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Technical Report

Electromagnetic compatibility and Radio spectrum Matters (ERM); System Reference Document for revised spectrum requirements for RFID equipment and inductive loop systems operating in the frequency range of 9 kHz to 148,5 kHz

Reference

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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

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Contents

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Foreword

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

The present document includes necessary information to support the co-operation under the MoU between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Postal and Telecommunications Administrations (CEPT).

The present document covers RFID and SRD applications in the LF range of 9 kHz to 148,5 kHz as covered by the ERC/REC 70-03 [i.1].

Introduction

The market for inductive devices and in particular RFID and Electronic Article Surveillance (EAS systems have grown strong with steady growth in many markets).

- Especially RFIDs operating in the LF range are essential technologies in daily life and the well functioning of industrial processes. RFIDs e.g. are used in the automotive industry, access control, waste management and animal ID and many other areas.

- EAS anti-theft systems are the only real protection against theft in shops, mega-stores, supermarkets etc. The market growth for EAS tags has increased due to a more wide open European market including free travel of the European population.

The ERC/REC 70-03 [i.1] noted in support of the requested changes:

"The pattern of radio use is not static. It is continuously evolving to reflect the many changes that are taking place in the radio environment; particularly in the field of technology. Spectrum allocations must reflect these changes and the position set out in this Recommendation is therefore subject to continuous review."

It should be noted that the band from 9 kHz to 148,5 kHz is frequently used by active implantable medical implant devices and other SRDs which are also rapidly expanding. The RFID and EAS manufacturers should take measures to avoid or minimize interference to active medical implants and other SRD devices operating in the same bands. Guidance relative to active implantable medical devices is available in standard ANSI/AAMI PC69 [i.17], ISO 14708-3 [i.18], and ISO 14708-4 [i.19].

Given the above developments in the market, the present document has been prepared to make proposals which would lead to harmonized European spectrum for these applications.

The present document proposes:

a) a RFID mask which limits the RFID operation to the range of 105,5 kHz to 148,5 kHz. The emission level is reduced from 42 dBµA/m to 15 dBµA/m below 105,5 kHz. The maximum emission limits of the RFID carriers from 119 kHz to 135 kHz are nearly identical to the annex 9 limits of the ERC/REC 70-03 [i.1];

b) for EAS systems the range of 80 kHz to 90 kHz with the same level as the RFID devices.

Status of the pre-approval draft

The present document was approved by TG28.

Target version	Pre-approval date version				
V1.1.1	**A**	**s**	**m**	**Date**	**Description**
V1.1.1		0.0.1		May 7th 85 2008	First draft for review and approval in TG28 #20
V1.1.1		0.0.2		May 14th 2008	document approved by TG28 for submission to approval in ERM_35
V1.1.1		0.0.3		June 26, 2008	Mini ETSI internal enquiry version
V1.1.1		0.0.4		August 8th, 2008	Consideration of comments from MinEA, Medtronic and additional clarifications by the rapporteur
V1.1.1		0.0.5		August 20, 2008	Minor editorials done
V1.1.1		0.0.6		August 22, 2008	Minor editorials done to match the contents of ERC/REC 70-03 [i.1]
V1.1.1		0.0.7		August 25, 2008	Clean version with heading style corrected to match ETSI skeleton document guidelines. Document submitted for approval for publication and to CEPT for consideration
V1.1.1		0.0.8		Sept. 17th 2008	According to the review during TG28_21, minor clarifications of calculated fieldstrength levels section 5.1.3, 6.2.1 and Annex B were made *(Changes are in the order of fractions of a dB).*

1 Scope

The present document describes the status of the RFID and EAS developments in the LF environment and identifies needed amendments to the annex 9 of the ERC/REC 70-03 [i.1] as well as in the ETSI generic standard EN 300 330 [i.4] (see clause 9).

The present document applies to radio systems and specifically inductive SRDs. As presently covered by the ERC/REC 70-03 [i.1], annex 9 relating to the use of short-range devices. It reviews the present regulations for inductive RFIDs, EAS systems, the related markets and the evolution of the technology in the LF bands. On the other hand changes in the present status of primary services in the LF range are also analysed in view of the proposed changes.

The present document is related to the Commission Decision 2006/771/EC [**Error! Reference source not found.**] on the harmonization of the radio spectrum use by short-range devices and the CEPT Report 14 [i.2] to the European Commission in response to the second SRD mandate [**Error! Reference source not found.**]. It is proposed to amend these documents accordingly.

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

- Detailed market information (annex A).
- Technical information (annex B).
- Expected compatibility issues (annex C).

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

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2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

Not applicable.

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area**.** For non-specific references, the latest version of the referenced document (including any amendments) applies.

[i.1] CEPT ERC/REC 70-03 relating to the use of Short Range Devices (SRD).

NOTE: Available at http://www.ero.dk

[i.2] CEPT Report 14 (July 2006): "Develop a strategy to improve the effectiveness and flexibility of spectrum "The RFID Revolution: Your voice on the Challenges, Opportunities and Threats".

NOTE: Available at http://ec.europa.eu/infomation-society/policy/rfid/doc/rfidswp-en.pdf.

[i.3] Commission Decision 2008/432/EC of 3 May 2008 amending Decision 2006/771/EC on harmonisation of the radio spectrum for use by short-range devices".

[i.4] ETSI EN 300 330 (all parts): "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".

[i.5] ISO 14223-2: "Radio Frequency Identification of Animals - Advanced Transponders - Part 2: Code and Command Structure".

[i.6] ISO 14223-1: "Radio Frequency Identification of Animals - Advanced Transponders - Part 1: Air interface".

[i.7] ISO 18000-2: "Information technology - Radiofrequency identification for item management - Part 2: Parameters for air interface communications below 135 kHz".

[i.8] ISO 11785: "Radio frequency identification of Animals - Technical concept".

[i.9] CEN prEN 14803: "Identification and/or determination of the quantity of waste".

[i.10] ITU-R Recommendation SM.1538: "Technical and operating parameters and spectrum requirements for short-range radiocommunication devices".

[i.11] Directive 1999/5 of the European Parliament and of the Council on radio equipment and telecommunication terminal equipment and the mutual recognition of conformity (R&TTE Directive).

[i.12] DECCA NAVIGATOR - CHAIN DESCRIPTION

NOTE: Available at http://www.jproc.ca/hyperbolic/decca-chains.html.

[i.13] ITU-R Recommendation P.372: "Radio noise". .

[i.14] ERC Report 44 (January 1997): "Sharing between inductive systems and radiocommunication systems in the band 9 - 135 kHz".

[i.15] ERC Report 69 (February 1999): "Propagation model and interference range calculations for inductive systems 10 kHz - 30 MHz".

[i.16] ECC Report 7 (February 2002): "Compatibility between inductive LF RFID systems and radio communication systems in the frequency range 135 kHz - 148 kHz".

[i.17] ANSI/AAMI PC69: "Active implantable medical devices - Electromagnetic compatibility - EMC test protocols for implantable cardiac pacemakers and implantable cardioverter defibrillators".

[i.18] ISO 14708-3: "Implants for surgery - Active implantable medical devices - Part 3: Implantable neurostimulators".

[i.19] ISO 14708-4: "Implants for surgery - Active implantable medical devices - Part 4: Implantable infusion pumps".

[i.20] ERC/DEC(01)13: "ERC Decision of 12 March 2001on harmonised frequencies, technical characteristics and exemption from individual licensing of Short Range Devices used for inductive applications operating in the frequency bands 9 - 59.750 kHz, 59.750 - 60.250 kHz 60.250 - 70 kHz, 70 - 119 kHz, 119 - 135 kHz".

[i.21] Commission Decision 2006/771/EC of 9 November 2006 on harmonisation of the radio spectrum for use by short-range device.

3 Definitions, symbols and abbreviations

3.1 Definitions

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

duty cycle: defined as the ratio, expressed as a percentage, of the maximum transmitter "on" time on one carrier frequency, relative to a one hour period

NOTE: For specific applications with very low duty cycles and very short periods of transmissions, the definition of duty cycle should be subject to study.

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

NOTE: SRDs use either integral, dedicated or external antennas and all modes of modulation can be permitted subject to relevant standards. SRDs are normally "license exempt".

Tag, Transponder: device that responds to an interrogation signal.

3.2 Symbols

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

E electrical field strength
f frequency
H magnetic field strength
P power
d distance
t time
λ wavelength

3.3 Abbreviations

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

CEPT Conference of Post and Telecommunications administrations
DC Duty Cycle
EAS Electronic Article Surveillance

NOTE: Also named Anti-theft system.

EC European Commission
ECC Electronic Communications Committee
EFIS European Frequency Information System
ERM Electromagnetic compatibility and Radio spectrum Matters
EU European Union
FM ???
GPS Global Position System
ILS Instrument Low-approach System
LF Low Frequency

RFID Radio Frequency IDentification
WGFM Working Group Frequency Management

4 Comments on the System Reference Document

Comments from MinEA and Medtronic have been received. These comments from MinEA and Medtronic have been included.

5 Executive Summary

5.1 Background information

5.1.1 General remarks

The present document applies to the ERC/REC 70-03 [i.1], annex 9 in the LF range of 9 kHz to 148,5 kHz with a view to amend the annex 9 in order to meet the evolving market requirements.

The review of annex 9 is subject to frequency ranges in two areas

a) LF RFIDs in the range of 105,5 kHz to 148,5 kHz; and

b) EAS systems in the range of 80 kHz to 90 kHz.

Decision 2008/432/EC, Amendment to the Commission Decision of May 23rd, 2008 2006/771/EC [**Error! Reference source not found.**] on harmonization of the radio frequency spectrum for use by short-range devices is recommended.

5.1.2 LF RFIDs in the range of 105,5 kHz to 148,5 kHz

5.1.2.1 Significance of the LF RFID technology and markets

Among all RFIDs the LF type present the very first RFID technology. LF RFID has been developed in the early 80s. From 1990 onwards RFIDs were already deployed in high volume in various markets as car immobilizers, livestock, access control, laundry, security and personal identification, ski pass, environmental and waste management, door locks, manufacturing control, parking control and many other applications. This market development is reflected in a number of ISO and other industry standards which have been published for such applications [i.5], [i.6], [i.7], [i.8], [i.9] and [i.16].

Especially the automotive industry has reached a high penetration in a number of applications. One of the applications are the car key and access technology which has significantly reduced the number of stolen cars.

Among all RFID technologies they still represent the majority of implemented RFID applications and represent one of the highest running rates and business turnover with continued growth [**Error! Reference source not found.**].

Additionally, the LF RFID frequencies enjoy global harmonization and can be deployed in all three ITU-R regions without frequency or emission level restrictions, thanks to ISO and industry initiatives [i.10].

5.1.2.2 Certification problems for SRDs relating to the annex 9 of the ERC/REC 70-03

LF RFID operation overlaps the three different frequency bands "c", "c1" and "c2" and the EN 300 330 [i.4] has no defined transmission mask for LF RFIDs, This leads to certification problems. The test house certification process (and RTTE Class 1 [i.22]) ask for the definition of the permitted frequency range including the used modulation bandwidth. Further according to the EN 300 330 [i.4], The permitted frequency range and bandwidth is requested to be stated by the supplier.The ERC/REC 70-03 [i.1], annex 9 for RFID defines the frequency range for LF RFID devices ambiguously and insufficiently. The frequency range "c" ranges from 119 kHz to 135 kHz which actually is used for the RFID carrier frequencies for all globally used applications. The carrier frequencies are 120 kHz, 125 kHz and 134,2 kHz as specified by ISO and noted by other documents [i.5], [i.6], [i.7], [i.8], [i.9] and [i.16].

Various state-of-the-art RF ID reader protocols require data to be sent to the tag for a number of functions, not only for read-write, but also e.g. for bulk-read modes in order to fast, unambiguously identify, categorize and then sequentially read a large number of tags for instance in a given reader generated activation field where tags up to 100 or more can be handled in one interrogation sequence.

During the past, the range "c" has been sufficient for "read-only" systems which do not require reader modulation and data to be sent and to communicate with tags. The so-called bulk read mode or "reader-talks-first" technology is needed to avoid transponder signal pollution which frequently occurs in read-only tag scenarios. Bidirectional reader-tag communication is inevitable for efficient spectrum use of RFID systems.

All LF Reader signals with modulation for bidirectional communication, produce sidebands exceeding the present LF band "c" range as defined in ERC/REC 70-03 [i.1], annex 9. The bands "c1" and "c2" allow operation of systems in the range up to 148,5 kHz but they are not defined as a contiguous bands for RFID operation together with band "c" which is required for type certifications according to EN 300 330 [i.4].

Therefore annex B of the present document defines a spectrum mask for LF RFIDs to include all corresponding frequency bands ("b", "c", "c1" "c2"). This is proposed to be implemented in EN 300 330 [i.4] (see clause B.1.1).

The field strength levels of the proposed spectrum mask can use the field strength levels of the ranges c, c1 and c2 which have been defined in previous amendments of the ERC/REC 70-03 [i.1].

For further information see annex B.

5.1.3 EAS systems in the range of 80 kHz to 90 kHz

Electronic Article Surveillance (EAS) anti-theft systems has successfully been on the market for more than 60 years and is the only real protection against theft in shops, mega-stores, supermarkets, etc. The market growth for EAS tags has increased due to a more wide open European market including free travel of the European population and there is increasing market need to reduce the size of the tag to allow for attachment to as many items as possible.

Low cost EAS systems are using two different types of technology in the frequency range from 9 kHz to approximately 120 kHz:

a) Large tags based on a printed resonating coil on a flexible foil.

b) Smaller tags using an amorphous metal material.

The large tag is used primary to protect large items where the large area can be accepted, for example on or inside a package or on library books where the tag is integrated into the book binder itself.

The smaller tag using amorphous metal material has been very universally usable for anti-theft purposes. The mechanism is coupling between a magnetic RF field and the tag mechanical resonance. The resonance Q of a tag is in the order of 400. The European market for this type of tag is currently $3{,}1 \cdot 10^{10}$ Euro/year.

Technology developments in the area of amorphous material have increased the usability of these tags. It is now possible to design a good quality tag with a significant smaller size. As the mechanical resonance frequency for the tag depends on the tag size a smaller tag will require a higher frequency. Industry has determined a suitable frequency range between 80 kHz to 90 kHz. Two centre frequencies of 82 kHz and 85 kHz are proposed for two independent market segments.

In order to read the tags reliably, a radiated field limit of +67,5 dBμA/m measured at 10 m distance is required. This value is determined via the necessary link budget in combination with the already used formula for magnetic field limits in ERC/REC 70-03 [i.1], annex 9:

H(f) = 72 dBµA/m @ 10 m at 30 kHz - 3,5 dB/oct (eq. 1)

For operating frequencies below 59,750 kHz, between 60,250 kHz to 70 kHz and 119 kHz to 135 kHz, the above limit applies in both ERC/REC 70-03 [i.1], annex 9 and in EN 300 330 [i.4].

However, the limit in (eq. 1) is not currently applied between 80 kHz to 90 kHz and the present document requests this change.

It is assumed that there are no compatibility issues with the proposed limit as the EAS systems are operation in the reactive near field where the radiated magnetic field strength decreases with -60 dB/decade versus distance.

It is important to note that the band 80 kHz to 90 kHz is allocated to naval navigation such as Decca in which the transmitters were mounted as coastal stations. The Decca receivers were mounted onboard ships and operated off-shore and therefore never in proximity with EAS systems. It is important to note that the Decca system operation was discontinued in year 2000 [i.12].

Naval navigation systems are today served by means of the Global Position System (GPS).

5.2 Technical information

5.2.1 LF RFIDs in the range of 105,5 kHz to 148,5 kHz

The unique physical properties and parameters of LF makes LF RFID almost mandatory for a number of applications. Some of the particular LF properties for RFIDs are:

- Near field propagation which results in a well controlled area of operation because of the fast roll-off.
- Low transponder size and cost for instance tags can be built in rice corn size e.g. for animal implanted applications.
- World wide deployment because of harmonized frequency limits. LF regulations exist in all three ITU regions for the same frequency bands an field strength allowance levels. Consequently LF RFID readers can be marketed in all ITU regions countries without technical adaptations and changes, similarly tags have no national restrictions and operate globally with no performance differences or penalties.

5.2.2 EAS systems in the range of 80 kHz to 90 kHz

The physical properties and parameters of low frequencies make the EAS unique when operating below 100 kHz and using a magnetic material. Some of the important properties for EAS are:

- The wave impedance in the reactive near-field is extremely low. Consequently, it almost impossible to tamper with an EAS tag by shielding.
- Near-field propagation with -60 dB/decade roll-off of the magnetic field strength versus distance.
- EAS tags can be built very small using low cost amorphous material having a very high permeability.
- The 9 kHz to 148,5 kHz regulations are almost harmonized throughout the world. If European regulation can be changed to the proposed limits in the frequency range 80 kHz to 90 kHz, then a small EAS tag will be world-wide harmonised. This will allow goods to be equipped with small EAS tags at a hidden position at the source of manufacturing for world-wide distribution.

The industry has proposed change to a smaller EAS tag operating at a higher frequency inside the range 80 kHz to 90 kHz. This requires a change of the regulation in Europe. In other parts of the world, the limits are already sufficient.

5.3 Market Information

5.3.1 LF RFID in the range of 105,5 kHz to 148,5 kHz

Market information that supports the predicted rapid growth of RFID in the LF range is provided at clause A.1.

5.3.2 EAS systems in the range of 80 kHz to 90 kHz

Market information for EAS systems is provided in clause A.2.

5.4 Technical issues

5.4.1 LF RFID in the range of 105,5 kHz to 148,5 kHz

Clause B.1 shows the technical details.

5.4.2 EAS and other systems

Clause B.2 shows the technical details of EAS systems in the range of 80 kHz to 90 kHz.

6 Technical Radio Spectrum requirements and justification

6.1 Current regulations

6.1.1 LF RFID in the range of 105,5 kHz to 148,5 kHz

The ERC/REC 70-03 [i.1], annex 9 defines inductive frequency ranges under discussion as follows in table 1.

Table 1: ERC/REC 70-03 [i.1], annex 9, excerpt

Frequency band	Magnetic field	Duty cycle	Channel spacing	ECC/ERC decision	Notes
b 70-119 kHz	42 dBµA/m at 10 m	No Restriction	No spacing	ERC/DEC/(01)13 [i.1]	In case of external antennas only loop coil antennas may be employed
c 119-135 kHz	66 dBµA/m at 10 m	No Restriction	No spacing	ERC/DEC/(01)13 [i.1]	In case of external antennas only loop coil antennas may be employed. Field strength level descending 3 dB/oct at 30 kHz
c1 135-140 kHz	42 dBµA/m at 10 m	No Restriction	No spacing		In case of external antennas only loop coil antennas may be employed
c2 140-148,5 kHz	37,7 dBµA/m at 10 m	No Restriction	No spacing		In case of external antennas only loop coil antennas may be employed

Additionally the maximum allowed H-field limits for bands c1 and c2 are illustrated in figure 2 in annex 9 of ERC/REC 70-03 [i.1].

The Commission Decision 2006/771/EC [[i.23] on harmonization of the radio spectrum for use by short range devices defines the inductive frequency ranges under discussion as follows in table 2.

Table 2: Inductive frequency ranges, excerpt

Type of short-range device	Frequency band	Power limit / field strength limit / power density limit	Additional parameters / spectrum access & mitigation requirements	Other usage restrictions	Implementation deadline
Inductive applications	20,050 kHz to 59,750 kHz	72 dBµA/m at 10 m			1 June 2007
	59,750 kHz to 60,250 kHz	42 dBµA/m at 10 m			1 June 2007
	60,250 kHz to 70,000 kHz	69 dBµA/m at 10 m			1 June 2007
	70 kHz to 119 kHz	42 dBµA/m at 10 m			1 June 2007
	119 kHz to 127 kHz	66 dBµA/m at 10 m			1 June 2007
	127 kHz to 140 kHz	42 dBµA/m at 10 m			1 June 2008
	140 kHz to 148,5 kHz	37,7 dBµA/m at 10 m			1 June 2008

6.1.2 EAS systems in the range of 80 kHz to 90 kHz

The current regulation for the frequency range 80 kHz to 90 kHz is +42 dBµA/m @ 10 m as given in the frequency range b in table 1.

6.2 Proposed Regulation

The proposed regulations are not restricted to LF RFID and EAS applications but should be open for all inductive applications.

6.2.1 LF RFID in the range of 105,5 kHz to 148,5 kHz

For EN 300 330 [i.4] a figure for the allowed H-field limits of the TX mask needs to be added.

In annex 9 of ERC/REC 70-03 [i.1] and EN 300 330 [i.4] and in the EC SRD Decision, a minor correction of the stated H-field limit will also need to be corrected from 66 dBµA/m to 66,2 dBµA/m.

6.2.2 EAS systems in the range of 80 kHz to 90 kHz

The proposed limit is +67,5 dBµA/m @ 10 m for the frequency range 80 kHz to 90 kHz.

7 Main conclusions and ETSI actions

7.1 LF RFIDs in the range of 105,5 kHz to 148,5 kHz

To satisfy the above requirements for LF RFID systems it is proposed to review the LF Harmonized Standard EN 300 330 [i.4] in specifying a new TX mask (as defined in annex B). Also a minor correction of the stated H-field limit from 66 dBµA/m to 66,2 dBµA/m is needed.

ETSI ERM has approved a new work item for the revision of the existing EN 300 330 [i.4] in line with the proposed changes. The change needs to cover the proposed annex 9 of ERC/REC 70-03 [i.1] amendment in the relevant paragraphs.

7.2 EAS systems in the frequency range 80 kHz to 90 kHz

To satisfy the requirements for future EAS systems it is proposed to review the present regulation and change the limit in the frequency range 80 kHz to 90 kHz from +42 dBµA/m @ 10 m to +67,5 dBµA/m @ 10 m.

8 Requested ECC and EC actions

ETSI requests ECC to consider the present document, which includes the necessary information to support the co-operation under the MoU between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT).

ECC working group FM is requested to review the proposal for the revision of the ERC/REC 70-03 [i.1] with regard to the proposed LF RFID mask and the proposed review of the levels in the frequency range of 80 kHz to 90 kHz.

The EC is requested to review the Commission Decision 2006/771/EC [i.21] on harmonization of the radio spectrum for use by short range devices for the inductive devices.

Annex A: Detailed market information - Market size, Applications and requirements

A.1 LF RFID in the range of 105,5 kHz to 148,5 kHz

The market forecasts indicate a very high growth rate for all RFID applications. The LF RFID market is an established market since 1990 in a number of market segments as car immobilizers, livestock, access control, personal identification, ski pass, environmental and waste management, door locks, manufacturing control, parking control among many other applications. A number of ISO standards have been published LF RFID technology. [i.5], [i.6], [i.7], [i.8] and [i.16].

Especially the automotive industry is an important sector and has reached a high penetration. The total LF RFID market is continuing to grow because of the benefits of the LF propagation as well as the expansion of established and proven technologies. Further on the LF portion of the RFID market still represents the majority of all RF applications.

The automotive market is in particular reflected in the section 6.1.3 of the CEPT report 14 [i.2].

The report noted under specific objects of the Second Mandate under 4.2.1:

"promote more permissive conditions of use for short-range devices, (including inductive applications), harmonising European regulations on the least restrictive and justified limitations necessary to avoid harmful interference to radio Services, ……"

Secondly under Conclusions 5.1 xi, it is stated: the ERC/REC 70-03 [i.1] as a vital regulatory reference for SRDs:

"That the SRD industry greatly values ERC Recommendation 70-03 as a vital regulatory reference document and as a guide to the spectrum available for SRD use within CEPT countries. However, as product lifetimes decrease, industry requires the speedier adoption of all the regulatory parameters in the Recommendation by all Administrations without national restrictions"

Among all RFIDs, LF RFIDs present the first developed and employed RFID technology, they were developed in the early 80s and deployed in high volume from 1990 onwards in various volume markets

The present running rates of LF RFID systems are difficult to summarize but are in the order of 1 to 2 billion tags per year with particular growth in the more sophisticated technologies. These reader protocols which require data to be sent to the tag for various functions, for read-write, and also e.g. for bulk-read modes in order to read a large number of tags fast and unambiguously to identify, categorize and then sequentially handle up to 100 or more tags in one interrogation sequence.

A.2 EAS systems in the frequency range 80 kHz to 90 kHz

The market growth for EAS tags has increased due to a more wide open European market including free travel of the European population.

In spite of the development of RFID tags these have not been able to replace the EAS tags. Although the RFID tag can include a lot of information, the cost of an RFID tag is still almost an order of magnitude higher that an EAS tag. RFID tags include a silicon chip whereas the EAS may only include a small piece of amorphous material combined with a small bias magnet. Additionally, an EAS magnetic tag has an excellent protection against tampering due to its operation in the low frequency inductive near-field.

EAS tags are manufactured in a world-wide volume of $7 \cdot 10^{12}$ per year at price of one euro cent or less each. This is corresponding to a total value of approximately $7 \cdot 10^{10}$ Euro per year. The European share is 45 % corresponding to $3{,}1 \cdot 10^{10}$ Euro/year.

The corresponding EAS readers are either replacement of former generation of readers or new installations of the latest readers at a lower cost. The readers are mainly installed in shops, malls, supermarkets etc. Readers are manufactured at approximately 50 k to 100 k units/year.

In the frequency range 80 kHz to 90 kHz it is the intention to have two product offerings operating at two different frequencies. One is a simple feature set at low cost the other with a full feature set at a higher cost. The two offerings can only be made at two different frequencies.

Annex B: Technical Information

B.1 LF RFID in the range of 105,5 kHz to 148,5 kHz

B.1.1 General considerations and Tx mask

The LF RFID mask in figure B.1 specifies frequency and emission levels according to the present allowed field strength levels of the annex 9.

NOTE: Note that:

- the mask is foreseen to be put into the revised EN 300 330 [i.4];
- the table in annex 9 of ERC/REC 70-03 [i.1] has specified the level of 66 dBµA/m.

The unique physical properties and parameters of LF makes LF RFID well suited for applications in controlled areas. In addition the LF range up to 148,5 kHz enjoys global harmonization [i.10]. Some of the particular LF properties are:

- Near field propagation results in a well controlled area of operation because of the fast roll-off. The excitation field strength for transponders diminishes with 60 dB/decade and the transponders will not suffer reflections and other unwanted effects.
- Low transponder cost and small size (e.g. rice corn size for animal implanted applications of transponders).
- World wide deployment because of harmonized frequency limits and regulations in all 3 ITU regions.

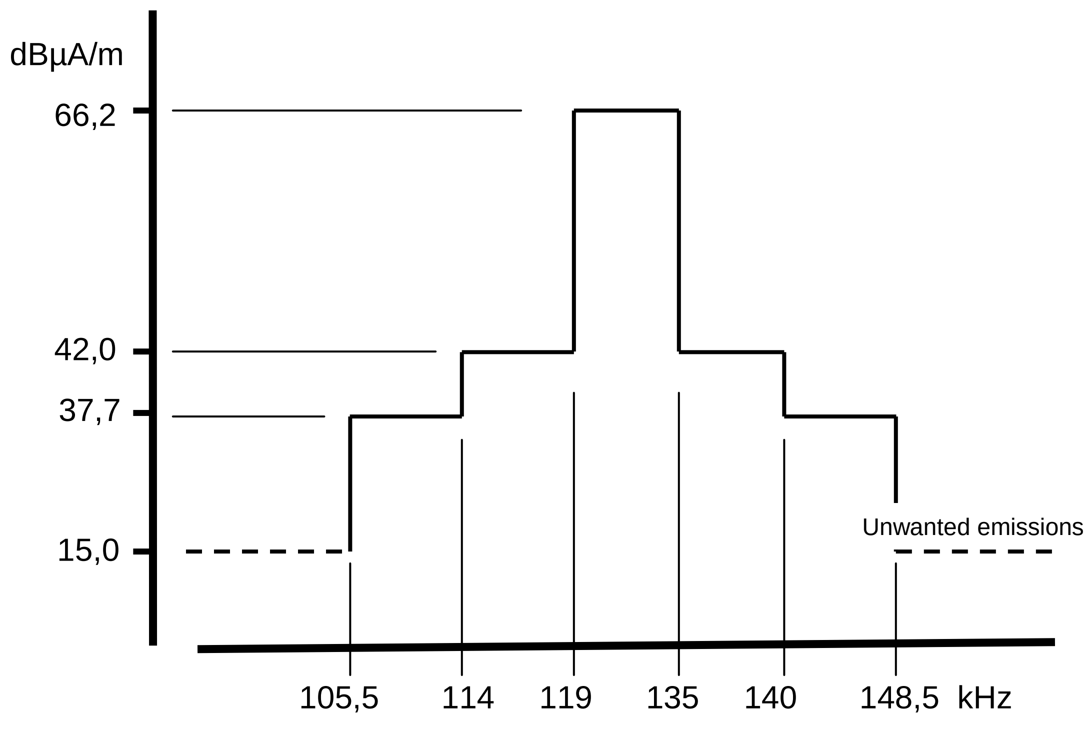

Figure B.1: LF RFID Tx mask

B.2 EAS systems in the frequency range 80 kHz to 90 kHz

B.2.1 General considerations

An EAS system can operate either with a wide-band RF sweep modulation or with pulse modulation.

RF wide-band sweep is not used at low inductive frequencies as interference will occur to sensitive services inside the RF sweep band. The wide-band RF sweep is commonly used at higher frequencies such as around 8,2 MHz.

The common used modulation is pulse modulation with a pulse-width of around 2 ms. The duty cycle is around 10 % to 15 % with a repetition time of 15 ms to 20 ms. Consequently, the transmitted bandwidth is around 1 kHz or less.
If a tag is in the EAS transmitted field, the tag will be detected by the EAS receiver during the subsequent transmitter off-state.

The EAS systems operating in the frequency range 80 kHz to 90 kHz are working in the reactive near field where the radiating magnetic H-field is reducing with 60 dB/decade versus distance. Consequently, the interference distances to other services are very short most often in the order of 100 m or less.

Therefore, the proposed frequency range of 80 kHz to 90 kHz does not contain other services operating in close proximity of less than 100 m.

Equipment operating at close distance to EAS systems are for example receiving the UK 60 kHz or European 77,5 kHz time standards. The proposed frequency range of 80 kHz to 90 kHz for EAS is outside the frequencies of the mentioned time standards which then are protected.

Furthermore, the band, 80 kHz to 90 kHz, now proposed for EAS systems was earlier inside the frequency range for the Decca navigation system. However, the Decca system was discontinued in year 2000.

B.2.2 Elements influencing the link budget

The link budget for an EAS system using a small amorphous tag is calculated in ERC Report 44 [i.14]. The required radiated field from the system reader is calculated to +69 dBμA/m at 10 m for operation at 50 kHz. The required field at 82 kHz is approximated 2 dB less due to the corresponding lower ambient noise level.

B.2.2.1 Near-field propagation by loop antenna.

Radiated H-field from a rectangular loop antenna in the reactive near-field at a measuring point P is given in ERC Report 44 [i.14] by equation (B.1) below:

$$|H| = \frac{I \cdot a \cdot b}{4 \cdot \pi \sqrt{r^2 + \left(\frac{a}{2}\right)^2 + \left(\frac{b}{2}\right)^2}} \cdot \left\{ \frac{1}{r^2 + \left(\frac{a}{2}\right)^2} + \frac{1}{r^2 + \left(\frac{b}{2}\right)^2} \right\} \qquad \text{(B.1)}$$

Where:

r = the distance from the radiating loop antenna.

a = the shorter side of the rectangular loop antenna.

b = the longer side of the rectangular loop antenna.

I = the loop RF current (for a N turn loop I in (1) is replaced by N×I).

H = the numeric value of the magnetic field strength.

In the case where P is far away from the loop this formula simplifies to formula (B.2):

$$|H| = \frac{I \cdot a \cdot b}{2 \cdot \pi \cdot r^3} = \frac{I \cdot A}{2 \cdot \pi \cdot r^3} \quad a.b \ll r \qquad \text{(B.2)}$$

Where A = the surface area of the loop antenna.

The product I·A= I·a·b is also called the magnetic dipole moment, M.

B.2.2.2 Near/Far-field propagation by loop antenna.

Radiated H-field from a loop antenna in the reactive near-field and the far-field at a measuring point P is given in ERC Report 69 [i.15] by equations (B.3 and B.4) below:

a) In the coaxial direction:

$$|H| = \frac{M}{2 \cdot \pi} \cdot \frac{\sqrt{\left(\frac{\lambda}{2 \cdot \pi}\right)^2 + r^2}}{\left(\frac{\lambda}{2 \cdot \pi}\right)^2 \cdot r^3} \qquad \text{(B.3)}$$

For $r^2 \ll \left(\frac{\lambda}{2 \cdot \pi}\right)^2$ is equation B.2 equal to equation B.3.

b) In the coplanar direction:

$$|H| = \frac{M}{4 \cdot \pi} \cdot \frac{\sqrt{\left(\frac{\lambda}{2 \cdot \pi}\right)^4 - \left(\left(\frac{\lambda}{2 \cdot \pi}\right)^2\right) r^2 + r^4}}{\left(\frac{\lambda}{2 \cdot \pi}\right)^2 r^3} \qquad \text{(B.4)}$$

where:

λ = the wavelength in m.

r = the distance from the antenna in m.

M = the magnetic dipole moment in A×m^{2}.

$|H|$ = the numeric value of the magnetic field strenth.

The propagation field strength versus distance for equations (B.2), (B.3) and (B.4) are shown in figure B.2.

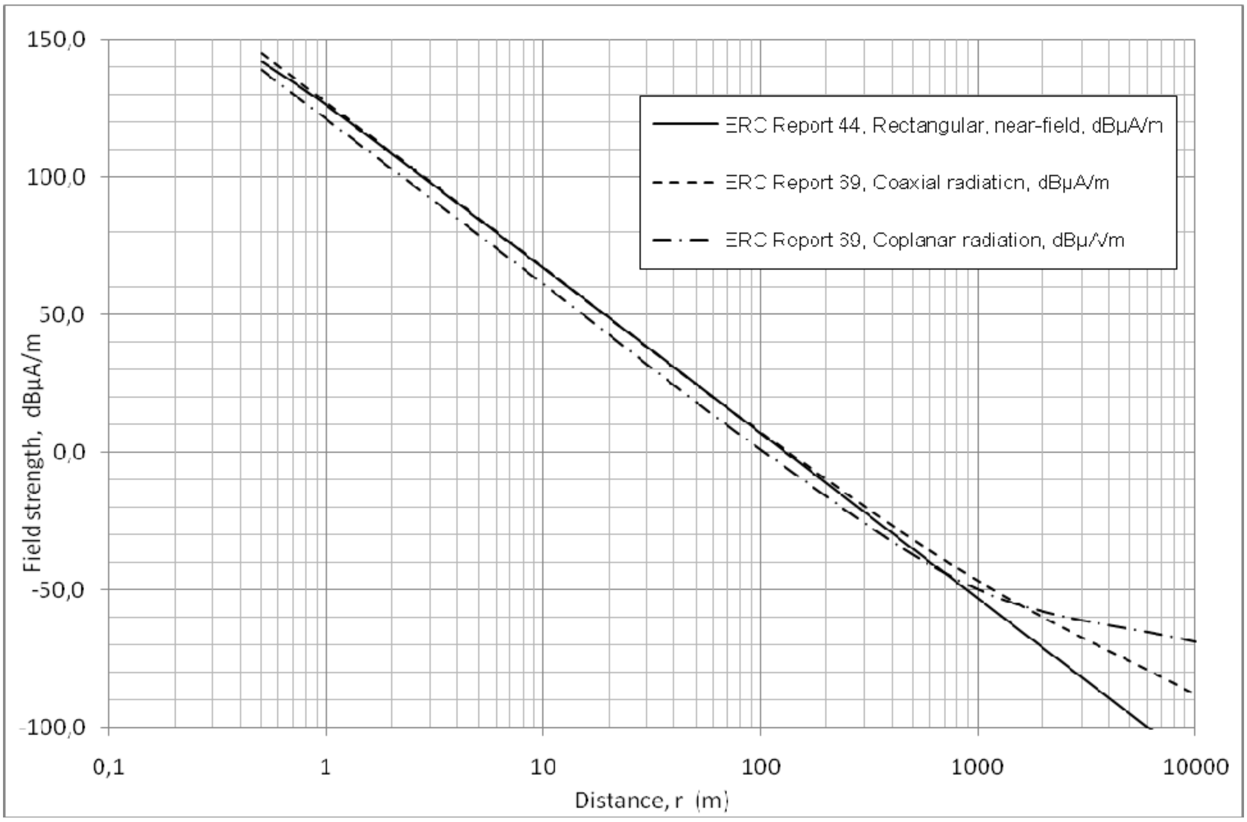

Figure B.2: EAS H-field versus distance, r, for equation (B.1), (B.3) and (B.4)

According to ITU-R Recommendation P.372 [i.13] the atmospheric noise is calculated in ERC Report 69 [i.15]. The noise is converted to dBµA/m in table B.3:

Table B.3: Atmospheric noise in 2,7 kHz bandwidth

	Distribution		
	20 %	**50 %**	**80 %**
Atmospheric noise	-29,5 dBµA/m	-20,5 dBµA/m	-14,5 dBµA/m

B.2.2.3 Transponder radiated field

The level of a radiated field from the transponder received by the interrogator is dependent on the following transponder parameters:

a) physical size;

b) material properties;

c) distances from the transmitter and the receiver antennas;

d) orientation in the H-field;

e) frequency.

The magnetic radiated field at distance r from the transponder can be calculated as:

$$H_{rx} = H_{tx} \cdot \frac{V_{eff}}{2 \cdot \pi \cdot r^3}$$

where V_{eff} is the effective volume of the transponder. V_{eff} can vary significantly between different technologies and is not identical to the real volume.

For most applications the transponder is required to be as small as possible. This makes the radiated field very low and, due to the limited effective volume of a transponder, the field attenuation even in the dominant direction will be at least 100 dB at 1 m distance.

In many applications it is not possible to control the physical orientation of the transponder to be optimal. Therefore the orientation loss, the order of which is 6 dB to 8 dB, has to be taken into account in the system calculation.

B.2.2.4 The ambient noise level

The ambient noise is dependent on the location of the equipment. Most equipment is used in commercial and industrial environments, where the ambient noise, especially below 100 kHz, is very high. The main noise sources are the harmonics of different electric equipment, for example switch mode power supplies, electric motors, PC's, TV sets, fluorescent lights and electric distribution in general. The noise level in an industrial environment, measured in a 1 kHz bandwidth, varies in the range 5 dBµA/m to 30 dBµA/m at 50 kHz. A typical level is 13 dBµA/m. The noise level falls at 3,5 dB/octave and it is typically -13 dBµA/m at 8 MHz.

However, the increase of switched mode power supplies in electronic equipment the interference to EAS systems is rather high. The increase of using the so-called "green lamps" (energy saving lamps) has minimised to influence where these interference sources are placed. Therefore, an EAS system can easily be only 2 m to 3 m from the interference sources.

ERC Report 44 [i.14] describes interference field-strength measured at the EAS antenna. The measured level is +13,5 dBµA/m at 50 kHz at the EAS receiving antenna. It is assumed that the average noise level is decreasing with 10 dB/decade. The corresponding noise level at 85 kHz is +11,2 dBµA/m.

B.2.2.5 The resulting link budget

The receiver sensitivity depends on the ambient magnetic noise level. For a reliable operation, 8 dB S/N ratio is assumed.

System description:

a) transponder distance from a receiver: 1 m;

b) ambient noise floor: 11,2 dBµA/m;

c) orientation loss of a tag: 8 dB (4dB+ 4dB);

d) transponder effective volume: 50 $cm^{3.}$

The Link budget calculation in given in table B.2.

Table B.2: Link budget for EAS system operating at 85 kHz

Item	Calculation, if any	Amount
Ambient noise at 85 kHz		11,2 dBµA/m
Transponder orientation loss (receive)		4 dB
Required receiver S/N		8 dB
Receiver min. field level	Sum of above	23,2 dBµA/m
Transponder loss for V_{eff} = 50 cm at 1m	Measured value at 1 m	99,3 dB
Transponder orientation loss (re-transmit)		4 dB
Required transmitter field at 1 m	Sum of above	126,5 dBµA/m
Transmit H-field at 10 m	TX (1m) - 60 log(10 m/1 m)	67,2 dBµA/m

On the basis of the calculation in table B.2, the required transmitter field is +67,2 dBµA/m at 10 m.

Annex C: Expected compatibility issues

C.1 Existing allocations

The ERC/REC 70-03 [i.1] specifies the following emission levels for inductive SRDs.

Table C.1: Excerpt of annex 9 of the ERC/REC 70-03 [i.1]

Frequency band	Magnetic field	Duty cycle	Channel spacing	ECC/ERC decision	Notes
b 70-119 kHz	42 dBμA/m at 10 m	No Restriction	No spacing	ERC/DEC(01)13 [i.20]	In case of external antennas only loop coil antennas may be employed
c 119-135 kHz	66 dBμA/m at 10 m	No Restriction	No spacing	ERC/DEC(01)13 [i.20]	In case of external antennas only loop coil antennas may be employed. Field strength level descending 3 dB/oct at 30 kHz
c1 135-140 kHz	42 dBμA/m at 10 m	No Restriction	No spacing		In case of external antennas only loop coil antennas may be employed
c2 140-148,5 kHz	37.7 dBμA/m at 10 m	No Restriction	No spacing		In case of external antennas only loop coil antennas may be employed

C.2 Coexistence and sharing issues

C.2.1 LF RFID in the range of 105,5 kHz to 148,5 kHz

No coexistence studies are needed because no changes to the present emission levels are requested.

There are no compatibility issues because the proposed TX mask levels is already covered by the annex 9 of ERC/REC 70-03 [i.1].

C.2.2 EAS systems in the frequency range 80 kHz to 90 kHz

Based on considerations below there may not be a need for special protection of the above services from the inductive systems if the limit is increased to the proposed level in the frequency range 80 kHz to 90 kHz.

The European Frequency Information System (EFIS) gives the following information.

Table C.2: European frequency allocation table

FREQUENCY BAND	ALLOCATIONS	APPLICATIONS
72.0 - 84.0 kHz	FIXED MARITIME MOBILE RADIONAVIGATION	Medical implants (9.0 - 315.0 kHz) Inductive applications (9.0 - 30000.0 kHz) Inductive applications (20.05 - 148.5 kHz) Maritime Standard Frequency and Time Signal Defence systems (72.0 - 148.5 kHz)
84.0 - 86.0 kHz	RADIONAVIGATION	Medical implants (9.0 - 315.0 kHz) Inductive applications (9.0 - 30000.0 kHz) Inductive applications (20.05 - 148.5 kHz) Defence systems (72.0 - 148,5 kHz)
86.0 - 90.0 kHz	FIXED MARITIME MOBILE RADIONAVIGATION	Medical implants (9.0 - 315.0 kHz) Inductive applications (9.0 - 30000.0 kHz) Inductive applications (20.05 - 148.5 kHz) Defence systems (72.0 - 148.5 kHz) Maritime
90.0 - 110 kHz	RADIO NAVIGATION	Medical implants (9.0 - 315.0 kHz) Inductive applications (9.0 - 30000.0 kHz) Inductive applications (20.5 - 148.5 kHz) Defence Systems (72-148,5 kHz) Loran C

The different types of primary and secondary services, as defined in the ITU Radio Regulations, are identified. These types are grouped into generic types, which have similar protection needs.

For the following services compatibility considerations are given in ERC Report 44 [i.14]:

- Maritime radio navigation / Mobile.
- Aeronautical radio navigation.
- Land radio navigation.
- Fixed, point to point communication.
- Fixed, point to multi-point communication.

The conclusions in ERC Report 44 [i.14] indicates that there might not be a compatibility issue when operation at these frequencies with a higher limit.

History

Document history		
V1.1.1	October 2008	Publication