



MulteFire Release 1.0 Regulatory Analysis White Paper





Introduction

also involves compliance in EMC, Safety, RF Exposure, etc.

This document provides a regulatory analysis for MulteFire 1.0 products covering both UEs and eNBs for the (FCC) Federal Communications Commission in the United States, Innovation, Science and Economic Development (ISED) in Canada, and the Radio Equipment Directive (RED) in Europe.

The purpose of this document is to identify the existing radio regulatory requirements for unlicensed devices that may fit with MulteFire 1.0 products: eNBs and UEs. It contains references to the relevant regulations under the regulatory framework in the 5 GHz band for -license-exempt regime or shared spectrum in the United States, Canada and Europe.

The present document details the applicable radio standards and test methods against FCC, ISED and RED regulations. In addition, it is provided as a guidance that defines the test modes to be implemented in UEs and eNBs MulteFire 1.0 devices.

It does not attempt to provide an overall product compliance path for a MulteFire device, which

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1. MulteFire 1.0 Overview

MulteFire™ is a new innovative technology designed to create new wireless networks by operating LTE technology standalone in unlicensed or shared spectrum. It is designed to efficiently coexist with other technologies such as Wi-Fi or LAA, using Listen-Before-Talk (LBT) [1].

The MulteFire Release 1.0 specification is mainly based on 3GPP standards.

UE and eNB MulteFire 1.0 products operating in the 5GHz unlicensed spectrum band as shown in table 1 are considered in the present document. Channelization for the 5GHz frequency band assuming a 20 MHz channel nominal bandwidth are included in tables 2, 3, and 4.

Frequency bands (MHz)	MulteFire band
5150 – 5250	240a
5250 – 5350	240b
5470 – 5725	240c
5725 – 5925	240d

Table 1. Operating frequency bands for MulteFire 240a band

5160	5180	5200	5220	5240	5260	5280	5300	5320	5340
240a					240b				

Table 2. Frequency channel for 240a and 240b bands

5480	5500	5520	5540	5560	5580	5600	5620	5640	5660	5680	5700	5720
240c												

Table 3. Frequency channel for 240a and 240b bands

5745	5765	5785	5805	5825	5845	5865	5885	5905
240d								

Table 4. Table 2. Frequency channel for 240d band

The multicarrier modulation technique Orthogonal Frequency Division Multiplexing (OFDM) is the transmission scheme used in MulteFire devices for downlink and uplink. The modulation supported by the subcarrier are specified in table 5.

	Modulation schemes
Downlink (eNB)	QPSK, 16QAM, 64 QAM, 256 QAM
Uplink (UE)	QPSK, 16QAM, 64 QAM

Table 5. Subcarriers modulation scheme

2. Regulatory Requirements

Technical rules for unlicensed devices operating in the 5GHz band are set out in the different regulations established by FCC, ISSED and RED as it is shown in the following table:

	240a	240b	240c	240d (only 5725 – 5850 MHz)
FCC	47 CFR 15; Section 15.407 [2]			
ISSED	RSS 247 [3]			
RED	2005/513/EC [4] 2007/90/EC [5]		2006/771/EC and its amendment 'Decision (EU) 2019/1345' [6] ECC/REC(06)04 ¹ [7]	

Table 6. Rules for 5GHz unlicensed spectrum

The available unlicensed 5GHz spectrum covers the entire 240 MulteFire band except for the upper band 240d (5850-5925 MHz), which is reserved for vehicles communication in the States, Canada and Europe.

The annex I intends to summarize the major technical requirements established in the mentioned rules and to which MulteFire eNB and UE devices may be subjected.

When operating in frequencies subject to DFS, the device must employ this feature. Annex III Dynamic Frequency Selection explains the requirements to be considered when setting the device for testing these features and includes a corresponding table that summarizes the applicable rules depending on the device role and the frequency band for each specific scheme of certification.

3. Test procedures

To demonstrate compliance with the FCC's and ISSED's rules, it is required to use the appropriate

¹This ECC recommendation is followed by some European countries and it may be applicable only for eNB devices

measurement methods specified in each particular section of the corresponding rules. As many measurement methods are not specified under the rules, FCC finds acceptable other measurements in accordance with Section 2.947 [8] and ISED publishes on its web site a list of normative test standards and acceptable alternate procedures [9].

Related to the RED scheme of certification, the most common way to comply with the essential requirements is to apply the voluntary harmonized standards developed by ETSI. The European Commission formally request to ETSI to develop harmonized standard to radio equipment under the RED (2014/53/EU). [10]

Although harmonised standards are voluntary, applying those that are published by the Commission in the Official Journal of the European Union (OJ) gives presumption of conformity with the essential or other requirements that aims to cover under the Radio Equipment Directive.

In the following table, it is specified the applicable test methods for MulteFire 1.0 devices for the different schemes of certification.

	240a/240b/240c	240d (only 5725 – 5850 MHz)
FCC/ ISED	ANSI C63.10-2013 [11] KDB 789033 [12] KDB 905462 [13]	
RED	EN 301 893 V2.1.1 [14]	EN 300 440 V2.2.1 (for UE) [15] EN 302 502 (only for eNB) V2.1.1 [16]

The version published in the OJ is EN 300 440 V2.1.1, although the version applicable shall be the V2.2.1 as the previous one does not comply with the essential requirements for receivers (category 2 and 1). Please refer to the list of standard harmonized published in the OJEU.

The annex II of the present document provides some general guidance for setting the device testing modes in order to show compliance according with FCC regulation.

4. References

[1] MulteFire Alliance, «MulteFire Release 1.0».

- [2] «The Code of Federal Regulations, Title 47, Part 15, Subpart E,» [En línea]. Available: <https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=0c5eba9f213a8c707286f10396e99d9f&mc=true&n=pt47.1.15&r=PART&ty=HTML#sp47.1.15.e>.
- [3] ISED, «Radio Standards Specification RSS-247, Issue 2, Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices,» [En línea]. Available: <https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf10971.html>.
- [4] «Commission decision of 11 July 2005 on the harmonised use of radio spectrum in the 5 GHz frequency band for the implementation of wireless access systems including radio local area networks (WAS/RLANs),» [En línea]. Available: <https://www.ecodocdb.dk/download/d5507b80-0125/2005513EC.PDF>.
- [5] «Commission decisions of 12 February 2007 amending Decision 2005/513/EC on the harmonised use of radio spectrum in the 5 GHz frequency band for the implementation of Wireless Access Systems including Radio Local Area Networks (WAS/RLANs),» [En línea]. Available: <https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:041:0010:0010:EN:PDF>.
- [6] «Commission implementing decision (EU) 2019/1345 of 2 August 2019 amending Decision 2006/771/EC updating harmonised technical conditions in the area of radio spectrum use for short-range devices,» [En línea]. Available: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2019:212:FULL&from=EN>.
- [7] «ECC Recommendation (06)04, Use of the bnd 5 725–5 875 Mhz for Broadband Fixed Wireless Access (BFWA),» [En línea]. Available: <https://www.ecodocdb.dk/download/7fc4eee1-d9dc/REC0604.PDF>.
- [8] FCC, «Equipment Authorization – Measurement Procedures,» [En línea]. Available: <https://www.fcc.gov/general/equipment-authorization-measurement-procedures>.
- [9] ISED, «Normative Test Standards and Acceptable Alternate Procedures,» [En línea]. Available: http://www.ic.gc.ca/eic/site/ceb-bhst.nsf/eng/h_tt00094.html.

- [10] «The European regulatory environment for radio equipment and spectrum,» [En línea]. Available: https://www.etsi.org/e-brochure/radio/ETSI_ECC%20Brochure_2016_Web.pdf.
- [11] «ANSI C63.10-2013. American National Standard of Procedures for Compliance Testing of Unlicensed Wireless».
- [12] FCC, «KDB Publication Number: 789033,» [En línea]. Available: <https://apps.fcc.gov/oetcf/kdb/forms/FTSSearchResultPage.cfm?switch=P&id=52935>.
- [13] FCC, «KDB Publication 905462. Compliance Measurement Procedures for Unlicensed National Information Infrastructure Devices Operating in the 5250 MHz to 5350 and 5470 MHz to 5725 MHz Bands incorporating Dynamic Frequency Selection,» [En línea]. Available: <https://apps.fcc.gov/oetcf/kdb/forms/FTSSearchResultPage.cfm?switch=P&id=27155>.
- [14] «ETSI EN 301 893 V2.1.1 (2017-05),» [En línea]. Available: https://www.etsi.org/deliver/etsi_en/301800_301899/301893/02.01.01_60/en_301893v020101p.pdf.
- [15] «ETSI EN 300 440 V2.2.1 (2018-07),» [En línea]. Available: https://www.etsi.org/deliver/etsi_en/300400_300499/300440/02.02.01_60/en_300440v020201p.pdf.
- [16] «ETSI EN 302 502 V2.1.1 (2017-03),» [En línea]. Available: https://www.etsi.org/deliver/etsi_en/302500_302599/302502/02.01.01_60/en_302502v020101p.pdf.

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Glossary of terms

3GPP – Third Generation Partnership Project

BFWA – Broadband Fixed Wireless Access

DFS – Dynamic Frequency Selection

UE– User Equipment

eNB – Evolved NodeB

FCC – Federal Communication Commission

ISED – Innovation, Science and Economic
Development

RLAN – Radio Local Network

SRD – Short Range Devices

TPC – Transmit Power Control

UNII – Unlicensed National Information
Infrastructure devices

LBT – Listen-Before-Talk

RED – Radio Equipment Directive

Annex I. Regulatory Technical Requirements

The present annex shows a high level summary of the major regulatory technical requirements for MulteFire eNBs and UEs devices. For further details and additional requirements, please refer to the corresponding rules.

Important note: In the table below the UE is considered as a client device and the eNB as a master device. Definitions are included in the specific rules.

	FCC		Canada		EU	
	eNB	UE	eNB	UE	eNB	UE
5150-5250 MHz						
Rules	47 CFR 15; Section 15.407		RSS 247		EN301 893	
Power and EIRP	Max conducted power 30dBm, Max EIRP 36dBm (note 1)	Max conducted power 30dBm, Max EIRP 36dBm	(EIRP) 23 dBm or 10 + 10 log10B dBm, whichever power is less. B is the 99% emission bandwidth in megahertz		23 dBm EIRP	
Power Density	17 dBm/MHz	11 dBm/MHz	10 dBm/MHz		10 dBm/MHz (EIRP)	
DFS (Y/N)	N		N		N	
TPC (Y/N)	N		N		N	
Indoor/Outdoor	Indoor/outdoor		Indoor		Indoor	
Unwanted emission	-27 dBm/MHz e.i.r.p outside 5150-5350 MHz		-27 dBm/MHz e.i.r.p outside 5150-5350 MHz (note 2)		Refer to point 4.2.4 of EN301 893	
Note 1	Additional rule for outdoor operation: Max EIRP < 21 dBm at any elevation angle > 30° from horizon.					
Note 2	Any unwanted emissions that fall into the band 5250-5350 MHz shall be attenuated below the channel power by at least 26 dB					

	FCC		Canada		EU	
	eNB	UE	eNB	UE	eNB	UE
5250-5350 MHz						
	47 CFR 15; Section 15.407		RSS 247		EN301 893	
Power and EIRP	Conducted Power limit: min (30, 10logB) B: 26dB BW EIRP Limit: 36 dBm		Conducted Power limit: min (30, 10logB) B:99% BW (Canada) EIRP Limit: 36 dBm (note 1)		23 dBm EIRP with TPC 23/20 dBm EIRP without TPC (note 3)	
Power Density	11 dBm/MHz		11 dBm/MHz		10 dBm/MHz EIRP with TPC 10/7 dBm/MHz EIRP without TPC (note 4)	
DFS (Y/N)	Y (refer to annex III)		Y (refer to annex III)		Y (refer to annex III)	
TPC (Y/N)	YES, if Max EIRP ≥ 27 dBm and able to lower EIRP below 24dBm NO, if Max EIRP < 27dBm		YES, devices with a maximum e.i.r.p. greater than 500 mW shall implement TPC in order to		Yes, if Max EIRP ≥ 20 dbm and able to lower EIRP below 17 dBm	

		have the capability to operate at least 6 dB below the maximum permitted e.i.r.p. of 1 W.	
Indoor/Outdoor	Indoor/outdoor	Indoor/outdoor	Indoor/outdoor
Unwanted emission	-27 dBm/MHz e.i.r.p outside 5150-5350 MHz	-27 dBm/MHz e.i.r.p outside 5250-5350 MHz (note 2)	Refer to point 4.2.4 of EN301 893
Note 1	See additional requirements for outdoor operation in RSS 247, point 6.2.2.3 Maximum conducted output power shall not exceed 250 mW or $11 + 10 \log_{10} B$, dBm, whichever is less		
Note 2	Or -27 dBm/MHz e.i.r.p outside 5150-5350 MHz and its power shall comply with the spectral power density for operation within the band 5150-5250 MHz		
Note 3	The applicable limit is 20 dBm, except for transmissions whose nominal bandwidth falls completely within the band 5 150 MHz to 5 250 MHz, in which case the applicable limit is 23 dBm		
Note 4	The applicable limit is 7 dBm/MHz, except for transmissions whose nominal bandwidth falls completely within the band 5 150 MHz to 5 250 MHz, in which case the applicable limit is 10 dBm/MHz.		

	FCC		Canada		EU	
	eNB	UE	eNB	UE	eNB	UE
5470-5725 MHz			(note 1)			
	47 CFR 15; Section 15.407		RSS 247		EN301 893	
Power and EIRP	Conducted Power limit: min (30, 10logB) B: 26dB BW EIRP Limit: 36 dBm		Conducted Power limit: min (30, 10logB) B:99% BW (Canada) EIRP Limit: 36 dBm (note 2)		30 dBm EIRP with TPC 27 dBm EIRP without TCP (note 4)	
Power Density	11 dBm/MHz		11 dBm/MHz		17 dBm/MHz EIRP with TPC 14 dBm/MHz EIRP without TCP (note 4)	
DFS (Y/N)	Y (refer to annex III)		Y (refer to annex III)		Y (refer to annex III)	
TPC (Y/N)	YES, if Max EIRP ≥ 27 dBm and able to lower EIRP below 24dBm NO, if Max EIRP < 27dBm		YES, devices with a maximum e.i.r.p. greater than 500 mW shall implement TPC in order to have the capability to operate at least 6 dB below the maximum permitted e.i.r.p. of 1 W.		Yes, if Max EIRP ≥ 27 dbm and able to lower EIRP below 24 dBm	
Indoor/Outdoor	Indoor/outdoor		Indoor/outdoor		Indoor/outdoor	
Unwanted emission	≤-27 dBm/MHz outside 5470- 5725 MHz		≤-27 dBm/MHz outside 5470-5725 MHz (note 3)		Refer to point 4.2.4 of EN301 893	
Note 1	Transmitting in the band 5600-5650 MHz is not allowed					
Note 2	Maximum conducted output power shall not exceed 250 mW or 11 + 10 log10B, dBm, whichever is less.					
Note 3	Devices with bandwidth overlapping the band edge of 5725 MHz can meet the emission limit of -27 dBm/MHz e.i.r.p.at 5850 MHz instead of 5725 MHz.					

Note 4	Slave devices without a Radar Interference Detection function shall comply with the limits for the frequency range 5 250 MHz to 5 350 MHz.
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	FCC		Canada		EU	
	eNB	UE	eNB	UE	eNB	UE
5725–5850 MHz					Note 1	
Rules	47 CFR 15; Section 15.407		RSS 247		EN302 502	EN300 440 (note 3)
Power and EIRP	Max conducted power 30dBm, Max EIRP 36dBm		Max conducted power 30dBm, Max EIRP 36dBm		30 dBm Mean RF Power and 36 dBm EIRP (CH BW: 20 MHz) 27 dBm Mean RF Power 33 dBm EIRP (CH BW: 10 MHz)	14 dBm EIRP (note 3)
Power Density	30 dBm/500kHz		30 dBm/500kHz		(EIRP) 23 dBm/MHz	–
DFS (Y/N)	N		N		Y (refer to annex III)	N
TPC (Y/N)	N		N		Y (note 2)	N
Indoor/Outdoor	Indoor/Outdoor		Indoor/Outdoor		Indoor/Outdoor	
Unwanted emission	See 15.407(b)(4)(i)		See 6.2.4.2 Unwanted emission limits of RSS 247		Refer to point 4.2.3 of EN 302 502	See EN 300 440
Minimum BW required	6-dB BW ≥ 500 kHz		6-dB BW ≥ 500 kHz		–	–
Note 1	Frequency range 5725-5875 MHz					
Note 2	The BFWA device shall have the capability to reduce the operating mean EIRP level to a level not exceeding 24 dBm for CH BW = 20 MHz and 21 dBm for CH BW = 10 MHz.					
Note 3	Standard applicable to non-specific short-range devices (SRDs), eNB devices may be also subjected to this specified standard.					

Channelization and rules

5 GHz channel allocations assuming a nominal occupied channel BW of 20 MHz along with the reference rules and test procedure are shown below.

	5150-5250					5250-5350					5470-5725											5725-5925										
Channel (MHz)	5160	5180	5200	5220	5240	5260	5280	5300	5320	5340	5480	5500	5520	5540	5560	5580	5600	5620	5640	5660	5680	5700	5720	5745	5765	5785	5805	5825	5845	5865	5885	5905
	240a					240b					240c											240d										
FCC	47 CFR 15; Section 15.407					47 CFR 15; Section 15.407					47 CFR 15; Section 15.407										S T R	47 CFR 15; Section 15.407					Not allowed					

ISED	RSS 247		RSS 247	RSS 247	Not allowed 5600-5650 MHz		A D D L E	RSS 247	Not allowed
RED	ETSI EN 301 893		ETSI EN 301 893	ETSI EN 301 893			N O	ETSI EN 300 440 ETSI EN 302 502	NO

The channel with frequency centre in 5720 MHz is considered a straddle channel in accordance to KDB No. 789033 since it operates in MulteFire band 240c and 240d. The worst case out-of-band emission limit, i.e., -27 dBm/MHz peak EIRP, applies at the band edges. The band edges are considered to be 5.47 GHz and 5.85 GHz. In addition, this channel is not subject to the EN 301 893 as the channel frequency is not included in the standard (refer to point 4.2.1).

Annex II. Description of test modes

This annex provides a general description of test modes to be implemented in the eNBs and UEs in order to perform the test methods required to comply with the FCC, ISED and RED rules.

FCC and ISED certification scopes – general information on test modes

- The device shall be configured to operate at 100% duty cycle. In case that this would not be possible then, it shall be operated using the maximum possible duty cycle.
Please refer to ANSI 63.10 clause 12.2 to look into further details.
- The device shall be configured to be tested operating at the highest transmit power allowed for each antenna configuration. In case that the device supports multiple outputs such as MIMO, these modes must be accessible to be selected.
Further information regarding to MIMO requirements can be found in KDB 62911 D01 Multiple Transmitter Output.
- The device must allow being configured in order to detect the worst operating mode that produces the highest level of emissions. For this reason, parameters as follows must be configurable if possible:
 - Schemes of modulation (modulation and bit rate), channel spacing and bandwidths.
 - Individual RF channels in the frequency range and sub-bands.
 - Output RF power levels
 - Simultaneous transmission and transmission chain separately if MIMO supported.
 - Number of transmitted Resource Blocks (RB) and offset position within the supported bandwidths.
- The software of the device shall allow configuration and operation on all available unlicensed wireless device channels.
- The software of the device shall allow configuration and operation in the unmodulated carrier model, where applicable.

European certification scope – general information on test modes

- The device shall be allowed configuring continuous transmission (with 100 % duty cycle) at the rated maximum power, modulated by a test data sequence and code sequence. The type of modulation and bit rate must also be varied and selected within all the different possible schemes of modulation and channel spacing. The tests are performed with the bit rate, which is the worst case.
- The device must allow configuring number of transmitted Resource Blocks (RB) and offset position within the supported bandwidths.
- The device must allow the selection of individual RF channels in the frequency range and sub-bands.
- If the output RF power is variable or selectable, it is necessary in the test mode the possibility of selection of the different output RF power levels.
- If the equipment supports MIMO (more than 1 transmission chain capable of simultaneous transmission), it is necessary the possibility of selection of each transmission chain separately and selection of simultaneous transmission in several chains.
- If the device operates partly or fully in the ranges 5 250 MHz to 5 350 MHz or 5 470 MHz to 5 725 MHz shall employ DFS and must allow configuring the selection of the operating channel
- The equipment shall be so constructed that settings (hardware and/or software) related to DFS shall not be accessible to the user if changing those settings result in the equipment no longer being

compliant with the DFS requirements in clause 4.2.6 of the Standard EN 301 893 V2.1.1.

- The equipment should not allow the user to change the country of operation and/or the operating frequency band if that results in the equipment no longer being compliant with the DFS requirements.
- The equipment should not accept software and/or firmware which results in the equipment no longer being compliant with the DFS requirements such as:
 - software and/or firmware provided by the manufacturer but intended for other regulatory regimes;
 - modified software and/or firmware where the software and/or firmware is available as open source code;
 - previous versions of the software and/or firmware (downgrade).
- The manufacturer must provide any additional information such as if the device can operate unmodulated, the list of ancillary equipment that the device supports, operating voltages and/or extreme operating temperature supported. Further information regarding to the Stations must be provided as per the clause 5.4.1 of the Standard ETSI EN 302 502 V2.1.1.
- The manufacturer shall specify the receiver category of his choice. In particular, manufacturers and users should pay particular attention to the potential for interference from other systems operating in the same or adjacent bands for any SRD, which may have inherent safety of human life implications.
- Monitoring of PER (Packet Error Rate) in reception.
- Enable RX only mode (no TX).

List of tests

Below it may find a list of test corresponding to specific standards applicable.

Columns:

- **Requirement Conditionality U/C:** Indicates whether the requirement is unconditionally applicable (U) or is conditional upon the manufacturer's claimed functionality of the equipment (C).
- **Condition:** Explains the conditions when the requirement is or is not applicable for a requirement which is classified "conditional".

Harmonised Standard ETSI EN 301 893 V2.1.1			
Requirement	Requirement Conditionality		
Description	U/C	Condition	Additional notes
Carrier Frequencies	U		
Nominal, and occupied, channel bandwidth	U		
RF output power	U		
TPC	C	1) Not required for channels whose nominal bandwidth falls completely within the band 5 150 MHz to 5 250 MHz. 2) Not required for devices that operate at a maximum mean e.i.r.p. of 20 dBm when operating in 5 250 MHz to 5 350 MHz or 27 dBm when operating in 5 470 MHz to 5 725 MHz.	This condition may be applicable to MulteFire devices 1.0.
Power Density	U		
Transmitter unwanted emissions outside the 5 GHz	U		

RLAN bands			
Transmitter unwanted emissions within the 5 GHz RLAN bands	U		
Receiver spurious emissions	U		
DFS: Channel Availability Check	C	<p>1) Not required for channels whose nominal bandwidth falls completely within the band 5 150 MHz to 5 250 MHz.</p> <p>2) Not required for Slave devices with a maximum transmit power of less than 200 mW e.i.r.p.</p> <p>3) Not required at initial use of a channel for slave devices with a maximum transmit power of 200 mW e.i.r.p.</p>	This condition may be applicable to MulteFire devices 1.0.
DFS: Off-Channel CAC – Radar Detection Threshold Level	C	<p>1) Where implemented by the manufacturer.</p> <p>2) Not required for channels whose nominal bandwidth falls completely within the band 5 150 MHz to 5 250 MHz.</p> <p>3) Not required for slave devices with a maximum transmit power of less than 200 mW e.i.r.p.</p> <p>4) Not required at initial use of a channel for Slave devices with a maximum transmit power of 200 mW e.i.r.p.</p>	This condition may be applicable to MulteFire devices 1.0.
DFS: Off-Channel CAC – Detection Probability	C	<p>Applicable to MulteFire 1.0:</p> <p>1) Where implemented by the manufacturer.</p> <p>2) Not required for channels whose nominal bandwidth falls completely within the band 5 150 MHz to 5 250 MHz.</p> <p>3) Not required for slave devices with a maximum transmit power of less than 200 mW e.i.r.p.</p> <p>4) Not required at initial use of a channel for Slave devices with a maximum transmit power of 200 mW e.i.r.p.</p>	This condition may be applicable to MulteFire devices 1.0
DFS: In service Monitoring	C	<p>1) Not required for channels whose nominal bandwidth falls completely within the band 5 150 MHz to 5 250 MHz.</p> <p>2) Not required for Slave devices with a maximum transmit power of less than 200 mW e.i.r.p.</p>	This condition may be applicable to MulteFire devices 1.0
DFS: Channel shutdown	C	Not required for channels whose nominal bandwidth falls completely within the band 5 150 MHz to 5 250 MHz.	This condition may be applicable to MulteFire devices 1.0
DFS: Non-occupancy period	C	<p>1) Not required for channels whose nominal bandwidth falls completely within the band 5 150 MHz to 5 250 MHz.</p> <p>2) Not required for Slave devices with a maximum transmit power of less than 200 mW e.i.r.p</p>	This condition may be applicable to MulteFire devices 1.0
DFS: Uniform spreading	C	<p>1) Not required for channels whose nominal bandwidth falls completely within the band 5 150 MHz to 5 250 MHz.</p> <p>2) Not required for slave devices.</p>	This condition may be applicable to MulteFire devices 1.0
Adaptivity	U		

Receiver Blocking	U		
User Access Restrictions	U		
Geo-location capability	C	Where implemented by the manufacturer.	This condition may be applicable to MulteFire devices 1.0

Harmonised Standard ETSI EN 300 440 v2.2.1			
Requirement	Requirement Conditionality		
Test case	U/C	Condition	Additional notes
e.i.r.p	C	Applies to all devices with transmitters	
Permitted range of operating frequencies	C	Applies to all devices with transmitters	
Unwanted emissions in the spurious domain	C	Applies to all devices with transmitters	
Duty Cycle	C	Transmitting devices which do not use LBT, DAA, or RFID transmitters operating in the 2 446 to 2 454 MHz band transmitting more than 500 mW e.i.r.p. power level	This condition may not be applicable to MulteFire 1.0 devices.
Additional requirements for FHSS equipment	C	Equipment utilizing FHSS modulation	This condition may not be applicable to MulteFire 1.0 devices.
Adjacent channel selectivity	C	Applies to equipment Category 1 receivers	This condition may be applicable to MulteFire devices 1.0.
Blocking or desensitization	C	Applies to category 1, 2, and 3 SRD communication media receivers	This condition may be applicable to MulteFire devices 1.0.
Spurious radiation	C	Applies to all receivers, except receivers used in combination with permanently collocated transmitters continuously transmitting	This condition may be applicable to MulteFire devices 1.0.
Spectrum access technique	C	Equipment which are not using duty cycle restrictions for media access	This condition may be applicable to MulteFire 1.0 devices.
GBSAR antenna pattern	C	Applies only GBSAR systems	This condition may not be applicable to MulteFire 1.0 devices.
Limits for GBSAR	C	Applies only GBSAR systems	This condition may not be

			applicable to MulteFire 1.0 devices.
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Harmonised Standard ETSI EN 302 502 V2.1.1			
Requirement		Requirement Conditionality	
Test case	U/ C	Condition	Additional Notes
Designation of Centre Frequencies and frequency error	U		
Transmitter RF Output Power, EIRP and EIRP Spectral Density	U		
Transmitter unwanted emissions	U		
Transmitter Power Control	U		
Receiver Spurious Emissions	U		
Dynamic Frequency Selection (DFS)	C	Dynamic Frequency Selection (DFS) is only required in the frequency range 5 725 MHz to 5 850 MHz	This condition may be applicable to MulteFire devices 1.0.
Receiver Blocking	U		
User Access Restrictions	U		

Annex III. Dynamic Frequency Selection (DFS)

MF devices operating with any part of its 26-dB emission bandwidth in the 5.25–5.35 GHz and 5.47–5.725 GHz bands shall employ a DFS radar detection mechanism.

A minimum of one device operating in master mode and one device operating in client mode is needed to perform this testing.

Equipment with an integral antenna may be equipped with a temporary antenna connector in order to facilitate conducted tests. When the antenna cannot be separated from the device and a radio frequency (RF) test port is not provided, radiated measurements will be performed.

Operational modes suggested for DFS testing

- Ability to turn on/off test mode in order to verify normal operation under normal DFS tests.
- Display radar detection(s).
- Upon radar detection, the test mode should disable the 30-minute non-occupancy period and return the device to the original test frequency within a few seconds. It is acceptable to disable the channel move upon radar detection while in test mode. This will keep the device on the test frequency.
- Test frequencies should not be hard coded into any test mode since the test engineer randomly selects them.
- Ability to re-set and / or edit the “blocked” frequency list.
- Ability to turn on/off “Channel Availability Check Time” if the device has to reboot as part of normal DFS operation when radar is detected.
- Test mode interfaces such as an ASCII terminal interface or Web based interface (this requires an automatic refresh of the web page at an interval sufficient to not slow down test time).

The following items will be considered when testing DFS:

- The operating frequency range(s) of the equipment.
- The operating modes (Master and/or Client) of the MF device. Bridge modes and MESH modes, as applicable, must be included in the description.
- For Client devices, indicate whether or not it has radar detection capability and indicate the FCC identifier for the Master Device that is used with it for DFS testing.
- Highest and the lowest possible power level (equivalent isotropic radiated power (EIRP)) of the equipment will be listed.
- List all antenna assemblies and their corresponding gains.
 - If radiated tests are to be performed, the MF Device should be tested with the lowest gain antenna assembly (regardless of antenna type).
 - The report should indicate which antenna assembly was used for the tests.
 - For devices with adjustable output power, list the output power range and the maximum EIRP for each antenna assembly.
 - If conducted tests are to be performed, indicate which antenna port/connection was used for the tests and the antenna assembly gain that was used to set the DFS Detection Threshold level during calibration of the test setup.

- Calibrated conducted DFS Detection Threshold level must be indicated.
 - For devices with adjustable output power, list the output power range and the maximum EIRP for each antenna assembly.
 - Antenna connector impedance. Ensuring that the measurement instruments match (usually 50 Ohms) or using a minimum loss pad and taking into account the conversion loss.
- Antenna gain measurement verification for tested antenna.
 - Procedure description
 - Antenna configuration and how it is mounted
 - If an antenna cable is supplied with the device, cable loss needs to be taken into account. Indicate the maximum cable length and either measure the gain with this cable or adjust the measured gain accordingly. State the cable loss.
- Test sequences or messages that should be used for communication between Master and Client Devices, which are used for Channel loading.
 - Stream the test file from the Master Device to the Client Device for IP based systems or frame based systems, which dynamically allocate the talk/listen ratio.
 - For frame based systems with fixed talk/listen ratio, set the ratio to the worst case (maximum) that is user configurable during this test as specified by the manufacturer and stream the test file from the Master to the Client.
 - For other system architectures, supply appropriate Channel loading methodology.
- A description of the Transmit Power Control.
- System architectures, data rates, Channel bandwidths—Indicating the type(s) of system architecture (e.g. IP based or Frame based) that the device employs. Each type of unique architecture must be tested.
- The time required for the Master Device and/or Client Device to complete its power-on cycle.
- Manufacturer statement confirming that information regarding the parameters of the detected Radar Wave forms is not available to the end user.
- The manufacturer is permitted to select the first channel either manually or randomly. The manufacturer may also block DFS channels from use.

Applicability DFS	EU			
5150–5250 MHz	N/A			
5250–5350 MHz	ETSI EN 301 893 V2.1.1			
		eNB	UE with radar detection	UE without radar detection
Channel Availability Check	Clause 4.2.6.2.2	Required	Required	Not Required
		Time 60 s / Detection Probability 60%	Time 60 s / Detection Probability 60%	
Off-Channel CAC (Where implemented by the manufacturer)	Clause 4.2.6.2.3	Required	Required	Not Required
		Time: 4 m – 6 h / Detection Probability 60%	Time: 4 m – 6 h / Detection Probability 60%	
In-Service Monitoring	Clause 4.2.6.2.4	Required	Required	Not Required
		Detection Probability 60%	Detection Probability 60%	
Channel Shutdown	Clause 4.2.6.2.5	Required	Required	Required
		Channel Move Time 10 s / Channel Closing Transmission Time 1 s	Channel Move Time 10 s / Channel Closing Transmission Time 1 s	Channel Move Time 10 s / Channel Closing Transmission Time 1 s
Non-Occupancy Period	Clause 4.2.6.2.6	Required	Required	Not Required
		Time 30 min	Time 30 min	
Uniform Spreading	Clause 4.2.6.2.7	Required	Not Required	Not Required
5470–5725 MHz	ETSI EN 301 893 V2.1.1			
		eNB	UE with radar detection	UE without radar detection
Channel Availability Check	Clause 4.2.6.2.2	Required	Required	Not Required
		Time 60 s (Note 1) / Detection Probability 60% (Note 3)	Time 60 s (Note 1) / Detection Probability 60% (Note 3)	
Off-Channel CAC (Where implemented by the manufacturer)	Clause 4.2.6.2.3	Required	Required	Not Required
		Time: 4 m – 6 h (Note 2) / Detection Probability 60% (Note 3)	Time: 4 m – 6 h (Note 2) / Detection Probability 60% (Note 3)	
In-Service Monitoring	Clause 4.2.6.2.4	Required	Required	Not Required
		Detection Probability 60%	Detection Probability 60%	
Channel Shutdown	Clause 4.2.6.2.5	Required	Required	Required
		Channel Move Time 10 s / Channel Closing Transmission Time 1 s	Channel Move Time 10 s / Channel Closing Transmission Time 1 s	Channel Move Time 10 s / Channel Closing Transmission Time 1 s
Non-Occupancy Period	Clause 4.2.6.2.6	Required	Required	Not Required
		Time 30 min	Time 30 min	
Uniform Spreading	Clause 4.2.6.2.7	Required	Not Required	Not Required
Note 1	For channels whose nominal bandwidth falls completely or partly within the band 5600 MHz to 5650 MHz, the Channel Availability Check Time shall be 10 minutes			
Note 2	For channels whose nominal bandwidth falls completely or partly within the band 5600 MHz to 5650 MHz, the Off-Channel CAC Time shall be within the range 1 hour to 24 hours.			

DFS Test Signals simulating fixed frequency radars	Radar test signal	Pulse width W (μs) choose one value	pulse repetition frequency PRF (pps) choose one value			Pulses per burst		Detection probability with 30 % channel load
	1 - Fixed	1	750			15		Pd > 60 %
	2 - Variable	1, 2, 5	200, 300, 500, 800, 1000			10		Pd > 60 %
	3 - Variable	10, 15	200, 300, 500, 800, 1000			15		Pd > 60 %
	4 - Variable	1, 2, 5, 10, 15	1200, 1500, 1600			15		Pd > 60 %
	5 - Variable	1, 2, 5, 10, 15	2300, 3000, 3500, 4000			25		Pd > 60 %
	6 - Variable Modulated	20, 30	2000, 3000, 4000			20		Pd > 60 %
Check notes in the Table D.3 a): DFS Test Signals simulating fixed frequency radars								
DFS Test Signals simulating Frequency Hopping radars	Radar test signal	Pulse width W (μs)	Pulse repetition frequency PRF (pps)	Pulses per burst	Burst length (ms)	Bursts per Trial	Pulse modulation	Detection probability Pd with 30 % channel load
	1	1	3000	9	3	8	none	For ChS = 10 MHz, Pd > 60 %; for ChS = 20 MHz, Pd > 70 %
	2	20	4500	9	2	2	chirp	For ChS = 10 MHz, Pd > 60 %; for ChS = 20 MHz, Pd > 70 %
Check notes in the Table D.3 b): DFS Test Signals simulating Frequency Hopping radars								
Applicability DFS	FCC							
5150-5250 MHz	N/A							
5250-5350 MHz	KDB 905462 D02 UNII DFS Compliance Procedures							
		eNB			UE with radar detection		UE without radar detection	
Non-Occupancy Period (Prior to Use of a Channel)	Clause 7.8.2 & Clause 7.8.3	Required			Required		Not Required	
		Time 30 mins			30 mins			
DFS Detection Threshold (Prior to Use of a Channel)	Clause 7.8.2	Required			Required		Not Required	

Channel Availability Check Time (Prior to Use of a Channel)	Clause 7.8.2	Required	Not Required	Not Required
		Time 60 s		
U-NII Detection Bandwidth (Prior to Use of a Channel)	Clause 7.8.2	Required	Required	Not Required
		Minimum 100% of the U-NII 99% transmission power bandwidth.	Minimum 100% of the U-NII 99% transmission power bandwidth.	
DFS Detection Threshold (during normal operation)	Clause 7.8.1	Required	Required	Not Required
Channel Closing Transmission Time (during normal operation)	Clause 7.8.3	Required	Required	Required
		Time 200 ms + an aggregate of 60 ms over remaining 10 s period.	Time 200 ms + an aggregate of 60 ms over remaining 10 s period.	Time 200 ms + an aggregate of 60 ms over remaining 10 s period.
Channel Move Time (during normal operation)	Clause 7.8.3	Required	Required	Required
		Time 10 s	Time 10 s	Time 10 s
U-NII Detection Bandwidth (during normal operation)	Clause 7.8.2	Required	Required	Not Required
5470–5725 MHz				
KDB 905462 D02 UNII DFS Compliance Procedures				
		eNB	UE with radar detection	UE without radar detection
Non-Occupancy Period (Prior to Use of a Channel)	Clause 7.8.2 & Clause 7.8.3	Required	Required	Not Required
		Time 30 mins	30 mins	
DFS Detection Threshold (Prior to Use of a Channel)	Clause 7.8.2	Required	Required	Not Required
Channel Availability Check Time (Prior to Use of a Channel)	Clause 7.8.2	Required	Not Required	Not Required
		Time 60 s		
U-NII Detection Bandwidth (Prior to Use of a Channel)	Clause 7.8.2	Required	Required	Not Required
		Minimum 100% of the U-NII 99% transmission power bandwidth.	Minimum 100% of the U-NII 99% transmission power bandwidth.	
DFS Detection Threshold (during normal operation)	Clause 7.8.1	Required	Required	Not Required
Channel Closing Transmission Time (during normal operation)	Clause 7.8.3	Required	Required	Required
		Time 200 ms + an aggregate of 60 ms over remaining 10 s period.	Time 200 ms + an aggregate of 60 ms over remaining 10 s period.	Time 200 ms + an aggregate of 60 ms over remaining 10 s period.
Channel Move Time (during normal operation)	Clause 7.8.3	Required	Required	Required
		Time 10 s	Time 10 s	Time 10 s

U-NII Detection Bandwidth (during normal operation)	Clause 7.8.2	Required	Required	Not Required		
5725-5875 MHz	N/A					
Radar Detection Threshold Levels	-64 dBm when EIRP ≥ 200 milliwatt and EIRP < 200 milliwatt that do not meet the power spectral density requirement -62 dBm when EIRP < 200 milliwatt and power spectral density < 10 dBm/MHz Check notes in the Table 3: DFS Detection Thresholds for Master Devices and Client Devices with Radar Detection.					
RADAR TEST WAVEFORMS						
	Radar Type	Pulse Width(μsec)	PRI(μsec)	Number of Pulses	Minimum Percentage of Successful Detection	Minimum Number of Trials
	0	1	1428	18	Note 1	Note 1
	1	1	Test A: 15 unique PRI values randomly selected from the list of 23 PRI values in Table 5a	$\text{Roundup} \left\{ \left(\frac{1}{360} \right) \cdot \left(\frac{19 \cdot 10^6}{\text{PRI}_{\mu\text{sec}}} \right) \right\}$	60%	30
			Test B: 15 unique PRI values randomly selected within the range of 518-3066 μsec, with a minimum increment of 1 μsec, excluding PRI values selected in Test A			
	2	1-5	150-230	23-29	60%	30
	3	6-10	200-500	16-18	60%	30
	4	11-20	200-500	12-16	60%	30
	5 (Note 2)	50-100	1000-2000	1-3	80%	30
	6 (Note 3)	1	333	9	70%	30
	Aggregate (Radar Types 1-4)				80%	120
	Note 1 :Short Pulse Radar Type 0 should be used for the detection bandwidth test, channel move time, and channel closing time tests					
	Note 2 : Long Pulse Radar Test Waveform with a chirp width of 5-20MHz and 8-20 Number of bursts					
	Note 3 :Frequency hopping radar with a hopping rate of 0.333 KHz					

Applicability DFS	ISED
RSS 247 Clause 6.3	ISED requires the use of either the FCC KDB Procedure 905462 or the DFS test procedure in the ETSI EN 301 893 for demonstrating compliance with the DFS radar detection requirements set out in this section. If any part of an operating device's emission bandwidth falls in the bands 5250–5350 MHz, 5470–5600 MHz or 5650–5725 MHz, the device shall comply with requirements included in the RSS 247 Clauses 6.3.1 and 6.3.2.
Radar Detection Threshold Levels	–62 dBm when EIRP < 200 mW AND a Power Spectral Density < 10 dBm/MHz –64 dBm when $200 \text{ mW} \leq \text{EIRP} \leq 1 \text{ W}$ Note: The detection threshold power is the received power, averaged over a 1-microsecond reference to a 0 dBi antenna



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