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Test Report

Report Number:

F145833E1
3rd Version

Applicant:

Wachendorff Elektronik GmbH &Co. KG

Manufacturer:

Wachendorff Elektronik GmbH &Co. KG

Equipment under Test (EUT):

X25 Console

DAkkS
Deutsche Akkreditierungsstelle
D-PL-17186-01-01
D-PL-17186-01-02
D-PL-17186-01-03

Laboratory accredited by
Deutsche Akkreditierungsstelle GmbH (DAkkS)
in compliance with DIN EN ISO/IEC 17025
under the Reg. No. D-PL-17186-01-02,
FCC Test site registration number 90877 and
Industry Canada Test site registration IC3469A-1

REFERENCES

[1] ANSI C63.4-2009 American National Standard for Methods of Measuring of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

[2] FCC CFR 47 Part 15 (December 2014) Radio Frequency Devices

[3] FCC Public Notice DA 00-705 (March 2000)

[4] RSS-210 Issue 8 (December 2010) Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment

[5] RSS-Gen Issue Issue 4 (November 2014) General Requirements for Compliance of Radio Apparatus

TEST RESULT

The requirements of the tests performed as shown in the overview (clause 4) were fulfilled by the equipment under test.
The complete test results are presented in the following.

Test engineer:	Wolfgang KASALOWSKY	W. Kasalowsky	23 March 2015
	Name	Signature	Date
Authorized reviewer:	Bernd STEINER	B. Steiner	23 March 2015
	Name	Signature	Date

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1 IDENTIFICATION

1.1 APPLICANT

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Applicant represented during the test by the following person:	Eugen EIGENSEHER

1.2 MANUFACTURER

Name:	Wachendorff Elektronik GmbH &Co. KG
Address:	Industriestraße 7, 65366 Geisenheim
Country:	Germany
Name for contact purposes:	Stefan HICKMANN
Phone:	+ 49 6722 9965-578
Fax:	+ 49 6722 9965-85
eMail Address:	hs@wachendorff.de
Applicant represented during the test by the following person:	Eugen EIGENSEHER

1.3 TEST LABORATORY

The tests were carried out at: **PHOENIX TESTLAB GmbH**
Königswinkel 10
32825 Blomberg
Germany

accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025 under the Reg. No. D-PL-17186-01-02, FCC Test site registration number 90877 and Industry Canada Test site registration IC3469A-1.

1.4 EUT (EQUIPMENT UNDER TEST)

Test object: *	Electronic Console with LCD display and touchscreen
Type: *	X25 Console
Product number: *	AGA4397
Serial number: *	201441002AD
Hardware version: *	Rev. C
Software version: *	EMC Test App 1.1.0 Linux weimx6 3.0.35-rt56-bttest
FCC ID	2ADFIOPX25

1.5 PRODUCT INFORMATION

X25 Console	
Power Supply	DC from vehicle battery
Supply voltage:	12 / 24 V_{DC} (battery)
Power setting for Bluetooth measurements	13
Bluetooth module	
Manufacturer	Panasonic Electronic Devices Europe GmbH
Type	PAN1315
Type of modulation used	FHSS: GFSK (1 Mbps), π/4-DQPSK (2 Mbps) and 8DPSK (3 Mbps)
Bluetooth specification	v2.1 + EDR
Operating Frequency Range	2402 to 2480 MHz
Number of Hopping Frequencies	79
Antenna	Bluetooth Antenne X25, P/N ANUFI00W00
Antenna type	Asymetric dipole structure
Max. Antenna gain	-1.7 dBi
Antenna connector:	Internal, Hirose U.FL

Channel 0	RX:	2402 MHz	TX:	2402 MHz
Channel 39	RX:	2441 MHz	TX:	2441 MHz
Channel 78	RX:	2480 MHz	TX:	2480 MHz

The following external I/O cables were used:

Identification	Connector		Length
	EUT	Ancillary	
Main Connector	AMP 26 pins	DC 24 V	1.5 m *
Extension connector	AMP 26 pins	-	1.5 m *

*: Length during the test if no other specified.

1.6 DATES

Date of receipt of test sample:	28 October 2014
Start of test:	29 October 2014
End of test:	10 February 2015

2 OPERATIONAL STATES

The equipment under test (EUT) is an electronic console with LCD display and touchscreen. The X25 console is assigned for mounting on a vehicle. The console allows operators to work with auto steering, guidance and other control functions from the console.

The console contains a Bluetooth module

All tests were carried out with a sample with test software installed.

Operation mode:

With a test software which was provided by the applicant the hopping can be enabled and disabled. Furthermore the equipment could be set to transmit only and receive only mode with a certain modulation scheme and data rate on a certain frequency. This software was installed on the EUT.

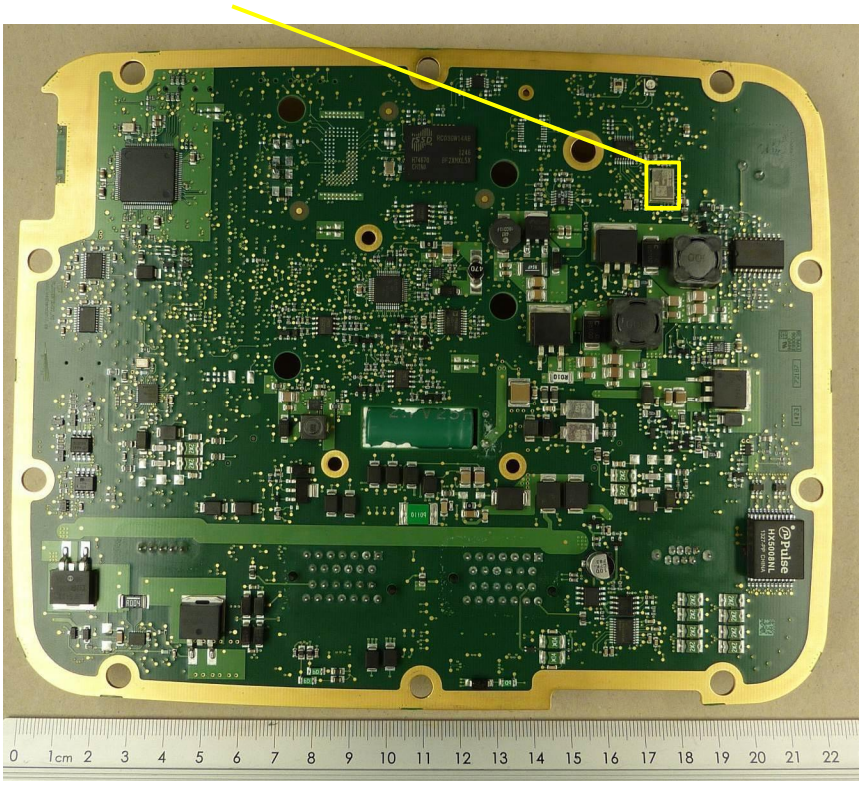
The EUT was a Bluetooth 2.1 device which was able to operate with GFSK, DQPSK and 8DPSK. The table below shows the worst case modulation and data rate for appropriate test cases.

Operation mode	Description of the operation mode	Modulation	Data rate / Mbps
1 1a 1b	Continuous transmitting on 2402 MHz	GFSK π/4-DQPSK 8DPSK	1 2 3
2 2a 2b	Continuous transmitting on 2441 MHz	GFSK π/4-DQPSK 8DPSK	1 2 3
3 3a 3b	Continuous transmitting on 2480 MHz	GFSK π/4-DQPSK 8DPSK	1 2 3
4 4a 4b	Transmitter hopping on all channels	GFSK π/4-DQPSK 8DPSK	1 2 3

The power level was set to 13 for the following measurements.

Physical boundaries of the Bluetooth antenna

Physical boundaries of the Bluetooth module



The following test modes were adjusted during the tests:

Test items	Operation mode
20 dB bandwidth	1, 1a, 1b, 2, 2a, 2b, 3, 3a ,3b
Carrier frequency separation	1, 2, 3
Number of hopping channels	4
Dwell time	2b
Maximum peak output power	1, 1a, 1b, 2, 2a, 2b, 3, 3a ,3b
Band edge compliance (radiated)	1, 1a, 1b, 3, 3a ,3b
Radiated emissions (transmitter)	1b, 2b, 3b

3 OVERVIEW

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS 210, Issue 8 [4] or RSS-Gen, Issue 4 [5]	Status	Refer page
20 dB bandwitdh	General	15.247 (a) (1)	A8.1 (a) [4]	Passed	10 et seq.
Carrier frequency separation	General	15.247 (a) (1)	A8.1 (b) [4]	Passed	16 et seq.
Number of hopping channels	2400.0 - 2483.5	15.247 (a) (1) (iii)	A8.1 (c) [4]	Passed	19 et seq.
Dwell time	2400.0 - 2483.5	15.247 (a) (1) (iii)	A8.1 (d) [4]	Passed	21 et seq.
Maximum peak output power	2400.0 - 2483.5	15.247 (b) (1)	A8.4 (2) [4]	Passed	24 et seq.
Band edge compliance	2400.0 - 2483.5	15.247 (d)	A8.5 [4]	Passed	30 et seq.
Radiated emissions (transmitter)	0.009 - 25,000	15.247 (d) 15.205 (a) 15.209 (a)	A8.5 [4] 8.10 [5], 8.9 [5]	Passed	37 et seq.
Conducted emissions on supply line	0.15 - 30	15.207 (a)	8.8 [5]	Not applicable *	

*: Not applicable because of vehicular environment.

4 TEST RESULTS

4.1 20 DB BANDWIDTH

4.1.1 Method of measurement (20 dB bandwidth)

The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable. If the EUT is not equipped with an antenna connector, a temporary antenna connector has to be installed. The EUT has to be switched on and the hopping function has to be disabled, the transmitter shall work with its maximum data rate.

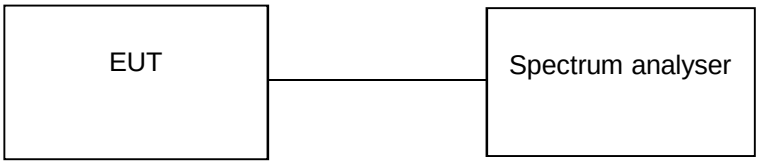
The following spectrum analyser settings shall be used:

- Span: App. 2 to 3 times the 20 dB bandwidth, centred on the actual hopping channel.
- Resolution bandwidth: ≥ 1 % of the 20 dB bandwidth.
- Video bandwidth: ≥ the resolution bandwidth.
- Sweep: Auto.
- Detector function: peak.
- Trace mode: Max hold.

After trace stabilisation the marker shall be set on the signal peak. The first display line has to be set on this value. The second display line has to be set 20 dB below the first line (or the peak marker). The frequency lines shall be set on the intersection points between the second display line and the measured curve.

The measurement will be performed at the upper, the lower end and the middle of the assigned frequency band.

Test set-up:

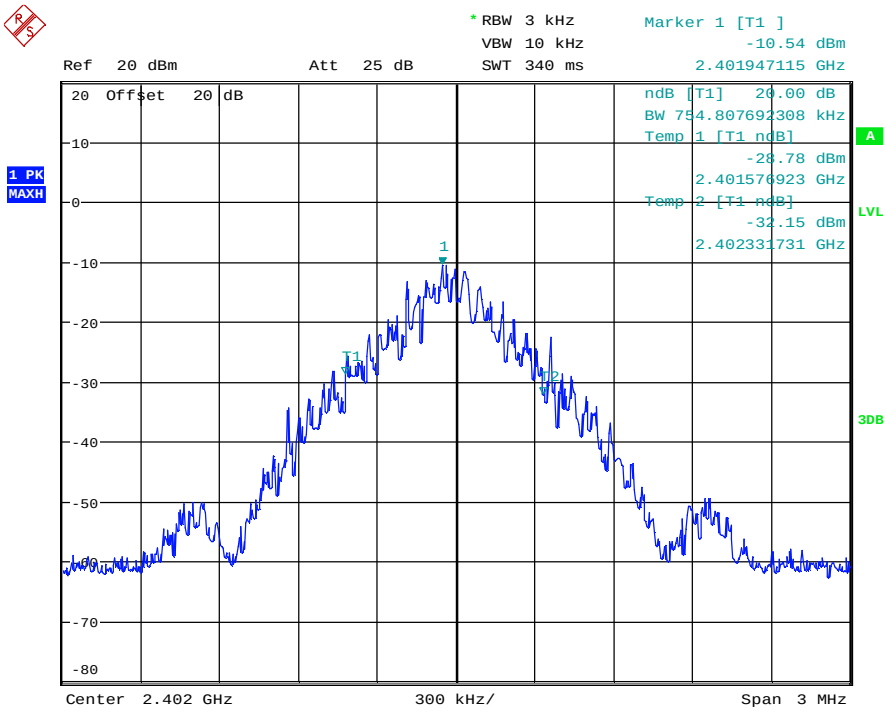


4.1.2 Test results (20 dB bandwidth)

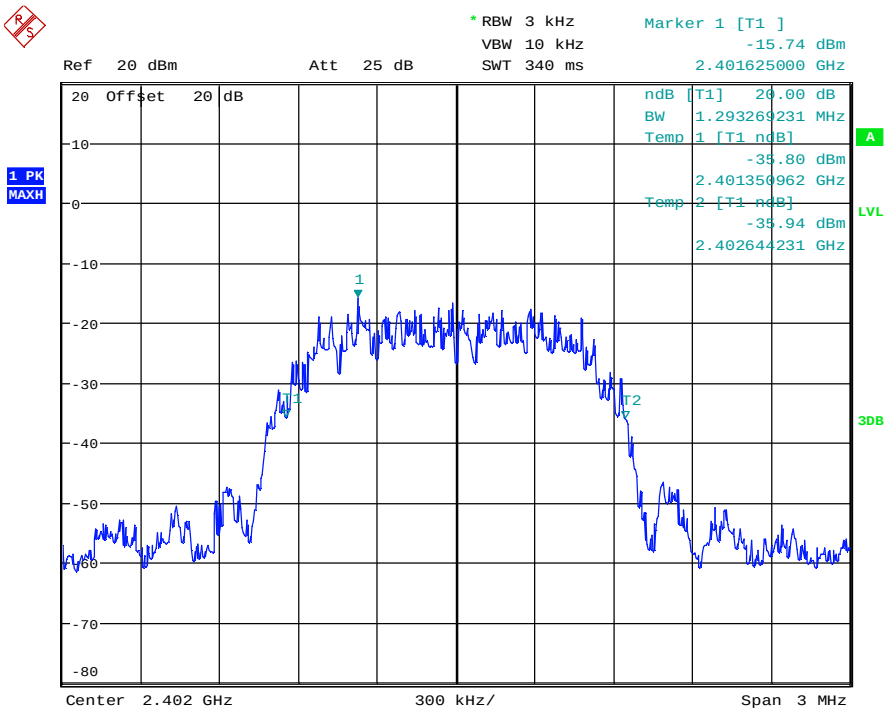
Ambient temperature	22 °C

Relative humidity	24 %

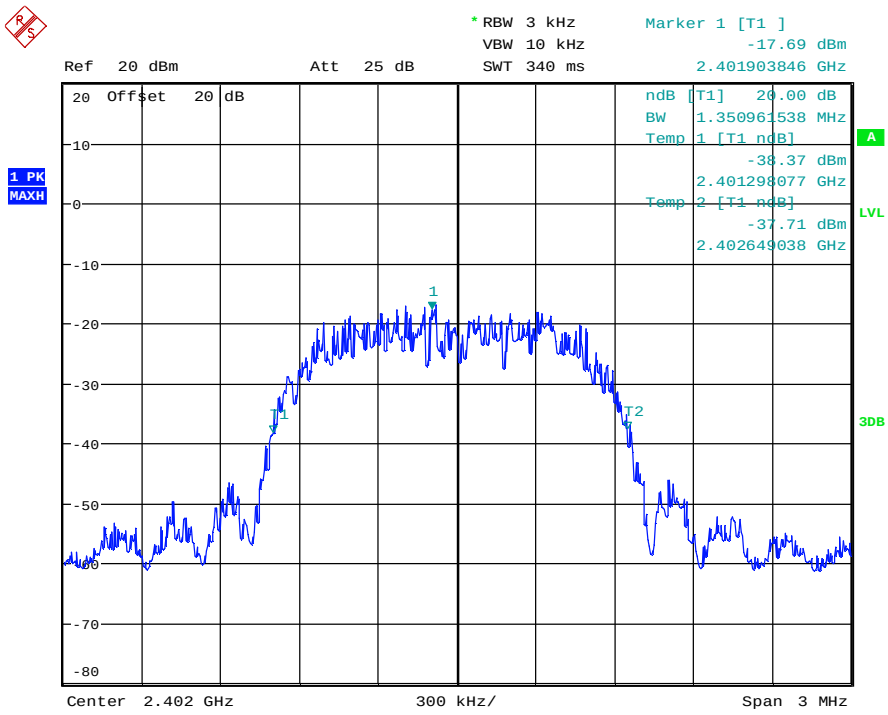
145833_BW_DH5_LOW.wmf: 20 dB bandwith at 2402 MHz in DH5 mode



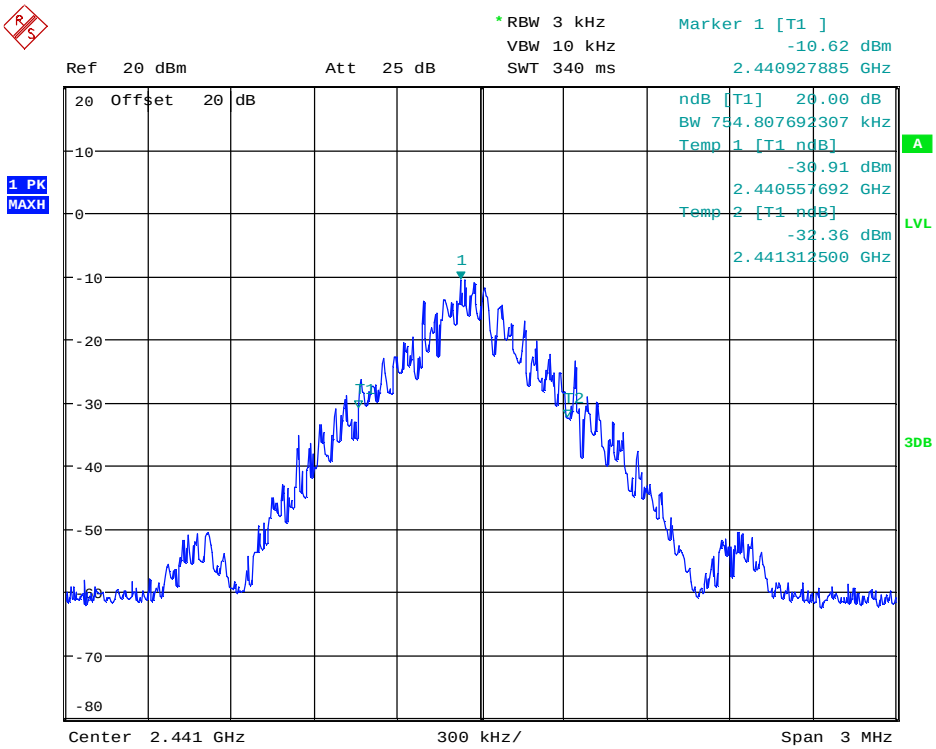
145833_BW_2DH5_LOW.wmf: 20 dB bandwith at 2402 MHz in 2DH5 mode



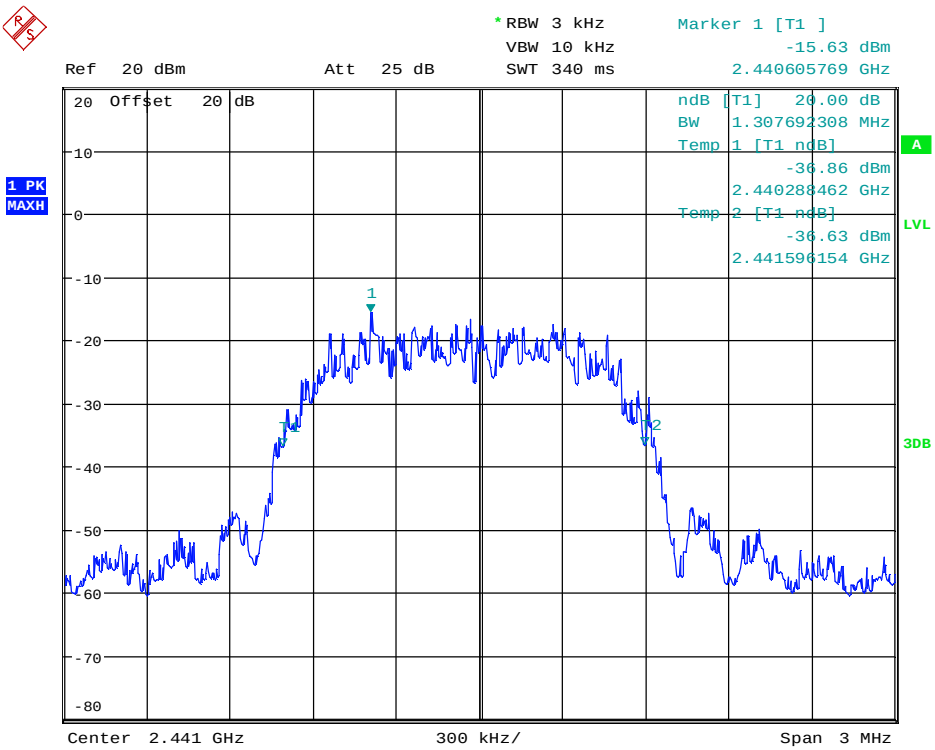
145833_BW_3DH5.wmf: 20 dB bandwith at 2402 MHz in 3DH5 mode



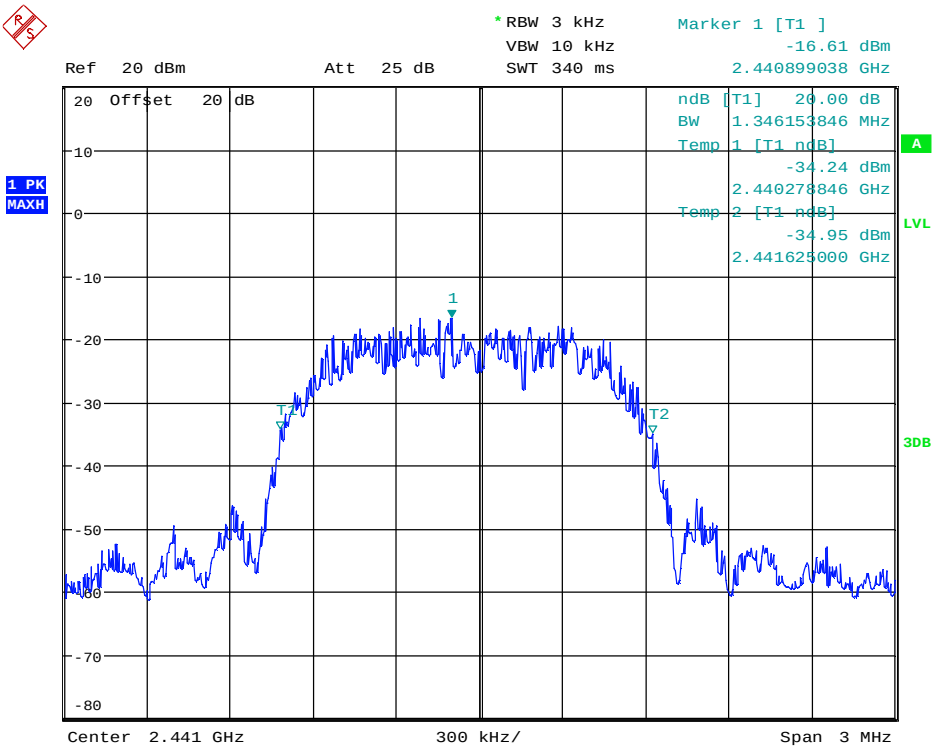
145833_BW_DH5_MID.wmf: 20 dB bandwith at 2441 MHz in DH5 mode



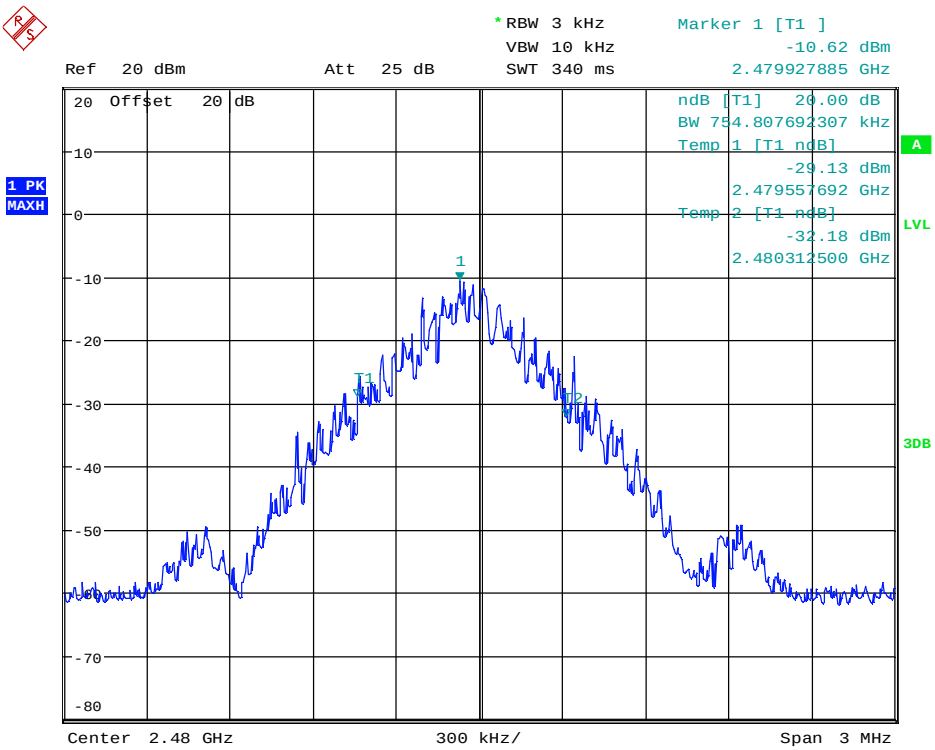
145833_BW_2DH5_MID.wmf: 20 dB bandwith at 2441 MHz in 2DH5 mode



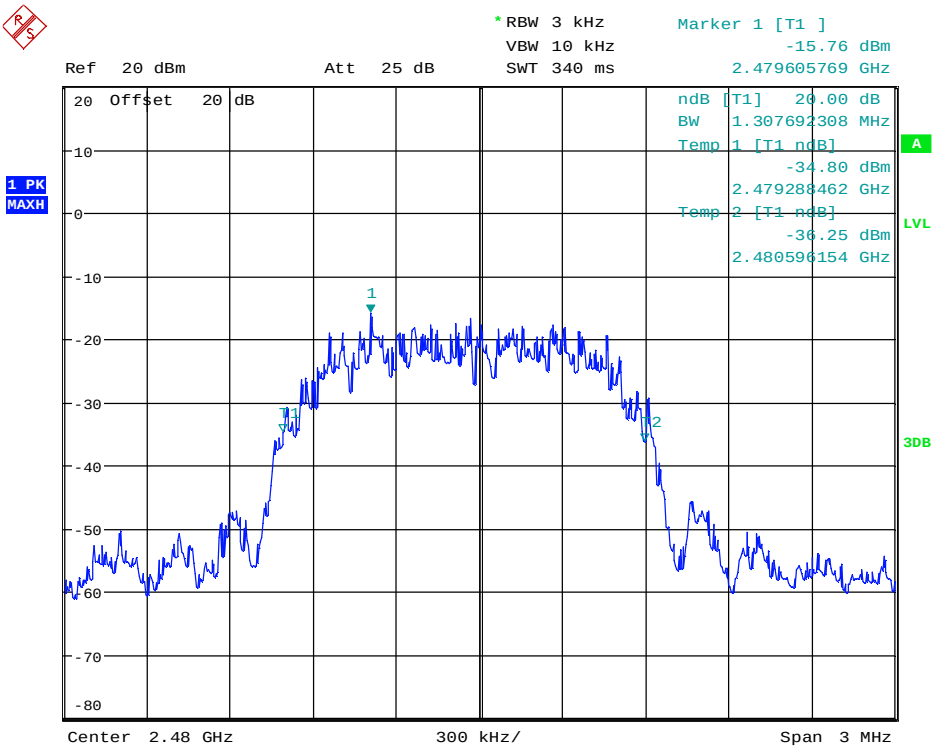
145833_BW_3DH5_MID.wmf: 20 dB bandwith at 2441 MHz in 3DH5 mode



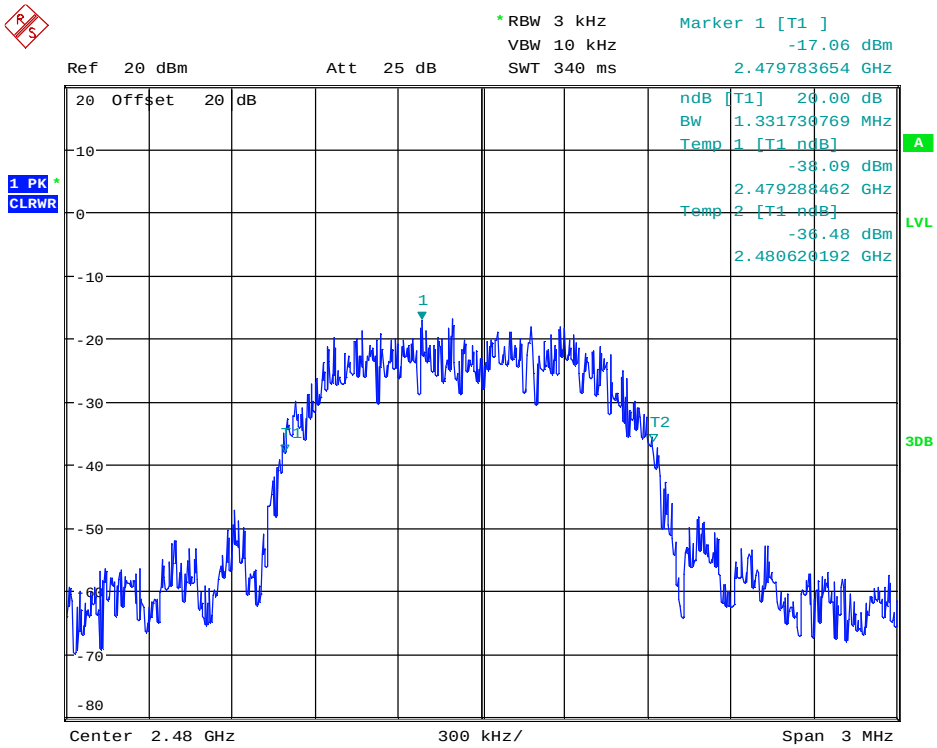
145833_BW_DH5_HIGH.wmf: 20 dB bandwith at 2480 MHz in DH5 mode



145833_BW_2DH5_HIGH.wmf: 20 dB bandwith at 2480 MHz in 2DH5 mode



145833_BW_3DH5_HIGH.wmf: 20 dB bandwith at 2480 MHz in 3DH5 mode



Operation Mode	Channel number	Channel frequency [MHz]	20 dB bandwidth [kHz]
1	0	2402	754.808
1a	0	2402	1293.269
1b	0	2402	1350.962
2a	39	2441	754.808
2b	39	2441	1307.692
2c	39	2441	1346.154
3a	78	2480	754.808
3b	78	2480	1307.692
3c	78	2480	1331.731

TEST EQUIPMENT USED FOR THE TEST:

26

4.2 CARRIER FREQUENCY SEPARATION

4.2.1 Method of measurement (carrier frequency separation)

The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable. If the EUT is not equipped with an antenna connector, a temporary antenna connector has to be installed. The EUT has to be switched on and the hopping function has to be enabled.

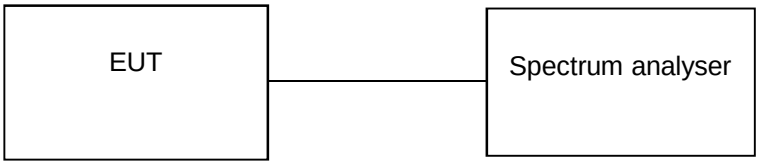
The following spectrum analyser settings shall be used:

- Span: Wide enough to capture the peaks of two adjacent channels.
- Resolution bandwidth: ≥ 1 % of the span.
- Video bandwidth: ≥ the resolution bandwidth.
- Sweep: Auto.
- Detector function: peak.
- Trace mode: Max hold

After trace stabilisation the marker and the delta marker function will be used to determine the separation between the peaks of two adjacent channel signals.

The measurement will be performed at the upper, the lower end and the middle of the assigned frequency band.

Test set-up:

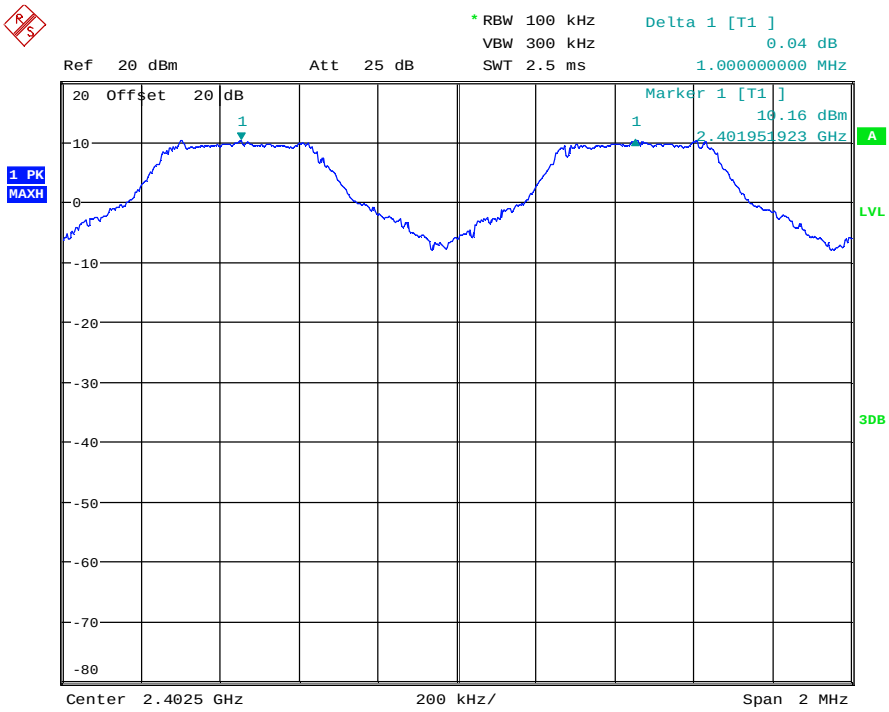


4.2.2 Test results (carrier frequency separation)

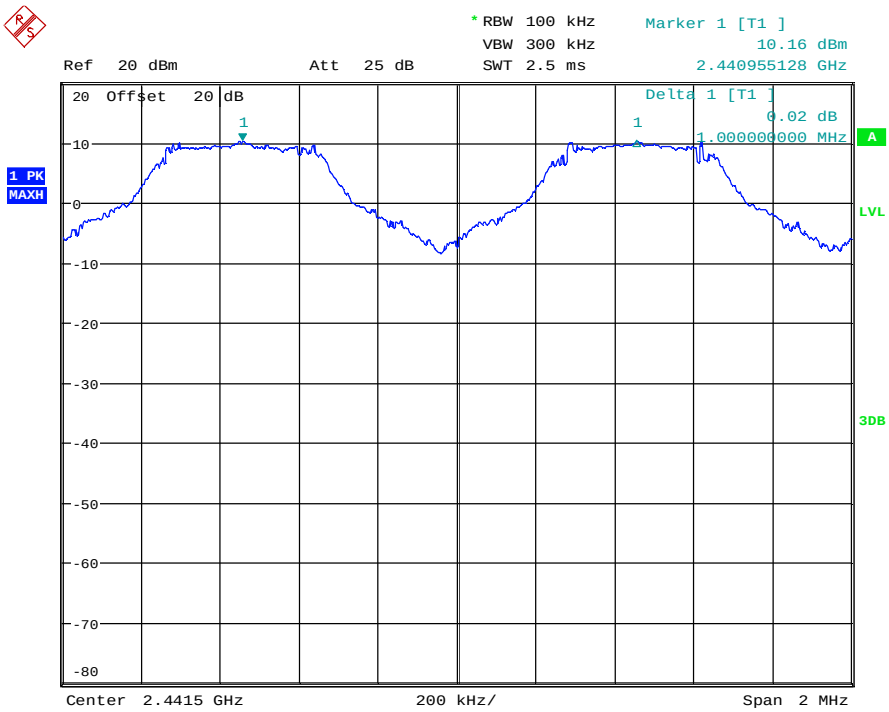
Ambient temperature	22 °C

Relative humidity	56 %

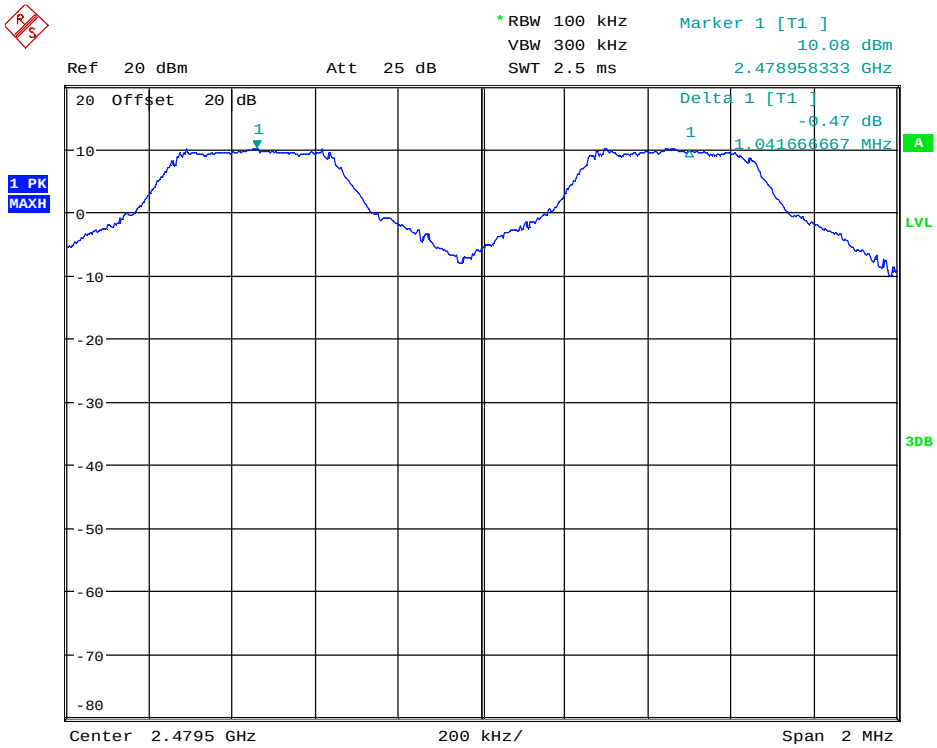
145833_FREQ_SEP_LOW.wmf



145833_FREQ_SEP_MID.wmf



145833_FREQ_SEP_HIGH.wmf



Channel number	Channel frequency [MHz]	Channel separation [kHz]	Minimum limit [kHz]
Operation mode 4			
0	2402	1000.000	900.962 ($^2/_3$ of the 20 dB bandwidth)
38	2441	1000.000	900.962 ($^2/_3$ of the 20 dB bandwidth)
78	2480	1041.667	900.962 ($^2/_3$ of the 20 dB bandwidth)
Measurement uncertainty			$<10^{-7}$

Test result: Passed

TEST EQUIPMENT USED FOR THE TEST:

26

4.3 NUMBER OF HOPPING FREQUENCIES

4.3.1 Method of measurement (number of hopping frequencies)

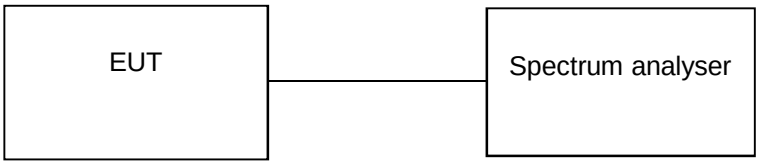
The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable. If the EUT is not equipped with an antenna connector, a temporary antenna connector has to be installed. The EUT has to be switched on and the hopping function has to be enabled.

The following spectrum analyser settings shall be used:

- Span: the frequency band of operation.
- Resolution bandwidth: ≥ 1 % of the span.
- Video bandwidth: ≥ the resolution bandwidth.
- Sweep: Auto.
- Detector function: Peak.
- Trace mode: Max hold.

After trace stabilisation the number of hopping channels could be counted. It might be possible to divide the span into some sub ranges in order to clearly show all hopping frequencies.

Test set-up:

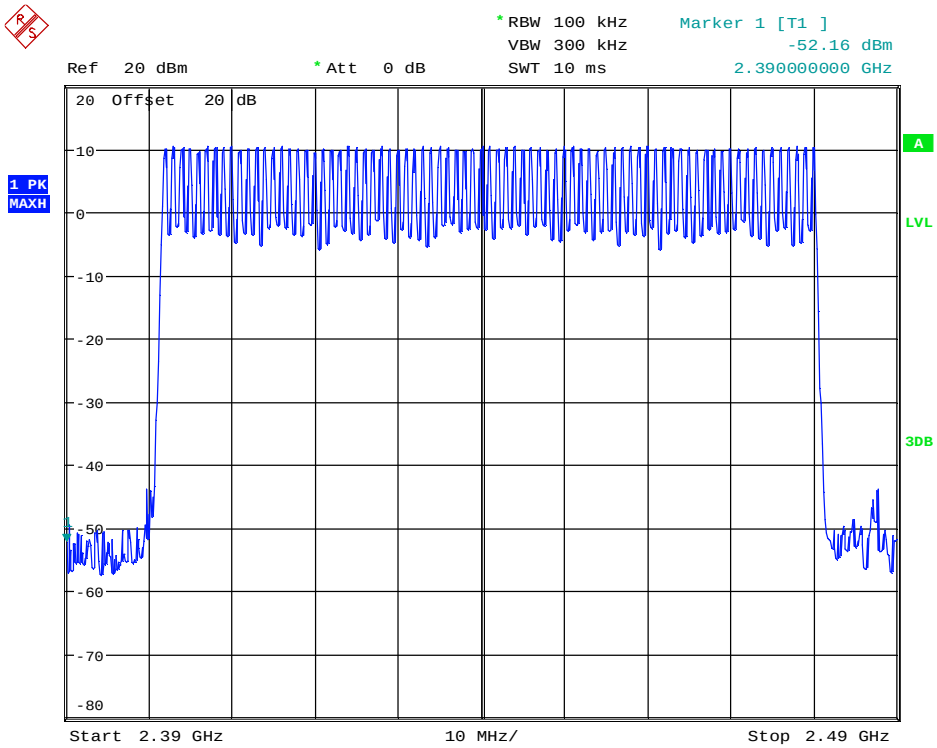


4.3.2 Test results (number of hopping frequencies)

Ambient temperature	22 °C

Relative humidity	56 %

145833_NO_HOP_CH.wmf: Number of Hopping Frequencies



Number of hopping channels	Limit
79	At least 15

Test result: Passed

TEST EQUIPMENT USED FOR THE TEST:

26

4.4 DWELL TIME

4.4.1 Method of measurement (dwell time)

The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable. If the EUT is not equipped with an antenna connector, a temporary antenna connector has to be installed. The EUT has to be switched on and the hopping function has to be enabled.

The following spectrum analyser settings shall be used:

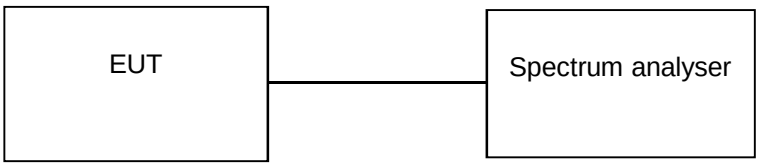
- Span: Zero, centred on a hopping channel.
- Resolution bandwidth: 1 MHz.
- Video bandwidth: ≥ the resolution bandwidth.
- Sweep: As necessary to capture the entire dwell time per hopping channel.
- Detector function: peak.
- Trace mode: Max hold.

The marker and delta marker function of the spectrum analyser will be used to determine the dwell time.

The measurement will be performed at the upper and lower end and the middle of the assigned frequency band.

If the EUT is possible to operate with different mode of operation (data rates, modulation formats etc.) the test will be repeated with every different operation mode of the EUT.

Test set-up:

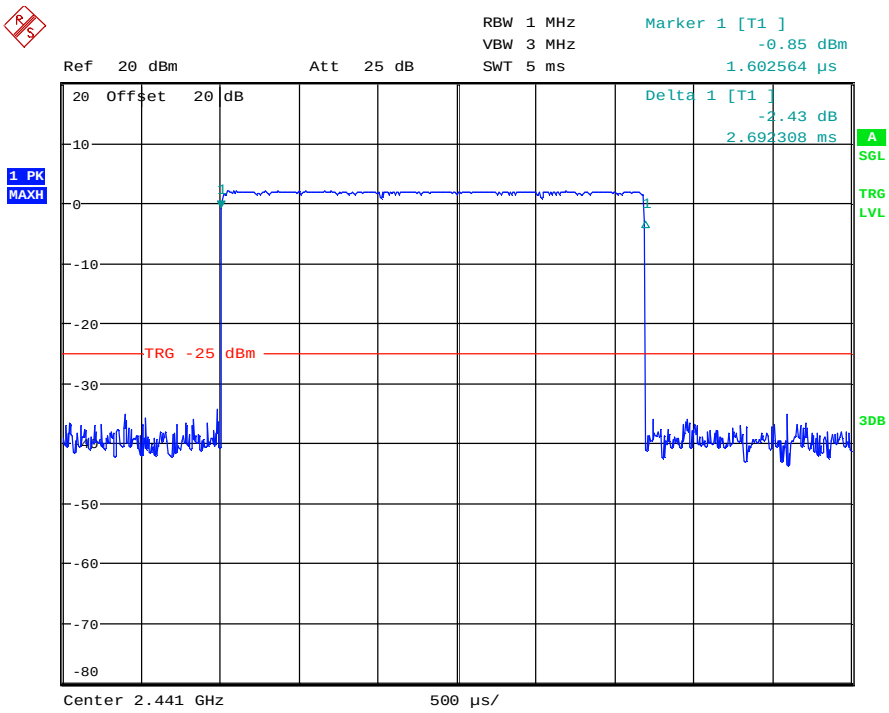


4.4.2 Test results (dwell time)

Ambient temperature	22 °C

Relative humidity	56 %

145833_DWELL_TIME_3DH5.wmf:



The dwell time is calculated with the following formula:

Dwell time = t_{pulse} x n_{hops} / number of hopping channels x 31.6 (equal to 0.4 s x number of hopping channels)

Where:

t_{pulse} is the measured pulse time (pls. refer the plots of the spectrum analyser above) [s],
n_{hops} is the number of hops per second in the actual operating mode of the transmitter [1/s].

The hopping rate of the system is 1600 hops per second and the system uses 79 channels. For this reason one time slot has a length of 625 µs.

With the used hopping mode (DH1) a packet needs 1 timeslot for transmitting and the next timeslot for receiving. So the system makes in worst case 800 hops per second in transmit mode (n_{hops} = 800 1/s).

With the used hopping mode (DH3) a packet needs 3 timeslots for transmitting and the next timeslot for receiving. So the system makes in worst case 400 hops per second in transmit mode (n_{hops} = 400 1/s).

With the used hopping mode (DH5) a packet needs 5 timeslots for transmitting and the next timeslot for receiving. So the system makes in worst case 267 hops per second in transmit mode (n_{hops} = 267 1/s).

Operation mode 2b				
Channel number	Channel frequency [MHz]	t_{pulse} [µs]	Dwell time [ms]	Limit [ms]
39	2441	2692	287.920	400
Measurement uncertainty			$<10^{-7}$	

Test result: Passed

TEST EQUIPMENT USED FOR THE TEST:

26

4.5 MAXIMUM PEAK OUTPUT POWER

4.5.1 Method of measurement (maximum peak output power)

The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable. If the EUT is not equipped with an antenna connector, a temporary antenna connector has to be installed. The EUT has to be switched on and the hopping function has to be disenabled.

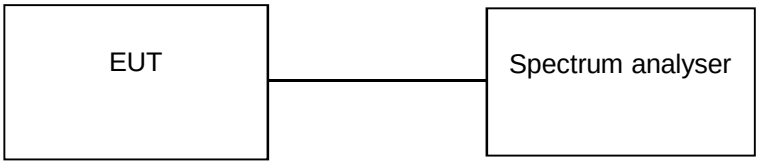
The following spectrum analyser settings shall be used:

- Span: Approx. 5 times the 20 dB bandwidth, centred on a hopping channel.
- Resolution bandwidth: > the 20 dB bandwidth of the emission being measured.
- Video bandwidth: ≥ the resolution bandwidth.
- Sweep: Auto.
- Detector function: peak.
- Trace mode: Max hold.

After trace stabilisation the marker shall be set on the signal peak. The indicated level is the peak output power, which has to be corrected with the value of the cable loss and an external attenuation (if necessary).

The measurement will be performed at the upper and lower end and the middle of the assigned frequency band.

Test set-up:

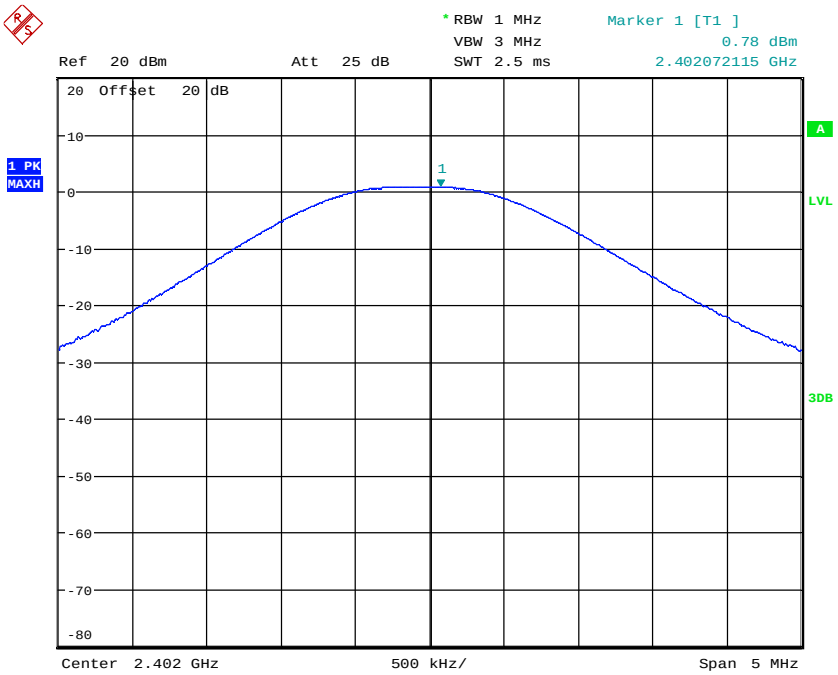


4.5.2 Test results (maximum peak output power)

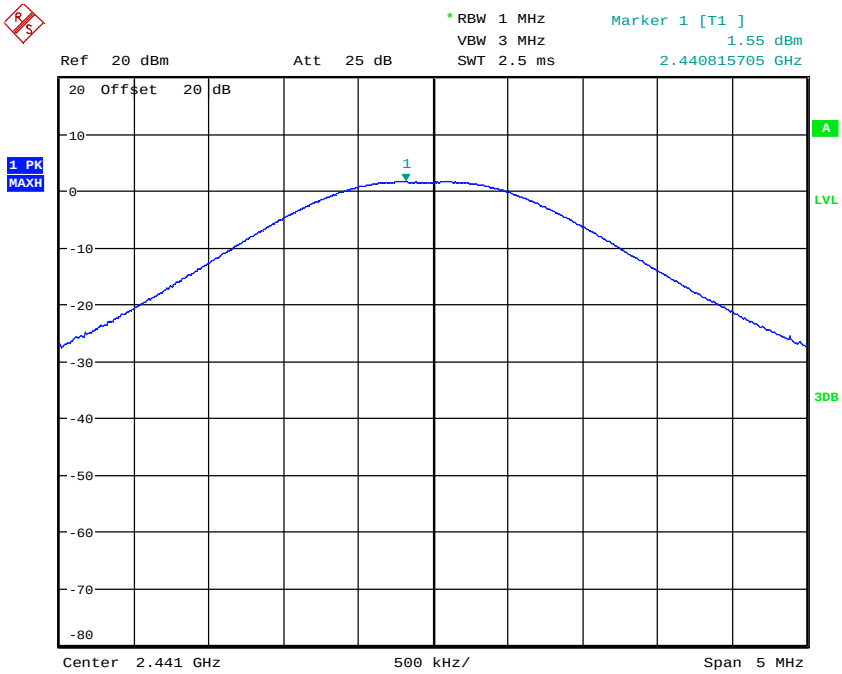
Ambient temperature	22 °C

Relative humidity	24 %

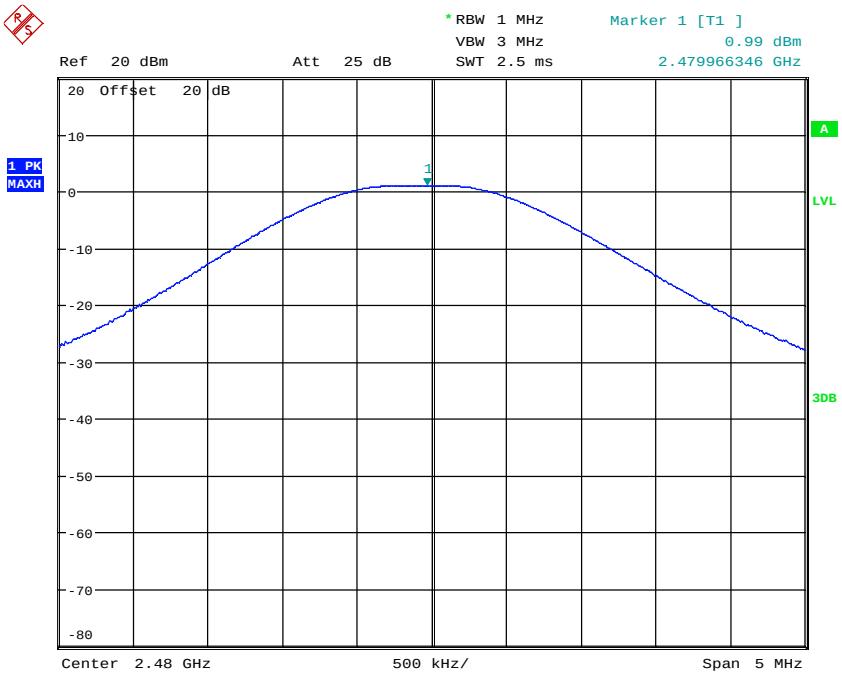
145833_PWR13_DH5_CH0.wmf: Maximum peak output power at 2402 MHz in DH5 mode:



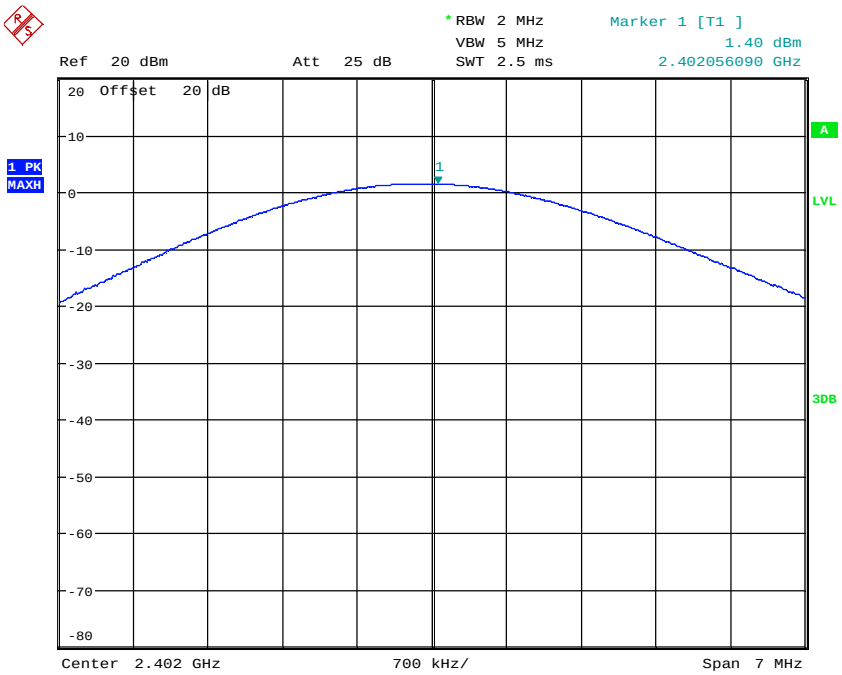
145833_PWR13_DH5_CH39.wmf: Maximum peak output power at 2441 MHz in DH5 mode:



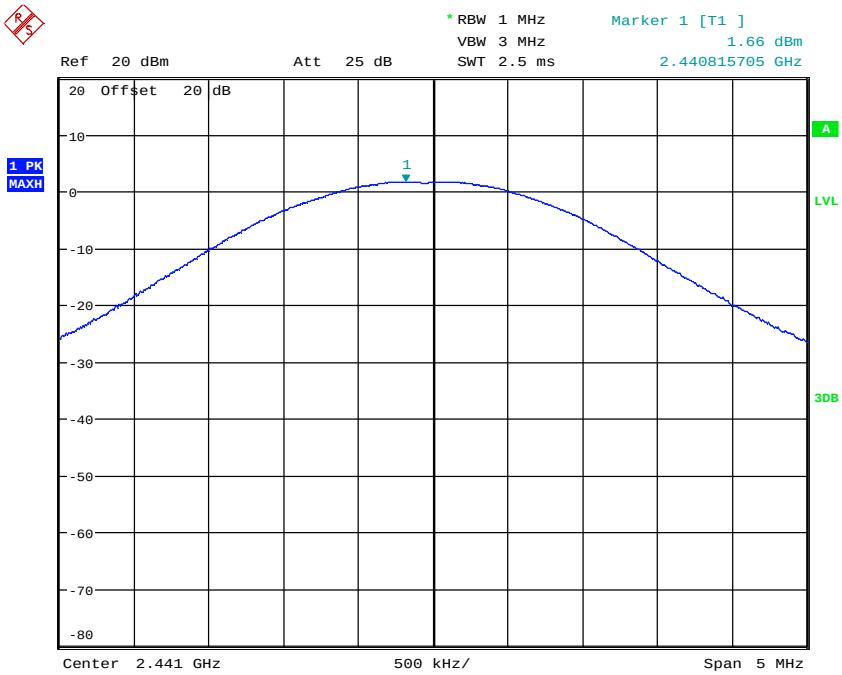
145833_PWR13_DH5_CH78.wmf: Maximum peak output power at 2480 MHz in DH5 mode:



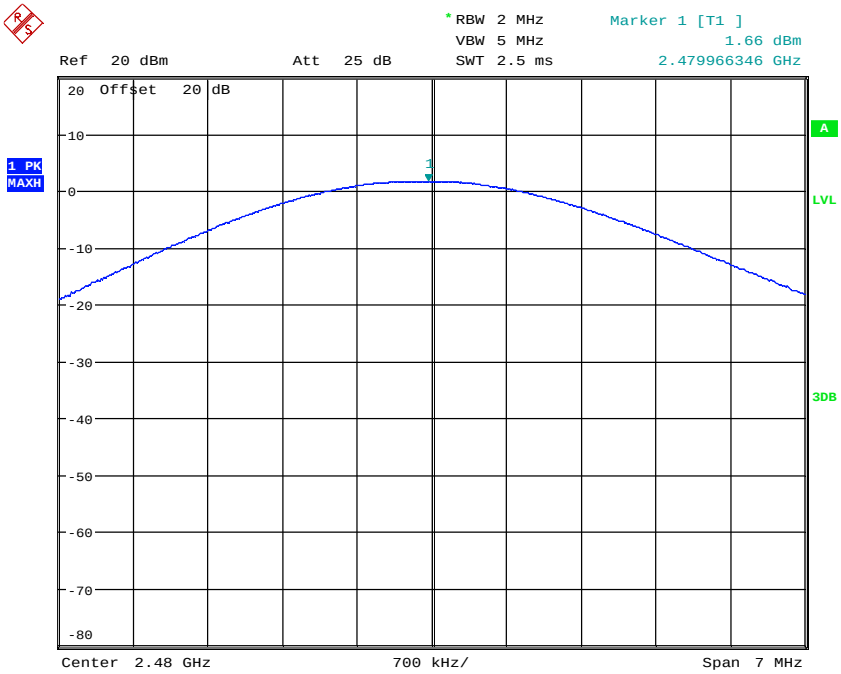
145833_PWR13_2DH5_CH1.wmf: Maximum peak output power at 2402 MHz in 2DH5 mode:



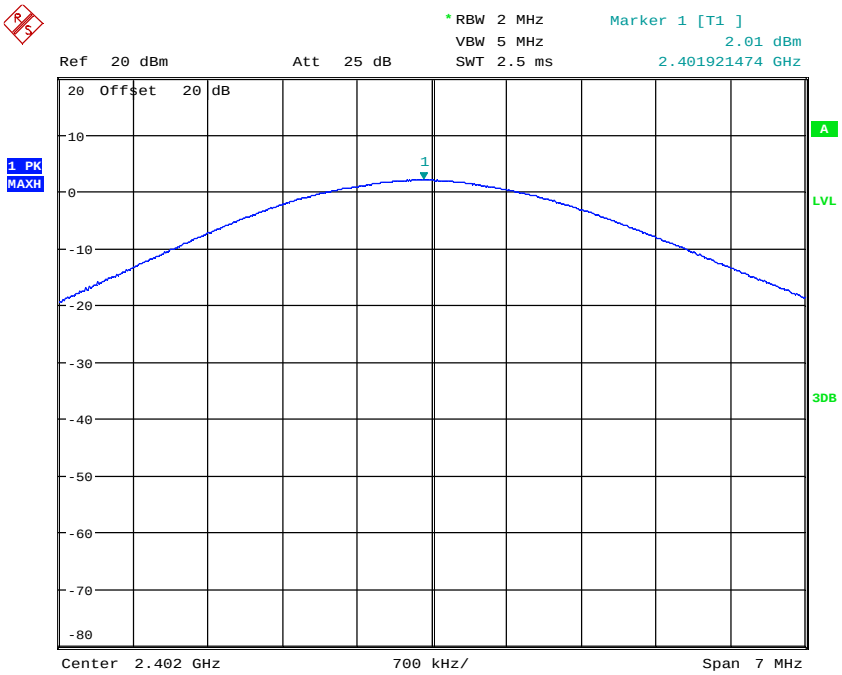
145833_PWR13_2DH5_CH39.wmf: Maximum peak output power at 2441 MHz in 2DH5 mode:



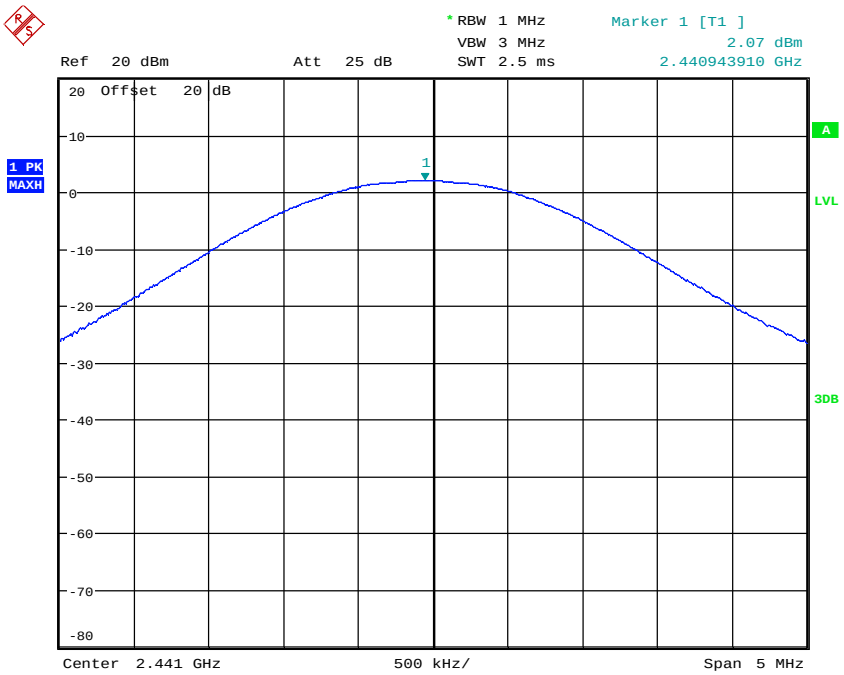
145833_PWR13_2DH5_CH78.wmf: Maximum peak output power at 2480 MHz in 2DH5 mode:



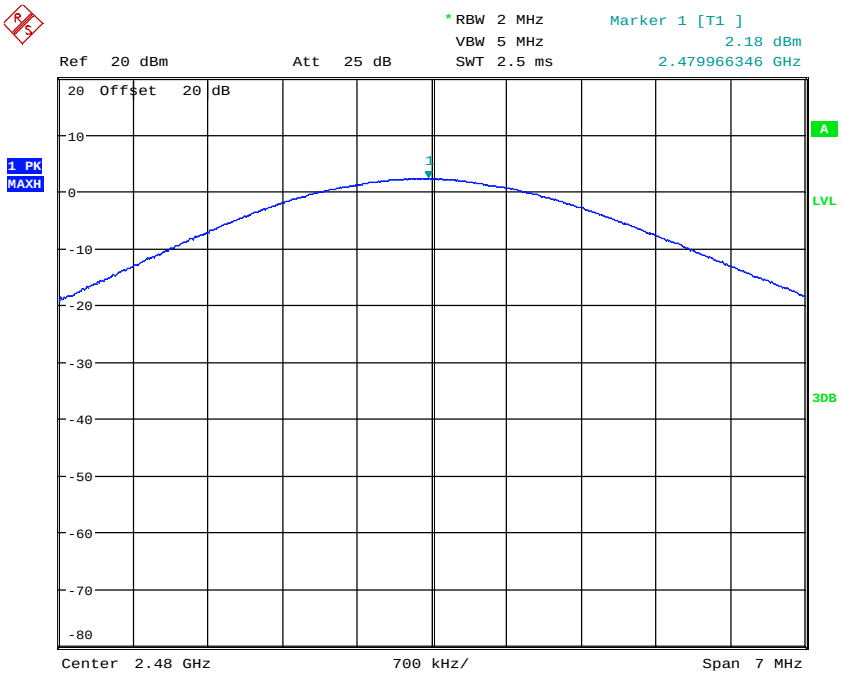
145833_PWR13_3DH5_CH1.wmf: Maximum peak output power at 2402 MHz in 3DH5 mode:



145833_PWR13_3DH5_CH39.wmf: Maximum peak output power at 2441 MHz in 3DH5 mode:



145833_PWR13_3DH5_CH78.wmf: Maximum peak output power at 2480 MHz in 3DH5 mode:



Operation mode	Channel number	Channel frequency [MHz]	Maximum peak output power [dBm]	Peak power limit [dBm]
1	0	2402	0.78	30.0
2	38	2440	1.55	30.0
3	78	2480	0.99	30.0
1a	0	2402	1.40	30.0
2a	38	2440	1.66	30.0
3a	78	2480	1.66	30.0
1b	0	2402	2.01	30.0
2b	38	2440	2.07	30.0
3b	78	2480	2.18	30.0
Measurement uncertainty			+0.66 dB / -0.72 dB	

Test result: Passed

TEST EQUIPMENT USED FOR THE TEST:

26

4.6 BAND-EDGE COMPLIANCE

4.6.1 Method of measurement (band edges next to unrestricted bands (radiated))

The related measurements were carried out in a radiated manner.

Measurement Procedure – Reference Level:

- RBW = 100 kHz.
- VBW ≥ 300 kHz.
- Set the span to ≥ 1.5 times the DTS Bandwidth.
- Detector = Peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilise.
- Use the peak marker function to determine the the maximum amplitude level.

Measurement Procedure – Unwanted Emissions

- Set the center frequency and span to encompass the frequency range to be measured.
- RBW = 100 kHz.
- VBW ≥ 300 kHz.
- Detector = Peak.
- Ensure that the number of measurement points ≥ span/RBW.
- Sweep time = auto couple.
- Trace Mode = max hold.
- Allow the trace to stabilise.
- Use the peak marker function to determine the maximum amplitude level.

The measurement procedure at the band edges was simplified by performing the measurement in just one plot. Both, the in-band-emission and the unwanted emission were be encompassed by the span. After trace stabilization, the maximum peak was be determined by a peak detector and the value was marked by an appropriate limit line. The second limit line, which is 20 dB below the first, marks the limit for the emissions in the unrestricted band. A maximum-peak-detector marks the highest emission in the unrestricted band next to the band edge.

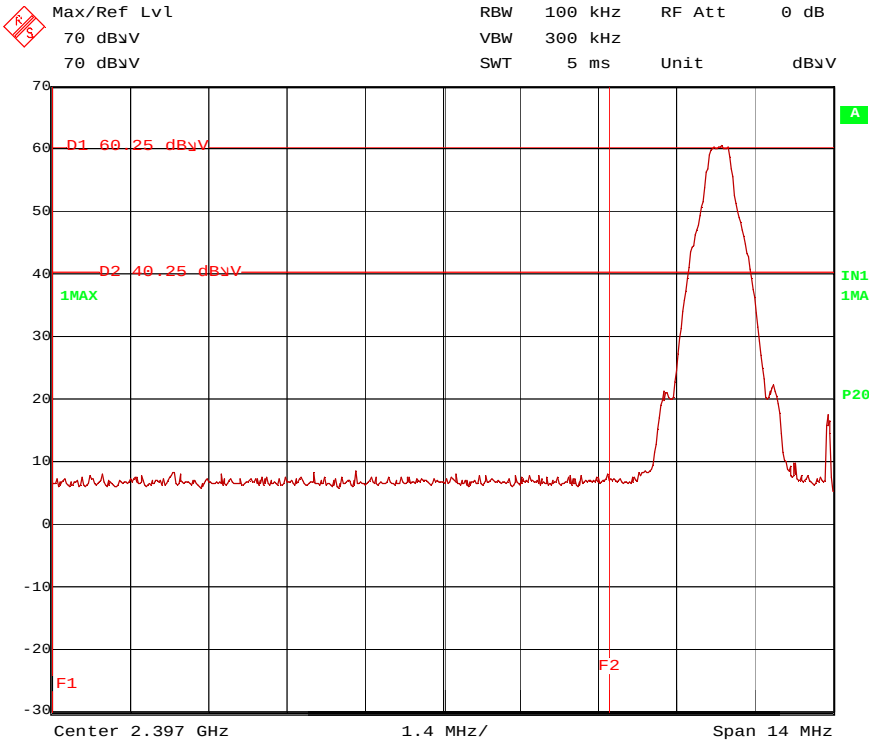
The measurements were performed at the lower end of the 2.4 GHz band.

4.6.2 Test result (band edges next to unrestricted bands (radiated))

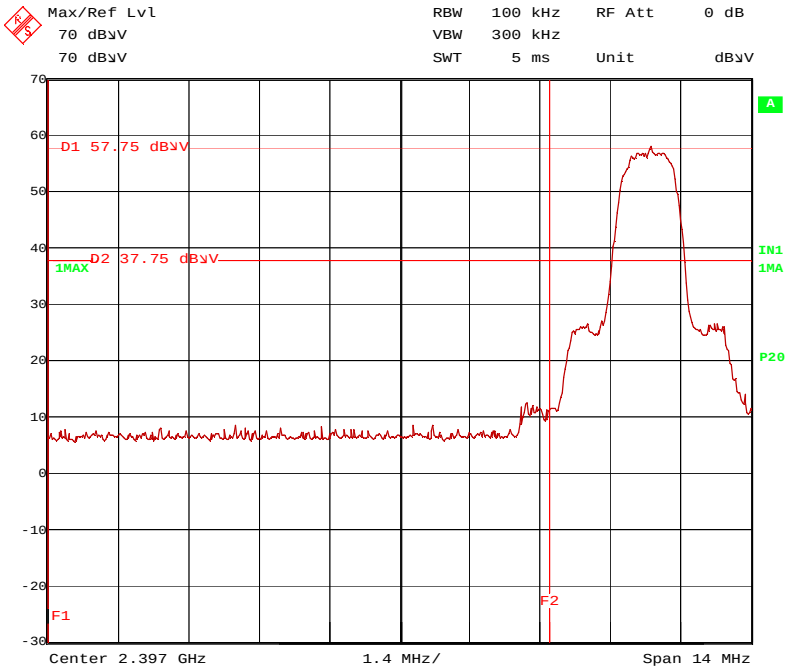
Ambient temperature	22 °C

Relative humidity	37 %

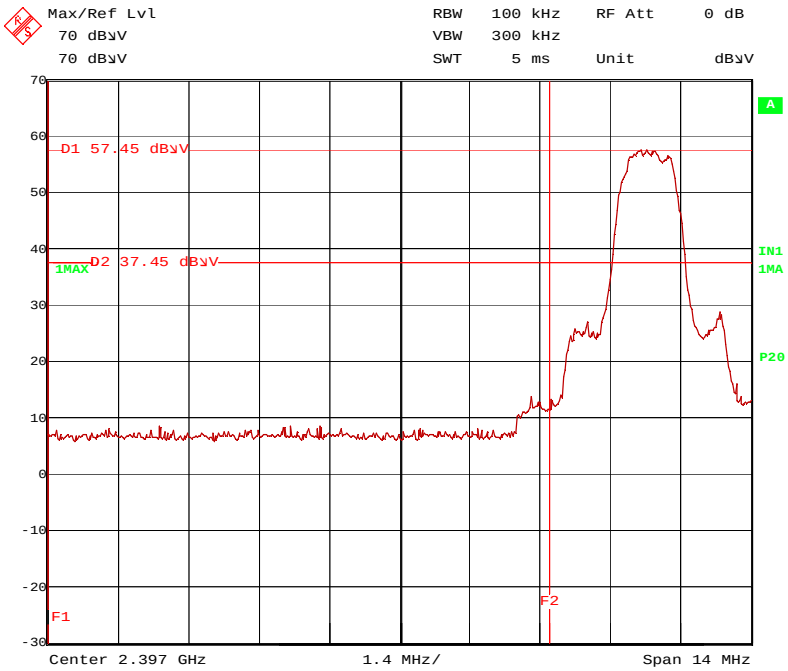
145833_ch0_pwr13_bandedge_unrestr_DH5_1.wmf: band-edge compliance (operation mode 1):



145833_ch0_pwr13_bandedge_unrestr_2DH5_1.wmf: band-edge compliance (operation mode 1a):



145833_ch0_pwr13_bandedge_unrestr_3DH5_1.wmf: band-edge compliance (operation mode 1b):



Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

1 - 5, 7, 10, 11

4.6.3 Method of measurement (band edges next to restricted bands (radiated))

The same test set-up and test method as used for the final conducted emission measurement shall be used (refer also subclause 4.7.1 of this test report).

The measurement was performed at the upper end of the 2.4 GHz band.

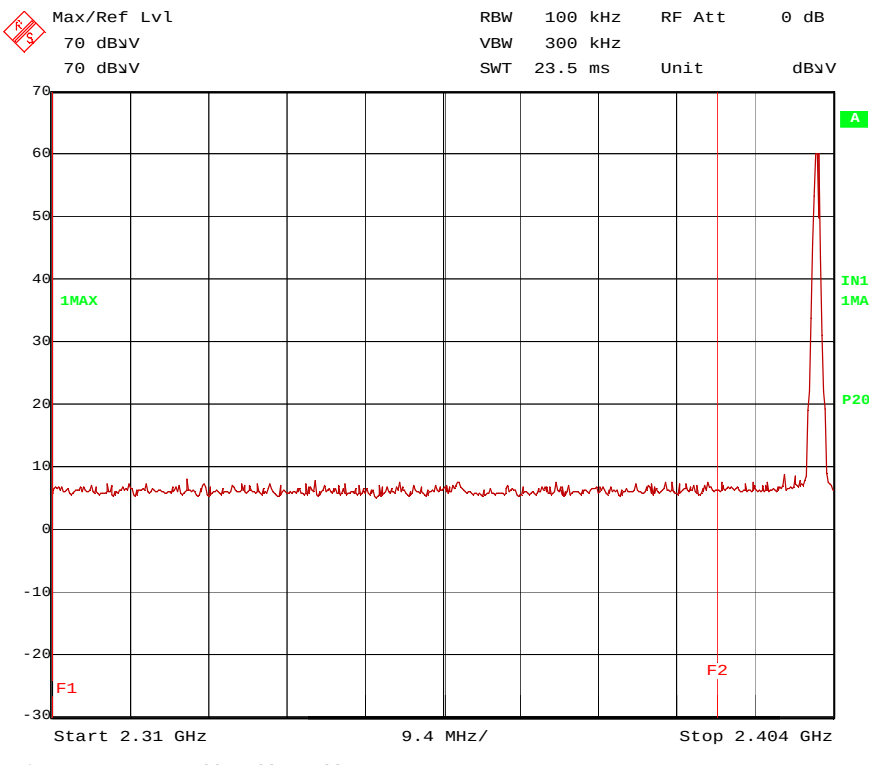
4.6.4 Test result (band edges next to restricted bands (radiated))

Ambient temperature	22 °C

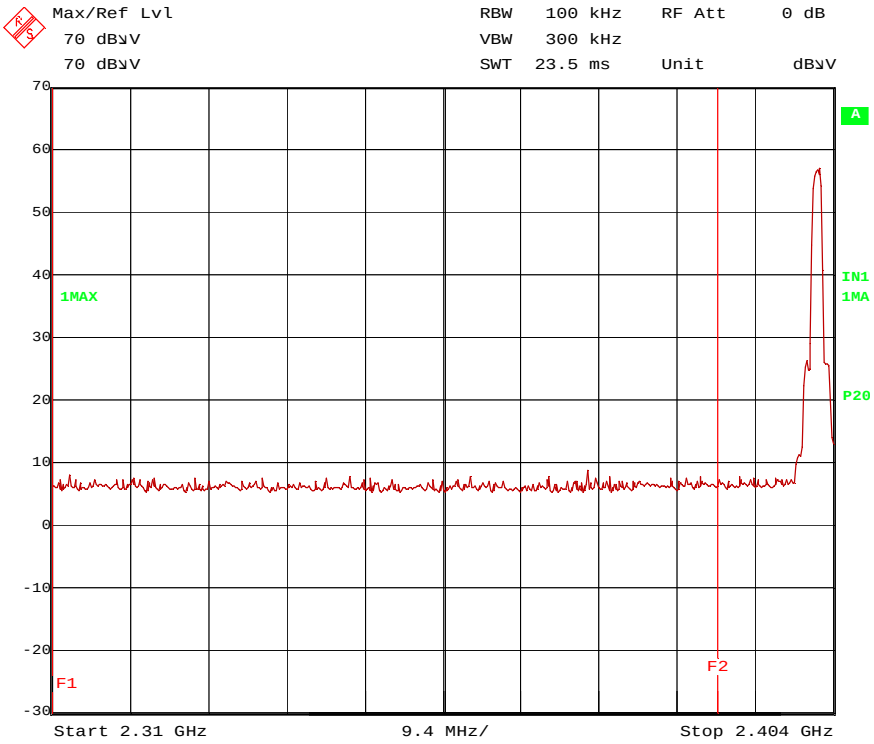
Relative humidity	37 %

The plots show the pre measurement results. The final results are listed in the following table.

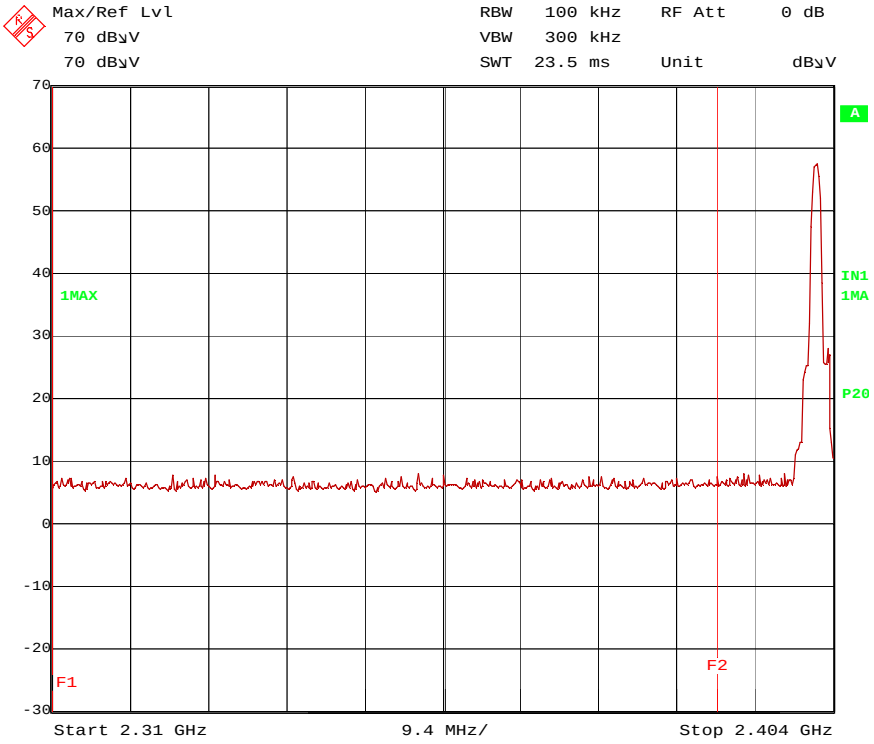
145833_ch0_pwr13_bandedge_restr_DH5.wmf: band-edge compliance (operation mode 1):



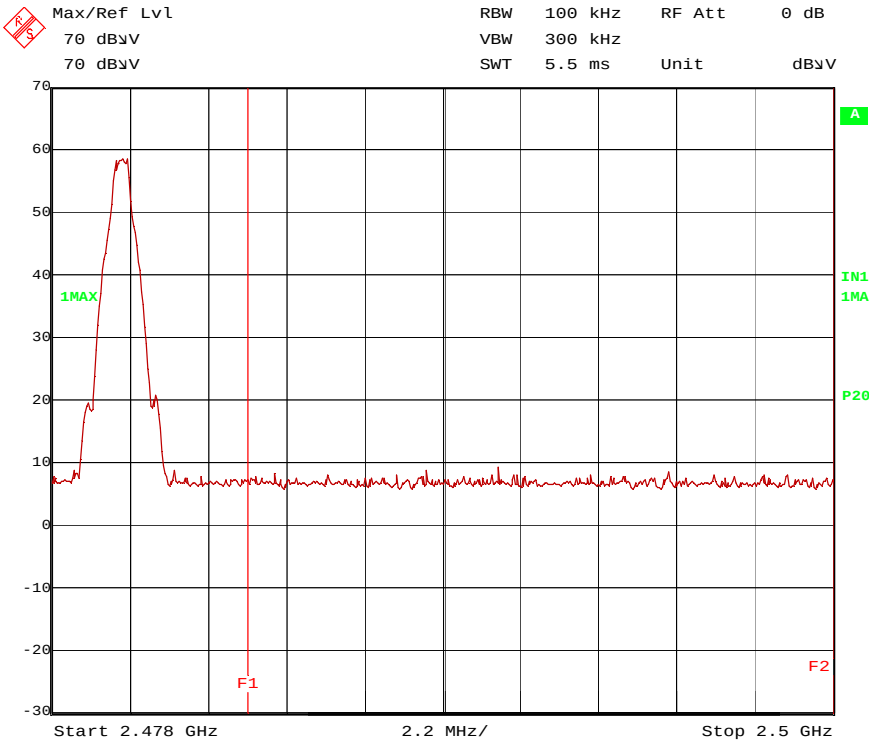
145833_ch0_pwr13_bandedge_restr_2DH5.wmf: band-edge compliance (operation mode 1a):



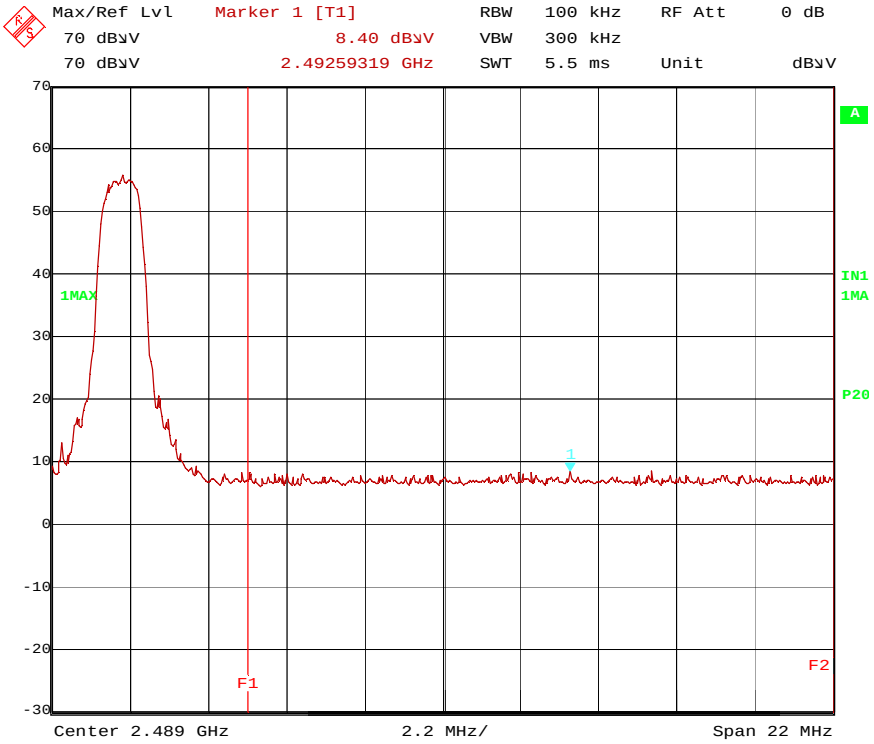
145833_ch0_pwr13_bandedge_restr_3DH5.wmf: band-edge compliance (operation mode 1b):



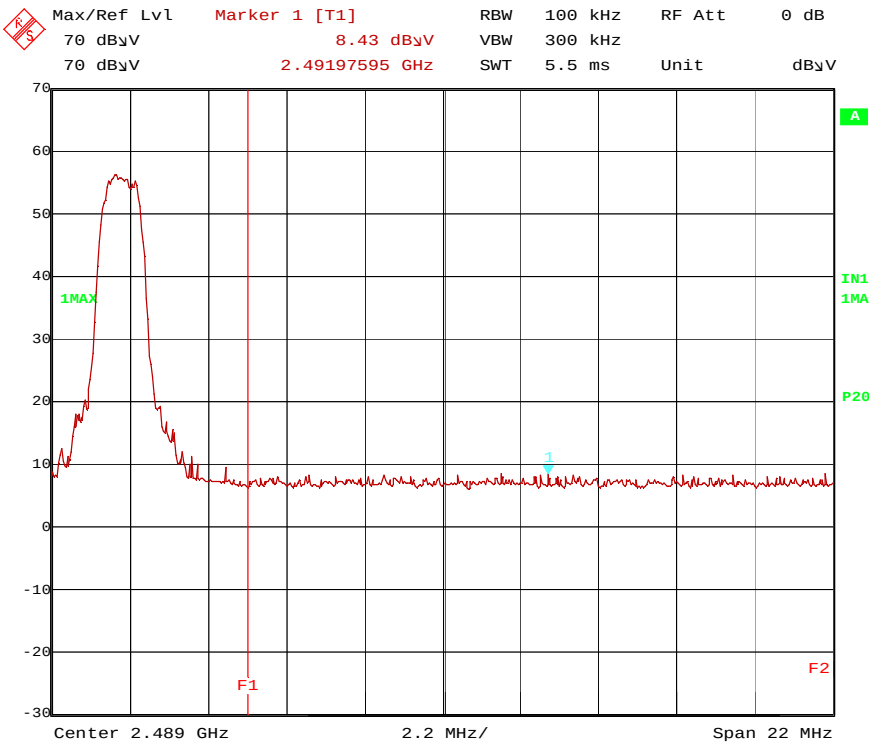
145833_ch78_pwr13_bandedge_restr_DH5.wmf: band-edge compliance (operation mode 3):



145833_ch78_pwr13_bandedge_restr_2DH5_1.wmf: band-edge compliance (operation mode 3a):



145833_ch78_pwr13_bandedge_restr_3DH5_1.wmf: band-edge compliance (operation mode 3b):



No spurious emissions were found in the restricted bands during the preliminary measurements. Therefore the level of the noise floor was measured in the final measurement to show the compliance to the limits for restricted bands:

Band Edge Compliance, DH5-mode, channel 78 (Operation mode 3)											
Mode	Channel	Frequency [MHz]	Field Strength [dBµV/m]	Peak Limit [dBµV/m]	Margin [dB]	Reading [dBµV]	Antenna Factor / 1/m	Preamp / dB	Cable Loss / dB	Restricted Band?	Result
BT_2DH5	BT78	2492.6	52.95	74.00	21.05	20.60	28.55	0.00	3.80	Y	Passed
Mode	Channel	Frequency [MHz]	Field Strength [dBµV/m]	Average Limit [dBµV/m]	Margin [dB]	Reading [dBm]	Antenna Factor / 1/m	Preamp / dB	Cable Loss / dB	Restricted Band?	Result
BT_2DH5	BT78	2492.6	34.80	54.00	19.20	2.45	28.55	0.00	3.80	Y	Passed
Measurement uncertainty						+2.2 dB / -3.6 dB					

TEST: Passed

TEST EQUIPMENT USED FOR THE TEST:

1 - 5, 7, 10, 11

4.7 MAXIMUM UNWANTED EMISSIONS

4.7.1 Method of measurement (radiated emissions)

The radiated emission measurement is subdivided into four stages.

- A preliminary measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 30 MHz to 1 GHz.
- A final measurement carried out on an open area test side with reflecting ground plane and various antenna height in the frequency range 30 MHz to 1 GHz.
- A preliminary measurement carried out in a fully anechoic chamber with a variable antenna distance and height in the frequency range 1 GHz to 110 GHz.
- A final measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 1 GHz to 110 GHz.

All measurements will be carried out with the EUT working on the middle of the assigned frequency band.

Preliminary and final measurement (1 GHz to 110 GHz)

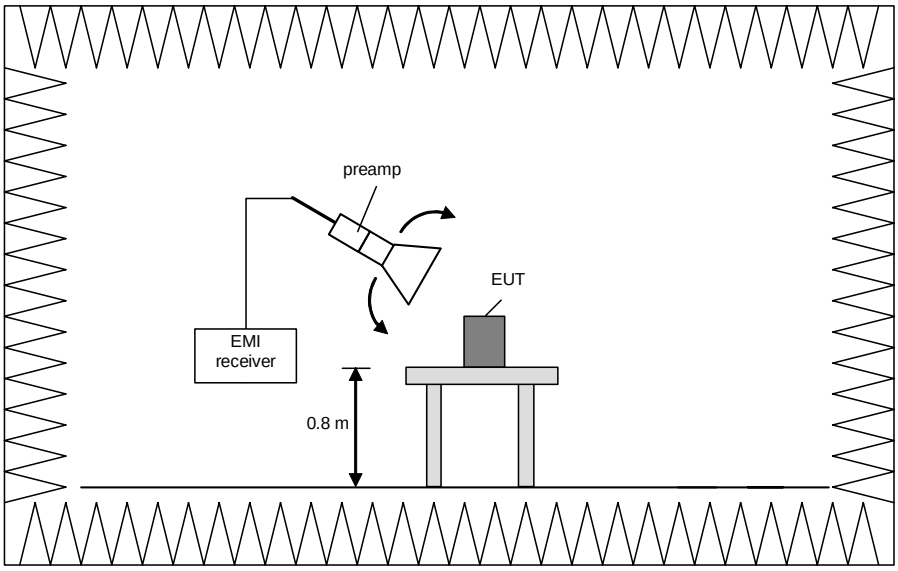
This measurement will be performed in a fully anechoic chamber. Tabletop devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices will be placed directly on the turntable/ground plane. The set-up of the Equipment under test will be in accordance to ANSI C63.4-2009 [1].

Preliminary measurement (1 GHz to 110 GHz)

The frequency range will be divided into different sub ranges depending on the frequency range of the used horn antenna. The spectrum analyser set to MAX Hold mode and a resolution bandwidth of 100 kHz. The measurement will be performed in horizontal and vertical polarisation of the measuring antenna, the antenna close to the EUT and while moving the antenna over all sides of the EUT. With the spectrum analyser in CLEAR / WRITE mode the cone of the emission should be found and than the measuring distance will be set to 3 m with the receiving antenna moving in this cone of emission. At this position the final measurement will be carried out.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	100 kHz
4 GHz to 12 GHz	100 kHz
12 GHz to 18 GHz	100 kHz
18 GHz to 26.5 GHz	100 kHz
26.5 GHz to 40 GHz	100 kHz
40 GHz to 60 GHz	100 kHz
50 GHz to 75 GHz	100 kHz
75 GHz to 110 GHz	100 kHz

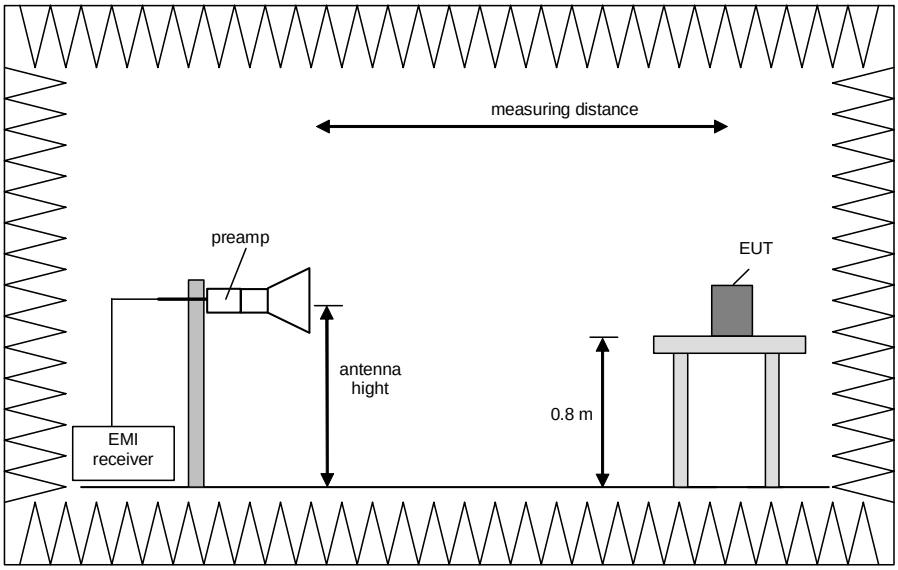


Final measurement (1 GHz to 110 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The EMI Receiver set to peak and average mode and a resolution bandwidth of 1 MHz. The measurement will be performed in horizontal and vertical polarisation of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 ° in order to have the antenna inside the cone of radiation.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	1 MHz
4 GHz to 12 GHz	1 MHz
12 GHz to 18 GHz	1 MHz
18 GHz to 26.5 GHz	1 MHz
26.5 GHz to 40 GHz	1 MHz
40 GHz to 60 GHz	1 MHz
50 GHz to 75 GHz	1 MHz
75 GHz to 110 GHz	1 MHz



Procedure of measurement:

The measurements were performed in the frequency range 1 GHz to 4 GHz, 4 GHz to 12 GHz, 12 GHz to 18 GHz, 18 GHz to 26.5 GHz, 26.5 GHz to 40 GHz, 40 GHz to 60 GHz, 60 GHz to 75 GHz and 75 GHz to 110 GHz.
The following procedure will be used:

1) Monitor the frequency range at horizontal polarisation and move the antenna over all sides of the EUT (if necessary move the EUT to another orthogonal axis).
2) Change the antenna polarisation and repeat 1) with vertical polarisation.
3) Make a hardcopy of the spectrum.
4) Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
5) Change the analyser mode to Clear / Write and found the cone of emission.
6) Rotate and move the EUT, so that the measuring distance can be enlarged to 3 m and the antenna will be still inside the cone of emission.
7) Measure the level of the detected frequency with the correct resolution bandwidth, with the antenna polarisation and azimuth and the peak and average detector, which causes the maximum emission.
8) Repeat steps 1) to 7) for the next antenna spot if the EUT is larger than the antenna beamwidth.

Steps 1) to 6) are defined as preliminary measurement.

4.7.2 Test results (radiated emissions)

4.7.2.1 Preliminary radiated emission measurement

Ambient temperature	22 °C		Relative humidity	37 %

Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in annex A.

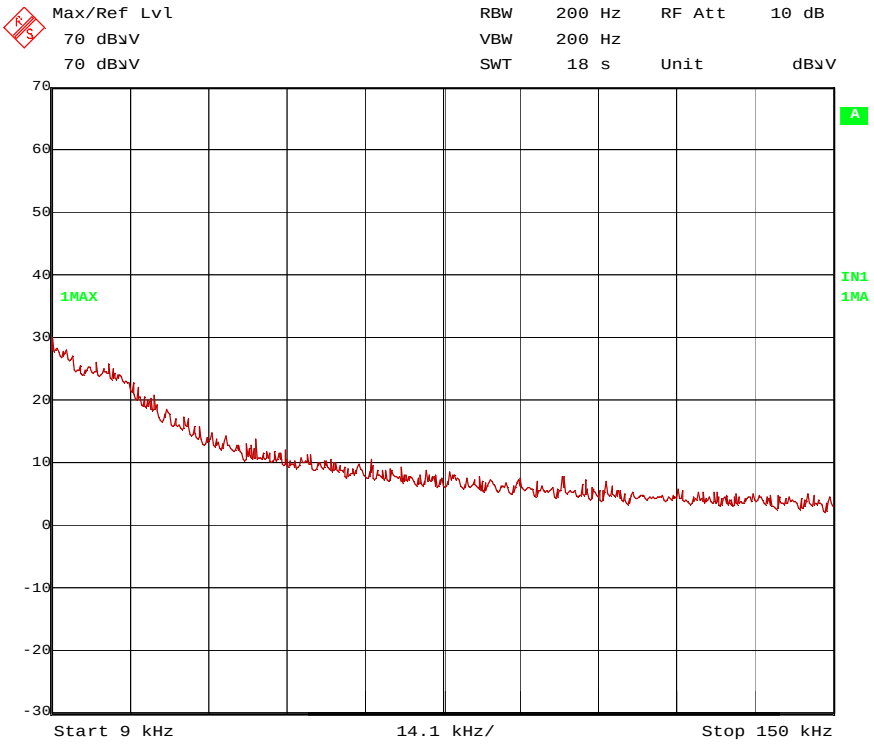
Test record: All results are shown in the following.

Supply voltage: During all measurements the host of the EUT was powered with 5 V DC via a laboratory power supply.

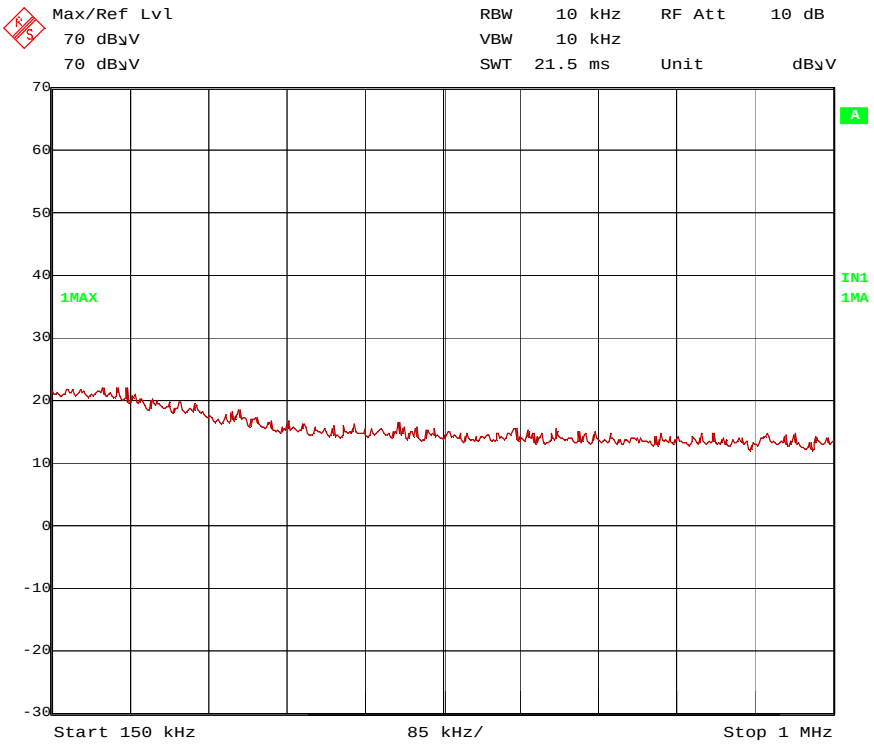
Remark: Only the plots of the worst case emissions are submitted for every frequency range above 1 GHz in the preliminary results.

The Emissions below 1 GHz were similar for all transmit frequencies, modulation schemes and data rates. Therefore only the results of an exemplary test case are submitted below.

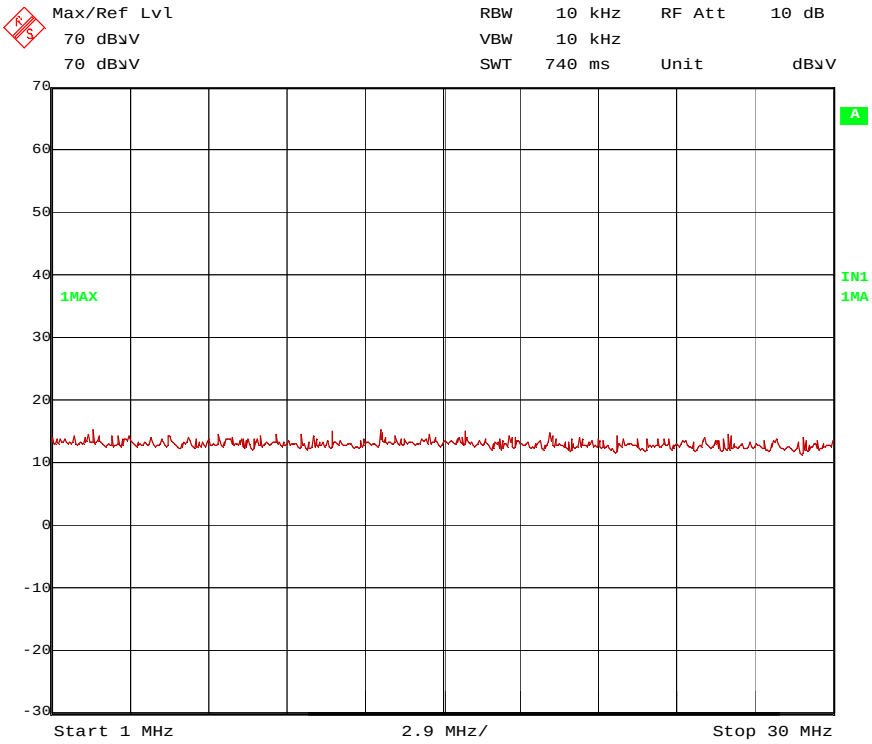
145833_ch39_pwr13_9-150k.wmf: Spurious emissions from 9 kHz to 150 kHz:



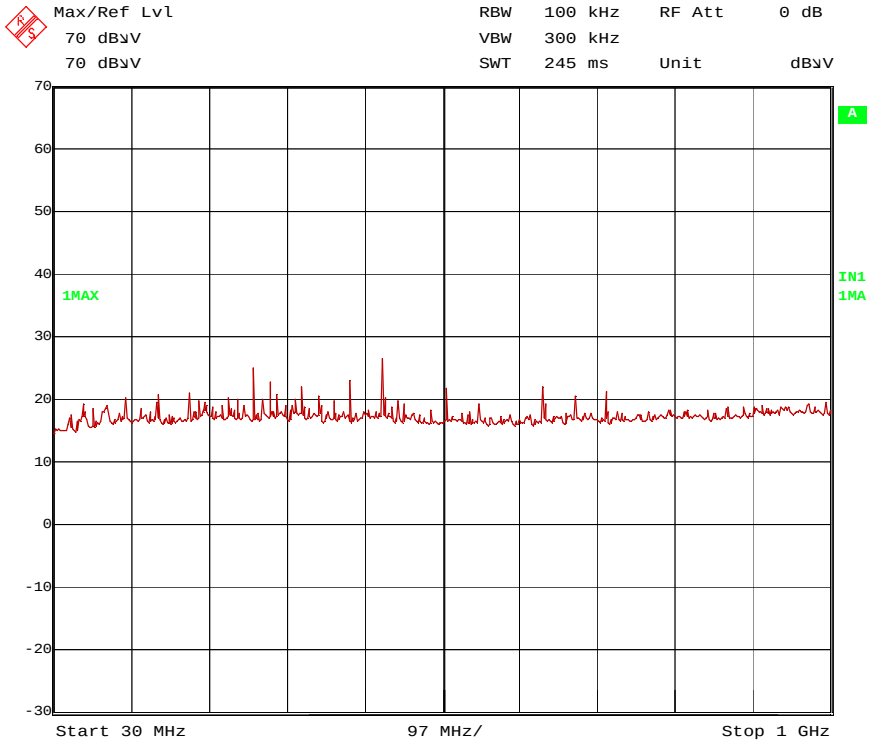
145833_ch39_pwr13_150k-1M.wmf: Spurious emissions from 150 kHz to 1 MHz:



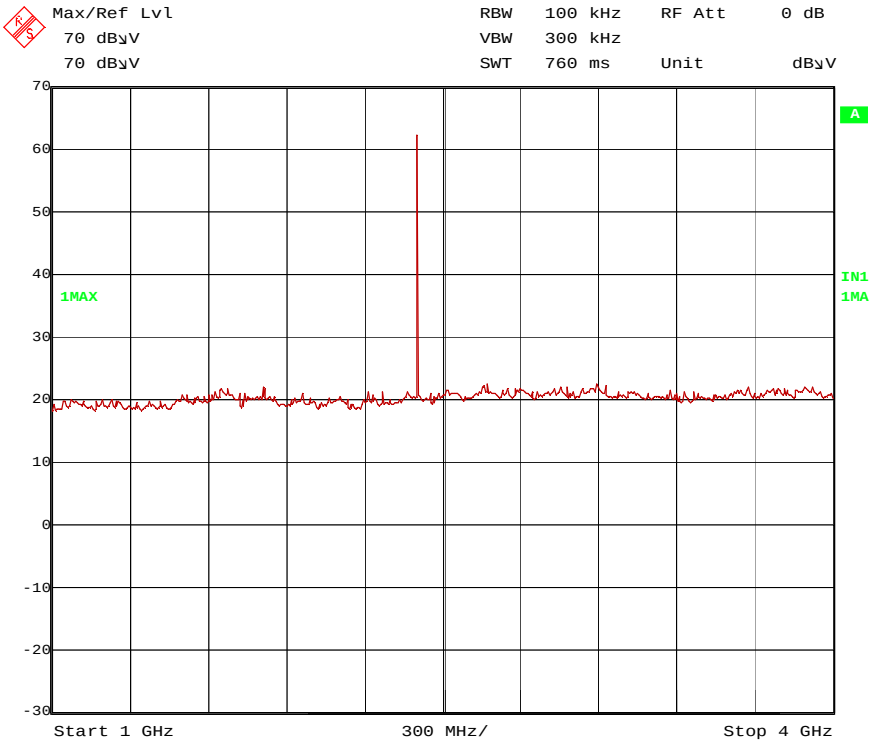
145833_ch39_pwr13_1-30M: Spurious emissions from 1 MHz to 30 MHz:



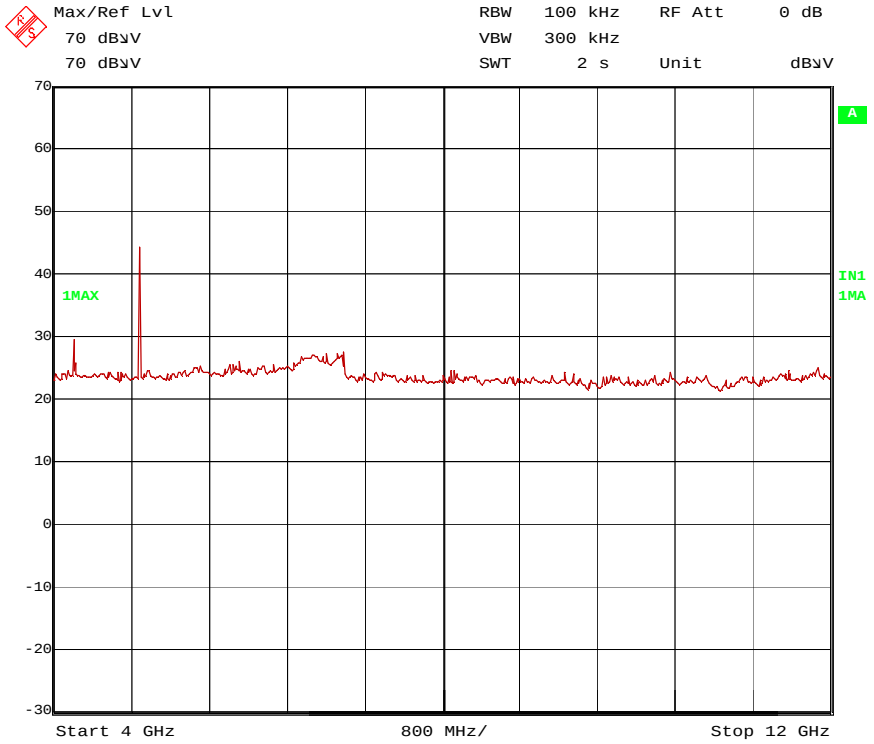
145833_ch39_pwr13_30M-1G_2.wmf: Spurious emissions from 30 MHz to 1 GHz:



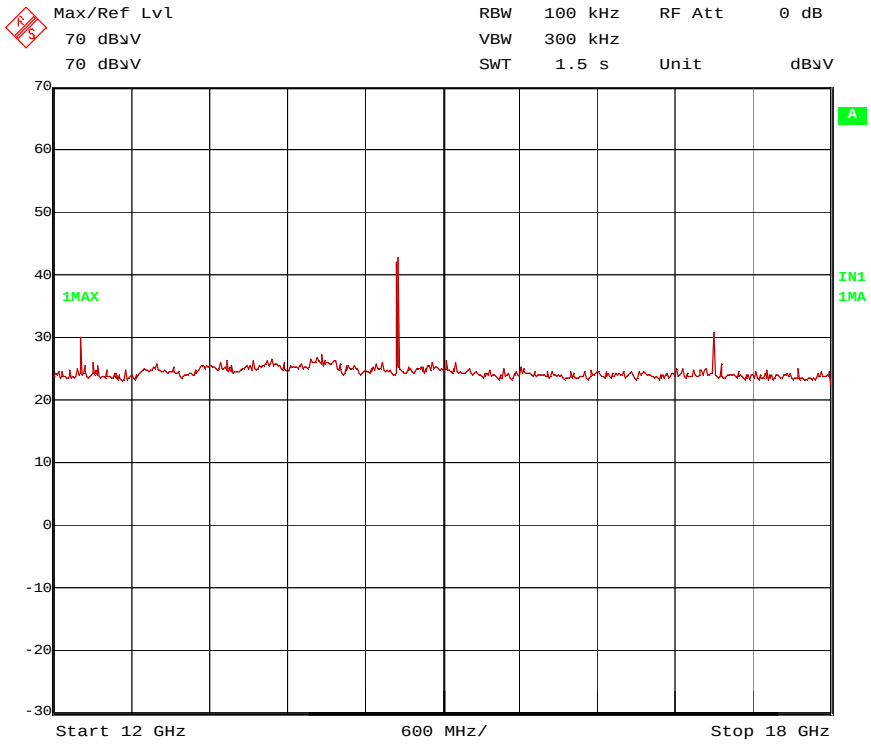
145833_ch0_pwr14_1-4G.wmf: Spurious emissions from 1 GHz to 4 GHz (operation mode 2):



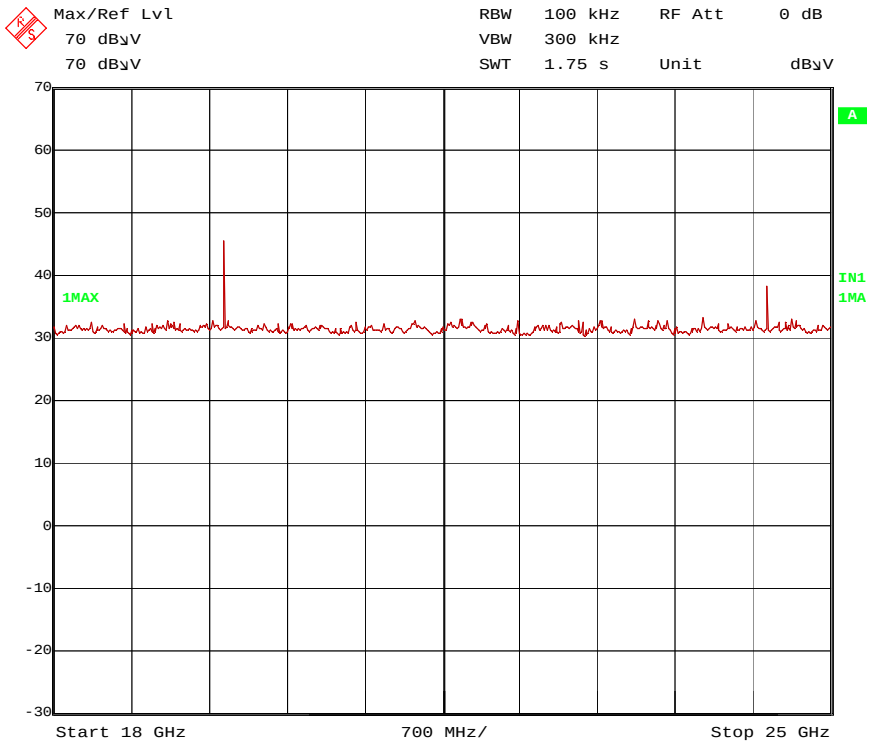
145833_ch39_pwr14_4-12G.wmf: Spurious emissions from 4 GHz to 12 GHz (operation mode 2):



145833_ch39_pwr13_12-18G_V.wmf: Spurious emissions from 12 to 18 GHz (operation mode 2):



145833_ch39_pwr13_18-25G.wmf: Spurious emissions from 18 – 25 GHz (operation mode 2):



The following frequencies were found inside the restricted bands during the preliminary radiated emission test:

- 280 MHz, 400 MHz, 4223.9 MHz, 4804 MHz, 4882 MHz, 4960 MHz, 12005 MHz, 12210 MHz, 12400 MHz, 19216 MHz, 19528 MHz, 19840 MHz

The following frequencies were found outside the restricted bands during the preliminary radiated emission test:

- 14412 MHz, 14646 MHz, 14880 MHz, 24020 MHz, 24410 MHz, 24800 MHz.

These frequencies have to be measured in a final measurement. The results are presented in the following.

TEST EQUIPMENT USED FOR THE TEST:

1 - 18

4.7.2.2 Final radiated emission measurement (9 kHz to 1 GHz)

Ambient temperature:	22 °C		Relative humidity:	37 %

Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m.

Cable guide: The cable of the EUT was fixed on the non-conducting table. For further information of the cable guide refer to the pictures in annex A of this test report.

Power supply: During the measurements the EUT was supplied with $24V_{DC}$ from power supply.

Operation states: As described in chapter 2.

Result measured with the quasipeak detector:

Frequency MHz	Level dBµV/m	Transducer dB	Limit dBµV/m	Margin dB	Height cm	Azimuth deg	Polarisation
280.000	44.8	16.7	46.0	1.2	100	2.00	vertical
400.000	45.6	20.1	46.0	0.6	212	354.00	horizontal

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

19 - 25

4.7.2.3 Final radiated emission measurement (1 GHz to 25 GHz)

Ambient temperature	22 °C		Relative humidity	37 %

Position of EUT:	The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.
Cable guide:	For detail information of test set-up and the cable guide refer to the pictures in annex A of this test report.
Test record:	All results are shown in the following.
Supply voltage:	During all measurements the host of the EUT was powered with 12 V via an laboratory power supply.
Resolution bandwidth:	For all measurements a resolution bandwidth of 1 MHz was used.
Additional information:	For simplification all values were compared to the restricted band limits. Mode DH5 was found to have the worst case spurious emissions.

Transmitter operates at the lower end of the assigned frequency band (operation mode 1)

Result measured with the peak detector:

Frequency MHz	Meas. Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band
4223.9	45.4	74.0	28.6	34.62	32.1	25.5	4.2	150	V	Yes
4804	54.2	74.0	19.8	42.1	32.6	24.9	4.4	150	H	Yes
12010	49.4	74.0	24.6	39.05	33.6	26.3	3.1	150	H	Yes
14412	54.1	74.0	19.9	43.81	33.7	26.8	3.4	150	H	No
16814	50.9	74.0	23.1	41.74	33.8	28.4	3.8	150	H	No
19216	46.2	74.0	27.8	42.63	37.1	37.7	4.2	150	H	Yes
24020	46.8	74.0	27.2	43.01	37.2	38.2	4.8	150	H	No
Measurement uncertainty				+2.2 dB / -3.6 dB						

Result measured with the average detector:

Frequency MHz	Meas. Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band
4223.9	38.0	54.0	16.0	27.28	32.1	25.5	4.2	150	V	Yes
4804	50.9	54.0	3.1	38.73	32.6	24.9	4.4	150	H	Yes
12010	40.4	54.0	13.6	30.12	33.6	26.3	3.1	150	H	Yes
14412	45.3	54.0	8.7	34.96	33.7	26.8	3.4	150	H	No
16814	40.9	54.0	13.1	31.77	33.8	28.4	3.8	150	H	No
19216	34.4	54.0	19.6	30.82	37.1	37.7	4.2	150	H	Yes
24020	34.3	54.0	19.7	30.51	37.2	38.2	4.8	150	H	No
Measurement uncertainty				+2.2 dB / -3.6 dB						

Transmitter operates at the middle of the assigned frequency band (operation mode 2)

Result measured with the peak detector:

Frequency MHz	Meas. Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band
4882	54.0	74.0	20.0	41.9	32.8	25.1	4.4	150	H	Yes
12205	51.3	74.0	22.7	40.99	33.6	26.4	3.1	150	H	Yes
14646	55.5	74.0	18.5	45.28	33.7	27.0	3.5	150	H	No
17087	48.0	74.0	26.0	38.7	33.8	28.2	3.8	150	H	No
19528	49.9	74.0	24.1	46.46	37.1	37.8	4.2	150	H	Yes
24410	47.1	74.0	26.9	43.27	37.2	38.5	5.1	150	H	No
Measurement uncertainty				+2.2 dB / -3.6 dB						

Result measured with the average detector:

Frequency MHz	Meas. Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band
4882	50.1	54.0	3.9	38	32.8	25.1	4.4	150	H	Yes
12205	42.3	54.0	11.7	32.03	33.6	26.4	3.1	150	H	Yes
14646	47.2	54.0	6.8	36.98	33.7	27.0	3.5	150	H	No
17087	38.0	54.0	16.0	28.62	33.8	28.2	3.8	150	H	No
19528	39.4	54.0	14.6	35.99	37.1	37.8	4.2	150	H	Yes
24410	34.5	54.0	19.5	30.68	37.2	38.5	5.1	150	H	No
Measurement uncertainty				+2.2 dB / -3.6 dB						

Transmitter operates at the upper end of the assigned frequency band (operation mode 3)

Result measured with the peak detector:

Frequency MHz	Meas. Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band
4960	51.5	74.0	22.5	39.4	32.9	25.3	4.5	150	H	Yes
12400	51.6	74.0	22.4	41.12	33.7	26.3	3.1	150	H	Yes
14880	56.5	74.0	17.5	46.46	33.7	27.2	3.6	150	H	No
17360	44.5	74.0	29.5	35.14	33.9	28.5	4.0	150	H	No
19840	50.3	74.0	23.7	46.59	37.0	37.6	4.3	150	H	Yes
24800	46.9	74.0	27.1	43.27	37.3	38.3	4.7	150	H	No
Measurement uncertainty				+2.2 dB / -3.6 dB						

Result measured with the average detector:

Frequency MHz	Meas. Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band
4960	47.3	54.0	6.7	35.2	32.9	25.3	4.5	150	H	Yes
12400	42.9	54.0	11.1	32.42	33.7	26.3	3.1	150	H	Yes
14880	48.4	54.0	5.6	38.38	33.7	27.2	3.6	150	H	No
17360	32.0	54.0	22.0	22.58	33.9	28.5	4.0	150	H	No
19840	40.1	54.0	13.9	36.38	37.0	37.6	4.3	150	H	Yes
24800	34.9	54.0	19.1	31.3	37.3	38.3	4.7	150	H	No
Measurement uncertainty				+2.2 dB / -3.6 dB						

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

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5 TEST EQUIPMENT AND ANCILLARIES USED FOR TESTS

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal. Due
1	Fully anechoic chamber M20	-	Albatross Projects	B83107-E2439-T232	480303	Weekly verification (system cal.)	
2	Measuring receiver	ESI 40	Rohde & Schwarz	100064	480355	02/26/2014	02/2016
3	Controller	MCU	Maturo	MCU/043/971107	480832	-	-
4	Turntable	DS420HE	Deisel	420/620/80	480315	-	-
5	Antenna support	AS615P	Deisel	615/310	480187	-	-
6	Antenna	CBL6112 B	Chase	2688	480328	04/14/2014	04/2017
7	Antenna	3115 A	EMCO	9609-4918	480183	11/10/2011	11/2017
8	Standard Gain Horn 11.9 GHz – 18 GHz	18240-20	Flann Microwave	483	480294	Six month verification (system cal.)	
9	Standard Gain Horn 17.9 GHz – 26.7 GHz	20240-20	Flann Microwave	411	480297	Six month verification (system cal.)	
10	RF-cable No. 3	Sucoflex 106B	Huber&Suhner	0563/6B / Kabel 3	480670	Weekly verification (system cal.)	
11	RF-cable No. 40	Sucoflex 106B	Huber&Suhner	0708/6B / Kabel 40	481330	Weekly verification (system cal.)	
12	RF-cable No. 36	Sucoflex 106B	Huber&Suhner	500003/6B / Kabel 36-	481680	Weekly verification (system cal.)	
13	RF-cable 2 m	KPS-1533-800-KPS	Insulated Wire		480302	Six month verification (system cal.)	
14	Preamplifier	JS3-00101200-23-5A	Miteq	681851	480337	Six month verification (system cal.)	
15	Preamplifier	JS3-12001800-16-5A	Miteq	571667	480343	Six month verification (system cal.)	
16	Preamplifier	JS3-18002600-20-5A	Miteq	658697	480342	Six month verification (system cal.)	
17	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	02/18/2014	02/2016
18	4 GHz High Pass Filter	WHKX4.0/18 G-8SS	Wainwright Instruments	1	480587	Weekly verification (system cal.)	
19	EMI-Software	ES-K1	Rohde & Schwarz	-	480111	-	-
20	Open area test site	-	Phoenix Test-Lab	-	480085	Weekly verification (system cal.)	
21	Measuring receiver	ESIB7	Rohde & Schwarz	100304	480521	06/02/2013	02/2015
22	Controller	HD100	Deisel	100/670	480139	-	-
23	Turntable	DS420HE	Deisel	420/620/80	480087	-	-
24	Antenna support	AS615P	Deisel	615/310	480086	-	-
25	Antenna	CBL6111 D	Chase	25761	480894	18/09/2014	09/2017
26	Spectrum analyser	FSU	Rohde & Schwarz	200125	480956	24/02/2012	02/2015

6 REPORT HISTORY

Report Number	Date	Comment
F145833E1	16 December 2014	Document created
F145833E1 2nd Version	18 February 2015	Conducted Measurements added
F145833E1 3rd Version	23 February 2015	Antenna information added. Bandedge compliance: correction of operation modes

7 LIST OF ANNEXES

ANNEX A TEST SET-UP PHOTOS 6 pages

145298_10.jpg: Test setup - Radiated emission (fully anechoic chamber)
145298_11.jpg: Test setup - Radiated emission (fully anechoic chamber)
145298_12.jpg: Test setup - Radiated emission (fully anechoic chamber)
145298_13.jpg: Test setup - Radiated emission (fully anechoic chamber)
145298_14.jpg: Test setup - Radiated emission (fully anechoic chamber)
145298_15.jpg: Test setup - Radiated emission (fully anechoic chamber)

ANNEX B EXTERNAL PHOTOGRAPHS 3 pages

145298_16.jpg: EUT– Front side view
145298_17.jpg: EUT– Back side view
145298_18.jpg: Test box (ancillary equipment)

ANNEX C INTERNAL PHOTOGRAPHS 8 pages

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145833_02.JPG: Mainboard
145833_03.JPG: Mainboard
145833_04.JPG: CPU board
145833_05.JPG: CPU board
145833_06.JPG: Cabinet opened and mainboard removed
145833_07.JPG: Monitor backside
145833_19.JPG: Monitor PCB, front side
145833_08.JPG: Bluetooth module at mainboard
145833_09.JPG: Bluetooth antenna