ETSI TR 103 059 V1.2.1 (2013-11)

Technical Report

Electromagnetic compatibility and Radio spectrum Matters (ERM); Short-Range Devices (SRD) for operation in the 13,56 MHz band; System Reference Document for Radio Frequency Identification (RFID) equipment

Reference
RTR/ERM-TG28-046

Keywords
radio, RFID, short range, SRD, SRDOC

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Contents

Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (http://ipr.etsi.org).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

Executive summary

The present document analyses the potential and status of 13,56 MHz RF Identification Systems and the need for regulatory and standard improvements as:

- 13 MHz RFID systems cover the widest range of markets and applications among the RFID families, this is detailed in clause 6.1 and annex A.
- The prospects for the next decade for the 13,56 MHz RFID technology is that these RFIDs have the highest turnover and increase rate compared to other frequencies. The rate is estimated for about 50 % or higher of all SRD applications. This is based on:
  - the mature and versatile 13,56 MHz technology is providing either large reading range with high data rates and bulk reading capability or very high data rates at low reading ranges needed for the required safety and security features and as requested by the EC mandate M436 for private/public and commercial use;
  - 13,56 MHz systems are used in a large amount of installed systems covering various markets. The present document covers two different application types which require different TX emission masks for different emission levels and bandwidths:
    a) Narrowband/long range applications as used in libraries, access control, logistics and materials handling, waste management, apparel tagging in manufacturing laundry services, etc. These systems are typically installed in industrial or shopping sites. From all 13,56 MHz applications they represent some 3 % of all deployed systems.
    b) Wideband/short range applications for use in ticketing and payment systems to secure transactions (i.e. smart cards, e-Passport, mass transportation tickets), NFC, employing authentication to provide secure identification mechanisms for persons and objects. These systems represent about 97 % of the market for 13,56 MHz RFID systems.
  - All 13,56 MHz RFID systems feature unique properties as highest spectrum efficiency as dense operation of 13,56 MHz RFID systems in a given area.
- 13,56 MHz frequency band is harmonized in all three ITU regions which assures coverage of all markets.

Furthermore recent developments in the evolution of the technology and ISO standards as well as market developments or requirements in social, public, commercial and industrial areas have shown the need for amending the ERC/REC 70-03, annex 9 as well as amending the EN 300 330-1 [i.2] as presented in the present document.

Introduction

The present document has been developed to support the co-operation between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT) for internal reference within ETSI [i.1].

RFIDs have been in use for almost all areas of the industrial-commercial, the public and private sector.

Especially the 13,56 MHz RFID technology is matured and has achieved tag deployment rates in the several billion unit range. This frequency is highly attractive because of the global harmonization of this frequency band since it is an ISM band in all 3 ITU regions.

The 13,56 MHz RFIDs use the inductive near field propagation mode which has the unique advantage of allowing a high reader field strength without disturbing the in-band or adjacent band radio services because of the fast field strength roll-off of 60 dB/Decade [i.2] and [i.5].

This means that the reading range is confined or limited while RFID's using EM/far-field operation can suffer from reflections and diffractions.

The two most limiting factors for 13,56 MHz RFIDs are regulatory constraints with regard to the modulation allowance level which is addressed in the present document.

1 Scope

The present document provides information on short range device equipment for RFIDs operating in the 13,56 MHz frequency range from 13,553 MHz to 13,567 MHz and covering the requirements for carrier and the associated modulation emissions.

The present document includes the necessary information to support the co-operation between ETSI and the ECC including:

- market information;
- technical information;
- regulatory issues.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ECC-ETSI MoU (version of April 2004).

[i.2] ETSI EN 300 330-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio equipment in the frequency range 9 kHz to 25 MHz and inductive loop systems in the frequency range 9 kHz to 30 MHz; Part 1: Technical characteristics and test methods".

[i.3] ERC Report 69 (February 1999): "Propagation model and interference range calculations for inductive systems 10 kHz - 30 MHz".

NOTE: Available at: http://www.satoworldwide.com/news_releases_02062008_DIP.htm.

[i.4] Wired Science: "New RFID Tag could mean the end of Bar Codes".

NOTE: Available at: http://www.satoworldwide.com/news_releases_02062008_DIP.htm.

[i.5] ERC Report 44 (January 1997): "Sharing between inductive systems and radiocommunication systems in the band 9 - 135 kHz".

[i.6] ECC Report 74: "Compatibility between radio frequency identification devices (rfid), and the radioastronomy service at 13 MHz".

[i.7] Poly IC printed electronics.

NOTE: Available at: http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=1233745&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D1233745.

[i.8] ISO/IEC 14443-2 "Identification cards - Contactless integrated circuit(s) cards - Proximity cards - Part 2: Radio frequency power and signal interface.

[i.9] ISO/IEC 15693-1 "Identification cards - Contactless integrated circuit cards -- Vicinity cards -- Part 1: Physical characteristics".

[i.10] ERC Recommendation 70-03: "Relating to the use of short range devices (srd)".

[i.11] ISO/DIS 17367: "Supply chain applications of RFID - Product tagging".

[i.12] CEN EN 14803: "Identification and/or determination of the quantity of waste".

[i.13] FM(10)092 Annex 24: "Dynamic Evolution of RFID Market".

[i.14] Klaus Finkenzeller: "RFID Handbook", Chapter 5.1.11: "Selection of frequency for inductive coupled RFID systems", issue 2008, ISBN 978-3-446-41200-2.

[i.15] VDC Market Report: "RFID and related solutions".

[i.16] EETimes publishes an article about PolyIC: "Organic RFID breakthroughs detailed".

NOTE: Available at: http://www.eetimes.com/document.asp?doc_id=1170339.

[i.17] ISO/IEC 18000-3: " Information technology - Radio frequency identification for item management - Part 3: Parameters for air interface communications at 13,56 MHz".

[i.18] ISO/IEC 10536: "Identification cards -- Contactless integrated circuit(s) cards".

[i.19] ISO/IEC TR 18047-3: "Information technology -- Radio frequency identification device conformance test methods -- Part 3: Test methods for air interface communications at 13,56 MHz".

[i.20] ISO/IEC 15693-3: "Identification cards - Contactless integrated circuit cards - Vicinity cards - Part 3: Anticollision and transmission protocol".

[i.21] ISO/IEC 10373-4: "Identification cards -- Test methods -- Part 4: Contactless integrated circuit cards".

[i.22] ISO/IEC 10373-6: "Identification cards - Test methods - Part 6: Proximity cards".

[i.23] ISO/IEC 10373-7: "Identification cards -- Test methods -- Part 7: Vicinity cards".

[i.24] ETSI EN 302 291: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Close Range Inductive Data Communication equipment operating at 13,56 MHz".

[i.25] ISO/IEC 18092: "Information technology -- Telecommunications and information exchange between systems -- Near Field Communication -- Interface and Protocol (NFCIP-1)".

[i.26] ECMA 340: "Near Field Communication Interface and Protocol (NFCIP-1)".

[i.27] Void.

[i.28] ISO/IEC 18046 (parts 1 to 3): "Information technology -- Radio frequency identification device performance test methods".

[i.29] ISO/IEC18000-1: "Information technology -- Radio frequency identification for item management -- Part 1: Reference architecture and definition of parameters to be standardized".

[i.30] ITU Radio Regulations.

[i.31] Void.

[i.32] ECC Report 67: Compatibility study for generic limits for the emission levels of inductive SRDs below 30 MHz.

[i.33] RFID report BNetzA: Measurements to characterize HF RFID signals and to determine the interference to the HF broadcast service: M66-17R0-SE24-at-13MHz-Test-Report.

[i.34] Liaison statement from ETSI-ERM to ECC WGSE #63 dated 2012-11-07, Doc. ECC/SE(13)016.

[i.35] M436: Standardization Mandate To The European Standardization Organization Organizations CEN, CENELEC and ETSI In The Field Of Information And Communication Technologies Applied To Radio Frequency (RFID And Systems.

[i.36] Summary for the 13.56 MHz RFID Measurement campaign (for BC.

[i.37] ETSI Liaison statement from ECC WGSE to ETSI-ERM: SE(13)049A20-LS to ETSI TC ERM on ETSI TR 103 059 for RFID 13.56 MHz.doc.

[i.38] "Measuring Lean benefits using Radio Frequency Identification (RFID) technology".

NOTE: http://www.rfidinfo.jp/whitepaper/381.pdf.

[i.39] 2006/771/EC: Commission Decision of 9 November 2006 on harmonisation of the radio spectrum for use by short-range devices.

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

bulk reading: extension of single reading to a set of tags within the illumination field

identification system: equipment consisting of a transmitter(s), receiver(s) (or a combination of the two) and an antenna(s) to identify objects by means of a transponder

Short Range Devices (SRDs): radio devices which provide either unidirectional or bi-directional communication and which have low capability of causing interference to other radio equipment

tag: device that responds to an interrogation signal

3.2 Symbols

For the purposes of the present document, the following symbols apply:

P	Power
R	Distance
f	frequency
f_C	carrier frequency in Hz
H	magnetic field strength
kB/s	Data transmission speed
λ	Wave length

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AIDC	Automatic Identification and Data Capture
AM	Amplitude Modulation
ANFR	Agence Nationale des Fréquences
ASK	Amplitude Shift Keying

BC	BroadCasting
DRM	Digital Radio Mondiale
EAS	Electronic Article Surveillance
ECC	Electronic Communications Committee
EM	ElectroMagnetic
EPC	Electronic Product Code
ERC	European Radiocommunications Committee
FD	Full Duplex
HF	High Frequency
IC	Integrated Circuit
ISM	Industrial Scientific Medical
ISO	International Standards Organisation
LF	Low Fequency
LS	Liason Statement
NB	Narrow Band
NFC	Near Field Communication
NRZ	Non Return Zero
PSK	Phase Shift Keying
RF	Radio Frequency
RR	Radio Regulations
RX	Radio Receiver
SRD	Short Range Device
TG	Task Group
TX	Transmitter
UHF	Ultra High Frequency
WB	Wide BAnd

4 Comments on the System Reference Document

4.1 Comments on the revised version 1.2.1

No comments are received to date.

4.2 Revised items in version 1.2.1

The revision of V1.2.1 covers two different application families. The combined transmitter mask of the version V1.1.1 has been changed in clause 8 to two individual transmitter masks for a Narrowband/Long range and a Wideband/Short range application.

The main changes are in:

- Executive summary
- Clause 6.1, Market information
- Clause 7, Technical information (7.1.1, 7.2.1 and 7.3)
- Clause 8 Radio spectrum request and justification (8.1, 8.1.1, 8.2 and 8.2.2)
- Clause 9, Regulations, (9.1, 9.2 and 9.3)

Other revisions concern textual updates in various places.

5 Background information

5.1 The current situation

RFIDs operating at 13,56 MHz meet a number of different market requirements and have reached the highest market acceptance and penetration among all other RFID technologies operating at other frequency ranges.

The increase rate over the next decade is about 50 % or higher. This is based on an already high level of installed systems and particularly the number of tags. This high level of acceptance is due to the versatile yet simple 13,56 MHz inductive technology.

13,56 MHz benefits are:

- Frequency band is harmonized ➔ in ITU regions 1, 2 and 3
- Near field properties RFIDs have distinct features ➔ well defined and limited operating range
- Very high spectrum efficient technology ➔ 13,56 MHz ±7 kHz is sufficient
- High coverage of Standards ➔ by global standards (ISO) and regional as well as different application specific standards
- Highest data rate and bidirectional communications ➔ up to 423 kB/s for sophisticated, secure data transmission and anti-collision and up to 30 MB/s for short distance systems
- Low cost structure ➔ using mature and high volume technologies
- Choice of technology for or short or long operating ranges ➔ at very high or high data rates

Regarding the achievable operating range, the regulation for the carrier field strength level was increased from 42 dBµA/m to 60 dBµA/m a few years ago in order to provide higher reading ranges and to meet the market demands. At the time, the market primarily required read-only tags and the achievable high reading range was effectively enabled by the 60 dBµA/m limit.

The increased complexity of RFID systems, the level of sophistication of the various applications, last but not least the need for data protection and enhanced capability for data security have dictated the shift from read-only and unidirectional data communication to bidirectional communication between reader and the tag. New applications necessitate the bandwidth increase from ±900 kHz to ±7 MHz.

Bidirectional communication to the tags is essential for present RFID systems with sophisticated protocols e.g. for addressing individual tags, and also enabling data security functions. For bulk reading environments fast protocols for tag serialization is required, which is only feasible with bidirectional communication.

The large majority of the RFID systems respectively the tags are passive, this is a precondition for high market penetration and reliable operation at low cost. Passive tags face a number of limitations for realizing the chip technology, especially if bidirectional communication between reader and tag is required.

The bidirectional communication requires that the tag activation signal is to be ASK or PSK modulated. The ASK modulation level has to be minimum ~10 % (respectively a modulation index of 18 %) in order to be reliably detected by the passive tags.

The present modulation mask, initially defined for operation at a carrier level of 42 dBµA/m, works satisfactorily with the present modulation mask level of 9 dBµA/m. However using the increased carrier level of 60 dBµA/m the modulation level of 9 dBµA/m is too low.

The present document supports the need for amending the modulation emission levels and defines the required modulation mask to allow reliable bidirectional communication at the carrier operation level of 60 dBµA/m.

The present modulation mask, initially defined for operation at a carrier level of 42 dBµA/m, works satisfactorily with the present modulation mask level of 9 dB/µA/m but with the increased carrier level the modulation level is too low and no longer functional to support bidirectional communication at 60 dBµA/m.

The present document supports the need for amending the modulation emission levels and defines the required modulation mask to support bidirectional communication at the operation level of 60 dBµA/m.

5.2 The 13,56 MHz inductive RFID technology

- RFID systems at 13,56 MHz basically operate as magnetically coupled and tuned circuits.
- Systems can use the design trade-off potential to either make use of high quality factors (Q) for the antenna circuits in order to provide the highest efficiency to power the tags over the maximum required reading distance at moderate data rates, or using a lower Q and broadband tuned circuits supporting high data rates up to 100 kBit/s resulting in lower ranges.
- A distinct advantage of the 13,56 MHz technology is the fact that 13,56 MHz RFID systems operate in the near field propagation domain which features:
  - high field strength roll-off of ~60 dB/decade [i.2] and [i.5];
  - lower interference potential to other services operating in the same or nearby frequency bands [i.3] and [i.6];
  - the re-use of the frequency band allowing high spectrum efficiency as dense operation of 13,56 MHz RFID systems in a given area;
  - controlled and limited operating range and free from reflections and diffraction.

Inductive technology RFIDs therefore have favourable propagation properties and ideally suited for Short Range Device (SRD) operation which are not present with other RFIDs operating in higher frequency ranges and at EM fields.

Another aspect for future high market growth and significantly lower cost is that the printed chip technology for RFIDs is opening significantly larger markets as compared to the present RFID forecasts because of the much lower cost [i.4] and [i.7].

The most limiting factor for further deployment of the 13,56 MHz RFID technology is the regulatory constraint for the modulation emission level and bandwidth as detailed in the present document.

5.3 The socio-economic benefits

The RFIDs are an established technology in the industry, known as "Automatic Identification and Data Capture (AIDC) technology" and have developed nowadays as an active and indispensable part in all areas of daily life.

AIDC technologies primarily known as Bar Codes. The next generation and successor or complementary technology to Bar Codes is the RFID technology which is more versatile and essential for applications such as e. g. logistics, apparel and textiles, industrial installations, payment, access control, ecology savings, libraries, medical and many other applications as explained in annex A [i.4].

There are a number of new applications and markets which are imperative for the public. A number of states have already regulated some applications using the new technologies because of the saving cost, allowing international control/security functions, such as e-Pass and the ID card, driver licenses or similar applications. These are all using 13,56 MHz RFID according to ISO standards.

Therefore 13,56 MHz tags presenting high volumes and provide fast growing markets over the next decade and beyond.

The enabler for the various new applications is on one hand a wideband/short range transmitter mask to cope with wide modulation range of ±7 MHz for applications requiring high data speed as defined in ISO/IEC 14443-2 [i.8] and on the other hand narrowband/long ranges to allow a sufficiently high modulation level as required by ISO/IEC 15693-1 [i.9] and ISO/IEC 18000-3 [i.17].

This can be optimally realized with two transmitter masks like: (a) a wideband/short range transmitter masks for the ISO/IEC 14443 [i.8] and (b) a narrow/long range transmitter mask for the ISO/IEC 15693-1 [i.9], and similar applications.

As example of the socio-economic benefits in the various applications in the industrial area where RFIDs conforming to the narrow band/long range mask ISO/IEC 15693 [i.9] and ISO/IEC 18000-3 [i.17] can be used and is shown in table 1 identifying savings and performance improvements using RFIDs in a manufacturing environment [i.38].

This is typical for ISO/IEC 18000-3 [i.17] for 13,56 MHz in industrial applications.

Table 1: Savings of Radio Frequency Identification (RFID) technology

Parameter	Benefit
Productivity	Increased between 10 % and 100 %
Throughput times	Decreased between 40 % and 90 %
Inventories	Decreased between 40 % and 90 %
Scrap	Reduced between 10 % and 50 %
Space savings	Between 30 % and 60 %
Overtime	Decreased up to 90 %
Safety-related injuries	Decreased up to 50 %
Product development time	Decreased up to 30 %

Other main application examples of ISO/IEC 15693 [i.9] and ISO/IEC 18000-3 [i.17] are ticketing, and access control e.g. ski pass, parking, tracking and tracing, libraries, etc.

The various other ISO and other technical standards for 13,56 MHz RFID's are given in clause 6.3.

6 Market information

6.1 General

Besides the Low Frequency (LF) RFID systems, the 13,56 MHz technology is one of the first RFID technologies brought to the market back in 1995 or earlier in the form of the first smartcard applications. Presently the market covers a variety of applications.

The market for 13,56 MHz applications is established in the following application areas which are characterized in two main areas, a narrowband/long range application and in a wideband/short range application *(the list of applications may not be complete)*:

- For the Narrowband/Long Range RFID TX mask the main applications are:

  1) Logistics and materials handling, where goods and mobile assets are tagged for their use along the supply chain [i.11].

  2) Libraries, books handling.

  3) Ecology related applications such as waste management.

  4) Item level tagging - especially efficient if combined with an Electronic Article Surveillance (EAS) function which can be performed in the same chip.

NOTE: The 60 dBμA/m emission level according to ERC/REC 70-03 [i.10], Annex 9 provided the needed reading ranges of RFIDs to cover combine the EAS function with RFIDs. These EAS devices are extremely range critical and the needed operational EAS ranges were previously only achieved at different frequencies with very simple EAS technologies.

  5) Automatic display of information where items are tagged to provide additional information to consumers on products and services.

  6) Medical applications in identifying equipment, medical process steps, monitoring, etc.

  7) Inventory audit, for example in warehouses where boxes or pallets are tagged to improve the speed, accuracy and efficiency of stock taking.

8) Asset monitoring and maintenance, where mostly fixed and high value assets are tagged to store information, e.g. for maintenance purposes.

9) Tagging in the apparel manufacturing and laundry services for industrial and private use.

10) Item flow control in processes, RFID tags are attached to items which are moving along a production line.

For the Wideband/Short Range RFID mask the main applications are:

1) Payment systems to secure transactions (i.e. smart cards).

2) e-Passport, ID cards, with authentication to provide secure identification mechanisms for persons.

3) Ticketing, mass transportation.

4) NFC and Data streaming.

5) Document tracking.

6) Medical, patient tracking.

7) Security access.

Table 2 summarizes the various RFID applications, operating ranges and associated to the required transmitter mask of figure 9.

Table 2: Overview of major 13,56 MHz Applications

Application	Solutions	Type	TX Mask Type	Environment
Library	Security Gates	Long Range	NB, Fig 10	Medium and large Libraries
	Automatic Sorter	Long Range	NB, Fig 10	
	Book return	Short Range	WB, Fig 11	
	Self-service, Check-In/Check-out	Short Range	WB, Fig 11	
	Hand Held Reader	Short Range	WB, Fig 11	
Logistic & Supply chain Management	Dock doors	Long Range	NB, Fig 10	Industrial facility
	Industrial automatic sorter	Long Range	NB, Fig 10	
	Document tracking	Short Range	WB, Fig 11	
Healthcare	RFID-Tunnel inside the production line	Long Range	NB, Fig 10	Industrial facility
	Document tracking	Short Range	WB, Fig 11	Hospital
	Patient safety	Short Range	WB, Fig 11	
Laundry	RFID-Tunnel/Industrial tracking	Long Range	NB, Fig 10	Industrial facility
	Laundry dispenser	Short Range	WB, Fig 11	Hospital, Factory
Access control	Security access	Short Range	WB, Fig 11	Building
	Ticketing	Short Range/	WB, Fig 11	Public transport/Sport stations, etc.
	ID Card Identification	Short Range	WB, Fig 11	Various
Payment	Payment systems	Short Range	WB, Fig 11	Large Shops
e-Passport/National ID Cards	Passports & ID Cards	Short Range	WB, Fig 11	Airports, customs, frontiers
Near field Communication	NFC	Short Range	WB, Fig 11	Shops, Public

Figure 1 highlights the percentage of the two application categories. This is a projection for 2020, approximately 6 years after the introduction. The wideband application present the majority of 97 % and the narrowband applications are only used in about 3 % of all the new applications.

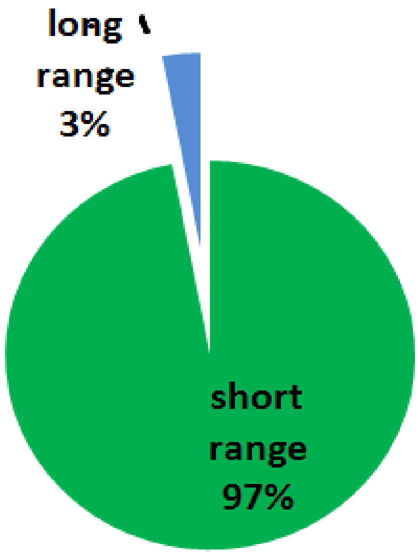


Figure 1

6.2 History, technology and systems

The first developments of RFIDs wireless cards were based on the *"Close Coupling (smart) Cards"* which had to be positioned rather precisely to match the position of the coils of the card with the position of the reader coils in order to have a functioning inductive coupled link for power and data.

Therefore these close coupling cards were slot operated (these close coupling cards were operated at 4,9 MHz and presented the forerunner of the 13,56 MHz system).

The 13,56 MHz RFID Systems for proximity cards were first developed by Mikron in the early 90's as Fare Collection systems and deployed in volume as MIFARE system from 1996 onwards. The first major application was a 13,56 MHz RFID card (U-pass) deployed for instance in Seoul for ticketing/payment systems. The MIFARE card was only for short distance operation. In 1998 Mikron was acquired by Philips® and later transferred to NXP® which continued the success story of this ISO/IEC 14443-2 Amd. 3 [i.8] smartcard technology with about 1 Billion cards sold.

While the ISO/IEC 14443-2 Amd. 3 [i.8] card was designed for short range and proximity operation (5 cm to 10 cm) and with inherent safety functionality. From 1999 onwards, the ISO/IEC 15693-1 [i.9] the RFID technology was expanded the operation range and the application was called the vicinity RFID card. A few years later ISO SC 31 developed the ISO/IEC 18000-3 [i.17] for industrial applications. This allowed reading ranges up to 1,5 m, initially for access control but also successful in many different industrial applications.

This is one example for the unique 13,56 MHz technology providing either long range which is enabled by high Q Tag antenna circuits which limits the bandwidth and data speed or system designers have the choice for short range RFID systems with very high data speed at larger modulation bandwidth.

6.3 Overview of 13,56 MHz RFID family and standards

There are more than five 5 different standards available for the RFID frequency band of 13,56 MHz, they differ in different reading ranges, modes, modulation rates and data speed according to the different applications, see figure 2.

Table 3 provides an overview of the different 13,56 MHz RFID technologies, applications and the corresponding reading ranges as one of the key parameters for RFID systems.

Table 3: 13,56 MHz RFID reading range overview

Application/technology	Standard	Reading range
Close coupling Card (initially for 4,9 MHz)	ISO/IEC 10536 [i.18]	<1 cm
IC Cards (smart cards), e-Pass	ISO/IEC 14443-2 [i.8]	~10 cm
Vicinity cards, for access control, etc.	ISO/IEC 15693-1 [i.9]	~150 cm
NFC/mobile RFID applications, data streaming, etc.	ECMA 340 [i.26]	~10 cm
Logistics, manufacturing, item tagging, asset control, etc.	ISO/IEC 18000-3 [i.17]	~150 cm

13,56 MHz RFID standards are handled in several Standardization Groups, ISO/IEC JTC1/SC17 (cards), ISO/IEC JTC1/SC31 (logistics), CEN, CENELEC and NFC/ECMA (mobile phone) in cooperation with ETSI ERM TG23.

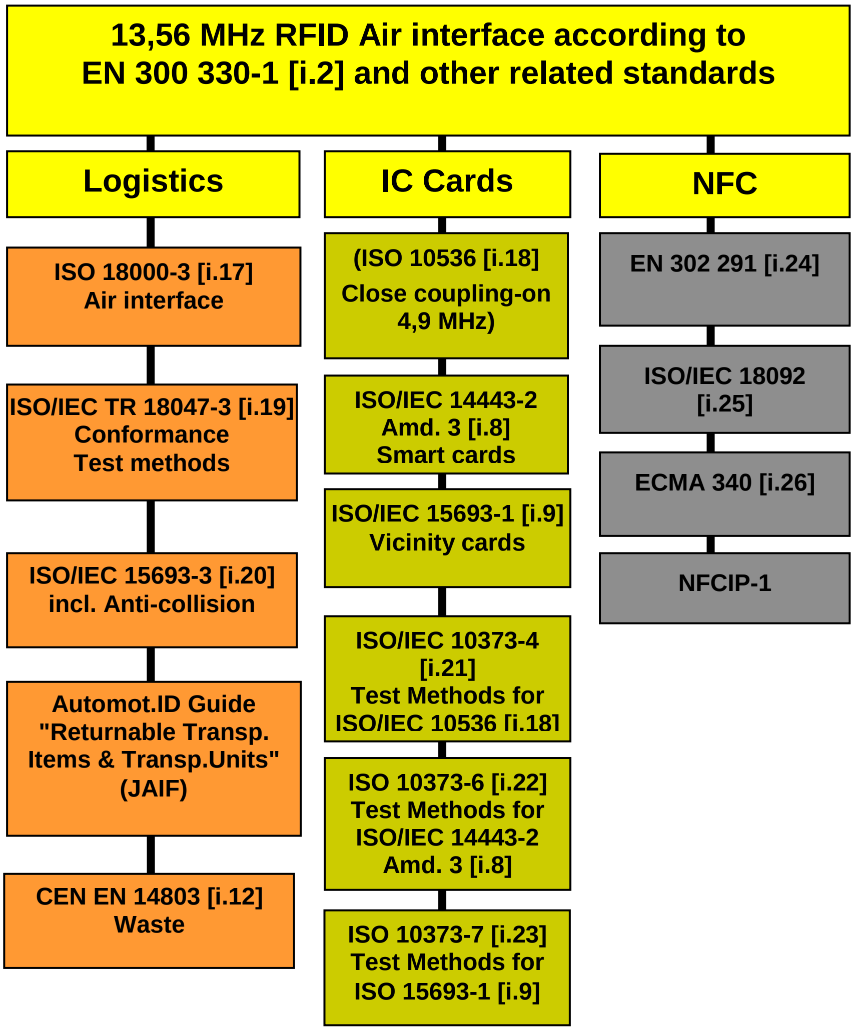


Figure 2: Overview of the 13,56 MHz RFID standard family

The 13,56 MHz RFID standard for logistics (ISO/IEC 18000-3 [i.17]) operates with different modes, recently a mode M3 was added which resembles the Gen2 EPC protocol to provide compatibility on the data protocol level as used in UHF RFID tags.

The ISO standards for logistics and also provides bulk reading of many tags in a given or defined area. This is also inherent to ISO/IEC 15693-1 [i.9]. Bulk reading *(also referred to as anti-collision mechanism)* is not needed for RFID systems operating at low ranges for instance for ISO/IEC 14443-2 Amd. 3 [i.8] smart cards because the low reading distance of a few centimetres provide physical tag differentiation in order to provide privacy.

The NFC family is a data communication device used as high speed data transmission media between different cards, card and terminals, mobile phones i.e. as mobile ticketing, access card, credit cards and other applications requiring very high data speed.

The NFC devices are very flexible; they can function as contactless chip cards as well as a reader device for reading other cards.

Another functionality of NFC is a card to card communication to operate as data link. Depending on the function, NFC cards can have a battery or operate as passive or active RFID devices.

7 Technical information

7.1 Detailed technical description

7.1.1 13,56 MHz Receiver-Reader restrictions due to present regulations

All high volume applications use the re-usable passive tags for low cost, small size, avoiding environmental problems and also for simple design and ease of application reasons.

The regulation for the present modulation emissions (mask) as provided in EN 300 330 [i.2] is too restrictive for new applications. The emitted spectrum widths and the modulation levels have to be modified as proposed by the two new modulation masks:

- For the narrowband and long range applications, passive Radio Frequency Identification systems are unable to use the maximum carrier allowance of 60 dBµA/m for bidirectional passive RFIDs because of modulation sideband restrictions with regard to the needed modulation level. The intended regulation for 13,56 MHz RFIDs of 60 dBµA/m cannot be used.

- For the wideband and very short range passive RFID systems, the present transmitter mask is too narrow to allow most of the listed applications nunder 6.1.

While in technically optimized and "classic" radio communication systems with for instance battery powered tags can operate with low transmitter modulation levels, passive or RF powered tags have to live with a number of compromises and therefore the proposed system provides higher downlink modulation level for operating at the needed long range.

For instance the receiver of passive tags suffers restrictions for the chip design which results in a limited sensitivity of the readers receiver.

The receiver of the RFID reader also has to decode the very low transponder return signal and in presence of the very strong signal which is required to power the tag over the long needed operating range. Additionally the 13,56 MHz systems have to use the same antenna for transmit and receive so decoupling of both signals is not feasible.

As such the system design restrictions and limitations are due to the physically co-located receiver and transmitter which are operating simultaneously and also using the same antenna for receive and transmit. Therefore the system suffers from e.g. carrier phase noise, and blocking effects which require the higher downlink modulation level. In practice the requirement for the reader function a difference between the powering signal and the received tag signal should be below 90 dB to 100 dB for a reliable communication link (see also figure 6).

The simultaneous operation of powering the tag, downlink modulation and real time reception of the tag signal operate as full duplex systems as detailed in figure 3.

7.1.2 Detailed technical description of 13,56 MHz systems

In figure 3 a basic RFID Full Duplex (FD) system *(with regard to Power and Read function)* is explained. The reader signal powers and activates the tag. At the same time the powering signal is ASK modulated to instruct the tag for certain functions like listen for following commands, to receive data to update the tags memory with newer information, or request the tags ID number e.g. for bulk reading situations to receive a serial number of a certain tag in order to be able to call up individual tags.

The binary data as read out from the memory can be transmitted directly or is often encoded for synchronism between TX and RX. The synchronism between the transmitter and the receiver is provided if the receiver clock is derived from the transmitted signal either from the RF signal directly as NRZ (Non-Return-to-Zero) or from an encoded modulation signal as e.g. Manchester or Miller encoding (called self-clocking).

Mostly at LF and HF the clock signal is derived from the carrier frequency. The clock as time base is provided by dividing the frequency by an integer number to provide the synchronism between the transmitted data signal and a clock. In this case the binary signal can be transmitted directly without further encoding. This is called the NRZ which saves transmission bandwidth as compared to e.g. Manchester or MILLER. NRZ encoded signal transmission can speed up the data rate up to a factor 2 or vice versa for a given data rate cut the transmission bandwidth is accordingly lower.

The modulation on the tag and reader side is in most cases ASK or a phase encoded ASK. In absence of own power supply and on board oscillators, tags can only use absorption or damping modulation imposed onto the received (powering) signal thus the tuned circuit.

In this case the received carrier signal is periodically damped according to the encoded modulation. Since periodically damping absorbs energy from the tag, the Manchester encoding can be made more spectrum efficient if e.g. a Miller pulse-pause coding scheme is used where the pauses are made very short compared to the pause or the clock durations.

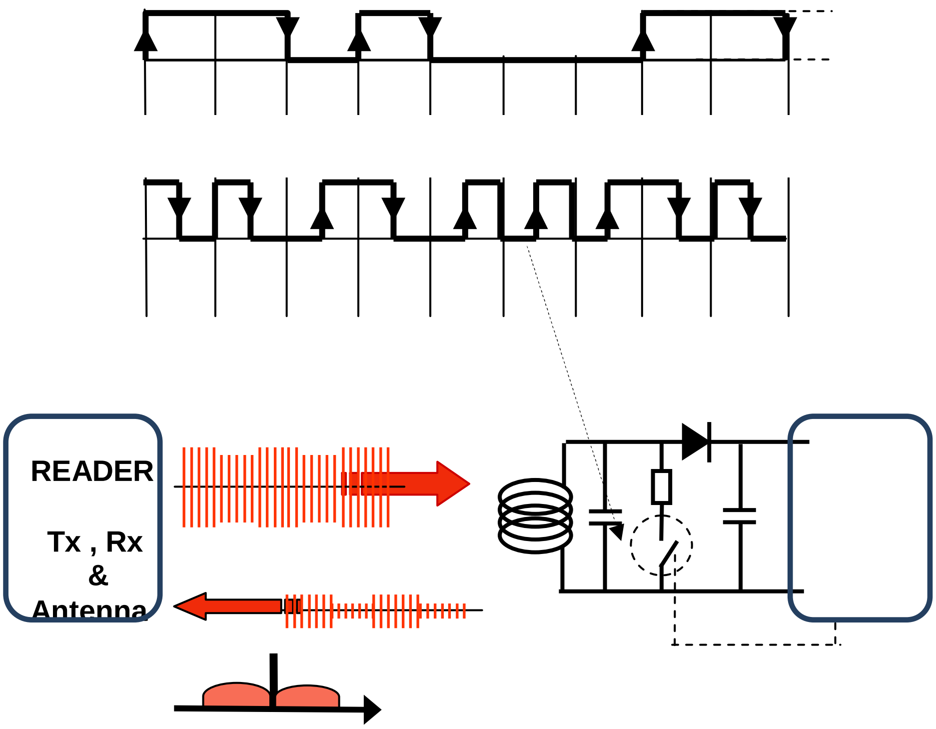


Figure 3: 13,56 MHz Full Duplex RFID system

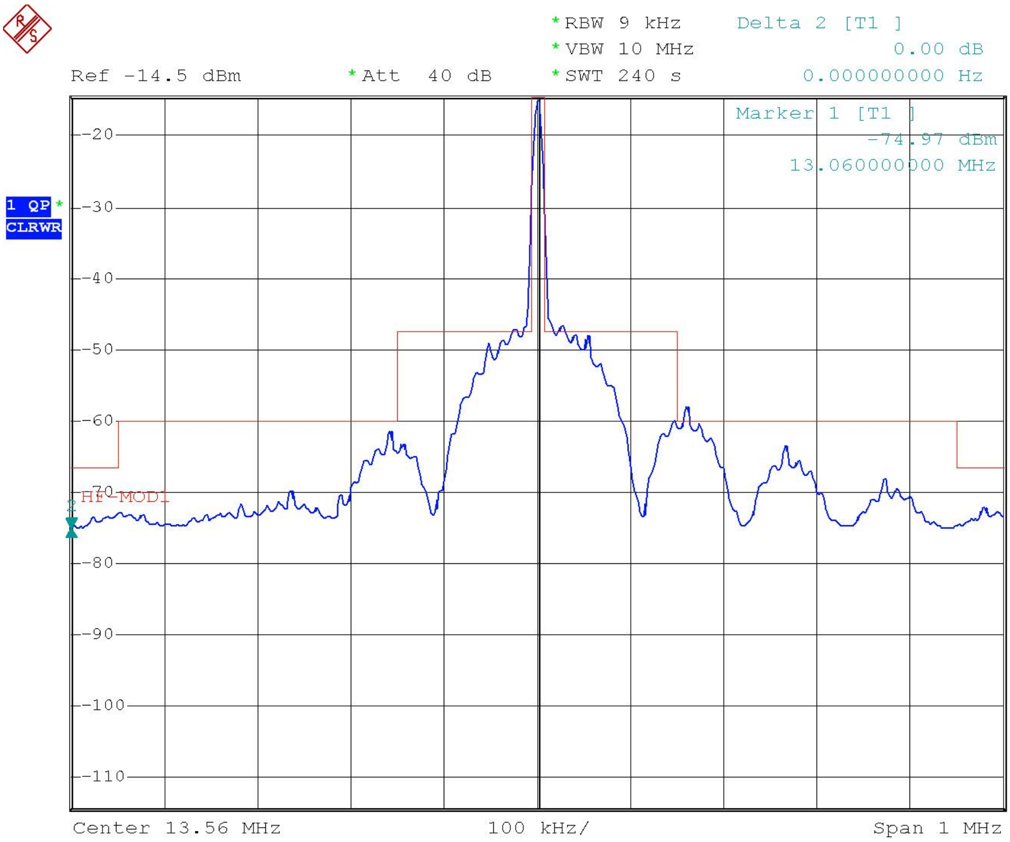
The basic problem addressed in the present document is that the ISO standards ISO/IEC 18000-3 [i.17] and ISO/IEC 15693-1 [i.9] are using a very low modulation index or modulation depth because of regulartory constraints in that the level of the allowed modulation sidebands in relation to the carrier is very low.

The ratio of the modulation to the carrier for reliable bidirectional communication should be in the order of 33 dB as it is defined in the ERC/REC 70-03 [i.10], annex 9 considering the carrier level of 42 dBµA/m measured at d = 10 meter and the associated sideband allowance of 9 dBµA/m.

For the maximum allowed carrier level of 60 dBµA/m the modulation index with the present carrier - sideband emission allowance at a 51 dB lower level is too low and no reliable data transmission from reader to tag is possible.

Therefore 13,56 MHz RFID bidirectional systems and downlink modulation cannot use the 60 dBµA/m level and are restricted to carrier levels in the order of 42 dBµA/m.

Figure 4 displays from a practical measurement a modulated transmitter signal according to the maximum allowed modulation mask just designed to reach the maximum sideband limit of 9 dBµA/m.



ISO Readers are presently limited by the spectrum mask and they cannot use the maximum allowed carrier field strength of 60 dBµA/m.

Figure 4: 13,56 MHz spectrum measurement showing the maximum modulation level according to ERC/REC 70-03 [i.10]

7.2 Status of technical parameters

7.2.1 Allocations in the band 13,36 MHz to 13,76 MHz

Previous investigations of the present document by the ECC have revealed that the emissions in the range 13,36 MHz to 13,76 MHz need to be considered for further studies.

Table 4 lists all services in the range of 13,360 MHz to 13,76 MHz.

Table 4: Allocations of services in the relevant allocations

Frequency Range	Type	Application
13,360 - 13,410 MHz	Fixed, Radio Astronomy	Radio Astronomy, Defence, Railway applications, SRDs,
13,410 - 13,450 MHz	Fixed, Mobile except aeronautical mobile (R)	Defence, SRDs, Railway applications
13,450 - 13,550 MHz	Fixed, Mobile except aeronautical mobile (R)	Defence
13,550 - 13,570 MHz	Fixed, Mobile except aeronautical mobile (R)	Defence.
13,553 - 13,567 MHz	ISM-Band	SRD, RFID
13,570 - 13,600 MHz	Broadcasting, *Footnote, ITU-R Radio Regulations 5.134* [i.30]	Broadcasting, DRM
13,600 - 13,800 MHz	Broadcasting	Broadcasting DRM & AM

7.2.2 Sharing and compatibility studies (if any) already available

Previous ECC studies for inductive systems as defined in ERC/REC 70-03 annex 9 and implemented in EN 300 330 [i.2] have resulted in the transmitter mask as shown in figure 8. This mask has been modified as shown in figures 9 and 10 to allow two major application families.

The following compatibility studies are available:

- The ECC report 67 [i.32] covers the LF and HF range below 30 MHz general field strength levels and has determined generic field strength levels up to 30 MHz which were implemented in ERC/REC 70-03 and in EN 300 330 [i.2].
- ERC Report 74 [i.6] addresses the compatibility of 13,56 MHz RFID systems to radio astronomy receiving stations which operate in the same band. The report was issued in May 1999 after extensive Field tests and studies involving several representative RFID systems from RFID systems suppliers in cooperation with Radio Astronomy experts. The tests were arranged and conducted under the supervision of the French administration ANFR.

  Extensive field tests in report 74 were done in Nancay, where decametric observations are done with an antenna array with a maximum effective aperture of 2 x 4 000 m^2 and is one of the largest astronomy site worldwide for decametric observations in the 13 MHz band [i.6].

  For the compatibility measurements the astronomy receiver at the Nancay site was configured to observe the frequency range from 13 MHz to 14 MHz which covered the carrier frequency as well as the modulation spectrum of the RFID systems which overlaps the astronomy allocation.

  The report reveals that no disturbance was recorded and the fact was that if RFID system is placed inside the astronomy site e.g. on the visitors parking site, and no interference signal from the RFID systems could be detected. This included the emission of the RFID carrier at a level of +42 dBµA/m [i.6].
- The compatibility to the BC service in the range 13,570 MHz to 13,800 MHz was investigated by a BNetzA report The report [i.33] has also analysed the wideband short range and the narrowband long range emission masks. Considering the narrow band long range RFID reader operating according to the TX mask of figure 9, the conclusion was [i.33]:

  > *"The measurements have shown with a remarkable reproducibility that the interfering range of the long range, low bandwidth and low data rate RFID systems making use of the sideband limits according to the newly proposed mask to the adjacent broadcast reception is at most 190 m, under worse case conditions".*

  Secondly considering emission levels according to the wideband short-range type applications using the mask of figure 10 the conclusion was:

  > *"The interference range of the wideband/short range RFID readers is not relevant, regardless of the mask applied".*

7.3 RFID system parameters

A RFID system consists of an interrogator or a reader and one or several tags as data carriers.

The reader emits a carrier signal to power the tags. The threshold of the induced field strength to power the tag is in the order of 80 dBµA/m to just activate the tag. Considering a regulation for instance allowing a field strength limit of 42 dBµA/m at d = 10 m the operating range is about 1 m, which is the intersection of the 80 dBµA/m sensitivity line with the field strength derating line as can be noted from the figure 5. This sensitivity level considers for instance an ISO/IEC 15693-1 [i.9] where a typical antenna size has to fit in a standard card (85,6 mm to 54 mm = tag size).

The derating of the field strength in the near field is given in figure 3. Considering a reader which emits a maximum field strength of 60 dBµA/m (measured at d = 10) meter, the maximum RFID system operating range is about 1,5 m to 2 m which can be realized with the proposed TX mask of figure 9.

The maximum range depends primarily on the efficiency of the tuned circuit (Q) and the size of the antenna coil of the tag for a given field strength level under the ETSI test conditions (EN 300 330-1 [i.2]).

Figure 5 displays the roll-off of the field strength from the reader antenna creating the interrogation field. The intersection of the individual tag threshold level with the roll-of curve determines the maximum reading or powering range of a system.

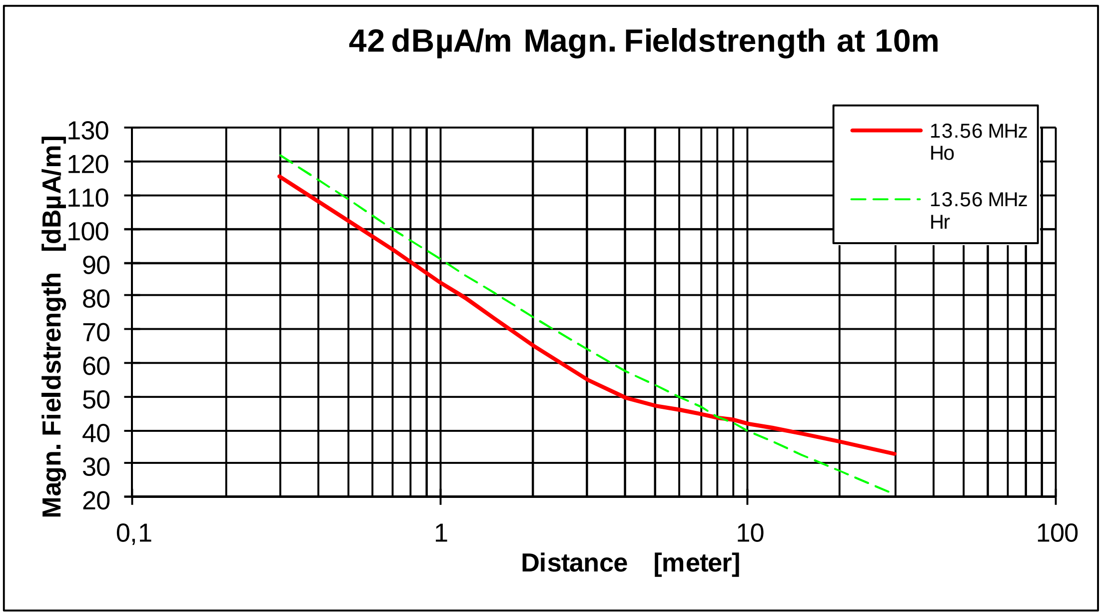


Figure 5: 13,56 MHz field strength derating in the nearfield for coaxial and coplanar position of reader and tag

The downlink transmitter signal is shown in figure 6. A too deep modulation would reduce the reading range because the powering capability is reduced.

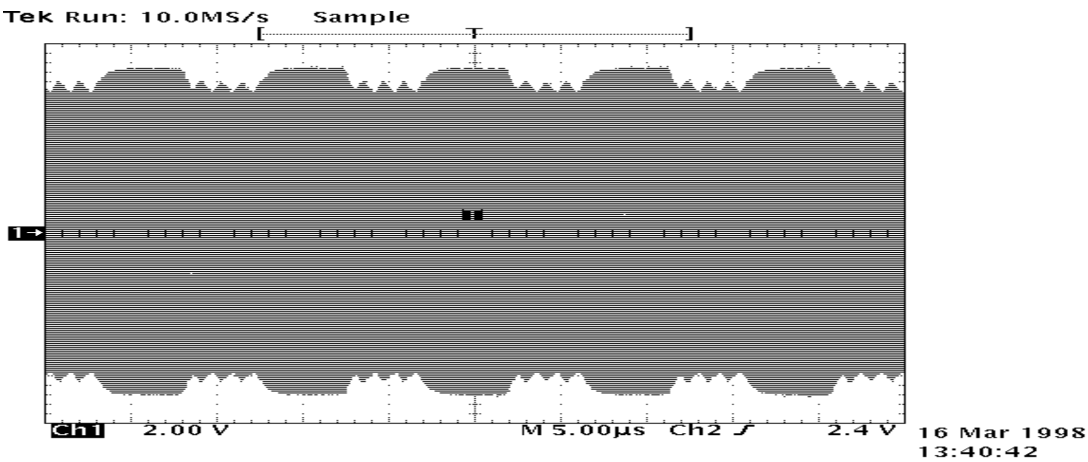


Figure 6: Typical downlink modulation signal (reader to tag)

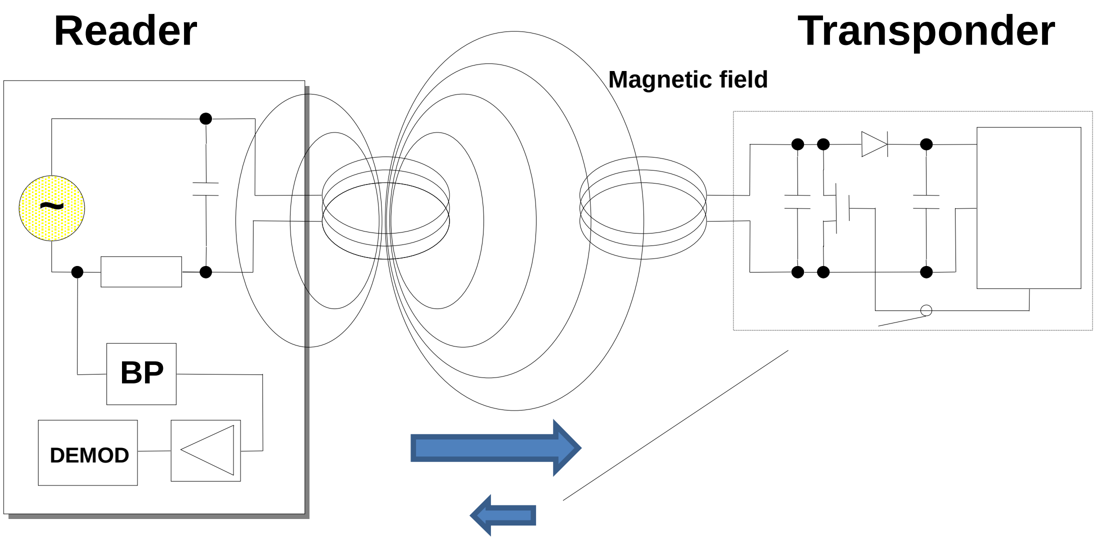


Figure 7: Typical functionality of a 13,56 MHz RFID system

Figure 7 presents a 13,56 MHz system based on inductive technology consisting of reader with receiver and transmitter functions for the reader as well as the transponder.

The receiver input of the reader has to handle a weak transponder or tag return signal with a very low degree of modulation while at the same time the own emitted high carrier level to power the tag is present at the same antenna causing desensitization or blocking effects.

The tag return signal modulation depth is also compromised because a higher (damping) modulation reduces the power for activation of the chip.

These are very demanding conditions for the tags receiver/transmitter so that the chip designers have to deal with several compromises to provide a reliable function for the RFID function.

Figure 8 displays the signal levels at the receiver input.

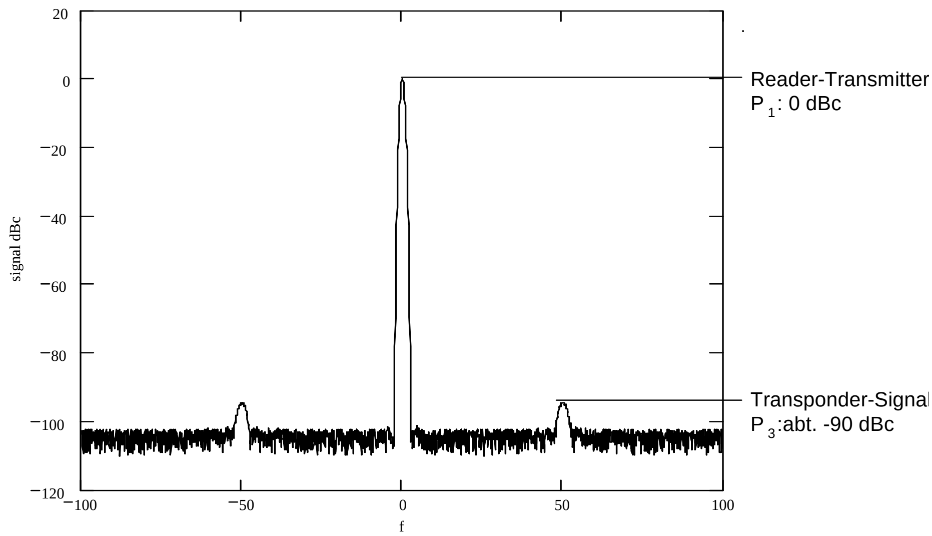


Figure 8: Signal levels at the input of the receiver of the reader

8 Radio spectrum request and justification

8.1 Radio spectrum request for the narrowband/long range RFID mask

As detailed in clause 1.1.1, the present TX RFID mask according to EN 300 330 [i.2] (see figure 11 of the present document) is insufficient to provide a reliable bidirectional data link for 13,56 MHz long range readers operating at carrier levels of 60 dBµA/m which is the defined carrier level in the 13,56 MHz band of ERC/REC 70-03 (see Annex 9, range f1).

The requested narrowband mask of figure 9 indicates an increase of the first level of modulation from 9 dBµA/m to 27 dBµA/m for a range of ±100 kHz close to the carrier and sloping down by 30,5 dB to ±200 kHz from 27 dBµA/m to a level -3,5 dBµA/m. The third modulation emission level starts at 450 kHz and is attenuated down to -5 dBµA/m.

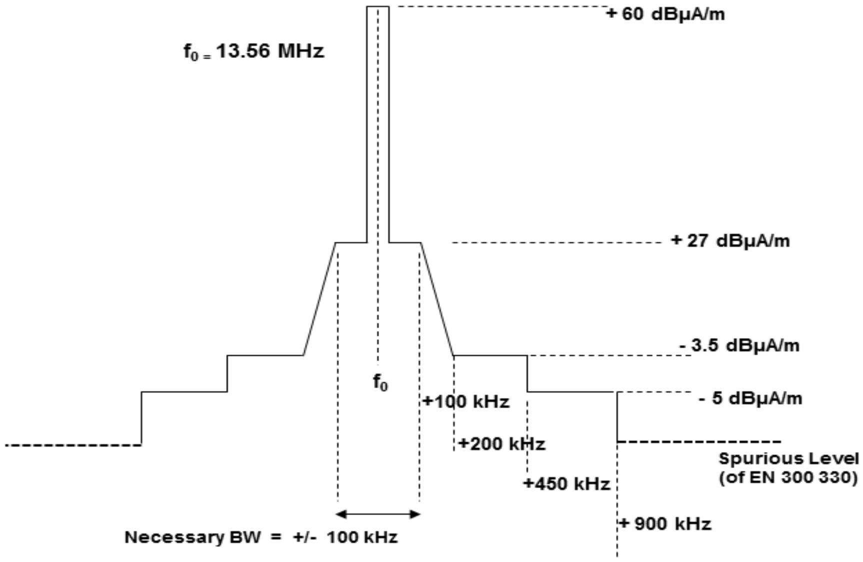


Figure 9: Emitted spectrum of a narrowband/long range 13,56 MHz reader

8.1.1 Justification for the narrowband/long range reader RFID mask

Clauses 6.1 and 7.2.2 list all applications and categorizes them into the two required emission masks.

The evolution of the 13,56 MHz RFID technology over the last years went in two directions:

a) Long operation range.

b) Increased reading speed.

The longer operating range comes along with activating a large number of tags simultaneously. In order to avoid "self pollution" with many tags in the reader area, an algorithm for singulation and individual addressing of the tags is required and in turn requires higher data speed which is only feasible with the proposed mask. This feature of handling many tags in a given activation area, is known as Bulk Reading which is a requirement if the read range of RFID systems is increased.

For example the present modulation mask of figure 11 only allows the identification of a maximum number of tags within 1 second of only 30. The new mask according to figure 9 can increase the read speed from 30 tags to 800 tags per second thus enabling bulk reading of a large number of tags within a short time as for instance in the apparel manufacturing and laundry services.

The benefits of system improvements and savings by the proposed new mask of figure 9 in the industrial area are summarized in table 1. For instance the productivity increase is between 10 % and 100 % while the throughput times decrease between 40 % and 90 %. Inventories as well as overtime decreased up to 90 %. Other improvements such as safety related injuries as well as product development cycles decreased up to 50 % and 30 % respectively.

To meet the market needs of longer operating range and sufficient reading speed, a higher sideband modulation level within the first 100 kHz from the carrier is required as shown in figure 9.

For the compatibility assessment it should be noted that the market size for systems deploying the narrowband mask is relatively small compared to the wideband applications and systems are mainly positioned in sites which are less critical for potentially causing interference to other services.

The market for narrowband/long range reader systems represents about 3 % of the total market covered by the present document.

The proposed mask enables the operation of RFID systems which are covered by ISO/IEC 15693-1 [i.9] and ISO/IEC 18000-3 [i.17].

8.2 Radio spectrum request for the wideband/short range reader RFID mask

The present TX RFID mask (see figure 11) is limiting the bandwidth to ±900 kHz while new wideband applications require ±7 MHz (see also clause 5.1 Current situation).

The modulation emissions according to the mask of figure 10 expands the modulation range beyond ±900 kHz up to ±7 MHz but are in conformance with the present mask of figure 11 for the limits up to ±900 kHz.

The extended range up to ±7 MHz is allowed in the range i2 of the ERC/REC 70-03 annex 9 for a level up to - 20 dBµA/m which is met by the proposed mask of figure 10.

This high speed is realized by providing a high clock frequency hence data rates where the carrier of 13,56 MHz is divided by 2 to create the clock of 6,8 MHz.

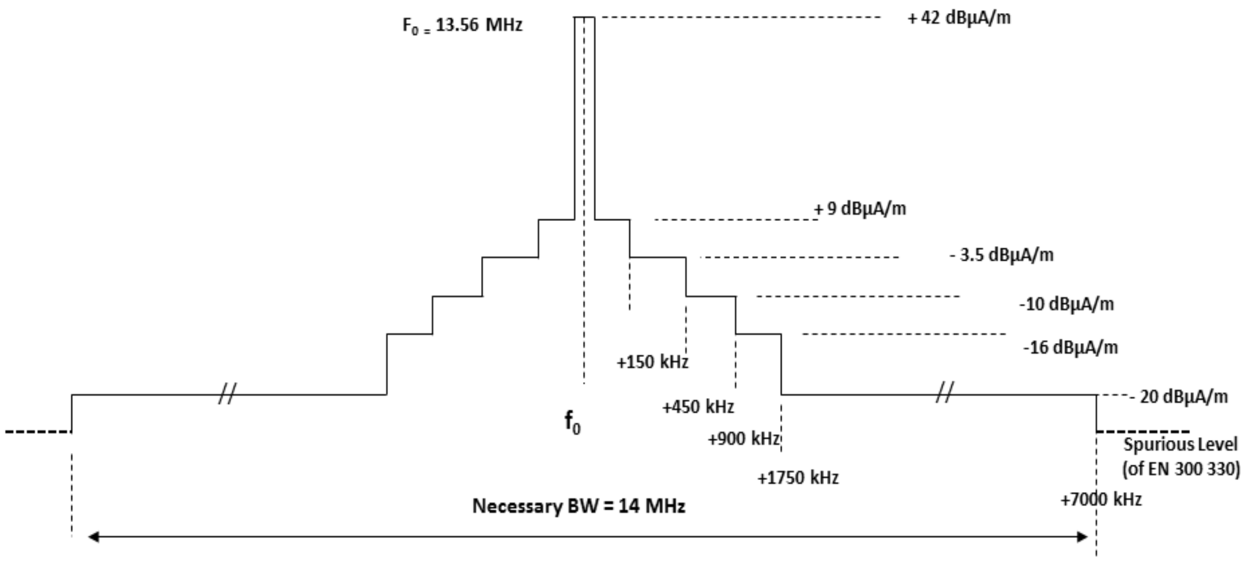


Figure 10: Emitted spectrum of a wideband/short range 13,56 MHz reader

8.2.1 Justification for the wideband/short range reader RFID mask

For the spectrum request of clause 8.2, a higher data speed is needed which is enabled by the proposed spectrum extension up to ±7 MHz. The new amended ISO/IEC 14443-2 Amd. 3 [i.8] requires data rates of up to 6,8 Mbit/s respectively 27 Mbit/s depending whether ASK or PSK modulation for the individual application is used.

The high data speed is used because of the introduction of the global ISO/IEC 14443 [i.8] standard amendment for applications like E-Pass, NFC, Payment Systems and all other applications listed under clause 6.1.

These applications are coping with high security protocols for privacy as well as to deal with inherently high up- and downlink data transmission speeds for instance in case of controlling e-Passports at border crossings, e.g. the picture of a person stored in the chip of the passport has to be presented almost instantaneously.

The extended bandwidth therefore enables fast security algorithms and transmission speeds which are primarily needed to meet privacy requirements as described in the EC mandate M436 [i.35].

The present mask as per figure 11 does not allow the introduction of the required safety and security features as requested by the recent EC mandate M436 [i.35] (see also clause 5.1 Current situation). These authentication and crypto functions are presently not feasible with bidirectional communication.

9 Regulations

9.1 Current regulations

The present regulation is given in the ERC/REC 70-03 [i.10], annex 9 is given in table 5 and also by the figure 11 of the EN 300 330 [i.2]. The modulation mask has been previously implemented in the annex 9 around 2006 after compatibility studies.

Subsequently the modulation mask of figure 11 was implemented also in the EN 300 330 [i.2] under the MOU CEPT/ECC and ETSI.

Later the Commission has communicated to the ECC that technical specifications should be removed from ECC documents to ETSI harmonized standard which represents the present status. This was also noted by a LS from ETSI_ERM to CEPT/ECC-WGSE on 2012-11-07 [i.34].

Table 5: Current regulation (as given in the ERC/REC 70-03 [i.10], annex 9)

f	13,553 MHz - 13,567 MHz	42 dBμA/m at 10 m	No requirement	No spacing	
f1	13,553 MHz - 13,567 MHz	60 dBμA/m at 10 m	No requirement	No spacing	For RFID and EAS only

The transmitter mask of figure 11 has been previously released by the ECC and published in a former version of the ERC/REC 70-03 in annex 9 until the EC requested the ECC to transfer the transmitter mask to the EN 300 330 [i.2].

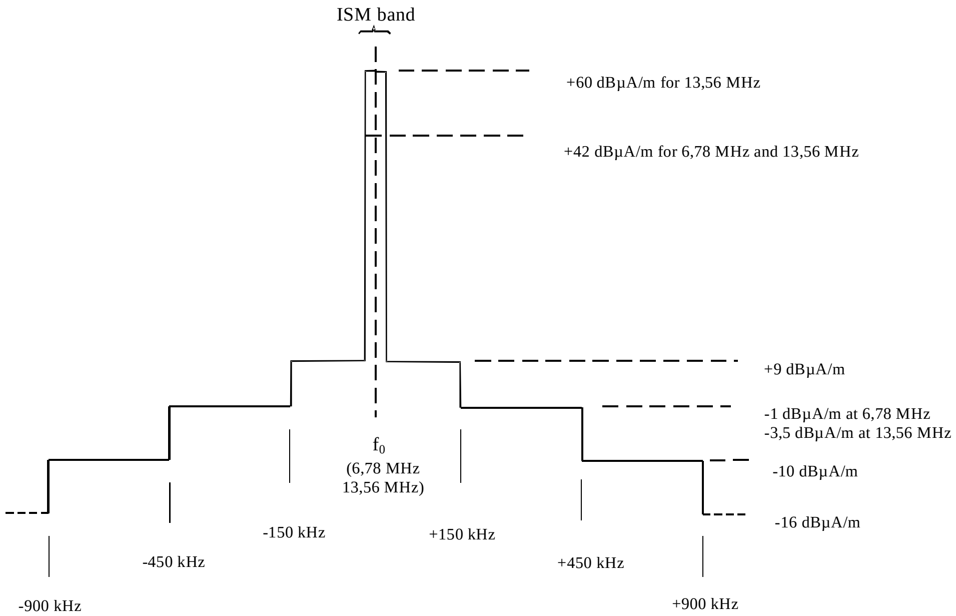


Figure 11: Current regulation as given in the normative annex G of the EN 300 330 [i.2]

9.2 Proposed regulation

The proposed regulations are given in the transmitter masks of figures 9 and 10.

9.3 Requested ECC and EC actions

9.3.1 Requested ECC studies

The ECC is requested to consider the emissions according to figure 9 for compatibility to services in the frequency range of 13,36 MHz to 13,76 MHz considering the following documents:

- ERC report 67, Compatibility study for generic limits for the emission levels of inductive SRDs below 30 MHz [i.32].
- RFID report BNetzA: Measurements to characterize HF RFID signals and to determine the interference to the HF broadcast service: M66_17R0_SE24_at_13MHz_Test_Report [i.33].
- Liaison statement from ETSI_ERM to ECC WGSE #63 dated 2012-11-07, Doc. ECC/SE(13)016 [i.34].
- ECC Report 74: Compatibility between radio frequency identification devices (rfid), and the radioastronomy service at 13 MHz [i.6].
- Summary for the 13,56 MHz RFID Measurement campaign (for BC): M66_28R1_SE24_13 MHz_RFID_Summary Proposal [i.36].
- Liaison statement from ECC WGSE to ETSI_ERM: SE(13)049A20_LS to ETSI TC ERM on TR 103 059 for RFID 13,56 MHz.doc [i.37].

9.3.2 Requested ECC regulatory actions

- Conduct studies and an amendment of the ERC/REC 70-03 [i.10], annex 9 for considering the proposed emissions of the transmitter mask of figures 10 and 11.
- To consider the results of the ERC/REC 70-03 [i.10] amendment for the next amendment of the EC SRD Decision.

9.3.3 Requested EC regulatory actions

Amendment of the SRD Commission Decision 2006/771/EC [i.39] considering the upcoming ECC report for the annual update of the Commission Decision.

Annex A: Detailed market information

A.1 Applications

The list of applications covers a wide range of markets ranging from logistics and materials handling, Ticketing in mass transportation, payment systems, smart cards, e-Passport, mass transportation tickets, libraries and books, book handling, ecology related applications, waste management, item level tagging, manufacturing control, automatic display of information to purchase items in warehouses, medical applications in identifying equipment, medical/hospital process steps, monitoring, inventory audit, asset monitoring and maintenance, where mostly fixed and high value assets are tagged to store information, tagging in the apparel manufacturing and laundry services for industrial and private use, item flow control in processes, authentication to provide secure identification mechanisms for persons and objects; access control.

The 13,56 MHz applications have been proven and are used in established markets, running in high volume.

A.2 Evolution and outlook of the 13,56 MHz RFID market

The HF RFIDs are predominantly using 13,56 MHz. Some applications in the early days of RFID were using systems at 27 MHz or 6,78 MHz. These as well as the first 13,56 MHz systems were found in standalone or closed systems for specific application.

With the proliferation of systems, the logistics and interfacing and penetration of global markets only 13,56 MHz systems are deployed. The 13,56 MHz RFID technology is covered by various global and regional standards are the basis for worldwide acceptance of the 13,56 MHz RFIDs.

13,56 MHz is presently the most important frequency band for RFID in terms of value as well as in volume shipments of tags and systems.

Many new markets for passive RFID, from RFID enabled phones such as NFC, to financial cards, national ID cards, passports and tickets in addition to a significant number of the new smart active labels are operating at HF. Many applications, which were typically met with LF RFID such as secure access and tagging metallic items, are moving to 13,56 MHz.

The market prediction from market researchers assesses the global market for 13,56 MHz RFID will triple from $2,9 billion in 2008 to $8,6 billion in 2018. [i.13], notably exceeding UHF passive RFID for some time to come.

In 2007, 50 % of the global RFID market value was on 13,56 MHz established and from an earlier forecast [i.14] the figure A.1 provides a former market assessment, evolution or trend and the ratio of tags shipped for the years 2000 to 2005. Considering the present situation, this volume has been exceeded by factors.

Considering the figure A.1, - although showing past years - the ratio of tags by frequency is still representing the current distribution of RFID systems per frequency range and secondly the much steeper trend of the 13,56 MHz penetration is still valid.

Especially in view of the actual and forecasts of new technologies, some estimations expect x-times the volume and expenditures spent on 13,56 MHz as compared to any other frequency.

The 13,56 MHz dominance has been retained as RFID entered a phase of rapid growth in the last two years mainly because of the e-passport, now issued by over 70 countries, financial cards such as the MasterCard Paypass®, e-Pass® and driver licences. Furthermore the printed electronic technology is progressing and expectations are that it can be made available within the next 5 + years. This is feasible at 13,56 MHz but printed technology is not likely to occur at UHF so that the HF tags will be significantly lower in cost and multiplying the market figures [i.7], [i.15] and [i.16].

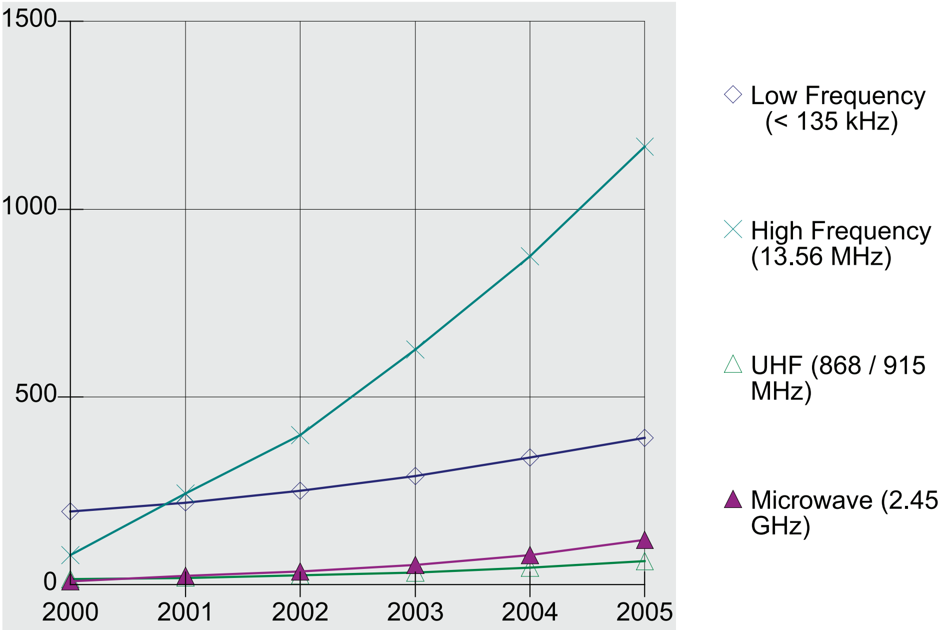


Figure A.1: Distribution and evolution of RFID systems

Annex B: Technical information

B.1 Technical description

B.1.1 Rationale and design considerations and for 13,56 MHz systems

Considering inductive RFID systems below 30 MHz, the only options considering the radio regulations for SRDs are at LF, 6,78 MHz, 13,56 MHz and 27 MHz bands. The powering efficiency is the highest at 6,78 MHz to 13,56 MHz considering normalized conditions for the test such as constant excitation field strength for all frequencies and effective sizes of the tag antennas.

Since 6,78 MHz is an ISM band but requires special authorization by individual national administrations therefore it is not harmonized, while 13,56 MHz is an ISM band and available for SRDs therefore is a globally harmonized band. Consequently the industry has favoured the 13,56 MHz band for RFIDs and the international RFID standards.

Considering a constant field strength of e.g. 105 dBµA/m the operating range of comparable reader and tag antenna sizes has its maximum around f = 10 MHz e.g. ISO/IEC 15693-1 [i.9] which assures the highest powering efficiency for 13,56 MHz systems. Figure B.1 shows the powering efficiency as a function of frequency highlighting the potential ISM/SRD bands.

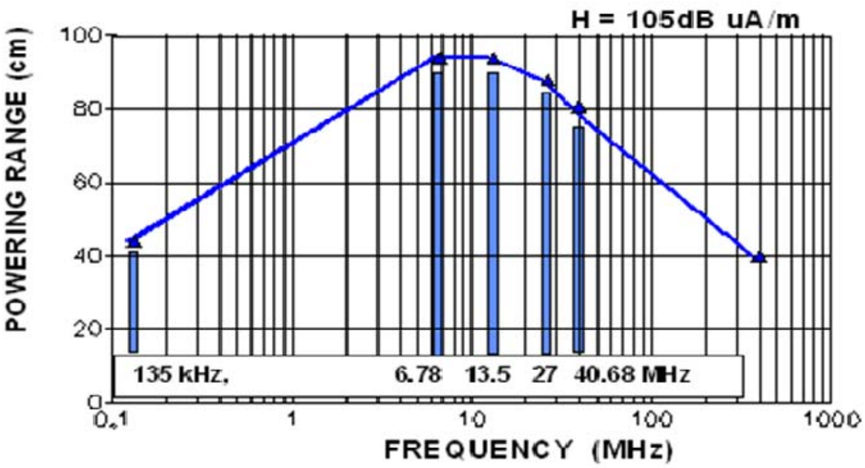


Figure B.1: Comparison of powering efficiency for RFID systems at available LF and RF frequencies for SRDs

B.1.2 System functions

Clauses 7.1.2, 7.3 and figures 5, 6 and 7 are describing the basic system functions and the main system relevant issues.

B.2 Technical justifications for spectrum

B.2.1 Power and frequency issues

As noted in clause 7.1.1 the powering level of 60 dBµA/m is required for more sophisticated bidirectional RFID systems to meet the market demands. However for the allowed carrier the level of 60 dBµA/m, the present modulation regulation with 9 dBµA/m is too low because the modulation sideband are not allowing downlink function because such a low level of modulation relative to the high carrier cannot be detected by the tags.

The passive tags have a number of restrictions to reliably detect such low modulation levels (see also clause 7.1.1).

Regarding the frequency issue, the required RFID mask for proper system functioning is explained and defined in clause 8.

B.3 Technical standards for RFID

ISO technical standards are application oriented and ISO has different sections which engage in the creation of RFID standards for global use.

At present 3 sections under the ISO, IEC and the Joint Technical Committee (JTC1) are active in the standardization of RFID systems and in the definition of measurement parameters as well as the definition of performance and conformance of RFID systems.

The ISO/IEC JTC1 with its SC31 Committees SC31 and SC17 defines the 13,56 MHz RFID relevant are RFID standards.

Figure B.2 shows the standardization bodies relating to RFID functions within ISO/IEC.

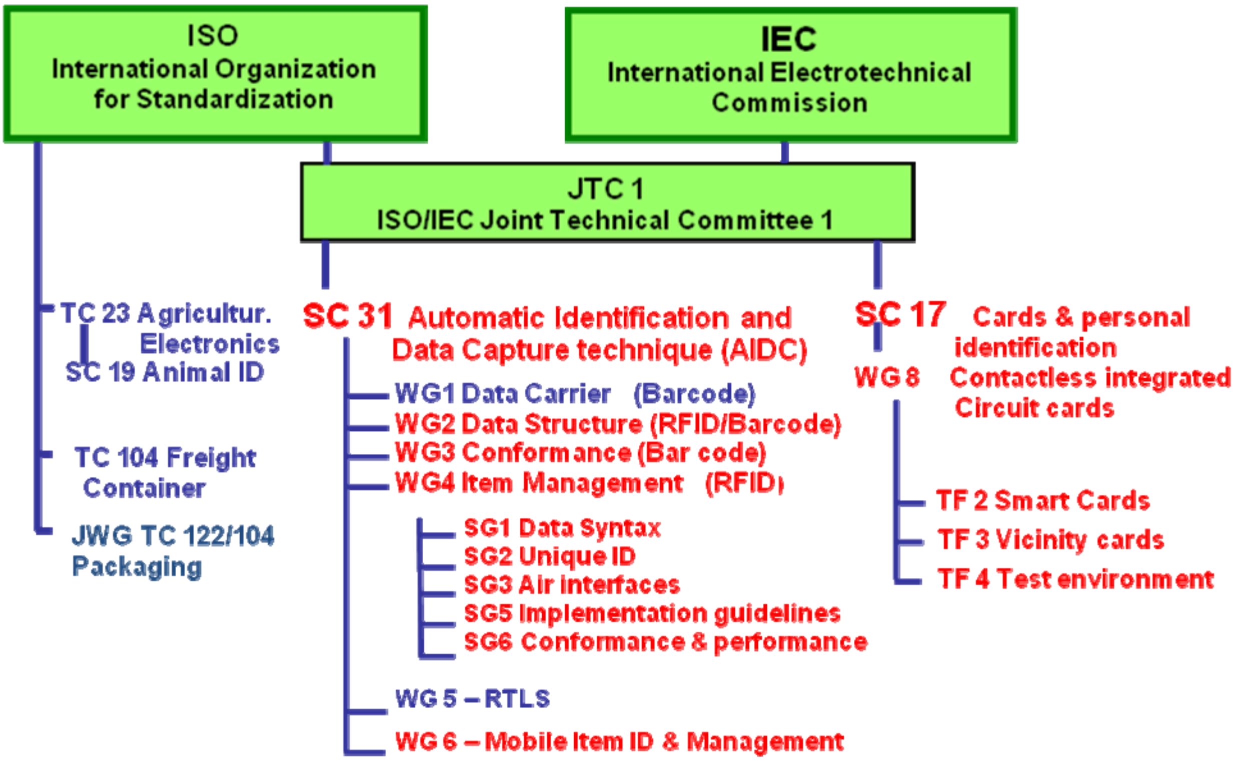


Figure B.2: overview over 13,56 MHz RFID standardization activities in ISO/IEC highlighting bodies engaged with 13,56 MHz RFID systems in red

Table B.1 lists the relevant ISO standards for air interface RFID related standards for the 13 MHz frequency band.

Table B.1: ISO RFID relevant ISO standards for the 13,56 MHz band

18000	**Air Interface**
ISO/IEC18000-1 [i.29]	Reference architecture and definition of parameters to be standardized
18000-1 R1	Reference architecture and definition of parameters to be standardized - Revision
ISO/IEC 18000-3 [i.17]	**Air interface at 13,56 MHz** - Mode 1 based on ISO/IEC 15693-1 [i.9], 2 speeds 26 kB & 52 kB - Mode 2 high speed interface, 424 kB, 8 return channels! Both modes are **not** interoperable (Magellan technology)
18000-3 R1	Revision 1 (Batteries & sensors)
18000-3 R2	Revision 2 (Mode 3) - *Rev to meet EPC global, Gen 2 Protocol*
ISO/IEC TR 18001 [i.27]	**Application Requirements Profiles**
ISO/IEC 18046 [i.28]	Radio frequency identification device performance test methods
ISO/IEC 18046-1 [i.28]	Radio frequency identification device performance test methods - Part 1: Test methods for system performance
ISO/IEC 18046-2 [i.28]	Radio frequency identification device performance test methods - Part 2: Test methods for interrogator performance
ISO/IEC 18046-3 [i.28]	Radio frequency identification device performance test methods - Part 3: Test methods for tag performance
ISO/IEC 14443-2 Amd. 3 [i.8]	Identification cards - Contactless integrated circuit(s) cards - Proximity cards Part 1: Physical characteristics
ISO/IEC 15693-1 [i.9]	Information technology - Radio frequency identification for item management - Unique identification for RF tags

Annex C: Bibliography

- A breakthrough RFID printing technology that enables direct encoding to and printing of small RFID tags. "Measuring Lean benefits using Radio Frequency Identification (RFID) technology".

NOTE: Available at: http://www.rfidinfo.jp/whitepaper/381.pdf.

- RFI Mitigation workshop, Bonn, March 28. 30 2001: "New generation of robust receivers at Nançay Radioastronomy Observatory".

- ISO/IEC TR 18001: "Information technology -- Radio frequency identification for item management -- Application requirements profiles".

- EFIS (ECO Frequency Information System).

NOTE http://www.efis.dk/views2/search-allocations.jsp.

History

Document history		
V1.1.1	March 2012	Publication
V1.2.1	November 2013	Publication