FCC ID: 2AA7R465BT01 IC ID: 11431A-465BT01

EMI – TEST REPORT

- FCC Part 15.247, RSS210 -

Test Report No. : T36945-01-00TK	23. April 2014 Date of issue

Type / Model Name : 465-BT

Product Description : BT-Module, Class 2

Applicant : IST Innovation - Service - Technology GmbH

Address : Keimstrasse 7

86420 DIEDORF, GERMANY

Manufacturer : IST Technologies Ltd.

Address : Flat 1203, Block C6,

Heng Feng, Industrial City, He Zhou, Si Xiang

Bao An, Shenzhen, Guang Dong, CHINA

Licence holder : IST Innovation - Service - Technology GmbH

Address : Keimstrasse 7

86420 DIEDORF, GERMANY

Test Result according to the standards listed in clause 1 test standards:	**POSITIVE**

DAkkS Deutsche Akkreditierungsstelle D-PL-12030-01-01 D-PL-12030-01-02

Contents

1 TEST STANDARDS

The tests were performed according to following standards:

FCC Rules and Regulations Part 15, Subpart A - General (September, 2010)

Part 15, Subpart A, Section 15.31	Measurement standards
Part 15, Subpart A, Section 15.33	Frequency range of radiated measurements
Part 15, Subpart A, Section 15.35	Measurement detector functions and bandwidths

FCC Rules and Regulations Part 15, Subpart C - Intentional Radiators (September, 2010)

Part 15, Subpart C, Section 15.203	Antenna requirement
Part 15, Subpart C, Section 15.204	External radio frequency power amplifiers and antenna modifications
Part 15, Subpart C, Section 15.205	Restricted bands of operation
Part 15, Subpart C, Section 15.207	Conducted limits
Part 15, Subpart C, Section 15.209	Radiated emission limits, general requirements
Part 15, Subpart C, Section 15.247	Operation within the bands 902 - 928 MHz, 2400 - 2483.5 MHz and 5725 - 5850 MHz

FCC Rules and Regulations Part 1, Subpart I - Procedures Implementing the National Environmental Policy Act of 1969

Part 1, Subpart I, Section 1.1310	Radiofrequency radiation exposure limits
Part 1, Subpart 2, Section 2.1093	Radiofrequency radiation exposure evaluation: portable device

OET Bulletin 65, 65A, 65B, 65C Edition 97-01, August 1997 – Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields.

ANSI C63.4: 2009	Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
ANSI C95.1: 2005	IEEE Standard for Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz
CISPR 16-4-2: 2003	Uncertainty in EMC measurement
CISPR 22: 2005 EN 55022: 2006	Information technology equipment
DA 00-705	Filing and measurement guidelines for FHSS systems

2 SUMMARY

2.1 Test result summery

Bluetooth device using frequency hopping:

Operating in the 2402 MHz – 2480 MHz band:

FCC Rule Part	RSS Rule Part	Description	Result
15.207(a)	RSS Gen, 7.2.4.	AC power line conducted emissions	not applicable
15.247(a)(1)	RSS210, A8.1(a)	20 dB EBW	passed
15.247(a)(1)	RSS-210, A8.1(b)	Channel separation	passed
15.247(a)(1)	RSS-210, A8.1(d)	Dwell time	passed
15.247(b)(1)	RSS-210, A8.4(2)	Peak power	passed
15.247(d)	RSS-210, A8.5	Spurious emissions	passed
15.247(d)	RSS-210, A8.5	Out-of-band emission, radiated	passed
15.247(d)	RSS-Gen, 7.2.2	Emissions in restricted bands	passed
15.247(e)	RSS-210, A8.2(b)	Hopping sequence	passed
15.247(a)	RSS-210, A8.1(b)	Receiver input bandwith	passed
15.247(a)	RSS-210, A8.1(d)	Number of hopping channels	passed
15.247(a)	-	Equal hopping frequency use	passed
15.35(c)	RSS-Gen, 4.5	Pulsed operation	not applicable
15.247(i)	RSS 102, 2.5.2	MPE	passed
15.247(b)(4)	RSS-Gen, 7.1.2	Antenna requirement	passed
	RSS-Gen, 7.2.6	Transmitter frequency stability	not applicable
OET Bulletin 65	RSS102, 3.2	Co-location, Co-transmission	not applicable

The mentioned RSS Rule Parts in the above table are related to:
RSS Gen, Issue 3, December 2010
RSS 210, Issue 8, December 2010
RSS 102, Issue 4, March 2010

FCC ID: 2AA7R465BT01 IC ID: 11431A-465BT01

GENERAL REMARKS:

The EUT uses an **apm 8262** Bluetooth module which is fully compliant to Bluetooth V2.1+EDR and has an integrated PCB mounted antenna. A temporary connector can be implemented instead of the determined antenna but is reserved for conducted test measurements. Radiated measurements were performed without the temporary connector and the intended antenna. The EUT was operated using the special test software "Blue Suite 3" to set the intended test modes, TX continuous and RX continuous. An USB to SPI adaptor was used to connect the EUT to the Control-PC. The antenna being used has been tested as model number V15.
The EUT has four different assembly types:

Type one: **465BT a**, top mounted antenna, no audio chip and no Apple Authentification Chip (AAC) mounted
Type two: **465BT b**, top mounted antenna, audio chip and Apple Authentification Chip (AAC) mounted
Type three: **465BT c**, bottom mounted antenna, no audio chip and no Apple Authentification Chip (AAC) mounted
Type four: **465BT d**, bottom mounted antenna, audio chip and Apple Authentification Chip (AAC) mounted

Items	Description
BT Module type	apm 8262
Power type	3.3 VDC
Modulation	FHSS (GFSK / π/4-DQPSK / 8DPSK)
Frequency range	2400 MHz to 2483.5 MHz
Channel numbers	79
Data rate (Mbps)	1 (GFSK), 2 (π/4-DQPSK), 3 (8DPSK)
Antenna type	Integrated, PCB mounted
Bluetooth version compliant to	V2.1+EDR
Bluetooth conformance test	B017589
Bluetooth conformance test, implementation of audio and video functions	B021233

Operation frequency and channel plan

The operating frequency range is 2400 MHz to 2483.5 MHz.

Channel plan:

Channel	Frequency	Channel	Frequency	Channel	Frequency	Channel	Frequency
1	2402	28	2429	41	2442	61	2462
2	2403	29	2430	42	2443	62	2463
3	2404	30	2431	43	2444	63	2464
4	2405	31	2432	44	2445	64	2465
5	2406	32	2433	45	2446	65	2466
6	2407	33	2434	46	2447	66	2467
7	2408	34	2435	47	2448	67	2468
8	2409	35	2436	48	2449	68	2469
9	2410	36	2437	49	2450	69	2470
10	2411	37	2438	50	2451	70	2471
11	2412	38	2439	51	2452	71	2472
12	2413	39	2440	52	2453	72	2473
13	2414	40	2441	53	2454	73	2474
14	2415	21	2422	54	2455	74	2475
15	2416	22	2423	55	2456	75	2476
16	2417	23	2424	56	2457	76	2477
17	2418	24	2425	57	2458	77	2478
18	2419	25	2426	58	2459	78	2479
19	2420	26	2427	59	2460	79	2480
20	2421	27	2428	60	2461		

Transmit operating modes

- synchronous mode (SCO or eSCO traffic, for HV, DV or DM packets) for transmitting voice or data,
- asynchronous mode (ACL traffic, for DM or DH packets) for transmitting data,
- mixed transfer mode (for voice and data,

The most important mode is the ACL mode at a data rate of 3 Mbps for the worst case.

Packets:
A summery of the packets in ACL mode and their characteristics is shown in the following table:

Type	Payload Header (bytes)	User Payload (bytes)	FEC	CRC	Symmetric Max. Rate (kb/s)	Asymmetric Max. Rate (kb/s)	
						Forward	Reverse
DM1	1	0 - 17	2/3	yes	108.8	108.8	108.8
DH1	1	0 - 27	no	yes	172.8	172.8	172.8
DM3	2	0 - 121	2/3	yes	258.1	387.2	54.4
DH3	2	0 - 183	no	yes	390.4	585.6	86.4
DM5	2	0 - 224	2/3	yes	286.7	477.8	36.3
DH5	2	0 - 339	no	yes	433.9	723.2	57.6
AUX1	1	0 - 29	no	no	185.6	185.6	185.6
2-DH1	2	0 - 54	no	yes	345.6	345.6	345.6
2-DH3	2	0 - 367	no	yes	782.9	1174.4	172.8
2-DH5	2	0 - 679	no	yes	869.1	1448.5	115.2
3-DH1	2	0 - 83	no	yes	531.2	531.2	531.2
3-DH3	2	0 - 552	no	yes	1177.6	1766.4	235.6
3-DH5	2	0 - 1021	no	yes	1306.9	2178.1	177.1

Modulation types:
For the DH5 packet the pay load modulation GFSK, for 2-DH5 the modulation π/4-DQPSK, for 3-DH5 the modulation 8DPSK is used. The packet 3-DH5 shows most of modulation side bands and means the worst case.

Tested channels

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
1	2402	40	2441	79	2480

Antennas

The following antennas shall be used with the EUT:

Number	Characteristic	Model number	Plug	Frequency range (GHz)	Gain (dBi)	Cable loss (dB)	Effective gain (dBi)
1	Omni	465M04-E01	none	2.4	-3	0	-3

Note: The antenna has already been tested as V15 and is renamed for the usage in the 465 BT module into 465M04-E01. The test report data is noticed below.

Report Reference: ADE_IST_1103_102
Date: 17.07.2012

Operating frequency range:
The manufacturer declares that the maximum frequency of this device is 2402 MHz to 2480 MHz. This is according the Bluetooth Core Specification 2.1 +EDR (+ critical errata) for devices which will be operated in the USA. This was checked during the Bluetooth Qualification tests (Test Case: TRM/CA/04-E). Other frequency ranges (e.g. for Spain, France, Japan) are not supported by this device.

The frequency range was scanned from 9 kHz MHz to 25000 MHz. All emissions not reported in this test report were more than 20 dB below the specified limit. The lowest generated frequency is related to the chipset crystal oscillator and has 24 MHz.

FINAL ASSESSMENT:

The equipment under test **fulfills** the EMI requirements cited in clause 1 test standards.

Date of receipt of test sample : acc. to storage records

Testing commenced on : 27 September 2013

Testing concluded on : 15 October 2013

Checked by:

Klaus Gegenfurtner
I confirm the correctness and Integrity of this documents
2014.04.24 09:00:38 +02'00'

Klaus Gegenfurtner
Dipl. Ing. (FH)
Manager Radio Team

Tested by:

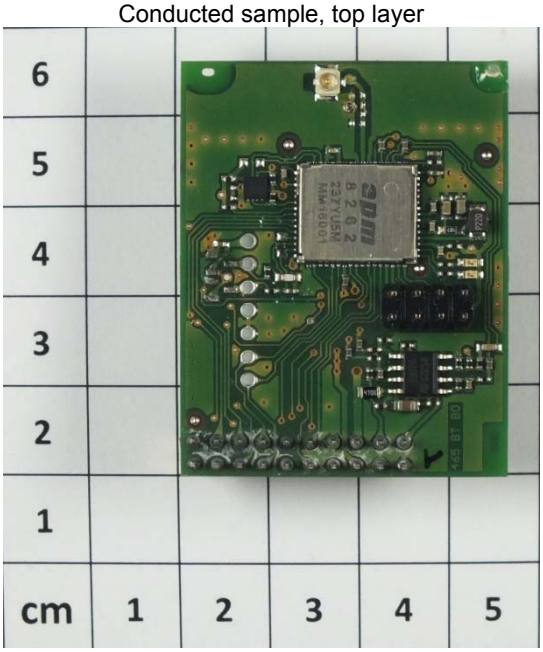
Tobias Kammerer
I`m the author of this document
2014.04.24 07:51:14 +02'00'

Tobias Kammerer
Radio Team

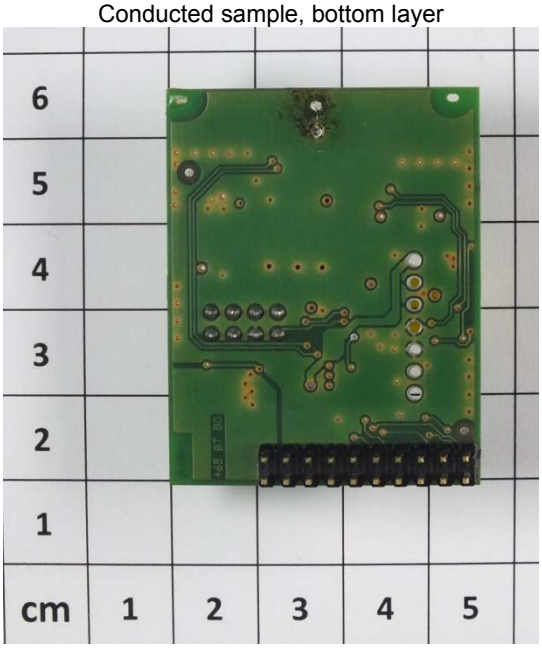
3 EQUIPMENT UNDER TEST

3.1 Photo documentation of the EUT – Detailed photos see attachment A

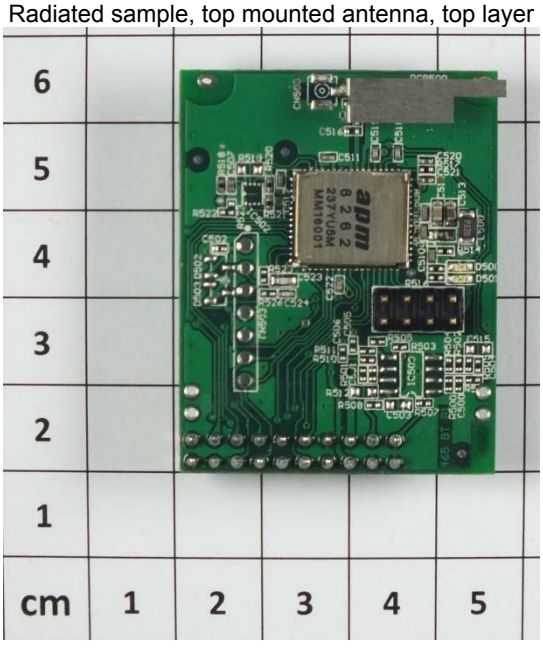
Conducted sample, top layer



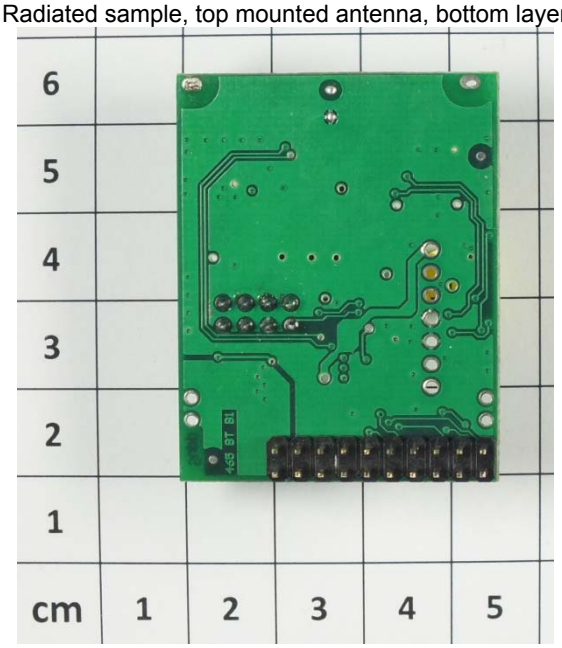
Conducted sample, bottom layer



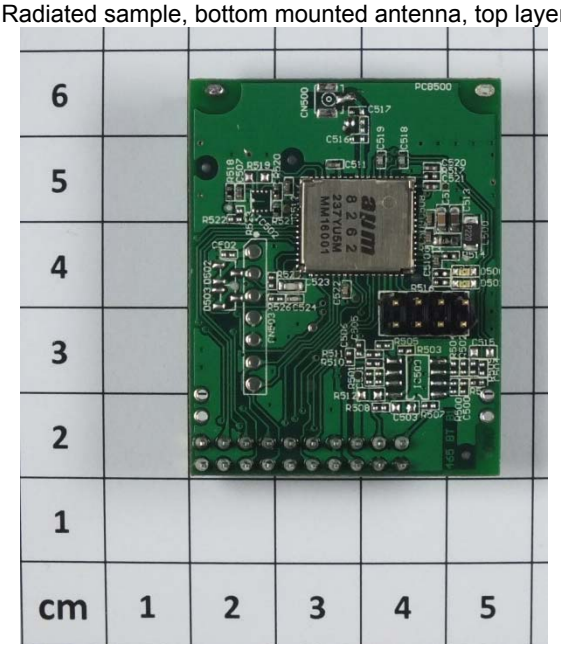
Radiated sample, top mounted antenna, top layer



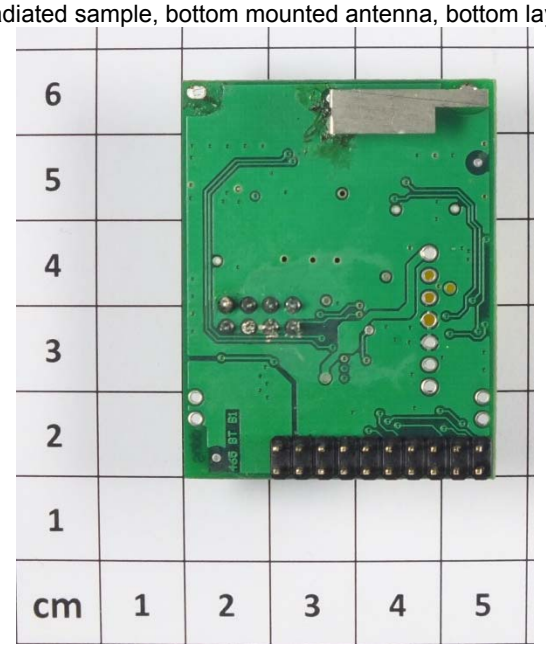
Radiated sample, top mounted antenna, bottom layer



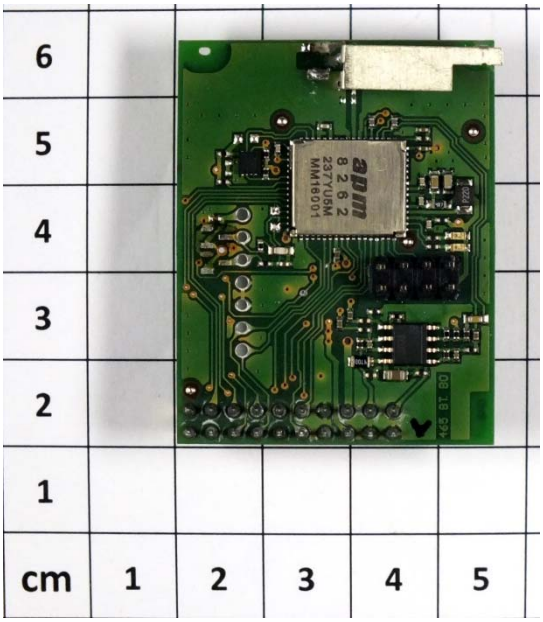
Radiated sample, bottom mounted antenna, top layer



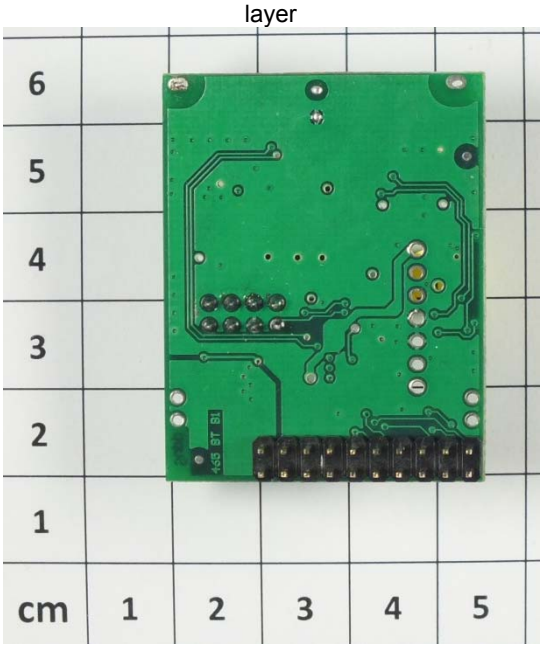
Radiated sample, bottom mounted antenna, bottom layer



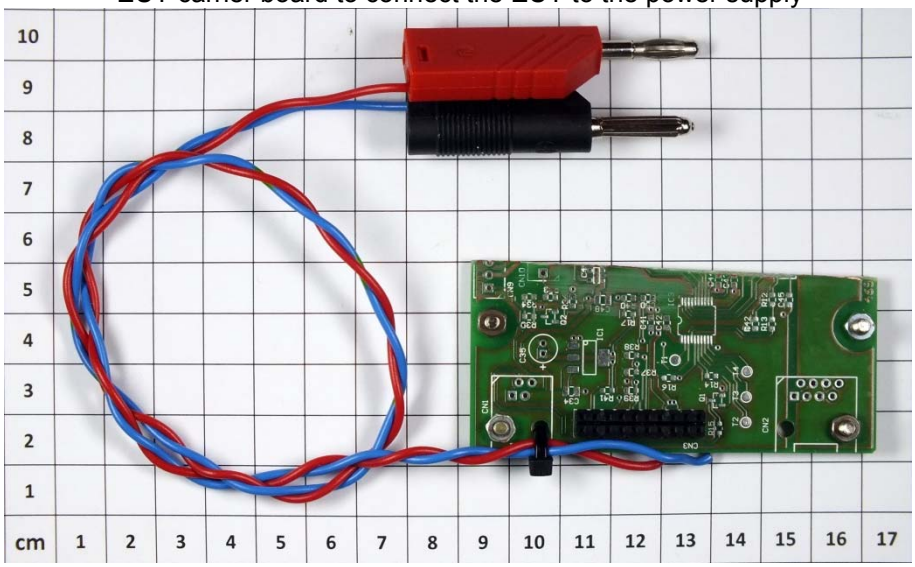
Radiated sample, top mounted antenna and AAC, top layer



Radiated sample, top mounted antenna and AAC, bottom layer



EUT carrier board to connect the EUT to the power supply



3.2 Power supply system utilised

Power supply voltage: : 3.3 VDC

3.3 Short description of the EUT

The EUT is a Bluetooth module working in the 2.4 GHz ISM frequency band. The main use is as wireless high definition audio transceiver following the Bluetooth 2.1 + EDR conventions. The EUT meets the power class 2 and will be used for different wireless audio applications.

Number of tested samples:
1pc, for conducted measurements with audio chip and Apple Authentification Chip (AAC)
1pc, for radiated measurements, top mounted antenna, no additional parts
1pc, for radiated measurements, bottom mounted antenna, no additional parts
1pc, for radiated measurements, top mounted antenna with audio chip and AAC

Serial number: All EUTs are pre-production samples without a serial number

EUT operation mode:

The equipment under test was operated during the measurement under the following conditions:

- TX mode, GFSK

- TX mode, π/4-DQPSK

- TX mode, 8DPSK

EUT configuration:

(The CDF filled by the applicant can be viewed at the test laboratory.)

The following peripheral devices and interface cables were connected during the measurements:

- Power supply (mtp 02-02/50-10-016) Model : HAMEG HM 8143
- USB to SPI Converter for CSR Systems Model : 1324 USB-SPI Converter
- Fujitsu Notebook (mtp 02-01/01-07-006) Model : Lifebook 1560

4 TEST ENVIRONMENT

4.1 Address of the test laboratory

CSA Group Bayern GmbH
Ohmstrasse 1-4
94342 STRASSKIRCHEN
GERMANY

4.2 Environmental conditions

During the measurement the environmental conditions were within the listed ranges:

Temperature:	15-35 ° C
Humidity:	30-60 %
Atmospheric pressure:	86-106 kPa

4.3 Statement of the measurement uncertainty

The data and results referenced in this document are true and accurate. It is noted that the expanded measurement uncertainty corresponds to the measurement results from the standard measurement uncertainty multiplied by the coverage factor k = 2. The true value is located in the corresponding interval with a probability of 95 % The measurement uncertainty was calculated for all measurements listed in this test report acc. to CISPR 16-4-2 / 11.2003 „Uncertainties, statistics and limit modelling – Uncertainty in EMC measurements“ and is documented in the quality system acc. to DIN EN ISO/IEC 17025. For all measurements shown in this report, the measurement uncertainty of the test laboratory, CSA Group Bayern GmbH, is below the measurement uncertainty as defined by CISPR. Therefore, no special measures must be taken into consideration with regard to the limits according to CISPR. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device.

4.4 Measurement protocol for FCC and IC

4.4.1 GENERAL INFORMATION

4.4.1.1 Test methodology

Conducted and radiated disturbance testing is performed according to the procedures set out by the International Special Committee on Radio Interference (CISPR) Publication 22, European Standard EN 55022 as shown under section 1 of this report.

The Open Area test site is a listed Open Site under the Canadian Test-Sites File-No:

IC 3009A-1

In compliance with RSS 210 testing for RSS compliance may be achieved by following the procedures set out in ANSI C63.4 and applying the CISPR 22 limits.

4.4.1.2 Justification

The equipment under test (EUT) is configured in a typical user arrangement in accordance with the manufacturer's instructions. A cable is connected to each available port and either terminated with a peripheral using the appropriate impedance characteristic or left unterminated. Where appropriate, cables are manually manipulated with respect to each other thus obtaining maximum disturbances from the unit.

4.4.1.3 Details of test procedures

The test methods used comply with CISPR Publication 22, EN 55022 - " Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement" and with ANSI C63.4 - "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz". In compliance with 47 CFR Part 15 Subpart A, Section 15.38 testing for FCC compliance may be achieved by following the procedures set out in ANSI C63.4 and applying the CISPR 22 limits.

4.5 Determination of worst case measurement conditions

Measurements have been made in all three orthogonal axes and the settings of the EUT were changed to locate at which position and at what setting of the EUT produce the maximum of the emissions. For the further measurement the EUT is set in X position with the following settings:

Following channels and test modes were selected for the final test as listed below:

Technology	Available channels	Tested channels	Modulation	Packet type
Bluetooth	1 - 79	1, 40, 79	GFSK	DH5
Bluetooth	1 - 79	1, 40, 79	π/4-DQPSK	2-DH5
Bluetooth	1 - 79	1, 40, 79	8DPSK	3-DH5

5 TEST CONDITIONS AND RESULTS

5.1 Conducted emissions

For test instruments and accessories used see section 6 Part **A 4**.

5.1.1 Description of the test location

Test location: NONE

Remarks: The measurement is not applicable. The EUT has no AC mains connection.

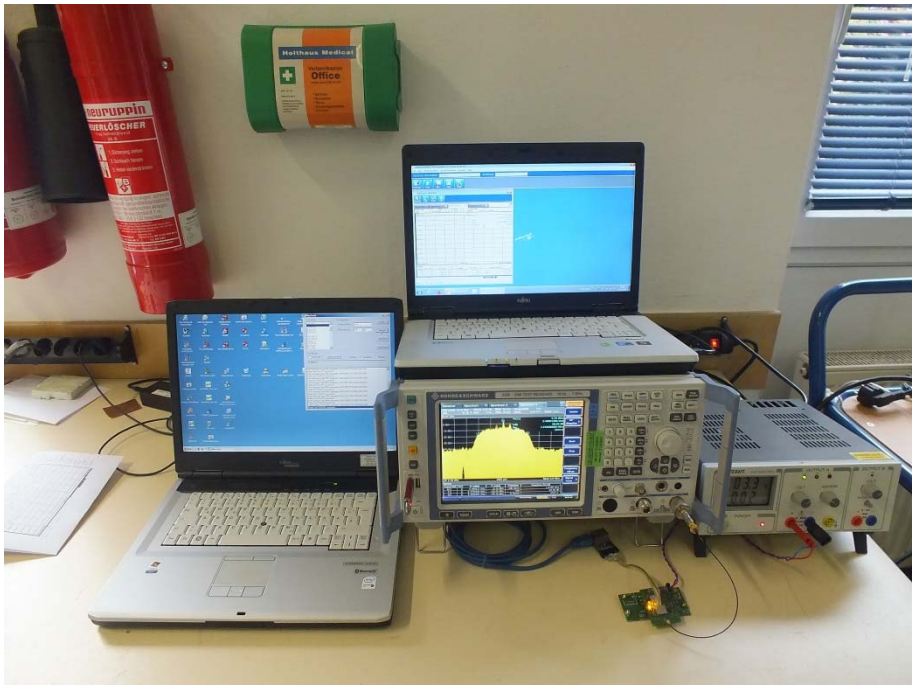
5.2 Emission bandwidth

For test instruments and accessories used see section 6 Part **MB**.

5.2.1 Description of the test location

Test location: AREA4

5.2.2 Photo documentation of the test set-up



5.2.1 Applicable standard

According to FCC Part 15C, Section 15.247(a):
Frequency hopping systems shall have hopping carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

5.2.2 Description of Measurement

The bandwidth is measured at an amplitude level reduced from the reference level by a specified ratio of -20 dB. The reference level is the level of the highest signal amplitude observed from the transmitter at either the fundamental frequency or the first-order modulation products in all typical modes of operation including the unmodulated carrier, even if atypical.
Analyser settings:
RBW: 30 kHz, VBW: 100 kHz, Sweep time: auto, Detector: Peak, Trace mode: Max hold

5.2.3 Test result

EBW, DH5 Packet

Channel	f (MHz)	EBW 20 dB (MHz)	2/3 EBW 20 dB (MHz)	Limit (MHz)
CH1	2402	0.818	0.545	1.0
CH40	2441	0.815	0.543	1.0
CH79	2480	0.818	0.545	1.0

OBW, DH5 Packet

Channel	f (MHz)	OBW 99% (MHz)	2/3 OBW 99% (MHz)	Limit (MHz)
CH1	2402	0.854	0.569	1.0
CH40	2441	0.857	0.571	1.0
CH79	2480	0.851	0.567	1.0

EBW, 2-DH5 Packet

Channel	f (MHz)	EBW 20 dB (MHz)	2/3 EBW 20 dB (MHz)	Limit (MHz)
CH1	2402	1.247	0.831	1.0
CH40	2441	1.247	0.831	1.0
CH79	2480	1.241	0.827	1.0

OBW, 2-DH5 Packet

Channel	f (MHz)	OBW 99% (MHz)	2/3 OBW 99% (MHz)	Limit (MHz)
CH1	2402	1.187	0.791	1.0
CH40	2441	1.178	0.785	1.0
CH79	2480	1.175	0.783	1.0

EBW, 3-DH5 Packet

Channel	f (MHz)	EBW 20 dB (MHz)	2/3 EBW 20 dB (MHz)	Limit (MHz)
CH1	2402	1.232	0.821	1.0
CH40	2441	1.259	0.839	1.0
CH79	2480	1.259	0.839	1.0

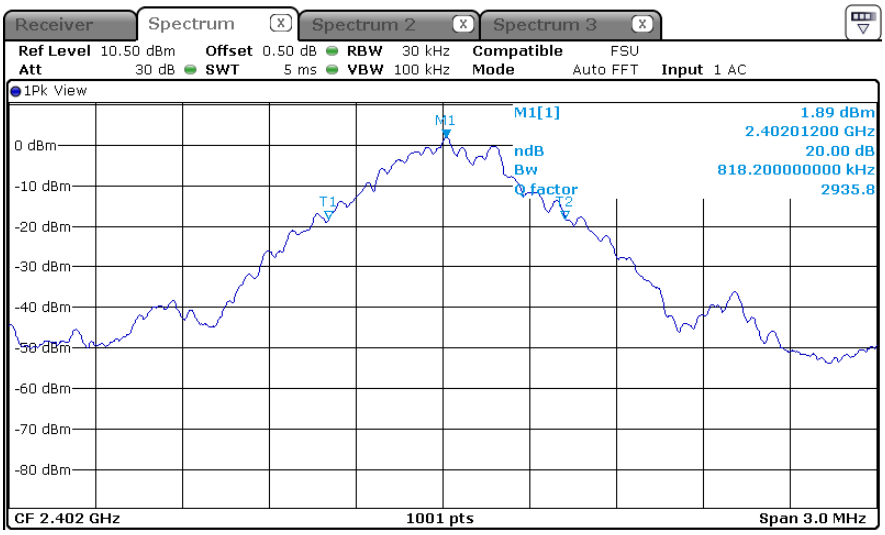
OBW, 3-DH5 Packet

Channel	f (MHz)	OBW 99% (MHz)	2/3 OBW 99% (MHz)	Limit (MHz)
CH1	2402	1.181	0.787	1.0
CH40	2441	1.178	0.785	1.0
CH79	2480	1.172	0.781	1.0

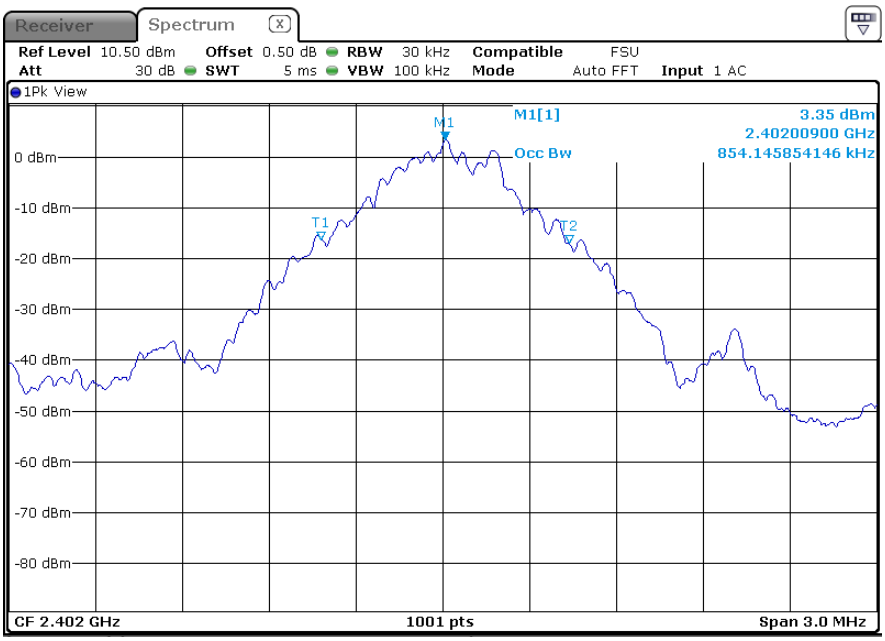
Remarks: For detailed test result please refer to following test protocols.

5.2.4 Test protocol

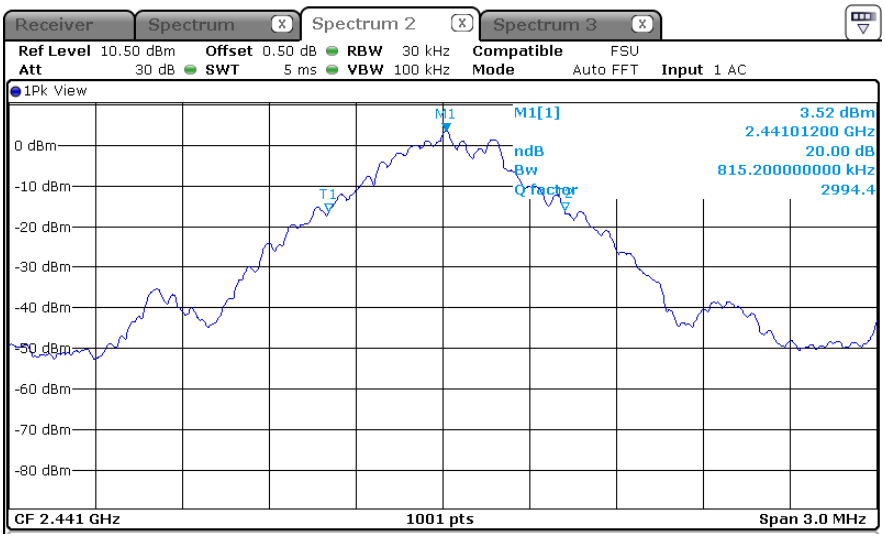
Emission bandwidth, channel 1, DH5 Packet



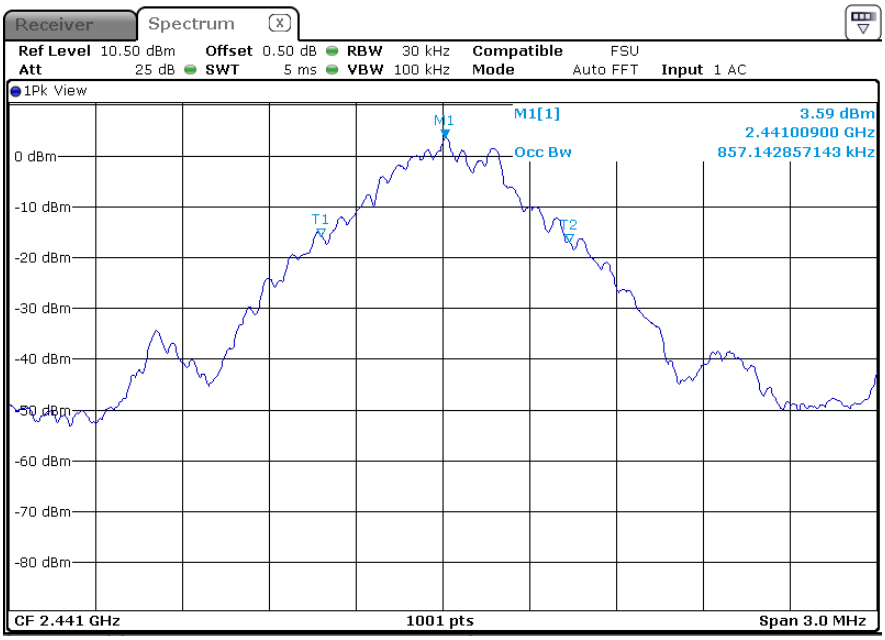
Occupied bandwidth, channel 1, DH5 Packet



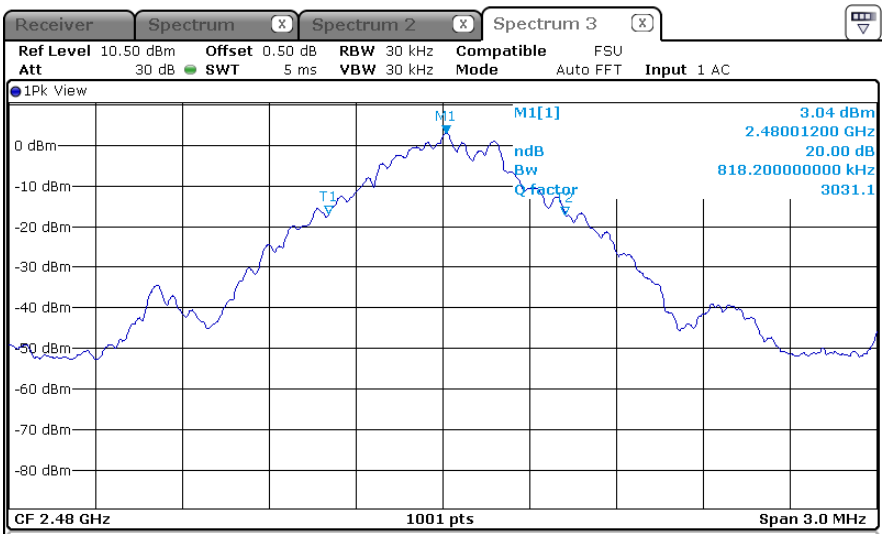
Emission bandwidth, channel 40, DH5 Packet



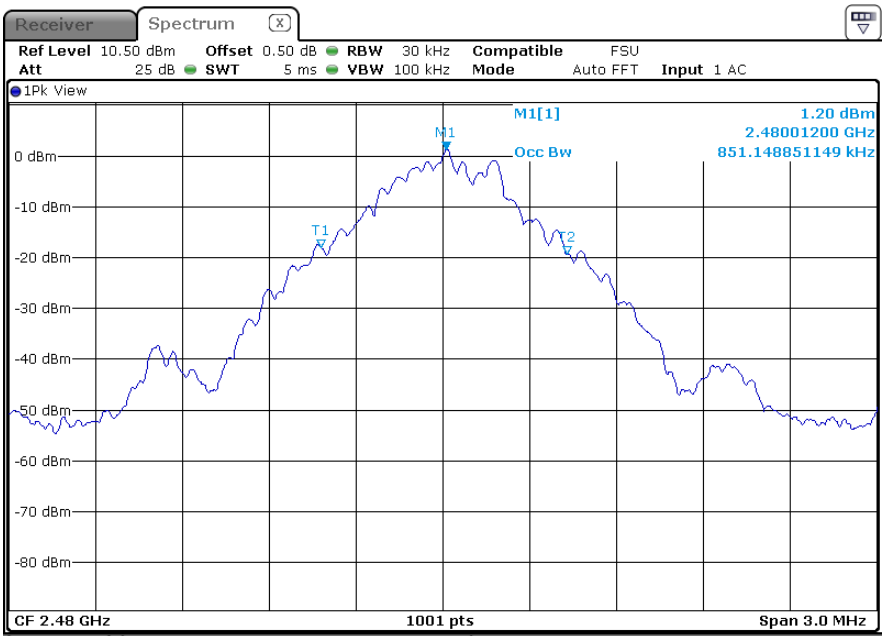
Occupied bandwidth, channel 40, DH5 Packet



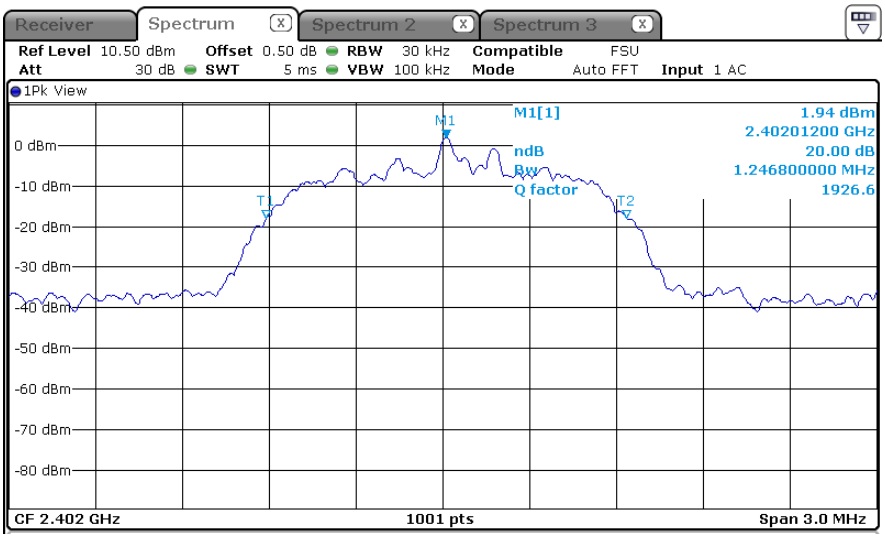
Emission bandwidth, channel 79, DH5 Packet



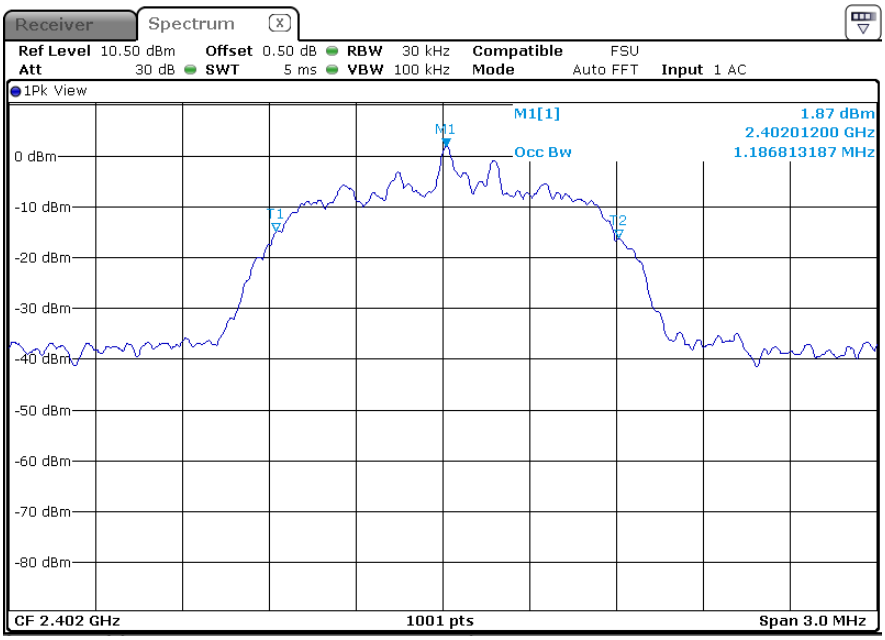
Occupied bandwidth, channel 79, DH5 Packet



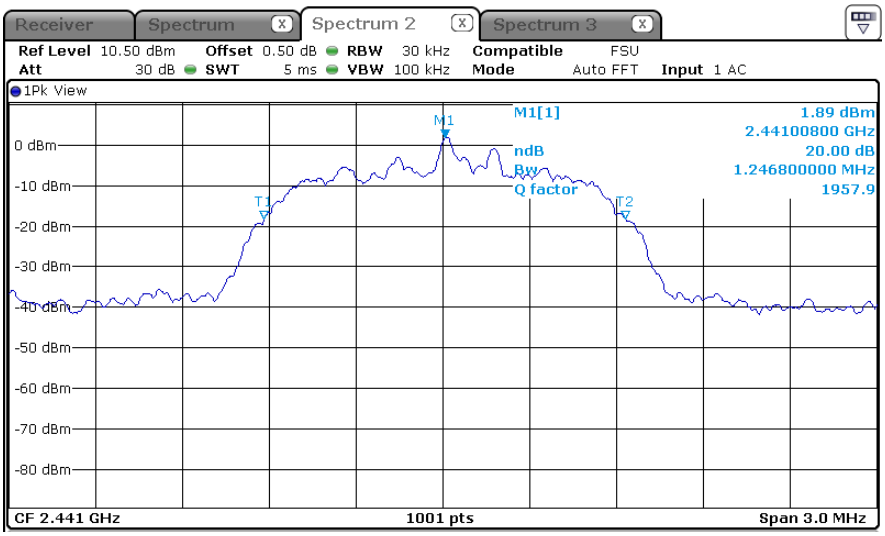
Emission bandwidth, channel 1, 2-DH5 Packet



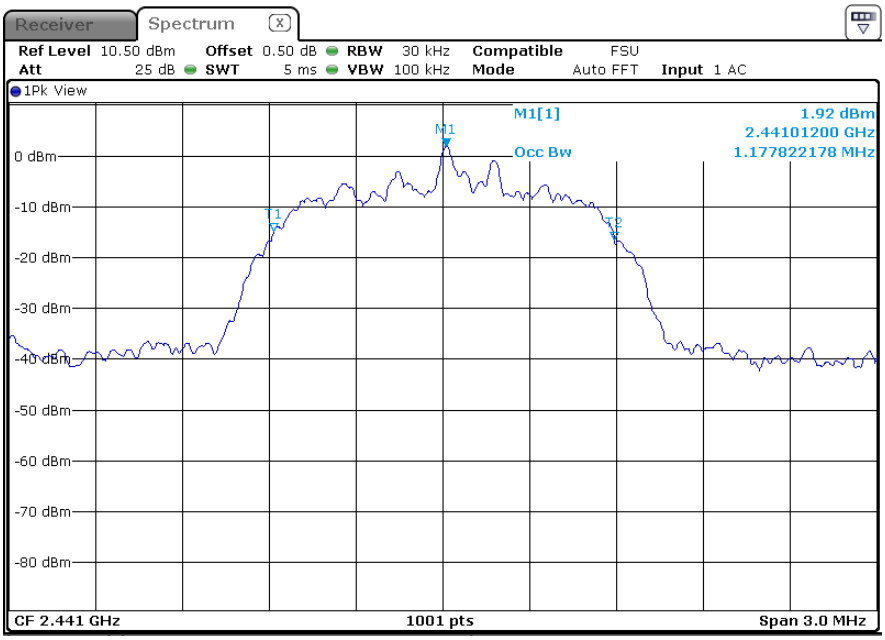
Occupied bandwidth, channel 1, 2-DH5 Packet



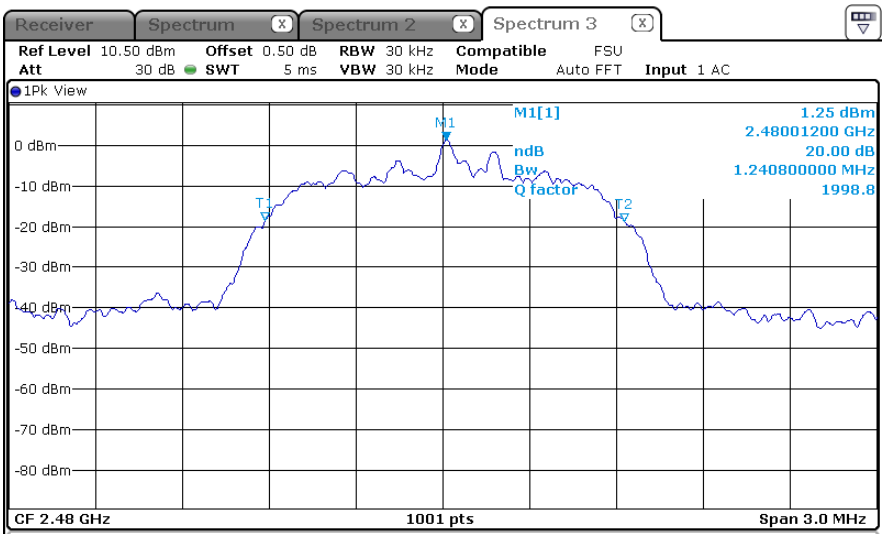
Emission bandwidth, channel 40, 2-DH5 Packet



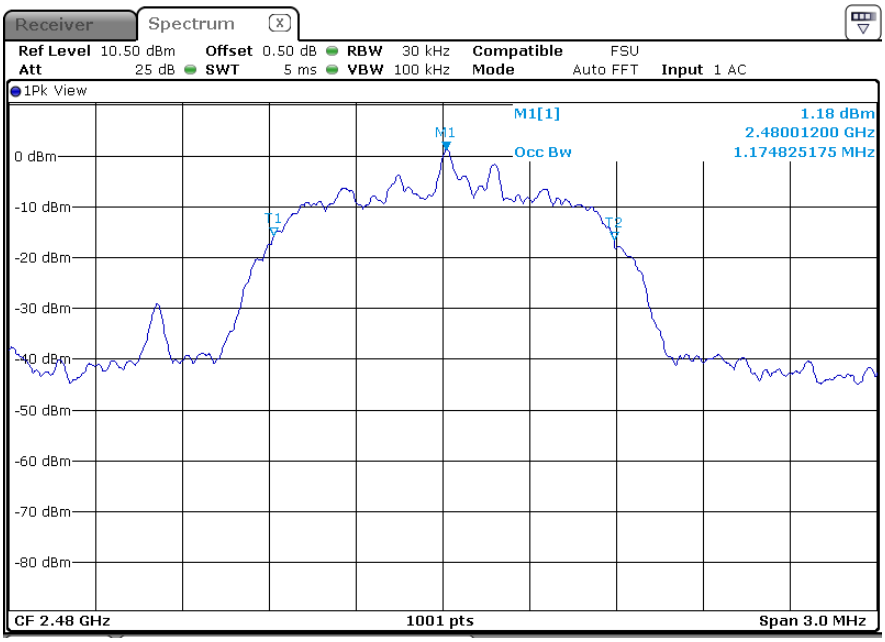
Occupied bandwidth, channel 40, 2-DH5 Packet



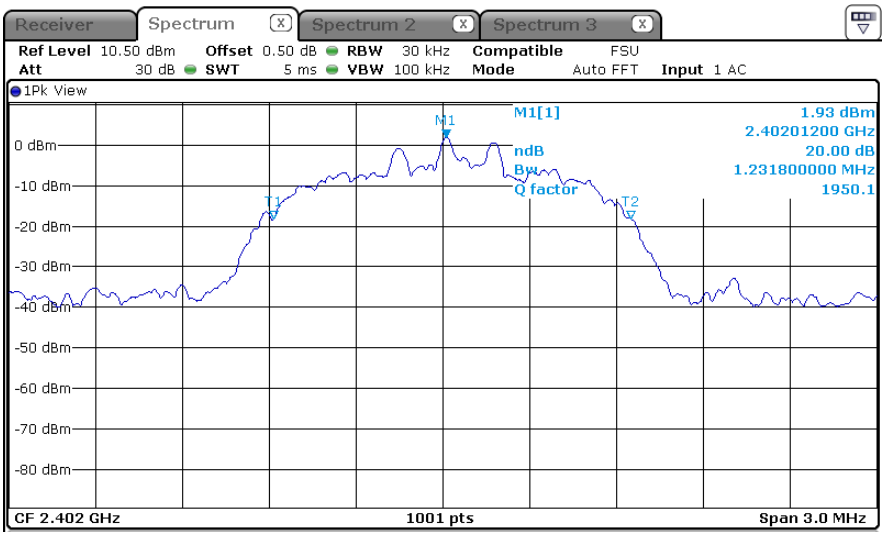
Emission bandwidth, channel 79, 2-DH5 Packet



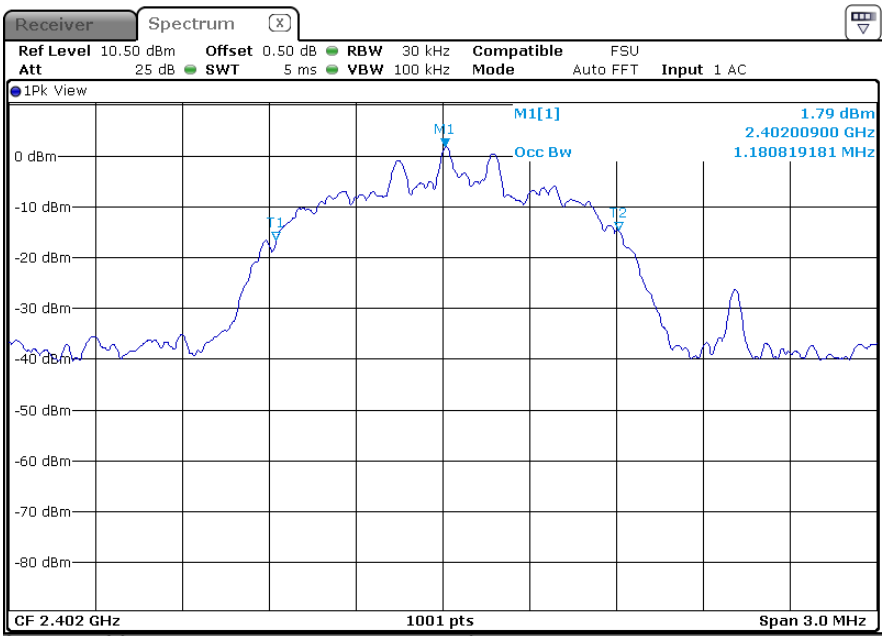
Occupied bandwidth, channel 79, 2-DH5 Packet



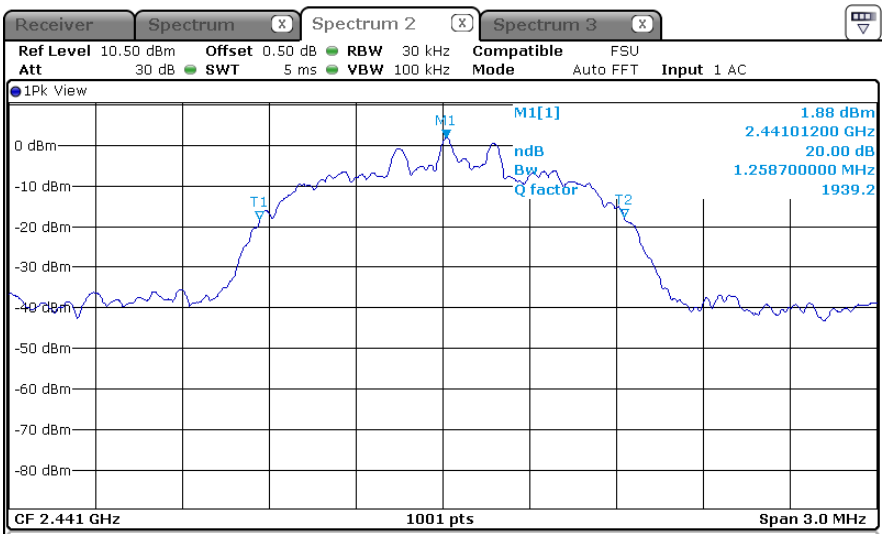
Emission bandwidth, channel 1, 3-DH5 Packet



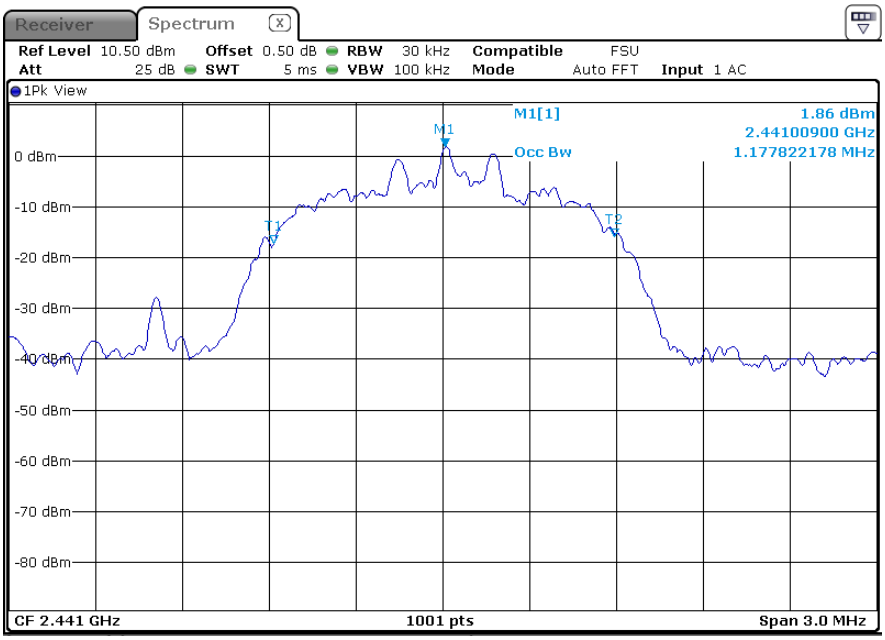
Occupied bandwidth, channel 1, 3-DH5 Packet



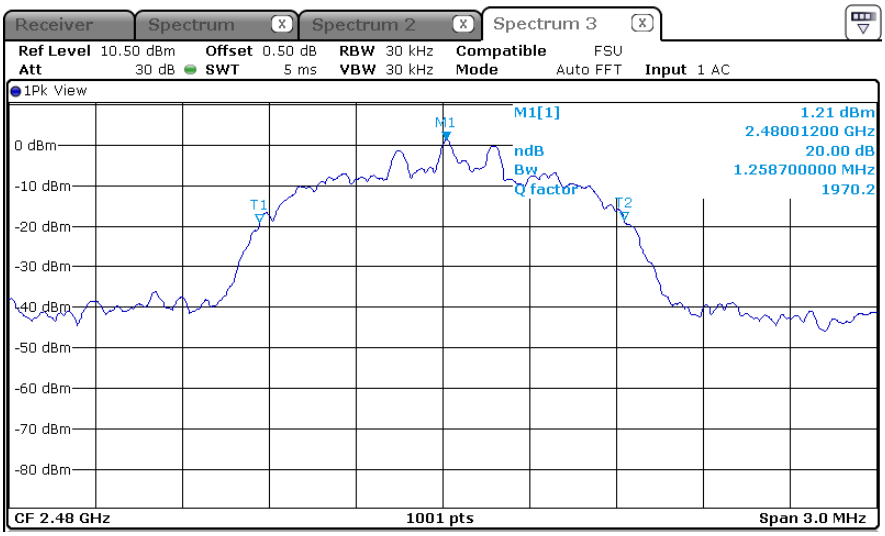
Emission bandwidth, channel 40, 3-DH5 Packet



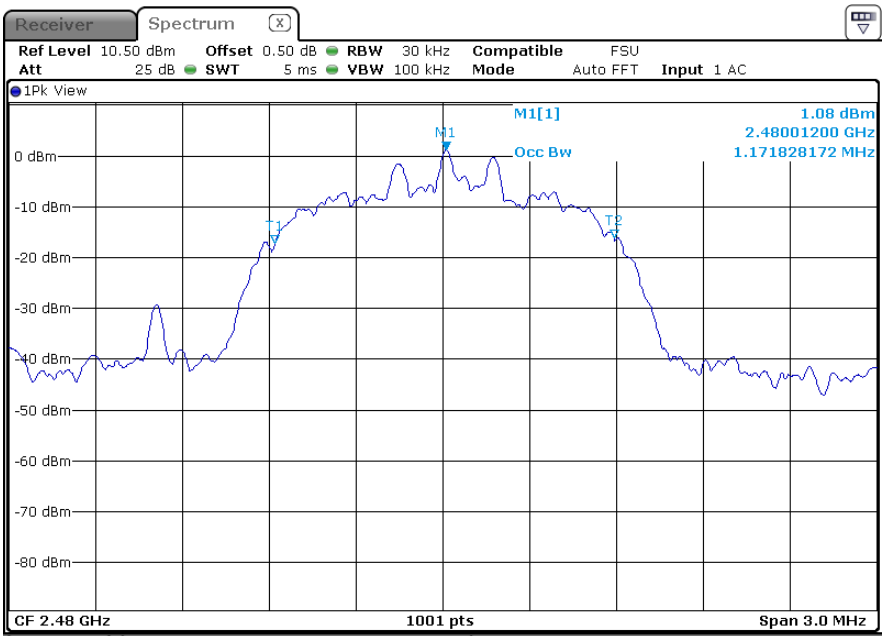
Occupied bandwidth, channel 40, 3-DH5 Packet



Emission bandwidth, channel 79, 3-DH5 Packet



Occupied bandwidth, channel 79, 3-DH5 Packet



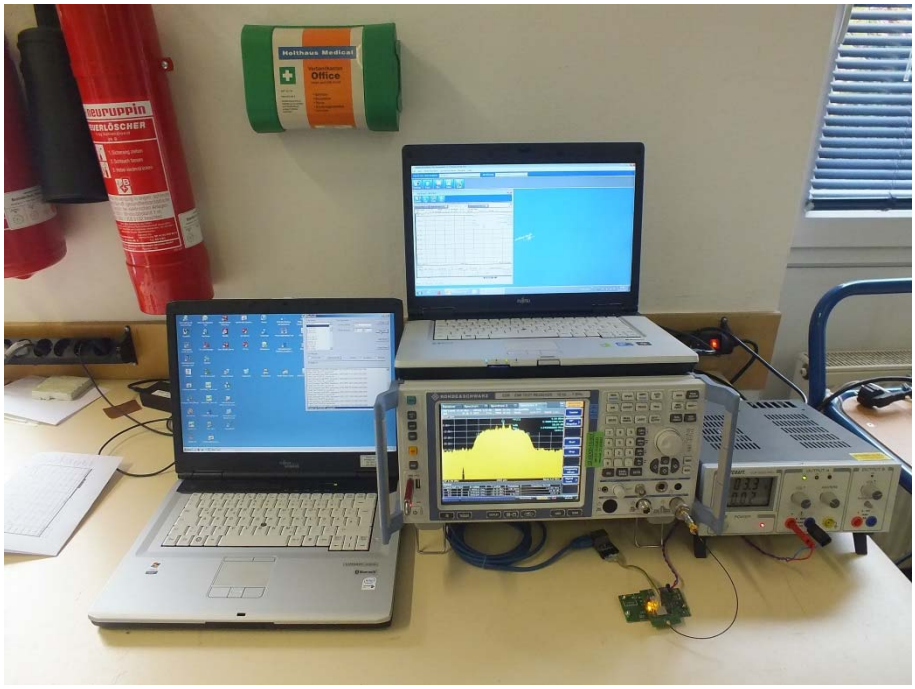
5.3 Maximum peak output power conducted

For test instruments and accessories used see section 6 Part **CPC 3**.

5.3.1 Description of the test location

Test location: AREA4

5.3.2 Photo documentation of the test set-up



5.3.3 Applicable standard

According to FCC Part 15C, Section 15.247(a)(1):
The maximum peak output power of an intentional radiator shall not exceed the limit defined in dependency of the channel separation and of the number of hopping channels.

5.3.4 Description of Measurement

A spectrum analyser is connected to the output of the transmitter via a suitable attenuator while EUT is operating in transmit mode using the assigned frequency according to DA 00-705. The correction factor takes the cable loss into account.

Analyser settings:
RBW: 3 MHz, VBW = 10 MHz, Detector: Max peak, Trace: Max hold, Sweep time: auto

5.3.5 Test result

DH5 Packet

Channel No.	f (MHz)	A (dBm)	Gain (dBi)	P (dBm)	Limit (dBm)	Delta (dB)
CH1	2402	3.87	-3.0	0.9	30	-29.1
CH40	2441	4.04	-3.0	1.0	30	-29.0
CH79	2480	3.62	-3.0	0.6	30	-29.4

2-DH5 Packet

Channel No.	f (MHz)	A (dBm)	Gain (dBi)	P (dBm)	Limit (dBm)	Delta (dB)
CH1	2402	3.12	-3.0	0.1	30	-29.9
CH40	2441	3.19	-3.0	0.2	30	-29.8
CH79	2480	2.58	-3.0	-0.4	30	-30.4

3-DH5 Packet

Channel No.	f (MHz)	A (dBm)	Gain (dBi)	P (dBm)	Limit (dBm)	Delta (dB)
1	2402	3.32	-3.0	0.3	30	-29.7
40	2441	3.44	-3.0	0.4	30	-29.6
79	2480	2.88	-3.0	-0.1	30	-30.1

Peak Power Limit according to FCC Part 15C, Section 15.247(b)(1):

Frequency	Channel separation	Hopping	Peak power limit	
(MHz)	(MHz)	Channels	(dBm)	(Watt)
2400-2483.5	1.0	≥ 75	30	1

The requirements are **fulfilled**

Remarks: _____

_____

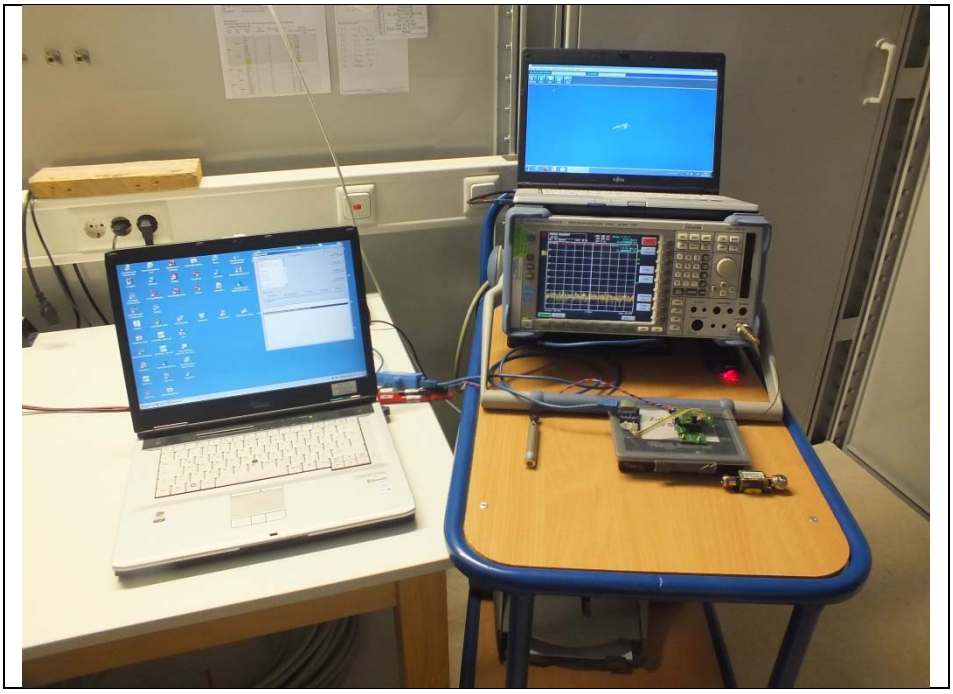
5.4 Spurious emissions conducted

For test instruments and accessories used see section 6 Part **SEC1, SEC2 and SEC3**.

5.4.1 Description of the test location

Test location: AREA4

5.4.2 Photo documentation of the test set-up



5.4.3 Applicable standard

According to FCC Part 15C, Section 15.247(d):
In any 100 kHz bandwidth outside the frequency bands 2400 – 2483.5 MHz and 5725 – 5850 MHz, the digitally modulated radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or an radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required.

5.4.4 Description of Measurement

A spectrum analyser is connected to the output of the transmitter via a suitable attenuator while EUT is operating in transmit mode using the assigned frequency according to DA 00-705. In the range from 9 kHz up to 150 kHz a correction of 6 dB and in the range from 150 kHz up to 30 MHz a correction of 4.7 dB oper air test site correction factor is taken into account.

Spectrum analyser/Test receiver settings:

9 - 150 kHz:	RBW: 300 Hz,	VBW: 1 kHz,	Detector: Max peak,	Trace Mode: Max hold;
0.15 - 30 MHz:	RBW: 10 kHz,	VBW: 30 kHz,	Detector: Max peak,	Trace Mode: Max hold;
30 – 1000 MHz:	RBW: 100 kHz,	VBW: 300 kHz,	Detector: Max peak,	Trace Mode: Max hold;
1 – 25 GHz:	RBW: 100 kHz,	VBW: 300 kHz,	Detector: Max peak,	Trace Mode: Max hold;

5.4.5 Test result

Lowest frequency generated in the EUT: 24 MHz

Determination of the limit level for modulation type DH5: CH79, max level = -16.5 dBm
Determination of the limit level for modulation type 2-DH5 and 3-DH5: CH79, max level = -18.4 dBm;

Lowest frequency: 2402 MHz							
Test conditions: TX , Pmax, DH5 Packet							
Reference power level: maximum						3.5 dBm	
			Test results				
Start *f*	Stop *f*	RBW	Maximum emission		Correction	Limit	Margin
(MHz)	(MHz)	(kHz)	(MHz)	(dBm)	(dB)	(dBm)	(dB)
0.009	0.15	0.3	0.036	-83.6	6.0	-16.5	-61.1
0.15	30	10	23.969	-83.3	4.7	-16.5	-62.2
30	1000	100	223.932	-77.5	0.0	-16.5	-61.0
1000	2400	100	1601.50	-57.4	0.0	-16.5	-40.9
2483.5	4000	100	3204.25	-53.8	0.0	-16.5	-37.4
4000	8000	100	4804.00	-45.0	0.0	-16.5	-28.5
8000	16000	100	9608.00	-68.0	0.0	-16.5	-51.5
16000	25000	100	23956.00	-70.3	0.0	-16.5	-53.8
Measurement uncertainty			±3 dB				

Middle frequency: 2441 MHz							
Test conditions: TX , Pmax, DH5 Packet							
Reference power level: maximum						3.5 dBm	
			Test results				
Start *f*	Stop *f*	RBW	Maximum emission		Correction	Limit	Margin
(MHz)	(MHz)	(kHz)	(MHz)	(dBm)	(dB)	(dBm)	(dB)
0.009	0.15	0.3	0.036	-91.5	6.0	-16.5	-69.0
0.15	30	10	23.915	-83.1	4.7	-16.5	-61.9
30	1000	100	224.029	-79.4	0.0	-16.5	-62.9
1000	2400	100	1626.25	-57.1	0.0	-16.5	-40.6
2483.5	4000	100	3253.75	-53.1	0.0	-16.5	-36.7
4000	8000	100	4882.00	-49.6	0.0	-16.5	-33.1
8000	16000	100	9764.00	-59.2	0.0	-16.5	-42.7
16000	25000	100	23913.25	-69.9	0.0	-16.5	-53.4
Measurement uncertainty			±3 dB				

Highest frequency: 2480 MHz							
Test conditions: TX , Pmax, DH5 Packet							
Reference power level: maximum						3.5 dBm	
			Test results				
Start *f*	Stop *f*	RBW	Maximum emission		Correction	Limit	Margin
(MHz)	(MHz)	(kHz)	(MHz)	(dBm)	(dB)	(dBm)	(dB)
0.009	0.15	0.3	0.036	-86.0	6.0	-16.5	-63.5
0.15	30	10	24.054	-82.9	4.7	-16.5	-61.7
30	1000	100	224.029	-78.5	0.0	-16.5	-62.0
1000	2400	100	1652.50	-57.1	0.0	-16.5	-40.7
2483.5	4000	100	3305.50	-53.3	0.0	-16.5	-36.9
4000	8000	100	4960.50	-40.7	0.0	-16.5	-24.2
8000	16000	100	9916.00	-68.6	0.0	-16.5	-52.2
16000	25000	100	16498.38	-62.2	0.0	-16.5	-45.7
Measurement uncertainty			±3 dB				

Lowest frequency: 2402 MHz							
Test conditions: TX, Pmax, 2-DH5 Packet							
Reference power level: maximum						1.6 dBm	
			Test results				
Start *f*	Stop *f*	RBW	Maximum emission		Correction	Limit	Margin
(MHz)	(MHz)	(kHz)	(MHz)	(dBm)	(dB)	(dBm)	(dB)
0.009	0.15	0.3	0.036	-85.4	6.0	-18.4	-61.0
0.15	30	10	23.992	-82.8	4.7	-18.4	-59.7
30	1000	100	224.029	-76.3	0.0	-18.4	-58.0
1000	2400	100	1601.50	-55.4	0.0	-18.4	-37.0
2483.5	4000	100	3204.25	-53.0	0.0	-18.4	-34.6
4000	8000	100	4803.50	-54.0	0.0	-18.4	-35.7
8000	16000	100	9612.00	-72.9	0.0	-18.4	-54.5
16000	25000	100	23960.50	-69.4	0.0	-18.4	-51.1
Measurement uncertainty			±3 dB				

Middle frequency: 2441 MHz							
Test conditions: TX, Pmax, 2-DH5 Packet							
Reference power level: maximum						1.6 dBm	
			Test results				
Start *f*	Stop *f*	RBW	Maximum emission		Correction	Limit	Margin
(MHz)	(MHz)	(kHz)	(MHz)	(dBm)	(dB)	(dBm)	(dB)
0.009	0.15	0.3	0.036	-85.2	6.0	-18.4	-60.8
0.15	30	10	24.034	-83.4	4.7	-18.4	-60.3
30	1000	100	160.015	-78.5	0.0	-18.4	-60.2
1000	2400	100	1626.25	-55.7	0.0	-18.4	-37.3
2483.5	4000	100	3253.75	-52.8	0.0	-18.4	-34.4
4000	8000	100	4882.00	-52.6	0.0	-18.4	-34.2
8000	16000	100	9764.00	-69.9	0.0	-18.4	-51.5
16000	25000	100	24.23	-69.7	0.0	-18.4	-51.3
Measurement uncertainty			±3 dB				

Highest frequency: 2480 MHz							
Test conditions: TX, Pmax, 2-DH5 Packet							
Reference power level: maximum						1.6 dBm	
			Test results				
Start *f*	Stop *f*	RBW	Maximum emission		Correction	Limit	Margin
(MHz)	(MHz)	(kHz)	(MHz)	(dBm)	(dB)	(dBm)	(dB)
0.009	0.15	0.3	0.035	-86.4	6.0	-18.4	-62.1
0.15	30	10	24.034	-82.7	4.7	-18.4	-59.7
30	1000	100	256.036	-75.5	0.0	-18.4	-57.2
1000	2400	100	1652.50	-56.1	0.0	-18.4	-37.8
2483.5	4000	100	3305.50	-52.7	0.0	-18.4	-34.3
4000	8000	100	4960.00	-49.9	0.0	-18.4	-31.5
8000	16000	100	9916.00	-67.8	0.0	-18.4	-49.5
16000	25000	100	16497.25	-69.1	0.0	-18.4	-50.7
Measurement uncertainty			±3 dB				

Lowest frequency: 2402 MHz							
Test conditions: TX, Pmax, 3-DH5 Packet							
Reference power level: maximum						1.6 dBm	
			Test results				
Start *f*	Stop *f*	RBW	Maximum emission		Correction	Limit	Margin
(MHz)	(MHz)	(kHz)	(MHz)	(dBm)	(dB)	(dBm)	(dB)
0.009	0.15	0.3	0.039	-87.3	6.0	-18.4	-63.0
0.15	30	10	24.028	-83.9	4.7	-18.4	-60.8
30	1000	100	231.982	-78.1	0.0	-18.4	-59.7
1000	2400	100	1601.50	-60.4	0.0	-18.4	-42.0
2483.5	4000	100	3204.25	-53.2	0.0	-18.4	-34.8
4000	8000	100	4804.00	-53.5	0.0	-18.4	-35.1
8000	16000	100	9612.00	-72.9	0.0	-18.4	-54.5
16000	25000	100	23929.00	-70.1	0.0	-18.4	-51.7
Measurement uncertainty			±3 dB				

Middle frequency: 2441 MHz							
Test conditions: TX, Pmax, 3-DH5 Packet							
Reference power level: maximum						1.6 dBm	
			Test results				
Start *f*	Stop *f*	RBW	Maximum emission		Correction	Limit	Margin
(MHz)	(MHz)	(kHz)	(MHz)	(dBm)	(dB)	(dBm)	(dB)
0.009	0.15	0.3	0.036	-81.1	6.0	-18.4	-56.8
0.15	30	10	23.939	-83.1	4.7	-18.4	-60.0
30	1000	100	256.036	-77.3	0.0	-18.4	-58.9
1000	2400	100	1626.25	-56.5	0.0	-18.4	-38.2
2483.5	4000	100	3253.75	-53.0	0.0	-18.4	-34.6
4000	8000	100	4882.00	-52.8	0.0	-18.4	-34.5
8000	16000	100	9764.00	-69.9	0.0	-18.4	-51.5
16000	25000	100	24103.38	-69.4	0.0	-18.4	-51.1
Measurement uncertainty			±3 dB				

Highest frequency: 2480 MHz							
Test conditions: TX, Pmax, 3-DH5 Packet							
Reference power level: maximum						1.6 dBm	
			Test results				
Start *f*	Stop *f*	RBW	Maximum emission		Correction	Limit	Margin
(MHz)	(MHz)	(kHz)	(MHz)	(dBm)	(dB)	(dBm)	(dB)
0.009	0.15	0.3	0.036	-84.9	6.0	-18.4	-60.5
0.15	30	10	24.028	-83.1	4.7	-18.4	-60.0
30	1000	100	263.989	-79.5	0.0	-18.4	-61.2
1000	2400	100	1652.50	-55.2	0.0	-18.4	-36.8
2483.5	4000	100	3305.50	-51.4	0.0	-18.4	-33.1
4000	8000	100	4959.50	-53.3	0.0	-18.4	-34.9
8000	16000	100	9916.00	-67.8	0.0	-18.4	-49.5
16000	25000	100	16498.88	-65.3	0.0	-18.4	-47.0
Measurement uncertainty			±3 dB				

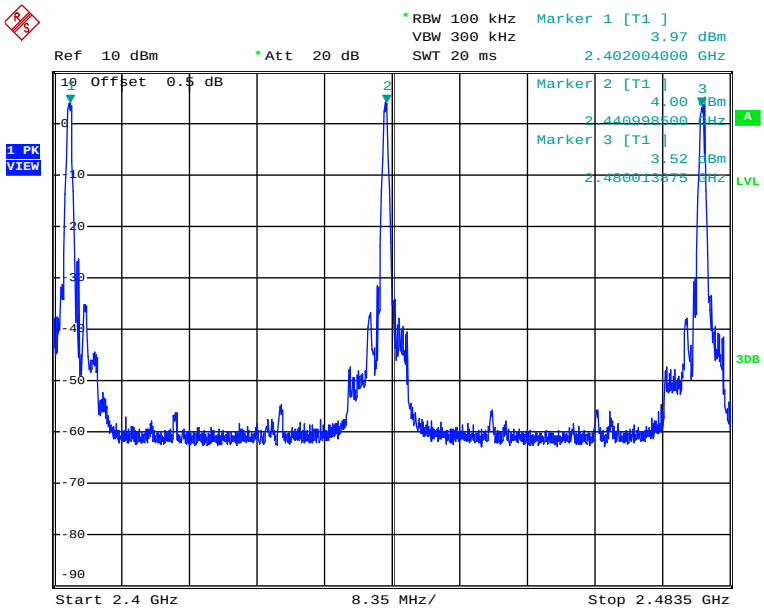
Peak-Limit according to FCC Part 15C, Section 15.247(d):
In any 100 kHz bandwidth outside the frequency band 2400 – 2483.50 MHz, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limit specified in Section 15.209(a).

The requirements are **fulfilled**

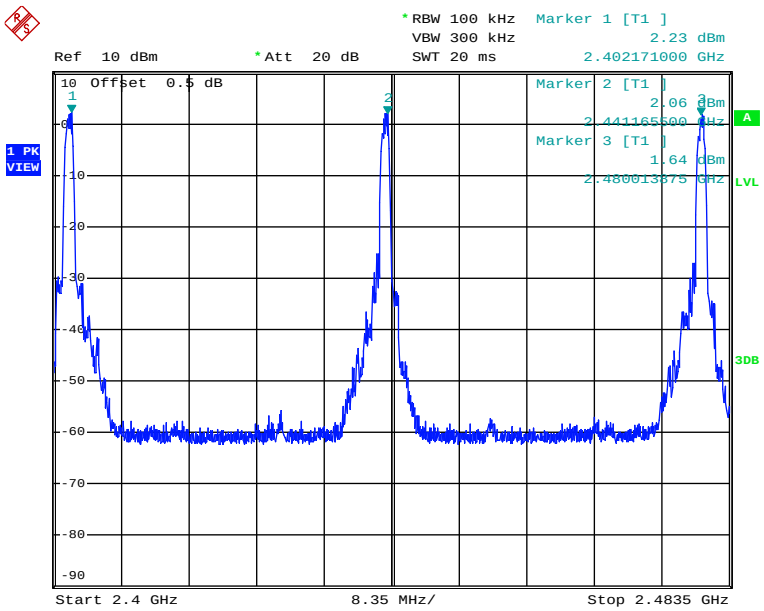
Remarks: For detailed test results please refer to following test protocols.

5.4.6 Test protocol

Determination of the limit level for modulation type DH5
2.4 GHz – 2.4835 GHz, Channel 79

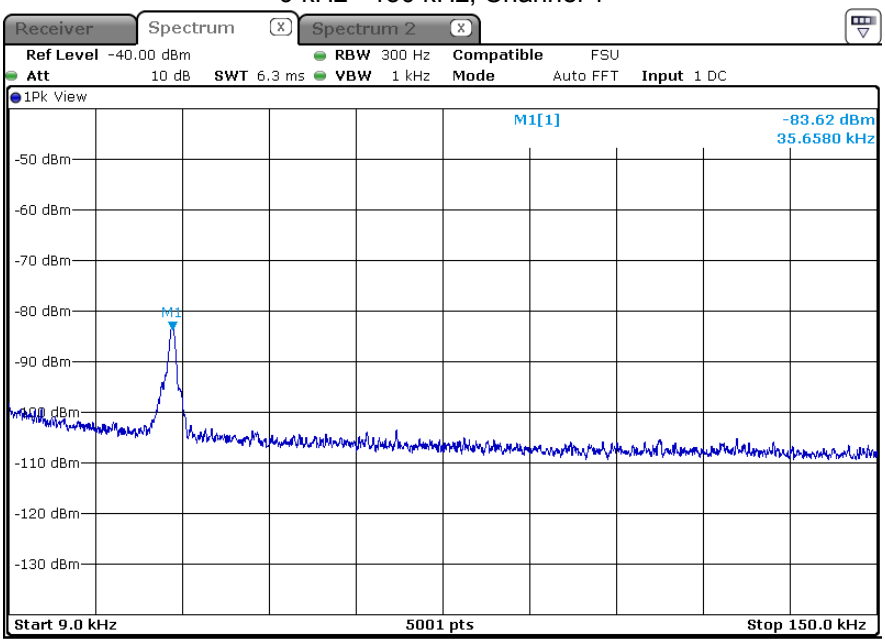


Determination of the limit level for modulation type 2-DH5 and 3-DH5
2.4 GHz – 2.4835 GHz, Channel 79

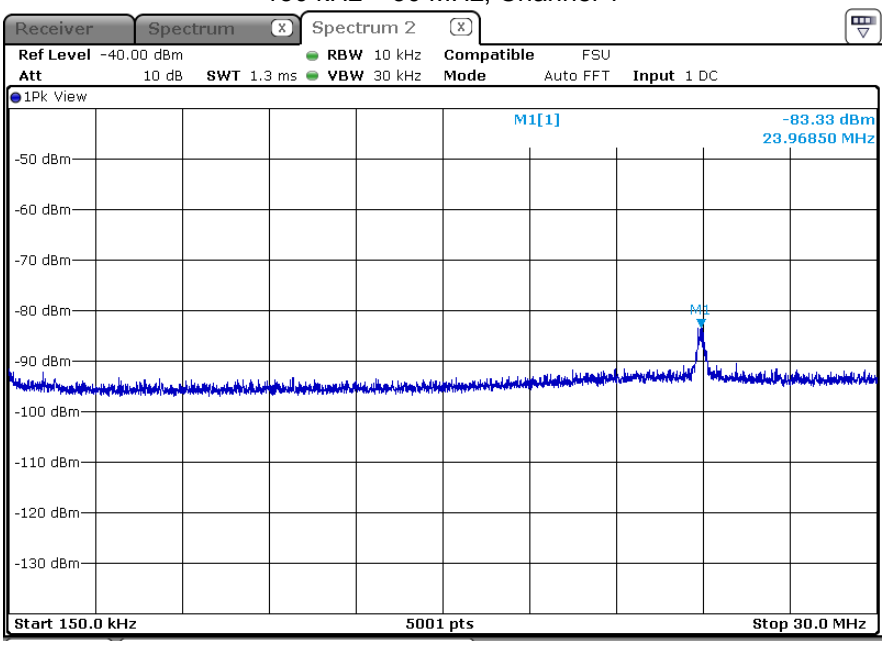


5.4.6.1 Spurious emissions conducted, DH5 packet:

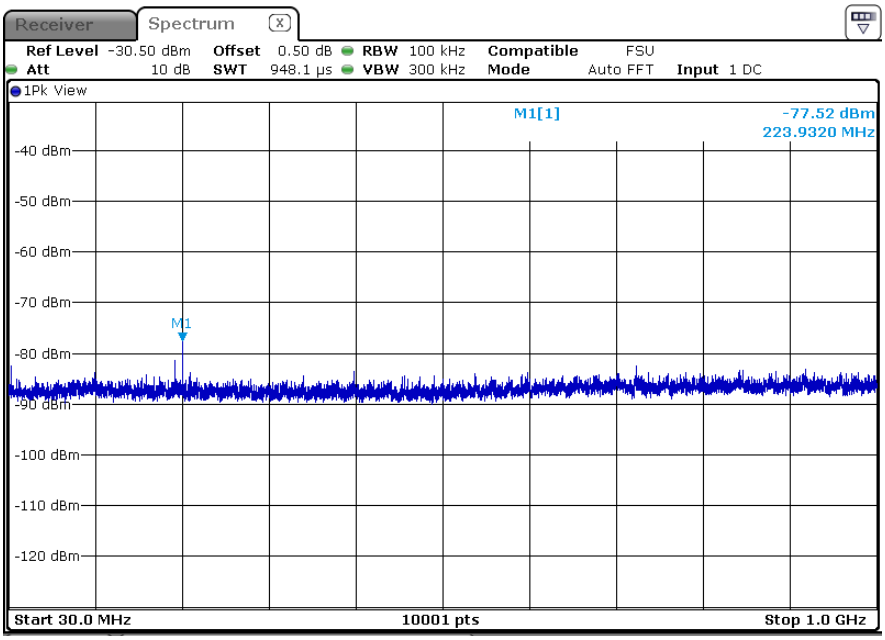
9 kHz - 150 kHz, Channel 1



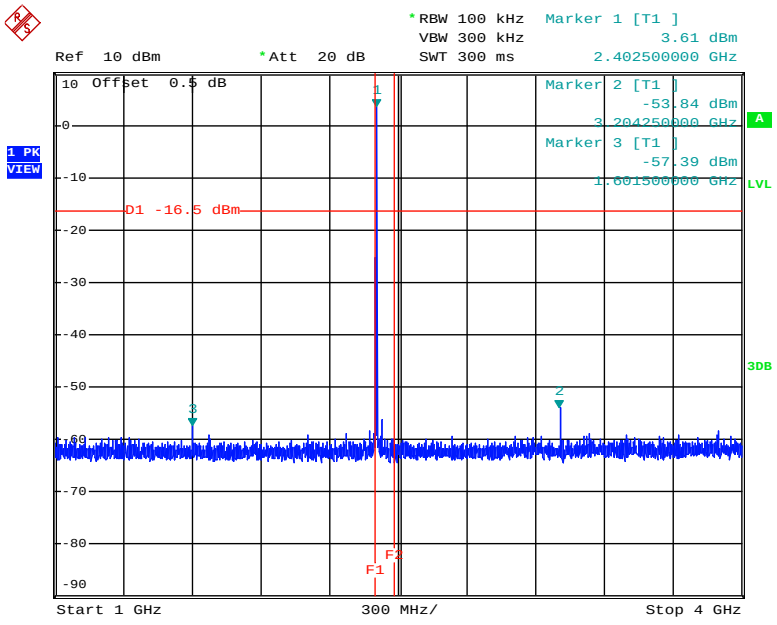
150 kHz – 30 MHz, Channel 1



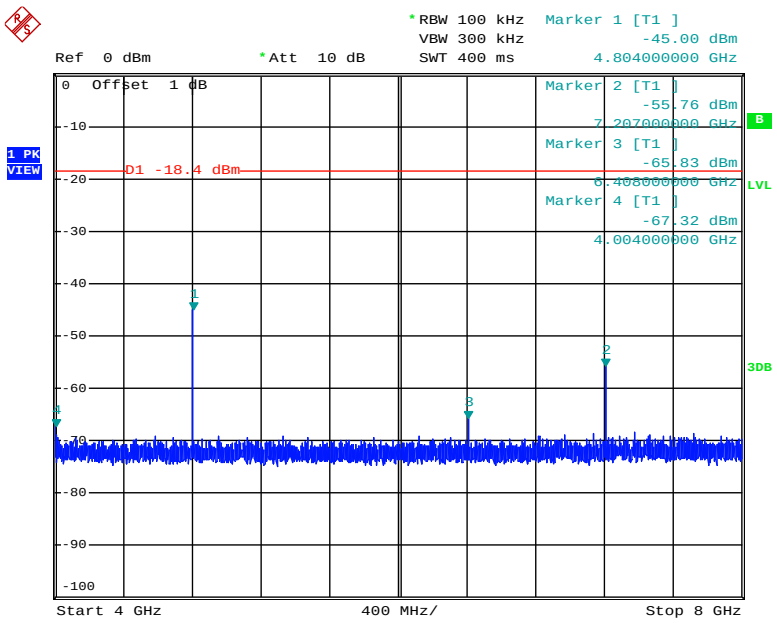
30 MHz – 1 GHz, Channel 1



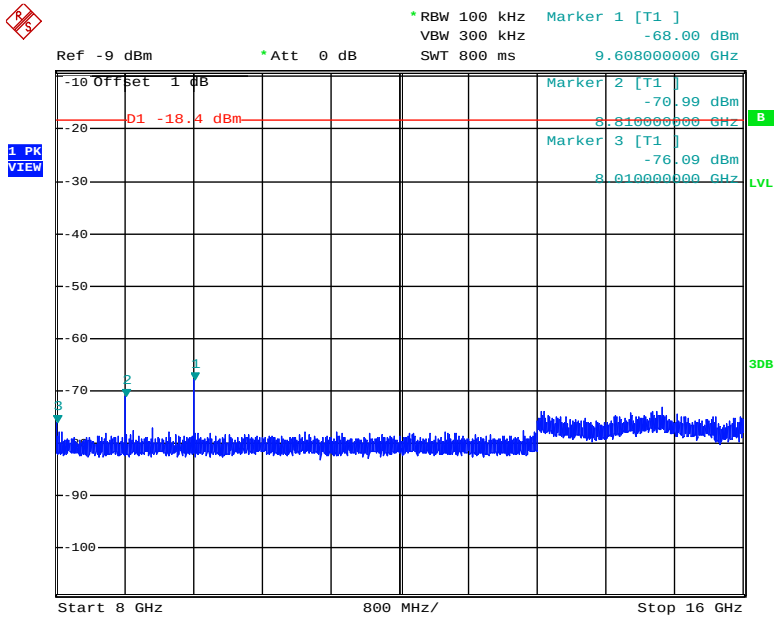
1 GHz – 4 GHz, Channel 1



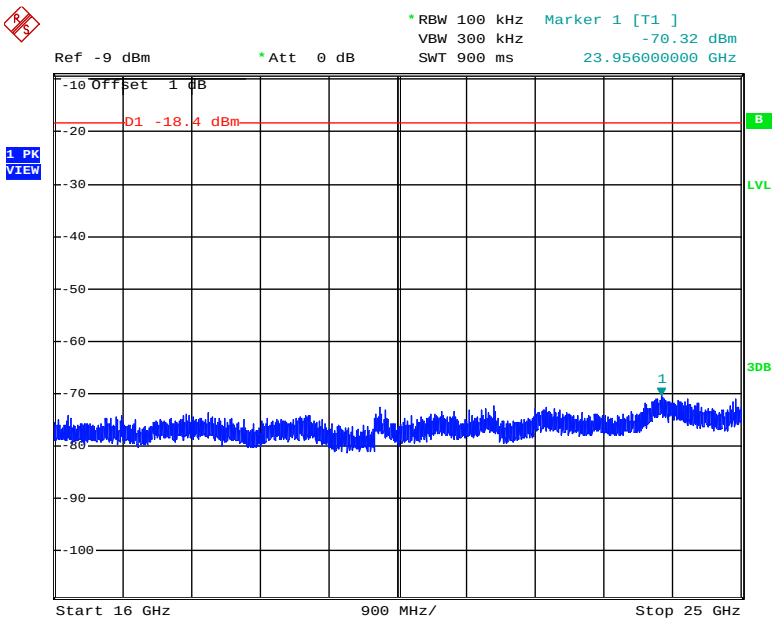
4 GHz – 8 GHz, Channel 1



8 GHz – 16 GHz, Channel 1

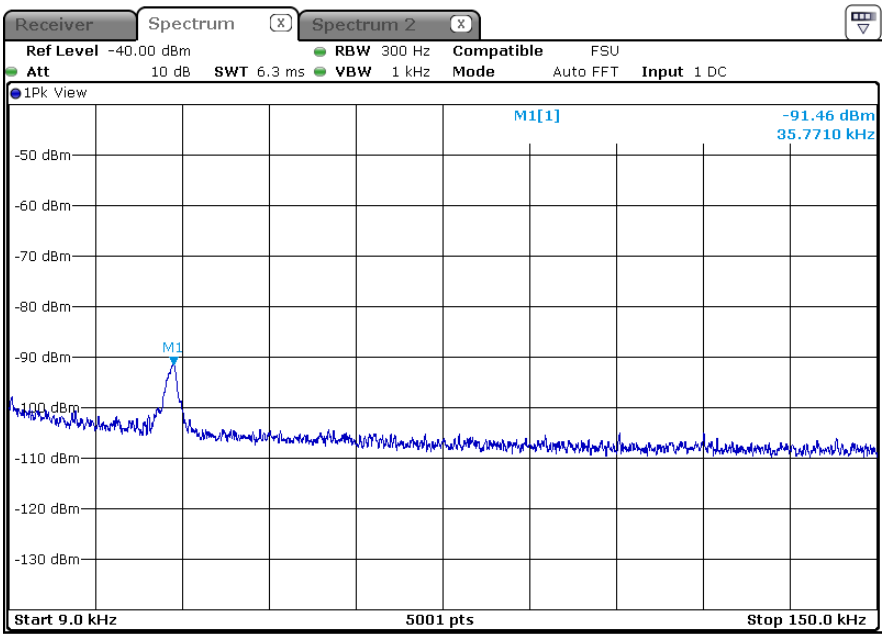


16 GHz – 25 GHz, Channel 1

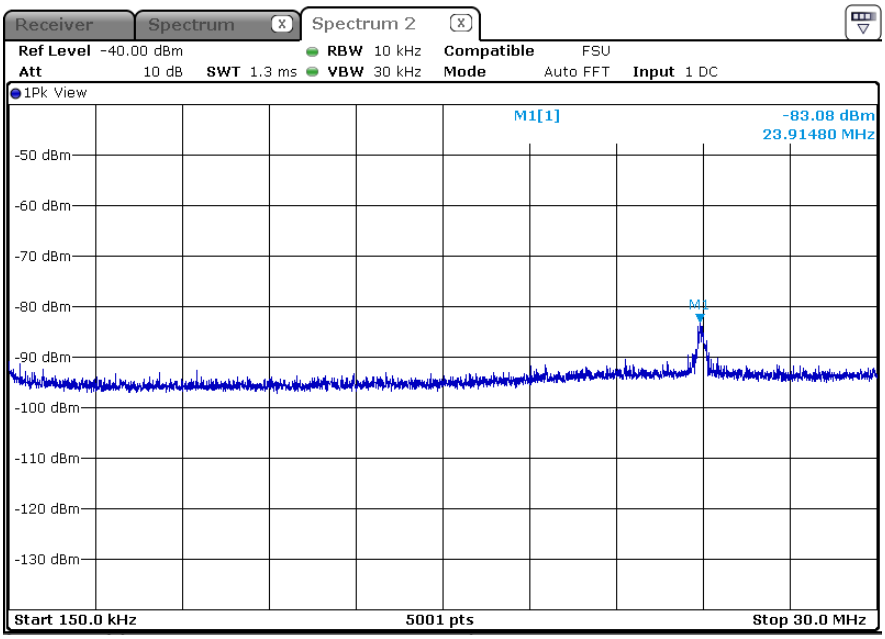


Spurious emissions conducted, DH5 packet:

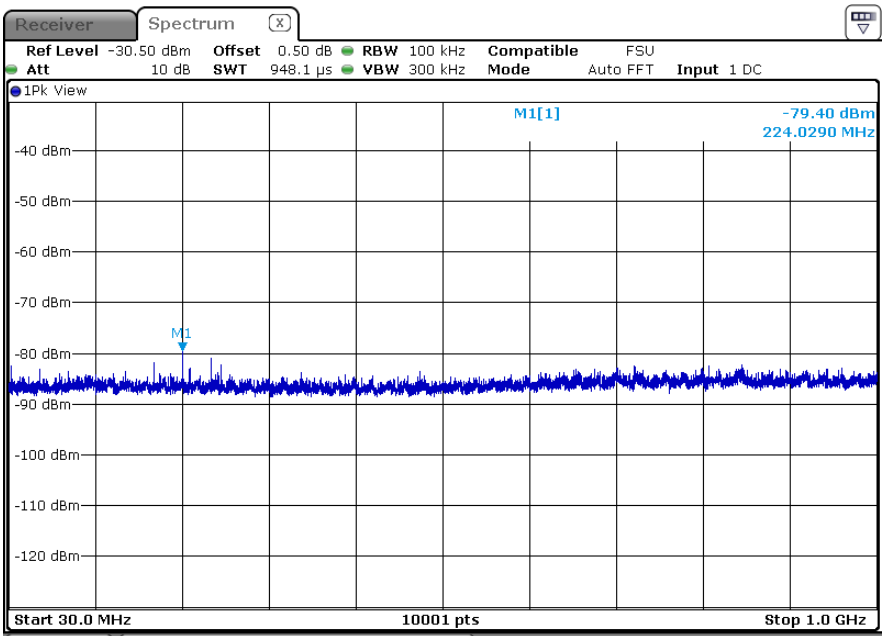
9 kHz - 150 kHz, Channel 40



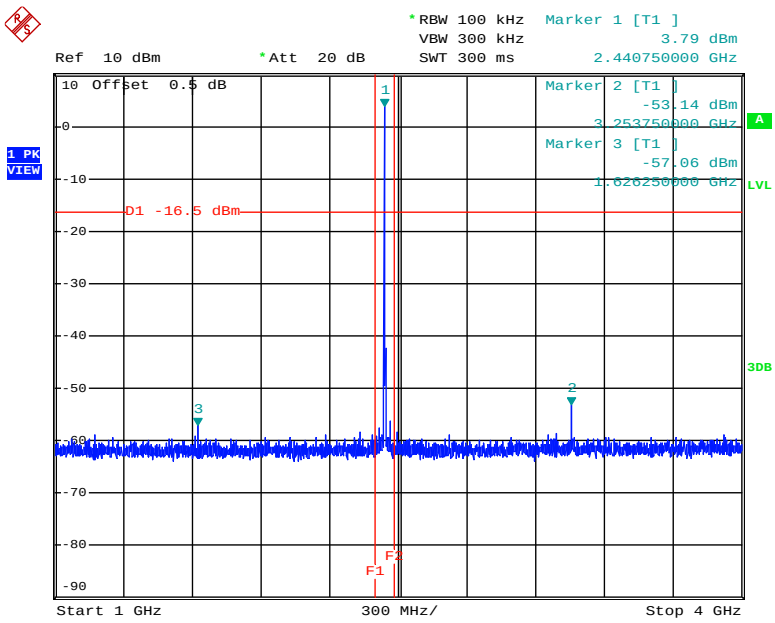
150 kHz – 30 MHz, Channel 40



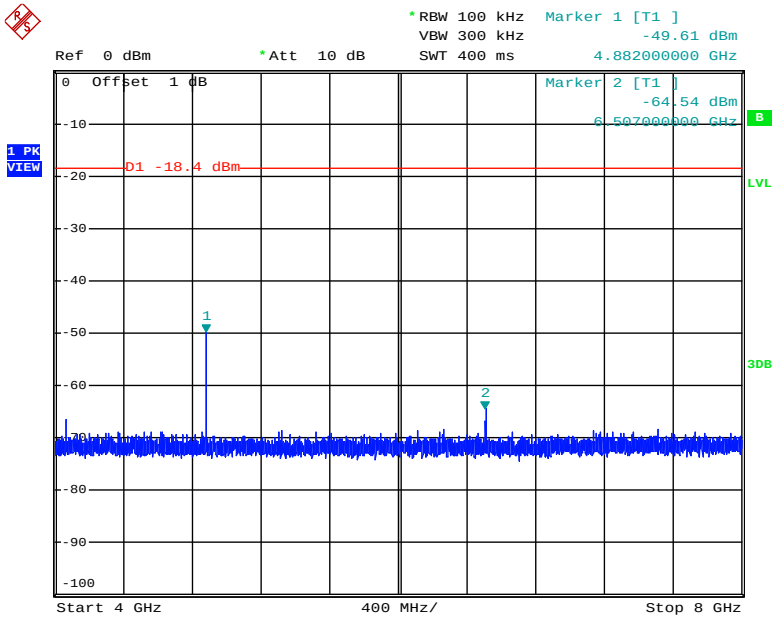
30 MHz – 1 GHz, Channel 40



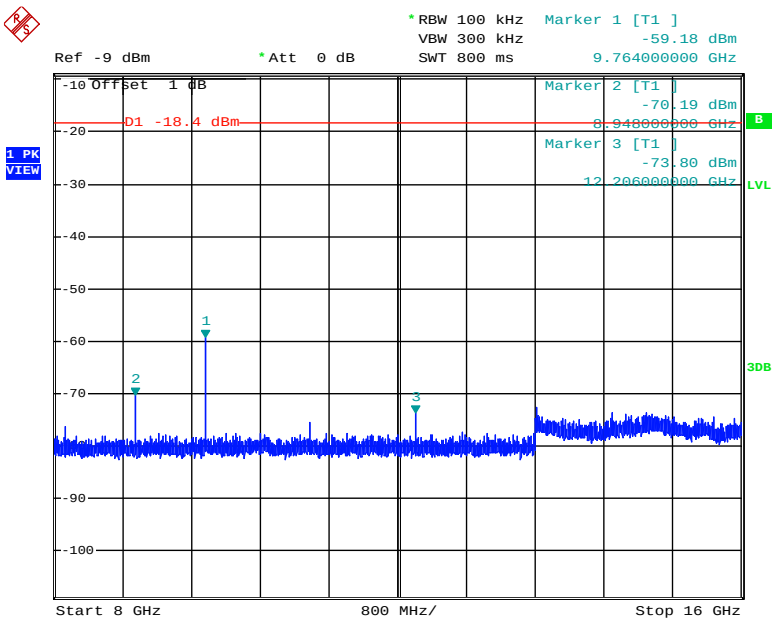
1 GHz – 4 GHz, Channel 40



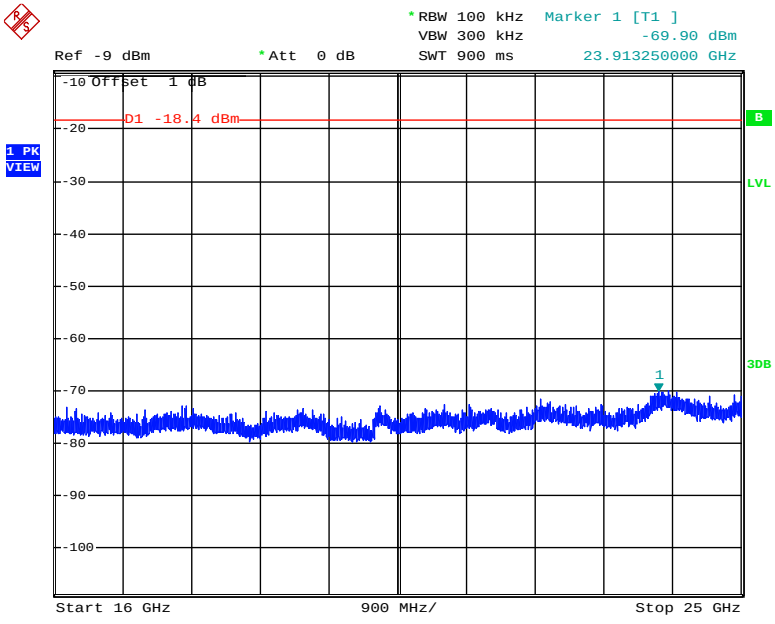
4 GHz – 8 GHz, Channel 40



8 GHz – 16 GHz, Channel 40

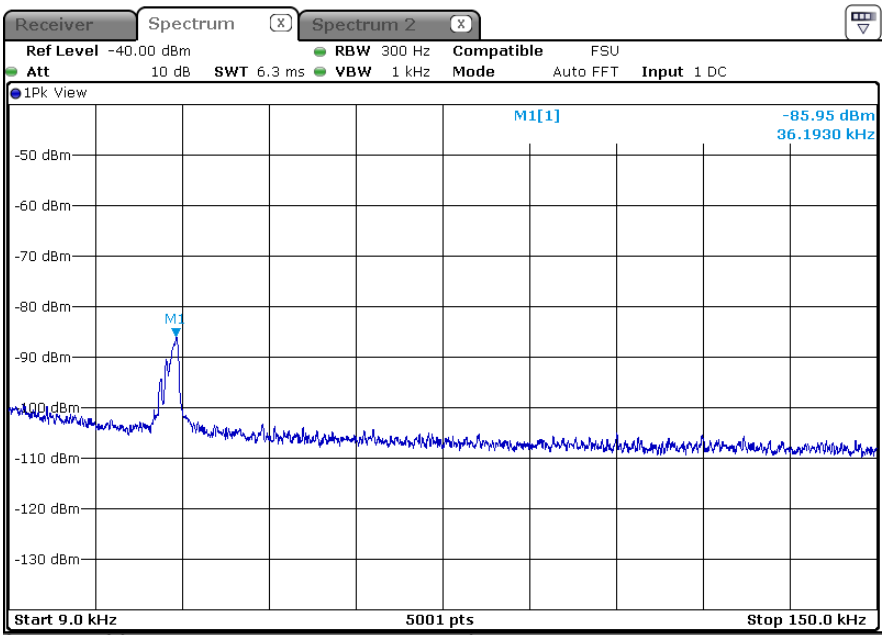


16 GHz – 25 GHz, Channel 40

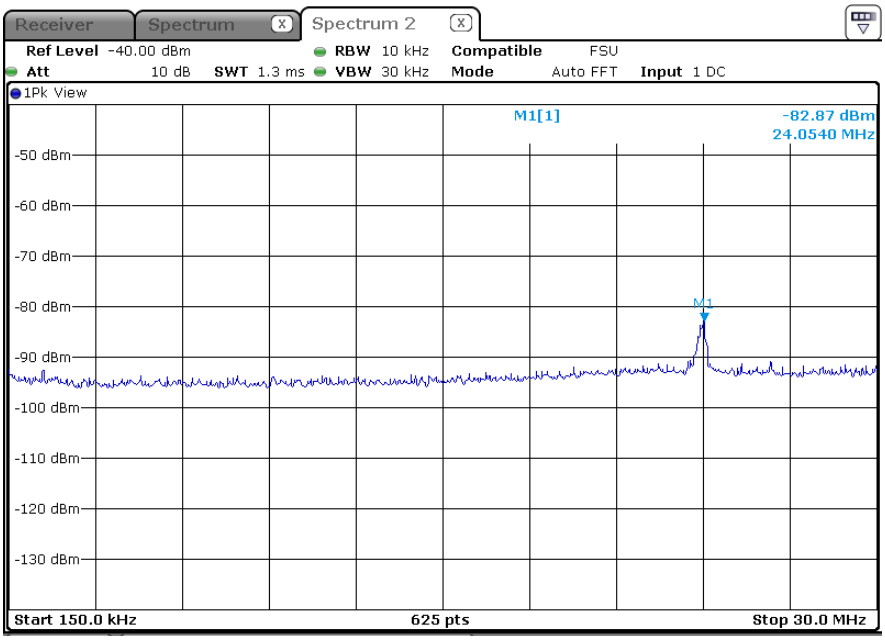


Spurious emissions conducted, DH5 packet:

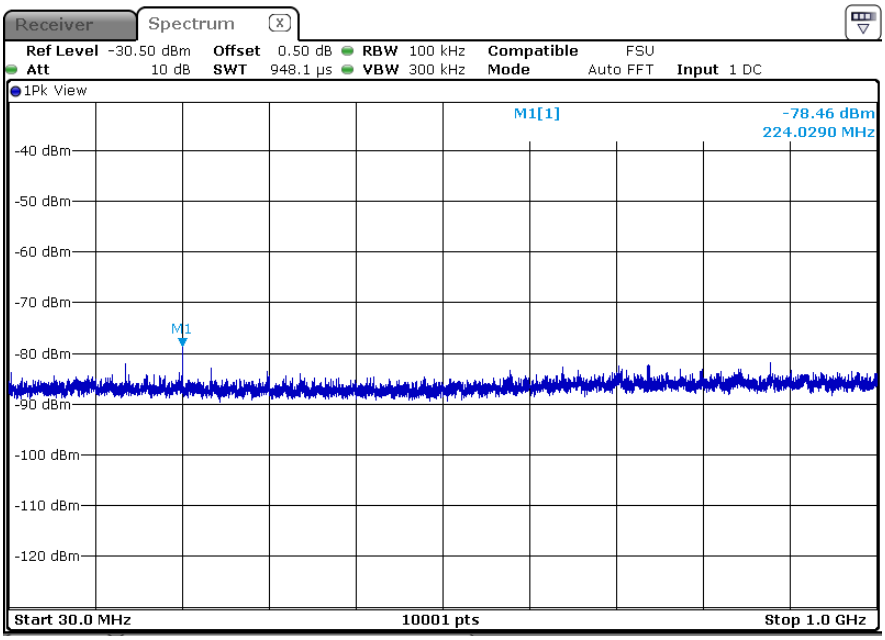
9 kHz - 150 kHz, Channel 79



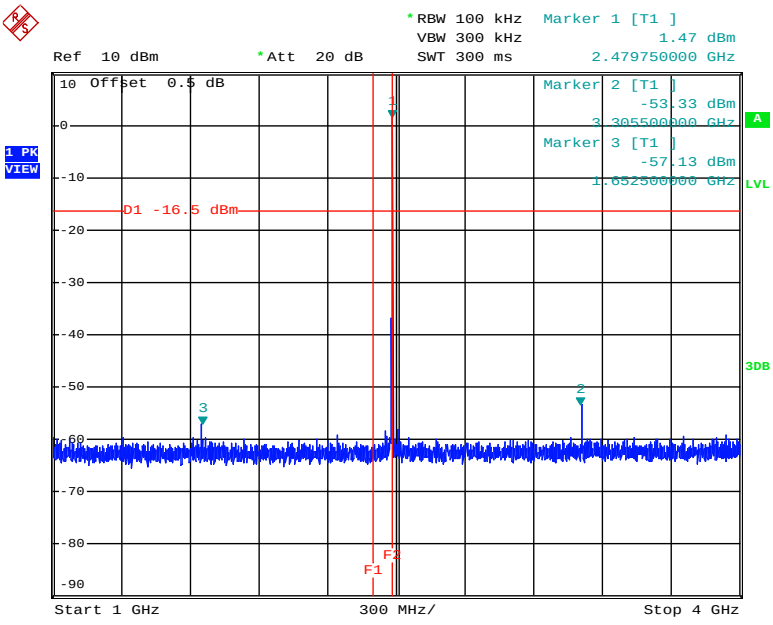
150 kHz – 30 MHz, Channel 79



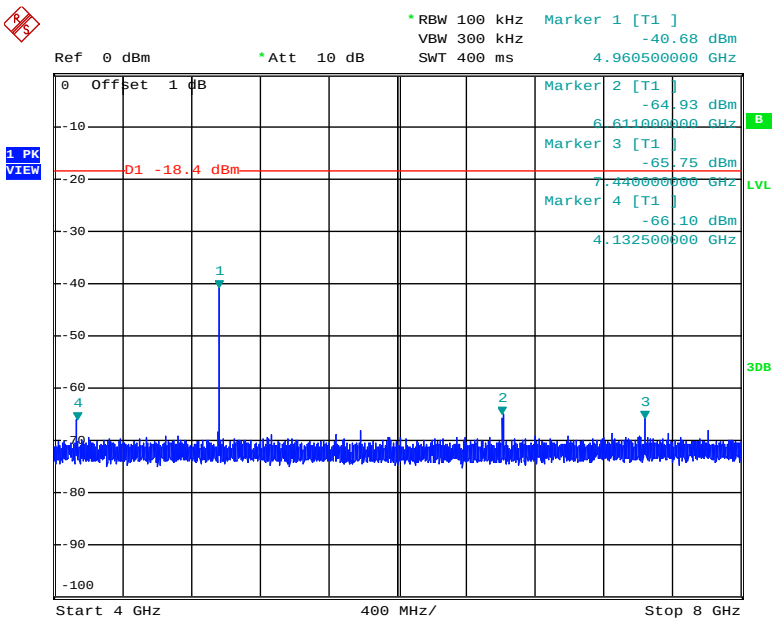
30 MHz – 1 GHz, Channel 79



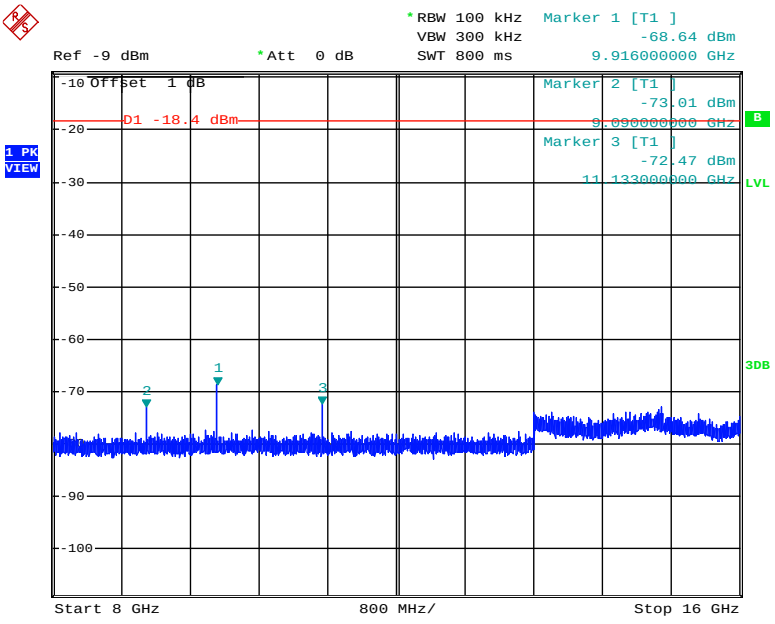
1 GHz – 4 GHz, Channel 79



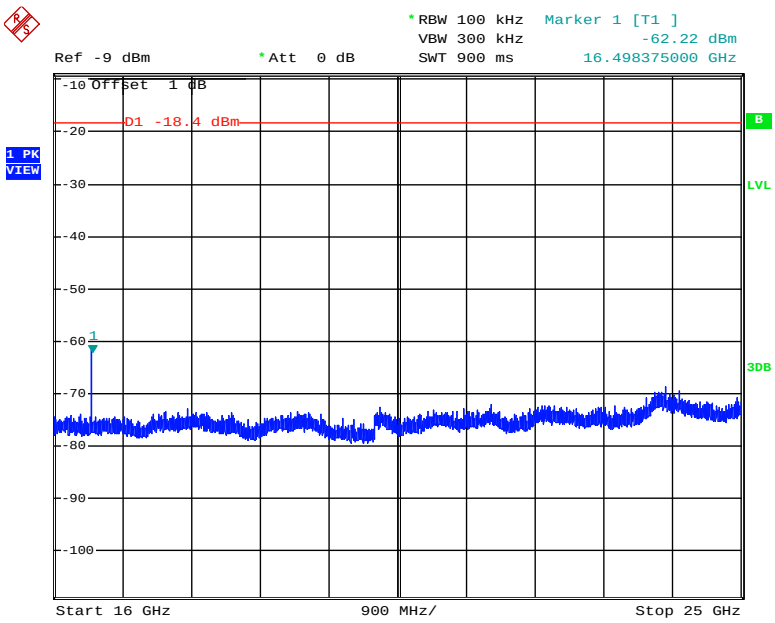
4 GHz – 8 GHz, Channel 79



8 GHz – 16 GHz, Channel 79

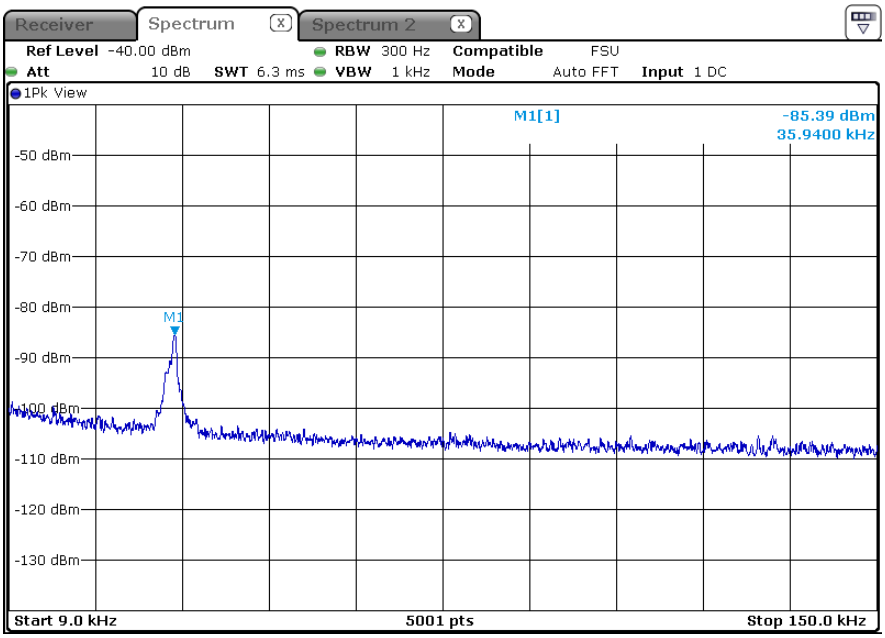


16 GHz – 25 GHz, Channel 79

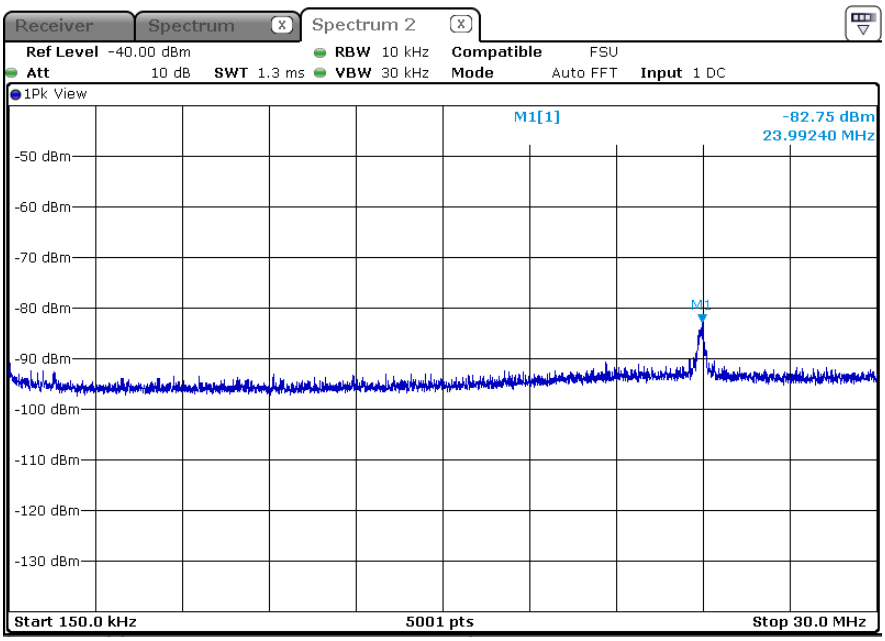


5.4.6.2 Spurious emissions conducted, 2-DH5 packet:

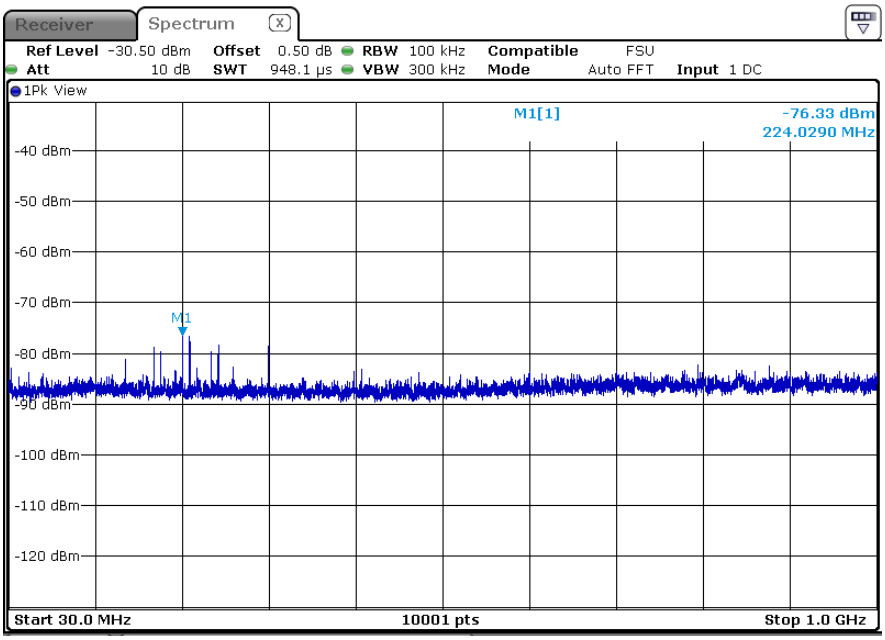
9 kHz - 150 kHz, Channel 1



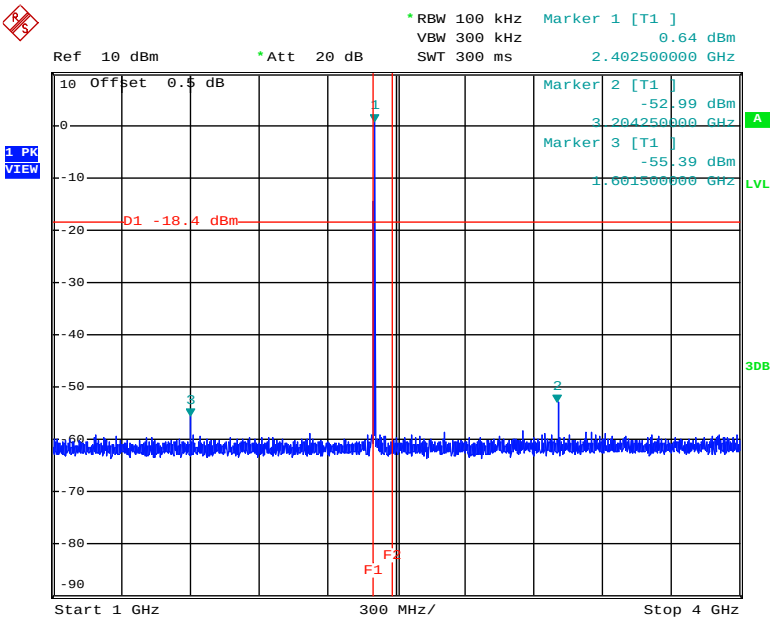
150 kHz – 30 MHz, Channel 1



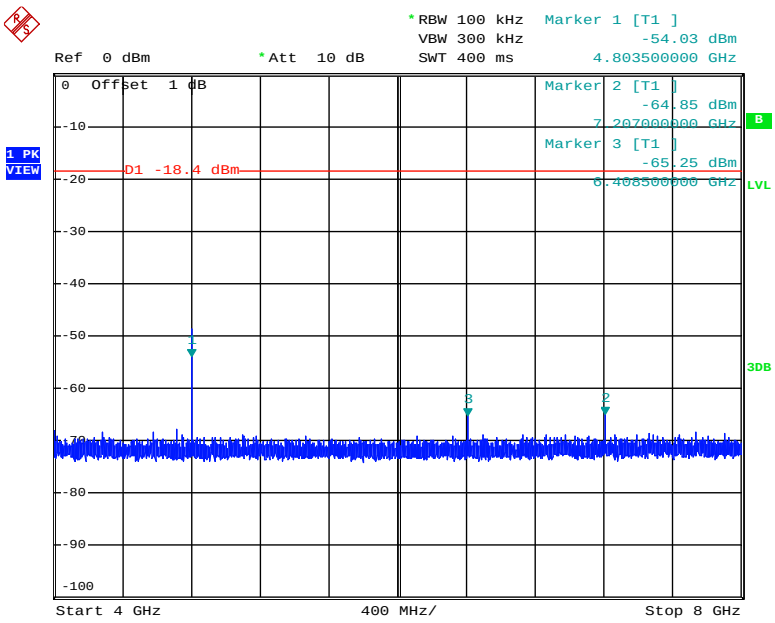
30 MHz – 1 GHz, Channel 1



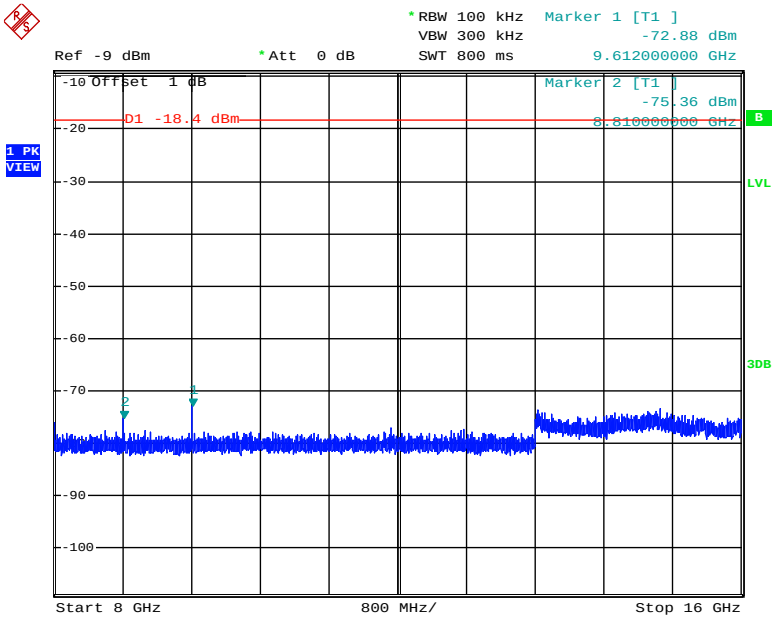
1 GHz – 4 GHz, Channel 1



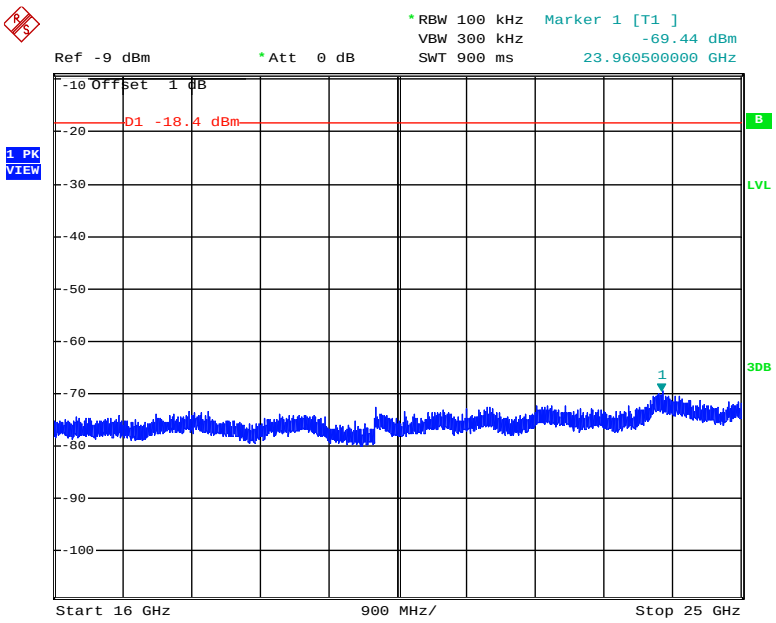
4 GHz – 8 GHz, Channel 1



8 GHz – 16 GHz, Channel 1

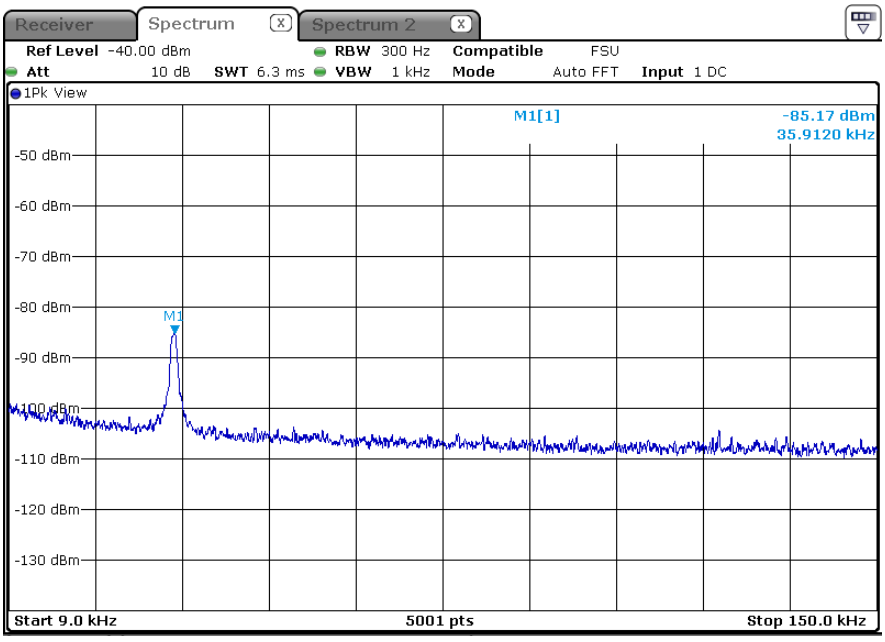


16 GHz – 25 GHz, Channel 1

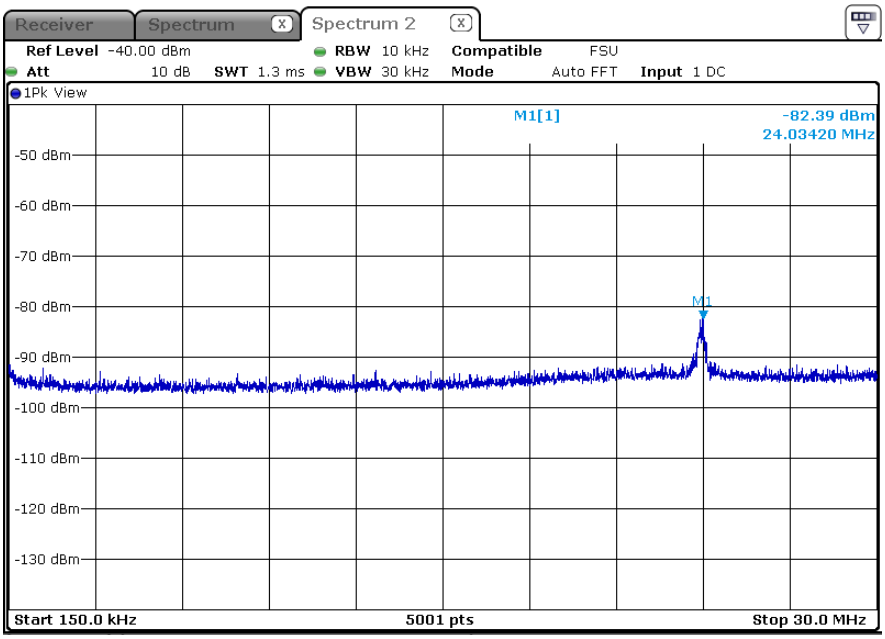


Spurious emissions conducted, 2-DH5 packet:

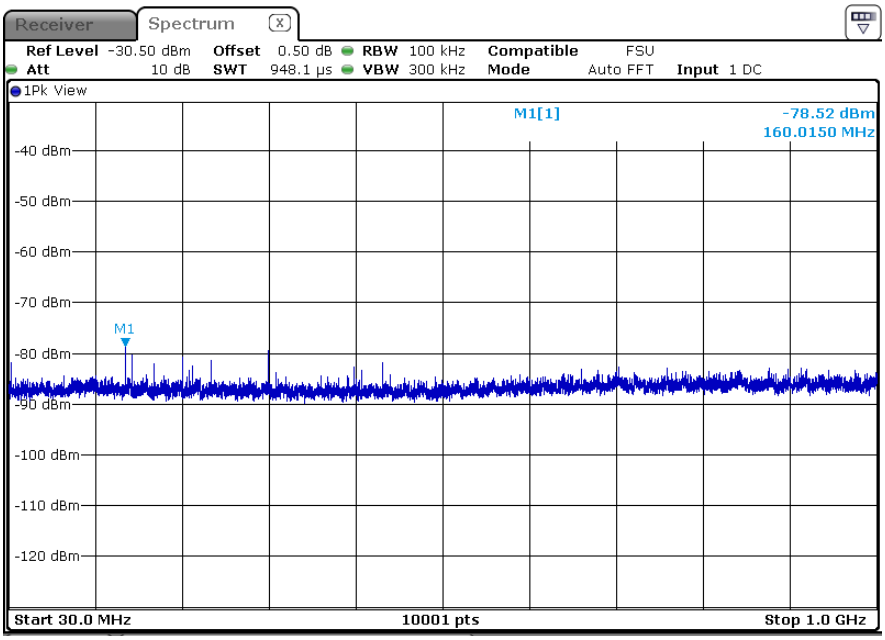
9 kHz - 150 kHz, Channel 40



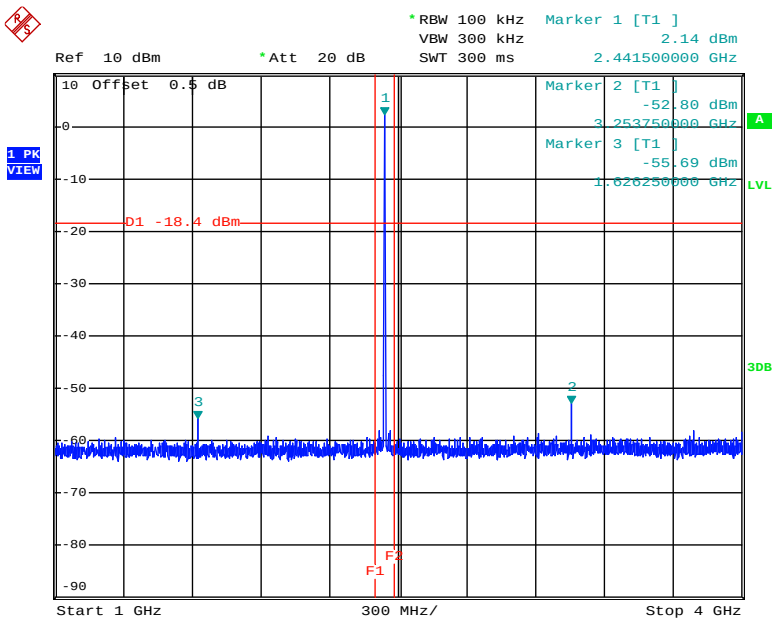
150 kHz – 30 MHz, Channel 40



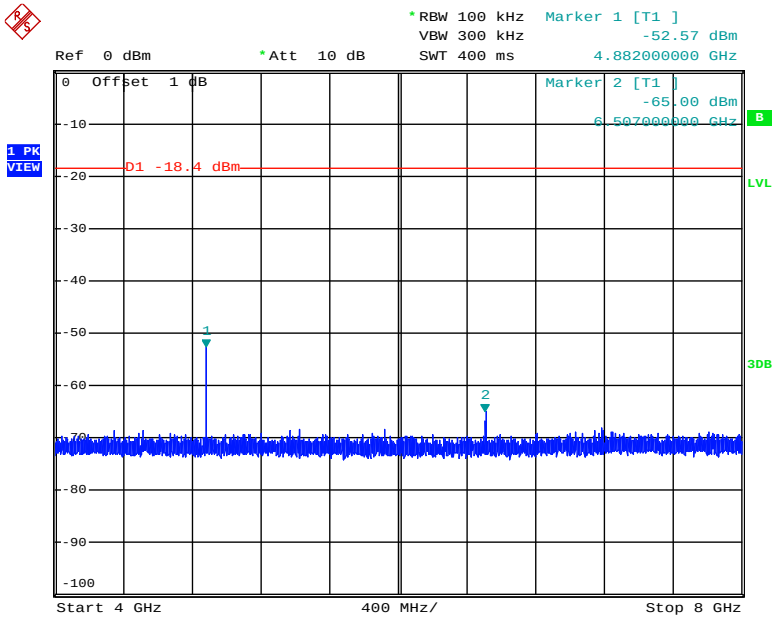
30 MHz – 1 GHz, Channel 40



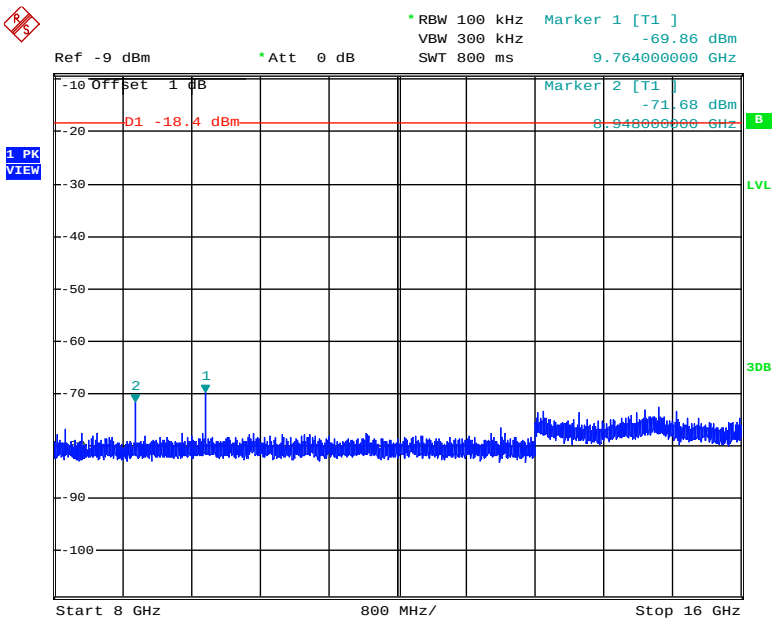
1 GHz – 4 GHz, Channel 40



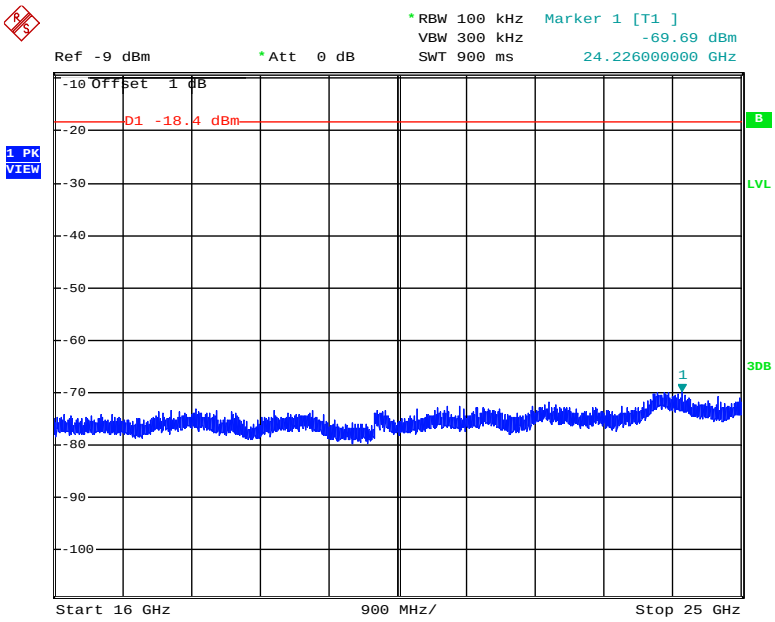
4 GHz – 8 GHz, Channel 40



8 GHz – 16 GHz, Channel 40

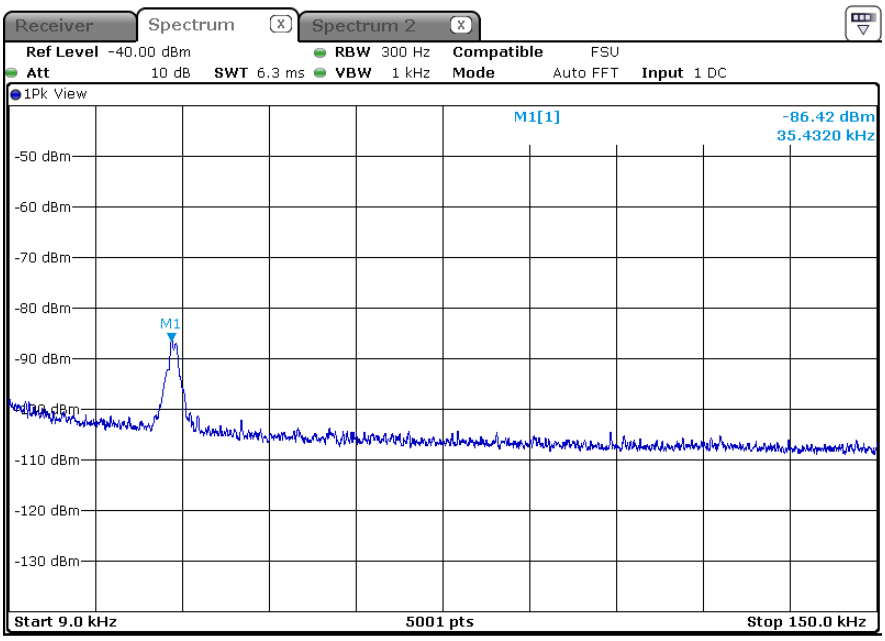


16 GHz – 25 GHz, Channel 40

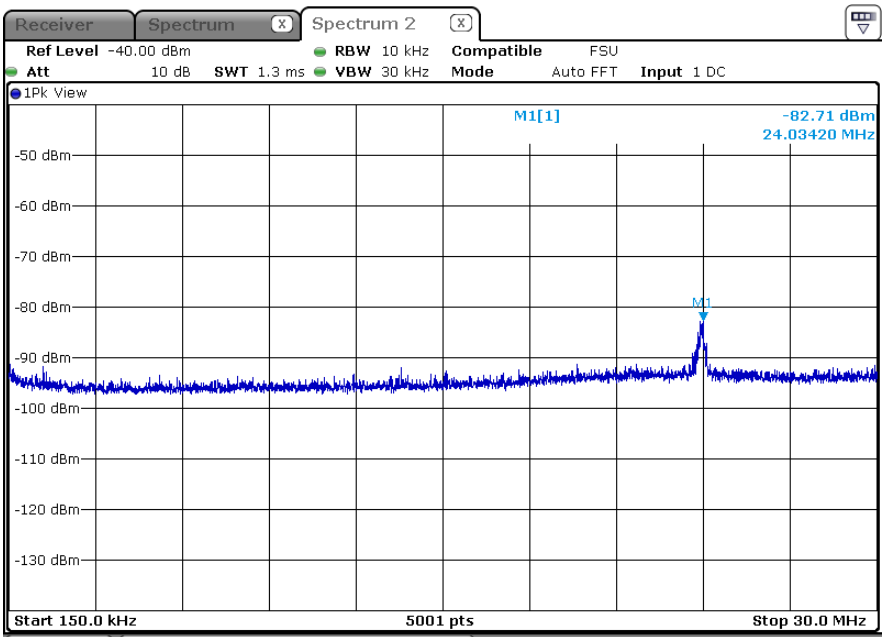


Spurious emissions conducted, 2-DH5 packet:

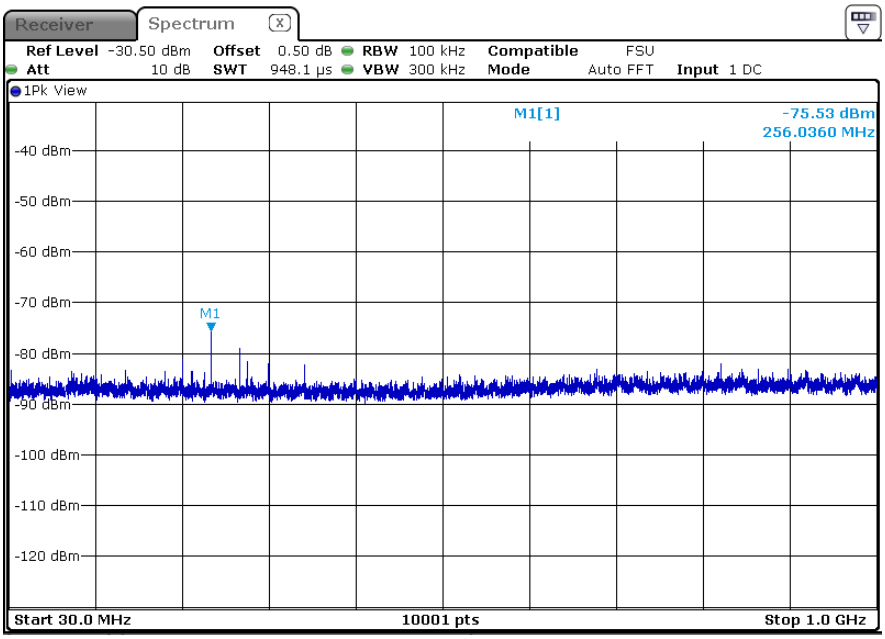
9 kHz - 150 kHz, Channel 79



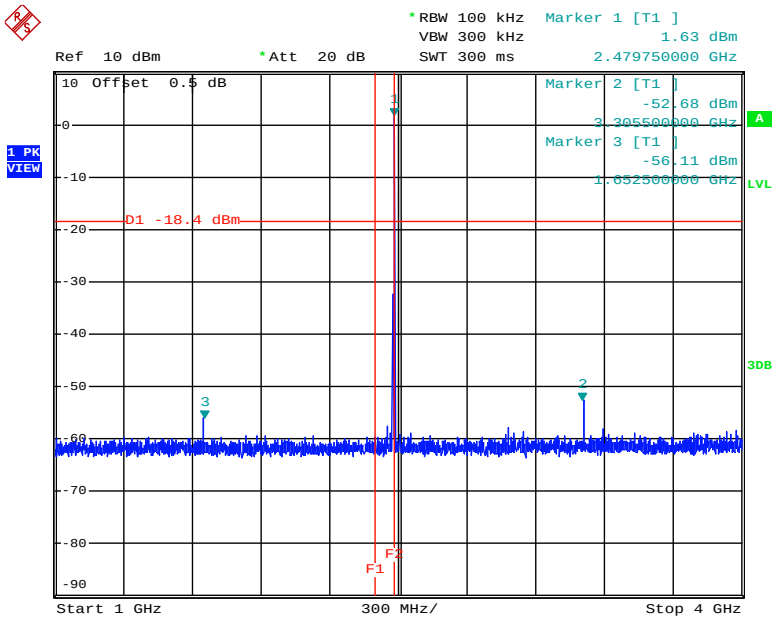
150 kHz – 30 MHz, Channel 79



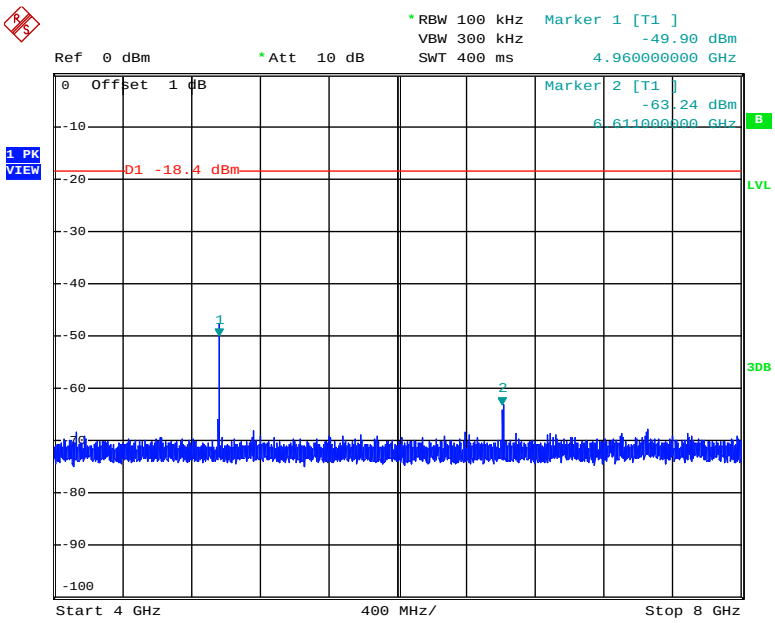
30 MHz – 1 GHz, Channel 79



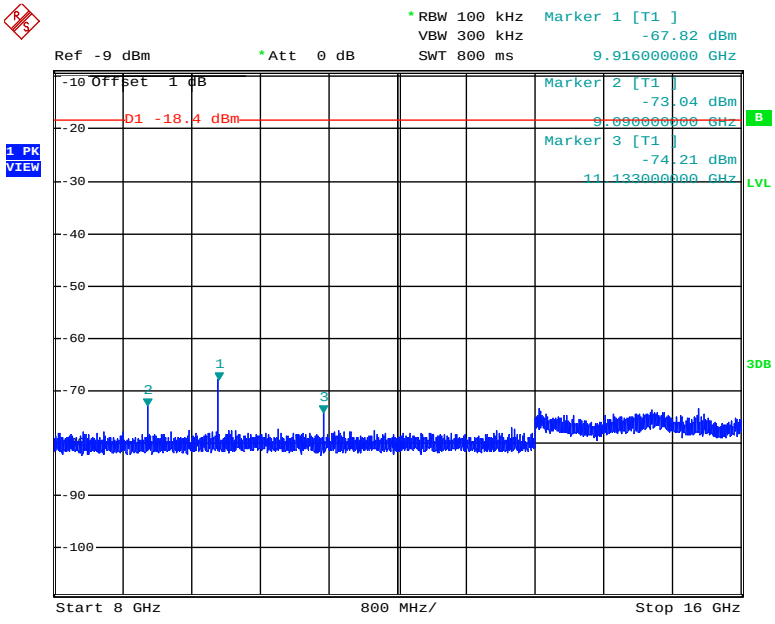
1 GHz – 4 GHz, Channel 79



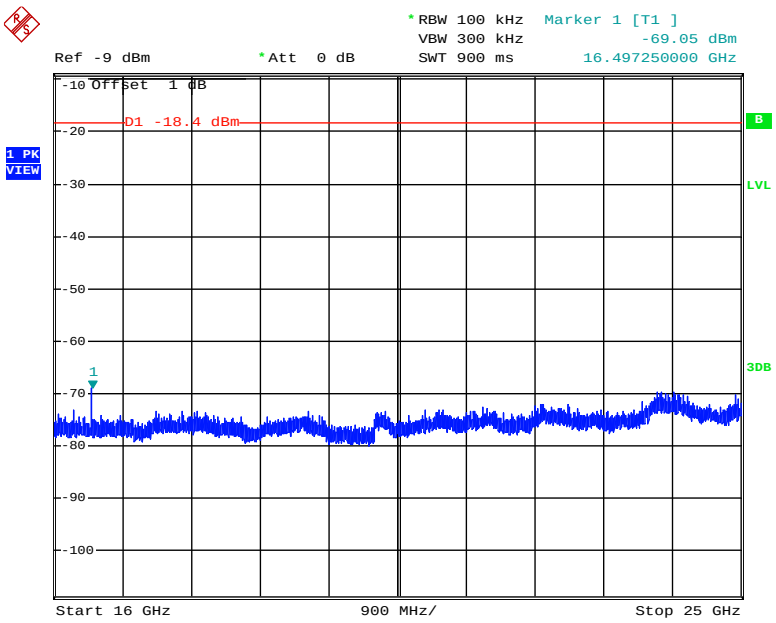
4 GHz – 8 GHz, Channel 79



8 GHz – 16 GHz, Channel 79

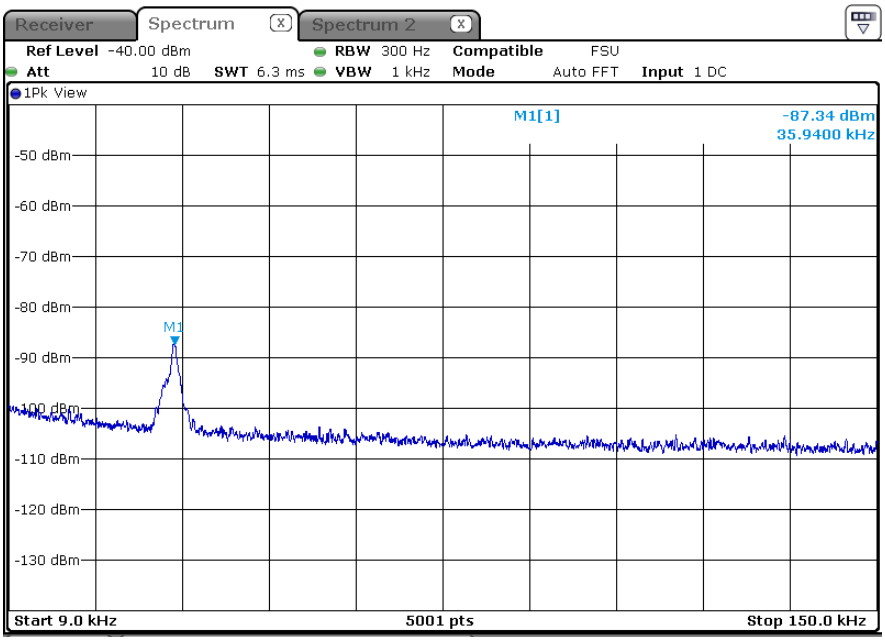


16 GHz – 25 GHz, Channel 79

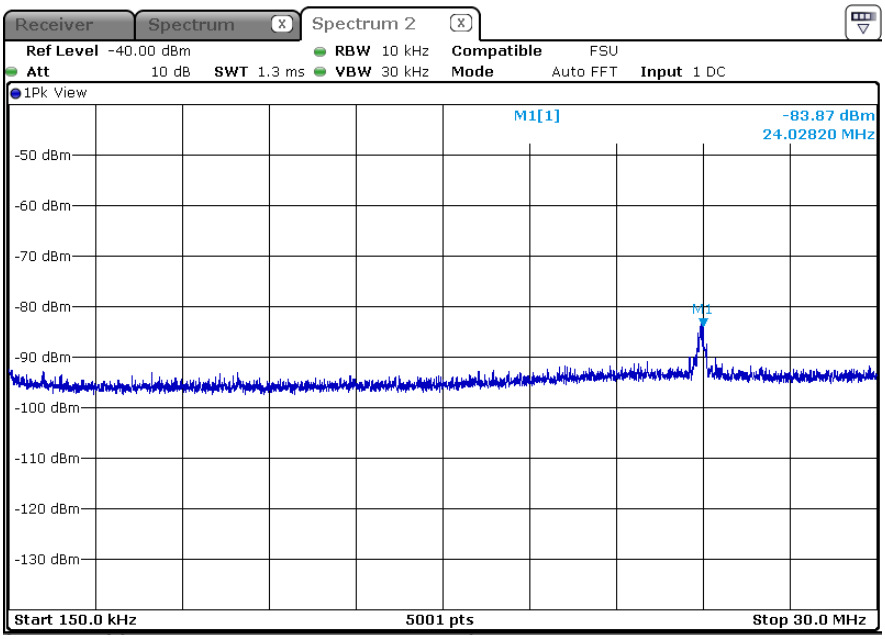


5.4.6.3 Spurious emissions conducted, 3-DH5 packet:

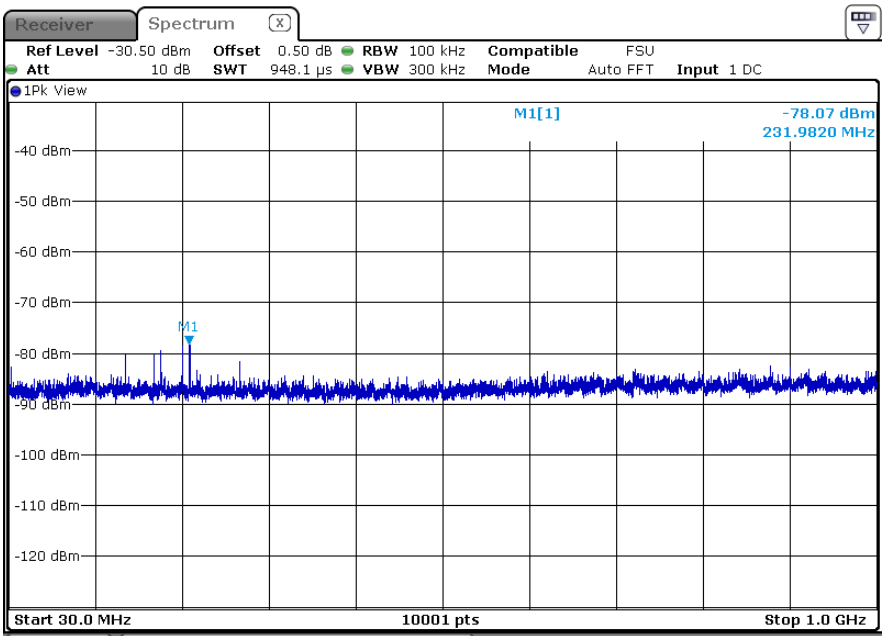
9 kHz - 150 kHz, Channel 1



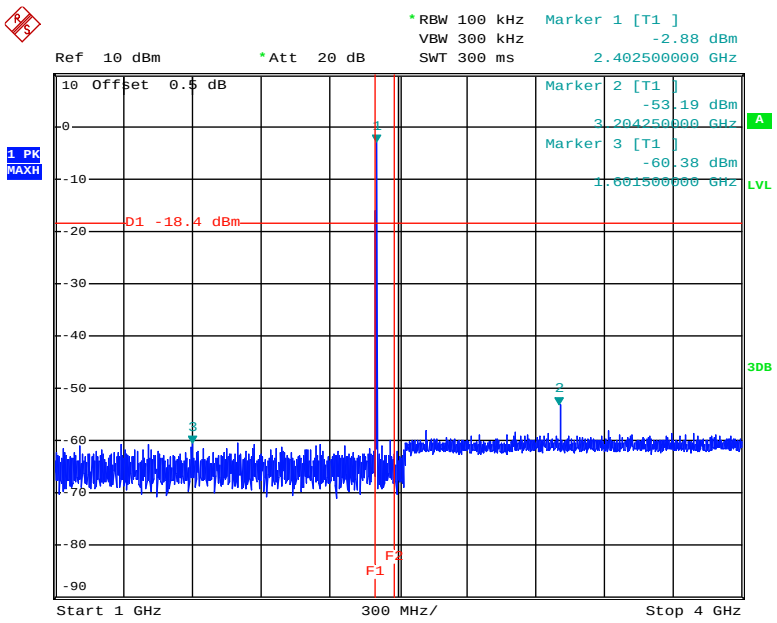
150 kHz – 30 MHz, Channel 1



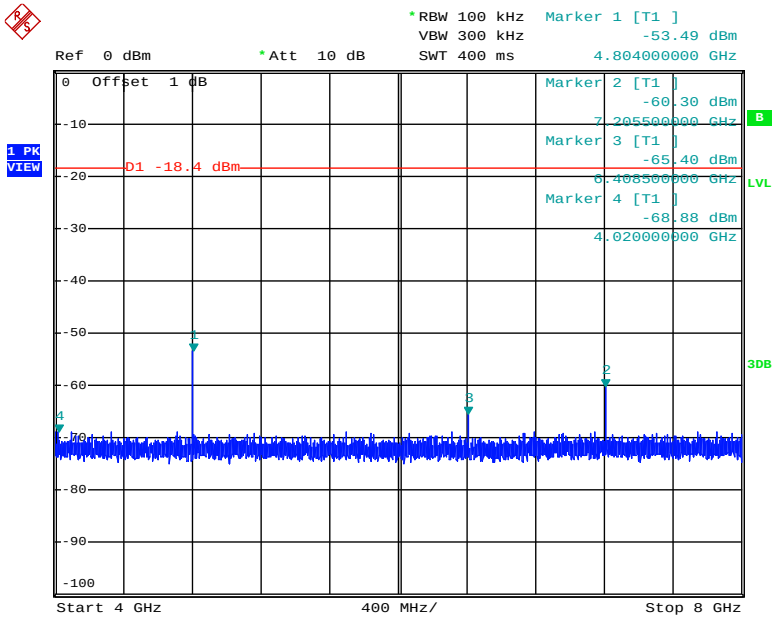
30 MHz – 1 GHz, Channel 1



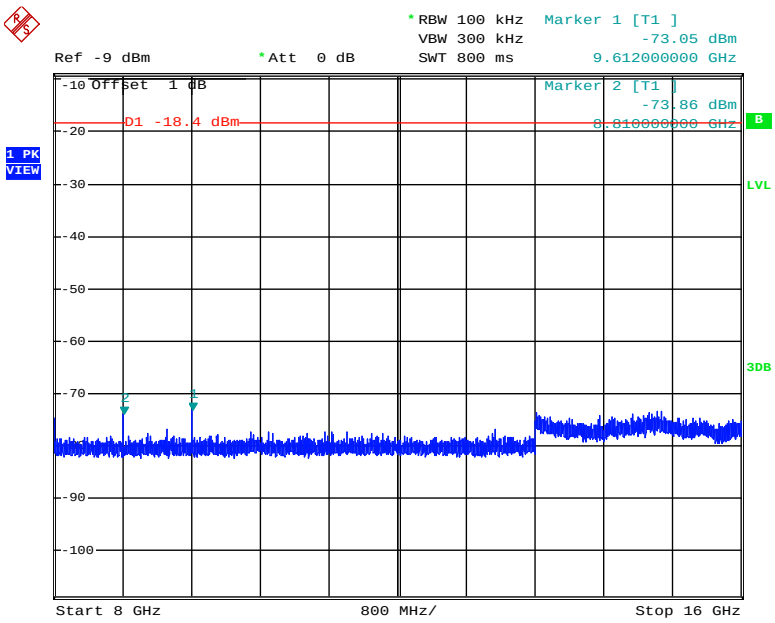
1 GHz – 4 GHz, Channel 1



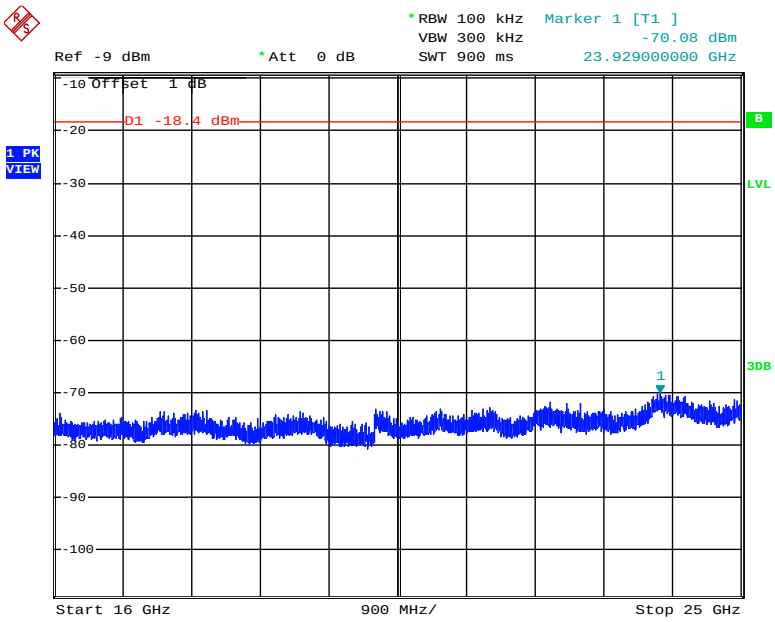
4 GHz – 8 GHz, Channel 1



8 GHz – 16 GHz, Channel 1

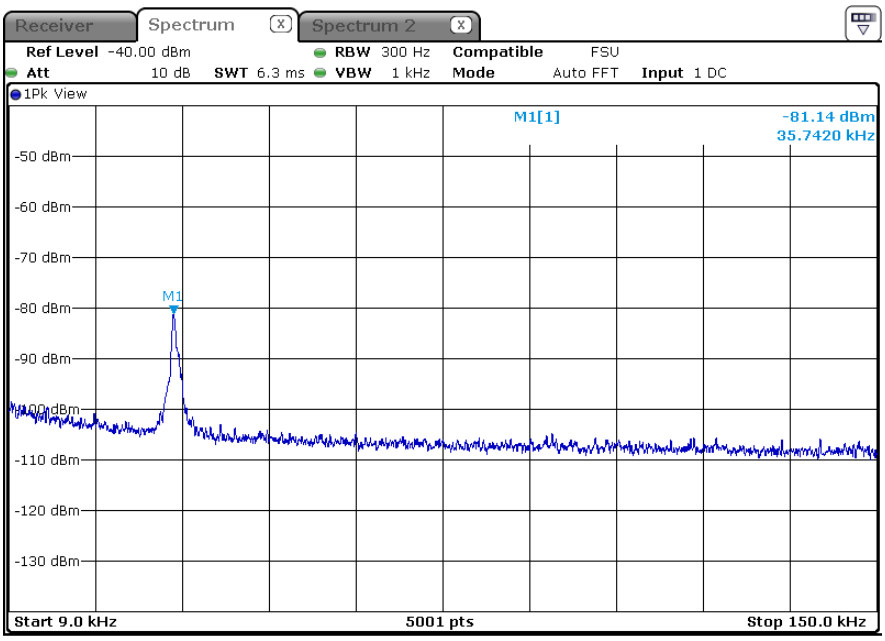


16 GHz – 25 GHz, Channel 1

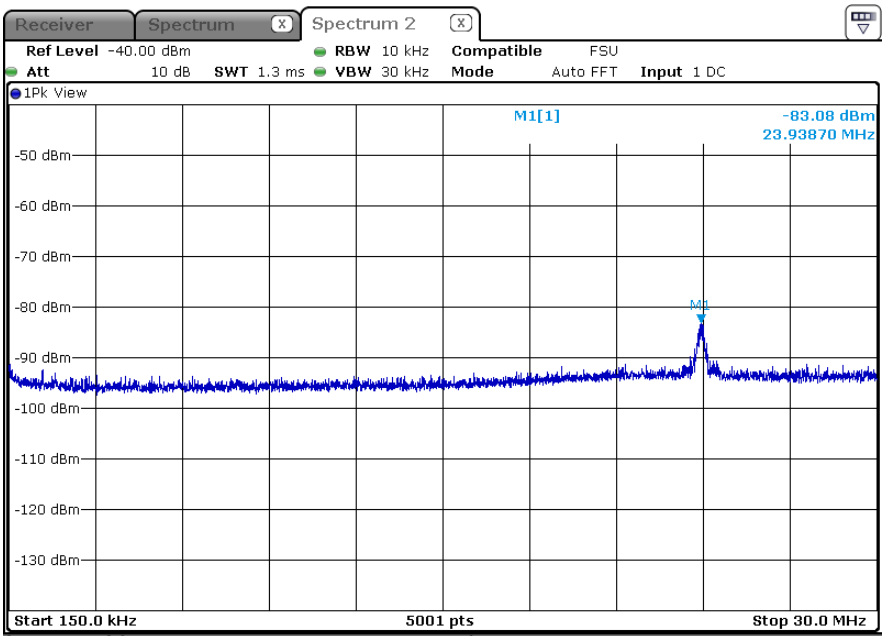


Spurious emissions conducted, 3-DH5 packet:

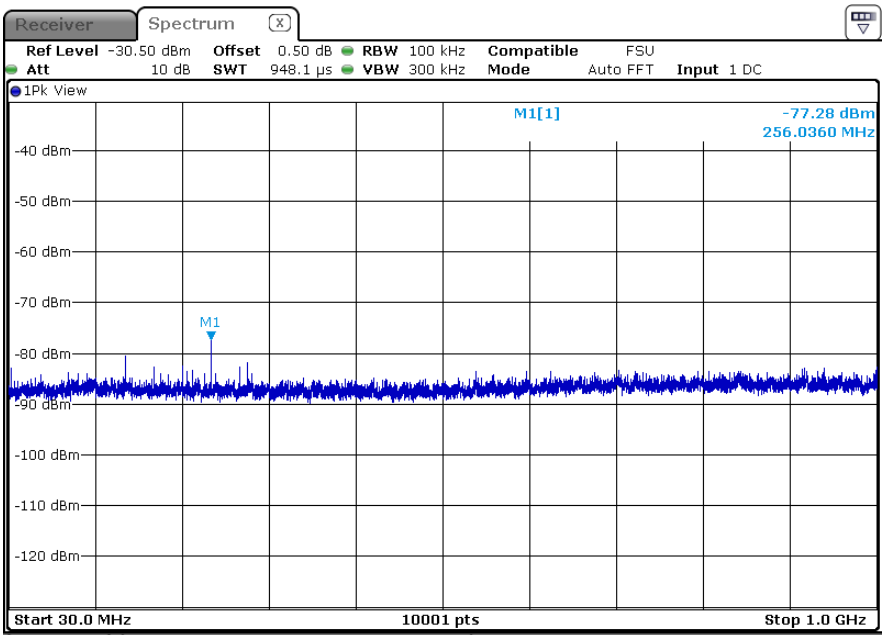
9 kHz - 150 kHz, Channel 40



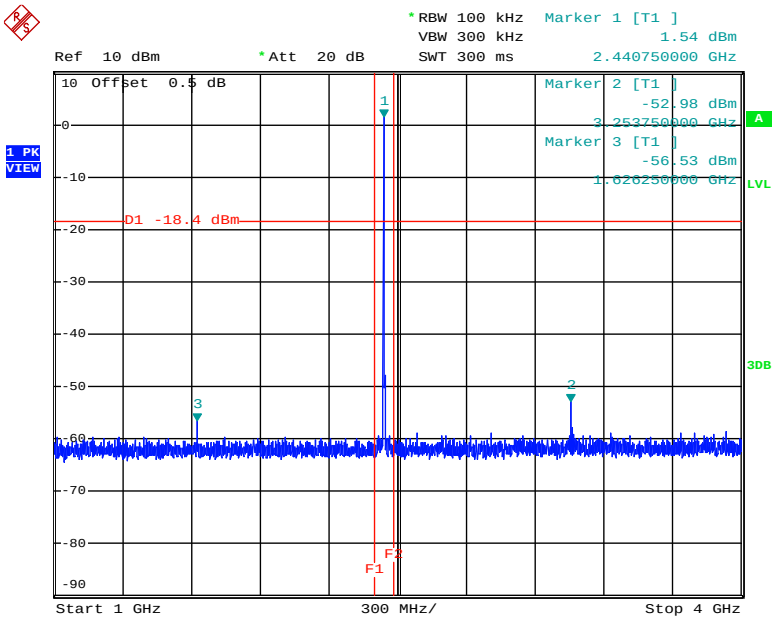
150 kHz – 30 MHz, Channel 40



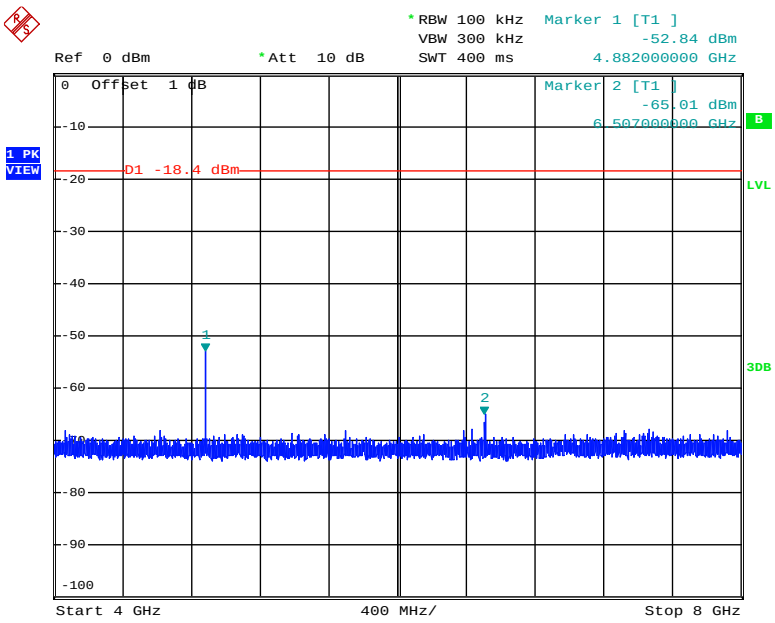
30 MHz – 1 GHz, Channel 40



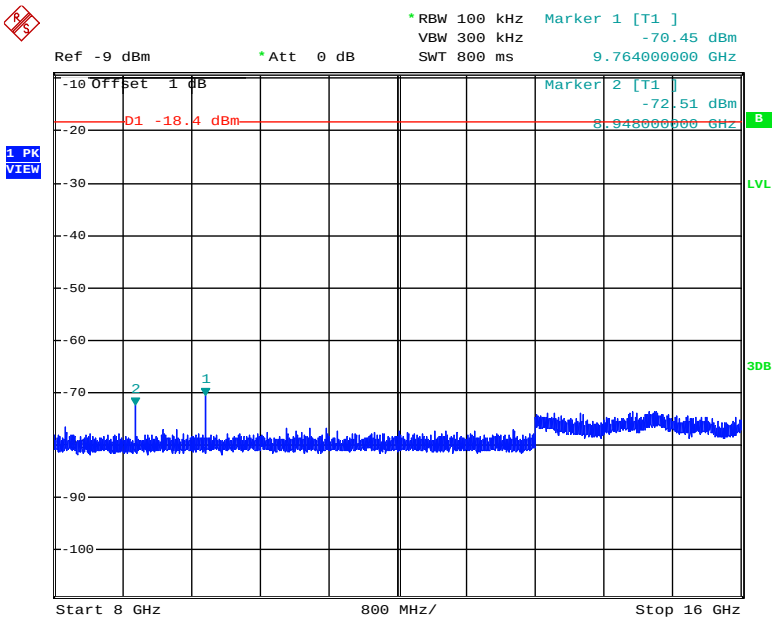
1 GHz – 4 GHz, Channel 40



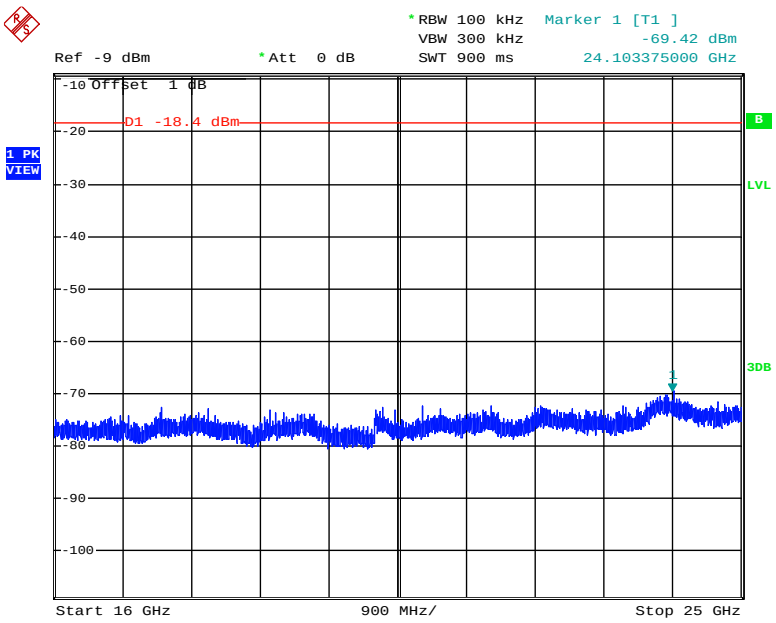
4 GHz – 8 GHz, Channel 40



8 GHz – 16 GHz, Channel 40

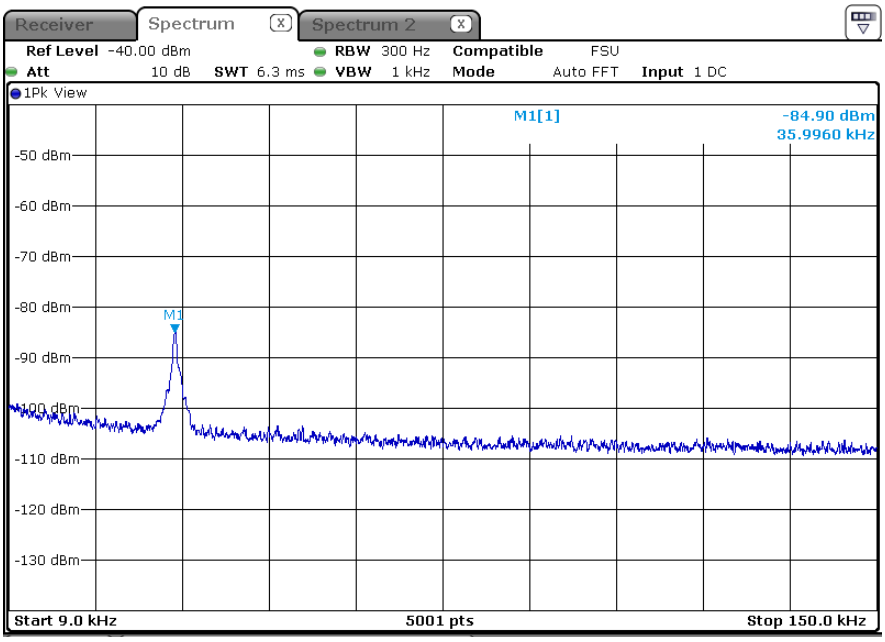


16 GHz – 25 GHz, Channel 40

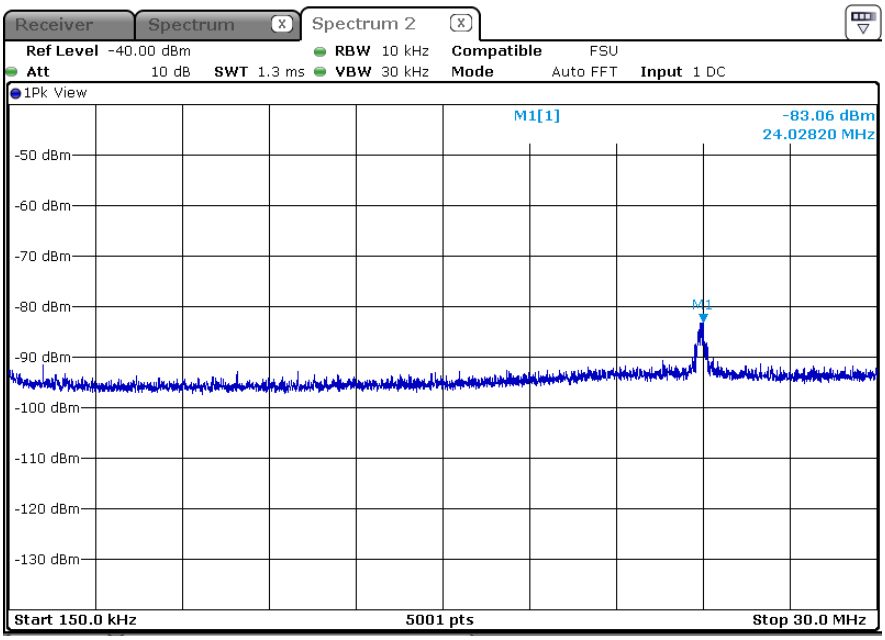


Spurious emissions conducted, 3-DH5 packet:

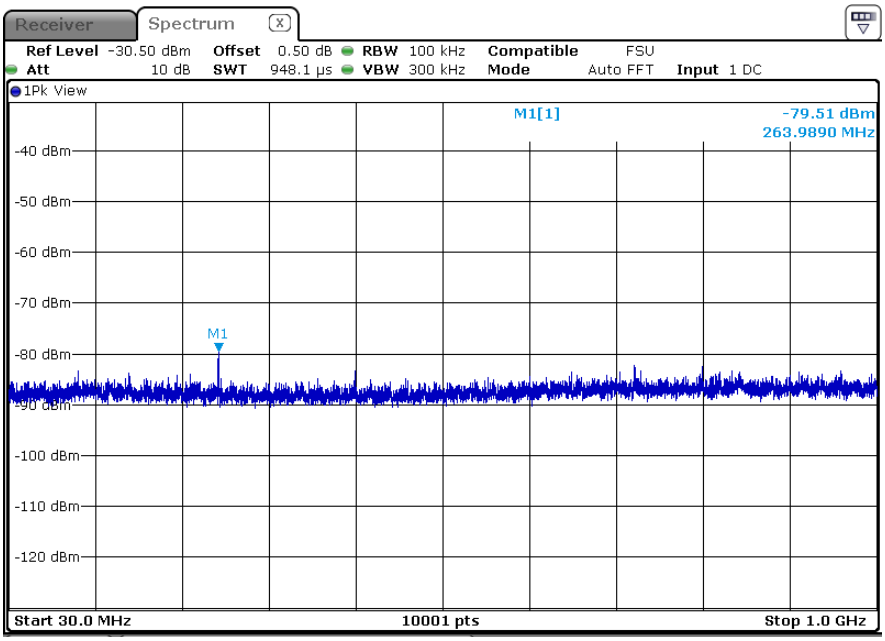
9 kHz - 150 kHz, Channel 79



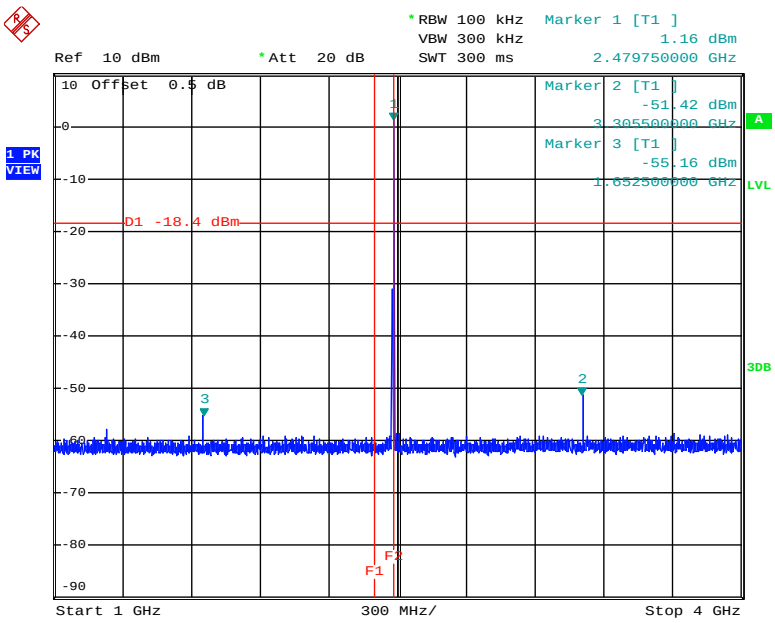
150 kHz – 30 MHz, Channel 79



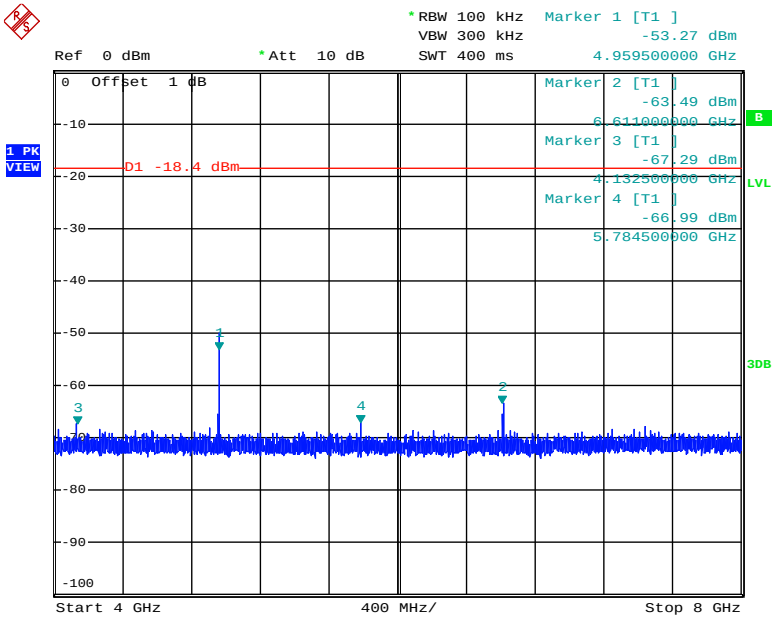
30 MHz – 1 GHz, Channel 79



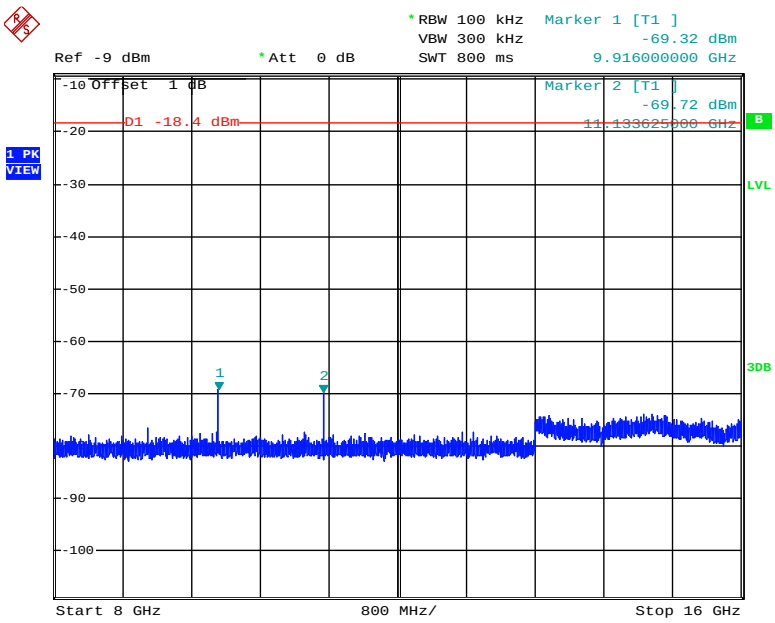
1 GHz – 4 GHz, Channel 79



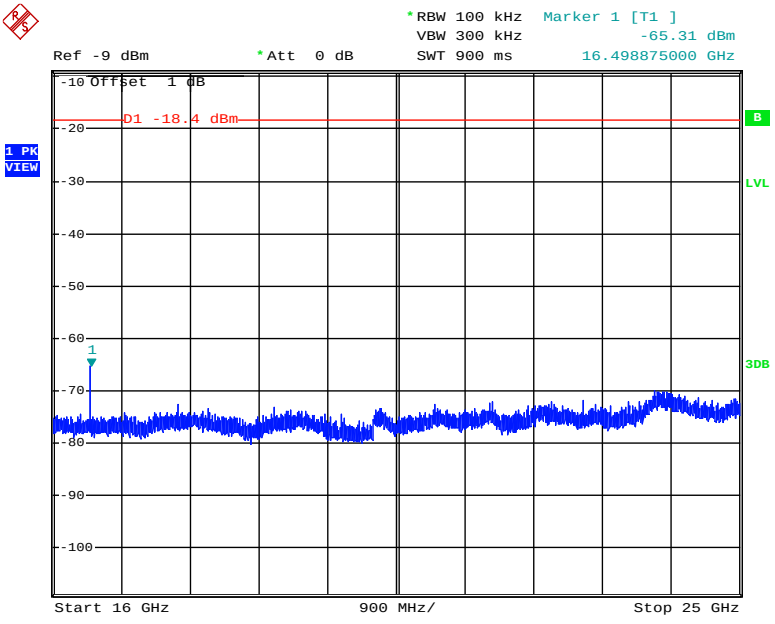
4 GHz – 8 GHz, Channel 79



8 GHz – 16 GHz, Channel 79



16 GHz – 25 GHz, Channel 79



5.5 Band edge compliance

For test instruments and accessories used see section 6 Part **SEC3**.

5.5.1 Description of the test location

Test location: AREA4

5.5.2 Applicable standard

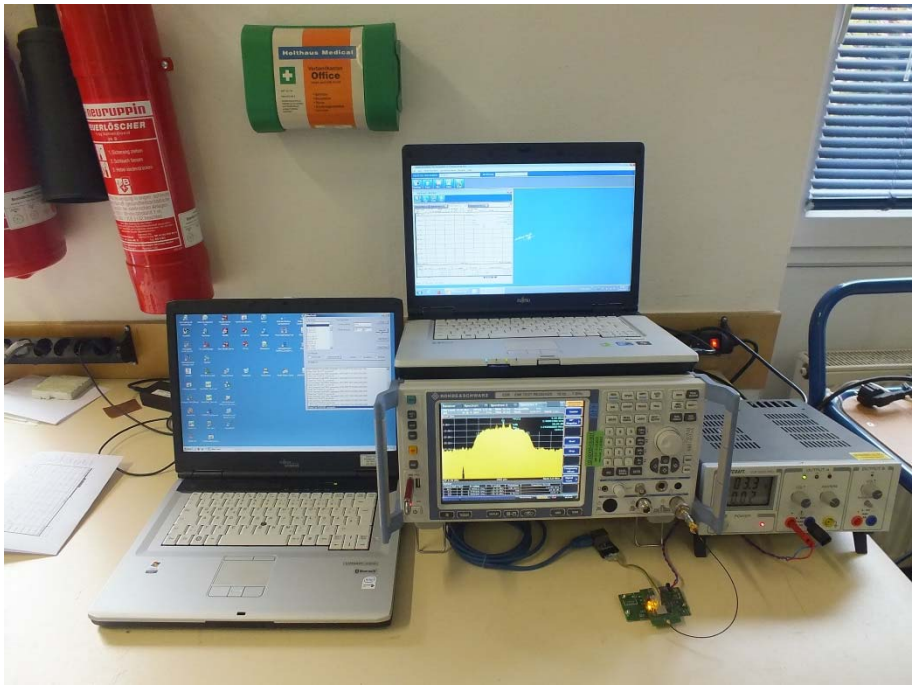
According to FCC Part 15C, Section 15.247(d):
In any 100 kHz bandwidth outside the frequency bands 2400 – 2483.5 MHz and 5725 – 5850 MHz, the digitally modulated radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or an radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required.

5.5.3 Description of Measurement

A spectrum analyser is connected to the output of the transmitter via a suitable attenuator while EUT was operating in transmit mode at the assigned frequency according DA 00-705:2000.

Spectrum analyser settings:
RBW: 100 kHz, VBW: 100 kHz, Detector: Max peak, Trace: Max hold, Sweep: auto

5.5.4 Photo documentation of the test set-up



5.5.5 Test result

DH5 Packet

f (MHz)	Delta level (dBc)	Limit (dBc)
Low Channel	27.65	< -16.5
High Channel	40.59	< -16.5

2DH5 Packet

f (MHz)	Delta level (dBc)	Limit (dBc)
Low Channel	25.60	< -18.4
High Channel	36.58	< -18.4

3DH5 Packet

f (MHz)	Delta level (dBc)	Limit (dBc)
Low Channel	25.37	< -18.4
High Channel	35.97	< -18.4

Hopping mode (3DH5 Packet)

f (MHz)	Delta level (dBc)	Limit (dBc)
Low Channel	25.49	< -18.4
High Channel	36.20	< -18.4

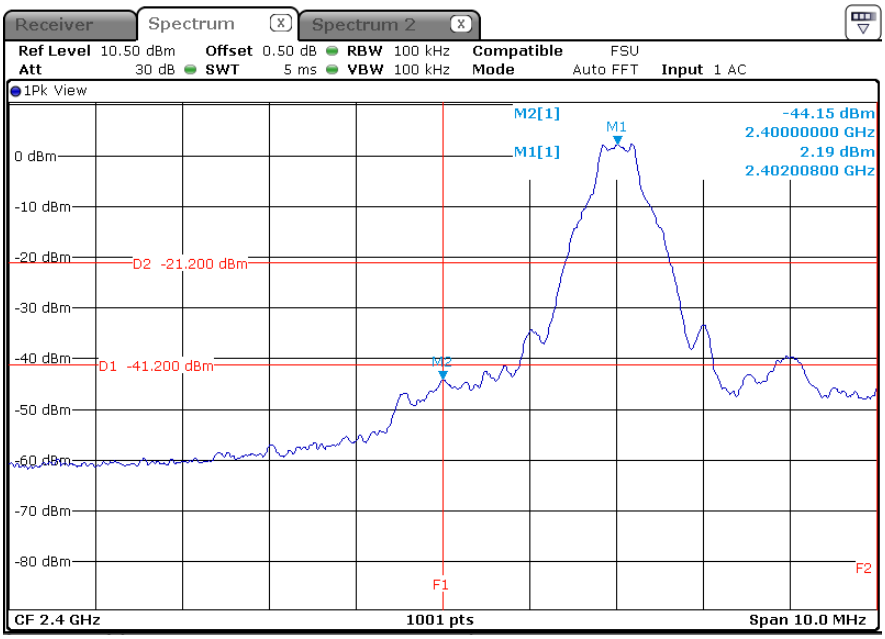
Peak-Limit according to FCC Part 15C, Section 15.247(d):
In any 100 kHz bandwidth outside the frequency band 2400 – 2483.50 MHz, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limit specified in Section 15.209(a).

The requirements are **fulfilled**

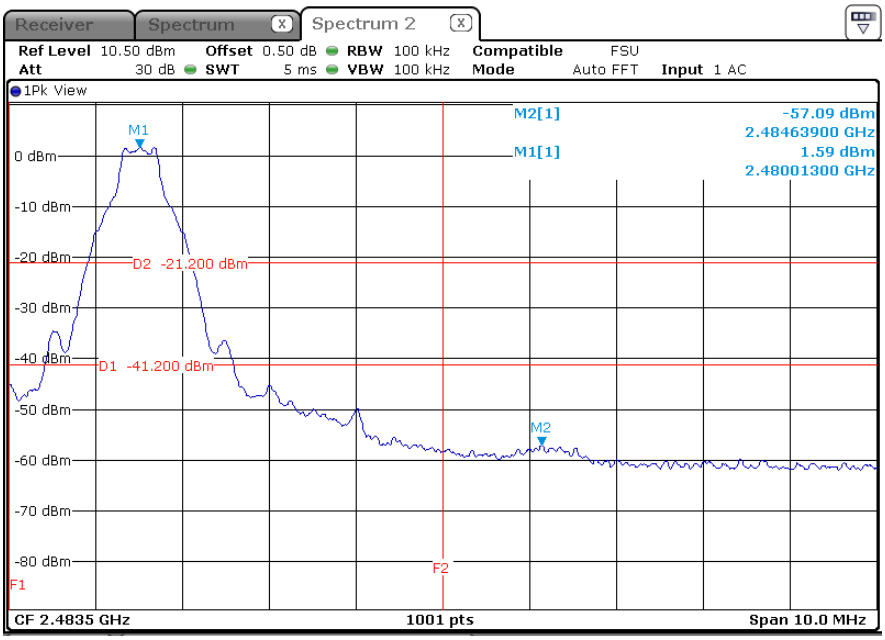
Remarks: For detailed test result please refer to following test protocols.

5.5.6 Test protocol

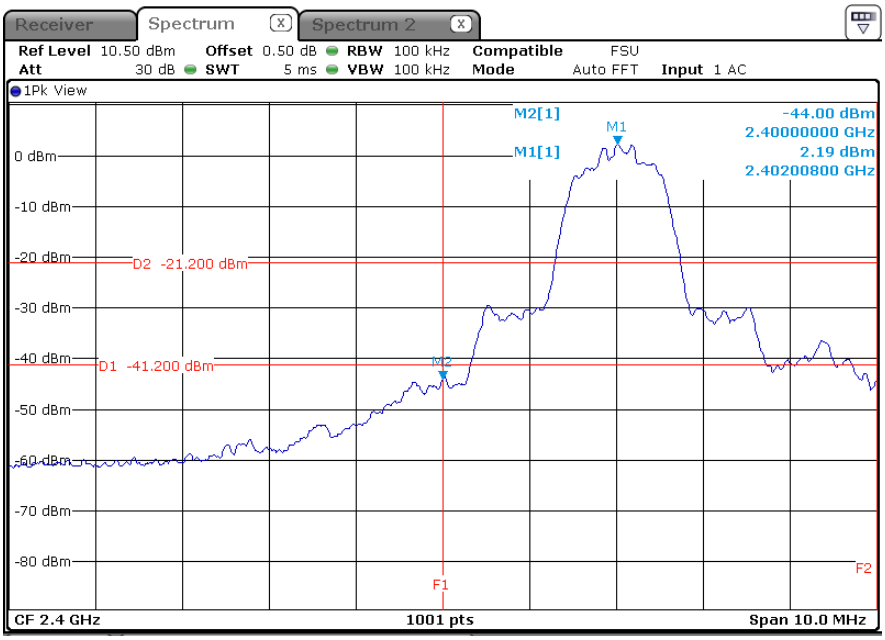
DH5 Packet, CH1



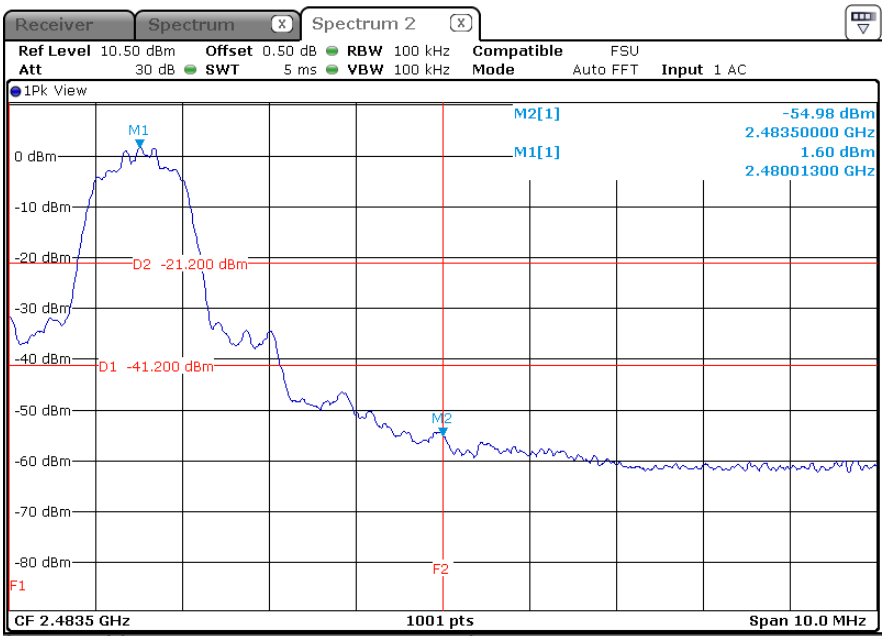
CH79



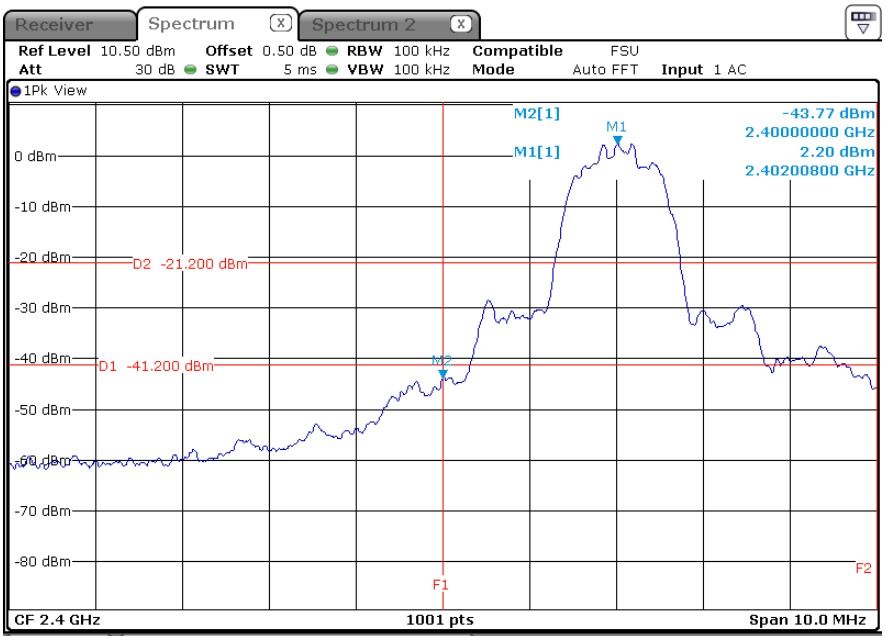
2-DH5 Packet, CH1



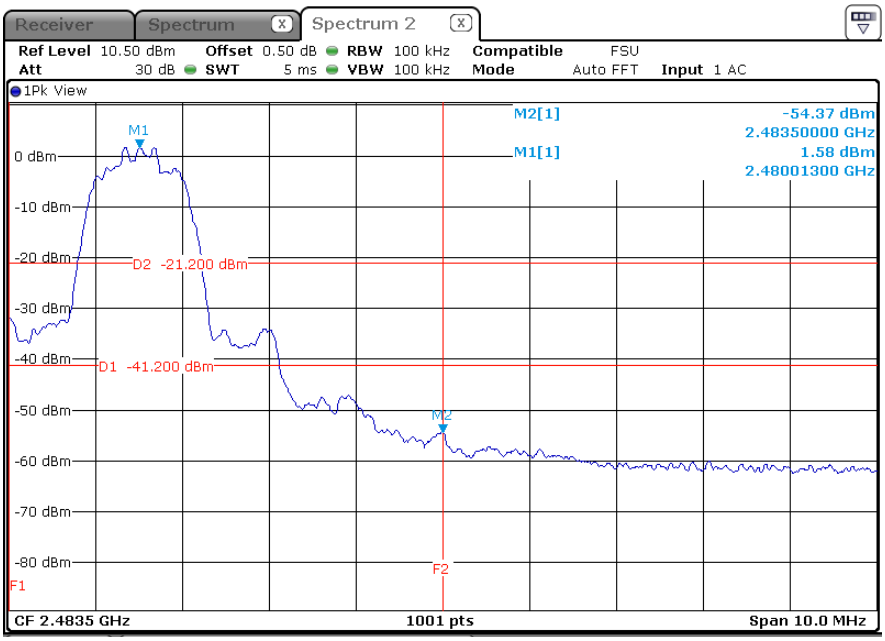
CH79



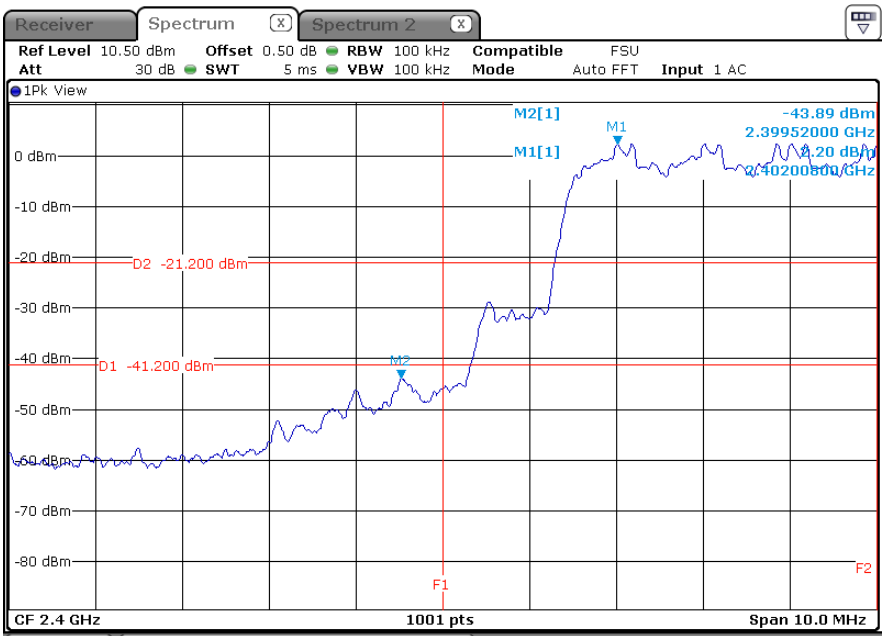
3-DH5 Packet, CH1

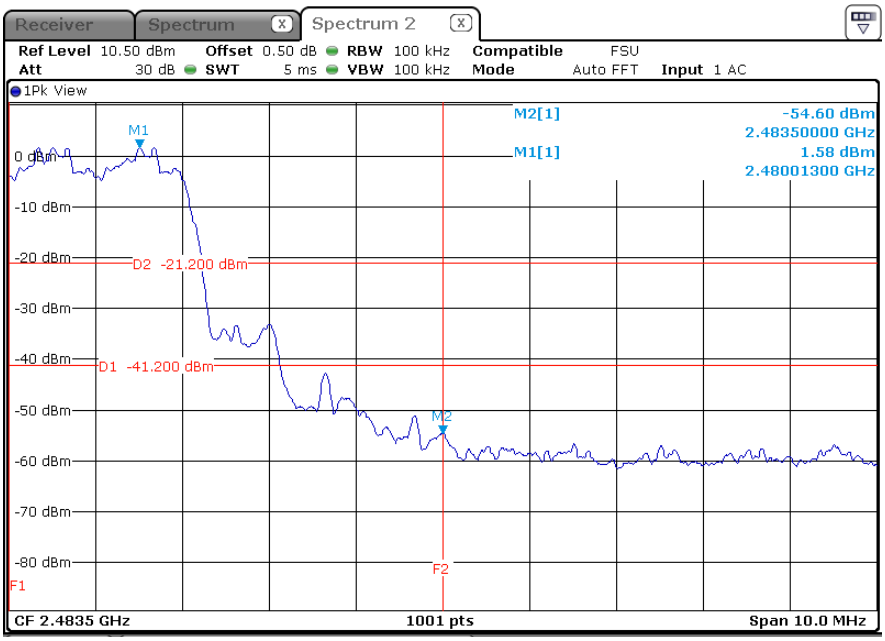


CH79



Hopping mode (3-DH5 Packet)





5.6 Radiated emissions in restricted bands

For test instruments and accessories used see section 6 Part **SER3**.

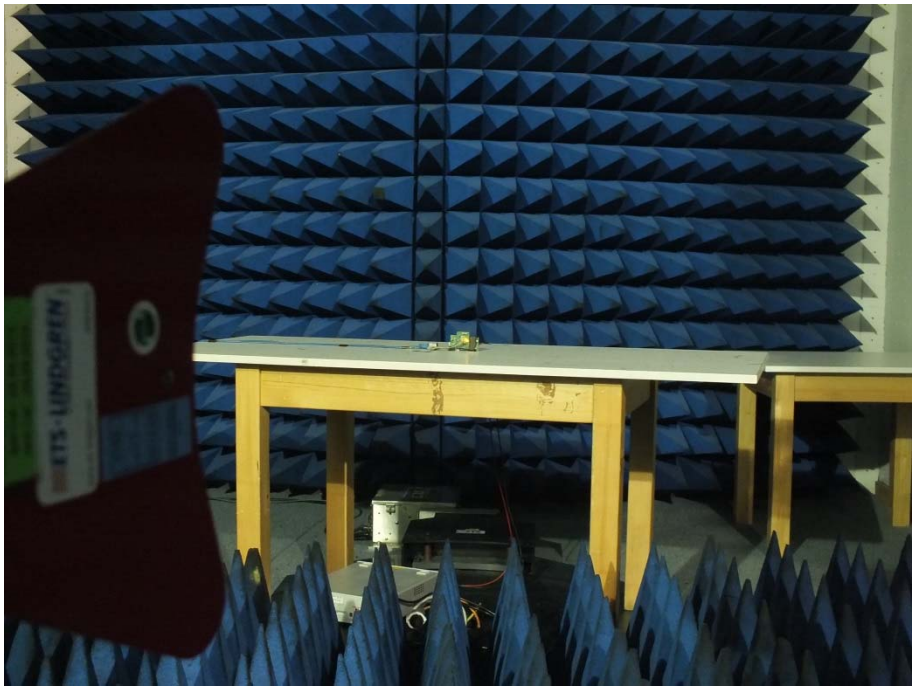
5.6.1 Description of the test location

Test location: AREA4

Test distance: 3 m

5.6.2 Photo documentation of the test set-up

Test setup 1 – 18 GHz



5.6.3 Applicable standard

According to FCC Part 15, Section 15.205(a):
In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limit specified in Section 15.209(a).

5.6.4 Description of Measurement

The restricted bands are measured radiated. The span of the spectrum analyser was set wide enough to capture the restricted band and measure the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation.

Spectrum analyser settings:
RBW: 1 MHz, VBW: 3 MHz, Sweep: Auto, Detector function: Peak

5.6.5 Test result

Restricted band 2310 – 2390 MHz:

3-DH5

Channel number	Frequency (MHz)	L: PK dB(µV/m)	Limit PK dB(µV/m)	Limit AV dB(µV/m)	Delta (dB)
1	2361.82	43.57	74	54	-10.43
79	2373.70	43.85	74	54	-10.15

Restricted band 2483.5 – 2500 MHz:

3-DH5

Channel number	Frequency (MHz)	L: PK dB(µV/m)	Limit PK dB(µV/m)	Limit AV dB(µV/m)	Delta (dB)
1	2484.42	43.83	74	54	-10.17
79	2483.51	50.57	74	54	-3.43

Restricted band 4500 – 5150 MHz:

3-DH5

Channel number	Frequency (MHz)	L: PK dB(µV/m)	Limit PK dB(µV/m)	Limit AV dB(µV/m)	Delta (dB)
1	4654.05	46.23	74	54	-7.77
79	4981.33	46.18	74	54	-7.82

Restricted band 5350 – 5460 MHz:

3-DH5

Channel number	Frequency (MHz)	L: PK dB(µV/m)	Limit PK dB(µV/m)	Limit AV dB(µV/m)	Delta (dB)
1	5389.71	47.13	74	54	-6.87
79	5397.99	47.79	74	54	-6.21

Restricted band 7250 – 7750 MHz:

3-DH5

Channel number	Frequency (MHz)	L: PK dB(µV/m)	Limit PK dB(µV/m)	Limit AV dB(µV/m)	Delta (dB)
1	7408.00	46.89	74	54	-7.11
79	7474.00	46.35	74	54	-7.65

Restricted band 10600 – 12700 MHz:

3-DH5

Channel number	Frequency (MHz)	L: PK dB(µV/m)	Limit PK dB(µV/m)	Limit AV dB(µV/m)	Delta (dB)
1	12470.05	49.74	74	54	-4.26
79	12573.48	49.42	74	54	-4.58

Restricted band 2655 – 2900 MHz (Canada):

3-DH5

Channel number	Frequency (MHz)	L: PK dB(µV/m)	Limit PK dB(µV/m)	Limit AV dB(µV/m)	Delta (dB)
1	2838.05	44.74	74	54	-9.26
79	2868.28	44.53	74	54	-9.47

Peak-Limit according to FCC Part 15C, Section 15.205(a):
In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limit specified in Section 15.209(a).

Frequency	Limits acc. 15.209		Measurement distance
(MHz)	PK dB(µV/m)	AV dB(µV/m)	(m)
Above 960	74	54	3

Restricted bands of operation:
The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in Section 15.209:

MHz	MHz	MHz	GHz
0.090 – 0.110	16.42 – 16.423	399.9 – 410	4.5 – 5.15
0.495 – 0.505	16.69475 – 16.69525	608 – 614	5.35 – 5.46
2.1735 – 2.1905	16.80425 – 16.80475	960 – 1240	7.25 – 7.75
4.125 – 4.128	25.5 – 25.67	1300 – 1427	8.025 – 8.5
4.17725 – 4.17775	37.5 – 38.25	1435 – 1626.5	9.0 – 9.2
4.20725 – 4.20775	73 – 74.6	1645.5 – 1646.5	9.3 – 9.5
6.215 – 6.218	74.8 – 75.2	1660 – 1710	10.6 – 12.7
6.26775 – 6.26825	108 – 121.94	1718.8 – 1722.2	13.25 – 13.4
6.31175 – 6.31225	123 – 138	2200 – 2300	14.47 – 14.5
8.291 – 8.294	149.9 – 150.05	2310 – 2390	15.35 – 16.2
8.362 – 8.366	156.52475 – 156.52525	2483.5 – 2500	17.7 – 21.4
8.37625 – 8.38675	156.7 – 156.9	2690 – 2900	22.01 – 23.12
8.41425 – 8.41475	162.0125 – 167.17	3260 – 3267	23.6 – 24.0
12.29 – 12.293	167.72 – 173.2	3332 – 3339	31.2 – 31.8
12.51975 – 12.52025	240 – 285	3345.8 – 3358	36.43 – 36.5
12.57675 – 12.57725	322 – 335.4	3600 – 4400	Above 38.6

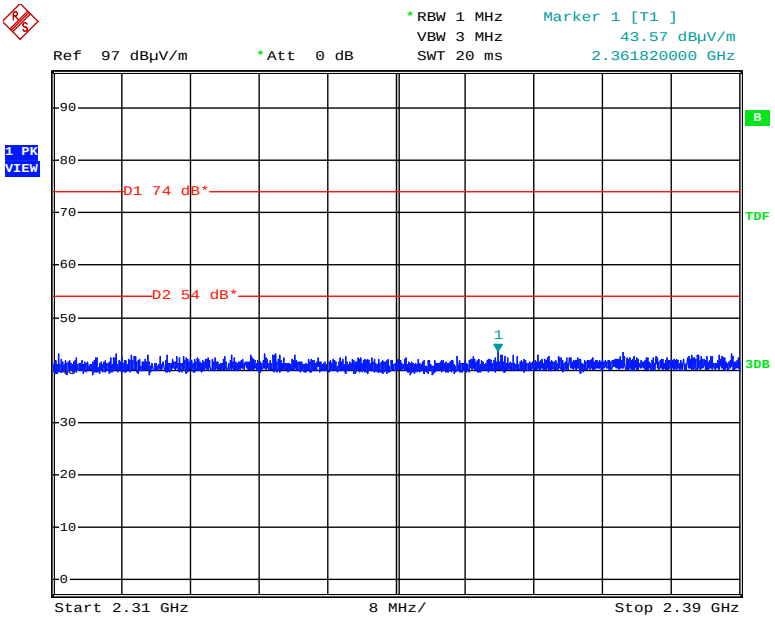
The requirements are **fulfilled**

Remarks: For detailed test result please refer to following test protocol. Only the worst case plots are listed.

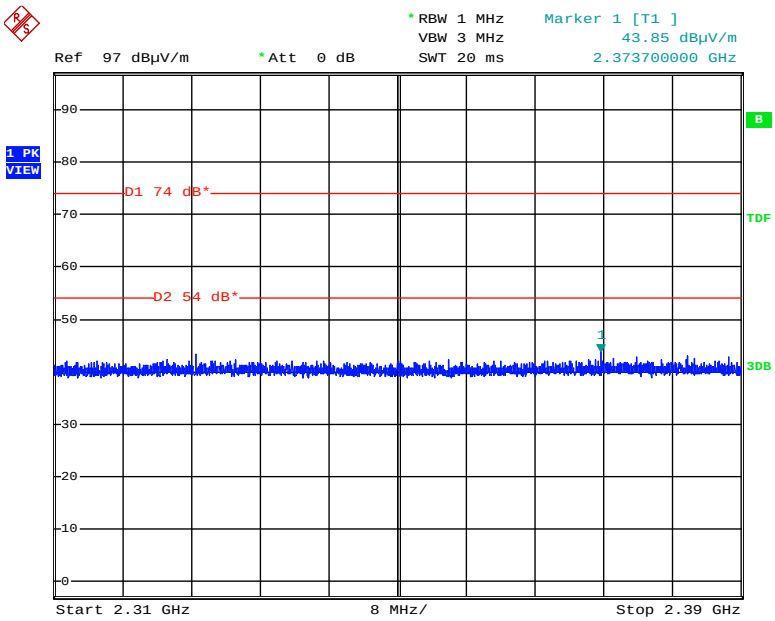
5.6.6 Test protocol

Restricted band 2310 – 2390 MHz:

CH1

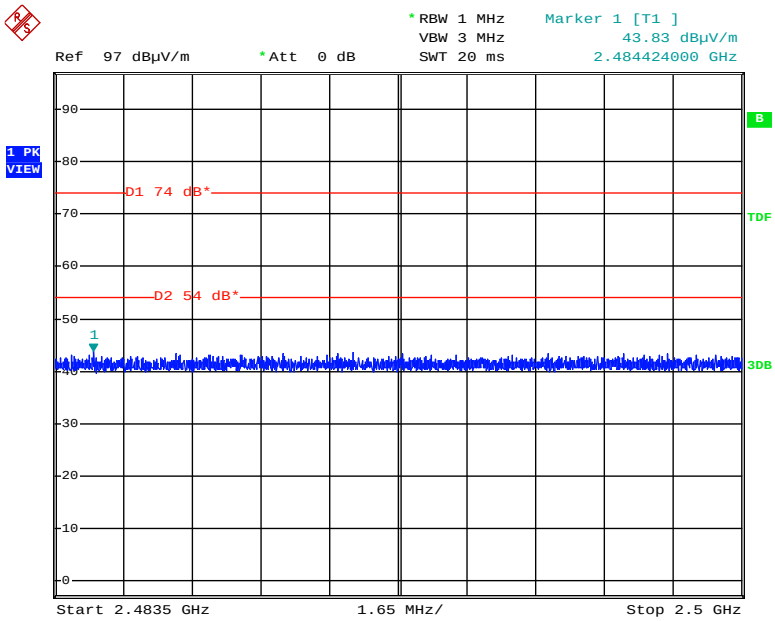


CH79

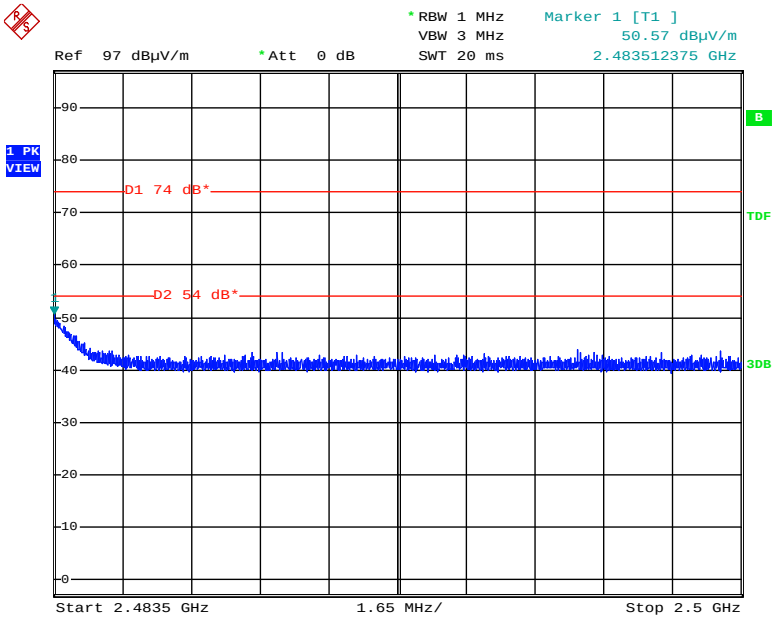


Restricted band 2483.5 – 2500 MHz:

CH1

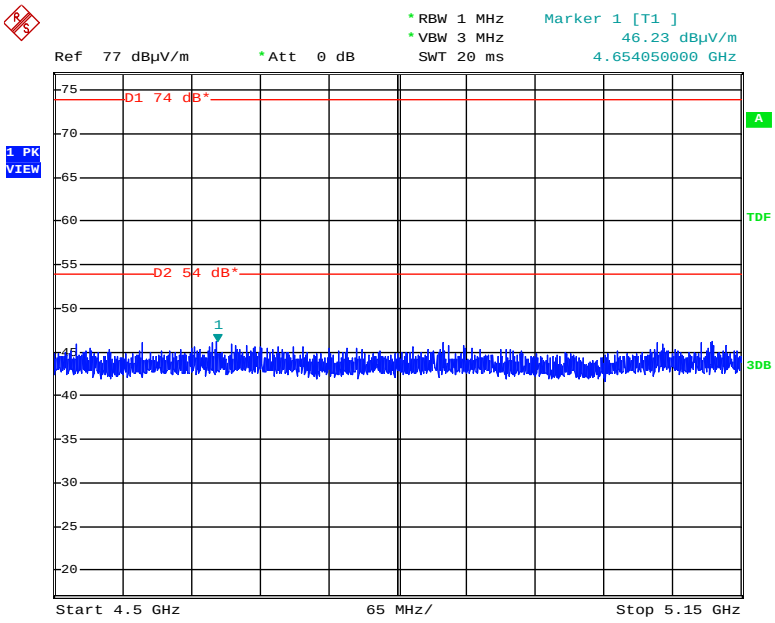


CH79

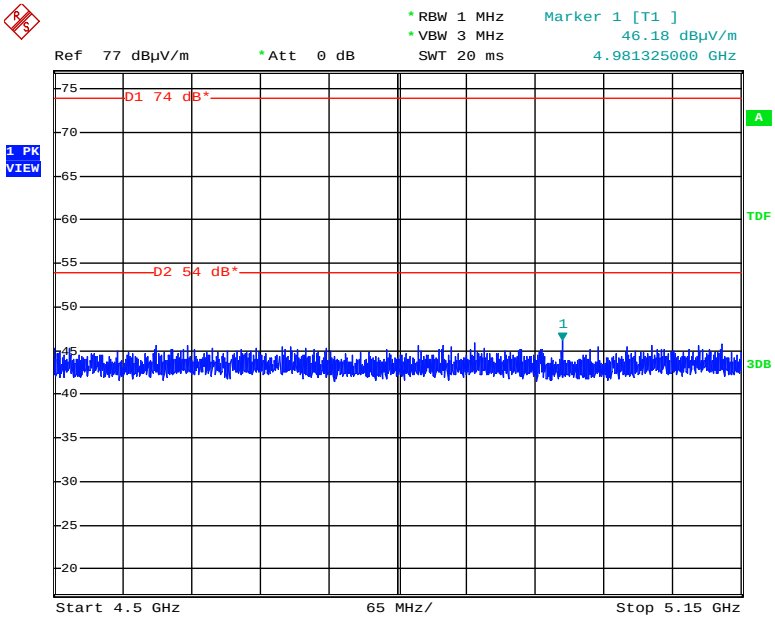


Restricted band 4500 – 5150 MHz:

CH1

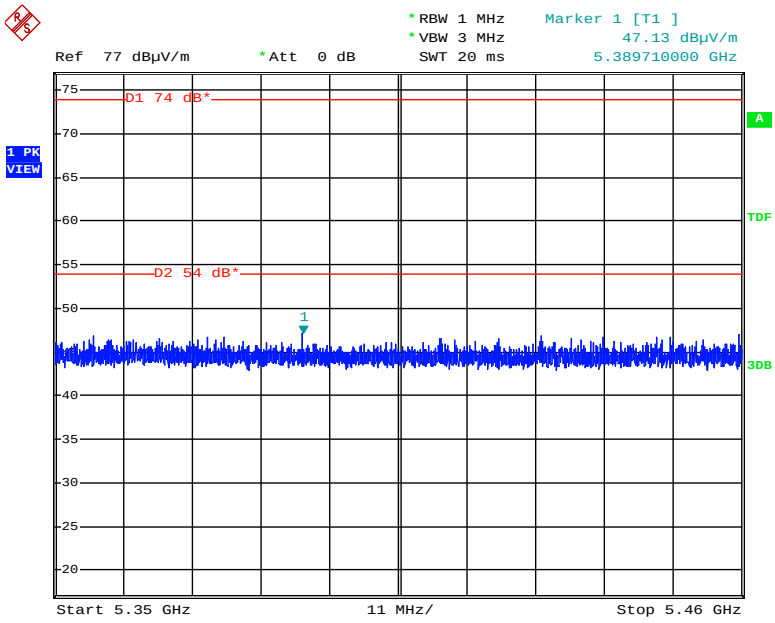


CH79

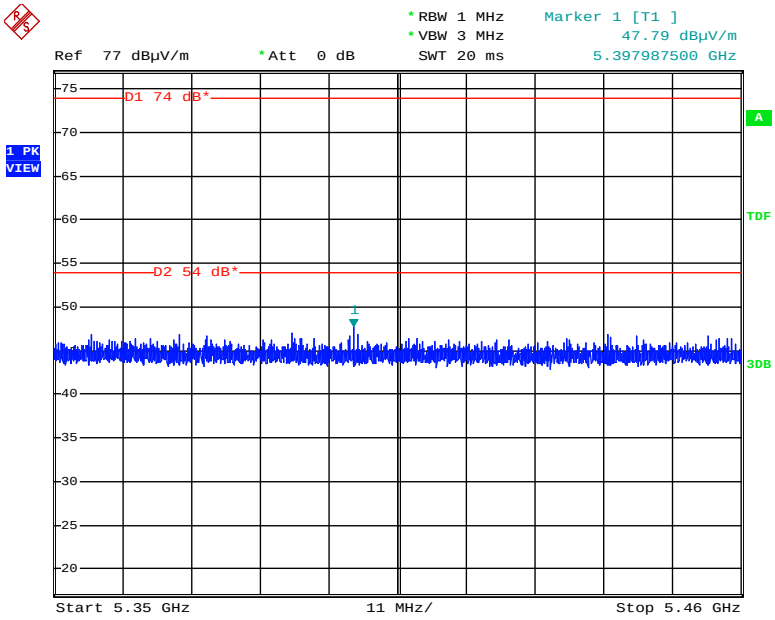


Restricted band 5350 – 5460 MHz:

CH1

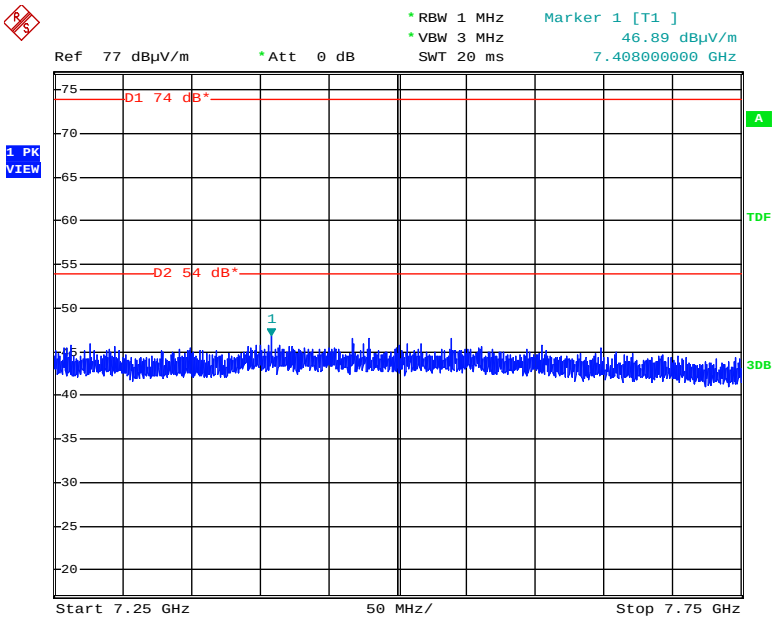


CH79

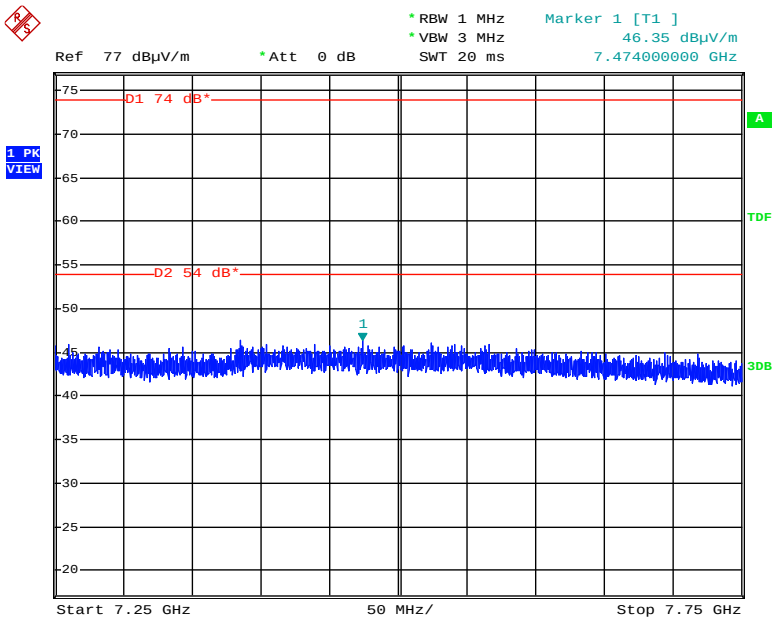


Restricted band 7250 – 7750 MHz:

CH1

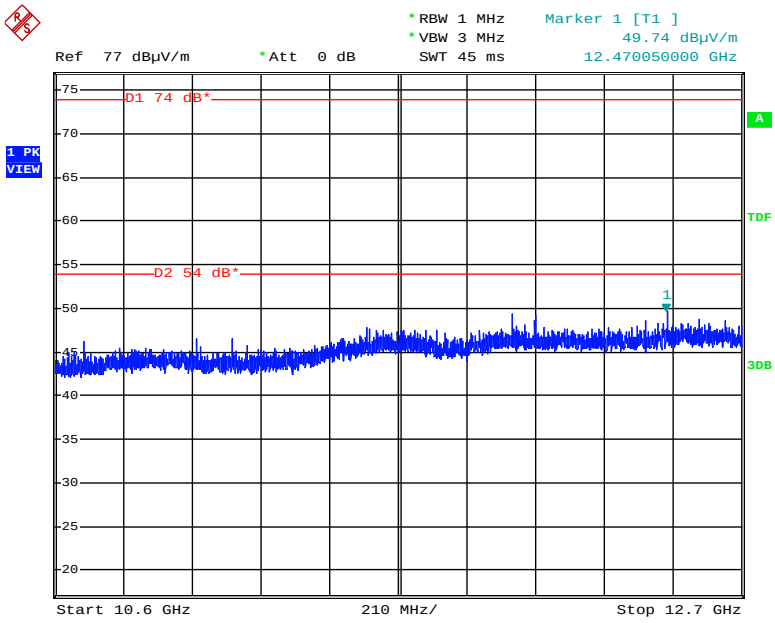


CH79

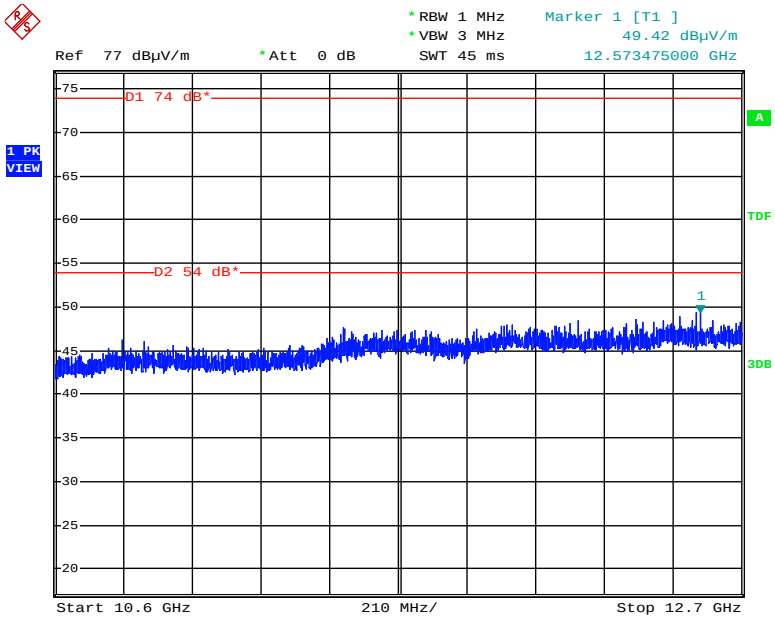


Restricted band 10600 – 12700 MHz:

CH1

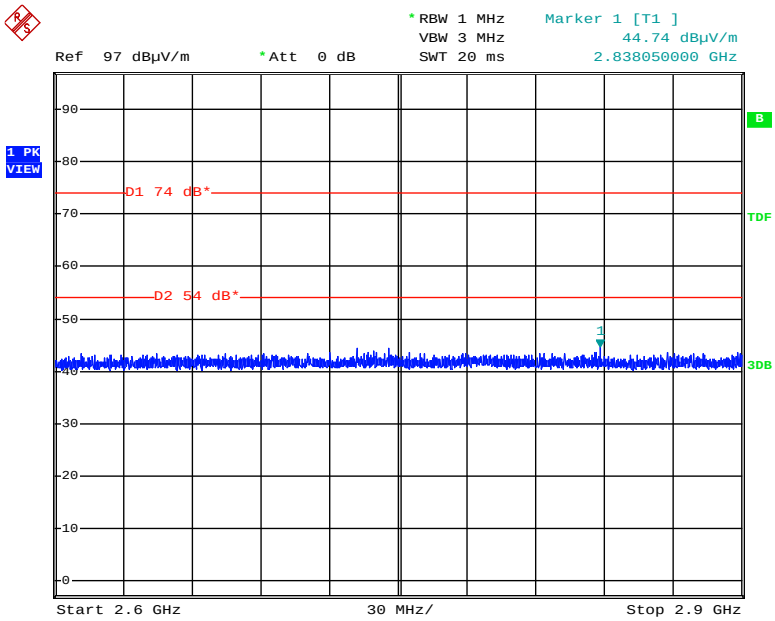


CH79

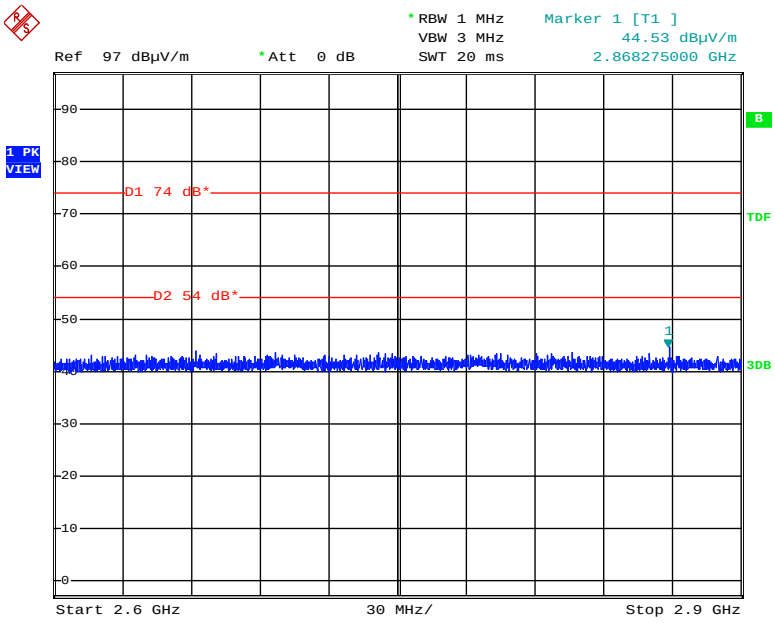


Restricted band 2655 – 2900 MHz:

CH1



CH79



5.7 Pseudorandom frequency hopping sequence

Requirement according to FCC Part 15C, Section 15.247(a):
The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies.

Co-ordination of the hopping sequence in data mode to avoid simultaneous occupancy by multiple transmitters:
Bluetooth units which want to communicate with other units must be organized in a structure called piconet. This piconet consists of maximum 8 Bluetooth units. One unit is the master the other seven are the slaves. The master co-ordinates frequency occupation in this piconet for all units. As the master hop sequence is derived from its BD address which is unique for each Bluetooth device, additional masters intending to establish new piconets will always use different hop sequences.
Example of a 79 hopping sequence in data mode:
40, 21, 44, 23, 42, 53, 46, 55, 48, 33, 52, 35, 50, 65, 54, 67, 56, 37, 60, 39, 58, 69, 62, 71, 64, 25, 68, 27, 66, 57, 70, 59, 72, 29, 76, 31, 74, 61, 78, 63, 01, 41, 05, 43, 03, 73, 07, 75, 09, 45, 13, 47, 11, 77, 15, 00, 64, 49, 66, 53, 68, 02, 70, 06, 01, 51, 03, 55, 05, 04

Derivation and examples for a hopping sequence in hybrid mode
For the generation of the inquiry and page hop sequences the same procedures as described for the data mode are used (see chapter 5), but this time with different input vectors:
a. For the inquiry hop sequence, a predefined fixed address is always used. This results in the same 32 frequencies used by all devices doing an inquiry but every time with a different start frequency and phase in this sequence.
b. For the page hop sequence, the device address of the paged unit is used as input vector. This results in the use of a subset of 32 frequencies which is specific for that initial state of the connection establishment between the two units. A page to different devices would result in a different subset of 32 frequencies.
So it is ensured that also in hybrid mode the frequency use equally averaged.
Example of a hopping sequence in inquiry mode:
48, 50, 09, 13, 52, 54, 41, 45, 56, 58, 11, 15, 60, 62, 43, 47, 00, 02, 64, 68, 04, 06, 17, 21, 08, 10, 66, 70, 12, 14, 19, 23
Example of a hopping sequence in paging mode:
08, 57, 68, 70, 51, 02, 42, 40, 04, 61, 44, 46, 63, 14, 50, 48, 16, 65, 52, 54, 67, 18, 58, 56, 20, 53, 60, 62, 55, 06, 66, 64

Remarks: This item is part of the Bluetooth Core Specifications V2.1+EDR compliance and approved.

5.8 Equal hopping frequency use

Requirement according to FCC Part 15C, Section 15.247(a):
Each frequency must be used equally on the average by each transmitter.

The generation of the hopping sequence in connection mode depends essentially on two input values:
1. LAP/UAP of the master of the connection.
2. Internal master clock.
The LAP (lower address part) is the 24 LSB's of the 48 BD_ADDRESS. The BD_ADDRESS is an unambiguous number of every Bluetooth unit. The UAP (upper address part) are the 24 MSB's of the 48 BD_ADDRESS. The internal clock of a Bluetooth unit is derived from a free running clock which is never adjusted and is never turned off. For synchronization with other units only offset are used. It has no relation to the time of the day. Its resolution is at least half the Rx/Tx slot length of 312.5 µs. The clock has a cycle of about one day (23hr30min). In most case, it is implemented as 28 bit counter. For the deriving of the hopping sequence the entire LAP (24 bits), 4 LSB's (4 bits) (Input 1) and the 27 MSB's of the clock (Input 2) are used. With this input values different mathematical procedures (permutations, additions, XOR-operations) are performed to generate the sequence. This will be done at the beginning of every new transmission.
Regarding short transmissions the Bluetooth system has the following behaviour: The first connection between the two devices is established, a hopping sequence was generated. For transmitting the wanted data the complete hopping sequence was not used. The connection ended. The second connection will be established. A new hopping sequence is generated. Due to the fact that the Bluetooth clock has a different value the hopping sequence will always differ from the first one, because the period between the two transmissions is longer and it cannot be shorter than the minimum resolution of the clock is 312.5 µs. This circumstance is always the same therefore the average of the frequency use is the same on all transmitters.

Remarks: This item is part of the Bluetooth Core Specifications V2.1+EDR compliance and approved.

5.9 Receiver input bandwidth

Requirement according to FCC Part1 5C, Section 15.247(a):
The system receivers shall have input bandwidth that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signal.

Receiver input bandwidth and behaviors for repeated single or multiple packets:
The input bandwidth of the receiver is 1 MHz. In every connection one Bluetooth device is the master and the other one is the slave. The master determines the hopping sequence (see chapter 5). The slave follows this sequence. Both devices shift between Rx and Tx time slot according to the clock of the master. Additionally the type of connection (e.g. single or multi-slot packet) is set up at the beginning of the connection. The master adapts its hopping frequency and its Tx/Rx timing according to the packet type of the connection. Also the slave of the connection will use these settings. Repeating of a packet has no influence on the hopping sequence. The hopping sequence generated by the master of the connection will be followed in any case. That means, a repeated packet will not be send on the same frequency, it is send on the next frequency of the hopping sequence.

Remarks: This item is part of the Bluetooth Core Specifications V2.1+EDR compliance and approved.

5.10 Correction for pulsed operation (duty cycle)

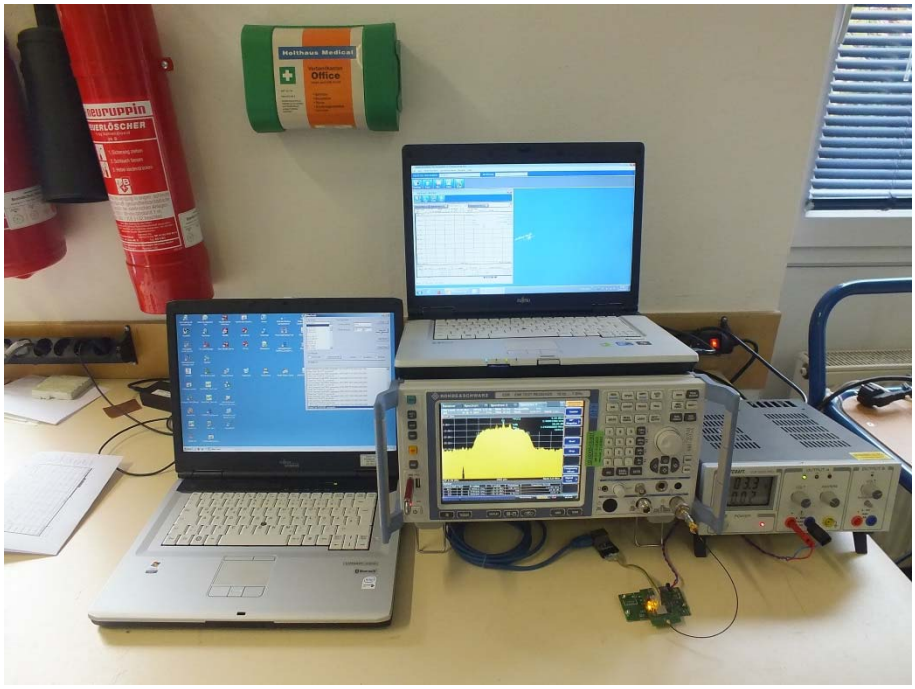
Remarks: Not applicable.

5.11 Dwell time

5.11.1 Description of the test location

Test location: AREA4

5.11.2 Photo documentation of the test set-up



5.11.3 Applicable standard

According to FCC Part 15, Section 15.247(a):
In Section 15.247(a)(1i)(1ii) and (1iii) are dwell times defined for the special frequency ranges should not exceed by a frequency hopping system.

5.11.4 Functional description of Bluetooth timing

Dwell time in data mode:
The dwell time of 0.3797s within a 30 second period in data mode is independent from the packet type (packet length). The calculation for a 30 second period is a follows:

Dwell time = time slot length * hop rate / number of hopping channels * 30s
Example for a DH1 packet (with a maximum length of one time slot)
Dwell time = 625 µs * 1600 * 1/s / 79 * 30s = 0.3797s (in a 30s period)

For multi-slot packet the hopping is reduced according to the length of the packet.
Example for a DH5 packet (with a maximum length of five time slots)
Dwell time = 5 * 625 µs * 1600 * 1/5 * 1/s / 79 * 30s = 0.3797s (in a 30s period)

This is according the Bluetooth Core Specification V 1.0B (+ critical errata) for all Bluetooth devices. Therefore all Bluetooth devices comply with the FCC dwell time requirement in data mode.
This was checked during the Bluetooth Qualification tests and approved.

The Dwell time in hybrid mode is approximately 2.6 ms (in a 12.8 s period).

5.11.5 Description of Measurement

A spectrum analyser is connected to the output of the transmitter via a suitable attenuator while EUT is operating in transmit mode using the assigned frequency according to DA 00-705. The correction factor takes the cable loss into account. The span of the spectrum analyser was set to zero span and the frequency of the measured hopping channel was centered. Sweep time setting was as long as necessary to capture the entire dwell time per hopping channel. Pre-measurements showed the longest dwell time in 3-DH5 packet type.

Spectrum analyser settings:
RBW: 1 MHz, VBW: 3 MHz, Detector function: Maximum peak, Trace: Maximum hold

5.11.6 Test result

Operation mode:
3-DH5 Packet mode permits maximum 1600 hops per second in each channel, supporting 1 TX- and 1 RX-channel.

Hops per second	1600
Number of channels	79
Length of one hop	$T_{hop} = t_{TX} + t_{RX}$ = 2.905 ms + 0.860 ms = 3.765 ms
Spreading factor:	74.0
Limit for total frequency residence time:	< 0.4 s

Operating mode	Time of period (s)	Residence time, time of 1 burst (ms)	Number of Bursts (per period)	Total frequency residence time (s)
Hopping 3-DH5	0.4 s * 74.0 = 29.6s	2.905	101	0.293

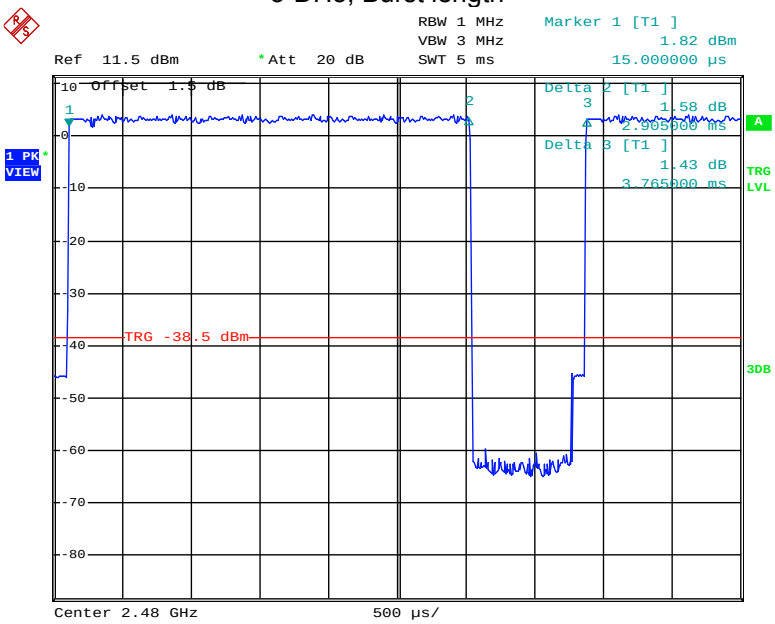
The requirements are **fulfilled**

Remarks: This item is part of the Bluetooth Core Specifications V2.1+EDR compliance and approved.

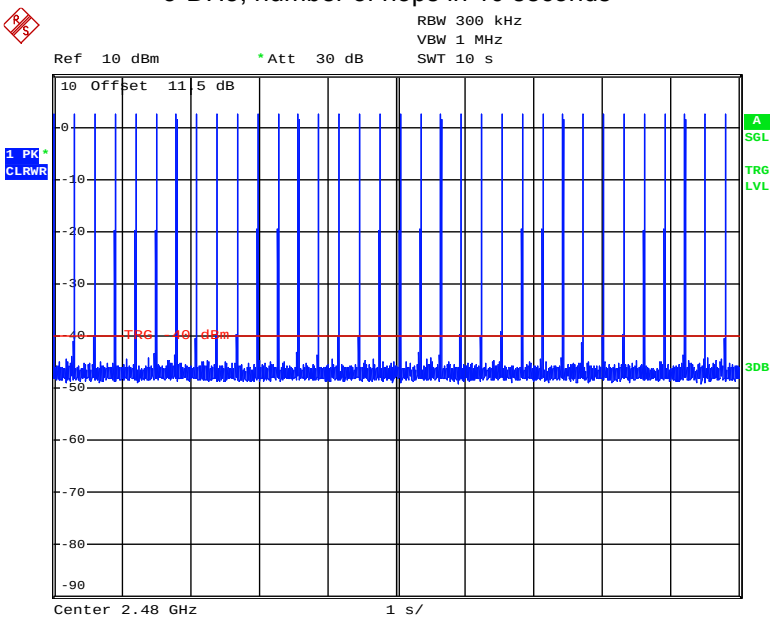
For detailed test result please refer to following test protocol. Only the worst case plots are listed.

5.11.7 Test protocol

3-DH5, Burst length



3-DH5, number of hops in 10 seconds



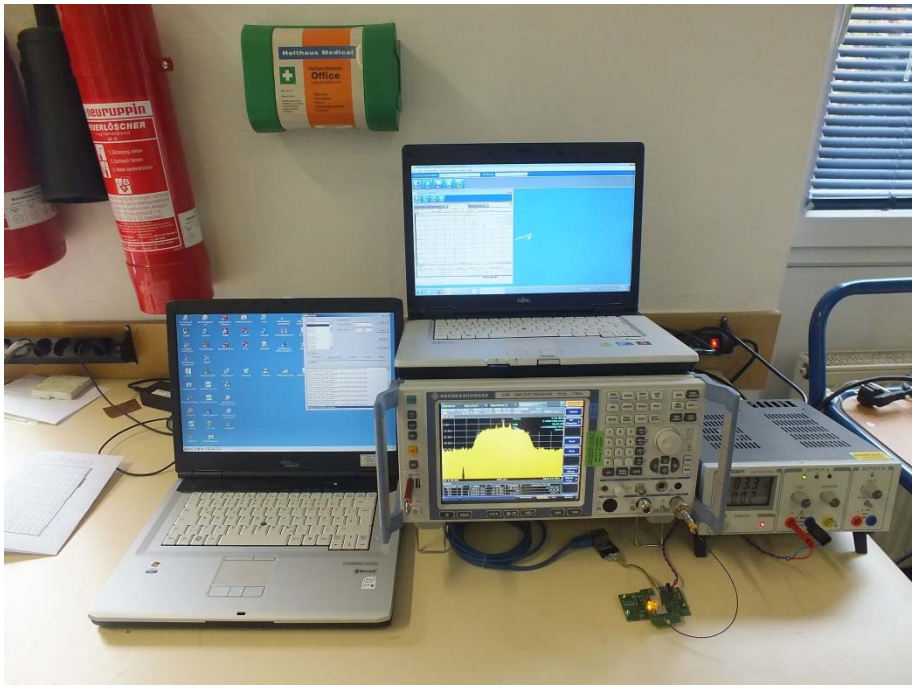
5.12 Carrier frequency separation

For test instruments and accessories used see section 6 Part **MB**.

5.12.1 Description of the test location

Test location: AREA4

5.12.2 Photo documentation of the test set-up



5.12.3 Applicable standard

According to FCC Part 15, Section 15.247(a):
Frequency hopping systems operating in the frequency band of 2400 MHz – 2483.5 MHz may have hopping channel carrier frequencies that are separated by 25 kHz or 2/3 of the 20 dB bandwidth of the hopping channel.

5.12.4 Description of Measurement

The measurement is performed using a spectrum analyser in single sweep mode. A part of the operating frequency is used for better resolution. In normal application mode all the channels of the part of operating frequency are displayed and the separation is measured. The 20 dB OBW has to be measured before to compare whether the OBW requirement is fulfilled.

5.12.5 Test result

Channel separation in hybrid mode:
The nominal channel spacing of the Bluetooth system is 1MHz independent of the operating mode. The maximum “initial carrier frequency tolerance” which is allowed for Bluetooth is f_{center} = 75 kHz.
This was checked during the Bluetooth Qualification tests (Test Case: TRM/CA/07-E) for three frequencies (2402 MHz, 2441 MHz, and 2480 MHz) and approved.

Additionally an example for the channel separation in 3-DH5 modulation is given below:

Channel	2/3 of 20 dB BW (MHz)	Hopping channels	Separation (MHz)	Limit (MHz)
39/40	0.839	79	1	0.839

Limit according to FCC Part 15C, Section 15.247(a):

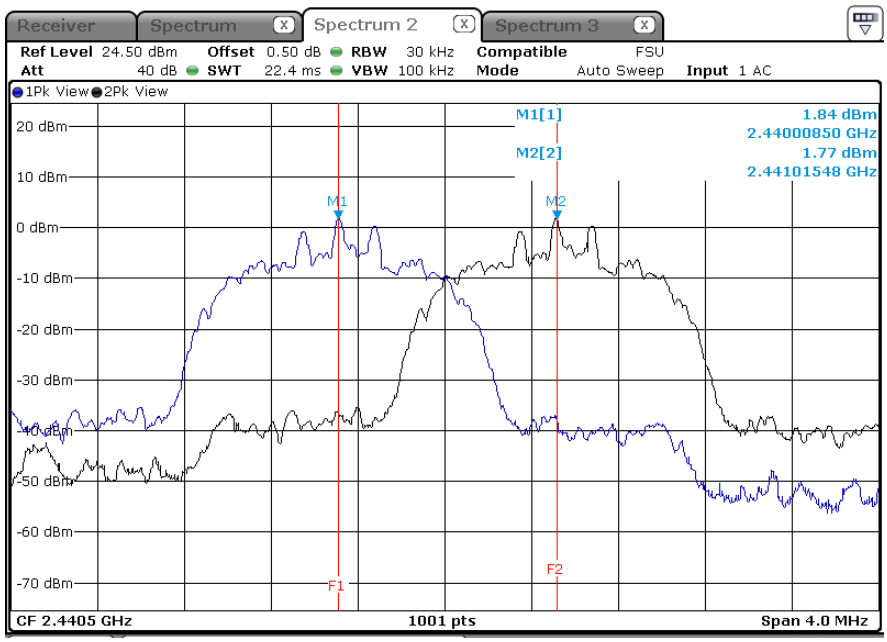
Frequency	Hopping channels	Limit channel separation
(MHz)		
All systems		> 25 kHz or 20 dB bandwidth, which ever is greater
2400 - 2483.5	≥ 15	> 25 kHz or 2/3 of 20 dB bandwidth, which ever is greater

The requirements are **fulfilled**

Remarks: For detailed test result please refer to following test protocol.

5.12.6 Test protocol

Channel separation between CH39 and CH40



5.13 Number of hopping channels

For test instruments and accessories used see section 6 Part **MB**.

5.13.1 Description of the test location

Test location: AREA4

5.13.2 Test result

Hopping channel frequency range	Number of all available hopping channels
2402 - 2480	79

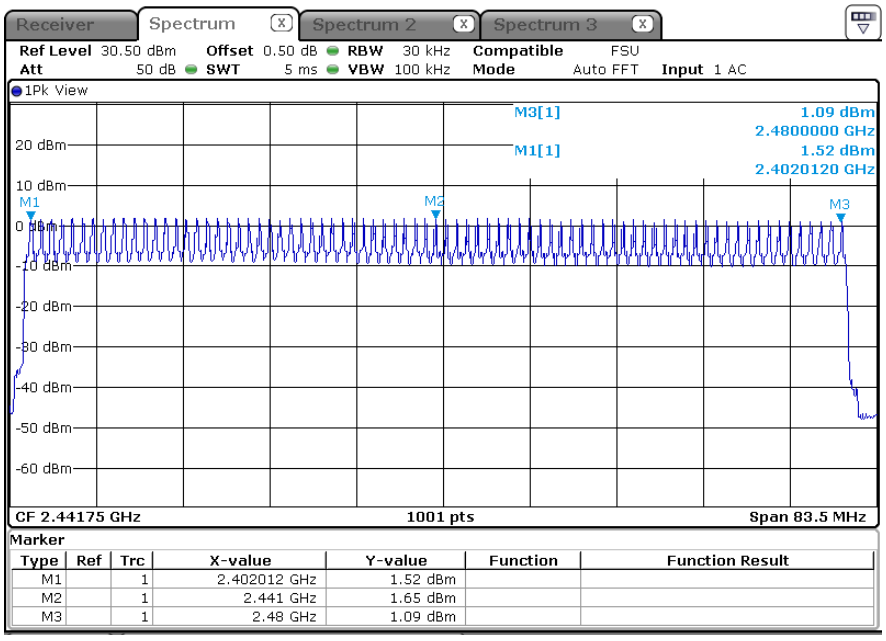
Limit according to FCC Part 15C, Section 15.247(1):

Frequency range (MHz)	LIMIT (Number of Hopping Channels)			
	20dB Bandwidth < 250kHz	20dB Bandwidth > 250kHz	20dB Bandwidth < 1 MHz	20dB Bandwidth > 1MHz
2400 – 2483.5	15	15	15	15

The requirements are **fulfilled**

Remarks: For detailed test result please refer to following test protocol.

5.13.3 Test protocol



5.14 Antenna application

5.14.1 Applicable standard

According to FCC Part 15C, Section 15.203:
An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit that broken antennas can be replaced by the user, but the use of a standard antenna jack is prohibited.

The EUT has a integrated chip antenna; special tools are needed for replacing the antenna that prevents manipulation by a user. No external power amplifier can be connected. The requirements of part 15.203 and 15.204 are met.

5.14.2 Antenna requirements

According to FCC Part 15C, Section 15.247 (b)(4):
The conducted output power limit specified in paragraph (b) of 15.247 is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from intentional radiator shall be reduced below the stated values in paragraph (b)(1), (b)(2) and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

For the used antenna type, 465M04-E01, an output power reduction is not necessary.

5.15 Maximum permissible exposure (MPE)

For test instruments and accessories used see section 6 Part **CPC 3**.

5.15.1 Description of the test location

Test location: AREA4

5.15.2 Applicable standard

According to FCC Part 15, Section 15.247(i):
Systems operating under the provisions of this section shall be operated in a manner that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.
The test methods used comply with ANSI/IEEE C95.1, "IEEE Standard for Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz".
This test report shows the compliance with the limits for Maximum Permissible Exposure (MPE) specified in FCC Part 1, Section 1.1310 and the criteria to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in FCC Part 1, Section 1.1307(b).

5.15.3 Description of Measurement

The maximum total power input to the antenna is measured conducted as described in clause 5.3 of this document. To calculate the MPE in a defined distance away from the product the Friis transmission formula is used.

Friis transmission formula:

$$P_d = \frac{P_{out} * G}{4 * \Pi * r^2}$$

P_d = power density (mW/cm^2)
P_{out} = output power to antenna (mW)
G = gain of antenna (linear scale)
r = distance between antenna and observation point (cm)

According to FCC Rules 47CFR 2.1093(b) the EUT is not a portable device. The EUT is designed to be used that radiating structures are 5 mm outside of the body of the user (r = 0.5 cm). The maximum permissible exposure was calculated for a radial distance of 5 mm.

5.15.4 Test result

Worst case: Antenna type with a peak antenna gain of -3 dBi, Power setting: max

DH5

Channel No.	A (dBm)	Ant. gain (dBi)	A (mW)	G linear	P (mW)	S (mW/cm2)	Limit S_{eq} (mW/cm2)
1	3.9	-3.0	2.44	0.50	1.22	0.388911	1.0
40	4.0	-3.0	2.54	0.50	1.27	0.404436	1.0
79	3.6	-3.0	2.30	0.50	1.15	0.367156	1.0

2-DH5

Channel No.	A (dBm)	Ant. gain (dBi)	A (mW)	G linear	P (mW)	S (mW/cm2)	Limit S_{eq} (mW/cm2)
1	3.1	-3.0	2.05	0.50	1.03	0.327228	1.0
40	3.2	-3.0	2.08	0.50	1.04	0.332545	1.0
79	2.6	-3.0	1.81	0.50	0.91	0.288968	1.0

3-DH5

Channel No.	A (dBm)	Ant. gain (dBi)	A (mW)	G linear	P (mW)	S (mW/cm2)	Limit S_{eq} (mW/cm2)
1	3.3	-3.0	2.15	0.50	1.08	0.342650	1.0
40	3.4	-3.0	2.21	0.50	1.11	0.352249	1.0
79	2.9	-3.0	1.94	0.50	0.97	0.309635	1.0

Limits for maximum permissible exposure (MPE):

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm2)	Averaging Time (minutes)
(B) Limits for General Population / Uncontrolled Exposure				
0.3 – 3.0	614	1.63	100	30
3.0 – 30	824/f	2.19/f	180/ f^2	30
30 - 300	27.5	0.073	0.2	30
300-1500	---	---	f/1500	30
1500-100000	**---**	**---**	**1**	**30**

f = Frequency (MHz)

The requirements are **fulfilled.**

Remarks: The EUT fulfills the SAR Test Exclusion Thresholds for 100 MHz – 6 GHz and ≤ 50 mm being given in Apendix A of KDB 447498 D01 General RF Exposure Guidance v05r02 .

6 USED TEST EQUIPMENT AND ACCESSORIES

All test instruments used are calibrated and verified regularly. The calibration history is available on request.

Test ID	Model Type	Equipment No.	Next Calib.	Last Calib.	Next Verif.	Last Verif.
CPC 3	FSP 30	02-02/11-05-001	24/10/2014	24/10/2013		
MB	ESR7	02-02/03-13-001	21/05/2014	21/05/2013		
SEC 1-3	ESR7	02-02/03-13-001	21/05/2014	21/05/2013		
	FSP 40	02-02/11-11-001	30/09/2014	30/09/2013		
	WLJS 1200-3EF	02-02/50-05-041				
	WHK 3.0/18G-10EF	02-02/50-05-180				
SER 3	AMF-40-005-180-24-10P	01-02/17-02-009			24/04/2014	24/04/2013
	FSP 40	02-02/11-11-001	30/09/2014	30/09/2013		
	3117	02-02/24-05-009	04/04/2014	04/04/2013		
	Sucoflex N-1600-SMA	02-02/50-05-073				
	Sucoflex N-2000-SMA	02-02/50-05-075				
	WHK 3.0/18G-10EF	02-02/50-05-180				