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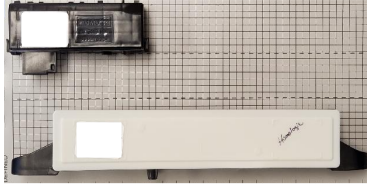
Issued: March 8, 2022

EMC Test Report

regarding

USA: CFR Title 47, Part 15.109 (Emissions)

for



F02-RX433UDA

Category: Receiver

Judgments:

15.109 Compliant

Testing Completed: March 4, 2022



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Revision History

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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 April 2032.

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
Biconical	EMCO / 93110B	9802-3039	BICEMCO01	Keysight / Aug-2023
Log Periodic Antenna	EMCO / 3146	9305-3614	LOGEMCO01	Keysight / Aug-2023
BNC-BNC Coax	WRTL / RG58/U	001	CAB001-BLACK	AHD / Sept-2022
3.5-3.5MM Coax	PhaseFlex / PhaseFlex	001	CAB015-PURP	AHD / Jul-2022
Spectrum Analyzer	R & S / FSV30	101660	RSFSV30001	RS / Apr-2023
Quad Ridge Horn	Singer / A6100	C35200	HQR1TO18S01	Keysight / Aug-2022

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 F02-RX433UDA for compliance to:

Country/Region	Rules or Directive	Referenced Section(s)
United States	Code of Federal Regulations	CFR Title 47, Part 15.109

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"
TP0102RA	"AHD Internal Document TP0102 - Radiated Emissions Test Procedure"

3 Configuration and Identification of the Equipment Under Test

3.1 Description and Declarations

The equipment under test is a superheterodyne receiver. The EUT is approximately 26.5 x 5.5 x 5 cm (Large Housing) and 10 x 5 x 3.5 cm (Small Housing) (approx) in dimension, and is depicted in Figure 1. It is powered by 13.4 VDC vehicular power system. In use, this device is permanently affixed inside a motor vehicle. Table 3 outlines provider declared EUT specifications.

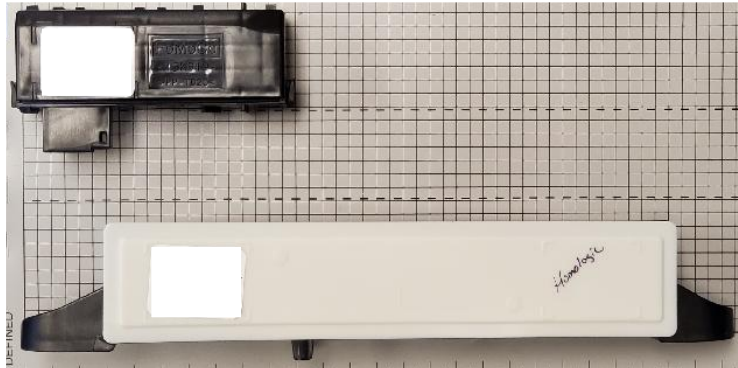


Figure 1: Photos of EUT.

Table 3: EUT Declarations.

General Declarations	
Equipment Type:	Receiver
Country of Origin:	Not Declared
Nominal Supply:	13.4 VDC
Oper. Temp Range:	Not Declared
Frequency Range:	433.92 MHz
Antenna Dimension:	Not Declared
Antenna Type:	metal frame
Antenna Gain:	Not Declared
United States	
FCC ID Number:	L2C0086R
Classification:	CYY

3.1.1 EUT Configuration

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

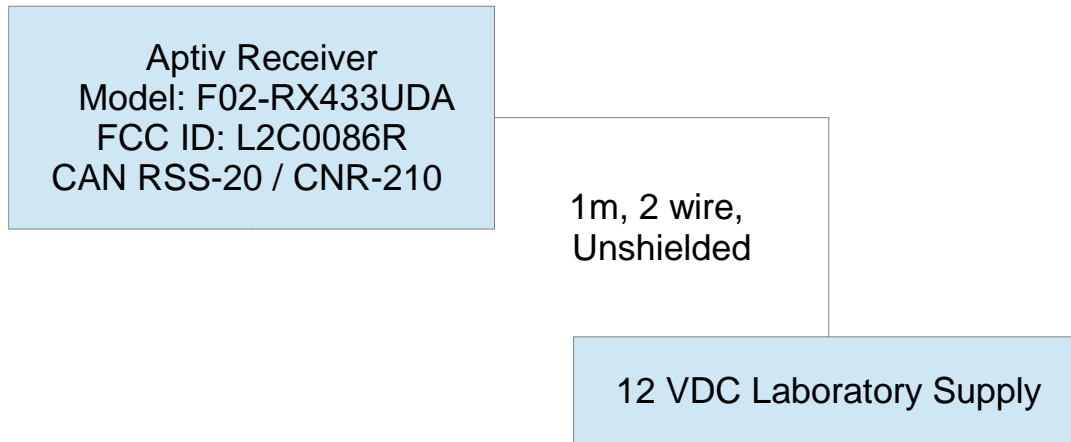


Figure 2: EUT Test Configuration Diagram.

3.1.2 Modes of Operation

The EUT employs a single mode, as tested.

3.1.3 Variants

There are two variants of the EUT which utilize a large and small plastic housing. Both variants utilize the same PCB assembly.

3.1.4 Test Samples

Two samples in total were provided (one of each large and small housing), both of which were provided with software modified to keep the receiver awake.

3.1.5 Functional Exerciser

Normal operating EUT functionality was verified by observation of transmitted signal.

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).

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.

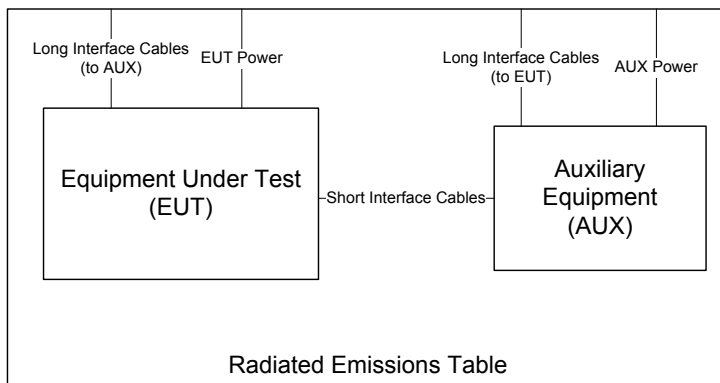


Figure 3: Radiated Emissions Diagram of the EUT.

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 regulations. Shielded loops are placed at a 1 meter receive height at the desired measurement distance. For exposure in this band, the broadband probes employed are 10cm diameter single-axis shielded transducers and measurements are repeated and summed over three axes.

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° 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 4×5 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 $\text{dB}\mu\text{V}/\text{m}$ 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

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

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



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 Unintentional Emissions

4.2.1 Radiated Receiver Spurious

The results for the measurement of radiated receiver spurious emissions (emissions arising from the receiver chain, e.g. LO or VCO) at the nominal voltage and temperature are reported in Table 4. Receive chain emissions are measured to 5 times the highest receive chain frequency employed or 4 GHz, whichever is higher. If no emissions are detected, only those noise floor emissions at the LO/VCO frequency are reported.

Table 4: Receiver Chain Spurious Emissions ≥ 30 MHz.

Frequency Range		Det	IF Bandwidth	Video Bandwidth	Test Date:	17-Feb-22
25 MHz $\leq f \leq$ 1 000 MHz		Pk/QPk	120 kHz	300 kHz	Test Engineer:	J. Nantz
f > 1 000 MHz		Pk/Avg	1 MHz	3 MHz	EUT:	Aptiv FO2-RX433UDA
					EUT Mode:	Awake
					Meas. Distance:	3 meters

Transmitter Unintentional Spurious Emissions													FCC/IC
R0	Freq. MHz	Ant. Used	Ant. Pol.	Table Azim. deg	Ant Height m	Ka dB/m	Kg dB	E3(Pk) dB μ V/m	E3 (Qpk) dB μ V/m	FCC/IC E3lim (Pk) dB μ V/m	FCC/IC E3lim (Avg) dB μ V/m	Pass dB	Comments
R1	433.9	LOGEMCO01	H	90.0	1.0	16.3	-4.6	29.4		66.0	46.0	16.6	max all, noise
R2	433.9	LOGEMCO01	V		1.4	16.3	-4.6	28.8		66.0	46.0	17.2	max all, noise
R3	867.8	LOGEMCO01	H	90.0	1.0	22.2	-6.9	30.3		66.0	46.0	15.7	max all, noise
R4	867.8	LOGEMCO01	V		1.4	22.2	-6.9	28.6		66.0	46.0	17.4	max all, noise
R5	1301.8	HQR1TO18S01	H/V	max all	1.5	32.4	-3.5	32.7		74.0	54.0	21.3	max all, noise
R6	1735.7	HQR1TO18S01	H/V	max all	1.5	30.4	-4.2	33.2		74.0	54.0	20.8	max all, noise
R7	2169.6	HQR1TO18S01	H/V	max all	1.5	29.8	-4.8	39.4		74.0	54.0	14.6	max all, noise
R8	2603.5	HQR1TO18S01	H/V	max all	1.5	30.1	-5.3	34.4		74.0	54.0	19.6	max all, noise
R9	3037.4	HQR1TO18S01	H/V	max all	1.5	30.7	-5.7	37.7		74.0	54.0	16.3	max all, noise
R10	3471.4	HQR1TO18S01	H/V	max all	1.5	31.3	-6.1	38.9		74.0	54.0	15.1	max all, noise
R11	3905.3	HQR1TO18S01	H/V	max all	1.5	31.8	-6.4	40.3		74.0	54.0	13.7	max all, noise
R12	4339.2	HQR1TO18S01	H/V	max all	1.5	32.1	-6.7	43.8		74.0	54.0	10.2	max all, noise
#	C1	C2	C3	C4	C5	C6	#	C7	C8	C9	C10	C11	C12

(ROW) R0 (COLUMN) C7/C8 NOTE: When E-field or EIRP is reported directly from Spectrum Analyzer, Antenna Factors and Cable losses are included directly in SA settings and Pr is not reported.

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 5: 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 MHz)	$\pm 4.0 \text{ dB}$
Radiated Emm. Amplitude (200 – 1000 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



Figure 5: Accreditation Documents