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Electromagnetic Compatibility Test Report

Description: CAM Pressure Remote Gen 2

Model: CAM-PR2

Project ID: P00053433

Airgas USA, LLC
184 Sandbank Road
Cheshire, CT 06410

Prepared by:

TUV Rheinland of North America, Inc.

The test results contained in this report refer exclusively to the product(s) presented for testing. No liability may be assumed for models or products not referred to herein. This test report may not be published or duplicated in part without permission of the testing body. This test report by itself does not constitute authorization for the use of any TUV Rheinland test mark. The report must not be used by the client to claim product certification, approval, or endorsement by A2LA.

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Client:	Airgas USA, LLC 184 Sandbank Road Cheshire, CT 06410	Contact: Tel: Fax: e-mail:	Ling Sze 203-272-5800 x229 -- ling.sze@airgas.com
Identification:	CAM Pressure Remote Gen 2	Serial No.:	00:17:0D:00:00:68:82:55, 00:17:0D:00:00:68:68:69
Test item:	CAM-PR2	Date Test Completed:	01/22/2021
Testing location:	TUV Rheinland of North America 710 Resende Road, Building 199 Webster, NY 14580 U.S.A.	Tel: (585) 645-0125 Fax: -	
Test specification:	Emissions: FCC CFR 47 §15.247 (2021), RSS-247 (2017)		
Test Result and/or Conclusion:	The above product was found to be Compliant to the above test standard(s)		
Report written/updated by: Alexander Sowinski		reviewed by: James Borrott	
 5 February 2021 Date Signature		 5 February 2021 Date Signature	
		 VCCI	 Industry Canada ISD
5253	3331.08	1097 (A-0329)	482B-1

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1 General Information

1.1 Scope

This report is intended to document the status of conformance with FCC CFR 15.247 (2021) and RSS-247 (2017) based on the results of testing performed on the CAM Pressure Remote Gen 2, Model Number: CAM-PR2, manufactured by Airgas USA, LLC. This report only applies to the specific samples tested under the stated test conditions. It is the responsibility of the manufacturer to assure that additional production units of this model are manufactured with identical or EMI equivalent electrical and mechanical components.

1.2 Purpose

Testing was performed to evaluate the EMC performance of the EUT (Equipment Under Test) in accordance with the applicable requirements, procedures, and criteria defined in the application of regulations and application of standards listed in this report. The EUT contains a 6LoWPAN transmitter operating in the 2400 – 24835 MHz band using the IEEE 802.15.4e protocol. Per the applicable standards, the device is tested on a Low (Ch11 @ 2.405 GHz), Mid (Ch18 @ 2.440 GHz), and High (Ch26 @ 2.480 GHz) channel.

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1.3 Summary of Test Results

Applicant:	Airgas USA, LLC 184 Sandbank Road Cheshire, CT 06410	Tel:	203-272-5800 x229	Contact:	Ling Sze
		Fax:	--	e-mail:	ling.sze@airgas.com
Description:	CAM Pressure Remote Gen 2	Model Number:	CAM-PR2		
Serial Number:	00:17:0D:00:00:68:82:55, 00:17:0D:00:00:68:68:69	Test Voltage/Freq.:	3 VDC		
Test Date Completed:	01/22/2021	Test Engineer:	Alexander Sowinski		
Standards	Description	Severity Level or Limit		Criteria	Test Result
FCC CFR 47 §15.247 (2021), RSS-247 (2017) Product Family Standard Emissions	Emissions requirements for devices operating within the bands 902-928 MHz, 2400- 2483.5 MHz, and 5725- 5850 MHz	See Basic Standards Below		See Below	Complies
FCC CFR 47 §15.247 (b.3); RSS-247 5.4(d)	Maximum Output Power	< 1 Watt (30 dBm)		Limit	Complies
FCC CFR 47 §15.247 (a.2); RSS-247 5.2(a)	DTS and Occupied Bandwidth	OBW > 500 kHz		Limit	Complies
FCC CFR 47 §15.247 (e); RSS- 247 5.2(b)	Peak Power Spectral Density	< 8 dBm in any 3 kHz band		Limit	Complies
FCC CFR 47 §15.247 (d); RSS-247 5.5	Out of Band Emissions: Non-restricted	All spurious emissions < 20 dBr		Limit	Complies
FCC CFR 47 §15.247 (d); RSS-247 5.5	Out of Band Emissions: Restricted	Peak Detector: < 74 dBµV/m @ 3 meters AVG Detector: < 54 dBµV/m @ 3 meters		Limit	Complies
FCC CFR 47 §15.247 (d); RSS-247 5.5	Transmitter Spurious Emissions	Class B 30 – 1000 MHz Class B 1000 – 26500 MHz		Limit	Complies

2 Laboratory Information

2.1 Accreditations & Endorsements

2.1.1 US Federal Communications Commission

TUV Rheinland of North America located at, 710 Resende Road Webster, NY 14580 is accredited by the commission for performing testing services for the general public on a fee basis. This laboratory test facilities have been fully described in reports submitted to and accepted by the FCC (Registration No 5253). The laboratory scope of accreditation includes: Title 47 CFR Part 15, and 18. The accreditation is updated every 3 years.

2.1.2 ILAC/A2LA

This is a program which is administered under the auspices of A2LA. The laboratory has been assessed and accredited in accordance with ISO Standard 17025:2017 (Certificate Number: 3331.08). The scope of laboratory accreditation includes emission and immunity testing. The accreditation is updated annually.

2.1.3 VCCI

VCCI Accredited test lab. Registration numbers A-0329.

2.1.4 Industry Canada

(Registration No.: 482B-1) The 10 meter Semi-Anechoic chamber has been accepted by Industry Canada to perform testing to 3 and to 10m, based on the test procedures described in ANSI C63.4-2014.

2.1.5 BSMI

Registration No.: SL2-IN-E-1159R. The BSMI accreditation was obtained by NIST MRA with the BSMI.

2.1.6 Korea

(Designation No.: US0192). Recognized by National Radio Research Agency (RRA) as an accredited Conformity Assessment Body (CAB) under the terms for Korea Phase I of the APEC TEL.

2.2 Test Software

- 1) CIGUI 32 Version 1.4 for California Instruments AC power source
- 2) HP software E7415A Version A.01.45
- 3) National Instruments 'Measurement & Automation Employer' Version 4.6.2f1
- 4) TILE version 3.4.K.28
- 5) Voltech PM 6000 Firmware 1.22.07RC6, Software IEC61000-3 for PM6000 Release 1.24.12
- 6) California Instruments AC power source MXHCL
- 7) Rohde & Schwarz EMI Measurement software EMC32 version 8.50.0
- 8) TILE version 4.0.B
- 9) Keytek CEWare 2.10

2.3 Measurement Uncertainty

Two types of measurement uncertainty are expressed in this report, per *ISO Guide To The Expression Of Uncertainty In Measurement*, 1st Edition, 1995.

The Combined Standard Uncertainty is the standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities, equal to the positive square root of a sum of terms, the terms being the variances or co-variances of these other quantities weighted according to how the measurement result varies with changes in these quantities. The term standard uncertainty is the result of a measurement expressed as a standard deviation.

The Expanded Uncertainty defines an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand. The fraction may be viewed as the coverage probability or level of confidence of the interval.

2.3.1 Sample Calculation – radiated & conducted emissions

The field strength is calculated by subtracting the Amplifier Gain and adding the Cable Loss and Antenna Correction Factor to the measured reading. The basic equation is as follows:

$$\text{Field Strength (dB}\mu\text{V/m)} = \text{RAW} - \text{AMP} + \text{CBL} + \text{ACF}$$

Where: RAW = Measured level before correction (dB μ V)

AMP = Amplifier Gain (dB)

CBL = Cable Loss (dB)

ACF = Antenna Correction Factor (dB/m)

$$\mu\text{V/m} = 10^{\frac{\text{dB}\mu\text{V} / \text{m}}{20}}$$

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Sample radiated emissions calculation @ 30 MHz

Measurement +Antenna Factor–Amplifier Gain+Cable loss=Radiated Emissions (dBuV/m)

25 dBuV/m + 17.5 dB – 20 dB + 1.0 dB = 23.5 dBuV/m

2.3.2 Measurement Uncertainty Emissions

Per CISPR 16-4-2	Ulab	Ucisp
Radiated Disturbance @ 10m		
30 MHz – 1,000 MHz	4.57 dB	5.2 dB
Radiated Disturbance @ 3m		
1.0 GHz – 6.0 GHz	5.18 dB	5.2 dB
6.0 GHz – 18.0 GHz	5.48 dB	5.5 dB
18.0 GHz – 26.5 GHz	5.21 dB	
26.5 GHz – 40.0 GHz	4.99 dB	
Conducted Disturbance @ Mains Terminals		
150 kHz – 30 MHz	2.62 dB	3.6 dB
Disturbance Power		
30 MHz – 300 MHz	3.88 dB	4.5 dB

Measurement Uncertainty Emissions

The estimated combined standard uncertainty for radiated emissions measurements is ± 4.57 dB	Per CISPR16-4-2 Method
The estimated combined standard uncertainty for radiated emissions measurements from 1 GHz to 6 GHz is ± 5.18 dB	Per CISPR16-4-2 Method
The estimated combined standard uncertainty for radiated emissions measurements from 6 GHz to 18 GHz is ± 5.48 dB	Per CISPR16-4-2 Method
The estimated combined standard uncertainty for conducted emissions measurements is ± 2.62 dB.	Per CISPR16-4-2 Method

Expanded measurement uncertainty numbers are shown in the tables above. Compliance criteria are not based on measurement uncertainty.

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2.4 Calibration Traceability

All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Measurement method complies with ANSI/NCSL Z540-1-1994 and ISO Standard ISO IEC 17025:2017. Equipment calibration records are kept on file at the test facility.

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2.5 Measurement Equipment Identification



Measurement Equipment List

Service Start Date 01/18/2021
Service End Date 01/22/2021

Cost Center 22919
Deliverable/Report Number 32195194.001
AMEL ID 0234160767A00040

Client Airgas USA LLC
Product CAM Pressure Remote Gen 2
Comment FCC and RSS 247 Testing

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Equip.	Description	Model	Manufacturer	Last Date MM/DD/YYYY	Due Date MM/DD/YYYY
G1701077	SunAR JB6 Antenna	JB6	SunAR	04/30/2020	04/30/2022
G1701081	Fluke Multimeter 87 V 39760226	87 V	Fluke	08/01/2019	02/01/2021
G1701082	Temperature/Humidity/Barometer	68000-49	Control Company	10/31/2018	02/28/2021
G1701086	Microtronics BRM50702	BRM50702	Microtronics	07/30/2019	02/28/2021
G1701089	R&S EMI Receiver ESW44 101880	ESW44	Rohde & Schwarz	10/15/2019	02/15/2021
G1701233	EMCO Horn Antenna 3115 9812-5635	3115	EMCO	02/28/2020	02/28/2022
G1701365	EMCO Horn 3160-10 1180	3160-10	EMCO	08/11/2020	08/11/2022
G1701385	R&S EMI Receiver ESU40 100274	ESU40	Rohde & Schwarz	07/29/2019	02/28/2021
G1701452	RF Path 30-1000MHz	RF Cable Path		07/30/2019	02/28/2021
G1701552	Antenna Loop	6502	EMCO	02/26/2020	02/26/2021

Note:

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3 Product Information

3.1 Test Plan

The EUT product information, test configuration, mode of operation, test types, test procedures, test levels, pass/failure criteria, in this report were carried out per the product test plan located in appendix A of this report.

3.2 EUT Photos

Due to the confidentiality agreement with the client, all pictures of EUT have been placed in document 32195197.001.

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4 Emissions

4.1 Maximum Output Power

This test measures the maximum equivalent isotropic radiated power of the EUT during a transmission.

4.1.1 Over View of Test

Results	Complies (as tested per this report)					Date	01/19/2021	
Standard	FCC CFR 47 §15.247 (b.3); RSS-247 5.4(d)							
Product Model	CAM-PR2				Serial#	00:17:0D:00:00:68:68:69		
Configuration	See test plan for details.							
Test Set-up	Tested conducted, sample placed on test bench in shielded room, see test plans for details.							
EUT Powered By	3 VDC	Temp	22° C	Humidity	36%	Pressure	994 mbar	
Frequency Range	Channel 11: 2405 MHz Channel 18: 2440 MHz Channel 26: 2480 MHz							
Perf. Criteria	< 1 Watt (30 dBm)			Perf. Verification		Readings Under Limit		
Mod. to EUT	None			Test Performed By		Alexander Sowinski		

4.1.2 Test Procedure

Maximum output power tests were performed using the procedures of FCC CFR 47 §15.247 (b.3); RSS-247 5.4(d) and/or ANSI C63.10 including methods for signal maximizations and EUT configuration. Sample was connected directly to spectrum analyzer and measurements were taken per the applicable standard(s).

4.1.3 Deviations

There were no deviations from the test methodology listed in the test plan for the maximum output power test.

4.1.4 Final Test

All final maximum output power measurements were below (in compliance) the limits.

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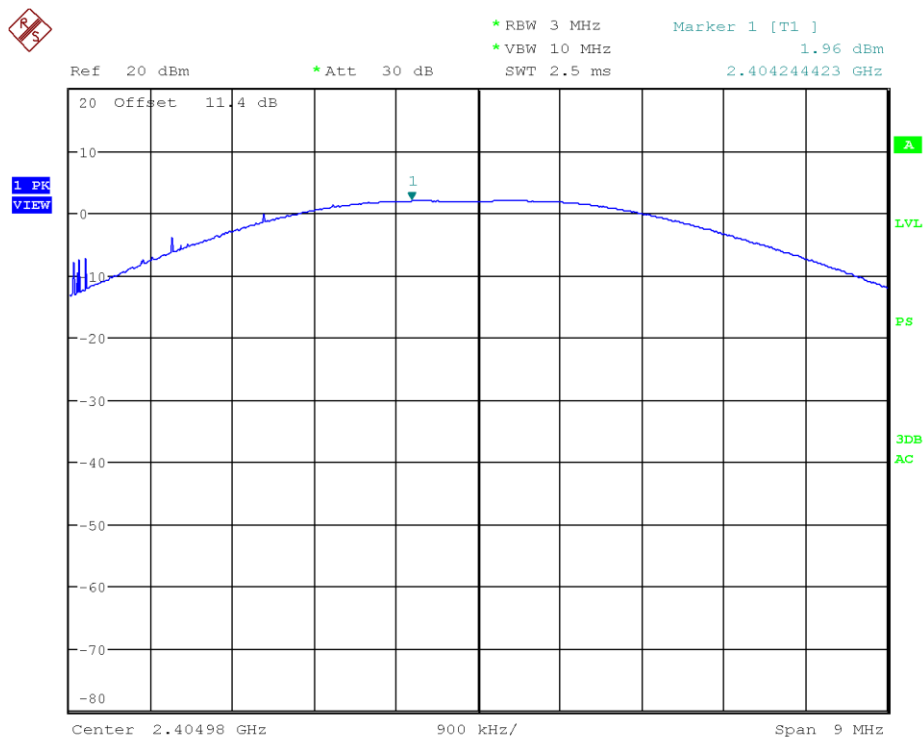
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4.1.5 Final Data

Data Rate	Operating Channel [MHz]	Power [dBm]	Limit [dBm]	Margin [dB]
250 kbps	2405	1.96	30	-28.04
	2440	1.74	30	-28.26
	2480	1.29	30	-28.71

4.1.6 Plots



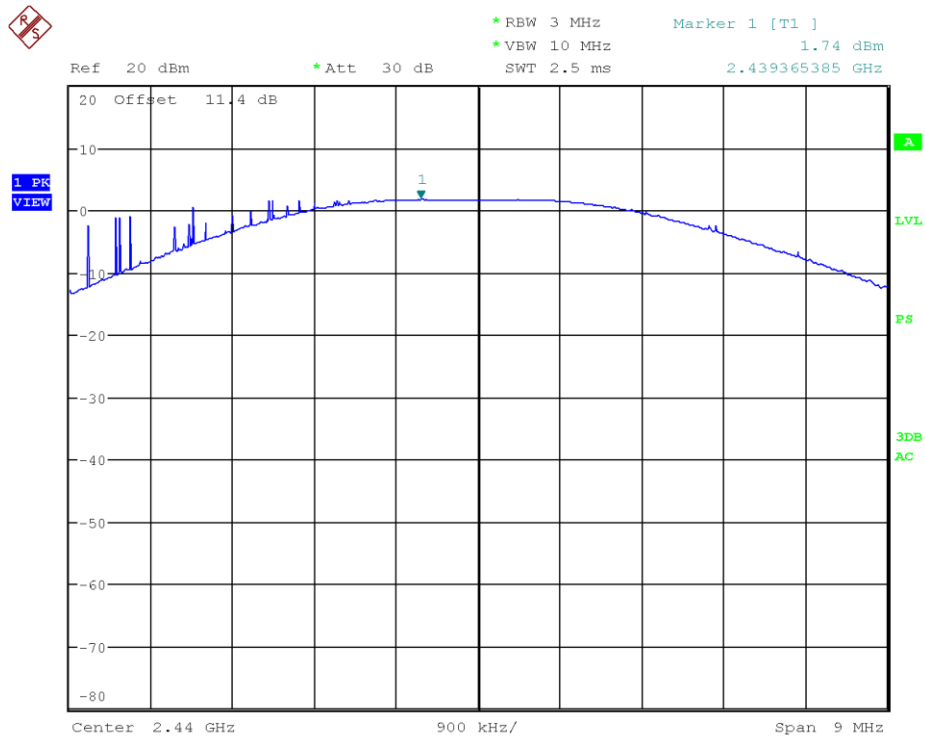
Date: 19.JAN.2021 01:28:15

Figure 1 – Output Power CH11 2405 MHz

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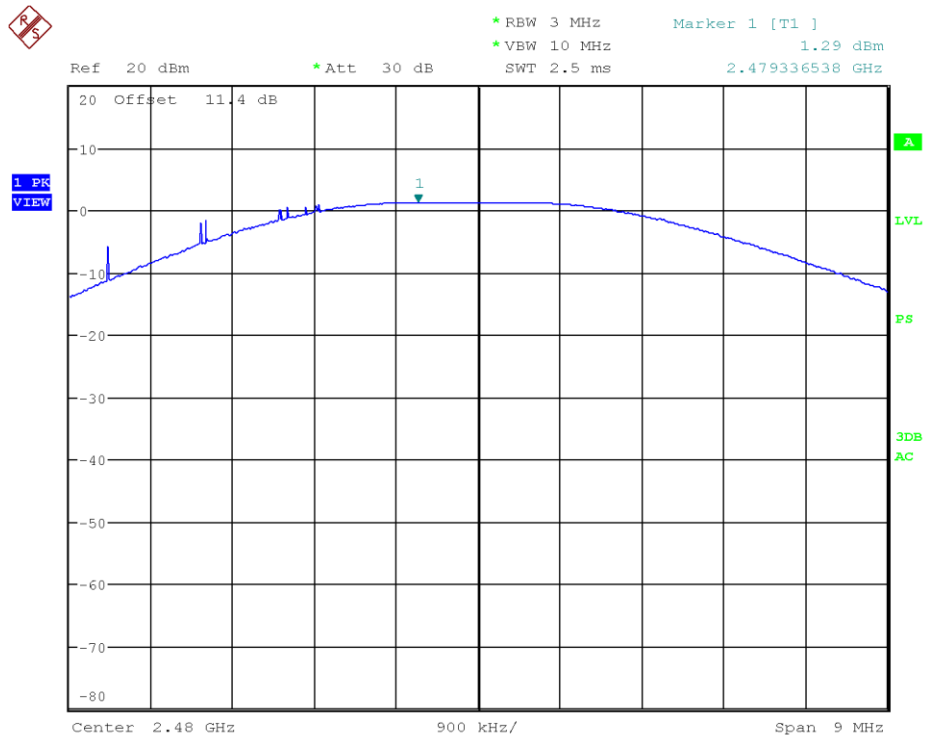
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Figure 2 – Output Power CH18 2440 MHz

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Date: 19.JAN.2021 01:34:44

Figure 3 – Output Power CH26 2480 MHz

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4.2 DTS Bandwidth (6dB) and Occupied Bandwidth (99%)

The occupied bandwidth is measured at an amplitude level reduced from the reference level by a specified ratio. The reference level is the level of the highest amplitude signal observed from the transmitter at the fundamental frequency.

4.2.1 Over View of Test

Results	Complies (as tested per this report)					Date	01/19/2021	
Standard	FCC CFR 47 §15.247 (a.2); RSS-247 5.2(a)							
Product Model	CAM-PR2				Serial#	00:17:0D:00:00:68:68:69		
Configuration	See test plan for details.							
Test Set-up	Tested in shielded room, EUT placed on table. See test plans for details.							
EUT Powered By	3 VDC	Temp	22° C	Humidity	36%	Pressure	994 mbar	
Frequency Range	Channel 11: 2405 MHz Channel 18: 2440 MHz Channel 26: 2480 MHz							
Perf. Criteria	OBW > 500 kHz		Perf. Verification		Readings above minimum value			
Mod. to EUT	None		Test Performed By		Alexander Sowinski			

4.2.2 Test Procedure

Occupied bandwidth tests were performed using the procedures of FCC CFR 47 §15.247 (a.2); RSS-247 5.2(a) and/or ANSI C63.4 including methods for signal maximizations and EUT configuration. The 99% bandwidth is the bandwidth in which 99% of the transmitted power occupied. The 6dB bandwidth is defined the bandwidth of 6 dBr from highest transmitted level of the fundamental frequency. .

4.2.3 Deviations

There were no deviations from the test methodology listed in the test plan for the occupied bandwidth test.

4.2.4 Final Test

All final occupied bandwidth measurements were within (in compliance) the limits.

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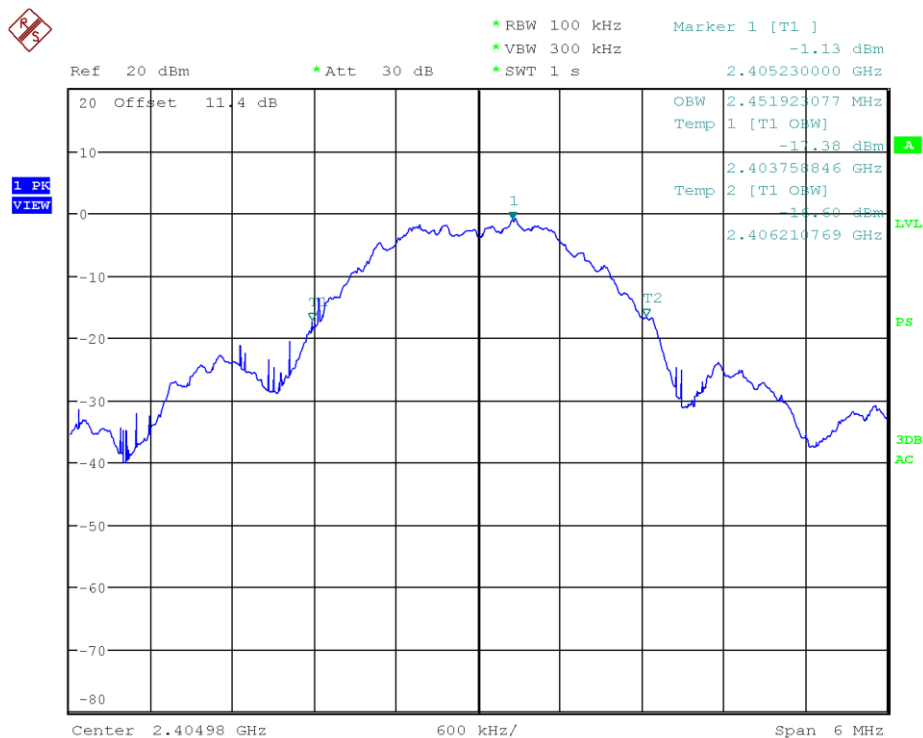
32195194.001

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4.2.5 Final Data

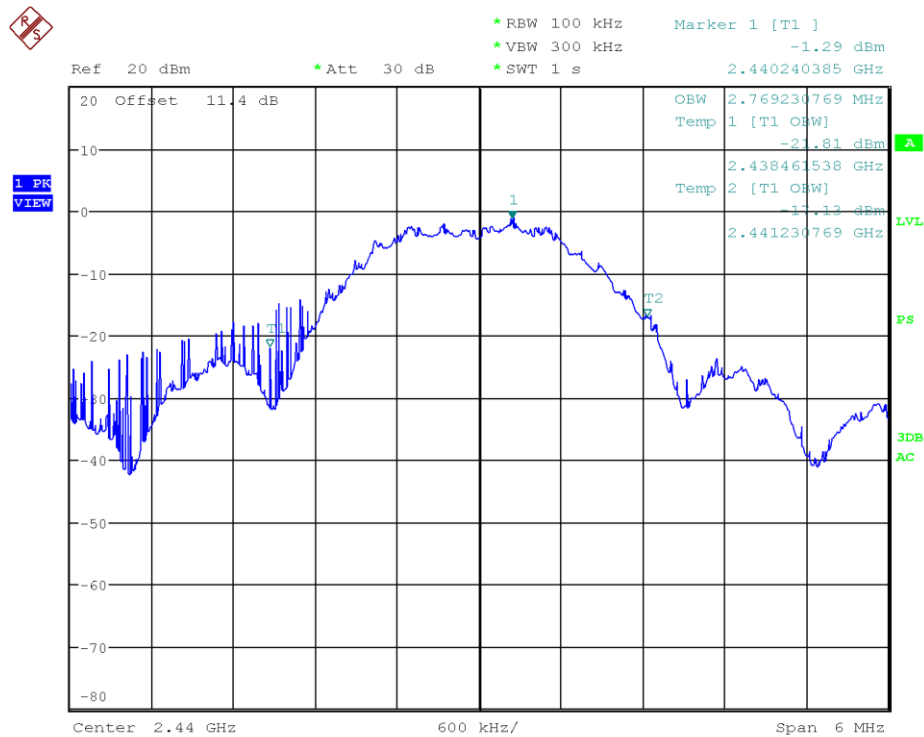
Data Rate	Frequency [MHz]	99% OBW [MHz]	6 dB OBW [MHz]
250 kbps	2405	2.451923	1.576923
	2440	2.679231	1.500000
	2480	2.519231	1.557692

4.2.6 Plots



Date: 19.JAN.2021 01:20:03

Figure 4 – 99% OBW CH11 2405 MHz



Date: 19.JAN.2021 01:18:49

Figure 5 – 99% OBW CH18 2440 MHz

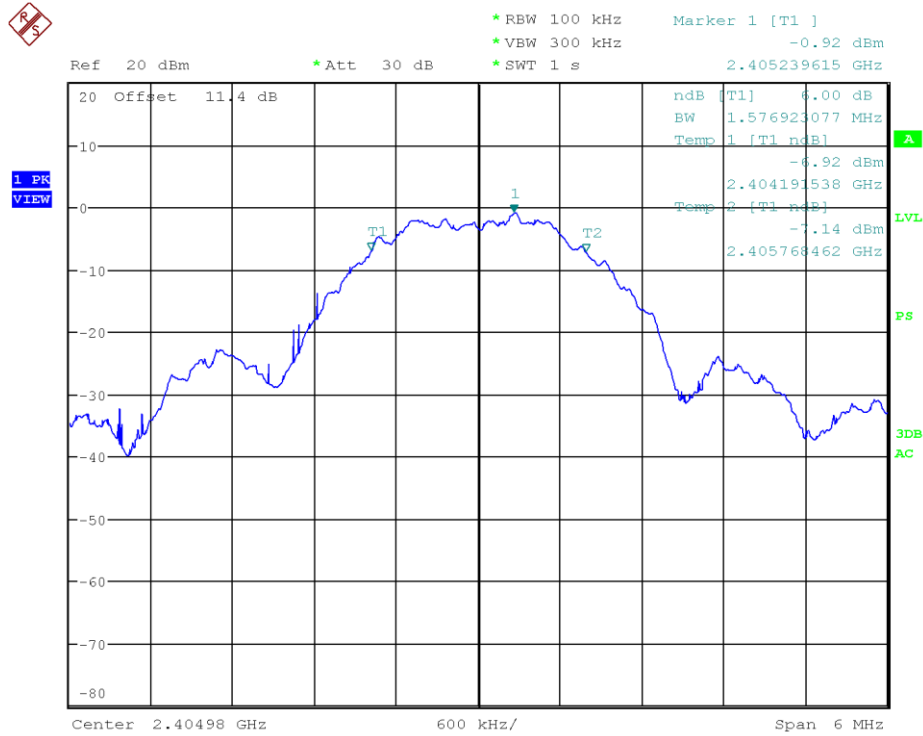


Figure 6 – 99% OBW CH26 2480 MHz

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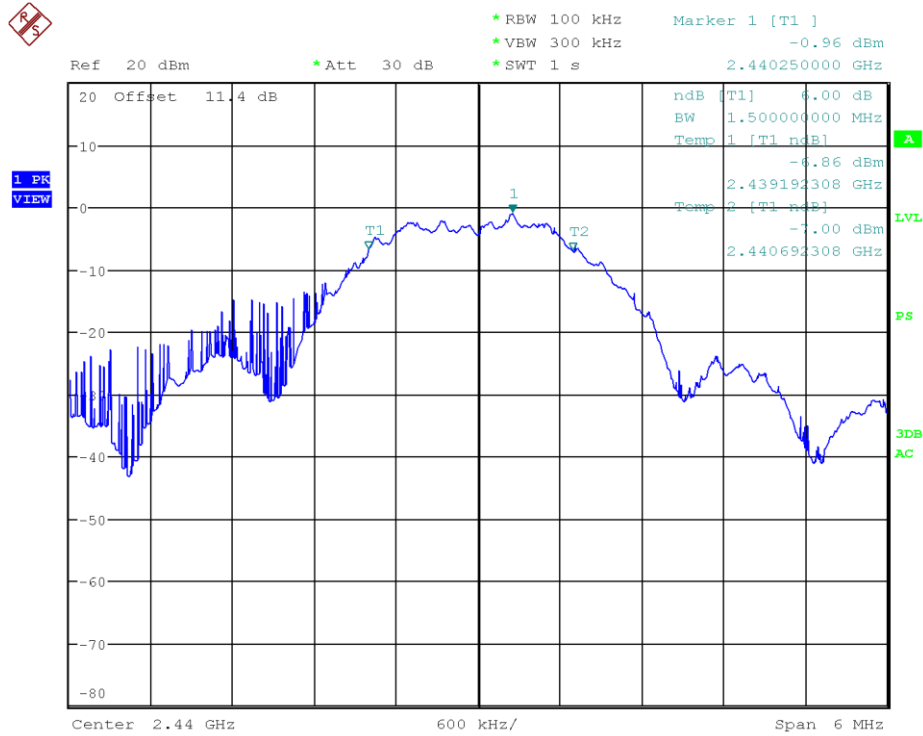
Date: 19.JAN.2021 01:20:51

Figure 7 – 6dB OBW CH11 2405 MHz

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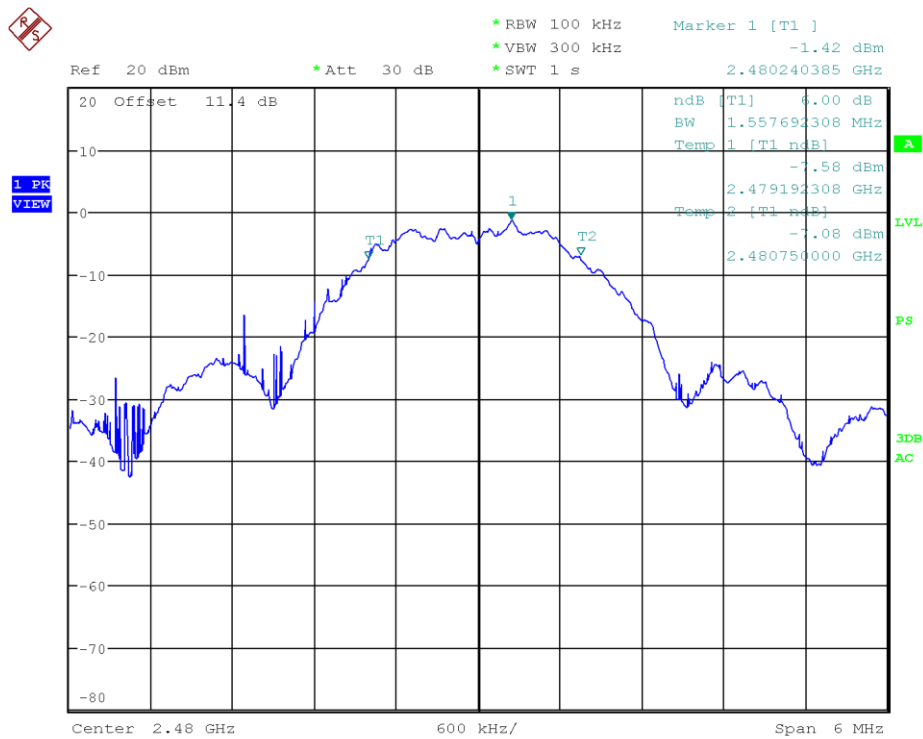
Date: 19.JAN.2021 01:17:40

Figure 8 – 6dB OBW CH18 2440 MHz

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Date: 19.JAN.2021 01:16:14

Figure 9 – 6dB OBW CH26 2480 MHz

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4.3 Peak Power Spectral Density

This test evaluates the peak power spectral density of the EUT's transmitter across low, mid, and high channels.

4.3.1 Test Over View

Results	Complies (as tested per this report)					Date	01/18/2021	
Standard	FCC CFR 47 §15.247 (e); RSS-247 5.2(b)							
Product Model	CAM-PR2				Serial#	00:17:0D:00:00:68:68:69		
Configuration	See test plan for details.							
Test Set-up	Tested in shielded room, EUT placed on table. See test plan for details.							
EUT Powered By	3 VDC	Temp	23° C	Humidity	34%	Pressure	1001 mbar	
Frequency Range	Channel 11: 2405 MHz Channel 18: 2440 MHz Channel 26: 2480 MHz							
Perf. Criteria	< 8dBm / 3 kHz band (Below Limit)			Perf. Verification	Readings under Limit			
Mod to EUT	None			Test Performed By	Alexander Sowinski			

4.3.2 Test Procedure

Peak power spectral density was measured conducted via connecting a sample directly to the spectrum analyzer. Measurements were taken per FCC CFR §15.247 and ANSI C63.10.

4.3.3 Deviations

There were no deviations from the test methodology listed in the test plan for the peak power spectral density test.

4.3.4 Final Test

The peak power spectral density of the EUT was below the limits specified in the standard.

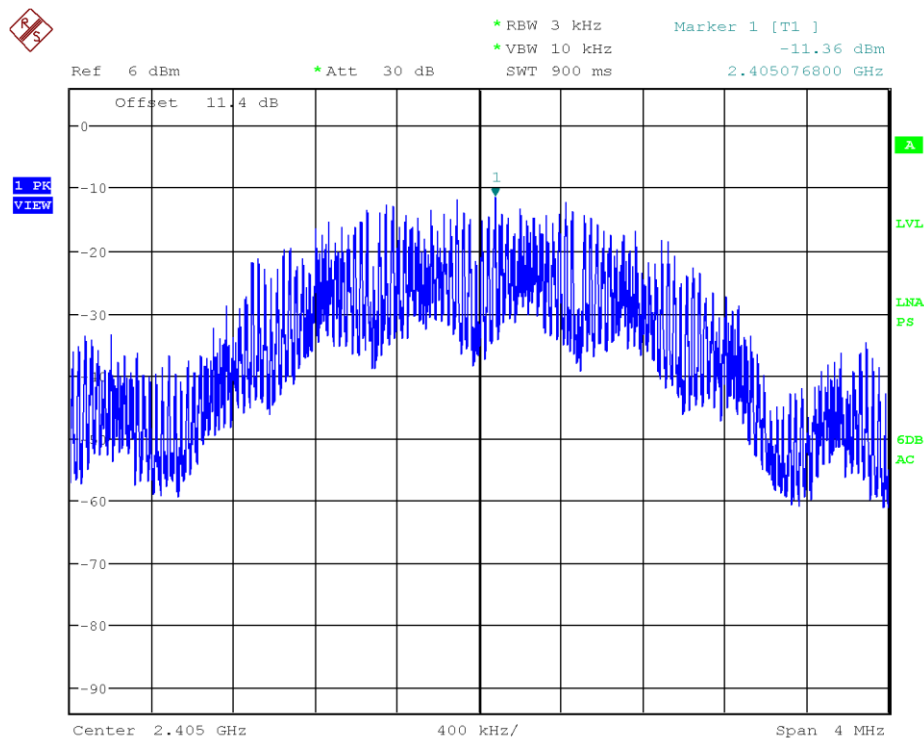
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4.3.5 Final Data

Data Rate	Frequency [MHz]	Total PSD [dBm]	Limit [dBm]	Margin [dB]
250 kbps	2405	-11.36	8	-19.36
	2440	-12.14	8	-20.14
	2480	-12.27	8	-20.27

4.3.6 Plots



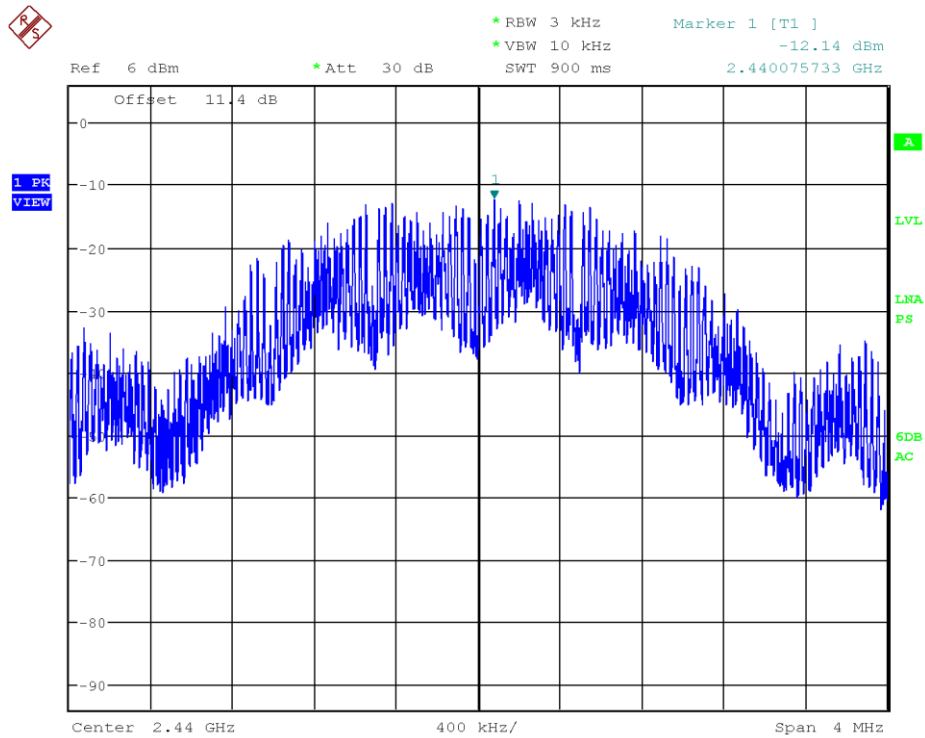
Date: 18.JAN.2021 04:10:50

Figure 10 – PSD CH11 2405 MHz

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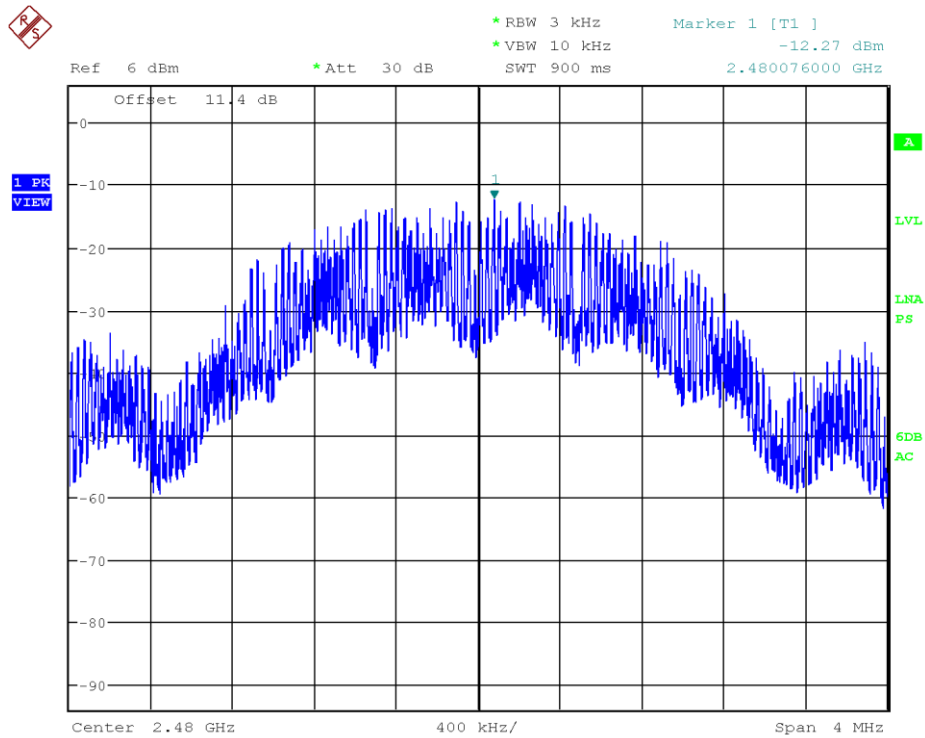
Date: 18.JAN.2021 04:17:35

Figure 11 – PSD CH18 2440 MHz

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Date: 18.JAN.2021 04:23:26

Figure 12 – PSD CH26 2480 MHz

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4.4 Out of Band Emissions – Non-restricted bands

This test evaluates the spurious emissions of the EUT in the out of band domain.

4.4.1 Test Over View

Results	Complies (as tested per this report)					Date	01.18.2021	
Standard	FCC CFR 47 §15.247 (d); RSS-247 5.5							
Product Model	CAM-PR2				Serial#	00:17:0D:00:00:68:68:69		
Configuration	See test plan for details.							
Test Set-up	Tested in shielded room, EUT placed on table. See test plan for details.							
EUT Powered By	3 VDC	Temp	23° C	Humidity	34%	Pressure	1001mbar	
Frequency Range	Channel 11: 2405 MHz Channel 18: 2440 MHz Channel 26: 2480 MHz							
Perf. Criteria	< 20 dBr (20 dB below TX Peak Power) (Below Limit)			Perf. Verification	Readings under Limit			
Mod to EUT	None			Test Performed By	Alexander Sowinski			

4.4.2 Test Procedure

Conducted measurements per ANSI C63.10-2013 Sections 6.10, 11.11, 14.3.3 were used to measure the undesirable emission requirement in non-restricted bands. The measurement was conducted from 30MHz to 26.5GHz on 3 channels in each mode on the EUT. Band edge tests were conducted on the low and high channel of each mode. The worst case measurement of each mode is recorded in this report.

4.4.3 Deviations

There were no deviations from the test methodology listed in the test plan for the out of band emissions test.

4.4.4 Final Test

The out of band emissions of the EUT were below the limit specified by the standard.

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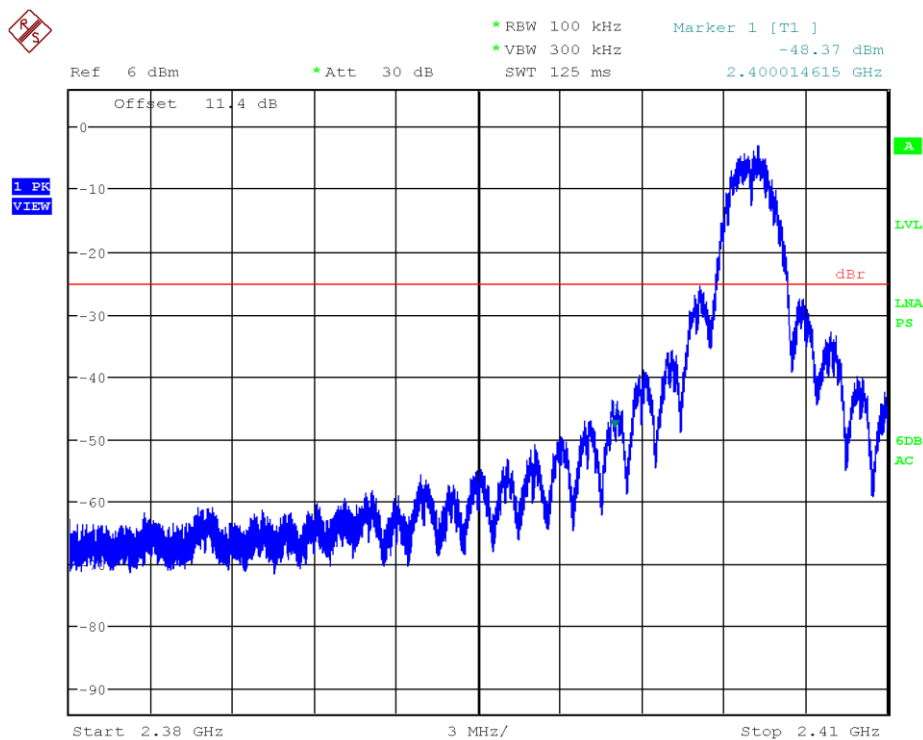
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4.4.5 Final Data

Data Rate	Band Edge	Center Freq [MHz]	Measured [dBc]	Limit [dBc]	Freq [MHz]	Result
250 kbps	Low	2405	50.33	20	2400	Pass
	High	2480	53.83	20	2483.5	Pass

4.4.6 Plots



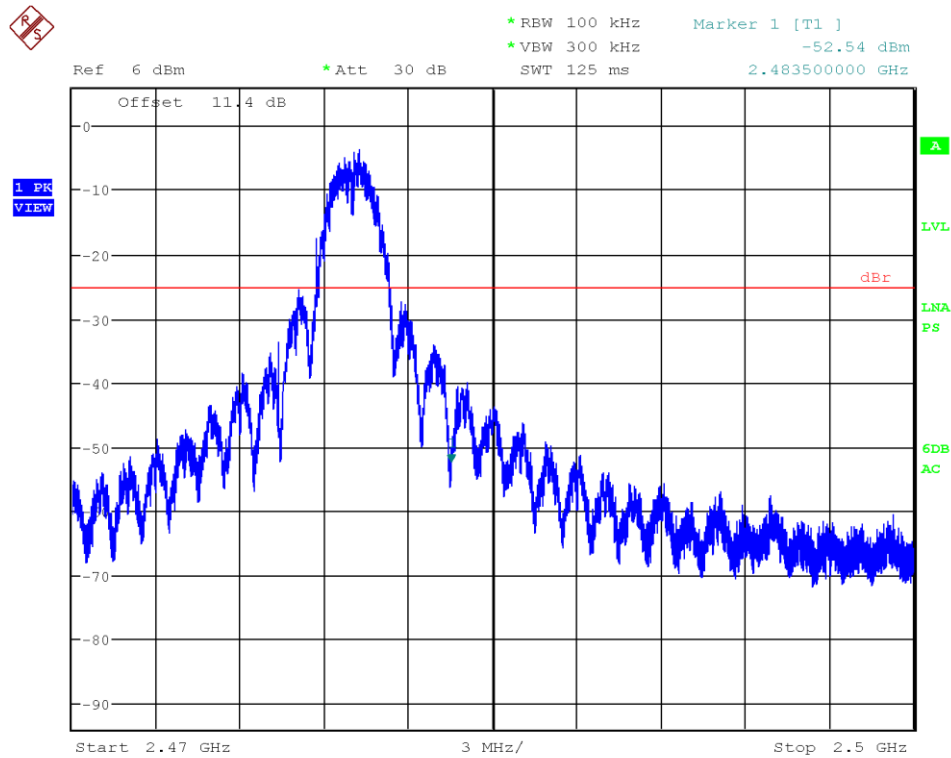
Date: 18.JAN.2021 04:48:32

Figure 13 – OOB CH11 2405 Lower Band Edge

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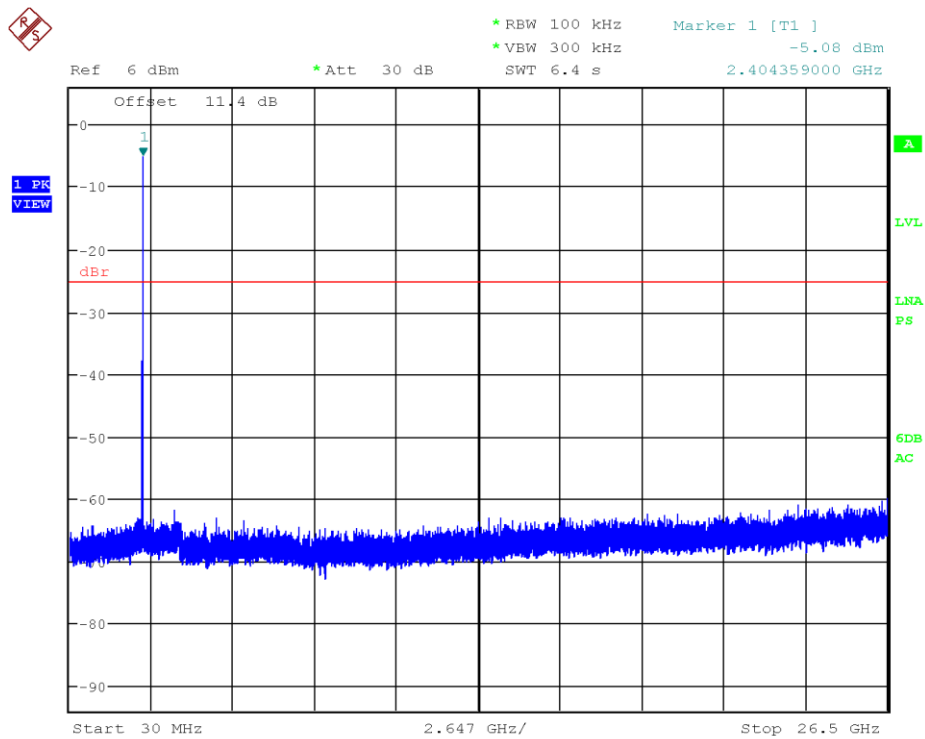
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Figure 14 – OOB CH26 2480 Upper Band Edge

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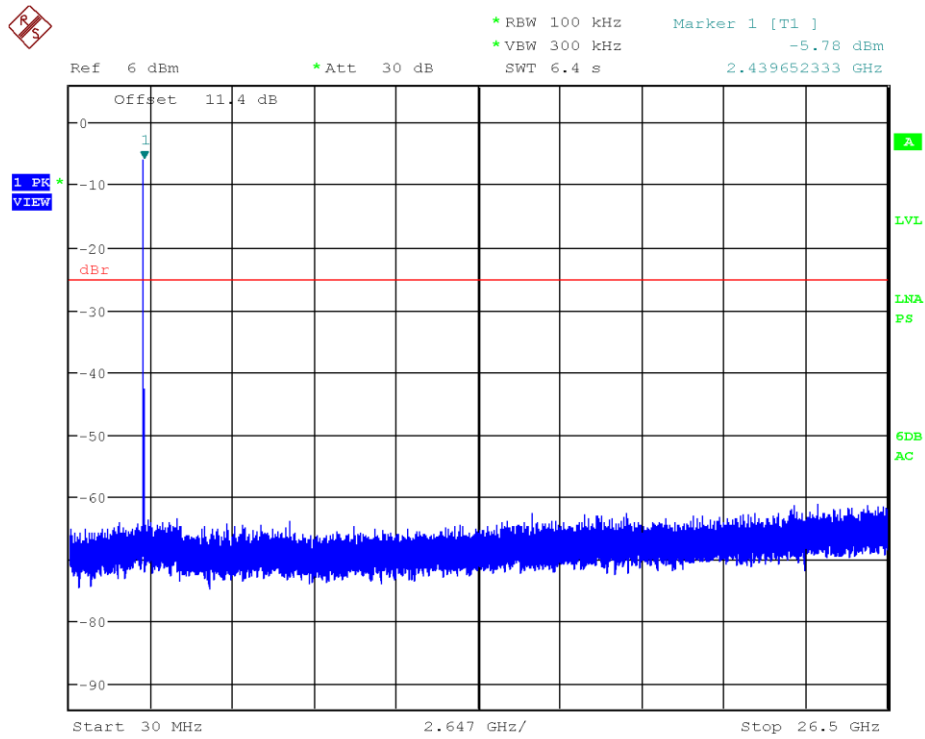
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Figure 15 – OOB CH11 30 – 26500 MHz

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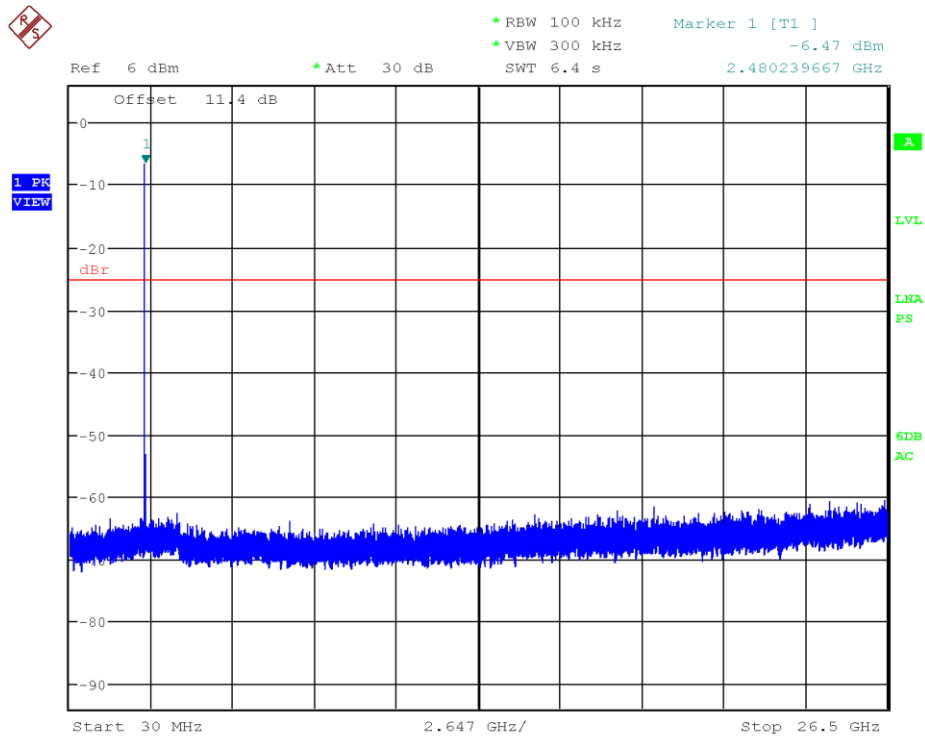
Date: 18.JAN.2021 04:50:01

Figure 16 – OOB CH18 30 – 26500 MHz

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Date: 18.JAN.2021 04:51:03

Figure 17 – OOB CH26 30 – 26500 MHz

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4.5 Out of Band Emissions – Restricted Bands

This test evaluates the radiated spurious emissions that fall into the restricted bands of the out of band domain.

4.5.1 Test Over View

Results	Complies (as tested per this report)					Date	03/17/2020	
Standard	FCC CFR 47 §15.247 (d); RSS-247 5.5							
Product Model	CAM-PR2				Serial#	00:17:0D:00:00:68:68:69		
Configuration	See test plan for details.							
Test Set-up	Tested in shielded room, EUT placed on table. See test plan for details.							
EUT Powered By	3 VDC	Temp	23° C	Humidity	36%	Pressure	1004mbar	
Frequency Range	Channel 11: 2405 MHz Channel 26: 2480 MHz							
Perf. Criteria	< 54 dBµV/m @ 3 m (AVG) < 74 dBµV/m @ 3 m (Peak)			Perf. Verification		Readings under Limit		
Mod to EUT	None			Test Performed By		Alexander Sowinski		

4.5.2 Test Procedure

Radiated measurements per ANSI C63.10-2013 Section 6.10.5 were used to measure the undesirable emission requirement in restricted bands. Peak and Average traces were recorded while maximizing the fundamental emission. The measurement was performed with modulation. This test was conducted on the upper and lower most channels in each mode on the EUT. The worst case measurement of each channel is recorded in this report. All channels were tested at highest power settings. The measurement receiver was configured with RBW = 1MHz, VBW=3MHz.

4.5.3 Deviations

There were no deviations from the test methodology listed in the test plan for the out of band emissions test.

4.5.4 Final Test

The out of band emissions of the EUT were below the limit specified by the standard. Plots contain a Blue Peak Max-Hold trace and a Cyan AVG Max-Hold trace.

4.5.5 Final Data

Lower Band Edge							
Freq [MHz]	Mode/Data Rate	Center Freq [MHz]	Detector	Measured [dBμV/m]	Limit [dBμV/m]	Margin [dB]	Result
2389.9	250 kbps	2405	Peak	31.40	74	-42.60	Pass
2389.9	250 kbps	2405	Avg	25.84	54	-28.16	Pass
Upper Band Edge							
Freq [MHz]	Mode/Data Rate	Center Freq [MHz]	Detector	Measured [dBμV/m]	Limit [dBμV/m]	Margin [dB]	Result
2483.5	250 kbps	2480	Peak	52.45	74	-21.55	Pass
2483.5	250 kbps	2480	Avg	45.26	54	-8.74	Pass

Note: No spurious emissions were detected in the Lower restricted band.

4.5.6 Plots

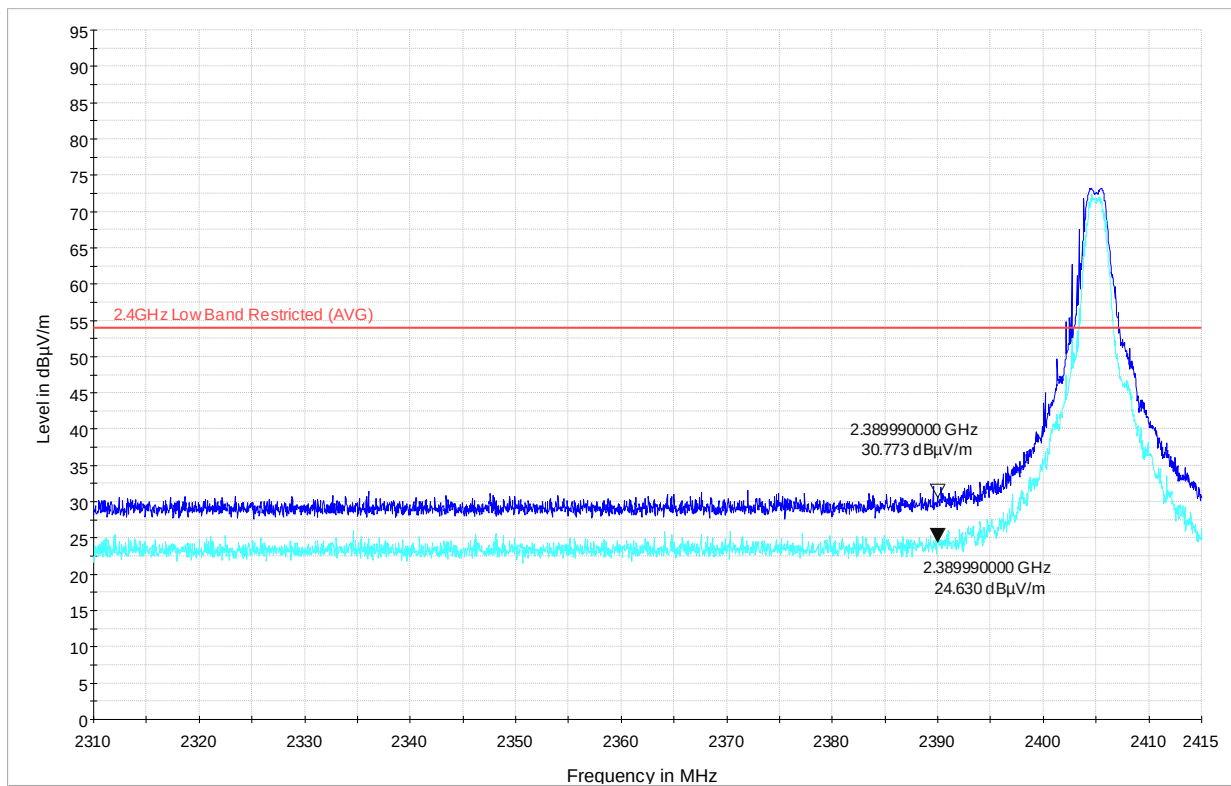


Figure 18 – Lower Band Edge CH11 2405 MHz Antenna Vertical

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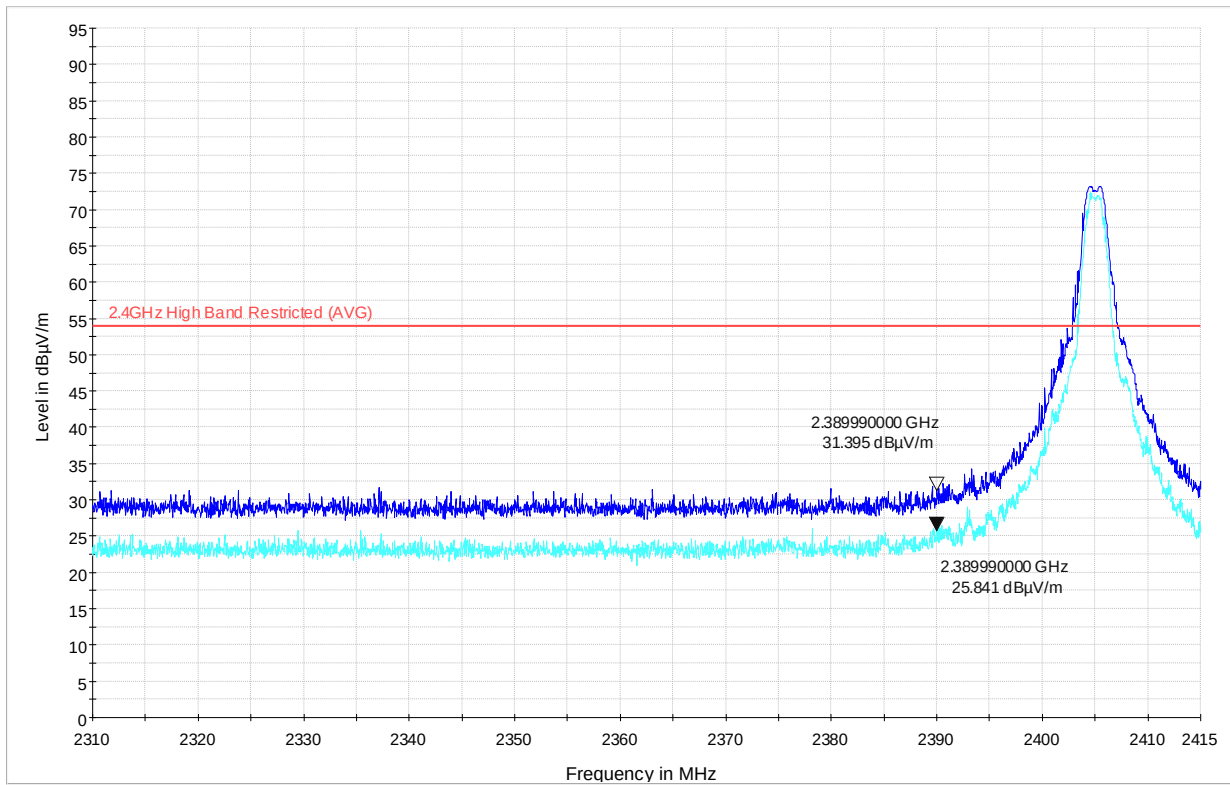


Figure 19 – Lower Band Edge CH11 2405 MHz Antenna Horizontal

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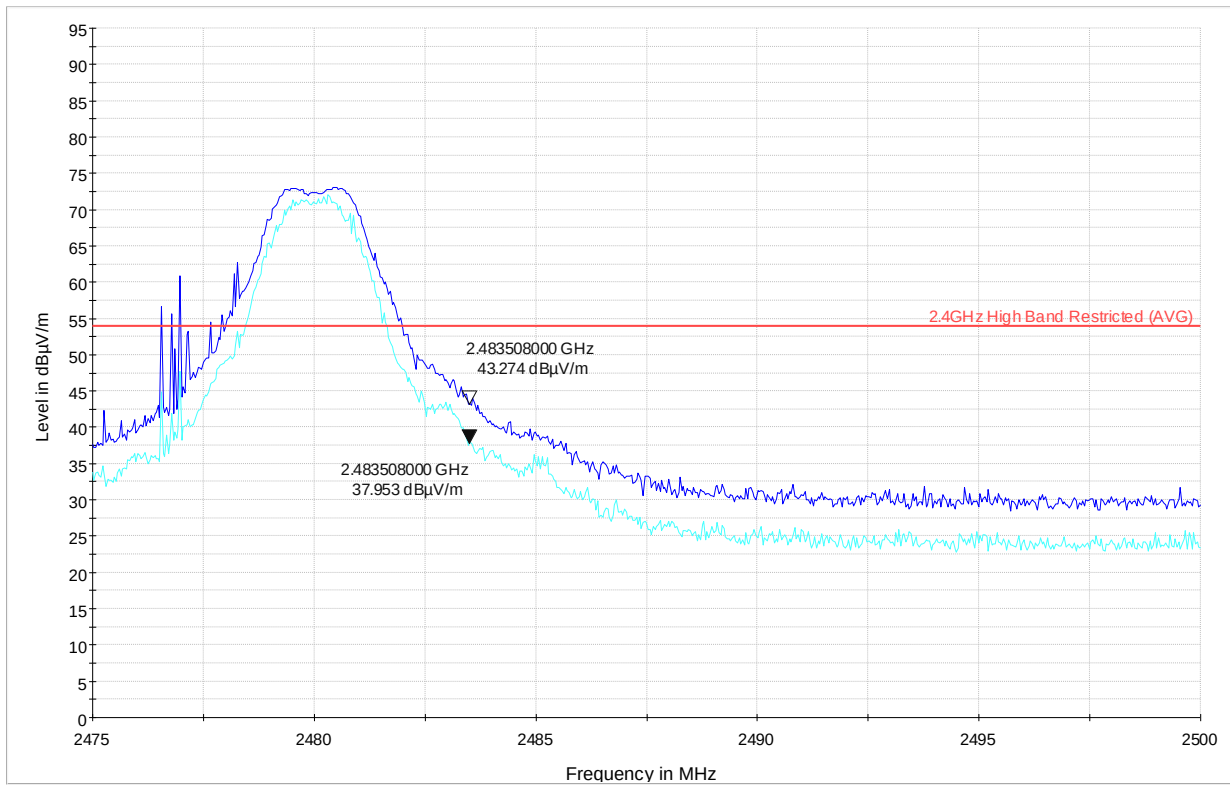


Figure 20 – Upper Band Edge CH26 2480 MHz Antenna Vertical

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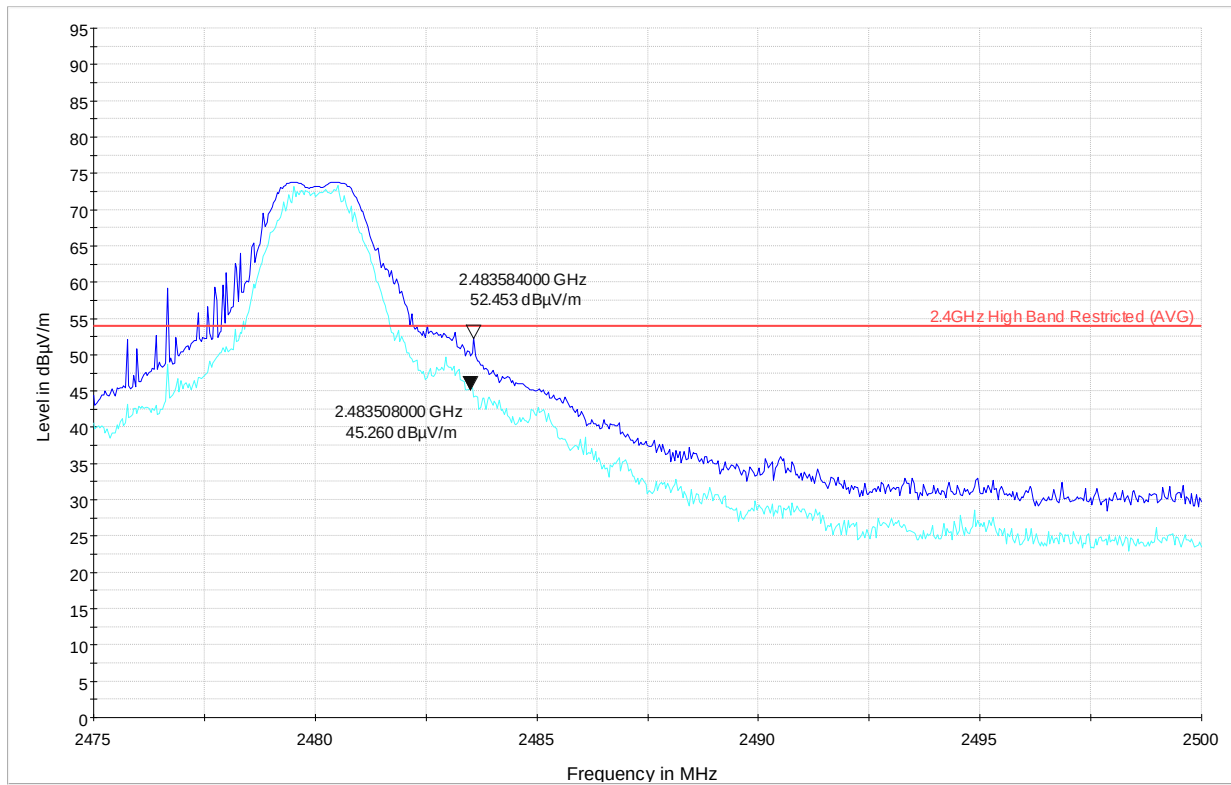


Figure 21 – Upper Band Edge CH26 2480 MHz Antenna Horizontal

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4.6 Transmitter Spurious Emission

This purpose of this test is to evaluate the radiated spurious emissions of the EUT.

4.6.1 Test Over View

Results	Complies (as tested per this report)					Date	01/19/2021	
Standard	FCC CFR 47 §15.247 (d); RSS-247 5.5							
Product Model	CAM-PR2				Serial#	00:17:0D:00:00:68:82:55		
Configuration	See test plan for details.							
Test Set-up	Tested at 3 meters, semi-anechoic chamber, EUT placed on turntable. See test plan for details.							
EUT Powered By	3 VDC	Temp	22° C	Humidity	36%	Pressure	994 mbar	
Frequency Range	Channel 11: 2405 MHz Channel 18: 2440 MHz Channel 26: 2480 MHz							
Perf. Criteria	Class B (Below Limit)			Perf. Verification	Readings under Limit			
Mod to EUT	None			Test Performed By	Alexander Sowinski			

4.6.2 Test Procedure

Testing was performed in accordance with FCC CFR §15.247 and ANSI C63.10. In the range below 1GHz, sample was place on the turntable at a height of 80 cm. In the range above 1GHz, the EUT was placed on the turntable at a height of 150 cm. Measurements were taken rotating the turntable between 0 and 360° and varying the antenna height between 100 and 400 cm. Worst case results were recorded and reported below. A 2.4GHz notch filter was installed on the signal path to protect the measurement receiver. No spurious emissions were detected below 30MHz or above 18GHz. In the range below 1GHz, the measurement receiver is configured with RBW = 100 kHz, VBW = 300 kHz. In the range above 1GHz, the measurement receiver is configured with RBW = 1 MHz, VBW = 3 MHz.

4.6.3 Deviations

There were no deviations from the test methodology listed in the test plan for the transmitter spurious emissions test.

4.6.4 Final Test

The final transmitter spurious emission measurements were below the limit. Plots contain a Blue Peak Max-Hold trace and a Red Peak Clear-Write trace.

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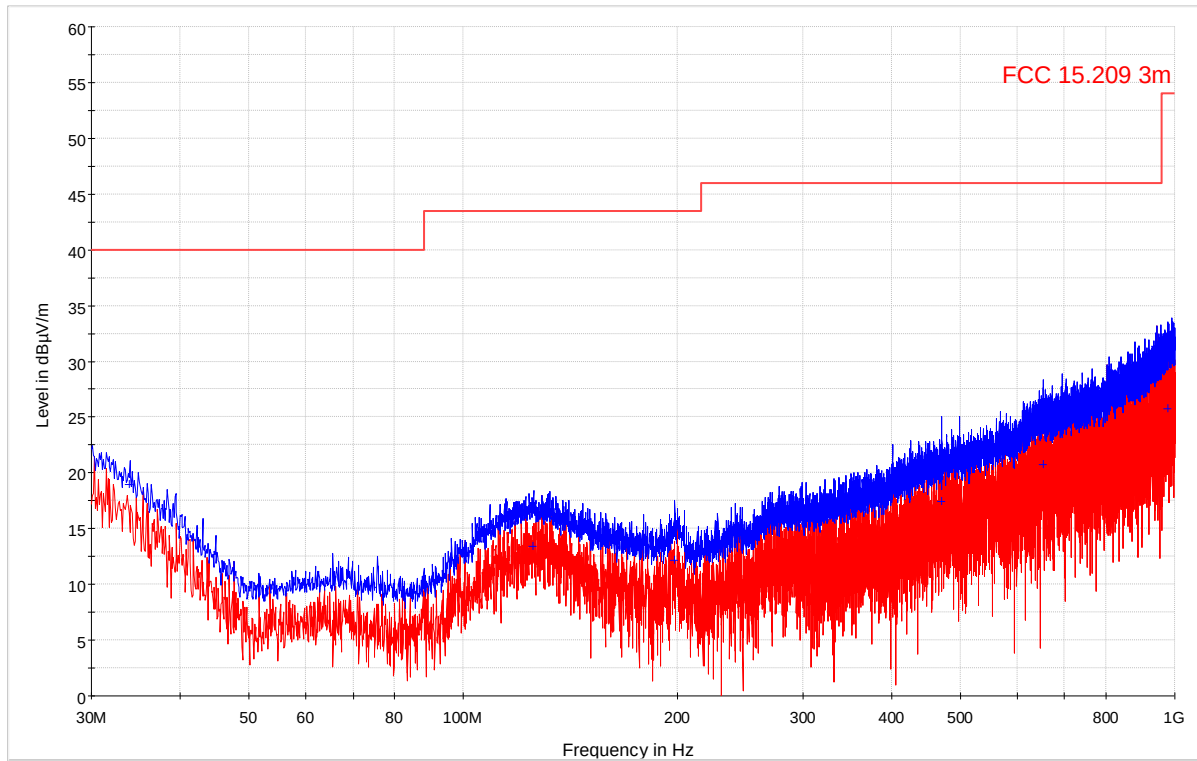
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4.6.5 Final Data

NOTES: 30 – 1000 MHz, CH11-2405 MHz

Radiated Emissions Vertical



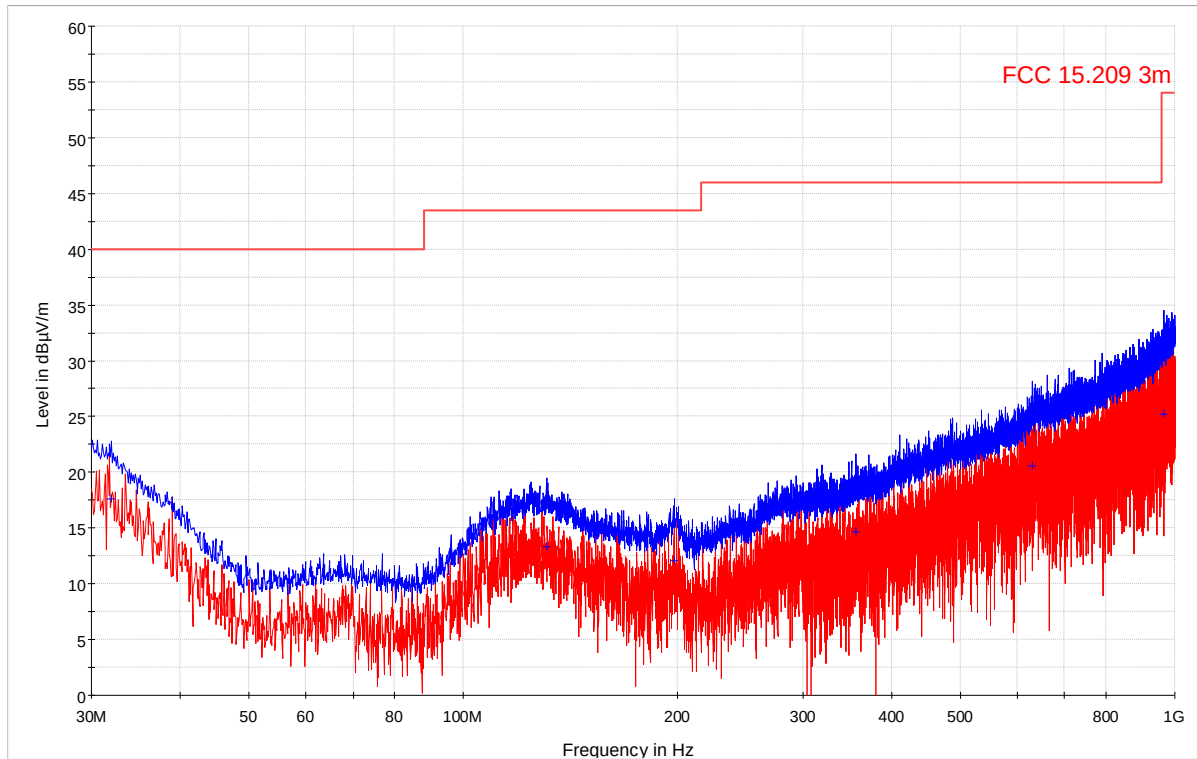
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NOTES: 30 – 1000 MHz, CH11-2405 MHz

**Radiated Emissions
Horizontal**



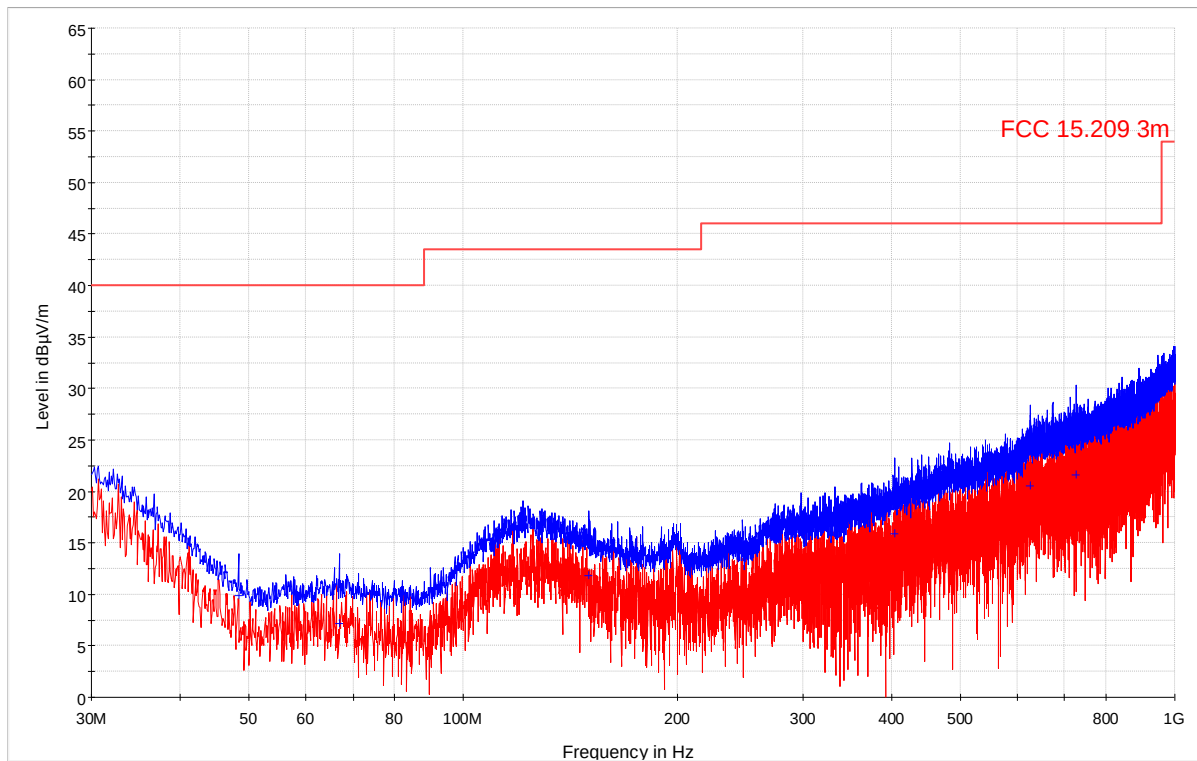
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NOTES: 30 – 1000 MHz, CH18-2440 MHz

**Radiated Emissions
Vertical**



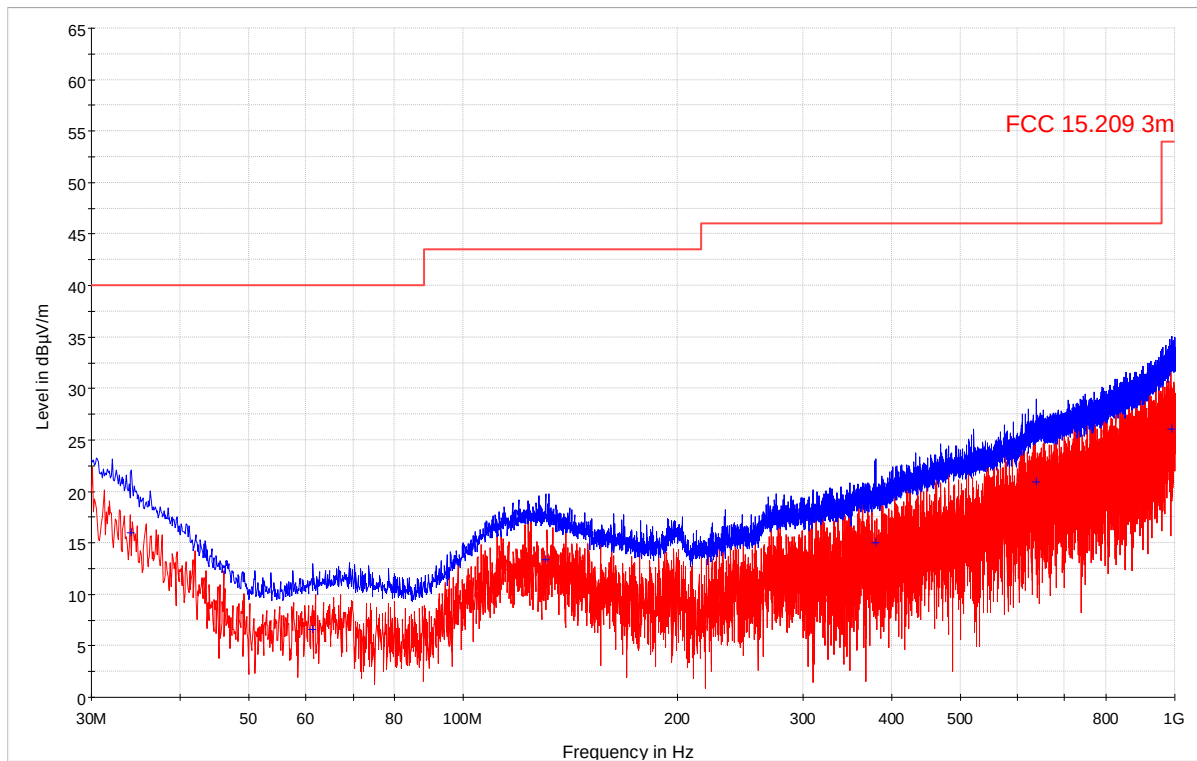
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NOTES: 30 – 1000 MHz, CH18-2440 MHz

**Radiated Emissions
Horizontal**



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NOTES: 30 – 1000 MHz, CH26-2480 MHz

**Radiated Emissions
Vertical**



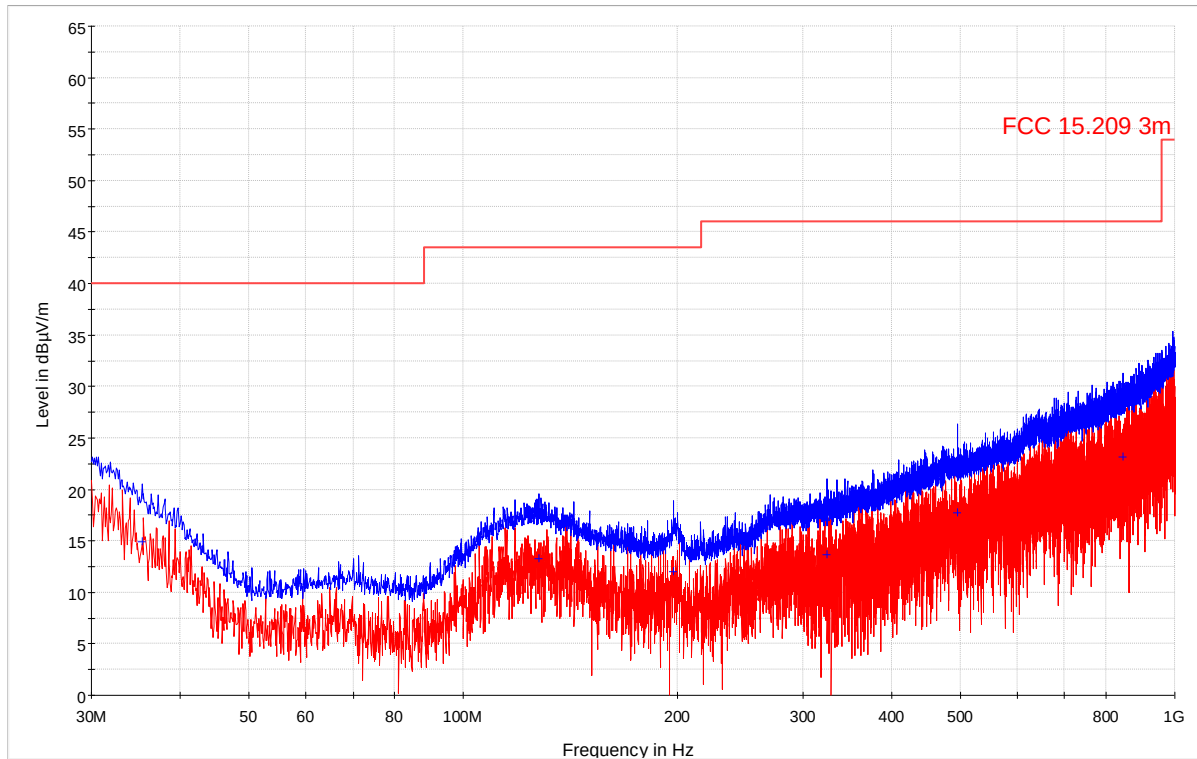
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NOTES: 30 – 1000 MHz, CH26-2480 MHz

**Radiated Emissions
Horizontal**



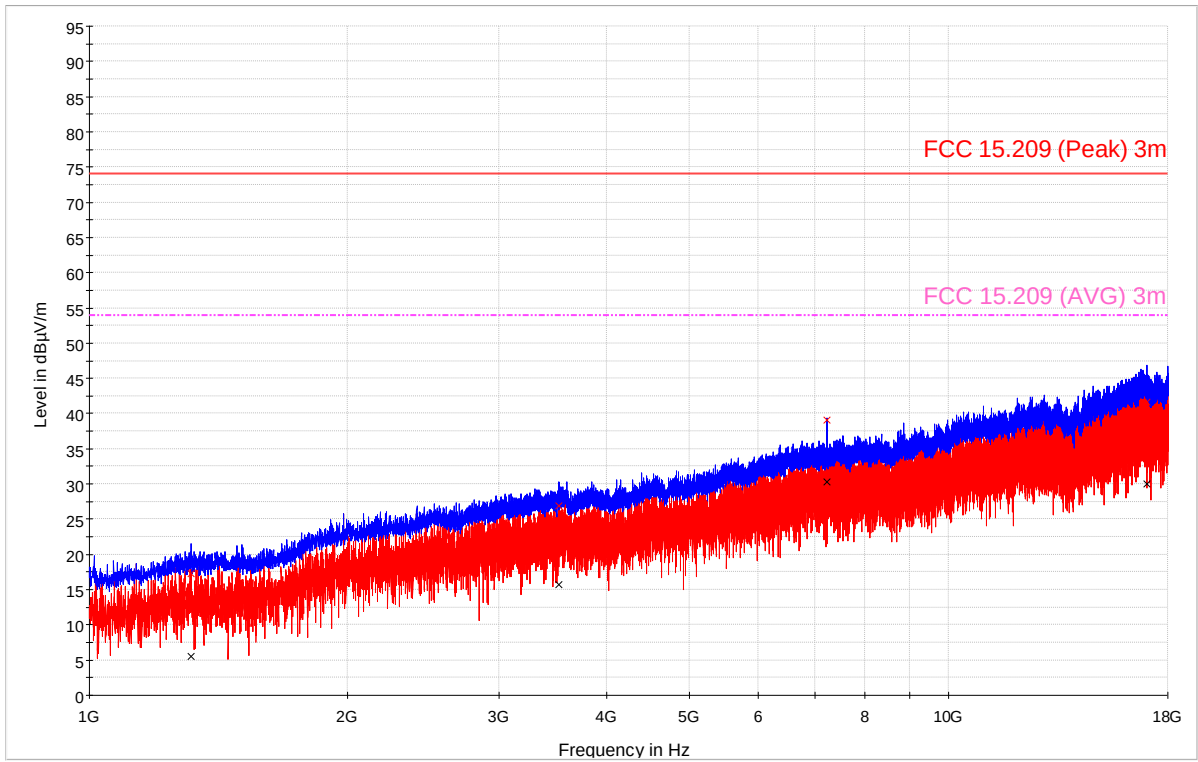
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NOTES: 1 – 18 GHz, CH11-2405 MHz

**Radiated Emissions
Vertical**



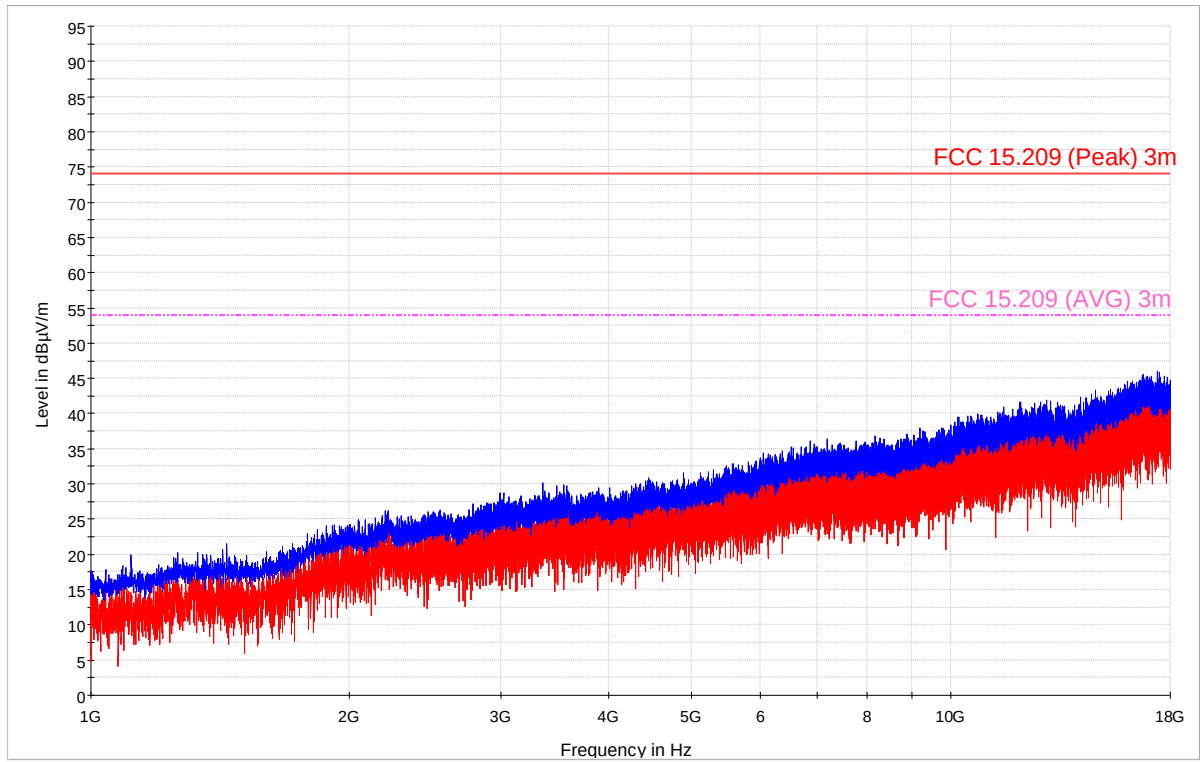
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NOTES: 1 – 18 GHz, CH11-2405 MHz

**Radiated Emissions
Horizontal**



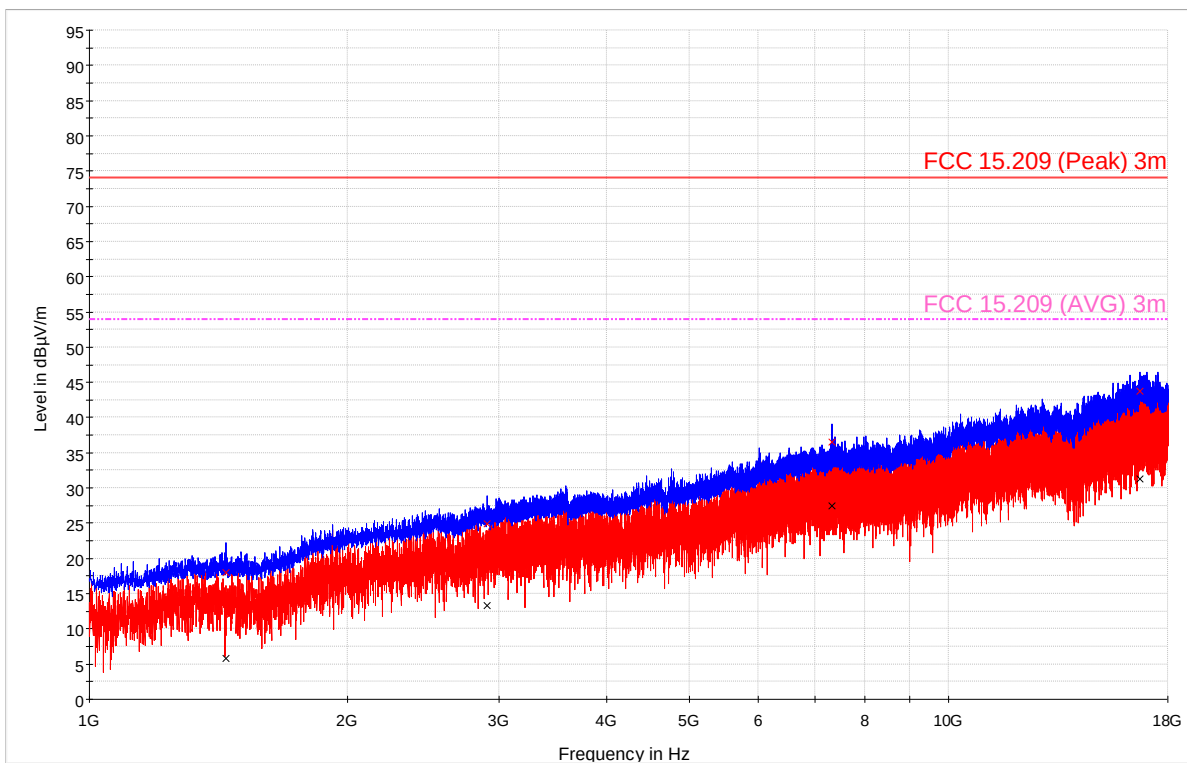
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NOTES: 1 – 18 GHz, CH18-2440 MHz

**Radiated Emissions
Vertical**



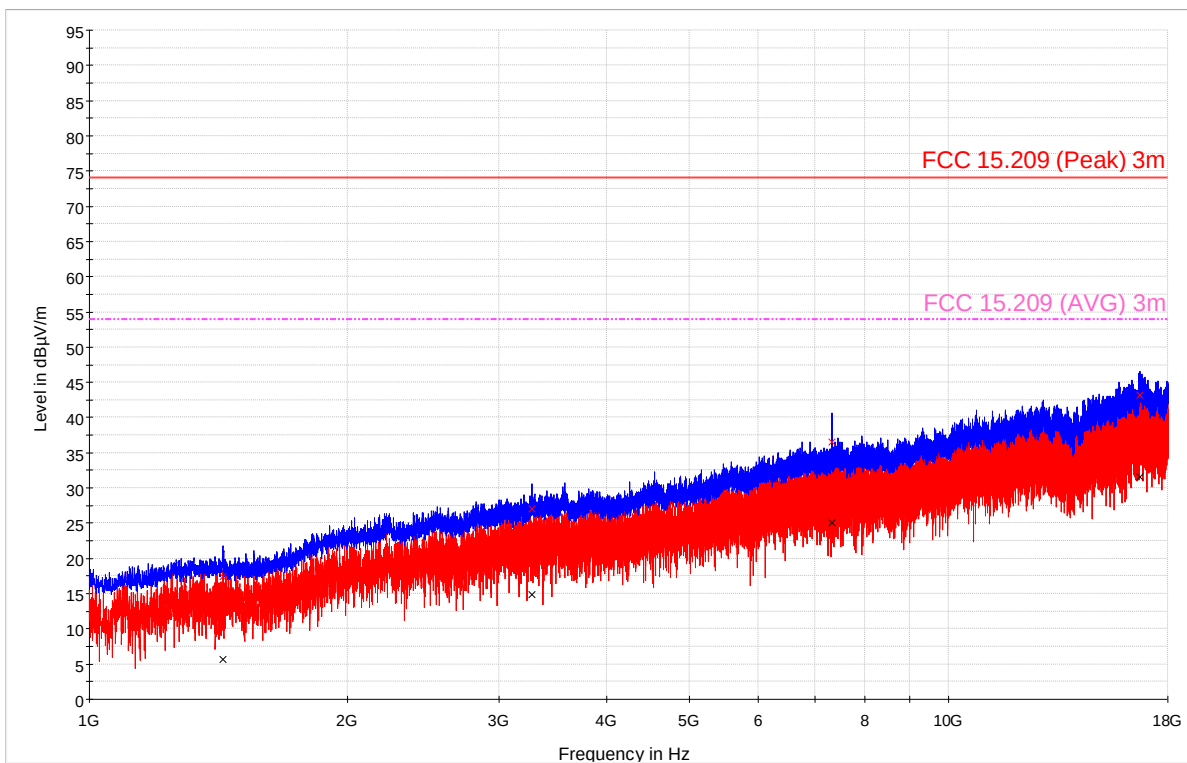
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NOTES: 1 – 18 GHz, CH18-2440MHz

**Radiated Emissions
Horizontal**



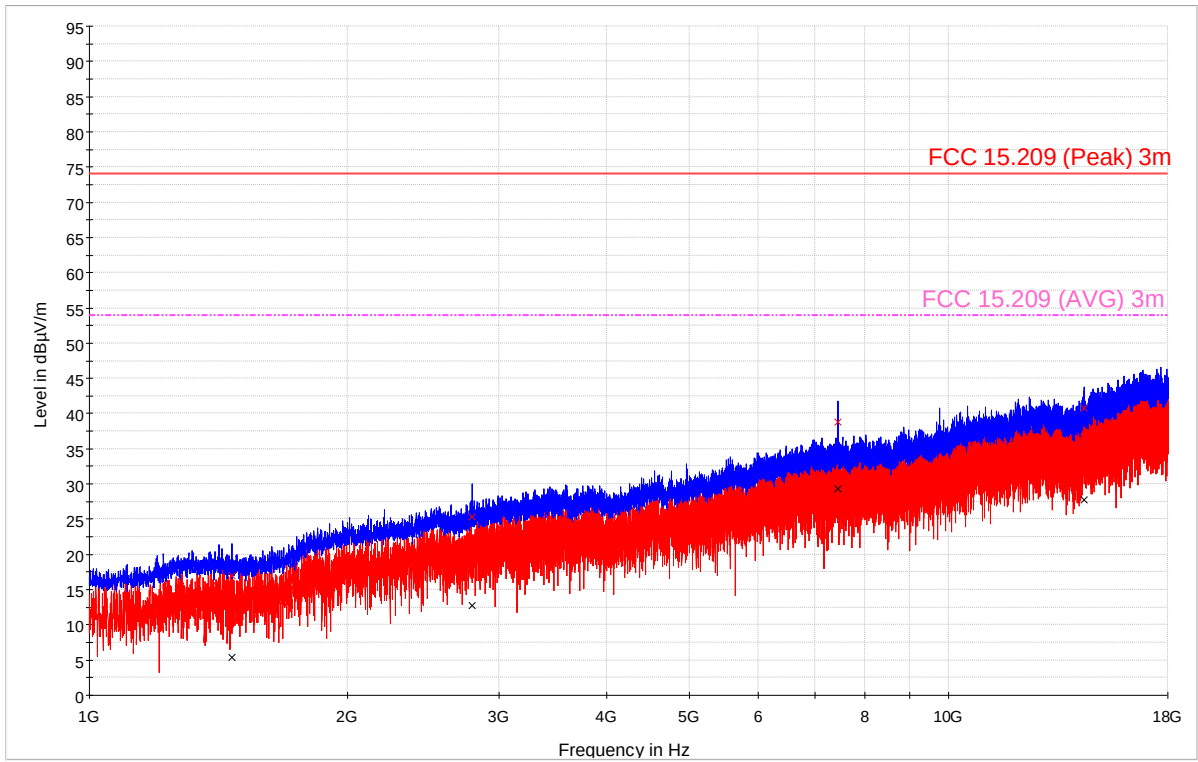
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NOTES: 1 – 18 GHz, CH26-2480 MHz

**Radiated Emissions
Vertical**



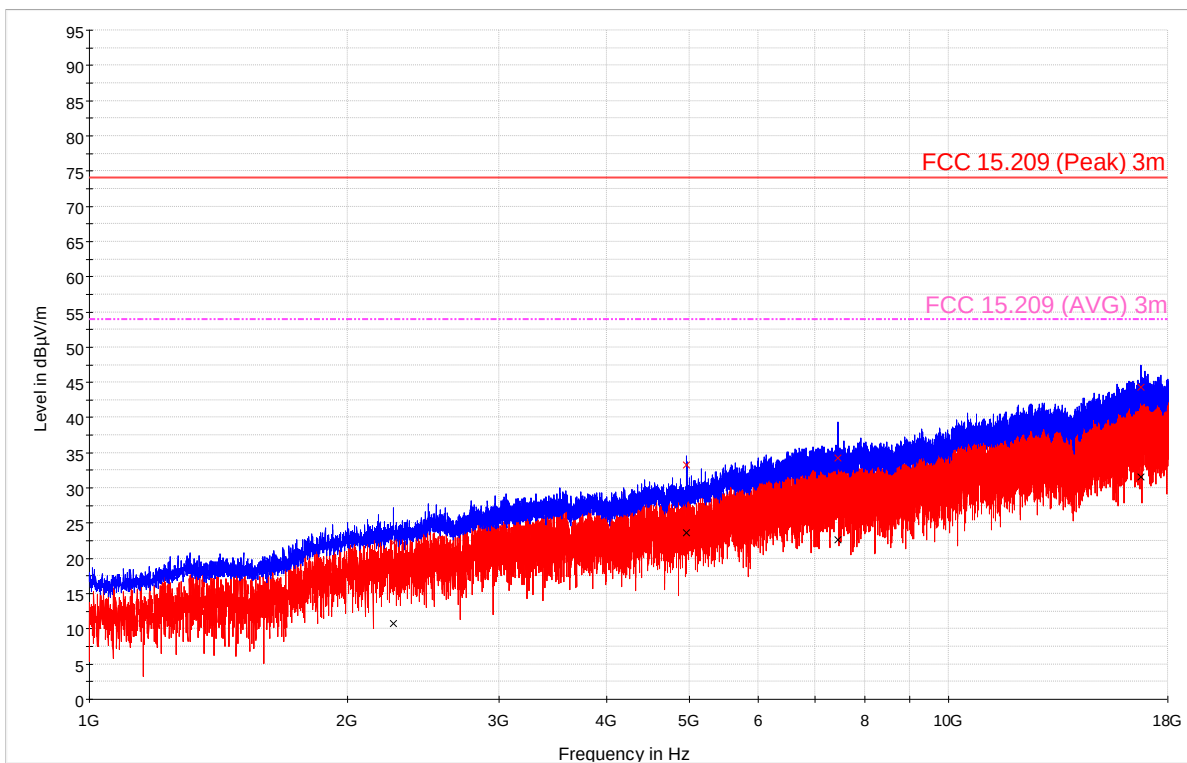
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NOTES: 1 – 18 GHz, CH26-2480 MHz

**Radiated Emissions
Horizontal**



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4.6.6 Final Tabulated Data

Table 1: 30 – 1000 MHz CH11 Tabulated Data

Frequency	QuasiPeak	Height	Polarization	Azimuth	Limit - QPK	Margin
MHz	dBμV/m	cm		deg	dBμV/m	dB
32.04	17.6	400.0	H	78.0	40.0	-22.4
33.96	18.9	100.0	V	27.0	40.0	-21.1
125.44	13.5	100.0	V	342.0	43.5	-30.0
130.88	13.4	400.0	H	204.0	43.5	-30.1
198.20	12.1	400.0	H	316.0	43.5	-31.4
198.28	12.1	100.0	V	113.0	43.5	-31.4
356.60	14.6	400.0	H	233.0	46.0	-31.4
470.48	17.5	100.0	V	180.0	46.0	-28.5
631.32	20.6	400.0	H	153.0	46.0	-25.4
652.76	20.7	100.0	V	312.0	46.0	-25.3
966.04	25.3	400.0	H	55.0	54.0	-28.7
978.84	25.7	100.0	V	53.0	54.0	-28.3

Table 2: 30 – 1000 MHz CH18 Tabulated Data

Frequency	QuasiPeak	Height	Polarization	Azimuth	Limit - QPK	Margin
MHz	dBμV/m	cm		deg	dBμV/m	dB
34.16	16.0	400.0	H	345.0	40.0	-24.0
48.32	9.8	100.0	V	291.0	40.0	-30.2
61.44	6.6	400.0	H	189.0	40.0	-33.4
66.96	7.2	100.0	V	164.0	40.0	-32.8
130.48	13.4	400.0	H	121.0	43.5	-30.1
150.28	11.8	100.0	V	129.0	43.5	-31.7
380.16	15.0	400.0	H	78.0	46.0	-31.0
403.92	15.9	100.0	V	214.0	46.0	-30.1
625.68	20.5	100.0	V	254.0	46.0	-25.5
638.68	20.9	400.0	H	162.0	46.0	-25.1
726.36	21.6	100.0	V	330.0	46.0	-24.4
990.68	26.0	400.0	H	307.0	54.0	-28.0

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Table 3: 30 – 1000 MHz CH26 Tabulated Data

Frequency	QuasiPeak	Height	Polarization	Azimuth	Limit - QPK	Margin
MHz	dBμV/m	cm		deg	dBμV/m	dB
35.32	14.9	400.0	H	342.0	40.0	-25.1
39.60	19.3	100.0	V	263.0	40.0	-20.7
126.40	13.4	100.0	V	133.0	43.5	-30.1
127.68	13.3	400.0	H	210.0	43.5	-30.2
197.52	12.0	400.0	H	100.0	43.5	-31.5
206.92	9.6	100.0	V	296.0	43.5	-33.9
309.84	13.5	100.0	V	87.0	46.0	-32.5
324.20	13.7	400.0	H	49.0	46.0	-32.3
495.32	17.8	400.0	H	157.0	46.0	-28.2
536.24	18.6	100.0	V	17.0	46.0	-27.4
808.60	22.8	100.0	V	203.0	46.0	-23.2
846.16	23.1	400.0	H	280.0	46.0	-22.9

Table 4: 1 – 18 GHz CH11 Tabulated Data

Frequency	MaxPeak	CAverage	Height	Polarization	Azimuth	Limit - PK	Margin - PK	Limit - AVG	Margin - AVG
MHz	dBμV/m	dBμV/m	cm		deg	dBμV/m	dB	dBμV/m	dB
1286.75	16.6	4.7	250.0	H	239.0	74.0	-57.4	54.0	-49.3
1314.00	17.2	5.5	110.0	V	147.0	74.0	-56.8	54.0	-48.5
3342.50	26.0	14.4	250.0	H	183.0	74.0	-48.0	54.0	-39.6
3522.25	27.0	15.7	110.0	V	291.0	74.0	-47.0	54.0	-38.3
7216.25	39.0	30.3	110.0	V	38.0	74.0	-35.0	54.0	-23.7
7217.00	33.5	22.9	250.0	H	84.0	74.0	-40.5	54.0	-31.1
16899.50	43.5	31.6	250.0	H	125.0	74.0	-30.5	54.0	-22.4
17001.50	41.6	30.1	110.0	V	357.0	74.0	-32.4	54.0	-23.9

Table 5: 1 – 18 GHz CH18 Tabulated Data

Frequency	MaxPeak	CAverage	Height	Polarization	Azimuth	Limit - PK	Margin - PK	Limit - AVG	Margin - AVG
MHz	dBμV/m	dBμV/m	cm		deg	dBμV/m	dB	dBμV/m	dB
1429.00	17.4	5.6	250.0	H	297.0	74.0	-56.6	54.0	-48.4
1442.50	17.9	5.8	110.0	V	111.0	74.0	-56.1	54.0	-48.2
2905.75	24.9	13.3	110.0	V	264.0	74.0	-49.1	54.0	-40.7
3276.25	27.1	14.8	250.0	H	159.0	74.0	-46.9	54.0	-39.2
7318.25	36.5	25.1	250.0	H	12.0	74.0	-37.5	54.0	-28.9
7321.25	36.6	27.5	110.0	V	236.0	74.0	-37.4	54.0	-26.5
16691.50	43.8	31.2	110.0	V	8.0	74.0	-30.2	54.0	-22.8
16725.00	43.2	31.5	250.0	H	82.0	74.0	-30.8	54.0	-22.5

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Table 6: 1 – 18 GHz CH26 Tabulated Data

Frequency	MaxPeak	CAverage	Height	Polarization	Azimuth	Limit - PK	Margin - PK	Limit - AVG	Margin - AVG
MHz	dBμV/m	dBμV/m	cm		deg	dBμV/m	dB	dBμV/m	dB
1464.00	17.0	5.4	110.0	V	283.0	74.0	-57.0	54.0	-48.6
2259.25	22.2	10.8	250.0	H	109.0	74.0	-51.8	54.0	-43.2
2787.75	25.3	12.7	110.0	V	153.0	74.0	-48.7	54.0	-41.3
4958.75	33.3	23.6	250.0	H	2.0	74.0	-40.7	54.0	-30.4
7441.25	34.2	22.6	250.0	H	218.0	74.0	-39.8	54.0	-31.4
7441.75	38.8	29.3	110.0	V	38.0	74.0	-35.2	54.0	-24.7
14378.50	40.8	27.8	110.0	V	116.0	74.0	-33.2	54.0	-26.2
16731.25	44.3	31.5	250.0	H	2.0	74.0	-29.7	54.0	-22.5

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Appendix A

5 Test Plan

This test report is intended to follow the test plan outlined herein unless otherwise stated. The test plan provides product information, reference standards, and testing details. The product information below came via client, product manual, product itself and or the internet. Test procedure information will reference standards or internal TUV Rheinland NA procedures.

5.1 General Information

Client	Airgas USA, LLC
Address 1	184 Sandbank Road
Address 2	Cheshire, CT 06410
Contact Person	Ling Sze
Telephone	203-272-5800 x229
Fax	--
e-mail	ling.sze@airgas.com

5.2 Model(s) Name

CAM-PR2

5.3 Type of Product

CAM Pressure Remote Gen 2

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5.4 Equipment Under Test (EUT) Description

Pressure Remote is intended for pressure monitoring of gas or air up to 3000 psi (206 bar), or 300 bar in five of transducer fitting options. It wirelessly send information to the Concentrator, which relay the information to the Airgas Cloud Services (ACS) Database.

Pressure Remotes has Airgas (CAM-PR2-01 to CAM-PR2-06) vs Air Liquide (CAM-PR2-11 to CAM-PR2-16) versions. The main differences are in the front overlay's graphic, firmware, and back label information.

Sample "00:17:0D:00:00:68:82:55" was configured for radiated measurements while sample "00:17:0D:00:00:68:68:69" was configured for conducted measurements.

5.5 Wireless

☒	Yes	☐	No
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EUT Wireless Details	
FCC ID:	2ALBX-CAMPRMR02
IC ID:	22533-CAMPRMR02
Environment:	Portable
Operating Temperature Range:	-20 – 60°C
Multiple Feeds:	☒ No ☐ Yes, and how many:
Hardware Version:	CAM-PR2
Software Version:	V3.00.55
Transmitter Frequency Band:	2400 – 2483.5 MHz
Device Rated Output Power:	8 dBm
Power Setting:	Maximum
Antenna Type and Gain:	Chip, 1.7 dBi
Modulation Type:	6LoWPAN - BPSK
Data Rate:	250 kbps
Max Duty Cycle:	100%
Type of Equipment:	Portable.

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5.6 General Product Information

Size		H	10 mm	W	27.6 mm	L	27.6 mm
Weight		< 1 kg		Fork-Lift Needed		No	
Notes	CAM Pressure Remote Gen 2						

5.7 Modifications

None.

5.8 EUT Electrical Power Information

5.8.1 Electrical Power Type

☐	AC	☐	DC	☒	Batteries	☐	Host -
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5.8.2 Electrical Power Information

Name	Type	Voltage		Frequency	Current	Notes
		min	max			
Internal Battery	Li-ion	3	3.6	VDC	< 20 mA	
Notes	See LS14500, TL-5903 Datasheet					

5.9 EUT Modes of Operation during Testing

For testing the 6LoWPAN transmitter, sample 00:17:0D:00:00:68:68:69 was used for conducted tests. Power was set to maximum output (8dBm), 100% duty cycle, and the channels 11, 18, and 26 were examined. For the radiated tests, sample 00:17:0D:00:00:68:82:55 was used with the same settings.

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5.10 EUT Clock/Oscillator Frequencies

Please specify the maximum clock frequency used in the product – 20 MHz

In the table below, please specify other clock frequencies and sensitive operating frequencies in the product.

Clock Frequencies & Sensitive Frequencies
20MHz crystal input
32.768kHz crystal input
7.3728MHz oscillator

5.11 Electrical Support Equipment

Type	Manufacturer	Model	Connected To
TAG Converter PCB	Custom	Na	Laptop (J2-2) and CAM Pressure Remote PCB (J2)
Laptop	Toshiba	37116766W	TAG Converter PCB (J2-2)
Laptop Power Cable	Toshiba	Na	Laptop
Concentrator	Airgas	CCEU-WF25	Pressure Remote (Wirelessly)

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Item	Notes
Gas	None
Water	None
Air	None

5.13 EUT Equipment/Cabling Information

EUT Port	Connected To	Location	Cable Type		
			Length	Shielded	Bead
J2	TAG Converter PCB	J2-2	< 1m	Unshielded	

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5.14 Emissions

5.14.1 Maximum Output Power

5.14.1.1 Maximum Output Power Test Set-up

Standard	FCC CFR 47 §15.247 (b.3); RSS-247 5.4(d)		TUV Test Procedure		MS-0005082
Limit	< 1 Watt (30 dBm)		Emissions Verification		Emissions Under Limit
Frequency Range	Channel 11 – 2405 MHz Channel 18 – 2440 MHz Channel 26 – 2480 MHz	Test Type	Conducted	Det	Peak
Configuration	See Appendix A, EUT Configuration				
EUT Powered By	See Appendix A, EUT Electrical Power Information				
Notes	None				

5.14.2 DTS Bandwidth

5.14.2.1 DTS Bandwidth Test Set-up

Standard	FCC CFR 47 §15.247 (a.2); RSS-247 5.2(a)		TUV Test Procedure	MS-0005180
Limit	DTS OBW > 500 kHz	Report 99% OBW	Emissions Verification	Emissions within Limit
Frequency Range	Channel 11 – 2405 MHz Channel 18 – 2440 MHz Channel 26 – 2480 MHz		Detector	Peak
Configuration	See Appendix A, EUT Configuration			
EUT Powered By	See Appendix A, EUT Electrical Power Information			
Notes	None			

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5.14.3 Peak Power Spectral Density Test

5.14.3.1 Peak Power Spectral Density Test Set-up

Standard	FCC CFR 47 §15.247 (e); RSS-247 5.2(b)	TUV Test Procedure	MS-0005182
Limit	< 8 dBm / 3 kHz band	Emission Verification	Emission Under Limit
Frequency Range	Channel 11 – 2405 MHz Channel 18 – 2440 MHz Channel 26 – 2480 MHz	Detector	Peak
Configuration	See Appendix A, EUT Configuration		
EUT Powered By	See Appendix A, EUT Configuration		
Notes	None		

5.14.4 Out of Band Emissions: Non-Restricted Bands

5.14.4.1 Out of Band Emissions: Non-Restricted Bands Test Set-up

Standard	FCC CFR 47 §15.247 (d); RSS-247 5.5	TUV Test Procedure	MS-0005191
Limit	< 20 dB below Peak output power measured in a 100 kHz band.	Emission Verification	Emissions Under Limit
Frequency Range	Channel 11 – 2405 MHz Channel 18 – 2440 MHz Channel 26 – 2480 MHz	Detector	Peak
EUT Powered By	See Appendix A, EUT Electrical Power Information		
Configuration	See Appendix A, EUT Configuration		
Notes	None		

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5.14.5 Out of Band Emissions: Restricted Bands

5.14.5.1 Out of Band Emissions: Restricted Bands Test Set-up

Standard	FCC CFR 47 §15.247 (d); RSS-247 5.5	TUV Test Procedure	MS-0005176
Limit	< 54 dBμV/m @ 3 meters, AVG < 74 dBμV/m @ 3 meters, Peak	Emission Verification	Emissions Under Limit
Frequency Range	Channel 11 – 2405 MHz Channel 26 – 2480 MHz	Detector	AVG, Peak
EUT Powered By	See Appendix A, EUT Electrical Power Information		
Configuration	See Appendix A, EUT Configuration		
Notes	None		

5.14.6 Transmitter Spurious Emissions

5.14.6.1 Transmitter Spurious Emissions Test Set-up

Standard	FCC CFR 47 §15.247 (d); RSS-247 5.5	TUV Test Procedure	MS-0005188
Frequency Range	9 – 490 kHz	Limit	< $20\log(2400/F) + 80$ dBμV/m @ 3m (QP)
	490 – 1705 kHz		< $20\log(24000/F) + 80$ dBμV/m @ 3m (QP)
	1.705 – 30 MHz		< 69.5 dBμV/m @ 3m (QP)
	30 – 88 MHz		< 40.0 dBμV/m @ 3m (QP)
	88 – 216 MHz		< 43.5 dBμV/m @ 3m (QP)
	216 – 960 MHz		< 46.0 dBμV/m @ 3m (QP)
	960 – 1000 MHz		< 54.0 dBμV/m @ 3m (QP)
	1000 – 26500 MHz		< 54.0 dBμV/m @ 3m (AVG) < 74.0 dBμV/m @ 3m (Peak)
Frequency Range	Channel 11 – 2405 MHz Channel 18 – 2440 MHz Channel 26 – 2480 MHz	Detector	AVG, Peak, QP
EUT Powered By	See Appendix A, EUT Electrical Power Information		
Configuration	See Appendix A, EUT Configuration		
Notes	None		

Report No.:

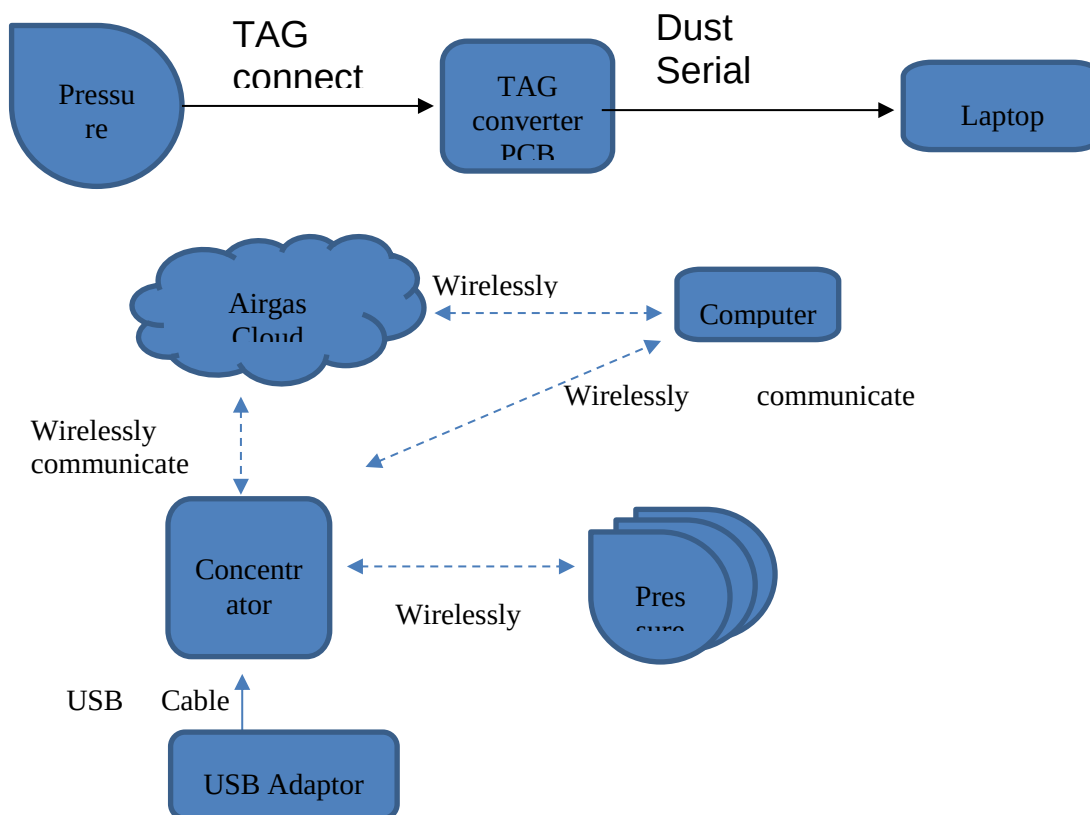
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5.15 EUT Configuration

Configuration	Description
Continuous TX Mode	Duty cycle 100%, Output power maximum (8 dBm)
Notes	All configurations are the same except as noted above

5.16 Block Diagram



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