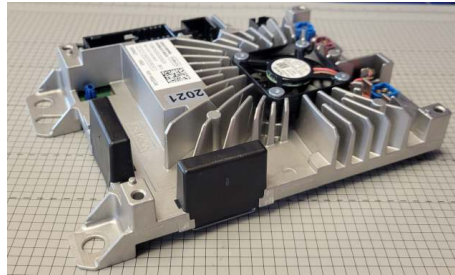


# Cabinet Emissions Test Report

regarding

**USA: CFR Title 47, Part 15.247 + 15.407 (Emissions)**  
**Canada: IC RSS-247/GENe (Emissions)**

for



## SG5PHX

**Category: Vehicular Domain Controller**

Judgments:

**FCC 15.247, ISED RSS-247v2 Compliant**

Testing Completed: March 5, 2023



Prepared for:

## Ford Motor Company

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Date of Issue: March 22, 2023

## Revision History

Rev. No.	Date	Details	Revised By
r0	March 22, 2023	Initial Release.	J. Brunett
r1	May 4, 2023	Limits corr.	J. Brunett
r2	May 31, 2023	Add UNII type designation.	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 April 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
EMI Receiver	R & S / ESW26	101313	RSESW2601	RS / October-2023
Spectrum Analyzer	R & S / FSV30	101660	RSFSV30001	RS / Apr-2024
Spec. Analyzer 70GHz	Anritsu / MS2760A	1705006	ANMS2760A1	ANR / Sept-2023
BNC-BNC Coax	WRTL / RG58/U	001	CAB001-BLACK	AHD / Sept-2023
3.5-3.5MM Coax	PhaseFlex / PhaseFlex	001	CAB015-PURP	AHD / Jun-2023
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

## 2 Test Specifications and Procedures

### 2.1 Test Specification and General Procedures

The goal of Ford Motor Company 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 Ford Motor Company SG5PHX for compliance to:

Country/Region	Rules or Directive	Referenced Section(s)
United States	Code of Federal Regulations	CFR Title 47, Part 15.247 + 15.407
Canada	ISED Canada	IC RSS-247/GENe

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"
TP0102RA	"AHD Internal Document TP0102 - Radiated Emissions Test Procedure"
ICES-003; Issue 7 (2020)	"Information Technology Equipment (ITE) - Limits and methods of measurement"

### 3 Configuration and Identification of the Equipment Under Test

#### 3.1 Description and Declarations

The equipment under test is a vehicle entertainment and information system containing Bluetooth, BLE, and 2x2 WiFi. The EUT is approximately 15 x 22 x 4 cm in dimension, and is depicted in Figure 1. It is powered by 13.5 VDC nominal vehicular power system. In use, this device is a vehicle entertainment module permanently installed into Ford motor vehicles. Table 3 outlines provider declared EUT specifications.

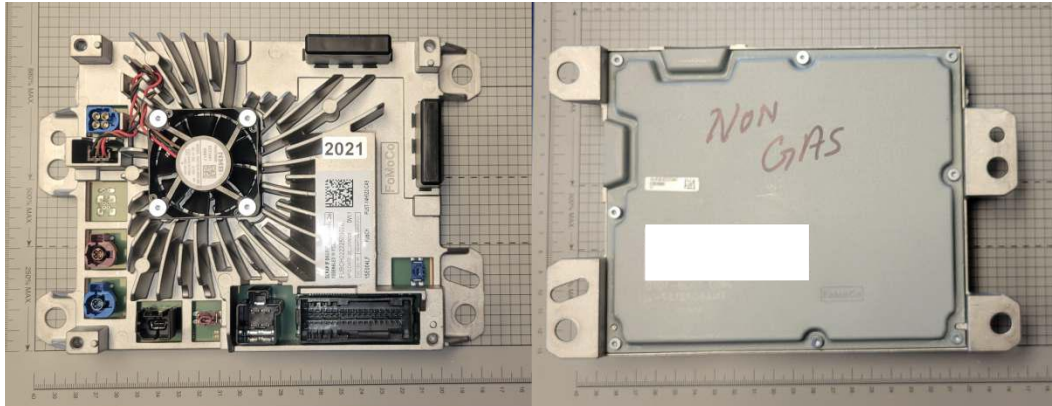


Figure 1: Photos of EUT.

Table 3: EUT Declarations.

General Declarations	
<b>Equipment Type:</b>	Vehicular Domain Controller
<b>Country of Origin:</b>	Not Declared
<b>Nominal Supply:</b>	13.5 VDC nominal
<b>Oper. Temp Range:</b>	-40°C to +75°C
United States	
<b>FCC ID Number:</b>	KMH-SG5PHX
<b>Classification:</b>	DTS + NII
Canada	
<b>IC Number:</b>	1422A-SG5PHX
<b>Classification:</b>	Vehicle Entertainment/Network Device

### 3.1.1 EUT Configuration

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

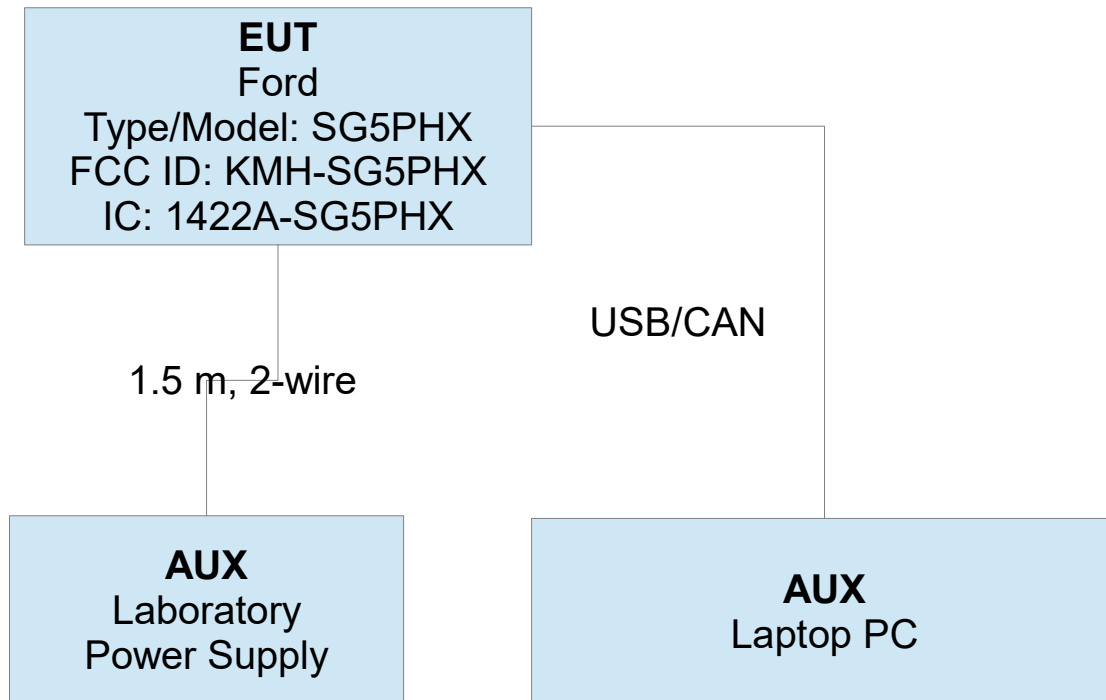


Figure 2: EUT Test Configuration Diagram.

### 3.1.2 Modes of Operation

The EUT employs two radio paths (PATH A and PATH B), over six modes. In this report, only cabinet spurious emissions are reported (with both radio paths terminated in 50 ohm loads). The EUT is stepped through the worst case modes of operation and worst-case cabinet emissions are reported. Emissions were determined to be the worst for the lowest data rates of the WLAN modes on lowest and highest operating channels in MIMO configurations where applicable.

### 3.1.3 Variants

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

### 3.1.4 Test Samples

Four samples of the EUT were provided in total, two normal (production ready) samples (SN: 2020, 2021) with integral antennas and two with the antennas replaced by coaxial cable connections (SN:2016, 1376). Each sample provided was capable of receiving radio instructions via CAN + USB interface to a personal computer. The manufacturer provided software tools and firmware need to place the EUT radio into test and normal operating modes.

### 3.1.5 Functional Exerciser

Normal functionality was confirmed by measurement of transmitted signals.



**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). Cabinet emissions with the EUT antenna ports terminated are the only measurements reported in this test report.

## 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.

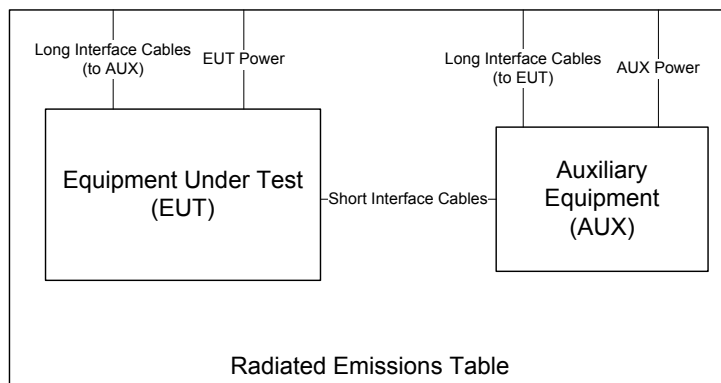


Figure 3: Radiated Emissions Diagram of the EUT.

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  $360^\circ$  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  $\text{dB}\mu\text{V}/\text{m}$  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.

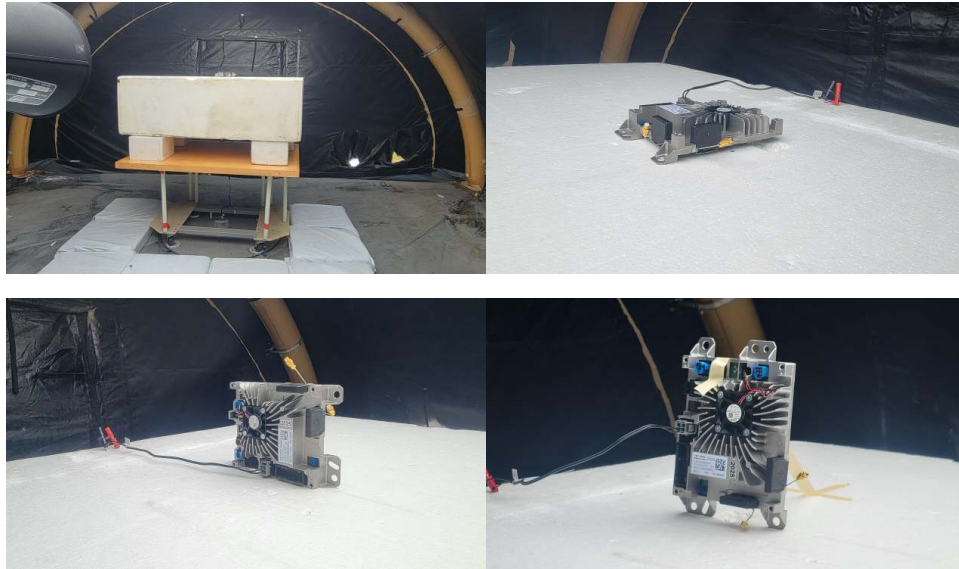


Figure 4: Radiated Emissions Test Setup Photograph(s).

#### **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.



Table 4(c): Radiated Digital Spurious Emissions.

EUT Modes: a1 802.11 b, g, n (2G Band) - max all a5  
 EUT: Ford SG5PHX a2 802.11 n, ax (20 MHz - 5G Band) - max all a6  
 Test Date(s): 02/07/23 a3 802.11 n, ac, ax (40 MHz - 5G Band) - max all a7  
 Test Engineer: J. Brunett a4 802.11 ac, ax (80 MHz - 5G Band) - max all a8

R0	Frequency		Temp. Hum C, %	Site			EUT			Test Antenna				Cable Mixer CL/Kg dB	Receiver Bandwidth RBW/VBW MHz	Field Strength @ DR			EIRP		Regulation USA/CAN §	Pass/Fail dB	Comments						
	Start MHz	Stop MHz		MR	DR	N/F	CF	Mode	Volt (V)	Dim cm	Pol. H/V	Ant. Height m	Dim. cm			Ka dBm	Meas.	Lim.	QPk/Avg Meas./Lim.	Pk Calc.				Qpk/Avg Calc./Lim.					
R1	30.0	88.0	5.39	all	3.0	3.0	0.0	0.0	a3	13.4	5.0	H/V	1-4		0.12	0.30	31.2		40.0	-64.0	-95.2	15.209 / GEN	8.8	exempt, non-radio, background					
R3	88.0	216.0	5.39	all	3.0	3.0	0.0	0.0	a3	13.4	5.0	H/V	1-4		0.12	0.30	33.0		43.5	-62.2	-95.2	15.209 / GEN	10.5	exempt, non-radio, background					
R4	216.0	1000.0	5.39	all	3.0	3.0	0.0	0.0	a3	13.4	5.0	H/V	1-4		0.12	0.30	29.3		46.0	-65.9	-95.2	15.209 / GEN	16.7	exempt, non-radio, background					
R6	707.0	707.0	5.39	all	3.0	3.0	0.0	0.0	a3	13.4	5.0	H	1-4		0.12	0.30	24.0		46.0	-71.2	-95.2	15.209 / GEN	22.0	exempt, non-radio					
R7	707.0	707.0	5.39	all	3.0	3.0	0.0	0.0	a3	13.4	5.0	V	1-4		0.12	0.30	23.2		46.0	-72.0	-95.2	15.209 / GEN	22.8	exempt, non-radio					
R8	1000.0	6000.0	5.39	all	3.0	3.0	0.9	0.0	a3	13.4	5.0	H/V	1.5	15.0	40.0	1.00	3.00	41.2	74.0	54.0	-54.0	-95.2	15.209 / GEN	12.8					
R9	5150.0	5150.0	5.39	all	3.0	3.0	0.8	0.0	a3	13.4	5.0	H/V	1.5	15.0	40.0	1.00	3.00	41.2	74.0	54.0	-54.0	-95.2	15.209 / GEN	12.8	connector leakage				
R10	5350.0	5350.0	5.39	all	3.0	3.0	0.8	0.0	a3	13.4	5.0	H/V	1.5	15.0	40.0	1.00	3.00	40.1	74.0	54.0	-55.1	-95.2	15.209 / GEN	13.9	connector leakage				
R12	6000.0	18000.0	5.39	all	3.0	3.0	2.7	0.0	a3	13.4	5.0	H/V	1.5	15.0	40.0	1.00	3.00	36.9	74.0	54.0	-58.3	-95.2	15.209 / GEN	17.1					
R13	18000.0	26500.0	5.39	all	3.0	3.0	1.8	0.0	a3	13.4	5.0	H/V	1.5	10.2	40.0	1.00	3.00	32.9	74.0	54.0	-62.3	-95.2	15.209 / GEN	21.1					
R15	26500.0	40000.0	5.39	all	3.0	3.0	2.3	0.0	a3	13.4	5.0	H/V	1.5	9.2	40.0	1.00	3.00	44.9	74.0	35.0	54.0	-50.3	-60.2	15.209 / GEN	19.0				
R17																													
R18																													
#	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.  
 R1-R5 C28 For a vehicular mounted radio device, only spurious arising from the RF chain are subject to the spurious emissions limits. If these emissions are from digital circuitry, they may not be subject.

Table 4(d): Radiated Digital Spurious Emissions.

EUT Modes: a1 802.11 b, g, n (2G Band) - max all a5  
 EUT: Ford SG5PHX a2 802.11 n, ax (20 MHz - 5G Band) - max all a6  
 Test Date(s): 02/07/23 a3 802.11 n, ac, ax (40 MHz - 5G Band) - max all a7  
 Test Engineer: J. Brunett a4 802.11 ac, ax (80 MHz - 5G Band) - max all a8

R0	Frequency		Temp. Hum C, %	Site			EUT			Test Antenna				Cable Mixer CL/Kg dB	Receiver Bandwidth RBW/VBW MHz	Field Strength @ DR			EIRP		Regulation USA/CAN §	Pass/Fail dB	Comments						
	Start MHz	Stop MHz		MR	DR	N/F	CF	Mode	Volt (V)	Dim cm	Pol. H/V	Ant. Height m	Dim. cm			Ka dBm	Meas.	Lim.	QPk/Avg Meas./Lim.	Pk Calc.				Qpk/Avg Calc./Lim.					
R1	30.0	88.0	5.39	all	3.0	3.0	0.0	0.0	a4	13.4	5.0	H/V	1-4		0.12	0.30	31.2		40.0	-64.0	-95.2	15.209 / GEN	8.8	exempt, non-radio, background					
R3	88.0	216.0	5.39	all	3.0	3.0	0.0	0.0	a4	13.4	5.0	H/V	1-4		0.12	0.30	33.0		43.5	-62.2	-95.2	15.209 / GEN	10.5	exempt, non-radio, background					
R4	216.0	1000.0	5.39	all	3.0	3.0	0.0	0.0	a4	13.4	5.0	H/V	1-4		0.12	0.30	29.3		46.0	-65.9	-95.2	15.209 / GEN	16.7	exempt, non-radio, background					
R6	700.0	700.0	5.39	all	3.0	3.0	0.0	0.0	a4	13.4	5.0	H	1-4		0.12	0.30	29.3		46.0	-65.9	-95.2	15.209 / GEN	16.7	exempt, non-radio					
R7	700.0	700.0	5.39	all	3.0	3.0	0.0	0.0	a4	13.4	5.0	V	1-4		0.12	0.30	24.5		46.0	-70.7	-95.2	15.209 / GEN	21.5	exempt, non-radio					
R8	1000.0	6000.0	5.39	all	3.0	3.0	0.9	0.0	a4	13.4	5.0	H/V	1.5	15.0	40.0	1.00	3.00	40.9	74.0	54.0	-54.3	-95.2	15.209 / GEN	13.1					
R9	5150.0	5150.0	5.39	all	3.0	3.0	0.8	0.0	a4	13.4	5.0	H/V	1.5	15.0	40.0	1.00	3.00	39.8	74.0	54.0	-55.4	-95.2	15.209 / GEN	14.2	connector leakage				
R10	5350.0	5350.0	5.39	all	3.0	3.0	0.8	0.0	a4	13.4	5.0	H/V	1.5	15.0	40.0	1.00	3.00	40.9	74.0	54.0	-54.3	-95.2	15.209 / GEN	13.1	connector leakage				
R12	6000.0	18000.0	5.39	all	3.0	3.0	2.7	0.0	a4	13.4	5.0	H/V	1.5	15.0	40.0	1.00	3.00	37.2	74.0	54.0	-58.0	-95.2	15.209 / GEN	16.8					
R14	18000.0	26500.0	5.39	all	3.0	3.0	1.8	0.0	a4	13.4	5.0	H/V	1.5	10.2	40.0	1.00	3.00	33.4	74.0	54.0	-61.8	-95.2	15.209 / GEN	20.6					
R15	26500.0	40000.0	5.39	all	3.0	3.0	2.3	0.0	a4	13.4	5.0	H/V	1.5	9.2	40.0	1.00	3.00	46.2	74.0	36.4	54.0	-49.0	-58.8	15.209 / GEN	17.6				
R17																													
R18																													
#	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.  
 R1-R5 C28 For a vehicular mounted radio device, only spurious arising from the RF chain are subject to the spurious emissions limits. If these emissions are from digital circuitry, they may not be subject.

## 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 <sup>†</sup>
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 ( $f > 1000 \text{ MHz}$ )	$\pm 3.7 \text{ dB}$

<sup>†</sup>Ref: CISPR 16-4-2:2011+A1:2014



Figure 5: Accreditation Documents