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06/04/2025

Amarillo Technologies
4218 Erik Ave
Amarillo, TX, 79106 USA

Dear Jerry Harder,

Enclosed is the EMC Wireless test report for compliance testing of the Amarillo Technologies AT-5 as tested to the requirements of FCC 15.247 for Intentional Radiators. This test report pertains specifically to the Long Range(LoRa) transmitter onboard which operates in the 902MHz to 928MHz band.

Thank you for using the services of Eurofins MET Labs. If you have any questions regarding these results or if MET can be of further service to you, please feel free to contact me.

Sincerely yours,
EUROFINS MET LABS

Nancy LaBrecque
Documentation Department

Reference: WIRA135463-FHSS – R2

915 MHz ISM
Test Report

for the

Amarillo Technologies
AT-5

Tested under
FCC 15.247
For Intentional Radiators

Veer Patel, Wireless/EMC Engineer
Electromagnetic Compatibility Lab

Nancy LaBrecque
Documentation Department

Engineering Statement: The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of the FCC Rules Part 15.247 under normal use and maintenance.

Matthew Hinojosa
EMC Manager, Austin Electromagnetic Compatibility Lab

Report Status Sheet

Revision	Report Date	Reason for Revision
∅	May 2, 2025	Initial Issue.
1	5/23/2025	TCB review comments addressed.
2	06/04/2025	Additional TCB comments addressed.

Table of Contents

List of Tables

List of Figures

List of Terms and Abbreviations

AC	**A**lternating **C**urrent
ACF	**A**ntenna **C**orrection **F**actor
Cal	**Cal**ibration
d	**M**easurement **D**istance
dB	**D**eci**b**els
dBµA	**D**eci**b**els above one **micro**amp
dBµV	**D**eci**b**els above one **micro**volt
dBµA/m	**D**eci**b**els above one **micro**amp **per m**eter
dBµV/m	**D**eci**b**els above one **micro**volt **per m**eter
DC	**D**irect **C**urrent
E	**E**lectric Field
DSL	**D**igital **S**ubscriber **L**ine
ESD	**E**lectro**s**tatic **D**ischarge
EUT	**E**quipment **U**nder **T**est
f	**F**requency
FCC	**F**ederal **C**ommunications **C**ommission
GRP	**G**round **R**eference **P**lane
H	Magnetic Field
HCP	**H**orizontal **C**oupling **P**lane
Hz	**H**ert**z**
IEC	**I**nternational **E**lectrotechnical **C**ommission
kHz	**k**ilo**h**ert**z**
kPa	**k**ilo**pa**scal
kV	**k**ilo**v**olt
LISN	**L**ine **I**mpedance **S**tabilization **N**etwork
MHz	**M**ega**h**ertz
µH	**microh**enry
µ	**microf**arad
µs	**micros**econds
NEBS	**N**etwork **E**quipment-**B**uilding **S**ystem
PRF	**P**ulse **R**epetition **F**requency
RF	**R**adio **F**requency
RMS	**R**oot-**M**ean-**S**quare
TWT	**T**raveling **W**ave **T**ube
V/m	**V**olts **per m**eter
VCP	**V**ertical **C**oupling **P**lane

I. Executive Summary

A. Purpose of Test

An EMC evaluation was performed to determine compliance of the AT-5, with the requirements of FCC 15.247. Amarillo Technologies should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the AT-5, has been **permanently** discontinued.

B. Executive Summary

The following tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with FCC 15.247, in accordance with Amarillo Technologies purchase order number 21025-A. All tests were conducted using measurement procedures ANSI C63.4-2014 and ANSI C63.10-2013.

FCC Reference 47 CFR Part 15.247:2005	IC Reference RSS-247 Issue 3 RSS-GEN Issue 5	Description	Compliance
Title 47 of the CFR, Part 15 §15.203	---	Antenna Requirement	Compliant
Title 47 of the CFR, Part 15 §15.207(a)	RSS-GEN(8.8)	Conducted Emission Limits	N/A
Title 47 of the CFR, Part 15 §15.247(a)(2)	RSS-247 (5.2)	20dB Occupied Bandwidth	Compliant
---	RSS-GEN(6.7)	99% Occupied Bandwidth	Compliant
Title 47 of the CFR, Part 15 §15.247(b)	RSS-247(5.4)	Peak Power Output	Compliant
Title 47 of the CFR, Part 15 §15.247(d); §15.209; §15.205	RSS-GEN (6.13), (8.9), & (8.10)	Radiated Spurious Emissions Requirements	Compliant
Title 47 of the CFR, Part 15 §15.247(d)	RSS-247(5.5)	RF Conducted Spurious Emissions Requirements	Compliant
Title 47 of the CFR, Part 15; §15.247(e)	RSS-247(5.2)	Peak Power Spectral Density	N/A

Table 1. Executive Summary

II. Equipment Configuration

A. Overview

Eurofins MET Labs was contracted by Amarillo Technologies to perform testing on the AT-5, under Amarillo Technologies's purchase order number 21025-A.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the AT-5.

The results obtained relate only to the item(s) tested.

Product Name:	AT-5 Intelligent Lock	
Model(s) Tested:	AT-5	
FCCID:	2BOPUAT5	
Sample Number:	25382-1	
Equipment Specifications:	Primary Power:	3VDC Battery Powered
	Type of Modulations:	CSS
	Equipment Code:	FHSS
	Peak RF Output Power:	14 dBm typical (as high as 20 dBm)
	EUT Frequency Ranges:	902MHz to 928 MHz
	Antenna Gain[1]:	-1 dBi
Analysis:	The results obtained relate only to the item(s) tested.	
Environmental Test Conditions:	Temperature: 15-35° C	
	Relative Humidity: 30-60%	
	Barometric Pressure: 860-1060 mbar	
Evaluated by:	Veer Patel	
Report Date(s):	May 2, 2025	

Table 2. EUT Summary Table

[1] The antenna gain information was provided by Amarillo Technologies and may affect compliance.

B. References

CFR 47, Part 15, Subpart C	Federal Communication Commission, Code of Federal Regulations, Title 47, Part 15: General Rules and Regulations, Allocation, Assignment, and Use of Radio Frequencies
RSS-247, Issue 3, August 2023	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
RSS-GEN, Issue 5, March 2019	General Requirements and Information for the Certification of Radio Apparatus
ANSI C63.4:2014	Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical And Electronic Equipment in the Range of 9 kHz to 40 GHz
ISO/IEC 17025:2017	General Requirements for the Competence of Testing and Calibration Laboratories
ANSI C63.10-2013	American National Standard for Testing Unlicensed Wireless Devices

Table 3. References

C. Test Site

All testing was performed at Eurofins MET Labs, 13501 McCallen Pass, Austin, TX 78753. All equipment used in making physical determinations is accurate and bears recent traceability to the National Institute of Standards and Technology.

Radiated Emissions measurements were performed in a 10 meter semi-anechoic chamber (equivalent to an Open Area Test Site). In accordance with §2.948(a)(3), a complete site description is contained at MET Laboratories.

ISED Lab Info:
CAB Identifier: US0004
Company Number: 2043D

FCC Lab Info:
Designation Number: US1127

D. Measurement Uncertainty

Test Method	Typical Expanded Uncertainty	K	Confidence Level
Occupied Bandwidth Measurements	±4.52 Hz	2	95%
Conducted Power Measurements	±2.74 dB	2	95%
Power Spectral Density Measurements	±2.74 dB	2	95%
Conducted Spurious Emissions	±2.80 dB	2	95%
Conducted Emissions (Mains)	±2.97 dB	2	95%
Radiated Spurious Emissions (9kHz – 1GHz)	±2.95 dB	2	95%
Radiated Spurious Emissions (1GHz - 40GHz)	±3.54 dB	2	95%

Table 4. Uncertainty Calculations Summary

E. Description of Test Sample

The AT-5 is a Bluetooth Controlled lock that includes various sensors to detect the occurrence of certain lock events (e.g., battery removed, shackle cut, and so on). Upon the occurrence of a lock event, the event is logged internally, handled, and reported out via a LoRa transmission. The AT-5 is used in connection with a broader software system that automates and enforces rules connected with lockout tagout procedures for industrial facilities.

Figure 1. Block Diagram of Test Configuration

F. Equipment Configuration

The EUT was set up as outlined in Figure 1 above. The laptop computer was used to send test commands to force the transmitters to operate in the appropriate test mode.

G. Support Equipment

Ref. ID	Name/Description	Manufacturer	Model Number	Customer Supplied Calibration Data
Test Laptop	Dell	Latitude 5411	BPN66D3	n/a

Table 5. Support Equipment

H. Ports and Cabling Information

Ref. Id	Port Name on EUT	Cable Description or reason for no cable	Qty	Length as tested (m)	Max Length (m)	Shielded? (Y/N)	Termination Box ID & Port Name
	N/A	Battery Power EUT and no cable connection was required					

Table 6. Ports and Cabling Information

I. Mode of Operation

The AT-5 is connected to a computer, it was used to set the EUT in low, middle and high channel. AT-5 Test Utility v1.1.0.11058 was used to operate the EUT.

Transmit Band	Modulation	Channel Frequencies Tested	Test Tool Power Setting
915MHz to 928MHz	CSS	902.3MHz/908.7MHz/914.9MHz	8

Table 7. Test Channels Utilized

J. Method of Monitoring EUT Operation

A spectrum analyzer was used to confirm proper transmitter operation.

K. Modifications

a) Modifications to EUT

No modifications were made to the EUT.

b) Modifications to Test Standard

No modifications were made to the test standard.

L. Disposition of EUT

The test sample including all support equipment submitted to the Electro-Magnetic Compatibility Lab for testing was returned to Amarillo Technologies upon completion of testing.

III. Electromagnetic Compatibility Criteria for Intentional Radiators

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.203 Antenna Requirement

Test Requirement: **§ 15.203:** An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

The structure and application of the EUT were analyzed to determine compliance with Section 15.203 of the Rules. Section 15.203 states that the subject device must meet at least one of the following criteria:

a.) Antenna must be permanently attached to the unit.

b.) Antenna must use a unique type of connector to attach to the EUT.

c.) Unit must be professionally installed. Installer shall be responsible for verifying that the correct antenna is employed with the unit.

Results: The EUT as tested is compliant the criteria of §15.203. The TX antenna is permanently attached to the unit and is not accessible by the end user.

Test Engineer(s): Veer Patel

Test Date(s): 03/26/2025

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(a)(1)(i) 20 dB Bandwidth

Test Requirements: **§ 15.247(a)(1)(i):** Operation under the provisions of this section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

Test Procedure: The transmitter was on and transmitting at the highest output power. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using a RBW approximately 1% of the total emission bandwidth, and the VBW > RBW. The 20 dB Bandwidth was measured and recorded. The measurements were performed on the low, mid and high channels.

Test Results The EUT was compliant with § 15.247 (a)(1)(i).

The 20 dB Bandwidth was determined from the plots on the following pages.

Test Engineer(s): Veer Patel

Test Date(s): 03/26/2025

Electromagnetic Compatibility Criteria for Intentional Radiators

RSS-GEN (6.7) 99% Bandwidth

Test Requirements: The occupied bandwidth or the "99% emission bandwidth" is defined as the frequency rang between two points, one above and the other blow the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

Test Procedure: The transmitter was connected to the spectrum analyzer through an attenuator. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using a RBW approximately equal to 1% of the total emission bandwidth, and the VBW > RBW. The 99% Bandwidth was measured and recorded.

Test Results The 99% Bandwidth determined from the plots on the following pages.

Test Engineer(s): Veer Patel

Test Date(s): 03/26/2025

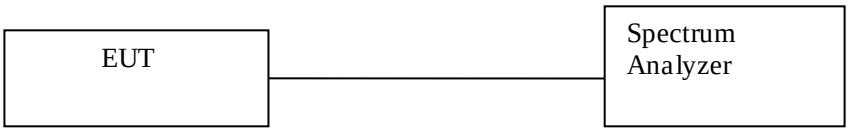
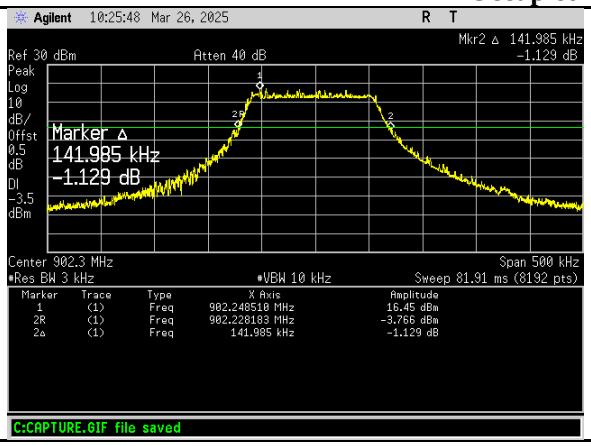
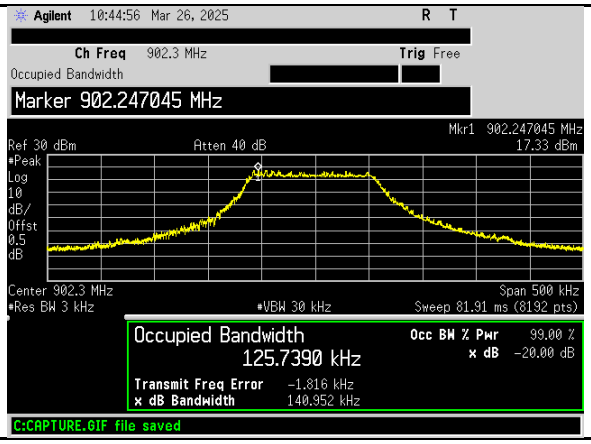
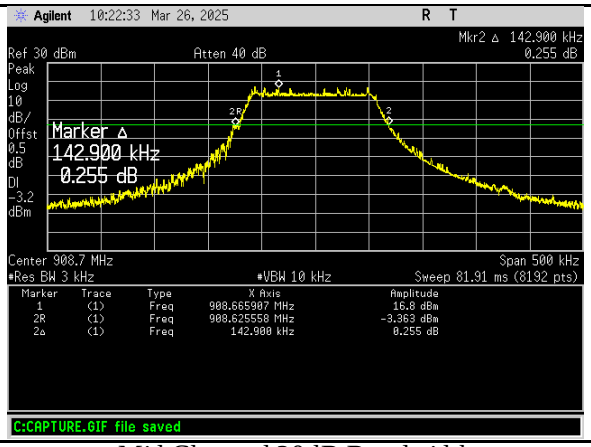
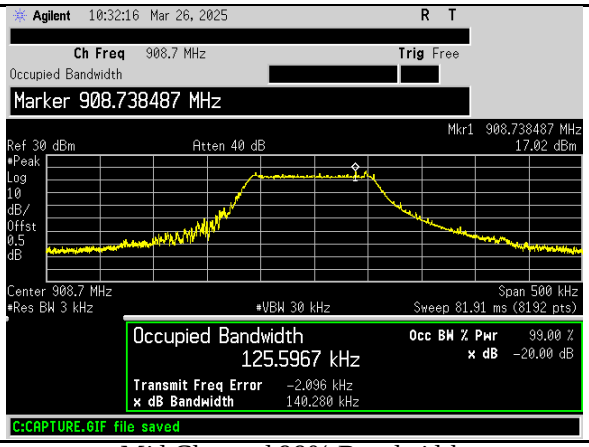
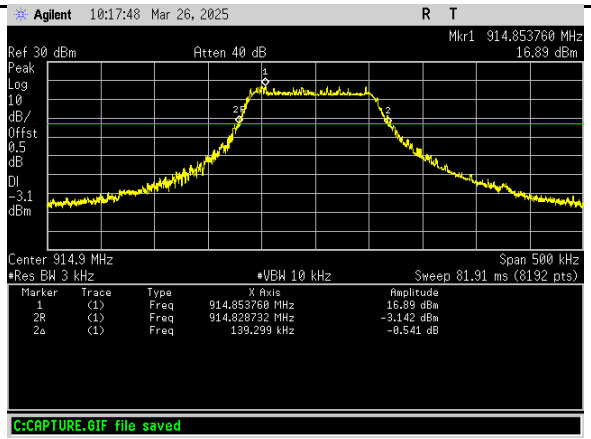
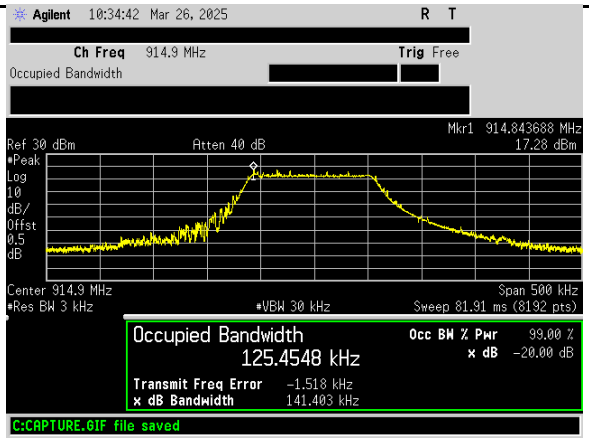


Figure 2. Block Diagram, Occupied Bandwidth Test Setup

Channel	Frequency (MHz)	20dB Bandwidth Limit (MHz)	Measured 20dB Bandwidth (MHz)	Measured 99% Bandwidth (MHz)	Result
Low	902.3	0.250	0.141905	0.125739	Pass
Middle	908.7	0.250	0.1429	0.1255967	Pass
High	914.9	0.250	0.139299	0.1254548	Pass

Table 8. 99% and 20 dB Occupied Bandwidth, Test Results

Occupied Bandwidth Test Results

Occupied Bandwidth Plots	
	
Low Channel 20dB Bandwidth	Low Channel 99% Bandwidth
	
Mid Channel 20dB Bandwidth	Mid Channel 99% Bandwidth
	
High Channel 20dB Bandwidth	High Channel 99% Bandwidth

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(b) Peak Power Output

Test Requirements: **§15.247(b)(2):** The maximum peak output power of the intentional radiator shall not exceed the following:

Frequency Hopping Systems (MHz)	Output Limit (Watts)
902-928	1.000

Table 9. Output Power Requirements from §15.247(b)

§15.247(b)(2) : For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels.

Test Procedure: The transmitter was connected to a calibrated spectrum analyzer. The analyzer reference level was offset by cable loss connecting to the test sample. The peak power was measured at the low, mid and high channels of each band at the maximum power level. The antenna gain provided by the manufacturer was added to the measured conducted power to arrive at the EIRP.

The analyzer settings are shown in the following table:

RBW:	300kHz	Detector:	Peak	Reference Level:	30dBm
VBW:	1MHz	Sweep Time:	Auto	Internal Attenuation:	40dB

Figure 3. Analyzer Settings During Measurement

Test Results: The EUT was compliant with the Peak Power Output limits of **§15.247(b)** and the EIRP limits from RSS-247.

Test Engineer(s): Veer Patel

Test Date(s): 03/26/2025

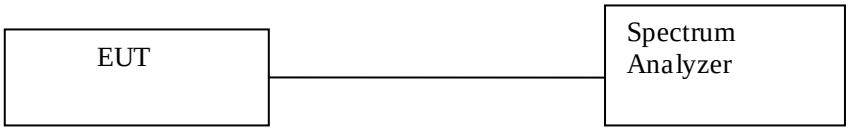


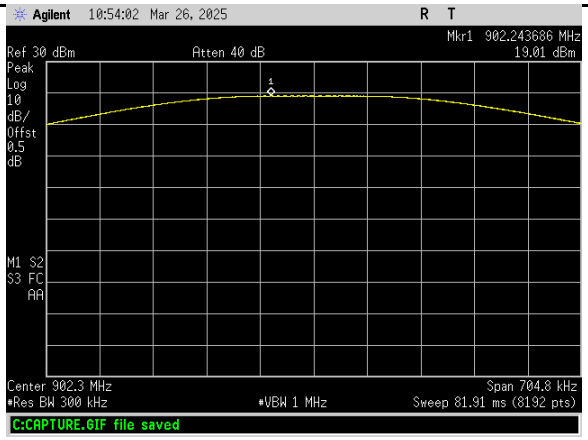
Figure 4. Peak Power Output Test Setup

Peak Power Output Test Results

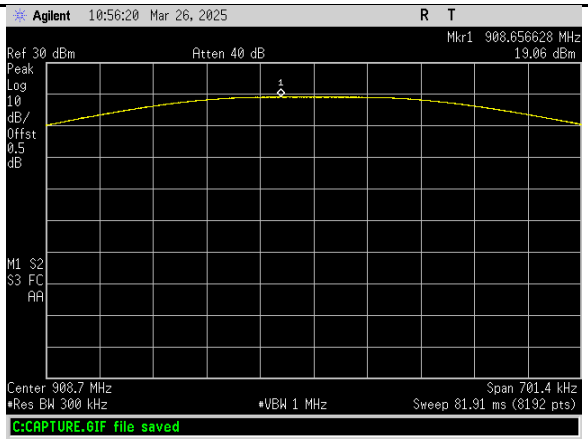
Channel	Frequency (MHz)	Peak Power (dBm)	Peak Power Limit (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)	Result
Low	902.3	19.01	30	-1	18.01	36	Pass
Middle	908.7	19.08	30	-1	18.08	36	Pass
High	914.9	19.04	30	-1	18.04	36	Pass

Table 10. Peak Power and EIRP, Test Results

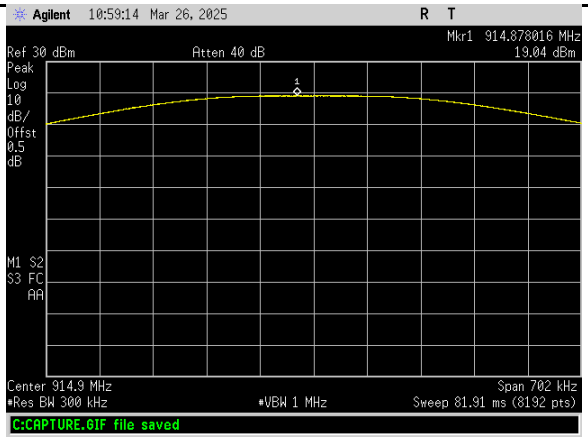
Peak Power Plots



Low Channel



Mid Channel



High Channel

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(d) RF Conducted Spurious Emissions Requirements

Test Requirement: **15.247(d)** In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

Test Procedure: For intentional radiators with a digital device portion which operates below 10 GHz, the spectrum was investigated as per §15.33(a)(1) and §15.33(a)(4); i.e., the lowest RF signal generated or used in the device up to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

The transmitter was connected directly to a Spectrum Analyzer through an attenuator. The power level was set to the maximum level. The RBW was set to 100 kHz. The VBW was set to 3x the RBW. The spectrum analyzer was set to an auto sweep time and a peak detector was used. Measurements were carried out at the low, mid and high channels.

See following pages for detailed test results with RF Conducted Spurious Emissions.

The analyzer settings are shown in the following table:

RBW:	100kHz	Detector:	Peak	Reference Level:	30dBm
VBW:	300kHz	Sweep Time:	Auto	Internal Attenuation:	50dB

Figure 5. Analyzer Settings During Measurement

Test Results: The EUT was compliant with the Conducted Spurious Emission limits of **§15.247(d)**.

Test Engineer(s): Veer Patel

Test Date(s): 03/26/2025

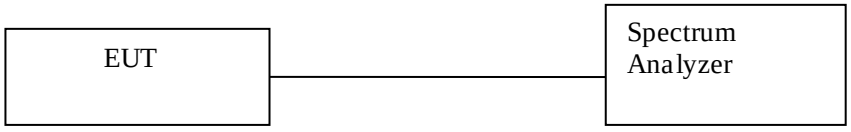
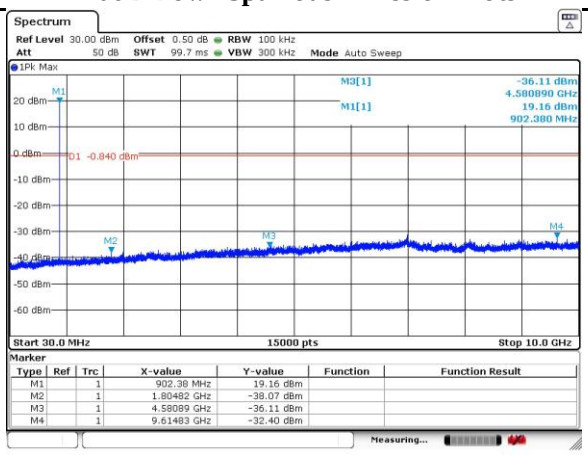
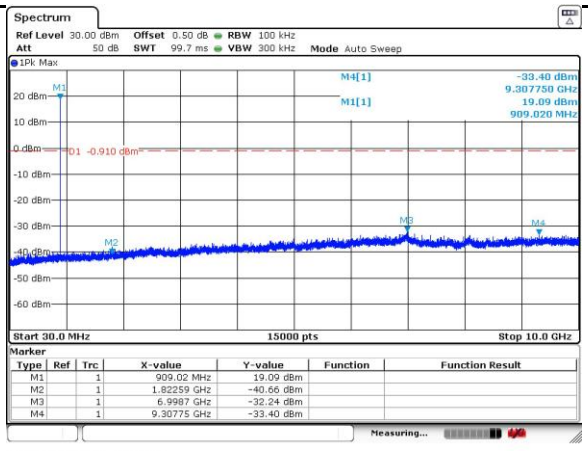


Figure 6. Block Diagram, Conducted Spurious Emissions Test Setup

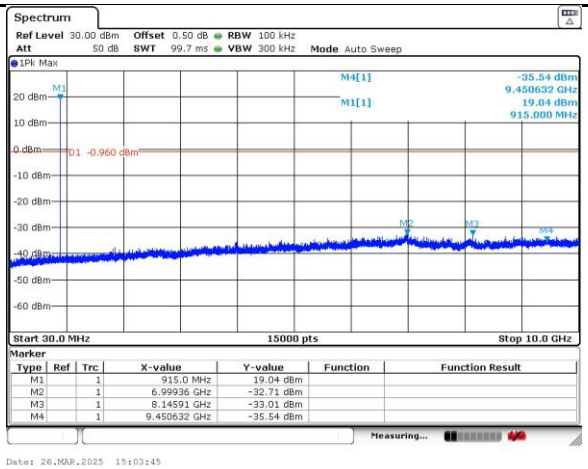
-20dB Down Spurious Emission Plots



Low Channel

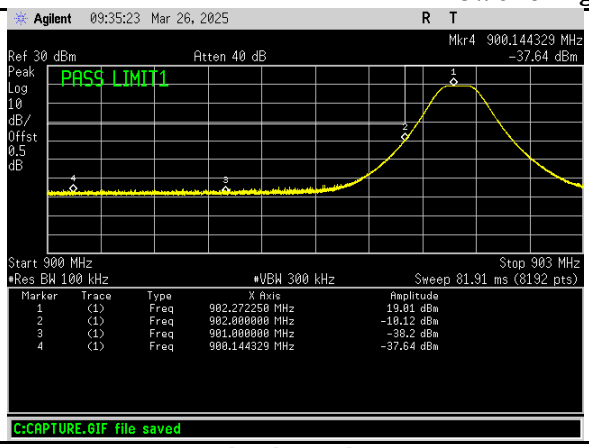


Mid Channel

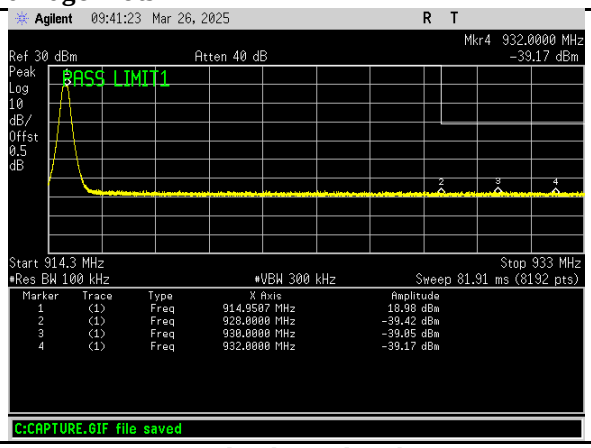


High Channel

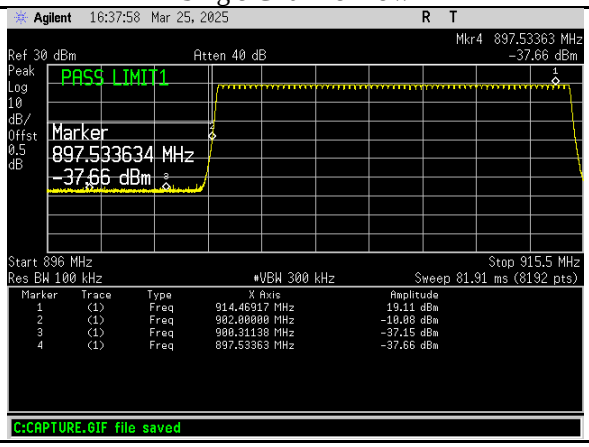
Low and High Band Edge Plots



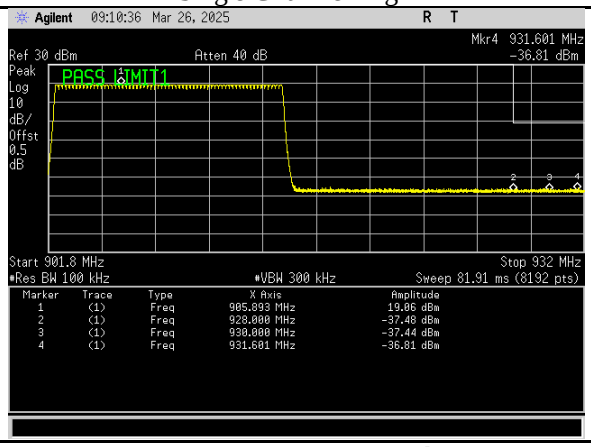
Single Channel Low



Single Channel High



Frequency Hopping Low



Frequency Hopping High

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(d) Radiated Spurious Emissions Requirements

Test Requirements: **§15.247(d); §15.205:** Emissions outside the frequency band.

§15.247(d): In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a).

§15.205(a): Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090–0.110----------	16.42–16.423	399.9–410	4.5–5.15
[1] 0.495–0.505----------	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905----------	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128----------	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775----------	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775----------	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218----------	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825----------	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225----------	123–138	2200–2300	14.47–14.5
8.291–8.294----------	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366----------	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675----------	156.7–156.9	2655–2900	22.01–23.12
8.41425–8.41475----------	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293----------	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025----------	240–285	3345.8–3358 36.	43–36.5
12.57675–12.57725----------	322–335.4	3600–4400	([2])

Table 11. Restricted Bands of Operation

[1] Until February 1, 1999, this restricted band shall be 0.490 – 0.510 MHz.

[2] Above 38.6

Test Requirement(s): **§ 15.209 (a):** Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in Table 12.

Frequency (MHz)	§ 15.209(a),Radiated Emission Limits (dBµV) @ 3m
30 - 88	40.00
88 - 216	43.50
216 - 960	46.00
Above 960	54.00

Table 12. Radiated Emissions Limits Calculated from FCC Part 15, § 15.209 (a)

Test Procedures: The radiated methodology referenced in ANSI C63.10: 2013 Section 11.12.1 was utilized in order to assess the unwanted emissions in the restricted bands.

A radiated scan was performed with the antenna of proper impedance installed. The transmitter was turned on. Measurements were performed of the low, mid and high Channels. The EUT was rotated orthogonally through all three axes if multiple mounting orientations are supported. Plots shown are corrected for both antenna correction factor and distance and compared to a 3 m limit line.

Radiated measurements below 30MHz were performed in a semi-anechoic chamber that has been correlated to an open area site.

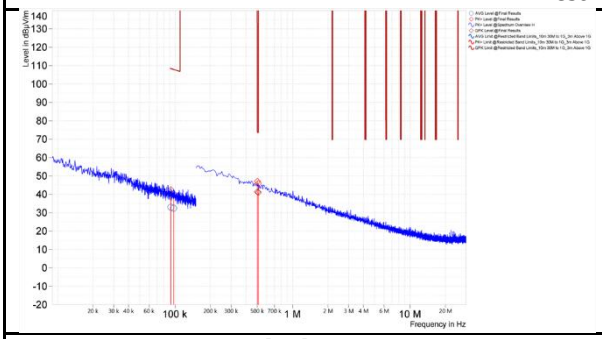
Test Software: TILE Version 7.4.2.5 (Manufactured by ETS Lindgren) and ELEKTRA Version 4.61 (Manufactured by Rohde&Schwarz) was utilized to perform these measurements.

Test Results: The EUT was compliant with the Radiated Spurious Emission limits of **§ 15.247(d)**.

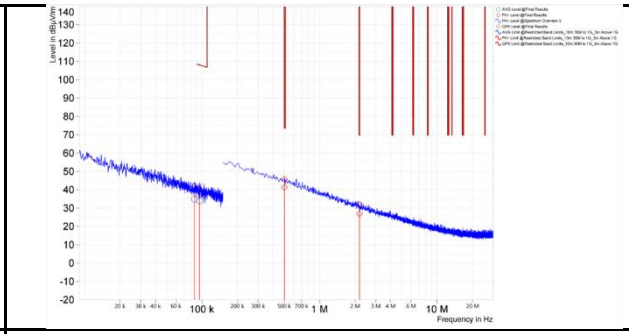
Test Engineer(s): An Dang/Veer Patel

Test Date(s): 03/24/2025 – 04/01/2025

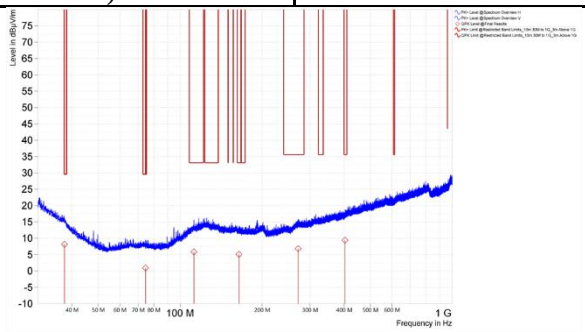
Restricted Band Plots



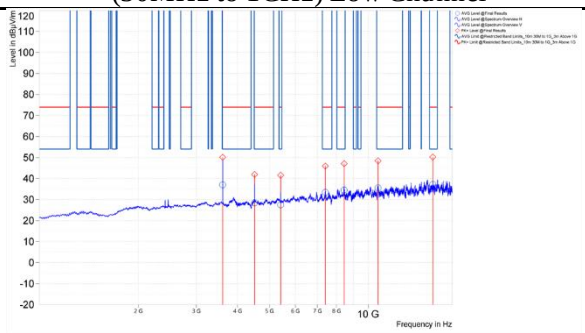
Vertical (9kHz to 30MHz)



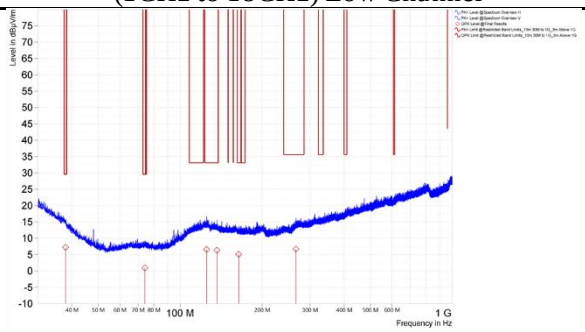
Horizontal (9kHz to 30MHz)



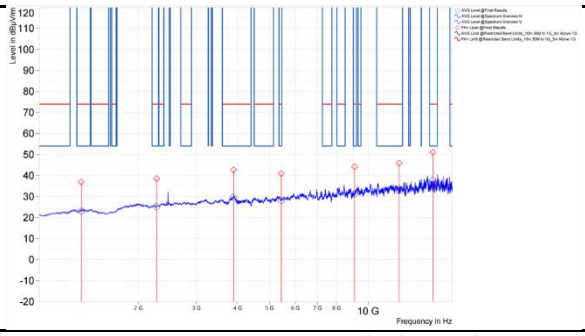
(30MHz to 1GHz) Low Channel



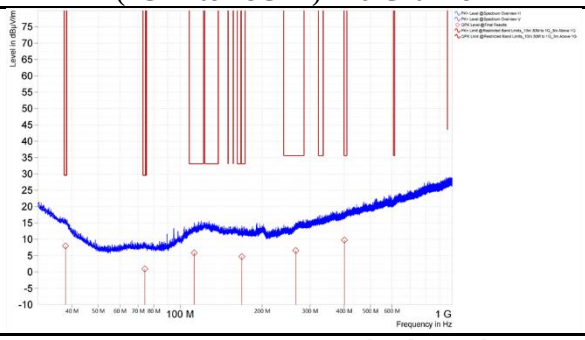
(1GHz to 18GHz) Low Channel



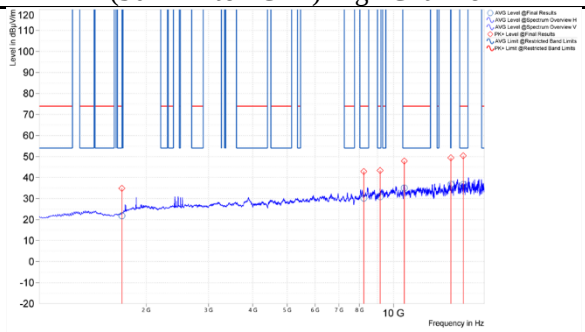
(30MHz to 1GHz) Mid Channel



(1GHz to 18GHz) Mid Channel



(30MHz to 1GHz) High Channel



(1GHz to 18GHz) High Channel

Worst Case Cabinet Spurious Emissions

Frequency [MHz]	PK+ Level [dBµV/m]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Meas. BW [kHz]	Result
0.092	42.46	108.34	65.88	11.66	H	195.4	1	0.200	Pass
0.095	39.76	108.08	68.32	11.52	V	156.4	1	0.200	Pass
0.097	40.26	107.88	67.62	11.43	H	203.8	1	0.200	Pass
0.501	47.03	73.69	26.66	11.27	H	327.8	1	9.000	Pass
0.501	45.70	73.69	28.00	11.27	V	115.2	1	9.000	Pass
0.510	45.94	73.54	27.60	11.35	H	65.6	1	9.000	Pass
2.184	31.80	69.54	37.74	11.69	V	307.7	1	9.000	Pass

Figure 7. Worst Case Cabinet Radiation, 9kHz - 30MHz

Frequency [MHz]	QPK Level [dBµV/m]	QPK Limit [dBµV/m]	QPK Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Meas. BW [kHz]	Result
37.560	8.12	29.55	21.43	-5.72	H	76.7	3.26	120.000	Pass
74.580	0.87	29.55	28.68	-12.21	V	253.3	1.58	120.000	Pass
112.350	5.81	33.07	27.26	-7.26	H	256.5	3.5	120.000	Pass
164.400	5.07	33.07	28.00	-7.81	H	135	2.54	120.000	Pass
271.380	6.83	35.57	28.74	-6.03	V	138.2	1.5	120.000	Pass
403.170	9.39	35.57	26.18	-2.83	H	46.3	3.97	120.000	Pass

Figure 8. Worst Case Cabinet Radiation, 30MHz - 1GHz Low

Frequency [MHz]	PK+ Level [dBµV/m]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AVG Level [dBµV/m]	AVG Limit [dBµV/m]	AVG Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Result
3,609.000	50.07	74.00	23.93	37.03	54.00	16.97	-2.43	V	189.3	1.43	Pass
4,511.500	41.91	74.00	32.09	28.48	54.00	25.52	-3.13	V	259.2	1.5	Pass
5,413.500	41.55	74.00	32.45	27.50	54.00	26.50	-4.27	V	59.8	1.27	Pass
7,403.500	45.93	74.00	28.07	33.41	54.00	20.59	-2.51	V	282.6	3.03	Pass
8,441.500	47.07	74.00	26.93	34.51	54.00	19.49	-3.72	V	75.6	1.82	Pass
10,709.000	48.45	74.00	25.55	35.53	54.00	18.47	-0.90	V	64.5	3.43	Pass
15,699.000	50.19	74.00	23.81	37.18	54.00	16.82	1.05	V	131.3	1.01	Pass

Figure 9. Worst Case Cabinet Radiation, 1GHz to 18GHz Low

Frequency [MHz]	QPK Level [dBµV/m]	QPK Limit [dBµV/m]	QPK Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Meas. BW [kHz]	Result
37.920	7.23	29.55	22.32	-6.29	V	168.3	3.89	120.000	Pass
74.190	0.93	29.55	28.62	-12.20	V	270	3.17	120.000	Pass
124.950	6.57	33.07	26.50	-6.15	V	225.1	3.53	120.000	Pass
136.500	6.33	33.07	26.74	-6.74	V	240.4	1.02	120.000	Pass
164.100	5.06	33.07	28.01	-7.78	H	62.4	3.37	120.000	Pass
266.310	6.68	35.57	28.89	-6.16	V	342.3	1.89	120.000	Pass

Figure 10. Worst Case Cabinet Radiation, 30MHz - 1GHz Mid

Frequency [MHz]	PK+ Level [dBµV/m]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AVG Level [dBµV/m]	AVG Limit [dBµV/m]	AVG Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Result
1,340.500	36.89	74.00	37.11	22.99	54.00	31.01	0.57	H	163.2	2.38	Pass
2,272.000	38.50	74.00	35.50	25.28	54.00	28.72	-2.82	H	33.5	3.05	Pass
3,894.000	42.65	74.00	31.35	29.75	54.00	24.25	-1.65	H	117.8	1.07	Pass
5,437.000	40.95	74.00	33.05	28.16	54.00	25.84	-4.21	V	259.2	2.49	Pass
9,087.000	44.14	74.00	29.86	31.19	54.00	22.81	-4.43	H	20	1.52	Pass
12,415.000	45.87	74.00	28.13	32.78	54.00	21.22	-2.68	H	240.2	1.45	Pass
15,709.500	51.00	74.00	23.00	37.68	54.00	16.32	1.01	H	23.3	1.49	Pass

Figure 11. Worst Case Cabinet Radiation, 1GHz to 18GHz Mid

Frequency [MHz]	QPK Level [dBµV/m]	QPK Limit [dBµV/m]	QPK Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Meas. BW [kHz]	Result
37.920	7.96	29.55	21.59	-6.29	V	183.6	3.78	120.000	Pass
74.130	0.91	29.55	28.64	-12.20	V	9.9	2.54	120.000	Pass
112.620	5.82	33.07	27.25	-7.20	H	90	2.47	120.000	Pass
168.540	4.70	33.07	28.37	-8.06	H	75.7	1.38	120.000	Pass
265.890	6.57	35.57	29.00	-6.17	V	207.2	1.14	120.000	Pass
401.160	9.76	35.57	25.81	-2.87	V	270	2.41	120.000	Pass

Figure 12. Worst Case Cabinet Radiation, 30MHz - 1GHz High

Frequency [MHz]	PK+ Level [dBµV/m]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AVG Level [dBµV/m]	AVG Limit [dBµV/m]	AVG Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Result
1,709.000	34.85	74.00	39.15	21.83	54.00	32.17	-2.30	V	260.4	3.12	Pass
8,234.000	42.89	74.00	31.11	30.23	54.00	23.77	-3.15	V	293.1	1.14	Pass
9,149.000	43.36	74.00	30.64	30.85	54.00	23.15	-3.91	V	179.7	1.03	Pass
10,706.000	47.87	74.00	26.13	35.01	54.00	18.99	-0.86	V	264.9	1.16	Pass
14,492.500	49.39	74.00	24.61	36.76	54.00	17.24	-0.04	H	101.5	2.83	Pass
15,712.500	50.35	74.00	23.65	36.69	54.00	17.31	0.99	H	263.1	3.37	Pass

Figure 13. Worst Case Cabinet Radiation, 1GHz to 18GHz High

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(a)(1) Carrier Frequency Separation

Test Requirements: Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

Test Procedures: The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:
a) Span: Wide enough to capture the peaks of two adjacent channels.
b) RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
c) Video (or average) bandwidth (VBW) ≥ RBW.
d) Sweep: Auto.
e) Detector function: Peak.
f) Trace: Max hold.
g) Allow the trace to stabilize.

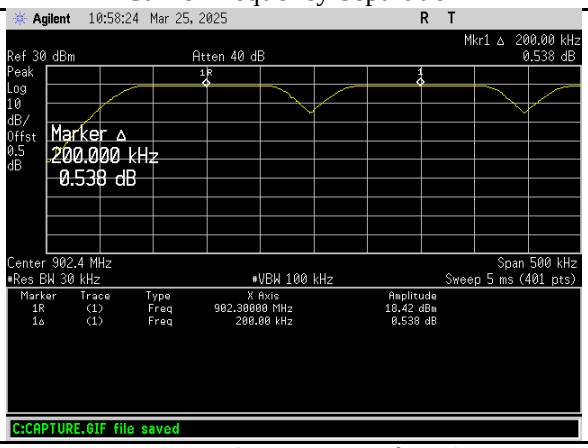
Use the marker-delta function to determine the separation between the peaks of the adjacent channels. Compliance of an EUT with the appropriate regulatory limit shall be determined. A plot of the data shall be included in the test report.

Test Results: The EUT was compliant with the 15.247(a)(1) Carrier Frequency Separation.

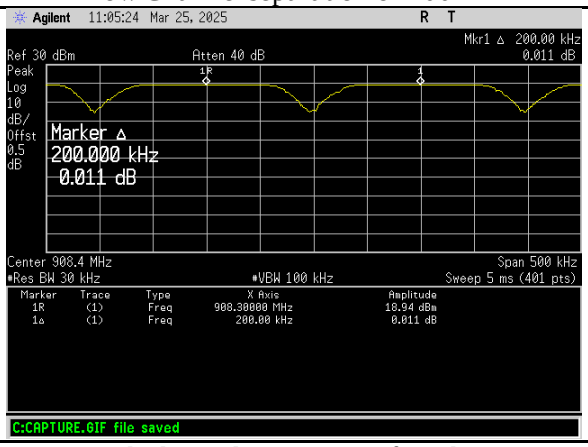
Test Engineer(s): Veer Patel

Test Date(s): 03/31/2025

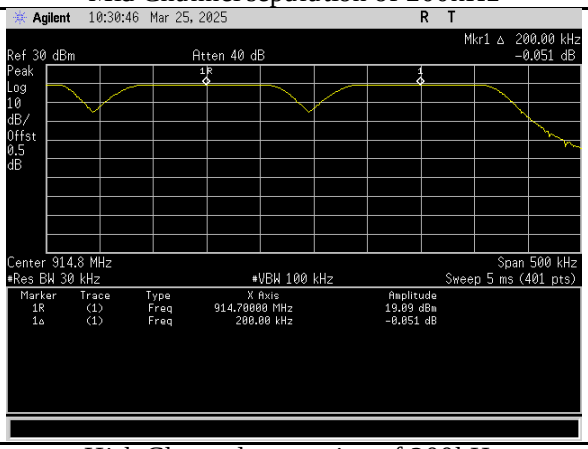
Carrier Frequency Separation



Low Channel separation of 200kHz



Mid Channel separation of 200kHz



High Channel separation of 200kHz

Channel	Separation	Limit[2]	Result
Low	200kHz	≥ 140kHz	Pass
Mid	200kHz	≥ 140kHz	Pass
High	200kHz	≥ 140kHz	Pass

[2] Since the 20dB Bandwidth is greater than 25kJz the carrier frequency separation limit is the 20dB bandwidth.

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(a)(1)(i) Number of Hopping Channels

Test Requirements: (1)Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(i)For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

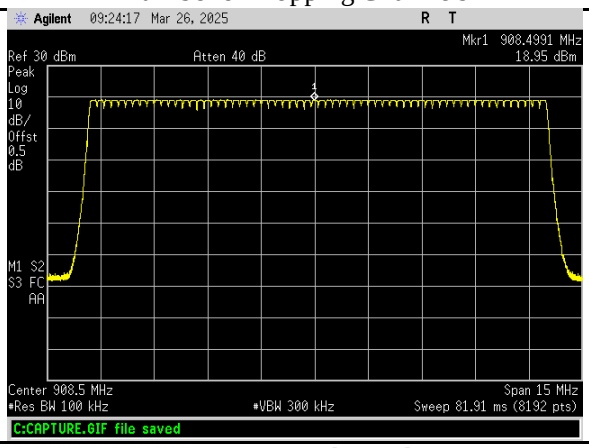
Test Procedures: The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:
a) Span: The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
b) RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
c) VBW ≥ RBW.
d) Sweep: Auto.
e) Detector function: Peak.
f) Trace: Max hold.
g) Allow the trace to stabilize.

It might prove necessary to break the span up into subranges to show clearly all of the hopping frequencies. Compliance of an EUT with the appropriate regulatory limit shall be determined for the number of hopping channels. A plot of the data shall be included in the test report.

Test Results: The EUT was compliant with the 15.247(a)(1)(i) Number of Hopping Channels.

Test Engineer(s): Veer Patel

Test Date(s): 03/26/2025

Number of Hopping Channels

64 Hopping Channels

No. of Channels Allowed	No. of Channels	Result
≥50	64	Pass

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(a)(1)(i) Time of Occupancy

Test Requirements: For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz..

Test Procedures: The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:
a) Span: Zero span, centered on a hopping channel.
b) RBW shall be ⍰ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
c) Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel.
d) Detector function: Peak.
e) Trace: Max hold.

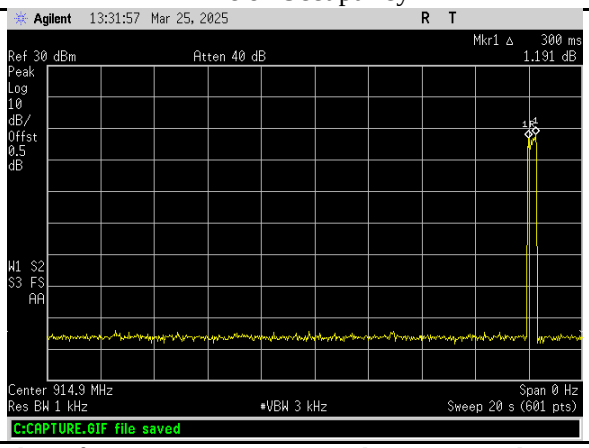
Use the marker-delta function to determine the transmit time per hop. If this value varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation in transmit time.

Test Results: The EUT was compliant with the 15.247(f) Time of Occupancy.

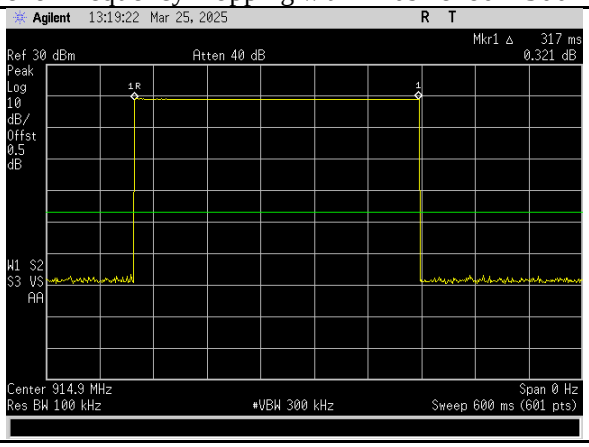
Test Engineer(s): Veer Patel

Test Date(s): 03/25/2025

Time of Occupancy



Number of Frequency Hopping within 20s Period = 300ms



On Time = 317ms

Number of TX in 20s Period	Burst Length	Occupancy Time	Limit	Result
1	300ms	317ms	≤0.4	Pass

IV. Test Equipment

Test Equipment

Calibrated test equipment utilized during testing was maintained in a current state of calibration per the requirements of ISO/IEC 17025:2017.

MET Asset #	Nomenclature	Manufacturer	Model	Last Cal Date	Cal Due Date
1A1250	EMI Test Receiver	Rohde & Schwarz	ESW44	04/08/2024	04/08/2025
100984	Spectrum Analyzer	Rohde & Schwarz	FSV40	03/13/2025	03/13/2027
1A1141	Spectrum Analyzer	Agilent	E4407B	4/29/2024	4/29/2025
1A1147	Bi-Log Antenna	Suno Sciences Corp	JB3	04/06/2023	04/06/2025
1A1259	Thermohygrometer with barometer	Traceable	6453	04/25/2024	04/25/2025
1A1176	Loop Antenna	ETS Lindgren	6502	08/22/2024	08/22/2026
1A1183	Double Ridged Waveguide Antenna	ETS Lindgren	3117	02/20/2024	02/20/2026
1A1161	18G – 40G Horn Antenna	ETS Lindgren	3116C-PA	08/01/2024	01/01/2026
1A1099	Generator	COM-Power Corp	CGO 51000	See Note	
1A1080	Multi Device Controller	ETS EMCO	2090	See Note	
1A1088	Preamplifier	Rohde & Schwarz	TS-PR1	See Note	
1A1044	Generator	COM-Power Corp	CG- 520	See Note	
1A1073	Multi Device Controller	ETS EMCO	2090	See Note	
1A1180	Amplifier	Miteq	AMF-7D-01001800-22-10P	See Note	

Table 13. Test Equipment List
Note: Functionally tested equipment is verified using calibrated instrumentation at the time of testing.

End of Report