fondirigenti

SVILUPPO RISORSE PER L'AZIENDA
CISITA
PARMA

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DIGITAL INNOVATION HUB

L'RFID come sistema per l'identificazione nei processi produttivi e logistici

Ing. Andrea VOLPI

- Principi RFID
- RFID Lab: visita, illustrazione esperienze ed esercitazione

RFid LAB
UNIVERSITÀ DEGLI STUDI DI PARMA

Function of RFID

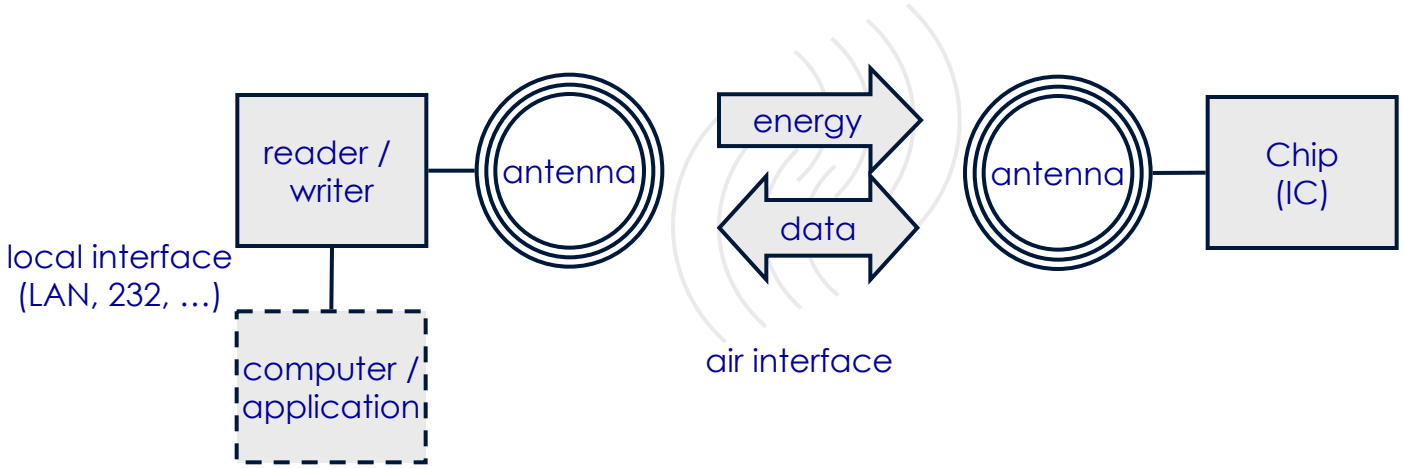
Identification systems in production and logistics

Industrial Engineering Department
University of Parma - Italy

Elements of a RFID system

A RFID system is composed of 2 elements:

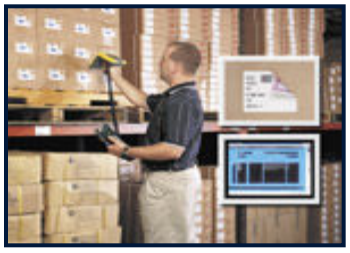
1. the **transponder (tag)** which consists of a coupling element (antenna) to the reader and a microchip (IC) with read/write non-volatile memory (EEPROM)
   - attached or integrated on the object that has to be identified
2. the **reader** which contains of a RF-module, a controlling unit and a coupling element (antenna) to the transponder
   - read/write functions are available



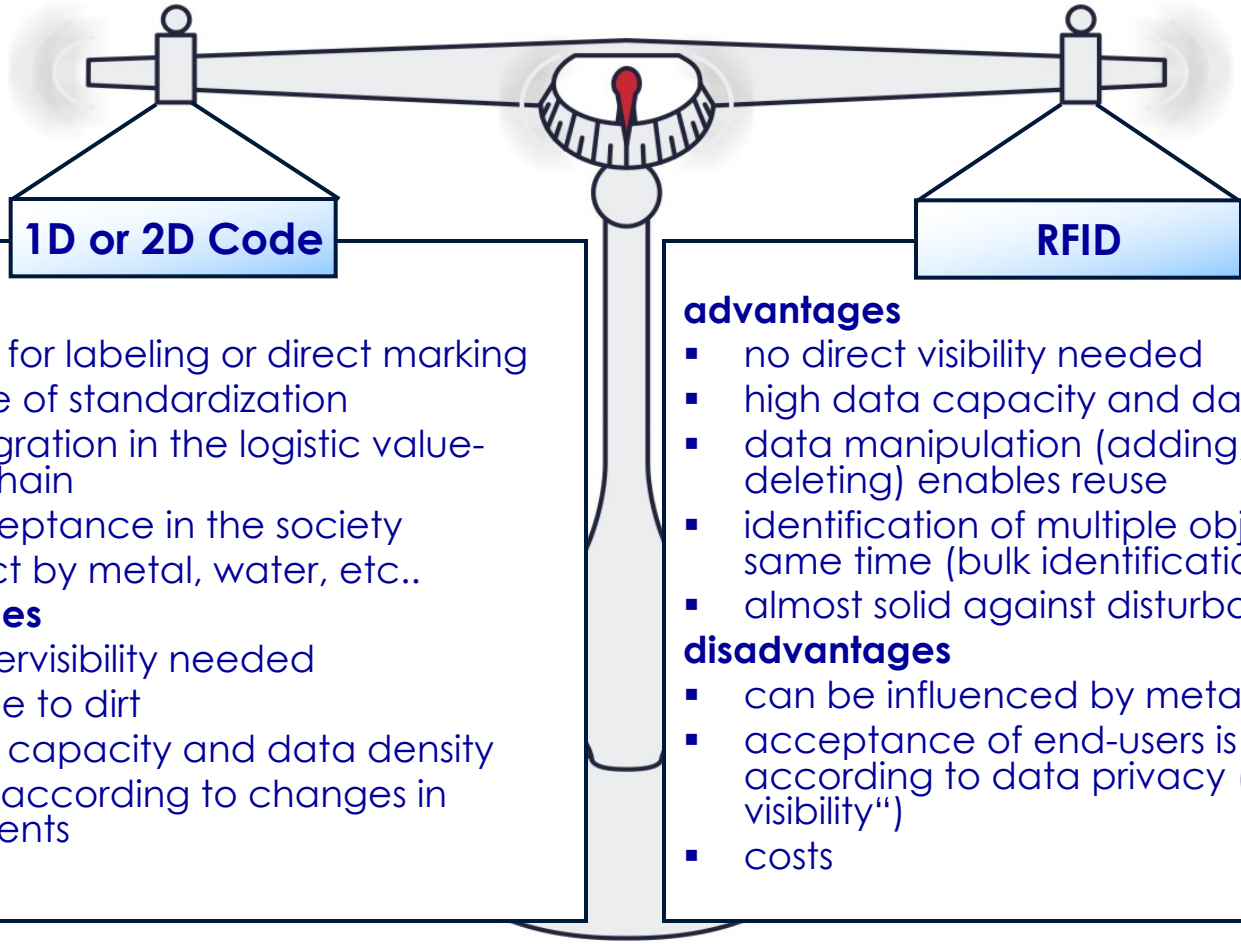
Principle of RFID

RFID offers an easy, flexible and reliable identification, tracing and controlling of objects and persons with the help of information technology.

1. tagging	2. reading/writing	3. IT system
Objects and persons that have to be identified are attached with a tag.	The reader collects information of the tag. With the use of a writing unit new information can be stored in the memory of the tag.	The reader is able to use collected information autonomous or to give it to an IT system.



Radio frequency and optical identification



1D or 2D Code

advantages
- low costs for labeling or direct marking
- high state of standardization
- high integration in the logistic value-added chain
- high acceptance in the society
- no impact by metal, water, etc..

disadvantages
- direct intervisibility needed
- vulnerable to dirt
- low data capacity and data density
- inflexible according to changes in requirements

RFID

advantages
- no direct visibility needed
- high data capacity and data density
- data manipulation (adding, changing, deleting) enables reuse
- identification of multiple objects at the same time (bulk identification)
- almost solid against disturbance

disadvantages
- can be influenced by metal and water
- acceptance of end-users is doubtful according to data privacy ("customer visibility“)
- costs

Frequency ranges

frequency range		wave length range		international naming
from	to	from	to	
0 Hz	30 Hz	∞	10.000 km	Sub ELF
30 Hz	300 Hz	10.000 km	1.000 km	ELF (Extremely Low Frequency)
300 Hz	3 kHz	1.000 km	100 km	VF (Voice Frequency)
3 kHz	30 kHz	100 km	10 km	VLF (Very Low Frequency)
30 kHz	300 kHz	10 km	1 km	**LF (Low Frequency)**
300 kHz	3 MHz	1 km	100 m	MF (Medium Frequency)
3 MHz	30 MHz	100 m	10 m	**HF (High Frequency)**
30 MHz	300 MHz	10 m	1 m	VHF (Very High Frequency)
300 MHz	3 GHz	1 m	0,1 m	**UHF (Ultra High Frequency)**
3 GHz	30 GHz	10 cm	1 cm	SHF (Super High Frequency)
30 GHz	300 GHz	10 mm	1 mm	EHF (Extremely High Frequency)

LF (125kHz; 134kHz)

advantages

- high interference resistance
- insensitivity to metal environments
- reading ranges to approx. 0,2 m

disadvantages

- limited area of application
- often proprietary
- relatively slow data transfers

application area

- identification of animals
- immobilizer system
- industrial applications

designs

- wrapped inductor
- glass transponder
- capsuled transponder

HF (13,56 MHz)

advantages

- Frequency range standardized world-wide
- different tags, smart label etc. available
- transceiver and antennas in different forms and designs available
- bulk reading possible
- middle data transfer rates

disadvantages

- small reading ranges
- sensitive to metal environments
- Higher costs

application area

- item management (e.g. Pfizer)
- production logistics and controlling
- mass applications

designs

- flexible substrates (Inlays)
- laminates of foil and paper (Smart label)
- cards (Smart Cards) and tickets

13,56 MHz Chips, examples

manufacturer	Chip Type	UID	R/W Memory	ISO Stand.
EM	H4006 P4022	64bit 64bit		
Infineon	my-d 2P/S my-d 10P/S Mifare	64bit 64bit 32bit	2kbit 10kbit 1kbyte	15693 15693 14443 A
Philips	I Code 1 I Code SLI Mifare	64bit 64bit 32bit	352bit 896bit 6016bit	 15693 14443 A
STM	LRI 512 SR 176	64bit 64bit	512bit 176bit	15693 14443 B
TI	Tag It Tag IT ISO	64bit 64bit	256bit 2048bit	15693

UHF passive

advantages

- good reading ranges
- middle bulk reading capability
- high data transfer rates
- great range of products

disadvantages

- different frequency ranges
- susceptible to interference
- sensitive to water and metal

application area

- pallets / container
- vehicle container
- production controlling
- item management (near field)

designs

- capsuled transponder
- laminates of foil and paper (Smart Label)

UHF active

advantages

- very good reading ranges (to 100m)
- high data transfer rates

disadvantages

- Few manufacturers
- Limited life time (approx. 5 years)
- High transponder costs
- Reduced temperature ranges

application area

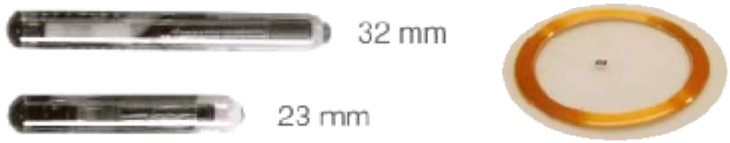
- for closed loops
- access control (also passenger car)
- vehicle identification (VOLKSWAGEN)
- As a data logger in combination with temperature sensors

designs

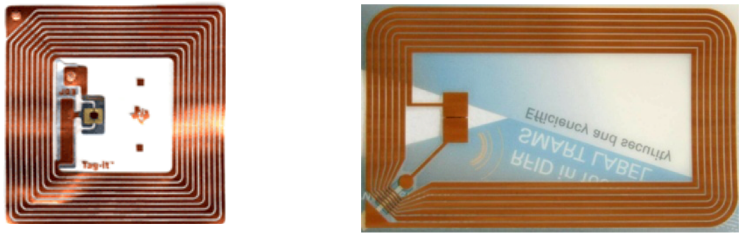
- capsuled transponder
- cards / badges

Overview about tag designs

LF



HF

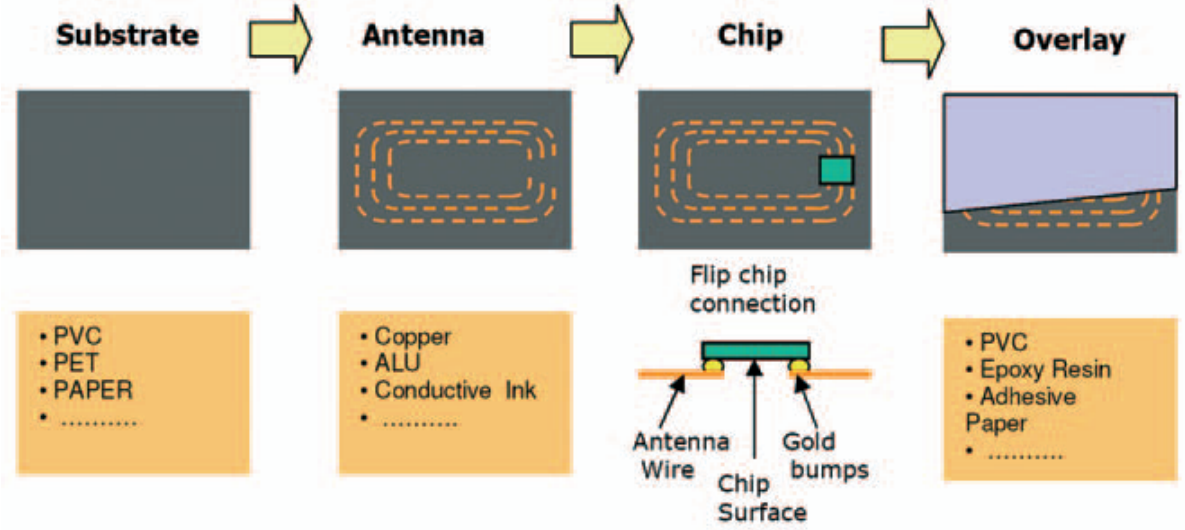


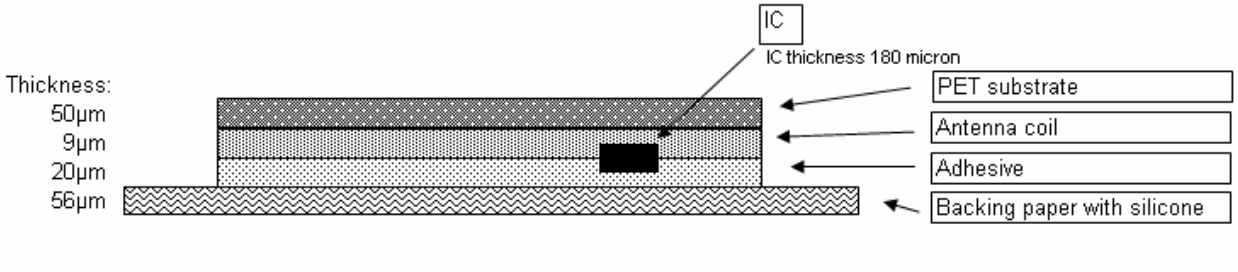
UHF

passiv | aktiv

microwave

Overview about tag designs





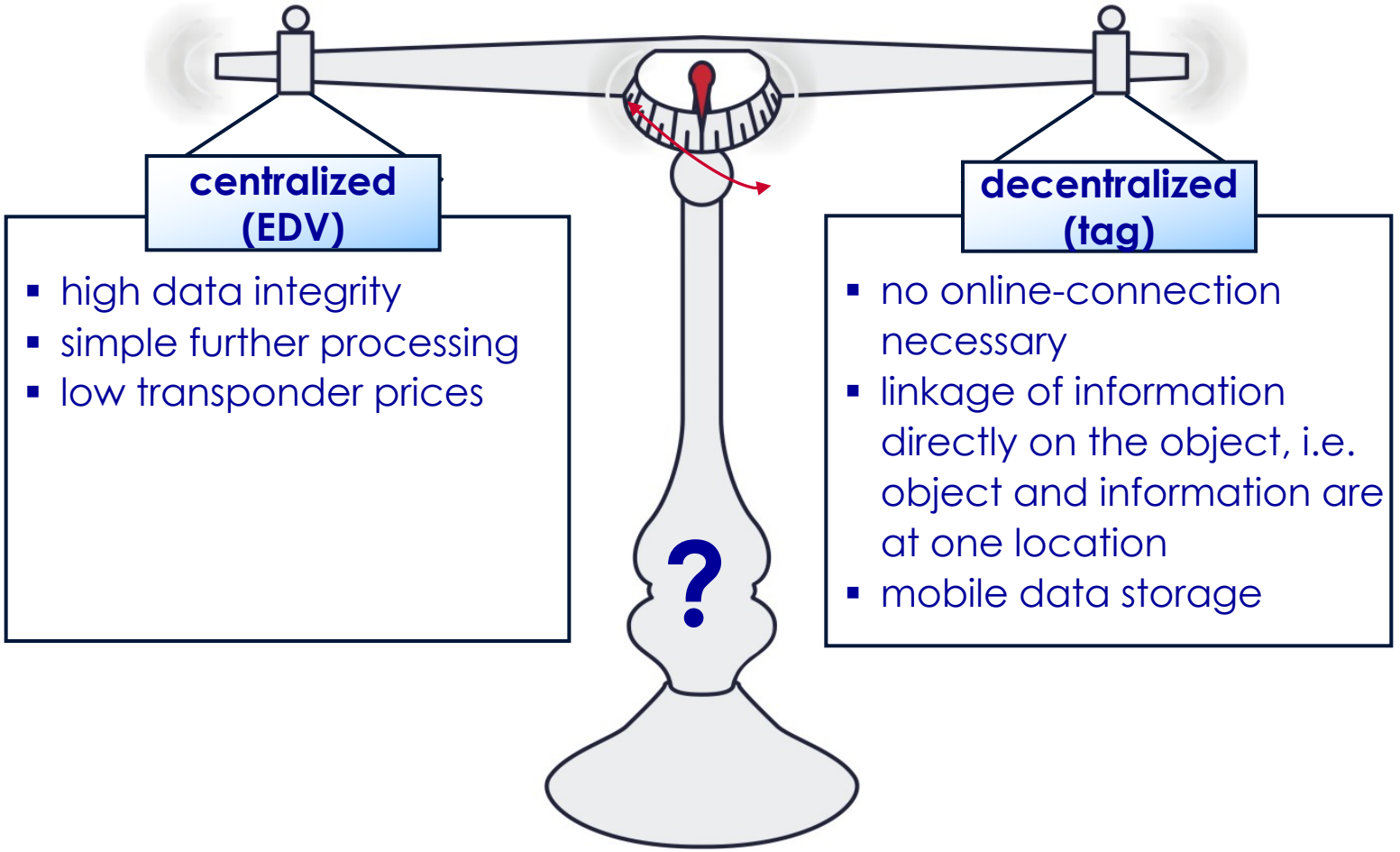
Frequency band summary

	LF	HF	UHF media	UHF alta
Bande di frequenza	125 KHz & 134,2 KHz	13,56 MHz	865,6÷867,6; 868-869 MHz in EU 902÷928 MHz in USA 950 MHz in Japan	2.400÷2.483 MHz in EU 2.400÷2.500 MHz in USA
Standard ISO	18000-2	18000-3 mode 1/2 15693 14443 (typeA/B)	18000-6 type A/B/C	18000-4 mode 1/2
Standard EPCglobal	—	13,56 class 1	Class 0 Class 1 Class 1 Gen2	—
Accoppiamento	Induttivo (magnetico)	Induttivo (magnetico)	Elettromagnetico	Elettromagnetico
Alimentazione del TAG	Passivi Qualche TAG attivo	Nella stragrande maggioranza passivi	Passivi & attivi	Passivi & attivi
Distanza operativa	Tipica <0,5m Per TAG passivi si va dal 'contatto' fino a 70/80cm, dipendendo dalla potenza emessa dal lettore e dalla forma e dimensioni delle antenne. Nei sistemi con TAG attivi si possono raggiungere facilmente i 2m.	Tipica ≈1m Operatività fino a 1,2m in scrittura e 1,5m in lettura. La distanza operativa dipende dalla potenza emessa dal lettore e dalla forma delle antenne specialmente quella del tag: a superficie più grande corrisponde raggio d'azione più ampio	Tipica 2÷5 m, lettura TAG passivi in logistica. Distanza operativa influenzata dalle norme nazionali sulla potenza emessa: **In USA:** ≈4÷5m per Reader non regolamentati; ≈10m per apparati con licenza **In Europa:** ≈33cm per apparati limitati a 25 mW ≈1m per apparati limitati a 0,5 W ≈2m per apparati limitati a 2 W ≈ 100m se attivi	Tipica 1÷2 m Da 2 a 5m per tag passivi possono superare i 30-50m se attivi.
Capacità di Lettura/Scrittura	Disponibili TAG sia R/O che R/W	Disponibili sia del tipo R/O che R/W.	Generalmente R/W; disponibili R/O.	Disponibili sia R/O che R/W.
Capacità di Trasporto Dati	Da dispositivi R/O a bassa capacità (64bit) a dispositivi R/W con capacità fino a 2kbit	Generalmente di tipo R/W offrono capacità di memoria da 64 bit a decine di kbit. Spesso contengono 64 bit di codice unico identificativo scritto in produzione e quindi R/O.	Generalmente di tipo R/W offrono capacità di memoria che può variare da 64 bit fino ad alcuni kbit. Spesso contengono 64 bit di codice unico identificativo (UID) programmato durante la produzione e quindi R/O.	Sia passivi che attivi offrono capacità di memoria da 128 bit ad alcuni kbit (attivi).
Velocità trasferimento dati	Bassa velocità di trasferimento tipicamente da 0,2 a 1kbit/s.	Tipicamente nell'intorno di 25kbit/s.	Tipicamente nell'intorno di 28kbit/s ma esistono dispositivi quotati per 100kbit/s.	Tipici tra 100 e 250 kbit/s; max 1 Mbit/s. Dipendente dal dispositivo.

Frequency band summary

	LF	HF	UHF media	UHF alta
Letture Multiple	Disponibili sia per lettura singola che con meccanismi di anti-collisione.	Meccanismi anti-collisione per la lettura di circa 20/30 tag/s max; dipendendo dalle caratteristiche del sistema e dagli algoritmi impiegati.	Meccanismi anti-collisione per lettura di ~100 tag/s dipendendo da sistema ed algoritmi Per EPC Class1/Gen2, letture di 600 tag/s in EU e 1500 in USA.	Disponibili dispositivi per letture singole o multiple. 0,05 s per leggere alcune decine di TAG da 128 bit.
Formati	Disponibili in package e formati diversi: tipicamente incapsulati in vetro e/o ceramica per la tracciabilità animale (inserimento nello stomaco dei bovini) e in package plastici per usi industriali.	Vasta scelta, consente di coprire un gran numero di applicazioni. Il formato più diffuso è la cosiddetta "etichetta intelligente" che vede chip ed antenna integrate in una etichetta stampabile.	Vari formati per le diverse esigenze ambientali compresa l'applicabilità a unità metalliche. Uno dei formati più apprezzabili è la cosiddetta "etichetta intelligente" che vede chip ed antenna integrate in quella che appare una banale etichetta stampata.	Vari formati per le diverse esigenze ambientali compresa l'applicabilità a unità metalliche.
Costi	Dipendono in grande misura dal formato e dal tipo di applicazione che devono sostenere.	Meno costosi dei TAG LF Dipendono dal supporto fisico del TAG. Il costo minore è quello delle 'etichette intelligenti'; 40/60 €cent. legato anche alle quantità richieste.	Meno costosi dei TAG HF. Il costo minore è quello delle 'etichette intelligenti'; 20/40 €cent legato anche alle quantità richieste.	Essendo ancora un mercato di nicchia, quindi con volumi limitati, i costi sono tipicamente maggiori dell'HF ed UHF media.
Applicazioni	Identificazione animali, controllo accessi, identificazione veicoli immobilizer per auto, container, ecc.	Logistica (singoli oggetti) smart card biglietti smistamento bagagli	Logistica della filiera di fornitura (pallet) Logistica (singoli oggetti) Controllo bagagli	Logistica (asset tracking) Tool collection
Influenze ambientali	Propagazione agevole attraverso liquidi e tessuti organici. Sensibilità ad orientamento antenne	Praticamente Insensibili alla presenza di liquidi non conduttori e a tessuti organici.	Le prestazioni sono ridotte in presenza di metalli, liquidi, tessuti organici ed umidità.	Più sensibili dell'UHF media a metalli o liquidi
Caratteristiche generali	Antenne di grandi dimensioni costosi	Ottimi per applicazioni a distanza non grande e con limitato numero di TAG	Adatti per lunghe distanze o gruppi numerosi di TAG	Simili all'UHF media ma più rapidi in lettura
NOTE	Grande quantità prodotte a causa della tecnologia matura Tendono ad essere soppiantati dai TAG a frequenza maggiore	Attualmente i più disponibili ed i più diffusi perché di uso universale	Differenti frequenze e potenze nelle differenti regioni	Lavorano su banda molto affollata, convivendo con: ≡WiFI 802.11 B/G ≡Bluetooth ≡ZigBee

Centralized vs. decentralized data storage



Influencing the reading range (1)

factors for influencing

transponder

- energy supply (passive by transceiver, active by battery)
- orientation to the reader antenna
- material on which the transponder is attached
- sensibility of the RFID chip
- efficiency of the transponder antenna

inside the reading field

- speed of the transponder (time inside the reading field)
- attendance of other transponders
- material between transceiver and transponder

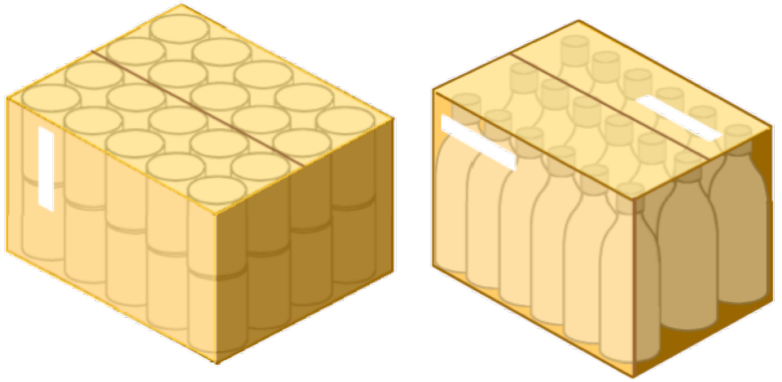
- features of the antenna

noise and interferences

- radio communication
  - WLAN, mobile phone, …
- electric devices
  - electrical engines
  - aerator
  - neon light
- other transceivers / antennas

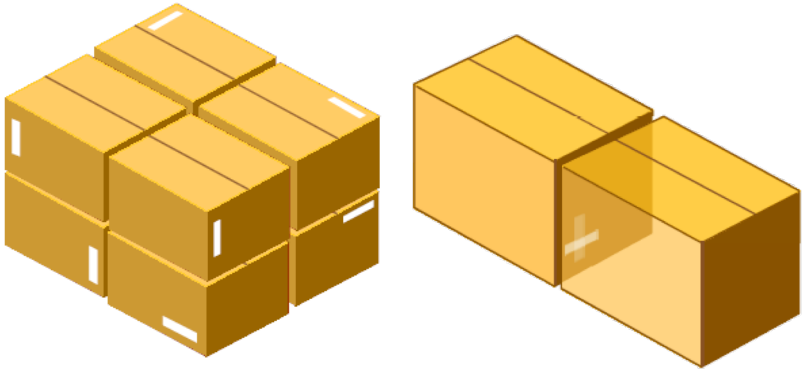
Recommendation for placing and arranging

placing of smart labels / inlays



- Smart labels should be attached on positions where you can find a sufficient distance to the content of a packaging.

arrangement of cases on a pallet

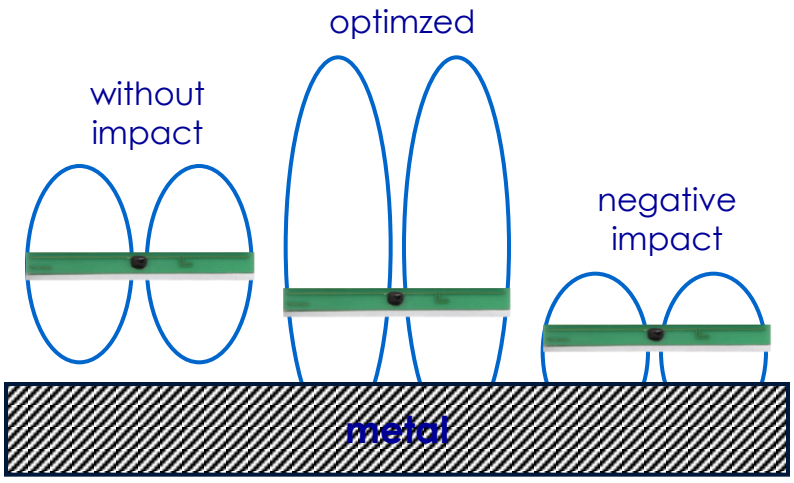


- if possible, label should point to the outside
- two label should never touch each other

Influence on the reading range by different materials

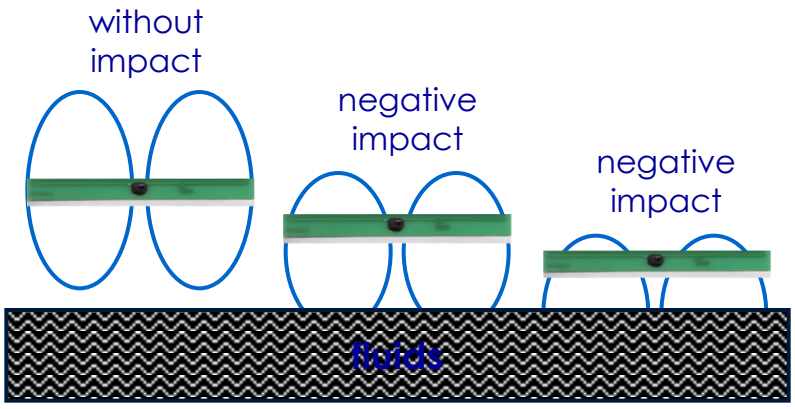
impact of metal (UHF)

- an optimal adaption to metal could lead to a higher reading range



impact of fluids (UHF)

- fluids like water have a negative impact on reading ranges



Influence on the reading range by different materials

Materiali	Effetti sui segnali RF
Cartone	– Assorbimento (umidità) – Desintonizzazione (dielettrico)
Liquidi conduttori (shampoo)	– Assorbimento – Un (sottile) strato di acqua salata (1 mm o più) blocca l'emissione del TAG
Plastica	– Desintonizzazione (dielettrico)
Metalli	– Riflessione
Gruppi di lattine	– Effetti complessi (lenti, filtri) – Riflessione
Corpi di esseri umani o animali	– Assorbimento – Desintonizzazione (dielettrico) – Riflessione
Foglio di alluminio per cucina (27 μm o più)	– Blocco dell'emissione del TAG

Reading rate

influences

- The dimension of the reading field (readings per crossing)
- the amount of data to be transmitted
- number of the transponder in the field
- the data transmission rate
- definition of filters

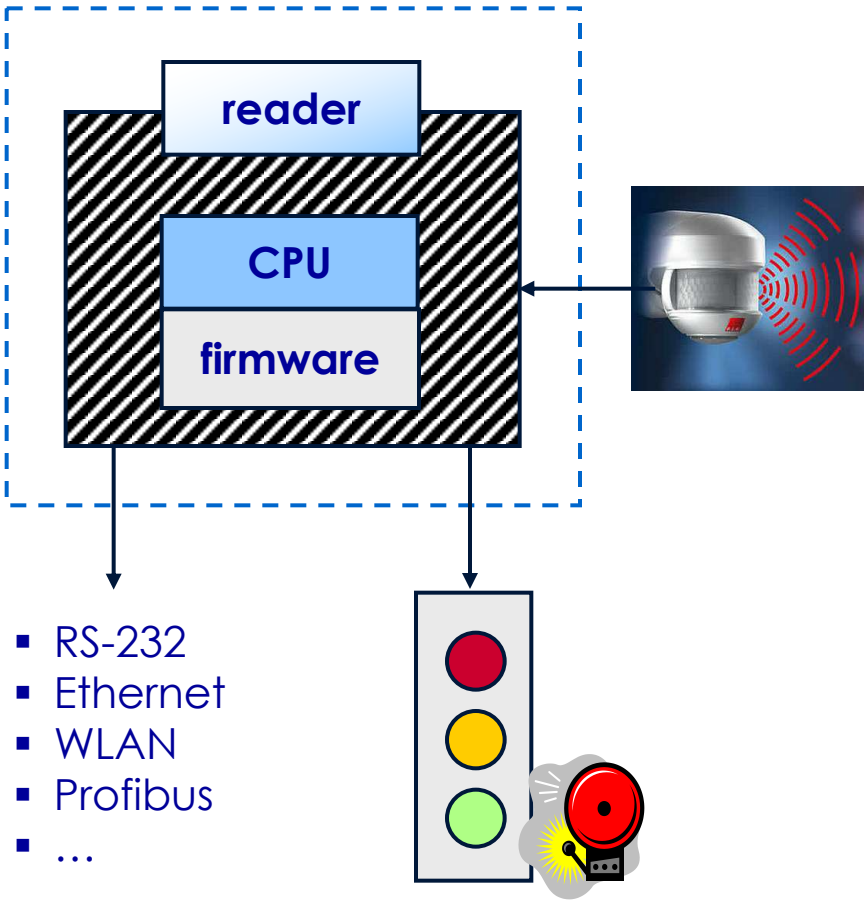
reading errors

- transponder is not read
- wrong data is read or data is read wrong
- reading of transponders that in fact are not existent or undesired (Ghost Reads)

to do

- selection of the right RFID frequency
- adjustment of the transmission power
- selection of the right antenna, antenna position and antenna orientation
- grounding of the system
- controlling (measurement) of the radiated power
- determination of the best transponder position (attachment, orientation)
- setting filters
- building up multiple transceiver / gates
- using absorber

Design of a reader



- RS-232
- Ethernet
- WLAN
- Profibus
- …

hardware

- RF-part
- CPU / memory
- Input / Output
  - signal light
  - motion sensor
- communication interfaces

firmware

- coding / decoding
- filter

Different identification systems

great reading range
HF/UHF Long Range

source: Samsys

source: Deister

middle reading range
HF Mid-Range

source: Deister, Feig

short reading range
Short Range

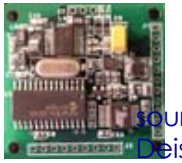
- mobile devices

source: Feig

- mobile data identifica

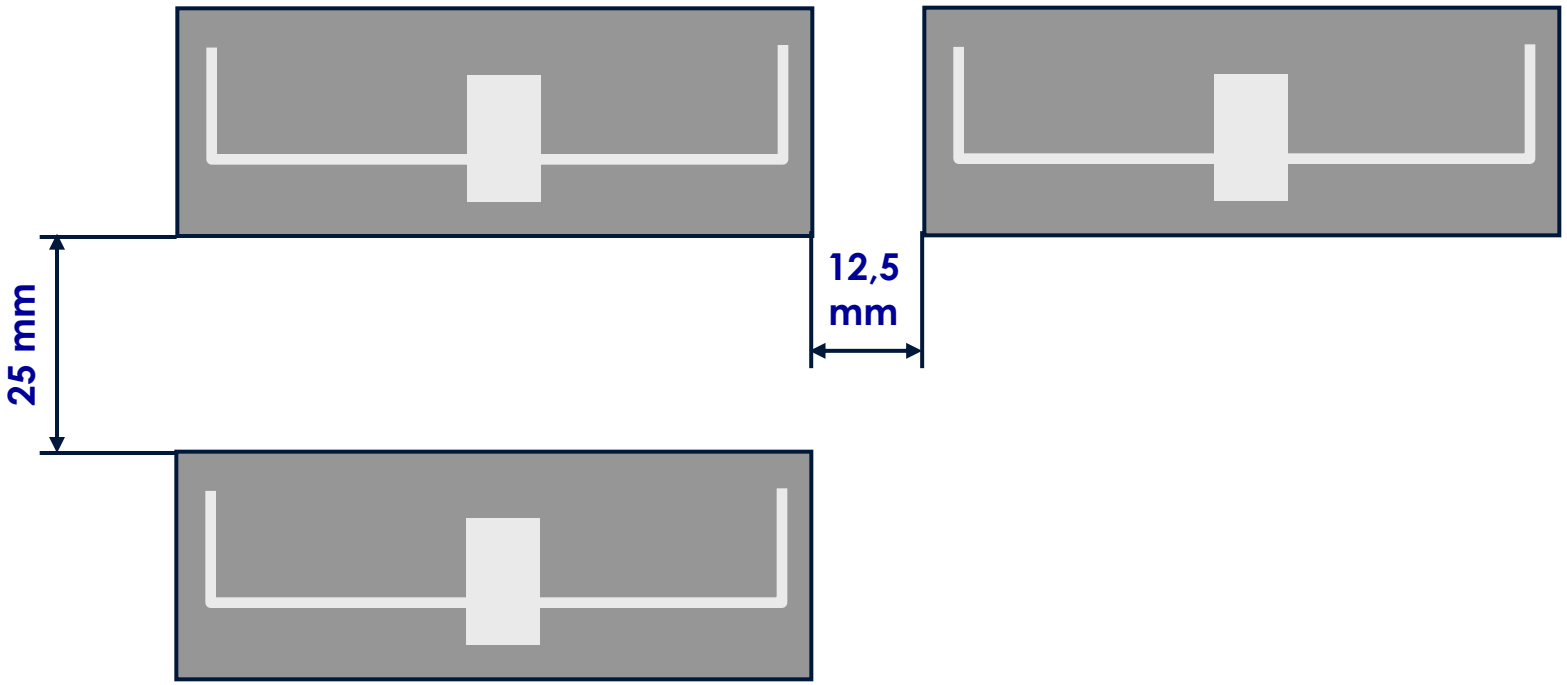
source: NordicID

- modules

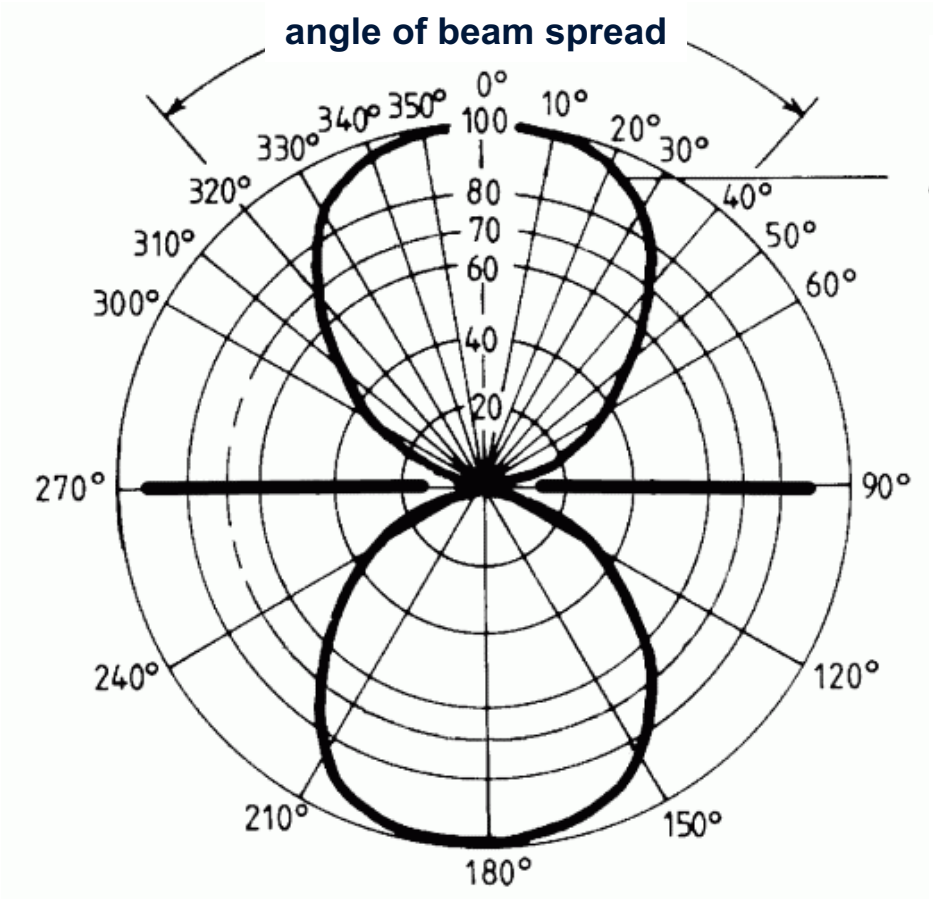


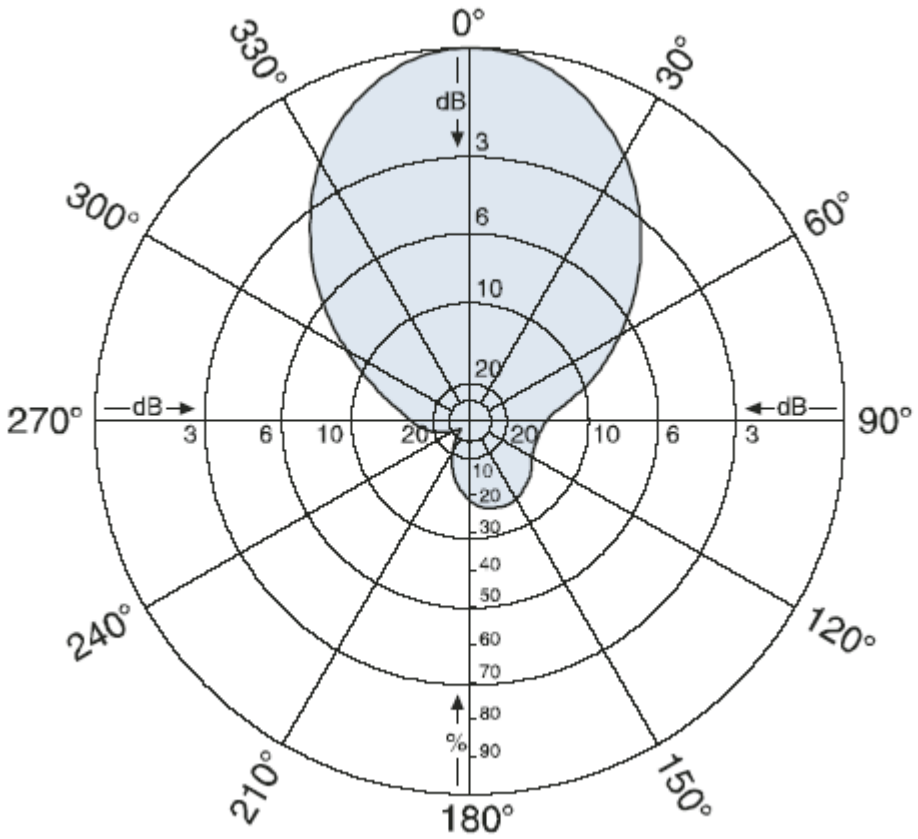
source: Samsys, Deister

Recommended distance between inlays



Radiation of dipole antennas





Antenna gain

conversion

power level

- L_P [dBm] = 10 ·log(P/0,001)

radiation power

- P [Watt] = 0,001 ·$10^{(dBm/10)}$

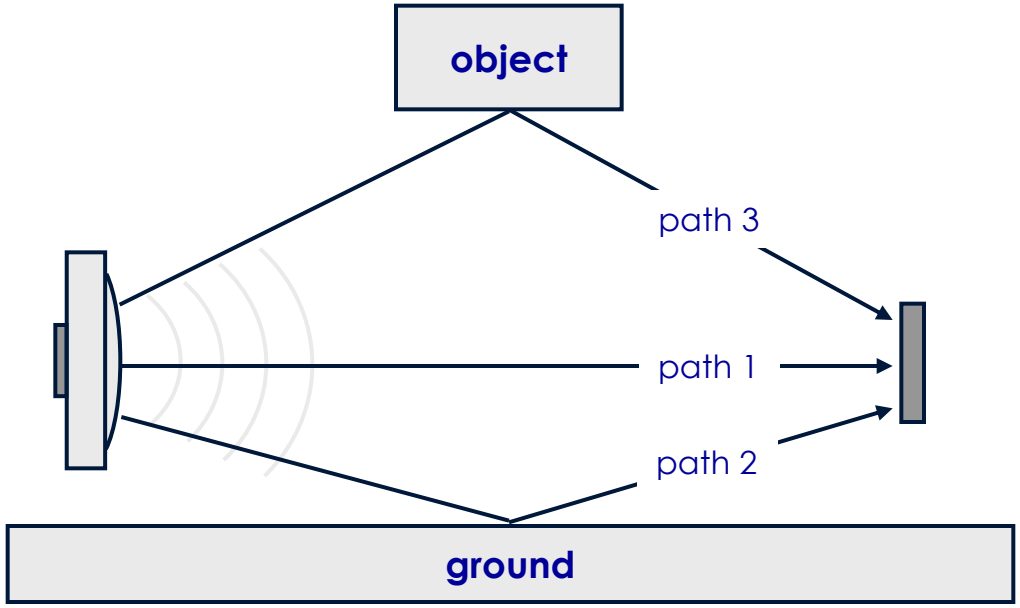
- 3 dB difference is consistent with a duplication of the power.

- The power at the reader is generally given as **power P** in **watt** or as **power level L_P** in **dBm** (decibel milliwatt).

- The antenna gain is given in **dBi** (decibel in relation to an ideal isotropic emitter with dBi = 0)

Reflections / multipath

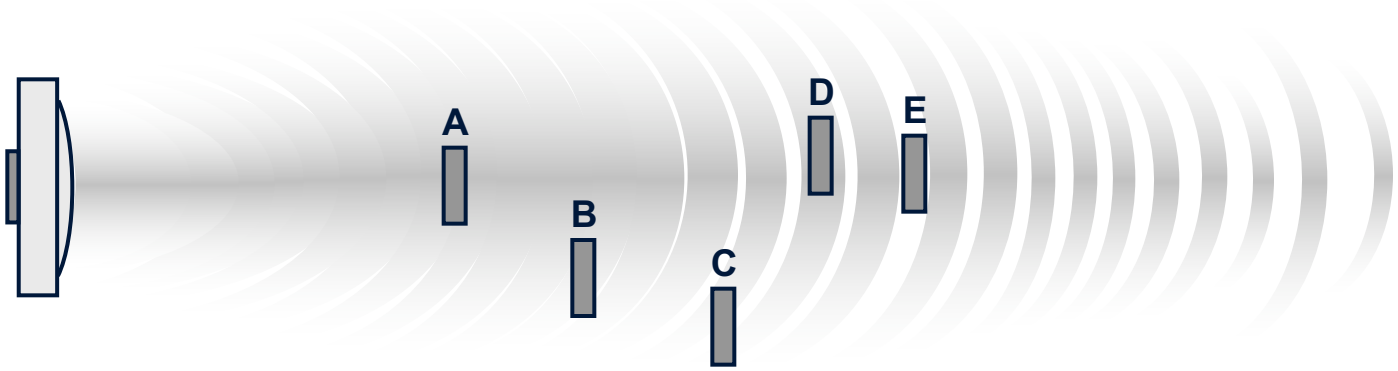
- reflections could lead to maxima and minima (reading holes)



Impacts of reflections

readings

- A and D are read without problems
- B is read after some time
- C and E are problematic

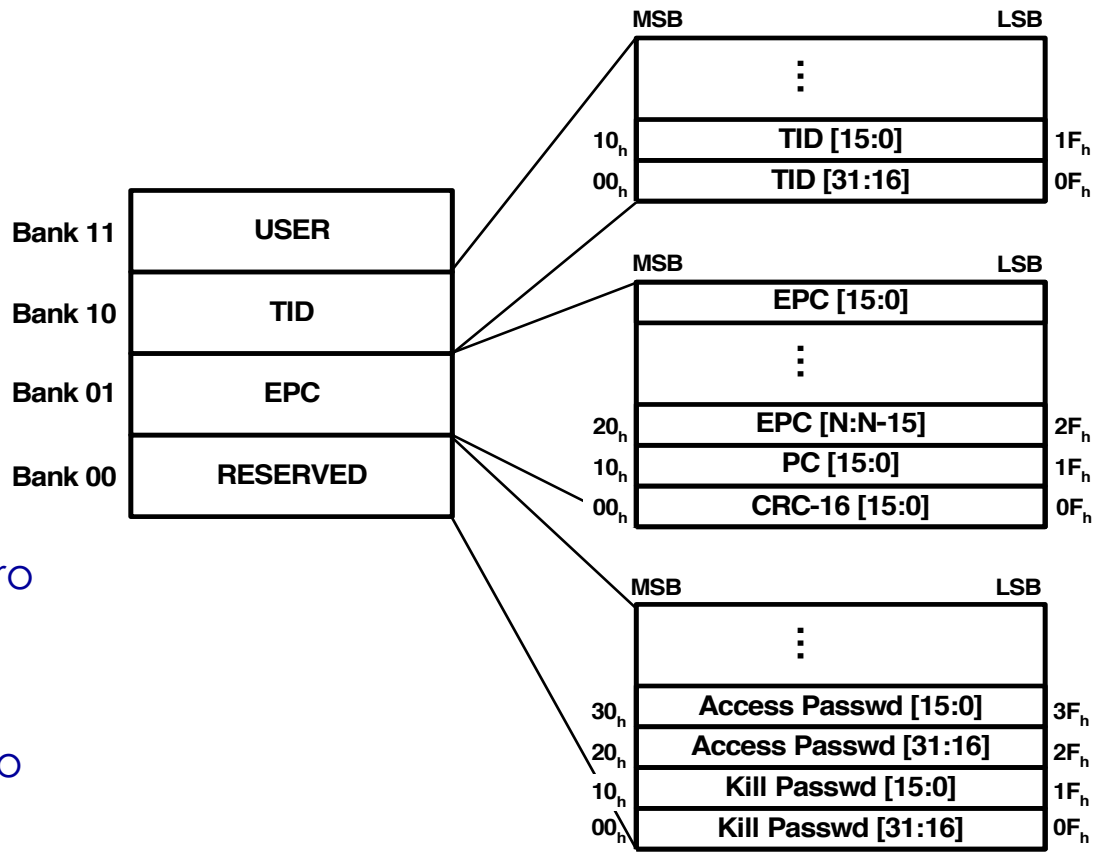


methods of resolution

- remove metallic objects
- use multiple antennas
- movement of transponder within the field (passing-trough)

Class 1 Gen 2 structure of memory

- Mandatory Memory
  - TID
  - EPC
  - Reserved
- Optional Memory
  - User
- Kill password
  - 32 bits
  - If unused, bits are zero
- Access password
  - 32 bits
  - If unused,bits are zero



Class 1 Gen 2 structure of memory

MEM BANK #	MEM BANK NAME	MEM BANK BIT ADDRESS	BIT NUMBER															
			15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
10_2	TID (ROM)	10_h-$1F_h$	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
		00_h-$0F_h$	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0
01_2	EPC (NVM)	70_h-$7F_h$	EPC[15:0]															
		60_h-$6F_h$	EPC[31:16]															
		50_h-$5F_h$	EPC[47:32]															
		40_h-$4F_h$	EPC[63:48]															
		30_h-$3F_h$	EPC[79:64]															
		20_h-$2F_h$	EPC[95:80]															
		10_h-$1F_h$	PROTOCOL-CONTROL BITS (PC)															
		00_h-$0F_h$	CRC-16															
00_2	RESERVED (NVM)	40_h-$4F_h$	LOCK_BITS[9:0]										KILL		FACTORY SETTINGS			
		30_h-$3F_h$	ACCESS PASSWORD[15:0]															
		20_h-$2F_h$	ACCESS PASSWORD[31:16]															
		10_h-$1F_h$	KILL PASSWORD[15:0]															
		00_h-$0F_h$	KILL PASSWORD[31:16]															

Tag Data Specification: SGTIN-96

SGTIN-96 = Serial Global Trade Idetnfication Number

- based on the EAN.UCC Global Trade Item Number (GTIN) code defined in the General EAN.UCC Specifications
- combination of GTIN and a unique serial number
- identify a single physical object

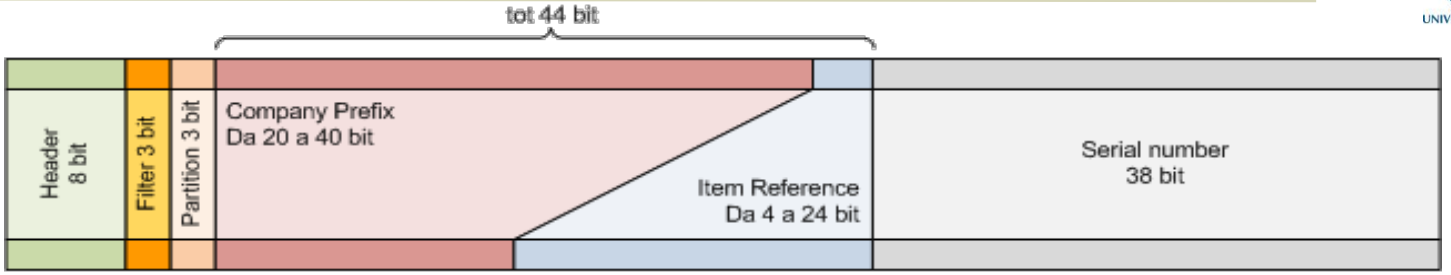
GTIN in Fashion: INDICOD-ECR specification

EAN/UCC-13 and EAN/UCC-8 are used to identify a **consumer unit**

Different GTIN for :

- Brand
- Material (wool, cotton, silk, etc)
- Size
- Color
- Model
- Exposition

Tag Data Specification: SGTIN-96



- **Header:** 0011 0000.
- **Filter Value:** is not part of the SGTIN pure identity, but is additional data that is used for fast filtering and pre-selection of basic logistics types.
- **Partition:** is an indication of where the subsequent Company Prefix and Item Reference numbers are divided. This organization matches the structure in the EAN.UCC GTIN

Type	Filter
All other	000
Retail Consumer Trade Item	001
Standard Trade Item Grouping	010
Single Shipping/ Consumer Trade Item	011
Reserved	From 100 to 111

Partition Value (P)	Company Prefix Bits (cifre)	Item Reference Bits (cifre)
0 (000)	40 (12)	4 (1)
1 (001)	37 (11)	7 (2)
2 (010)	34 (10)	10 (3)
3 (011)	30 (9)	14 (4)
4 (100)	27 (8)	17 (5)
5 (101)	24 (7)	20 (6)
6 (110)	20 (6)	24 (7)

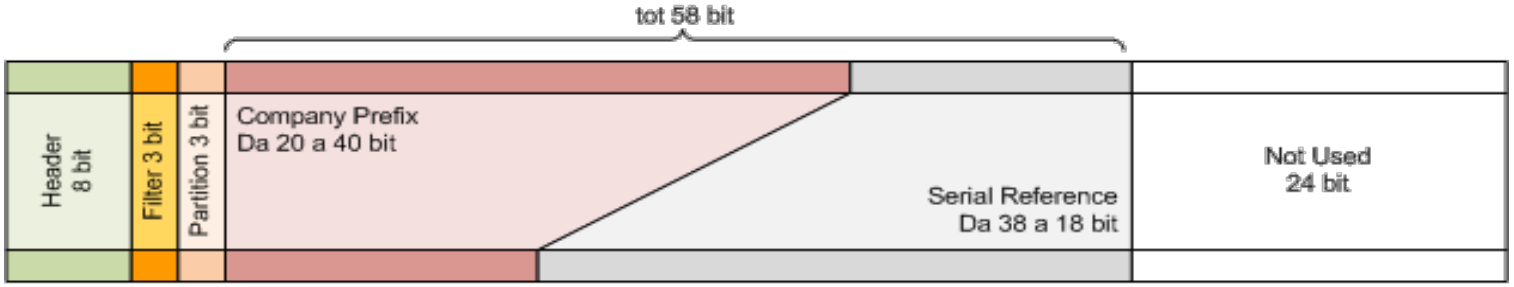
Tag Data Specification: SGTIN-96

- **Company Prefix**: contains a literal embedding of the EAN.UCC Company Prefix
- **Item Reference**: contains a literal embedding of the GTIN Item Reference number. The Indicator Digit is combined with the Item Reference field in the following manner: Leading zeros on the item reference are significant.
- **Serial Number**: serial number to be associated with a GTIN

Tag Data Specification: SSCC-96

SSCC-96 = Serial Shipping Container Code

- SSCC identifies a Shipping Unit
- It is already intended for assignment to individual objects



- **Header:** 0011 0001.
- **Filter Value:** is not part of the SSCC or EPC identifier, but is used for fast filtering and pre-selection of basic logistics types.
- **Partition:** is an indication of where the subsequent Company Prefix and Serial Reference numbers are divided.

Type	Filter Value
All other	000
Undefined	001
Logistical / Shipping Unit	010
Reserved	From 011 to 111

Partition Value (P)	Company Prefix Bits (M)	Serial Reference Bits (N)
0 (000)	40	18
1 (001)	37	21
2 (010)	34	24
3 (011)	30	28
4 (100)	27	31
5 (101)	24	34
6 (110)	20	38

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Grazie per l'attenzione!

Ing. Andrea VOLPI

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