

TEST REPORT

ACCORDING TO: FCC 47 CFR part 15 section 15.255:2017

FOR:

Siklu Communication Ltd.

**Point-to-point wireless Ethernet link
operating in 57-71 GHz**

Models: EH-600T-ODU-PoE

EH-600TX-ODU-PoE

EH-600TL-ODU-PoE

FCC ID:2ACYESK-60GTDD-B1

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1 Applicant information

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Telephone: +972 3921 4015
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Contact name: Mr. Baruch Schwarz

2 Equipment under test attributes

Product name: Point-to-point wireless Ethernet link operating at 57-71 GHz
Product type: Transceiver
Model(s): EH-600T-ODU-PoE
Serial number: S810000100
Hardware version: D0
Software release: 7.5
Receipt date: 05-Dec-17

3 Manufacturer information

Manufacturer name: Siklu Communication Ltd.
Address: 43 Hasivim street, Petach-Tikva 49517, Israel
Telephone: +972 3921 4015
Fax: +972 3921 4162
E-Mail: baruch@siklu.com
Contact name: Mr. Baruch Schwarz

4 Test details

Project ID: 30351
Location: Hermon Laboratories Ltd. P.O. Box 23, Binyamina 3055001, Israel
Test started: 05-Dec-17
Test completed: 22-Jan-18
Test specification(s): FCC 47 CFR part 15 section 15.255:2017

5 Tests summary

Test	Status
Transmitter characteristics	
FCC Section 15.255(c)(ii), Transmitter power and power spectral density	Pass
FCC Section 15.215(c), Occupied bandwidth	Pass
FCC Section 15.255(d)(2), Radiated spurious emissions below 40 GHz	Pass
FCC Section 15.255(d)(3), Radiated emissions outside assigned band and above 40 GHz up to 200 GHz	Pass
FCC Section 15.255(f), Frequency tolerance	Tested without limit
FCC Section 15.255(g), RF exposure	Pass, exhibit included in Application for certification

The product was approved under FCC ID:2ACYESK-60GTDD-B1 for operation in 57 – 64 GHz band. The relevant tests were done to support operation in 57 – 71 GHz band in accordance with FCC 47CFR part 15:2017 and submit Application for Class II permissive changes certification.

The change is software controlled, no hardware change was made.

This test report supersedes the previously issued test report identified by Doc ID:SIKRAD_FCC.30351.

The test results relate only to the items tested. Pass/ fail decision was based on nominal values.

	Name and Title	Date	Signature
Tested by:	Mr. S. Samokha, test engineer Mr. K. Zushchuk, test engineer	January 22, 2018	 
Reviewed by:	Mrs. M. Cherniavsky, certification engineer	February 8 , 2018	
Approved by:	Mr. M. Nikishin, EMC and Radio group manager	March 26, 2018	

6 EUT description

6.1 General information

The EUT is an outdoor unit of point-to-point high BW system, the first TDD member of Siklu's EtherHaul family of wireless products, featuring carrier grade, high capacity Ethernet with flexible support of the 57-71 GHz regulated V-Band. The EUT radio supports up to 1 Gbps.

Siklu's EtherHaul EH-600T Rev D0 wireless backhaul radio link operates in the new E-band spectrum, which has clear technological and economical advantages over the existing lower frequency bands.

The EtherHaul EH-600T Rev D0 system comprises:

- the EtherHaul EH-600T-ODU-POE outdoor unit (radio link unit and antenna);
- the EtherHaul system host software and command line interface for complete and flexible system configuration, administration and management.

During the testing the EUT system was powered by 48 VDC.

6.2 Ports and lines

Port type	Port description	Connected from	Connected to	Qty.	Cable type	Cable length, m
Telecom	Ethernet-POE	EUT ETH1	POE/POH	1	Shielded	2
Telecom	Ethernet-PSE	EUT ETH2	Open circuit	1	Shielded	2
Telecom	Ethernet-PSE	EUT ETH3	Open circuit	1	Shielded	2

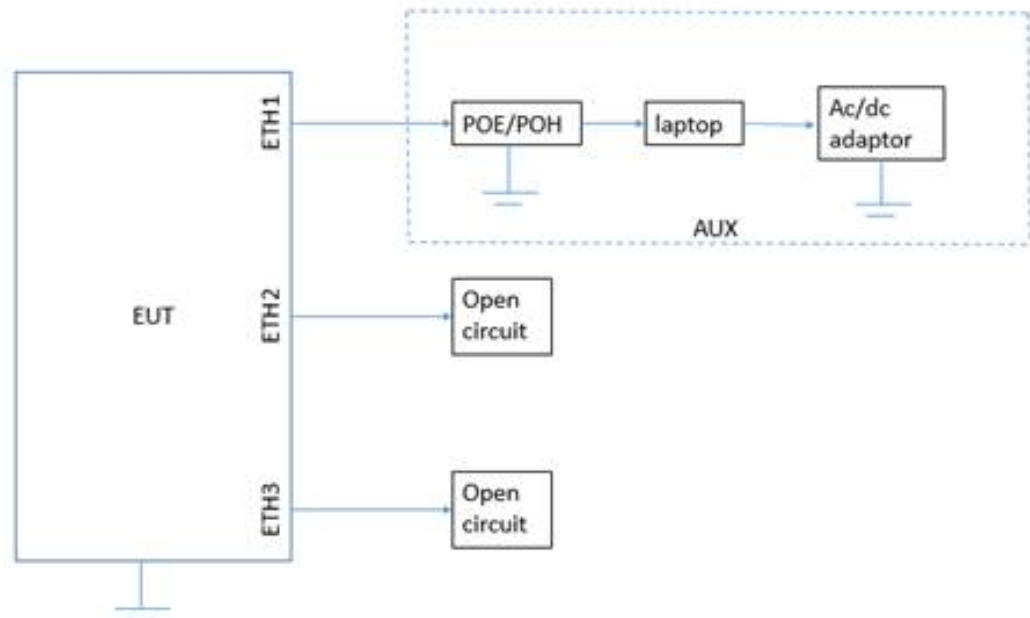
6.3 Support and test equipment

Description	Manufacturer	Model number	Serial number
Test generator MetroExpert	VeEX.Inc.	VE PAL MX300	TM4B02KA810633
Laptop	IBM	ThinkPad 1874	L3-ADLL8
POE	Power Dsine Microsemi	9001G-40/SP rev.B	11226519000962A01
AC/DC Adapter	Mean Well	PLC 60-48	7203369

6.4 Changes made in the EUT

No changes were performed in the EUT during testing.

6.5 Test configuration



6.6 Transmitter characteristics

Type of equipment				
V	Stand-alone (Equipment with or without its own control provisions)			
	Combined equipment (Equipment where the radio part is fully integrated within another type of equipment)			
	Plug-in card (Equipment intended for a variety of host systems)			
Intended use		Condition of use		
V	fixed	Always at a distance more than 2 m from all people		
	mobile	Always at a distance more than 20 cm from all people		
	portable	May operate at a distance closer than 20 cm to human body		
Assigned frequency range		57.0 GHz – 71.0 GHz		
Operating frequencies (tested)		69875 MHz		
Maximum rated output power		At transmitter 50 Ω RF output connector		7.05 dBm
Is transmitter output power variable?		V No		
		Yes	continuous variable	
			stepped variable with stepsize dB	
			minimum RF power dBm	
			maximum RF power	
Antenna connection				
unique coupling	V	standard connector	Integral	with temporary RF connector without temporary RF connector
Antenna/s technical characteristics				
Type	Manufacturer		Model number	Gain
Integrated (cassegain reflector)	Siklu Ltd.		GENT006	37 dBi
Transmitter 99% power bandwidth, MHz		Transmitter aggregate data rate/s, Mbps		Type of modulation
250		80		QPSK
500		160		QPSK
500		852		16QAM
500		1280		64QAM
Type of multiplexing		TDD		
Transmitter power source				
		Nominal rated voltage	Battery type	
V	DC	Nominal rated voltage	48 V	
		Voltage range	POE 42-57 V	
	AC mains	Nominal rated voltage	Frequency	
Common power source for transmitter and receiver		V	yes	no



Test specification: Section 15.255(c)(ii), Transmitter power and power spectral density			
Test procedure: 47 CFR, Section 2.1046; Section 15.255(b); ANSI C63.10, Section 9.11			
Test mode: Compliance		Verdict: PASS	
Date(s): 11-Jan-18			
Temperature: 25 °C	Relative Humidity: 44 %	Air Pressure: 1012 hPa	Power: 48 VDC
Remarks:			

7 Transmitter tests

7.1 Transmitter power test

7.1.1 General

This test was performed to measure the peak output power at RF antenna connector. Specification test limits are given in Table 7.1.1.

Table 7.1.1 Conducted output power limits

Assigned frequency range, MHz	Maximum output power			
	Peak output power		EIRP, dBm*	
	mW	dBm	Peak	Average
57000 – 71000	500	27.0	57	54

*EIRP limit was calculated as follows:

Average power: $82 \text{ dBm} - 2 \text{ dB} \times (51-37) = 54 \text{ dBm}$

Peak power: $85 \text{ dBm} - 2 \text{ dB} \times (51-37) = 57 \text{ dBm}$.

7.1.2 Test procedure

- 7.1.2.1 The EUT was set up as shown in Figure 7.1.1, energized and its proper operation was checked.
- 7.1.2.2 The EUT was adjusted to produce maximum available for end user RF output power.
- 7.1.2.3 The average and peak voltage was measured at the high frequency with oscilloscope and provided in the associated plots.
- 7.1.2.4 The step 7.1.2.3 was repeated for all modulations and emissions bandwidth.
- 7.1.2.5 The unmodulated signal was applied to Zero-Biased Detector via variable attenuator as shown in Figure 7.1.2.
- 7.1.2.6 The variable attenuator was adjusted such that the oscilloscope indicated a voltage equal to the peak voltage recorded in the step 7.1.2.3.
- 7.1.2.7 The variable attenuator was disconnected from the Zero-Biased Detector.
- 7.1.2.8 Without changing any settings, the variable attenuator was connected to a power meter as shown in Figure 7.1.3.
- 7.1.2.9 The power was measured and result was recorded in Table 7.1.2 and Table 7.1.3.
- 7.1.2.10 The steps 7.1.2.5 through 7.1.2.10 were repeated for the average voltage recorded in the step 7.1.2.3 and 7.1.2.4.

Test specification:		Section 15.255(c)(ii), Transmitter power and power spectral density	
Test procedure:		47 CFR, Section 2.1046; Section 15.255(b); ANSI C63.10, Section 9.11	
Test mode:		Verdict: PASS	
Date(s):			
11-Jan-18			
Temperature: 25 °C	Relative Humidity: 44 %	Air Pressure: 1012 hPa	Power: 48 VDC
Remarks:			

Figure 7.1.1 Peak output power test setup

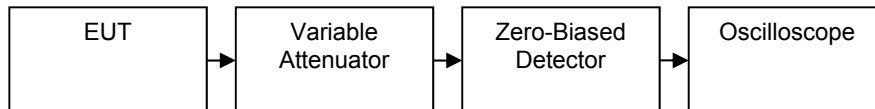


Figure 7.1.2 Peak output power test setup

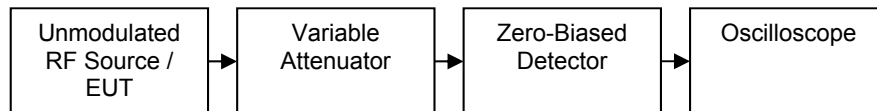
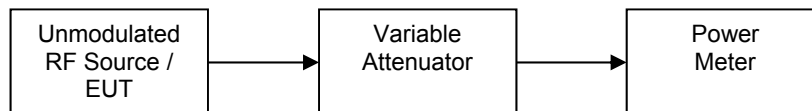


Figure 7.1.3 Peak output power test setup





Test specification: Section 15.255(c)(ii), Transmitter power and power spectral density			
Test procedure: 47 CFR, Section 2.1046; Section 15.255(b); ANSI C63.10, Section 9.11			
Test mode: Compliance		Verdict: PASS	
Date(s): 11-Jan-18			
Temperature: 25 °C	Relative Humidity: 44 %	Air Pressure: 1012 hPa	Power: 48 VDC
Remarks:			

Table 7.1.2 Peak output power test results

OPERATING FREQUENCY RANGE: 57.0 – 71.0 GHz
DETECTOR USED: Peak
VIDEO BANDWIDTH: >10 MHz
TRANSMITTER OUTPUT POWER SETTINGS: Maximum

Frequency, MHz	Modulation	Bit rate, Mbps	Duty Cycle, %	Peak output power, dBm	EIRP, dBm*	Limit, dBm	Margin, dB**	Verdict
69875	QPSK/250	80	100	7.05	44.05	57.00	-12.95	Pass
69875	QPSK/500	160	100	6.45	43.45	57.00	-13.55	Pass
69875	16QAM	852	100	6.38	43.38	57.00	-13.62	Pass
69875	64QAM	1280	100	6.30	43.30	57.00	-13.70	Pass

* - EIRP, dBm = Power output power, dBm + Antenna Gain(dBi), where Antenna Gain = 37.0 dBi

** - Margin, dB = EIRP, dBm – Limit, dBm

Table 7.1.3 Average output power test results

OPERATING FREQUENCY RANGE: 57.0 – 71.0 GHz
DETECTOR USED: Average
VIDEO BANDWIDTH: >10 MHz
TRANSMITTER OUTPUT POWER SETTINGS: Maximum

Frequency, MHz	Modulation	Bit rate, Mbps	Duty Cycle, %	Average output power, dBm	EIRP, dBm *	Limit, dBm	Margin, dB**	Verdict
69875	QPSK/250	80	100	3.50	40.50	54.00	-13.50	Pass
69875	QPSK/500	160	100	4.00	41.00	54.00	-13.00	Pass
69875	16QAM	852	100	4.00	41.00	54.00	-13.00	Pass
69875	64QAM	1280	100	3.80	40.80	54.00	-13.20	Pass

* - EIRP, dBm = Average output power, dBm + Antenna Gain(dBi), where Antenna Gain = 37.0 dBi

** - Margin, dB = EIRP, dBm – Limit, dBm

Reference numbers of test equipment used

HL 1299	HL 1300	HL 1301	HL 3290	HL 3291	HL 3295	HL 3333	HL 4273
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Full description is given in Appendix A.

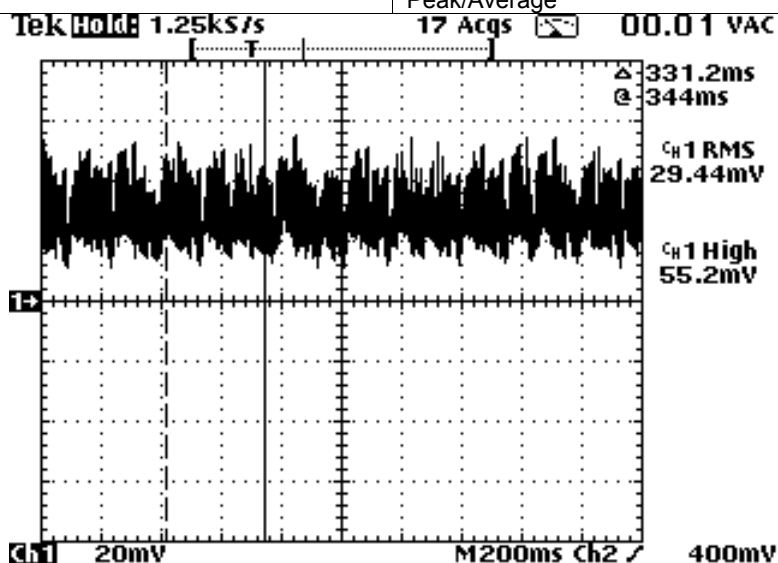


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Test specification: Section 15.255(c)(ii), Transmitter power and power spectral density			
Test procedure: 47 CFR, Section 2.1046; Section 15.255(b); ANSI C63.10, Section 9.11			
Test mode: Compliance		Verdict: PASS	
Date(s): 11-Jan-18			
Temperature: 25 °C	Relative Humidity: 44 %	Air Pressure: 1012 hPa	Power: 48 VDC
Remarks:			

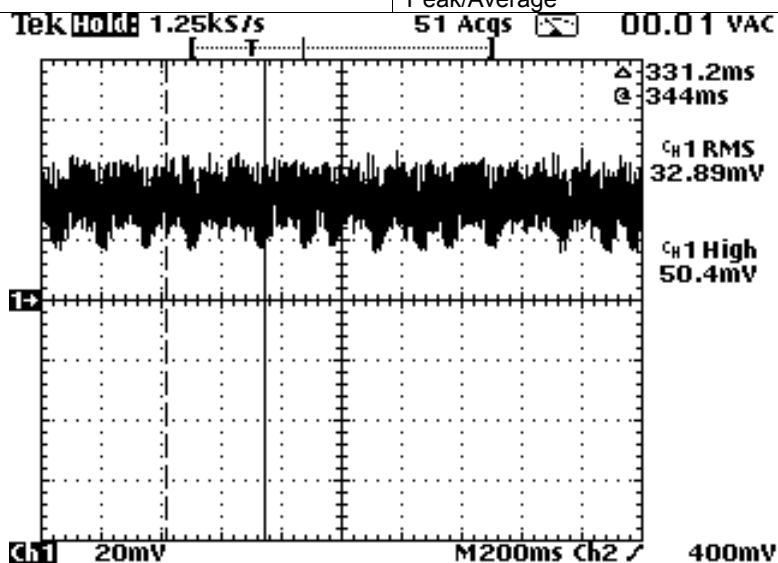
Plot 7.1.1 Output power test result

MODULATION:	QPSK
EMISSION BANDWIDTH:	250 MHz
DETECTOR:	Peak/Average



Plot 7.1.2 Output power test result

MODULATION:	QPSK
EMISSION BANDWIDTH:	500 MHz
DETECTOR:	Peak/Average



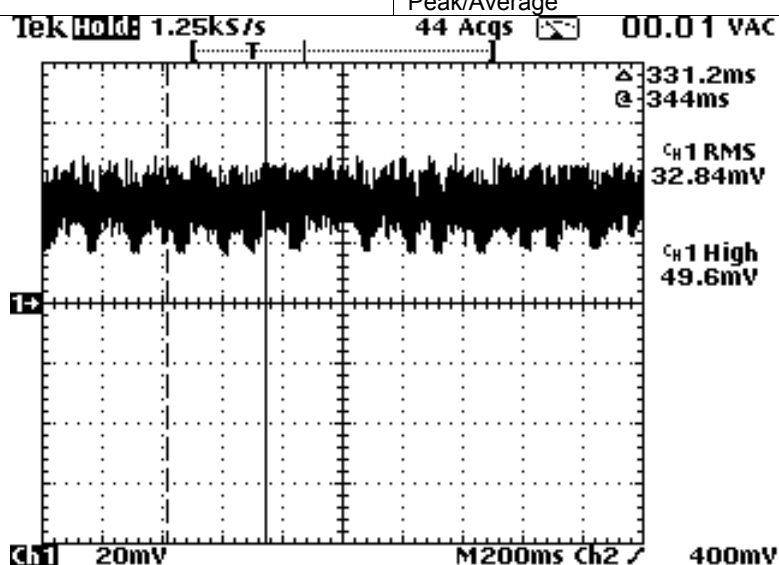


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Test specification: Section 15.255(c)(ii), Transmitter power and power spectral density			
Test procedure: 47 CFR, Section 2.1046; Section 15.255(b); ANSI C63.10, Section 9.11			
Test mode: Compliance		Verdict: PASS	
Date(s): 11-Jan-18			
Temperature: 25 °C	Relative Humidity: 44 %	Air Pressure: 1012 hPa	Power: 48 VDC
Remarks:			

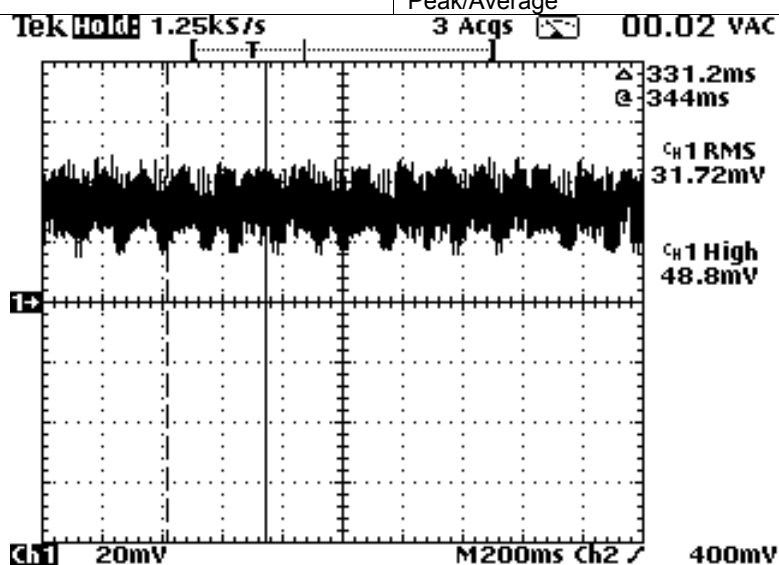
Plot 7.1.3 Output power test result

MODULATION:	16QAM
EMISSION BANDWIDTH:	500 MHz
DETECTOR:	Peak/Average



Plot 7.1.4 Output power test result

MODULATION:	64QAM
EMISSION BANDWIDTH:	500 MHz
DETECTOR:	Peak/Average



Test specification:		Section 15.215(c), Occupied bandwidth	
Test procedure:		47 CFR, Section 2.1049, ANSI C63.10, Section 9.3	
Test mode:		Verdict: PASS	
Date(s):			
11-Jan-18			
Temperature: 25 °C	Relative Humidity: 44 %	Air Pressure: 1015 hPa	Power: 48 VDC
Remarks:			

7.2 Occupied bandwidth test

7.2.1 General

This test was performed to measure transmitter occupied bandwidth. Specification test limits are given in Table 7.2.1.

Table 7.2.1 Occupied bandwidth limits

Assigned frequency range, MHz	Modulation envelope reference points	Max bandwidth, MHz
57000 - 71000	20 dBc	250 / 500
57000 - 71000	99%	250 / 500

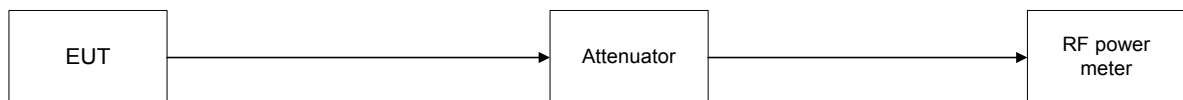
7.2.2 Test procedure

7.2.2.1 The EUT was set up as shown in Figure 7.2.1, energized and its proper operation was checked.

7.2.2.2 The EUT was set to transmit modulated carrier as provided in Table 7.2.2.

7.2.2.3 The transmitter occupied bandwidth was measured with spectrum analyzer as frequency delta between reference points on modulation envelope. The test results are provided in Table 7.2.2 and the associated plots

Figure 7.2.1 Occupied bandwidth test setup





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Test specification: Section 15.215(c), Occupied bandwidth			
Test procedure: 47 CFR, Section 2.1049, ANSI C63.10, Section 9.3			
Test mode: Compliance		Verdict: PASS	
Date(s): 11-Jan-18			
Temperature: 25 °C	Relative Humidity: 44 %	Air Pressure: 1015 hPa	Power: 48 VDC
Remarks:			

Table 7.2.2 Occupied bandwidth test results

OPERATING FREQUENCY RANGE: 57000 –71000 MHz
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: 1% OBW

Frequency, MHz	Modulation	Occupied bandwidth 99%, MHz	Occupied bandwidth 20 dBc MHz	Verdict
EBW = 250 MHz				
69875	QPSK	240.67	261.50	Pass
EBW = 500 MHz				
69875	QPSK	471.36	485.30	Pass
69875	16QAM	471.34	485.90	Pass
69875	64QAM	472.46	491.30	Pass

Reference numbers of test equipment used

HL 1303	HL 2358	HL 2909	HL 3291	HL 3295	HL 3305	HL 3433	HL 3434
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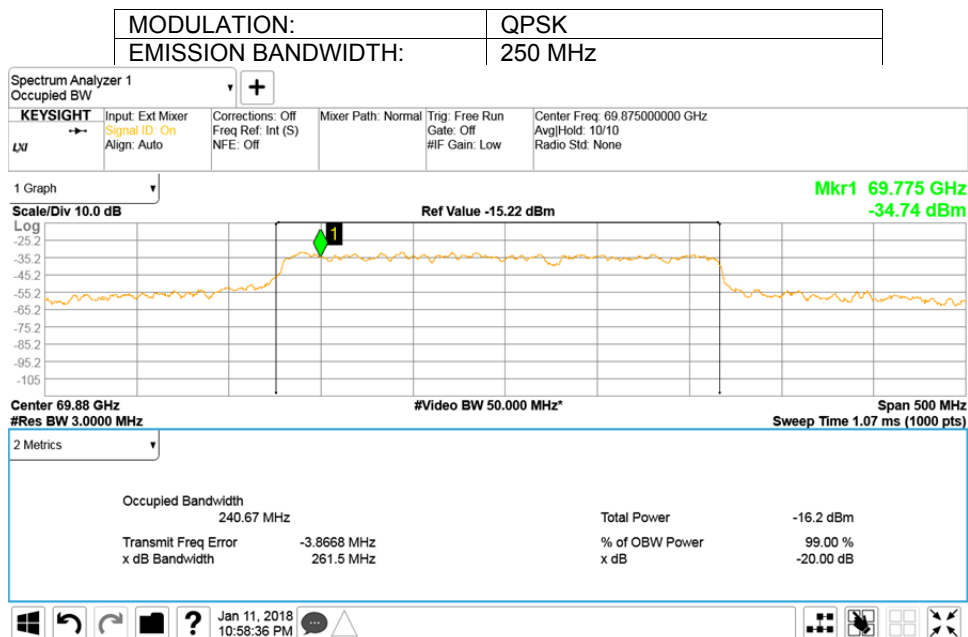
Full description is given in Appendix A.



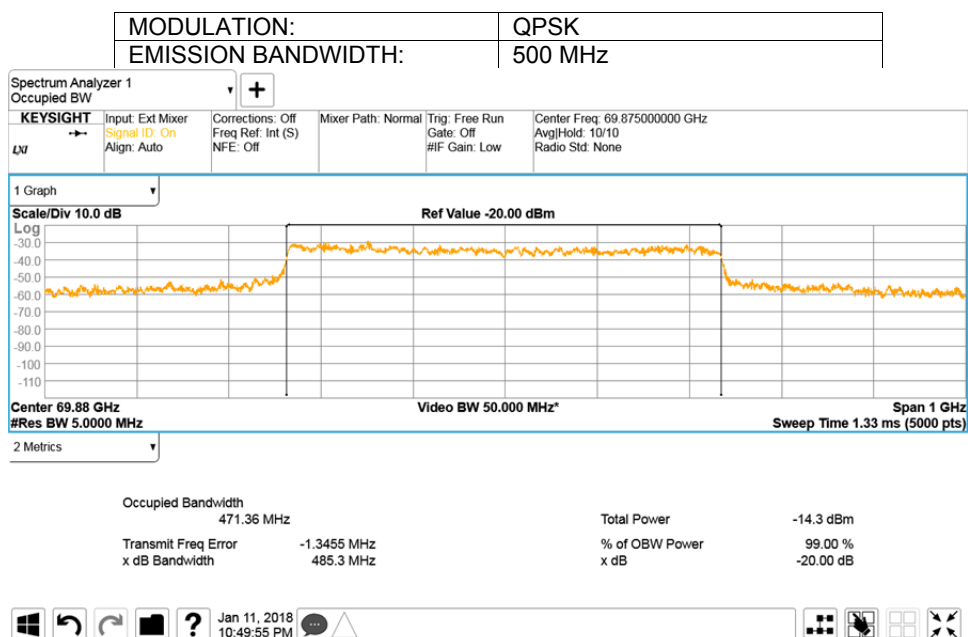
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Test specification: Section 15.215(c), Occupied bandwidth			
Test procedure: 47 CFR, Section 2.1049, ANSI C63.10, Section 9.3			
Test mode: Compliance		Verdict: PASS	
Date(s): 11-Jan-18			
Temperature: 25 °C	Relative Humidity: 44 %	Air Pressure: 1015 hPa	Power: 48 VDC
Remarks:			

Plot 7.2.1 Occupied bandwidth



Plot 7.2.2 Occupied bandwidth

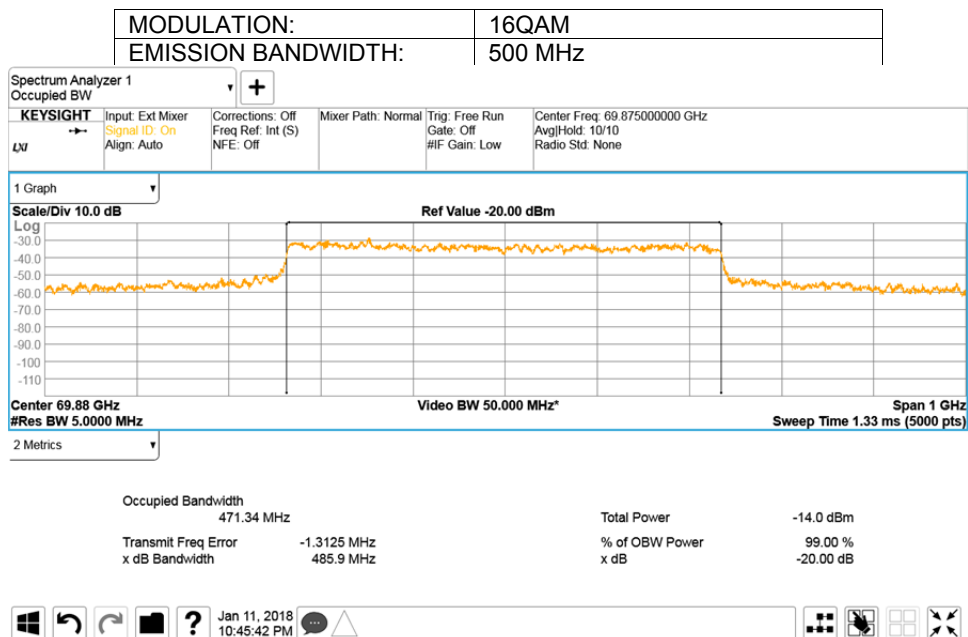




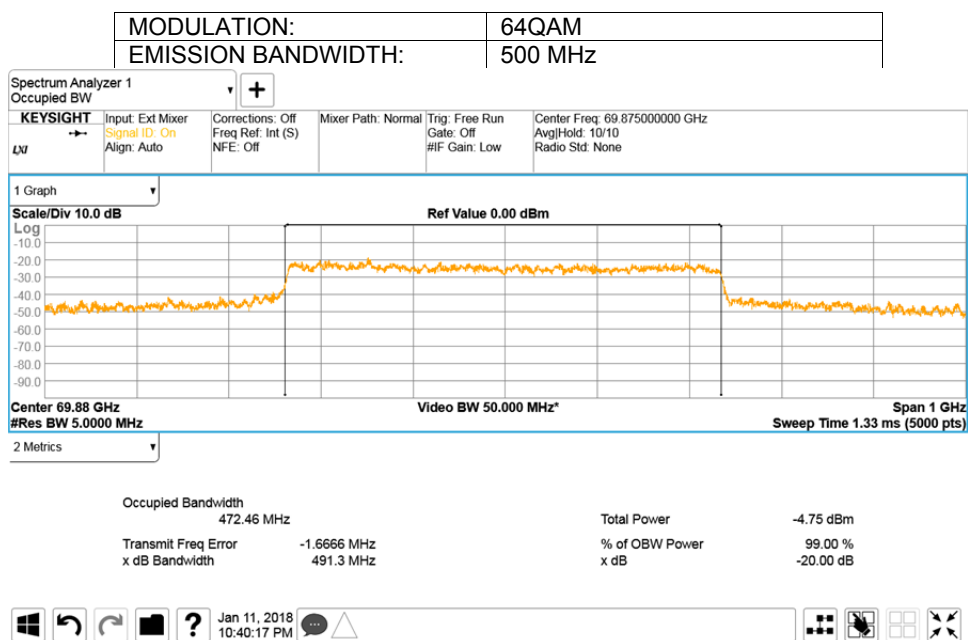
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Test specification: Section 15.215(c), Occupied bandwidth			
Test procedure: 47 CFR, Section 2.1049, ANSI C63.10, Section 9.3			
Test mode: Compliance		Verdict: PASS	
Date(s): 11-Jan-18			
Temperature: 25 °C	Relative Humidity: 44 %	Air Pressure: 1015 hPa	Power: 48 VDC
Remarks:			

Plot 7.2.3 Occupied bandwidth



Plot 7.2.4 Occupied bandwidth





Test specification: Section 15.255(d)(2), Out of band radiated emissions below 40 GHz			
Test procedure: 47 CFR, Section 2.1053; ANSI C63.10, Section 9.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 05-Dec-17 - 10-Dec-17			
Temperature: 24.3 °C	Relative Humidity: 48 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

7.3 Out of band radiated emissions below 40 GHz

7.3.1 General

This test was performed to measure field strength of spurious emissions from the EUT. Specification test limits are given in Table 7.3.1.

Table 7.3.1 Radiated emission limits

Frequency, MHz	Field strength at 3 m within restricted bands, dB(μV/m)***		
	Peak	Quasi Peak	Average
0.009 – 0.090	148.5 – 128.5	NA	128.5 – 108.5**
0.090 – 0.110	NA	108.5 – 106.8**	NA
0.110 – 0.490	126.8 – 113.8	NA	106.8 – 93.8**
0.490 – 1.705	NA	73.8 – 63.0**	NA
1.705 – 30.0*		69.5**	
30 – 88		40.0	
88 – 216		43.5	
216 – 960		46.0	
960 – 1000		54.0	

*- The above field strength limits applied from the lowest radio frequency generated in the device, without going below 9 kHz up to the tenth harmonic of the highest fundamental frequency.

** - The limit for 3 m test distance was calculated using the inverse square distance extrapolation factor as follows:

$$\text{Lim}_{S_2} = \text{Lim}_{S_1} + 40 \log (S_1/S_2),$$

where S_1 and S_2 – standard defined and test distance respectively in meters.

*** - The limit decreases linearly with the logarithm of frequency.

7.3.2 Test procedure for spurious emission field strength measurements in 9 kHz to 30 MHz band

7.3.2.1 The EUT was set up as shown in Figure 7.3.1, energized and the performance check was conducted.

7.3.2.2 The specified frequency range was investigated with loop antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360°, the measuring antenna was rotated around its vertical axis and the measuring antenna polarization was switched from vertical to horizontal.

7.3.2.3 The worst test results (the lowest margins) were recorded in Table 7.3.2 and shown in the associated plots.

7.3.3 Test procedure for spurious emission field strength measurements above 30 MHz

7.3.3.1 The EUT was set up as shown in Figure 7.3.2, Figure 7.3.3, energized and the performance check was conducted.

7.3.3.2 The specified frequency range was investigated with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360°, the measuring antenna height was changed from 1 to 4 m, its polarization was switched from vertical to horizontal.

7.3.3.3 The worst test results (the lowest margins) were recorded in Table 7.3.2 and shown in the associated plots.

Test specification: Section 15.255(d)(2), Out of band radiated emissions below 40 GHz			
Test procedure: 47 CFR, Section 2.1053; ANSI C63.10, Section 9.13			
Test mode:	Compliance	Verdict: PASS	
Date(s):	05-Dec-17 - 10-Dec-17		
Temperature: 24.3 °C	Relative Humidity: 48 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

Figure 7.3.1 Radiated emissions below 30 MHz test set up

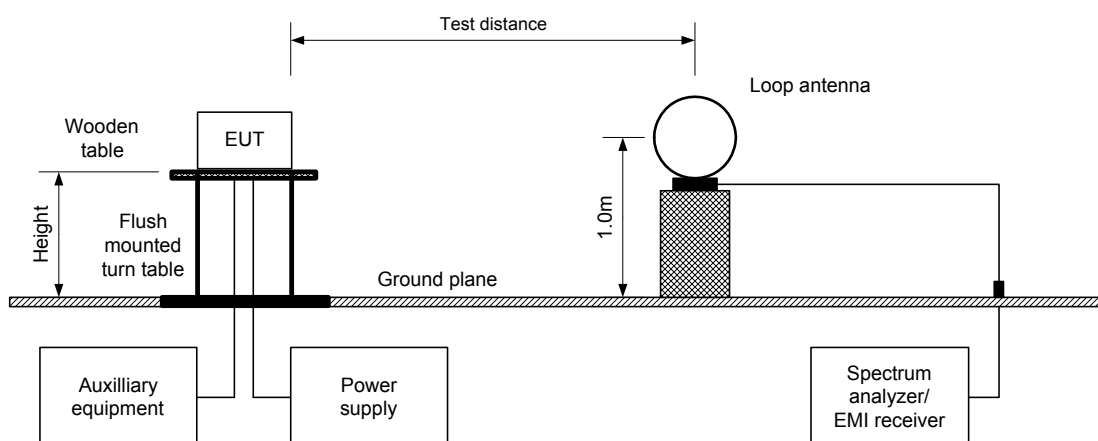
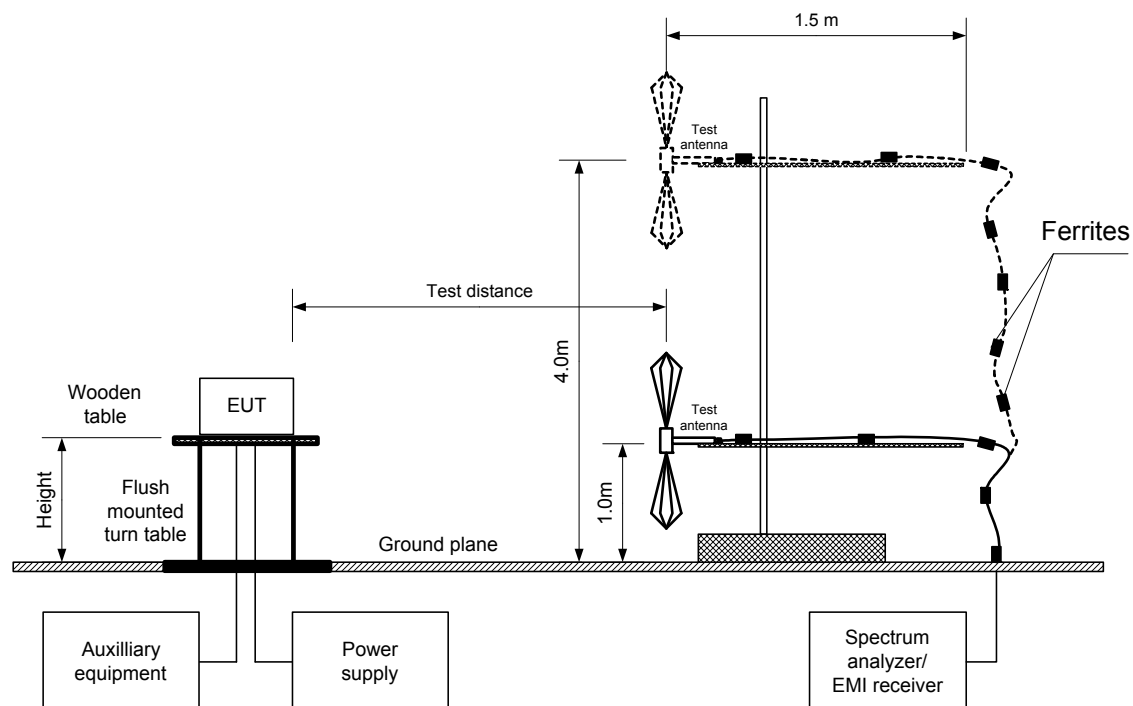
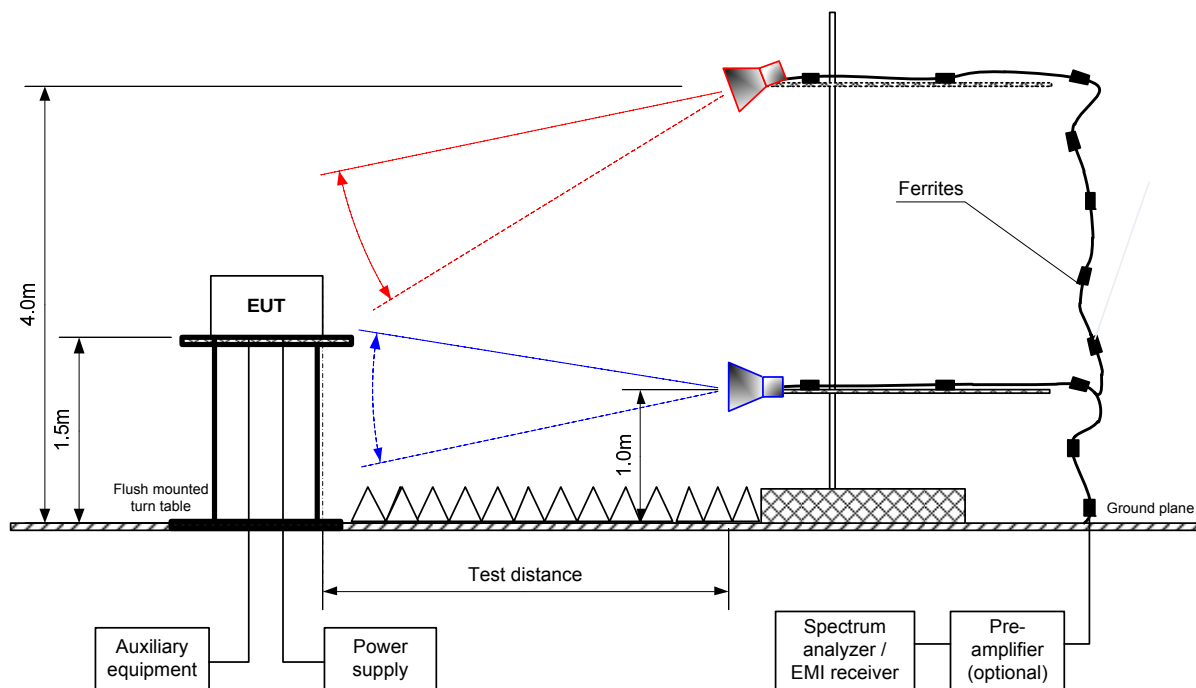


Figure 7.3.2 Radiated emissions above 30 MHz test set up



Test specification: Section 15.255(d)(2), Out of band radiated emissions below 40 GHz			
Test procedure: 47 CFR, Section 2.1053; ANSI C63.10, Section 9.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 05-Dec-17 - 10-Dec-17			
Temperature: 24.3 °C	Relative Humidity: 48 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

Figure 7.3.3 Setup for spurious emission field strength measurements above 1000 MHz





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Test specification: Section 15.255(d)(2), Out of band radiated emissions below 40 GHz			
Test procedure: 47 CFR, Section 2.1053; ANSI C63.10, Section 9.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 05-Dec-17 - 10-Dec-17			
Temperature: 24.3 °C	Relative Humidity: 48 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

Table 7.3.2 Out of band radiated emissions test results

TEST DISTANCE: 3 m
EUT POSITION: Typical (Vertical)
MODULATION: QPSK
MODULATING SIGNAL: PRBS
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
INVESTIGATED FREQUENCY RANGE: 0.009 – 40000 MHz
RESOLUTION BANDWIDTH: 1.0 kHz (9 kHz – 150 kHz)
9.0 kHz (150 kHz – 30 MHz)
120 kHz (30 MHz – 1000 MHz)
VIDEO BANDWIDTH: ≥ Resolution bandwidth
TEST ANTENNA TYPE: Active loop (9 kHz – 30 MHz)
Biconilog (30 MHz – 1000 MHz)
Double-Ridged Waveguide Horn (above 1 GHz)

Frequency, MHz	Peak emission, dB(μV/m)	Quasi-peak			Antenna polarization	Antenna height, m	Turn-table position**, degrees	Verdict
		Measured emission, dB(μV/m)	Limit, dB(μV/m)	Margin, dB*				
39.091000	36.31	30.50	40.00	-9.50	Vert	102	12	Pass
40.962833	37.21	30.79	40.00	-9.21	Vert	133	180	
44.500000	31.67	25.83	40.00	-14.17	Vert	177	-155	
61.887333	37.29	32.55	40.00	-7.45	Vert	102	59	
66.281833	33.11	27.86	40.00	-12.14	Vert	132	13	
78.390333	30.24	24.18	40.00	15.82	Vert	100	1	
499.977333	35.62	33.12	46.00	12.88	Hor	177	-122	

*- Margin = Measured emission - specification limit.

** - EUT front panel refer to 0 degrees position of turntable.

Reference numbers of test equipment used

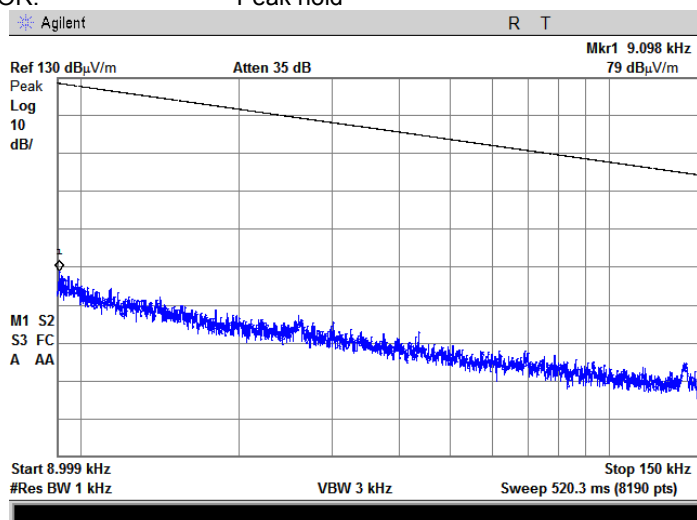
HL 0446	HL 0604	HL 3001	HL 3818	HL 3901	HL 4353	HL 4360	HL 4933
HL 4956	HL 5245						

Full description is given in Appendix A.

Test specification: Section 15.255(d)(2), Out of band radiated emissions below 40 GHz			
Test procedure: 47 CFR, Section 2.1053; ANSI C63.10, Section 9.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 05-Dec-17 - 10-Dec-17			
Temperature: 24.3 °C	Relative Humidity: 48 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

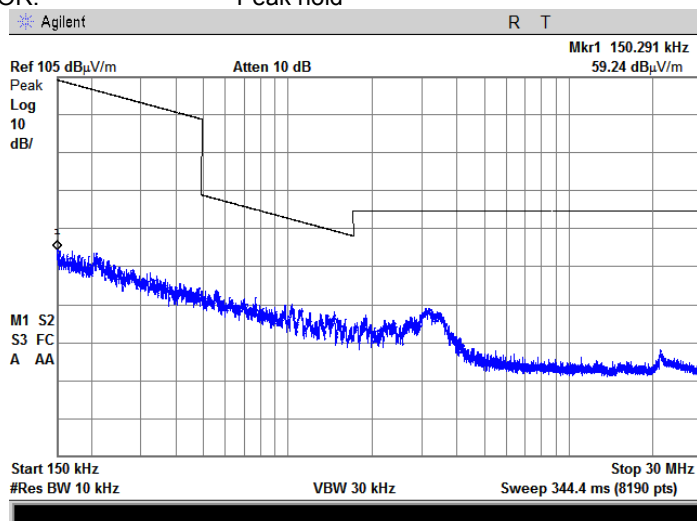
Plot 7.3.1 Radiated emission measurements from 9 to 150 kHz

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical
DETECTOR: Peak hold



Plot 7.3.2 Radiated emission measurements from 0.15 to 30 MHz

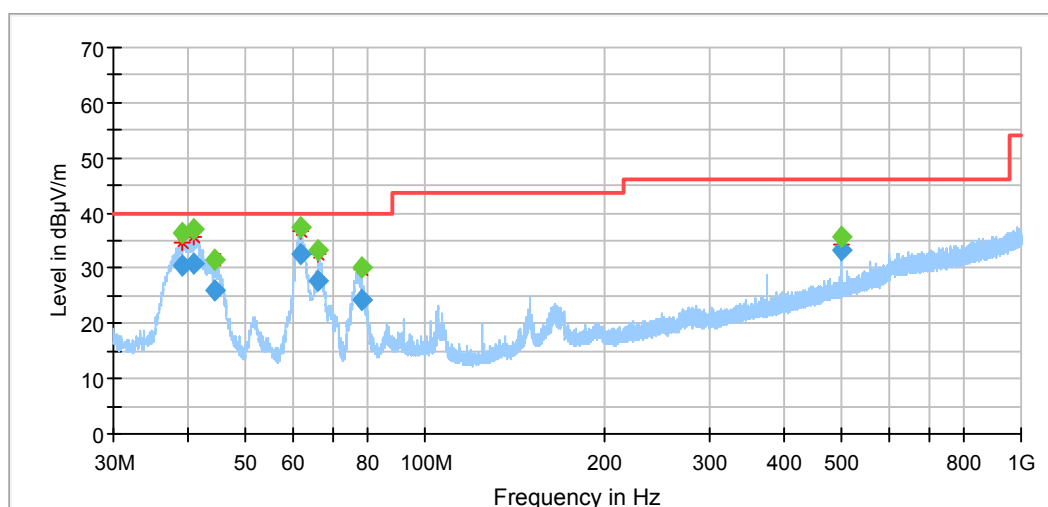
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Horizontal
DETECTOR: Peak hold



Test specification: Section 15.255(d)(2), Out of band radiated emissions below 40 GHz			
Test procedure: 47 CFR, Section 2.1053; ANSI C63.10, Section 9.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 05-Dec-17 - 10-Dec-17			
Temperature: 24.3 °C	Relative Humidity: 48 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

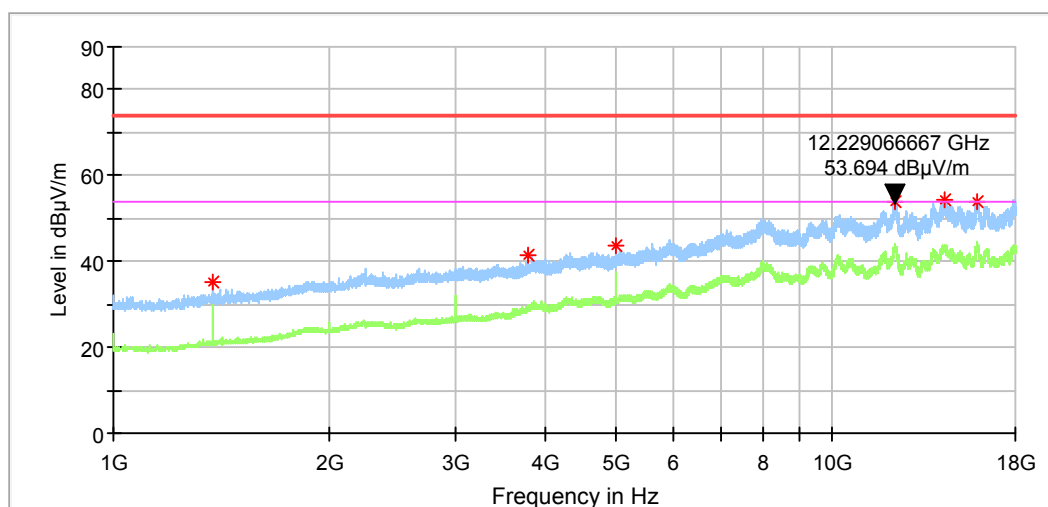
Plot 7.3.3 Radiated emission measurements from 30 to 1000 MHz

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical
DETECTOR: Peak hold



Plot 7.3.4 Radiated emission measurements from 1 to 18 GHz

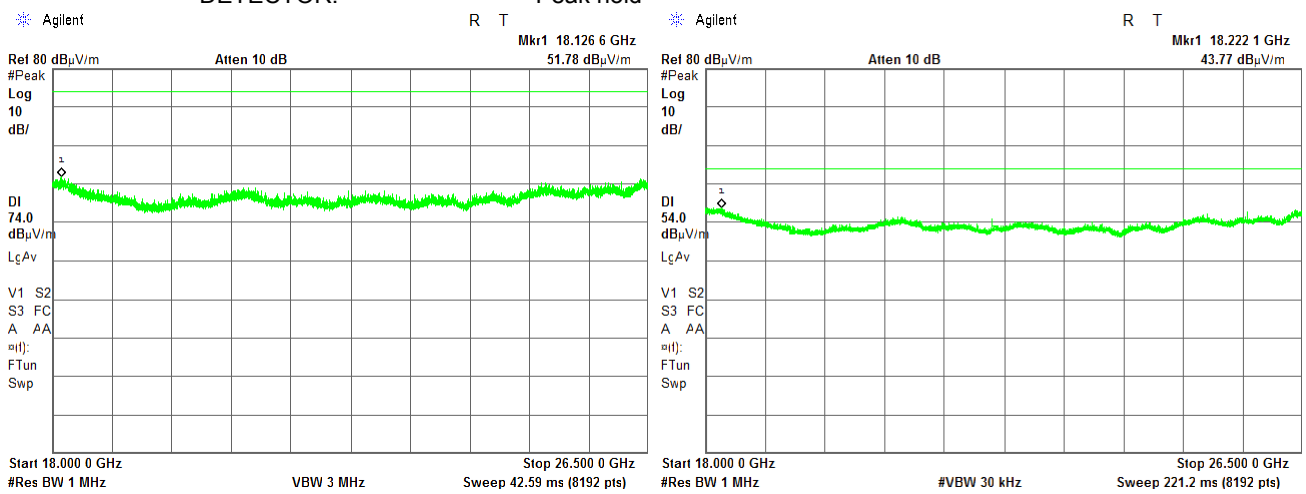
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical
DETECTOR: Peak hold



Test specification:		Section 15.255(d)(2), Out of band radiated emissions below 40 GHz	
Test procedure:		47 CFR, Section 2.1053; ANSI C63.10, Section 9.13	
Test mode:		Verdict: PASS	
Date(s):			
05-Dec-17 - 10-Dec-17			
Temperature: 24.3 °C	Relative Humidity: 48 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

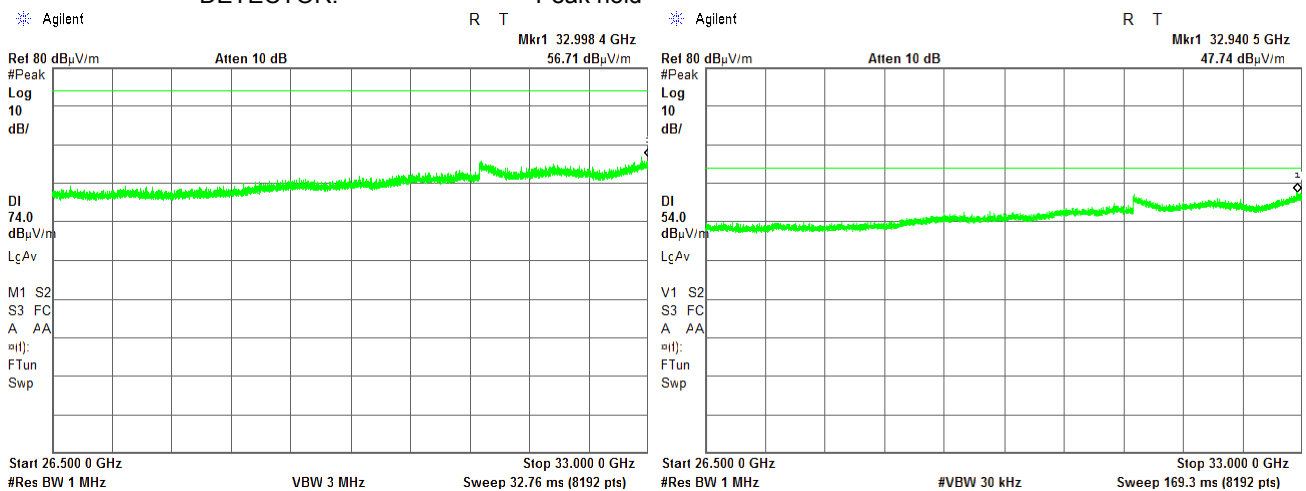
Plot 7.3.5 Radiated emission measurements from 18 to 26.5 GHz

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical
DETECTOR: Peak hold



Plot 7.3.6 Radiated emission measurements from 26.5 to 33 GHz

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical
DETECTOR: Peak hold



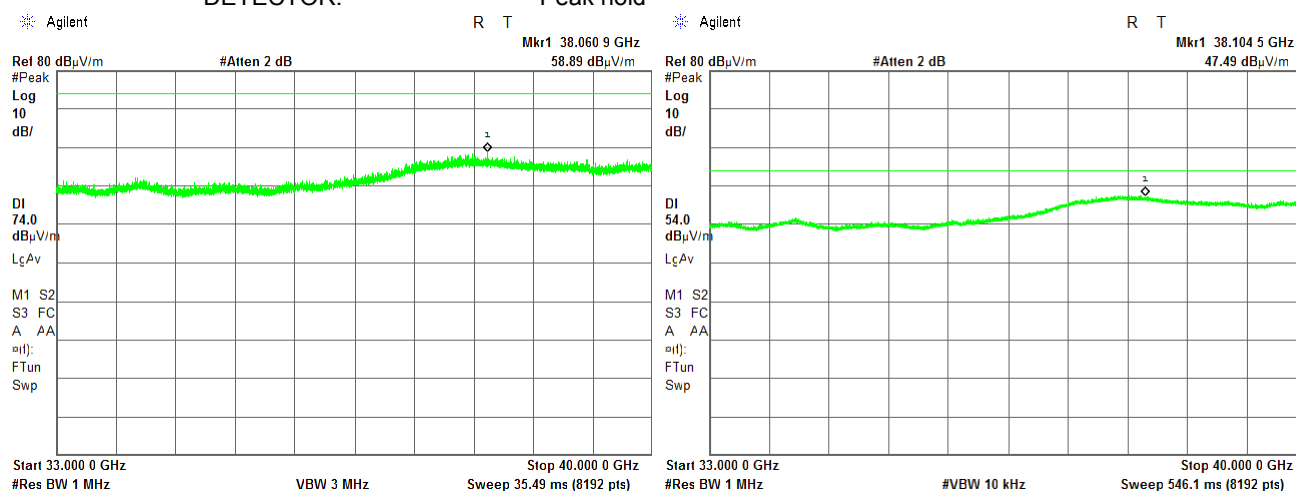


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Test specification: Section 15.255(d)(2), Out of band radiated emissions below 40 GHz			
Test procedure: 47 CFR, Section 2.1053; ANSI C63.10, Section 9.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 05-Dec-17 - 10-Dec-17			
Temperature: 24.3 °C	Relative Humidity: 48 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

Plot 7.3.7 Radiated emission measurements from 33 to 40 GHz

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical
DETECTOR: Peak hold



Test specification: Section 15.255(d)(3), Out of band radiated emissions above 40 GHz			
Test procedure: ANSI C63.10, Sections 9.9, 9.12			
Test mode: Compliance		Verdict: PASS	
Date(s): 07-Jan-18			
Temperature: 24.4 °C	Relative Humidity: 46 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

7.4 Out of band radiated emissions above 40 GHz up to 200 GHz

7.4.1 General

This test was performed to measure radiated spurious emissions from the EUT. Specification test limits are given in Table 7.4.1, Table 7.4.2.

Table 7.4.1 Radiated spurious emission test limits

Frequency, GHz	Equivalent field strength limit @ 3m, dB(μV/m)***
40– 200	85.3

* - Excluding the in band emission within ± 250 % of the authorized bandwidth from the carrier

** - P is transmitter output power in Watts

*** - Equivalent field strength limit was calculated from maximum allowed ERP of spurious as follows:
 $E = \sqrt{30 \times P \times 1.64} / r$, where P is ERP in Watts, 1.64 is numeric gain of ideal dipole and r is antenna to EUT distance in meters

Table 7.4.2 Radiated spurious emission test limits

Frequency, GHz	Power density at 3 m distance pW/cm ²	Distance, m	Field strength dB(μV/m)*, peak	Field strength dB(μV/m)*, average
40 – 220	90.0	3.0	105.3	85.3
40 - 90	90.0	3.0	105.3	85.3
90 - 110	90.0	0.5	120.9*	100.9*
110 - 130	90.0	0.07	137.9*	117.9*
130 - 140	90.0	0.05	140.9*	120.9*
140 - 200	90.0	0.001	165.3*	145.3*

*- The limit for other test distance was calculated using the inverse distance extrapolation factor as follows:

$$\text{Lim}_{S_2} = \text{Lim}_{S_1} + 20 \log (S_1/S_2),$$

7.4.2 Test procedure for spurious emission field strength measurements

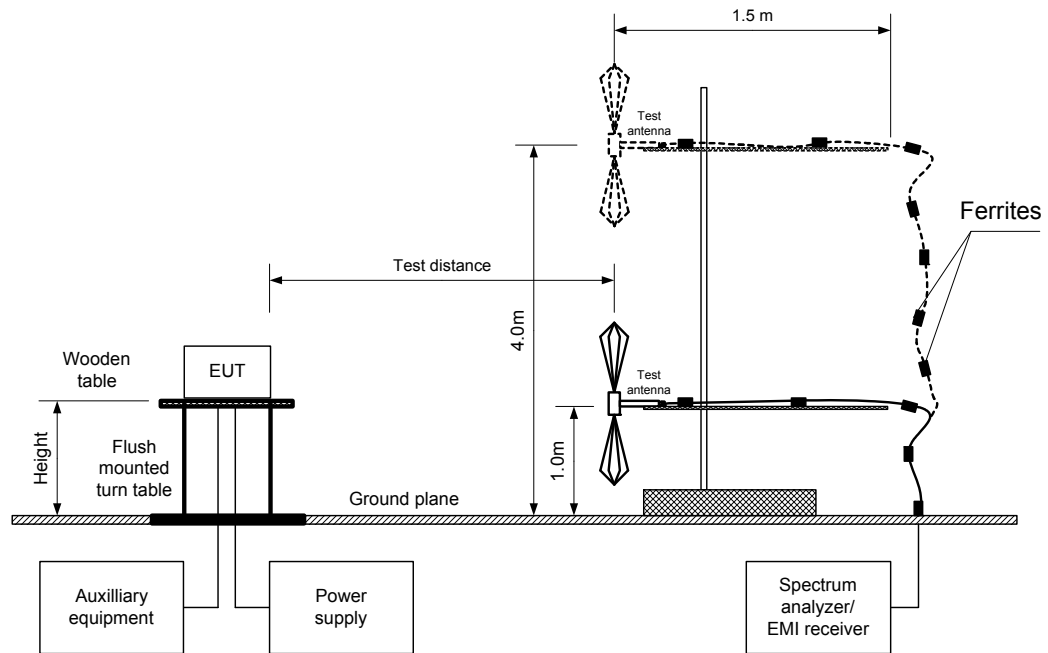
7.4.2.1 The EUT was set up as shown in Figure 7.4.1, energized and the performance check was conducted.

7.4.2.2 The specified frequency range was investigated with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360°, the measuring antenna height was changed from 1 to 4 m, its polarization was switched from vertical to horizontal.

7.4.2.3 The test results are given in Table 7.4.3 and shown in the associated plots.

Test specification:		Section 15.255(d)(3), Out of band radiated emissions above 40 GHz	
Test procedure:		ANSI C63.10, Sections 9.9, 9.12	
Test mode:		Verdict: PASS	
Date(s):			
07-Jan-18			
Temperature: 24.4 °C	Relative Humidity: 46 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

Figure 7.4.1 Radiated emissions above 40 GHz test set up





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Test specification: Section 15.255(d)(3), Out of band radiated emissions above 40 GHz			
Test procedure: ANSI C63.10, Sections 9.9, 9.12			
Test mode: Compliance		Verdict: PASS	
Date(s): 07-Jan-18			
Temperature: 24.4 °C	Relative Humidity: 46 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

Table 7.4.3 Out of band radiated emissions test results

TEST DISTANCE: 0.001 - 3 m
EUT POSITION: Typical (Vertical)
MODULATION: QPSK
CHANNEL BANDWIDTH: 250 MHz
TRANSMITTER OUTPUT POWER: Maximum
INVESTIGATED FREQUENCY RANGE: 40 – 200 GHz
RESOLUTION BANDWIDTH: 1000 kHz
VIDEO BANDWIDTH: ≥ Resolution bandwidth
TEST ANTENNA TYPE: Standard Gain Horn 24dB (40-60 GHz)
Standard Gain Horn 24dB (50-75 GHz)
Standard Gain Horn 24dB (75-110 GHz)
Standard Gain Horn 24dB (90-140 GHz)
Standard Gain Horn 25dB (140-200 GHz)

Frequency, MHz	Antenna		Azimuth, degrees*	Peak field strength(VBW=3 MHz)			Average field strength(VBW=1 kHz)			Verdict
	Polariz.	Height, m		Measured, dB(μV/m)	Limit, dB(μV/m)	Margin, dB**	Measured, dB(μV/m)	Limit, dB(μV/m)	Margin, dB**	
Carrier frequency 69875 MHz										
No emissions were found										Pass

*- EUT front panel refer to 0 degrees position of turntable.

**- Margin = Measured emission - specification limit.

Reference numbers of test equipment used

HL 0747	HL 0770	HL 0771	HL 0772	HL 1304	HL 1305	HL 1312	HL 2909
HL 3235	HL 3296	HL 3297	HL 3306	HL 3329	HL 3433	HL 3434	HL 3536
HL 3901	HL 4023						

Full description is given in Appendix A.

Reference numbers of test equipment used

HL No.	Description	Manufacturer	Model	Ser. No.	Last Cal./ Check	Due Cal./ Check
NA	Signal Analyzer	Keysight	MXA N9020B	MY56080135	22-Jun-17	22-Jun-18
NA	Waveguide Harmonic Mixer	Keysight	M1971E Opt 003	MY56130185	11-Apr-17	10-May-18

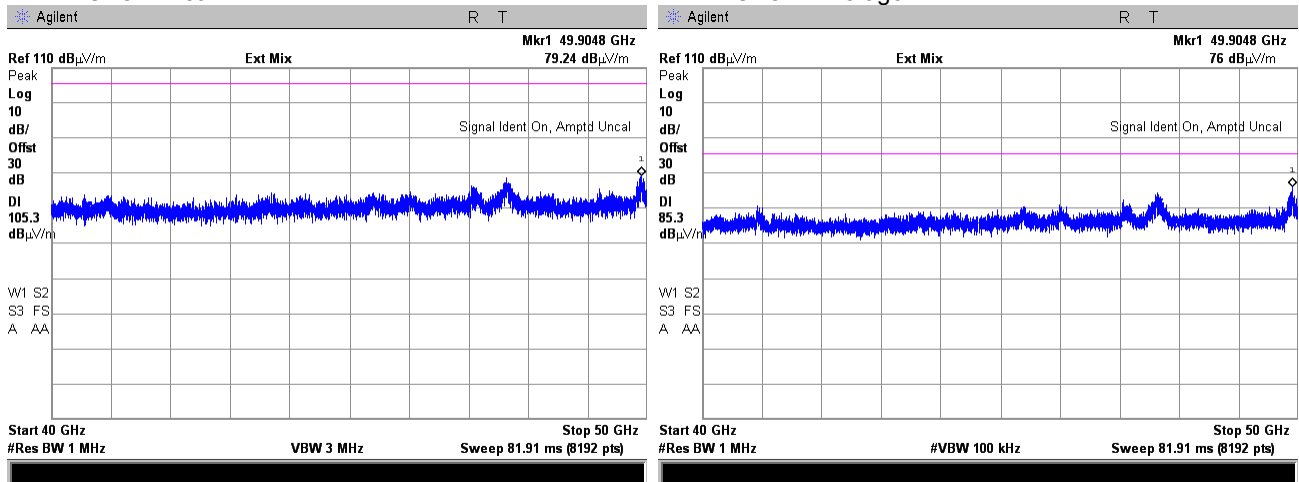
Full description is given in Appendix A.

Test specification:		Section 15.255(d)(3), Out of band radiated emissions above 40 GHz	
Test procedure:		ANSI C63.10, Sections 9.9, 9.12	
Test mode:		Verdict: PASS	
Date(s):			
07-Jan-18			
Temperature: 24.4 °C	Relative Humidity: 46 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

Plot 7.4.1 Radiated emission measurements from 40 to 50 GHz GHz

TEST SITE:
TEST DISTANCE:
ANTENNA POLARIZATION:
DETECTOR: Peak

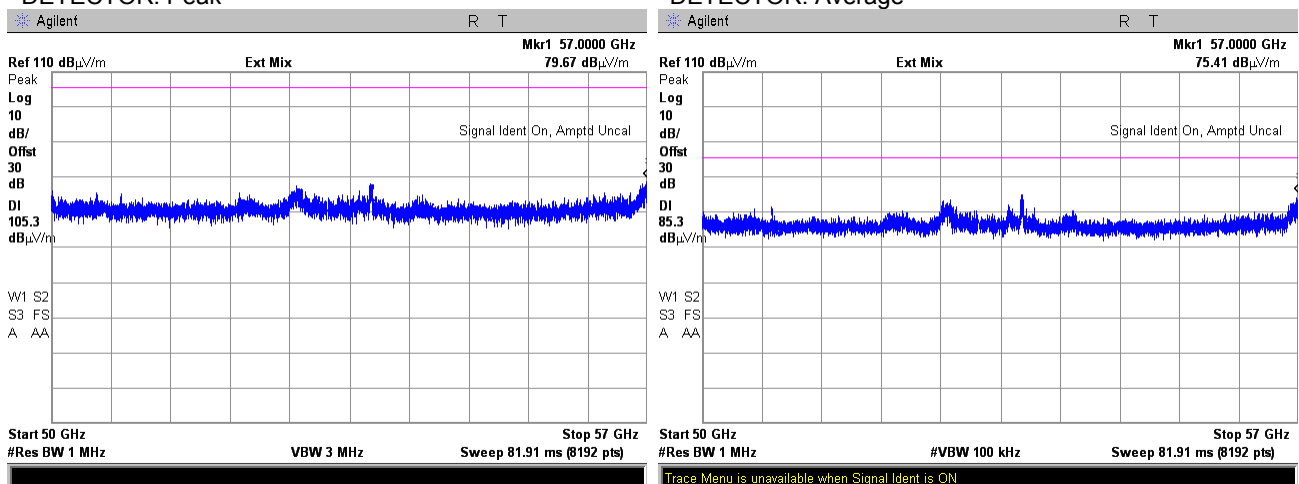
OATS
3 m
Vertical & Horizontal
DETECTOR: Average



Plot 7.4.2 Radiated emission measurements from 50 to 57 GHz

TEST SITE:
TEST DISTANCE:
ANTENNA POLARIZATION:
DETECTOR: Peak

OATS
3 m
Vertical & Horizontal
DETECTOR: Average

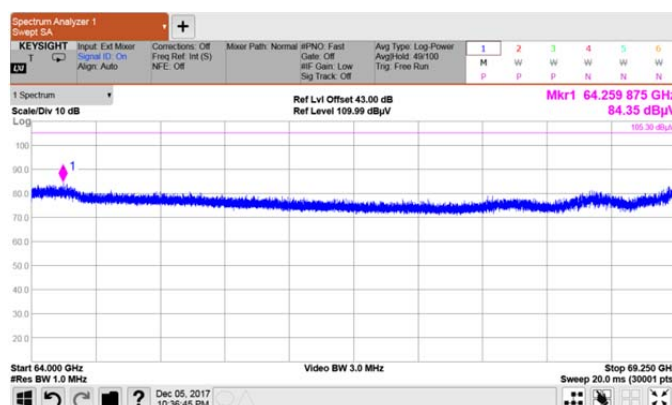


Test specification:		Section 15.255(d)(3), Out of band radiated emissions above 40 GHz	
Test procedure:		ANSI C63.10, Sections 9.9, 9.12	
Test mode:		Verdict: PASS	
Date(s):			
07-Jan-18			
Temperature: 24.4 °C	Relative Humidity: 46 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

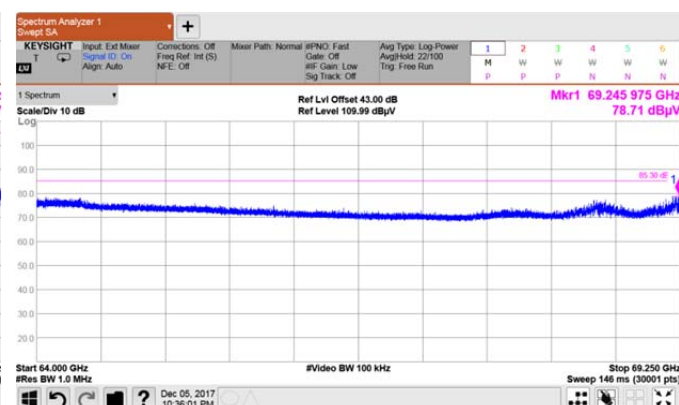
Plot 7.4.3 Radiated emission measurements from 64 to 69.25 GHz

TEST SITE:
TEST DISTANCE:
DETECTOR: Peak
ANTENNA POLARIZATION:

OATS
3 m
DETECTOR: Average
Vertical and Horizontal



Screen 17-20 Horizontal



Test specification:		Section 15.255(d)(3), Out of band radiated emissions above 40 GHz	
Test procedure:		ANSI C63.10, Sections 9.9, 9.12	
Test mode:		Compliance	Verdict: PASS
Date(s):		07-Jan-18	
Temperature: 24.4 °C	Relative Humidity: 46 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

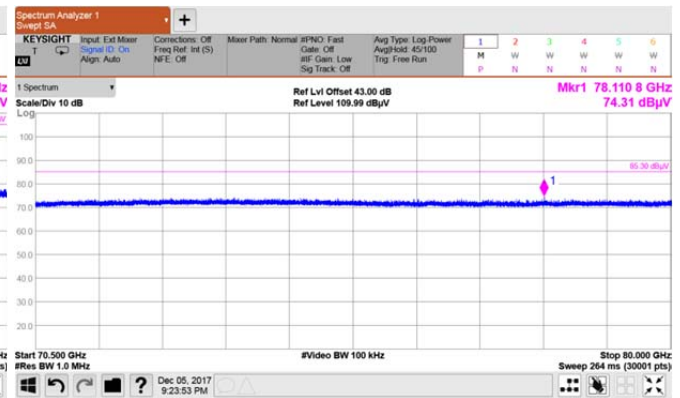
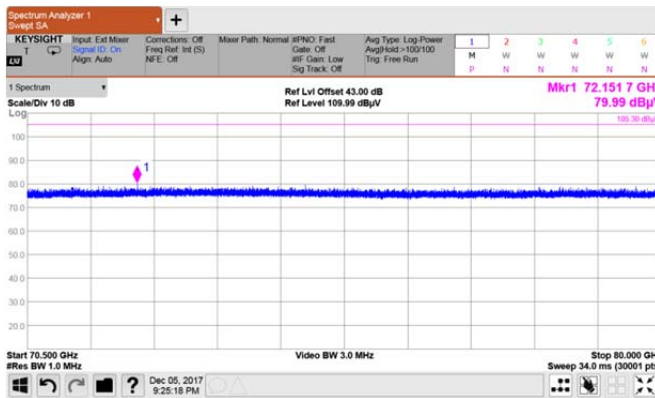
Plot 7.4.4 Radiated emission measurements from 70.5 to 80 GHz

TEST SITE:
TEST DISTANCE:
DETECTOR: Peak

OATS
3 m
DETECTOR: Average

ANTENNA POLARIZATION:

Vertical and Horizontal



Test specification:		Section 15.255(d)(3), Out of band radiated emissions above 40 GHz	
Test procedure:		ANSI C63.10, Sections 9.9, 9.12	
Test mode:		Verdict: PASS	
Date(s):			
07-Jan-18			
Temperature: 24.4 °C	Relative Humidity: 46 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

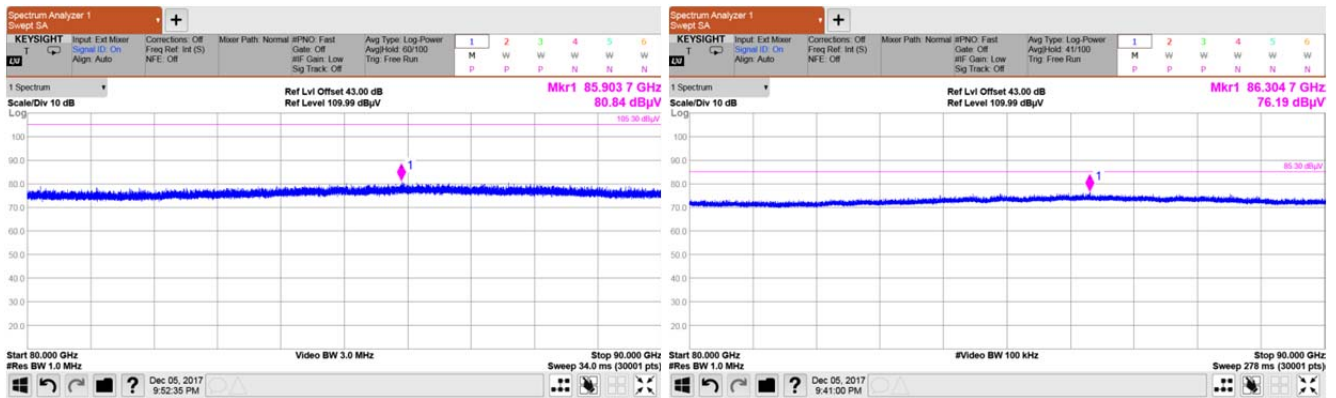
Plot 7.4.5 Radiated emission measurements from 80 to 90 GHz

TEST SITE:
TEST DISTANCE:
DETECTOR: Peak

OATS
3 m
DETECTOR: Average

ANTENNA POLARIZATION:

Vertical and Horizontal

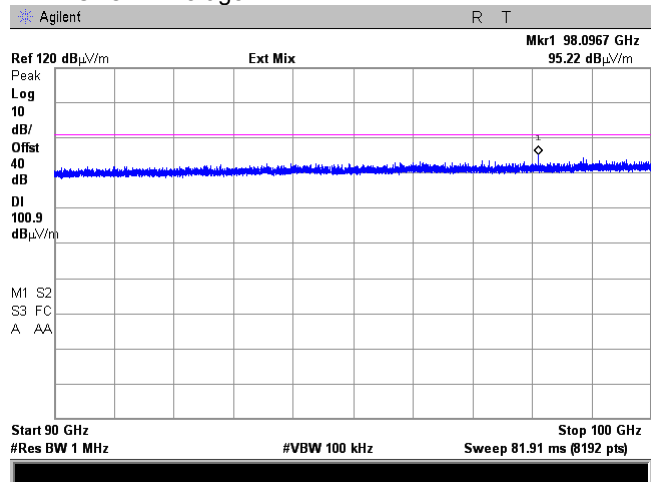
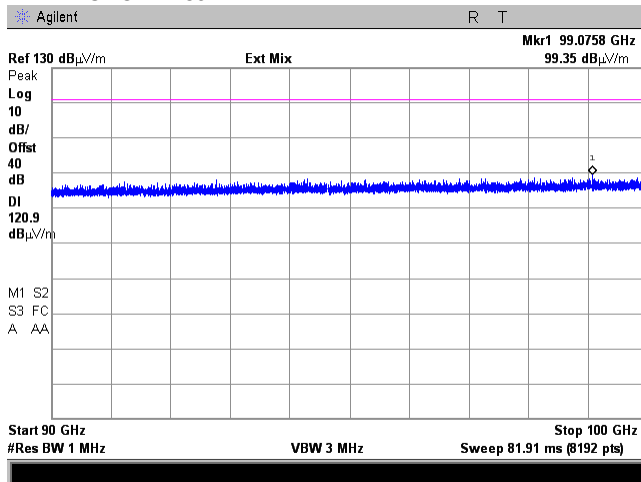


Test specification:		Section 15.255(d)(3), Out of band radiated emissions above 40 GHz	
Test procedure:		ANSI C63.10, Sections 9.9, 9.12	
Test mode:		Verdict: PASS	
Date(s):			
07-Jan-18			
Temperature: 24.4 °C	Relative Humidity: 46 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

Plot 7.4.6 Radiated emission measurements from 90 to 100 GHz

TEST SITE:
TEST DISTANCE:
ANTENNA POLARIZATION:
DETECTOR: Peak

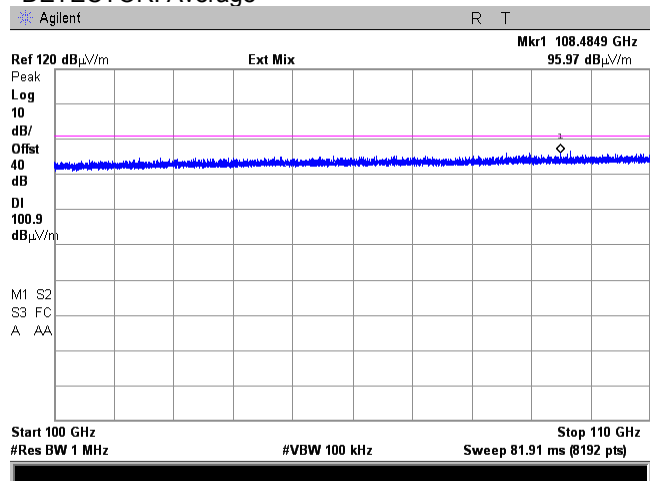
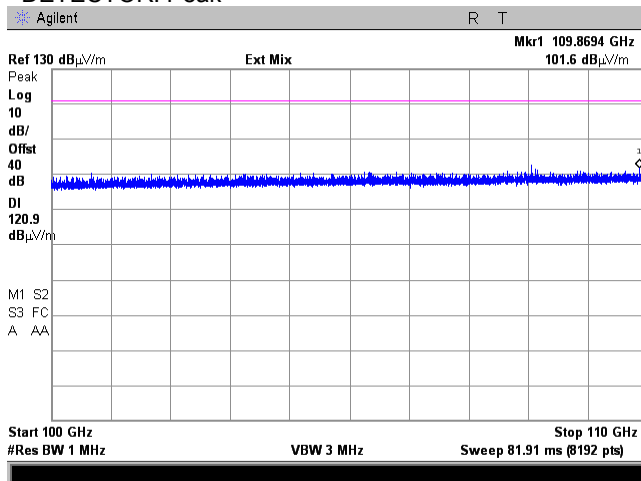
OATS
0.5 m
Vertical and Horizontal
DETECTOR: Average



Plot 7.4.7 Radiated emission measurements from 100 to 110 GHz

TEST SITE:
TEST DISTANCE:
ANTENNA POLARIZATION:
DETECTOR: Peak

OATS
0.5 m
Vertical and Horizontal
DETECTOR: Average

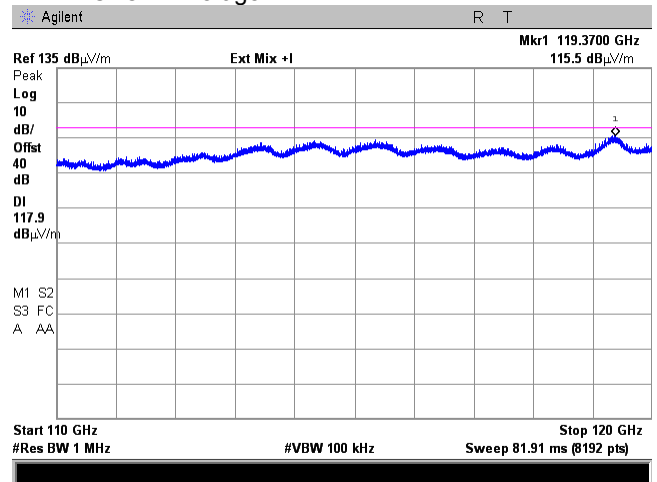
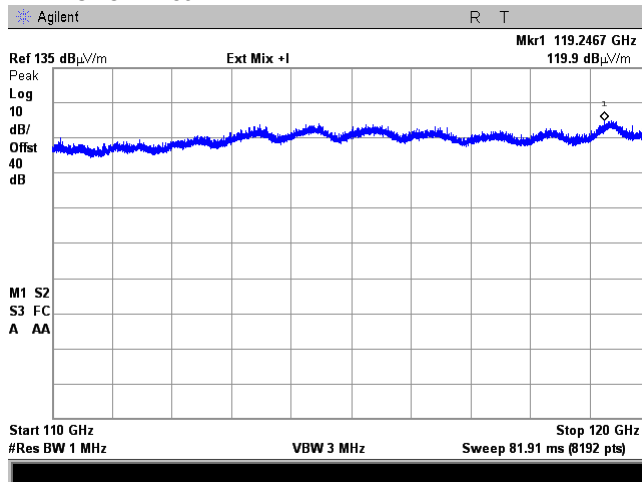


Test specification: Section 15.255(d)(3), Out of band radiated emissions above 40 GHz			
Test procedure: ANSI C63.10, Sections 9.9, 9.12			
Test mode: Compliance		Verdict: PASS	
Date(s): 07-Jan-18			
Temperature: 24.4 °C	Relative Humidity: 46 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

Plot 7.4.8 Radiated emission measurements from 110 to 120 GHz

TEST SITE:
TEST DISTANCE:
ANTENNA POLARIZATION:
DETECTOR: Peak

OATS
0.07 m
Vertical and Horizontal
DETECTOR: Average

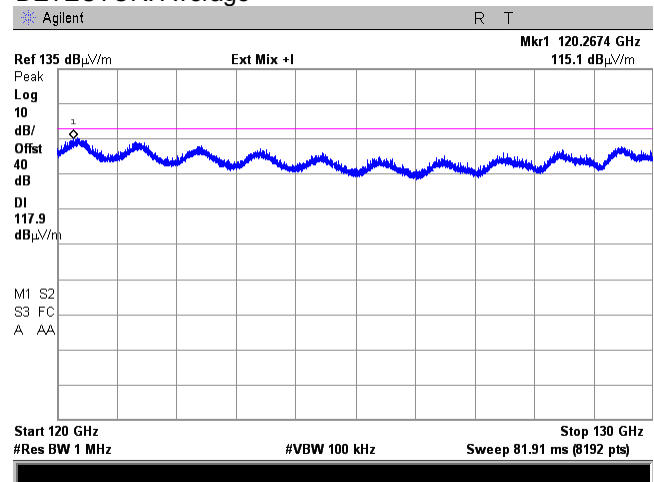
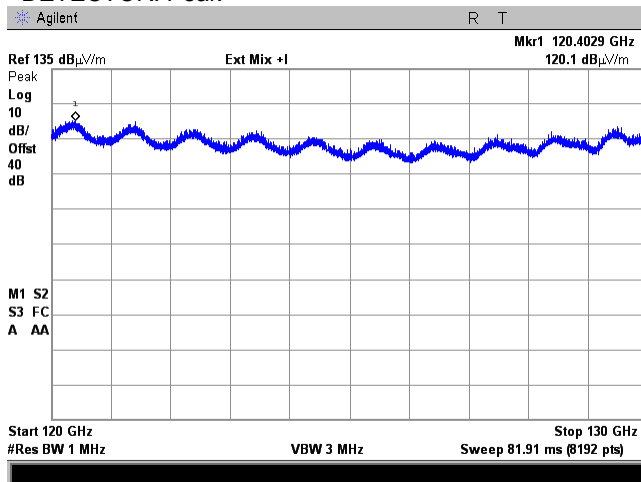


Peak 137.9 dBuV/m limit applied.

Plot 7.4.9 Radiated emission measurements from 120 to 130 GHz

TEST SITE:
TEST DISTANCE:
ANTENNA POLARIZATION:
DETECTOR: Peak

OATS
0.07 m
Vertical and Horizontal
DETECTOR: Average



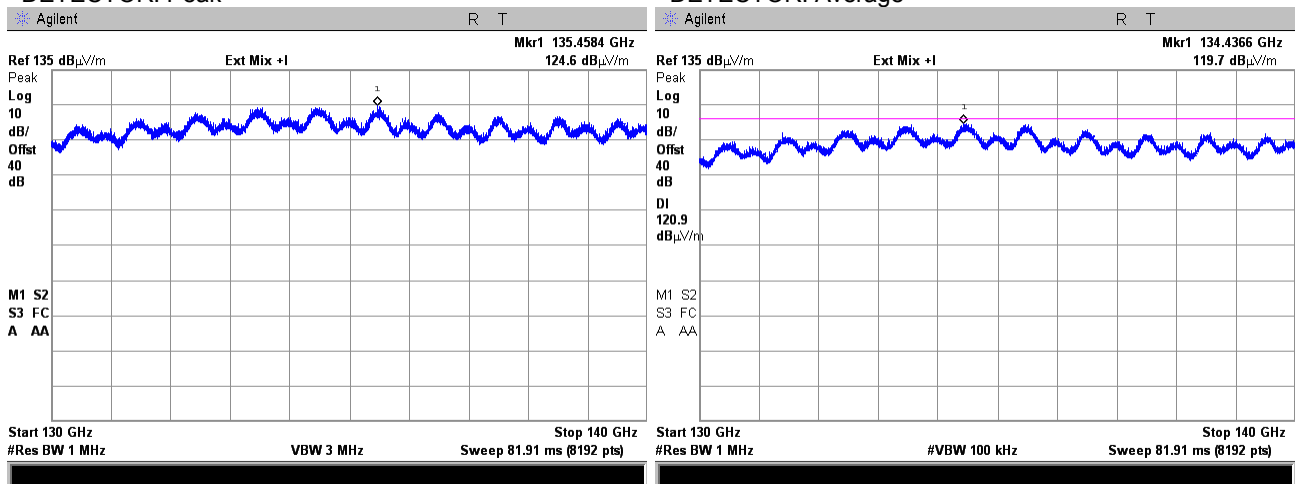
Peak 137.9 dBuV/m, average 117.9 dBuV/m limits applied.

Test specification:		Section 15.255(d)(3), Out of band radiated emissions above 40 GHz	
Test procedure:		ANSI C63.10, Sections 9.9, 9.12	
Test mode:		Verdict: PASS	
Date(s):			
07-Jan-18			
Temperature: 24.4 °C	Relative Humidity: 46 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

Plot 7.4.10 Radiated emission measurements from 130 to 140 GHz

TEST SITE:
TEST DISTANCE:
ANTENNA POLARIZATION:
DETECTOR: Peak

OATS
0.05 m
Vertical and Horizontal
DETECTOR: Average

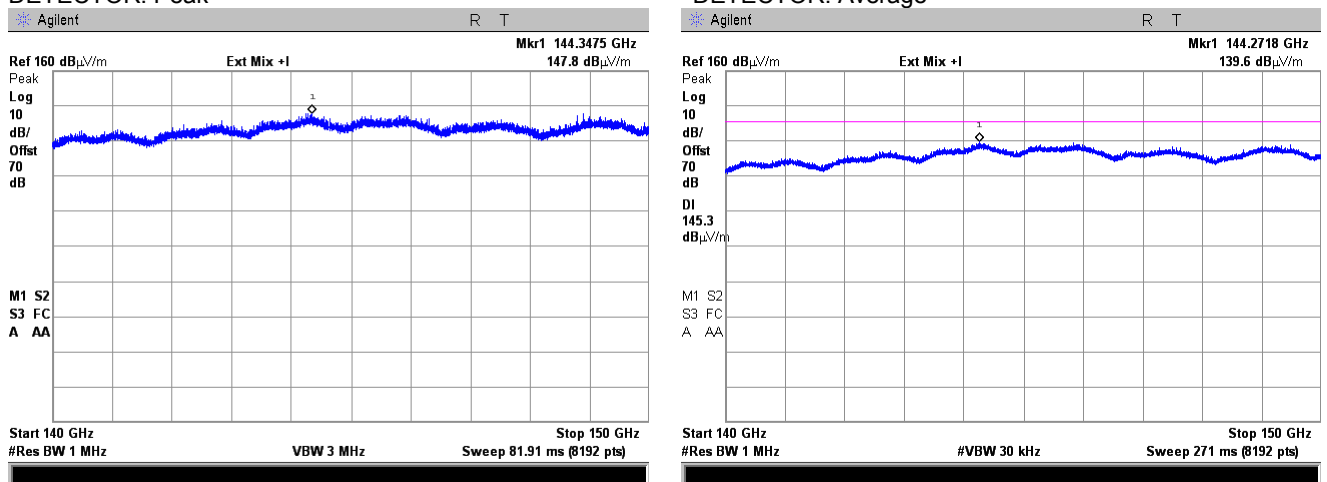


Peak 140.9 dBuV/m, average 120.9 dBuV/m limits applied.

Plot 7.4.11 Radiated emission measurements from 140 to 150 GHz

TEST SITE:
TEST DISTANCE:
ANTENNA POLARIZATION:
DETECTOR: Peak

OATS
0.001 m
Vertical and Horizontal
DETECTOR: Average



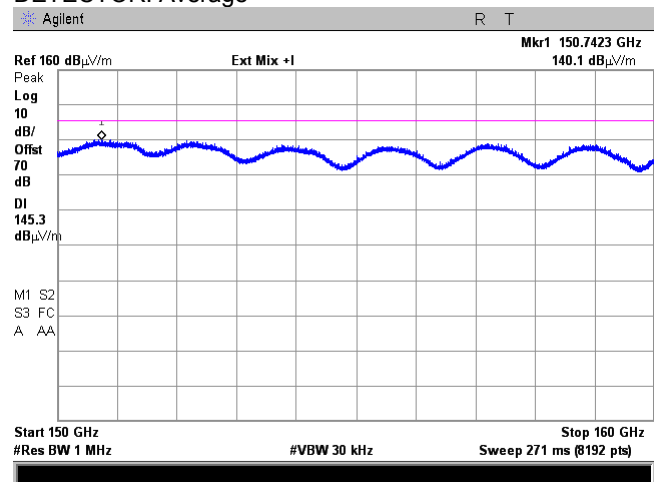
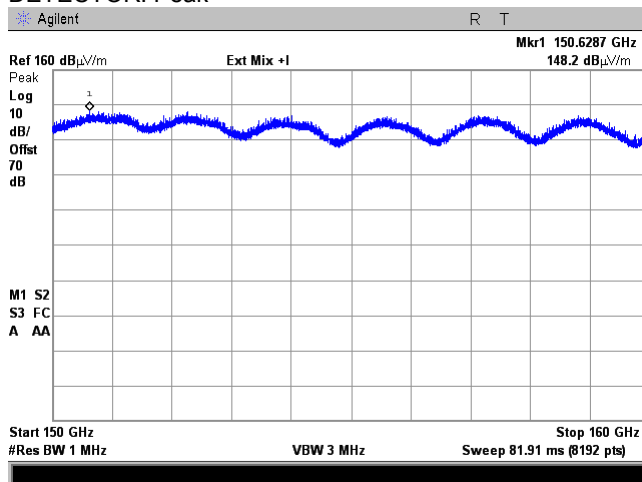
Peak 165.3 dBuV/m, average 145.38 dBuV/m limits applied.

Test specification:		Section 15.255(d)(3), Out of band radiated emissions above 40 GHz	
Test procedure:		ANSI C63.10, Sections 9.9, 9.12	
Test mode:		Verdict: PASS	
Date(s):			
07-Jan-18			
Temperature: 24.4 °C	Relative Humidity: 46 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

Plot 7.4.12 Radiated emission measurements from 150 to 160 GHz

TEST SITE:
TEST DISTANCE:
ANTENNA POLARIZATION:
DETECTOR: Peak

OATS
0.001 m
Vertical and Horizontal
DETECTOR: Average

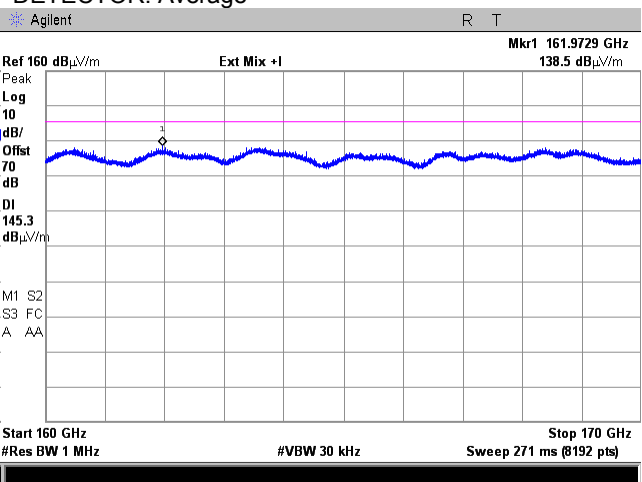
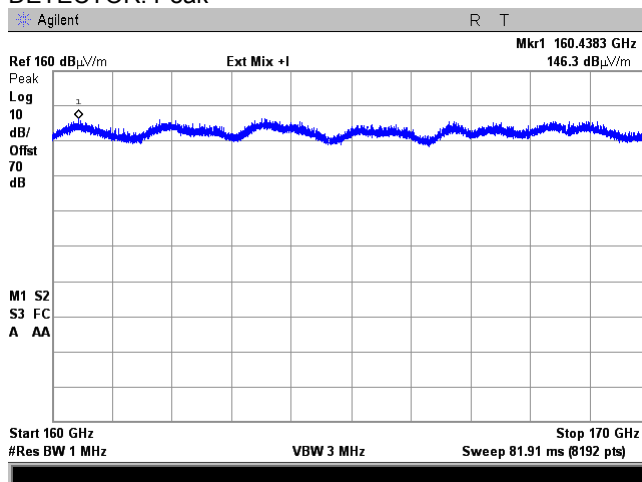


Peak 165.3 dBuV/m, average 145.38 dBuV/m limits applied.

Plot 7.4.13 Radiated emission measurements from 160 to 170 GHz

TEST SITE:
TEST DISTANCE:
ANTENNA POLARIZATION:
DETECTOR: Peak

OATS
0.001 m
Vertical and Horizontal
DETECTOR: Average



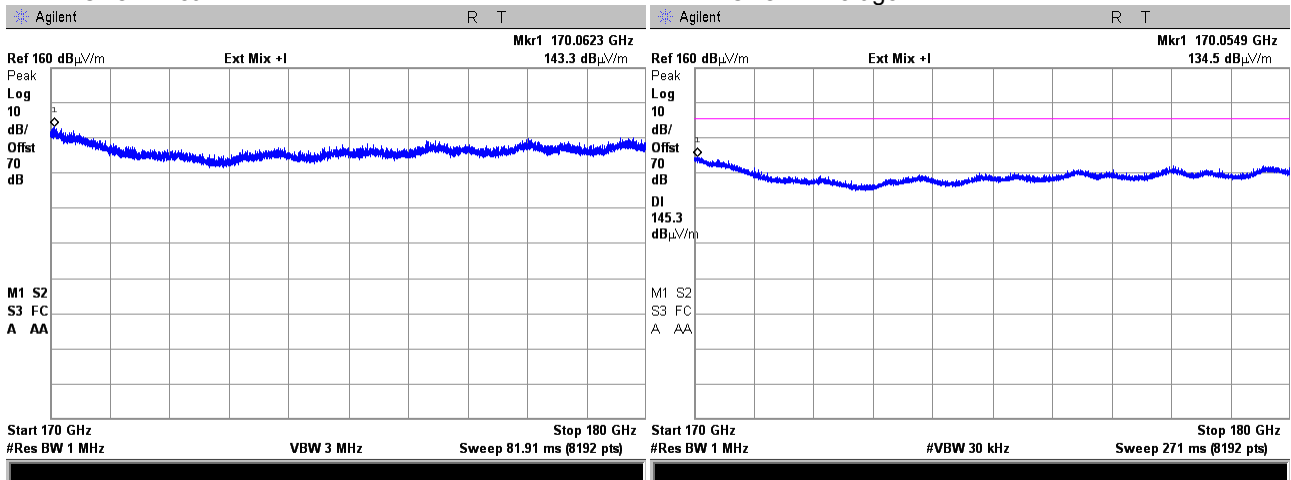
Peak 165.3 dBuV/m, average 145.38 dBuV/m limits applied.

Test specification: Section 15.255(d)(3), Out of band radiated emissions above 40 GHz			
Test procedure: ANSI C63.10, Sections 9.9, 9.12			
Test mode: Compliance		Verdict: PASS	
Date(s): 07-Jan-18			
Temperature: 24.4 °C	Relative Humidity: 46 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

Plot 7.4.14 Radiated emission measurements from 170 to 180 GHz

TEST SITE:
TEST DISTANCE:
ANTENNA POLARIZATION:
DETECTOR: Peak

OATS
0.001 m
Vertical and Horizontal
DETECTOR: Average

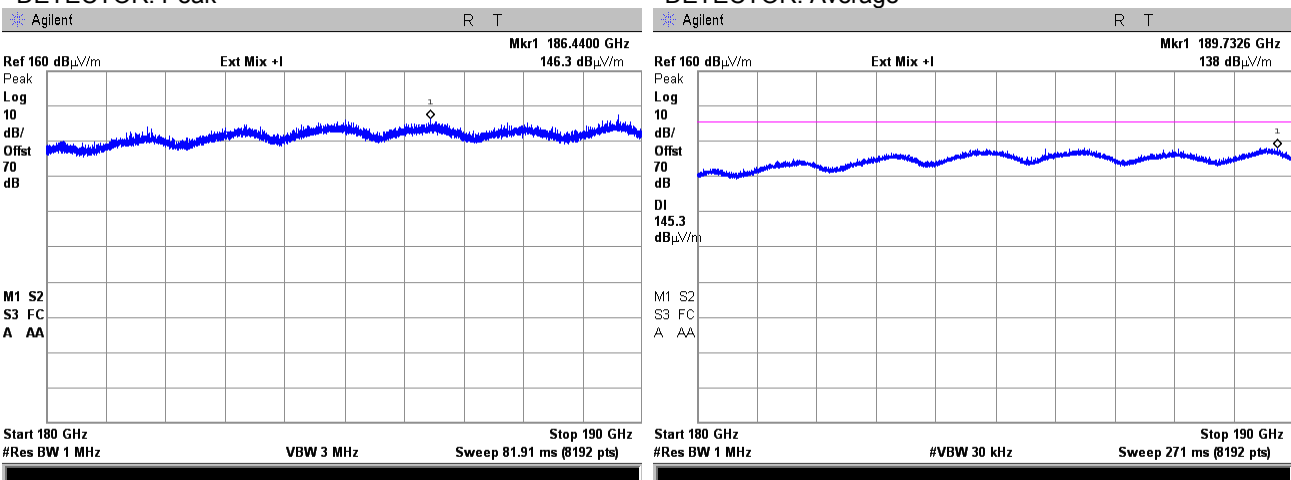


Peak 165.3 dBuV/m, average 145.38 dBuV/m limits applied.

Plot 7.4.15 Radiated emission measurements from 180 to 190 GHz

TEST SITE:
TEST DISTANCE:
ANTENNA POLARIZATION:
DETECTOR: Peak

OATS
0.001 m
Vertical and Horizontal
DETECTOR: Average



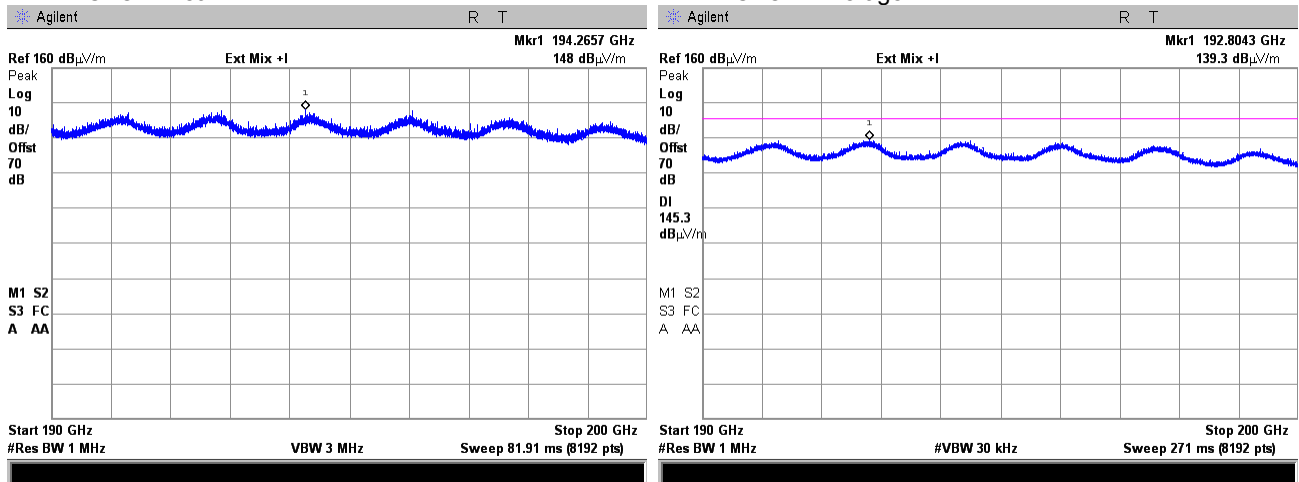
Peak 165.3 dBuV/m, average 145.38 dBuV/m limits applied.

Test specification:		Section 15.255(d)(3), Out of band radiated emissions above 40 GHz	
Test procedure:		ANSI C63.10, Sections 9.9, 9.12	
Test mode:		Verdict: PASS	
Date(s):			
07-Jan-18			
Temperature: 24.4 °C	Relative Humidity: 46 %	Air Pressure: 1020 hPa	Power: 48 VDC
Remarks:			

Plot 7.4.16 Radiated emission measurements from 190 to 200 GHz

TEST SITE:
TEST DISTANCE:
ANTENNA POLARIZATION:
DETECTOR: Peak

OATS
0.001 m
Vertical and Horizontal
DETECTOR: Average



Peak 165.3 dBuV/m, average 145.38 dBuV/m limits applied.

Test specification: Section 15.255(f), Frequency tolerance			
Test procedure: 47 CFR, Section 2.1055; ANSI C63.10, Section 9.14			
Test mode: Compliance	Verdict: PASS		
Date(s): 21-Jan-18			
Temperature: 25 °C	Relative Humidity: 53 %	Air Pressure: 1019 hPa	Power: 48 VDC
Remarks:			

7.5 Frequency stability test

7.5.1 General

This test was performed to measure frequency stability of transmitter RF carrier. Specification test limits are given in Table 7.5.1.

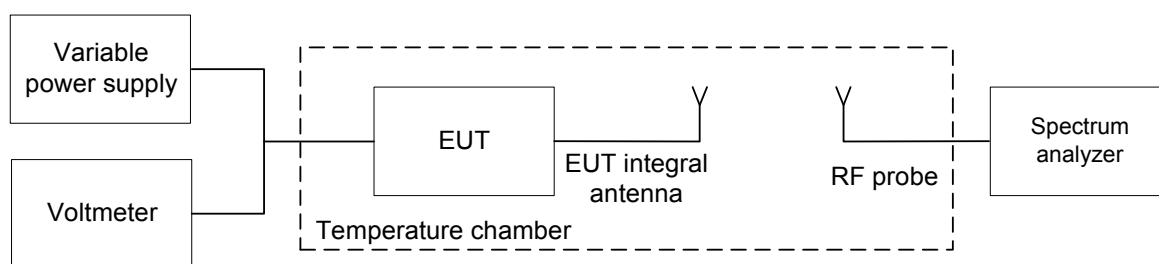
Table 7.5.1 Frequency stability limits

Assigned frequency, MHz	Maximum allowed frequency displacement
69875	NA

7.5.2 Test procedure

- 7.5.2.1 The EUT was set up as shown in Figure 7.5.1, energized and its proper operation was checked.
- 7.5.2.2 The EUT power was turned off. Temperature within test chamber was set to +30°C and a period of time sufficient to stabilize all of the oscillator circuit components was allowed.
- 7.5.2.3 The EUT was powered on and carrier frequency was measured at start up moment +30°C and then every minute until frequency had been stabilized or 10 minutes elapsed whichever reached the last. The EUT was powered off.
- 7.5.2.4 The above procedure was repeated at the rest of the test temperatures and voltages as provided in Table 7.5.2. The EUT was powered off.
- 7.5.2.5 Frequency displacement was calculated and compared with the limit as provided in Table 7.5.2.

Figure 7.5.1 Frequency stability test setup





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Test specification: Section 15.255(f), Frequency tolerance			
Test procedure: 47 CFR, Section 2.1055; ANSI C63.10, Section 9.14			
Test mode: Compliance		Verdict: PASS	
Date(s): 21-Jan-18			
Temperature: 25 °C	Relative Humidity: 53 %	Air Pressure: 1019 hPa	Power: 48 VDC
Remarks:			

Table 7.5.2 Frequency stability test results

OPERATING FREQUENCY: 57000 – 71000 MHz
 NOMINAL POWER VOLTAGE: 48 V
 TEMPERATURE STABILIZATION PERIOD: 20 min
 POWER DURING TEMPERATURE TRANSITION: Off
 SPECTRUM ANALYZER MODE: Counter
 RESOLUTION BANDWIDTH: 3 kHz
 VIDEO BANDWIDTH: 10 kHz
 MODULATION: Unmodulated

T, °C	Voltage, V	Frequency, MHz							Max frequency drift, kHz	
		Start up	1 st min	2 nd min	3 ^d min	4 th min	5 th min	10 th min	Positive	Negative
High frequency 69875 MHz										
-20	nominal	69875.0806	69875.0871	69.875.0882	69875.0884	69875.0886	69875.0887	69875.0880	1137.2	0
-10	nominal	69875.0430	NA	NA	NA	NA	NA	69874.9863	1091.5	0
0	nominal	69874.8249	69874.7945	69874.7872	69874.7775	69874.7692	69874.7628	69874.7306	873.4	0
10	nominal	69874.5727	NA	NA	NA	NA	NA	69874.4700	621.2	0
20	+15%	69873.8976	NA	NA	NA	NA	NA	69873.8969	0	54.6
20	nominal	69873.9000	NA	NA	NA	NA	NA	69873.9515	0	51.5
20	-15%)	69873.8960	NA	NA	NA	NA	NA	69873.8957	0	55.8
30	nominal	69874.0338	69874.0375	69874.0378	69874.0077	69874.0005	69.873.9955	69873.9764	86.3	0
40	nominal	69873.8772	NA	NA	NA	NA	NA	69873.8163	0	135.2
50	nominal	69873.7733	NA	NA	NA	NA	NA	69873.7833	0	178.2

* - Reference frequency

Reference numbers of test equipment used

HL 2358	HL 2909	HL 3210	HL 3305				
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Full description is given in Appendix A.

8 APPENDIX A Test equipment and ancillaries used for tests

HL No	Description	Manufacturer	Model	Ser. No.	Last Cal./ Check*	Due Cal./ Check*
0446	Antenna, Loop, Active, 10 kHz - 30 MHz	EMCO	6502	2857	19-Jan-17	19-Feb-18
0604	Antenna BiconiLog Log-Periodic/T Bow-TIE, 26 - 2000 MHz	EMCO	3141	9611-1011	12-May-17	12-May-18
0747	Mixer, Millimeter Wave Harmonic 90 - 140 GHz	Oleson Microwave Labs	M08HW	F80429-1	03-Mar-17	03-Mar-20
0770	Antenna Standard Gain Horn, 40-60 GHz WR-19, U-band, 24 dB mid-band gain	Quinstar Technology	QWH-1900-AA	118	18-Jul-17	18-Jul-18
0771	Antenna Standard Gain Horn, 60-90 GHz, WR-12, 24 dB mid-band gain	Quinstar Technology	QWH-1200-AA	111	13-Jul-17	13-Jul-18
0772	Antenna Standard Gain Horn, 75-110 GHz, WR-10, 24 dB mid-band gain	Quinstar Technology	QWH-0800-AA	110	13-Jul-17	13-Jul-18
1299	Transition waveguide ET28S -19R	Custom Microwave	ET28S - 19R	1299	30-Jul-15	30-Jul-18
1300	Transition waveguide ET28S -19R	Custom Microwave	ET28S - 19R	1300	30-Jul-15	30-Jul-18
1301	Transition waveguide ET28S -12R	Custom Microwave	ET28S - 12R	1301	30-Jul-15	30-Jul-18
1303	Transition waveguide ET28S -12R	Custom Microwave	ET28S - 12R	S0951	30-Jul-15	30-Jul-18
1304	Transition waveguide ET28S - 8R	Custom Microwave	ET28S - 8R	1304	30-Jul-15	30-Jul-18
1305	Transition waveguide ET28S - 8R	Custom Microwave	ET28S - 8R	1305	30-Jul-15	30-Jul-18
1312	Mixer Millimeter Wave Harmonic 140-220 GHz	Oleson Microwave Labs	M05HWD	G91112-1	03-Mar-17	03-Mar-20
2358	Power Supply, 2 X 0-36VDC / 5A, 5VDC / 5A	Horizon Electronics	DHR3655 D	767469	05-Jun-17	05-Jun-18
2909	Spectrum analyzer, ESA-E, 100 Hz to 26.5 GHz	Agilent Technologies	E4407B	MY414447 62	09-Mar-17	09-Mar-18
3001	EMC Analyzer, 9 kHz to 3 GHz	Agilent Technologies	E7402A	US394401 80	09-Oct-17	09-Oct-18
3210	Temperature Chamber, (-50...+100) °C	Associated Environmental Systems	NA	NA	03-Sep-17	03-Sep-18
3235	Harmonic mixer 40 to 60 GHz	Agilent Technologies	11970U	MY300301 82	16-Aug-16	16-Aug-19
3290	Attenuator, direct reading, 40 to 60 GHz, 0.4 W	Quinstar Technology	QAD-U00000	10381008	10-Dec-17	10-Dec-18
3291	Attenuator, direct reading, 60 to 90 GHz, 0.2 W	Quinstar Technology	QAD-E00000	10381009	10-Dec-17	10-Dec-18
3295	Tapered transition, WR-28, UG-599 to WR-15, UG-385 (26.5-40 GHz to 50-75 GHz)	Quinstar Technology	QWP-AV0000	10381005	30-Jul-15	30-Jul-18

HL No	Description	Manufacturer	Model	Ser. No.	Last Cal./ Check*	Due Cal./ Check*
3296	Tapered transition, WR-28, UG-599 to WR-10, UG-387 (26.5-40 GHz to 75-100 GHz)	Quinstar Technology	QWP-AW0000	10381006	30-Jul-15	30-Jul-18
3297	Tapered , WR-28, UG-599 to WR-10, UG-387 (26.5-40 GHz to 75-100 GHz)	Quinstar Technology	QWP-AW0000	10381007	30-Jul-15	30-Jul-18
3305	Harmonic mixer 50 to 75 GHz	Agilent Technologies	11970V	MY30030149	16-Aug-16	16-Aug-19
3306	Harmonic mixer 75 to 110 GHz	Agilent Technologies	11970W	MY25210273	16-Aug-16	16-Aug-19
3329	Antenna Standard Gain Horn, 140-220 GHz, WR-5, 24 dB mid-band gain	Quinstar Technology	NA	NA	19-Jul-17	19-Jul-18
3333	Oscilloscope, 1 GHz, 4 channels	LeCroy Corporation	LC584AL	10239	18-Jan-17	18-Jan-18
3433	Test Cable , DC-18 GHz, 1.5 m, SMA - SMA	Mini-Circuits	CBL-5FT-SMSM+	25679	27-Mar-17	27-Mar-18
3434	Test Cable , DC-18 GHz, 1.5 m, SMA - SMA	Mini-Circuits	CBL-5FT-SMSM+	25683	27-Mar-17	27-Mar-18
3536	Antenna Standard Gain Horn, 90-140 GHz, WR-8, 24 dB mid-band gain	Quinstar Technology	QWH-FPRR00	11159004001	15-Jun-17	15-Jun-18
3818	PSA Series Spectrum Analyzer, 3 Hz- 44 GHz	Agilent Technologies	E4446A	MY48250288	07-May-17	07-May-18
3901	Microwave Cable Assembly, 40.0 GHz, 3.5 m, SMA/SMA	Huber-Suhner	SUCOFLE X 102A	1225/2A	20-Feb-17	20-Feb-18
4023	Diplexer for use OML mixers with Agilent spectrum analyzer	Oleson Microwave Labs	DPL.26	NA	10-Dec-17	10-Dec-18
4273	Test Cable , DC-18 GHz, 1.8 m, SMA/M - N/M	Mini-Circuits	CBL-6FT-SMNM+	70045	04-Jun-17	04-Jun-18
4353	Low Loss Armored Test Cable, DC - 18 GHz, 6.2 m, N type-M/N type-M	MegaPhase	NC29-N1N1-244	12025101003	15-Mar-17	15-Mar-18
4360	EMI Test Receiver, 20 Hz to 40 GHz.	Rohde & Schwarz	ESU40	100322	26-Dec-17	26-Dec-18
4933	Active Horn Antenna, 1 GHz to 18 GHz	Com-Power Corporation	AHA-118	701046	04-Jan-18	04-Jan-19
4956	Active horn antenna, 18 to 40 GHz	Com-Power Corporation	AHA-840	105004	11-Jan-18	11-Jan-19
5245	RF cable, 18 GHz, 3 m, N-type	Huber-Suhner	ST18A/N m/Nm/3000	602211/18A	27-Jul-17	27-Jul-18

*The calibration was valid during the testing time

8.1 Test equipment and ancillaries used for tests

HL No.	Description	Manufacturer	Model	Ser. No.	Last Cal./ Check	Due Cal./ Check
NA	Signal Analyzer	Keysight	MXA N9020B	MY56080135	22-Jun-17	22-Jun-18
NA	Waveguide Harmonic Mixer	Keysight	M1971E Opt 003	MY56130185	11-Apr-17	10-May-18

9 APPENDIX B Measurement uncertainties

Expanded uncertainty at 95% confidence in Hermon Labs EMC measurements

Test description	Expanded uncertainty
Radiated emissions at 10 m measuring distance Horizontal polarization Vertical polarization	Biconilog antenna: ± 5.0 dB Biconical antenna: ± 5.0 dB Log periodic antenna: ± 5.1 dB Double ridged horn antenna: ± 5.3 dB Biconilog antenna: ± 5.5 dB Biconical antenna: ± 5.5 dB Log periodic antenna: ± 5.6 dB Double ridged horn antenna: ± 5.8 dB
Radiated emissions at 3 m measuring distance Horizontal polarization Vertical polarization	Biconilog antenna: ± 5.3 dB Biconical antenna: ± 5.0 dB Log periodic antenna: ± 5.3 dB Double ridged horn antenna: ± 5.3 dB Biconilog antenna: ± 6.0 dB Biconical antenna: ± 5.7 dB Log periodic antenna: ± 6.0 dB Double ridged horn antenna: ± 6.0 dB
Conducted emissions at RF antenna connector	9 kHz to 2.9 GHz: ± 2.6 dB 2.9 GHz to 6.46 GHz: ± 3.5 dB 6.46 GHz to 13.2 GHz: ± 4.3 dB 13.2 GHz to 22.0 GHz: ± 5.0 dB 22.0 GHz to 26.8 GHz: ± 5.5 dB 26.8 GHz to 40.0 GHz: ± 4.8 dB

Hermon Laboratories is accredited by A2LA for calibration according to present requirements of ISO/IEC 17025 and NCSL Z540-1. The accreditation is granted to perform calibration of parameters that are listed in the Scope of Hermon Laboratories Accreditation.

Hermon Laboratories calibrates its reference and transfer standards by calibration laboratories accredited to ISO/IEC 17025 by a mutually recognized Accreditation Body or by a recognized national metrology institute. All reference and transfer standards used in the calibration system are traceable to national or international standards.

In-house calibration of all test and measurement equipment is performed on a regular basis according to Hermon Laboratories calibration procedures, manufacturer calibration/verification procedures or procedures defined in the relevant standards. The Hermon Laboratories test and measurement equipment is calibrated within the tolerances specified by the manufacturers and/or by the relevant standards.

10 APPENDIX C Test facility description

Tests were performed at Hermon Laboratories Ltd., which is a fully independent, private, EMC, Radio, Safety, Environmental and Telecommunication testing facility.

Hermon Laboratories is recognized and accredited by the Federal Communications Commission (USA) for 1, 2, 15, 18 parts of Code of Federal Regulations 47 (CFR 47), Test Firm Registration Number is 927748, Designation Number is IL1001; registered by Industry Canada for electromagnetic emissions, file number IC 2186A-1 for OATS, certified by VCCI, Japan (the registration numbers are R-808 for OATS, R-1082 for anechoic chamber, G-869 for RE measurements above 1 GHz, C-845 for conducted emissions site and T-1606 for conducted emissions at telecommunication ports).

The laboratory is accredited by American Association for Laboratory Accreditation (USA) according to ISO/IEC 17025 for electromagnetic compatibility, product safety, telecommunications testing, environmental simulation and calibration (for exact scope please refer to Certificate No. 839.01, 839.03 and 839.04).

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Person for contact: Mr. Michael Nikishin, EMC&Radio group manager

11 APPENDIX D Specification references

47CFR part 27: 2017	Private land mobile radio services
47CFR part 1: 2017	Practice and procedure
47CFR part 2: 2017	Frequency allocations and radio treaty matters; general rules and regulations
ANSI C63.10: 2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
ANSI C63.2: 1996	American National Standard for Instrumentation-Electromagnetic Noise and Field Strength, 10 kHz to 40 GHz-Specifications.
ANSI C63.4: 2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

12 APPENDIX E Test equipment correction factors

Antenna factor
Active loop antenna
Model 6502, S/N 2857, HL 0446

Frequency, MHz	Magnetic antenna factor, dB	Electric antenna factor, dB
0.009	-32.8	18.7
0.010	-33.8	17.7
0.020	-38.3	13.2
0.050	-41.1	10.4
0.075	-41.3	10.2
0.100	-41.6	9.9
0.150	-41.7	9.8
0.250	-41.6	9.9
0.500	-41.8	9.8
0.750	-41.9	9.7
1.000	-41.4	10.1
2.000	-41.5	10.0
3.000	-41.4	10.2
4.000	-41.4	10.1
5.000	-41.5	10.1
10.000	-41.9	9.6
15.000	-41.9	9.6
20.000	-42.2	9.3
25.000	-42.8	8.7
30.000	-44.0	7.5

Antenna factor in dB(1/m) is to be added to receiver meter reading in dB(μ V) to convert it into field strength in dB(μ V/m).

Antenna factor
Standard gain horn antenna
Quinstar Technology
Model QWH
Ser.No.112, HL 0768, 0769, 0770, 0771, 0772

Frequency min, GHz	Frequency max, GHz	Antenna factor, dB(1/m)
18.000	26.500	32.01
26.500	40.000	35.48
40.000	60.000	39.03
60.000	90.000	42.55
90.000	140.000	46.23
140.000	220.000	50.11

Antenna factor in dB(1/m) is to be added to receiver meter reading in dB(μ V) to convert it into field intensity in dB(μ V/m).

Antenna factor
Biconilog antenna EMCO Model 3141
Ser.No.1011, HL 0604

Frequency, MHz	Antenna factor, dB(1/m)	Frequency, MHz	Antenna factor, dB(1/m)	Frequency, MHz	Antenna factor, dB(1/m)
26	7.8	580	20.6	1320	27.8
28	7.8	600	21.3	1340	28.3
30	7.8	620	21.5	1360	28.2
40	7.2	640	21.2	1380	27.9
60	7.1	660	21.4	1400	27.9
70	8.5	680	21.9	1420	27.9
80	9.4	700	22.2	1440	27.8
90	9.8	720	22.2	1460	27.8
100	9.7	740	22.1	1480	28.0
110	9.3	760	22.3	1500	28.5
120	8.8	780	22.6	1520	28.9
130	8.7	800	22.7	1540	29.6
140	9.2	820	22.9	1560	29.8
150	9.8	840	23.1	1580	29.6
160	10.2	860	23.4	1600	29.5
170	10.4	880	23.8	1620	29.3
180	10.4	900	24.1	1640	29.2
190	10.3	920	24.1	1660	29.4
200	10.6	940	24.0	1680	29.6
220	11.6	960	24.1	1700	29.8
240	12.4	980	24.5	1720	30.3
260	12.8	1000	24.9	1740	30.8
280	13.7	1020	25.0	1760	31.1
300	14.7	1040	25.2	1780	31.0
320	15.2	1060	25.4	1800	30.9
340	15.4	1080	25.6	1820	30.7
360	16.1	1100	25.7	1840	30.6
380	16.4	1120	26.0	1860	30.6
400	16.6	1140	26.4	1880	30.6
420	16.7	1160	27.0	1900	30.6
440	17.0	1180	27.0	1920	30.7
460	17.7	1200	26.7	1940	30.9
480	18.1	1220	26.5	1960	31.2
500	18.5	1240	26.5	1980	31.6
520	19.1	1260	26.5	2000	32.0
540	19.5	1280	26.6		
560	19.8	1300	27.0		

Antenna factor in dB(1/m) is to be added to receiver meter reading in dB(μ V) to convert it into field strength in dB(μ V/m).



HERMON LABORATORIES

Antenna factor, HL 4933

**Active Horn Antenna Factor Calibration**

1 GHz to 18 GHz

Equipment:			ACTIVE HORN ANTENNA		
Model:			AHA-118		
Serial Number:			701046		
Calibration Distance:			3 Meter		
Polarization:			Horizontal		
Calibration Date:			11/12/2014		
Frequency (GHz)	Preamplifier Gain (dB)	Antenna Factor with pre-amp (dB/m)	Frequency (GHz)	Preamplifier Gain (dB)	Antenna Factor with pre-amp (dB/m)
1	40.96	-16.47	10	40.94	-1.97
1.5	41.21	-14.53	10.5	40.63	-1.06
2	41.44	-13.30	11	40.74	-1.50
2.5	41.71	-12.87	11.5	40.65	-0.52
3	41.96	-12.26	12	40.76	-0.15
3.5	42.14	-11.77	12.5	41.03	-0.85
4	42.13	-10.91	13	41.37	-0.81
4.5	41.79	-9.41	13.5	41.18	0.05
5	41.44	-7.54	14	40.98	0.36
5.5	40.91	-6.47	14.5	40.81	1.26
6	40.69	-5.48	15	40.65	0.25
6.5	40.64	-5.53	15.5	40.93	-1.05
7	40.76	-4.12	16	41.31	-1.44
7.5	40.94	-3.12	16.5	40.96	-0.80
8	40.68	-1.69	17	40.64	-0.02
8.5	40.08	-1.71	17.5	40.57	1.81
9	40.41	-1.86	18	40.08	3.63
9.5	41.21	-2.73			
Calibration according to ARP 958					
Antenna Factor to be added to receiver reading:					
Meter Reading (dBuV) + Antenna Factor (dB/m) = Corrected Reading (dBuV/m)					



HERMON LABORATORIES

Antenna factor, HL 4956

**Active Horn Antenna Factor Calibration**

18 GHz to 40 GHz

Equipment:			ACTIVE HORN ANTENNA		
Model:			AHA-840		
Serial Number:			105004		
Calibration Distance:			3 meter		
Polarization:			Horizontal		
Calibration Date:			1/26/2015		
Frequency (GHz)	Preamplifier Gain (dB)	Antenna Factor with pre-amp (dB/m)	Frequency (GHz)	Preamplifier Gain (dB)	Antenna Factor with pre-amp (dB/m)
18	38.83	-1.06	29.5	42.47	-5.33
18.5	39.34	-2.65	30	41.91	-4.86
19	39.71	-3.88	30.5	41.60	-4.64
19.5	39.87	-4.35	31	41.52	-4.60
20	39.98	-3.97	31.5	41.56	-4.79
20.5	40.42	-3.68	32	41.80	-5.21
21	41.12	-4.06	32.5	42.29	-5.54
21.5	41.74	-5.46	33	42.79	-5.63
22	42.14	-6.22	33.5	42.88	-5.38
22.5	42.35	-6.42	34	42.62	-4.76
23	42.50	-6.59	34.5	42.63	-4.84
23.5	42.65	-6.82	35	43.15	-5.13
24	42.81	-7.01	35.5	43.91	-5.83
24.5	42.86	-7.37	36	44.59	-6.39
25	42.73	-7.53	36.5	45.04	-6.64
25.5	42.77	-7.45	37	45.08	-6.40
26	42.85	-7.21	37.5	44.82	-5.75
26.5	42.98	-7.17	38	44.16	-4.58
27	43.14	-7.22	38.5	42.90	-2.66
27.5	43.18	-7.32	39	42.39	-1.71
28	43.04	-7.10	39.5	43.76	-2.49
28.5	43.01	-6.73	40	45.98	-5.21
Calibration per ANSI C63.5: 2006 Standard Site Method, Equations 1-6 (3-antenna) Corrected Reading (dBμV/m) = Meter Reading (dBμV) + AFE(dB/m)					

Cable loss
Test Cable, Mini-Circuits, CBL-5FT-SMSM+, SMA-SMA, 18 GHz, 1.5 m, S/N 25679
Mini-Circuits, HL 3433

Frequency, MHz	Cable loss, dB	Frequency, MHz	Cable loss, dB
10.0	0.06	9000	2.01
100	0.17	9500	2.06
500	0.41	10000	2.05
1000	0.58	10500	2.18
1500	0.72	11000	2.26
2000	0.86	11500	2.28
2500	0.96	12000	2.43
3000	1.04	12500	2.53
3500	1.13	13000	2.52
4000	1.23	13500	2.56
4500	1.31	14000	2.60
5000	1.41	14500	2.59
5500	1.49	15000	2.67
6000	1.55	15500	2.76
6500	1.63	16000	2.86
7000	1.71	16500	2.91
7500	1.78	17000	2.95
8000	1.86	17500	3.02
8500	1.92	18000	3.07

Cable loss
Test Cable, Mini-Circuits, CBL-5FT-SMSM+, SMA-SMA, 18 GHz, 1.5 m, S/N 25683
Mini-Circuits, HL 3434

Frequency, MHz	Cable loss, dB	Frequency, MHz	Cable loss, dB
10.0	0.06	9000	1.96
100	0.16	9500	2.01
500	0.40	10000	2.01
1000	0.57	10500	2.14
1500	0.72	11000	2.21
2000	0.85	11500	2.24
2500	0.95	12000	2.36
3000	1.03	12500	2.47
3500	1.11	13000	2.46
4000	1.21	13500	2.50
4500	1.29	14000	2.53
5000	1.39	14500	2.53
5500	1.46	15000	2.62
6000	1.52	15500	2.70
6500	1.60	16000	2.80
7000	1.68	16500	2.86
7500	1.75	17000	2.88
8000	1.83	17500	2.94
8500	1.88	18000	3.00

Cable loss
Microwave Cable Assembly, Huber-Suhner, 40 GHz, 3.5 m, SMA-SMA, S/N 1225/2A
HL 3901

Frequency, MHz	Cable loss, dB	Frequency, MHz	Cable loss, dB	Frequency, MHz	Cable loss, dB
10	0.09	9500	4.29	21000	6.67
100	0.41	10000	4.40	22000	6.92
500	0.93	10500	4.52	23000	7.00
1000	1.33	11000	4.64	24000	7.18
1500	1.63	11500	4.76	25000	7.29
2000	1.90	12000	4.87	26000	7.55
2500	2.12	12500	4.99	27000	7.70
3000	2.33	13000	5.11	28000	7.88
3500	2.50	13500	5.20	29000	8.02
4000	2.67	14000	5.31	30000	8.15
4500	2.82	14500	5.42	31000	8.35
5000	2.99	15000	5.51	32000	8.40
5500	3.16	15500	5.58	33000	8.62
6000	3.32	16000	5.68	34000	8.73
6500	3.51	16500	5.78	35000	8.78
7000	3.65	17000	5.91	36000	8.94
7500	3.79	17500	5.99	37000	9.21
8000	3.92	18000	6.07	38000	9.37
8500	4.04	19000	6.36	39000	9.45
9000	4.18	20000	6.49	40000	9.52

Cable loss
Test cable, Mini-Circuits, S/N 70045, 18 GHz, 1.8 m, SMA/M - N/M
CBL-6FT-SMNM+, HL 4273

Frequency, MHz	Cable loss, dB	Frequency, MHz	Cable loss, dB	Frequency, MHz	Cable loss, dB	Frequency, MHz	Cable loss, dB
10	0.09	4800	1.76	9800	2.70	14800	3.59
30	0.11	4900	1.78	9900	2.71	14900	3.59
50	0.14	5000	1.81	10000	2.73	15000	3.60
100	0.20	5100	1.82	10100	2.75	15100	3.63
200	0.30	5200	1.86	10200	2.76	15200	3.67
300	0.38	5300	1.89	10300	2.79	15300	3.70
400	0.45	5400	1.92	10400	2.81	15400	3.68
500	0.50	5500	1.96	10500	2.82	15500	3.70
600	0.55	5600	2.00	10600	2.83	15600	3.71
700	0.60	5700	2.03	10700	2.87	15700	3.77
800	0.65	5800	2.04	10800	2.87	15800	3.75
900	0.69	5900	2.07	10900	2.88	15900	3.77
1000	0.73	6000	2.10	11000	2.89	16000	3.79
1100	0.77	6100	2.10	11100	2.91	16100	3.85
1200	0.80	6200	2.11	11200	2.92	16200	3.82
1300	0.84	6300	2.11	11300	2.94	16300	3.83
1400	0.88	6400	2.14	11400	2.95	16400	3.88
1500	0.92	6500	2.15	11500	2.98	16500	3.89
1600	0.95	6600	2.15	11600	3.00	16600	3.92
1700	0.98	6700	2.16	11700	3.02	16700	3.88
1800	1.01	6800	2.19	11800	3.04	16800	3.95
1900	1.04	6900	2.22	11900	3.08	16900	3.91
2000	1.07	7000	2.24	12000	3.09	17000	3.97
2100	1.09	7100	2.26	12100	3.12	17100	3.92
2200	1.13	7200	2.29	12200	3.13	17200	3.94
2300	1.15	7300	2.32	12300	3.16	17300	3.94
2400	1.18	7400	2.36	12400	3.17	17400	3.98
2500	1.21	7500	2.39	12500	3.19	17500	3.93
2600	1.24	7600	2.41	12600	3.20	17600	3.95
2700	1.27	7700	2.43	12700	3.21	17700	3.96
2800	1.30	7800	2.46	12800	3.21	17800	3.97
2900	1.34	7900	2.49	12900	3.22	17900	3.96
3000	1.36	8000	2.52	13000	3.22	18000	3.97
3100	1.38	8100	2.52	13100	3.24		
3200	1.41	8200	2.54	13200	3.24		
3300	1.45	8300	2.59	13300	3.27		
3400	1.46	8400	2.61	13400	3.28		
3500	1.49	8500	2.60	13500	3.31		
3600	1.51	8600	2.63	13600	3.31		
3700	1.55	8700	2.65	13700	3.35		
3800	1.34	8800	2.65	13800	3.37		
3900	1.36	8900	2.65	13900	3.40		
4000	1.38	9000	2.66	14000	3.43		
4100	1.41	9100	2.66	14100	3.45		
4200	1.45	9200	2.67	14200	3.46		
4300	1.46	9300	2.67	14300	3.46		
4400	1.49	9400	2.67	14400	3.49		
4500	1.51	9500	2.68	14500	3.50		
4600	1.55	9600	2.69	14600	3.50		
4700	1.34	9700	2.69	14700	3.52		

Cable loss
Low Loss Armored Test Cable, MegaPhase, 18 GHz, 6.2 m, N type-M/N type-M,
NC29-N1N1-244S/N 12025101 003,
HL 4353

Frequency, MHz	Cable loss, dB	Frequency, MHz	Cable loss, dB
50	0.20	9000	2.71
100	0.27	9500	2.81
300	0.47	10000	2.90
500	0.61	10500	2.97
1000	0.87	11000	3.06
1500	1.07	11500	3.13
2000	1.24	12000	3.20
2500	1.39	12500	3.26
3000	1.53	13000	3.34
3500	1.65	13500	3.39
4000	1.77	14000	3.47
4500	1.89	14500	3.54
5000	1.99	15000	3.62
5500	2.07	15500	3.69
6000	2.20	16000	3.76
6500	2.30	16500	3.83
7000	2.39	17000	3.86
7500	2.51	17500	3.94
8000	2.58	18000	4.02
8500	2.65		

Cable loss
RF Cable, Huber-Suhner, 18 GHz, 3 m, N- type,
ST18A/Nm/Nm/3000, S/N 602211/18A
HL 5245

Frequency, MHz	Cable loss, dB	Frequency, MHz	Cable loss, dB
0.1	0.01	5500	1.76
50	0.16	6000	1.85
100	0.23	6500	1.93
200	0.32	7000	2.02
300	0.39	7500	2.11
400	0.45	8000	2.19
500	0.51	8500	2.26
600	0.56	9000	2.30
700	0.60	9500	2.33
800	0.65	10000	2.37
900	0.68	10500	10500
1000	0.72	11000	11000
1100	0.76	11500	11500
1200	0.80	12000	12000
1300	0.83	12500	12500
1400	0.86	13000	13000
1500	0.89	13500	13500
1600	0.92	14000	14000
1700	0.95	14500	14500
1800	0.98	15000	15000
1900	1.01	15500	15500
2000	1.03	16000	16000
2500	1.16	16500	16500
3000	1.27	17000	17000
3500	1.38	17500	17500
4000	1.48	18000	18000
4500	1.58		
5000	1.67		

13 APPENDIX F Abbreviations and acronyms

A	ampere
AC	alternating current
A/m	ampere per meter
AM	amplitude modulation
AVRG	average (detector)
BB	broad band
cm	centimeter
dB	decibel
dBm	decibel referred to one milliwatt
dB(μ V)	decibel referred to one microvolt
dB(μ V/m)	decibel referred to one microvolt per meter
dB(μ A)	decibel referred to one microampere
dB Ω	decibel referred to one Ohm
DC	direct current
EIRP	equivalent isotropically radiated power
ERP	effective radiated power
EUT	equipment under test
F	frequency
GHz	gigahertz
GND	ground
H	height
HL	Hermon laboratories
Hz	hertz
ITE	information technology equipment
k	kilo
kHz	kilohertz
LISN	line impedance stabilization network
LO	local oscillator
m	meter
MHz	megahertz
min	minute
mm	millimeter
ms	millisecond
μ s	microsecond
NA	not applicable
NB	narrow band
NT	not tested
OATS	open area test site
Ω	Ohm
QP	quasi-peak
PM	pulse modulation
PS	power supply
RE	radiated emission
RF	radio frequency
rms	root mean square
Rx	receive
s	second
T	temperature
Tx	transmit
V	volt
VA	volt-ampere

END OF DOCUMENT