



FCC/IC Test Report

For:
Particle Industries, Inc.

Model:
BRN404X
BORON 404X with BQ24195L (PMIC)

Product Description:
LTE Development Board with EtherSIM

Contains FCC ID: 2AEMI-BRN404X
Contains IC: 20127-BRN404X

Applied Rules and Standards:
47 CFR Parts: 15B, and ICES-003 Issue 7

REPORT #: EMC_PARTI_001_21001_FCC_15B_Rev1

DATE: 2023-02-13



A2LA Accredited

IC recognized #
3462B-2

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1 Assessment

The following device as further described in section 3 of this report was evaluated against the applicable criteria specified in the Code of Federal Regulations Title 47 parts 15B and ICES-003 Issue 7.

No deficiencies were ascertained.

| Company | Description | Model |
|---------------------------|-------------------------------------|---|
| Particle Industries, Inc. | LTE Development Board with EtherSIM | BRN404X BORON 404X with BQ24195L (PMIC) |

Responsible for Testing Laboratory:

| 2023-02-13 | Compliance | Arndt Stoecker (Director of Regulatory Services) | |
|------------|------------|---|-----------|
| Date | Section | Name | Signature |

Responsible for the Report:

| 2023-02-13 | Compliance | Cheng Song (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 |
| EMC Lab Manager: | Arndt Stoecker |
| Responsible Project Leader: | Phillip Quintal |

2.2 Identification of the Client

| | |
|--------------------------|---------------------------|
| Client Firm/Name: | Particle Industries, Inc. |
| Street Address: | 325 9th St |
| City/Zip Code | San Francisco, CA 94103 |
| Country | USA |

2.3 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 | BRN404X, BORON 404X with BQ24195L (PMIC) |
| HW Version | V1.5.0 |
| SW Version | V4.0.0 |
| Product Description | LTE Development Board with EtherSIM |
| Contains FCC-ID | 2AEMI-BRN404X |
| Contains IC: | 20127-BRN404X |
| PMN | Boron |
| Operating Voltage Range | DC 5V from Host Unit or DC 3.7V from Li-ion battery Vmin = 3.4V, Vmax = 4.4V, Vnom = 3.7V |
| Operating Temperature Range | Tmin: -20 °C / Tmax: 60 °C / Tnom: 25 °C |
| Radios included in the device | <p>Cellular:</p> <ul style="list-style-type: none"> • u-blox SARA-R510S • FCC ID: XPYUBX19KM01; IC: 8595A-UBX19KM01 <p>Bluetooth:</p> <ul style="list-style-type: none"> • Nordic Semiconductor nRF52840 SoC • Bluetooth 5 LE |
| Antenna Information: | <p>Cellular:</p> <ul style="list-style-type: none"> • G142-10006-A antenna • Wide band FPC antenna: 3.86dBi max gain <p>Bluetooth:</p> <ul style="list-style-type: none"> • PCB antenna: 2dBi max gain |
| Sample Revision | <input type="checkbox"/> Prototype <input type="checkbox"/> Production <input checked="" type="checkbox"/> Pre-Production |
| EUT Diameter | <input checked="" type="checkbox"/> < 60 cm <input type="checkbox"/> Other _____ |

3.2 EUT Sample details

| EUT # | Model Number | HW Version | SW Version | Comments |
|-------|--------------|------------|------------|----------|
| 1 | BRN404X | V1.5.0 | V4.0.0 | |

3.3 Accessory Equipment (AE) details

| AE # | Type | Model | Manufacturer | Serial Number |
|-------------|-------------|--------------|---------------------|----------------------|
| 1 | | | | |

3.4 Test Sample Configuration

| Set-up # | EUT / AE used for set-up | Comments |
|-----------------|---------------------------------|-----------------|
| 1 | EUT#1 | Idle |

4 Subject of Investigation

The objective of the measurements done by CETECOM Inc. was to evaluate the compliance of the EUT against the relevant requirements specified in the Code of Federal Regulations Title 47 parts 15B and ICES-003 Issue 7.

4.1 Date of Testing:

09/07/2022 – 09/08/2022

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=2.

| Measurement System | EMC 1 | EMC 2 |
|----------------------------------|---------|---------|
| Conducted emissions (mains port) | 1.12 dB | 0.46 dB |
| Radiated emissions (< 30 MHz) | 3.66 dB | 3.88 dB |
| (30 MHz – 1GHz) | 3.17 dB | 3.34 dB |
| (1 GHz – 3 GHz) | 5.01 dB | 4.45 dB |
| (>3 GHz) | 4.0 dB | 4.79 dB |

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.

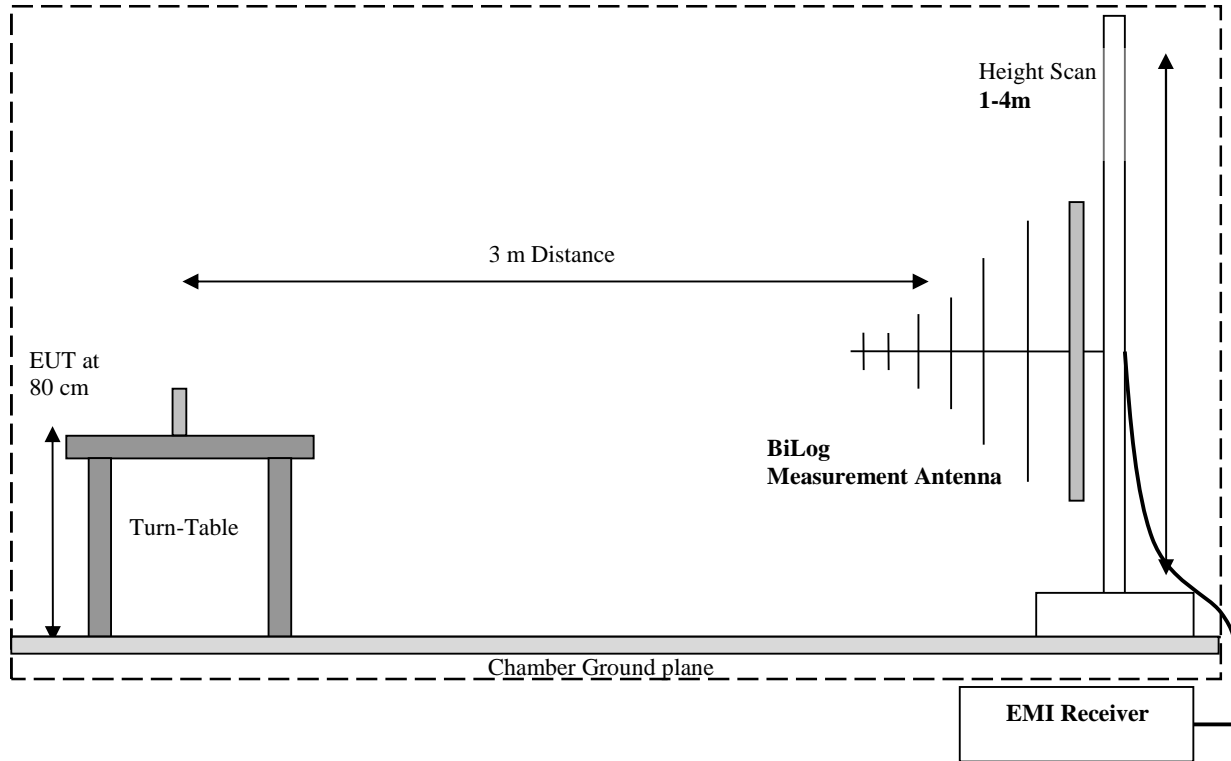
5 Measurement Procedures

Testing is performed according to the guidelines provided in ANSI C63.4-2014 American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

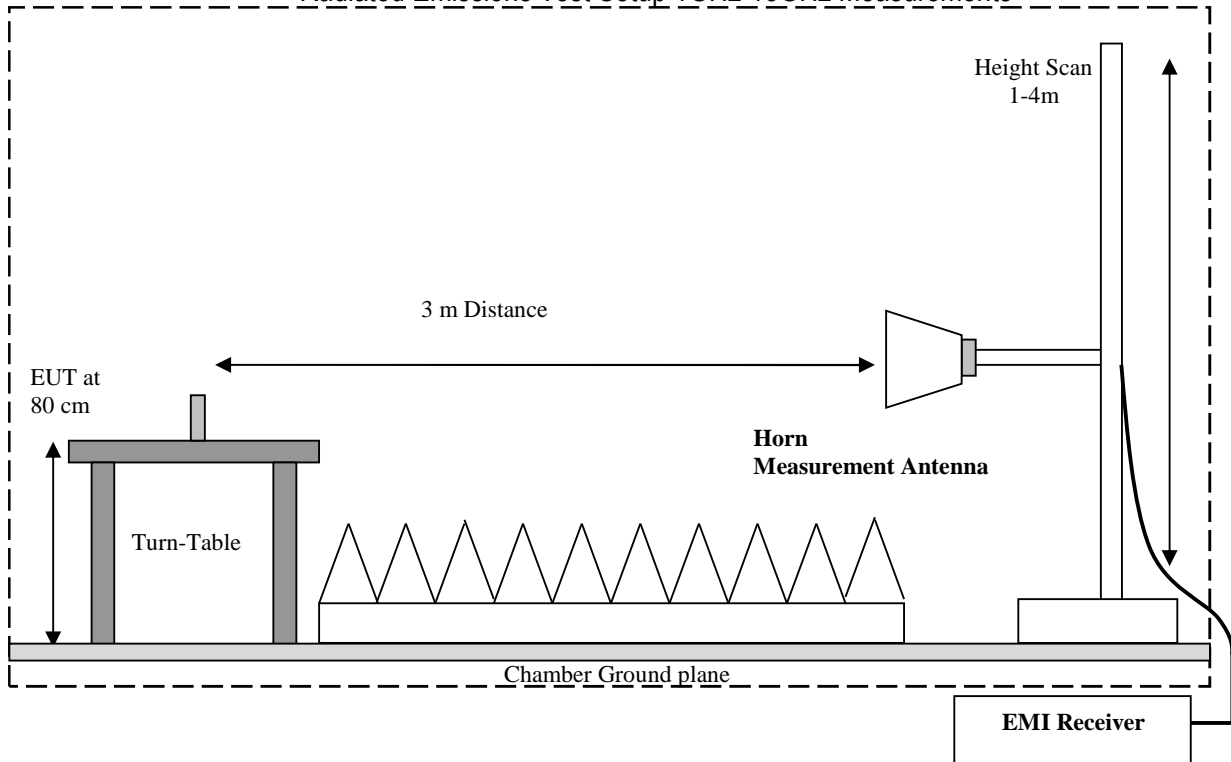
5.1 **Radiated Measurement for EUT with diameter less than 60 cm**

- The exploratory measurement is accomplished by running a matrix of 16 sweeps over the required frequency range with R&S Test-SW EMC32 for 4 positions 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.

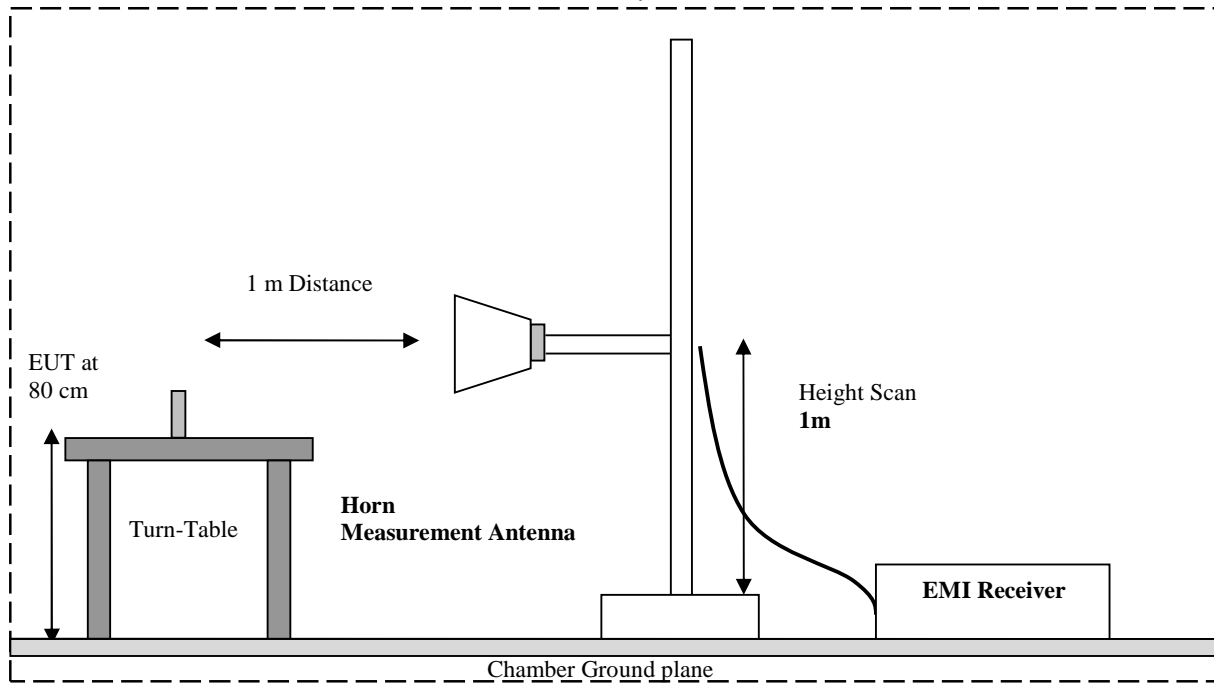
Radiated Emissions Test Setup 30MHz-1GHz Measurements



Radiated Emissions Test Setup 1GHz-18GHz Measurements



Radiated Emissions Test Setup 18GHz-40GHz Measurements



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

| Test Specification | Test Case | Temperature and Voltage Conditions | Mode | Pass | Fail | NA | NP | Result |
|-------------------------------|---------------------|------------------------------------|---------|------|------|----|----|----------|
| FCC §15.109 ICES-003, §6.2 | Radiated Emissions | Nominal | RX Mode | ■ | □ | □ | □ | Complies |
| FCC §15.107 ICES-003, §6.1 | Conducted Emissions | Nominal | RX Mode | □ | □ | □ | ■ | Note 2 |

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

Note 2: EUT does not draw power from public mains.

7 Test Result Data

7.1 Radiated Emissions Measurement according to CFR 47 Part 15.109 and ICES-003 6.2

| Spectrum Analyzer settings | | |
|---|----------------|----------------|
| Sweep Frequency Range | 30 MHz – 1 GHz | 1 GHz – 40 GHz |
| Resolution Bandwidth | 120 kHz | 1 MHz |
| Detector (Exploratory Measurements) | Peak | Peak, Average |
| Detector (Final Measurements) | Quasi-Peak | Peak, Average |
| Trace Mode | Max Hold | Max Hold |
| Step Size | 40 kHz | 800 kHz |
| Measurement Time (Exploratory Measurements) | 2 ms | 2 ms |
| Measurement Time (Final Measurements) | 100 ms | 100 ms |

7.1.1 Limits:

| Class A Limits | | |
|-----------------------------|---|---|
| Frequency of emission (MHz) | Field Strength @ 10 m ($\mu\text{V/m}$) | Field Strength @ 3 m ($\text{dB}\mu\text{V/m}$) |
| 30-88 | 90 | 49.5 |
| 88-216 | 150 | 54 |
| 216-960 | 210 | 56.9 |
| Above 960 | 300 | 60 |

| Class B Limits | | |
|-----------------------------|--|---|
| Frequency of emission (MHz) | Field Strength @ 3 m ($\mu\text{V/m}$) | Field Strength @ 3 m ($\text{dB}\mu\text{V/m}$) |
| 30-88 | 100 | 40 |
| 88-216 | 150 | 43.5 |
| 216-960 | 200 | 46 |
| Above 960 | 500 | 54 |

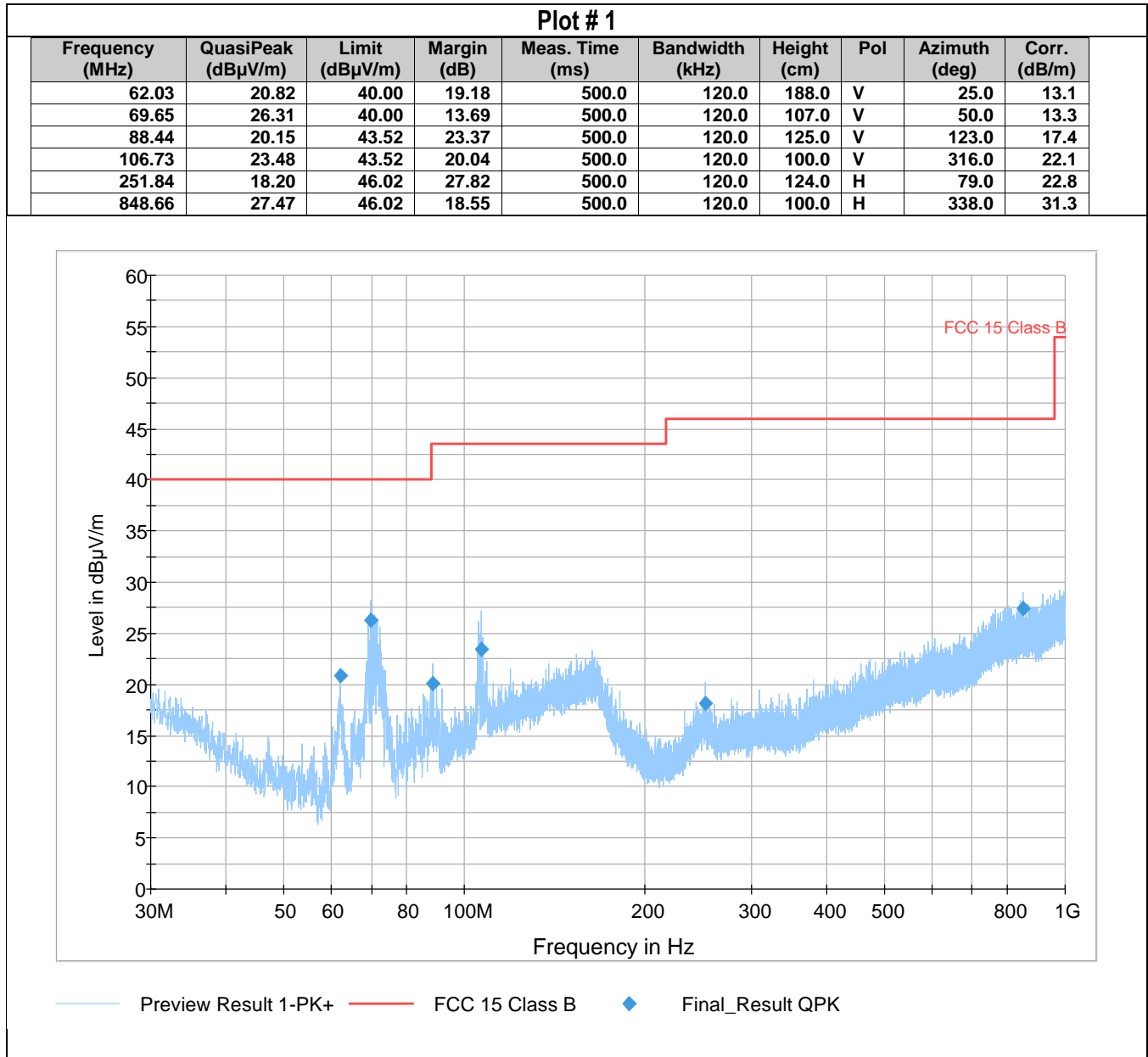
Note: For measurements below 1 GHz, the limits above use a quasi-peak detector. For measurements above 1 GHz, the limits above use an average detector.

7.1.2 Test Summary:

| Environmental Conditions | |
|--------------------------|-----------|
| Ambient Temperature: | 24.6°C |
| Relative Humidity: | 45.1% |
| Atmospheric Pressure: | 1010 mbar |

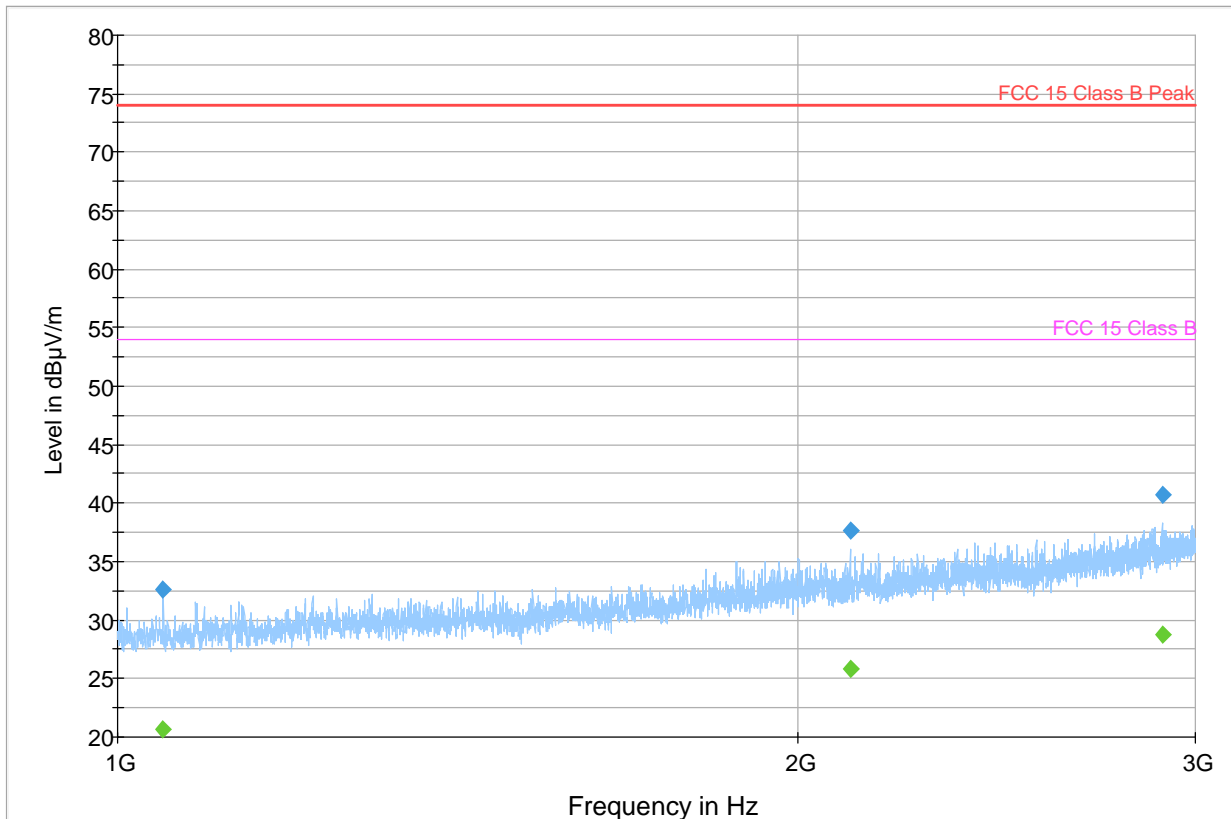
| Test Results | | | | | | |
|--------------|--------------|--------------------|-----------------|--------------------|-------------------|--------|
| Plot # | EUT Set-Up # | EUT operating mode | Scan Frequency | Power Supply Input | Comments | Result |
| 1 - 3 | 1 | RX Mode | 30 MHz – 18 GHz | Battery | Final measurement | Pass |

7.1.3 Measurement Plots:



Plot # 2

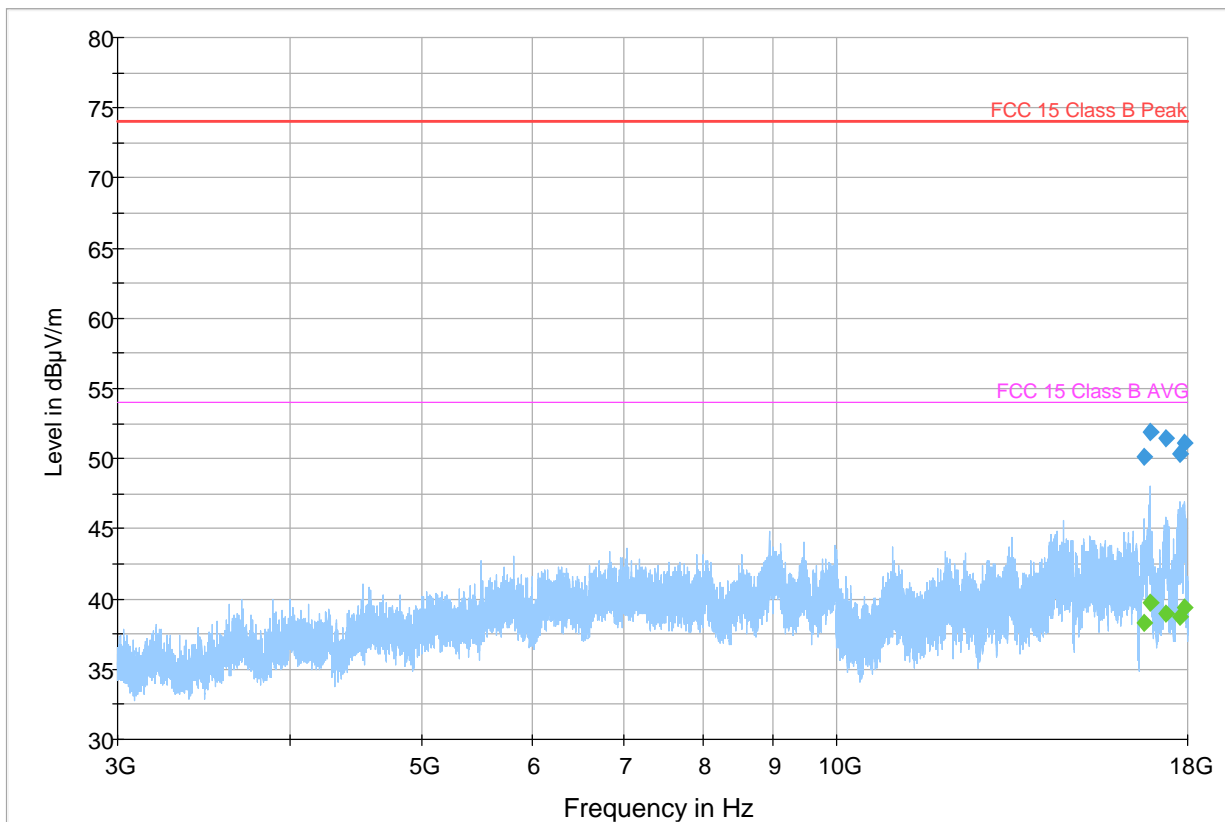
| Frequency (MHz) | MaxPeak (dBμV/m) | RMS (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Meas. Time | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB/m) |
|-----------------|------------------|--------------|----------------|-------------|------------|-----------------|-------------|-----|---------------|--------------|
| 1047.75 | 32.60 | --- | 73.98 | 41.38 | 500.0 | 1000.0 | 193.0 | V | 115.0 | -7.2 |
| 1047.75 | --- | 20.69 | 53.98 | 33.29 | 500.0 | 1000.0 | 193.0 | V | 115.0 | -7.2 |
| 2109.50 | 37.62 | --- | 73.98 | 36.36 | 500.0 | 1000.0 | 194.0 | V | -6.0 | -3.0 |
| 2109.50 | --- | 25.86 | 53.98 | 28.12 | 500.0 | 1000.0 | 194.0 | V | -6.0 | -3.0 |
| 2899.75 | --- | 28.75 | 53.98 | 25.23 | 500.0 | 1000.0 | 154.0 | V | 185.0 | 0.1 |
| 2899.75 | 40.67 | --- | 73.98 | 33.31 | 500.0 | 1000.0 | 154.0 | V | 185.0 | 0.1 |



- ◆ Preview Result 1-PK+ — FCC 15 Class B Peak — FCC 15 Class B
- ◆ Final_Result RMS

Plot # 3

| Frequency (MHz) | MaxPeak (dBμV/m) | RMS (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Meas. Time | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB/m) |
|-----------------|------------------|--------------|----------------|-------------|------------|-----------------|-------------|-----|---------------|--------------|
| 16742.98 | 50.16 | --- | 73.98 | 23.82 | 500.0 | 1000.0 | 293.0 | V | 40.0 | -12.5 |
| 16742.98 | --- | 38.30 | 53.98 | 15.68 | 500.0 | 1000.0 | 293.0 | V | 40.0 | -12.5 |
| 16894.40 | 51.91 | --- | 73.98 | 22.07 | 500.0 | 1000.0 | 127.0 | H | 68.0 | -11.9 |
| 16894.40 | --- | 39.71 | 53.98 | 14.27 | 500.0 | 1000.0 | 121.0 | H | 36.0 | -11.9 |
| 17350.11 | 51.43 | --- | 73.98 | 22.55 | 500.0 | 1000.0 | 300.0 | H | 104.0 | -10.1 |
| 17350.11 | --- | 38.94 | 53.98 | 15.04 | 500.0 | 1000.0 | 300.0 | H | 104.0 | -10.1 |
| 17781.67 | --- | 38.70 | 53.98 | 15.28 | 500.0 | 1000.0 | 147.0 | V | 161.0 | -8.0 |
| 17781.67 | 50.32 | --- | 73.98 | 23.66 | 500.0 | 1000.0 | 147.0 | V | 161.0 | -8.0 |
| 17885.53 | 51.17 | --- | 73.98 | 22.81 | 500.0 | 1000.0 | 107.0 | V | 201.0 | -7.0 |
| 17885.53 | --- | 39.43 | 53.98 | 14.55 | 500.0 | 1000.0 | 107.0 | V | 201.0 | -7.0 |



- ◆ Preview Result 1-PK+
 — FCC 15 Class B Peak
 — FCC 15 Class B AVG
- ◆ Final_Result PK+
 ◆ Final_Result RMS

8 Test setup photos

Setup photos are included in supporting file name: "EMC_PARTI-001-21001_FCC_Setup_Photos"

9 Test Equipment And Ancillaries Used For Testing

| Equipment Type | Manufacturer | Model | Serial # | Calibration Cycle | Last Calibration Date |
|--------------------|-----------------|--------------------|-----------|-------------------|-----------------------|
| BILOG ANTENNA | ETS.LINDGREN | 3142E | 00166067 | 3 YEARS | 10/21/2021 |
| HORN ANTENNA | EMCO | 3115 | 00035111 | 3 YEARS | 09/30/2021 |
| HORN ANTENNA | ETS.LINDGREN | 3117 | 00215984 | 3 YEARS | 01/31/2021 |
| TEST RECEIVER | R&S | ESU40 | 100251 | 3 YEARS | 09/13/2021 |
| PULSE LIMITER | R&S | 20db Pulse Limiter | 102473 | 3 YEARS | 8/25/2020 |
| DIGITAL THRMOMETER | CONTROL COMPANY | 36934-164 | 181230565 | 3 YEARS | 10/20/2021 |

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 | Prepared by |
|------------|----------------------------------|-------------------|-------------|
| 2022-11-28 | EMC_PARTI-001-21001_FCC_15B | Initial Version | Cheng Song |
| 2023-02-13 | EMC_PARTI-001-21001_FCC_15B_Rev1 | Updated section 6 | Cheng Song |

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