



**Technical Report to the FCC and ISED Regarding
Gentex Corporation - Homelink® 5**

**Model: UAHL5H
FCC ID: NZLUAHL5H
ISED: 4112A-UAHL5H**

**Emission Designator: 186KF7D
12/4/2023**

A report concerning approval for Gentex Corporation Homelink® model UAHL5H
Please issue grant immediately upon review.

Measurements Made by:

Bolay Pacheco
Laboratory Validation Engineer III
Gentex Corporation

Report Prepared by:

Patricia Klawitter
Laboratory Validation Engineer I
Gentex Corporation

Submitted by:

Brian Miller
Laboratory Group Leader – Regulatory II
Gentex Corporation

Measurements Reviewed by:

Dan Brasier
Laboratory Development Engineer II
Gentex Corporation

Report Approved by:

Jason Vargo
Laboratory Manager I
Gentex Corporation

Test Report Revision

REV Number	Date	Author	Description
1.0	12/4/2023	Patricia Klawitter	

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® HL5 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 and 15B. The device will have an FCC ID # of NZLUAHL5H and an ISED ID # of 4112A-UAHL5H under both rule parts. A separate report is submitted for functionality covered under 47 CFR 15.231 and 15B.

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
Gentex Corporation
600 N. Centennial Street
Zeeland, MI 49464

Site Address
Gentex Corporation
380 Riley Street
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 2.

2. Product Labeling

2.1. Identifiers

The FCC Identifier assigned is FCC ID: NZLUAHL5H. The ISED certification number is 4112A-UAHL5H. 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 2. 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.

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 table to a power supply connection on the turntable. The power supply is located beneath the floor of 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: 11/19/2023 – 11/20/2023

6.2. Test Method Deviations: None

6.3. Temperature and Humidity conditions

	Measured Value	Unit
Temperature	21.3-22.9	°C
Humidity	39.9-44.5	%R.H.

6.4. Summary of Results (Part 15.247)

Measurement	Margin	Frequency
Worst Case Spurious Emission	67.24 dBuV/m	6.76
Maximum 20dB BW	205.5kHz	2706.75MHz
Maximum 99% BW	186kHz	294.5kHz
Maximum Carrier Frequency Separation	499.3kHz	314kHz
Number of Hopping Frequencies	50	293.8kHz
Peak Output Power	-12.229dBm	-
Time of Occupancy	4.2391ms multiplied by 50= 0.2119s	902.25MHz
		0.188s
		914.75MHz

- 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 at least **47dB** below the fundamental for frequencies less than 902MHz for hopping and non-hopping as shown by the plots below. Emissions are over **47dB** 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 100ms period. The duty cycle is calculated as the (dwell time/100ms) where the dwell time is limited to 100ms. The duty cycle factor is $20 \cdot \text{Log}(\text{duty cycle})$. The duty cycle factor is calculated as **-27.2dB**. ($-27.2\text{dB} = 20 \cdot \text{Log}(4.348\text{ms}/100\text{ms})$).

- **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): 4.7 dB
- Radiated Emissions – LPA (250-1000 MHz): 5.6 dB
- Radiated Emissions – DRWG (26.5 GHz): 4.9 dB
- Conducted Emissions: 1.05 dB
- Frequency: 0.12ppm

6.5. Test Equipment Setup and Procedure

6.5.1. Test Equipment Used for Conducted Measurement

Description	Model #	ID Number	Cal Due
Rohde & Schwarz ESR Receiver	ESR26	6595	11/14/2024
Cable	PE341-60	CBL 119	4/30/2024
Pasternack Attenuator	PE7004-3, 3dB fixed	AT25	1/31/2024

6.5.2. Test Equipment Used for Radiated Measurement Equipment

Description	Model #	ID Number	Cal Due
EMCO LPA Antenna [250-1000MHz]	3148	H6192	5/3/2024
Com-Power Double Ridged Guide [1-18GHz]	AHA-118	8893	12/16/2025
Rohde & Schwarz ESW Receiver	ESW26	9860	1/18/2024
Cables, attenuator, and port feed through	various	CF GCL	4/30/2024
3m Chamber SW	N/A	SW30	3/31/2024
HomeLink5 Diagnostic Application	N/A	SW44	3/31/2024
Gentex Emissions SW	N/A	SW48	3/31/2024
ETS-Lindgren Boresight Tower	2171B	Tower 2	VBU
ETS-Lindgren Shielded Enclosure	3M Chamber	PJ2246	12/30/2023
Omega Environmental Conditions	iBTHX-W Virtual	8292	10/2/2024
Stanley Tape Measure	N/A	6539	6/19/2026
Fluke Multimeter	87	H4554	1/5/2024
ETS-Lindgren Absorber Material	EHP-12PCL	Absorber 1	VBU

6.5.3. Test Equipment Setup and Procedure

ESW Receiver Settings Emissions:

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

ESW 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 table to a power supply connector. The power supply is located under 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

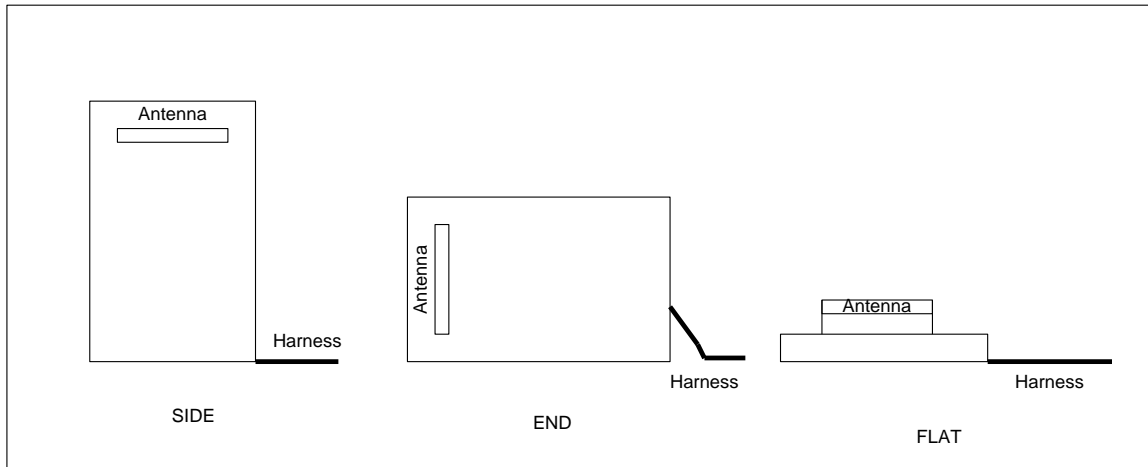


Figure 6.2.3 EUT Orthogonal Orientations

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 orientation 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.

3.5ms while Wireless Diagnostic mode was used for the on time, as this was the worst case.

Duty cycle Correction Factor = $20 \cdot \log(\text{On Time}(\text{ms}) / 100\text{ms})$.

$-27.2\text{dB} = 20 \cdot \log(4.348\text{ms}/100\text{ms})$

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

The Peak Tx Spurious Emissions limit for the fundamental is given by:

Limit dBuV/m = $1W \text{ ERP} = 127.38 \text{ dBuV/m}$, which is the fundamental limit.

The Rx Spurious Emissions limit for the fundamental is given by:

Limit dBuV/m = $20 \cdot \log(200\text{uV/m}) = 46.0\text{dBuV/m}$

The Rx Spurious Emissions limit for the harmonics is given by:

Limit dBuV/m = $20 \cdot \log(500\text{uV/m}) = 54.0\text{dBuV/m}$

Appendix A

A. Radiated (Tx) Measurements

Note: The Duty Cycle Correction factors are the worst case based on a 4.348ms 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. DUT Transmitting at 902.25MHz (Fundamental) – FCC 15.247

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	97.39	127.3	29.91
1804.5	Side	V	61.74	77.4	15.65
2706.75	Side	V	67.24	74.0	6.76
3609	Side	V	58.19	74.0	15.81
4511.25	Side	V	51.47	74.0	22.53
5413.5	Side	V	60.32	74.0	13.68
6315.75	Side	V	52.94	77.4	24.45
7218	Side	H	56.82	74.0	17.18
8120.25	Side	H	56.76	74.0	17.24
9022.5	Side	H	51.87	74.0	22.13

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	V	61.74	-27.2	34.5	57.4	22.85
2706.75	Side	V	67.24	-27.2	40.0	54.0	13.96
3609	Side	V	58.19	-27.2	31.0	54.0	23.01
4511.25	Side	V	51.47	-27.2	24.3	54.0	29.73
5413.5	Side	V	60.32	-27.2	33.1	54.0	20.88
6315.75	Side	V	52.94	-27.2	25.7	57.4	31.65
7218	Side	H	56.82	-27.2	29.6	54.0	24.38
8120.25	Side	H	56.76	-27.2	29.6	54.0	24.44
9022.5	Side	H	51.87	-27.2	24.7	54.0	29.33

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	95.98	127.3	31.32
1829.5	Side	V	57.88	76.0	18.10
2744.25	Side	H	66.18	74.0	7.82
3659	Side	H	59.7	74.0	14.30
4573.75	Side	H	52.38	74.0	21.62
5488.5	Side	V	58.61	74.0	15.39
6403.25	Side	H	55.8	76.0	20.18
7318	Side	H	55.38	74.0	18.62
8232.75	Side	H	56.81	74.0	17.19
9147.5	Side	H	52.16	74.0	21.84

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	V	57.88	-27.2	30.7	56.0	25.30
2744.25	Side	H	66.18	-27.2	39.0	54.0	15.02
3659	Side	H	59.7	-27.2	32.5	54.0	21.50
4573.75	Side	H	52.38	-27.2	25.2	54.0	28.82
5488.5	Side	V	58.61	-27.2	31.4	54.0	22.59
6403.25	Side	H	55.8	-27.2	28.6	56.0	27.38
7318	Side	H	55.38	-27.2	28.2	54.0	25.82
8232.75	Side	H	56.81	-27.2	29.6	54.0	24.39
9147.5	Side	H	52.16	-27.2	25.0	54.0	29.04

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	93.88	127.3	33.42
1853.5	Side	V	57.75	73.9	16.13
2780.25	Side	H	65.85	74.0	8.15
3707	Side	H	58.47	74.0	15.53
4633.75	Side	H	53.85	74.0	20.15
5560.5	Side	V	60.97	74.0	13.03
6487.25	Side	H	55.14	73.9	18.74
7414	Side	H	55.66	74.0	18.34
8340.75	Side	H	57.44	74.0	16.56
9267.5	Side	H	50.73	74.0	23.27

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	V	57.75	-27.2	30.6	53.9	23.33
2780.25	Side	H	65.85	-27.2	38.7	54.0	15.35
3707	Side	H	58.47	-27.2	31.3	54.0	22.73
4633.75	Side	H	53.85	-27.2	26.7	54.0	27.35
5560.5	Side	V	60.97	-27.2	33.8	54.0	20.23
6487.25	Side	H	55.14	-27.2	27.9	53.9	25.94
7414	Side	H	55.66	-27.2	28.5	54.0	25.54
8340.75	Side	H	57.44	-27.2	30.2	54.0	23.76
9267.5	Side	H	50.73	-27.2	23.5	54.0	30.47

4. Conducted Measurements

a. 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

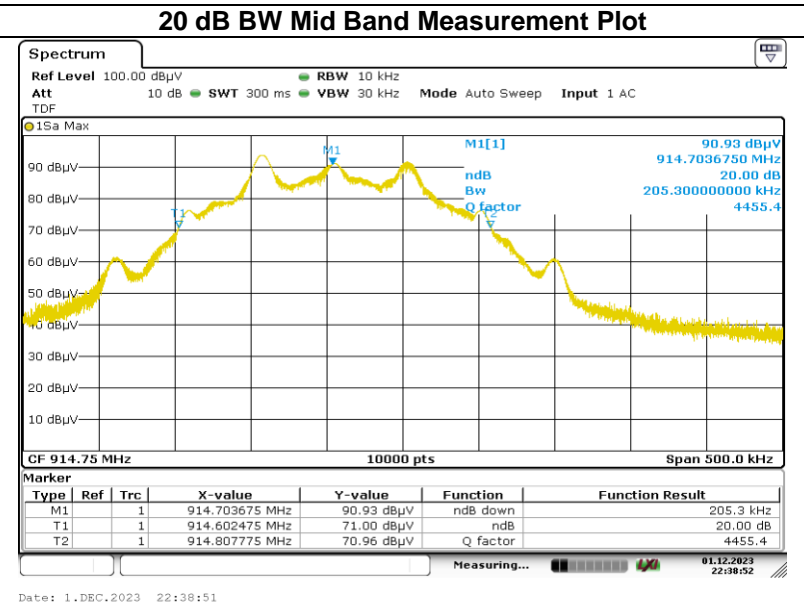
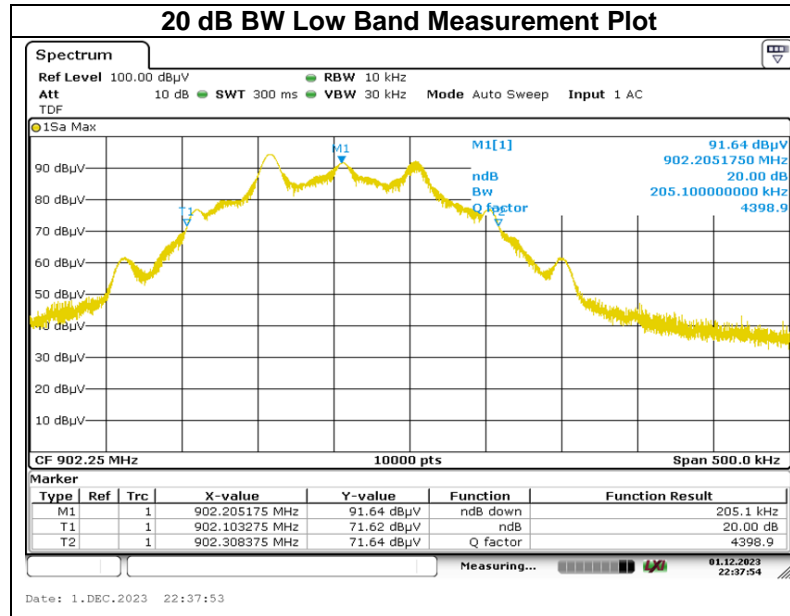
20dB Bandwidth Requirement: Per 15.247(a)(1), Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25kHz or the 20dB bandwidth of the hopping channel, whichever is greater. Per section 15.247(a)(1)(i), for frequency hopping systems operating in the 902-928 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.

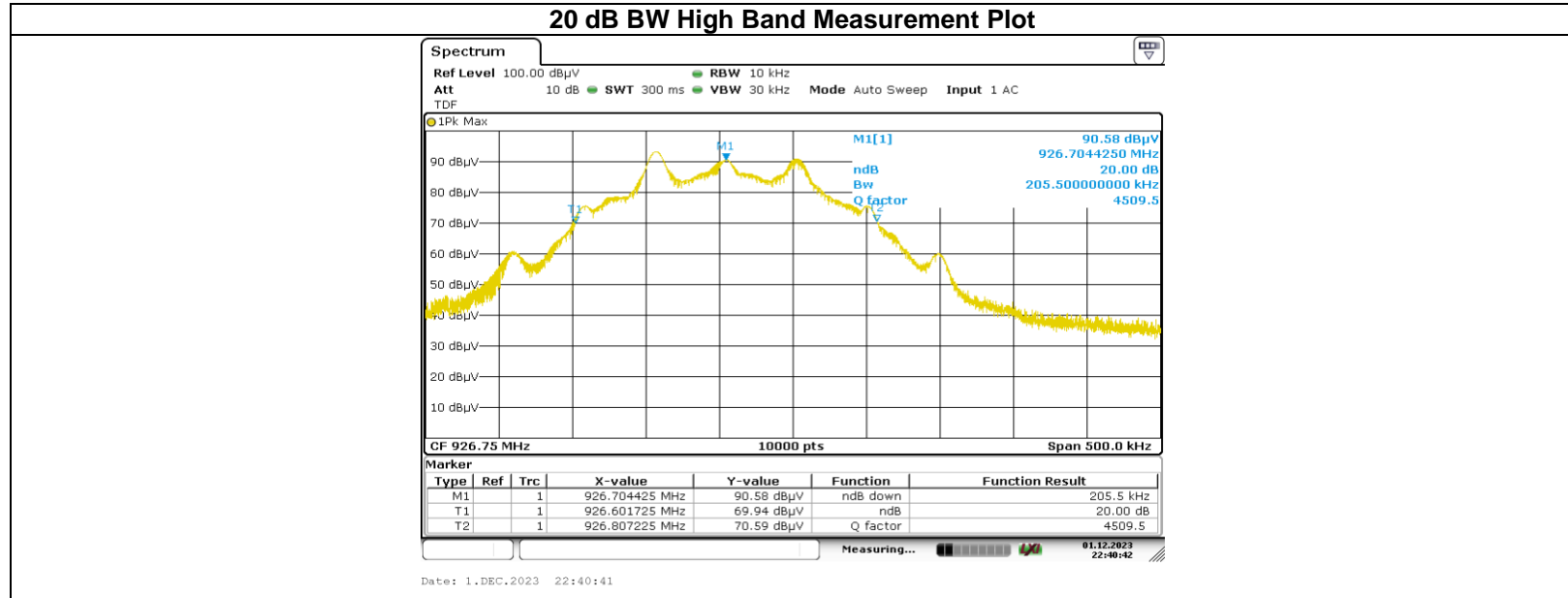
In measurement of the 20dB bandwidth, the transmit frequency was set to low, middle, and high hopping channels. The resolution band width (RBW) was set to > than 1% of the 20dB bandwidth. The span was set to approximately 2 to 3 times the 20dB bandwidth.

20dB BW Results

Channel	20dB BW (kHz)	Limit (kHz)	Margin
Low	205.1	500	294.9
Mid	205.3		294.7
High	205.5		294.5

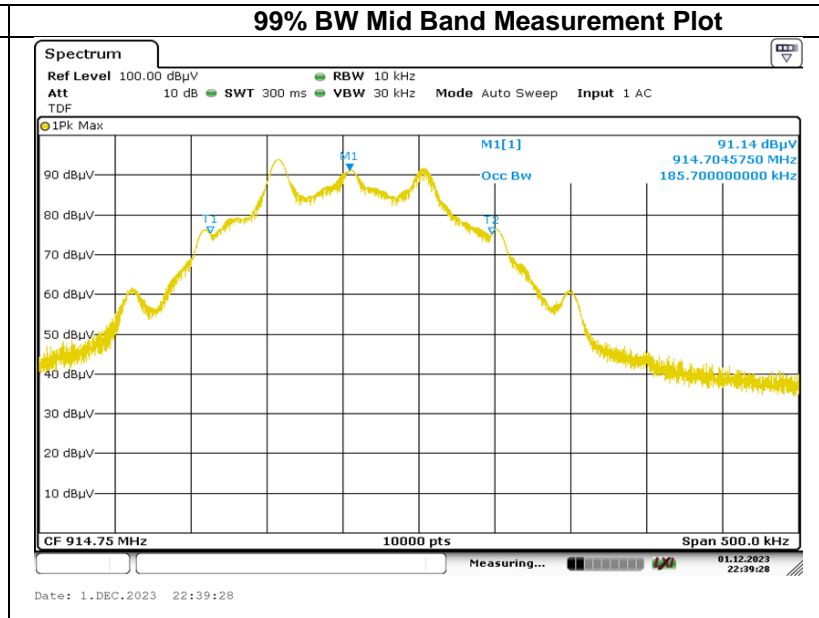
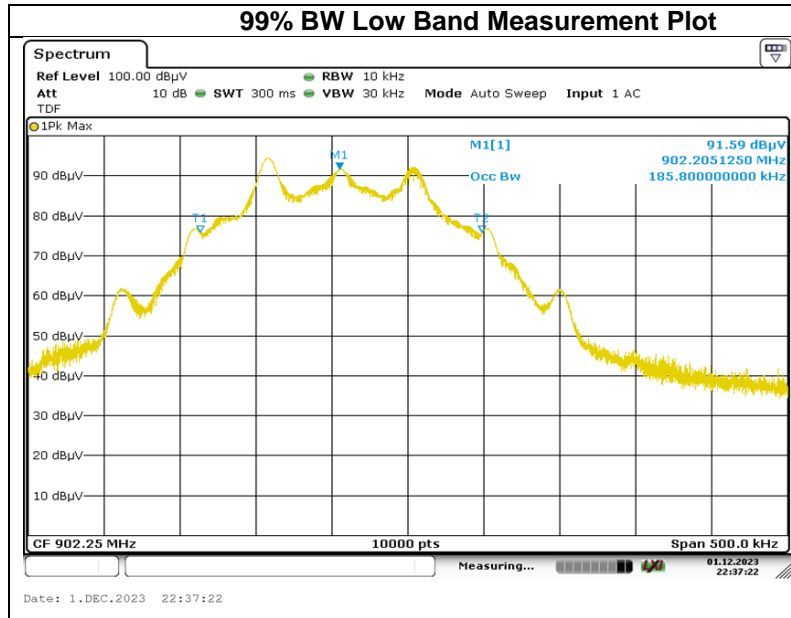


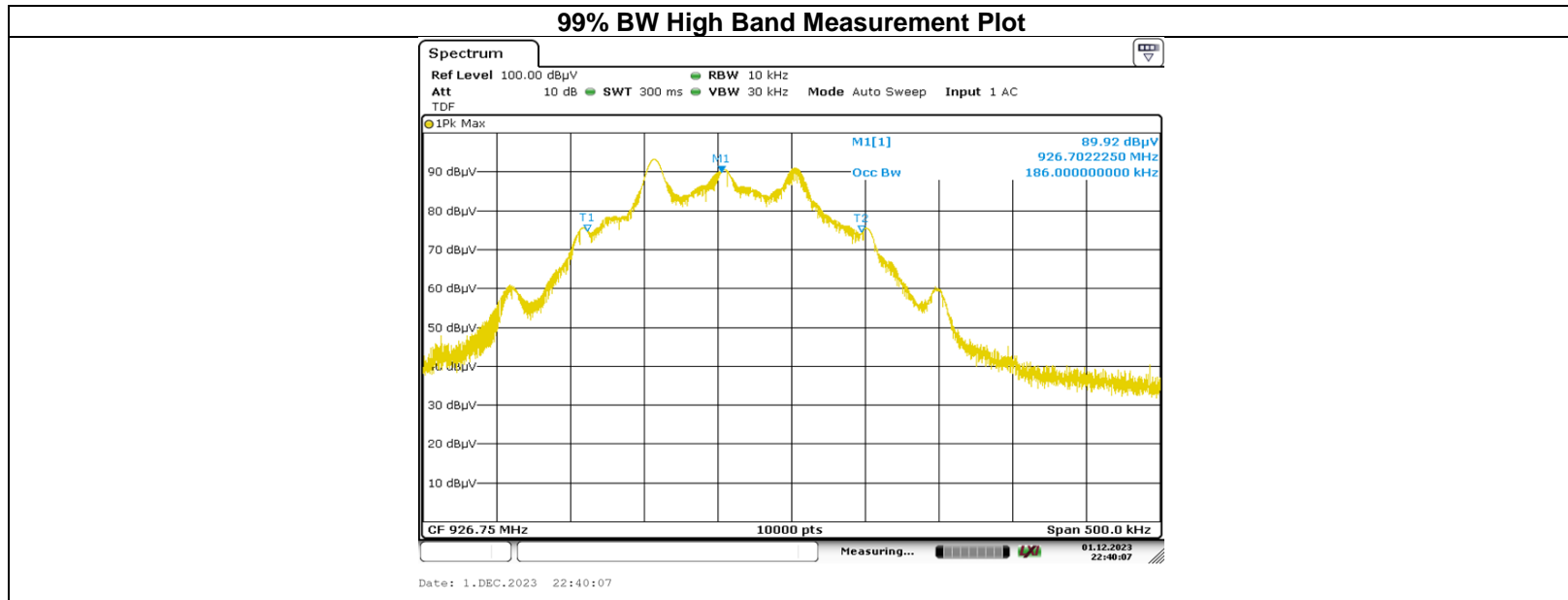
20 dB BW High Band Measurement Plot



99% BW Results

Channel	99% BW (kHz)	Limit (kHz)	Margin
Low	185.8	500	314.2
Mid	185.7		314.3
High	186		314.0





b. 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.

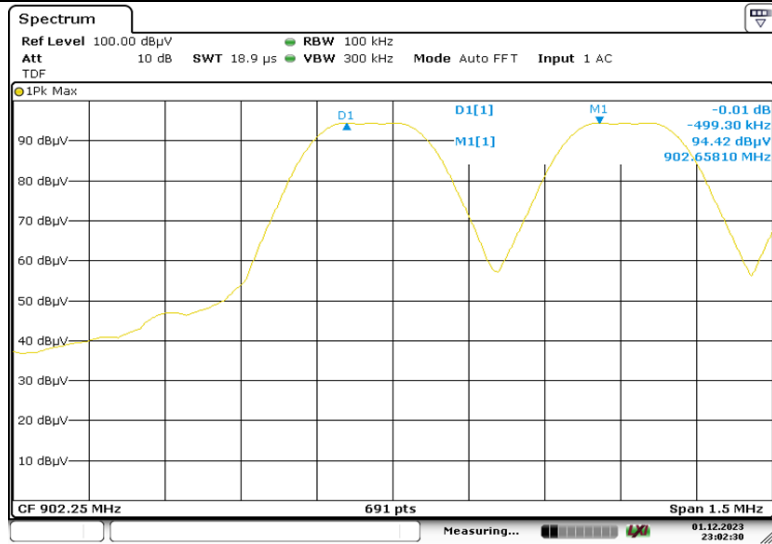
This measurement is a conducted measurement. Prior to the measurement the EUT is placed into hopping mode via a communications board attached to the EUT.

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 maximum carrier frequency separation is measured as **499.3kHz**, which is greater than the 20dB bandwidth measurement (**205.5kHz**).

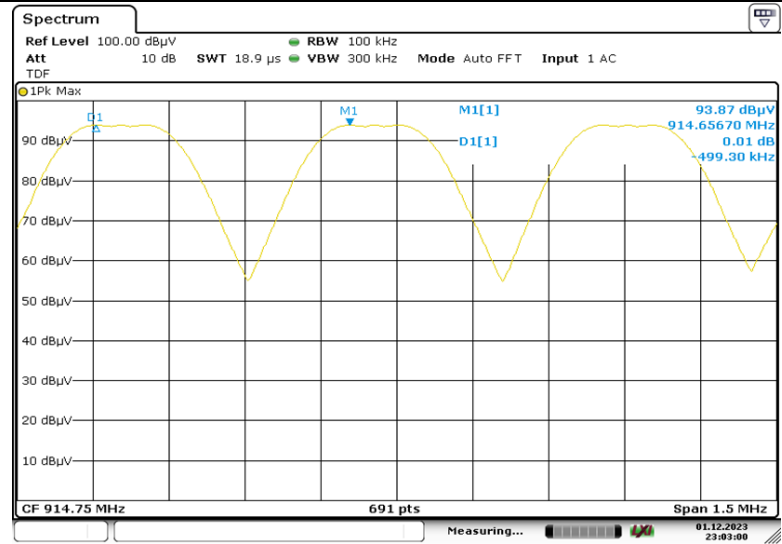
Channel	Carrier Frequency Separation (kHz)	Minimum Requirement (kHz)	Margin
Low	499.3	205.5	293.8
Mid	499.3		293.8
High	499.3		293.8

Channel Separation Low Band Measurement Plot



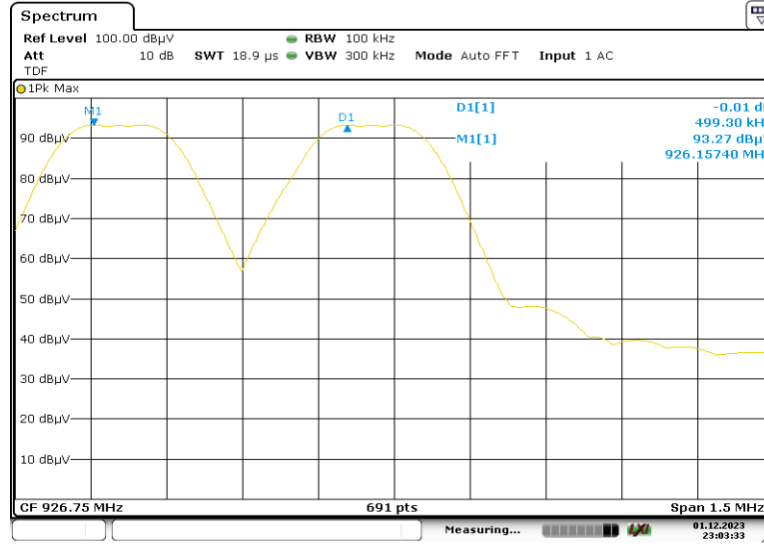
Date: 1.DEC.2023 23:02:30

Channel Separation Mid Band Measurement Plot



Date: 1.DEC.2023 23:02:59

Channel Separation High Band Measurement Plot



Date: 1.DEC.2023 23:03:33

c. 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

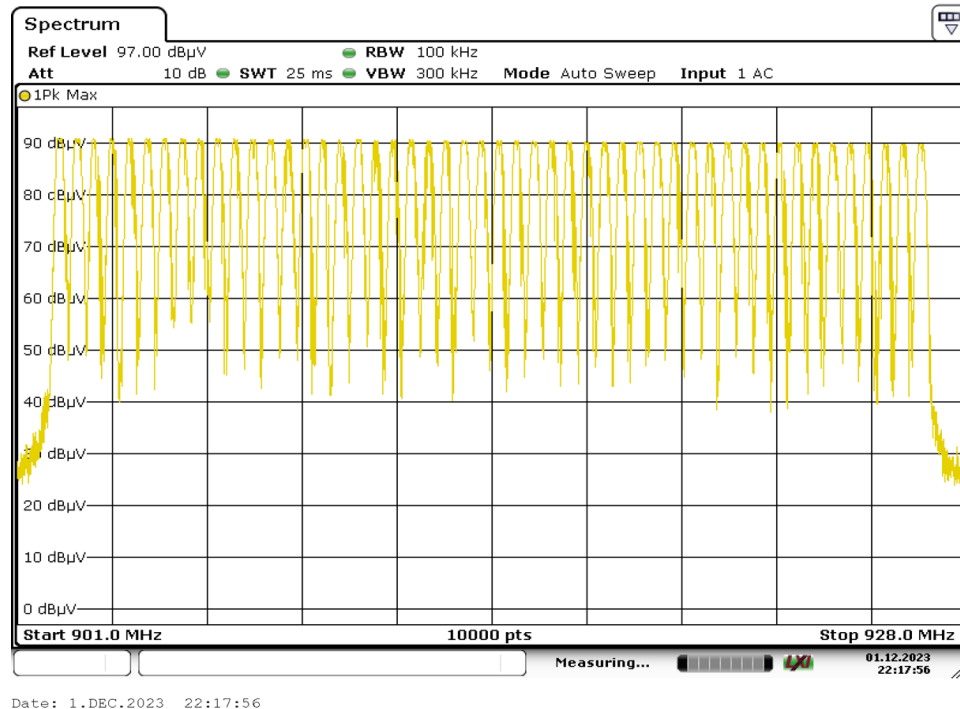
Trace: Max Hold

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.



d. 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

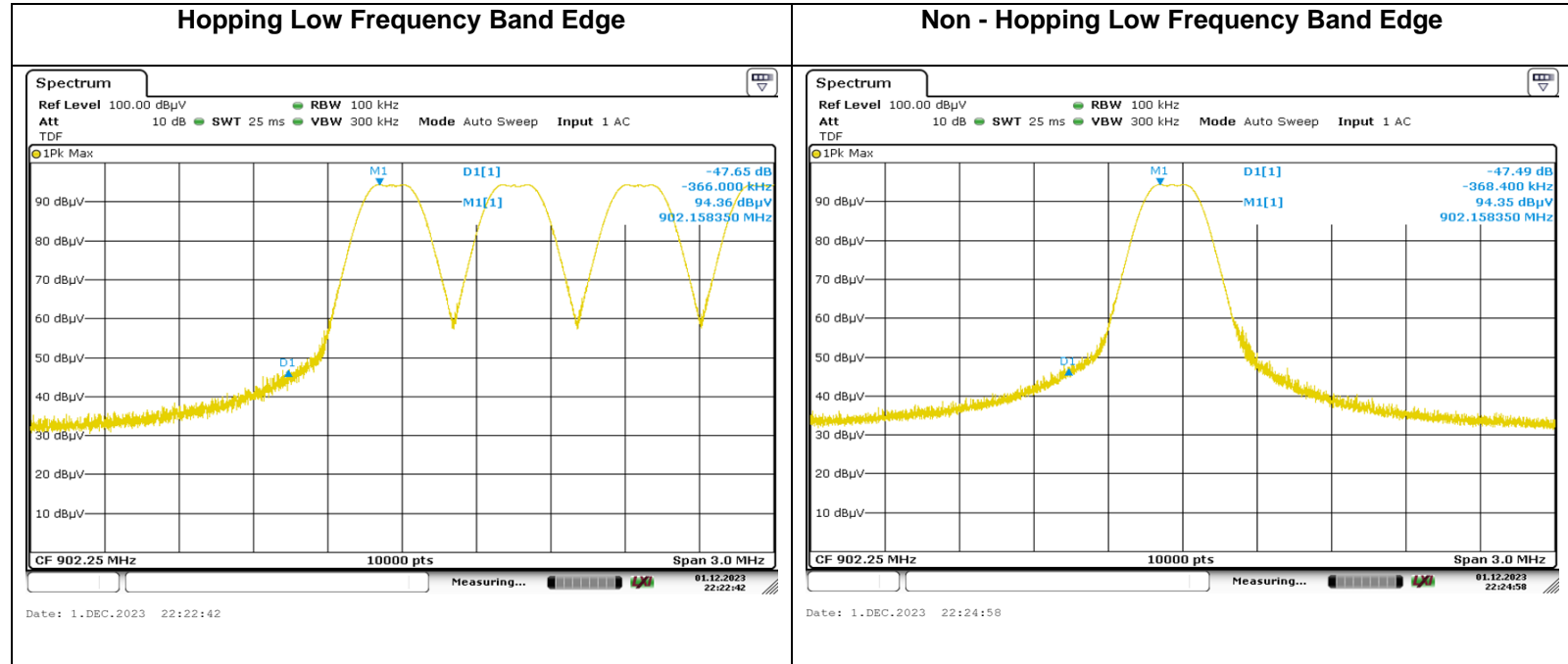
Trace: Max Hold

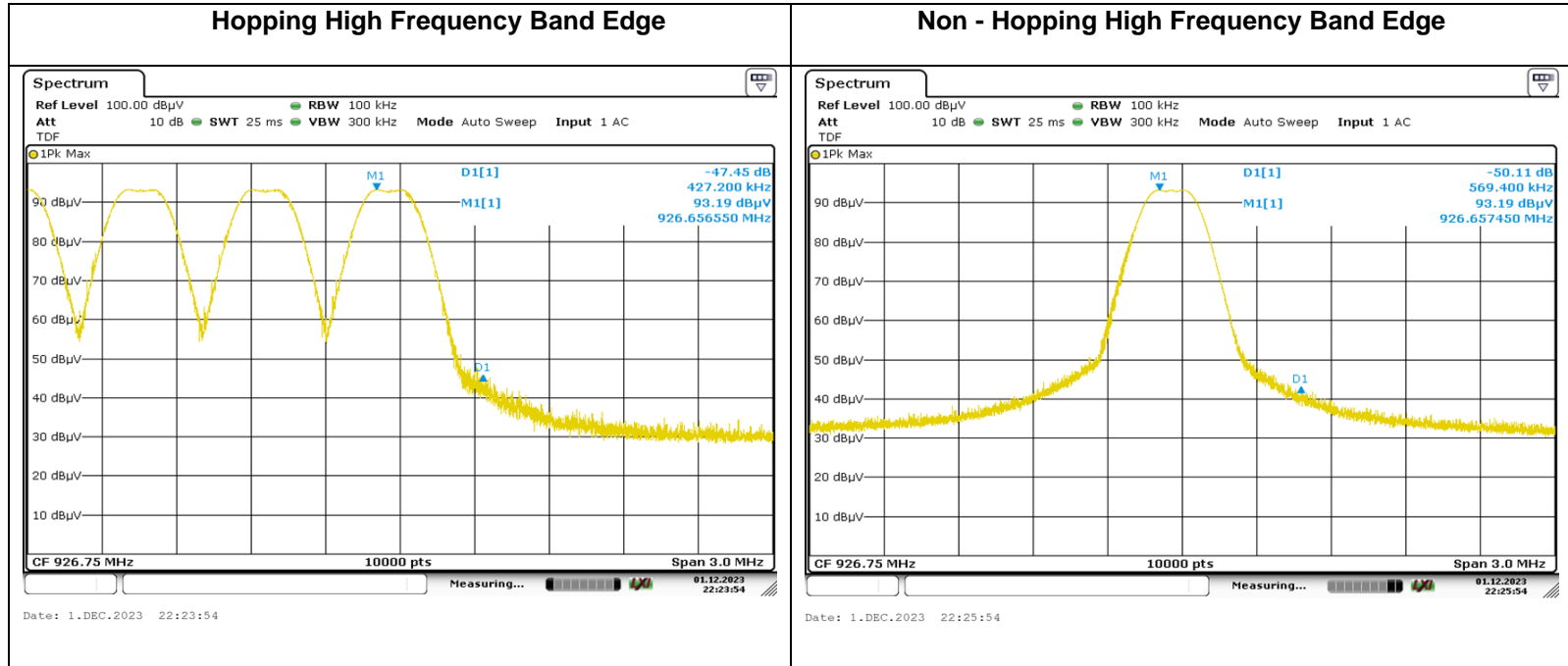
Per section 15.247(d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the 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 at least 47dB 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 over 47dB 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	47.65	20	47.65
Low	Non-Hopping	47.49	20	47.49
High	Hopping	47.45	20	47.45
High	Non-Hopping	50.11	20	50.11





e. 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	-12.229	30	42.2
Mid	-12.9		42.9
High	-13.599		43.6

EMC2023-11990 BMW class II

Plot: 4-1-1

Engineer: EMC Lab User

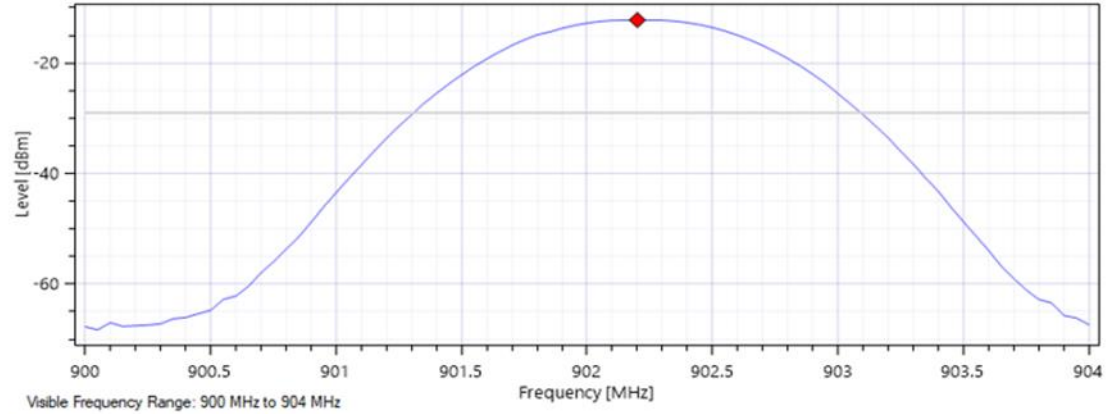
Test Date: December 01, 2023

Trace Readings

----- Peak - 1000 kHz
█ low Readings

Limit Lines

----- Auxiliary Limits
 PK Power - Low (No Detector)



Test Profile: ANSI C63.10-2013, Regulatory Antenna Conducted Emissions
Measurement Parameters: Refer to "4-1 Segment 1 Settings" included at the end of the report.

Trace: low, Band: PK Power - Low (Peak Detector)

Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dBm)
902.200000	-12.229	-29	16.771

EMC2023-11990 BMW class II

Plot: 4-1-2

Engineer: Patricia Klawitter

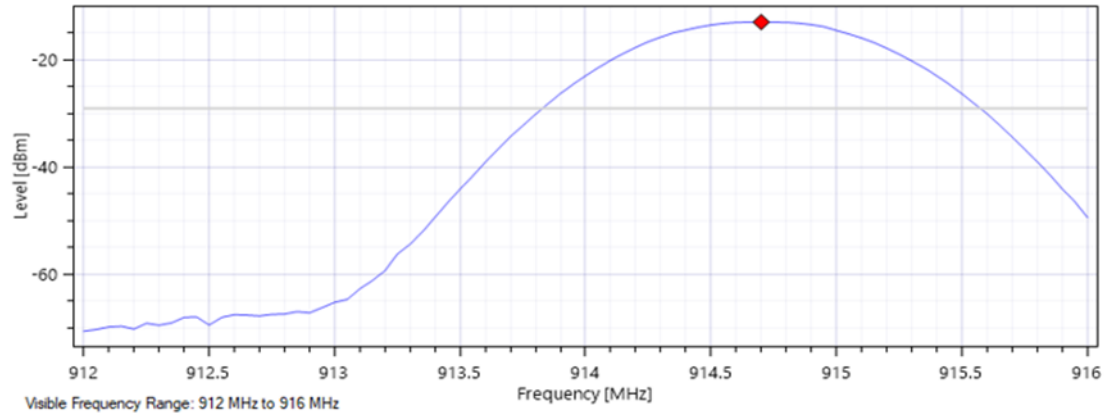
Test Date: December 01, 2023

Trace Readings

----- Peak - 1000 kHz
█ mid Readings

Limit Lines

----- Auxiliary Limits
 █ PK Power - Mid (No Detector)



Test Profile: ANSI C63.10-2013, Regulatory Antenna Conducted Emissions
Measurement Parameters: Refer to "4-1 Segment 2 Settings" included at the end of the report.

Trace: mid, Band: PK Power - Mid (Peak Detector)

Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dBm)
914.700000	-12.9	-29	16.1

EMC2023-11990 BMW class II

Plot: 4-1-3

Engineer: Patricia Klawitter

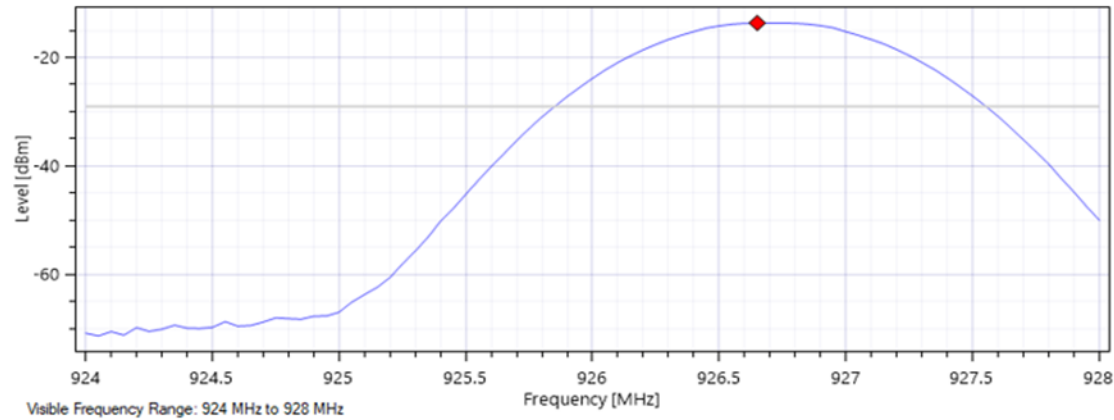
Test Date: December 01, 2023

Trace Readings

----- Peak - 1000 kHz
█ high Readings

Limit Lines

----- Auxiliary Limits
 PK Power - High (No Detector)



Test Profile: ANSI C63.10-2013, Regulatory Antenna Conducted Emissions
Measurement Parameters: Refer to "4-1 Segment 3 Settings" included at the end of the report.

Trace: high, Band: PK Power - High (Peak Detector)

Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dBm)
926.650000	-13.599	-29	15.401

f. 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 $\gg 1/T$ 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.

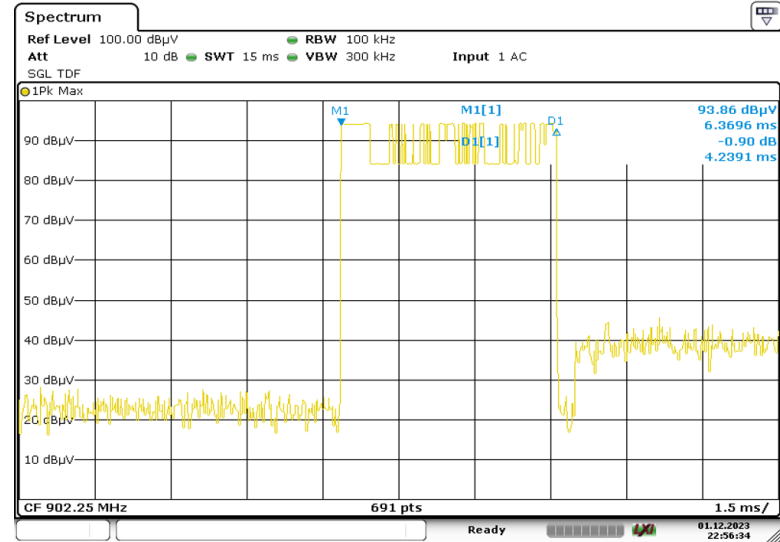
This measurement is a conducted measurement. Prior to the measurement the EUT is placed into hopping mode via a communications board attached to the EUT. The part was placed in Wireless Diagnostics mode with the “Hop” message as it produced the worst-case total dwell times. Within Wireless diagnostic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

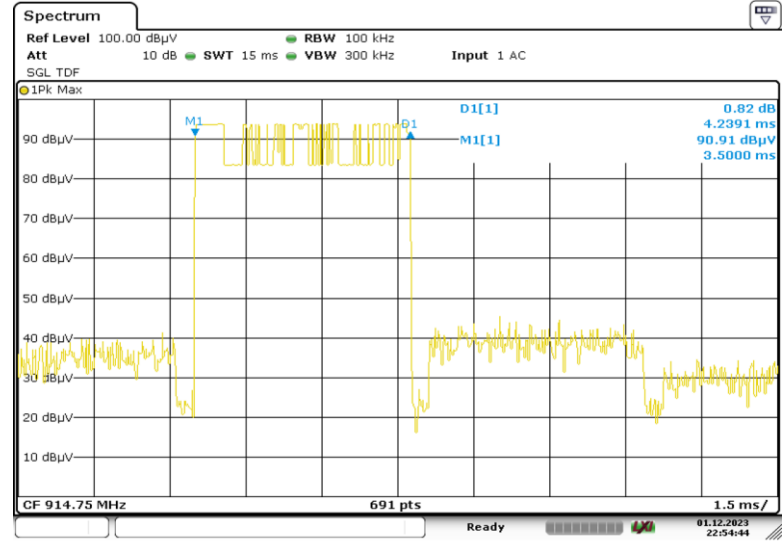
Channel	Dwell Time (ms)	Time of Occupancy (s)	Limit (s)	Margin
Low	4.2391	0.212	0.4	0.188
Mid	4.2391	0.212		0.188
High	4.2174	0.211		0.189

Dwell Time Low Band Measurement Plot for Wireless Diagnostics Mode

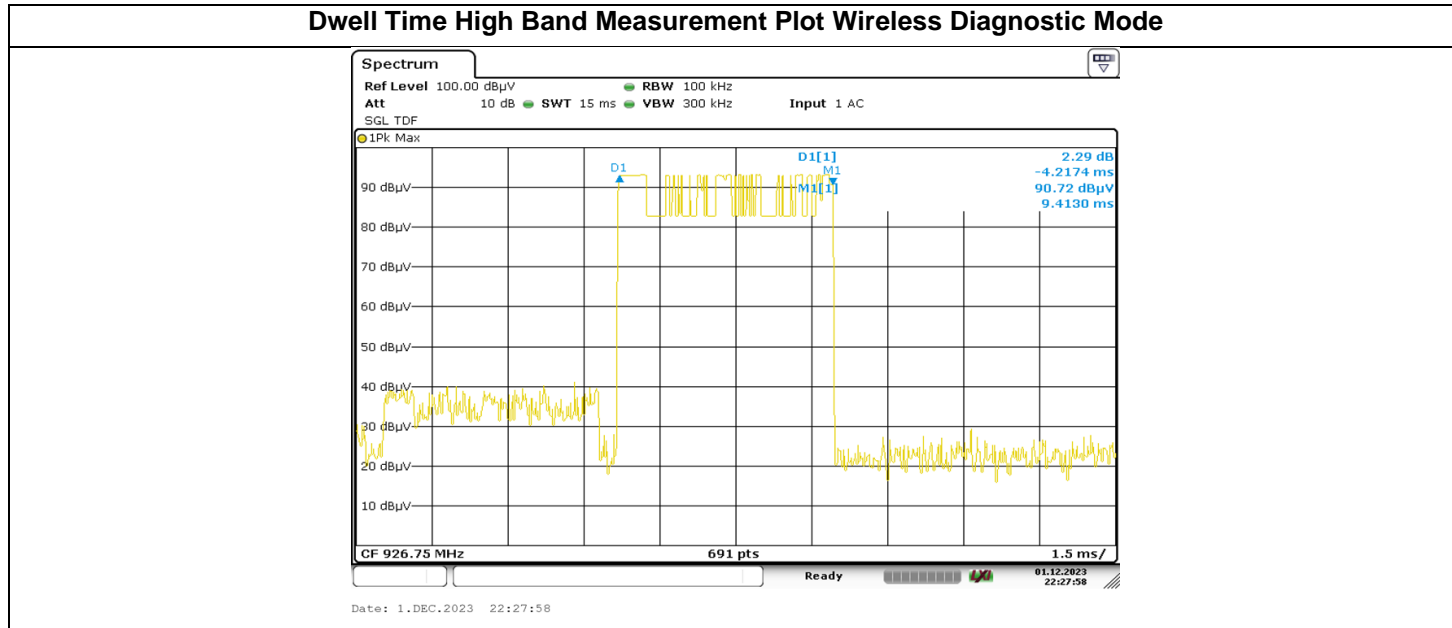


Date: 1.DEC.2023 22:56:34

Dwell Time Mid Band Measurement Plot Wireless Diagnostic Mode



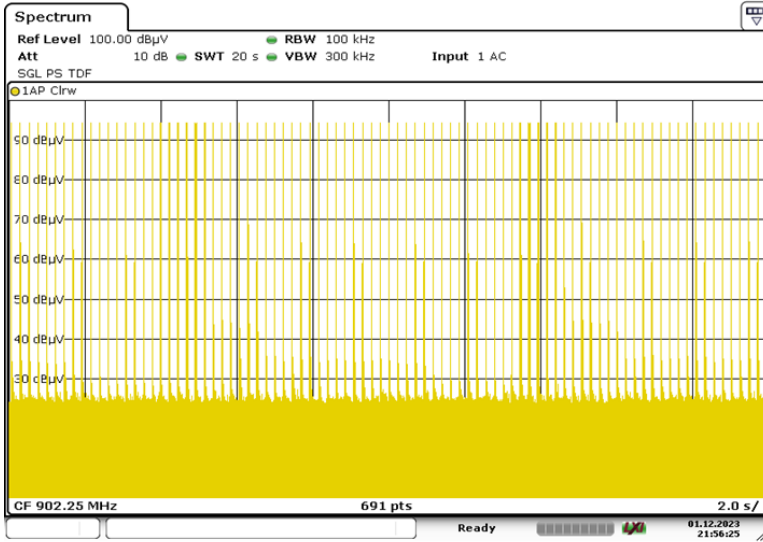
Date: 1.DEC.2023 22:54:44



Dwell time per frequency = $4.2391/250$ per cycle = 1.69% or 169msec in 10 seconds or 338msec in 20 seconds, where the limit is 0.4 seconds leaving a margin of 0.188 seconds.

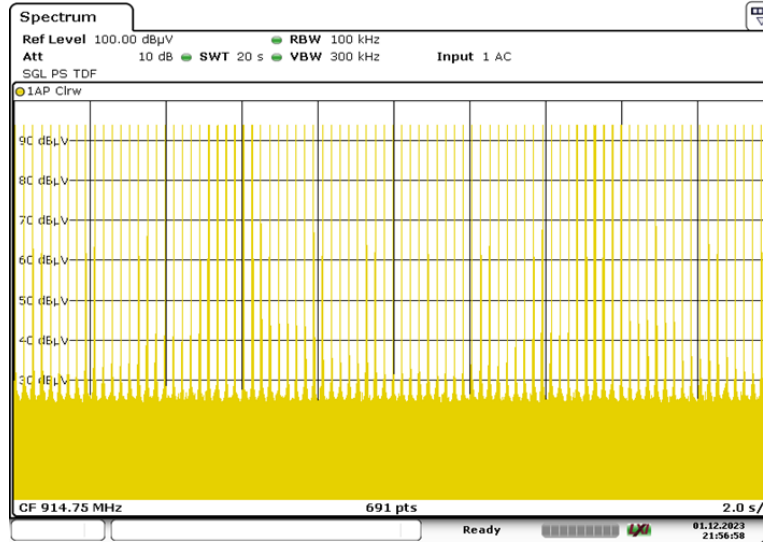
Then the sweep time was expanded to 20 seconds to capture the number of hops in the appropriate sweep time. A single sweep is made for each band, shown in the plots below.

Number of Hops Low Band Measurement Plot Wireless Diagnostic Mode



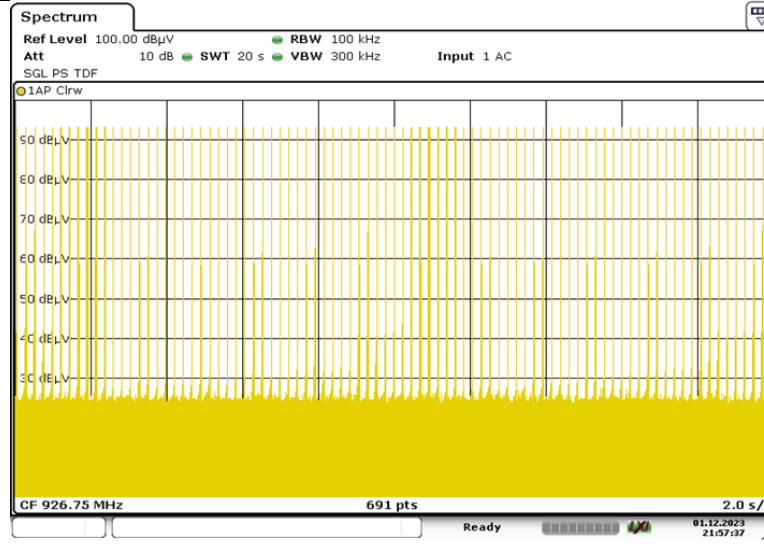
Date: 1.DEC.2023 21:56:25

Number of Hops Mid Band Measurement Plot Wireless Diagnostic Mode



Date: 1.DEC.2023 21:56:58

Number of Hops High Band Measurement Plot Wireless Diagnostic mode



Date: 1.DEC.2023 21:57:37

g. Duty Cycle Correction Measurements (FCC Part 15.247)

Measurement Settings:

Frequency Span: Zero span, centered on a hopping channel

Attenuation: Auto

RBW: 100/120kHz

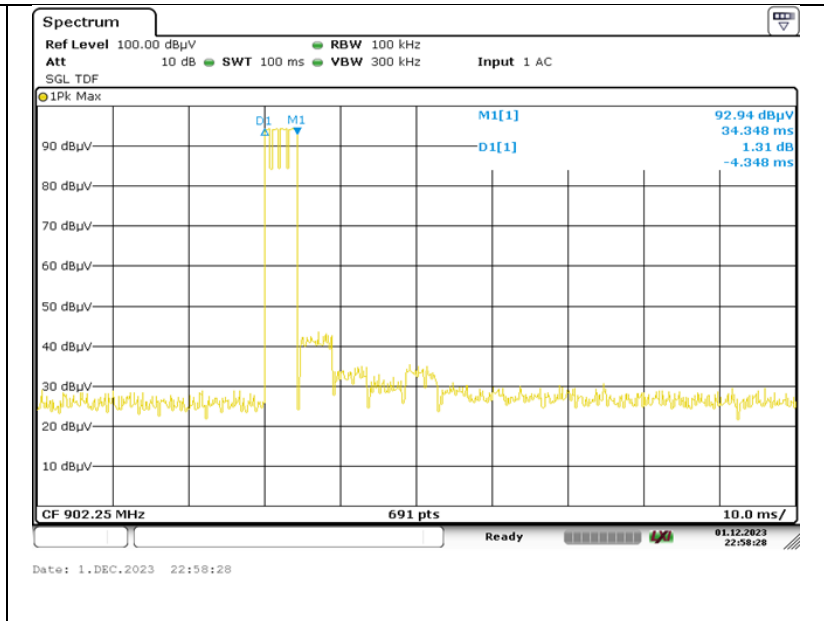
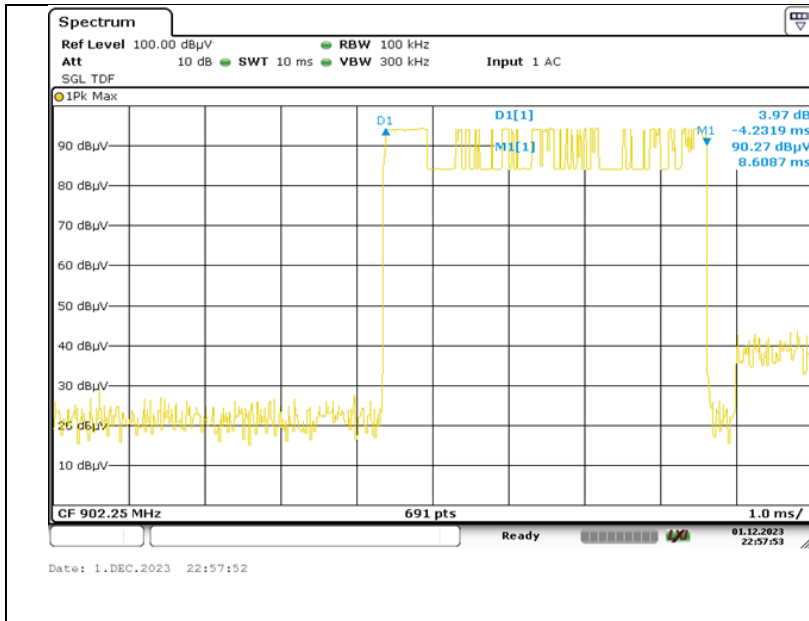
VBW: 3x RBW, 300kHz is typical

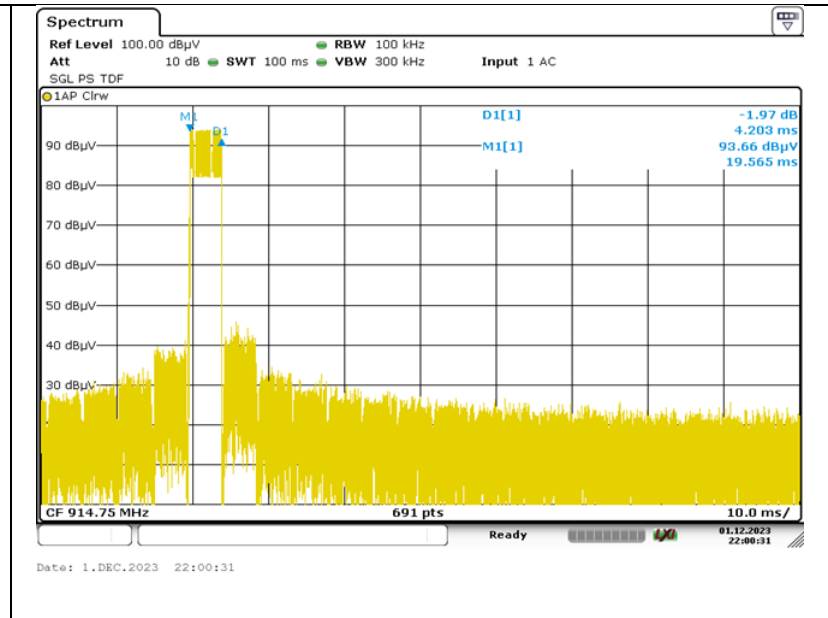
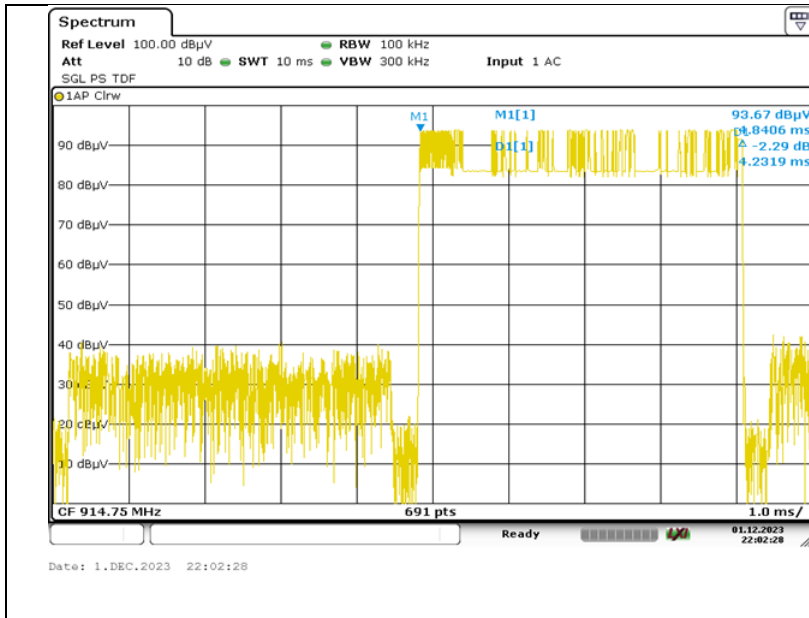
Sweep time: 20s

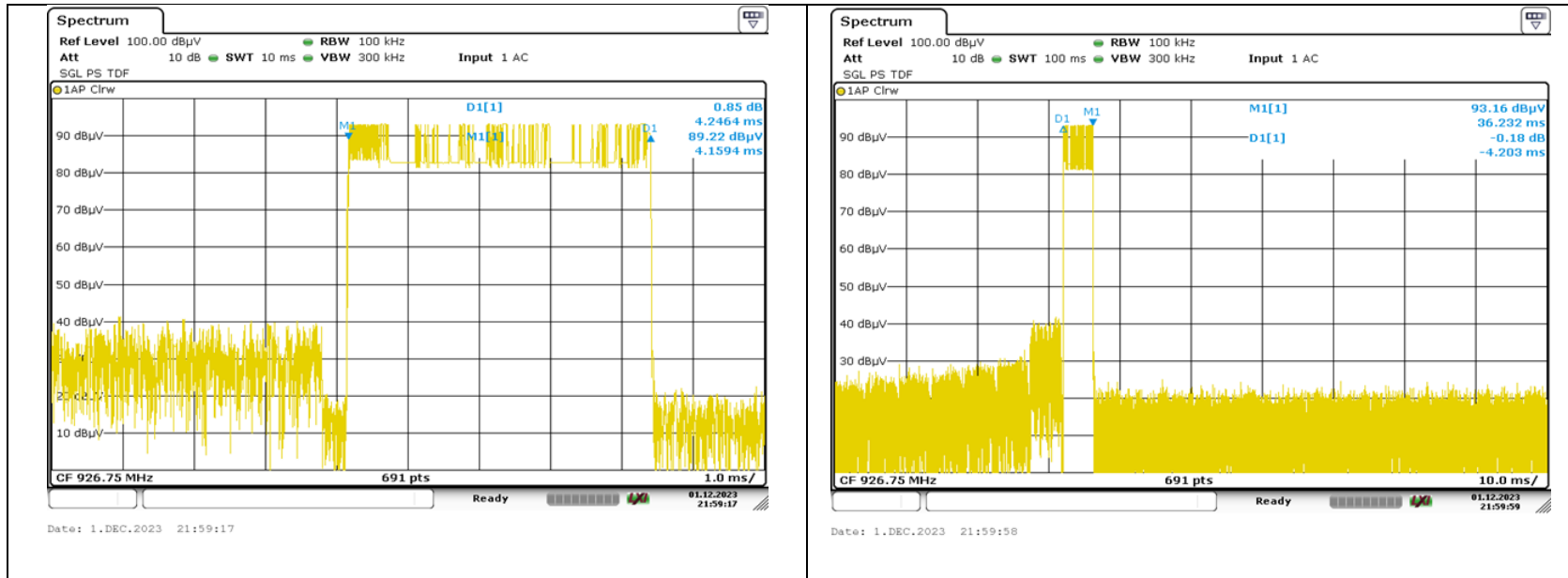
Detector: Peak

Trace: Clear-write, single sweep

Channel	Sweep Time (ms)		Duty Cycle Correction (100ms)
	10ms	100ms	
Low	4.2319	4.348	-27.2
Mid	4.2319	4.203	-27.5
High	4.2646	4.23	-27.5







2. 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	25.045	20	5.0
Mid	22.955		3.0
High	20.041		0.0

Peak – 902.25MHz

Plot: 5-1-1

Engineer: Patricia Klawitter

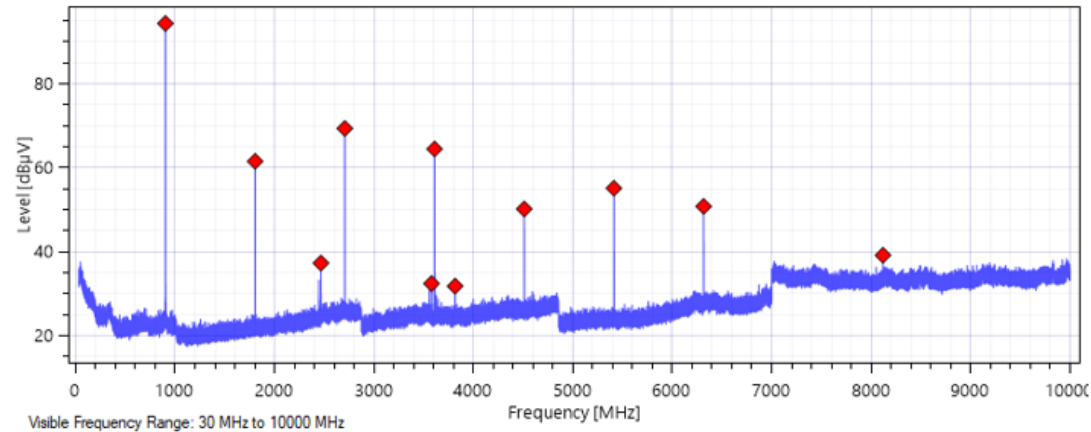
Test Date: December 01, 2023

Trace Readings

..... Peak - 100 kHz

■ OOB Low Readings

Limit Lines



Test Profile: ANSI C63.10 Emissions Outside the Band 30MHz to 10GHz

Measurement Parameters: Refer to "5-1 Segment 1 Settings" included at the end of the report.

Trace: OOB Low, Band: Band 1 (Peak Detector)

Frequency (MHz)	Level (dBuV)	Limit (dBuV)	Margin (dBuV)
902.250000	94.421	No Limit at Frequency	No Limit at Frequency
1,804.500000	61.552	No Limit at Frequency	No Limit at Frequency
2,465.975000	37.294	No Limit at Frequency	No Limit at Frequency
2,706.475000	69.376	No Limit at Frequency	No Limit at Frequency
3,578.175000	32.417	No Limit at Frequency	No Limit at Frequency
3,608.825000	64.495	No Limit at Frequency	No Limit at Frequency
3,815.575000	31.808	No Limit at Frequency	No Limit at Frequency
4,510.950000	50.2	No Limit at Frequency	No Limit at Frequency
5,412.950000	55.144	No Limit at Frequency	No Limit at Frequency
6,315.100000	50.807	No Limit at Frequency	No Limit at Frequency
8,119.425000	39.167	No Limit at Frequency	No Limit at Frequency

Peak – 914.75MHz

Plot: 5-1-2

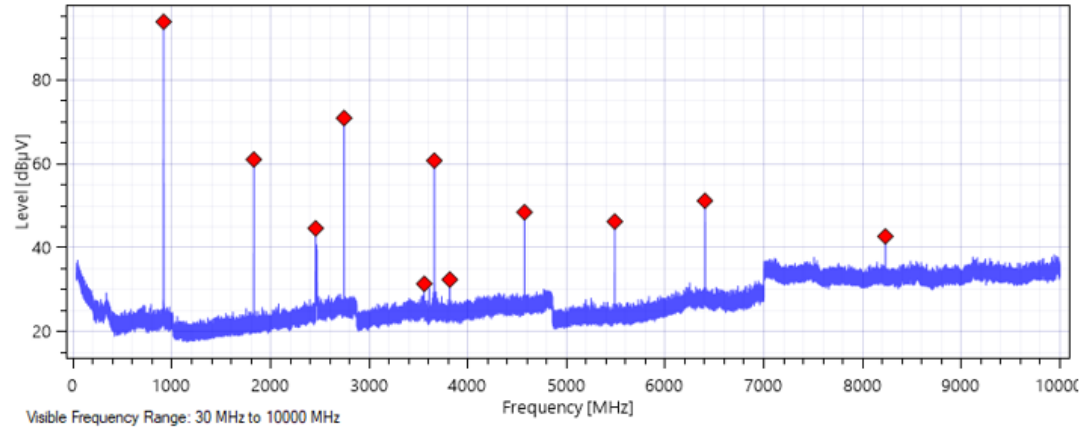
Engineer: Patricia Klawitter

Test Date: December 01, 2023

Trace Readings

..... Peak - 100 kHz
█ OOB mid Readings

Limit Lines



Test Profile: ANSI C63.10 Emissions Outside the Band 30MHz to 10GHz
Measurement Parameters: Refer to "5-1 Segment 1 Settings" included at the end of the report.

Trace: OOB mid, Band: Band 1 (Peak Detector)

Frequency (MHz)	Level (dBuV)	Limit (dBuV)	Margin (dBuV)
914.750000	93.874	No Limit at Frequency	No Limit at Frequency
1,829.500000	61.042	No Limit at Frequency	No Limit at Frequency
2,455.725000	44.657	No Limit at Frequency	No Limit at Frequency
2,744.125000	70.921	No Limit at Frequency	No Limit at Frequency
3,556.900000	31.428	No Limit at Frequency	No Limit at Frequency
3,658.625000	60.786	No Limit at Frequency	No Limit at Frequency
3,815.675000	32.441	No Limit at Frequency	No Limit at Frequency
4,573.500000	48.482	No Limit at Frequency	No Limit at Frequency
5,488.250000	46.274	No Limit at Frequency	No Limit at Frequency
6,402.600000	51.209	No Limit at Frequency	No Limit at Frequency
8,231.925000	42.737	No Limit at Frequency	No Limit at Frequency

Peak – 926.75MHz

Plot: 5-1-3

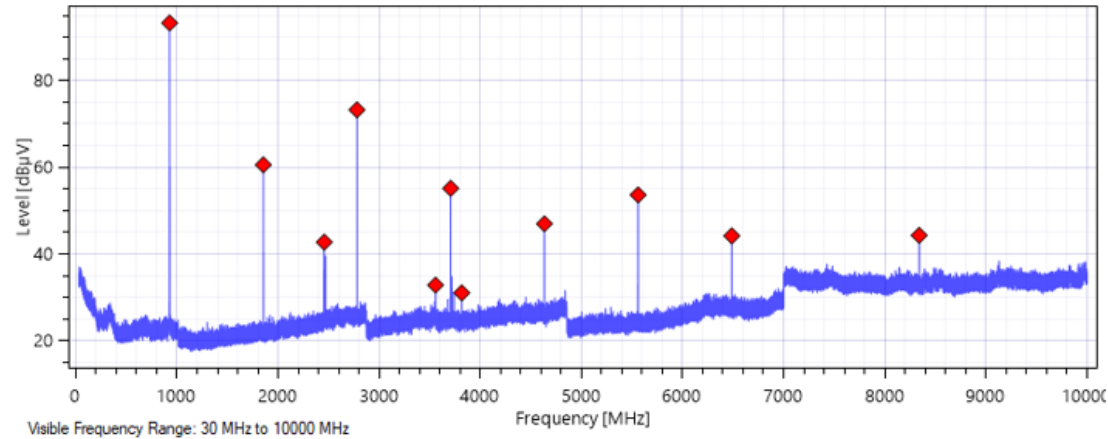
Engineer: Patricia Klawitter

Test Date: December 01, 2023

Trace Readings

..... Peak - 100 kHz
█ OOB High Readings

Limit Lines



Test Profile: ANSI C63.10 Emissions Outside the Band 30MHz to 10GHz
Measurement Parameters: Refer to "5-1 Segment 1 Settings" included at the end of the report.

Trace: OOB High, Band: Band 1 (Peak Detector)

Frequency (MHz)	Level (dBuV)	Limit (dBuV)	Margin (dBuV)
926.750000	93.312	No Limit at Frequency	No Limit at Frequency
1,853.500000	60.59	No Limit at Frequency	No Limit at Frequency
2,455.725000	42.742	No Limit at Frequency	No Limit at Frequency
2,779.975000	73.271	No Limit at Frequency	No Limit at Frequency
3,556.875000	32.85	No Limit at Frequency	No Limit at Frequency
3,706.625000	55.162	No Limit at Frequency	No Limit at Frequency
3,816.050000	31.062	No Limit at Frequency	No Limit at Frequency
4,633.550000	46.984	No Limit at Frequency	No Limit at Frequency
5,560.525000	53.64	No Limit at Frequency	No Limit at Frequency
6,486.600000	44.203	No Limit at Frequency	No Limit at Frequency
8,339.925000	44.314	No Limit at Frequency	No Limit at Frequency