N° 1-6736
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TEST REPORT

EUT Description	**WLAN and BT, 2x2 PCIe M.2 1216 adapter card**
Brand Name	**Intel® Wi-Fi 6E AX211**
Model Name	**AX211D2W**
Date of Test Start/End	**2020-12-05 / 2021-01-22**
Features	**802.11ax, Dual Band, 2x2 Wi-Fi + Bluetooth® 5.2 (see section 5)**

Applicant	**Intel Corporation SAS**
Address	**425 rue de Goa - Le Cargo B6 - 06600, Antibes, France**
Contact Person	**Laurence Peignot**
Telephone/Fax/ Email	**laurence.peignot@intel.com**

Reference Standards	**ETSI EN 300 328 V2.2.2 (see section 1)**

Test Report identification	**201120-03.TR12**
Revision Control	**Rev. 00** **This test report revision replaces any previous test report revision (see section 8)**

The test results relate only to the samples tested.
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1. Standards, reference documents and applicable test methods

1. ETSI EN300 328 v2.2.2, Wideband transmission systems; Data transmission equipment operating in the 2,4 GHz band; Harmonised Standard for access to radio spectrum

2. General conditions, competences and guarantees

- ✓ Intel Corporation SAS Wireless RF Lab (Intel WRF Lab) is an ISO/IEC 17025:2017 testing laboratory accredited by the French Committee for Accreditation (Cofrac) with the certificate number 1-6736.
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3. Environmental Conditions

✓ At the site where the measurements were performed the following limits were not exceeded during the tests:

Temperature	22.6ºC ± 2.5ºC
Humidity	38.8% ± 11.5%

4. Test samples

Sample	Control #	Description	Model	Serial #	Date of receipt	Note
#01	201120-03.S03	WiFi 6E Module	AX211D2W	WFM:D8F8834C251B	2020-23-11	Conducted tests
	170000-01.S19	Laptop	Latitude E5450	4TXV562	2020-02-04	
	200611-01.S12	Extender	PCB00651_01	-	2020-11-30	
#02	201120-03.S09	WiFi 6E Module	AX211D2W	WFM:DF8834E4C92	2020-11-23	Used 1GHz-6.4GHz Tx Radiated Spurious Emission tests
	200102-01.S03	Extender	ADEXELEC	-	2020-01-02	
	200611-01.S06	Adaptor	PowerBy SNJ A4	-	2020-11-30	
	200602-03.S06	Absorber	MCS0	-	2020-07-03	
	180000-01.S05	Socket	Adapter 1216SD to M.2	-	2017-08-09	
	170801-01.S10	Laptop	Latitude E7470	7KNOXF2	2017-09-08	
	200611-03.S28	Main Antenna	SkyCross	-	2020-07-01	
	200611-03.S29	Aux Antenna	SkyCross	-	2020-07-01	
#03	201120-03.S08	WiFi 6E Module	AX211D2W	WFM:D8F8834E56AB	2020-11-23	Used for 30MHz-1GHz Tx Radiated Spurious Emission tests, 30MHz-1GHz Rx Radiated Spurious Emission tests and 6.4GHz-12.75GHz Tx Radiated Spurious Emissions tests
	200611-03.S26	Extender	ADEXELEC	-	2020-07-01	
	200611-01.S07	Adaptor	PowerBy SNJ A4	-	2020-11-30	
	200602-03.S06	Absorber	MCS0	-	2020-07-03	
	180000-01.S02	Socket	Adapter 1216SD to M.2	-	2017-08-09	
	170000-01.S01	Laptop	Latitude E5470	DBPLMC2	2017-03-28	
	200928-03.S08	Main Antenna	SkyCross	-	2020-09-01	
	200928-03.S09	Aux Antenna	SkyCross	-	2020-09-01	
#04	201120-03.S02	WiFi 6E Module	AX211D2W	WFM:D8F8834C2462	2020-11-23	Used for 1-12.75GHz Rx Radiated Spurious Emission tests
	200611-01.S06	Adaptor	PowerBy SNJ A4	-	2020-11-30	
	200602-03.S06	Absorber	MCS0	-	2020-07-03	
	200615-05.S06	Host	Latitude 7490	63QMRQ2	2020-06-12	

5. EUT Features

The herein information is provided by the customer

Brand Name	Intel® Wi-Fi 6E AX211
Model Name	AX211D2W
Software Version	DRTU version: 11195_99_2100_51G
Driver Version	V99.0.58.3_t64
Prototype / Production	Production
Supported Radios	802.11b/g/n/ax 2.4GHz (2400.0 – 2483.5 MHz) 802.11a/n/ac/ax 5.2GHz (5150.0 – 5350.0 MHz) 5.6GHz (5470.0 – 5725.0 MHz) 5.8GHz (5725.0 – 5875.0 MHz) Bluetooth 5.2 2.4GHz (2400.0 – 2483.5 MHz)

Antenna Information

Transmitter	Main (chain A)	Aux (chain B)
Manufacturer	SkyCross	Skycross
Antenna type	PIFA antenna	PIFA antenna
Part number	N/A	N/A
Declared antenna gain (dBi)	+3	+3

Document

Filename	Date of receipt
Intel_Ref_Antenna data_HMC-M2 Ant_Spec_Universe_SkyCross Antenna	2013-01-28
Annex E_EN300328 V2 2 2 for 2x2.pdf	2020-08-13

6. Remarks and comments

1. According to the applicant declaration the device AX211D2W operating in BDR/EDR mode is an adaptive equipment with a maximum RF output power greater than 10 dBm e.i.r.p. so it is considered as receiver category 1.

7. Test Verdicts summary

The statement of conformity to applicable standards in the table below are based on the measured values, without taking into account the measurement uncertainties.

7.1. BT Basic Rate / Enhanced Data Rate

Mode	ETSI clause	Test	Verdict
2.4GHz	4.3.1.2	RF output power	P
	4.3.1.3	Duty Cycle, Tx-sequence, TX gap	NA
	4.3.1.4	Accumulated Transmit Time, Frequency Occupation and Hopping Sequence	P
	4.3.1.5	Hopping Frequency Separation	P
	4.3.1.6	Medium Utilization (MU) factor	NA
	4.3.1.7	Adaptivity (Adaptive Frequency Hopping)	P
	4.3.1.8	Occupied Channel Bandwidth	P
	4.3.1.9	Transmitter unwanted emissions in the out-of-band domain	P
	4.3.1.10	Transmitter unwanted emissions in the spurious domain	P
	4.3.1.11	Receiver spurious emissions	P
	4.3.1.12	Receiver Blocking	P

P: Pass
F: Fail
NM: Not Measured
NA: Not Applicable

8. Document Revision History

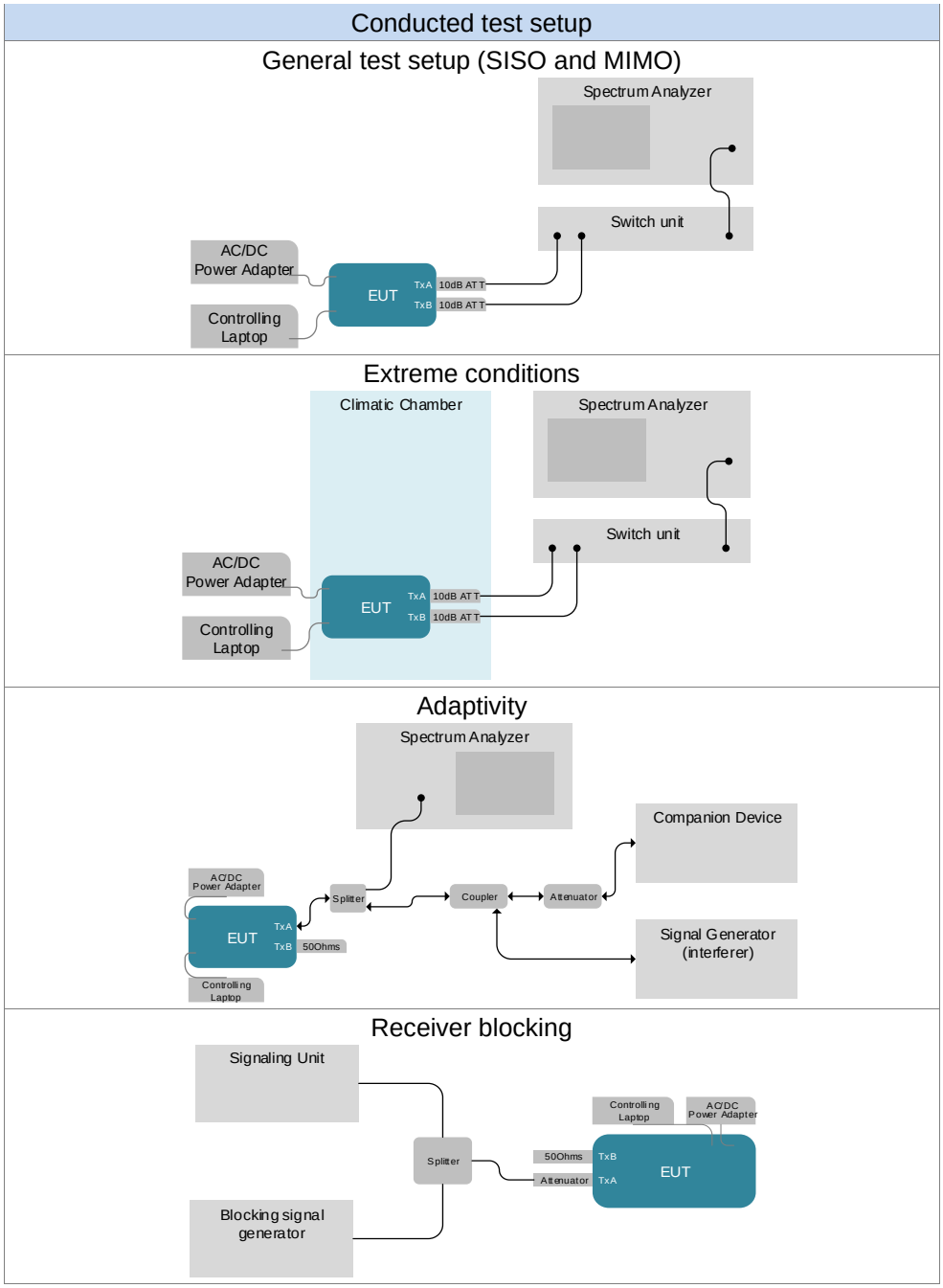
Revision #	Modified by	Revision Details
Rev. 00	N.Bui	First Issue

Annex A. Test & System Description

A.1 Measurement System

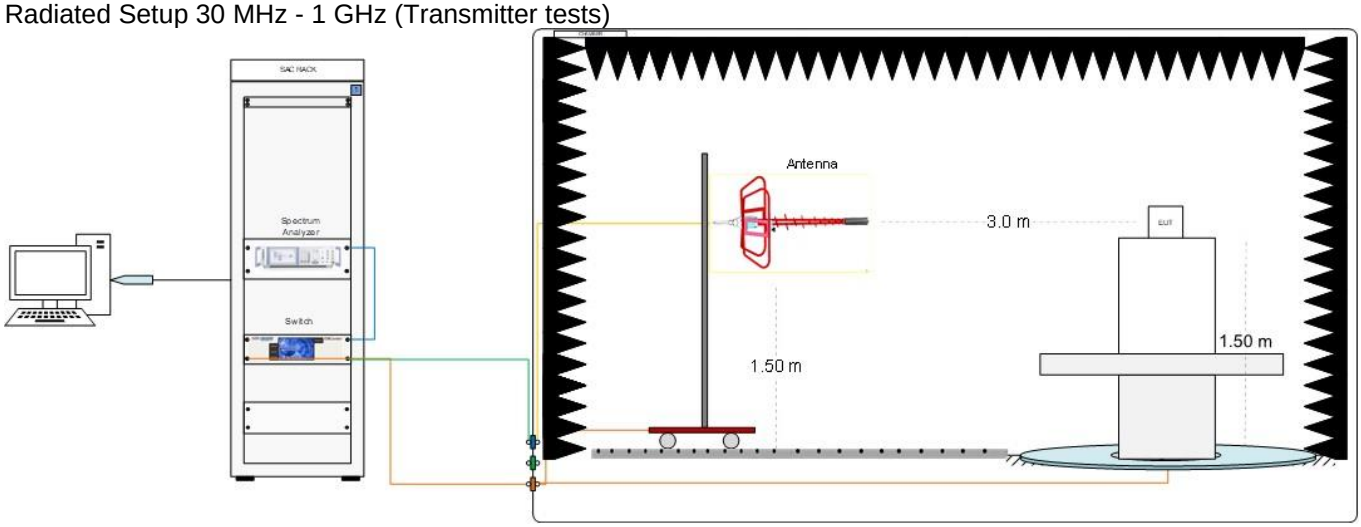
Measurements were performed using the following setups and made in accordance to the general provisions of ETSI EN 300 328 V2.2.2

Rohde & Schwarz TS8997 system with the switching unit OSP120, OSP B-157 and software EMC32 were employed. The DUT was installed in a test fixture and then connected to a laptop computer and AC/DC power adapter. The laptop computer was used to configure the EUT to continuously transmit at a specified output power using all different modes and modulation schemes, using the Intel proprietary tool DRTU.
Setups for conducted and radiated measurements are shown below.

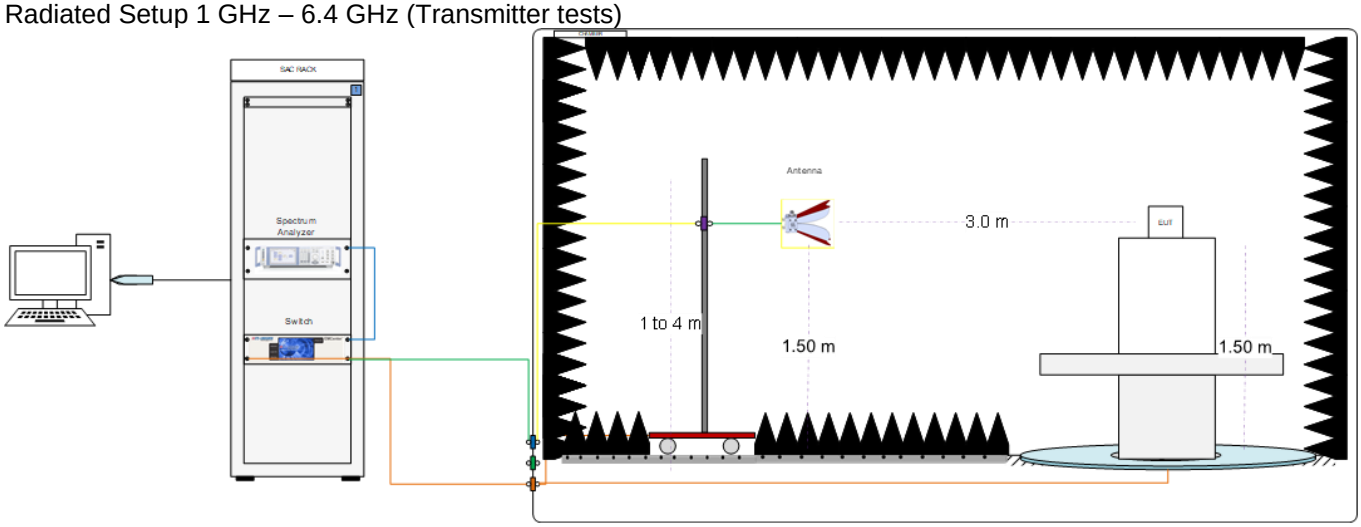


Radiated test setup

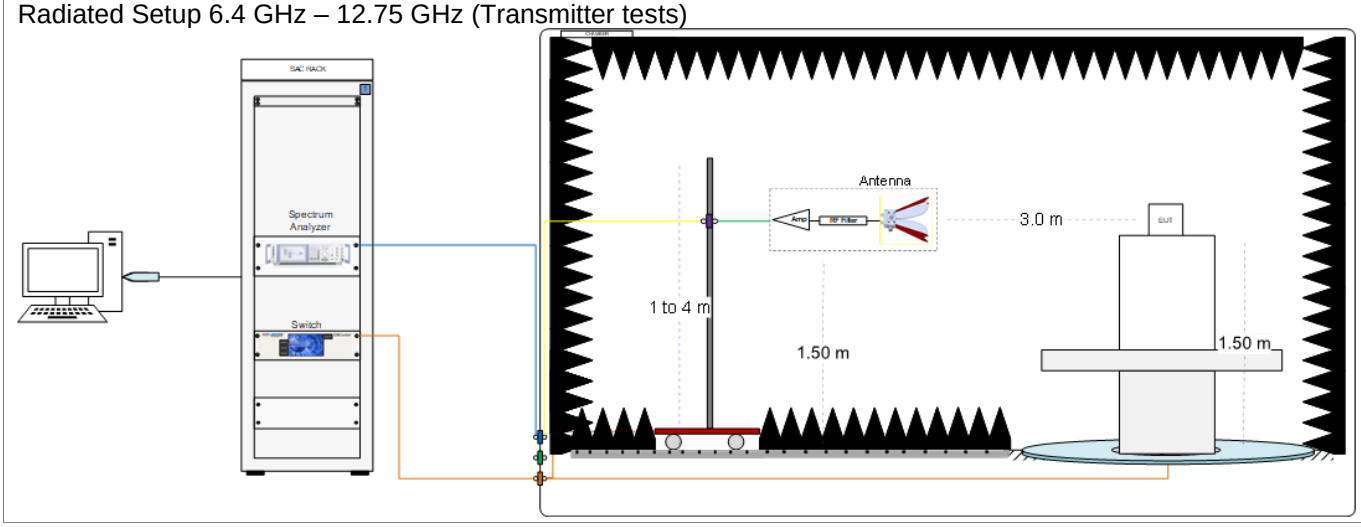
Radiated Setup 30 MHz - 1 GHz (Transmitter tests)



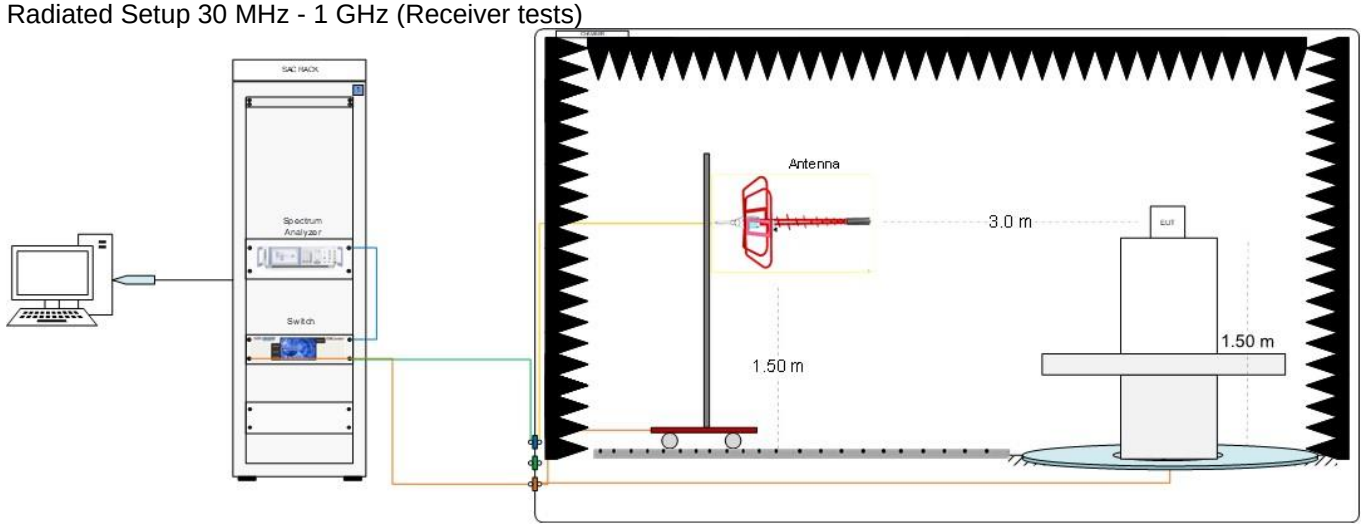
Radiated Setup 1 GHz – 6.4 GHz (Transmitter tests)



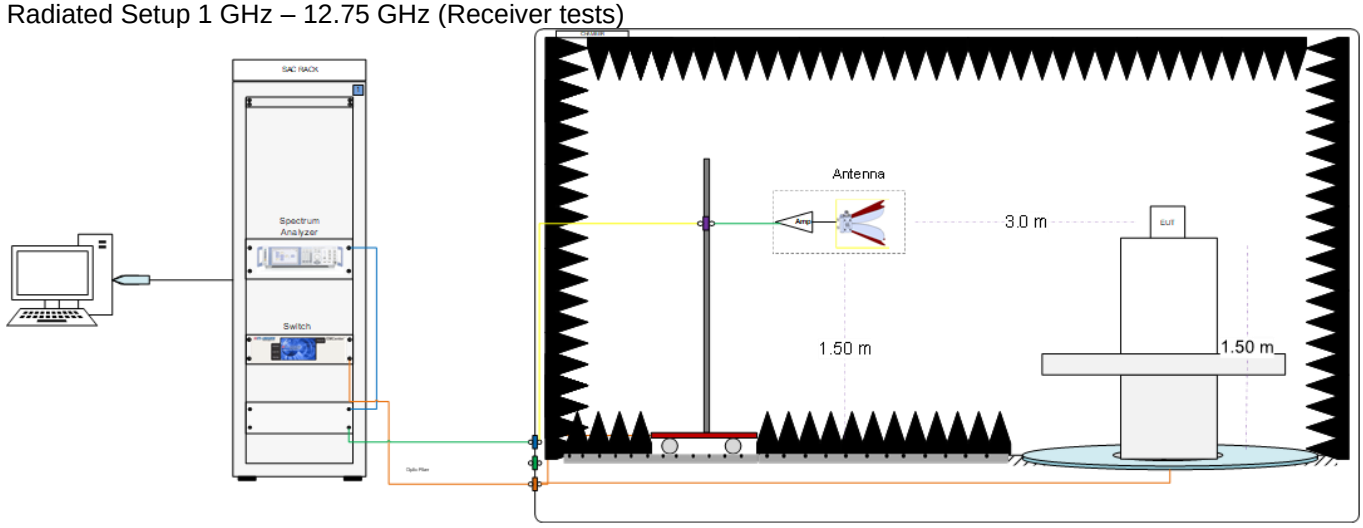
Radiated Setup 6.4 GHz – 12.75 GHz (Transmitter tests)



Radiated Setup 30 MHz - 1 GHz (Receiver tests)



Radiated Setup 1 GHz – 12.75 GHz (Receiver tests)



A.2 Test Equipment List

Conducted Setup

ID#	Device	Type/Model	Serial #	Manufacturer	Cal. Date	Cal. Due Date
0017	Vector signal generator	SMJ100A	100458	Rohde & Schwarz	2019-04-23	2021-04-23
0016	Signal Generator	SMF100A	102117	Rohde & Schwarz	2020-05-14	2022-05-14
0056	Switch unit	OSP 120	100945	Rohde & Schwarz	2020-04-21	2022-04-21
0293	DC Power supply	E3640A	MY40006885	Agilent	N/A	N/A
0299	Multimeter	34401A	US36065790	HP	2019-12-11	2021-12-11
0300	Climatic chamber	SLT34/40	56746020930010	Secasi	2019-11-20	2021-11-20
0318	Spectrum analyzer	FSV30	103310	Rohde & Schwarz	2020-06-03	2022-06-03
0581	Temp & Humidity Logger	RA12E-TH1-RAS	RA12-B89BE3	Avtech	2020-01-23	2022-01-23
0741	Measurement Software	EMC32 v11.00.00	200226	Rohde & Schwarz	N/A	N/A
0847	RF Cable 0.5m	PE3CA1039	-	Pasternack	2020-08-26	2021-02-26
0848	RF Cable 1.2m	PE3C0666	-	Pasternack	2020-08-26	2021-02-26
0869	Cable SMA Male to ML51-P	HRMP-ML51LP	DTR178-100RS	Hirose	2020-08-26	2021-02-26
0870	Cable SMA Male to ML51-P	HRMP-ML51LP	DTR178-100RS	Hirose	2020-08-26	2021-02-26
0876	Thermometer	t3000FC	-	Fluke	2019-11-29	2021-11-29
0991	RF Cable 2m + 10dB ATT	0900670672000PJ	1936949	Radiall	2020-08-26	2021-02-26
0992	RF Cable 2m + 10dB ATT	0900670672000PJ	1936947	Radiall	2020-08-26	2021-02-26

N/A: Not Applicable

Receiver blocking Setup

ID#	Device	Type/Model	Serial #	Manufacturer	Cal. Date	Cal. Due Date
0100	Communication tester	CMW500	129337	Rohde & Schwarz	2019-04-02	2021-04-02
0309	Signal generator	SMB100A	178217	Rohde & Schwarz	2020-04-17	2022-04-17
0378	RF Cable 1.2m	UFA147A-0-0480-200200	MFR 64639 223720-001	Micro-coax	2020-08-26	2021-02-26
0796	Temp & Humidity Logger	RA12E-TH1-RAS	RA12-D4F316	Avtech	2019-07-05	2021-07-05
0866	RF Cable 0.5m	FMC0202085-18	-	Fairview	2020-08-26	2021-02-26
0873	RF splitter	PE2083	-	Pasternack	N/A	N/A
0874	RF Cable 0.9m	PE3CA 1039-36	-	Pasternack	2020-08-26	2021-02-26

N/A: Not Applicable

Radiated Setup #1

ID#	Device	Type/Model	Serial #	Manufacturer	Cal. Date	Cal. Due Date
0135	Anechoic Chamber	FACT3	5720	ETS-Lindgren	2020-01-07	2022-01-07
0136	Turn Table	ETS	-	ETS-Lindgren	N/A	N/A
1076	Spectrum Analyzer	FSW43	101847	Rohde & Schwarz	2020-11-02	2022-11-02
0530	Measurement SW	EMC32, v10.40.10	100623	Rohde & Schwarz	N/A	N/A
0147	Switch & Positioning systems	EMC Center	00159757	ETS-Lindgren	N/A	N/A
0137	Biconilog Antenna	3142E	00156946	ETS-Lindgren	2020-03-12	2022-03-12
0141	Horn Antenna+ Amplifier + HPF6.4	3117	00157736	ETS-Lindgren	2020-04-02	2022-04-02
0325	Horn antenna 3117	3117	00157734	ETS-Lindgren	2019-08-12	2021-08-12
0343	Double-Ridged Horn Antenna with Pre-Amplifier	3117-PA	00201542	ETS-Lindgren	2019-08-16	2021-08-16
1098	Cable 1.5m - DC-18GHz	CBL-1.5M-SMSM+	202879	Mini-Circuits	2020-11-27	2021-05-27
0263	Cable 1m - 1GHz to 18GHz	UFA147A	-	Utilflex	2020-08-25	2021-02-25
0371	Cable 1m – 30 MHz - 18GHz	UFB311A-0-0590-50U50U	MFR 64639 223230-001	Micro-coax	2020-08-25	2021-02-25
1099	Cable 7m DC-18 GHz	0501051057000GX	19.35.850	Radial	2020-11-27	2021-05-27
0859	Cable 2.5m - 30MHz to 18GHz	0500990992500KE	19.23.395	Radiall	2020-11-27	2021-05-27
1033	Boresight antenna mast	BAM 4.0-P	P/278/2890.01	Maturo	N/A	N/A
0797	Temp & Humidity Logger	RA12E-TH1-RAS	RA12-D0EB1A	Avtech	2019-07-04	2021-07-04

N/A: Not Applicable

Radiated Setup #2

ID#	Device	Type/Model	Serial #	Manufacturer	Cal. Date	Cal. Due Date
0337	Anechoic chamber	RFD-FA-100	5996	ETS Lindgren	2020-07-06	2022-07-06
0238	Switch & Positioner	EMCenter	00151232	ETS Lindgren	N/A	N/A
0382	Antenna Tower	2171B-3.0M	00150123	ETS Lindgren	N/A	N/A
0383	Turntable	-	-	ETS Lindgren	N/A	N/A
0329	Measurement SW	EMC32, v10.50.10	100401	Rohde & Schwarz	N/A	N/A
0133	Spectrum Analyzer	FSV40	101358	Rohde & Schwarz	2020-02-25	2022-02-25
0138	Double Ridge Horn (1-18GHz)	3117	00152266	ETS Lindgren	2020-03-08	2022-03-08
0141	Horn Antenna 3117 + Amplifier + HPF6.4	3117	00157736	ETS-Lindgren	2020-04-01	2022-04-01
0343	Double-Ridged Horn Antenna with Pre-Amplifier	3117-PA	00201542	ETS-Lindgren	2019-08-16	2021-08-16
0871	RF Cable 1-18GHz, 1.5 m	0501050991200GX	19.21.710	Radiall	2020-08-20	2021-02-20
0860	RF Cable 1-18GHz, 1.2 m	2301761761200PJ	12.22.1104	Radiall	2020-08-20	2021-02-20
0275	RF Cable 1-18GHz - 6.5m	140-8500-11-51	001	Spectrum	2020-08-20	2021-02-20
0684	RF Cable 1GHz-18GHz 1.5m	-	-	Spirent	2020-08-20	2021-02-20
0725	RF Cable 1-9.5GHz 1.2m	0500990991200KE	-	Radiall	2020-08-20	2021-02-20
0796	Temp & Humidity Logger	RA12E-TH1-RAS	RA12-D4F316	Avtech	2019-07-05	2021-07-05

N/A: Not Applicable

Shared Radiated Equipment

ID#	Device	Type/Model	Serial #	Manufacturer	Cal. Date	Cal. Due Date
0616	Power Sensor	NRP-Z81	104385	Rohde & Schwarz	2020-04-08	2022-04-08
0617	Power Sensor	NRP-Z81	104386	Rohde & Schwarz	2020-04-08	2022-04-08
0618	Power Sensor	NRP-Z81	104382	Rohde & Schwarz	2020-04-08	2022-04-08

A.3 Measurement Uncertainty Evaluation

The system uncertainty evaluation is shown in the table below with a coverage factor of k = 2 to indicate a 95% level of confidence:

Measurement type	Uncertainty	Unit
Occupied Channel Bandwidth	±2.08	%
RF Output Power, conducted	±0.99	dB
Power Spectral Density, conducted	±0.99	dB
Unwanted Emission, conducted	±1.53	dB
Radiated test < 1GHz	±4.04	dB
Radiated test 1GHz –12.75 GHz	±4.01	dB
Temperature	±0.30	ºC
Supply voltages	<±0.01	%
Time	±0.12	%

Annex B. Test Results

The herein test results were performed by:

Test case measurement	Test Engineer
RF output power, duty cycle	G. Roustan
Accumulated Transmit Time, Frequency Occupation and Hopping Sequence	G. Roustan
Hopping frequency separation	G. Roustan
Adaptivity (Adaptive Frequency Hopping)	G. Roustan
Occupied channel bandwidth	G. Roustan
Transmitter unwanted emission in the out-of-band domain	G. Roustan
Transmitter unwanted emissions in the spurious domain	A. Lounes, N. Bui, N. Nachabe
Receiver spurious emissions	A. Lounes, N. Bui. N. Nachabe
Receiver blocking	Z. Ouachicha

B.1 Test Conditions

ETSI clause	Conditions	ETSI EN 300 328 V2.2.2 Annex E
5.1.2.1	The normal temperature and humidity conditions for tests shall be any convenient combination of temperature and humidity within the following ranges: • Temperature: +15 °C to +35 °C; • Relative humidity: 20 % to 75 %.	
5.1.2.2	The normal test voltage for the equipment shall be the nominal voltage for which the equipment was designed.	**"Information provided by the customer"**
5.1.3	Some tests in the present document need to be repeated at extreme temperatures. Where that is the case, measurements shall be made over the extremes of the operating temperature range as declared by the manufacturer.	

B.2 RF output Power

Test limits

ETSI clause	Limits
4.3.1.2.3	The RF output power for FHSS equipment shall be equal to or less than 20 dBm. For non-adaptive FHSS equipment, where the manufacturer has declared an RF output power lower than 20 dBm e.i.r.p., the RF output power shall be equal to or less than that declared value. This limit shall apply for any combination of power level and intended antenna assembly.

Test conditions

ETSI clause	Conditions
5.4.2.1	The measurements for RF output power shall be performed at both normal environmental conditions and at the extremes of the operating temperature range. The equipment shall be operated under its worst case configuration.

Test procedure

The conducted setups shown in section *Test & System Description* were used to measure the RF output power accordingly with ETSI EN 300 328 V2.2.2 §5.3.2. The antenna terminal of the EUT is connected to the OSP120 through an attenuator and a cable, the spectrum analyzer is connected to the receiver port on the OSP. System connection cable loss is compensated by the EMC32 software on the measured parameters.

Antenna gain is taken into account and added by the software to the measurements. The EIRP power (dBm) is calculated by adding the declared maximum antenna gain to the measured conducted power. The declared maximum antenna gain is +3dBi.

Results tables

Normal conditions

Antenna gain: +3dBi

				Power [dBm]	
Mode	Modulation	Packet	Meas Duty Cycle. [%]	Measured Conducted	EIRP
BR	GFSK	DH5	76.996	9.6	12.6
EDR	π/4-DQPSK	2DH5	77.115	7.0	10.0
EDR	8-PSK	3DH5	77.167	7.0	10.0

Extreme temperature conditions (Tmax = +70°C)

Antenna gain: +3dBi

				Power [dBm]	
Mode	Modulation	Packet	Meas Duty Cycle. [%]	Measured Conducted	EIRP
BR	GFSK	DH5	76.997	9.0	12.0
EDR	π/4-DQPSK	2DH5	77.118	7.0	10.0
EDR	8-PSK	3DH5	77.171	7.1	10.1

Extreme temperature conditions (Tmin = -10°C)

Antenna gain: +3dBi

				Power [dBm]	
Mode	Modulation	Packet	Meas Duty Cycle. [%]	Measured Conducted	EIRP
BR	GFSK	DH5	76.996	9.6	12.6
EDR	π/4-DQPSK	2DH5	77.112	7.7	10.7
EDR	8-PSK	3DH5	77.164	7.5	10.5

B.3 Accumulated Transmit Time, Frequency Occupation and Hopping Sequence

Test limits

<table>
<tr><th>ETSI clause</th><th>Limits</th></tr>
<tr><td>4.3.1.4.3.2</td><td>
Adaptive FHSS equipment
Adaptive FHSS equipment shall be capable of operating over a minimum of 70 % of the band specified in table 1.
Table 1: Service frequency bands
<table>
<tr><th></th><th>Service frequency bands</th></tr>
<tr><td>Transmit</td><td>2 400 MHz to 2 483,5 MHz</td></tr>
<tr><td>Receive</td><td>2 400 MHz to 2 483,5 MHz</td></tr>
</table>
The Accumulated Transmit Time on any hopping frequency shall not be greater than 400 ms within any observation period of 400 ms multiplied by the minimum number of hopping frequencies (N) that have to be used.

In order for the equipment to comply with the Frequency Occupation requirement, it shall meet either of the following two options:
Option 1: Each hopping frequency of the hopping sequence shall be occupied at least once within a period not exceeding four times the product of the dwell time and the number of hopping frequencies in use.
Option 2: The occupation probability for each frequency shall be between ((1 / U) × 25 %) and 77 % where U is the number of hopping frequencies in use.

The hopping sequence(s) shall contain at least N hopping frequencies at all times, where N is 15 or 15 divided by the minimum Hopping Frequency Separation in MHz, whichever is the greater.
</td></tr>
</table>

Test conditions

ETSI clause	Conditions
5.4.4.1	These measurements shall only be performed at normal test conditions. The equipment shall be configured to operate at its maximum Dwell Time and maximum Duty Cycle. The measurement shall be performed on a minimum of two (active) hopping frequencies chosen arbitrary from the actual hopping sequence.

Test procedure

The conducted setup shown in section *Test & System Description* was used to measure the Accumulated Transmit Time accordingly with ETSI EN 300 328 V2.2.2 §5.4.4.2.1. Minimum Frequency Occupation and Hopping Sequence. The antenna terminal of the EUT is connected to the OSP120 through an attenuator and a cable, the spectrum analyzer is connected to the receiver port on the OSP. System connection cable loss is compensated by the EMC32 software on the measured parameters.
The declared maximum antenna gain is +3dBi.

Results tables

Dwell Time

Mode	Packet Type	Frequency [MHz]	Accumulated Transmit Time (ms)	Measurement Time (ms)
BR	DH5	2402	49.066	6000
		2480	57.723	6000
EDR	2DH5	2402	49.089	6000
		2480	54.870	6000
EDR	3DH5	2402	53.516	6000
		2480	56.810	6000

$Measurement\ Time_{ms} = 400_{ms} \times 15\ (minimum\ hoppping\ frequencies) = 6000ms$

Minimum Frequency Occupation

Mode	Packet Type	Frequency [MHz]	Minimum Frequency Occupation (ms)	Limit (ms)	Measurement Time (ms)
BR	DH5	2402	1223.630	> 0	126400
		2480	1282.680	> 0	126400
EDR	2DH5	2402	1211.860	> 0	126400
		2480	1220.560	> 0	126400
EDR	3DH5	2402	1228.610	> 0	126400
		2480	1287.500	> 0	126400

$Measurement\ Time_{ms} = 4 \times Dwell\ time_{ms} \times (Actual\ number\ of\ hopping\ frequencies\ in\ uses) = 126400ms$

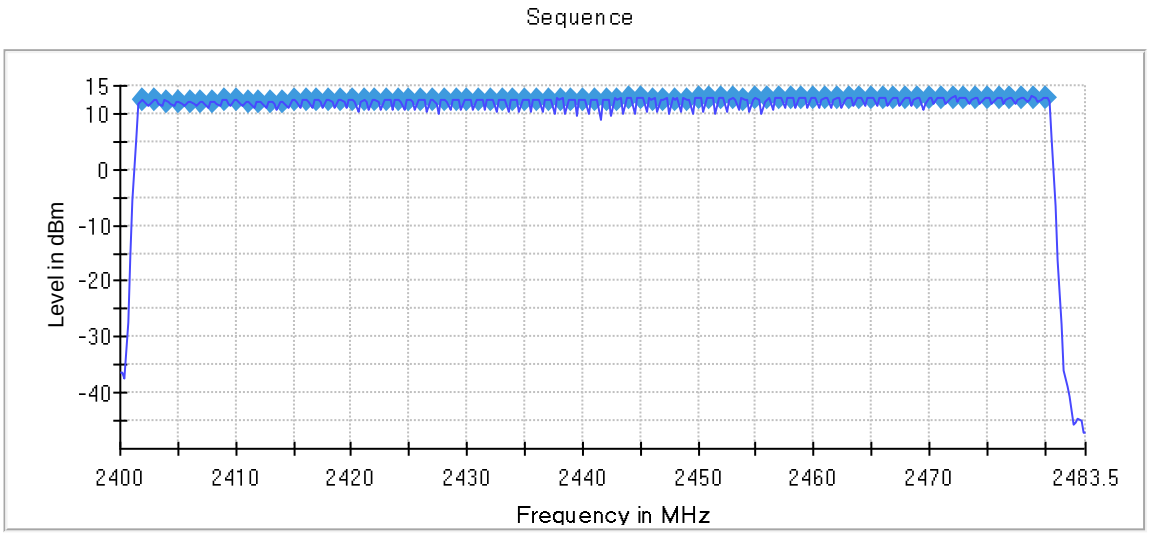
Hopping sequence

Mode	Packet Type	Number of Hopping frequencies
BR	DH5	79
EDR	2DH5	79
EDR	3DH5	79

Hopping Sequence Results

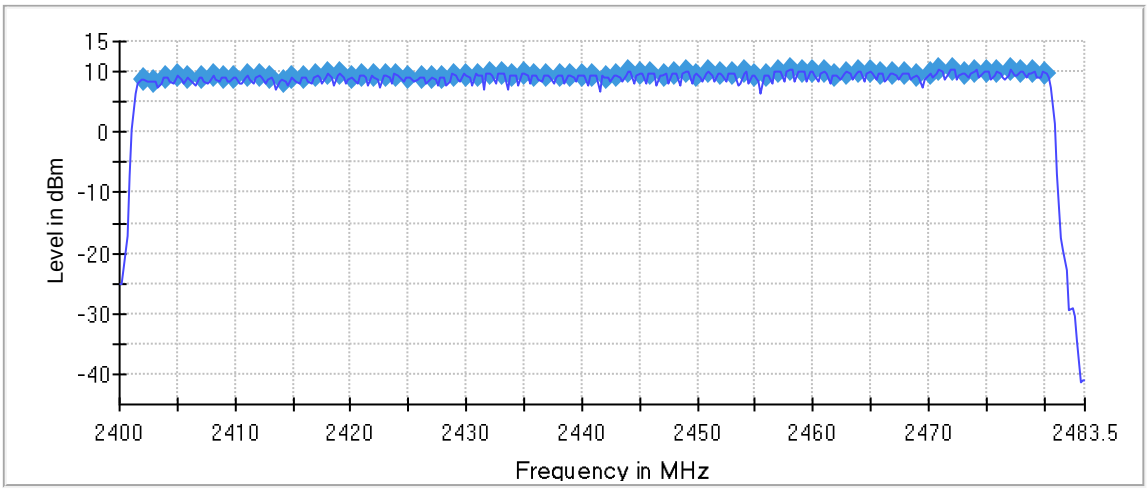
BR - GFSK

DH5



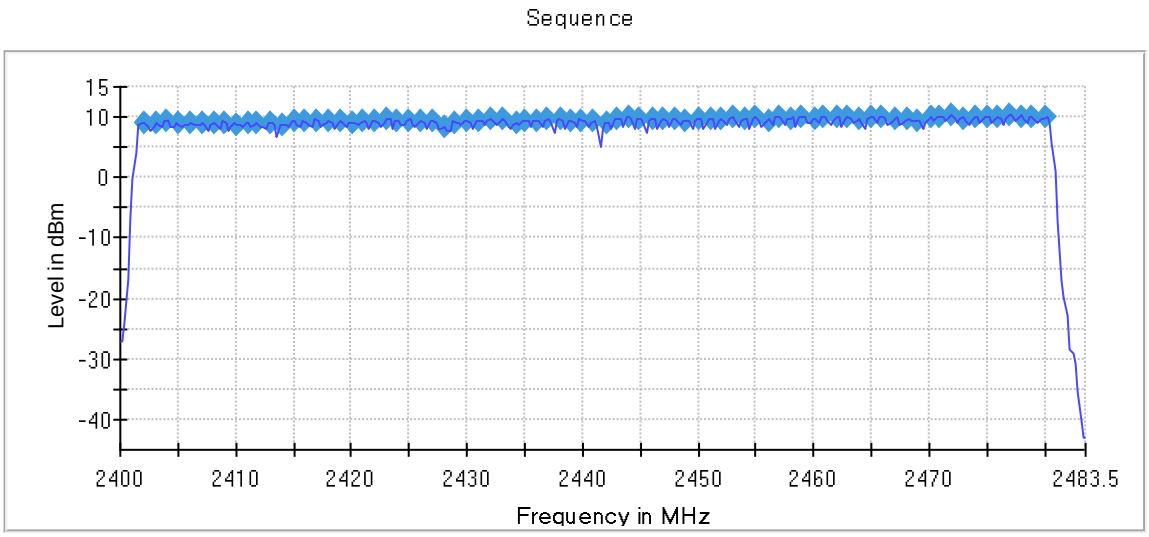
EDR - π/4 DQPSK

2DH5



EDR - 8PSK

3DH5



B.4 Hopping frequency separation

Tests limits

ETSI clause	Limits
4.3.1.5.3.2	For adaptive FHSS equipment, the minimum Hopping Frequency Separation shall be 100 kHz

Test conditions

ETSI clause	Conditions
5.4.5.1	These measurements shall only be performed at normal test conditions. The measurement shall be performed on two adjacent hopping frequencies.

Test procedure

The conducted setup shown in section *Test & System Description* was used to measure the hopping frequency separation accordingly with ETSI EN 300 328 V2.2.2 §5.4.5.2.1. The antenna terminal of the EUT is connected to the OSP120 through an attenuator and a cable, the spectrum analyzer is connected to the receiver port on the OSP. System connection cable loss is compensated by the EMC32 software on the measured parameters.

The declared maximum antenna gain is +3dBi.

Results tables

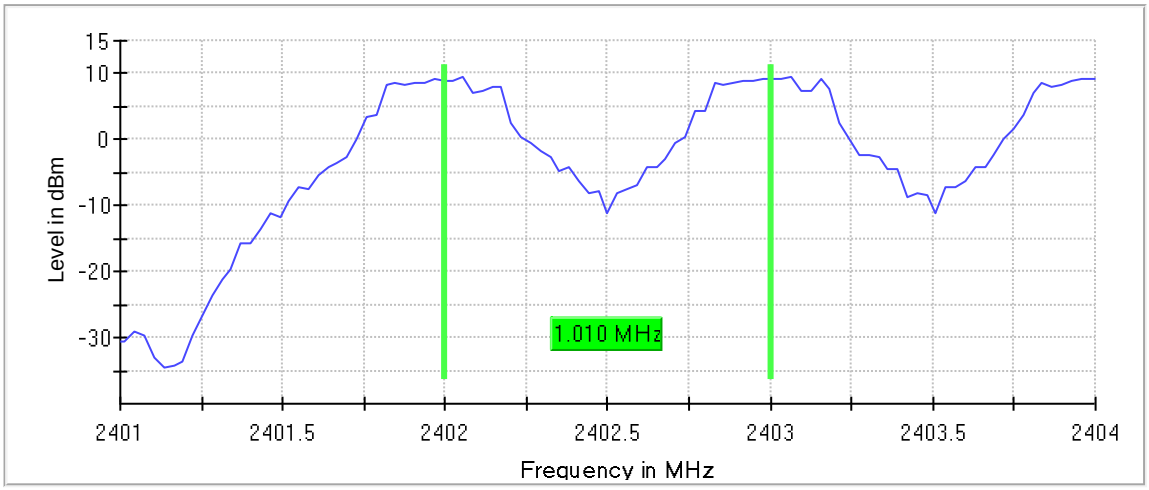
Mode	Frequency [MHz]	Hopping frequency separation [MHz]
BR GFSK	2440	1.010
	2441	
EDR π/4-DQPSK	2479	0.980
	2480	
EDR 8-DPSK	2439	1.040
	2440	

Results screenshot

BR - GFSK

DH5

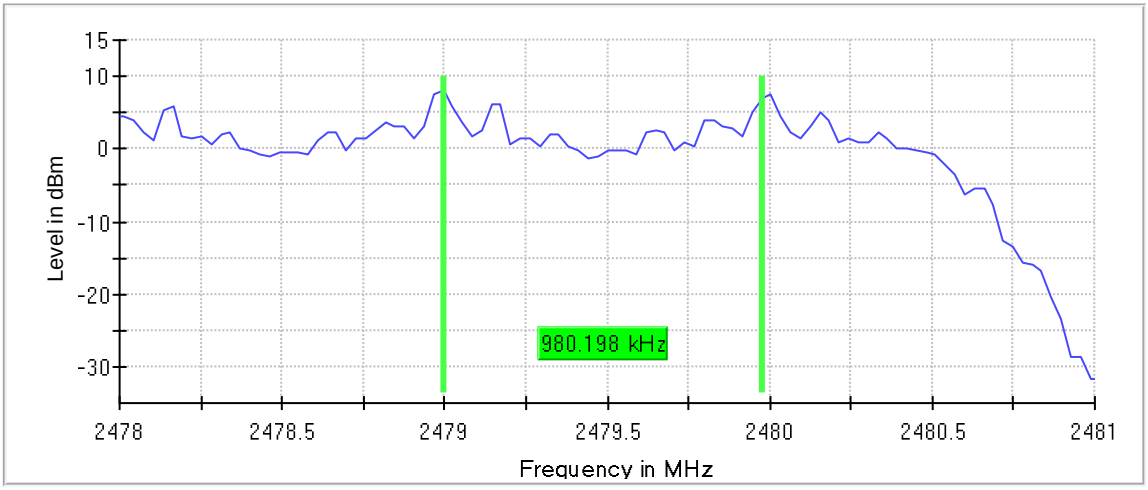
HFS



EDR - π/4 DQPSK

2DH5

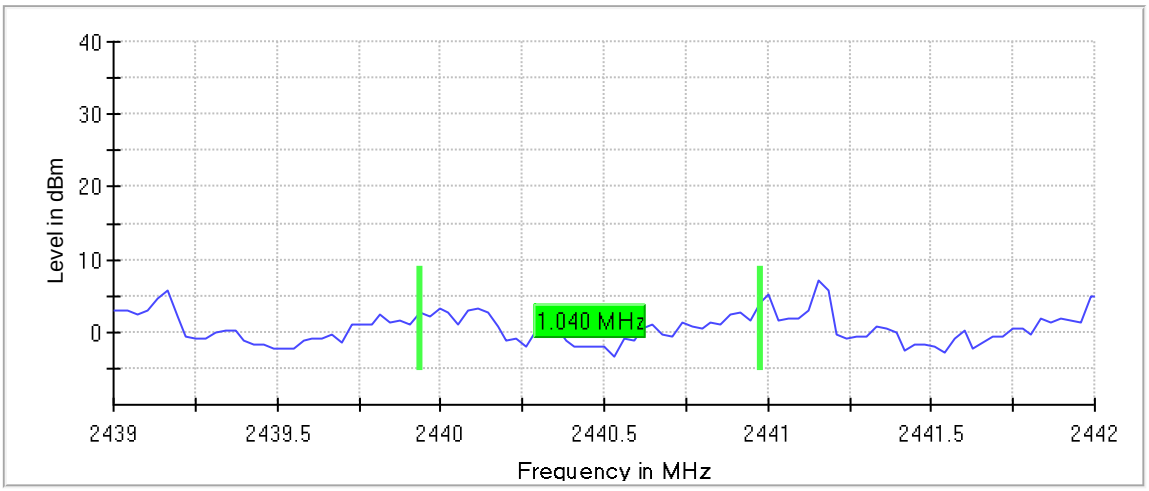
HFS



EDR - 8PSK

3DH5

HFS



B.5 Adaptivity (Adaptive Frequency Hopping)

Test limits

ETSI clause	Limits
4.3.1.7.3.2	*Adaptive FHSS using LBT.* Adaptive FHSS equipment using LBT shall comply with the following minimum set of requirements: 1) At the start of every dwell time, before transmission on a hopping frequency, the equipment shall perform a Clear Channel Assessment (CCA) check using energy detect. The CCA observation time shall be not less than 0,2 % of the Channel Occupancy Time with a minimum of 18 µs. If the equipment finds the hopping frequency to be clear, it may transmit immediately. 2) If it is determined that a signal is present with a level above the detection threshold defined in step 5 the hopping frequency shall be marked as 'unavailable'. Then the equipment may jump to the next frequency in the hopping scheme even before the end of the dwell time, but in that case the 'unavailable' channel cannot be considered as being 'occupied' and shall be disregarded with respect to the requirement of the minimum number of hopping frequencies as defined in clause 4.3.1.4.3.2. Alternatively, the equipment can remain on the frequency during the remainder of the dwell time. However, if the equipment remains on the frequency with the intention to transmit, it shall perform an Extended CCA check in which the (unavailable) channel is observed for a random duration between the value defined for the CCA observation time in step 1 and 5 % of the Channel Occupancy Time defined in step 3. If the Extended CCA check has determined the frequency to be no longer occupied, the hopping frequency becomes available again. If the Extended CCA time has determined the channel still to be occupied, it shall perform new Extended CCA checks until the channel is no longer occupied. 3) The total time during which an equipment has transmissions on a given hopping frequency without reevaluating the availability of that frequency is defined as the Channel Occupancy Time. The Channel Occupancy Time for a given hopping frequency, which starts immediately after a successful CCA, shall be less than 60 ms followed by an Idle Period of minimum 5 % of the Channel Occupancy Time with a minimum of 100 µs. After the Idle Period has expired, the procedure as in step 1 shall be repeated before having new transmissions on this hopping frequency during the same dwell time. For LBT based adaptive FHSS equipment with a dwell time < 60 ms, the maximum Channel Occupancy Time is limited by the dwell time. 4) 'Unavailable' channels may be removed from or may remain in the Hopping Sequence, but in any case: - apart from Short Control Signalling Transmissions referred to in clause 4.3.1.7.4, there shall be no transmissions on 'unavailable' channels; - a minimum of N hopping frequencies as defined in clause 4.3.1.4.3.2 shall always be maintained. 5) The detection threshold shall be proportional to the transmit power of the transmitter: for a 20 dBm e.i.r.p. transmitter the detection threshold level (TL) shall be equal to or less than -70 dBm/MHz at the input to the receiver assuming a 0 dBi (receive) antenna assembly. This threshold level (TL) may be corrected for the (receive) antenna assembly gain (G); however, beamforming gain (Y) shall not be taken into account. For power levels less than 20 dBm e.i.r.p., the detection threshold level may be relaxed to: TL = -70 dBm/MHz + 10 × log10 (100 mW / Pout) (Pout in mW e.i.r.p.) 6) The equipment shall comply with the requirements defined in step 1 to step 4 of the present clause in the presence of an unwanted CW signal as defined in table 2.

5.4.6.2.1.2	**Table 2: Unwanted Signal parameters** Wanted signal mean power from companion device (dBm): sufficient to maintain the link (see note 2) Unwanted signal frequency (MHz): 2395 or 2488.5 (see note 1) Unwanted CW signal power (dBm): -35 (see note 3) NOTE 1 : The highest frequency shall be used for testing operating channels within the range 2 400 MHz to 2 442 MHz, while the lowest frequency shall be used for testing operating channels within the range 2 442 MHz to 2 483,5 MHz. See clause 5.4.6.1. NOTE 2: A typical conducted value which can be used in most cases is -50 dBm/MHz. NOTE 3: The level specified is the level in front of the UUT antenna. In case of conducted measurements, this level has to be corrected by the actual antenna assembly gain. Step4, Note 2: The UUT is assumed to stop transmissions within a period equal to the maximum Channel Occupancy Time.

Test conditions

ETSI clause	Conditions
5.4.6.1	These measurements shall only be performed at normal test conditions.

Test procedure

The adaptivity setup shown in section *Test & System Description* was used to measure adaptivity. The EUT (client) is connected to a companion device through a power splitter and an attenuator. Proprietary software was used on the EUT to configure a normal transmission with sufficient payload.

Interference and unwanted signals are emulated by using a modulated signal and a continuous wave (CW) respectively, generated by the vector signal generator (VSG) and the continuous wave generator.
The declared maximum antenna gain is +3dBi.

The power levels for the signals are as follows:
EUT = max power level
Interference signal (modulated signal), considering antenna gain = -67dBm/MHz at antenna connector
Unwanted signal (CW) = -32dBm

The frequency used for the interference signal is the same as the transmission frequency of the tested channel. The unwanted signal is fixed at 2488.5 MHz for the lowest channel tested and to 2395 MHz for the highest channel tested.

Results tables

2424 MHz

Normal Operation

DutyCycle DUT (%)	Monitoring Length (ms)	COT Max (ms)	Limit Max (ms)	COT Min (ms)	Number of COTs	Idle Time Min (ms)	Idle Time Max (ms)	Idle Time Limit Min (ms)
62.367	10000.000	10.366	15.000	0.138	188	0.884	352.993	0.500

Reaction on Interferer and Blocker

DC in max DC Evaluation Window (%)	Limit Max (%)	Result	Length of max DC Evaluation Window (ms)	Start of max DC Evaluation Window (ms)
0.000	10.000	PASS	125935.000	1015.000

Stop of max DC Evaluation Window (ms)	Interferer On (ms)	Blocker On (ms)	Monitoring Offset (ms)	Monitoring Start (ms)	Monitoring Length (ms)
126950.000	1000.000	62000.000	15.000	1015.000	121985.000

2470 MHz

Normal Operation

DutyCycle DUT (%)	Monitoring Length (ms)	COT Max (ms)	Limit Max (ms)	COT Min (ms)	Number of COTs	Idle Time Min (ms)	Idle Time Max (ms)	Idle Time Limit Min (ms)
66.778	10000.000	7.240	15.000	0.004	260	0.885	146.509	0.500

Reaction on Interferer and Blocker

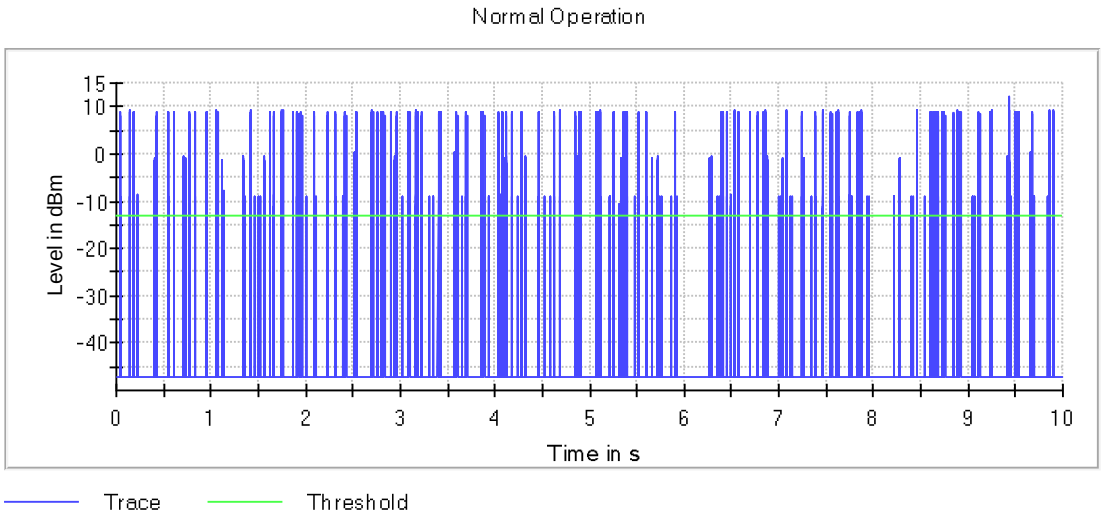
DC in max DC Evaluation Window (%)	Limit Max (%)	Result	Length of max DC Evaluation Window (ms)	Start of max DC Evaluation Window (ms)
0.000	10.000	PASS	125935.000	1015.000

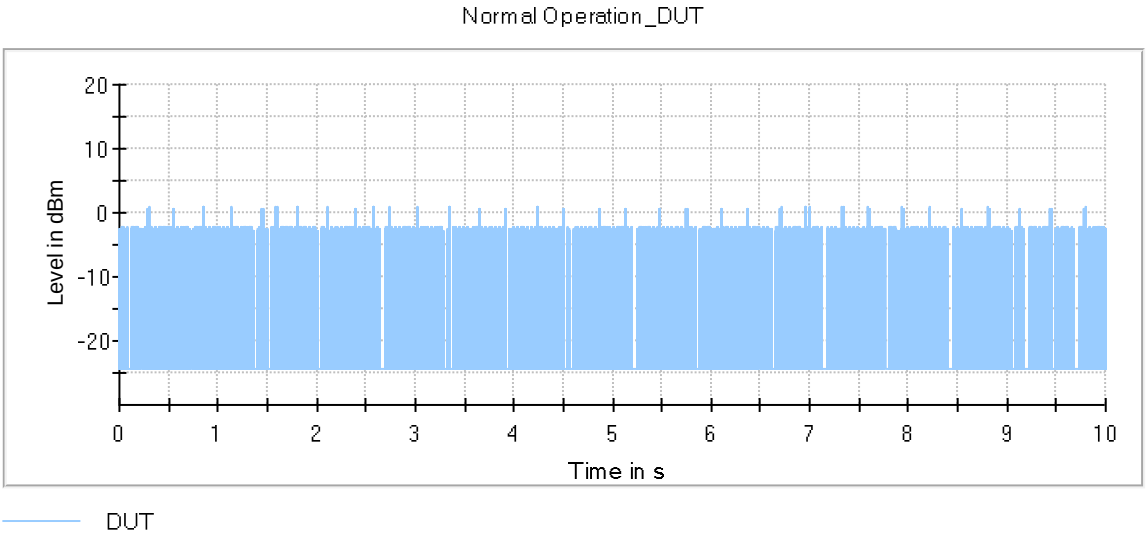
Stop of max DC Evaluation Window (ms)	Interferer On (ms)	Blocker On (ms)	Monitoring Offset (ms)	Monitoring Start (ms)	Monitoring Length (ms)
126950.000	1000.000	62000.000	15.000	1015.000	121985.000

Results Screenshot

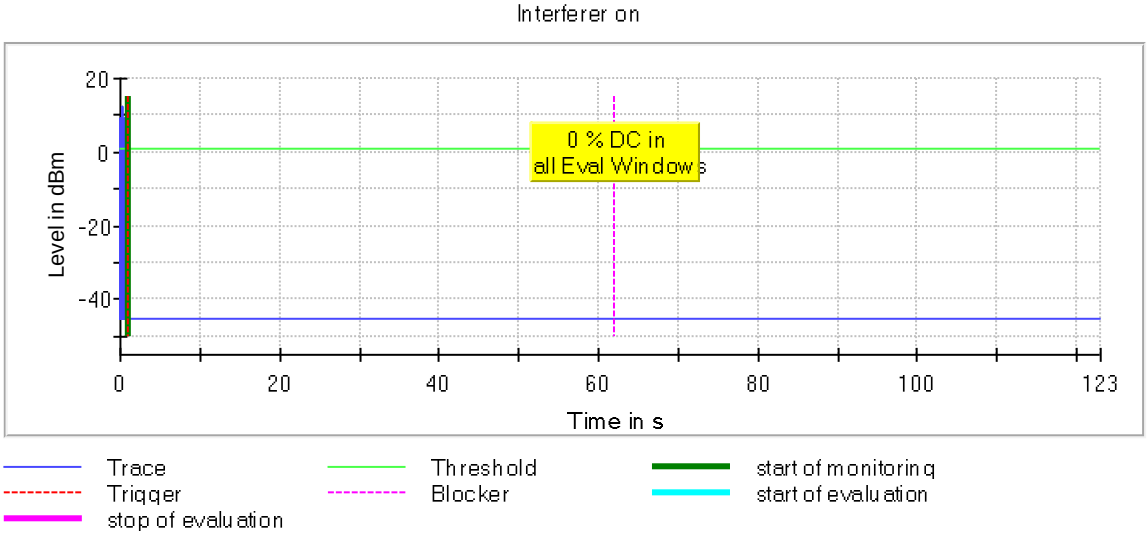
2424 MHz

Normal Operation



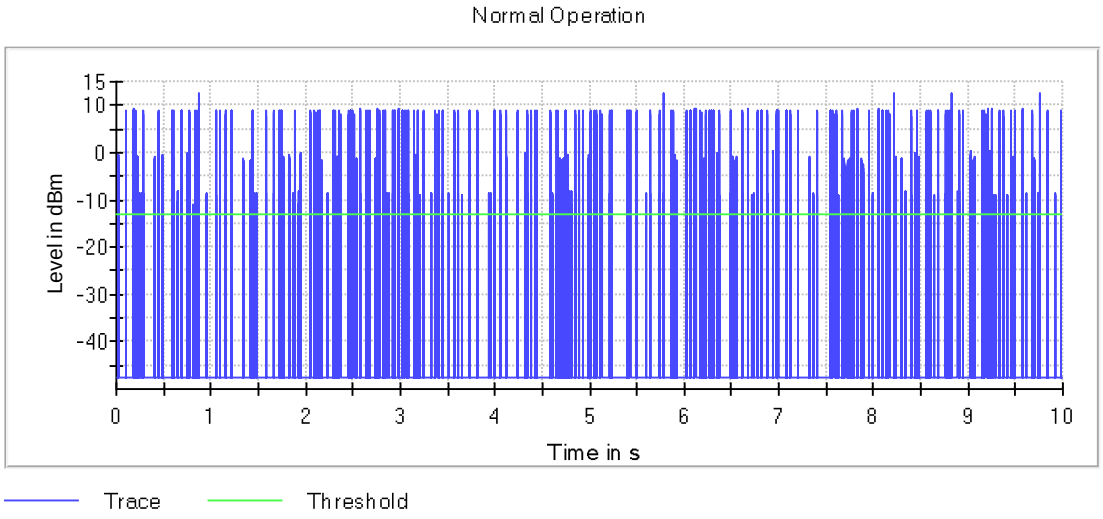


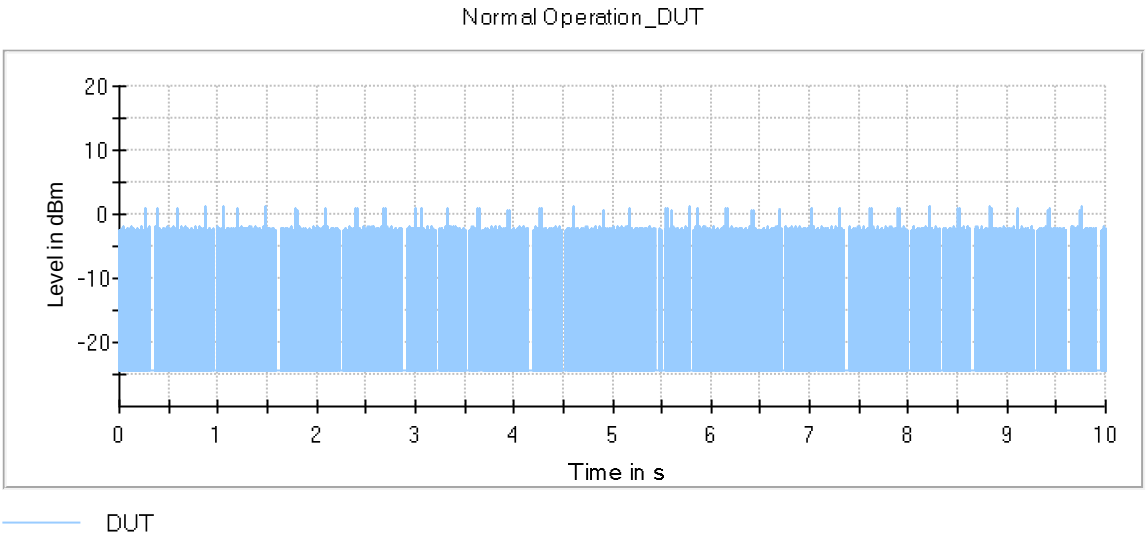
Reaction on Interferer and Blocker



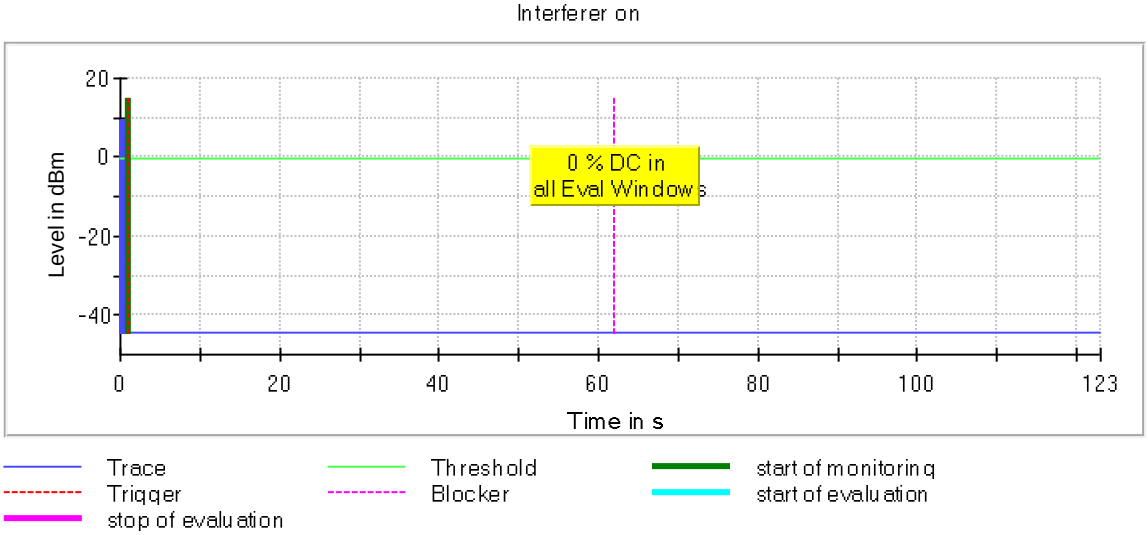
2470 MHz

Normal Operation





Reaction on Interferer and Blocker



B.6 Occupied Channel Bandwidth

Test limits

ETSI clause	Limits
4.3.1.8.3	The Occupied Channel Bandwidth for each hopping frequency shall be within the band given in table 1. *(2.4 GHz to 2.4835 GHz)*

Test conditions

ETSI clause	Conditions
5.4.7.1	These measurements shall only be performed at normal test conditions. The measurement shall be performed only on the lowest and the highest frequency within the stated frequency range.

Test procedure

The conducted setup shown in section *Test & System Description* was used to measure the occupied channel bandwidth accordingly with ETSI EN 300 328 V2.2.2 §5.4.7.2.1. The antenna terminal of the EUT is connected to the OSP120 through an attenuator and a cable, the spectrum analyzer is connected to the receiver port on the OSP. System connection cable loss is compensated by the EMC32 software on the measured parameters.

The declared maximum antenna gain is +3dBi.

Results tables

Low channel

Mode	Packet Type	Frequency [MHz]	Channel Center Frequency (MHz)	Occupied Channel Bandwidth (MHz)	Lower Band Edge (MHz)
BR	DH5	2402	2402	0.796020	2401.597015
EDR	2DH5	2402	2402	1.000000	2401.500000
EDR	3DH5	2402	2402	0.990049	2401.507463

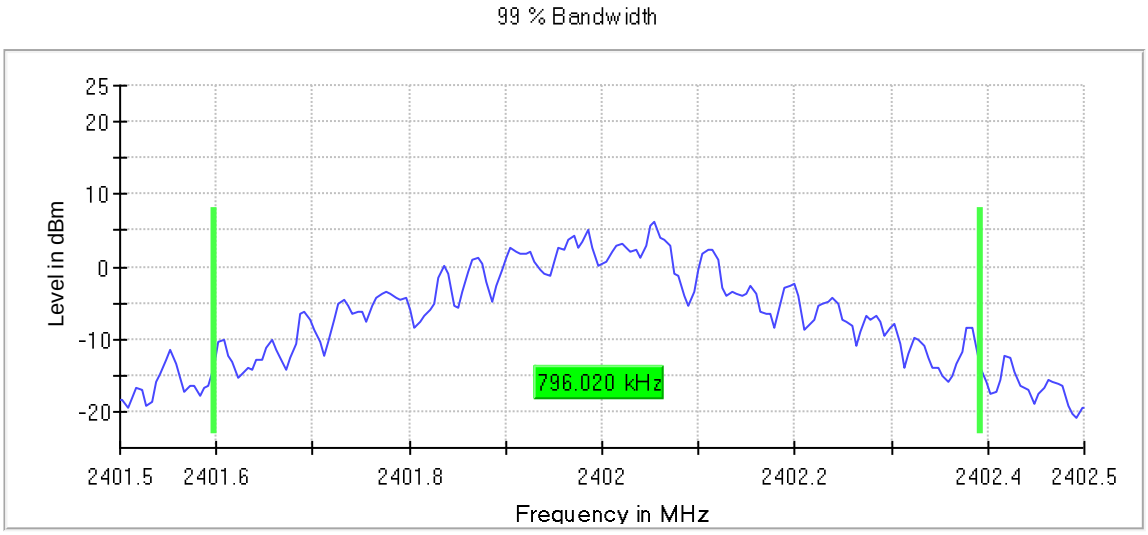
High channel

Mode	Packet Type	Frequency [MHz]	Channel Center Frequency (MHz)	Occupied Channel Bandwidth (MHz)	Upper Band Edge (MHz)
BR	DH5	2480	2480	0.800995	2480.398015
EDR	2DH5	2480	2480	1.000000	2480.500000
EDR	3DH5	2480	2480	0.995024	2480.492500

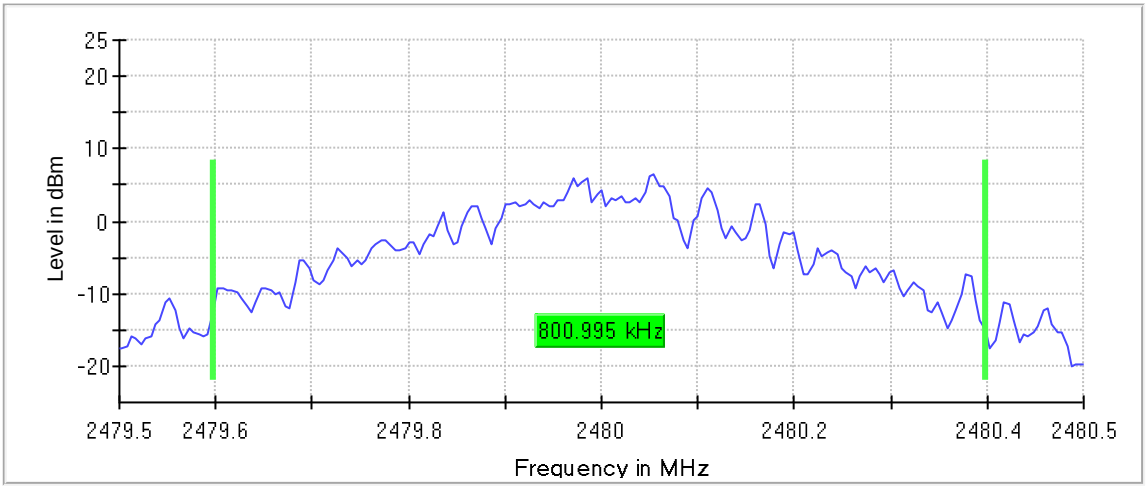
Results screenshot

BR – DH5

BW – 2402 MHz

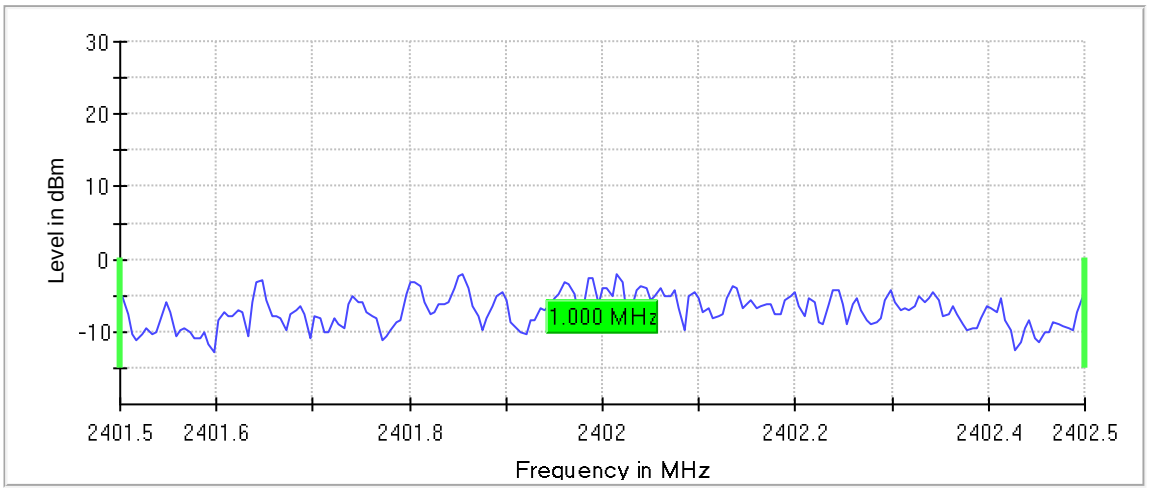


BW – 2480 MHz

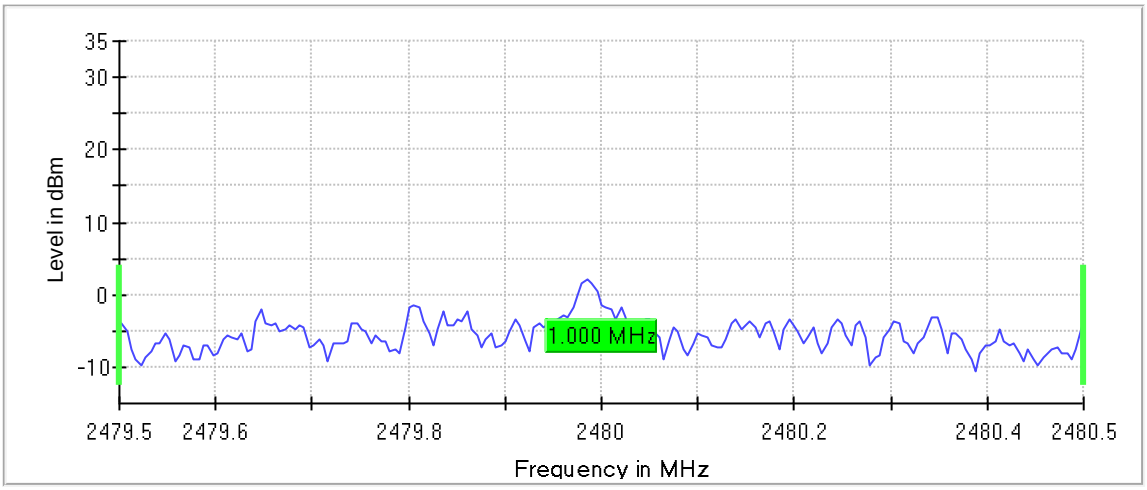


EDR – 2DH5

BW – 2402 MHz

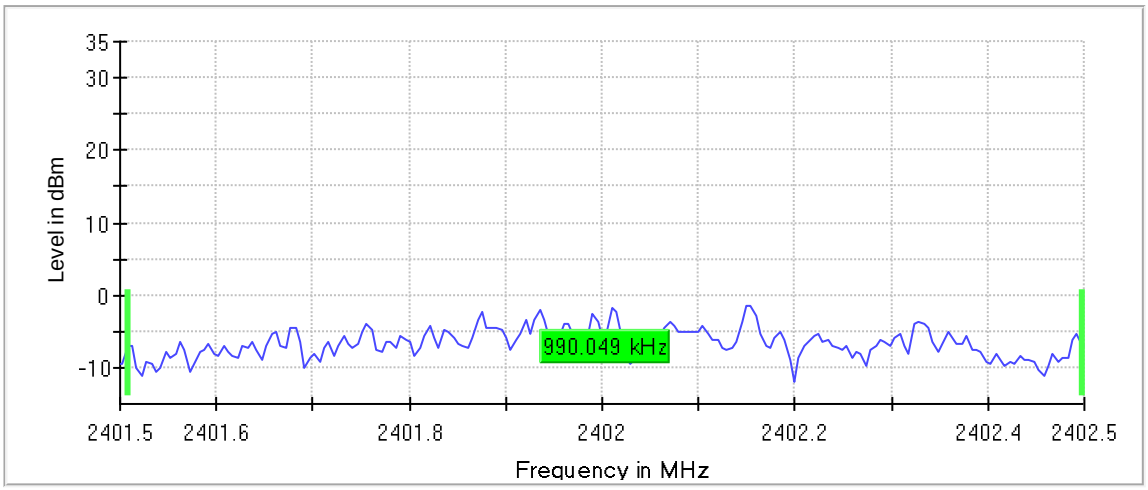


BW – 2480 MHz

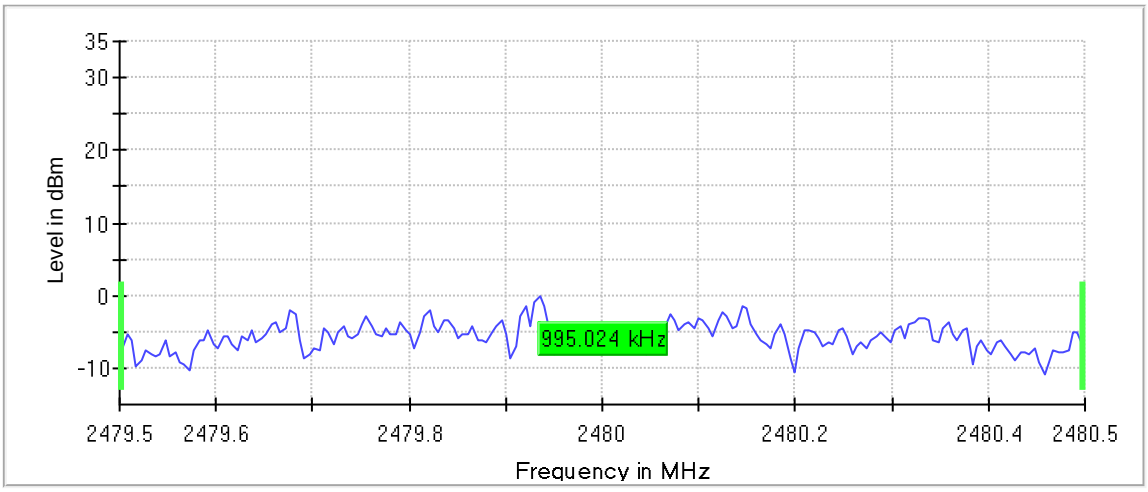


EDR – 3DH5

BW – 2402 MHz

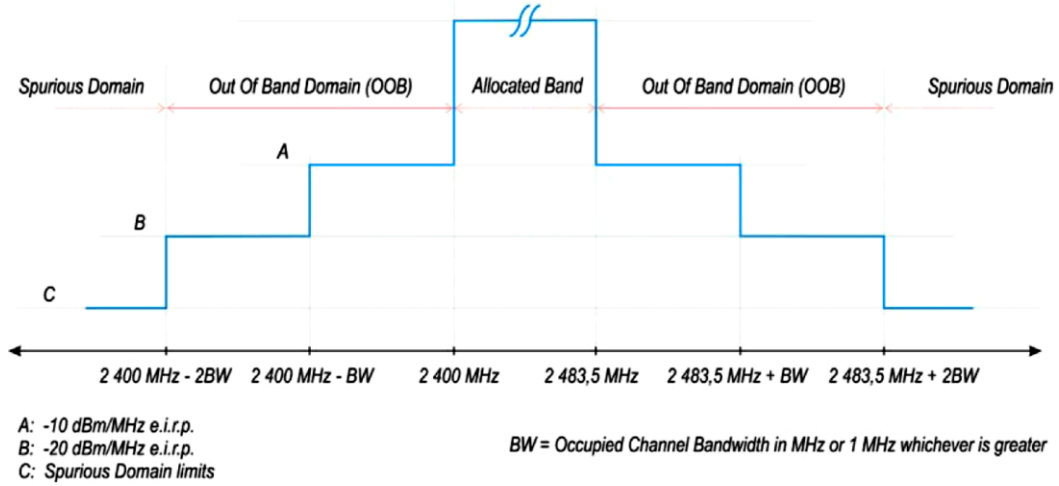


BW – 2480 MHz



B.7 Transmitter unwanted emission in the out-of-band domain

Test limits

ETSI clause	Limits
4.3.1.9.3	The transmitter unwanted emissions in the out-of-band domain but outside the allocated band, shall not exceed the values provided by the mask in figure 1 

Test conditions

ETSI clause	Limits
5.4.8.1	These measurements shall only be performed at normal test conditions. For FHSS equipment, the measurements shall be performed during normal operation (hopping).

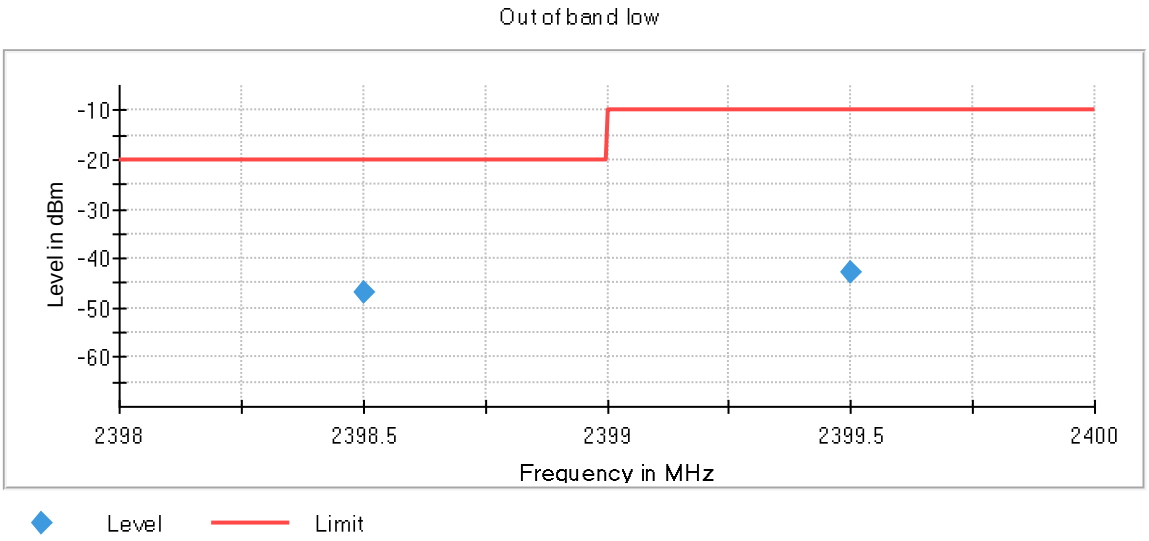
Test procedure

The conducted setup shown in section *Test & System Description* was used to measure the unwanted emissions in the out of band domain (Band Edge) accordingly with ETSI EN 300 328 V2.2.2 §5.4.8.2.1. The antenna terminal of the EUT is connected to the OSP120 through an attenuator and a cable, the spectrum analyzer is connected to the receiver port on the OSP. System connection cable loss is compensated by the EMC32 software on measured parameters.

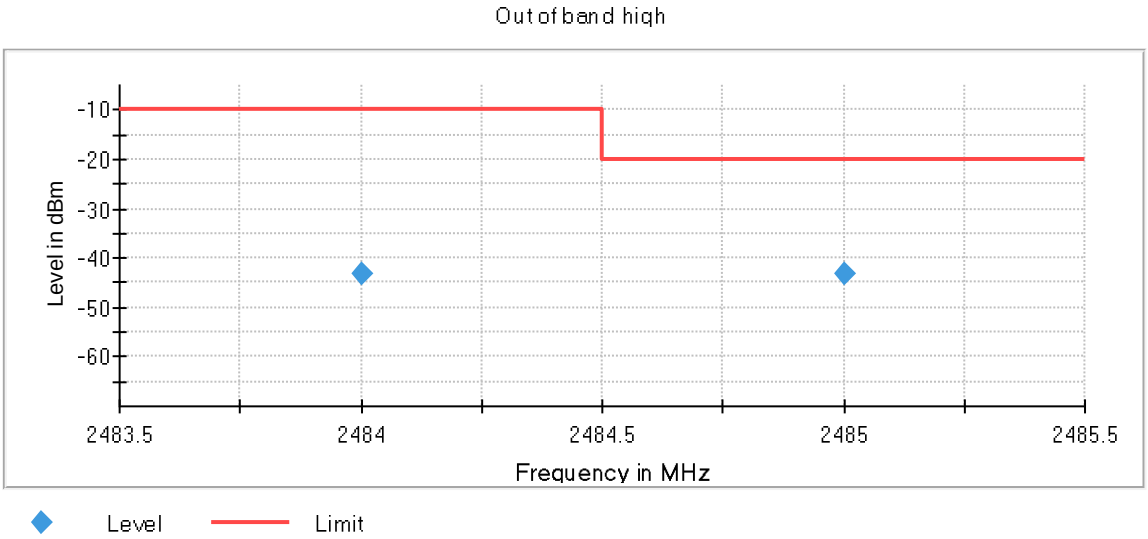
Results screenshot

BR – DH5

UNWANTED OOB Low Freq Section

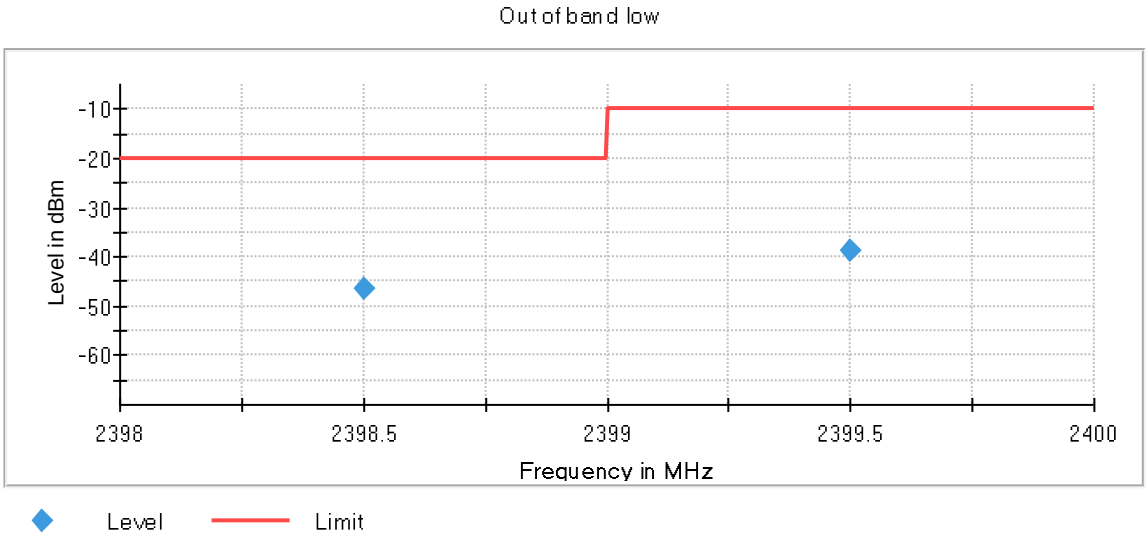


UNWANTED OOB High Freq Section

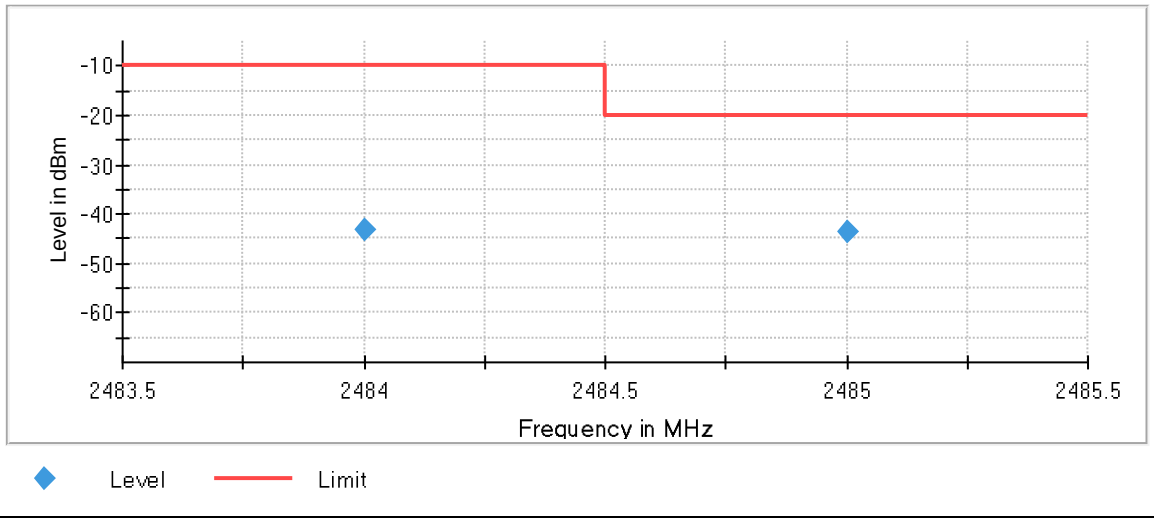


EDR – 2DH5

UNWANTED OOB Low Freq Section

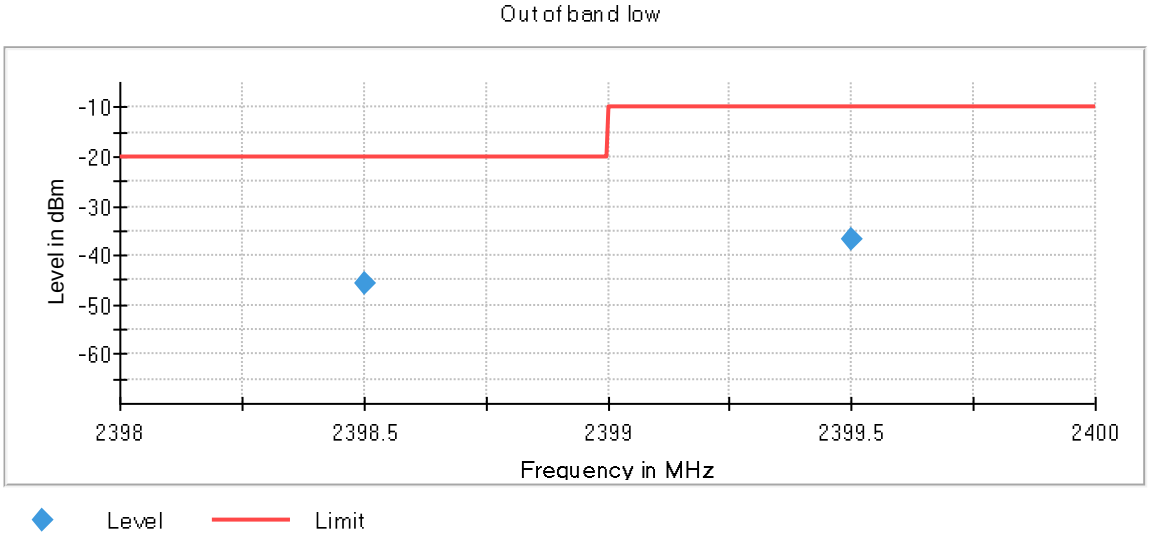


UNWANTED OOB High Freq Section

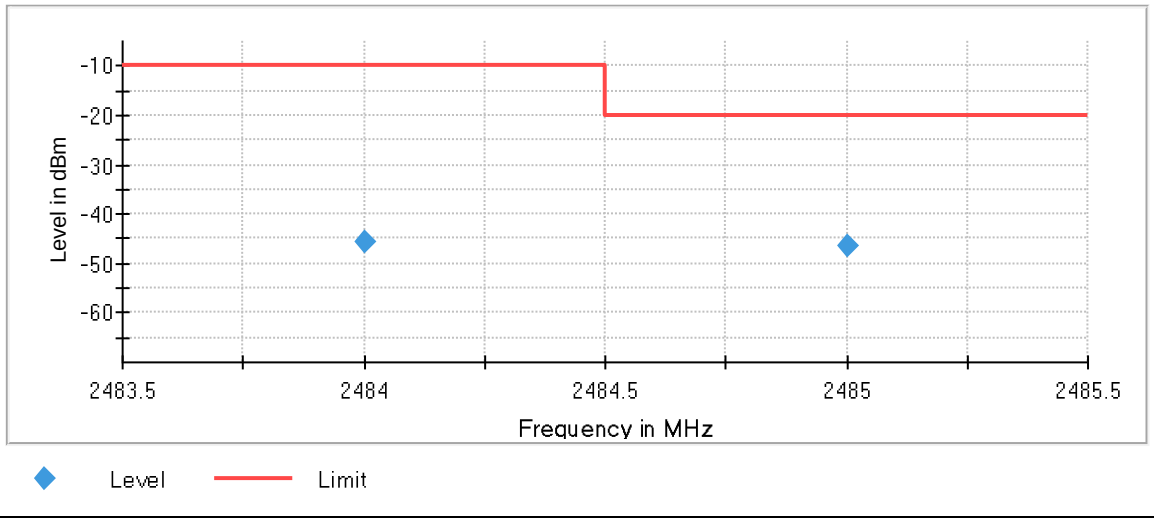


EDR – 3DH5

UNWANTED OOB Low Freq Section



UNWANTED OOB High Freq Section



B.8 Transmitter unwanted emissions in the spurious domain

Test limits

<table>
<tr><th>ETSI clause</th><th>Limits</th></tr>
<tr><td>4.3.1.10.3</td><td>The transmitter unwanted emissions in the spurious domain shall not exceed the values given in table 4.
For emissions radiated by the cabinet or emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and as e.i.r.p. for emissions above 1 GHz.

Table 4: Transmitter limits for spurious emissions
<table>
<tr><th>Frequency range</th><th>Maximum power</th><th>Bandwidth</th></tr>
<tr><td>30 MHz to 47 MHz</td><td>-36 dBm</td><td>100 kHz</td></tr>
<tr><td>47 MHz to 74 MHz</td><td>-54 dBm</td><td>100 kHz</td></tr>
<tr><td>74 MHz to 87.5 MHz</td><td>-36 dBm</td><td>100 kHz</td></tr>
<tr><td>87.5 MHz to 118 MHz</td><td>-54 dBm</td><td>100 kHz</td></tr>
<tr><td>118 MHz to 174 MHz</td><td>-36 dBm</td><td>100 kHz</td></tr>
<tr><td>174 MHz to 230 MHz</td><td>-54 dBm</td><td>100 kHz</td></tr>
<tr><td>230 MHz to 470 MHz</td><td>-36 dBm</td><td>100 kHz</td></tr>
<tr><td>470 MHz to 694 MHz</td><td>-54 dBm</td><td>100 kHz</td></tr>
<tr><td>694 MHz to 1 GHz</td><td>-36 dBm</td><td>100 kHz</td></tr>
<tr><td>1 GHz to 12.75 GHz</td><td>-30 dBm</td><td>1 MHz</td></tr>
</table>
</td></tr>
</table>

Test conditions

ETSI clause	Limits
5.4.8.1	These measurements shall only be performed at normal test conditions. For equipment using FHSS modulation, the measurements may be performed when normal hopping is disabled. In this case measurements need to be performed when operating at the lowest and the highest hopping frequency. When this is not possible, the measurement shall be performed during normal operation (hopping).

Test procedure

The radiated setups (transmitter) shown in section *Test & System Description* were used to measure the transmission spurious emissions accordingly with ETSI EN 300 328 V2.2.2 §5.4.9.2.1. Depending of the frequency range and bands being tested, different antennas and filters were used, in consequence different setups are employed.

The final measurement is done by varying the antenna height from 1 to 4 meters, the EUT azimuth over 360º and for both Vertical and Horizontal polarizations.

The radiated spurious emission was measured on the worst case configuration selected from each transmission mode on the low and high channel.

Test Results

Tx Spurious Emissions – 30MHz to 1GHz

Tx Spurious Emissions – All modes

Frequency	RMS	Limit (e.i.r.p)	Margin	Polarization
MHz	dBm	dBm	dB	---
71.9	-65.8	-51.9	13.9	V

Note 1: The spurious signals detected do not depend on either the operating channel or the modulation mode.

Tx Spurious Emissions – 1GHz to 12.75GHz

Tx Spurious Emissions – BR, GFSK, DH5, 2402 MHz

Frequency	RMS	Limit	Margin	Polar
MHz	dBm	dBm	dB	---
3391.0	-46.8	-30.0	16.8	V
10305.0	-59.1	-30.0	29.1	V

Tx Spurious Emissions – BR, GFSK, DH5, 2480 MHz

Frequency	RMS	Limit	Margin	Polar
MHz	dBm	dBm	dB	---
3377.0	-47.1	-30.0	17.1	H
10422.5	-59.5	-30.0	29.5	V

Tx Spurious Emissions – BR, π/4-DQPSK, 2-DH5, 2402 MHz

Frequency	RMS	Limit	Margin	Polar
MHz	dBm	dBm	dB	---
3381.5	-46.8	-30.0	16.8	V
10422.5	-59.5	-30.0	29.5	V

Tx Spurious Emissions – BR, π/4-DQPSK, 2-DH5, 2480 MHz

Frequency	RMS	Limit	Margin	Polar
MHz	dBm	dBm	dB	---
3383.0	-47.1	-30.0	17.1	H
10393.0	-59.4	-30.0	29.4	V

Tx Spurious Emissions – BR, EDR, 8-DPSK, 3-DH5, 2402 MHz

Frequency	RMS	Limit	Margin	Polar
MHz	dBm	dBm	dB	---
3384.5	-46.8	-30.0	16.8	V
10395.5	-59.6	-30.0	29.6	V

Tx Spurious Emissions – BR, EDR, 8-DPSK, 3-DH5, 2480 MHz

Frequency	RMS	Limit	Margin	Polar
MHz	dBm	dBm	dB	---
3388.0	-47.1	-30.0	17.1	H
10379.5	-59.5	-30.0	29.5	V

B.9 Receiver spurious emissions

Test limits

<table>
<tr><th>ETSI clause</th><th>Limits</th></tr>
<tr><td>4.3.1.11.3</td><td>The spurious emissions of the receiver shall not exceed the values given in table below.

For emissions radiated by the cabinet or for emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and e.i.r.p. for emissions above 1 GHz.
<table>
<tr><th>Frequency range</th><th>Maximum power</th><th>Bandwidth</th></tr>
<tr><td>30 MHz to 1GHz</td><td>-57 dBm</td><td>100 kHz</td></tr>
<tr><td>1GHz to 12.75 GHz</td><td>-47 dBm</td><td>1 MHz</td></tr>
</table>
</td></tr>
</table>

Test conditions

ETSI clause	Limits
5.4.10.1	These measurements shall only be performed at normal test conditions. Testing shall be performed when the equipment is in a receive-only mode. For FHSS equipment, the measurements may be performed when normal hopping is disabled. In this case measurements need to be performed when operating at the lowest and the highest hopping frequency. These frequencies shall be recorded. When disabling the normal hopping is not possible, the measurement shall be performed during normal operation (hopping).

Test procedure

The radiated setups (receiver) shown in section *Test & System Description* were used to measure the receiver spurious emissions accordingly with ETSI EN 300 328 V2.2.2 §5.4.10.2.2. Depending of the frequency range and bands being tested, different antennas and filters were used, in consequence different setups are employed.

The final measurement is done by varying the antenna height from 1 to 4 meters, the EUT azimuth over 360º and for both Vertical and Horizontal polarizations.

The radiated spurious emission was measured on the worst case configuration selected from each transmission mode on the low and high channel

Test Results

Rx Spurious Emissions – 30MHz to 1GHz

Rx Spurious Emissions – All modes

Frequency	RMS	Limit (e.i.r.p)	Margin	Polarization
MHz	dBm	dBm	dB	---
72.0	-63.7	-54.9	8.8	V

Note 1: The spurious signals detected do not depend on either the operating channel or the modulation mode.

Rx Spurious Emissions – 1GHz to 12.75 GHz

Rx Spurious Emissions – BR, GFSK, DH5, 2402 MHz

Frequency	RMS	Limit	Margin	Polar
MHz	dBm	dBm	dB	---
12370.0	-58.2	-47.0	11.2	H

Rx Spurious Emissions – BR, GFSK, DH5, 2480 MHz

Frequency	RMS	Limit	Margin	Polar
MHz	dBm	dBm	dB	---
12341.3	-57.9	-47.0	10.9	H

Rx Spurious Emissions – BR, π/4-DQPSK, 2-DH5, 2402 MHz

Frequency	RMS	Limit	Margin	Polar
MHz	dBm	dBm	dB	---
12304.7	-59.0	-47.0	12.0	V

Rx Spurious Emissions – BR, π/4-DQPSK, 2-DH5, 2480 MHz

Frequency	RMS	Limit	Margin	Polar
MHz	dBm	dBm	dB	---
12438.6	-58.9	-47.0	11.9	V

Rx Spurious Emissions – BR, π/4-DQPSK, 3-DH5, 2402 MHz

Frequency	RMS	Limit	Margin	Polar
MHz	dBm	dBm	dB	---
12436.3	-59.0	-47.0	11.9	H

Rx Spurious Emissions – BR, π/4-DQPSK, 3-DH5, 2480 MHz

Frequency	RMS	Limit	Margin	Polar
MHz	dBm	dBm	dB	---
12323.9	-58.2	-47.0	11.2	V

B.10 Receiver Blocking

Test limits

<table>
<tr><th>ETSI clause</th><th>Limits</th></tr>
<tr><td>4.3.1.12.3

4.3.1.12.4</td><td>
The minimum performance criterion shall be a PER less than or equal to 10 %.

While maintaining the minimum performance criteria as defined in clause 4.3.1.12.3, the blocking levels at specified frequency offsets shall be equal to or greater than the limits defined for the applicable receiver category provided in table below.

Receiver blocking parameters for Receiver Category 1 equipment
<table>
<tr><th>Wanted signal mean power from companion device (dBm) (see notes 1 and 4)</th><th>Blocking signal frequency (MHz)</th><th>Blocking signal power (dBm) (see note 4)</th><th>Type of blocking signal</th></tr>
<tr><td>(-133 dBm + 10 × log₁₀(OCBW)) or -68 dBm whichever is less (see note 2)</td><td>2380
2504
2300
2584</td><td rowspan="2">-34</td><td rowspan="2">CW</td></tr>
<tr><td>(-139 dBm + 10 × log₁₀(OCBW)) or -74 dBm whichever is less (see note 3)</td><td>2300
2330
2360
2524
2584
2674</td></tr>
<tr><td colspan="4">
NOTE 1: OCBW is in Hz
NOTE 2: In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to Pmin + 26 dB where Pmin is the minimum level of wanted signal required to meet the minimum performance criteria as defined in clause 4.3.1.12.3 in the absence of any blocking signal.
NOTE 3 In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to Pmin + 20 dB where Pmin is the minimum level of wanted signal required to meet the minimum performance criteria as defined in clause 4.3.1.12.3 in the absence of any blocking signal.
NOTE 4: The level specified is the level at the UUT receiver input assuming a 0 dBi antenna assembly gain. In case of conducted measurements, this level has to be corrected for the (in-band) antenna assembly gain (G). In case of radiated measurements, this level is equivalent to a power flux density (PFD) in front of the UUT antenna with the UUT being configured/positioned as recorded in clause 5.4.3.2.2.
</td></tr>
</table>
</td></tr>
</table>

Test conditions

ETSI clause	Conditions
5.4.11.1	These measurements shall only be performed at normal test conditions.

Test procedure

The receiver blocking setup shown in section *Test & System Description* was used to measure receiver blocking signal. The signaling Unit is a CMW500.

The packet error rate (PER) is measured with the CMW500. The blocking signal is emulated by the Signal generator SMB100A. Antenna gain and insertion loss are taken into account.

Test results

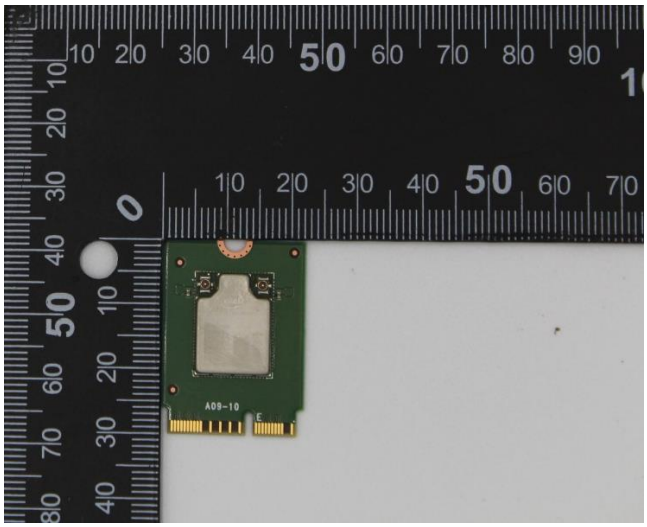
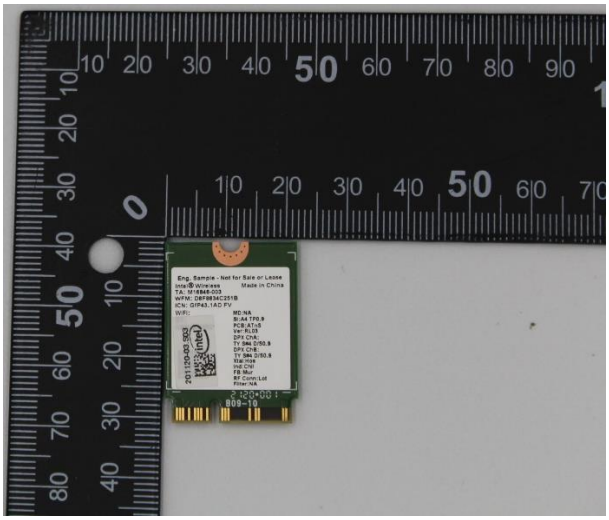
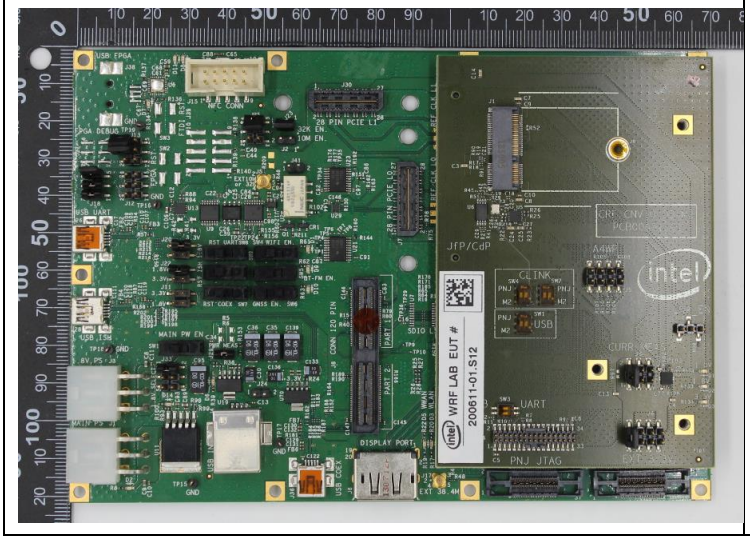
Configuration	99% Occupied bandwidth [MHz]	Wanted signal mean power from companion device (dBm)	PER [%] Without blocking signal	Blocking signal [MHz]	Blocking signal Power [dBm]	PER [%] With Blocking signal	Verdict
		Without blocking signal		With blocking signal			
BT DH5-Hopping Chain A	0.786	-75.99	2.80	2380	-36	1.07	Pass
		-76.05	2.80	2504	-36	1.05	Pass
		-81.99	1.87	2300	-36	0.54	Pass
		-81.99	1.87	2360	-36	1.05	Pass
		-81.99	1.87	2330	-36	1.01	Pass
		-81.99	1.87	2524	-36	1.11	Pass
		-81.99	1.87	2584	-36	0.90	Pass
		-81.99	1.87	2674	-36	0.75	Pass

Annex C. Photographs

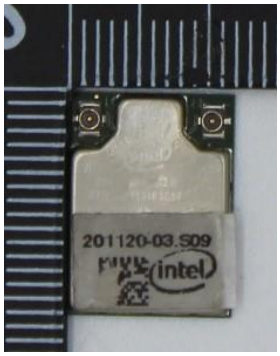
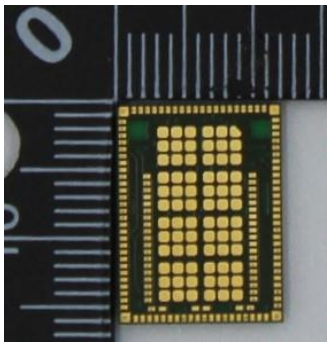
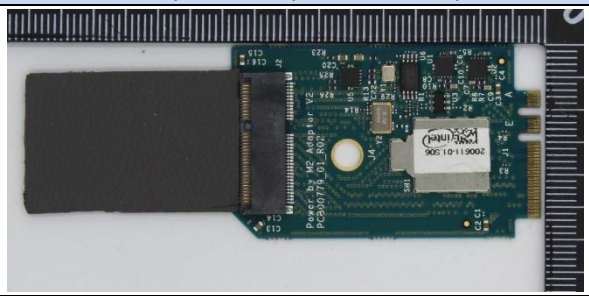
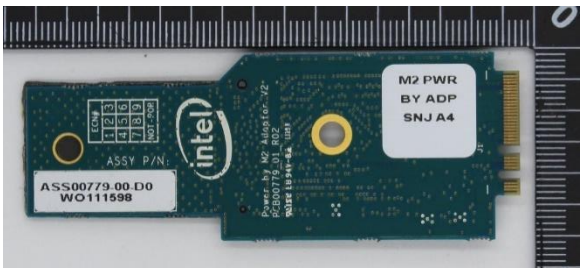
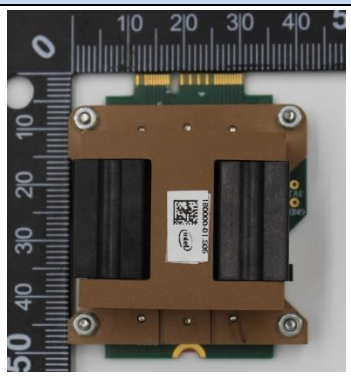
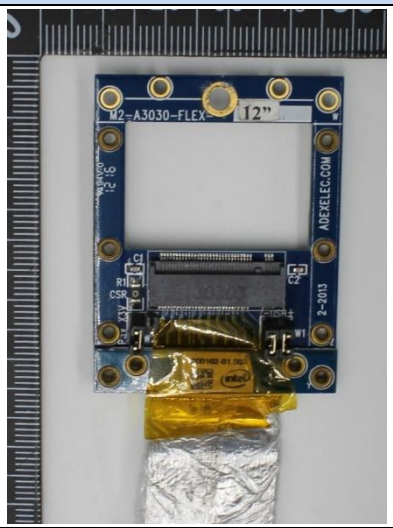
C.1 Test Setup

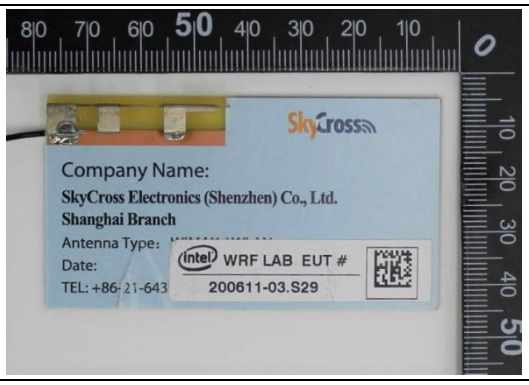
Radiated Setup 30 MHz – 1 GHz (Transmitter & Receiver tests)	Radiated Setup 1 GHz – 6.4 GHz (Transmitter tests)
	
Radiated Setup 6.4 GHz – 12.75 GHz (Transmitter tests) 1 GHz – 12.75 GHz (Receiver tests)	
	

C.2 Test Sample

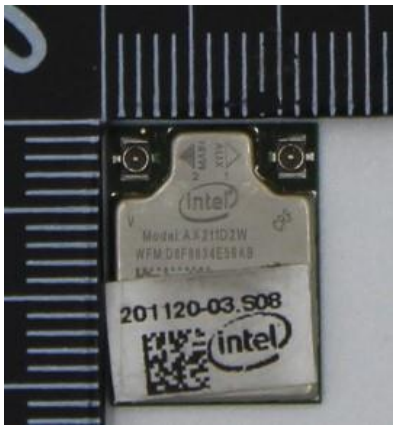
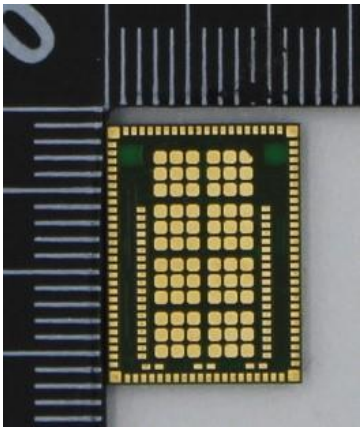
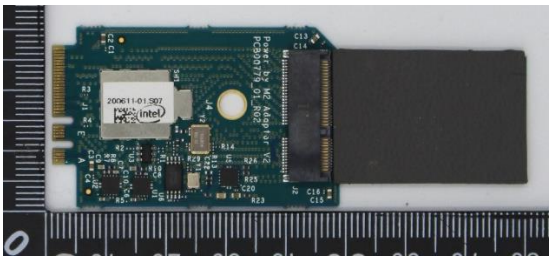
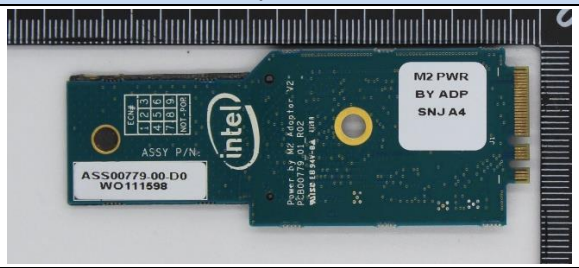
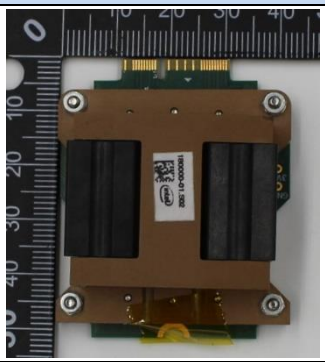
Sample #01	
Module Front	Module Back
	
Extender board	Laptop
	

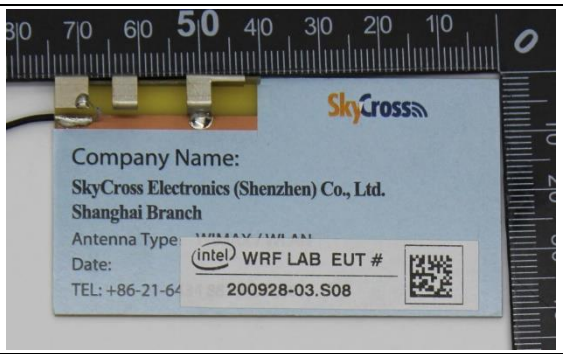
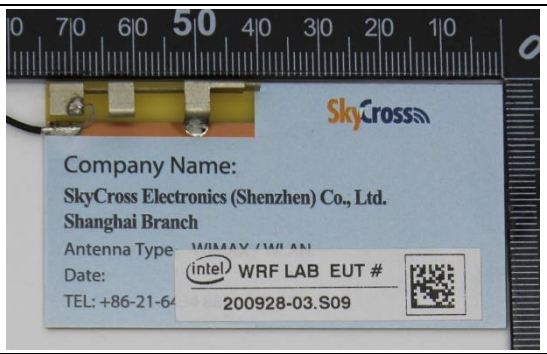
Sample #02

Module Front	Module Back
	
Adaptor front (with absorber)	Adaptor back
	
Socket front	Socket back
	
Extender board	Laptop
	
Main Antenna	Aux Antenna

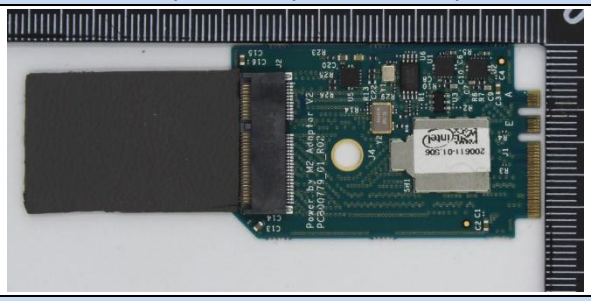
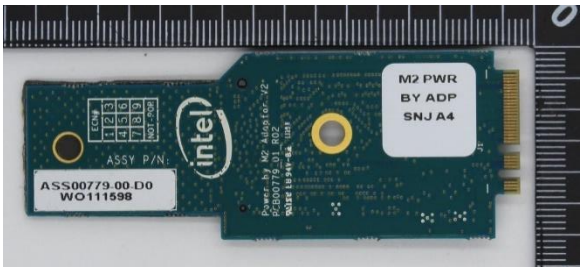
 SkyCross Company Name: SkyCross Electronics (Shenzhen) Co., Ltd. Shanghai Branch Antenna Type: Date: TEL: +86-21-6434 WRF LAB EUT # 200611-03.S28	 SkyCross Company Name: SkyCross Electronics (Shenzhen) Co., Ltd. Shanghai Branch Antenna Type: Date: TEL: +86-21-643 WRF LAB EUT # 200611-03.S29

Sample #03

Module Front	Module Back
	
Adaptor front (with absorber)	Adaptor back
	
Socket front	Socket back
	
Extender board	Laptop
	
Main Antenna	Aux Antenna

 SkyCross Company Name: SkyCross Electronics (Shenzhen) Co., Ltd. Shanghai Branch Antenna Type: Date: TEL: +86-21-64 WRF LAB EUT # 200928-03.S08	 SkyCross Company Name: SkyCross Electronics (Shenzhen) Co., Ltd. Shanghai Branch Antenna Type: Date: TEL: +86-21-64 WRF LAB EUT # 200928-03.S09

Sample #03

Module Front	Module Back
	
Adaptor front (with absorber)	**Adaptor back**
	
Laptop (Host)	
	

End of the report

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