

LM-Instruments Oy

TEST REPORT

SCOPE OF WORK

EMISSIONS TESTING – LM DTS™, Model: Tray Reader

REPORT NUMBER

105031787MPK-001

ISSUE DATE

June 30, 2022

[REVISED DATE]

N/A

PAGES

30

DOCUMENT CONTROL NUMBER

Non-Specific Radio Report Shell Rev. December 2017

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Class II Permissive Change TEST REPORT

Report Number: 105031787MPK-001
Project Number: G105031787

Report Issue Date: June 30, 2022

Testing performed on the
LM DTS™
Model: Tray Reader

FCC ID: 2AGUB-73000

to

FCC Part 15 Subpart C (15.247)

for

LM-Instruments Oy

Tested by:

Intertek
1365 Adams Court
Menlo Park, CA 94025 USA

Client:

LM-Instruments Oy
Norrbyn Rantatie 8
21 600 Parainen, Finland

Report prepared by:



Kenneth Roque / EMC Project Engineer

Report reviewed by:



Anderson Soungpanya / EMC Team Lead

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Report No. 105031787MPK-001

Equipment Under Test:	LM DTS™
Model(s) Tested:	Tray Reader
Applicant:	LM-Instruments Oy
Contact:	Tomi Muuri
Address:	LM-Instruments Oy Norrbyn Rantatie 8 21 600 Parainen
Country:	Finland
Tel. Number:	+358 50 4821 868
Email:	tomi.muuri@lm-dental.com
Applicable Regulation:	FCC Part 15 Subpart C (15.247)
Date of Test:	April 8, 2022 – April 10, 2022

We attest to the accuracy of this report:



Kenneth Roque
EMC Project Engineer



Anderson Soungpanya
EMC Team Lead

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1.0 Summary of Tests

Test	Reference FCC	Result
RF Output Power	15.247(b)(3)	Complies
Transmitter Radiated Emissions	15.247(d), 15.209, 15.205	Complies
Antenna Requirement	15.203	Complies (Internal Antenna)

EUT Receive Date: March 28, 2022

EUT Receive Condition: The pre-production version of the EUT was received in good condition with no apparent damage. As declared by the Applicant, it is identical to the production units.

Test Start Date: April 8, 2022

Test Completion Date: April 10, 2022

The test results in this report pertain only to the item tested.

2.0 General Information

2.1 Product Description

LM-Instruments Oy supplied the following description of the EUT:

LM DTS™ Readers are a cutting edge multi-read UHF (Ultra High Frequency) RFID read point solutions that offer ease in deployment due to their small size. With the antenna, cables and reader enclosed in a single reader it can be placed in any environment with minimal effect on the surroundings. Readers can be wall mounted in case you don't have table space.

LM DTS™ Readers use UHF (Ultra High Frequency) RFID technology to efficiently track, monitor and control instruments and materials. The RFID tag can be attached to any material from different manufacturers enabling complete traceability of the materials by scanning them with the LM DTS™ readers. Instruments, handpieces, filling materials, implants etc. are wirelessly read in just a few seconds. Integration to LM DTS™ cloud server is made via Ethernet cable or WLAN connection.

For more information, see user's manual provided by the manufacturer.

This test report covers only the 900 MHz UHF RFID radio.

Information about the 900 MHz UHF RFID radio is presented below:

Radio Information	
Applicant	LM-Instruments Oy
Model Number	Tray Reader
FCC Identifier	2AGUB-73000
Rated RF Output	23.73 dBm
Frequency Range	917.10 – 926.90 MHz
Type of Transmitter	Frequency Hopping Spread Spectrum (FHSS)
Type of Modulation	ASK
Number of hopping Channel(s)	50
Antenna(s) & Gain	Internal Antenna, Gain: -10.0 dBi
Applicant Name & Address	LM-Instruments Oy Norbyn Rantatie 8 21 600 Parainen, Finland

2.2 Related Submittal(s) Grants

None.

2.3 Test Facility

The test site used to collect the radiated data is site 1 (10-m semi-anechoic chamber). This test facility and site measurement data have been fully placed on file with the FCC, IC and A2LA accredited.

2.4 Test Methodology

Antenna conducted measurements were performed according to the FCC documents "Guidance for Performing Compliance Measurement on Digital Transmission Systems (DTS) Operating under §15.247" (KDB 558074 D01 DTS Meas Guidance v05r02).

Radiated emissions and AC mains conducted emissions measurements were performed according to the procedures in ANSI C63.10: 2013. Radiated tests were performed at an antenna to EUT distance of 3 meters, unless stated otherwise in the "Data Sheet" of this report.

2.5 Measurement Uncertainty

Compliance with the limits was based on the results of the measurements and doesn't take into account the measurement uncertainty.

Estimated Measurement Uncertainty

Measurement	Expanded Uncertainty (k=2)		
	0.15 MHz – 1 GHz	1 GHz – 2.5 GHz	> 2.5 GHz
RF Power and Power Density – antenna conducted	-	0.7 dB	-
Unwanted emissions – antenna conducted	1.1 dB	1.3 dB	1.9 dB
Bandwidth – antenna conducted	-	30 Hz	-

Measurement	Expanded Uncertainty (k=2)			
	0.15 MHz – 30MHz	30 – 200 MHz	200 MHz – 1 GHz	1 GHz – 18 GHz
Radiated emissions	-	4.7	4.6	5.1 dB
AC mains conducted emissions	2.1 dB	-	-	-

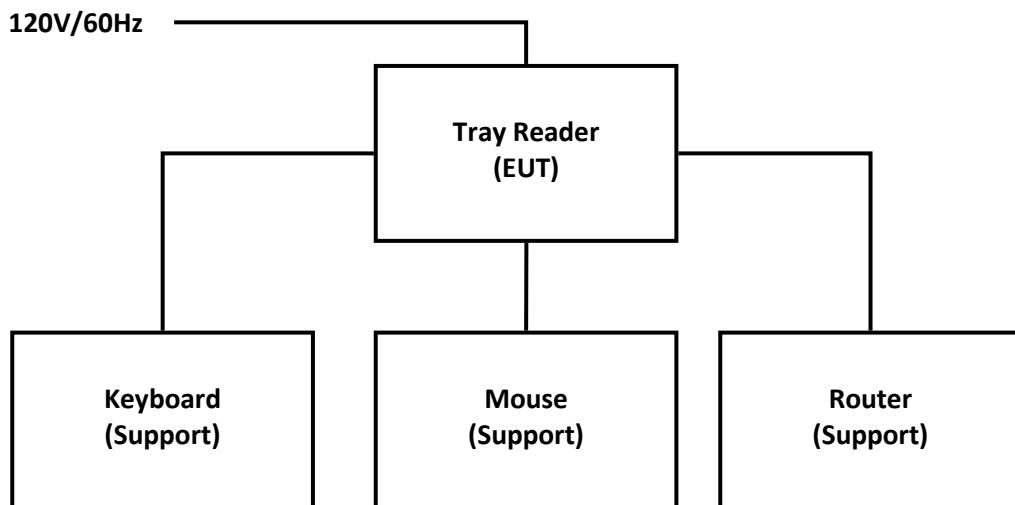
3.0 System Test Configuration

3.1 Support Equipment and description

Support Equipment		
Description	Manufacturer	Model No./ Serial No.
Keyboard	Logitech	K120 / 1602MR02E558
Mouse	HP	MOFYUO / 672652-001
Router	TP-Link	TL-WR740N / 12B94105234

3.2 Block Diagram of Test Setup

Equipment Under Test			
Description	Manufacturer	Model Number	Serial Number
Tracking System	LM-Instruments Oy	Tray Reader	T470011 2133041
AC/DC Switching Adapter	Mean Well	GEM12I12	N/A



S = Shielded
U = Unshielded

F = With Ferrite
m = Length in Meters

EUT Photos

3.3 Justification

For radiated emission measurements the EUT is placed on a non-conductive table. The EUT was configured to continuously transmit.

Class II permissive change testing was carried out on FCC ID: 2AGUB-73000. LM-Instruments Oy manufacturer is using a custom antenna that is constructed from 8 linearly polarized antennas, grouped in two groups of 4 antennas and mounted at various angles. RF signal is fed through a passive power splitter to two SP4T RF switches which each then pass the signal to one antenna at a time.

3.4 Software Exercise Program

The EUT exercise program used during radiated and conducted testing was provided by LM-Instruments Oy.

3.5 Mode of Operation During Test

During the transmitter tests, the transmitter was setup to transmit continuously using the highest RF power setting provided by LM-Instruments Oy. Per LM-Instruments Oy, the highest output power is set to 23dBm.

EUT was placed into transmit mode at the lowest (917.10 MHz), middle (921.90 MHz), and highest (926.90MHz) channels.

3.6 Modifications Required for Compliance

No modifications were made by the manufacturer or Intertek in order to bring the EUT into compliance.

3.7 Additions, Deviations and Exclusions from Standards

No additions, deviations or exclusions from the standard were made.

4.0 Measurement Results

4.1 Maximum Conducted Output Power at Antenna Terminals FCC Rule: 15.247(b)(3)

4.1.1 Requirement

For antennas with gains of 6 dBi or less, maximum allowed transmitter output is 1 watt (+30 dBm).

For antennas with gains greater than 6 dBi, transmitter output level must be decreased appropriately, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

4.1.2 Procedure

The procedure described in FCC Publication KDB 558074 D01 Meas Guidance v05r02 was used. Specifically, section 11.9.1.1 RBW \geq DTS bandwidth in ANSI 63.10.

1. Set the RBW \geq DTS Bandwidth
2. Set the VBW \geq 3 x RBW
3. Set the span \geq 3 x RBW
4. Detector = Peak
5. Sweep time = Auto couple
6. Trace mode = Max Hold
7. Allow trace to fully stabilize
8. Use peak marker function to determine the peak amplitude level.

A spectrum analyzer was connected to the antenna port of the transmitter.

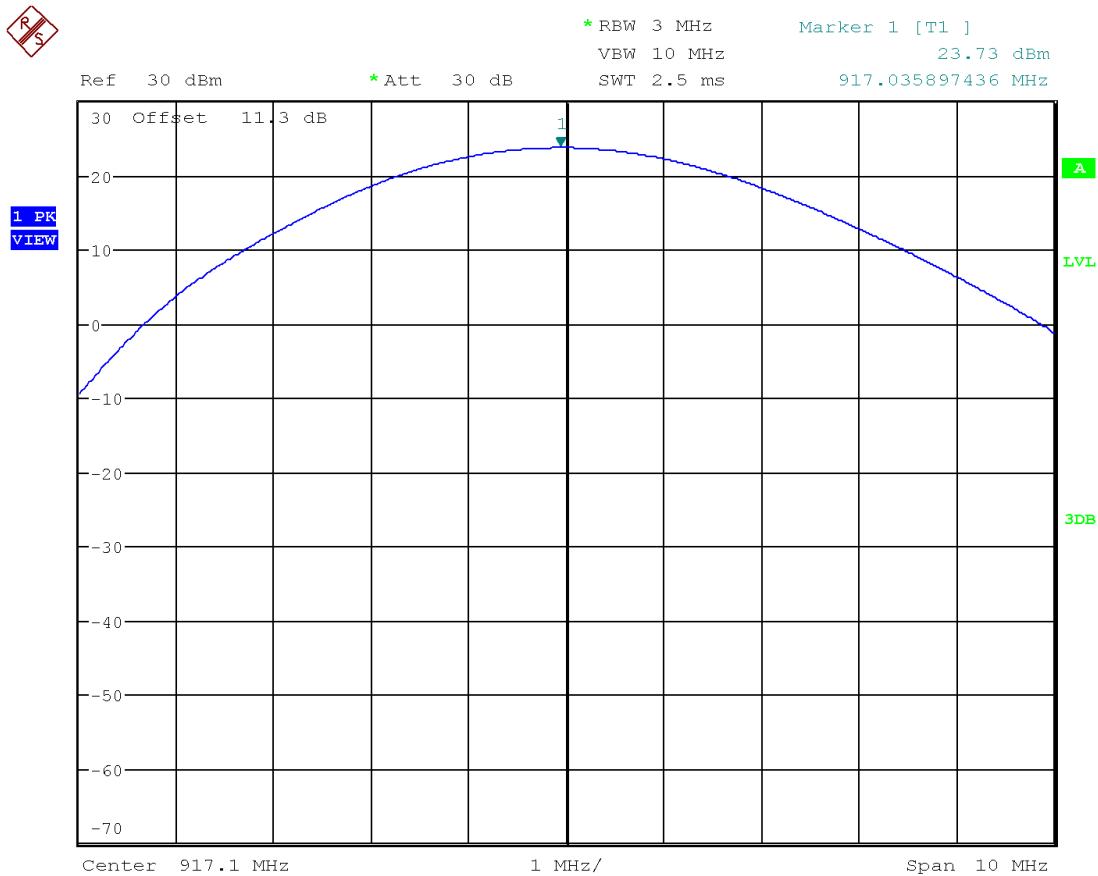
4.1.3 Test Result

Refer to the following plots 1.1 – 1.3 for the test details.

Model	Frequency	Conducted Power (Peak)		Plot
		MHz	dBm	
Tray Reader	917.10		23.73	236.048
	921.90		23.44	220.800
	926.90		23.47	222.331

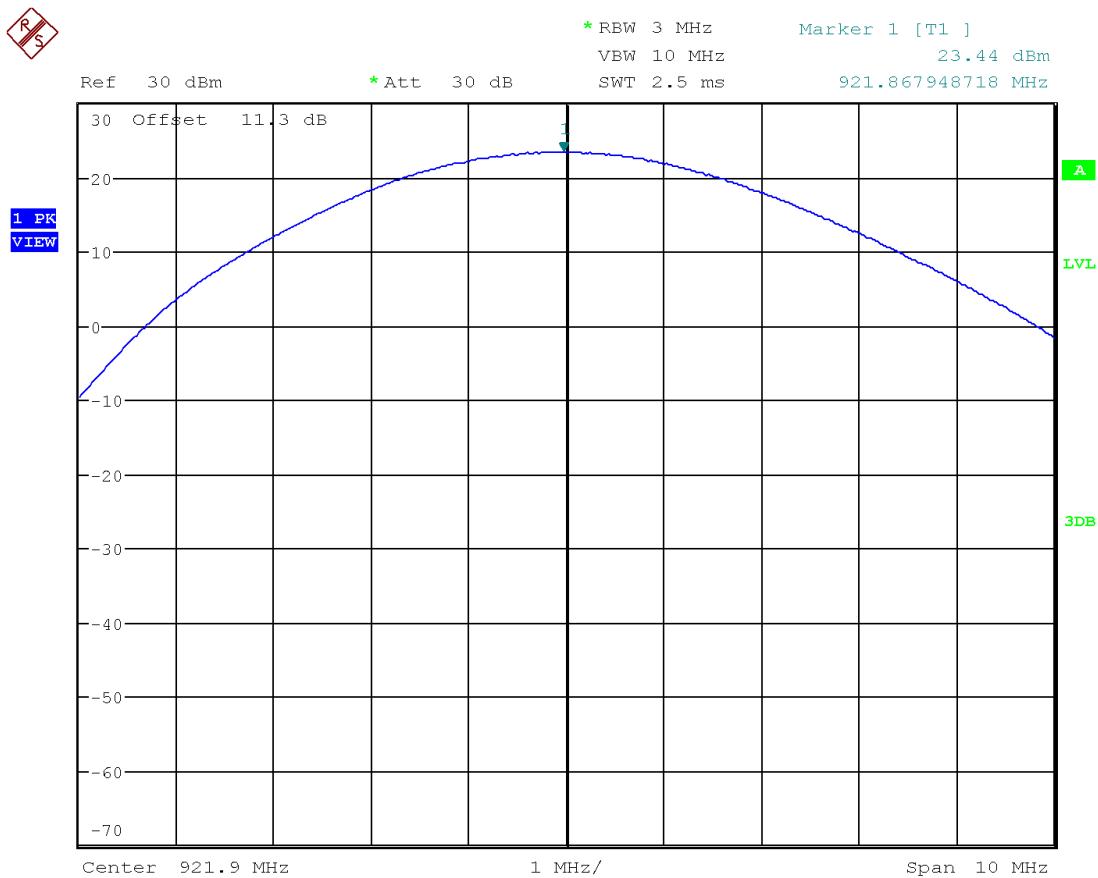
Tested By	Test Date	Results
Kenneth Roque	April 8, 2022	Complies

Plot 1.1



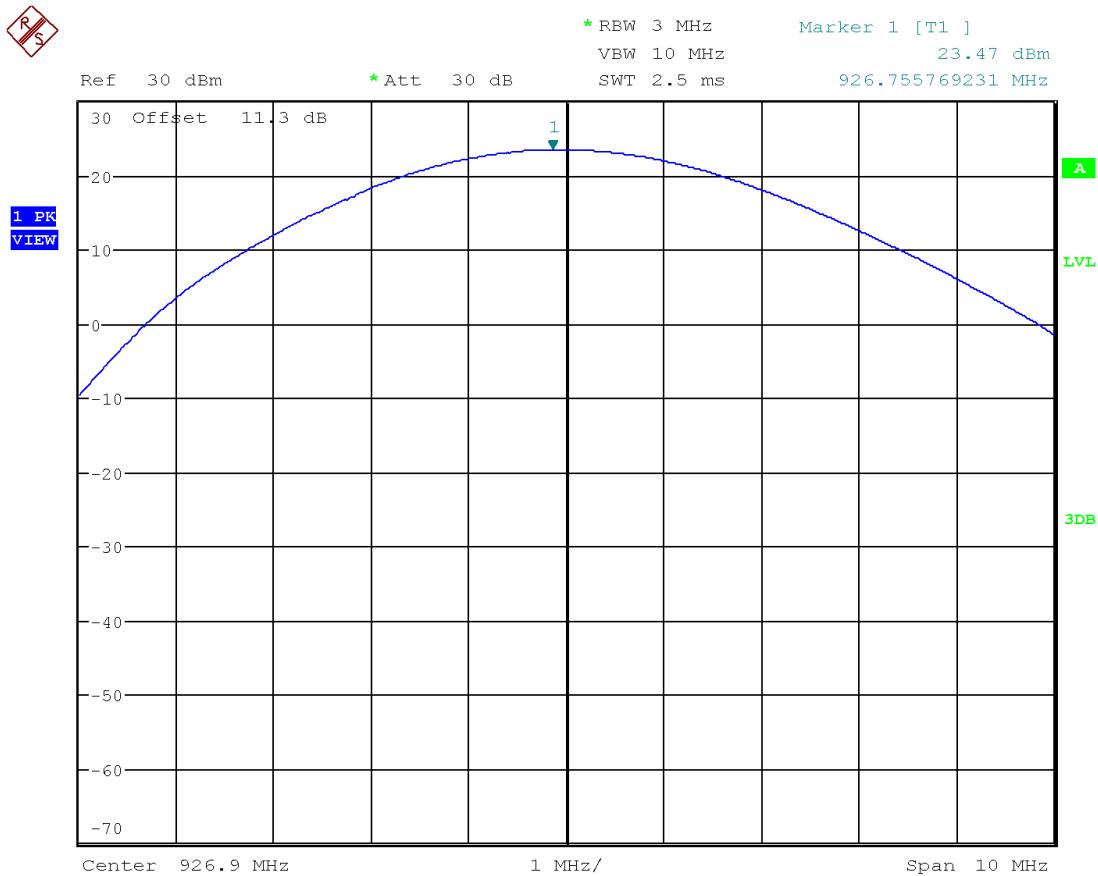
Date: 8.APR.2022 14:02:38

Plot 1.2



Date: 8.APR.2022 14:04:44

Plot 1.3



Date: 8.APR.2022 14:07:20

4.2 Transmitter Radiated Emissions

FCC Rules: 15.247(d), 15.209, 15.205

4.2.1 Requirement

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)).

For out of band radiated emissions (except for frequencies in restricted bands), in any 100 kHz bandwidths outside the EUT pass-band, the RF power shall be at least 20dB (peak) or 30 dB (average) below that of the maximum in-band 100 kHz emissions.

4.2.2 Procedure – Radiated Emissions

Radiated emission measurements were performed from 9 kHz to 26.5 GHz according to the procedure described in ANSI C63.10: 2013. Spectrum Analyzer Resolution Bandwidth is 200Hz or greater for frequencies 9kHz to 30MHz, 100 kHz or greater for frequencies 30 MHz to 1000 MHz, 1 MHz for frequencies above 1000 MHz. Above 1000 MHz Peak and Average measurements were performed.

For average measurement in the lower restricted band, the procedure described in ANSI C63.10: 2013 Section 11.12.2.5.3 was used. For average measurement in the higher restricted band (2483.5MHz – 2500MHz), the integration method of ANSI C63.4, Section 11.13.3.5 was used.

The EUT is placed on a plastic turntable that is 80 cm in height for below 1000MHz and 1.5m in height for above 1GHz. If the EUT attaches to peripherals, they are connected and operational (as typical as possible). During testing, all cables were manipulated to produce worst-case emissions. The signal is maximized through rotation. The antenna height and polarization are varied during the search for maximum signal level. The antenna height is varied from 1 to 4 meters.

Radiated emissions are taken at 3 meters for frequencies above 1 GHz and at 10 meters for frequencies below 1 GHz.

Measurements made from 30MHz to 1GHz had a 902-928 MHz notch filter in place. A preamp was used from 30MHz to 10GHz.

All measurements were made with a Peak Detector and compared to QP limits for 30MHz – 1GHz and Average limits for 1GHz – 10GHz.

Correlation measurements were performed below 30MHz between 10m ALSE and Open Field site according to FCC KDB 414788 D01 Radiated Test Site v01r01 section 2. All readings were within the acceptable tolerance.

Radiated measurements were performed on the X, Y and Z orientation of the EUT. Data is presented with the worst-case configuration (the configuration which resulted in the highest emission levels).

4.2.3 Field Strength Calculation

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF – AG; if measurement is performed at a distance other than specified in the rule, a Distance Correction Factor (DCF) shall be added.

Where FS = Field Strength in dB(μ V/m)

RA = Receiver Amplitude (including preamplifier) in dB(μ V); AF = Antenna Factor in dB(1/m)

CF = Cable Attenuation Factor in dB; AG = Amplifier Gain in dB

Assume a receiver reading of 52.0 dB(μ V) is obtained. The antennas factor of 7.4 dB(1/m) and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving field strength of 32 dB(μ V/m). This value in dB(μ V/m) was converted to its corresponding level in μ V/m.

RA = 52.0 dB(μ V)

AF = 7.4 dB(1/m)

CF = 1.6 dB

AG = 29.0 dB

FS = 52.0+7.4+1.6-29.0 = 32 dB(μ V/m).

Level in μ V/m = Common Antilogarithm $[(32 \text{ dB}\mu\text{V}/\text{m})/20] = 39.8 \mu\text{V}/\text{m}$.

4.2.4 Test Results

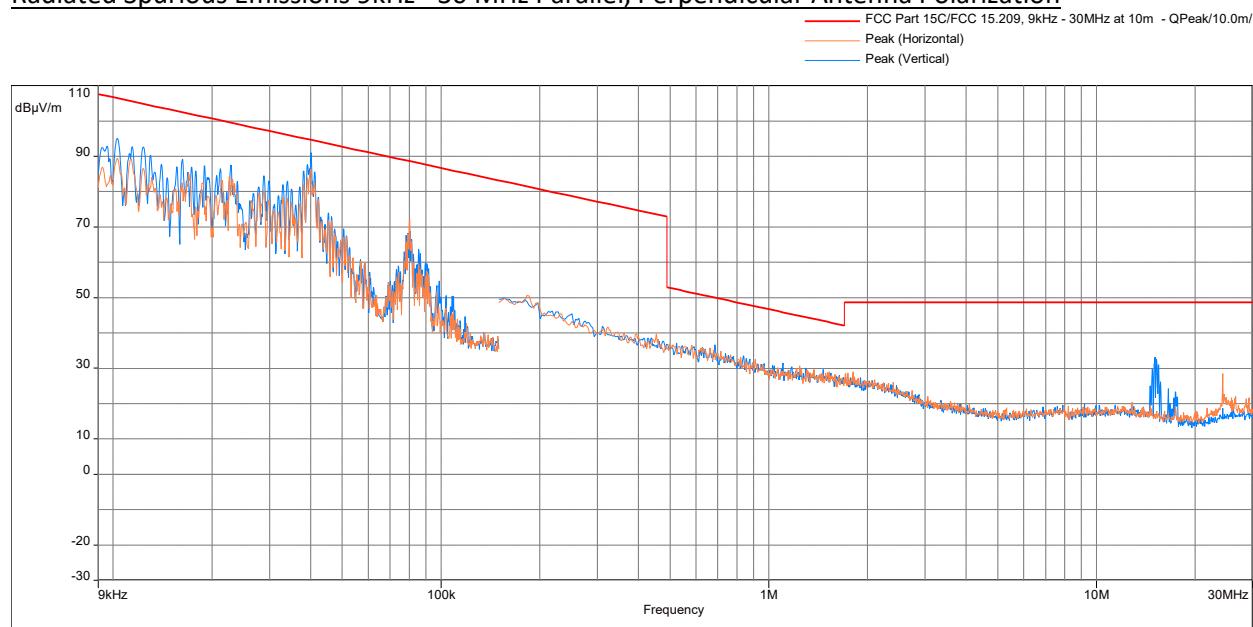
The data on the following pages list the significant emission frequencies, the limit and the margin of compliance.

Tested By	Test Date	Results
Aaron Chang	April 10, 2022	Complies

Out-of-Band Radiated Spurious Emissions

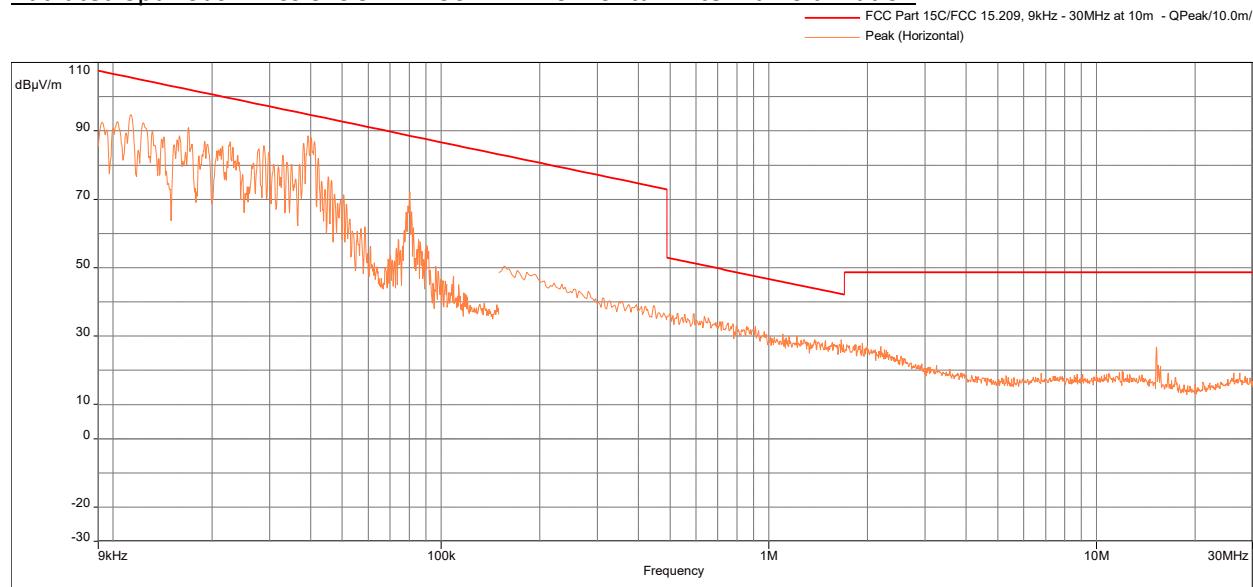
Radiated Spurious Emissions Low Channel, Tx at 917.10MHz

Radiated Spurious Emissions 9kHz - 30 MHz Parallel, Perpendicular Antenna Polarization



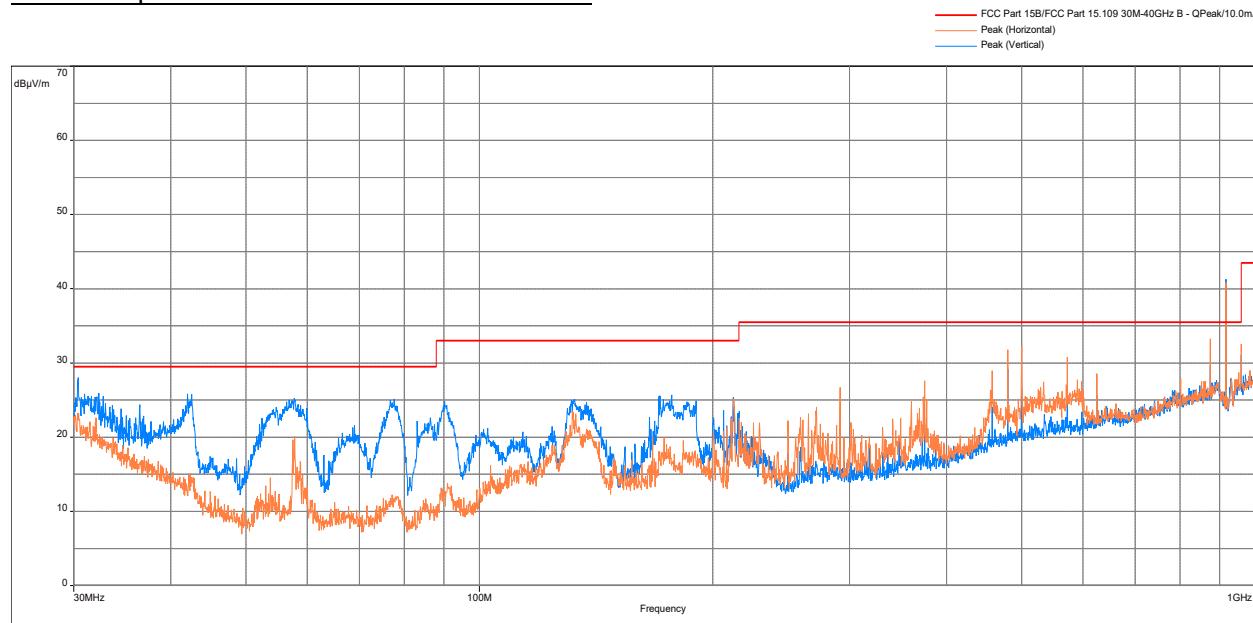
Model: ; Client: ; Comments: ; Test Date: 04/08/2022 08:51

Radiated Spurious Emissions 9kHz - 30 MHz Horizontal Antenna Polarization

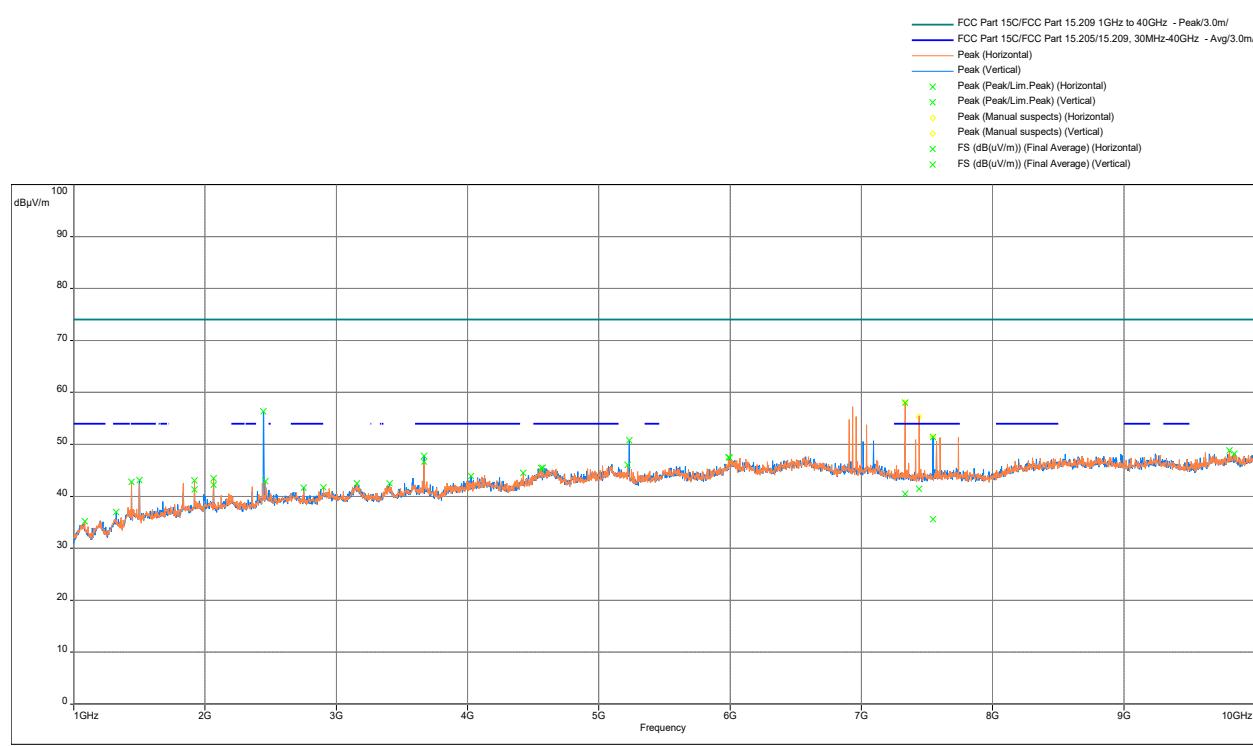


Model: ; Client: ; Comments: ; Test Date: 04/08/2022 09:04

Radiated Spurious Emissions 30 MHz - 1000 MHz



Radiated Spurious Emissions 1000 - 10000 MHz, Peak Scan



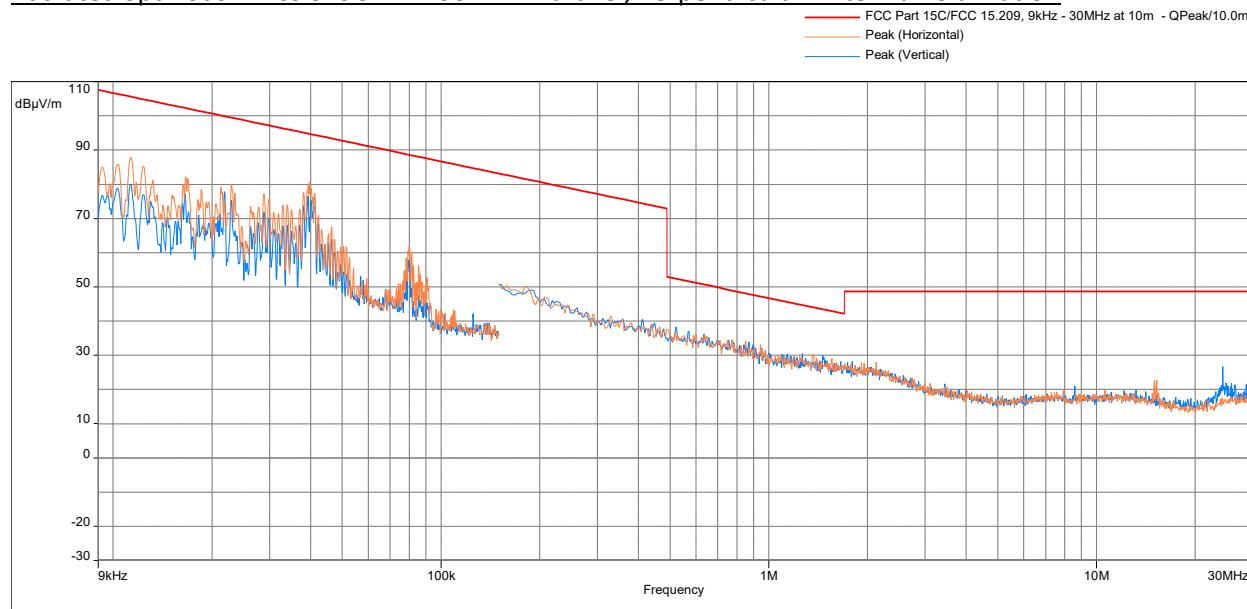
Radiated Spurious Emissions Low Channel, Tx at 917.10MHz

Frequency	FS@10m	Limit@ 10m	Margin	Height	Azimuth	Polarity	Correction
MHz	dBuV/m	dBuV/m	(dB)	(m)	(deg)		dB
0.040119	91.01	94.63	-3.61	1.0	252	Parallel	42.81
0.039146	87.65	94.84	-7.19	1.0	252	Parallel	43.03
0.040091	86.37	94.63	-8.26	1.0	333.5	Perpendicular	42.99
0.039329	88.52	94.8	-6.27	1.0	258	Horizontal	-15.9
30.420	28.01	29.5	-1.49	1.01	244.5	Vertical	-6.07
32.328	25.94	29.5	-3.56	1.01	9.75	Vertical	-7.27
42.060	25.82	29.5	-3.68	1.01	319.5	Vertical	-14.45
479.983	31.81	35.5	-3.69	1.98	209.25	Horizontal	-6.18
499.965	32.28	35.5	-3.22	1.98	288.25	Horizontal	-6.1
874.935	33.24	35.5	-2.26	1.02	356.75	Horizontal	-0.08
959.907	32.55	35.5	-2.95	1.02	76.25	Horizontal	1.68

Frequency	Peak FS@3m	Avg Limit@3m	Margin	Height	Azimuth	Polarity	Correction
MHz	dBuV/m	dBuV/m	(dB)	(m)	(deg)		dB
7333.412	40.5	54	-13.5	1.83	168.5	Horizontal	-2.49
7440.081	41.41	54	-12.59	4	87	Horizontal	-2.41
7546.748	35.62	54	-18.38	1.54	144.5	Vertical	-2.04

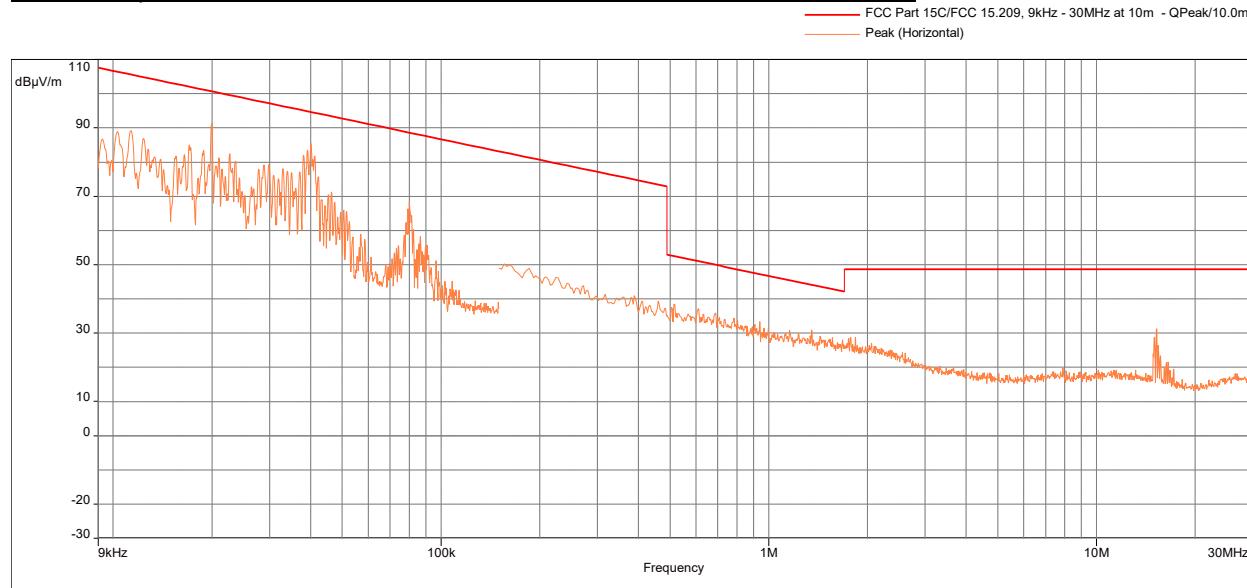
Radiated Spurious Emissions Mid Channel, Tx at 921.90MHz

Radiated Spurious Emissions 9kHz - 30 MHz Parallel, Perpendicular Antenna Polarization



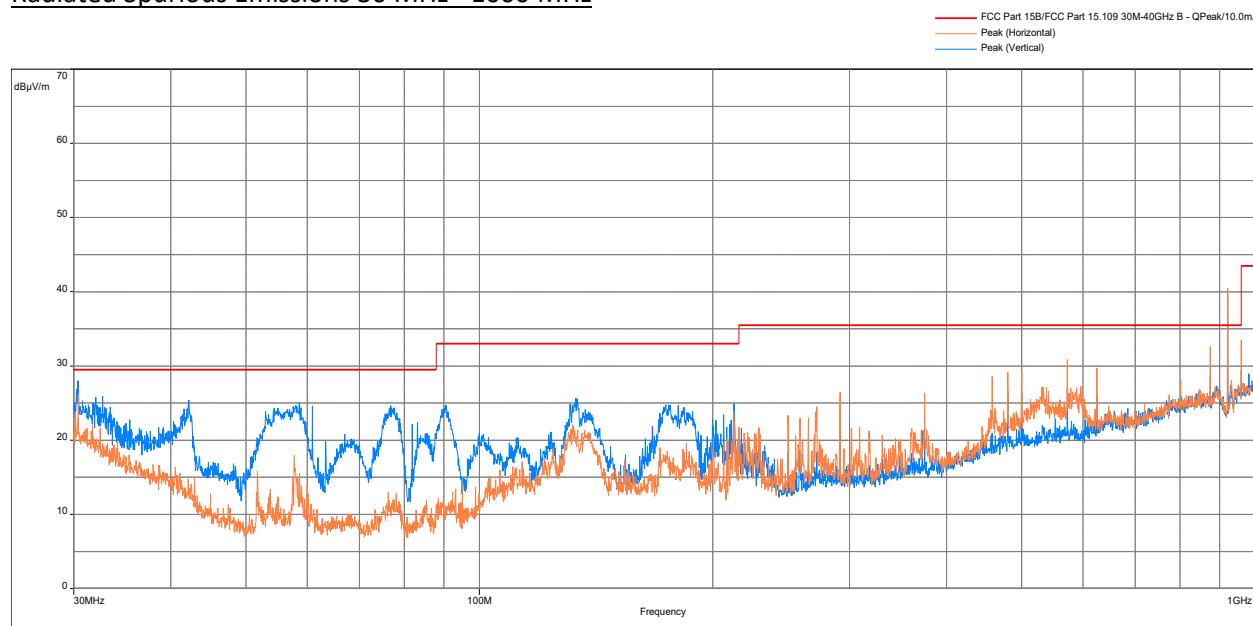
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Radiated Spurious Emissions 9kHz - 30 MHz Horizontal Antenna Polarization

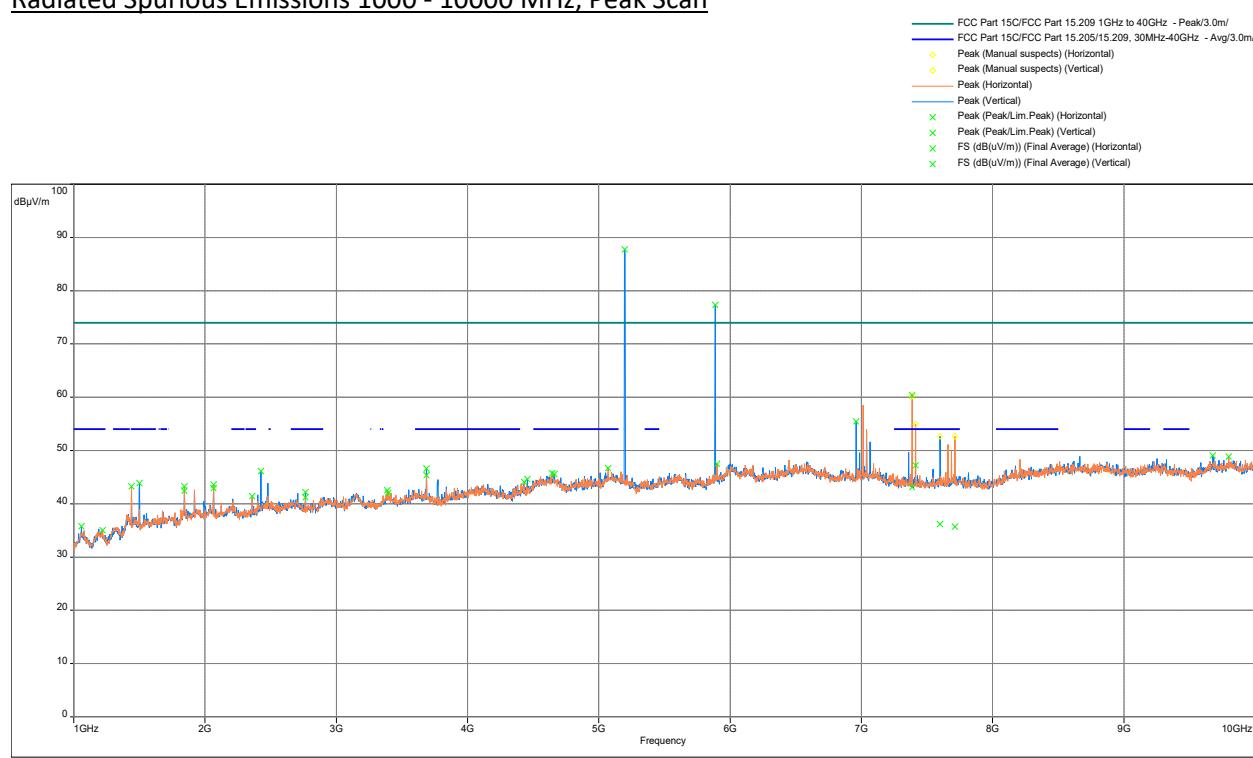


Model: ; Client: ; Comments: ; Test Date: 04/08/2022 09:20

Radiated Spurious Emissions 30 MHz - 1000 MHz



Radiated Spurious Emissions 1000 - 10000 MHz, Peak Scan



Radiated Spurious Emissions Mid Channel, Tx at 921.90MHz

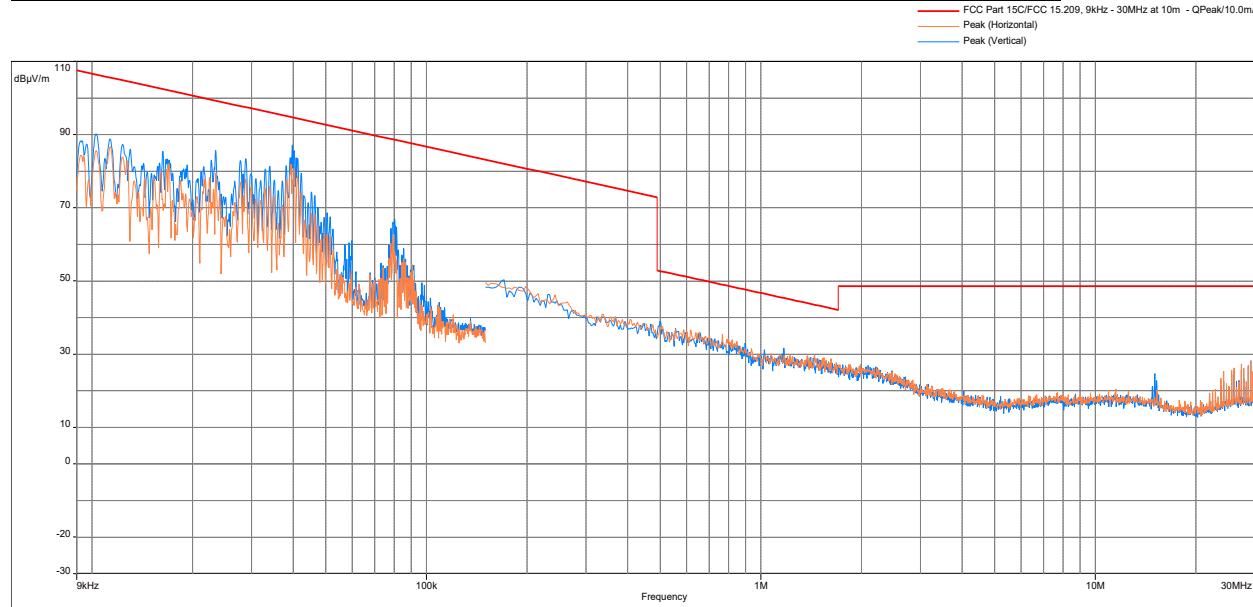
Frequency	FS@10m	Limit@ 10m	Margin	Height	Azimuth	Polarity	Correction
MHz	dBuV/m	dBuV/m	(dB)	(m)	(deg)		dB
1.4634	30.07	43.42	-13.35	1.0	334.25	Perpendicular	13.78
1.36788	30.24	44.01	-13.77	1.0	49.25	Parallel	14.06
1.561905	29.06	42.86	-13.8	1.0	145.5	Parallel	13.48
0.040076	85.56	94.63	-9.07	1.0	311.75	Horizontal	42.82
30.388	28.01	29.5	-1.49	1.01	348	Vertical	-6.05
30.420	26.19	29.5	-3.31	2.99	345.25	Horizontal	-6.07
32.005	25.81	29.5	-3.69	1.01	0.25	Vertical	-7.06
32.684	25.95	29.5	-3.55	1.01	260.5	Vertical	-7.52
874.935	32.63	35.5	-2.87	2.01	347	Horizontal	-0.08
959.939	33.48	35.5	-2.02	1.0	84.5	Horizontal	1.68

Frequency	Peak FS@3m	Avg Limit@3m	Margin	Height	Azimuth	Polarity	Correction
MHz	dBuV/m	dBuV/m	(dB)	(m)	(deg)		dB
7386.746	43.15	54	-10.85	2.52	69.5	Horizontal	-2.49
7413.415	47.25	54	-6.75	1.96	261.5	Horizontal	-2.41
7600.082	36.14	54	-17.86	1.66	85.5	Vertical	-2.04
7713.419	35.69	54	-18.31	3.93	87	Horizontal	-1.96

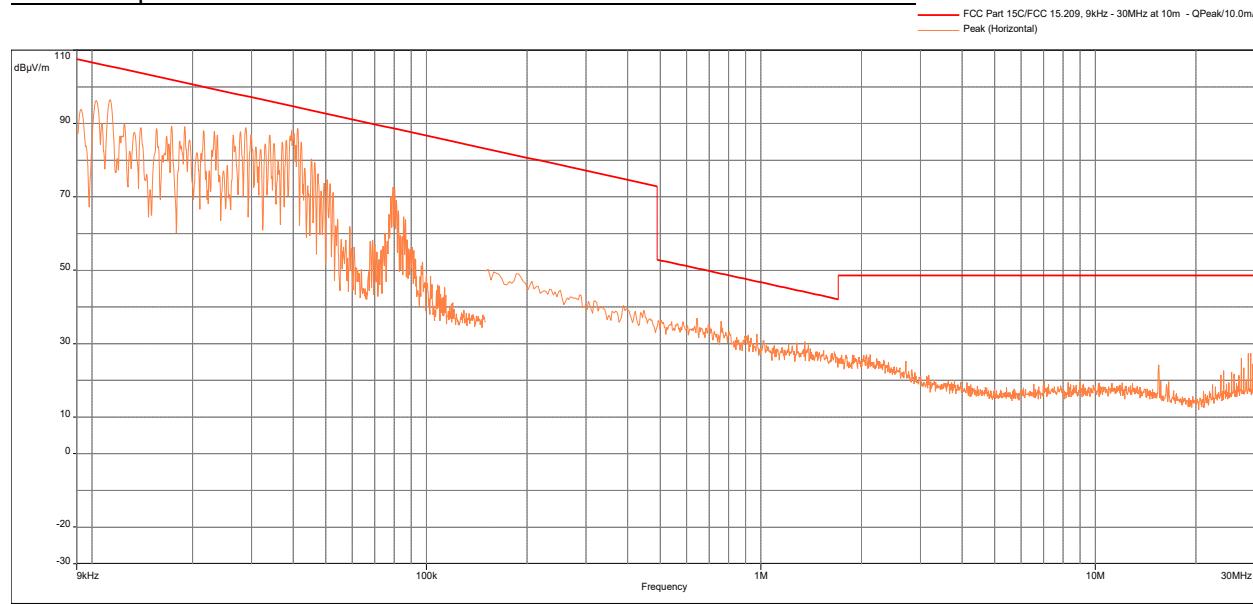
5.3 GHz and 5.8 GHz were investigated and deemed to be transient emissions.

Radiated Spurious Emissions High Channel, Tx at 926.90MHz

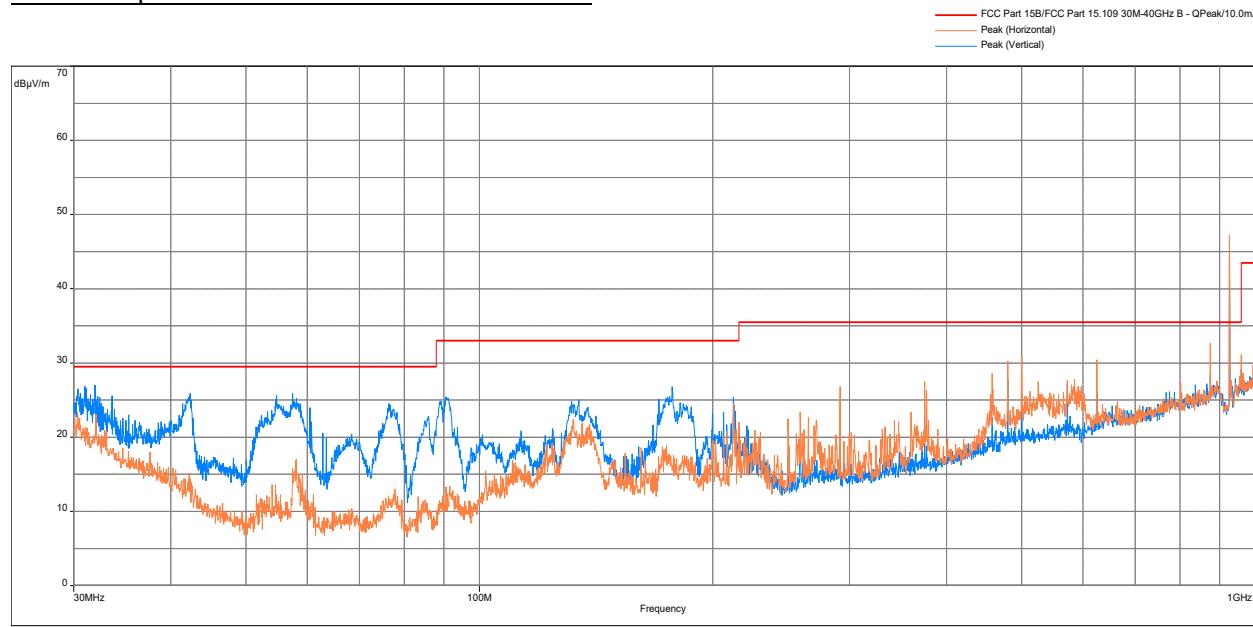
Radiated Spurious Emissions 9kHz - 30 MHz Parallel, Perpendicular Antenna Polarization



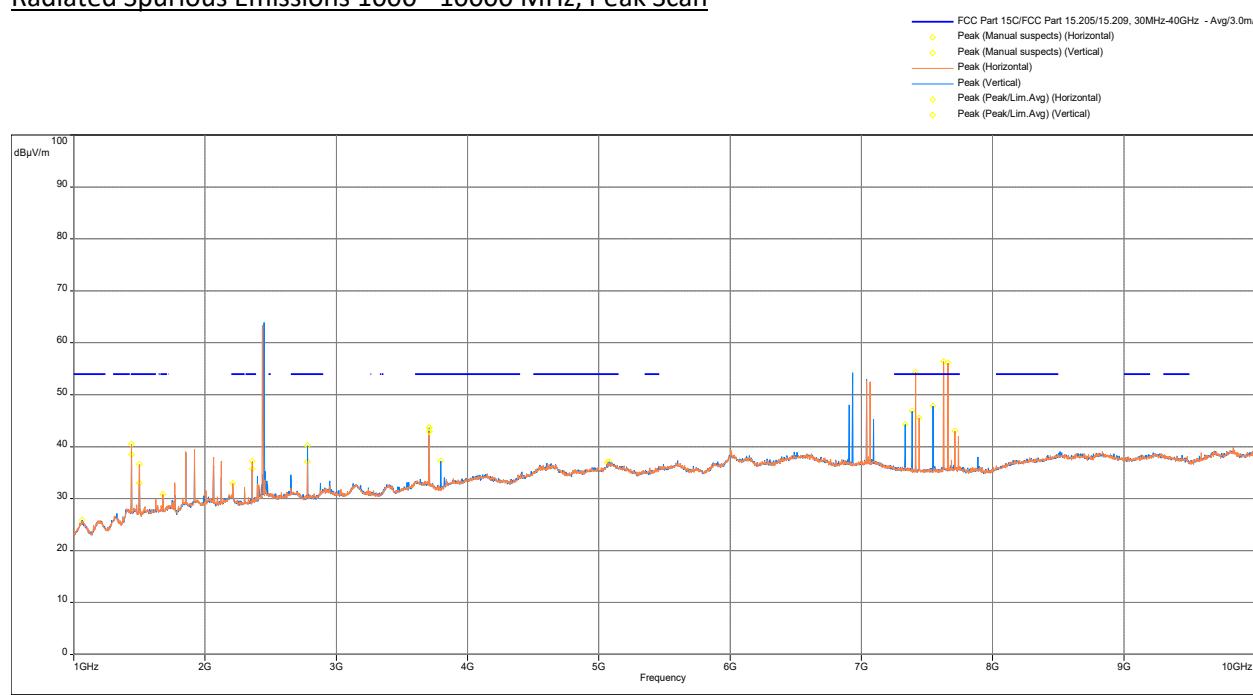
Radiated Spurious Emissions 9kHz - 30 MHz Horizontal Antenna Polarization



Radiated Spurious Emissions 30 MHz - 1000 MHz



Radiated Spurious Emissions 1000 - 10000 MHz, Peak Scan



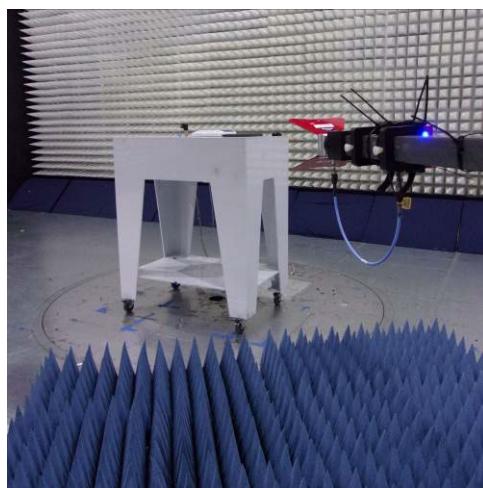
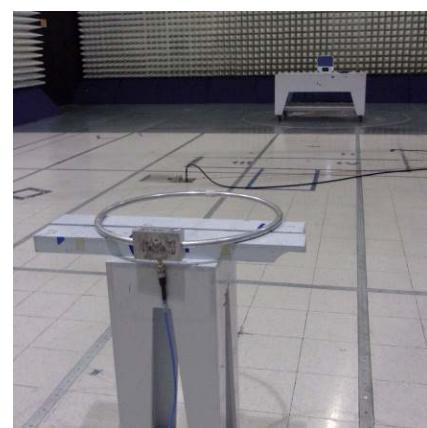
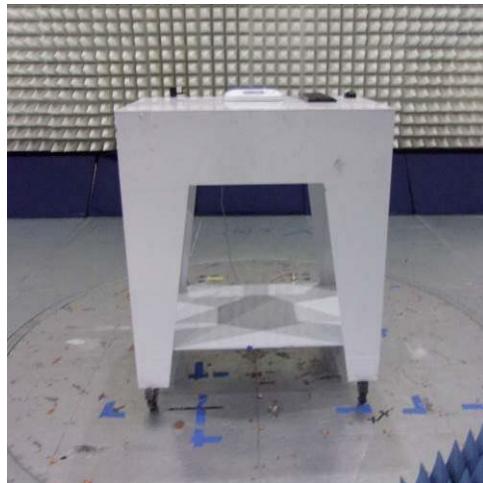
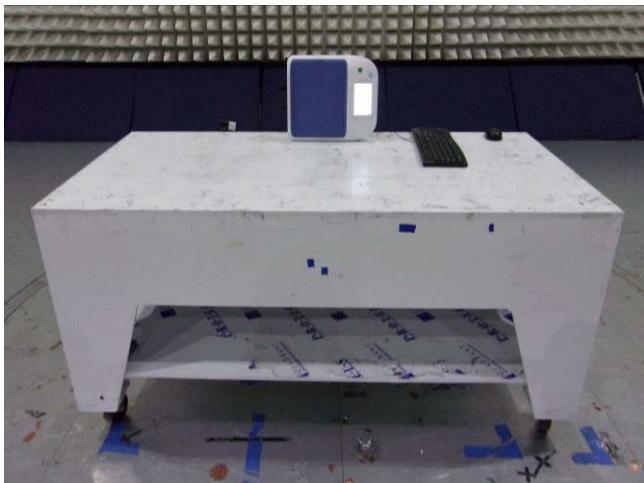
Radiated Spurious Emissions High Channel, Tx at 926.90MHz

Frequency	FS@10m	Limit@ 10m	Margin	Height	Azimuth	Polarity	Correction
MHz	dBuV/m	dBuV/m	(dB)	(m)	(deg)		dB
0.039724	87.24	94.71	-7.47	1.0	44.5	Perpendicular	42.98
0.040175	85.66	94.61	-8.95	1.0	44.5	Perpendicular	42.87
0.039371	81.96	94.79	-12.83	1.0	359.75	Parallel	43.07
0.041233	88.65	94.39	-5.73	1.0	335	Horizontal	42.62
30.388	26.54	29.5	-2.96	1.0	0	Vertical	-6.05
31.002	26.84	29.5	-2.66	1.0	199	Vertical	-6.47
31.940	27.03	29.5	-2.47	1.0	278.5	Vertical	-7.02
42.416	25.96	29.5	-3.54	1.0	321.25	Vertical	-14.69
57.419	25.91	29.5	-3.59	1.0	0	Vertical	-19.47
874.935	32.67	35.5	-2.83	1.0	351.5	Horizontal	-0.08

Frequency	Peak FS@3m	Avg Limit@3m	Margin	Height	Azimuth	Polarity	Correction
MHz	dBuV/m	dBuV/m	(dB)	(m)	(deg)		dB
3707.533	43.68	54	-10.32	1.01	303.75	Vertical	-7.41
3707.533	42.88	54	-11.12	1.51	282.25	Horizontal	-7.41
7386.749	47.74	54	-6.26	1.88	260.25	Horizontal	-2.49
7412.353	40.46	54	-13.54	2.26	355	Vertical	-2.41
7626.751	39.95	54	-14.05	1.94	201	Horizontal	-1.91

4.2.5 Test Setup Photographs

The following photographs show the testing configurations used.



5.0 List of Test Equipment

Measurement equipment used for emission compliance testing utilized the equipment on the following list:

Equipment	Manufacturer	Model/Type	Asset #	Cal Int	Cal Due
EMI Receiver	Rohde and Schwarz	ESU40	ITS 00961	12	03/10/23
Spectrum Analyzer	Rohde and Schwarz	FSU	ITS 00913	12	05/24/22
Loop Antenna	EMCO	6512	ITS 01598	12	06/21/22
Bilog Antenna	SunAR RF Motion	JB1	ITS 01577	12	02/10/23
Active Horn Antenna	ETS-Lindgren	3117-PA	ITS 01365	12	04/20/22
Pre-Amplifier	Sonoma Instrument	310N	ITS 00415	12	04/28/22
Notch Filter	Micro-Tronics	BRC50722	ITS 01170	12	04/28/22
RF Cable	MegaPhase	TM40-K1K1-59	ITS 01156	12	07/07/22
RF Cable	TRU Corporation	TRUCore 300	ITS 01465	12	09/14/22
RF Cable	TRU Corporation	TRUCore 300	ITS 01467	12	09/14/22
RF Cable	TRU Corporation	TRUCore 300	ITS 01470	12	09/14/22
RF Cable	TRU Corporation	TRUCore 300	ITS 01629	12	04/28/22
RF Cable	MegaPhase	EMC1-K1K1-236	ITS 01908	12	05/24/22
RF Cable	TRU Corporation	TRUCore 300	ITS 01330	12	06/29/22
10m Semi-Anechoic Chamber	Panashield	10m Chamber	ITS 00984	36	07/29/23

Software used for emission compliance testing utilized the following:

Name	Manufacturer	Version	Template/Profile
BAT-EMC	Nexio	3.20.0.23	LM Dental 900MHz 4-10-2022.bpp

6.0 Document History

Revision/ Job Number	Writer Initials	Reviewers Initials	Date	Change
1.0 / G105031787	KR	AS	April 25, 2022	Original document
1.1 / G105031787	KR	AS	June 30, 2022	Updated Typos

END OF REPORT