

FCC Part 15 Subpart B&C §15.247

Test Report

Equipment Under Test	SMART CONTROLLER
Model Name	MC710
Applicant	MOVON CORPORATION
FCC ID	TDU-MC710
Manufacturer	QINGDAO MOVON ELECTRONICS CO., LTD.
Date of Test(s)	2011.03.11 ~ 2011.03.28
Date of Issue	2011.03.31.

In the configuration tested, the EUT complied with the standards specified above.

Issue to	Issue by
MOVON CORPORATION Hyunjuk Bldg., 140-28, Sanseong-dong, Gangnam-Gu, Seoul, Korea Tel.: +82 +2 2050 4670 Fax: +82 +2 539 5692	MOVON CORPORATION 194-1, Geumeo-ri, Pogok-eup, Cheoin-gu, Yongin-si, Gyeonggi-do, Korea, 449-812 Tel.: +82 +31 338 8837 Fax: +82 +31 338 8847

Revision history

Revision	Date of issue	Description	Revised by
--	Mar. 31, 2011	Initial	--

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1. Attestation of test results

1.1. Details of applicant

Applicant : MOVON CORPORATON
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1.2. Summary of test results

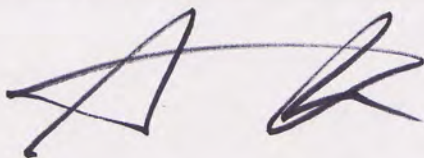
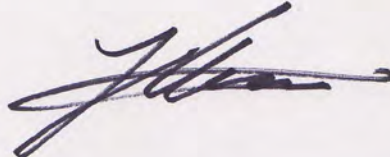
The EUT has been tested according to the following specifications;

Section in FCC part 15	Description	Result
§15.205(a) §15.209 §15.247(d)	Transmitter radiated spurious emissions, Conducted spurious emission	C
§15.109(a)	Receiver radiated spurious emission	C
§15.247(a)(1)	20 dB bandwidth and 99 % bandwidth	C
§15.247(b)(1)	Maximum peak output power	C
§15.247(a)(1)	Frequency separation	C
§15.247(a)(1)(iii)	Number of hopping frequency	C
§15.247(a)(1)(iii)	Time of occupancy(Dwell time)	C
§15.247(i) §1.1307(b)(1)	RF exposure evaluation	C

※ Abbreviation

C Complied
 N/A Not applicable
 F Fail

Approval Signatories

Test and Report Completed by :	Report Approval by :
	
Swen Lim Test Engineer MOVON CORPORATION	Issac Jin Technical Manager MOVON CORPORATION

2. EUT Description

Kind of product	SMART CONTROLLER
Model	MC710
Serial Number	N/A
Power supply	DC 3.70 V
Frequency range	2 402 MHz ~ 2 480 MHz
Modulation technique	GFSK, $\pi/4$ DQPSK, 8DPSK
Number of channels	79
Operating conditions	- 20 °C ~ + 55 °C
Antenna gain	2.38 dBi(Max.)

2.1. Declarations by the manufacturer

The EUT does not do anything at charging mode (Power is turned off when it is charging)

2.2. Details of modification

None

3. Information about the FHSS characteristics

3.1. Pseudorandom frequency hopping sequence

The channel is represented by a pseudo-random hopping sequence hopping through the 79 RF channels. The hopping sequence is unique for the piconet and is determined by the Bluetooth device address of the master; the phase in the hopping sequence is determined by the Bluetooth clock of the master. The channel is divided into time slots where each slot corresponds to an RF hop frequency. Consecutive hops correspond to different RF hop frequencies. The nominal hop rate is 1 600 hops/s.

3.2. Medium access protocol

The manufacturer declares that the device uses Bluetooth protocol.
It confirmed that Medium access protocol is implemented.

3.3. Occupied hops while the equipment is operating

While the equipment is operating (transmitting and/or receiving) each channel of the hopping sequence is occupied at least once during four times the product of the dwell time per hop and the number of channels.

4. Measurement equipment

Equipment	Manufacturer	Model	Calibration due.
EMI Test Receiver	R&S	ESIB26	2011-12-27
Signal Generator	R&S	SMR27	2011-12-27
Spectrum Analyzer	R&S	FSV-40	2011-10-22
Power Meter	Agilent	E4416A	2011-11-23
Power Sensor	Agilent	9327A	2011-11-23
Double Redge Horn Antenna	R&S	HF906	2012-12-17
Horn Antenna	A.H.SYSTEMS	SAS-572	2011-09-14
Ultra Broadband Antenna	R&S	HL562	2011-11-30
Power Amplifier	MITEQ	AM-1431	2011-12-24
Power Amplifier	MITEQ	AFS43-01002600	2011-12-24
High Pass Filter	Wainwright	WHK3.0/18G-10SS	2011-11-23
DC Power Supply	HP	6674A	2011-12-21
Controller	INNCO	CO2000	N/A
Antenna Master	INNCO	MA4000	N/A

※ Remark;
Support equipment

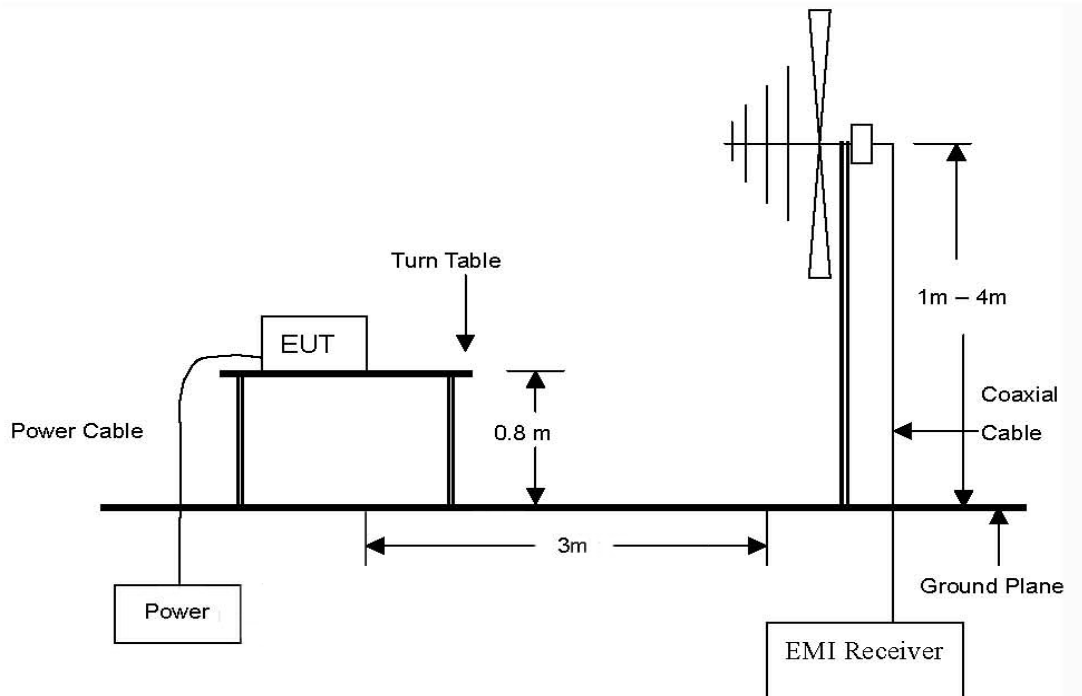
Description	Manufacturer	Model	Serial number
Notebook computer	Samsung Electronics.	SENS P30	W3179RFX300144N

5. Transmitter radiated spurious emissions and conducted spurious emissions

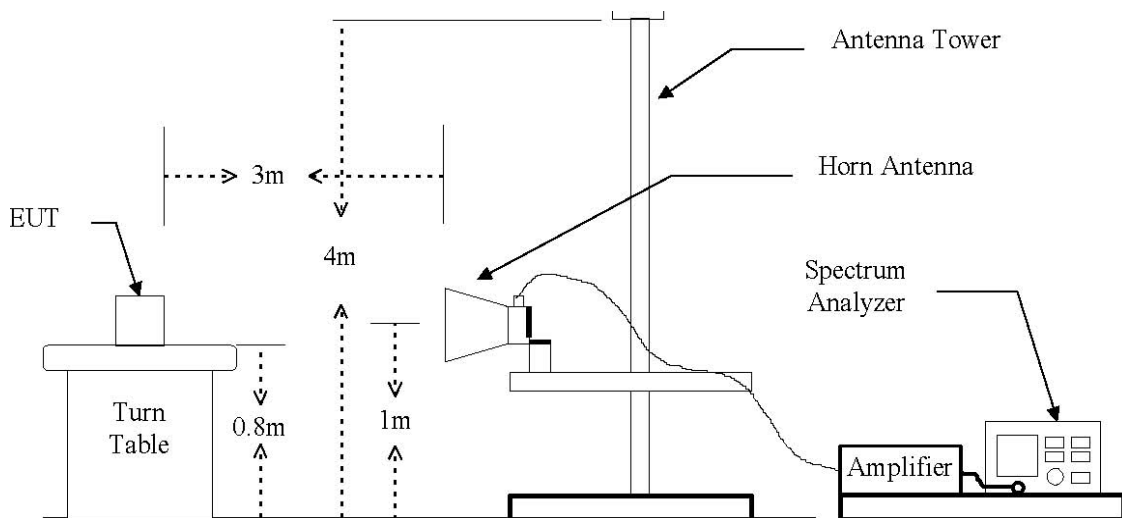
5.1. Test setup

5.1.1. Transmitter radiated spurious emissions

The diagram below shows the test setup that is utilized to make the measurements for emission from 30 MHz to 1 GHz emissions.



The diagram below shows the test setup that is utilized to make the measurements for emission from 1 GHz to 24 GHz emissions.



5.2. Limit

According to §15.247(d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, 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, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph(b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in section §15.209(a) is not required. In addition, radiated emission which in the restricted band, as define in section §15.205(a), must also comply the radiated emission limits specified in section §15.209(a) (see section §15.205(c))

According to § 15.109(a), for an intentional radiator devices, the general required of field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values :

Frequency (MHz)	Distance (Meters)	Radiated (dBμV/m)	Radiated (μV/m)
30 - 88	3	40.0	100
88 – 216	3	43.5	150
216 – 960	3	46.0	200
Above 960	3	54.0	500

5.3. Test procedures

Radiated emissions from the EUT were measured according to the dictates of ANSI C63.4:2003

5.3.1. Test procedures for radiated spurious emissions

1. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter anechoic chamber test site. The table was rotated 360 degrees to determine the position of the highest radiation.
2. During performing radiated emission below 1 GHz, the EUT was set 3 meters away from the interference receiving antenna, which was mounted on the top of a variable-height antenna tower. During performing radiated emission above 1 GHz, the EUT was set 3 meters away from the interference-receiving antenna.
3. The antenna is a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
4. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the table was turned from 0 degrees to 360 degrees to find the maximum reading.
5. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.
6. If the emission level of the EUT in peak mode was 10 dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

※ Remark;

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Peak detection (PK) or Quasi-peak detection (QP) at frequency below 1 GHz.
2. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 1 MHz for Peak detection and frequency above 1 GHz.
3. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 10 Hz for Average detection (AV) at frequency above 1 GHz.

5.3.2. Test procedures for conducted spurious emissions

1. The transmitter output was connected to the spectrum analyzer through an attenuator.
2. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using RBW = 100 kHz, VBW = 100 kHz.

5.4. Test result

Ambient temperature: 23 °C
Relative humidity: 46 % R.H.

5.4.1. Spurious radiated emission

The frequency spectrum from 30 MHz to 1 000 MHz was investigated. Emission levels are not reported much lower than the limits by over 30 dB. All reading values are peak values.

Operation mode: GFSK

A. Low channel (2 402 MHz)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
232.16	68.95	Peak	H	10.87	-39.49	40.33	46.00	5.67
300.20	67.68	Peak	H	12.62	-39.05	41.25	46.00	4.75
333.25	65.36	Peak	H	13.18	-38.79	39.75	46.00	6.25
366.29	64.96	Peak	V	14.11	-38.49	40.58	46.00	5.42
383.79	66.91	Peak	H	14.80	-38.44	43.27	46.00	2.73
391.56	65.11	Peak	H	15.11	-38.42	41.80	46.00	4.20
401.28	61.94	Peak	V	15.49	-38.40	39.03	46.00	6.97
434.33	61.19	Peak	V	16.50	-38.35	39.34	46.00	6.66
500.42	61.51	Peak	H	17.68	-38.09	41.10	46.00	4.90
566.51	61.00	Peak	H	18.32	-37.91	41.41	46.00	4.59
667.60	56.95	Peak	V	19.59	-37.63	38.91	46.00	7.09
Above 960.00	Not detected							

B. Middle channel (2 441 MHz)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
232.16	66.89	Peak	V	10.87	-39.49	38.27	46.00	7.73
255.49	69.00	Peak	H	11.69	-39.31	41.38	46.00	4.62
307.98	65.05	Peak	H	12.75	-39.00	38.80	46.00	7.20
319.64	69.10	Peak	H	12.95	-38.92	43.13	46.00	2.87
335.19	67.23	Peak	H	13.21	-38.77	41.67	46.00	4.33
352.69	67.03	Peak	H	13.57	-38.57	42.03	46.00	3.97
366.29	64.97	Peak	V	14.11	-38.49	40.59	46.00	5.41
383.79	67.95	Peak	H	14.80	-38.44	44.31	46.00	1.69
500.42	57.90	Peak	V	17.68	-38.09	37.49	46.00	8.51
566.51	60.63	Peak	V	18.32	-37.91	41.04	46.00	4.96
867.82	54.68	Peak	V	21.82	-38.24	38.26	46.00	7.74
Above 960.00	Not detected							

C. High channel (2 480 MHz)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
232.16	66.39	Peak	H	10.87	-39.49	37.77	46.00	8.23
288.54	67.55	Peak	H	12.38	-39.11	40.82	46.00	5.18
300.20	67.16	Peak	V	12.62	-39.05	40.73	46.00	5.27
327.41	67.60	Peak	H	13.08	-38.85	41.83	46.00	4.17
366.29	67.54	Peak	V	14.11	-38.49	43.16	46.00	2.84
383.79	63.92	Peak	H	14.80	-38.44	40.28	46.00	5.72
395.45	60.99	Peak	H	15.27	-38.41	37.85	46.00	8.15
401.28	62.47	Peak	V	15.49	-38.40	39.56	46.00	6.44
434.33	62.95	Peak	V	16.50	-38.35	41.10	46.00	4.90
500.42	59.94	Peak	V	17.68	-38.09	39.53	46.00	6.47
634.55	57.90	Peak	V	19.23	-37.72	39.41	46.00	6.59
Above 960.00	Not detected							

Operation mode: 8DPSK

A. Low channel (2 402 MHz)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
288.54	68.03	Peak	H	12.38	-39.11	41.30	46.00	4.70
341.02	66.95	Peak	H	13.31	-38.70	41.56	46.00	4.44
352.69	70.53	Peak	H	13.57	-38.57	45.53	46.00	0.47
383.79	66.71	Peak	H	14.80	-38.44	43.07	46.00	2.93
455.71	65.07	Peak	V	17.06	-38.28	43.85	46.00	2.15
566.51	61.79	Peak	V	18.32	-37.91	42.20	46.00	3.80
Above 960.00	Not detected							

B. Middle channel (2 441 MHz)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
319.64	68.24	Peak	H	12.95	-38.92	42.27	46.00	3.73
335.19	66.23	Peak	H	13.21	-38.77	40.67	46.00	5.33
352.69	68.94	Peak	H	13.57	-38.57	43.94	46.00	2.06
467.37	62.44	Peak	V	17.22	-38.24	41.42	46.00	4.58
500.42	58.69	Peak	V	17.68	-38.09	38.28	46.00	7.72
533.47	57.95	Peak	V	17.97	-37.96	37.96	46.00	8.04
566.51	57.15	Peak	V	18.32	-37.91	37.56	46.00	8.44
801.72	60.21	Peak	H	20.64	-37.85	43.00	46.00	3.00
Above 960.00	Not detected							

C. High channel (2 480 MHz)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
352.69	68.62	Peak	H	13.57	-38.57	43.62	46.00	2.38
383.79	65.32	Peak	H	14.80	-38.44	41.68	46.00	4.32
467.37	62.44	Peak	V	17.22	-38.24	41.42	46.00	4.58
801.72	60.02	Peak	H	20.64	-37.85	42.81	46.00	3.19
834.77	58.34	Peak	H	21.15	-38.22	41.27	46.00	4.73
867.82	57.63	Peak	H	21.82	-38.24	41.21	46.00	4.79
Above 960.00	Not detected							

※ **Remark**

1. Actual = Reading + Ant. factor + Amp + CL (Cable loss)

5.4.2. Spurious radiated emission

The frequency spectrum above 1 000 MHz was investigated. Emission levels are not reported much lower than the limits by over 30 dB.

Operation mode: GFSK

A. Low channel (2 402 MHz)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (MHz)	Reading (dBμV)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 390.00*	48.12	Peak	V	28.76	-38.61	38.12	74.00	35.73
2 390.00*	47.96	Peak	H	28.76	-38.61	38.11	74.00	35.89
4 804.00	62.14	Peak	V	32.82	-35.65	59.11	74.00	14.69
4 804.00	44.19	Average	V	32.82	-35.65	41.36	54.00	12.64
4 804.00	61.23	Peak	H	32.82	-35.65	58.40	74.00	15.60
4 804.00	44.15	Average	H	32.82	-35.65	41.32	54.00	12.68
Above 4 900.00	Not detected							

B. Middle channel (2 441 MHz)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (MHz)	Reading (dBμV)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 882.00	61.26	Peak	V	33.08	-35.58	58.76	74.00	15.24
4 882.00	43.25	Average	V	33.08	-35.58	40.75	54.00	13.25
4 882.00	63.99	Peak	H	33.08	-35.58	61.49	74.00	12.51
4 882.00	44.09	Average	H	33.08	-35.58	41.59	54.00	12.41
Above 4 900.00	Not detected							

C. High channel (2 480 MHz)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
2 483.50*	57.44	Peak	V	29.09	-38.58	47.95	74.00	26.05
2 483.50*	39.26	Average	V	29.09	-38.58	29.77	54.00	24.23
2 483.50*	58.75	Peak	H	29.09	-38.58	49.26	74.00	24.74
2 483.50*	41.12	Average	H	29.09	-38.58	31.63	54.00	22.37
4 960.00	56.15	Peak	V	33.33	-35.52	53.96	74.00	20.04
4 960.00	35.59	Average	V	33.33	-35.52	33.40	54.00	20.60
4 960.00	63.43	Peak	H	33.33	-35.52	61.24	74.00	12.76
4 960.00	36.87	Average	H	33.33	-35.52	34.68	54.00	19.32
Above 5 000.00	Not detected							

Operation mode: 8DPSK

A. Low channel (2 402 MHz)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
2 390.00*	47.80	Peak	V	28.76	-38.61	37.95	74.00	36.05
2 390.00*	49.66	Peak	H	28.76	-38.61	39.81	74.00	34.19
4 804.00	55.34	Peak	V	32.82	-35.65	52.51	74.00	21.49
4 804.00	40.22	Average	V	32.82	-35.65	37.39	54.00	16.61
4 804.00	58.47	Peak	H	32.82	-35.65	55.64	74.00	18.36
4 804.00	41.36	Average	H	32.82	-35.65	38.53	54.00	15.47
Above 4 900.00	Not detected							

B. Middle channel (2 441 MHz)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
4 882.00	55.68	Peak	V	33.08	-35.58	53.18	74.00	20.82
4 882.00	40.31	Average	V	33.08	-35.58	37.81	54.00	16.19
4 882.00	58.47	Peak	H	33.08	-35.58	55.97	74.00	18.03
4 882.00	42.25	Average	H	33.08	-35.58	39.75	54.00	14.25
Above 4 900.00	Not detected							

C. High channel (2 480 MHz)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
2 483.50*	53.74	Peak	V	29.09	-38.58	44.25	74.00	29.75
2 483.50*	35.41	Average	V	29.09	-38.58	25.92	54.00	28.08
2 483.50*	56.23	Peak	H	29.09	-38.58	46.74	74.00	27.26
2 483.50*	36.65	Average	H	29.09	-38.58	27.16	54.00	26.84
4 960.00	50.17	Peak	V	33.33	-35.52	47.98	74.00	26.02
4 960.00	32.23	Average	V	33.33	-35.52	30.04	54.00	23.96
4 960.00	57.24	Peak	H	33.33	-35.52	55.05	74.00	18.95
4 960.00	33.39	Average	H	33.33	-35.52	31.20	54.00	22.80
Above 5 000.00	Not detected							

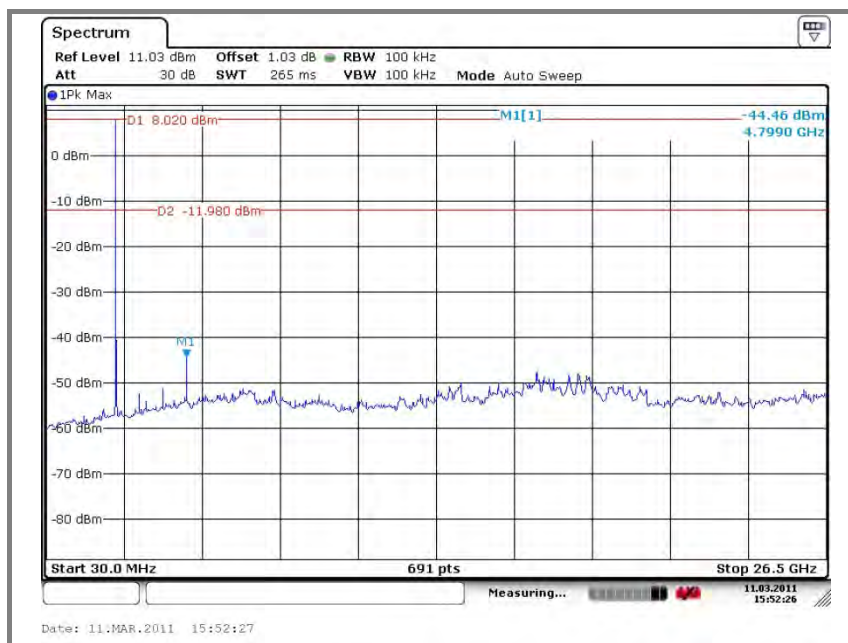
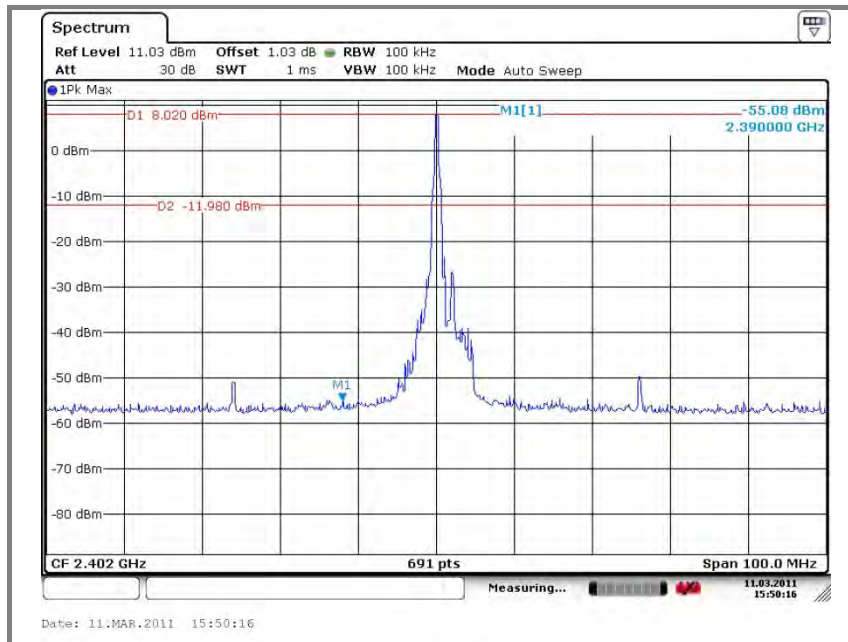
※ Remark

1. “*” means the restricted band.
2. Measuring frequencies from 1 GHz to the 10th harmonic of highest fundamental Frequency.
3. Radiated emissions measured in frequency above 1 000 MHz were made with an instrument using peak/average detector mode.
4. Average test would be performed if the peak result were greater than the average limit.
5. Actual = Reading + Ant. factor + Amp + CL (Cable loss)

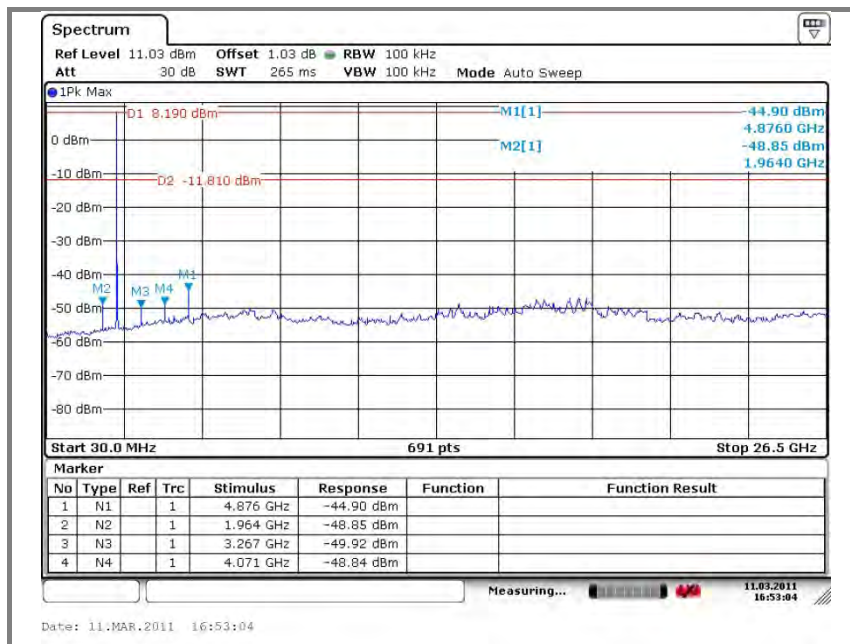
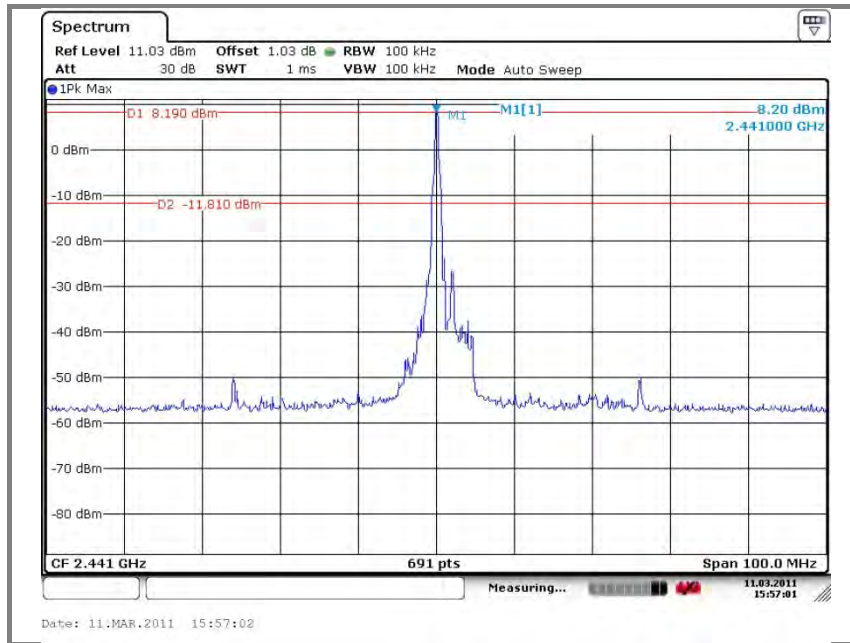
5.4.3. Spurious RF conducted emissions: Plot of spurious RF conducted emission

Operation mode: GFSK

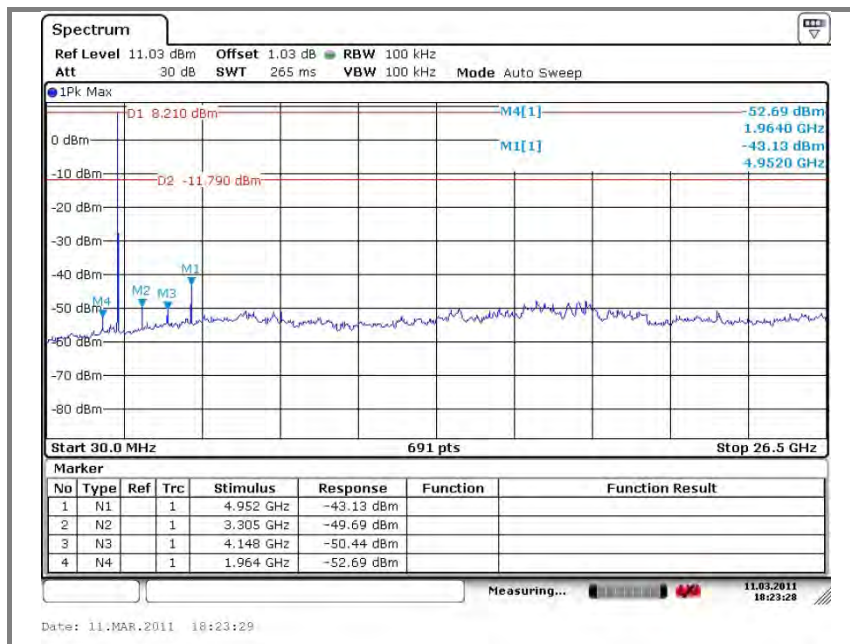
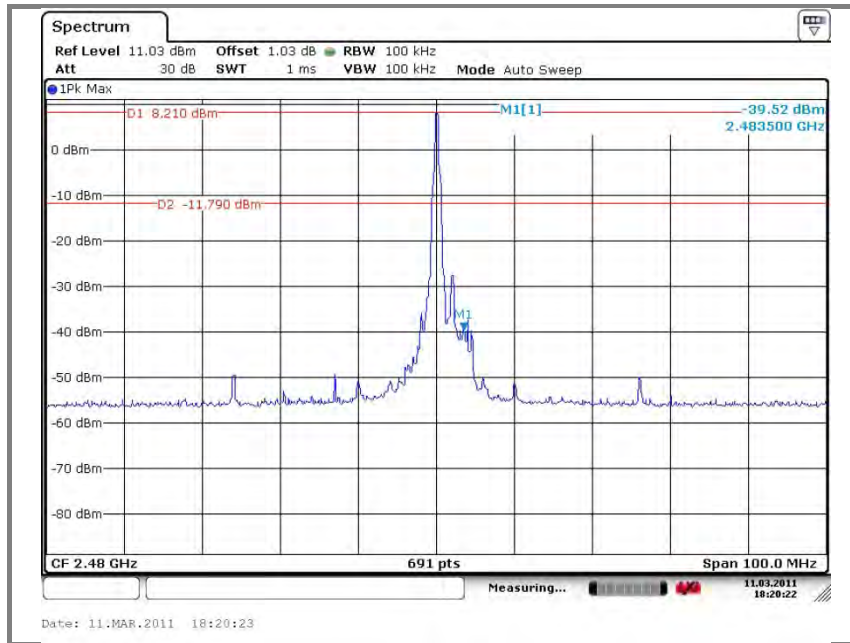
A. Low channel (2 402 MHz)



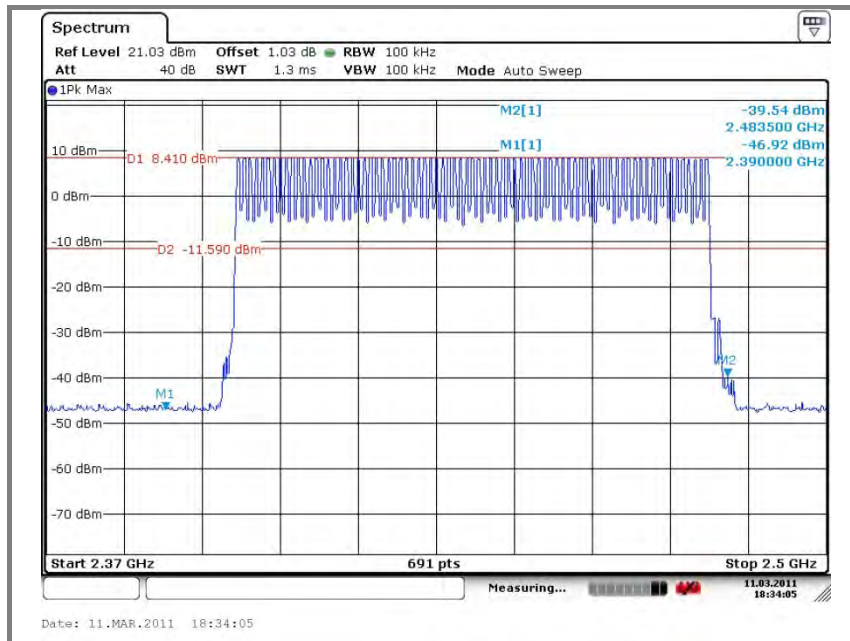
B. Middle channel (2 441 MHz)



C. High channel (2 480 MHz)

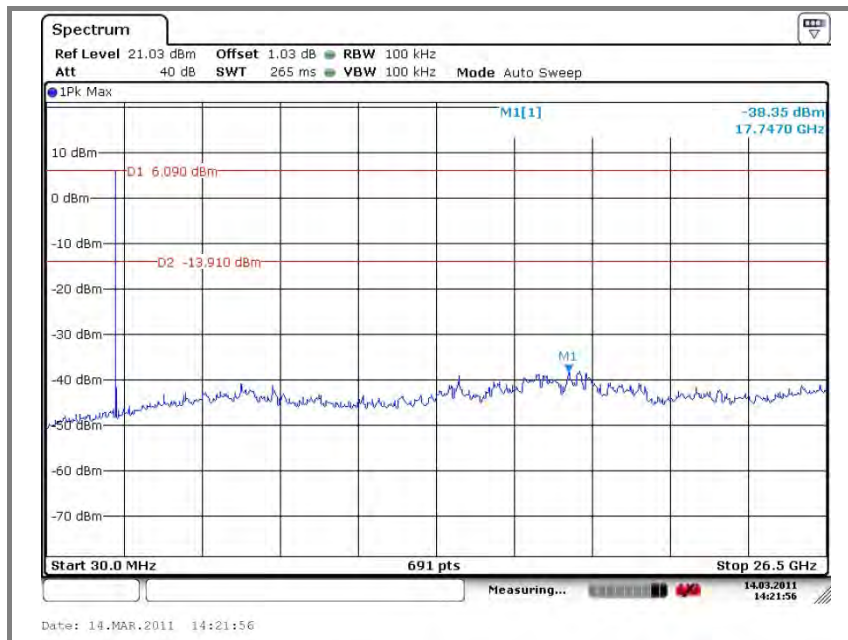
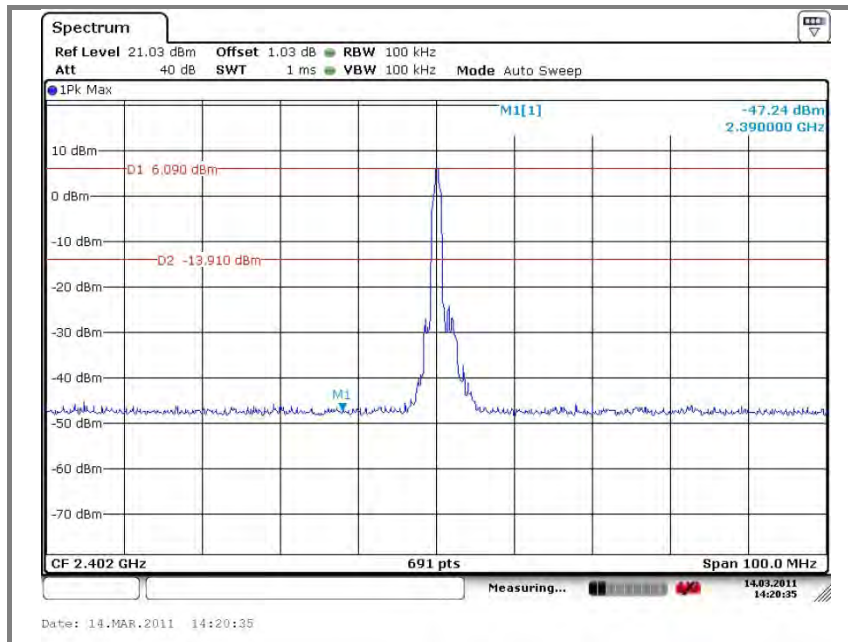


D. Band edge at hopping mode

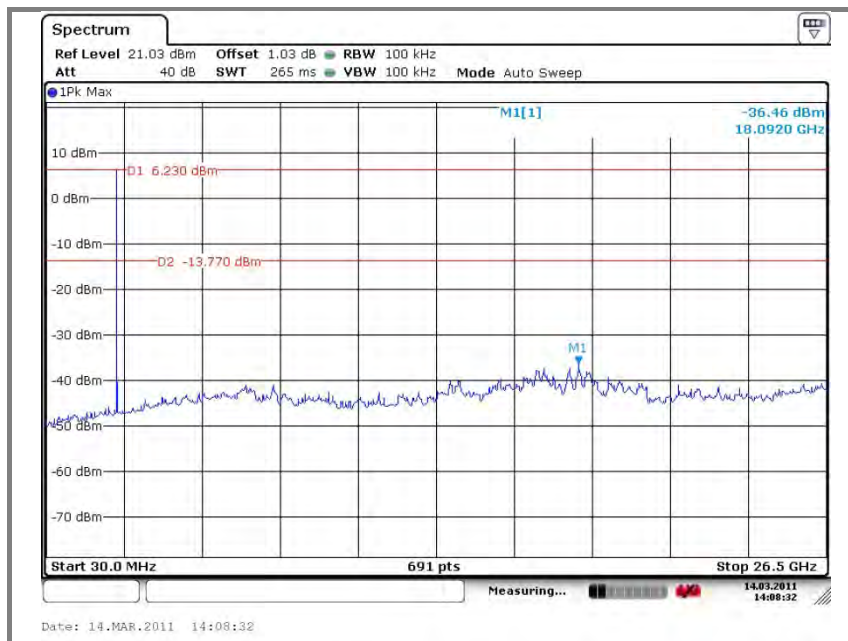
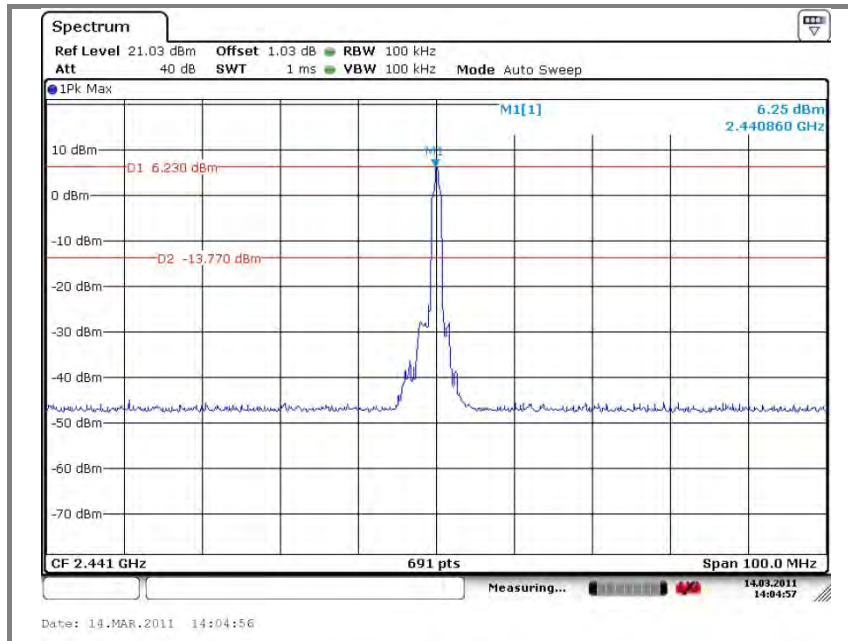


5.4.4. Spurious RF conducted emissions: Plot of spurious RF conducted emission Operation mode: 8DPSK

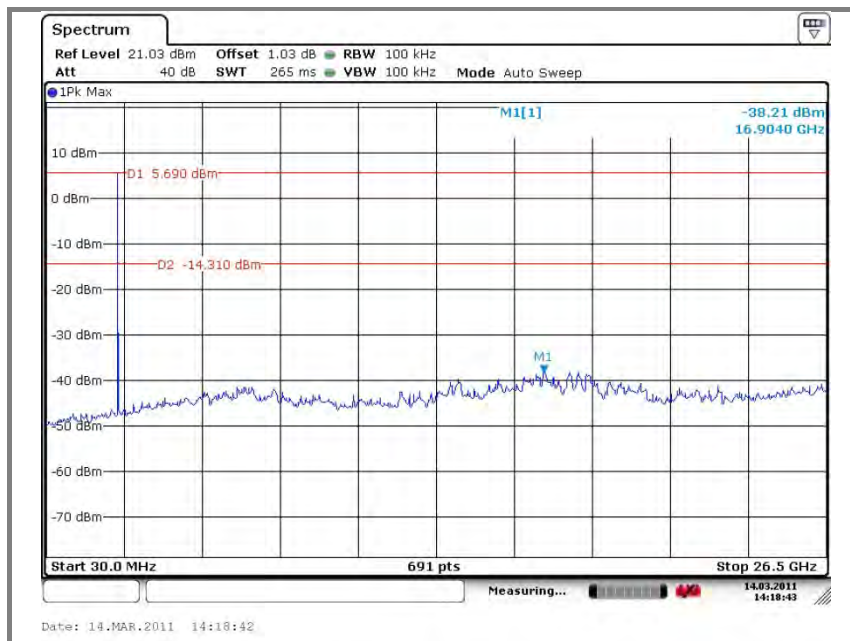
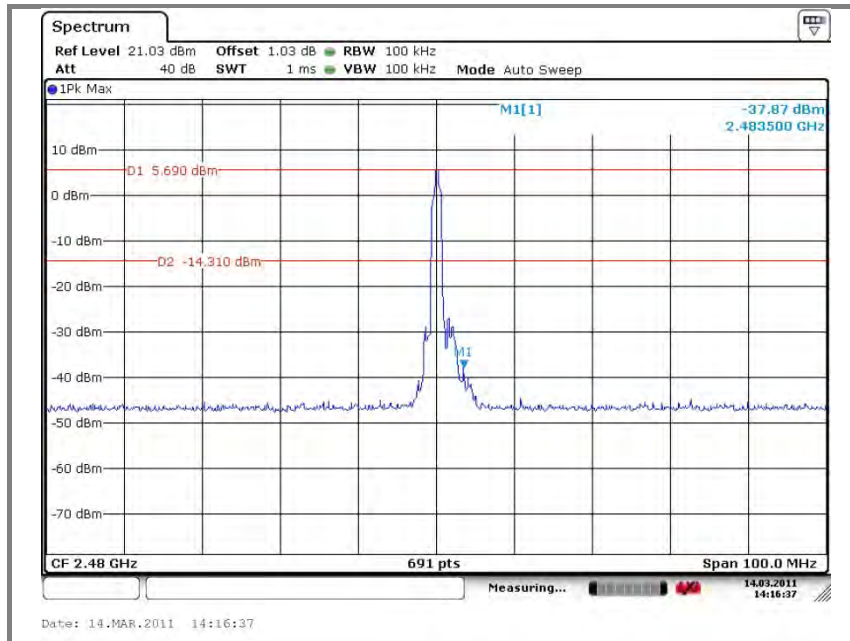
A. Low channel (2 402 MHz)



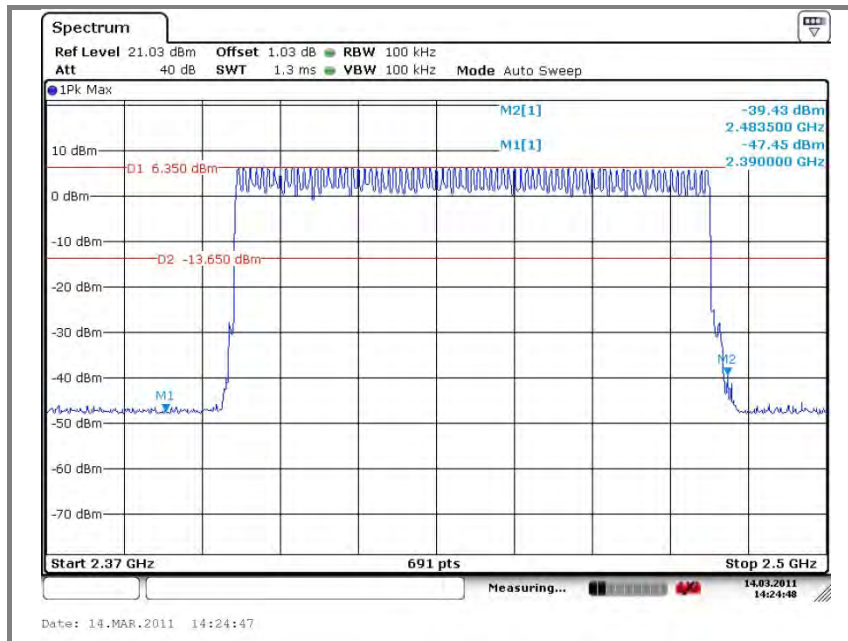
B. Middle channel (2 441 MHz)



C. High channel (2 480 MHz)



D. Band edge at hopping mode



6. Receiver radiated spurious emissions

6.1. Test setup

Same as clause 5.1.

6.1.1. Receiver radiated spurious emissions

Same as clause 5.1.1

6.2. Limit

According to §15.109(a), Except for Class A digital devices, the field strength of radiated emission from unintentional radiator at a distance of 3 m shall not exceed the following values:

Frequency (MHz)	Distance (Meters)	Radiated (dB μ V/m)	Radiated (μ V/m)
30 - 88	3	40.0	100
88 – 216	3	43.5	150
216 – 960	3	46.0	200
Above 960	3	54.0	500

6.3. Test procedures

Same as clause 2.3.

Radiated emissions from the EUT were measured according to the dictates of ANSI C63.4:2003

6.3.1. Test procedures for radiated spurious emissions

Same as Clause 5.3.1.

6.4. Test results

Ambient temperature: 23 °C
Relative humidity: 46 % R.H.

6.4.1. Spurious radiated emission.

The frequency spectrum from 30 MHz to 26.5 GHz was investigated. Emission levels are not reported much lower than the limits by over 30 dB. All reading values are peak values.

Operation mode: **GFSK**

A. Low channel (2 402 MHz)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (MHz)	Reading (dBμV)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
366.29	65.59	Peak	V	14.11	-38.49	41.21	46.00	4.79
401.28	67.26	Peak	V	15.49	-38.40	44.35	46.00	1.65
467.38	62.62	Peak	V	17.22	-38.24	41.60	46.00	4.40
801.72	57.07	Peak	H	20.64	-37.85	39.86	46.00	6.14
867.82	56.80	Peak	H	21.82	-38.24	40.38	46.00	5.62
Above 960.00	Not detected							

※ Remark:

1. All spurious emission at channels are almost the same from 30 MHz to 26.5 GHz, so that the low channel was chosen as representative in final test.
2. Actual = Reading + Ant. factor + Amp + CL (Cable loss)

Operation mode: 8DPSK

A. Low channel (2 402 MHz)

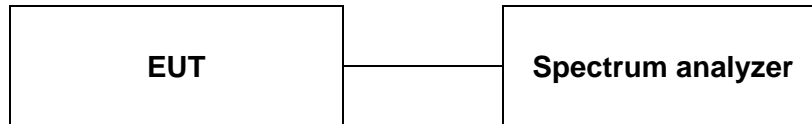
Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (MHz)	Reading (dBμV)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
224.389	69.13	Peak	H	10.57	-39.53	40.17	46.00	5.83
255.491	69.48	Peak	V	11.69	-39.31	41.86	46.00	4.14
352.685	65.41	Peak	V	13.57	-38.57	40.41	46.00	5.59
383.788	67.64	Peak	V	14.80	-38.44	44.00	46.00	2.00
801.723	57.40	Peak	H	20.64	-37.85	40.19	46.00	5.81
Above 960.00	Not detected							

※ Remark:

1. All spurious emission at channels are almost the same from 30 MHz to 26.5 GHz, so that the low channel was chosen at representative in final test.
2. Actual = Reading + Ant. factor + Amp + CL (Cable loss)

7. 20 dB bandwidth measurement & 99 % bandwidth measurement

7.1. Test setup



7.2. Limit

Not applicable

7.3. Test procedure

1. The 20 dB band width was measured with a spectrum analyzer connected to RF antenna connector (conducted measurement) while EUT was operating in transmit mode at the appropriate center frequency. The analyzer center frequency was set to the EUT carrier frequency, using the analyzer. Display Line and Marker Delta functions, the 20 dB band width of the emission was determined.
2. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using RBW = 10 kHz, VBW = 10 kHz, Span = 5 MHz.

7.4. Test results

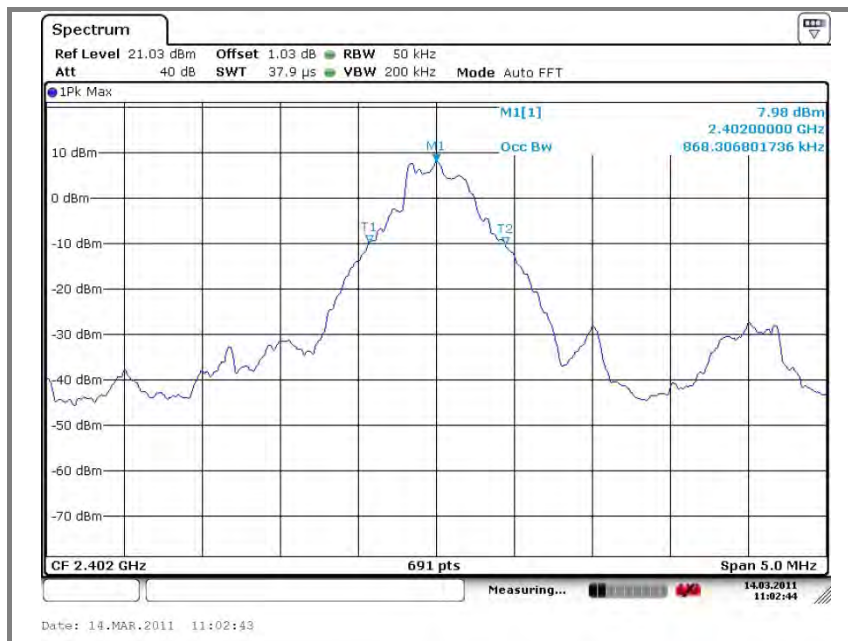
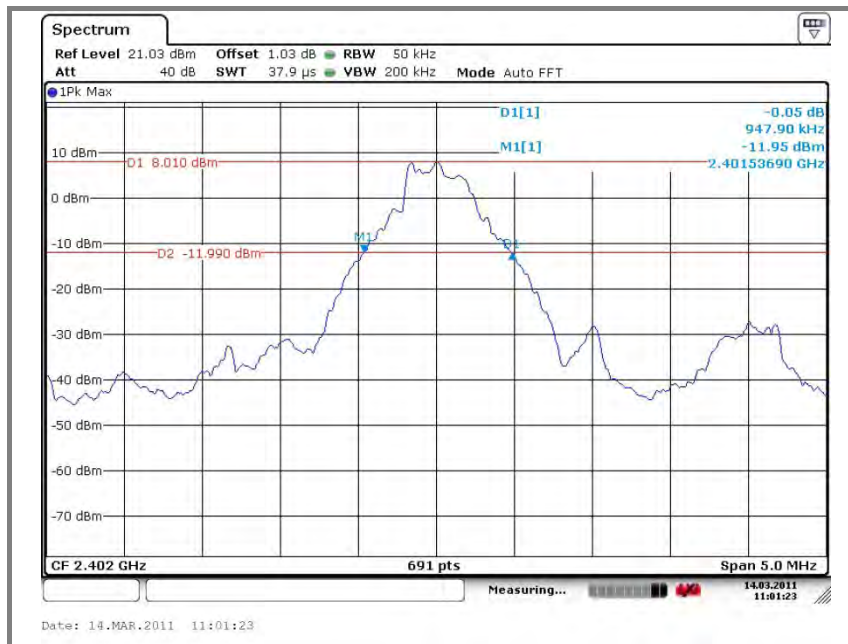
Ambient temperature: 23 °C

Relative humidity: 46 % R.H.

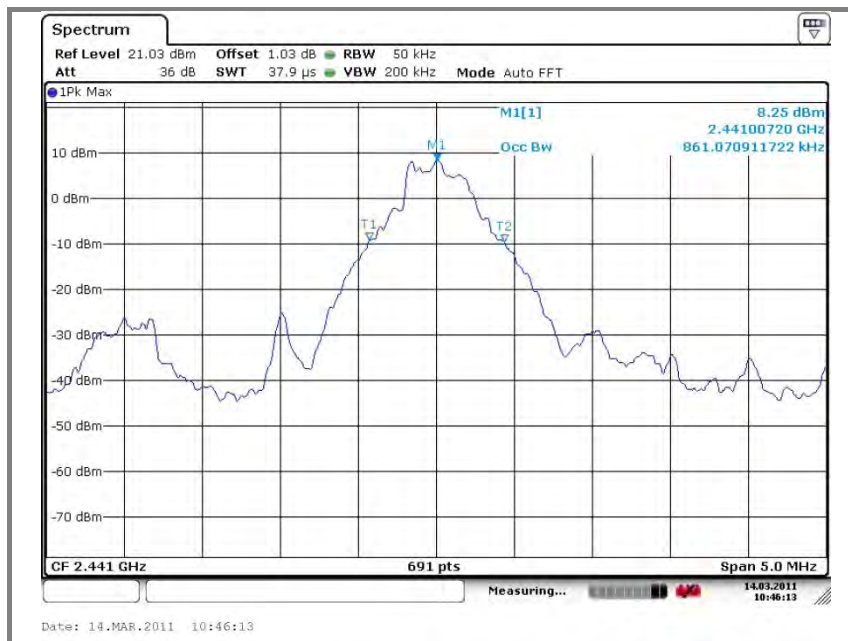
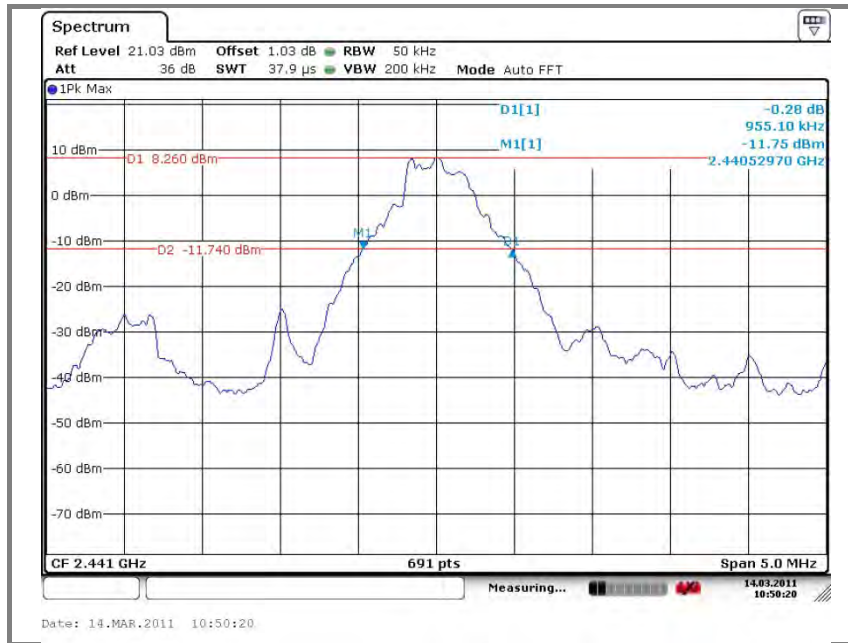
Operation mode	Frequency(MHz)	20 dB bandwidth(MHz)	99 % bandwidth(MHz)
GFSK	2 402	0.948	0.868
	2 441	0.955	0.861
	2 480	0.955	0.854
8DPSK	2 402	1.259	1.172
	2 441	1.259	1.165
	2 480	1.266	1.165

Operation mode: GFSK

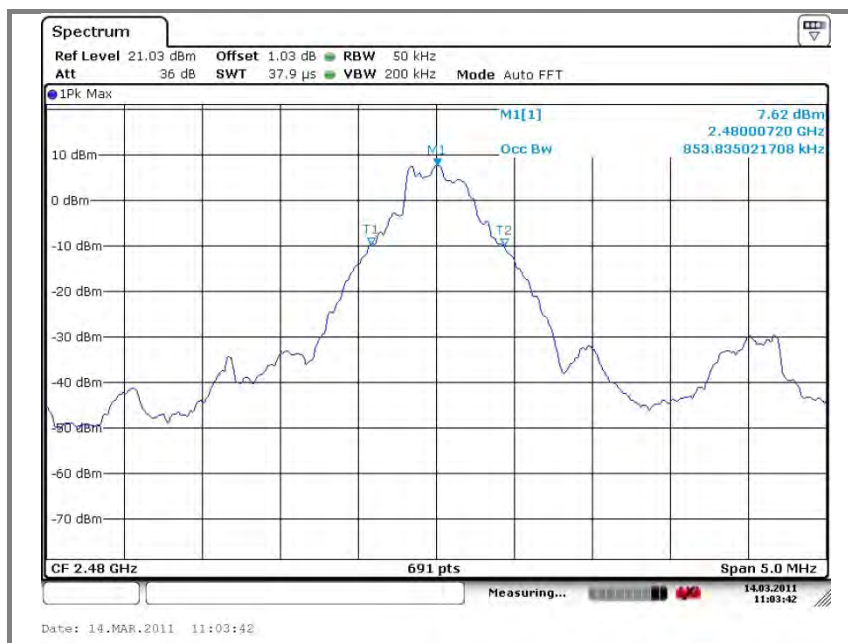
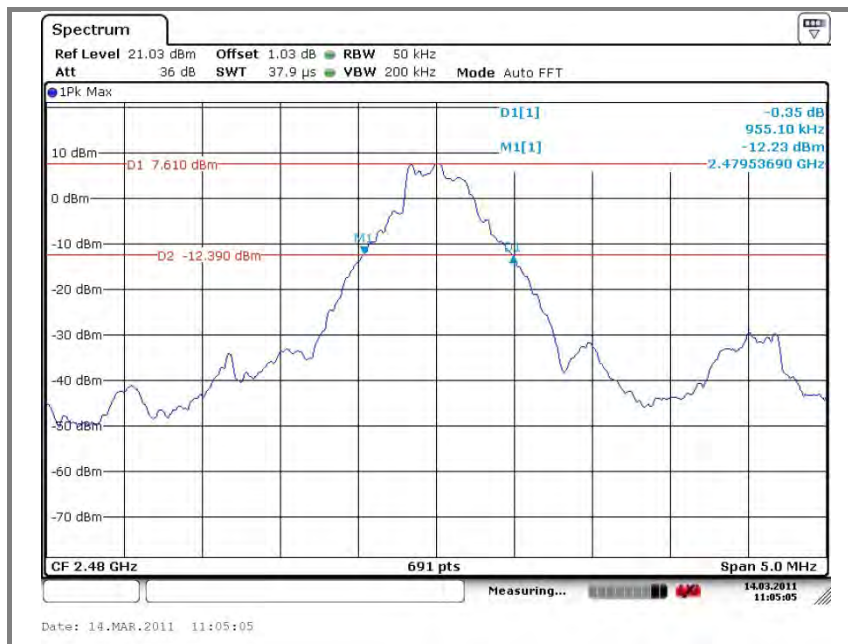
A. Low channel (2 402 MHz) – 20 dB bandwidth & 99 % bandwidth



B. Middle channel (2 441 MHz) – 20 dB bandwidth & 99 % bandwidth

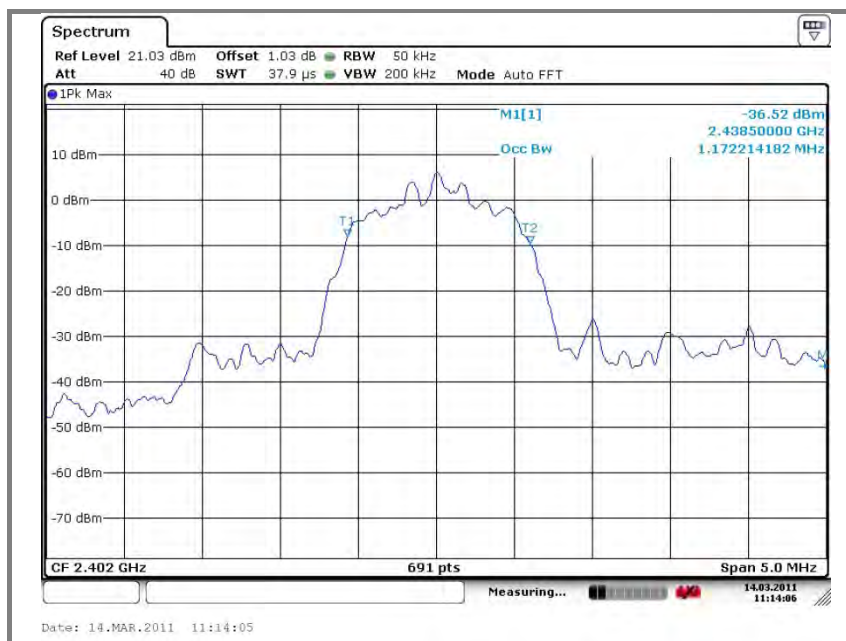
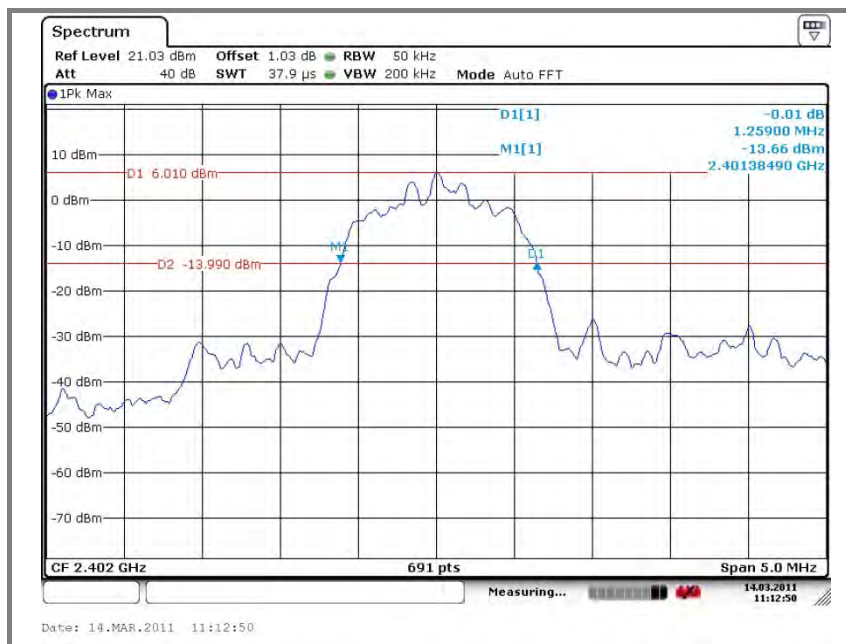


C. High channel (2 480 MHz) – 20 dB bandwidth & 99 % bandwidth

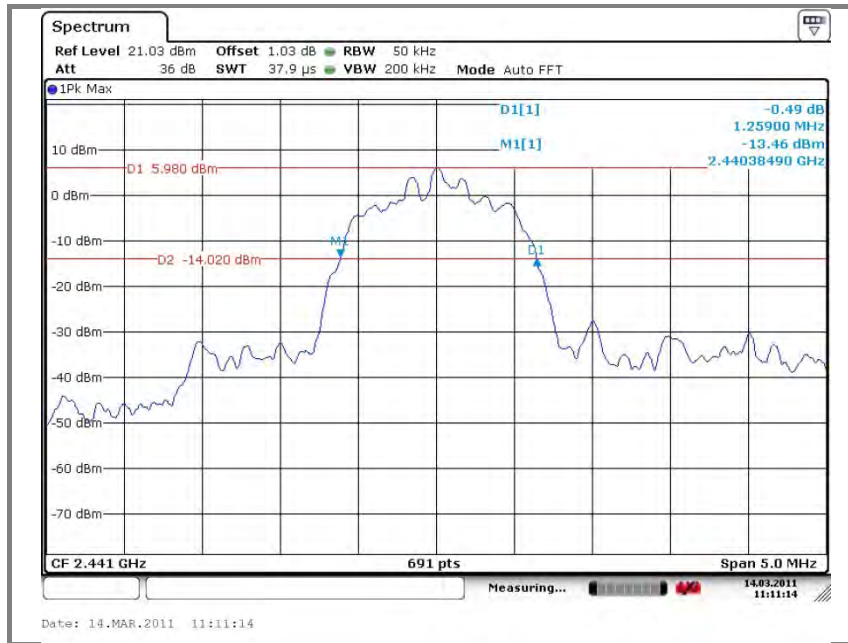


Operation mode: 8DPSK

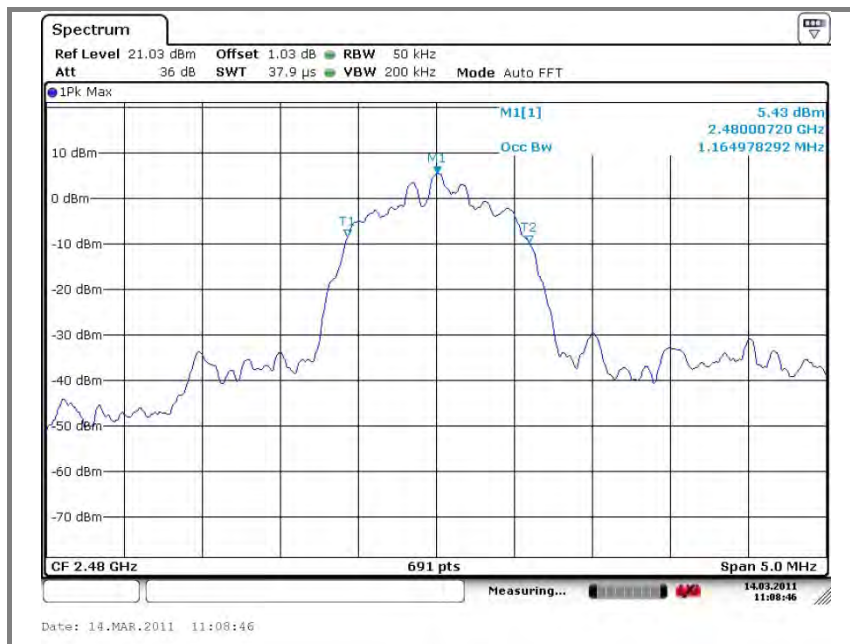
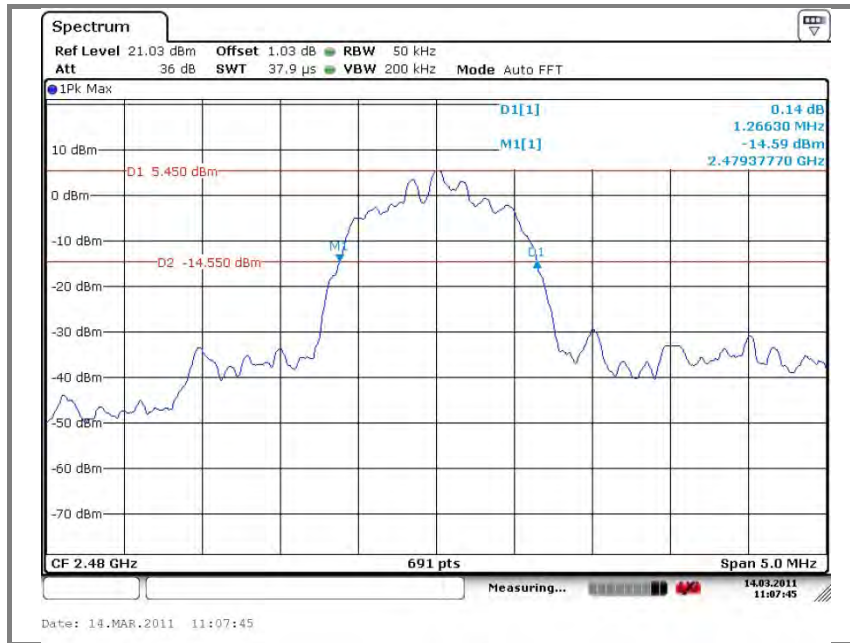
A. Low channel (2 402 MHz) – 20 dB bandwidth & 99 % bandwidth



B. Middle channel (2 441 MHz) – 20 dB bandwidth & 99 % bandwidth

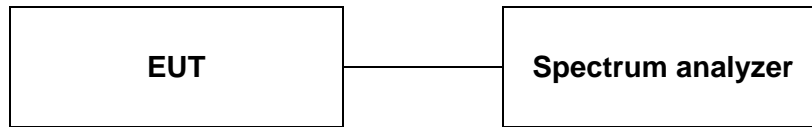


C. High channel (2 480 MHz) – 20 dB bandwidth & 99 % bandwidth



8. Maximum peak output power measurement

8.1. Test setup.



8.2. Limit

The maximum peak output power of the intentional radiator shall not exceed the following:

1. §15.247(a)(1), Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW
2. §15.247(b)(1), For frequency hopping systems operating in the 2 400 – 2 483.5 MHz employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5 725 – 5 805 MHz band: 1 Watt.

8.3. Test procedure

1. The RF power output was measured with a Spectrum analyzer connected to the RF Antenna connector(conducted measurement) while EUT was operating in transmit mode at the appropriate center frequency, A spectrum analyzer was used to record the shape of the transmit signal.
2. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using;
Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel
RBW ≥ 20 dB BW, VBW ≥ RBW, Sweep = auto, Detector function = peak, Trace = max hold

8.4. Test results

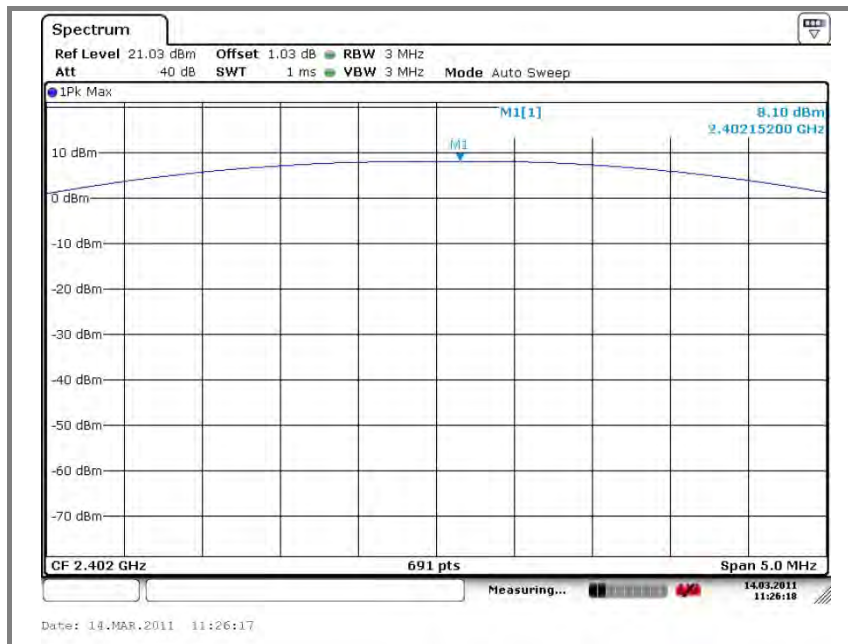
Ambient temperature: 23 °C

Relative humidity: 46 % R.H.

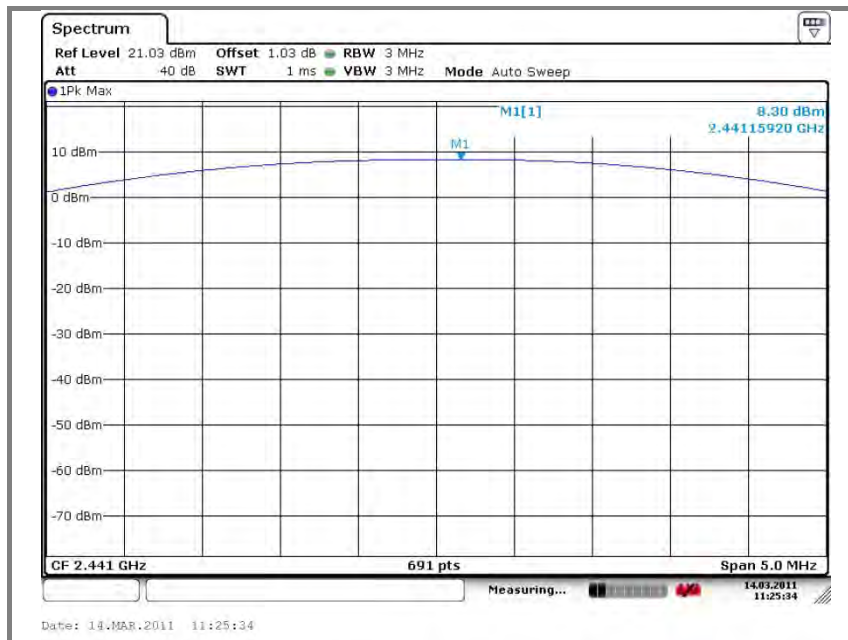
Operation mode	Frequency(MHz)	Peak output power(dBm)	Limit(dBm)
GFSK	2 402	8.10	30
	2 441	8.30	30
	2 480	7.96	30
8DPSK	2 402	7.22	30
	2 441	7.37	30
	2 480	6.92	30

Operation mode: GFSK

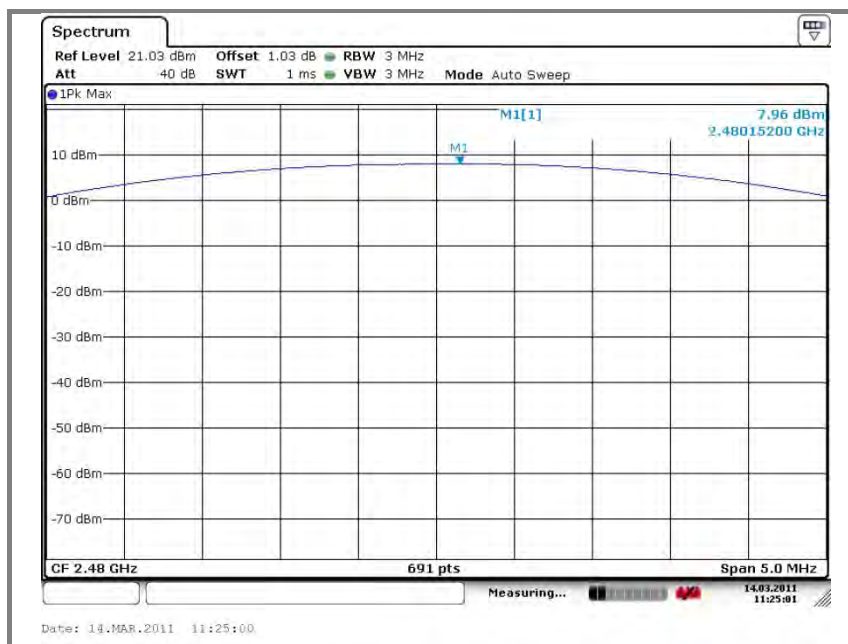
A. Low channel (2 402 MHz)



B. Middle channel (2 441 MHz)

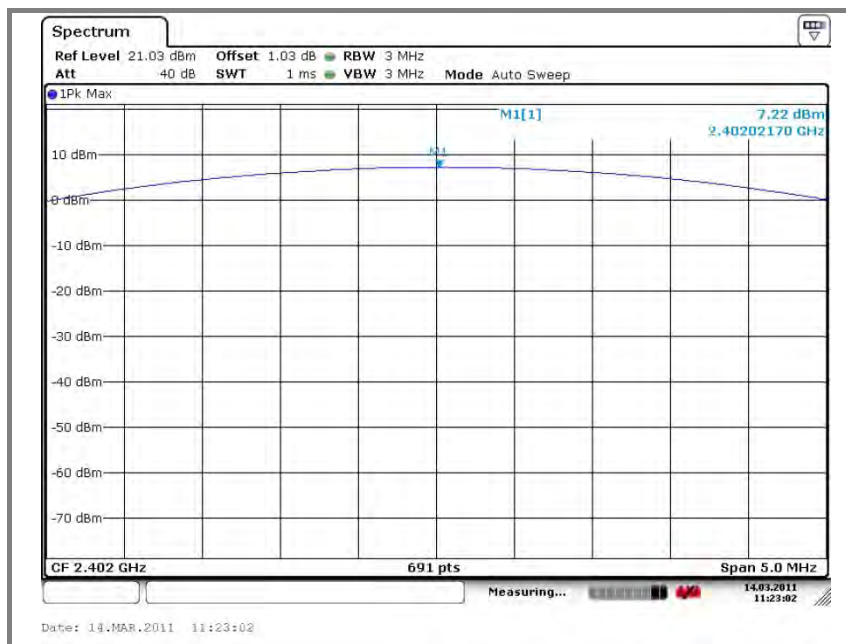


C. High channel (2 480 MHz)

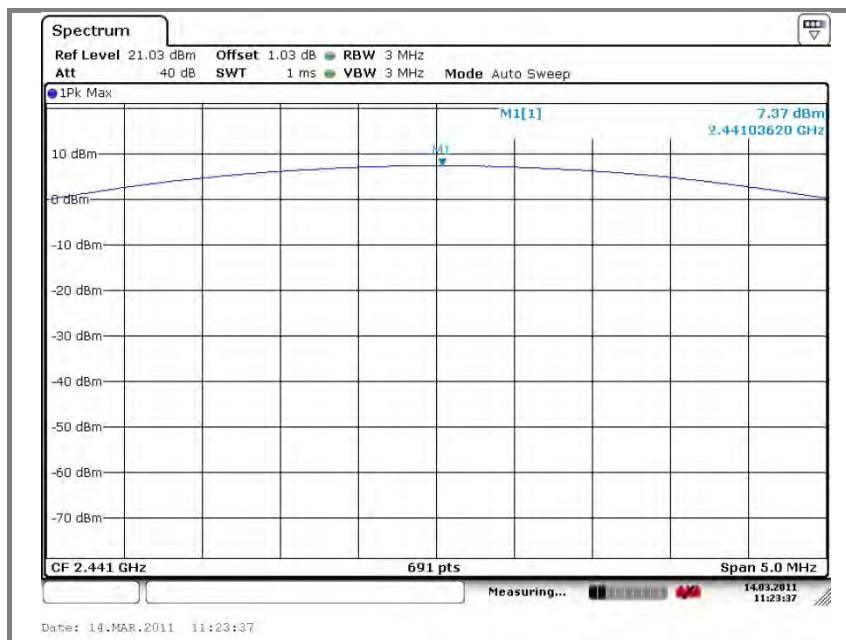


Operation mode: 8DPSK

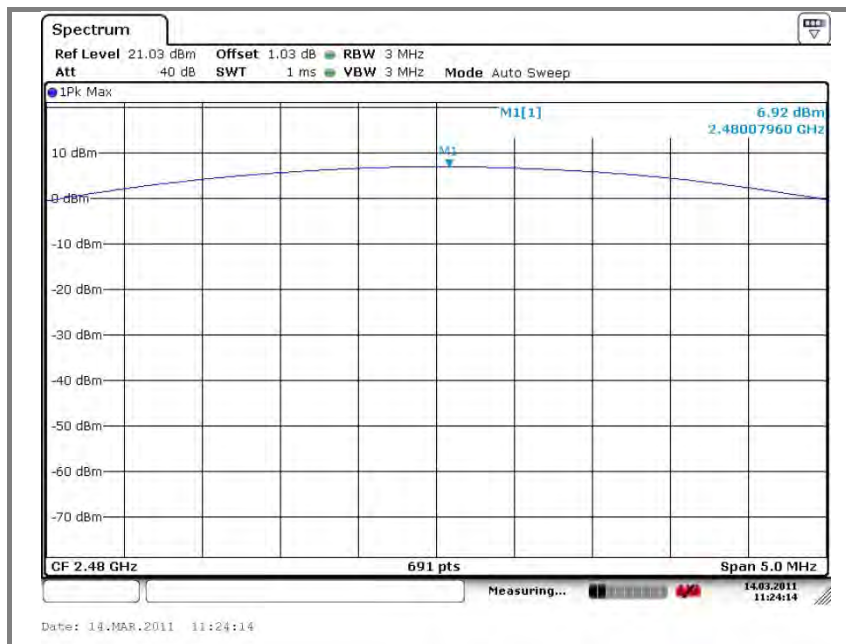
A. Low channel (2 402 MHz)



B. Middle channel (2 441 MHz)

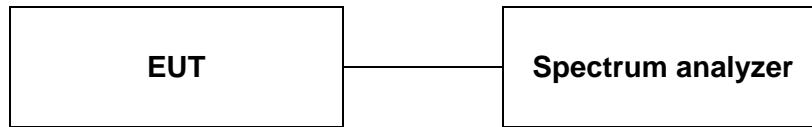


C. High channel (2 480 MHz)



9. Hopping channel separation

9.1. Test setup



9.2. Limit

§15.247(a)(1) Frequency hopping system operating in 2 400 – 2 483.5 MHz. Band may have hopping channel carrier frequencies that are separated by 25 kHz or two-third of 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

9.3. Test procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT as shown in test setup without connection to measurement instrument. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range.
3. By using the max hold function record the separation of adjacent channels.
4. Measure the frequency difference of these two adjacent channels by spectrum analyzer mark function. And then plot the result on spectrum analyzer screen.
5. Repeat above procedures until all frequencies measured were complete.
6. Set center frequency of spectrum analyzer = middle of hopping channel.
7. Set the spectrum analyzer as RBW = 100 kHz, VBW = 100 kHz, Span = 5 MHz and Sweep = auto.

9.4. Test results

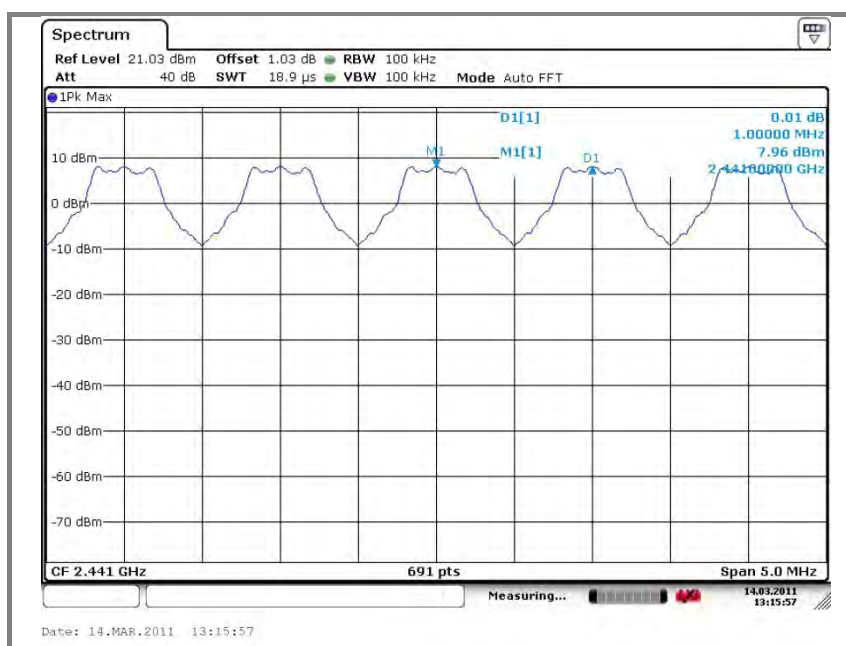
Ambient temperature: 23 °C
Relative humidity: 46 % R.H.

Operation mode	Frequency (MHz)	Adjacent hopping Channel separation (kHz)	Two-third of 20 dB bandwidth (kHz)	Minimum bandwidth (kHz)
GFSK	2 441	1 000	636.67	25
8DPSK	2 441	1 000	839.33	25

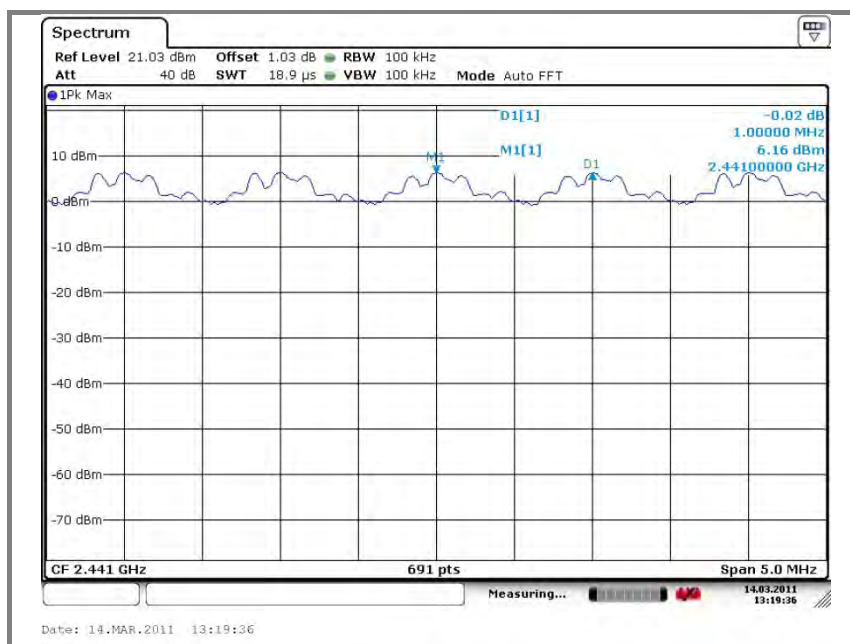
※ Remark:

20 dB bandwidth measurement, the measured channel separation should be greater than two-third of 20 dB bandwidth or Minimum bandwidth.

Operation mode : GFSK

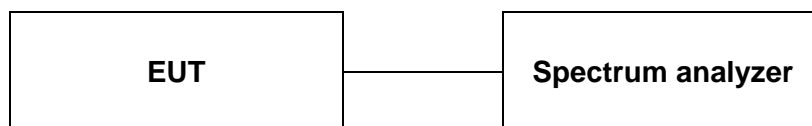


Operation mode : 8DPSK



10. Number of hopping frequency

10.1. Test setup



10.2. Limit

§15.247(a)(1)(iii) For frequency hopping system operating in the 2 400 - 2 483.5 MHz bands shall use at least 15 hopping frequencies.

10.3. Test procedure

1. Place the EUT on the table and set it in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna the port to the Spectrum analyzer
3. Set spectrum analyzer Start = 2 400 MHz, Stop = 2 441.5 MHz, Sweep = auto and Start = 2 441.5 MHz, Stop = 2 483.5 MHz, Sweep = auto.
4. Set the spectrum analyzer as RBW, VBW = 300 kHz.
5. Max hold, view and count how many channel in the band.

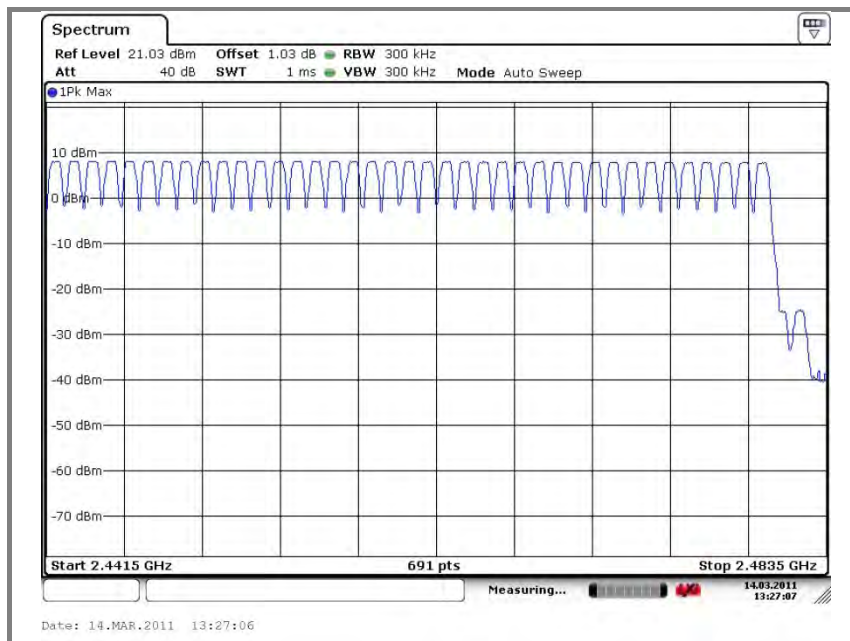
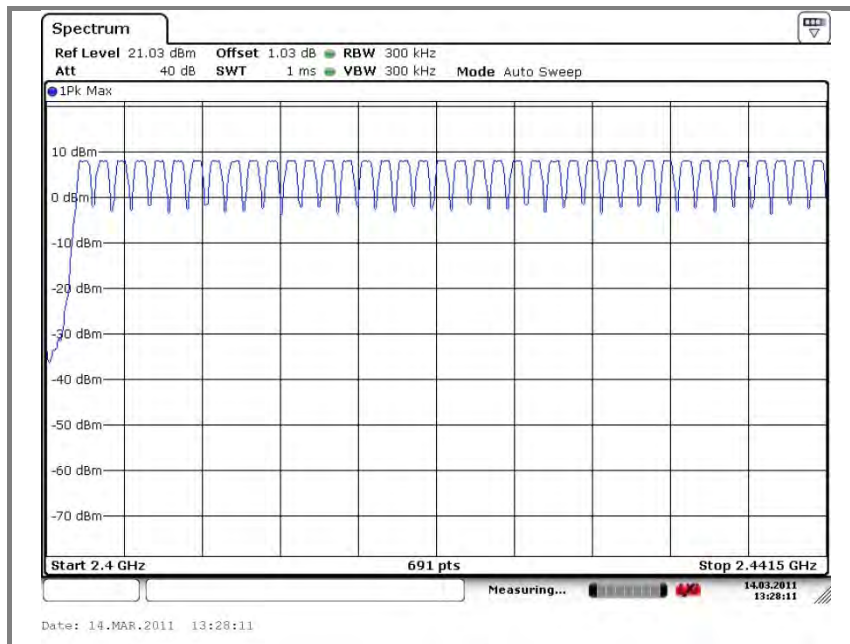
10.4. Test results

Ambient temperature: 23 °C

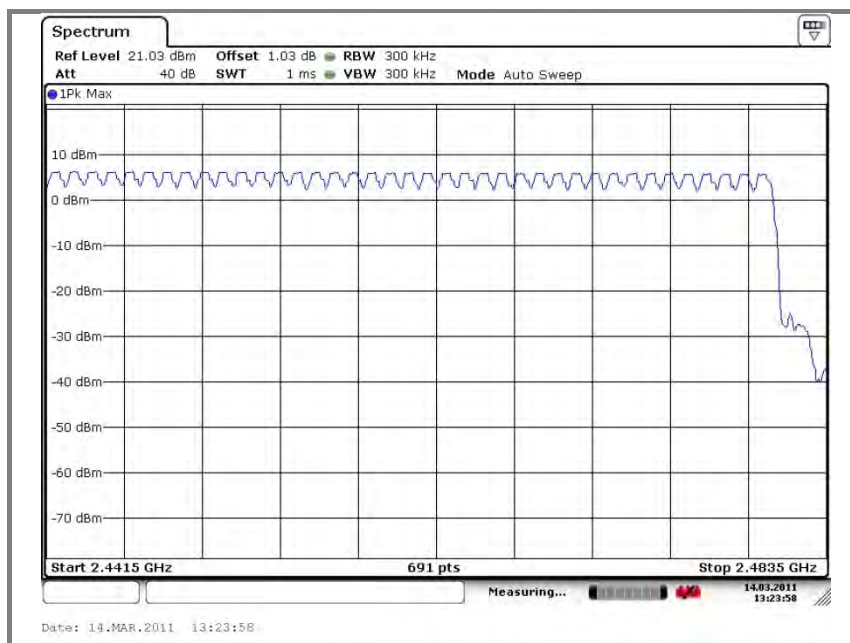
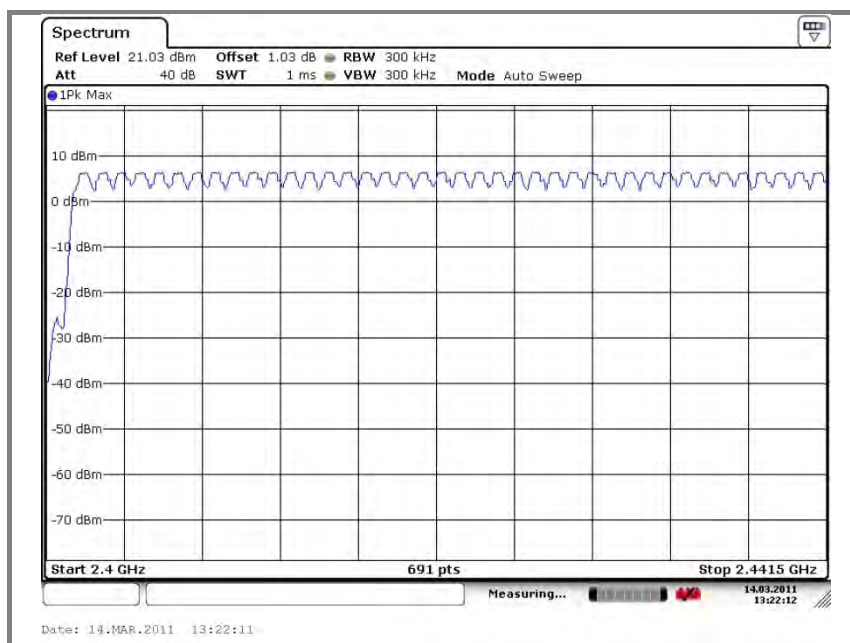
Relative humidity: 46 % R.H.

Operation mode	Number of Hopping Frequency	Limit
GFSK	79	≥ 15
8DPSK	79	≥ 15

Operation mode: GFSK

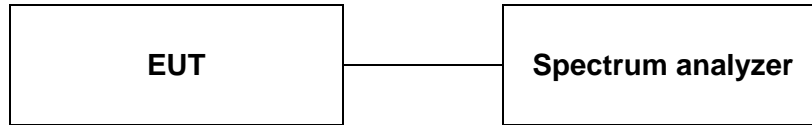


Operation mode: 8DPSK



11. Time of occupancy(Dwell time)

11.1. Test setup



11.2. Limit

§15.247(a)(1)(iii) For frequency hopping system operating in the 2 400 – 2 483.5 MHz band, the average time of occupancy on any frequency shall not be greater than 0.4 second within a 31.6 second period.

A period time = 0.4(s) * 79 = 31.6(s)

11.3. Test procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT as shown in test setup without connection to measurement instrument. Turn on the EUT and connect its antenna terminal to measurement instrument via a low loss cable.
3. Adjust the center frequency of spectrum analyzer on any frequency be measured and set spectrum analyzer to zero span mode. And then, set RBW and VBW of spectrum analyzer to proper value.
4. Measure the time duration of one transmission on the measured frequency. And then plot the result with time difference of this time duration.
5. Repeat above procedures until all frequencies measured were complete.
6. The Bluetooth has 6 type of payload, DH1, DH3, DH5, 3DH1, 3DH3, 3DH5. The hopping rate is 1 600 per second.

11.4. Test results

Ambient temperature: 23 °C

Relative humidity: 46 % R.H.

Time of occupancy on the TX channel in 31.6 sec

= time domain slot length × (hop rate ÷ number of hop per channel) × 31.6

Operation mode: GFSK

Packet type	Frequency (MHz)	Dwell Time (ms)	Time of occupancy on the Tx channel in 31.6 sec (ms)	Limit for time of occupancy on the Tx Channel in 31.6 sec (ms)
DH1	2 441	0.399	127.68	400
DH3	2 441	1.652	264.32	400
DH5	2 441	2.913	310.72	400

Operation mode: 8DPSK

Packet type	Frequency (MHz)	Dwell Time (ms)	Time of occupancy on the Tx channel in 31.6 sec (ms)	Limit for time of occupancy on the Tx Channel in 31.6 sec (ms)
3DH1	2 441	0.413	132.16	400
3DH3	2 441	1.667	266.72	400
3DH5	2 441	2.884	307.63	400

※ Remark:

DH1: $0.399 \text{ (ms)} \times [(1\ 600 \div 2) \div 79] \times 31.6 \text{ (s)} = 127.68 \text{ (ms)}$

DH3: $1.652 \text{ (ms)} \times [(1\ 600 \div 4) \div 79] \times 31.6 \text{ (s)} = 264.32 \text{ (ms)}$

DH5: $2.913 \text{ (ms)} \times [(1\ 600 \div 6) \div 79] \times 31.6 \text{ (s)} = 310.72 \text{ (ms)}$

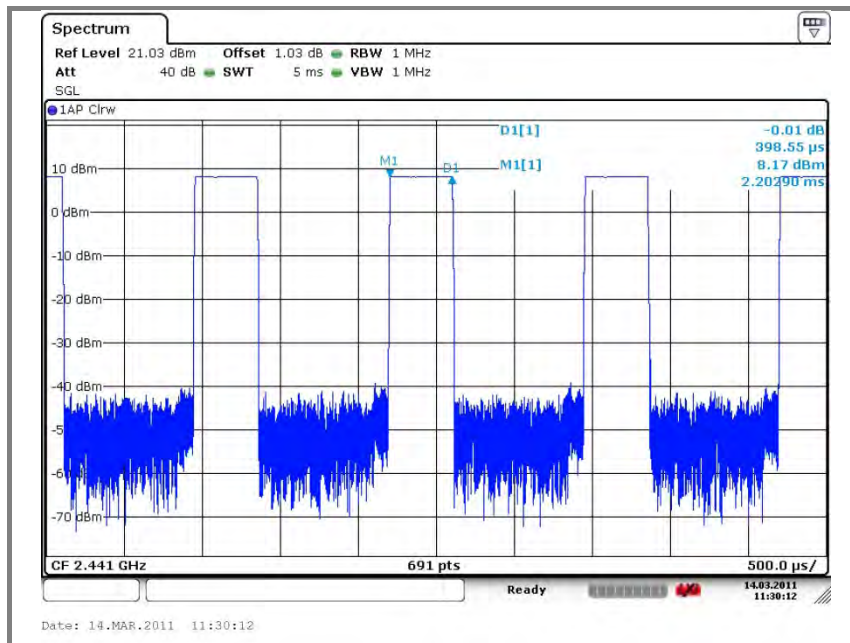
3DH1: $0.413 \text{ (ms)} \times [(1\ 600 \div 2) \div 79] \times 31.6 \text{ (s)} = 132.16 \text{ (ms)}$

3DH3: $1.667 \text{ (ms)} \times [(1\ 600 \div 4) \div 79] \times 31.6 \text{ (s)} = 266.72 \text{ (ms)}$

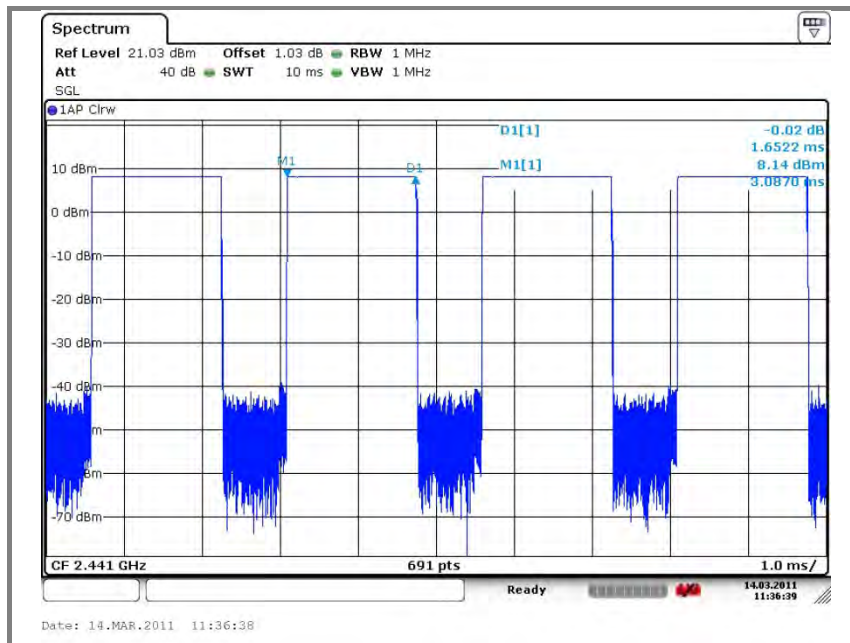
3DH5: $2.884 \text{ (ms)} \times [(1\ 600 \div 6) \div 79] \times 31.6 \text{ (s)} = 307.63 \text{ (ms)}$

Operation mode: GFSK

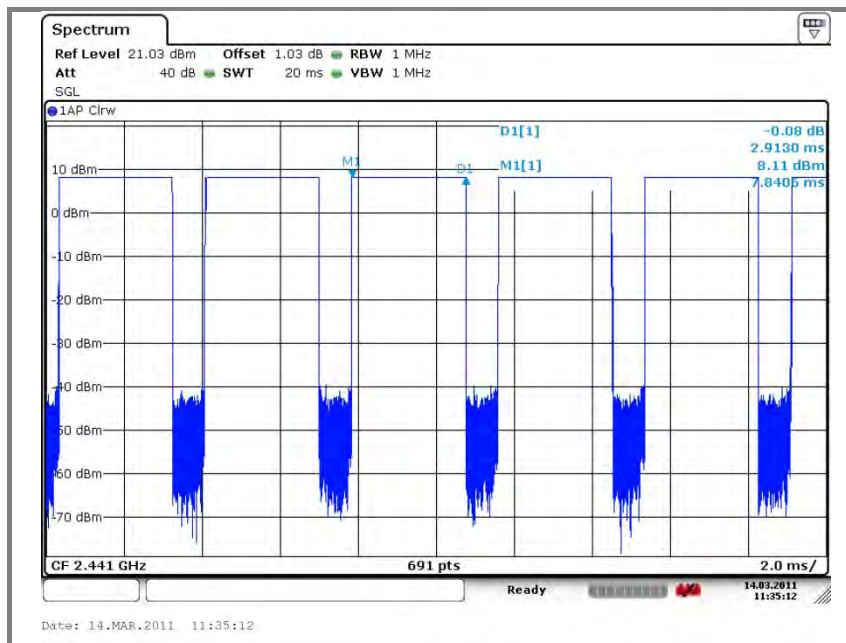
A. DH1



B. DH3

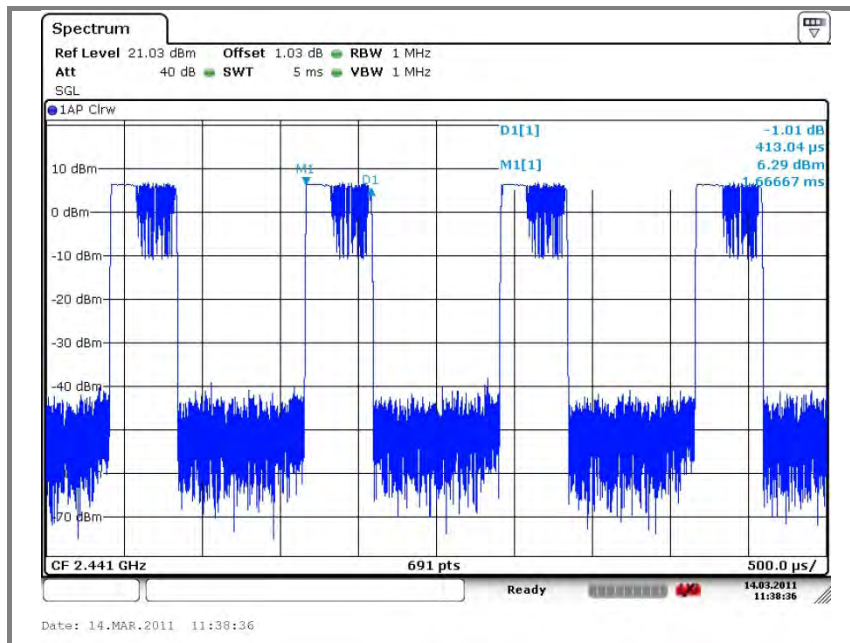


C. DH5

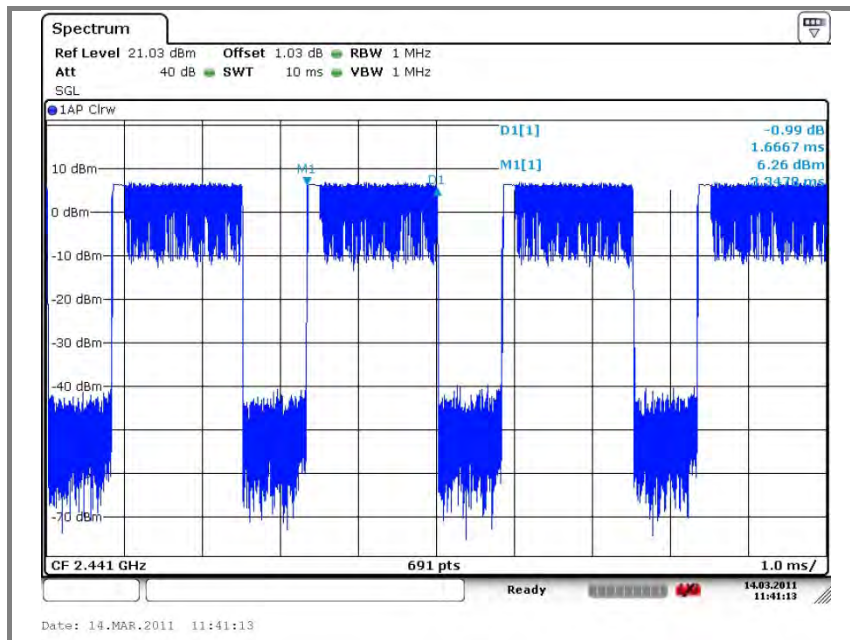


Operation mode: 8DPSK

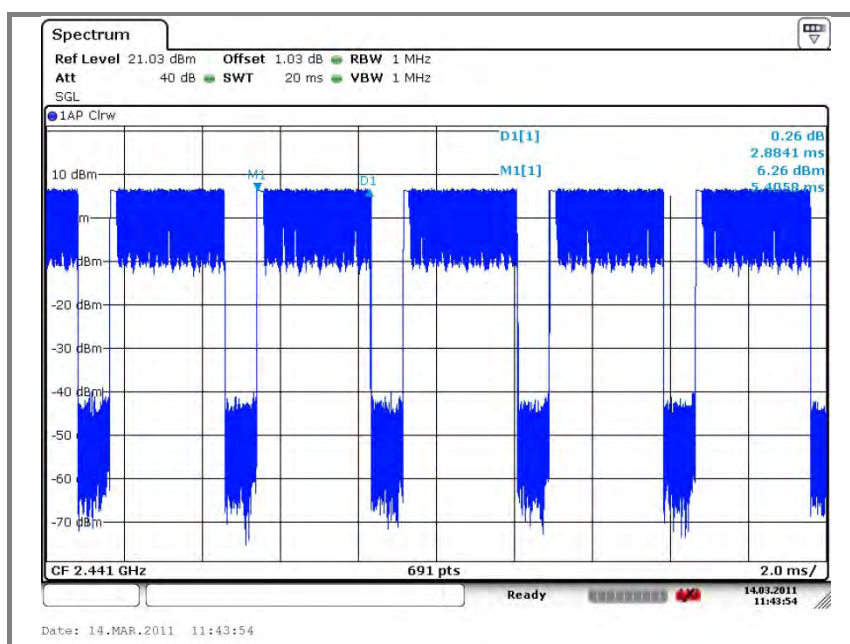
A. 3DH1



B. 3DH3



C. 3DH5



12. Antenna requirement

12.1. Standard Applicable

For intentional device, according to FCC 47 CFR 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. And according to FCC 47 CFR Section §15.247 (b) if transmitting antennas of directional gain greater than 6 dBi are used, the power shall be reduced by the amount in dB that the gain of the antenna exceeds 6 dBi.

12.2. Antenna Connected Construction

Antenna used in this product is Integral type (Chip Antenna) gain of 2.38 dBi.

13. RF exposure evaluation

13.1. Environmental evaluation and exposure limit according to FCC CFR 47 part 1, 1.1307(b), 1.1310

According to FCC 1.1310 : The criteria listed in the following table shall be used to evaluate the environment impact of human exposure to radio frequency (RF) radiation as specified in §1.1307(b)

Limits for maximum permissible exposure (MPE)

Frequency range (MHz)	Electric field strength(V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Average time
(A) Limits for Occupational / Control exposures				
300 – 1 500	--	--	F/300	6
1 500 – 100 000	--	--	5	6
(B) Limits for General Population / Uncontrol Exposures				
300 – 1 500	--	--	F/1 500	6
<u>1 500 – 100 000</u>	--	--	<u>1</u>	<u>30</u>

13.2. Friis transmission formula

$$Pd = (P_{out} \times G) / (4 \times \pi \times R^2)$$

Where Pd = power density in mW/cm²

Pout = output power to antenna in mW

G = gain of antenna in linear scale

Pi = 3.141 6

R = distance between observation point and center of the radiator in cm

Pd the limit of MPE, 1 mW/cm². If we know the maximum gain of the antenna and the total power input to the antenna, through the calculation, we will know the distance where the MPE limit is reached.

13.3. Test result of RF exposure evaluation

Test Item : RF Exposure evaluation data

Test Mode : Normal operation

13.4. Output power into antenna & RF exposure evaluation distance

Operating mode	Frequency (MHz)	Output average power to antenna (dBm)	Antenna gain (dBi)	Power density at 20 cm (mW/cm ²)	Limit (mW/cm ²)
GFSK	2 402	3.52	2.38	0.000 774	1
	2 441	3.49	2.38	0.000 769	
	2 480	2.91	2.38	0.000 673	
8DPSK	2 402	0.68	2.38	0.000 403	
	2 441	0.62	2.38	0.000 397	
	2 480	0.45	2.38	0.000 382	

※ Remark

The power density Pd (5th column) at a distance of 20 cm calculated from the friis transmission formula is far below the limit of 1 mW/cm².

14. Test setup photo of EUT

Photo of radiated spurious emission

