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Sister Lakes, Michigan 49047 USA
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**APF4P-WR2309TX**
Issued: **May 26, 2023**

# EMC Test Report

regarding

**USA: CFR Title 47, Part 95 Subpart M** (Emissions)

for

PHOTOS HELD SHORT TERM
CONFIDENTIAL

# FLR4P

**Category: FMCW Radar**

Judgments:
**FCC Part 95M and ISED RSS-251v2 Compliant**
Testing Completed: May 10, 2023

TESTING
NVLAP LAB CODE 200129-0

Prepared for:

## Aptiv Services US, LLC

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Date of Issue: May 26, 2023

## Revision History

| Rev. No. | Date | Details | Revised By |
|---|---|---|---|
| r0 | May 26, 2023 | Initial Release. | J. Brunett |
| r1 | May 30, 2023 | Correct SNs. | J. Brunett |
| r2 | June 3, 2023 | Add fund. plots. | J. Brunett |

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# 1 Test Report Scope and Limitations

## 1.1 Laboratory Authorization

Test Facility description and attenuation characteristics are on file with the FCC Laboratory, Columbia, Maryland (FCC Reg. No: US5348 and US5356) and with ISED Canada, Ottawa, ON (File Ref. No: 3161A and 24249). Amber Helm Development L.C. holds accreditation under NVLAP Lab Code 200129-0.

## 1.2 Report Retention

For equipment verified to comply with the regulations herein, the manufacturer is obliged to retain this report with the product records for the life of the product, and no less than ten years. A copy of this Report will remain on file with this laboratory until June 2033.

## 1.3 Subcontracted Testing

This report does not contain data produced under subcontract.

## 1.4 Test Data

This test report contains data included within the laboratory's scope of accreditation. Any data in this report that is not covered under the laboratory's scope is clearly identified.

## 1.5 Limitation of Results

The test results contained in this report relate only to the item(s) tested. Any electrical or mechanical modification made to the test item subsequent to the test date shall invalidate the data presented in this report. Any electrical or mechanical modification made to the test item subsequent to this test date shall require reevaluation.

## 1.6 Copyright

This report shall not be reproduced, except in full, without the written approval of Amber Helm Development L.C.

## 1.7 Endorsements

This report shall not be used to claim product endorsement by any accrediting, regulatory, or governmental agency.

### 1.8 Test Location

The EUT was fully tested by **Amber Helm Development L.C.**, headquartered at 92723 Michigan Hwy-152, Sister Lakes, Michigan 49047 USA. Table 1 lists all sites employed herein. Specific test sites utilized are also listed in the test results sections of this report where needed.

Table 1: Test Site List.

| Description | Location | Quality Num. |
|---|---|---|
| OATS (3 meter) | 3615 E Grand River Rd., Williamston, Michigan 48895 | OATSC |

### 1.9 Traceability and Equipment Used

Pertinent test equipment used for measurements at this facility is listed in Table 2. The quality system employed at Amber Helm Development L.C. has been established to ensure all equipment has a clearly identifiable classification, calibration expiry date, and that all calibrations are traceable to the SI through NIST, other recognized national laboratories, accepted fundamental or natural physical constants, ratio type of calibration, or by comparison to consensus standards.

Table 2: Equipment List.

| Description | Manufacturer/Model | SN | Quality Num. | Cal/Ver By / Date Due |
|---|---|---|---|---|
| Spectrum Analyzer | R & S / FSV30 | 101660 | RSFSV30001 | RS / Apr-2024 |
| Spectrum Analyzer | Rohde & Schwarz / FSV3 | 101131 | RSFSV301 | RS / Nov-2023 |
| Harmonic Mixer | Hewlett Packard / 11970A | MY3003A1226 | MIX26TO4001 | AHD / Mar-2025 |
| Harmonic Mixer | Hewlett Packard / 11970U | 2332A01153 | MIX40TO7001 | AHD / CNR |
| Harmonic Mixer | VDI / SAX 108 | A30316 | MIX60TO9001 | AHD / On-use |
| Harmonic Mixer | Hewlett Packard / 11970W | 2521A00179 | MIX70TO11001 | AHD / On-use |
| Harmonic Mixer | Pacific mmWave / GMA | 26 | MIX110TO23001 | PMP / On-use |
| Biconical | EMCO / 93110B | 9802-3039 | BICEMCO01 | Keysight / Aug-2023 |
| Log Periodic Antenna | EMCO / 3146 | 9305-3614 | LOGEMCO01 | Keysight / Aug-2023 |
| Quad Ridge Horn | Singer / A6100 | C35200 | HQR1TO18S01 | Keysight / Aug-2024 |
| K-Band Horn | JEF / NRL Std. | 001 | HRNK01 | AHD / Jul-2023 |
| Ka-Band Horn | JEF / NRL Std. | 001 | HRNKA001 | AHD / Jul-2023 |
| U-Band Horn | Cust. Micro. / HO19R | - | HRNU01 | Cust.M. / On-Use |
| E-Band Horn | Flann / 26240-25-1030B | 250901 | HRNE01 | Flann / On-Use |
| W-Band Horn | Cust. Micro. / HO10R | - | HRNW01 | Cust.M. / On-Use |
| D/G-Band Horn | Cust. Micro. / HO5R | - | HRNG01 | Cust.M. / On-Use |

# 2 Test Specifications and Procedures

## 2.1 Test Specification and General Procedures

The goal of Aptiv Services US, LLC is to demonstrate that the Equipment Under Test (EUT) complies with the Rules and/or Directives below. Detailed in this report are the results of testing the Aptiv Services US, LLC FLR4P for compliance to:

| **Country/Region** | **Rules or Directive** | **Referenced Section(s)** |
|---|---|---|
| United States | Code of Federal Regulations | CFR Title 47, Part 95 Subpart M |

It has been determined that the equipment under test is subject to the rules and directives above at the date of this testing. In conjunction with these rules and directives, the following specifications and procedures are followed herein to demonstrate compliance (in whole or in part) with these regulations.

| | |
|---|---|
| ANSI C63.4:2014 | "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" |
| ANSI C63.10:2013 | "American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices" |
| ANSI C63.26:2015 | "American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services" |
| KDB 653005 D01 v01r02 | "Equipment Authorization Guidance for 76-81 GHz Radar Devices " |
| TP0102RA | "AHD Internal Document TP0102 - Radiated Emissions Test Procedure" |

# 3 Configuration and Identification of the Equipment Under Test

## 3.1 Description and Declarations

The EUT is an vehicular radar. The EUT is approximately 19 x 11 x 2 cm in dimension, and is depicted in Figure 1. It is powered by 12 VDC vehicle power system. In use, this device is permanently affixed in a motor vehicle. Table 3 outlines provider declared EUT specifications.

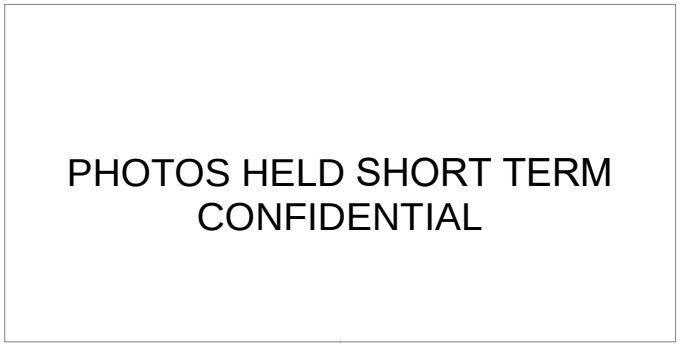



Figure 1: Photos of EUT.

Table 3: EUT Declarations.

| **General Declarations** | |
|---|---|
| **Equipment Type:** | FMCW Radar |
| **Country of Origin:** | Not Declared |
| **Nominal Supply:** | 12 VDC |
| **Oper. Temp Range:** | $-40^{o}$C to $+85^{o}$C |
| **Frequency Range:** | 77 to 78 GHz |
| **Antenna Dimension:** | 6cm |
| **Antenna Type:** | integral patch arrays |
| **Antenna Gain:** | 16.5 dBi |
| **Number of Channels:** | 1 |
| **Channel Spacing:** | Not Applicable |
| **Alignment Range:** | Not Declared |
| **Type of Modulation:** | FMCW |
| | |
| **United States** | |
| **FCC ID Number:** | L2CFLR4P |
| **Classification:** | VRD |

### 3.1.1 EUT Configuration

The EUT is configured for testing as depicted in Figure 2.

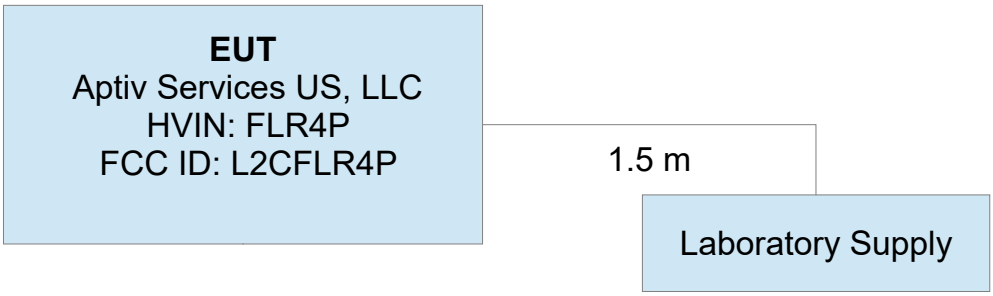



Figure 2: EUT Test Configuration Diagram.

### 3.1.2 Modes of Operation

The manufacturer considers the modes of operation of this product to be of a proprietary nature. Please reference confidential Modes of Operation exhibit for complete details.

### 3.1.3 Variants

There is only a single variant of the EUT, as tested.

### 3.1.4 Test Samples

Two normal operating samples (SN: 1798, 1801) were provided for testing along with three samples configured for CW transmission at Lowest, Middle, and Highest frequencies of operation (SN: 1799, 1800, 1802).

### 3.1.5 Functional Exerciser

Normal operating EUT functionality was verified prior to testing by observation of the emissions spectrum.

### 3.1.6 Modifications Made

There were no modifications made to the EUT by this laboratory.

### 3.1.7 Production Intent

The EUT appears to be a production ready sample.

### 3.1.8 Declared Exemptions and Additional Product Notes

The EUT is permanently installed in a transportation vehicle. As such, digital emissions are exempt from US and Canadian digital emissions regulations (per FCC 15.103(a) and IC correspondence on ICES-003). In the mm-wave band, narrow pulses arise as the FMCW signal chirps past the receiver tuned frequency. To avoid amplitude measurement error due to Pulse Desensitization, we measure peak emissions only when the radar is either placed into CW mode or when the signal “Dwells” at a single frequency for an extended period of time.

# 4 Emissions

## 4.1 General Test Procedures

### 4.1.1 Radiated Test Setup and Procedures

Radiated electromagnetic emissions from the EUT are first pre-scanned in our screen room. Spectrum and modulation characteristics of all emissions are recorded. Instrumentation, including spectrum analyzers and other test equipment as detailed in Section 1.8 are employed. After pre-scan, emission measurements are made on the test site of record. If the EUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in relevant test standards are followed. Alternatively, a layout closest to normal use (as declared by the provider) is employed if the resulting emissions appear to be worst-case in such a configuration. See Figure 3. All intentionally radiating elements that are not fixed-mounted in use are placed on the test table lying flat, on their side, and on their end (3-axes) and the resulting worst case emissions are recorded. If the EUT is fixed-mounted in use, measurements are made with the device oriented in the manner consistent with installation and then emissions are recorded. If the EUT exhibits spurious emissions due to internal receiver circuitry, such emissions are measured with an appropriate carrier signal applied.

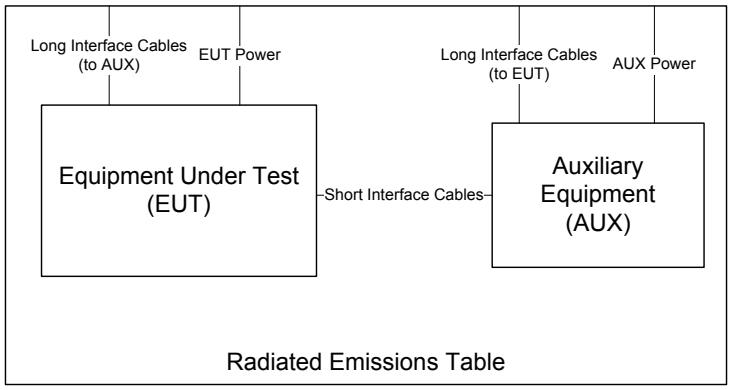



Figure 3: Radiated Emissions Diagram of the EUT.

For devices with intentional emissions below 30 MHz, a shielded loop antenna and/or E-field and H-Field broadband probes are used depending on the regulation. Shielded loops are placed at a 1 meter receive height at the desired measurement distance. For exposure in this band, 10cm diameter single-axis broadband probes meeting the requirements of ISED SPR-002 section 5.2 are employed. Measurements are repeated and summed over three axes, and the entire frequency range is measured with and without the EUT transmitting.

Emissions between 30 MHz and 1 GHz are measured using calibrated broadband antennas. For both horizontal and vertical polarizations, the test antenna is raised and lowered from 1 to 4 m in height until a maximum emission level is detected. The EUT is then rotated through $360^o$ in azimuth until the highest emission is detected. The test antenna is then raised and lowered one last time from 1 to 4 m and the worst case value is recorded. Emissions above 1 GHz are characterized using standard gain or broadband ridge-horn antennas on our OATS with a $4 \times 5$ m rectangle of ECCOSORB absorber covering the OATS ground screen and a 1.5m table height. Care is taken to ensure that test receiver resolution and video bandwidths meet the regulatory requirements, and that the emission bandwidth of the EUT is not reduced. Photographs of the test setup employed are depicted in Figure 4.

Where regulations allow for direct measurement of field strength, power values (dBm) measured on the test receiver / analyzer are converted to dB$\mu$V/m at the regulatory distance, using

$$E_{dist} = 107 + P_R + K_A - K_G + K_E - C_F$$

where $P_R$ is the power recorded on spectrum analyzer, in dBm, $K_A$ is the test antenna factor in dB/m, $K_G$ is the combined pre-amplifier gain and cable loss in dB, $K_E$ is duty correction factor (when applicable) in dB, and $C_F$ is a distance conversion (employed only if limits are specified at alternate distance) in dB. This field strength value is then compared with the regulatory limit. If effective isotropic radiated power (EIRP) is computed, it is computed as

$$EIRP(dBm) = E_{3m}(dB\mu V/m) - 95.2.$$

When presenting data at each frequency, the highest measured emission under all possible EUT orientations (3-axes) is reported.

Where regulations call for substitution method measurements, the EUT is replaced by a substitution antenna if field strength measurements indicate the emission is close to the regulatory limit. This antenna is co-polarized with the test antenna and tuned (when necessary) to the emission frequency, after which the test antenna height is again optimized. The substitution antenna's signal level is adjusted such that its emission is equal to the level measured from the EUT. The signal level applied to the substitution antenna is then recorded. Effective isotropic radiated power (EIRP) and effective radiated power (ERP) in dBm are formulated from

$$EIRP = P_T - G_A = ERP + 2.16, \tag{1}$$

where $P_T$ is the power applied to substitution antenna in dBm, including correction for cable loss, and $G_A$ is the substitution antenna gain, in dBi.

When microwave measurements are made at a range different than the regulatory distance or made at close-range to improve receiver sensitivity, the reading is corrected back to the regulatory distance. This is done using a 20 dB/decade field behavior as dictated by the test procedures. When measurements are made in the near-field, the near-field/far-field boundary (N/F) is reported. It is computed as

$$N/F = 2D^2/\lambda$$

where $D$ is the maximum dimension of the transmitter or receive antenna, and $\lambda$ is the wavelength at the measurement frequency. Typically for high frequency measurements the receive antenna is connected to test receiver / analyzer through an external mixer. In this case, cable loss, IF amplifier gain, and mixer conversion losses are corrected for in the data table, or directly in the analyzer.


Figure 4: Radiated Emissions Test Setup Photograph(s).

### 4.1.2 Conducted Emissions Test Setup and Procedures

### 4.1.3 Power Supply Variation

Tests at extreme supply voltages are made if required by the procedures specified in the test standard, and results of this testing are detailed in this report.

## 4.2 Intentional Emissions

### 4.2.1 Fundamental Emission Pulsed Operation

The details and results of testing the EUT for pulsed operation are summarized in Table 4. Plots showing the measurements made to obtain these values are provided in Figure 5.

Table 4: Pulsed Emission Characteristics (Duty Cycle).

**EUT:** Aptiv FLR4P
**Test Date(s):** 05/01/23
**Test Engineer:** J. Brunett
**Meas. Distance:** 3 m

**EUT Modes:**
**a1** Normal Modulated
**a2** CW Low
**a3** CW Mid
**a4** CW High

**FMCW Chirp Details – Exposure Duty Cycle**

| R0 | Transmit Mode | Voltage | Freq | Receiver Bandwidth RBW | Receiver Bandwidth VBW | Total Cycle Time | FMCW On-Time | BPSK Ant Duty | Exposure Duty Factor | min FMCW Period | CHIRP BW | Dwell/MHz/Chirp | Chirps / On-Time | Max On-Time per Chirp-MHz |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage | GHz | MHz | | ms | ms | dB | dB | ms | MHz | ms | # | ms |
| R1 | **a1** | 12.0 | 77.700 | 28.000 | 40.000 | 49.3 | 10.20 | -3.0 | **-9.8** | 0.029 | 975.0 | 0.00003 | 358 | 0.010 |
| R2 | | | | | | | | | | | | | | |
| R3 | | | | | | | | | | | | | | |
| # | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | C14 |

| (ROW) | (COLUMN) | NOTES |
|---|---|---|
| R0 | C3 | Worst-case frequency selected at center of operating band. |
| R0 | C6 | BPSK array interleaving. 25% A1 Gain, 25% A2 Gain, and 50% A3 Gain: 10*LOG10(0.25*10^(0/10)+0.25*10^(-3/10)+0.50*10^(-6/10)) = -3.0, see Modes Exhibit for Details. |
| R0 | C7 | Exposure Duty Correction = 10*Log(Total On-Time/Total Cycle-Time) + BPSK Antenna Duty |
| R0 | C10 | Dwell / MHz / Chirp is the CW time spent in any given 1MHz window within the channel during a single chirp = FMCW Period / CHIRP BW, |
| R0 | C11 | Chirps / On-Time = FMCW On-Time / FMCW Period |
| R0 | C12 | Max On-Time / Cycle = Chirps / On-Time x Dwell / MHz / Chirp, Total on time in a 1 MHz band per Chirp Cycle |
| R1 | all | Chirp modulation for Tx1 and Tx23 modes is identical, only the transmit antenna array is changed. |

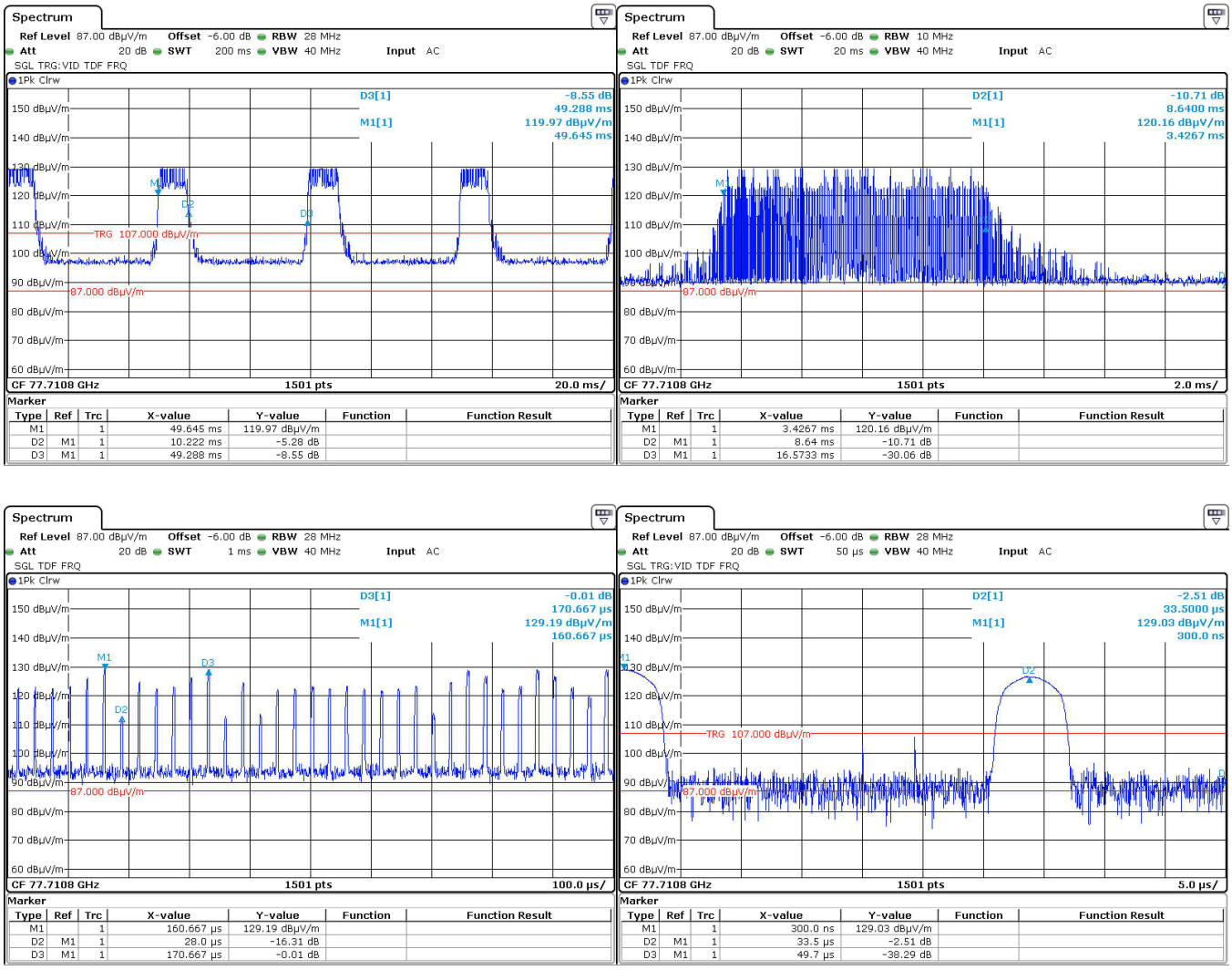



Figure 5: Example Pulsed Emission Characteristics (Duty Cycle).

### 4.2.2 Fundamental Emission Bandwidth

Emission bandwidth (EBW) of the EUT is measured with the device placed in the worst case test mode. Radiated emissions are recorded following the test procedures listed in Section 2.1. The 99% EBW is measured as the max-held peak-detected signal when the IF bandwidth is greater than or equal to 1% of the receiver span. The results of EBW testing are summarized in Table 5. Plots showing measurements employed to obtain the emission bandwidth reported are provided in Figure 6.

Table 5: Intentional Emission Bandwidth.

| **Det** | **IF Bandwidth** | **Video Bandwidth** | **EUT:** | Aptiv FLR4P |
|---|---|---|---|---|
| Pk | 10 MHz | 28 MHz | **Test Date(s):** | 5/1/2023 |
| | | | **Test Engineer:** | J. Brunett |

**EUT Modes**: **a1** Normal Modulated
**a2** CW Low
**a3** CW Mid
**a4** CW High

| **Occupied Bandwidth** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| R0 | Transmit Mode | Temperature ( C ) | Voltage (V) | fL (MHz) | fL Limit (MHz) | fH (MHz) | fH Limit (MHz) | 99% OBW (MHz) | Freq Stab. ppm | Notes/Pass/Fail |
| R1 | **a1** | 85.0 | 18.0 | 77024.9 | 76000.0 | 77993.2 | 81000.0 | 968.4 | 20.5 | |
| R2 | | 85.0 | 9.0 | 77024.8 | 76000.0 | 77993.1 | 81000.0 | 968.4 | 19.4 | |
| R3 | | 80.0 | 12.0 | 77024.8 | 76000.0 | 77993.1 | 81000.0 | 968.4 | 18.9 | |
| R4 | | 70.0 | 12.0 | 77024.7 | 76000.0 | 77993.1 | 81000.0 | 968.4 | 18.3 | |
| R5 | | 60.0 | 12.0 | 77024.7 | 76000.0 | 77993.0 | 81000.0 | 968.4 | 17.9 | |
| R6 | | 50.0 | 12.0 | 77024.6 | 76000.0 | 77993.0 | 81000.0 | 968.4 | 16.9 | |
| R7 | | 40.0 | 12.0 | 77024.3 | 76000.0 | 77992.7 | 81000.0 | 968.4 | 13.3 | |
| R8 | | 30.0 | 12.0 | 77024.1 | 76000.0 | 77992.5 | 81000.0 | 968.4 | 10.8 | |
| R9 | | 20.0 | 12.0 | 77023.3 | 76000.0 | 77991.7 | 81000.0 | 968.4 | 0.0 | |
| R10 | | 10.0 | 12.0 | 77023.0 | 76000.0 | 77991.3 | 81000.0 | 968.4 | -4.1 | |
| R11 | | 0.0 | 12.0 | 77022.8 | 76000.0 | 77991.2 | 81000.0 | 968.4 | -6.2 | |
| R12 | | -10.0 | 12.0 | 77022.8 | 76000.0 | 77991.2 | 81000.0 | 968.4 | -6.5 | |
| R13 | | -20.0 | 12.0 | 77022.7 | 76000.0 | 77991.1 | 81000.0 | 968.4 | -7.5 | |
| R14 | | -30.0 | 12.0 | 77022.6 | 76000.0 | 77991.0 | 81000.0 | 968.4 | -9.1 | |
| R15 | | -40.0 | 18.0 | 77022.3 | 76000.0 | 77990.6 | 81000.0 | 968.4 | -13.2 | |
| R16 | | -40.0 | 9.0 | 77022.8 | 76000.0 | 77991.2 | 81000.0 | 968.4 | -6.3 | |
| # | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | | C9 |

| (ROW) | (COLUMN) | NOTES |
|---|---|---|
| R0 | C4, C6 | Computed via CW mode frequency shift and nominal OBW measurements. |

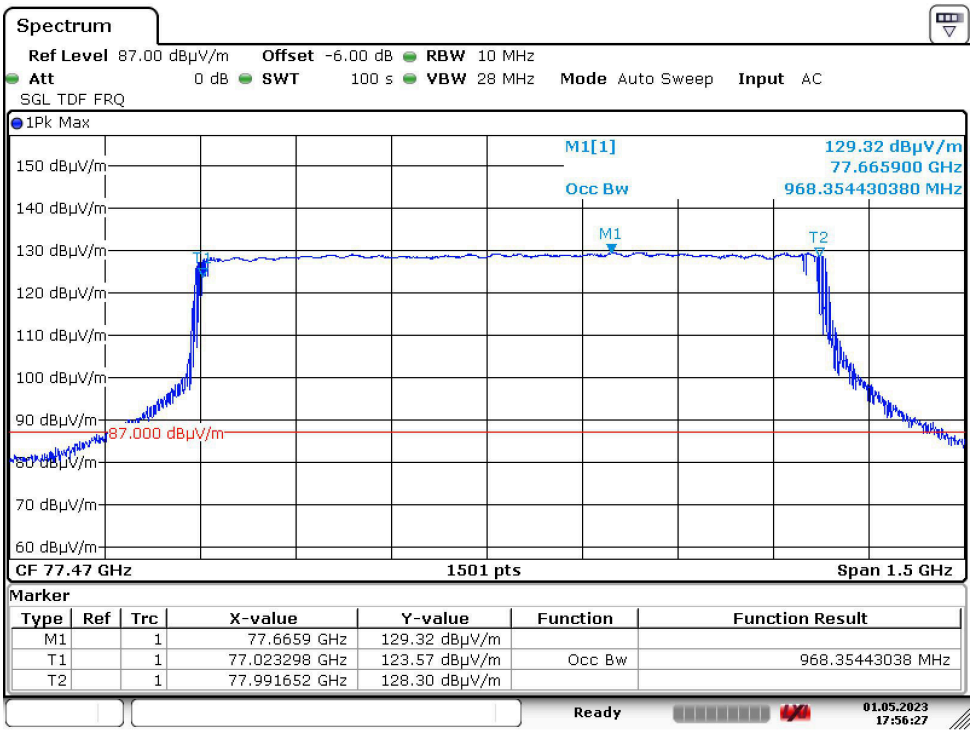



Figure 6: Example Intentional Emission Bandwidth.

### 4.2.3 Fundamental Emission

Following the test procedures listed in Section 2.1, radiated emissions measurements are made on the EUT for both Horizontal and Vertical polarized fields. Table 6 details the results of these measurements.

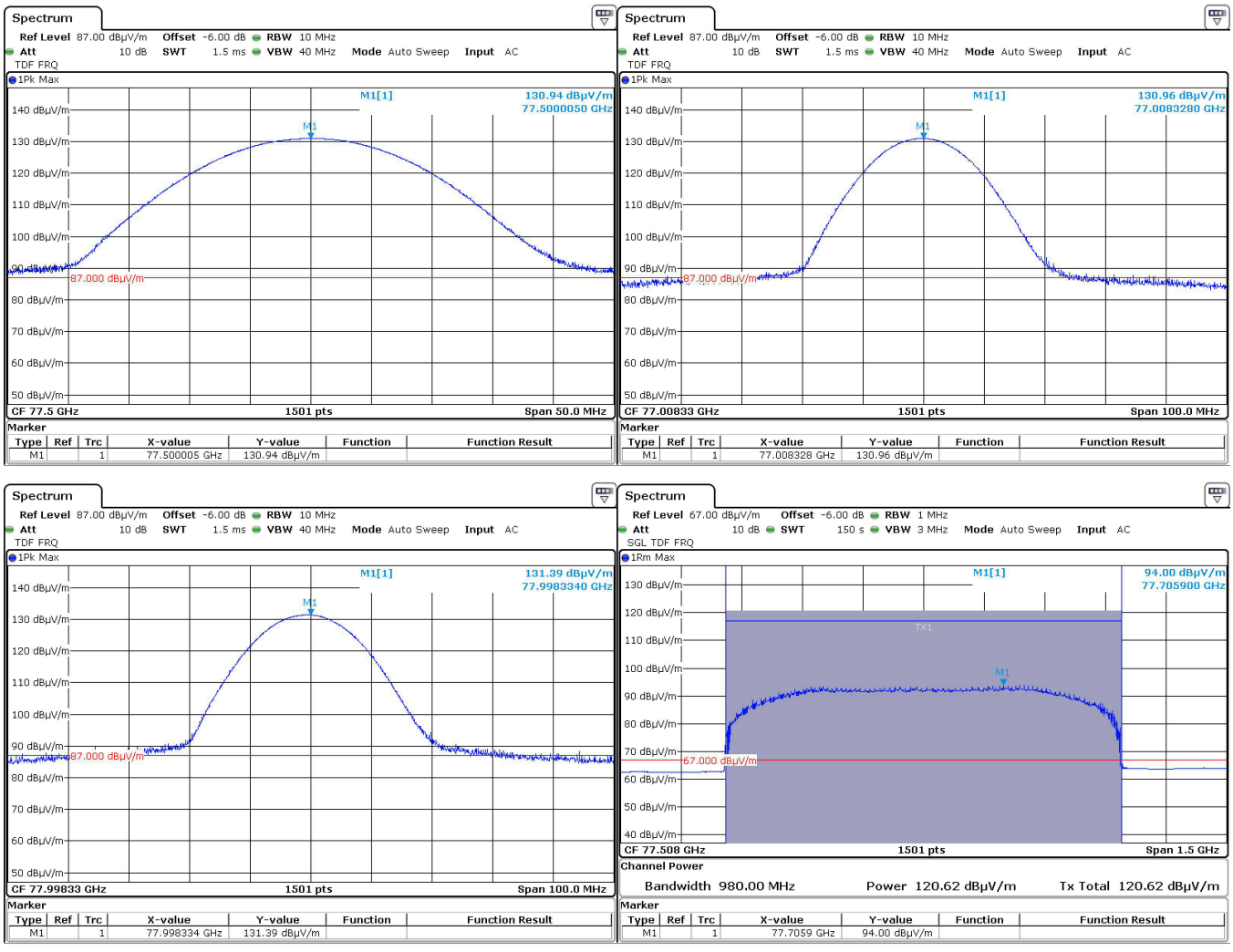
Table 6(a): Fundamental Radiated Emissions.

**EUT Modes:** **a1** Normal Modulated **a5**
**EUT:** Aptiv FLR4P **a2** CW Low **a6**
**Test Date(s):** 05/01/23 **a3** CW Mid **a7**
**Test Engineer:** J. Brunett **a4** CW High **a8**

| R0 | Frequency | | Site | | | | | | EUT | | | Test Antenna | | | | Cable/Mixer | Receiver | | Field Strength @ DR | | | | EIRP | | | | Regulation | Details | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Start | Stop | Temp. Hum | Table Angle | MR | DR | N/F | CF | Mode | Volt. | Dim | Pol. | Ant. Height | Dim. | Ka | CL/Kg | Bandwidth RBW | VBW | Pk Meas. | Pk Limit | Avg Meas. | Avg Limit | Pk Calc. | Pk Limit | Avg Calc. | Avg Limit | USA/CAN 95M/251 | Pass/Fail | |
| | MHz | MHz | C, % | deg | | | m | dB | | (V) | cm | H/V | m | cm | dB/m | dB | MHz | | dBuV/m | | | | dBm | | | | § | dB | |
| R1 | SETUP | | OATSC | | | | | | SAMPLE A | | | HRNE01 | | | | VDIE01 | FSV3 | | NOTES: EUT Copolarized along long axis of radome. | | | | | | | | | | |
| R2 | 77008.3 | 77008.3 | 20, 38 | 0.0 | 3.0 | 3.0 | 1.3 | 0.0 | **a2** | 12.0 | 5.0 | V | 1.5 | 2.0 | | -6.0 | 1.00 | 28.00 | 131.0 | | | | 35.8 | 55.0 | | | 95M/251 | 19.2 | Peak Meas, CW mode |
| R3 | 77500.0 | 77500.0 | 20, 38 | 0.0 | 3.0 | 3.0 | 1.3 | 0.0 | **a3** | 12.0 | 5.0 | V | 1.5 | 2.0 | | -6.0 | 1.00 | 28.00 | 130.9 | | | | 35.7 | 55.0 | | | 95M/251 | 19.3 | Peak Meas, CW mode |
| R4 | 77998.3 | 77998.3 | 20, 38 | 0.0 | 3.0 | 3.0 | 1.3 | 0.0 | **a4** | 12.0 | 5.0 | V | 1.5 | 2.0 | | -6.0 | 1.00 | 28.00 | 131.4 | | | | 36.2 | 55.0 | | | 95M/251 | **18.8** | Peak Meas, CW mode |
| R5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R6 | 76000.0 | 81000.0 | 20, 38 | 0.0 | 3.0 | 3.0 | 1.4 | 0.0 | **a1** | 12.0 | 5.0 | H | 1.5 | 2.0 | | -6.0 | 1.00 | 3.00 | | | 120.6 | | | | 25.4 | 50.0 | 95M/251 | 24.6 | FCC RMS Meas, chirp |
| R7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | C14 | C15 | C16 | C17 | C18 | C19 | C20 | C21 | C22 | C23 | C24 | C25 | C26 | C27 | C28 | C29 |

| (ROW) | (COLUMN) | NOTE: |
|---|---|---|
| R0 | C5 | MR is Measurement Range, which may be reduced from DR to achieve necessary SNR. |
| R0 | C6 | DR is the regulatory Desired Range measurement distance. |
| R0 | C7 | N/F is Near-Field / Far-Field distance computed for max of Antenna Dimension (C10 or C14) computed above 1 GHz. |
| R0 | C8 | CF is computed using a 20 dB/decade Decay Rate. |
| R2-R7 | C19 | Measurement settings for peak power according to KDB 653005 D01 76-81 GHz Radars v01r01, 4 (c) but with radar in CW mode negating concerns for pulse desensitization. |
| R10, R11 | C19 | Measurement settings for RMS power integrated over the OBW according to KDB 653005 D01 76-81 GHz Radars v01r01, 4(b) |

Table 6(b): Fundamental Radiated Emissions.



## 4.3 Unintentional Emissions

### 4.3.1 Transmit Chain Spurious Emissions

The results for the measurement of transmit chain spurious emissions at the nominal voltage and temperature are provided in Table 7.

Table 7(a): Transmit Chain Spurious Emissions.

**EUT Modes:** **a1** Normal Modulated **a5** max all modes (a1 - a4)
**EUT:** Aptiv FLR4P **a2** CW Low **a6**
**Test Date(s):** 05/12/23 **a3** CW Mid **a7**
**Test Engineer:** J. Brunett **a4** CW High **a8**

| R0 | Frequency | | Site | | | | | | EUT | | | | Test Antenna | | | | Cable | Receiver | | Field Strength @ DR | | | | EIRP | | | | Regulation | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Start | Stop | Temp. | Table | MR | DR | N/F | CF | | | | | Pol. | Ant. | Dim. | Ka | Mixer | Bandwidth | | Pk | | QPk/Avg | | Pk | | Qpk/Avg | | USA/CAN | | |
| | | | Hum | Angle | | | | | Mode | Volt. | Dim | | | Height | | | CL/Kg | RBW | VBW | Meas. | Lim. | Meas. | Lim. | Calc. | Lim. | Calc. | Lim. | 95M/GEN | Pass/Fail | |
| | MHz | MHz | C, % | deg | m | | | dB | | (V) | cm | | H/V | m | cm | dB/m | dB | MHz | | dBuV/m | | | | dBm | | | | § | dB | |
| R1 | SETUP | | OATSC | | | | | | 3XSAMPLES | | | | BICEMCO01 | | | | CBL01 | FSV3 | | | | | | | | | | | | |
| R2 | 30.0 | 88.0 | 20 38 | 0.0 | 3.0 | 3.0 | 0.0 | 0.0 | **a5** | 24.0 | 5.0 | H/V | 1-4 | | | | | 0.12 | 0.30 | 31.2 | 60.0 | 25.4 | 40.0 | -64.0 | | -69.8 | | 15.209 / GEN | 14.6 | |
| R3 | 88.0 | 216.0 | 20 38 | 0.0 | 3.0 | 3.0 | 0.0 | 0.0 | **a5** | 24.0 | 5.0 | H/V | 1-4 | | | | | 0.12 | 0.30 | 24.2 | 63.5 | 21.4 | 43.5 | -71.0 | | -73.8 | | 15.209 / GEN | 22.1 | |
| R4 | SETUP | | OATSC | | | | | | 3XSAMPLES | | | | LOGEMCO01 | | | | CBL01 | FSV3 | | | | | | | | | | | | |
| R5 | 216.0 | 1000.0 | 20 38 | 0.0 | 3.0 | 3.0 | 0.0 | 0.0 | **a5** | 24.0 | 5.0 | H/V | 1-4 | | | | | 0.12 | 0.30 | 39.2 | 66.0 | 38.8 | 46.0 | -56.0 | | -56.4 | | 15.209 / GEN | 7.2 | |
| R6 | 250.0 | 250.0 | 20 38 | 0.0 | 3.0 | 3.0 | 0.0 | 0.0 | **a5** | 24.0 | 5.0 | H | 1-4 | | | | | 0.12 | 0.30 | 39.2 | 66.0 | 36.1 | 46.0 | -56.0 | | -59.1 | | 15.209 / GEN | 9.9 | |
| R7 | 250.0 | 250.0 | 20 38 | 0.0 | 3.0 | 3.0 | 0.0 | 0.0 | **a5** | 24.0 | 5.0 | V | 1-4 | | | | | 0.12 | 0.30 | 34.2 | 66.0 | 20.4 | 46.0 | -61.0 | | -74.8 | | 15.209 / GEN | 25.6 | |
| R8 | SETUP | | OATSC | | | | | | 3XSAMPLES | | | | HQR1TO18S01 | | | | CBL04 | FSV30 | | | | | | | | | | | | |
| R9 | 1000.0 | 6000.0 | 20 38 | 0.0 | 3.0 | 3.0 | 0.9 | 0.0 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 15.0 | | | | 1.00 | 3.00 | 38.2 | 74.0 | 0.0 | 54.0 | -57.0 | | -95.2 | | 15.209 / GEN | 35.8 | |
| R10 | 1890.0 | 1890.0 | 20 38 | 0.0 | 3.0 | 3.0 | 0.3 | 0.0 | **a5** | 24.0 | 5.0 | H | 1.5 | 15.0 | | | | 1.00 | 3.00 | 38.2 | 74.0 | | 54.0 | -57.0 | | -95.2 | | 15.209 / GEN | 15.8 | |
| R11 | 2135.0 | 2135.0 | 20 38 | 0.0 | 3.0 | 3.0 | 0.3 | 0.0 | **a5** | 24.0 | 5.0 | V | 1.5 | 15.0 | | | | 1.00 | 3.00 | 37.6 | 74.0 | | 54.0 | -57.6 | | -95.2 | | 15.209 / GEN | 16.4 | |
| R12 | 6000.0 | 18000.0 | 20 38 | 0.0 | 3.0 | 3.0 | 2.7 | 0.0 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 15.0 | | | | 1.00 | 3.00 | 49.0 | 74.0 | 36.9 | 54.0 | -46.3 | | -58.3 | | 15.209 / GEN | 17.1 | |
| R13 | SETUP | | OATSC | | | | | | 3XSAMPLES | | | | HRNK01 | | | | BL04 + PN40AM | FSV30 | | | | | | | | | | | | |
| R14 | 18000.0 | 26500.0 | 20 38 | 0.0 | 3.0 | 3.0 | 1.8 | 0.0 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 10.2 | | | 40.0 | 1.00 | 3.00 | 55.6 | 74.0 | 47.3 | 54.0 | -39.6 | | -47.9 | | 15.209 / GEN | 6.7 | |
| R15 | 25650.0 | 25650.0 | 20 38 | 0.0 | 3.0 | 3.0 | 1.8 | 0.0 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 10.2 | | | 40.0 | 1.00 | 3.00 | 51.2 | 74.0 | 47.3 | 54.0 | -44.0 | | -47.9 | | 15.209 / GEN | **6.7** | CW / LO |
| R16 | 25983.0 | 25983.0 | 20 38 | 0.0 | 3.0 | 3.0 | 1.8 | 0.0 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 10.2 | | | 40.0 | 1.00 | 3.00 | 55.6 | 74.0 | 46.1 | 54.0 | -39.6 | | -49.1 | | 15.209 / GEN | 7.9 | chirping |
| R17 | SETUP | | OATSC | | | | | | 3XSAMPLES | | | | HRNKA01 | | | | PN40AMP | FSV3 | | | | | | | | | | | | |
| R18 | 26500.0 | 40000.0 | 20 38 | 0.0 | 3.0 | 3.0 | 2.3 | 0.0 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 9.2 | | | 40.0 | 1.00 | 3.00 | 40.1 | 74.0 | | 54.0 | -55.1 | | -95.2 | | 15.209 / GEN | 33.9 | |
| R19 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| # | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | C14 | C15 | | C16 | C17 | C18 | C19 | C20 | C21 | C22 | C23 | C24 | C25 | C26 | C27 | C28 | C29 |

| (ROW) | (COLUMN) | NOTE: |
|---|---|---|
| R0 | C5 | MR is Measurement Range, which may be reduced from DR to achieve necessary SNR. |
| R0 | C6 | DR is the regulatory Desired Range measurement distance. |
| R0 | C7 | N/F is Near-Field / Far-Field distance computed for max of Antenna Dimension (C10 or C14) computed above 1 GHz. |
| R0 | C8 | CF is computed using a 20 dB/decade Decay Rate. |
| R7,R11 | C28 | For a vehicular mounted radio device, only spurious arrising from the RF chain are subject to the spurious emissions limits. If these emissions are from digital circuitry, they may not be subject. |

# Table 7(b): Transmit Chain Spurious Emissions.

**EUT Modes:** **a1** Normal Modulated **a5** max all modes (a1 - a4)
**EUT:** Aptiv FLR4P **a2** CW Low **a6**
**Test Date(s):** 05/13/23 **a3** CW Mid **a7**
**Test Engineer:** J. Brunett **a4** CW High **a8**

| R0 | Frequency | | Site | | | | | | EUT | | | | Test Antenna | | | | Cable | Receiver | | Field Strength @ DR | | | | EIRP/MHz | | | | Regulation | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Start | Stop | Temp. | Table | MR | DR | N/F | CF | Mode | Volt. | Dim | Pol. | Ant. | Dim. | Ka | | Mixer | Bandwidth | | Pk | | QPk/RMS | | Pk | | Avg / RMS | | Canada | | |
| | | | Hum | Angle | | | | | | | | | Height | | | | CL/Kg | RBW | VBW | Meas. | Lim. | Meas. | Lim. | Calc. | Lim. | Calc. | Lim. | RSS-251 | Pass/Fail | |
| | GHz | GHz | C, % | deg | m | | | dB | | (V) | cm | H/V | m | cm | dB/m | | dB | MHz | | dBuV/m | | | | dBm/MHz | | | | § | dB | |
| R1 | SETUP | | OATSC | | | | | | 3XSAMPLES | | | | HRNU01 | | | | MIX40TO7001 | FSV3 | | | | | | | | | | | |
| R2 | 40.0 | 70.0 | 20 38 | 0.0 | 0.3 | 3.0 | 1.9 | 20.0 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 6.3 | | | | 1.00 | 3.00 | 55.2 | | 46.3 | | -40.0 | | -48.9 | -30.0 | 10.2 | 18.9 | noise floor |
| R3 | SETUP | | OATSC | | | | | | 3XSAMPLES | | | | HRNE01 | | | | MIX60TO9001 | FSV3 | | | | | | | | | | | |
| R4 | 70.0 | 73.5 | 20 38 | 0.0 | 3.0 | 3.0 | 1.2 | 0.0 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 2.0 | | | | 1.00 | 3.00 | 58.9 | | 49.2 | | -36.3 | | -46.0 | -30.0 | 10.2 | 16.0 | noise floor |
| R5 | 73.5 | 76.0 | 20 38 | 0.0 | 3.0 | 3.0 | 1.3 | 0.0 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 2.0 | | | | 1.00 | 3.00 | 60.1 | | 51.9 | | -35.1 | | -43.3 | -30.0 | 10.2 | 13.3 | noise floor |
| R6 | 81.0 | 90.0 | 20 38 | 0.0 | 3.0 | 3.0 | 1.5 | 0.0 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 2.0 | | | | 1.00 | 3.00 | 69.9 | | 60.1 | | -25.3 | | -35.1 | -30.0 | 10.2 | 5.1 | noise floor |
| R7 | SETUP | | OATSC | | | | | | 3XSAMPLES | | | | HRNF01 | | | | MIX90TO14001 | FSV3 | | | | | | | | | | | |
| R8 | 90.0 | 140.0 | 20 38 | 0.0 | 3.0 | 3.0 | 2.3 | 0.0 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 1.8 | | | | 1.00 | 3.00 | 70.3 | | 61.0 | | -24.9 | | -34.2 | -30.0 | 10.2 | **4.2** | noise floor |
| R9 | SETUP | | OATSC | | | | | | 3XSAMPLES | | | | HRNG01 | | | | MIX140TO22001 | FSV3 | | | | | | | | | | | |
| R10 | 140.0 | 162.0 | 20 38 | 0.0 | 0.3 | 3.0 | 2.7 | 20.0 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 1.0 | | | | 1.00 | 3.00 | 66.1 | | 56.4 | | -29.1 | | -38.8 | -30.0 | 10.2 | 8.8 | noise floor |
| R11 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R12 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| R13 | Frequency | | Site | | | | | | EUT | | | | Test Antenna | | | | Cable | Receiver | | Field Strength @ DR | | | | S @ DR | | | | Regulation | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Start | Stop | Temp. | Table | MR | DR | N/F | CF | Mode | Volt. | Dim | Pol. | Ant. | Dim. | Ka | | Mixer | Bandwidth | | Pk | | QPk/Avg | | Pk | | Avg | | USA | | |
| | | | Hum | Angle | | | | | | | | | Height | | | | CL/Kg | RBW | VBW | Meas. | Lim. | Meas. | Lim. | Calc. | Lim. | Calc. | Lim. | Part 95M | Pass/Fail | |
| | GHz | GHz | C, % | deg | m | | | dB | | (V) | cm | H/V | m | cm | dB/m | | dB | MHz | | dBuV/m | | | | dBm/cm2 | | | | § | dB | |
| R14 | SETUP | | OATSC | | | | | | SAMPLE A | | | | HRNU01 | | | | MIX40TO7001 | FSV3 | | | | | | | | | | | |
| R15 | 40.0 | 70.0 | 20 38 | 0.0 | 0.3 | 3.0 | 1.9 | 20.0 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 6.3 | | | | 1.00 | 3.00 | 55.2 | | 44.8 | | -100.5 | | -110.9 | -62.2 | 95.3379 | 48.7 | noise floor |
| R16 | SETUP | | OATSC | | | | | | SAMPLE A | | | | HRNE01 | | | | MIX60TO9001 | FSV3 | | | | | | | | | | | |
| R17 | 70.0 | 73.5 | 20 38 | 0.0 | 3.0 | 3.0 | 1.2 | 0.0 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 2.0 | | | | 1.00 | 3.00 | 58.9 | | 49.2 | | -96.8 | | -106.5 | -62.2 | 95.3379 | 44.3 | noise floor |
| R18 | 73.5 | 76.0 | 20 38 | 0.0 | 3.0 | 3.0 | 1.3 | 0.0 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 2.0 | | | | 1.00 | 3.00 | 60.1 | | 51.9 | | -95.6 | | -103.8 | -62.2 | 95.3379 | 41.6 | noise floor |
| R19 | 81.0 | 90.0 | 20 38 | 0.0 | 3.0 | 3.0 | 1.5 | 0.0 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 2.0 | | | | 1.00 | 3.00 | 69.9 | | 60.1 | | -85.8 | | -95.6 | -62.2 | 95.3379 | 33.4 | noise floor |
| R20 | SETUP | | OATSC | | | | | | SAMPLE A | | | | HRNF01 | | | | MIX90TO14001 | FSV3 | | | | | | | | | | | |
| R21 | 90.0 | 140.0 | 20 38 | 0.0 | 3.0 | 3.0 | 2.3 | 0.0 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 1.8 | | | | 1.00 | 3.00 | 70.3 | | 61.0 | | -85.4 | | -94.7 | -62.2 | 95.3379 | 32.5 | noise floor |
| R22 | SETUP | | OATSC | | | | | | SAMPLE A | | | | HRNG01 | | | | MIX140TO22001 | FSV3 | | | | | | | | | | | |
| R23 | 140.0 | 220.0 | 20 38 | 0.0 | 1.0 | 3.0 | 3.7 | 9.5 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 1.0 | | | | 1.00 | 3.00 | 66.1 | | 56.4 | | -89.6 | | -99.3 | -62.2 | 95.3379 | 37.1 | noise floor |
| R24 | SETUP | | OATSC | | | | | | SAMPLE A | | | | HRNG01 | | | | MIX220TO33001 | FSV3 | | | | | | | | | | | |
| R25 | 220.0 | 243.0 | 20 38 | 0.0 | 0.1 | 3.0 | 4.1 | 29.5 | **a5** | 24.0 | 5.0 | H/V | 1.5 | 1.0 | | | | 1.00 | 3.00 | 69.2 | | 60.4 | | -86.5 | | -95.3 | -62.2 | 95.3379 | 33.1 | noise floor |
| R26 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R27 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| # | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | C14 | C15 | C16 | C17 | C18 | C19 | C20 | C21 | C22 | C23 | C24 | C25 | C26 | C27 | C28 | C29 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| (ROW) | (COLUMN) | NOTE: |
|---|---|---|
| R0 | C5 | MR is Measurement Range, which may be reduced from DR to achieve necessary SNR. |
| R0 | C6 | DR is the regulatory Desired Range measurement distance. |
| R0 | C7 | N/F is Near-Field / Far-Field distance computed for max of Antenna Dimension (C11 or C14) computed above 1 GHz. |
| R0 | C8 | CF is computed using a 20 dB/decade Decay Rate. |
| R0 | C23 | EIRP is computed from field strength at 3 meter distance in a 1 MHz RBW / 3 MHz VBW. |
| R15 | C23 | Spatial Power Density S @ 3m (dBm/cm^2) = EIRP (dBm) – 10*log10(4*pi*((300cm)^2)) = EIRP (dBm) – 60.5 dB, E-Field (dBuV/m) @ 3m - 155.7 dB |
| R15 | C23 | S @ DR: 600 pW/cm2 = -62.2 dBm/cm2, 1000 pW/cm2 = -60 dBm/cm2, FCC Regulatory Limit; ISED Regulatory Limit EIRP / MHz |

## 5 Measurement Uncertainty and Accreditation Documents

The maximum values of measurement uncertainty for the laboratory test equipment and facilities associated with each test are given in the table below. This uncertainty is computed for a 95.45% confidence level based on a coverage factor of $k = 2$.

Table 8: Measurement Uncertainty.

| Measured Parameter | Measurement Uncertainty† |
|---|---|
| Radio Frequency | $\pm(f_{Mkr}/10^7 + RBW/10 + (SPN/(PTS-1))/2 + 1\,\text{Hz})$ |
| Conducted Emm. Amplitude | $\pm 1.9\,\text{dB}$ |
| Radiated Emm. Amplitude ($f < 30\,\text{MHz}$) | $\pm 3.1\,\text{dB}$ |
| Radiated Emm. Amplitude ($30 - 200\,\text{MHz}$) | $\pm 4.0\,\text{dB}$ |
| Radiated Emm. Amplitude ($200 - 1000\,\text{MHz}$) | $\pm 5.2\,\text{dB}$ |
| Radiated Emm. Amplitude ($f > 1000\,\text{MHz}$) | $\pm 3.7\,\text{dB}$ |

†Ref: CISPR 16-4-2:2011+A1:2014


United States Department of Commerce
National Institute of Standards and Technology

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*is accredited by the National Voluntary Laboratory Accreditation Program for specific services, listed on the Scope of Accreditation, for:*

**Electromagnetic Compatibility & Telecommunications**

*This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communique dated January 2009).*

2022-06-28 through 2023-06-30
*Effective Dates*

*For the National Voluntary Laboratory Accreditation Program*







Figure 7: Accreditation Documents