

EMC TEST REPORT



Standard(s):

**47 CFR FCC Part 15.247
RSS 247, Issue 2, 2017**

**FCC ID: DGFCHIM29088
IC: 458A-CHIM29088**

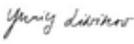
**Product: 3M Filtrete™ Smart Air Filter
Models: FILTRETE- 29088**

**Company Name:
3M Company**

**Address:
3M Center, Building 251
St. Paul, MN 55144-1000**

**Report Number: HRE202008050-1
Report Issue Date: October 6, 2021**

Report Prepared by:

Signature: 
**Yuriy Litvinov
Lead EMC Engineer**

**Tested by:
3M EMC Laboratory
410 E. Fillmore Avenue, Building 76-01-1
St. Paul, Minnesota 55107-1000, USA**

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1.0 Test Summary

Based on the results of our investigation, we have concluded the product tested **comply** with the requirements of the standard(s) indicated. The results obtained in this test report pertain only to the item(s) tested.

	Requirement – Test	Test Description	Result	Comments
4.1	FCC Part 15.247(a)(2)/ RSS-247(5.2)/RSS-Gen (6.6)	DTS Bandwidth	pass	
4.2	FCC Part 15.247(b)(3)/ RSS-247(5.4(4))	Maximum Peak Conducted Output Power	pass	
4.3	FCC Part 15.247(e)/ RSS-247(5.2(b))	Maximum Power Spectral Density level	pass	
4.4	FCC Part 15.209 RSS-Gen, 8.9	Radiated Emissions in restricted band	pass	
4.5	FCC Part 15.247(d)/ RSS-247(5.5)	Radiated Emissions in non-restricted band	pass	
4.6	FCC Part 15.247(d)(1)/ RSS-247(5.5)	DTS Band-edge Emissions Measurements	pass	
4.7	FCC Part 15.207/ RSS-Gen (8.8)	Conducted Emissions	N/A	
4.8	FCC Part 15.247(i)/ RSS 102 Issue 5	RF Exposure Compliance	pass	

Note:

Device is Battery operated

1.1 Measurement Uncertainty

The measured value related to the corresponding limit will be used to decide whether the equipment meets the requirements. The measurement uncertainty figures were calculated and correspond to a coverage factor of k=2, providing a confidence level of respectively 95.45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian).

Radiated emissions 30MHz to 1000MHz	4.9 dB
Radiated emissions 1GHz to 18GHz	4.6 dB
Conducted emissions 150KHz to 30MHz (AMN)	2.7 dB
Conducted emissions 150KHz to 30MHz (AAN)	1.92 dB
RF frequency	$\pm 3 \times 10^{-8}$
RF power, conducted	1.4 dB
RF Power Spectral Density	0.96 dB



2.0 Equipment Description

2.1 Equipment Under Test	
Description:	Device is used to track and monitor life of the AC filter using the 3M Filtrete™ Smart application and replace when recommended.
Model(s):	FILTRETE-29088
Serial number:	N/A
3M Division:	Construction and Home Improvement Markets
Modifications and Special Measures:	none
Frequency Range:	2402.0-2480.0 MHz
Channel No.:	39
Modulation Type:	GFSK
FCC Classification:	Digital Transmission System (DTS)
Peak Conducted Output Power:	4.5dBm (2.8mW), (EIRP 6dBm)
Antenna Type and Antenna Assembly Gain:	<input type="checkbox"/> External <input checked="" type="checkbox"/> Integral PCB Antenna <input type="checkbox"/> Dedicated
	<input checked="" type="checkbox"/> 1.5dBi <input checked="" type="checkbox"/> Declared by the Manufacturer <input type="checkbox"/> Measured
Test Deviations or Exclusions	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No
Rated Power:	Voltage: <input type="checkbox"/> 120VAC <input type="checkbox"/> 230VAC <input checked="" type="checkbox"/> 3.6VDC
	Phase: <input type="checkbox"/> 1ph <input type="checkbox"/> 3ph <input checked="" type="checkbox"/> Battery
	Frequency: <input type="checkbox"/> 50Hz <input type="checkbox"/> 60Hz
	Current:
Test Dates:	08/25-08/26/2021
Received Date:	08/25/2021
Received Conditions:	<input type="checkbox"/> Poor <input checked="" type="checkbox"/> Good
	<input checked="" type="checkbox"/> Prototype <input type="checkbox"/> Production

3.0 EUT Configuration

3.1 System Configuration

No.	Product Type	Manufacturer	Model	Comments
1				
2				

3.2 Input/Output Ports of EUT

No.	Description	Type	Comments
1			
2			

3.3 Cables

No.	Description	Type	Length	Shielding	Comments
1					
2					

3.4 Measurement Arrangements of EUT

	Intended Operational Arrangement(s)	Comments
<input checked="" type="checkbox"/>	Table-top only	
<input type="checkbox"/>	Floor-standing only	
<input type="checkbox"/>	Floor-standing or table-top	
<input type="checkbox"/>	Other	

3.5 Primary function(s) of EUT

No.	List of Essential Functions
1	Monitoring the life of the filter
2	

3.6 Exercising of EUT and Interfaces

No.	Mode of Operation
1	Transmitting at lowest (0), middle (19) and highest (39) channels of operation with unmodulated CW carrier
2	Continues transmission of modulated signal at lowest (0), middle (19) and highest (39) channels
3	Device programming using Nordic software for continues transmission of modulated carrier at maximum rated RF output power and Duty Cycle.



4.0 Test Conditions and Results

4.1 DTS Bandwidth	
	Laboratory Ambient Temperature: 23°C
	Relative Humidity: 48%
	Atmospheric Pressure: 1011 mbars
Reference Standard(s):	<input checked="" type="checkbox"/> ANSI C63.10:2013 <input checked="" type="checkbox"/> FCC Part 15.247/RSS 247 <input checked="" type="checkbox"/> KDB 558074
Frequency Range:	<input checked="" type="checkbox"/> 2402.0-2480.0 MHz RBW = 100KHz VBW ≥ 3 x RBW
Nominal Voltage:	<input type="checkbox"/> 120VAC <input checked="" type="checkbox"/> 3.6VDC
Test Personnel:	Yuriy Litvinov <i>Yuriy Litvinov</i> Date: 08/26/2021
	Measurement Point <input checked="" type="checkbox"/> Conducted <input type="checkbox"/> Radiated

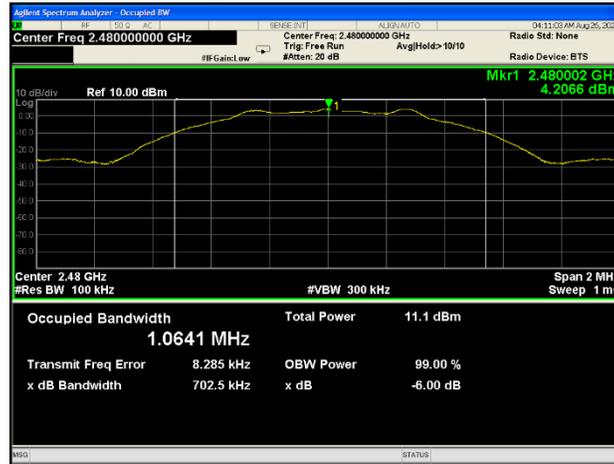
Frequency (MHz)	Data Rate	99% dB Bandwidth (KHz)	6 dB Bandwidth (KHz)	6dB OBW Limit (KHz)	Results
2402	1 Mbps	1061	689.4	> 500	pass
2440	1 Mbps	1063	698.1	> 500	pass
2480	1 Mbps	1064	702.5	> 500	pass



OBW – Low Channel



OBW – Mid Channel



OBW – High Channel



4.2	Maximum Output Power		
Method:	Measurements was performed with CW carrier at the highest power level at which the transmitter is intended to operate. The analyzer offset was adjusted to compensate for the attenuator and other losses.		
	Laboratory Ambient Temperature:	23°C	
	Relative Humidity:	48%	
	Atmospheric Pressure:	1011 mbars	
Reference Standard(s):	<input checked="" type="checkbox"/> ANSI C63.10:2013 <input checked="" type="checkbox"/> FCC Part 15.247/RSS 247 <input checked="" type="checkbox"/> KDB 558074	Measurement Point	
Frequency Range:	<input checked="" type="checkbox"/> 2402.0 – 2480.0 MHz	<input checked="" type="checkbox"/> Conducted <input type="checkbox"/> Radiated at 3 meters	
Antenna Gain:	1.5dBi	Maximum Conducted Power (EIRP):	
Limit:	30 dBm	6.0 dBm	
Nominal Voltage:	<input type="checkbox"/> 120VAC <input checked="" type="checkbox"/> 3.6VDC		
Test Personnel:	Yuriy Litvinov <i>Yuriy Litvinov</i>	Date: 08/26/2021	

Note: EIRP (dBm) = Conducted Power (dBm) +Antenna Gain (dBi)= 4.5+1.5=6.0dBm



Low Channel



Mid Channel



High Channel



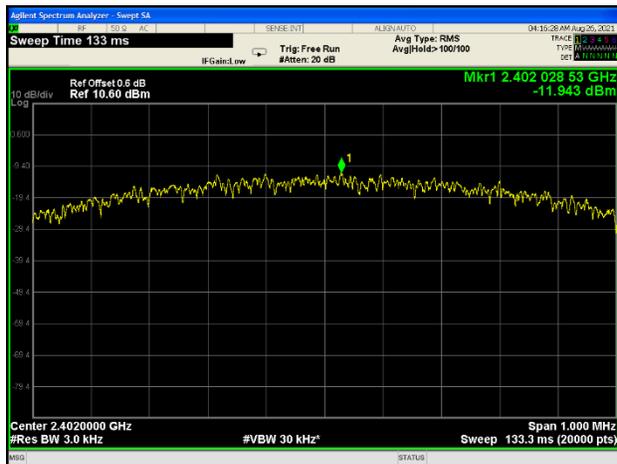
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Date: October 6, 2021

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4.3	Maximum Power Spectral Density level		
Method:	Measurements was performed with modulated carrier at the highest power level at which the transmitter is intended to operate. The analyzer offset was adjusted to compensate for the attenuator and other losses.		
	Laboratory Ambient Temperature:	23°C	
	Relative Humidity:	48%	
	Atmospheric Pressure:	1011 mbars	
Reference Standard(s):	<input checked="" type="checkbox"/> ANSI C63.10:2013 <input checked="" type="checkbox"/> FCC Part 15.247/RSS 247 <input checked="" type="checkbox"/> KDB 558074	Measurement Point	
		<input checked="" type="checkbox"/> Conducted <input type="checkbox"/> Radiated at 3 meters	
Frequency Range:	<input checked="" type="checkbox"/> 2402.0 – 2480.0 MHz		PSD Results
PSD Limit:	8 dBm in any 3KHz band		-11.3 dBm
Nominal Voltage:	<input type="checkbox"/> 120VAC <input checked="" type="checkbox"/> 3.6VDC		
Test Personnel:	Yuriy Litvinov <i>Yuriy Litvinov</i>		Date: 08/26/2021



PSD Low Channel



PSD Mid Channel

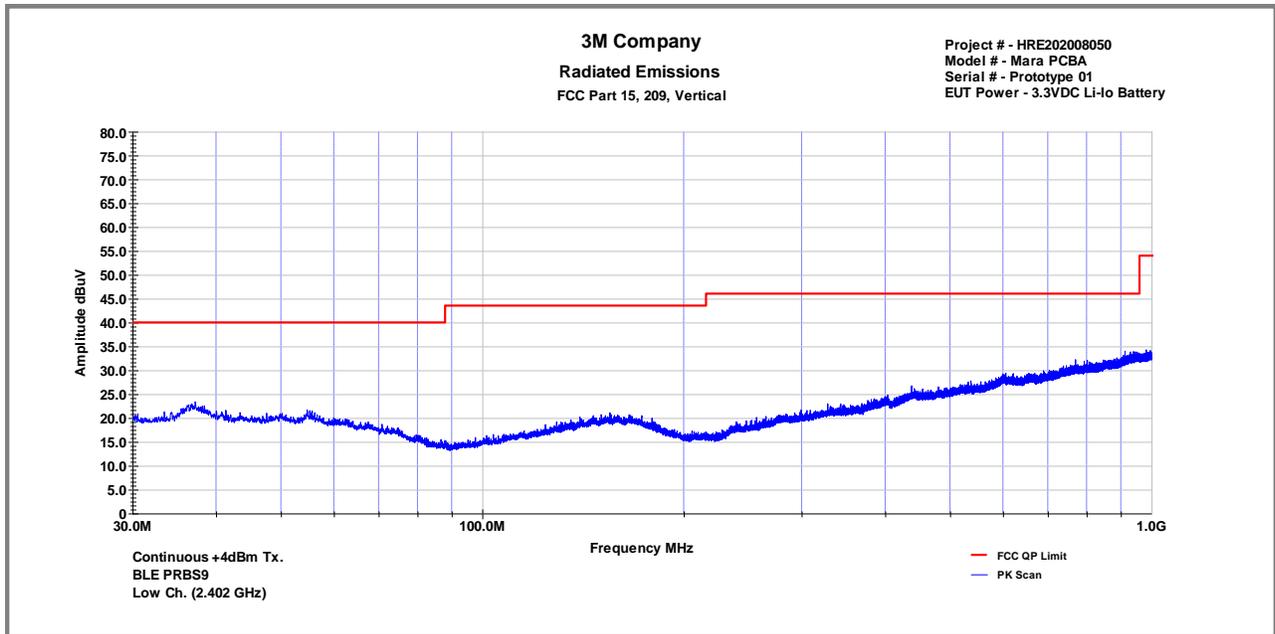
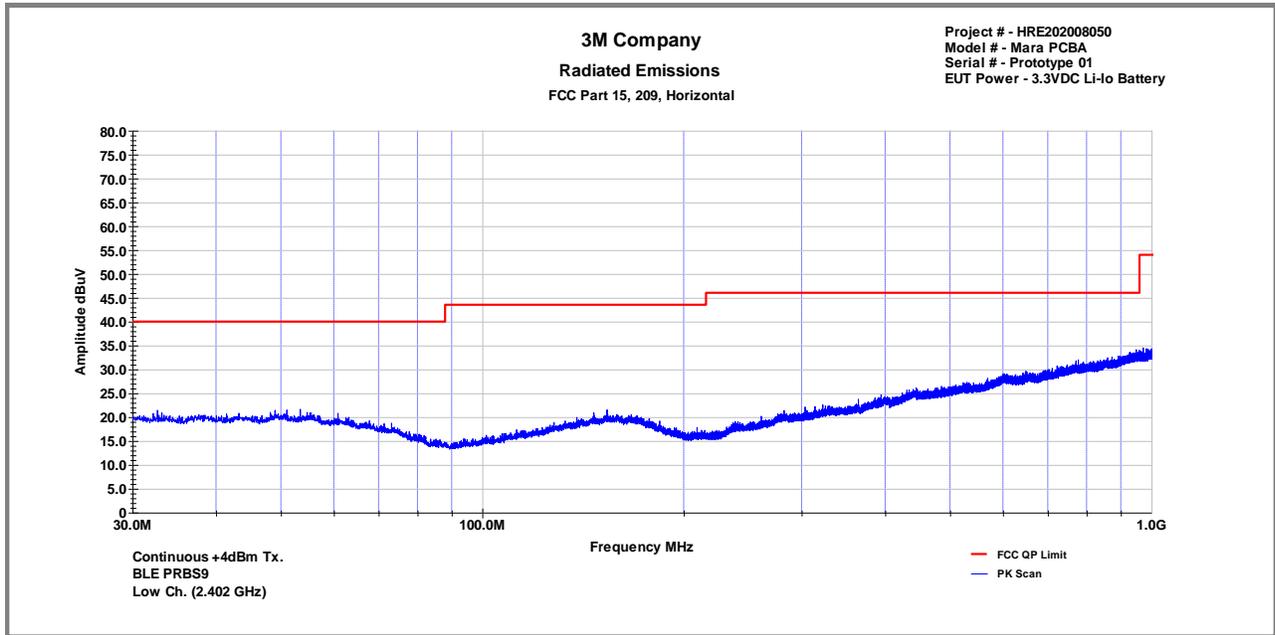


PSD High Channel

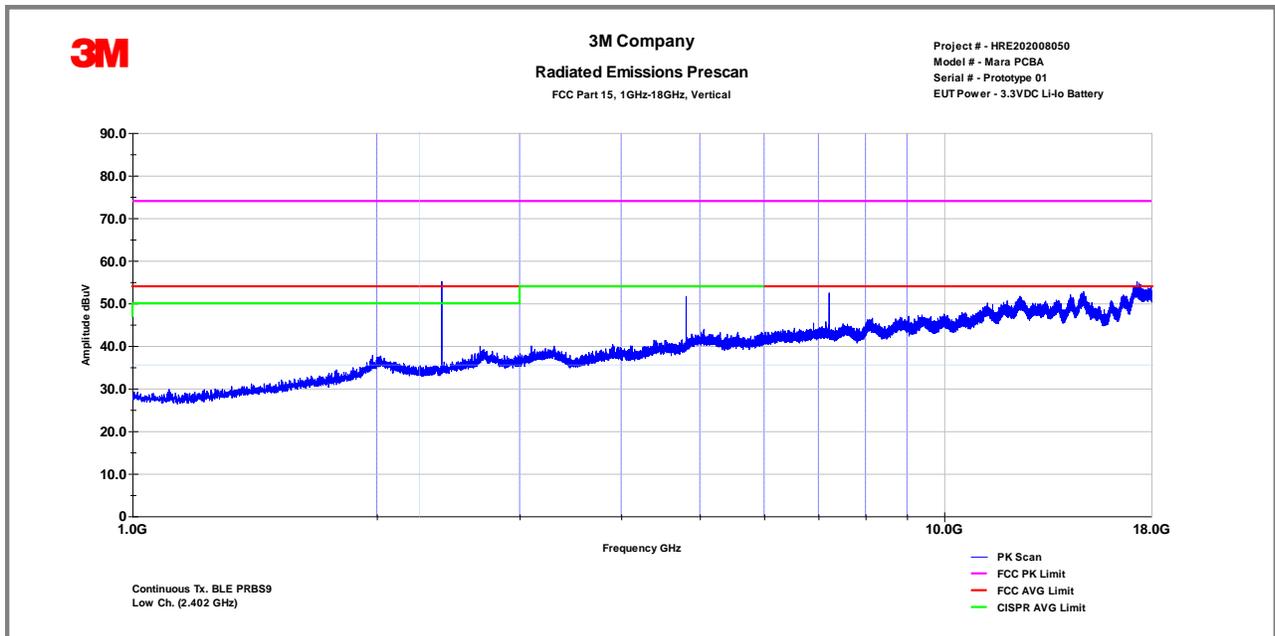
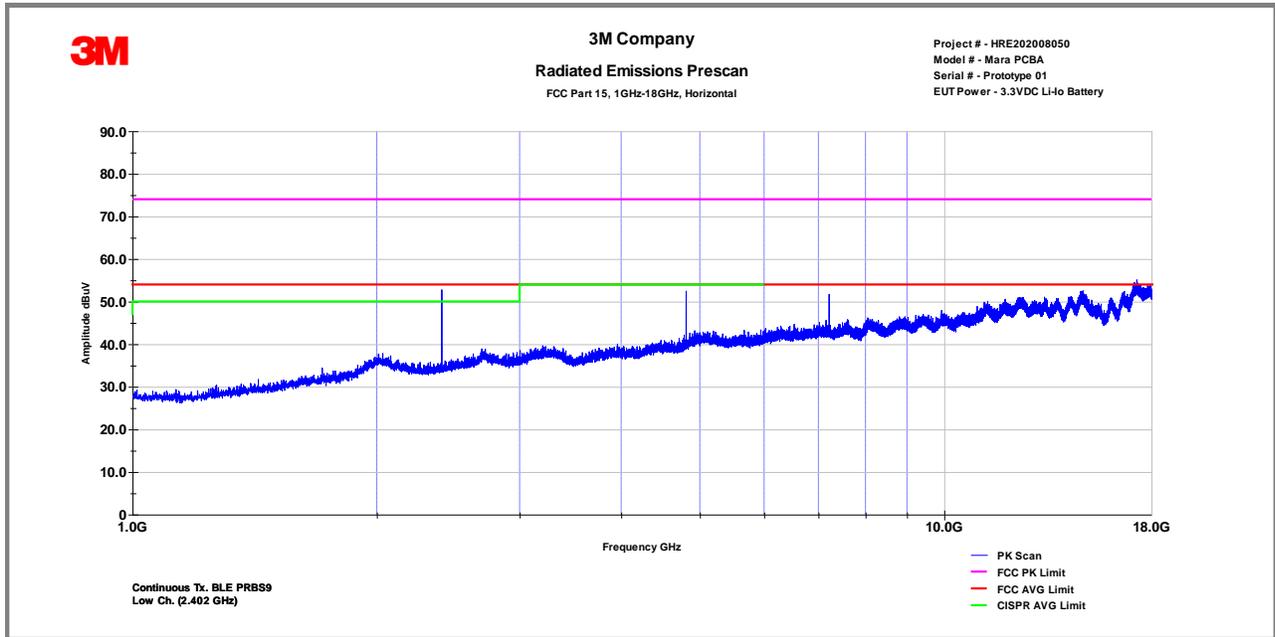


4.4 Radiated Emissions in restricted band					
Method:	Measurements were made in a 3-meter semi-anechoic chamber that complies to CISPR 16/ANSI C63.4 standards. EUT was rotated through three orthogonal axes to determine which attitude (orientation) and arrangement produces the highest emission relative to the limit; the attitude and device arrangement that produces the highest emission relative to the limit was used in making final radiated emission measurements. Spurious Radiated emissions measurements were performed with external preamp and a high pass filter. Final measurements were then performed by rotating the EUT 360° and adjusting the receive antenna height from 1 to 4 m. All frequencies were investigated in both horizontal and vertical antenna polarity, where applicable.				
Test Verification: <input checked="" type="checkbox"/>	Laboratory Ambient Temperature: 23°C				
	Relative Humidity: 55%				
	Atmospheric Pressure: 1011 mbars				
Reference Standard(s):	<input checked="" type="checkbox"/> ANSI C63.10:2013, Section 11.12.1 <input checked="" type="checkbox"/> FCC Part 15.247/RSS 247 <input checked="" type="checkbox"/> KDB 558074				
	Measurement Distance <input checked="" type="checkbox"/> 3 Meters <input type="checkbox"/>				
Frequency Range:	<input checked="" type="checkbox"/> 30 MHz to 1 GHz <input checked="" type="checkbox"/> 1 GHz to 25 GHz				
Nominal Voltage:	<input type="checkbox"/> 120VAC <input checked="" type="checkbox"/> 3.6VDC				
Test Personnel:	Keith Schwartz <i>KS</i> Date: 08/26/2021				
Limits –15.209 and RSS Gen					
Frequency (MHz)	Limit dB (µV/m)			Distance	Results
	Quasi-Peak	Average	Peak		
0.009-0.490		2400/F(KHz)		300	N/A
0.490-1.705	24000/F(KHz)			30	N/A
1.705-30	30			30	N/A
30 to 88	40			3	pass
88 to 216	43.5			3	pass
216 to 960	46			3	pass
Above 960		54	74	3	pass

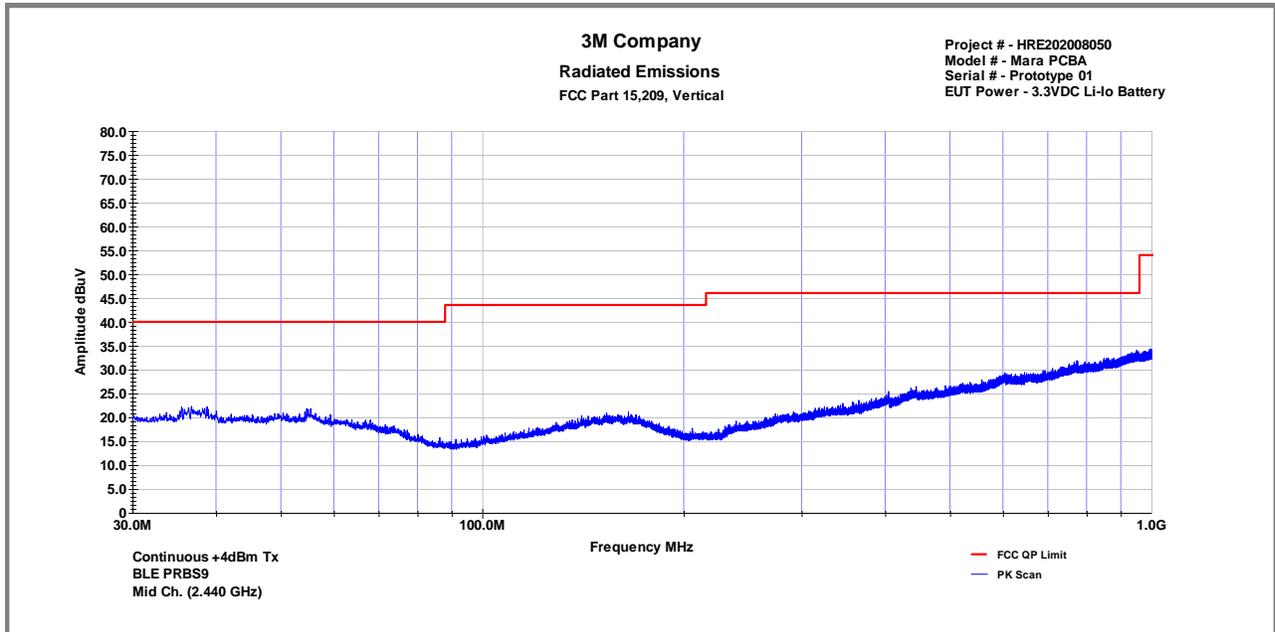
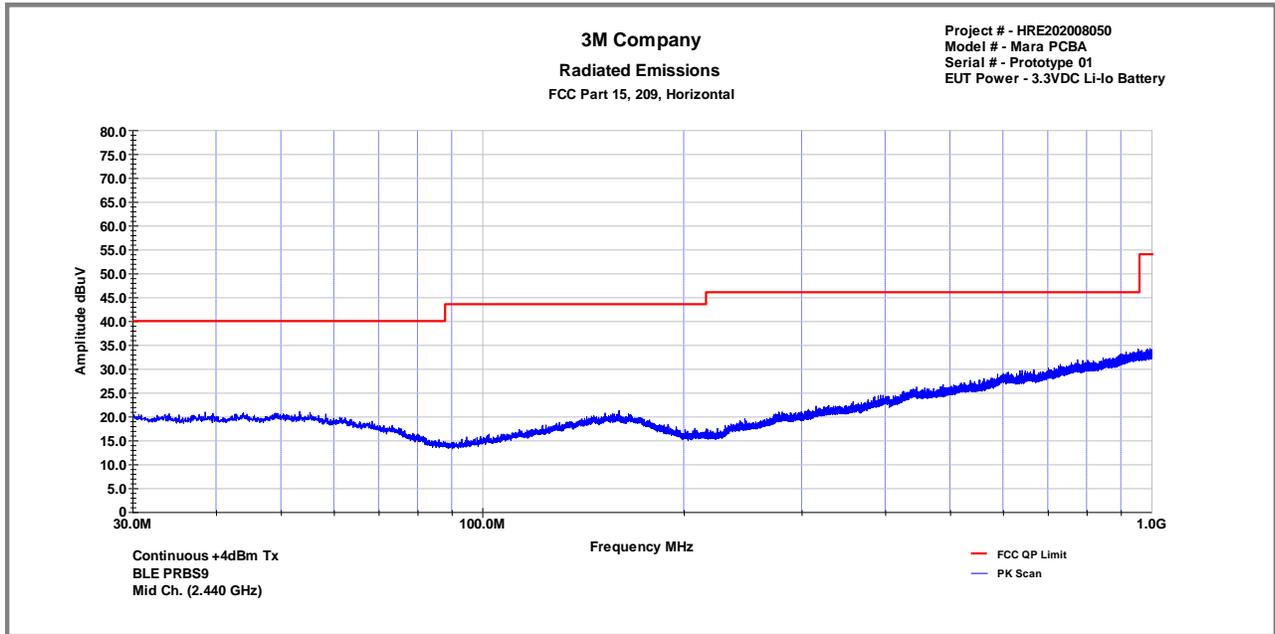
Modifications:	
Note:	<p>The lower limit applies at the transition frequency. An inverse proportionality factor of 20 dB per decade has been used to normalize the measured data to the specified distance for determining compliance</p> <p>For emission in the restricted bands, the limit of 15.209 was used.</p> <p>There are no emissions were detected in the restricted band within 30dB below 15.209 limit adjacent or nearby to 2400-2483.5MHz frequency band during operation at the high channel.</p> <p>No radiated spurious emissions were detected above 18GHz</p>



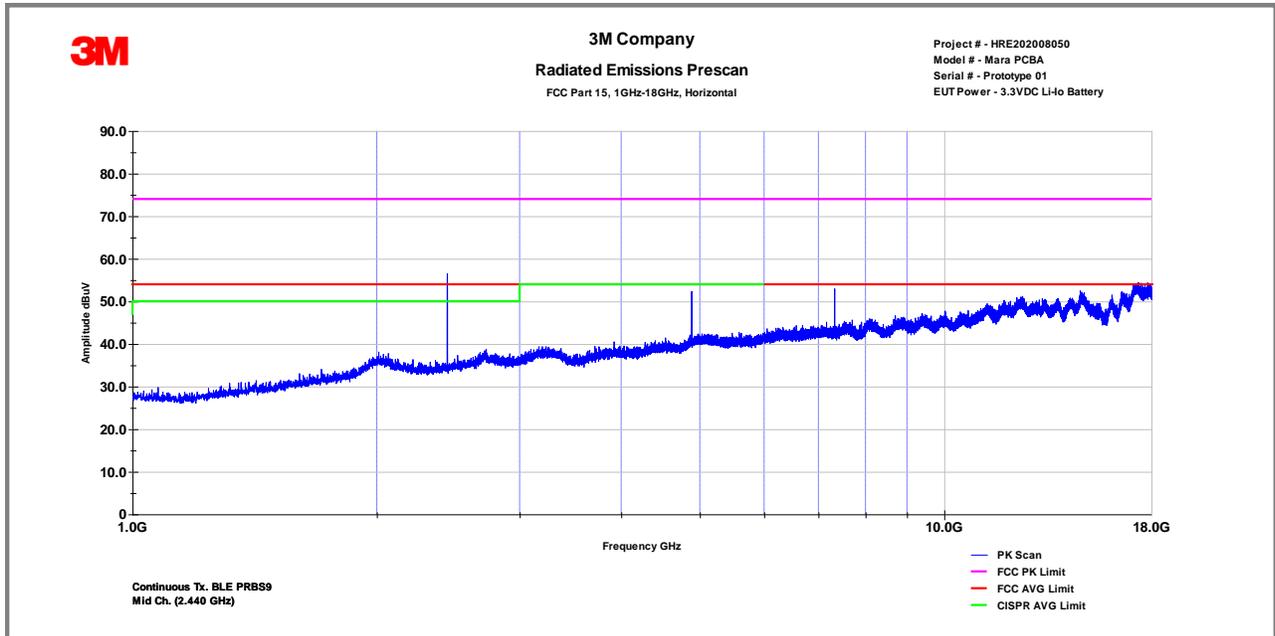
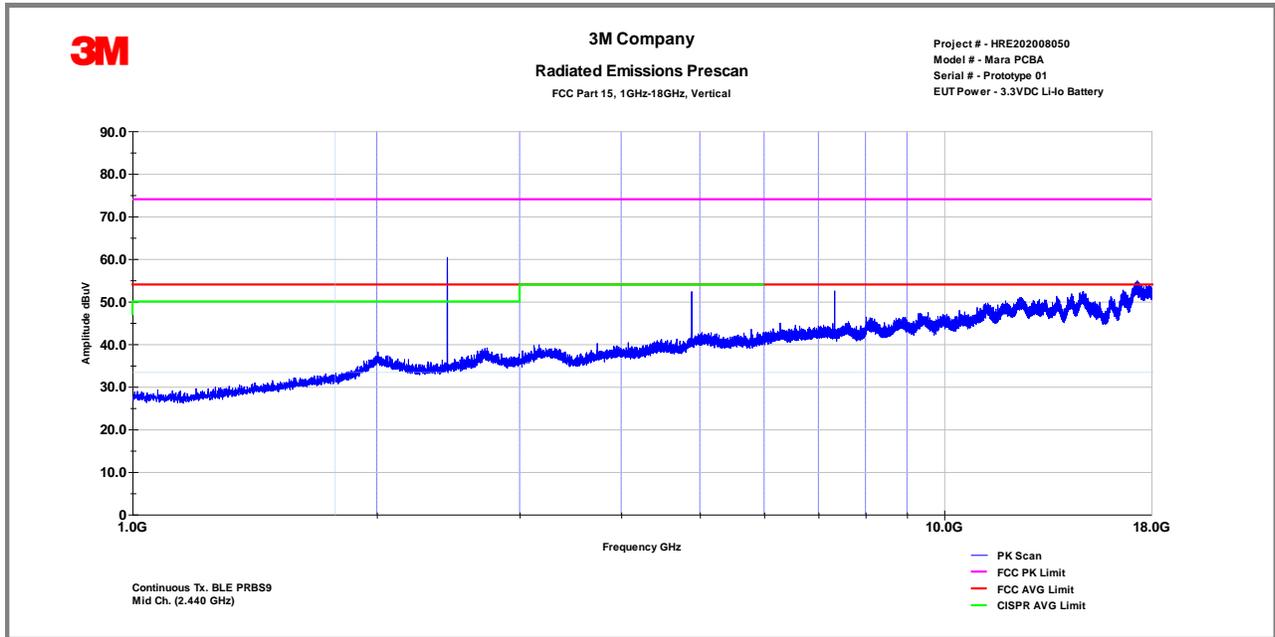
FCC Part 15.209 Radiated Emissions in restricted band – Low Channel



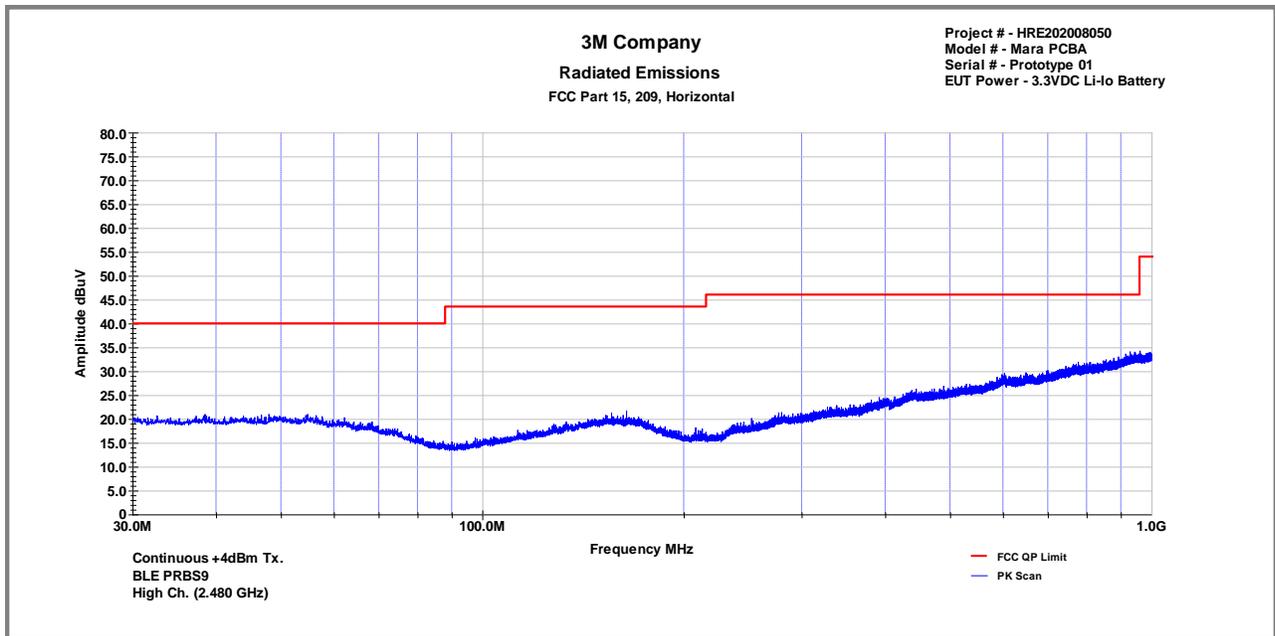
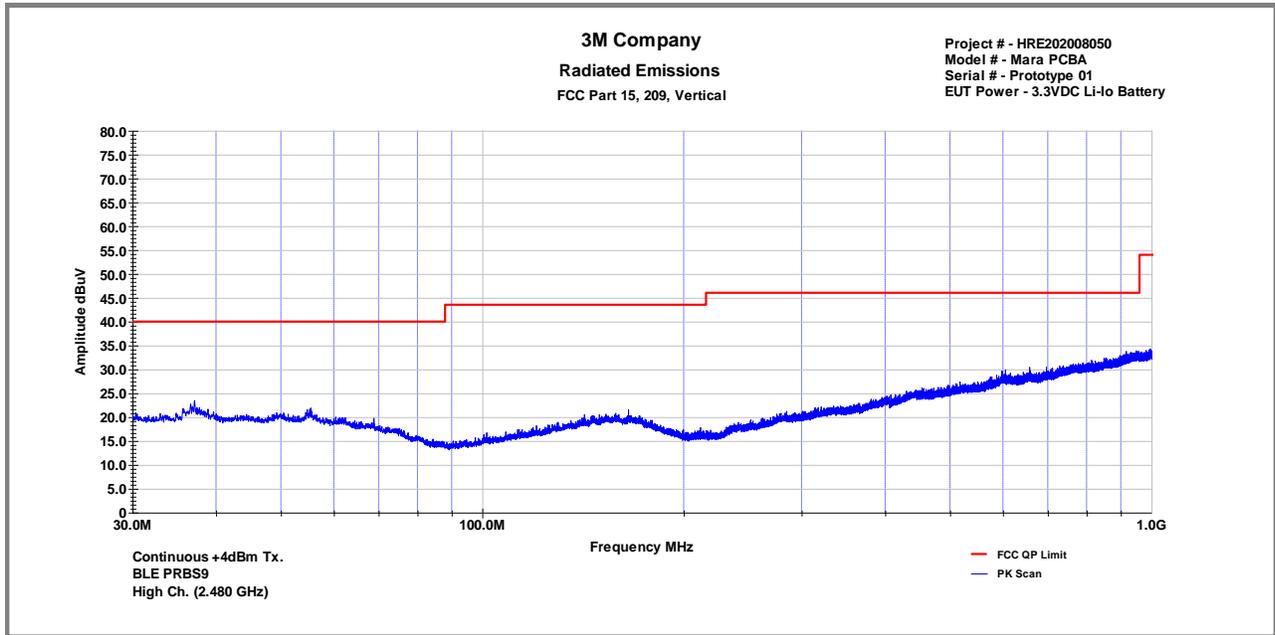
FCC Part 15.209 Radiated Emissions in restricted band – Low Channel



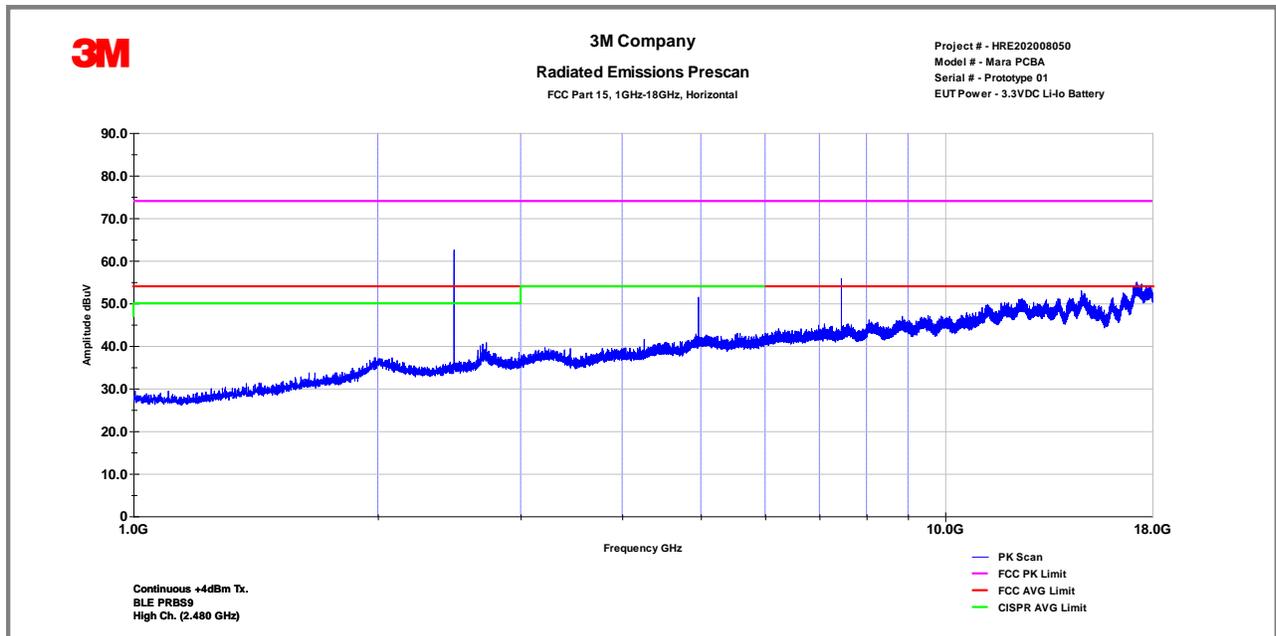
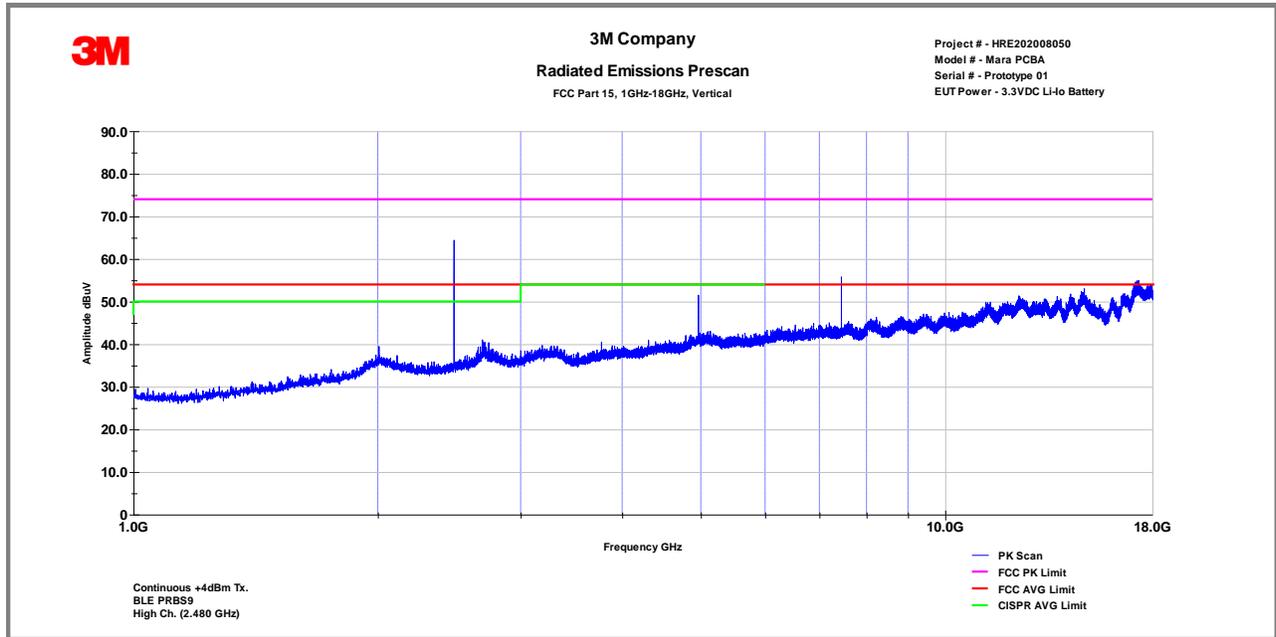
FCC Part 15.209 Radiated Emissions in restricted band – Mid Channel



FCC Part 15.209 Radiated Emissions in restricted band – Mid Channel



FCC Part 15.209 Radiated Emissions in restricted band – High Channel



FCC Part 15.209 Radiated Emissions in restricted band – High Channel



Tables - Radiated Emissions in restricted band

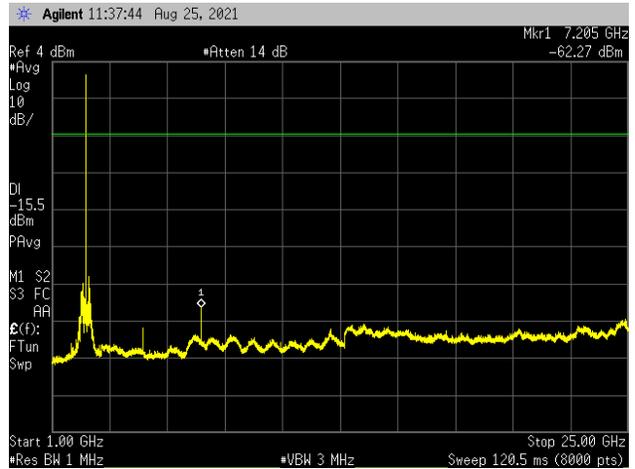
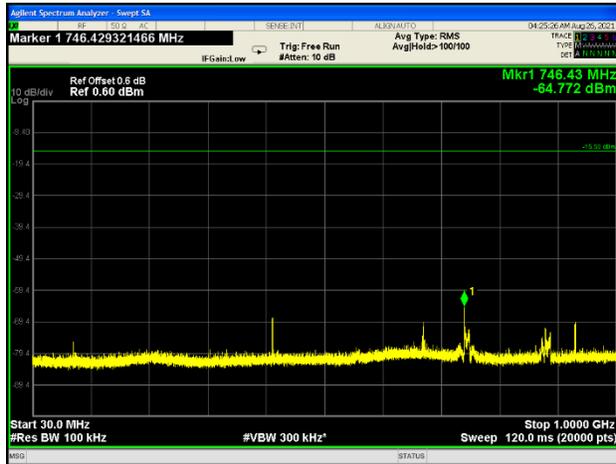
Pol	Frequency (MHz)	Peak dB μ V/m	AVG dB μ V/m	Total CF dB	Net Peak dB μ V/m	Net AVE dB μ V/m	PK Limit dB μ V/m	AVE Limit dB μ V/m	PK Margin dB	AVG Margin dB
V	4803.40	58.73	51.7	-6.22	52.51	45.52	74.00	54.00	-21.49	-8.48
H	4803.40	59.79	53.0	-6.22	53.57	46.79	74.00	54.00	-20.43	-7.21
V	9608.00	47.97	34.84	-1.60	46.37	33.24	74.00	54.00	-27.63	-20.76
H	9608.00	49.12	35.55	-1.60	47.52	33.95	74.00	54.00	-26.48	-20.05
V	12010.00	46.11	31.62	3.51	49.62	35.13	74.00	54.00	-24.38	-18.87
H	12010.00	45.42	31.65	3.51	48.93	35.16	74.00	54.00	-25.07	-18.84
Notes:	Net Reading (dBuV) = Reading (dBuV) + (Antenna with amp CF(dB)+Cable CF(dB))									
	Low Channel									

Pol	Frequency (MHz)	Peak dB μ V/m	AVG dB μ V/m	Total CF dB	Net Peak dB μ V/m	Net AVE dB μ V/m	PK Limit dB μ V/m	AVE Limit dB μ V/m	PK Margin dB	AVG Margin dB
V	4880.00	57.93	50.8	-5.30	52.63	45.46	74.00	54.00	-21.37	-8.54
H	4880.00	58.95	52.1	-5.30	53.65	46.79	74.00	54.00	-20.35	-7.21
V	7320.15	58.12	49.1	-3.60	54.52	45.45	74.00	54.00	-19.48	-8.55
H	7320.15	57.84	48.8	-3.60	54.24	45.24	74.00	54.00	-19.76	-8.76
V	12200.00	45.03	31.7	3.27	48.30	35.00	74.00	54.00	-25.70	-19.00
H	12200.00	45.24	31.8	3.27	48.51	35.02	74.00	54.00	-25.49	-18.98
Notes:	Net Reading (dBuV) = Reading (dBuV) + (Antenna with amp CF(dB)+Cable CF(dB))									
	Mid Channel									

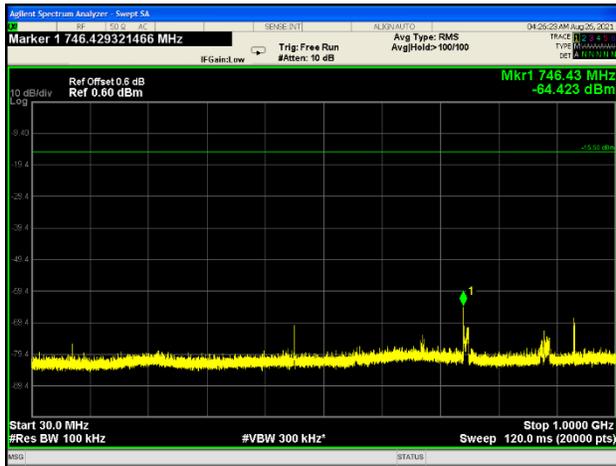
Pol	Frequency (MHz)	Peak dB μ V/m	AVG dB μ V/m	Total CF dB	Net Peak dB μ V/m	Net AVE dB μ V/m	PK Limit dB μ V/m	AVE Limit dB μ V/m	PK Margin dB	AVG Margin dB
V	2700.00	46.87	35.63	-12.00	34.87	23.63	74.00	54.00	-39.13	-30.37
H	2700.00	46.71	35.66	-12.00	34.71	23.66	74.00	54.00	-39.29	-30.34
V	4959.86	58.07	51.0	-5.01	53.06	46.01	74.00	54.00	-20.94	-7.99
H	4959.86	58.38	51.4	-5.01	53.37	46.40	74.00	54.00	-20.63	-7.60
V	7439.40	55.64	46.2	-2.90	52.74	43.30	74.00	54.00	-21.26	-10.70
H	7439.40	59.76	50.8	-2.90	56.86	47.91	74.00	54.00	-17.14	-6.09
V	12240.00	45.72	31.6	3.59	49.31	35.20	74.00	54.00	-24.69	-18.80
H	12240.00	45.57	31.62	3.59	49.16	35.21	74.00	54.00	-24.84	-18.7
Notes:	Net AVG VBW>1/T=2KHz Reading (dBuV) = Reading (dBuV) + (Antenna with amp CF(dB)+Cable CF(dB))									
	High Channel									



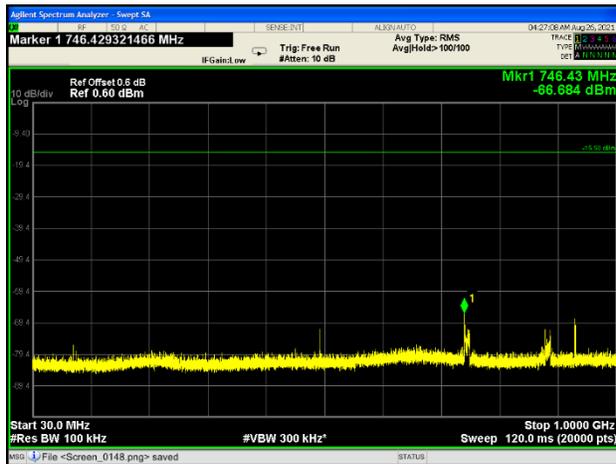
4.5 Radiated Emissions in non-restricted band	
Method:	The measurements were made with transmitter set to transmit continuously low, medium and high channels.
	Laboratory Ambient Temperature: 23°C
	Relative Humidity: 48%
	Atmospheric Pressure: 1011 mbars
Reference Standard(s):	<input checked="" type="checkbox"/> ANSI C63.10:2013 <input checked="" type="checkbox"/> FCC Part 15.247/RSS 247 <input checked="" type="checkbox"/> KDB 558074
Frequency Range:	<input checked="" type="checkbox"/> 2402.0-2480.0 MHz
In-band power in 100KHz:	<input checked="" type="checkbox"/> 4.5dBm
Limit:	<input checked="" type="checkbox"/> -15.5dBm (20dBc below in-band power)
Nominal Voltage:	<input type="checkbox"/> 120VAC <input checked="" type="checkbox"/> 3.6VDC
Test Personnel:	Yuriy Litvinov <i>Yuriy Litvinov</i>
	Date: 08/25/2021
Measurement Point	<input checked="" type="checkbox"/> Conducted <input type="checkbox"/> Radiated
	Results: >60dBc
Note:	



Conducted Spurious - Low Channel



Conducted Spurious - Mid Channel



Conducted Spurious - High Channel



4.6	Band-Edge Compliance		
Method:	The measurements were made with transmitter set to transmit continuously with modulated signal at low and high channels.		
	Laboratory Ambient Temperature:	23°C	
	Relative Humidity:	48%	
	Atmospheric Pressure:	1011 mbars	
Reference Standard(s):	<input checked="" type="checkbox"/> ANSI C63.10:2013, Section 11.13.2 <input checked="" type="checkbox"/> FCC Part 15.247/RSS 247 <input checked="" type="checkbox"/> KDB 558074	Measurement Point	
		<input checked="" type="checkbox"/> Conducted <input type="checkbox"/> Radiated	
Frequency Range:	<input checked="" type="checkbox"/> 2402.0-2480.0 MHz	Results	
Limit:	<input checked="" type="checkbox"/> >20dBc	Low Ch., 2402 MHz > 48dBc High Ch., 2480 MHz > 52dBc	
Nominal Voltage:	<input type="checkbox"/> 120VAC <input checked="" type="checkbox"/> 3.6VDC		
Test Personnel:	Yuriy Litvinov <i>Yuriy Litvinov</i>	Date: 08/25/2021	

Note:	
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Band Edge - Low Channel
Center Freq. 2.400GHz



Band Edge - High Channel
Center Freq. 2.4835GHz



4.7	Conducted Emissions Data			
Method:	The AMN was placed 0.8 m from the boundary of the unit under test and bonded to a ground reference plane. This distance was between the closest points of the AMN and the EUT. All other units of the EUT and associated equipment was at least 0.8 m from the AMN. All power was connected to the system through Artificial Mains Network (AMN). Conducted voltage measurements on mains lines were made at the output of the AMN.			
	All power was connected to the system through Artificial Mains Network (AMN). All tested telecommunications lines were connected to an Asymmetric Artificial Network (AAN) and conducted voltage measurements on telecommunications lines were made at the output of the ISN. Where an AAN was not appropriate or available measurements were made using a Capacitive Voltage Probe.			
Test Verification: <input type="checkbox"/>	Laboratory Ambient Temperature:			
	Relative Humidity:			
	Atmospheric Pressure:			
Reference Standard(s):	<input type="checkbox"/> RSS GEN/FCC 15.207		Measurement Point <input type="checkbox"/> Mains <input type="checkbox"/> Telecommunication ports <input type="checkbox"/>	
	<input type="checkbox"/> ANSI C63.4:2014			
	<input type="checkbox"/> ANSI C63.10:2013			
Nominal Voltage:	<input type="checkbox"/> 120VAC <input type="checkbox"/> 230VAC <input type="checkbox"/> VDC			
Test Personnel:		Date:		
Limits – Part 15.209/RSS Gen – AC Mains				
Frequency (MHz)	Limit dB (µV)			
	Quasi-Peak	Average	Result	Comments
0.15 to 0.50	66 to 56	56 to 46	N/A	Time Domain Scan
0.50 to 5	56	46	N/A	Time Domain Scan
5 to 30	60	50	N/A	Time Domain Scan

Modifications:	
Note:	



4.8 RF Exposure Evaluation		
Reference Standard(s):	<input checked="" type="checkbox"/> KDB 447498 <input checked="" type="checkbox"/> RSS 102, Issue 5 <input type="checkbox"/>	<input checked="" type="checkbox"/> MPE <input type="checkbox"/> SAR Evaluation <input type="checkbox"/> SAR Test Exclusion
Frequency Range:	<input checked="" type="checkbox"/> 2402-2480.0MHz <input type="checkbox"/>	
Antenna Separation Distance: >20cm		
BT Antenna Gain (maximum): 1.5dBi		
BLE Maximum Output Power: 2.8mW(4.5dBm)		
BLE maximum Power Density: 0.0084 Watts/m ²		
RF Exposure Conditions: Mobile		
MPE Limits		
FCC Part 1.1310 MPE Limit	10 Watts/m ² @2.4GHz	
RSS 102, Issue 5, MPE Limit	5.3508 Watts/m ² @2.4GHz	

Note:	
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5.0	Test Equipment				
Test Equipment Used					
Description	Manufacturer	Model	Identifier	Last Cal. Date	Check
Biconilog Antenna	Schwarzbeck	VULB 9168	9168-1070	10/20/2020	<input checked="" type="checkbox"/>
Horn Antenna	A.H. Systems	SAS 571	1010	10/20/2020	<input checked="" type="checkbox"/>
Loop Antenna	A.H. Systems	EHA-51B	1213E	10/20/2020	<input type="checkbox"/>
EMI Receiver	Rohde & Schwarz	ESW26	101412	10/20/2020	<input checked="" type="checkbox"/>
Signal Analyzer	Agilent	N9000A	MY53031040	10/20/2020	<input checked="" type="checkbox"/>
EMI Receiver	Agilent	E4448A	1530975	10/20/2020	<input checked="" type="checkbox"/>
LISN	TESEQ	NNB51	1130	10/20/2020	<input type="checkbox"/>
Coaxial Cable	Insulated Wire	2803	CBL2039	10/20/2020	<input checked="" type="checkbox"/>
EMC Software	ETS-Lindgren	TILE 7		N/A	<input checked="" type="checkbox"/>
Equipment Calibration Interval:		<input checked="" type="checkbox"/> 12 months		<input type="checkbox"/> 24 months	

6.0	Report revision history		
Revision Level	Date	Report Number	Notes
0	10/06/2021	HRE202008050-1	Original Issue