

Report on the Radio Testing
For
Pace plc
on
DOCSIS 3 HYBRID GATEWAY STB
Report no. TRA-028175-47-00A
2nd December 2015

RF915 2.0



Report Number: TRA-028175-47-00A
Issue: A

REPORT ON THE RADIO TESTING OF A
Pace plc
DOCSIS 3 HYBRID GATEWAY STB
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247

TEST DATE: 1st October - 13th November 2015

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Department Manager - Radio

Date: 2nd December 2015

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- [1] THIS DOCUMENT MAY BE REPRODUCED ONLY IN ITS ENTIRETY AND WITHOUT CHANGE
[2] THE RESULTS CONTAINED IN THIS DOCUMENT RELATE ONLY TO THE ITEM(S) TESTED

RF915 2.0

1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	2nd December 2015	Original

2 Summary

TEST REPORT NUMBER:	TRA-028175-47-00A
WORKS ORDER NUMBER	TRA-028175-00
PURPOSE OF TEST:	USA: Testing of radio frequency equipment per the relevant authorization procedure of chapter 47 of CFR (code of federal regulations) Part 2, subpart J.
TEST SPECIFICATION(S):	47CFR15.247
EQUIPMENT UNDER TEST (EUT):	DOCSIS 3 HYBRID GATEWAY STB
FCC IDENTIFIER:	NQ8ND7506
EUT SERIAL NUMBER:	FN34A152840077
MANUFACTURER/AGENT:	Pace plc
ADDRESS:	Victoria Road Saltair Shipley West Yorkshire BD18 3LF United Kingdom
CLIENT CONTACT:	Robert Turner ☎ 01274 537080 ✉ robert.turner@pace.com
ORDER NUMBER:	Not Applicable
TEST DATE:	1st October - 13th November 2015
TESTED BY:	D Winstanley, A Tosif Element

2.1 Test Summary

Test Method and Description		Requirement Clause 47CFR15	Applicable to this equipment	Result / Note
Radiated spurious emissions (restricted bands of operation and cabinet radiation)		15.205	☒	Pass
AC power line conducted emissions		15.207	☐	Note 1
Occupied bandwidth		15.247(a)(2)	☐	Note 2
Conducted carrier power	Peak	15.247(b)(3)	☐	Note 2
	Max.		☐	
Conducted RF power out-of-band		15.247(d)	☐	Note 2
Power spectral density, conducted		15.247(e)	☐	Note 2
Calculation of duty correction		15.35(c)	☐	N/A

Notes:

1. See Test report TRA-028175-47-06A. AC Power line Conducted emissions were recorded with all radio devices active simultaneously
2. See Test report TRA-028175-47-01A. Emissions from antenna ports are recoded as evidence towards limited modular approval, details of operation and power settings are recorded in the relevant report.
3. Maximum conducted carrier power and power spectral density result for operational modes accounting for antenna array gain are included in this report.

The results contained in this report relate only to the items tested, in the condition at time of test, 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. Any modifications made are identified in Section 8 of this report.

Particular operating modes, apparatus monitoring methods and performance criteria required by the standards tested to have been performed except where identified in Section 5.2 of this test report (Deviations from Test Standards).

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4 Introduction

This report TRA-028175-47-00A presents the results for radiated emissions and conducted measurements accounting for directional gain of antennas for the 2.4 GHz WiFi Radio testing on a Pace plc, DOCSIS 3 HYBRID GATEWAY STB to specification 47CFR15 Radio Frequency Devices

The testing was carried out for Pace plc by Element, at the address(es) detailed below.

☐	Element Hull Unit E South Orbital Trading Park Hedon Road Hull HU9 1NJ UK	☒	Element Skelmersdale Unit 1 Pendle Place Skelmersdale West Lancashire WN8 9PN UK
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This report details the configuration of the equipment, the test methods used and any relevant modifications where appropriate.

All test and measurement equipment under the control of the laboratory and requiring calibration is subject to an established programme and procedures to control and maintain measurement standards. The quality management system meets the principles of ISO 9001, and has quality control procedures for monitoring the validity of tests undertaken. Records and sufficient detail are retained to establish an audit trail of calibration records relating to its test results for a defined period. Under control of the established calibration programme, key quantities or values of the test & measurement instrumentation are within specification and comply with the relevant traceable internationally recognised and appropriate standard specifications, which are UKAS calibrated as such where these properties have a significant effect on results. Participation in inter-laboratory comparisons and proficiency testing ensures satisfactory correlation of results conform to Elements own procedures, as well as statistical techniques for analysis of test data providing the appropriate confidence in measurements.

Throughout this report EUT denotes equipment under test.

FCC Site Listing:

Element is accredited for the above sites under the US-EU MRA, Designation number UK0009.

The test site requirements of ANSI C63.4-2014 are met up to 1GHz.

The test site SVSWR requirements of CISPR 16-1-4:2010 are met over the frequency range 1 GHz to 18 GHz.

5 Test Specifications

5.1 Normative References

- FCC 47 CFR Ch. I – Part 15 – Radio Frequency Devices.
- ANSI C63.10-2013 – American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.
- ANSI C63.4-2014 – American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
- Industry Canada RSS-210, Issue 8, December 2010 – Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment.
- Industry Canada RSS-Gen, Issue 4, November 2014 – General Requirements for Compliance of Radio Apparatus

5.2 Deviations from Test Standards

There were no deviations from the test standard.

6 Glossary of Terms

§	denotes a section reference from the standard, not this document
AC	Alternating Current
ANSI	American National Standards Institute
BW	bandwidth
C	Celsius
CFR	Code of Federal Regulations
CW	Continuous Wave
dB	decibel
dBm	dB relative to 1 milliwatt
DC	Direct Current
DSSS	Direct Sequence Spread Spectrum
EIRP	Equivalent Isotropically Radiated Power
ERP	Effective Radiated Power
EUT	Equipment Under Test
FCC	Federal Communications Commission
FHSS	Frequency Hopping Spread Spectrum
Hz	hertz
IC	Industry Canada
ITU	International Telecommunication Union
LBT	Listen Before Talk
m	metre
max	maximum
MIMO	Multiple Input and Multiple Output
min	minimum
MRA	Mutual Recognition Agreement
N/A	Not Applicable
PCB	Printed Circuit Board
PDF	Portable Document Format
Pt-mpt	Point-to-multipoint
Pt-pt	Point-to-point
RF	Radio Frequency
RH	Relative Humidity
RMS	Root Mean Square
Rx	receiver
s	second
SVSWR	Site Voltage Standing Wave Ratio
Tx	transmitter
UKAS	United Kingdom Accreditation Service
V	volt
W	watt
Ω	ohm

7 Equipment Under Test

7.1 EUT Identification

- Name: DOCSIS 3 HYBRID GATEWAY STB
- Serial Number: FN34A152840077
- Model Number: ND7506
- Build Revision

260-2251000	Layer 3 TV DDR3 Main Board Assembly
262-2227000	Layer 3 TV Server Front Panel assembly
260-2264000	PCA 2.4G WIFI MODULE
260-E397020	PCA 5G WIFI
- Software Version

Video Soc

BootLoader: CBL v1.74

Firmware version: v1.161

Bluetooth Driver version: BCM20705B0_002.001.014.0590.0927

CableModem

CM Bootloader : v1.144

CM App: v1.144-ltw

7.2 System Equipment

Equipment listed below forms part of the overall test setup and is required for equipment functionality and/or monitoring during testing. The compliance levels achieved in this report relate only to the EUT and not items given in the following list.

- Name: HDMI HDCP Ready Unit
- Sample Number: S03
- Serial Number: DP2012110417
- Model Number: None

- Name: Arris Cadant C3 CMTS
- Sample Number: S04
- Serial Number: 65000181-002109
- Model Number: None

- Name: PX031ECB Box
- Sample Number: S05
- Serial Number: PADA00015189
- Model Number: None

- Name: Dell Latitude Laptop
- Sample Number: S06
- Serial Number: SAL-17646
- Model Number: D430

- Name: Dell Latitude Laptop
- Sample Number: S07
- Serial Number: PACE0000019241
- Model Number: E6400

- Name: AOC 4K Television
- Sample Number: TRA-024769S07
- Serial Number: HCXE8JA002064
- Model Number: None

7.3 EUT Mode of Operation

7.3.1 Radiated Transmission

The EUT was under the control of test software named 'digdebug' which when run exercised the EUT in its worst case configuration. While the test was running the EUT was decoding AV (audio visual) data from a MOCA (Multimedia over Coax Alliance) stream and then displaying it via HDMI at 2160p resolution. The EUT was connected to a DOCSIS head end. The HDD of the EUT was also active, with data being written to it and then read back. An internal SD card was inserted in order that the SD card TX and RX clock lines (50MHz) were active. A source playing HD AV was connected to the HDMI input of the EUT. Both USB ports were connected to USB 3.0 memory sticks. All other ports were terminated appropriately.

Wifi transmitter control was via commands sent through a terminal program (Tera Term in this case). The commands provided by the manufacturer setup the device into a permanent transmit mode. The commands allowed adjustment of the following parameters of significant interest.

Modulation Scheme	Channel	Power setting	Data Rate	Transmit Chain Setting
802.11b	1	90	11 mbps	txchain 7
	6	84	11 mbps	txchain 7
	11	82	11 mbps	txchain 7
802.11 g	1	78	54 mbps	txchain 7
	6	103	54 mbps	txchain 7
	11	74	54 mbps	txchain 7
802.11n HT20	1	73	MCS7	txchain 7
	6	107	MCS7	txchain 7
	11	75	MCS7	txchain 7
802.11n HT40	3	66	MCS23	txchain 7
	6	80	MCS23	txchain 7
	9	59	MCS23	txchain 7

7.3.2 Conducted Transmission – Accounting for directional gain of antennas

WiFi transmitter control was via commands sent through a terminal program (Tera Term in this case). The commands provided by the manufacturer setup the device into a permanent transmit mode. The commands allowed adjustment of the following parameters of significant interest. As required by the specification correction of the applicable limit is required if the directional array gain exceeds the specified limit.

Modulation Scheme	Channel	Power setting	Data Rate	Transmit Chain Setting
802.11n HT20	1	90	MCS7	txchain 1, txchain 2, txchain 4
	6	93	MCS7	txchain 1, txchain 2, txchain 4
	11	93	MCS7	txchain 1, txchain 2, txchain 4
802.11n HT40	3	88	MCS23	txchain 1, txchain 2, txchain 4
	6	91	MCS23	txchain 1, txchain 2, txchain 4
	9	91	MCS23	txchain 1, txchain 2, txchain 4

txchain 1 : Chain 0 only

txchain 2 : Chain 1 only

txchain 4 : Chain 2 only

txchain 7 : Chains 0, 1 and 2 simultaneously

Where applicable only the selected chain under test is active, unused chains are terminated in a load.

7.3.3 Reception

This report covers transmitter operation only, results for unintentional emissions can be found in test report TRA-028175-44-00A

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	2400 – 2483.5 MHz
Modulation type(s):	DSSS, OFDM
Occupied channel bandwidth(s):	20 MHz – 40 MHz
Channel spacing:	5 MHz
Declared output power(s):	Up to 1 Watt (conducted)
Warning against use of alternative antennas in user manual (yes/no):	Not Applicable
Nominal Supply Voltage:	110 Vac
Location of notice for license exempt use:	Label / user manual / both.
Duty cycle:	Upto 100 %

7.4.2 Product specific declarations

Multiple antenna configuration(s), e.g. MIMO:	MIMO
Fixed pt-pt operations (yes/no):	No
Installation manual advice on pt-pt operational restrictions (yes/no):	Not Applicable
Fixed pt-mpt operations (yes/no):	Not Applicable
Simultaneous tx (yes/no):	Yes

7.4.3 Antennas

Type:	Omni directional/polarity Antennas, except the Bluetooth and Front Low band - PCB style
Frequency range:	2400 – 2483.5 MHz
Impedance:	50 Ohms
Gain:	See chart
Polarisation:	Omni
Beam width:	Not Applicable
Connector type:	U-FL
Mounting:	Case Mounted

	Freq (MHz)	Peak Gain	Directivity	Efficiency
Left LB	2400	3.16	5.26	61.69 %
	2450	2.82	5.32	56.27 %
	2500	2.88	5.94	49.37 %
	Average			55.78 %

	Freq (MHz)	Peak Gain	Directivity	Efficiency
Front LB	2400	4.639	6.418	66.40 %
	2450	4.166	6.123	63.72 %
	2500	4.507	6.462	63.75 %
	Average			64.62 %

	Freq (MHz)	Peak Gain	Directivity	Efficiency
Right LB	2400	4.050	5.672	68.83 %
	2450	4.188	5.889	67.59 %
	2500	3.798	5.933	61.17 %
	Average			65.86 %

7.4.4 Unequal Array Gain with Equal Transmit Powers

Let the antenna gains be designated by $G_1, G_2, \dots, G_N$ dBi:

If transmit signals are correlated, then

$$\text{Directional gain} = 10 \log (10^{G_1/20} + 10^{G_2/20} + \dots + 10^{G_N/20}) \text{ ANT dBi}$$

Based on the antenna gain figures above provided by the manufacturer directional gain figures and correction are as follows

Channel	Bottom	Middle	Top
Direction Gain of Antenna	8.74	8.52	8.52
Exceeds 6 dBi ?	Yes	Yes	Yes
Exceeds 6 dBi by	2.74	2.52	2.52

7.5 EUT Description

The EUT is a DOCSIS 3 Gateway, delivering broadband to the home via Ethernet or 2.4GHz Wi-Fi. The Gateway is capable of taking IP sourced video streams and displaying them on a TV via HDMI 2, Component and CVBS. It can connect to client boxes, routing video to up to three additional rooms within the home. Primary connection to the clients is via 5GHz Wi-Fi (802.11ac) but the client can also be connected via MOCA or Ethernet. Bluetooth is implemented on the Gateway to provide the option to connect to a smart remote control.

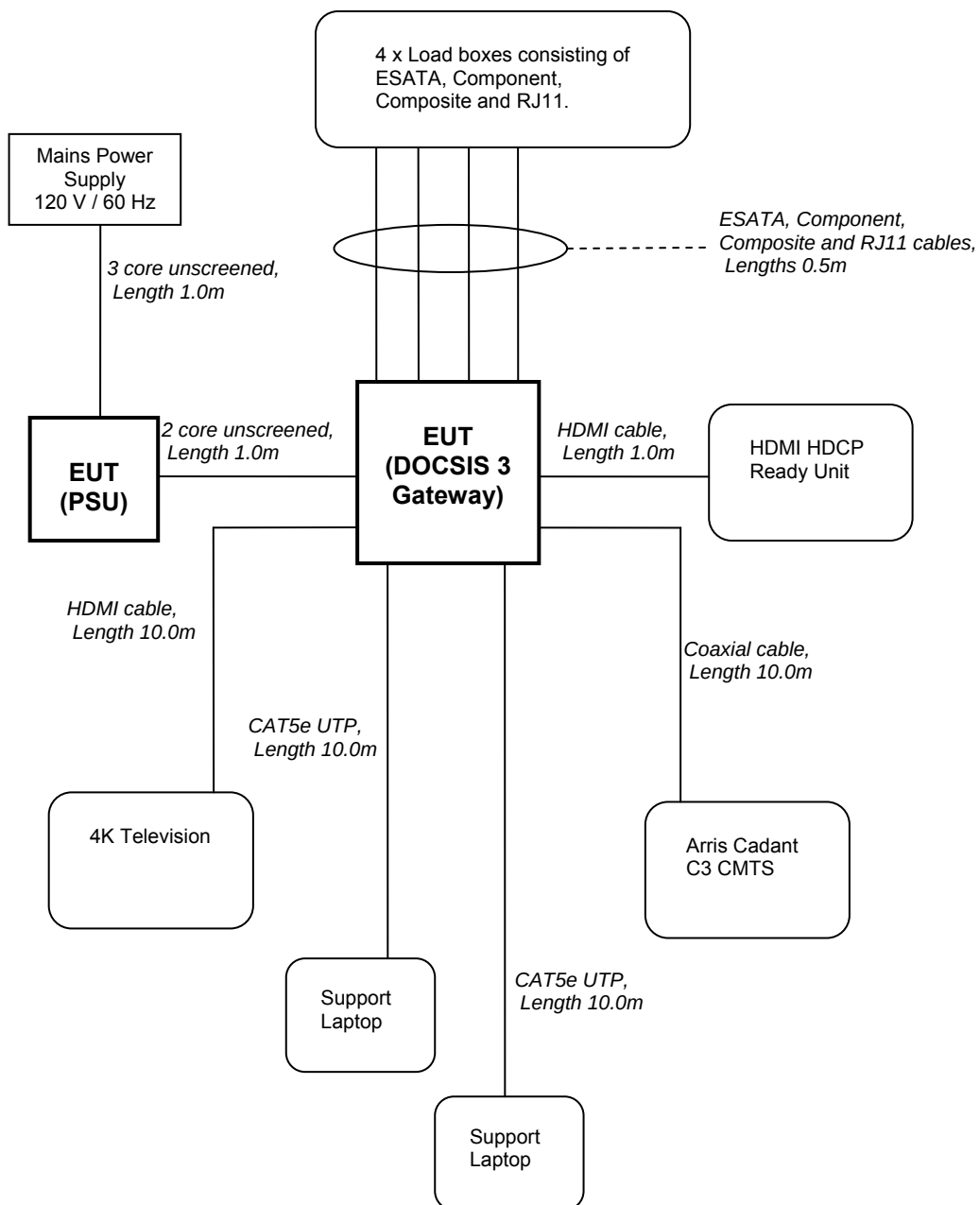
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

9.1 Block Diagram

The following diagram shows basic EUT interconnections with cable type and cable lengths identified:



10 General Technical Parameters

10.1 Normal Conditions

The E U T was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was approx. 5 V dc from the adaptor / 110 V ac, 60 Hz, from the mains.

10.2 Varying Test Conditions

There are no specific frequency stability requirements for the type of device. The results contained in this report demonstrate that the occupied bandwidth is contained within the authorised band and the manufacturer has declared sufficient frequency stability (refer to section 7.4).

Variation of supply voltage is required to ensure stability of the declared output power. During carrier power testing the following variations were made:

	Category	Nominal	Variation
☒	Mains	110 V ac +/-2 %	85 % and 115 %
☐	Battery	New battery	N/A

11 Radiated emissions

11.1 Definitions

Spurious emissions

Emissions on a frequency or frequencies, which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

Restricted bands

A frequency band in which intentional radiators are permitted to radiate only spurious emissions but not fundamental signals.

11.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Chamber (REF940)
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Channels / Frequencies Measured:	2412 MHz / 2437 MHz / 2462 MHz
EUT Channel Bandwidths:	20 MHz / 40 MHz
Deviations From Standard:	None
Measurement BW:	30 MHz to 1 GHz: 120 kHz Above 1 GHz: 1 MHz
Measurement Detector:	Up to 1 GHz: quasi-peak Above 1 GHz: RMS average and Peak

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 °C to +35 °C (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 110V ac	230 V ac ± 10 % (as declared)

11.3 Test Limit

Unwanted emissions that fall within the restricted frequency bands shall comply with the limits specified:

General Field Strength Limits for License-Exempt Transmitters at Frequencies above 30 MHz

Frequency (MHz)	Field Strength ($\mu\text{V/m}$ at 3 m)
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

11.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure i, the emissions from the EUT were measured on a spectrum analyzer / EMI receiver.

Radiated electromagnetic emissions from the EUT are checked first by preview scans. Preview scans for all spectrum and modulation characteristics are checked, using a peak detector and where applicable worst-case determined for function, operation, orientation, etc. for both vertical and horizontal polarisations. Pre-scan plots are shown with a peak detector and 100 kHz RBW.

If the EUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.10 are followed. Alternatively, a layout closest to normal use (as declared by the provider) is employed, (see EUT setup photographs for more detail).

Emissions between 30 MHz and 1 GHz are measured using calibrated broadband antennas. Emissions above 1 GHz are characterized using standard gain horn antennas. Pre-amplifiers and filters are used where required. Care is taken to ensure that test receiver resolution bandwidth, video bandwidth and detector type(s) meet the regulatory requirements.

For both horizontal and vertical polarizations, the EUT is then rotated through 360 degrees in azimuth until the highest emission is detected. At the previously determined azimuth the test antenna is raised and lowered from 1 to 4 m in height until a maximum emission level is detected, this maximum value is recorded.

Power values measured on the test receiver / analyzer are converted to field strength, FS, in dBµV/m at the regulatory distance, using:

$$FS = PR + CL + AF - PA + DC - CF$$

Where,

PR is the power recorded on the receiver / spectrum analyzer in dBµV;

CL is the cable loss in dB;

AF is the test antenna factor in dB/m;

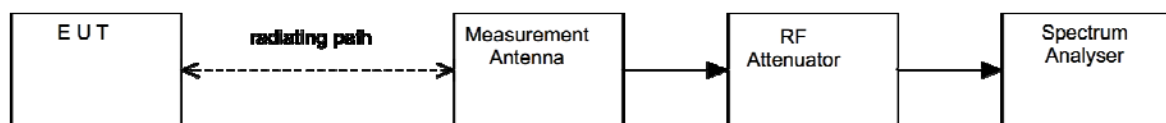
PA is the pre-amplifier gain in dB (where used);

DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);

CF is the distance factor in dB (where measurement distance different to limit distance);

This field strength value is then compared with the regulatory limit.

Figure i Test Setup



11.5 Test Equipment

<i>Type of Equipment</i>	<i>Maker/Supplier</i>	<i>Model Number</i>	<i>Element Number</i>	<i>Calibration Due Date</i>
Bilog	Chase	CBL611/A	UH191	26/02/2017
ESVS10	R&S	ESVS10	L352	07/08/2016
Spectrum Analyser	R&S	FSU26	REF909	13/02/2016
Horn Antenna	EMCO	3115	L139	20/09/2015
Pre-Amplifier	Agilent	8449B	L572	10/02/2016
Horn Antenna	Flann	20240-20	L300	10/02/2016
Horn Antenna	Flann	22240-20	L301	Note 1
BandStop Filter (2.4GHz)	BSC	SN 4478	U543	23/08/2017
BandStop Filter (5.15 - 5.35 GHz)	BSC	SN4832	REF841	Cal in use
BandStop Filter (5.725 - 5.875 GHz)	BSC	SN 4834	REF843	Cal in use

ANSI C63.10 - 4.4.3 a) Antenna calibration

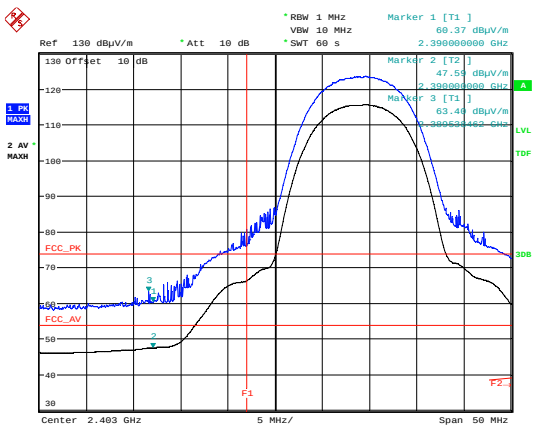
Standard gain horns need not be periodically recalibrated, unless damage or deterioration is suspected or known to have occurred. If a standard gain horn is not periodically recalibrated, then its critical dimensions (see IEEE Std 1309-2005) shall be verified and documented on an annual basis

11.6 Test Results

Modulation: 802.11b; Data rate: 11Mbps – 2412 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
Pk	4823.90	62.2	5.2	33.1	35.9	0.00	0.00	64.6	1690.44	5012
Av	4823.90	50.8	5.2	33.1	35.9	0.00	0.00	53.1	453.94	500
Pk	2490.65	67.5	3.0	28.3	36.1	0.00	0.00	62.7	1363.01	5012
Av	2490.65	55.4	3.0	28.3	36.1	0.00	0.00	50.6	337.68	500

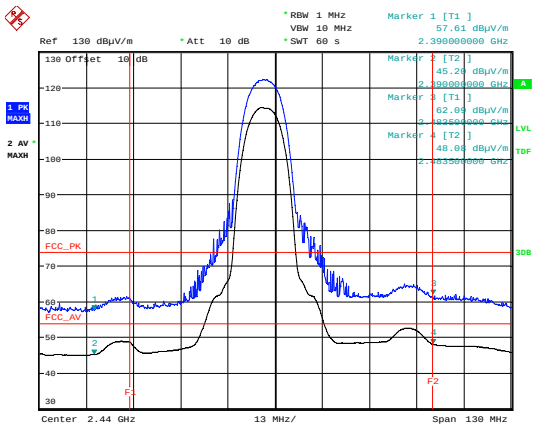
Modulation: 802.11b; Data rate: 11Mbps – 2437 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
Pk	4873.98	62.4	5.2	33.3	35.9	0.00	0.00	65.0	1774.19	5012
Av	4873.98	50.8	5.2	33.3	35.9	0.00	0.00	53.4	468.81	500

Modulation: 802.11b; Data rate: 11Mbps – 2462 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
Pk	4923.88	61.6	5.1	33.4	35.9	0.00	0.00	64.2	1629.30	5012
Av	4924.88	50.8	5.1	33.4	35.9	0.00	0.00	53.5	470.44	500
Pk	2382.60	68.7	3.0	28.2	36.2	0.00	0.00	63.7	1536.38	5012
Av	2382.60	56.9	3.0	28.2	36.2	0.00	0.00	51.9	395.37	500



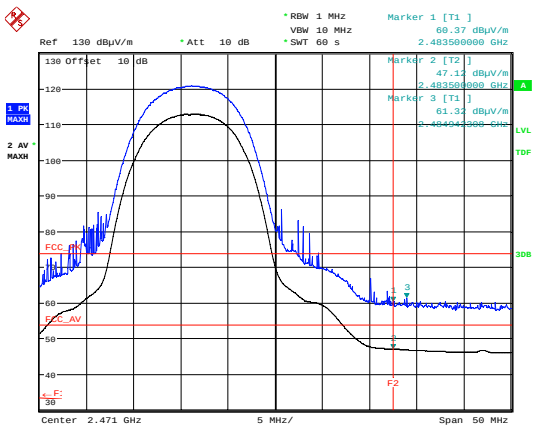
Date: 14.OCT.2015 11:04:59

Modulation: 802.11b; Data rate: 11Mbps – 2412 MHz



Date: 14.OCT.2015 10:58:54

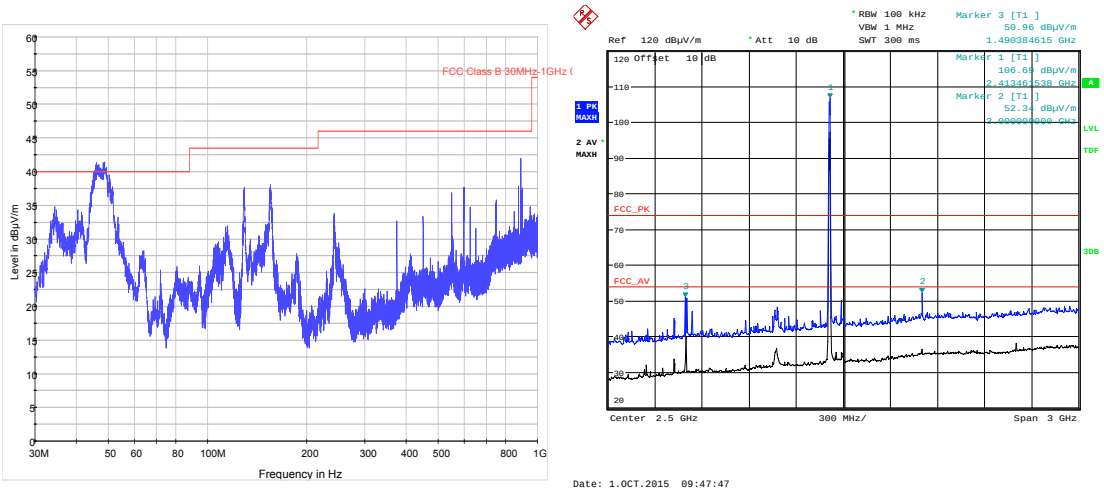
Modulation: 802.11b; Data rate: 11Mbps – 2437 MHz



Date: 14.OCT.2015 11:06:59

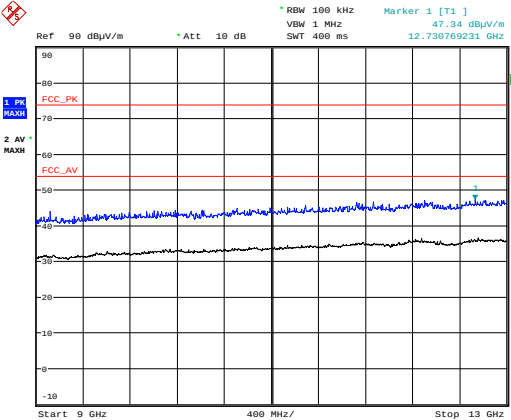
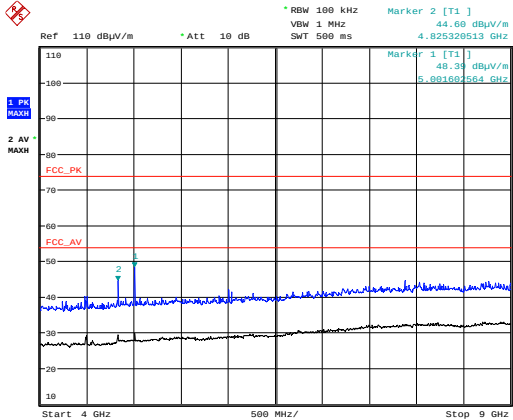
Modulation: 802.11b; Data rate: 11Mbps – 2462 MHz

Modulation: 802.11b; Data rate: 11Mbps – 2412 MHz



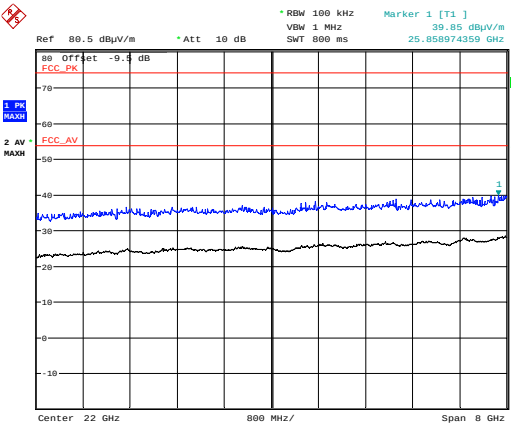
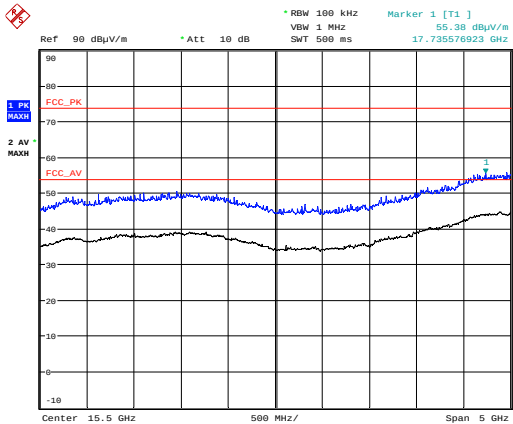
30 MHz – 1 GHz

1 GHz – 4 GHz



4 GHz – 9 GHz

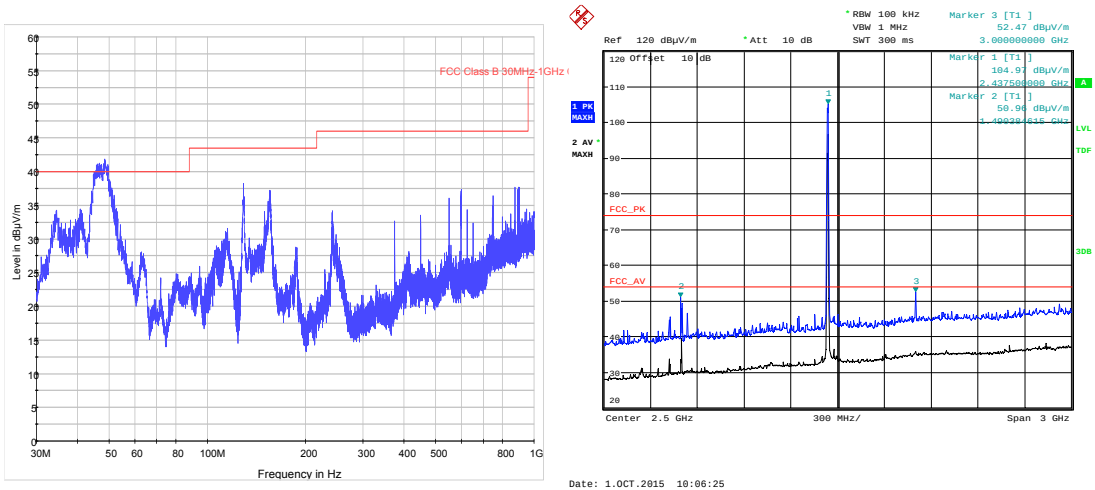
9 GHz – 13 GHz



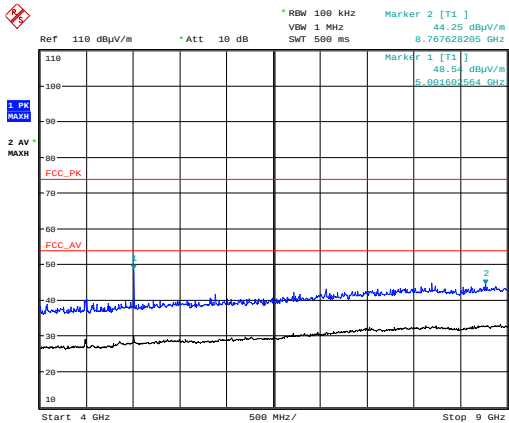
13 GHz – 18 GHz

18 GHz – 25 GHz

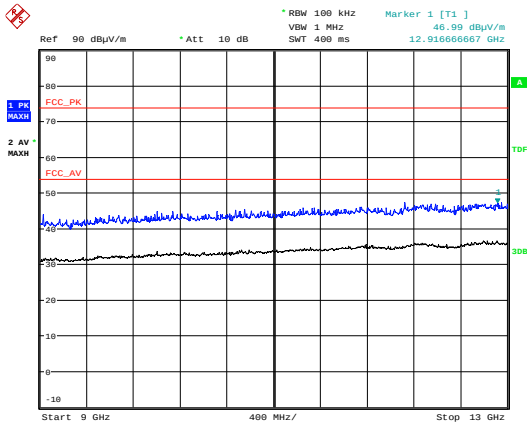
Modulation: 802.11b; Data rate: 11Mbps – 2437 MHz



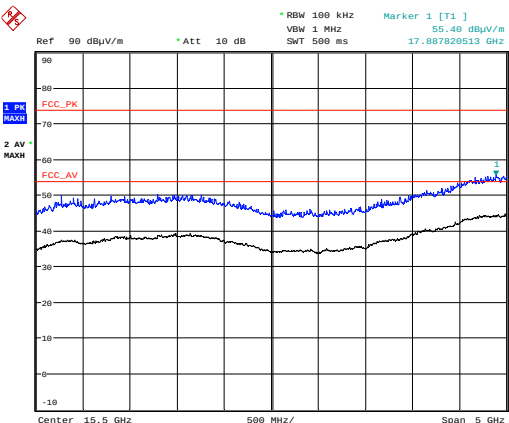
30 MHz – 1 GHz



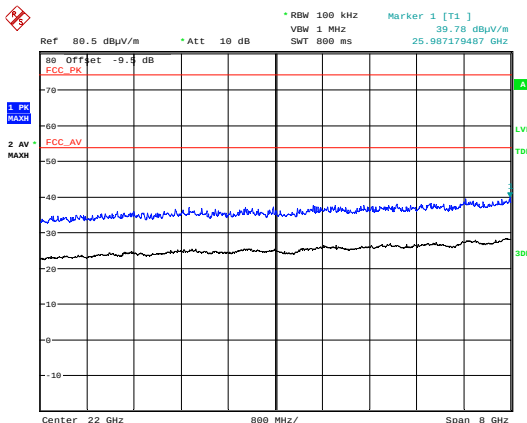
1 GHz – 4 GHz



4 GHz – 9 GHz



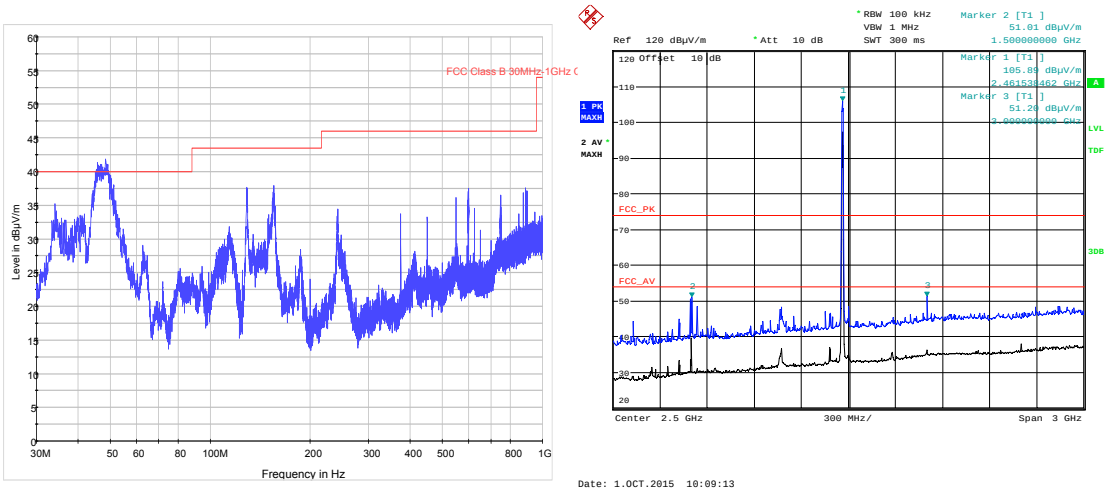
9 GHz – 13 GHz



13 GHz – 18 GHz

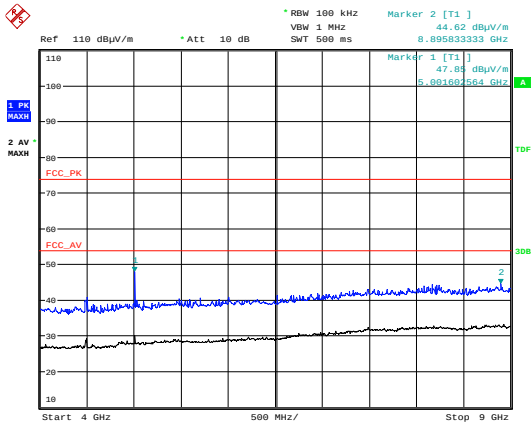
18 GHz – 25 GHz

Modulation: 802.11b; Data rate: 11Mbps – 2462 MHz



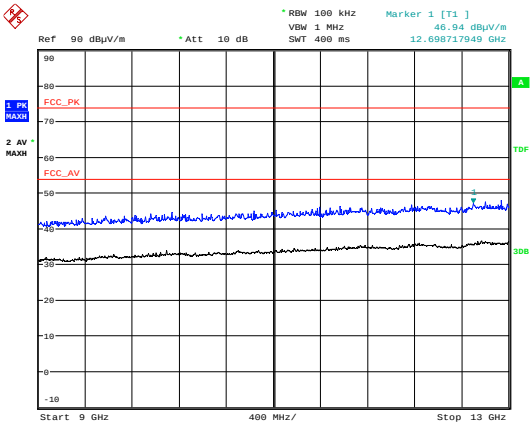
Date: 1.OCT.2015 10:09:13

30 MHz – 1 GHz



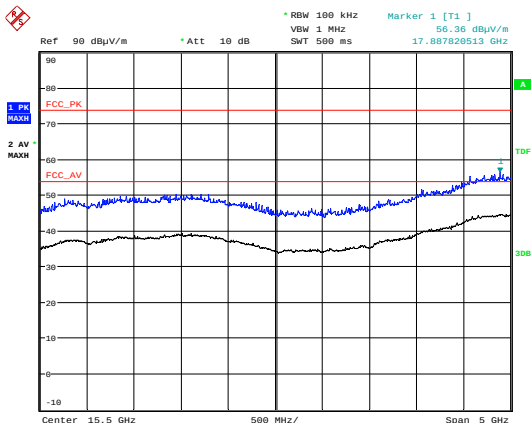
Date: 1.OCT.2015 13:17:27

1 GHz – 4 GHz



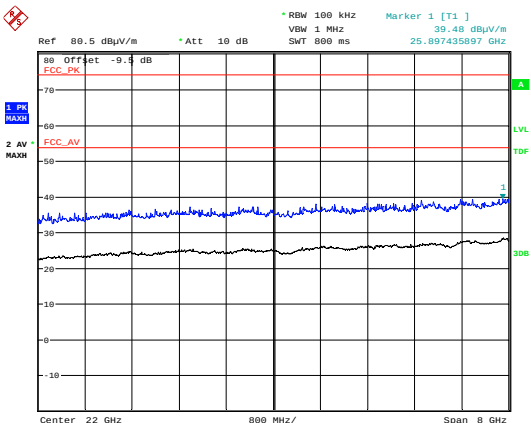
Date: 1.OCT.2015 14:24:17

4 GHz – 9 GHz



Date: 1.OCT.2015 15:31:41

9 GHz – 13 GHz



Date: 2.OCT.2015 10:28:34

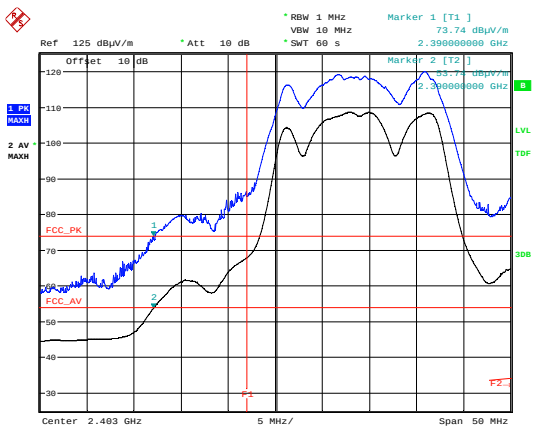
13 GHz – 18 GHz

18 GHz – 25 GHz

Modulation: 802.11g; Data rate: 54Mbps – 2412 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
Pk	2487.28	65.22	3.0	28.3	36.1	0.00	0.00	60.4	1044.72	5012
Av	2487.28	53.33	3.0	28.3	36.1	0.00	0.00	48.5	265.77	500
Pk	4823.90	58.98	5.2	33.1	35.9	0.00	0.00	61.4	1170.85	5012
Av	4823.90	43.16	5.2	33.1	35.9	0.00	0.00	45.6	189.45	500

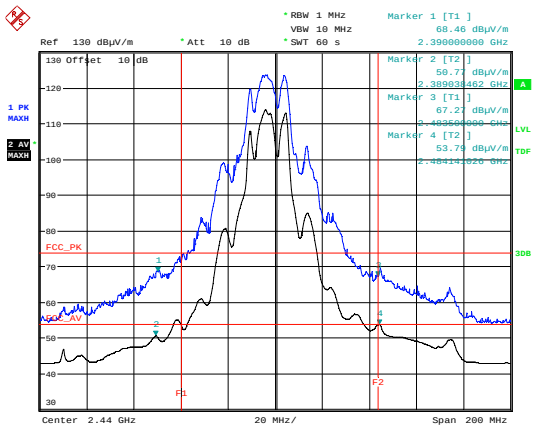
Modulation: 802.11g; Data rate: 54Mbps – 2437 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
Pk	4873.98	64.88	5.2	33.3	35.9	0.00	0.00	67.5	2365.92	5012
Av	4873.98	51.07	5.2	33.3	35.9	0.00	0.00	53.7	482.50	500

Modulation: 802.11g; Data rate: 54Mbps – 2462 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
Pk	4923.88	53.77	5.1	33.4	35.9	0.00	0.00	56.4	659.17	5012
Av	4924.88	40.78	5.1	33.4	35.9	0.00	0.00	43.4	147.74	500



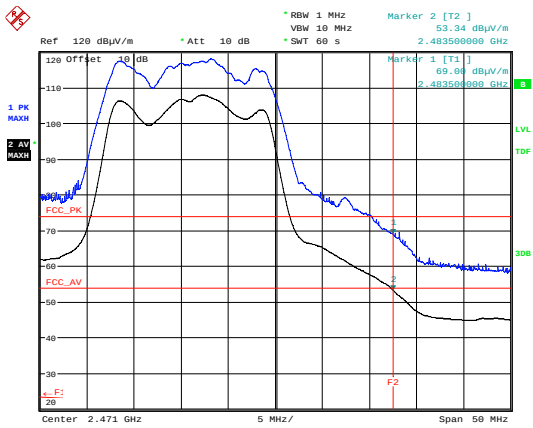
Date: 9.OCT.2015 09:13:45

Modulation: 802.11g; Data rate: 54Mbps – 2412 MHz



Date: 14.OCT.2015 10:35:34

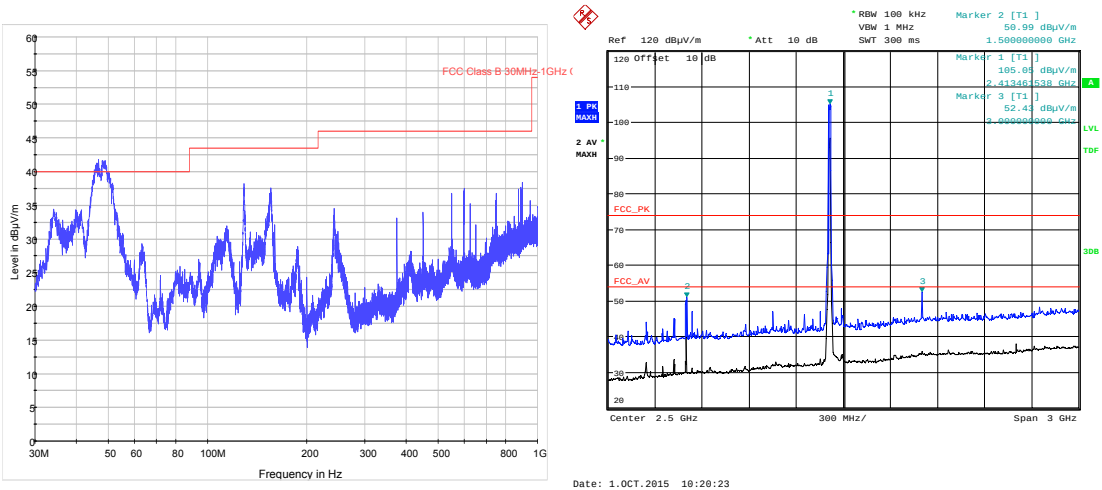
Modulation: 802.11g; Data rate: 54Mbps – 2437 MHz



Date: 9.OCT.2015 08:57:54

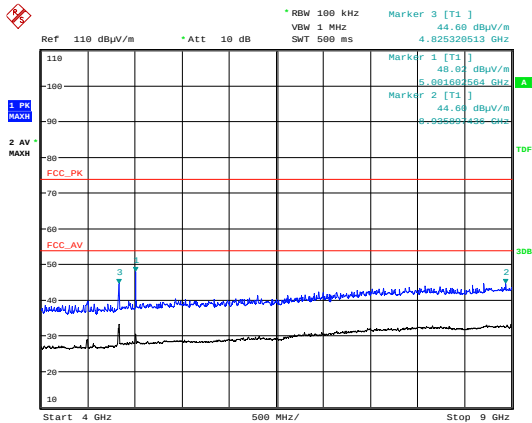
Modulation: 802.11g; Data rate: 54Mbps – 2462 MHz

Modulation: 802.11g; Data rate: 54Mbps – 2412 MHz



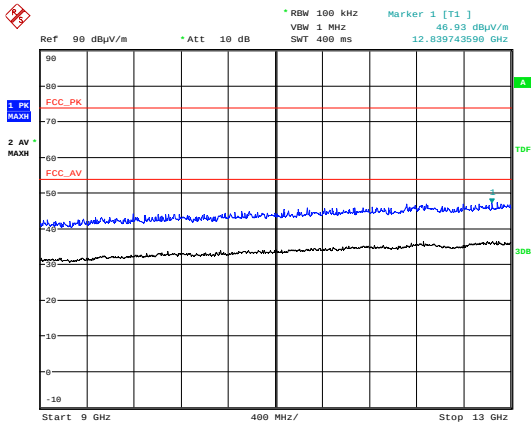
Date: 1.OCT.2015 10:20:23

30 MHz – 1 GHz



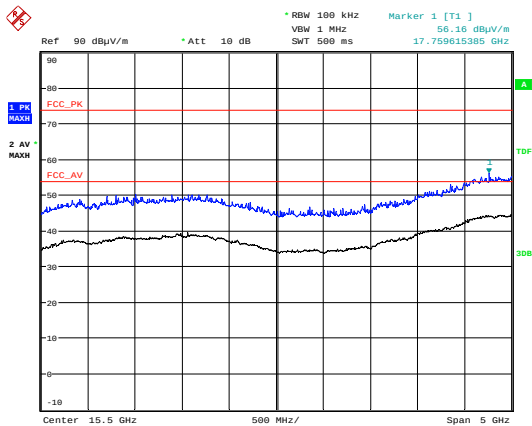
Date: 1.OCT.2015 13:23:38

1 GHz – 4 GHz



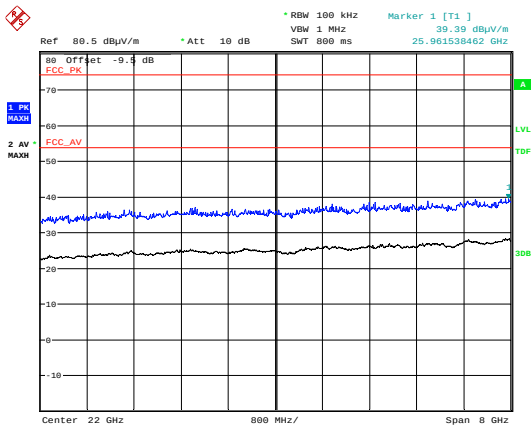
Date: 1.OCT.2015 14:38:45

4 GHz – 9 GHz



Date: 1.OCT.2015 15:37:31

9 GHz – 13 GHz

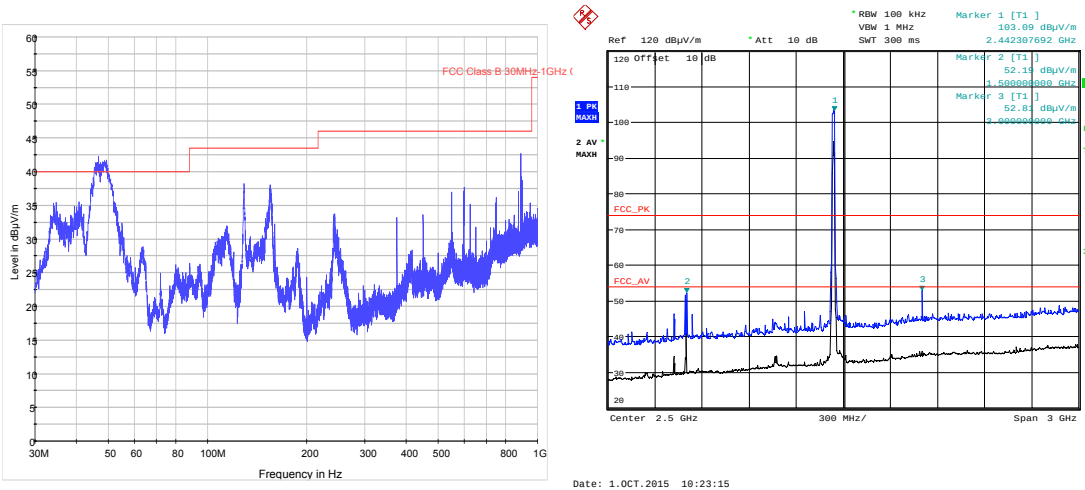


Date: 2.OCT.2015 10:31:03

13 GHz – 18 GHz

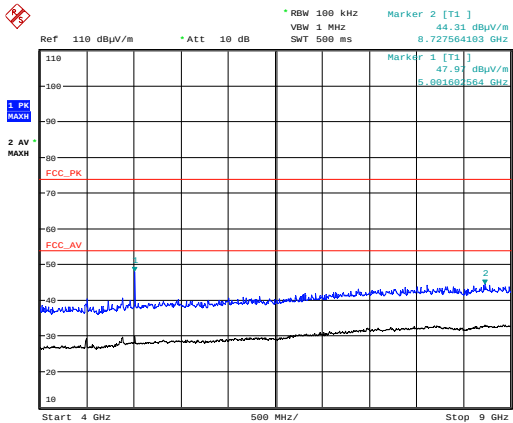
18 GHz – 25 GHz

Modulation: 802.11g; Data rate: 54Mbps – 2437 MHz

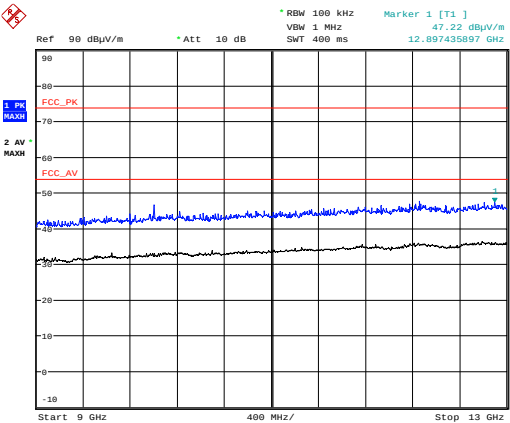


30 MHz – 1 GHz

1 GHz – 4 GHz



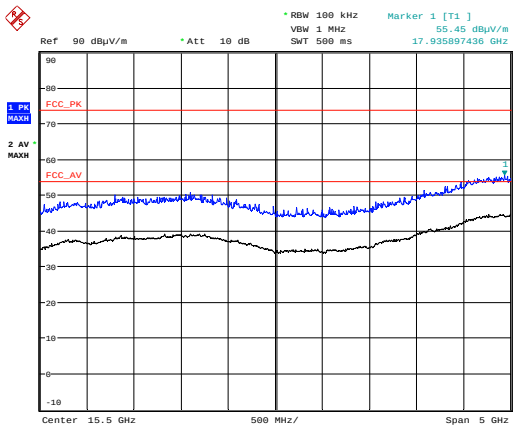
Date: 1.OCT.2015 13:25:43



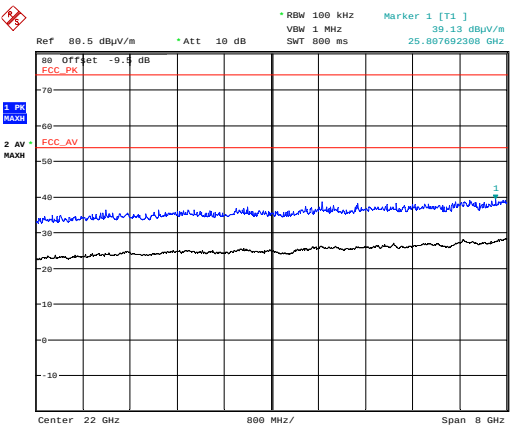
Date: 1.OCT.2015 14:32:44

4 GHz – 9 GHz

9 GHz – 13 GHz



Date: 1.OCT.2015 15:39:16

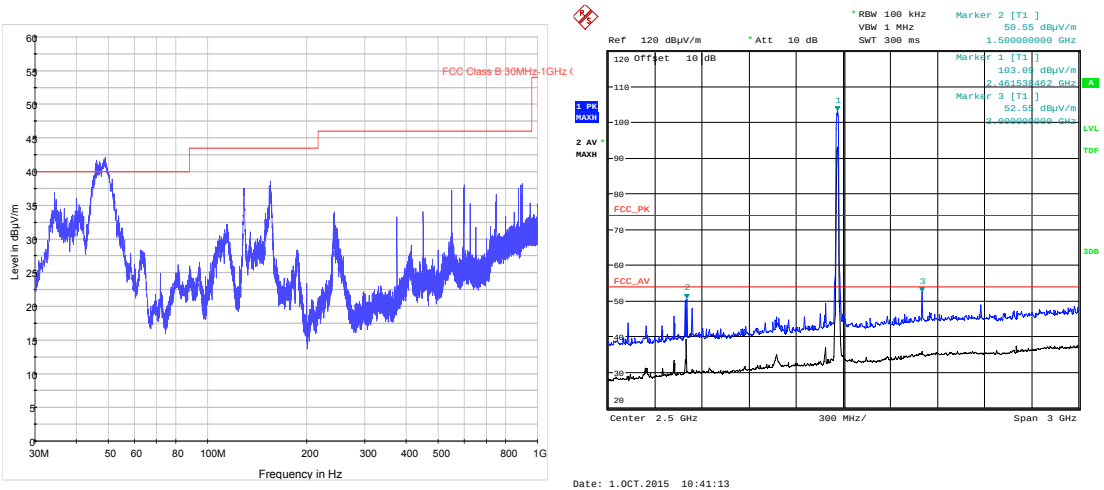


Date: 2.OCT.2015 10:36:02

13 GHz – 18 GHz

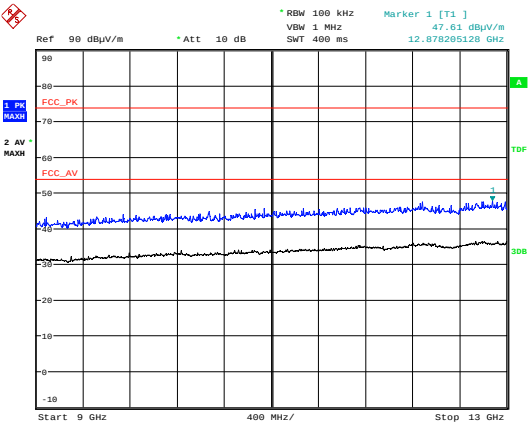
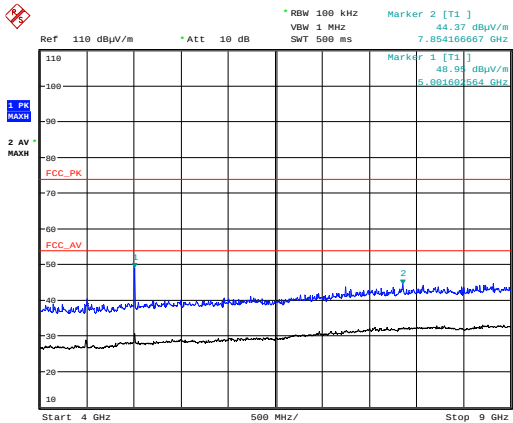
18 GHz – 25 GHz

Modulation: 802.11g; Data rate: 54Mbps – 2462 MHz



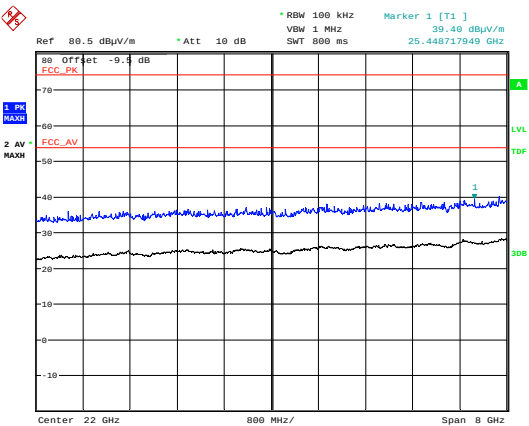
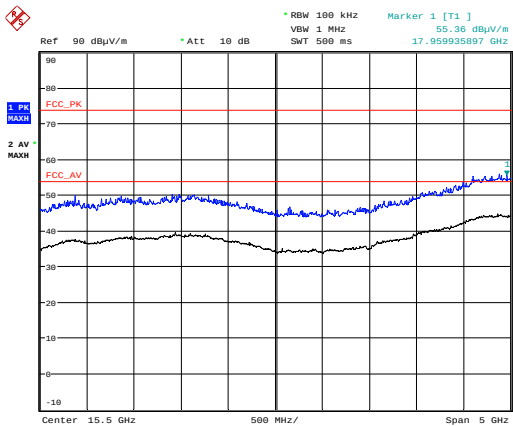
30 MHz – 1 GHz

1 GHz – 4 GHz



4 GHz – 9 GHz

9 GHz – 13 GHz



13 GHz – 18 GHz

18 GHz – 25 GHz

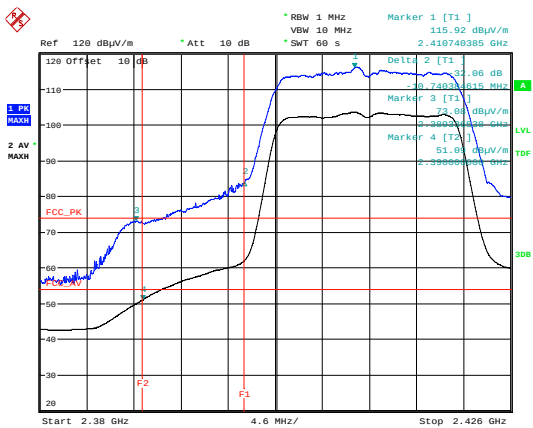
Date: 1.OCT.2015 15:45:29

Date: 2.OCT.2015 10:38:11

Modulation: 802.11n HT20; Data rate: MCS 7 – 2412 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
Pk	4827.69	52.67	5.2	33.1	35.9	0.00	0.00	55.1	566.24	5012
Av	4827.69	35.21	5.2	33.1	35.9	0.00	0.00	37.6	75.86	500

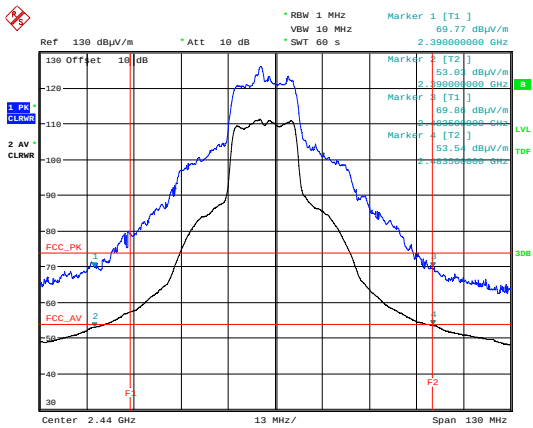
Modulation: 802.11n HT20; Data rate: MCS 7 – 2437 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
Pk	4878.01	64.26	5.2	33.3	35.9	0.00	0.00	66.9	2202.93	5012
Av	4878.01	42.34	5.2	33.3	35.9	0.00	0.00	44.9	176.60	500

Modulation: 802.11n HT20; Data rate: MCS 7 – 2462 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
Pk	4927.69	54.33	5.1	33.4	35.9	0.00	0.00	56.9	703.07	5012
Av	4927.69	35.57	5.1	33.4	35.9	0.00	0.00	38.2	81.10	500



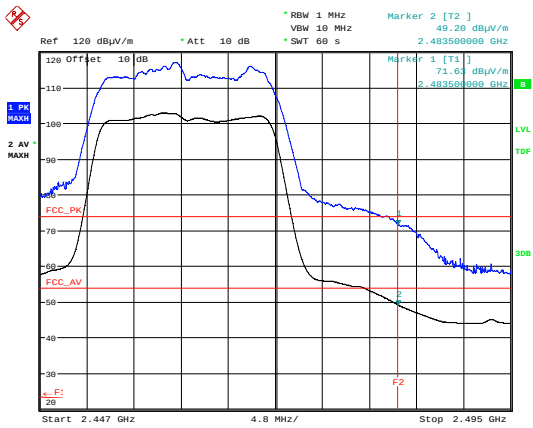
Date: 7.OCT.2015 15:13:13

Modulation: 802.11n HT20; Data rate: MCS 7 – 2412 MHz



Date: 8.OCT.2015 15:49:10

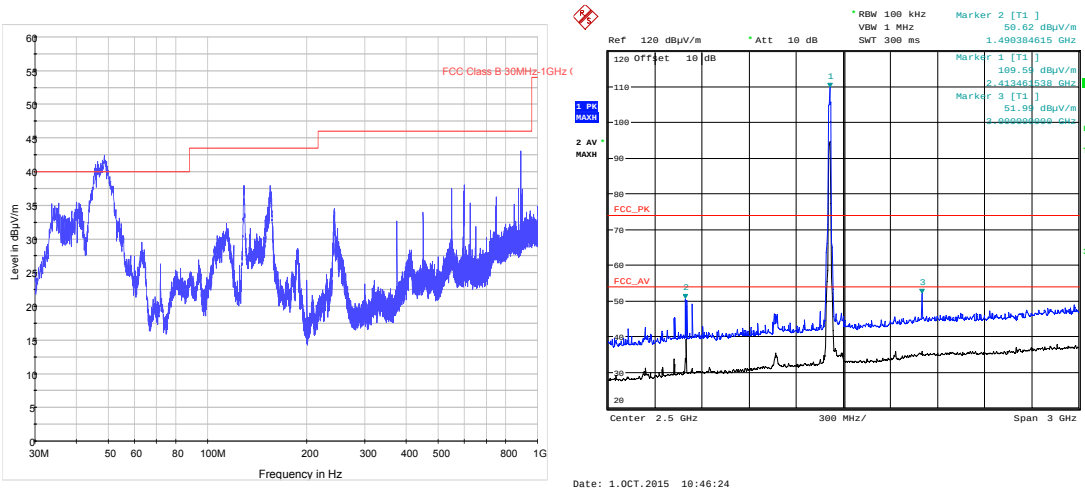
Modulation: 802.11n HT20; Data rate: MCS 7 – 2437 MHz



Date: 9.OCT.2015 08:38:17

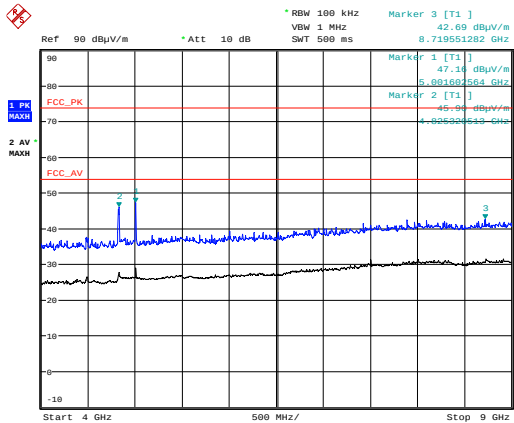
Modulation: 802.11n HT20; Data rate: MCS 7 – 2462 MHz

Modulation: 802.11n HT20; Data rate: MCS 7 – 2412 MHz

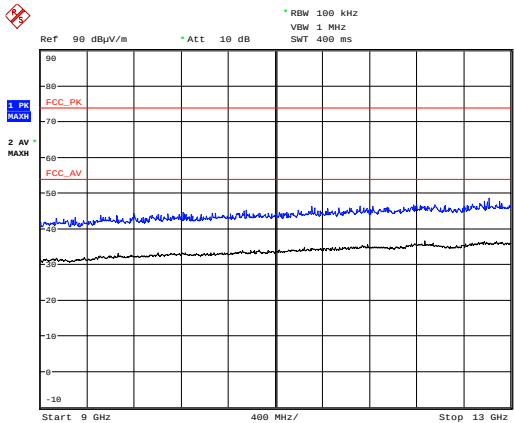


30 MHz – 1 GHz

1 GHz – 4 GHz



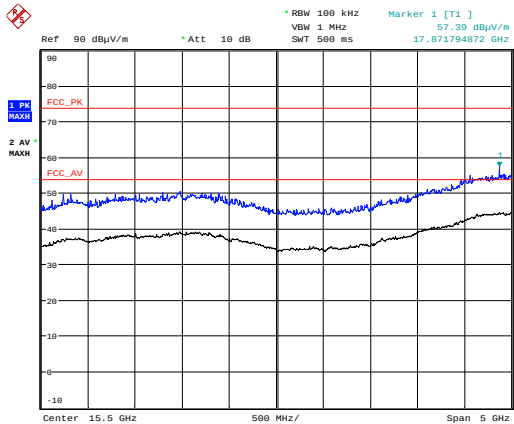
Date: 1.OCT.2015 13:42:31



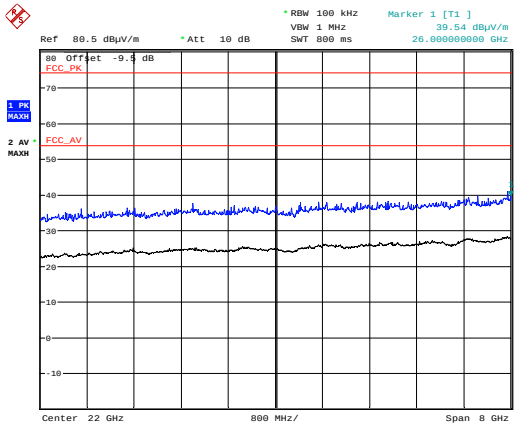
Date: 1.OCT.2015 14:48:36

4 GHz – 9 GHz

9 GHz – 13 GHz



Date: 1.OCT.2015 15:47:35

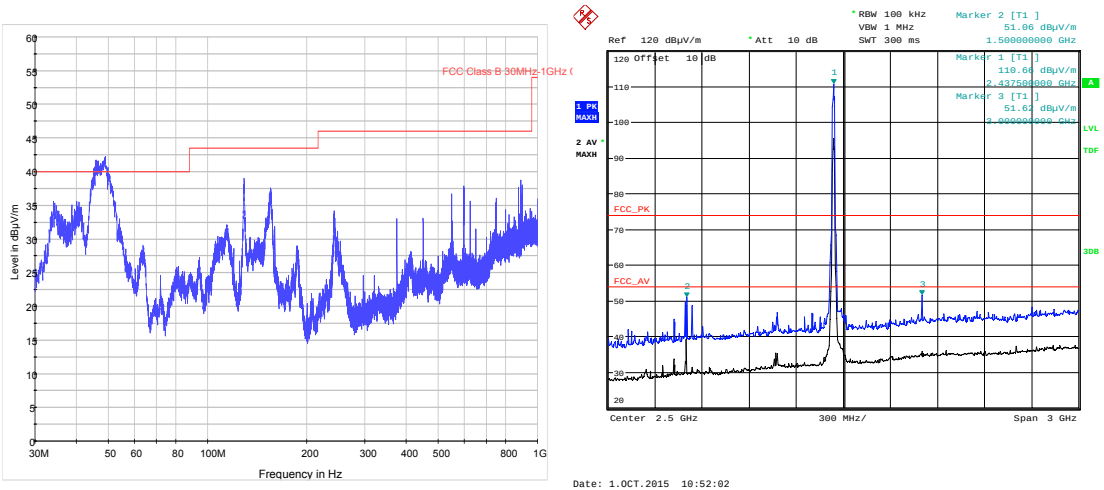


Date: 2.OCT.2015 10:47:25

13 GHz – 18 GHz

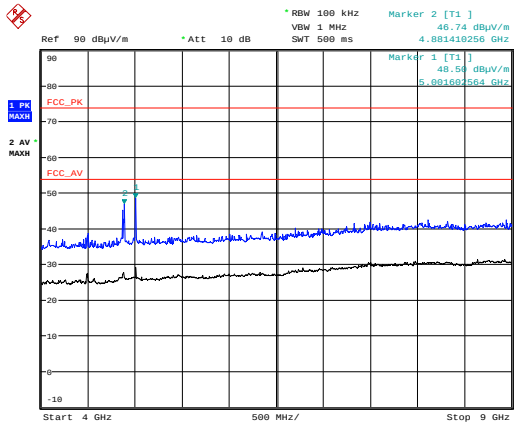
18 GHz – 25 GHz

Modulation: 802.11n HT20; Data rate: MCS 7 – 2437 MHz

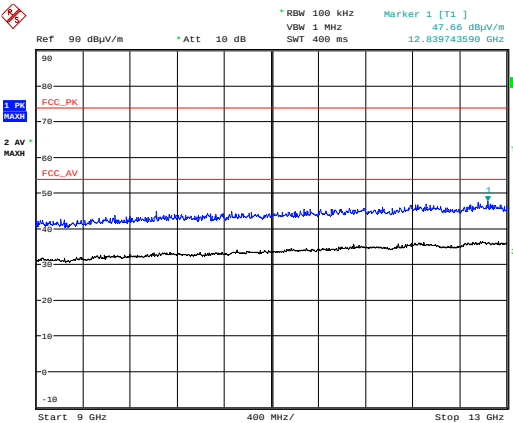


30 MHz – 1 GHz

1 GHz – 4 GHz



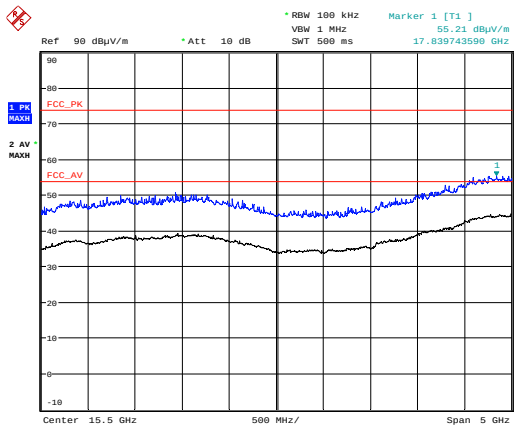
Date: 1.OCT.2015 13:47:30



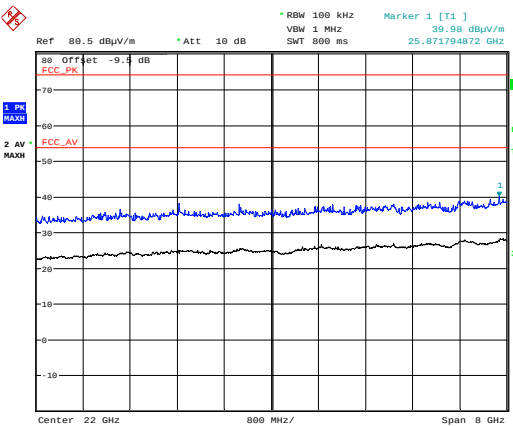
Date: 1.OCT.2015 14:47:15

4 GHz – 9 GHz

9 GHz – 13 GHz



Date: 1.OCT.2015 15:51:56

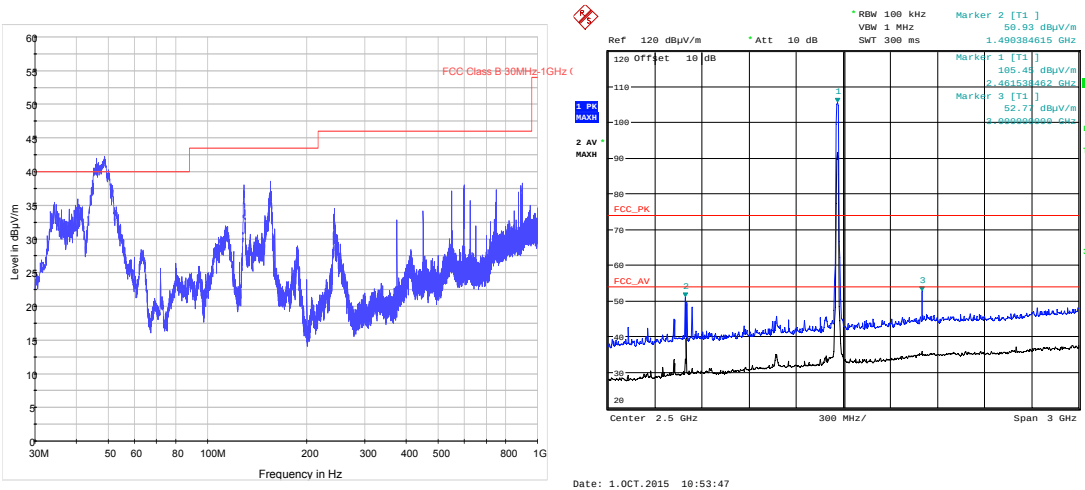


Date: 2.OCT.2015 10:49:27

13 GHz – 18 GHz

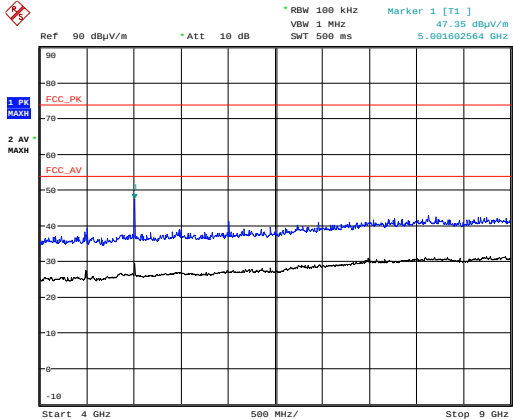
18 GHz – 25 GHz

Modulation: 802.11n HT20; Data rate: MCS 7 – 2462 MHz

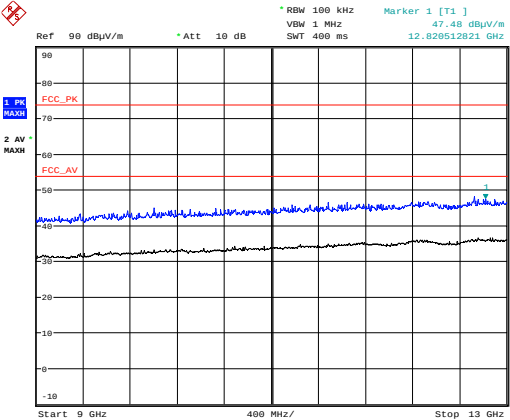


30 MHz – 1 GHz

1 GHz – 4 GHz



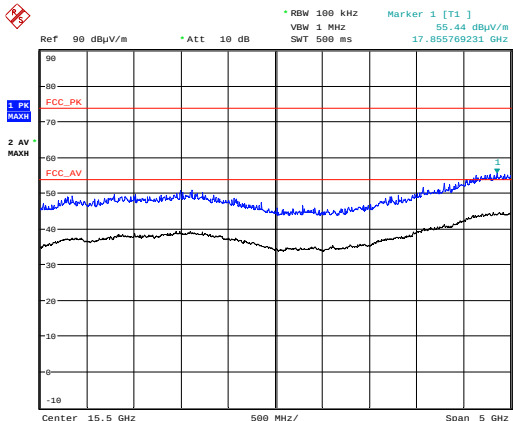
Date: 1.OCT.2015 13:55:09



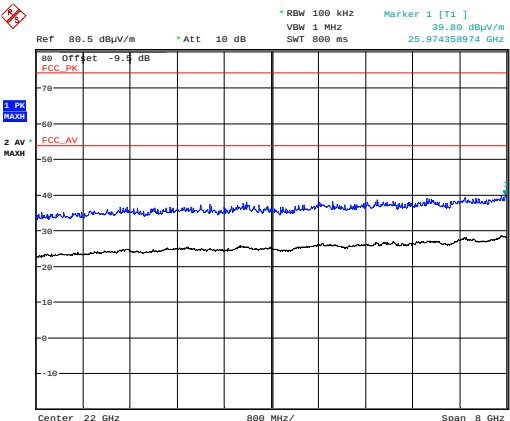
Date: 1.OCT.2015 14:51:26

4 GHz – 9 GHz

9 GHz – 13 GHz



Date: 1.OCT.2015 15:54:17



Date: 2.OCT.2015 10:55:41

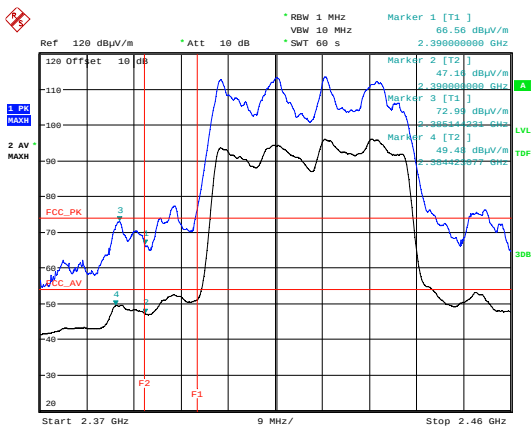
13 GHz – 18 GHz

18 GHz – 25 GHz

Modulation: 802.11n HT40; Data rate: MCS 23 – 2422 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
Pk	4823.90	51.33	5.20	33.10	35.91	0.00	0.00	53.72	485.29	5012
Av	4823.90	35.03	5.20	33.10	35.91	0.00	0.00	37.42	74.30	500

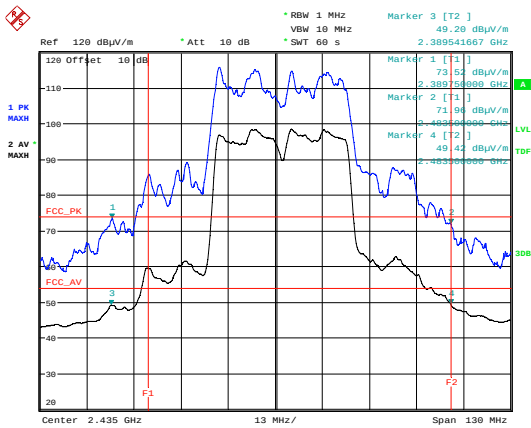
Modulation: 802.11n HT40; Data rate: MCS 23 – 2437 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
Pk	4876.48	52.87	5.20	33.30	35.90	0.00	0.00	55.47	593.61	5012
Av	4876.48	36.67	5.20	33.30	35.90	0.00	0.00	39.27	91.94	500

Modulation: 802.11n HT40; Data rate: MCS 23 – 2452 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
Pk	4923.88	49.89	5.10	33.40	35.89	0.00	0.00	52.50	421.70	5012
Av	4924.88	34.80	5.10	33.40	35.89	0.00	0.00	37.41	74.22	500



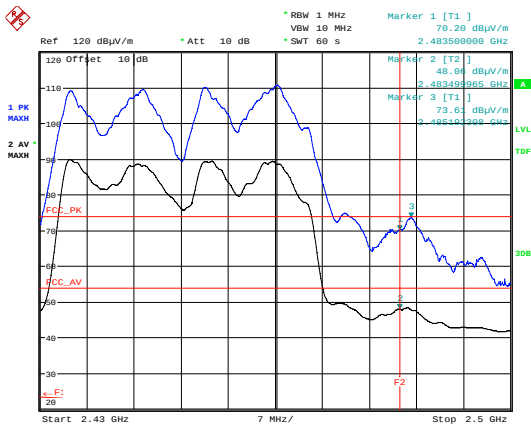
Date: 7.OCT.2015 14:49:50

Modulation: 802.11n HT40; Data rate: MCS 23 – 2422 MHz



Date: 7.OCT.2015 14:39:01

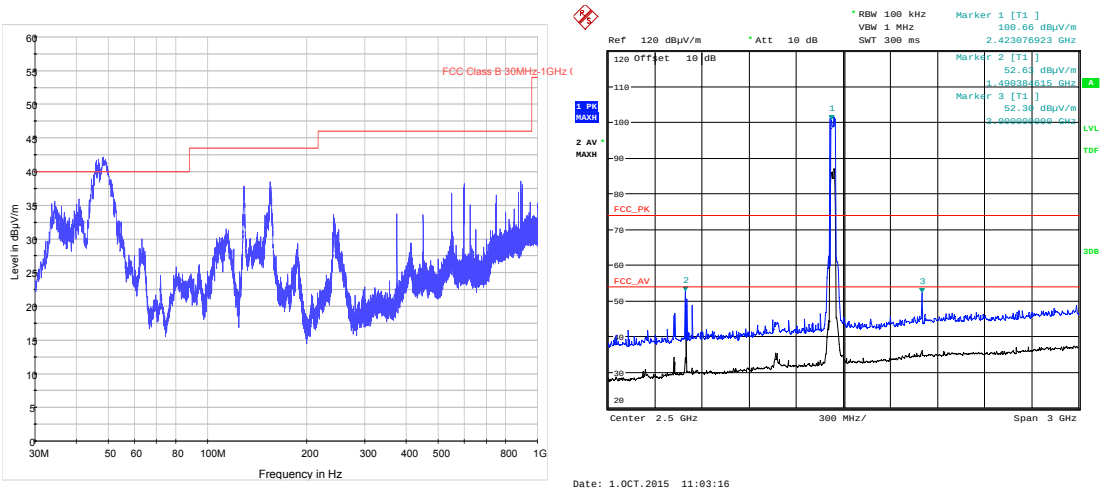
Modulation: 802.11n HT40; Data rate: MCS 23 – 2437 MHz



Date: 7.OCT.2015 14:15:00

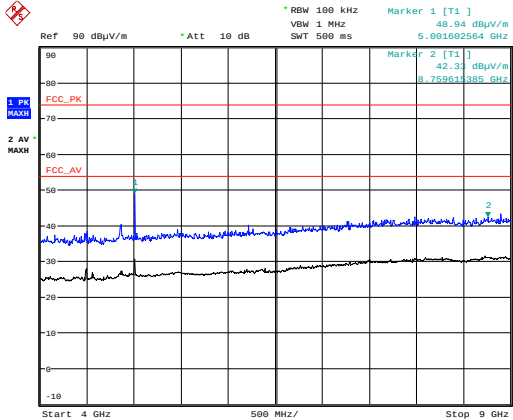
Modulation: 802.11n HT40; Data rate: MCS 23 – 2452 MHz

Modulation: 802.11n HT40; Data rate: MCS 23 – 2422 MHz

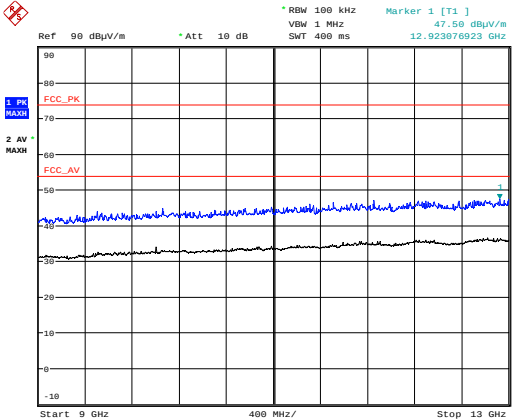


30 MHz – 1 GHz

1 GHz – 4 GHz



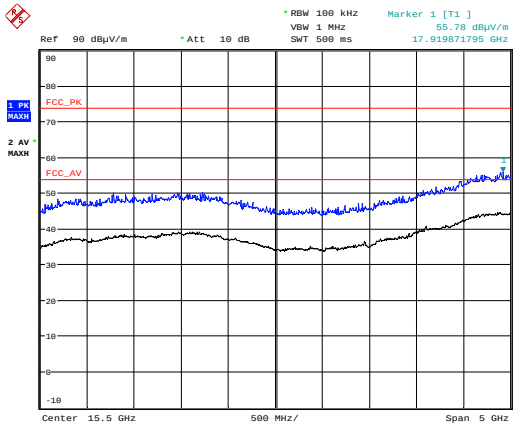
Date: 1.OCT.2015 14:01:39



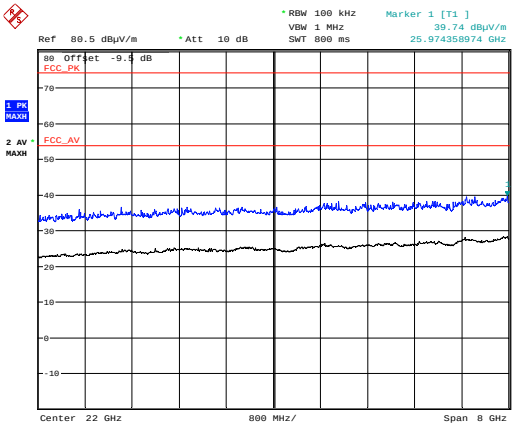
Date: 1.OCT.2015 14:56:47

4 GHz – 9 GHz

9 GHz – 13 GHz



Date: 1.OCT.2015 16:19:44

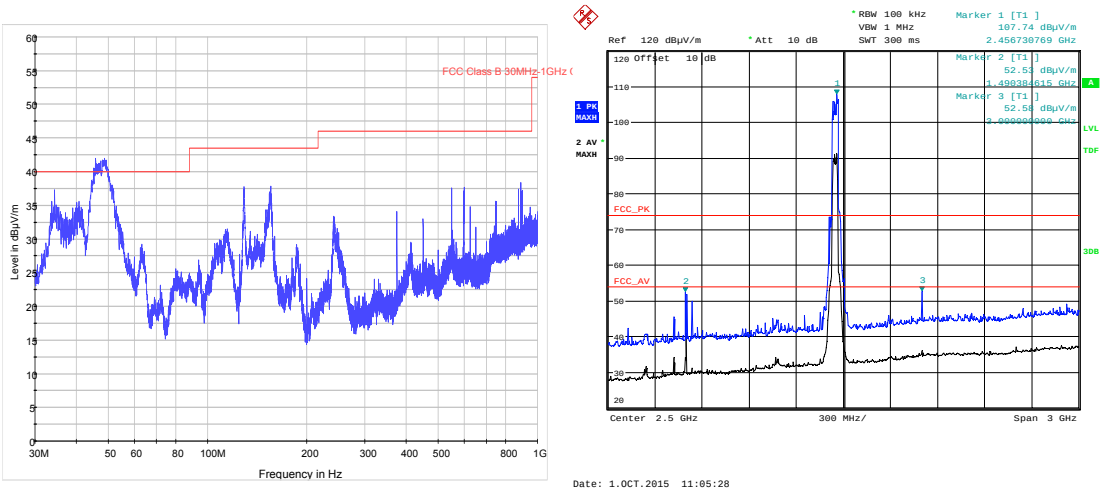


Date: 2.OCT.2015 10:57:44

13 GHz – 18 GHz

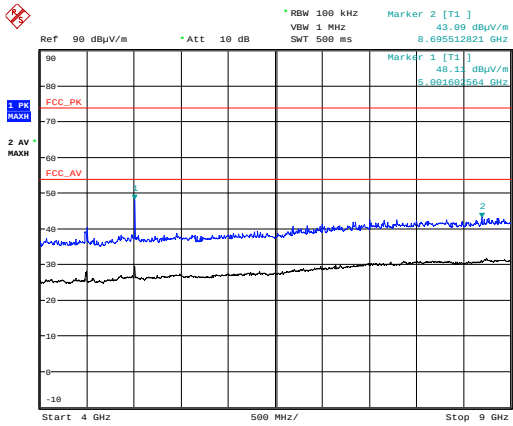
18 GHz – 25 GHz

Modulation: 802.11n HT40; Data rate: MCS 23 – 2437 MHz

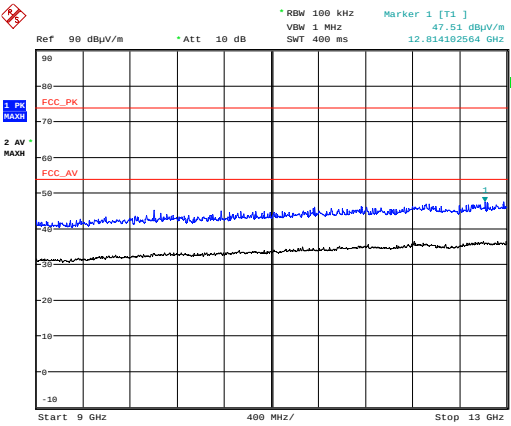


30 MHz – 1 GHz

1 GHz – 4 GHz



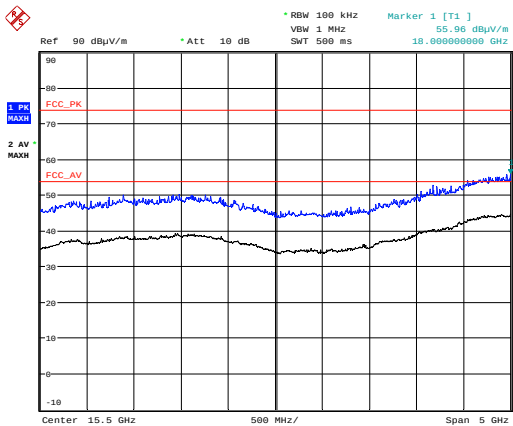
Date: 1.OCT.2015 14:08:04



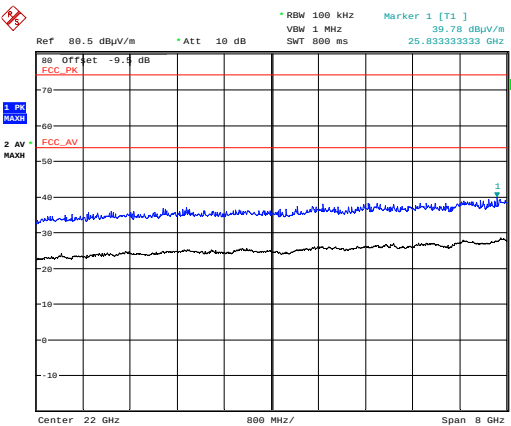
Date: 1.OCT.2015 14:58:15

4 GHz – 9 GHz

9 GHz – 13 GHz



Date: 1.OCT.2015 16:21:24

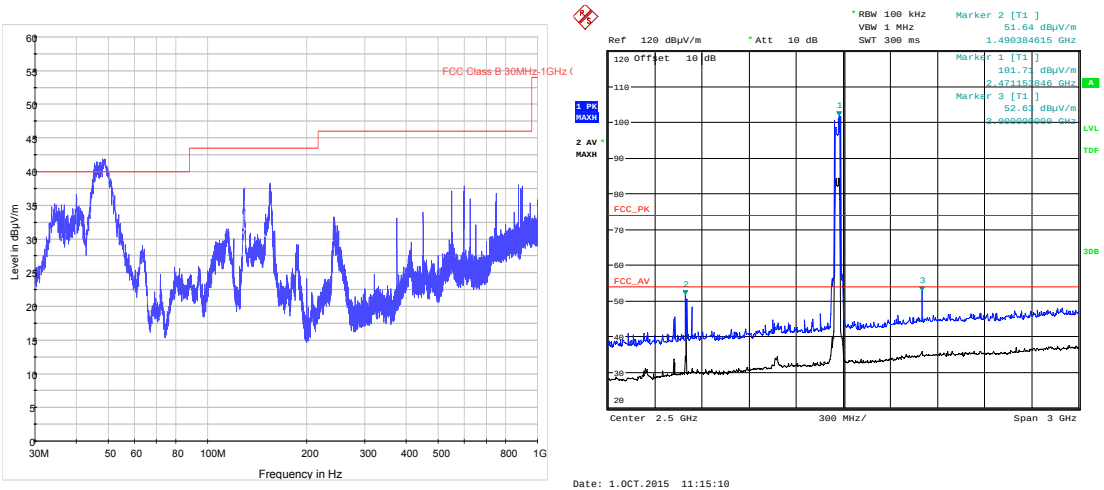


Date: 2.OCT.2015 11:02:01

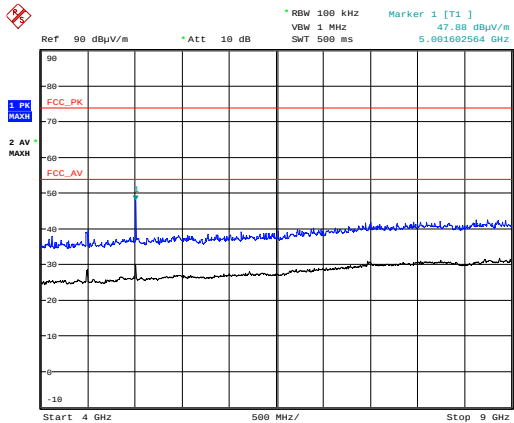
13 GHz – 18 GHz

18 GHz – 25 GHz

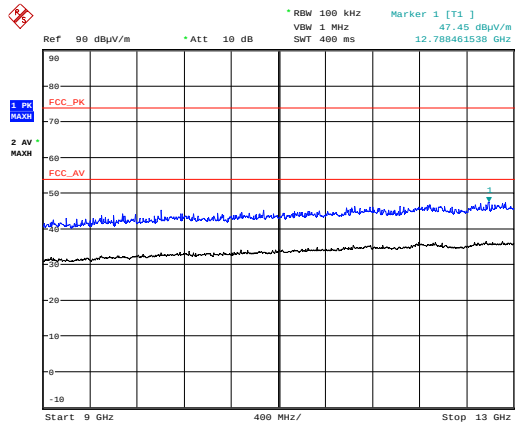
Modulation: 802.11n HT40; Data rate: MCS 23 – 2452 MHz



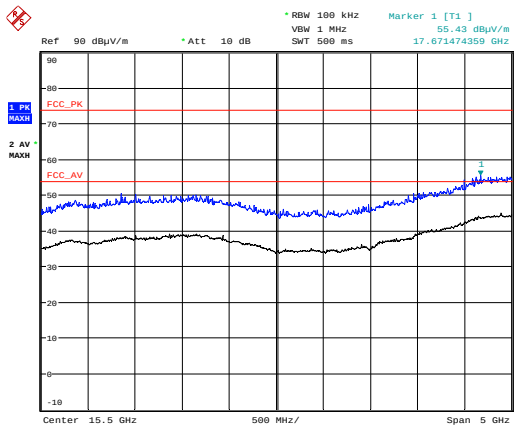
30 MHz – 1 GHz



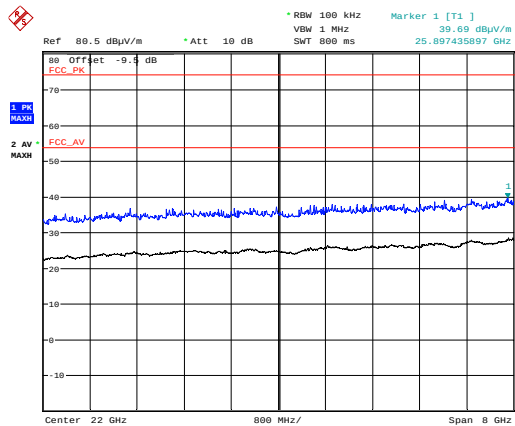
1 GHz – 4 GHz



4 GHz – 9 GHz



9 GHz – 13 GHz



13 GHz – 18 GHz

18 GHz – 25 GHz

12 Maximum conducted output power – Accounting for directional gain of antennas

12.1 Definition

The maximum peak conducted output power is defined as the maximum power level measured with a peak detector using a filter with width and shape of which is sufficient to accept the signal bandwidth.

The maximum conducted output power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level.

12.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.2, KDB 558074
EUT Channels / Frequencies Measured:	2412 MHz / 2437 MHz / 2462 MHz
EUT Occupied Bandwidths:	20 MHz / 40 MHz
EUT Duty Cycle:	<98%
Deviations From Standard:	None
Measurement BW:	500 kHz 1 MHz
Measurement Span:	25 MHz 100MHz
Measurement Detector:	RMS
Voltage Extreme Environment Test Range:	Mains Power = 85 % and 115 % of Nominal (FCC only requirement); Battery Power = new battery.

Environmental Conditions (Normal Environment)

Temperature: xx °C	+15 °C to +35 °C (as declared)
Humidity: xx % RH	20 % RH to 75 % RH (as declared)

12.3 Test Limit

For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

The conducted output power limit specified above is based on the use of antennas with directional gains that do not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated Value by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

As determined (see section 7.4.4) the maximum directional gain due to array gain is 8.74dBi this exceed 6dBi and therefore the limit is reduced by 2.74dB.

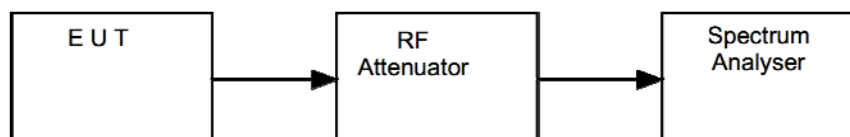
The limit is reduced from 1W (30 dBm) to 0.532 W (27.26 dBm)

12.4 Test Method

The EUT was setup as per section 9 of this report and, as per Figure iv, the analyser was used to measure each antenna output in turn, having taken account of all path losses. The resolution bandwidth of the spectrum analyser was set between 1 and 5 % of the EUT occupied bandwidth and the analyser band power function used to calculate the average power. The results were summed as in the tables below.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst case configuration in each bandwidth.

Figure iv Test Set-up



12.5 Test Equipment

<i>Type of Equipment</i>	<i>Maker/Supplier</i>	<i>Model Number</i>	<i>Element Number</i>	<i>Calibration Due Date</i>
Spectrum Analyser	R&S	FSU26	REF909	13/02/2016
Spectrum Analyser	R&S	FSU26	UH405	11/05/2016
Spectrum Analyser	R&S	ESR26	UH489	21/04/2016
3 dB Attenuator			N/A	In Use
20 dB Attenuator	Radiall	R411810121	N/A	In Use

12.6 Test Results

Modulation: 802.11n HT20; Data rate: MCS7					
Channel MHz	Power setting	Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
2412	90	0	-3.09	23	97.95
		1	-2.16	23	121.34
		2	-2.00	23	125.89
Total:					345.18
Result:					PASS
2437	93	0	-0.94	23	160.69
		1	-0.65	23	171.79
		2	-0.40	23	181.97
Total:					514.46
Result:					PASS
2462	93	0	-0.90	23	162.18
		1	-0.58	23	174.58
		2	-0.23	23	189.23
Total:					526.00
Result:					PASS

Modulation: 802.11n HT40; Data rate: MCS23					
Channel MHz	Power setting	Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
2422	88	0	-1.95	23	127.35
		1	-1.44	23	143.22
		2	-1.14	23	153.46
Total:					424.03
Result:					PASS
2437	91	0	-0.90	23	162.18
		1	-0.51	23	177.42
		2	-0.36	23	183.65
Total:					523.25
Result:					PASS
2452	91	0	-1.10	23	154.88
		1	-0.79	23	166.34
		2	-0.52	23	177.01
Total:					498.23
Result:					PASS

13 Power spectral density – Accounting for directional gain of antennas

13.1 Definition

The power per unit bandwidth.

13.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Channels / Frequencies Measured:	2412 MHz / 2437 MHz / 2462 MHz
EUT Channel Bandwidths:	20 MHz / 40 MHz
Deviations From Standard:	None
Measurement BW:	30 kHz, 50 kHz
Measurement Span: (requirement 1.5 times Channel BW)	25MHz, 50MHz
Measurement Detector:	RMS

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 °C to +35 °C (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 110V ac	230 V ac $\pm 10\%$ (as declared)

13.3 Test Limit

The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

The power spectral density limit specified above is based on the use of antennas with directional gains that do not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated Value by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

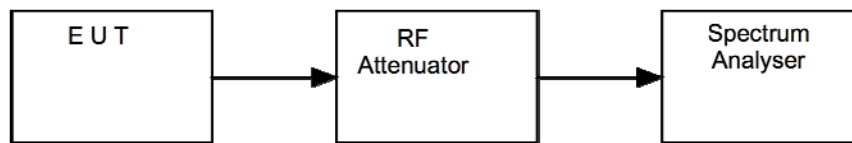
As determined (see section 7.4.4) the maximum directional gain due to array gain is 8.74dBi this exceed 6dBi and therefore the limit is reduced by 2.74 dB. The limit is reduced from 8 dBm to 5.26 dBm

13.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vi, the peak emission of the EUT was measured on a spectrum analyser, with path losses taken into account.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst case configuration in each bandwidth.

Figure vi Test Setup



13.5 Test Equipment

<i>Type of Equipment</i>	<i>Maker/Supplier</i>	<i>Model Number</i>	<i>Element Number</i>	<i>Calibration Due Date</i>
Spectrum Analyser	R&S	FSU26	REF909	13/02/2016
Spectrum Analyser	R&S	FSU26	UH405	11/05/2016
Spectrum Analyser	R&S	ESR26	UH489	21/04/2016
3 dB Attenuator			N/A	In Use
20 dB Attenuator	Radiall	R411810121	N/A	In Use

13.6 Test Results

Modulation: 802.11n HT20; Data rate: MCS7					
Channel MHz	Power setting	Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
2412	90	0	-26.75	23.00	0.42
		1	-26.21	23.00	0.48
		2	-26.19	23.00	0.48
Total (dBm):					1.40
Result:					Pass
2437	93	0	-25.77	23.00	0.53
		1	-25.42	23.00	0.57
		2	-24.43	23.00	0.72
Total (dBm):					2.60
Result:					Pass
2462	93	0	-25.68	23.00	0.54
		1	-25.40	23.00	0.58
		2	-24.94	23.00	0.64
Total (dBm):					2.44
Result:					Pass

Modulation: 802.11n HT40; Data rate: MCS23					
Channel MHz	Power setting	Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
2422	88	0	-27.23	23.00	0.38
		1	-26.68	23.00	0.43
		2	-26.60	23.00	0.44
Total (dBm):					0.94
Result:					Pass
2437	91	0	-26.81	23.00	0.42
		1	-26.42	23.00	0.45
		2	-25.58	23.00	0.55
Total (dBm):					1.53
Result:					Pass
2452	91	0	-26.38	23.00	0.46
		1	-25.49	23.00	0.56
		2	-25.28	23.00	0.59
Total (dBm):					2.08
Result:					Pass

14 Measurement Uncertainty

Calculated Measurement Uncertainties

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95 % confidence:

[1] Radiated spurious emissions

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

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

[2] AC power line conducted emissions

Uncertainty in test result = **3.4 dB**

[3] Occupied bandwidth

Uncertainty in test result = **15.5 %**

[4] Conducted carrier power

Uncertainty in test result (Power Meter) = **1.08 dB**

[5] Conducted / radiated RF power out-of-band

Uncertainty in test result – up to 8.1 GHz = **3.31 dB**

Uncertainty in test result – 8.1 GHz to 15.3 GHz = **4.43 dB**

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

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

[6] Power spectral density

Uncertainty in test result (Spectrum Analyser) = **2.48 dB**