GENTEX CORPORATION

Technical Report to the FCC and ISED Regarding Gentex Corporation - Homelink© V

Model: UAHL5P
FCC ID: NZLUAHL5P
ISED: 4112A-UAHL5P

Emission Designator: 181K1F7D
1/3/2025

A report concerning approval for Gentex Corporation Homelink® model UAHL5P
Please issue grant immediately upon review.

Measurements Made by:

Bolay.Pacheco Digitally signed by Bolay.Pacheco Date: 2025.01.09 09:13:17 -05'00'

Bolay Pacheco
Laboratory Validation Engineer III
Gentex Corporation

Measurements Reviewed by:

Daniel S Brasier Digitally signed by Daniel S Brasier Date: 2025.01.03 15:02:42 -05'00'

Dan Brasier
Laboratory Development Engineer II
Gentex Corporation

Report Prepared by:

Patricia Szeszulski Digitally signed by Patricia Szeszulski Date: 2025.01.07 09:15:25 -05'00'

Patricia Szeszulski
Laboratory Validation Engineer I
Gentex Corporation

Report Approved by:

Jason Vargo Laboratory Lab Manager I Digitally signed by Jason Vargo Laboratory Lab Manager I Date: 2025.01.08 08:13:01 -05'00'

Jason Vargo
Laboratory Manager I
Gentex Corporation

Submitted by:

brian.miller Digitally signed by brian.miller Date: 2025.01.06 10:56:51 -05'00'

Brian Miller
Laboratory Group Leader – Regulatory II
Gentex Corporation

Test Report Revision

REV Number	Date	Author	Description
1.0	11/4/2024	Patricia Szeszulski	Initial release
2.0	1/3/2025	Patricia Szeszulski	Updated dwell time and 20dB bandwidth sections per reviewer's feedback

Results relate only to the items tested as received.

Compliance has been evaluated based on the Lab Manual section 7.6.2. The decision rule used regarding measurement uncertainty was to determine results solely on whether the measured values met the defined acceptance criteria without factoring in measurement uncertainty values.

1. General Information

1.1. Product Description

The Gentex Corporation HomeLink® HLV Universal Garage Door Opener is a low-power transceiver OEM device that is installed into a rearview mirror of the automobile. The installation is provided by trained technicians during the course of the manufacture of the automobile. It is powered by the 12 Volt system of the automobile.

This Universal Garage Door Opener has the capability to

1. Learn the frequency and bit code format of the user's existing garage door remote control devices
2. Transmit and receive frequency hopping spread spectrum in the 902 to 928 MHz band using an internal antenna as per Federal Communications Commission "Code of Federal Regulations", Title 47, Part 15.247

The unit is designed for the periodic operation of a control signal, which typically activates a garage door opener receiver.

The unit is supplied to the automobile manufacturer without harness. For testing purposes, a typical assembly and 2-conductor cable harness were used to power the unit.

The three-button HomeLink® unit replaces up to three hand-held transmitters. In addition to the typical operation of the garage door, the unit will learn the radio frequency codes of other transmitter types to activate entry door locks, estate gates, security systems, and home or office lighting.

The antenna system is an integral part of the unit. It cannot be altered nor replaced by the user. The service of this system is only available from the Automobile Manufacturer's Dealerships and Gentex Corporation.

1.2. Related Grants

This device will have functionality that is covered under 47 CFR 15.231. The device will have an FCC ID # of NZLUAHL5P and an ISED ID # of 4112A-UAHL5P under both rule parts. A separate report is submitted for functionality covered under 47 CFR 15.231.

1.3. Test Methodology

Radiated Emissions testing was performed according to ANSI C63.10:2013. The power source for this product is a 12V automotive vehicle battery.

Conducted measurements were performed using a power supply.

Measurements were performed per FCC OET KDB 558074.

The unit is supplied to the automobile manufacturer without harness. For testing purposes, a 2-conductor cable harness was used to interface to the unit. The unit ground is provided through the negative terminal of the harness.

1.4. Test Facility

The 3-meter semi-anechoic chamber where these measurements were taken, is located on the grounds of Gentex Corporation's Corporate Labs, in the city of Zeeland, county of Ottawa, state of Michigan, United States of America.

For radiated measurements above 1 GHz, RF absorbing material is placed between the antenna and EUT in accordance with ANSI C63.4:2014 Section 5.5 and chamber manufacturer's instructions.

The 3m chamber has been added to our A2LA scope of accreditation on 05/20/2016 and includes accreditation to ANSI C63.4:2014 and ANSI C63.10:2013. The report filed with ISED, dated February 11, 2015, was accepted via a letter dated February 11, 2015. Our 3m chamber is registered with the ISED under Site# 4112A-2 and FCC under registration number 357351.

Corporate Mailing/Shipping Address	Site Address
Gentex Corporation	Gentex Corporation
600 N. Centennial Street	380 Riley Street
Zeeland, MI 49464	Zeeland, MI 49423

1.5. Accreditation

The Gentex Corporate EMC Lab is accredited to ISO/IEC 17025 by the American Association for Laboratory Accreditation (A2LA). Our laboratory scope and accreditation certificate #2529.01 are available from their web site www.a2la.org. Our scope of accreditation covers ANSI C63.4:2014, ANSI C63.10:2013, and Radiated Emissions at 3m, FCC 47 CFR Part 15, ISED RSS-210, and ISED RSS-247 Issue 3.

2. Product Labeling

2.1. Identifiers

The FCC Identifier assigned is FCC ID: NZLUAHL5P. The ISED certification number is 4112A-UAHL5P. These identifiers will be labeled on the product housing.

The label will be placed on the exterior of the HL housing using laser etching that will permanently affix the label.

Because of the small size of the device and because the installation is inside a portion of the automobile, the following statements will appear in the user's manual. Refer to attachment "Users Manual.pdf" for the entire text of the user's manual.

> "This device complies with FCC rules Part 15 and with ISED RSS-247 Issue 3. Operation is subject to the following two conditions:
> (1) This device may not cause harmful interference,
> (2) This device must accept any interference that may be received including interference that may cause undesired operation.
>
> WARNING: The transmitter has been tested and complies with FCC and ISED rules. Changes or modifications not expressly approved by the party responsible for the compliance could void the user's authority to operate the device."

The term "ISED:" before the certification/registration number only signifies that ISED technical specifications were met.

ISED: 4112A-UAHL5P FCC ID: NZLUAHL5P MODEL: UAHL5P

2.2. Label Drawing and Location on Product

The label drawing and location of the label on the assembly is included in the “Label Location.pdf” attachment.

3. Test Configuration

Radiated Emission measurements presented in the report were made in accordance with ANSI C63.10:2013. The EUT was placed on a 1 x 1.5m non-metallic table elevated 80cm above a conducting ground plane for measurements below 1GHz and elevated to 1.5m for measurements above 1GHz. The harness was run down the edge of the test table to a power supply beneath the turntable.

For radiated measurements above 1 GHz, RF absorbing material is placed between the antenna and EUT in accordance with ANSI C63.4:2014 Section 5.5 and chamber manufacturer’s instructions.

For conducted measurements, a non-metallic table approximately 80cm x 90cm, 85cm above the floor was used.

4. Block Diagram

For system block diagram please refer to attachment named “HLV Block Diagram.pdf”

5. Powerline Conducted Emissions Measurements

Powerline Conducted Measurements are not required for this product as the part is powered via 12V battery.

6. Emissions Data

6.1. Date(s) Tested: 10/31/2024-11/1/2024

6.2. Test Method Deviations: None

6.3. Temperature and Humidity conditions

	Measured Value	Unit
Temperature	22.3-23.8	ºC
Humidity	45.5-48.3	%R.H.

6.4. Summary of Results (Part 15.247)

Measurement		Margin	Frequency
Worst Case Spurious Emission	62.29dBuV/m	11.71	2706.75MHz
Maximum 20dB BW	205.4 kHz	294.6kHz	-
Maximum 99% BW	181.1 kHz	318.9kHz	-
Minimum Carrier Frequency Separation	499.2 kHz	327.2kHz	-
Number of Hopping Frequencies	50	-	-
Peak Output Power	1.16	28.8dB	902.25MHz
Time of Occupancy	0.364 seconds	0.036s	-

- **Band Edge Measurement Requirement:** Per section 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. 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).

Emissions are below the fundamental for frequencies less than 902MHz for hopping and non-hopping as shown by the plots below. Emissions are below the fundamental above 928MHz for hopping and for non-hopping as shown by the plots below.

- **Duty Cycle Factor Corrections**: Since the frequency hopping is turned off for the radiated measurements, a duty cycle factor is used to correct the average readings based on the dwell time. This factor is computed from the time domain trace of the dwell time in any 100 ms period. The duty cycle is calculated as the (dwell time/100ms) where the dwell time is limited to 100ms. The duty cycle factor is 20*Log (duty cycle). The duty cycle factor is calculated as **-27.5dB**. (-27.5dB = 20*Log(4.23ms/100ms)).

- **Measurement Uncertainty:** The standard uncertainty of measurement has been determined in accordance with the ISO Guide to the Expression of Uncertainty in Measurements. The estimation of measurement uncertainty reported is the expanded uncertainty for a coverage factor of k=2.26 and confidence interval of approximately 95%.

Expanded Uncertainty $U_{(k=2.26)}$ is as follows:

- Radiated Emissions – Bicon (30-250 MHz): 4.1 dB
- Radiated Emissions – LPA (250-1000 MHz): 5.0 dB
- Radiated Emissions – DRWG (26.5 GHz): 4.2 dB
- Conducted Emissions: 1.04 dB
- Frequency: 0.007 ppm

6.5. Test Equipment Setup and Procedure

6.5.1. Sample(s) Used for Measurements

Sample ID(s):	905-6548-146021-2, 905-6548-151431-1

6.5.2. Test Equipment Used for Conducted Measurement

Equipment used			
ID / Serial #	**Manufacturer**	**Description**	**Cal / PM Due Date**
5188	Rohde and Schwarz	EMI Receiver Firmware 3.66 SP1	11/13/2025
CBL 119	Pasternack	PE341-60	4/30/2025
SW48	Gentex	Gentex Emissions Measurement Software	3/31/2025
PS103	MW	2-amp power supply	VBU
PJ2246	ETS-Lindgren	Sheilded Enclosure	12/31/2024
6368	Rhode & Schwarz	Signal Generator	9/14/2025

6.5.3. Test Equipment Used for Radiated Measurement Equipment

Equipment used			
ID / Serial #	**Manufacturer**	**Description**	**Cal / PM Due Date**
6595	Rohde and Schwarz	EMI Receiver Firmware 3.66 SP1	11/13/2024
CF GCL	Megaphase/Pasternack	3m Chamber Port and Cables	4/30/2025
H6192	EMCO	3148 Log Periodic RX	5/13/2027
8893	Com-Power	AHA-118 Horn	4/22/2027
Tower 2	ETS-Lindgren	2171B Boresight Tower	VBU
PJ2246	ETS-Lindgren	Shielded Enclosure	12/31/2024
7187	Omega	iBTHX-W Virtual	9/24/2025
HL5 Transceiver-GCL	Gentex	Default Receiver	VBU
6539	Stanley	Tape Measure	6/19/2026
H4554	87V	Multimeter	1/11/2025
S/N:419726	AIM TTI	PL303-P	VBU
SW30	Gentex	3m Chamber Software	3/31/2025
SW48	Gentex	Gentex Emissions Measurement Software	3/31/2025
Absorber 1	ETS-Lindgren	Absorbers	VBU

6.5.4. Test Equipment Setup and Procedure

EMI Receiver Settings Emissions:

Detector Function : Peak
Resolution Bandwidth :120kHz (below 1GHz)
:1MHz (above 1GHz)
Video Bandwidth: :300kHZ (below 1GHz)
:3MHz (above 1GHz)

EMI Receiver (in Spectrum Analyzer mode) Settings Occupied Bandwidth:

Detector	: Peak
Resolution Bandwidth	:1 MHz (to determine peak level)
	:10 kHz (to determine occupied bandwidth)
Video Bandwidth	:3 MHz (to determine peak level)
	:30 kHz (to determine occupied bandwidth)

Spectrum Analyzer Settings for Conducted measurements:

Detector Function	: Peak
Resolution Bandwidth	:120kHz (below 1GHz)
	:1MHz (above 1GHz)
Video Bandwidth:	:300kHZ (below 1GHz)
	:3MHz (above 1GHz)

For the testing, the EUT was placed at the center of a non-conducting table 80cm above the ground plane pursuant to ANSI C63.10:2013 for stand-alone equipment. The 2-conductor harness was run down the edge of the test table to a power supply underneath the turntable.

Equipment is placed in one of the three orthogonal orientations, End, Side, and Flat. These orientations are described below in Figure 6.2.3

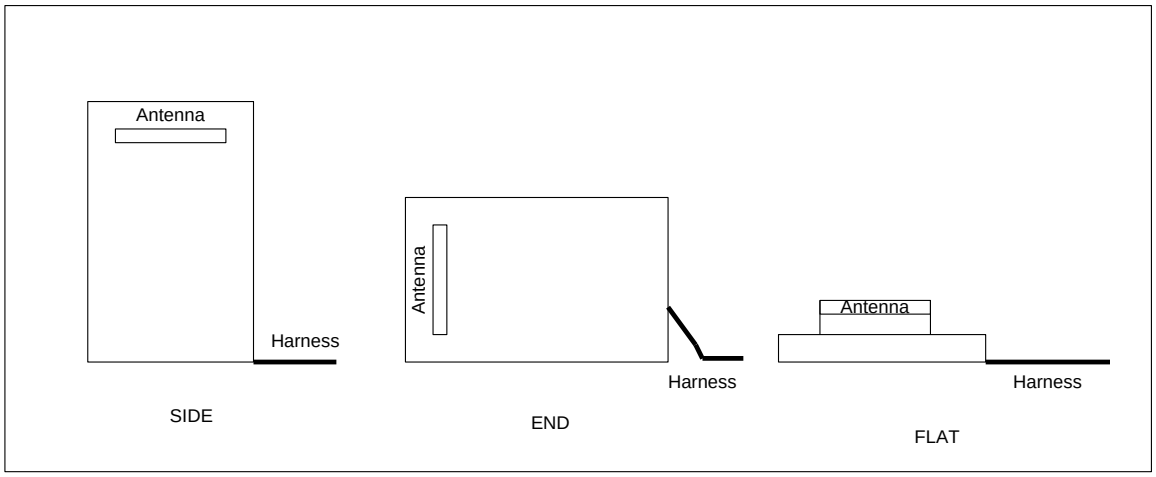


Figure 6.2.3 EUT Orthogonal Orientations

While in the prescribed orientation, the vertical antenna positioner sweeps in elevation from 1 to 4m in height until the operator finds the peak. The 3m turntable is then rotated through 360 degrees until a peak is found. The table is stopped at the peak location and the peak in elevation re-verified. Procedure is repeated for applicable orientations/measurement antenna polarizations. Radiated testing was performed in the in-vehicle position only.

6.6. Measured Data – See Appendix A

7. Formulas and Sample Calculations

7.1. Adjustment to account for duty cycle

To calculate the duty cycle correction factor for the average measurement, the following calculation was performed.

4.23ms while in Wireless Diagnostic mode was used for the on time, as this was the worst case.

Duty cycle Correction Factor = 20*Log (On Time(ms) /100ms).

-27.5dB = 20*Log(4.23ms/100ms)

7.2. Calculation of ISED Limits from RSS-247and 47 CFR Part 15.247

The Peak Tx Spurious Emissions limit for the fundamental is given by:
Limit dBuV/m= 1W ERP = 127.38 dBuV/m, which is the fundamental limit.

The Rx Spurious Emissions limit for the fundamental is given by:
Limit dBuV/m= 20*Log(200uV/m) =46.0dBuV/m

The Rx Spurious Emissions limit for the harmonics is given by**:**
Limit dBuV/m= 20*Log(500uV/m) =54.0dBuV/m

8. Power Targets

Region	Frequency (MHz)	CW Target (Hex)		
		0-33%	34 - 66%	67 - 100%
0	285-303	11	11	11
1	303-322	11	11	11
2	335-360	10	10	10
3	360-380	12	12	13
4	380-400	0D	0D	0D
5	410-440	04	04	04
9	900-928 (FHSS)	7F	N/A	

Appendix A

1. Radiated (Tx) Measurements

Note: The Duty Cycle Correction factors are the worst case based on a 4.23ms dwell time.

Measurement Settings:
Measurement Frequency: Below 1GHz
Span: 500kHz or greater
RBW: 100/120kHz
VBW: 300kHz or 3 x RBW
Sweep Time: 25ms
Attenuation: Auto
Measurement Frequency: Above 1GHz
Span: 500kHz or greater
RBW: 1MHz
VBW: 3MHz or 3 x RBW
Sweep Time: 25ms
Attenuation: Auto

1.1. DUT Transmitting at 902.25MHz (Fundamental) –

Peak Measurement - 902.25MHz

Frequency (MHz)	Orientation (Flat/End/Side)	Measurement Polarization (H/V)	Measurement (dBuV/m)	Peak Limit (dBuV/m)	Margin (dB)
902.25	Side	H	98.66	127.3	28.64
1804.5	Side	H	64.22	78.7	14.44
2706.75	Side	H	62.29	74.0	**11.71**
3609	Side	H	60.82	74.0	13.18
4511.25	Side	V	53.01	74.0	20.99
5413.5	Side	H	57.94	74.0	16.06
6315.75	Side	H	45.45	78.7	33.21
7218	Side	H	47.07	74.0	26.93
8120.25	Side	H	49.7	74.0	24.30
9022.5	Side	V	51.22	74.0	22.78

Average Measurement - 902.25MHz

Frequency (MHz)	Orientation (Flat/End/Side)	Measurement Polarization (H/V)	Measurement (dBuV/m)	Duty Cycle Correction (dB)	Average Level (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)
1804.5	Side	H	64.22	-27.5	36.7	58.7	21.91
2706.75	Side	H	62.29	-27.5	34.8	54.0	**19.18**
3609	Side	H	60.82	-27.5	33.3	54.0	20.65
4511.25	Side	V	53.01	-27.5	25.5	54.0	28.46
5413.5	Side	H	57.94	-27.5	30.5	54.0	23.53
6315.75	Side	H	45.45	-27.5	18.0	58.7	40.68
7218	Side	H	47.07	-27.5	19.6	54.0	34.40
8120.25	Side	H	49.7	-27.5	22.2	54.0	31.77
9022.5	Side	V	51.22	-27.5	23.7	54.0	30.25

1.2. DUT Transmitting at 914.75MHz (Fundamental) – FCC 15.247

Peak Measurement - 914.75MHz

Frequency (MHz)	Orientation (Flat/End/Side)	Measurement Polarization (H/V)	Measurement (dBuV/m)	Peak Limit (dBuV/m)	Margin (dB)
914.75	Side	H	96.19	127.3	31.11
1829.5	Side	H	58.87	76.2	17.32
2744.25	Side	H	61.88	74.0	**12.12**
3659	Side	H	59.21	74.0	14.79
4573.75	Side	V	52.9	74.0	21.10
5488.5	Side	V	60.83	74.0	13.17
6403.25	Side	V	44.06	76.2	32.13
7318	Side	V	42.25	74.0	31.75
8232.75	Side	V	48.4	74.0	25.60
9147.5	Side	H	46.49	74.0	27.51

Average Measurement - 914.75MHz

Frequency (MHz)	Orientation (Flat/End/Side)	Measurement Polarization (H/V)	Measurement (dBuV/m)	Duty Cycle Correction (dB)	Average Level (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)
1829.5	Side	H	58.87	-27.5	31.4	56.2	24.79
2744.25	Side	H	61.88	-27.5	34.4	54.0	**19.59**
3659	Side	H	59.21	-27.5	31.7	54.0	22.26
4573.75	Side	V	52.9	-27.5	25.4	54.0	28.57
5488.5	Side	V	60.83	-27.5	33.4	54.0	20.64
6403.25	Side	V	44.06	-27.5	16.6	56.2	39.60
7318	Side	V	42.25	-27.5	14.8	54.0	39.22
8232.75	Side	V	48.4	-27.5	20.9	54.0	33.07
9147.5	Side	H	46.49	-27.5	19.0	54.0	34.98

1.3. DUT Transmitting at 926.75MHz (Fundamental) – FCC 15.247

Peak Measurement - 926.75MHz

Frequency (MHz)	Orientation (Flat/End/Side)	Measurement Polarization (H/V)	Measurement (dBuV/m)	Peak Limit (dBuV/m)	Margin (dB)
926.75	Side	H	93.81	127.3	33.49
1853.5	Side	H	56.46	73.8	17.35
2780.25	Side	H	62.25	74.0	**11.75**
3707	Side	H	55.85	74.0	18.15
4633.75	Side	V	52.43	74.0	21.57
5560.5	Side	V	59.53	74.0	14.47
6487.25	Side	H	45.97	73.8	27.84
7414	Side	H	44.31	74.0	29.69
8340.75	Side	H	52.26	74.0	21.74
9267.5	Side	V	45.67	74.0	28.33

Average Measurement - 926.75MHz

Frequency (MHz)	Orientation (Flat/End/Side)	Measurement Polarization (H/V)	Measurement (dBuV/m)	Duty Cycle Correction (dB)	Average Level (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)
1853.5	Side	H	56.46	-27.5	29.0	53.8	24.82
2780.25	Side	H	62.25	-27.5	34.8	54.0	**19.22**
3707	Side	H	55.85	-27.5	28.4	54.0	25.62
4633.75	Side	V	52.43	-27.5	25.0	54.0	29.04
5560.5	Side	V	59.53	-27.5	32.1	54.0	21.94
6487.25	Side	H	45.97	-27.5	18.5	53.8	35.31
7414	Side	H	44.31	-27.5	16.8	54.0	37.16
8340.75	Side	H	52.26	-27.5	24.8	54.0	29.21
9267.5	Side	V	45.67	-27.5	18.2	54.0	35.80

2. Conducted Measurements

2.1. Occupied Bandwidth Measurement (FCC Part 15.247)

Measurement Settings:
Frequency Span: 2 to 5 times the Occupied Bandwidth or OBW. 500kHz is typical.
RBW: 1 to 5% of the OBW. 10kHz is typical.
VBW: 3 times the RBW.
Detector: Peak
Trace: Max Hold

20dB Bandwidth Requirement: Per 15.247(a)(1), Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25kHz or the 20dB bandwidth of the hopping channel, whichever is greater. Per section 15.247(a)(1)(i), for frequency hopping systems operating in the 902-928 MHz band, the 20dB bandwidth shall be measured for determination of the carrier frequency separation limits and must not exceed 500 kHz. In this design, the 20dB bandwidth of the hopping channel is less than 250kHz, so the system shall use at least 50 hopping channels.

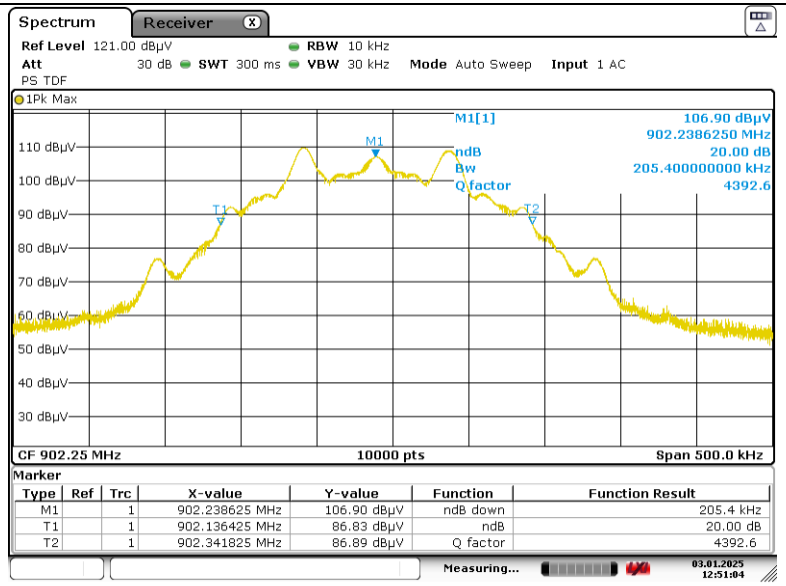
This measurement is a conducted measurement. Prior to the measurement the EUT is placed into hopping mode via a communications board attached to the EUT.

In measurement of the 20dB bandwidth, the transmit frequency was set to low, middle, and high hopping channels. The resolution band width (RBW) was set to > than 1% of the 20dB bandwidth. The span was set to 2 to 3 times the 20dB bandwidth.

20dB BW Results

Channel	20dB BW (kHz)	Limit (kHz)	Margin
Low	205.4	500	294.6
Mid	205.25		294.8
High	204.9		295.1

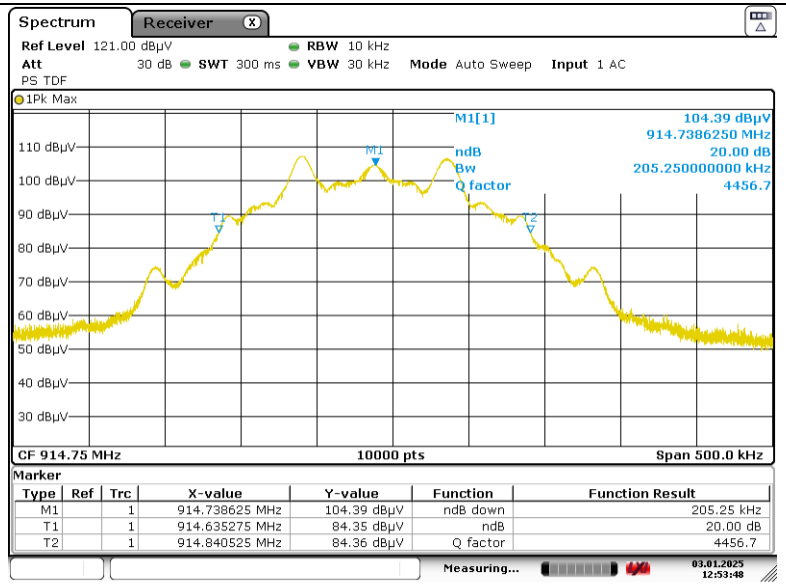
20 dB BW Low Band Measurement Plot



Marker						
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	902.238625 MHz	106.90 dBµV	ndB down	205.4 kHz
T1		1	902.136425 MHz	86.83 dBµV	ndB	20.00 dB
T2		1	902.341825 MHz	86.89 dBµV	Q factor	4392.6

Date: 3.JAN.2025 12:51:04

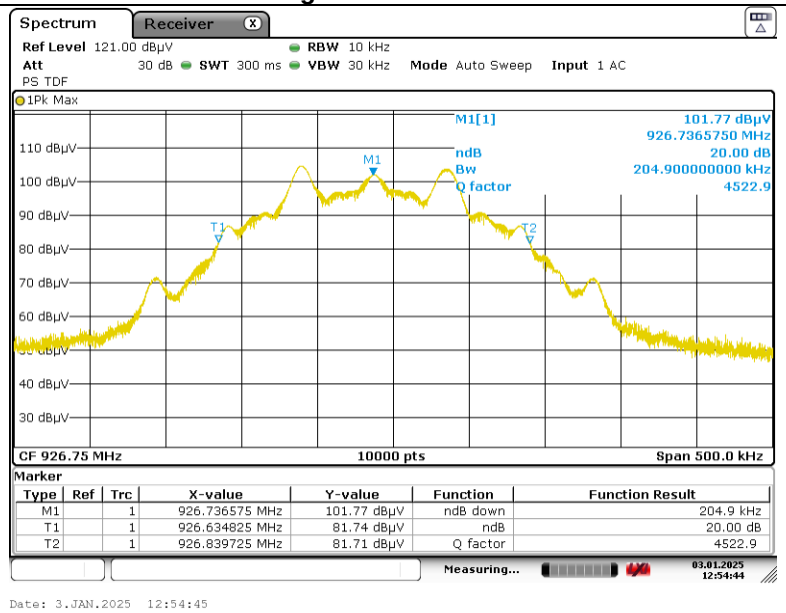
20 dB BW Mid Band Measurement Plot



Marker						
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	914.738625 MHz	104.39 dBµV	ndB down	205.25 kHz
T1		1	914.635275 MHz	84.35 dBµV	ndB	20.00 dB
T2		1	914.840525 MHz	84.36 dBµV	Q factor	4456.7

Date: 3.JAN.2025 12:53:48

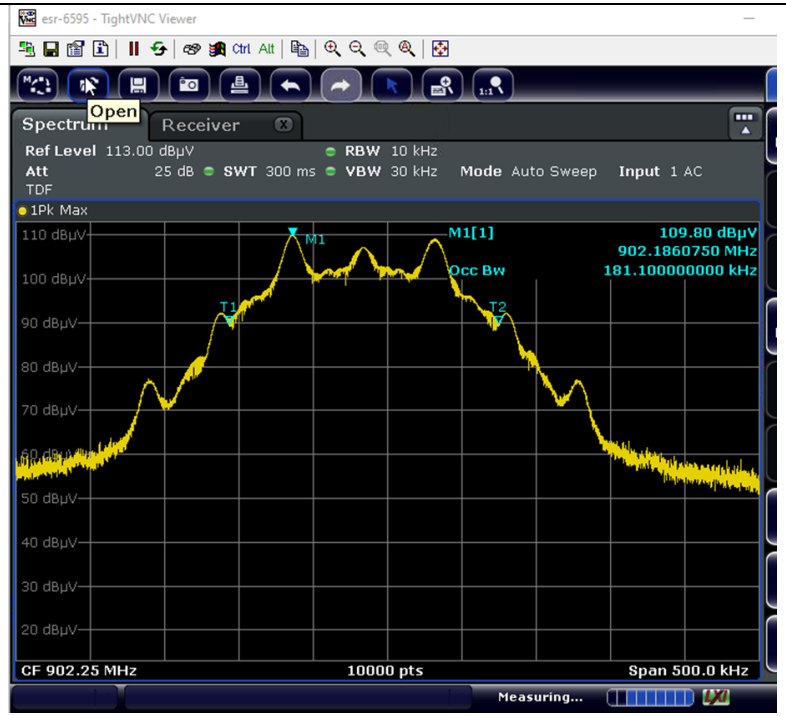
20 dB BW High Band Measurement Plot



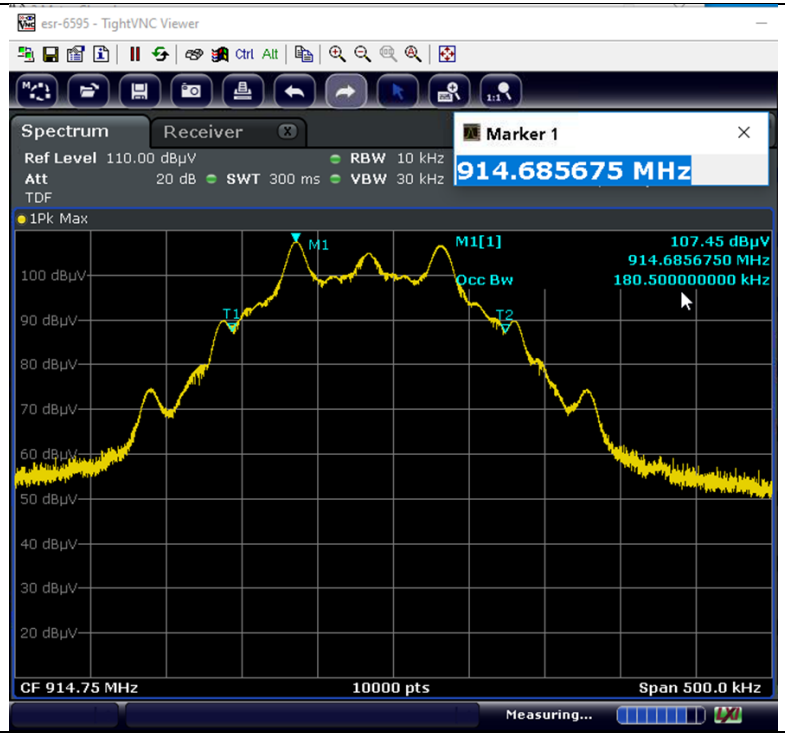
99% BW Results

Channel	99% BW (kHz)	Limit (kHz)	Margin
Low	181.1	500	318.9
Mid	180.5		319.5
High	180.6		319.4

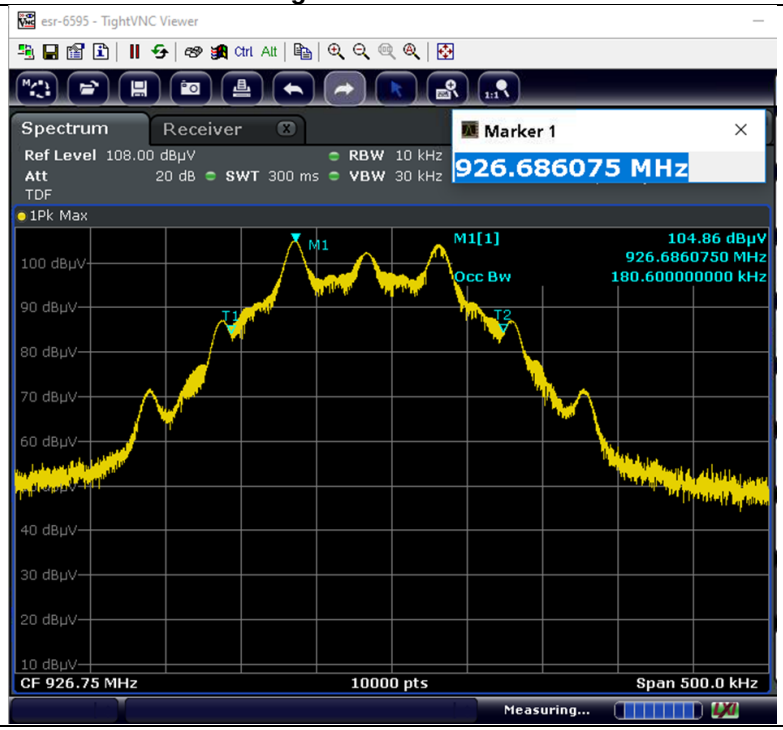
99% BW Low Band Measurement Plot



99% BW Mid Band Measurement Plot



99% BW High Band Measurement Plot



2.2. Carrier Frequency Separation Measurement (FCC Part 15.247)

Measurement Settings:
Frequency Span: Wide enough to capture 2 channels. 1.5MHz is typical.
RBW: 30% of the channel spacing. 100kHz is typical.
VBW: Greater or equal to the RBW
Sweep: No faster than coupled (auto) time
Detector: Peak
Trace: Max hold

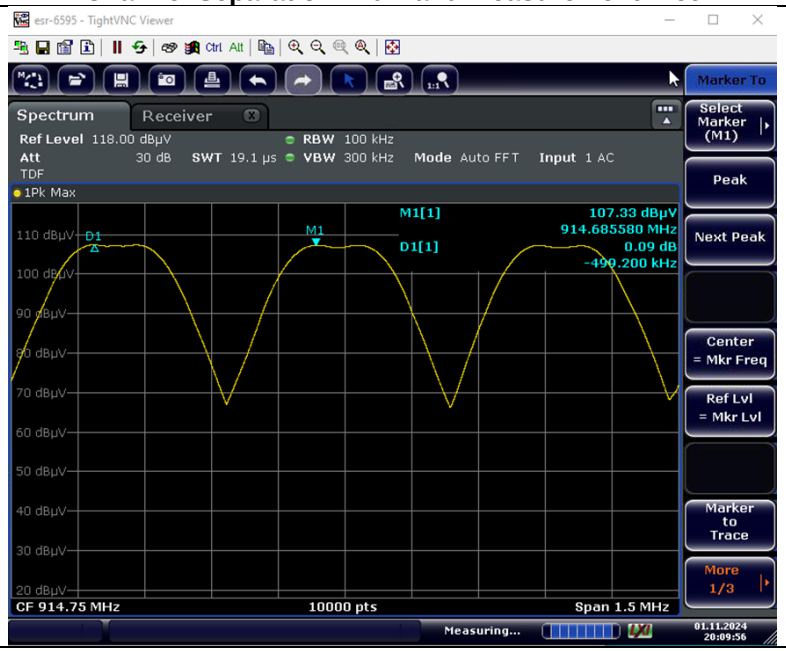
Carrier Frequency Separation Requirement: Per 15.247(a)(1), Frequency Hopping Systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

This measurement is a conducted measurement. Prior to the measurement the EUT is placed into hopping mode via a communications board attached to the EUT.

In measurement of the Carrier Frequency Separation, the RBW was set to > than 1% of the span. The peak detector and 'Max-Hold' function were engaged. The span was set wide enough to capture the peaks of at least two adjacent channels. When the trace stabilizes after multiple scans, the marker-delta function is used to determine the separation between the adjacent channels. Measurements were made for low, mid, and high channels.

The plot shows that the minimum carrier frequency separation is measured as **499.2kHz**, which is greater than the 20dB bandwidth measurement (**205.4kHz**).

Channel	Carrier Frequency Seperation (kHz)	Minimum Requirement (kHz)	Margin
Low	499.95	205.4	294.6
Mid	499.2		293.8
High	500.25		294.9

Channel Separation Low Band Measurement Plot	Channel Separation Mid Band Measurement Plot
	

Channel Separation High Band Measurement Plot

2.3. Number of Hopping Frequencies Measurement (FCC Part 15.247)

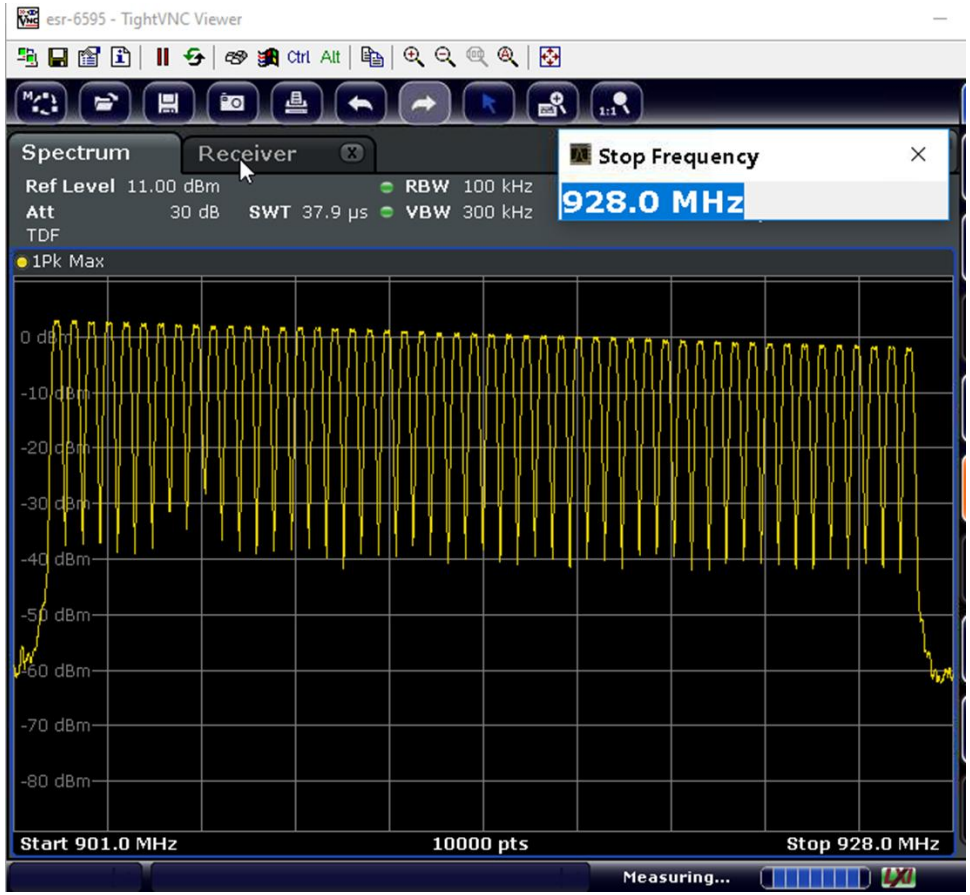
Measurement Settings:
Frequency Span: 902-928MHz
RBW: Set to less than 30% of the channel spacing or the 20dB OBW. 100kHz is typical.
VBW: Greater or equal to the RBW
Sweep: No faster than coupled (auto) time
Detector: Peak
Trace: Max Hold

Number of Hopping Frequencies Requirement: Per section 15.247(a)(1)(i), for frequency hopping systems operating in the 902-928 MHz band, the 20dB bandwidth shall be measured for determination of the carrier frequency separation limits and must not exceed 500 kHz. In this design, the 20dB bandwidth of the hopping channel is less than 250kHz, so the system shall use at least 50 hopping channels.

This measurement is a conducted measurement. Prior to the measurement the EUT is placed into hopping mode via a communications board attached to the EUT.

In measurement of the number of hopping frequencies, the DUT was allowed to continuously transmit. The RBW was set to < than 1% of the span. The peak detector and 'Max-Hold' function were engaged. The span was set wide enough to capture the entire frequency band of operation. When the trace stabilizes after multiple scans, the number of hopping frequencies is counted.

The plot shows the number of hopping frequencies equals 50, which meets the requirements.


esr-6595 - TightVNC Viewer
Ctrl Alt
Spectrum
Receiver
Ref Level 11.00 dBm
RBW 100 kHz
Att 30 dB
SWT 37.9 µs
VBW 300 kHz
TDF
Stop Frequency
928.0 MHz
1Pk Max
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
Start 901.0 MHz
10000 pts
Stop 928.0 MHz
Measuring...

2.4. Band Edge Measurement (FCC Part 15.247)

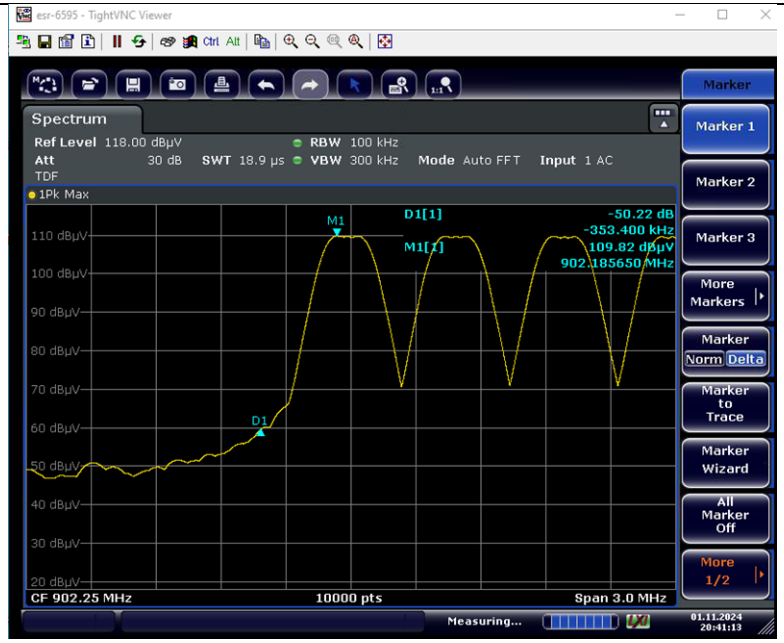
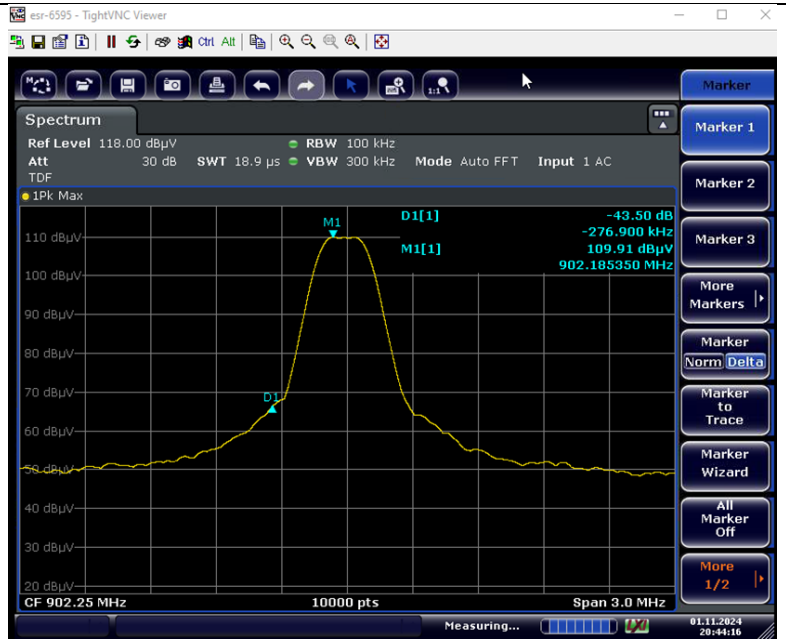
Measurement Settings:
Frequency Span: 3MHz
RBW: 100kHz is typical
VBW: 3x RBW, 300kHz is typical
Sweep time: No faster than coupled (auto) time
Detector: Peak
Trace: Max Hold

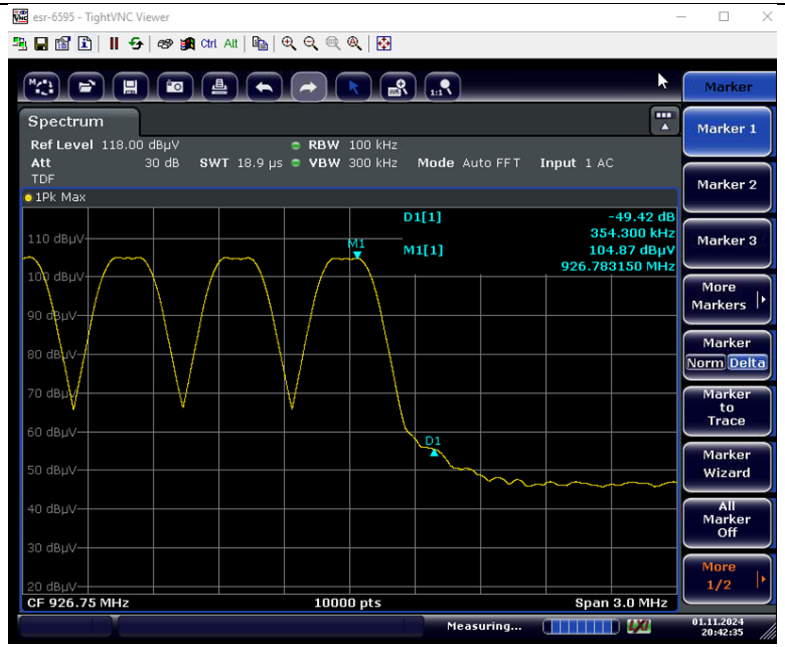
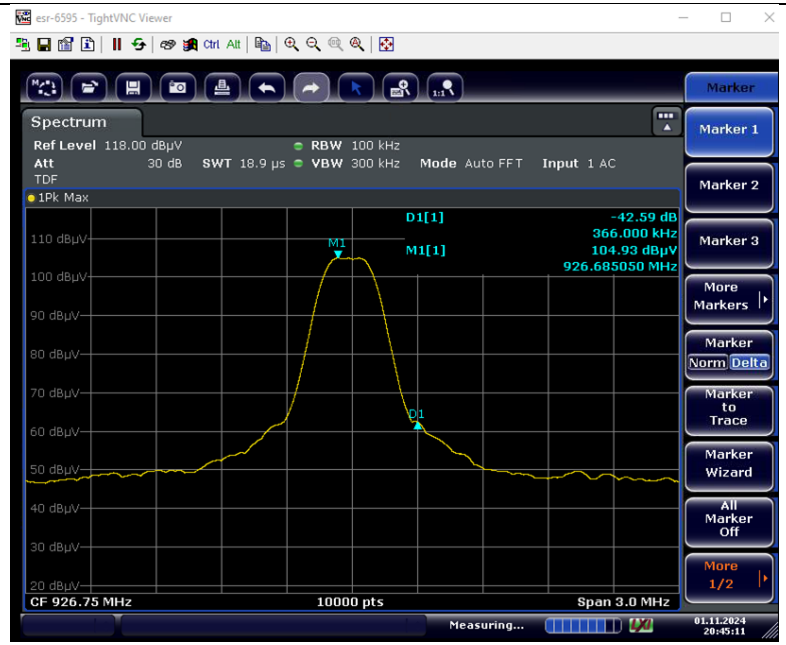
Per section 15.247(d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the 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. 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).

This measurement is a conducted measurement. Prior to the measurement the EUT is placed into hopping mode via a communications board attached to the EUT. The measurements are also performed without hopping on multiple channels.

For the Low Frequency Band Edge, emissions are below the fundamental for frequencies less than 902MHz for hopping and non-hopping as shown by the plots below. For the High Frequency Band Edge, emissions are below the fundamental above 928MHz for hopping and for non-hopping as shown by the plots below.

Band Edge	Mode	Worst Case OOB Spur Delta from Peak Fundamental (dB)	Minimum Requirement (dB)	Margin
Low	Hopping	50.22	20	30.22
Low	Non-Hopping	43.5	20	23.5
High	Hopping	49.42	20	29.42
High	Non-Hopping	42.59	20	22.59

Hopping Low Frequency Band Edge	Non - Hopping Low Frequency Band Edge
	

Hopping High Frequency Band Edge	Non - Hopping High Frequency Band Edge
	

2.5. Peak Power (FCC Part 15.247)

Measurement Settings:
Sweep 1: Peak - 1000 kHz
Segment: 1
Start Frequency: 900 MHz
End Frequency: 904 MHz
Band: PK Power - Low
Detector: Peak
Sweep Mode: Stepped

Attenuator: AUTO
Pre-Amp: Off
Max Hold Trace Mode: Off
Bandwidth Filter: EMI (6dB)
RBW: 1000 kHz
Step Size: 50 kHz
Dwell Time: 5ms

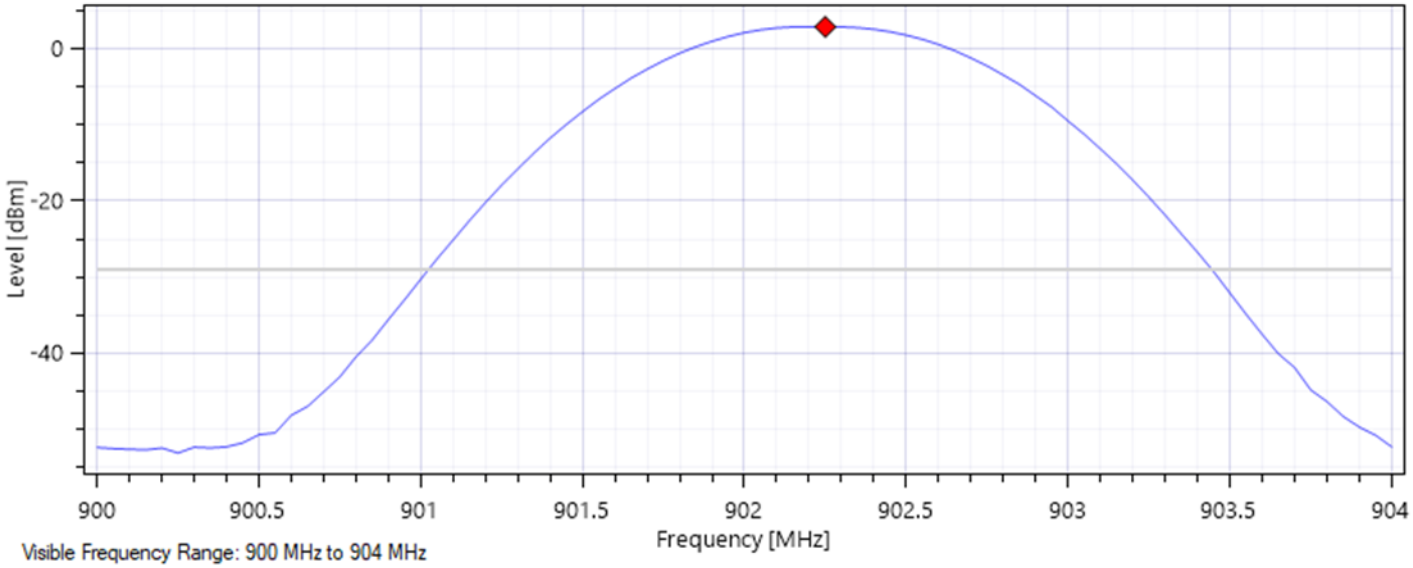
Per section 15.247(b)(2), for frequency hopping systems operating in the 902-928 MHz band and employing at least 50 hopping channels, the maximum peak output power shall not be greater than 1W (30dBm).

This measurement is a conducted measurement performed with a receiver per test method ANSI C63.10 section 7.8.5. Prior to the measurement the EUT is placed into hopping mode via a communications board attached to the EUT.

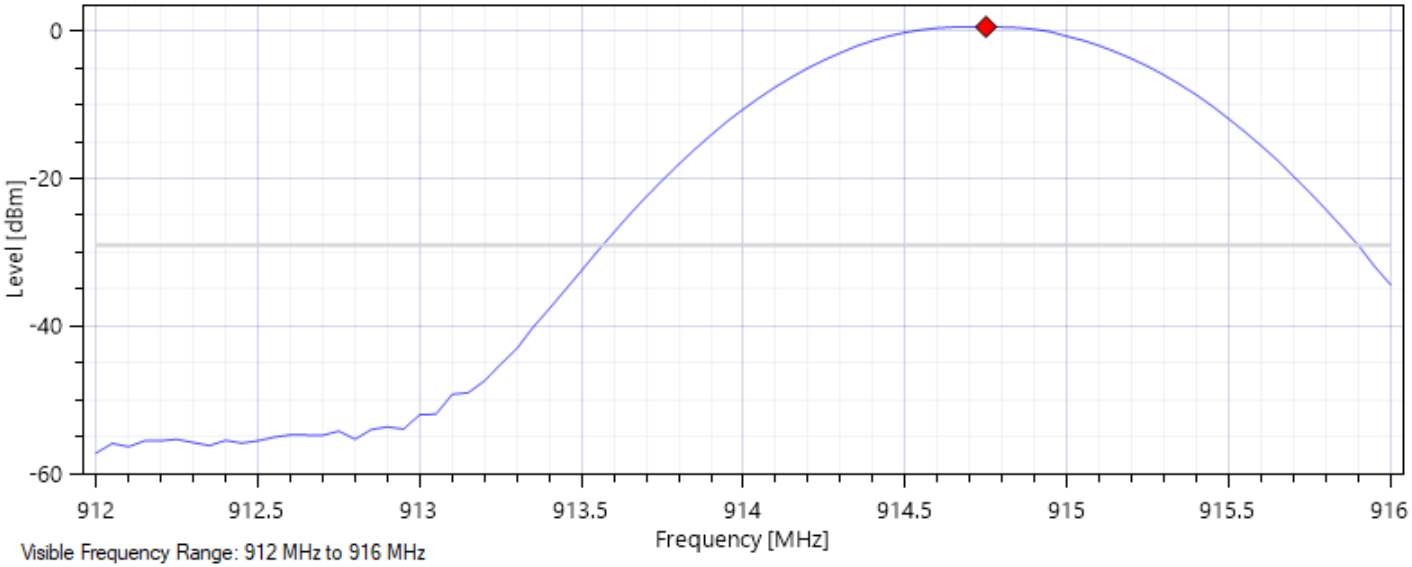
Peak power was measured with the transmitter set separately at 902.25MHz, 914.75MHz, and also 926.75MHz. For each of the frequencies, the peak power was less than 30dBm.

Channel	Peak Power (dBm)	Limit	Margin
Low	1.16	30	28.8
Mid	0.577		29.4
High	-1.926		31.9

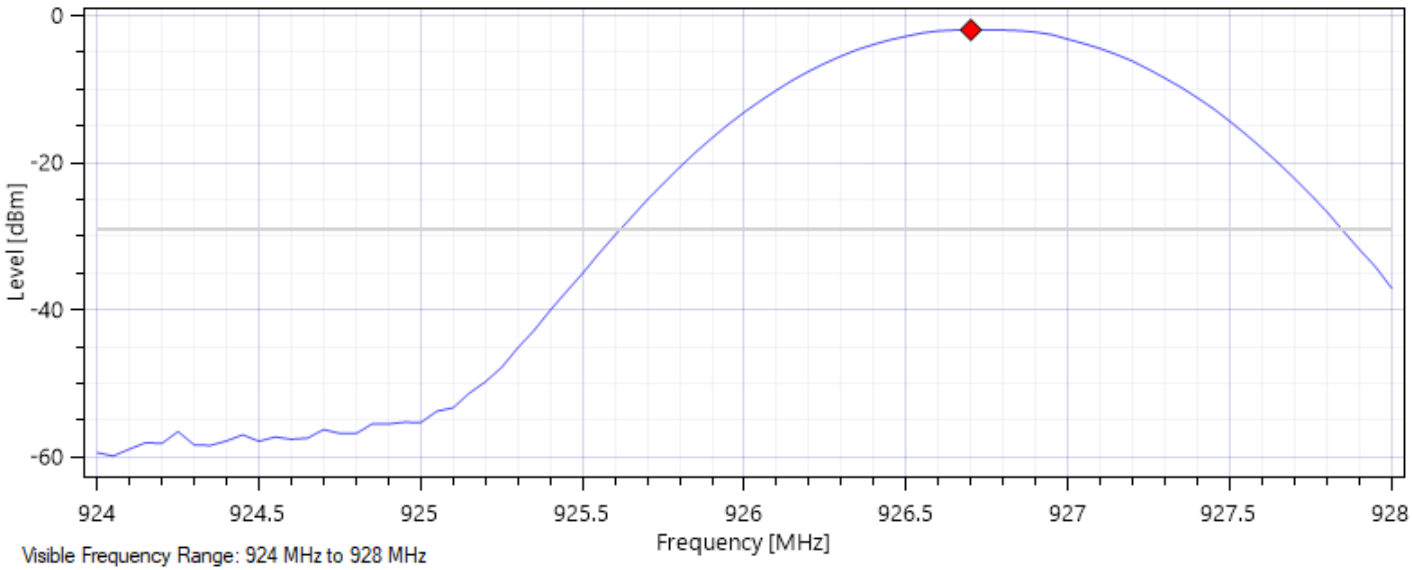
902.25 Peak Output Power



914.75 Peak Output Power



926.75 Peak Output Power



2.6. Time of Occupancy (FCC Part 15.247)

Measurement Settings:

Frequency Span: Zero span, centered on a hopping channel
RBW: Shall be less than or equal to channel spacing (500kHz), and where possible RBW should be set >> 1/T where T is the expected transmission time per hop. 100kHz is typical.
Sweep time: 10s
Detector: Peak
Trace: Clear-write, single sweep

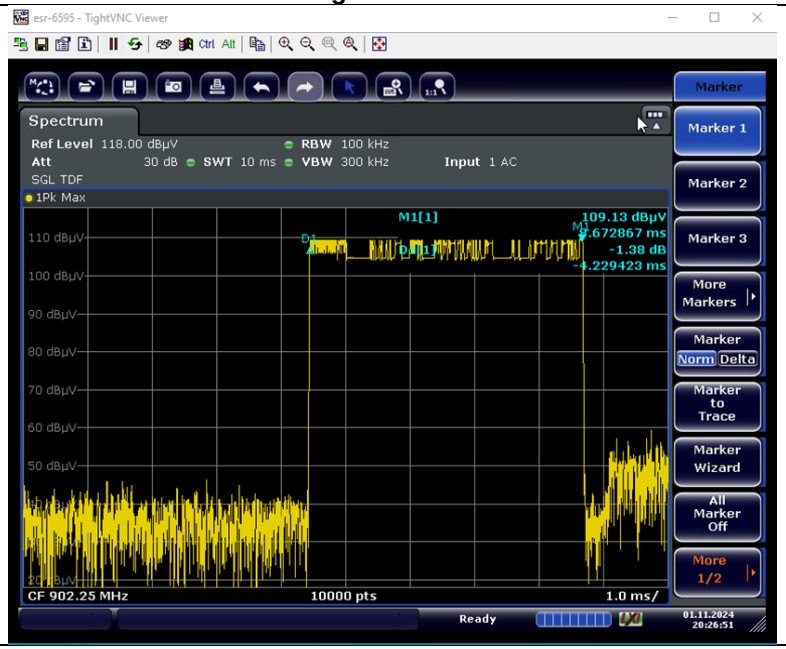
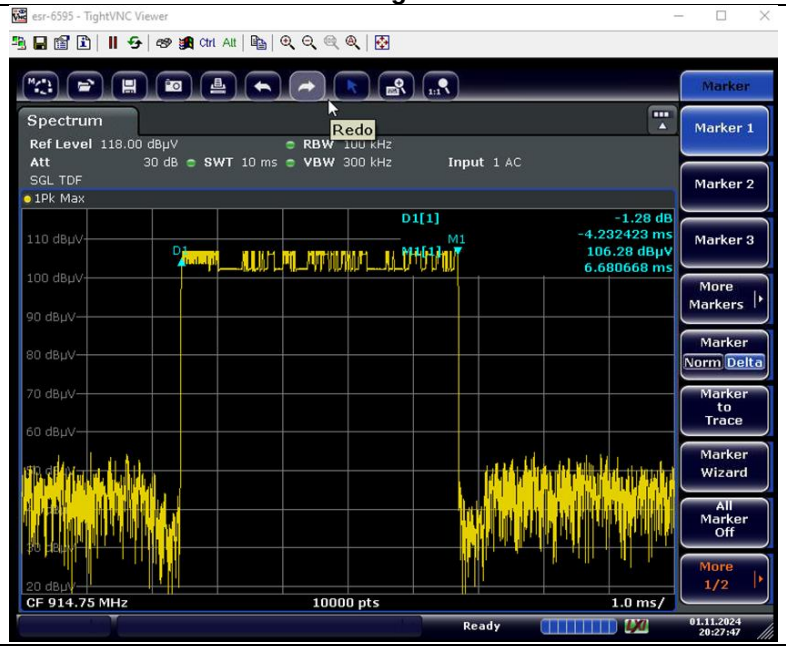
Per section 15.247(a)(1)(i), for frequency hopping systems operating in the 902-928 MHz band, if the 20dB bandwidth of the hopping channel is less than 250kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period.

This measurement is a conducted measurement. Prior to the measurement the EUT is placed into hopping mode via a communications board attached to the EUT. The part was placed in Wireless Diagnostics mode with the “Hop” message as it produced the worst-case total dwell times. Within Wireless diagnostic mode, the “Info” message produced longer individual on times but did not have as many transmissions in a 20sec period.

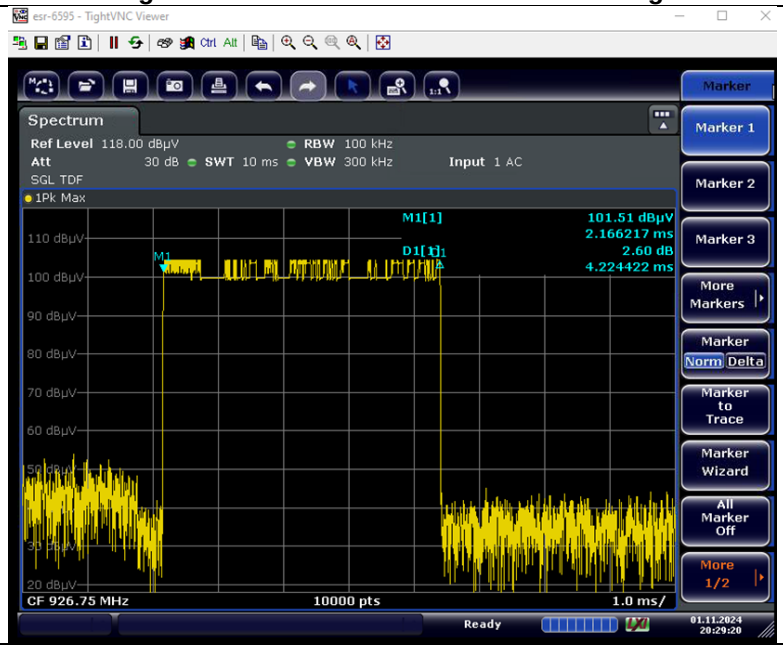
In measurement of the time of occupancy, the RBW was set to 1MHz. The peak detector and ‘Max-Hold’ function were engaged. With the span set to 0Hz, the sweep time was adjusted to capture a single event in order to measure the dwell time per hop.

The figures below show the hop dwell time for each band

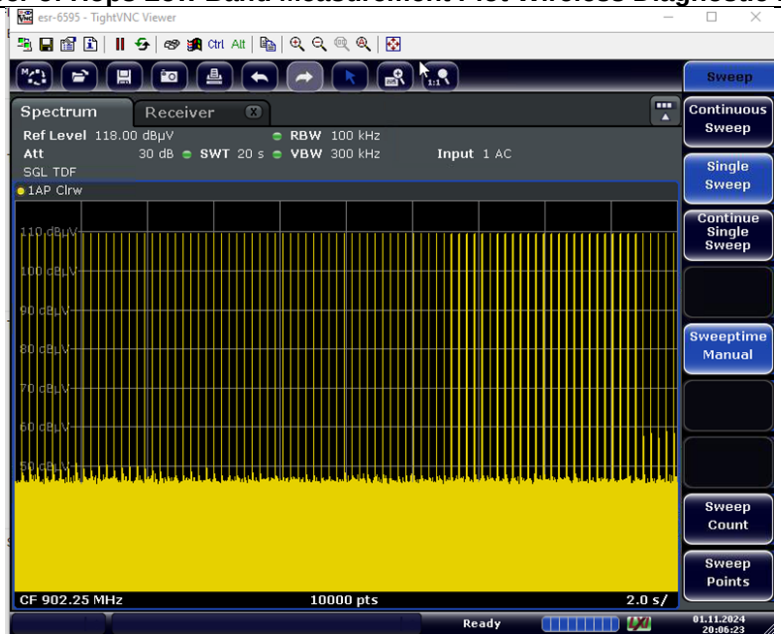
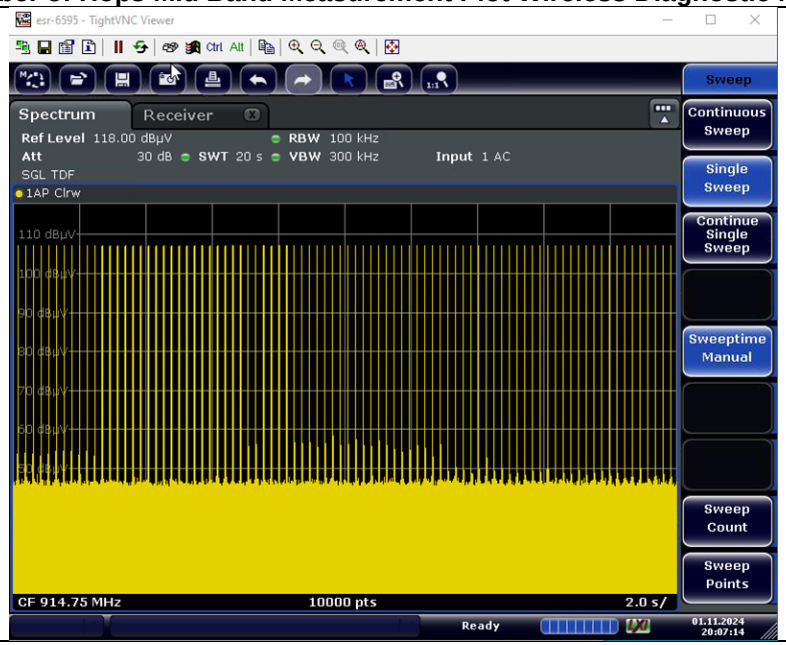
Channel	Dwell Time (ms)	Time of Occupancy (s)	Limit (s)	Margin
Low	4.229	0.364	0.4	0.036
Mid	4.232	0.364		0.036
High	4.224	0.363		0.037

Dwell Time Low Band Measurement Plot for Wireless Diagnostics Mode	Dwell Time Mid Band Measurement Plot Wireless Diagnostic Mode
	

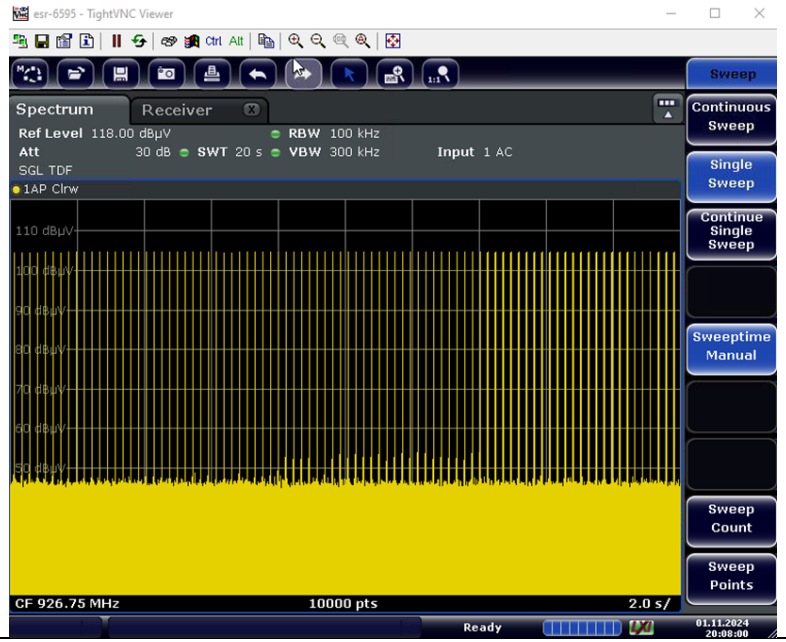
Dwell Time High Band Measurement Plot Wireless Diagnostic Mode



Then the sweep time was expanded to 20 seconds to capture the number of hops in the appropriate sweep time. A single sweep is made for each band, shown in the plots below. The number of hops over a 20 second period was found to be 86. When multiplied by the worst-case dwell time of 4.232 milliseconds, the time of occupancy was found to be 0.364 seconds giving a margin of 0.036 seconds.

Number of Hops Low Band Measurement Plot Wireless Diagnostic Mode	Number of Hops Mid Band Measurement Plot Wireless Diagnostic Mode
	

Number of Hops High Band Measurement Plot Wireless Diagnostic mode

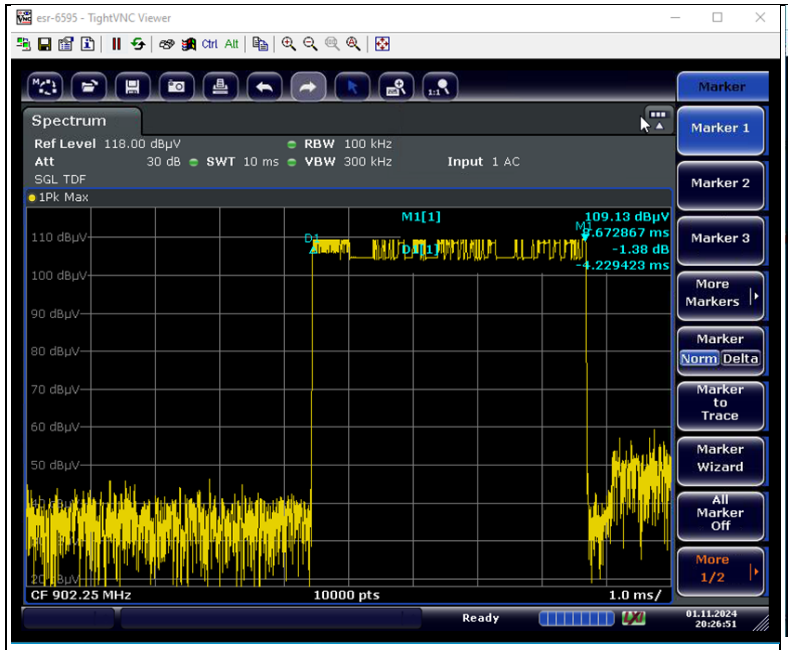


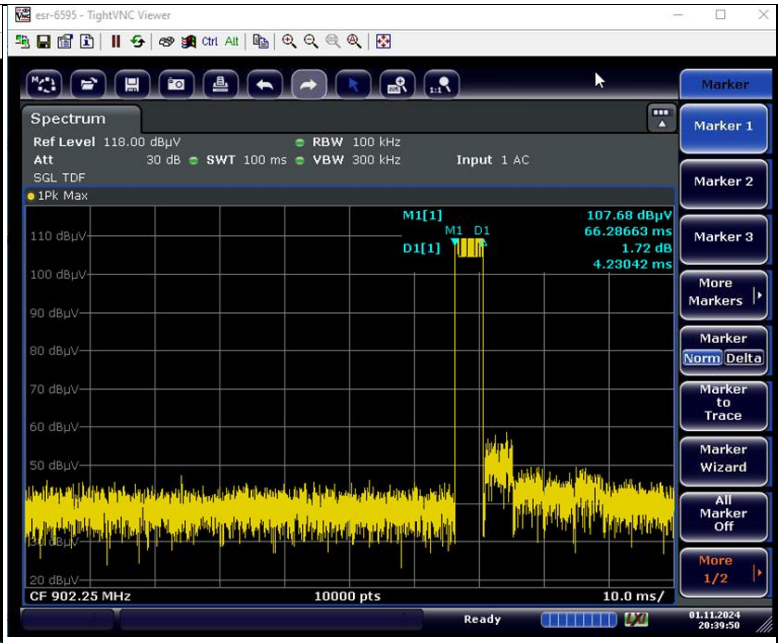
2.7. Duty Cycle Correction Measurements (FCC Part 15.247)

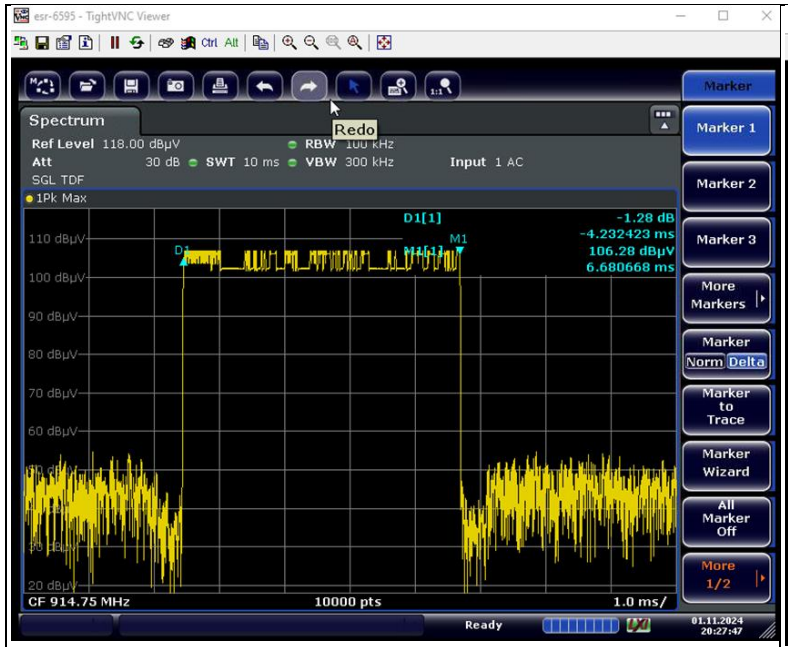
Measurement Settings:

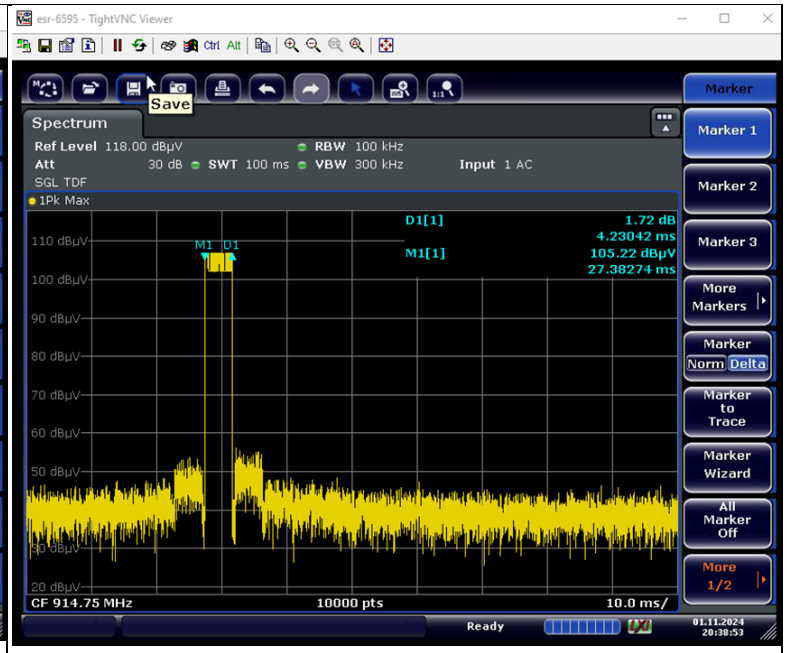
Frequency Span: Zero span, centered on a hopping channel
Attenuation: Auto
RBW: 100/120kHz
VBW: 3x RBW, 300kHz is typical
Sweep time: 20s
Detector: Peak
Trace: Clear-write, single sweep

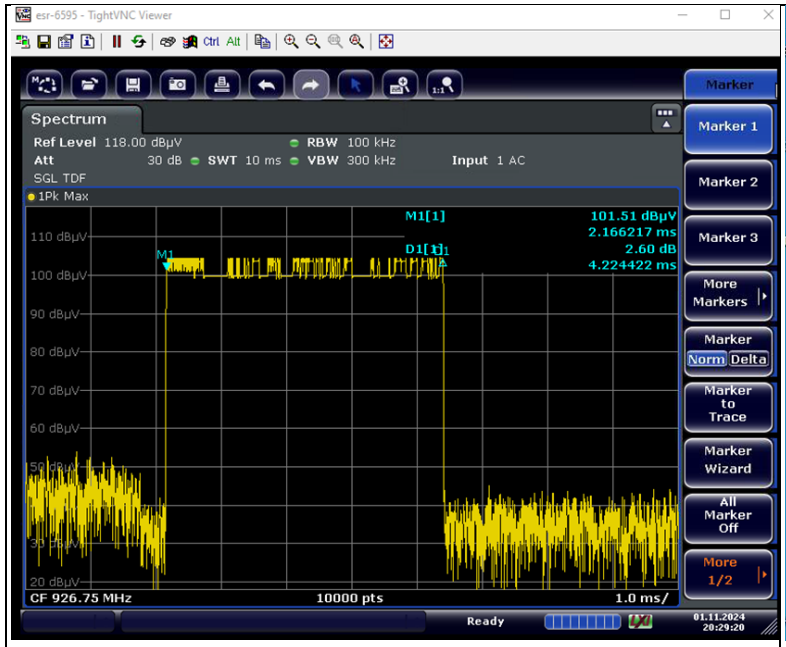
Channel	Sweep Time (ms)		Duty Cycle Correction (100ms)
	10ms	100ms	
Low	4.229	4.23	-27.5
Mid	4.232	4.23	-27.5
High	4.224	4.22	-27.5

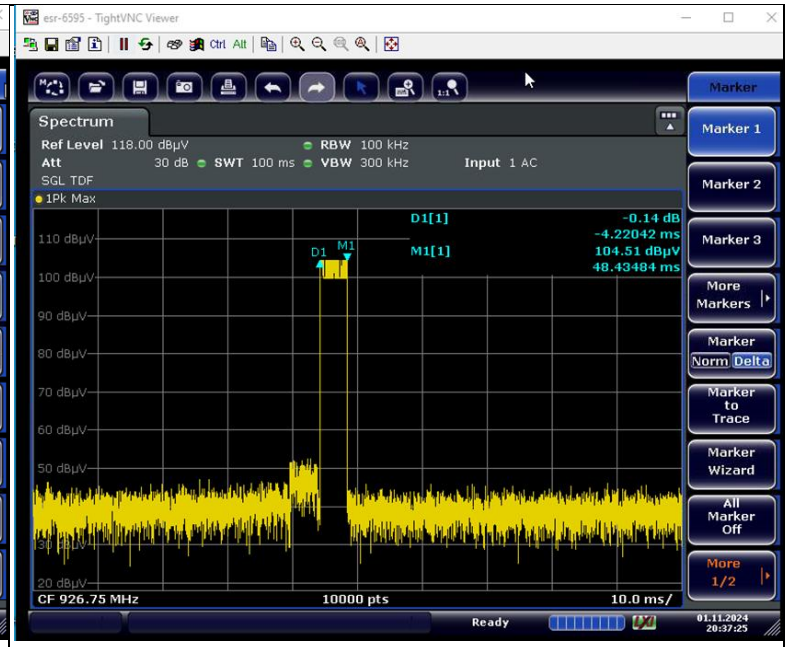

esr-6595 - TightVNC Viewer
Spectrum
Ref Level 118.00 dBµV
RBW 100 kHz
Att 30 dB
SWT 10 ms
VBW 300 kHz
Input 1 AC
SGL TDF
1Pk Max
M1[1]
109.13 dBµV
4.672867 ms
-1.38 dB
-4.229423 ms
CF 902.25 MHz
10000 pts
1.0 ms/
Marker
Marker 1
Marker 2
Marker 3
More Markers
Marker Norm Delta
Marker to Trace
Marker Wizard
All Marker Off
More 1/2
Ready
01.11.2024 20:26:51


esr-6595 - TightVNC Viewer
Spectrum
Ref Level 118.00 dBµV
RBW 100 kHz
Att 30 dB
SWT 100 ms
VBW 300 kHz
Input 1 AC
SGL TDF
1Pk Max
M1[1]
107.68 dBµV
66.28663 ms
1.72 dB
4.23042 ms
CF 902.25 MHz
10000 pts
10.0 ms/
Marker
Marker 1
Marker 2
Marker 3
More Markers
Marker Norm Delta
Marker to Trace
Marker Wizard
All Marker Off
More 1/2
Ready
01.11.2024 20:39:50


esr-6595 - TightVNC Viewer
Redo
Spectrum
Ref Level 118.00 dBµV
RBW 100 kHz
Att 30 dB
SWT 10 ms
VBW 300 kHz
Input 1 AC
SGL TDF
1Pk Max
D1[1]
-1.28 dB
-4.232423 ms
106.28 dBµV
6.680668 ms
M1
CF 914.75 MHz
10000 pts
1.0 ms/
Ready
Marker
Marker 1
Marker 2
Marker 3
More Markers
Marker Norm Delta
Marker to Trace
Marker Wizard
All Marker Off
More 1/2


esr-6595 - TightVNC Viewer
Save
Spectrum
Ref Level 118.00 dBµV
RBW 100 kHz
Att 30 dB
SWT 100 ms
VBW 300 kHz
Input 1 AC
SGL TDF
1Pk Max
D1[1]
1.72 dB
4.23042 ms
105.22 dBµV
27.38274 ms
M1[1]
M1
D1
CF 914.75 MHz
10000 pts
10.0 ms/
Ready
Marker
Marker 1
Marker 2
Marker 3
More Markers
Marker Norm Delta
Marker to Trace
Marker Wizard
All Marker Off
More 1/2


esr-6595 - TightVNC Viewer
Spectrum
Ref Level 118.00 dBµV
RBW 100 kHz
Att 30 dB
SWT 10 ms
VBW 300 kHz
Input 1 AC
SGL TDF
1Pk Max
M1[1]
101.51 dBµV
2.166217 ms
D1[1]
2.60 dB
4.224422 ms
CF 926.75 MHz
10000 pts
1.0 ms/
Marker
Marker 1
Marker 2
Marker 3
More Markers
Marker Norm Delta
Marker to Trace
Marker Wizard
All Marker Off
More 1/2
Ready
01.11.2024 20:29:20


esr-6595 - TightVNC Viewer
Spectrum
Ref Level 118.00 dBµV
RBW 100 kHz
Att 30 dB
SWT 100 ms
VBW 300 kHz
Input 1 AC
SGL TDF
1Pk Max
D1[1]
-0.14 dB
-4.22042 ms
M1[1]
104.51 dBµV
48.43484 ms
CF 926.75 MHz
10000 pts
10.0 ms/
Marker
Marker 1
Marker 2
Marker 3
More Markers
Marker Norm Delta
Marker to Trace
Marker Wizard
All Marker Off
More 1/2
Ready
01.11.2024 20:37:25

2.8. Conducted Emissions Sweep – 30MHz to 10GHz

Measurement Settings:

Sweep 1: Peak - 100 kHz
Segment: 1
Start Frequency: 30 MHz
End Frequency: 10000 MHz
Band: Band 5
Detector: Peak
Sweep Mode: FFT

Attenuator: AUTO
Pre-Amp: Off
Max Hold Trace Mode: Off
Bandwidth Filter: EMI (6dB)
RBW: 100 kHz
Step Size: AUTO (25 kHz)
Dwell Time: 5ms

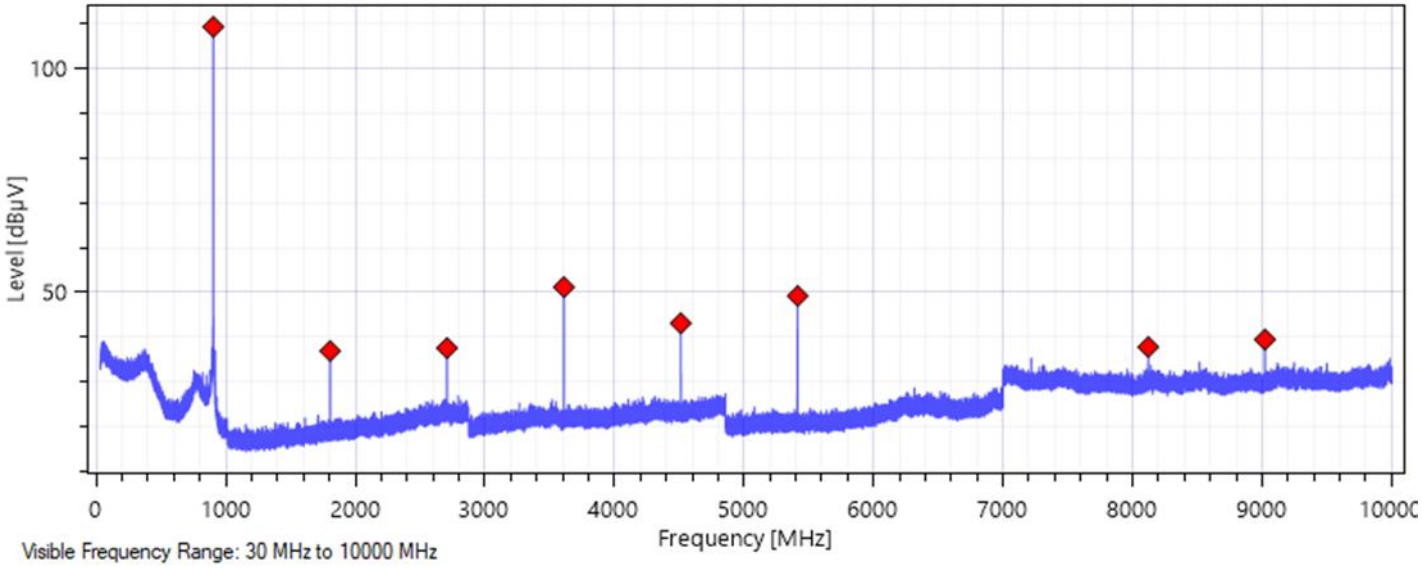
Per section 15.247(d), for frequency hopping systems operating in the 902-928 MHz band and employing at least 50 hopping channels, the emissions in any 100kHz bandwidth outside the frequency band in which the spread spectrum is operating shall be at least 20dB below that in the 100kHz bandwidth within the band containing the highest level of the desired power.

This measurement is a conducted measurement performed with a receiver per test method ANSI C63.10 section 7.8.7. Prior to the measurement the EUT is placed into single channel (low, mid, or high) operation via communications attached to the EUT.

The emissions sweep was performed with the transmitter set separately at 902.25MHz, 914.75MHz, and 926.75MHz. For each of the sweeps, the emissions were below the limit.

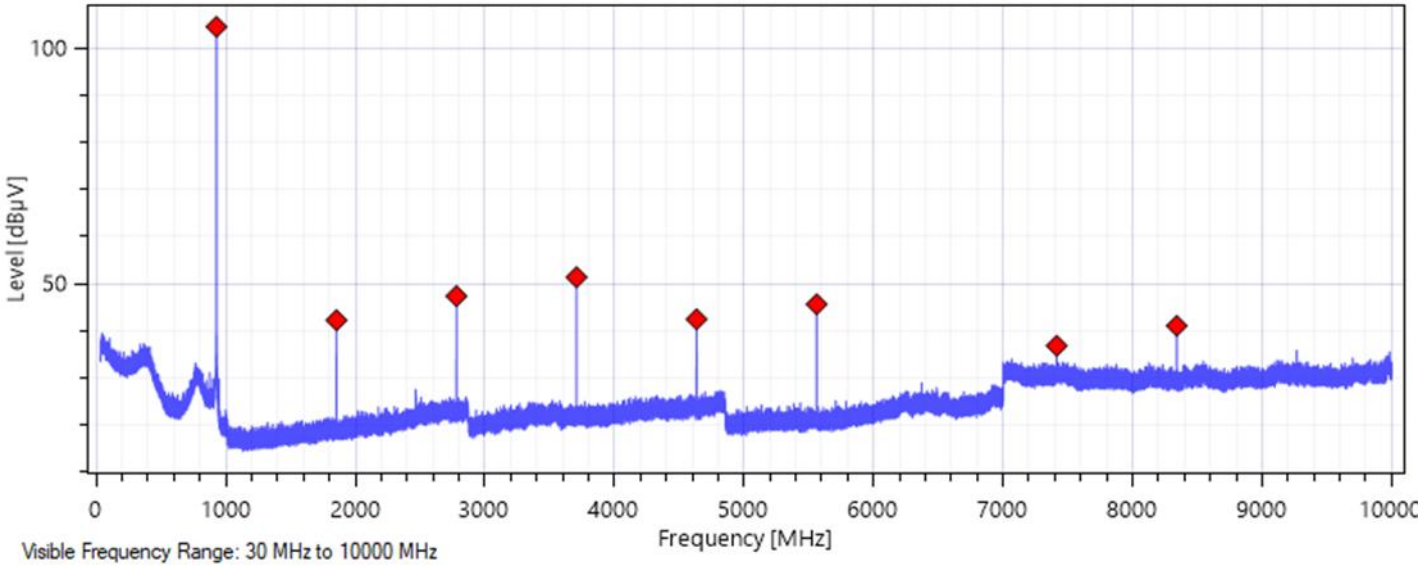
Channel	Worse-Case Delta - (dB)	Limit (dB)	Margin
Low	58.189	20	38.2
Mid	56.235		36.2
High	53.114		33.1

Peak – 902.25MHz



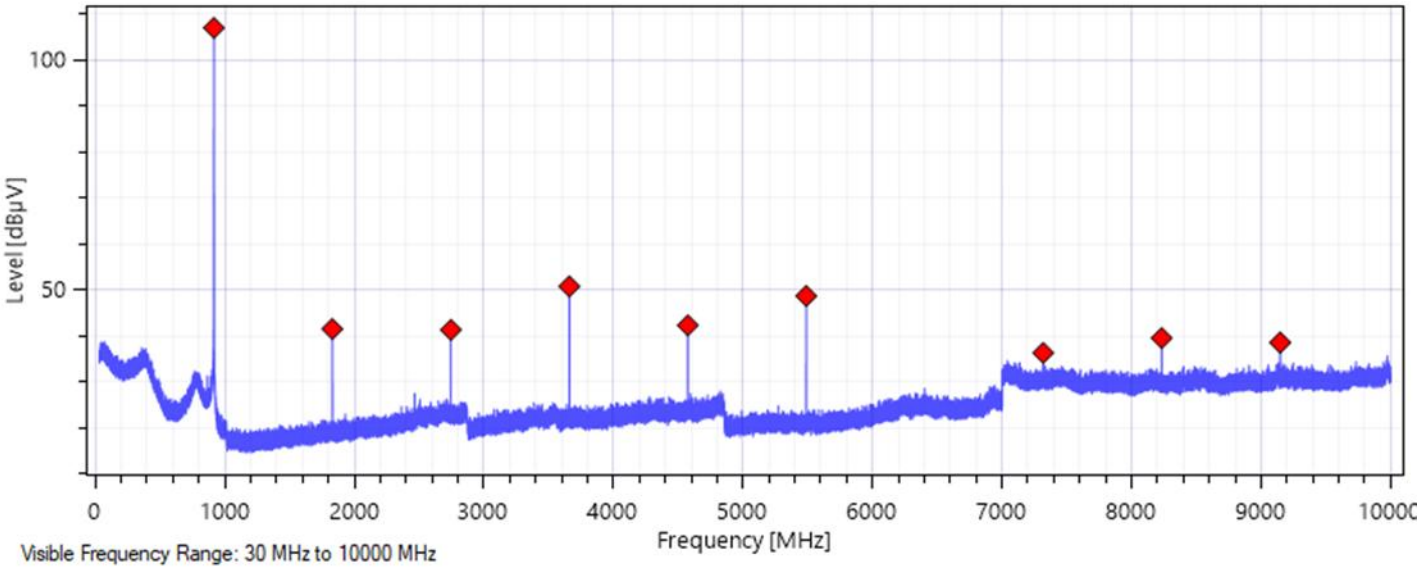
Frequency (MHz)	Level (dBµV)
926.775000	104.513
1,853.375000	42.279
2,780.050000	47.375
3,707.125000	51.399
4,633.425000	42.465
5,560.675000	45.658
7,413.475000	36.841
8,340.175000	41.09

Peak – 914.75MHz



Frequency (MHz)	Level (dBµV)
914.775000	106.936
1,829.375000	41.458
2,744.350000	41.263
3,659.125000	50.701
4,573.425000	42.244
5,488.400000	48.62
7,317.475000	36.246
8,232.175000	39.484
9,146.825000	38.493

Peak – 926.75MHz



Frequency (MHz)	Level (dBµV)
902.275000	109.414
1,804.375000	36.966
2,706.550000	37.614
3,609.125000	51.225
4,511.175000	43.154
5,413.700000	49.267
8,120.550000	37.849
9,021.850000	39.488