

**Electromagnetic compatibility
and Radio Spectrum Matters ERM
ERM TEST REPORT
281943-6**

Test Report

*Electromagnetic compatibility
and Radio spectrum Matters (ERM)*



Equipment Under Test: 802.11 b/g/n Module

Model: WF111-A
WF111-E

Brand: Silicon Laboratories Finland Oy

Manufacturer: Silicon Laboratories Finland Oy
Bertel Jungin aukio 3
FI-02600 Espoo
FINLAND

Customer: Silicon Laboratories Finland Oy
Bertel Jungin aukio 3
FI-02600 Espoo
FINLAND

The equipment under test was tested according following standard(s)

Title of the standard	Reference standard	Version (Date)
Electromagnetic compatibility and Radio spectrum Matters (ERM); Wideband transmission systems; Data transmission equipment operating in the 2,4 GHz ISM band and using wide band modulation techniques; Harmonized EN covering essential requirements under article 3.2 of the R&TTE Directive	ETSI EN 300 328	v1.9.1 (2015-02)

Date: 5.8.2016

Issued by:



Emil Haverinen
Testing Engineer

Date: 5.8.2016

Checked by:



Rauno Repo
Testing Engineer

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Equipment Under Test (EUT)

802.11 b/g/n Module	
Model:	WF111-A WF111-E

Description of the EUT

WF111 is a 2.4 GHz band 802.11 b/g/n WLAN module for portable and battery powered applications. The EUT was attached to evaluation board. Two samples were used in the tests. WF111-A was used in radiated spurious emissions tests and WF111-E was used in radiated spurious emissions tests and in conducted RF tests. WF111-A is equipped with internal chip antenna. WF111-E is equipped with a U.FL connector.

Measurements were made only with 1 Mbps data rate.

Power Requirements

Operating voltage range:	2.7 – 4.8 VDC
Normal input voltage:	3.3 VDC

Mechanical Size of the EUT

Height: 2.1 mm	Width: 19 mm	Depth: 12.00 mm
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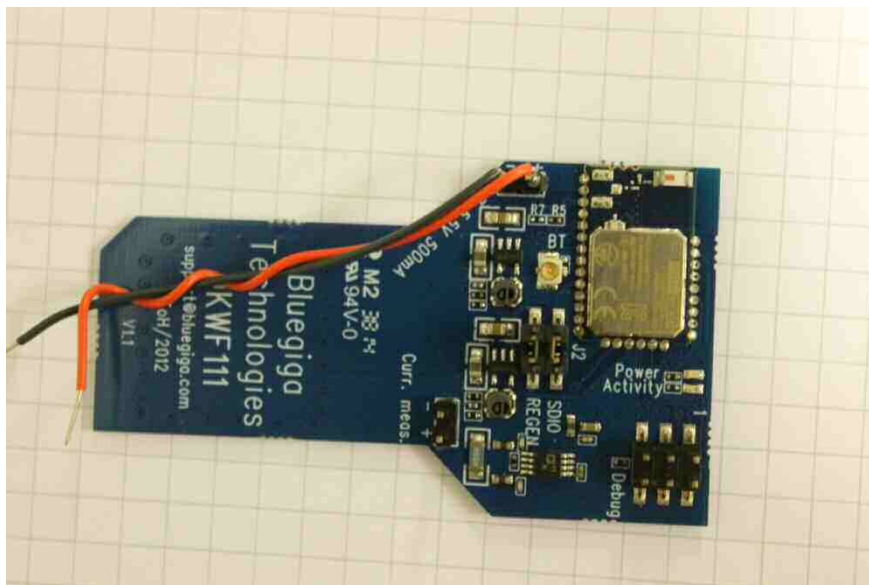
Equipment category and characteristics

Operating Frequency Range (OFR):	2412 – 2472 MHz
Channels:	13
Channel separation:	5 MHz
Channel bandwidth:	18.207724 MHz
Effective conducted power:	19.0 dBm
Transmission technique:	DSSS
Modulation:	CCK, QPSK, OFDM
External antenna gain:	2.14 dBi
Integral antenna gain:	0.5 dBi
Geo-location capability:	None

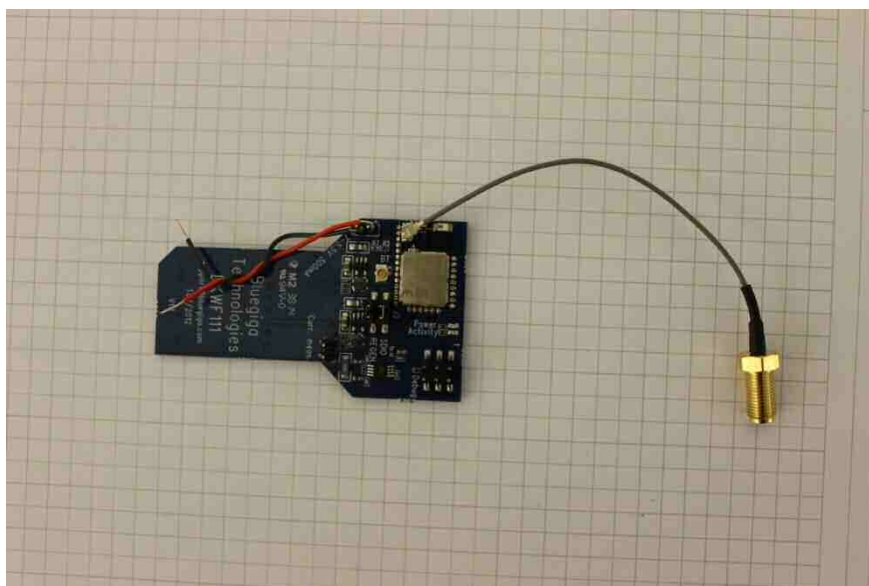
Peripherals

- External DC power supply Thandar TS3021S
- Laptop PC HP ProBook 4740s

Photographs of the EUT



Picture 1. WF111-A radiated test sample connected to the development board



Picture 2. WF111-E sample for conducted RF tests



Picture 3. The external antenna used in testing

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Unless otherwise stated the results shown in this test report refer only to the sample(s) tested and such sample(s) are retained for 90 days only. This document cannot be reproduced except in full, without prior approval of the Company.

EUT Test Conditions During Testing

During the tests EUT was set to continuous transmit or receive mode and to the channel under test. Normal modulation and maximum transmit power was used in all tests. The EUT was set on to the wanted test channel and transmit/receive mode with UniTest App software. The conducted tests were made with 1 Mbps data rate.

Table 1. Normal and extreme test conditions.

Test conditions:		Temperature [°C]:	Voltage [V]:
Normal		+20 – 25	2.7
Extreme	Minimum	-40	3.3
	Maximum	+85	4.8

Extreme temperature and voltage ranges were provided by the customer.

Table 2. The test frequencies used in the tests.

Frequency [MHz]:	Channel:
2412	Low
2437	Middle
2472	High

Test Suite

Test	Test Specification	Applicable	Test Result
RF Output Power	EN 300 328 V.1.9.1 (2015-02)	YES	PASS
Power Spectral Density	EN 300 328 V.1.9.1 (2015-02)	YES	PASS
Duty cycle, Tx-sequence, Tx-gap	EN 300 328 V.1.9.1 (2015-02)	N/A	-(1)
Accumulated Transmit Time, Frequency Occupation and Hopping Sequence	EN 300 328 V.1.9.1 (2015-02)	N/A	-(2)
Hopping Frequency Separation	EN 300 328 V.1.9.1 (2015-02)	N/A	-(2)
Medium Utilisation (MU) factor	EN 300 328 V.1.9.1 (2015-02)	N/A	-(3)
Adaptivity	EN 300 328 V.1.9.1 (2015-02)	YES	PASS
Occupied Channel Bandwidth	EN 300 328 V.1.9.1 (2015-02)	YES	PASS
Transmitter unwanted spurious emissions in the out-of-band domain	EN 300 328 V.1.9.1 (2015-02)	YES	PASS
Transmitter unwanted spurious emissions in the spurious domain	EN 300 328 V.1.9.1 (2015-02)	YES	PASS
Receiver spurious emissions	EN 300 328 V.1.9.1 (2015-02)	YES	PASS
Receiver blocking	EN 300 328 V.1.9.1 (2015-02)	YES	PASS

- 1) These requirements apply to non-adaptive frequency hopping equipment or to adaptive frequency hopping equipment operating in a non-adaptive mode. Also these requirements do not apply for equipment with a maximum declared RF Output power of less than 10 dBm E.I.R.P.
- 2) This requirement applies to all types of frequency hopping equipment.
- 3) This requirement applies to adaptive equipment unless operating in a non-adaptive mode. Also this requirement does not apply for equipment with a maximum declared RF Output power of less than 10 dBm E.I.R.P.

According to the standard the measurement results have been compared directly with the limits without considering measurement uncertainties.

Explanations:

PASS The EUT passed that particular test.
 FAIL The EUT failed that particular test.
 N/A Not Applicable
 N/T Not Tested

Summary of Testing

Testing location:

☐ CB Testing Laboratory:

☐ Testing Location / address:

SGS Fimko Ltd
Särkiniementie 3
FI-00210, HELSINKI
FINLAND

☒ Testing Location / address:

SGS Fimko Ltd
Karakaarenkuja 4
FI-02610, ESPOO
FINLAND

RF Output Power

Standard: EN 300 328 v.1.9.1.
Tested by: NKO
Date: 31.3.2016 – 29.4.2016
Temperature: 21 °C
Humidity: 30 % RH
Test result: **PASS**

Measurement uncertainty: ± 0.349 dB

Level of confidence 95 % (k = 2)

Test plan

Measurements are performed according to ETSI EN 300 328 v.1.9.1 clause 5.3.2.2.1.2.

The RF output power is defined as the mean equivalent isotropically radiated power (E.I.R.P.) of the equipment during a transmission burst.

The transmitter is connected via the 50 Ω -power attenuator to the measuring equipment. The power is measured with the highest operating power level. The maximum isotropic radiated power of the equipment is calculated from the measured power (P) added by antenna gain (G) and beamforming gain (Y).

The measurements are done under normal and extreme test conditions. For systems using FHSS modulation, the measurements shall be performed during normal operation (hopping). For systems using wide band modulations other than FHSS, the measurement shall be performed at the lowest, the middle, and the highest channel on which the equipment can operate.

$$\text{E.I.R.P} = P + G + Y$$

Test results

WF111-A

Antenna gain (G):	0.5	dBi
Beamforming gain (Y):	0	dBi

Test conditions		Transmit power E.I.R.P. [dBm]		
Temperature	Voltage	Low	Mid	High
-40 °C	3.3 VDC	17.4	17.1	16.8
+20 – 25 °C	3.3 VDC	15.4	15.5	14.9
+85 °C	3.3 VDC	15.2	17.0	16.4
Limit:		+20 dBm		
Maximum transmit power E.I.R.P		+17.4 dBm		
Measurement uncertainty (Level of confidence 95 % k = 2)		±0.349 dBm		

WF111-E

Antenna gain (G):	2.14	dBi
Beamforming gain (Y):	0	dBi

Test conditions		Transmit power E.I.R.P. [dBm]		
Temperature	Voltage	Low	Mid	High
-40 °C	3.3 VDC	19.0	18.7	18.4
+20 – 25 °C	3.3 VDC	17.0	17.1	16.5
+85 °C	3.3 VDC	16.8	18.6	18.0
Limit:		+20 dBm		
Maximum transmit power E.I.R.P		+19.0 dBm		
Measurement uncertainty (Level of confidence 95 % k = 2)		±0.349 dBm		

Power Spectral Density

Standard: EN 300 328 v.1.9.1.
Tested by: NKO
Date: 31.3.2016
Temperature: 21 °C
Humidity: 30 % RH
Test result: **PASS**

Measurement uncertainty: ± 0.372 dB

Level of confidence 95 % (k = 2)

Test plan

Measurements are performed according to ETSI EN 300 328 v.1.9.1 clause 5.3.3.2.1.

The Power spectral density is the mean equivalent isotropically radiated power (e.i.r.p) spectral density during a transmission burst. The maximum power spectral density is limited to 10 dBm per MHz.

Test results

DUT Frequency (MHz)	Center Frequency of Segment (MHz)	Level (dBm)	Limit (dBm)	Result	Comment
2412.000000	2411.046817	9.4	≤ 10.0	PASS	
2437.000000	2436.050337	8.2	≤ 10.0	PASS	
2472.000000	2472.933155	8.1	≤ 10.0	PASS	

Transmitter Spurious Emissions in the Out-Of-Band Domain

Standard: EN 300 328 v.1.9.1.
Tested by: NKO
Date: 31.3.2016
Temperature: 21 °C
Humidity: 30 % RH
Test result: **PASS**

Measurement uncertainty: ± 1.39 dB

Level of confidence 95 % (k = 2)

Test plan

Measurements are performed according to ETSI EN 300 328 v.1.9.1 clause 5.3.9.2.1.

Transmitter unwanted emissions in the out-of-band domain are emissions when the equipment is in Transmit mode, on frequencies immediately outside the necessary bandwidth which results from the modulation process, but excluding spurious.

The transmitter is connected via the 50 Ω -power attenuator to a spectrum analyzer. The out-of-band spurious emissions are measured by using the time domain power function of the spectrum analyzer.

Test results

Table 3. Test results under normal condition low and high channels data rate 1 Mbps.

DUT Frequency (MHz)	Nominal Bandwidth (MHz)	Temperature (°C)	Frequency (MHz)	Level (dBm)	Limit (dBm)	Result
2412.000000	20.000000	21.0	2369.623859	-47.6	-20.0	PASS
2412.000000	20.000000	21.0	2370.061930	-47.6	-20.0	PASS
2412.000000	20.000000	21.0	2371.061930	-47.6	-20.0	PASS
2412.000000	20.000000	21.0	2372.061930	-47.6	-20.0	PASS
2412.000000	20.000000	21.0	2373.061930	-47.5	-20.0	PASS
2412.000000	20.000000	21.0	2374.061930	-47.5	-20.0	PASS
2412.000000	20.000000	21.0	2375.061930	-47.5	-20.0	PASS
2412.000000	20.000000	21.0	2376.061930	-47.5	-20.0	PASS
2412.000000	20.000000	21.0	2377.061930	-47.5	-20.0	PASS
2412.000000	20.000000	21.0	2378.061930	-47.5	-20.0	PASS
2412.000000	20.000000	21.0	2379.061930	-47.5	-20.0	PASS
2412.000000	20.000000	21.0	2380.061930	-47.5	-20.0	PASS
2412.000000	20.000000	21.0	2381.061930	-47.5	-20.0	PASS
2412.000000	20.000000	21.0	2382.061930	-47.4	-20.0	PASS
2412.000000	20.000000	21.0	2383.061930	-47.4	-20.0	PASS
2412.000000	20.000000	21.0	2384.061930	-47.4	-20.0	PASS
2412.000000	20.000000	21.0	2385.061930	-47.4	-10.0	PASS
2412.000000	20.000000	21.0	2385.500000	-47.3	-10.0	PASS
2412.000000	20.000000	21.0	2386.500000	-47.3	-10.0	PASS
2412.000000	20.000000	21.0	2387.500000	-47.3	-10.0	PASS
2412.000000	20.000000	21.0	2388.500000	-47.3	-10.0	PASS
2412.000000	20.000000	21.0	2389.500000	-47.2	-10.0	PASS
2412.000000	20.000000	21.0	2390.500000	-47.2	-10.0	PASS
2412.000000	20.000000	21.0	2391.500000	-46.8	-10.0	PASS
2412.000000	20.000000	21.0	2392.500000	-46.3	-10.0	PASS
2412.000000	20.000000	21.0	2393.500000	-44.7	-10.0	PASS
2412.000000	20.000000	21.0	2394.500000	-44.5	-10.0	PASS
2412.000000	20.000000	21.0	2395.500000	-44.9	-10.0	PASS
2412.000000	20.000000	21.0	2396.500000	-41.9	-10.0	PASS
2412.000000	20.000000	21.0	2397.500000	-40.8	-10.0	PASS
2412.000000	20.000000	21.0	2398.500000	-42.4	-10.0	PASS
2412.000000	20.000000	21.0	2399.500000	-38.0	-10.0	PASS
2412.000000	20.000000	21.0	2484.000000	-47.7	-10.0	PASS
2412.000000	20.000000	21.0	2485.000000	-47.6	-10.0	PASS
2412.000000	20.000000	21.0	2486.000000	-47.6	-10.0	PASS
2412.000000	20.000000	21.0	2487.000000	-47.5	-10.0	PASS
2412.000000	20.000000	21.0	2488.000000	-47.4	-10.0	PASS
2412.000000	20.000000	21.0	2489.000000	-47.2	-10.0	PASS
2412.000000	20.000000	21.0	2490.000000	-47.6	-10.0	PASS

Transmitter Spurious Emissions

[illegible]

Transmitter Spurious Emissions

2472.000000	20.000000	21.0	2498.413073	-47.8	-10.0	PASS
2472.000000	20.000000	21.0	2499.413073	-47.9	-20.0	PASS
2472.000000	20.000000	21.0	2500.413073	-48.0	-20.0	PASS
2472.000000	20.000000	21.0	2501.413073	-48.0	-20.0	PASS
2472.000000	20.000000	21.0	2502.413073	-48.0	-20.0	PASS
2472.000000	20.000000	21.0	2503.413073	-48.1	-20.0	PASS
2472.000000	20.000000	21.0	2504.413073	-48.1	-20.0	PASS
2472.000000	20.000000	21.0	2505.413073	-48.1	-20.0	PASS
2472.000000	20.000000	21.0	2506.413073	-48.1	-20.0	PASS
2472.000000	20.000000	21.0	2507.413073	-48.1	-20.0	PASS
2472.000000	20.000000	21.0	2508.413073	-47.8	-20.0	PASS
2472.000000	20.000000	21.0	2509.413073	-48.2	-20.0	PASS
2472.000000	20.000000	21.0	2510.413073	-47.9	-20.0	PASS
2472.000000	20.000000	21.0	2511.413073	-48.3	-20.0	PASS
2472.000000	20.000000	21.0	2512.413073	-48.0	-20.0	PASS
2472.000000	20.000000	21.0	2513.413073	-48.3	-20.0	PASS
2472.000000	20.000000	21.0	2513.826147	-48.3	-20.0	PASS

Transmitter Unwanted Emissions in the Spurious Domain

Standard: EN 300 328 v.1.9.1
Tested by: NKO
Date: 13.4.2016
Temperature: 22 °C
Humidity: 35 %
Test result: **PASS**

Measurement uncertainty: ± 5.29 dB

Level of confidence 95 % (k = 2)

Test plan

Measurements are performed according to ETSI EN 300 328 v.1.9.1 clause 5.3.10.2.2.

Transmitter unwanted emissions in the spurious domain are emissions outside the allocated band and outside the Out-of-band Domain when the equipment is in transmit mode.

The transmitter is operating at the maximum rated carrier power. First all frequencies where a spurious emission component is detected are recorded in both measuring antenna polarization. Then each spurious frequency level is measured. The highest level of the spurious component is searched by rotating transmitter 360° with both measuring antenna polarization.

The spurious emissions are measured under normal conditions. Test will be made in lowest and highest operation frequencies. Emissions are measured in the frequency range 30 – 12 750 MHz. Radiated transmitter spurious emissions were measured with 1Mbps data rate.

Test results

WF111-A

Channel Low

Frequency (MHz)	RMS (dBm)	Bandwidth (kHz)	Polarization	Margin (dB)	Limit (dBm)	Comment
4824.00	-61.6	1000.000	H	31.6	-30.0	
7326.00	-60.2	1000.000	H	30.2	-30.0	

Channel High

Frequency (MHz)	RMS (dBm)	Bandwidth (kHz)	Polarization	Margin (dB)	Limit (dBm)	Comment
4944.00	-58.0	1000.000	H	28.0	-30.0	
7416.00	-60.7	1000.000	H	30.7	-30.0	

Transmitter Spurious Emissions
WF111-E
Channel Low

Frequency (MHz)	RMS (dBm)	Bandwidth (kHz)	Polarization	Margin (dB)	Limit (dBm)	Comment
2400.00	-42.6	1000.000	V	12.6	-30.0	

Channel High

Frequency (MHz)	RMS (dBm)	Bandwidth (kHz)	Polarization	Margin (dB)	Limit (dBm)	Comment
2483.5	-44.0	1000.000	V	14.0	-30.0	

Occupied Channel Bandwidth

Standard: EN 300 328 v.1.9.1
Tested by: NKO
Date: 31.6.2016
Temperature: 21 °C
Humidity: 30 % RH
Test result: NKO

Measurement uncertainty: $\pm 2.24\text{E}+05$ Hz

Level of confidence 95 % (k = 2)

Test plan

Measurements are performed according to ETSI EN 300 328 v.1.9.1 clause 5.3.8.2.1.

The Occupied Channel Bandwidth is the bandwidth that contains 99 % of the power of the signal. The Occupied Channel Bandwidth shall fall completely within the assigned band.

In addition, for non-adaptive systems using wide band modulations other than FHSS and with E.I.R.P greater than 10 dBm, the occupied channel bandwidth shall be less than 20 MHz.

The measurements are done under normal test conditions. The transmitter is connected via the 50 Ω -power attenuator to the measuring equipment.

Test results

DUT Frequency (MHz)	Nominal Bandwidth (MHz)	Channel Center Frequency (MHz)	Occupied Channel Bandwidth (MHz)	Lower Band Edge (MHz)	Upper Band Edge (MHz)
2412.000000	20.000000	2412.000000	15.428071	2404.285964	2419.714036
2472.000000	20.000000	2471.910011	15.408074	2464.205974	2479.614048

DUT Frequency (MHz)	Limit Occupied Channel Bandwidth (MHz)	Result	Comment
2412.000000	---	PASS	Adaptive (no BW limit)
2472.000000	---	PASS	Adaptive (no BW limit)

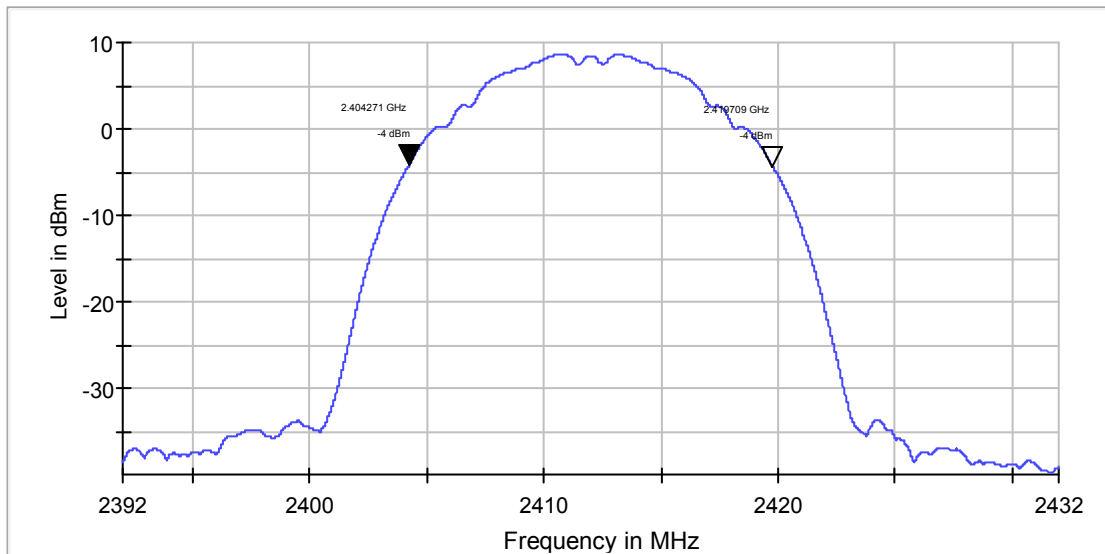


Figure 1. Occupied Channel Bandwidth Channel Low.

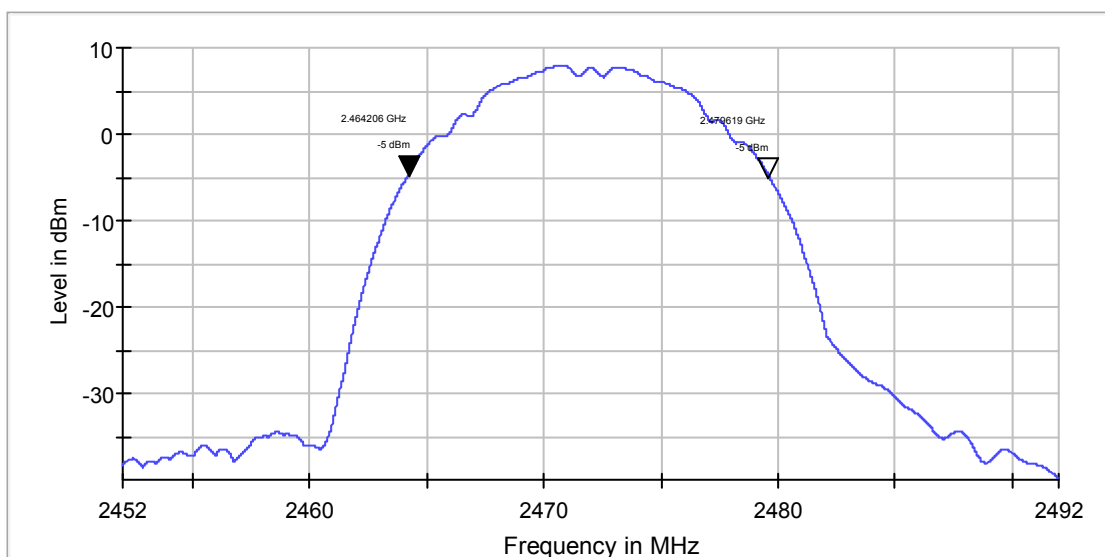


Figure 2. Occupied Channel Bandwidth Channel High.

Receiver Spurious Emissions

Standard: EN 300 328 v.1.9.1
Tested by: NKO
Date: 13.4.2016
Temperature: 22 °C
Humidity: 35 %

Test result: **PASS**

Measurement uncertainty ± 5.25dB (Level of confidence 95 % (k = 2))

Test plan

Measurements are performed according to ETSI EN 300 328 v.1.9.1 clause 5.3.11.2.2.

The receiver is connected to its integrated or dedicated antenna and oriented to its normal usage position and height on the turntable in the anechoic chamber. The measurements are made with the receiver on the receiving state. First all frequencies where a spurious emission component are detected are recorded in both measuring antenna polarization. Then each spurious frequency level is measured. The highest level of the spurious component is searched by rotating transmitter 360° with both measuring antenna polarization.

The receiver spurious emissions are measured under normal conditions.

Test will be made in lowest and highest operation frequencies.

Test results

WF111-A

Ch Low

No final measurements were made due to the low emissions level.

Ch High

No final measurements were made due to the low emissions level.

WF111-E

Ch Low

No final measurements were made due to the low emissions level.

Ch High

No final measurements were made due to the low emissions level.

Adaptivity & Receiver Blocking

Standard: EN 300 328 v.1.9.1
Tested by: EHA
Date: 5.8.2016
Temperature: 23 °C
Humidity: 60 % RH

Test result: **PASS**

Test plan

Measurements are performed according to ETSI EN 300 328 v.1.9.1 clause 5.3.7.2.1.

Adaptivity test was done in normal operation mode with WF110 module connected to Wi-Fi access point. External 45 dB attenuator was set between the EUT and peripheral receiver (on top of couplers attenuation + setup attenuation). This was sufficient to maintain link between the receiver and the EUT.

Test Results

Ch Low

Frequency (MHz)	Test Step	Max Burst Power (dBm)	COT (ms)	Limit (ms)	CCA Time (µs)	Limit (µs)	Result
2412.000000	Test Step 1	19.7	7.113	<13.000	481.000	>20.000	PASS

DUT Frequency (MHz)	Test Step	No. of Bursts	Limit	Max Burst Power (dBm)	Result	Comment
2412.000000	Test Step 2	0	0	---	PASS	
2412.000000	Test Step 3	0	0	---	PASS	

Ch High

Frequency (MHz)	Test Step	Max Burst Power (dBm)	COT (ms)	Limit (ms)	CCA Time (µs)	Limit (µs)	Result
2462.000000	Test Step 1	19.1	0.28	<13.000	44.0	>20.000	PASS

DUT Frequency (MHz)	Test Step	No. of Bursts	Limit	Max Burst Power (dBm)	Result	Comment
2462.000000	Test Step 2	0	0	---	PASS	
2462.000000	Test Step 3	0	0	---	PASS	

RF-Test Equipment

Equipment	Manufacturer	Type	Inv number	Prev Calib	Next Calib
ATTENUATOR	-	NM/F 50ohm 10dB	-	2015-08-26	2016-08-26
TURNTABLE	DEISEL	DS 430	-	-	-
MAST & TURNTABLE CONTROLLER	DEISEL	HD-100	-	-	-
ANTENNA MAST	DEISEL	MA 240	7896	-	-
ANTENNA	EMCO	3117	7293	2016-03-16	2018-03-06
PREAMPLIFIER	HEWLETT PACKARD	83017A (25 dB)	5226	2016-02-03	2017-02-03
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	-	-
EMI TEST RECEIVER	ROHDE & SCHWARZ	ESU 26	8453	2016-06-10	2017-06-10
SIGNAL ANALYZER	ROHDE & SCHWARZ	FSV40	9093	2016-06-10	2017-06-10
SWITCH UNIT	ROHDE & SCHWARZ	OSP 120	9289	2016-03-14	2019-03-14
RF SIGNAL GENERATOR	ROHDE & SCHWARZ	SMB100A	9288	2014-03-18	2017-03-18
VECTOR SIGNAL GENERATOR	ROHDE & SCHWARZ	SMBV100A	9290	2014-03-13	2017-03-17
ANTENNA	SCHWARZBECK	VULB 9168	8911	2014-11-04	2016-11-04
TEMPERATURE/ HUMIDITY METER	VAISALA	HMT 333	8638	2016-03-01	2017-03-01
HIGH PASS FILTER	WAINWRIGHT	WHKX4.0/18G-10SS	-	2016-01-22	2017-01-22