FCC Measurement/Technical Report on

Host-based multiradio module with Wi-Fi, Bluetooth and NFC

EMMY-W165

in WLAN 5 GHz mode

FCC ID: XPYEMMYW165
IC: 8595A-EMMYW165

Test Report Reference: MDE_UBLOX_1623_FCCc

Test Laboratory:
7layers GmbH
Borsigstrasse 11
40880 Ratingen
Germany

DAkkS Deutsche Akkreditierungsstelle D-PL-12140-01-01

1 APPLIED STANDARDS AND TEST SUMMARY

1.1 APPLIED STANDARDS

Type of Authorization
Certification for an Intentional Radiator (Digital Device / Spread Spectrum).

Applicable FCC Rules

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 (10-1-15 Edition) and 15 (10-1-15 Edition). The following subparts are applicable to the results in this test report.

Part 2, Subpart J - Equipment Authorization Procedures, Certification

Part 15, Subpart C – Intentional Radiators

§ 15.201 Equipment authorization requirement

§ 15.207 Conducted limits

§ 15.209 Radiated emission limits; general requirements

Part 15, Subpart E – Unlicensed National Information Infrastructure Devices

§ 15.403 Definitions

§ 15.407 General technical requirements

Note 1:
According to applicant's description:
"All product variants, EMMY-W161-A, EMMY-W163-A and EMMY-W165-A, share the same PCB design and have an identical TX/RX 5 GHz RF path, so that the re-use of test reports appears to us beneficial and applicable.
The EMMY-W161 and EMMY-W165 are very similar were the only difference is the type of band pass filter in the 2.4 GHz WLAN and Bluetooth receive/transmit RF-paths. EMMY-W161 is equipped with a BAW-type band pass filter and EMMY-W165 instead has a ceramic band pass filter. The same type of ceramic band pass filter is used on EMMY-W163 thus the 2.4 GHz WLAN receive/transmit RF-paths of EMMY-W165 are identical to EMMY-W163.
The 5 GHz WLAN receive/transmit RF-path is identical on all three variants of EMMY-W16x."

Note 2:
This report is focused on 5 GHz WLAN mode. For 5 GHz WLAN mode were only "spot checks" performed to show evidence, that EMMY-W165 has the same or improved RF-characteristic compared to EMMY-W161 (please refer to Test Report "MDE_UBLOX_1551_FCCf").

Note 3:
Following "spot checks" were selected:

- output power: per modulation group: only channel with highest output power (from EMMY-W161)
- other conducted tests: repeat tests were the margin to Limit ≤ 1 dB (from EMMY-W161)
- Simultaneous transmission

Note 4:
The tests were performed with reference to the FCC Public Notice "Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices -
Part 15, Subpart E, 789033 D02 General U-NII Test Procedures v01r03, 2016-08-22".

ANSI C63.10-2013 is applied.

FCC ET Docket No. 13-49, FIRST REPORT AND ORDER, April 1, 2014 ("new rules") is applied.

Note 5:
The stricter limits were applied from the different device types: outdoor access point / indoor access point / mobile and portable client.

Summary Test Results:

The EUT complied with all performed tests as listed in chapter 1.3 Measurement Summary / Signatures.

1.2 FCC-IC CORRELATION TABLE

Correlation of measurement requirements for UNII / LE-LAN (e.g. WLAN 5 GHz) equipment from FCC and IC

UNII equipment

Measurement	FCC reference	IC reference
Conducted emissions on AC Mains	§ 15.207	RSS-Gen Issue 4: 8.8
Occupied bandwidth	§ 15.403 (i) (26 dB) / § 15.407 (e) (6 dB)	RSS-247 Issue 1: 6.2.1 (1), 6.2.2 (1), 6.2.3 (1) (99%) RSS-247 Issue 1: 6.2.4 (1) (6 dB)
Maximum conducted output power	§ 15.407 (a) (1),(2),(3),(4)	RSS-247 Issue 1: : 6.2.1 (1), 6.2.2 (1), 6.2.3 (1), 6.2.4 (1)
Maximum power spectral density	§ 15.407 (a) (1),(2),(3),(5)	RSS-247 Issue 1: : 6.2.1 (1), 6.2.2 (1), 6.2.3 (1), 6.2.4 (1)
Transmitter undesirable emissions; General Field Strength Limits, Restricted Bands	15.407 (b) § 15.209 (a)	RSS-Gen Issue 4: 6.13/8.9/8.10; RSS-247 Issue 1: : 6.2.1 (2), 6.2.2 (2), 6.2.3 (2), 6.2.4 (2)
Frequency stability	§ 15.407 (g)	RSS-Gen Issue 4: 6.11/8.11
Transmit Power Control (TPC) and Dynamic Frequency Selection (DFS)	§ 15.407 (h)	RSS-247 Issue 1: 6.2.2 (1), 6.2.3 (1), 6.3
Antenna requirement	§ 15.203 / 15.204	RSS-Gen Issue 4: 8.3
Receiver spurious emissions	–	-

Note 1:
Industry Canada RSS-247 Issue 1
6.2.3 Frequency Bands 5470-5600 MHz and 5650-5725 MHz
Until further notice, devices subject to this section shall not be capable of transmitting in the band 5600-5650 MHz. This restriction is for the protection of Environment Canada's weather radars operating in this band.

1.3 MEASUREMENT SUMMARY / SIGNATURES

47 CFR CHAPTER I FCC PART 15 Subpart E §15.407 **FCC §15.31, §15.407 (a)(1)**

Maximum Conducted Output Power
The measurement was performed according to ANSI C63.10 **Final Result**

OP-Mode Radio Technology, Operating Frequency, Subband	Setup	FCC	IC
WLAN a, high, U-NII-1 Remark: set EUT target power 16	DE1015044 aa01	Passed	Passed
WLAN ac 20 MHz, high, U-NII-1 Remark: set EUT target power 16	DE1015044 aa01	Passed	Passed
WLAN ac 20 MHz, mid, U-NII-1 Remark: set EUT target power 16	DE1015044 aa01	Passed	Passed
WLAN ac 40 MHz, high, U-NII-1 Remark: set EUT target power 16	DE1015044 aa01	Passed	Passed
WLAN ac 80 MHz, high, U-NII-2C Remark: set EUT target power 16 (MCS0)	DE1015044 aa01	Passed	Passed
WLAN ac 80 MHz, mid, U-NII-1 Remark: set EUT target power 8	DE1015044 aa01	Passed	Passed
WLAN n 20 MHz, mid, U-NII-1 Remark: set EUT target power 16	DE1015044 aa01	Passed	Passed
WLAN n 40 MHz, high, U-NII-1 Remark: set EUT target power 16	DE1015044 aa01	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart E §15.407 **FCC §15.31, §15.407 (a)(1),(5)**

Peak Power Spectral Density
The measurement was performed according to ANSI C63.10 **Final Result**

OP-Mode Radio Technology, Operating Frequency, Subband	Setup	FCC	IC
WLAN a, high, U-NII-1 Remark: set EUT target power 16	DE1015044 aa01	Passed	Passed
WLAN a, mid, U-NII-1 Remark: set EUT target power 16	DE1015044 aa01	Passed	Passed
WLAN ac 20 MHz, high, U-NII-1 Remark: set EUT target power 16	DE1015044 aa01	Passed	Passed
WLAN ac 20 MHz, mid, U-NII-1 Remark: set EUT target power 16	DE1015044 aa01	Passed	Passed
WLAN ac 40 MHz, high, U-NII-1 Remark: set EUT target power 16	DE1015044 aa01	Passed	Passed
WLAN ac 80 MHz, high, U-NII-2C Remark: set EUT target power 16 (MCS0)	DE1015044 aa01	Passed	Passed
WLAN ac 80 MHz, mid, U-NII-1 Remark: set EUT target power 8	DE1015044 aa01	Passed	Passed
WLAN n 20 MHz, high, U-NII-1 Remark: set EUT target power 16	DE1015044 aa01	Passed	Passed
WLAN n 20 MHz, mid, U-NII-1 Remark: set EUT target power 16	DE1015044 aa01	Passed	Passed
WLAN n 40 MHz, high, U-NII-1 Remark: set EUT target power 16	DE1015044 aa01	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart E §15.407	FCC §15.407 (b), (1),(2),(3),(4); FCC §15.205, §15.209, §15.407 (b) (5),(6)

Spurious RF Conducted Emissions at Antenna Port
The measurement was performed according to ANSI C63.10 **Final Result**

OP-Mode Radio Technology, Operating Frequency, Subband	Setup	FCC	IC
WLAN n 20 MHz, additional channel, U-NII-2C Remark: MCS0	DE1015044 aa01	Passed	Passed
WLAN n 40 MHz, low, U-NII-1 Remark: MCS0	DE1015044 aa01	Passed	Passed
WLAN n 40 MHz, high, U-NII-2A Remark: MCS0	DE1015044 aa01	Passed	Passed
WLAN n 40 MHz, high, U-NII-2A Remark: MCS7	DE1015044 aa01	Passed	Passed
WLAN n 40 MHz, high, U-NII-3 Remark: MCS0	DE1015044 aa01	Passed	Passed
WLAN ac 20 MHz, high, U-NII-3 Remark: MCS0	DE1015044 aa01	Passed	Passed
WLAN ac 40 MHz, low, U-NII-1 Remark: MCS0	DE1015044 aa01	Passed	Passed
WLAN ac 40 MHz, low, U-NII-2C Remark: MCS0	DE1015044 aa01	Passed	Passed
WLAN ac 80 MHz, mid, U-NII-1 Remark: MCS0	DE1015044 aa01	Passed	Passed
WLAN ac 80 MHz, mid, U-NII-1 Remark: MCS9	DE1015044 aa01	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C §15.407	FCC §15.407 (b), (1),(2),(3),(4); FCC §15.205, §15.209, §15.407 (b) (5),(6)

Simultaneous Transmission - Spurious Radiated Emissions
The measurement was performed according to ANSI C63.10 **Final Result**

OP-Mode Active Transmitters	Setup	FCC	IC
NFC + Bluetooth BDR + WLAN 5 GHz	DE1015044 ab01	Passed	Passed

MARCO KULLIK
2016.09.27
12:22:15 +02'00'

(responsible for accreditation scope)
Mr. Marco Kullik

WOLFGANG PETER
RICHTER
2016.09.27 10:34:04
+02'00'

(responsible for testing and report)
Mr. Wolfgang Richter

1.4 REVISION HISTORY

Report version control			
Version	**Release date**	**Change Description**	**Version validity**
initial	2016-09-27	--	valid

2 ADMINISTRATIVE DATA

2.1 TESTING LABORATORY

Company Name:	7layers GmbH
Address:	Borsigstr. 11 40880 Ratingen Germany

This facility has been fully described in a report submitted to the FCC and accepted under the registration number 96716.

This facility has been fully described in a report submitted to the IC and accepted under the registration number: Site# 3699A-1.

The test facility is also accredited by the following accreditation organisation:

Laboratory accreditation no:	DAkkS D-PL-12140-01-01
Responsible for accreditation scope:	Mr. Marco Kullik
Report Template Version:	2016-06-07

2.2 PROJECT DATA

Responsible for testing and report:	Mr. Wolfgang Richter
Employees who performed the tests:	documented internally at 7Layers
Date of Report:	2016-09-27
Testing Period:	2016-08-30 to 2016-09-05

2.3 APPLICANT DATA

Company Name:	u-blox AG
Address:	Zürcherstrasse 68 8800 Thalwil Switzerland
Contact Person:	Mr. Giulio Comar

2.4 MANUFACTURER DATA

Company Name:	please see applicant data
Address:	
Contact Person:	

3 TEST OBJECT DATA

3.1 GENERAL EUT DESCRIPTION

Kind of Device product description	WLAN 2.4 GHz, 5 GHz, BT, NFC, SRD (5.8 GHz) - Single Antenna
Product name	Host-based multiradio module with Wi-Fi, Bluetooth and NFC
Type	EMMY-W165
Declared EUT data by the supplier	
Voltage Type	DC
Voltage Level	normal: 3.3 V DC low: 3.0 V DC high: 3.6 V DC
Modulation Type for WLAN 5 GHz	OFDM, HT20 MCS0 – MCS7, HT40 MCS0 –MCS7, VHT20 MCS0 – MCS8, VHT40 MCS0 –MCS9, VHT80 MCS0 –MCS9 please see each test protocol
General product description	EMMY-W161, EMMY-W163 and EMMY-W165 are ultra-compact multi-radio modules providing Wi-Fi, Classic Bluetooth, Bluetooth low energy and NFC mode of operation. It is designed for both simultaneous and independent operations of: • Wi-Fi IEEE 802.11ac and a/b/g/n • Dual-mode Bluetooth 4.2 • NFC
Specific product description for the EUT	EMMY-W165: Shielded module, single antenna pin for WLAN 802.11 ac/a/b/g/n and Bluetooth communication
The EUT provides the following ports:	- DC power supply - antenna port - signal ports
Data rates	WLAN a: please see chapter "WLAN Power Table" WLAN n 20 MHz: please see chapter "WLAN Power Table" WLAN n 40 MHz: please see chapter "WLAN Power Table" WLAN ac 20: please see chapter "WLAN Power Table" WLAN ac 40: please see chapter "WLAN Power Table" WLAN ac 80: please see chapter "WLAN Power Table"
Access point use	Indoor or outdoor
Device type	Master or client, mobile and portable client
Special software used for testing	Special software used to setup EUT for testing: u-blox Labtool

The main components of the EUT are listed and described in chapter 3.2 EUT Main components.

3.2 EUT MAIN COMPONENTS

Sample Name	Sample Code	Description
DE1015044aa01	aa01	"#1" Conducted Sample
Sample Parameter	**Value**	
Antenna	Antenna connector on evaluation board (target platform): The following antennas are designated for 2.4 and 5 GHz WLAN, as well as Bluetooth transmission on EMMY-W165. - Table 2 of Test Object Specification:	

				Peak gain [dBi]	
#	Manufacturer	Part number	Antenna type	2.4 GHz band	5 GHz band
W1	Antenova	A10194 [1]	SMD chip antenna 10x10x0.9 [mm]	1.8	4.1
W2	Linx	ANT-DB1-RAF-RPS [4]	Dual-band dipole antenna	2.5	**4.6**
W3	Taoglas	GW.40.2153	Dual-band dipole antenna	**3.74**	2.5
W4	Taoglas	GW.59.3153 [5]	Dual-band dipole antenna	2.37	2.93
W5	Walsin	RFDPA870900SBLB8G1	Dual-band dipole antenna	2	3
W6	Linx	ANT-2.4-CW-RCT-RP [3]	Single-band dipole antenna	2.2	N/A
W7	Delock	88395 [6]	Dual-band dipole antenna	1.5	2.1

Serial No.	-
HW Version	03
SW Version	N/A
Comment	-

Sample Name	Sample Code	Description
DE1015044ab01	ab01	"#2" Radiated Sample
Sample Parameter	**Value**	
Integral Antenna	Antenna on evaluation board (target platform): Antenova, Type A10194, SMD chip antenna, 1.8 dBi Peak gain in 2.4 GHz band, 4.1 dBi Peak gain in 5 GHz band	
Serial No.	-	
HW Version	03	
SW Version	N/A	
Comment	-	

3.3 WLAN POWER TABLE

Declared Power limits vs channel for FCC, U-NII-1 & 2A, 20 MHz BW

Modulation group	WLAN TX Power in dBm at frequency in MHz							
	5180	5200	5220	5240	5260	5280	5300	5320
OFDM 6, 9, 12, 18 Mbps	13	16	16	16	16	16	16	13
OFDM 24, 36 Mbps	13	16	16	16	16	16	16	13
OFDM 48, 54 Mbps	13	13	13	13	13	13	13	13
HT20 MCS0, MCS1, MCS2	13	16	16	16	16	16	16	13
HT20 MCS3, MCS4	13	16	16	16	16	16	16	13
HT20 MCS5, MCS6, MCS7	13	13	13	13	13	13	13	13
VHT20 MCS0, MCS1, MCS2	13	16	16	16	16	16	16	13
VHT20 MCS3, MCS4	13	16	16	16	16	16	16	13
VHT20 MCS5, MCS6, MCS7	13	13	13	13	13	13	13	13
VHT20 MCS8	13	13	13	13	13	13	13	13

Declared Power limits vs channel for FCC, U-NII-1 & 2A, 40 MHz BW

Modulation group	WLAN TX Power in dBm at frequency in MHz			
	5190	5230	5270	5310
HT40 MCS0, MCS1, MCS2	12	16	16	12
HT40 MCS3, MCS4	12	16	16	12
HT40 MCS5, MCS6, MCS7	12	12	12	12
VHT40 MCS0, MCS1, MCS2	12	16	16	12
VHT40 MCS3, MCS4	12	16	16	12
VHT40 MCS5, MCS6, MCS7	12	12	12	12
VHT40 MCS8, MCS9	10	10	10	10

Declared Power limits vs channel for FCC, U-NII-1 & 2A, 80 MHz BW

Modulation group	WLAN TX Power in dBm at frequency in MHz	
	5210	5290
VHT80 MCS0, MCS1, MCS2	8	8
VHT80 MCS3, MCS4	8	8
VHT80 MCS5, MCS6, MCS7	8	8
VHT80 MCS8, MCS9	8	8

Declared Power limits vs channel for FCC, U-NII-2C, 20 MHz BW

Modulation group	WLAN TX Power in dBm at frequency in MHz											
	5500	5520	5540	5560	5580	5600	5620	5640	5660	5680	5700	5720
OFDM 6, 9, 12, 18 Mbps	13	16	16	16	16	16	16	16	16	16	13	-
OFDM 24, 36 Mbps	13	16	16	16	16	16	16	16	16	16	13	-
OFDM 48, 54 Mbps	13	13	13	13	13	13	13	13	13	13	13	-
HT20 MCS0, MCS1, MCS2	13	16	16	16	16	16	16	16	16	16	13	-
HT20 MCS3, MCS4	13	16	16	16	16	16	16	16	16	16	13	-
HT20 MCS5, MCS6, MCS7	13	13	13	13	13	13	13	13	13	13	13	-
VHT20 MCS0, MCS1, MCS2	13	16	16	16	16	16	16	16	16	16	16	16
VHT20 MCS3, MCS4	13	16	16	16	16	16	16	16	16	16	16	16
VHT20 MCS5, MCS6, MCS7	13	13	13	13	13	13	13	13	13	13	13	13
VHT20 MCS8	13	13	13	13	13	13	13	13	13	13	13	13

Declared Power limits vs channel for FCC, U-NII-2C, 40 MHz BW

Modulation group	WLAN TX Power in dBm at frequency in MHz					
	5510	5550	5590	5630	5670	5710
HT40 MCS0, MCS1, MCS2	12	16	16	16	12	-
HT40 MCS3, MCS4	12	16	16	16	12	-
HT40 MCS5, MCS6, MCS7	12	12	12	12	12	-
VHT40 MCS0, MCS1, MCS2	12	16	16	16	16	16
VHT40 MCS3, MCS4	12	16	16	16	16	16
VHT40 MCS5, MCS6, MCS7	12	12	12	12	12	12
VHT40 MCS8, MCS9	10	10	10	10	10	10

Declared Power limits vs channel for FCC, U-NII-2C, 80 MHz BW

Modulation group	WLAN TX Power in dBm at frequency in MHz		
	5530	5610	5690
VHT80 MCS0, MCS1, MCS2	8	12	16
VHT80 MCS3, MCS4	8	13	13
VHT80 MCS5, MCS6, MCS7	8	10	10
VHT80 MCS8, MCS9	8	8	8

Note 1:
Industry Canada RSS-247 Issue 1
6.2.3 Frequency Bands 5470-5600 MHz and 5650-5725 MHz
Until further notice, devices subject to this section shall not be capable of transmitting in the band 5600-5650 MHz.
This restriction is for the protection of Environment Canada's weather radars operating in this band.

Declared Power limits vs channel for FCC, U-NII-3, 20 MHz BW

Modulation group	WLAN TX Power in dBm at frequency in MHz				
	5745	5765	5785	5805	5825
OFDM 6, 9, 12, 18 Mbps	14	16	16	16	14
OFDM 24, 36 Mbps	14	16	16	16	14
OFDM 48, 54 Mbps	13	13	13	13	13
HT20 MCS0, MCS1, MCS2	13	16	16	16	13
HT20 MCS3, MCS4	13	16	16	16	13
HT20 MCS5, MCS6, MCS7	13	13	13	13	13
VHT20 MCS0, MCS1, MCS2	13	16	16	16	16
VHT20 MCS3, MCS4	13	16	16	16	16
VHT20 MCS5, MCS6, MCS7	13	13	13	13	13
VHT20 MCS8	13	13	13	13	13

Declared Power limits vs channel for FCC, U-NII-3, 40 MHz BW

Modulation group	WLAN TX Power in dBm at frequency in MHz		
	5755	5795	
HT40 MCS0, MCS1, MCS2	12	16	
HT40 MCS3, MCS4	12	16	
HT40 MCS5, MCS6, MCS7	12	12	
VHT40 MCS0, MCS1, MCS2	12	12	
VHT40 MCS3, MCS4	12	12	
VHT40 MCS5, MCS6, MCS7	12	12	
VHT40 MCS8, MCS9	12	12	

Declared Power limits vs channel for FCC, U-NII-3, 80 MHz BW

Modulation group	WLAN TX Power in dBm at frequency in MHz	
	5775	
VHT80 MCS0, MCS1, MCS2	8	
VHT80 MCS3, MCS4	8	
VHT80 MCS5, MCS6, MCS7	8	
VHT80 MCS8, MCS9	8	

3.4 ANCILLARY EQUIPMENT

For the purposes of this test report, ancillary equipment is defined as equipment which is used in conjunction with the EUT to provide operational and control features to the EUT. It is necessary to configure the system in a typical fashion, as a customer would normally use it. But nevertheless Ancillary Equipment can influence the test results.

Device	**Details (Manufacturer, Type Model, OUT Code)**	**Description**
Evaluation board	u-blox , EVB-W16, -	Target platform

3.5 AUXILIARY EQUIPMENT

For the purposes of this test report, auxiliary equipment is defined as equipment which is used temporarily to enable operational and control features especially used for the tests of the EUT which is not used during normal operation or equipment that is used during the tests in combination with the EUT but is not subject of this test report. It is necessary to configure the system in a typical fashion, as a customer would normally use it.
But nevertheless Auxiliary Equipment can influence the test results.

Device	**Details (Manufacturer, HW, SW, S/N)**	**Description**
AC/DC power supply (115 V 60 Hz)	PeakTech, -, -, 081062045	PeakTech 6005D

3.6 EUT SETUPS

This chapter describes the combination of EUTs and equipment used for testing. The rationale for selecting the EUTs, ancillary and auxiliary equipment and interconnecting cables, is to test a representative configuration meeting the requirements of the referenced standards.

Setup	Combination of EUTs	Description and Rationale
DE1015044aa01	DE1015044aa01, evaluation board, AC/DC power supply	Setup for conducted measurement
DE1015044ab01	DE1015044ab01, evaluation board, AC/DC power supply	Setup for radiated measurement

3.7 OPERATING MODES

This chapter describes the operating modes of the EUTs used for testing.

3.7.1TEST CHANNELS

a-mode, n-mode

U-NII-Subband 1 5150 - 5250 MHz			U-NII-Subband 2A 5250 - 5350 MHz			U-NII-Subband 2C 5470 - 5725 MHz			U-NII-Subband 3 5725 - 5850 MHz			Nom. BW
low	mid	high	low	mid	high	low	mid	high	low	mid	high	20 MHz
36	44	48	52	56	64	100	116	140	149	157	165	Ch.-No.
5180	5220	5240	5260	5280	5320	5500	5580	5700	5745	5785	5825	MHz
low	mid	high	low	mid	high	low	mid	high	low	mid	high	40 MHz
38	N/A	46	54	N/A	62	102	110	134	151	N/A	159	Ch.-No.
5190	N/A	5230	5270	N/A	5310	5510	5550	5670	5755	N/A	5795	MHz

ac-mode

U-NII-Subband 1 5150 - 5250 MHz			U-NII-Subband 2A 5250 - 5350 MHz			U-NII-Subband 2C 5470 - 5725 MHz			U-NII-Subband 3 5725 - 5850 MHz			Nom. BW
low	mid	high	low	mid	high	low	mid	high	low	mid	high	20 MHz
36	44	48	52	56	64	100	116	144	149	157	165	Ch.-No.
5180	5220	5240	5260	5280	5320	5500	5580	5720	5745	5785	5825	MHz
low	mid	high	low	mid	high	low	mid	high	low	mid	high	40 MHz
38	N/A	46	54	N/A	62	102	110	142	151	N/A	159	Ch.-No.
5190	N/A	5230	5270	N/A	5310	5510	5550	5710	5755	N/A	5795	MHz
low	mid	high	low	mid	high	low	mid	high	low	mid	high	80 MHz
N/A	42	N/A	N/A	58	N/A	106	122	138	155	N/A	N/A	Ch.-No.
N/A	5210	N/A	N/A	5290	N/A	5530	5610	5690	5775	N/A	N/A	MHz

In case of testing another channel, the measurement summary state "additional channel" and the channel or centre frequency of the operating frequency is stated in the test protocol.

3.7.2TEST MODULATIONS

If not stated in the test protocols following operating modes are used:

WLAN a-Mode; 20 MHz; 6 Mbit/s; 100 % duty cycle
WLAN n-Mode; 20 MHz; 6,5 Mbit/s MCS0; 100 % duty cycle
WLAN n-Mode; 40 MHz;13,5 Mbit/s MCS0; 100 % duty cycle
WLAN ac-Mode; 20 MHz; 6,5 Mbit/s MCS0; 100 % duty cycle
WLAN ac-Mode; 40 MHz; 13,5Mbit/s MCS0; 100 % duty cycle
WLAN ac-Mode; 80 MHz; 433 Mbit/s MCS9; 100 % duty cycle

3.8 PRODUCT LABELLING

3.8.1FCC ID LABEL

Please refer to the documentation of the applicant.

3.8.2LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.

4 TEST RESULTS

4.1 MAXIMUM CONDUCTED OUTPUT POWER

Standard **FCC Part 15 Subpart E**

The test was performed according to:
ANSI C63.10

4.1.1TEST DESCRIPTION

The Equipment Under Test (EUT) was set up to perform the output power measurements. The results recorded were measured with the modulation which produces the worst-case (highest) output power. The reference level of the spectrum analyzer was set higher than the output power of the EUT.

The EUT was connected to the spectrum analyzer via a short coax cable with a known loss.

Analyzer settings:

- Resolution Bandwidth (RBW): 1 MHz
- Video Bandwidth (VBW): 3 MHz
- Trace: Average, RMS power averaging mode
- Sweeps: 1000
- Sweep time: 20 ms (coupled)
- Detector: RMS
- Trigger: free run (100 % duty cycle)

The channel power function of the spectrum analyser was used (Used channel bandwidth = nominal bandwidth)

Note:
The analyser settings are according FCC Public Note "Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices - Part 15, Subpart E, 789033 D02", method **SA-1**.

4.1.2TEST REQUIREMENTS / LIMITS

A) FCC
For systems using digital modulation techniques in the 5.15 – 5.25 GHz bands:
§15.407 (a) (1) (i): Outdoor access point:
Limit: 1 W (30 dBm) provided the maximum antenna gain does not exceed 6 dBi.
The maximum e.i.r.p. at any elevation angle above 30 degrees as measured from the horizon must not exceed 125 mW (21 dBm).
§15.407 (a) (1) (ii): Indoor access point:
Limit: 1 W (30 dBm) provided the maximum antenna gain does not exceed 6 dBi.
§15.407 (a) (1) (iv): Mobile and portable client devices:
Limit: 250 mW (24 dBm) provided the maximum antenna gain does not exceed 6 dBi.

For systems using digital modulation techniques in the 5.25 – 5.35 GHz and 5.47 – 5.725 GHz bands:
§15.407 (a) (2)
Limit: 250 mW (24 dBm) or 11 dBm + 10 log (26 dB bandwidth/MHz) whatever is the lesser.

For systems using digital modulation techniques in the 5.725 – 5.850 GHz bands:
§15.407 (a) (3)
Limit: 1 W (30 dBm) or 17 dBm + 10 log (26 dB bandwidth/MHz) whatever is the lesser.
FCC ET Docket No. 13-49, FIRST REPORT AND ORDER, April 1, 2014 ("new rules"):
§15.407 (a) (3):
Limit: 1 W (30 dBm).

§15.407 (a) (4):
The maximum conducted output power must be measured over any interval of continuous transmission using instrumentation calibrated in terms of an rms-equivalent voltage.

B) IC
Different frequency bands and limits apply, as compared to the FCC requirements.

RSS-247, 6.2.1 (1), Band 5150-5250 MHz, indoor operation only:
Limit (e.i.r.p.): 200 mW (23 dBm) or 10 + 10 log10 B [dBm], whichever power is less.
B is the 99% emission bandwidth in MHz.

RSS-247, 6.2.2 (1), Band 5250-5350 MHz:
Limits:
Maximum conducted Power: 250 mW (24 dBm) or 11 + 10 log10 B [dBm], whichever power is less.
e.i.r.p.: 1.0 W (30 dBm) or 17 + 10 log10 B [dBm], whichever power is less.

Note: For EUTs operating at a higher e.i.r.p. than 200 mW (23 dBm), compliance with the e.i.r.p. elevation mask is required.

RSS-247, 6.2.3 (1), Bands 5470-5600 MHz and 5650-5725 MHz:
Limits:
Maximum conducted Power: 250 mW (24 dBm) or 11 + 10 log10 B [dBm], whichever power is less.
e.i.r.p.: 1.0 W (30 dBm) or 17 + 10 log10 B [dBm], whichever power is less.

RSS-247, 6.2.4 (1), Band 5725-5825 MHz:
Limits:
Maximum conducted Power: 1W (30 dBm) or 17 + 10 log10 B [dBm], whichever power is less.
e.i.r.p.: 4.0 W (36 dBm) or 23 + 10 log10 B [dBm], whichever power is less.

All frequency bands: B is the 99% emission bandwidth in MHz.

4.1.3TEST PROTOCOL

Ambient temperature: 24 °C
Air Pressure: 1015 hPa
Humidity: 38 %

WLAN a-Mode; 20 MHz; 6 Mbit/s

U-NII-Subband	Ch. No.	Freq. [MHz]	Cond. Power [dBm]	EIRP [dBm]	Cond. Limit FCC [dBm]	Margin [dB]	Cond. Limit IC [dBm]	Margin [dB]	EIRP Limit IC [dBm]	Margin [dB]	
1	36,0	5180,0			24,0		N/A	N/A	22,4		1)
	44,0	5220,0			24,0		N/A	N/A	22,4		1)
	48,0	5240,0	16,1	20,7	24,0	7,9	N/A	N/A	22,4	**1,7**	1)
2A	52,0	5260,0			24,0		23,4		29,4		1)
	56,0	5280,0			24,0		23,4		29,4		1)
	64,0	5320,0			24,0		23,3		29,3		1)
2C	100,0	5500,0			24,0		23,3		29,3		
	116,0	5580,0			24,0		23,3		29,3		
	140,0	5700,0			24,0		23,3		29,3		
3	149,0	5745,0			30,0		29,4		36,0		
	157,0	5785,0			30,0		29,3		36,0		
	165,0	5825,0			30,0		29,3		36,0		

WLAN n-Mode; 20 MHz; 6,5 Mbit/s MCS0

U-NII-Subband	Ch. No.	Freq. [MHz]	Cond. Power [dBm]	EIRP [dBm]	Cond. Limit FCC [dBm]	Margin [dB]	Cond. Limit IC [dBm]	Margin [dB]	EIRP Limit IC [dBm]	Margin [dB]	
1	36,0	5180,0			24,0		N/A	N/A	22,6		1)
	44,0	5220,0	16,4	21,0	24,0	7,6	N/A	N/A	22,6	**1,6**	1)
	48,0	5240,0			24,0		N/A	N/A	22,6		1)
2A	52,0	5260,0			24,0		23,6		29,6		1)
	56,0	5280,0			24,0		23,6		29,6		1)
	64,0	5320,0			24,0		23,5		29,5		1)
2C	100,0	5500,0			24,0		23,5		29,5		
	116,0	5580,0			24,0		23,6		29,6		
	140,0	5700,0			24,0		23,6		29,6		
3	149,0	5745,0			30,0		29,6		36,0		
	157,0	5785,0			30,0		29,5		36,0		
	165,0	5825,0			30,0		29,5		36,0		

WLAN n-Mode; 40 MHz;13,5 Mbit/s MCS0

U-NII-Subband	Ch. No.	Freq. [MHz]	Cond. Power [dBm]	EIRP [dBm]	Cond. Limit FCC [dBm]	Margin [dB]	Cond. Limit IC [dBm]	Margin [dB]	EIRP Limit IC [dBm]	Margin [dB]	
1	38,0	5190,0			24,0		N/A	N/A	23,0		1)
	46,0	5230,0	16,7	21,3	24,0	7,3	N/A	N/A	23,0	**1,7**	1)
2A	54,0	5270,0			24,0		24,0		30,0		1)
	62,0	5310,0			24,0		24,0		30,0		1)
2C	102,0	5510,0			24,0		24,0		30,0		
	110,0	5550,0			24,0		24,0		30,0		
	138,0	5670,0			24,0		24,0		30,0		
3	151,0	5755,0			30,0		30,0		36,0		
	159,0	5795,0			30,0		30,0		36,0		

Remark: 1) = no additional limit applies related to the elevation.
Remark: 2) only spot checks performed

Ambient temperature: 24 °C
Air Pressure: 1015 hPa
Humidity: 38 %

WLAN ac-Mode; 20 MHz; 6,5 Mbit/s MCS0

U-NII-Subband	Ch. No.	Freq. [MHz]	Cond. Power [dBm]	EIRP [dBm]	Cond. Limit FCC [dBm]	Margin [dB]	Cond. Limit IC [dBm]	Margin [dB]	EIRP Limit IC [dBm]	Margin [dB]	
1	36,0	5180,0			24,0		N/A	N/A	22,6		1)
	44,0	5220,0	16,3	20,9	24,0	7,7	N/A	N/A	22,6	**1,7**	1)
	48,0	5240,0	16,2	20,8	24,0	7,8	N/A	N/A	22,6	1,8	1)
2A	52,0	5260,0			24,0		23,6		29,6		1)
	56,0	5280,0			24,0		23,6		29,6		1)
	64,0	5320,0			24,0		23,6		29,5		1)
2C	100,0	5500,0			24,0		23,5		29,5		
	116,0	5580,0			24,0		23,5		29,5		
	140,0	5700,0			24,0		23,5		29,6		
3	149,0	5745,0			30,0		29,6		36,0		
	157,0	5785,0			30,0		29,5		36,0		
	165,0	5825,0			30,0		29,5		36,0		

WLAN ac-Mode; 40 MHz; 13,5 Mbit/s MCS0

U-NII-Subband	Ch. No.	Freq. [MHz]	Cond. Power [dBm]	EIRP [dBm]	Cond. Limit FCC [dBm]	Margin [dB]	Cond. Limit IC [dBm]	Margin [dB]	EIRP Limit IC [dBm]	Margin [dB]	
1	38,0	5190,0			24,0		N/A	N/A	23,0		1)
	46,0	5230,0	16,7	21,3	24,0	7,3	N/A	N/A	23,0	**1,7**	1)
2A	54,0	5270,0			24,0		24,0		30,0		1)
	62,0	5310,0			24,0		24,0		30,0		1)
2C	102,0	5510,0			24,0		24,0		30,0		
	110,0	5550,0			24,0		24,0		30,0		
	138,0	5670,0			24,0		24,0		30,0		
3	151,0	5755,0			30,0		30,0		36,0		
	159,0	5795,0			30,0		30,0		36,0		

WLAN ac-Mode; 80 MHz; 433 Mbit/s MCS9

U-NII-Subband	Ch. No.	Freq. [MHz]	Cond. Power [dBm]	EIRP [dBm]	Cond. Limit FCC [dBm]	Margin [dB]	Cond. Limit IC [dBm]	Margin [dB]	EIRP Limit IC [dBm]	Margin [dB]	1)
1	42,0	5210,0	8,3	12,5	24,0	15,7	N/A	N/A	23,0	**10,1**	1)
2A	58,0	5290,0			24,0		24,0		30,0		1)
2C	106,0	5530,0			24,0		24,0		30,0		
	122,0	5610,0			24,0		24,0		30,0		
	138,0	5690,0			24,0		24,0		30,0		
3	155,0	5775,0			30,0		30,0		36,0		

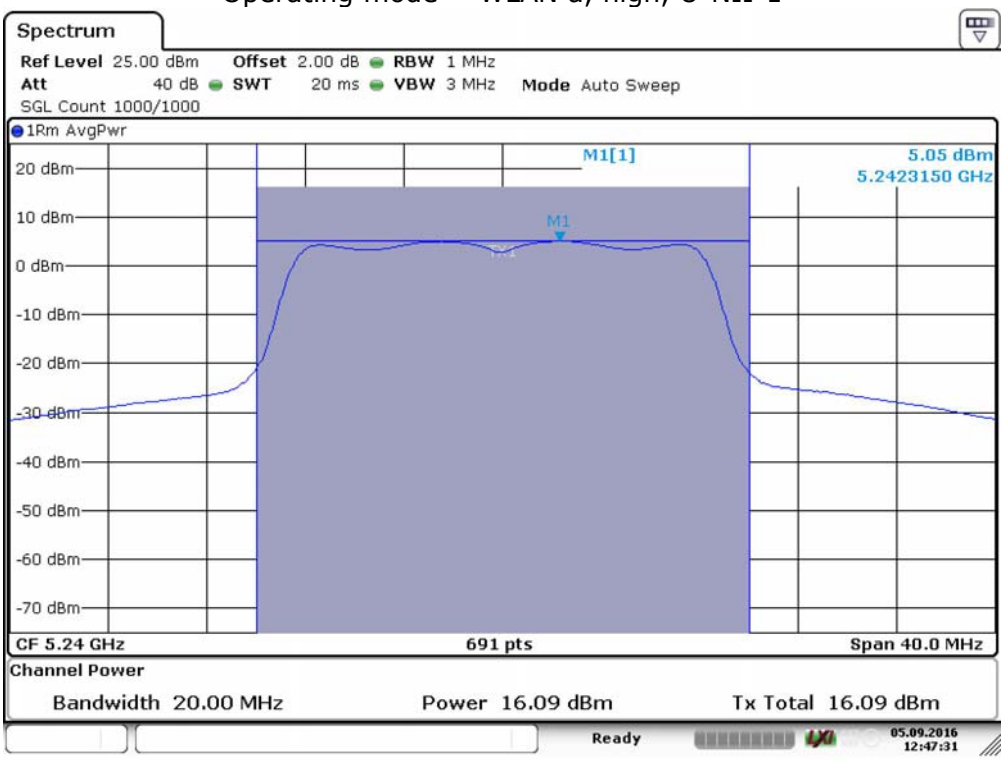
WLAN ac-Mode; 80 MHz; 433 Mbit/s MCS0

U-NII-Subband	Ch. No.	Freq. [MHz]	Cond. Power [dBm]	EIRP [dBm]	Cond. Limit FCC [dBm]	Margin [dB]	Cond. Limit IC [dBm]	Margin [dB]	EIRP Limit IC [dBm]	Margin [dB]	1)
2C	138,0	5690,0	13,6	18,2	24,0	10,4	24,0	10,4	30,0	**11,8**	

Remark: 1) = no additional limit applies related to the elevation.
Remark: 2) only spot checks performed

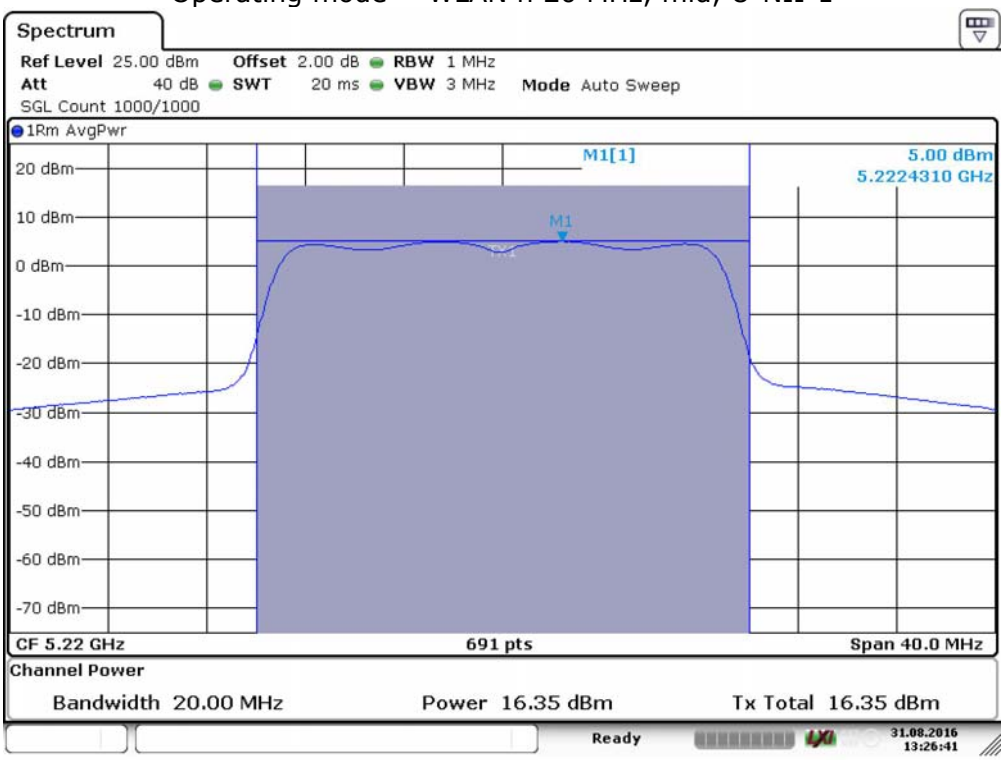
4.1.4MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

Operating mode = WLAN a, high, U-NII-1



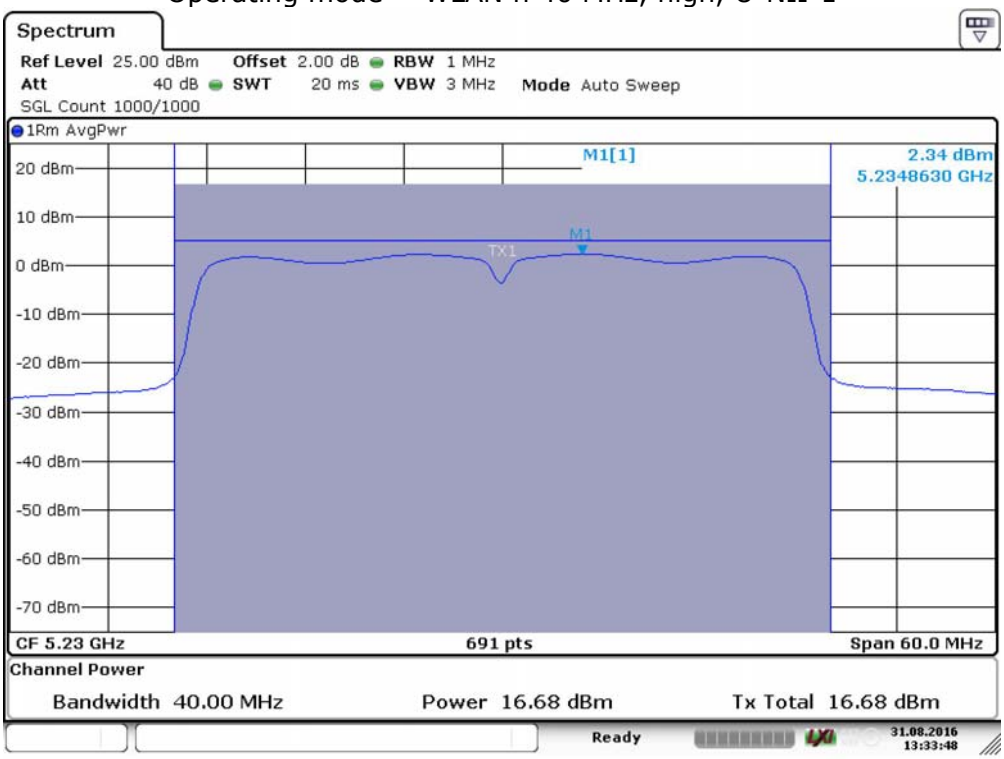
Date: 5.SEP.2016 12:47:32

Operating mode = WLAN n 20 MHz, mid, U-NII-1



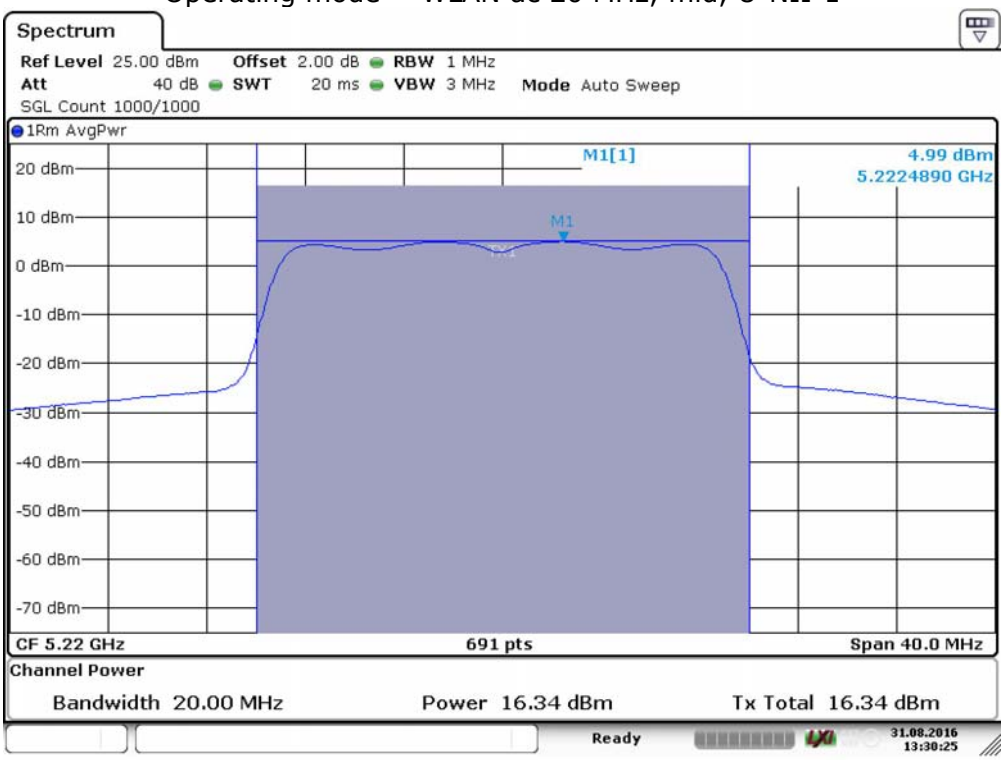
Date: 31.AUG.2016 13:26:42

Operating mode = WLAN n 40 MHz, high, U-NII-1



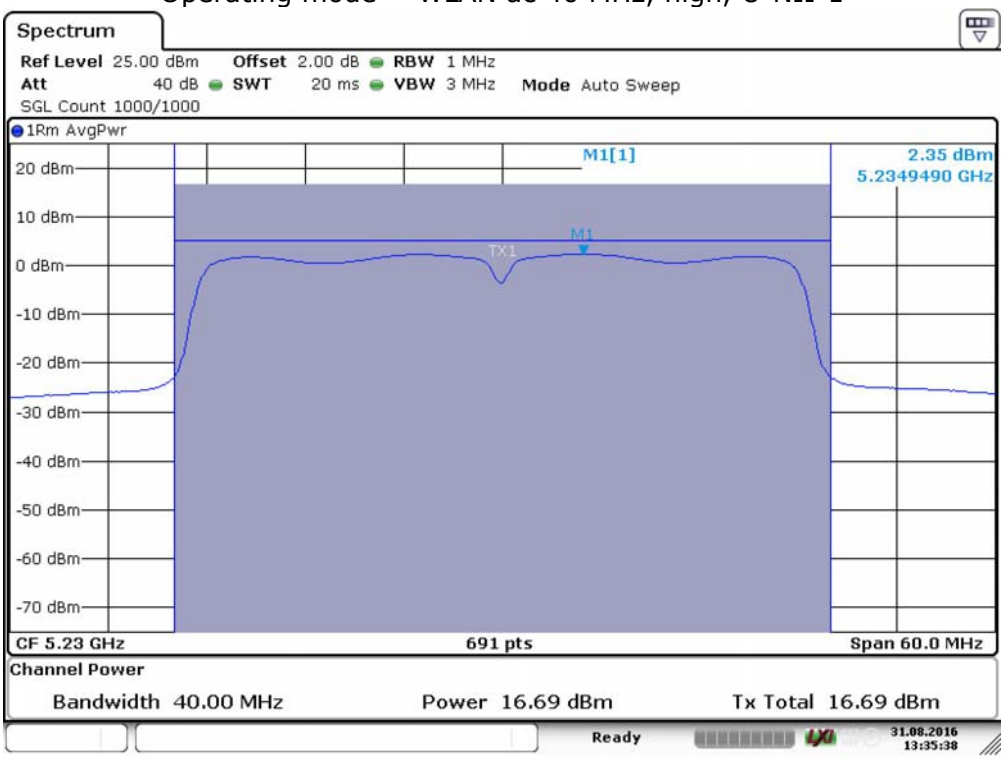
Date: 31.AUG.2016 13:33:49

Operating mode = WLAN ac 20 MHz, mid, U-NII-1



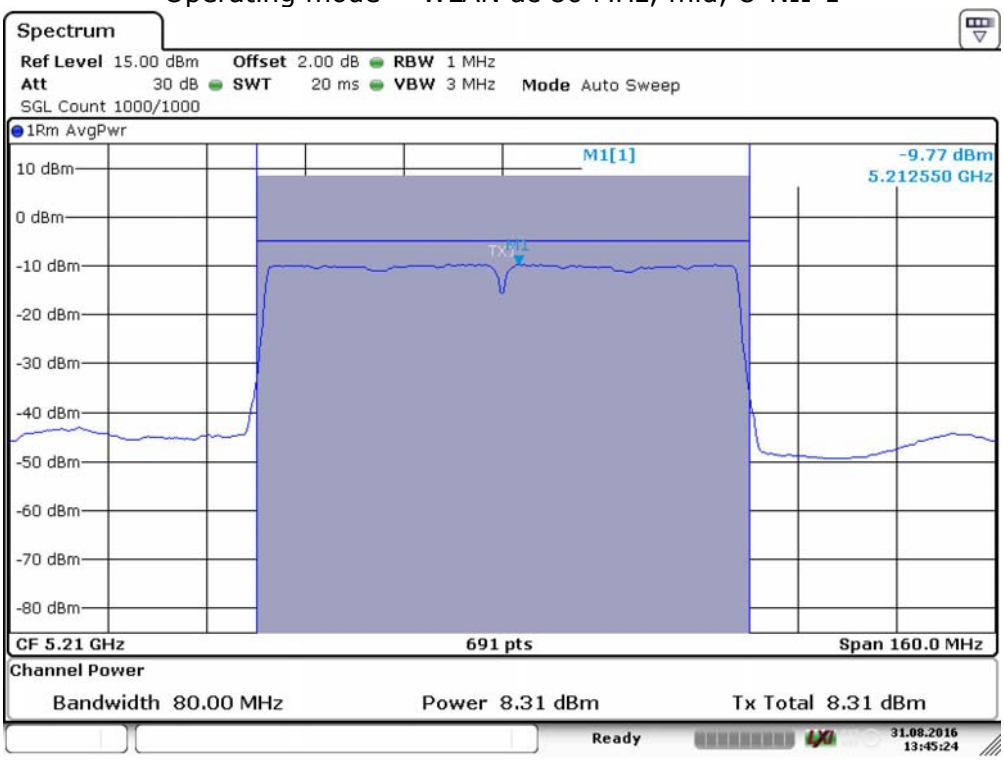
Date: 31.AUG.2016 13:30:26

Operating mode = WLAN ac 40 MHz, high, U-NII-1



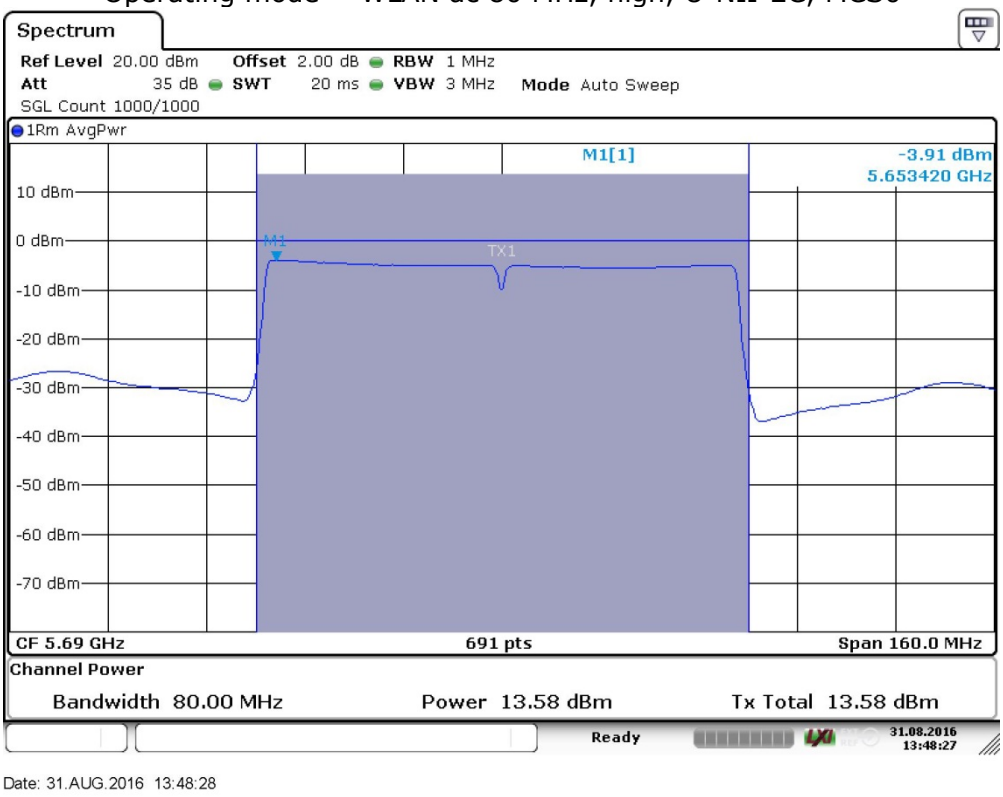
Date: 31.AUG.2016 13:35:38

Operating mode = WLAN ac 80 MHz, mid, U-NII-1



Date: 31.AUG.2016 13:45:25

Operating mode = WLAN ac 80 MHz, high, U-NII-2C, MCS0



Date: 31.AUG.2016 13:48:28

4.1.5TEST EQUIPMENT USED

R&S TS8997

4.2 PEAK POWER SPECTRAL DENSITY

Standard **FCC Part 15 Subpart E**

The test was performed according to:
ANSI C63.10

4.2.1TEST DESCRIPTION

The Equipment Under Test (EUT) was set up in a shielded room to perform the Maximum Power Spectral Density measurements.
The results recorded were measured with the modulation which produces the worst-case (highest) output power.

The EUT was connected to the spectrum analyzer via a short coax cable with a known loss.

Analyzer settings:

- Resolution Bandwidth (RBW): 1 MHz
- Video Bandwidth (VBW): 3 MHz
- Trace: Average, RMS power averaging mode
- Sweeps: 1000
- Sweeptime: 20 ms
- Detector: RMS
- Trigger: free run (100 % duty cycle)

Note:
The analyser settings are according FCC Public Note "Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices - Part 15, Subpart E, 789033 D02", method **SA-1**.

4.2.2TEST REQUIREMENTS / LIMITS

A) FCC
FCC Part 15, Subpart E, §15.407 (a) (1)
For systems using digital modulation techniques in the 5.15 – 5.25 GHz bands:
(i) and (ii), outdoor and indoor access points: Limit: 17 dBm/MHz.
(iv), mobile and portable client devices: Limit: 11 dBm/MHz.

FCC Part 15, Subpart E, §15.407 (a) (2)
For systems using digital modulation techniques in the 5.25 – 5.35 GHz and 5.47 – 5.725 GHz bands:
Limit: 11 dBm/MHz.

FCC Part 15, Subpart E, §15.407 (a) (3)
For systems using digital modulation techniques in the 5.725 – 5.850 GHz bands:
Limit: 30 dBm/500 kHz.

Note: The limit will be also fulfilled when measuring at any bandwidth greater than 500 kHz. This applies to signals where the maximum conducted output power was measured at a bandwidth exceeding 500 kHz and which fulfil that limit of 30 dBm.

B) IC
Different frequency bands and limits apply, as compared to the FCC requirements.

RSS-247, 6.2.1 (1), Band 5150-5250 MHz, indoor operation only:
Limit (e.i.r.p.): 10 dBm/MHz.

RSS-247, 6.2.2 (1), Band 5250-5350 MHz:
Limit: 11 dBm/MHz.

RSS-247, 6.2.3 (1), Bands 5470-5600 MHz and 5650-5725 MHz:
Limit: 11 dBm/MHz.

RSS-247, 6.2.4 (1), Band 5725-5850 MHz:
Limit: 30 dBm/500 kHz.

4.2.3TEST PROTOCOL

Ambient temperature: 32 °C
Air Pressure: 1010 hPa
Humidity: 40 %
WLAN a-Mode; 20 MHz; 6 Mbit/s

U-NII-Subband	Ch. No.	Freq. [MHz]	MPSD [dBm/MHz]	FCC Limit [dBm/MHz]	Margin [dB]	IC Limit [dBm/MHz]	Margin [dB]	IC EIRP MPSD
1,0	36,0	5180,0		17,0		10,0		
	44,0	5220,0	5,2	17,0	11,8	10,0	**0,2**	9,8
	48,0	5240,0	5,1	17,0	11,5	10,0	0,3	9,7
2A	52,0	5260,0		11,0		11,0		unit:
	56,0	5280,0		11,0		11,0		dBm/
	64,0	5320,0		11,0		11,0		MHz
2C	100,0	5500,0		11,0		11,0		
	116,0	5580,0		11,0		11,0		
	140,0	5700,0		11,0		11,0		
3,0	149,0	5745,0		30,0		17,0		
	157,0	5785,0		30,0		17,0		
	165,0	5825,0		30,0		17,0		

WLAN n-Mode; 20 MHz; 6,5 Mbit/s MCS0

U-NII-Subband	Ch. No.	Freq. [MHz]	MPSD [dBm/MHz]	FCC Limit [dBm/MHz]	Margin [dB]	FCC Limit [dBm/MHz]	Margin [dB]	IC EIRP MPSD
1,0	36,0	5180,0		17,0		10,0		
	44,0	5220,0	5,0	17,0	12,0	10,0	0,4	9,6
	48,0	5240,0	5,1	17,0	11,9	10,0	**0,3**	9,7
2A	52,0	5260,0		11,0		11,0		unit:
	56,0	5280,0		11,0		11,0		dBm/
	64,0	5320,0		11,0		11,0		MHz
2C	100,0	5500,0		11,0		11,0		
	116,0	5580,0		11,0		11,0		
	140,0	5700,0		11,0		11,0		
3,0	149,0	5745,0		30,0		17,0		
	157,0	5785,0		30,0		17,0		
	165,0	5825,0		30,0		17,0		

Remarks:
1) The stricter FC-limit (11 dBm/MHz) in U-NII-1 band for mobile and portable client devices is also passed.
2) only spot checks
3) Please see next sub-clause for the measurement plot.

WLAN n-Mode; 40 MHz;13,5 Mbit/s MCS0

U-NII-Subband	Ch. No.	Freq. [MHz]	MPSD [dBm/MHz]	FCC Limit [dBm/MHz]	Margin [dB]	FCC Limit [dBm/MHz]	Margin [dB]	IC EIRP MPSD
1,0	38,0	5190,0		17,0		10,0		
	46,0	5230,0	2,3	17,0	14,7	10,0	**3,1**	6,9
2A	54,0	5270,0		11,0		11,0		unit:
	62,0	5310,0		11,0		11,0		dBm/
2C	102,0	5510,0		11,0		11,0		MHz
	110,0	5550,0		11,0		11,0		
	138,0	5670,0		11,0		11,0		
3,0	151,0	5755,0		30,0		17,0		
	159,0	5795,0		30,0		17,0		

WLAN ac-Mode; 20 MHz; 6,5 Mbit/s MCS0

U-NII-Subband	Ch. No.	Freq. [MHz]	MPSD [dBm/MHz]	FCC Limit [dBm/MHz]	Margin [dB]	FCC Limit [dBm/MHz]	Margin [dB]	IC EIRP MPSD
1,0	36,0	5180,0		17,0		10,0		7,8
	44,0	5220,0	5,0	17,0	12,0	10,0	**0,4**	9,6
	48,0	5240,0	4,9	17,0	12,1	10,0	0,5	9,5
2A	52,0	5260,0		11,0		11,0		unit:
	56,0	5280,0		11,0		11,0		dBm/
	64,0	5320,0		11,0		11,0		MHz
2C	100,0	5500,0		11,0		11,0		
	116,0	5580,0		11,0		11,0		
	140,0	5700,0		11,0		11,0		
3,0	149,0	5745,0		30,0		17,0		
	157,0	5785,0		30,0		17,0		
	165,0	5825,0		30,0		17,0		

WLAN ac-Mode; 40 MHz; 13,5Mbit/s MCS0

U-NII-Subband	Ch. No.	Freq. [MHz]	MPSD [dBm/MHz]	FCC Limit [dBm/MHz]	Margin [dB]	IC Limit [dBm]	Margin [dB]	IC EIRP MPSD
1,0	38,0	5190,0		17,0		10,0		
	46,0	5230,0	2,3	17,0	14,7	10,0	**3,1**	6,9
2A	54,0	5270,0		11,0		11,0		unit:
	62,0	5310,0		11,0		11,0		dBm/
2C	102,0	5510,0		11,0		11,0		MHz
	110,0	5550,0		11,0		11,0		
	138,0	5670,0		11,0		11,0		
3,0	151,0	5755,0		30,0		17,0		
	159,0	5795,0		30,0		17,0		

WLAN ac-Mode; 80 MHz; 433 Mbit/s MCS9

U-NII-Subband	Ch. No.	Freq. [MHz]	MPSD [dBm/MHz]	FCC Limit [dBm/MHz]	Margin [dB]	IC Limit [dBm]	Margin [dB]	IC EIRP MPSD
1,0	42,0	5210,0	-9,8	17,0	26,8	10,0	**15,2**	-5,2
2A	58,0	5290,0		11,0		11,0		unit:
2C	106,0	5530,0		11,0		11,0		dBm/
	138,0	5690,0		11,0		11,0		MHz
3,0	155,0	5775,0		30,0		17,0		

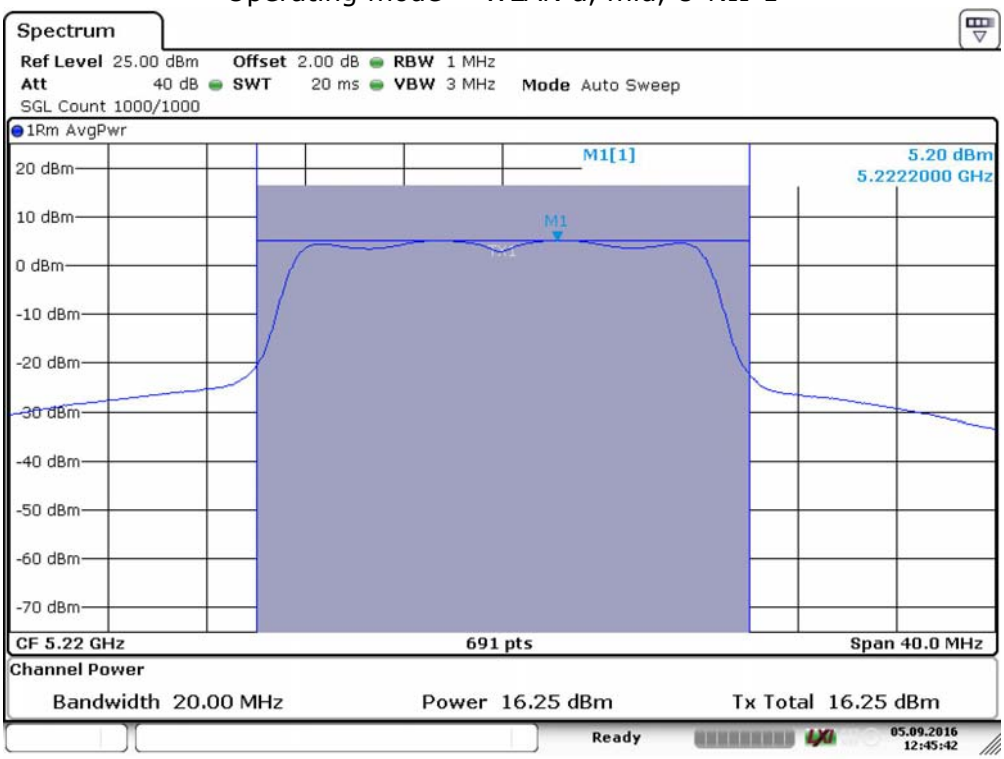
WLAN ac-Mode; 80 MHz; 433 Mbit/s MCS0

U-NII-Subband	Ch. No.	Freq. [MHz]	MPSD [dBm/MHz]	FCC Limit [dBm/MHz]	Margin [dB]	IC Limit [dBm]	Margin [dB]	IC EIRP MPSD
2C	138,0	5690,0	-3,9	11,0	14,9	11,0	**14,9**	

Remarks:
1) The stricter FC-limit (11 dBm/MHz) in U-NII-1 band for mobile and portable client devices is also passed.
2) only spot checks
3) Please see next sub-clause for the measurement plot.

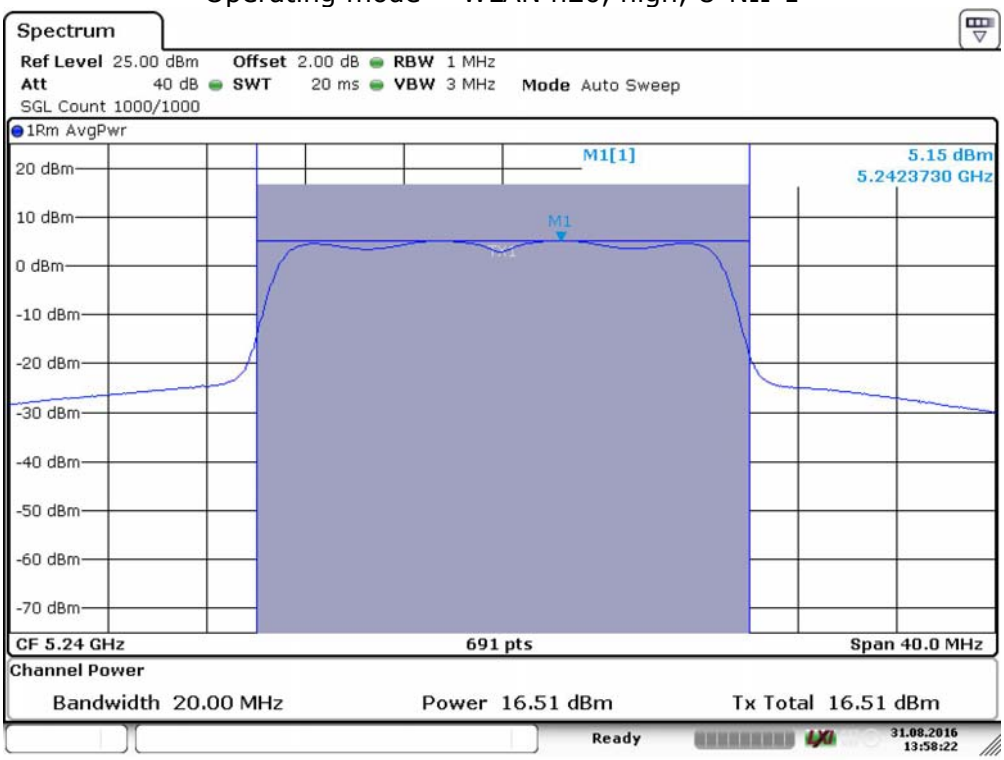
4.2.4MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

Operating mode = WLAN a, mid, U-NII-1



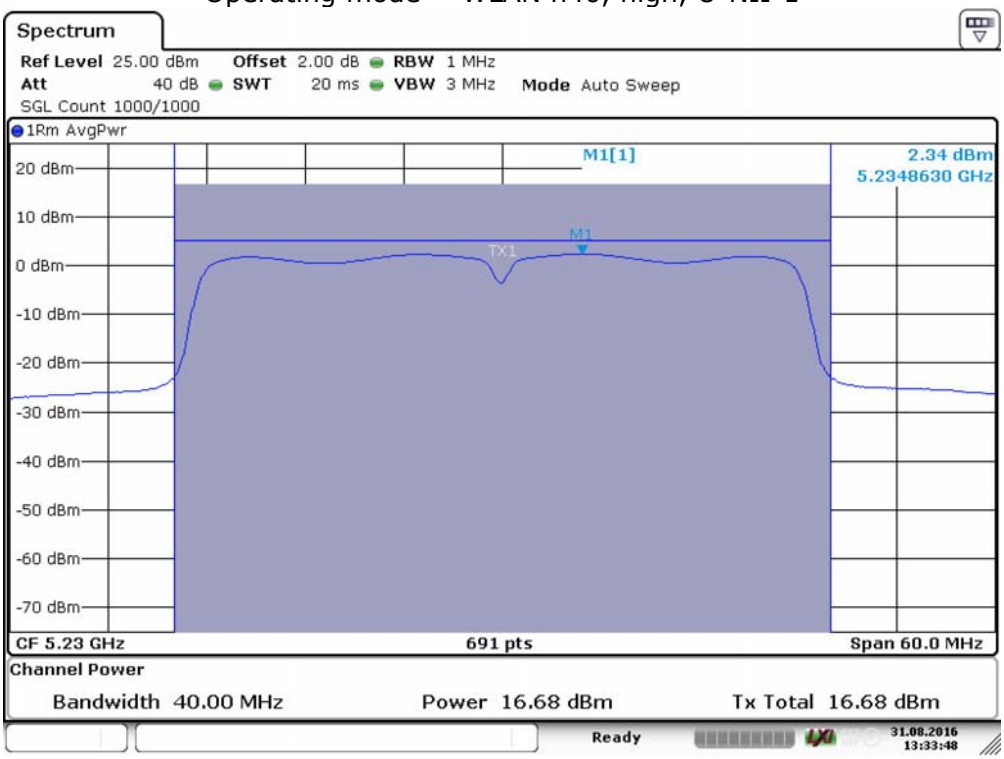
Date: 5.SEP.2016 12:45:42

Operating mode = WLAN n20, high, U-NII-1



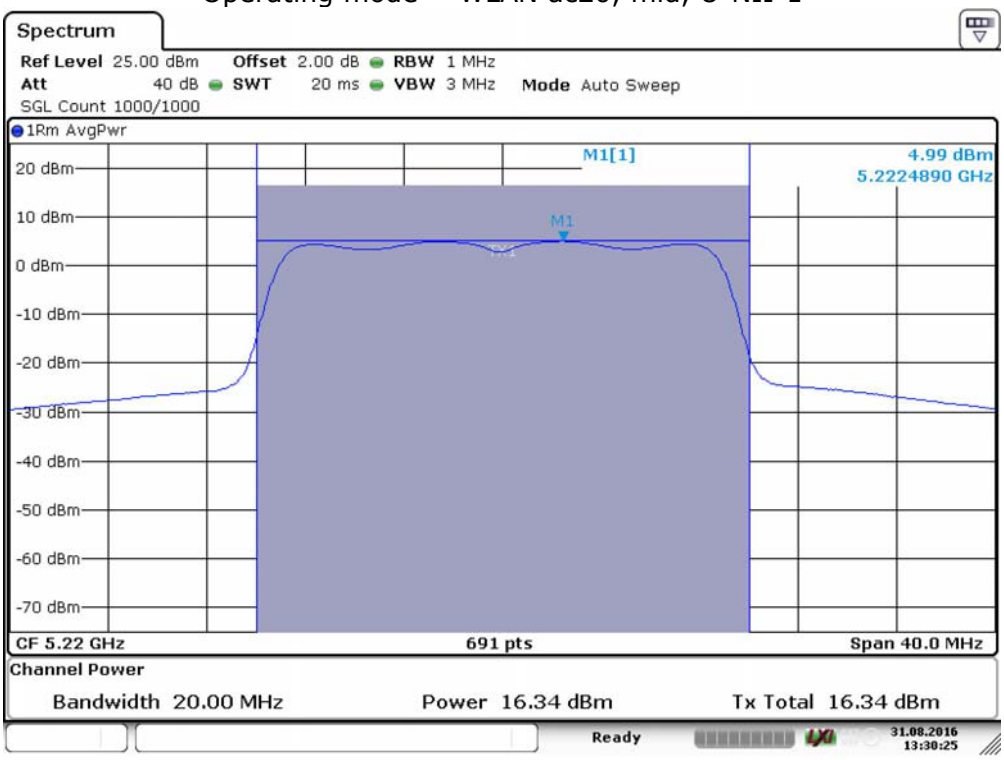
Date: 31.AUG.2016 13:58:22

Operating mode = WLAN n40, high, U-NII-1



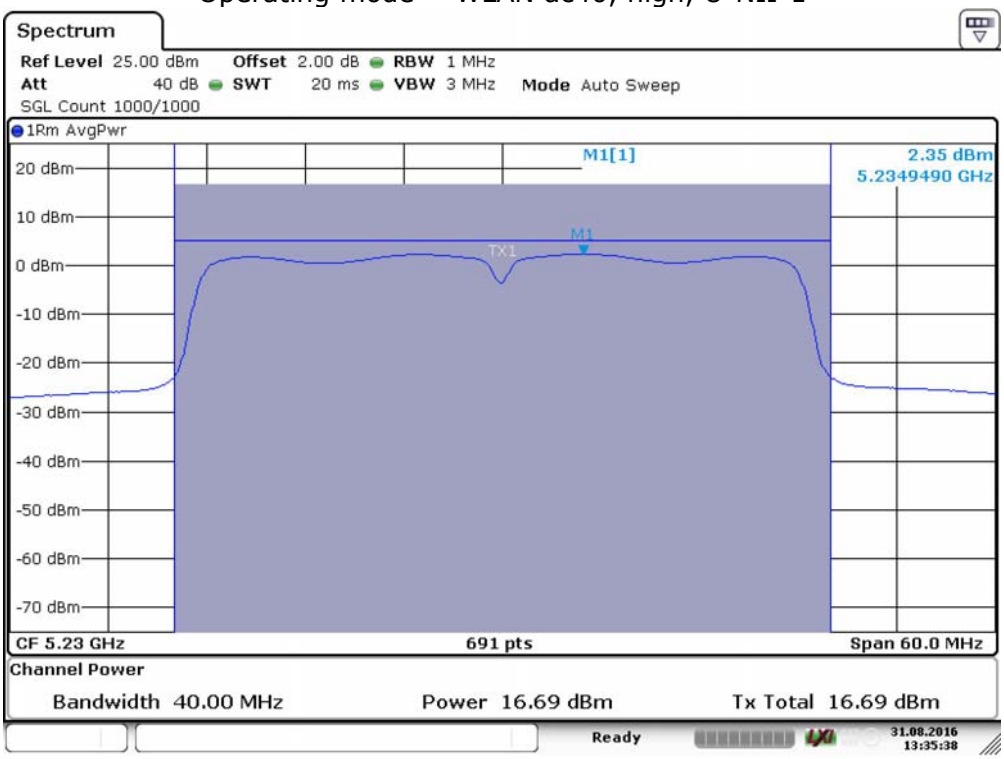
Date: 31.AUG.2016 13:33:49

Operating mode = WLAN ac20, mid, U-NII-1



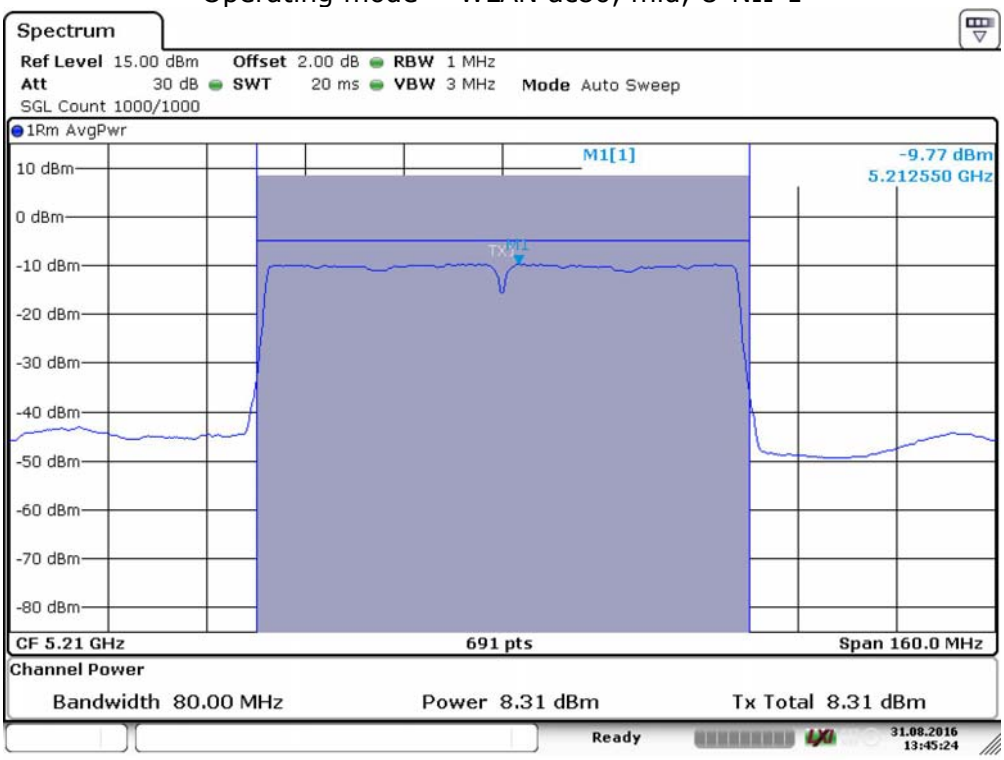
Date: 31.AUG.2016 13:30:26

Operating mode = WLAN ac40, high, U-NII-1



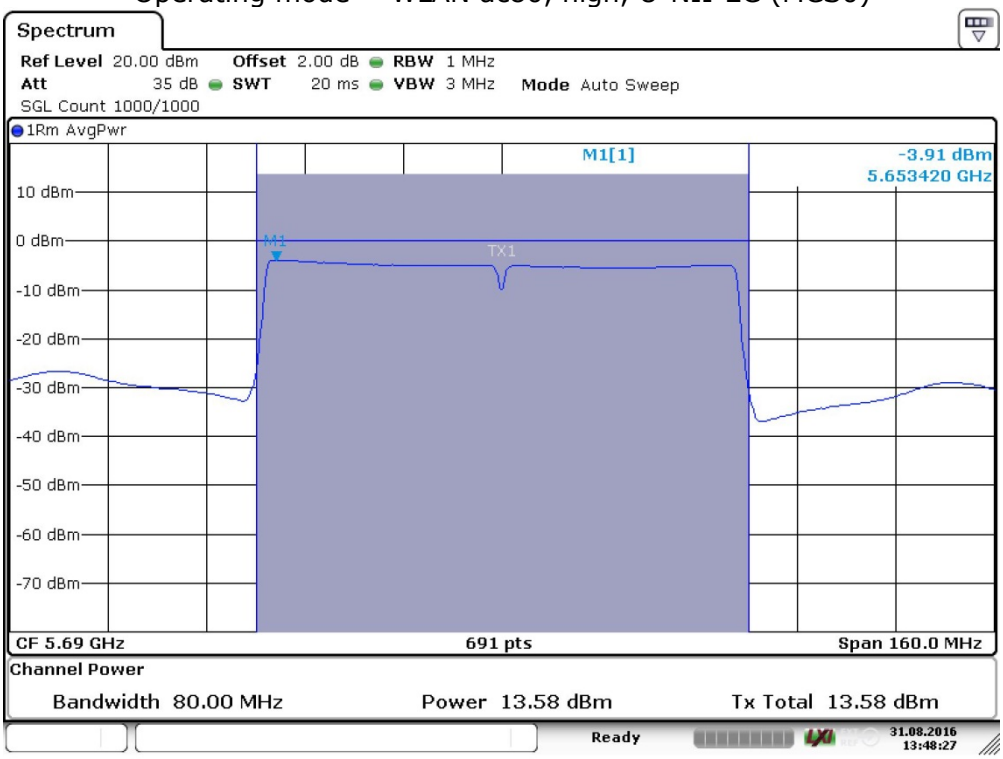
Date: 31.AUG.2016 13:35:38

Operating mode = WLAN ac80, mid, U-NII-1



Date: 31.AUG.2016 13:45:25

Operating mode = WLAN ac80, high, U-NII-2C (MCS0)



Date: 31.AUG.2016 13:48:28

4.2.5TEST EQUIPMENT USED

R&S TS8997

4.3 SPURIOUS RF CONDUCTED EMISSIONS AT ANTENNA PORT

Standard **FCC Part 15 Subpart E**

The test was performed according to:
ANSI C63.10

4.3.1TEST DESCRIPTION

The Equipment Under Test (EUT) was set up to perform the conducted spurious emissions measurements. The antenna port of the EUT was connected to spectrum analyzer via a short coax cable with a known cable loss C_L. The measured voltage U_{meas} at the 50 Ohm input of the analyser was used to calculate the EUT output power at the antenna port:

$P = U_{meas} + C_L - 107$

where
P is the output power in dBm
U_{meas} is the measured voltage at the 50 Ohm input of the analyzer in dBµV
C_L is the cable loss of the used cable.

The maximum transmit isotropically antenna gain G_i (in dBi) was added to the measured output power P to determine the equivalent isotropically radiated power EIRP.

$EIRP = P + Gi$

where
P is the output power in dBm
G_i is maximum transmit antenna gain in dBi.

The resultant EIRP level was converted to an equivalent electric filed strength using the following relationship:

$E = EIRP - 20 \log d + 104.8$

where
E is the electric field strength in dBµV/m
EIRP is the equivalent isotropically radiated power in dBm
d is the specified measurement distance in m.

The appropriate maximum ground reflection factor was added to the EIRP:
6 dB for frequencies ≤ 30 MHz;
4.7 dB for frequencies between 30 MHz and 1000 MHz, inclusive; and
0 dB for frequencies > 1000 MHz).

Frequency range [MHz]	measurement distance d [m]	-20 log d [dB]	ground reflection factor [dB]
0,009 – 0,49	300	-49,54	6
0,49 – 30	30	-29,54	6
30 – 1000	3	-9,54	4,7
>1000	3	-9,54	0

1. Measurement up to 30 MHz

Step 1: pre measurement

This is a preliminary test to identify the highest amplitudes relative to the limit.

- Detector: Peak-Maxhold/ Quasipeak (FFT-based)
- Frequency range: 0.009 - 0.15 MHz and 0.15 – 30 MHz
- Frequency steps: 0.05 kHz and 2.25 kHz
- IF–Bandwidth: 0.2 kHz and 9 kHz
- Measuring time / Frequency step: 100 ms (FFT-based)

Intention of this step is, to determine the EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

Step 2: final measurement

EMI receiver settings:

- Detector: Peak / Average / Quasi-Peak (depending on frequency)
- Frequency range: 0.009 – 30 MHz
- Frequency steps: measurement at frequencies detected in step 1
- IF–Bandwidth: 0.2 - 10 kHz (depending on frequency)
- Measuring time / Frequency step: 1 s

2. Measurement above 30 MHz and up to 1 GHz

Step 1: pre measurement

This is a preliminary test to identify the highest amplitudes relative to the limit.

Settings:

- Detector: Peak-Maxhold / Quasipeak (FFT-based)
- Frequency range: 30 – 1000 MHz
- Frequency steps: 30 kHz
- IF–Bandwidth: 120 kHz
- Measuring time / Frequency step: 100 ms

Step 2: final measurement

EMI receiver settings:

- Detector: Quasi-Peak (< 1 GHz)
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 1 s

3. Measurement above 1 GHz

Step 1: pre measurement

Ssettings:

- Detector: Peak, Average
- IF Bandwidth = 1 MHz

Step 2: final measurement

Spectrum analyzer settings:

- Detector: Peak / Average
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 1 MHz
- Measuring time: 1 s

4.3.2TEST REQUIREMENTS / LIMITS

A) FCC

FCC Part 15 Subpart E, §15.407 (b)(1)
For transmitters operating in the 5150–5250 MHz band:
Limit: –27 dBm/MHz EIRP outside of the band 5150–5350 MHz.

FCC Part 15 Subpart E, §15.407 (b)(2)
For transmitters operating in the 5250–5350 MHz band:
Limit: –27 dBm/MHz EIRP outside of the band 5150–5350 MHz.

FCC Part 15 Subpart E, §15.407 (b)(3)
For transmitters operating in the 5470–5725 MHz band:
Limit: –27 dBm/MHz EIRP outside of the band 5470–5725 MHz.

FCC Part 15 Subpart E, §15.407 (b)(4)
For transmitters operating in the 5725–5850 MHz band:
Limit: –27 dBm/MHz EIRP outside of the band 5715–5860 MHz and additionally
Limit: –17 dBm/MHz EIRP within the frequency ranges 5715–5725 and 5850–5860 MHz.

B) IC
Different frequency bands and limits apply, as compared to the FCC requirements.

RSS-247, 6.2.1 (2), Emissions outside the band 5150-5250 MHz, indoor operation only:
Limit: –27 dBm/MHz EIRP outside of the band 5150–5250 MHz.

RSS-247, 6.2.2 (2), Emissions outside the band 5250-5350 MHz:
Limit: –27 dBm/MHz EIRP outside of the band 5250–5350 MHz.

RSS-247, 6.2.3 (2), Emissions outside the bands 5470-5600 MHz and 5650-5725 MHz:
Limit: –27 dBm/MHz EIRP outside of the band 5470–5725 MHz.
Note: No operation is permitted for the frequency range 5600–5650 MHz.

RSS-247, 6.2.4 (2), Emissions outside the band 5725-5825 MHz:
Limit: –27 dBm/MHz EIRP outside of the band 5715–5835 MHz and additionally
Limit: –17 dBm/MHz EIRP within the frequency ranges 5715–5725 and 5825–5835 MHz.

C) FCC & IC

FCC Part 15 Subpart E, §15.405
The provisions of §§ 15.203 and 15.205 are included.

§15.407 (b)(6)
Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in § 15.209.

§15.407 (b)(7)
The provisions of §15.205 apply to intentional radiators operating under this section

FCC Part 15, Subpart C, §15.209, Radiated Emission Limits

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
0.009 – 0.49	2400/F(kHz)@300m	3	(48.5 – 13.8)@300m
0.49 – 1.705	24000/F(kHz)@30m	3	(33.8 – 23.0)@30m
1.705 – 30	30@30m	3	29.5@30m

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
30 – 88	100@3m	3	40.0@3m
88 – 216	150@3m	3	43.5@3m
216 – 960	200@3m	3	46.0@3m
960 - 26000	500@3m	3	54.0@3m
26000 - 40000	500@3m	1	54.0@3m

§15.35(b) ..., there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit....

Used conversion factor:

- Limit (dBµV/m) = 20 log (Limit (µV/m)/1µV/m)
- Limit (dBµV/m) = EIRP [dBm] – 20 log (d [m]) + 104.8

Limit types (in result tables on next page):
RB – Emissions falls into a "Restricted Band" according FCC §§15.205 and 15.209 *)
UE – "Undesirable Emission Limit" according FCC §15.407
BE-RB – Band Edge Limit basing on "Restricted Band Limits"
BE-UE – Band Edge Limit basing on "Undesirable Emission Limit"
*) Below 1 GHz the limits of §15.209 are applied for all frequencies.

4.3.3TEST PROTOCOL

Ambient temperature: 24–29 °C
Air Pressure: 1000–1009 hPa
Humidity: 33–49 %
Band U-NII-1 & 2A

Mode / Set EUT target power	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin [dB]	Limit Type
HT40, MCS0 / 12 dBm	5190,0	5149,187500	51.6	AV	1000	54	2,4	RB
HT40, MCS0 / 12 dBm	5310,0	5350,220000	51.7	AV	1000	54	2,3	RB
HT40, MCS7 / 12 dBm	5310,0	5350,220000	51.8	AV	1000	54	2,2	RB
VHT40, MCS0 / 12 dBm	5190,0	5149,675000	52,6	AV	1000	54	1,4	RB
VHT80, MCS0 / 8 dBm	5210,0	5140,575000	52,5	AV	1000	54	1,5	RB
VHT80, MCS9 / 8 dBm	5210,0	5141,225000	53,0	AV	1000	54	**1,0**	RB

Remark: Please see next sub-clause for the measurement plot.

Ambient temperature: 24–29 °C
Air Pressure: 1000–1009 hPa
Humidity: 33–49 %

Band U-NII-2C

Mode / Set EUT target power	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin [dB]	Limit Type
HT20, MCS0 / 16 dBm	5680,0	5725,0	52,0	PEAK	1000	68,2	16,2	UE
VHT40, MCS0 / 12 dBm	5510,0	5469,844000	66,5	PEAK	1000	68,2	**1,7**	UE

Ambient temperature: 24–29 °C
Air Pressure: 1000–1009 hPa
Humidity: 33–49 %

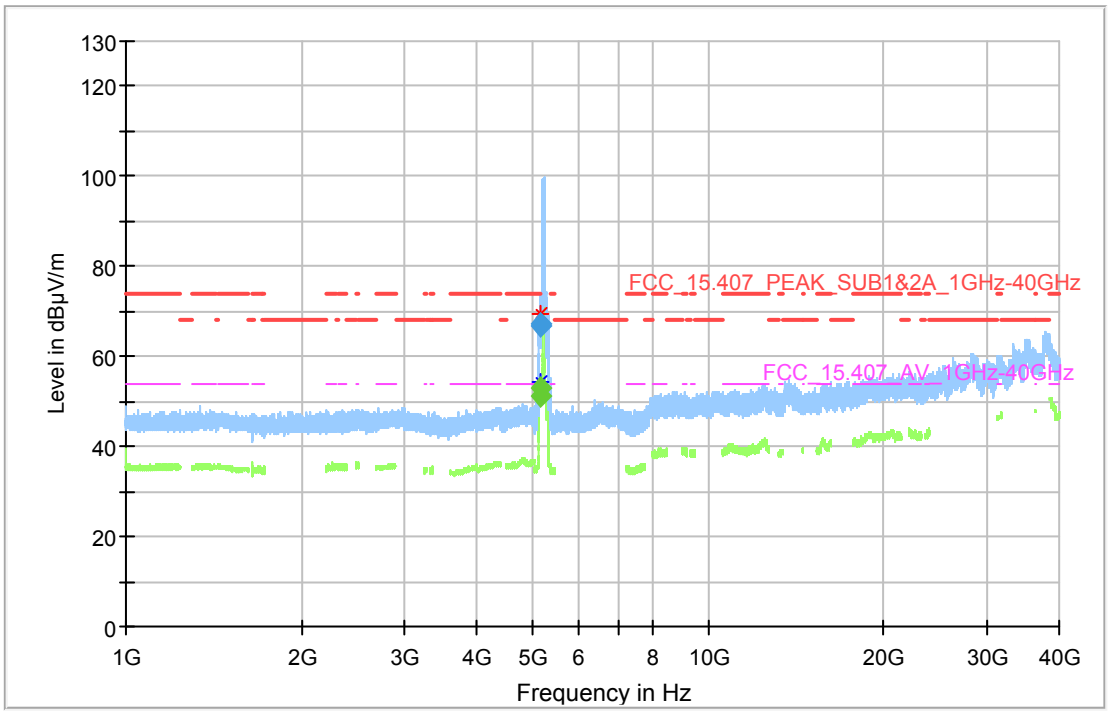
Band U-NII-3

Mode / Set EUT target power	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin [dB]	Limit Type
HT40, MCS0 / 16 dBm	5795,0	5861.550000	64.6	PEAK	1000	68.2	**3,6**	UE
VHT20, MCS0 / 16 dBm	5825,0	5865.400000	61.2	PEAK	1000	68.2	7,0	UE

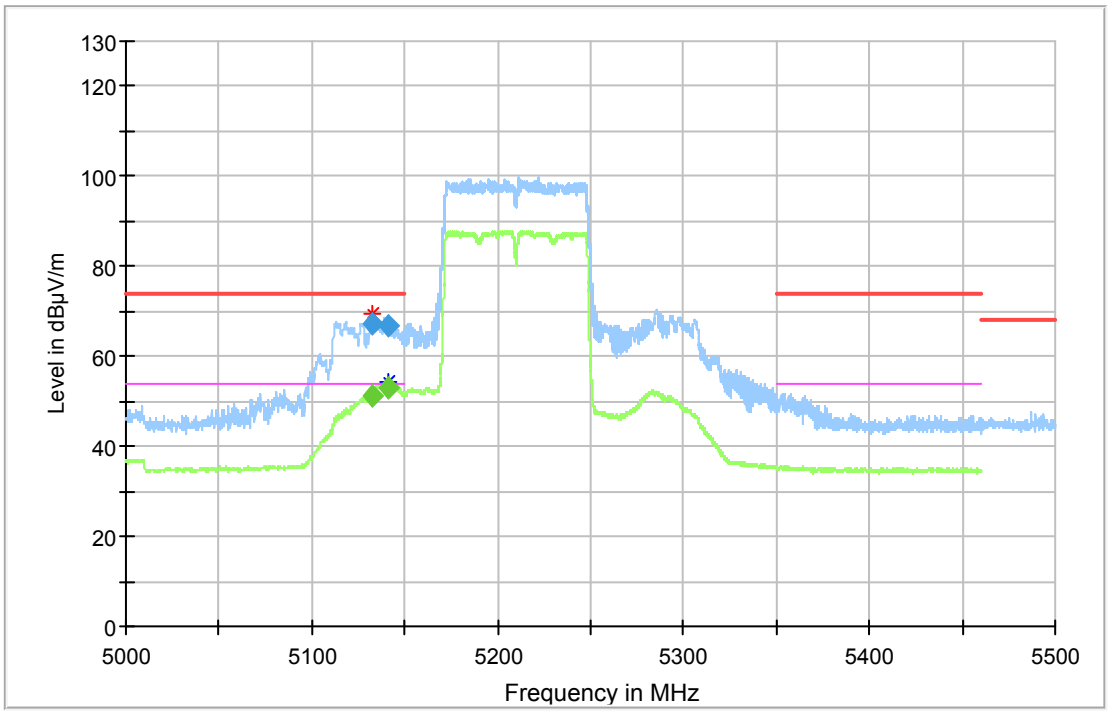
Remark: Please see next sub-clause for the measurement plot.

4.3.4MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

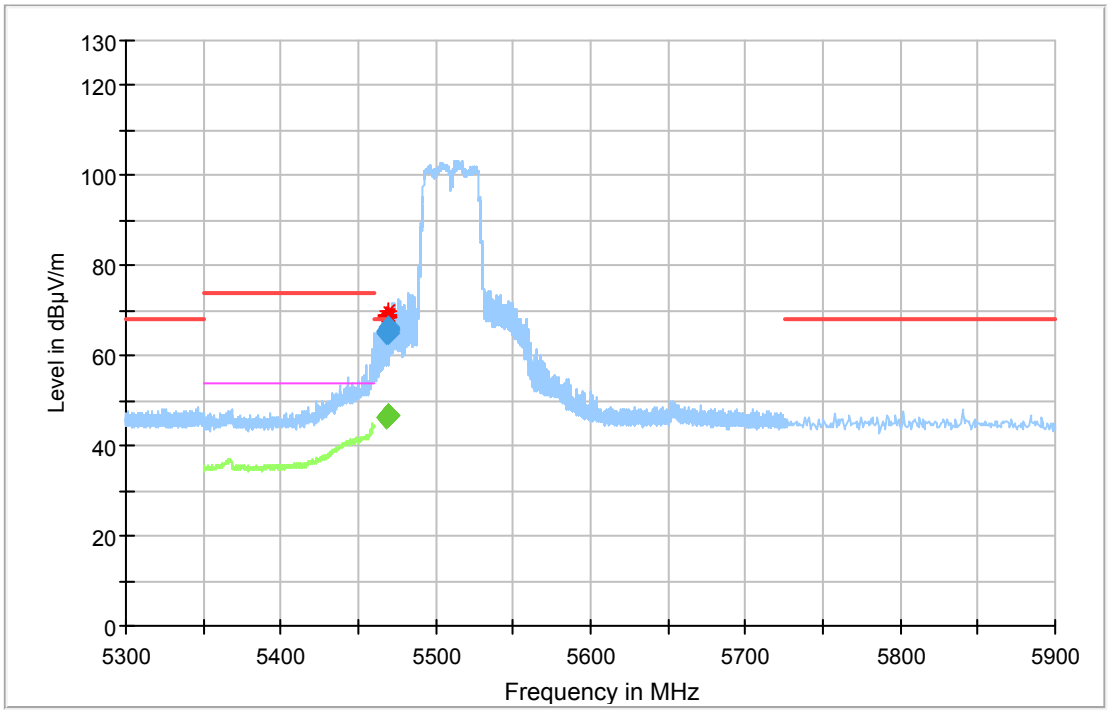
Operating mode = WLAN ac 80 MHz (VHT80, MCS9, 8 dBm), low, U-NII-1 & 2A



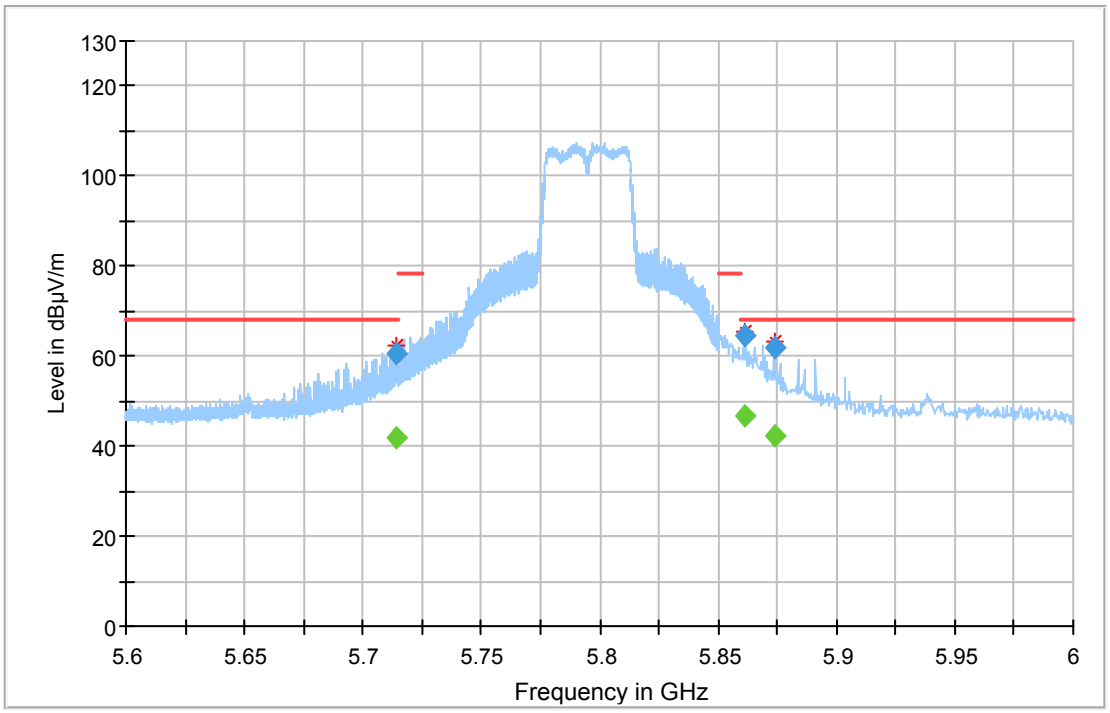
Plot zoomed



Operating mode = WLAN ac 40 MHz (VHT40, MCS0, 12 dBm), low, U-NII-2C



Operating mode = WLAN n 40 MHz (HT40, MCS0, 16 dBm), high, U-NII-3



4.3.5TEST EQUIPMENT USED

Radiated Emissions

4.4 SIMULTANEOUS TRANSMISSION – SPURIOUS RADIATED EMISSIONS

Standard **FCC Part 15 Subpart E**

The test was performed according to:
ANSI C63.10

4.4.1TEST DESCRIPTION

Please see test description for the test case "UNDESIRABLE EMISSIONS; GENERAL FIELD STRENGTH LIMITS"

4.4.2TEST REQUIREMENTS / LIMITS

WLAN 5 GHz
Please see "Test Requirements / Limits" for the test case "UNDESIRABLE EMISSIONS; GENERAL FIELD STRENGTH LIMITS"

Additional for NFC:
FCC §15.225 (d) The field strength of any emissions appearing outside of the 13.110-14.010 MHz band shall not exceed the general radiated emission limits in §15.209.

Additional for Bluetooth
FCC Part 15, Subpart C, §15.247 (d)
... In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

FCC Part 15, Subpart C, §15.209, Radiated Emission Limits

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
0.009 – 0.49	2400/F(kHz)@300m	3	(48.5 – 13.8)@300m
0.49 – 1.705	24000/F(kHz)@30m	3	(33.8 – 23.0)@30m
1.705 – 30	30@30m	3	29.5@30m

The measured values are corrected with an inverse linear distance extrapolation factor (40 dB/decade) according FCC 15.31 (2).

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
30 – 88	100@3m	3	40.0@3m
88 – 216	150@3m	3	43.5@3m
216 – 960	200@3m	3	46.0@3m
960 - 26000	500@3m	3	54.0@3m
26000 - 40000	500@3m	1	54.0@3m

The measured values above 26 GHz are corrected with an inverse linear distance extrapolation factor (20 dB/decade).

§15.35(b) ..., there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit....

Used conversion factor: Limit (dBµV/m) = 20 log (Limit (µV/m)/1µV/m)

4.4.3TEST PROTOCOL

Possible simultaneous operating modes according to applicant's description	Remark
NFC + WLAN 2.4 GHz	Not part of this report
NFC + BT	covered from worst case mode: NFC + BT + WLAN 5 GHz
NFC + BT-LE	BT-LE covered from BT
NFC + WLAN 5 GHz	covered from worst case mode: NFC + BT + WLAN 5 GHz
NFC + BT + WLAN 5 GHz	Worst case operating mode, no intended operating mode, only possible with special SW, Selected worst case operating modes: same as selected for EMMY-W161 for better comparison

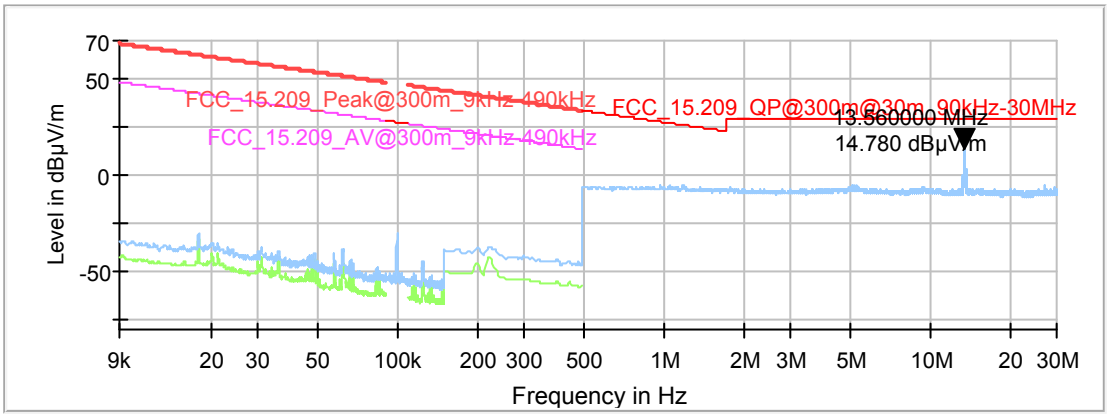
Ambient temperature: 21–25 °C
Air Pressure: 1002–1020 hPa
Humidity: 38–45 %
WLAN b-Mode; 20 MHz

Mode / Set EUT target power	**Ch. Center Freq. [MHz]**	**Spurious Freq. [MHz]**	**Spurious Level [dBµV/m]**	**Detec-tor**	**RBW [kHz]**	**Limit [dBµV/m]**	**Margin to Limit [dB]**
BT BDR (DH1, Ch.0) / max. power WLAN 5 GHz (a-Mode; 20 MHz; 6 Mbit/s) / 16 dBm NFC in continuous modulation mode	2402,0 5240,0 13,56	0,009 to 30	noise	Peak, AV	-	(13,56 MHz excluded)	> 20
BT BDR (DH1, Ch.0) / max. power WLAN 5 GHz (a-Mode; 20 MHz; 6 Mbit/s) / 16 dBm NFC in continuous modulation mode	2402,0 5240,0 13,56	352,56	36,6	QP	120	46	9,4
BT BDR (DH1, Ch.0) / max. power WLAN 5 GHz (a-Mode; 20 MHz; 6 Mbit/s) / 16 dBm NFC in continuous modulation mode	2402,0 5240,0 13,56	2324,8800 2835,53 15717,9083 20959,8700	47,7 (incl. DCC) 44,1 44,1 51,3 (100 % duty cycle, no duty cycle correction (DCC) applicable)	AV	1000	54 54 54 54 (CF at 2402 MHz and 5240 MHz excluded)	6,3 9,1 9,1 **2,7**

Mode / Set EUT target power	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]
BT BDR (DH1, Ch.0) / max. power WLAN 5 GHz (a-Mode; 20 MHz; 6 Mbit/s) / 16 dBm NFC in continuous modulation mode	2402,0 5240,0 13,56	26000 to 40000	noise	Peak, AV	-	74 54	> 20

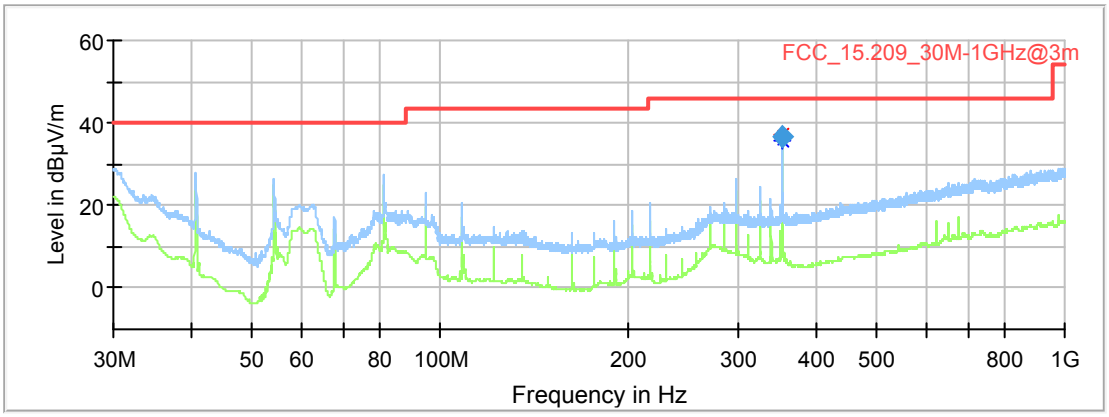
Remark: Please see next sub-clause for the measurement plot.

4.4.4MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")



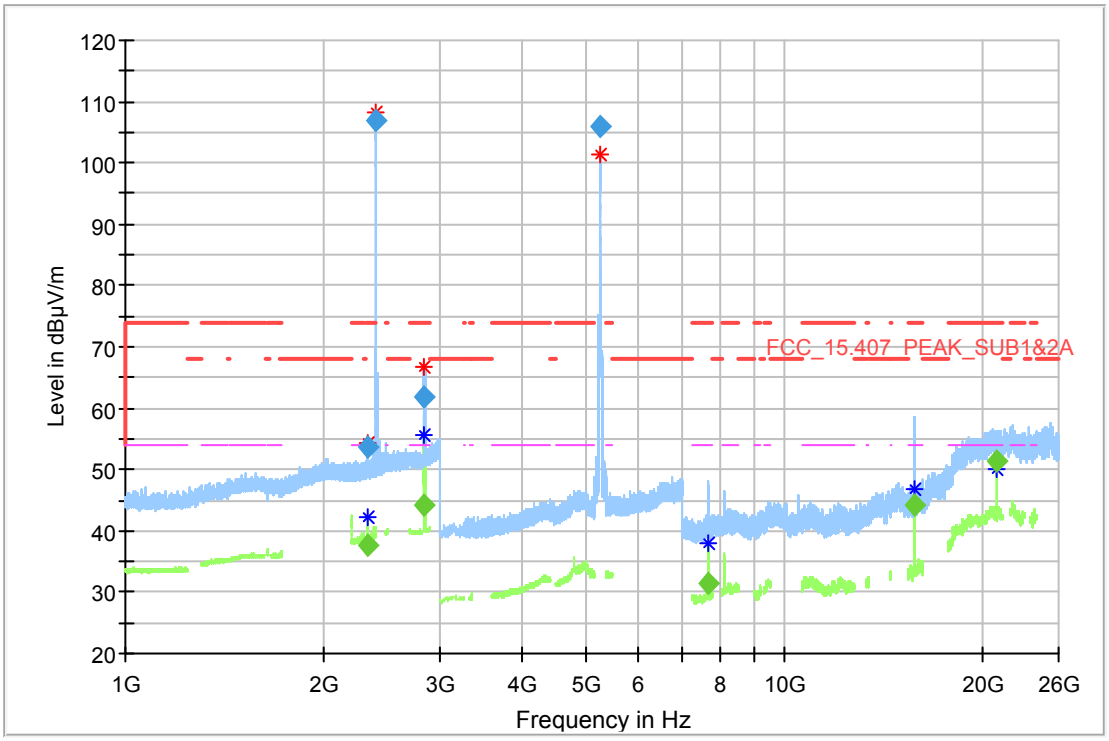
Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
-	-	-	-	-	-	-	-	-	-



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
352,560000	36,57	46,00	9,43	1000,0	120,000	102,0	H	-22,0	15,1

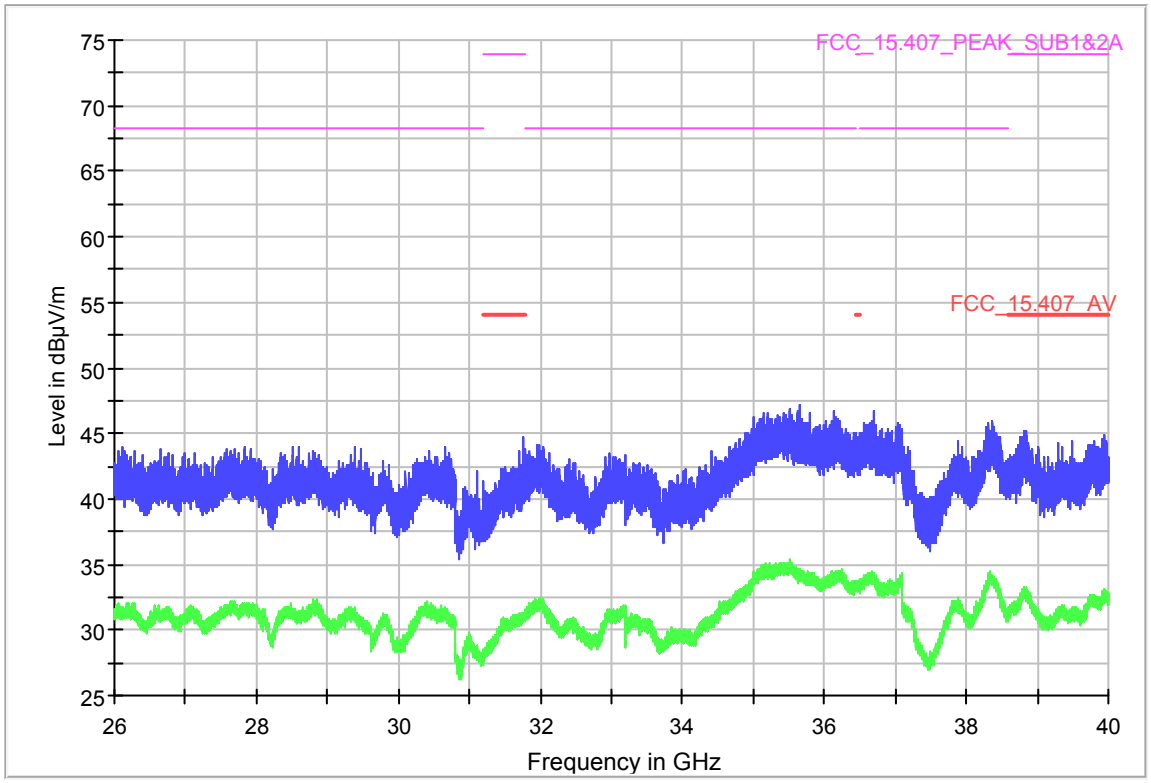


Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
2324,880000	---	37,53	54,00	**16,47**	1000,0	1000,000	150,0	V	97,0	103,9	11,4
2324,880000	53,72	---	74,00	20,28	1000,0	1000,000	150,0	V	90,0	99,2	11,4
2402,061500 (carrier)	106,91	---	---	---	1000,0	1000,000	150,0	V	89,0	93,9	11,8
2834,480000	61,79	---	74,00	12,21	1000,0	1000,000	150,0	V	93,0	88,9	13,6
2835,530000	---	44,10	54,00	**9,90**	1000,0	1000,000	150,0	V	96,0	104,0	13,6
5241,416667 (carrier)	105,85	---	---	---	1000,0	1000,000	150,0	V	-191,0	89,9	11,9
7639,875000	---	31,53	54,00	22,47	1000,0	1000,000	150,0	V	-97,0	78,0	-
15717,908333	---	44,09	54,00	**9,91**	1000,0	1000,000	150,0	V	3,0	95,8	-
20959,870000	---	51,28	54,00	**2,72**	1000,0	1000,000	150,0	H	56,0	91,9	21,5

(continuation of the "Final_Result" table from column 15 ...)

Frequency (MHz)	Comment
2324,880000	+10,2 dB duty cycle corr.
2324,880000	duty cycle correction N/A
2402,061500	BT carrier excluded
2834,480000	duty cycle correction N/A
2835,530000	duty cycle correction N/A
5241,416667	WLAN carrier excluded
7639,875000	duty cycle correction N/A
15717,908333	duty cycle correction N/A
20959,870000	duty cycle correction N/A



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)
-	-	-	-	-	-	-	-	-	-	-

4.4.5TEST EQUIPMENT USED

Radiated Emissions

5 TEST EQUIPMENT

1 Conducted Emissions
Shielded Room 02

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	ESH 3-Z5	Two-Line V-Network	Rohde & Schwarz	828304/029	2015-03	2017-03
1.2	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz	101424	2014-11	2016-11
1.3	ISN T800	Impedance Stabilization Network	Teseq	36159		
1.4	EP 1200/B, NA/B1	Amplifier with integrated variable Oscillator	Spitzenberger & Spieß	B6278	2015-07	2018-07
1.5	ESIB 26	Spectrum Analyzer	Rohde & Schwarz	830482/004	2015-12	2017-12
1.6	Opus10 THI (8152.00)	ThermoHygro Datalogger 02 (Environ)	Lufft Mess- und Regeltechnik GmbH	7489	2015-02	2017-02
1.7	ESH 3-Z5	Two-Line V-Network	Rohde & Schwarz	829996/002	2015-03	2017-03
1.8	CMU 200	Universal Radio Communication Tester	Rohde & Schwarz GmbH & Co. KG	102366	2016-06	2019-05
1.9	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13 (Environ)	Lufft Mess- und Regeltechnik GmbH	13936	2015-02	2017-02
1.10	CMD 55	Digital Radio Communication Tester	Rohde & Schwarz	831050/020	2014-12	2017-12
1.11	ESH 3-Z6	One-Line V-Network	Rohde & Schwarz	100489	2014-06	2017-11
1.12	ESH 3-Z6	One-Line V-Network	Rohde & Schwarz	100570	2013-11	2016-11
1.13	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304		
1.14	CMW 500	CMW 500	Rohde & Schwarz	107500	2015-07	2017-07

2 Radiated Emissions

Lab to perform radiated emission tests

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.1	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronic GmbH	00083069		
2.2	WHKX 7.0/18G-8SS	High Pass Filter	Wainwright	09		
2.3	5HC3500/18000-1.2-KK	High Pass Filter	Trilithic	200035008		
2.4	Fully Anechoic Room	8.80m x 4.60m x 4.05m (l x w x h)	Albatross Projects	P26971-647-001-PRB		
2.5	AM 4.0	Antenna mast	Maturo GmbH	AM4.0/180/11920513		
2.6	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz	101424	2014-11	2016-11
2.7	TT 1.5 WI	Turn Table	Maturo GmbH	-		
2.8	Anechoic Chamber	10.58 x 6.38 x 6.00 m³	Frankonia	none	2014-01	2017-01
2.9	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2016-02	2018-02
2.10	ESIB 26	Spectrum Analyzer	Rohde & Schwarz	830482/004	2015-12	2017-12
2.11	Tilt device Maturo (Rohacell)	Antrieb TD1.5-10kg	Maturo GmbH	TD1.5-10kg/024/3790709		
2.12	5HC2700/12750-1.5-KK	High Pass Filter	Trilithic	9942012		
2.13	AS 620 P	Antenna mast	HD GmbH	620/37		
2.14	4HC1600/12750-1.5-KK	High Pass Filter	Trilithic	9942011		
2.15	ASP 1.2/1.8-10 kg	Antenna Mast	Maturo GmbH	-		
2.16	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785		
2.17	JS4-00101800-35-5P	Broadband Amplifier 30 MHz - 18 GHz	Miteq	896037		
2.18	HL 562	Ultralog new biconicals	Rohde & Schwarz GmbH & Co. KG	830547/003	2015-06	2018-06

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.19	Opus10 THI (8152.00)	ThermoHygro Datalogger 12 (Environ)	Lufft Mess- und Regeltechnik GmbH	12482	2015-03	2017-03
2.20	JS4-00102600-42-5A	Broadband Amplifier 30 MHz - 26 GHz	Miteq	619368		
2.21	HFH2-Z2	Loop Antenna	Rohde & Schwarz GmbH & Co. KG	829324/006	2014-11	2017-11
2.22	FSW 43	Spectrum Analyzer	Rohde & Schwarz	103779	2014-11	2016-11
2.23	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13 (Environ)	Lufft Mess- und Regeltechnik GmbH	13936	2015-02	2017-02
2.24	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304		
2.25	3160-10	Standard Gain / Pyramidal Horn Antenna 40 GHz	EMCO Elektronik GmbH	00086675		
2.26	HL 562 Ultralog	Log.-per. Antenna	Rohde & Schwarz GmbH & Co. KG	100609	2016-04	2019-04
2.27	PAS 2.5 - 10 kg	Antenna Mast	Maturo GmbH	-		
2.28	HF 907	Double-ridged horn	Rohde & Schwarz GmbH & Co. KG	102444	2015-05	2018-05

3 R&S TS8997
EN300328/301893 Test Lab

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
3.1	A8455-4	4 Way Power Divider (SMA)		-		
3.2	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2016-02	2018-02
3.3	Opus10 THI (8152.00)	ThermoHygro Datalogger 03 (Environ)	Lufft Mess- und Regeltechnik GmbH	7482	2015-02	2017-02
3.4	SMB100A	Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz GmbH & Co. KG	107695	2014-06	2017-06
3.5	VT 4002	Climatic Chamber	Vötsch	58566002150010	2016-03	2018-03
3.6	FSV30	Signal Analyzer 10 Hz - 30 GHz	Rohde & Schwarz	103005	2016-02	2018-02
3.7	1515 / 93459	Broadband Power Divider SMA (Aux)	Weinschel Associates	LN673		
3.8	Datum, Model: MFS	Rubidium Frequency Standard	Datum-Beverly	5489/001	2016-07	2017-07

The calibration interval is the time interval between “Last Calibration” and “Calibration Due”

6 ANTENNA FACTORS, CABLE LOSS AND SAMPLE CALCULATIONS

This chapter contains the antenna factors with their corresponding path loss of the used measurement path for all antennas as well as the insertion loss of the LISN.

6.1 LISN R&S ESH3-Z5 (150 KHZ – 30 MHZ)

Frequency		Corr.	LISN insertion loss ESH3-Z5	cable loss (incl. 10 dB atten-uator)
MHz		dB	dB	dB
0,15		10,1	0,1	10,0
5		10,3	0,1	10,2
7		10,5	0,2	10,3
10		10,5	0,2	10,3
12		10,7	0,3	10,4
14		10,7	0,3	10,4
16		10,8	0,4	10,4
18		10,9	0,4	10,5
20		10,9	0,4	10,5
22		11,1	0,5	10,6
24		11,1	0,5	10,6
26		11,2	0,5	10,7
28		11,2	0,5	10,7
30		11,3	0,5	10,8

Sample calculation

U_{LISN} (dB µV) = U (dB µV) + Corr. (dB)
U = Receiver reading
LISN Insertion loss = Voltage Division Factor of LISN
Corr. = sum of single correction factors of used LISN, cables, switch units (if used)
Linear interpolation will be used for frequencies in between the values in the table.

6.2 ANTENNA R&S HFH2-Z2 (9 KHZ – 30 MHZ)

Frequency	AF HFH-Z2)	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-40 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
0,009	20,50	-79,6	0,1	0,1	0,1	0,1	-80	300	3
0,01	20,45	-79,6	0,1	0,1	0,1	0,1	-80	300	3
0,015	20,37	-79,6	0,1	0,1	0,1	0,1	-80	300	3
0,02	20,36	-79,6	0,1	0,1	0,1	0,1	-80	300	3
0,025	20,38	-79,6	0,1	0,1	0,1	0,1	-80	300	3
0,03	20,32	-79,6	0,1	0,1	0,1	0,1	-80	300	3
0,05	20,35	-79,6	0,1	0,1	0,1	0,1	-80	300	3
0,08	20,30	-79,6	0,1	0,1	0,1	0,1	-80	300	3
0,1	20,20	-79,6	0,1	0,1	0,1	0,1	-80	300	3
0,2	20,17	-79,6	0,1	0,1	0,1	0,1	-80	300	3
0,3	20,14	-79,6	0,1	0,1	0,1	0,1	-80	300	3
0,49	20,12	-79,6	0,1	0,1	0,1	0,1	-80	300	3
0,490001	20,12	-39,6	0,1	0,1	0,1	0,1	-40	30	3
0,5	20,11	-39,6	0,1	0,1	0,1	0,1	-40	30	3
0,8	20,10	-39,6	0,1	0,1	0,1	0,1	-40	30	3
1	20,09	-39,6	0,1	0,1	0,1	0,1	-40	30	3
2	20,08	-39,6	0,1	0,1	0,1	0,1	-40	30	3
3	20,06	-39,6	0,1	0,1	0,1	0,1	-40	30	3
4	20,05	-39,5	0,2	0,1	0,1	0,1	-40	30	3
5	20,05	-39,5	0,2	0,1	0,1	0,1	-40	30	3
6	20,02	-39,5	0,2	0,1	0,1	0,1	-40	30	3
8	19,95	-39,5	0,2	0,1	0,1	0,1	-40	30	3
10	19,83	-39,4	0,2	0,1	0,2	0,1	-40	30	3
12	19,71	-39,4	0,2	0,1	0,2	0,1	-40	30	3
14	19,54	-39,4	0,2	0,1	0,2	0,1	-40	30	3
16	19,53	-39,3	0,3	0,1	0,2	0,1	-40	30	3
18	19,50	-39,3	0,3	0,1	0,2	0,1	-40	30	3
20	19,57	-39,3	0,3	0,1	0,2	0,1	-40	30	3
22	19,61	-39,3	0,3	0,1	0,2	0,1	-40	30	3
24	19,61	-39,3	0,3	0,1	0,2	0,1	-40	30	3
26	19,54	-39,3	0,3	0,1	0,2	0,1	-40	30	3
28	19,46	-39,2	0,3	0,1	0,3	0,1	-40	30	3
30	19,73	-39,1	0,4	0,1	0,3	0,1	-40	30	3

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
distance correction = -40 * LOG (d_{Limit}/ d_{used})
Linear interpolation will be used for frequencies in between the values in the table.
Table shows an extract of values

6.3 ANTENNA R&S HL562 (30 MHZ – 1 GHZ)

(d_{Limit} = 3 m)

Frequency	AF R&S HL562	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-20 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
30	18,6	0,6	0,29	0,04	0,23	0,02	0,0	3	3
50	6,0	0,9	0,39	0,09	0,32	0,08	0,0	3	3
100	9,7	1,2	0,56	0,14	0,47	0,08	0,0	3	3
150	7,9	1,6	0,73	0,20	0,59	0,12	0,0	3	3
200	7,6	1,9	0,84	0,21	0,70	0,11	0,0	3	3
250	9,5	2,1	0,98	0,24	0,80	0,13	0,0	3	3
300	11,0	2,3	1,04	0,26	0,89	0,15	0,0	3	3
350	12,4	2,6	1,18	0,31	0,96	0,13	0,0	3	3
400	13,6	2,9	1,28	0,35	1,03	0,19	0,0	3	3
450	14,7	3,1	1,39	0,38	1,11	0,22	0,0	3	3
500	15,6	3,2	1,44	0,39	1,20	0,19	0,0	3	3
550	16,3	3,5	1,55	0,46	1,24	0,23	0,0	3	3
600	17,2	3,5	1,59	0,43	1,29	0,23	0,0	3	3
650	18,1	3,6	1,67	0,34	1,35	0,22	0,0	3	3
700	18,5	3,6	1,67	0,42	1,41	0,15	0,0	3	3
750	19,1	4,1	1,87	0,54	1,46	0,25	0,0	3	3
800	19,6	4,1	1,90	0,46	1,51	0,25	0,0	3	3
850	20,1	4,4	1,99	0,60	1,56	0,27	0,0	3	3
900	20,8	4,7	2,14	0,60	1,63	0,29	0,0	3	3
950	21,1	4,8	2,22	0,60	1,66	0,33	0,0	3	3
1000	21,6	4,9	2,23	0,61	1,71	0,30	0,0	3	3

(d_{Limit} = 10 m)

30	18,6	-9,9	0,29	0,04	0,23	0,02	-10,5	10	3
50	6,0	-9,6	0,39	0,09	0,32	0,08	-10,5	10	3
100	9,7	-9,2	0,56	0,14	0,47	0,08	-10,5	10	3
150	7,9	-8,8	0,73	0,20	0,59	0,12	-10,5	10	3
200	7,6	-8,6	0,84	0,21	0,70	0,11	-10,5	10	3
250	9,5	-8,3	0,98	0,24	0,80	0,13	-10,5	10	3
300	11,0	-8,1	1,04	0,26	0,89	0,15	-10,5	10	3
350	12,4	-7,9	1,18	0,31	0,96	0,13	-10,5	10	3
400	13,6	-7,6	1,28	0,35	1,03	0,19	-10,5	10	3
450	14,7	-7,4	1,39	0,38	1,11	0,22	-10,5	10	3
500	15,6	-7,2	1,44	0,39	1,20	0,19	-10,5	10	3
550	16,3	-7,0	1,55	0,46	1,24	0,23	-10,5	10	3
600	17,2	-6,9	1,59	0,43	1,29	0,23	-10,5	10	3
650	18,1	-6,9	1,67	0,34	1,35	0,22	-10,5	10	3
700	18,5	-6,8	1,67	0,42	1,41	0,15	-10,5	10	3
750	19,1	-6,3	1,87	0,54	1,46	0,25	-10,5	10	3
800	19,6	-6,3	1,90	0,46	1,51	0,25	-10,5	10	3
850	20,1	-6,0	1,99	0,60	1,56	0,27	-10,5	10	3
900	20,8	-5,8	2,14	0,60	1,63	0,29	-10,5	10	3
950	21,1	-5,6	2,22	0,60	1,66	0,33	-10,5	10	3
1000	21,6	-5,6	2,23	0,61	1,71	0,30	-10,5	10	3

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
distance correction = -20 * LOG (d_{Limit}/ d_{used})
Linear interpolation will be used for frequencies in between the values in the table.
Tables show an extract of values.

6.4 ANTENNA R&S HF907 (1 GHZ – 18 GHZ)

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay + cable inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit, atten-uator & pre-amp)	cable loss 4 (to receiver)		
MHz	dB (1/m)	dB	dB	dB	dB	dB		
1000	24,4	-19,4	0,99	0,31	-21,51	0,79		
2000	28,5	-17,4	1,44	0,44	-20,63	1,38		
3000	31,0	-16,1	1,87	0,53	-19,85	1,33		
4000	33,1	-14,7	2,41	0,67	-19,13	1,31		
5000	34,4	-13,7	2,78	0,86	-18,71	1,40		
6000	34,7	-12,7	2,74	0,90	-17,83	1,47		
7000	35,6	-11,0	2,82	0,86	-16,19	1,46		

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay inside chamber)	cable loss 2 (inside chamber)	cable loss 3 (outside chamber)	cable loss 4 (switch unit, atten-uator & pre-amp)	cable loss 5 (to receiver)	used for FCC 15.247
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	
3000	31,0	-23,4	0,47	1,87	0,53	-27,58	1,33	
4000	33,1	-23,3	0,56	2,41	0,67	-28,23	1,31	
5000	34,4	-21,7	0,61	2,78	0,86	-27,35	1,40	
6000	34,7	-21,2	0,58	2,74	0,90	-26,89	1,47	
7000	35,6	-19,8	0,66	2,82	0,86	-25,58	1,46	

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay inside chamber)	cable loss 2 (High Pass)	cable loss 3 (pre-amp)	cable loss 4 (inside chamber)	cable loss 5 (outside chamber)	cable loss 6 (to receiver)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	dB
7000	35,6	-57,3	0,56	1,28	-62,72	2,66	0,94	1,46
8000	36,3	-56,3	0,69	0,71	-61,49	2,84	1,00	1,53
9000	37,1	-55,3	0,68	0,65	-60,80	3,06	1,09	1,60
10000	37,5	-56,2	0,70	0,54	-61,91	3,28	1,20	1,67
11000	37,5	-55,3	0,80	0,61	-61,40	3,43	1,27	1,70
12000	37,6	-53,7	0,84	0,42	-59,70	3,53	1,26	1,73
13000	38,2	-53,5	0,83	0,44	-59,81	3,75	1,32	1,83
14000	39,9	-56,3	0,91	0,53	-63,03	3,91	1,40	1,77
15000	40,9	-54,1	0,98	0,54	-61,05	4,02	1,44	1,83
16000	41,3	-54,1	1,23	0,49	-61,51	4,17	1,51	1,85
17000	42,8	-54,4	1,36	0,76	-62,36	4,34	1,53	2,00
18000	44,2	-54,7	1,70	0,53	-62,88	4,41	1,55	1,91

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear interpolation will be used for frequencies in between the values in the table.
Tables show an extract of values.

6.5 ANTENNA EMCO 3160-09 (18 GHZ – 26.5 GHZ)

Frequency	AF EMCO 3160-09	Corr.	cable loss 1 (inside chamber)	cable loss 2 (pre-amp)	cable loss 3 (inside chamber)	cable loss 4 (switch unit)	cable loss 5 (to receiver)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB
18000	40,2	-23,5	0,72	-35,85	6,20	2,81	2,65
18500	40,2	-23,2	0,69	-35,71	6,46	2,76	2,59
19000	40,2	-22,0	0,76	-35,44	6,69	3,15	2,79
19500	40,3	-21,3	0,74	-35,07	7,04	3,11	2,91
20000	40,3	-20,3	0,72	-34,49	7,30	3,07	3,05
20500	40,3	-19,9	0,78	-34,46	7,48	3,12	3,15
21000	40,3	-19,1	0,87	-34,07	7,61	3,20	3,33
21500	40,3	-19,1	0,90	-33,96	7,47	3,28	3,19
22000	40,3	-18,7	0,89	-33,57	7,34	3,35	3,28
22500	40,4	-19,0	0,87	-33,66	7,06	3,75	2,94
23000	40,4	-19,5	0,88	-33,75	6,92	3,77	2,70
23500	40,4	-19,3	0,90	-33,35	6,99	3,52	2,66
24000	40,4	-19,8	0,88	-33,99	6,88	3,88	2,58
24500	40,4	-19,5	0,91	-33,89	7,01	3,93	2,51
25000	40,4	-19,3	0,88	-33,00	6,72	3,96	2,14
25500	40,5	-20,4	0,89	-34,07	6,90	3,66	2,22
26000	40,5	-21,3	0,86	-35,11	7,02	3,69	2,28
26500	40,5	-21,1	0,90	-35,20	7,15	3,91	2,36

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear interpolation will be used for frequencies in between the values in the table.
Table shows an extract of values.

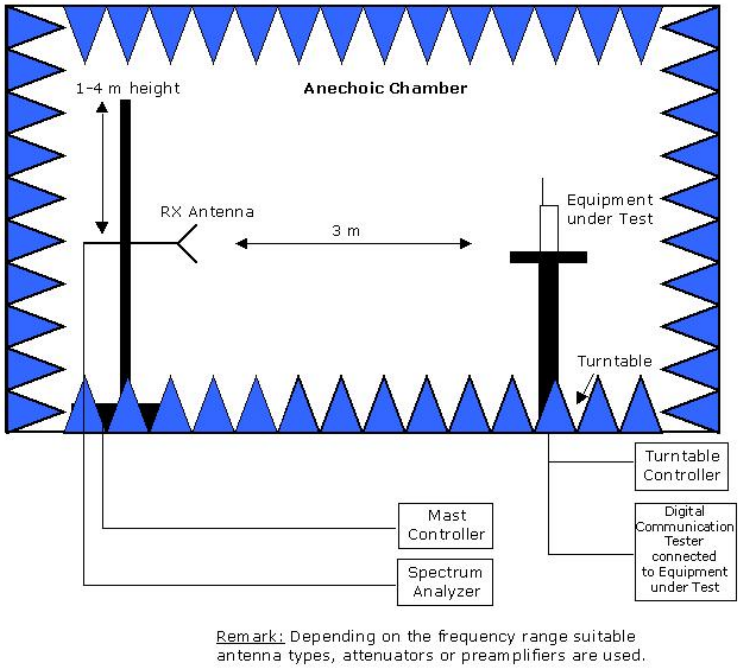
6.6 ANTENNA EMCO 3160-10 (26.5 GHZ – 40 GHZ)

Frequency	AF EMCO 3160-10	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-20 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
GHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
26,5	43,4	-11,2	4,4				-15,6	3	0,5
27,0	43,4	-11,2	4,4				-15,6	3	0,5
28,0	43,4	-11,1	4,5				-15,6	3	0,5
29,0	43,5	-11,0	4,6				-15,6	3	0,5
30,0	43,5	-10,9	4,7				-15,6	3	0,5
31,0	43,5	-10,8	4,7				-15,6	3	0,5
32,0	43,5	-10,7	4,8				-15,6	3	0,5
33,0	43,6	-10,7	4,9				-15,6	3	0,5
34,0	43,6	-10,6	5,0				-15,6	3	0,5
35,0	43,6	-10,5	5,1				-15,6	3	0,5
36,0	43,6	-10,4	5,1				-15,6	3	0,5
37,0	43,7	-10,3	5,2				-15,6	3	0,5
38,0	43,7	-10,2	5,3				-15,6	3	0,5
39,0	43,7	-10,2	5,4				-15,6	3	0,5
40,0	43,8	-10,1	5,5				-15,6	3	0,5

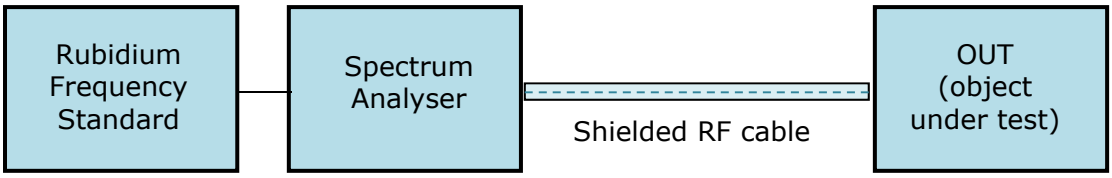
Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear interpolation will be used for frequencies in between the values in the table.
distance correction = -20 * LOG (d_{Limit}/ d_{used})
Linear interpolation will be used for frequencies in between the values in the table.
Table shows an extract of values.

7 SETUP DRAWINGS



Drawing 1: Setup in the Anechoic chamber. For measurements below 1 GHz the ground was replaced by a conducting ground plane.



Drawing 2: Setup for conducted radio tests.

8 MEASUREMENT UNCERTAINTIES

Test Case	Parameter	Uncertainty
AC Power Line	Power	± 3.4 dB
Field Strength of spurious radiation	Power	± 5.5 dB
6 dB / 26 dB / 99% Bandwidth	Power Frequency	± 2.9 dB ± 11.2 kHz
Conducted Output Power	Power	± 2.2 dB
Band Edge Compliance	Power Frequency	± 2.2 dB ± 11.2 kHz
Frequency Stability	Frequency	± 25 Hz
Power Spectral Density	Power	± 2.2 dB

9 PHOTO REPORT

Please see separate photo report.