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Compliance test report ID **206474-1TRFWL**

Date of issue
August 9, 2012

FCC 47 CFR Part 15 Subpart C, §15.247

Operation in the 902–928 MHz, 2400–2483.5 MHz, 5725–5850 MHz
and

RSS-210, Issue 8 Annex 8

Frequency Hopping and Digital Modulation Systems Operating in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz Bands

Applicant	**Control Microsystems Inc. operating as Schneider Electric**
Product	**2.4 GHz FHSS RF Module**
Model	**100250**
FCC ID	**OV7100250**
IC Reg #	**1614A-100250**

Nemko Canada Inc., a testing laboratory, is accredited by the Standards Council of Canada. The tests included in this report are within the scope of this accreditation

SCC Accredited LAB
LAB Accrédité CCN

Test location

Nemko Canada Inc.
303 River Road
Ottawa, ON, K1V 1H2
Canada
Test site FCC ID: 176392 and IC ID: 2040A-4 (3 m semi anechoic chamber)

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Tested by Andrey Adelberg, Senior Wireless/EMC Specialist

Reviewed by Kevin Rose, Wireless/EMC Specialist

August 9, 2012
Date

APPROVED
By Kevin Rose at 4:26 pm, 8/23/12

Limits of responsibility

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.
This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contain in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

Copyright notification

Table of Contents

Section 1 Report summary

1.1 Applicant and manufacturer

Control Microsystems Inc. operating as Schneider Electric
48 Steacie Drive
Kanata, Ontario
Canada K2K 2A9

1.2 Test specifications

Standard	Description
FCC 47 CFR Part 15, Subpart C, Chapter 15.247	Operation in the 902–928 MHz, 2400–2483.5 MHz, 5725–5850 MHz
RSS-210, Issue 8 Annex 8	Frequency Hopping and Digital Modulation Systems Operating in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz Bands

1.3 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was completed against all relevant requirements of the test standard. Results obtained indicate that the product under test complies in full with the requirements tested. The test results relate only to the items tested.

See “Summary of test results” for full details.

1.4 Exclusions

None

1.5 Test report revision history

Revision #	Details of changes made to test report
TRF	Original report issued

Section 2 Summary of test results

2.1 FCC Part 15 Subpart C – general requirements, test results

Part	Test description	Verdict
§15.207(a)	Conducted limits	Pass
§15.31(e)	Variation of power source	Pass[1]
§15.203	Antenna requirement	Pass

Notes:
[1] Measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, was performed with the supply voltage varied between 85 % and 115 % of the nominal rated supply voltage. No noticeable output power variation was observed

2.2 FCC Part 15 Subpart C – Intentional Radiators, test results

Part	Test description	Verdict
§15.247(a)(1)	Frequency hopping systems	
§15.247(a)(1)(i)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(a)(1)(ii)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
§15.247(a)(1)(iii)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Pass
§15.247(a)(2)	Minimum 6 dB bandwidth for systems using digital modulation techniques	Not applicable
§15.247(b)	Maximum conducted peak output power and EIRP	
§15.247(b)(1)	Maximum peak output power of frequency hopping systems operating in the 2400–2483.5 MHz band and 5725–5850 MHz band	Pass
§15.247(b)(2)	Maximum peak output power of frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(b)(3)	Maximum peak output power of systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands	Not applicable
§15.247(b)(4)	Conducted peak output power limitations	
§15.247(b)(4)(i)	Maximum peak output power for systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point operations.	Not applicable
§15.247(b)(4)(ii)	Maximum peak output power for systems operating in the 5725–5850 MHz band that are used exclusively for fixed, point-to-point operations.	Not applicable
§15.247(c)(1)	Fixed point-to-point operation with directional antenna gains greater than 6 dBi	Not applicable
§15.247(c)(2)	Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams	Not applicable
§15.247(d)	Spurious emissions	Pass
§15.247(e)	Power spectral density for digitally modulated devices	Not applicable
§15.247(f)	Time of occupancy and power spectral density for hybrid systems	Not applicable

2.3 IC RSS-GEN, Issue 3, test results

Part	Test description	Verdict
4.6.1	Occupied bandwidth	Pass
6.1	Receiver spurious emissions limits (radiated)	Not applicable
6.2	Receiver spurious emissions limits (antenna conducted)	Not applicable
7.2.4	AC power lines conducted emission limits	Pass
Notes: [1] According to Notice 2012-DRS0126 (from January 2012) section 2.2 of RSS-Gen, Issue 3 has been revised. The EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements.		

2.4 IC RSS-210, Issue 8, test results

Part	Test description	Verdict
A8.1	Frequency hopping systems	
A8.1 (a)	Bandwidth of a frequency hopping channel	Pass
A8.1 (b)	Minimum channel spacing for frequency hopping systems	Pass
A8.1 (c)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
A8.1 (d)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Pass
A8.1 (e)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
A8.2	Digital modulation systems	
A8.2 (a)	Minimum 6 dB bandwidth	Not applicable
A8.2 (b)	Maximum power spectral density	Not applicable
A8.3	Hybrid systems	
A8.3 (1)	Digital modulation turned off	Not applicable
A8.3 (2)	Frequency hopping turned off	Not applicable
A8.4	Transmitter output power and e.i.r.p. requirements	
A8.4 (1)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
A8.4 (2)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Pass
A8.4 (3)	Frequency hopping systems operating in the 5725–5850 MHz	Not applicable
A8.4 (4)	Systems employing digital modulation techniques	Not applicable
A8.4 (5)	Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
A8.4 (6)	Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams	Not applicable
A8.5	Out-of-band emissions	Pass
Notes: None		

Section 3 Equipment under test (EUT) details

3.1 Sample information

Receipt date	May 15, 2012
Nemko sample ID number	1

3.2 EUT information

Product name	2.4 GHz FHSS RF Module
Model	100250
Serial number	None

3.3 Technical information

Operating band	2400–2483.5 MHz
Operating frequency	2403–2481 MHz
Modulation type	FHSS: FSK and GFSK
Occupied bandwidth (99 %)	FSK: 305.29 kHz, GFSK: 439.10 kHz
Emission designator	FSK: 305K3F1D, GFSK: 439K1G1D
Power requirements	11–30 V_{DC} via AC/DC adapter from 120 V_{AC}, 60 Hz
Antenna information	Schneider Electric omnidirectional antenna, 3.7 dBi M/N: 307691AR Nearson Inc. M/N: S131CL-10-AH-2450S 2dBi 1/2Wave omnidirectional antenna PCTel omnidirectional antenna, 10 dBi M/N: MFB24010 PCTel Yagi antenna, 10 dBi MYP24010PTNF PCTel Yagi antenna, 15 dBi M/N: WISP24015PTNF The EUT uses a unique antenna coupling/ non-detachable antenna to the intentional radiator.

3.4 Product description and theory of operation

The EUT is a wireless module that uses proprietary frequency hopping technique within 2.4 GHz ISM band.

3.5 EUT exercise details

EUT was set to transmit continuously on selected channels with hopping turned off as well as normal test mode with hopping turned on via engineering menu.

3.6 EUT setup diagram

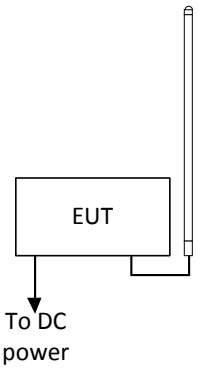


Diagram 3.6-1: Setup diagram

Section 4 Engineering considerations

4.1 Modifications incorporated in the EUT

There were no modifications performed to the EUT during this assessment.

4.2 Technical judgment

None

4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5 Test conditions

5.1 Atmospheric conditions

Temperature: 15–30 °C
Relative humidity: 20–75 %
Air pressure: 86–106 kPa

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

5.2 Power supply range

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages ±5 %, for which the equipment was designed.

Section 6 Measurement uncertainty

6.1 Uncertainty of measurement

Nemko Canada Inc. has calculated measurement uncertainty and is documented in EMC/MUC/001 “Uncertainty in EMC measurements.” Measurement uncertainty was calculated using the methods described in CISPR 16-4 Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: Uncertainty in EMC measurements; as well as described in UKAS LAB34: The expression of Uncertainty in EMC Testing. Measurement uncertainty calculations assume a coverage factor of K=2 with 95% certainty.

Section 7 Test equipment

7.1 Test equipment list

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
3 m EMI test chamber	TDK	SAC-3	FA002047	1 year	Mar. 09/13
Flush mount turntable	Sunol	FM2022	FA002082	—	NCR
Controller	Sunol	SC104V	FA002060	—	NCR
Antenna mast	Sunol	TLT2	FA002061	—	NCR
Power supply	California Inst.	3001I	FA001021	1 year	Feb 08/13
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 40	FA002071	1 year	Feb. 09/13
Bilog antenna	Sunol	JB3	FA002108	1 year	Feb. 07/13
Horn antenna #2	EMCO	3115	FA000825	1 year	Feb. 24/13
Horn antenna 18–26.5 GHz	Electro-metrics	SH-50/60-1	FA000479	—	VOU
1–18 GHz pre-amplifier	JCA	JCA118-503	FA002091	1 year	Aug. 15/12
18–26 GHz pre-amplifier	Narda	BBS-1826N612	FA001550	—	VOU
Note: NCR - no calibration required and VOU - verify on use					

Section 8 Testing data

8.1 AC power line conducted emissions

8.1.1 Definitions and limits

FCC Clause 15.207(a): Conducted limits
RSS-Gen Clause 7.2.4: AC power line conducted emissions limits

FCC:
Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 Ω line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

IC:
The purpose of this test is to measure unwanted radio frequency currents induced in any AC conductor external to the equipment which could conduct interference to other equipment via the AC electrical network.

Except when the requirements applicable to a given device state otherwise, for any licence-exempt radiocommunication device equipped to operate from the public utility AC power supply, either directly or indirectly, the radio frequency voltage that is conducted back onto the AC power lines in the frequency range of 0.15 MHz to 30 MHz shall not exceed the limits shown in Table 2. The tighter limit applies at the frequency range boundaries.

The conducted emissions shall be measured with a 50 Ω/50 µH line impedance stabilization network. A description of the method of measurement that is acceptable to Industry Canada is found in RSS-212.

Table 8.1-1: Conducted emissions limit

Frequency of emission (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50
* - Decreases with the logarithm of the frequency.		

8.1.2 Test summary

Test date	May 15, 2012	**Test engineer**	Andrey Adelberg	**Verdict**	Pass
Temperature	23 °C	**Air pressure**	1002 mbar	**Relative humidity**	31 %

8.1.3 Observations/special notes

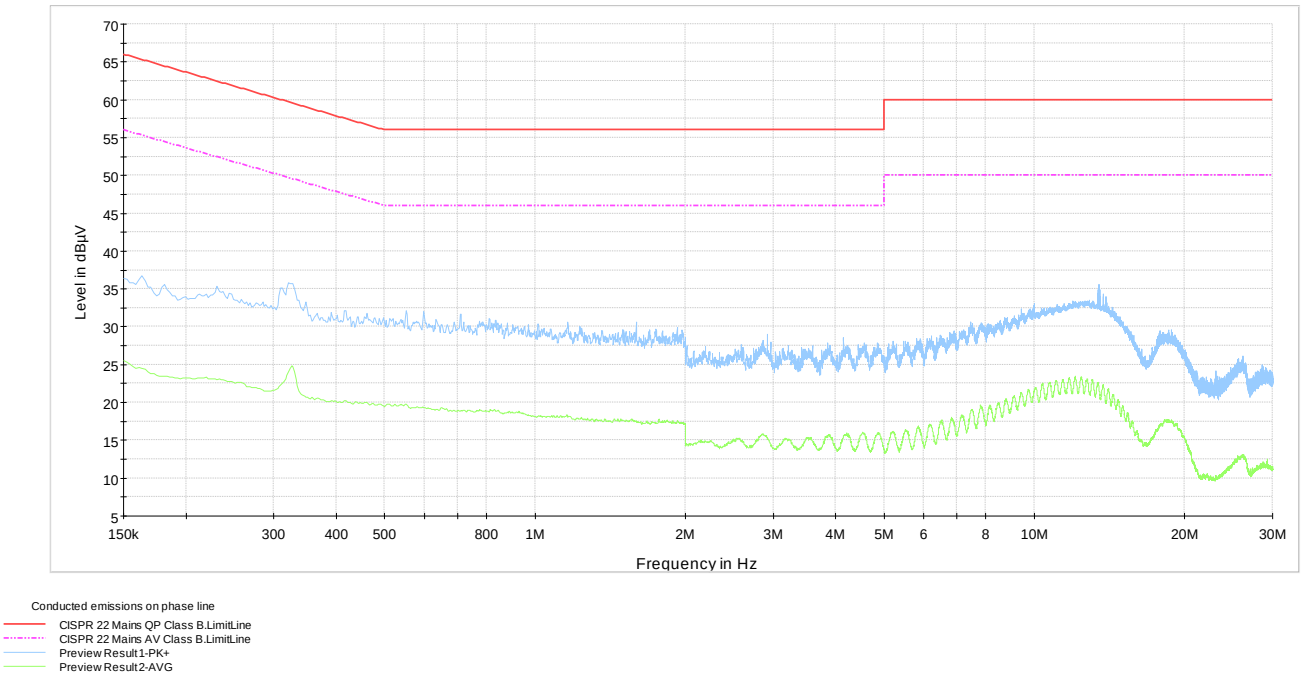
The EUT was set up as tabletop configuration.

The spectral scan has been corrected with transducer factors (i.e. cable loss, LISN factors, and attenuators) for determination of compliance.

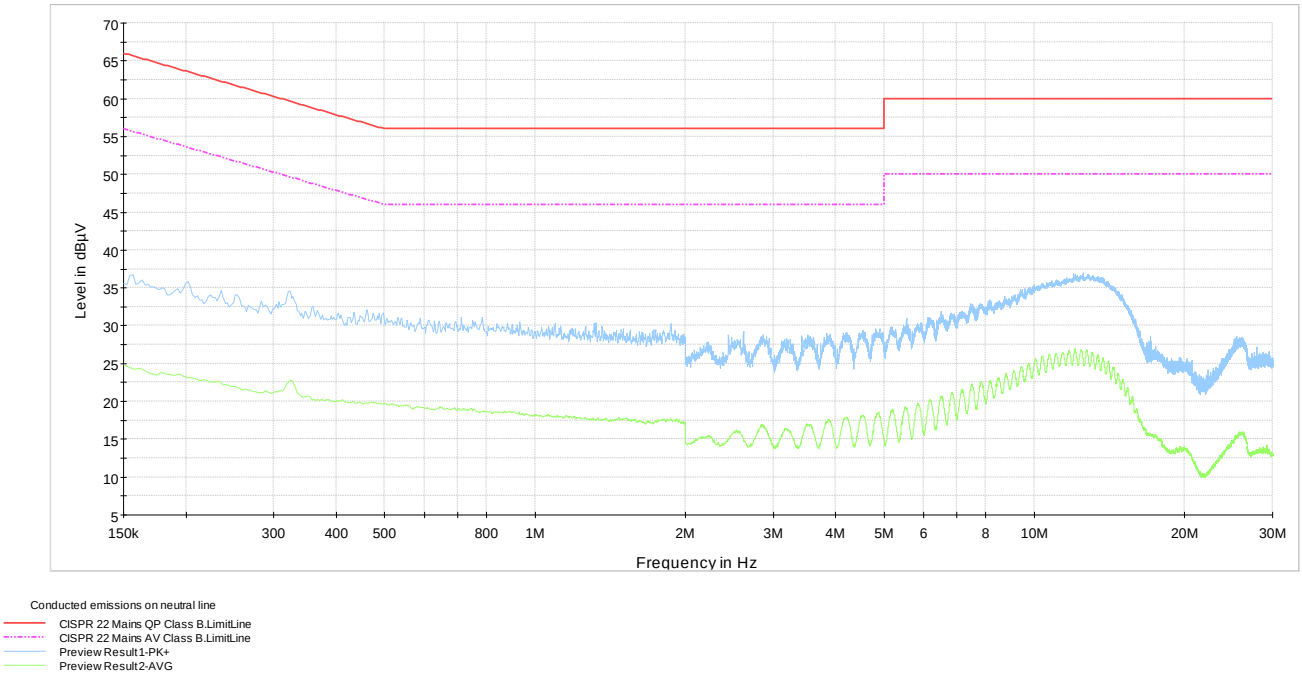
Receiver/spectrum analyzer settings
Preview measurements – Receiver:
Peak and Average detector (Max hold), RBW = 9 kHz, VBW = 30 kHz, Measurement time = 100 ms
Final measurements – Receiver:
Q-Peak and Average detector, RBW = 9 kHz, VBW = 30 kHz, Measurement time = 100 ms

Measurement details
A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 6 dB or above limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement. The spectral scan has been corrected with transducer factors (i.e. cable loss, LISN factors, and attenuators) for determination of compliance.

8.1.4 Test data



Plot 8.1-1: Conducted emissions on phase line



Plot 8.1-2: Conducted emissions on neutral line

8.2 Frequency hopping requirements

8.2.1 Definitions and limits

FCC Clause 15.247(a)(1) and RSS-210 Clause A8.1: Frequency hopping requirements

FCC:

(a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(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. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(iii) Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

IC:

A8.1 (a) Bandwidth of a frequency hopping channel

The bandwidth of a frequency hopping channel is the 20 dB emission bandwidth, measured with the hopping stopped. The system RF bandwidth is equal to the channel bandwidth multiplied by the number of channels in the hopset. The hopset shall be such that the near term distribution of frequencies appears random, with sequential hops randomly distributed in both direction and magnitude of change in the hopset while the long term distribution appears evenly distributed.

A8.1 (b) Minimum channel spacing for frequency hopping systems

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. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 0.125 W. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

A8.1 (d) Frequency hopping systems operating in the 2400–2483.5 MHz band

Frequency hopping systems operating in the 2400–2483.5 MHz band shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that a minimum of 15 hopping channels are used.

8.2.2 Test summary

Test date	May 15, 2012	**Test engineer**	Andrey Adelberg	**Verdict**	Pass
Temperature	22 °C	**Air pressure**	1003 mbar	**Relative humidity**	32 %

8.2.3 Observations/special notes and procedures

All plots indicate wrong date. Actual date of testing is in the “Test summary” section.

Carrier Frequency Separation
The EUT must have its hopping function enabled. Use the following spectrum analyzer settings:
Span = wide enough to capture the peaks of two adjacent channels
Resolution (or IF) Bandwidth (RBW) ≥ 1% of the span
Video (or Average) Bandwidth (VBW) ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold

Allow the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels. The limit is specified in one of the subparagraphs of this Section.

Number of Hopping Frequencies
The EUT must have its hopping function enabled. Use the following spectrum analyzer settings:
Span = the frequency band of operation
RBW ≥ 1% of the span
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold

Allow the trace to stabilize. It may prove necessary to break the span up to sections, in order to clearly show all of the hopping frequencies. The limit is specified in one of the subparagraphs of this Section.

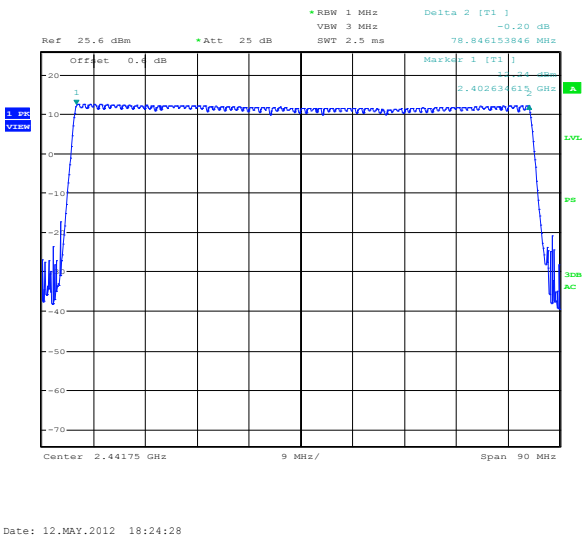
Time of Occupancy (Dwell Time)
The EUT must have its hopping function enabled. Use the following spectrum analyzer settings:
Span = zero span, centered on a hopping channel
RBW = 1 MHz
VBW ≥ RBW
Sweep = as necessary to capture the entire dwell time per hopping channel
Detector function = peak
Trace = max hold

If possible, use the marker-delta function to determine the dwell time. If this value varies with different modes of operation (e.g., data rate, modulation format, etc.), repeat this test for each variation. The limit is specified in one of the subparagraphs of this Section.
An oscilloscope may be used instead of a spectrum analyzer.

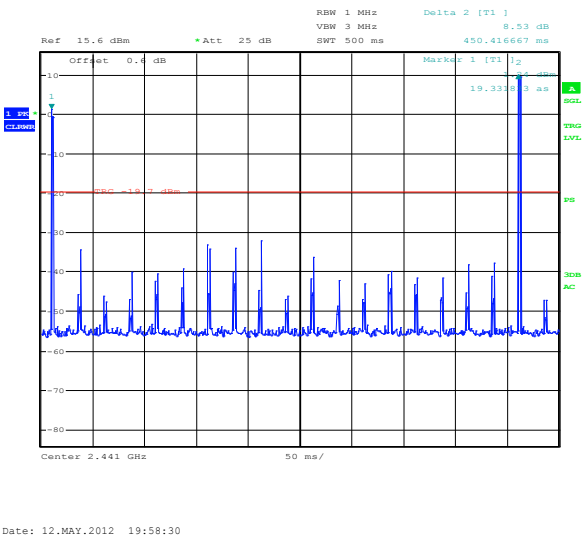
20 dB Bandwidth
Use the following spectrum analyzer settings:
Span = approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel
RBW ≥ 1% of the 20 dB bandwidth
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold

The EUT should be transmitting at its maximum data rate. Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. Use the marker-delta function to measure 20 dB down one side of the emission. Reset the marker-delta function, and move the marker to the other side of the emission, until it is (as close as possible to) even with the reference marker level. The marker-delta reading at this point is the 20 dB bandwidth of the emission. If this value varies with different modes of operation (e.g., data rate, modulation format, etc.), repeat this test for each variation. The limit is specified in one of the subparagraphs of this Section.

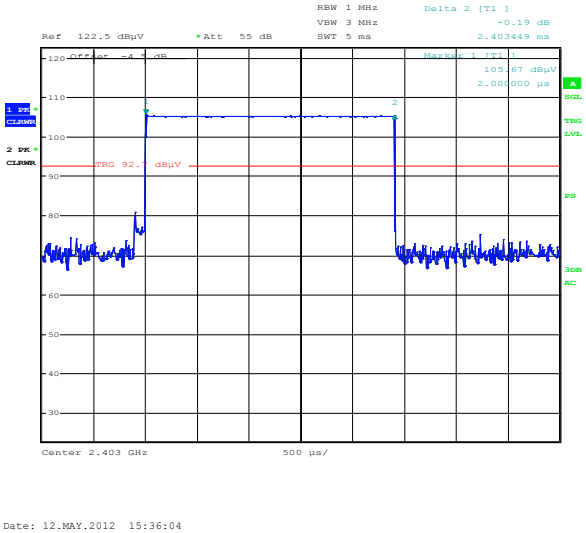
8.2.4 Test data



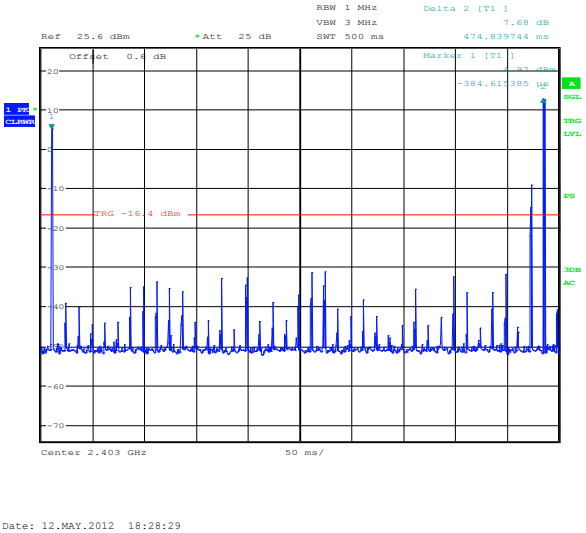
Plot 8.2-1: Number of hopping channels (79 channels)



Plot 8.2-2: Average rate of channel usage for FSK

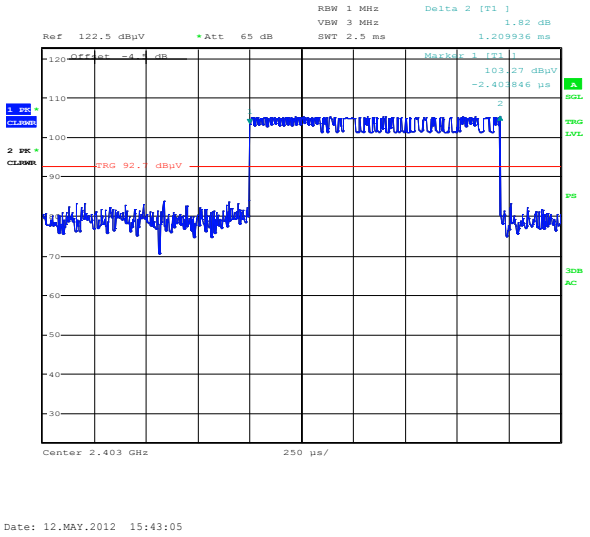


Plot 8.2-3: FSK dwell time of single hop



Plot 8.2-4: Average rate of channel usage for GFSK

8.2.4 Test data, continued



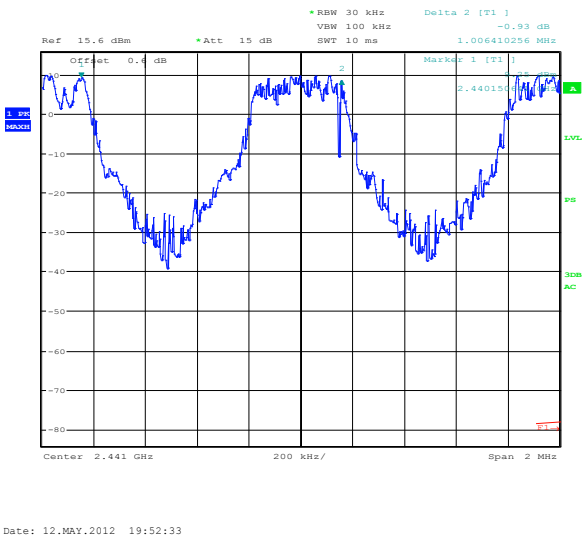
Plot 8.2-5: GFSK dwell time of single hop

Table 8.2-1: Average time of occupancy calculation

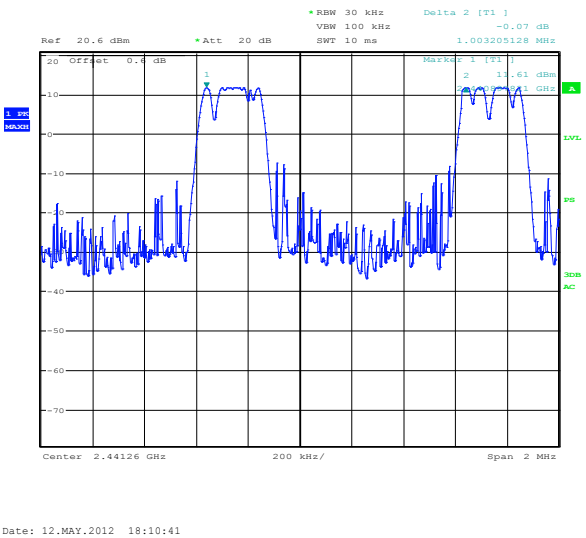
Modulation	Dwell time (ms)	Average rate of channel usage (ms)	Number of appearances per channel	Average time of occupancy (ms)	Limit (ms)	Margin (ms)
FSK	2.4	450.4	70.16	168.38	400	231.62
GFSK	1.2	474.8	66.55	79.87	400	320.13

Note: Test time is 0.4 s × 79 = 31.6 s
Number of appearances = test time ÷ avg. rate of channel usage
Average time of occupancy = dwell time × number of appearances

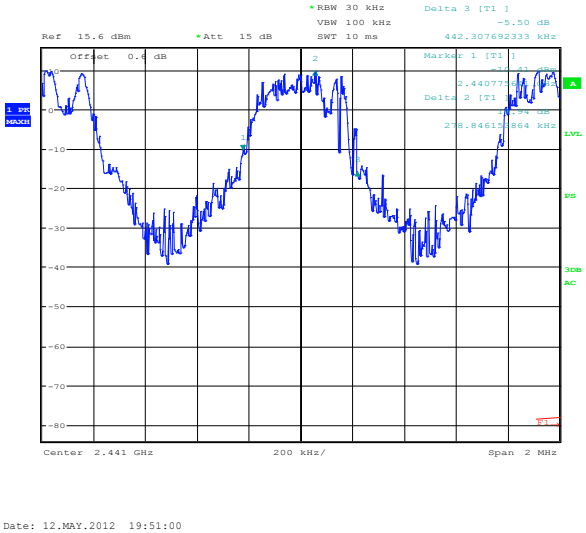
8.2.4 Test data, continued



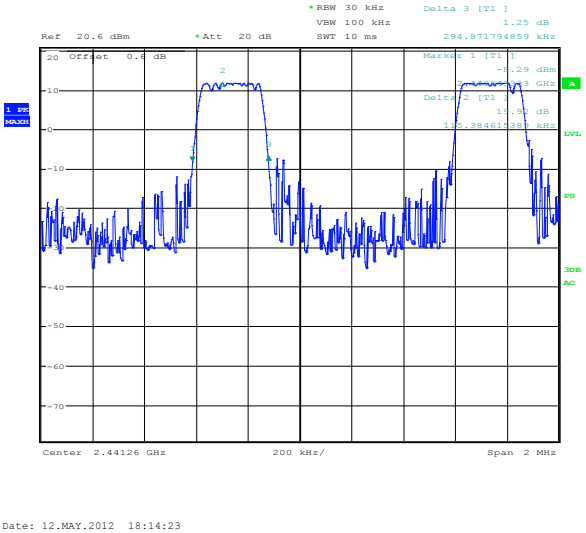
Plot 8.2-6: Channel spacing for FSK



Plot 8.2-7: Channel spacing for GFSK



Plot 8.2-8: 20 dB bandwidth with FSK modulation



Plot 8.2-9: 20 dB bandwidth with GFSK modulation

Table 8.2-2: 20 dB bandwidth results

Modulation	Channel spacing (kHz)	20 dB bandwidth and channel spacing minimum limit (kHz)	Margin (kHz)
FSK	1006.4	442.31	564.09
GFSK	1003.2	294.87	708.33

8.3 RSS-Gen Clause 4.6.1 Occupied bandwidth

8.3.1 Definitions and limits

When an occupied bandwidth value is not specified in the applicable RSS, the transmitted signal bandwidth to be reported is to be its 99 percent emission bandwidth, as calculated or measured.

The transmitter shall be operated at its maximum carrier power measured under normal test conditions.

The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts. The resolution bandwidth shall be set to as close to 1 percent of the selected span as is possible without being below 1 percent. The video bandwidth shall be set to 3 times the resolution bandwidth. Video averaging is not permitted. Where practical, a sampling detector shall be used since a peak or, peak hold, may produce a wider bandwidth than actual.

The trace data points are recovered and are directly summed in linear terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5 percent of the total is reached and that frequency recorded. The process is repeated for the highest frequency data points. This frequency is recorded.

The span between the two recorded frequencies is the occupied bandwidth.

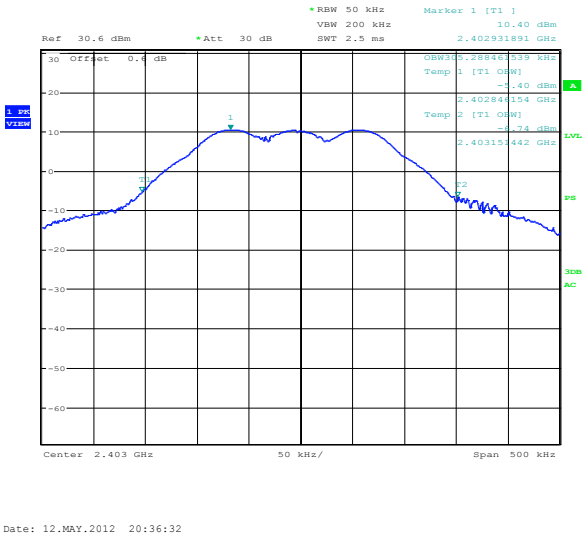
8.3.2 Test summary

Test date	May 15, 2012	**Test engineer**	Andrey Adelberg	**Verdict**	Pass
Temperature	22 °C	**Air pressure**	1003 mbar	**Relative humidity**	32 %

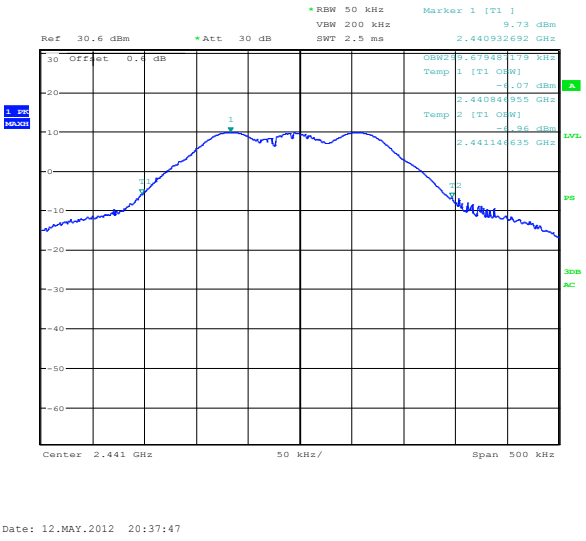
8.3.3 Observations/special notes

Measurements were performed with peak detector using RBW = 1–5 % of EBW. VBW was set wider than RBW.
All plots indicate wrong date. Actual date of testing is in the “Test summary” section.

8.3.4 Test data

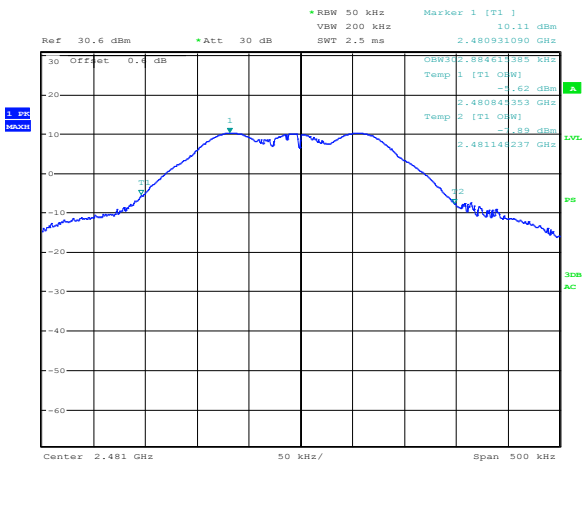


Plot 8.3-1: 99 % bandwidth – Low channel of FSK

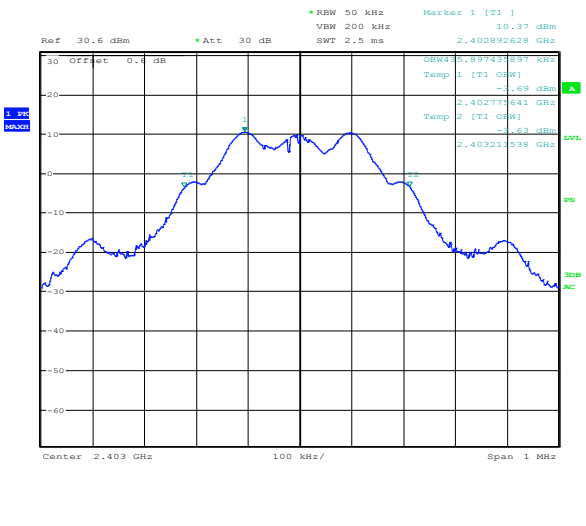


Plot 8.3-2: 99 % bandwidth – Mid channel of FSK

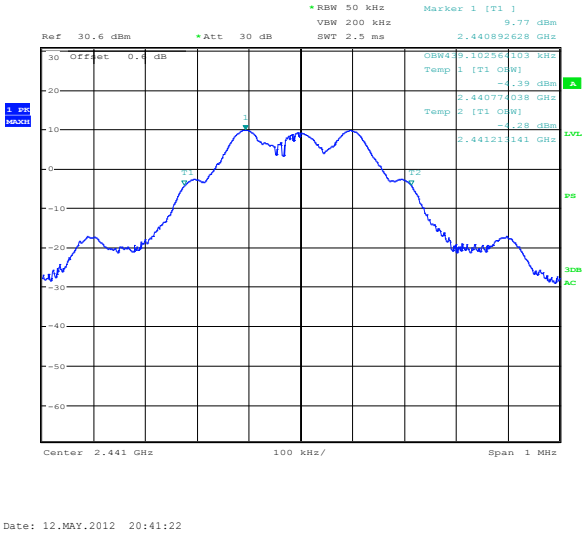
8.3.4 Test data, continued



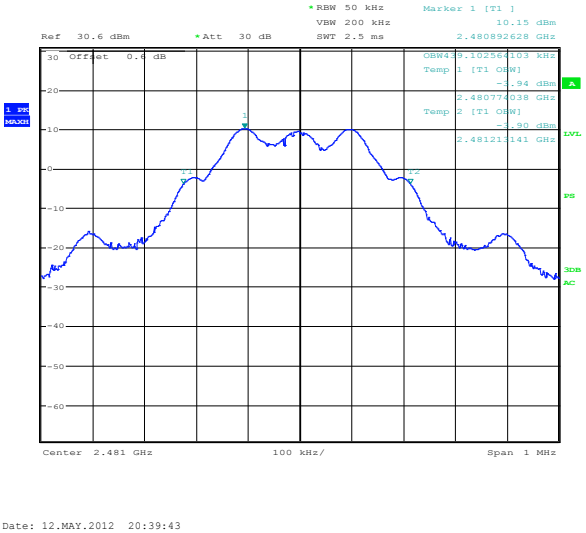
Plot 8.3-3: 99 % bandwidth – High channel of FSK



Plot 8.3-4: 99 % bandwidth – Low channel of GFSK



Plot 8.3-5: 99 % bandwidth – Mid channel of GFSK



Plot 8.3-6: 99 % bandwidth – High channel of GFSK

Table 8.3-1: 99 % bandwidth results

Modulation	Channel	99 % bandwidth, (kHz)
FSK	Low	305.29
	Mid	299.68
	High	302.88
GFSK	Low	435.89
	Mid	439.10
	High	439.10

8.4 Transmitter output power and EIRP requirements for frequency hopping systems

8.4.1 Definitions and limits

FCC Clause 15.247(b) and RSS-210 Clause A8.4 (1, 2, 3) Transmitter output power and e.i.r.p. requirements for frequency hopping systems

FCC:

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(1) For frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725–5850 MHz band: 1 W (30 dBm). For all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 W (21 dBm).

(4) The conducted output power limit specified in paragraph (b) of this section 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 the intentional radiator shall be reduced below the stated values in paragraphs (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.

(i) Systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

Fixed, point-to-point operation, as used in paragraph (b)(4)(i) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

IC:

With the digital modulation operation of the hybrid system turned off, the frequency hopping operation shall have an average time of occupancy on any frequency not exceeding 0.4 seconds within duration in seconds equal to the number of hopping frequencies multiplied by 0.4.

A8.4 (2) Transmitter Output Power and e.i.r.p. Requirements for Frequency hopping systems operating in the 2400–2483.5 MHz band

For frequency hopping systems operating in the band 2400–2483.5 MHz employing at least 75 hopping channels, the maximum peak conducted output power shall not exceed 1 W; for all other frequency hopping systems in the band, the maximum peak conducted output power shall not exceed 0.125 W (21 dBm). Except as provided in Section A8.4(5), the e.i.r.p. shall not exceed 4 W (36 dBm).

A8.4 (5) Point-to-point systems in the bands 2400–2483.5 MHz and 5725–5850 MHz

Point-to-point systems in the bands 2400–2483.5 MHz and 5725–5850 MHz are permitted to have an e.i.r.p. higher than 4 W (36 dBm) provided that the higher e.i.r.p. is achieved by employing higher gain directional antennas and not higher transmitter output powers. Point-to-multipoint systems, omnidirectional applications and multiple co-located transmitters transmitting the same information are prohibited from exceeding 4 W (36 dBm) e.i.r.p. However, remote stations of point-to-multipoint systems shall be allowed to operate at greater than 4 W (36 dBm) e.i.r.p. under the same conditions as for point-to-point systems.

8.4.2 Test summary

Test date	May 15, 2012	**Test engineer**	Andrey Adelberg	**Verdict**	Pass
Temperature	22 °C	**Air pressure**	1003 mbar	**Relative humidity**	32 %

8.4.3 Observations/special notes and procedures

Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel
RBW > the 20 dB bandwidth of the emission being measured
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold

Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. The indicated level is the peak output power. The limit is specified in one of the subparagraphs of this Section. Submit this plot. A peak responding power meter may be used instead of a spectrum analyzer.

Describe how the EUT complies with the de facto EIRP limit for every antenna proposed for use with the EUT. This includes those devices that will be used in point-to-point applications. If the peak output power, as measured above, must be reduced so that the de facto EIRP limit may be met for a particular antenna, describe exactly how much it will be reduced for that antenna. If the peak output power level is raised above the limit in order to compensate for cable loss between the EUT and the antenna, specify the minimum length of cable which will always be used, the type of cable, and its loss, in dB per unit length, for the frequency of the emission. The limit is specified in one of the subparagraphs of this Section. Also, specify who will be responsible for ensuring that compliant operation is maintained for every antenna that will be used with the EUT.
All plots indicate wrong date. Actual date of testing is in the “Test summary” section.

8.4.4 Test data

Table 8.4-1: Conducted output power results for FSK, hopping turned on

Frequency (MHz)	Conducted output power (dBm)	Limit (dBm)	Margin (dB)
2403	10.58	30.00	19.42
2441	9.67	30.00	20.33
2481	10.23	30.00	19.77

Table 8.4-2: Conducted output power results for FSK, hopping turned off

Frequency (MHz)	Conducted output power (dBm)	Limit (dBm)	Margin (dB)
2403	10.42	30.00	19.58
2441	9.53	30.00	20.47
2481	10.20	30.00	19.80

Table 8.4-3: Conducted output power results for GFSK, hopping turned on

Frequency (MHz)	Conducted output power (dBm)	Limit (dBm)	Margin (dB)
2403	10.58	30.00	19.42
2441	9.81	30.00	20.19
2481	10.21	30.00	19.79

Table 8.4-4: Conducted output power results for GFSK, hopping turned off

Frequency (MHz)	Conducted output power (dBm)	Limit (dBm)	Margin (dB)
2403	10.55	30.00	19.45
2441	9.72	30.00	20.28
2481	10.19	30.00	19.81

8.4.4 Test data, continued

Table 8.4-5: EIRP calculation results for FSK, hopping turned on

Frequency (MHz)	Peak output power (dBm)	Cable loss (dB)	Antenna gain (dBi)	EIRP (dBm)	Limit (dBm)	Margin (dB)
2403	10.58	0.63	3.70	13.65	36.00	22.35
2441	9.67	0.63	3.70	12.74	36.00	23.26
2481	10.23	0.63	3.70	13.30	36.00	22.70
2403	10.58	0.63	2.00	11.95	36.00	24.05
2441	9.67	0.63	2.00	11.04	36.00	24.96
2481	10.23	0.63	2.00	11.60	36.00	24.40
2403	10.58	0.63	10.00	19.95	36.00	16.05
2441	9.67	0.63	10.00	19.04	36.00	16.96
2481	10.23	0.63	10.00	19.60	36.00	16.40
2403	10.58	0.63	15.00	24.95	36.00	11.05
2441	9.67	0.63	15.00	24.04	36.00	11.96
2481	10.23	0.63	15.00	24.60	36.00	11.40
EIRP = Conducted output power [dBm] − cable loss [dB] + antenna gain [dBi]						

Table 8.4-6: EIRP calculation results for FSK, hopping turned off

Frequency (MHz)	Peak output power (dBm)	Cable loss (dB)	Antenna gain (dBi)	EIRP (dBm)	Limit (dBm)	Margin (dB)
2403	10.42	0.63	3.70	13.49	36.00	22.51
2441	9.53	0.63	3.70	12.60	36.00	23.40
2481	10.20	0.63	3.70	13.27	36.00	22.73
2403	10.42	0.63	2.00	11.79	36.00	24.21
2441	9.53	0.63	2.00	10.90	36.00	25.10
2481	10.20	0.63	2.00	11.57	36.00	24.43
2403	10.42	0.63	10.00	19.79	36.00	16.21
2441	9.53	0.63	10.00	18.90	36.00	17.10
2481	10.20	0.63	10.00	19.57	36.00	16.43
2403	10.42	0.63	15.00	24.79	36.00	11.21
2441	9.53	0.63	15.00	23.90	36.00	12.10
2481	10.20	0.63	15.00	24.57	36.00	11.43
EIRP = Conducted output power [dBm] − cable loss [dB] + antenna gain [dBi]						

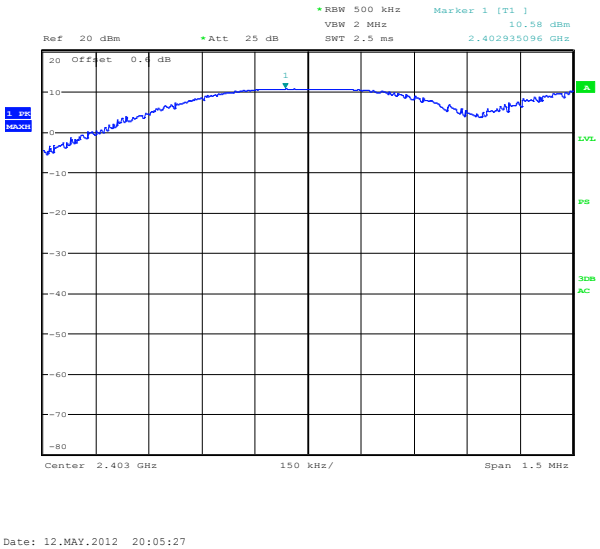
Table 8.4-7: EIRP calculation results for GFSK, hopping turned on

Frequency (MHz)	Peak output power (dBm)	Cable loss (dB)	Antenna gain (dBi)	EIRP (dBm)	Limit (dBm)	Margin (dB)
2403	10.58	0.63	3.70	13.65	36.00	22.35
2441	9.81	0.63	3.70	12.88	36.00	23.12
2481	10.21	0.63	3.70	13.28	36.00	22.72
2403	10.58	0.63	2.00	11.95	36.00	24.05
2441	9.81	0.63	2.00	11.18	36.00	24.82
2481	10.21	0.63	2.00	11.58	36.00	24.42
2403	10.58	0.63	10.00	19.95	36.00	16.05
2441	9.81	0.63	10.00	19.18	36.00	16.82
2481	10.21	0.63	10.00	19.58	36.00	16.42
2403	10.58	0.63	15.00	24.95	36.00	11.05
2441	9.81	0.63	15.00	24.18	36.00	11.82
2481	10.21	0.63	15.00	24.58	36.00	11.42
EIRP = Conducted output power [dBm] − cable loss [dB] + antenna gain [dBi]						

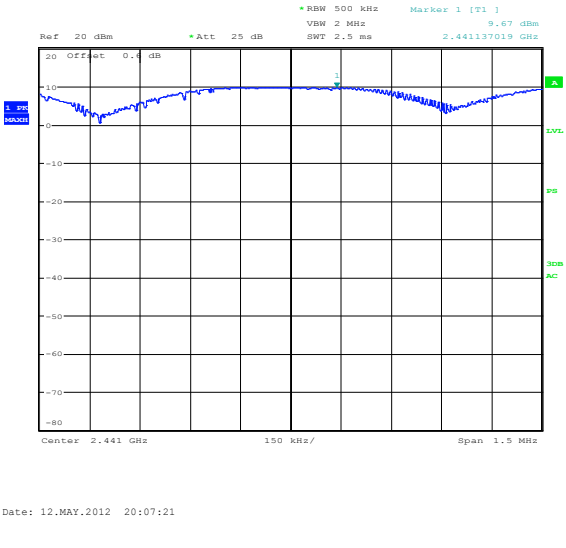
8.4.4 Test data, continued

Table 8.4-8: EIRP calculation results for GFSK, hopping turned off

Frequency (MHz)	Peak output power (dBm)	Cable loss (dB)	Antenna gain (dBi)	EIRP (dBm)	Limit (dBm)	Margin (dB)
2403	10.55	0.63	3.70	13.62	36.00	22.38
2441	9.72	0.63	3.70	12.79	36.00	23.21
2481	10.19	0.63	3.70	13.26	36.00	22.74
2403	10.55	0.63	2.00	11.92	36.00	24.08
2441	9.72	0.63	2.00	11.09	36.00	24.91
2481	10.19	0.63	2.00	11.56	36.00	24.44
2403	10.55	0.63	10.00	19.92	36.00	16.08
2441	9.72	0.63	10.00	19.09	36.00	16.91
2481	10.19	0.63	10.00	19.56	36.00	16.44
2403	10.55	0.63	15.00	24.92	36.00	11.08
2441	9.72	0.63	15.00	24.09	36.00	11.91
2481	10.19	0.63	15.00	24.56	36.00	11.44
EIRP = Conducted output power [dBm] − cable loss [dB] + antenna gain [dBi]						

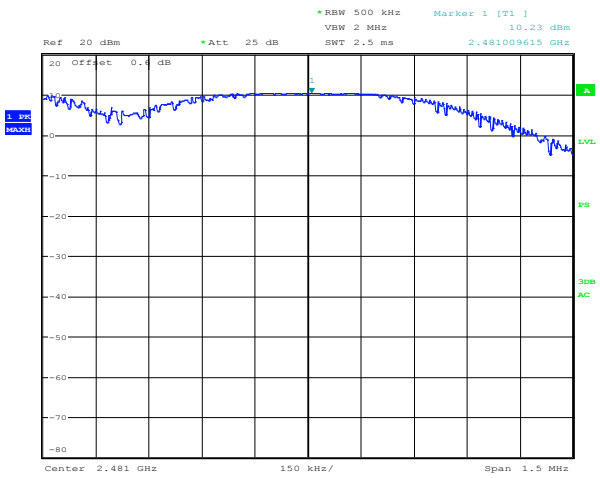


Plot 8.4-1: Peak output power on low channel, FSK, hopping on

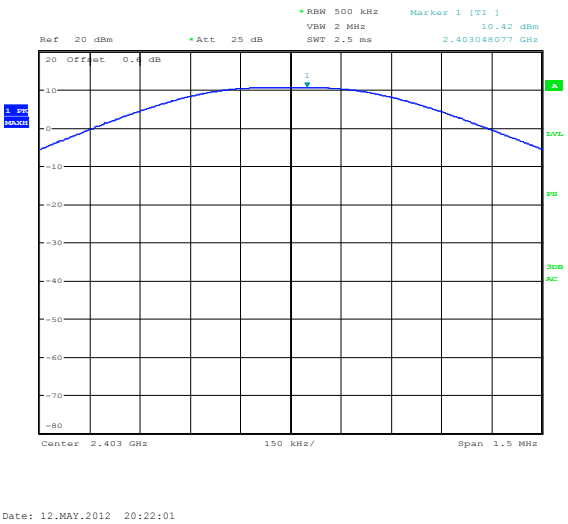


Plot 8.4-2: Peak output power on mid channel, FSK, hopping on

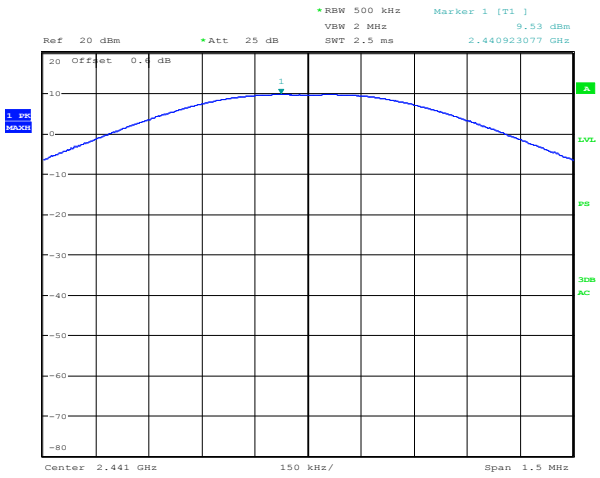
8.4.4 Test data, continued



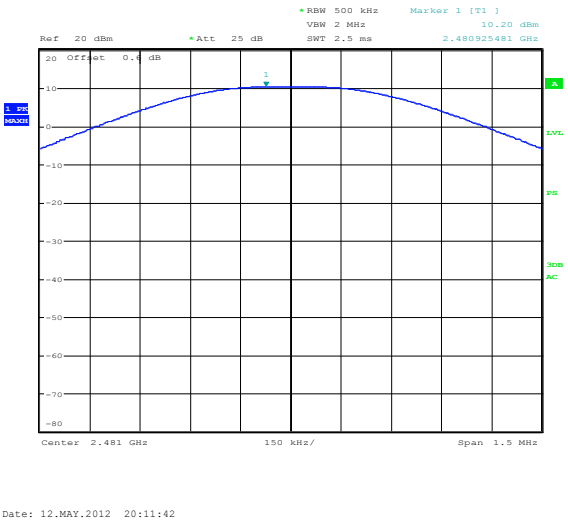
Plot 8.4-3: Peak output power on high channel, FSK, hopping on



Plot 8.4-4: Peak output power on low channel, FSK, hopping off

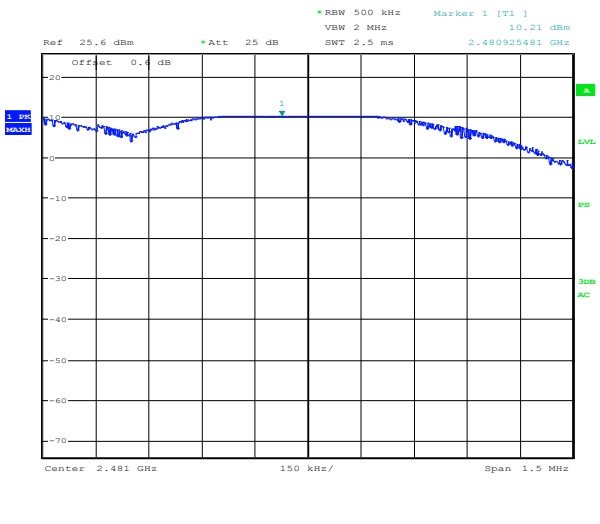


Plot 8.4-5: Peak output power on mid channel, FSK, hopping off

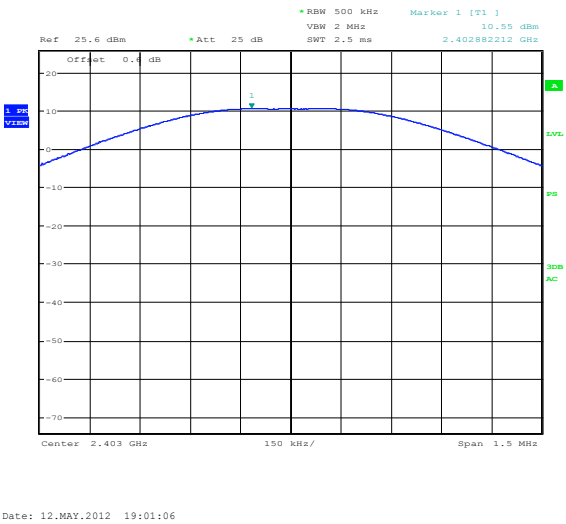


Plot 8.4-6: Peak output power on high channel, FSK, hopping off

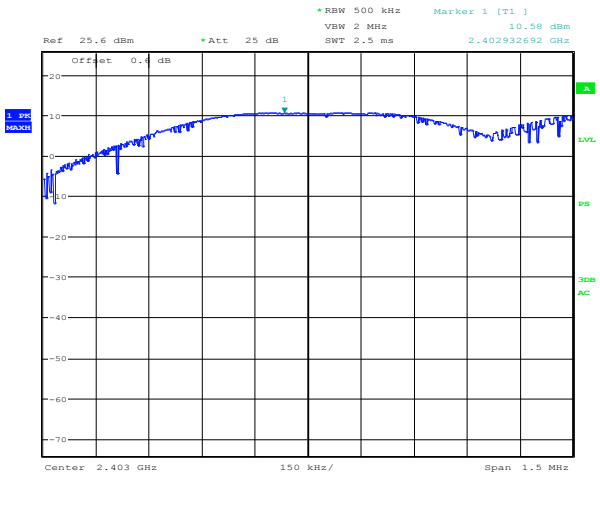
8.4.4 Test data, continued



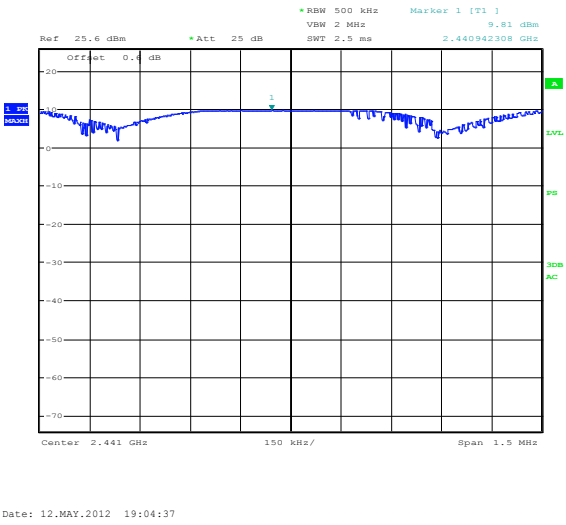
Plot 8.4-7: Peak output power on high channel, GFSK, hopping on



Plot 8.4-8: Peak output power on high channel, GFSK, hopping off

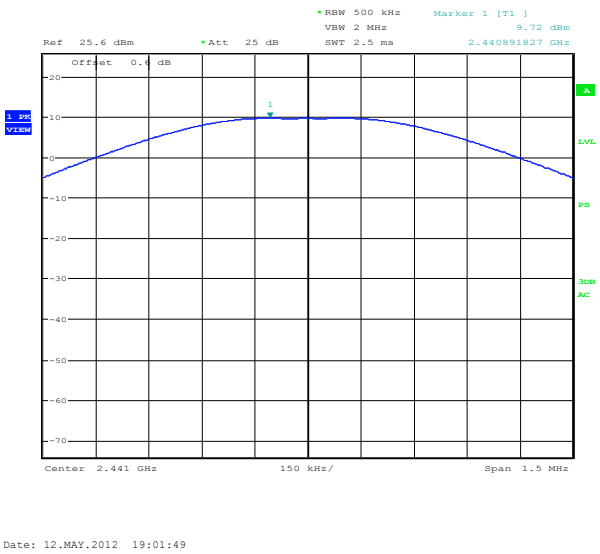


Plot 8.4-9: Peak output power on low channel, GFSK, hopping on

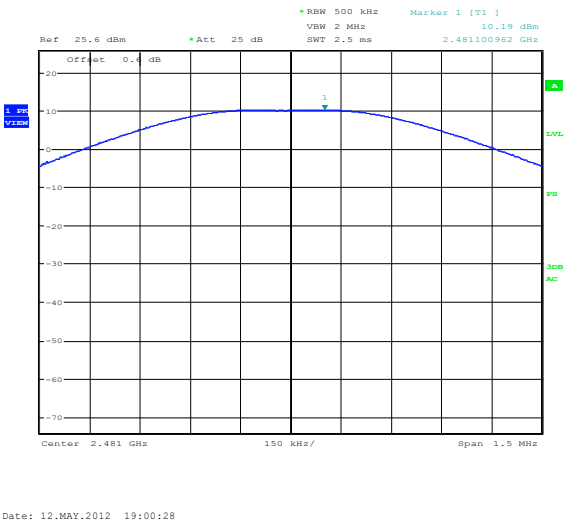


Plot 8.4-10: Peak output power on mid channel, GFSK, hopping on

8.4.4 Test data, continued



Plot 8.4-11: Peak output power on mid channel, GFSK, hopping off



Plot 8.4-12: Peak output power on high channel, GFSK, hopping off

8.5 Spurious (out-of-band) emissions

8.5.1 Definitions and limits

FCC Clause 15.247(d): Spurious emissions
RSS-210 Clause A8.5 Out-of-band emissions

FCC:
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 §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

IC:
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the radio frequency power that is produced 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 Section A8.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Table 8.5-1 is not required.

Table 8.5-1: FCC §15.209 and RSS-Gen – Radiated emission limits

Frequency (MHz)	Field strength (μV/m)	Field strength (dBμV/m)	Measurement distance (m)
0.009–0.490*	2400/F	$67.6-20\times\log_{10}(F)$	300
0.490–1.705*	24000/F	$87.6-20\times\log_{10}(F)$	30
1.705–30.0*	30	29.5	30
30–88	100	40.0	3
88–216	150	43.5	3
216–960	200	46.0	3
above 960	500	54.0	3
*– applicable only to FCC requirements			

Table 8.5-2: FCC Restricted bands of operation

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
13.36–13.41			

8.5.1 Definitions and limits, continued

Table 8.5-3: IC Restricted bands of operation

MHz	MHz	MHz	GHz
0.090–0.110	12.51975–12.52025	399.9–410	5.35–5.46
2.1735–2.1905	12.57675–12.57725	608–614	7.25–7.75
3.020–3.026	13.36–13.41	960–1427	8.025–8.5
4.125–4.128	16.42–16.423	1435–1626.5	9.0–9.2
4.17725–4.17775	16.69475–16.69525	1645.5–1646.5	9.3–9.5
4.20725–4.20775	16.80425–16.80475	1660–1710	10.6–12.7
5.677-5.683	25.5–25.67	1718.8–1722.2	13.25–13.4
6.215–6.218	37.5–38.25	2200–2300	14.47–14.5
6.26775–6.26825	73–74.6	2310–2390	15.35–16.2
6.31175–6.31225	74.8–75.2	2655–2900	17.7–21.4
8.291–8.294	108–138	3260–3267	22.01–23.12
8.362–8.366	156.52475–156.52525	3332–3339	23.6–24.0
8.37625–8.38675	156.7–156.9	3345.8–3358	31.2–31.8
8.41425–8.41475	240–285	3500–4400	36.43–36.5
12.29–12.293	322–335.4	4500–5150	Above 38.6

Note: Certain frequency bands listed in Table 8.5-3 and above 38.6 GHz are designated for low-power licence-exempt applications. These frequency bands and the requirements that apply to the devices are set out in this Standard

8.5.2 Test summary

Test date	May 15, 2012	**Test engineer**	Andrey Adelberg	**Verdict**	Pass
Temperature	22 °C	**Air pressure**	1003 mbar	**Relative humidity**	32 %

8.5.3 Observations/special notes and procedures

All plots indicate wrong date. Actual date of testing is in the “Test summary” section.

Unwanted Emissions into Non-Restricted Frequency Bands
If the peak output power procedure is used to measure the fundamental emission power to demonstrate compliance to 15.247(b)(3) requirements, then the peak conducted output power measured within any 100 kHz outside the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum measured in-band peak PSD level.
If the average output power procedure is used to measure the fundamental emission power to demonstrate compliance to 15.247(b)(3) requirements, then the power in any 100 kHz outside of the authorized frequency band shall be attenuated by at least 30 dB relative to the maximum measured inband average PSD level.
In either case, attenuation to levels below the general emission limits specified in §15.209(a) is not required.
The following procedures can be utilized to demonstrate compliance to these limits:
First, establish a reference level by using the following procedure for measuring the peak power level in any 100 kHz bandwidth within the fundamental emission:

8.5.3 Observations/special notes and procedures, continued

Measurement Procedure – Reference Level

a. Set the RBW = 100 kHz.
b. Set the VBW ≥ 300 kHz.
c. Set the span to 5–30 % greater than the EBW.
d. Detector = peak.
e. Sweep time = auto couple.
f. Trace mode = max hold.
g. Allow trace to fully stabilize.
h. Use the peak marker function to determine the maximum power level in any 100 kHz band segment within the fundamental EBW.

Next, determine the power in 100 kHz band segments outside of the authorized frequency band using the following measurement:

Band-edge Compliance of RF Conducted Emissions (frequency hopping)

Use the following spectrum analyzer settings:
Span = wide enough to capture 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
RBW ≥ 1% of the span
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold

Allow the trace to stabilize. Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge. Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission. The marker-delta value now displayed must comply with the limit specified in this Section.

Now, using the same instrument settings, enable the hopping function of the EUT. Allow the trace to stabilize. Follow the same procedure listed above to determine if any spurious emissions caused by the hopping function also comply with the specified limit.

Spurious RF Conducted Emissions (frequency hopping)

Use the following spectrum analyzer settings:
Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic. Typically, several plots are required to cover this entire span.
RBW = 100 kHz
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold

Allow the trace to stabilize. Set the marker on the peak of any spurious emission recorded. The level displayed must comply with the limit specified in this Section.

Duty cycle/average factor calculations

§15.35(c) permits a duty cycle reduction to the measured field strength (or equivalent power) when pulsed operation is employed. This allowance is only applicable to unwanted emissions that demonstrate the same pulse characteristics as does the fundamental emission (e.g., harmonic emissions). The duty cycle (d.c.) is determined as follows:

For a pulse train ≤ 100 ms: d.c. = cumulative on time/cumulative off time over the pulse train.

For a pulse train > 100 ms: d.c. = cumulative on time/100 ms.

See C63.10 for further guidance in determining the applicable duty cycle.

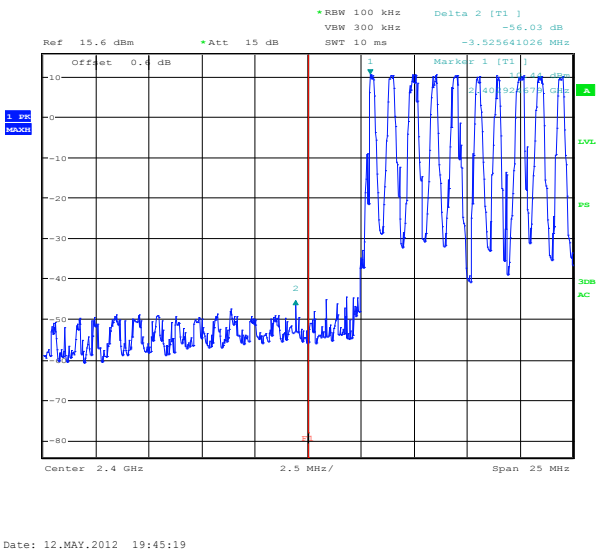
$$Duty\ cycle\ /\ average\ factor = 20 \times \log_{10}\left(\frac{Tx_{100\,ms}}{100\,ms}\right)$$

FSK*: $20 \times \log_{10}(2.4 / 100) = -32.38$ dB

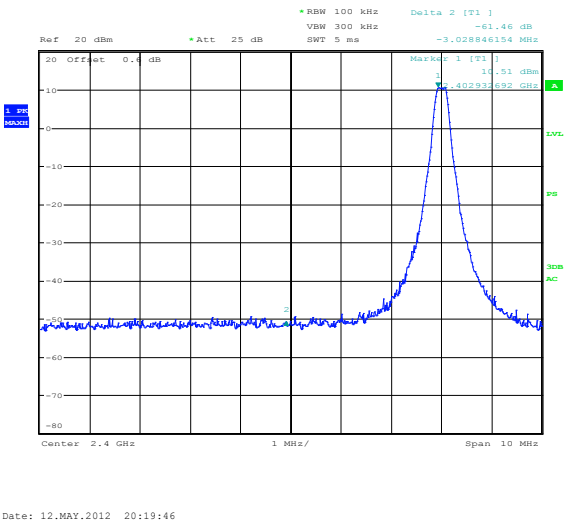
GFSK*: $20 \times \log_{10}(1.2 / 100) = -38.35$ dB

* - Please refer to plots 8.2–2 through 8.2–5 for timing details.

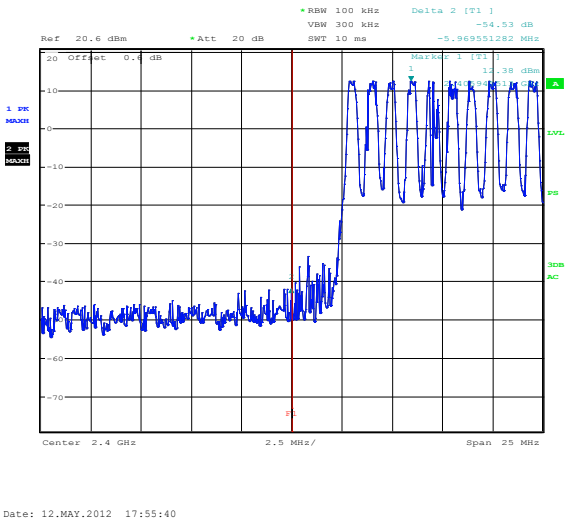
8.5.4 Test data



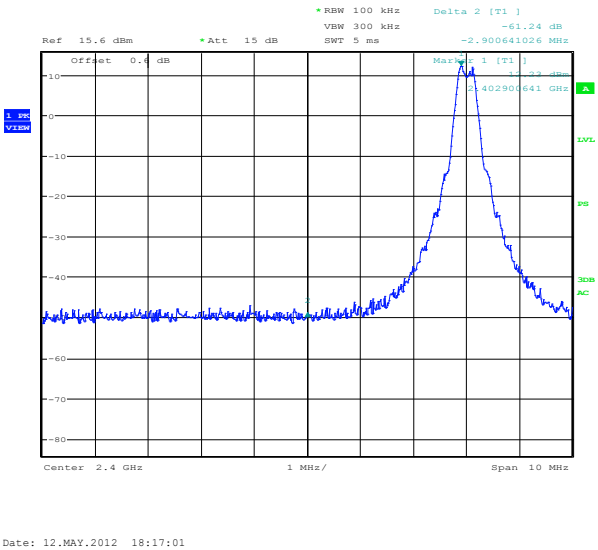
Plot 8.5-1: Lower bad edge, FSK, hopping on



Plot 8.5-2: Lower bad edge, FSK, hopping off



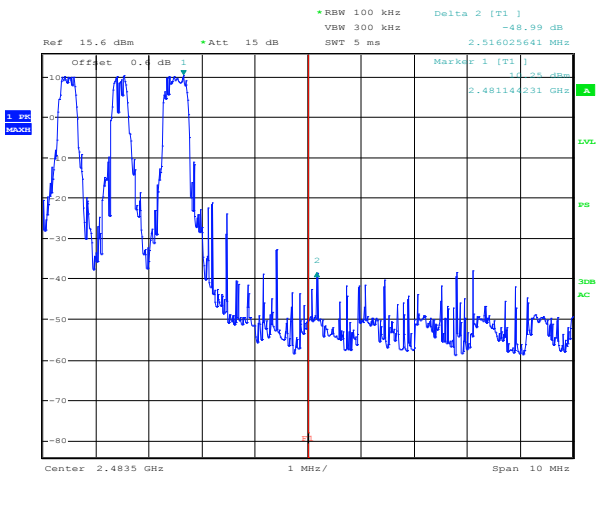
Plot 8.5-3: Lower bad edge, GFSK, hopping on



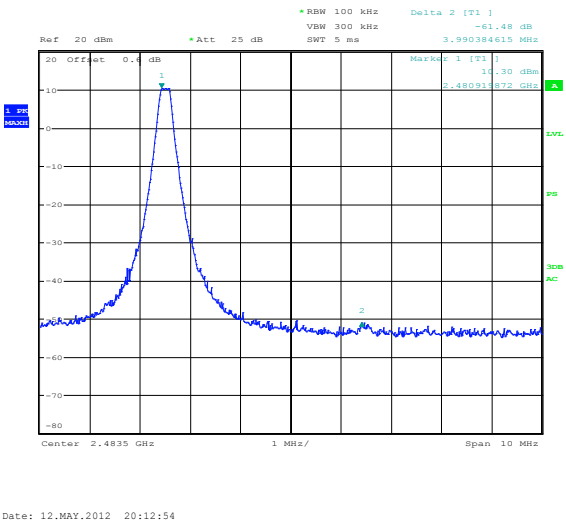
Plot 8.5-4: Lower bad edge, GFSK, hopping off

The value of `Delta 2 [T1 ]` on the plots above shows actual band edge measurement, the minimum limit is –20 dB.

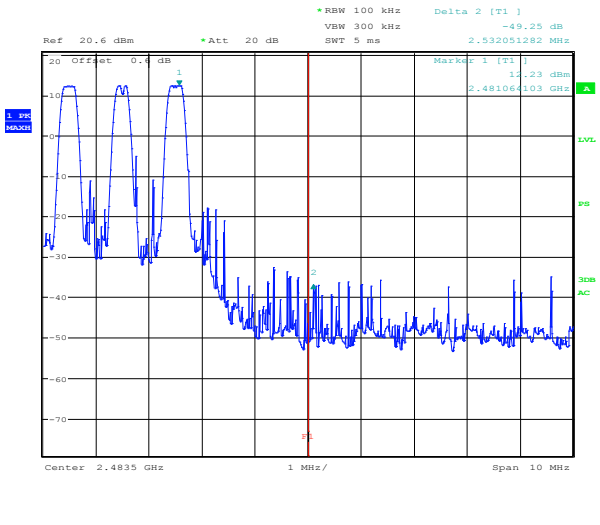
8.5.4 Test data, continued



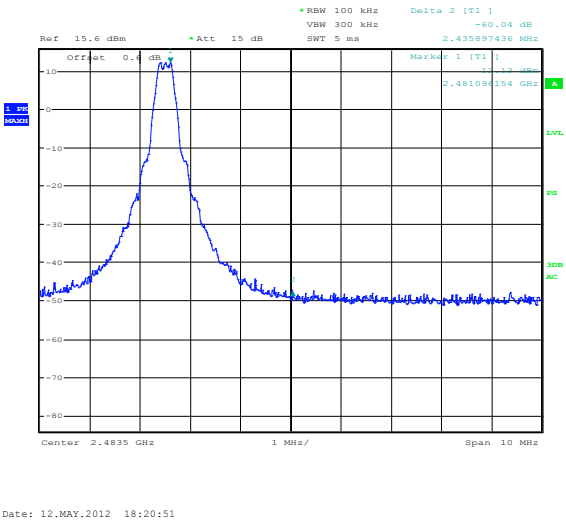
Plot 8.5-5: Upper bad edge, FSK, hopping on



Plot 8.5-6: Upper bad edge, FSK, hopping off



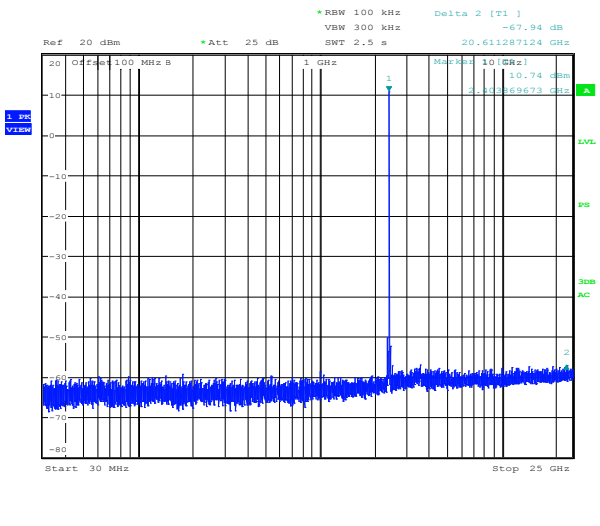
Plot 8.5-7: Upper bad edge, GFSK, hopping on



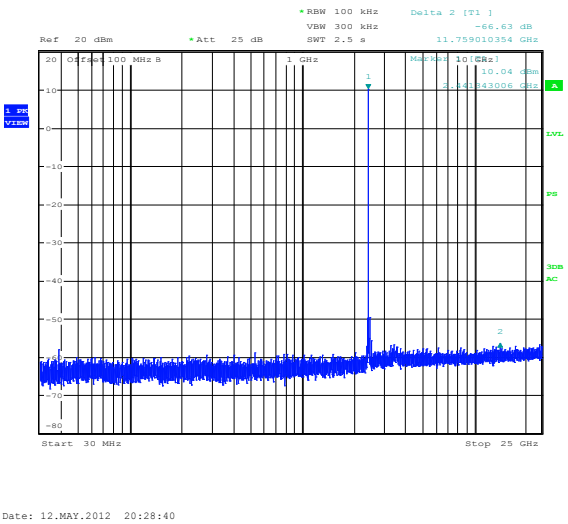
Plot 8.5-8: Upper bad edge, GFSK, hopping off

The value of `Delta 2 [T1 ]` on the plots above shows actual band edge measurement, the minimum limit is –20 dB.

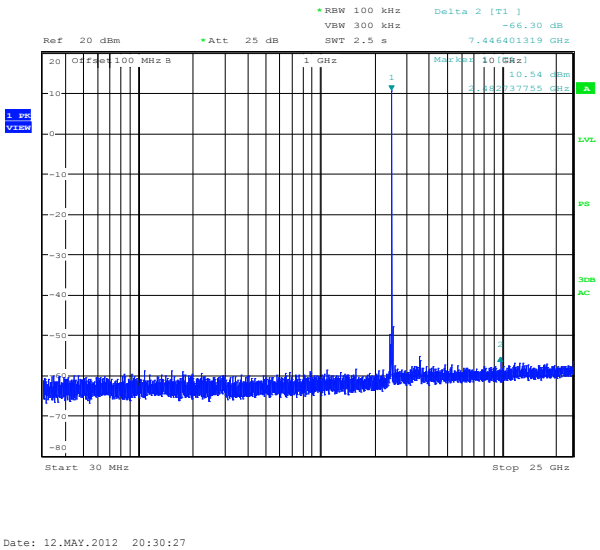
8.5.4 Test data, continued



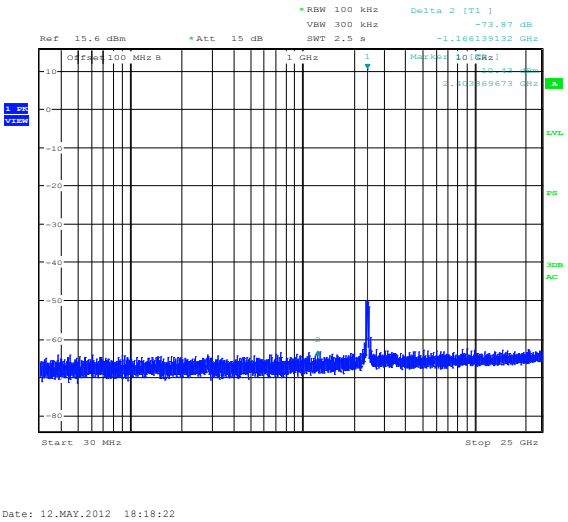
Plot 8.5-9: Conducted spurious emissions, low channel, FSK



Plot 8.5-10: Conducted spurious emissions, mid channel, FSK

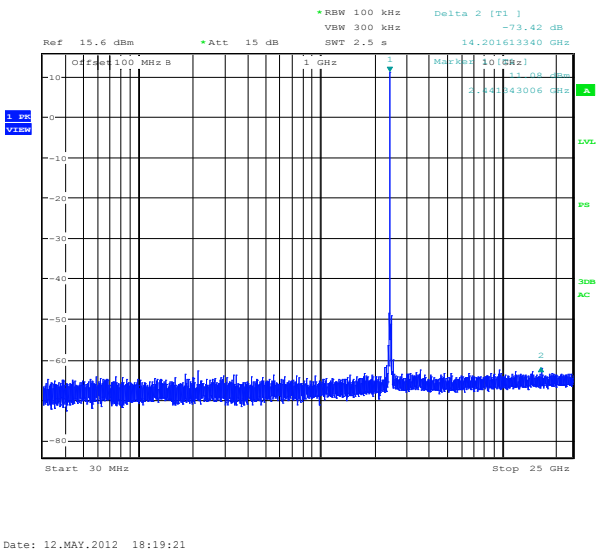


Plot 8.5-11: Conducted spurious emissions, high channel, FSK

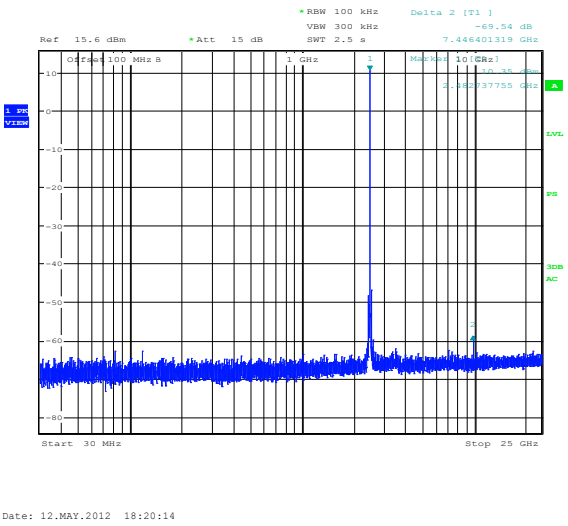


Plot 8.5-12: Conducted spurious emissions, low channel, GFSK

8.5.4 Test data, continued



Plot 8.5-13: Conducted spurious emissions, mid channel, GFSK



Plot 8.5-14: Conducted spurious emissions, high channel, GFSK

Table 8.5-4: Cabinet radiation emissions for FSK

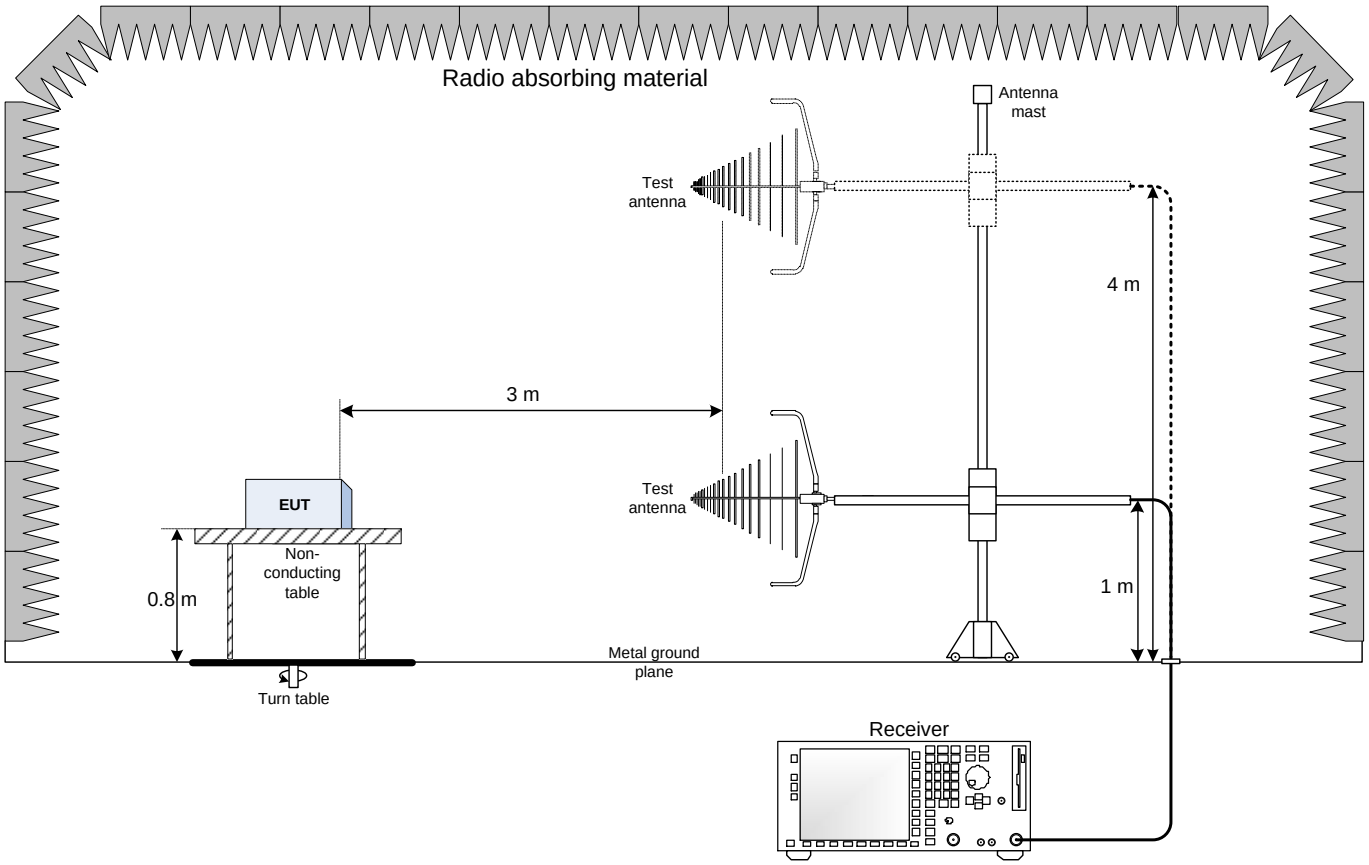
Channel	Frequency, (MHz)	Peak field strength, (dBµV/m)	Peak limit, (dBµV/m)	Margin, (dB)	Average field strength, (dBµV/m)	Average factor, (dB)	Corrected average, (dBµV/m)	Average limit, (dBµV/m)	Margin, (dB)
Low	2390	50.20	74.00	23.80	35.40	-32.38	3.02	54.00	50.98
Low	4806	57.51	74.00	16.49	54.06	-32.38	21.68	54.00	32.32
Mid	4882	60.41	74.00	13.59	55.47	-32.38	23.09	54.00	30.91
Mid	7323	63.23	74.00	10.77	59.93	-32.38	27.55	54.00	26.45
High	2483.5	59.13	74.00	14.87	46.97	-32.38	14.59	54.00	39.41
High	4962	62.34	74.00	11.66	60.24	-32.38	27.86	54.00	26.14
High	7443	64.27	74.00	9.73	61.38	-32.38	29.00	54.00	25.00

Table 8.5-5: Cabinet radiation emissions for GFSK

Channel	Frequency, (MHz)	Peak field strength, (dBµV/m)	Peak limit, (dBµV/m)	Margin, (dB)	Average field strength, (dBµV/m)	Average factor, (dB)	Corrected average, (dBµV/m)	Average limit, (dBµV/m)	Margin, (dB)
Low	2390	50.20	74.00	23.80	35.40	-38.35	-2.95	54.00	56.95
Low	4806	59.42	74.00	14.58	55.47	-38.35	17.13	54.00	36.88
Mid	4882	60.74	74.00	13.26	58.21	-38.35	19.87	54.00	34.14
Mid	7323	63.77	74.00	10.23	60.34	-38.35	22.00	54.00	32.01
High	2483.5	58.48	74.00	15.52	46.37	-38.35	8.03	54.00	45.98
High	4962	63.92	74.00	10.08	60.88	-38.35	22.54	54.00	31.47
High	7443	50.20	74.00	23.80	35.40	-38.35	-2.95	54.00	56.95

Section 9 Block diagrams of test set-ups

9.1 Radiated emissions set-up



9.2 Conducted emissions set-up