



Inter**Lab**<sup>®</sup>

FCC Measurement/Technical Report on  
Bluetooth transceiver  
DC W221 MOPF Model No. BE 9027

**Report Reference:** MDE\_Harman\_0804\_FCCb

**Test Laboratory:**

7 layers AG  
Borsigstrasse 11  
40880 Ratingen  
Germany  
email: [info@7Layers.de](mailto:info@7Layers.de)



DAT-P-192/99-01

**Note:**

The following test results relate only to the devices specified in this document. This report shall not be reproduced in parts without the written approval of the testing laboratory.

7 layers AG  
Borsigstrasse 11  
40880 Ratingen, Germany  
Phone: +49 (0) 2102 749 0  
Fax: +49 (0) 2102 749 350  
[www.7Layers.com](http://www.7Layers.com)

*Aufsichtsratsvorsitzender •  
Chairman of the Supervisory Board:*  
Markus Becker  
*Vorstand • Board:*  
Dr. Hans-Jürgen Meckelburg  
René Schildknecht

*Registergericht • registered in:*  
Düsseldorf, HRB 44096  
*USt-IdNr • VAT Nr:*  
DE 203159652  
*TAX No. 147/5869/0385*



## Table of Contents

<b>0 Summary</b>	<b>3</b>
0.1 Technical Report Summary	3
0.2 Measurement Summary	4
<b>1 Administrative Data</b>	<b>7</b>
1.1 Testing Laboratory	7
1.2 Project Data	7
1.3 Applicant Data	7
1.4 Manufacturer Data	7
<b>2 Test object Data</b>	<b>8</b>
2.1 General EUT Description	8
2.2 EUT Main components	9
2.3 Ancillary Equipment	9
2.4 Auxiliary Equipment	9
2.5 EUT Setups	10
2.6 Operating Modes	10
2.7 Product labelling	10
<b>3 Test Results</b>	<b>11</b>
3.1 Occupied bandwidth	11
3.2 Peak power output	14
3.3 Spurious RF conducted emissions	17
3.4 Spurious radiated emissions	20
3.5 Band edge compliance	28
3.6 Dwell time	32
3.7 Channel separation	34
3.8 Number of hopping frequencies	36
<b>4 Test Equipment</b>	<b>37</b>
<b>5 Photo Report</b>	<b>38</b>
<b>6 Setup Drawings</b>	<b>41</b>
<b>7 Annex measurement plots</b>	<b>42</b>
7.1 Occupied bandwidth	42
7.2 Peak power output	51
7.3 Band edge compliance conducted and Spurious RF conducted emissions	60
7.4 Band edge compliance radiated	78
7.5 Radiated emissions (f < 30 MHz)	81
7.6 Dwell time	83
7.7 Channel separation	84
7.8 Number of hopping frequencies	85



## **0 Summary**

### **0.1 Technical Report Summary**

#### **Type of Authorization**

Certification for an Intentional Radiator (Frequency Hopping Spread Spectrum).

#### **Applicable FCC Rules**

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 (10-1-07 Edition) and 15 (10-1-07 Edition). The following subparts are applicable to the results in this test report.

Part 2, Subpart J - Equipment Authorization Procedures, Certification

Part 15, Subpart C – Intentional Radiators

§ 15.201 Equipment authorization requirement

§ 15.207 Conducted limits

§ 15.209 Radiated emission limits; general requirements

§ 15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz

#### **Note:**

The tests were selected and performed with reference to the FCC Public Notice DA 00-705, released March 30, 2000

Instead of applying ANSI C63.4-1992 which is referenced in the FCC Public Note, the newer ANSI C63.4-2003 is applied.

#### **Summary Test Results:**

**The EUT complied with all performed tests as listed in chapter 0.2 Measurement Summary.**



## 0.2 Measurement Summary

---

### FCC Part 15, Subpart C § 15.207

Conducted emissions (AC power line)			
The measurement was performed according to ANSI C63.4			
<b>OP-Mode</b>	<b>Setup</b>	<b>Port</b>	<b>Final Result</b>
-	-	AC Port (power line)	2003 N/A

---

### FCC Part 15, Subpart C § 15.247 (a) (1)

Occupied bandwidth			
The measurement was performed according to FCC § 15.31			
<b>OP-Mode</b>	<b>Setup</b>	<b>Port</b>	<b>Final Result</b>
op-mode 1	Setup_b01	Ext. ant.connector	10-1-07 passed
op-mode 2	Setup_b01	Ext. ant.connector	passed
op-mode 3	Setup_b01	Ext. ant.connector	passed
op-mode 6	Setup_b01	Ext. ant.connector	passed
op-mode 7	Setup_b01	Ext. ant.connector	passed
op-mode 8	Setup_b01	Ext. ant.connector	passed
op-mode 10	Setup_b01	Ext. ant.connector	passed
op-mode 11	Setup_b01	Ext. ant.connector	passed
op-mode 12	Setup_b01	Ext. ant.connector	passed

---

### FCC Part 15, Subpart C § 15.247 (b) (1)

Peak power output			
The measurement was performed according to FCC § 15.31			
<b>OP-Mode</b>	<b>Setup</b>	<b>Port</b>	<b>Final Result</b>
op-mode 1	Setup_b01	Ext. ant.connector	10-1-07 passed
op-mode 2	Setup_b01	Ext. ant.connector	passed
op-mode 3	Setup_b01	Ext. ant.connector	passed
op-mode 6	Setup_b01	Ext. ant.connector	passed
op-mode 7	Setup_b01	Ext. ant.connector	passed
op-mode 8	Setup_b01	Ext. ant.connector	passed
op-mode 10	Setup_b01	Ext. ant.connector	passed
op-mode 11	Setup_b01	Ext. ant.connector	passed
op-mode 12	Setup_b01	Ext. ant.connector	passed

---

### FCC Part 15, Subpart C § 15.247 (d)

Spurious RF conducted emissions			
The measurement was performed according to FCC § 15.31			
<b>OP-Mode</b>	<b>Setup</b>	<b>Port</b>	<b>Final Result</b>
op-mode 1	Setup_b01	Ext. ant.connector	10-1-07 passed
op-mode 2	Setup_b01	Ext. ant.connector	passed
op-mode 3	Setup_b01	Ext. ant.connector	passed
op-mode 6	Setup_b01	Ext. ant.connector	passed
op-mode 7	Setup_b01	Ext. ant.connector	passed
op-mode 8	Setup_b01	Ext. ant.connector	passed
op-mode 10	Setup_b01	Ext. ant.connector	passed
op-mode 11	Setup_b01	Ext. ant.connector	passed
op-mode 12	Setup_b01	Ext. ant.connector	passed



**FCC Part 15, Subpart C**

**§ 15.247 (d), § 15.35 (b), § 15.209**

Spurious radiated emissions

The measurement was performed according to ANSI C63.4

2003

<b>OP-Mode</b>	<b>Setup</b>	<b>Port</b>	<b>Final Result</b>
op-mode 1	Setup_a01	Enclosure	passed
op-mode 2	Setup_a01	Enclosure	passed
op-mode 3	Setup_a01	Enclosure	passed
op-mode 6	Setup_a01	Enclosure	passed
op-mode 7	Setup_a01	Enclosure	passed
op-mode 8	Setup_a01	Enclosure	passed
op-mode 10	Setup_a01	Enclosure	passed
op-mode 11	Setup_a01	Enclosure	passed
op-mode 12	Setup_a01	Enclosure	passed

**FCC Part 15, Subpart C**

**§ 15.247 (d)**

Band edge compliance

The measurement was performed according to FCC § 15.31  
(10-1-07) / ANSI C63.4 (2003)

10-1-07 / 2003

<b>OP-Mode</b>	<b>Setup</b>	<b>Port</b>	<b>Final Result</b>
op-mode 1	Setup_b01	Ext. ant.connector	passed
op-mode 3	Setup_b01	Ext. ant.connector	passed
op-mode 3	Setup_a01	Enclosure	passed
op-mode 6	Setup_b01	Ext. ant.connector	passed
op-mode 8	Setup_b01	Ext. ant.connector	passed
op-mode 8	Setup_a01	Enclosure	passed
op-mode 10	Setup_b01	Ext. ant.connector	passed
op-mode 12	Setup_b01	Ext. ant.connector	passed
op-mode 12	Setup_a01	Enclosure	passed

**FCC Part 15, Subpart C**

**§ 15.247 (a) (1) (iii)**

Dwell time

The measurement was performed according to FCC § 15.31

10-1-07

**OP-Mode**  
op-mode 2

**Setup**  
Setup\_b01

**Port**  
Ext. ant.connector

**Final Result**  
passed

**FCC Part 15, Subpart C**

**§ 15.247 (a) (1)**

Channel separation

The measurement was performed according to FCC § 15.31

10-1-07

**OP-Mode**  
op-mode 4

**Setup**  
Setup\_b01

**Port**  
Ext. ant.connector

**Final Result**  
passed

**FCC Part 15, Subpart C**

**§ 15.247 (a) (iii)**

Number of hopping frequencies

The measurement was performed according to FCC § 15.31

10-1-07

**OP-Mode**  
op-mode 4

**Setup**  
Setup\_b01

**Port**  
Ext. ant.connector

**Final Result**  
passed

N/A not applicable (the EUT is powered by DC)

**This test report replaces the test report referenced by:  
MDE\_Harman\_0804\_FCCa.**



7 layers AG, Borsigstr. 11  
40880 Ratingen, Germany  
Phone +49 (0)2102 749 0

Responsible for  
Accreditation Scope:

*M. Schulz*

Responsible  
for Test Report:

*A. Pest*



## 1 Administrative Data

### 1.1 Testing Laboratory

Company Name: 7 Layers AG  
Address Borsigstr. 11  
40880 Ratingen  
Germany

This facility has been fully described in a report submitted to the FCC and accepted under the registration number 96716.

The test facility is also accredited by the following accreditation organisation:  
- Deutscher Akkreditierungs Rat DAR-Registration no. DAT-P-192/99-01

Responsible for Accreditation Scope: Dipl.-Ing. Bernhard Retka  
Dipl.-Ing. Robert Machulec  
Dipl.-Ing. Thomas Hoell  
Dipl.-Ing. Andreas Petz

Report Template Version: 2009-01-27

### 1.2 Project Data

Responsible for testing and report: Dipl.-Ing. Andreas Petz  
Date of Test(s): 2008-11-19 to 2009-02-11  
Date of Report: 2009-04-29

### 1.3 Applicant Data

Company Name: HARMAN/BECKER Automotive Systems GmbH  
Address: Söflinger Strasse 100  
89077 Ulm  
Germany  
Contact Person: Mr. Dirk Aicher

### 1.4 Manufacturer Data

Company Name: please see applicant data  
Address:  
Contact Person:



## 2 Test object Data

### 2.1 General EUT Description

<b>Equipment under Test</b>	Bluetooth transceiver
<b>Type Designation:</b>	DC W221 MOPF Model No. BE 9027
<b>Kind of Device:</b> <b>(optional)</b>	Headunit of car radio system
<b>Voltage Type:</b>	DC
<b>Voltage level:</b>	13.2 V
<b>Modulation Type:</b>	GFSK, 8DPSK, $\pi/4$ DQPSK

#### General product description:

Bluetooth is a short-range radio link intended to be a cable replacement between portable and/or fixed electronic devices.

Bluetooth operates in the unlicensed ISM Band at 2.4 GHz. In the US a band of 83.5 MHz width is available. In this band, the Bluetooth technology defines 79 RF channels spaced 1 MHz (2402 - 2480 MHz). The actual RF channel is chosen from a pseudo-random hopping sequence through the 79 channels. A channel is occupied for a defined amount of time slots, with a nominal slot length of 625  $\mu$ s. The maximum time slot length on one channel is defined by the packet type and is 0.625 ms for DH1 packets, 1.875 ms for DH3 and 3.125 ms for DH5. The nominal hop rate is 1600 hops/s for DH1, 1600/3 for DH3 and 1600/5 for DH5. All frequencies are equally used. The maximum nominal average time of occupancy is 0.4 s within a period of 79\*0.4 seconds.

The basic data rate of 1 Mbps uses GFSK modulation and the enhanced data rate uses PSK modulation. For the enhanced data rate of 3 Mbps 8DPSK modulation and of 2 Mbps  $\pi/4$  DQPSK modulation is used.

#### Specific product description for the EUT:

The EUT is a car radio system which uses Bluetooth technology to be connected to e.g. a mobile phone.

#### The EUT provides the following ports:

##### Ports

- Bluetooth antenna connector
- Enclosure
- DC Port (vehicular battery)
- GPS antenna connector
- Microphone Input
- CAN bus connectors
- MOST connector (optical)
- Display Port

**The main components of the EUT are listed and described in Chapter 2.2.**



## 2.2 EUT Main components

### Type, S/N, Short Descriptions etc. used in this Test Report

Short Description	Equipment under Test	Type Designation	Serial No.	HW Status	SW Status	Date of Receipt
EUT A (Code: 43050e01)	Bluetooth transceiver	DC W221 MOPF Model No. BE 9027	8C000380	D1	998	2008-11-17
Remark: EUT A is equipped with an external connector and an external antenna (gain = 2.4 dBi).						
EUT B (Code: 43050a01)	Bluetooth transceiver	DC W221 MOPF Model No. BE 9027	8C000348	D1	998	2008-11-17
Remark: EUT B is equipped with an external antenna connector.						

**NOTE: The short description is used to simplify the identification of the EUT in this test report.**

## 2.3 Ancillary Equipment

For the purposes of this test report, ancillary equipment is defined as equipment which is used in conjunction with the EUT to provide operational and control features to the EUT. It is necessary to configure the system in a typical fashion, as a customer would normally use it. But nevertheless Ancillary Equipment can influence the test results.

Short Description	Equipment under Test	Type Designation	Serial no.	HW Status	SW Status	FCC ID
AE1	External BT antenna	WISI AG98 / BR221/216	-	-	-	-

## 2.4 Auxiliary Equipment

For the purposes of this test report, auxiliary equipment is defined as equipment which is used temporarily to enable operational and control features especially used for the tests of the EUT which is not used during normal operation or equipment that is used during the tests in combination with the EUT but is not subject of this test report. It is necessary to configure the system in a typical fashion, as a customer would normally use it. But nevertheless Auxiliary Equipment can influence the test results.

Short Description	Equipment under Test	Type Designation	Serial no.	HW Status	SW Status	FCC ID
AUX1	Can Box High	-	-	-	-	-



## 2.5 EUT Setups

This chapter describes the combination of EUTs and ancillary equipment used for testing.

Setup No.	Combination of EUT's	Description
Setup_a01	EUT A + AE1 + AUX1	setup for radiated measurements
Setup_b01	EUT B + AUX 1	setup for conducted measurements

## 2.6 Operating Modes

This chapter describes the operating modes of the EUTs used for testing.

Op. Mode	Description of Operating Modes	Remarks
op-mode 1	The EUT transmits on 2402 MHz	Loopback mode, basic data rate 1 Mbps
op-mode 2	The EUT transmits on 2441 MHz	Loopback mode, basic data rate 1 Mbps
op-mode 3	The EUT transmits on 2480 MHz	Loopback mode, basic data rate 1 Mbps
op-mode 4	The EUT is in Hopping mode	The EUT is hopping on 79 channels, basic data rate 1 Mbps
op-mode 6	The EUT transmits on 2402 MHz	Loopback mode, enhanced data rate 3 Mbps
op-mode 7	The EUT transmits on 2441 MHz	Loopback mode, enhanced data rate 3 Mbps
op-mode 8	The EUT transmits on 2480 MHz	Loopback mode, enhanced data rate 3 Mbps
op-mode 10	The EUT transmits on 2402 MHz	Loopback mode, enhanced data rate, 2 Mbps
op-mode 11	The EUT transmits on 2441 MHz	Loopback mode, enhanced data rate, 2 Mbps
op-mode 12	The EUT transmits on 2480 MHz	Loopback mode, enhanced data rate, 2 Mbps

## 2.7 Product labelling

### 2.7.1 FCC ID label

Please refer to the documentation of the applicant.

### 2.7.2 Location of the label on the EUT

Please refer to the documentation of the applicant.



## 3 Test Results

### 3.1 Occupied bandwidth

**Standard** FCC Part 15, 10-1-07  
Subpart C

**The test was performed according to:** FCC §15.31, 10-1-07

#### 3.1.1 Test Description

The Equipment Under Test (EUT) was setup to perform the occupied bandwidth measurements.

The reference level is the level of the highest amplitude signal observed from the transmitter at either the fundamental frequency or first-order modulation products in all typical modes of operation, including the unmodulated carrier, even if atypical.

The results recorded were measured with the modulation which produces the worst-case (widest) occupied bandwidth. The resolution bandwidth for measuring the reference level and the occupied bandwidth was 30 kHz.

The EUT was connected to the spectrum analyzer via a short coax cable.

#### 3.1.2 Test Requirements / Limits

FCC Part 15, Subpart C, §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. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

#### **Implication by the test laboratory:**

Since the Bluetooth technology defines a fixed channel separation of 1 MHz this design parameter defines the maximum allowed occupied bandwidth depending on the EUT's output power:

1. Under the provision that the system operates with an output power not greater than 125 mW (21.0 dBm):  
Implicit Limit: Max. 20 dB BW =  $1.0 \text{ MHz} / 2/3 = 1.5 \text{ MHz}$
2. If the system output power exceeds 125 mW (21.0 dBm):  
Implicit Limit: Max. 20 dB BW = 1.0 MHz

Used conversion factor: Output power (dBm) =  $10 \log (\text{Output power (W)} / 1\text{mW})$

The measured output power of the system is below 125 mW (21.0 dBm).

For the results, please refer to the related chapter of this report.

Therefore the limit is determined as 1.5 MHz.

### 3.1.3 Test Protocol

Temperature: 21 °C  
 Air Pressure: 1012 hPa  
 Humidity: 30 %

Op. Mode	Setup	Port
op-mode 1	Setup_b01	Ext. ant.connector

20 dB bandwidth MHz	Remarks
0.896	-

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 2	Setup_b01	Ext. ant.connector

20 dB bandwidth MHz	Remarks
0.896	-

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 3	Setup_b01	Ext. ant.connector

20 dB bandwidth MHz	Remarks
0.896	-

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 6	Setup_b01	Ext. ant.connector

20 dB bandwidth MHz	Remarks
1.191	-

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 7	Setup_b01	Ext. ant.connector

20 dB bandwidth MHz	Remarks
1.191	-

Remark: Please see annex for the measurement plot.



Op. Mode	Setup	Port
op-mode 8	Setup_b01	Ext. ant.connector

20 dB bandwidth MHz	Remarks
1.191	-

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 10	Setup_b01	Ext. ant.connector

20 dB bandwidth MHz	Remarks
1.112	-

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 11	Setup_b01	Ext. ant.connector

20 dB bandwidth MHz	Remarks
1.112	-

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 12	Setup_b01	Ext. ant.connector

20 dB bandwidth MHz	Remarks
1.106	-

Remark: Please see annex for the measurement plot.

### 3.1.4 Test result: Occupied bandwidth

FCC Part 15, Subpart C	Op. Mode	Result
	op-mode 1	passed
	op-mode 2	passed
	op-mode 3	passed
	op-mode 6	passed
	op-mode 7	passed
	op-mode 8	passed
	op-mode 10	passed
	op-mode 11	passed
	op-mode 12	passed



## 3.2 Peak power output

**Standard** FCC Part 15, 10-1-07  
Subpart C

**The test was performed according to:** FCC §15.31, 10-1-07

### 3.2.1 Test Description

The Equipment Under Test (EUT) was set up to perform the output power measurements. The resolution bandwidth for measuring the output power was set to 3 MHz. The reference level of the spectrum analyzer was set higher than the output power of the EUT. The EUT was connected to the spectrum analyzer via a short coax cable with a known loss.

### 3.2.2 Test Requirements / Limits

FCC Part 15, Subpart C, §15.247 (b) (1)

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

(1) For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt.

Used conversion factor: Limit (dBm) = 10 log (Limit (W)/1mW)

==> Maximum Output Power: 30 dBm



### 3.2.3 Test Protocol

Temperature: 21 °C  
Air Pressure: 1012 hPa  
Humidity: 30 %

Op. Mode	Setup	Port
op-mode 1	Setup_b01	Ext. ant.connector

Output power dBm	Remarks
2.3	The EIRP including antenna gain (2.4 dBi) is 4.7 dBm

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 2	Setup_b01	Ext. ant.connector

Output power dBm	Remarks
2.4	The EIRP including antenna gain (2.4 dBi) is 4.8 dBm

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 3	Setup_b01	Ext. ant.connector

Output power dBm	Remarks
2.1	The EIRP including antenna gain (2.4 dBi) is 4.5 dBm

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 6	Setup_b01	Ext. ant.connector

Output power dBm	Remarks
2.7	The EIRP including antenna gain (2.4 dBi) is 5.1 dBm

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 7	Setup_b01	Ext. ant.connector

Output power dBm	Remarks
2.3	The EIRP including antenna gain (2.4 dBi) is 4.7 dBm

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 8	Setup_b01	Ext. ant.connector

Output power dBm	Remarks
1.6	The EIRP including antenna gain (2.4 dBi) is 4.0 dBm

Remark: Please see annex for the measurement plot.



Op. Mode	Setup	Port
op-mode 10	Setup_b01	Ext. ant.connector

Output power dBm	Remarks
2.7	The EIRP including antenna gain (2.4 dBi) is 5.1 dBm

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 11	Setup_b01	Ext. ant.connector

Output power dBm	Remarks
2.4	The EIRP including antenna gain (2.4 dBi) is 4.8 dBm

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 12	Setup_b01	Ext. ant.connector

Output power dBm	Remarks
1.9	The EIRP including antenna gain (2.4 dBi) is 4.3 dBm

Remark: Please see annex for the measurement plot.

### 3.2.4 Test result: Peak power output

FCC Part 15, Subpart C	Op. Mode	Result
	op-mode 1	passed
	op-mode 2	passed
	op-mode 3	passed
	op-mode 6	passed
	op-mode 7	passed
	op-mode 8	passed
	op-mode 10	passed
	op-mode 11	passed
	op-mode 12	passed



### 3.3 Spurious RF conducted emissions

**Standard** FCC Part 15, 10-1-07  
Subpart C

**The test was performed according to:** FCC §15.31, 10-1-07

#### 3.3.1 Test Description

The Equipment Under Test (EUT) was set up to perform the spurious emissions measurements.

The EUT was connected to spectrum analyzer via a short coax cable with a known loss.

Analyzer settings:

- Detector: Peak-Maxhold
- Frequency range: 30 – 25000 MHz
- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Sweep Time: 330 s

The reference value for the measurement of the spurious RF conducted emissions is determined during the test “band edge compliance” (cf. chapter 3.5). This value is used to calculate the 20 dBc limit.

#### 3.3.2 Test Requirements / Limits

FCC Part 15, Subpart C, §15.247 (c)

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum 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.

### 3.3.3 Test Protocol

Temperature: 21 °C  
 Air Pressure: 1012 hPa  
 Humidity: 30 %

Op. Mode	Setup	Port
op-mode 1	Setup_b01	Ext. ant.connector

Frequency MHz	Corrected measurement value dBm	Reference value dBm	Limit dBm	Delta to limit dB
-	-	-	-	-

Remark: No (further) spurious emissions in the range 20 dB below the limit found.  
 Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 2	Setup_b01	Ext. ant.connector

Frequency MHz	Corrected measurement value dBm	Reference value dBm	Limit dBm	Delta to limit dB
-	-	-	-	-

Remark: No (further) spurious emissions in the range 20 dB below the limit found.  
 Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 3	Setup_b01	Ext. ant.connector

Frequency MHz	Corrected measurement value dBm	Reference value dBm	Limit dBm	Delta to limit dB
-	-	-	-	-

Remark: No (further) spurious emissions in the range 20 dB below the limit found.  
 Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 6	Setup_b01	Ext. ant.connector

Frequency MHz	Corrected measurement value dBm	Reference value dBm	Limit dBm	Delta to limit dB
-	-	-	-	-

Remark: No (further) spurious emissions in the range 20 dB below the limit found.  
 Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 7	Setup_b01	Ext. ant.connector

Frequency MHz	Corrected measurement value dBm	Reference value dBm	Limit dBm	Delta to limit dB
-	-	-	-	-

Remark: No (further) spurious emissions in the range 20 dB below the limit found.  
 Please see annex for the measurement plot.



Op. Mode	Setup	Port
op-mode 8	Setup_b01	Ext. ant.connector

Frequency MHz	Corrected measurement value dBm	Reference value dBm	Limit dBm	Delta to limit dB
-	-	-	-	-

Remark: No (further) spurious emissions in the range 20 dB below the limit found.  
Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 10	Setup_b01	Ext. ant.connector

Frequency MHz	Corrected measurement value dBm	Reference value dBm	Limit dBm	Delta to limit dB
-	-	-	-	-

Remark: No (further) spurious emissions in the range 20 dB below the limit found.  
Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 11	Setup_b01	Ext. ant.connector

Frequency MHz	Corrected measurement value dBm	Reference value dBm	Limit dBm	Delta to limit dB
-	-	-	-	-

Remark: No (further) spurious emissions in the range 20 dB below the limit found.  
Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 12	Setup_b01	Ext. ant.connector

Frequency MHz	Corrected measurement value dBm	Reference value dBm	Limit dBm	Delta to limit dB
-	-	-	-	-

Remark: No (further) spurious emissions in the range 20 dB below the limit found.  
Please see annex for the measurement plot.

### 3.3.4 Test result: Spurious RF conducted emissions

FCC Part 15, Subpart C	Op. Mode	Result
	op-mode 1	passed
	op-mode 2	passed
	op-mode 3	passed
	op-mode 6	passed
	op-mode 7	passed
	op-mode 8	passed
	op-mode 10	passed
	op-mode 11	passed
	op-mode 12	passed



### 3.4 Spurious radiated emissions

**Standard** FCC Part 15, 10-1-07  
Subpart C

**The test was performed according to:** ANSI C 63.4, 2003

#### 3.4.1 Test Description

The test set-up was made in accordance to the general provisions of ANSI C 63.4-2003. The Equipment Under Test (EUT) was set up on a non-conductive table 1.0 x 2.0 m in the semi-anechoic chamber. The test was performed at the distance of 3 m between the EUT and the receiving antenna.

The radiated emissions measurements were made in a typical installation configuration. The measurement procedure is implemented into the EMI test software ES-K1 from R&S.

##### 1. Measurement up to 30 MHz

The test set-up was made in accordance to the general provisions of ANSI C 63.4-2003. The Equipment Under Test (EUT) was set up on a non-conductive table in the anechoic chamber.

The radiated emissions measurements were made in a typical installation configuration. The measurement procedure is implemented into the EMI test software ES-K1 from R&S. The Loop antenna HFH2-Z2 is used.

##### **Step 1:** pre-measurement

- Anechoic chamber
- Antenna distance: 10 m
- Detector: Peak-Maxhold
- Frequency range: 0.009 - 0.15 and 0.15 – 30 MHz
- Frequency steps: 0.1 kHz and 5 kHz
- IF-Bandwidth: 0.2 kHz and 10 kHz
- Measuring time / Frequency step: 100 ms

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

##### **Step 2:** final measurement

For the relevant emissions determined in step 1, an additional measurement with the following settings will be performed. Intention of this step is to find the maximum emission level.

- Open area test side
- Antenna distance: according to the Standard
- Detector: Quasi-Peak
- Frequency range: 0.009 – 30 MHz
- Frequency steps: measurement at frequencies detected in step 1
- IF-Bandwidth: 200 Hz - 10 kHz
- Measuring time / Frequency step: 100 ms

##### 2. Measurement above 30 MHz and up to 1 GHz

##### **Step 1:** Preliminary scan

Preliminary test to identify the highest amplitudes relative to the limit.

Settings for step 1:

- Detector: Peak-Maxhold
- Frequency range: 30 – 1000 MHz
- Frequency steps: 60 kHz
- IF-Bandwidth: 120 kHz

- Measuring time / Frequency step: 100  $\mu$ s (BT Timing 1.25 ms)
- Turntable angle range:  $-180$  to  $180^\circ$
- Turntable step size:  $90^\circ$
- Height variation range: 1 – 3 m
- Height variation step size: 2 m
- Polarisation: Horizontal + Vertical

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

**Step 2:** second measurement

For the relevant emissions determined in step 1, an additional measurement with the following settings will be performed. Intention of this step is, to find out the approximate turntable angle and antenna height for each frequency.

- Detector: Peak – Maxhold
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 100 ms
- Turntable angle range:  $-180$  to  $180^\circ$
- Turntable step size:  $45^\circ$
- Height variation range: 1 – 4 m
- Height variation step size: 0.5 m
- Polarisation: horizontal + vertical

After this step the EMI test system has determined the following values for each frequency (of step 1):

- Frequency
- Azimuth value (of turntable)
- Antenna height

The last two values have now the following accuracy:

- Azimuth value (of turntable):  $45^\circ$
- Antenna height: 0.5 m

**Step 3:** final measurement

In this step the accuracy of the turntable azimuth and antenna height will be improved.

This is necessary to find out the maximum value of every frequency.

For each frequency, which was determined the turntable azimuth and antenna height will be adjusted. The turntable azimuth will be slowly varied by  $\pm 22.5^\circ$  around this value. During this action the value of emission is continuously measured. The turntable azimuth at the highest emission will be recorded and adjusted. In this position the antenna height is also slowly varied by  $\pm 25$  cm around the antenna height determined. During this action the value of emission is also continuously measured. The antenna height of the highest emission will also be recorded and adjusted.

- Detector: Peak – Maxhold
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 100 ms
- Turntable angle range:  $-22.5^\circ$  to  $+ 22.5^\circ$  around the determined value
- Height variation range:  $-0.25$  m to  $+ 0.25$  m around the determined value

**Step 4:** final measurement with QP detector

With the settings determined in step 3, the final measurement will be performed:

EMI receiver settings for step 4:

- Detector: Quasi-Peak ( $< 1$  GHz)
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 1 s



**3. Measurement above 1 GHz**

The following modifications apply to the measurement procedure for the frequency range above 1 GHz:

The measurement distance was reduced to 1 m. The results were extrapolated by the extrapolation factor of 20 dB/decade (inverse linear-distance for field strength measurements, inverse linear-distance squared for the power reference level measurements). Due to the fact that in this frequency range a double ridged wave guided horn antenna (up to 18 GHz) and a horn antenna (18-25 GHz) are used, the steps 2-4 are omitted. Step 1 was performed with one height of the receiving antenna only.

EMI receiver settings:

- Detector: Peak, Average
- RBW = VBW = 100 kHz

After the measurement a plot will be generated which contains a diagram with the results of the preliminary scan and a chart with the frequencies and values of the results of the final measurement.

**3.4.2 Test Requirements / Limits**

FCC Part 15, Subpart C, §15.247 (d)

... 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)).

FCC Part 15, Subpart C, §15.209, Radiated Emission Limits

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limit(dBµV/m @10m)
0.009 – 0.49	2400/F(kHz)	300	Limit (dBµV/m)+30dB
0.49 – 1.705	24000/F(kHz)	30	Limit (dBµV/m)+10dB
1.705 - 30	30	30	Limit (dBµV/m)+10dB

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limit (dBµV/m)
30 - 88	100	3	40.0
88 - 216	150	3	43.5
216 - 960	200	3	46.0
above 960	500	3	54.0

§15.35(b)

..., there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit....

Used conversion factor: Limit (dBµV/m) = 20 log (Limit (µV/m)/1µV/m)



### 3.4.3 Test Protocol

Temperature: 24 °C  
 Air Pressure: 1012 - 1018 hPa  
 Humidity: 35 - 39 %

#### 3.4.3.1 Measurement up to 30 MHz

Op. Mode	Setup	Port
op-mode 1	Setup_a01	Enclosure

Polarisation	Frequency MHz	Corrected value dBµV/m			Limit dBµV/m	Limit dBµV/m	Limit dBµV/m	Delta to limit dB	Delta to limit dB
		QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
0°	-	-	-	-	-	-	-	-	-
90°	-	-	-	-	-	-	-	-	-

Remark: No (further) spurious emissions in the range 20 dB below the limit found therefore step 2 was not performed. The found peak at 99.2 kHz is emission from loop antenna power supply.

#### 3.4.3.2 Measurement above 30 MHz

Op. Mode	Setup	Port
op-mode 1	Setup_a01	Enclosure

Polarisation	Frequency MHz	Corrected value dBµV/m			Limit dBµV/m	Limit dBµV/m	Limit dBµV/m	Delta to limit dB	Delta to limit dB
		QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
Vertical + horizontal	1000	41.2	-	-	54.0	-	-	12.8	-
Vertical + horizontal	1023	-	45.1	38.9	-	74.0	54.0	28.9	15.1
Vertical + horizontal	1089	-	47.8	42.6	-	74.0	54.0	26.2	11.4
Vertical + horizontal	1125	-	45.4	39.3	-	74.0	54.0	28.6	14.7
Vertical + horizontal	1155	-	45.2	39.3	-	74.0	54.0	28.8	14.7
Vertical + horizontal	1625	-	44.6	36.9	-	74.0	54.0	29.4	17.1
Vertical + horizontal	4804	-	54.0	42.2	-	74.0	54.0	20.0	11.6

Remark: No (further) spurious emissions in the range 20 dB below the limit found.



**Op. Mode**      **Setup**                      **Port**  
 op-mode 2      Setup\_a01                      Enclosure

Polarisation	Frequency MHz	Corrected value dBµV/m			Limit dBµV/m	Limit dBµV/m	Limit dBµV/m	Delta to limit dB	Delta to limit dB
		QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
Vertical + horizontal	1000	40.3	-	-	54.0	-	-	13.7	-
Vertical + horizontal	1023	-	45.1	39.0	-	74.0	54.0	28.9	15.0
Vertical + horizontal	1089	-	47.8	42.6	-	74.0	54.0	26.2	11.4
Vertical + horizontal	1125	-	45.2	39.3	-	74.0	54.0	28.8	14.7
Vertical + horizontal	1155	-	45.2	39.3	-	74.0	54.0	28.8	14.7
Vertical + horizontal	1625	-	45.0	37.1	-	74.0	54.0	29.0	16.9
Vertical + horizontal	4882	-	56.6	45.1	-	74.0	54.0	17.4	8.9

Remark: No (further) spurious emissions in the range 20 dB below the limit found.

**Op. Mode**      **Setup**                      **Port**  
 op-mode 3      Setup\_a01                      Enclosure

Polarisation	Frequency MHz	Corrected value dBµV/m			Limit dBµV/m	Limit dBµV/m	Limit dBµV/m	Delta to limit dB	Delta to limit dB
		QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
Vertical + horizontal	1000	40.0	-	-	54.0	-	-	14.0	-
Vertical + horizontal	1023	-	45.1	39.1	-	74.0	54.0	28.9	14.9
Vertical + horizontal	1089	-	47.5	42.5	-	74.0	54.0	26.5	11.5
Vertical + horizontal	1125	-	45.9	39.5	-	74.0	54.0	28.1	14.5
Vertical + horizontal	1155	-	45.9	39.5	-	74.0	54.0	28.1	14.5
Vertical + horizontal	1625	-	45.3	37.3	-	74.0	54.0	28.7	16.7
Vertical + horizontal	2484	-	54.6	41.7	-	74.0	54.0	19.4	12.3
Vertical + horizontal	4960	-	51.0	39.4	-	74.0	54.0	23.0	14.6

Remark: No (further) spurious emissions in the range 20 dB below the limit found.

**Op. Mode**      **Setup**                      **Port**  
 op-mode 6      Setup\_a01                      Enclosure

Polarisation	Frequency MHz	Corrected value dBµV/m			Limit dBµV/m	Limit dBµV/m	Limit dBµV/m	Delta to limit dB	Delta to limit dB
		QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
Vertical + horizontal	1023	-	44.7	38.9	-	74.0	54.0	29.3	15.1
Vertical + horizontal	1089	-	47.3	42.6	-	74.0	54.0	26.7	11.4
Vertical + horizontal	1125	-	45.8	39.1	-	74.0	54.0	28.2	14.9
Vertical + horizontal	1155	-	46.0	39.3	-	74.0	54.0	28.0	14.7
Vertical + horizontal	1625	-	45.7	36.9	-	74.0	54.0	28.3	17.1

Remark: No (further) spurious emissions in the range 20 dB below the limit found.  
 The measurement was performed in the frequency range 1-8 GHz because no significant spurious emissions were found outside this range in op-mode 1.

**Op. Mode**      **Setup**                      **Port**  
 op-mode 7      Setup\_a01                      Enclosure

Polarisation	Frequency MHz	Corrected value dBµV/m			Limit dBµV/m	Limit dBµV/m	Limit dBµV/m	Delta to limit dB	Delta to limit dB
		QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
Vertical + horizontal	1023	-	44.7	38.9	-	74.0	54.0	29.3	15.1
Vertical + horizontal	1089	-	47.3	42.7	-	74.0	54.0	26.7	11.3
Vertical + horizontal	1125	-	45.5	39.1	-	74.0	54.0	28.5	14.9
Vertical + horizontal	1155	-	46.3	39.9	-	74.0	54.0	27.7	14.1
Vertical + horizontal	1625	-	45.0	37.0	-	74.0	54.0	29.0	17.0

Remark: No (further) spurious emissions in the range 20 dB below the limit found.  
 The measurement was performed in the frequency range 1-8 GHz because no significant spurious emissions were found outside this range in op-mode 2.

**Op. Mode**      **Setup**                      **Port**  
 op-mode 8      Setup\_a01                      Enclosure

Polarisation	Frequency MHz	Corrected value dBµV/m			Limit dBµV/m	Limit dBµV/m	Limit dBµV/m	Delta to limit dB	Delta to limit dB
		QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
Vertical + horizontal	1023	-	44.8	38.9	-	74.0	54.0	29.2	15.1
Vertical + horizontal	1089	-	47.5	42.6	-	74.0	54.0	26.5	11.4
Vertical + horizontal	1125	-	45.7	39.1	-	74.0	54.0	28.3	14.9
Vertical + horizontal	1155	-	45.4	39.3	-	74.0	54.0	28.6	14.7
Vertical + horizontal	1625	-	45.4	36.9	-	74.0	54.0	28.6	17.1
Vertical + horizontal	2484	-	58.9	39.3	-	74.0	54.0	15.1	14.7

Remark: No (further) spurious emissions in the range 20 dB below the limit found.  
 The measurement was performed in the frequency range 1-8 GHz because no significant spurious emissions were found outside this range in op-mode 3.



**Op. Mode**      **Setup**                      **Port**  
 op-mode 10      Setup\_a01                      Enclosure

Polarisation	Frequency MHz	Corrected value dBµV/m			Limit dBµV/m	Limit dBµV/m	Limit dBµV/m	Delta to limit dB	Delta to limit dB
		QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
Vertical + horizontal	1023	-	45.5	38.8	-	74.0	54.0	28.5	15.2
Vertical + horizontal	1089	-	47.8	42.6	-	74.0	54.0	26.2	11.4
Vertical + horizontal	1095	-	48.3	42.5	-	74.0	54.0	25.7	11.5
Vertical + horizontal	1125	-	45.4	39.3	-	74.0	54.0	28.6	14.7
Vertical + horizontal	1155	-	44.7	39.3	-	74.0	54.0	29.3	14.7
Vertical + horizontal	1625	-	45.3	36.9	-	74.0	54.0	28.7	17.1

Remark: No (further) spurious emissions in the range 20 dB below the limit found.  
 The measurement was performed in the frequency range 1-8 GHz because no significant spurious emissions were found outside this range in op-mode 1.

**Op. Mode**      **Setup**                      **Port**  
 op-mode 11      Setup\_a01                      Enclosure

Polarisation	Frequency MHz	Corrected value dBµV/m			Limit dBµV/m	Limit dBµV/m	Limit dBµV/m	Delta to limit dB	Delta to limit dB
		QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
Vertical + horizontal	1023	-	44.7	38.9	-	74.0	54.0	29.3	15.1
Vertical + horizontal	1089	-	47.4	42.6	-	74.0	54.0	26.6	11.4
Vertical + horizontal	1125	-	45.0	39.1	-	74.0	54.0	29.0	14.9
Vertical + horizontal	1155	-	45.4	39.3	-	74.0	54.0	28.6	14.7
Vertical + horizontal	1625	-	44.8	36.9	-	74.0	54.0	29.2	17.1

Remark: No (further) spurious emissions in the range 20 dB below the limit found.  
 The measurement was performed in the frequency range 1-8 GHz because no significant spurious emissions were found outside this range in op-mode 2.



Op. Mode	Setup	Port
op-mode 12	Setup_a01	Enclosure

Polarisation	Frequency MHz	Corrected value dBµV/m			Limit dBµV/m			Delta to limit dB	
		QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
Vertical + horizontal	1023	-	45.2	38.9	-	74.0	54.0	28.8	15.1
Vertical + horizontal	1089	-	47.6	42.6	-	74.0	54.0	26.4	11.4
Vertical + horizontal	1125	-	45.3	39.1	-	74.0	54.0	28.7	14.9
Vertical + horizontal	1155	-	45.6	39.4	-	74.0	54.0	28.4	14.6
Vertical + horizontal	1625	-	45.2	36.9	-	74.0	54.0	28.8	17.1
Vertical + horizontal	2484	-	60.0	41.1	-	74.0	54.0	14.0	12.9

Remark: No (further) spurious emissions in the range 20 dB below the limit found.  
 The measurement was performed in the frequency range 1-8 GHz because no significant spurious emissions were found outside this range in op-mode 3.

### 3.4.4 Test result: Spurious radiated emissions

FCC Part 15, Subpart C	Op. Mode	Result
	op-mode 1	passed
	op-mode 2	passed
	op-mode 3	passed
	op-mode 6	passed
	op-mode 7	passed
	op-mode 8	passed
	op-mode 10	passed
	op-mode 11	passed
	op-mode 12	passed



### 3.5 Band edge compliance

**Standard** FCC Part 15, 10-1-07  
Subpart C

**The test was performed according to:** ANSI C 63.4, 2003  
FCC §15.31, 10-1-07

#### 3.5.1 Test Description

The procedure to show compliance with the band edge requirement is divided into two measurements: 1. Show compliance of the lower band edge by a conducted measurement and 2. show compliance of the higher band edge by a radiated and conducted measurement.

For the first measurement the EUT is set to transmit on the lowest channel (2402 MHz). The lower band edge is 2400 MHz.

Analyzer settings:

- Detector: Peak
- RBW= 100 kHz
- VBW= 300 kHz

For the second measurement the EUT is set to transmit on the highest channel (2480 MHz). The higher band edge is 2483.5 MHz.

Analyzer settings for conducted measurement:

- Detector: Peak
- RBW= 100 kHz
- VBW= 300 kHz

Analyzer settings for radiated measurement:

- Detector: Peak, Average
- RBW = VBW = 100 kHz

#### 3.5.2 Test Requirements / Limits

FCC Part 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.

...

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))."

For the measurement of the **lower band edge** the RF power at the band edge 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..."

For the measurement of the **higher band edge** the limit is "specified in Section 15.209(a)".

### 3.5.3 Test Protocol

#### 3.5.3.1 Lower band edge

##### Conducted measurement

Temperature: 21 °C  
 Air Pressure: 1012 hPa  
 Humidity: 30 %

Op. Mode	Setup	Port
op-mode 1	Setup_b01	Ext. ant.connector

Frequency MHz	Measured value dBm	Reference value dBm	Limit dBm	Delta to limit dB
2400.00	-43.6	2.4	-17.6	26.0

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 6	Setup_b01	Ext. ant.connector

Frequency MHz	Measured value dBm	Reference value dBm	Limit dBm	Delta to limit dB
2400.00	-49.4	2.5	-17.5	31.9

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 10	Setup_b01	Ext. ant.connector

Frequency MHz	Measured value dBm	Reference value dBm	Limit dBm	Delta to limit dB
2400.00	-49.0	2.7	-17.3	31.7

Remark: Please see annex for the measurement plot.

### 3.5.3.2 Higher band edge

#### Conducted measurement

Temperature: 21 °C  
 Air Pressure: 1012 hPa  
 Humidity: 30 %

Op. Mode	Setup	Port
op-mode 3	Setup_b01	Ext. ant.connector

Frequency MHz	Measured value dBm	Reference value dBm	Limit dBm	Delta to limit dB
2483.50	-44.8	2.2	-17.8	27.0

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 8	Setup_b01	Ext. ant.connector

Frequency MHz	Measured value dBm	Reference value dBm	Limit dBm	Delta to limit dB
2483.50	-41.7	1.2	-18.8	22.9

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 12	Setup_b01	Ext. ant.connector

Frequency MHz	Measured value dBm	Reference value dBm	Limit dBm	Delta to limit dB
2483.50	-40.7	1.7	-18.3	22.4

Remark: Please see annex for the measurement plot.



**Radiated measurement**

Temperature: 24 °C  
 Air Pressure: 1017 - 1018 hPa  
 Humidity: 35 - 36 %

Op. Mode	Setup	Port
op-mode 3	Setup_a01	Enclosure

Frequency MHz	Polarisation	Corrected value dBµV/m		Limit Peak dBµV/m	Limit AV dBµV/m	Delta to Peak limit/dB	Delta to AV limit dB
		Peak	AV				
2483.50	Vertical + horizontal	49.2	37.0	74.0	54.0	24.8	17.0

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 8	Setup_a01	Enclosure

Frequency MHz	Polarisation	Corrected value dBµV/m		Limit Peak dBµV/m	Limit AV dBµV/m	Delta to Peak limit/dB	Delta to AV limit dB
		Peak	AV				
2483.50	Vertical + horizontal	48.3	36.4	74.0	54.0	25.7	17.6

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 12	Setup_a01	Enclosure

Frequency MHz	Polarisation	Corrected value dBµV/m		Limit Peak dBµV/m	Limit AV dBµV/m	Delta to Peak limit/dB	Delta to AV limit dB
		Peak	AV				
2483.50	Vertical + horizontal	48.6	36.3	74.0	54.0	25.4	17.7

Remark: Please see annex for the measurement plot.

**3.5.4 Test result: Band edge compliance**

FCC Part 15, Subpart C	Op. Mode	Result
	op-mode 1	passed
	op-mode 3	passed
	op-mode 6	passed
	op-mode 8	passed
	op-mode 10	passed
	op-mode 12	passed



### 3.6 Dwell time

**Standard** FCC Part 15, 10-1-07  
Subpart C

**The test was performed according to:** FCC §15.31, 10-1-07

#### 3.6.1 Test Description

The Equipment Under Test (EUT) was set up to perform the dwell time measurements. The EUT was connected to the spectrum analyzer via a short coax cable. The worst-case time slot length is measured for the longest packet length which is the DH5 packet. The dwell time is independent from the modulation pattern. The dwell time is calculated by:

Dwell time = time slot length \* hop rate / number of hopping channels \* 31.6 s  
with:

- hop rate =  $1600/5 * 1/s$  for DH5 packets =  $320 s^{-1}$
- number of hopping channels = 79
- $31.6 s = 0.4$  seconds multiplied by the number of hopping channels =  $0.4 s * 79$

#### 3.6.2 Test Requirements / Limits

FCC Part 15, Subpart C, §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.

Since the Bluetooth technology uses 79 channels this period is calculated to be 31.6 seconds.



### 3.6.3 Test Protocol

Temperature: 21 °C  
 Air Pressure: 1012 hPa  
 Humidity: 30 %

Op. Mode	Setup	Port
op-mode 2	Setup_b01	Ext. ant.connector

Packet type	Time slot length ms	Dwell time	Dwell time ms
DH5	2.926	time slot length * 1600/5 /79 * 31.6	374.53

Remark: Please see annex for the measurement plots.

### 3.6.4 Test result: Dwell time

FCC Part 15, Subpart C		Op. Mode	Result
op-mode 2	DH5		passed



### 3.7 Channel separation

**Standard** FCC Part 15, 10-1-07  
Subpart C

**The test was performed according to:** FCC §15.31, 10-1-07

#### 3.7.1 Test Description

The Equipment Under Test (EUT) was set up to perform the channel separation measurements. The channel separation is independent from the modulation pattern. The EUT was connected to spectrum analyzer via a short coax cable.

Analyzer settings:

- Detector: Peak-Maxhold
- Span: 3 MHz
- Centre Frequency: 2442 MHz
- Resolution Bandwidth (RBW): 30 kHz
- Video Bandwidth (VBW): 100 kHz
- Sweep Time: Coupled

#### 3.7.2 Test Requirements / Limits

FCC Part 15, Subpart C, §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. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.



### 3.7.3 Test Protocol

Temperature: 21 °C  
Air Pressure: 1012 hPa  
Humidity: 30 %

Op. Mode	Setup	Port
op-mode 4	Setup_b01	Ext. ant.connector

Channel separation MHz	Remarks
1.000	-

Remark: Please see annex for the measurement plot.

### 3.7.4 Test result: Channel separation

FCC Part 15, Subpart C	Op. Mode	Result
	op-mode 4	passed



### 3.8 Number of hopping frequencies

**Standard** FCC Part 15, 10-1-07  
Subpart C

**The test was performed according to:** FCC §15.31, 10-1-07

#### 3.8.1 Test Description

The Equipment Under Test (EUT) was set up to perform the number of hopping frequencies measurement. The number of hopping frequencies is independent from the modulation pattern.

The EUT was connected to spectrum analyzer via a short coax cable.

Analyzer settings:

- Detector: Peak-Maxhold
- Centre frequency: 2442 MHz
- Frequency span: 84 MHz
- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Sweep Time: Coupled

#### 3.8.2 Test Requirements / Limits

FCC Part 15, Subpart C, §15.247 (a) (iii)

Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.

#### 3.8.3 Test Protocol

Temperature: 21 °C  
Air Pressure: 1012 hPa  
Humidity: 30 %

Op. Mode	Setup	Port
op-mode 4	Setup_b01	Ext. ant.connector

Number of hopping channels	Remarks
79	-

Remark: Please see annex for the measurement plot.

#### 3.8.4 Test result: Number of hopping frequencies

FCC Part 15, Subpart C	Op. Mode	Result
	op-mode 4	passed



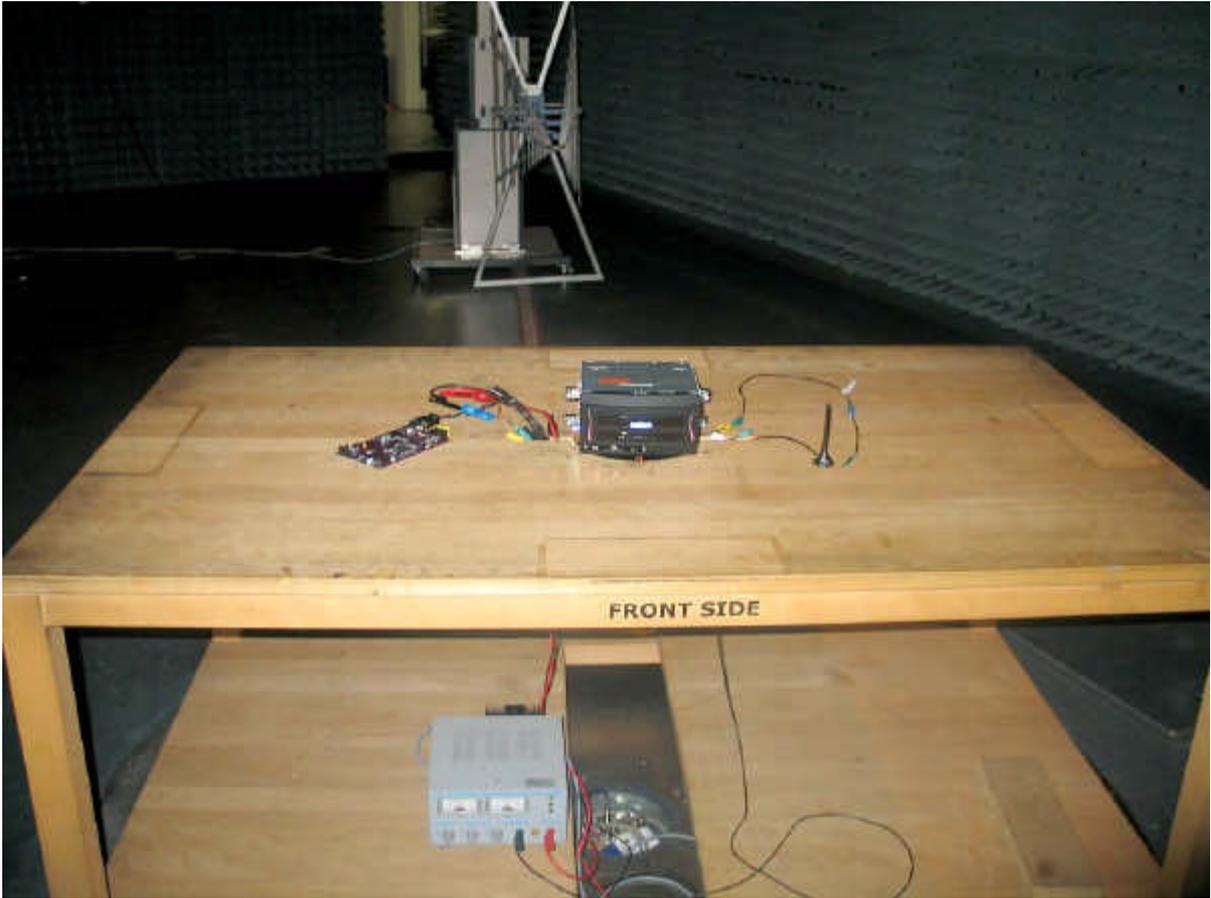
## 4 Test Equipment

Please refer to the separate report on "Test Equipment Calibration".

## 5 Photo Report



**Photo 1:** Test setup for radiated measurements (Enclosure, below 30 MHz)

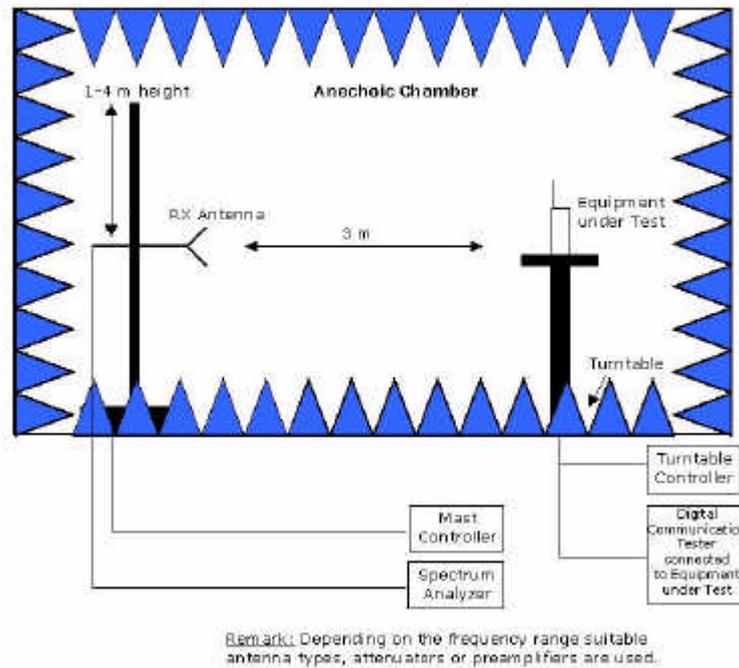


**Photo 2:** Test setup for radiated measurements (Enclosure, 30 MHz to 1 GHz)



**Photo 3:** Test setup for radiated measurements (Enclosure, above 1 GHz)

## 6 Setup Drawings



**Drawing 1:** Setup in the Anechoic chamber:  
Measurements below 1 GHz: Semi-anechoic, conducting ground plane.  
Measurements above 1 GHz: Fully-anechoic, absorbers on all surfaces.



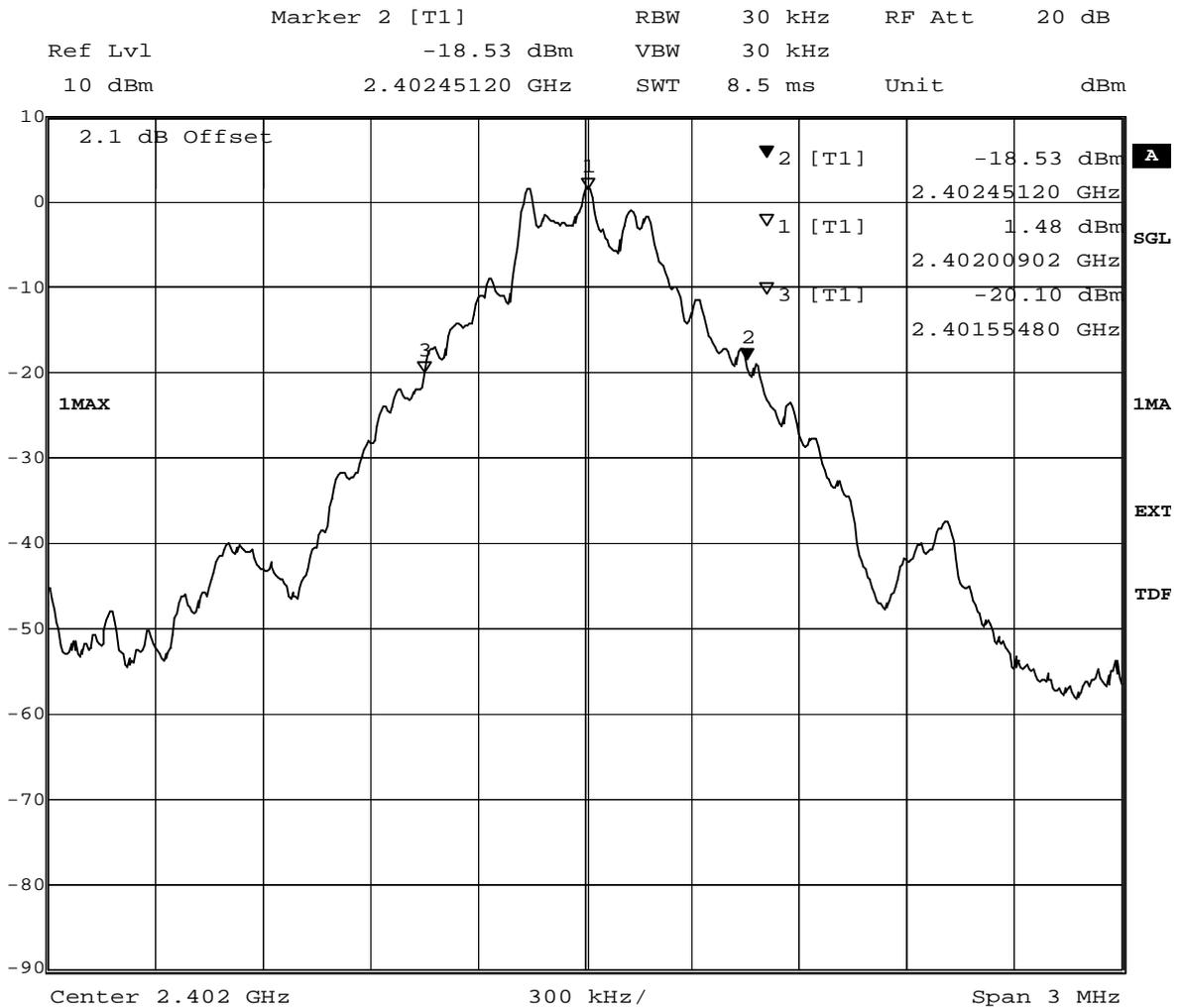
## 7 Annex measurement plots

### 7.1 Occupied bandwidth

#### 7.1.1 Occupied bandwidth operating mode 1

##### Op. Mode

op-mode 1



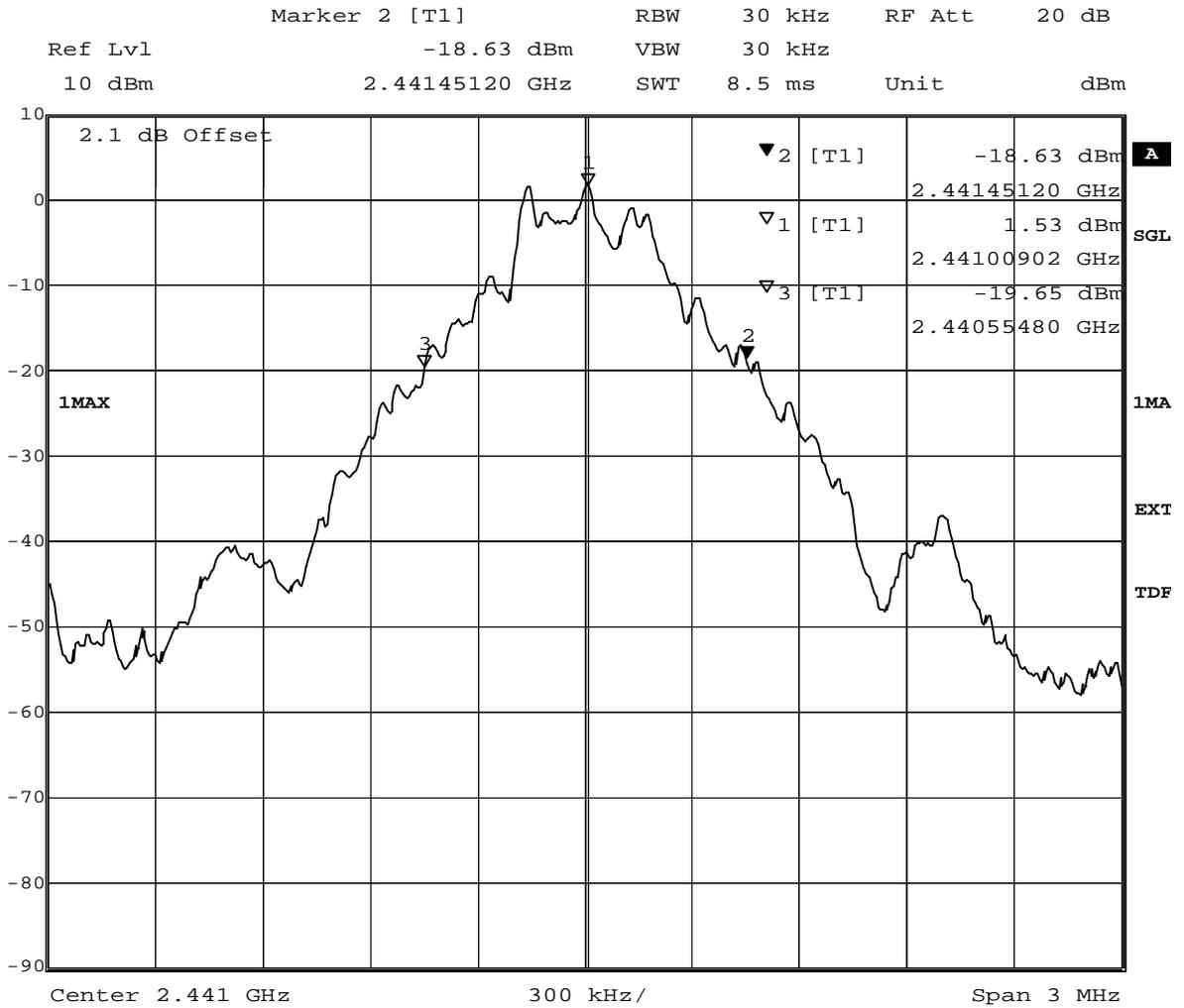
Title: 20dB Bandwidth  
 Comment A: CH B: 2402 MHz; 20dB bandwidth (kHz):896.4  
 Date: 28.NOV.2008 08:53:28



### 7.1.2 Occupied bandwidth operating mode 2

#### Op. Mode

op-mode 2



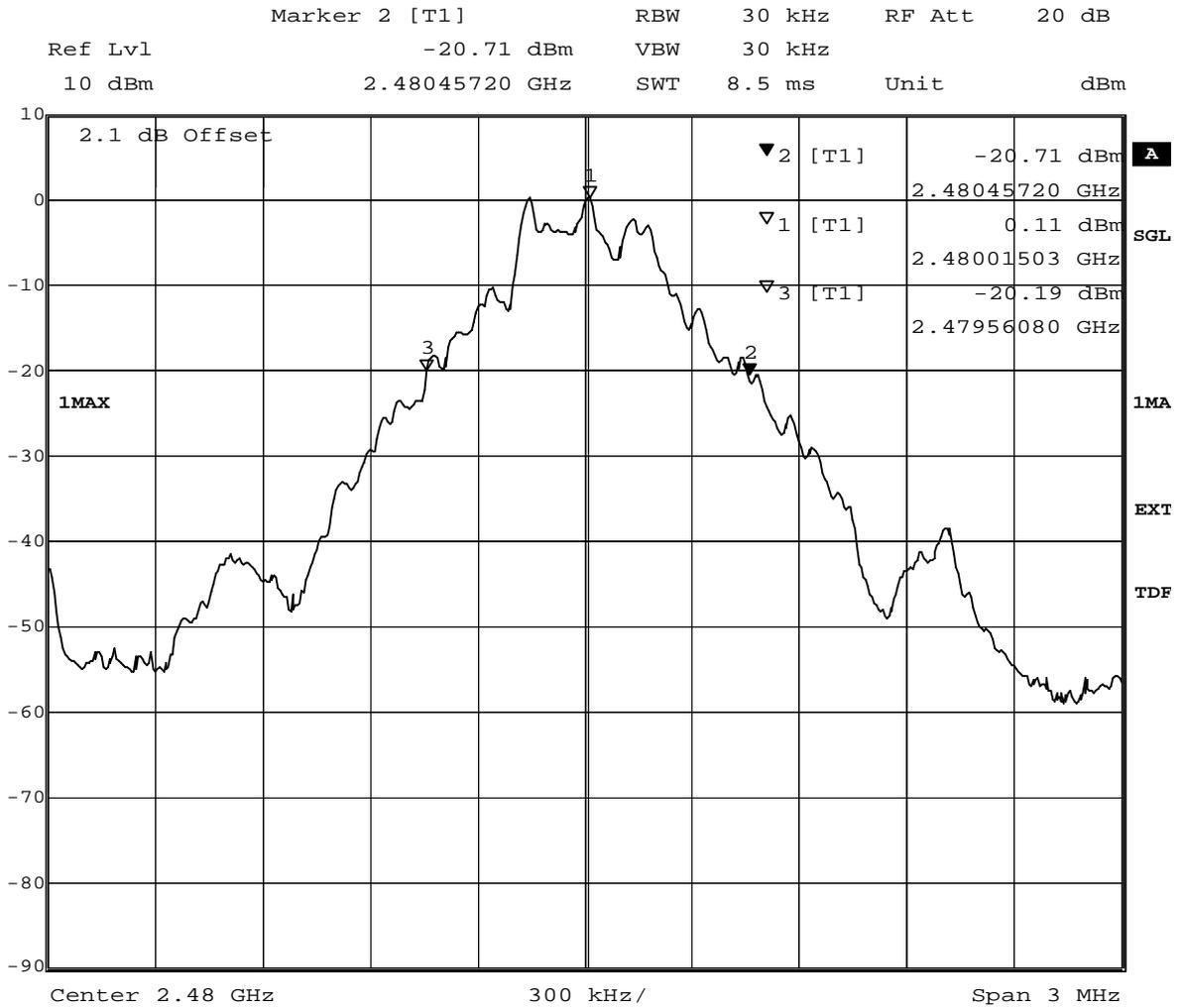
Title: 20dB Bandwidth  
 Comment A: CH M: 2441 MHz; 20dB bandwidth (kHz):896.4  
 Date: 28.NOV.2008 09:35:41



### 7.1.3 Occupied bandwidth operating mode 3

#### Op. Mode

op-mode 3



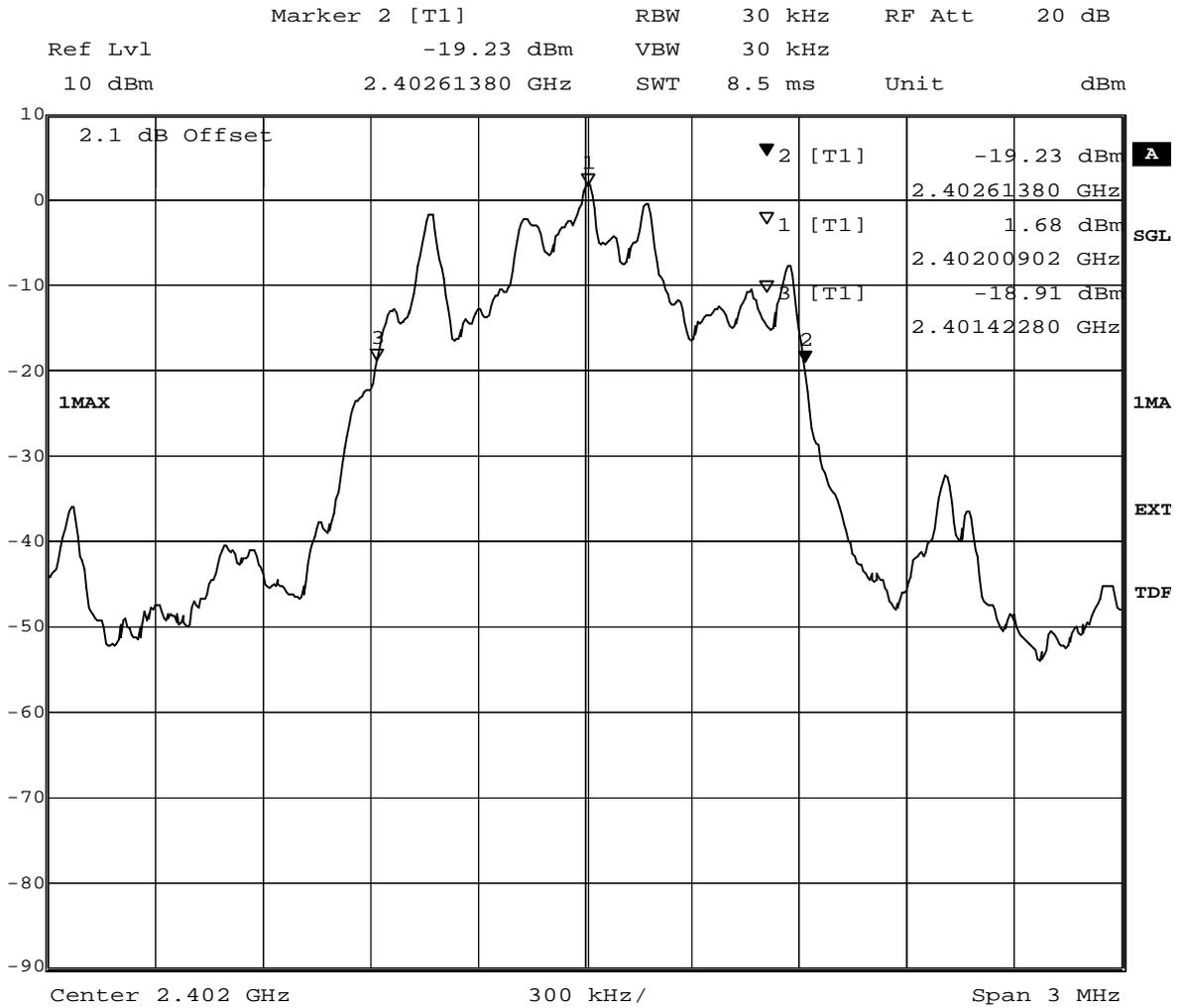
Title: 20dB Bandwidth  
 Comment A: CH T: 2480 MHz; 20dB bandwidth (kHz):896.4  
 Date: 11.FEB.2009 10:26:34



### 7.1.4 Occupied bandwidth operating mode 6

#### Op. Mode

op-mode 6



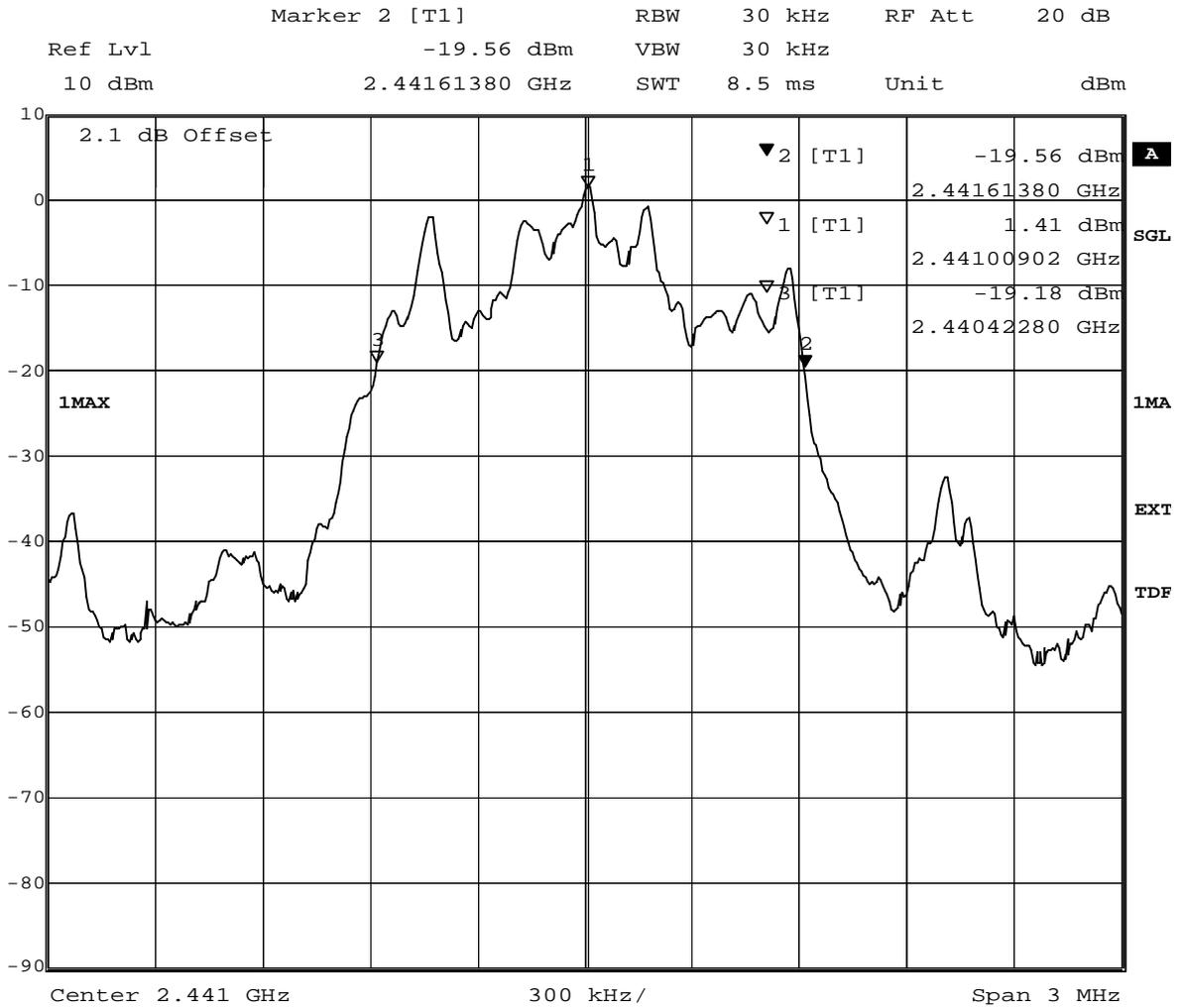
Title: 20dB Bandwidth  
 Comment A: CH B: 2402 MHz; 20dB bandwidth (kHz):1191  
 Date: 28.NOV.2008 14:21:23



### 7.1.5 Occupied bandwidth operating mode 7

#### Op. Mode

op-mode 7



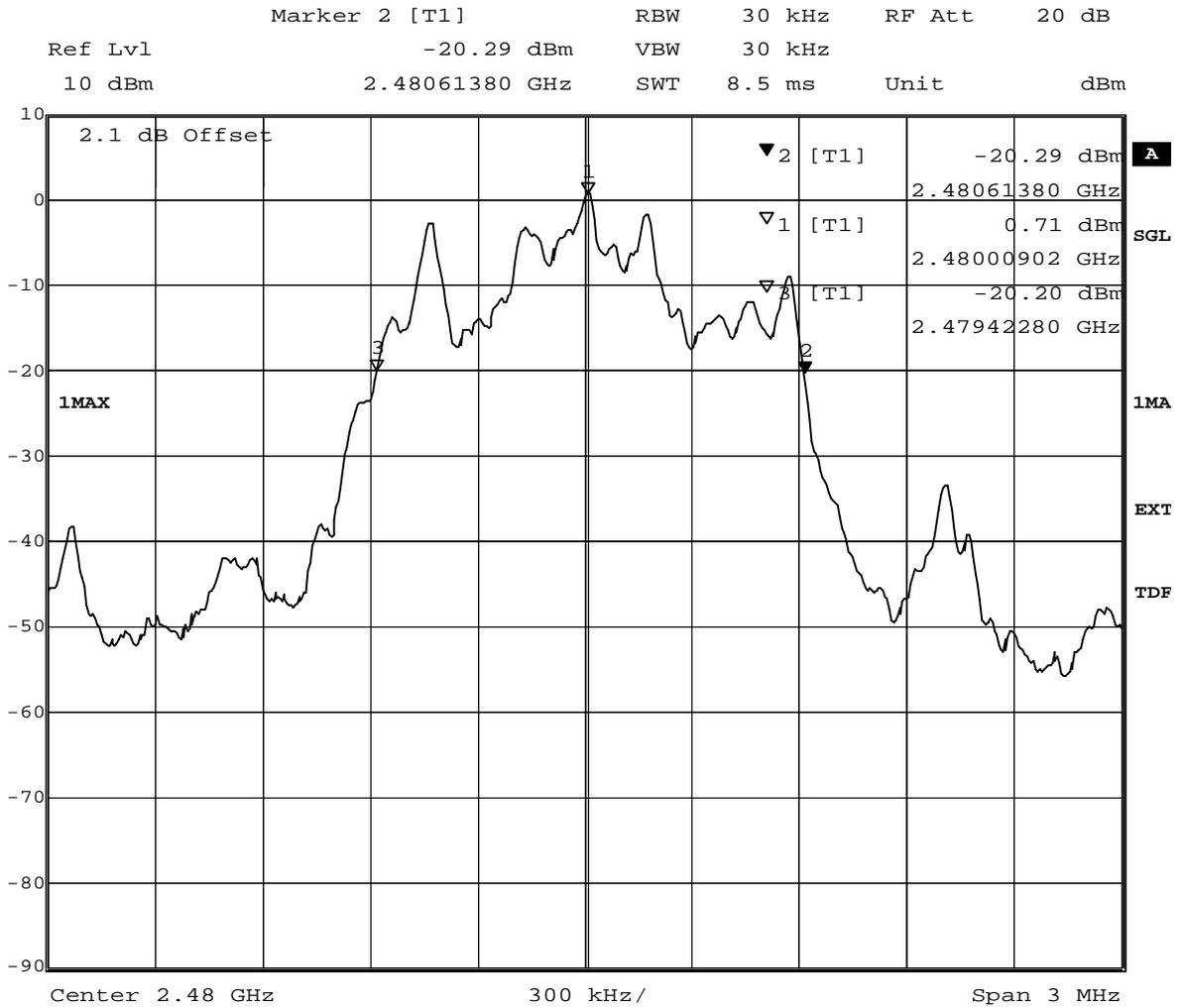
Title: 20dB Bandwidth  
Comment A: CH M: 2441 MHz; 20dB bandwidth (kHz):1191  
Date: 28.NOV.2008 14:50:13



### 7.1.6 Occupied bandwidth operating mode 8

#### Op. Mode

op-mode 8



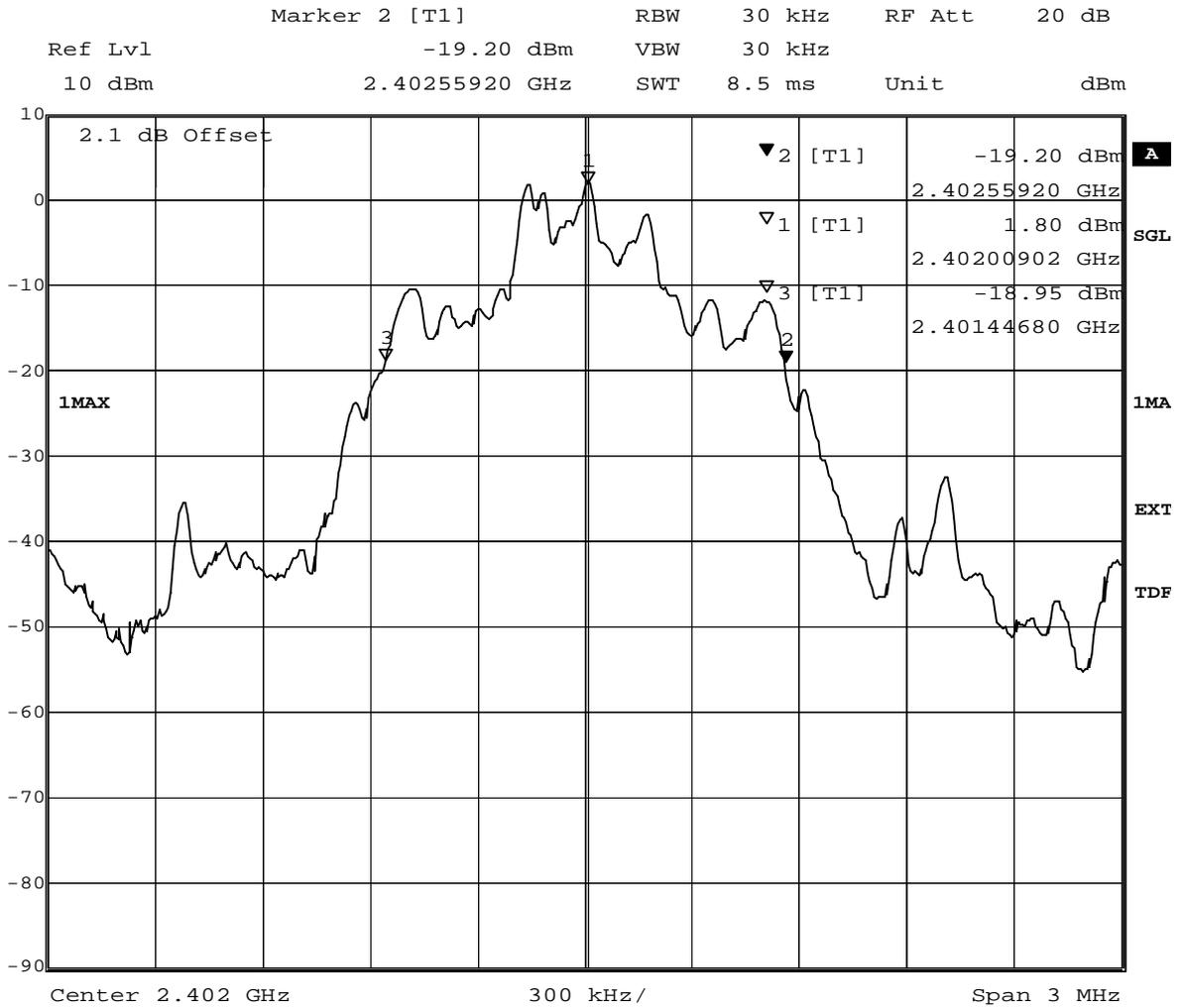
Title: 20dB Bandwidth  
 Comment A: CH T: 2480 MHz; 20dB bandwidth (kHz):1191  
 Date: 28.NOV.2008 15:33:08



### 7.1.7 Occupied bandwidth operating mode 10

#### Op. Mode

op-mode 10



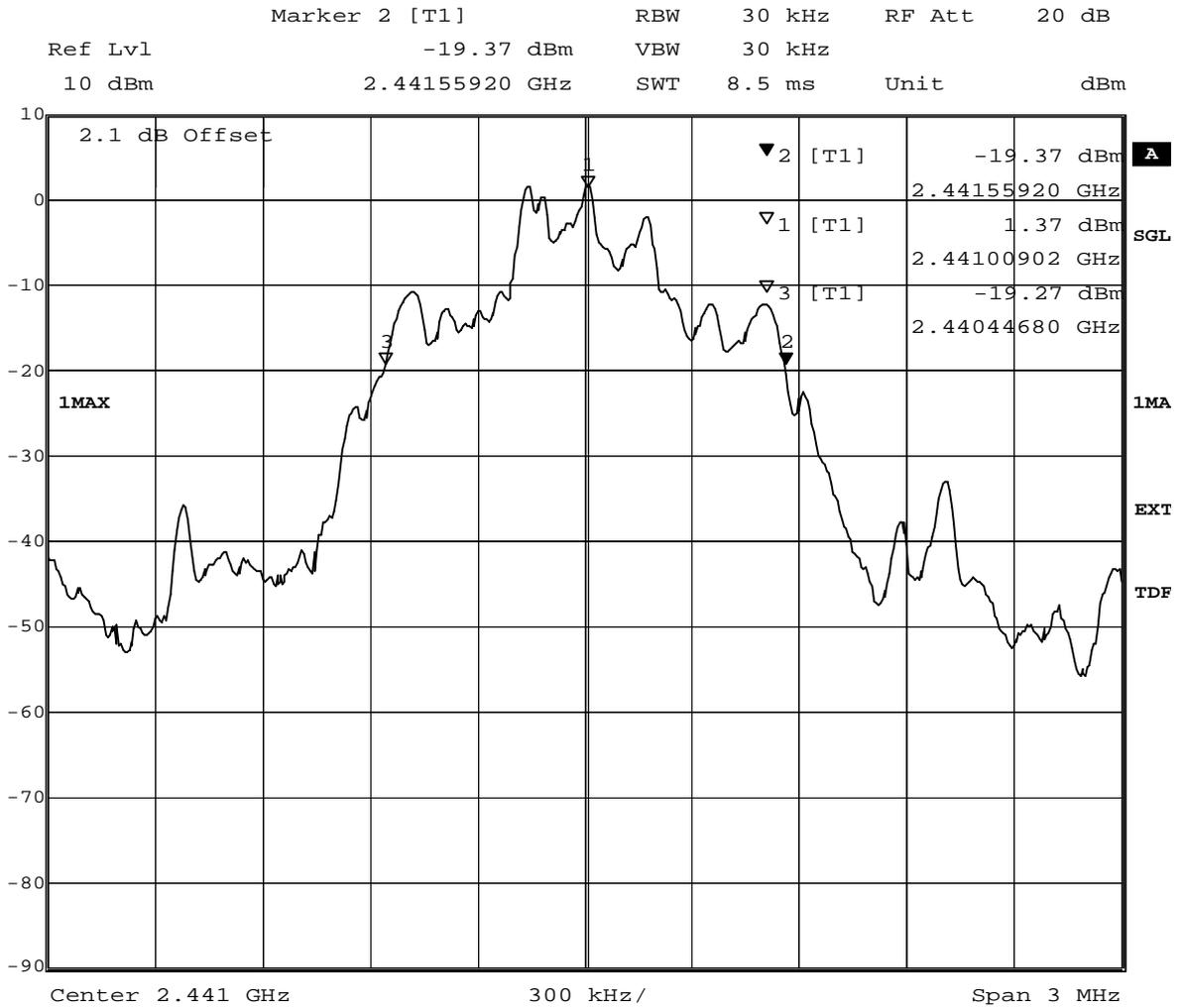
Title: 20dB Bandwidth  
 Comment A: CH B: 2402 MHz; 20dB bandwidth (kHz):1112.4  
 Date: 28.NOV.2008 11:58:49



### 7.1.8 Occupied bandwidth operating mode 11

#### Op. Mode

op-mode 11



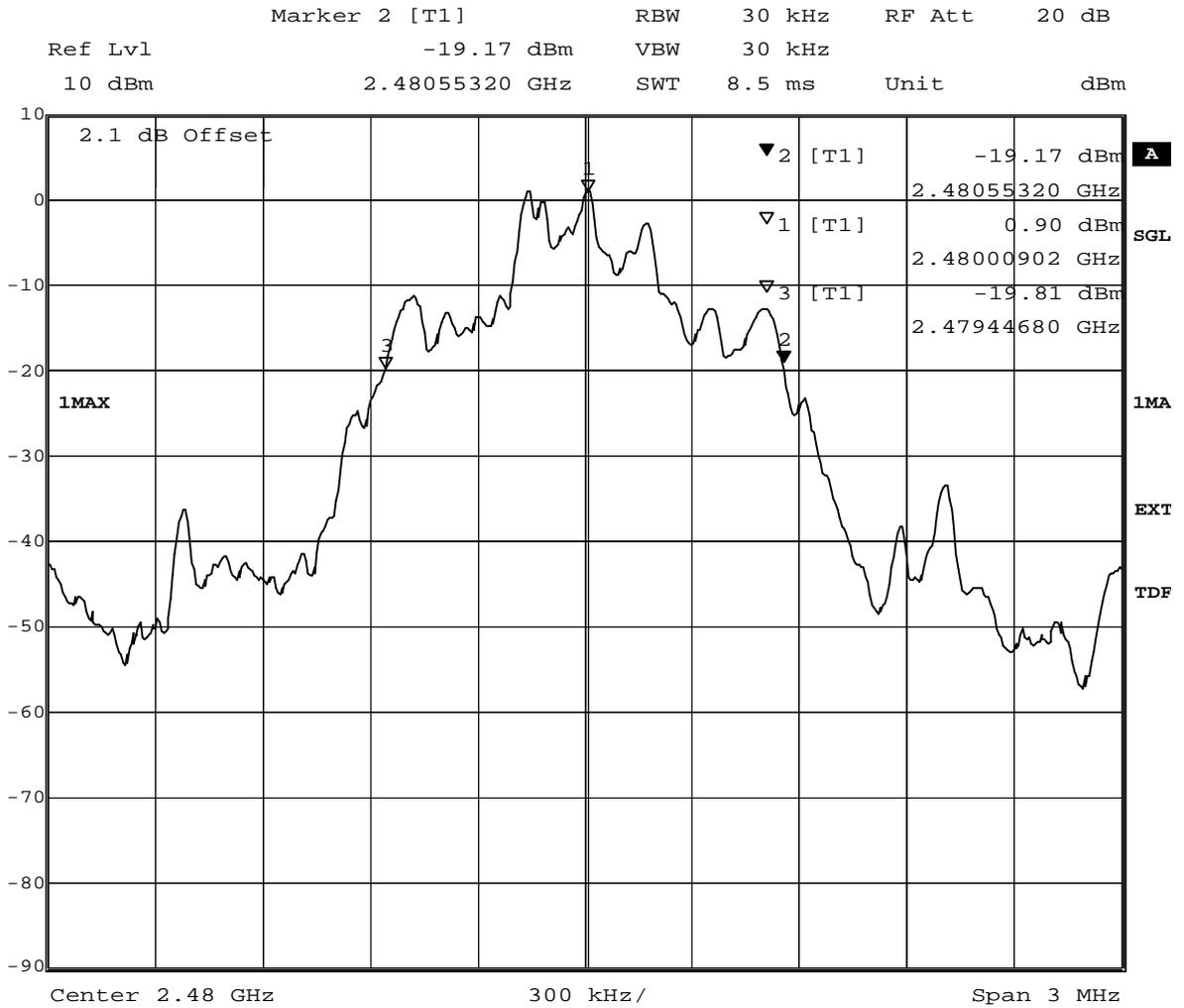
Title: 20dB Bandwidth  
 Comment A: CH M: 2441 MHz; 20dB bandwidth (kHz):1112.4  
 Date: 28.NOV.2008 12:49:02



### 7.1.9 Occupied bandwidth operating mode 12

#### Op. Mode

op-mode 12



Title: 20dB Bandwidth  
 Comment A: CH T: 2480 MHz; 20dB bandwidth (kHz):1106.4  
 Date: 28.NOV.2008 13:21:08

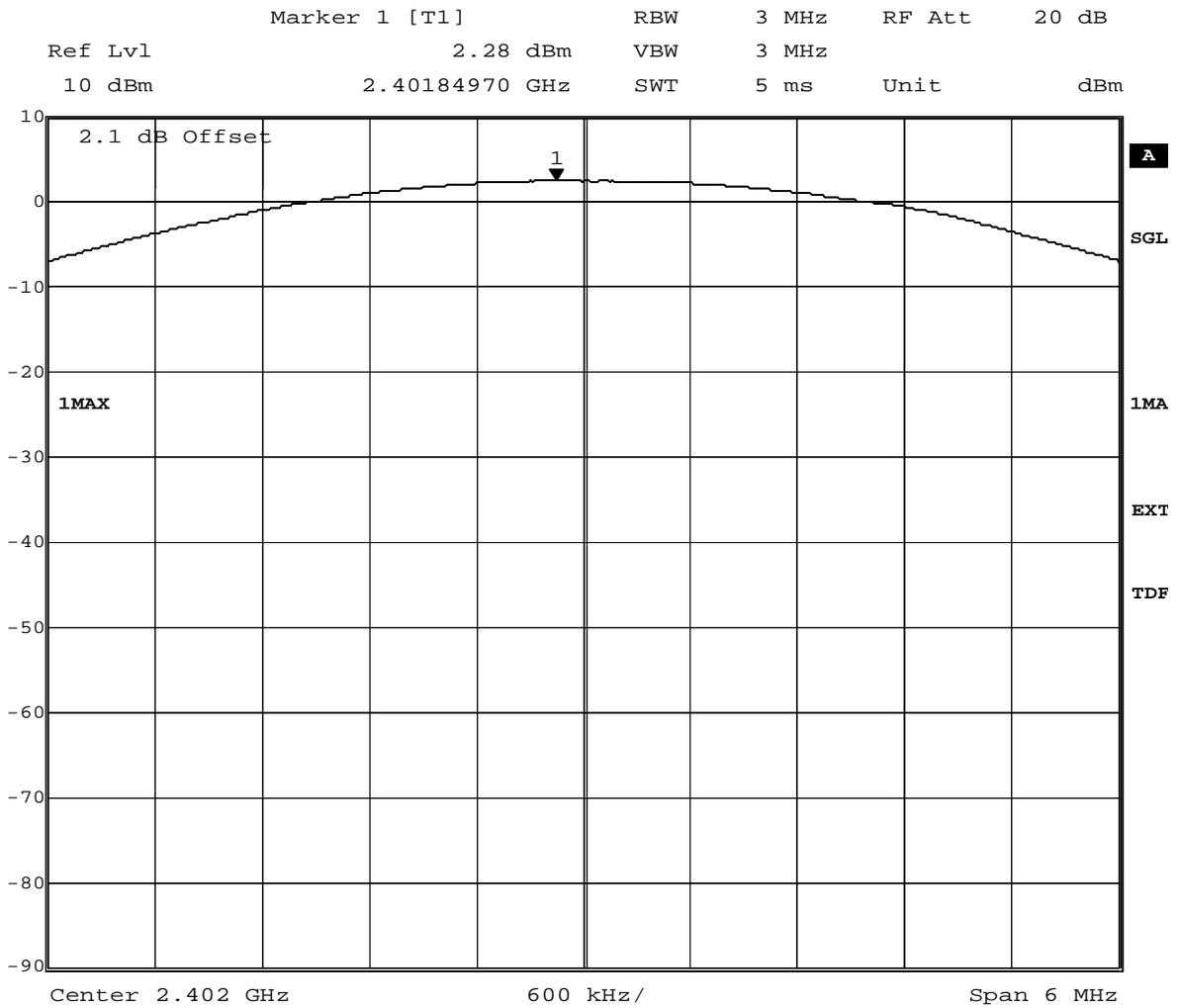


## 7.2 Peak power output

### 7.2.1 Peak power output operating mode 1

#### Op. Mode

op-mode 1



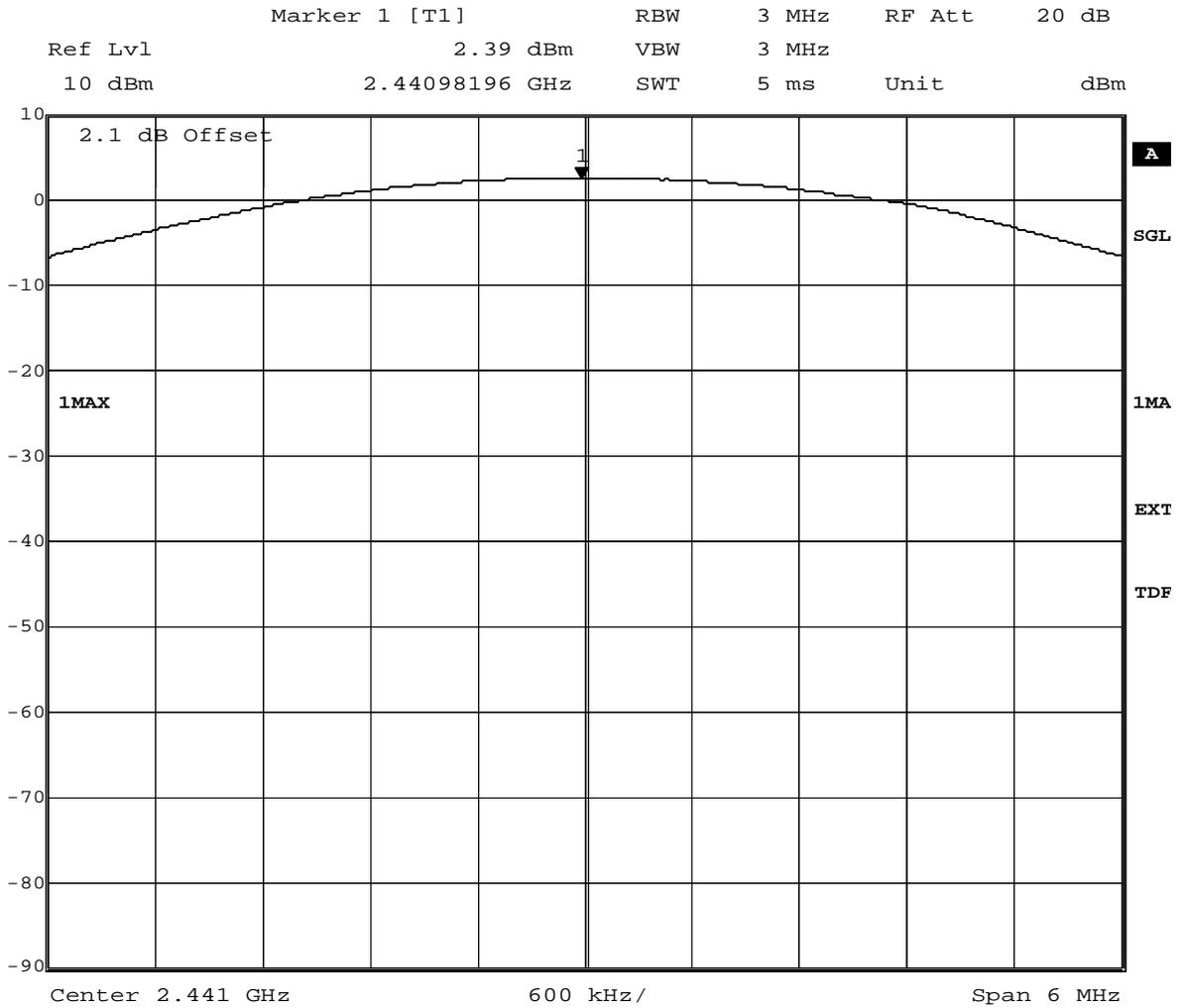
Title: Peak outputpower Power  
 Comment A: CH B: 2402 MHz  
 Date: 28.NOV.2008 08:57:14



## 7.2.2 Peak power output operating mode 2

### Op. Mode

op-mode 2



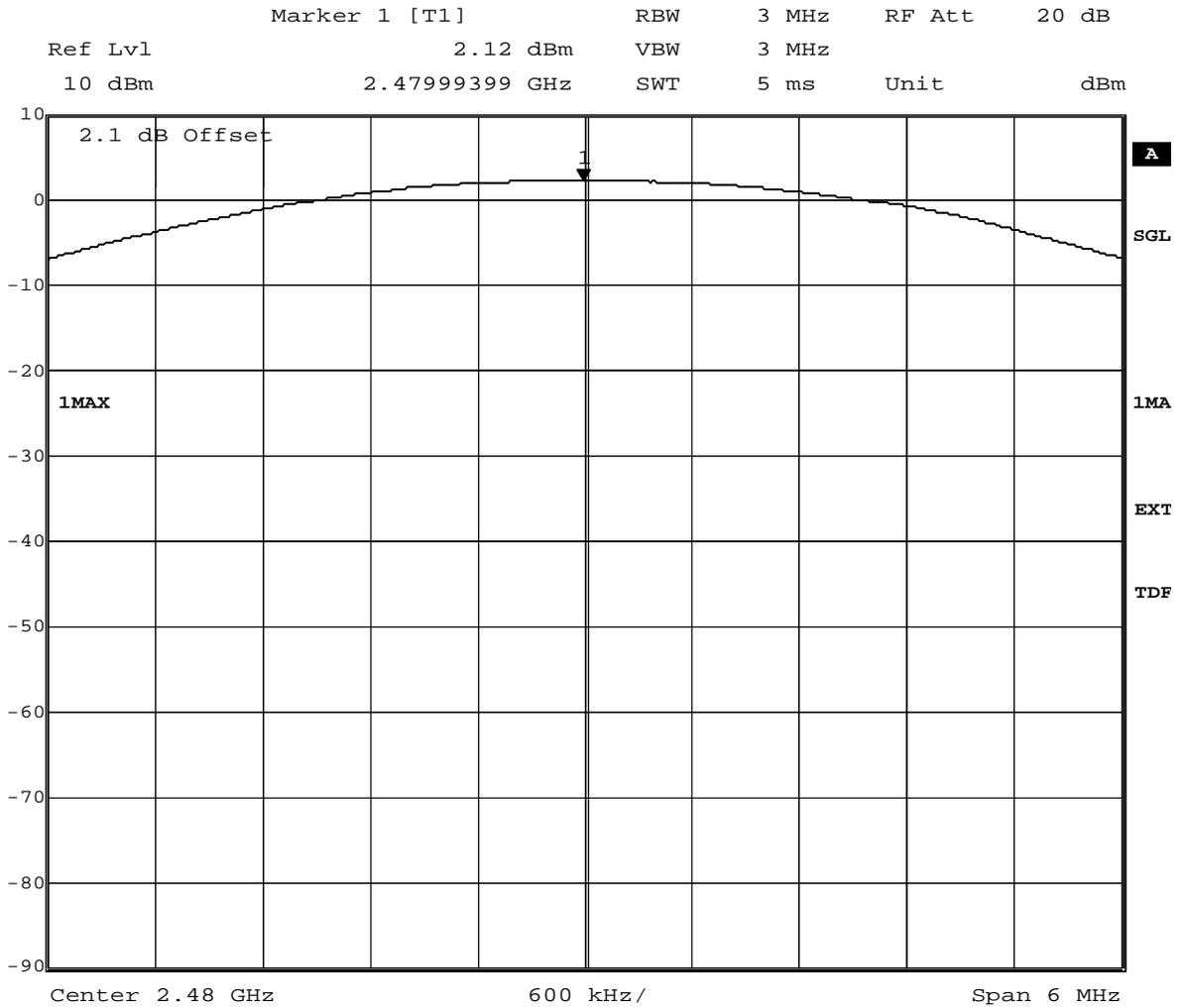
Title: Peak outputpower Power  
Comment A: CH M: 2441 MHz  
Date: 28.NOV.2008 09:41:51



### 7.2.3 Peak power output operating mode 3

#### Op. Mode

op-mode 3



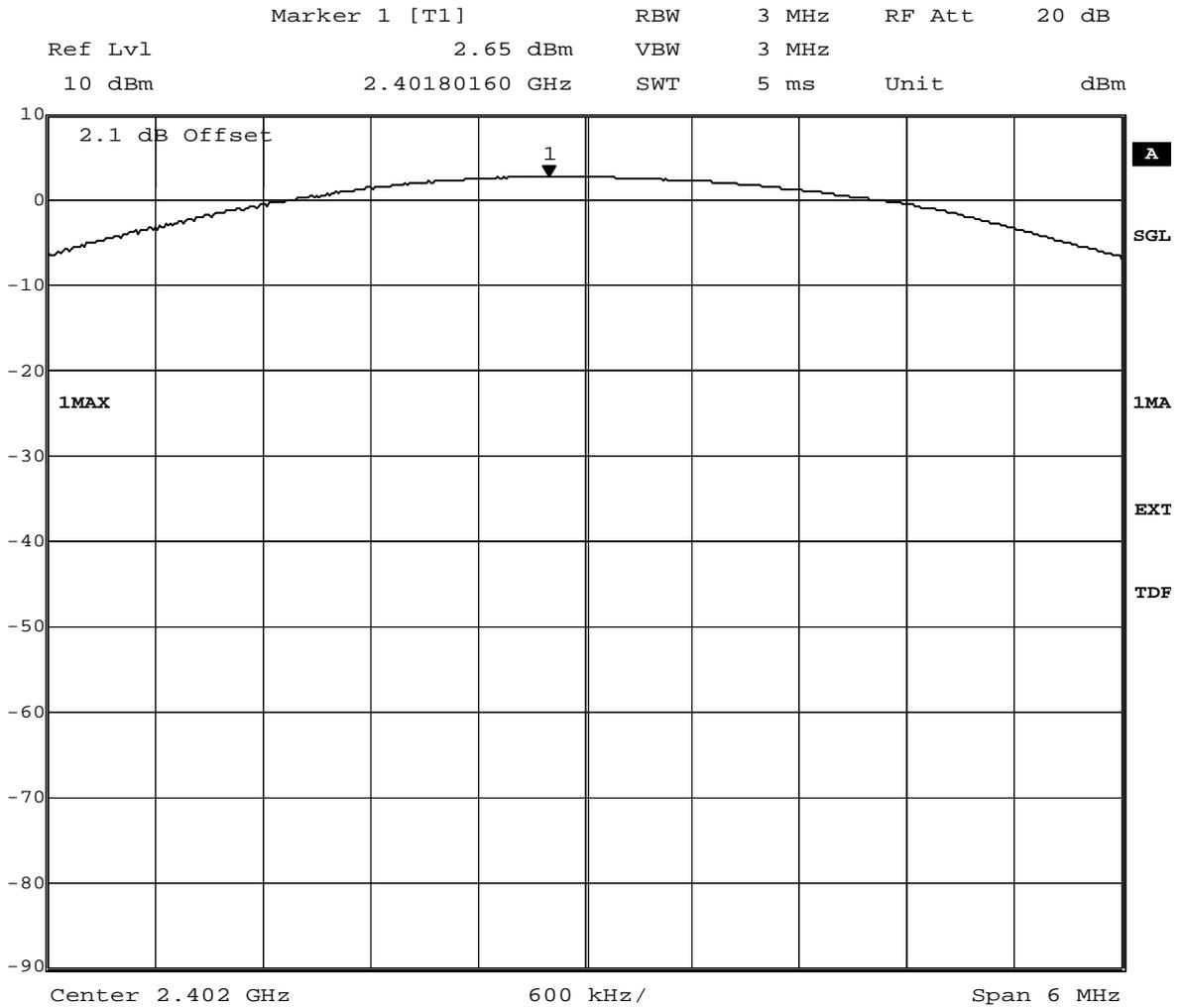
Title: Peak outputpower Power  
Comment A: CH T: 2480 MHz  
Date: 28.NOV.2008 10:52:53



### 7.2.4 Peak power output operating mode 6

#### Op. Mode

op-mode 6



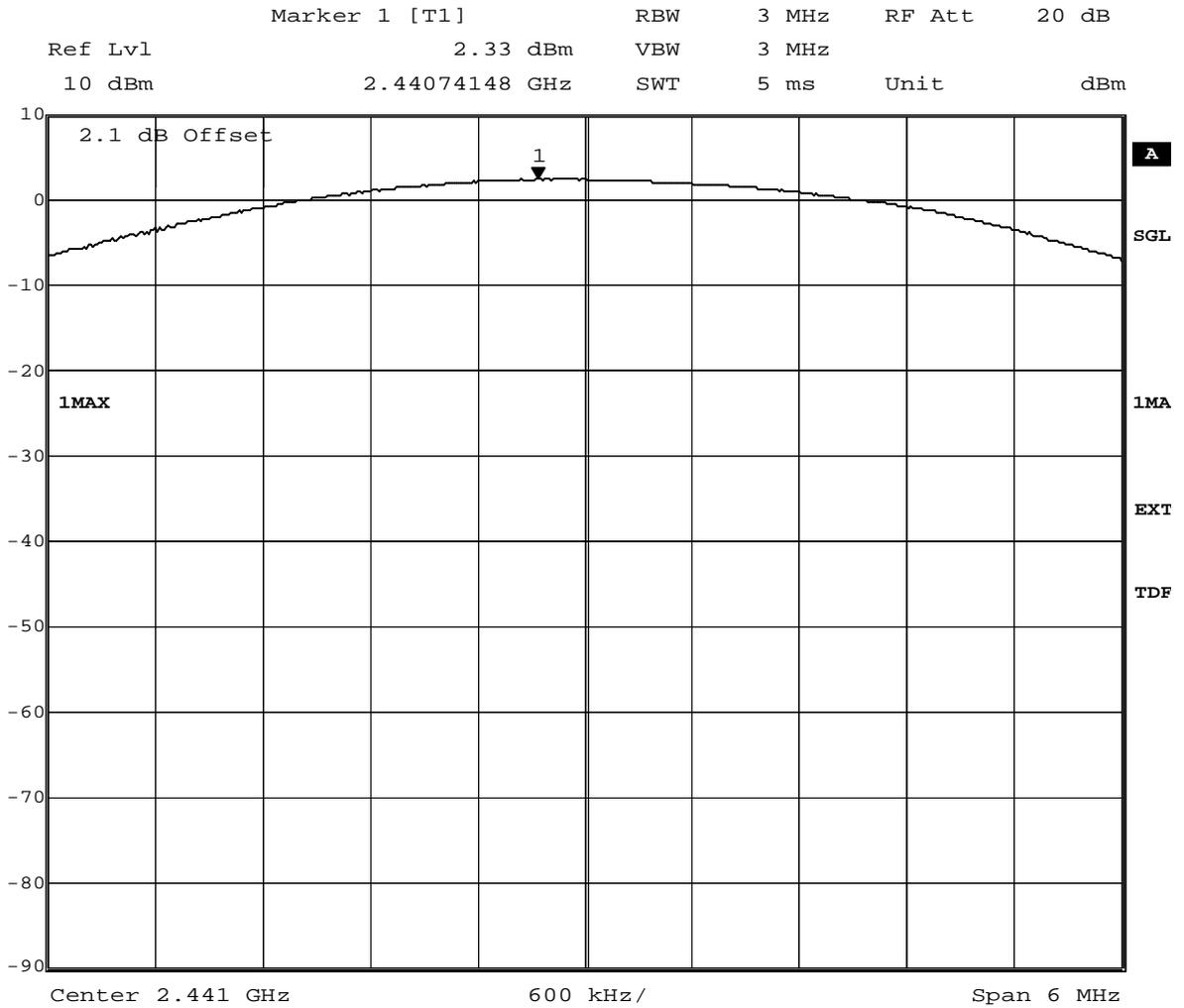
Title: Peak outputpower Power  
Comment A: CH B: 2402 MHz  
Date: 28.NOV.2008 14:27:50



### 7.2.5 Peak power output operating mode 7

#### Op. Mode

op-mode 7



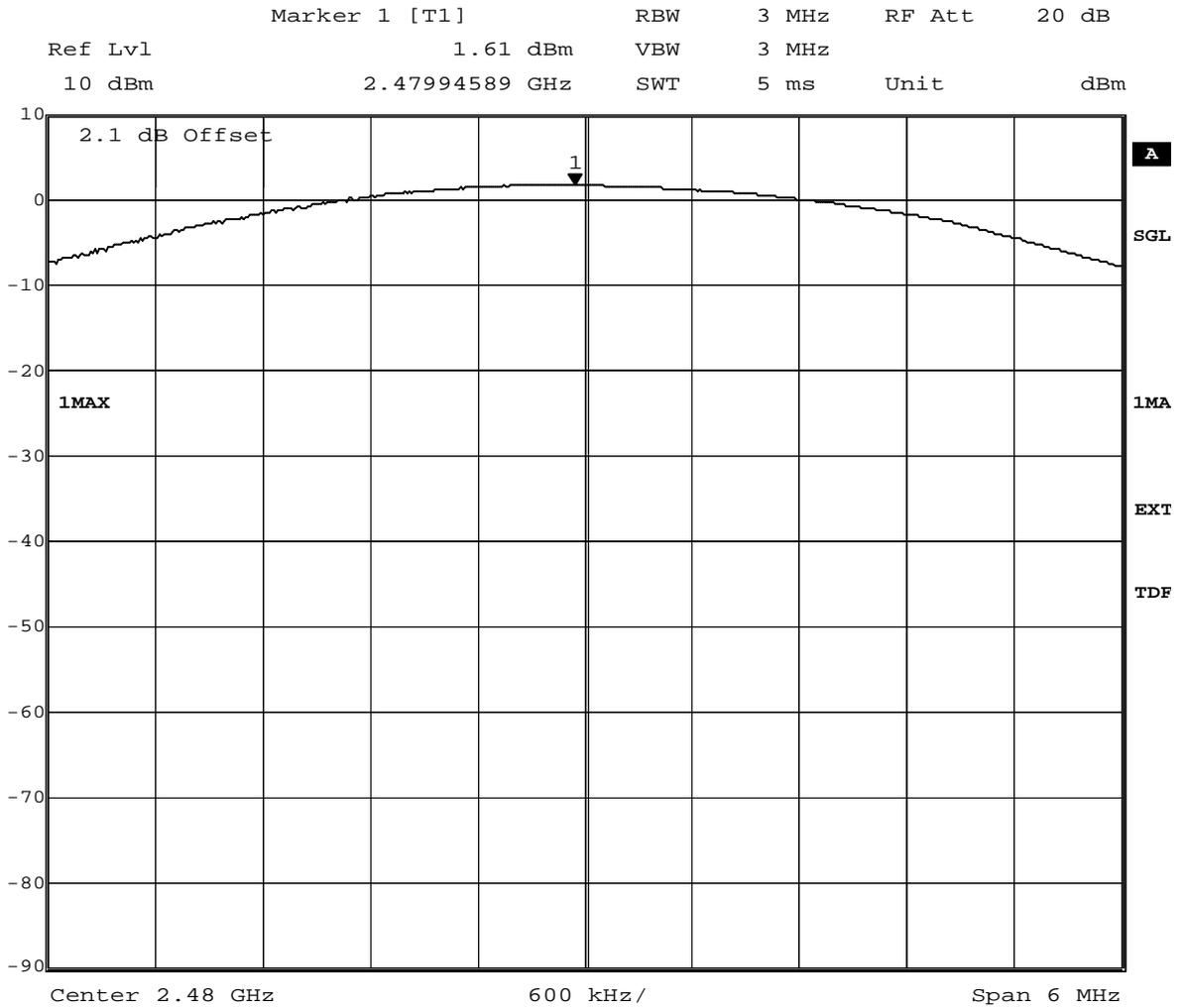
Title: Peak outputpower Power  
Comment A: CH M: 2441 MHz  
Date: 28.NOV.2008 14:56:30



### 7.2.6 Peak power output operating mode 8

#### Op. Mode

op-mode 8



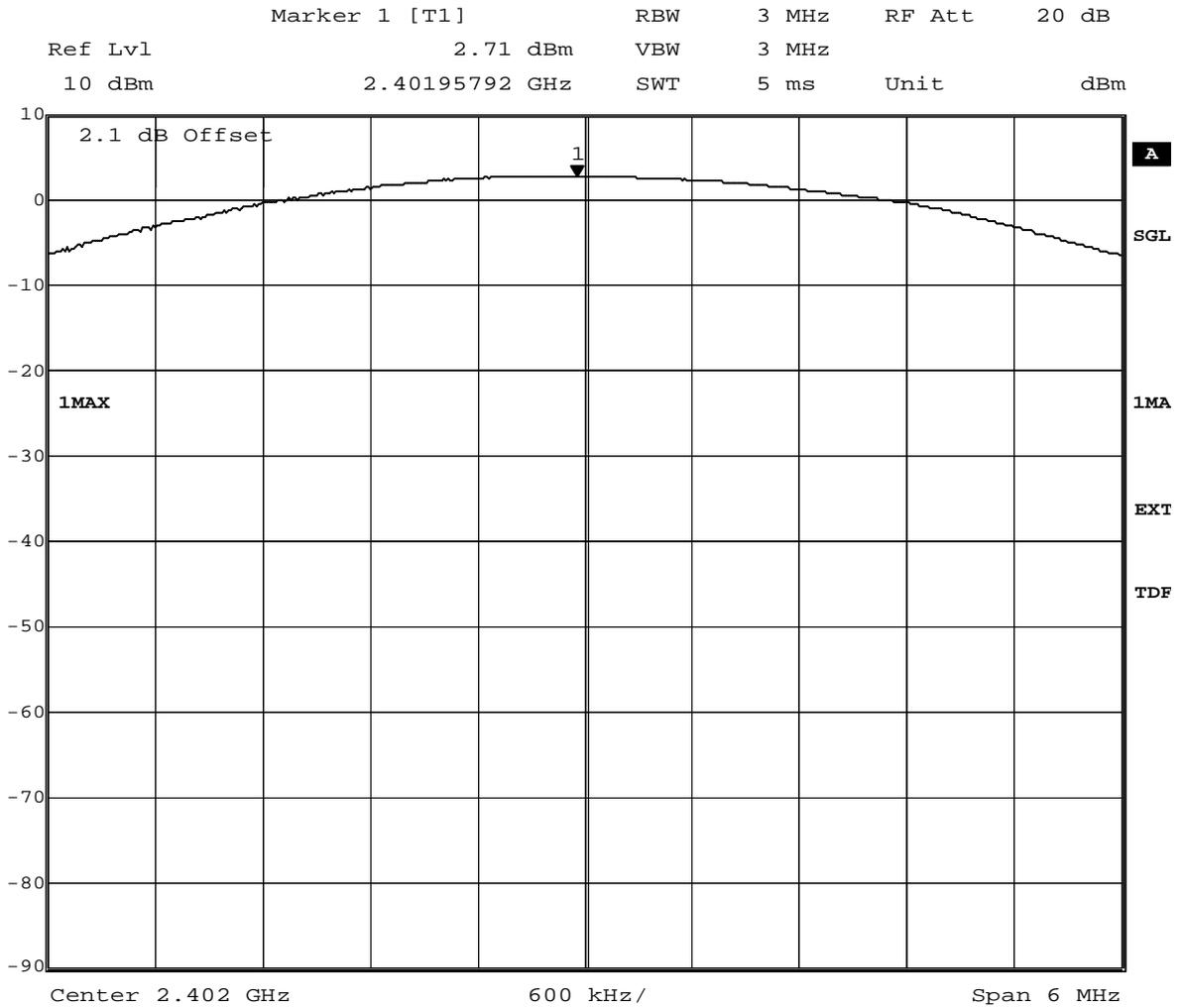
Title: Peak outputpower Power  
Comment A: CH T: 2480 MHz  
Date: 28.NOV.2008 15:36:49



## 7.2.7 Peak power output operating mode 10

### Op. Mode

op-mode 10



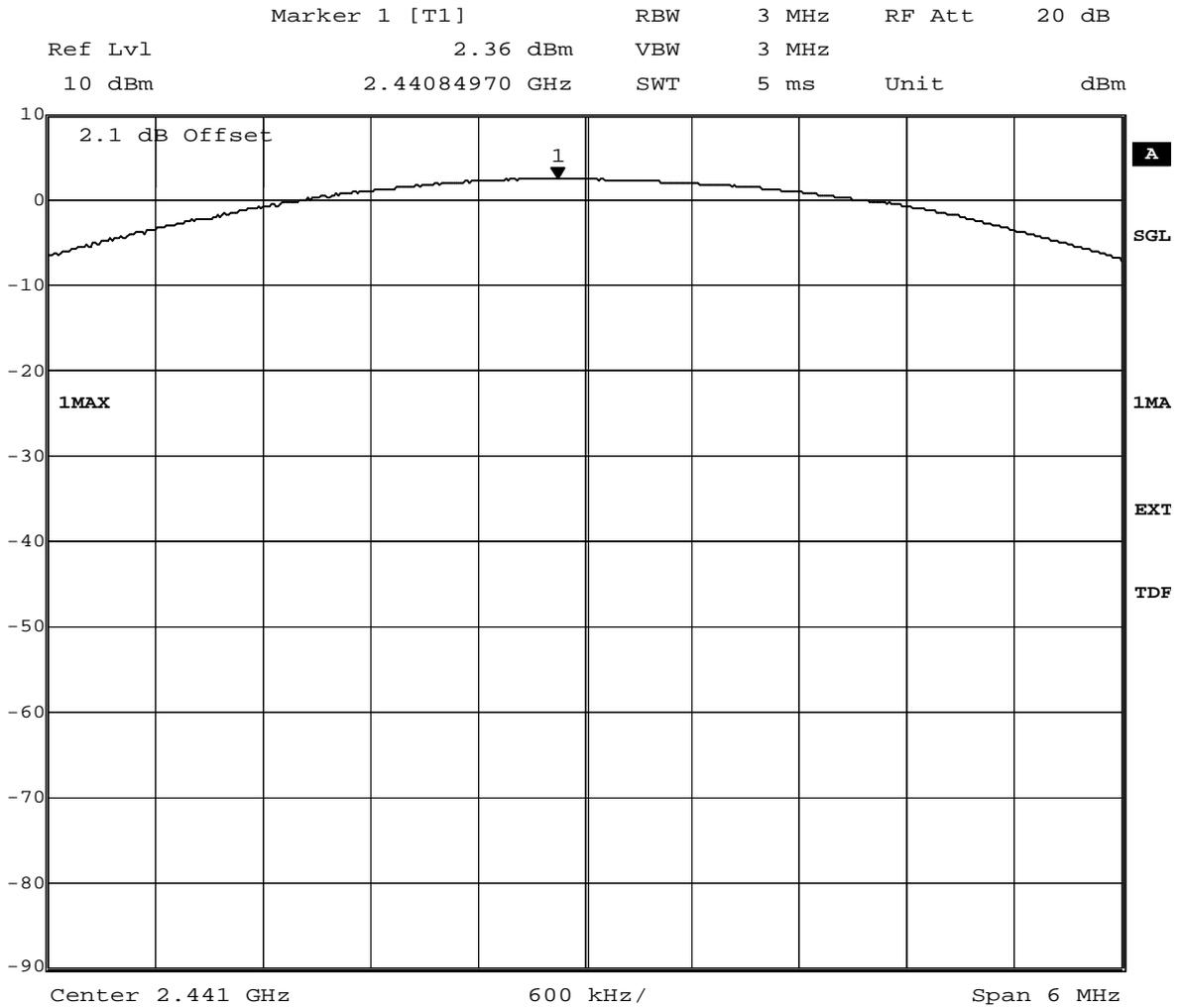
Title: Peak outputpower Power  
 Comment A: CH B: 2402 MHz  
 Date: 28.NOV.2008 12:05:47



### 7.2.8 Peak power output operating mode 11

#### Op. Mode

op-mode 11



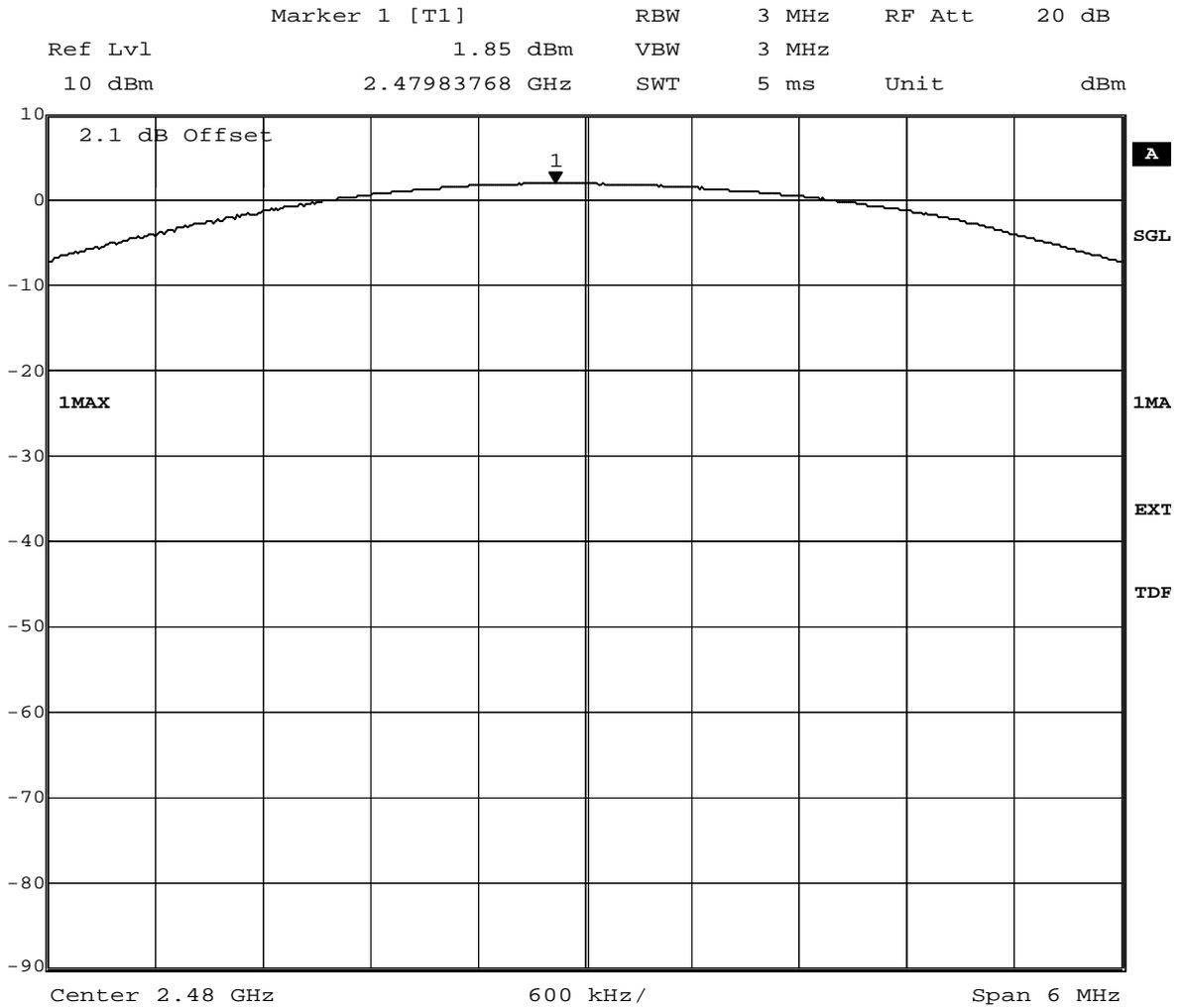
Title: Peak outputpower Power  
Comment A: CH M: 2441 MHz  
Date: 28.NOV.2008 12:55:46



### 7.2.9 Peak power output operating mode 12

#### Op. Mode

op-mode 12



Title: Peak outputpower Power  
Comment A: CH T: 2480 MHz  
Date: 28.NOV.2008 13:24:40

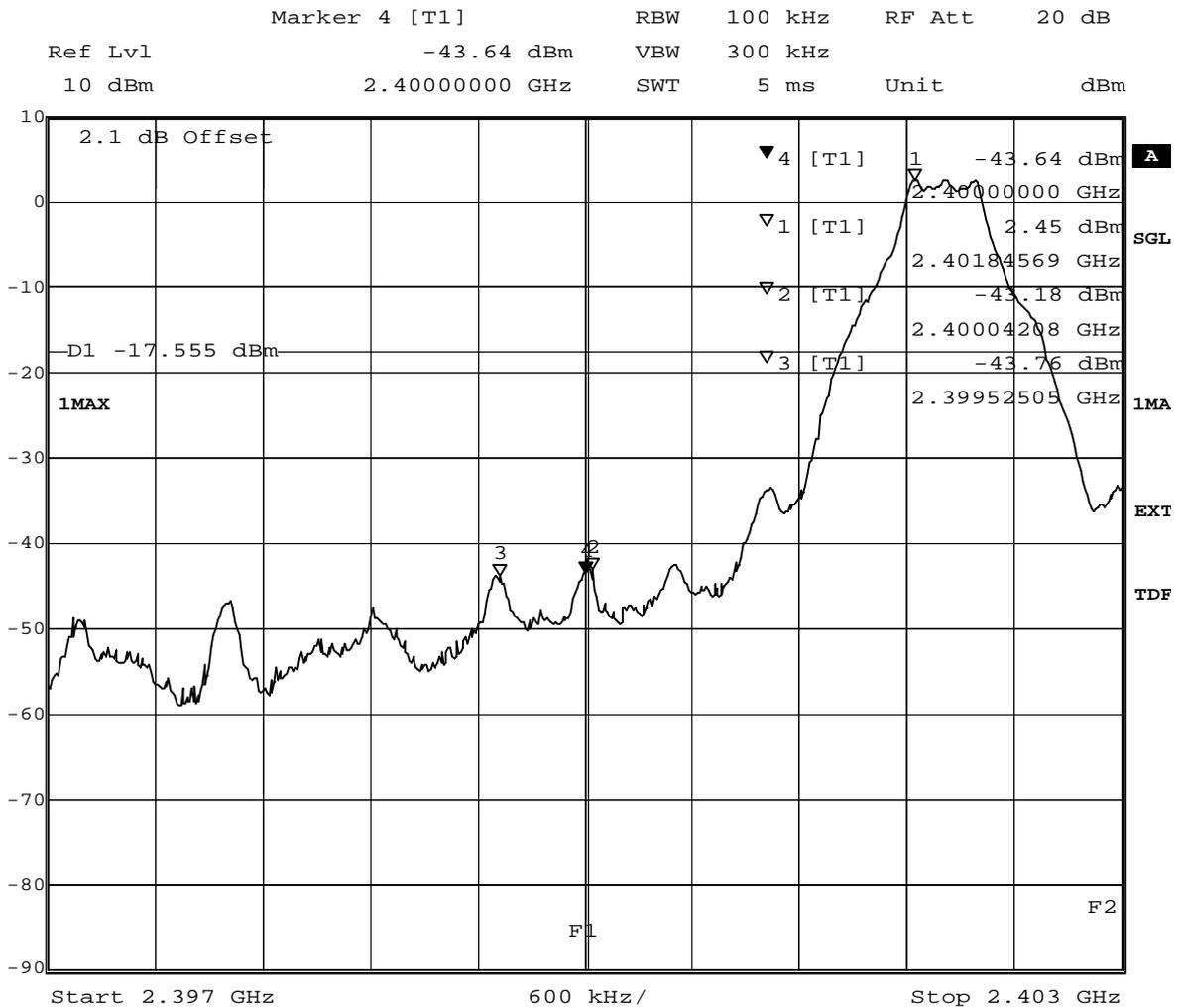


## 7.3 Band edge compliance conducted and Spurious RF conducted emissions

### 7.3.1 Band edge compliance conducted operating mode 1

#### Op. Mode

op-mode 1



Title: Band Edge Compliance  
 Comment A: CH B: 2402 MHz  
 Date: 28.NOV.2008 08:33:17

(determination of reference value for spurious emissions measurement)

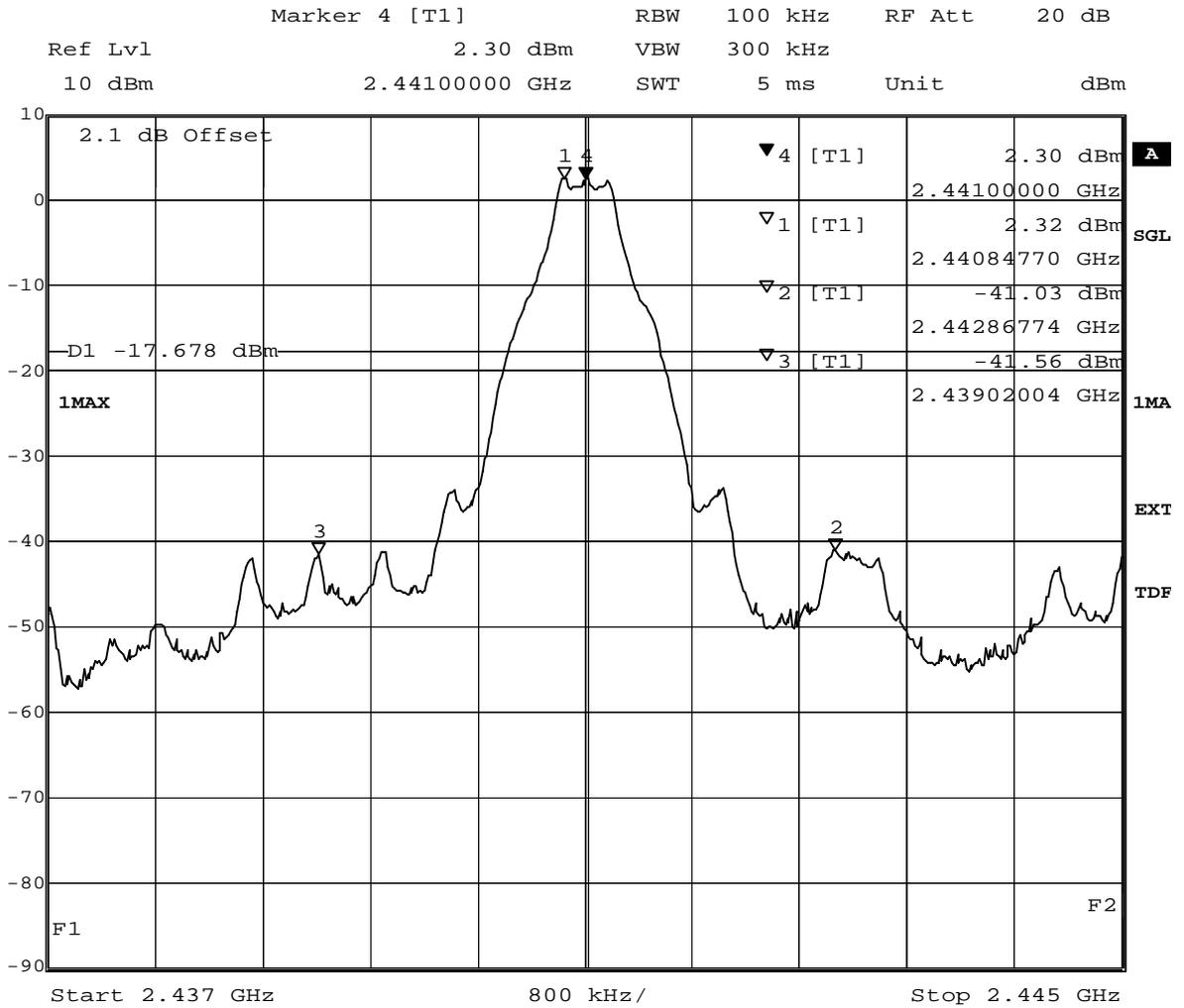




### 7.3.3 Spurious RF conducted emissions operating mode 2

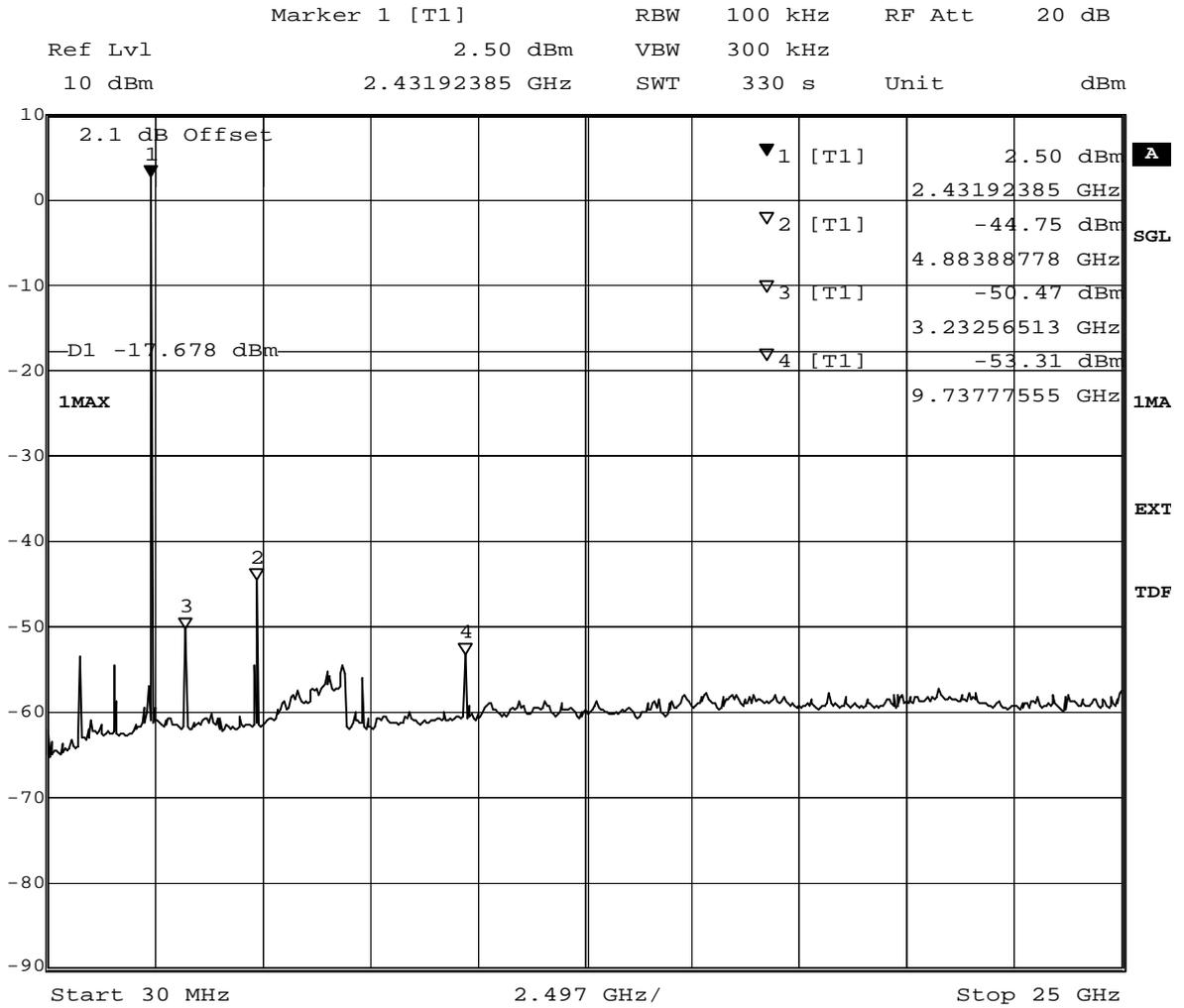
#### Op. Mode

op-mode 2



Title: Band Edge Compliance  
 Comment A: CH M: 2441 MHz  
 Date: 28.NOV.2008 09:17:00

(determination of reference value for spurious emissions measurement)



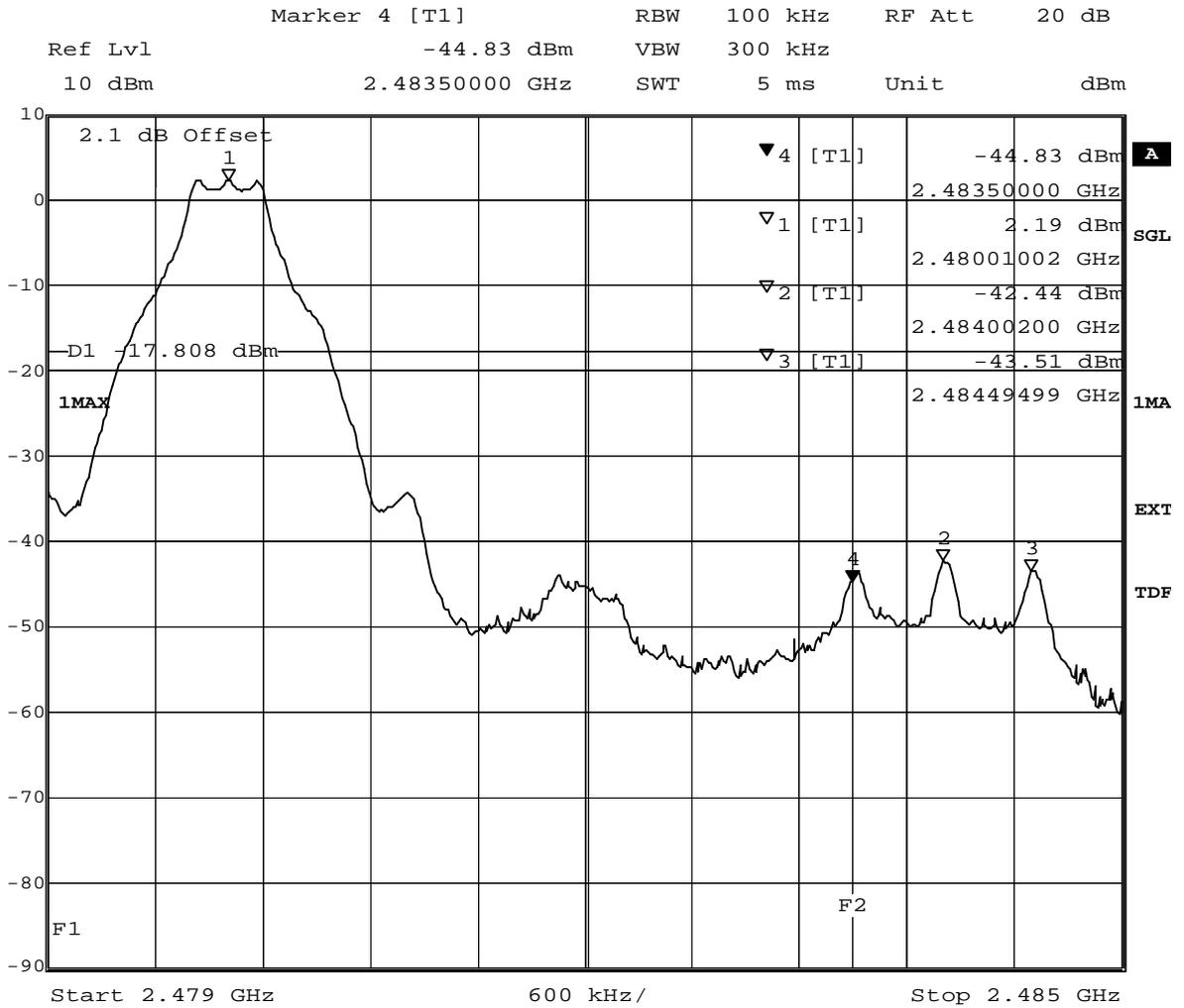
Title: spurious emissions  
 Comment A: CH M: 2441 MHz  
 Date: 28.NOV.2008 09:28:38

(spurious emissions measurement)

### 7.3.4 Band edge compliance conducted operating mode 3

#### Op. Mode

op-mode 3



Title: Band Edge Compliance  
 Comment A: CH T: 2480 MHz  
 Date: 28.NOV.2008 09:52:19

(determination of reference value for spurious emissions measurement)

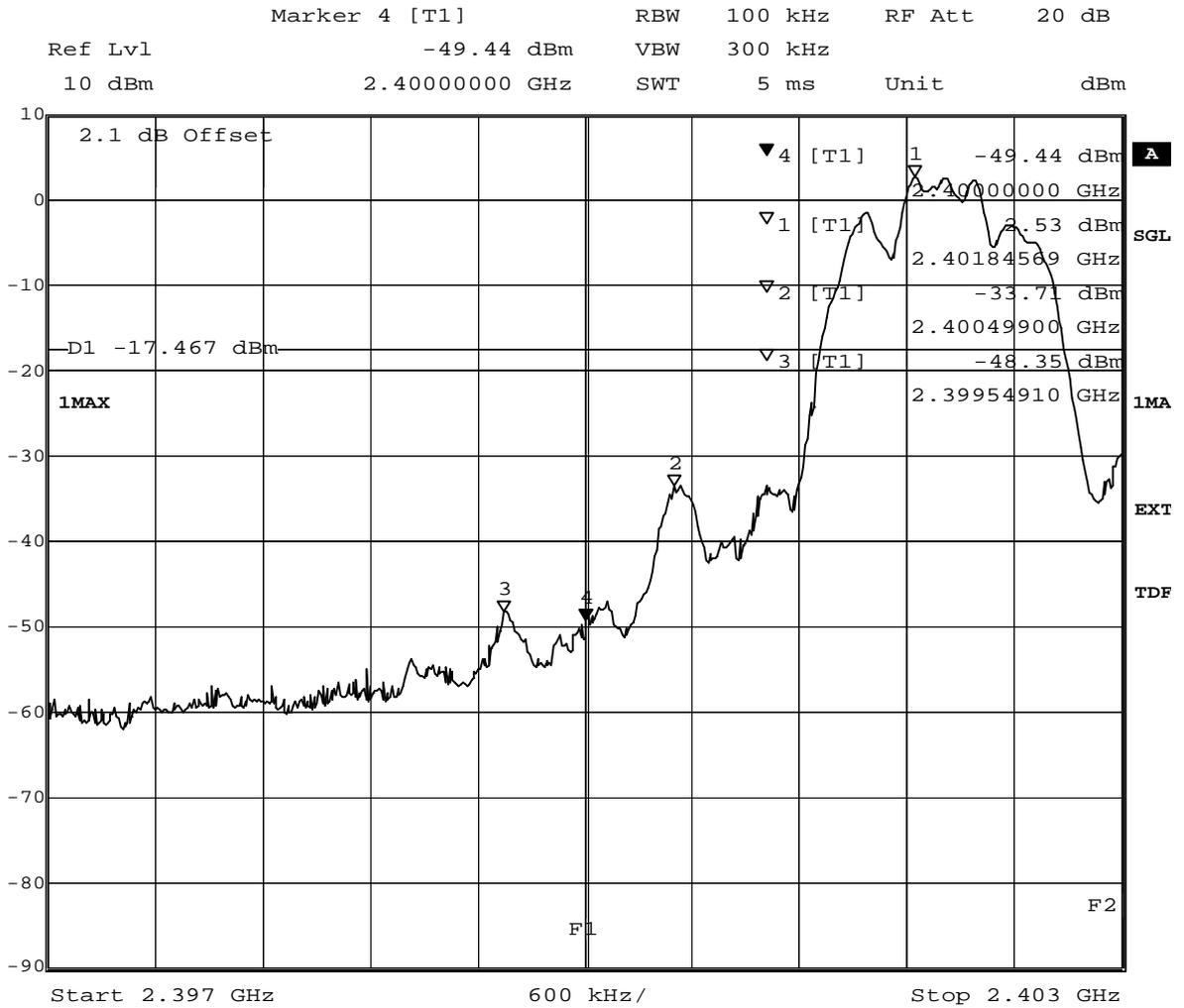




### 7.3.6 Band edge compliance conducted operating mode 6

#### Op. Mode

op-mode 6



Title: Band Edge Compliance  
 Comment A: CH B: 2402 MHz  
 Date: 28.NOV.2008 14:03:16

(determination of reference value for spurious emissions measurement)

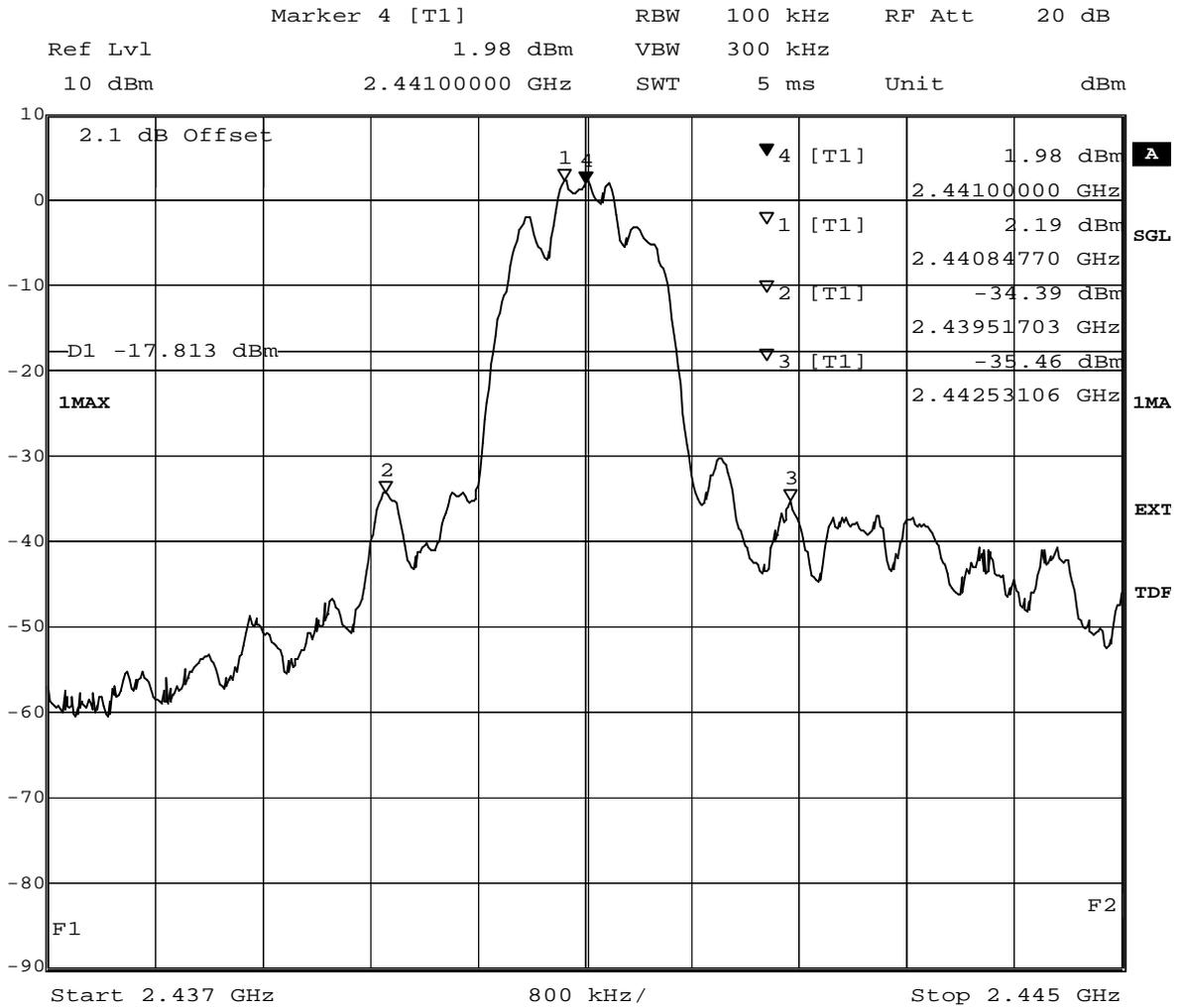




### 7.3.8 Spurious RF conducted emissions operating mode 7

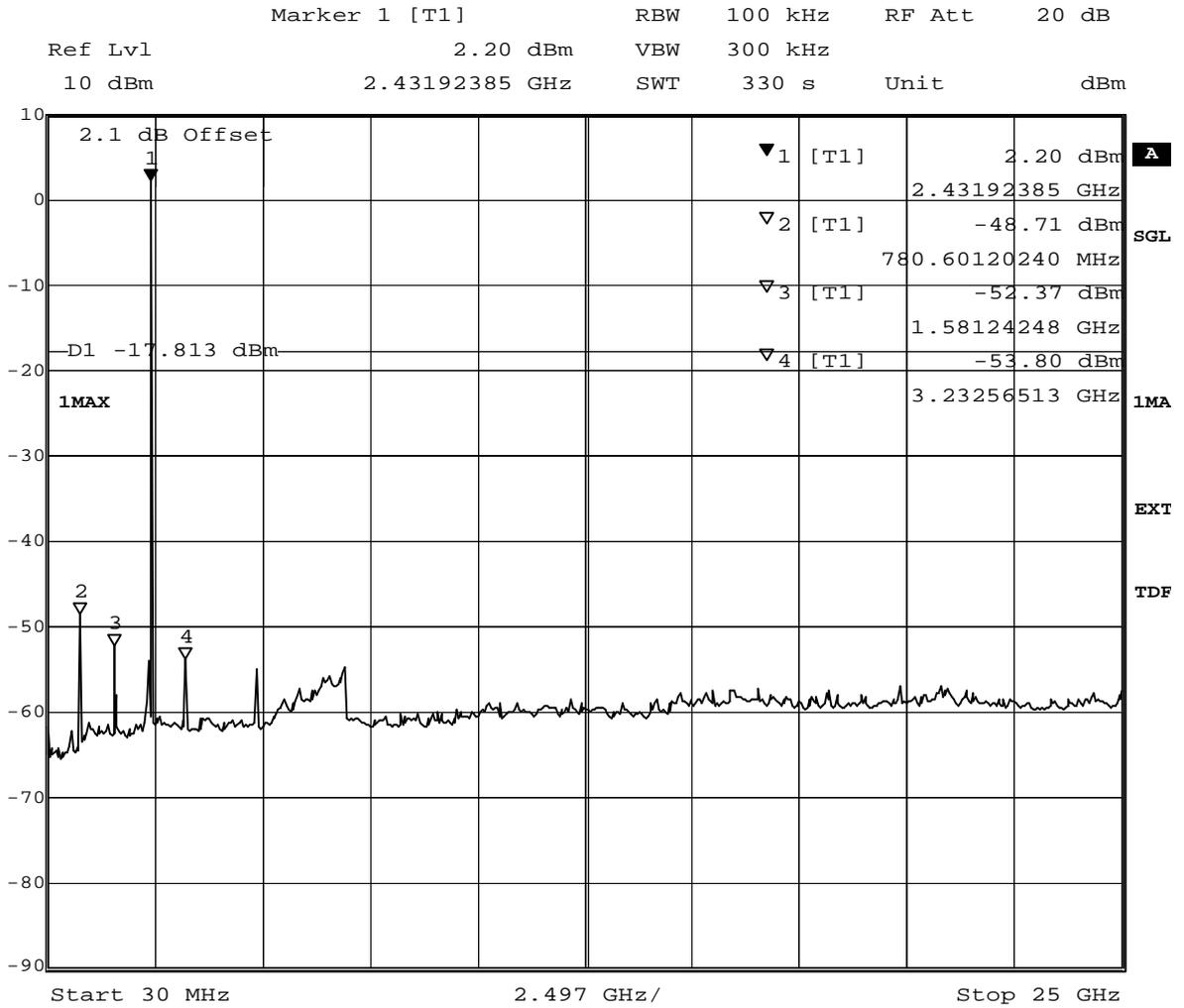
#### Op. Mode

op-mode 7



Title: Band Edge Compliance  
 Comment A: CH M: 2441 MHz  
 Date: 28.NOV.2008 14:33:43

(determination of reference value for spurious emissions measurement)



Title: spurious emissions  
 Comment A: CH M: 2441 MHz  
 Date: 28.NOV.2008 14:45:20

(spurious emissions measurement)



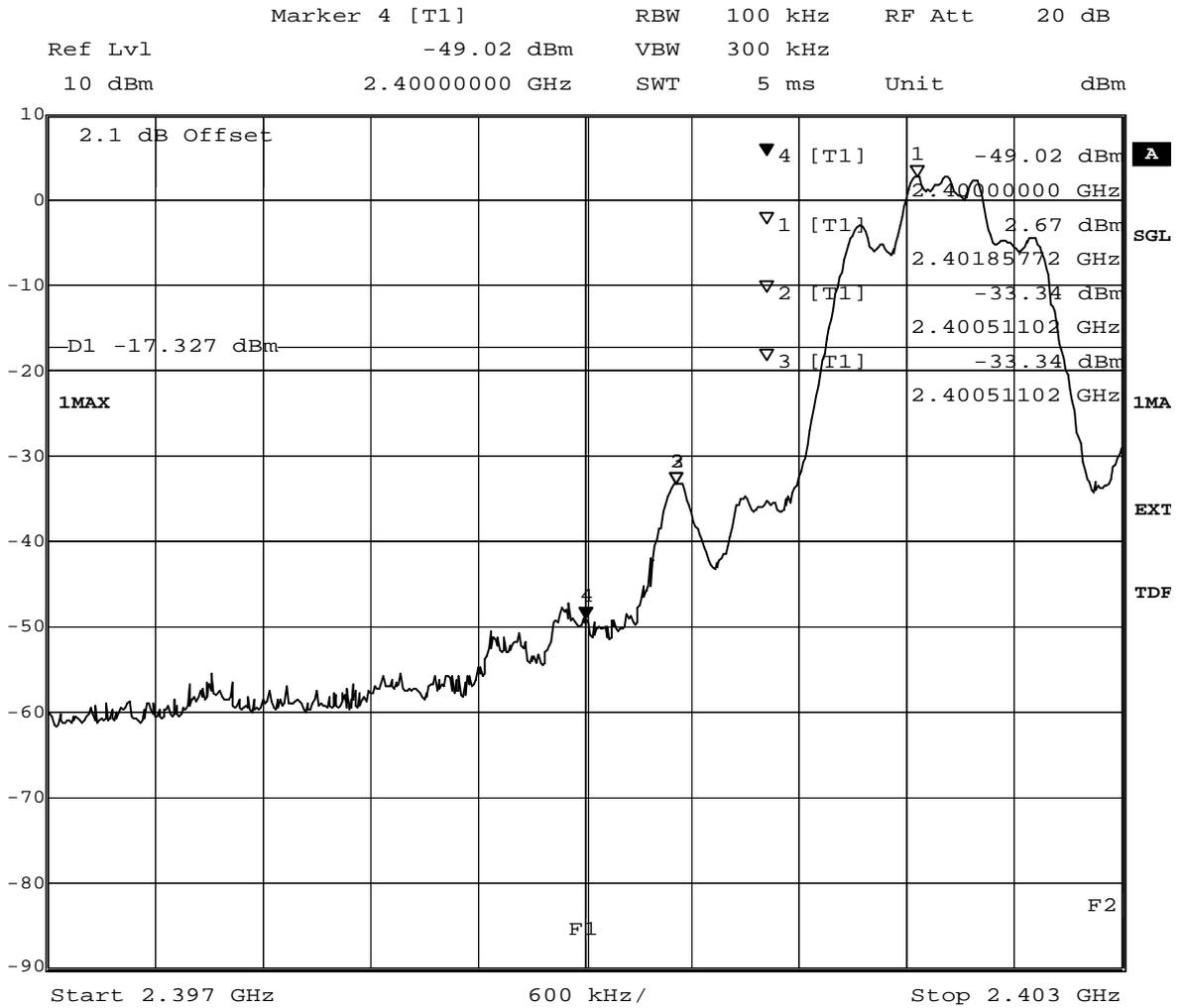




### 7.3.11 Band edge compliance conducted operating mode 10

#### Op. Mode

op-mode 10



Title: Band Edge Compliance  
 Comment A: CH B: 2402 MHz  
 Date: 28.NOV.2008 11:40:15

(determination of reference value for spurious emissions measurement)

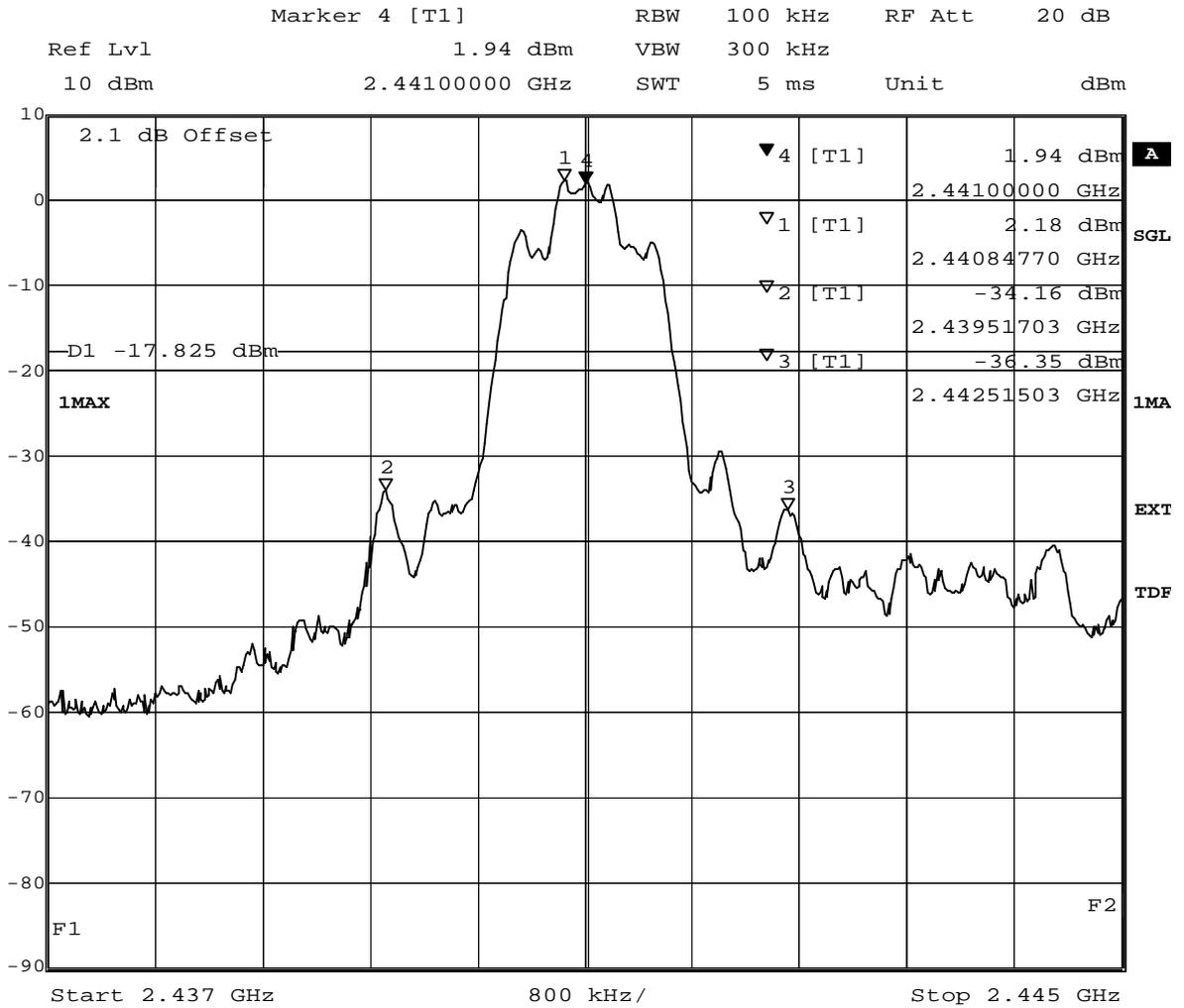




### 7.3.13 Band edge compliance conducted operating mode 11

#### Op. Mode

op-mode 11



Title: Band Edge Compliance  
 Comment A: CH M: 2441 MHz  
 Date: 28.NOV.2008 12:31:22

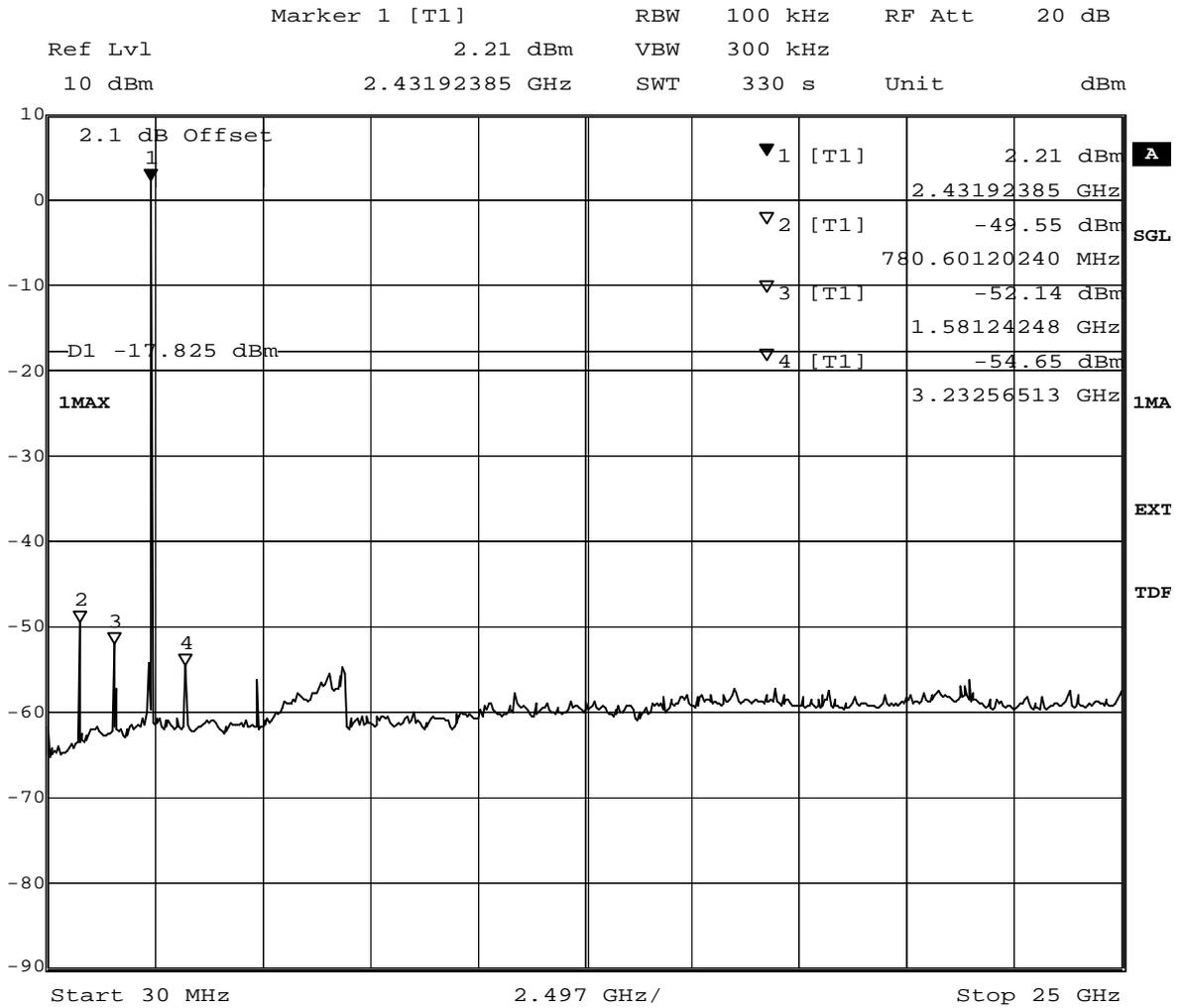
(determination of reference value for spurious emissions measurement)



### 7.3.14 Spurious RF conducted emissions operating mode 11

#### Op. Mode

op-mode 11



Title: spurious emissions  
 Comment A: CH M: 2441 MHz  
 Date: 28.NOV.2008 12:42:59

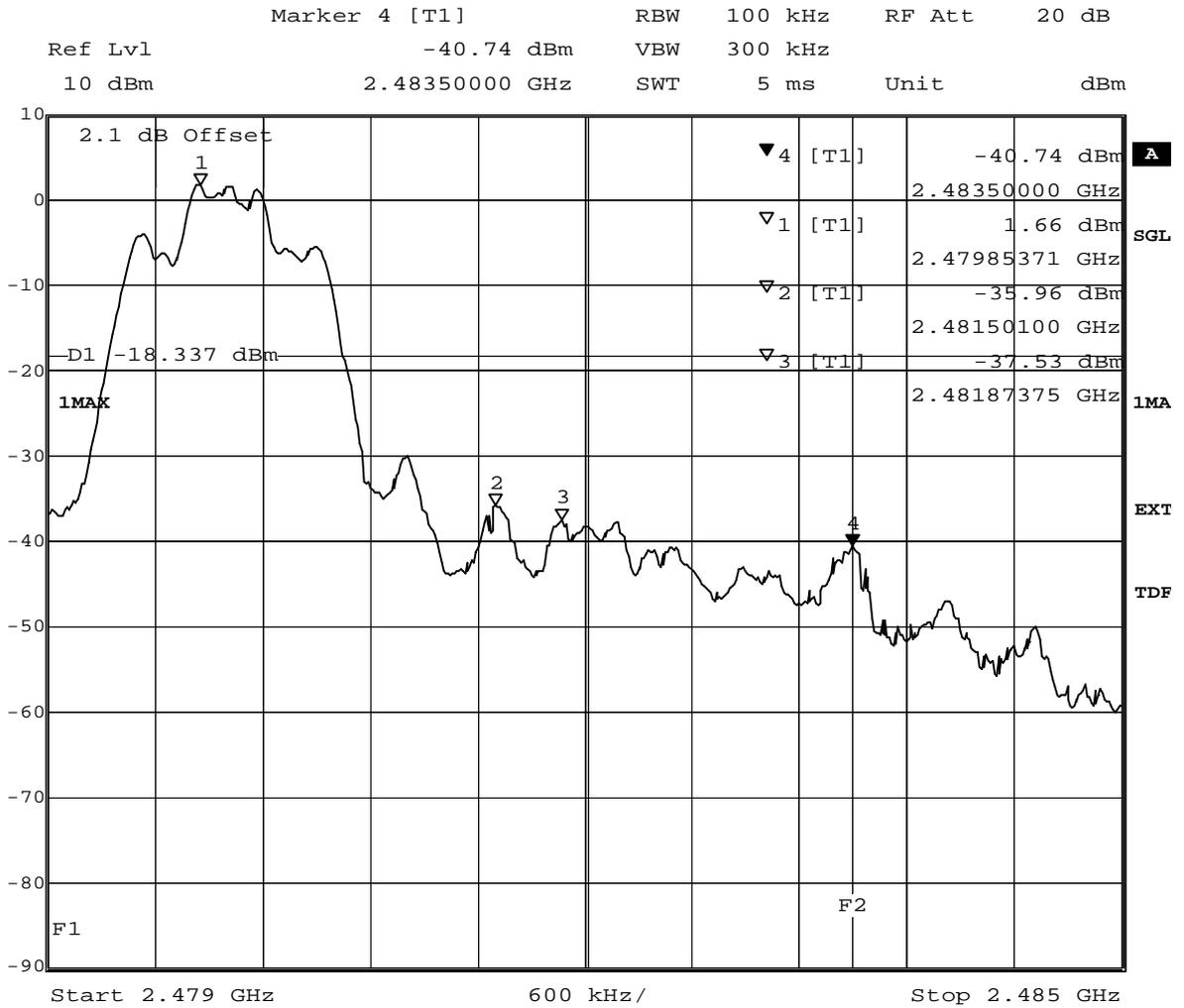
(spurious emissions measurement)



### 7.3.15 Band edge compliance conducted operating mode 12

#### Op. Mode

op-mode 12



Title: Band Edge Compliance  
 Comment A: CH T: 2480 MHz  
 Date: 28.NOV.2008 13:00:55

(determination of reference value for spurious emissions measurement)



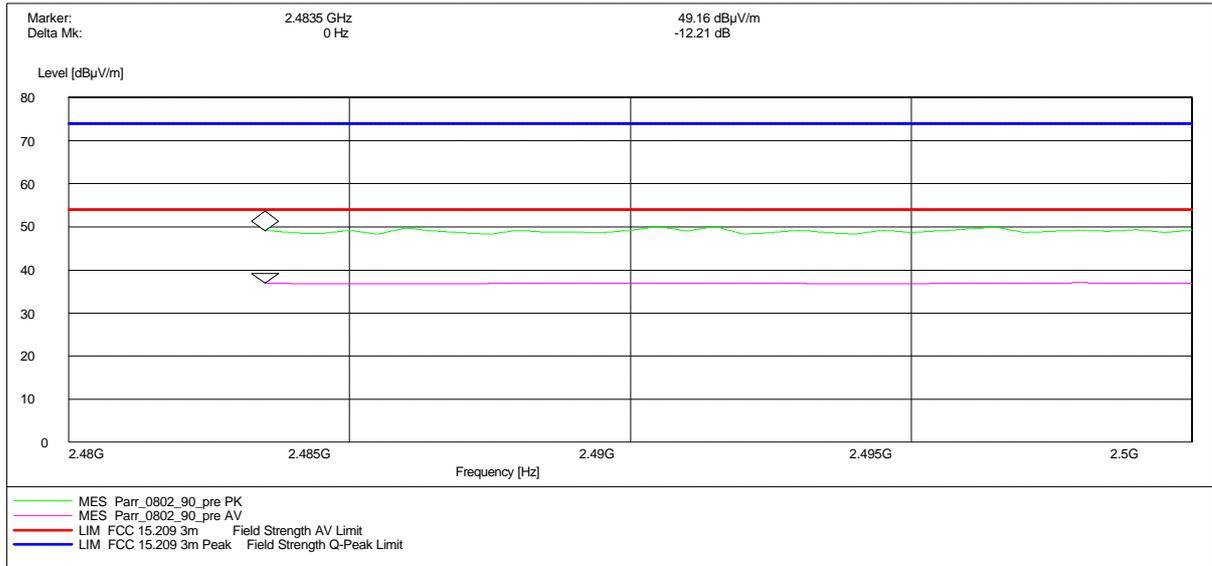


## 7.4 Band edge compliance radiated

### 7.4.1 Band edge compliance radiated operating mode 3

#### Op. Mode

op-mode 3

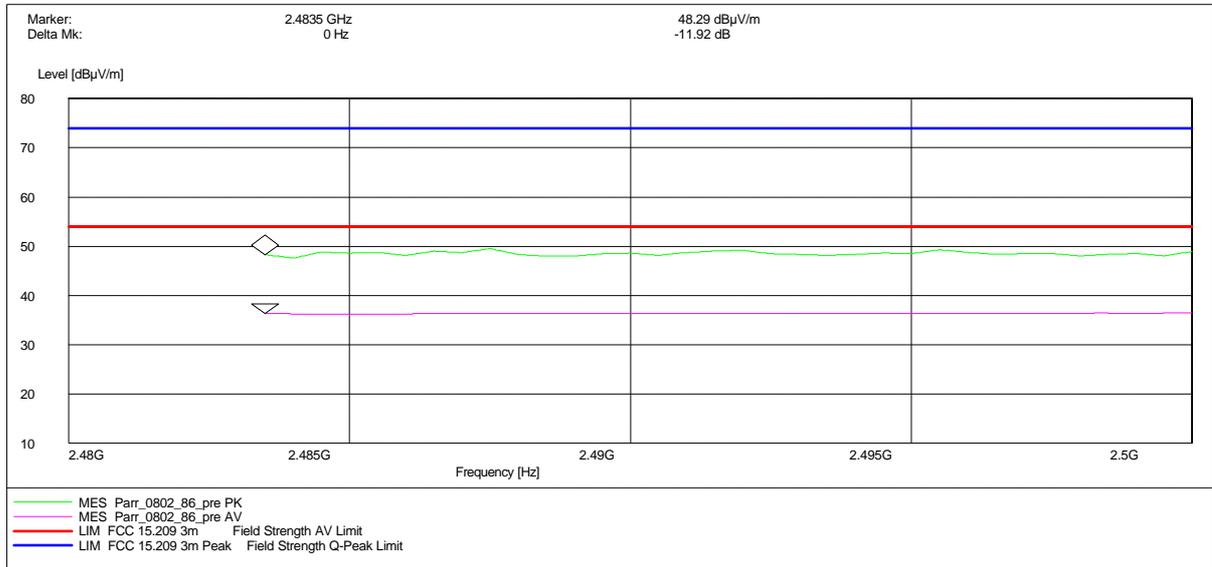


Radiated measurement (higher band edge)

## 7.4.2 Band edge compliance radiated operating mode 8

### Op. Mode

op-mode 8



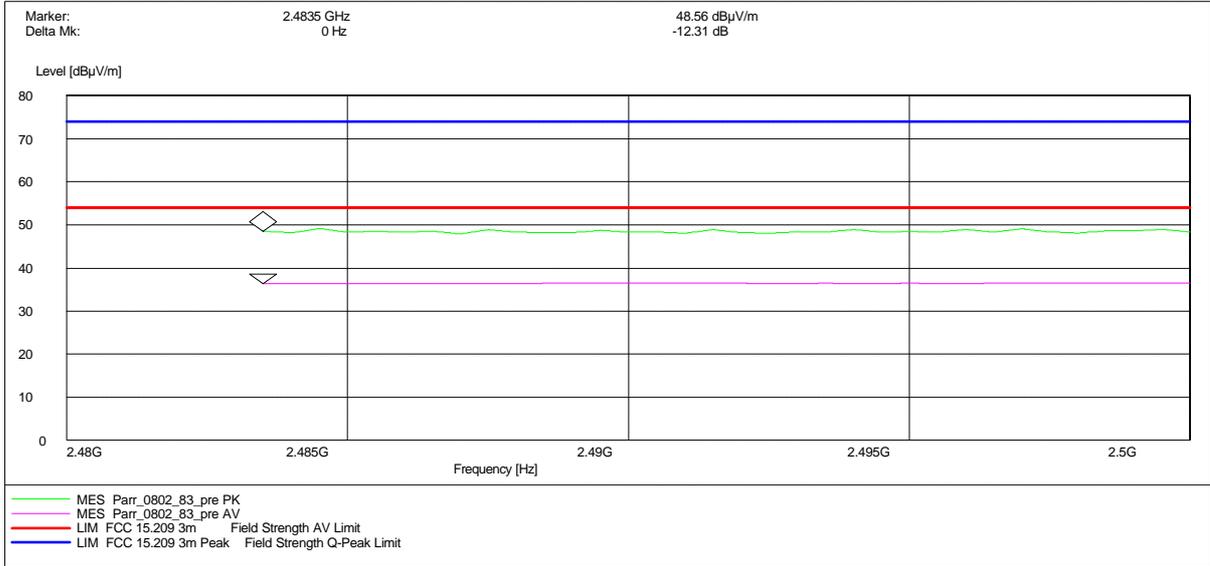
Radiated measurement (higher band edge)



### 7.4.3 Band edge compliance radiated operating mode 12

#### Op. Mode

op-mode 12



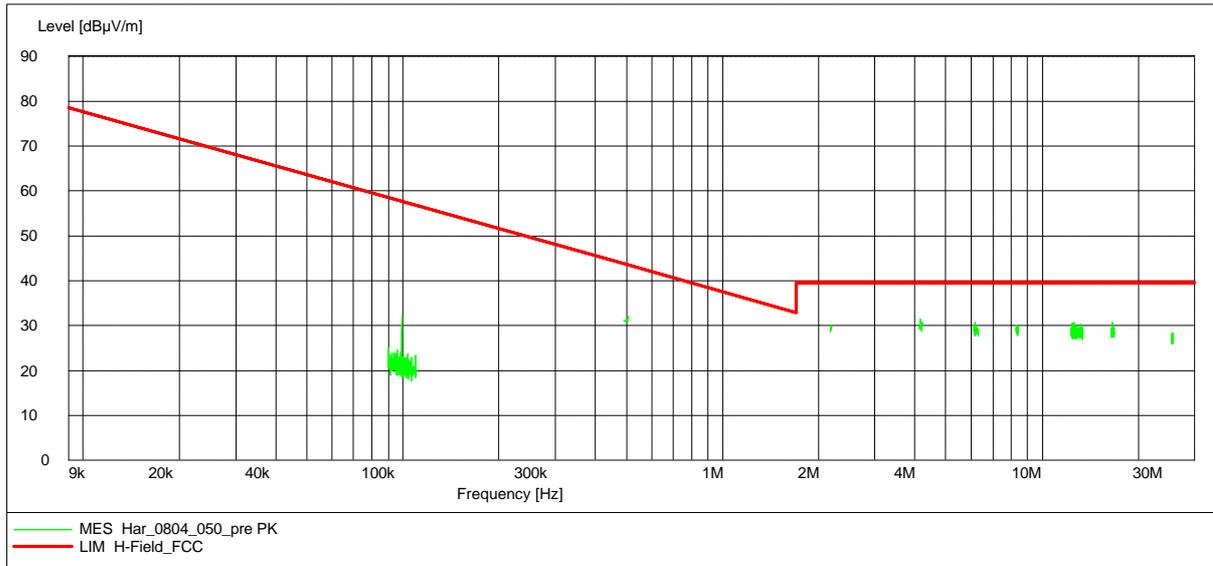
Radiated measurement (higher band edge)

## 7.5 Radiated emissions (f < 30 MHz)

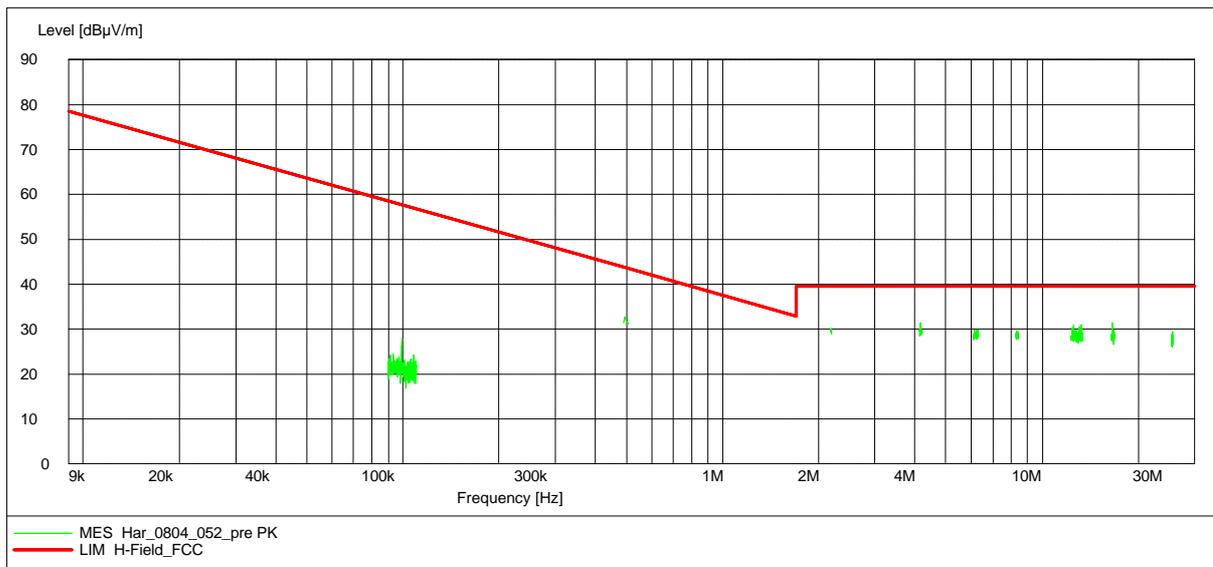
### Op. Mode

op-mode 1

Antenna position 90°  
EUT position front side



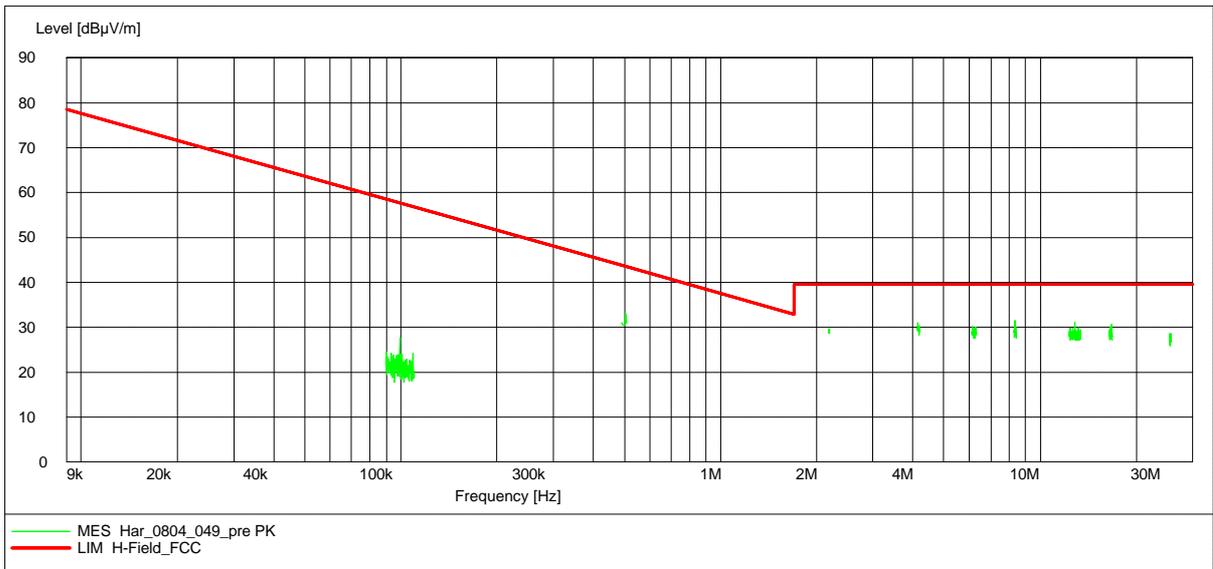
Antenna position 90°  
EUT position right side



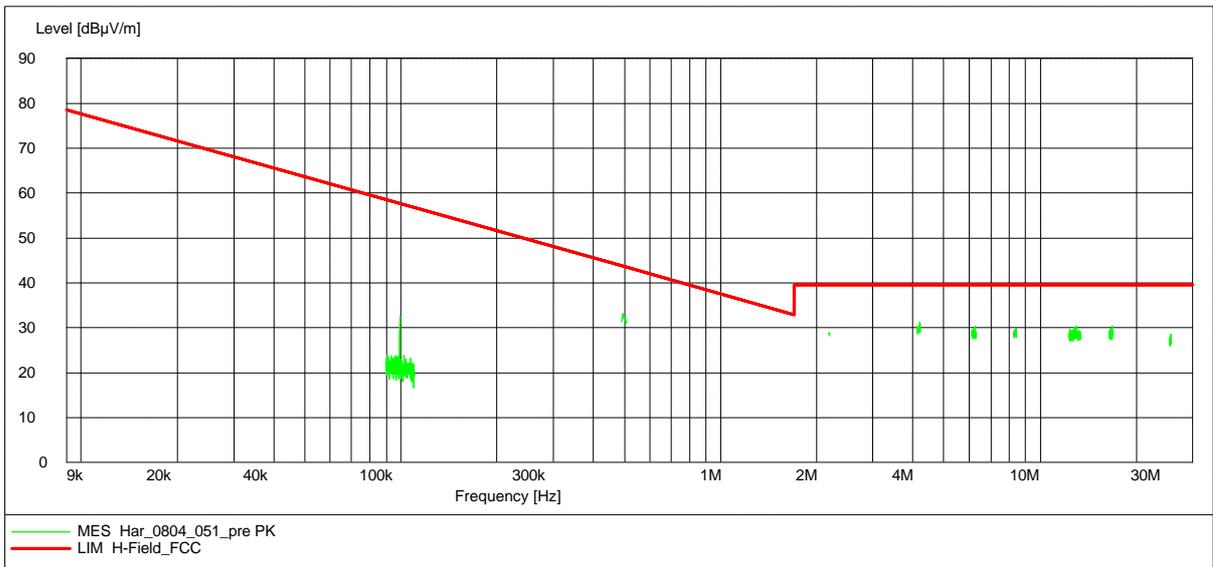
**Op. Mode**

op-mode 1

Antenna position 0°  
EUT position front side



Antenna position 0°  
EUT position right side

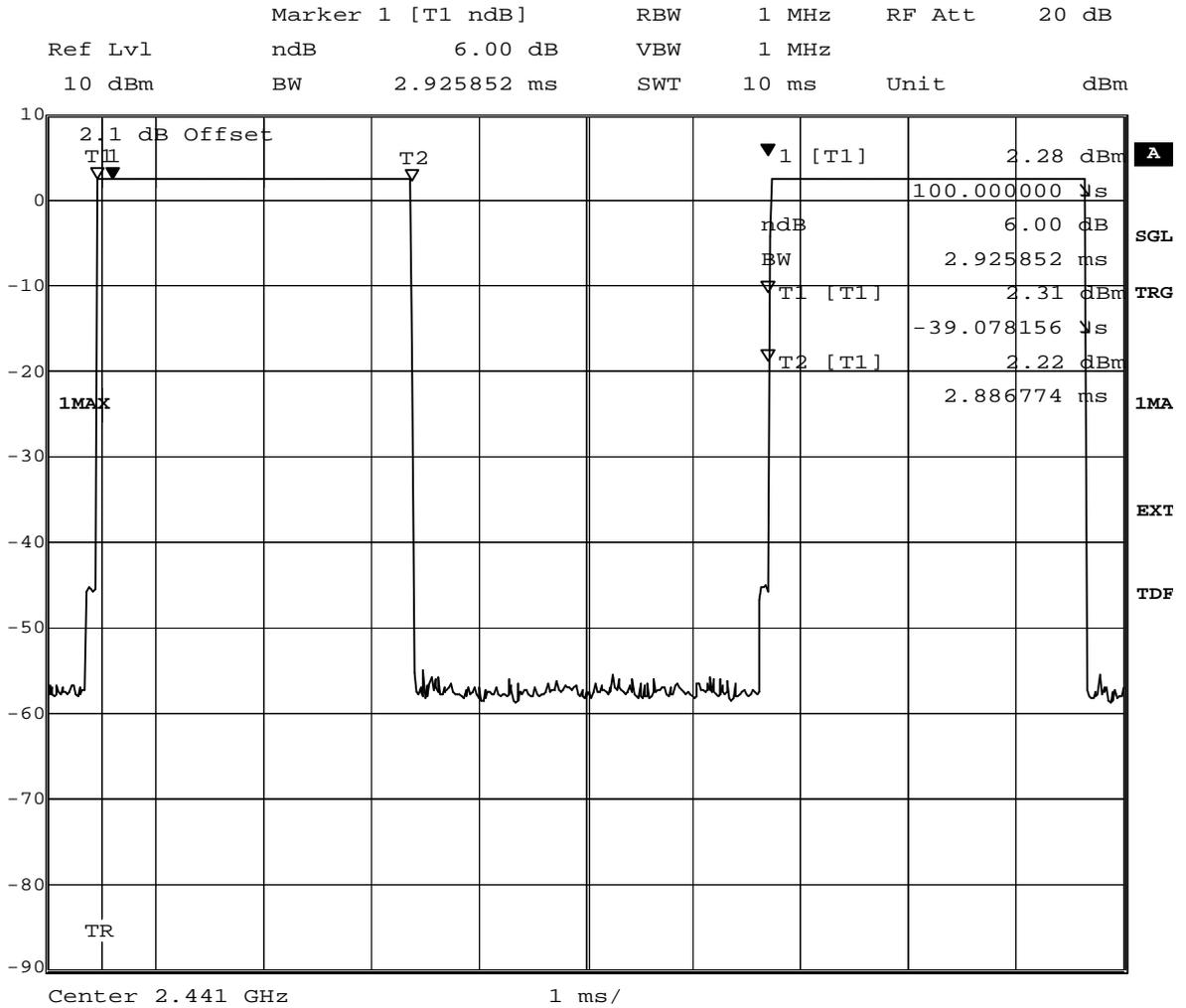




## 7.6 Dwell time

### Op. Mode

op-mode 2 Time slot measurement of a DH5 packet



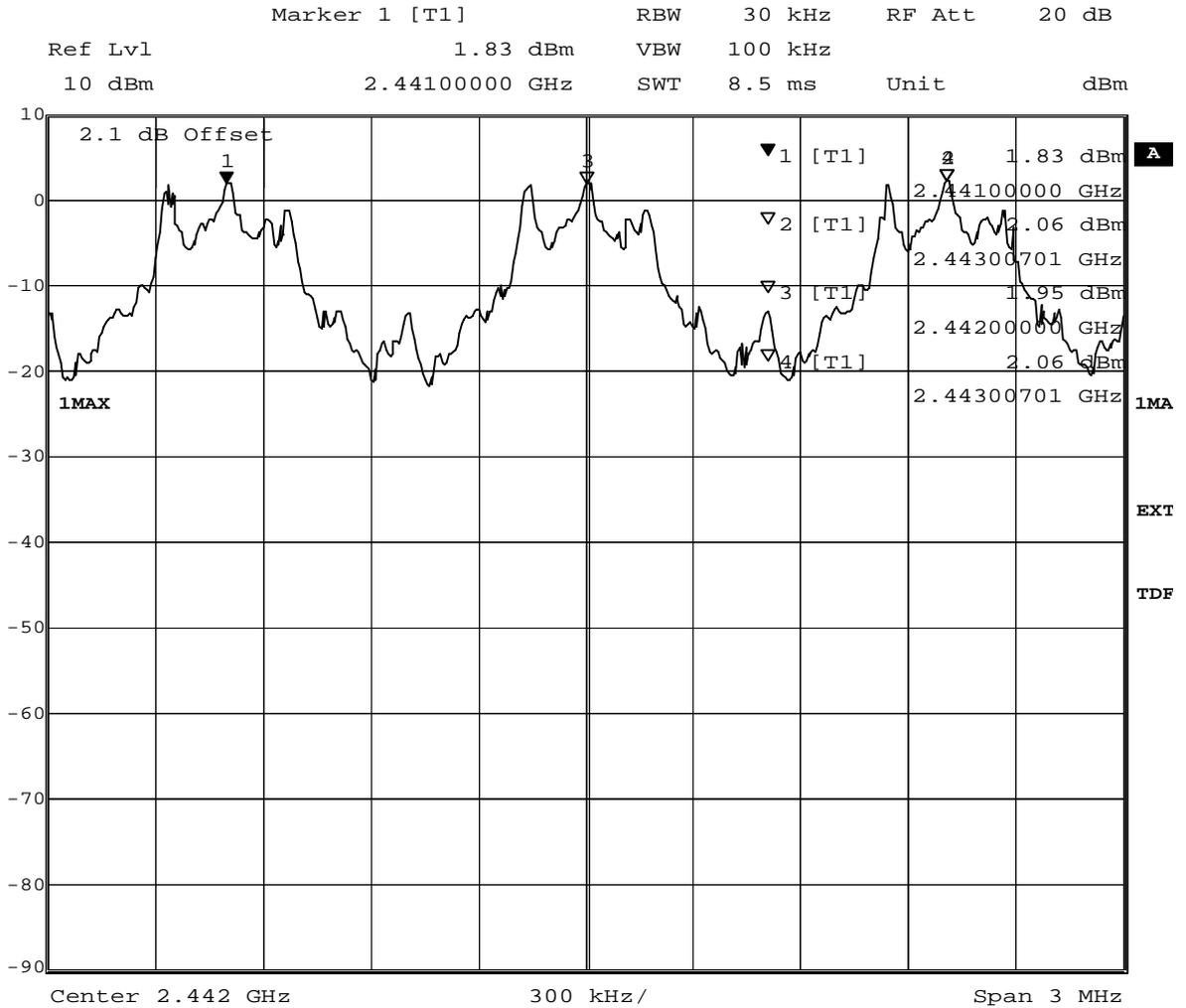
Title: Dwell time  
 Comment A: CH M: 2441 MHz  
 Date: 28.NOV.2008 11:09:41



## 7.7 Channel separation

### Op. Mode

op-mode 4



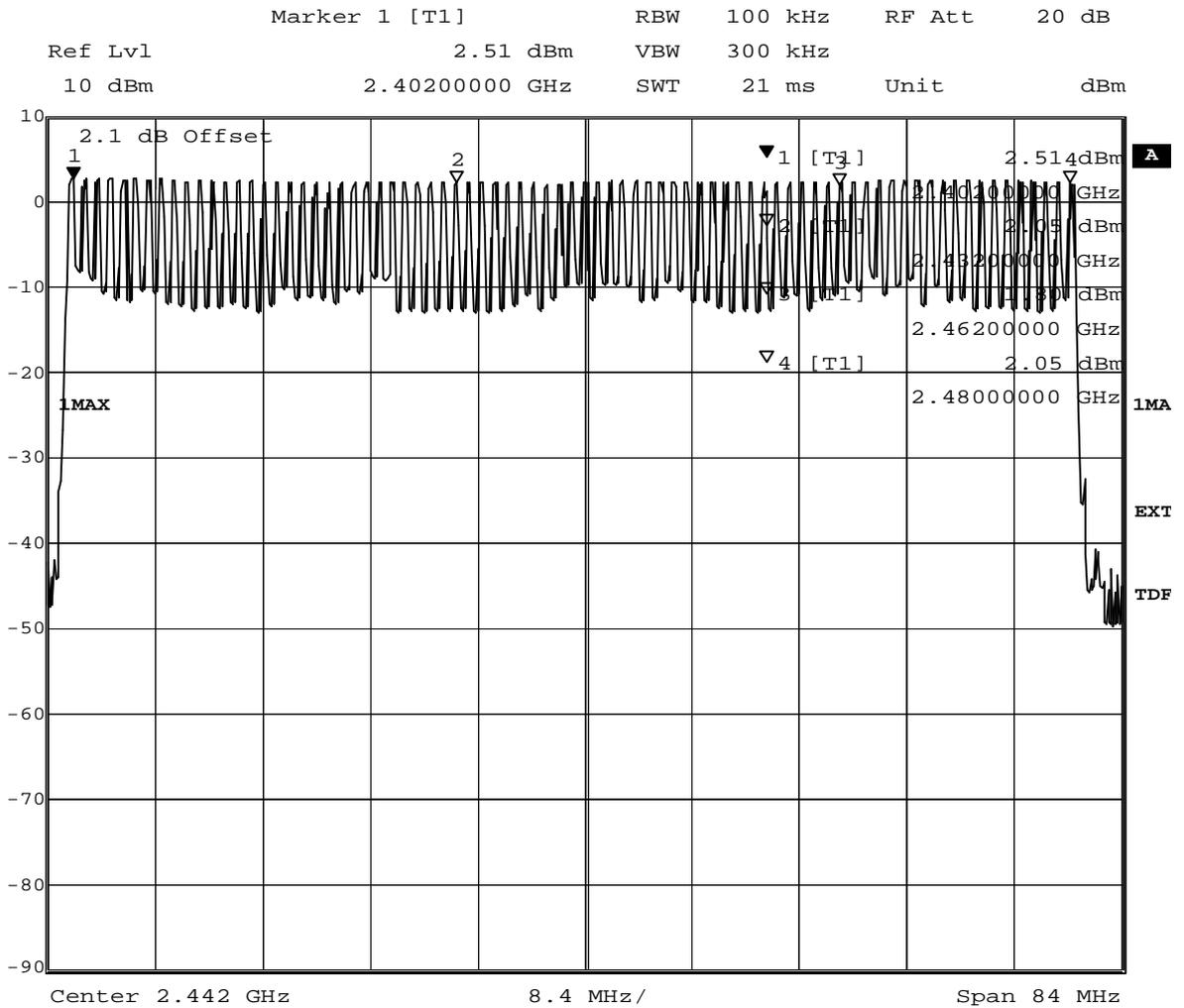
Title: Number of hopping frequencies  
 Comment A: CH H: Hopping  
 Date: 28.NOV.2008 11:27:05



## 7.8 Number of hopping frequencies

### Op. Mode

op-mode 4



Title: Number of hopping frequencies  
Comment A: CH H: Hopping  
Date: 28.NOV.2008 11:34:41