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Electromagnetic compatibility and Radio spectrum Matters (ERM); System Reference document (SRdoc); Technical characteristics and spectrum requirements of wideband SRDs with advanced spectrum sharing capability for operation in the UHF 870 - 876 MHz and 915 - 921 MHz frequency bands

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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).

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Introduction

Wideband SRDs are a subset of the broader SRD family that can enable further market growth for divers applications including Internet of Things, Machine-to-Machine communications, smart home/building automation and 'wearables'. This can be achieved in particular through advanced characteristics of these devices such as higher data rates, improved power usage, and efficient spectrum utilization. Therefore, Wideband SRD's are expected to grow rapidly over the foreseeable future for mass market applications. Based on these expected growth rates and currently limited available frequency bands, there is an essential need for additional spectrum for Wideband SRDs to accommodate the anticipated market growth. The present document requests modifications to the regulatory rules of the UHF 870 - 876 MHz and 915 - 921 MHz frequency bands to enable the operation of Wideband SRDs with advanced spectrum sharing capabilities in these bands.

1 Scope

The present document applies to the potential future usage of Wideband SRDs with advanced spectrum sharing capabilities in the UHF 870 - 876 MHz and 915 - 921 MHz frequency bands. In particular, it:

- Gives an SRD market overview and explains the development and emergence of new Wideband SRD technologies.
- Describes technical characteristics of Wideband SRDs, including advanced spectrum sharing capabilities, as they relate to the usage of the UHF 870 - 876 MHz and 915 - 921 MHz spectrum.
- Details the requested regulatory changes to allow for efficient use of Wideband SRDs.

The present document is intended to include all necessary information required by the Electronic Communications Committee (ECC) under the MoU between ETSI and the ECC.

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 referenced 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] CEPT ECC ERC Recommendation 70-03: "Relating to the Use of Short Range Devices (SRD)", 07 February 2014.

[i.2] ABI Research, "Short Range Wireless and Cellular ICs Enabling the Connected World of Tomorrow", July 2013 (PT-1027).

[i.3] ABI Research Report "Home Automation Systems", May 5, 2014 (MD-HAS-1047).

[i.4] IHS, "Wearable Technology - World", October 2013.

[i.5] IEEE P802.11ah / Draft 2.0 June 2014. "Part II: Wireless LAN Medium Access Control (MAC) and Physical (PHY) Layer Specifications. Amendment 6: Sub 1 GHz License Exempt Operation".

[i.6] ETSI EN 300 220-1 (V2.4.1) (2012-01): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio equipment to be used in the 25 MHz to 1 000 MHz frequency range with power levels ranging up to 500 mW; Part 1: Technical characteristics and test methods".

[i.7] ETSI EN 300 328 (V1.8.1) (2012-04): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Wideband transmission systems; Data transmission equipment operating in the 2,4 GHz ISM band and using wide band modulation techniques; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive".

[i.8] ETSI EN 303 204 (V1.1.0): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Network Based Short Range Devices (SRD); Radio equipment to be used in the 870 MHz to 876 MHz frequency range with power levels ranging up to 500 mW".

[i.9] CEPT ECC Report 200: "Co-existence studies for proposed SRD and RFID applications in the frequency band 870-876 MHz and 915-921 MHz", September 2013.

[i.10] CEPT ECC Report 189: "Future Spectrum Demand for Short Range Devices in the UHF Frequency Bands".

[i.11] CEPT ECC Report 181: "Improving Spectrum Efficiency in the SRD Bands", September 2012.

[i.12] ETSI TR 103 055 (V1.1.1) (2011-09): "Electromagnetic compatibility and Radio spectrum Matters (ERM); System Reference document (SRdoc): Spectrum Requirements for Short Range Device, Metropolitan Mesh Machine Networks (M3N) and Smart Metering (SM) applications".

[i.13] ETSI TR 102 649-2 (V1.3.1) (2012-08): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Technical characteristics of Short Range Devices (SRD) and RFID in the UHF Band; System Reference Document for Radio Frequency Identification (RFID) and SRD equipment; Part 2: Additional spectrum requirements for UHF RFID, non-specific SRDs and specific SRDs".

[i.14] IEEE 802.11: "IEEE Standard for Information technology --Telecommunications and information exchange between systems Local and metropolitan area networks--Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications".

[i.15] IEEE 802.11n: "IEEE Standard for Information technology -- Local and metropolitan area networks -- Specific requirements -- Part 11: Wireless LAN Medium Access Control (MAC)and Physical Layer (PHY) Specifications Amendment 5: Enhancements for Higher Throughput".

[i.16] IEEE 802.11ac: "IEEE Standard for Information technology -- Telecommunications and information exchange between systems - Local and metropolitan area networks -- Specific requirements -- Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications -- Amendment 4: Enhancements for Very High Throughput for Operation in Bands below 6 GHz".

[i.17] ABI Research Report "Commercial Building Automation", March 19, 2013. (MD-CBA-102).

3 Definitions and abbreviations

3.1 Definitions

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

channel: small frequency sub-band within the operating frequency band into which a Radio Signal fits

duty cycle: for the purposes of the ERC Recommendation 70-03 [i.1], the duty cycle is 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 frequency agile devices the duty cycle limit applies to the total transmission.

Listen Before Talk (LBT): action taken by a device to detect an unoccupied channel prior to transmitting

frequency agility: ability of a device to selectively change its frequency sub-band of operation within the larger operating frequency band

Non-specific Short Range Devices (SRDs): SRDs that do not necessarily fit under the specific applications outlined in ERC/REC 70-03 [i.1], Annexes 2 to 13

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

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".

Specific Short Range Devices (SRDs): SRDs that are used in specific applications (e.g. Applications of ERC/REC 70-03 [i.1], Annexes 2 to 13)

Wideband SRDs: SRD devices that use wideband modulation techniques with channel bandwidths larger than 600 kHz (which current regulations for UHF 870 - 876 MHz and 915 - 921 MHz already specify) and up to 1 MHz

NOTE: This definition is for the purpose of notational simplicity and clarity in the context of drafting the present document and does not claim a consensus on global definition for Wideband SRDs.

3.2 Abbreviations

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

AC	Access Category
ACK	Acknowledgement
AFA	Adaptive Frequency Agility/Autonomous Frequency Assignment
AP	Acces-Point
BPSK	Binary Phase Shift Keying
BSS	Basic Service Set
CA	Collision Avoidance
CAGR	Compound Annual Growth Rate
CCA	Clear Channel Assessment
CEPT	Commission Européenne des Postes et Télécommunications
CSMA	Carrier Sense Multiple Access
CW	Contention Window
DCF	Distributed Coordination Function
DIFS	DCF Interframe Spacing
DSSS	Direct Sequence Spread Spectrum
e.r.p/e.i.r.p.	effective radiated power/effective isotropic radiated power
ECC	Electronic Communications Committee of the CEPT
EDCA	Enhanced Distributed Channel Access
ER-GSM	Extended Railways GSM
FFT	Fast Fourier Transform
FHSS	Frequency Hopping Spread Spectrum
GSM-R	Global System for Mobile communication for Railway application
HVAC	Heating, Ventilation and Air Conditioning
IoT	Internet of Things
IP	Internet Protocol
ISM	Industrial Scientific and Medical
LBT	Listen-Before-Talk
M2M	Machine-to-Machine communication
MAC	Medium Access Layer
OBSS	Other Basic Service Set
OFDM	Orthogonal Frequency Division Multiplexing
PER	Packet Error Rate
PHY	Physical Layer
PSD	Power Spectral Density
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RAW	Restricted Access Window
RFID	Radio Frequency Identification
SIFS	Short Interframe Spacing
SRD	Short-Range Device

SST	Sub-band Selective Transmission
STA	Station
TWT	Target Wake Time
TXOP	Transmit Opportunity
UHF	Ultra-High Frequency

4 Comments on the System Reference Document

The statements in clause 4.1 have been recorded.

4.1 Statements by ETSI Members

BWMi statement concerning the utilization in Germany of the UHF frequency bands 870 - 876 MHz and 915 - 921 MHz.

In Germany a designation of the frequency bands 870 - 876 MHz and 915 - 921 MHz for wideband SRD applications as described in this SRdoc is not foreseen due to incumbent German military and GSM-R usage.

5 Executive summary

The present document proposes modifications to the regulatory rules of the SRDs [i.1] in Sub-1 GHz frequency ranges, to be considered with the aim of helping market introduction and proliferation of Wideband SRDs in the overall context of ongoing strategic re-alignment of SRD uses and allowing new bands and applications, e.g. in 870 - 876 MHz and 915 - 921 MHz frequency bands. Current usage rules [i.1] governing maximum allowable transmit bandwidth and duty cycle will not allow even basic SRD Wideband deployments and therefore these parameters need to be reviewed by taking into account the information given in the present document. In return, Wideband SRDs will implement advanced spectrum sharing techniques such as more sophisticated LBT and AFA procedures to ensure coexistence and balance the changes to spectrum usage. These changes will ultimately lead to SRD systems that are capable of more data rates to support the needs of various SRD applications and allow more efficient and fair utilization of the spectrum.

The present document first presents market data and predictions for the growth of the "Internet of Things" (IoT) and in a broader sense Machine-to-Machine (M2M) communications market in Europe and worldwide. The technologies for IoT are also evolving to address the ever emerging market needs and use cases and one direction is towards Wideband SRD systems such as (but not limited to) those based on IEEE 802.11ah [i.5]. Based on expected growth rates and currently limited available frequency bands, there is an essential need for new spectrum designations for these types of Wideband SRDs to support IoT deployments.

The IEEE 802.11ah [i.5] is an example technology for Wideband SRDs that allows for a wide-range of data rates through the use of OFDM modulation and has built-in mechanisms for efficient spectrum sharing. The present document describes its salient technical characteristics and features such as LBT based on CSMA-CA and AFA using Sub-channel Selective Transmissions.

Based on the market data and the technical requirements for deployment of IEEE 802.11ah [i.5] (and other Wideband SRD-type systems), spectrum designation is being requested. For Wideband SRDs to be efficiently deployed in the UHF 870 - 876 MHz and 915 - 921 MHz frequency bands and to specifically support more sensor-type network use cases, the following changes to spectrum regulations need to be considered:

- Creation of sub-band definitions between 870 - 875,8 MHz and 915,2 - 920,80 MHz for Wideband SRDs.
- Increase of Maximum Transmission Bandwidth from 600 kHz to 1 MHz.
- Inclusion of IEEE 802.11 [i.14] CSMA-CA as a compliant method of LBT within 870 - 876 MHz and 915 - 921 MHz, with the minimum CCA interval times and timing parameters defined to align with IEEE 802.11ah [i.5] values.
- Relaxation of Maximum Duty Cycle for AP-type devices implementing LBT+AFA from 1 % to 10 %, and for non-AP devices using LBT+AFA from 1 % to 2,8 %.

6 Market information

Markets that stand to benefit from Wideband SRD's are expected to grow rapidly over the foreseeable future. For example ABI Research is projecting that globally installed base of wirelessly connected devices will grow from over 10 billion units in 2013 to over 30 billion units in 2020 [i.2]. The market for smart home/building automation, IoT/M2M, and "Wearables" is expected to grow at a very rapid pace. For example, according to ABI Research [i.3], the market for new installs of Home Automation systems in Europe is expected to grow by 40 % (CAGR) between 2014 and 2019 to 7,3 million in 2019. The market for wirelessly enabled building automation devices installed in Europe is expected to grow at a rate of 19 % (CAGR) between 2014 and 2018 to 6,9 million new installs in 2018 [i.17]. The unit shipment volume market for the emerging market of "Wearable" technology in Europe is projected to be around 70 million units in 2018 according to IHS [i.4]. This market (e.g. for smartwatches, fitness trackers, etc.) is projected to have a high wireless connectivity attach rate (over 60 %).

Additional relevant market data is given in annex A of the present document. Wideband SRDs are expected to become the key enablers for new deployments and applications in the above sectors. Examples of benefits of Wideband SRD enabled devices include increased energy efficiency in homes/buildings, medical/fitness applications to help reduce medical expenses, remote elderly care, security/surveillance cameras, etc.

Another example of the market momentum towards the adoption of Wideband SRD technology is that the Wi-Fi Alliance (a global, non-profit industry association of more than 600 leading companies devoted to seamless interoperability) is working on the development of an industry interoperability program for devices that implement the IEEE 802.11ah [i.5] standard under development.

The key advantages of using Wideband SRDs for wireless connectivity are:

- Provide higher data rates for IoT and similar data-rich applications.
- Enable IP networking for security and scalability.
- Open up new use cases for low power, battery operated, wireless sensors.
- Enables the use of one network in a home or building with enough capacity and features to support a variety of integrated sensor type services and applications.

The expected high growth in the number of deployed Wideband SRDs drives the need for an increase in overall network capacity. It is expected that the exiting 7 MHz of spectrum available for SRDs in the 863 - 870 MHz band will be quickly exhausted. A complicating factor here is that usage of the 863 - 870 MHz spectrum is constrained by the 3 % duty cycle limitation for all devices using this spectrum even with advanced spectrum sharing techniques like LBT/AFA.

Additional spectrum for Wideband SRDs in the 870 - 876 MHz and 915 - 921 MHz bands will be required to accommodate the anticipated market growth for IoE, M2M and "Wearable" devices. Applications and devices in these high growth markets increasingly require higher data rates than SRDs that have been historically deployed in these spectrum bands. For example Wideband SRDs are needed to support IP networking, to offer more robust security and to enable more sophisticated IP based applications (like for smartgrid networking). In order to enable networks, which could scale up to meet the anticipated demand, more advanced spectrum sharing techniques and the ability to use wider channel bandwidths will be needed for these bands.

One additional consideration, which may apply, is that the IoE market will likely serve as an engine for technology innovation and economic growth in the foreseeable future. The availability of larger amounts of Sub-1 GHz spectrum with fewer spectrum usage limitations in key markets like the USA, South Korea, Japan, Australia and possibly China may put the competitive advantage of EU member countries at risk.

7 Technical characteristics

This clause will describe the technical details of Wideband SRDs and specifically cover the future IEEE 802.11ah system (currently in drafting process, expected completion of standard specification by early 2015 [i.5]), focusing on the PHY/MAC characteristics and notably its advanced spectrum sharing capabilities, which are relevant to operation and coexistence in the UHF 870 - 876 MHz and 915 - 921 MHz bands.

The term Wideband SRD is used to describe devices using technologies and protocols that have larger operation bandwidths (e.g. ≥ 1 MHz) than most current SRDs on the market. These Wideband SRDs will also generally have higher supported data rates as a consequence of the wider operation bandwidths.

7.1 Description of IEEE 802.11ah as an Example Technology for Wideband SRDs

Like other IEEE 802.11-based systems, the IEEE 802.11ah [i.5] system is based on a network topology consisting of Access Points (APs) and stations (STAs). The APs act as nodes that the STAs are associated with, and APs can generally be expected to serve large numbers of STAs in IEEE 802.11ah [i.5]. An AP and the STA(s) associated to it comprise a Basic Service Set (BSS) and BSSs are set up with an operating channel bandwidth around a carrier frequency from a set of valid carrier frequencies, which are determined by regulations in the region of operation. An overall network can consist of multiple BSSs of different coverage radiuses spread over a geographical area, with individual BSSs overlapping or partially overlapping the frequencies and channel(s) of other BSSs (OBSS), see Figure 1 for an illustrative example.

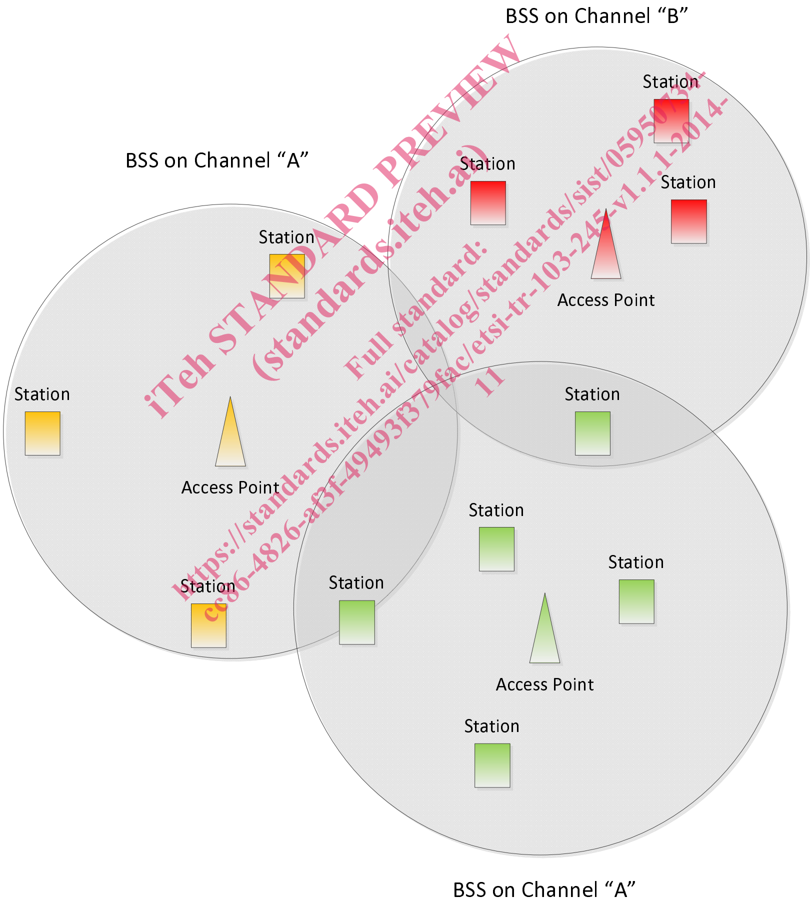

Figure 1: An illustrative example of a IEEE 802.11ah [i.5] network consisting of multiple BSSs

An AP is responsible for broadcasting management frames (e.g. beacon frames) to be received by the STAs in its BSS. These management frames contain operational parameters and information necessary for the STAs to operate and remain synchronized within the BSS.

Similar to other IEEE 802.11-based systems [i.14], APs are responsible for setting up associations with STAs entering the BSS, and additionally serve data traffic to STAs on the downlink and respond with ACKs for incoming uplink traffic. Because of the APs role in the BSS, they will generally need to transmit more frequently than an individual STA would.