

FCC LISTED, REGISTRATION
NUMBER: 720267

Informe de ensayo nº:
Test report No:

IC LISTED REGISTRATION
NUMBER IC 4621A-1

NIE: 45355RRF.001A1

Test report (Modification 1) USA FCC Part 15.247, 15.209 CANADA RSS-247, RSS-Gen

Radio Frequency Devices. Operation within the bands 902 - 928 MHz, 2400 -2483.5 MHz, and
5725 - 5850 MHz.

Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt
Local Area Network (LE-LAN) Devices.

General Requirements and Information for the Certification of Radio Apparatus.

Identificación del objeto ensayado.....: Identification of item tested	Wireless sensor node for the Internet of Things
Marca Trade	Libelium
Modelo y/o referencia tipo Model and /or type reference	Waspmote Plug & Sense! 802.15.4
Other identification of the product	FCC ID: XKM-WPS-2400-V1 IC: 8472A-WPS2400V1
Final HW version	1.0
Final SW version	1.0
Características Features	Can transmit with the 802.15.4 protocol in the 2.4 GHz ISM band. Contains an XBee-PRO 802.15.4 radio.
Fabricante Manufacturer	LIBELIUM COMUNICACIONES DISTRIBUIDAS S.L C/ Escatrón 16 (Edificio Libelium), CP: 50014, Zaragoza (SPAIN)
Método de ensayo solicitado, norma.....: Test method requested, standard	USA FCC Part 15.247 10-1-15 Edition: Operation within the bands 902 - 928 MHz, 2400 -2483.5 MHz, and 5725 - 5850 MHz. - Emission limitations radiated (Transmitter) USA FCC Part 15.209 10-1-15 Edition: Radiated emission limits; general requirements. CANADA RSS-247 Issue 1 (May 2015). CANADA RSS-Gen Issue 4 (November 2014). Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 558074 D01 DTS Meas Guidance v03r03 dated 06/09/2015. ANSI C63.10-2013: American National Standard for Testing Unlicensed Wireless Devices.
Resultado.....: Summary	IN COMPLIANCE

Aprobado por (nombre / cargo y firma) Approved by (name / position & signature)	A. Llamas RF Lab. Manager		Firmado digitalmente por ALEJANDRO LLAMAS RODRIGUEZ Fecha: 2016.09.19 12:04:46 +02'00'
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Competences and guarantees

AT4 wireless is a laboratory with a measurement facility in compliance with the requirements of Section 2.948 of the FCC rules and has been added to the list of facilities whose measurements data will be accepted in conjunction with applications for Certification under Parts 15 or 18 of the Commission's Rules. Registration Number: 720267.

AT4 wireless is a laboratory with a measurement site in compliance with the requirements of RSS 212, Issue 1 (Provisional) and has been added to the list of filed sites of the Canadian Certification and Engineering Bureau. Reference File Number: IC 4621A-1.

In order to assure the traceability to other national and international laboratories, AT4 wireless has a calibration and maintenance program for its measurement equipment.

AT4 wireless guarantees the reliability of the data presented in this report, which is the result of the measurements and the tests performed to the item under test on the date and under the conditions stated on the report and, it is based on the knowledge and technical facilities available at AT4 wireless at the time of performance of the test.

AT4 wireless is liable to the client for the maintenance of the confidentiality of all information related to the item under test and the results of the test.

The results presented in this Test Report apply only to the particular item under test established in this document.

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General conditions

1. This report is only referred to the item that has undergone the test.
2. This report does not constitute or imply on its own an approval of the product by the Certification Bodies or competent Authorities.
3. This document is only valid if complete; no partial reproduction can be made without previous written permission of AT4 wireless.
4. This test report cannot be used partially or in full for publicity and/or promotional purposes without previous written permission of AT4 wireless and the Accreditation Bodies.

Uncertainty

Uncertainty (factor $k=2$) was calculated according to the AT4 wireless internal document PODT000.

Usage of samples

Samples undergoing test have been selected by: **the client**

Sample S/01 is composed of the following elements:

Control N°	Description	Model	Serial N°	Date of reception
45355E/004	Sensor node with antenna connector	Waspnote Plug & Sense! 802.15.4	---	2015-10-26
45355E/005	Antenna RF 2.4GHz	---	---	2015-10-26

1. Sample S/01 has undergone following test(s).
All tests indicated in appendix A.

Test sample description

The test sample consists of a device that receives data from sensors and sends information with its wireless radio. It is battery powered and can be easily programmed.

Identification of the client

LIBELIUM COMUNICACIONES DISTRIBUIDAS S.L.
C/ Escatrón 16 (Edificio Libelium), CP: 50014, Zaragoza (SPAIN)

Testing period

The performed test started on 2015-10-26 and finished on 2015-10-28.

The tests have been performed at AT4 wireless.

Environmental conditions

In the control chamber, the following limits were not exceeded during the test:

Temperature	Min. = 15 °C Max. = 35 °C
Relative humidity	Min. = 20 % Max. = 75 %
Shielding effectiveness	> 100 dB
Electric insulation	> 10 kΩ
Reference resistance to earth	< 1 Ω

In the semianechoic chamber, the following limits were not exceeded during the test.

Temperature	Min. = 15 °C Max. = 35 °C
Relative humidity	Min. = 20 % Max. = 75 %
Air pressure	Min. = 860 mbar Max. = 1060 mbar
Shielding effectiveness	> 100 dB
Electric insulation	> 10 kΩ
Reference resistance to earth	< 1 Ω
Normal site attenuation (NSA)	< ±4 dB at 10 m distance between item under test and receiver antenna, (30 MHz to 1000 MHz)
Field homogeneity	More than 75% of illuminated surface is between 0 and 6 dB (26 MHz to 1000 MHz).

Modifications to the reference test report

It was introduced the following modifications in respect to the test report number 45355RRF.001 related with the same samples, in the next clauses and sub-clauses:

Clauses / Sub-clauses	Modification	Justification
Cover sheet / Other identification of the product/IC	IC code is changed to 8472A-WPS2400V1	Typographical error

This modification test report cancels and replaces the test report 45355RRF.001.

Remarks and comments

1: Test not requested. Only radiated spurious emissions tests were requested.

2: Used instrumentation:

		Last Cal. date	Cal. due date
1.	Semianechoic Absorber Lined Chamber ETS FACT3 200STP	N.A.	N.A.
2.	BiconicalLog antenna ETS LINDGREN 3142E	2014/03	2017/03
3.	Multi Device Controller EMCO 2090	N.A.	N.A.
4.	Double-ridge Guide Horn antenna 1-18 GHz SCHWARZBECK BBHA 9120 D	2013/11	2016/11
5.	Broadband Horn antenna 18-40 GHz SCHWARZBECK BBHA 9170	2014/03	2017/03
6.	EMI Test Receiver R&S ESU 40	2014/02	2016/02
7.	Spectrum analyser Rohde & Schwarz FSW50	2013/10	2015/10
8.	RF pre-amplifier 10 MHz-6 GHz SCHWARZBECK BBV9743	2015/03	2016/03
9.	RF pre-amplifier 1-18 GHz Bonn Elektronik BLMA 0118-3A	2015/05	2016/05
10.	RF pre-amplifier 18-40 GHz BONN ELEKTRONIK BLMA 1840-1M	2014/02	2016/02

Testing verdicts

Not applicable	N/A
Pass	P
Fail	F
Not measured	N/M

FCC PART 15 PARAGRAPH / RSS-247		VERDICT			
		NA	P	F	NM
Section 15.247 Subclause (a) (2) / RSS-247 5.2. (1)	6 dB Bandwidth				NM ¹
Section 15.247 Subclause (b) / RSS-247 5.4. (4)	Maximum output power and antenna gain				NM ¹
Section 15.247 Subclause (d) / RSS-247 5.5	Emission limitations conducted (Transmitter)				NM ¹
Section 15.247 Subclause (d) / RSS-247 5.5. ..	Band-edge emissions compliance (Transmitter)				NM ¹
Section 15.247 Subclause (e) / RSS-247 5.2. (2)	Power spectral density				NM ¹
Section 15.247 Subclause (d) / RSS-247 5.5. ...	Emission limitations radiated (Transmitter)		P		

1: See section “Remarks and comments”.

Appendix A – Test result

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TEST CONDITIONS

Power supply (V):

$V_{\text{nominal}} = 3.6 \text{ Vdc}$

Type of power supply = DC voltage from rechargeable battery.

Type of antenna = External attachable antenna.

TEST FREQUENCIES:

Lowest channel: 2410 MHz

Middle channel: 2440 MHz

Highest channel: 2465 MHz

RADIATED MEASUREMENTS

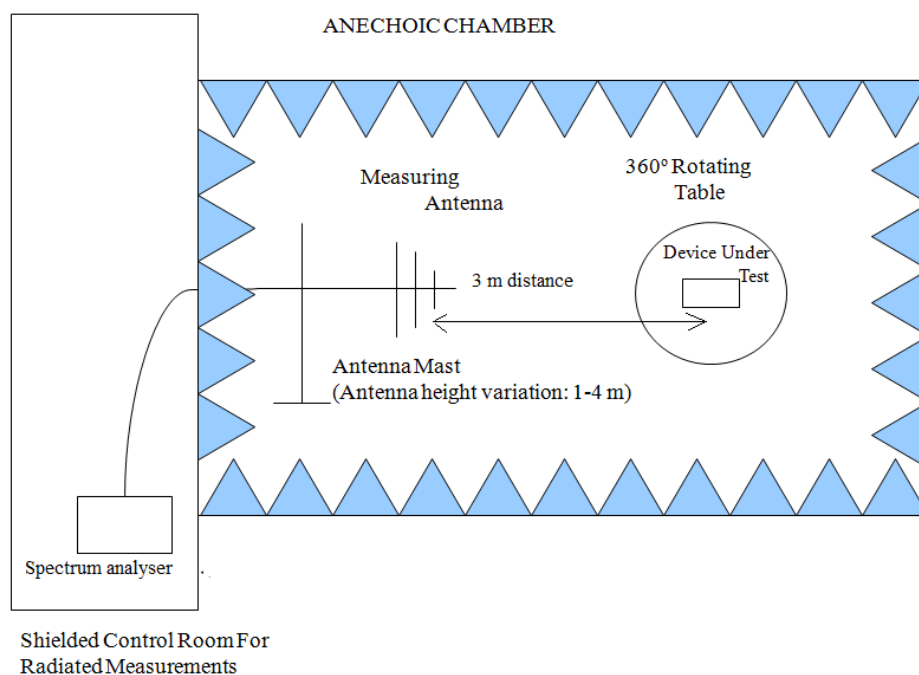
All radiated tests were performed in a semi-anechoic chamber. The measurement antenna is situated at a distance of 3 m for the frequency range 30 MHz-1000 MHz (30 MHz-1000 MHz Bilog antenna) and at a distance of 1m for the frequency range 1 GHz-25 GHz (1 GHz-18 GHz Double ridge horn antenna and 18 GHz-40 GHz horn antenna).

For radiated emissions in the range 1 GHz-25 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

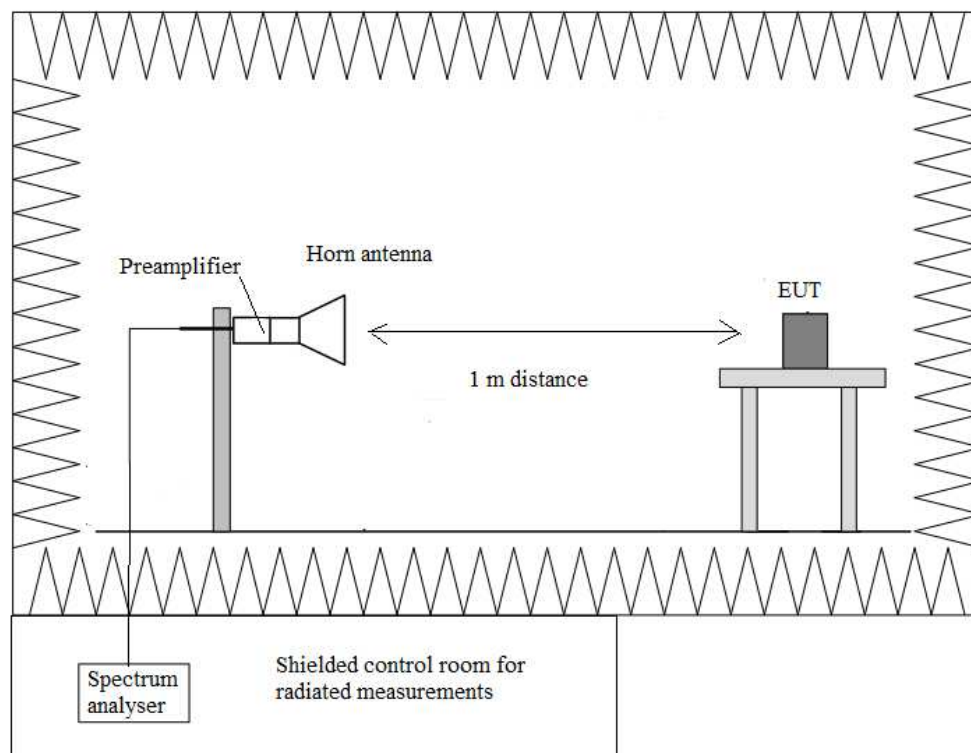
The equipment under test was set up on a non-conductive (wooden) platform 1.5 meter above the ground plane and the situation and orientation was varied to find the maximum radiated emission. It was also rotated 360° and the antenna height was varied from 1 to 4 meters to find the maximum radiated emission.

Measurements were made in both horizontal and vertical planes of polarization.

Radiated measurements setup $f < 1$ GHz



Radiated measurements setup $f > 1$ GHz



Section 15.247 Subclause (d) / RSS-247 5.5. Emission limitations radiated (Transmitter)

SPECIFICATION

Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)) / RSS-Gen 8.9.:

Frequency Range (MHz)	Field strength ($\mu\text{V/m}$)	Field strength ($\text{dB}\mu\text{V/m}$)	Measurement distance (m)
0.009-0.490	2400/F(kHz)	-	300
0.490-1.705	24000/F(kHz)	-	30
1.705 - 30.0	30	-	30
30 - 88	100	40	3
88 - 216	150	43.5	3
216 - 960	200	46	3
960 - 25000	500	54	3

The emission limits shown in the above table are based on measurements employing CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

For average radiated emission measurements above 1000 MHz, there is also a limit corresponding to 20 dB above the indicated values in the table is specified when measuring with peak detector function.

RESULTS:

The situation and orientation was varied to find the maximum radiated emission. It was also rotated 360° and the antenna height was varied from 1 to 4 meters to find the maximum radiated emission.

Measurements were made in both horizontal and vertical planes of polarization.

All tests were performed in a semi-anechoic chamber at a distance of 3 m for the frequency range 30 MHz-1000 MHz and at distance of 1m for the frequency range 1 GHz-25 GHz.

The field strength is calculated by adding correction factor to the measured level from the spectrum analyzer. This correction factor includes antenna factor, cable loss and pre-amplifiers gain.

Frequency range 30 MHz-1000 MHz.

1. CHANNEL: LOWEST (2410 MHz).

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBμ V/m)	Measurement Uncertainty (dB)
526.3490	V	Quasi-peak	33.27	±3.88

2. CHANNEL: MIDDLE (2440 MHz).

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBμ V/m)	Measurement Uncertainty (dB)
646.2410	V	Quasi-peak	32.80	±3.88

3. CHANNEL: HIGHEST (2465 MHz).

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBμ V/m)	Measurement Uncertainty (dB)
150.7650	V	Quasi-peak	31.42	±3.88
746.4420	V	Quasi-peak	32.43	±3.88

Frequency range 1 GHz-25 GHz

The results in the next tables show the maximum measured levels in the 1-25 GHz range including the restricted bands 2.31-2.39 GHz and 2.4835-2.5 GHz (see next plots).

Spurious signals with peak levels above the average limit (54 dBμV/m at 3 m) are measured with average detector for checking compliance with the average limit.

1. CHANNEL: LOWEST (2410 MHz).

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Measurement Uncertainty (dB)
2.15390	V	Peak	44.88	± 4.69
2.38960	V	Peak	65.71	± 4.69
		AVG	45.13	± 4.69
2.48560	V	Peak	57.09	± 4.69
		AVG	36.20	± 4.69
2.66590	V	Peak	48.33	± 4.69
2.68233	V	Peak	47.43	± 4.69
4.81975	V	Peak	42.17	± 4.69
7.22975	V	Peak	44.79	± 4.69
9.64025	V	Peak	49.15	± 4.69
14.46025	V	Peak	49.01	± 4.69

2. CHANNEL: MIDDLE (2440 MHz).

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Measurement Uncertainty (dB)
2.38947	V	Peak	57.20	± 4.69
		AVG	38.37	± 4.69
2.48597	V	Peak	59.42	± 4.69
		AVG	35.79	± 4.69
2.50390	V	Peak	50.93	± 4.69
4.87975	V	Peak	43.18	± 4.69
7.31975	V	Peak	43.90	± 4.69
9.75975	V	Peak	47.13	± 4.69

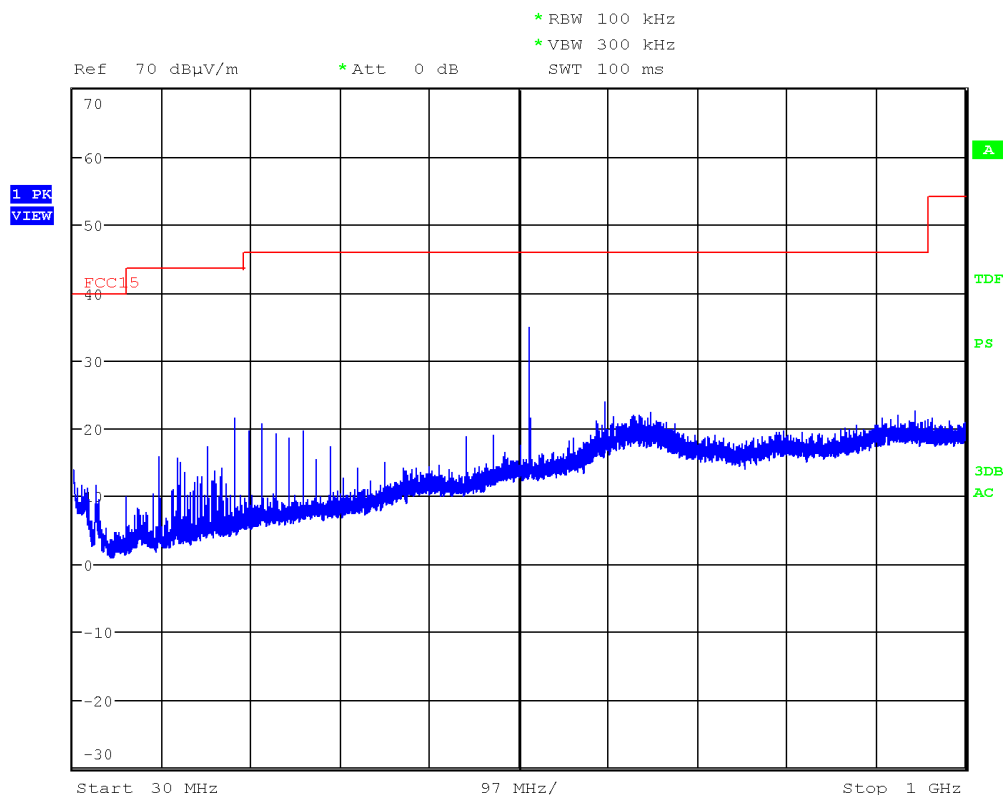
3. CHANNEL: HIGHEST (2465 MHz).

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Measurement Uncertainty (dB)
2.30490	V	Peak	51.32	± 4.69
2.38872	V	Peak	54.76	± 4.69
		AVG	36.52	± 4.69
2.48391	V	Peak	66.99	± 4.69
		AVG	43.77	± 4.69
2.73690	V	Peak	47.66	± 4.69
4.93025	V	Peak	44.01	± 4.69
7.39525	V	Peak	44.39	± 4.69
9.85975	V	Peak	48.40	± 4.69

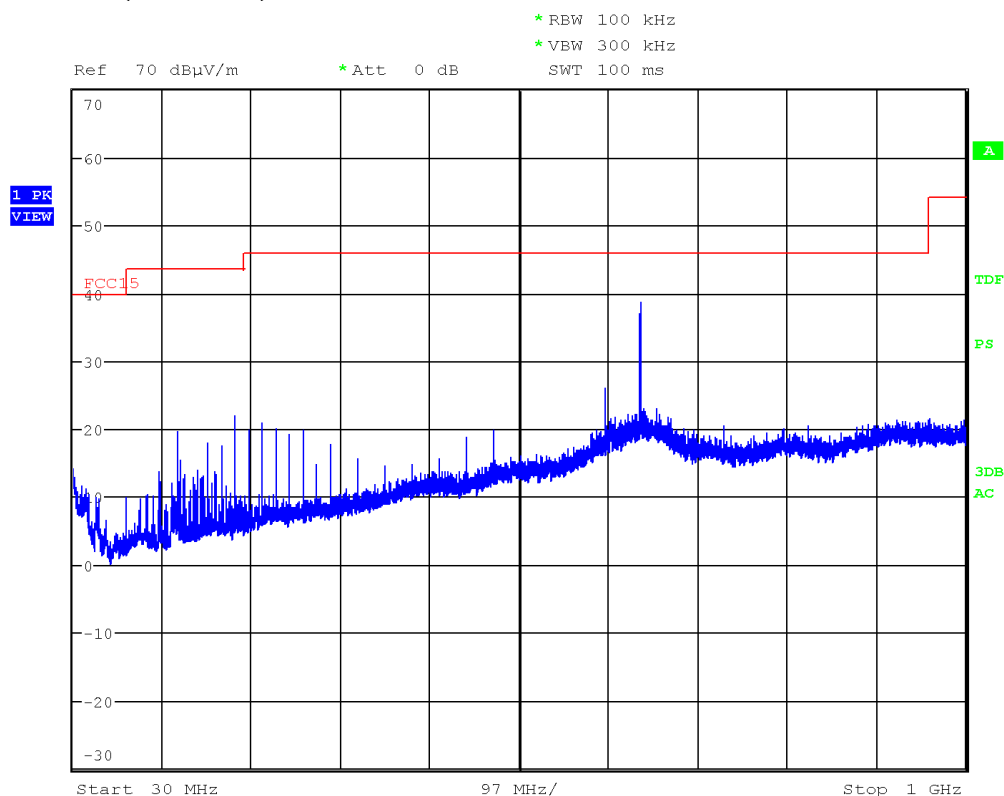
Verdict: PASS

FREQUENCY RANGE 30 MHz-1000 MHz.

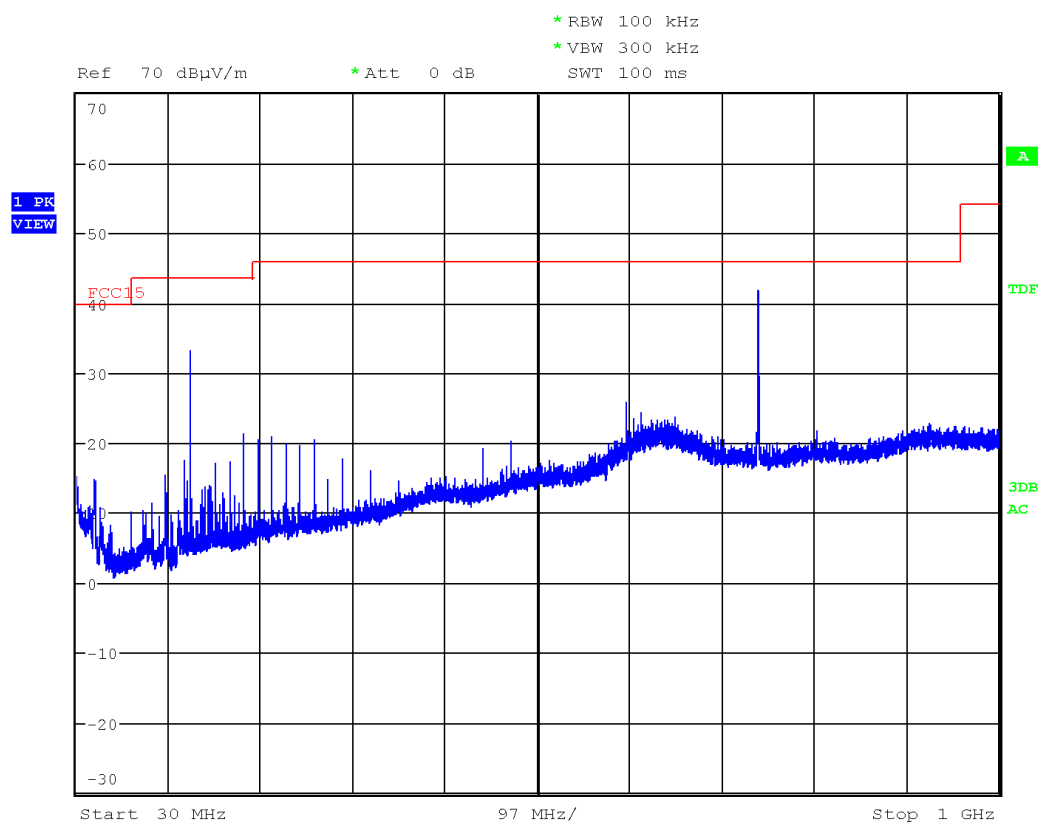
CHANNEL: Lowest (2410 MHz).



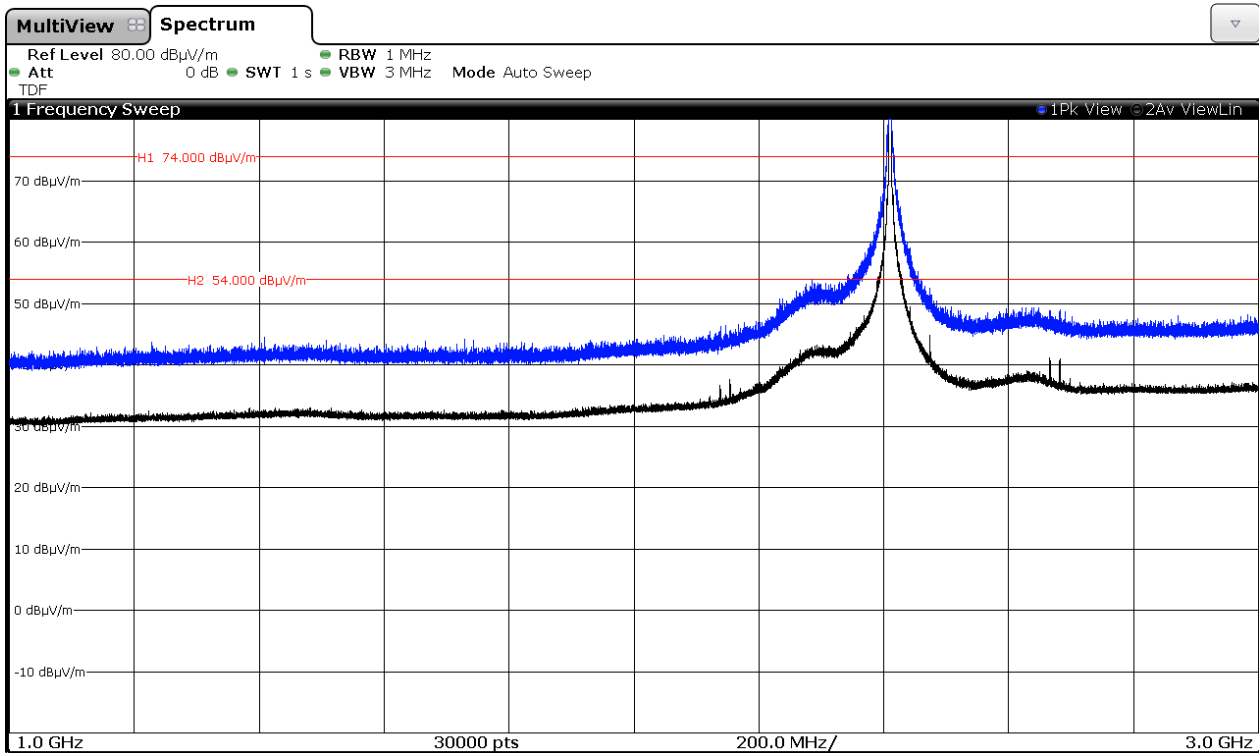
CHANNEL: Middle (2440 MHz).



CHANNEL: Highest (2465 MHz).

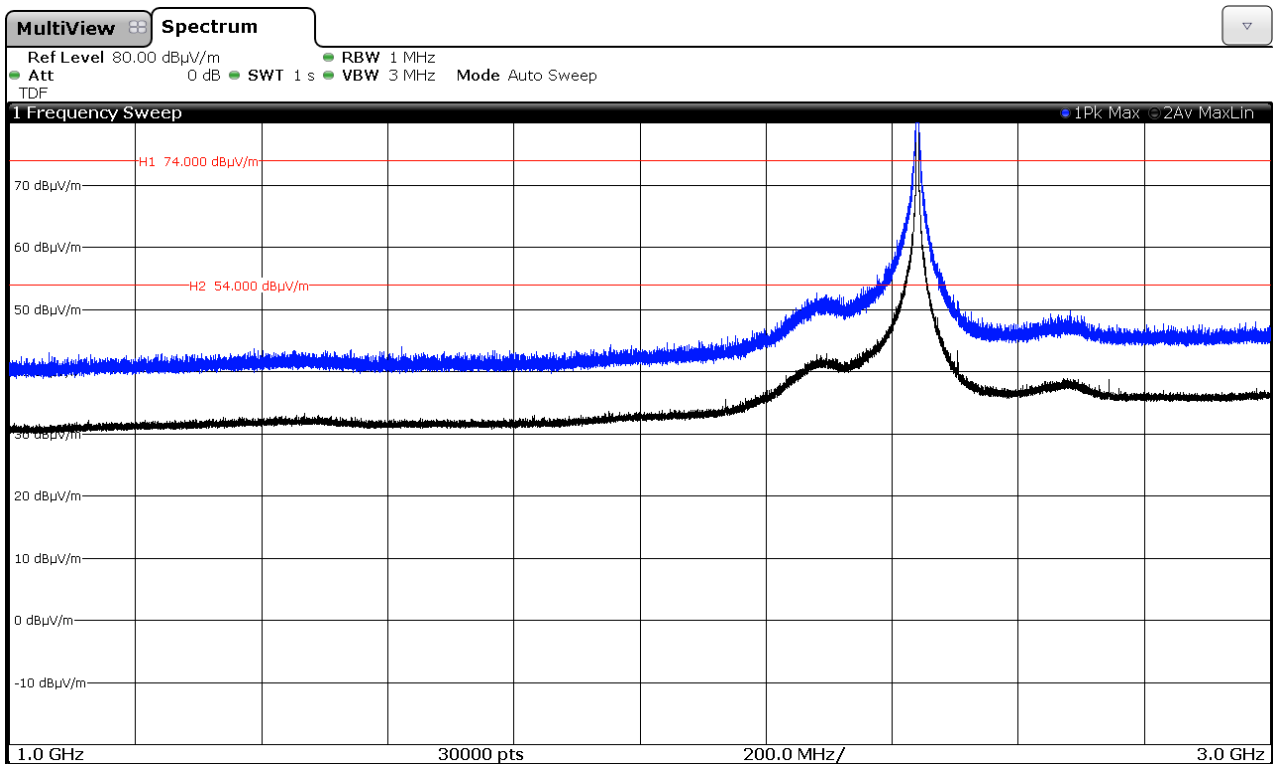


FREQUENCY RANGE 1 GHz to 3 GHz.
CHANNEL: Lowest (2410 MHz).



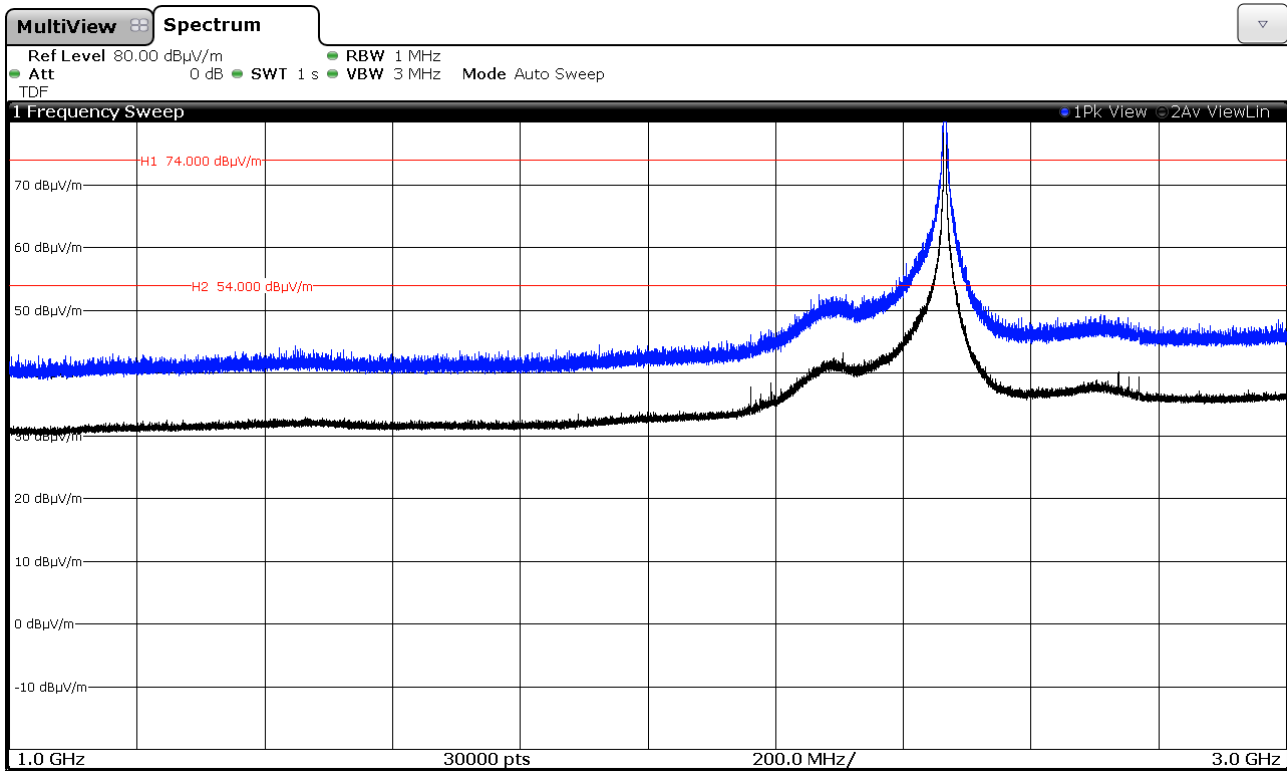
Note: The peak shown in the plot above the limit is the carrier frequency.

CHANNEL: Middle (2440 MHz).



Note: The peak shown in the plot above the limit is the carrier frequency.

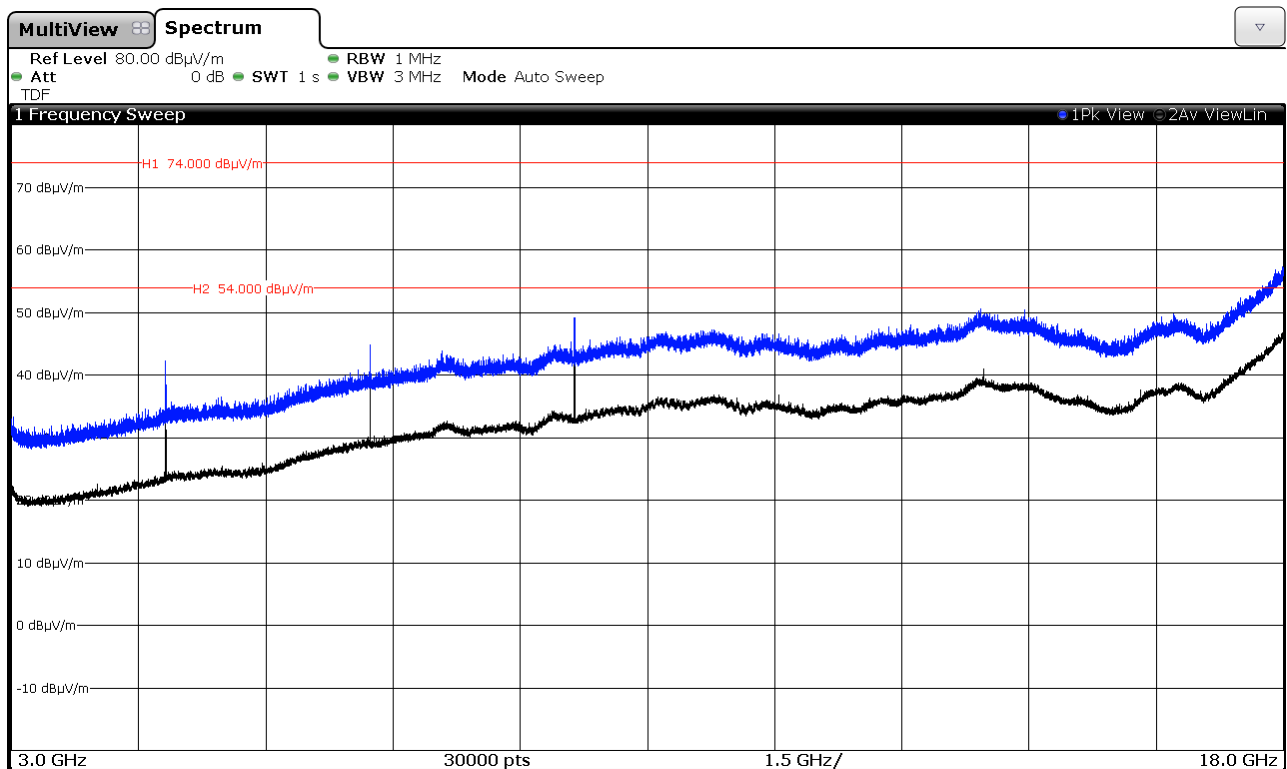
CHANNEL: Highest (2465 MHz).



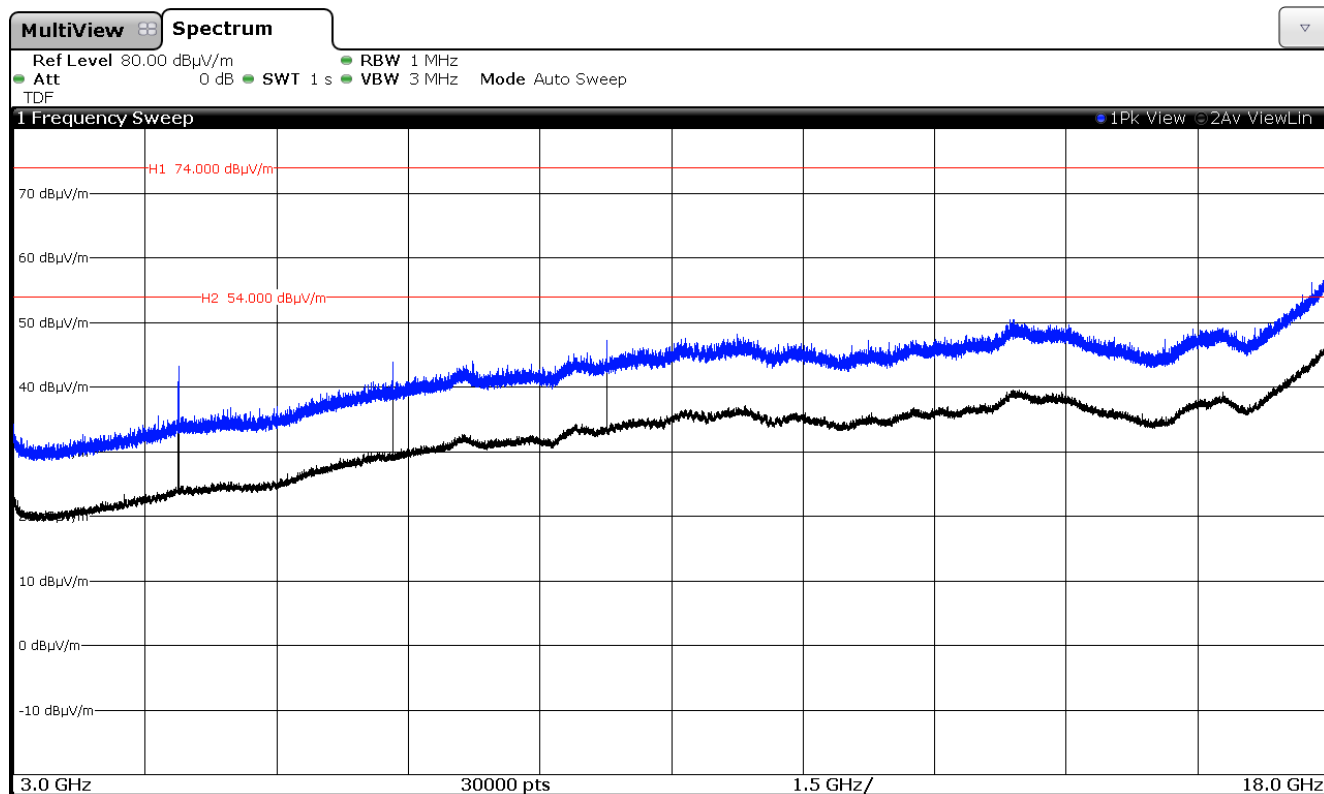
Note: The peak shown in the plot above the limit is the carrier frequency.

FREQUENCY RANGE 3 GHz to 18 GHz.

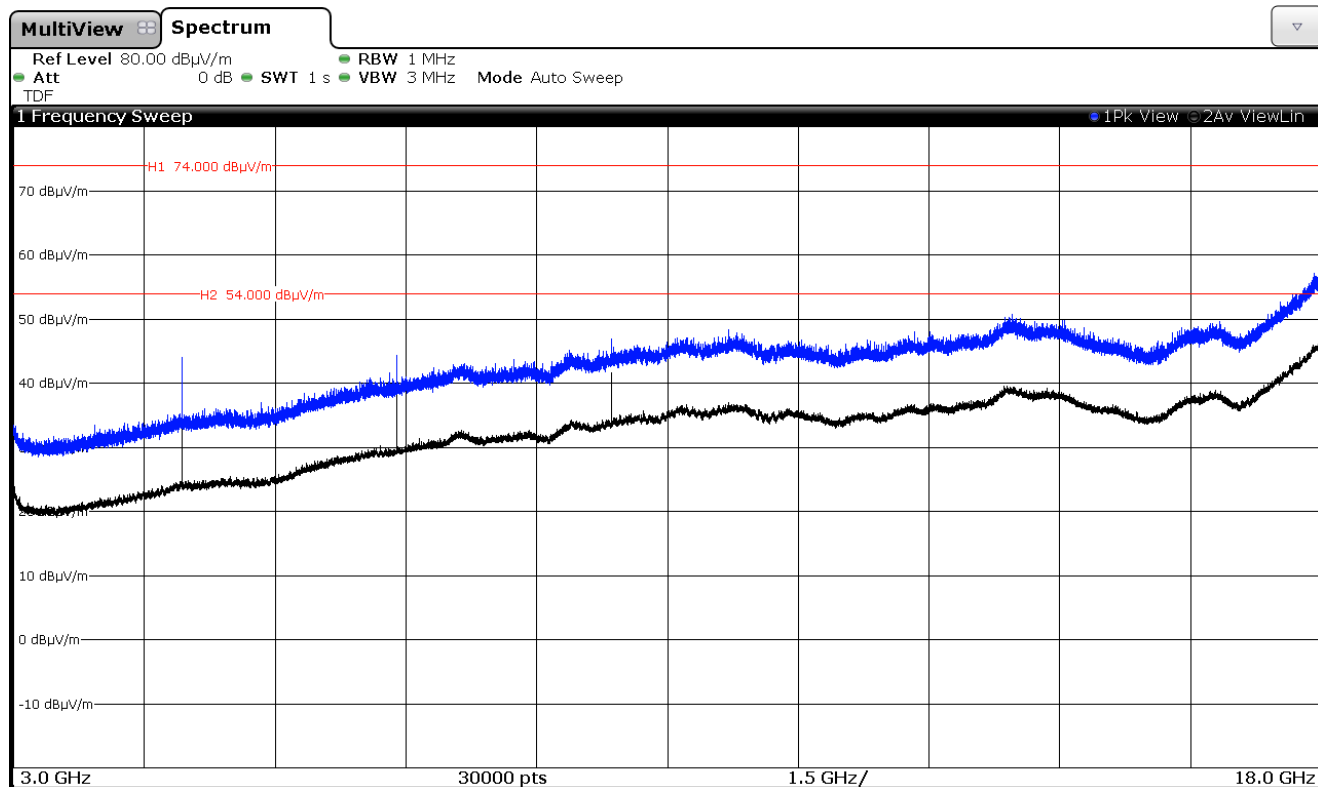
CHANNEL: Lowest (2410 MHz).



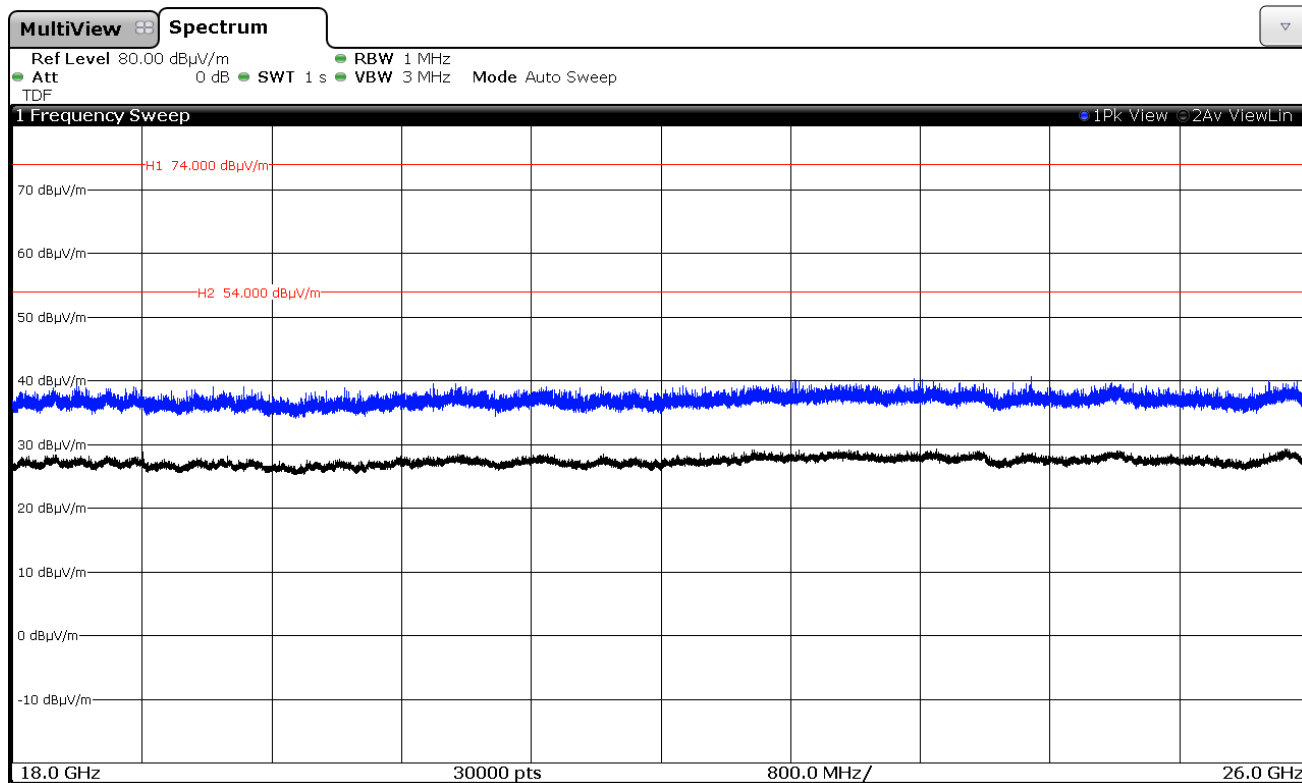
CHANNEL: Middle (2440 MHz).



CHANNEL: Highest (2465 MHz).



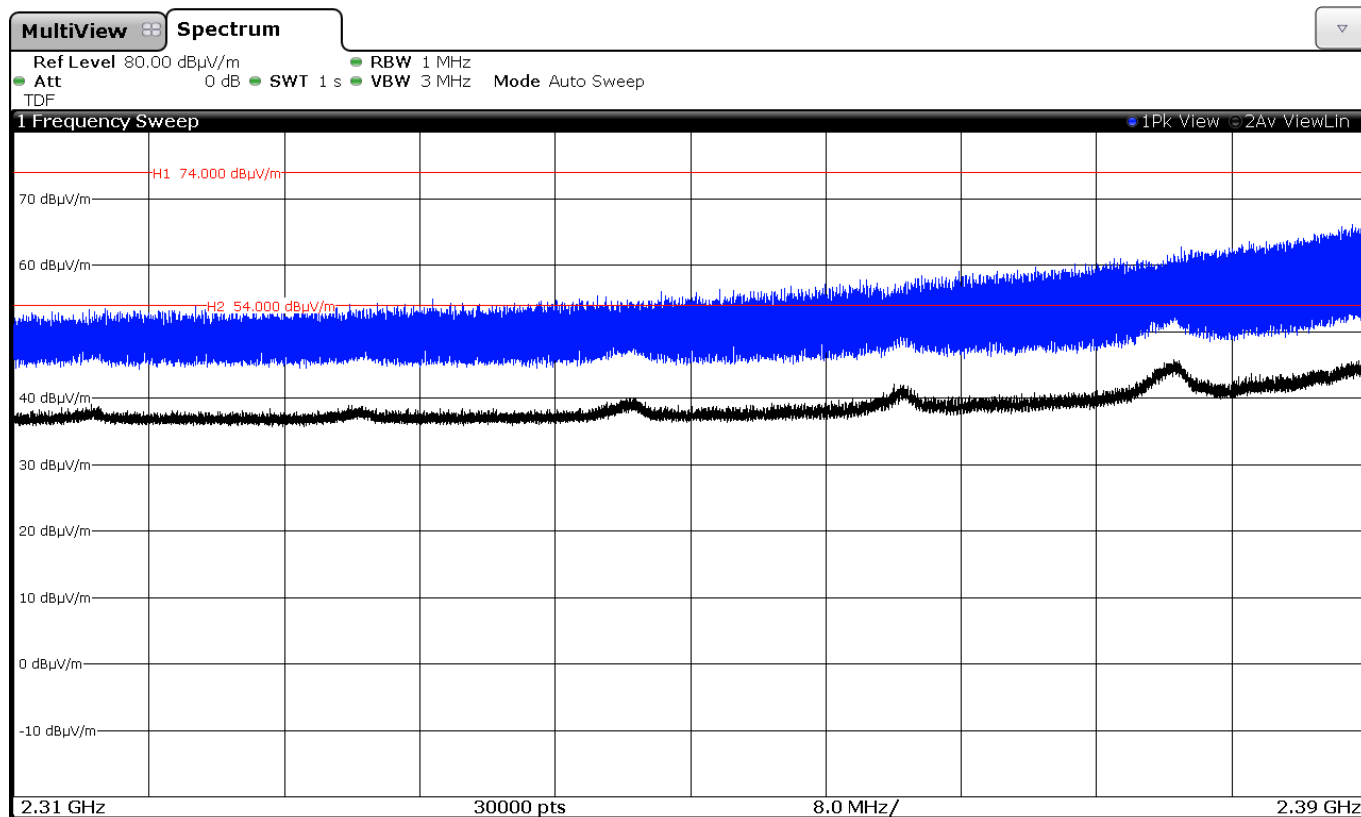
FREQUENCY RANGE 18 GHz to 26 GHz.



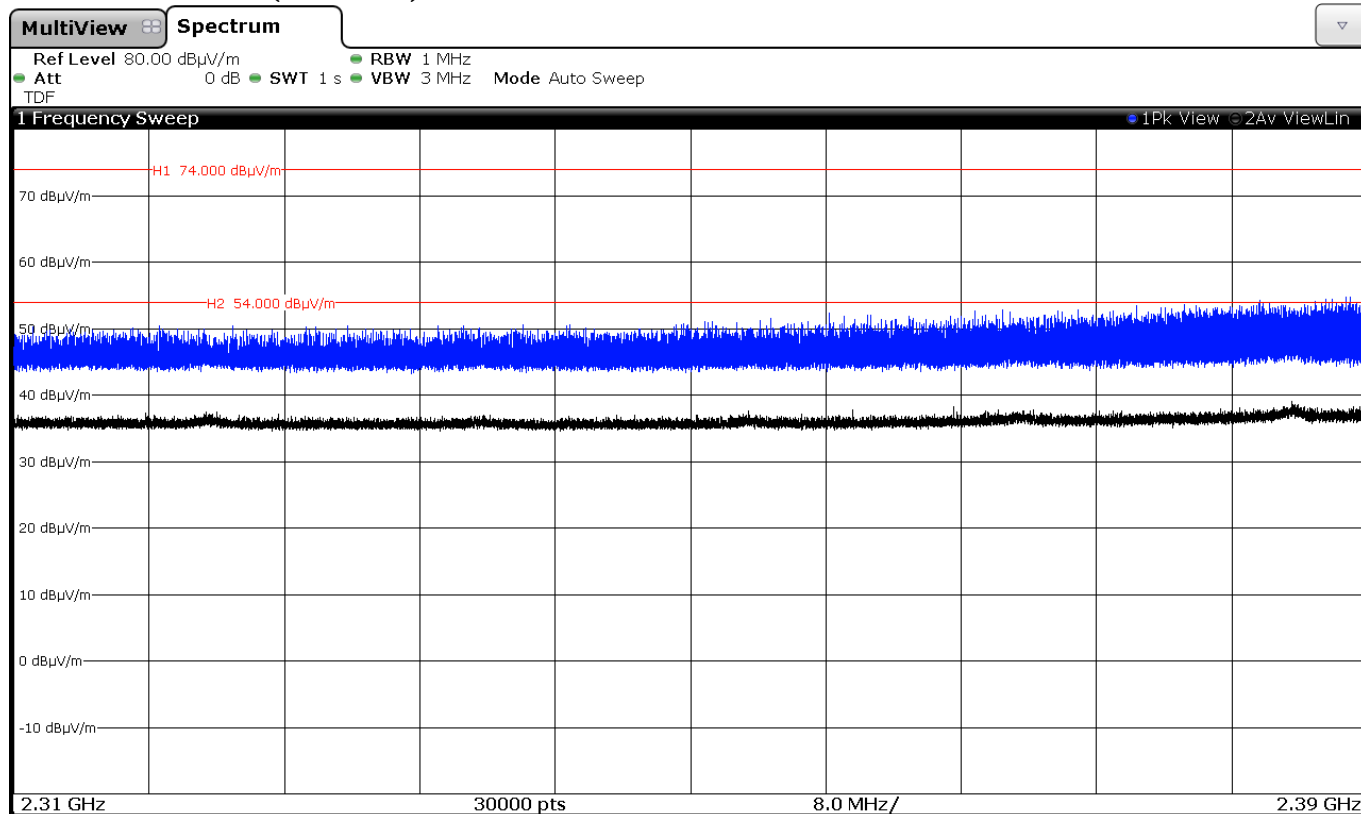
(This plot is valid for all three channels).

FREQUENCY RANGE 2.31 GHz to 2.39 GHz. (RESTRICTED BAND)

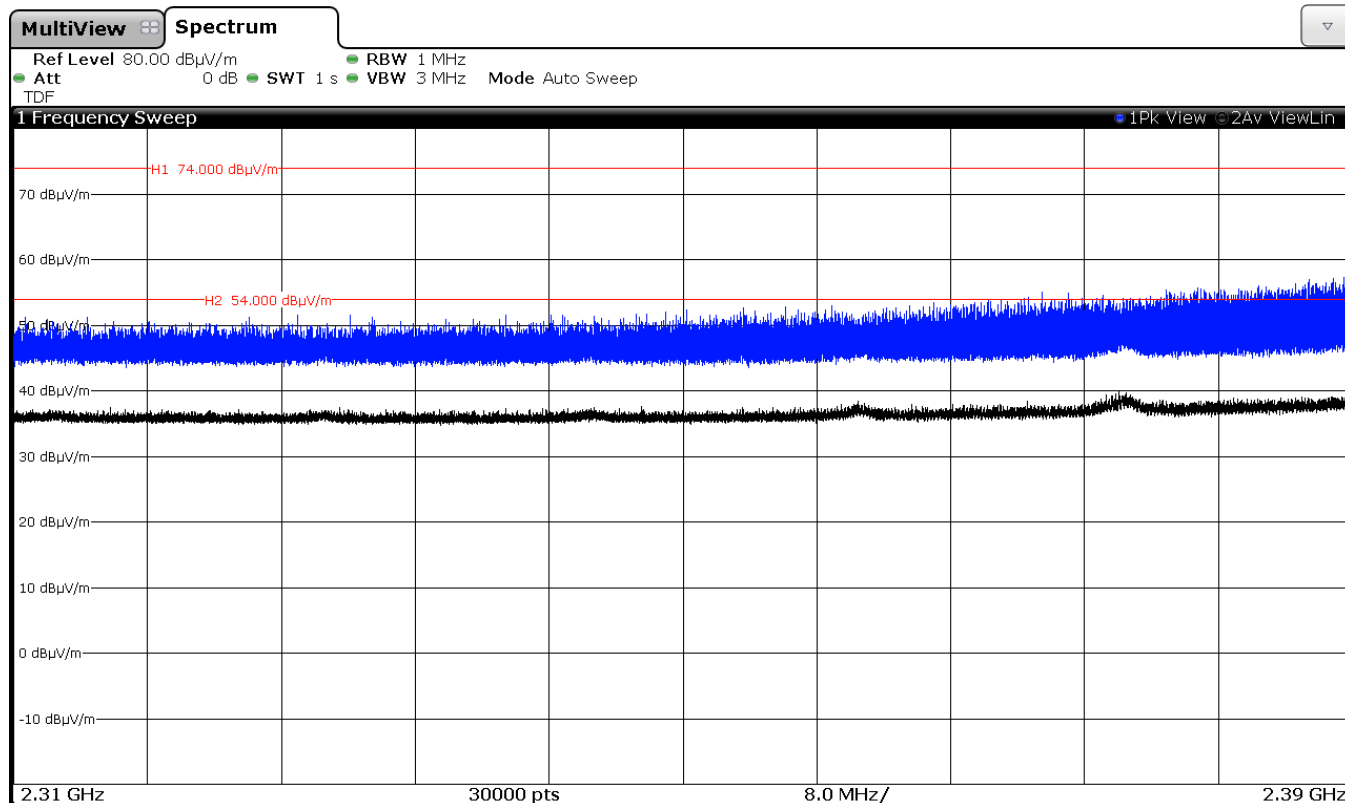
CHANNEL: Lowest (2410 MHz).



CHANNEL: Middle (2440 MHz).

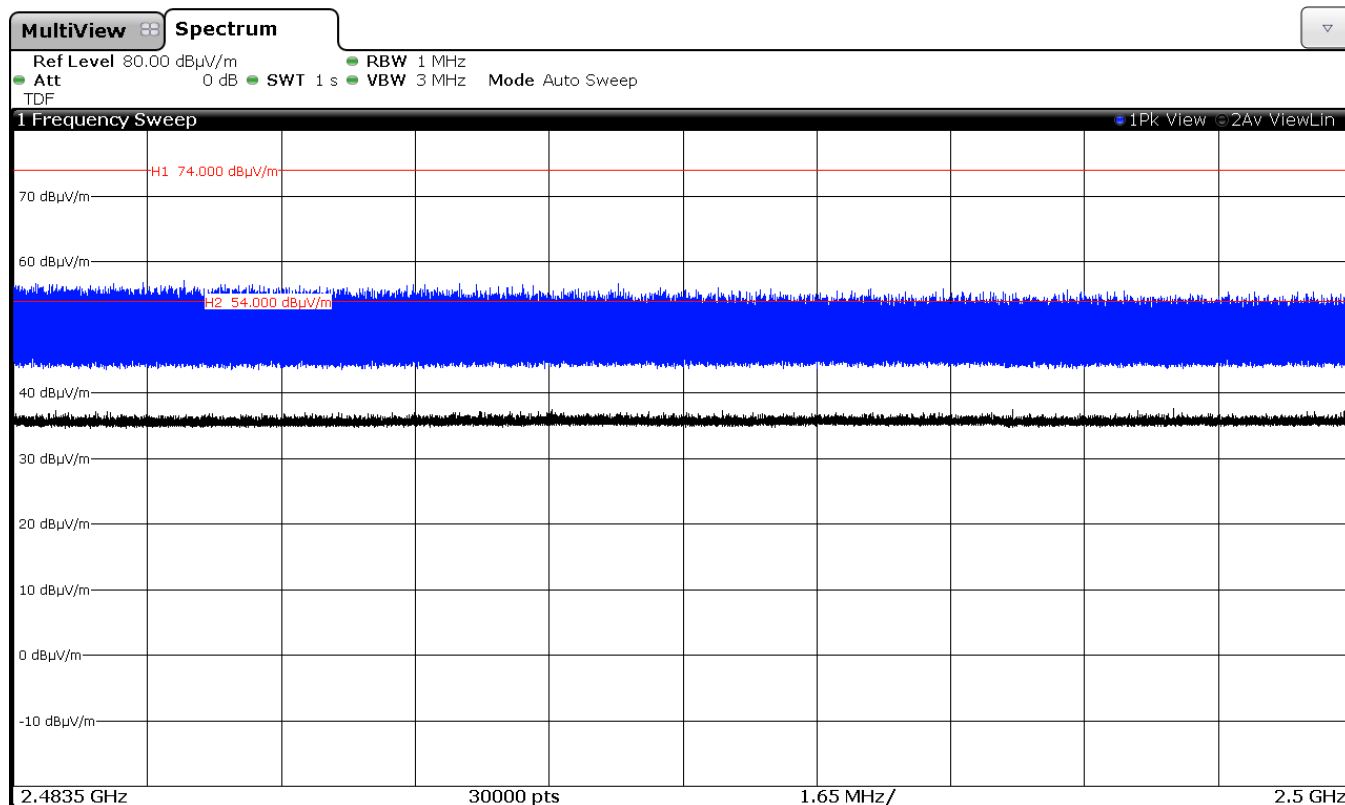


CHANNEL: Highest (2465 MHz).

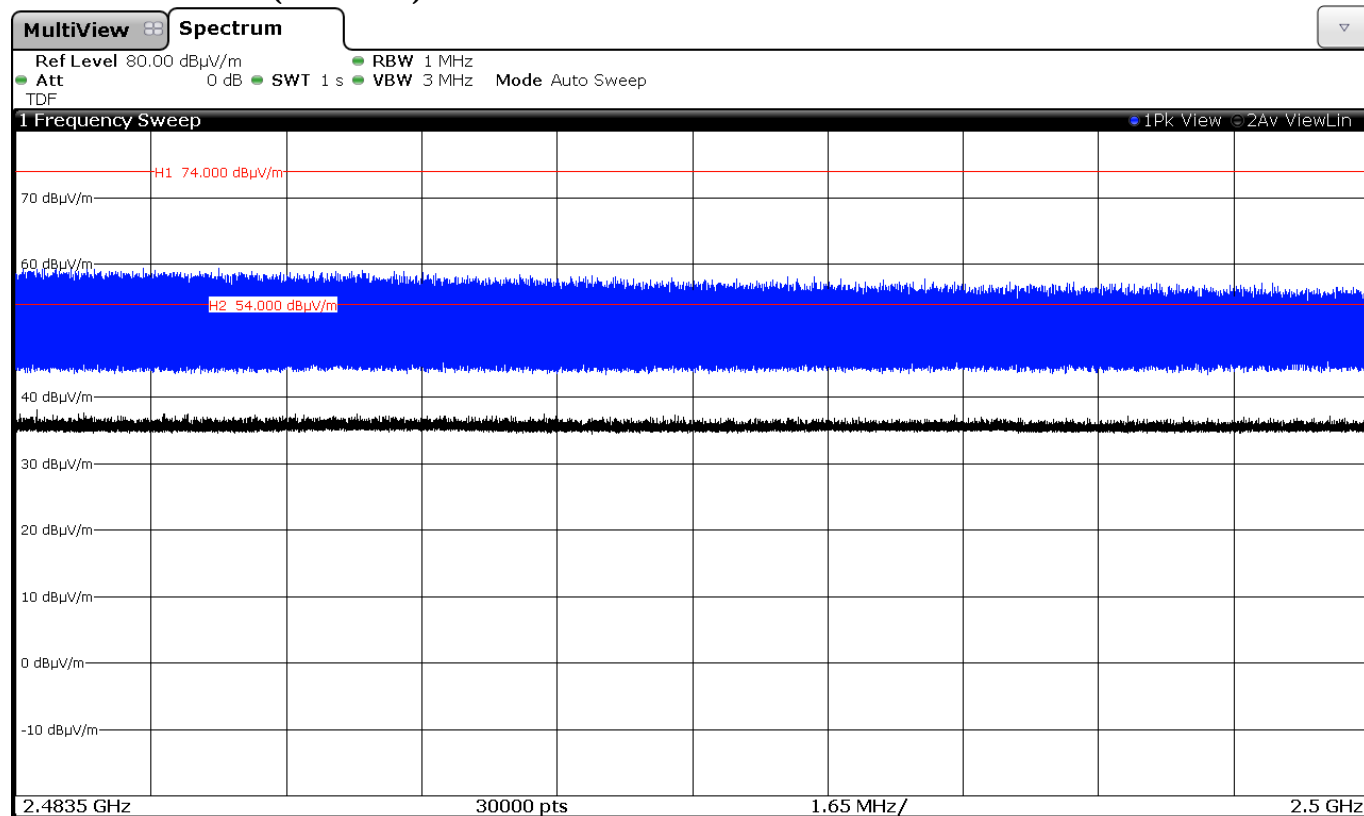


FREQUENCY RANGE 2.4835 GHz to 2.5 GHz. (RESTRICTED BAND)

CHANNEL: Lowest (2410 MHz).



CHANNEL: Middle (2440 MHz).



CHANNEL: Highest (2465 MHz).

