SK TECH CO., LTD. *Page 1 of 28*

TEST REPORT

Test Report No.:	**SKTRFC-100930-011**		
Applicant:	**TMT ENGINEERING CO., LTD.**		
Applicant Address:	901, Gangbuk electronic complex #229-10, Beon-dong, Gangbuk-gu, Seoul, 142-705 South Korea		
Manufacturer:	**TMT ENGINEERING CO., LTD.**		
Manufacturer Address:	901, Gangbuk electronic complex #229-10, Beon-dong, Gangbuk-gu, Seoul, 142-705 South Korea		
Device Under Test:	**ZIGBEE WIRELESS DONGLE**		
FCC ID:	**YTZ-TF-200**	**Model Name:**	**TF-200**
Brand/Trade Name:	**TMT ENGINEERING**		
Receipt No.:	SKTEU10-0649	**Date of receipt:**	May 27, 2010
Date of Issue:	September 30, 2010		
Location of Testing:	**SK TECH CO., LTD.** #820-2, Wolmoon-ri, Wabu-up, Namyangju-si, Kyunggi-do, 472-905 South Korea		
Test Procedure:	**ANSI C63.4:2003**		
Test Specification:	**47CFR, Part 15 Rules**		
FCC Equipment Class:	**DTS - Part 15 Digital Transmission System**		
Test Result:	The above-mentioned device has been tested and passed.		

Tested & Reported by: *Seungtaek Shim* **Approved by:** *Jongsoo Yoon*

Signature	*September 30, 2010* *Date*	*Signature*	*September 30, 2010* *Date*

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

☞

- **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 Digital Transmission System. 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)
(OPEN AREA TEST SITE INDUSTRY CANADA NUMBER: IC 5429)

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 No.	Serial No.	Calibrated until	Used
1	Spectrum Analyzer	Agilent	E4405B	US40520856	2011.05	
2	EMC Spectrum Analyzer	Agilent	E7405A	US40240203	2011.03	
3	EMI Test Receiver	Rohde&Schwarz	ESIB40	100277	2011.03	☒
4	EMI Test Receiver	Rohde&Schwarz	ESHS10	862970/019	2011.07	☒
5	Artificial Mains Network	Rohde&Schwarz	ESH3-Z5	836679/018	2011.07	☒
6	Pre-amplifier	HP	8447F	3113A05153	2011.07	☒
7	Pre-amplifier	MITEQ	AFS44	1116321	2010.12	
8	Pre-amplifier	MITEQ	AFS44	1116322	2011.07	☒
9	Power Meter	Agilent	E4417A	MY45100426	2011.07	☒
10	Power Meter	Agilent	E4418B	US39402176	2011.07	
11	Power Sensor	Agilent	E9327A	MY44420696	2011.07	☒
12	Power Sensor	Agilent	8482A	MY41094094	2011.07	
13	Attenuator (10dB)	HP	8491B	38067	2011.07	☒
14	Attenuator (20dB)	Weinschel	44	AH6967	2011.07	
15	High Pass Filter	Wainwright	WHKX3.0/18G	8	2011.07	☒
16	VHF Precision Dipole Antenna (TX/RX)	Schwarzbeck	VHAP	1014 / 1015	2011.05	
17	UHF Precision Dipole Antenna (TX/RX)	Schwarzbeck	UHAP	989 / 990	2011.05	
18	Loop Antenna	Schwarzbeck	HFH2-Z2	863048/019	2010.11	☒
19	TRILOG Broadband Antenna	Schwarzbeck	VULB9168	230	2011.07	☒
20	TRILOG Broadband Antenna	Schwarzbeck	VULB9168	189	2011.05	
21	Horn Antenna	AH Systems	SAS-200/571	304	N/A	
22	Horn Antenna	EMCO	3115	00040723	2011.04	☒
23	Horn Antenna	EMCO	3115	00056768	2010.09	
24	Horn Antenna	Schwarzbeck	BBHA9170	BBHA9170318	2010.08	☒
25	Vector Signal Generator	Agilent	E4438C	MY42080359	2011.08	
26	PSG analog signal generator	Agilent	E8257D-520	MY45141255	2011.07	
27	DC Power Supply	HP	6633A	3448A032223	2011.08	☒
28	DC Power Supply	HP	6268B	2542A-07856	2011.07	
29	Hygro/Thermo Graph	SATO	PC-5000TRH-II	-	2011.07	☒

2.3 Test Date

Date of Test: July 15, 2010 ~ September 16, 2010

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 5.0 V (AC/DC Adaptor)
Local Oscillator or X-Tal	X-Tal: 16MHz (RF Module)
Transmit Frequency	2405 MHz ~ 2480 MHz (IEEE 802.15.4)
Antenna Type	Integral (Helical antenna, Reverse polarity SMA type, Declared PEAK Gain: 2.85 dBi)
Type of Modulation	DSSS modulation (O-QPSK)
RF Output power	Under 10 dBm (declared by the applicant)
External Ports	Antenna connector RS-232C connector DC Jack (AC/DC Adaptor, AC 100-240 V / DC 5 V, 2 A)

3.2 Equipment Modifications

None

3.3 Submitted Documents

Block diagram

Schematic diagram

Antenna Specification

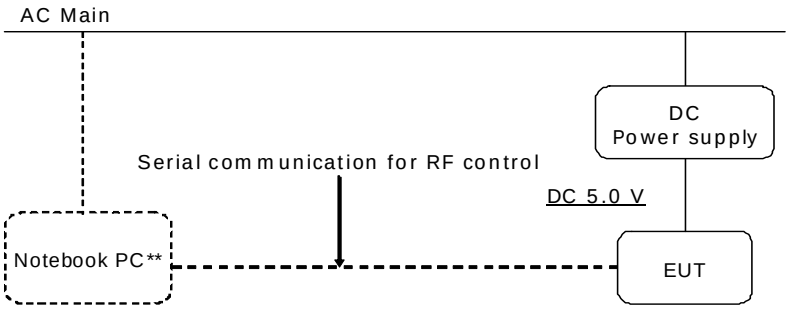
Part List

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 was provided by the applicant (Power setting value: 45).



[System Block Diagram of Test Configuration]

** *For control of the RF module via UART interface at the Serial port in the EUT. For radiated spurious emission measurements, the measurements were performed without PC after setting the radio module to TEST MODE.*

4.2 List of Peripherals

Equipment Type	Manufacturer	Model	S/N
Notebook PC	DELL	INSPIRON	14791079949

4.3 Type of Used Cables

#	START		END		CABLE	
	NAME	I/O PORT	NAME	I/O PORT	LENGTH(m)	SHIELDED
1	Notebook PC	Serial	EUT	Serial	1.0	YES

4.4 Uncertainty

Measurement Item	Combined Standard Uncertainty *Uc*	Expanded Uncertainty $U = k \times Uc$ ($k = 1.96$)
Conducted RF power	± 1.49 dB	± 2.92 dB
Radiated disturbance	± 2.30 dB	± 4.51 dB
Conducted disturbance	± 1.96 dB	± 3.84 dB

5. TEST AND MEASUREMENTS

Summary of Test Results

Requirement	CFR 47 Section	Report Section	Test Result
Antenna Requirement	15.203, 15.247(b)(4)	5.1	PASS
6dB Bandwidth	15.247(a)(2)	5.2	PASS
Maximum Peak Output Power	15.247(b)(3), (4)	5.3	PASS
Spurious Emission, Band Edge, and Restricted bands	15.247(d), 15.205(a), 15.209(a)	5.4	PASS
Peak Power Spectral Density	15.247(e)	5.5	PASS
AC power Line conducted Emissions	15.207(a)	5.6	PASS
RF Exposure	15.247(i), 1.1307(b)(1)	5.7	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 the integral antenna with reverse polarity SMA connector type.

The directional gain of the antenna is 2.85 dBi.

5.2 6 dB BANDWIDTH

5.2.1 Regulation

According to §15.247(a)(2), systems using digital modulation techniques may operate in the 902 - 928 MHz, 2400 - 2483.5 MHz, and 5725 - 5850 MHz bands. The minimum 6dB bandwidth shall be at least 500 kHz.

5.2.2 Test Procedure

1. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable.
2. Set the spectrum analyzer as follows:
   RBW = 100 kHz, VBW ≥ RBW
   Span >> RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
3. Mark the peak frequency and -6dB (upper and lower) frequency.
4. Set the RBW to as close to 1% of the selected span as is possible without being below 1%.
5. Set the DETECTOR to sample where practical. [REMARK: the function of the PEAK HOLD was used]
6. Measure the 99% occupied bandwidth.
7. Repeat until all the rest channels are investigated.

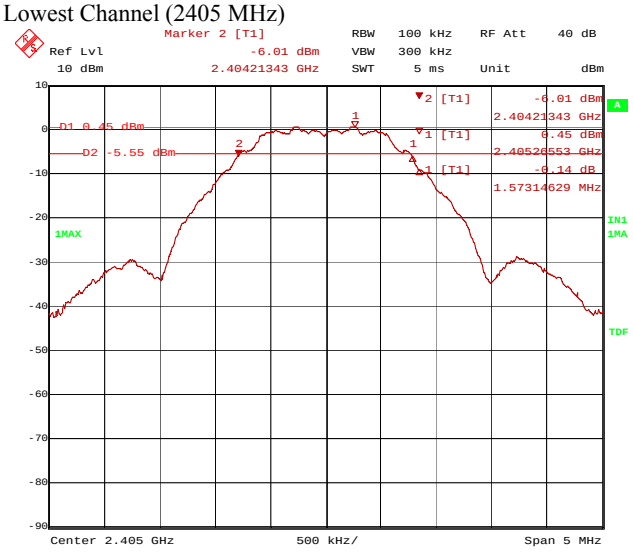
5.2.3 Test Results: PASS

Table 1: Measured values of the 6dB Bandwidth

Operating frequency	Occupied Bandwidth (99%)	6dB Bandwidth	Limit
2405 MHz	2.09 MHz	1.57 MHz	≥ 500 kHz
2445 MHz	2.08 MHz	1.55 MHz	≥ 500 kHz
2480 MHz	2.08 MHz	1.57 MHz	≥ 500 kHz

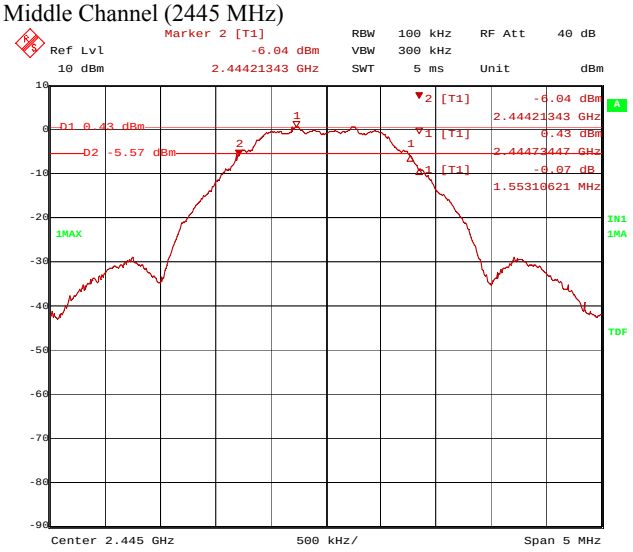
Figure 1. Plot of the 6dB Bandwidth

Lowest Channel (2405 MHz)



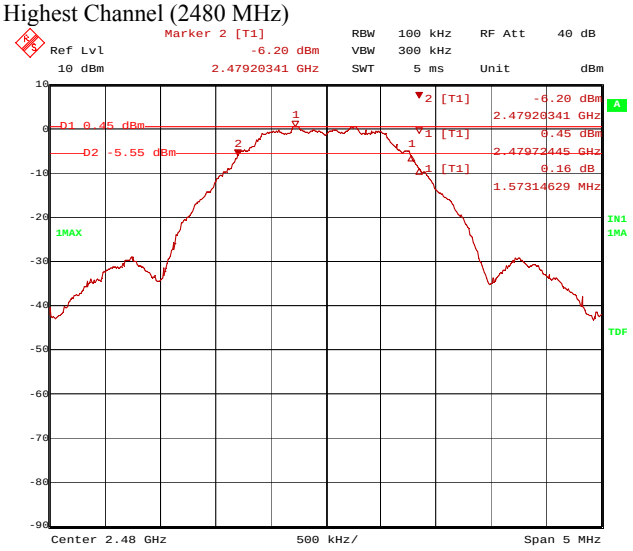
Date: 16.SEP.2010 15:35:14

Middle Channel (2445 MHz)



Date: 16.SEP.2010 15:38:53

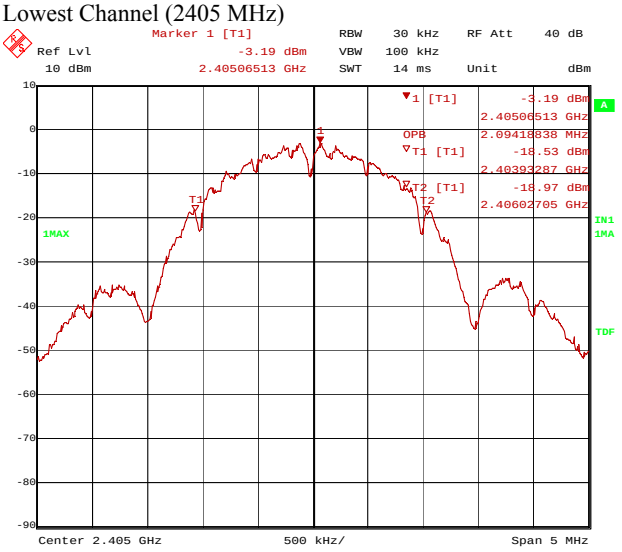
Highest Channel (2480 MHz)



Date: 16.SEP.2010 15:42:39

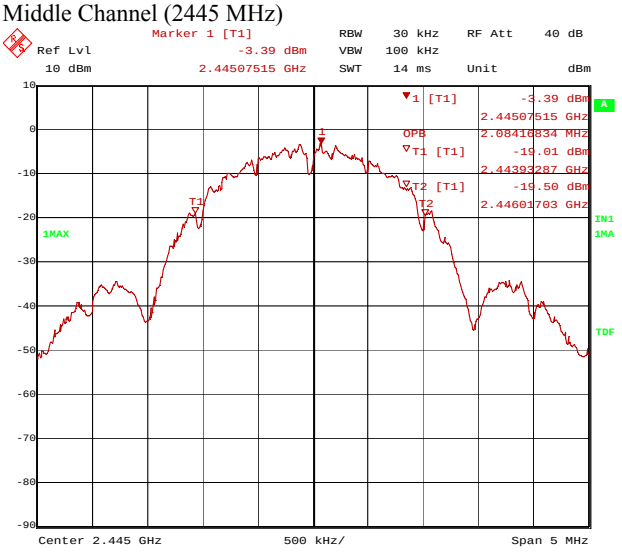
Figure 2. Plot of the Occupied Bandwidth (99%)

Lowest Channel (2405 MHz)



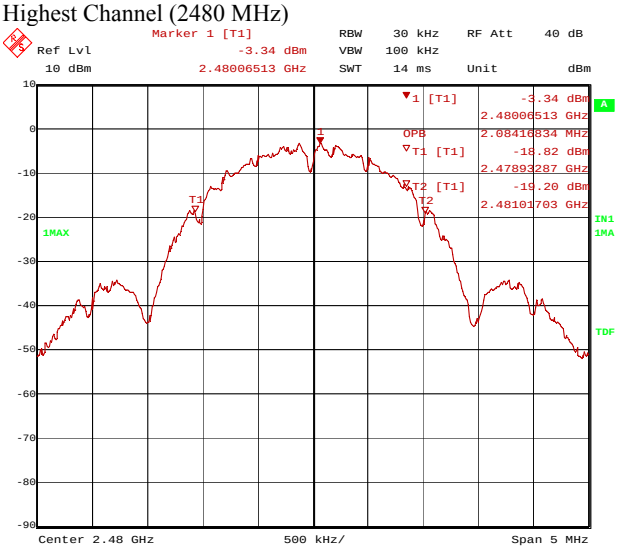
Date: 16.SEP.2010 17:19:24

Middle Channel (2445 MHz)



Date: 16.SEP.2010 17:21:06

Highest Channel (2480 MHz)



Date: 16.SEP.2010 17:23:55

5.3 MAXIMUM PEAK OUTPUT POWER

5.3.1 Regulation

According to §15.247(b)(3), for systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

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.

5.3.2 Test Procedure

1. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable and attenuator.
2. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via SPI interface and make sure the spectrum analyzer is operated in its linear range.
3. Set the spectrum analyzer as follows:
   Span = approximately 5 times the 20 dB bandwidth, centered channel
   RBW > the 20 dB bandwidth of the emission being measured
   VBW ≥ RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
4. Measure the highest amplitude appearing on spectral display and record the level to calculate results.
5. Repeat above procedures until all frequencies measured were complete.

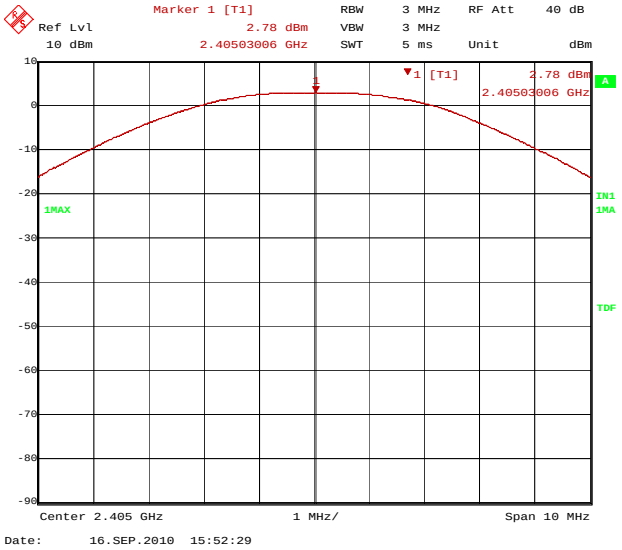
5.3.3 Test Results: PASS

Table 2: Measured values of the Maximum Peak Conducted Output Power

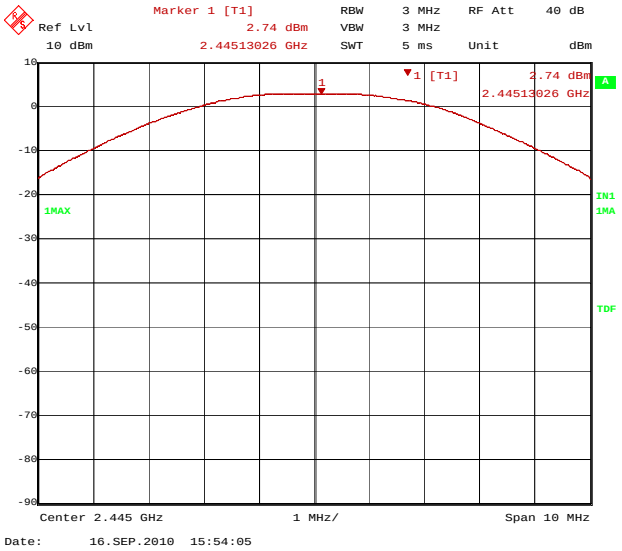
Operating Frequency	PEAK POWER		Limit
	[dBm]	[mW]	
2405 MHz	2.78	1.90	1 W
2445 MHz	2.74	1.88	1 W
2480 MHz	2.81	1.91	1 W

Figure 3. Plot of the Maximum Peak Conducted Output Power

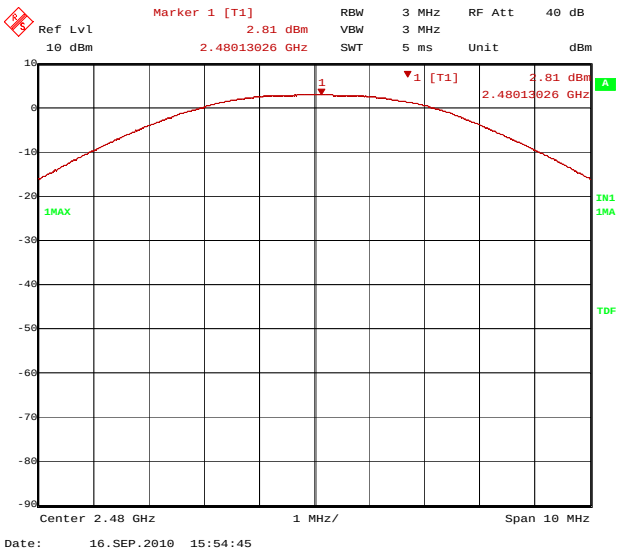
Lowest Channel (2405 MHz)



Middle Channel (2445 MHz)



Highest Channel (2480 MHz)



5.4 SPURIOUS EMISSIONS, BAND EDGE, AND RESTRICTED BANDS

5.4.1 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.

5.4.2 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 for above 30 MHz, and at 3 meter distance for below 30 MHz.
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 15 MHz to 30 MHz using the loop antenna, from 30 to 1000 MHz using the Trilog broadband antenna, and from 1 GHz to tenth harmonic of the highest fundamental frequency 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.

5.4.3 Test Results: PASS

Band-edge compliance of RF conducted/radiated emissions was shown in the Figure 4 and 5.
Spurious RF conducted emissions were shown in the Figure 6.
Emission plot for the preliminary radiated measurements were shown in the Figure 7.

NOTE 1: for conducted measurement, we took the insertion loss of the cable loss into consideration within the measuring instrument. And for radiated measurement, the results were calibrated to the field strength within the measuring instrument; Table 3 contains the correction factors at the operating frequencies such as antenna factor, cable loss, etc.

NOTE 2: The preliminary radiated measurements were performed in the anechoic chamber in order to find the frequency, which falls in the restricted bands as defined in Section 15.205, and the results for the final measurements were indicated in the Table 3.

Table 3: Measured values of the Field strength of spurious emission (Radiated)

Frequency	Receiver Bandwidth	Pol.	Antenna Height	Turn Table	Reading	Amp Gain	ATT	AF	CL	Actual	Limit	Margin
[MHz]	[kHz]	[V/H]	[m]	[degree]	[dB(μV)]	[dB]	[dB]	[dB(1/m)]	[dB]	[dB(μV/m)]	[dB(μV/m)]	[dB]
Average/Peak/Quasi-peak data, emissions below 30 MHz												
Quasi-peak data, emissions below 1000 MHz												
719.99	120	V	1.86	3	31.52	28.92	-	20.86	2.71	26.17	46.00	19.83
719.99	120	H	1.18	325	35.41	28.92	-	20.86	2.71	30.06	46.00	15.94
751.99	120	V	1.01	338	30.71	28.84	-	21.37	2.81	29.46	46.00	16.54
751.99	120	H	1.09	327	34.12	28.84	-	20.86	2.71	26.17	46.00	19.83

No Spurious Radiated Emissions Found

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

Table 3: Measured values of the Field strength of spurious emission (Radiated)

Frequency	Receiver Bandwidth	Pol.	Antenna Height	Turn Table	Reading	Amp Gain	ATT	AF	CL	Actual	Limit	Margin
[MHz]	[kHz]	[V/H]	[m]	[degree]	[dB(μV)]	[dB]	[dB]	[dB(1/m)]	[dB]	[dB(μV/m)]	[dB(μV/m)]	[dB]
AVERAGE data, emissions above 1000 MHz												
2405.0	1000	V	1.13	94	89.50	44.16	10.26	27.96	5.28	88.84	---	---
2405.0	1000	H	1.26	97	87.31	44.16	10.26	27.96	5.28	86.65	---	---
1443.0	1000	V	1.97	42	42.59	43.58	10.19	25.29	3.93	38.42	54.00	15.58
1443.0	1000	H	1.03	344	42.04	43.58	10.19	25.29	3.93	37.87	54.00	16.13
1924.0	1000	V	1.83	40	50.15	43.96	10.22	26.44	4.62	47.47	54.00	6.53
1924.0	1000	H	1.00	358	48.35	43.96	10.22	26.44	4.62	45.67	54.00	8.33
2348.4	1000	V	1.13	94	-	44.13	10.25	27.64	5.15	36.81	54.00	17.19
2346.8	1000	H	1.26	97	-	44.13	10.25	27.64	5.15	36.02	54.00	17.98
2886.0	1000	V	1.00	53	41.63	44.32	10.27	29.58	5.86	43.02	54.00	10.98
2886.0	1000	H	1.97	249	36.76	44.32	10.27	29.58	5.86	38.15	54.00	15.85
3848.0	1000	V	1.55	29	41.07	44.25	1.53	32.11	6.80	37.26	54.00	16.74
3848.0	1000	H	1.55	285	45.04	44.25	1.53	32.11	6.80	41.23	54.00	12.77
4811.0	1000	V	1.56	13	48.55	44.56	1.18	32.76	7.84	45.77	54.00	8.23
4811.0	1000	H	1.58	261	47.00	44.56	1.18	32.76	7.84	44.22	54.00	9.78
2445.0	1000	V	1.42	58	90.11	44.16	10.26	27.96	5.28	89.45	---	---
2445.0	1000	H	1.90	95	88.03	44.16	10.26	27.96	5.28	87.37	---	---
1467.0	1000	V	1.21	15	46.87	43.66	10.19	25.52	4.07	42.99	54.00	11.01
1467.0	1000	H	1.00	344	45.11	43.66	10.19	25.52	4.07	41.23	54.00	12.77
1956.0	1000	V	1.00	13	50.97	44.04	10.22	26.67	4.75	48.57	54.00	5.43
1956.0	1000	H	1.04	341	48.04	44.04	10.22	26.67	4.75	45.64	54.00	8.36
2934.0	1000	V	1.69	109	41.27	44.32	10.27	29.58	5.86	42.66	54.00	11.34
2934.0	1000	H	1.43	70	38.88	44.32	10.27	29.58	5.86	40.27	54.00	13.73
3912.0	1000	V	1.63	60	41.57	44.24	1.53	32.38	6.80	38.04	54.00	15.96
3912.0	1000	H	1.52	75	47.19	44.24	1.53	32.38	6.80	43.66	54.00	10.34
4889.0	1000	V	1.53	289	48.43	44.60	1.18	32.77	7.89	45.67	54.00	8.33
4889.0	1000	H	1.58	257	50.04	44.60	1.18	32.77	7.89	47.28	54.00	6.72
2480.0	1000	V	1.33	191	87.40	44.20	10.26	28.29	5.39	87.14	---	---
2480.0	1000	H	1.93	108	87.62	44.20	10.26	28.29	5.39	87.36	---	---
1488.3	1000	V	1.24	359	42.00	43.66	10.19	25.52	4.07	38.12	54.00	15.88
1488.3	1000	H	1.00	346	41.22	43.66	10.19	25.52	4.07	37.34	54.00	16.66
1984.0	1000	V	1.84	230	49.77	44.04	10.22	26.67	4.75	47.37	54.00	6.63
1984.0	1000	H	2.09	297	47.07	44.04	10.22	26.67	4.75	44.67	54.00	9.33
2483.6	1000	V	1.33	191	-	44.20	10.27	28.29	5.39	38.57	54.00	15.43
2483.6	1000	H	1.93	108	-	44.20	10.27	28.29	5.39	38.37	54.00	15.63
2976.0	1000	V	1.49	217	41.44	44.35	10.27	29.90	5.96	43.22	54.00	10.78
2976.0	1000	H	1.53	273	40.29	44.35	10.27	29.90	5.96	42.07	54.00	11.93
3968.0	1000	V	1.52	303	37.93	44.23	1.53	32.66	7.01	34.90	54.00	19.10
3968.0	1000	H	1.58	245	41.78	44.23	1.53	32.66	7.01	38.75	54.00	15.25
4960.0	1000	V	1.22	283	43.39	44.64	1.18	32.78	7.92	40.63	54.00	13.37
4960.0	1000	H	1.59	276	42.83	44.64	1.18	32.78	7.92	40.07	54.00	13.93

Table 3: Measured values of the Field strength of spurious emission (Radiated)												
Frequency	Receiver Bandwidth	Pol.	Antenna Height	Turn Table	Reading	Amp Gain	ATT	AF	CL	Actual	Limit	Margin
[MHz]	[kHz]	[V/H]	[m]	[degree]	[dB(μV)]	[dB]	[dB]	[dB(1/m)]	[dB]	[dB(μV/m)]	[dB(μV/m)]	[dB]
PEAK data, emissions above 1000 MHz												
2405.0	1000	V	1.13	94	93.10	44.16	10.26	27.96	5.28	92.44	---	---
2405.0	1000	H	1.26	97	90.91	44.16	10.26	27.96	5.28	90.25	---	---
1443.0	1000	V	1.97	42	50.82	43.58	10.19	25.29	3.93	46.65	74.00	27.35
1443.0	1000	H	1.03	344	51.22	43.58	10.19	25.29	3.93	47.05	74.00	26.95
1924.0	1000	V	1.83	40	56.23	43.96	10.22	26.44	4.62	53.55	74.00	20.45
1924.0	1000	H	1.00	358	54.85	43.96	10.22	26.44	4.62	52.17	74.00	21.83
2347.2	1000	V	1.13	94	-	44.13	10.25	27.64	5.15	53.15	74.00	20.85
2348.0	1000	H	1.26	97	-	44.13	10.25	27.64	5.15	50.89	74.00	23.11
2886.0	1000	V	1.00	53	51.53	44.32	10.27	29.58	5.86	52.92	74.00	21.08
2886.0	1000	H	1.97	249	48.68	44.32	10.27	29.58	5.86	50.07	74.00	23.93
3848.0	1000	V	1.55	29	50.52	44.25	1.53	32.11	6.80	46.71	74.00	27.29
3848.0	1000	H	1.55	285	52.41	44.25	1.53	32.11	6.80	48.60	74.00	25.40
4811.0	1000	V	1.56	13	57.86	44.56	1.18	32.76	7.84	55.08	74.00	18.92
4811.0	1000	H	1.58	261	56.05	44.56	1.18	32.76	7.84	53.27	74.00	20.73
2445.0	1000	V	1.42	58	93.68	44.16	10.26	27.96	5.28	93.02	---	---
2445.0	1000	H	1.90	95	91.56	44.16	10.26	27.96	5.28	90.90	---	---
1467.0	1000	V	1.21	15	53.82	43.66	10.19	25.52	4.07	49.94	74.00	24.06
1467.0	1000	H	1.00	344	52.30	43.66	10.19	25.52	4.07	48.42	74.00	25.58
1956.0	1000	V	1.00	13	57.80	44.04	10.22	26.67	4.75	55.40	74.00	18.60
1956.0	1000	H	1.04	341	53.96	44.04	10.22	26.67	4.75	51.56	74.00	22.44
2934.0	1000	V	1.69	109	53.08	44.32	10.27	29.58	5.86	54.47	74.00	19.53
2934.0	1000	H	1.43	70	51.37	44.32	10.27	29.58	5.86	52.76	74.00	21.24
3912.0	1000	V	1.63	60	50.78	44.24	1.53	32.38	6.80	47.25	74.00	26.75
3912.0	1000	H	1.52	75	60.15	44.24	1.53	32.38	6.80	56.62	74.00	17.38
4889.0	1000	V	1.53	289	57.80	44.60	1.18	32.77	7.89	55.04	74.00	18.96
4889.0	1000	H	1.58	257	62.23	44.60	1.18	32.77	7.89	59.47	74.00	14.53
2480.0	1000	V	1.33	191	90.95	44.20	10.26	28.29	5.39	90.69	---	---
2480.0	1000	H	1.93	108	91.19	44.20	10.26	28.29	5.39	90.93	---	---
1488.3	1000	V	1.24	359	49.64	43.66	10.19	25.52	4.07	45.76	74.00	28.24
1488.3	1000	H	1.00	346	48.89	43.66	10.19	25.52	4.07	45.01	74.00	28.99
1984.0	1000	V	1.84	230	54.85	44.04	10.22	26.67	4.75	52.45	74.00	21.55
1984.0	1000	H	2.09	297	52.30	44.04	10.22	26.67	4.75	49.90	74.00	24.10
2483.6	1000	V	1.33	191	-	44.20	10.27	28.29	5.39	51.10	74.00	22.90
2483.6	1000	H	1.93	108	-	44.20	10.27	28.29	5.39	51.22	74.00	22.78
2976.0	1000	V	1.49	217	53.39	44.35	10.27	29.90	5.96	55.17	74.00	18.83
2976.0	1000	H	1.53	273	50.48	44.35	10.27	29.90	5.96	52.26	74.00	21.74
3968.0	1000	V	1.52	303	47.80	44.23	1.53	32.66	7.01	44.77	74.00	29.23
3968.0	1000	H	1.58	245	50.09	44.23	1.53	32.66	7.01	47.06	74.00	26.94
4960.0	1000	V	1.22	283	53.98	44.64	1.18	32.78	7.92	51.22	74.00	22.78
4960.0	1000	H	1.59	276	53.49	44.64	1.18	32.78	7.92	50.73	74.00	23.27

Margin (dB) = Limit – Actual

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

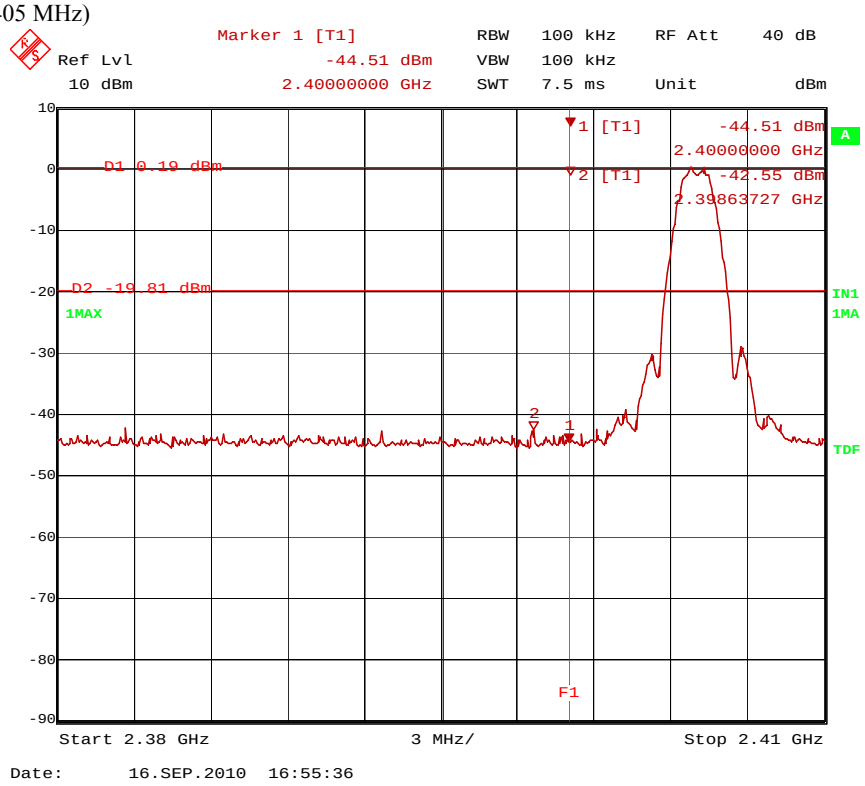
1. H = Horizontal, V = Vertical Polarization

2. ATT = Attenuation (10dB pad and/or Insertion Loss of HPF), AF/CL = Antenna Factor and Cable Loss

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

Figure 4. Plot of the Band Edge (Conducted)

Lowest Channel (2405 MHz)



Highest Channel (2480 MHz)

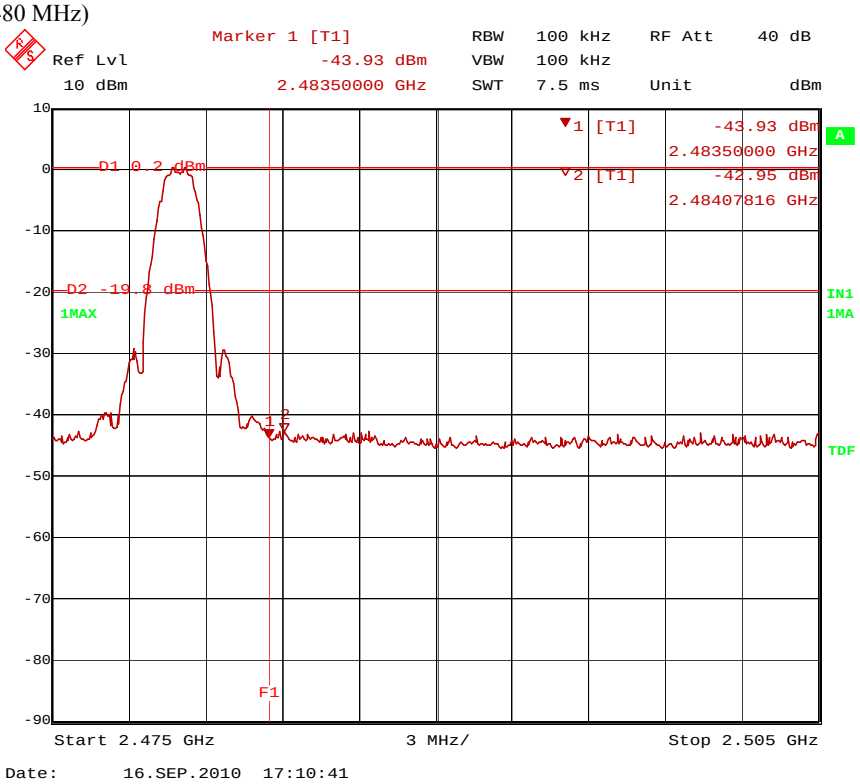
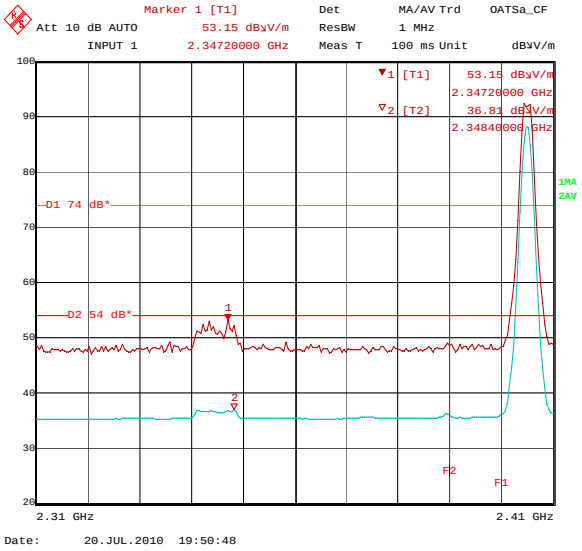
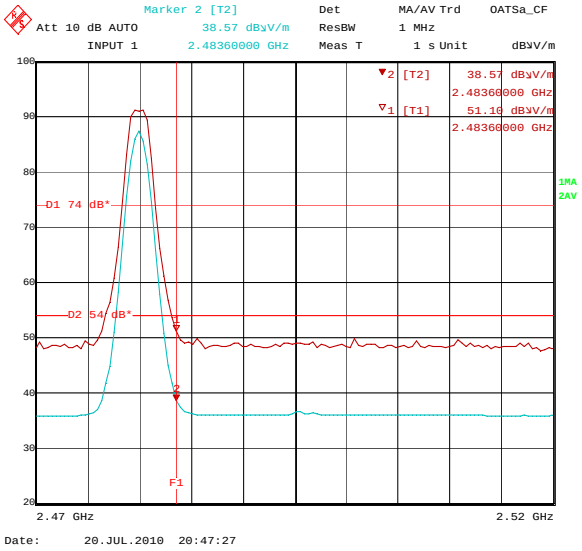


Figure 5. Plot of the Band Edge (Radiated)

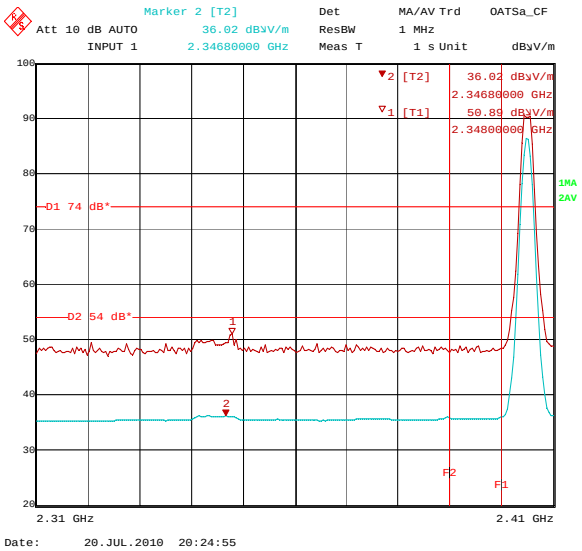
Lowest Channel (2405 MHz)
Vertical



Highest Channel (2480 MHz)
Vertical



Lowest Channel (2405 MHz)
Horizontal



Highest Channel (2480 MHz)
Horizontal

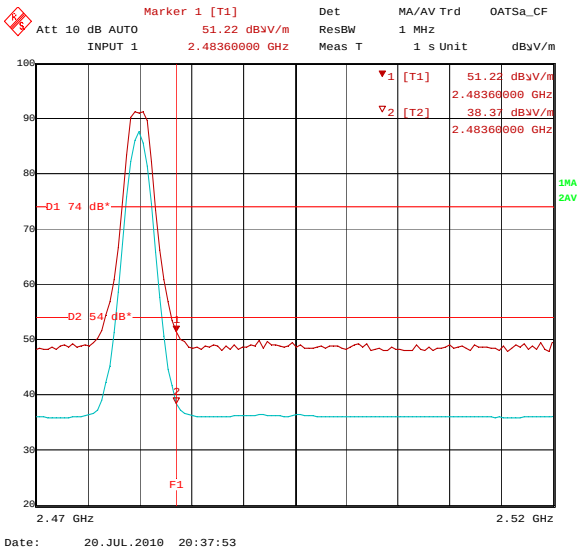
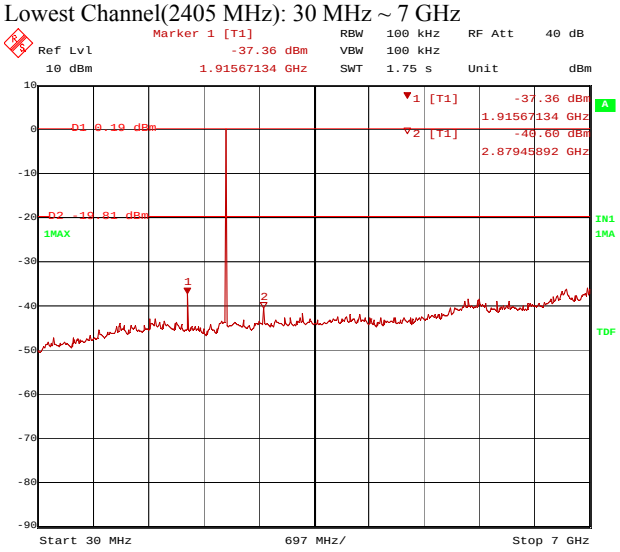
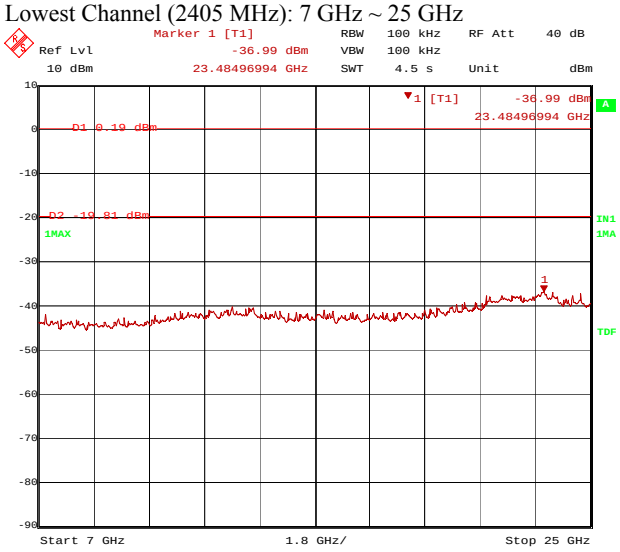


Figure 6. Spurious RF conducted emissions

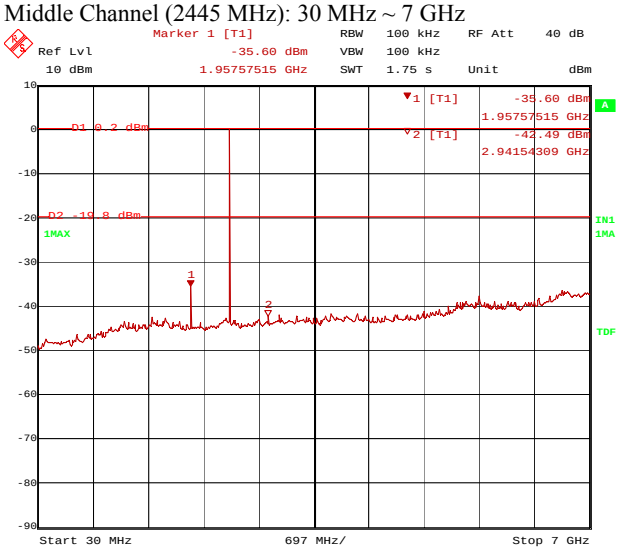
Lowest Channel(2405 MHz): 30 MHz ~ 7 GHz



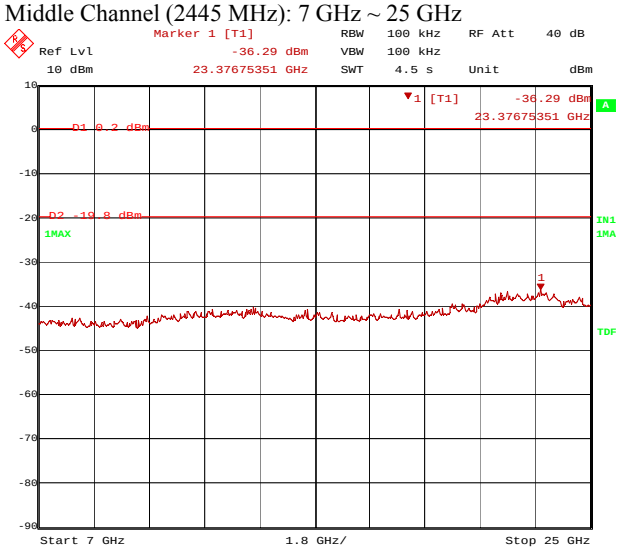
Lowest Channel (2405 MHz): 7 GHz ~ 25 GHz



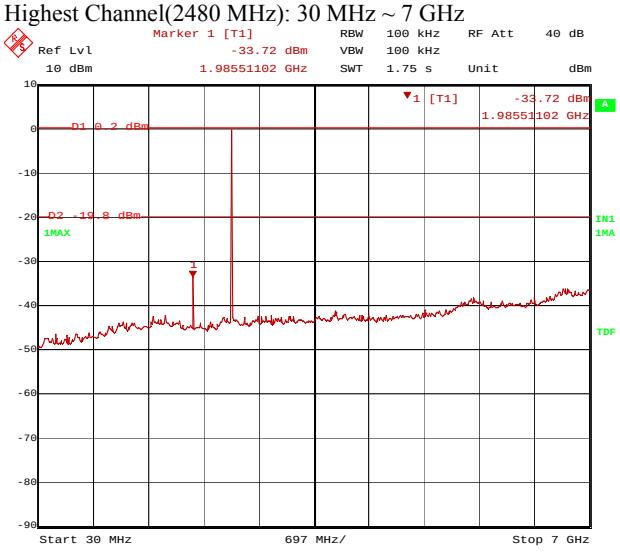
Middle Channel (2445 MHz): 30 MHz ~ 7 GHz



Middle Channel (2445 MHz): 7 GHz ~ 25 GHz



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



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

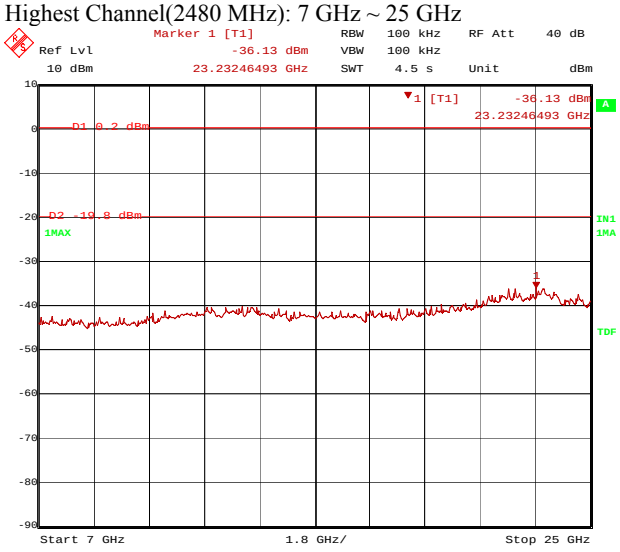
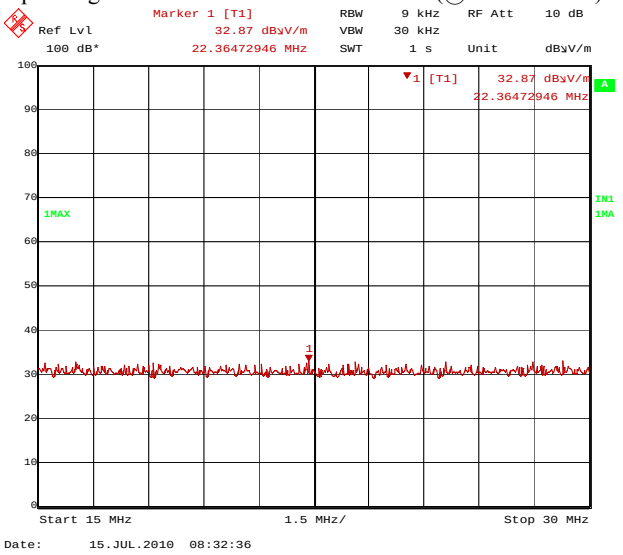
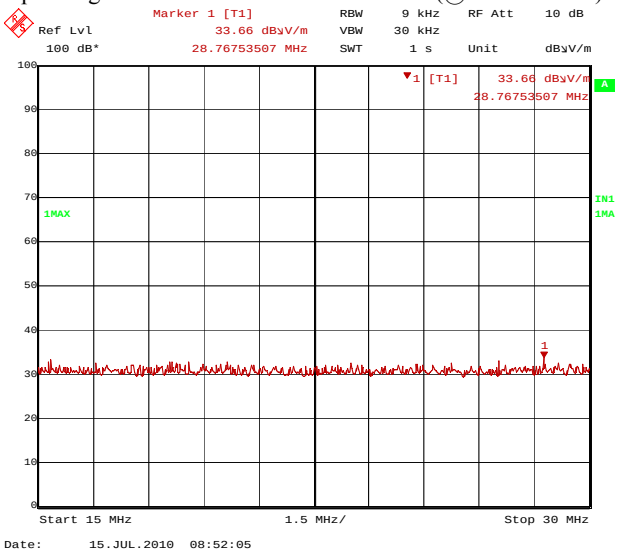


Figure 7. Emission plot for the preliminary radiated measurements

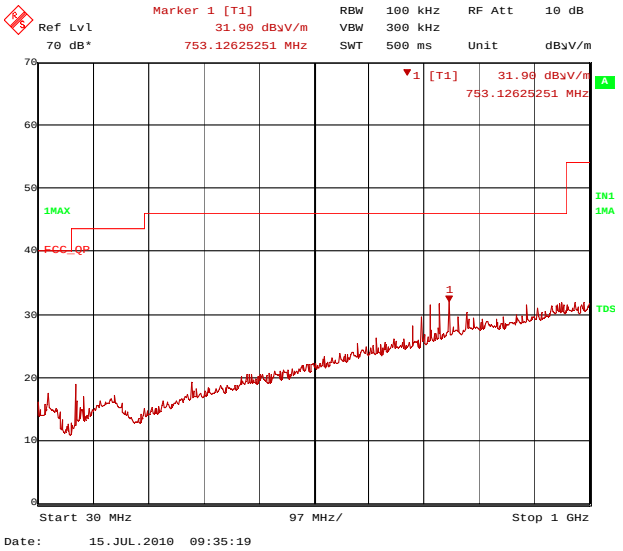
Operating at 2405 MHz: 15 MHz ~ 30 MHz (@ 3-m distance)



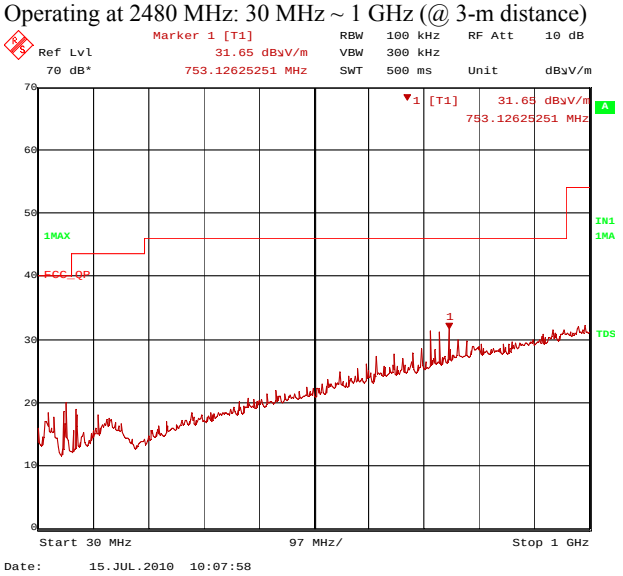
Operating at 2480 MHz: 15 MHz ~ 30 MHz (@ 3-m distance)



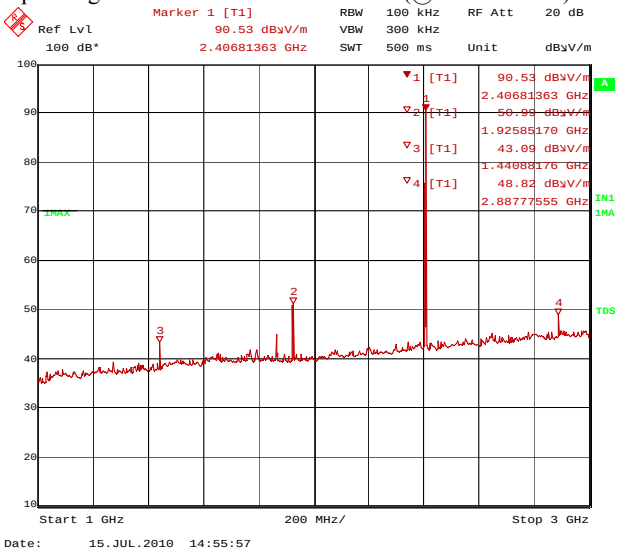
Operating at 2405 MHz: 30 MHz ~ 1 GHz (@ 3-m distance)



Operating at 2480 MHz: 30 MHz ~ 1 GHz (@ 3-m distance)



Operating at 2405 MHz: 1 GHz ~ 3 GHz (@ 3-m distance)



Operating at 2480 MHz: 1 GHz ~ 3 GHz (@ 3-m distance)

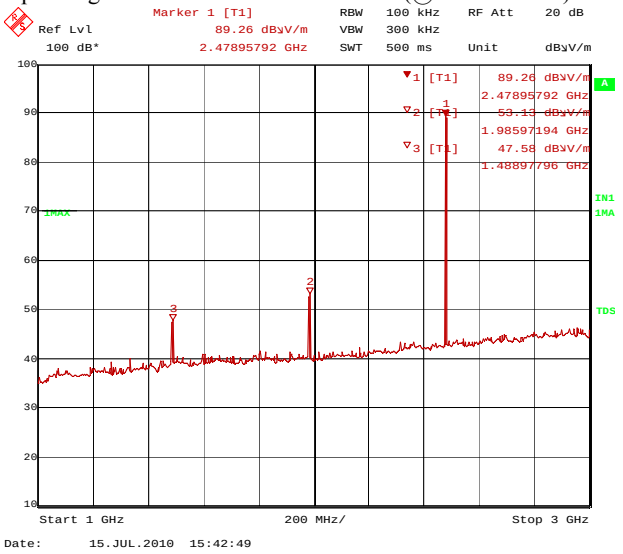
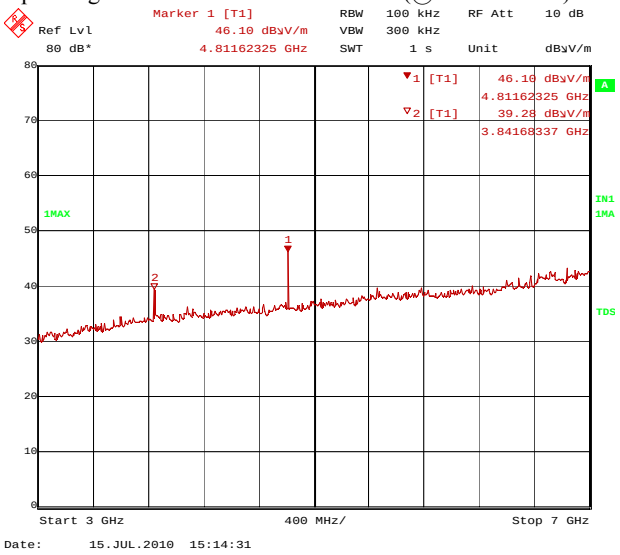
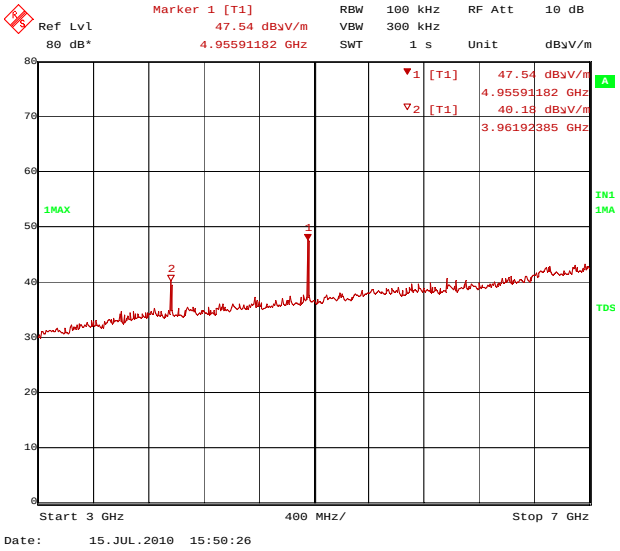


Figure 7. Emission plot for the preliminary radiated measurements

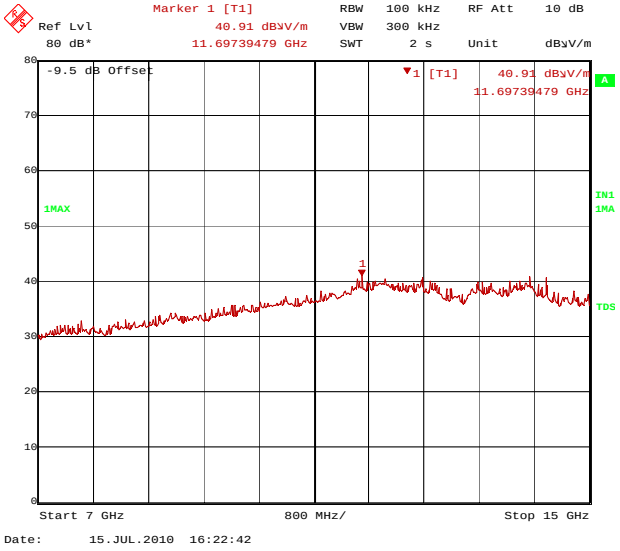
Operating at 2405 MHz: 3 GHz ~ 7 GHz (@ 3-m distance)



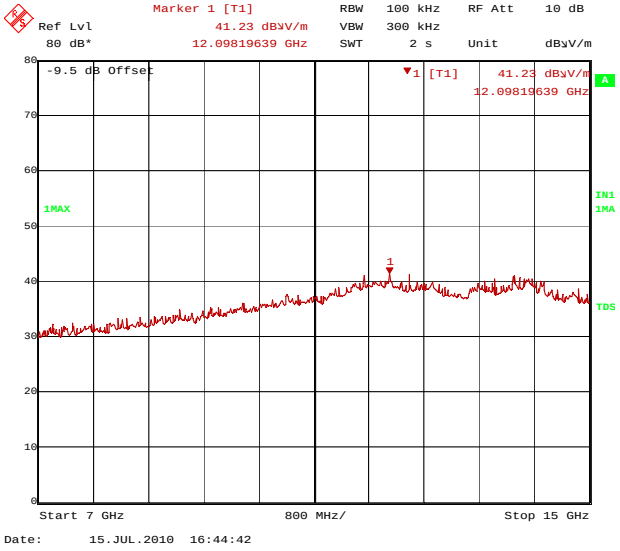
Operating at 2480 MHz: 3 GHz ~ 7 GHz (@ 3-m distance)



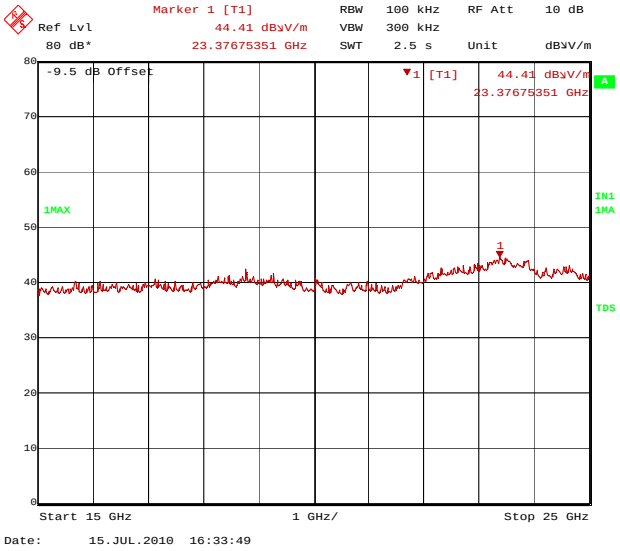
Operating at 2405 MHz: 7 GHz ~ 15 GHz (@ 1-m distance)



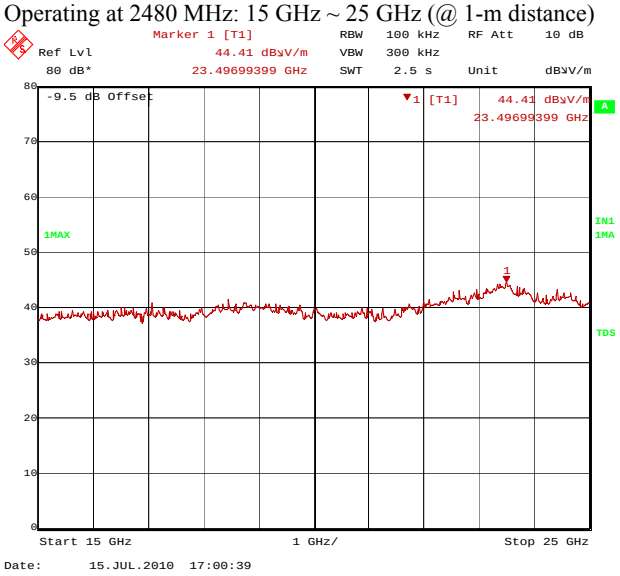
Operating at 2480 MHz: 7 GHz ~ 15 GHz (@ 1-m distance)



Operating at 2405 MHz: 15 GHz ~ 25 GHz (@ 1-m distance)



Operating at 2480 MHz: 15 GHz ~ 25 GHz (@ 1-m distance)



5.5 PEAK POWER SPECTRAL DENSITY

5.5.1 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.

5.5.2 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 locate and zoom in on emission peak(s) within the passband.
4. Set the spectrum analyzer as follows:
   RBW = 3 kHz, VBW ≥ RBW
   Span = 1.5 MHz
   Sweep = 500 seconds
   Detector function = peak
   Trace = max hold
5. Measure the highest amplitude appearing on spectral display and record the level to calculate results.

5.5.3 Test Results: PASS

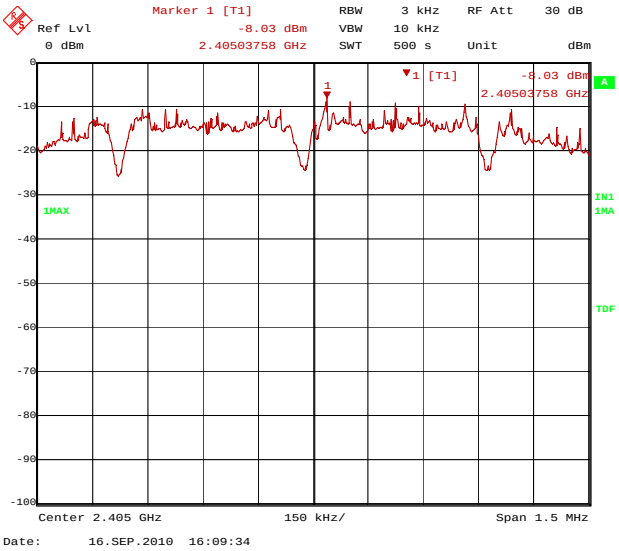
Table 4: Measured values of the Peak Power Spectral Density (Conducted)

Operating frequency	Measured Value (PPSD)	Limit
2405 MHz	-8.03 dBm	8.0 dBm
2445 MHz	-8.27 dBm	8.0 dBm
2480 MHz	-8.57 dBm	8.0 dBm

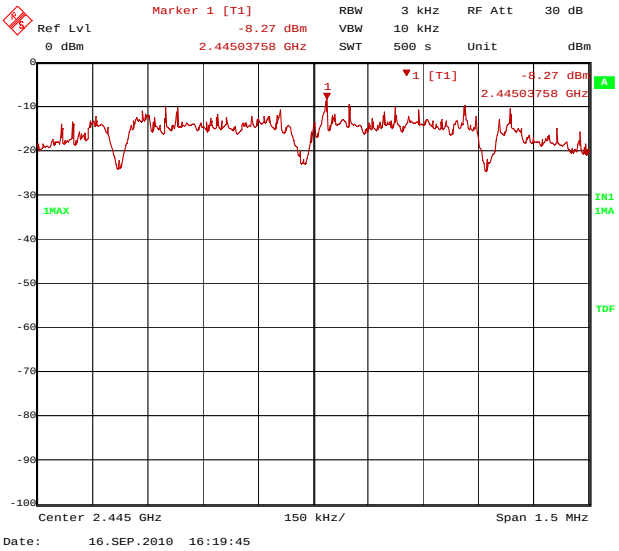
Measured Value = Reading (cable loss corrected)

Figure 8. Plot of the Peak Power Spectral Density

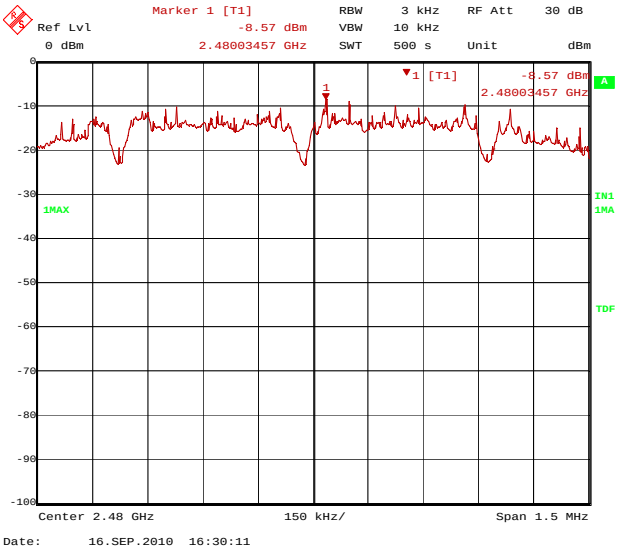
Lowest Channel (2405 MHz)



Middle Channel (2445 MHz)



Highest Channel (2480 MHz)



5.6 AC POWER LINE CONDUCTED EMISSIONS

5.6.1 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.

5.6.2 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.

5.6.3 Test Results: **PASS**

Table 5: Measured values of the AC Power Line Conducted Emissions Transmitting at 2445 MHz

Frequency [MHz]	Reading [dBμV]	L / N	CF [dB]	CL [dB]	Actual [dBμV]	Limit [dBμV]	Margin [dB]
QUASI-PEAK DATA							
0.160	38.90	L	0.35	0.05	39.30	65.46	26.16
9.835	33.16	N	0.68	0.20	34.04	60.00	25.96
10.230	31.44	N	0.53	0.24	32.21	60.00	27.79
15.440	42.98	L	0.75	0.29	44.02	60.00	15.98
16.030	42.68	L	0.75	0.29	43.72	60.00	16.28
20.750	45.60	L	0.82	0.33	46.75	60.00	13.25
21.240	48.02	N	0.96	0.33	49.31	60.00	10.69
24.000	51.62	L	0.82	0.33	52.77	60.00	7.23
26.750	52.34	N	0.94	0.37	53.65	60.00	6.35
27.340	50.82	L	0.88	0.37	52.07	60.00	7.93
AVERAGE DATA							
0.295	25.53	N	0.28	0.05	25.86	50.38	24.52
4.620	16.09	L	0.28	0.12	16.49	46.00	29.51
9.835	27.72	N	0.46	0.20	28.38	50.00	21.62
15.440	38.17	N	0.75	0.29	39.21	50.00	10.79
16.030	38.13	N	0.75	0.29	39.17	50.00	10.83
21.240	42.34	N	0.82	0.33	43.49	50.00	6.51
24.000	45.86	N	0.82	0.33	47.01	50.00	2.99**
26.360	45.19	N	0.88	0.37	46.44	50.00	3.56**
26.750	46.22	N	0.88	0.37	47.47	50.00	2.53**
27.340	45.49	L	0.88	0.37	46.74	50.00	3.26**

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

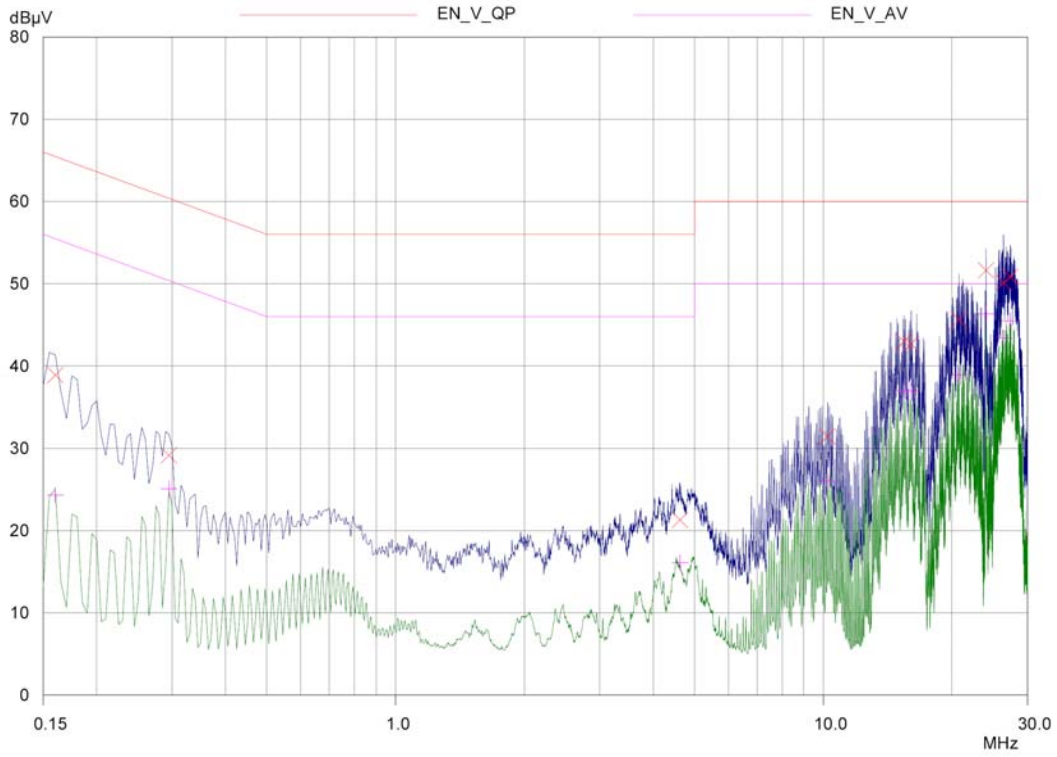
**: The measured result is within the test standard limit by a margin less than the measurement uncertainty; it is therefore not possible to state compliance based on the 95 % level of confidence. However, the result indicates that compliance is more probable than non-compliance

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

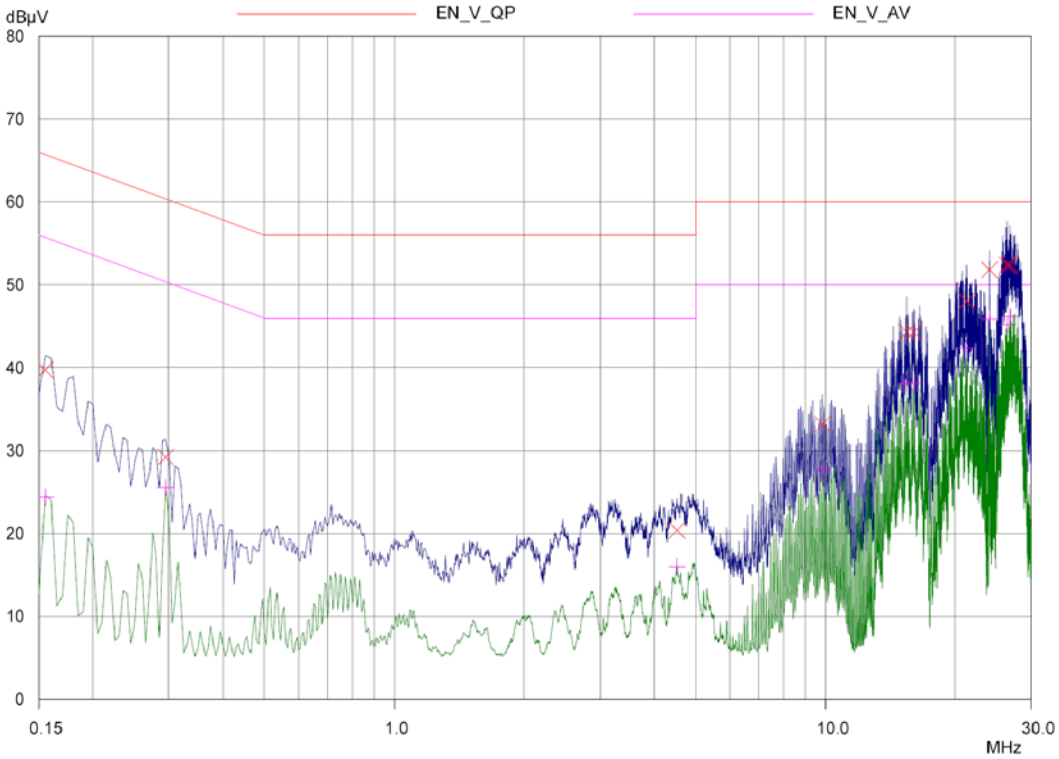
Figure 9. Plot of the AC Power Line Conducted Emissions

Transmitting at 2445 MHz

Line – PE(Peak and Average detector used)



Neutral – PE(Peak and Average detector used)



5.7 RF Exposure

5.7.1 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

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

$\left(\Rightarrow R = \sqrt{PG/4\pi S}\right)$ R = distance to the center of radiation of the antenna [cm]

EUT: Maximum peak output power = 1.91 [mW](= 2.81 dBm) & Antenna gain =1.93 (= 2.85 [dBi])	
100 mW, at 20 cm from an antenna 6 [dBi]	S = PG/4πR² = 100 × 3.98 / (4 × π × 400) = 0.0792 [mW/cm^2] < 1.0 [mW/cm^2]
1.91 mW, at 20 cm from the antenna 2.85 [dBi]	S = PG/4πR² = 0.0007 [mW/cm^2] < 1.0 [mW/cm^2]
1.91 mW, at 2.5 cm from the antenna 2.85 [dBi]	S = PG/4πR² = 0.0469 [mW/cm^2]

5.7.2 RF Exposure Compliance Issue

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

The users manual for end users must include the following information in a prominent location "IMPORTANT NOTE: To comply with FCC RF exposure compliance requirements, this device must not be co-located or operating in conjunction with any other antenna or transmitter."