

RF Test Report

Project Number: 5209337**Offer Number:** SUW-202308005164**Report Number:** 5209337EMC04**Revision Level:** 0**Client:** Persistent Systems LLC**Equipment Under Test:** Wave Relay® MANET System**Host Name:** Aircraft Kit**Host Model:** WR-AIR-SYS-1-02 (with RF-2150 Radio Module)**Module FCC ID:** 2AG3JRF-2150**Applicable Standards:** FCC Part 2 and Part 90**ANSI C63.26:2015****Report issued on:** 06 December 2024**Test Result:** Compliant

FOR THE SCOPE OF ACCREDITATION UNDER CERTIFICATE NUMBER: 3212.01

Report must not be used by the client to claim product certification, approval, or endorsement by A2LA, NIST, or any agency of the Federal Government.

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1 Summary of Test Results

Test Description	Test Specification	Test Result
RF Output Power	FCC Part 2.1046 & 90.205(o)	N/T ¹
Occupied Bandwidth	FCC Part 2.1049 & 90.209	N/T ¹
Emissions Masks	FCC Part 90.210	N/T ¹
Frequency Stability	FCC 2.1055 & 90.213	N/T ¹
Field Strength of Spurious Radiation	FCC 2.1053 & 90.210	Compliant

Note 1: Not tested. The EUT incorporates a certified limited module (2AG3JRF-2150), so all the conducted radio test results of the module are valid. Only radiated spurious emissions are measured with the radio module installed in the new host product.

1.1 Modifications Required for Compliance

None

2 General Information

2.1 Client Information

Name: Persistent Systems LLC
Address: 303 Fifth Ave. Suite 306
City, State, Zip, Country: New York City, New York, 10016, USA

2.2 Test Laboratory

Name: SGS North America, Inc.
Address: 620 Old Peachtree Road NW, Suite 100
City, State, Zip, Country: Suwanee, GA 30024, USA

Accrediting Body: A2LA
Type of lab: Testing Laboratory
Certificate Number: 3212.01
Designation Number: US1126

2.3 General Information of EUT

Equipment Under Test: Wave Relay® MANET System
Host Name: Aircraft Kit
Host Model: WR-AIR-SYS-1-02 (with RF-2150 Radio Module)
Serial Number: Sample ID: SUWEM2407000342 M6
Module FCC ID: 2AG3JRF-2150

Frequency Range: 2457 – 2472 MHz
Data Modes: WLAN 802.11b, 802.11g, 802.11n
Antenna Gain*: Chain 1: ANT-2108; 1.5 dBi
Chain 2: ANT-2013; 3.0 dBi
Chain 3: ANT-2108; 1.5 dBi

Rated Voltage: 28 VDC
Test Voltage: 28 VDC

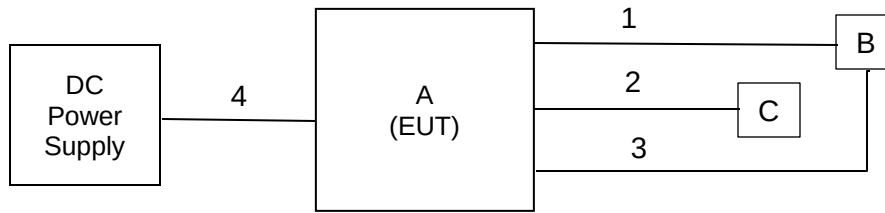
Sample Received Date: 11 September 2024
Dates of testing: 06-07 November 2024

*Data was not measured by SGS laboratory and therefore SGS is not responsible for accuracy. Data obtained via customer, specification sheet, previous filing or other.

2.4 Operating Modes and Conditions

The EUT was connected to a laptop via ethernet and USB cables provided by the client. After the radio module kernel was loaded, the USB cable could be removed. The ART GUI was then used to configure the radio to transmit at the desired data mode and power with max duty cycle at low, mid, and high channels. MIMO 3x3 mode was tested and a power setting of 31 dBm was used, following the 3x3 power setting used for the RF module testing. And the following worst-case data rates were used based on the data rate analysis done on the RF module: 802.11b: 2Mbps, 802.11g: 6Mbps, 802.11n: 6.5Mbps.

2.5 EUT Connection Block Diagram



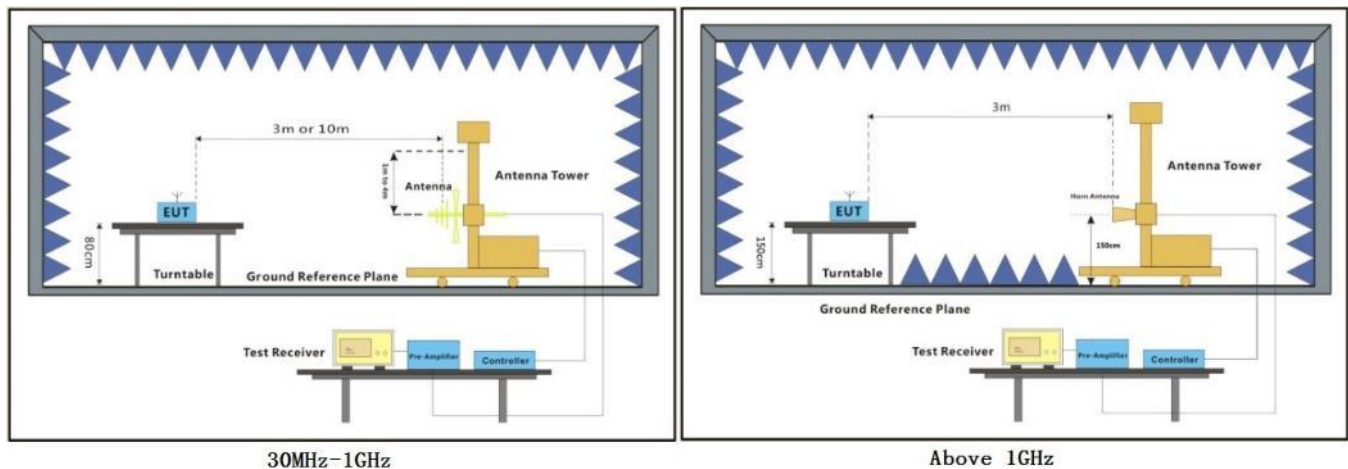
2.6 System Configurations

Device Reference	Manufacturer	Description	Model Number	Serial Number
A	Persistent Systems	Aircraft Kit (EUT)	WR-AIR-SYS-1-02	Not labeled
B	Persistent Systems	Antenna	ANT-2108	Not labeled
C	Persistent Systems	Antenna	ANT-2013	Not labeled

2.7 Cable List

Cable reference	Port Name	Start	End	Cable Length (m)	Ferrite installed?	Shielded?
1	Antenna Chain 1	EUT	Antenna ANT-2108	3.06m	No	Co-Axial
2	Antenna Chain 2	EUT	Antenna ANT-2013	3.06m	No	Co-Axial
3	Antenna Chain 3	EUT	Antenna ANT-2108	3.06m	No	Co-Axial
4	DC Power	EUT	DC Power Supply	3.3m	No	Yes

2.8 Test Setup Diagrams (Radiated)



3 Field Strength of Spurious Radiation

3.1 Test Result

Test Description	Test Specification	Test Result
Radiated Spurious Emissions	FCC 2.1053 & 90.210	Compliant

3.2 Test Method

The measurement methods defined in ANSI C63.26 were used.

Lowest, middle, and highest channels were investigated. The device was commanded to continuously transmit on low, middle and high channels at the maximum power settings determined in the RF module testing. The MIMO 3x3 mode was used for this testing.

Test distances:

30 to 1000 MHz - The EUT to measurement antenna distance was 3 meters

1 to 18 GHz - The EUT to measurement antenna distance was 3 meters

18 to 26 GHz - The EUT to measurement antenna distance was 3 meters

Limit [from § 90.210(b)(3)]:

The power of any emission must be attenuated below the unmodulated carrier power (P in Watts) as follows: On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least $43 + 10 \log (P)$ dB.

Note that this works out to be an absolute maximum limit of -13 dBm.

3.3 Test Site

10m Absorber Lined Shielded Enclosure (ALSE), Suwanee, GA

Environmental Conditions	30-1000MHz	3-18GHz	18-26GHz
Temperature:	23.01 °C	22.83 °C	23.0 °C
Relative Humidity:	64.3 %	67.2 %	64.3 %
Atmospheric Pressure:	97.47 kPa	97.44 kPa	97.5 kPa

3.4 Test Equipment

30-1000 MHz

Test End Date: 7-Nov-2024

Tester: ZH

Equipment	Model	Manufacturer	Asset	Cal Date	Cal Due Date
ANTENNA, BILOG	JB6	SUNOL	B079690	19-Apr-2024	19-Apr-2026
N to N RF Cable	LMR-400	TIMES MICROWAVE SYSTEMS	24016	9-Sep-2024	9-Sep-2025
RF CABLE	SF106	HUBER & SUHNER	B079713	20-Aug-2024	20-Aug-2025
RF CABLE NM TO NM, 0.01-18GHZ	90-195-118	TELEDYNE STORM MICROWAVE	20125	7-Aug-2024	7-Aug-2025
RF CABLE	SF106	HUBER & SUHNER	B085895	20-Mar-2024	20-Mar-2025
LOW NOISE AMPLIFIER	ZKL-2+	MINI-CIRCUITS	B079800	9-Sep-2024	10-Sep-2025
EMI TEST RECEIVER	ESW44	ROHDE & SCHWARZ	22032	15-Nov-2023	15-Nov-2024

1-18 GHz

Test End Date: 7-Nov-2024

Tester: PL, ZH

Equipment	Model	Manufacturer	Asset	Cal Date	Cal Due Date
ANTENNA, DRG HORN (MEDIUM)	3117	ETS LINDGREN	B079691	2-Aug-2024	2-Aug-2026
RF CABLE, NM TO NM.	90-195-157	TELEDYNE STORM MICROWAVE	21019	20-Mar-2024	20-Mar-2025
RF CABLE	SF106	HUBER & SUHNER	B085895	20-Mar-2024	20-Mar-2025
LOW NOISE AMPLIFIER	TS-PR18	ROHDE & SCHWARZ	15003	8-Oct-2024	8-Oct-2025
EMI TEST RECEIVER	ESW44	ROHDE & SCHWARZ	22032	15-Nov-2023	15-Nov-2024
FILTER, HIGH PASS, >2800MHZ	HPM50111	MICRO-TRONICS	22017	14-Jun-2024	14-Jun-2025
ATTENUATOR, 20W 30DB DC-18GHZ	BW-N30W20+	MINI-CIRCUITS	21018	19-Mar-2024	19-Mar-2025

18-26 GHz

Test End Date: 7-Nov-2024

Tester: PL

Equipment	Model	Manufacturer	Asset	Cal Date	Cal Due Date
ANTENNA, DRG HORN (SMALL)	3116B	ETS LINDGREN	B079695	6-Oct-2021	30-Nov-2024
SMA to SMA RF Cable	NC12-K1K1-138	MEGAPHASE	22002	6-Feb-2024	6-Feb-2025
2.92MM MALE TO 2.92MM MALE RF CABLE	HULL140A-29P-29P-60	HASCO COMPONENTS	18033	20-Mar-2024	20-Mar-2025
LOW NOISE AMPLIFIER	NSP1840-HG	MITEQ	B087572	3-May-2024	21-Oct-2025
EMI TEST RECEIVER	ESW44	ROHDE & SCHWARZ	22032	15-Nov-2023	15-Nov-2024

Software Profiles:

"RSE 30-1000 MHz T7 240701" TILE! profile dated 01 July 2024

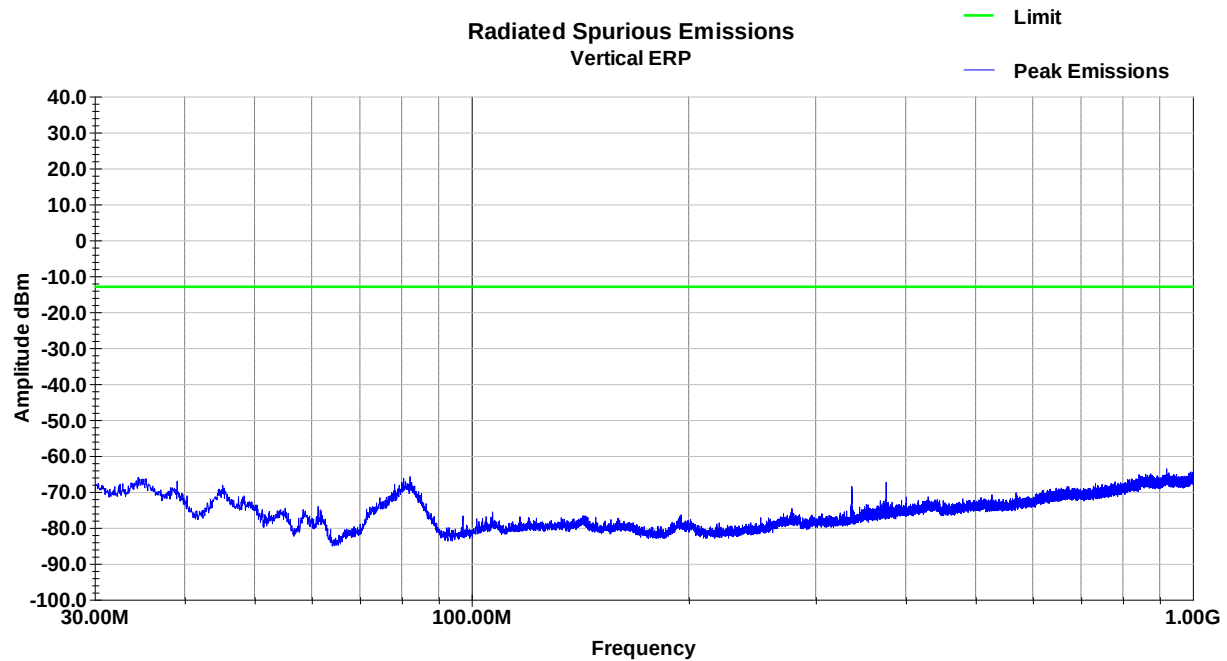
"RSE 1-18 GHz T7 210212" TILE! profile dated 12 February 2021

"RSE 18-26 GHz TILE7 240607" TILE! profile dated 07 June 2024

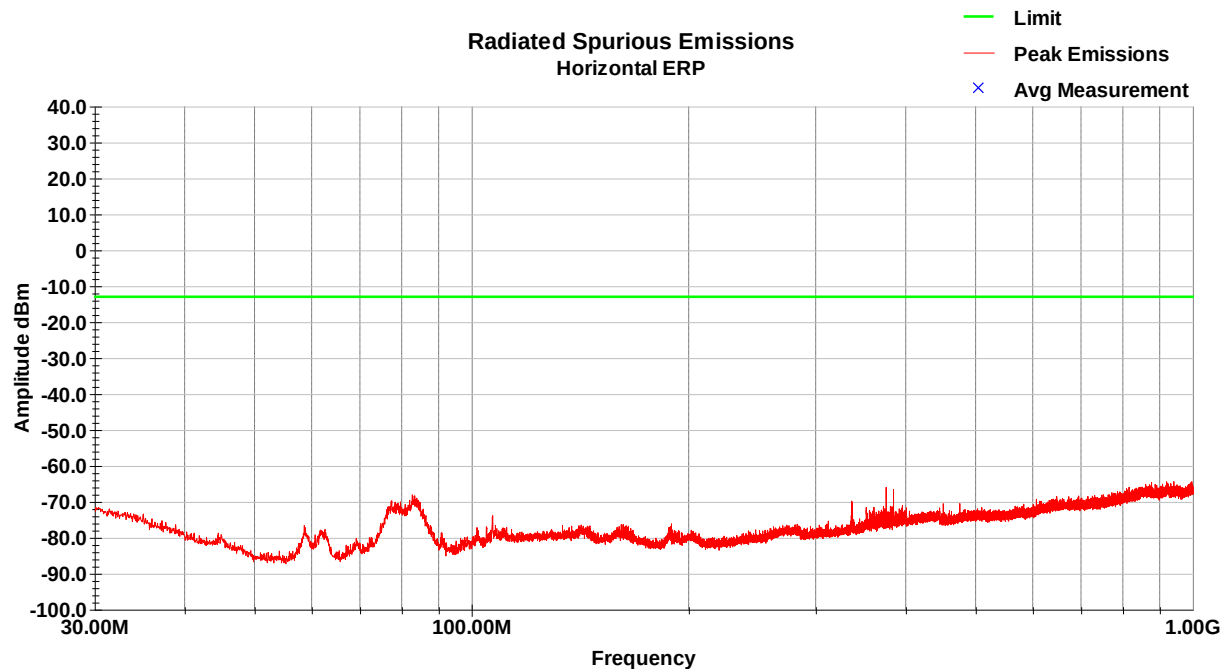
3.5 Test Data

In the 30-1000MHz range there was little deviation with respect to data mode or channel (worst case shown below).

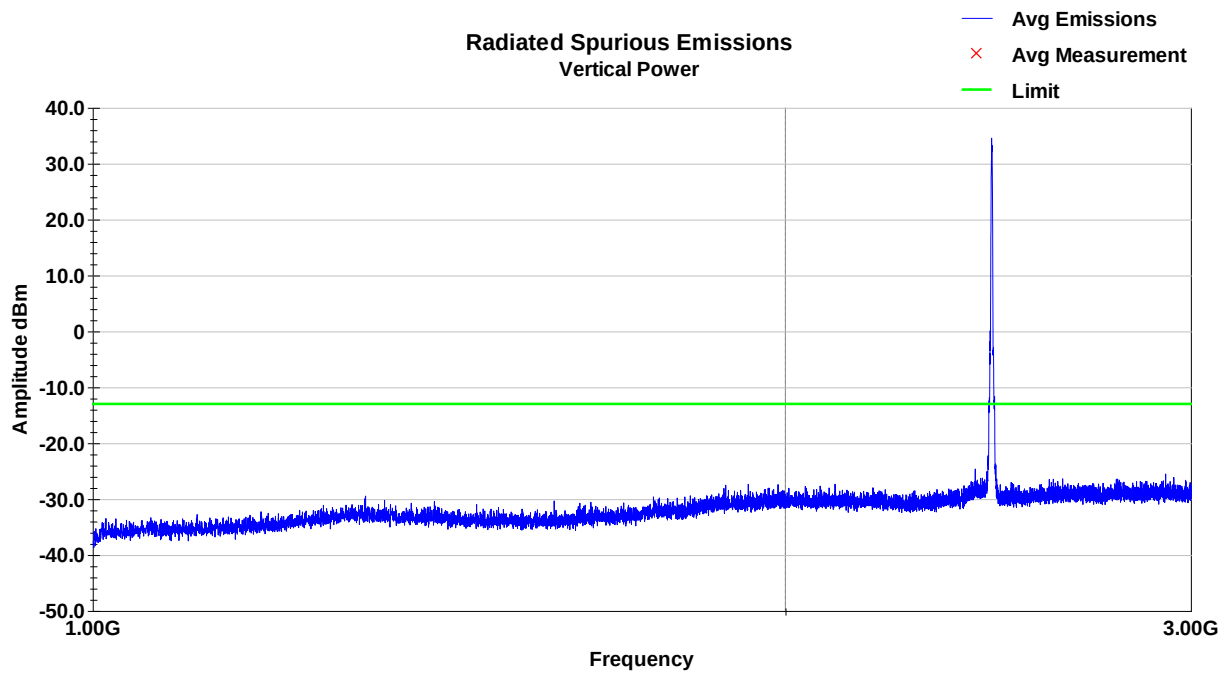
Vertical Radiated Spurious Emissions Plot – 30-1000MHz



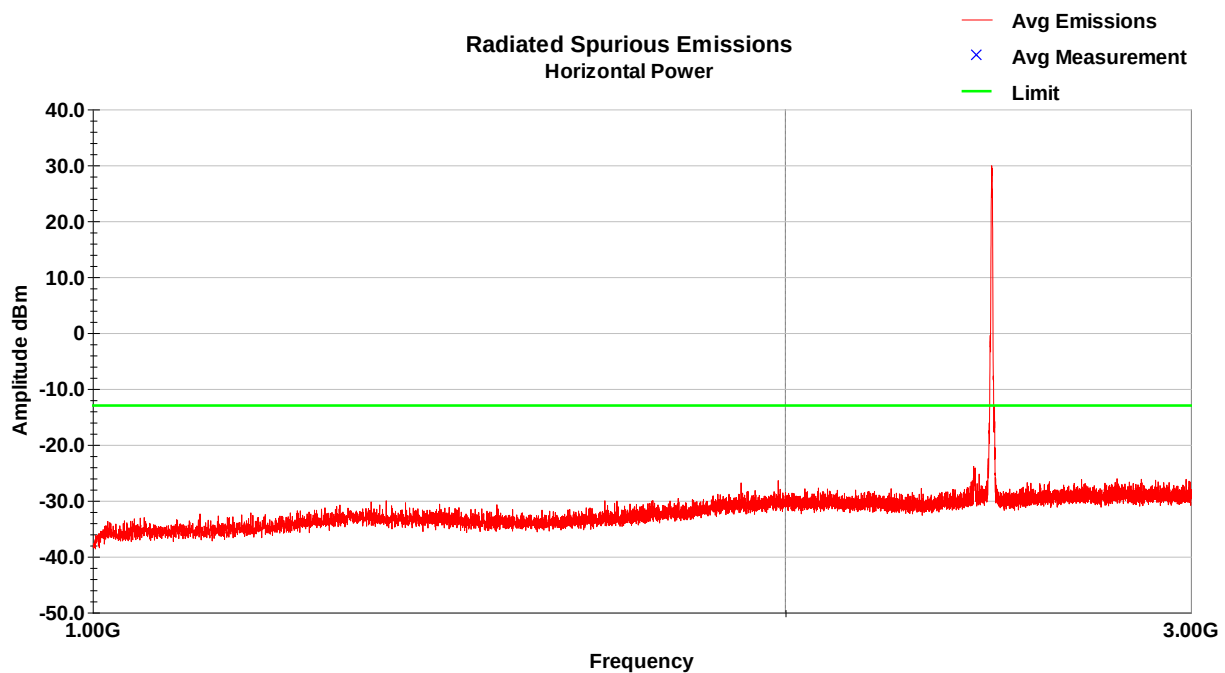
Horizontal Radiated Spurious Emissions Plot – 30-1000MHz



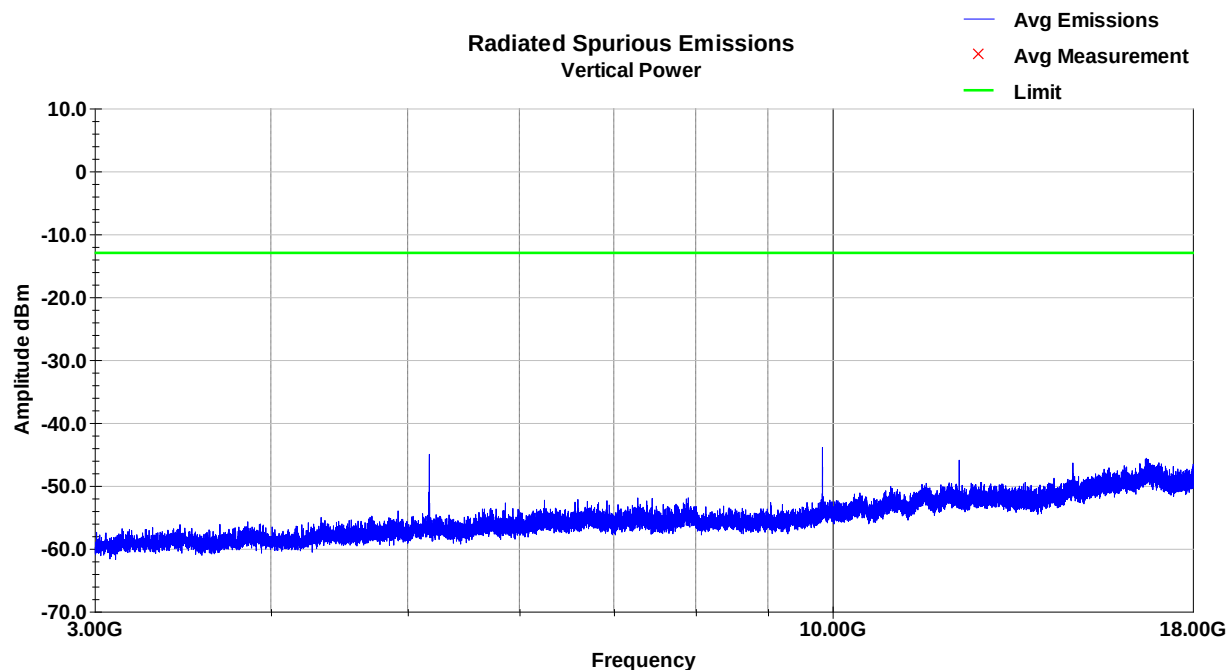
Vertical Radiated Spurious Emissions Plot – 1-3GHz (802.11b LCH)



Horizontal Radiated Spurious Emissions Plot – 1-3GHz (802.11b LCH)



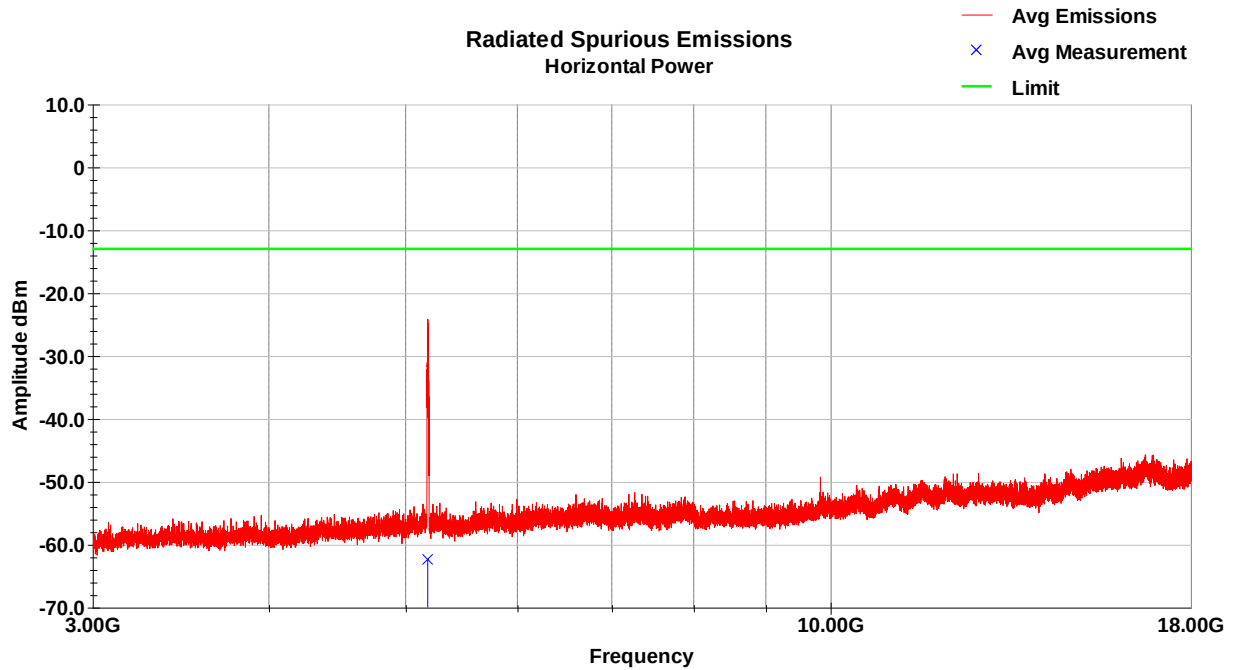
Vertical Radiated Spurious Emissions Plot – 3-18GHz (802.11b LCH)



Vertical Radiated Spurious Emissions Data – 3-18GHz (802.11b LCH)

No emissions within 20dB of the limit.

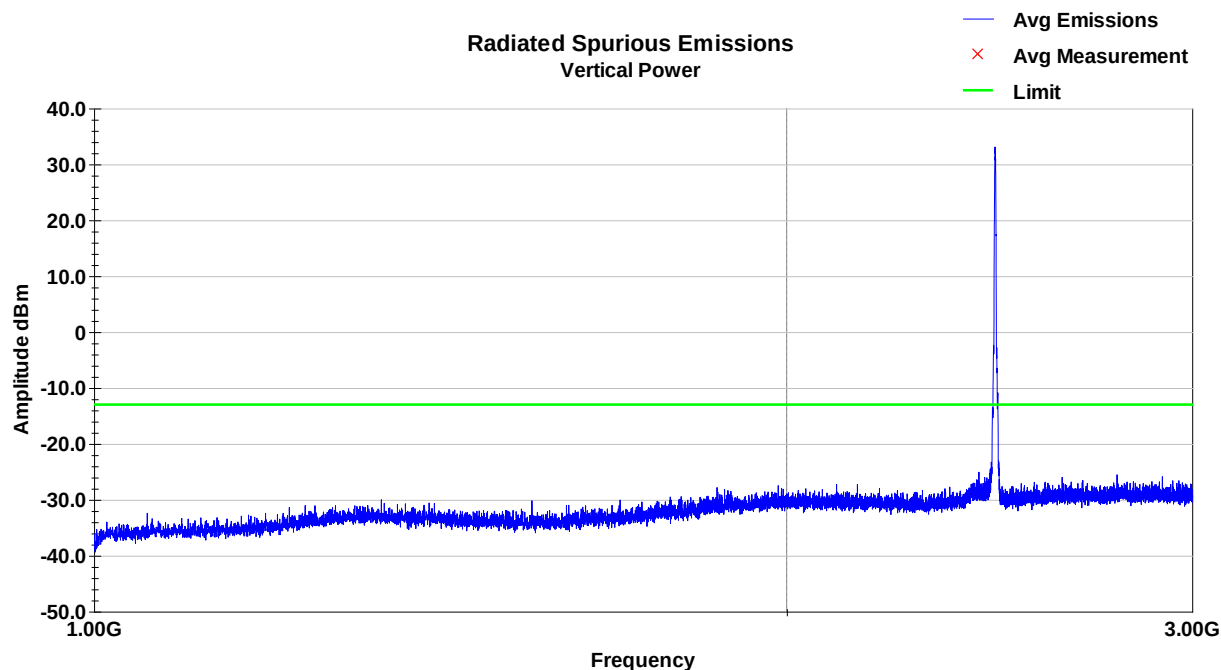
Horizontal Radiated Spurious Emissions Plot – 3-18GHz (802.11b LCH)



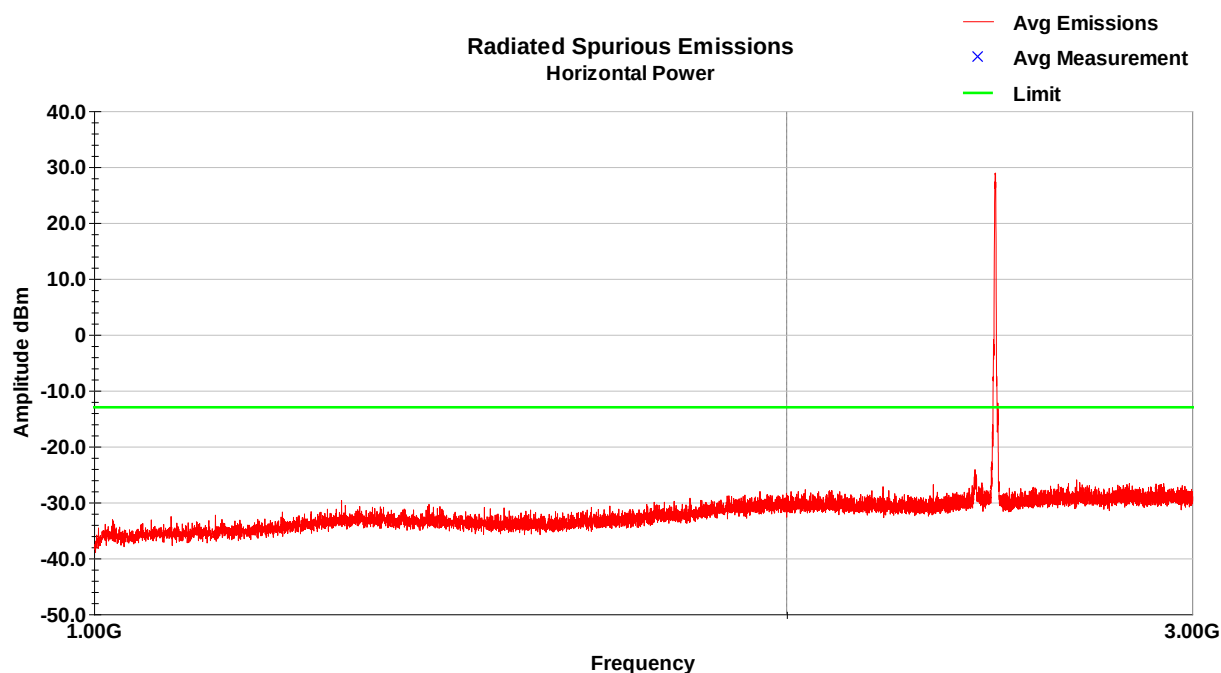
Horizontal Radiated Spurious Emissions Data – 3-18GHz (802.11b LCH)

Frequency MHz	Raw Avg dBm	Polarity V/H	Azimuth degrees	Height cm	AF dB/m	Loss dB	Amp dB	Avg Value dBm	Limit dBm	Margin dB
5183.48	-56.9	H	272.0	176.0	34.3	2.4	42.0	-62.3	-13.0	-49.3
Avg Value = Raw Avg + AF + Loss - Amp										
Margin = Avg Value - Limit										

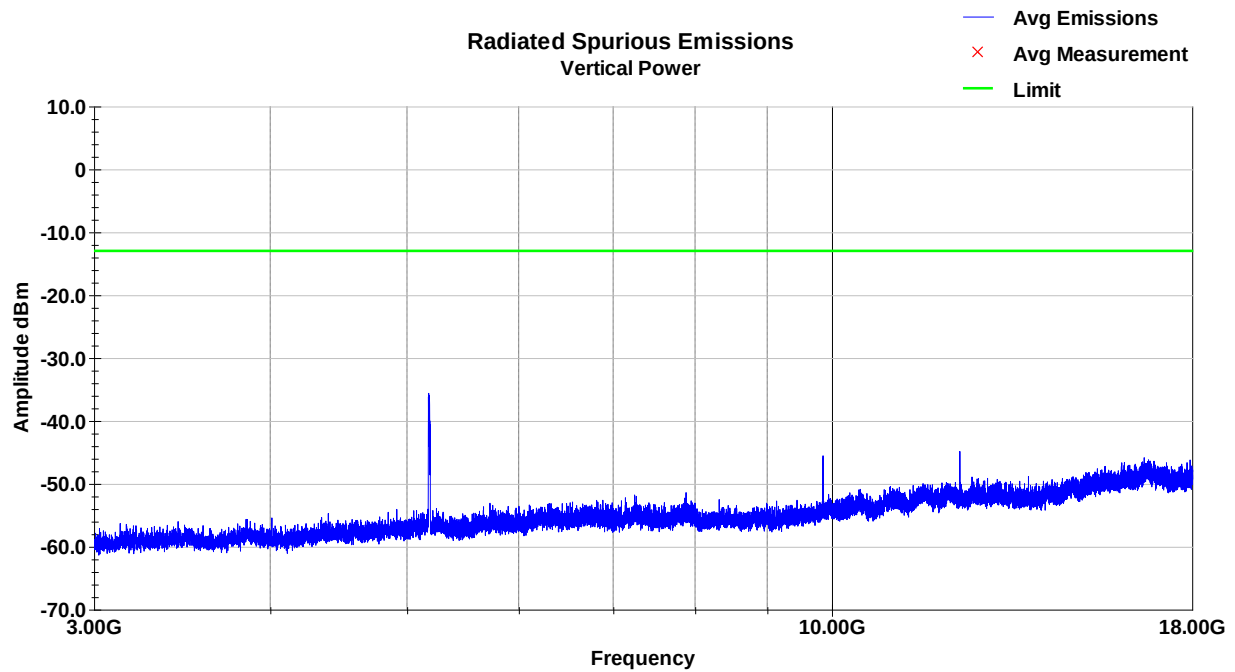
Vertical Radiated Spurious Emissions Plot – 1-3GHz (802.11b MCH)



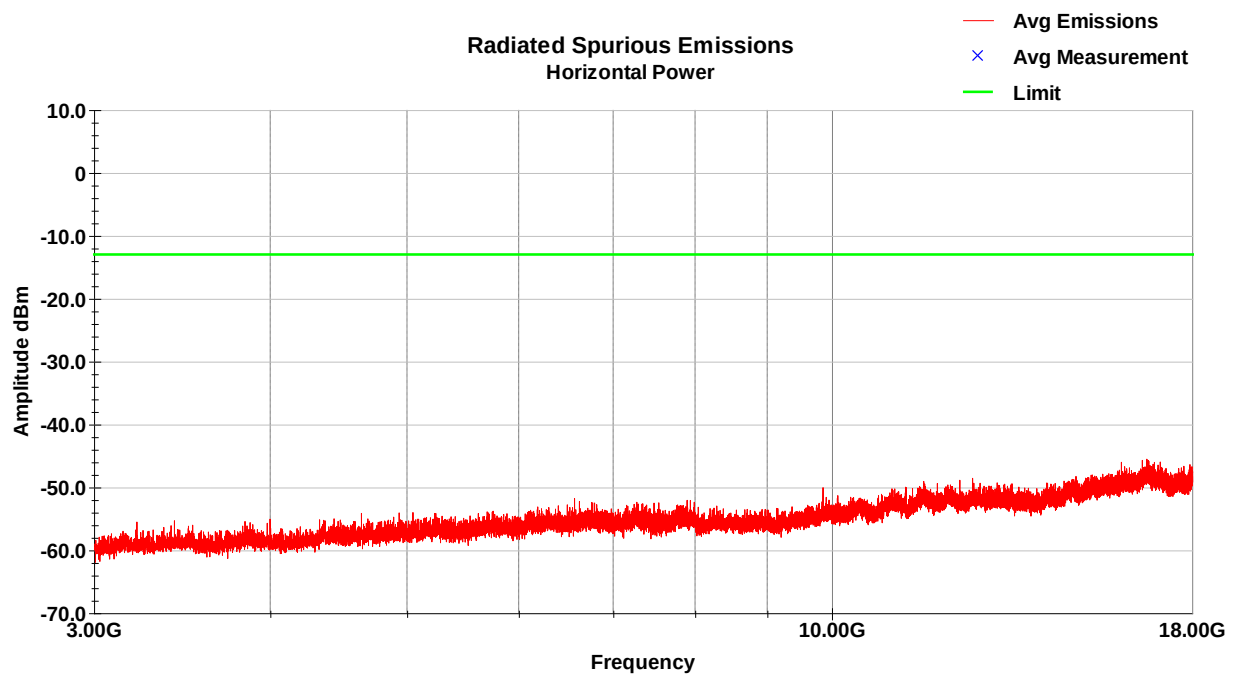
Horizontal Radiated Spurious Emissions Plot – 1-3GHz (802.11b MCH)



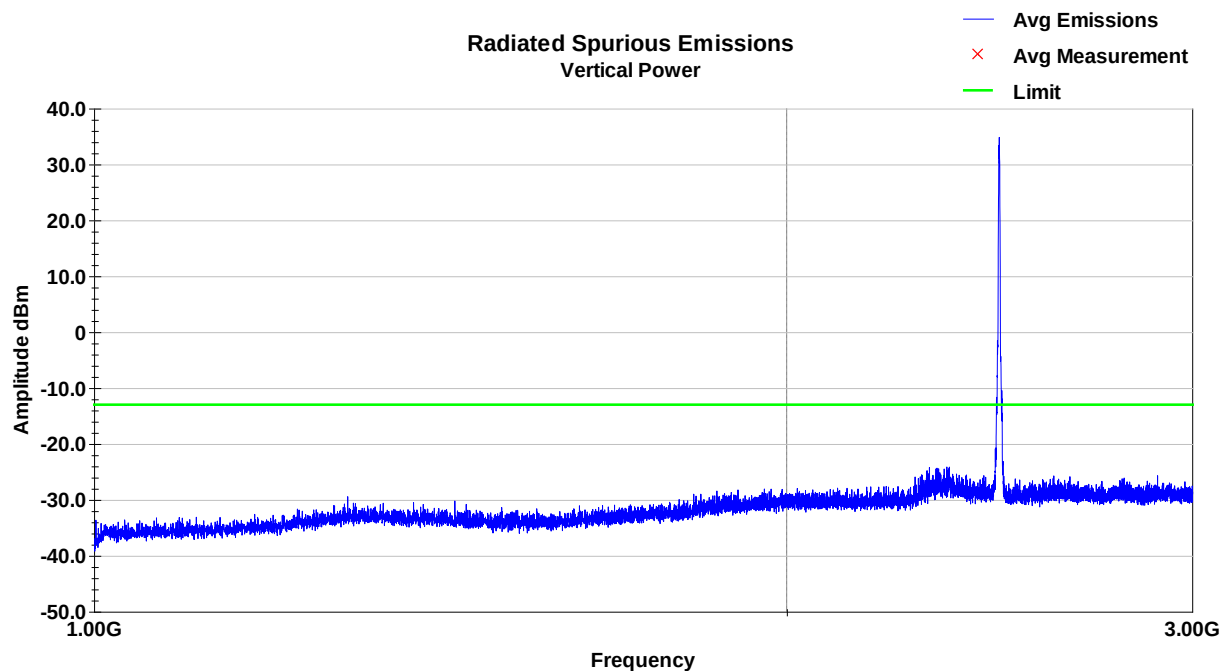
Vertical Radiated Spurious Emissions Plot – 3-18GHz (802.11b MCH)



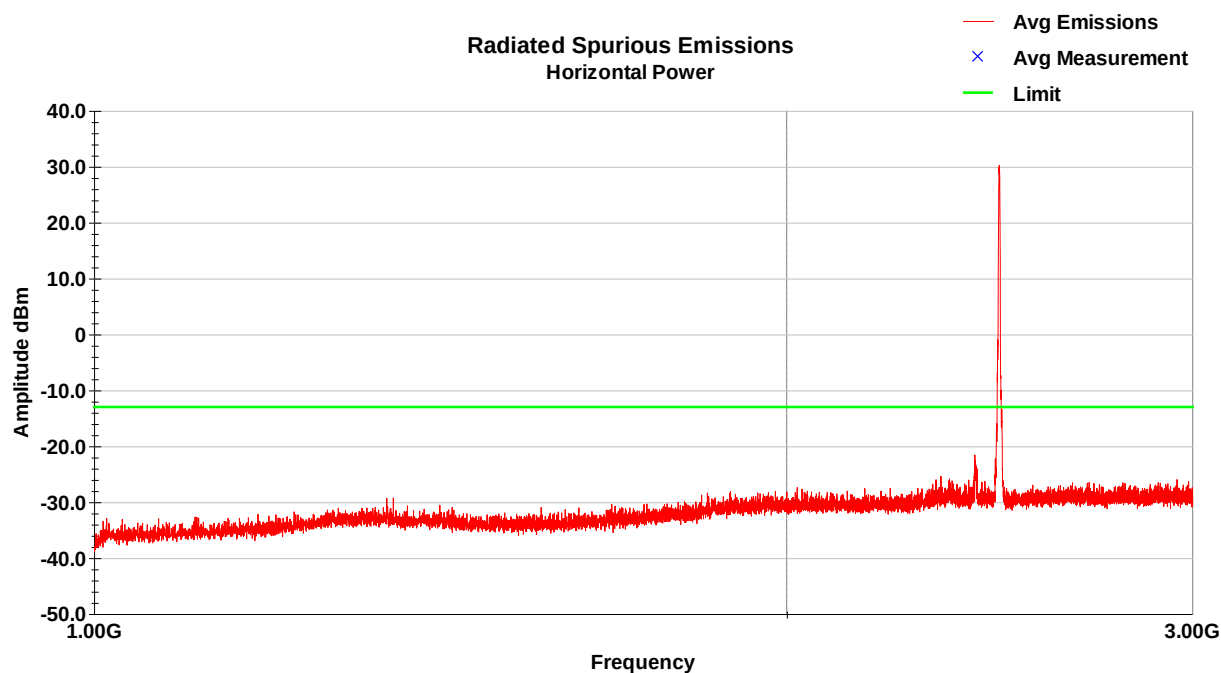
Horizontal Radiated Spurious Emissions Plot – 3-18GHz (802.11b MCH)



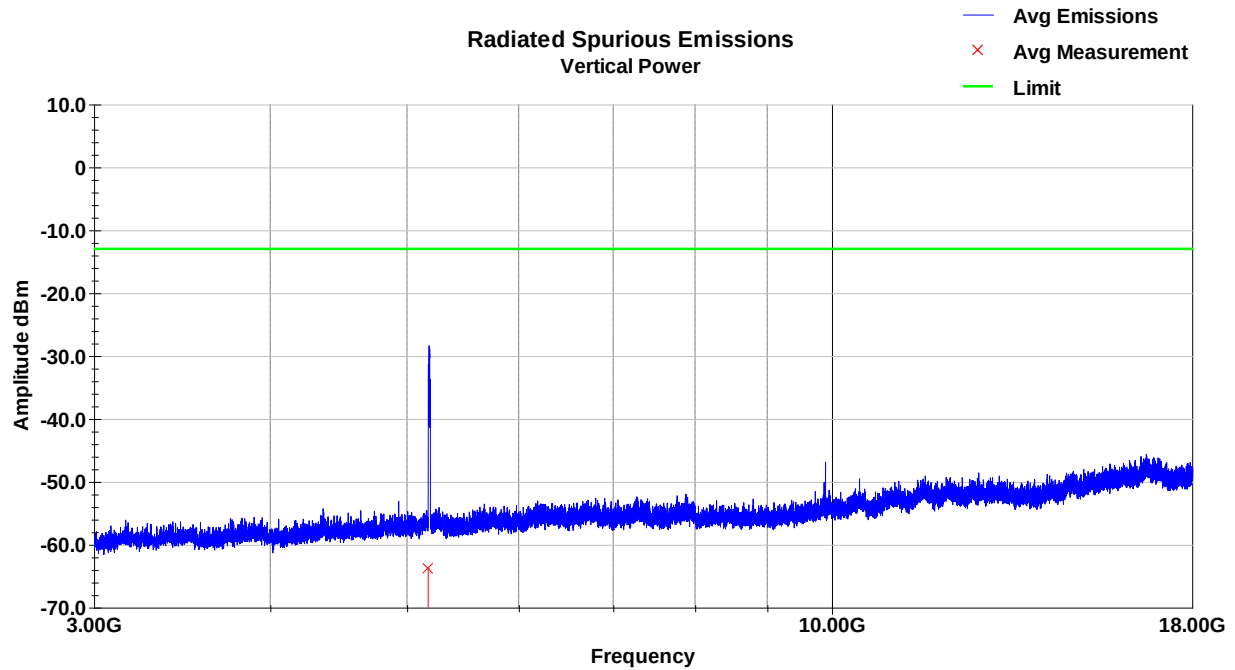
Vertical Radiated Spurious Emissions Plot – 1-3GHz (802.11b HCH)



Horizontal Radiated Spurious Emissions Plot – 1-3GHz (802.11b HCH)



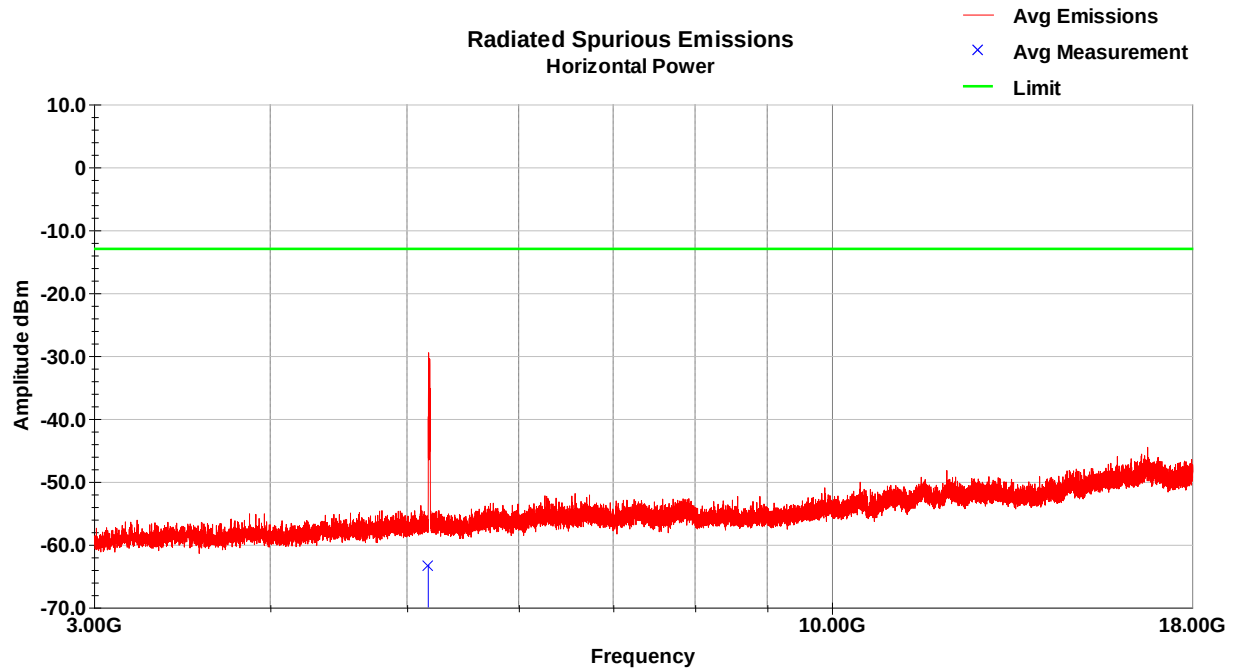
Vertical Radiated Spurious Emissions Plot – 3-18GHz (802.11b HCH)



Vertical Radiated Spurious Emissions Data – 3-18GHz (802.11b HCH)

Frequency MHz	Raw Avg dBm	Polarity V/H	Azimuth degrees	Height cm	AF dB/m	Loss dB	Amp dB	Avg Value dBm	Limit dBm	Margin dB
5176.24	-58.5	V	336.0	249.0	34.3	2.4	42.0	-63.7	-13.0	-50.7
Avg Value = Raw Avg + AF + Loss - Amp										
Margin = Avg Value - Limit										

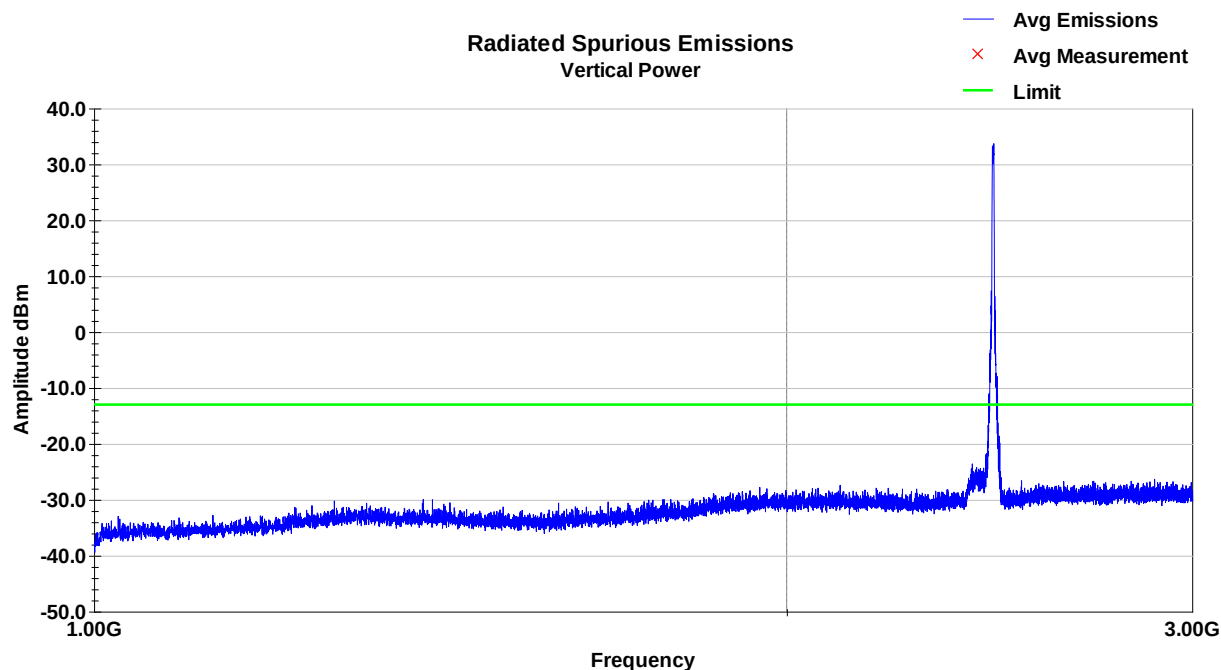
Horizontal Radiated Spurious Emissions Plot – 3-18GHz (802.11b HCH)



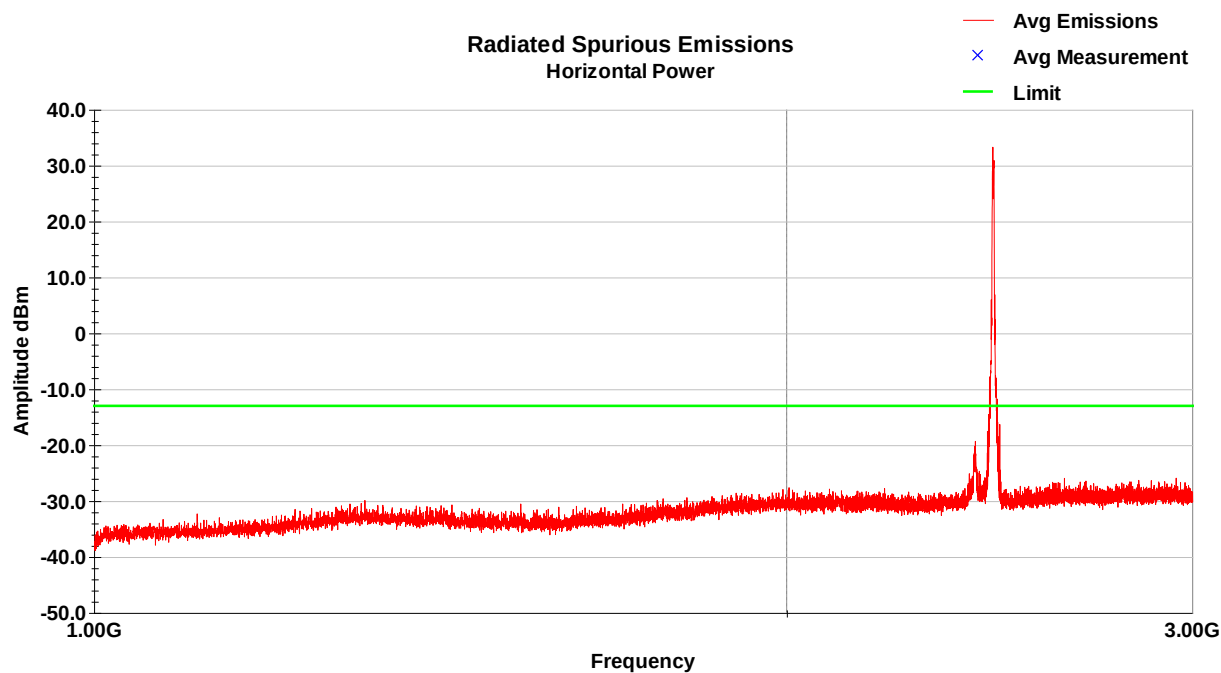
Horizontal Radiated Spurious Emissions Data – 3-18GHz (802.11b HCH)

Frequency MHz	Raw Avg dBm	Polarity V/H	Azimuth degrees	Height cm	AF dB/m	Loss dB	Amp dB	Avg Value dBm	Limit dBm	Margin dB
5177.16	-58.0	H	266.0	163.0	34.3	2.4	42.0	-63.3	-13.0	-50.3
Avg Value = Raw Avg + AF + Loss - Amp										
Margin = Avg Value - Limit										

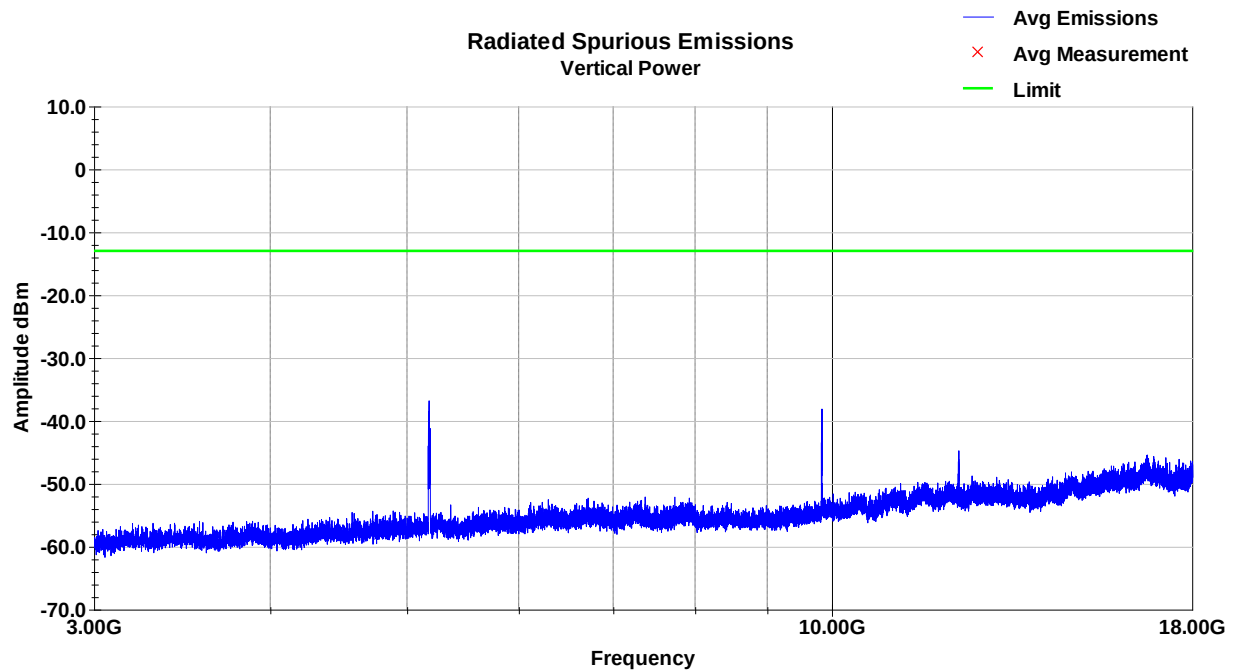
Vertical Radiated Spurious Emissions Plot – 1-3GHz (802.11g LCH)



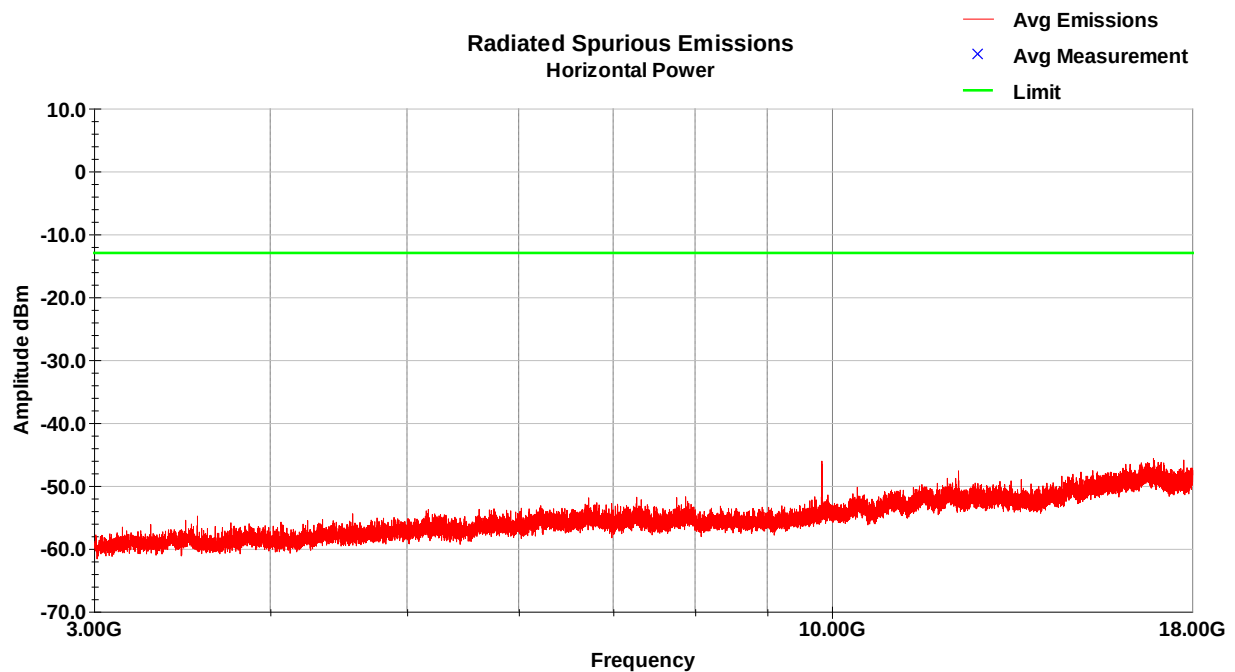
Horizontal Radiated Spurious Emissions Plot – 1-3GHz (802.11g LCH)



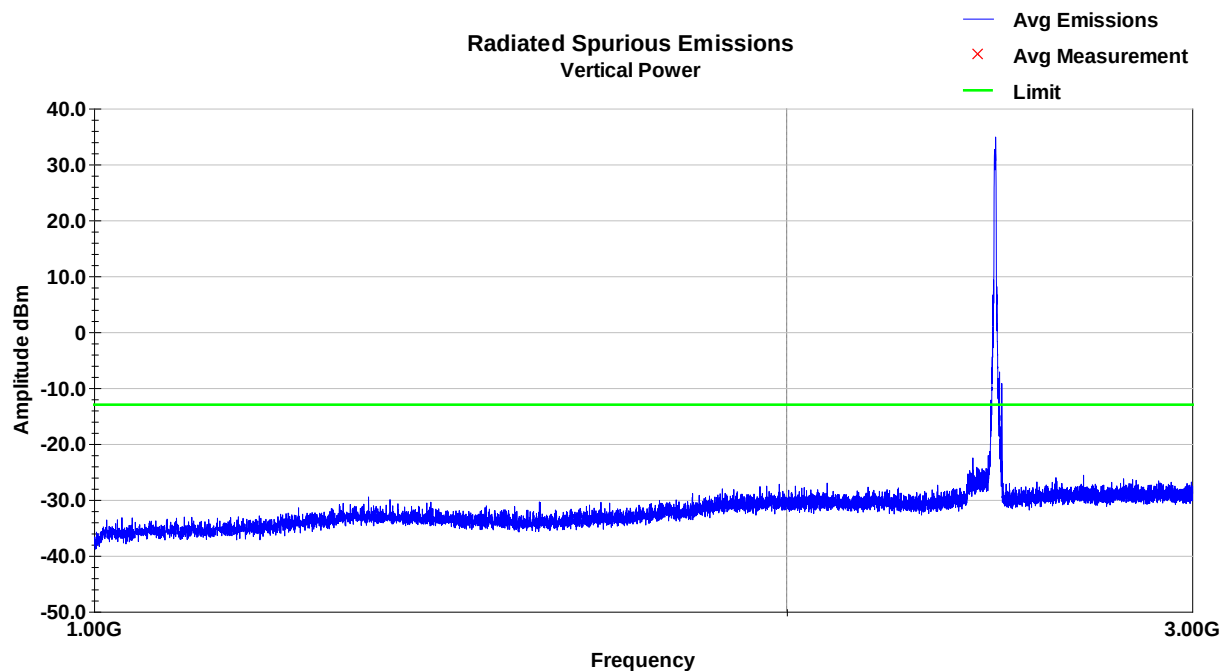
Vertical Radiated Spurious Emissions Plot – 3-18GHz (802.11g LCH)



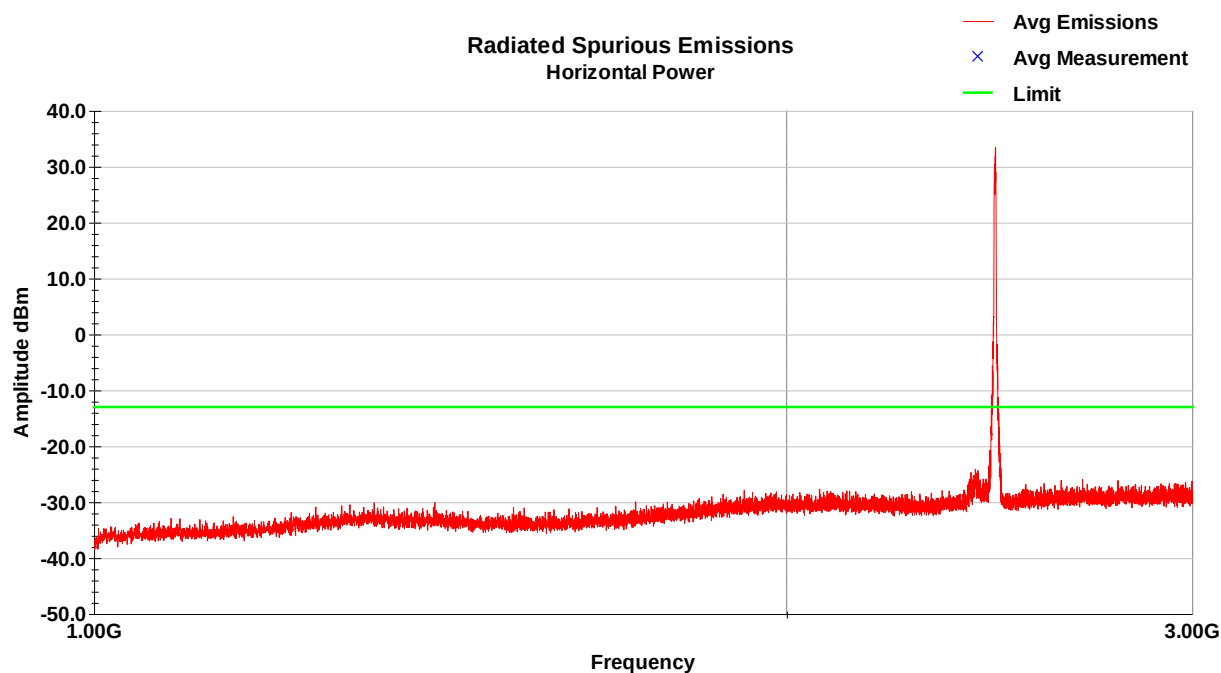
Horizontal Radiated Spurious Emissions Plot – 3-18GHz (802.11g LCH)



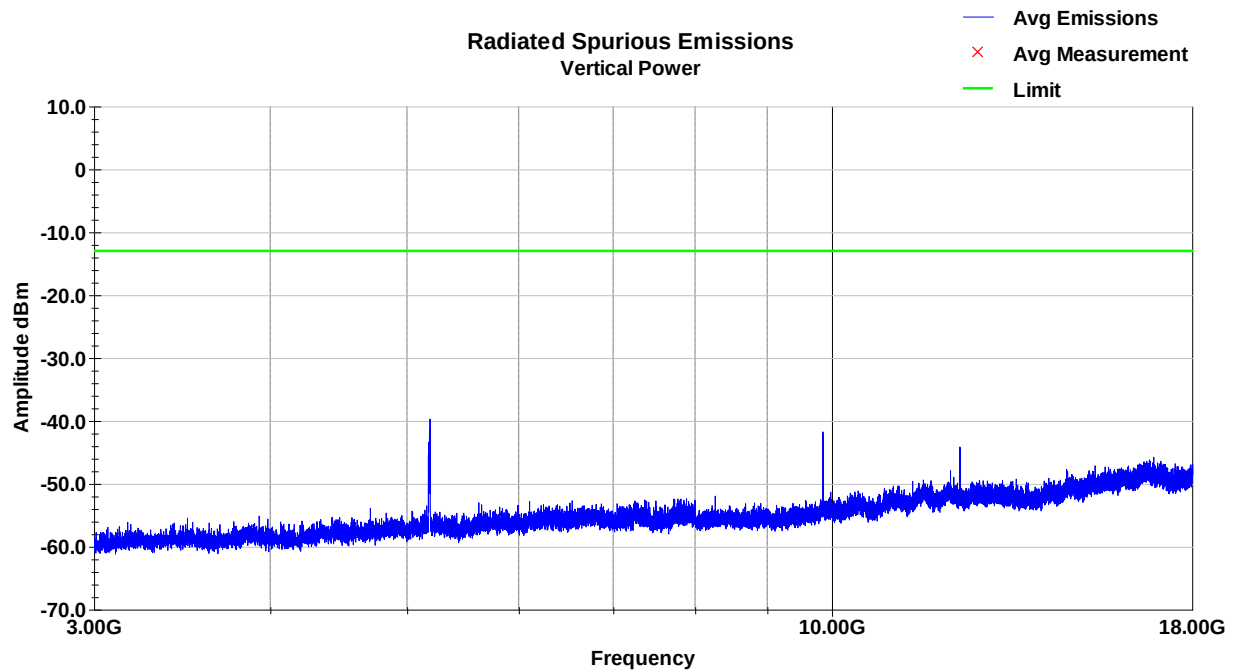
Vertical Radiated Spurious Emissions Plot – 1-3GHz (802.11g MCH)



Horizontal Radiated Spurious Emissions Plot – 1-3GHz (802.11g MCH)



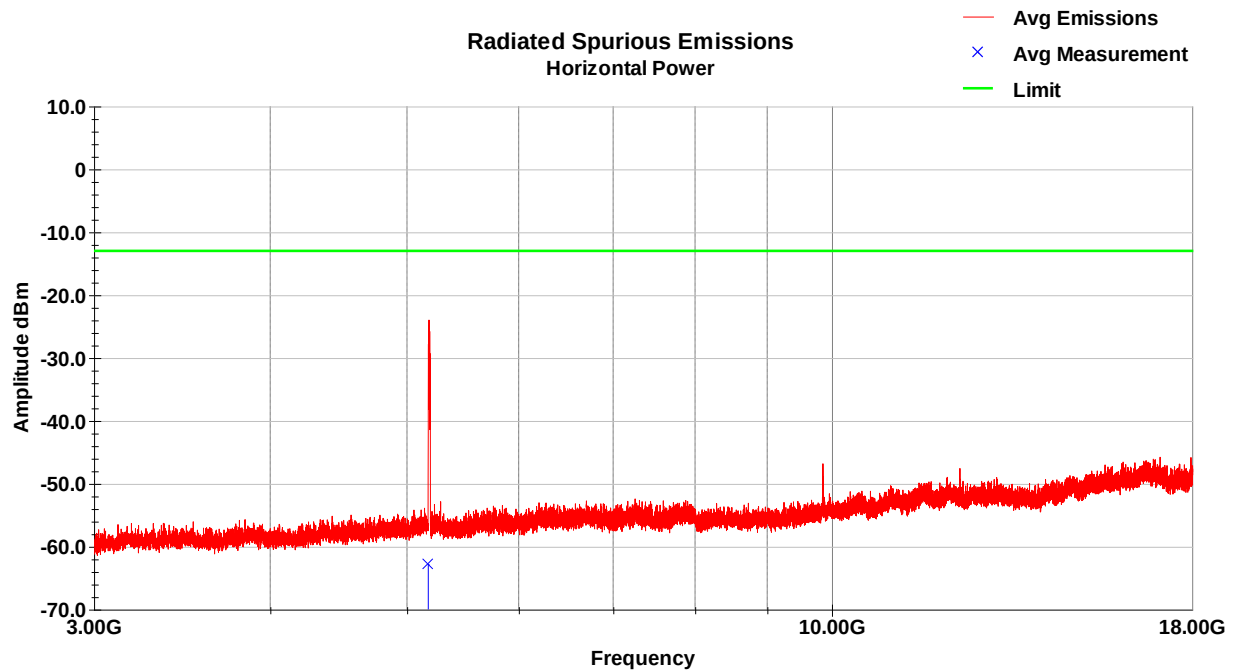
Vertical Radiated Spurious Emissions Plot – 3-18GHz (802.11g MCH)



Vertical Radiated Spurious Emissions Data – 3-18GHz (802.11g MCH)

No emissions within 20dB of the limit.

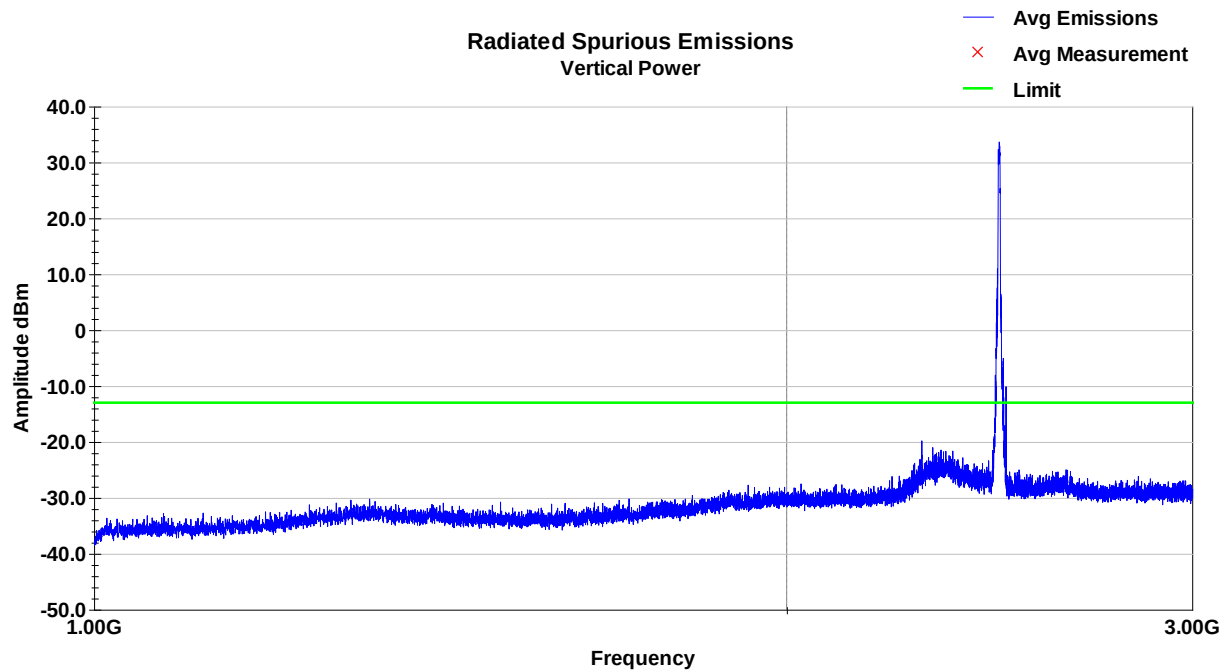
Horizontal Radiated Spurious Emissions Plot – 3-18GHz (802.11g MCH)



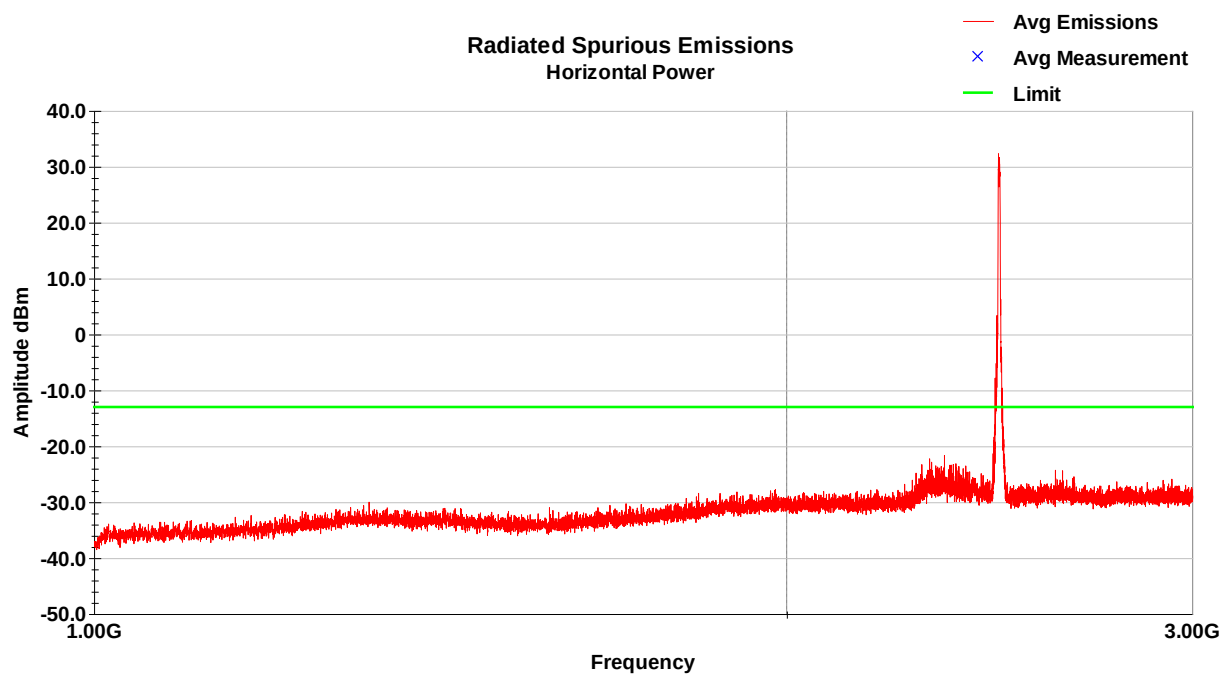
Horizontal Radiated Spurious Emissions Data – 3-18GHz (802.11g MCH)

Frequency MHz	Raw Avg dBm	Polarity V/H	Azimuth degrees	Height cm	AF dB/m	Loss dB	Amp dB	Avg Value dBm	Limit dBm	Margin dB
5176.80	-57.5	H	328.0	153.0	34.3	2.4	42.0	-62.8	-13.0	-49.8
Avg Value = Raw Avg + AF + Loss - Amp										
Margin = Avg Value - Limit										

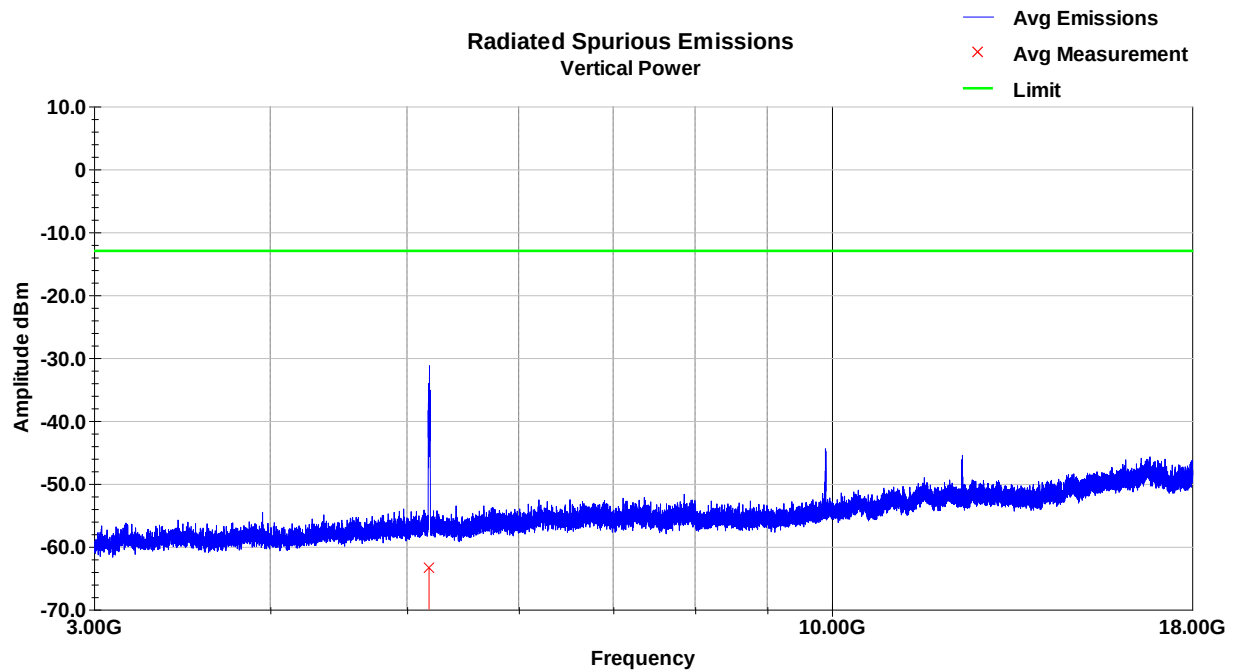
Vertical Radiated Spurious Emissions Plot – 1-3GHz (802.11g HCH)



Horizontal Radiated Spurious Emissions Plot – 1-3GHz (802.11g HCH)



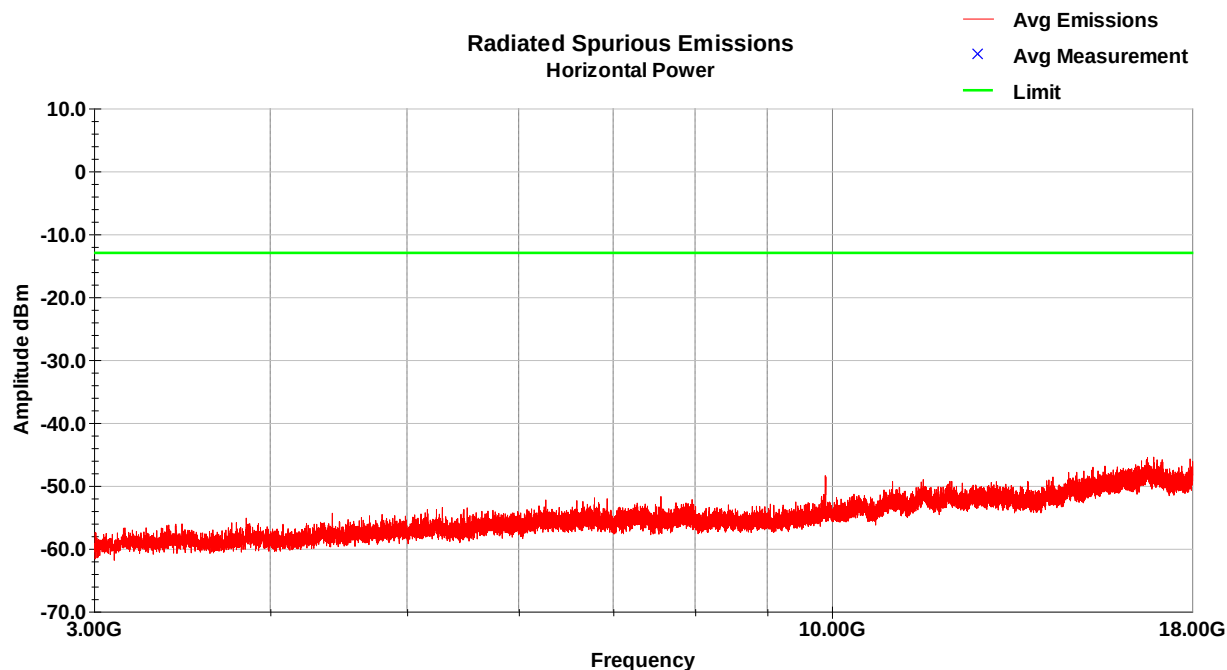
Vertical Radiated Spurious Emissions Plot – 3-18GHz (802.11g HCH)



Vertical Radiated Spurious Emissions Data – 3-18GHz (802.11g HCH)

Frequency MHz	Raw Avg dBm	Polarity V/H	Azimuth degrees	Height cm	AF dB/m	Loss dB	Amp dB	Avg Value dBm	Limit dBm	Margin dB
5183.68	-58.1	V	348.0	249.0	34.3	2.4	42.1	-63.5	-13.0	-50.5
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Margin = Avg Value - Limit										

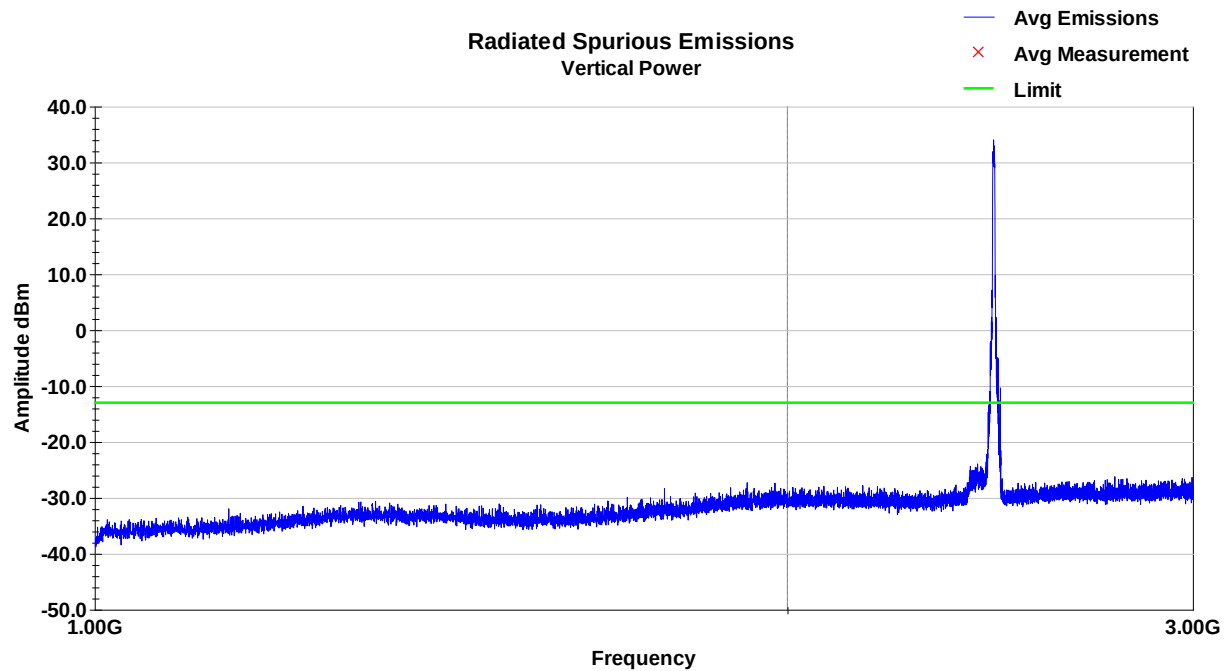
Horizontal Radiated Spurious Emissions Plot – 3-18GHz (802.11g HCH)



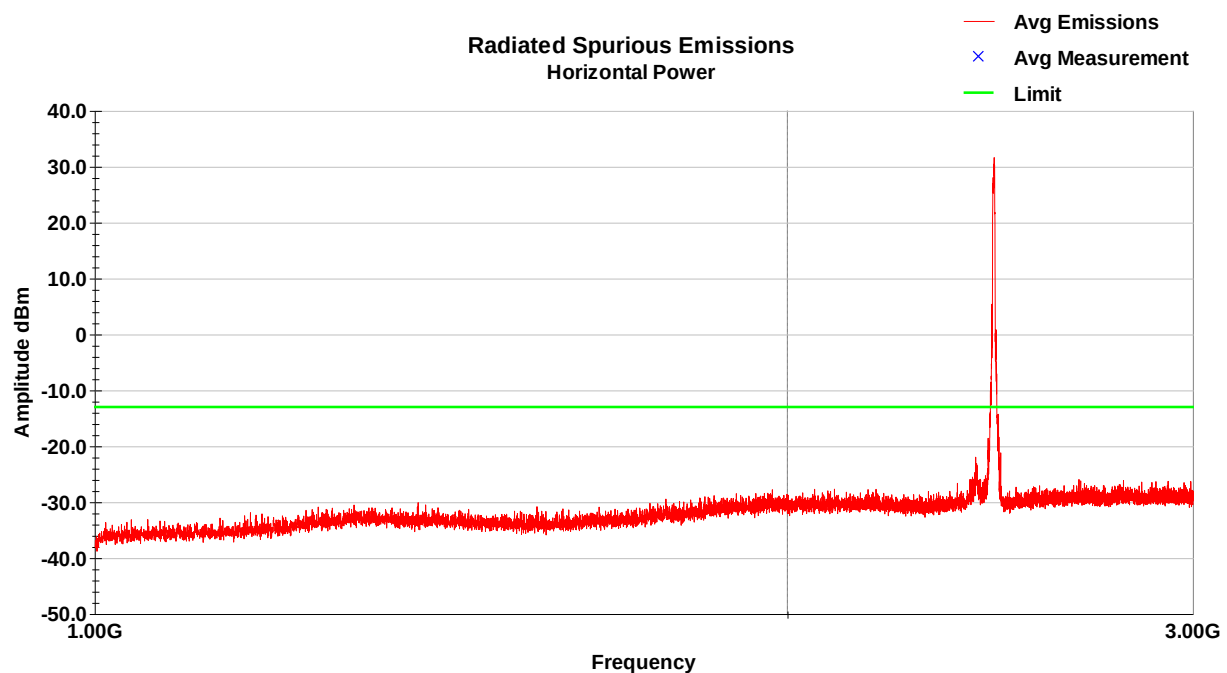
Horizontal Radiated Spurious Emissions Data – 3-18GHz (802.11g HCH)

No emissions within 20dB of the limit.

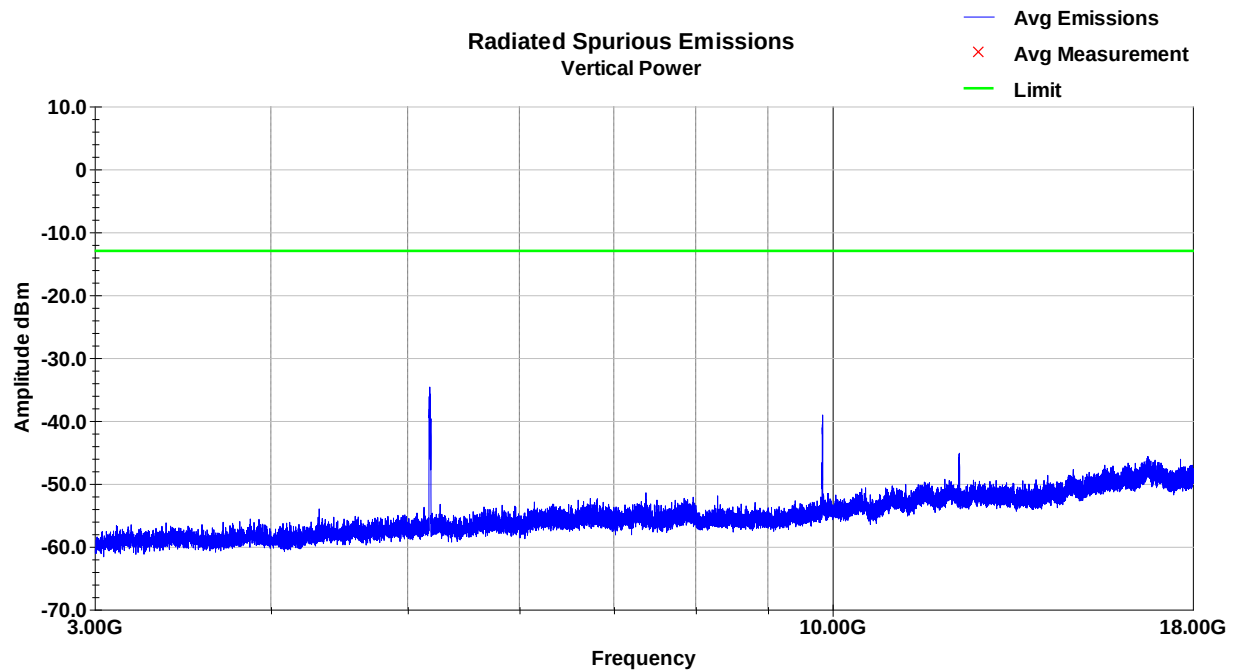
Vertical Radiated Spurious Emissions Plot – 1-3GHz (802.11n LCH)



Horizontal Radiated Spurious Emissions Plot – 1-3GHz (802.11n LCH)



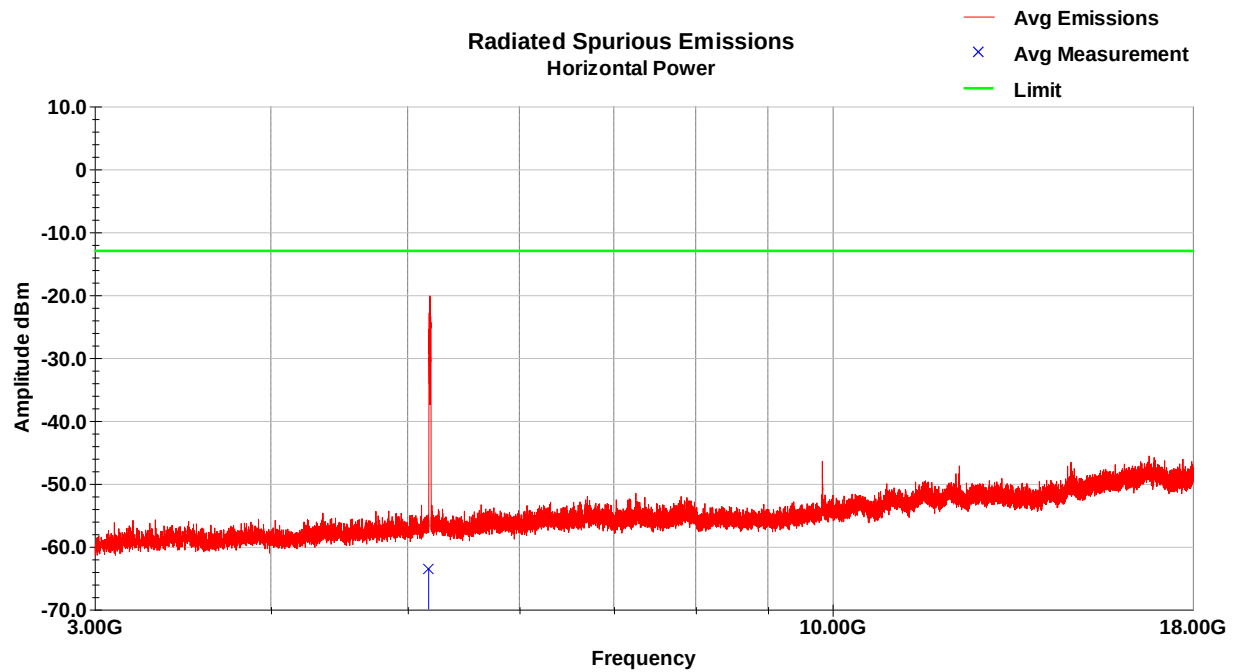
Vertical Radiated Spurious Emissions Plot – 3-18GHz (802.11n LCH)



Vertical Radiated Spurious Emissions Data – 3-18GHz (802.11n LCH)

No emissions within 20dB of the limit.

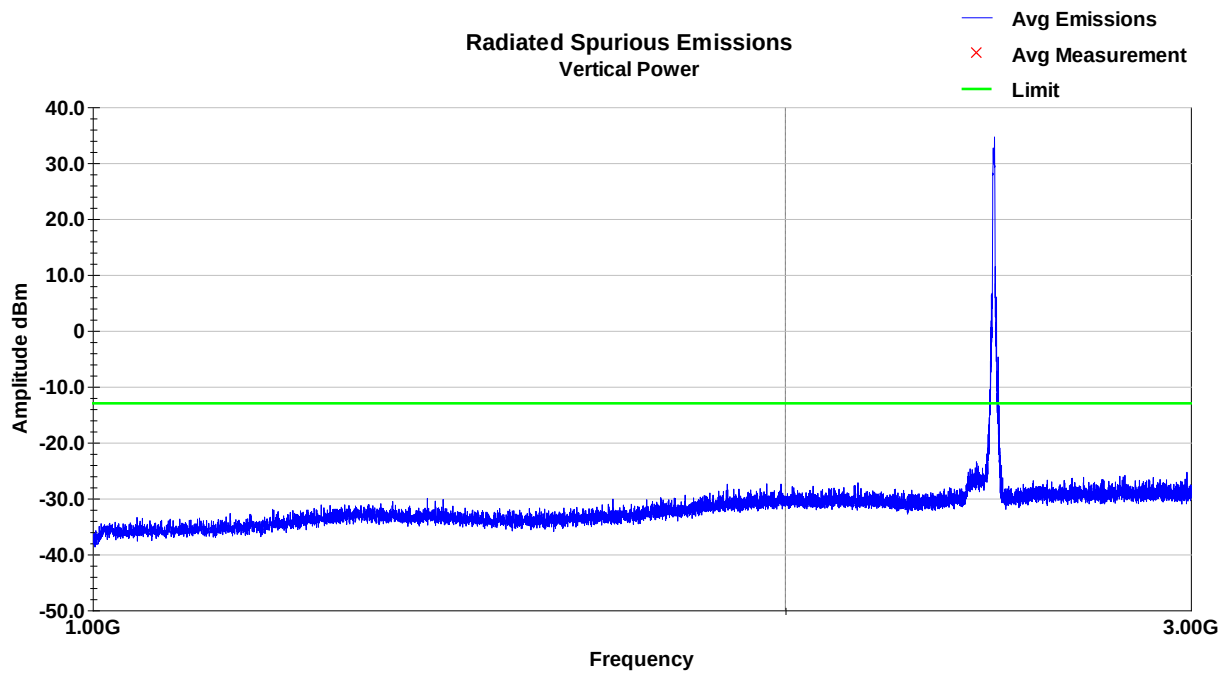
Horizontal Radiated Spurious Emissions Plot – 3-18GHz (802.11n LCH)



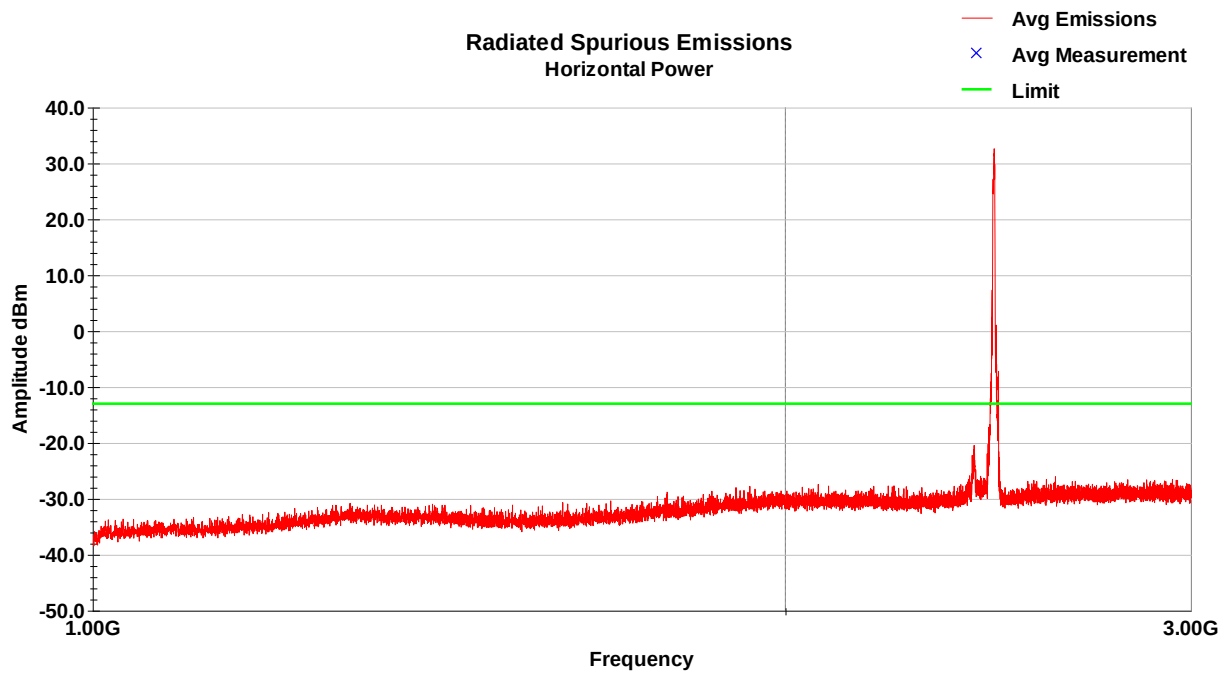
Horizontal Radiated Spurious Emissions Data – 3-18GHz (802.11n LCH)

Frequency MHz	Raw Avg dBm	Polarity V/H	Azimuth degrees	Height cm	AF dB/m	Loss dB	Amp dB	Avg Value dBm	Limit dBm	Margin dB
5174.76	-58.2	H	60.0	249.0	34.3	2.4	42.0	-63.5	-13.0	-50.5
Avg Value = Raw Avg + AF + Loss - Amp										
Margin = Avg Value - Limit										

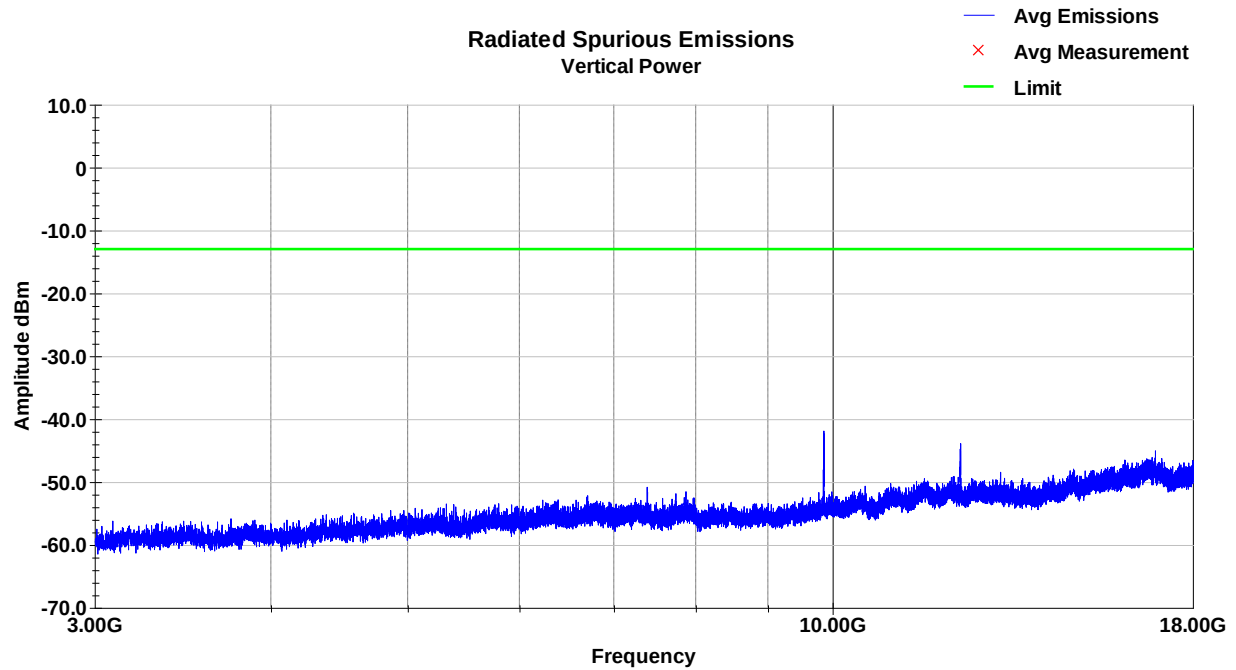
Vertical Radiated Spurious Emissions Plot – 1-3GHz (802.11n MCH)



Horizontal Radiated Spurious Emissions Plot – 1-3GHz (802.11n MCH)



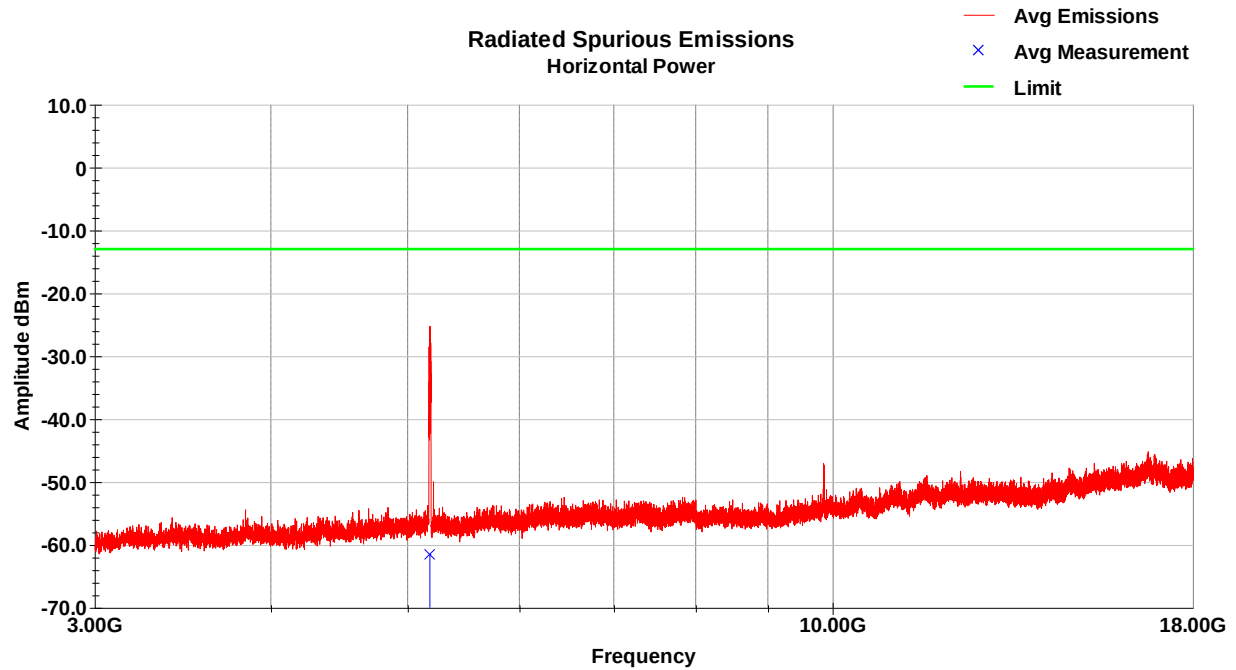
Vertical Radiated Spurious Emissions Plot – 3-18GHz (802.11n MCH)



Vertical Radiated Spurious Emissions Data – 3-18GHz (802.11n MCH)

No emissions within 20dB of the limit.

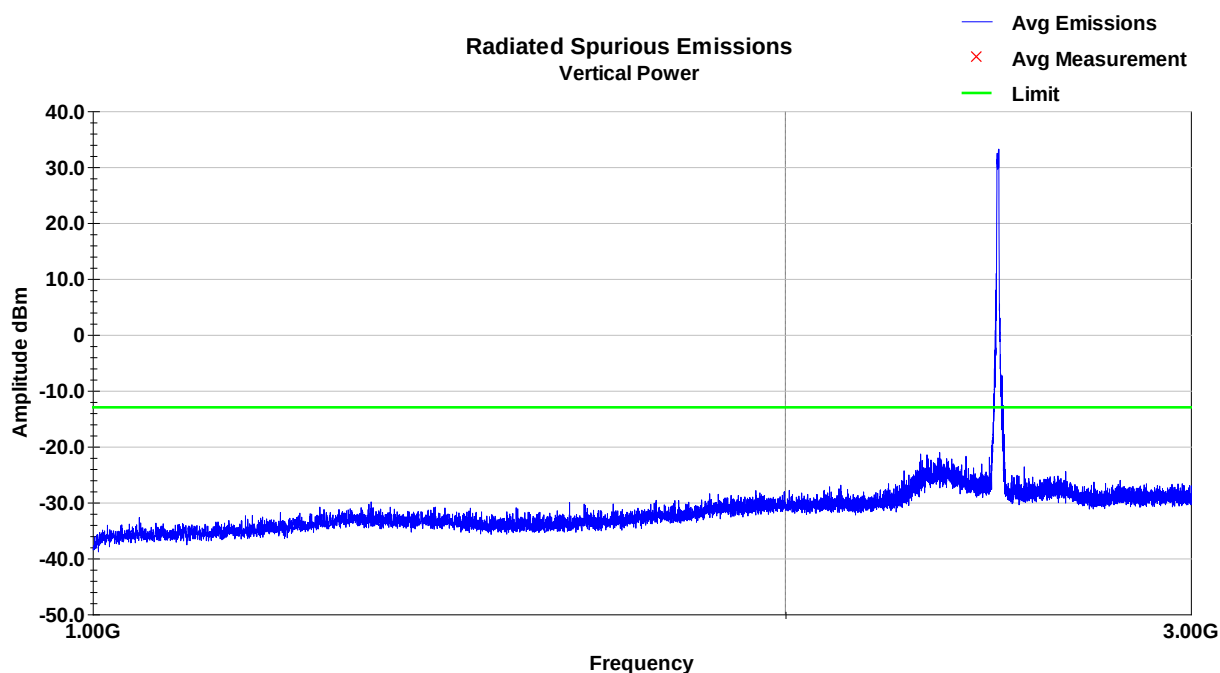
Horizontal Radiated Spurious Emissions Plot – 3-18GHz (802.11n MCH)



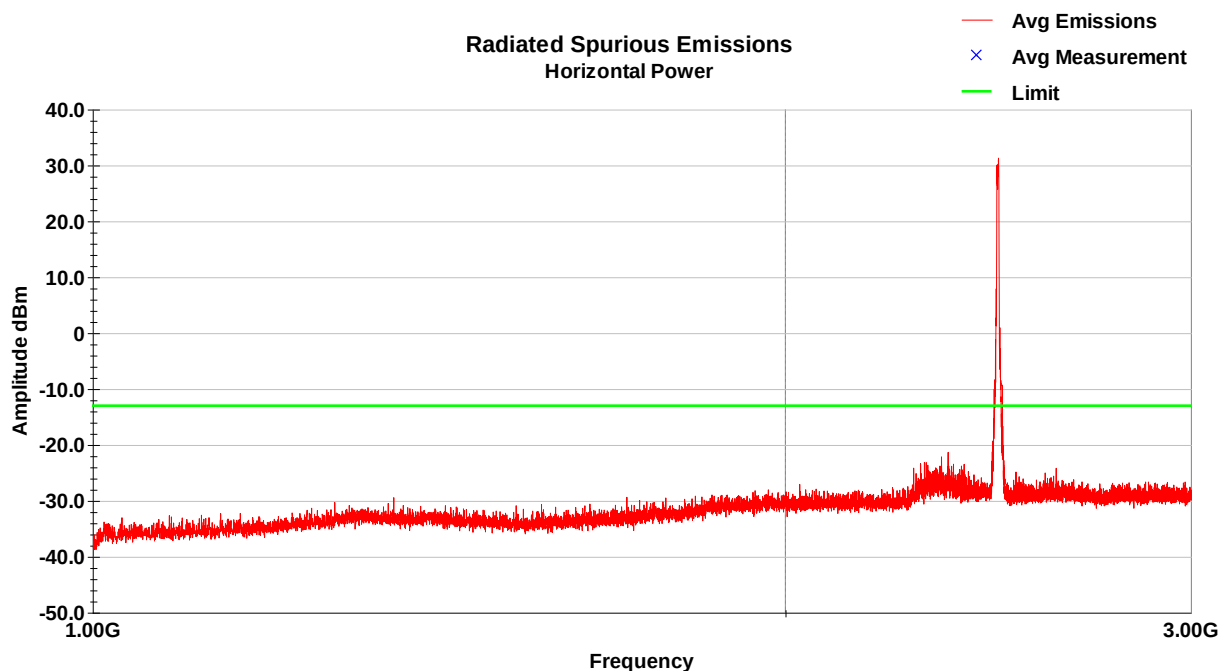
Horizontal Radiated Spurious Emissions Data – 3-18GHz (802.11n MCH)

Frequency MHz	Raw Avg dBm	Polarity V/H	Azimuth degrees	Height cm	AF dB/m	Loss dB	Amp dB	Avg Value dBm	Limit dBm	Margin dB
5184.68	-56.1	H	305.0	178.0	34.3	2.4	42.1	-61.4	-13.0	-48.4
Avg Value = Raw Avg + AF + Loss - Amp										
Margin = Avg Value - Limit										

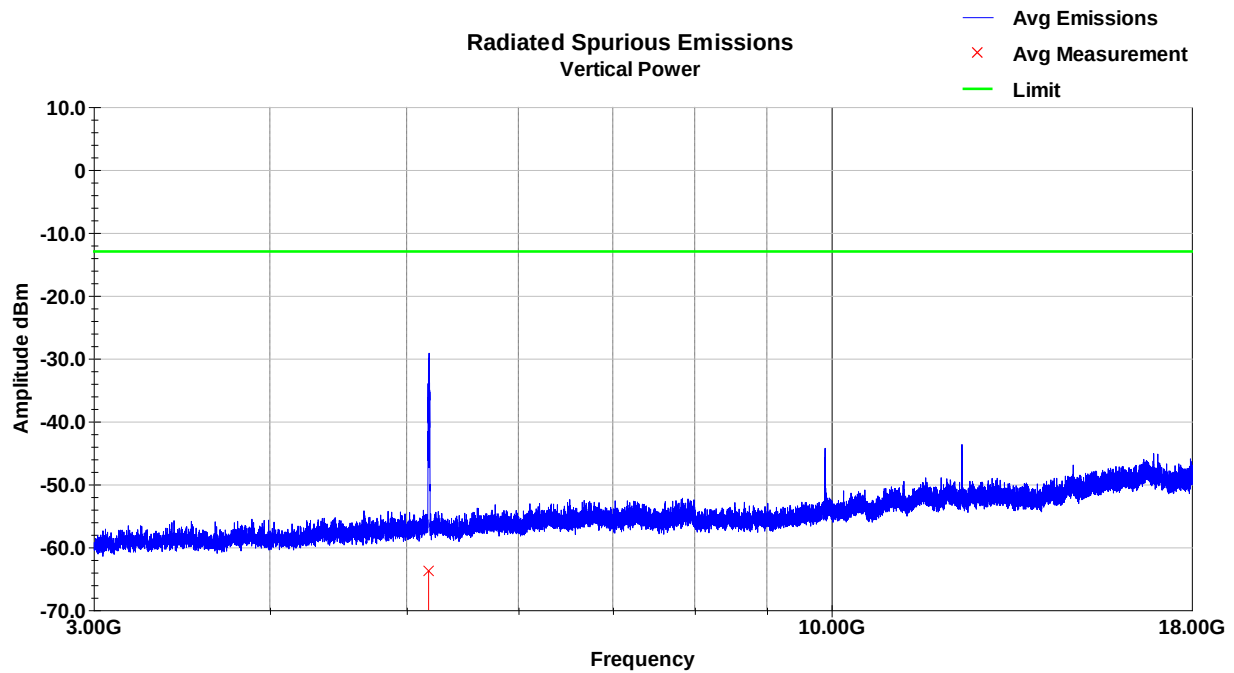
Vertical Radiated Spurious Emissions Plot – 1-3GHz (802.11n HCH)



Horizontal Radiated Spurious Emissions Plot – 1-3GHz (802.11n HCH)



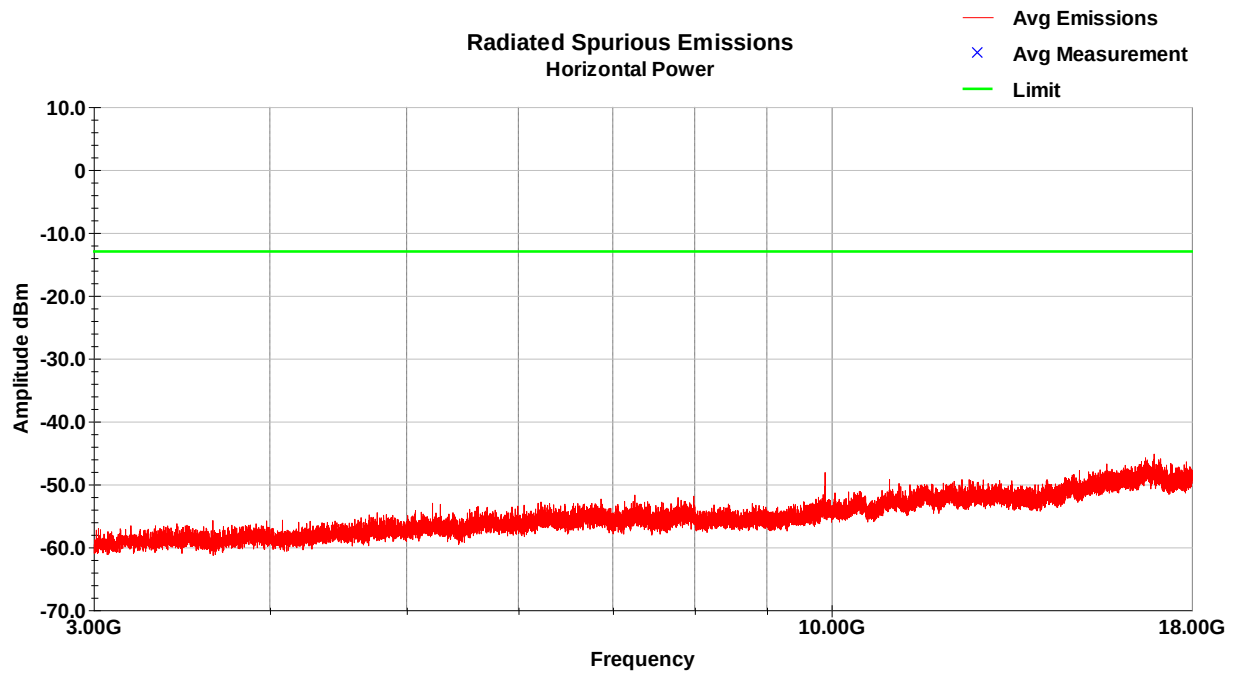
Vertical Radiated Spurious Emissions Plot – 3-18GHz (802.11n HCH)



Vertical Radiated Spurious Emissions Data – 3-18GHz (802.11n HCH)

Frequency MHz	Raw Avg dBm	Polarity V/H	Azimuth degrees	Height cm	AF dB/m	Loss dB	Amp dB	Avg Value dBm	Limit dBm	Margin dB
5182.72	-58.4	V	330.0	100.0	34.3	2.4	42.0	-63.7	-13.0	-50.7
Avg Value = Raw Avg + AF + Loss - Amp										
Margin = Avg Value - Limit										

Horizontal Radiated Spurious Emissions Plot – 3-18GHz (802.11n HCH)

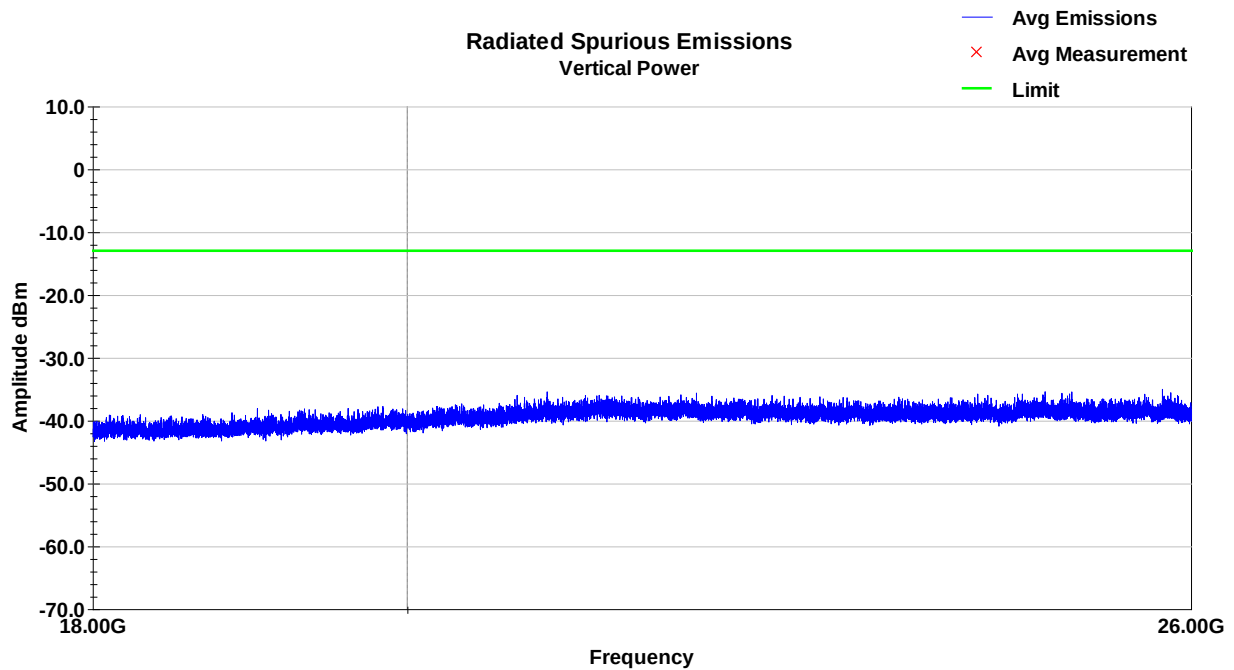


Horizontal Radiated Spurious Emissions Data – 3-18GHz (802.11n HCH)

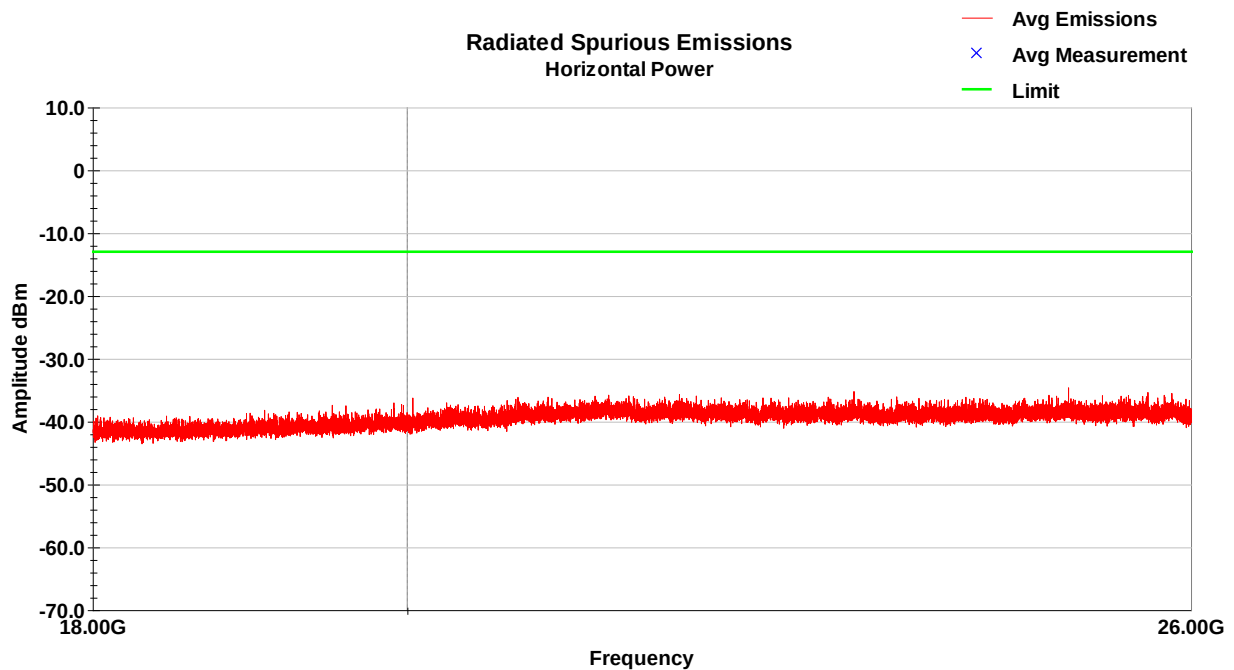
No emissions within 20dB of the limit.

In the 18-26GHz range there was little deviation with respect to data mode or channel (worst case shown below).

Vertical Radiated Spurious Emissions Plot – 18-26GHz



Horizontal Radiated Spurious Emissions Plot – 18-26GHz



4 Measurement Uncertainty

The measurement uncertainty figures are be calculated in accordance with TR 100 028-1 [2] and correspond to an expansion factor (coverage factor) $k = 2$ (which provide confidence levels of 95,45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian)).

Measurement uncertainty is not used to adjust the measurements to determine compliance.

Parameter	Expanded Uncertainty for Normal k factor equal to 2	
	Required	Laboratory Actual
Radio Frequency	$\pm 1 \times 10^{-5}$	$\pm 9.8 \times 10^{-8}$
total RF power, conducted	± 1.5 dB	± 1.2 dB
RF power density, conducted	± 3 dB	± 0.7 dB
spurious emissions, conducted	± 3 dB	± 2.1 dB
all emissions, radiated	± 6 dB	± 4.8 dB
temperature	$\pm 1^{\circ}\text{C}$	$\pm 0.5^{\circ}\text{C}$
humidity	± 5 %	$\pm 3.5\%$
DC and low frequency voltages	± 3 %	$\pm 0.4\%$

5 Revision History

Revision Level	Description of changes	Revision Date
0	Initial Release	06 December 2024