FCC 47 CFR PART 15 SUBPART C

TEST REPORT

FOR

WIRELESS CHARGING PAD MODULE

MODEL NUMBER: 52192780

REPORT NUMBER: R13640973-E1

FCC ID: 2AF5R-52192780

ISSUE DATE: 2021-08-12

Prepared for
FLEX AUTOMOTIVE
27755 Stansbury Blvd Ste 300
Farmington Hills, MI, 48334

Prepared by
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ACCREDITED
CERT #0751.06

Revision History

Rev.	Issue Date	Revisions	Revised By
V1	2021-06-30	Initial Issue	Cristian Melara
V2	2021-08-12	Deleted all AC Line Conducted Emissions data	Cristian Melara

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: Flex Automotive
27755 Stansbury Blvd Ste 300
Farmington Hills, MI, 48334

EUT DESCRIPTION: Wireless Charging Pad Module

MODEL: 52192780

SERIAL NUMBER: 0042

DATE RECEIVED: 2021-05-14

DATE TESTED: 2021-06-08 to 2021-06-23

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
FCC PART 15 SUBPART C	Complies

UL LLC tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not taken into account unless noted otherwise.

This document may not be altered or revised in any way unless done so by UL LLC and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL LLC will constitute fraud and shall nullify the document.

Approved & Released For
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Prepared By:

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CONSUMER TECHNOLOGY DIVISION
UL LLC

2. TEST RESULTS SUMMARY

FCC Clause	Requirement	Result	Comment
2.1049	Occupied Bandwidth	Complies	None.
15.209, 15.205	Radiated Emissions	Complies	None.
15.207	AC Mains Conducted Emissions	Complies	None.

This report contains data provided by the applicant which can impact the validity of results. UL LLC is only responsible for the validity of results after the integration of the data provided by the customer.

3. TEST METHODOLOY

The tests documented in this report were performed in accordance with ANSI C63.10-2013, FCC CFR 47 Part 2, FCC CFR 47 Part 15 and KDB 414788 D01 Radiated Test Site v01r01.

4. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 12 Laboratory Drive, Research Triangle Park, North Carolina, USA and 2800 Perimeter Park Dr., Suite B, Morrisville, North Carolina, USA. The following table identifies which facilities were utilized for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

UL LLC is accredited A2LA, certification # 0751.06, for all testing performed within the scope of this report. Testing was performed at the locations noted below.

	Address	ISED CABID	ISED Company Number	FCC Registration
☐	Building: 12 Laboratory Dr RTP, NC 27709, U.S.A	US0067	2180C	703469
☒	Building: 2800 Perimeter Park Dr. Suite B Morrisville, NC 27560	US0067	27265	703469

5. DECISION RULES AND MEASUREMENT UNCERTAINTY

5.1. METROLOGICAL TRACEABILITY

All test and measuring equipment utilized to perform the tests documented in this report are calibrated on a regular basis, with a maximum time between calibrations of one year or the manufacturers' recommendation, whichever is less, and where applicable is traceable to recognized national standards.

5.2. DECISION RULES

The Decision Rule is based on Simple Acceptance in accordance with ISO Guide 98-4:2012 Clause 8.2. (Measurement uncertainty is not taken into account when stating conformity with a specified requirement.)

5.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	U_{Lab}
Worst Case Conducted Disturbance, 0.15 to 30 MHz	3.40 dB
Worst Case Radiated Disturbance Loop, 9KHz to 30 MHz	2.87 dB
Worst Case Radiated Disturbance, 30 to 1000 MHz	6.01 dB
Worst Case Occupied Bandwidth	1.22 dB
DC Supply voltages	1.70%

Uncertainty figures are valid to a confidence level of 95%.

5.4. SAMPLE CALCULATION

RADIATED EMISSIONS

Where relevant, the following sample calculation is provided:

Field Strength (dBuV/m) = Measured Voltage (dBuV) + Antenna Factor (dB/m) + Cable Loss (dB) – Preamp Gain (dB)

36.5 dBuV + 18.7 dB/m + 0.6 dB – 26.9 dB = 28.9 dBuV/m

MAINS CONDUCTED EMISSIONS

Where relevant, the following sample calculation is provided:

Final Voltage (dBuV) = Measured Voltage (dBuV) + Cable Loss (dB) + Limiter Factor (dB) + LISN Insertion Loss.

36.5 dBuV + 0 dB +10.1 dB+ 0 dB = 46.6 dBuV

6. EQUIPMENT UNDER TEST

6.1. DESCRIPTION OF EUT

The EUT is a wireless charging module. The WPT frequency of operation is 127.66kHz.

6.2. MAXIMUM PEAK RADIATED E-FIELD STRENGTH

The transmitter has maximum peak radiated electric field strength as follows:

Fundamental Frequency (kHz)	Mode	E-Field, 300m Distance (dBuV/m)
127	Coil 0 - Charging w/ Load	7.06
127	Coil 1 - Charging w/ Load	22.03
127	Coil 2 - Charging w/ Load	18.98

6.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes a MP-A13 coil design antenna.

6.4. SOFTWARE AND FIRMWARE

The firmware installed in the EUT during testing was FLEX-WCPM-PS-D3.0.

The test utility software used during testing was WCPM Flex LIN v2.0

6.5. WORST-CASE CONFIGURATION AND MODE

The EUT is a charging module with wireless inductive charging. The following modes were investigated:

Mode	Descriptions
Load on Coil 0	EUT in charging mode w/ load on Coil 0
Load on Coil 1	EUT in charging mode w/ load on Coil 1
Load on Coil 2	EUT in charging mode w/ load on Coil 2

The EUT is intended to operate in one direction. Therefore all testing performed with the EUT in the intended orientation of operation.

The EUT charging with its load on coil 0, coil 1, and coil 2 are considered the worst case scenarios. Therefore, testing was completed with the EUT and the load on the respective coils only.

6.6. MODIFICATIONS

No modifications were made during testing.

6.7. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID**
Laptop	Lenovo	T450	PC-0A2UQS	PD97265NGU
Charger	Lenovo	ADLX45NDC2A	8SSA10E75790D1SG68B054C	NA

I/O CABLES

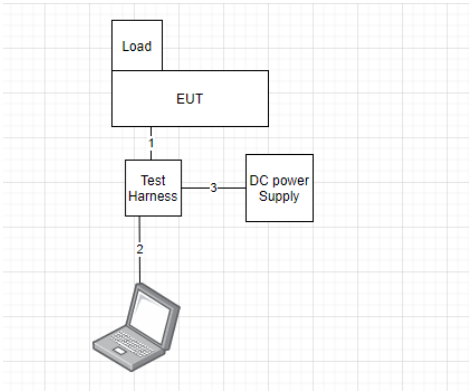
I/O Cable List						
Cable No.	**Port**	**# of Identical Ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	1	1	6-pin	Shielded	<3m	Connects to EUT
2	2	1	USB	Shielded	<3m	None
3	3	1	Banana plugs	Shielded	<3m	Connects to DC power supply

TEST SETUP

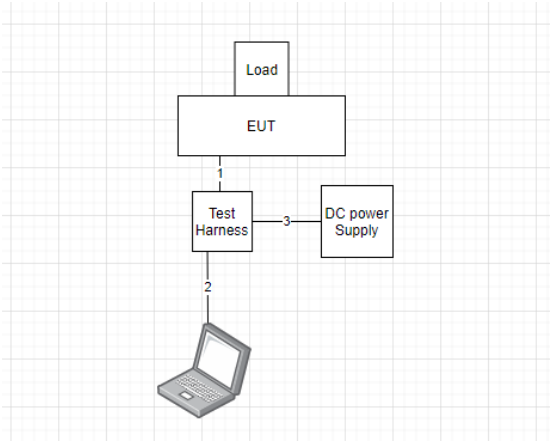
The EUT was tested in the charging mode with the load on coil 0, coil 1, and coil 2

SETUP DIAGRAM FOR TESTS

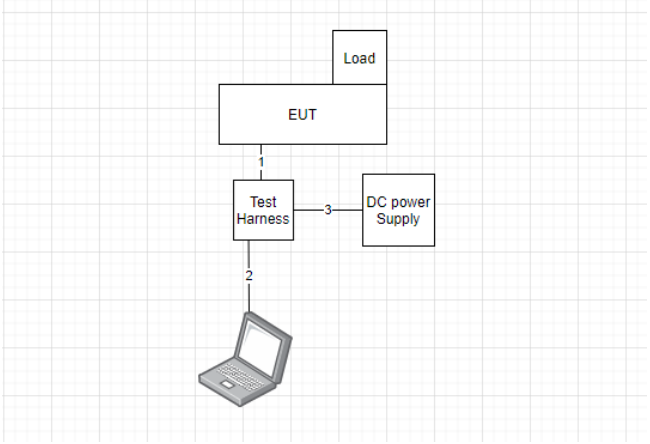
Configuration 1 – Load on Coil 1



Configuration 2 – Load on Coil 0



Configuration 3 – Load on Coil 2



7. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

Test Equipment Used - Wireless Conducted Measurement Equipment

Equip. ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
	Conducted 1				
T177	Spectrum Analyzer	Agilent	E4446A	2021-05-19	2022-05-19
MM0168	True RMS Multimeter	Agilent	U1232A	2020-08-19	2021-08-19
HI0090	Environmental Meter	Fisher Scientific	S/N: 161016511	2020-06-26	2021-06-26
76021	DC Regulated Power Supply	CircuitSpecialists.Com	CSI3005X5	NA	NA
SOFTEMI	Antenna Port Software	UL	Version 2021.05.28	NA	NA
9111-4442	Near Field Probe	EMCO	7405	NA	NA

Test Equipment Used - Radiated Disturbance Emissions Test Equipment (Morrisville - North Chamber)

Equip. ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
	0.009-30MHz	**(Loop Ant.)**			
AT0079	Active Loop Antenna	ETS-Lindgren	6502	2020-08-20	2021-08-20
	30-1000 MHz				
AT0074	Hybrid Broadband Antenna	Sunol Sciences Corp.	JB3	2020-07-27	2021-07-27
	Gain-Loss Chains				
N-SAC01	Gain-loss string: 0.009-30MHz	Various	Various	2020-07-29	2021-07-29
N-SAC02	Gain-loss string: 25-1000MHz	Various	Various	2020-07-29	2021-07-29
	Receiver & Software				
197954	Spectrum Analyzer	Rohde & Schwarz	ESW44	2021-03-30	2022-03-30
SOFTEMI	EMI Software	UL	Version 9.5 (04 Mar 2021)	NA	NA
	Additional Equipment used				
s/n 181474409	Environmental Meter	Fisher Scientific	15-077-963	2020-08-06	2021-08-06
76021	DC Regulated Power Supply	CircuitSpecialists.Com	CSI3005X5	NA	NA

Test Equipment Used - Line-Conducted Emissions – Voltage (Morrisville – Conducted 1)

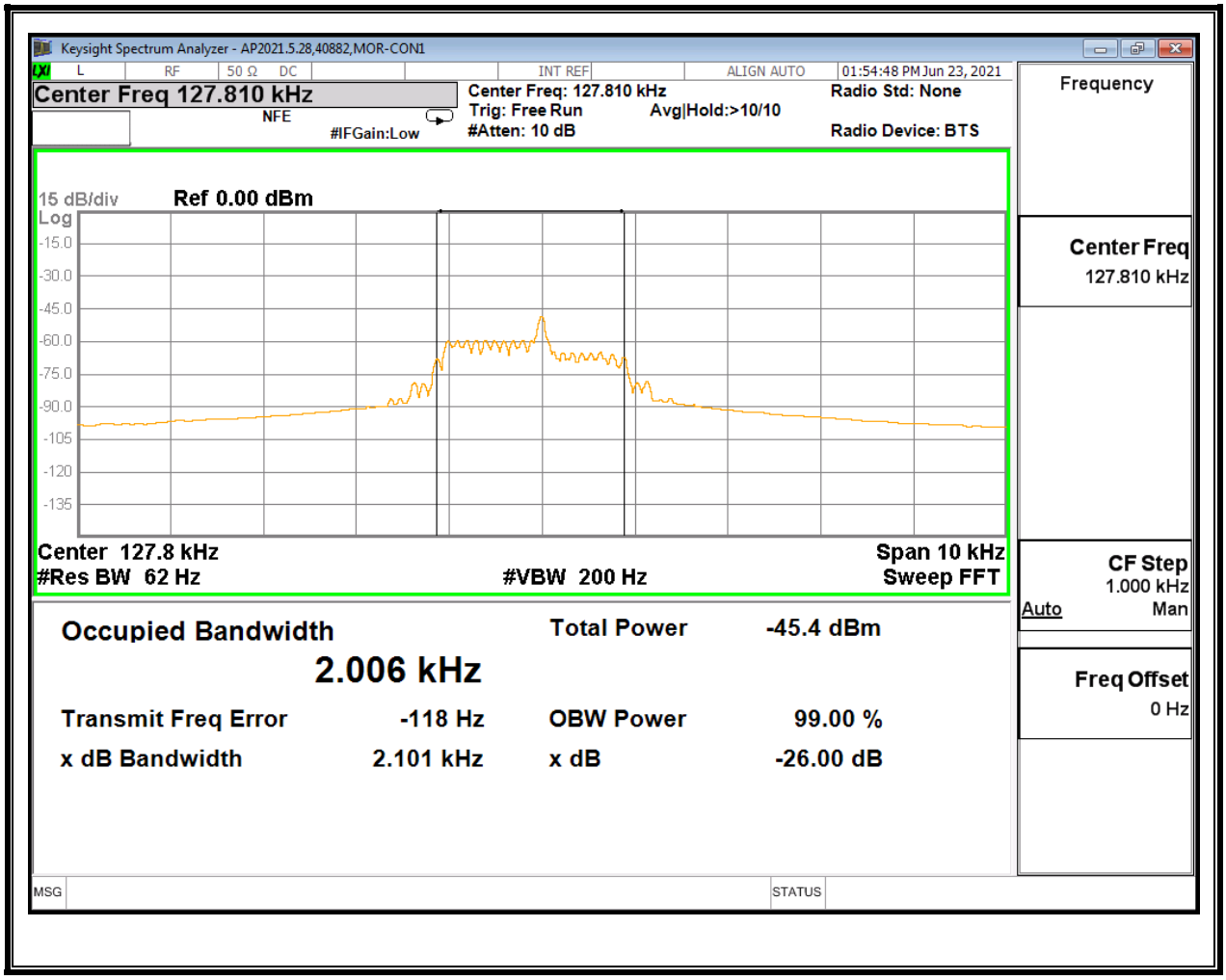
Equip. ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
CBL087	Coax cable, RG223, N-male to BNC-male, 20-ft.	Pasternack	PE3W06143-240	2021-04-05	2022-04-05
HI0090	Environmental Meter	Fisher Scientific	15-077-963	2020-06-26	2021-06-26
LISN003	LISN, 50-ohm/50-uH, 250uH 2-conductor, 25A	Fischer Custom Com.	FCC-LISN-50/250-25-2-01	2020-08-18	2021-08-18
75141	EMI Test Receiver 9kHz-7GHz	Rohde & Schwarz	ESCI 7	2020-08-18	2021-08-18
ATA222	Transient Limiter, 0.009-100MHz	Electro-Metrics	EM-7600	2021-04-05	2022-04-05
PS214	AC Power Source	Elgar	CW2501M (s/n 1523A02396)	NA	NA
SOFTEMI	EMI Software	UL	Version 9.5 (04 Mar 2021)		
	Miscellaneous (if needed)				
HPF017	100kHz High-pass Filter	Solar Electronics Co.	7801-100	2021-02-23	2022-02-23
LISN008	LISN, 50-ohm/50-uH, 2-conductor, 25A (For support gear only.)	Solar Electronics	8012-50-R-24-BNC	2020-08-08	2021-08-08
76021	DC Regulated Power Supply	CircuitSpecialists.Com	CSI3005X5	NA	NA

8. OCCUPIED BANDWIDTH

TEST PROCEDURE

The transmitter output is measured by a near field probe. The RBW shall be in the range of 1% to 5% of the actual occupied bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

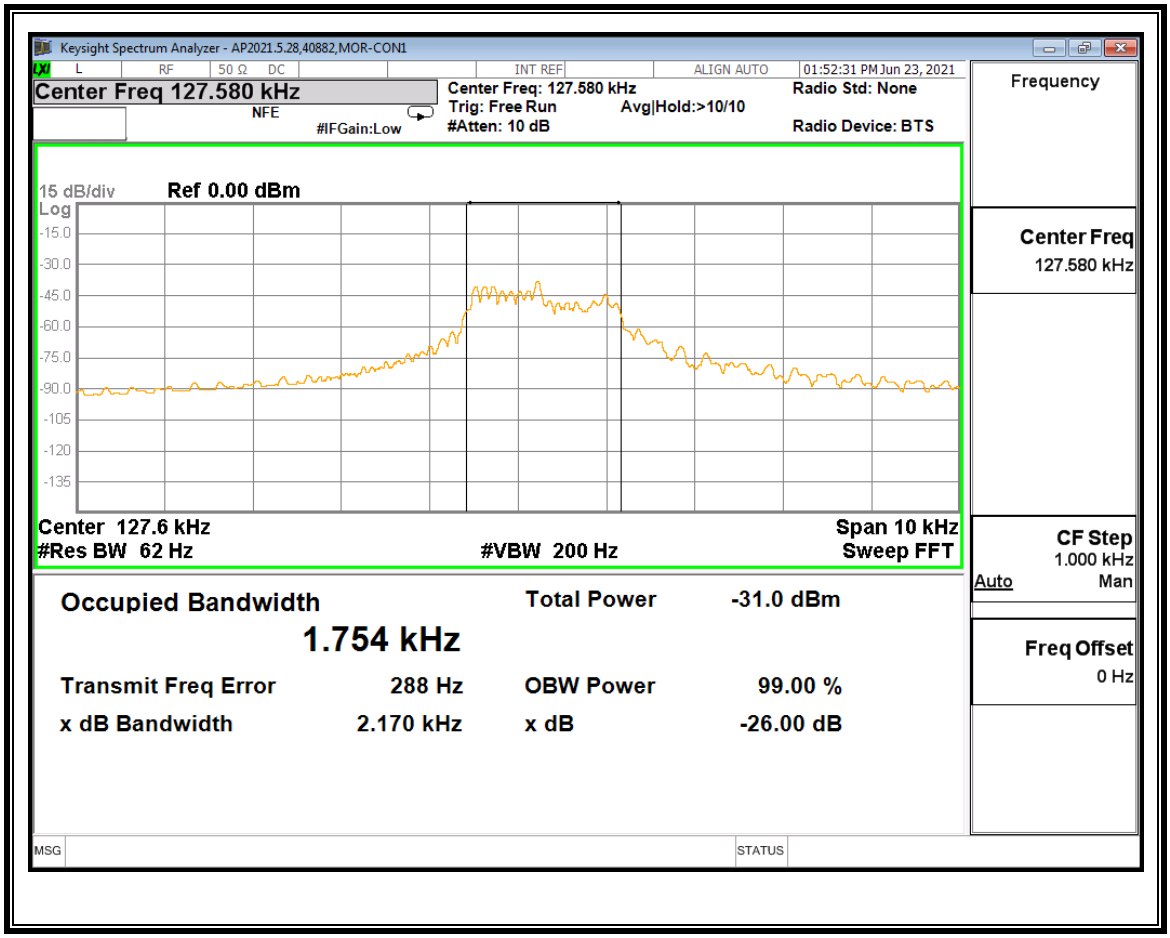
8.1. CHARGING W/ LOAD – Coil 0



TEST INFORMATION

Test Date: 40882
Tested By: 2021-06-23

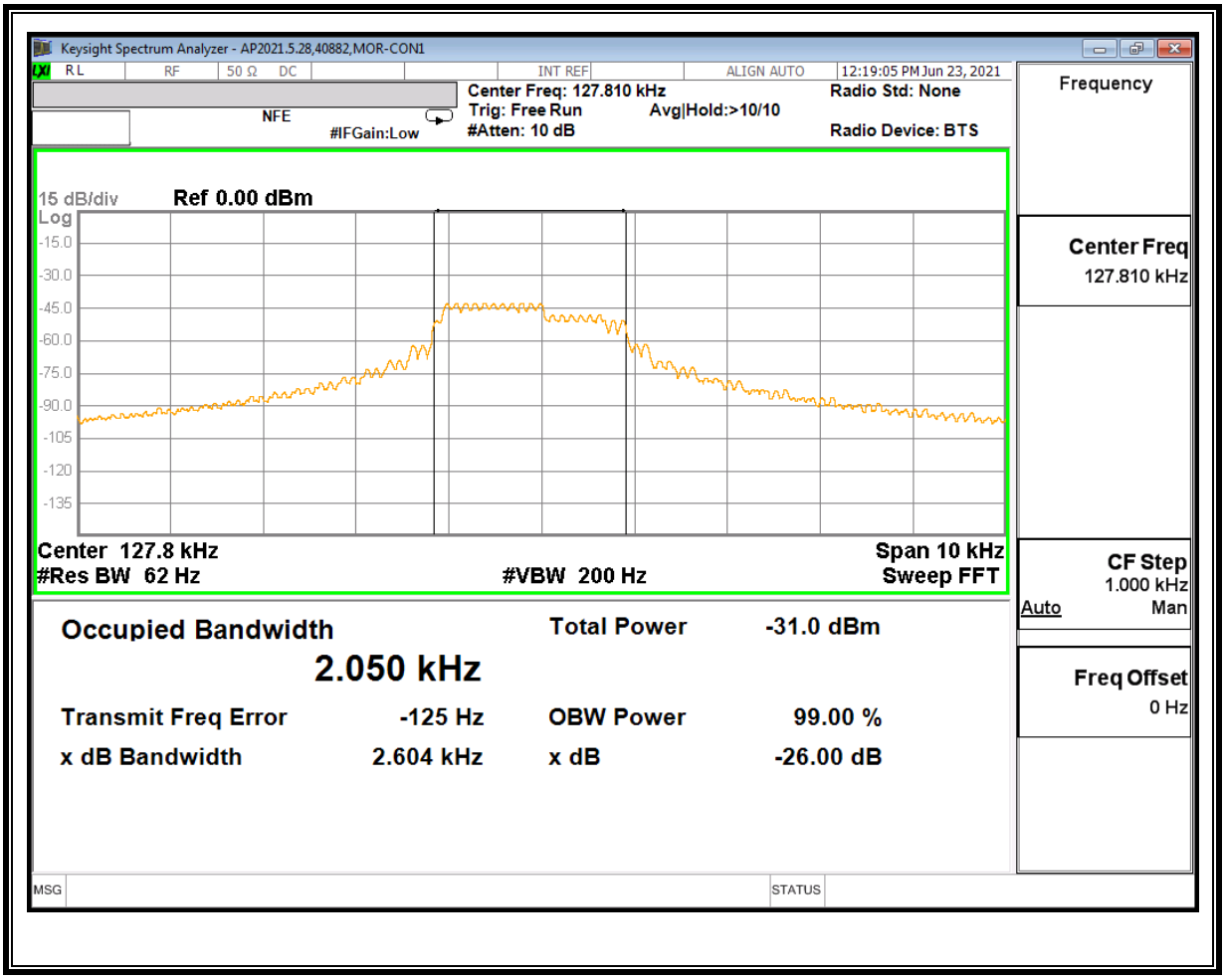
8.2. CHARGING W/ LOAD – Coil 1



TEST INFORMATION

Test Date: 40882
Tested By: 2021-06-23

8.3. CHARGING W/ LOAD – Coil 2



TEST INFORMATION

Test Date: 40882
Tested By: 2021-06-23

9. RADIATED EMISSION TEST RESULTS

9.1. LIMITS AND PROCEDURE

LIMITS

FCC §15.209 (a)

Frequency (MHz)	Field Strength (microvolts/meter)	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	3
88 to 216	150	3
216 to 960	200	3
Above 960 MHz	500	3
Note: The lower limit shall apply at the transition frequency.		

TEST PROCEDURE

The EUT is placed on a non-conducting table 80 cm above the ground plane for measurement below 1GHz; 1.5 m above the ground plane for measurement above 1GHz. The antenna to EUT distance is 3 meters. The EUT is configured in accordance with ANSI C63.10. The EUT is set to transmit in a continuous mode.

Resolution bandwidth is set to 100 kHz for peak detection measurements or 120 kHz for quasi-peak detection measurements in the 30-1000MHz range, 9kHz for peak and/or quasi-peak detection measurements in the 0.15-30MHz range and 200Hz for peak and/or quasi-peak detection measurements in the 9-150kHz range. Peak detection is used unless otherwise noted as quasi-peak.

The frequency range of interest is monitored at a fixed antenna height and EUT azimuth. The EUT is rotated through 360 degrees to maximize emissions received. The antenna is scanned from 1 to 4 meters above the ground plane to further maximize the emission. Measurements are made with the antenna polarized in both the vertical and the horizontal positions.

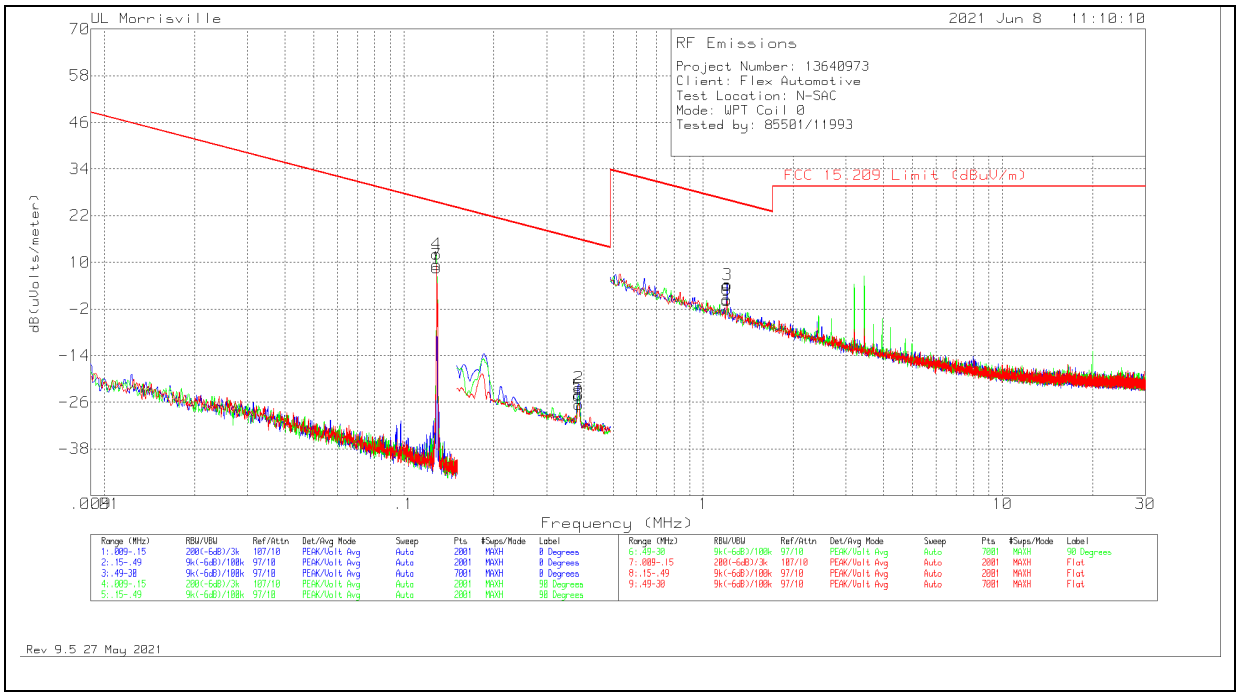
3D antenna use - For below 30MHz testing, investigation was done on three antenna orientations (parallel, perpendicular, and ground-parallel).

Based on FCC 15.31 (f) (2): measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field.

KDB 414788 Open Field Site (OFS) and Chamber Correlation Justification

OFS and chamber correlation testing had been performed and chamber measured test result is the worst-case test result.

9.1. TX SPURIOUS EMISSION 9kHz TO 30 MHz (CHARGING W/LOAD – Coil 0)



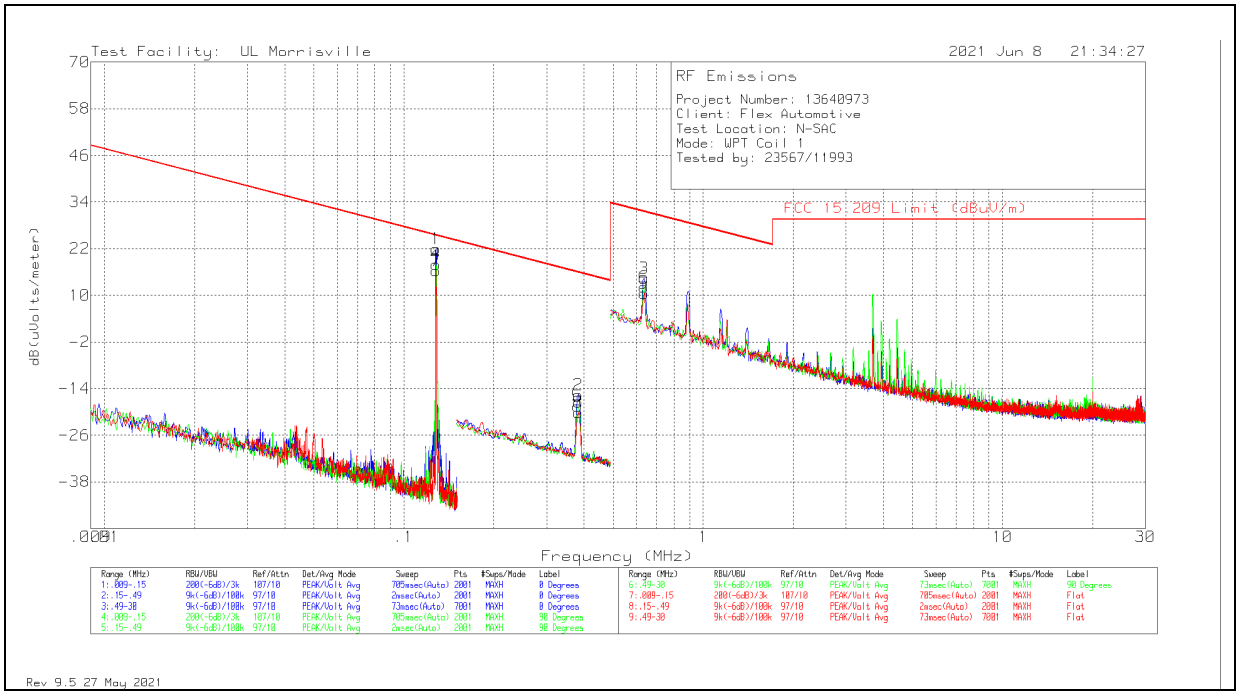
DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0079 (dB/m)	Cbl (dB)	Dist. Corr. Factor (dB)	Corrected Reading (dBuVolts/m)	FCC 15.209 QP/AV Limit (dBuV/m)	FCC 15.209 PK Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Loop Angle
1	.12729	76.06	Av	10.9	.1	-80	7.06	25.51	45.51	-18.45	64	100	0 degs
4	.1272	73.67	Av	10.9	.1	-80	4.67	25.51	45.51	-20.84	167	100	90 degs
7	.12688	73.41	Av	10.9	.1	-80	4.41	25.54	45.54	-21.13	237	100	Flat
5	.38222	44.9	Pk	10.6	.1	-80	-24.4	15.96	35.96	-40.36	0-360	400	90 degs
2	.38426	47.05	Pk	10.6	.1	-80	-22.25	15.91	35.91	-38.16	0-360	400	0 degs
8	.3846	42.69	Pk	10.6	.1	-80	-26.61	15.9	35.9	-42.51	0-360	400	Flat
6	1.19829	29.34	Pk	11	.2	-40	.54	26.03	-	-25.49	0-360	400	90 degs
9	1.19829	28.96	Pk	11	.2	-40	.16	26.03	-	-25.87	0-360	400	Flat
3	1.2025	33.04	Pk	11	.2	-40	4.24	26	-	-21.76	0-360	400	0 degs

Pk - Peak detector

Note for below 30 MHz scans: All measurements were made at a test distance of 3 m. The measured data was extrapolated from the test distance (3m) to the specification distance (300 m from 9-490 kHz and 30 m from 490 kHz – 30 MHz) to clearly show the relative levels of fundamental and spurious emissions and demonstrate compliance with the requirement that the level of any spurious emissions be below the level of the intentionally transmitted signal. The extrapolation factor for the limits were 40*Log (test distance / specification distance).

9.2. TX SPURIOUS EMISSION 9kHz TO 30 MHz (CHARGING W/LOAD – Coil 1)



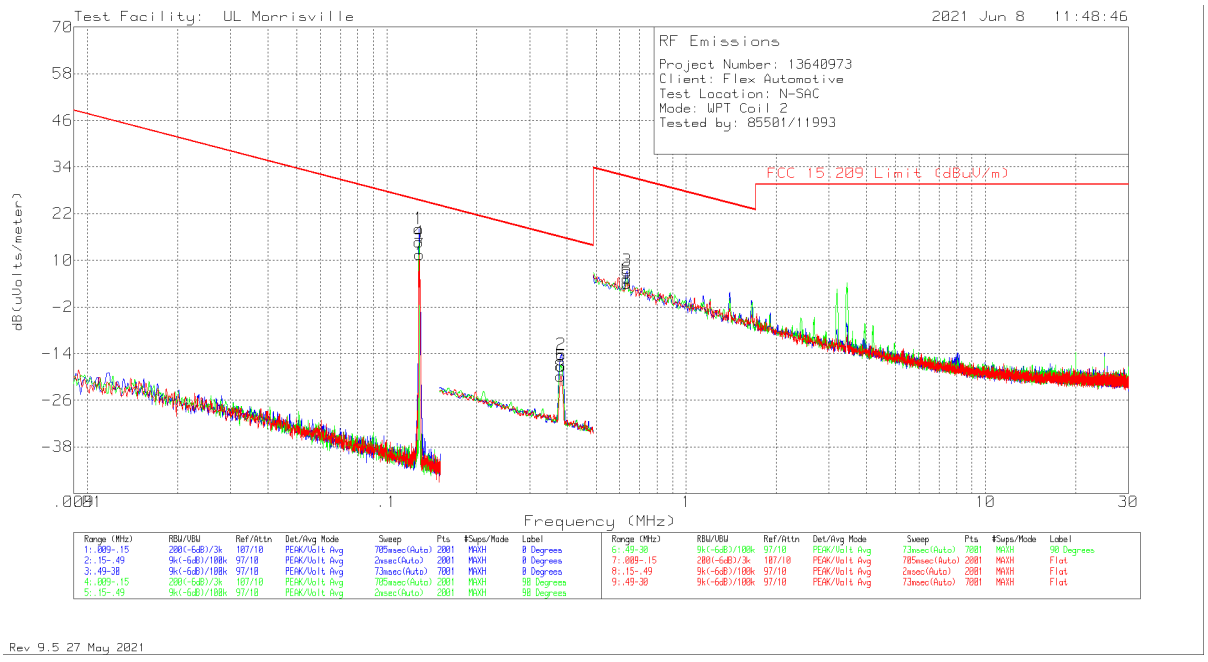
DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0079 (dB/m)	Cbl (dB)	Dist. Corr. Factor (dB)	Corrected Reading (dBuVolts/m)	FCC 15.209 QP/AV Limit (dBuV/m)	FCC 15.209 PK Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Loop Angle
1	.12759	91.03	Av	10.9	.1	-80	22.03	25.49	45.49	-3.46	5	100	0 degs
7	.12747	79.25	Av	10.9	.1	-80	10.25	25.5	45.5	-15.25	360	100	Flat
4	.12727	83.55	Av	10.9	.1	-80	14.55	25.51	45.51	-10.96	325	100	90 degs
5	.38069	50.81	Pk	10.6	.1	-80	-18.49	15.99	35.99	-34.48	0-360	103	90 degs
2	.38239	53.65	Pk	10.6	.1	-80	-15.65	15.95	35.95	-31.6	0-360	103	0 degs
8	.38273	49.14	Pk	10.6	.1	-80	-20.16	15.95	35.95	-36.11	0-360	103	Flat
3	.63334	43.31	Pk	10.8	.2	-40	14.31	31.57	-	-17.26	0-360	103	0 degs
6	.63334	41.05	Pk	10.8	.2	-40	12.05	31.57	-	-19.52	0-360	103	90 degs
9	.63334	39.56	Pk	10.8	.2	-40	10.56	31.57	-	-21.01	0-360	103	Flat

Pk - Peak detector

Note for below 30 MHz scans: All measurements were made at a test distance of 3 m. The measured data was extrapolated from the test distance (3m) to the specification distance (300 m from 9-490 kHz and 30 m from 490 kHz – 30 MHz) to clearly show the relative levels of fundamental and spurious emissions and demonstrate compliance with the requirement that the level of any spurious emissions be below the level of the intentionally transmitted signal. The extrapolation factor for the limits were 40*Log (test distance / specification distance).

9.3. TX SPURIOUS EMISSION 9kHz TO 30 MHz (CHARGING W/LOAD – Coil 2)



DATA

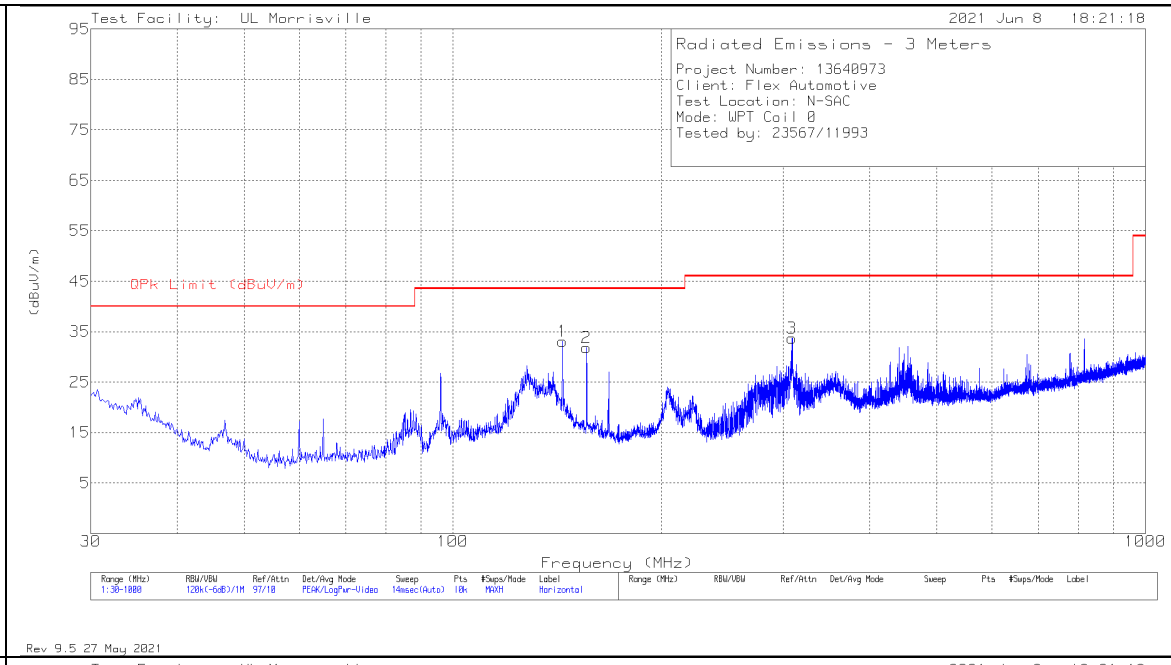
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0079 (dB/m)	Cbl (dB)	Dist. Corr. Factor (dB)	Corrected Reading (dBuVolts/m)	FCC 15.209 QP/AV Limit (dBuV/m)	FCC 15.209 PK Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Loop Angle
1	.12758	87.98	Av	10.9	.1	-80	18.98	25.49	45.49	-6.51	180	100	0 degs
4	.12768	83.45	Av	10.9	.1	-80	14.45	25.48	45.48	-11.03	105	100	90 degs
7	.12768	73.72	Av	10.9	.1	-80	4.72	25.48	45.48	-20.76	320	100	Flat
8	.38146	49.47	Pk	10.6	.1	-80	-19.83	15.97	35.97	-35.8	0-360	400	Flat
2	.38239	55.09	Pk	10.6	.1	-80	-14.21	15.95	35.95	-30.16	0-360	400	0 degs
5	.38316	51.99	Pk	10.6	.1	-80	-17.31	15.94	35.94	-33.25	0-360	400	90 degs
3	.63334	36.36	Pk	10.8	.2	-40	7.36	31.57	-	-24.21	0-360	400	0 degs
6	.63334	34.4	Pk	10.8	.2	-40	5.4	31.57	-	-26.17	0-360	400	90 degs
9	.63334	33.02	Pk	10.8	.2	-40	4.02	31.57	-	-27.55	0-360	400	Flat

Pk - Peak detector

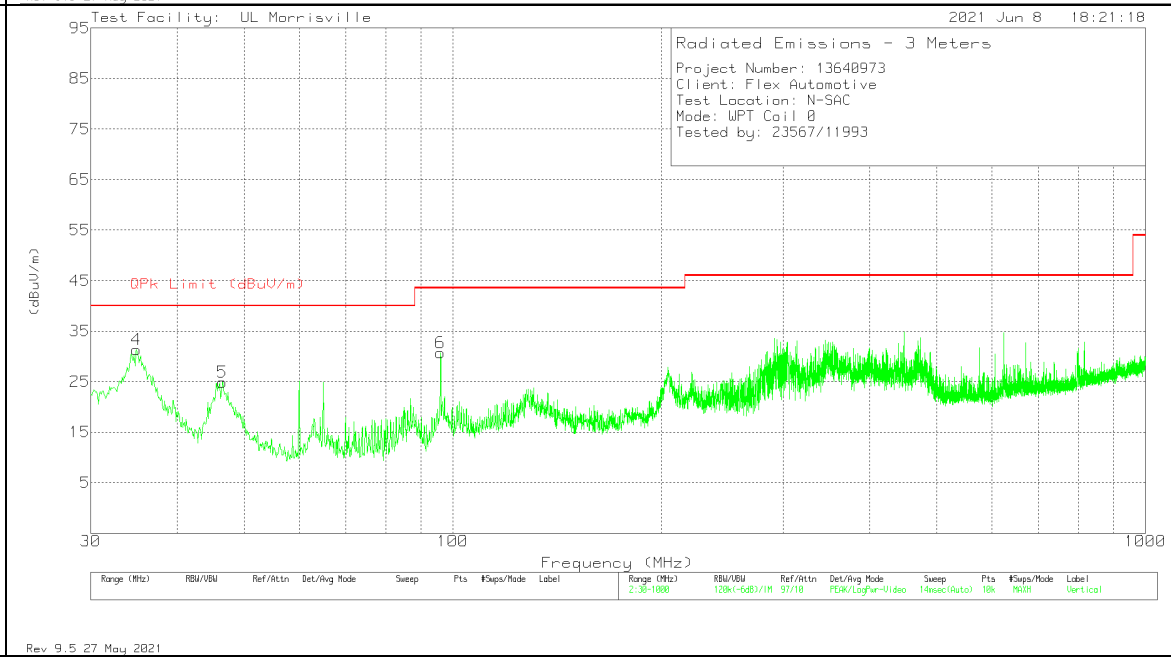
Note for below 30 MHz scans: All measurements were made at a test distance of 3 m. The measured data was extrapolated from the test distance (3m) to the specification distance (300 m from 9-490 kHz and 30 m from 490 kHz – 30 MHz) to clearly show the relative levels of fundamental and spurious emissions and demonstrate compliance with the requirement that the level of any spurious emissions be below the level of the intentionally transmitted signal. The extrapolation factor for the limits were 40*Log (test distance / specification distance).

9.4. TX SPURIOUS EMISSION 30 TO 1000 MHz (CHARGING W/LOAD – Coil 0)

Horizontal



Vertical



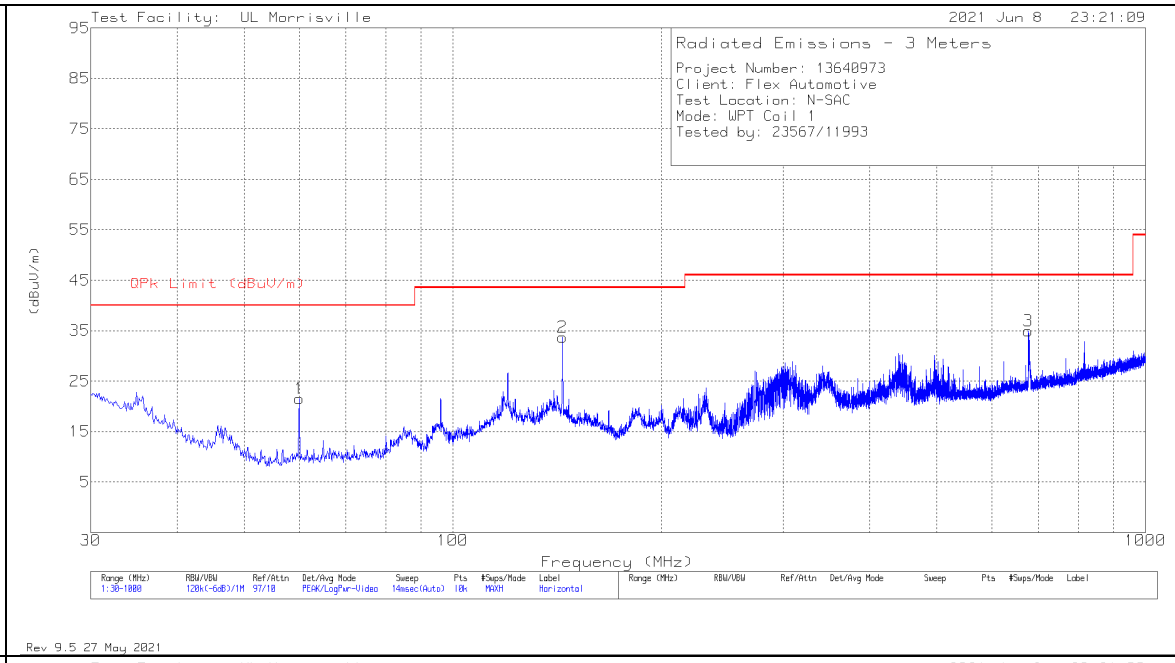
DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0074 (dB/m)	Amp/Cbl (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	34.947	39.3	Pk	23.4	-31.4	31.3	40	-8.7	0-360	100	V
5	46.49	40.61	Pk	15.5	-31.2	24.91	40	-15.09	0-360	100	V
6	95.96	45.99	Pk	15.2	-30.5	30.69	43.52	-12.83	0-360	100	V
1	143.975	44.18	Pk	18.8	-29.9	33.08	43.52	-10.44	0-360	100	H
2	156.003	43.02	Pk	18.6	-29.8	31.82	43.52	-11.7	0-360	399	H
3	308.972	42.45	Pk	19.8	-28.5	33.75	46.02	-12.27	0-360	200	H

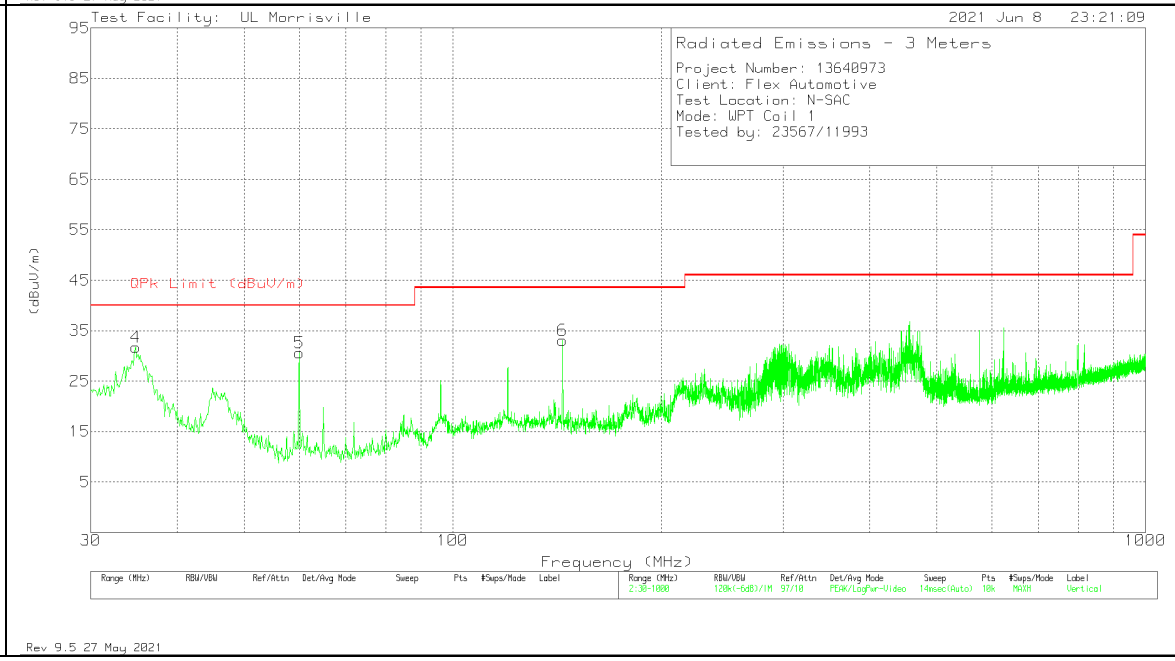
Pk - Peak detector

9.5. TX SPURIOUS EMISSION 30 TO 1000 MHz (CHARGING W/LOAD – Coil 1)

Horizontal



Vertical



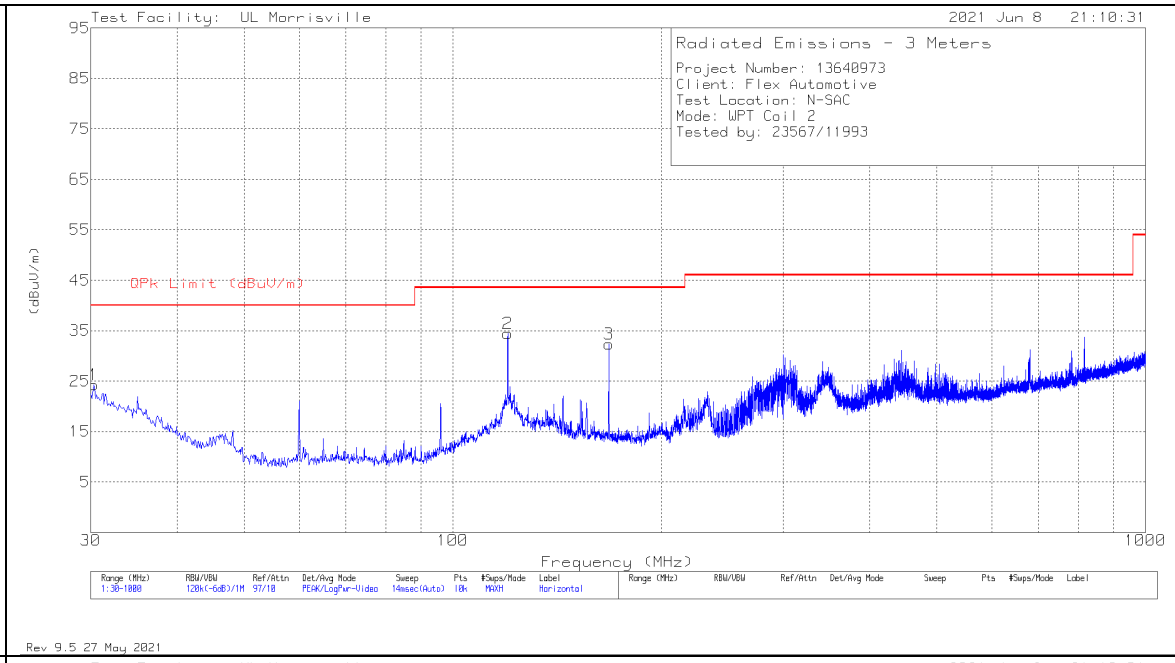
DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0074 (dB/m)	Amp/Cbl (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	34.85	39.67	Pk	23.5	-31.4	31.77	40	-8.23	0-360	100	V
1	59.973	38.96	Pk	13.5	-30.9	21.56	40	-18.44	0-360	400	H
5	59.973	48	Pk	13.5	-30.9	30.6	40	-9.4	0-360	100	V
2	143.975	44.84	Pk	18.8	-29.9	33.74	43.52	-9.78	0-360	300	H
6	143.975	44.21	Pk	18.8	-29.9	33.11	43.52	-10.41	0-360	100	V
3	677.184	35.55	Pk	25.9	-26.5	34.95	46.02	-11.07	0-360	100	H

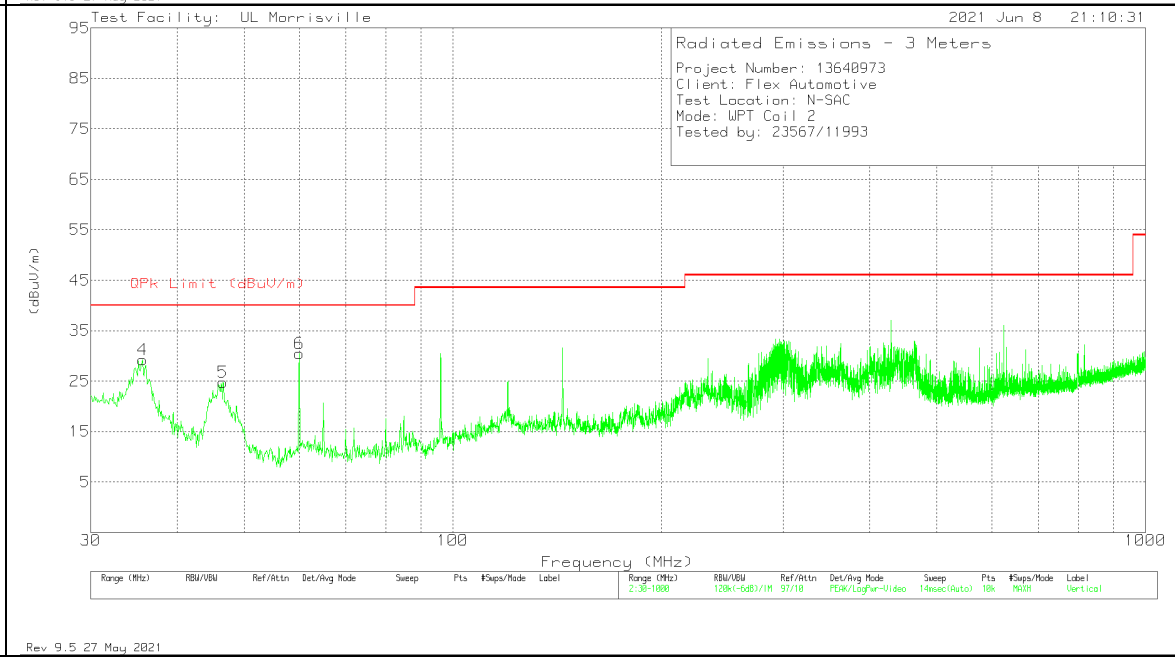
Pk - Peak detector

9.6. TX SPURIOUS EMISSION 30 TO 1000 MHz (CHARGING W/LOAD – Coil 2)

Horizontal



Vertical



DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0074 (dB/m)	Amp/Cbl (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	30.291	28.95	Pk	26.7	-31.4	24.25	40	-15.75	0-360	200	H
4	35.626	37.63	Pk	22.9	-31.3	29.23	40	-10.77	0-360	100	V
5	46.587	40.52	Pk	15.4	-31.2	24.72	40	-15.28	0-360	100	V
6	59.973	47.89	Pk	13.5	-30.9	30.49	40	-9.51	0-360	100	V
2	120.016	44.7	Pk	19.9	-30.2	34.4	43.52	-9.12	0-360	299	H
3	168.031	43.78	Pk	18.1	-29.6	32.28	43.52	-11.24	0-360	299	H

Pk - Peak detector