A RADIO TEST REPORT

FOR

AXELL WIRELESS

ON

BSF4004

DOCUMENT NO. TRA-023543-47-00-A

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TRaC Wireless Test Report	**:** TRA-023543-47-00-A
Applicant	**:** Axell Wireless
Apparatus	**:** BSF4004
Specification(s)	**:** CFR47 Part 90
Purpose of Test	**: Certification**
FCCID	**: NEOBSF4004SERIES**
Authorised by	: John Charters Digitally signed by John Charters DN: cn=John Charters, o=TRAC Global Ltd, ou=Radio Product Manager, email=john.charters@tracglobal.com, c=GB Date: 2014.11.19 14:46:30 Z : Radio Product Manager
Issue Date	**: 19th November 2014**
Authorised Copy Number	**:** *PDF*

Total number of pages: 71

Contents

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.

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Report author: D. Winstanley

1.2 Tests Requested By

This testing in this report was requested by :

Axell Wireless
Aerial House
Asheridge Road
Chesham
Buckinghamshire
HP5 1TU

1.3 Manufacturer

Aerial House
Asheridge Road
Chesham
Buckinghamshire
HP5 1TU

1.4 Apparatus Assessed

The following apparatus was assessed between

BSF4004

The BSF4004 is a booster that supports the following bands

Uplink - 428.0 – 430.0MHz
Downlink - 423.0 – 425.0MHz

1.5 Test Result Summary

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

The statements relating to compliance with the standards below apply ONLY as qualified in the notes and deviations stated in sections 1.6 to 1.7 of this test report.

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

Test Type	FCC Part	Appendix in Report	Result
RF Power Output	90.219(e)(1)	A1 & B1	Pass
Intermodulation Spurious Emissions	90.219(e)(3)	A2 & B2	Pass
Occupied Bandwidth & Modulation	90.219(a), 90.219(e)(4)(ii)	A3 & B3	Pass
Spurious Emissions at Antenna Terminals	90.219(e)(3)	A4 & B4	Pass
Field Strength of Spurious Emissions	90.219(e)(3)	A5 & B5	Pass
Frequency Stability	90.213	N/A(note 1)	N/A
Transient behaviour	90.214	N/A(note 2)	N/A
Passband Gain & 20dB bandwidth	N/A	A6 & B6	Pass
Audio Frequency Response (a)	TIA EIA-603.3.2.6	N/A	N/A
Modulation Limiting	TIA EIA-603.3.2.6	N/A	N/A
Label requirement	90.219(e)(5)(4)	N/A	Pass

Notes:
1 The EUT does not contain modulation circuitry, therefore the test was not performed.
2 The EUT is not a keyed carrier system, therefore the test was not performed.

Abbreviations used in the above table:

CFR	: Code of Federal Regulations	ANSI	: American National Standards Institution
REFE	: Radiated Electric Field Emissions	PLCE	: Power Line Conducted Emissions
A	Uplink Results Appendix	B	Downlink Results Appendix

1.6 Equipment Test Conditions

Product class:	Uplink	Class A [ ] Class B [X]
	Downlink	Class A [ ] Class B [X]
Product Use:	Private Land Mobile Repeater	
Supply Voltages:	Vnom	-48Vdc
Note: Vnom voltages are as stated above unless otherwise shown on the test report page		
Equipment Category:	Single channel	[ ]
	Two channel	[ ]
	Multi-channel	[X]
Channel spacing:	Wideband	Uplink
	Wideband	Downlink
Test Location	TRaC Global	
	Skelmersdale	[X]
	Hull	[ ]
	Other	[ ] Please Specify

1.7 Standard References

47 CFR 2	Code of Federal Regulations, Title 47, Part 2, “Frequency allocations and Radio Telemetry Matters; General Rules and Regulations”
47 CFR 90	Code of Federal Regulations, Title 47, Part 90,”Land Mobile Radio Service”
47 CFR 15	Code of Federal Regulations, Title 47, Part 15,”Radio Frequency Devices” Subpart B, “Unintentional Radiators”
C63.4-2003	American National Standards Institute (ANSI), “Methods of Measurement of Radio Noise Emissions from Low Voltage Electrical and Electronic Equipment in the Range 9 kHz to 40 GHz”
RSS-131	Zone Enhancers for the Land Mobile Service
RSS-GEN	General Requirements and Information for the Certification of Radio Apparatus
KDB 935210 D03	Wideband Consumer Signal Booster Compliance Measurement Guidance

1.8 Notes Relating To Assesment

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	: 17 to 23 °C
Humidity	: 45 to 75 %
Barometric Pressure	: 86 to 106 kPa

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

This assessment has been performed in accordance with the requirements of ISO/IEC 17025.

1.9 Deviations from Test Standards

There were no deviations from the standards tested to.

Section 2: Measurement Uncertainty

2.1 Measurement Uncertainty Values

For the test data recorded the following measurement uncertainty was calculated:

Radio Testing – General Uncertainty Schedule

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 (Power Meter) = **1.08dB**
Uncertainty in test result (Spectrum Analyser) = **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 (Frequency Counter) = **0.113ppm**
Uncertainty in test result (Spectrum Analyser) = **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 – Up to 8.1GHz = **3.31dB**
Uncertainty in test result – 8.1GHz – 15.3GHz = **4.43dB**
Uncertainty in test result – 15.3GHz – 21GHz = **5.34dB**
Uncertainty in test result – 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%**

[12] Power Line Conduction

Uncertainty in test result = **3.4dB**

[13] Spectrum Mask Measurements

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

[14] Adjacent Sub Band Selectivity

Uncertainty in test result = **1.24dB**

[15] Receiver Blocking – Listen Mode, Radiated

Uncertainty in test result = **3.42dB**

[16] Receiver Blocking – Talk Mode, Radiated

Uncertainty in test result = **3.36dB**

[17] Receiver Blocking – Talk Mode, Conducted

Uncertainty in test result = **1.24dB**

[18] Receiver Threshold

Uncertainty in test result = **3.23dB**

[19] 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: Uplink Formal Emission Test Results

Abbreviations used in the tables in this appendix:

Spec	: Specification
Mod	: Modification
EUT	: Equipment Under Test
SE	: Support Equipment
L	: Live Power Line
N	: Neutral Power Line
E	: Earth Power Line
Pk	: Peak Detector
QP	: Quasi-Peak Detector
Av	: Average Detector
CDN	: Coupling & decoupling network

ALSR	: Absorber Lined Screened Room
OATS	: Open Area Test Site
ATS	: Alternative Test Site
Ref	: Reference
Freq	: Frequency
MD	: Measurement Distance
SD	: Spec Distance
Pol	: Polarisation
H	: Horizontal Polarisation
V	: Vertical Polarisation

A1 RF Gain and Output Power

Test Details:	
Measurement standard	Part 2.1046, Part 90.219(e)(1)
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
Temperature ˚C	22
Humidity %	48
EUT set up	Refer to Appendix C

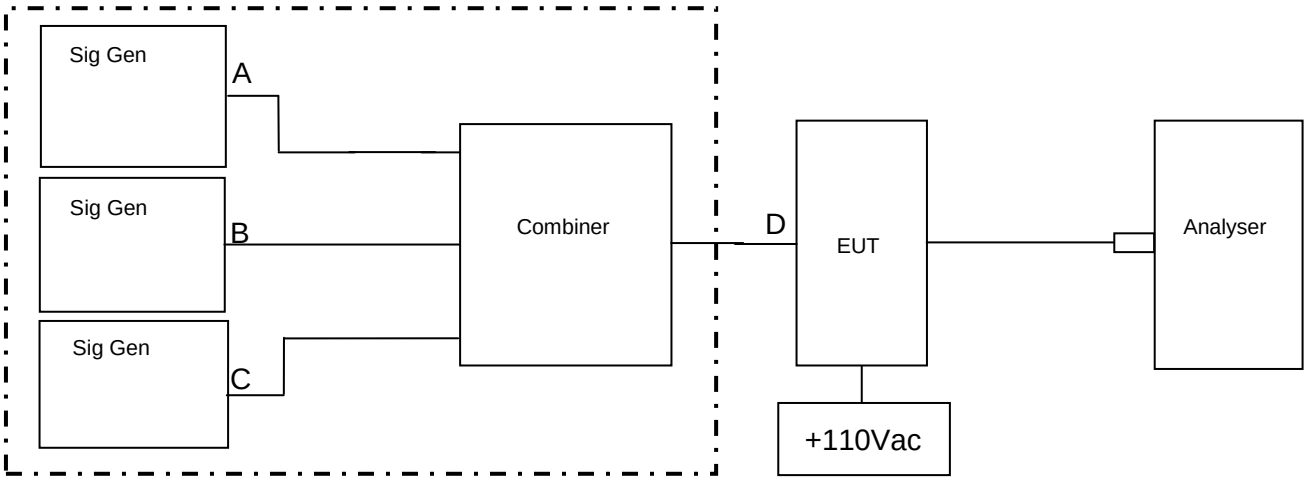
Frequency MHz	Signal Generator input level dBm	Input Cable Loss dB	Level at Spectrum Analyser dBm	Output Cable & Attenuator loss dB	Gain dB	Conducted Output Power dBm	Gain after 10dB input level increase dB
428.0	-55.50	0.50	-30.07	0.3	26.23	-29.77	17.12
429.0	-56.20	0.50	-30.10	0.3	26.90	-29.80	17.80
430.0	-55.90	0.50	-30.05	0.3	26.65	-29.75	17.53

Notes: 1.The signal generator input was increased by 10dBs and the level of the output signal remeasured.

As per D.3 Policies + Procedures (k) of KDB 935210 D03 Signal Boosters Certification v02 the EUT was tested at compression and 10dB into compression to show AGC operation

A2 Amplifier Intermodulation Spurious Emissions

Test Details:	
Measurement standard	Part 2.1053, 90.219(e)(3)
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C



Signal Generator B was varied in frequency to check if intermodulation products were produced. A Multitone generator or 3 signal generators may be used.

RF Input Frequency (MHz)			Highest Intermodulation Product Level (dBm)	Limit (dBm)
428.25	428.75	429.75	-82.35 dBm @ 429.25 MHz	-13

Sweep data is shown on the next page:

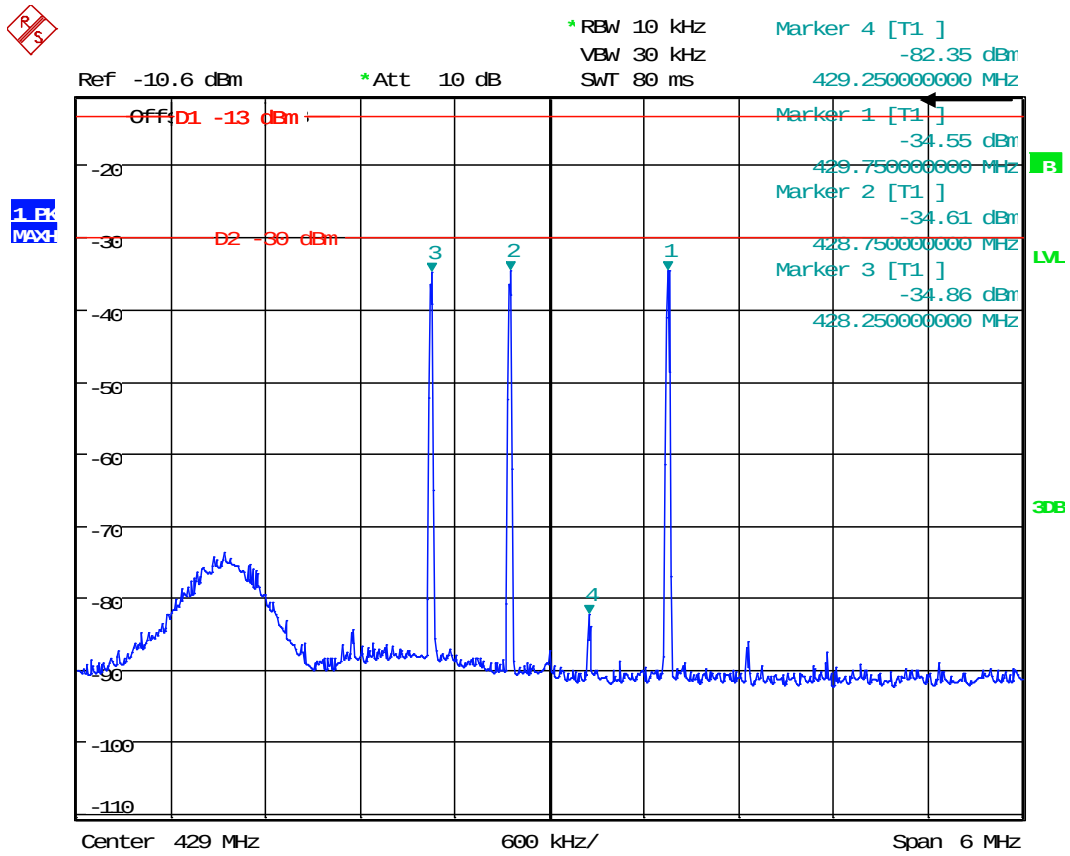
Results

The EUT was found to comply with the limits

See plots below

As per D.3 Policies + Procedures (k) of KDB 935210 D03 Signal Boosters Certification v02 the EUT was tested at compression and 10dB into compression to show AGC operation, worst case results taken.

Intermodulation Close View



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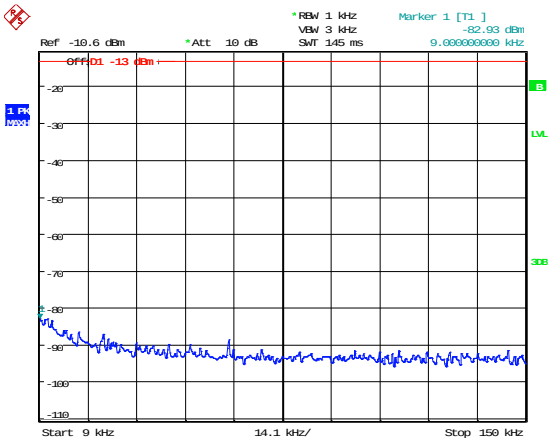
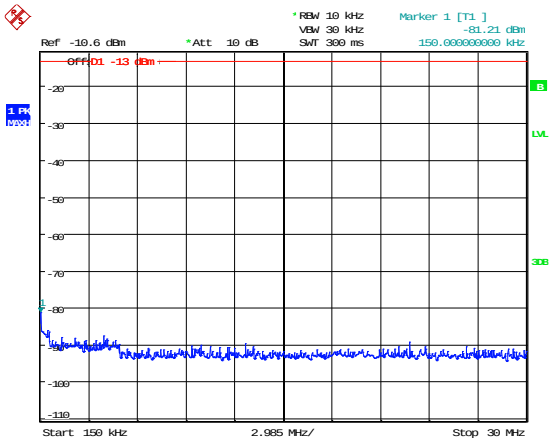
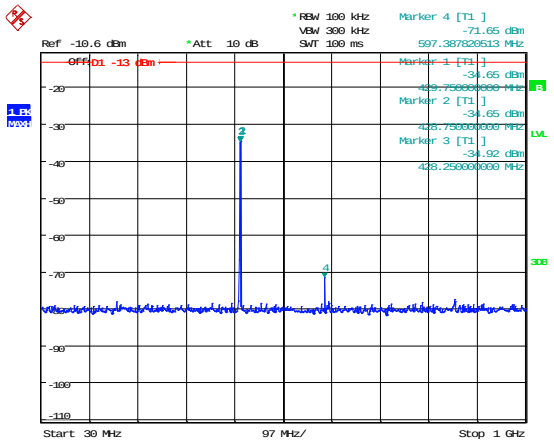


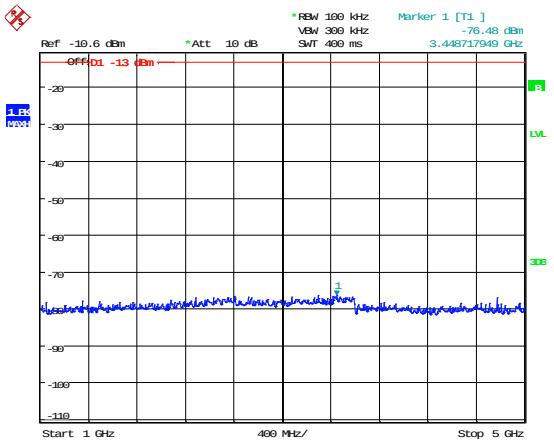
9-150kHz



150kHz – 30MHz



30MHz – 1GHz



1GHz – 5GHz

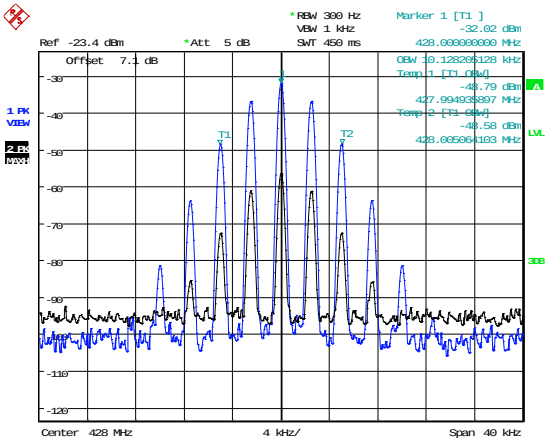
A3 Amplifier Modulated Channel Test

Test Details:	
Measurement standard	Part 2.1049, Part 219(a) Part 90.219(e)(4)(ii), 90.210(c), 90.210(d) and 90.210(e)
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C

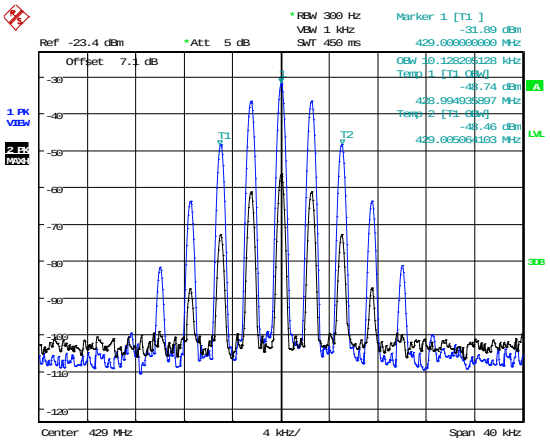
Modulation Type	Frequency Of Operation Channel (MHz)		
	428.0 MHz	429.0 MHz	430.0 MHz
Analogue	10.128 kHz	10.128 kHz	10.128 kHz
P25 (QPSK)	5.064 kHz	5.064 kHz	5.000 kHz
P25 (C4FM)	8.654 kHz	8.654 kHz	8.525 kHz

As per D.3 Policies + Procedures (k) of KDB 935210 D03 Signal Boosters Certification v02 the EUT was tested at compression and 10dB into compression to show AGC operation, worst case results taken.

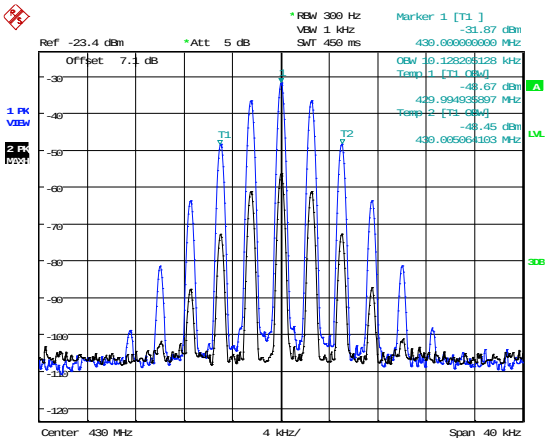
428.0 MHz Analogue Signal Generator and EUT



429.0 MHz Analogue Signal Generator and EUT

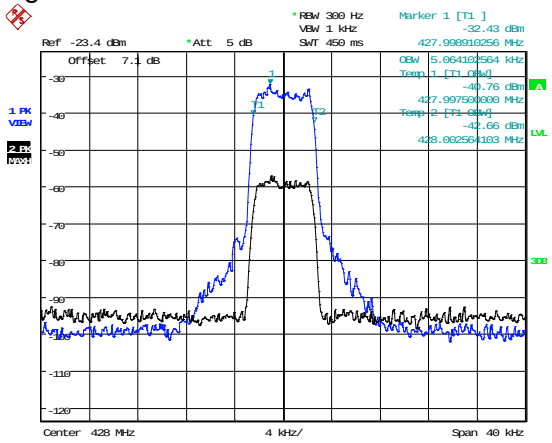


430.0 MHz Analogue Signal Generator and EUT

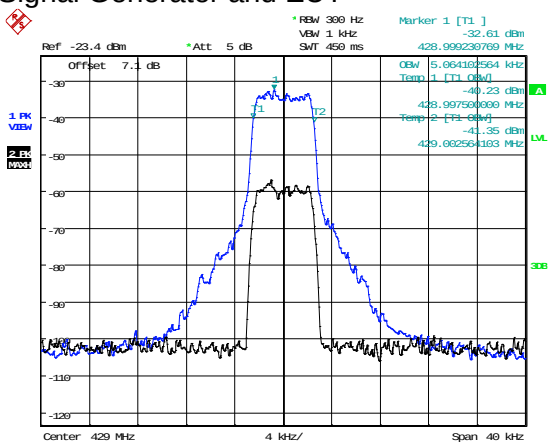


The above plots depicting the output waveshape show no measurable distortion visible when compared to the input signal.

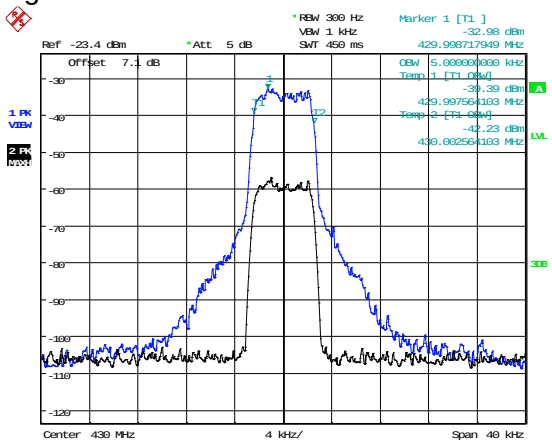
428.0 MHz P25 (QPSK) Signal Generator and EUT



429.0 MHz P25 (QPSK) Signal Generator and EUT

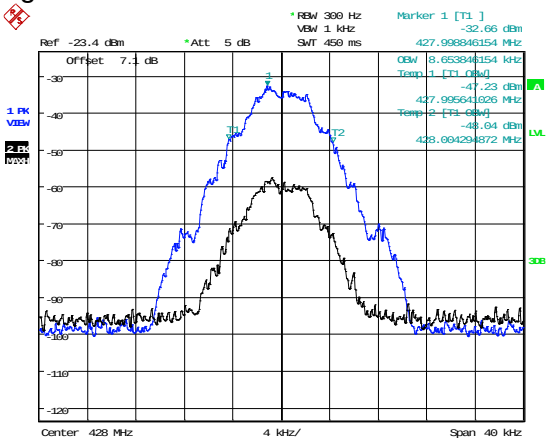


430.0 MHz P25 (QPSK) Signal Generator and EUT

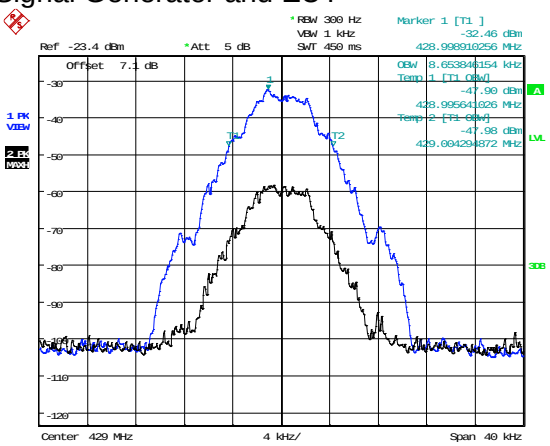


The above plots depicting the output waveshape show no measurable distortion visible when compared to the input signal.

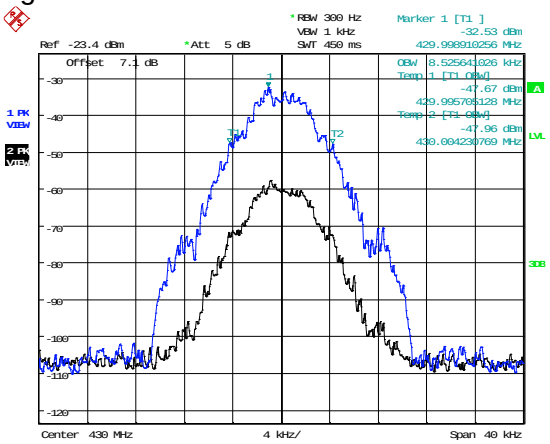
428.0 MHz P25 (C4FM) Signal Generator and EUT



429.0 MHz P25 (C4FM) Signal Generator and EUT



430.0 MHz P25 (C4FM) Signal Generator and EUT



The above plots depicting the output waveshape show no measurable distortion visible when compared to the input signal.

A4 Spurious Emissions at Antenna Terminals Less than 1MHz

Test Details:	
Measurement standard	Part 2.1053, 90.219(e)(3), 90.210(c), 90.210(d) and 90.210(e)
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C

Modulation Type	Bandedge	Carrier Frequency (MHz)	Max Level @ bandedge (dBm)
Analogue	Lower	Maximum output power is less than the spurious limit	
	Upper		
P25 (QPSK)	Lower	Maximum output power is less than the spurious limit	
	Upper		
P25 (C4FM)	Lower	Maximum output power is less than the spurious limit	
	Upper		

A5 Spurious Emissions at Antenna Terminals Greater than 1MHz

Test Details:	
Measurement standard	Part 2.1053, 90.219(e)(3)
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C

Bottom Channel

Frequency Range (MHz)	Freq. of Emission (MHz)	Measured Level (dBm)	Attenuator & Cable Losses (dB)	Spurious Emission Level (dBm)	Limit dBm
9 kHz - 5 GHz	No Significant Emissions Within 20 dB of the Limit				-13

Middle Channel

Frequency Range (MHz)	Freq. of Emission (MHz)	Measured Level (dBm)	Attenuator & Cable Losses (dB)	Spurious Emission Level (dBm)	Limit dBm
9 kHz - 5 GHz	No Significant Emissions Within 20 dB of the Limit				-13

Top channel

Frequency Range (MHz)	Freq. of Emission (MHz)	Measured Level (dBm)	Attenuator & Cable Losses (dB)	Spurious Emission Level (dBm)	Limit dBm
9 kHz - 5 GHz	No Significant Emissions Within 20 dB of the Limit				-13

Limit is determined by the outermost step of the emissions mask and is calculated as follows:

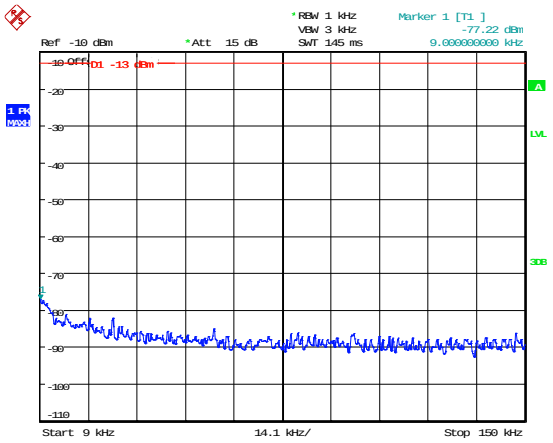
At least 43 + 10 log P dB

$(10\log P_{watts}) - (43+10\log (P_{watts} * 1000)) =$ LIMIT =-13 dBm

Result

The EUT was found to comply with the limits

Spurious Emissions at Antenna Terminals Greater than 1MHz 428.0 MHz



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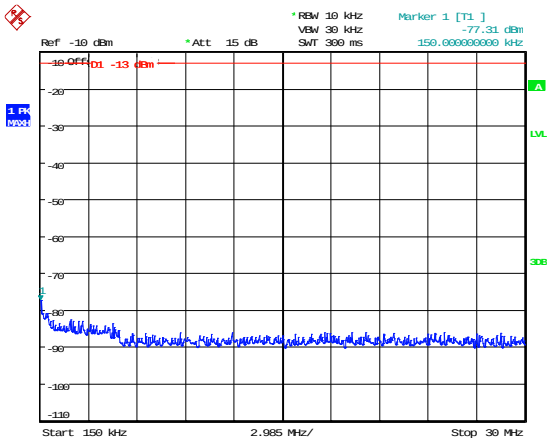
9-150kHz



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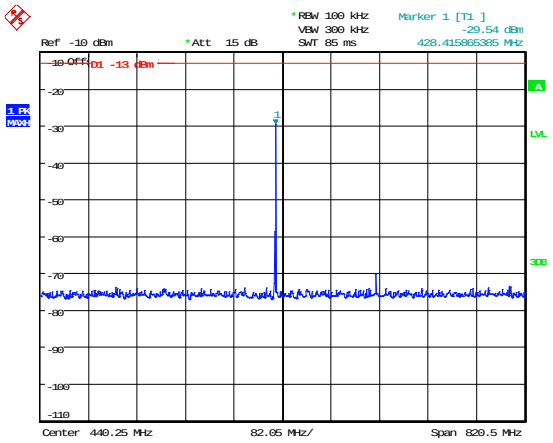
150kHz – 30MHz



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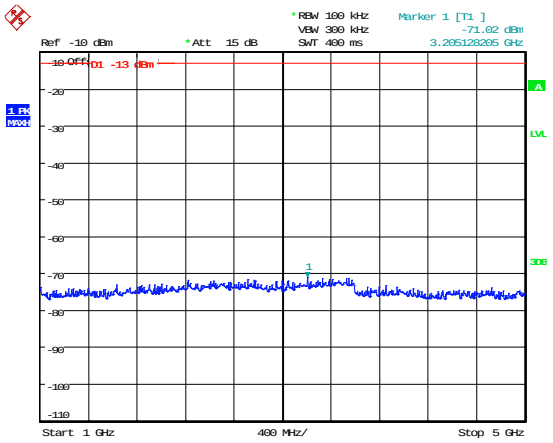
30MHz – 1GHz



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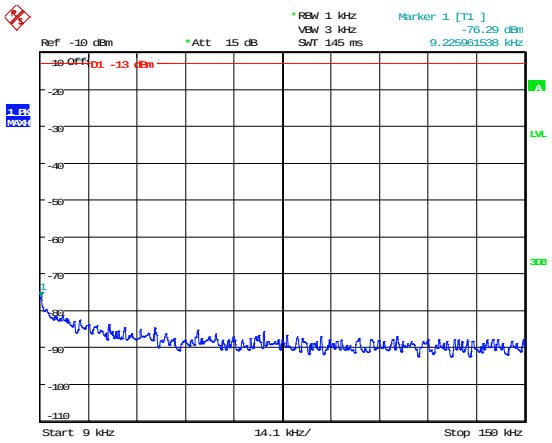
1GHz – 5GHz

Spurious Emissions at Antenna Terminals Greater than 1MHz 429.0 MHz



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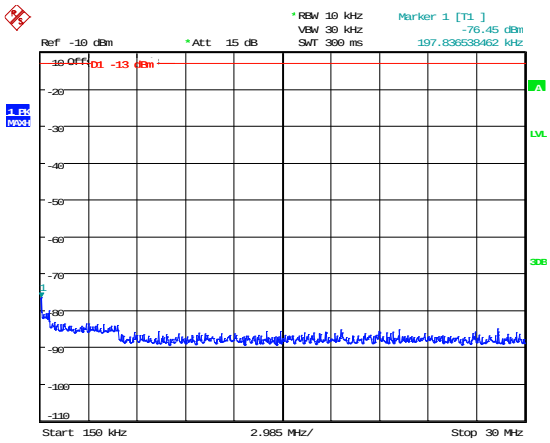
9-150kHz



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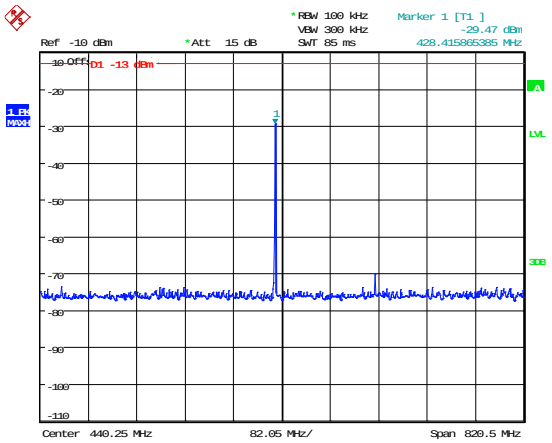
150kHz – 30MHz



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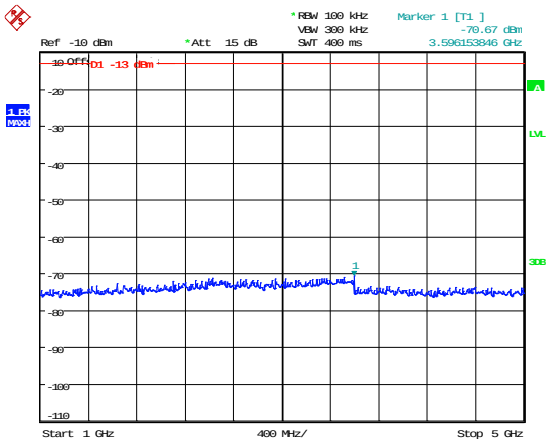
30MHz – 1GHz



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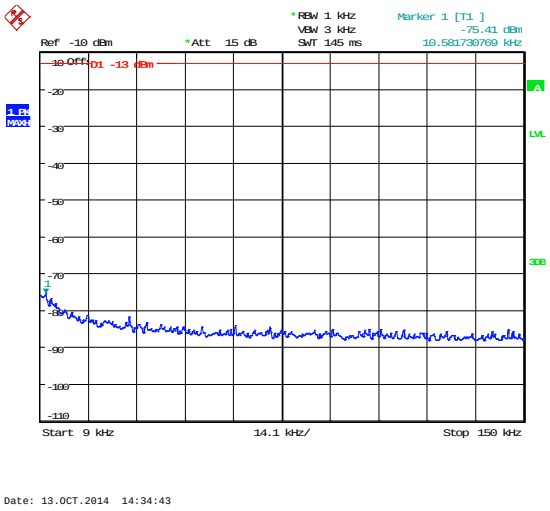
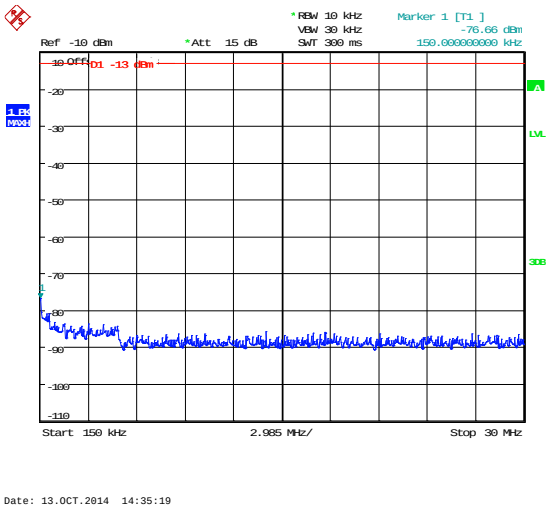
1GHz – 5GHz

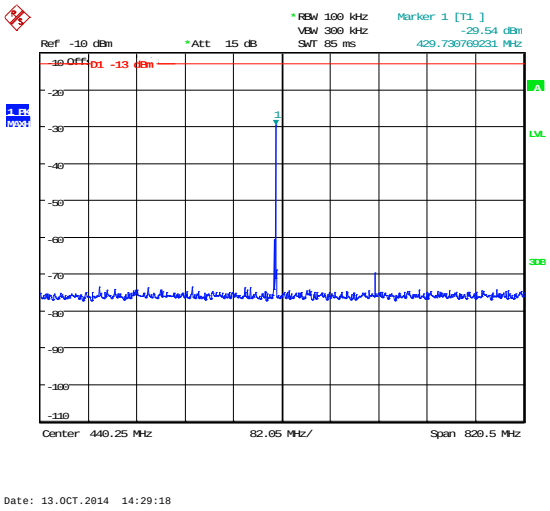
Spurious Emissions at Antenna Terminals Greater than 1MHz 430.0 MHz



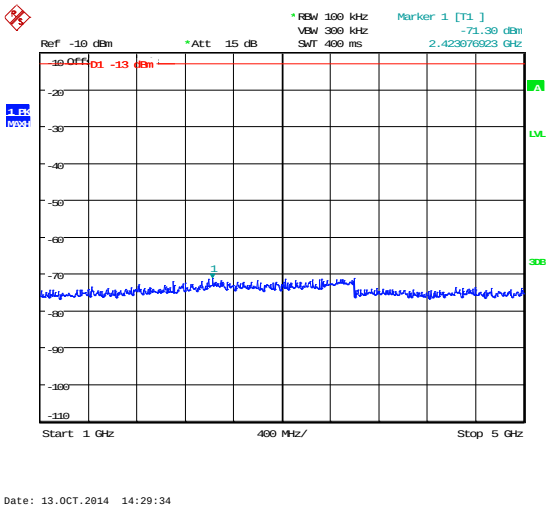
9-150kHz



150kHz – 30MHz



30MHz – 1GHz



1GHz – 5GHz

A6 Noise at Antenna Terminals

Test Details:	
Measurement standard	90.219(e)(2), 90.219(e)(3)
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C

Compliance with these levels will be deemed satisfaction of the good engineering practice requirement. In a 10 kHz measurement bandwidth:

(1) the ERP of noise within the signal booster passband should not exceed –43dBm;

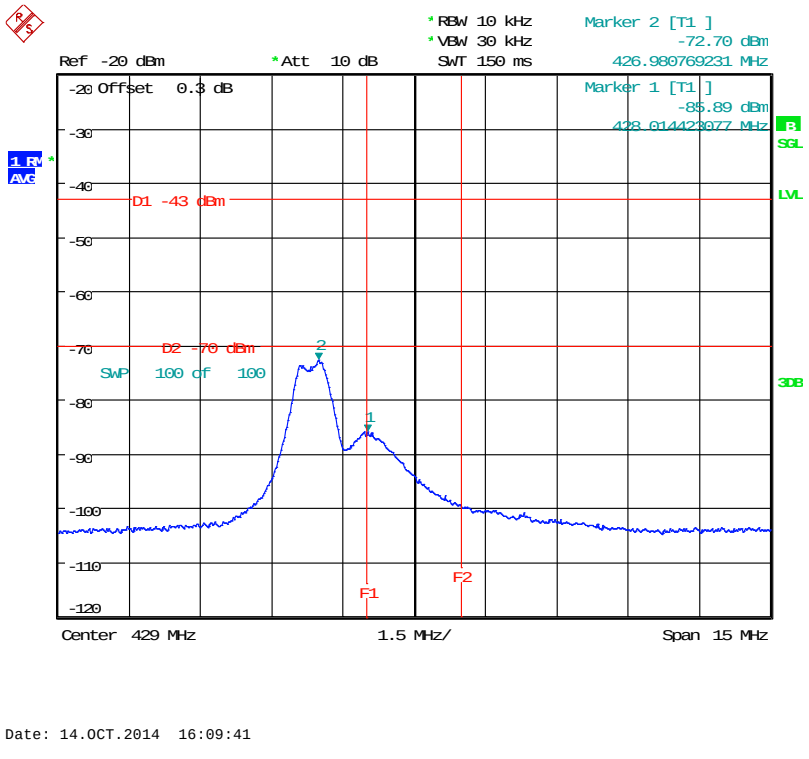
and

(2) the ERP of noise on spectrum more than 1 MHz outside of the signal booster passband should not exceed –70 dBm.

(3) The noise figure of a signal booster must not exceed 9 dB in either direction

See appendix E for declaration of good engineering practice

IN BAND AMPLIFIER NOISE



A7 Radiated Electric Field Emissions

Preliminary scans were performed using a peak detector with the RBW = 100kHz. The radiated electric field emission test applies to all spurious and harmonic emissions. The EUT was set to transmit as required.

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 : [X]

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

Test Details:	
Measurement standard	Title 47 of the CFR: Part 2.1053
Frequency range	30MHz – 5GHz
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Photographs (Appendix F)	

Bottom Frequency

FREQUENCY RANGE	FREQ. (MHz)	ERP/EIRP (dBm)	LIMIT (dBm)
30MHz - 5GHz	No Significant Emissions Within 20dB of the Limit		-13

Middle Frequency

FREQUENCY RANGE	FREQ. (MHz)	ERP/EIRP (dBm)	LIMIT (dBm)
30MHz - 5GHz	No Significant Emissions Within 20dB of the Limit		-13

Top Frequency

FREQUENCY RANGE	FREQ. (MHz)	ERP/EIRP (dBm)	LIMIT (dBm)
30MHz - 5GHz	No Significant Emissions Within 20dB of the Limit		-13

Result

The EUT was found to comply with the limits

Notes:

1. Emissions Checked up to 10 times Fc.

2. The unit was mounted on a turntable and rotated through 360^0 and in 3 orthogonal planes to find the worst case emission.

3. For Frequencies below 1 GHz, RBW = 120 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 = ≥RBW

4. Limit is determined as the outermost step of the emissions mask and is calculated as follows.

   At least 43 + 10 log P dB

   $(10\log P_{watts}) - (43+10\log (P_{watts} * 1000)) =$ LIMIT =-13 dBm

The upper and lower frequency of the measurement range was decided according to 47 CFR Part 2.1057.

(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:

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

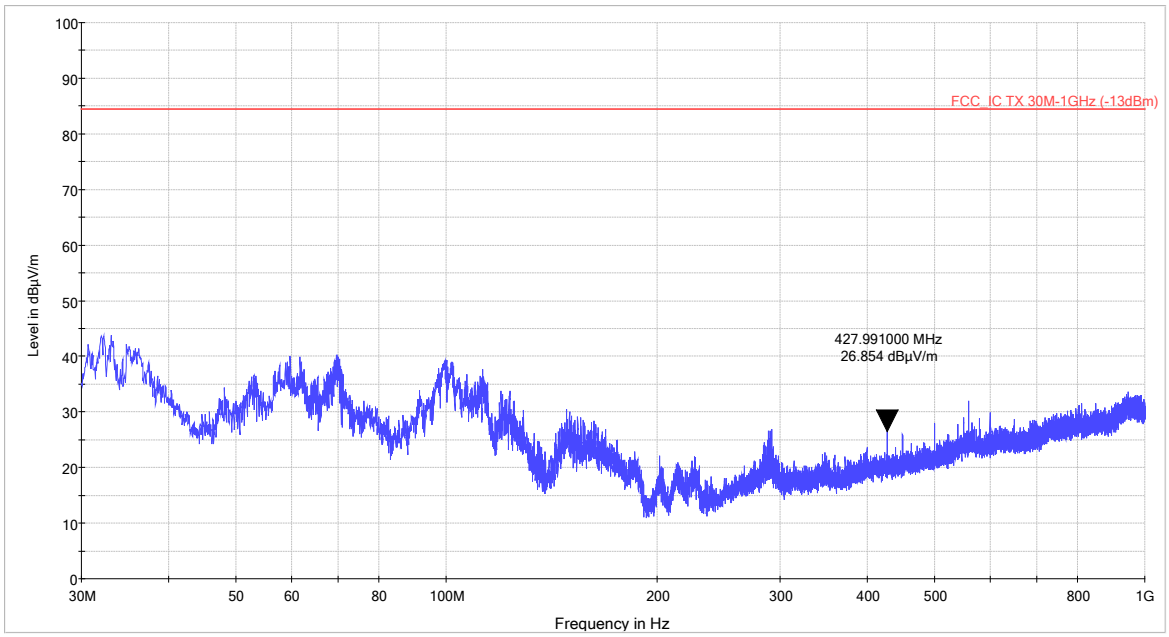
(b) The levels may have been rounded for display purposes.

(c) The following table summarises the effect of the EUT operating mode, internal configuration and arrangement of cables / samples on the measured emission levels :

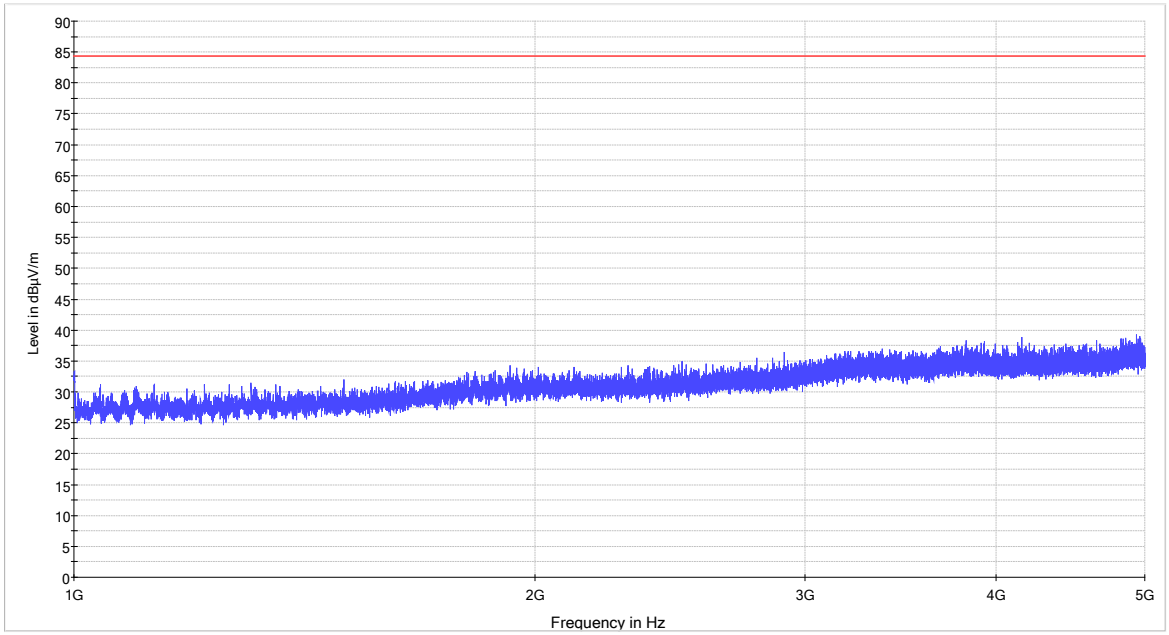
	See (i)	See (ii)	See (iii)	See (iv)
Effect of EUT operating mode on emission levels	✓			
Effect of EUT internal configuration on emission levels	✓			
Effect of Position of EUT cables & samples on emission levels	✓			

(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

Radiated Electric Field Emissions 428.0 MHz

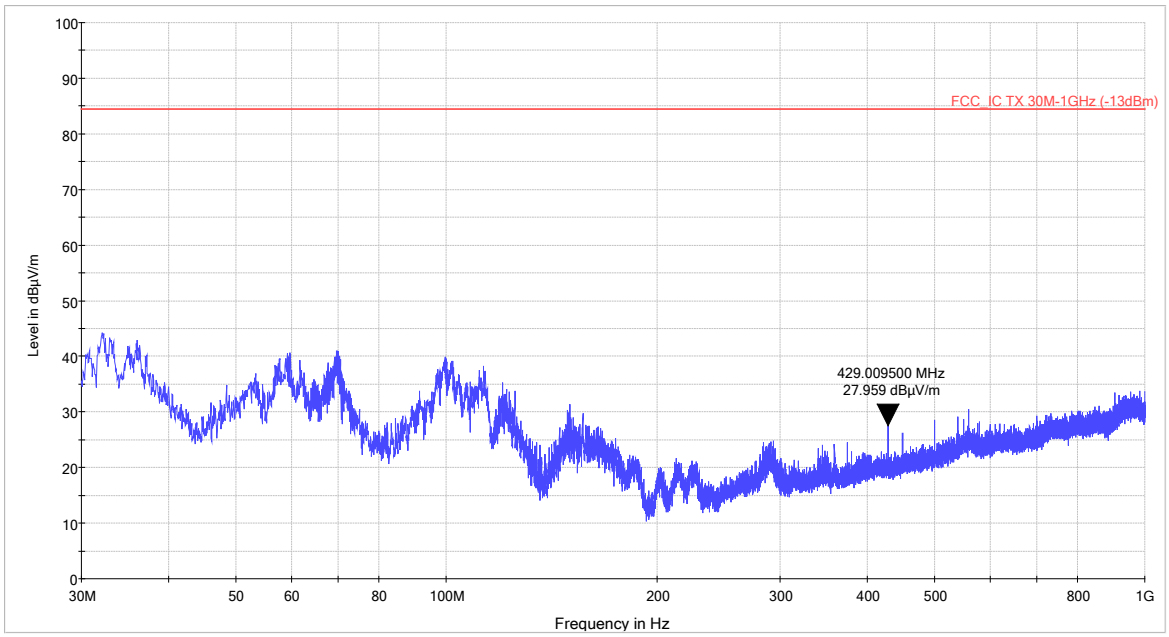


30MHz – 1GHz

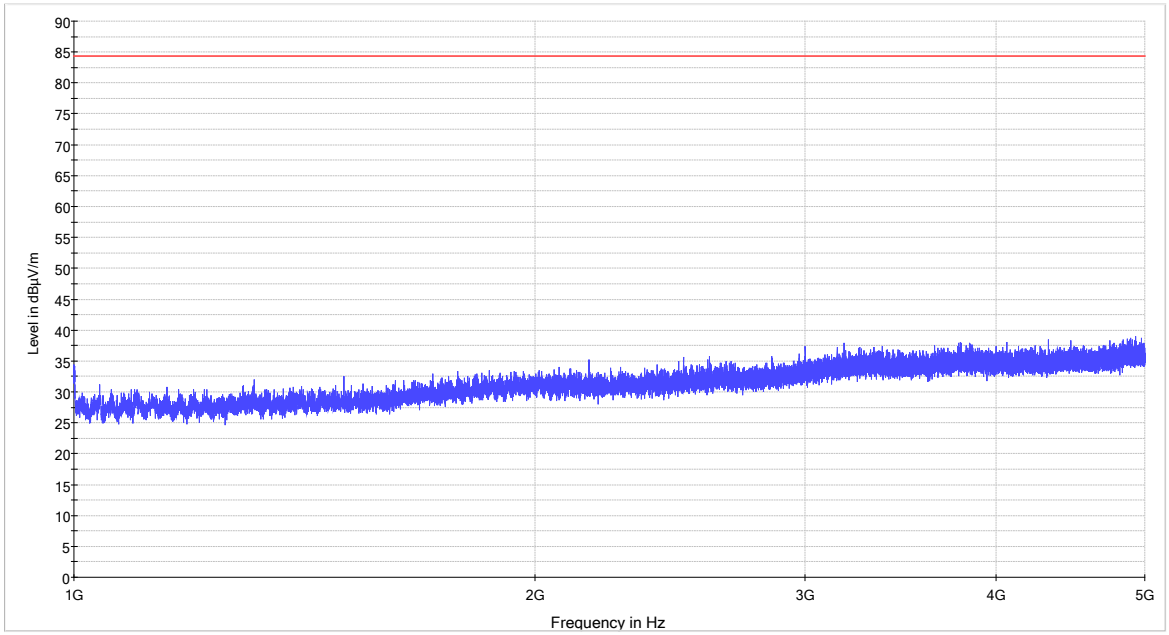


1GHz – 5GHz

Radiated Electric Field Emissions 429.0 MHz

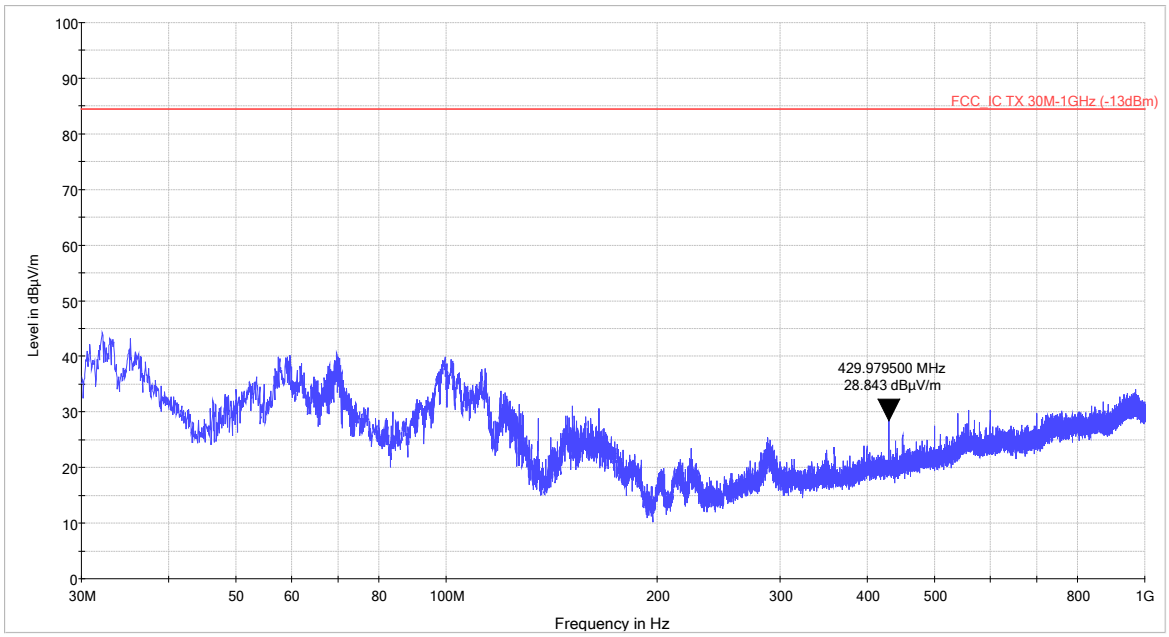


30MHz – 1GHz

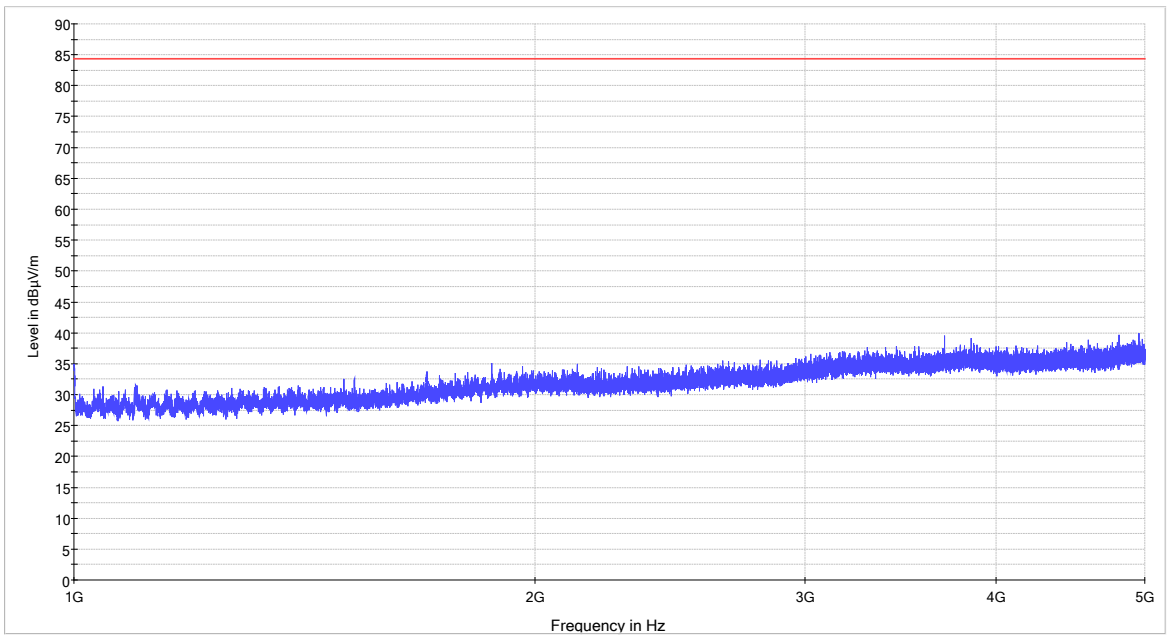


1GHz – 5GHz

Radiated Electric Field Emissions 430.0 MHz



30MHz – 1GHz



1GHz – 5GHz

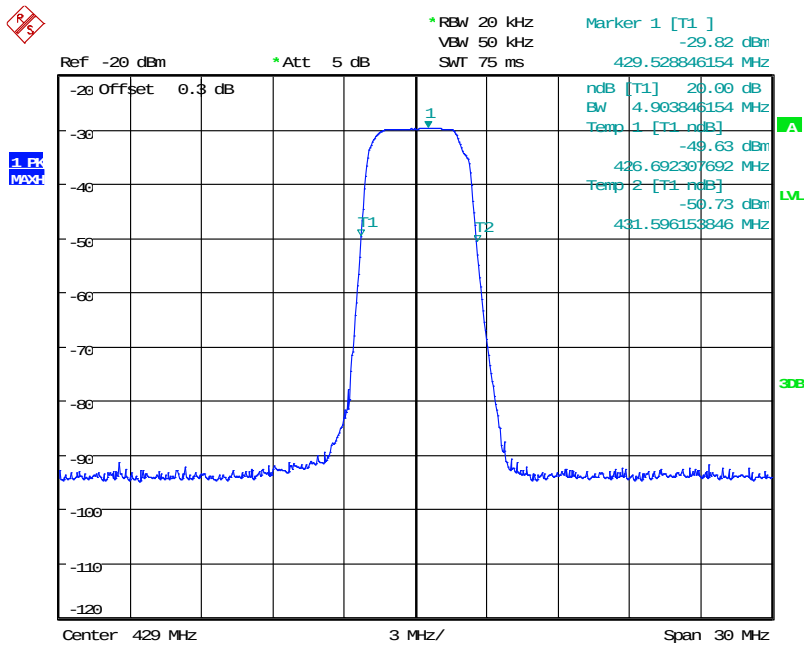
A8 Passband Gain & Bandwidth

Test Details:	
Measurement standard	D.3 Policies + Procedures (k) of KDB 935210 D03 Signal Boosters Certification v02
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C

Frequency MHz	Fl (MHz)	Fh (MHz)	20 dB Bandwidth (kHz)
428.0 – 430.0	426.692307	431.596153	4.904

1. See below for plots showing passband gain & bandwidth

With the aid of a CW Swept signal generator and spectrum analyser, the bandwidth and frequency response of the passband (i.e. at the point where the gain has fallen by 20 dB) is measured. This measurement shows the gain-versus-frequency response of the passband from the midband frequency f_0 of the channel up to at least f_0 + 250% of the 20 dB bandwidth.



Appendix B: Downlink Formal Emission Test Results

Abbreviations used in the tables in this appendix:

Spec	: Specification
Mod	: Modification
EUT	: Equipment Under Test
SE	: Support Equipment
L	: Live Power Line
N	: Neutral Power Line
E	: Earth Power Line
Pk	: Peak Detector
QP	: Quasi-Peak Detector
Av	: Average Detector
CDN	: Coupling & decoupling network

ALSR	: Absorber Lined Screened Room
OATS	: Open Area Test Site
ATS	: Alternative Test Site
Ref	: Reference
Freq	: Frequency
MD	: Measurement Distance
SD	: Spec Distance
Pol	: Polarisation
H	: Horizontal Polarisation
V	: Vertical Polarisation

B1 RF Gain and Output Power

Test Details:	
Measurement standard	Part 2.1046, Part 90.219(e)(1)
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C

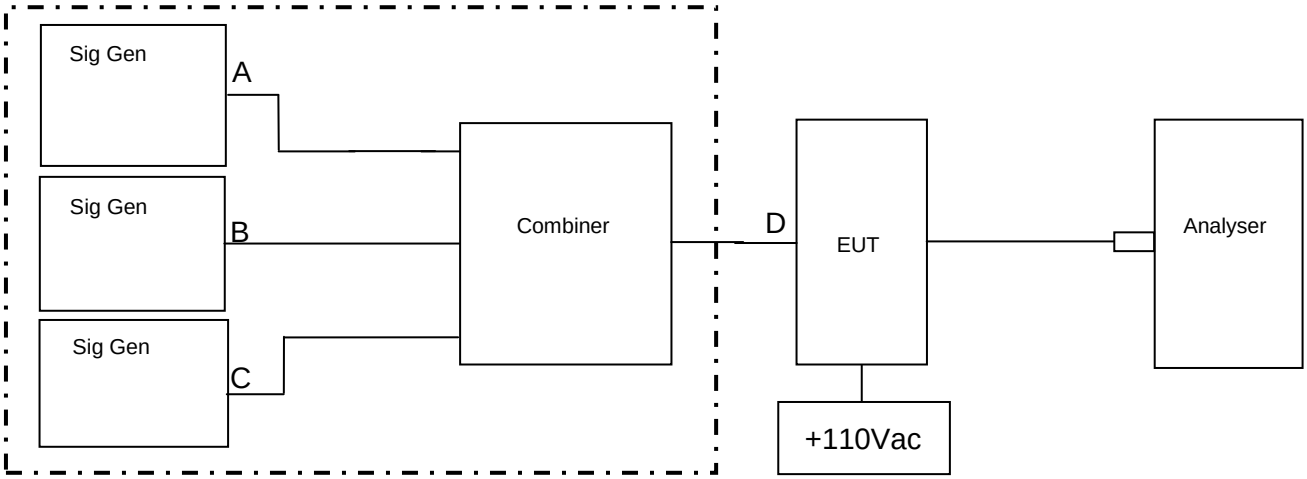
Frequency MHz	Signal Generator input level dBm	Input Cable Loss dB	Level at Spectrum Analyser dBm	Output Cable & Attenuator loss dB	Gain dB	Conducted Output Power dBm	Gain after 10dB input level increase dB
423.0	2.90	0.50	-1.75	40.9	36.75	39.15	27.14
424.0	2.80	0.50	-1.95	40.9	36.65	38.95	27.07
425.0	3.00	0.50	-3.17	40.9	35.23	37.73	25.70

Notes: 1.The signal generator input was increased by 10dBs and the level of the output signal remeasured.

As per D.3 Policies + Procedures (k) of KDB 935210 D03 Signal Boosters Certification v02 the EUT was tested at compression and 10dB into compression to show AGC operation

B2 Amplifier Intermodulation Spurious Emissions

Test Details:	
Measurement standard	Part 2.1053, Part 90.219(e)(3)
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C



Signal Generator B was varied in frequency to check if intermodulation products where produced. A Multitone generator or 3 signal generators may be used.

RF Input Frequency (MHz)			Highest Intermodulation Product Level (dBm)	Limit (dBm)
423.25	423.75	424.75	-16.12 dBm @ 424.25 MHz	-13

Sweep data is shown on the next page:

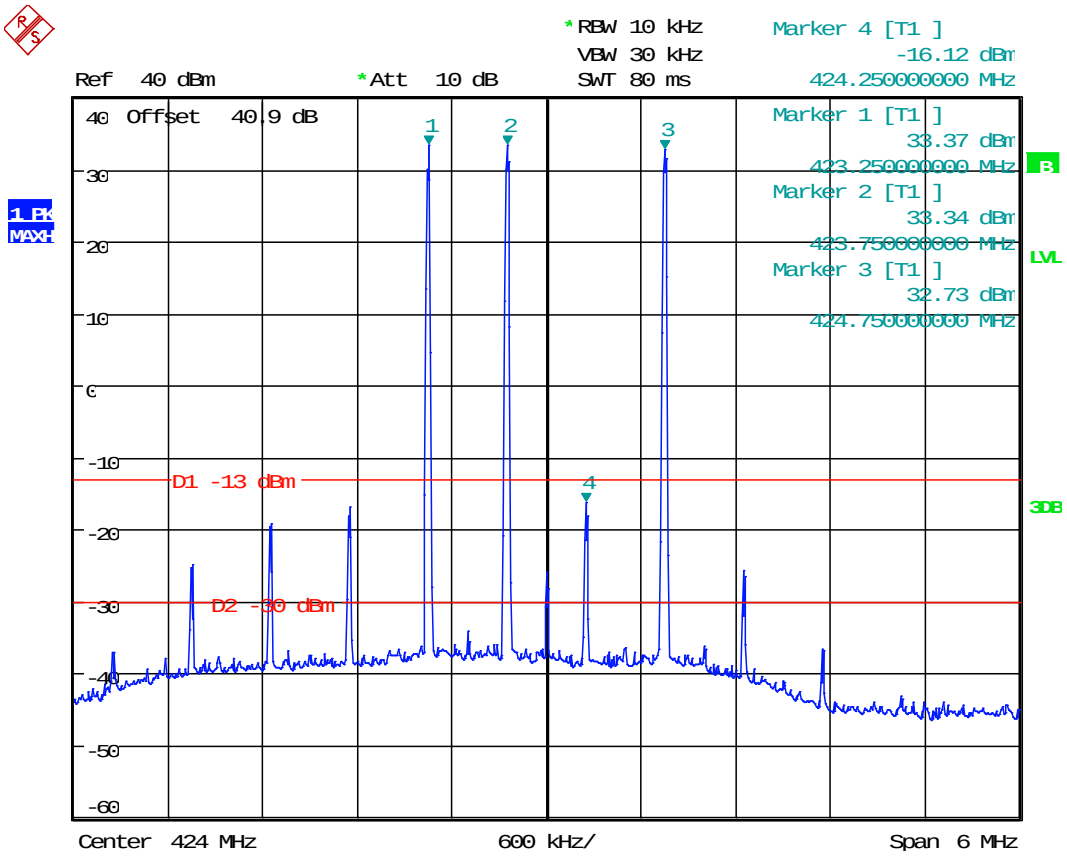
Results

The EUT was found to comply with the limits

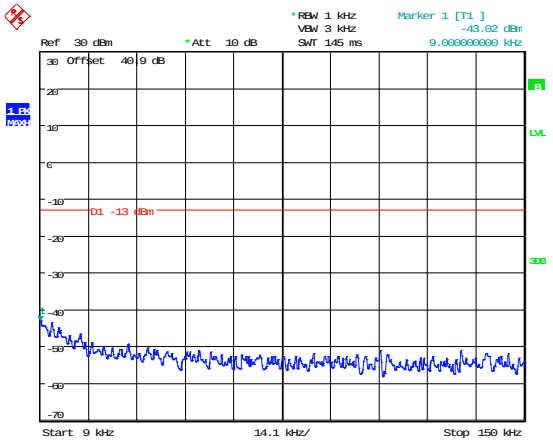
See plots below

As per D.3 Policies + Procedures (k) of KDB 935210 D03 Signal Boosters Certification v02 the EUT was tested at compression and 10dB into compression to show AGC operation

Intermodulation Close View

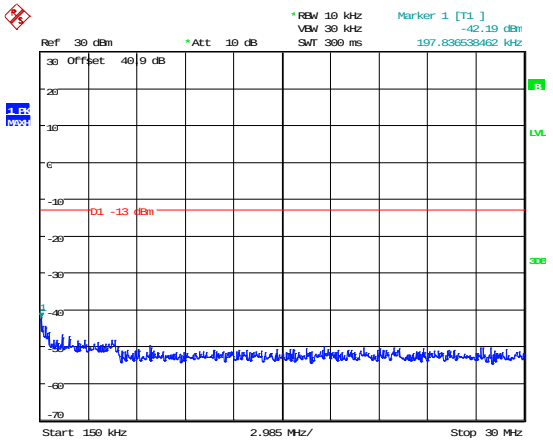


Date: 14.OCT.2014 10:35:35



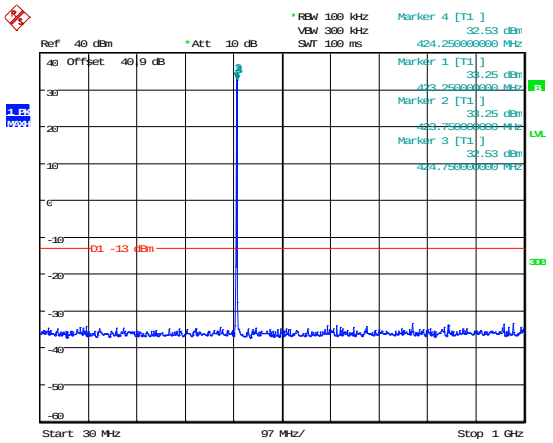
Date: 14.OCT.2014 10:36:46

9kHz - 150kHz



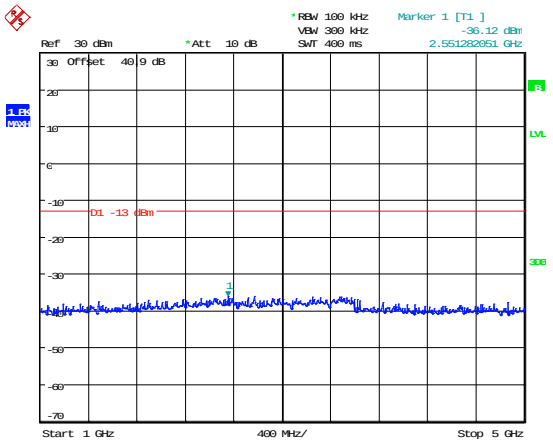
Date: 14.OCT.2014 10:37:01

150kHz – 30MHz



Date: 14.OCT.2014 10:36:02

30MHz – 1GHz



Date: 14.OCT.2014 10:36:34

1GHz – 5GHz

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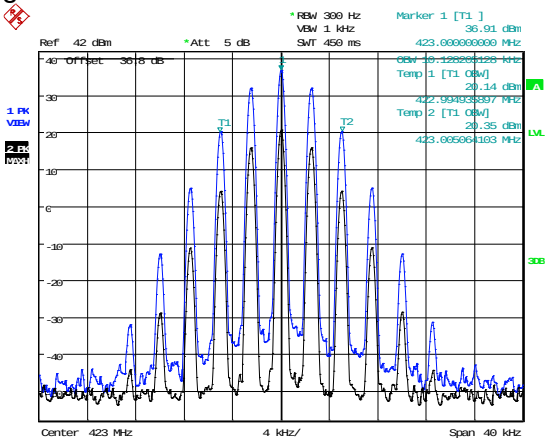
B3 Amplifier Modulated Channel Test

Test Details:	
Measurement standard	Part 2.1049, Part 219(a) Part 90.219(e)(4)(ii), 90.210(c), 90.210(d) and 90.210(e)
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C

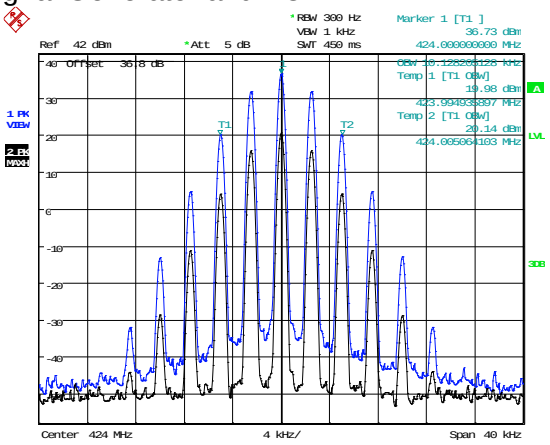
Modulation Type	Frequency Of Operation Channel (MHz)		
	423.0 MHz	424.0 MHz	425.0 MHz
Analogue	10.128 kHz	10.128 kHz	10.128 kHz
P25 (QPSK)	5.064 kHz	5.064 kHz	5.000 kHz
P25 (C4FM)	8.654 kHz	8.654 kHz	8.654 kHz

As per D.3 Policies + Procedures (k) of KDB 935210 D03 Signal Boosters Certification v02 the EUT was tested at compression and 10dB into compression to show AGC operation, worst case results taken.

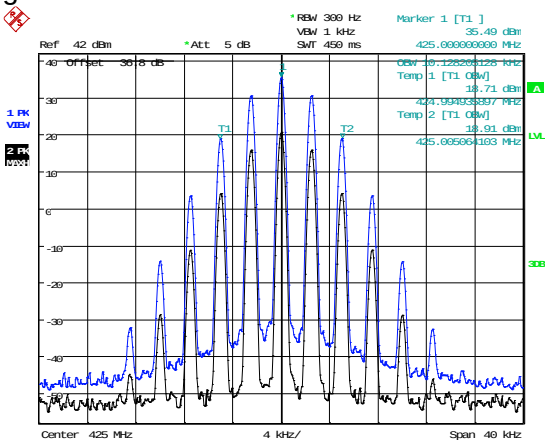
423.0 MHz - Analogue Signal Generator and EUT



424.0 MHz - Analogue Signal Generator and EUT

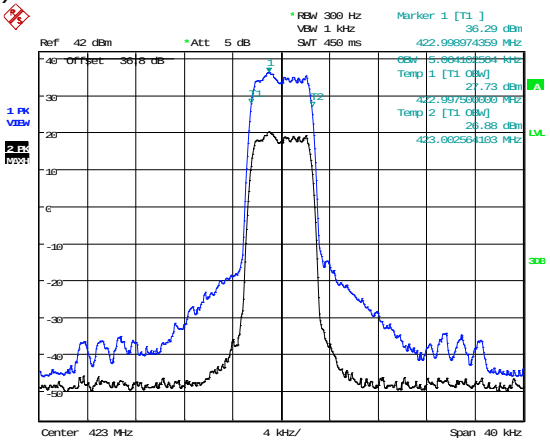


425.0 MHz - Analogue Signal Generator and EUT

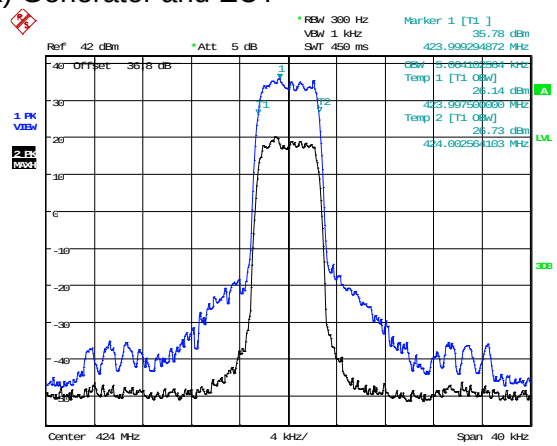


The above plots depicting the output waveshape show no measurable distortion visible when compared to the input signal.

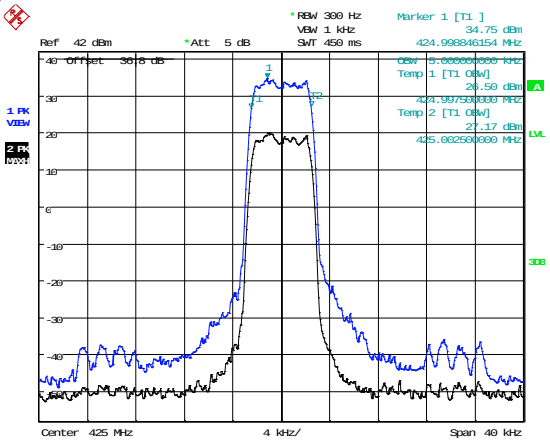
423.0 MHz – P25 (QPSK) Generator and EUT



424.0 MHz - P25 (QPSK) Generator and EUT

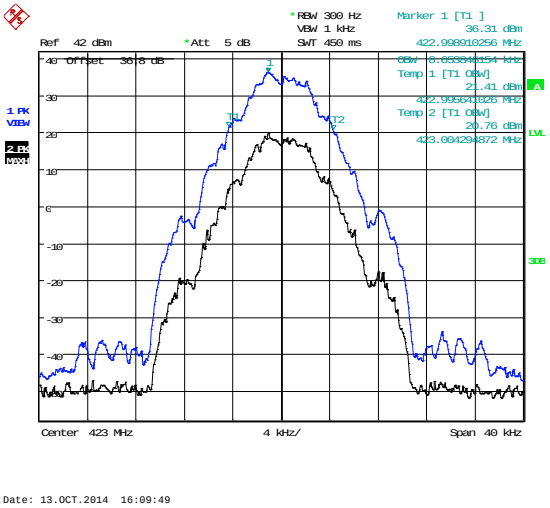


425.0 MHz - P25 (QPSK) Generator and EUT

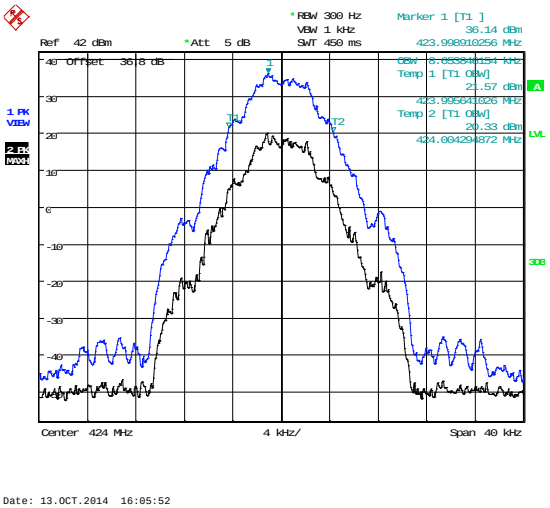


The above plots depicting the output waveshape show no measurable distortion visible when compared to the input signal.

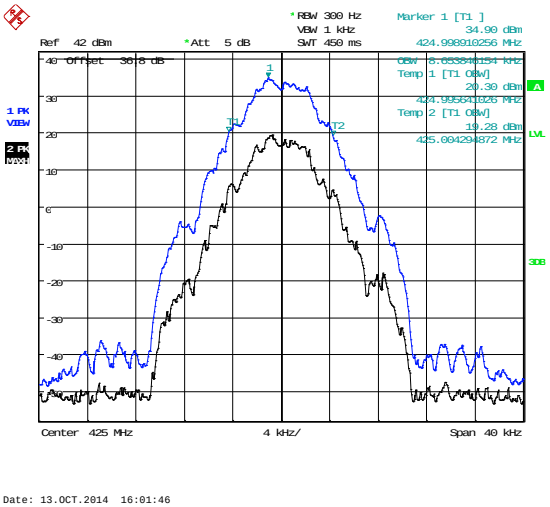
423.0 MHz - P25 (C4FM) Generator and EUT



424.0 MHz - P25 (C4FM) Generator and EUT



425.0 MHz - P25 (C4FM) Generator and EUT



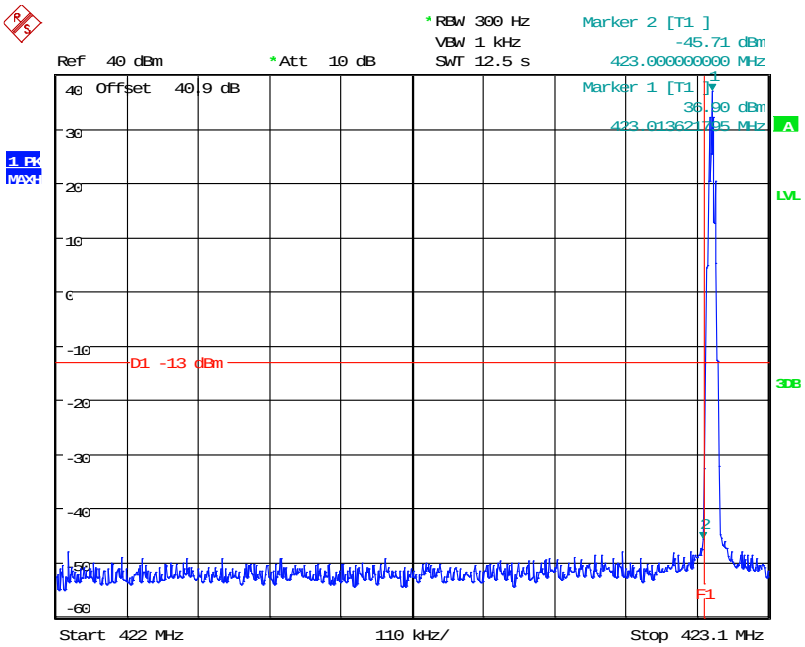
The above plots depicting the output waveshape show no measurable distortion visible when compared to the input signal.

B4 Spurious Emissions at Antenna Terminals Less than 1MHz

Test Details:	
Measurement standard	Part 2.1053, 90.219(e)(3), 90.210(c), 90.210(d) and 90.210(e)
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C

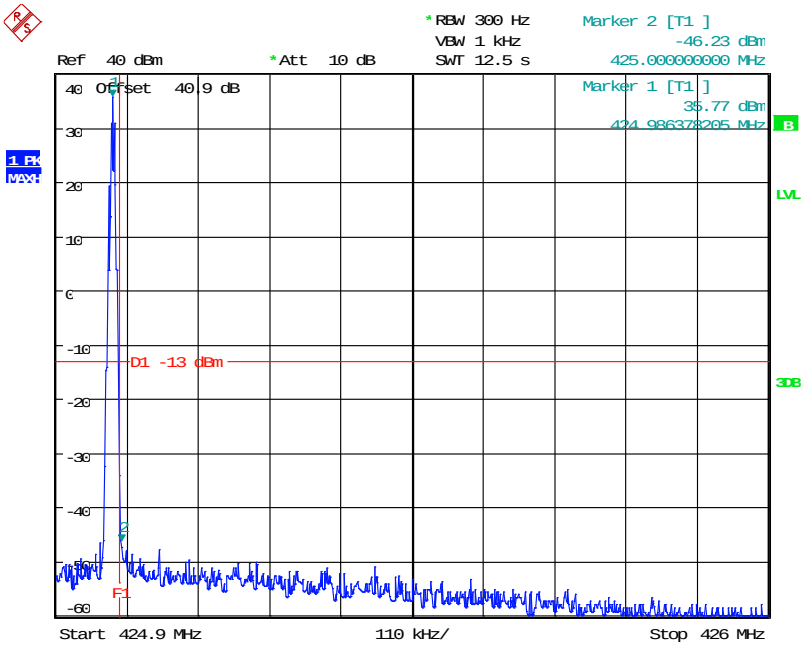
Modulation Type	Bandedge	Carrier Frequency (MHz)	Max Level @ bandedge (dBm)
Analogue	Lower	423.0125	-45.71
	Upper	424.4875	-46.23
P25 (QPSK)	Lower	423.0125	-38.49
	Upper	424.4875	-37.35
P25 (C4FM)	Lower	423.0125	-38.59
	Upper	424.4875	-39.11

Analogue Signal – Lower Bandedge



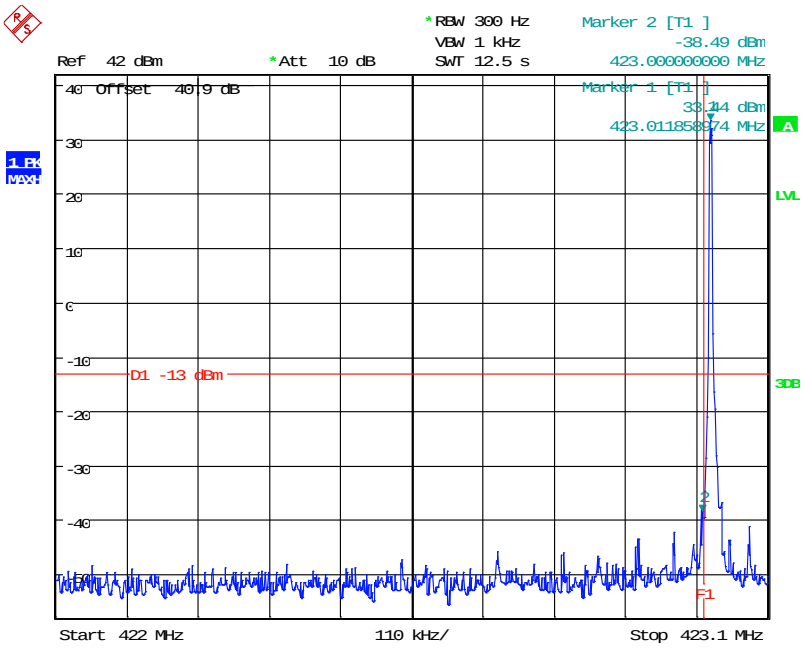
Date: 14.OCT.2014 08:41:32

Analogue Signal – Upper Bandedge



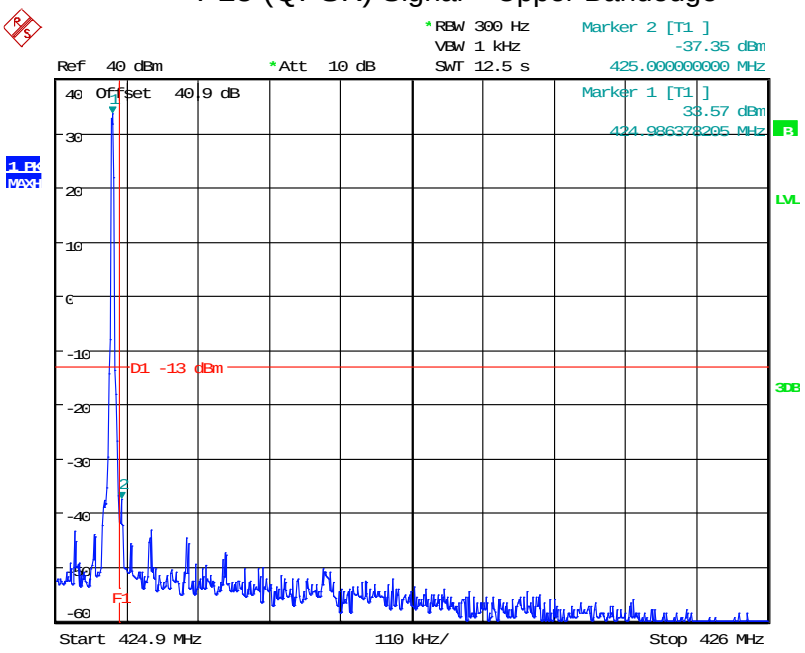
Date: 14.OCT.2014 08:39:58

P25 (QPSK) Signal – Lower Bandedge



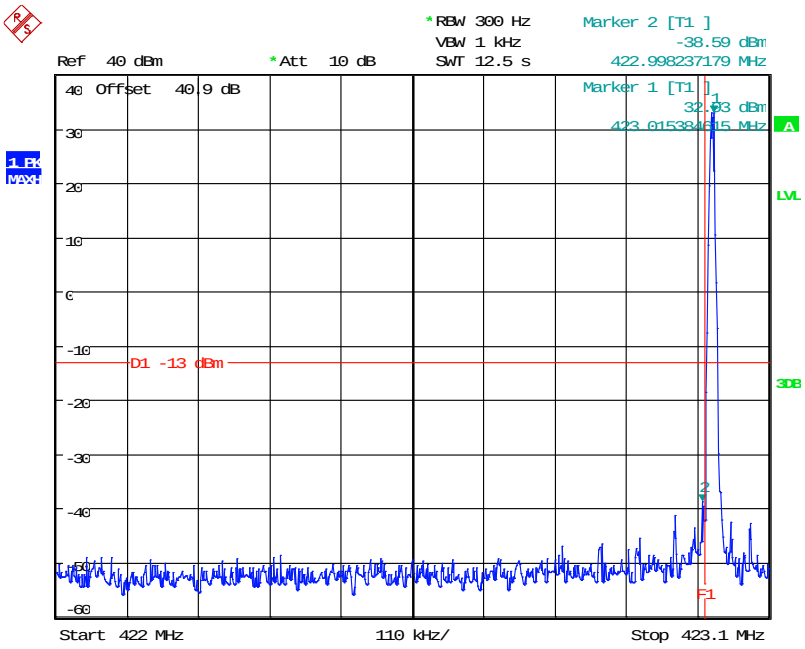
Date: 14.OCT.2014 08:46:35

P25 (QPSK) Signal – Upper Bandedge



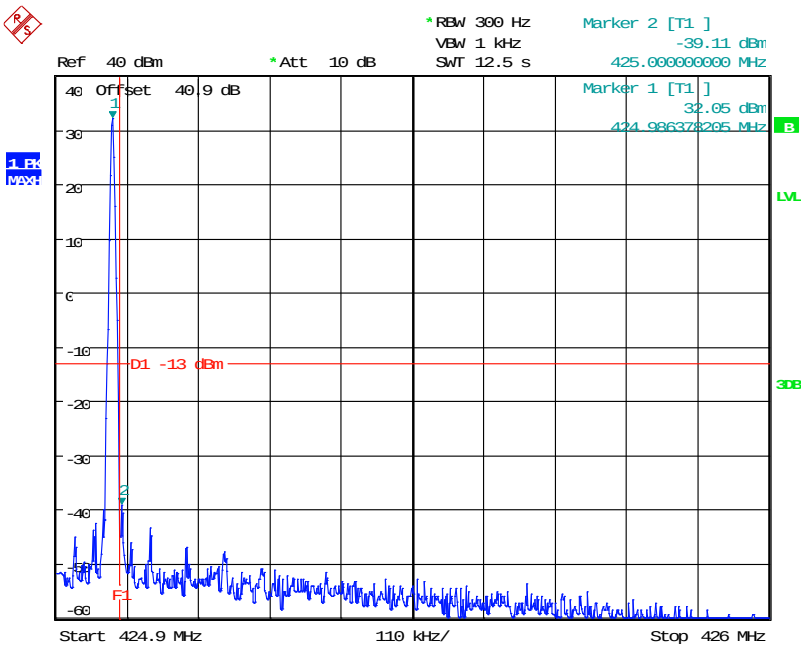
Date: 14.OCT.2014 08:44:20

P25 (C4FM) Signal – Lower Bandedge



Date: 14.OCT.2014 08:48:55

P25 (C4FM) Signal – Upper Bandedge



Date: 14.OCT.2014 08:43:28

B5 Spurious Emissions at Antenna Terminals Greater than 1MHz

Test Details:	
Measurement standard	Part 2.1053, 90.219(e)(3)
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C

Bottom Channel

Frequency Range (MHz)	Freq. of Emission (MHz)	Measured Level (dBm)	Attenuator & Cable Losses (dB)	Spurious Emission Level (dBm)	Limit dBm
9 kHz - 5 GHz	No Significant Emissions Within 20 dB of the Limit				-13

Middle Channel

Frequency Range (MHz)	Freq. of Emission (MHz)	Measured Level (dBm)	Attenuator & Cable Losses (dB)	Spurious Emission Level (dBm)	Limit dBm
9 kHz - 5 GHz	No Significant Emissions Within 20 dB of the Limit				-13

Top channel

Frequency Range (MHz)	Freq. of Emission (MHz)	Measured Level (dBm)	Attenuator & Cable Losses (dB)	Spurious Emission Level (dBm)	Limit dBm
9 kHz - 5 GHz	No Significant Emissions Within 20 dB of the Limit				-13

Limit is determined by the outermost step of the emissions mask and is calculated as follows:

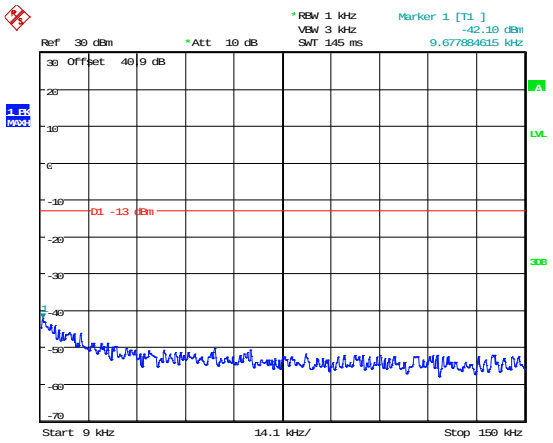
At least 43 + 10 log P dB

$(10\log P_{watts}) - (43+10\log (P_{watts} * 1000)) =$ LIMIT =-13 dBm

Result

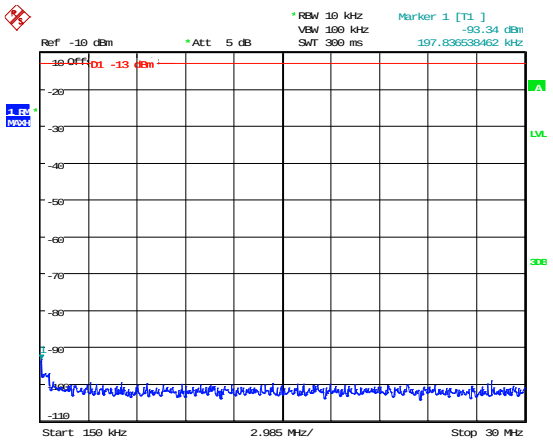
The EUT was found to comply with the limits

Spurious Emissions at Antenna Terminals Greater than 1MHz 423.0 MHz



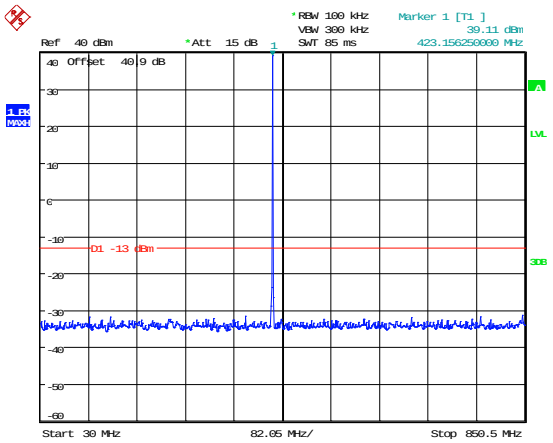
Date: 13.OCT.2014 14:17:22

9kHz -150kHz



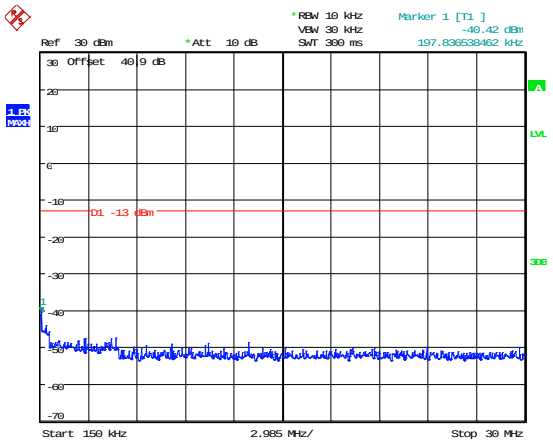
Date: 13.OCT.2014 14:10:37

150kHz – 30MHz



Date: 13.OCT.2014 14:24:46

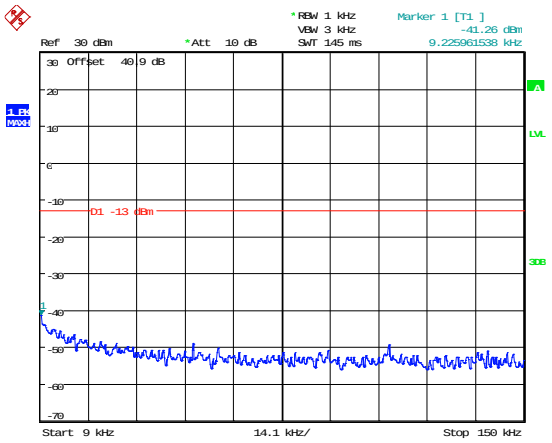
30MHz – 1GHz



Date: 13.OCT.2014 14:18:58

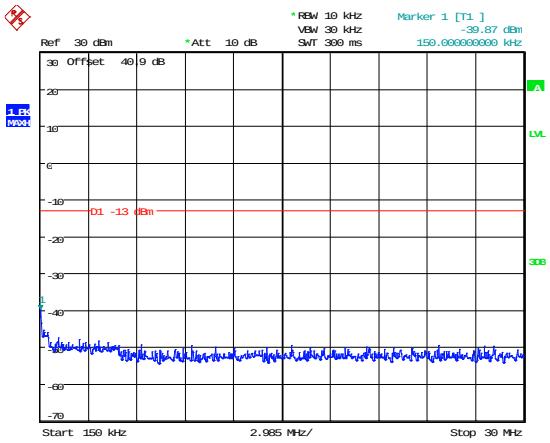
1GHz – 5GHz

Spurious Emissions at Antenna Terminals Greater than 1MHz 424.0 MHz



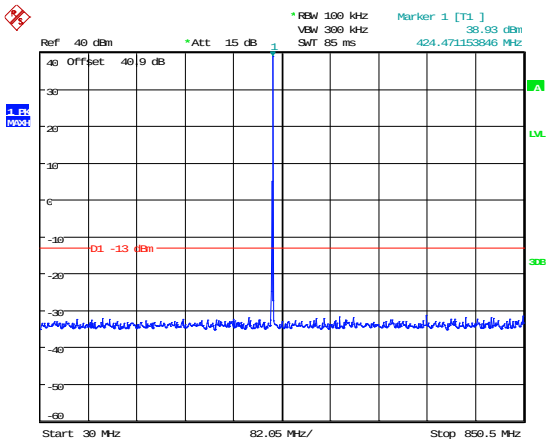
Date: 13.OCT.2014 14:17:38

9kHz -150kHz



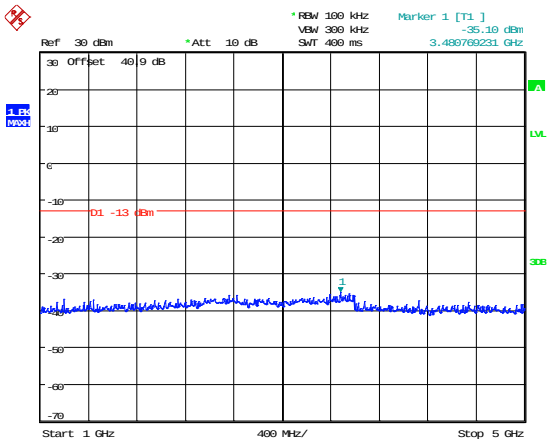
Date: 13.OCT.2014 14:18:39

150kHz – 30MHz



Date: 13.OCT.2014 14:24:35

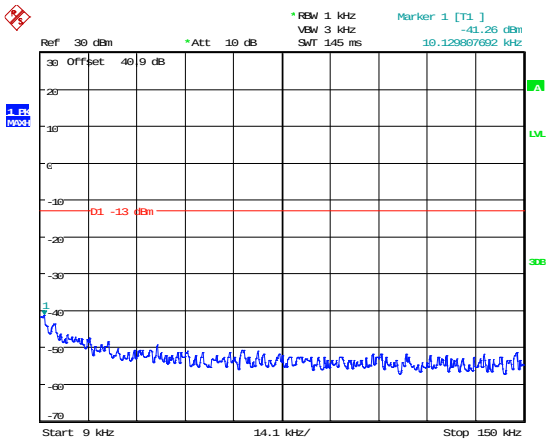
30MHz – 1GHz



Date: 13.OCT.2014 14:16:50

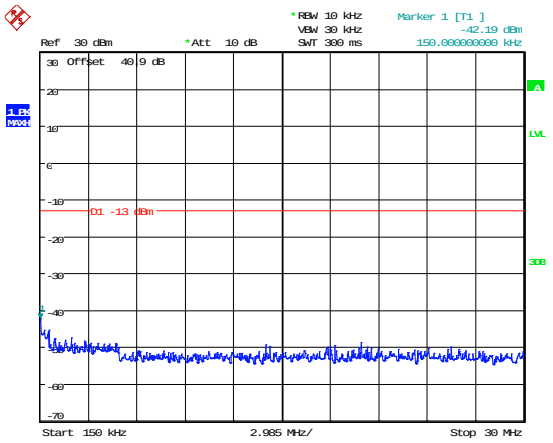
1GHz – 5GHz

Spurious Emissions at Antenna Terminals Greater than 1MHz 425.0 MHz



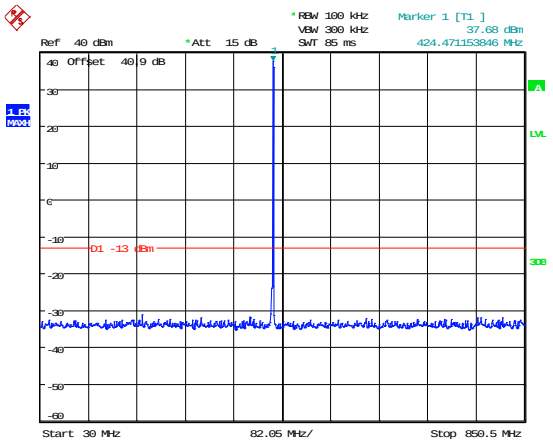
Date: 13.OCT.2014 14:18:09

9kHz -150kHz



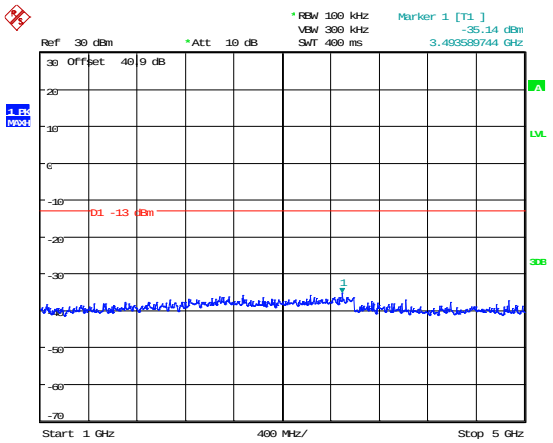
Date: 13.OCT.2014 14:18:24

150kHz – 30MHz



Date: 13.OCT.2014 14:24:23

30MHz – 1GHz



Date: 13.OCT.2014 14:16:37

1GHz – 5GHz

B6 Noise at Antenna Terminals

Test Details:	
Measurement standard	90.219(e)(2), 90.219(e)(3)
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C

Compliance with these levels will be deemed satisfaction of the good engineering practice requirement.

In a 10 kHz measurement bandwidth:

(1) the ERP of noise within the signal booster passband should not exceed –43dBm;

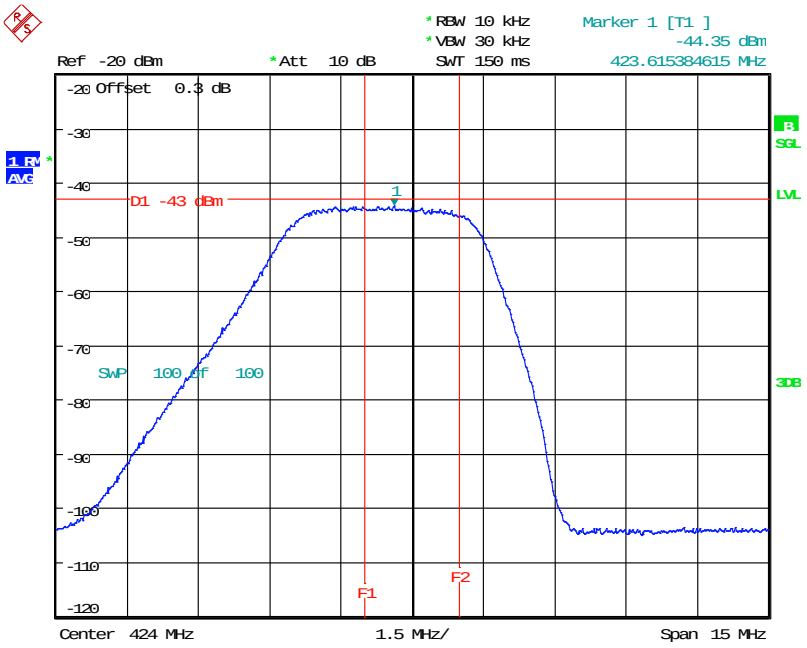
and

(2) the ERP of noise on spectrum more than 1 MHz outside of the signal booster passband should not exceed –70 dBm.

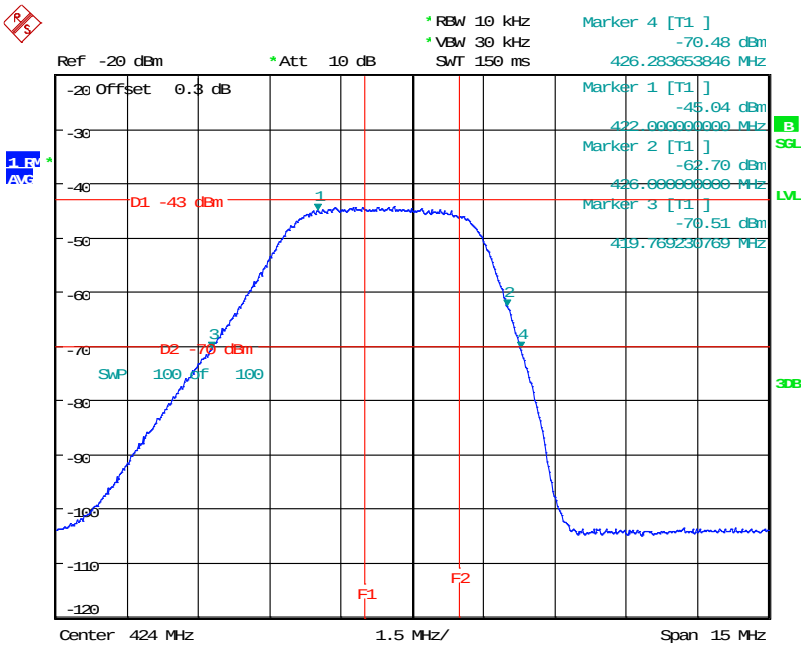
(3) The noise figure of a signal booster must not exceed 9 dB in either direction

See appendix E for declaration of good engineering practice

IN BAND AMPLIFIER NOISE



Date: 14.OCT.2014 15:31:05



Date: 14.OCT.2014 15:32:23

B7 Radiated Electric Field Emissions

Preliminary scans were performed using a peak detector with the RBW = 100kHz. The radiated electric filed emission test applies to all spurious and harmonic emissions . The EUT was set to transmit as required.

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 : [X]

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

Test Details:	
Measurement standard	Title 47 of the CFR: Part 2.1053
Frequency range	30MHz - 5GHz
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Photographs (Appendix F)	1 & 2

Bottom Frequency

FREQUENCY RANGE	FREQ. (MHz)	ERP/EIRP (dBm)	LIMIT (dBm)
30MHz - 5GHz	No Significant Emissions Within 20 dB of Limit		-13

Middle Frequency

FREQUENCY RANGE	FREQ. (MHz)	ERP/EIRP (dBm)	LIMIT (dBm)
30MHz - 5GHz	No Significant Emissions Within 20 dB of Limit		-13

Top Frequency

FREQUENCY RANGE	FREQ. (MHz)	ERP/EIRP (dBm)	LIMIT (dBm)
30MHz - 5GHz	No Significant Emissions Within 20 dB of Limit		-13

Result

The EUT was found to comply with the limits

Notes:

1. Emissions Checked up to 10 times Fc.

2. The unit was mounted on a turntable and rotated through 360^0 and in 3 orthogonal planes to find the worst case emission.

3. For Frequencies below 1 GHz, RBW = 120 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 = ≥RBW

4. Limit is determined as the outermost step of the emissions mask and is calculated as follows.

   At least 43 + 10 log P dB

   $(10\log P_{watts}) - (43+10\log (P_{watts} * 1000)) =$ LIMIT =-13 dBm

The upper and lower frequency of the measurement range was decided according to 47 CFR Part 2.1057.

(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:

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

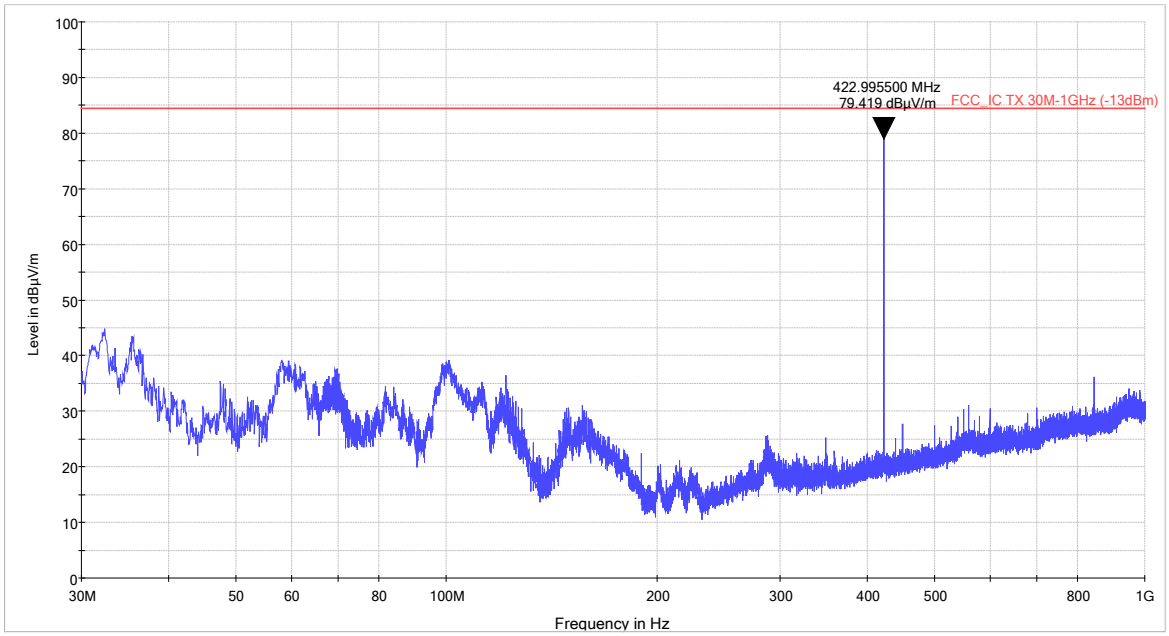
(b) The levels may have been rounded for display purposes.

(c) The following table summarises the effect of the EUT operating mode, internal configuration and arrangement of cables / samples on the measured emission levels :

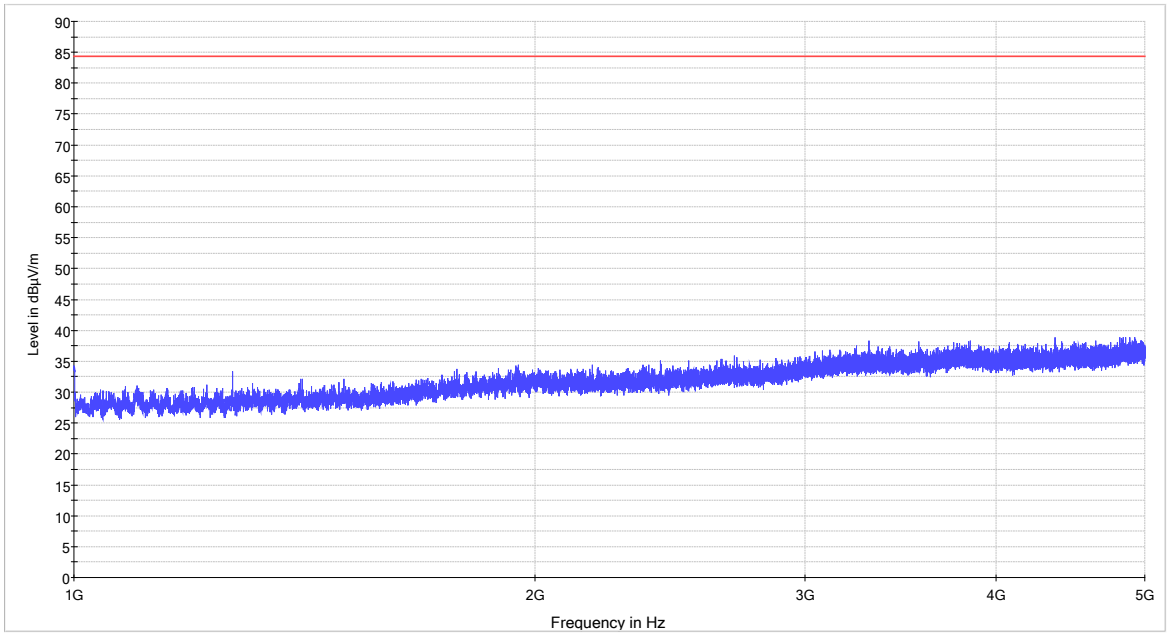
	See (i)	See (ii)	See (iii)	See (iv)
Effect of EUT operating mode on emission levels	✓			
Effect of EUT internal configuration on emission levels	✓			
Effect of Position of EUT cables & samples on emission levels	✓			

(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

Radiated Electric Field Emissions 423.0 MHz

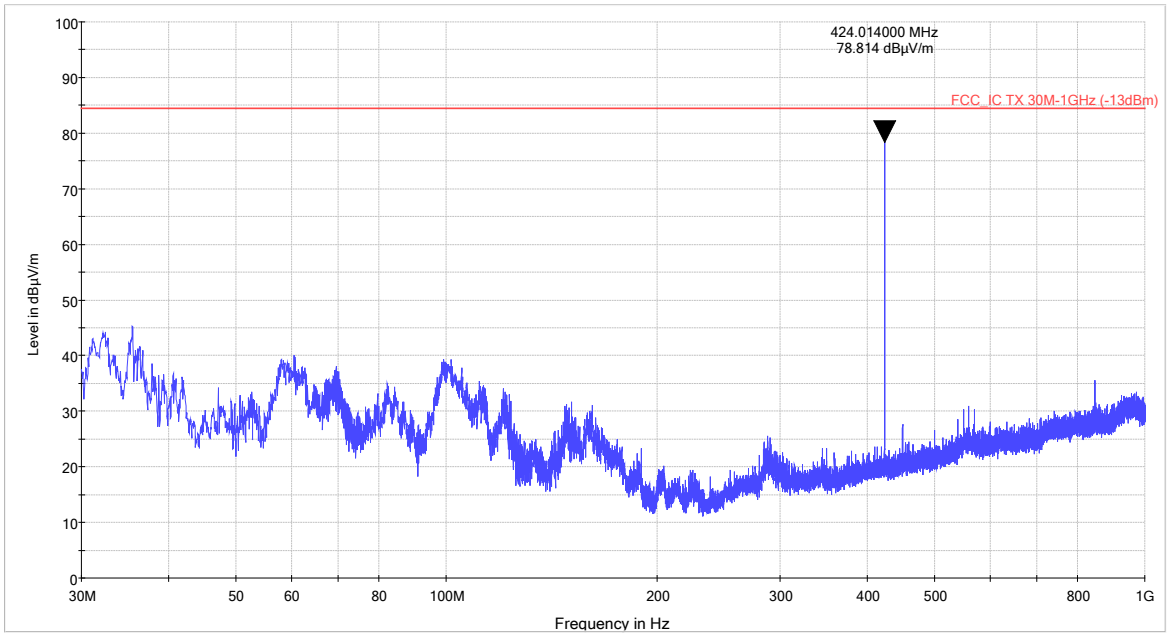


30MHz – 1GHz

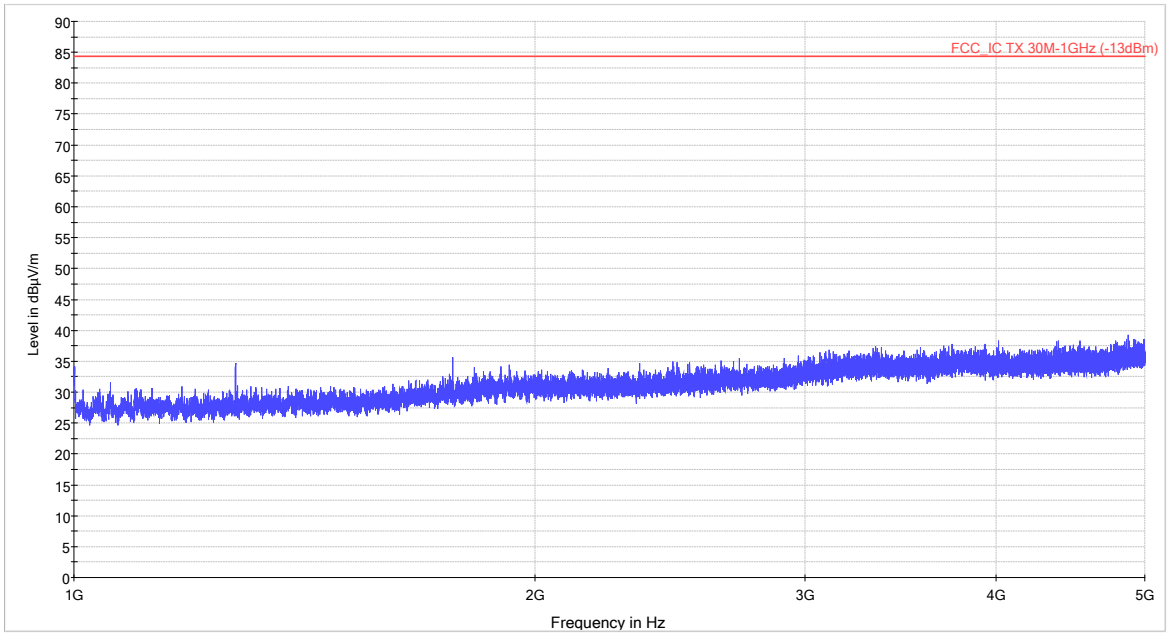


1GHz – 5GHz

Radiated Electric Field Emissions 424.0 MHz

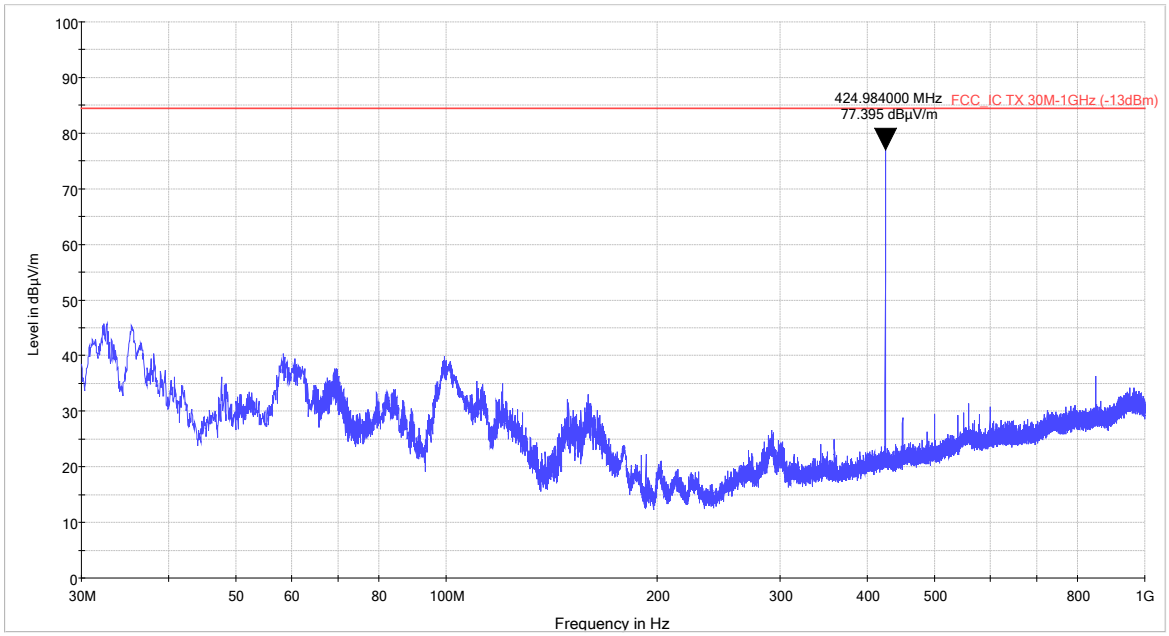


30MHz – 1GHz

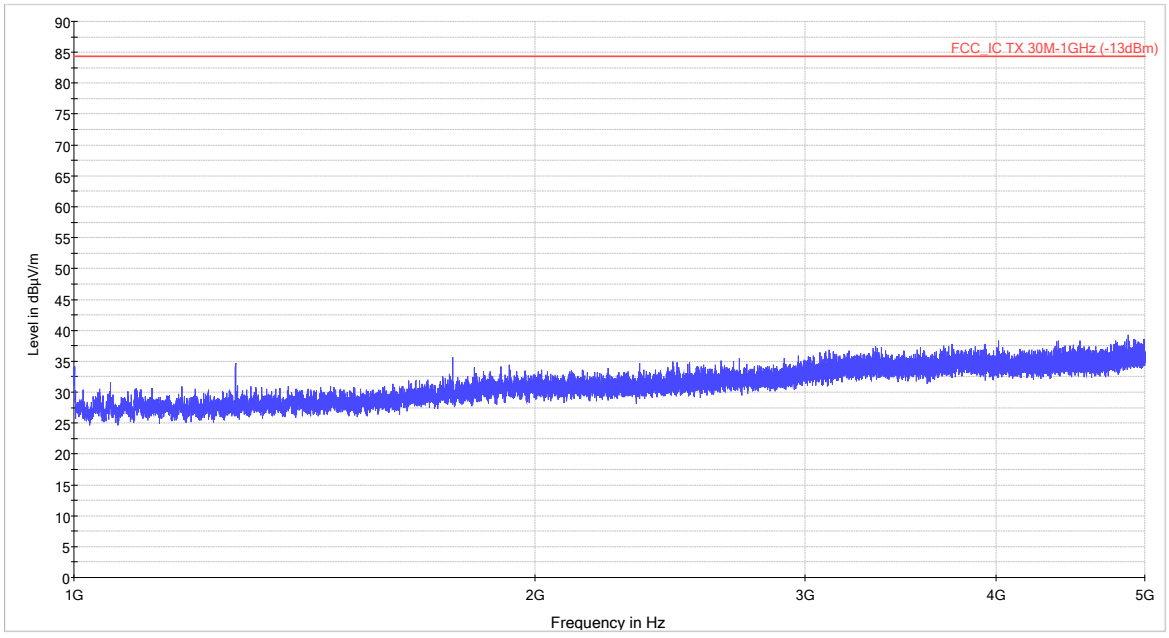


1GHz – 5GHz

Radiated Electric Field Emissions 425.0 MHz



30MHz – 1GHz



1GHz – 5GHz

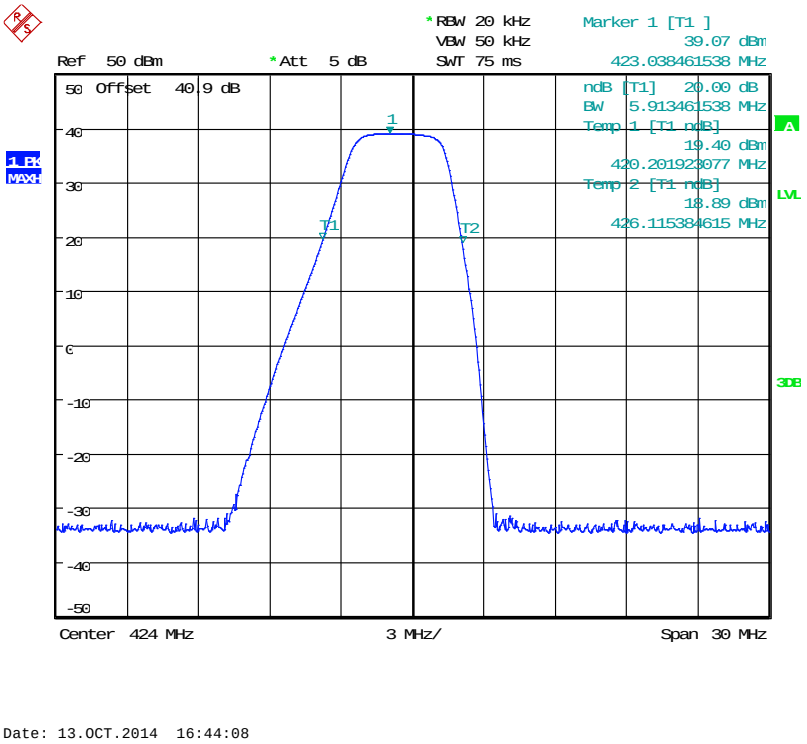
B8 Passband Gain & Bandwidth

Test Details:	
Measurement standard	D.3 Policies + Procedures (k) of KDB 935210 D03 Signal Boosters Certification v02
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C

Frequency MHz	Fl (MHz)	Fh (MHz)	20 dB Bandwidth (kHz)
423.0 – 425.0 MHz	420.201923	426.115384	5.913

2. See below for plots showing passband gain & bandwidth

With the aid of a CW Swept signal generator and spectrum analyser, the bandwidth and frequency response of the passband (i.e. at the point where the gain has fallen by 20 dB) is measured.
This measurement shows the gain-versus-frequency response of the passband from the midband frequency f_0 of the channel up to at least f_0 + 250% of the 20 dB bandwidth.



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 it's 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.

For further details of the test procedures and general test set ups used during testing please refer to the related document "EMC Test Methods - An Overview", which can be supplied by TRaC Global upon request.

C1) Test samples

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

Sample No.	Description	Identification
S01	BSF4004 -48V	BSF0038A/EML8
S02	OMU2-2 1S(0.23-2.2GHZ 2XPS US (ETH	OMU010492/EXND

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	Receiving a signal to ensure EUT is operating a maximum gain and maximum output power.

C3) EUT Configuration Information.

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

C4) List of EUT Ports

The tables below describe the termination of EUT ports:

Sample : S01 & S02
Tests : Conducted

Port	Description of Cable Attached	Cable length	Equipment Connected
Server	Coaxial	>1m	Sig Gen or 50Ω Load
UL1	Coaxial	>1m	Sig Gen or 50Ω Load
DL1	Coaxial	>1m	Sig Gen or 50Ω Load
Power	2x multicore	1m	-48Vdc

Sample : S01 & S02
Tests : Radiated Emissions

Port	Description of Cable Attached	Cable length	Equipment Connected
Server	Coaxial	>1m	Sig Gen or 50Ω Load
UL1	Coaxial	>1m	Sig Gen or 50Ω Load
DL1	Coaxial	>1m	Sig Gen or 50Ω Load
Power	2x multicore	1m	-48Vdc

* Only connected during setup.

C5 Details of Equipment Used

TRaC No	Equipment Type	Equipment Description	Manufacturer	Last Cal Calibration	Calibration Period	Due For Calibration
UH004	ESVS10	Receiver	R&S	27/02/2014	12	27/02/2015
UH028	UHALP 9108	Log Periodic Ant	Schwarbeck	08/07/2013	24	08/07/2015
UH029	VHBA 9123	Bicone Antenna	Schwarbeck	19/08/2013	24	19/08/2015
UH093	CBL6112B	Bilog	Chase	08/07/2013	24	08/07/2015
UH281	FSU46	Spectrum Analyser	R&S	26/03/2014	12	26/03/2015
UH405	FSU26	Spectrum Analyser	R&S	16/04/2014	12	16/04/2015
UH420	CBL6112	Bilog	Chase	25/07/2014	24	25/07/2016
UH456	ESR7	EMI Receiver	R&S	16/04/2014	12	16/04/2015
L138	3115	1-18GHz Horn	EMCO	17/10/2013	24	17/10/2015
L139	3115	1-18GHz Horn	EMCO	20/09/2013	24	20/09/2015
L176	2042	Signal Generator	Marconi	29/11/2013	12	29/11/2014
L254	2042	Signal Generator	Marconi	08/01/2014	12	08/01/2015
L193	VHA 9103 balu	Bicone Antenna	Chase	25/06/2014	24	25/06/2016
L203	UPA6108	Log Periodic Ant	Chase	25/06/2014	24	25/06/2016
L290	CBL611/A	Bilog	Chase	13/12/2012	24	13/12/2014
L352	ESVS10	Receiver	R&S	21/03/2014	12	21/03/2015
L572	8449B	Pre Amp	Agilent	11/02/2014	12	11/02/2015
REF909	FSU26	Spectrum Analyser	R&S	12/02/2014	12	12/02/2015
REF916	SMBV100A	Signal Generator	R&S	19/02/2014	12	19/02/2015
REF940	ATS	Radio Chamber - PP	Rainford EMC	08/09/2014	24	08/09/2016

Appendix D: Additional Information

No additional information is included within this test report.

Appendix E: Good Engineering Information from Manual

Antenna Installation

Installation of an antenna must comply with the FCC RF exposure requirements. The antenna used for this transmitter must be mounted on permanent structures.

The FCC regulation mandate that the ERP of type A signal boosters should not exceed 5W, this is equivalent to 8.2W EIRP.

Therefore the max antenna gain allowed for this type of signal booster should be limited to the values given by equation (1) for the service antenna and equation (2) for the donor antenna

Equation (1) - Max SERVICE antenna gain

Max SERVICE antenna gain (dBi) = 39.1 – (37dBm - # of antennas in dB – cable losses in dB).

For example:

No. of Antennas	Cable Losses	Max Allowed Antenna Gain
4	3	39.1 - (37-6-3) =11.1dBi
1	3	39.1- (37-0-3) = 5.1dbi
10	3	39.1- (37-10-3) = 15.1dbi

Equation (2) - Max DONOR antenna gain

Max DONOR antenna gain (dBi) = 39.1 – (37dBm - cable losses in dB).

For example:

No. of Antennas	Cable Losses	Max Allowed Antenna Gain
1	10	39.1 - (37-10) = 12.1dBi

Compliance with FCC deployment rule regarding the radiation of noise

Good engineering practice must be used in regard to the signal booster's noise radiation. Thus, the gain of the signal booster should be set so that the ERP of the output noise from the signal booster should not exceed the level of -43 dBm in 10 kHz measurement bandwidth.

In the event that the noise level measured exceeds the aforementioned value, the signal booster gain should be decreased accordingly.

In general, the ERP of noise on a spectrum more than 1 MHz outside of the pass band should not exceed -70 dBm in a 10 kHz measurement bandwidth.

The 3604 BSF0038 Series Repeater has a noise level of -45 dBm in 10 kHz measurement at 1 MHz spectrum outside the passband of the signal booster and an *in-band* noise level at around -45 dBm in a 10 kHz bandwidth. Therefore, the noise at the antenna input port should be calculated based on equation (3).

Equation (3) - Input Noise to service antenna

Input Noise to service antenna:

-45 dBm + Service Antenna gain – Antenna splitter losses in dB – cable loss in dB

Example:

Signal booster connected to 20 service antennas with a 100m long ½ inch cable.

Losses of such a cable with the connectors = ~ 12dB

Gain = ~ 2 dBi

Assuming 20 service antennas: antenna splitter losses = 15 dB

Based on equation (3) Input antenna noise (to the antenna) = -45+2-12 -15=-70 dBm

The inband input noise to the antenna should be -45+2 -12-15= -70dbm

NOTE: In this example there is no need to add an external band pass filter to attenuate the out of band noise. If fewer antennas are deployed then additional filtering may be required

Conclusion:

Good engineering practice requires that in general when the out of band noise measured at the service antenna input is more than -70 dBm per 10 kHz measurement bandwidth, an external band pass filter should be added to attenuate the out of band noise level.

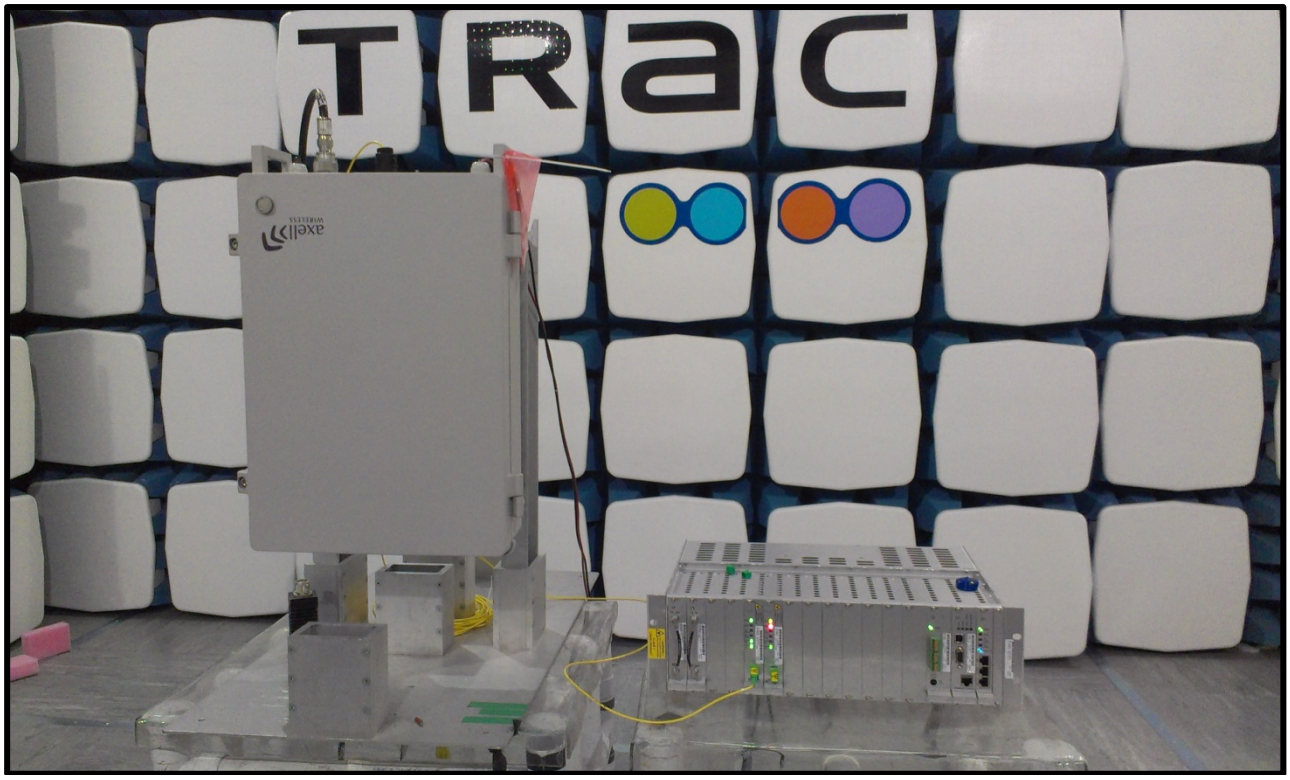
All Axell Wireless repeaters include high selectivity duplexers and filters to attenuate the out of band noise. Should additional filtering be required, we have a comprehensive range of interference filters which can be supplied upon request.

Appendix F: Photographs and Figures

The following photographs were taken of the test samples:

1. Radiated electric field emissions arrangement: BSF4004 Over view.
2. Radiated electric field emissions arrangement: BSF4004 close up.

Photograph 1



Photograph 2

TRAC
testing regulatory and compliance