

Test Report # 318219 A

Equipment Under Test: DTV Konnect Module

Test Date(s): 10/28/18 – 4/10/19

Prepared for: ATTN: Tim Stessman
Codes & Standards
Kohler Co., Kitchen and Bath Americas
444 Highland Drive
Kohler, WI 53044

Report Issued by: Shane Dock, EMC Engineer

Signature:



Date: 5/3/2019

Report Reviewed by: Adam Alger, Quality Manager

Signature: 

Date: 5/3/2019

Report Constructed by: Shane Dock, EMC Engineer

Signature:



Date: 12/17/2018

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Laird Technologies Test Services in Review

The Laird Technologies, Inc. laboratory located at W66 N220 Commerce Court Cedarburg, Wisconsin, 53012 USA is recognized through the following organizations:



A2LA – American Association for Laboratory Accreditation

Accreditation based on ISO/IEC 17025:2017 with Electrical (EMC) Scope

A2LA Certificate Number: 1255.01

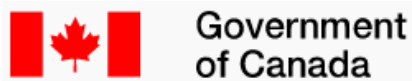
Scope of accreditation includes all test methods listed herein unless otherwise noted



Federal Communications Commission (FCC) – USA

Accredited Test Firm Registration Number: 953492

Recognition of two 3 meter Semi-Anechoic Chambers



Innovation, Science and Economic Development Canada

Accredited U.S. Identification Number: US0218

Recognition of two 3 meter Semi-Anechoic Chambers

Company: Kohler Co.	Page 3 of 64	Name: DTV Konnect Module
Report: 318219 A		Model: K-97999-NA
Job: C-3047		Serial: 02

1 TEST REPORT SUMMARY

During **10/28/18 – 4/10/19** the Equipment Under Test (EUT), **DTV Konnect Module**, as provided by **Kohler Co.** was tested to the following requirements:

Requirement	Description	Specification	Method	Result
FCC: 15.247 (a)(2) IC: RSS-247 5.2 (a)	Digital Modulation System 6 dB bandwidth	500 kHz	ANSI C63.10	Pass
FCC: 2.1049 IC: RSS-GEN 6.7	Occupied Bandwidth	Reported	ANSI C63.10	Pass
FCC: 15.247 (b)(3) IC: RSS-247 5.4 (d)	Maximum Conducted Output Power	30 dBm	ANSI C63.10	Pass
FCC: 15.247 (e) IC: RSS-247 5.2 (b)	Digital Modulation System Power Spectral Density	8 dBm / 3 kHz	ANSI C63.10	Pass
FCC: 15.247 (d) IC: RSS-247 5.5	RF Spurious Emissions at the Transmitter Antenna Terminal	30 dBc	ANSI C63.10	Pass
FCC: 15.247 (d) IC: RSS-GEN 8.10	Spurious Radiated Emissions in Restricted Bands	FCC 15.209 RSS-GEN 8.9	ANSI C63.10	Pass
FCC: 2.1055 (d) IC: RSS-GEN 6.11	Frequency Stability	Reported	ANSI C63.10	Pass
FCC: 15.207 IC: RSS-GEN 8.8	AC Power Line Conducted Emissions	0.150-30 MHz	ANSI C63.10	Pass

Notice:

The results relate only to the item tested and described in this report. Any modifications made to the equipment under test after the specified test date(s) may invalidate the data herein.

If the resulting measurement margin is seen to be within the uncertainty value, as listed in this report, the possibility exists that this unit may not meet the required limit specification if subsequently tested.

2 CLIENT INFORMATION

Company Name	Kohler Co.
Contact Person	Tim Stessman
Address	444 Highland Drive Kohler, WI 53044

2.1 Equipment Under Test (EUT) Information

The following information has been supplied by the client

Product Name	DTV Plus
Model Number	K-97999-NA
Serial Number	02
FCC / IC ID	FCC ID: N82-KOHLER029 IC ID: 4554A-KOHLER029

2.2 Product Description

DTV Konnect Module is comprised of a circuit board containing a 2.4 GHz Wi-Fi module. Circuit board is mounted within a plastic enclosure containing an internal, off-board antenna. A single cable provides power and communications from a host DTV+ Controller unit. The DTV Konnect Module provides cloud connectivity for the DTV+ Shower System to enable mobile app and voice control of showering functions.

2.3 Modifications Incorporated for Compliance

None noted at time of test

2.4 Deviations and Exclusions from Test Specifications

None noted at time of test

2.5 Additional Information

EUT provided with 12VDC power via controller. EUT programmed via serial connection with PuTTY (Texas Instruments Calibrator commands was used to set channel, power, and mode).

2.6 WLAN Information

Unit tested with an ini file provided by customer. The unit was tested at 2412 MHz, 2437 MHz, and 2462 MHz (Low, Mid, and High). For HT40, the EUT was tested at 2422, 2432 and 2442 MHz (labeled Low, Mid, and High). The HT40 MCS0 data rate was also tested at 2437 MHz, as the high channel has a reduced power.

3 REFERENCES

Publication	Edition	Date
CFR 47 Part 15	-	2018
ANSI C63.10	-	2013
RSS-247	2	2017
RSS GEN	5	2018

4 UNCERTAINTY SUMMARY

Using the guidance of the following publications the calculated measurement uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level, using a coverage factor of $k = 2$.

References	Version / Date
CISPR 16-4-1	Ed. 2 (2009-02)
CISPR 16-4-2	Ed. 2 (2011-06)
CISPR 32	Ed. 1 (2012-01)
ANSI C63.23	2012
A2LA P103	February 4, 2016
A2LA P103c	August 10, 2015
ETSI TR 100-028	V1.3.1 (2001-03)

Measurement Type	Configuration	Uncertainty $\pm$
Radiated Emissions	Biconical Antenna	5.0 dB
Radiated Emissions	Log Periodic Antenna	5.3 dB
Radiated Emissions	Horn Antenna	4.7 dB
AC Line Conducted Emissions	Artificial Mains Network	3.4 dB
Telecom Conducted Emissions	Asymmetric Artificial Network	4.9 dB
Disturbance Power Emissions	Absorbing Clamp	4.1 dB
Radiated Immunity	3 Volts/meter	2.2 dB
Conducted Immunity	CDN/EM/BCI	2.4/3.5/3.4 dB
EFT Burst/Surge	Peak pulse voltage	164 volts
ESD Immunity	15 kV level	1377 Volts

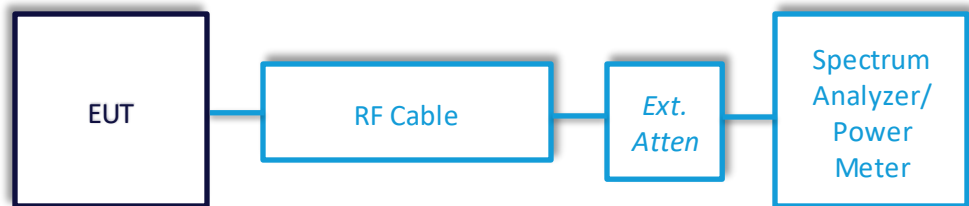
Parameter	ETSI U.C. $\pm$	U.C. $\pm$
Radio Frequency, from F0	1×10^{-7}	0.55×10^{-7}
Occupied Channel Bandwidth	5 %	2 %
RF conducted Power (Power Meter)	1.5 dB	1.2 dB
RF conducted emissions (Spectrum Analyzer)	3.0 dB	1.7 dB
All emissions, radiated	6.0 dB	5.3 dB
Temperature	1° C	0.65° C
Humidity	5 %	2.9 %
Supply voltages	3 %	1 %

5 TEST DATA

5.1 Antenna Port Conducted Emissions

Description of Measurement	The direct measurement of emissions at the antenna port of the EUT is achieved by use of a RF connection to a spectrum analyzer or power meter. The cable and attenuator factors are loaded into the analyzer or power meter allowing for direct measurement readings without the need for further corrections.
Example Calculations	Measurement (dBm) + Cable factor (dB) + External Attenuator (dB) = Corrected Reading (dBm) Margin (dB) = Limit (dBm) – Corrected Reading (dBm)

Block Diagram



5.1.1 Antenna Port Conducted Emissions – DTS/99% Bandwidth

Operator	Shane Dock
Test Date	11/1/16 – 11/6/16
Location	Conducted RF Area
Temp. / R.H.	70 degrees F/ 23% RH
Requirement	FCC 15.247 (a)(2) IC: RSS-247 5.2 (a)
Method	ANSI C63.10 Section 6.9

Limits:

Minimum 6 dB BW (MHz)
0.5

Test Parameters

Frequency	2412-2462 MHz
EUT	Unit Tested on Low, Mid, and High Channel

Instrumentation



Date : 8-Aug-2018 Test : Conducted RF Job : C-3047
PE : Shane Dock Customer : Kohler Quote : 318219

No.	Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due Date	Equipment Status
1	AA 960143	Cable	Gore	EKD01D01048.0	5546519	11/12/2018	11/12/2019	Active Verification
2	EE 960087	Analyzer - Spectrum	Agilent	N9010A	MY53400296	4/25/2018	4/25/2019	Active Calibration

Table

1 MBPS

Channel	Low	Mid	High
6 db BW (MHz)	9.7	10.0	10.0
99% BW (MHz)	14.6	14.5	14.5

6 MBPS

Channel	Low	Mid	High
6 db BW (MHz)	15.1	15.1	15.1
99% BW (MHz)	16.6	17.7	16.6

MCS0

Channel	Low	Mid	High
6 db BW (MHz)	15.1	15.1	15.1
99% BW (MHz)	17.6	18.9	17.6

11 MBPS

Channel	Low	Mid	High
6 db BW (MHz)	11.1	10.1	11.1
99% BW (MHz)	14.5	14.5	14.5

54 MBPS

Channel	Low	Mid	High
6 db BW (MHz)	15.1	15.4	15.3
99% BW (MHz)	16.6	16.9	16.6

MCS7

Channel	Low	Mid	High
6 db BW (MHz)	15.8	15.1	15.1
99% BW (MHz)	17.7	18.1	17.7

HT40 MCS0

Channel	Low	Mid	2437 MHz	High
6 db BW (MHz)	35.1	35.1	33.9	35.1
99% BW (MHz)	35.9	37.4	37.1	36.5

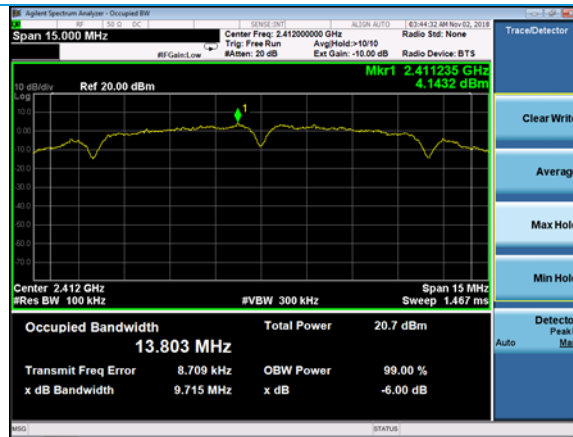
HT40 MCS7

Channel	Low	Mid	High
6 db BW (MHz)	35.1	35.1	35.1
99% BW (MHz)	36.1	36.3	36.3

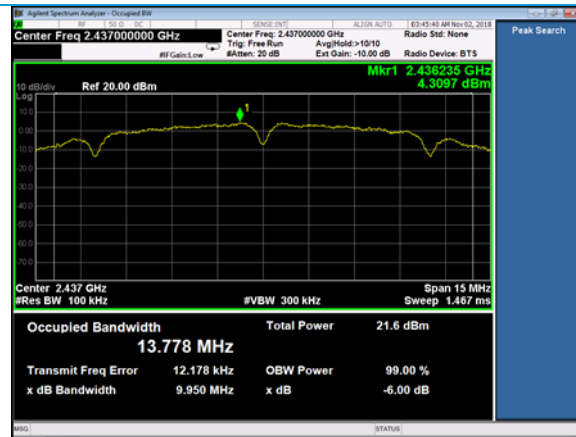
Worst Case Margin = Closest Measurement – Limit = 9700 kHz – 500kHz = 9200 kHz

Plots

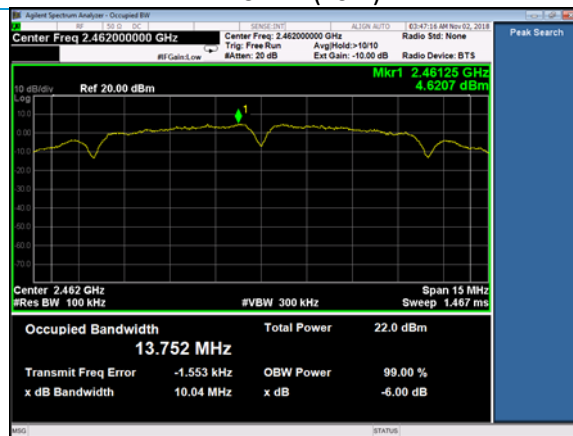
1 MBPS



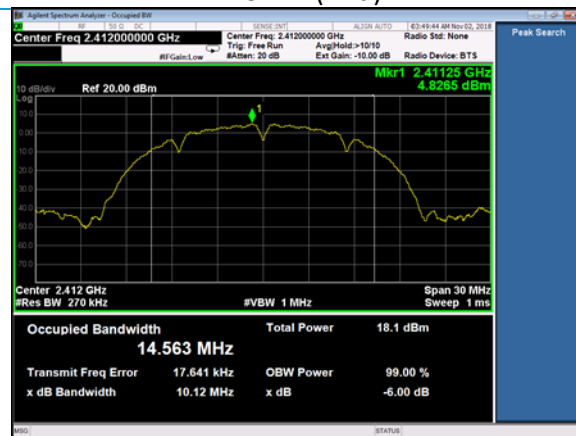
DTS BW (Low)



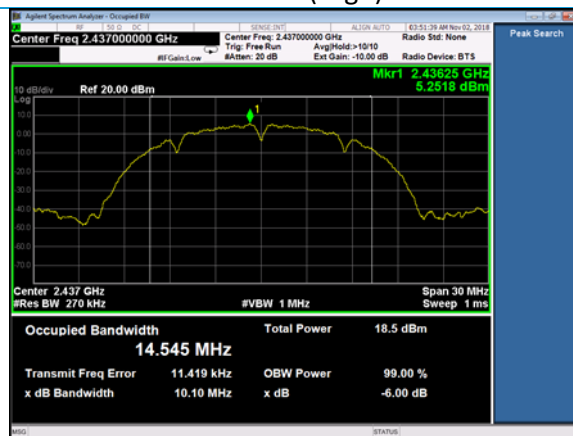
DTS BW (Mid)



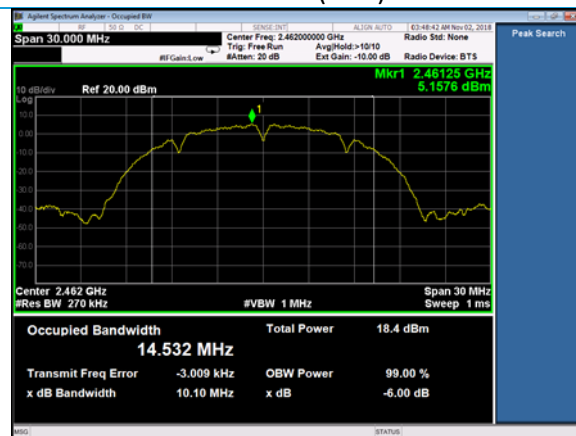
DTS BW (High)



99% BW (Low)

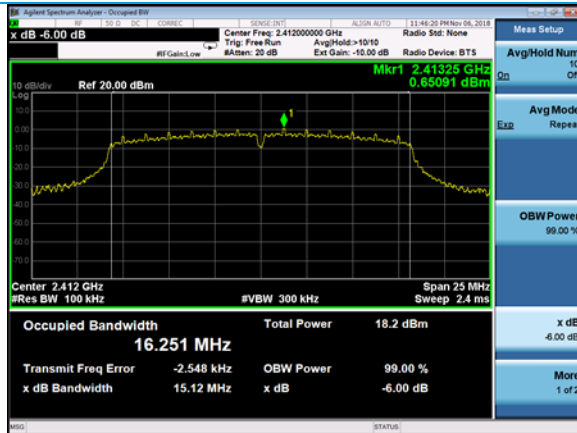


99% BW (Mid)

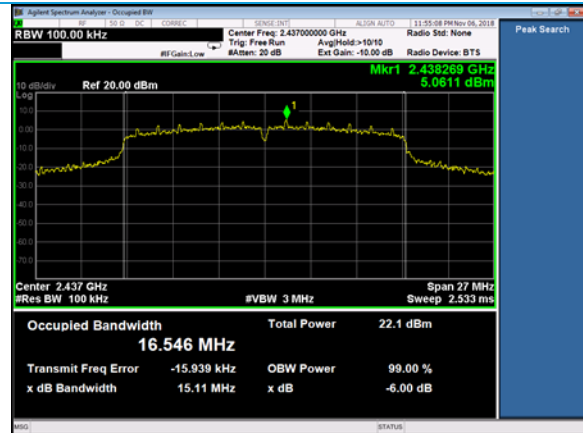


99% BW (High)

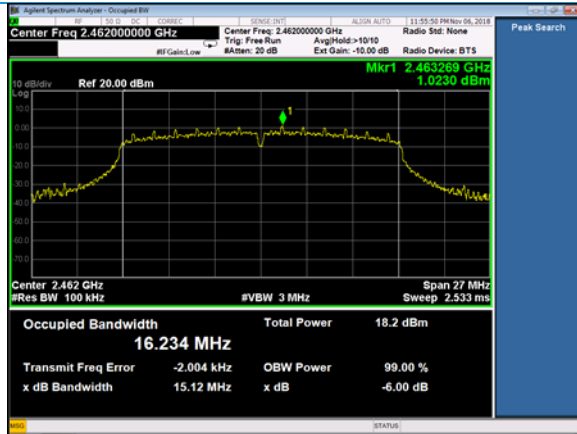
6 MBPS



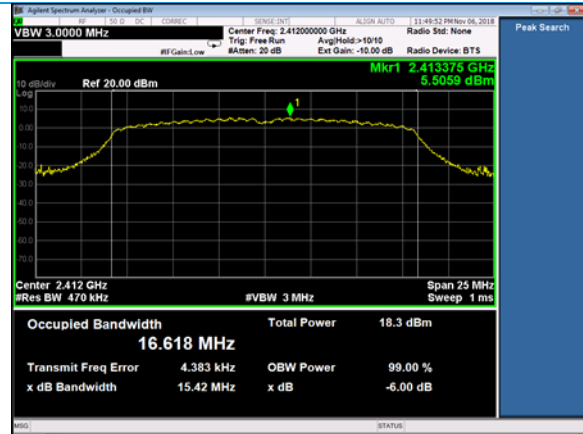
DTS BW (Low)



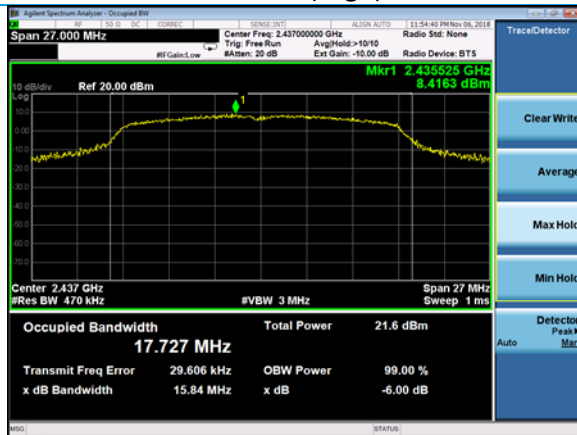
DTS BW (Mid)



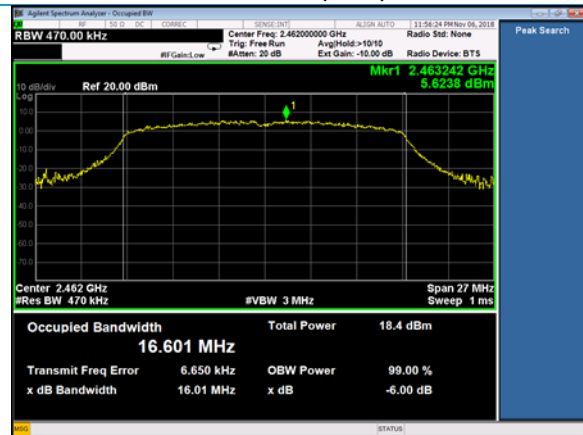
DTS BW (High)



99% BW (Low)

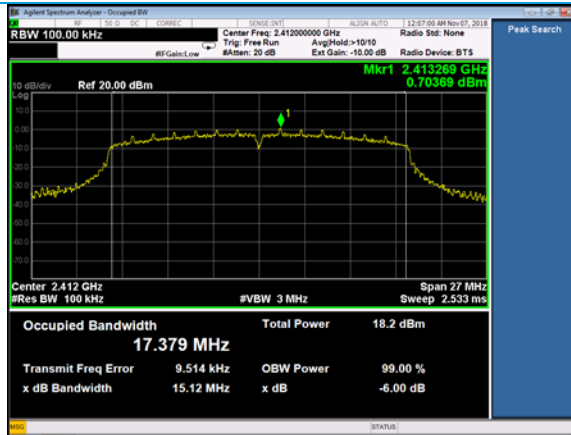


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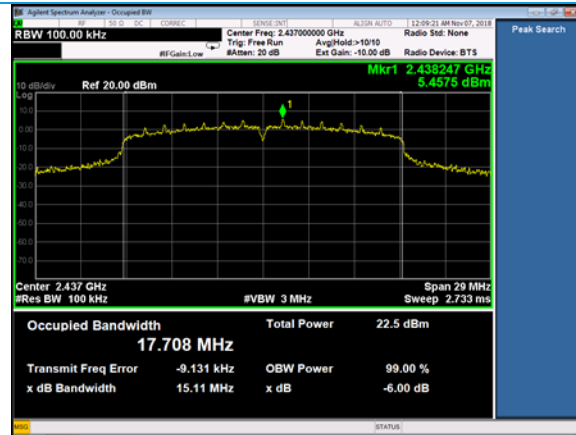


99% BW (High)

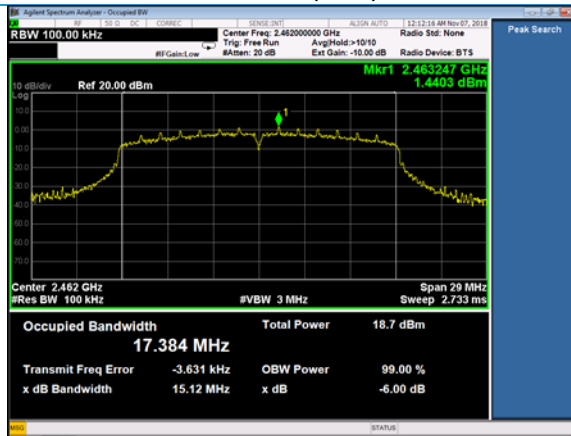
MCS0



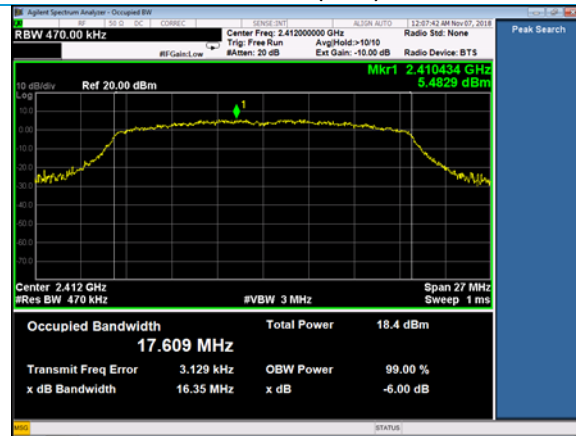
DTS BW (Low)



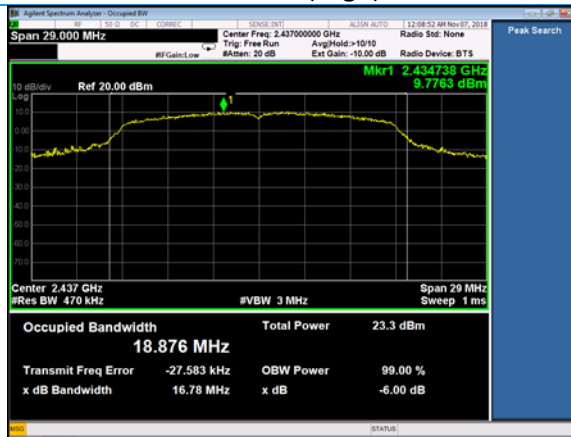
DTS BW (Mid)



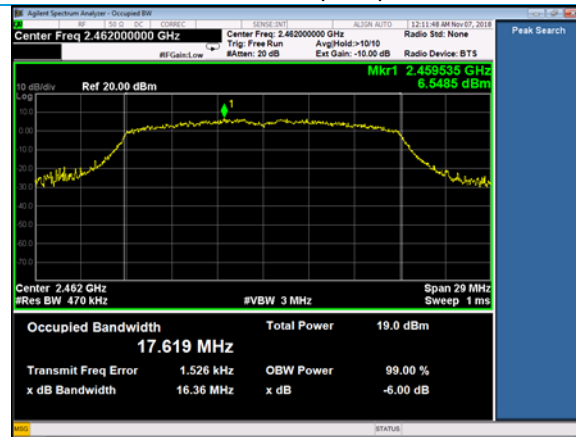
DTS BW (High)



99% BW (Low)

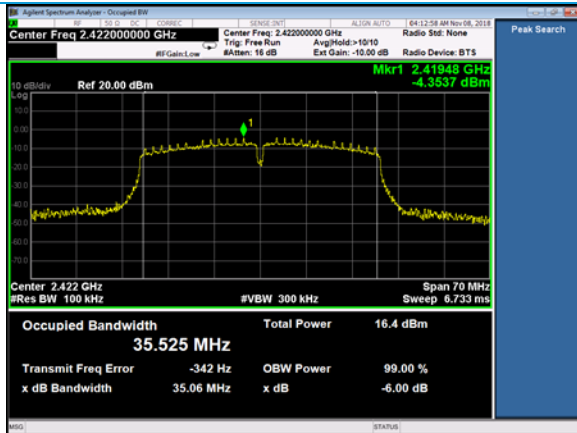


99% BW (Mid)

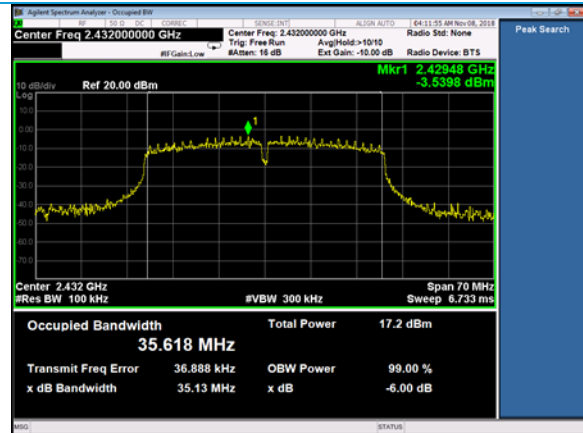


99% BW (High)

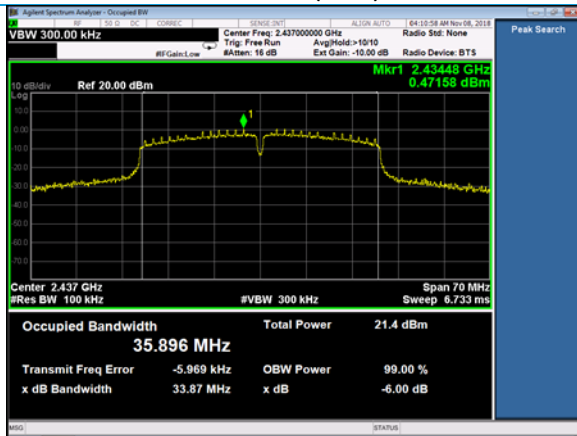
MCS0 HT40



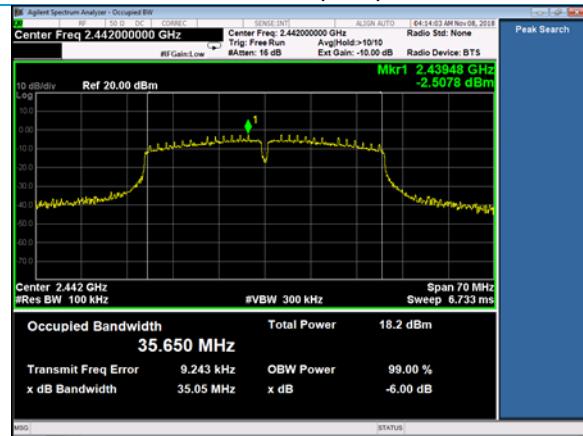
DTS BW (Low)



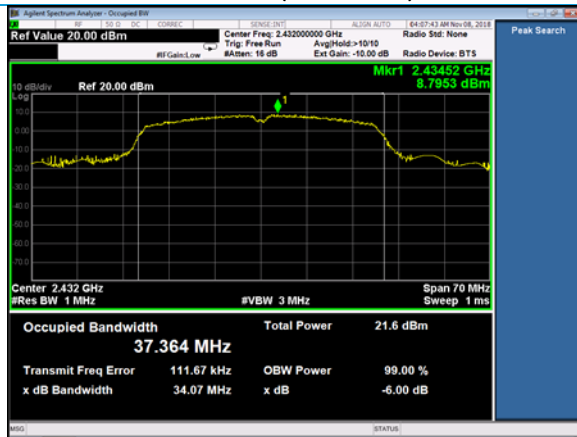
DTS BW (Mid)



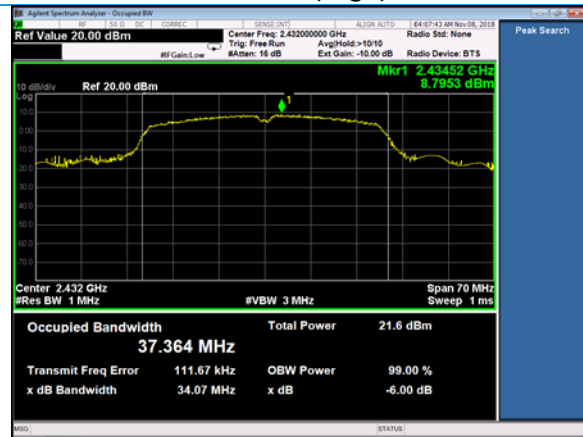
DTS BW (2437 MHz)



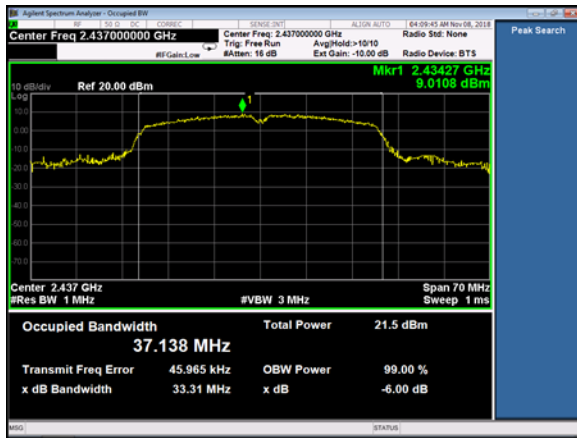
DTS BW (High)



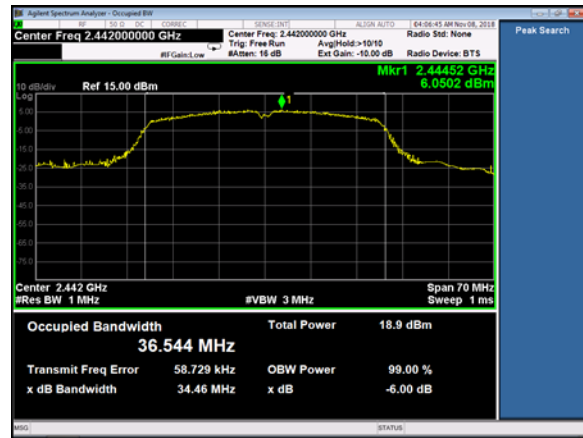
99% BW (Low)



99% BW (Mid)



99% BW (2437 MHz)



99% BW (High)

5.1.2 Antenna Port Conducted Emissions – Conducted Output Power

Operator	Shane Dock
Test Date	11/2/18 – 11/8/18
Location	Conducted RF Area
Temp. / R.H.	70 degrees F/ 23% RH
Requirement	FCC: 15.247 (b)(3) IC: RSS-247 5.4 (d)
Method	ANSI C63.10 Section 11.9.2.2.4

Limits: (Measured as Average)

Maximum Conducted Output Power (dBm)	Maximum Conducted Output Power (watts)
30	1

Test Parameters

Frequency	2412-2462 MHz
Settings	Low, Mid, and High Channels Measured
Notes	All power values corrected by $10 \log(1/x)$, where x is the duty cycle expressed as a decimal between 0 and 1. For example, with a duty cycle of 87%, this would be a correction of $10 \log(1/0.87)$.

Table

1 MBPS

Channel	Low	Mid	High
Output Power (dBm)	13.2	13.3	13.9
Duty Cycle (%)	91.6	91.6	91.6
Corrected Output Power (dBm)	13.6	13.7	14.3

6 MBPS

Channel	Low	Mid	High
Output Power (dBm)	9.3	13.4	10.6
Duty Cycle (%)	96.0	96.0	96.0
Corrected Output Power (dBm)	9.5	13.6	10.8

MCS0

Channel	Low	Mid	High
Output Power (dBm)	10.2	14.3	10.8
Duty Cycle (%)	93.7	93.7	93.7
Corrected Output Power (dBm)	10.5	14.6	11.1

11 MBPS

Channel	Low	Mid	High
Output Power (dBm)	11.5	12.6	12.9
Duty Cycle (%)	73.3	73.3	73.3
Corrected Output Power (dBm)	12.8	13.9	14.2

54 MBPS

Channel	Low	Mid	High
Output Power (dBm)	5.5	6.2	6.2
Duty Cycle (%)	57.6	57.6	57.6
Corrected Output Power (dBm)	7.9	8.6	8.6

MCS7

Channel	Low	Mid	High
Output Power (dBm)	5.5	6.2	6.2
Duty Cycle (%)	32.1	32.1	32.1
Corrected Output Power (dBm)	10.4	11.1	11.1

HT40 MCS0

Channel	Low	Mid	2437 MHz	High
Output Power (dBm)	6.4	10.8	11.1	8.3
Duty Cycle (%)	60.5	60.5	60.5	60.5
Corrected Output Power (dBm)	8.6	13.0	13.3	10.5

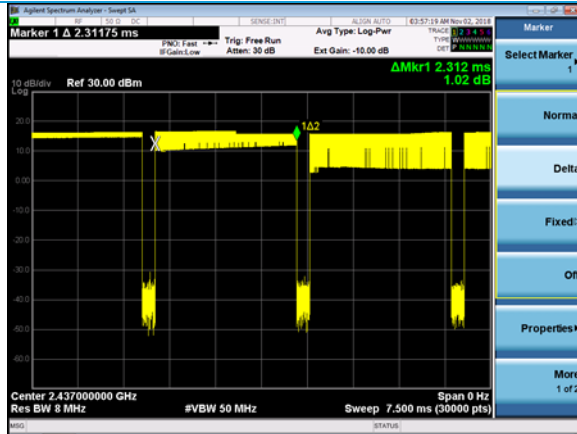
HT40 MCS7

Channel	Low	Mid	High
Output Power (dBm)	2.2	3.4	3.3
Duty Cycle (%)	24.3	24.3	24.3
Corrected Output Power (dBm)	8.3	9.5	9.4

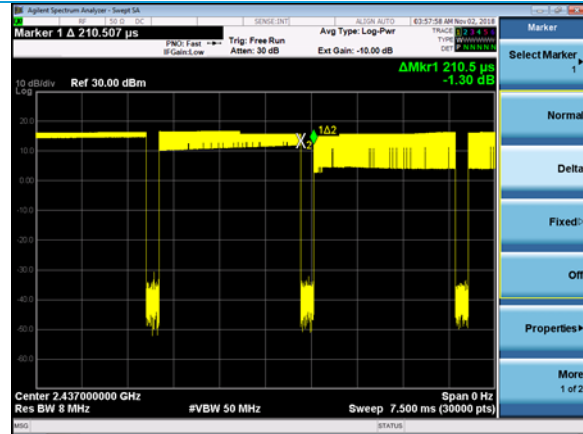
Worst Case Margin = Limit - Closest Measurement = 30.0 dBm – 14.6 dBm = 15.4 dB

Plots begin on the next page.

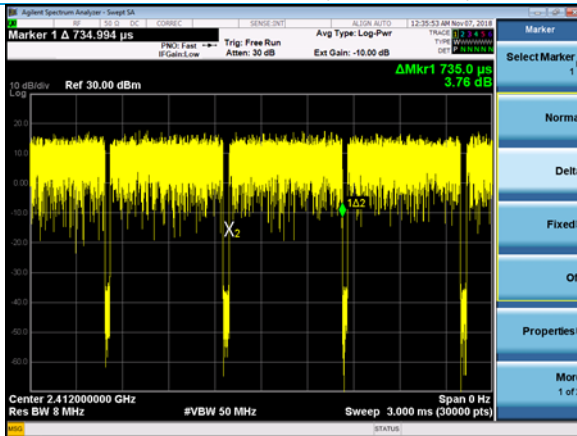
Duty Cycle



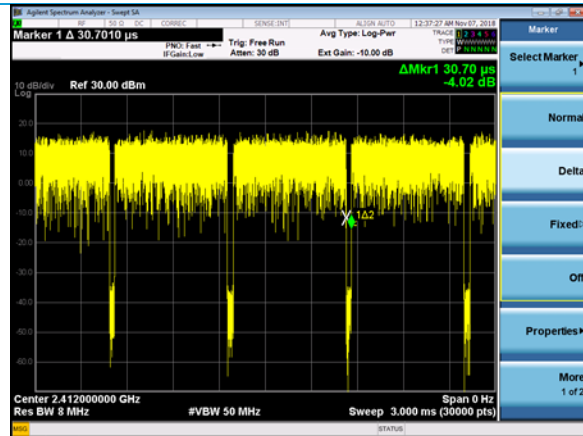
1 MBPS On Time (DC = 91.6%)



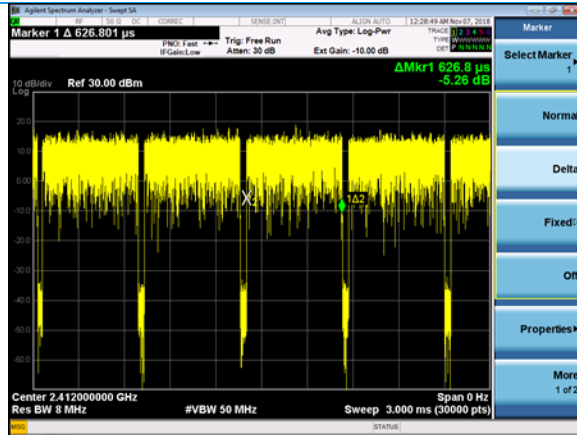
1 MBPS Off Time



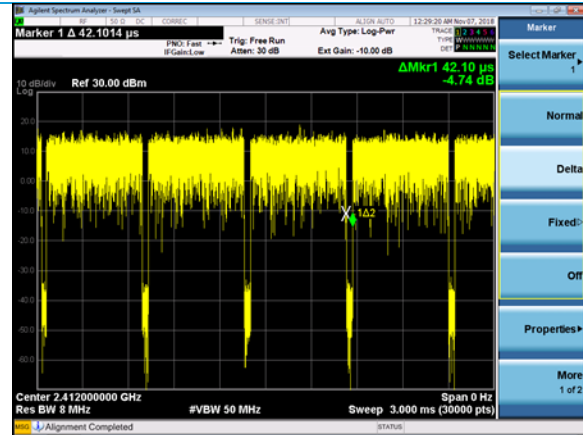
6 MBPS On Time (DC = 96.0%)



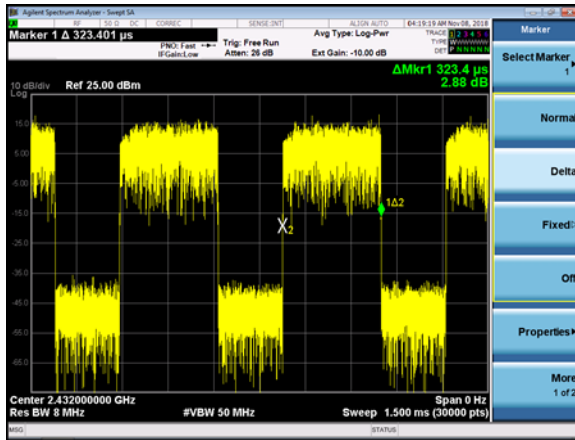
6 MBPS Off Time



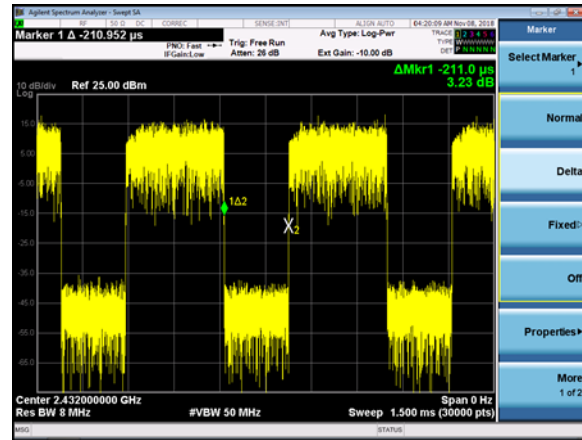
MCS0 On Time (DC = 93.7%)



MCS0 Off Time

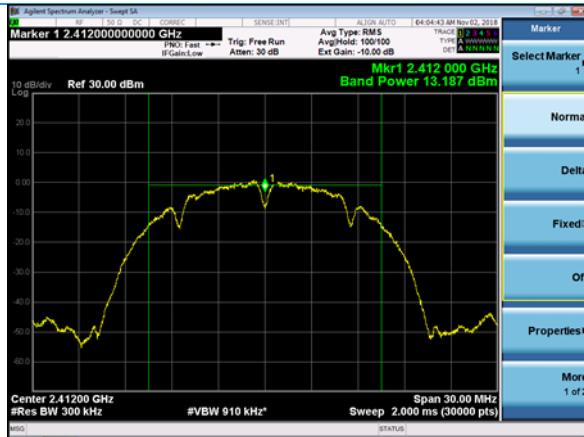


HT40 MCS0 On Time (DC = 60.5%)

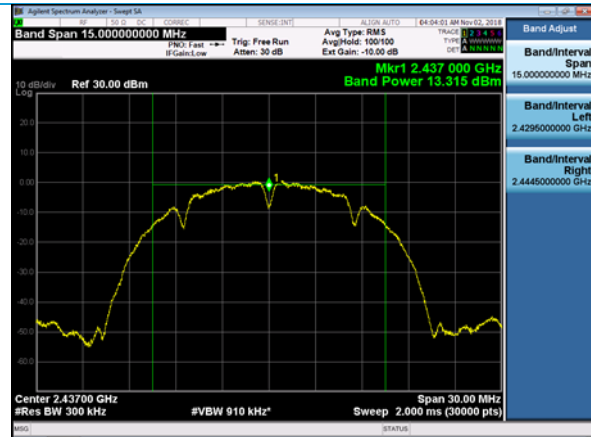


HT40 MCS0 Off Time

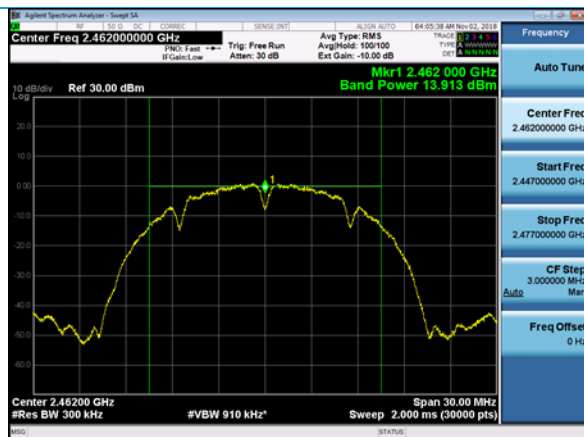
1 MBPS



Low Channel

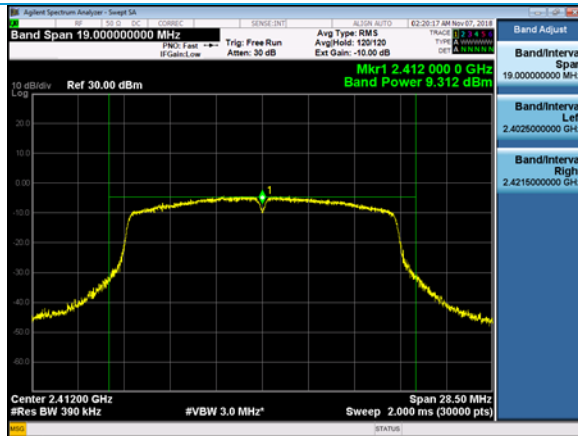


Mid Channel

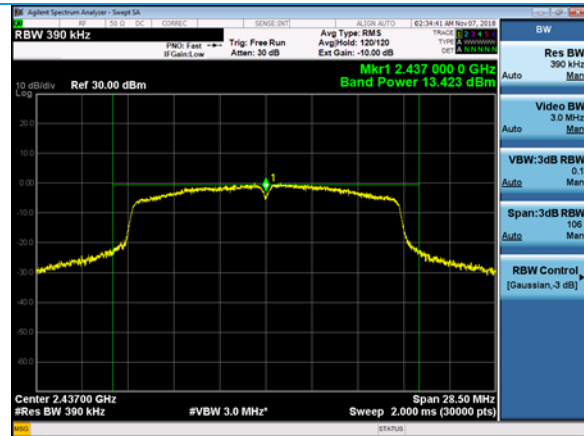


High Channel

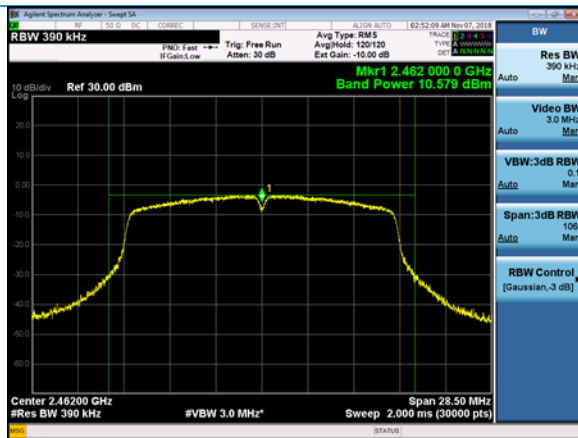
6 MBPS



Low Channel

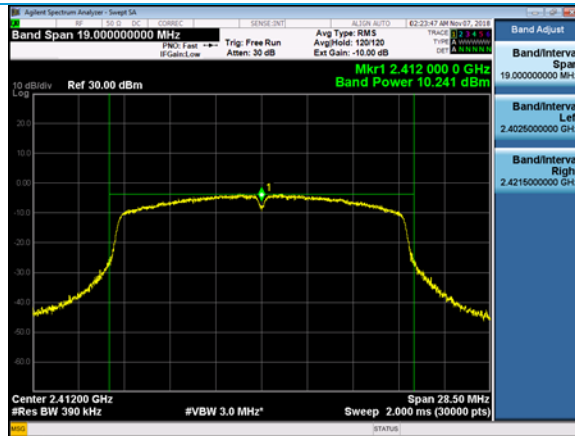


Mid Channel

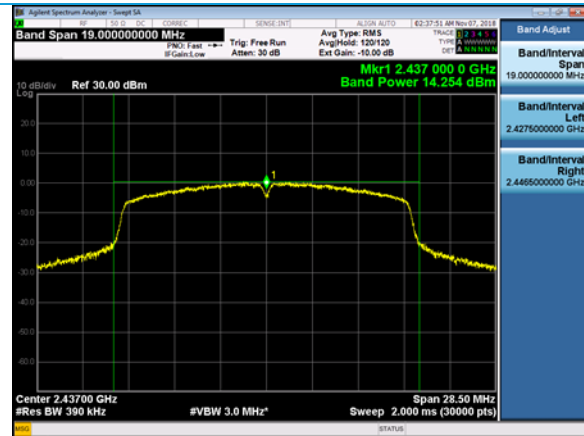


High Channel

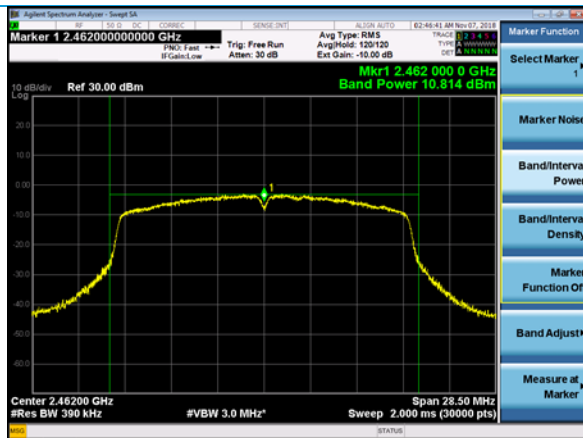
MCS0



Low Channel

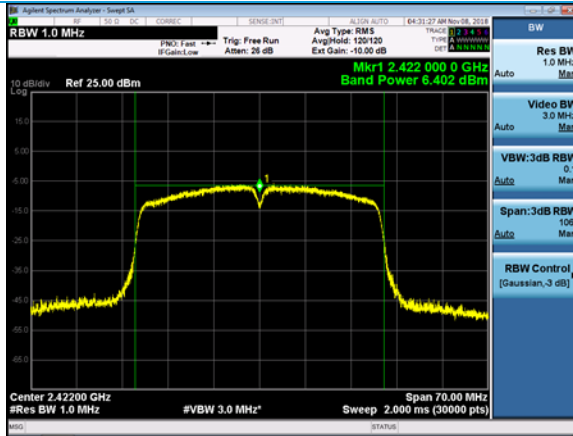


Mid Channel

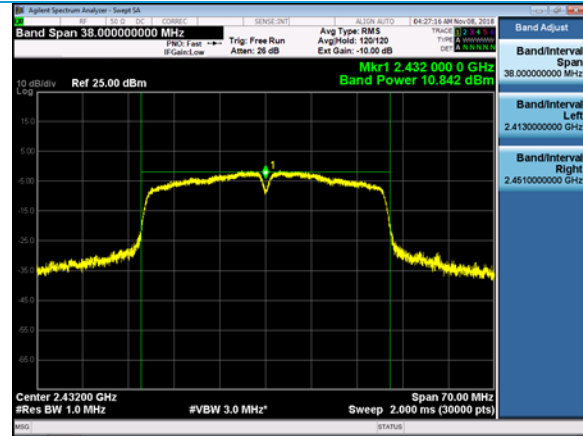


High Channel

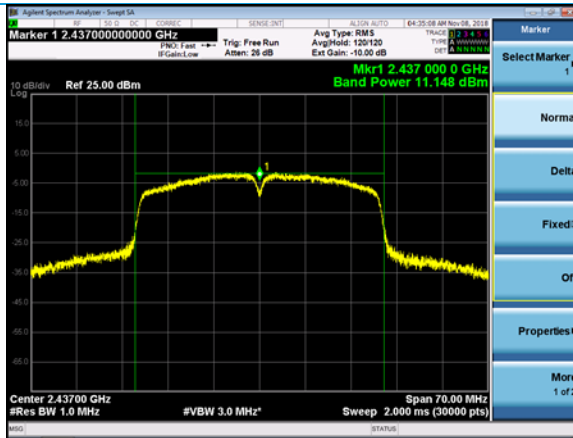
HT40 MCS0



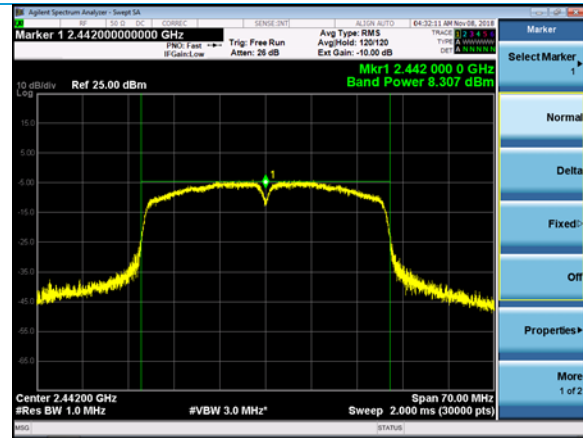
Low Channel



Mid Channel



2437 MHz



High Channel

5.1.3 Antenna Port Conducted Emissions – Power Spectral Density

Operator	Shane Dock
Test Date	11/7/18 – 11/8/18
Location	Conducted RF Area
Temp. / R.H.	70 degrees F/ 23% RH
Requirement	FCC: 15.247 (e) IC: RSS-247 5.2 (b)
Method	ANSI C63.10 Section 11.10.5

Limits:

Power Spectral Density (dBm/ 3 kHz)
8

Test Parameters

Frequency	2412-2462 MHz
Settings	Low, Mid, and High Channels Measured
Notes	All power values corrected by $10 \log(1/x)$, where x is the duty cycle expressed as a decimal between 0 and 1. For example, with a duty cycle of 87%, this would be a correction of $10 \log(1/0.87)$.

Table

1 MBPS

Channel	Low	Mid	High
PSD (dBm)	-3.9	-3.4	-3.4
Duty Cycle (%)	91.6	91.6	91.6
Corrected PSD (dBm)	-3.5	-3.0	-3.0

6 MBPS

Channel	Low	Mid	High
PSD (dBm)	-9.1	-5.3	-8.3
Duty Cycle (%)	96.0	96.0	96.0
Corrected PSD (dBm)	-8.9	-5.1	-8.1

MCS0

Channel	Low	Mid	High
PSD (dBm)	-8.8	-4.8	-8.3
Duty Cycle (%)	93.7	93.7	93.7
Corrected PSD (dBm)	-8.5	-4.5	-8.0

11 MBPS

Channel	Low	Mid	High
PSD (dBm)	-5.3	-5.4	-4.7
Duty Cycle (%)	73.3	73.3	73.3
Corrected PSD (dBm)	-4.0	-4.1	-3.3

54 MBPS

Channel	Low	Mid	High
PSD (dBm)	-10.1	-8.4	-9.0
Duty Cycle (%)	57.6	57.6	57.6
Corrected PSD (dBm)	-7.9	-6.2	-6.8

MCS7

Channel	Low	Mid	High
PSD (dBm)	-10.0	-9.9	-10.3
Duty Cycle (%)	32.1	32.1	32.1
Corrected PSD (dBm)	-5.1	-5.0	-5.4

HT40 MCS0

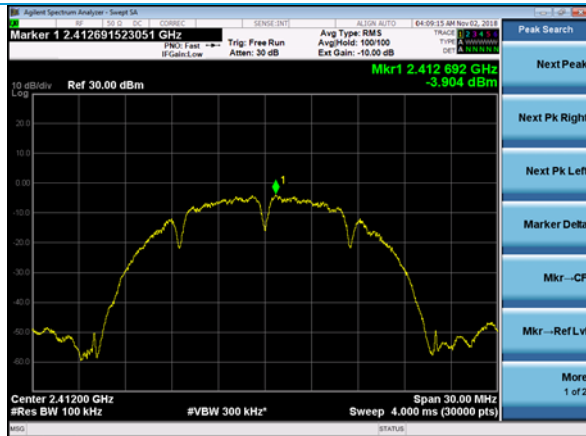
Channel	Low	Mid	2437 MHz	High
PSD (dBm)	-14.8	-10.5	-9.6	-13.0
Duty Cycle (%)	60.5	60.5	60.5	60.5
Corrected PSD (dBm)	-12.6	-8.3	-7.4	-10.8

HT40 MCS7

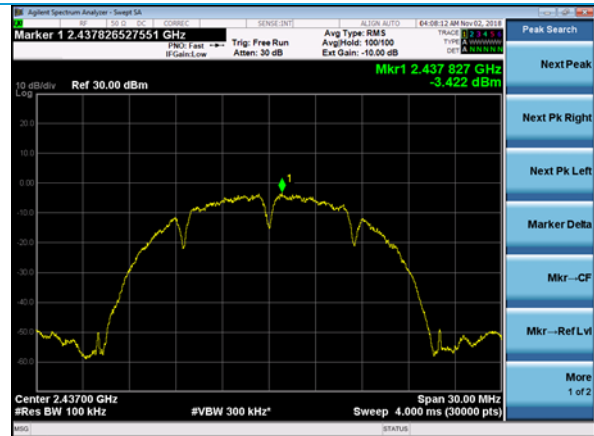
Channel	Low	Mid	High
PSD (dBm)	-16.3	-14.2	-13.8
Duty Cycle (%)	24.3	24.3	24.3
Corrected PSD (dBm)	-10.2	-8.1	-7.7

Worst Case Margin = Limit - Closest Measurement = 8 dBm – (-3.0 dBm) = 11.0 dB

1 MBPS



Low Channel

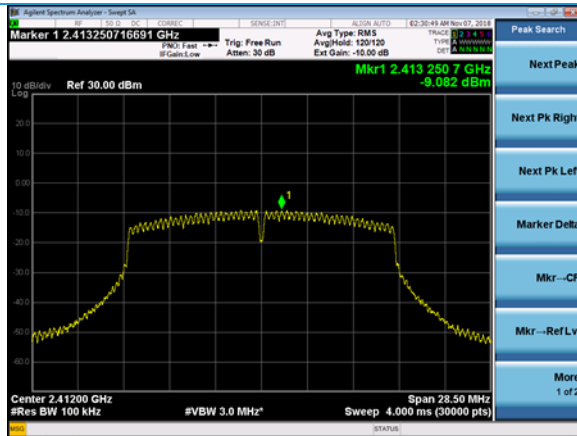


Mid Channel

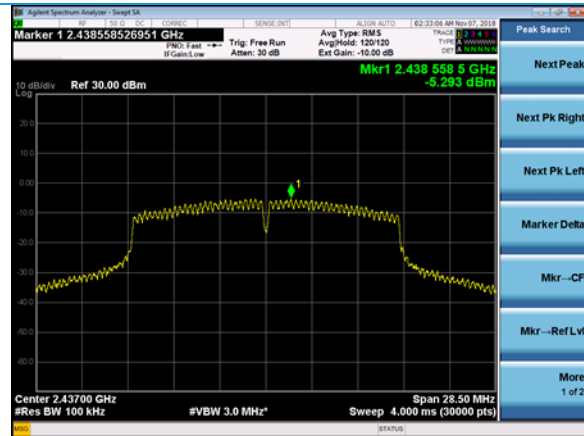


High Channel

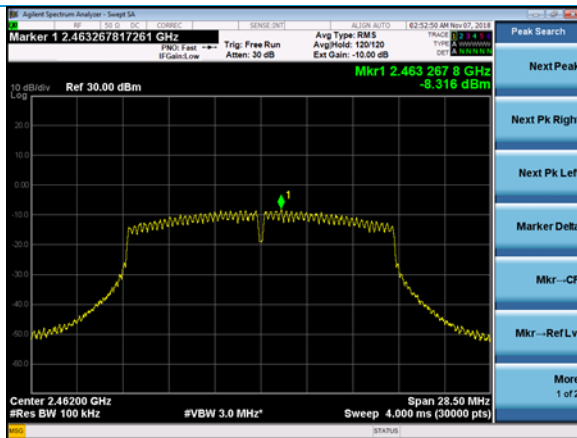
6 MBPS



Low Channel

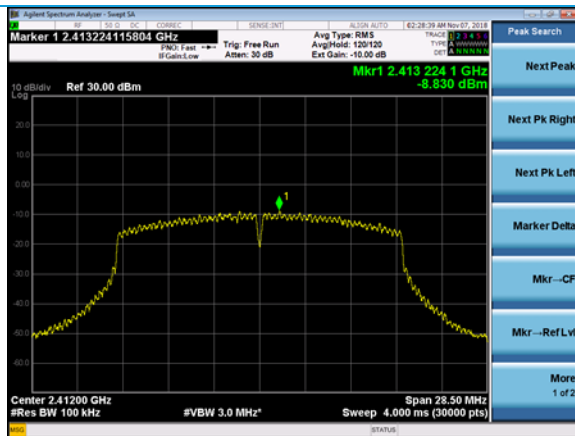


Mid Channel

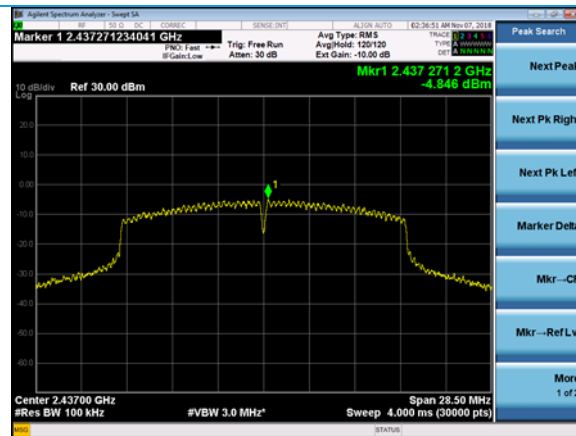


High Channel

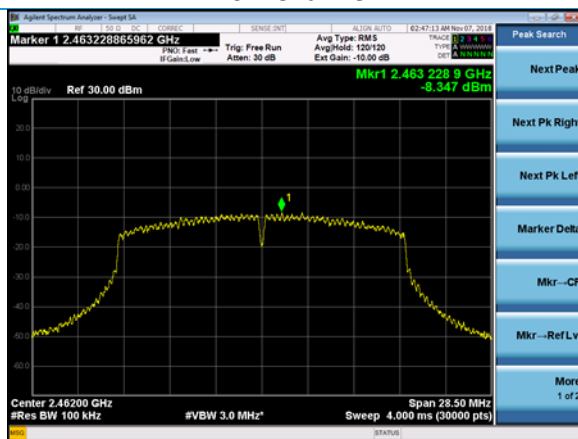
MCS0



Low Channel

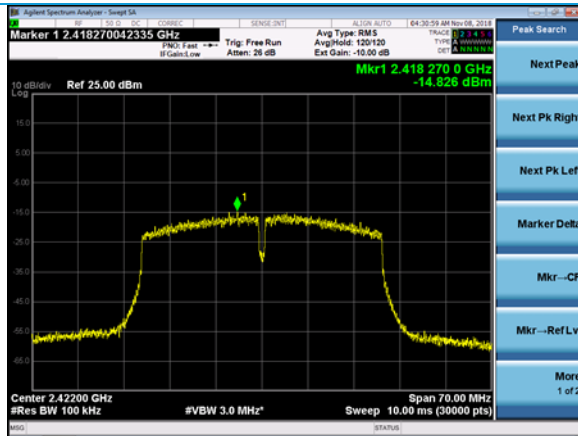


Mid Channel

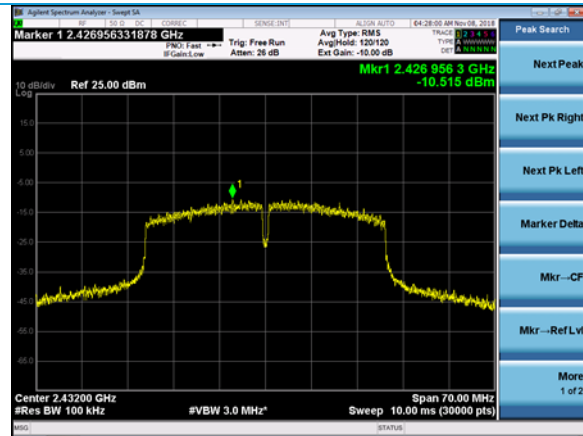


High Channel

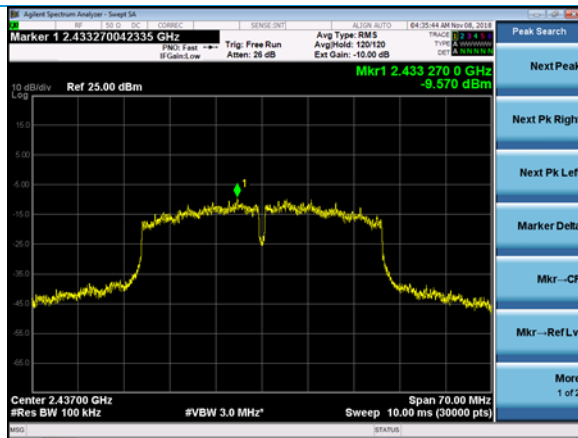
HT40 MCS0



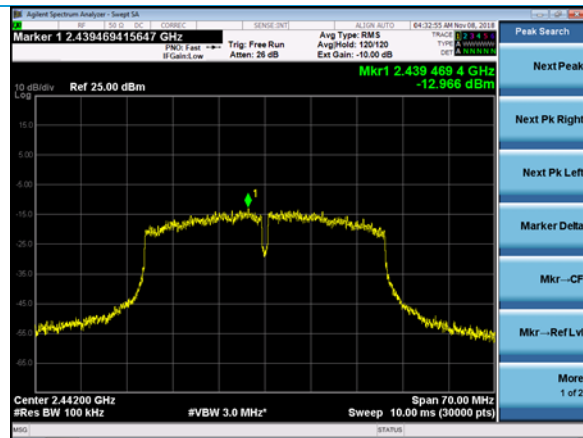
Low Channel



Mid Channel



2437 MHz



High Channel

5.1.4 Antenna Port Conducted Emissions – Tx Conducted Spurious

Operator	Shane Dock
Test Date	11/7/18 – 11/8/18
Location	Conducted RF Area
Temp. / R.H.	70 degrees F/ 23% RH
Requirement	FCC: 15.247 (d) IC: RSS-247 5.5
Method	ANSI C63.10 Section 11.11

Limits:

Spurious Emissions Limit (dBc from Reference Point)
30

Test Parameters

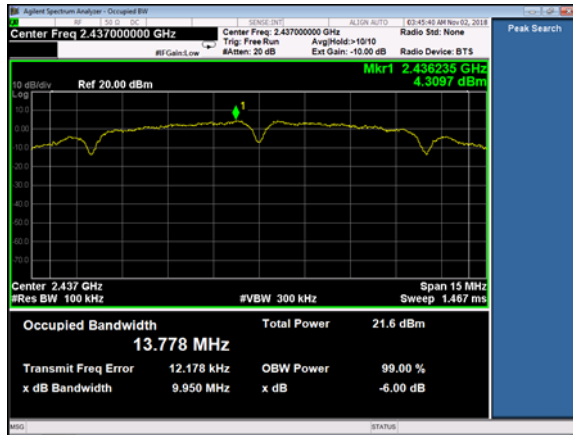
Frequency	30-25000 MHz
Settings	100kHz RBW/ 300kHz VBW
EUT	Low, Mid, High Checked at Max and Min Power
Note	Reference Levels derived from DTS Bandwidth screenshots from the highest PSD channel for their respective levels. Display lines on plots do not represent limit lines.

Table (Worst Case Emissions reported below for each data rate)

Data Rate	Frequency (MHz)	Peak Measurement (dBm)	Peak Limit (dBm)	Peak Margin (dB)
1 MBPS	2396.8	-40.9	-25.7	15.2
6 MBPS	2399.5	-30.1	-24.9	5.2
MCS0	2399.2	-31.9	-24.5	7.4
11 MBPS	2399.9	-40.1	-23.6	16.5
54 MBPS	2400.0	-35.7	-27.7	8.0
MCS7	2399.5	-33.9	-28.1	5.8
HT40 MCS0	2394.2	-42.4	-29.5	12.9
HT40 MCS7	2399.8	-39.4	-33.5	5.9

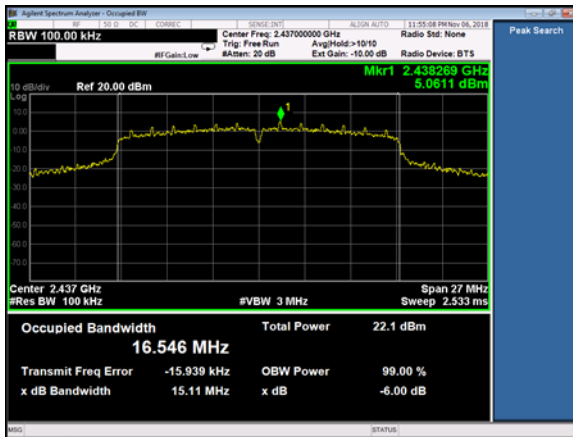
Plots (Worst Case for each mode)

1 MBPS Limit at 4.3 dBm – 30.0 dB = -25.7 dBm



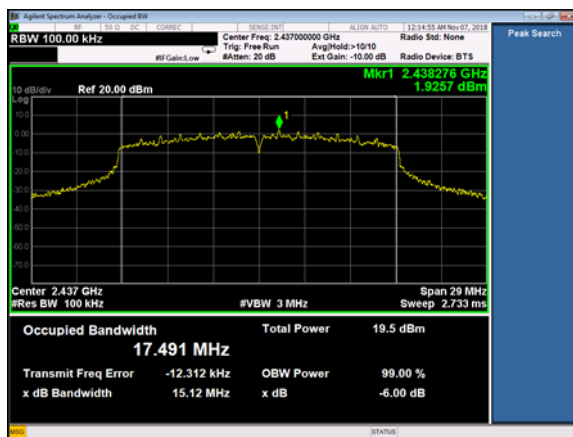
Mid Channel

6 MBPS Limit at -5.1 dBm – 30.0 dB = -35.1 dBm



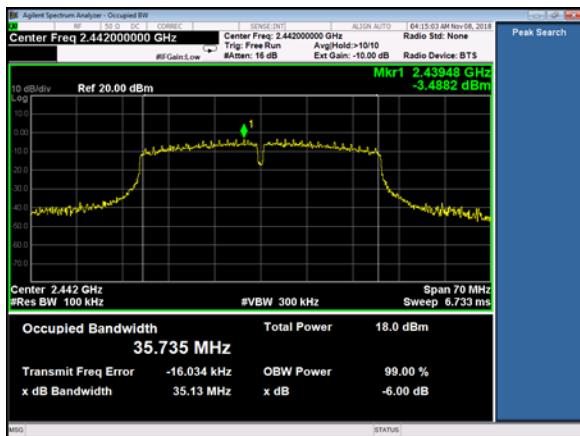
Mid Channel

MCS7 Limit at 1.9 dBm – 30.0 dB = -28.1 dBm



Mid Channel

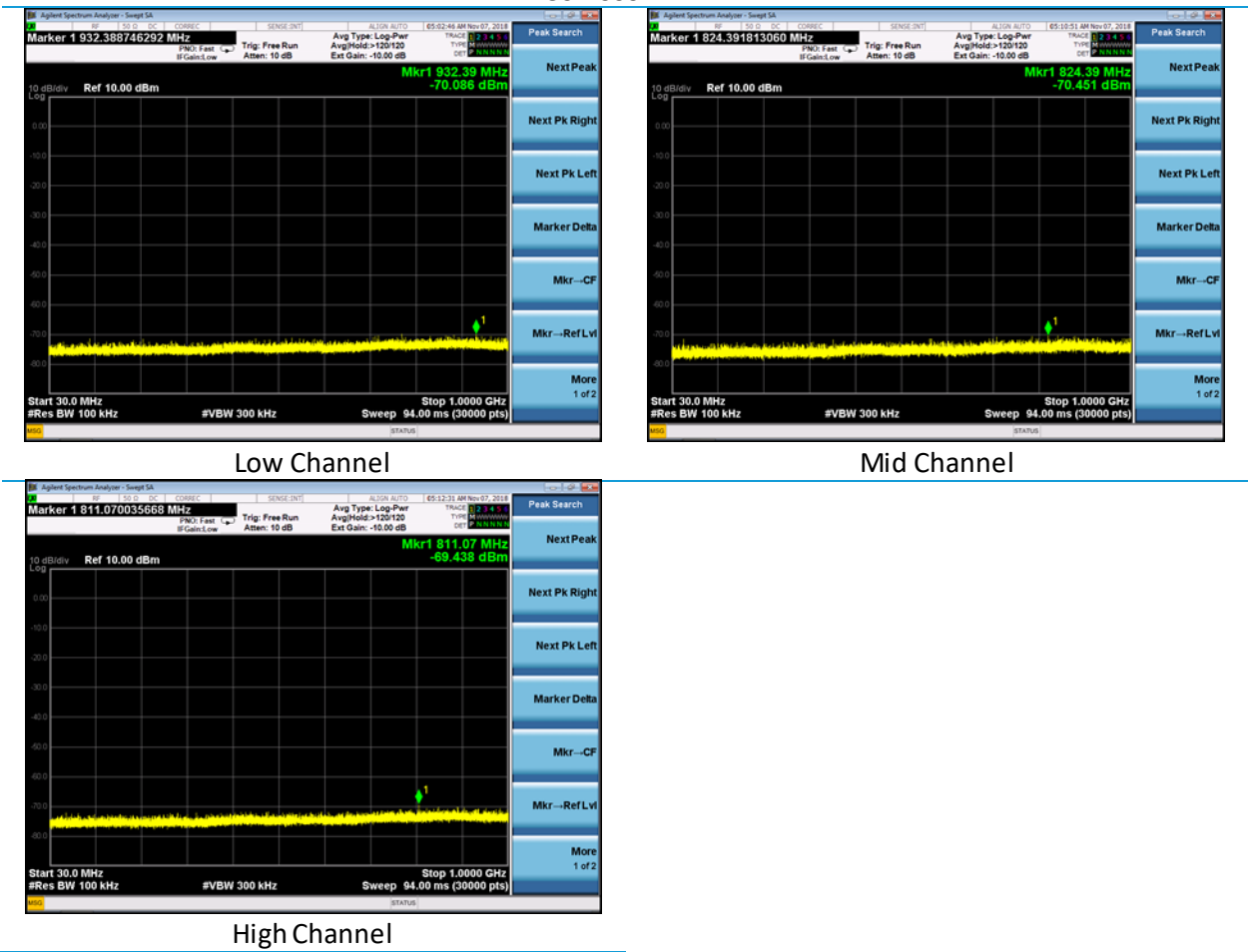
HT40 MCS7 Limit at -3.5 dBm – 30.0 dB = -33.5 dBm



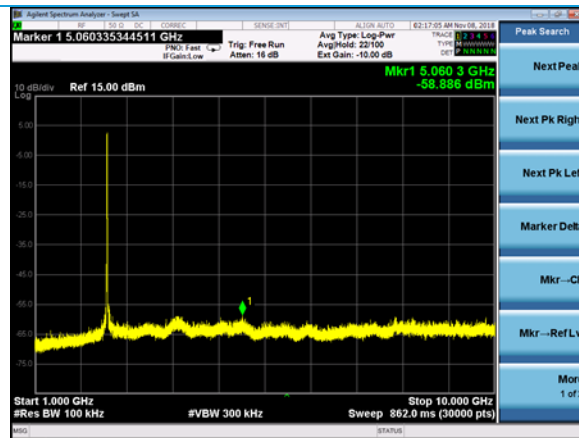
High Channel

1 MBPS

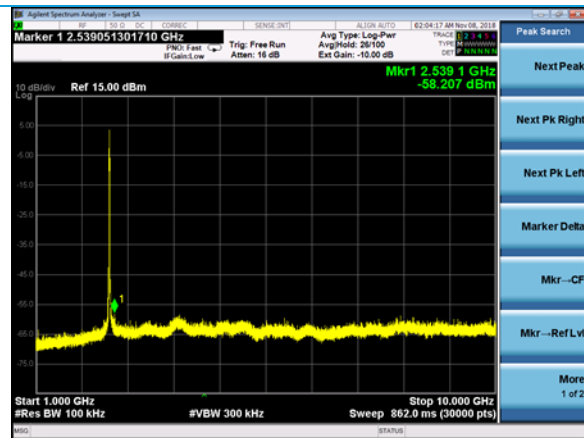
30-1000 MHz



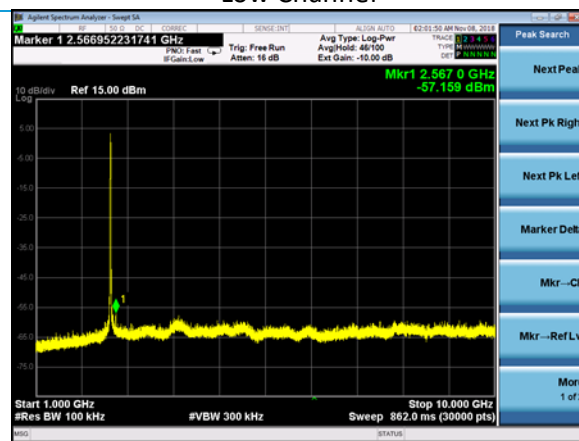
1000-10000 MHz



Low Channel

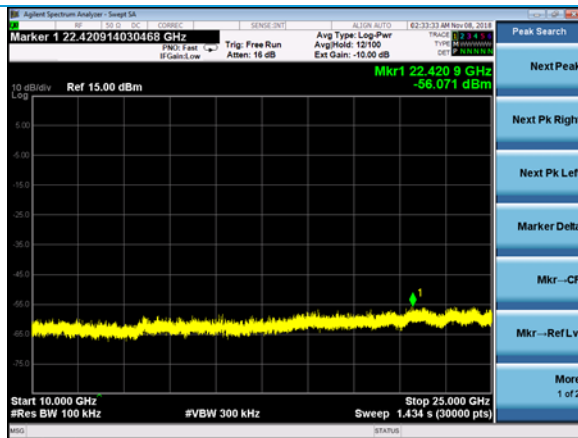


Mid Channel

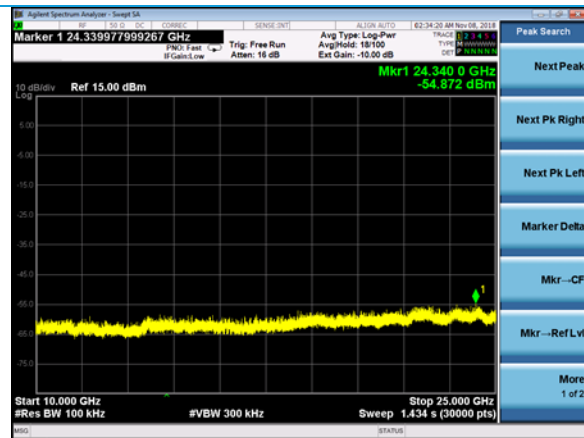


High Channel

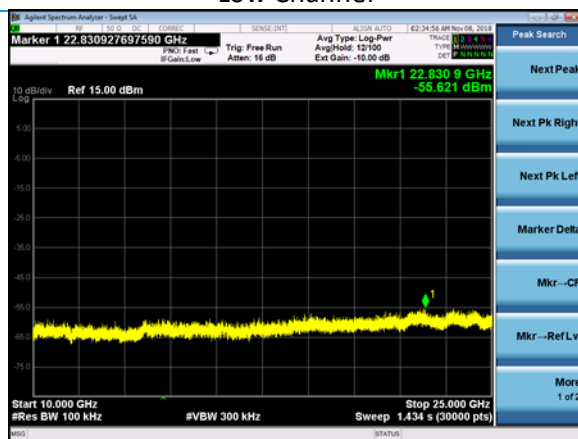
10000-25000 MHz



Low Channel

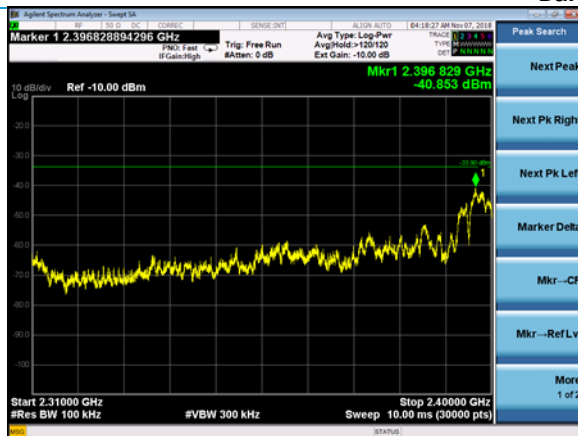


Mid Channel

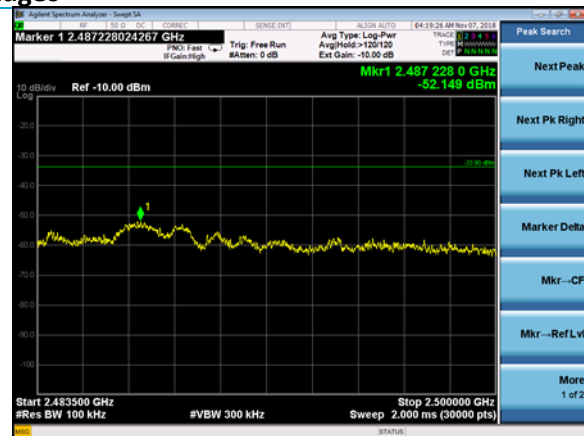


High Channel

Band Edges



Low Channel



High Channel