

# Test report

**331827-1R1TRFWL**

Date of issue: July 18, 2017

Applicant: HM Electronics, Inc

Product: Advanced Vehicle Detection Board

Model: RFM100                      Model variant: N/A

FCC ID: BYMRF100                      IC Registration number: 1806A-RFM100

Specifications:

◆ **FCC 47 CFR Part 15 Subpart C, §15.209**

Radiated emission limits; general requirements.

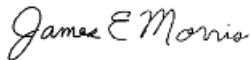
◆ **RSS-310**

Licence-Exempt Radio Apparatus: Category II Equipment

#### Test location

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|               |                                                  |
|---------------|--------------------------------------------------|
| Company name: | Nemko USA, Inc.                                  |
| Address:      | 2210 Faraday Ave, Suite 150                      |
| City:         | Carlsbad                                         |
| State:        | California                                       |
| Postal code:  | 92008                                            |
| Country:      | USA                                              |
| Telephone:    | +1 760 444 3500                                  |
| Website:      | <a href="http://www.nemko.com">www.nemko.com</a> |
| Site number:  | FCC: US5058; IC: 2040B                           |

|              |                                                                                     |
|--------------|-------------------------------------------------------------------------------------|
| Tested by:   | Mark Phillips, EMC Test Engineer                                                    |
| Reviewed by: | James Morris, EMC and Wireless Divisions Manager                                    |
| Date:        | August 2, 2017                                                                      |
| Signature:   |  |

#### Limits of responsibility

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Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contain in this report are within Nemko USA's ISO/IEC 17025 accreditation.

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## Section 1 Report summary

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### 1.1 Applicant

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|                 |                      |
|-----------------|----------------------|
| Company name    | HM Electronics, Inc. |
| Address         | 14110 Stowe Drive    |
| City            | Poway                |
| Province/State  | CA                   |
| Postal/Zip code | 92064                |
| Country         | U.S.A.               |

### 1.2 Manufacturer

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|                 |                      |
|-----------------|----------------------|
| Company name    | HM Electronics, Inc. |
| Address         | 14110 Stowe Drive    |
| City            | Poway                |
| Province/State  | CA                   |
| Postal/Zip code | 92064                |
| Country         | U.S.A.               |

### 1.3 Test specifications

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|                                              |                                                       |
|----------------------------------------------|-------------------------------------------------------|
| FCC 47 CFR Part 15, Subpart C, Clause 15.209 | Radiated emission limits; general requirements.       |
| RSS-310                                      | Licence-Exempt Radio Apparatus: Category II Equipment |

### 1.4 Statement of compliance

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In the configuration tested, the EUT was found compliant.

Testing was completed against all relevant requirements of the test standard. Results obtained indicate that the product under test complies in full with the requirements tested. The test results relate only to the items tested.

See "Summary of test results" for full details.

### 1.5 Exclusions

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None

### 1.6 Test report revision history

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| Revision # | Details of changes made to test report |
|------------|----------------------------------------|
| TRF        | Original report issued                 |
| R1TRF      | Updated test specifications            |

## Section 2 Summary of test results

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### 2.1 FCC Part 15 Subpart C – general requirements, test results

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| Part       | Test description | Verdict |
|------------|------------------|---------|
| §15.207(a) | Conducted limits | Pass    |

Notes: None

### 2.2 FCC Part 15 Subpart C – Intentional Radiators, test results

---

| Part    | Test description                                | Verdict |
|---------|-------------------------------------------------|---------|
| §15.209 | Radiated emission limits; general requirements. | Pass    |

Notes: None

### 2.3 RSS-310 Conducted emissions test results

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| Test description                         | Verdict |
|------------------------------------------|---------|
| AC power lines conducted emission limits | Pass    |

Notes: None

### 2.4 RSS-310 Radiated emissions test results

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| Test description             | Verdict |
|------------------------------|---------|
| Transmitter emissions limits | Pass    |

Notes: None

## Section 3 Equipment under test (EUT) details

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### 3.1 Sample information

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|                        |                |
|------------------------|----------------|
| Receipt date           | March 27, 2017 |
| Nemko sample ID number | 331827         |

### 3.2 EUT information

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|               |                                  |
|---------------|----------------------------------|
| Product name  | Advanced Vehicle Detection Board |
| Model         | RFM100                           |
| Model variant | N/A                              |
| Serial number | N/A (prototype)                  |

### 3.3 Technical information

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|                           |                                                                                        |
|---------------------------|----------------------------------------------------------------------------------------|
| Operating band            | N/A                                                                                    |
| Operating frequency       | 12 – 75 kHz                                                                            |
| Modulation type           | N/A                                                                                    |
| Occupied bandwidth (99 %) | N/A                                                                                    |
| Emission designator       | CW Swept Carrier                                                                       |
| Power requirements        | 12 VDC                                                                                 |
| Antenna information       | Underground Loop antenna for Vehicle Detection<br>The EUT is professionally installed. |

### 3.4 Product description and theory of operation

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Model RFM100 is a module that when installed in other systems such as a timer or base station and used in conjunction with a ground loop, the RFM100 detects the presence or absence of vehicles on top of the ground loop. It operates as a swept CW signal from 11kHz to 75kHz. The RFM100 monitors and adjust certain health conditions of the ground loop. It also provides user alerts of changes on the ground loop's health status. These alerts are communicated through the Bluetooth communication link.

### 3.5 EUT exercise details

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EUT was set for continuous operation.

### 3.6 EUT setup Figure

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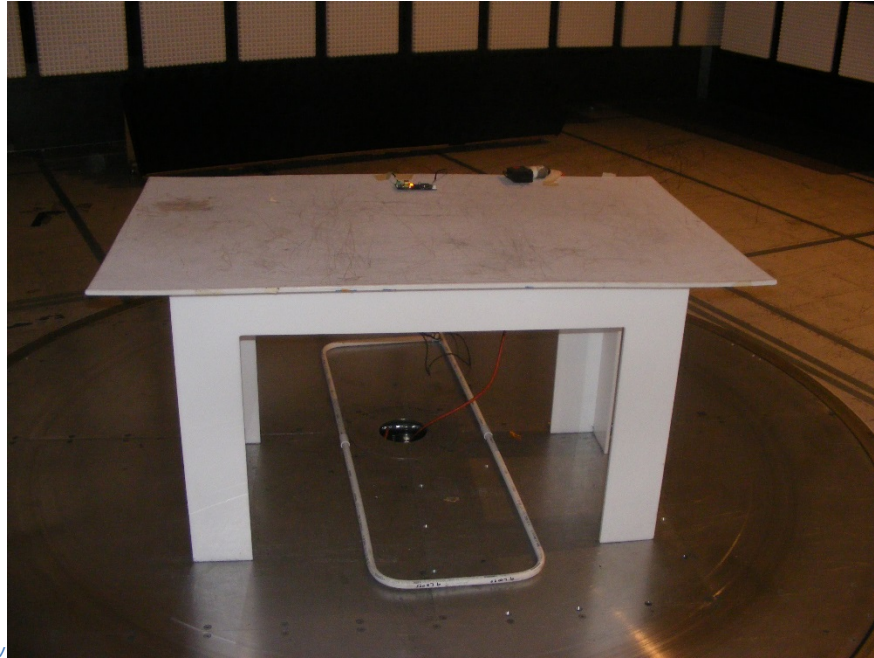


Figure 3.6-1: Setup Figure

### 3.7 EUT sub assemblies

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Table 3.7-1: EUT sub assemblies

| Description                      | Brand name | Model/Part number | Serial number   |
|----------------------------------|------------|-------------------|-----------------|
| Advanced Vehicle Detection Board | RFM100     | G2997             | N/A (prototype) |
|                                  |            |                   |                 |

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## Section 4 Engineering considerations

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### 4.1 Modifications incorporated in the EUT

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There were no modifications performed to the EUT during this assessment.

### 4.2 Technical judgment

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None

### 4.3 Deviations from laboratory tests procedures

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No deviations were made from laboratory procedures.



## Section 5 Test conditions

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### 5.1 Atmospheric conditions

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|                   |               |
|-------------------|---------------|
| Temperature       | 15–30 °C      |
| Relative humidity | 20–75 %       |
| Air pressure      | 860–1060 mbar |

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

### 5.2 Power supply range

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The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages  $\pm 5\%$ , for which the equipment was designed.

## Section 6 Measurement uncertainty

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### 6.1 Uncertainty of measurement

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Nemko USA Inc. has calculated measurement uncertainty and is documented in EMC/MUC/001 "Uncertainty in EMC measurements." Measurement uncertainty was calculated using the methods described in CISPR 16-4 Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: Uncertainty in EMC measurements; as well as described in UKAS LAB34: The expression of Uncertainty in EMC Testing. Measurement uncertainty calculations assume a coverage factor of  $K=2$  with 95% certainty.

## Section 7 Test equipment

### 7.1 Test equipment list

| Asset Tag | Description                        | Manufacturer    | Model    | Serial #  | Next Cal    |
|-----------|------------------------------------|-----------------|----------|-----------|-------------|
| D1033     | Antenna, DRWG                      | EMCO            | 3115     | 9609-4943 | 27-Jul-2017 |
| 809       | Multimeter                         | Fluke           | 111      | 77790102  | 29-Jun-2017 |
| E1019     | Two Line V-Network                 | Rohde & Schwarz | ENV216   | 101045    | 15-Jun-2017 |
| E1035     | Variac (Variable Transformer) 3KVA | Shanghai China  | TDGC     | N/A       | VOU         |
| 1480      | Antenna, Bilog                     | Schaffner-Chase | CBL6111C | 2572      | 21-Jul-2017 |
| E1120     | Signal and Spectrum Analyzer       | Rohde & Schwarz | FSV40    | 101395    | 25-May-2017 |
| E1121     | EMI Test Receiver                  | Rohde & Schwarz | ESU 40   | 100064    | 28-Apr-2017 |
| N/A       | 10m Chamber Cable - HF             | N/A             | N/A      | N/A       |             |
| N/A       | 10m Chamber Cable - LF             | N/A             | N/A      | N/A       |             |
| N/A       | RF Conducted Cables - HF           | N/A             | N/A      | N/A       |             |
| 317       | Preamp                             | HP              | 8449B    | N/A       |             |
| N/A       | Attenuator                         | HP              | 8493A    | 05391     |             |

## Section 8 Testing data

### 8.1 FCC 15.207(a) and RSS-310 AC power line conducted emissions limits

#### 8.1.1 Definitions and limits

**FCC:**

Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50  $\mu$ H/50  $\Omega$  line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

**IC:**

The purpose of this test is to measure unwanted radio frequency currents induced in any AC conductor external to the equipment which could conduct interference to other equipment via the AC electrical network.

Except when the requirements applicable to a given device state otherwise, for any licence-exempt radiocommunication device equipped to operate from the public utility AC power supply, either directly or indirectly, the radio frequency voltage that is conducted back onto the AC power lines in the frequency range of 0.15 MHz to 30 MHz shall not exceed the limits shown in Table 2. The tighter limit applies at the frequency range boundaries.

The conducted emissions shall be measured with a 50  $\Omega$ /50  $\mu$ H line impedance stabilization network (LISN).

**Table 8.1-1:** Conducted emissions limit

| Frequency of emission,<br>MHz | Conducted limit, dB $\mu$ V |           |
|-------------------------------|-----------------------------|-----------|
|                               | Quasi-peak                  | Average   |
| 0.15–0.5                      | 66 to 56*                   | 56 to 46* |
| 0.5–5                         | 56                          | 46        |
| 5–30                          | 60                          | 50        |

Note: \* - Decreases with the logarithm of the frequency.

#### 8.1.2 Test summary

|                |               |                    |           |
|----------------|---------------|--------------------|-----------|
| Test date:     | May 23, 2017  | Temperature:       | 21 °C     |
| Test engineer: | Mark Phillips | Air pressure:      | 1002 mbar |
| Verdict:       | Pass          | Relative humidity: | 56 %      |

### 8.1.3 Observations, settings and special notes

---

The EUT was set up as tabletop configuration.

The spectral scan has been corrected with transducer factors (i.e. cable loss, LISN factors, and attenuators) for determination of compliance.

A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 6 dB or above limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.

Receiver settings for preview measurements:

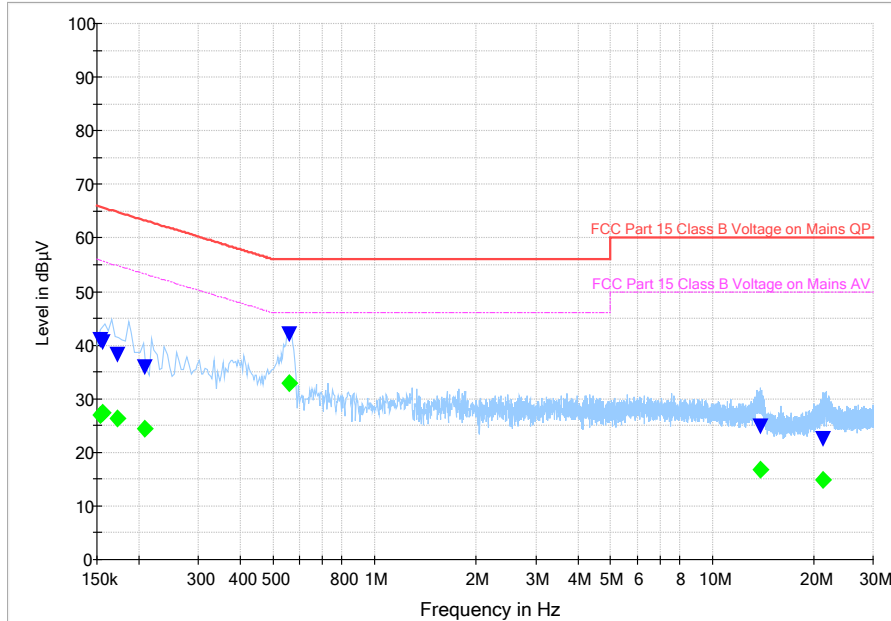
|                       |                  |
|-----------------------|------------------|
| Resolution bandwidth: | 9 kHz            |
| Video bandwidth:      | 30 kHz           |
| Detector mode:        | Peak and Average |
| Trace mode:           | Max Hold         |
| Measurement time:     | 1000 ms          |

Receiver settings for final measurements:

|                       |                        |
|-----------------------|------------------------|
| Resolution bandwidth: | 9 kHz                  |
| Video bandwidth:      | 30 kHz                 |
| Detector mode:        | Quasi-Peak and Average |
| Trace mode:           | Max Hold               |
| Measurement time:     | 1000 ms                |

8.1.4 Test data

Full Spectrum



Plot 8.1-1: Conducted emissions on phase and neutral line

| Frequency (MHz) | QuasiPeak (dBµV) | Average (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line |
|-----------------|------------------|----------------|--------------|-------------|-----------------|-----------------|------|
| 0.154000        | ---              | 27.04          | 55.78        | 28.74       | 5000.0          | 9.000           | L1   |
| 0.154000        | 40.98            | ---            | 65.78        | 24.80       | 5000.0          | 9.000           | L1   |
| 0.156500        | ---              | 27.31          | 55.65        | 28.34       | 5000.0          | 9.000           | N    |
| 0.156500        | 40.65            | ---            | 65.65        | 25.00       | 5000.0          | 9.000           | N    |
| 0.172500        | 38.28            | ---            | 64.84        | 26.56       | 5000.0          | 9.000           | N    |
| 0.172500        | ---              | 26.23          | 54.84        | 28.61       | 5000.0          | 9.000           | N    |
| 0.208500        | 35.92            | ---            | 63.27        | 27.34       | 5000.0          | 9.000           | L1   |
| 0.208500        | ---              | 24.40          | 53.27        | 28.87       | 5000.0          | 9.000           | L1   |
| 0.556500        | 42.06            | ---            | 56.00        | 13.94       | 5000.0          | 9.000           | L1   |
| 0.556500        | ---              | 32.89          | 46.00        | 13.11       | 5000.0          | 9.000           | L1   |
| 13.852500       | 24.94            | ---            | 60.00        | 35.06       | 5000.0          | 9.000           | L1   |
| 13.852500       | ---              | 16.73          | 50.00        | 33.27       | 5000.0          | 9.000           | L1   |
| 21.288500       | ---              | 14.97          | 50.00        | 35.03       | 5000.0          | 9.000           | N    |
| 21.288500       | 22.54            | ---            | 60.00        | 37.46       | 5000.0          | 9.000           | N    |

Table 8.1-2: Quasi-Peak and Average conducted emissions results on phase and neutral line

Sample calculation:

Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + attenuator (dB)

Result (dBµV) = XX dBµV (reading from receiver) + XX dB (Correction factor)

Example:

43.5 dBµV = 23.2 dBµV (receiver reading) + 10.1 dB (LISN factor IL) + 0.2 dB (cable loss) + 10 dB (attenuator)

## 8.2 Clause 15.209 and RSS-310 Field strength of emissions

### 8.2.1 Definitions and limits

In addition to the provisions of §15.205 RSS-310 the field strength of emissions from intentional radiators operated under this section shall not exceed the following:

**Table 8.2-1:** Field strength limits

| Fundamental frequency<br>(MHz) | Field strength of fundamental |          | Field strength of spurious emissions |          |
|--------------------------------|-------------------------------|----------|--------------------------------------|----------|
|                                | (mV/m)                        | (dBµV/m) | (µV/m)                               | (dBµV/m) |
| 902–928                        | 50                            | 94       | 500                                  | 54       |
| 2400–2483.5                    | 50                            | 94       | 500                                  | 54       |
| 5725–5875                      | 50                            | 94       | 500                                  | 54       |
| 24.0–24.25                     | 250                           | 108      | 2500                                 | 68       |

(e) As shown in §15.35(b), for frequencies above 1000 MHz, the field strength limits in paragraphs (a) and (b) of this section are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation. For point-to-point operation under paragraph (b) of this section, the peak field strength shall not exceed 2500 millivolts/meter (128 dBµV/m) at 3 meters along the antenna azimuth.

### 8.2.2 Test summary

|                |               |                    |           |
|----------------|---------------|--------------------|-----------|
| Test date:     | May 23, 2017  | Temperature:       | 21 °C     |
| Test engineer: | Mark Phillips | Air pressure:      | 1002 mbar |
| Verdict:       | Pass          | Relative humidity: | 56 %      |

### 8.2.3 Observations/special notes

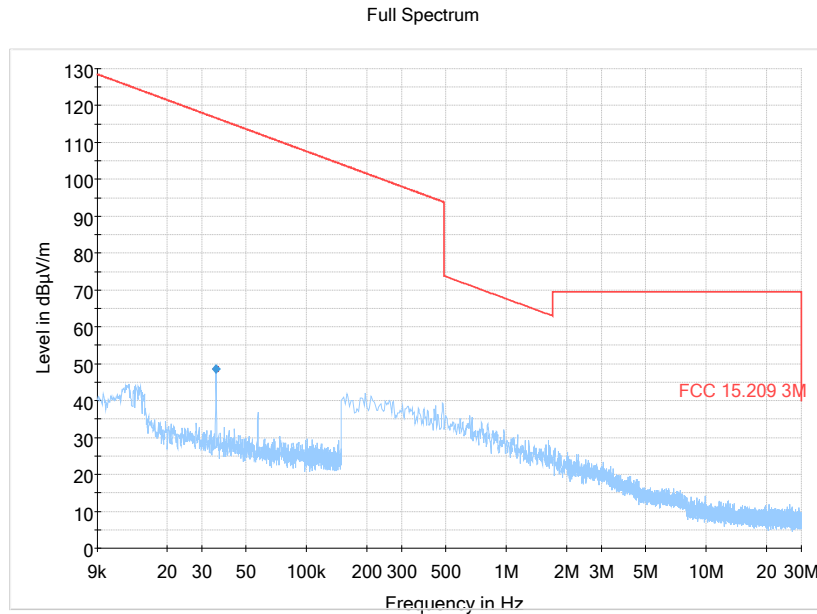
**Table 8.2-2:** §15.209 RSS Gen 7.2.5 – Radiated emission limits

| Frequency<br>(MHz) | Field strength |                               | Measurement distance<br>(m) |
|--------------------|----------------|-------------------------------|-----------------------------|
|                    | (µV/m)         | (dBµV/m)                      |                             |
| 0.009–0.490        | 2400/F         | 67.6–20×log <sub>10</sub> (F) | 300                         |
| 0.490–1.705        | 24000/F        | 87.6–20×log <sub>10</sub> (F) | 30                          |
| 1.705–30.0         | 30             | 29.5                          | 30                          |
| 30–88              | 100            | 40.0                          | 3                           |
| 88–216             | 150            | 43.5                          | 3                           |
| 216–960            | 200            | 46.0                          | 3                           |
| above 960          | 500            | 54.0                          | 3                           |

- The spectrum was searched from 30 MHz to the 10<sup>th</sup> harmonic.
- All measurements were performed at a distance of 3 m.
- All measurements were performed:
  - below 30 MHz: using a quasi-peak detector with 9 kHz/30 kHz RBW/VBW,
  - above 1 GHz: using peak detector with 1 MHz/3 MHz RBW/VBW for peak results

Transmit output power was measured while supply voltage was varied from 102 VAC to 138 VAC (85 % to 115 % of the nominal rated supply voltage). No change in transmit output power was observed.

8.2.4 Test data, continued



Plot 8.2-1: 9kHz – 30MHz

The spectral plot is a summation of a vertical and horizontal scan. The spectral scan has been corrected with transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators) for determination of compliance. Limits have been adjusted to reflect 3 m requirements.

A preview measurement was generated with receiver in continuous scan or sweep mode while the EUT was rotated and antenna adjusted to maximize radiated emission. Emissions detected within 6 dB or above limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.

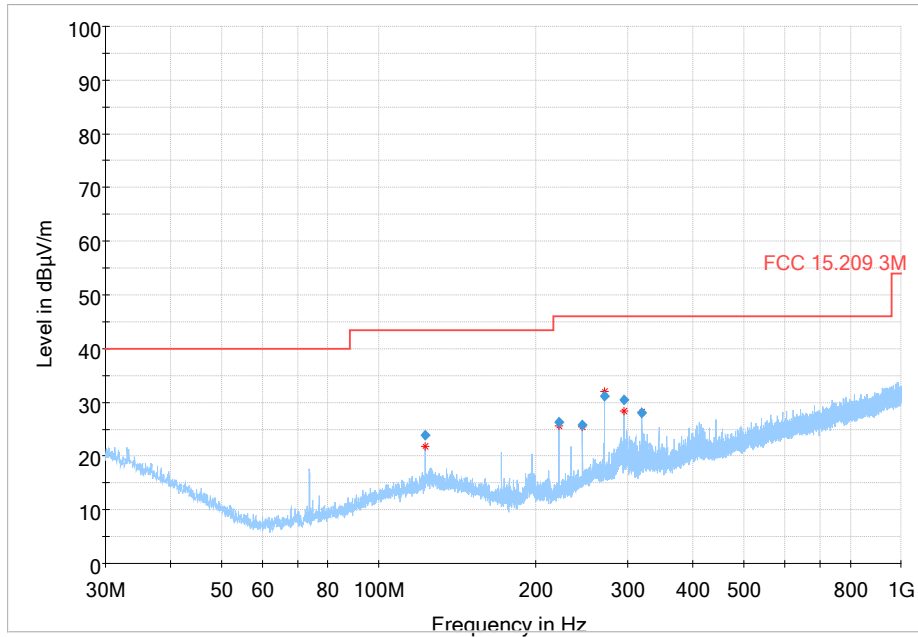
| Frequency (MHz) | QuasiPeak (dBµV/m) | Average (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Pol | Azimuth (deg) |
|-----------------|--------------------|------------------|----------------|-------------|-----------------|-----------------|-----|---------------|
| 0.035327        | 48.57              | ---              | 116.63         | 68.06       | 10000.0         | 0.200           | N/A | 188.0         |

Table 8.2-3: Field strength measurement results

Note: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.



Full Spectrum



Plot 8.2-2: 30MHz – 1000MHz

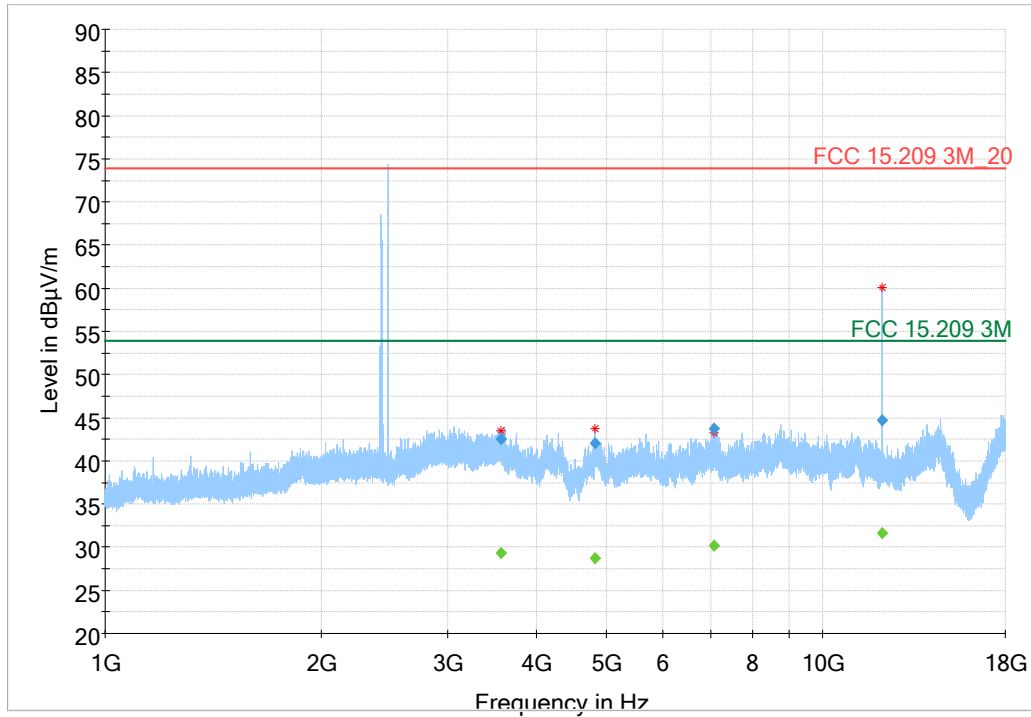
The spectral plot is a summation of a vertical and horizontal scan. The spectral scan has been corrected with transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators) for determination of compliance. Limits have been adjusted to reflect 3 m requirements.

| Frequency (MHz) | QuasiPeak (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) |
|-----------------|--------------------|----------------|-------------|-----------------|-----------------|-------------|-----|---------------|
| 122.857500      | 23.84              | 43.50          | 19.66       | 5000.0          | 120.000         | 330.1       | H   | 154.0         |
| 221.167000      | 26.24              | 46.00          | 19.76       | 5000.0          | 120.000         | 119.5       | H   | 70.0          |
| 245.748000      | 25.71              | 46.00          | 20.29       | 5000.0          | 120.000         | 334.5       | H   | 180.0         |
| 270.337500      | 31.14              | 46.00          | 14.86       | 5000.0          | 120.000         | 129.8       | H   | 310.0         |
| 294.918500      | 30.44              | 46.00          | 15.56       | 5000.0          | 120.000         | 124.4       | H   | 166.0         |
| 319.468000      | 27.95              | 46.00          | 18.05       | 5000.0          | 120.000         | 111.7       | H   | 160.0         |

Table 8.2-4: Field strength measurement results

Note: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

Full Spectrum



Emissions in 2400 – 2483.5 band are Bluetooth transmitter.

Plot 8.2-3: 1 – 18GHz

The spectral plot is a summation of a vertical and horizontal scan. The spectral scan has been corrected with transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators) for determination of compliance. Limits have been adjusted to reflect 3 m requirements.

| Frequency (MHz) | MaxPeak (dBµV/m) | Average (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) |
|-----------------|------------------|------------------|----------------|-------------|-----------------|-----------------|-------------|-----|---------------|
| 3564.620000     | ---              | 29.33            | 53.90          | 24.57       | 5000.0          | 1000.000        | 190.6       | H   | 266.0         |
| 3564.620000     | 42.55            | ---              | 73.90          | 31.35       | 5000.0          | 1000.000        | 190.6       | H   | 266.0         |
| 4822.760000     | ---              | 28.77            | 53.90          | 25.13       | 5000.0          | 1000.000        | 144.9       | V   | 278.0         |
| 4822.760000     | 42.10            | ---              | 73.90          | 31.80       | 5000.0          | 1000.000        | 144.9       | V   | 278.0         |
| 7066.920000     | 43.76            | ---              | 73.90          | 30.14       | 5000.0          | 1000.000        | 241.6       | H   | 223.0         |
| 7066.920000     | ---              | 30.14            | 53.90          | 23.76       | 5000.0          | 1000.000        | 241.6       | H   | 223.0         |
| 12130.040000    | 44.67            | ---              | 73.90          | 29.23       | 5000.0          | 1000.000        | 111.3       | H   | 128.0         |
| 12130.040000    | ---              | 31.59            | 53.90          | 22.31       | 5000.0          | 1000.000        | 111.3       | H   | 128.0         |

Table 8.2-5: Field strength measurement results

Note: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

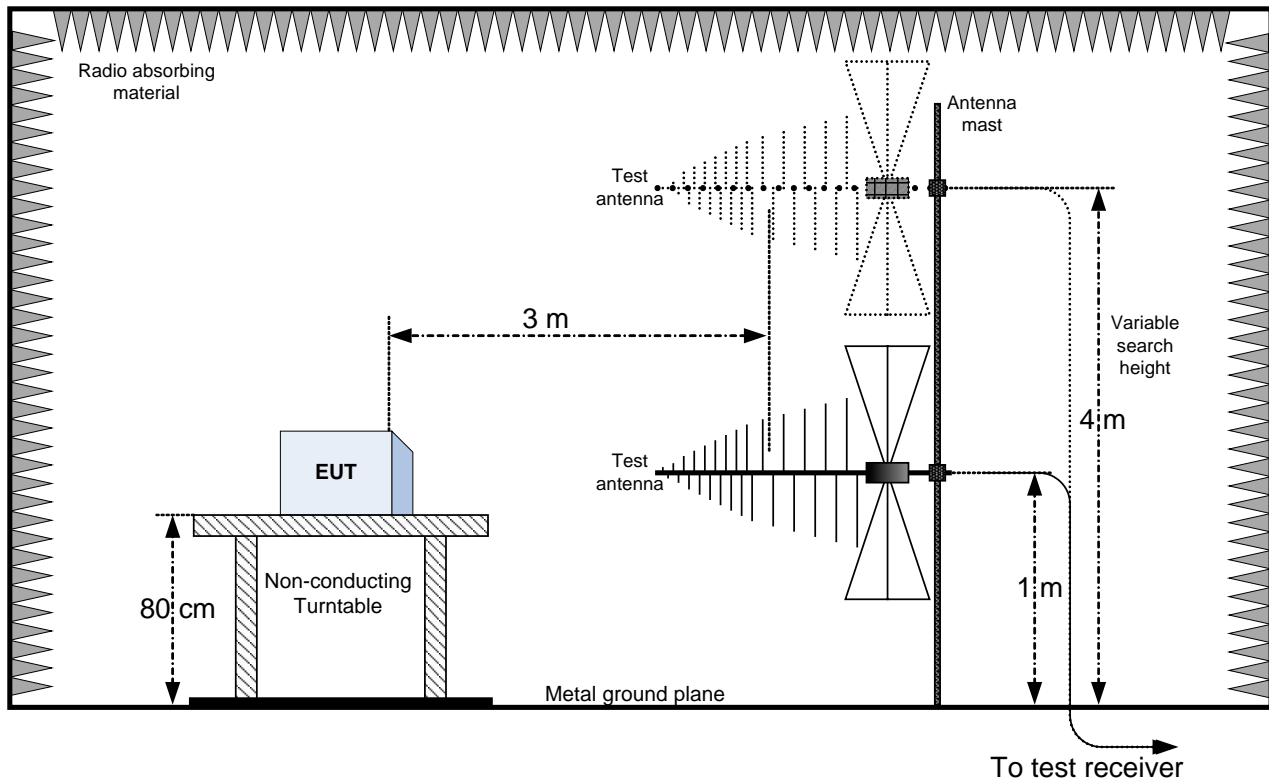
#### 8.2.5 Observations/special notes

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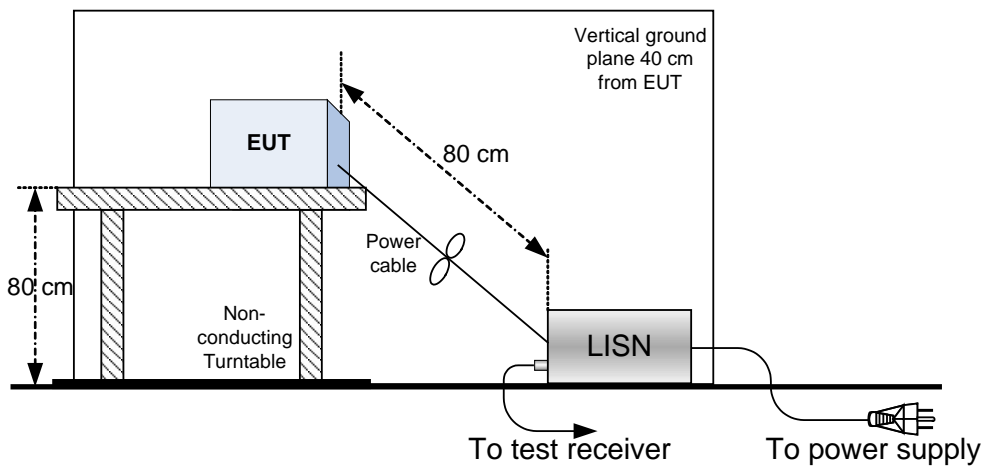
- The spectrum was searched from 30 MHz to the 10<sup>th</sup> harmonic.
- All measurements were performed at a distance of 3 m.
- All measurements were performed:
  - below 30 MHz: using a quasi-peak detector with 9 kHz/30 kHz RBW/VBW,
  - within 30–1000 MHz range: using a quasi-peak detector with 120 kHz/300 kHz RBW/VBW,
  - above 1 GHz: using peak detector with 1 MHz/3 MHz RBW/VBW for peak results
- and using peak detector with 1 MHz/10 Hz RBW/VBW for average results.

## Section 9 Block Figures of test set-ups

### 9.1 Radiated emissions set-up



### 9.2 Conducted emissions set-up



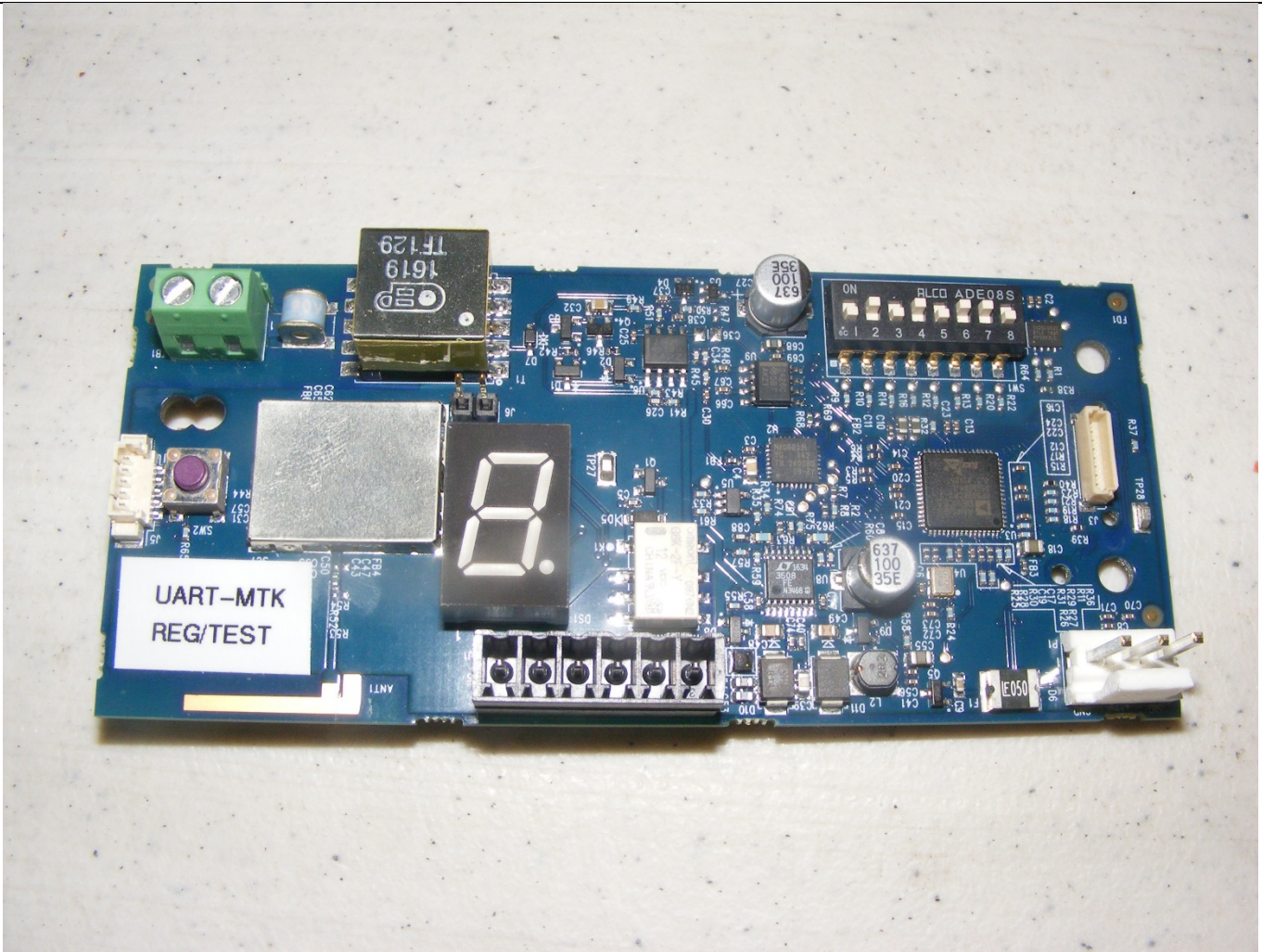
## Section 10 EUT photos

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### 10.1 External photos

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#### 10.1.1 EUT front view





10.1.2 EUT rear view

