



FCC Test Report

For:

Appareo Systems, LLC.

Model Name:

Galeo

Product Description:

Small tracking tag that communicates with a mobile application over BLE or cellular. The DUT acquires GPS location and reports its location back to the user.

FCC ID: 2AETC-GALEO

Per:

Title 47 CFR: Part 27

REPORT #: EMC_APPAR-003-20501_FCC_27

DATE: 10/12/2020



A2LA Accredited

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3462B-1
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CETECOM Inc.

411 Dixon Landing Road • Milpitas, CA 95035 • U.S.A.

Phone: + 1 (408) 586 6200 • Fax: + 1 (408) 586 6299 • E-mail: info@cetecom.com • <http://www.cetecom.com>
CETECOM Inc. is a Delaware Corporation with Corporation number: 2905571

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1 Assessment

The following device as further described in section 3 of this report was evaluated for radiated spurious emissions in simultaneous transmission of cellular and 2.4 GHz BLE radio according to criteria specified in the Code of Federal Regulations Title 47 CFR: Part 27

Company	Description	Model #
Appareo IoT, LLC	Small tracking tag that communicates with a mobile application over BLE or cellular. The DUT acquires GPS location and reports its location back to the user.	Galeo

No deficiencies were ascertained.

According to section 6 of this report, the overall result is PASS.

Responsible for Testing Laboratory:

10/12/2020	Compliance	Cindy Li (Lab Manager)	
Date	Section	Name	Signature

Responsible for the Report:

10/12/2020	Compliance	Kris Lazarov (EMC Engineer)	
Date	Section	Name	Signature

The test results of this test report relate exclusively to the test item specified in Section 3.
CETECOM Inc. USA does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item. The test report may only be reproduced or published in full. Reproduction or publication of extracts from the report requires the prior written approval of CETECOM Inc. USA.

2 Administrative Data

2.1 Identification of the Testing Laboratory Issuing the EMC Test Report

Company Name:	CETECOM Inc.
Department:	Compliance
Street Address:	411 Dixon Landing Road
City/Zip Code	Milpitas, CA 95035
Country	USA
Telephone:	+1 (408) 586 6200
Fax:	+1 (408) 586 6299
Lab Manager:	Li, Cindy
Responsible Project Leader:	Akanksha Baskaran

2.1 Identification of the Client

Applicant's Name:	Appareo Systems, LLC.
Street Address:	1810 NDSU Research Cir. N.
City/Zip Code	Fargo, ND 58102
Country	USA

2.2 Identification of the Manufacturer

Manufacturer's Name:	Same as client.
Manufacturers Address:	-----
City/Zip Code	-----
Country	-----

3 Equipment Under Test (EUT)

3.1 EUT Specifications

Model #:	Galeo
FCC ID:	2AETC-GALEO
HW Version :	X07
SW Version :	0.4.0.373
HVIN:	N/A
PMN:	N/A
Product Description:	Small tracking tag that communicates with a mobile application over BLE or cellular. The DUT acquires GPS location and reports its location back to the user.
Transceiver Technology / Type(s) of Modulation:	❖ Cellular Module: nRF9160 with CAT M1, FCC ID: 2ANPO00NRF9160 • 4G: Only LTE FDD Bands 4, 13 enabled
Frequency Range:	• LTE Band 4: 1710 ~ 1755 MHz • LTE Band 13: 777 ~ 787MHz
Max. declared antenna gain:	❖ Internal, Trace Antenna Inverted F • Peak gain [dBi] ▪ 777-787 MHz : -2.91 ▪ 1710-1785 MHz : 0.42
Operating voltage:	Vmin: 4.75 VDC / Vnom: 5.0 VDC / Vmax: 5.25 VDC
Operating Temperature Range	-20°C to 60 °C
Other Radios included in the device:	❖ Onboard BTLE based on Nordic Semiconductor device • nRF52832
Sample Revision	☐ Prototype Unit; ☐ Production Unit; ☒ Pre-Production
EUT Diameter	☒ < 60 cm ☐ Other _____

3.2 EUT Sample details

EUT #	IMEI / Serial Number	HW Version	SW Version	Notes/Comments
1	352656100307910	X07	0.4.0.373	Radiated

3.3 Accessory Equipment (AE) details

AE #	Type	Model	Manufacturer	Serial Number
Adapter	USB	N/A	N/A	N/A

3.4 Test Sample Configuration

EUT Set-up #	Combination of AE used for test set up	Comments
1	EUT#1	The EUT was connected to an engineering test harnesses for test setup by applying AT commands and is thereafter disconnected and the charger is connected.

3.5 Mode of Operation details

Mode of Operation	Description of Operating modes	Additional Information
Op. 1	Cellular & BLE Co-TX	Cellular was tested on Low, Mid and High Channels at the maximum power, simultaneous transmission with BTLE 2.4 GHz. Cellular was configured using AT commands, through TeraTerm terminal. software tool was provided by the client, to configure the BLE 2.4GHz radio: ▪ Mode: <u>BLE</u> ▪ Transmit mode: Continuous <u>TX</u> ▪ Duty cycle: <u>100%</u> ▪ Channel: Low , Mid, High, <u>Channel # 13</u> ▪ Data rate: <u>1 Mb/s</u> The internal antenna was connected.

3.6 Justification for Worst Case Mode of Operation

During the testing process the cellular radio was tested with transmitter set to low, mid and high channel at the maximum power in simultaneous transmission mode with the worst case mode of BLE 2.4 GHz radio.

For radiated measurements, all data in this report shows the worst case between horizontal and vertical antenna polarizations and for all orientations of the EUT.

4 Subject of Investigation

The objective of the evaluation conducted by CETECOM Inc. is to perform and check radiated spurious emissions against the limits per Code of Federal Regulations Title 47 CFR: Part 27 in simultaneous transmission mode of Nordic semiconductor Cellular Module: nRF9160 and with the nRF52832 BTLE implementation

4.1 Dates of Testing:

08/03/20 – 08/06/2020

4.2 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus, with 95% confidence interval (in dB delta to result), based on a coverage factor k=1.

Radiated measurement

9 kHz to 30MHz	±2.5 dB (Magnetic Loop Antenna)
30 MHz to 1000 MHz	±2.0 dB (Biconilog Antenna)
1 GHz to 40 GHz	±2.3 dB (Horn Antenna)

4.3 Environmental Conditions during Testing:

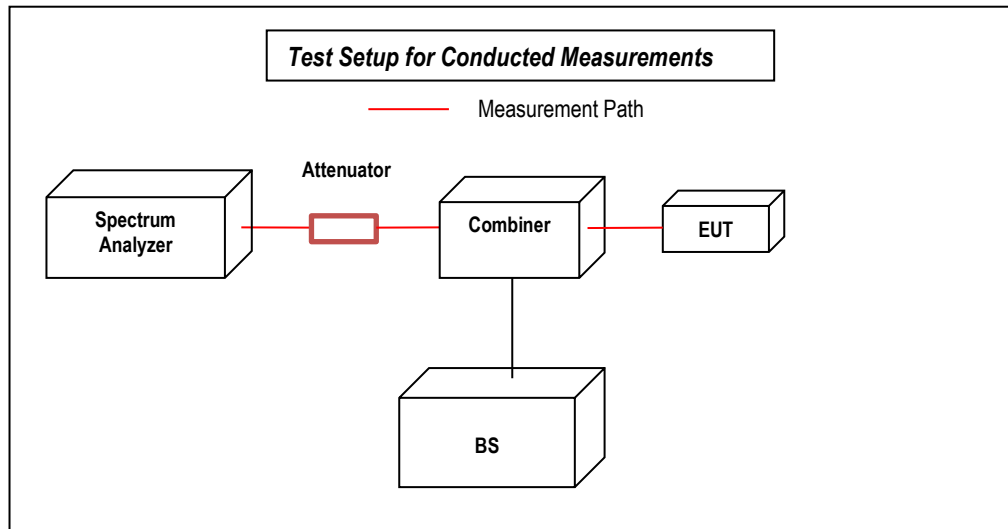
The following environmental conditions were maintained during the course of testing:

- Ambient Temperature: 20-25°C
- Relative humidity: 40-60%

Deviating test conditions are indicated at individual test description where applicable.

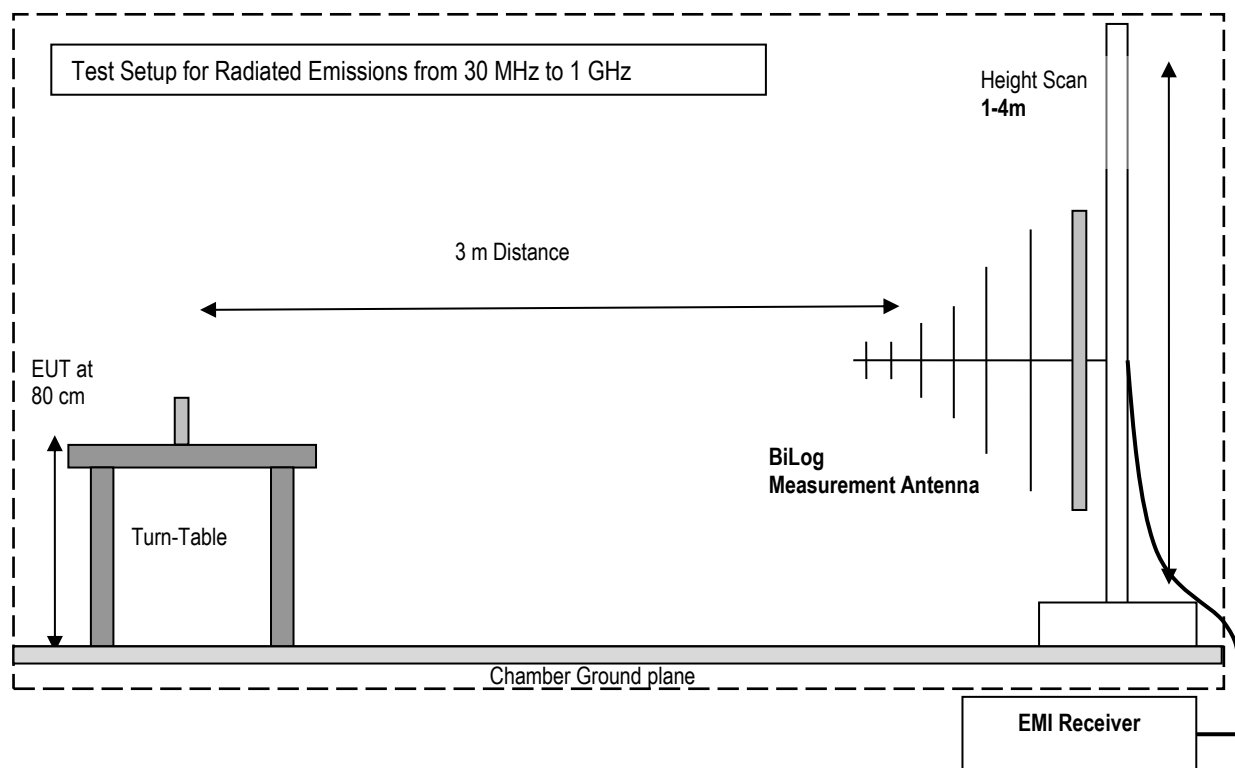
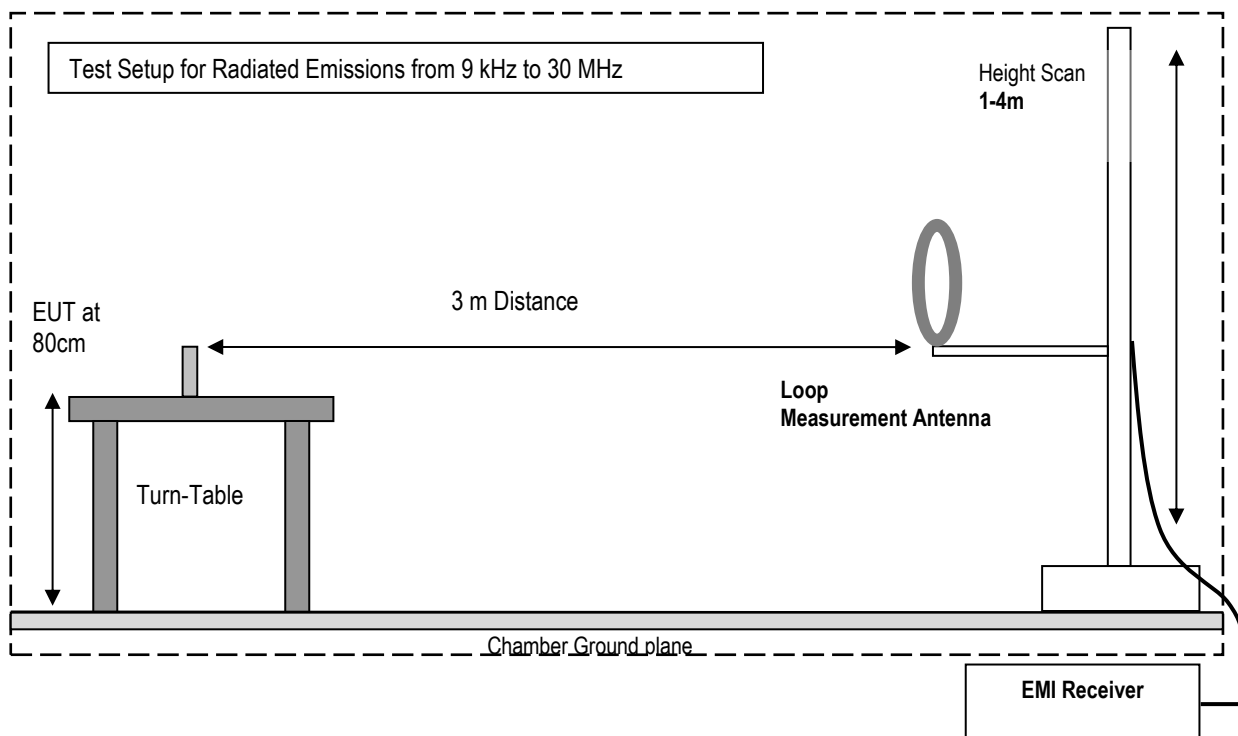
5 Measurement Procedures

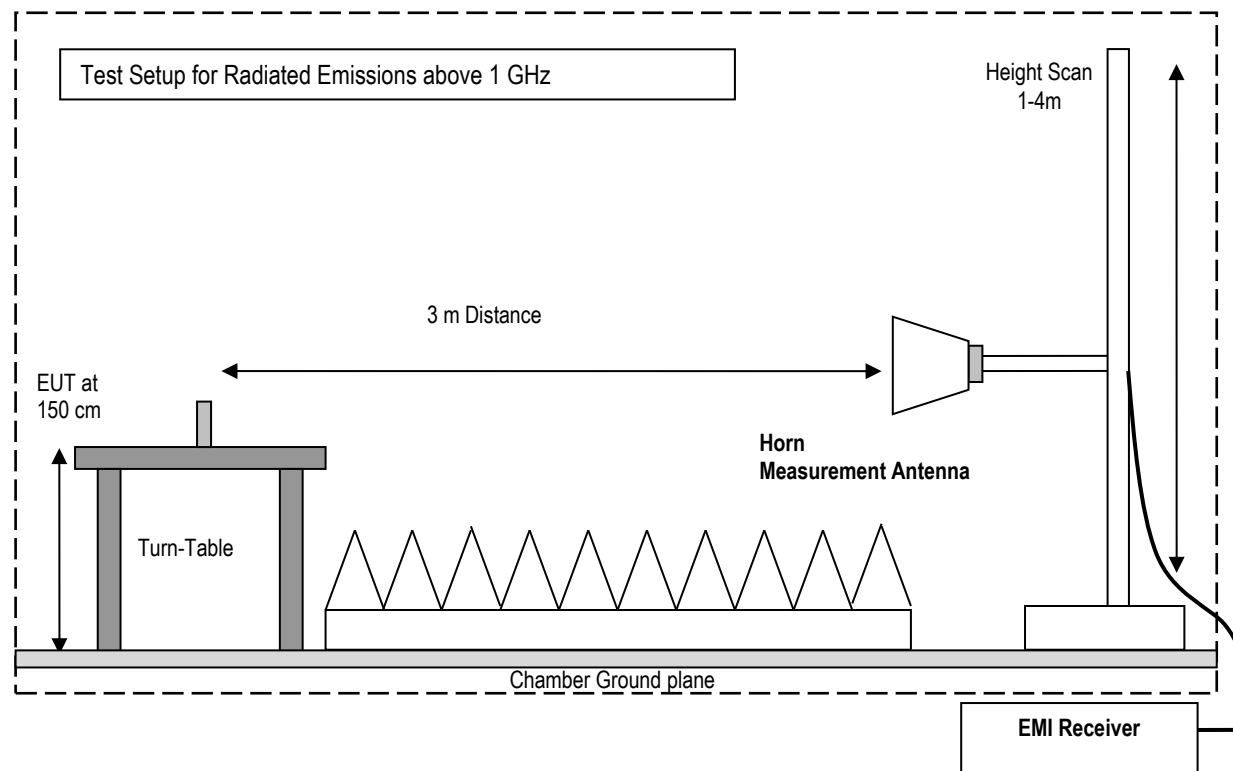
Testing is performed according to the guidelines provided in FCC publication (KDB) 971168 D01 v03r01 – “Measurement Guidance for Certification of Licensed Digital Transmitters” and according to ANSI C63.26 as detailed below.



5.1 Radiated Measurement

- The exploratory measurement is accomplished by running a matrix of 16 sweeps over the required frequency range with R&S Test-SW EMC32 for 360° continuous measurement of the turntable, two orthogonal positions of the EUT and both antenna polarizations. This procedure exceeds the requirement of the above standards to cover the 3 orthogonal axis of the EUT. A max peak detector is utilized during the exploratory measurement. The Test-SW creates an overall maximum trace for all 12 sweeps and saves the settings for each point of this trace. The maximum trace is part of the test report.
- The 10 highest emissions are selected with an automatic algorithm of EMC32 searching for peaks in the noise floor and ensuring that broadband signals are not selected multiple times.
- The maxima are then put through the final measurement and again maximized in a 90deg range of the turntable, fine search in frequency domain and height scan between 1m and 4m.
- The above procedure is repeated for all possible ways of power supply to EUT and for all supported modulations.
- In case there are no emissions above noise floor level only the maximum trace is reported as described above.
- The results are split up into up to 4 frequency ranges due to antenna bandwidth restrictions. A magnetic loop is used from 9 kHz to 30 MHz, a Biconilog antenna is used from 30 MHz to 1 GHz, and two different horn antennas are used to cover frequencies up to 40 GHz.





5.2 Sample Calculations for Field Strength Measurements

Field Strength is calculated from the Spectrum Analyzer/ Receiver readings, taking into account the following parameters:

- Measured reading in dB μ V
- Cable Loss between the receiving antenna and SA in dB and
- Antenna Factor in dB/m

All radiated measurement plots in this report are taken from a test SW that calculates the Field Strength based on the following equation:

$$FS \text{ (dB}\mu\text{V/m)} = \text{Measured Value on SA (dB}\mu\text{V)} + \text{Cable Loss (dB)} + \text{Antenna Factor (dB/m)}$$

Example:

Frequency (MHz)	Measured SA (dB μ V)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dB μ V/m)
1000	80.5	3.5	14	98.0

6 Measurement Results Summary

6.1 FCC 27:

Test Specification	Test Case	Temperature and Voltage Conditions	Mode	Pass	Fail	NA	NP	Result
§2.1046; §27.50 (d)	RF Output Power	Nominal	-	☐	☐	☐	☒	Note 1 Note 2
§2.1055; §27.54	Frequency Stability	Nominal	-	☐	☐	☐	☒	Note 1 Note 2
§2.1049; §27.53	Occupied Bandwidth	Nominal	-	☐	☐	☐	☒	Note 1 Note 2
§2.1051; §27.53	Band Edge Compliance	Nominal	-	☐	☐	☐	☒	Note 1 Note 2
§2.1051; §27.53	Conducted Spurious Emissions	Nominal	-	☐	☐	☐	☒	Note 1 Note 2
§2.1053; §27.53(g); §27.53(h);	Radiated Spurious Emissions	Nominal	LTE 4, 13	☒	☐	☐	☐	Complies

Note 1: NA= Not Applicable; NP= Not Performed.

Note 2: Leveraged from module certification of nRF9160 with FCC ID: 2ANPO00NRF9160

7 Test Result Data

7.1 ERP / EIRP

Module Supplier Name:	Nordic Semiconductor					
Model Number:	nRF9160					
FCC ID:	2ANPO00NRF9160					
Max. declared antenna gain:	❖ Internal, • Peak gain [dBi] ▪ 777-787 MHz: -2.91 ▪ 1710-1785 MHz: 0.42					
Band	Frequency range (MHz)	Emission Designator	Power (Watts)	Gain (dBi)	Gain (Lin)	ERP < 1GHz EIRP > 1GHz (Watts)
LTE 4	1710 – 1755	1M12G7W	0.207	0.42	1.102	0.228
LTE 4	1710 – 1755	952KD7W	0.171	0.42	1.102	0.188
LTE 4	1710 – 1755	204KG7W	0.218	0.42	1.102	0.240
LTE 13	777 – 787	1M11G7W	0.179	-2.91	0.512	0.056
LTE 13	777 – 787	947KD7W	0.183	-2.91	0.512	0.057
LTE 13	777 – 787	203KG7W	0.212	-2.91	0.512	0.066

Note: ERP / EIRP are calculated from maximum power in cellular module Report, adding known peak gain of the utilized cellular antenna.

7.2 Radiated Spurious Emissions

7.2.1 Measurement according to FCC: CFR 47 Part 2.1053; CFR Part 22.917; CFR Part 24.238, Part 27.53 utilizing KDB 971168 D01 Power Meas License Digital Systems v03r01, and according to ANSI C63.26 2015

Spectrum Analyzer Settings for FCC 22

Frequency Range	30 MHz – 1 GHz	1 – 1.58 GHz	1.58 – 9 GHz
Resolution Bandwidth	100 kHz	1 MHz	1 MHz
Video Bandwidth	100 kHz	1 MHz	1 MHz
Detector	Peak	Peak	Peak
Trace Mode	Max Hold	Max Hold	Max Hold
Sweep Time	Auto	Auto	Auto

Spectrum Analyzer Settings for FCC 24 and 27

Frequency Range	30MHz – 1 GHz	1 – 2.7 GHz	2.7 – 18 GHz	18 – 19.1 GHz
Resolution Bandwidth	100 kHz	1 MHz	1 MHz	1 MHz
Video Bandwidth	100 kHz	1 MHz	1 MHz	1 MHz
Detector	Peak	Peak	Peak	Peak
Trace Mode	Max Hold	Max Hold	Max Hold	Max Hold
Sweep Time	Auto	Auto	Auto	Auto

7.2.2 Limits:

7.2.2.1 FCC Part 22.917 (a); FCC Part 24.238 (a); FCC Part 27.53 (h)

Out of band emissions. The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least $43 + 10 \log(P)$ dB.

7.2.3 Test conditions and setup:

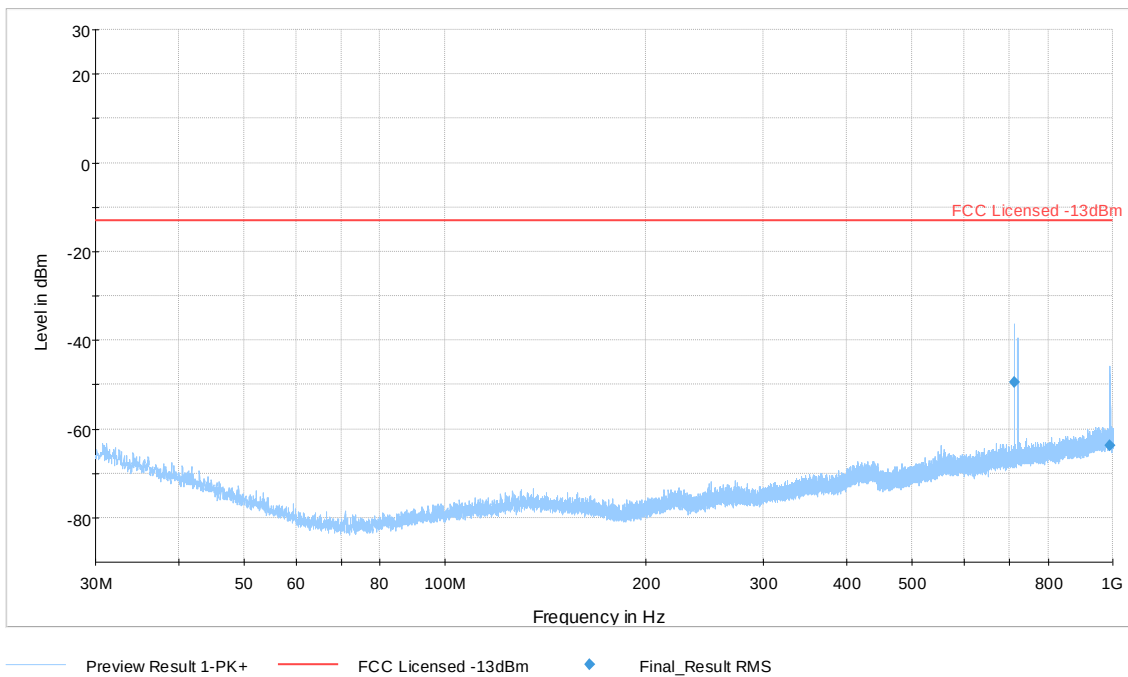
Ambient Temperature (C)	EUT operating mode	Power Input
22	Op. 1	Battery / USB Charger

7.2.4 Measurement result:

Plot #	Channel	EUT operating mode	Scan Frequency	Limit (dBm)	Result
1-3	Low	LTE Band 4	30 MHz – 18 GHz	-13	Pass
4-6	Mid		30kHz – 18 GHz	-13	Pass
7-9	High		30 MHz – 18 GHz	-13	Pass
10-12	Mid	LTE Band 13	30 MHz – 9 GHz	-13	Pass

7.2.5 Measurement plots:

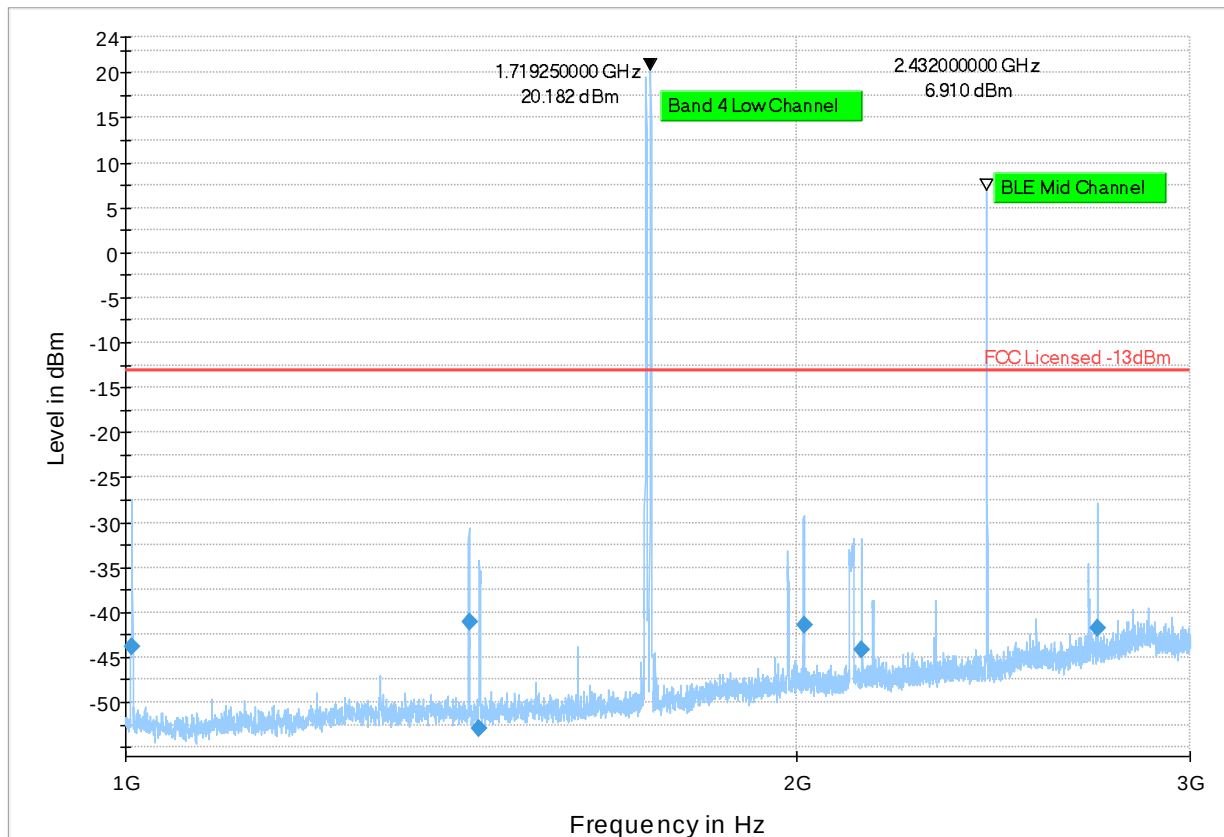
No significant emissions were found below 30 MHz, therefore no plots / result tables for this frequency range are submitted below.

LTE 4**Plot # 1 Radiated Emissions: 30 MHz – 1GHz****Channel: Low**

Plot # 2 Radiated Emissions: 1 GHz - 3 GHz

Channel: Low

Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Comment
1006.500000	-43.80	-13.00	30.80	500.0	1000.000	107.0	H	149.0	-68.2	
1425.250000	-41.12	-13.00	28.12	500.0	1000.000	142.0	H	145.0	-66.7	
1440.750000	-52.96	-13.00	39.96	500.0	1000.000	202.0	V	67.0	-66.7	
2013.500000	-41.44	-13.00	28.44	500.0	1000.000	176.0	H	159.0	-63.7	
2138.000000	-44.21	-13.00	31.21	500.0	1000.000	219.0	H	132.0	-63.4	
2726.000000	-41.77	-13.00	28.77	500.0	1000.000	243.0	H	147.0	-61.5	



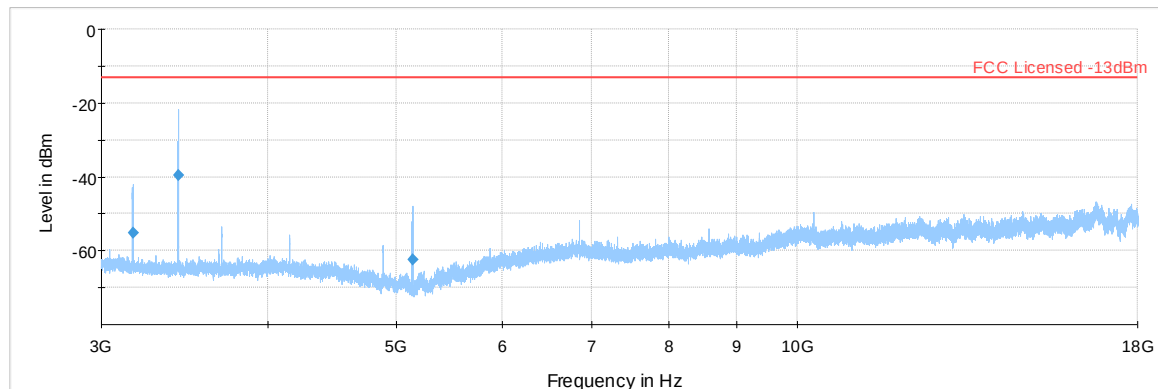
Preview Result 1-PK+ FCC Licensed -13dBm Final_Result RMS

Plot # 3 Radiated Emissions: 3 GHz – 18 GHz

Channel: Low

Final Result

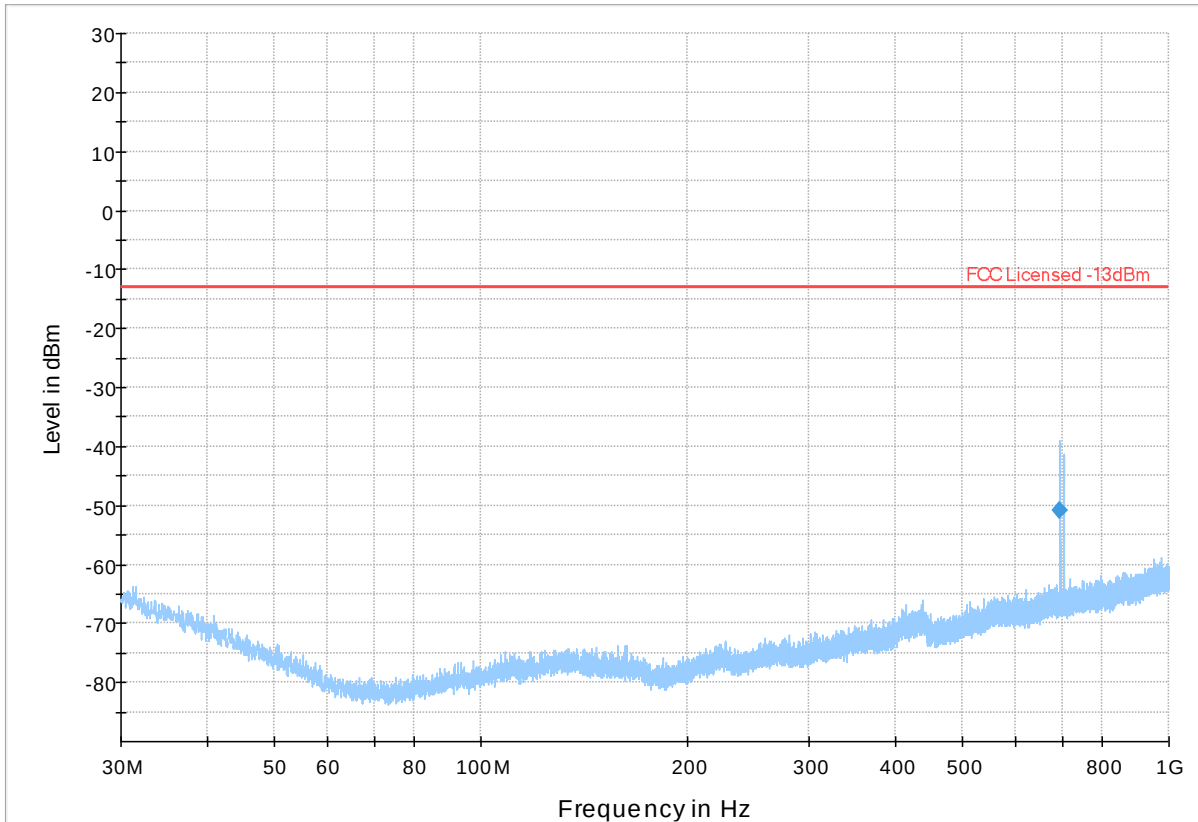
Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Comment
3169.000000	-55.20	-13.00	42.20	500.0	1000.000	151.0	V	233.0	-105.8	
3429.000000	-39.55	-13.00	26.55	500.0	1000.000	151.0	V	220.0	-105.2	
5143.750000	-62.49	-13.00	49.49	500.0	1000.000	270.0	V	109.0	-101.5	



Plot # 4 Radiated Emissions: 30 MHz – 1GHz

Channel: Mid

Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Comment
695.177500	-50.86	-13.00	37.86	500.0	100.000	100.0	H	53.0	-72.3	



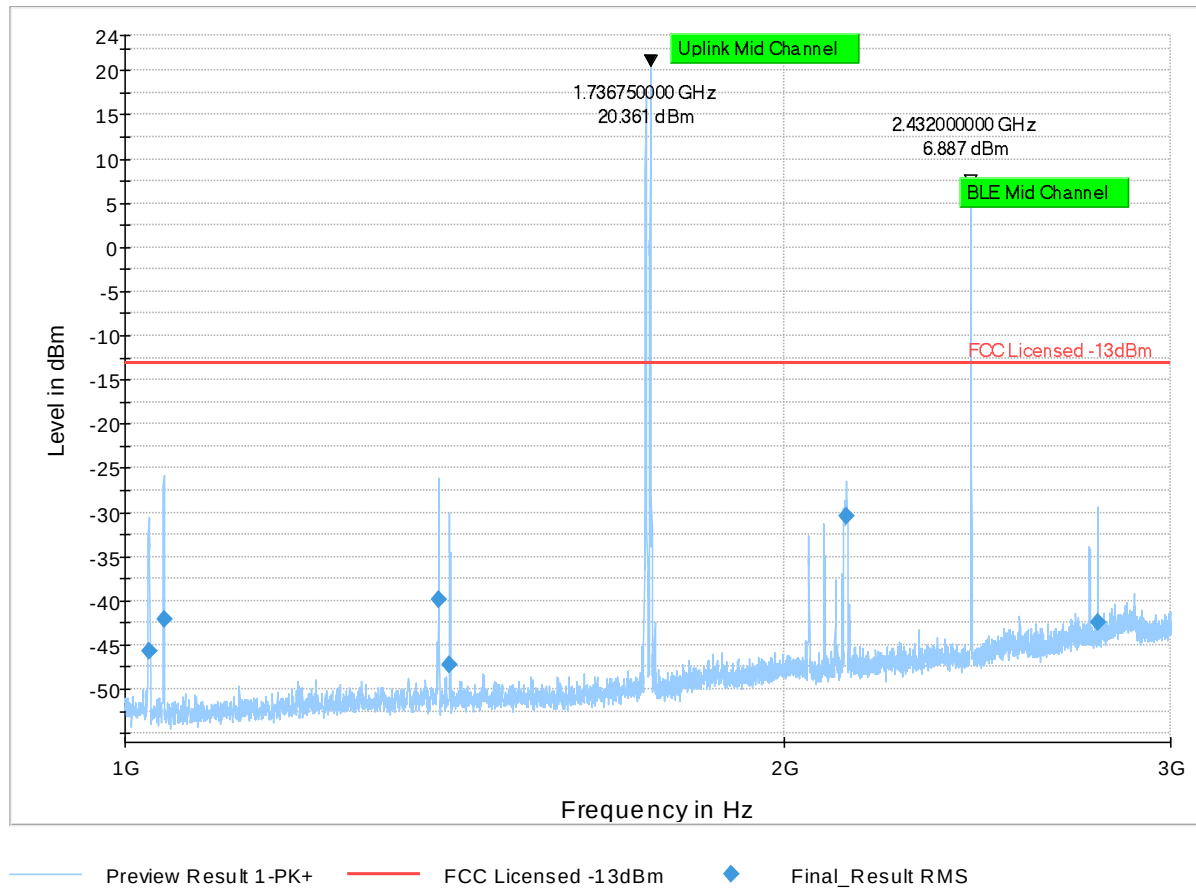
Preview Result 1-PK+ FCC Licensed -13dBm Final_Result RMS

Plot # 5 Radiated Emissions: 1 GHz - 3 GHz

Channel: Mid

Final_Result

Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Comment
1025.250000	-45.70	-13.00	32.70	500.0	1000.000	100.0	H	223.0	-68.1	
1041.500000	-42.04	-13.00	29.04	500.0	1000.000	100.0	H	221.0	-68.1	
1390.250000	-39.82	-13.00	26.82	500.0	1000.000	100.0	H	164.0	-66.6	
1406.500000	-47.24	-13.00	34.24	500.0	1000.000	141.0	H	162.0	-66.7	
2134.250000	-30.42	-13.00	17.42	500.0	1000.000	267.0	H	114.0	-63.5	
2778.750000	-42.42	-13.00	29.42	500.0	1000.000	236.0	H	162.0	-61.2	

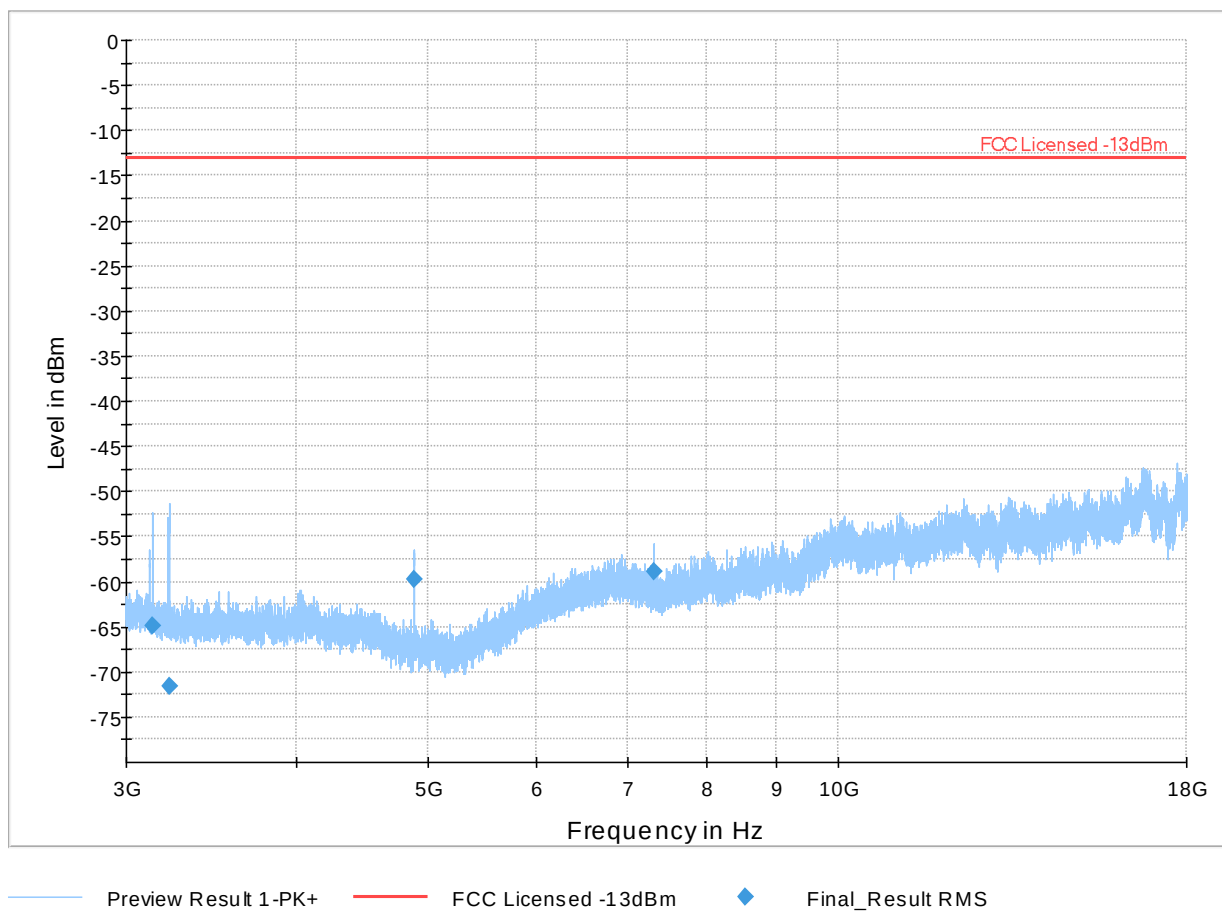


Plot # 6 Radiated Emissions: 3 GHz – 18 GHz

Channel: Mid

Final_Result

Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Comment
3136.250000	-64.92	-13.00	51.92	500.0	1000.000	150.0	V	121.0	-105.7	
3224.250000	-71.59	-13.00	58.59	500.0	1000.000	125.0	H	200.0	-105.9	
4880.500000	-59.80	-13.00	46.80	500.0	1000.000	150.0	V	13.0	-102.0	
7319.500000	-58.94	-13.00	45.94	500.0	1000.000	262.0	V	236.0	-99.0	

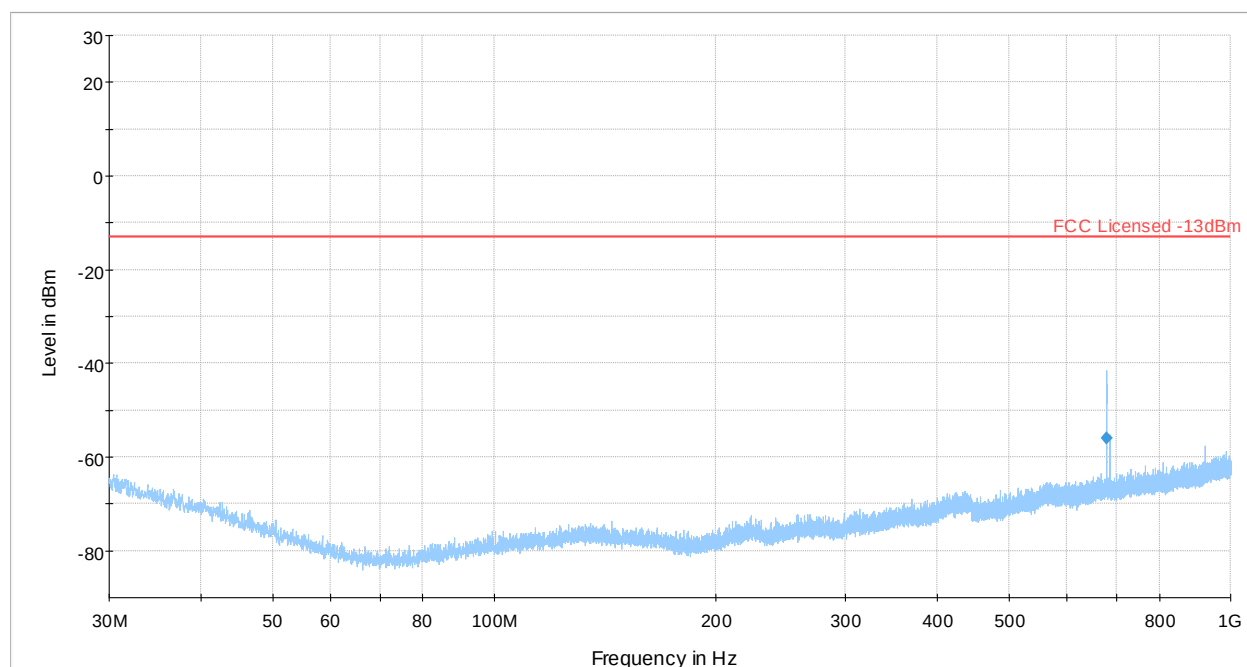


Plot # 7 Radiated Emissions: 30 MHz – 1GHz

Channel: High

Final Result

Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Comment
677.644760	-55.89	-13.00	42.89	500.0	100.000	100.0	H	47.0	-72.1	



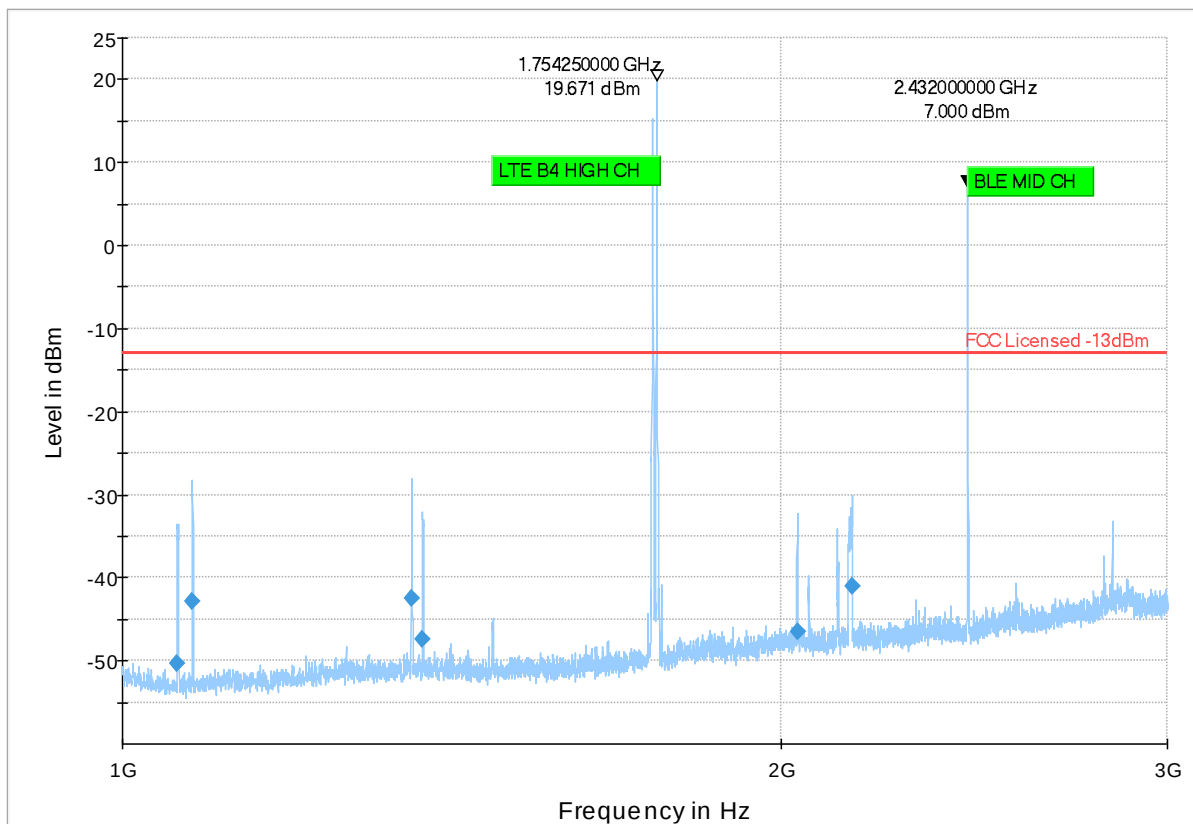
Preview Result 1-PK+ FCC Licensed -13dBm Final_Result RMS

Plot # 8 Radiated Emissions: 1 GHz - 3 GHz

Channel: High

Final_Result

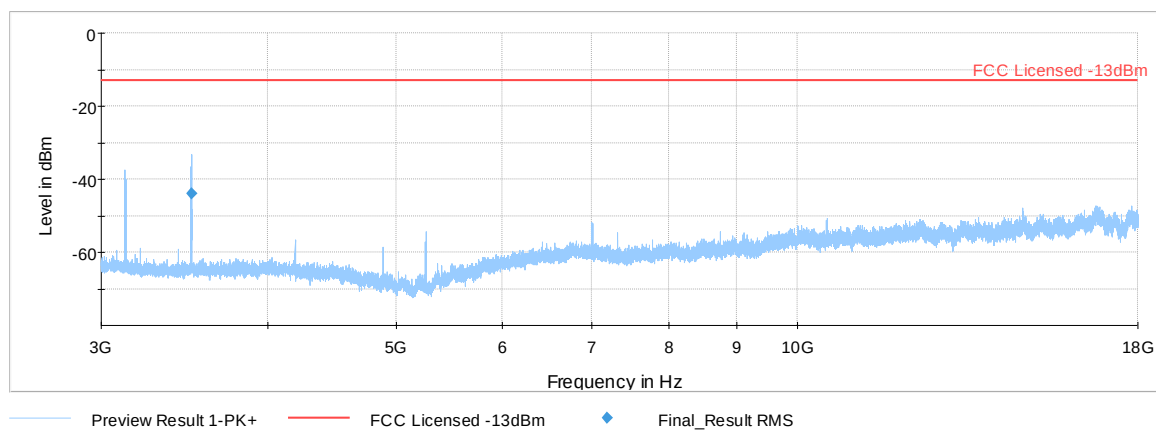
Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Comment
1059.750000	-50.27	-13.00	37.27	500.0	1000.000	100.0	H	226.0	-68.0	
1076.500000	-42.78	-13.00	29.78	500.0	1000.000	100.0	H	211.0	-67.9	
1355.000000	-42.53	-13.00	29.53	500.0	1000.000	107.0	H	147.0	-66.6	
1371.250000	-47.50	-13.00	34.50	500.0	1000.000	150.0	H	154.0	-66.6	
2033.000000	-46.46	-13.00	33.46	500.0	1000.000	100.0	H	153.0	-63.7	
2153.500000	-41.00	-13.00	28.00	500.0	1000.000	145.0	H	155.0	-63.4	



Preview Result 1-PK+ FCC Licensed -13dBm Final_Result RMS

Plot # 9 Radiated Emissions: 3 GHz – 18 GHz

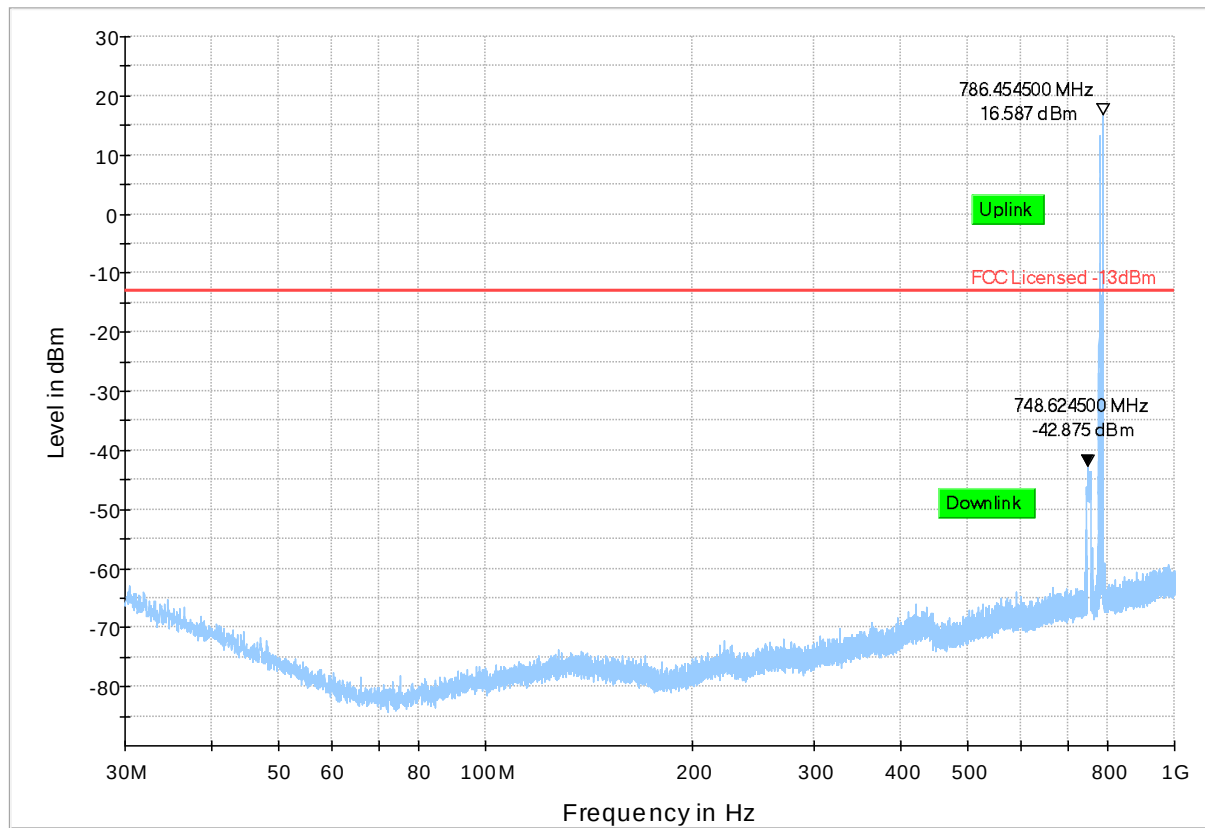
Channel: High



LTE 13

Plot # 10 Radiated Emissions: 30 MHz – 1GHz

Channel: Mid



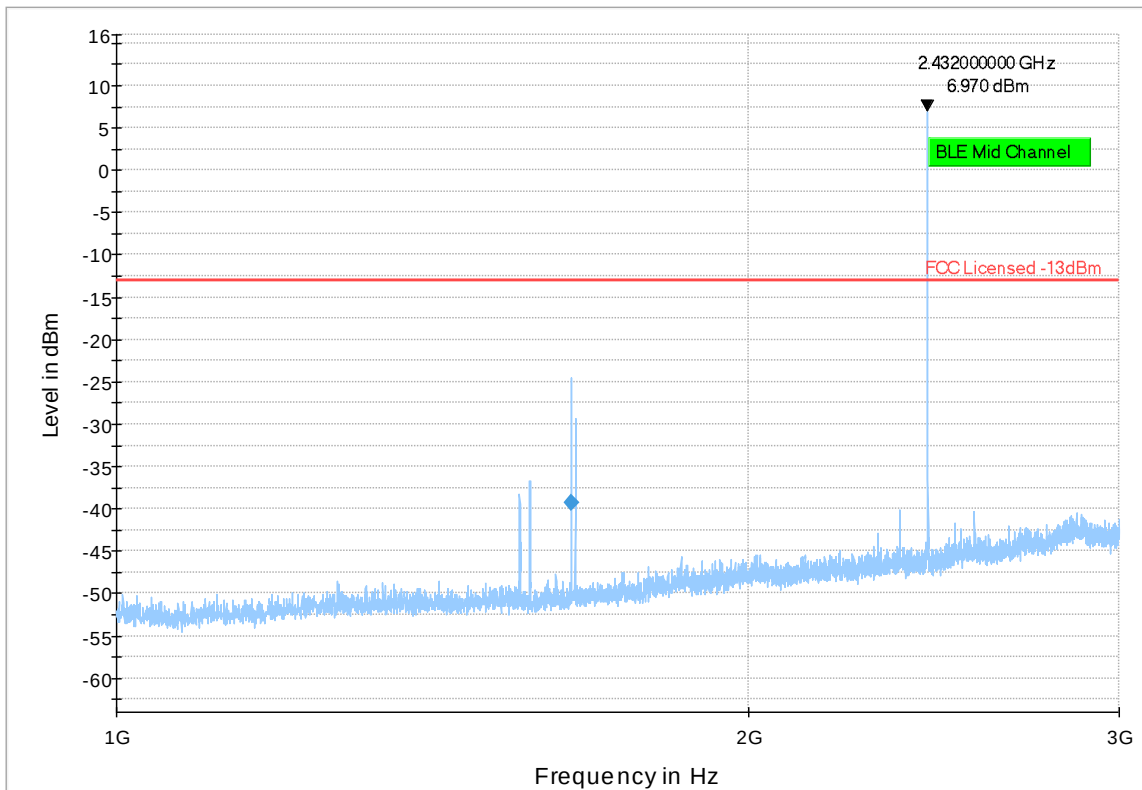
— Preview Result 1-PK+ * Critical_Freqs PK+ — FCC Licensed -13dBm ◆ Final_Result RM

Plot # 11 Radiated Emissions: 1 GHz - 3 GHz

Channel: Mid

Final Result

Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Comment
1645.500000	-39.36	-13.00	26.36	500.0	1000.000	116.0	H	156.0	-65.5	



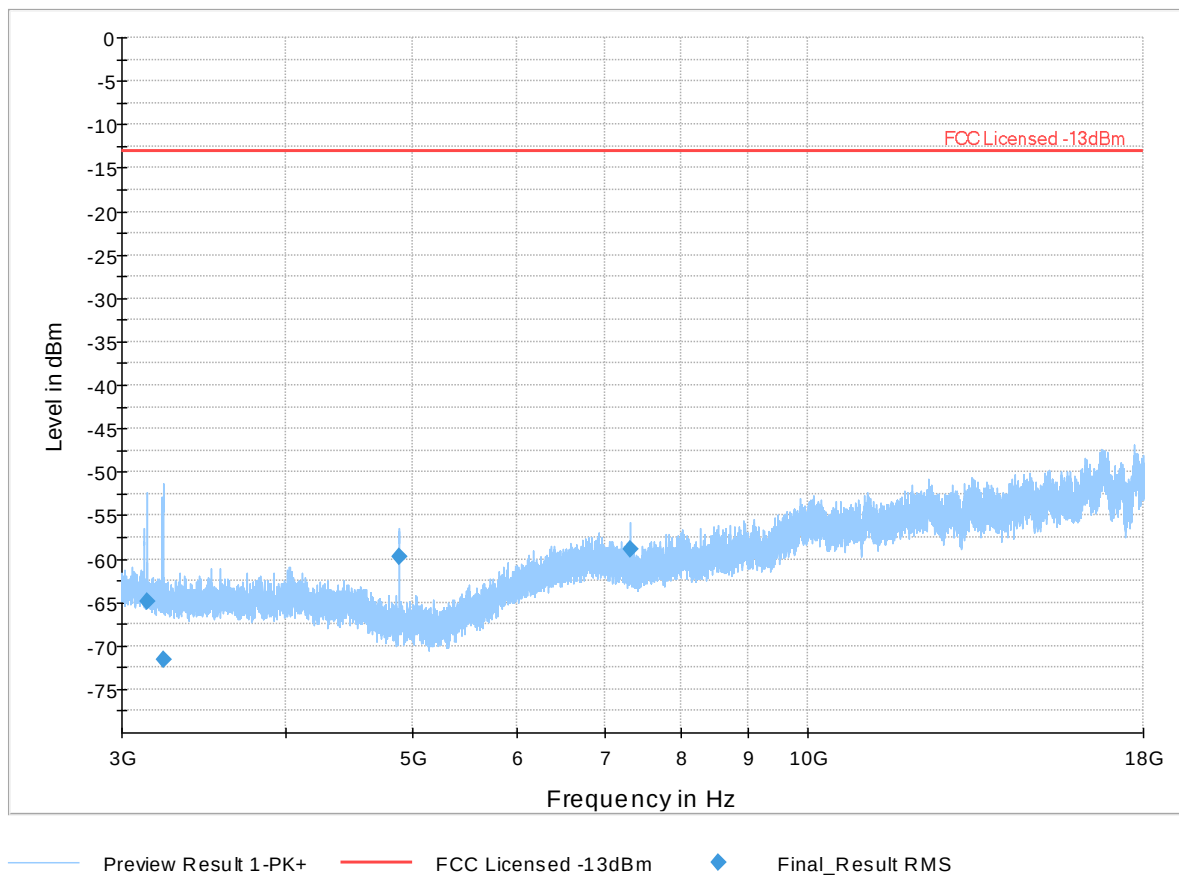
Preview Result 1-PK+ FCC Licensed -13dBm Final_Result RMS

Plot # 12 Radiated Emissions: 3 GHz – 18 GHz

Channel: Mid

Final_Result

Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Comment
3136.250000	-64.92	-13.00	51.92	500.0	1000.000	150.0	V	121.0	-105.7	
3224.250000	-71.59	-13.00	58.59	500.0	1000.000	125.0	H	200.0	-105.9	
4880.500000	-59.80	-13.00	46.80	500.0	1000.000	150.0	V	13.0	-102.0	
7319.500000	-58.94	-13.00	45.94	500.0	1000.000	262.0	V	236.0	-99.0	



8 Test setup photos

Setup photos are included in supporting file name: "EMC_APPAR-003-20501_FCC_27_Setup_Photos.pdf"

9 Test Equipment And Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
Loop Antenna	ETS Lindgren	6507	161344	3 years	10/26/2017
Biconlog Antenna	ETS Lindgren	3142E	166067	3 years	03/12/2020
Horn Antenna	ETS Lindgren	3115	35111	3 years	04/17/2019
Horn Antenna	ETS Lindgren	3117-PA	215984	3 years	01/26/2018
Horn Antenna	ETS Lindgren	3116C-PA	169535	3 years	09/24/2017
EMI Receiver	R&S	ESU40	100251	3 years	07/16/2019
Base Station simulator	R&S	CMW 500	116865	3 years	12/03/2019

Note: Equipment used meets the measurement uncertainty requirements as required per applicable standards for 95% confidence levels.

Calibration due dates, unless defined specifically, falls on the last day of the month. Items indicated "N/A" for cal status either do not specifically require calibration or is internally characterized before use.

10 Revision History

Date	Report Name	Changes to report	Report prepared by
8/14/2020	EMC_APPAR-003-20501_FCC_27	Draft Version	Chin Ming Lui
10/12/2020	EMC_APPAR-003-20501_FCC_27	Fixed typo on P7 & 14. Corrected frequency Sec 7.1 Removed Draft Watermark	Kris Lazarov

<<< The End >>>
