International Telecommunication Union

ITU-R

Radiocommunication Sector of ITU

Report ITU-R SM.2255-0

(10/2012)

Technical characteristics, standards, and frequency bands of operation for radio-frequency identification (RFID) and potential harmonization opportunities

SM Series

Spectrum management

150 ITU 1865-2015

ITU International Telecommunication Union

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***Note**: This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.*

Electronic Publication
Geneva, 2015

REPORT ITU-R SM.2255-0*

Technical characteristics, standards, and frequency bands of operation for radio-frequency identification (RFID) and potential harmonization opportunities

(2012)

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* Radiocommunication Study Group 1 made editorial amendments to this Report in year 2015.

1 Introduction

Radio-frequency identification (RFID) technology is widely deployed in various industries worldwide. Like other wireless communication technologies, the spectrum availability for RFID is the essential prerequisite for its functioning and global deployment. RFIDs are most often deployed in the ISM bands and operate in various frequency bands from LF to UHF because of the unique advantages and properties associated with the different frequency bands such as propagation, penetration and absorption. See also Recommendation ITU-R SM.1896.

Many RFIDs require global operation but currently face some limitations due to a lack of harmonization, especially at UHF.

This Report outlines key standards, operating parameters and frequency bands for the deployment of RFIDs in various administrations and includes information on harmonization possibilities.

2 RFID terms and definitions

RFID: Radio-Frequency Identification.

RFID system: An RFID system is an automatic identification and data capture system comprising one or more RFID reader (interrogators) and one or more RFID tags (transponders) in which data transfer is achieved by means of suitably modulated inductive or radiating electromagnetic energy. A tag is attached to the item to be identified, and a transmitter/receiver unit interrogates the tag and receives identification data back from the tag.

RFID tag: An RFID tag is any transponder plus the information storage mechanism attached to the object.

RFID devices are considered active if they are self-powered – i.e. they contain their own batteries and are always on, and passive if they receive power from an external source – i.e. radio frequencies transmitted by readers.

An RFID system typically consists of a reader (interrogator) and a tag (transponder). A tag is attached to the item to be identified, and a transmitter/receiver unit interrogates the tag and receives identification data back from the tag.

3 RFID applications

RFID are used in a variety of applications including retail and supply chain, healthcare, transportation and logistics, and mobile applications. The table below shows some typical RFID applications.

TABLE 1

Typical RFID applications

Application	Typical use	Frequency bands	Comments
Retail and supply chain	Inventory management and retail	860-960 MHz 13.56 MHz	Long-range with a limited computation power
Healthcare	Tracking patients	860-960 MHz 13.56 MHz LF < 135 kHz 2 450 MHz	Tracking, profiling, invisibility (ISO/IEC 18000-6B and C) (ISO/IEC 18000-3m1 and 3m3) (IEEE 802.15.4) (IEEE 802.11)
	Preventing medication errors	860-960 MHz 13.56 MHz	Tracking, profiling (ISO/IEC 18000-6B and C) (ISO/IEC 18000-3m1 and 3m3)
	Blood or medicines tracking	13.56 MHz	Tracking for anti-counterfeiting
Transport and logistics	Public transportation ticket	13.56 MHz	Near field communication (NFC) Tracking, profiling
	Highway toll	866 MHz, 915 MHz	Tracking, profiling (ISO/IEC 18000-6B)
	Vehicle tracking	Uplink 890-915 MHz Downlink 935-960 MHz	Tracking GSM frequency bands
	Fleet/freight container management	433.5-434.5 MHz	(ISO/IEC 18000-7)
		860-960 MHz	(ISO/IEC 18000-6)
		2 450 MHz	(ISO/IEC 24730-2)
e-government	e-passport	13.56 MHz	Short-range with powerful computation power (ISO/IEC 14443)
Mobile	Smart poster	860-960 MHz 13.56 MHz	(ISO/IEC 29143) (NFC) Invisibility

4 ISO/IEC Standards for RFID

ISO/IEC18000 is the ISO specification for RFID air interface communication. It is composed of six parts, with each part covering the air interface for RFID devices operating in specific bands.

ISO/IEC 18000 is a framework that defines common communication protocols for internationally useable frequencies for RFID. ISO/IEC 18000 is an enabling standard that supports and promotes a number of RFID implementations. Moreover, the ISO/IEC 18000 series of standards has as its goal, "where possible, to determine the use of the same protocols for all frequencies such that the problems of migrating from one to another are diminished; to minimize software and implementation costs; and to enable system management and control and information exchange to be common as far as is possible".

In addition to the communication protocols used in the air interface, the standards for each band of operation "define the forward and return link parameters for technical attributes including, but not limited to, operating frequency, operating channel accuracy, occupied channel bandwidth, maximum equivalent isotropically radiated power (e.i.r.p.), spurious emissions, modulation, duty cycle, data coding, bit rate, bit rate accuracy, bit transmission order, and where appropriate operating channels, frequency hop rate, hop sequence, spreading sequence and chip rate".

The Table below summarizes different parts of ISO/IEC 18000 and provides an overview of the standard.

TABLE 2

ISO 18000 standard

ISO/IEC standard	Overview of standard	Frequency band
18000-1:2008	Generic architecture concepts for item identification within the logistics and supply chain. Definition of parameters in any standardized air interface definition in the subsequent parts of ISO/IEC 18000	
18000-2:2004	Air interface for radio-frequency identification (RFID) devices used in item management applications	Below 135 kHz
18000-3:2008	Physical layer, collision management system and protocol values for RFID systems for Item in accordance with the requirements of ISO/IEC 18000-1	13.56 MHz (ISM)
18000-4:2008	Air interface for radio-frequency identification (RFID) devices used in item management applications	2.45 GHz (ISM)
18000-6:2004	Air interface for radio-frequency identification (RFID) used in item management applications	860-960 MHz (including sub-band 902-928 MHz of ISM in Region 2)
18000-7:2009	Air interface for radio-frequency identification (RFID) devices operating as an active RF tag used in item management applications	433 MHz (ISM in Region 1)

Harmonization of RFIDs needs to address not only the frequency bands (carriers) but also the field strength levels and the transmitter mask, which includes the modulation spectrum.

A number of ISO RFID air interface and product standards have been published in order to operate RFID at various frequencies throughout the spectrum, these standards are determined for a variety of applications such as logistics, identification cards, freight containers, livestock, cards, manufacturing automation, automotive and many other areas.

Table 3 gives an overview showing major applications versus the frequency bands where RFIDs are deployed; the Table does not necessarily cover all ISO and other industry RFID standards.

TABLE 3

ISO standards versus major markets/Applications and their RFID frequencies

ISO Standards	Item mgmt	Supply chain	Live-stock	Cards (ID, smart cards, passports, ticketing. etc.)	Freight container	NFC	IATA luggage IDs	Locating systems
ISO 18000-2	< 135 kHz							
ISO 18000-3	13.56 MHz							
ISO 18000-4	2.45 GHz							
ISO 18000-6	860-960 MHz						860-960 MHz (RPC 1740)	
ISO 18000-7	433 MHz							
ISO 14443				13.56 MHz				
ISO 10536				13.56 MHz				
ISO 15639				13.56 MHz				
ISO 18092						13.56 MHz		
ISO 11785			< 135 kHz					
ISO 14223			< 135 kHz					
ISO 24730-3								2.45 GHz
ISO 24730-5								2.45 GHz
ISO 10374					850-950 MHz (The 860-950 MHz portion of this band is considered in this Report) 2.45 GHz			
ISO 10891					860-960 MHz			
ISO 17363	433 MHz	433 MHz			433 MHz TBD			
ISO 17364	860-960 MHz	860-960 MHz 13.56 MHz						
ISO 17365	860-960 MHz	860-960 MHz 13.56 MHz						
ISO 17367	860-960 MHz	860-960 MHz 13.56 MHz						

TABLE 3 (*end*)

ISO Standards	Item mgmt	Supply chain	Live-stock	Cards (ID, smart cards, passports, ticketing. etc.)	Freight container	NFC	IATA luggage IDs	Locating systems
ISO 17366	860-960 MHz	860-960 MHz 13.56 MHz						
ISO 18185		2.45 GHz 433 MHz			2.45 GHz 433 MHz			
ISO 69873	< 135 kHz							

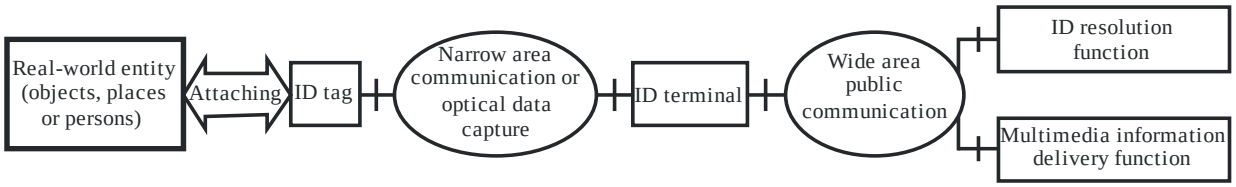
5 ITU-T Standards relevant to RFID

ITU-T has studied mainly about RFID but used NID, which stands for network aspects of identification systems (including RFID). Since identification information may be captured via RF, wire-line, optical scanner or camera from various data carriers such as RFID tags, smart cards, linear bar codes and two-dimensional symbols, the ITU-T agreed to focus only on network aspects of identification systems and excluded RF issues from its scope.

The telecommunication service defined in ITU-T Recommendations is to enable users to access multimedia information service triggered by tag-based identification. This service is realized by the data exchanges among the ID terminal, multimedia information delivery function and ID resolution function through the wide area public communication network such as the Internet, a mobile telephone network and NGN.

FIGURE 1

High-level functional model of the multimedia information access triggered by tag-based identification



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The ITU-T has developed and is developing the following Recommendations, as shown in Table 4:

TABLE 4

ITU-T standards for RFIDs

	ITU-T standards	Overview of standard	Type of standards
SG 13	Y.2213 (2008)	NGN service requirements and capabilities for network aspects of applications and services using tag-based identification	Requirements analysis
	Y.2016 (2009)	Functional requirements and architecture of the NGN for applications and services using tag-based identification	Architecture framework
SG 16	F.771 (2008)	Service description and requirements for multimedia information access triggered by tag-based identification	Requirements analysis
	H.621 (2008)	Architecture of a system for multimedia information access triggered by tag-based identification	Architecture framework
	H.642.3 | ISO/IEC 29177 (consented on May 2012)	Information technology – Automatic identification and data capture technique – Identifier resolution protocol for multimedia information access triggered by tag-based identification	Protocol specification
	H.642.1 | ISO/IEC 29174-1 (consented on May 2012)	Information technology – UII scheme and encoding format for Mobile AIDC services – Part 1: Identifier scheme for multimedia information access triggered by tag-based identification	Numbering scheme
	H.642.1 | ISO/IEC 29174-2 (consented on May 2012)	Information technology – UII scheme and encoding format for Mobile AIDC services – Part 2: Registration procedures	Registration procedure for numbering scheme
SG 17	X.668 (2008)	Information technology – Open Systems Interconnection – Procedures for the operation of OSI (Open Systems Interconnection) Registration Authorities	Numbering scheme
	X.1171 (2009)	Threats and requirements for protection of personally identifiable information in applications using tag-based identification	Architecture framework
	X.1275 (2010)	Guidelines on protection of personally identifiable information in the application of RFID technology	Development guideline
	X.672 (2010)	Information technology – Open systems interconnection – Object identifier resolution system (ORS)	Protocol specification

6 Bands and technical rules for RFID operating in certain bands

Table 5 below summarizes the band-by-band commonalities and differences for the deployment of RFIDs.

This table is not exhaustive.

TABLE 5

Bands and technical rules for RFID

Country	9-135 kHz	13.553-13.567 MHz (ISM)	433.05-434.79 MHz (ISM Region 1)	860-960 MHz (902-928 MHz ISM Region 2)	2 400-2 500 MHz (ISM)	5 725-5 875 MHz (ISM)
United States		15 848 μV/m at 30 m	11 000 μV/m at 3 m (RFID: for use in identifying the contents of shipping containers[1])	4 W e.i.r.p., digital modulation	4 W e.i.r.p., digital modulation	4 W e.i.r.p., digital modulation
Canada	2 400/F μV/m at 300 m (F in kHz)	15 848 μV/m at 30 m	11 000 μV/m at 3 m (RFID: for use in identifying the contents of shipping containers)	4 W e.i.r.p., digital modulation	2 400-2 483.5 MHz: 4 W e.i.r.p., digital modulation	4 W e.i.r.p., digital modulation

[1] Additionally, devices operating under these provisions shall be provided with a means of automatically limiting operation so that the duration of each transmission shall not be greater than 60 seconds and be only permitted to reinitiate an interrogation in the case of a transmission error. Absent such a transmission error, the silent period between transmissions shall not be less than 10 seconds. 47 CFR § 15.240.

TABLE 5 (*continued*)

Country	**9-135 kHz**	**13.553-13.567 MHz (ISM)**	**433.05-434.79 MHz (ISM Region 1)**	**860-960 MHz (902-928 MHz ISM Region 2)**	**2 400-2 500 MHz (ISM)**	**5 725-5 875 MHz (ISM)**
Australia	0-14 kHz: 200 µW e.i.r.p. 14-19.95 kHz: 50 µW e.i.r.p. 20.05-70 kHz: 7.5 µW e.i.r.p. 70-160 kHz: 3 µW e.i.r.p.	1 W e.i.r.p.	433.05-434.79 MHz: 25 mW e.i.r.p. (all transmitters, RFID may use)	918-926 MHz: 1 W e.i.r.p. 920-926 MHz: 4 W e.i.r.p. 915-928 MHz: 1W e.i.r.p. (frequency hopping and digital modulation transmitters, RFID may use where they comply)	2 400-2 483.5 MHz: 10 mW e.i.r.p. (all transmitters, RFID may use) 2 400-2 450 MHz: 1 W e.i.r.p. 2 400-2 483.5 MHz: 4 W e.i.r.p. (frequency hopping and digital modulation transmitters, RFID may use where they comply)	5 725-5 795 MHz and 5 815-5 875 MHz 1 W e.i.r.p. 5 725-5 875 MHz: 25 mW e.i.r.p. (All transmitters, RFID may use) 5 795-5 815 MHz: 2 W e.i.r.p. 5 725-5 850 MHz: 4 W (frequency hopping and digital modulation transmitters, RFID may use where they comply)
New Zealand		1 W e.i.r.p.		918-926 MHz: 1 W e.i.r.p.	2 400-2 450 MHz: 1 W e.i.r.p.	5 725-5 795 MHz and 5 815-5 875 MHz 1 W e.i.r.p.

TABLE 5 (*continued*)

Country	**9-135 kHz**	**13.553-13.567 MHz (ISM)**	**433.05-434.79 MHz (ISM Region 1)**	**860-960 MHz (902-928 MHz ISM Region 2)**	**2 400-2 500 MHz (ISM)**	**5 725-5 875 MHz (ISM)**
Countries Members of CEPT	Included in Annex 9 of ERC Recommendation 70-03 (see Annex 4 of the present document) Up to 72 dBµA/m at 10 m	Included in Annex 9 of ERC Recommendation 70-03 (see Annex 4 of the present document) Up to 60 dBµA/m at 10 m	Included in Annex 1 of ERC Recommendation 70-03 (see Annex 4 of the present document) Up to 10 mW e.r.p. Non-specific SRDs (RFID may use this band as long as they meet the technical parameters) 433.05-434.79 MHz: 10 mW e.r.p., duty cycle ≤ 10% 433.05-434.79 MHz: 1 mW e.r.p. 434.04-434.79 MHz: 10 mW e.r.p., channel BW ≤ 25 kHz	Included in Annex 11 of ERC Recommendation 70-03 (see Annex 4 of the present document) Up to 2 W e.r.p. in 865-868 MHz Channel size: 200 kHz 865-865.6 MHz: 100 mW e.r.p. 865.6-867.6 MHz: 2 W e.r.p. 867.6-868 MHz: 500 mW e.r.p.	Included in Annex 11 of ERC Recommendation 70-03 (see Annex 4 of the present document) Up to 4 W e.i.r.p. in 2 446-2 454 MHz 500 mW e.i.r.p. Indoor use only: 4 W e.i.r.p. and duty cycle 15%	Included in Annex 1 of ERC Recommendation 70-03 (see Annex 4 of the present document) for non-specific SRD applications, and also included in Annex 5 (RTTT) of ERC/Rec. 70-03 for RTTT applications Up to 25 mW e.i.r.p. 2-8 W e.i.r.p. for Road Transport and Traffic Telematics (RTTT) applications

TABLE 5 (*continued*)

Country	9-135 kHz	13.553-13.567 MHz (ISM)	433.05-434.79 MHz (ISM Region 1)	860-960 MHz (902-928 MHz ISM Region 2)	2 400-2 500 MHz (ISM)	5 725-5 875 MHz (ISM)
			1 mW e.r.p. and −13 dBm/10 kHz power density for bandwidth modulation larger than 250 kHz 10 mW e.r.p. and duty cycle 10% 434.04-434.79 MHz 1 mW e.r.p. and −13 dBm/10 kHz power density for bandwidth modulation larger than 250 kHz 10 mW e.r.p. and duty cycle 10% or duty cycle 100% subject to channel spacing up to 25 kHz			
China	9-50 kHz: 72 dBμA/m at 10 m (QP) 50-190 kHz: 72 dB μA/m at 10 m (QP) (from 50 to 190 kHz descending 3 dB/octave, QP)	42 dBμA/mat 10 m (QP)	10 mW e.r.p. Occupied bandwidth: 400 kHz	840.5-844.5 MHz: 2 W e.r.p. FHSS 920.5-924.5 MHz 2 W e.r.p. FHSS Channel space: 250 kHz	2 400-2 483.5 MHz: 10 mW e.i.r.p	

TABLE 5 (*end*)

Country	9-135 kHz	13.553-13.567 MHz (ISM)	433.05-434.79 MHz (ISM Region 1)	860-960 MHz (902-928 MHz ISM Region 2)	2 400-2 500 MHz (ISM)	5 725-5 875 MHz (ISM)
Republic of Korea	9-30 kHz: 72 dBμA/m @ 10 m 30-90 kHz: 72 – 10LOG(*f*/30) dBμA/m @ 10 m 90-110 kHz: 42 dBμA/m @ 10 m 110-135 kHz: 72 – 10LOG(*f*/30) dBμA/m @ 10 m	13.552-13.568 MHz: 93.5 dBμV/m @ 10 m	433.67-434.17 MHz: 3.6 mW e.i.r.p. (RFID: for use in identifying the contents of shipping containers)	917-923.5 MHz: 4 W e.i.r.p. Passive RFID with the exception of the output RF power is 10 mW	2 400-2 483.5 MHz: 3 mW/MHz (for FHSS type) 10 mW/MHz (for other spread spectrum type) 10 mW (other type)	5 725-5 825 MHz 3 mW/MHz (for FHSS type). The peak power of a hopping channel divided by whole hopping frequency band (MHz) 10 mW/MHz (for other spread spectrum type) 10 mW (other type)
Israel	125.0-148.5 kHz, Up to 72 dBμA/m at 10 m, can be approved	Up to 42 dBμA/m at 10 m	Up to 1 mW e.r.p.; 10 mW e.r.p can be considered for approval	915-916.8 MHz, only; In average out of band below 915 MHz, –74 dBm per 100 kHz. Above 917 MHz, –46 dBm per 30 kHz	Up to 4 W e.i.r.p. in 2 446-2 454 MHz. 100 mW (eirp) at 2 400-2 483.5 MHz	

7 Frequency band/technical differences

As can be seen from the summary table above (Table 5), there are regional differences in power limits, spectrum bands, channel plans, and other technical parameters that impede the functioning of RFIDs in a global marketplace. These differences are most striking in the range 860-960 MHz, as summarized below, but exist as well in other bands.

Many RFIDs are deployed globally; therefore, globally harmonized frequency bands and technical rules are desirable.

Many countries have regulated some of the RFID frequency bands in a common manner with similar field strength allowances. To be effective, however, harmonization is needed with regard to:

– Frequency bands;

– Modulation masks – in case bands are too narrow to accommodate modulation spectra;

– Power levels.

In the band 433.5-434.5 MHz, studies could be undertaken to determine whether harmonizing the technical requirements for RFID operating in this band would adversely affect the radiolocation service and the amateur service.

8 Benefits of global harmonization

Globally harmonized bands provide benefits for consumers, regulators, industries, and manufacturers alike. Specifically, harmonization creates:

– greater user confidence in the reliable functioning of devices when travelling abroad;

– a broader manufacturing base and increased volume of equipment (globalization of markets) resulting in economies of scale and expanded equipment availability;

– a potential reduction in the potential for harmful interference from RFID systems to radiocommunication services when RFIDs operate in suitable harmonized frequency bands;

– potential reduction in the influx of illegal or non-conforming SRDs into the marketplace of some countries.

Annex 1 provides spectrum harmonization considerations, proposals and comments on the status of harmonization. This Annex can serve as a framework for future work carried out on harmonization of frequency bands and technical rules for RFIDs.

Annexes 2 and 3 provide an overview of the technical specifications for the deployment of RFIDs in Canada and Brazil. Administrations are invited to provide similar information for this PDN Report.

Annex 1

Harmonization possibilities for RFIDs on a global basis

The following are RFID harmonization possibilities for certain frequency bands. Further compatibility studies within the ITU-R should be considered to assess whether these bands could be harmonized globally.

1 Introduction

1) LF RFID

The following frequency has high potential for full harmonization since many countries in all three ITU Regions have issued regulations, which are *de facto* harmonized for this range:

f = 9-135 kHz

2) HF RFID

The following frequency is based on ISM bands available in Regions 1, 2 and 3 but not fully harmonized for RFID applications with regard to either frequency bands, modulation masks or power levels. These bands could be fully harmonized for:

f = 13.56 MHz

3) UHF RFID

f = 860 to 960 MHz

f = 433 MHz

f = 2.45 GHz

4) Others

RFID technology is closely linked to EAS (Electronic Article Surveillance), which also requires harmonization because of its global deployment:

f = 7.4-8.8 MHz

Annex 2

Technical specifications for RFID in Canada

1 Technical standards in Canada

Active RFID devices operate in Canada on a licence-exempt (no-interference no-protection) basis subject to the requirements given in RSS-210[2] or RSS-310[3]. RSS-210 specifies the technical requirements that devices must meet and be certified against prior to entering the Canadian marketplace. RSS-310 also specifies the technical requirements that devices must meet but for which there is no requirement to obtain certification.

Many RFID devices operate in the ISM bands and these devices are subject to field-strength limits and other requirements for the purpose of not interfering with ISM equipment. These limits are set out in RSS-210. Annex 5 of RSS-210 sets the requirements for RFID devices used to identify the contents of commercial shipping containers in the band 433.5-434.5 MHz.

Any transmitting device (including RFID) that has a power consumption not exceeding 6 nanoWatts is excluded from any Industry Canada requirements (e.g. certification) and may operate in any radio frequency on a no-interference no-protection basis. Passive RFID devices may operate without certification from Industry Canada.

1.1 Emission limits for RFID in Canada

1.1.1 General field-strength limits

The following general field-strength limits from RSS-210 apply to licence-exempt devices operating below and above 30 MHz. RFID can operate in any band that is not on the restricted list given in RSS-210 subject to the emission limits listed below.

TABLE 1

General field-strength limits of unwanted emissions for transmitters and receivers at frequencies above 30 MHz

Frequency (MHz)	Field-strength microvolts/m at 3 metres (watts, e.i.r.p.)	
	Transmitter	Receiver
30-88	100 (3 nW)	100 (3 nW)
88-216	150 (6.8 nW)	150 (6.8 nW)
216-960	200 (12 nW)	200 (12 nW)
Above 960	500 (75 nW)	500 (75 nW)

[2] http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf01320.html.

[3] http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf08448.html.

TABLE 2

General field-strength limits of unwanted emissions for transmitters at frequencies below 30 MHz (transmit)

Frequency (fundamental or spurious)	Field strength (microvolts/m)	Magnetic H-field (microamperes/m)	Measurement distance (metres)
9-490 kHz	2 400/F (*F* in kHz)	2 400/377F (*F* in Hz)	300
490-1 705 kHz	24 000/F (*F* in kHz)	24 000/377F (*F* in kHz)	30
1.705-30 MHz	30	N/A	30

1.1.2 Field-strength levels for certain ISM bands

RFID that operate in the 13.56 MHz band would be subject to the field-strength limits in Table 2 whereas RFID that operate in the 902-928 MHz, 2 400-2 483.5 MHz, and 5 725-5 850 MHz ISM bands would be subject to the limits of Annex 8 of RSS-210. This Annex applies to frequency hopping and digital modulation technology. For RFID and other systems employing digital modulation techniques the e.i.r.p. shall not exceed 4 W and the maximum peak conducted output power shall not exceed 1 W.

1.1.3 RFID in the band 433.5-434.5 MHz

The band 420-440 MHz has a primary radiolocation allocation in Region 2. RFID operate in this band under a no interference/no protection from interference basis.

The provisions of Annex 5 of RSS-210 are for RFID devices used to identify the contents of commercial shipping containers. Operation must be limited to commercial and industrial areas such as ports, rail terminals and warehouses. Two-way operation is permitted to interrogate and to load data into devices. Voice communication is prohibited.

The field-strength of any emissions radiated within the band 433.5-434.5 MHz shall not exceed 11 000 microvolts/metre measured at 3 metres with an average detector. The peak level of any emission within this specified frequency band shall not exceed 55 000 microvolts/metre measured at 3 metres.

Annex 3

Technical specifications for RFID in Brazil

1 RFID Operation in Brazil

RFID devices operate on a licence-exempt basis, i.e. without rights for protection against harmful interference and cannot cause interference in any system operating on a primary basis. Anatel Resolution 506 approved the Regulation on technical specifications for SRD in Brazil, where Section XII specifically treats the RFID devices. These devices are subject to field-strength limits, including unwanted emissions.

2 Radiated emission limits – general requirements

RFID devices operating in the following bands are subject to the emission limits listed below.

Frequency (MHz, where not specified)	Field strength (microvolts/metre)	Measurement distance (metres)
119-135 kHz	2 400 / *F*(kHz)	300
13.11-13.36 and 13.41-14.01	106 000	30
433.5-434.5	70 359	3
860-869	70 359	3
894-898.5	70 359	3
902-907.5	70 359	3
915-928	70 359	3
2 400-2 483.5	50 000	3
5 725-5 850	50 000	3

a) Radiated emission limits in these bands are based on measurements employing an average detector.

b) The peak field strength of any emission shall not exceed 20 dB of the specified values.

c) Unwanted emissions outside the frequency bands set forth herein, except for harmonics, shall be attenuated by at least 50 dB above the level of fundamental frequency or must meet the general limits established for SRD, whichever is the lesser attenuation.

3 Alternate field-strength limits for interrogator transceivers

The following conditions set alternative emission limits for interrogator transceivers, in relation with those established in the general requirements.

a) Interrogators transceivers operating in the frequency bands of 902-907.5 MHz, 915-928 MHz, 2 400-2 483.5 MHz and 5 725-5 850 MHz shall not exceed the following conditions or the conditions established in Section V of this Regulation.

a.1) The maximum output peak power of the transmitter cannot be greater than 1 Watt.

a.2) The peak power spectrum density, in any 3 kHz band during any continuous time interval transmission, cannot be greater than 8 dBm.

a.3) For devices using transmitting antennas with directional gain greater than 6 dBi, the maximum output peak power from the transmitter shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

b) Additionally, the interrogator transceivers of the systems of automatic identification of vehicles using frequency scanning techniques and operating in the bands 2.9-3.26 GHz, 3.267-3.332 GHz, 3.339-3.3458 GHz and 3.358-3.6 GHz shall not exceed the following conditions:

b.1) The field strength at any point within the range of radio-frequency scanning shall be limited to 3 000 microvolts/m/MHz at 3 metres from the device in any direction.

b.2) When in its operating position, the systems of automatic identification of vehicles must not produce a field strength greater than 400 microvolts/m/MHz at 3 metres from the device in any direction within ±10 degrees of the horizontal plane.

b.3) The field strength of emissions outside the range of the radio-frequency scanning shall be limited to 100 microvolts/m/MHz at 3 metres from the device measured from 30 MHz to 20 GHz.

b.4) The minimum signal scanning repetition rate must not be less than 4 000 scans per second and the maximum should not exceed 50 000 scans per second.

Annex 4

Technical specifications for RFID in CEPT countries

1 RFID Operation in CEPT

The information about the usage of RFID in CEPT countries is depicted in various annexes of ERC Recommendation 70-03 on short-range devices. Notably, in Annex 1 on non-specific short-range devices including RFID, *inter alia* in 433 MHz, in Annex 9 on inductive applications including the frequencies below 135 kHz and the 13.56 MHz frequencies, and in Annex 11 on RFID. The RFID devices operate on a licence-exempt basis. They shall not claim protection against harmful interference and shall not cause harmful interference to the radio systems.

In the EU/EFTA Member States, application of certain short-range devices, including RFID, within the ERC Recommendation 70-03 framework, is subject to European Commission (EC) Decisions including 2006/804/EC (for RFID in the UHF spectrum) and 2006/771/EC (for SRD and RFID) and subsequent EC Decisions amending 2006/771/EC. The EU/EFTA Member States are obliged to implement these EC Decisions.

However the provided information herein represents the most widely accepted position within the CEPT but it should not be assumed that all frequency designations are available in all member countries of CEPT. For these reasons, those wishing to develop or market RFID and SRDs based on ERC Recommendation 70-03 are advised to contact the relevant national administration to verify that the position set out herein applies.

Additional information is available on the website of the European Communications Office (ECO) (www.cept.org/eco).

1.1 Emission limits for RFID

Inductive RFID applications such as those operating below 135 kHz or at 13.56 MHz can use the regulation as given in Annex 9 of ERC Recommendation 70-03.

This Annex covers frequency bands and regulatory as well as informative parameters recommended for inductive applications such as car immobilizers, animal identification, alarm systems, cable detection, waste management, personal identification, wireless voice links, access control, proximity sensors, data transfer to handheld devices, automatic article identification, wireless control systems, automatic road tolling and anti-theft systems including RF anti-theft induction systems.

TABLE 3

Regulatory parameters related to Annex 9 of ERC/REC 70-03 (February 2011)

Frequency band		Magnetic field strength	Spectrum access and mitigation requirement	Channel spacing	ECC/ERC Decision	Notes
a1	9-90 kHz	72 dBµA/m at 10 m (Note 1)	No requirement	No spacing		In case of external antennas only loop coil antennas may be employed. Field strength level descending 3 dB/oct at 30 kHz
a2	90-119 kHz	42 dBµA/m at 10 m	No requirement	No spacing		In case of external antennas only loop coil antennas may be employed
a3	119-135 kHz	66 dBµA/m at 10 m (Note 1)	No requirement	No spacing		In case of external antennas only loop coil antennas may be employed. Field strength level descending 3 dB/oct at 119 kHz
b	135-140 kHz	42 dBµA/m at 10 m	No requirement	No spacing		In case of external antennas only loop coil antennas may be employed
c	140-148.5 kHz	37.7 dBµA/m at 10 m	No requirement	No spacing		In case of external antennas only loop coil antennas may be employed
d	6 765-6 795 kHz	42 dBµA/m at 10 m	No requirement	No spacing		
e	7 400-8 800 kHz	9 dBµA/m at 10 m	No requirement	No spacing		
f	13.553-13.567 MHz	42 dBµA/m at 10 m	No requirement	No spacing		
f1	13.553-13.567 MHz	60 dBµA/m at 10 m	No requirement	No spacing		For RFID and EAS only
g	26.957-27.283 MHz	42 dBµA/m at 10 m	No requirement	No spacing	ERC/DEC/ (01)16	
h	10.200-11.000 MHz	9 dBµA/m at 10 m	No requirement	No spacing		
k	3 155-3 400 kHz	13.5 dBµA/m at 10 m	No requirement	No spacing		In case of external antennas only loop coil antennas may be employed
l1	148.5 kHz-5 MHz	–15 dBµA/m at 10 m	No requirement	No spacing		In case of external antennas only loop coil antennas may be employed. *The maximum field strength is specified in a bandwidth of 10 kHz. The maximum allowed total field strength is –5 dBµA/m at 10 m for systems operating at bandwidths larger than 10 kHz whilst keeping the density limit (–15 dBµA/m in a bandwidth of 10 kHz)*

TABLE 3 (*end*)

Frequency band		Magnetic field strength	Spectrum access and mitigation requirement	Channel spacing	ECC/ERC Decision	Notes
I2	5-30 MHz	–20 dBµA/m at 10 m	No requirement	No spacing		In case of external antennas only loop coil antennas may be employed. ***The maximum specified in a bandwidth of 10 kHz. The maximum allowed total field strength is –5 dBµA/m at 10 m for systems operating at bandwidths larger than 10 kHz whilst keeping the density limit (–20 dBµA/m in a bandwidth of 10 kHz)***
I3	400-600 kHz	–8 dBµA/m at 10 m	No requirement	No spacing		For RFID only. In case of external antennas only loop coil antennas may be employed. *The maximum field strength is specified in a bandwidth of 10 kHz.* *The maximum allowed total field strength is –5 dBµA/m at 10 m for systems operating at bandwidths larger than 10 kHz measured at the centre frequency whilst keeping the density limit (–8 dBµA/m in a bandwidth of 10 kHz.)* These systems should operate with a minimum operating bandwidth of 30 kHz

NOTE 1 – Limit is reduced to 42 dBµA/m at 10 m according to Table 1 in Annex 9 of ERC/REC 70-03.

TABLE 4

Standard frequency and time signals to be protected within 9-90 kHz and 119-135 kHz

Station	Frequency	Protection bandwidth	Maximum field strength at 10 m	Location
MSF	60 kHz	±250 Hz	42 dBµA/m	United Kingdom
RBU	66.6 kHz	±750 Hz	42 dBµA/m	Russian Federation
HBG	75 kHz	±250 Hz	42 dBµA/m	Switzerland
DCF77	77.5 kHz	±250 Hz	42 dBµA/m	Germany
DCF49	129.1 kHz	±500 Hz	42 dBµA/m	Germany

Additional information

Harmonized standards

ETSI EN 300 330 for all sub-bands

ETSI EN 302 291 sub-band f)

Frequency issues

Users should be aware that emissions from inductive applications could cause interference to nearby receivers of other radio services.

In case of loop antennas, integral or dedicated antennas should be used within an area between 0.05 m^2 and 0.16 m^2, the field strength is reduced by 10 * log (area/0.16 m^2); for an antenna area less than 0.05 m^2 the field strength is reduced by 10 dB.

Particular attention should also be paid to the more stringent protection requirements identified by the ITU for global distress and safety communication frequencies in the same or adjacent bands.

Technical parameters also referred to in the harmonized standard

Sub-band a3)

RFIDs operating in the frequency sub-band 119-135 kHz shall meet the spectrum mask given in ETSI EN 300 330. This will permit a simultaneous use of the various sub-bands within the range 90-148.5 kHz.

RFIDs operating at 433 MHz or in the 5.8 GHz ISM band are included in the Annex 1 of ERC Recommendation 70-03. RFID applications can also use all other frequency ranges included in that annex provided that they fulfil the respective technical conditions for the spectrum utilization:

Frequency band	Power/ Magnetic field	Spectrum access and mitigation require-ment	Channel spacing	ECC/E RC Decision	Notes
433.050-434.790 MHz (Note 2)	10 mW e.r.p.	< 10 % (Note 1)	No spacing		
433.050-434.790 MHz (Note 2*bis*)	1 mW e.r.p. –13 dBm/ 10 kHz	No requirement	No spacing		Power density limited to –13 dBm/10 kHz for wideband modulation with a bandwidth greater than 250 kHz
434.040-434.790 MHz (Note 2*bis*)	10 mW e.r.p.	No requirement	Up to 25 kHz		
5 725-5 875 MHz	25 mW e.i.r.p.	No requirement	No spacing		

NOTE 1 – When either a duty cycle, Listen Before Talk (LBT) or equivalent technique applies then it shall not be user dependent/adjustable and shall be guaranteed by appropriate technical means.

For LBT devices without Adaptive Frequency Agility (AFA), or equivalent techniques, the duty cycle limit applies.

For any type of frequency agile device the duty cycle limit applies to the total transmission unless LBT or equivalent technique is used.

NOTE 2 – Audio and video applications are allowed provided that a digital modulation method is used with a max. bandwidth of 300 kHz.

Analogue and digital voice applications are allowed with a max. bandwidth ≤ 25 kHz.

In sub-band 863-865 MHz voice and audio conditions of Annexes 10 and 13 of ERC/REC 70-03 apply respectively.

NOTE 2*bis* – Audio and video applications are excluded. Analogue or digital voice applications are allowed with a max. bandwidth ≤ 25 kHz and with spectrum access technique such as LBT or equivalent. The transmitter shall include a power output sensor controlling the transmitter to a maximum transmit period of 1 minute for each transmission.

Harmonized European Standards

ETSI EN 300 220 for frequencies up to 1 GHz

ETSI EN 300 440 for frequencies above 1 GHz

UHF RFID operating in 865-868 MHz or 2.4 GHz are included in Annex 11 of ERC Recommendation 70-03.

This Annex covers frequency bands and regulatory as well as informative parameters recommended for radio-frequency identification (RFID) applications including for example automatic article identification, asset tracking, alarm systems, waste management, personal identification, access control, proximity sensors, anti-theft systems, location systems, data transfer to handheld devices and wireless control systems. It should be noted that other types of RFID systems can be operated in accordance with other relevant annexes.

Regulatory parameters related to Annex 11 of ERC/REC 70-03

Frequency band	Power	Spectrum access and mitigation requirement	Channel spacing	ECC/ ERC Decision	Notes
a1 2 446-2 454 MHz	≤ 500 mW e.i.r.p.	No requirement	No spacing		
a2 2 446-2 454 MHz	> 500 mW-4 W e.i.r.p	≤ 15% duty cycle FHSS techniques should be used	No spacing		Power levels above 500 mW are restricted to be used inside the boundaries of a building and the duty cycle of all transmissions shall in this case be ≤ 15% in any 200 ms period (30 ms on/170 ms off)
b1 865.0-865.6 MHz	100 mW e.r.p.	No requirement	200 kHz		
b2 865.6-867.6 MHz	2 W e.r.p.	No requirement	200 kHz		
b3 867.6-868.0 MHz	500 mW e.r.p.	No requirement	200 kHz		

Harmonized European Standards

ETSI EN 300 440 Sub-band a)

ETSI EN 302 208 Sub-bands b1), b2) and b3)

Frequency issues

Sub-band a)

To assist enforcement authorities any emissions due to the RFID device when measured outside of the building at a distance of 10 metres shall not exceed the equivalent field strength for a 500 mW RFID device mounted outside the building when measured at the same distance. Where a building consists of a number of premises, such as shops within a shopping arcade or mall then the measurements shall be referenced to the boundary of the user's premises within the building.

Sub-bands b1), b2) and b3)

Channel centre frequencies are 864.9 MHz + (0.2 MHz * channel number).

The available channel numbers for each sub-band are:

b1: channel numbers 1 to 3

b2: channel numbers 4 to 13

b3: channel numbers 14 to 15.

NOTE – The same equipment is allowed to operate in several sub-bands.

Frequency hopping or other spread spectrum techniques shall not be used.

Technical parameters also referred to in the harmonized standard

Sub-band a)

In addition, antenna beamwidth limits shall be observed as described in the standard ETSI EN 300 440.

In addition, for an RFID device, which can exceed 500 mW, the device should be fitted with an automatic power control to reduce the radiated power below 500 mW; this automatic power control shall guarantee the reduction of the power to a maximum of 500 mW in cases where the device is moved and used outside the boundary of the user's building or premises as described above.