

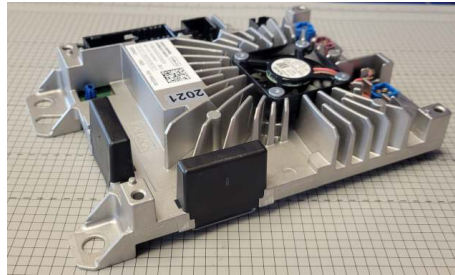
DFS Client Test Report

regarding

USA: CFR Title 47, Part 15.407 (Emissions)

Canada: IC RSS-247v2/GENE (Emissions)

for



SG5PHX

Category: Vehicular Domain Controller

Judgments:

FCC 15.407, ISED RSS-247v2 Compliant

Testing Completed: March 22, 2023



Prepared for:

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Revision History

Rev. No.	Date	Details	Revised By
r0	March 22, 2023	Initial Release.	J. Brunett
r1	June 1, 2023	Add results table.	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
DFS Master AP	Netgear / AX4	6A029A	NGAX401	AHD / On-use
Vec. Sig. Gen.	Rohde / SMBV100A	256003	RSSMBV01	AHD / On-Use
Power Meter	R & S / NRP50S	101087	RSNRP50	RS / Nov-2024

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 15.407
Canada	ISED Canada	IC RSS-247v2/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"
ANSI C63.10:2013	"American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices"
KDB 789033 D02 v02r01	"GUIDELINES FOR COMPLIANCE TESTING OF UNLICENSED NATIONAL INFORMATION INFRASTRUCTURE (U-NII) DEVICES PART 15, SUBPART E "
KDB 905462 D07 v02 r01	"OVERVIEW OF REVISED RULES FOR U-NII DEVICES"
KDB 905462 D03 v01 r02	"U-NII CLIENT DEVICES WITHOUT RADAR DETECTION CAPABILITY"
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 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.

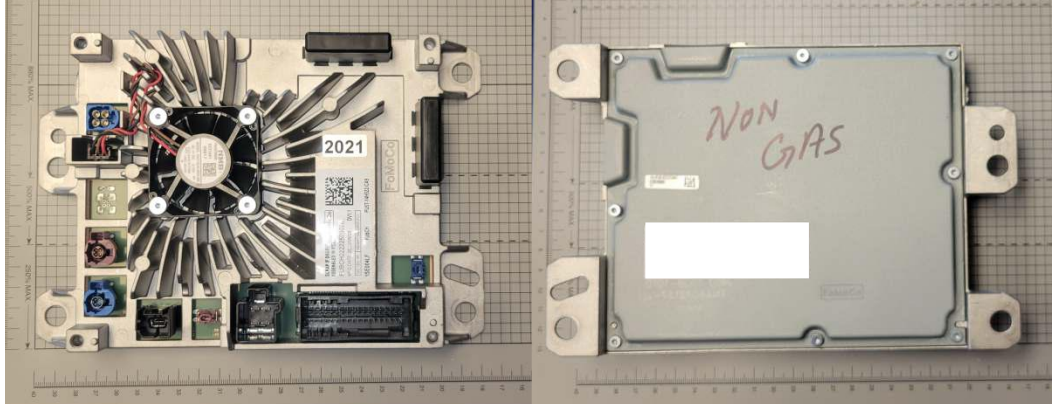


Figure 1: Photos of EUT.

Table 3: EUT Declarations.

General Declarations	
Equipment Type:	Vehicular Domain Controller
Country of Origin:	Not Declared
Nominal Supply:	13.5 VDC nominal
Oper. Temp Range:	-40°C to +75°C
Frequency Range:	5G LE-LAN(5150 – 5250, 5350 – 5590, 5650 – 5725, 5735 – 5835 MHz)
Antenna Dimension:	Integral
Antenna Type:	PCB Trace
Antenna Gain:	8.8 dBi max. (5150 – 5250, 5350 – 5590, 5650 – 5725, 5735 – 5835 MHz)
Number of Channels:	5G W53/UNII-2A 20M(52,56,60,64), 40M(54,62), 80M(58)
	5G W56/UNII-2C
	20M(100,104,108,112,116,132,136,140,144),
	40M(102,110,134,142), 80M(106,138)
Channel Spacing:	5G WIFI 20, 40, 80 MHz
Alignment Range:	Not Declared
Type of Modulation:	5G WIFI: A(20/40)SISO, N(20/40),AC(20/40/80),AX(20/40/80)SISO+MIMO
United States	
FCC ID Number:	KMH-SG5PHX
Classification:	NII
Canada	
IC Number:	1422A-SG5PHX
Classification:	Vehicle Entertainment/Network Device

3.1.1 EUT Configuration

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

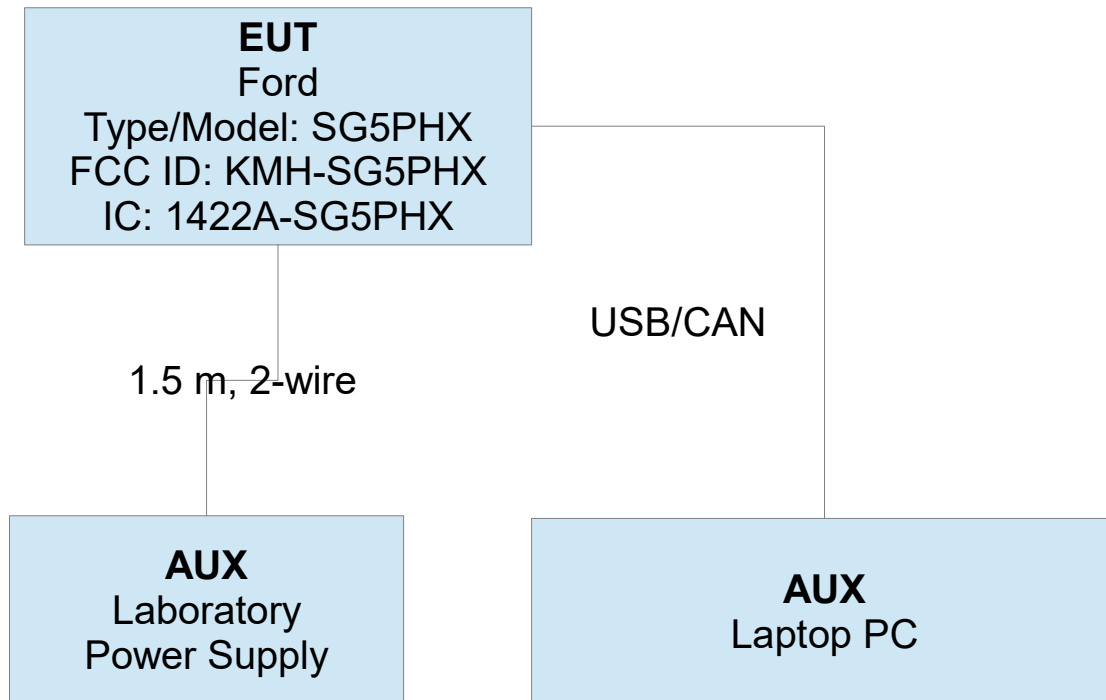


Figure 2: EUT Test Configuration Diagram.

3.1.2 Modes of Operation

The EUT employs two radio paths (PATH A and PATH B), over six modes. This report addresses only the following mode in the UNII-2A and UNII-2C bands subject to DFS requirements. **MODE 5G-STA:** In this mode the EUT operates as CLIENT ONLY radio WITHOUT RADAR DETECTION across the UNII-2A(W53) and UNII-2C(W56) bands between 5150 and 5720 MHz. This mode employs SISO PATH A, SISO PATH B, or MIMO PATH A + B simultaneously.

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. However, conducted RF emissions pretesting indicated that the EUT radio country designation across all UNII bands had to be fixed on the country code for Canada (CA) in order to meet the regulatory limitations for both USA and Canada. Manufacturer state the USA country code (US) settings will be set to match those of the CA country code, as tested.

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 employs AP mode of operation only the UNII-1/W52 and UNII-3/W58 bands. UNII-2A/W53, UNII-2C/W56 are employed only when in STA (client) mode. In the W53 and W56 bands the Radio operates as a slave/client without radar detection and is subject Channel Shutdown DFS as demonstrated herein. Radio emissions testing relating to radio compliance of this product is included in other associated test reports.

4 Emissions

4.1 DFS Channel Close, Move, and Non-Occupancy (Reg. 15.407(h) / RSS-247 6.3)

4.1.1 Test Setup

Conducted RF emissions at the channel and frequency noted in the results section were performed on the test bench as diagrammed in Figure 3.

Figure 3: DFS Client Test Setup Diagram.

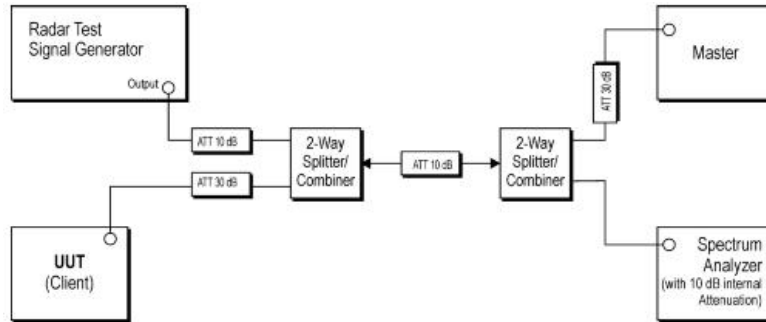


Figure Reference - FCC 905462 D02 UNII DFS Compliance Procedures New Rules v02, sec. 7.2.2

4.1.2 Test Procedure

Measurements were performed in accordance with the general provisions of FCC KDB 905462 D02 UNII DFS Compliance Procedures New Rules v02. The EUT was connected to a laptop computer and DC power supply. A second computer was used to configure the access point on the DFS channel(s), where a channel was selected randomly by the access point. To enable channel loading, data was streamed between the EUT and the AP connected computer. The EUT was networked to the associated Master Device and data was then streamed between the Master Device and the EUT. Radar test waveforms generated by the vector signal generator were next injected into the Master on the operating channel at the level of the DFS detection threshold (per the procedures noted above). Transmissions from the EUT (and the Master) at the end of the radar burst were recorded on the Operating Channel during the observation time and after radar detection. The Channel Move Time, Channel Closing Time, and Non-occupancy periods were recorded.

4.1.3 Test Results

Following the test procedures outlined in the previous section, the EUT was evaluated against(for) DFS Channel Close, Move, and Non-Occupancy as detailed in Table 4. A photograph of the test setup is provided in Figure 4.

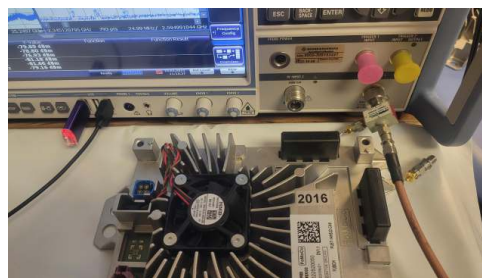


Figure 4: DFS Channel Close, Move, and Non-Occupancy Test Photographs.

Table 4(a): DFS Channel Close, Move, and Non-Occupancy Test Results.

Test Setup
 Conducted
EUT Declared Rx Category:
 Slave/Client w/o Radar Detection
Master AP Details
 Netgear AX4, FCC ID: PY318300430

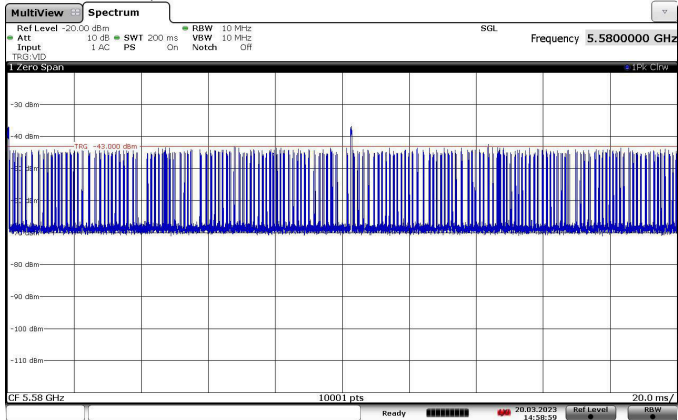
Rel. Hum.
 33%
Nom. Temp.
 20 C

Test Date: Mar 22, 2023
Test Engineer: Joseph Brunett
EUT: Ford SG5PHX
EUT Mode: Client

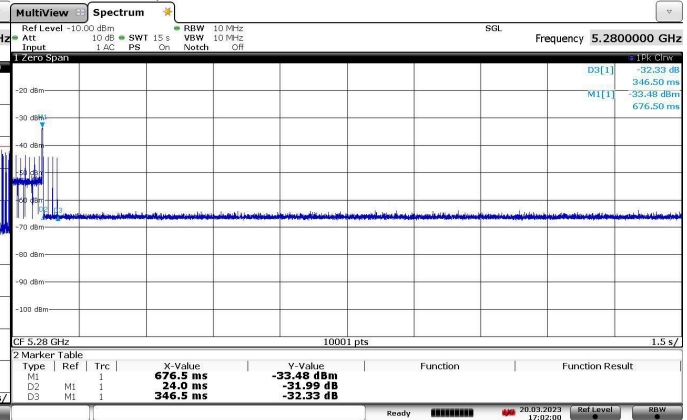
#	Mode	Test Operating Channel	Radar Test Pulse	Channel Move Time (s)	Channel Move Time Limit (s)	Pass / Fail
R1	MIMO 11N(20), Client	CH116	Type 0 Burst	<100 ms	10.0	Pass
R2				Closing Tx Time (s)	Closing Tx Time Limit (s)	Pass / Fail
R3				2 x 1.2 ms control pulses post 200ms window.	200ms + 60ms max in the following 10 sec.	Pass
R4				Non-occupancy Time (min)	Non-occupancy (min)	Pass / Fail
R5				32+	>30	Pass
R6						
R7						
#	C1	C2	C3	C4	C5	C6

Table 4(b): DFS Channel Close, Move, and Non-Occupancy Test Results.

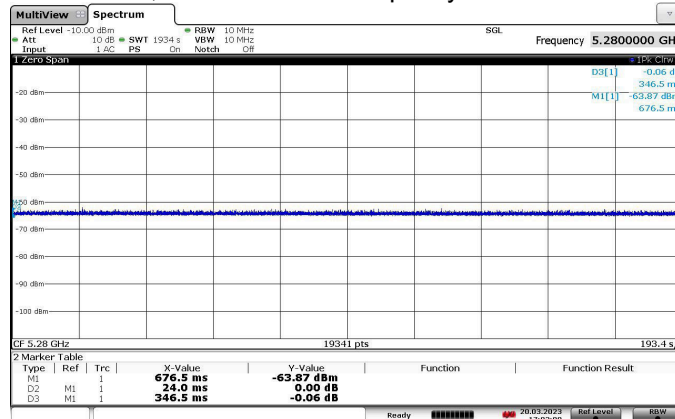
802.11ax, CH116 - Transmit Test



802.11ax, CH116 - Channel Move Time



802.11ax, CH116 - Non-Occupancy Period > 30min



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