tag understands all)
- Encoding: PIE
- Bandwidth: 26.7-128kbit/s

Tag→interrogator:
- Modulation: ASK or PSK (– reader understands all)
- Encoding: reader decides
  - FM0 baseband (40-640kbit/s)
  - Miller of a subcarrier (5-320kbit/s)
  - Data rate depends on Divide Ratio and TRcal, selected by reader QUERY command
EPC Anticollision

1. Reader first SELECTs who will take part in inventorying: session management, mask/truncate EPC, etc.
2. Reader issues QUERY to do slotted ALOHA:
   - On picture: tag selected slot 0
   - RN16 = random number
Thank you for your time!

Any questions?