InterLab®

FCC Measurement/Technical Report on

Bluetooth transceiver
UHV CAN FSE256x ECE

Report Reference: MDE_Harman_0711_FCCa

Test Laboratory:

DAT-P-192/99-01

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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.

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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			2003
OP-Mode	**Setup**	**Port**	**Final Result**
-	-	AC Port (power line)	N/A

FCC Part 15, Subpart C	§ 15.247 (a) (1)		
Occupied bandwidth			
The measurement was performed according to FCC § 15.31			10-1-07
OP-Mode	**Setup**	**Port**	**Final Result**
op-mode 1	Setup_b01	Antenna connector	passed
op-mode 2	Setup_b01	Antenna connector	passed
op-mode 3	Setup_b01	Antenna connector	passed

FCC Part 15, Subpart C	§ 15.247 (b) (1)		
Peak power output			
The measurement was performed according to FCC § 15.31			10-1-07
OP-Mode	**Setup**	**Port**	**Final Result**
op-mode 1	Setup_b01	Antenna connector	passed
op-mode 2	Setup_b01	Antenna connector	passed
op-mode 3	Setup_b01	Antenna connector	passed

FCC Part 15, Subpart C	§ 15.247 (d)		
Spurious RF conducted emissions			
The measurement was performed according to FCC § 15.31			10-1-07
OP-Mode	**Setup**	**Port**	**Final Result**
op-mode 1	Setup_b01	Antenna connector	passed
op-mode 2	Setup_b01	Antenna connector	passed
op-mode 3	Setup_b01	Antenna 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
OP-Mode	**Setup**	**Port**	**Final Result**
op-mode 1	Setup_a01	Enclosure	passed
op-mode 2	Setup_a01	Enclosure	passed
op-mode 3	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
OP-Mode	**Setup**	**Port**	**Final Result**
op-mode 1	Setup_b01	Antenna connector	passed
op-mode 3	Setup_b01	Antenna connector	passed
op-mode 3	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	**Setup**	**Port**	**Final Result**
op-mode 2	Setup_b01	Antenna connector	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	**Setup**	**Port**	**Final Result**
op-mode 4	Setup_b01	Antenna connector	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	**Setup**	**Port**	**Final Result**
op-mode 4	Setup_b01	Antenna connector	passed

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

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Responsible for Accreditation Scope: B. Roth

Responsible for Test Report: C. Pedd

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
Report Template Version:	2007-07-19

1.2 Project Data

Responsible for testing and report:	Dipl.-Ing. Andreas Petz
Date of Test(s):	2008-02-12 to 2008-02-28
Date of Report:	2008-02-29

1.3 Applicant Data

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

1.4 Manufacturer Data

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

2 Product labelling

2.1 FCC ID label

At the time of the report there was no FCC label available.

2.2 Location of the label on the EUT

see above

3 Test object Data

3.1 General EUT Description

Equipment under Test	Bluetooth® Transceiver
Type Designation:	UHV CAN FSE256x ECE
Kind of Device:	Bluetooth® Vehicular Handsfree
(optional)	
Voltage Type:	DC
Voltage level:	13.2 V

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 µs. The maximum dwell time 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 EUT provides the following ports:

Ports
Antenna connector
Enclosure
System connector

The main components of the EUT are listed and described in Chapter 3.2

3.2 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: 43043a01)	Bluetooth transceiver	UHV CAN FSE256x ECE	0885000228	H32	X460	2008-02-12
Remark: EUT A is equipped with an antenna connector; used with external antenna (gain = 2.0 dBi).						
EUT B (Code: 43043d01)	Bluetooth transceiver	UHV CAN FSE256x ECE	0885000035	H32	X460	2008-02-12
Remark: EUT B is equipped with an antenna connector.						

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

3.3 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	HW Status	SW Status	Serial no.	FCC ID
AE1	Cable harness	-	-	-	-	-
AE2	Bluetooth antenna	External antenna: Radiall, PCB half wave dipole	-	-	-	-

3.4 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 + AE 1 + AE2	setup for radiated measurements
Setup_b01	EUT B + AE 1	setup for conducted measurements

3.5 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
op-mode 2	The EUT transmits on 2441 MHz	Loopback mode
op-mode 3	The EUT transmits on 2480 MHz	Loopback mode
op-mode 4	The EUT is in hopping mode	The EUT is hopping on 79 channels

4 Test Results

4.1 Occupied bandwidth

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

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

4.1.1 Test Description

The Equipment Under Test (EUT) was setup in a shielded room 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.

4.1.2 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 EUTs output power:

1. Under the provision that the system's operates with an output power no greater than 125 mW (21.0 dBm):
   Implicit Limit: Max. 20 dB BW = 1.0 MHz / 2/3 = 1.5 MHz
2. If the system's 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 (Output power (W) / 1mW)

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.

4.1.3 Test Protocol

Temperature: 23 °C
Air Pressure: 1032 hPa
Humidity: 28 %

Op. Mode	Setup	Port
op-mode 1	Setup_b01	Antenna connector

20 dB bandwidth MHz	Remarks
0.968	-

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 2	Setup_b01	Antenna connector

20 dB bandwidth MHz	Remarks
0.950	-

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 3	Setup_b01	Antenna connector

20 dB bandwidth MHz	Remarks
0.950	-

Remark: Please see annex for the measurement plot.

4.1.4 Test result: Occupied bandwidth

FCC Part 15, Subpart C	Op. Mode	Result
	op-mode 1	passed
	op-mode 2	passed
	op-mode 3	passed

4.2 Peak power output

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

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

4.2.1 Test Description

The Equipment Under Test (EUT) was set up in a shielded room to perform the output power measurements.
The results recorded were measured with the modulation which produces the worst-case (highest) output power.
The resolution bandwidth for measuring the output power was 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.

4.2.2 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

4.2.3 Test Protocol

Temperature: 23 °C
Air Pressure: 1032 hPa
Humidity: 28 %

Op. Mode	Setup	Port
op-mode 1	Setup_b01	Antenna connector

Output power dBm	Remarks
3.05	The EIRP including antenna gain (2.0 dBi) is 5.05 dBm

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 2	Setup_b01	Antenna connector

Output power dBm	Remarks
2.67	The EIRP including antenna gain (2.0 dBi) is 4.67 dBm

Remark: Please see annex for the measurement plot.

Op. Mode	Setup	Port
op-mode 3	Setup_b01	Antenna connector

Output power dBm	Remarks
2.94	The EIRP including antenna gain (2.0 dBi) is 4.94 dBm

Remark: Please see annex for the measurement plot.

4.2.4 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

4.3 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

4.3.1 Test Description

The Equipment Under Test (EUT) was set up in a shielded room 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 4.5). This value is used to calculate the 20 dBc limit.

4.3.2 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.

4.3.3 Test Protocol

Temperature: 23 °C
Air Pressure: 1032 hPa
Humidity: 28 %

Op. Mode	Setup	Port
op-mode 1	Setup_b01	Antenna connector

Frequency MHz	Corrected measurement value dBm	Reference value DBm	Limit dBm	Delta to limit dB
4784	-32.17	2.87	-17.01	15.16

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	Antenna connector

Frequency MHz	Corrected measurement value dBm	Reference value DBm	Limit dBm	Delta to limit dB
4884	-31.00	2.53	-17.39	13.61

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	Antenna connector

Frequency MHz	Corrected measurement value dBm	Reference value DBm	Limit dBm	Delta to limit dB
4934	-28.19	2.88	-17.11	11.08

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

4.3.4 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

4.4 Spurious radiated emissions

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

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

4.4.1 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: 10m
- 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 µs

- Turntable angle range: –180 to 180 °
- Turntable step size: 90°
- Height variation range: 1 – 3m
- Height variation step size: 2m
- 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: 100ms
- Turntable angle range: –180 to 180 °
- Turntable step size: 45°
- Height variation range: 1 – 4m
- Height variation step size: 0.5m
- 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°
- Antenna height: 0.5m

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 +/- 22.5° 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 +/- 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: 100ms
- Turntable angle range: –22.5° to + 22.5 ° around the determined value
- Height variation range: -0.25m to + 0.25m 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(< 1GHz)
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 1s

3. Measurement above 1GHz

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

The measurement distance was reduced to 1m. 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.

4.4.2 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)

4.4.3 Test Protocol

Temperature: 21 – 24 °C
Air Pressure: 1034 – 1040 hPa
Humidity: 26 - 32 %

4.4.3.1 Measurement up to 30 MHz

Op. Mode	Setup	Port
op-mode 2	Setup_a01	Enclosure

Polari-sation	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.

4.4.3.2 Measurement above 30 MHz

Op. Mode	Setup	Port
op-mode 1	Setup_a01	Enclosure

Polari-sation	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	1602	-	45.93	35.54	-	74.00	54.00	28.07	18.46
Vertical + horizontal	4804		57.86	46.26	-	74.00	54.00	16.14	7.74

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

Op. Mode	Setup	Port
op-mode 2	Setup_a01	Enclosure

Polari-sation	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	1604	-	45.52	35.36	-	74.00	54.00	28.48	18.64
Vertical + horizontal	4882	-	59.09	47.50	-	74.00	54.00	14.91	6.50

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

Op. Mode	Setup	Port
op-mode 3	Setup_a01	Enclosure

Polari-sation	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	1601	-	45.39	35.28	-	74.00	54.00	28.61	18.72
Vertical + horizontal	2484	-	54.98	39.89	-	74.00	54.00	19.02	14.11
Vertical + horizontal	4960	-	62.31	50.55	-	74.00	54.00	11.69	3.45

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

4.4.4 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

4.5 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

4.5.1 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

4.5.2 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)".

4.5.3 Test Protocol

4.5.3.1 Lower band edge

Conducted measurement

Temperature: 23 °C
Air Pressure: 1032 hPa
Humidity: 28 %

Op. Mode	Setup	Port
op-mode 1	Setup_b01	Antenna connector

Frequency MHz	Measured value dBm	Reference value dBm	Limit dBm	Delta to limit dB
2400.00	-39.04	2.99	-17.01	22.03

Remark: Please see annex for the measurement plot.

4.5.3.2 Higher band edge

Conducted measurement

Temperature: 23 °C
Air Pressure: 1032 hPa
Humidity: 28 %

Op. Mode	Setup	Port
op-mode 3	Setup_b01	Antenna connector

Frequency MHz	Measured value dBm	Reference value dBm	Limit dBm	Delta to limit dB
2483.50	-42.87	2.89	-17.11	25.76

Radiated measurement

Temperature: 24 °C
Air Pressure: 1040 hPa
Humidity: 26 %

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	54.98	39.89	74.00	54.00	19.02	14.11

Remark: Please see annex for the measurement plot.

4.5.4 Test result: Band edge compliance

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

4.6 Dwell time

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

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

4.6.1 Test Description

The Equipment Under Test (EUT) was set up in a shielded room to perform the dwell time measurements.
The EUT was connected to the spectrum analyzer via a short coax cable with a known loss.
The time slot length is measured of three different packet types which are available in the Bluetooth technology. Those are DH1, DH3 and DH5 packets. The dwell time is calculated by:

Dwell time = time slot length * hop rate / number of hopping channels * 31.6

with:
- hop rate=1600 * 1/s for DH1 packets = 1600
- hop rate=1600/3 * 1/s for DH3 packets = 533.33
- hop rate=1600/5 * 1/s for DH5 packets = 320
- number of hopping channels=79
- 31.6 s=0.4 seconds multiplied by the number of hopping channels=0.4s * 79

4.6.2 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.

4.6.3 Test Protocol

Temperature: 23 °C
Air Pressure: 1032 hPa
Humidity: 28 %

Op. Mode	Setup	Port
op-mode 2	Setup_b01	Antenna connector

Packet type	Time slot length ms	Dwell time	Dwell time ms
DH1	0.421	time slot length * 1600 /79 * 31.6	269.44
DH3	1.683	time slot length * 1600/3 /79 * 31.6	359.04
DH5	2.926	time slot length * 1600/5 /79 * 31.6	374.53

Remark: Please see annex for the measurement plots.

4.6.4 Test result: Dwell time

FCC Part 15, Subpart C	Op. Mode		Result
	op-mode 2	DH1	passed
	op-mode 2	DH3	passed
	op-mode 2	DH5	passed

4.7 Channel separation

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

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

4.7.1 Test Description

The Equipment Under Test (EUT) was set up in a shielded room to perform the channel separation measurements.
The EUT was connected to spectrum analyzer via a short coax cable with a known loss.
Analyzer settings:
- Detector: Peak-Maxhold
- Span: 3 MHz
- Centre Frequency: 2441 MHz
- Resolution Bandwidth (RBW): 30 kHz
- Video Bandwidth (VBW): 100 kHz
- Sweep Time: Coupled

4.7.2 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.

4.7.3 Test Protocol

Temperature: 23 °C
Air Pressure: 1032 hPa
Humidity: 28 %

Op. Mode	Setup	Port
op-mode 4	Setup_b01	Antenna connector

Channel separation MHz	Remarks
1.0	-

Remark: Please see annex for the measurement plot.

4.7.4 Test result: Channel separation

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

4.8 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

4.8.1 Test Description

The Equipment Under Test (EUT) was set up in a shielded room to perform the number of hopping frequencies measurement.
The EUT was connected to spectrum analyzer via a short coax cable.
Analyzer settings:
- Detector: Peak-Maxhold
- Start frequency: 2402 MHz
- Stop frequency: 2483.5 MHz
- Resolution Bandwidth (RBW): 30 kHz
- Video Bandwidth (VBW): 30 kHz
- Sweep Time: Coupled

4.8.2 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.

4.8.3 Test Protocol

Temperature: 23 °C
Air Pressure: 1032 hPa
Humidity: 28 %

Op. Mode	Setup	Port
op-mode 4	Setup_b01	Antenna connector

Number of hopping channels	Remarks
79	-

Remark: Please see annex for the measurement plot.

4.8.4 Test result: Number of hopping frequencies

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

5 Test Equipment

EUT Digital Signalling System

Equipment	Type	Serial No.	Manufacturer
Digital Radio Communication Tester	CMD 55	831050/020	Rohde & Schwarz
Signalling Unit for Bluetooth Spurious Emissions	PTW60	100004	Rohde & Schwarz
Universal Radio Communication Tester	CMU 200	102366	Rohde & Schwarz
Universal Radio Communication Tester	CMU 200	837983/052	Rohde & Schwarz
Bluetooth Signalling Unit	CBT (1153.9000.35)	100302	Rohde & Schwarz

EMI Test System

Equipment	Type	Serial No.	Manufacturer
Comparison Noise Emitter	CNE III	99/016	York
EMI Analyzer	ESI 26	830482/004	Rohde & Schwarz
Signal Generator	SMR 20	846834/008	Rohde & Schwarz

EMI Radiated Auxiliary Equipment

Equipment	Type	Serial No.	Manufacturer
Antenna mast 4m	MA 240	240/492	HD GmbH H. Deisel
Biconical dipole	VUBA 9117	9117108	Schwarzbeck
Broadband Amplifier 18MHz-26GHz	JS4-18002600-32	849785	Miteq
Broadband Amplifier 30MHz-18GHz	JS4-00101800-35	896037	Miteq
Broadband Amplifier 45MHz-27GHz	JS4-00102600-42	619368	Miteq
Cable "ESI to EMI Antenna"	EcoFlex10	W18.01-2 + W38.01-2	Kabel Kusch
Cable "ESI to Horn Antenna"	UFB311A + UFB293C	W18.02-2 + W38.02-2	Rosenberger-Microcoax
Double-ridged horn	HF 906	357357/002	Rohde & Schwarz
Double-ridged horn	HF 906	357357/001	Rohde & Schwarz
High Pass Filter	5HC3500/12750-1.2-KK	200035008	Trilithic
High Pass Filter	5HC2700/12750-1.5-KK	9942012	Trilithic
High Pass Filter	4HC1600/12750-1.5-KK	9942011	Trilithic
KUEP pre amplifier	Kuep 00304000	001	7layers
Log.-per. Antenna	HL 562 Ultralog	830547/003	Rohde & Schwarz
Loop Antenna	HFH2-Z2	829324/006	Rohde & Schwarz
Pyramidal Horn Antenna 26.5 GHz	Model 3160-09	9910-1184	EMCO

EMI Conducted Auxiliary Equipment

Equipment	Type	Serial No.	Manufacturer
Cable "LISN to ESI"	RG214	W18.03+W48.03	Huber+Suhner
Two-Line V-Network	ESH 3-Z5	828304/029	Rohde & Schwarz
Two-Line V-Network	ESH 3-Z5	829996/002	Rohde & Schwarz

Auxiliary Test Equipment

Equipment	Type	Serial No.	Manufacturer
Broadband Resist. Power Divider N	1506A / 93459	LM390	Weinschel
Broadband Resist. Power Divider SMA	1515 / 93459	LN673	Weinschel
Digital Multimeter 01	Voltcraft M-3860M	IJ096055	Conrad
Digital Multimeter 02	Voltcraft M-3860M	IJ095955	Conrad
Digital Oscilloscope	TDS 784C	B021311	Tektronix
Fibre optic link Satellite	FO RS232 Link	181-018	Pontis
Fibre optic link Transceiver	FO RS232 Link	182-018	Pontis
I/Q Modulation Generator	AMIQ-B1	832085/018	Rohde & Schwarz
Notch Filter ultra stable	WRCA800/960-6E	24	Wainwright
Spectrum Analyzer 9 kHz to 3 GHz	FSP3	838164/004	Rohde & Schwarz
Temperature Chamber	VT 4002	58566002150010	Vötsch
Temperature Chamber	KWP 120/70	59226012190010	Weiss
ThermoHygro Datalogger 03	Opus10 THI (8152.00)	7482	Lufft Mess- und Regeltechnik GmbH

Anechoic Chamber

Equipment	Type	Serial No.	Manufacturer
Air Compressor (pneumatic)			Atlas Copco
Controller	CO 2000	CO2000/328/12470406 /L	Innco innovative constructions GmbH
EMC Camera	CE-CAM/1		CE-SYS
EMC Camera for observation of EUT	CCD-400E	0005033	Mitsubishi
Filter ISDN	B84312-C110-E1		Siemens&Matsushita
Filter telephone systems / modem	B84312-C40-B1		Siemens&Matsushita
Filter Universal 1A	B84312-C30-H3		Siemens&Matsushita
Fully/Semi AE Chamber	10.58x6.38x6		Frankonia
Turntable	DS 420S	420/573/99	HD GmbH, H. Deisel
Valve Control Unit (pneum.)	VE 615P	615/348/99	HD GmbH, H. Deisel

Equipment	Type	Serial No.	Manufacturer
10 MHz Reference	MFS	5489/001	Efratom
Power Meter 832025/059	NRVD	832025/059	Rohde & Schwarz
Power Sensor A 832279/013	NRV-Z1	832279/013	Rohde & Schwarz
Power Sensor B 832279/015	NRV-Z1	832279/015	Rohde & Schwarz
Power Supply	E3632A	MY40003776	Agilent
Power Supply	PS-2403D	-	Conrad
RF Step Attenuator 833695/001	RSP	833695/001	Rohde & Schwarz
Rubidium Frequency Normal	MFS	002	Efratom
Signal Analyzer FSIQ26 832695/007	FSIQ26	832695/007	Rohde & Schwarz
Signal Generator 833680/003	SMP 03	833680/003	Rohde & Schwarz
Signal Generator A 834344/002	SMIQ03B	834344/002	Rohde & Schwarz
Signal Generator B 832870/017	SMIQ03B	832870/017	Rohde & Schwarz
Signal Switching and Conditioning Unit	SSCU	338826/005	Rohde & Schwarz
Signalling Unit PTW60 838312/014	PTW60 for TS8960	838312/014	Rohde & Schwarz
System Controller 829323/008	PSM12	829323/008	Rohde & Schwarz

6 Photo Report

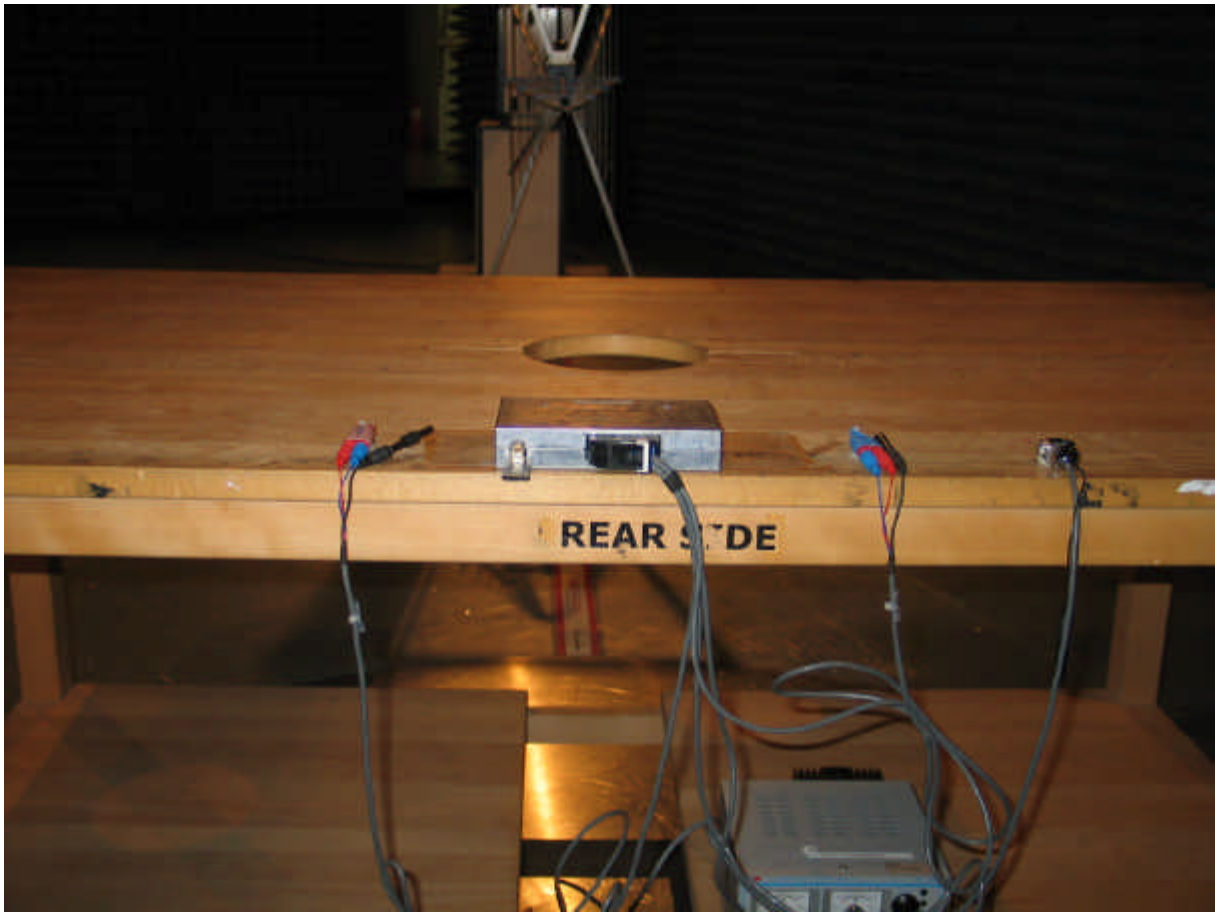


Photo 1: Test setup for radiated measurements below 1 GHz

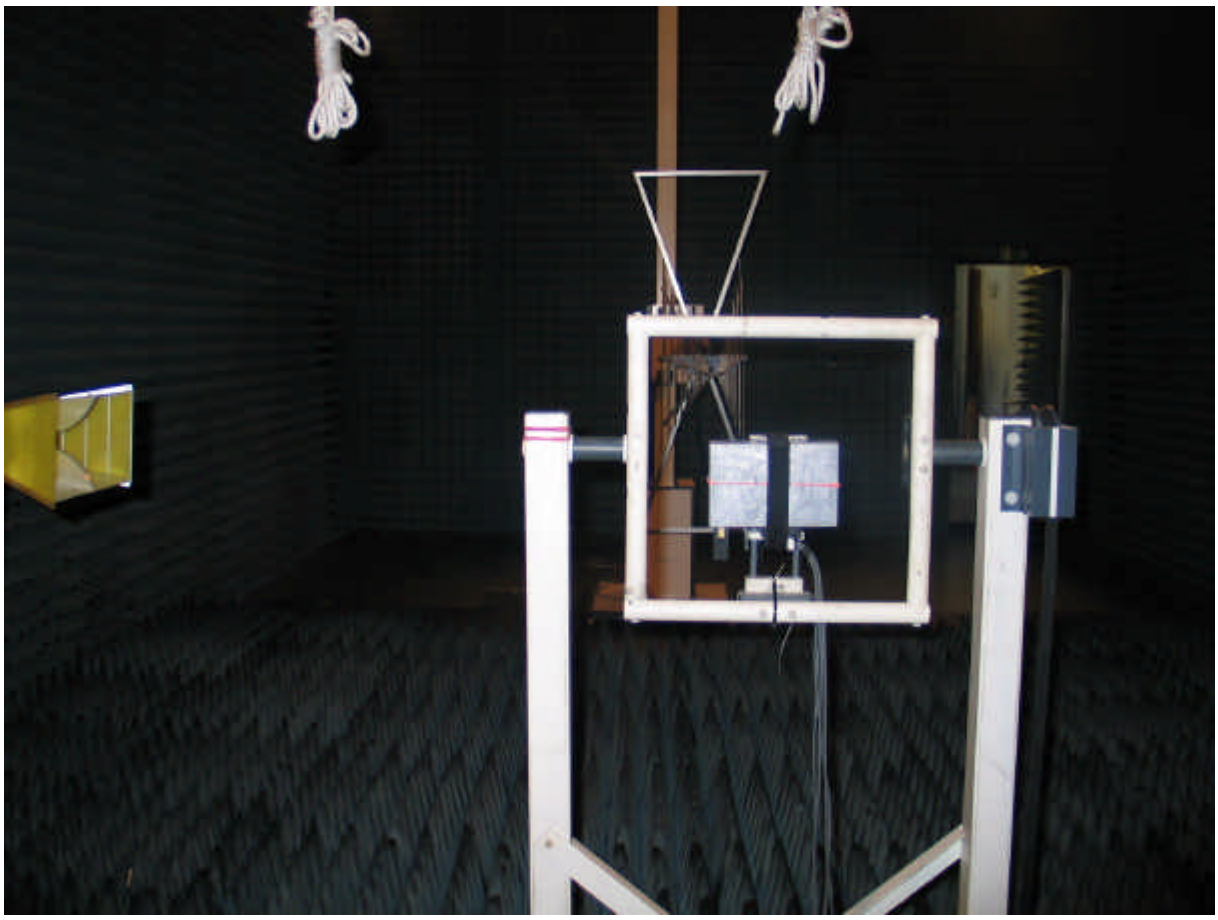


Photo 2: Test setup for radiated measurements above 1 GHz

Photo 3: EUT (front / top side), with interfaces

Photo 4: EUT (front / rear side)

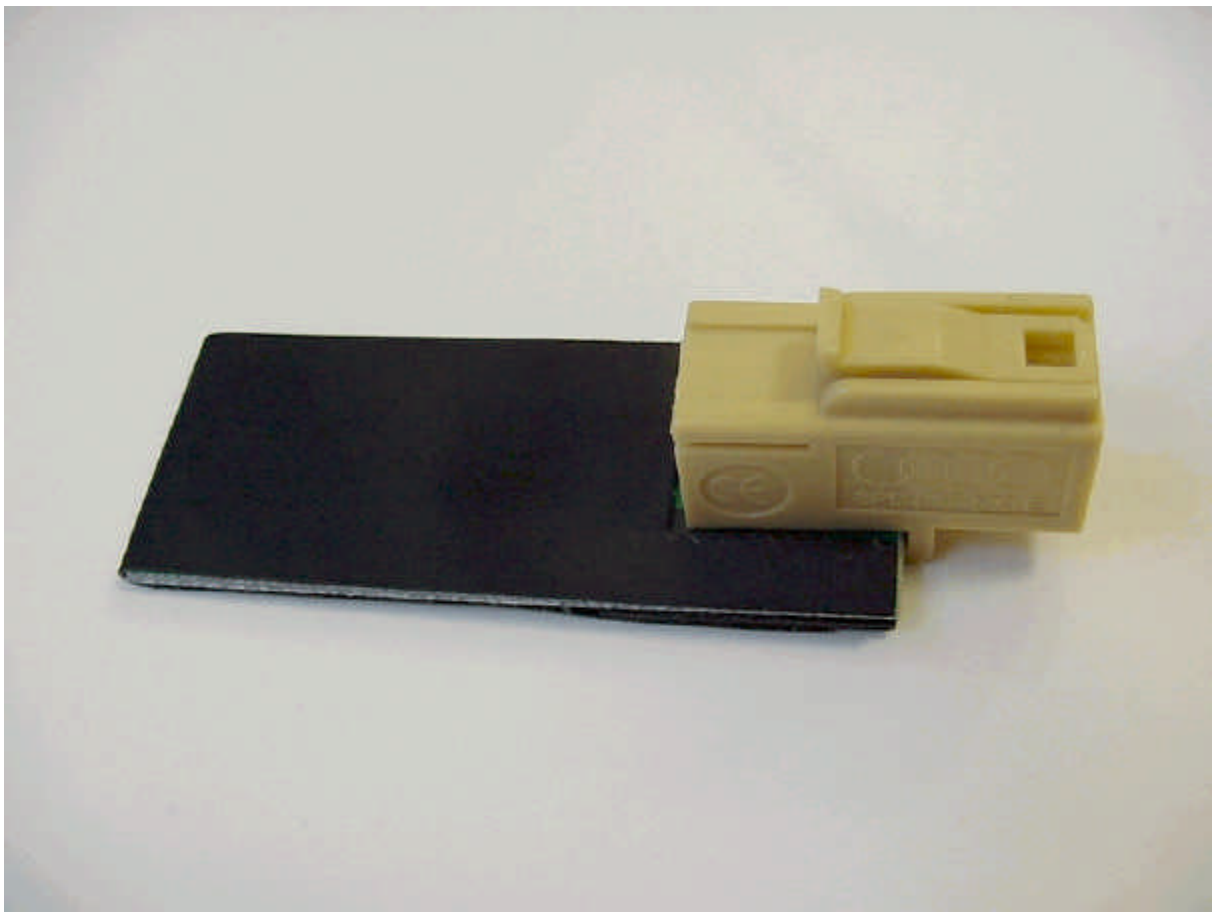
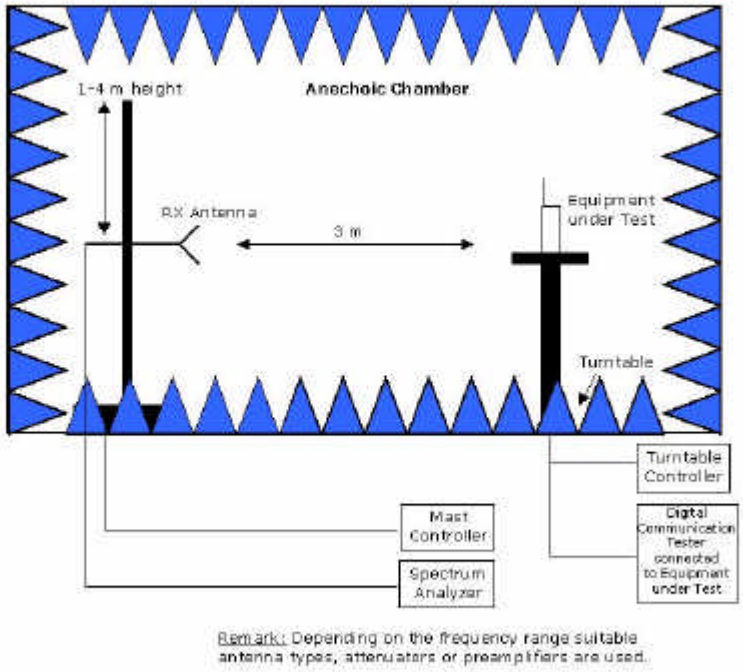


Photo 5: External antenna

7 Setup Drawings



Drawing 1: Setup in the Anechoic chamber. For measurements below 1 GHz the ground was replaced by a conducting ground plane.

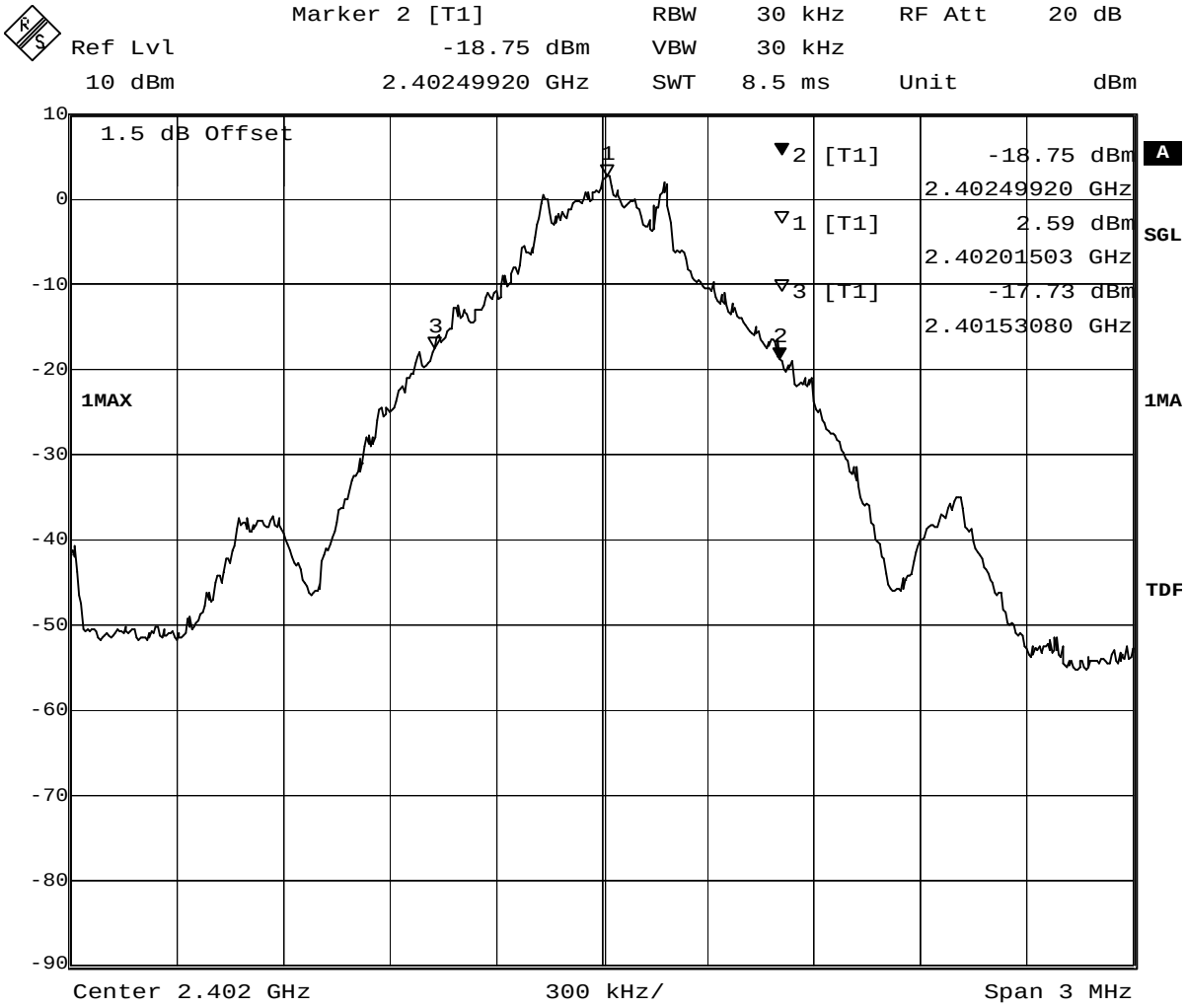
8 Annex measurement plots

8.1 Occupied bandwidth

8.1.1 Occupied bandwidth operating mode 1

Op. Mode

op-mode 1

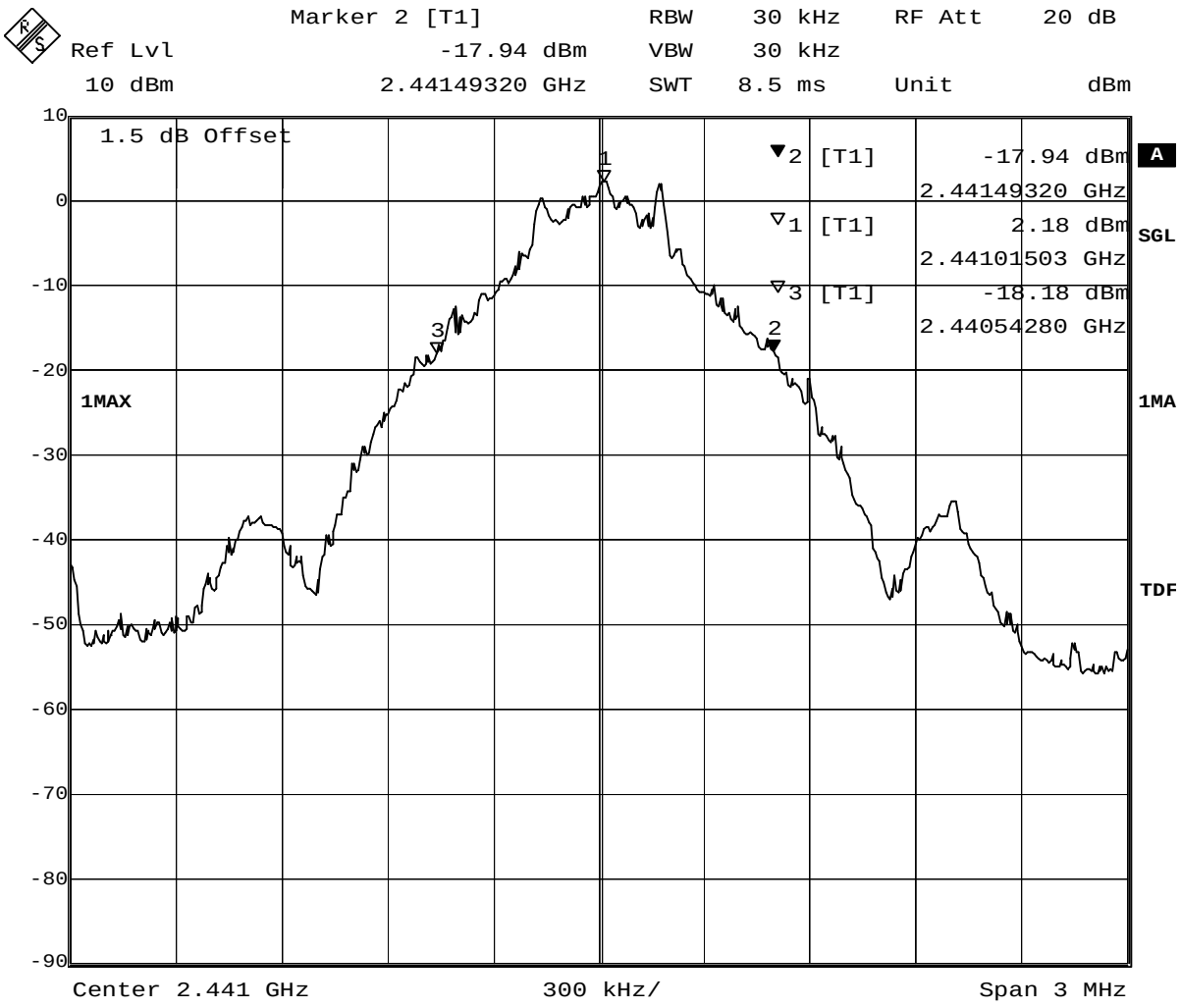


Title: 20dB Bandwidth
Comment A: CH B: 2402 MHz; 20dB bandwidth (kHz):968.4
Date: 18.FEB.2008 09:42:03

8.1.2 Occupied bandwidth operating mode 2

Op. Mode

op-mode 2

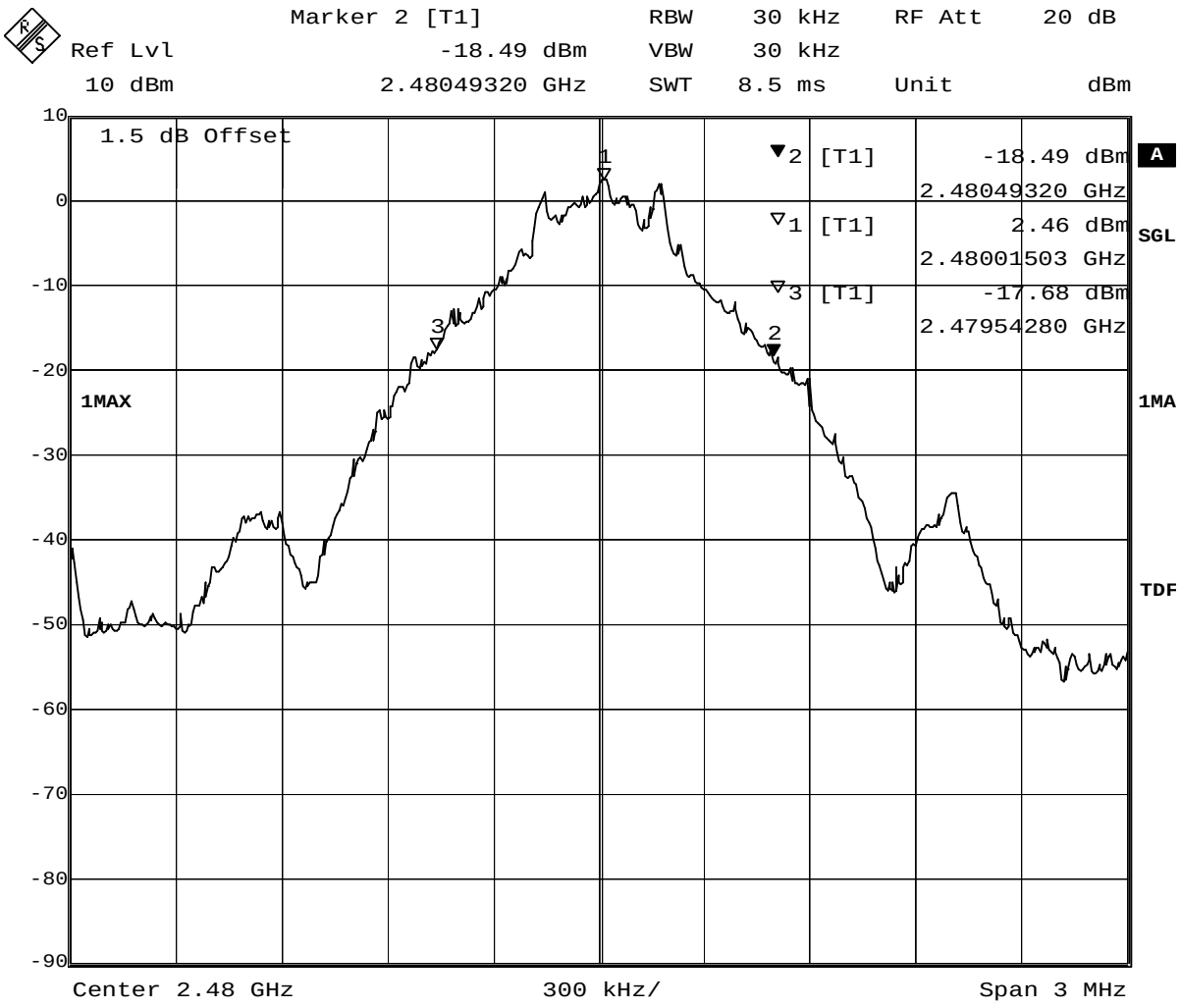


Title: 20dB Bandwidth
Comment A: CH M: 2441 MHz; 20dB bandwidth (kHz):950.4
Date: 18.FEB.2008 10:03:21

8.1.3 Occupied bandwidth operating mode 3

Op. Mode

op-mode 3



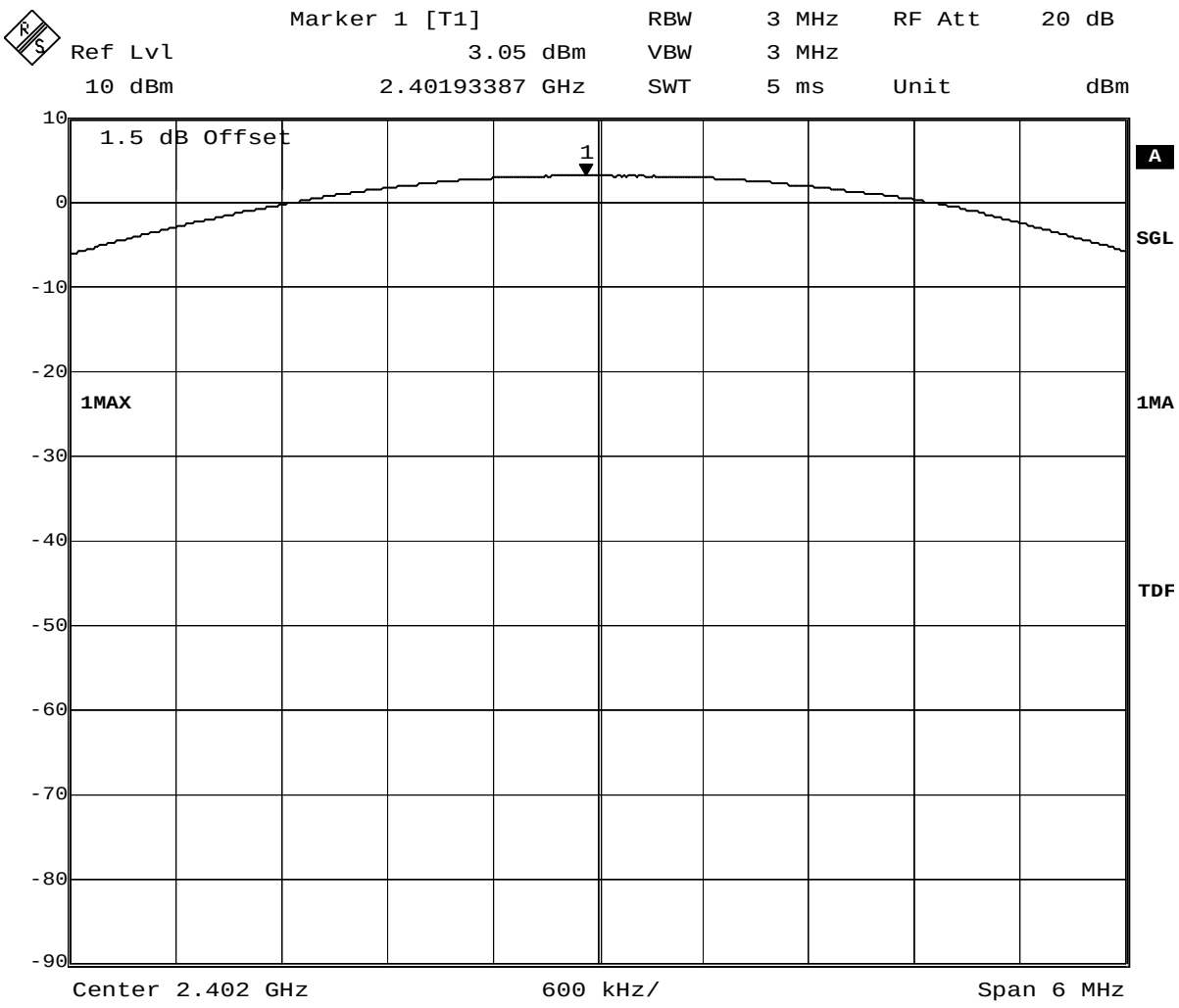
Title: 20dB Bandwidth
Comment A: CH T: 2480 MHz; 20dB bandwidth (kHz):950.4
Date: 18.FEB.2008 09:19:19

8.2 Peak power output

8.2.1 Peak power output operating mode 1

Op. Mode

op-mode 1

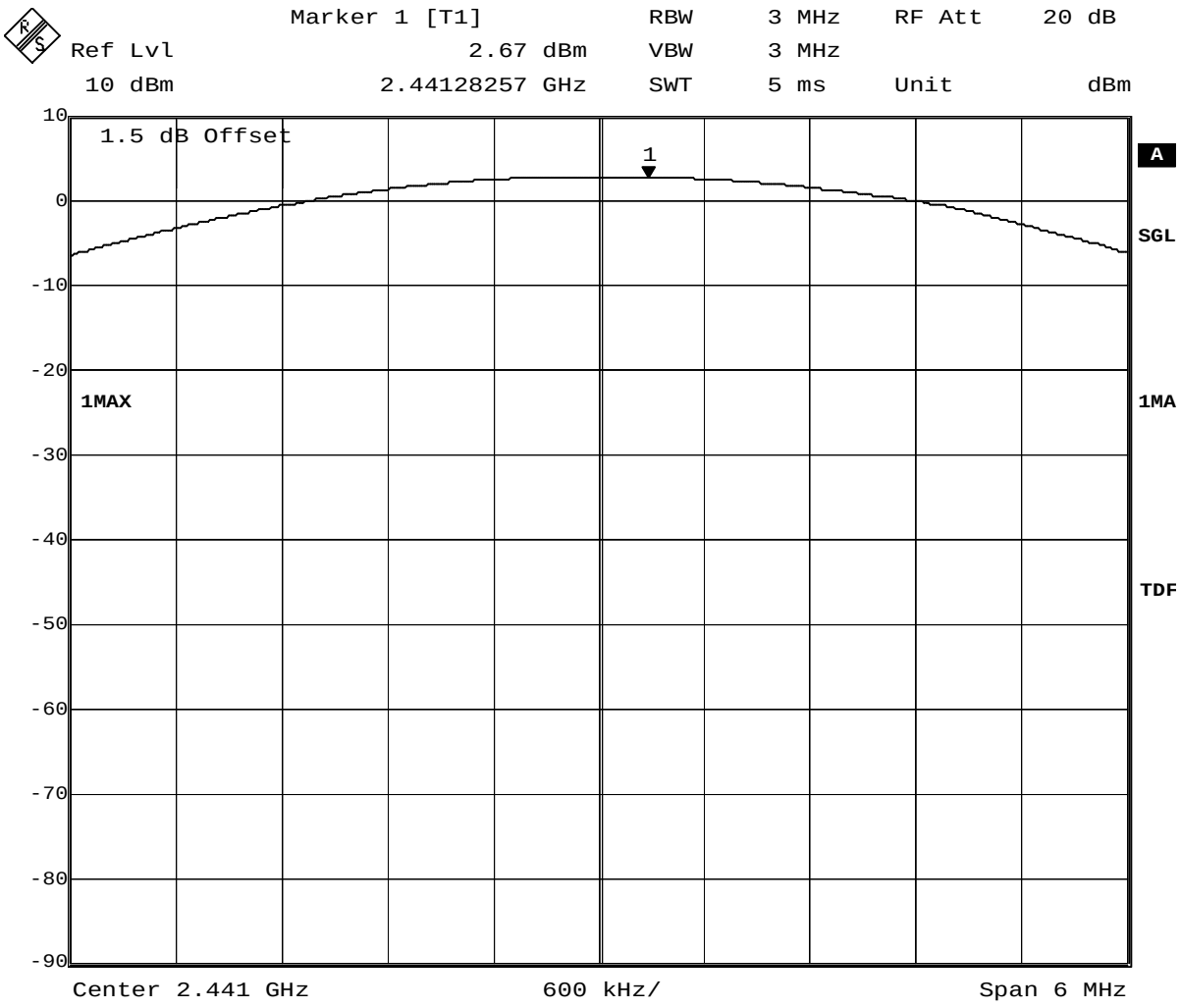


Title: Peak outputpower Power
Comment A: CH B: 2402 MHz
Date: 18.FEB.2008 09:42:29

8.2.2 Peak power output operating mode 2

Op. Mode

op-mode 2

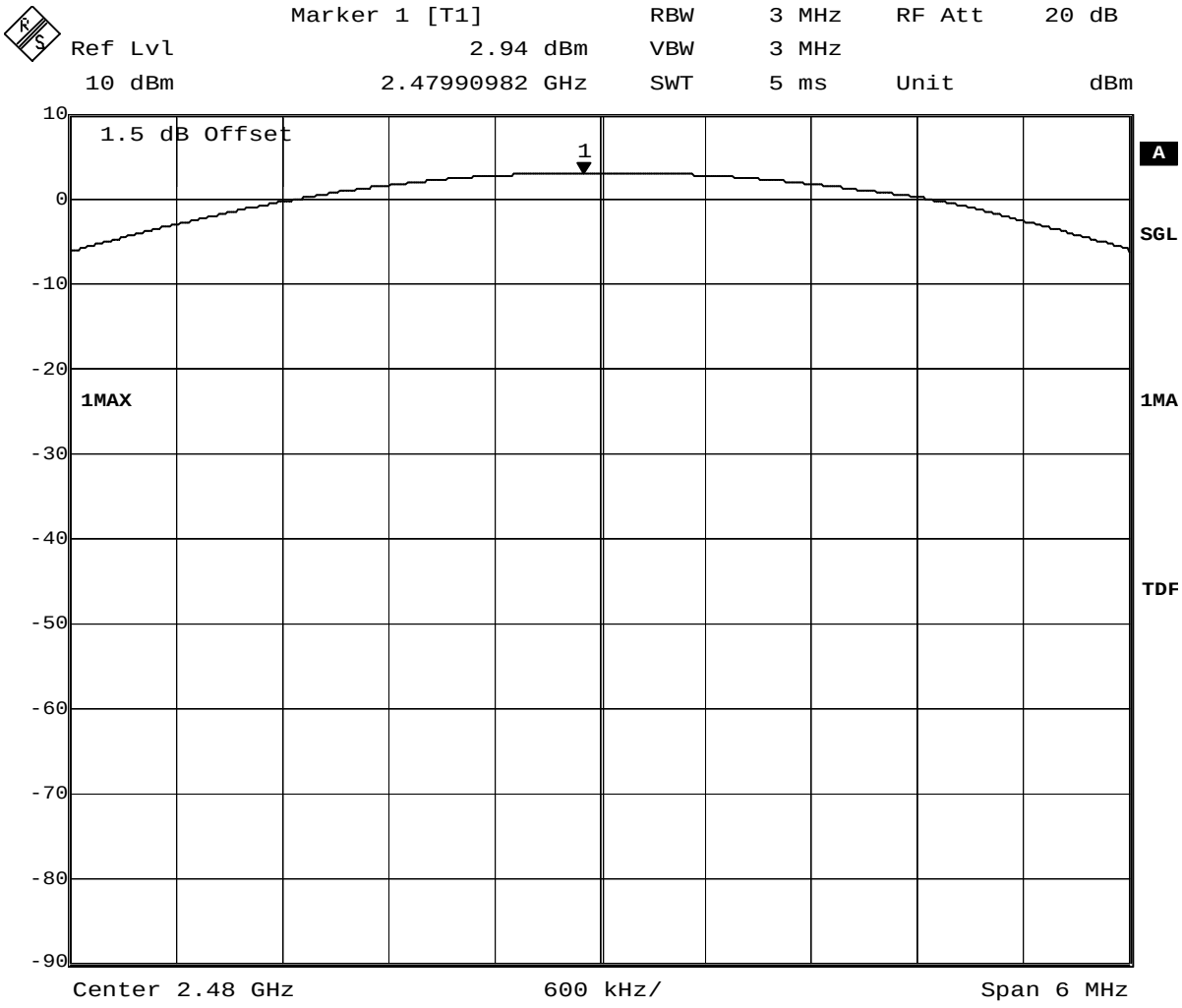


Title: Peak outputpower Power
Comment A: CH M: 2441 MHz
Date: 18.FEB.2008 10:03:47

8.2.3 Peak power output operating mode 3

Op. Mode

op-mode 3



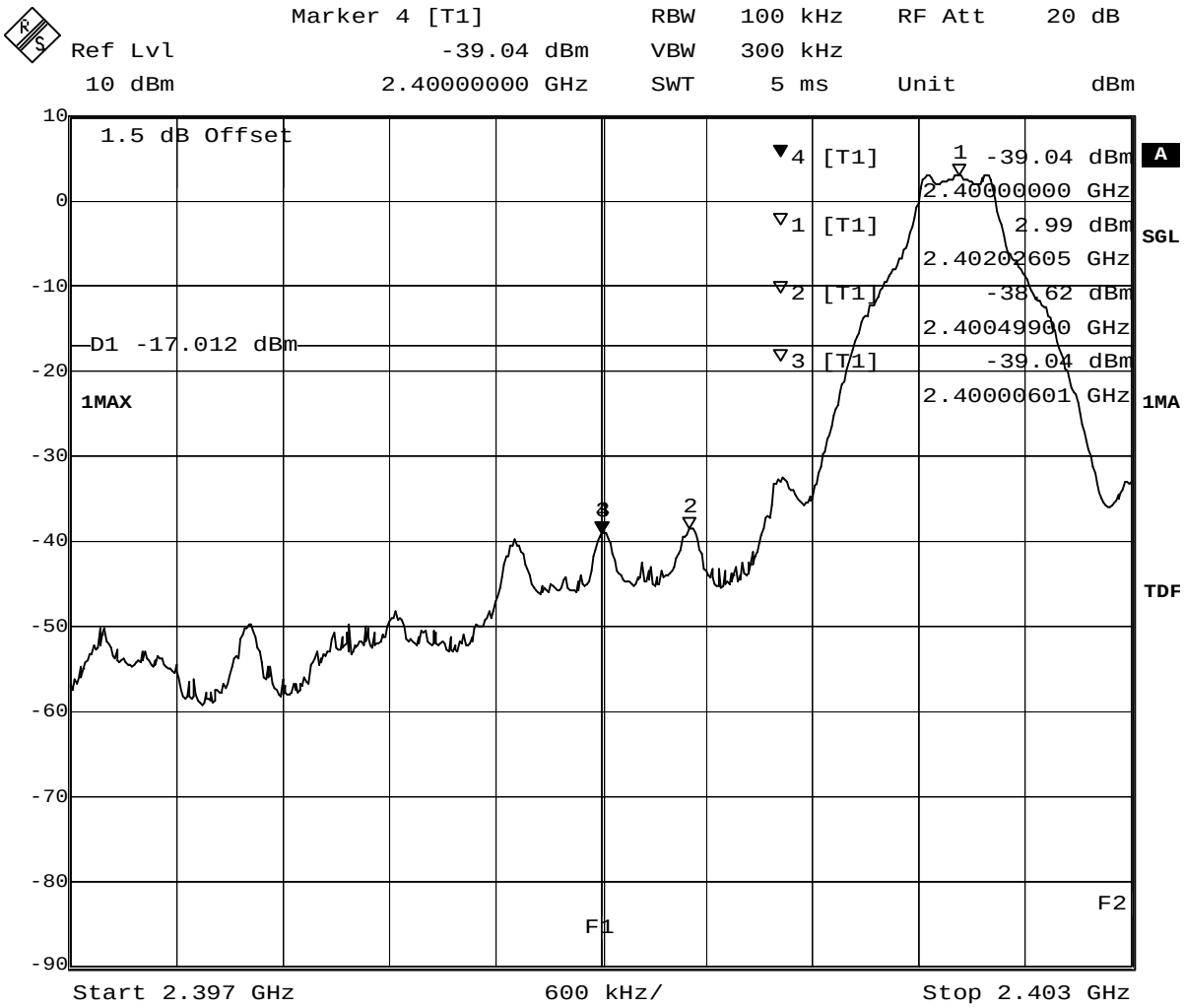
Title: Peak outputpower Power
Comment A: CH T: 2480 MHz
Date: 18.FEB.2008 09:19:45

8.3 Band edge compliance conducted and Spurious RF conducted emissions

8.3.1 Band edge compliance conducted operating mode 1

Op. Mode

op-mode 1



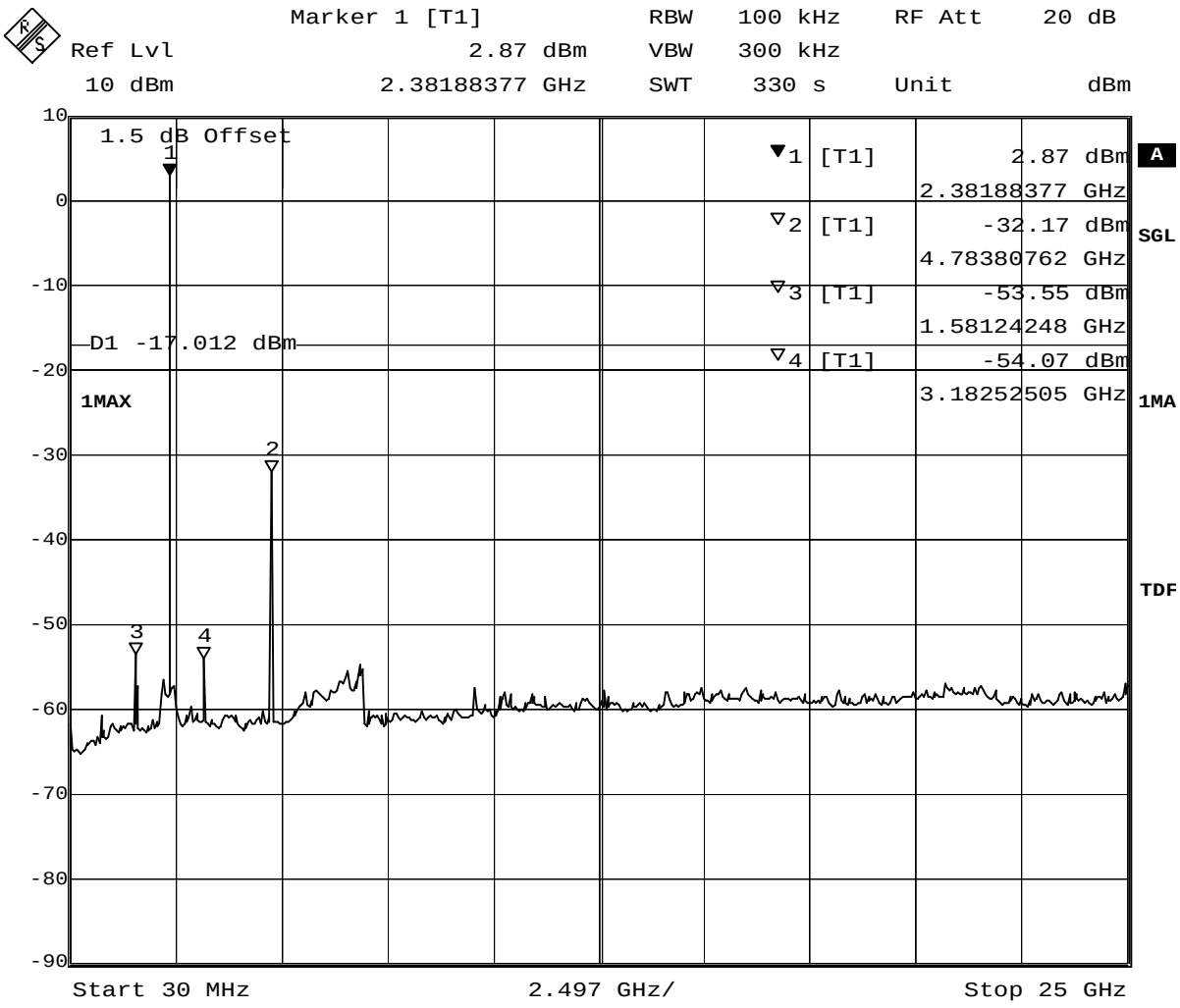
Title: Band Edge Compliance
Comment A: CH B: 2402 MHz
Date: 18.FEB.2008 09:26:46

(determination of reference value for spurious emissions measurement)

8.3.2 Spurious RF conducted emissions operating mode 1

Op. Mode

op-mode 1



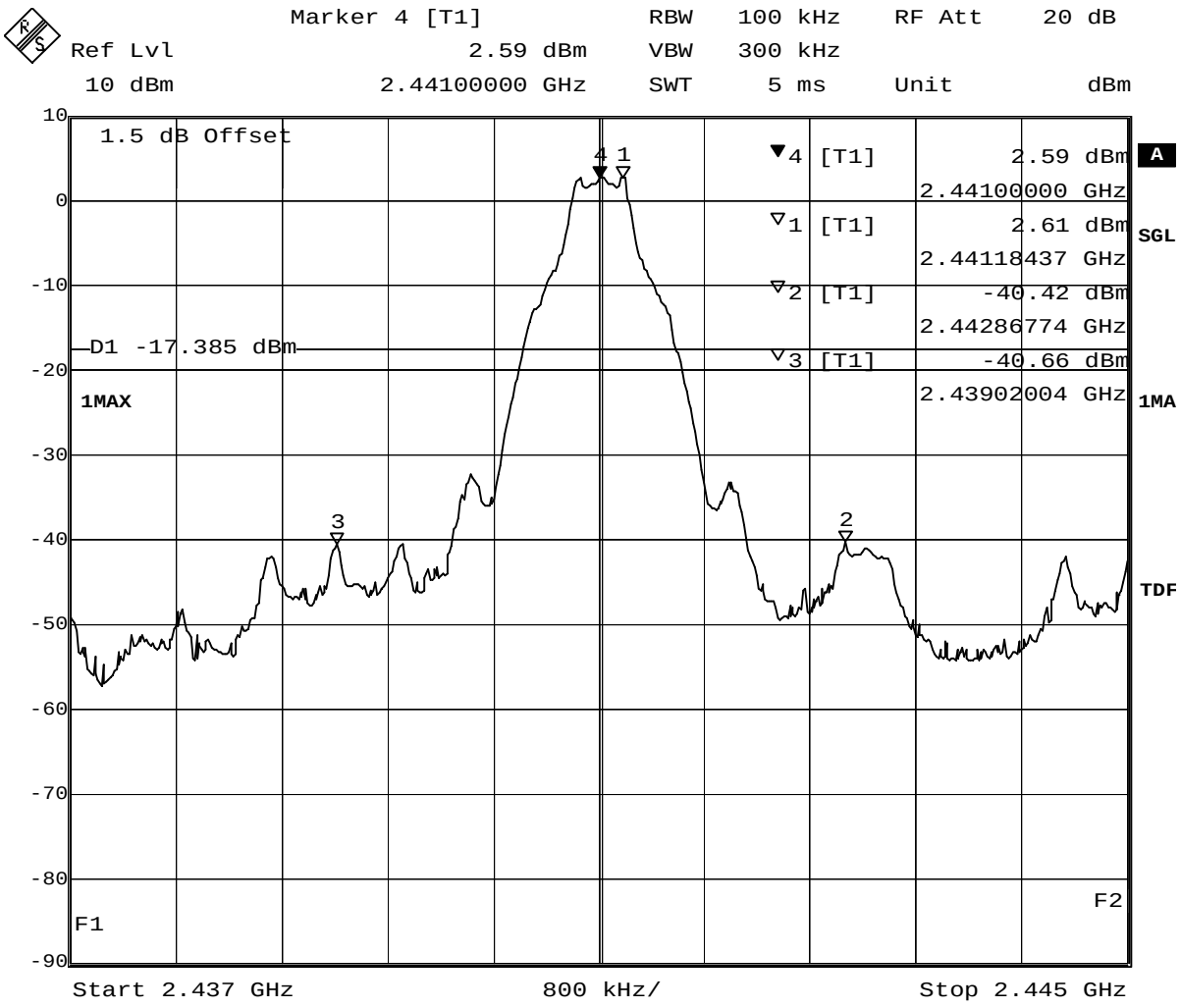
Title: spurious emissions
Comment A: CH B: 2402 MHz
Date: 18.FEB.2008 09:38:23

(spurious emissions measurement)

8.3.3 Spurious RF conducted emissions operating mode 2

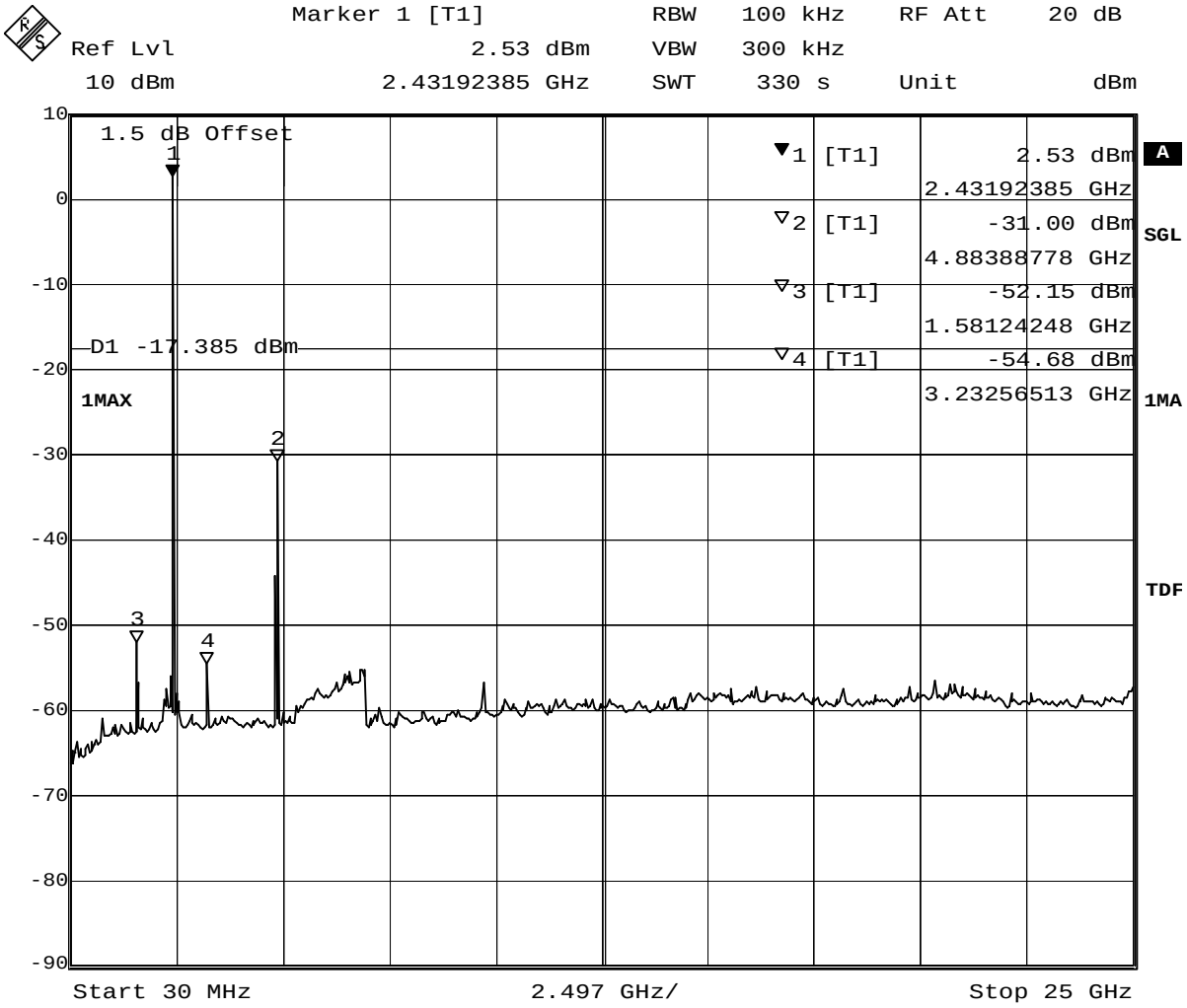
Op. Mode

op-mode 2



Title: Band Edge Compliance
Comment A: CH M: 2441 MHz
Date: 18.FEB.2008 09:48:23

(determination of reference value for spurious emissions measurement)



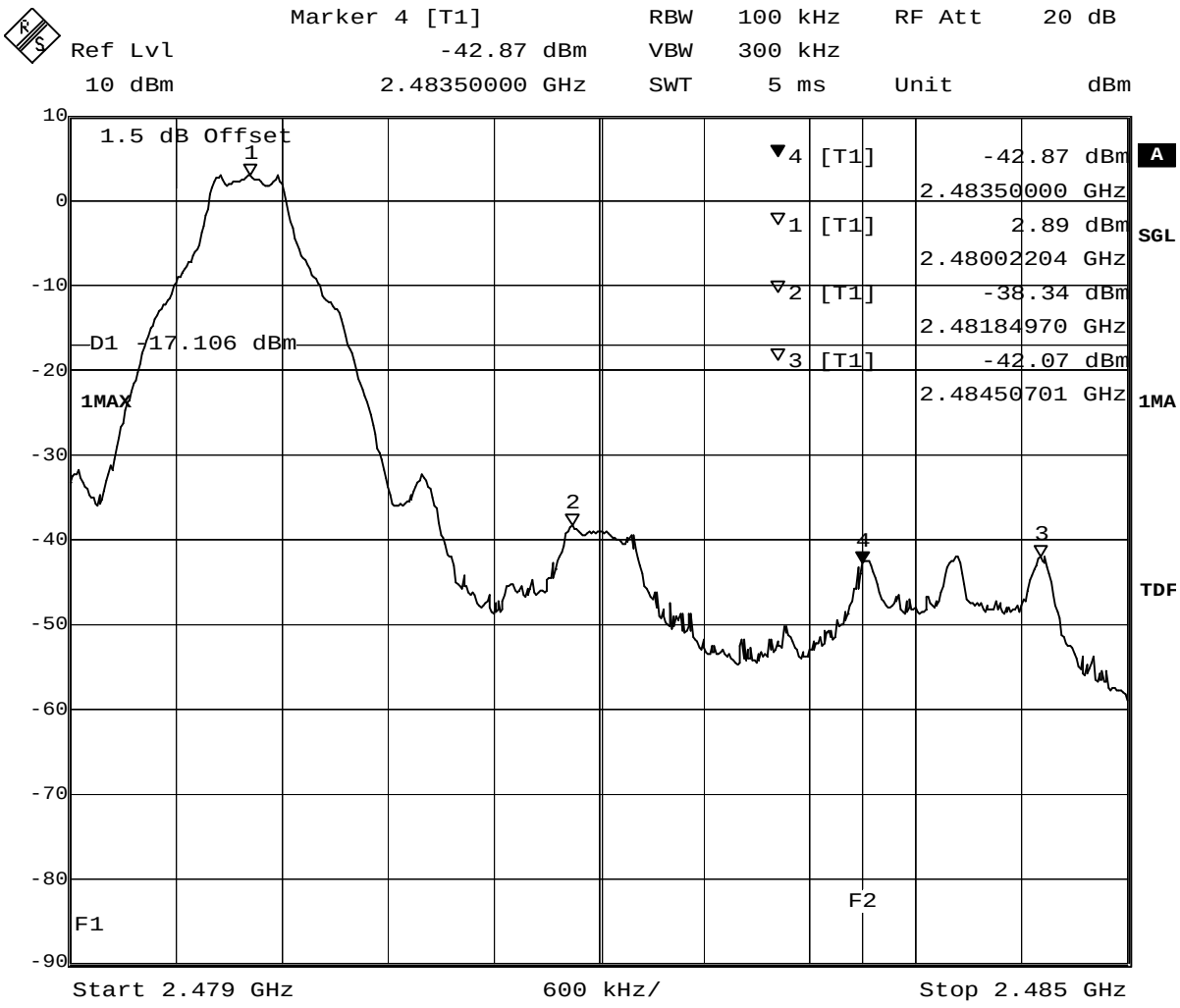
Title: spurious emissions
Comment A: CH M: 2441 MHz
Date: 18.FEB.2008 10:00:00

(spurious emissions measurement)

8.3.4 Band edge compliance conducted operating mode 3

Op. Mode

op-mode 3



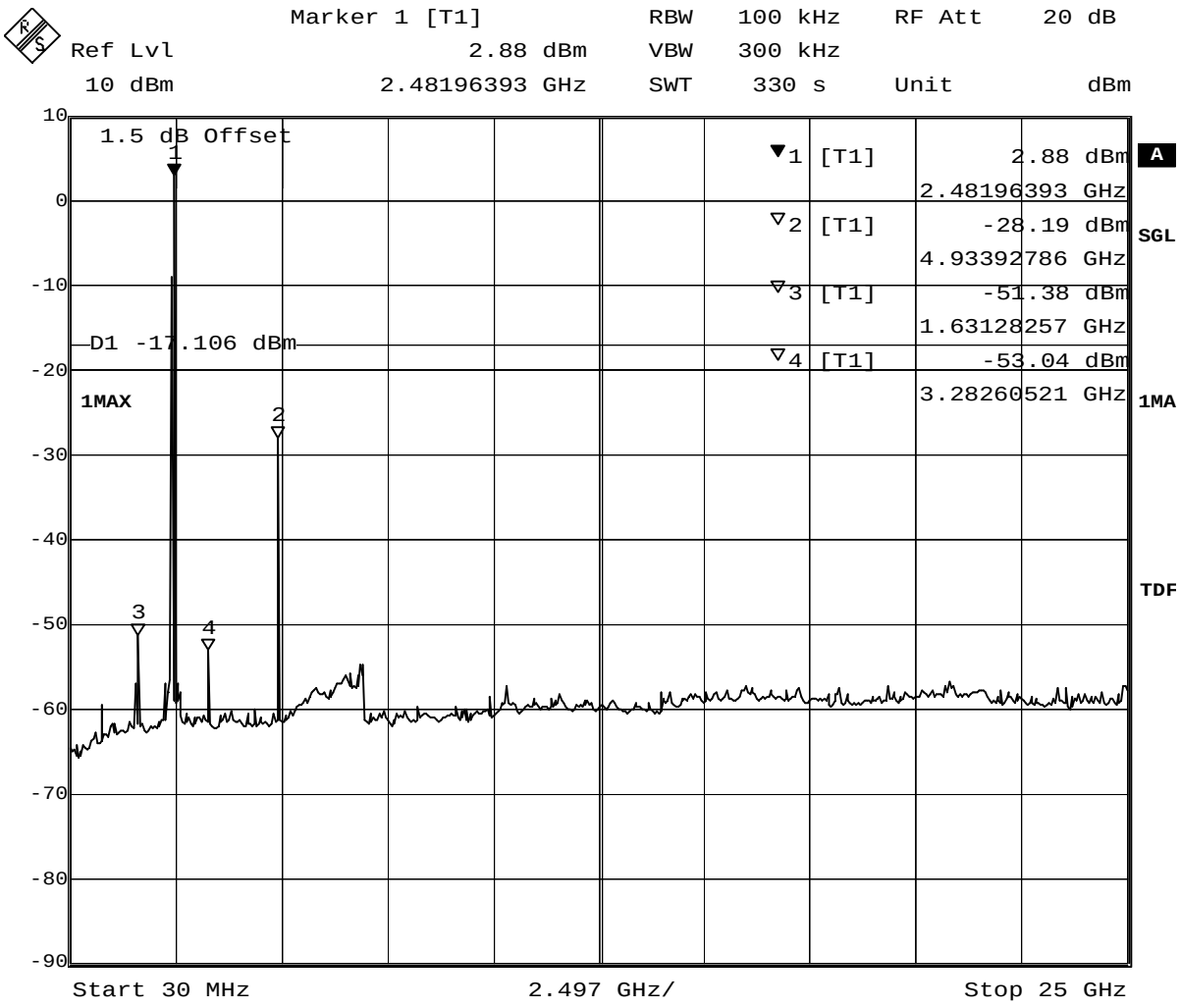
Title: Band Edge Compliance
Comment A: CH T: 2480 MHz
Date: 18.FEB.2008 09:04:15

(determination of reference value for spurious emissions measurement)

8.3.5 Spurious RF conducted emissions operating mode 3

Op. Mode

op-mode 3



Title: spurious emissions
Comment A: CH T: 2480 MHz
Date: 18.FEB.2008 09:15:54

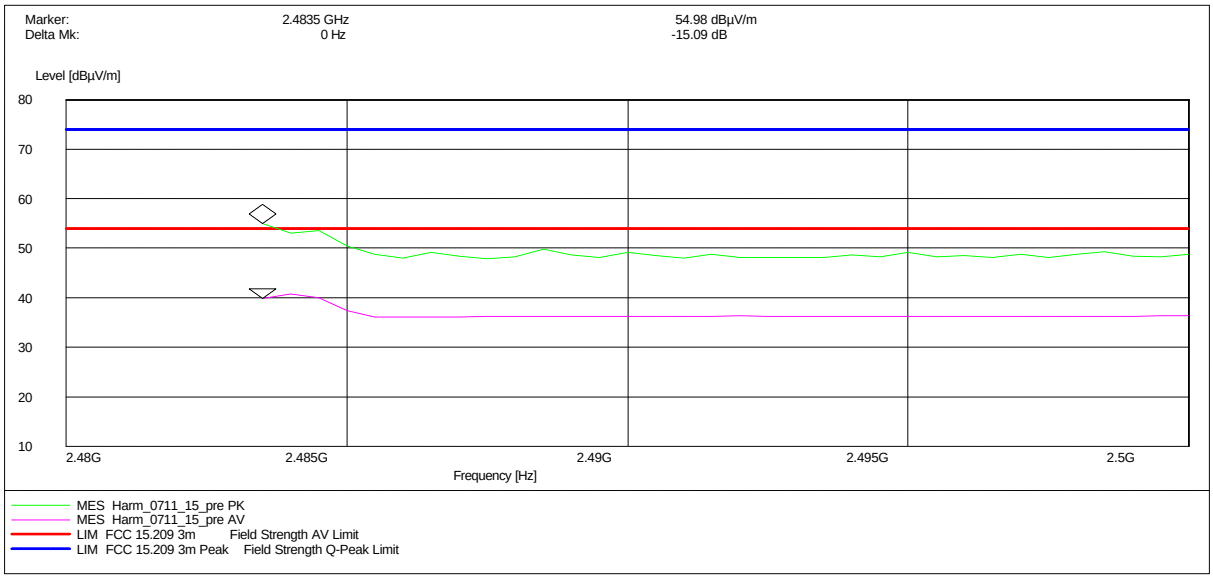
(spurious emissions measurement)

8.4 Band edge compliance radiated

Op. Mode

op-mode 3

Radiated measurement (higher band edge)

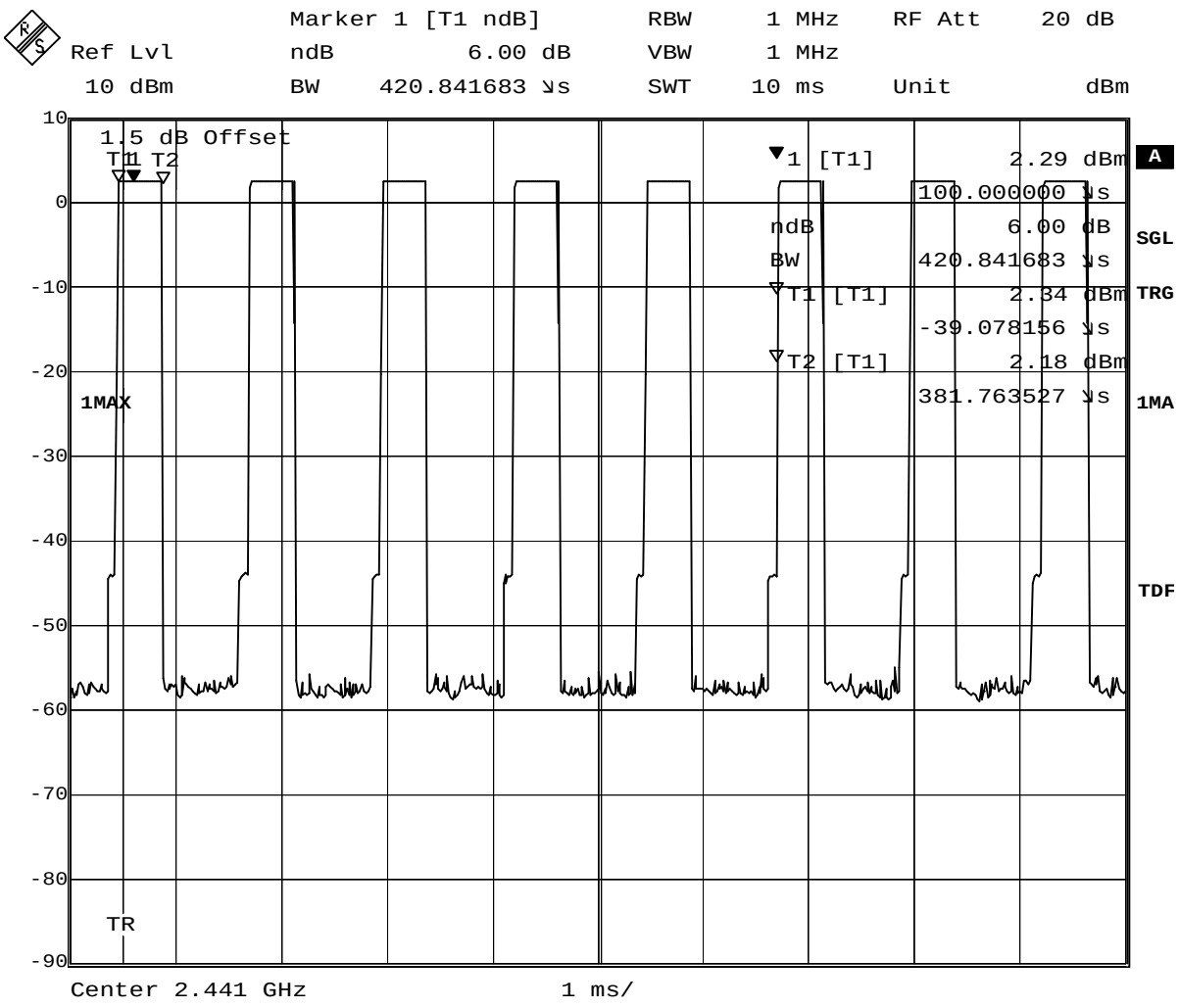


8.5 Dwell time

8.5.1 Dwell time operating mode 2 (DH1)

Op. Mode

op-mode 2 Time slot measurement of a DH1 packet

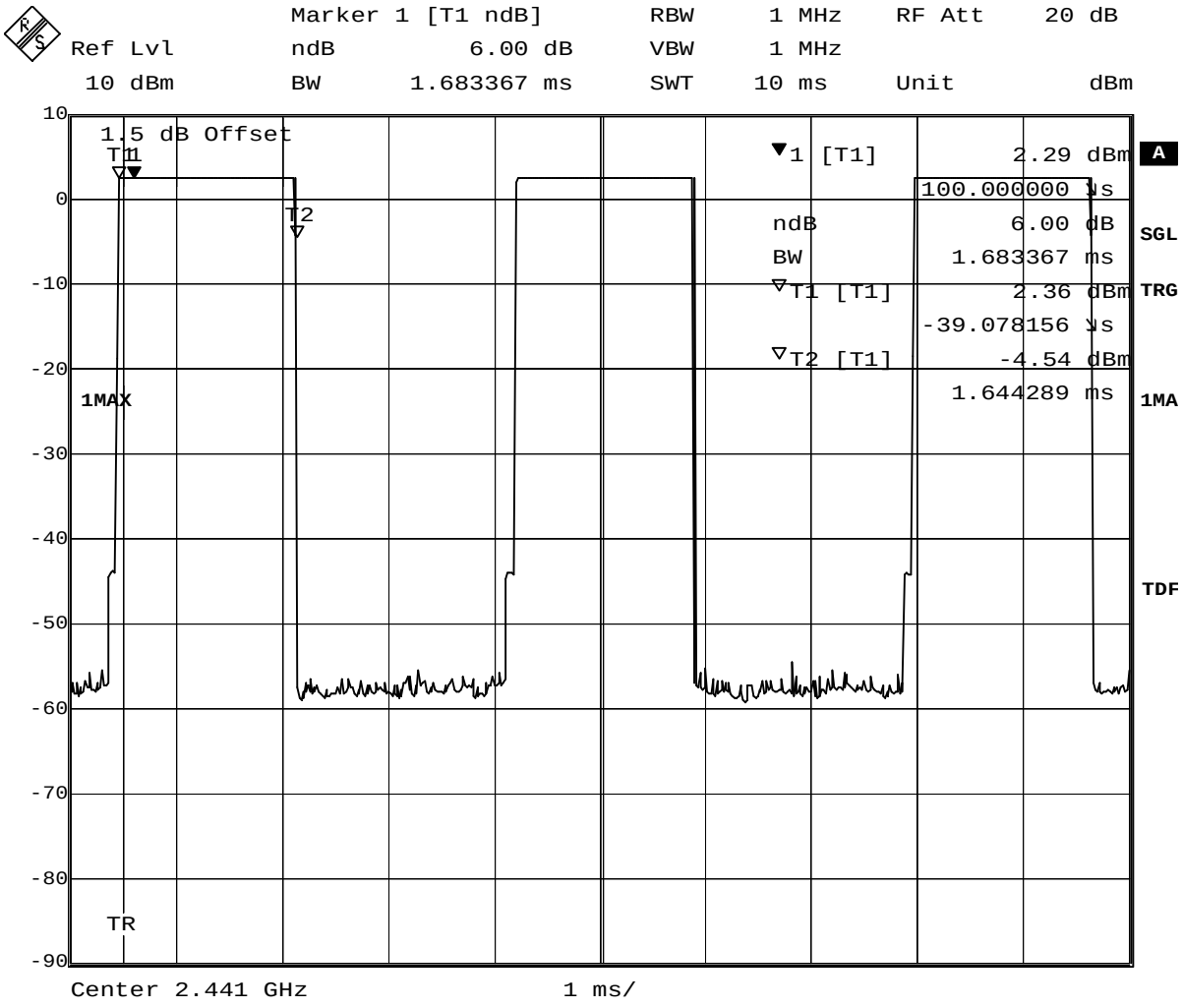


Title: Dwell time
Comment A: CH M: 2441 MHz
Date: 26.FEB.2008 13:49:33

8.5.2 Dwell time operating mode 2 (DH3)

Op. Mode

op-mode 2 Time slot measurement of a DH3 packet

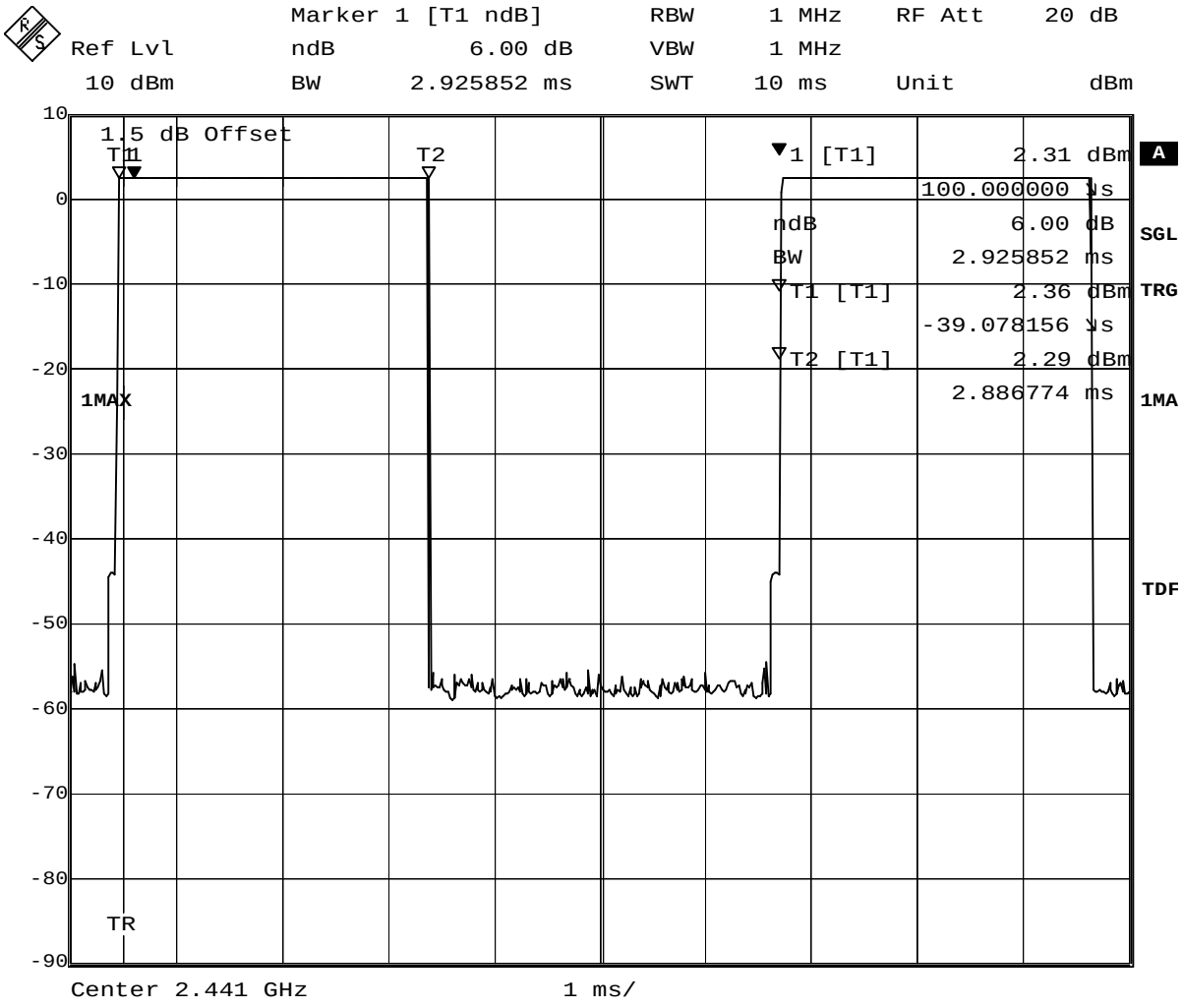


Title: Dwell time
Comment A: CH M: 2441 MHz
Date: 26.FEB.2008 13:53:23

8.5.3 Dwell time operating mode 2 (DH5)

Op. Mode

op-mode 2 Time slot measurement of a DH5 packet

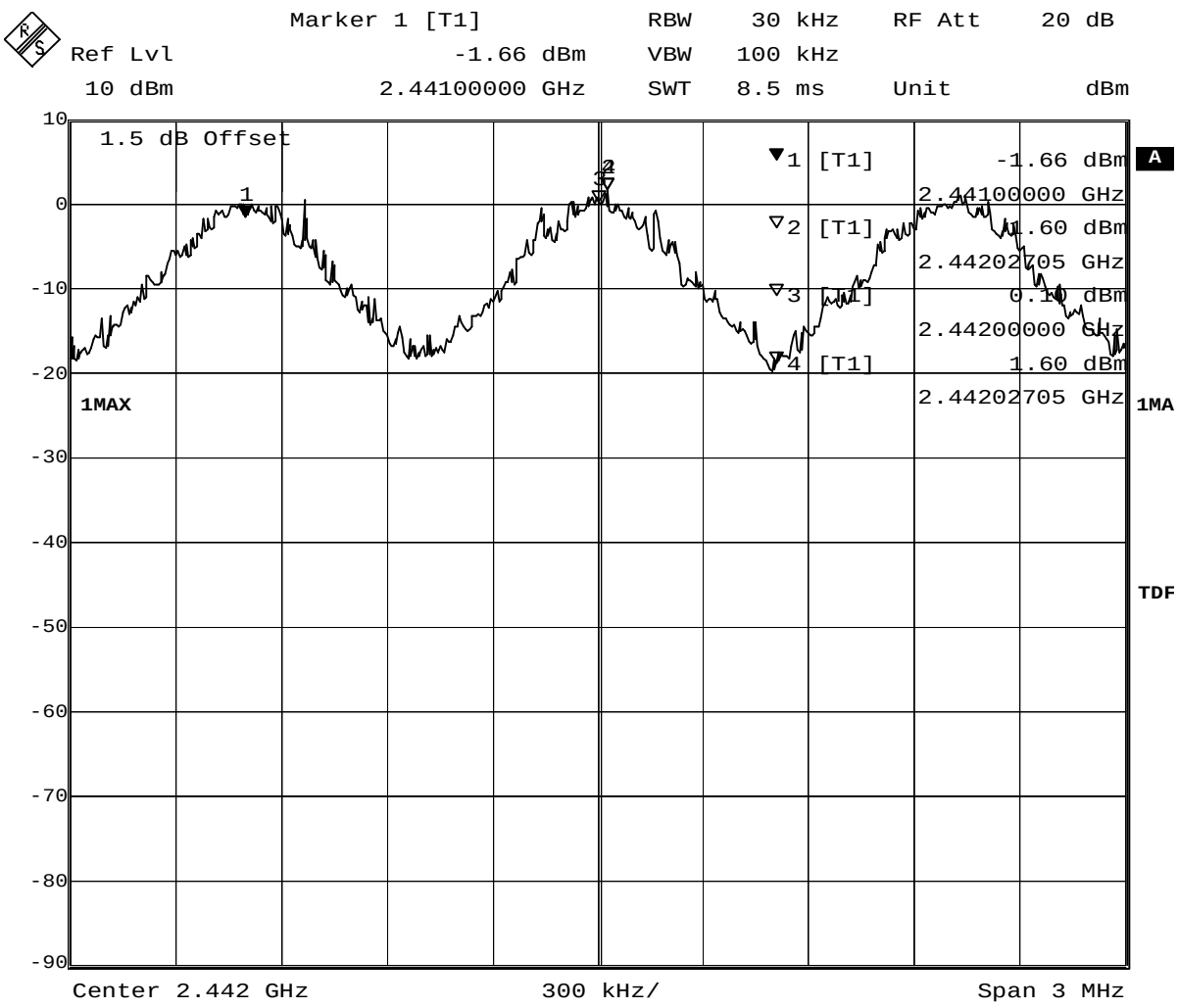


Title: Dwell time
Comment A: CH M: 2441 MHz
Date: 26.FEB.2008 13:55:14

8.6 Channel separation

Op. Mode

op-mode 4

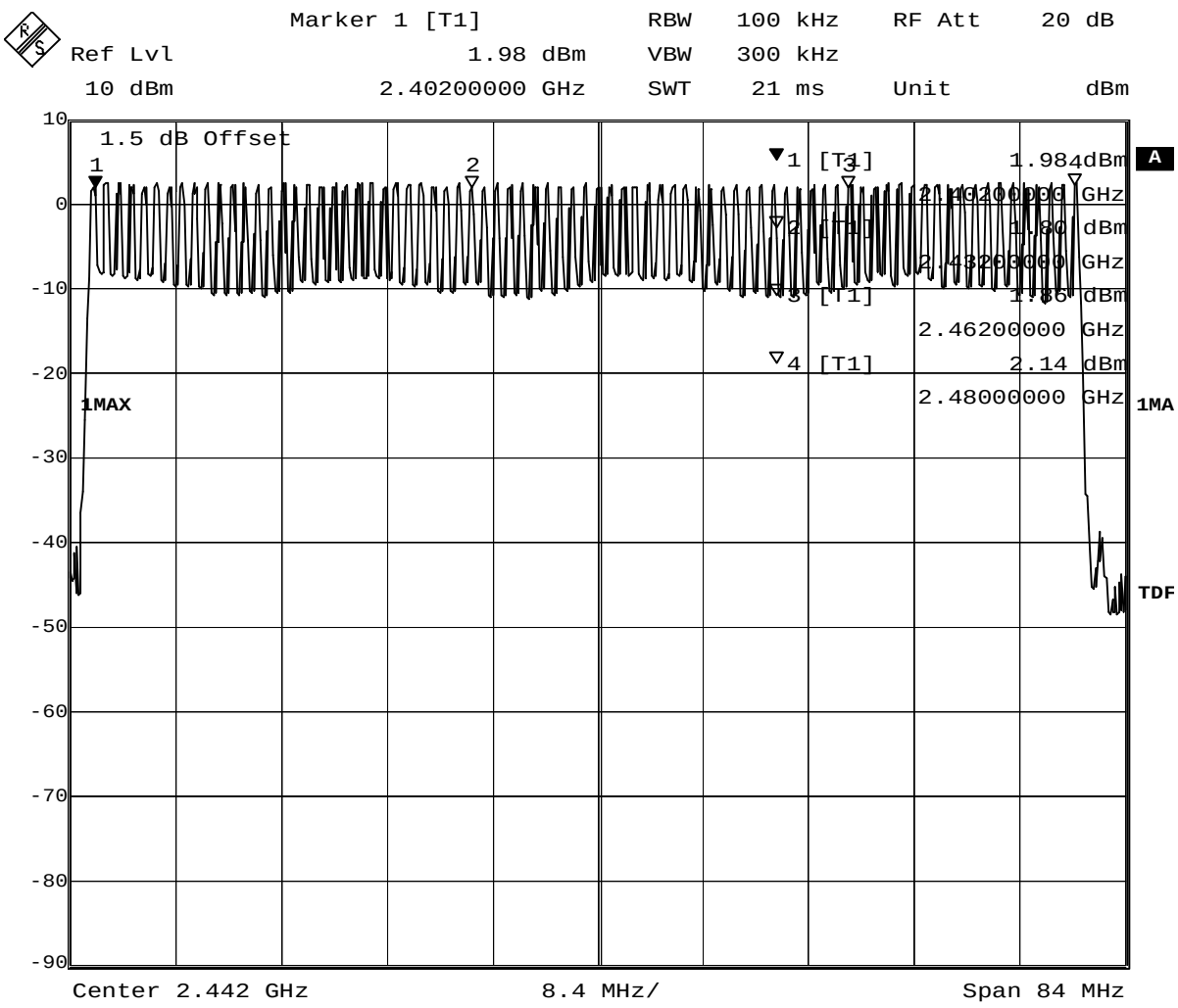


Title: Number of hopping frequencies
Comment A: CH H: Hopping
Date: 18.FEB.2008 10:22:17

8.7 Number of hopping frequencies

Op. Mode

op-mode 4



Title: Number of hopping frequencies
Comment A: CH H: Hopping
Date: 26.FEB.2008 13:00:20