SK TECH CO., LTD.

Certificate of Compliance

Test Report No.:	**SKTTRT-081218-020**		
Applicant:	**MOVON CORPORATION**		
Applicant Address:	6Fl. Hyunjuk Bldg., 140-28, Samsung-dong, Gangnam-Gu, Seoul, 135-090 Korea		
Manufacturer:	**MOVON CORPORATION**		
Manufacturer Address:	6Fl. Hyunjuk Bldg., 140-28, Samsung-dong, Gangnam-Gu, Seoul, 135-090 Korea		
Device Under Test:	**Bluetooth Wireless Headset**		
FCC ID: **IC:**	**TDU-R2**	**Model Name:**	**R2**
Brand/Trade Name:	**MOVON**		
Receipt No.:	SKTEU08-1033	**Date of receipt:**	November 19, 2008
Date of Issue:	December 18, 2008		
Location of Testing:	**SK TECH CO., LTD.** #820-2, Wolmoon-ri, Wabu-up, Namyangju-si, Kyunggi-do, 472-905 South Korea		
Test Procedure:	**ANSI C63.4, FCC Public Notice DA 00-705 (March 2000)**		
Test Specification:	**47CFR, Part 15 Rules**		
FCC Equipment Class:	**DSS - Part 15 Spread Spectrum Transmitter**		
Test Result:	The above-mentioned device has been tested and passed.		

Tested & Reported by: *Seong-Baek, Ko*

2008-12-18

Signature *Date*

Approved by: *Jong-Soo, Yoon*

2008-12-18

Signature *Date*

Other Aspects:	-
Abbreviations:	**· OK, Pass = passed · Fail = failed · N/A = not applicable**

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- **This test report is not permitted to copy partly and entirely without our permission.**
- **This test result is dependent on only equipment to be used.**
- **This test result is based on a single evaluation of submitted samples of the above mentioned.**

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1. GENERAL

These tests were performed using the test procedure outlined in ANSI C63.4, 2003 for intentional radiators, and in accordance with the limits set forth in FCC Part 15.247 for Spread Spectrum Transmitter. The EUT (Equipment Under Test) has been shown to be capable of compliance with the applicable technical standards.

We attest to the accuracy of data. All measurements reported herein were performed by SK TECH CO., LTD. and were made under Chief Engineer's supervision.
We assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

2. TEST SITE

SK TECH CO., LTD.

2.1 Location

#820-2, Wolmoon-ri, Wabu-up, Namyangju-si, Kyunggi-do, 472-905 South Korea
(FCC Registered Test Site Number: 90752)

This test site is in compliance with ISO/IEC 17025 for general requirements for the competence of testing and calibration laboratories.
This laboratory is recognized as a Conformity Assessment Body (CAB) for CAB's Designation Number: **KR0007** by FCC, is accredited by NVLAP for NVLAP Lab. Code: **200220-0**.

2.2 List of Test and Measurement Instruments

No.	Description	Manufacturer	Model #	Serial #	Calibrated until	Used
1	Spectrum Analyzer	Agilent	E4405B	US40520856	2009.07	
2	EMC Spectrum Analyzer	Agilent	E7405A	US40240203	2009.02	☒
3	EMI Test Receiver	Rohde&Schwarz	ESIB40	100277	2009.02	☒
4	EMI Test Receiver	Rohde&Schwarz	ESVS10	825120/008	2009.07	
5	EMI Test Receiver	Rohde&Schwarz	ESHS10	862970/019	2009.07	☒
6	Artificial Mains Network	Rohde&Schwarz	ESH3-Z5	836679/018	2009.07	☒
7	Pre-amplifier	HP	8447F	3113A05153	2009.07	☒
8	Pre-amplifier	MITEQ	AFS44	1116321	2009.03	☒
9	Pre-amplifier	MITEQ	AFS44	1116322	2009.03	
10	Power Meter	Agilent	E4417A	MY45100426	2009.07	
11	Power Sensor	Agilent	E9327A	MY44420696	2009.07	
12	Attenuator (10dB)	HP	8491B	38067	2009.07	☒
13	Oscilloscope	Agilent	54825A	MY40000269	2009.03	
14	Diode detector	Agilent	8473C	1882A03173	2009.02	
15	High Pass Filter	Wainwright	WHKX3.0/18G	8	2009.07	☒
16	VHF Precision Dipole Antenna (TX/RX)	Schwarzbeck	VHAP	1014 / 1015	2009.12	
17	UHF Precision Dipole Antenna (TX/RX)	Schwarzbeck	UHAP	989 / 990	2009.12	
18	Loop Antenna	Schwarzbeck	HFH2-Z2	863048/019	2009.11	
19	TRILOG Broadband Antenna	Schwarzbeck	VULB9168	9168-230	2009.07	☒
20	Horn Antenna	AH Systems	SAS-200/571	304	N/A	
21	Horn Antenna	EMCO	3115	00040723	2009.03	
22	Horn Antenna	EMCO	3115	00056768	2009.06	☒
23	Vector Signal Generator	Agilent	E4438C	MY42080359	2009.07	
24	PSG analog signal generator	Agilent	E8257D-520	MY45141255	2009.07	
25	DC Power Supply	HP	6622A	3448A03223	2009.11	☒
26	DC Power Supply	HP	6234A	2926A-01078	2009.03	
27	Digital Multimeter	HP	HP3458A	2328A14389	2009.03	☒
28	PCS Interface	HP	83236B	3711J00881	2009.03	
29	CDMA Mobile Test Set	HP	8924C	US35360253	2009.03	
30	Hygro/Thermo Graph	SATO	PC-5000TRH-II	-	2009.07	☒
31	Temperature/Humidity Chamber	All Three	ATM-50M	20030425	2009.03	
32	Temperature/Humidity Chamber	DAEJIN	DJ-THC02	06071	2009.03	

2.3 Test Date

Date of Test: November 24, 2008 ~ December 17, 2008

2.4 Test Environment

See each test item's description.

3. DESCRIPTION OF THE EQUIPMENT UNDER TEST

The product specification described herein was obtained from the product data sheet or user's manual.

3.1 Rating and Physical Characteristics

Power source	DC 3.7 V Li-ion Polymer battery
Transmit Frequency	2402 ~ 2480 MHz (1 MHz step, 79 channels)
X-tal or Oscillator	X-tal: 26 MHz
Antenna Type	Integral (Chip antenna, Gain: 0.86 dBi)
Type of Modulation	FHSS (GFSK), EDR(π /4 DQPSK)
RF Output power	0 dBm
External Ports	- DC Input for battery charging AC/DC Adaptor Manufacturer : DEE VAN ENTERPRISE CO., LTD. Model : DSA-31S FUS 5320 Input : 100-240VAC 50/60 Hz 0.2 A Output : +5.3 V ⎓ 0.2 A

3.2 Equipment Modifications

None

3.3 Submitted Documents

Block diagram

Schematic diagram

Antenna Specification

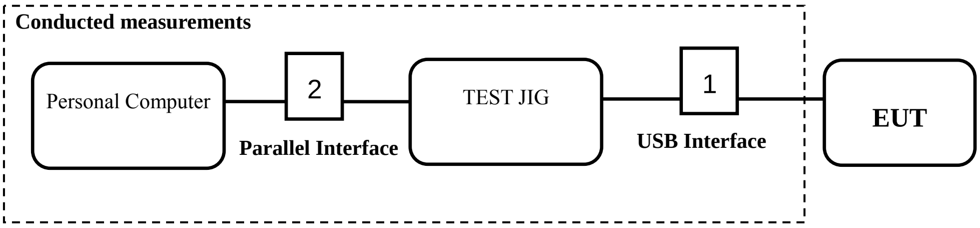
Part List

User manual

4. MEASUREMENT CONDITIONS

4.1 Description of test configuration

The measurements were taken in continuous transmitting mode using the TEST MODE. For controlling the EUT as TEST MODE, the test program and the Cable assembly were provided by the applicant.



[System Block Diagram of Test Configuration]

4.2 List of Peripherals

Equipment Type	Manufacturer	Model	S/N
Personal Computer**	DELL	DCNE	7XH86BX
TEST JIG**	MOVON CORPORATION	-	-

** For control of the RF module via UART interface in the EUT.
The AC power line conducted emission measurement was performed while charging the battery. The EUT is not operated the RF part in charging mode. If not otherwise stated, for modulating the transmitter, a pseudo random bit sequence with a pattern type DH5 was used.
The radiated measurements was performed at the stand-alone condition.

4.3 Type of Used Cables

#	START		END		CABLE	
	NAME	I/O PORT	NAME	I/O PORT	LENGTH(m)	SHIELDED
1	EUT	USB Interface	TEST JIG	TX/RX	0.3	NO
2	TEST JIG	Serial Interface	Personal Computer	Serial Port	1.8	YES

4.4 Uncertainty

Measurement Item	Combined Standard Uncertainty *Uc*	Expanded Uncertainty $U = kUc$ ($k = 2$)
Conducted RF power	± 1.49 dB	± 2.98 dB
Radiated disturbance	± 2.30 dB	± 4.60 dB
Conducted disturbance	± 1.96 dB	± 3.92 dB

5. TEST AND MEASUREMENTS

Summary of Test Results

Requirement	CFR 47 Section	RSS Standards	Report Section	Test Result
Antenna Requirement	15.203, 15.247(b)(4)	RSS-Gen, 7.1.4	5.1	PASS
Maximum Peak Output Power	15.247(b)(1), (4)	RSS-210, A8.4 (2)	5.2	PASS
Carrier Frequency Separation	15.247(a)(1)	RSS-210, A8.1 (2)	5.3	PASS
20dB Channel Bandwidth	15.247(a)(1)	RSS-210, A8.1 (2)	5.4	PASS
Number of Hopping Channels	15.247(a)(iii), 15.247(b)(1)	RSS-210, A8.1 (2) RSS-210, A8.4 (2)	5.5	PASS
Time of Occupancy (Dwell Time)	15.247(a)(iii)	RSS-210, A8.1 (4)	5.6	PASS
Spurious Emission, Band Edge, and Restricted bands	15.247(d), 15.205(a), 15.209(a)	RSS-210, A8.5 Table 1, 2, and 3	5.7	PASS
Peak Power Spectral Density	15.247(e)	RSS-210, A8.2	5.8	PASS
Conducted Emissions	15.207(a)	RSS-Gen, 7.2.2	5.9	PASS
RF Exposure	15.247(i), 1.1307(b)(1)	RSS-Gen, 5.5 RSS-102, 2.5	5.10	PASS

5.1 ANTENNA REQUIREMENT

5.1.1 Regulation

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

And according to §15.247(b)(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.

5.1.2 Result: PASS

The transmitter has an integral Chip antenna. The directional gain of the antenna is 0.86 dBi.

5.2 MAXIMUM PEAK OUTPUT POWER

5.2.1 Regulation

According to §15.247(b)(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 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

According to §15.247(b)(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.

5.2.2 Test Procedure

1. Check the calibration of the measuring instrument (spectrum analyzer) using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable and attenuator.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via UART interface and make sure the spectrum analyzer is operated in its linear range.
4. Set the spectrum analyzer as follows:
   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
5. Measure the highest amplitude appearing on spectral display and record the level to calculate results.
6. Repeat above procedures until all frequencies measured were complete.

5.2.3 Test Results: PASS

Table 1: Measured values of the Maximum Peak Output Power (Conducted)

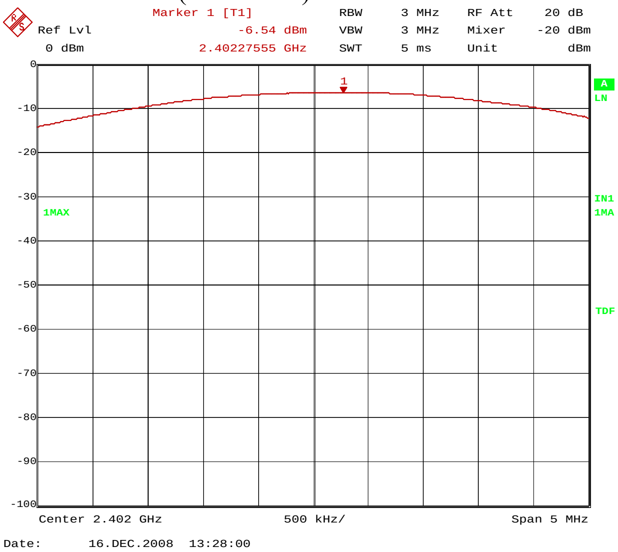
Operating Frequency	Resolution Bandwidth	Actual	Limit
GFSK Modulation			
2402 MHz	3 MHz	0.22 mW(-6.54 dBm)	1 W (30 dBm)
2441 MHz	3 MHz	0.31 mW(-5.02 dBm)	1 W (30 dBm)
2480 MHz	3 MHz	0.50 mW(-3.02 dBm)	1 W (30 dBm)
π /4 DQPSK Modulation			
2402 MHz	3 MHz	0.15 mW(-8.27 dBm)	1 W (30 dBm)
2441 MHz	3 MHz	0.20 mW(-6.93 dBm)	1 W (30 dBm)
2480 MHz	3 MHz	0.33 mW(-4.81 dBm)	1 W (30 dBm)

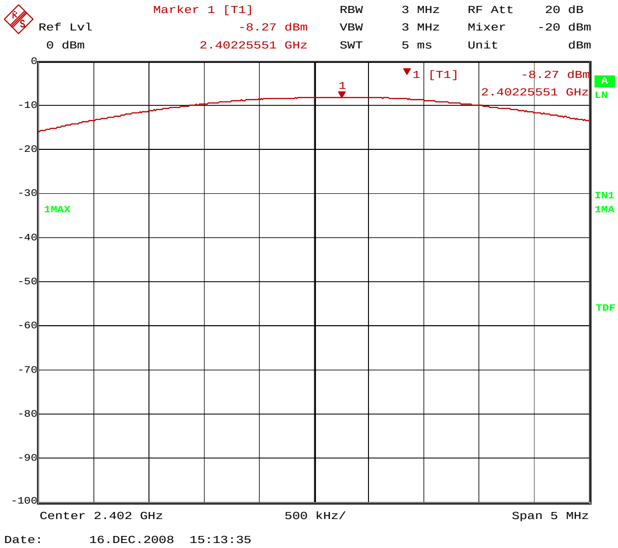
NOTE:
1. Since the directional gain of the integral antenna declared by the manufacturer (G_{ANT} = 0.86 dBi) does not exceed 6.0 dBi, there was no need to reduce the output power.
2. We took the insertion loss of the cable loss into consideration within the measuring instrument.

Figure 1. Plot of the Maximum Peak Output Power (Conducted)

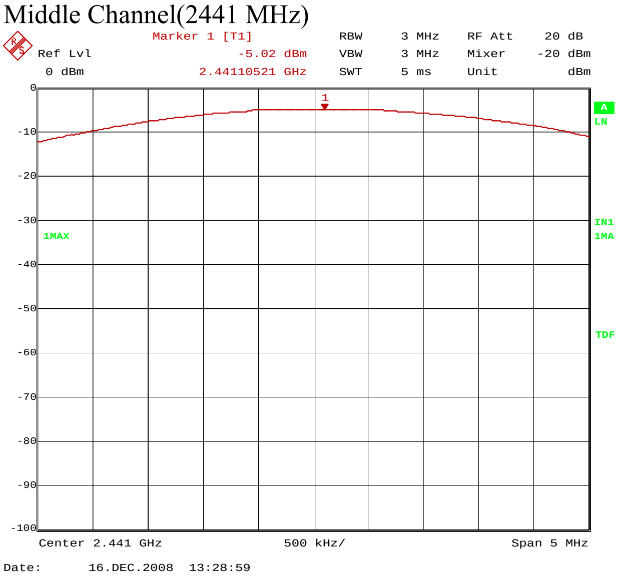
GFSK Modulation **π /4 DQPSK Modulation**

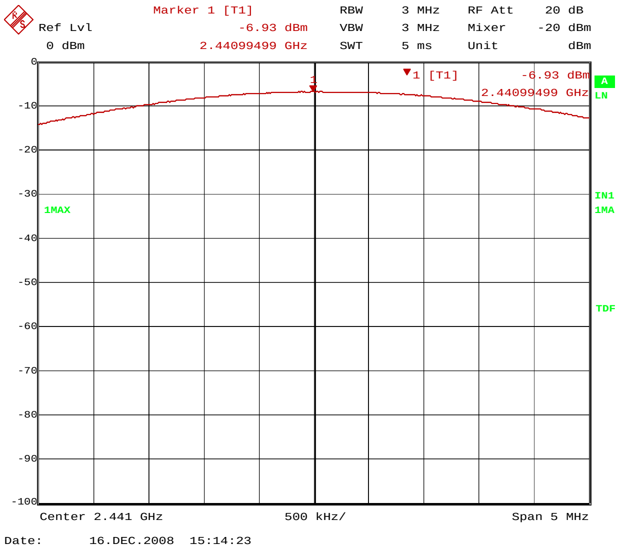
Lowest Channel(2402 MHz)



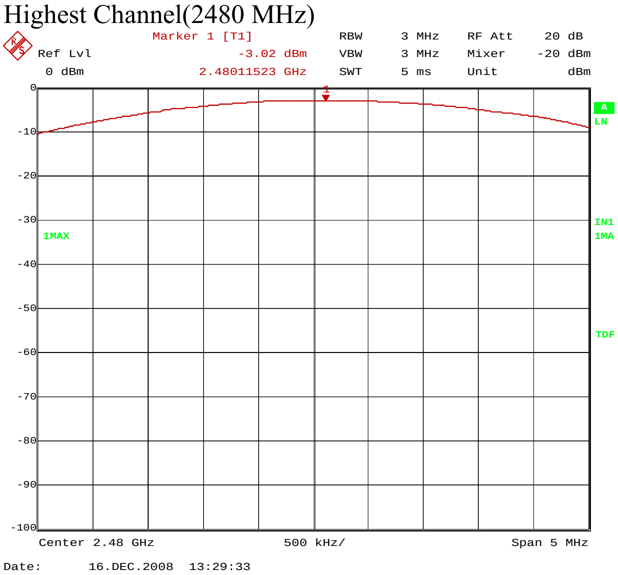


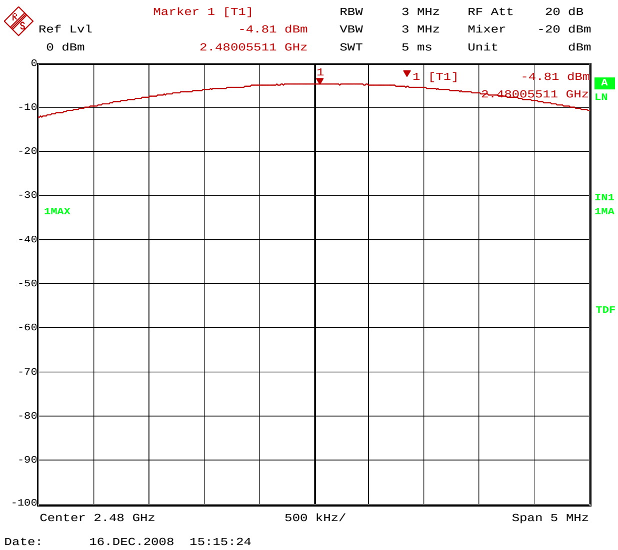
Middle Channel(2441 MHz)





Highest Channel(2480 MHz)





5.3 CARRIER FREQUENCY SEPARATION

5.3.1 Regulation

According to §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. 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.

5.3.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable and attenuator.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via UART interface.
4. Set the spectrum analyzer as follows:
   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
5. Measure the separation between the peaks of the adjacent channels using the marker-delta function.
6. Repeat above procedures until all frequencies measured were complete.

5.3.3 Test Results: PASS

Table 2: Measured values of the Carrier Frequency Separation

Operating frequency	Carrier frequency separation	Limit
GFSK Modulation		
2402 MHz	1004 kHz	≥ 25 kHz or 20 dB bandwidth
2441 MHz	1004 kHz	≥ 25 kHz or 20 dB bandwidth
2480 MHz	1004 kHz	≥ 25 kHz or 20 dB bandwidth
π/4 DQPSK Modulation		
2402 MHz	1010 kHz	≥ 25 kHz or 20 dB bandwidth
2441 MHz	998 kHz	≥ 25 kHz or 20 dB bandwidth
2480 MHz	998 kHz	≥ 25 kHz or 20 dB bandwidth

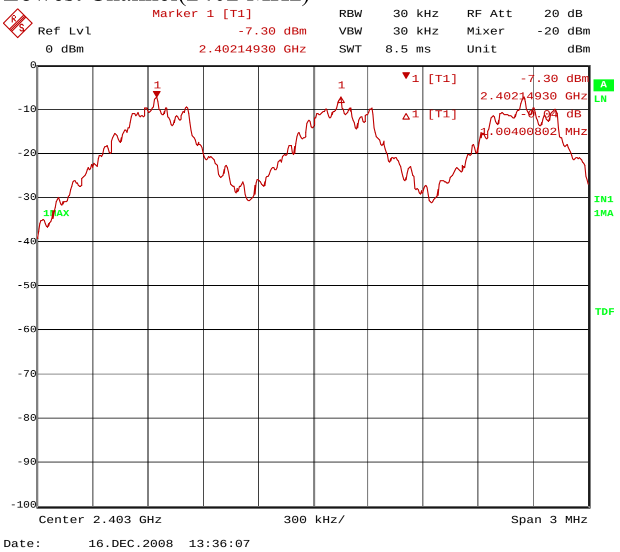
NOTE: We took the insertion loss of the cable loss into consideration within the measuring instrument.

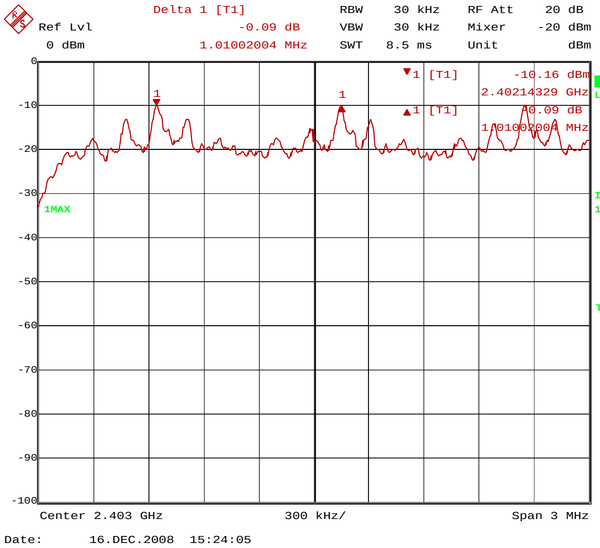
Figure 2. Plot of the Carrier Frequency Separation

GFSK Modulation

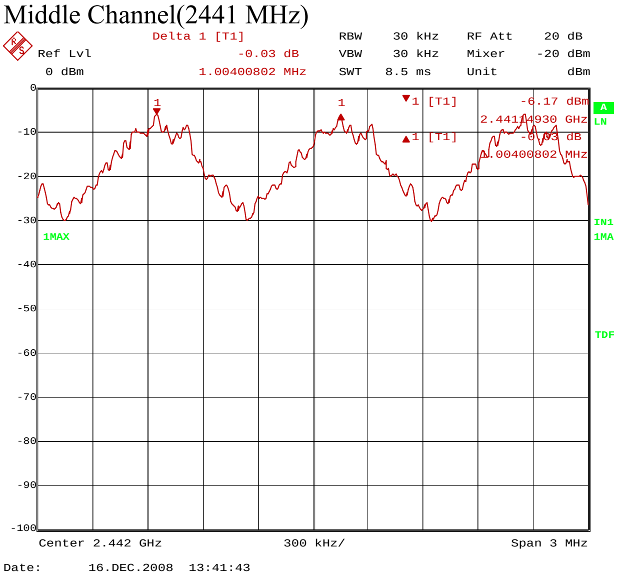
π /4 DQPSK Modulation

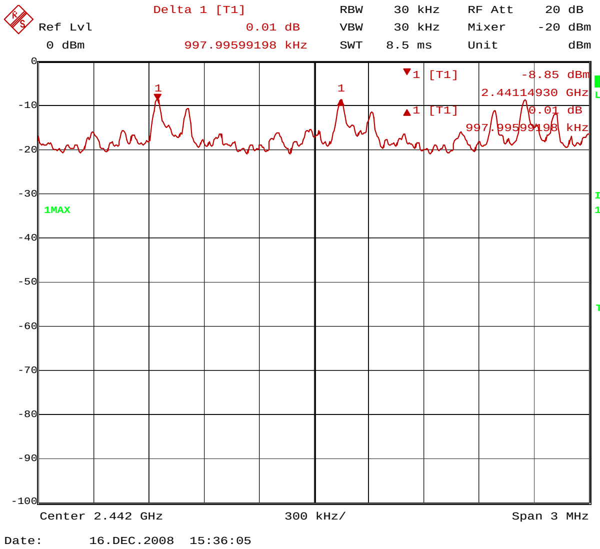
Lowest Channel(2402 MHz)



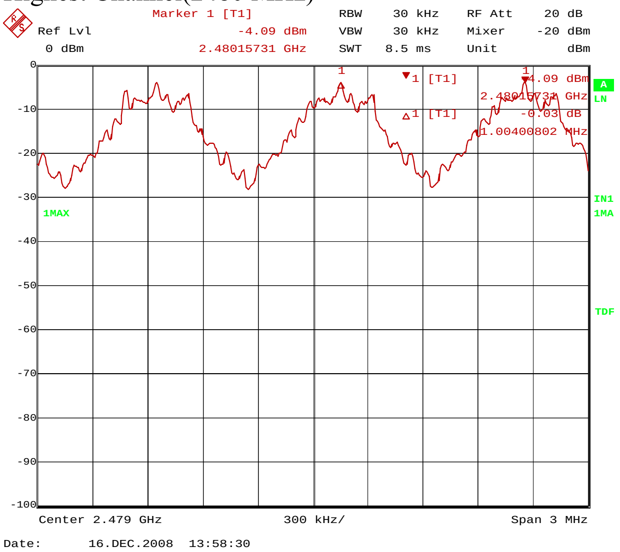


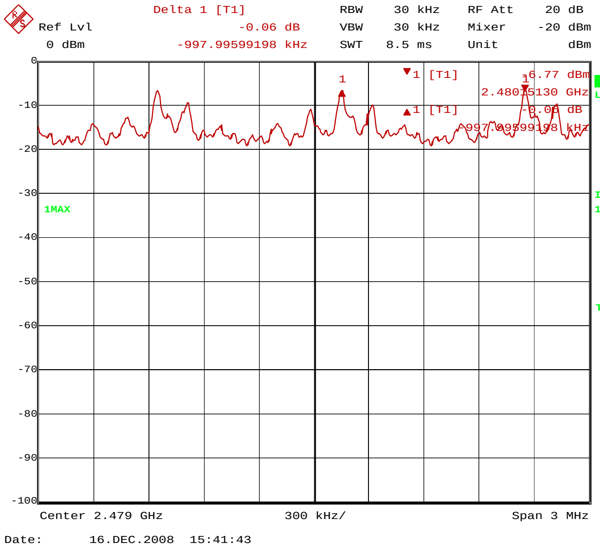
Middle Channel(2441 MHz)





Highest Channel(2480 MHz)





5.4 20 dB CHANNEL BANDWIDTH

5.4.1 Regulation

According to §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. 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.

5.4.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable and attenuator.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via UART interface and make sure the spectrum analyzer is operated in its linear range.
4. Set the spectrum analyzer as follows:
   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
5. Set a reference level on it equal to the highest peak value.
6. Measure the frequency difference of two frequencies that were attenuated 20dB from the reference level. Record the frequency difference as the emission bandwidth.
7. Repeat above procedures until all frequencies measured were complete.

5.4.3 Test Results: PASS

Table 3: Measured values of the 20 dB Channel Bandwidth

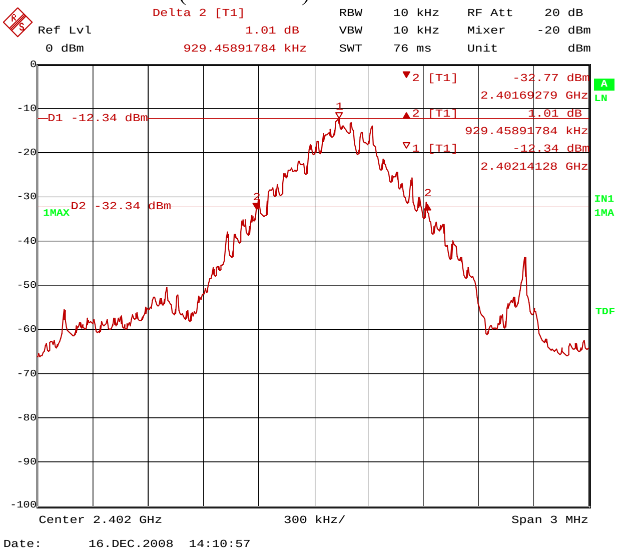
Operating frequency	20 dB Channel bandwidth	Limit	Carrier frequency separation
GFSK Modulation			
2402 MHz	929 kHz	< Carrier frequency separation	1004 kHz
2441 MHz	940 kHz	< Carrier frequency separation	1004 kHz
2480 MHz	932 kHz	< Carrier frequency separation	1004 kHz
π /4 DQPSK Modulation			
2402 MHz	1311 kHz	< Carrier frequency separation	1010 kHz
2441 MHz	1318 kHz	< Carrier frequency separation	998 kHz
2480 MHz	1312 kHz	< Carrier frequency separation	998 kHz

NOTE: We took the insertion loss of the cable loss into consideration within the measuring instrument.

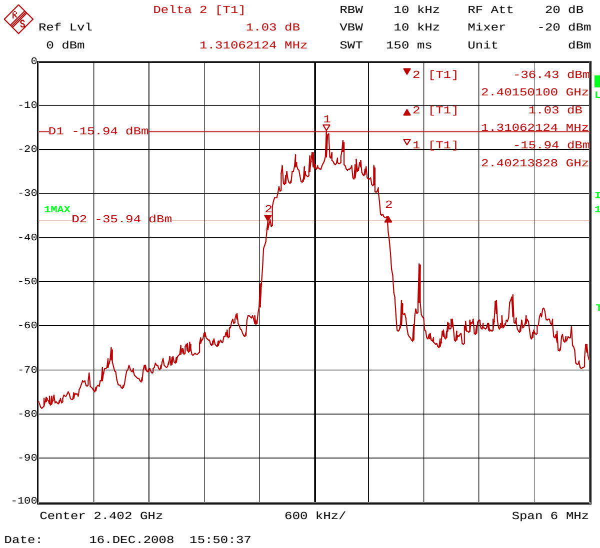
Figure 3. Plot of the 20 dB Channel Bandwidth

GFSK Modulation

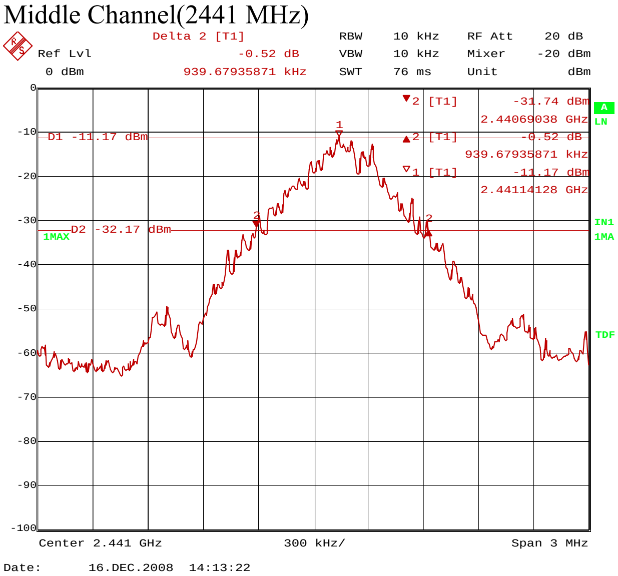
Lowest Channel(2402 MHz)

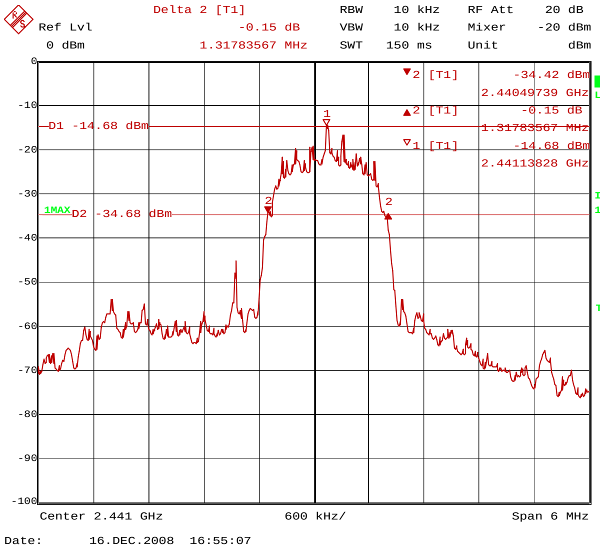


π /4 DQPSK Modulation

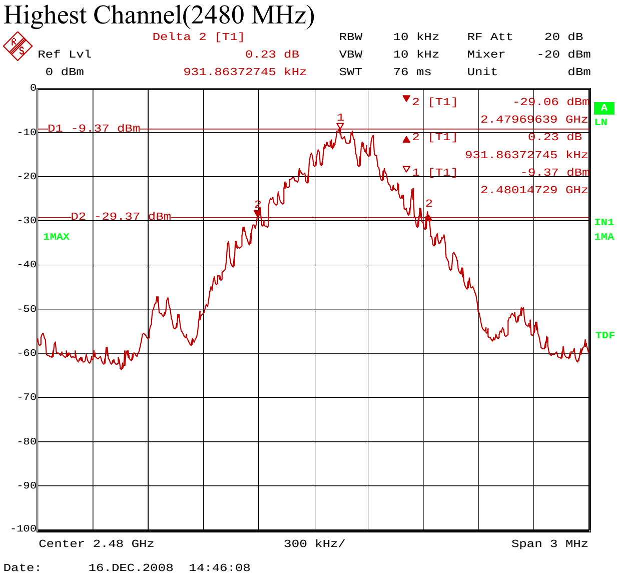


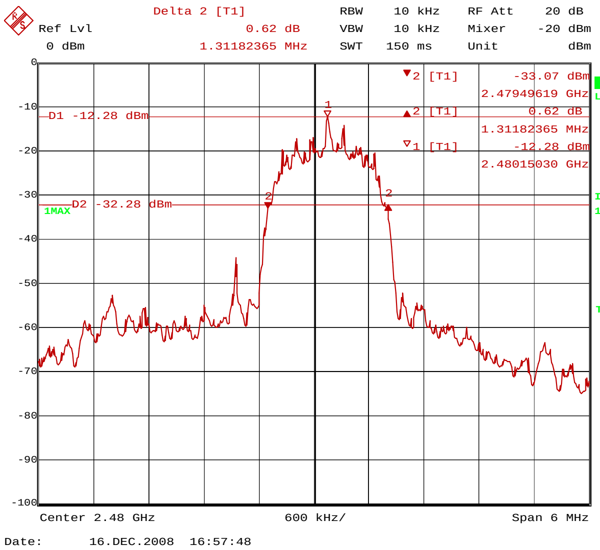
Middle Channel(2441 MHz)





Highest Channel(2480 MHz)





5.5 NUMBER OF HOPPING CHANNELS

5.5.1 Regulation

According to §15.247(a)(1)(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.

According to §15.247(b)(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 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

5.5.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable and attenuator.
3. Turn on the EUT and set the hopping function enabled by controlling it via UART interface.
4. Set the spectrum analyzer as follows:
   Span = the frequency band of operation
   RBW ≥ 1% of the span
   VBW ≥ RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
5. Record the number of hopping channels.

5.5.3 Test Results: PASS

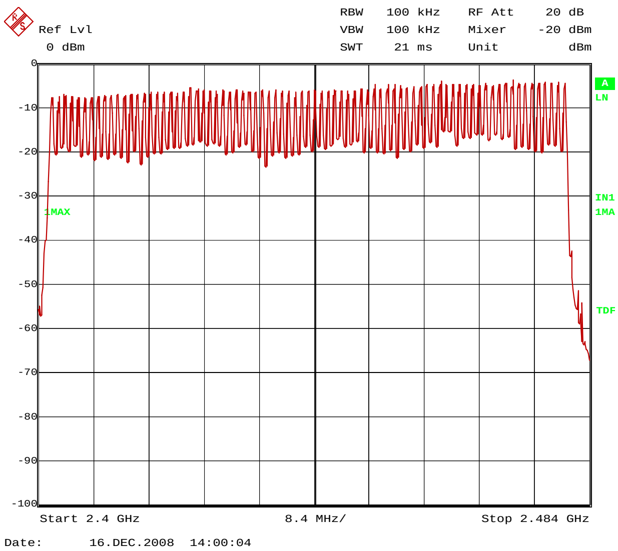
Table 4: Measured values of the Number of Hopping Channels

Operating frequency	Number of hopping channels	Limit
GFSK Modulation		
2402 - 2480 MHz	79	≥ 15
π /4 DQPSK Modulation		
2402 - 2480 MHz	79	≥ 15

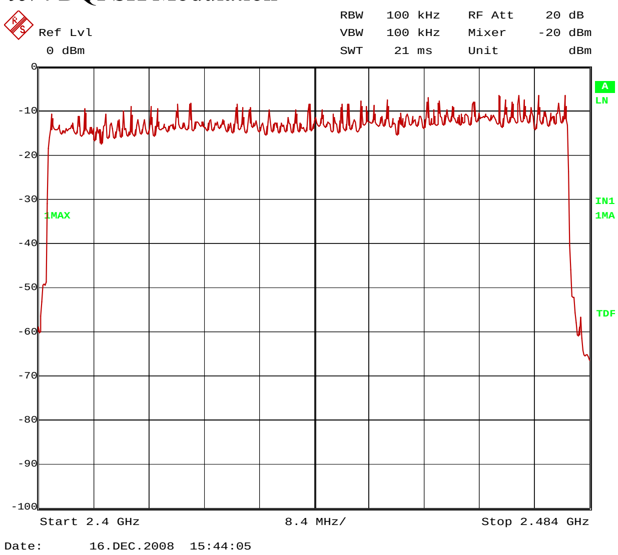
NOTE: We took the insertion loss of the attenuator and cable loss into consideration within the measuring instrument.

Figure 4. Plot of the Number of Hopping Channels (Conducted)

GFSK Modulation



π /4 DQPSK Modulation



5.6 TIME OF OCCUPANCY (DWELL TIME)

5.6.1 Regulation

According to §15.247(a)(1)(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.

5.6.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via UART interface.
4. Set the spectrum analyzer as follows:
   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
5. Measure the dwell time using the marker-delta function.
6. Repeat above procedures until all frequencies measured were complete.
7. Repeat this test for different modes of operation (e.g., data rate, modulation format, etc.), if applicable.

5.6.3 Test Results: PASS

Table 5: Measured values of the Time of Occupancy

Operating frequency	Reading	Hopping rate	Number of Channels	Actual	Limit
GFSK Modulation					
2402 MHz	2.902 ms	266.667 hops/s	79	0.310 seconds	0.4 seconds
2441 MHz	2.902 ms	266.667 hops/s	79	0.310 seconds	0.4 seconds
2480 MHz	2.902 ms	266.667 hops/s	79	0.310 seconds	0.4 seconds
π /4 DQPSK Modulation					
2402 MHz	2.910 ms	266.667 hops/s	79	0.310 seconds	0.4 seconds
2441 MHz	2.910 ms	266.667 hops/s	79	0.310 seconds	0.4 seconds
2480 MHz	2.910 ms	266.667 hops/s	79	0.310 seconds	0.4 seconds

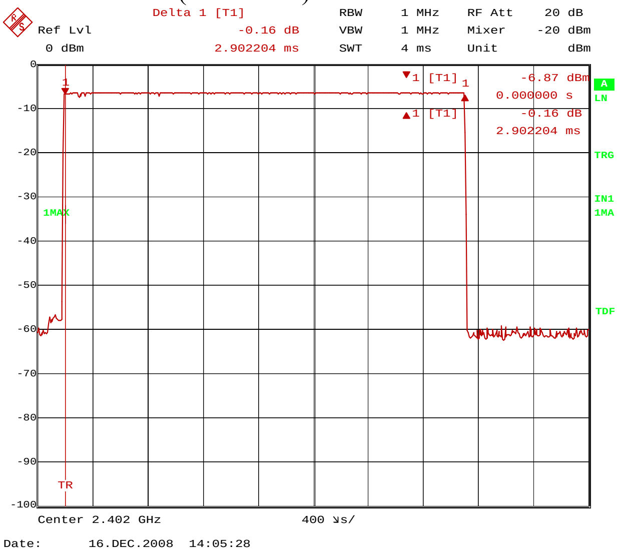
Actual = Reading × (Hopping rate / Number of channels) × Test period
Test period = 0.4 [seconds / channel] × 79 [channel] = 31.6 [seconds]

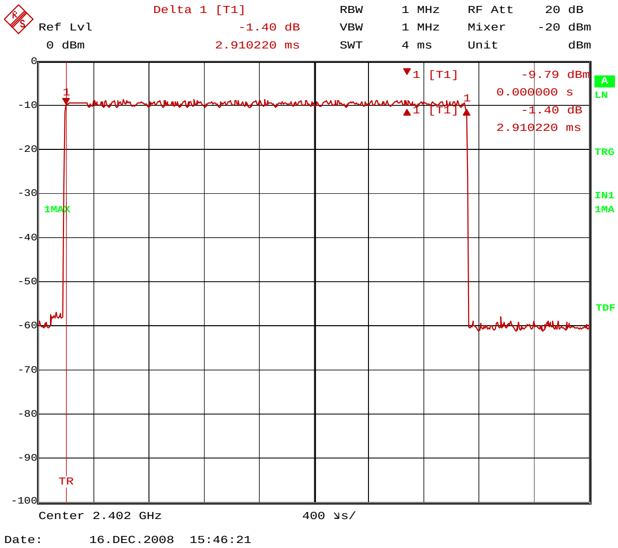
NOTE:
1. The EUT makes worst case 1600 hops per second or 1 time slot has a length of 625μs with 79 channels. The DH5 Packet for GFSK Modulation and the 2-DH5 Packet for π /4 DQPSK Modulation needs 5 time slot for transmitting and 1 time slot for receiving. Then the EUT makes worst case 266.667 hops per second with 79 channels.
2. We took the insertion loss of the cable loss into consideration within the measuring instrument.

Figure 5. Plot of the Time of Occupancy (Conducted)

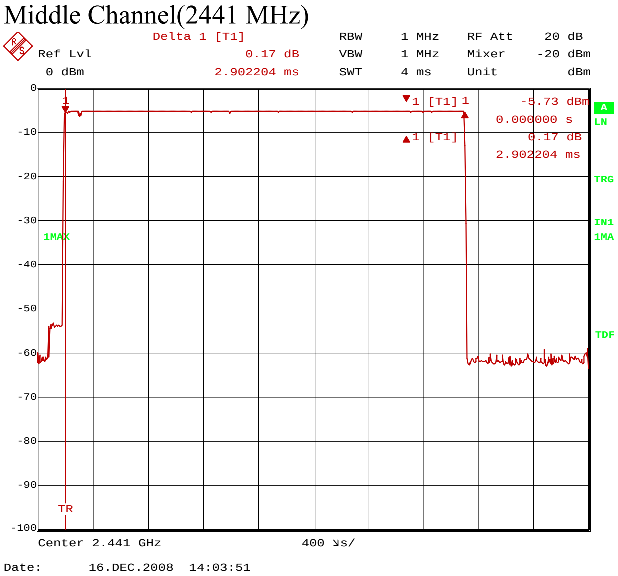
GFSK Modulation / **π /4 DQPSK Modulation**

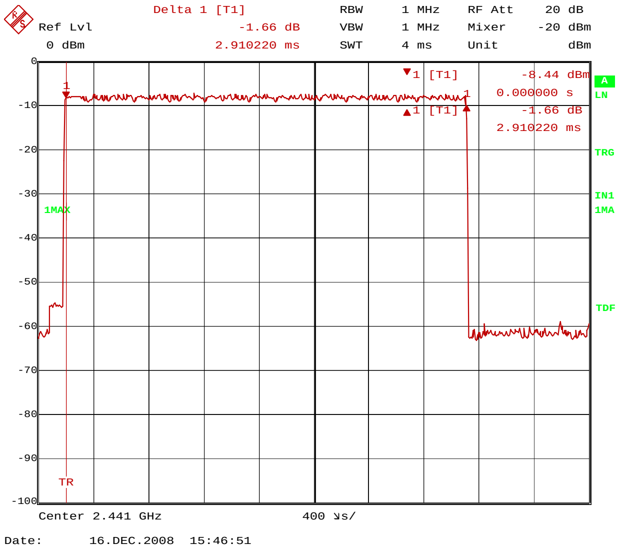
Lowest Channel(2402 MHz)



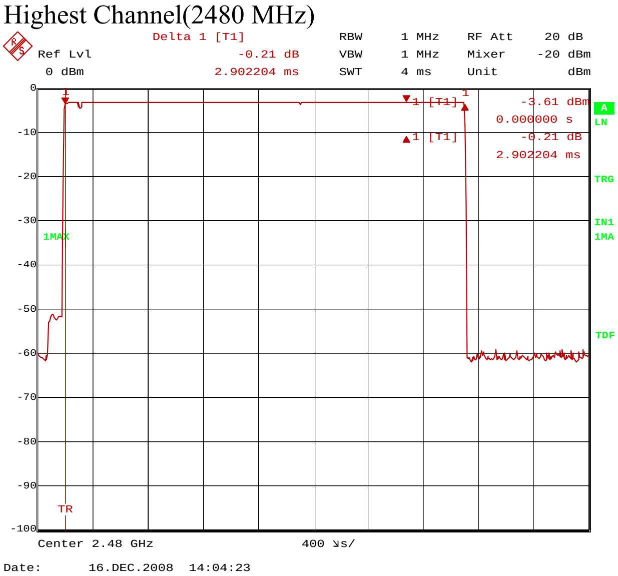


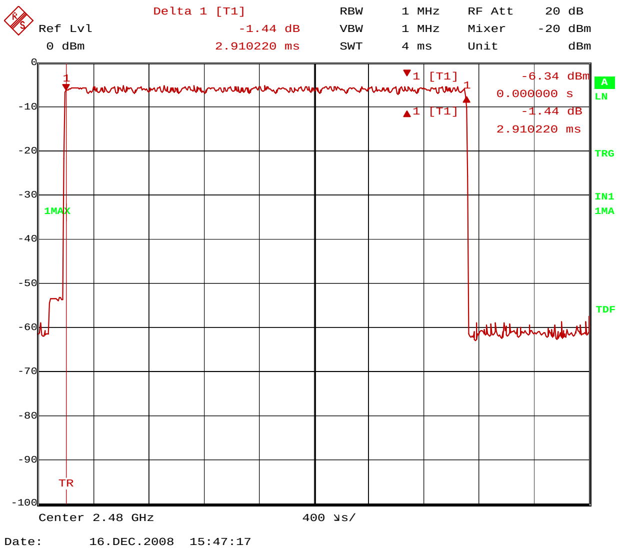
Middle Channel(2441 MHz)





Highest Channel(2480 MHz)





5.7 SPURIOUS EMISSIONS, BAND EDGE, AND RESTRICTED BANDS

5.7.1 Regulation

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 emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

According to §15.209(a), for an intentional device, the general requirement of field strength of radiated emissions from intentional radiators at a distance of 3 meters shall not exceed the following values:

Frequency (MHz)	Field strength (µV/m @ 3m)	Field strength (dBµV/m @ 3m)
30–88	100	40.0
88–216	150	43.5
216–960	200	46.0
Above 960	500	54.0

According to §15.109(a), for an unintentional device, except for Class A digital devices, the field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the above table.

** The emission limits shown in the above table are based on measurement instrumentation employing a CISPR quasi-peak detector and above 1000 MHz are based on the average value of measured emissions.

5.7.2 Test Procedure

1) Band-edge Compliance of RF Conducted Emissions

1. Set the spectrum analyzer as follows:
   - Span = wide enough to capture the peak level of the emission operating on the channel closest to the bandedge, 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
2. 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.
3. 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.

2) Spurious RF Conducted Emissions:

1. Set the spectrum analyzer as follows:
   - 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
2. Allow the trace to stabilize. Set the marker on the peak of any spurious emission recorded.

3) Spurious Radiated Emissions:

1. The preliminary radiated measurements were performed to determine the frequency producing the maximum emissions in an anechoic chamber at a distance of 3 meters.
2. The EUT was placed on the top of the 0.8-meter height, 1 × 1.5 meter non-metallic table. To find the maximum emission levels, the height of a measuring antenna was changed and the turntable was rotated 360˚.
3. The antenna polarization was also changed from vertical to horizontal. The spectrum was scanned from 30 to 1000 MHz using the TRILOG broadband antenna, and from 1000 MHz to 18000 MHz using the horn antenna.
4. To obtain the final measurement data, the EUT was arranged on a turntable situated on a 4 × 4 meter at the Open Area Test Site. The EUT was tested at a distance 3 meters.
5. Each frequency found during preliminary measurements was re-examined and investigated. The test-receiver system was set up to average, peak, and quasi-peak detector function with specified bandwidth.

6. The EUT is situated in three orthogonal planes (if appropriate)
7. The presence of ambient signals was verified by turning the EUT off. In case an ambient signal was detected, the measurement bandwidth was reduced temporarily and verification was made that an additional adjacent peak did not exist. This ensures that the ambient signal does not hide any emissions from the EUT.
8. If the emission on which a radiated measurement must be made is located at the edge of the authorized band of operation, then the alternative “marker-delta” method may be employed.

4) Marker-Delta Method at the edge of the authorized band of operation:

1. Perform an in-band field strength measurement of the fundamental emission using the RBW and detector function as the above Spurious Radiated Emissions test procedure.
2. Choose a spectrum analyzer span that encompasses both the peak of the fundamental emission and the band-edge emission under investigation. Set the analyzer RBW to 1% of the total span (but never less than 30 kHz) with a video bandwidth equal to or greater than the RBW. Record the peak levels of the fundamental emission and the relevant band-edge emission (i.e., run several sweeps in peak hold mode). Observe the stored trace and measure the amplitude delta between the peak of the fundamental and the peak of the band-edge emission. This is not a field strength measurement; it is only a relative measurement to determine the amount by which the emission drops at the band-edge relative to the highest fundamental emission level.
3. Subtract the delta measured in step (2) from the field strengths measured in step (1). The resultant field strengths (CISPR QP, average, or peak, as appropriate) are then used to determine band-edge compliance as required by Section 15.205.
4. The above "delta" measurement technique may be used for measuring emissions that are up to two "standard" bandwidths away from the band-edge, where a "standard" bandwidth is the bandwidth specified by C63.4 for the frequency being measured. For example, for band-edge measurements in the restricted band that begins at 2483.5 MHz, C63.4 specifies a measurement bandwidth of at least 1 MHz. Therefore you may use the "delta" technique for measuring emissions up to 2 MHz removed from the band-edge. Radiated emissions that are removed by more than two “standard” bandwidths must be measured as the above Spurious Radiated Emissions test procedure.

5.7.3 Test Results: PASS

Band-edge compliance of RF conducted/radiated emissions was shown in the Figure 6 and 7.
Spurious RF conducted emissions were shown in the Figure 8.

NOTE: We took the insertion loss of the cable loss into consideration within the measuring instrument.

GFSK Modulation

Table 6: Measured values of the Field strength of spurious emission (Radiated)

Frequency [MHz]	Receiver Bandwidth [kHz]	Pol. [V/H]	Antenna Height [m]	Turn Table [degree]	Reading [dB(μV)]	Amp Gain [dB]	ATT [dB]	AF [dB(1/m)]	CL [dB]	Actual [dB(μV/m)]	Limit [dB(μV/m)]	Margin [dB]
Quasi-peak data, emissions below 1000 MHz												
				No Spurious Radiated Emissions Found								
AVERAGE data, emissions above 1000 MHz												
2402.00	**1000**	**H**	**1.67**	**6**	**89.63**	**42.76**	**10.1**	**28.16**	**4.96**	**90.09**	-	-
1602.00*	1000	H	1.00	87	40.38	42.36	10.1	25.84	3.95	37.91	54.00	16.09
4804.00	1000	H	1.73	15	47.85	43.90	0.9	33.74	7.04	45.63	54.00	8.37
2441.00	**1000**	**H**	**1.64**	**187**	**89.91**	**42.76**	**10.1**	**28.16**	**4.96**	**90.37**	-	-
1626.00*	1000	H	1.00	97	40.73	42.36	10.1	25.84	3.95	38.26	54.00	15.74
4882.00	1000	H	1.73	22	45.23	43.95	0.9	33.83	7.16	43.17	54.00	10.83
2480.00	**1000**	**V**	**1.90**	**180**	**88.92**	**42.80**	**10.1**	**28.52**	**5.22**	**89.96**	-	-
1654.00*	100	H	1.00	179	40.92	42.42	10.1	26.06	4.08	38.74	54.00	15.26
4960.00	1000	H	1.73	27	43.22	44.00	0.9	33.92	7.30	41.34	54.00	12.66
PEAK data, emissions above 1000 MHz												
2402.00	**1000**	**H**	**1.67**	**6**	**93.41**	**42.76**	**10.1**	**28.16**	**4.96**	**93.87**	-	-
1602.00*	1000	H	1.00	87	51.39	42.36	10.1	25.84	3.95	48.92	74.00	25.08
4804.00	1000	H	1.73	15	63.65	43.90	0.9	33.74	7.04	61.43	74.00	12.57
2441.00	**1000**	**H**	**1.64**	**187**	**93.64**	**42.76**	**10.1**	**28.16**	**4.96**	**94.10**	-	-
1626.00*	1000	H	1.00	97	51.39	42.36	10.1	25.84	3.95	48.92	74.00	25.08
4882.00	1000	H	1.73	22	62.04	43.95	0.9	33.83	7.16	59.98	74.00	14.02
2480.00	**1000**	**V**	**1.90**	**180**	**92.50**	**42.80**	**10.1**	**28.52**	**5.22**	**93.54**	-	-
1654.00*	100	H	1.00	179	52.24	42.42	10.1	26.06	4.08	50.06	74.00	23.94
4960.00	1000	H	1.73	27	61.36	44.00	0.9	33.92	7.30	59.48	74.00	14.52

Margin (dB) = Limit – Actual

[Actual = Reading – Amp Gain + Attenuator + AF + CL]

1. H = Horizontal, V = Vertical Polarization
2. ATT = Attenuation (10dB pad and/or Insertion Loss of HPF), AF/CL = Antenna Factor and Cable Loss

* The spurious emission at the frequency does not fall in the restricted bands.

** The measured result is within the test standard limit by a margin less than the measurement uncertainty; it is therefore not possible to state compliance based on the 95 % level of confidence. However, the result indicates that compliance is more probable than non-compliance.

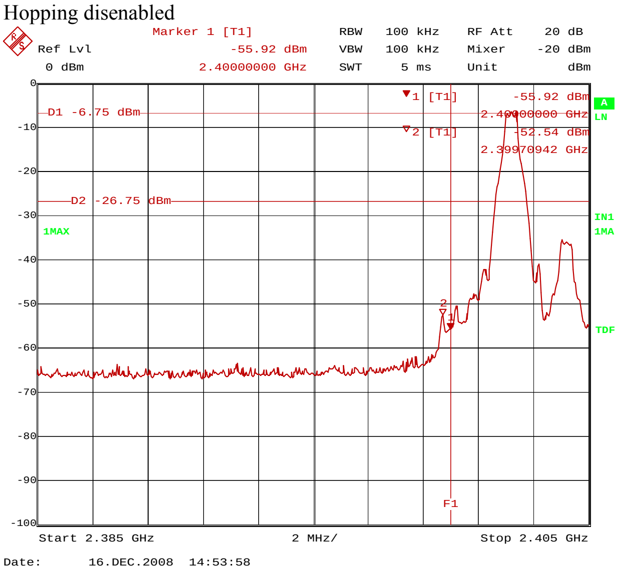
NOTE: All emissions not reported were more than 20 dB below the specified limit or in the noise floor.

Figure 6. Plot of the Band Edge (Conducted)

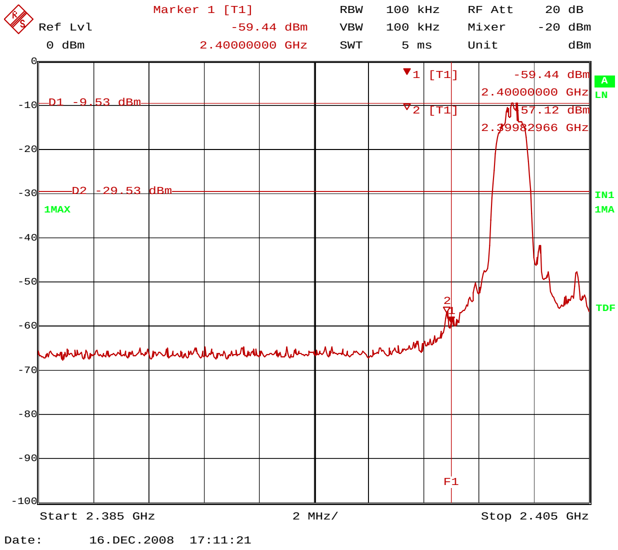
GFSK Modulation

Lower band-edge

Hopping disenabled

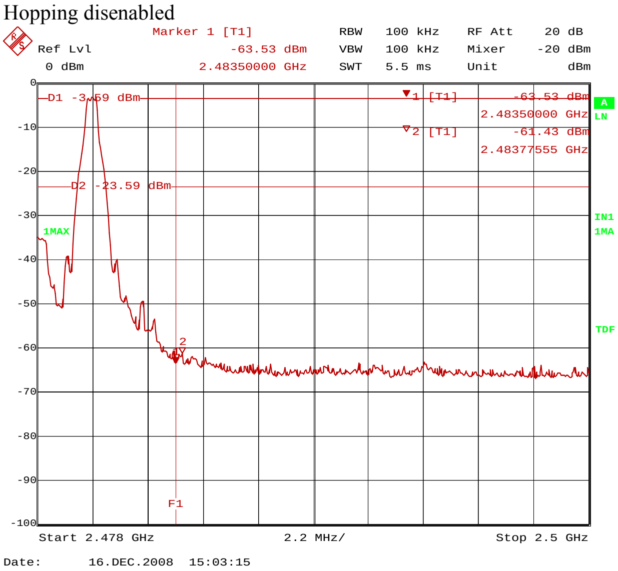


π /4 DQPSK Modulation



Upper band-edge

Hopping disenabled



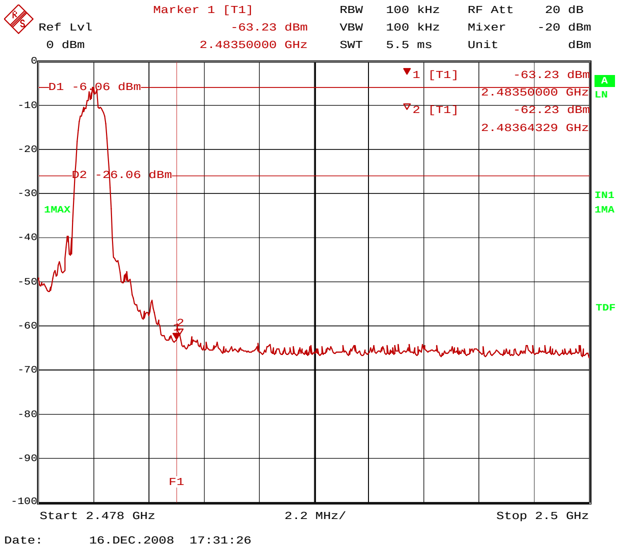
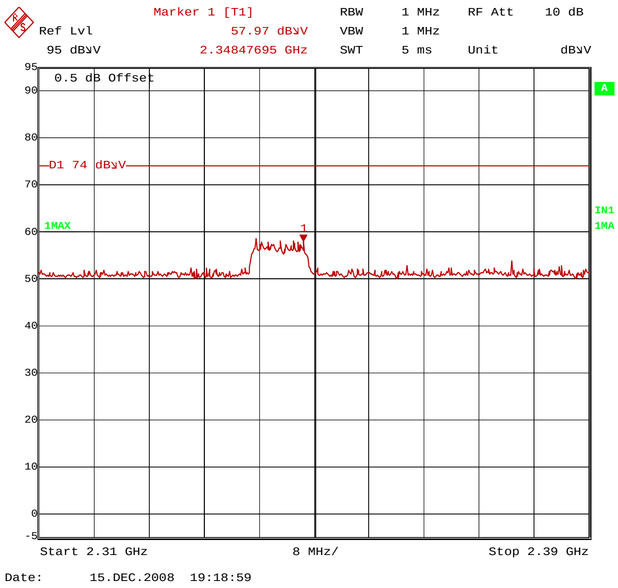
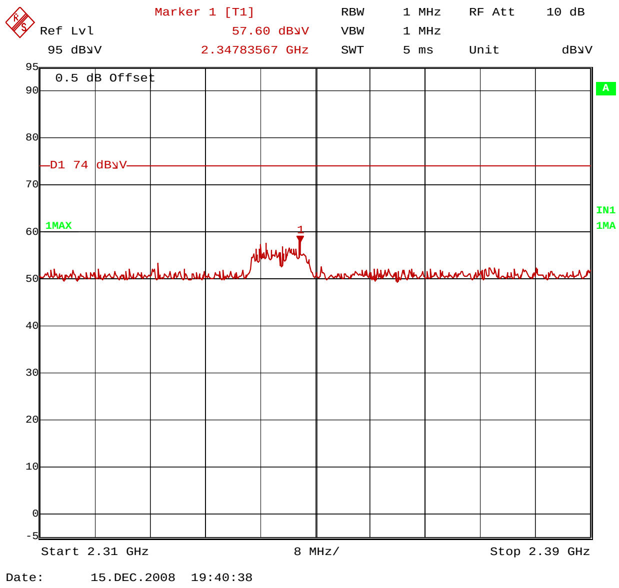


Figure 7. Plot of the Band Edge (Radiated)

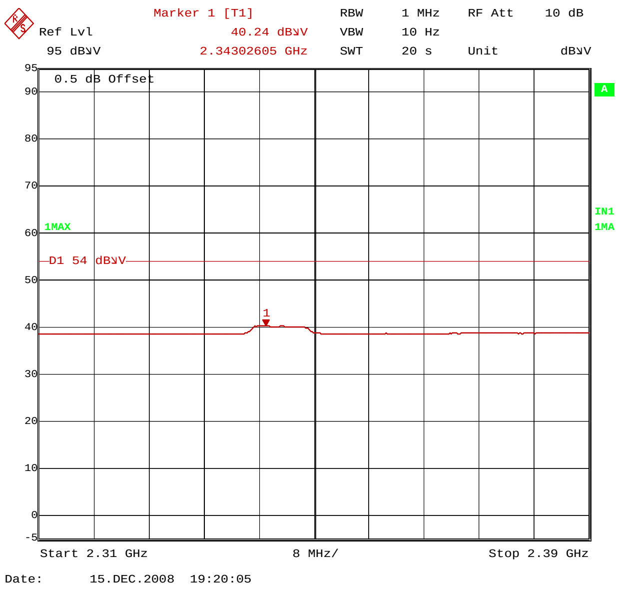
GFSK Modulation **π /4 DQPSK Modulation**

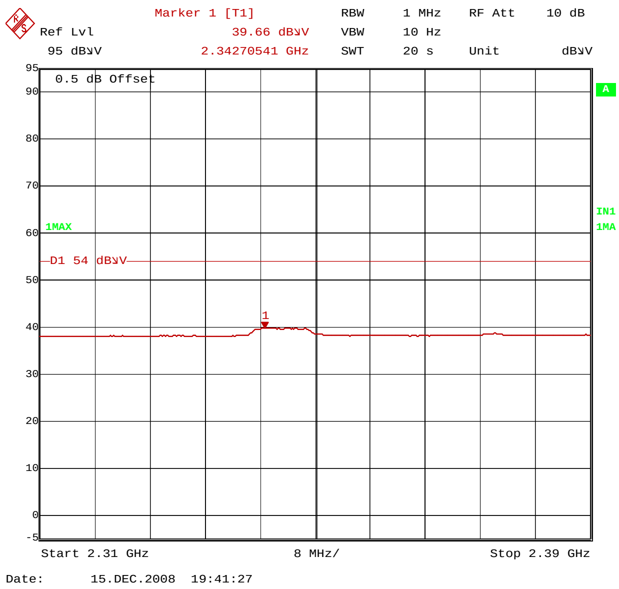
Lowest Channel (operating at 2402 MHz): PEAK





Lowest Channel (operating at 2402 MHz): AVERAGE



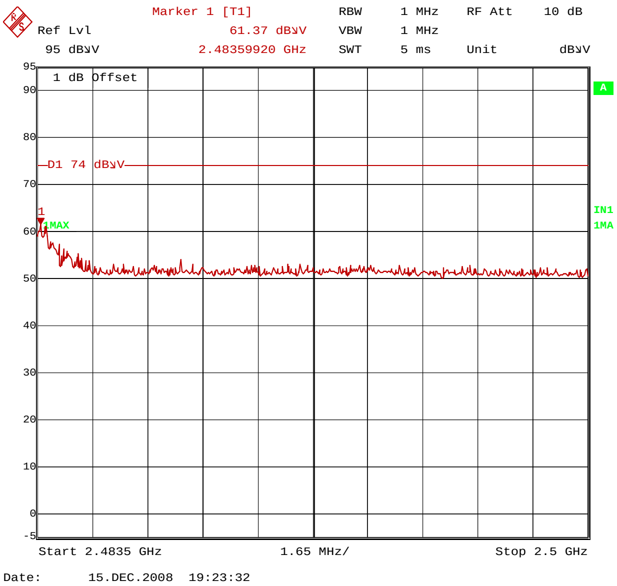


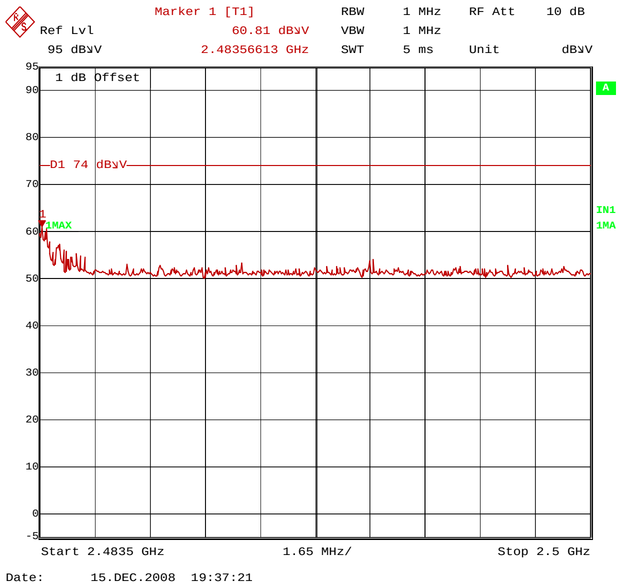
* The Measurement results were calibrated to the field strength by using the offset[+0.46 dB].
Table 6. contained the correction factors at the operating frequencies such as antenna factor, cable loss and so on.

Figure 7. Plot of the Band Edge (Radiated)

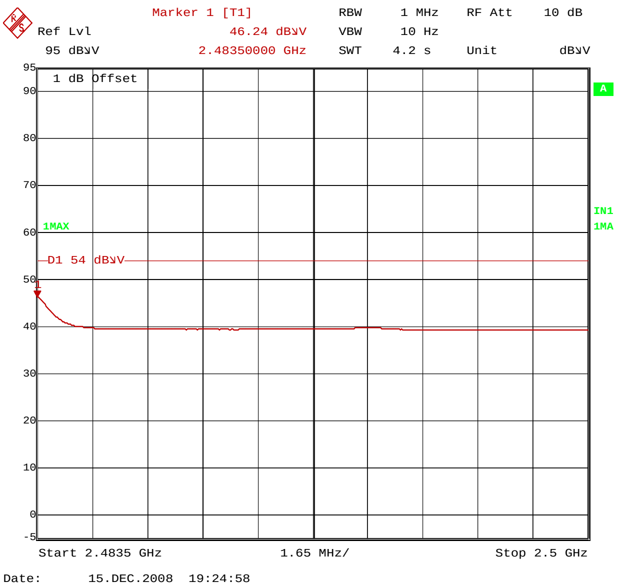
GFSK Modulation **π /4 DQPSK Modulation**

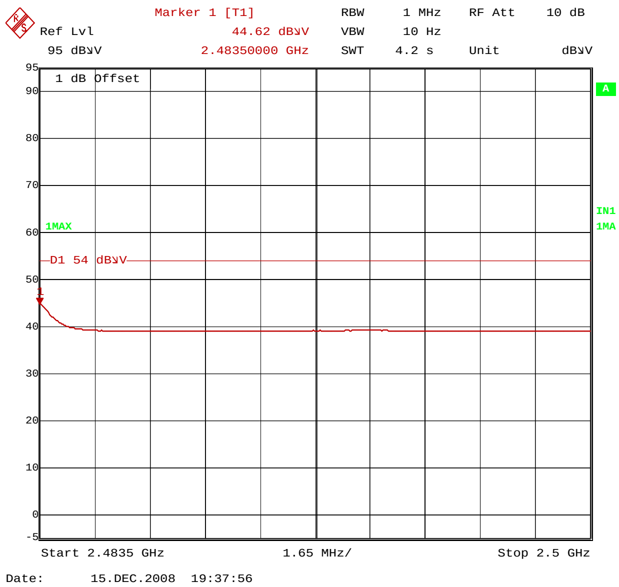
Highest Channel (operating at 2480 MHz): PEAK





Highest Channel (operating at 2480 MHz): AVERAGE

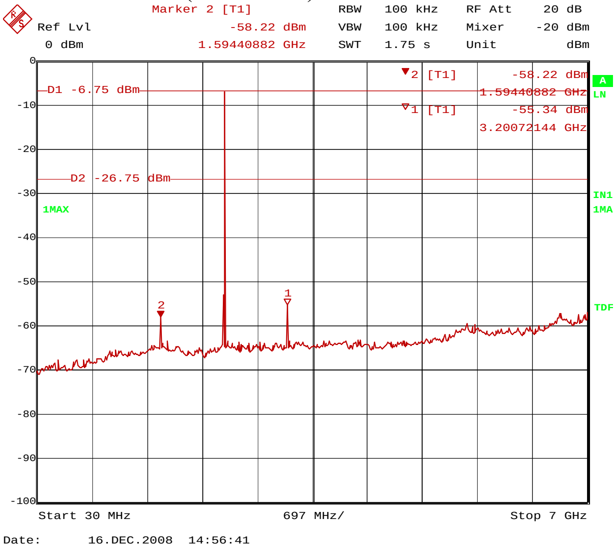




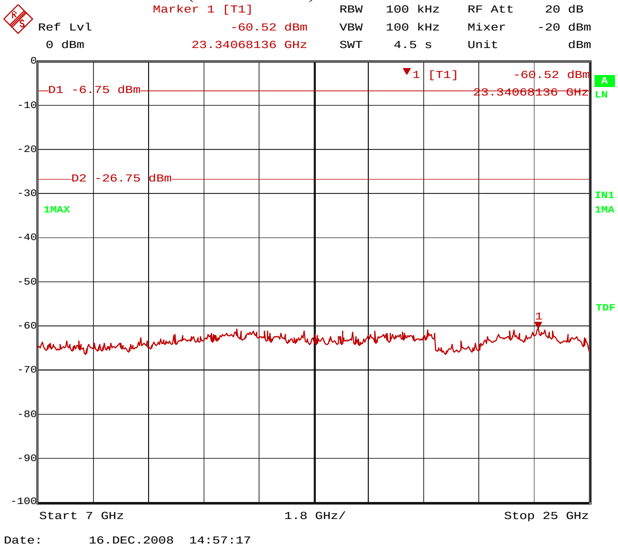
* The Measurement results were calibrated to the field strength by using the offset[+1.04 dB].
Table 6. contained the correction factors at the operating frequencies such as antenna factor, cable loss and so on.

Figure 8: Spurious RF conducted emissions__ GFSK Modulation

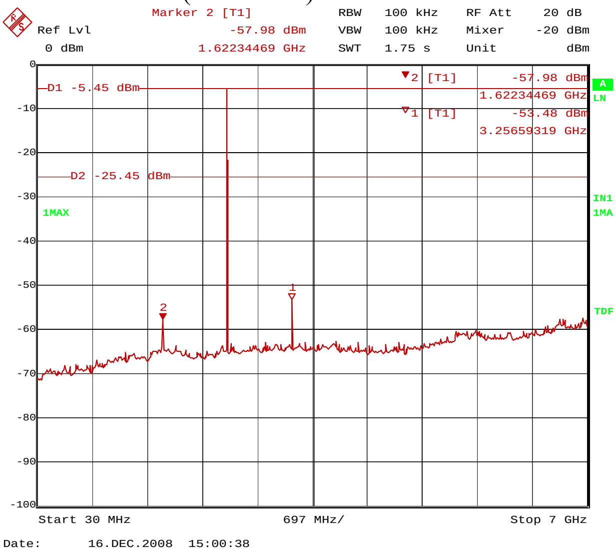
Lowest Channel (2402 MHz): 30 MHz ~ 7 GHz



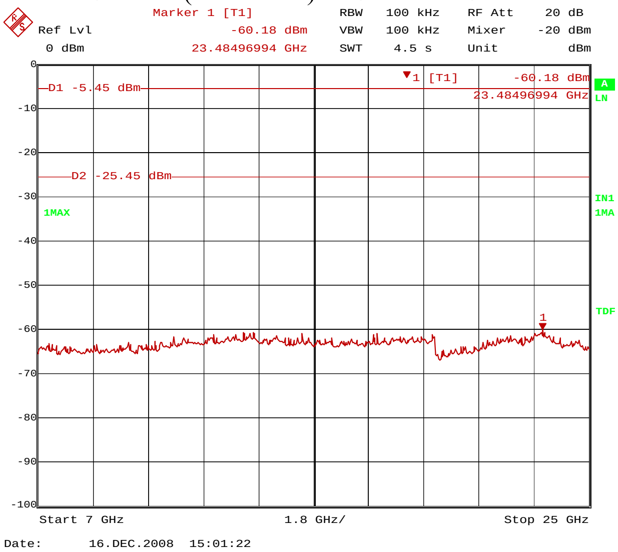
Lowest Channel (2402 MHz): 7 GHz ~ 25 GHz



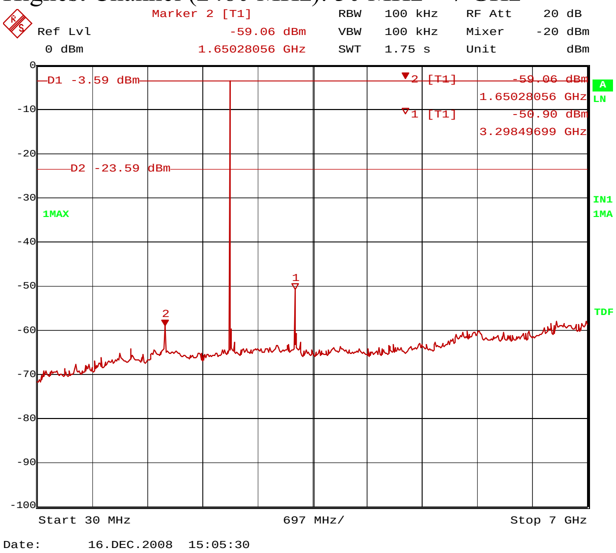
Middle Channel (2441 MHz): 30 MHz ~ 7 GHz



Middle Channel (2441 MHz): 7 GHz ~ 25 GHz



Highest Channel (2480 MHz): 30 MHz ~ 7 GHz



Highest Channel (2480 MHz): 7 GHz ~ 25 GHz

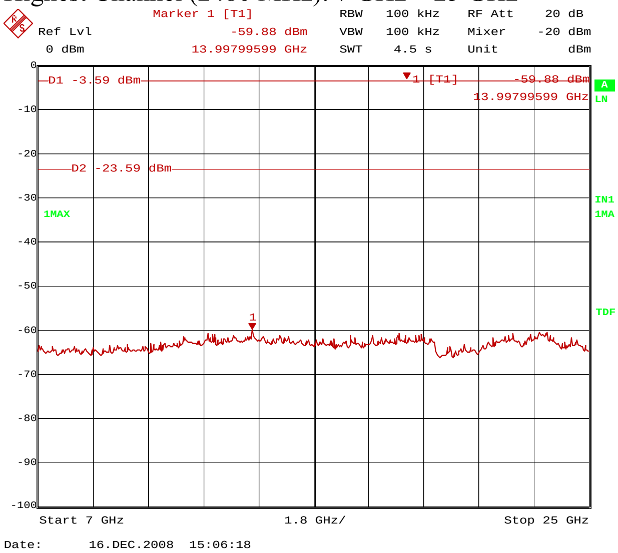
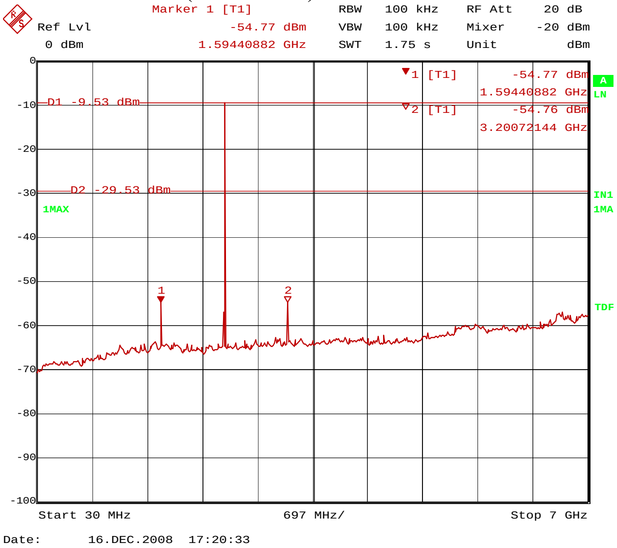
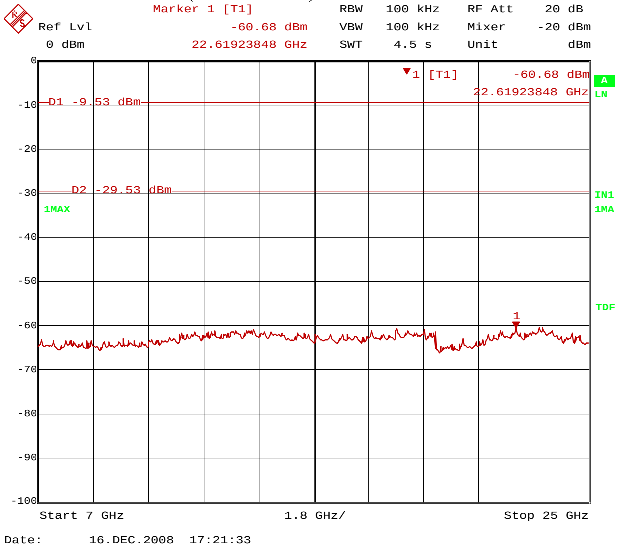


Figure 8: Spurious RF conducted emissions__ π /4 DQPSK Modulation

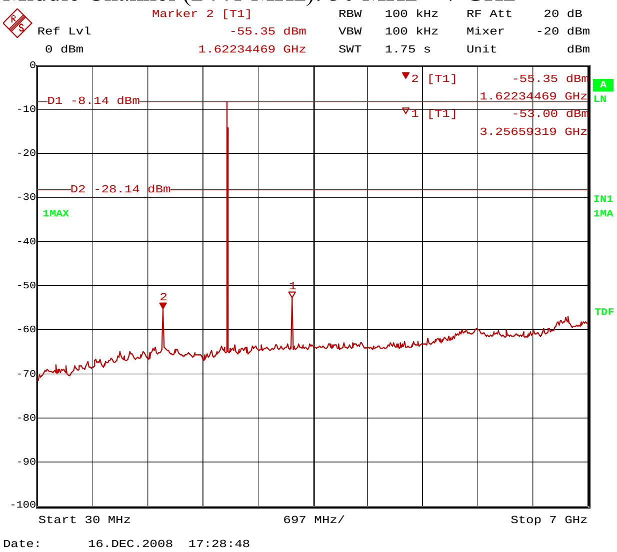
Lowest Channel (2402 MHz): 30 MHz ~ 7 GHz



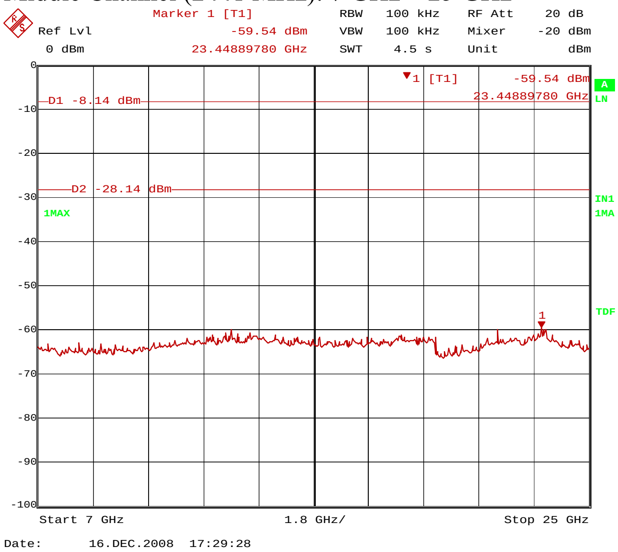
Lowest Channel (2402 MHz): 7 GHz ~ 25 GHz



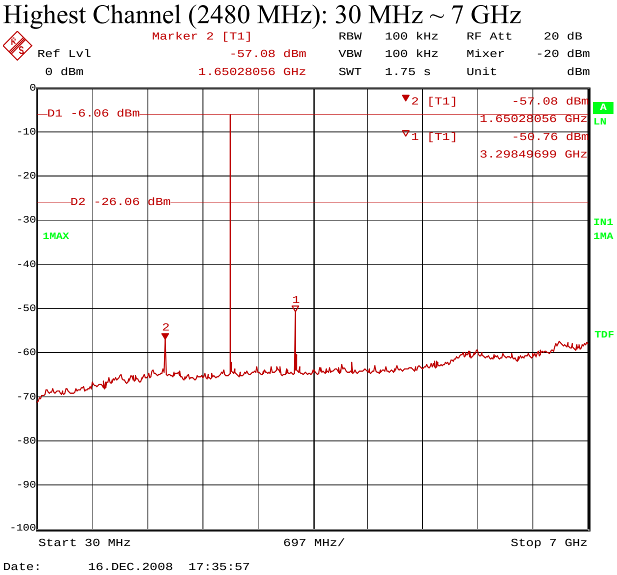
Middle Channel (2441 MHz): 30 MHz ~ 7 GHz



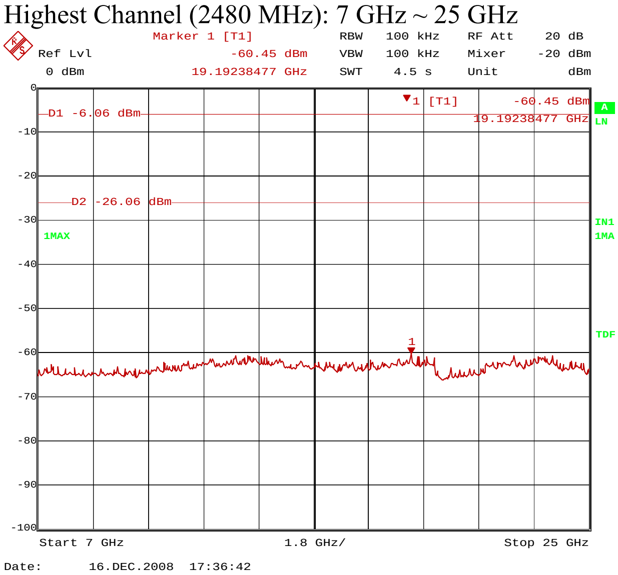
Middle Channel (2441 MHz): 7 GHz ~ 25 GHz



Highest Channel (2480 MHz): 30 MHz ~ 7 GHz



Highest Channel (2480 MHz): 7 GHz ~ 25 GHz



5.8 PEAK POWER SPECTRAL DENSITY

5.8.1 Regulation

According to §15.247(e), for digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

5.8.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable and attenuator.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via UART interface and make sure the spectrum analyzer is operated in its linear range.
4. Set the spectrum analyzer to MAX HOLD mode with RBW = 3kHz.
5. Measure the highest amplitude appearing on spectral display and record the level to calculate results.
6. Repeat above procedures until all frequencies measured were complete.

5.8.3 Test Results: PASS

Table 7: Measured values of the Peak Power Spectral Density

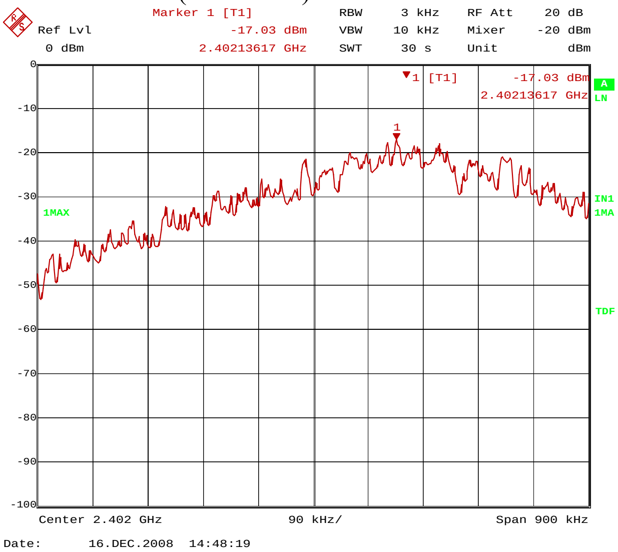
Operating frequency	Actual	Limit
GFSK Modulation		
2402 MHz	-17.03 dBm	8.0 dBm
2441 MHz	-13.86 dBm	8.0 dBm
2480 MHz	-16.13 dBm	8.0 dBm
π/4 DQPSK Modulation		
2402 MHz	-21.05 dBm	8.0 dBm
2441 MHz	-19.86 dBm	8.0 dBm
2480 MHz	-17.35 dBm	8.0 dBm

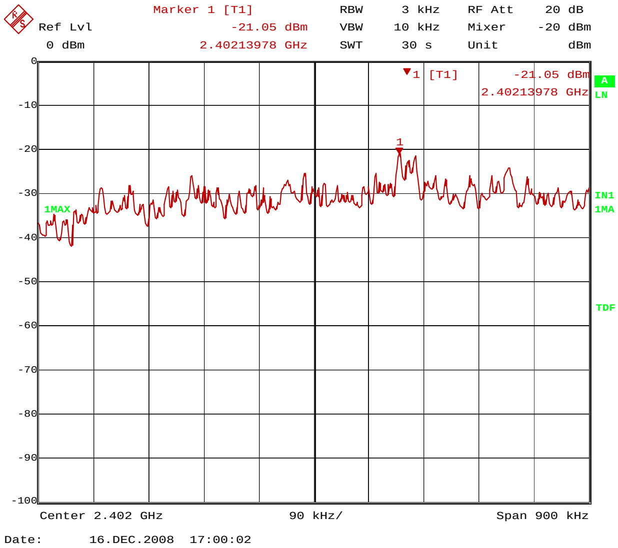
NOTE: We took the insertion loss of the cable loss into consideration within the measuring instrument.

Figure 9. Plot of the Peak Power Spectral Density

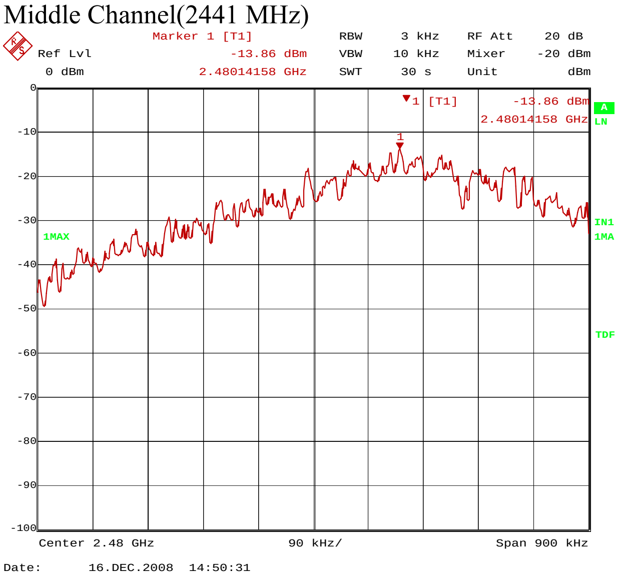
GFSK Modulation **π /4 DQPSK Modulation**

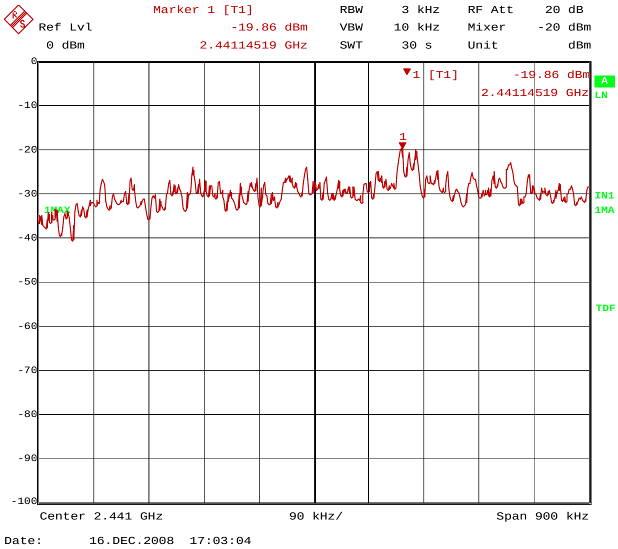
Lowest Channel(2402 MHz)



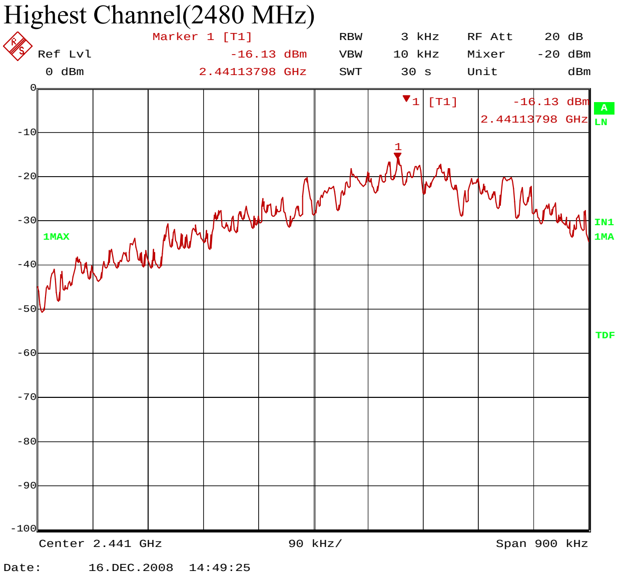


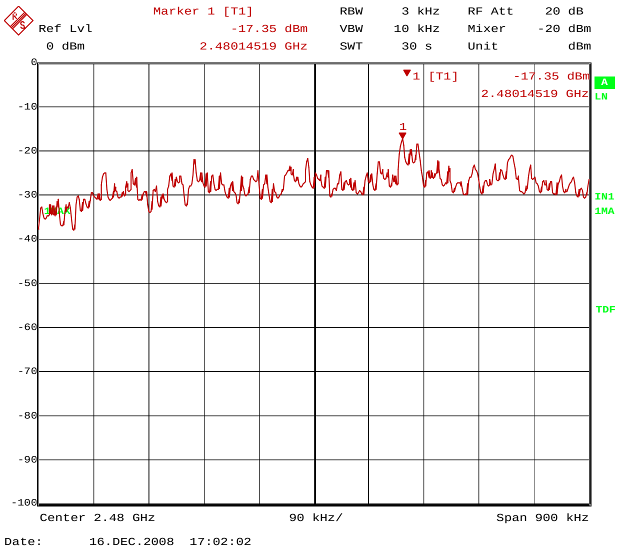
Middle Channel(2441 MHz)





Highest Channel(2480 MHz)





5.9 AC POWER LINE CONDUCTED EMISSIONS

5.9.1 Regulation

According to §15.207(a), 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 50μH/50Ω 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.

Frequency of emission (MHz)	Conducted limit (dBμV)	
	Qausi-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.

According to §15.107(a), for unintentional device, except for Class A digital devices, line conducted emission limits are the same as the above table.

5.9.2 Test Procedure

1. The EUT was placed on a wooden table of size, 1 m by 1.5 m, raised 80 cm in which is located 40 cm away from the vertical wall and 1.5m away from the side wall of the shielded room.
2. Each current-carrying conductor of the EUT power cord was individually connected through a 50Ω/50μH LISN, which is an input transducer to a Spectrum Analyzer or an EMI/Field Intensity Meter, to the input power source.
3. Exploratory measurements were made to identify the frequency of the emission that had the highest amplitude relative to the limit by operating the EUT in a range of typical modes of operation, cable position, and with a typical system equipment configuration and arrangement. Based on the exploratory tests of the EUT, the one EUT cable configuration and arrangement and mode of operation that had produced the emission with the highest amplitude relative to the limit was selected for the final measurement.
4. The final test on all current-carrying conductors of all of the power cords to the equipment that comprises the EUT (but not the cords associated with other non-EUT equipment is the system) was then performed over the frequency range of 0.15 MHz to 30 MHz.
5. The measurements were made with the detector set to PEAK amplitude within a bandwidth of 10 kHz or to QUASI-PEAK and AVERAGE within a bandwidth of 9 kHz. The EUT was in transmitting mode during the measurements.

5.9.3 Test Results: PASS

Table 9: Measured values of the Conducted Emissions

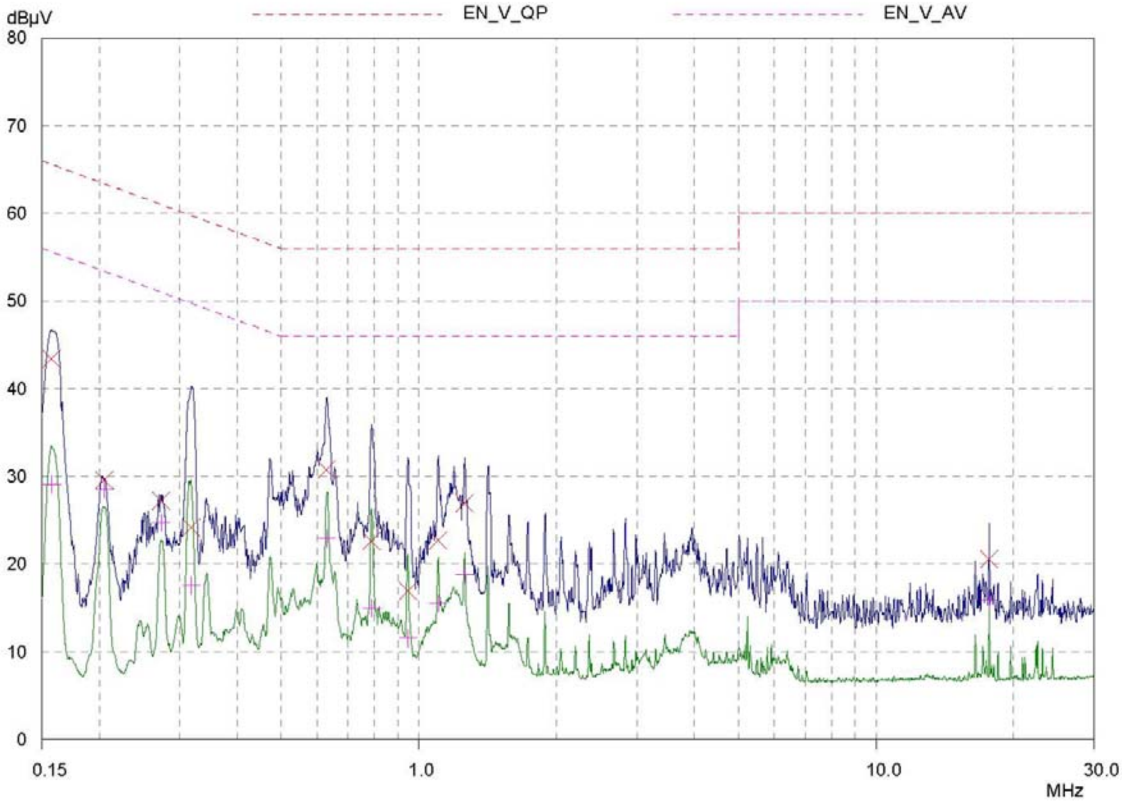
Frequency [MHz]	Reading [dBμV]	L / N	CF [dB]	CL [dB]	Actual [dBμV]	Limit [dBμV]	Margin [dB]
QUASI-PEAK DATA							
0.151	44.48	N	0.05	0.01	44.54	65.97	21.43
0.157	43.38	L	0.06	0.01	43.45	65.60	22.15
0.302	37.65	N	0.14	0.02	37.81	60.20	22.39
0.607	33.07	N	0.12	0.05	33.24	56.00	22.76
0.629	30.79	L	0.13	0.05	30.97	56.00	25.03
0.756	29.04	N	0.13	0.07	29.24	56.00	26.76
1.210	28.10	N	0.14	0.07	28.31	56.00	27.69
1.259	26.93	L	0.14	0.07	27.14	56.00	28.86
AVERAGE DATA							
0.204	30.69	53.45	0.14	0.02	30.85	53.45	22.60
0.206	28.52	53.38	0.12	0.02	28.66	53.38	24.72
0.272	26.58	51.06	0.14	0.02	26.74	51.06	24.32
0.302	28.11	50.20	0.14	0.02	28.27	50.20	21.93
0.607	23.40	46.00	0.12	0.05	23.57	46.00	22.43
0.629	22.90	46.00	0.13	0.05	23.08	46.00	22.92
0.756	21.32	46.00	0.13	0.07	21.52	46.00	24.48
1.210	21.08	46.00	0.14	0.07	21.29	46.00	24.71

Margin (dB) = Limit – Actual
[Actual = Reading + CF + CL]
L/N = LINE / NEUTRAL
CF/CL = Correction Factor and Cable Loss

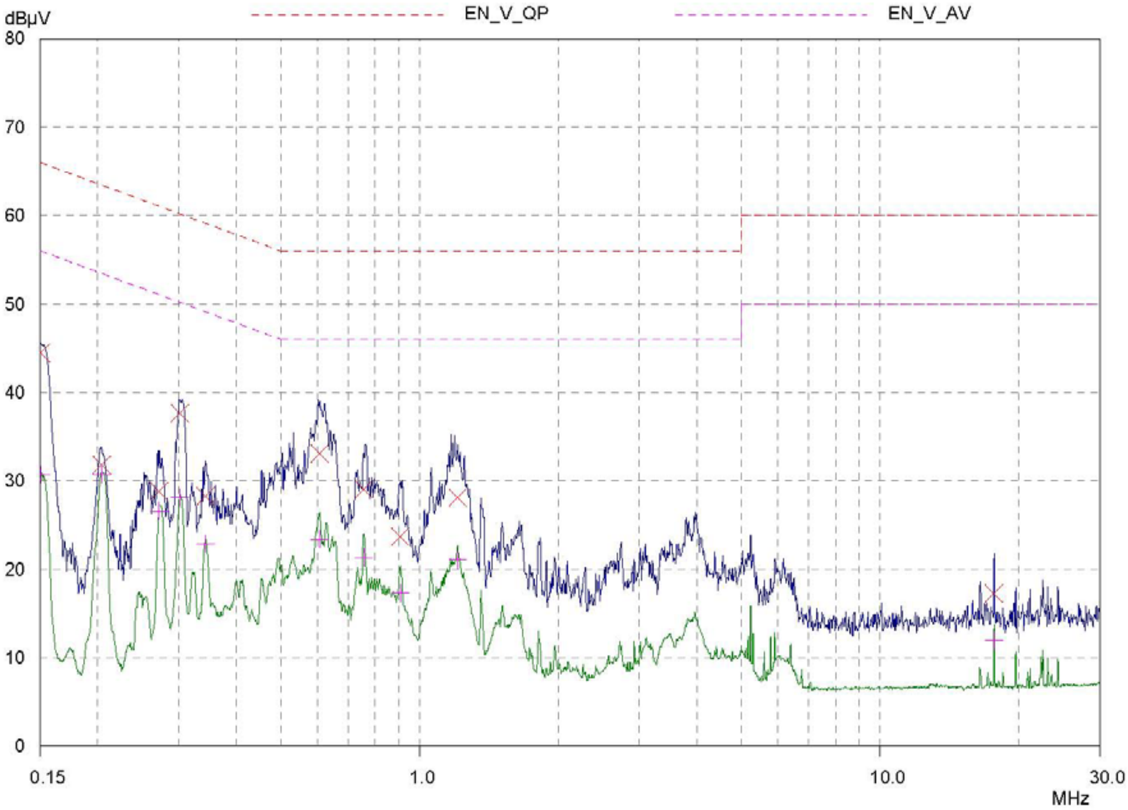
NOTE: The frequency range was scanned from 150 kHz to 30 MHz. All emissions not reported were more than 20 dB below the specified limit.

Figure 10. Plot of the AC Power Line Conducted Emissions

Line – PE(Peak and Average detector used)



Neutral – PE(Peak and Average detector used)



5.10 RF Exposure

5.10.1 Regulation

According to §15.247(i), systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines. See § 1.1307(b)(1) of this Chapter.

Limits for Maximum Permissive Exposure: RF exposure is calculated.

Frequency Range	Electric Field Strength [V/m]	Magnetic Field Strength [A/m]	Power Density [mW/cm^2]	Averaging Time [minute]
Limits for General Population/Uncontrolled Exposure				
0.3 ~ 1.34	614	1.63	*(100)	30
1.34 ~ 30	824/f	2.19/f	*(180/f^2)	30
30 ~ 300	27.5	0.073	0.2	30
300 ~ 1500	/	/	f/1500	30
1500 ~ 15000	/	/	1.0	30

f = frequency in MHz, * = Plane-wave equivalent power density

MPE (Maximum Permissive Exposure) Prediction

Predication of MPE limit at a given distance: Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = PG/4\pi R^2$$

$$\left(\Rightarrow R = \sqrt{PG/4\pi S}\right)$$

S = power density [mW/cm^2]
P = power input to antenna [mW]
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna [cm]

EUT: Maximum peak output power=0.50 [mW](= -3.02 dBm)& Antenna gain=1.22 (= 0.86 [dBi])	
100 mW, at 20 cm from an antenna 6 [dBi]	S = PG/4πR² = 100 × 3.98 / (4 × π × 400) = 0.0792 [mW/cm2] < 1.0 [mW/cm2]
0.50 mW, at 20 cm from the antenna 0.86 [dBi]	S = PG/4πR² = 0.0001 [mW/cm^2] < 1.0 [mW/cm^2]
0.50 mW, at 2.5 cm from the antenna 0.86 [dBi]	S = PG/4πR² = 0.0051 [mW/cm^2] < 1.0 [mW/cm^2]

5.10.2 RF Exposure Compliance Issue

The EUT is categorically excluded from routine environmental because it operates at very low power level. The equipment is deemed to comply with the SAR or MPE limits without testing due to this very low power level. SAR data was not submitted because the output power of the EUT was below the low thresholds in the July 02 TCB Exclusion List: for portable transmitters,

Low threshold [(60/f_{GHZ} ≈ 25) mW, d < 2.5 cm, (120/f_{GHZ} ≈ 50) mW, d ≥ 2.5 cm], and

High threshold [(900/f_{GHZ} ≈ 370) mW, d < 20 cm], where f_{GHz}: 2.44, d: distance to a person's body