



A Smarter Vision®

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

Model: UAHL5E
FCC ID: NZLUAHL5E
ISED: 4112A-UAHL5E

Emission Designator: 196KF7D
2/20/19

A report concerning approval for Gentex Corporation Homelink® model UAHL5E
Please issue grant immediately upon review.

Measurements Made by:

Digitally signed
by Bolay Pannell
Date: 2019.03.01
16:27:20 -05'00'

Bolay Pannell
Senior EMC Test Engineer
Gentex Corporation

Measurements Reviewed by:

Digitally signed by
Daniel Brasier
Date: 2019.03.01
15:39:39 -05'00'

Dan Brasier
Senior EMC Test Engineer
Gentex Corporation

Report and Application Prepared by:

Digitally signed by
Brian Miller
Date: 2019.03.03
09:13:13 -05'00'

Brian Miller
Regulatory Compliance Engineer
Gentex Corporation

Report Approved and Submitted by:

Craig Harder, NCT, Lab
Manager - Electromagnetic
Compatibility

Digitally signed by Craig Harder,
NCT, Lab Manager -
Electromagnetic Compatibility
Date: 2019.03.03 10:44:24 -05'00'

Craig Harder
Lab Manager - EMC Lab
Gentex Corporation

Test Report Revision

REV Number	Date	Author	Description
1.0	2/20/19	Brian Miller	Initial Release.

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.

Lab Project ID#: EMC2019-05010

FCC Report Form for 15.247 – 3m

Revision: 03/01/2019 Approved By: Craig Harder

Uncontrolled copy if printed unless stamped as a Lab Controlled Document

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 an overhead area 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 to 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. 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 a FCC ID # of NZLUAHL5E and an ISED ID # of 4112A-UAHL5E 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

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: NZLUAHL5E. The ISED certification number is 4112A-UAHL5E. 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.

ISED: 4112A-UAHL5E

FCC ID: NZLUAHL5E

MODEL: UAHL5E

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 straight down from the center of the turntable to a power supply sitting at the base of the table.

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

Radiated: 2/15/19 – 2/19/19

Conducted: 2/18/19

6.2. Test Method Deviations: None.

6.3. Temperature and Humidity

	Measured Value	Unit
Temperature	21.3	°C
Humidity	44.1	%R.H.

6.4. Summary of Results (Part 15.247)

Measurement		Margin	Frequency
Worst Case Spurious Emission	69.23dBuV/m	4.77	3609MHz
Worst Case Receiver Spurious Emission	42.36dBuV/m	3.64dB	914.75Mhz
Maximum 20dB BW	212kHz	288kHz	-
Maximum 99% BW	196kHz	304kHz	-
Maximum Carrier Frequency Separation	505kHz	293kHz	-
Number of Hopping Frequencies	50	-	-
Peak Output Power	0.64dBm	29.36dB	926.75MHz
Time of Occupancy	4.2ms multiplied by 80= 0.336s	0.064s	-

- **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 **40dB** below the fundamental for frequencies less than 902MHz for hopping and non-hopping as shown by the plots below. Emissions are over 60dB 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 $20 \cdot \log(\text{duty cycle})$. The duty cycle factor is calculated as **-27.53dB**. ($-27.53\text{dB} = 20 \cdot \log(4.2\text{ms}/100\text{ms})$).

- **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): 4.5 dB
- Radiated Emissions – LPA (250-1000 MHz): 4.1 dB
- Radiated Emissions – DRWG (1-18 GHz): 5.0 dB
- Conducted Emissions: 0.9 dB

6.5. Test Equipment Setup and Procedure

6.5.1. Test Equipment Used for Conducted Measurement

Description	Model #	ID Number	Last Cal Date	Cal Due
Rohde & Schwarz EMI Receiver	ESR26	6595	6/19/18	6/19/19
Cable	WHU18-1818-072	CBL 18	4/30/18	4/30/19

6.5.2. Test Equipment Used for Radiated Measurement Equipment

Description	Model #	ID Number	Last Cal Date	Cal Due
EMCO Biconical Antenna [30-250 MHz]	3110B	H6189	7/16/18	7/16/21
EMCO LPA Antenna [250-1000MHz]	3148	H6192	7/16/18	7/16/21
Com-Power Double Ridged Waveguide [1-18GHz]	AH-118	7182	12/4/18	12/4/21
Rohde & Schwarz EMI Receiver	ESR26	6595	6/19/18	6/19/19
Cables, attenuator and port feed through	various	3M Port Combo	8/31/18	8/31/19
Miteq Preamplifier	AMF-4D-0050100-24-	S/N:2053240	3/31/18	3/31/19



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	10P			
3m Chamber SW	N/A	SW30	3/31/18	3/31/19

6.5.3. 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 straight down from the center of the turntable to a power supply sitting at the base of the table.

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

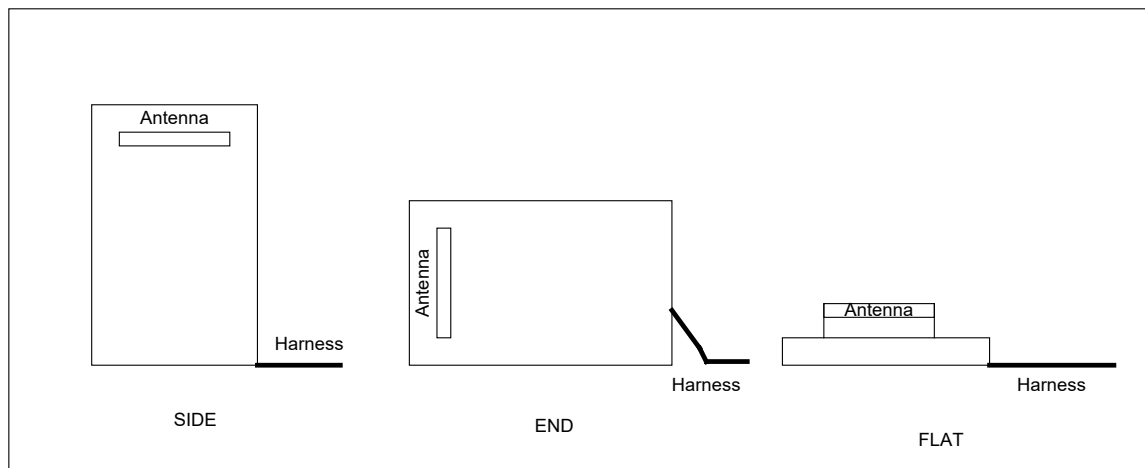


Figure 6.2.3 EUT Orthogonal Orientations

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.

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

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

-27.53dB = $20 \cdot \log(4.2\text{ms}/100\text{ms})$

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 ERP = 127.38 dBuV/m, which is the fundamental limit.

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

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

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

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

8. Other Attachments and Description

8.1. User Manual

Please refer to attachment "User_Manual_English.pdf" and "User_Manual_French.pdf".

8.2. Schematics/ Tuning Information

For schematics please refer to attachment "Schematic.pdf".

8.3. Theory of Operation

Please refer to attachment "HL5 Operation FCC 231_247.pdf"

8.4. Label Drawing and Location on Complete Assembly

For a drawing of the label and position of the label on the finished assembly refer to "Label Location.pdf".

8.5. Photos

For exterior photos, refer to exhibit "exterior photographs.pdf".

For interior photos, refer to exhibit "interior photographs.pdf".

For test setup photos, refer to exhibit "test setup photographs.pdf".

Appendix A

A. Radiated (Tx) Measurements

Note: The Duty Cycle Correction factors are worst case based on a 4.3ms dwell time.

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	End	H	92.21	127.3	35.09
1804.5	Side	H	54.87	72.2	17.34
2706.75	Side	H	63.3	74.0	10.70
3609	Side	H	69.23	74.0	4.77
4511.25	Side	H	54.29	74.0	19.71
5413.5	Side	V	58.00	74.0	16.00
6315.75	Side	H	52.73	72.2	19.48
7218	Side	H	54.35	74.0	19.65
8120.25	Side	H	55.27	74.0	18.73
9022.5	Side	H	54.07	74.0	19.93

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	54.87	-27.53	27.3	52.2	24.87
2706.75	Side	H	63.3	-27.53	35.8	54.0	18.23
3609	Side	H	69.23	-27.53	41.7	54.0	12.30
4511.25	Side	H	54.29	-27.53	26.8	54.0	27.24
5413.5	Side	V	58.00	-27.53	30.5	54.0	23.53
6315.75	Side	H	52.73	-27.53	25.2	52.2	27.01
7218	Side	H	54.35	-27.53	26.8	54.0	27.18
8120.25	Side	H	55.27	-27.53	27.7	54.0	26.26
9022.5	Side	H	54.07	-27.53	26.5	54.0	27.46

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)	FCC Limit (dBuV/m)	Margin (dB)
914.75	End	H	91.21	127.3	36.09
1829.5	Side	H	53.42	71.2	17.79
2744.25	Side	H	63.67	74.0	10.33
3659	Side	V	67.43	74.0	6.57
4573.75	Side	V	51.94	74.0	22.06
5488.5	Side	V	58.83	74.0	15.17
6403.25	Side	V	52.45	71.2	18.76
7318	Side	V	55.19	74.0	18.81
8232.75	Side	H	53.57	74.0	20.43
9147.5	Side	V	55.23	74.0	18.77

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)	FCC Limit (dBuV/m)	Margin (dB)
1829.5	Side	H	53.42	-27.53	25.9	51.2	25.32
2744.25	Side	H	63.67	-27.53	36.1	54.0	17.86
3659	Side	V	67.43	-27.53	39.9	54.0	14.10
4573.75	Side	V	51.94	-27.53	24.4	54.0	29.59
5488.5	Side	V	58.83	-27.53	31.3	54.0	22.70
6403.25	Side	V	52.45	-27.53	24.9	51.2	26.29
7318	Side	V	55.19	-27.53	27.7	54.0	26.34
8232.75	Side	H	53.57	-27.53	26.0	54.0	27.96
9147.5	Side	V	55.23	-27.53	27.7	54.0	26.30

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

Peak Measurement 926.75MHz

Peak Measurement 926.75MHz

Frequency (MHz)	Orientation (Flat/End/Side)	Measurement Polarization (H/V)	Measurement (dBuV/m)	FCC Limit (dBuV/m)	Margin (dB)
926.75	0	H	91.66	127.3	35.64
1853.5	Side	H	54.45	71.7	17.21
2780.25	Side	H	63.69	74.0	10.31
3707	Side	H	68.00	74.0	6.00
4633.75	Side	H	53.29	74.0	20.71
5560.5	Side	V	59.62	74.0	14.38
6487.25	Side	H	52.04	71.7	19.62
7414	Side	H	55.63	74.0	18.37
8340.75	Side	H	54.27	74.0	19.73
9267.5	Side	H	55.89	74.0	18.11

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)	FCC Limit (dBuV/m)	Margin (dB)
1853.5	Side	H	54.45	-27.53	26.9	51.7	24.74
2780.25	Side	H	63.69	-27.53	36.2	54.0	17.84
3707	Side	H	68.00	-27.53	40.5	54.0	13.53
4633.75	Side	H	53.29	-27.53	25.8	54.0	28.24
5560.5	Side	V	59.62	-27.53	32.1	54.0	21.91
6487.25	Side	H	52.04	-27.53	24.5	51.7	27.15
7414	Side	H	55.63	-27.53	28.1	54.0	25.90
8340.75	Side	H	54.27	-27.53	26.7	54.0	27.26
9267.5	Side	H	55.89	-27.53	28.4	54.0	25.64

1. Radiated Rx Spurious Emissions

The receiver circuit spurious emissions were measured in accordance to Industry Canada RSS-GEN Issue 4 Section 7 and ANSI C63.4-2013.

The FHSS operational band low, mid and high frequencies over which the receiver is designed to operate are 902.25, 914.75 and 926.75MHz. The HomeLink is supplied with commands to place it into diagnostic / manufacturing mode, and tune the receiver to these frequencies.

Worst case results are provided in the tables below. The low band has a minimum margin of 4.23dB, the mid band has a minimum margin of 3.64dB, and the high frequency band has a minimum margin of 3.93dB.

Frequency (MHz)	DUT Orientation	Antenna Polarization	Field Strength (dBuV/m)	Limit (dBuV/m)	Margin (dB)
901.25	Side	V	41.77	46	-4.23
1802.6	Side	V	33.95	54	-20.05
2703.9	Side	H	38.56	54	-15.44
3605.2	Side	H	40.26	54	-13.74
4506.5	Side	H	41.35	54	-12.65
914.75	Flat	H	42.36	46	-3.64
1829.5	Flat	V	34.56	54	-19.44
2744.25	Flat	V	37.26	54	-16.74
3659	Side	H	39.54	54	-14.46
4573.75	Side	H	50.07	54	-3.93
926.75	End	V	40.66	46	-5.34
1853.5	Flat	H	45.26	54	-8.74
2780.25	End	H	43.26	54	-10.74
3707	End	V	42.32	54	-11.68
4633.75	End	V	45.26	54	-8.74

1. Conducted Measurements

a. Occupied Bandwidth Measurement (FCC Part 15.247)

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.

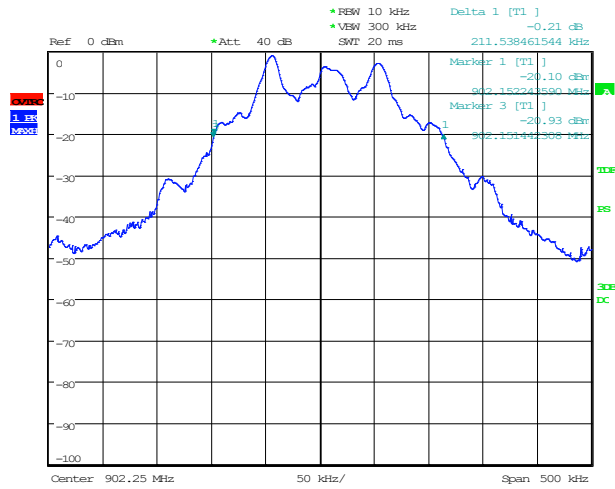
In measurement of the 20dB bandwidth, the transmit frequency was set to low, middle and high hopping channels. The resolution bandwidth (RBW) was set to > than 1% of the 20dB bandwidth. The span was set to approximately 2 to 3 times the 20dB bandwidth.

The plots show that the maximum 20dB bandwidth was 212kHz, which is within limit. The 99% bandwidth was measured to be 196kHz.

20dB BW Results

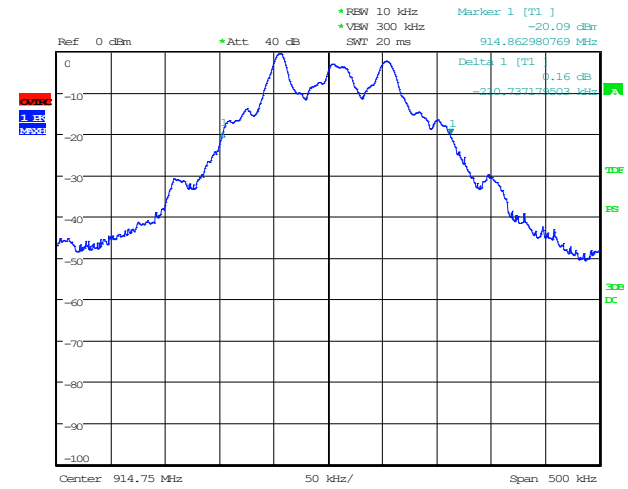
Frequency (MHz)	20dB Bandwidth (kHz)	Limit (kHz)
902.25	212	500
914.75	211	
926.75	204	

20 dB BW Low Band Measurement Plot



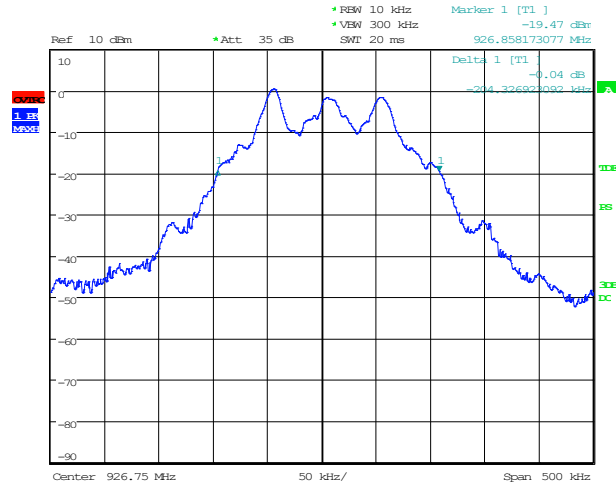
Date: 18.FEB.2019 12:58:15

20 dB BW Mid Band Measurement Plot



Date: 18.FEB.2019 13:01:59

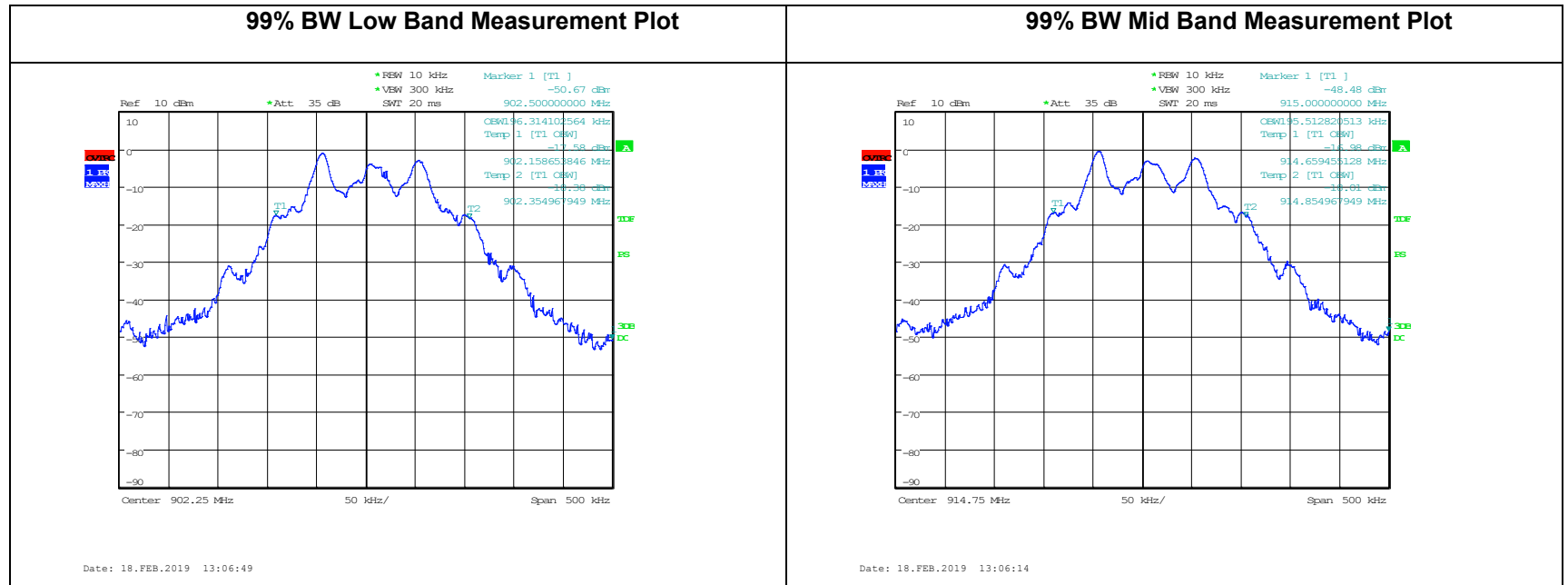
20 dB BW High Band Measurement Plot



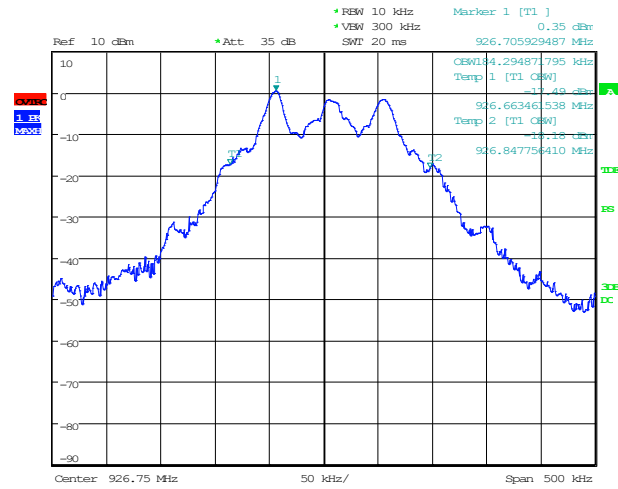
Date: 18.FEB.2019 13:03:53

99% BW Results

Frequency (MHz)	99% Bandwidth (kHz)	Limit (kHz)
902.25	196	500
914.75	196	
926.75	184	



99% BW High Band Measurement Plot



Date: 18.FEB.2019 13:05:27

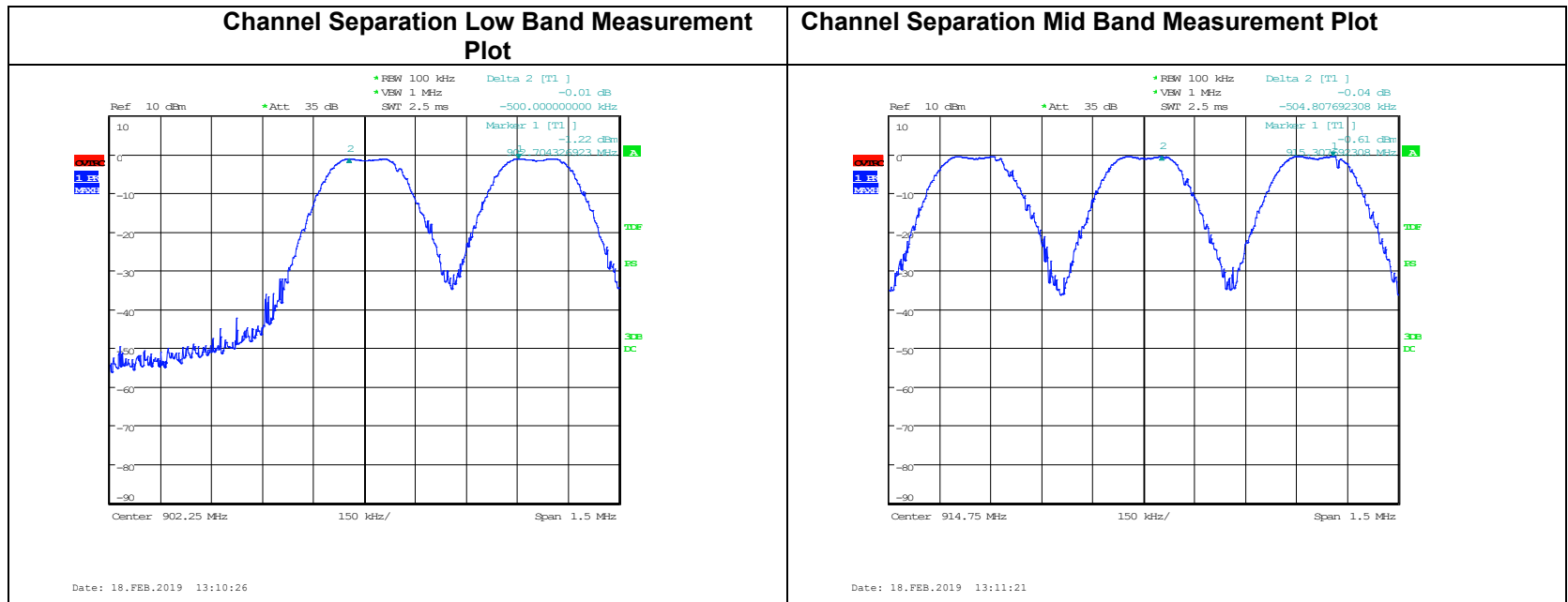
2. Carrier Frequency Separation Measurement (FCC Part 15.247)

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.

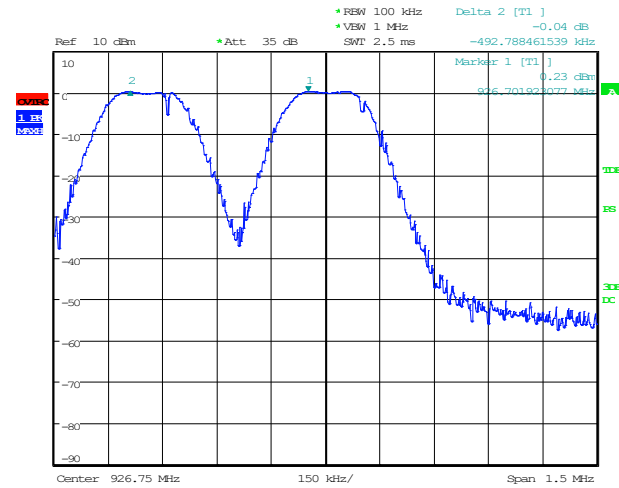
This measurement is a conducted measurement. Prior to the measurement the EUT is placed into hopping mode via a communications board attached to the EUT.

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 **505.00kHz**, which is greater than the 20dB bandwidth measurement (**212.00kHz**).



Channel Separation High Band Measurement Plot



Date: 18.FEB.2019 13:13:22

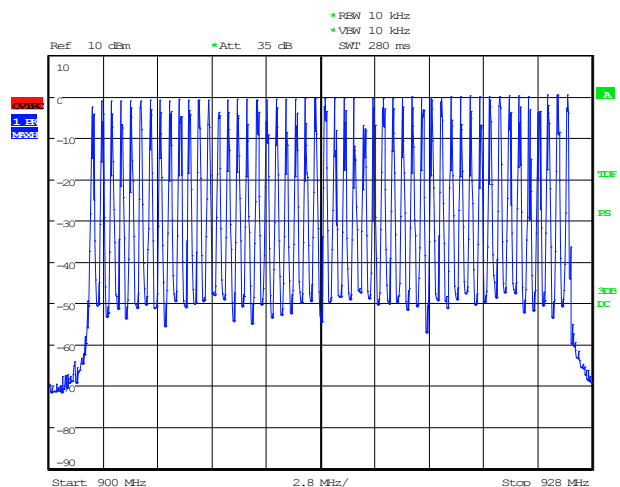
3. Number of Hopping Frequencies Measurement (FCC Part 15.247)

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.



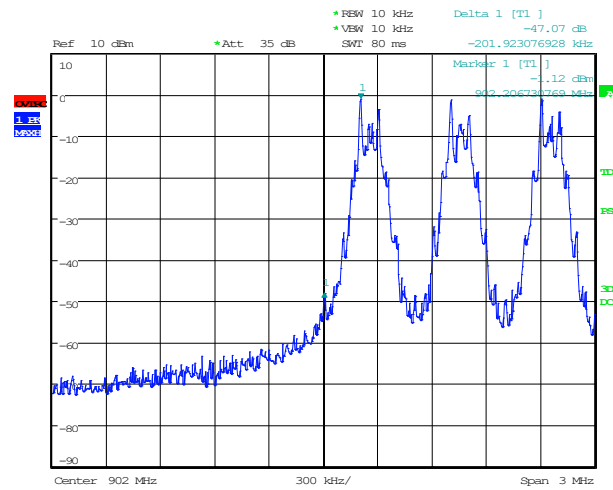
4. Band Edge Measurement (FCC Part 15.247)

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.

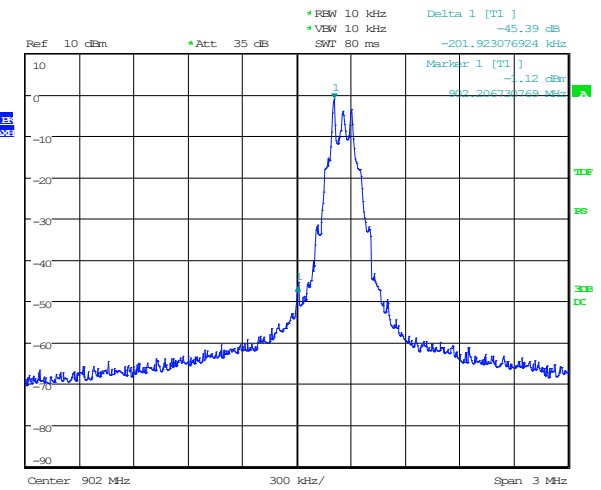
For the Low Frequency Band Edge, emissions are at least 40dB below the fundamental for frequencies less than 902MHz for hopping and non-hopping as shown by the plots below. For the High Frequency Band Edge, emissions are over 59dB below the fundamental above 928MHz for hopping and for non-hopping as shown by the plots below.

Hopping Low Frequency Band Edge



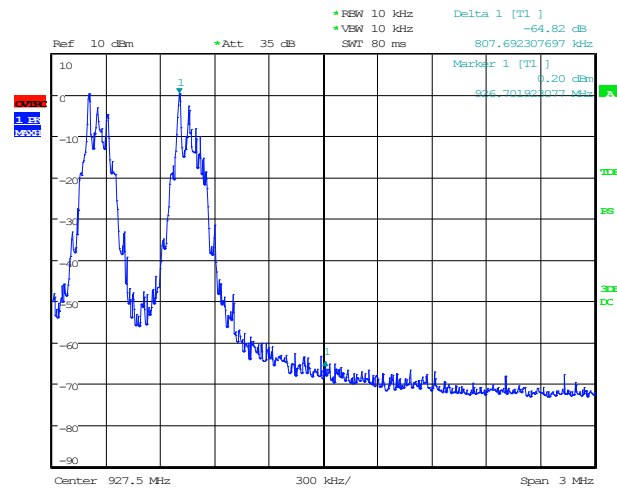
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Non - Hopping Low Frequency Band Edge



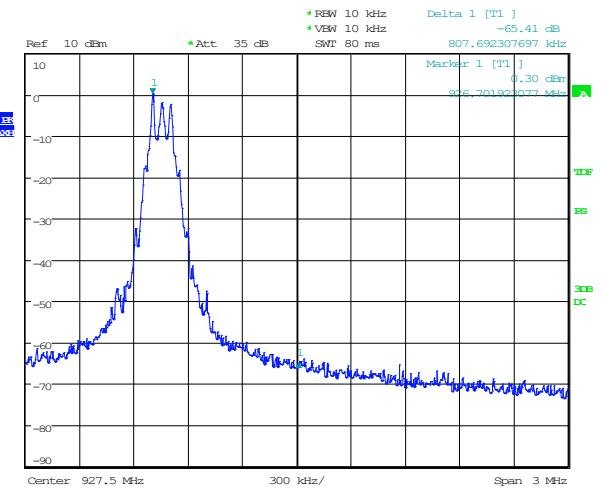
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Hopping High Frequency Band Edge



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Non - Hopping High Frequency Band Edge



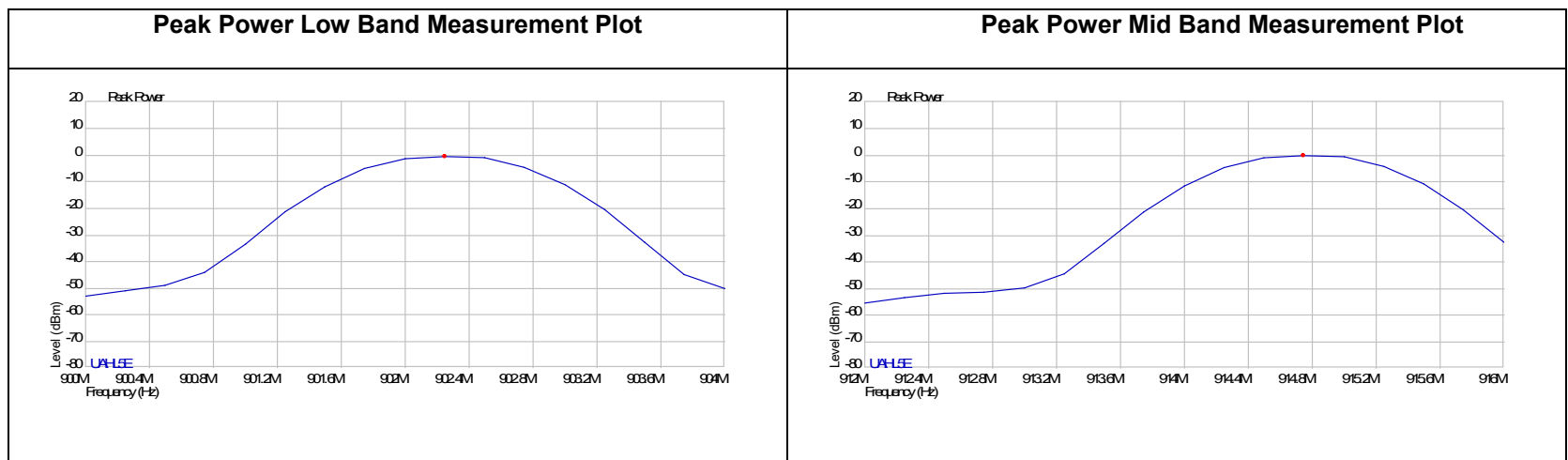
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5. Peak Power (FCC Part 15.247)

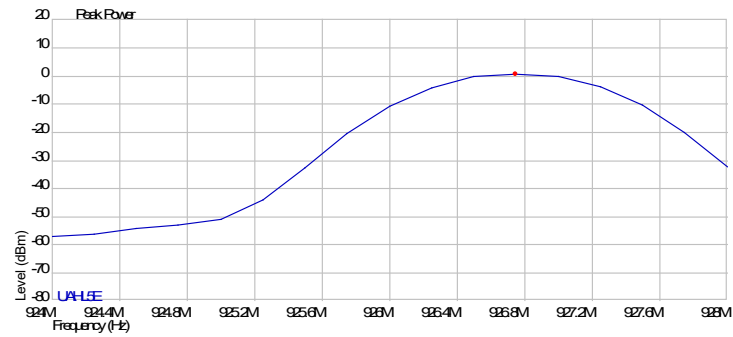
Per section 15.247(b)(2), for frequency hopping systems operating in the 902-928 MHz band and employing at least 50 hopping channels, the maximum peak output power shall not be greater than 1W (30dBm).

This measurement is a conducted measurement. 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. At 902.25 the peak power was -0.37dBm, at 914.75 the peak power was 0.05dBm, and at 926.75 the peak power was 0.64dBm, as shown in the plots below.



Peak Power High Band Measurement Plot



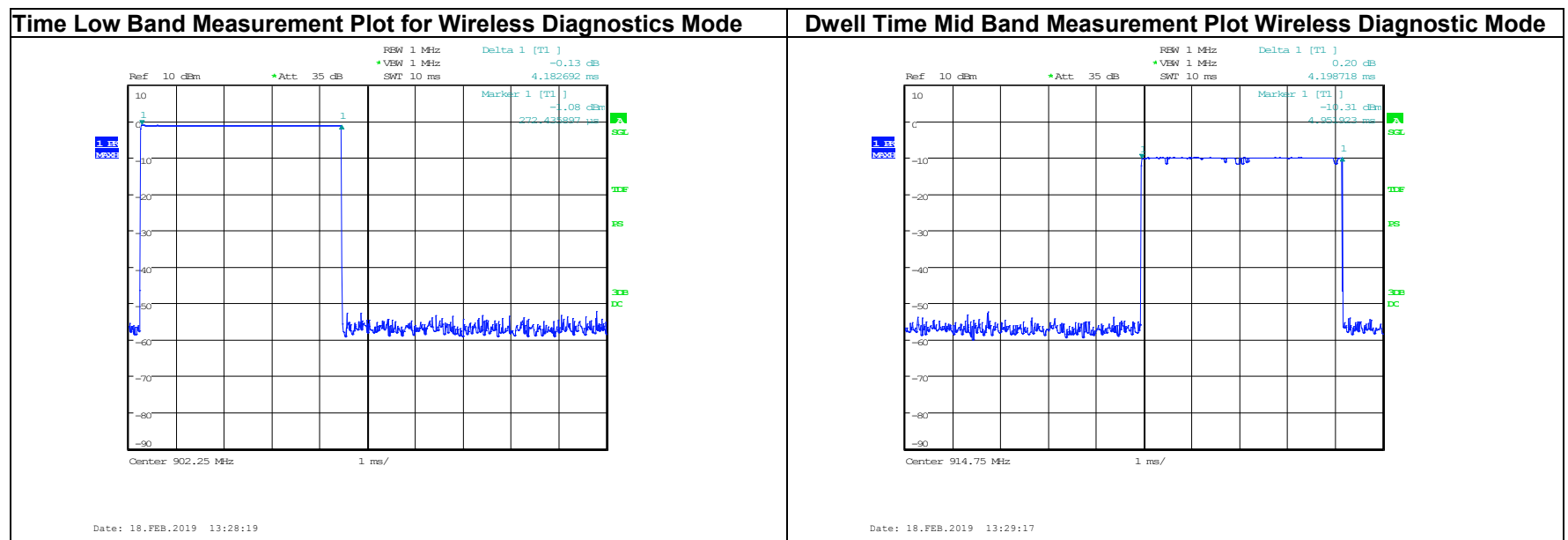
6. Time of Occupancy (FCC Part 15.247)

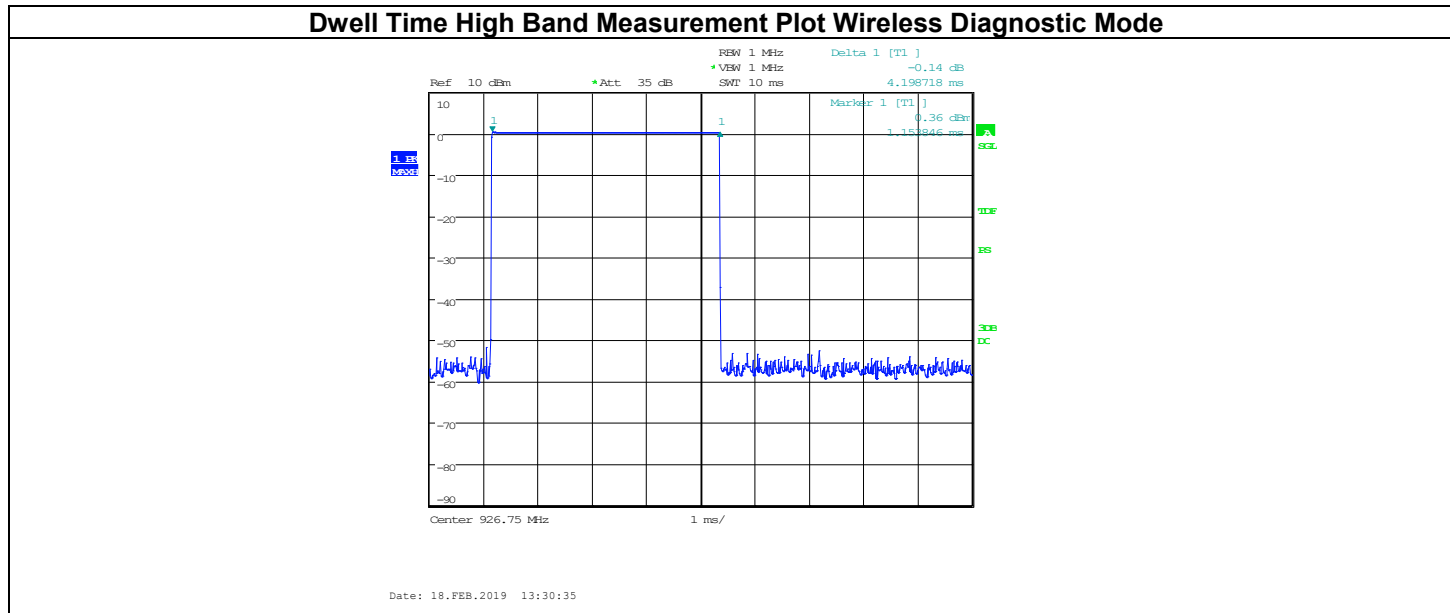
Per section 15.247(a)(1)(i), for frequency hopping systems operating in the 902-928 MHz band, if the 20dB bandwidth of the hopping channel is less than 250kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds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

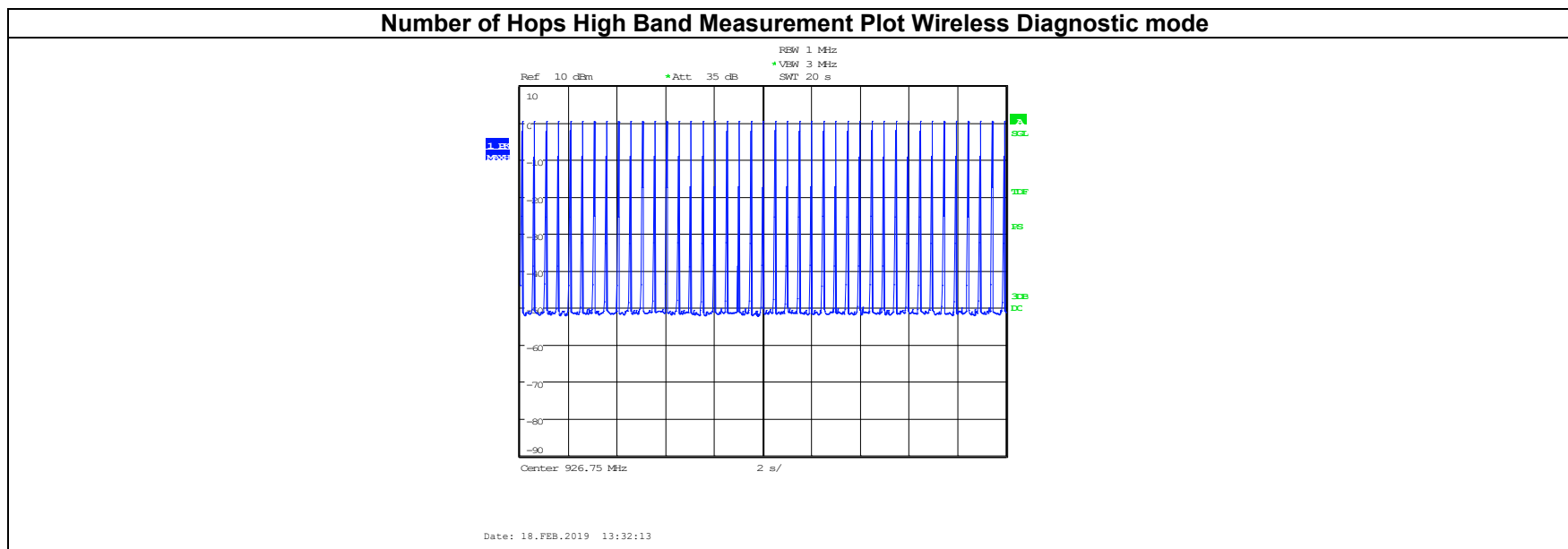
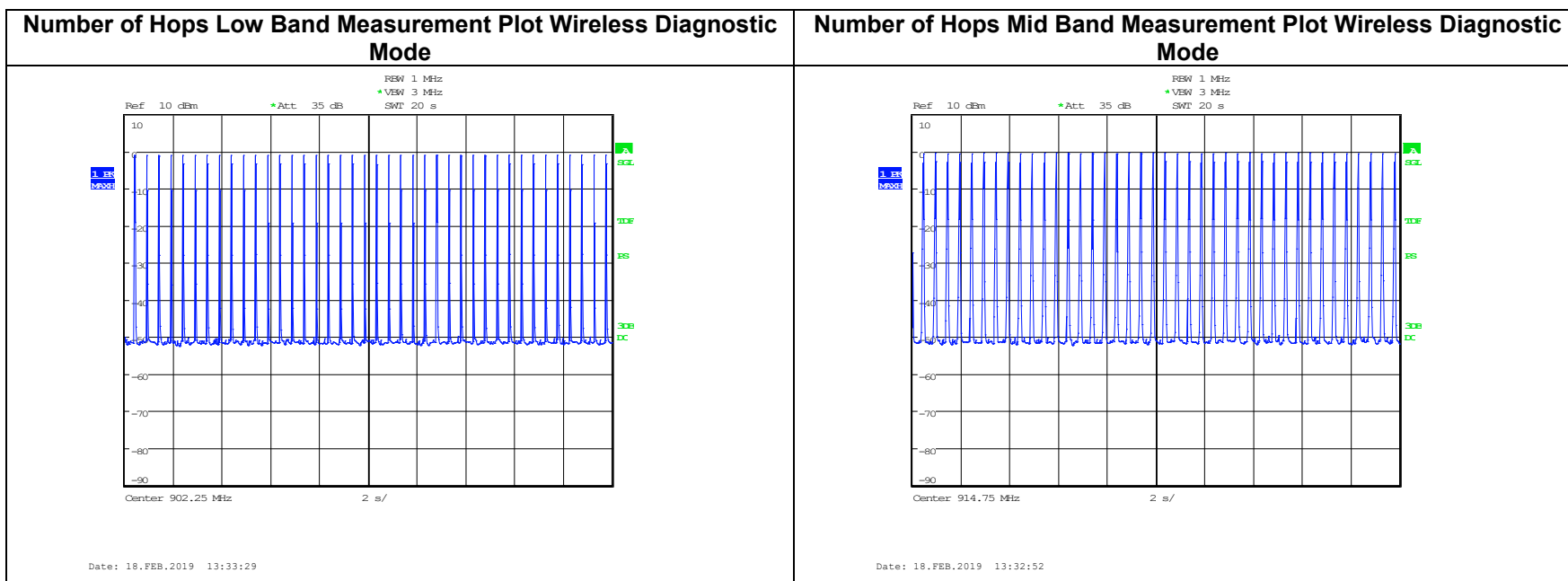
The figures below show the hop dwell time for each band



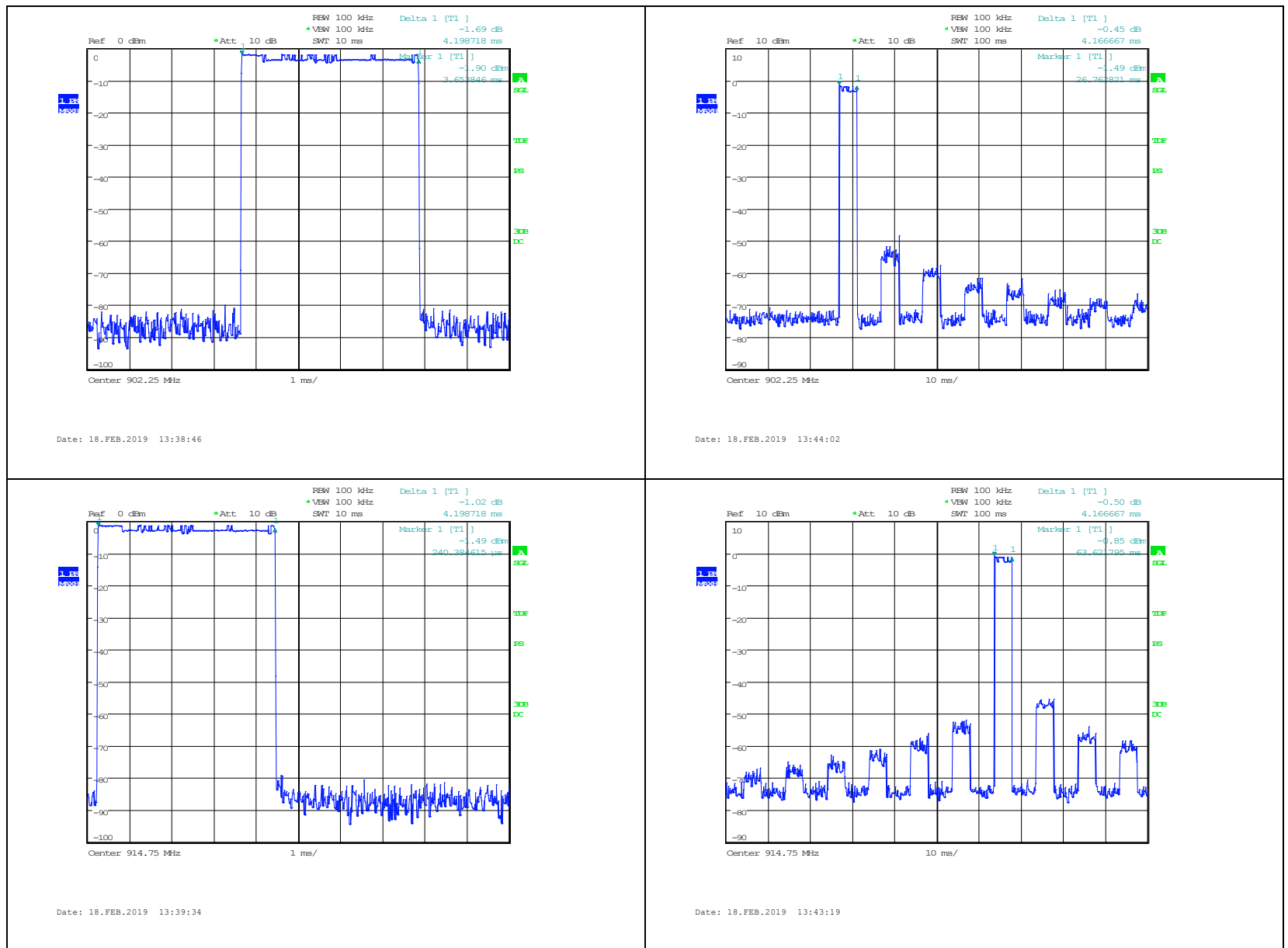


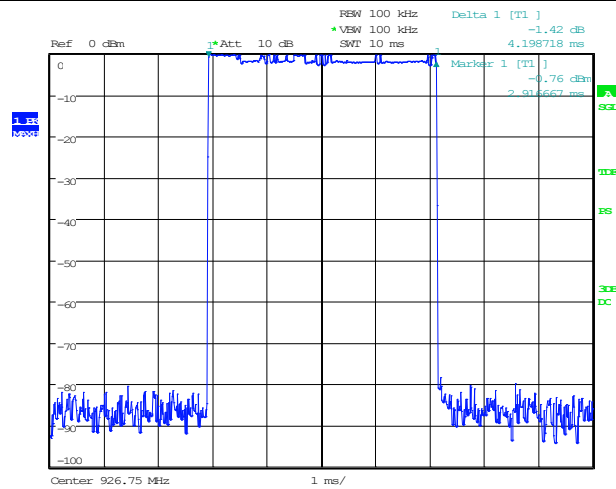
Dwell time per frequency = $4.2/250$ per cycle = 1.68% or 168msec in 10 seconds or 336msec in 20 seconds, where the limit is 0.4 seconds leaving a margin of 0.064 seconds.

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.

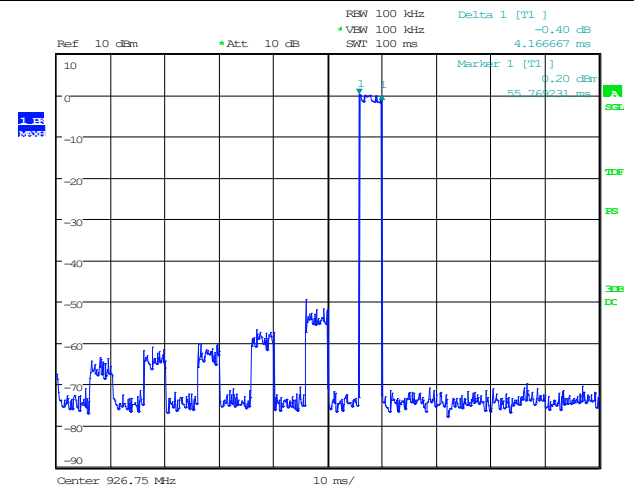


7. Duty Cycle Correction Measurements (FCC Part 15.247)





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