

**Radio Test report**

**FOR**

**WIMAC Ltd**

**ON**

**GEN2 LEAF NODE**

**DOCUMENT NO. TTR-000920-W-US-09**

**HULL**

Unit E, South Orbital Trading Park, Hedon Road, Hull, HU9 1NJ, UK.  
**T** +44 (0)1482 801801 **F** +44 (0)1482 801806 **E** [test@tracglobal.com](mailto:test@tracglobal.com)  
[www.tracglobal.com](http://www.tracglobal.com)

**TRaC Radio Test Report** : TTR-000920-W-US-09

**Applicant** : Wimac Ltd

**Apparatus** : Gen 2 Leaf Node

**FCC ID** : YRUWMLN-915

*K J Anderson*

**Authorised by** :

: K J Anderson, Authorised signatory

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**Section 1:**

**Introduction**

**1.1 General**

This report contains an assessment of an apparatus against Electromagnetic Compatibility Standards based upon tests carried out on samples submitted to the Laboratory.

Tests performed by: S Hodgkinson, Radio Test Engineer

TRaC Global  
Unit 1, Pendle Place  
Skelmersdale,  
West Lancs,  
WN8 9PN, UK

Telephone: +44 (0) 1695 556666  
Fax: +44 (0) 1695 577077

Email: [test@tracglobal.com](mailto:test@tracglobal.com)  
Web site: <http://www.tracglobal.com>

Tests performed by: S Hodgkinson, Radio Test Engineer

Report author: S Hodgkinson, Radio Test Engineer

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## **1.2 Tests Requested By**

This testing in this report was requested by :

Wimac Ltd  
Unit 5  
Westland Road  
Leeds  
West Yorkshire  
LS11 5XA

## **1.3 Manufacturer**

Wimac Ltd  
Unit 5  
Westland Road  
Leeds  
West Yorkshire  
LS11 5XA

## **1.4 Apparatus Assessed**

The following apparatus was assessed between: 8<sup>th</sup> – 28<sup>th</sup> September 2011

The GEN2 Leaf Node makes use of the Radio Band 902.0MHz – 928.0MHz

The GEN2 Leaf Node uses Frequency Hopping Spread Spectrum  
and employs the use of 64 channels from channel 0 = 905.2MHz – Channel 63 = 915.91MHz

## 1.5 EXAMINATIONS REQUIRED

Full details of test results are contained within Appendix A. The following table summarises the assessment.

### EQUIPMENT TEST / EXAMINATIONS REQUIRED

TEST/EXAMINATION	RULE PART	DETECTOR	APPLICABILITY
Intentional Emission Frequency:	15.247	Peak	Yes
Intentional Emission Field Strength:	-	-	No
Intentional Emission Band Occupancy:	15.247(a)1	Peak	Yes
Intentional Emission EIRP (mW):	15.247(b)1	Peak	Yes
Spurious Emissions – Conducted:	15.207(a)	Peak Average	Yes
Spurious Emissions – Conducted:	15.247	Peak	Yes
Spurious Emissions – Radiated <1000MHz:	15.209 ,15.247	Quasi Peak	Yes
Spurious Emissions – Radiated >1000MHz:	15.247 15.209	Peak average	Yes
Transmitter Carrier Frequency Separation:	15.247(a)(1)	Peak	Yes
Transmitter Maximum Peak Power Output Power:	15.247(b)(1)	Peak	Yes
Transmitter Band Edge Conducted Emissions:	15.247(c)	Peak	Yes
Transmitter Band Edge Radiated Emission:	15.247(c)	Peak	Yes
Extrapolation Factor:	15.31(f)	-	No
Maximum Frequency of Search:	15.33	-	Yes
Antenna Arrangements Integral:	15.203	-	Yes
Antenna Arrangements External Connector:	15.204	-	No
Restricted Bands:	15.205	-	Yes

Mod : Modification  
 CFR : Code of Federal Regulations  
 REFE : Radiated Electric Field Emissions

ANSI : American National Standards Institution  
 PLCE : Power Line Conducted Emissions

## **1.6 Notes relating to the assessment**

With regard to this assessment, the following points should be noted:

The results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

The apparatus was set up and exercised using the configurations, modes of operation and arrangements defined in this report only.

Particular operating modes, apparatus monitoring methods and performance criteria required by the standards tested to have been performed except where identified in Section 1.7 of this test report (Deviations from Test Standards).

For emissions testing, throughout this test report, "Pass" indicates that the results for the sample as tested were below the specified limit (refer also to Section 2, Measurement Uncertainty).

Where relevant, the apparatus was only assessed using the monitoring methods and susceptibility criteria defined in this report.

All testing with the exception of testing at the Open Area Test Site was performed under the following environmental conditions:

Temperature	: 20 to 25 °C
Humidity	: 48 to 55 %

All dates used in this report are in the format dd/mm/yy.

## **1.7 Deviations from Test Standards**

There were no deviations from the standards tested to.

**Section 2:****Measurement Uncertainty****2.1 Measurement Uncertainty Values**

The following page contains the measurement uncertainties for measurements

*All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95% confidence where no required test level exists.*

**[1] Adjacent Channel Power**

Uncertainty in test result = **1.86dB**

**[2] Carrier Power**

Uncertainty in test result (Equipment - TRLUH120) = **2.18dB**

Uncertainty in test result (Equipment – TRL05) = **1.08dB**

Uncertainty in test result (Equipment – TRL479) = **2.48dB**

**[3] Effective Radiated Power**

Uncertainty in test result = **4.71dB**

**[4] Spurious Emissions**

Uncertainty in test result = **4.75dB**

**[5] Maximum frequency error**

Uncertainty in test result (Equipment - TRLUH120) = **119ppm**

Uncertainty in test result (Equipment – TRL05) = **0.113ppm**

Uncertainty in test result (Equipment – TRL479) = **0.265ppm**

**[6] Radiated Emissions, field strength OATS 14kHz-18GHz Electric Field**

Uncertainty in test result (14kHz – 30MHz) = **4.8dB**,

Uncertainty in test result (30MHz – 1GHz) = **4.6dB**,

Uncertainty in test result (1GHz-18GHz) = **4.7dB**

**[7] Frequency deviation**

Uncertainty in test result = **3.2%**

**[8] Magnetic Field Emissions**

Uncertainty in test result = **2.3dB**

**[9] Conducted Spurious**

Uncertainty in test result (Equipment TRL479) Up to 8.1GHz = **3.31dB**

Uncertainty in test result (Equipment TRL479) 8.1GHz – 15.3GHz = **4.43dB**

Uncertainty in test result (Equipment TRL479) 15.3GHz – 21GHz = **5.34dB**

Uncertainty in test result (Equipment TRLUH120) Up to 26GHz = **3.14dB**

**[10] Channel Bandwidth**

Uncertainty in test result = **15.5%**

**[11] Amplitude and Time Measurement – Oscilloscope**

Uncertainty in overall test level = **2.1dB**, Uncertainty in time measurement = **0.59%**, Uncertainty in Amplitude measurement = **0.82%**

**[11] Power Line Conduction**

Uncertainty in test result = **3.4dB**

**[12] Spectrum Mask Measurements**

Uncertainty in test result = **2.59% (frequency)**  
Uncertainty in test result = **1.32dB (amplitude)**

**[13] Adjacent Sub Band Selectivity**

Uncertainty in test result = **1.24dB**

**[14] Receiver Blocking – Listen Mode, Radiated**

Uncertainty in test result = **3.42dB**

**[15] Receiver Blocking – Talk Mode, Radiated**

Uncertainty in test result = **3.36dB**

**[16] Receiver Blocking – Talk Mode, Conducted**

Uncertainty in test result = **1.24dB**

**[17] Receiver Threshold**

Uncertainty in test result = **3.23dB**

**[18] Transmission Time Measurement**

Uncertainty in test result = **7.98%**

**Section 3:**

**Modifications**

**3.1 Modifications Performed During Assessment**

No modifications were performed during the assessment

**Appendix A:****Formal Emission Test Results**

Abbreviations used in the tables in this appendix:

Spec	: Specification	ALSR	: Absorber Lined Screened Room
Mod	: Modification	OATS	: Open Area Test Site
EUT	: Equipment Under Test	ATS	: Alternative Test Site
SE	: Support Equipment		
		Ref	: Reference
		Freq	: Frequency
L	: Live Power Line	MD	: Measurement Distance
N	: Neutral Power Line	SD	: Spec Distance
E	: Earth Power Line	Pol	: Polarisation
Pk	: Peak Detector	H	: Horizontal Polarisation
QP	: Quasi-Peak Detector	V	: Vertical Polarisation
Av	: Average Detector	CDN	: Coupling & decoupling network

## A1 Conducted Fundamental Carrier Power

The EUT transmitting on its lowest channel centre and highest carrier frequency in turn.

Test Details:	
Regulation	CFR 47 Part 15 2011,Subpart (c) 15.247(b)(2)
Measurement standard	ANSI C63.10:2009
EUT sample number	S01
Modification state	0
SE in test environment	S02

Channel No	Channel Frequency (MHz)	Measured Peak Conducted Carrier Power (dBm)	Measured Peak Conducted Carrier Power (mW)	Limit (W)	Result
0	905.20	10.54dBm	11.32	1.0	Pass
31	910.47	6.51dBm	4.47		Pass
63	915.91	12.51dBm	17.82		Pass

Note: Channel 0 is the lowest operating frequency, and channel 63 is the highest operating frequency.

## A2 RF Antenna Conducted Spurious Emissions

Measurement of conducted spurious emissions at the antenna port was performed using a peak detector with the RBW set to 100kHz the VBW>RBW. Frequencies were scanned up through to the 10th harmonic with the EUT transmitting on its lowest, centre and highest carrier frequency in turn.

Test Details CH0/CH31/CH63	
Regulation	CFR 47 Part 15 2011 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.10:2009
Frequency range	30MHz to 10 GHz
EUT sample number	S01
Modification state	0
SE in test environment	S02

The worst case conducted emission measurements at the antenna port are listed below:

Ref No.	Measured Freq (MHz)	Det.	Is measured Frequency within the Restricted bands (Y/N)	Measured Peak Conducted power (RBW =100kHz) (dBuV)	15.247(d) Limit (dBuV)	Summary
<i>No significant emissions within 20 dB of the limit</i>						

### Notes:

1. The conducted emission limits as defined in CFR 47 Part 15.205(a) are based on a transmitted carrier level of 15.247(b). With the EUT transmitting on its lowest, centre and highest carrier frequencies in turn, emissions from the EUT are required to be 20 dB below the level of the highest fundamental as measured within a 100 kHz RBW in accordance with 15.247(d) using a peak detector.
2. The RBW = 100 kHz, Video bandwidth (VBW) > RBW and the radio spectrum was investigated up to the 10th harmonic in accordance 15.33 (a)(1).
3. The measurements at 902.0 MHz and 928.0 MHz were made to ensure band edge compliance.

The limit outside the restricted band in 100 kHz RBW is defined using the following formula in accordance with 15.247(d):

The limit in 100 kHz RBW = (Maximum Peak Conducted Carrier)-20dB

### A3 Radiated Electric Field Emissions Within The Restricted Band 15.205

Preliminary emission testing was performed using a peak detector with the RBW = 100kHz. The radiated electric field emission test applies to spurious emissions and harmonics that fall within the restricted bands listed in Section 15.205. The maximum permitted field strength is listed in Section 15.209. The EUT was set to transmit on its lowest, centre and highest carrier frequency in turn.

The following test site was used for final measurements as specified by the standard tested to :

10m open area test site :

3m alternative test site :

The effect of the EUT set-up on the measurements is summarised in note (c) below.

Test Details CH 0	
Regulation	CFR 47 Part 15 2011Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.10:2009
Frequency range	30MHz to 10 GHz
EUT sample number	S01
Modification state	0
SE in test environment	S02
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photograph 1 and 2

The worst case radiated emission measurements for spurious emissions and harmonics that fall within the restricted bands are listed below and designated with (r).

Note: For radiated emissions that fall within 30MHz -1GHz the required limits are as part 15.209. For other frequencies that do not fall into the restricted bands of operation that are  $\geq 1$  GHz the required Limit is 20dBc below the fundamental output power.

Ref No.	FREQ. (MHz)	MEAS Rx (dB $\mu$ V)	Detector	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	Hpf Filter Loss (dBm)	Duty cycle correction (dBm)	FIELD ST'GH (dB $\mu$ V/m)	( $\mu$ V/m)	LIMIT ( $\mu$ V/m)
1.	2717.94 r	55.36	Pk	1.2	29.10	35.50	1.30	N/A	51.46	374.11	5011Pk
2.	2717.94 r	49.92	Av	1.2	29.10	35.50	1.30	0.70	45.32	184.50	500Av
3.	3621.79 r	55.41	Pk	1.5	31.40	35.60	0.50	N/A	53.21	457.61	5011Pk
4.	3621.79 r	51.98	Av	1.5	31.40	35.60	0.50	0.70	49.08	284.44	500Av
5.	4525.64 r	57.84	Pk	1.5	32.30	35.70	0.50	N/A	56.44	663.74	5011Pk
6.	4525.64 r	55.40	Av	1.5	32.30	35.70	0.50	0.70	53.30	462.38	500Av
7.	5424.67 r	55.22	Pk	1.8	34.00	35.80	0.60	N/A	55.82	618.01	5011Pk
8.	5424.67 r	52.16	Av	1.8	34.00	35.80	0.60	0.70	52.06	400.00	500Av

**Radiated Electric Field Emissions Within The Restricted Band 15.205 continued:**

Preliminary emission testing was performed using a peak detector with the RBW = 100kHz. The radiated electric field emission test applies to spurious emissions and harmonics that fall within the restricted bands listed in Section 15.205. The maximum permitted field strength is listed in Section 15.209. The EUT was set to transmit on its lowest, centre and highest carrier frequency in turn.

The following test site was used for final measurements as specified by the standard tested to :

10m open area test site :

3m alternative test site :

The effect of the EUT set-up on the measurements is summarised in note (c) below.

Test Details CH31	
Regulation	CFR 47 Part 15 2011Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.10:2009
Frequency range	30MHz to 25 GHz
EUT sample number	S01
Modification state	0
SE in test environment	S02
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photograph 1 and 2

The worst case radiated emission measurements for spurious emissions and harmonics that fall within the restricted bands are listed below and designated with (r).

Note: For radiated emissions that fall within 30MHz -1GHz the required limits are as part 15.209. For other frequencies that do not fall into the restricted bands of operation that are  $\geq 1$  GHz the required Limit is 20dBc below the fundamental output power.

Ref No.	FREQ. (MHz)	MEAS Rx (dB $\mu$ V)	Detector	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	Hpf Filter Loss (dBm)	Duty cycle correction (dBm)	FIELD ST'GH (dB $\mu$ V/m)	( $\mu$ V/m)	LIMIT ( $\mu$ V/m)
1.	2733.97 r	54.70	Pk	1.2	29.10	35.50	1.00	N/A	50.50	334.96	5011Pk
2.	2733.97 r	49.83	Av	1.2	29.10	35.50	1.00	0.70	44.63	170.41	500Av
3.	3641.02 r	53.59	Pk	1.5	31.50	35.60	0.50	N/A	51.49	375.40	5011Pk
4.	3641.02 r	49.40	Av	1.5	31.50	35.60	0.50	0.70	46.60	213.79	500Av
5.	4554.48 r	55.39	Pk	1.5	32.30	35.70	0.50	N/A	53.99	500.61	5011Pk
6.	4554.48 r	52.59	Av	1.5	32.30	35.70	0.50	0.70	50.49	334.58	500Av
7.	5456.73 r	54.24	Pk	1.8	34.00	35.80	0.60	N/A	54.84	552.07	5011Pk
8.	5456.73 r	50.56	Av	1.8	34.00	35.80	0.60	0.70	50.46	333.42	500Av

### Radiated Electric Field Emissions Within The Restricted Band 15.205 continued:

Preliminary emission testing was performed using a peak detector with the RBW = 100kHz. The radiated electric field emission test applies to spurious emissions and harmonics that fall within the restricted bands listed in Section 15.205. The maximum permitted field strength is listed in Section 15.209. The EUT was set to transmit on its lowest, centre and highest carrier frequency in turn.

The following test site was used for final measurements as specified by the standard tested to :

10m open area test site :

3m alternative test site :

The effect of the EUT set-up on the measurements is summarised in note (c) below.

Test Details CH63	
Regulation	CFR 47 Part 15 2011 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.10:2009
Frequency range	30MHz to 25 GHz
EUT sample number	S01
Modification state	0
SE in test environment	S02
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photograph 1 and 2

The worst case radiated emission measurements for spurious emissions and harmonics that fall within the restricted bands are listed below and designated with (r).

Note: For radiated emissions that fall within 30MHz -1GHz the required limits are as part 15.209. For other frequencies that do not fall into the restricted bands of operation that are  $\geq 1$  GHz the required Limit is 20dBc below the fundamental output power.

Ref No.	FREQ. (MHz)	MEAS Rx (dB $\mu$ V)	Detector	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	Hpf Filter Loss (dBm)	Duty cycle correction (dBm)	FIELD ST'GH (dB $\mu$ V/m)	( $\mu$ V/m)	LIMIT ( $\mu$ V/m)
1.	2747.70r	54.99	Pk	1.2	29.10	35.50	1.00	N/A	49.69	305.14	5011Pk
2.	2747.70r	51.52	Av	1.2	29.10	35.50	1.00	0.70	46.52	211.83	500Av
3.	3663.66r	52.13	Pk	1.5	31.50	35.60	0.50	N/A	50.23	324.71	5011Pk
4.	3663.66r	46.10	Av	1.5	31.50	35.60	0.50	0.70	43.50	149.62	500Av
5.	4579.53r	54.96	Pk	1.5	32.30	35.70	0.50	N/A	53.66	481.94	5011Pk
6.	4579.53r	51.93	Av	1.5	32.30	35.70	0.50	0.70	49.93	313.69	500Av
7.	5495.49r	51.91	Pk	1.8	34.00	35.80	0.60	N/A	52.51	422.18	5011Pk
8.	5495.49r	47.43	Av	1.8	34.00	35.80	0.60	0.70	47.38	233.85	500Av

**Notes:**

- 1 Any testing performed below 30 MHz was performed using a magnetic loop antenna in accordance with ANSI C63.4: 2003 section 8.2.1.
- 2 In accordance with 15.35(b), above 1 GHz, emissions measured using a peak detector shall not exceed a level 20 dB above the average limit.
- 3 The measurements 928.0 MHz was made to ensure band edge compliance.
- 4 Demonstration of band edge compliance at 902.0MHz (which lies outside the restricted bands as defined in section CFR47Part 15.205(a) is contained in section A2, RF Antenna Conducted Spurious Emissions and Appendix B of this test report.
- 5 Testing was performed with the EUT orientated in three orthogonal planes and the maximum emissions level recorded. In addition, the EUT antenna was varied within its range of motion in order to maximise emissions.
- 6 For Frequencies Below 1 GHz, RBW= 100 kHz, testing was performed with CISPR16 compliant test receiver with QP detector. Above 1 GHz tests were performed using a spectrum analyser using the following settings:

Peak Detector	RBW= 1MHz, VBW $\geq$ RBW
Average Detector	RBW= 1MHz, VBW $\geq$ RBW

These settings as per ANSI C63.4 and DA 00-705.

- 7 In accordance with DA 00-705, the average level of the spurious radiated emission may be reduced by the duty cycle correction factor. If the dwell time per channel (refer to the measured channel occupancy time, section A7 of this test report) of the hopping signal is less than 100ms then the average measurement may be further adjusted by the duty cycle correction factor which is derived from

$$20\log_{10}\left(\frac{\text{dwell time}}{100ms}\right) = 20\log(92.19ms \div 100ms) = -0.70$$

The upper and lower frequency of the measurement range was decided according to CFR 47 Part 15:2011 Clause 15.33(a) and 15.33(a)(1).

Radiated emission limits (CFR 47 Part 15:2011 Clause 15.209) for emissions falling within the restricted bands defined in 15.205(a):

Frequency of emission (MHz)	Field strength $\mu$ V/m	Measurement Distance m	Field strength $\text{dB}\mu\text{V/m}$
0.009-0.490	2400/F(kHz)	300	67.6/F (kHz)
0.490-1.705	24000/F(kHz)	30	87.6/F (kHz)
1.705-30	30	30	29.5
30-88	100	3	40.0
88-216	150	3	43.5
216-960	200	3	46.0
Above 960	500	3	54.0

**Notes:**

- (a) Where results have been measured at one distance, and a signal level displayed at another, the results have been extrapolated using the following formula:

$$\text{Extrapolation (dB)} = 20 \log_{10} \left( \frac{\text{measurement distance}}{\text{specification distance}} \right)$$

The results displayed take into account applicable antenna factors and cable losses.

- (b) The levels may have been rounded for display purposes.
- (c) The following table summarises the effect of the EUT operating mode, internal configuration and arrangement of cables / samples on the measured emission levels :

	See (i)	See (ii)	See (iii)	See (iv)
Effect of EUT operating mode on emission levels	✓			
Effect of EUT internal configuration on emission levels	✓			
Effect of Position of EUT cables & samples on emission levels	✓			
(i) Parameter defined by standard and / or single possible, refer to Appendix D (ii) Parameter defined by client and / or single possible, refer to Appendix D (iii) Parameter had a negligible effect on emission levels, refer to Appendix D (iv) Worst case determined by initial measurement, refer to Appendix D				

**A4 Unintentional Radiated Electric Field Emissions - 15.109**

Preliminary scans were performed using a peak detector with the RBW = 100 kHz. The maximum permitted field strength is listed in Section 15.109. The EUT was set to receive mode only on its lowest, centre and highest carrier frequency in turn.

The following test site was used for final measurements as specified by the standard tested to:

3m open area test site :

3m alternative test site :

Test Details	
Regulation	CFR 47 Part 15 2011 Subpart (b) Clause 15.109
Measurement standard	ANSI C63.10:2009
Frequency range	30MHz to 10 GHz
EUT sample number	S01
Modification state	0
SE in test environment	N/A
SE isolated from EUT	N/A
EUT set up	Refer to Appendix C
Temperature	20 deg C
Photographs (Appendix F)	1, 2

Worse case results listed from bottom middle and top channels in receive mode.

Ref No.	FREQ. (MHz)	MEAS Rx (dB $\mu$ V)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	FIELD ST'GH (dB $\mu$ V/m)	EXTRAP FACT (dB)	FIELD ST'GH ( $\mu$ V/m)	LIMIT ( $\mu$ V/m)
1.	31.75	5.15	0.4	16.95	N/A	22.50	N/A	13.33	100
2.	33.05	7.53	0.4	16.27	N/A	24.20	N/A	16.34	100
3.	35.70	6.25	0.4	14.85	N/A	21.50	N/A	11.88	100
4.	43.65	16.19	0.4	10.61	N/A	27.20	N/A	22.90	100
5.	47.60	16.40	0.4	8.70	N/A	25.50	N/A	18.83	100
6.	56.00	22.30	0.4	5.90	N/A	28.60	N/A	26.91	100

## A5 Power Line Conducted Emissions

Previous power line conducted emission measurements were performed with a peak detector in a screened room.

The effect of the EUT set-up on the measurements is summarised in note (b).

Where applicable formal measurements of the emissions were performed with a peak, average and/or quasi peak detector. The EUT was set to transmit on its lowest, centre and highest carrier frequency in turn. The formal measurements are detailed below:

Test Details: Unit in Rx mode hopping all channels	
Regulation	CFR 47 Part 15 2011 Subpart (c) Clause 15.207
Measurement standard	ANSI C63.10:2009
Frequency range	150kHz to 30MHz
EUT sample number	S01
Modification state	0
SE in test environment	S02
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photograph 3

The worst case was with the supply voltage set at 305Vac

The worst-case power line conducted emission measurements are listed below:

Ref No.	Freq (MHz)	Conductor	Result (dBuV)	Detector	Spec Limit (dBuV)	Margin (dB)	Result
1	0.150	Live	59.48	QP	66.00	6.52	Pass
2	0.190	Live	51.89	QP	64.04	12.15	Pass
3	0.205	Live	49.57	QP	63.41	13.84	Pass
4	0.230	Live	45.04	QP	62.45	17.41	Pass
5	0.260	Live	43.29	QP	61.43	18.14	Pass
6	0.285	Live	42.37	QP	60.67	18.30	Pass
7	0.305	Live	41.76	QP	60.11	18.35	Pass
8	0.330	Live	40.48	QP	59.45	18.97	Pass
9	0.355	Live	38.87	QP	58.84	19.97	Pass

**Specification limits:**

Conducted emission limits (CFR 47 Part 15 2011:Clause 15.207).

Conducted disturbance at the mains ports.

Frequency range MHz	Limits dB $\mu$ V	
	Quasi-peak	Average
0.15 to 0.5	66 to 56 <sup>2</sup>	56 to 46 <sup>2</sup>
0.5 to 5	56	46
5 to 30	60	50

Notes:

1. The lower limit shall apply at the transition frequency.
2. The limit decreases linearly with the logarithm of the frequency in the range 0.15MHz to 0.5MHz.

Notes:

- (a) The levels may have been rounded for display purposes.
- (b) The following table summarises the effect of the EUT operating mode and internal configuration on the measured emission levels :

	See (i)	See (ii)	See (iii)	See (iv)
Effect of EUT operating mode on emission levels	✓			
Effect of EUT internal configuration on emission levels	✓			
(i) Parameter defined by standard and / or single possible, refer to Appendix C (ii) Parameter defined by client and / or single possible, refer to Appendix C (iii) Parameter had a negligible effect on emission levels, refer to Appendix C (iv) Worst case determined by initial measurement, refer to Appendix C				

## A6 20 dB Bandwidth and Channel Spacing

Title 47 of the CFR 47 Part 15 2011 Subpart (c) 15.247(a)(1)(i) requires the measurement of the bandwidth of the transmission between the -20 dB points on the transmitted spectrum. The results of this test determine the limits for channel spacing. The channel spacing shall be a minimum of 25 kHz or two-thirds of the 20 dB bandwidth, whichever is the greater. The formal measurements are detailed below:

Test Details:				
Regulation	CFR 47 Part 15 2011 Subpart (c) 15.247(a)(1)(i)			
EUT sample number	S01			
Modification state	0			
SE in test environment	S02			

905.20MHz	Fl (MHz)	Fh (MHz)	Measured 20 dB Bandwidth (MHz)	Result
	905.190448718	905.210961538	20.512kHz	Pass

910.47MHz	Fl (MHz)	Fh (MHz)	Measured 20 dB Bandwidth (MHz)	Result
	910.460544872	910.481057692	20.512kHz	Pass

915.91MHz	Fl (MHz)	Fh (MHz)	Measured 20 dB Bandwidth (MHz)	Result
	915.900544872	915.921057692	20.512kHz	Pass

Plots of the 20 dB bandwidth and channel spacing are contained in Appendix B of this test report.

## A7 Hopping frequencies

Hopping frequencies were verified using a spectrum analyser set to 80 MHz spans, displaying a set of the hopping channels in turn, while the EUT was operating in its normal frequency hopping mode.

Test Details:	
Regulation	CFR 47 Part 15 2011 Subpart (c) 15.247(a)(1)(i)
EUT sample number	S01
Modification state	0
SE in test environment	S02
SE isolated from EUT	None

No. of Hopping Channels	Requirement	Result
63	Minimum 50 channels shall be used	Pass

Plots showing the hopping channels are contained in Appendix B

## A8 Channel Occupancy

Channel occupancy time was verified using a spectrum analyser in zero span mode, centred on the highest output power whilst hopping, while the EUT was operating in its normal frequency hopping mode. The other channels were then verified to ensure that the channel occupancy was identical for all channels.

Test Details:	
Regulation	CFR 47 Part 15 2011 Subpart (c) 15.247(a)(1)
EUT sample number	S01
Modification state	0
SE in test environment	S02

Packet Width(ms)
92.193269

Plots showing the channel occupancy time are contained in Appendix B of this test report.

#### **A9      Antenna Gain**

The maximum antenna gain for the antenna types to be used with the EUT, as declared by the client, is 1.5 dBi.

**Appendix B:**

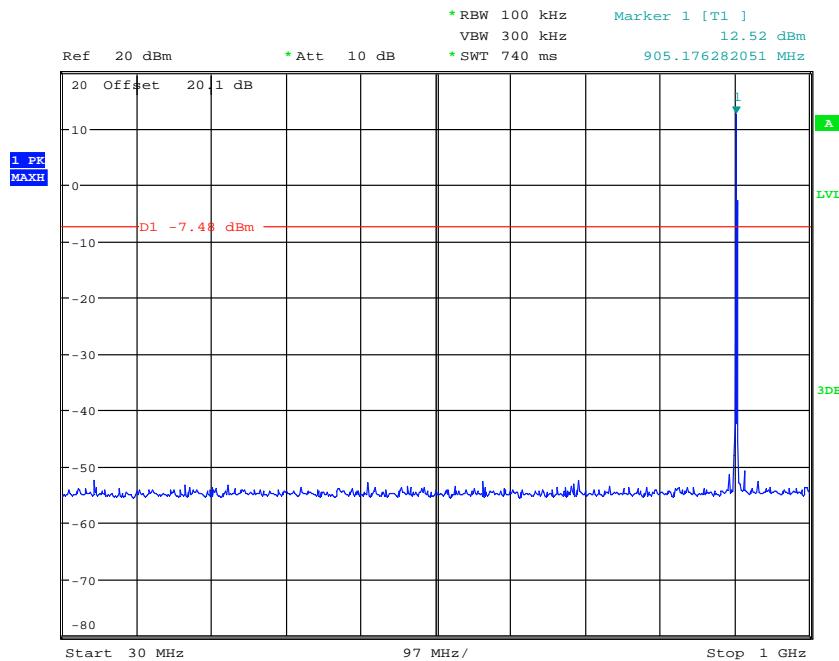
**Supporting Graphical Data**

This appendix contains graphical data obtained during testing.

Notes:

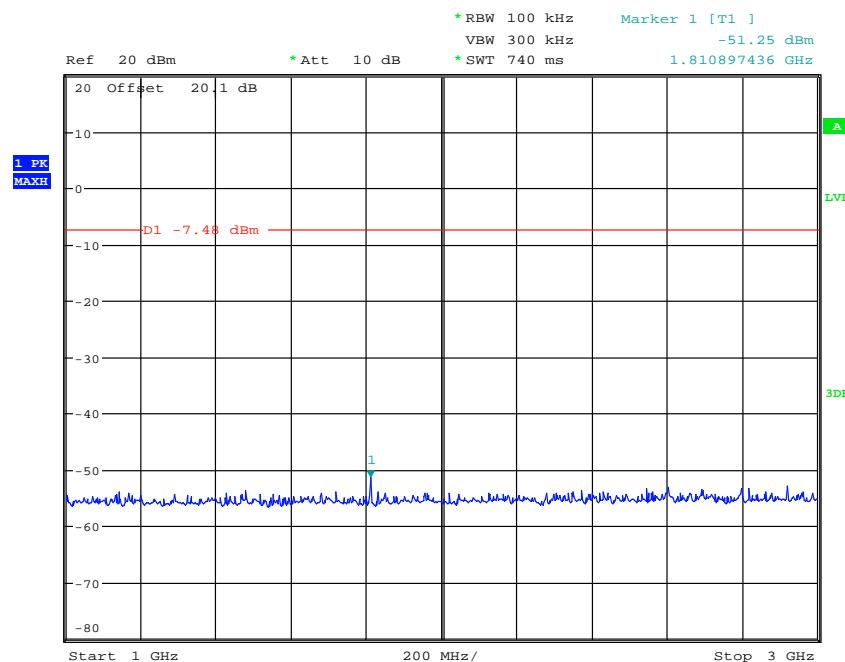
- (a) The radiated electric field emissions and conducted emissions graphical data in this appendix is preview data. For details of formal results, refer to Appendix A and Appendix B.

## Bottom Channel Conducted emissions 30MHz-1GHz



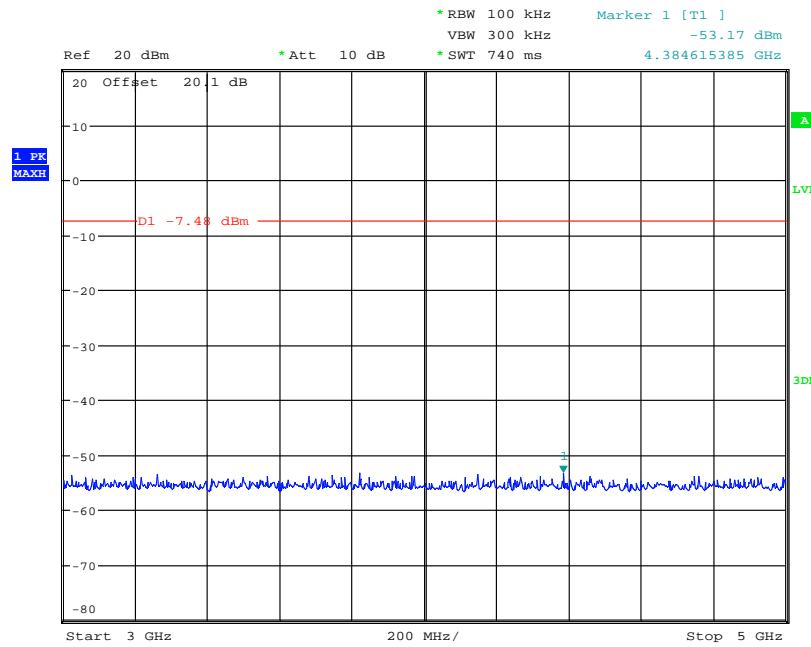
Date: 9.SEP.2011 10:01:26

## Bottom Channel Conducted emissions 1GHz – 3GHz



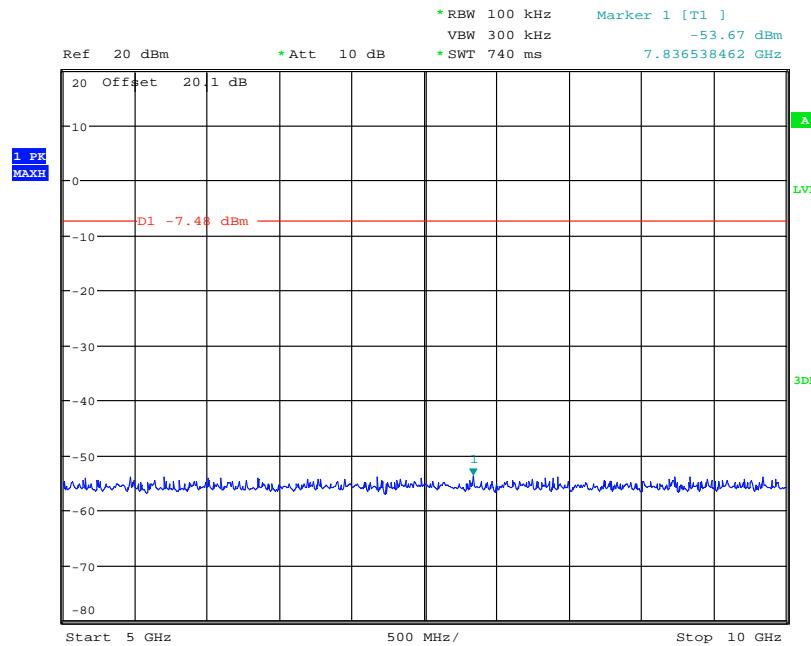
Date: 9.SEP.2011 10:02:02

## Bottom Channel Conducted emissions 3GHz – 5GHz



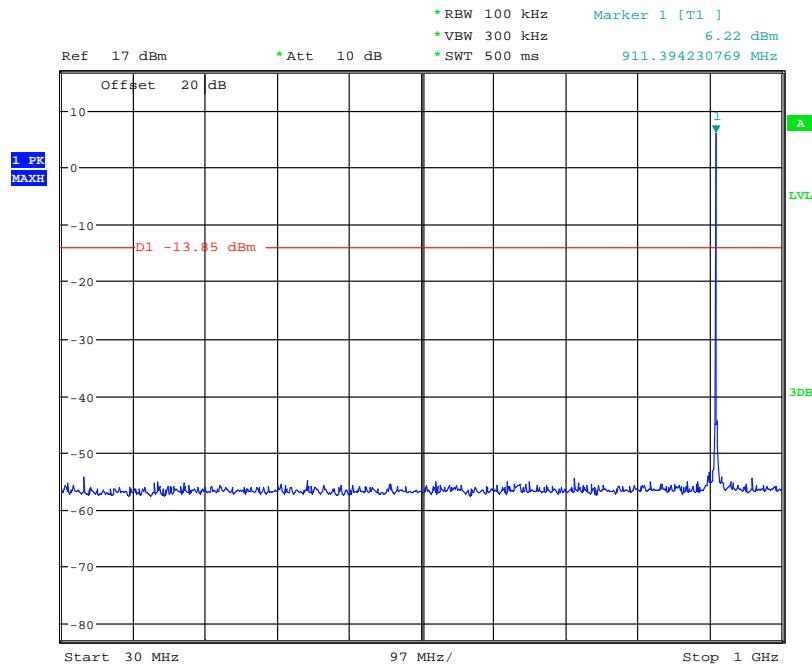
Date: 9.SEP.2011 10:02:27

## Bottom Channel Conducted emissions 5GHz -10GHz



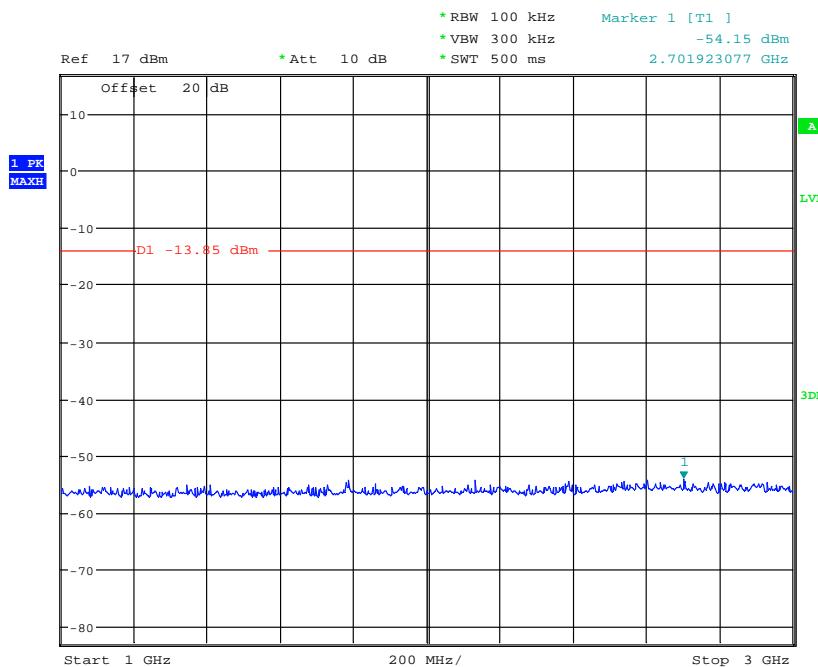
Date: 9.SEP.2011 10:03:29

## Middle Channel Conducted emissions 30MHz-1GHz



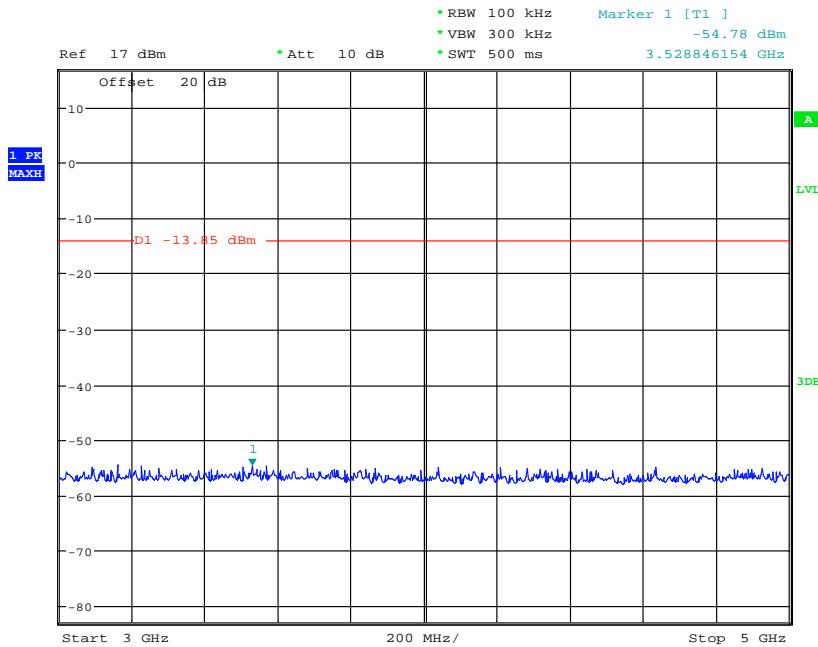
Date: 27.SEP.2011 12:44:44

## Middle Channel Conducted emissions 1GHz – 3GHz



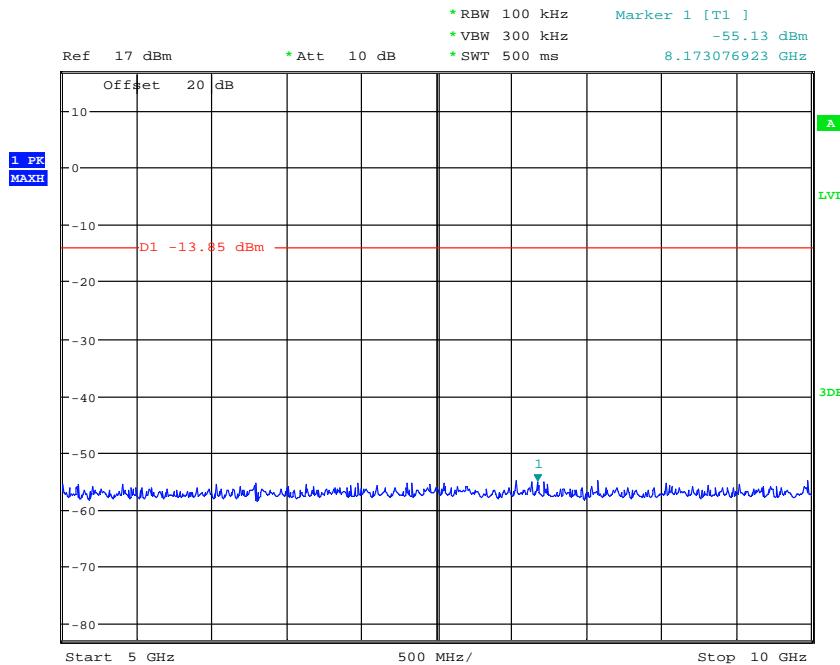
Date: 27.SEP.2011 12:46:19

## Middle Channel Conducted emissions 3GHz – 5GHz



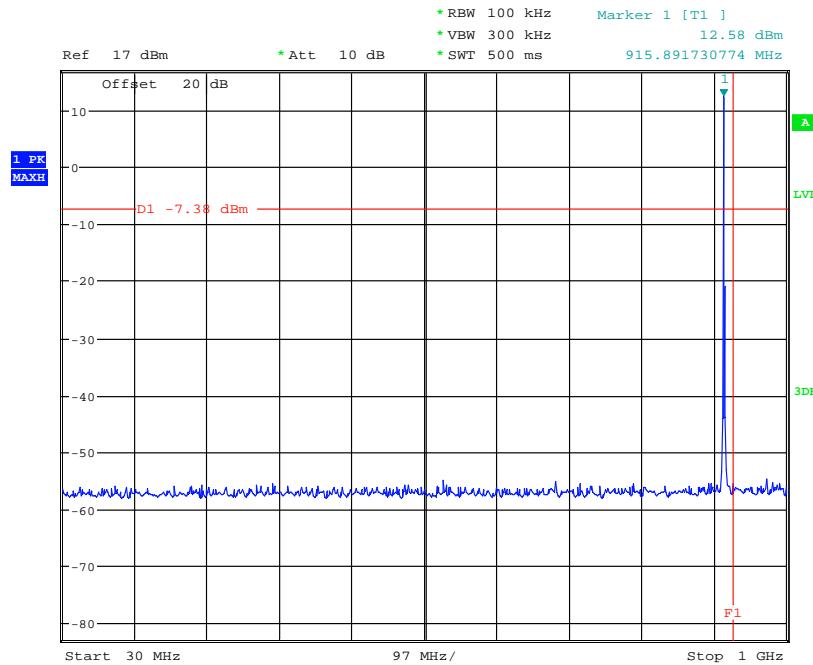
Date: 27.SEP.2011 12:46:48

## Middle Channel Conducted emissions 5GHz – 10GHz



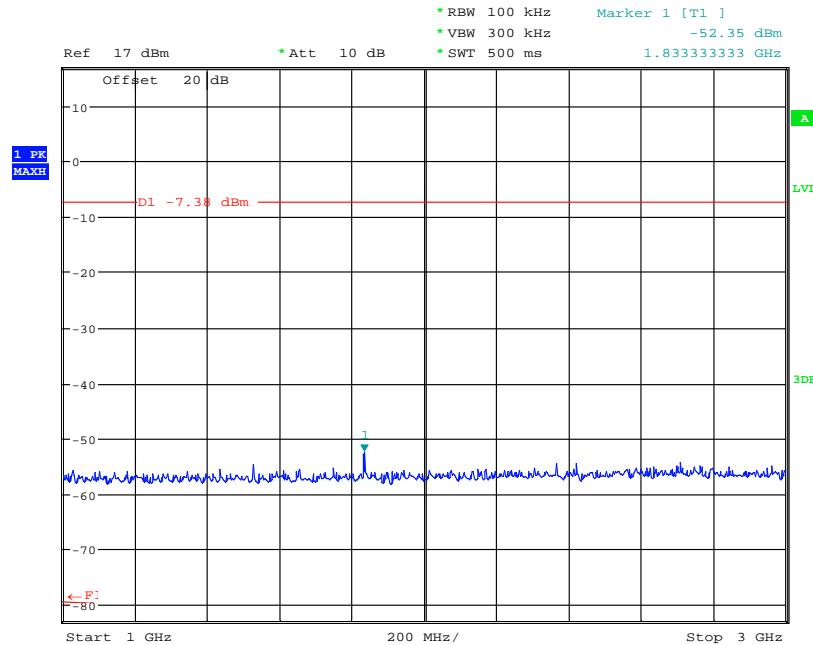
Date: 27.SEP.2011 12:47:21

## Top Channel Conducted emissions 30MHz-1GHz



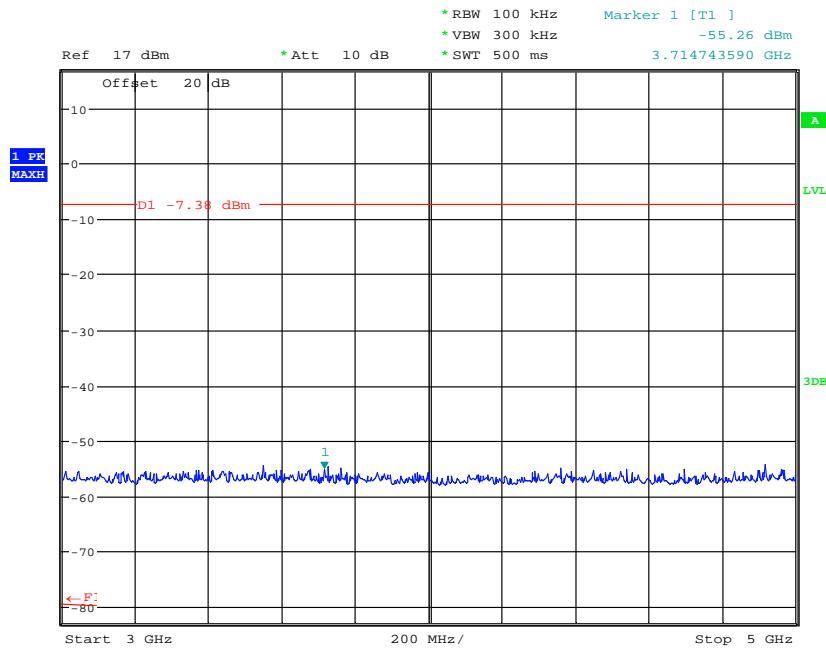
Date: 27.SEP.2011 12:39:36

## Top Channel Conducted emissions 1GHz – 3GHz



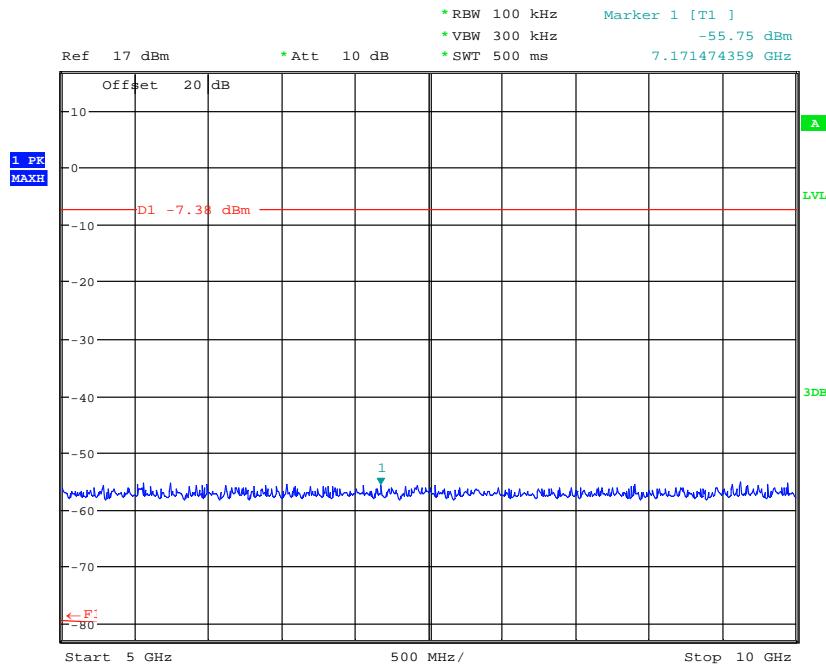
Date: 27.SEP.2011 12:40:03

## Top Channel Conducted emissions 3GHz – 5GHz



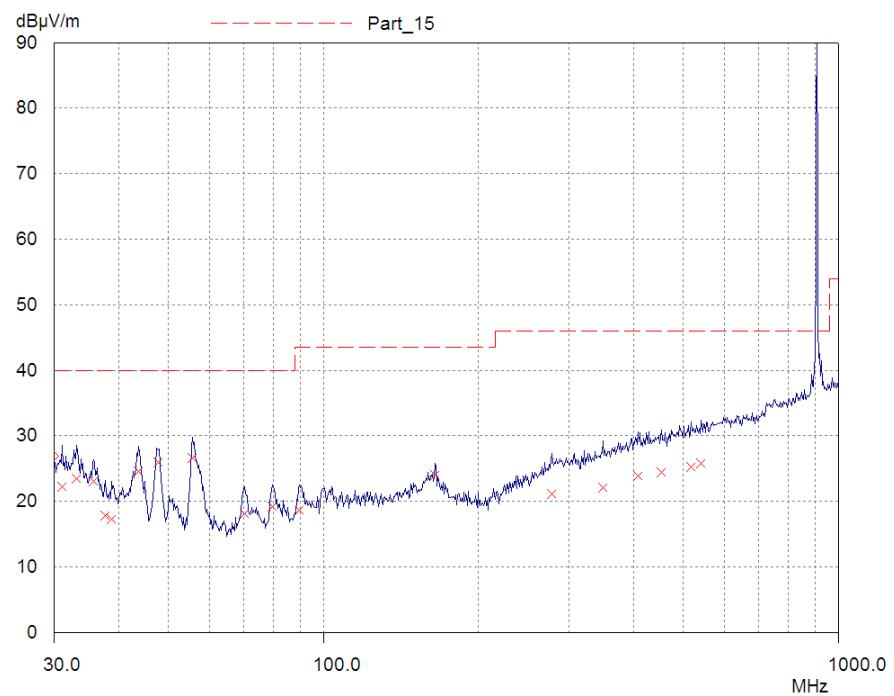
Date: 27.SEP.2011 12:40:29

## Top Channel Conducted emissions 5GHz – 10GHz

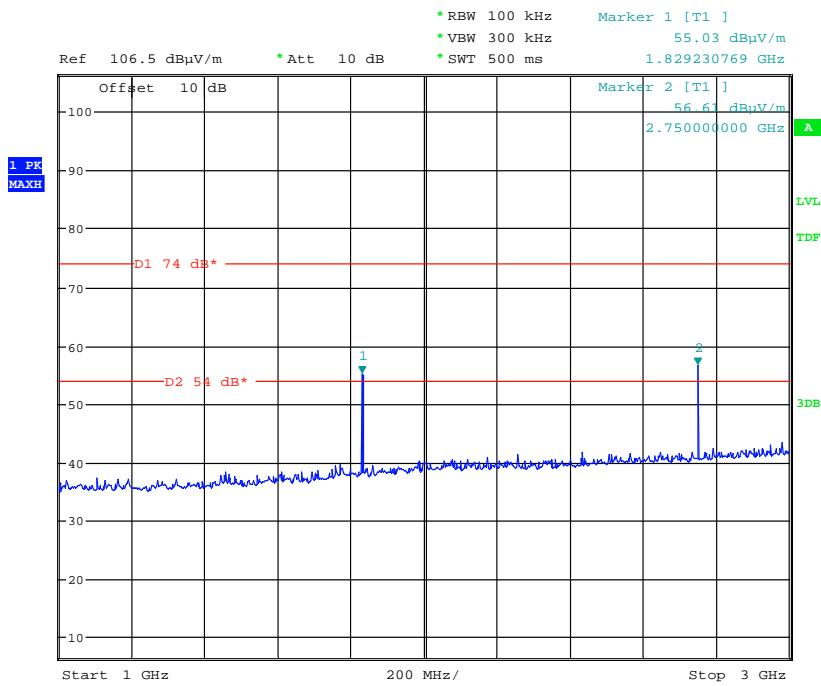


Date: 27.SEP.2011 12:41:00

## Bottom Channel Radiated emissions 30MHz-1GHz

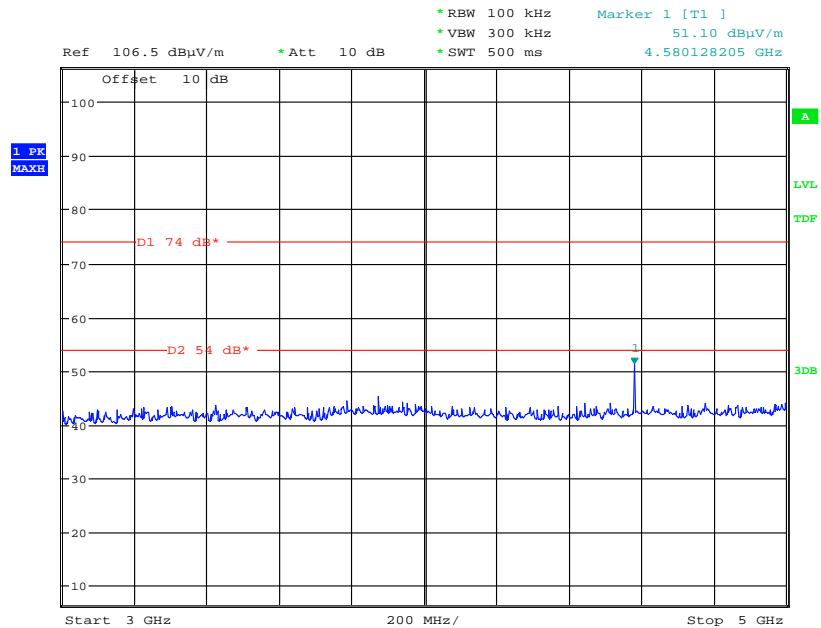


## Bottom Channel Radiated emissions Vertical 1GHz – 3GHz



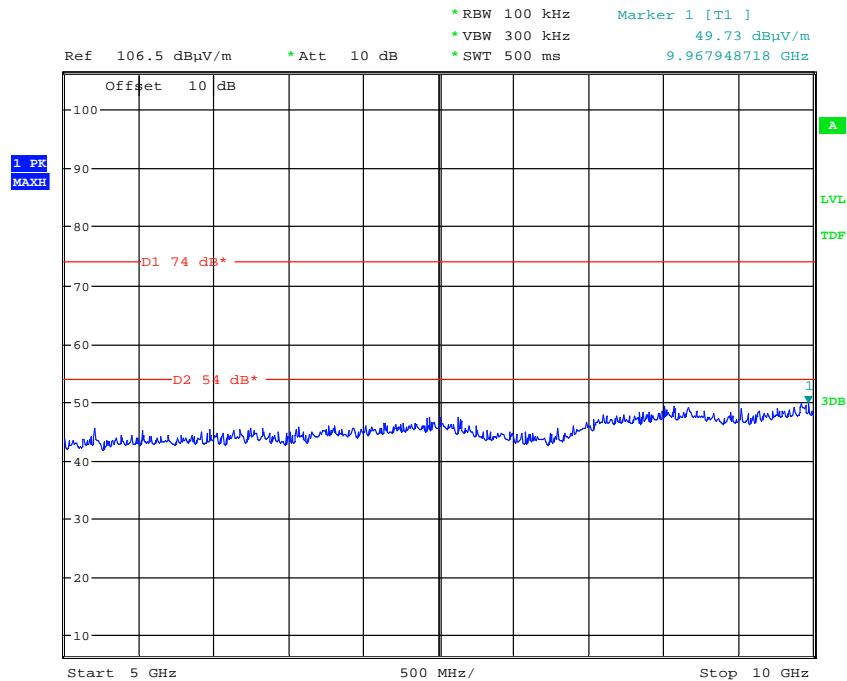
Date: 26.SEP.2011 11:15:39

## Bottom Channel Radiated emissions Vertical 3GHz – 5GHz



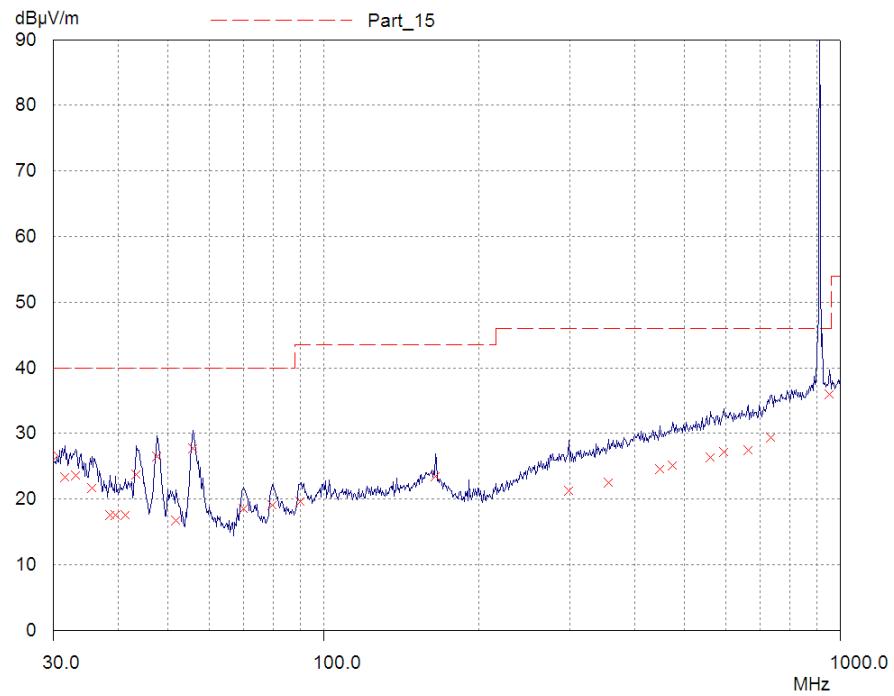
Date: 26.SEP.2011 11:16:12

## Bottom Channel Radiated emissions Vertical 5GHz – 10GHz

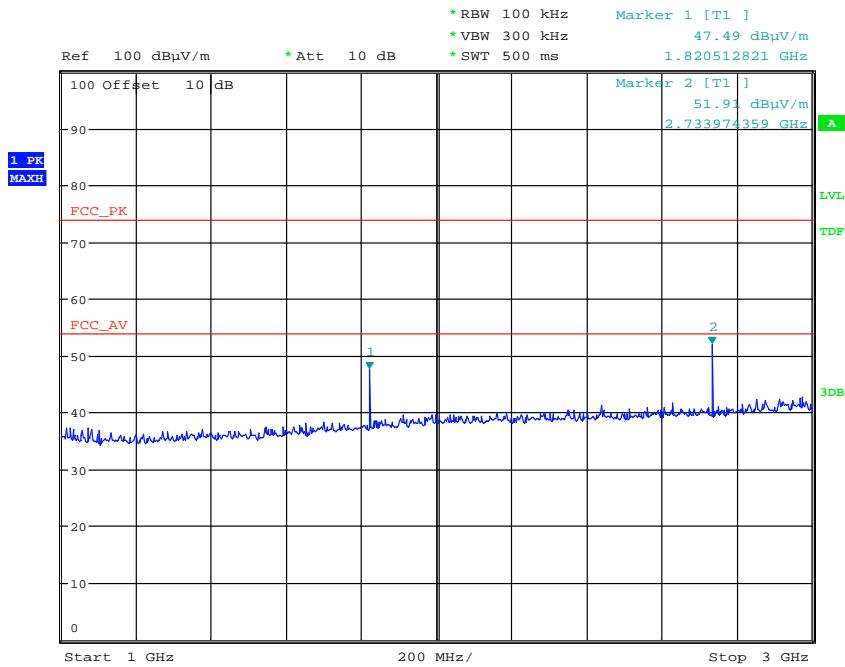


Date: 26.SEP.2011 11:16:39

## Middle Channel Radiated emissions Vertical 30MHz-1GHz

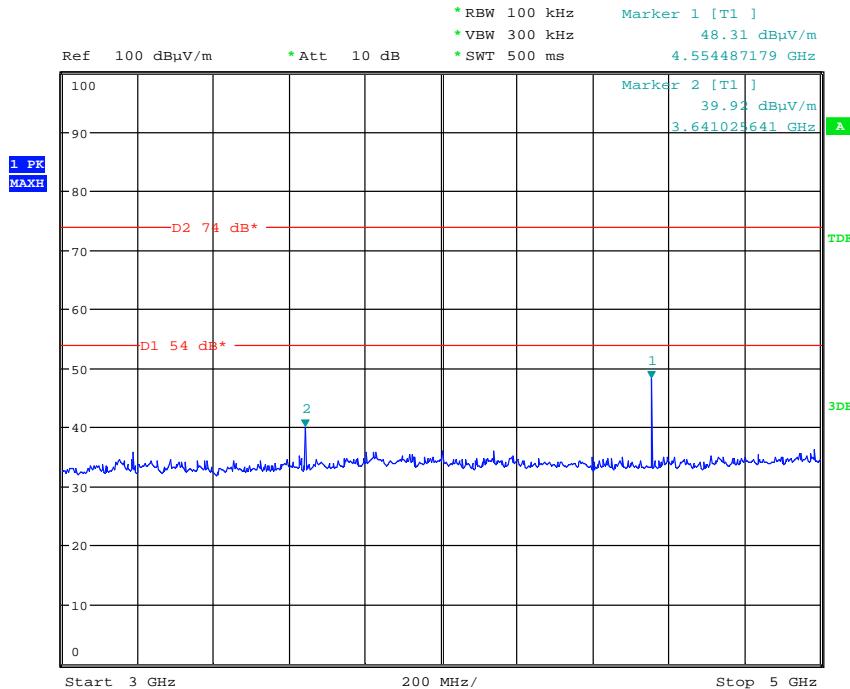


## Middle Channel Radiated emissions Vertical 1GHz – 3GHz



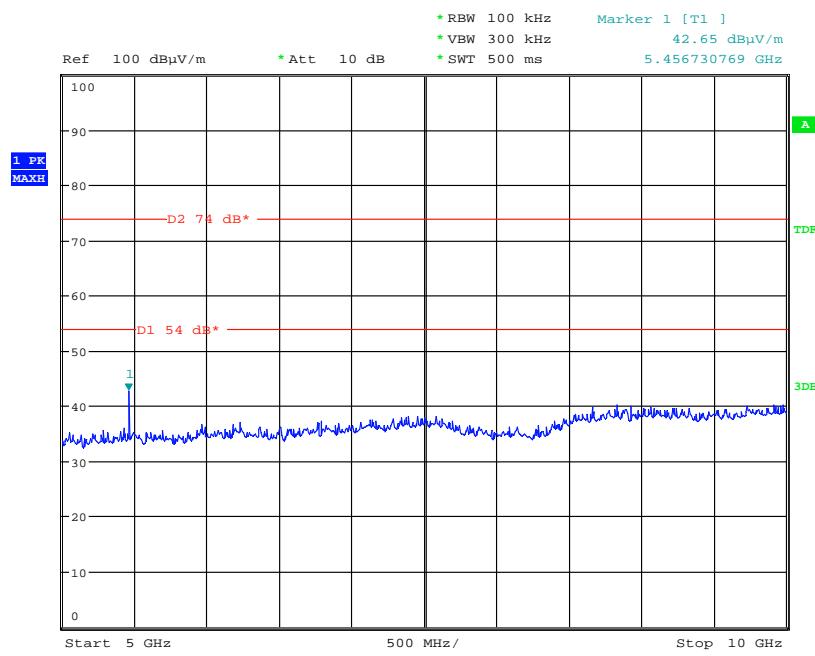
Date: 7.SEP.2011 11:38:06

## Middle Channel Radiated emissions Vertical 3GHz- 5GHz



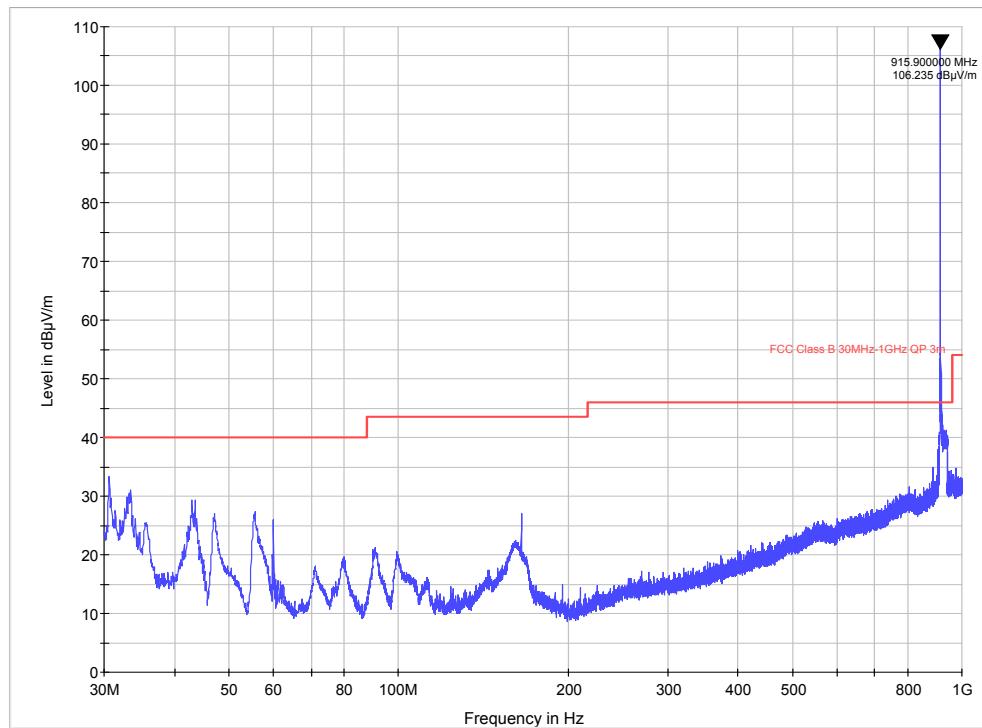
Date: 7.SEP.2011 10:45:24

## Middle Channel Radiated emissions Vertical 5GHz- 10GHz

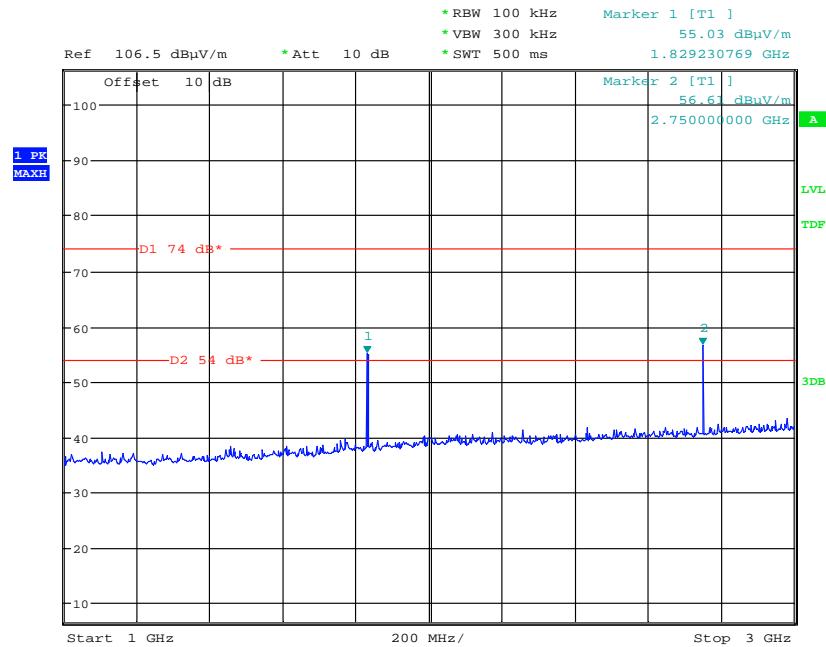


Date: 7.SEP.2011 10:46:03

## Top Channel Radiated emissions Vertical 30MHz-1GHz

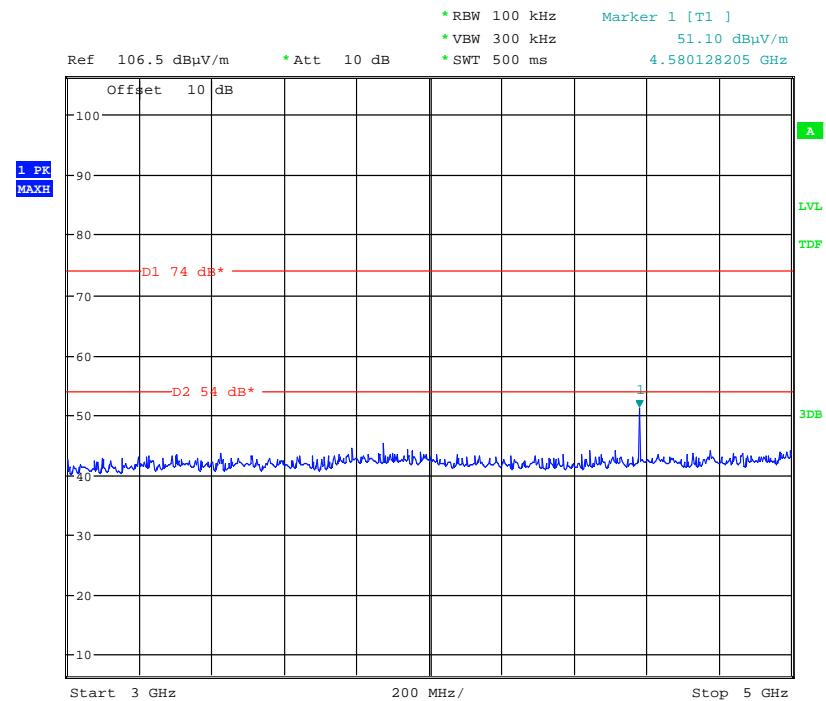


## Top Channel Radiated emissions Vertical 1GHz – 3GHz



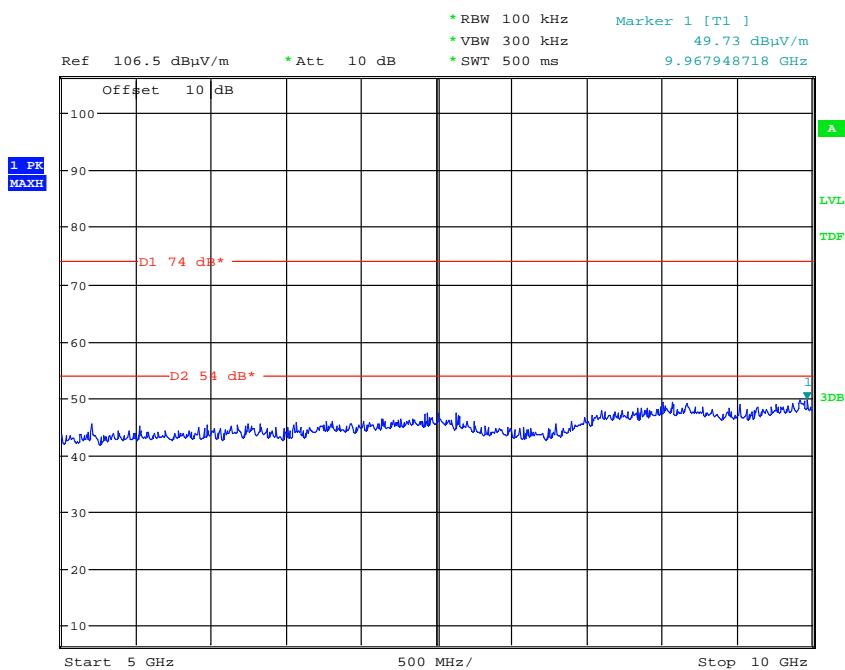
Date: 26.SEP.2011 11:15:39

## Top Channel Radiated emissions Vertical 3GHz - 5GHz



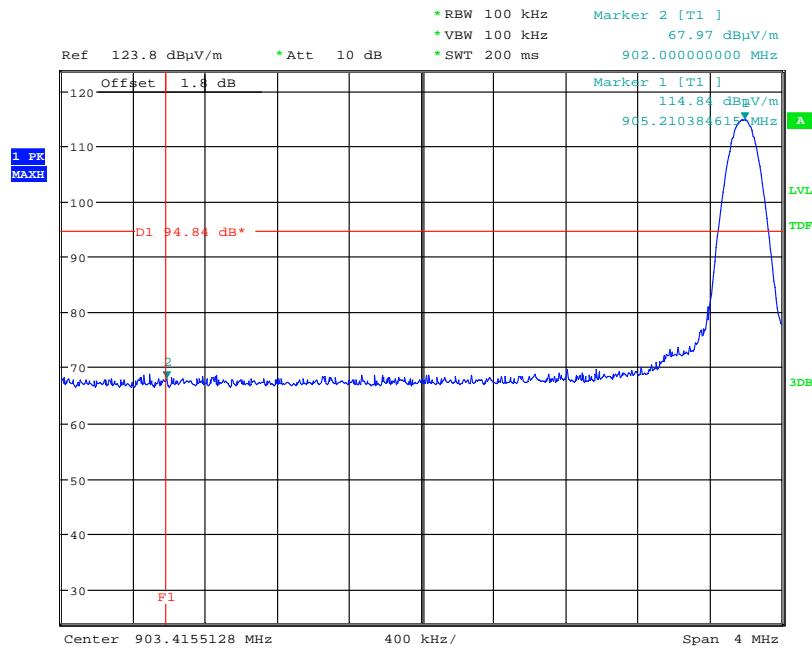
Date: 26.SEP.2011 11:16:12

## Top Channel Radiated emissions Vertical 5GHz – 10GHz



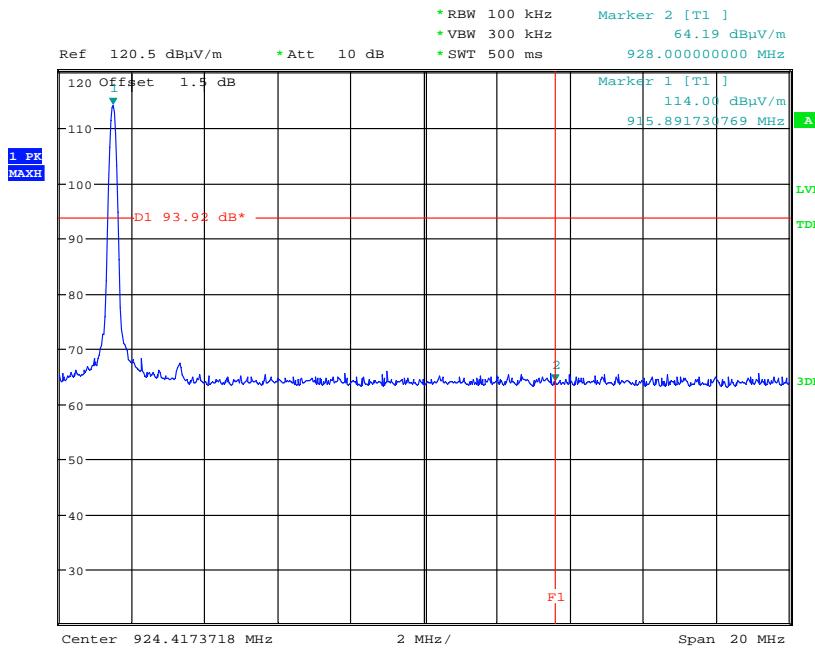
Date: 26.SEP.2011 11:16:39

## Radiated Lower Band edge compliance



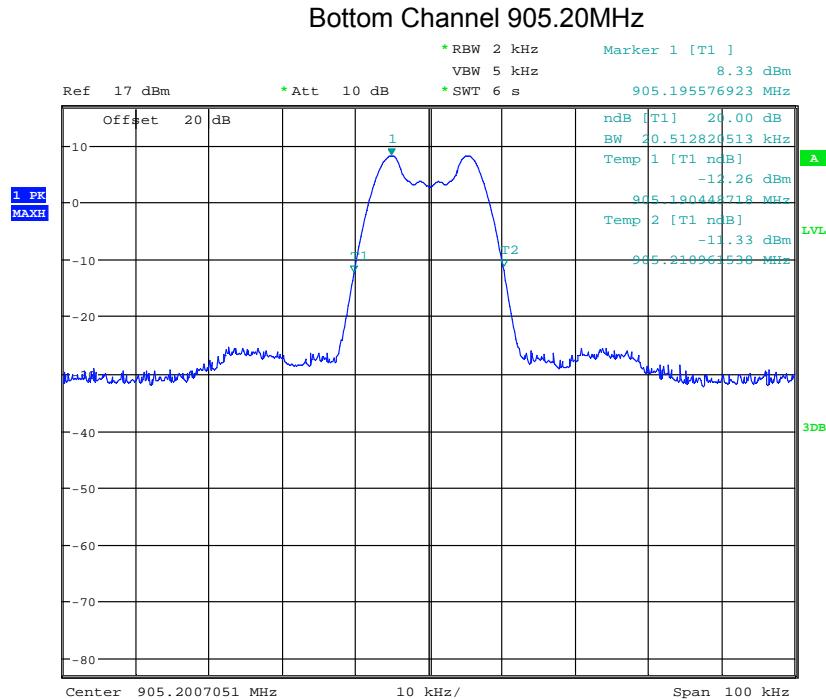
Date: 8.SEP.2011 16:18:48

## Radiated Upper Band edge compliance



Date: 27.SEP.2011 10:52:04

## 20dB Occupied Bandwidth

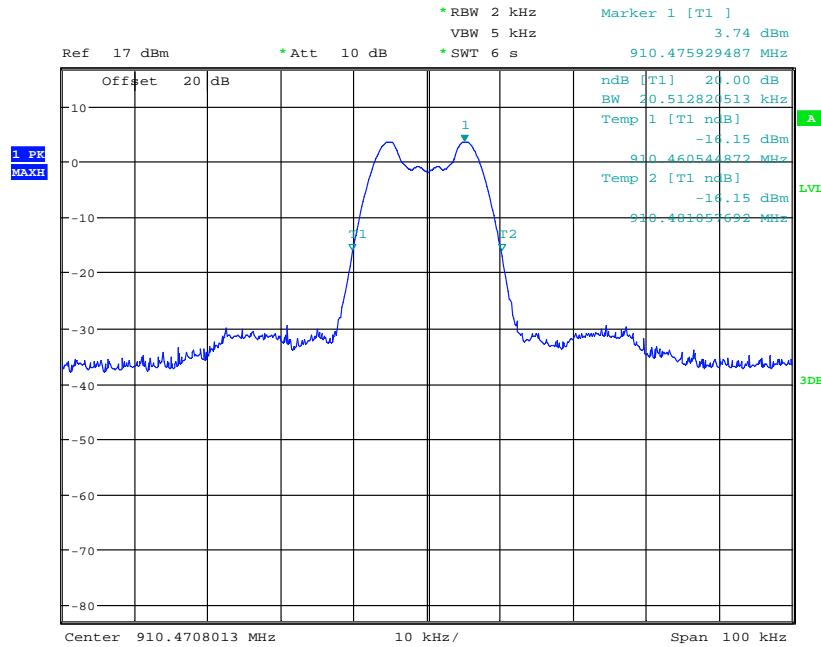


Date: 27.SEP.2011 15:48:14

fl = 905.190448718MHz  
fh = 905.210961538MHz

20dB occupied bandwidth = 20.512kHz

## Middle Channel 910.47MHz

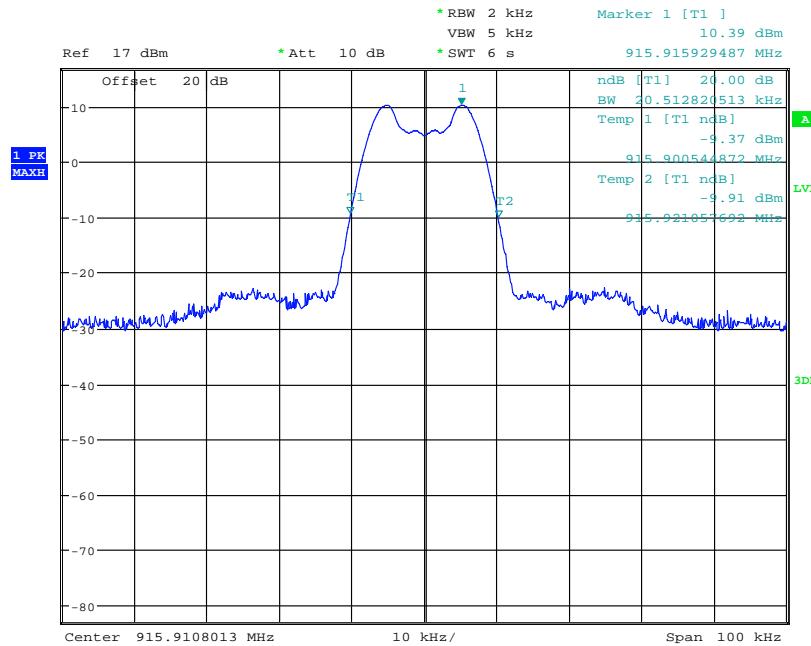


Date: 28.SEP.2011 09:16:31

$f_l = 910.460544872\text{MHz}$   
 $f_h = 910.481057692\text{MHz}$

20dB occupied bandwidth = 20.512kHz

## Top Channel 915.91MHz

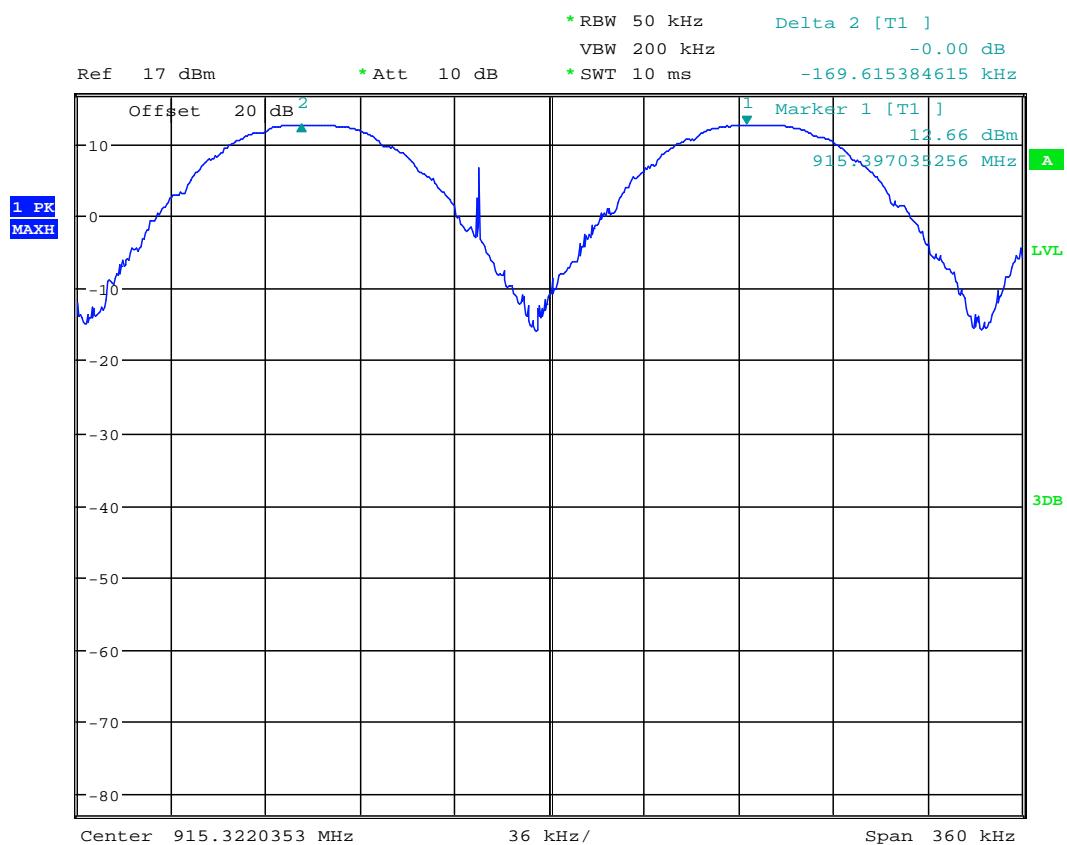


Date: 28.SEP.2011 09:24:28

$f_l = 915.900544872\text{MHz}$   
 $f_h = 915.921057692\text{MHz}$

20dB occupied bandwidth = 20.512kHz

## Carrier Frequency separation

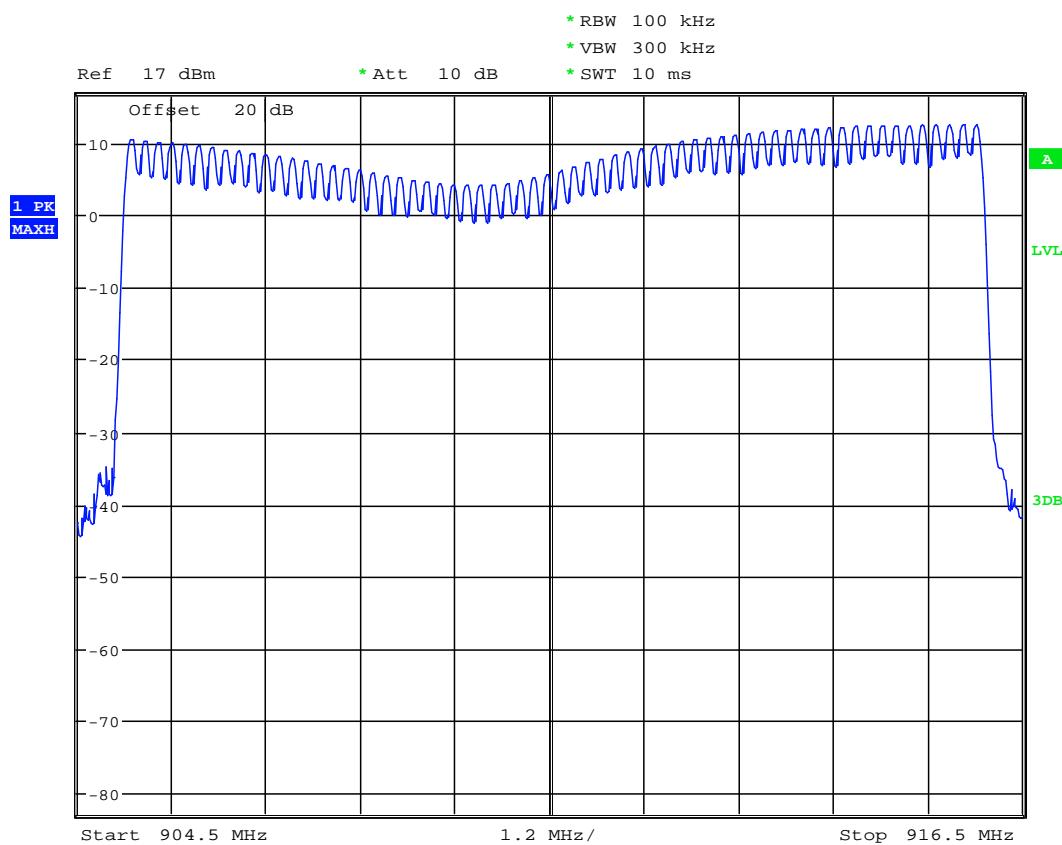


Date: 28.SEP.2011 09:43:47

Carrier Frequency separation = 169.615kHz

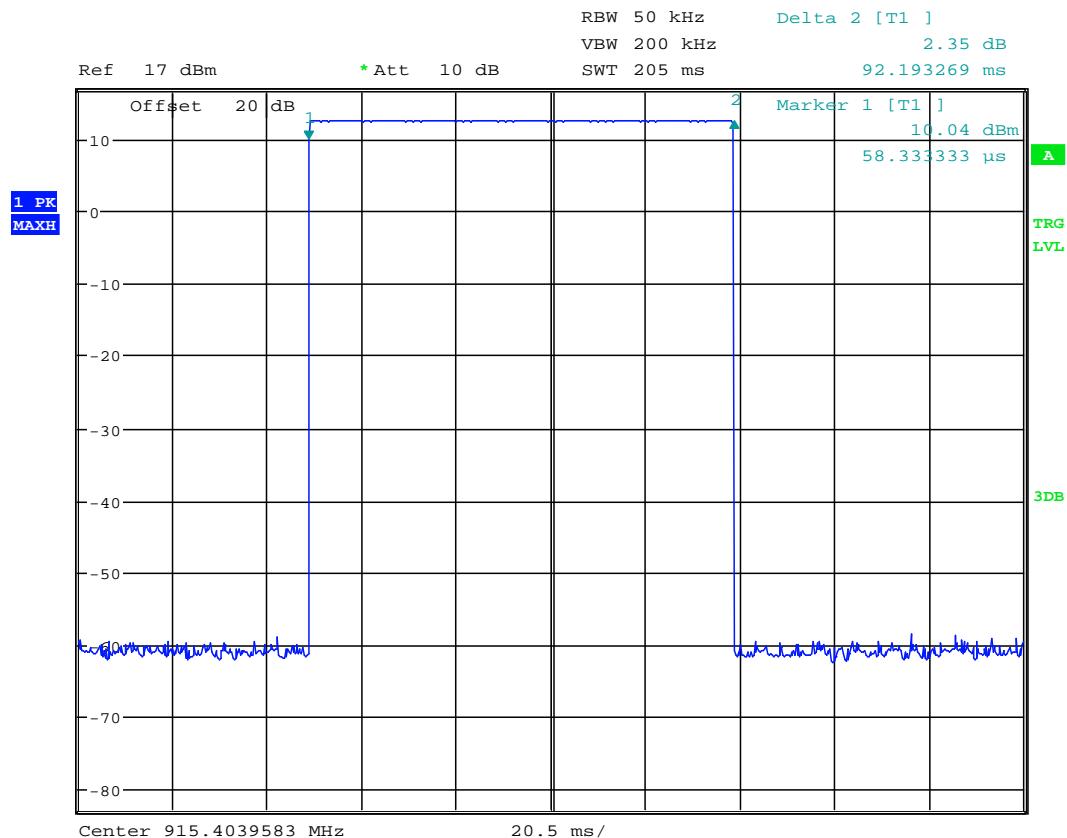
### Number of hopping channels

Number of hopping channels = 64 Channels



Date: 27.SEP.2011 15:18:29

## Channel occupancy

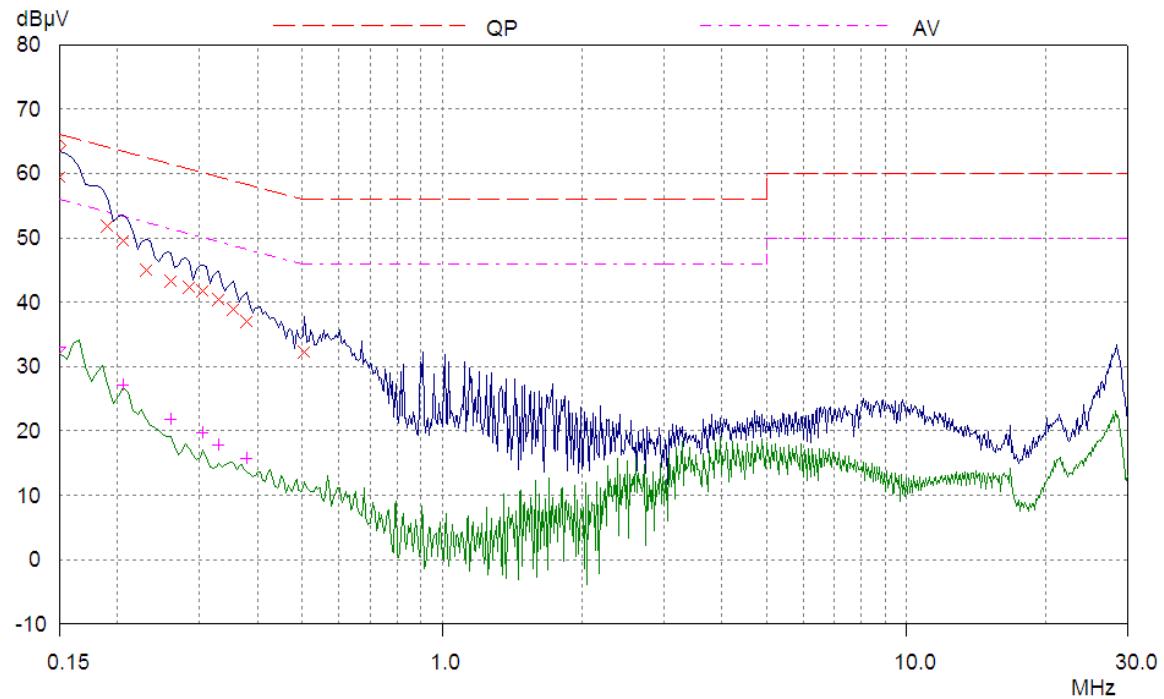


Date: 28.SEP.2011 10:15:16

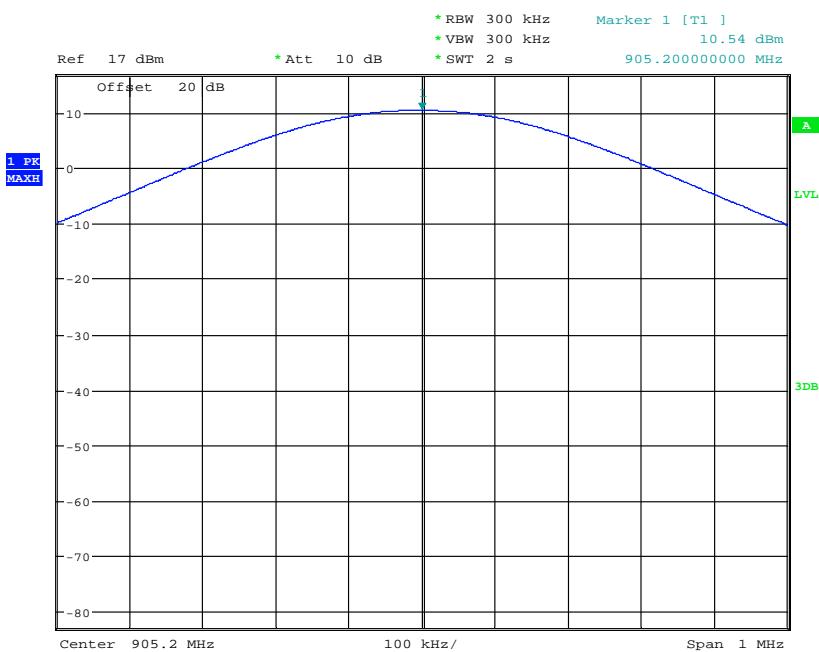
Channel occupancy = 92.19ms

**Channel repetition time**

See Client declaration in Annex D

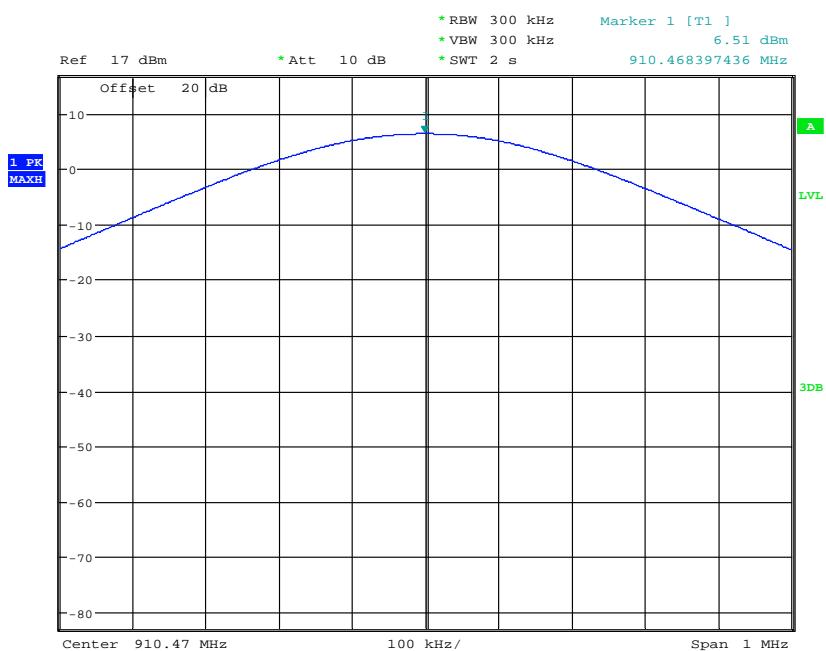
**AC Power Line Emissions Rx hopping mode.**

### Conducted carrier power 905.20MHz



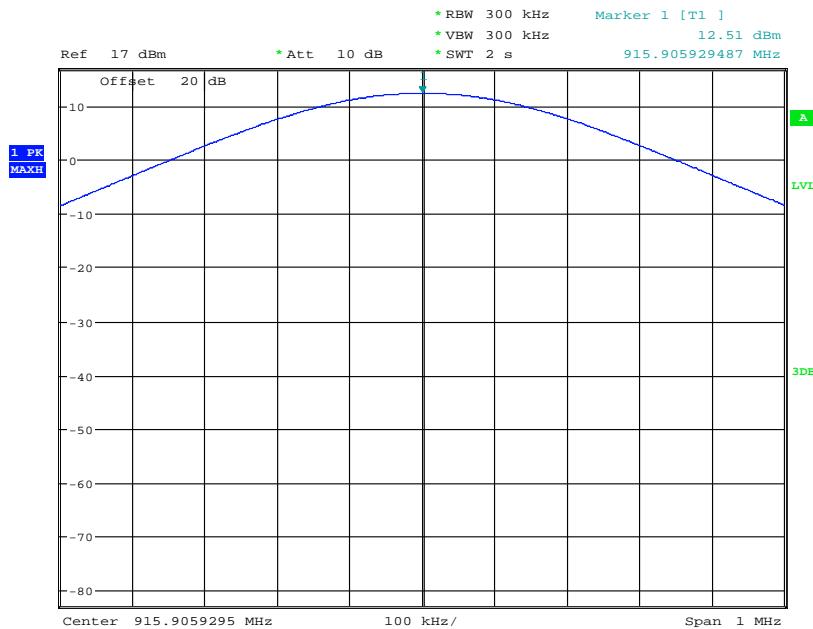
Date: 27.SEP.2011 14:53:53

### Conducted carrier power 910.47 MHz



Date: 27.SEP.2011 14:49:40

## Conducted carrier power 915.91MHz



Date: 27.SEP.2011 14:40:25

**Appendix C:****Additional Test and Sample Details**

This appendix contains details of:

1. The samples submitted for testing.
2. Details of EUT operating mode(s)
3. Details of EUT configuration(s) (see below).
4. EUT arrangement (see below).

Throughout testing, the following numbering system is used to identify the sample and its modification state:

**Sample No:** Sxx Mod w

where:

xx	= sample number	eg. S01
w	= modification number	eg. Mod 2

The following terminology is used throughout the test report:

**Support Equipment (SE)** is any additional equipment required to exercise the EUT in the applicable operating mode. Where relevant SE is divided into two categories:

SE in test environment: The SE is positioned in the test environment and is not isolated from the EUT (e.g. on the table top during REFE testing).

SE isolated from the EUT: The SE is isolated via filtering from the EUT. (e.g. equipment placed externally to the ALSR during REFE testing).

**EUT configuration** refers to the internal set-up of the EUT. It may include for example:

- Positioning of cards in a chassis.
- Setting of any internal switches.
- Circuit board jumper settings.
- Alternative internal power supplies.

Where no change in EUT configuration is **possible**, the configuration is described as “single possible configuration”.

**EUT arrangement** refers to the termination of EUT ports / connection of support equipment, and where relevant, the relative positioning of samples (EUT and SE) in the test environment.

**C1) Test samples**

The following samples of the apparatus were submitted by the client for testing:

Sample No.	Description	Identification
S01	GEN2 LEAFNODE	N/A

The following samples of apparatus were submitted by the client as host, support or drive equipment (auxiliary equipment):

Sample No.	Description	Identification
S02	Power Supply	N/A

**C2) EUT Operating Mode During Testing.**

During testing, the EUT was exercised as described in the following tables :

Test	Description of Operating Mode:
All tests detailed in this report	<i>EUT transmitting and receiving on maximum power using FHSS over 63 channels</i>

**C3) EUT Configuration Information.**

Sample	Internal Configuration Details
S01	Single possible internal configuration

The EUT was submitted for testing in one single possible configuration.

**C4) List of EUT Ports**

The table below describes the termination of EUT ports:

Sample : S01

Port	Description of Cable Attached	Cable length	Equipment Connected
<i>Not Applicable</i>			

Notes on the above:

A photograph showing the termination of EUT ports is contained within Appendix F

**C5 Details of Equipment Used**

TRAC Ref	Type	Description	Manufacturer	Date Calibrated.
TRLUH281	FSU46	Spectrum Analyser	Rhode & Schwarz	10/02/2011
TRL138	3115	Horn Antenna	Emco	10/09/2009
TRL139	3115	Horn Antenna	Emco	17/08/2009
TRL572	8449B	Pre amp	Agilent	24/11/2010
TRLUH04	ESVS10	Receiver	Rhode & Schwarz	14/12/2010
TRLUH372	6201-69	Pre amp	Watkins& Johnson	14/04/2010
TRLUH93	CBL6112B	Antenna	Chase	20/06/2011
TRLUH195	ESH3	Lisn	Rhode & Schwarz	01/03/2011

**Appendix D:****Additional Information****CHANNEL USAGE DECLARATION**

30<sup>th</sup> September 2011

Wimac Ltd  
Tyler Close  
Normanton  
West Yorkshire  
England  
WF6 1RL

To Whom It May Concern:

I declare that the Wimac LeafNode WMLN915A FCCID YRUWMLN-915, complies with the FCC requirement 15.247(a)(1)(i).

This is achieved by using a table generated using a 24 bit seed fed into a pseudo random number generator.

The devices will work through the table sequentially selecting the next channel for each communications slot.

The seed and generator have been chosen such that the hopping pattern adheres to the following criteria:

1. Any particular channel is not used for longer than 0.4 seconds in any 20 second period.
2. The 64 channels are all used equally.

The leafnode will transmit at a maximum rate of once every 2 seconds. When it is transmitting the leafnode transmitter will be active for 92ms.

There are 64 available channels, with channel 0 being at 905.2MHz. The channels are then equally spaced with 170kHz between adjacent channels, placing the top channel (63) at 915.91MHz and the mid channel (31) at 910.47MHz.

Data is transmitted at a rate of 2400 baud, with GFSK modulation and a deviation of +/- 7kHz.  
Wimac Ltd

*Paul Beech*

Paul Beech

Tyler Close, Normanton, Wakefield. WF6 1RL  
Tel: +44 (0) 113 383 1000 Fax: +44 (0) 113 383 1010  
E-mail: [info@wimac.co.uk](mailto:info@wimac.co.uk) [www.WiMAC.co.uk](http://www.WiMAC.co.uk)

Registered in England No. 5700361



**Appendix E:****Calculation of the duty cycle correction factor**

Using a spectrum analyser in zero span mode, centred on the fundamental carrier frequency with a RBW of 1MHz and a video Bandwidth of 1MHz the sweep time was set accordingly to capture the pulse train. The transmit pulsewidths and period was measured. A plots of the pulse train is contained in Appendix B of this test report.

If the pulse train was less than 100 ms, including blanking intervals, the duty cycle was calculated by averaging the sum of the pulsewidths over one complete pulse train. However if the pulse train exceeds 100ms then the duty cycle was calculated by averaging the sum of the pulsewidths over the 100ms width with the highest average value. (The duty cycle is the value of the sum of the pulse widths in one period (or 100ms), divided by the length of the period (or 100ms). The duty cycle correction factor was then expressed in dB and the peak emissions adjusted accordingly to give an average value of the emission.

Correction factor dB =  $20 \times (\log_{10} \text{Calculated Duty Cycle})$

Therefore the calculated duty cycle was determined:

The pulse train period was greater than >100ms and in as shown from the plots in contained in appendix B of this test report.

Duty cycle = the sum of the highest average value pulsewidths over 100ms  
100ms

e.g

$$= \frac{7.459\text{ms}}{100\text{ms}} = 0.07459$$

0.07459 or 7.459%

Correction factor (dB) =  $20 \times (\log_{10} 0.07459) = -22.54\text{dB}$

## Appendix F:

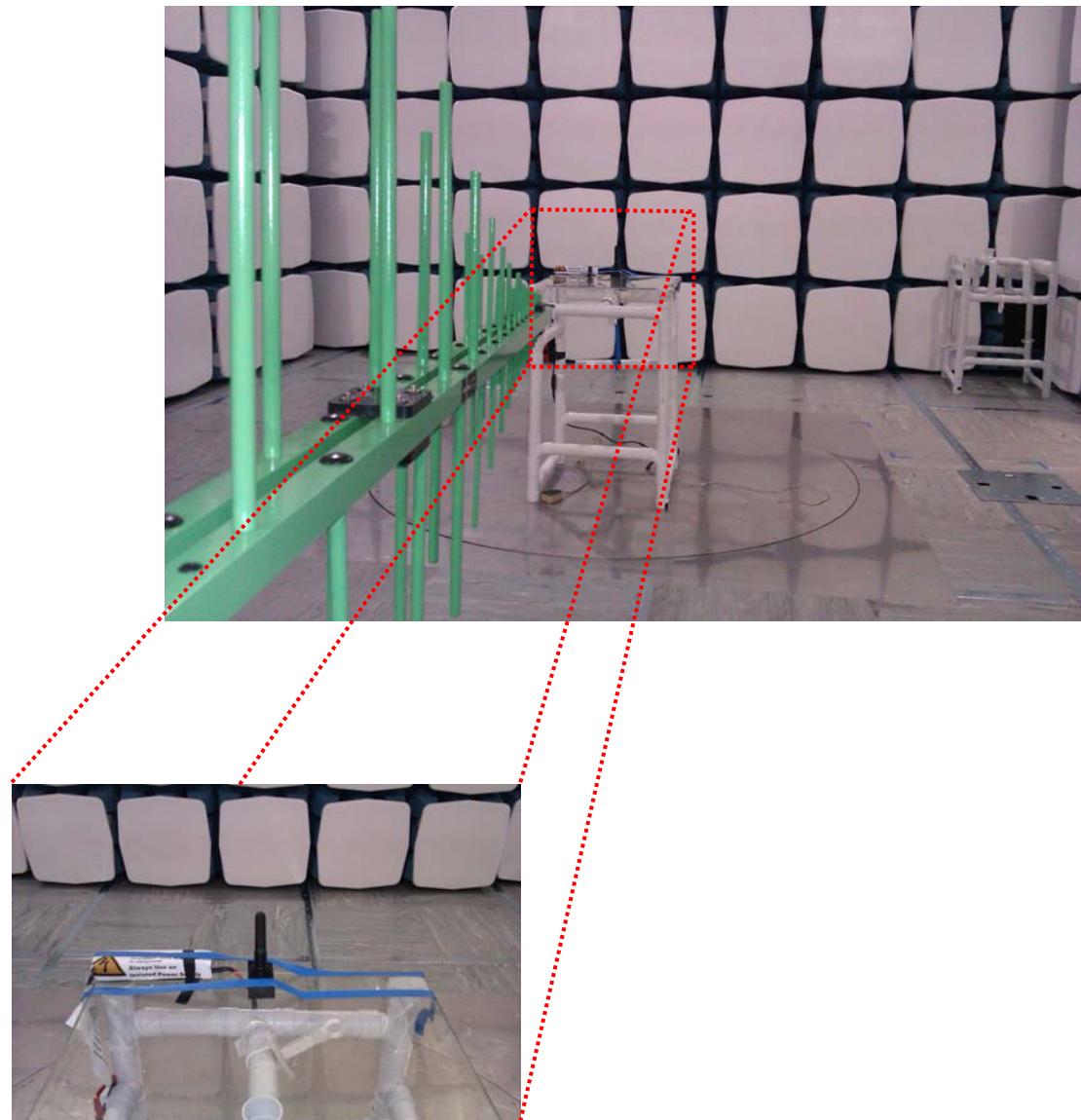
## Photographs and Figures

The following photographs were taken of the test samples:

- 1: Test Setup
- 2: Test Setup
- 3: Power line conducted emissions arrangement.
- 4: Overview.
- 5: Top view bottom case removed.
- 6: Top view case removed.
- 7: Underside view case removed.

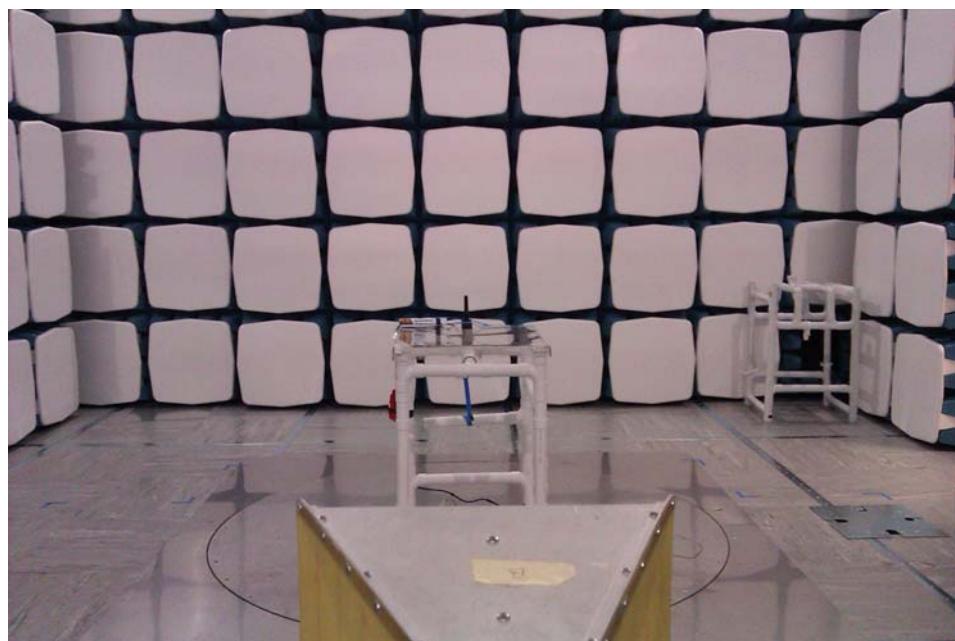
Photograph 1

Test Setup



Photograph 2

Test Setup



Photograph 3

Test Setup AC powerline



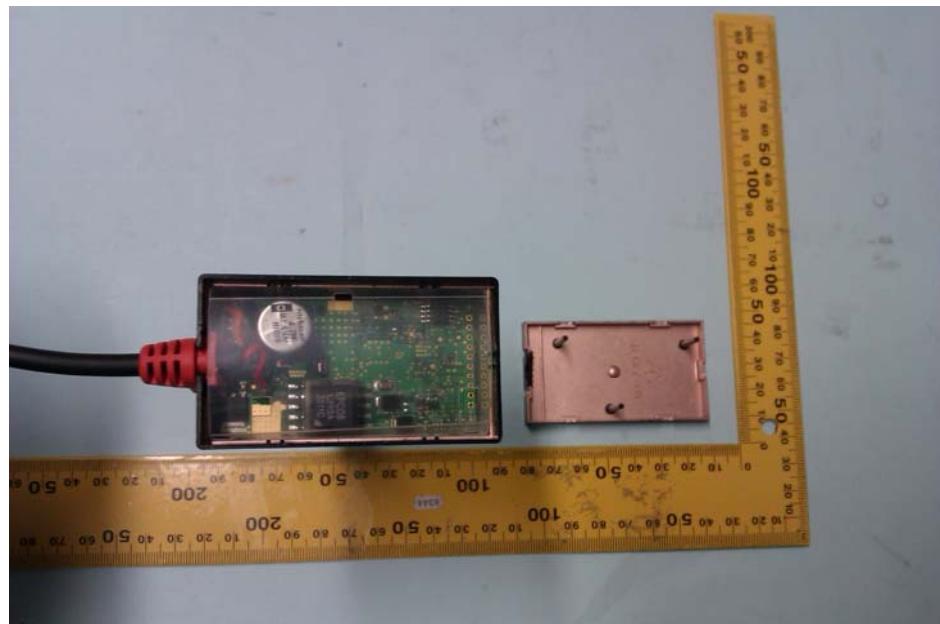
Photograph 4

Overview



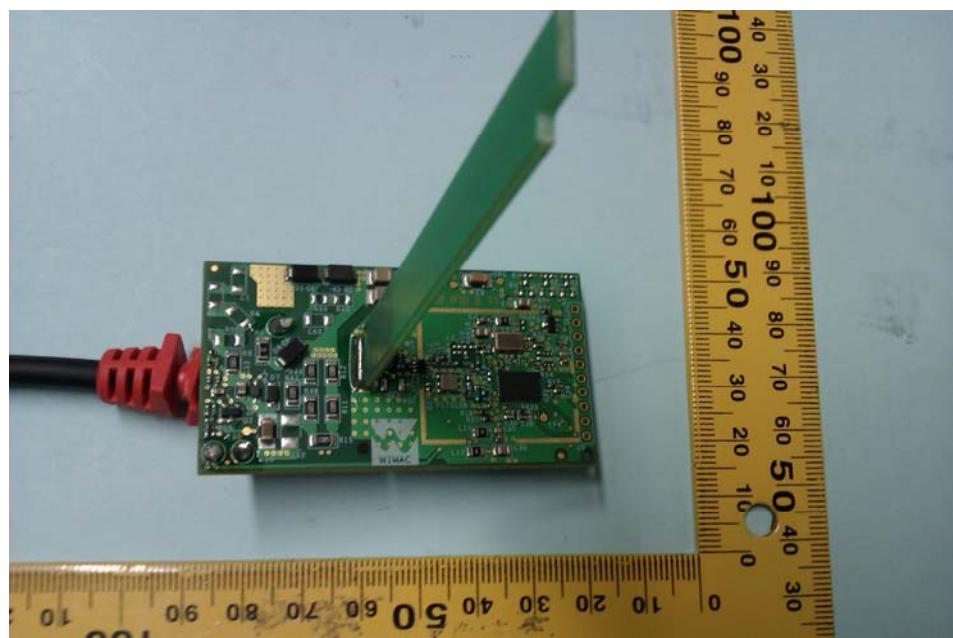
Photograph 5

Top view bottom case removed



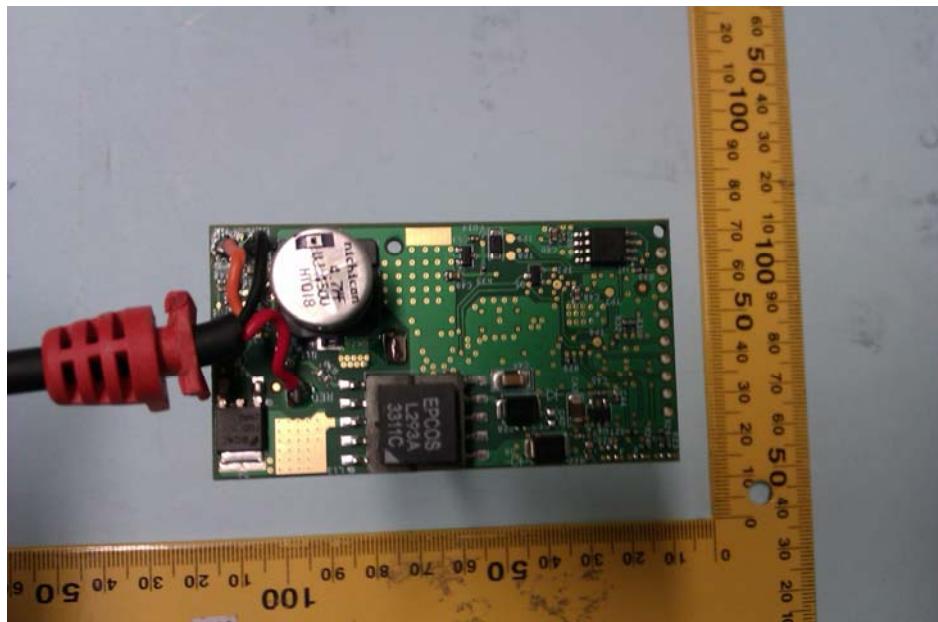
Photograph 6

topview case removed



Photograph 7

Underside view case removed



**HULL**

Unit E, South Orbital Trading Park, Hedon Road, Hull, HU9 1NJ, UK.  
**T** +44 (0)1482 801801 **F** +44 (0)1482 801806 **E** [test@tracglobal.com](mailto:test@tracglobal.com)  
[www.tracglobal.com](http://www.tracglobal.com)