RFID (Radio Frequency Identification) for Model Railways
NFC (Near Field Communication)

RFID (Radio Frequency Identification) for Model Railways

History and Facts

In 1945, Léon Theremin invented a listening device for the Soviet Union which retransmitted incident radio waves with the added audio information.

In the mid 1970's RFID started to become popular for tagging cattle

Worlds smallest RFID tag was manufactured by Hitachi and measures 0.05mm x 0.05mm

A scientist, Dr Elva Robinson, of Bristol University attached RFID tags to ants to see they chose a poor nest nearby and a good nest further away

Fujitsu Limited has developed 64Kbytes world's largest capacity ultra-high frequency (UHF)-band radio frequency identification (RFID) tag with high-capacity FRAM. (April 2014)

World wide market is said be worth around $20 billion (2020)

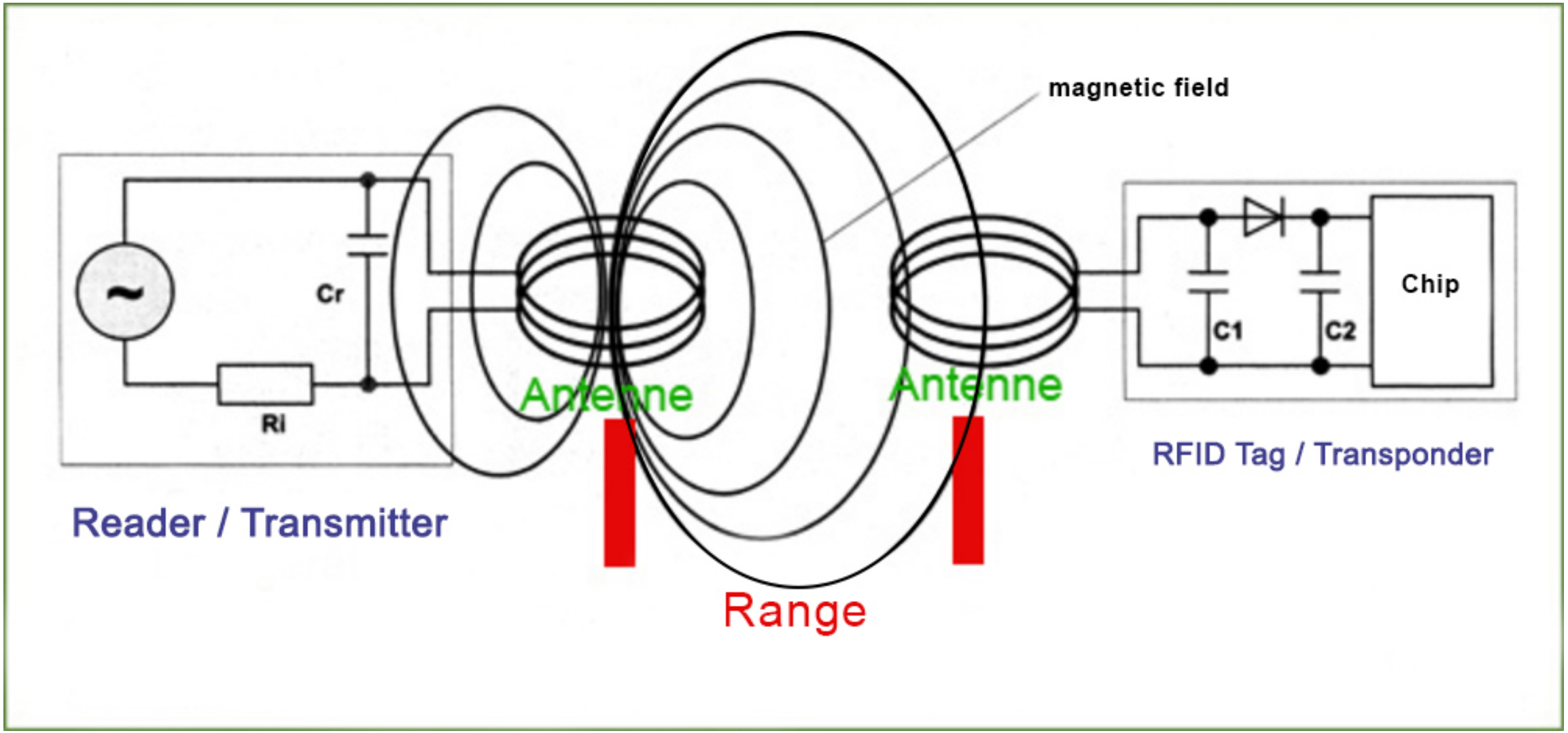
Applications

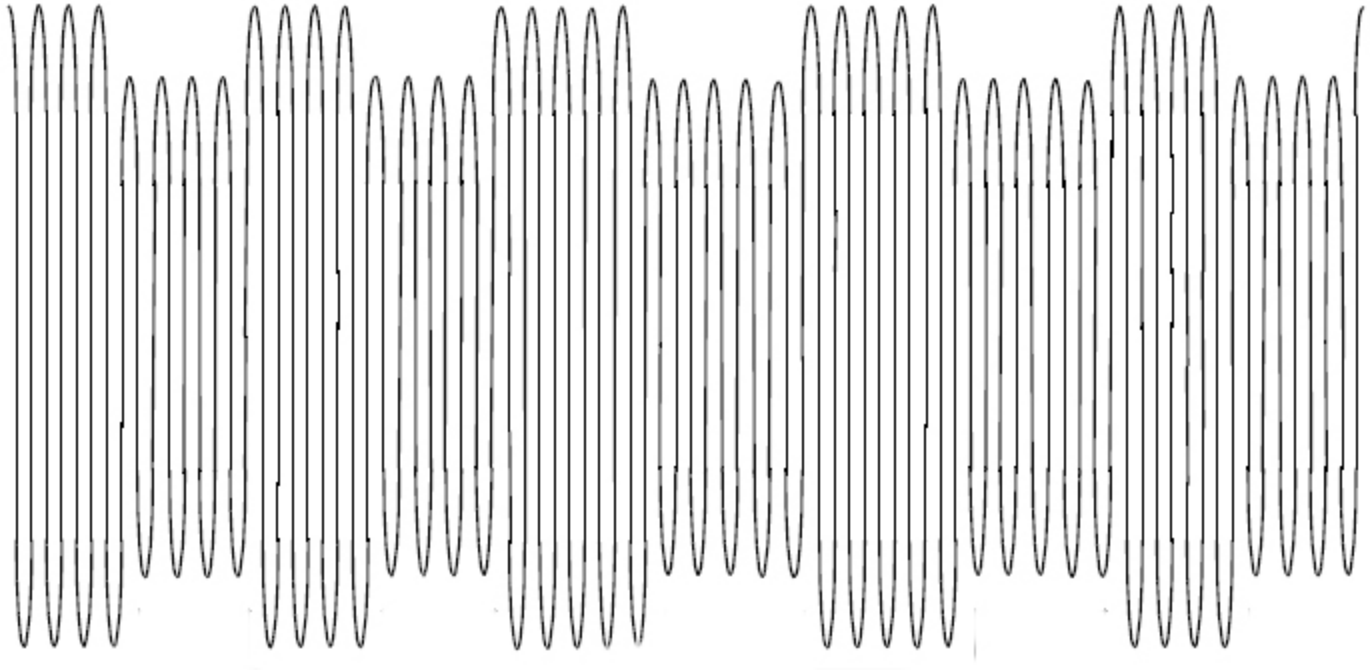
Animal Tagging
Access Control
Commerce
Retail
Advertising
Transportation
Defence
Track and Trace Vehicles in production
Passports
Transportation Payments
Pharmaceutical Industry
Hospital – Healthcare
Libraries
Museums
Sport - Timing Races
Telemetry
Waste Management

RFID Frequency Bands

Band	Regulations	Range	Data speed	Uses
LF: 120–150 kHz	Unregulated	8 cm	Low	Animal identification Factory data collection
HF: 13.56 MHz	ISM band worldwide	10 cm–1 m	Low to moderate	Smart cards
UHF: 433 MHz	Short range devices	1–100 m	Moderate	Defence applications, with active tags
UHF: 865–868 MHz (Europe) 902–928 MHz (North America)	ISM band	1–12 m	Moderate to high	EAN, various standards; used by railroads
microwave: 2450–5800 MHz	ISM band	1–2 m	High	802.11 WLAN, Bluetooth standards
microwave: 3.1–10 GHz	Ultra wide band	up to 200 m	High	Requires semi-active or active tags

How Does it Work?



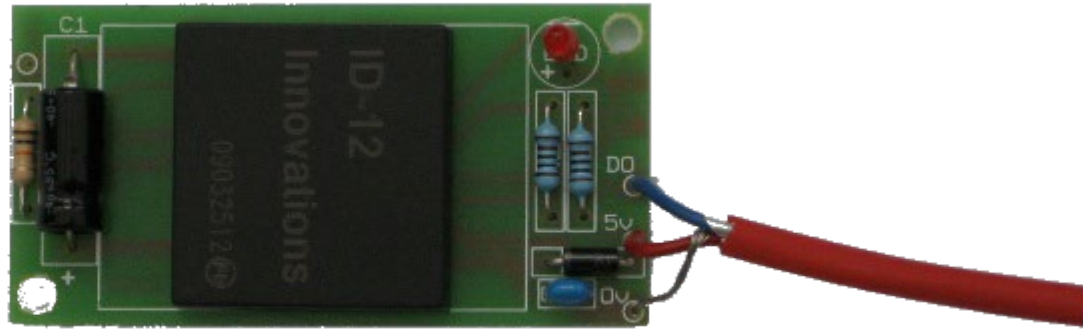


- The microprocessor must wait for a transition from low to high on its signal input pin
- The amplitude modulation pulses are decoded using a multibit data stream
- The multibit data stream must then be decoded to a single bit data stream..
- Output to correct data protocol

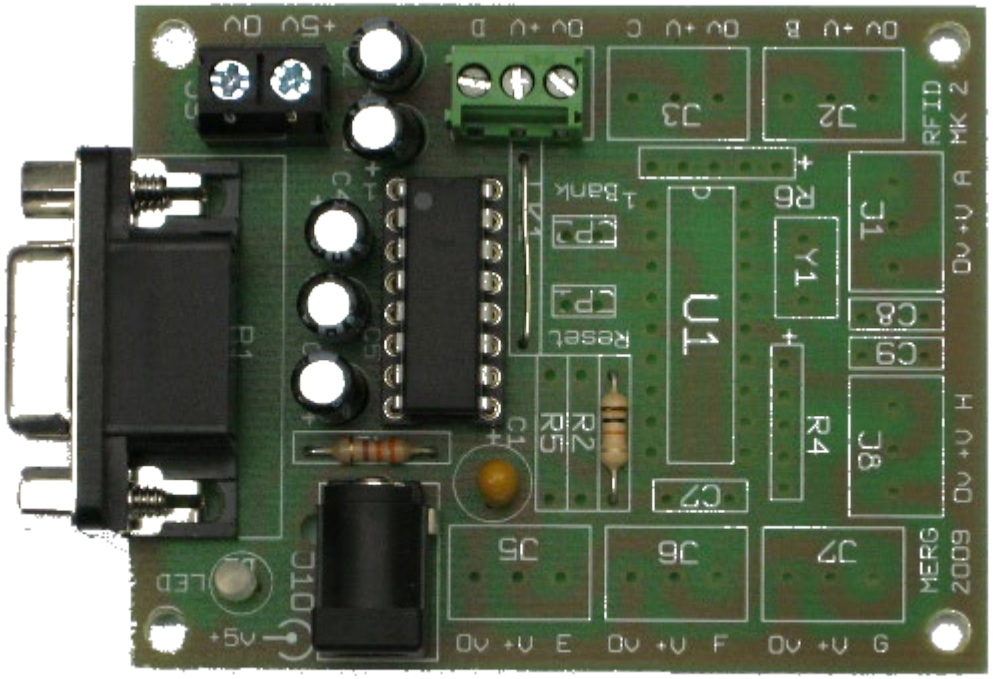
125khz LF Hardware

Read Only System

MERG KIT 30



https://www.merg.org.uk/merg_kitlocker/section.php?id=1



125khz LF Hardware

https://www.rfidshop.com/id-12-la-lf-reader-module-em42004102-17-p.asp

ID12A - 26mm x 25mm – Range up to 10cm - £18.50

https://www.aliexpress.com/item/32549156071.html?spm=a2g0o.productlist.0.0.74c74830TpGz94&algo_pvid=2c1d6df3-c1fe-404b-b285-41ac13914a46&algo_expid=2c1d6df3-c1fe-404b-b285-41ac13914a46-1&btsid=2100bdd716136577069068627e0775&ws_ab_test=searchweb0_0,searchweb201602_,searchweb201603_

EM18 - 32mm x 32mm – Range up to 12cm - £5.00

https://www.rfidshop.com/id-20-la-lf-reader-module-em42004102-15-p.asp

ID20LA – 38mm x 36mm – Range up to 15cm - £22.00

Also Available ID30 and ID40 - range from 30cm – 45cm

https://www.rfidshop.com/hid-global-12mm-glass-tag-em4200-237-p.asp

12mm Tag - £1.20
22mm Tag - £2.00

125 khz Data Protocol

4. Data Formats

Output Data Structure - ASCII - 9600 Baud, No Parity, 1 stop bit.

Output = CMOS (Push Pull) 0-Vdd

STX (02h)	DATA (10 ASCII)	CHECK SUM (2 ASCII)	CR	LF	ETX (03h)

16 Byte Data packet
10 byte Tag Data (2 byte Tag Version - 8 byte Tag UID Number)

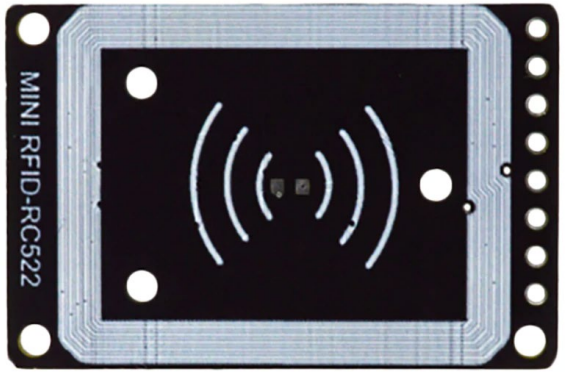
04 1A 1B 20 B8 9D

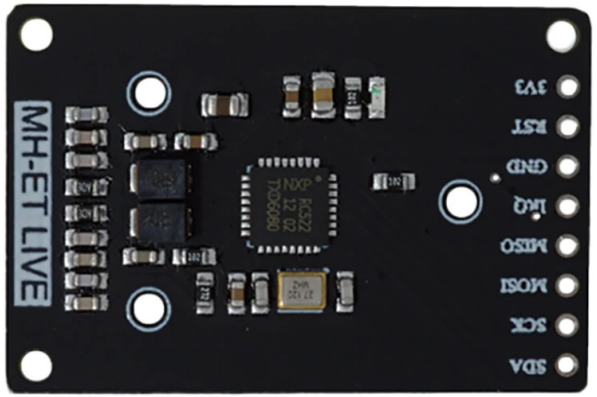
13.56Mhz HF Hardware

Read and Write System

RC522 Reader

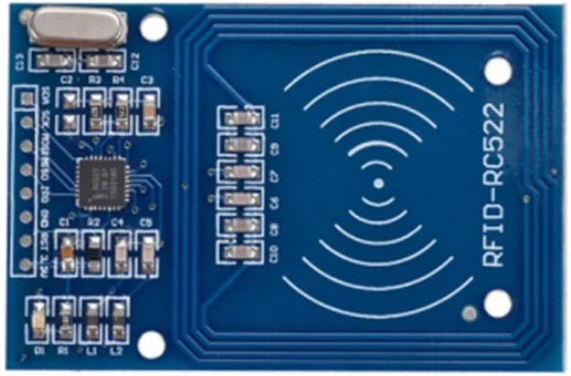
https://www.aliexpress.com/item/33058941232.html





£3.00 each Uses SPI Interface

https://www.aliexpress.com/item/32803648297.html?spm=a2g0o.productlist.0.0.ebb846e5tVpAAt&algo_pvid=e12da412-7be8-41cb-a1d9-3f447e3e0215&algo_expid=e12da412-7be8-41cb-a1d9-3f447e3e0215-14&btsid=2100bdde16124703066154384edf1b&ws_ab_test=searchweb0_0,searchweb201602_,searchweb201603_



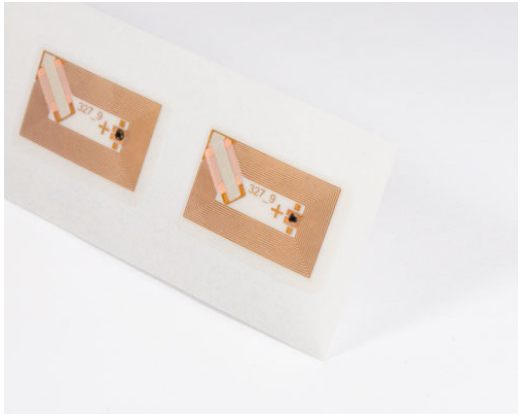
£1.00 each Uses SPI Interface

Only operates on 3.3V

12mm x 19mm NTAG123

https://seritag.com/nfc-tags/midas-clear-ntag213?vat=true

£0.20 each



25mm Circle NTAG213

https://www.idcardsdirect.co.uk/mifare-classic-1k-ev1-13-56mhz-rfid-round-label-sticker-25mm.html?utm_source=googleshopping&utm_medium=cpc&utm_campaign=googleshopping

£0.28 each

5mm x 5mm NTAG213

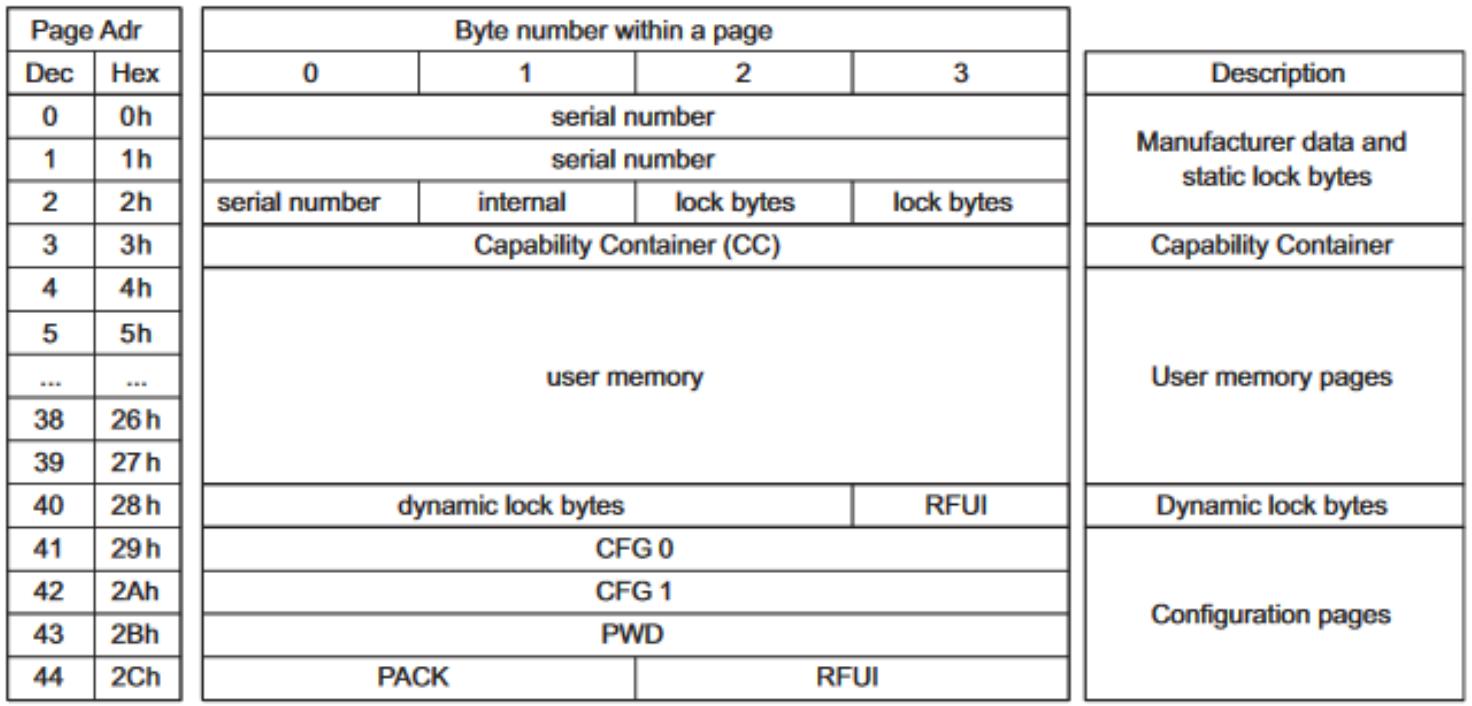
https://gbr.grandado.com/products/5pcs-programmable-5-5mm-ntag-213-micro-chip-fpc-mini-rfid-nfc-tag-6?variant=37929859809429

£3.00 each

RC522 – NTAG213 – 7 Byte UID

8.5 Memory organization

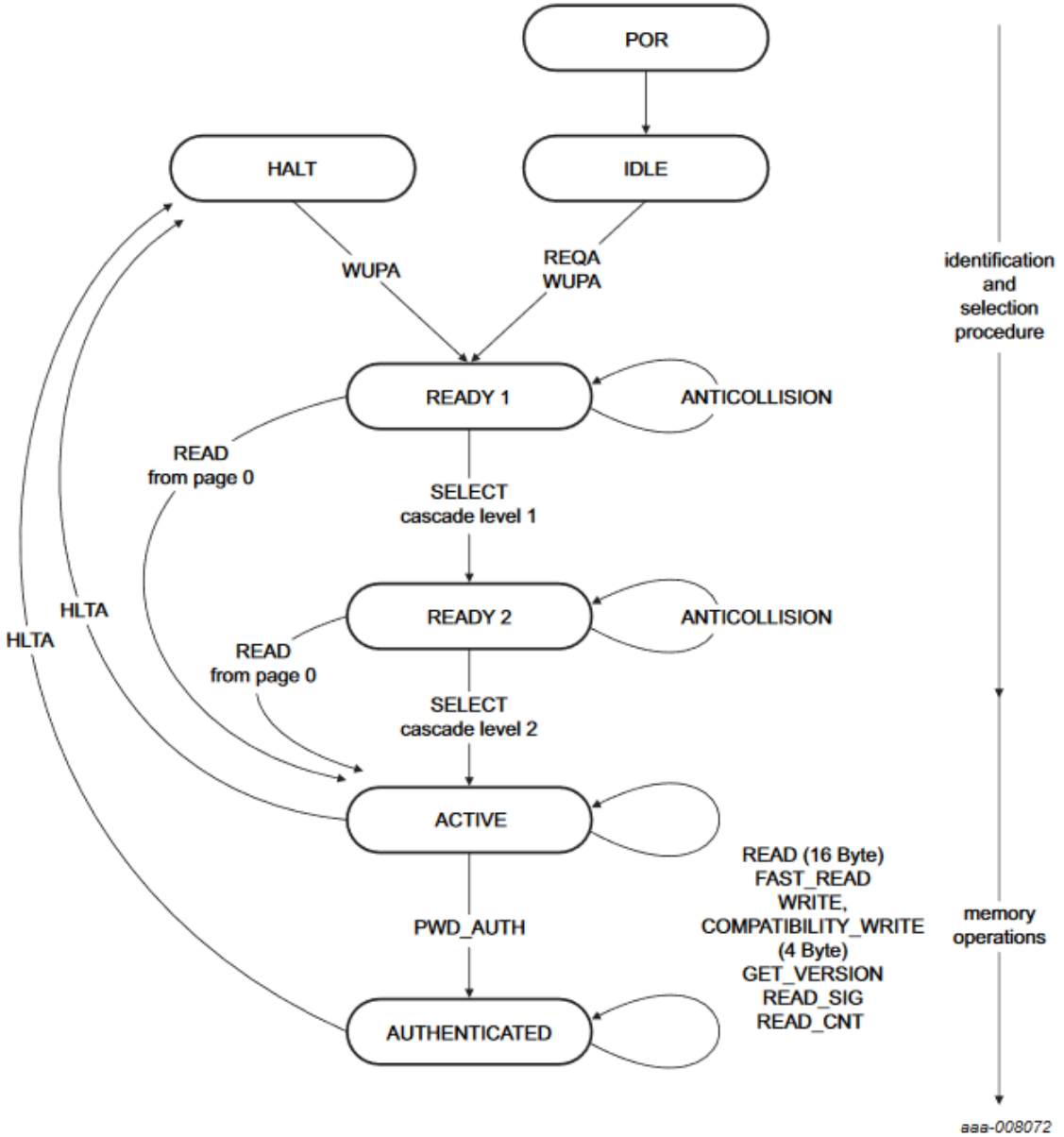
The EEPROM memory is organized in pages with 4 bytes per page. NTAG213 variant has 45 pages, NTAG215 variant has 135 pages and NTAG216 variant has 231 pages in total. The memory organization can be seen in Figure 5, Figure 6 and Figure 7, the functionality of the different memory sections is described in the following sections.



Page Adr		Byte number within a page				Description
Dec	Hex	0	1	2	3	
0	0h	serial number				Manufacturer data and static lock bytes
1	1h	serial number				
2	2h	serial number	internal	lock bytes	lock bytes	
3	3h	Capability Container (CC)				Capability Container
4	4h	user memory				User memory pages
5	5h					
...	...					
38	26 h					
39	27 h					
40	28 h	dynamic lock bytes			RFUI	Dynamic lock bytes
41	29 h	CFG 0				Configuration pages
42	2Ah	CFG 1				
43	2Bh	PWD				
44	2Ch	PACK		RFUI		

aaa-008087

Fig 5. Memory organization NTAG213



Remark: In all states, the command interpreter returns to the idle state on receipt of an unexpected command. If the IC was previously in the HALT state, it returns to that state.

Fig 4. State diagram

1. **Power On Request**
   - Enters Idle State
2. **Wake Up Protocol**
   - Enters Ready 1 state
3. **Resolves first part (3 Bytes) of UID**
   - Successful Select or Read –
     Enters Ready State 2
4. **Resolves second part (4 Bytes) of UID**
   - Successful Select or Read –
     Enters Active State
5. **Active State**
   - All memory operations are read after successful password verification
     Enters Authenticated State
6. **Authenticated State**
   In this state, all operations on memory pages, which are configured as password verification protected, can be accessed.

Advantages – Disadvantages of 125Khz System

Advantages

- Easy to interface – RS232 Serial – Arduino, Raspberry Pi, MERG Kit 30
- Relatively cheap
- Readily Available

Disadvantages

- Readers must be placed between 5cm and 10cm apart to prevent interference
- Sensitivity decreases slightly if placed directly under DCC rails
- Speed has a factor on read reliability (I haven’t come across this)
- The larger readers are expensive
- Can’t write to tag

Advantages – Disadvantages of 13.56Mhz System

Advantages

- RC522 reader easily available
- Very cheap
- Can write to Tag
- Tags can be read at high speed
- Not prone to sensitivity loss under DCC rails
- RC522 Library is well supported on Arduino
- Interface with CBUS – CANMIO RFID firmware

Disadvantages

- Tags do not work on or near metal
- Readers must be placed between 3cm and 5cm apart to prevent interference
- Only works on 3.3V
- Cheap RC522 readers can be unreliable
- No system available (at the moment) to write to tags
- Uses SPI interface – more wires