HERMON LABORATORIES

ELECTRICAL TESTING
0839.01

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TEST REPORT

ACCORDING TO: FCC 47 CFR Part 90, subpart I, and RSS-119 Issue 12:2015

FOR:

Telematics Wireless Ltd

Light Control Unit

Model: LCUN3HG

FCC ID: NTAN3G

IC: 4732A-N3G

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1 Applicant information

Client name:	Telematics Wireless Ltd
Address:	26 Hamelacha street, POB 1911, Holon, 5811801, Israel
Telephone:	+972 3557 5700
Fax:	+972 3557 5703
E-mail:	itsikk@tlmw.com
Contact name:	Mr. Itsik Kanner

2 Equipment under test attributes

Product name:	LCU NEMA
Product type:	Transceiver
Model(s):	LCUN3HG
Serial number:	9200118
Hardware version:	Rev. C
Software release:	AU2B6
Receipt date	18-Jul-19

3 Manufacturer information

Manufacturer name:	Telematics Wireless Ltd
Address:	26 Hamelacha street, POB 1911, Holon, 5811801, Israel
Telephone:	+972 3557 5700
Fax:	+972 3557 5703
E-Mail:	itsikk@tlmw.com
Contact name:	Mr. Itsik Kanner

4 Test details

Project ID:	33822
Location:	Hermon Laboratories Ltd. P.O. Box 23, Binyamina 3055001, Israel
Test started:	18-Jul-19
Test completed:	15-Oct-19
Test specification(s):	FCC 47 CFR Part 90, subpart I, and RSS-119 Issue 12:2015

5 Tests summary

Test	Status
Transmitter characteristics	
FCC Section 90.267 / RSS-119 Section 5.4, Maximum output power	Pass
FCC Section 90.209 / RSS-119 Section 5.5, Occupied bandwidth	Pass
FCC Section 90.210 / RSS-119 Section 5.8.4, Emission mask	Pass
FCC Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions	Pass
FCC Section 90.213 / RSS-119 Section 5.3, Frequency stability	Pass
FCC Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour	Pass
FCC Section 2.1091 / RSS-102 section 2.5, RF radiation exposure evaluation	Pass, Exhibit in application for certification provided

This test report supersedes the previously issued test report identified by Doc ID: TELRAD_FCC.33822_Rev1

Testing was completed against all relevant requirements of the test standard. The results obtained indicate that the product under test complies in full with the requirements tested.
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. V. Dorofeyev test engineer EMC & Radio	18 Jul 19 – 15 Oct 19	
Reviewed by:	Mrs. S. Peysahov Sheynin test engineer EMC & Radio	20 Oct 19 – 28 Oct 19	
Approved by:	Mr. S. Samokha, technical manager, EMC and Radio	28 Oct 19	

6 EUT description

Note: The following data in this clause is provided by the customer and represents his sole responsibility

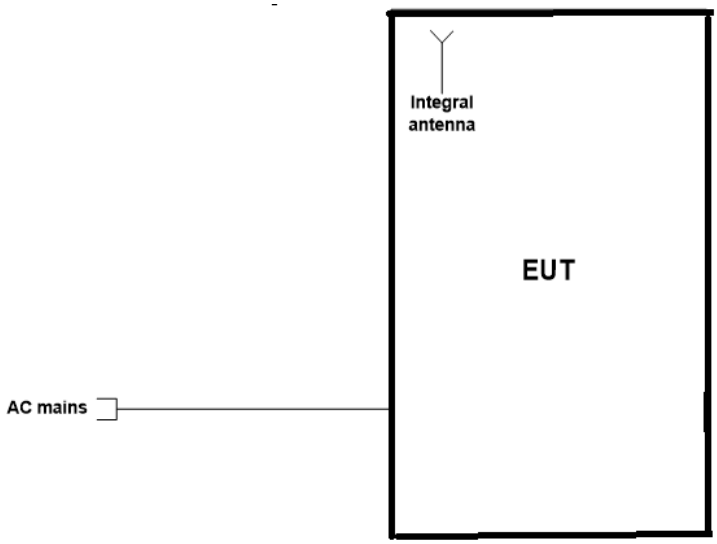
6.1 General information

LCU NEMA is a luminaire control unit, installed on top of the luminaire utilizing a standard (twist and lock) NEMA socket.

The LCU NEMA is powered by 347-480V AC

The operating frequency band is 450 to 470MHz. Output RF power 0.6 Watt

6.2 Test configuration



6.3 Changes made in EUT

No changes were implemented in the EUT during testing.

6.4 Transmitter characteristics

Type of equipment	
X	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**
	fixed	Always at a distance more than 2 m from all people
X	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 ranges	450- 470 MHz

Maximum rated output power	At transmitter 50 Ω RF output connector	27.96 dBm

Is transmitter output power variable?	X	No			
		Yes		continuous variable	
				stepped variable with stepsize	dB
			minimum RF power		dBm
			maximum RF power		dBm

Antenna connection				
unique coupling	standard connector	X	integral	with temporary RF connector
			X	without temporary RF connector

Antenna/s technical characteristics

Type	Manufacturer	Model number	Gain
Printed	Telematics Wireless	NA	-1 dBi Max

Transmitter aggregate data rate/s	4.8 kbps

Type of modulation	4GFSK

Modulating test signal (baseband)	PRBS

Transmitter power source

	Battery	**Nominal rated voltage**		Battery type	
	DC	**Nominal rated voltage**			
X	AC mains	**Nominal rated voltage**	347-480 VAC	Frequency	60 Hz

Test specification:	Section 90.267 / RSS-119 Section 5.4, Maximum output power		
Test procedure:	47 CFR, Section 2.1046		
Test mode:	Compliance	Verdict:	PASS
Date(s):	31-Jul-19		
Temperature: 25.1 ºC	Relative Humidity: 46 %	Air Pressure: 1005 hPa	Power: 480 VAC, 60 Hz
Remarks:			

7 Transmitter tests according to 47CFR part 90 and RSS-119 requirements

7.1 Peak output power test

7.1.1 General

This test was performed to measure effective radiated power emanated by transmitter at carrier frequency. Specification test limits are given in Table 7.1.1.

Table 7.1.1 Effective radiated power limit

Assigned frequency band, MHz	ERP		Equivalent field strength limit @ 3m, dB(μV/m)*
	W	dBm	
FCC			
450.0 – 470.0	2	33.01	130.39
RSS-119 Table 2			
450.0 – 470.0	60	47.78	145.16

* - Equivalent field strength limit was calculated from maximum allowed ERP as follows: E=sqrt(30×P×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

7.1.2 Test procedure for field strength measurements

7.1.2.1 The EUT was set up as shown in Figure 7.1.1, energized and the performance check was conducted.

7.1.2.2 The field strength of the EUT carrier frequency was measured with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360°, the measuring antenna height was swept throughout the range, specified in Table 7.1.2 in both vertical and horizontal polarizations.

7.1.2.3 The worst test results (the lowest margins) were recorded in Table 7.1.2 and shown in the associated plots.

Test specification:	**Section 90.267 / RSS-119 Section 5.4, Maximum output power**		
Test procedure:	47 CFR, Section 2.1046		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	31-Jul-19		
Temperature: 25.1 ºC	**Relative Humidity:** 46 %	**Air Pressure:** 1005 hPa	**Power:** 480 VAC, 60 Hz
Remarks:			

Figure 7.1.1 Setup for carrier field strength measurements

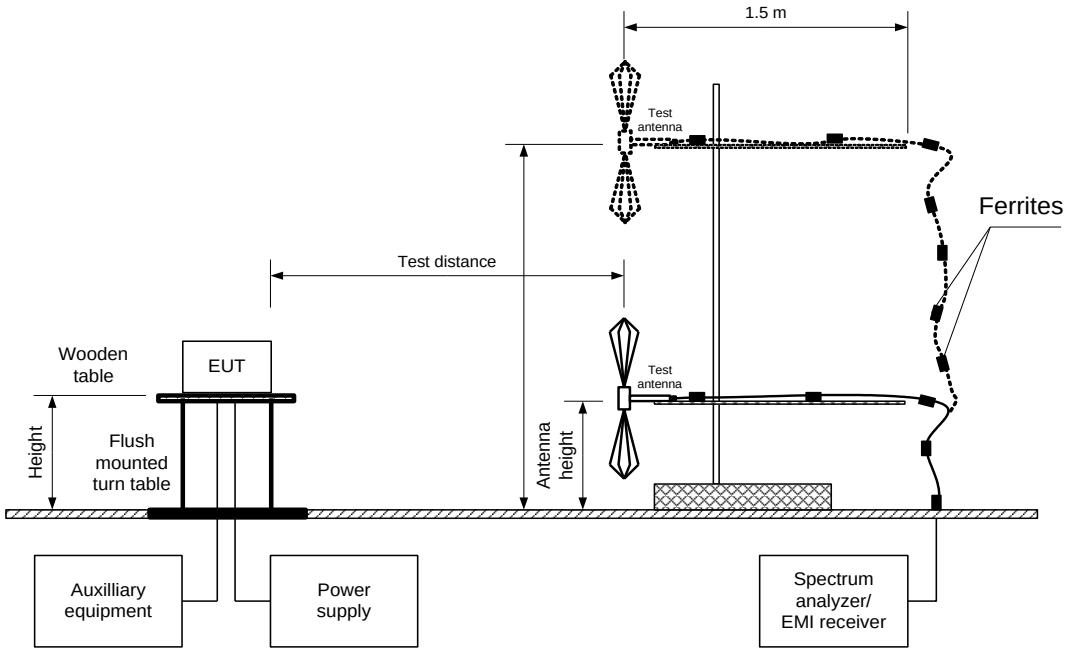


Table 7.1.2 Transmitter carrier field strength

ASSIGNED FREQUENCY RANGE:	450 - 470 MHz
TEST SITE:	Semi anechoic chamber
TEST DISTANCE:	3 m
EUT HEIGHT:	0.8 m
TEST ANTENNA HEIGHTS RANGE:	1.0 – 4.0 m
DETECTOR USED:	Peak
VIDEO BANDWIDTH:	> Resolution bandwidth
TEST ANTENNA TYPE:	Log periodic
MODULATION:	4GFSK
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum

Frequency, MHz	Field strength, dB(µV/m)	Antenna polarization	Azimuth, degrees	EUT antenna gain, dBi	Peak output power, dBm*	Limit, dBm	Margin, dB**	Verdict
450.0017	119.16	Vertical	0	-4	27.96	33.01	-5.05	Pass
460.0000	121.81	Vertical	0	-1	27.61	33.01	-5.40	Pass
469.9983	120.59	Vertical	0	-2	27.39	33.01	-5.62	Pass

*****- Peak output power was calculated from the field strength of carrier as follows: $P = (E \times d)^2 / (30 \times G)$,
where P is the peak output power in W, E is the field strength in V/m, d is the test distance in meters and G is the transmitter numeric antenna gain over an isotropic radiator. The above equation was converted in logarithmic units for 3 m test distance:
Peak output power in dBm = Field strength in dB(µV/m) - Transmitter antenna gain in dBi – 95.2 dB

******- Margin = Peak output power – specification limit.

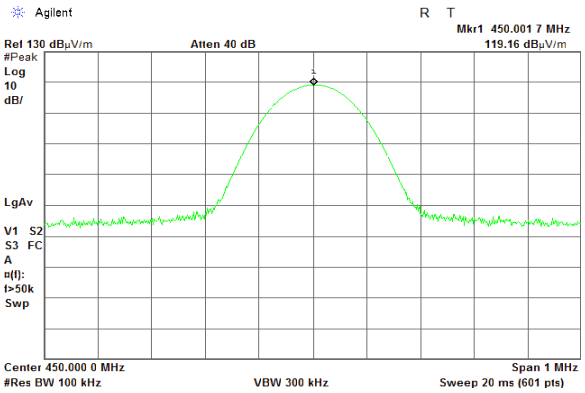
Reference numbers of test equipment used

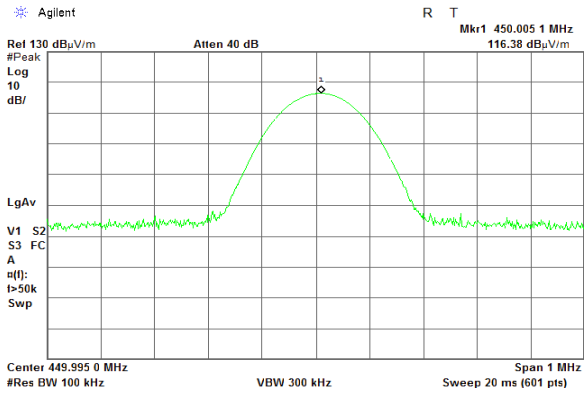
HL 0415	HL 3903	HL 0604	HL 5084	HL 5404			

Full description is given in Appendix A.

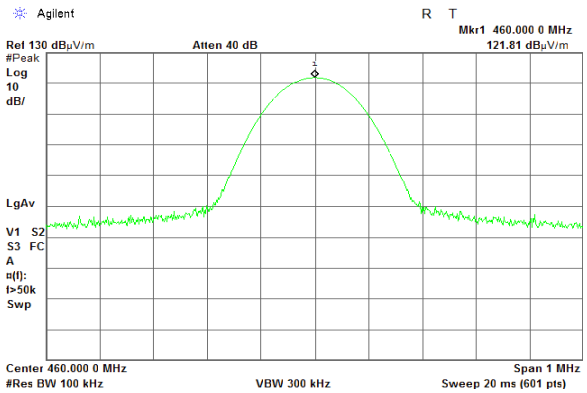
Test specification:	Section 90.267 / RSS-119 Section 5.4, Maximum output power		
Test procedure:	47 CFR, Section 2.1046		
Test mode:	Compliance	Verdict:	PASS
Date(s):	31-Jul-19		
Temperature: 25.1 ºC	Relative Humidity: 46 %	Air Pressure: 1005 hPa	Power: 480 VAC, 60 Hz
Remarks:			

Plot 7.1.1 Transmitter carrier field strength at low frequency in vertical and horizontal antenna polarization

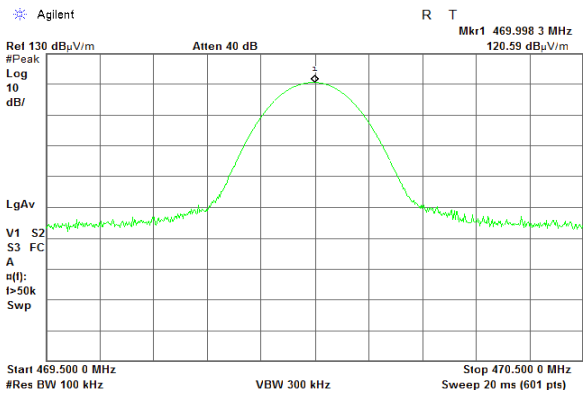




Plot 7.1.2 Transmitter carrier field strength at mid frequency in vertical antenna polarization



Plot 7.1.3 Transmitter carrier field strength at high frequency in vertical antenna polarization



Test specification:	Section 90.209 / RSS-119 Section 5.5, Occupied bandwidth		
Test procedure:	47 CFR, Section 2.1049		
Test mode:	Compliance	Verdict:	PASS
Date(s):	15-Oct-19		
Temperature: 24.3 ºC	Relative Humidity: 46 %	Air Pressure: 1009 hPa	Power: 480 VAC, 60 Hz
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, MHz	Modulation envelope reference points*, dBc	Maximum restricted bandwidth, kHz
450.0 – 470.0	26	6

* - Modulation envelope reference points are provided in terms of attenuation below the unmodulated carrier.

7.2.2 Test procedure

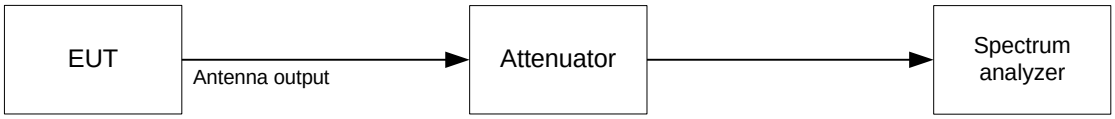
7.2.2.1 The EUT was set up as shown in Figure 7.2.1, energized and its proper operation was checked.

7.2.2.2 The EUT was set to transmit the unmodulated carrier and the reference peak power level was measured.

7.2.2.3 The EUT was set to transmit the normally modulated carrier.

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

Figure 7.2.1 Occupied bandwidth test setup



Test specification:	**Section 90.209 / RSS-119 Section 5.5, Occupied bandwidth**		
Test procedure:	47 CFR, Section 2.1049		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	15-Oct-19		
Temperature: 24.3 ºC	**Relative Humidity:** 46 %	**Air Pressure:** 1009 hPa	**Power:** 480 VAC, 60 Hz
Remarks:			

Table 7.2.2 Occupied bandwidth test results

DETECTOR USED:	Peak hold
RESOLUTION BANDWIDTH:	100 Hz
VIDEO BANDWIDTH:	1 kHz
MODULATION:	4GFSK
MODULATING SIGNAL:	ID code
BIT RATE:	4.8 kbps

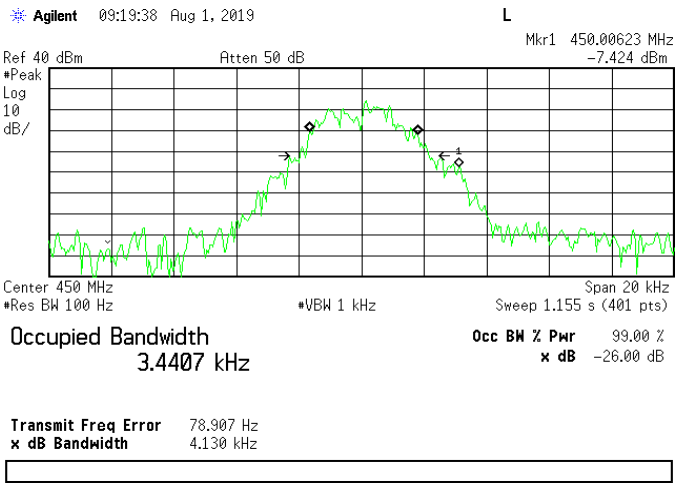
Carrier frequency, MHz	Occupied bandwidth, kHz	Limit, kHz	Margin, kHz	Verdict
MODULATION ENVELOPE REFERENCE POINTS: 99%				
450.000	3.440	6	-2.560	Pass
460.000	3.305	6	-2.695	Pass
470.000	3.688	6	-2.312	Pass
MODULATION ENVELOPE REFERENCE POINTS: 26 dBc				
450.000	4.130	6	-1.870	Pass
460.000	4.330	6	-1.670	Pass
470.000	4.917	6	-1.083788	Pass

Reference numbers of test equipment used

HL 2909	HL 1809	HL 4135					

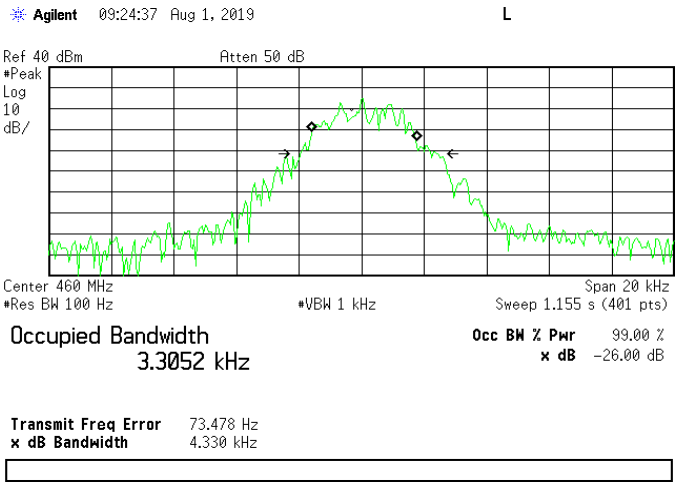
Full description is given in Appendix A.

Plot 7.2.1 Occupied bandwidth test result at low frequency

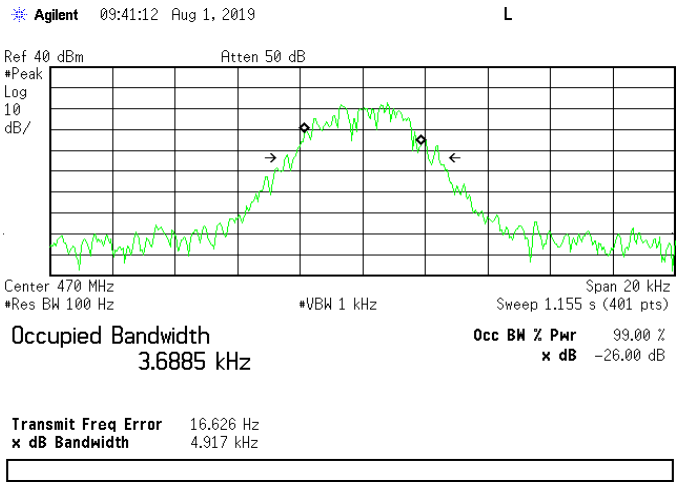


Test specification:	Section 90.209 / RSS-119 Section 5.5, Occupied bandwidth		
Test procedure:	47 CFR, Section 2.1049		
Test mode:	Compliance	Verdict:	PASS
Date(s):	15-Oct-19		
Temperature: 24.3 ºC	Relative Humidity: 46 %	Air Pressure: 1009 hPa	Power: 480 VAC, 60 Hz
Remarks:			

Plot 7.2.2 Occupied bandwidth test result at mid frequency



Plot 7.2.3 Occupied bandwidth test result at high frequency



Test specification:	**Section 90.210 / RSS-119 Section 5.8.4, Emission mask**		
Test procedure:	47 CFR, Sections 2.1051, 2.1047 and 90.210(e); TIA/EIA-603-E, Section 2.2.13		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	15 Oct-19		
Temperature: 24.3 ºC	**Relative Humidity:** 46 %	**Air Pressure:** 1009 hPa	**Power:** 480 VAC, 60 Hz
Remarks:			

7.3 Emission mask test

7.3.1 General

This test was performed to measure emission mask at RF antenna connector. Specification test limits are given in Table 7.3.1. The test results are provided in the associated plots.

Table 7.3.1 Emission mask limits

Frequency displacement from carrier	Attenuation below carrier, dBc
Emission mask E (Channel bandwidth 6.25 kHz, authorized bandwidth 6.0 kHz) without audio low pass filter)	
0 – 3.0 kHz	0
3.0 – 4.6 kHz	30 + 16.67(f_d** - 3 kHz) or 55+10logP(W) or 65 whichever is the lesser (FCC)
More than 4.6 kHz	55+10logP(W) or 57 whichever is the lesser (RSS-119) 55+10logP(W) or 65 whichever is the lesser (FCC)

* - linearly increase with frequency
** - displacement frequency

7.3.2 Test procedure

7.3.2.1 The EUT was set up as shown in Figure 7.3.1 energized and its proper operation was checked.

7.3.2.2 The emission mask was measured with spectrum analyzer as provided in the associated plots.

7.3.2.3 The test results are provided in Table 7.3.2 and the the associated plots.

Table 7.3.2 Emission mask test results

Carrier frequency, MHz	Limit	Verdict
450.000	Emission mask E	Pass
460.000		
470.000		

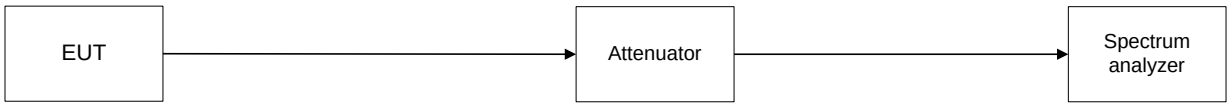
Reference numbers of test equipment used

HL 2909	HL 5175	HL 1809					

Full description is given in Appendix A.

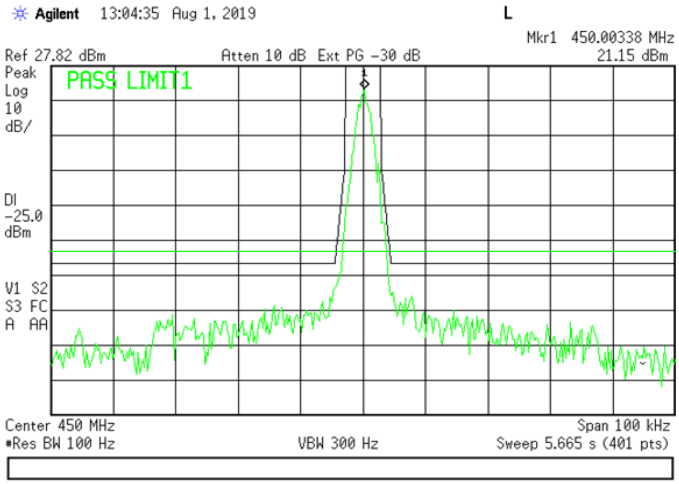
Test specification:	**Section 90.210 / RSS-119 Section 5.8.4, Emission mask**		
Test procedure:	47 CFR, Sections 2.1051, 2.1047 and 90.210(e); TIA/EIA-603-E, Section 2.2.13		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	15 Oct-19		
Temperature: 24.3 ºC	**Relative Humidity:** 46 %	**Air Pressure:** 1009 hPa	**Power:** 480 VAC, 60 Hz
Remarks:			

Figure 7.3.1 Emission mask test setup



Plot 7.3.1 Emission mask test results at low carrier frequency

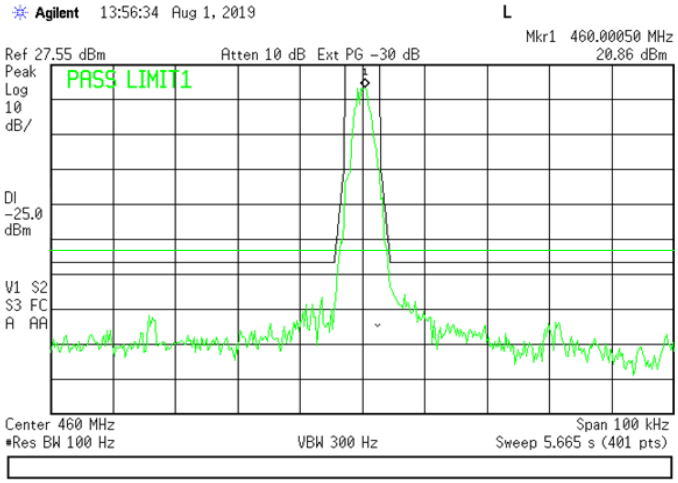
OPERATING FREQUENCY RANGE:	450.0 – 470.0 MHz
DETECTOR USED:	Peak
MODULATION:	4GFSK
MODULATING SIGNAL:	ID code
BIT RATE:	4.8 kbps
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum



Test specification:	**Section 90.210 / RSS-119 Section 5.8.4, Emission mask**		
Test procedure:	47 CFR, Sections 2.1051, 2.1047 and 90.210(e); TIA/EIA-603-E, Section 2.2.13		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	15 Oct-19		
Temperature: 24.3 ºC	**Relative Humidity:** 46 %	**Air Pressure:** 1009 hPa	**Power:** 480 VAC, 60 Hz
Remarks:			

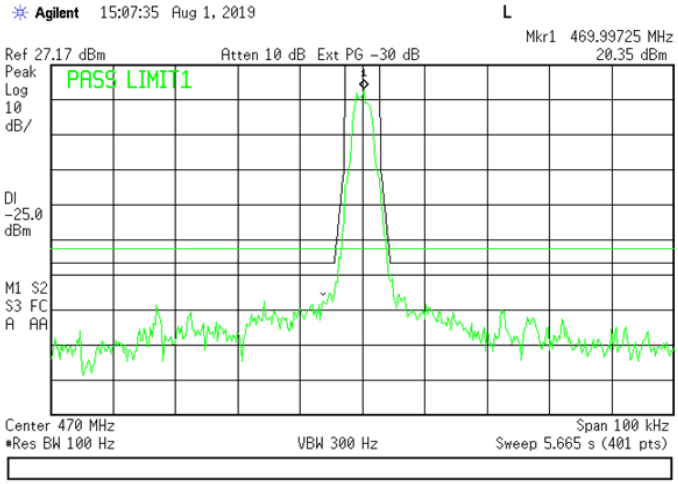
Plot 7.3.2 Emission mask test results at mid carrier frequency

OPERATING FREQUENCY RANGE:	450.0 – 470.0 MHz
DETECTOR USED:	Peak
MODULATION:	4GFSK
MODULATING SIGNAL:	ID code
BIT RATE:	4.8 kbps
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum



Plot 7.3.3 Emission mask test results at high carrier frequency

OPERATING FREQUENCY RANGE:	450.0 – 470.0 MHz
DETECTOR USED:	Peak
MODULATION:	4GFSK
MODULATING SIGNAL:	ID code
BIT RATE:	4.8 kbps
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum



Test specification:	**Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions**		
Test procedure:	47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	30-Jul-19		
Temperature: 24.8 ºC	**Relative Humidity:** 46 %	**Air Pressure:** 1006 hPa	**Power:** 480 VAC, 60 Hz
Remarks:			

7.4 Radiated spurious emission measurements

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 7.4.1 Radiated spurious emission test limits

Frequency, MHz	Attenuation below carrier, dBc	ERP of spurious, dBm	Equivalent field strength limit @ 3m, dB(µV/m)***
0.009 – 10th harmonic*	55+10logP**	-25	72.4

* - 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×P×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

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

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. To find maximum radiation the turntable was rotated 360^0 and the measuring antenna was rotated around its vertical axis.

7.4.2.3 The worst test results (the lowest margins) were recorded in Table 7.4.2 and shown in the associated plots.

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

7.4.3.1 The EUT was set up as shown in Figure 7.4.2, energized and the performance check was conducted.

7.4.3.2 The specified frequency range was investigated with antenna connected to spectrum analyzer. To find maximum radiation the turntable was rotated 360^0 and the measuring antenna height was swept from 1 to 4 m in both, vertical and horizontal, polarizations.

7.4.3.3 The worst test results (the lowest margins) were recorded in Table 7.4.2 and shown in the associated plots.

Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions		
Test procedure:	47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12		
Test mode:	Compliance	Verdict:	PASS
Date(s):	30-Jul-19		
Temperature: 24.8 ºC	Relative Humidity: 46 %	Air Pressure: 1006 hPa	Power: 480 VAC, 60 Hz
Remarks:			

Figure 7.4.1 Setup for spurious emission field strength measurements in 9 kHz to 30 MHz band

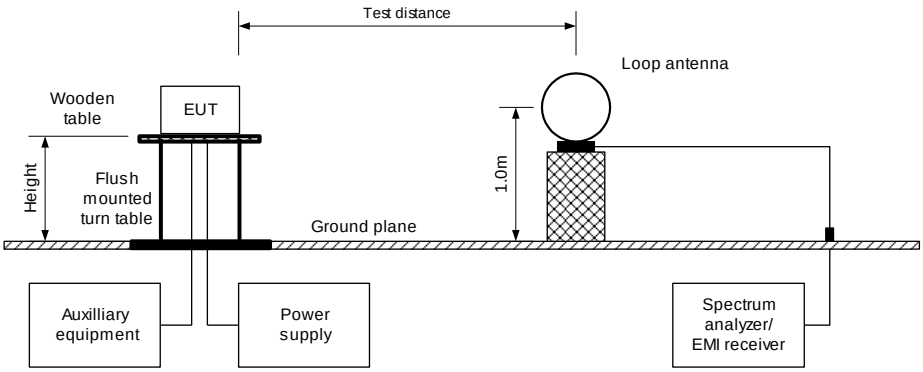
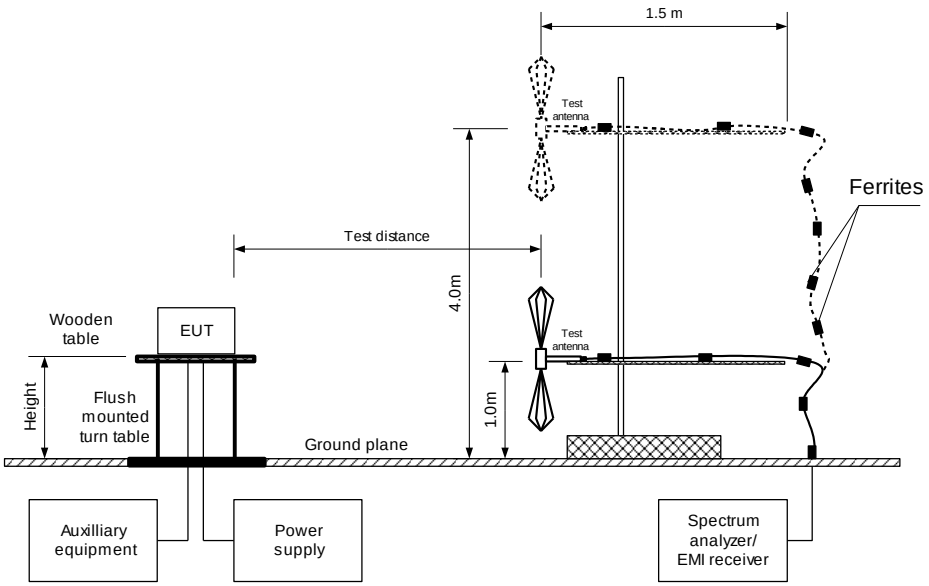


Figure 7.4.2 Setup for spurious emission field strength measurements above 30 MHz



Test specification:	**Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions**		
Test procedure:	47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	30-Jul-19		
Temperature: 24.8 ºC	**Relative Humidity:** 46 %	**Air Pressure:** 1006 hPa	**Power:** 480 VAC, 60 Hz
Remarks:			

Table 7.4.2 Spurious emission field strength test results

ASSIGNED FREQUENCY RANGE: 450.0 – 470.0 MHz
TEST DISTANCE: 3 m
TEST SITE: Semi anechoic chamber
INVESTIGATED FREQUENCY RANGE: 0.009 – 5000 MHz
DETECTOR USED: Peak
VIDEO BANDWIDTH: > Resolution bandwidth
TEST ANTENNA TYPE: Active loop (9 kHz – 30 MHz)
Biconilog (30 MHz – 1000 MHz)
Double ridged guide (above 1000 MHz)
MODULATION: 4GFSK
BIT RATE: 4.8 kbps
TRANSMITTER OUTPUT POWER Maximum

Frequency, MHz	Field strength, dB(μV/m)	Limit, dB(μV/m)	Margin, dB*	RBW, kHz	Antenna polarization	Antenna height, m	Turn-table position**, degrees	Verdict
Low carrier frequency 450MHz								
899.993500	67.04	72.4	-5.36	100	Vertical	1.02	73.0	Pass
Mid carrier frequency 460MHz								
920.026833	68.79	72.4	-3.61	100	Horizontal	1.54	132.0	Pass
High carrier frequency 470MHz								
939.969833	68.15	72.4	-4.25	100	Horizontal	1.54	139.0	Pass

*****- Margin = Field strength of spurious – calculated field strength limit.
******- EUT front panel refers to 0 degrees position of turntable.

Reference numbers of test equipment used

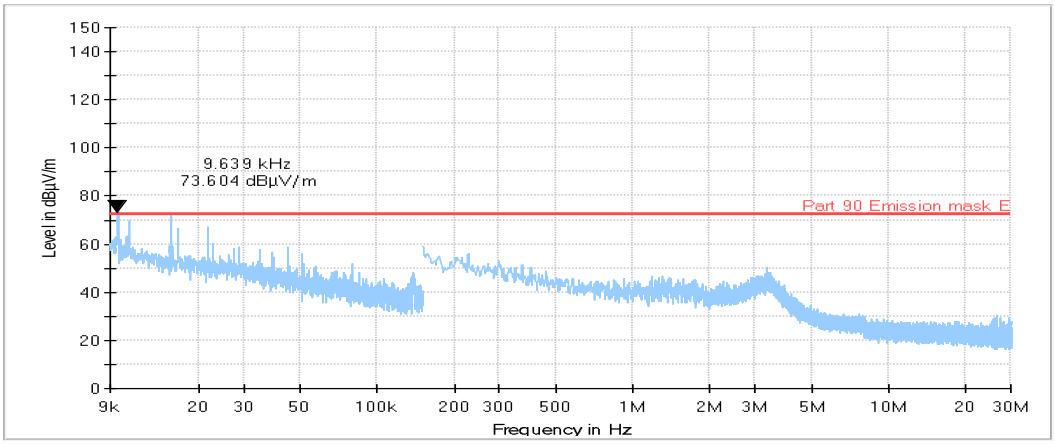
HL 4360	HL 3903	HL 4011	HL 3047	HL 5311	HL 5309	HL 5288	HL 5085
HL 5405	HL 4933	HL 0446	HL 3818				

Full description is given in Appendix A.

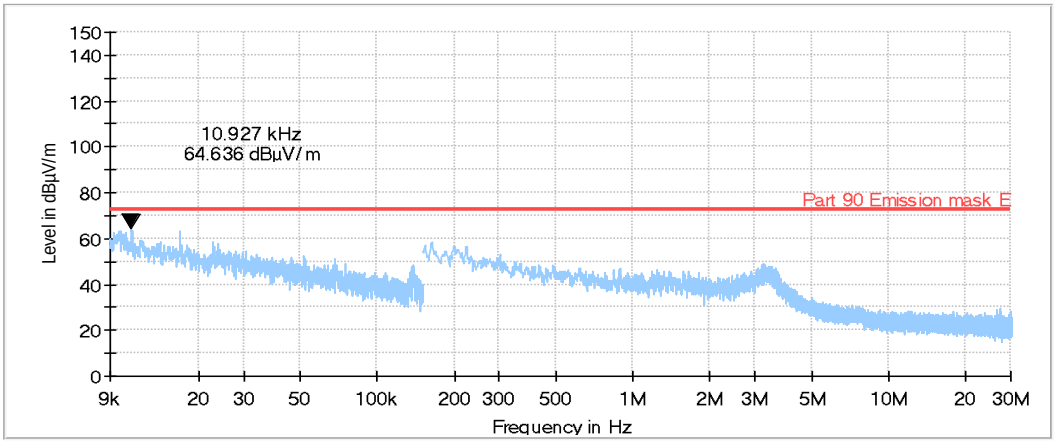
Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions		
Test procedure:	47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12		
Test mode:	Compliance	Verdict:	PASS
Date(s):	30-Jul-19		
Temperature: 24.8 ºC	Relative Humidity: 46 %	Air Pressure: 1006 hPa	Power: 480 VAC, 60 Hz
Remarks:			

Plot 7.4.1 Radiated emission measurements in 9 kHz - 30 MHz range

TEST SITE: Semi anechoic chamber
CARRIER FREQUENCY: Low
ANTENNA POLARIZATION: Vertical and Horizontal
TEST DISTANCE: 3 m

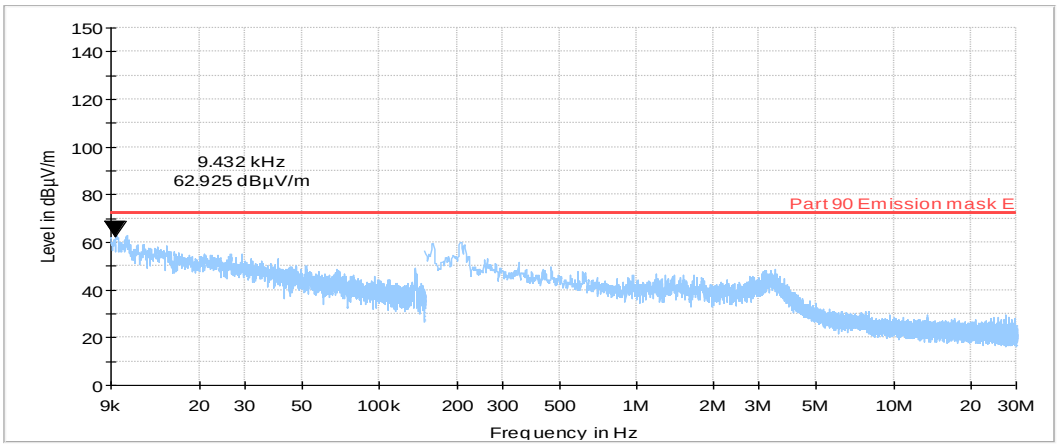


CARRIER FREQUENCY: Mid



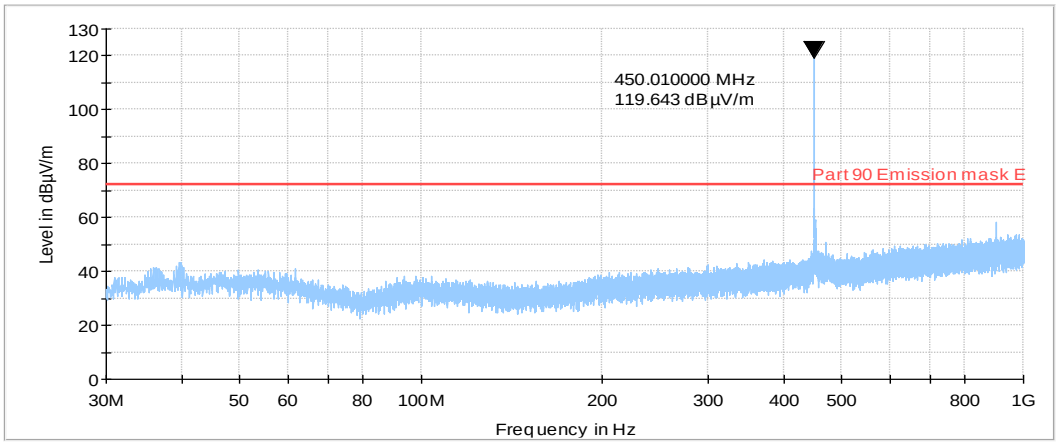
Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions		
Test procedure:	47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12		
Test mode:	Compliance	Verdict:	PASS
Date(s):	30-Jul-19		
Temperature: 24.8 ºC	Relative Humidity: 46 %	Air Pressure: 1006 hPa	Power: 480 VAC, 60 Hz
Remarks:			

CARRIER FREQUENCY: High



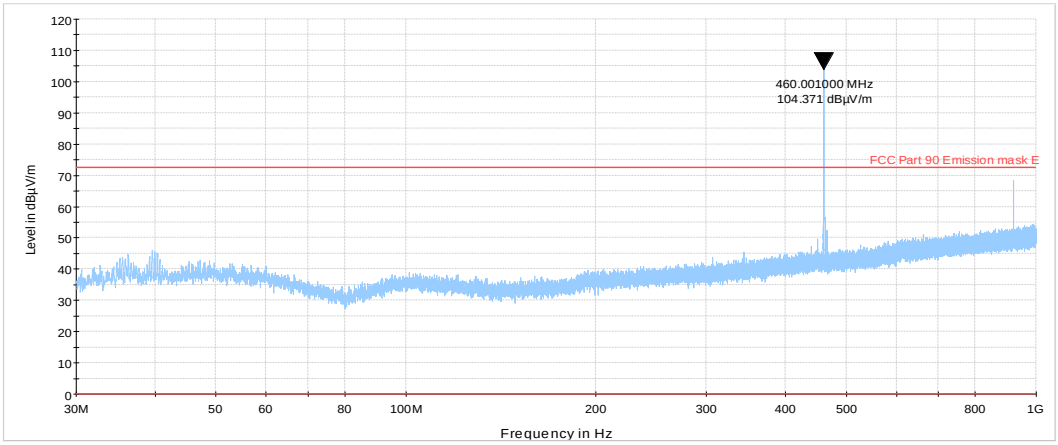
Plot 7.4.2 Radiated emission measurements in 30 - 1000 MHz range

TEST SITE: Semi anechoic chamber
CARRIER FREQUENCY: Low
ANTENNA POLARIZATION: Vertical and Horizontal
TEST DISTANCE: 3 m

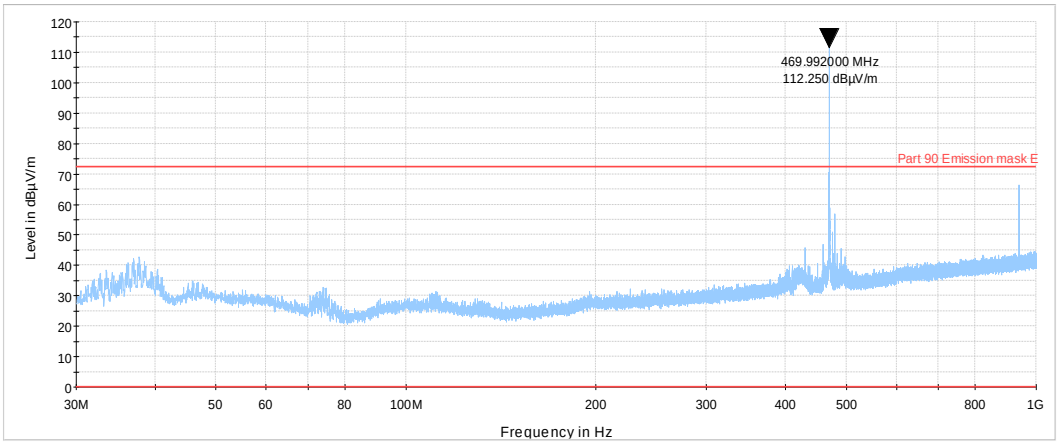


Test specification:	**Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions**		
Test procedure:	47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	30-Jul-19		
Temperature: 24.8 ºC	**Relative Humidity:** 46 %	**Air Pressure:** 1006 hPa	**Power:** 480 VAC, 60 Hz
Remarks:			

CARRIER FREQUENCY: Mid



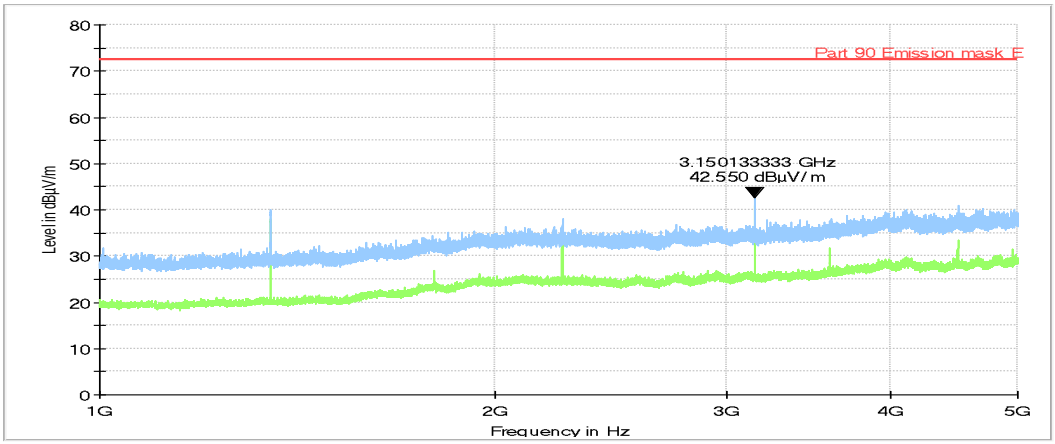
CARRIER FREQUENCY: High



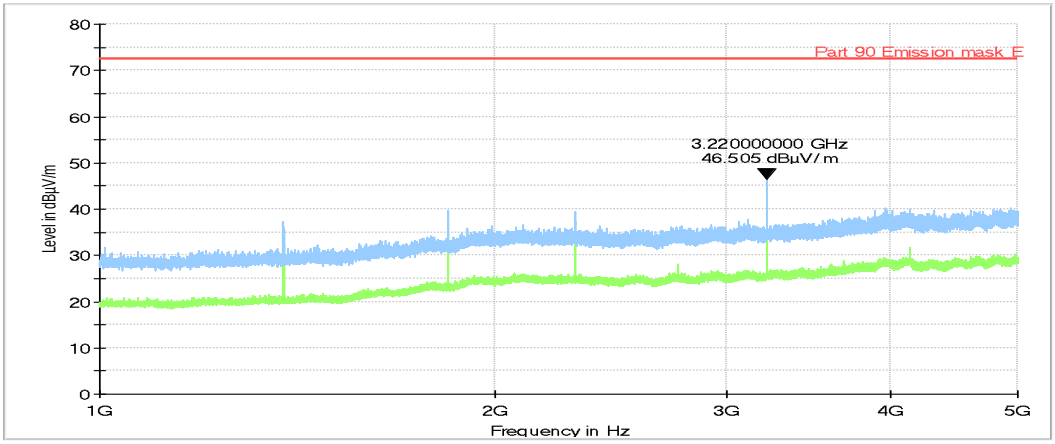
Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions		
Test procedure:	47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12		
Test mode:	Compliance	Verdict:	PASS
Date(s):	30-Jul-19		
Temperature: 24.8 ºC	Relative Humidity: 46 %	Air Pressure: 1006 hPa	Power: 480 VAC, 60 Hz
Remarks:			

Plot 7.4.3 Radiated emission measurements in 1000 – 5000 MHz range

TEST SITE: Semi anechoic chamber
CARRIER FREQUENCY: Low
ANTENNA POLARIZATION: Vertical and Horizontal
TEST DISTANCE: 3 m

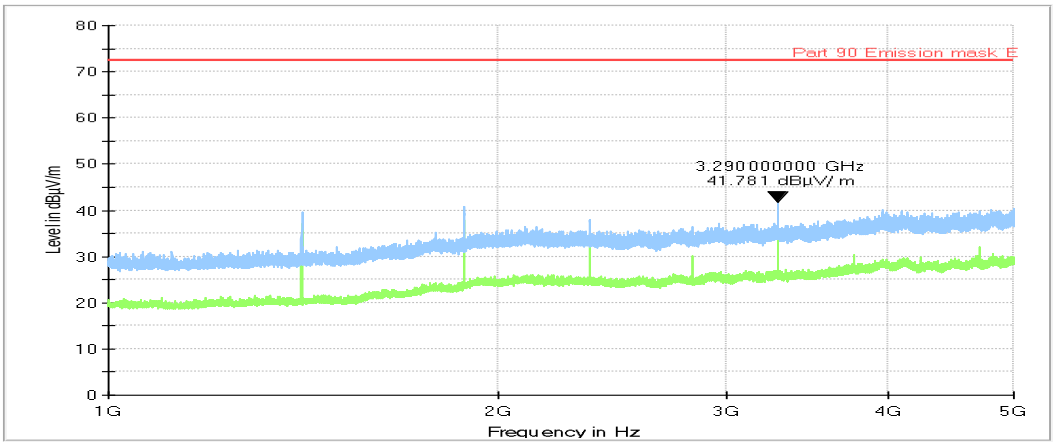


CARRIER FREQUENCY: Mid



Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions		
Test procedure:	47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12		
Test mode:	Compliance	Verdict:	PASS
Date(s):	30-Jul-19		
Temperature: 24.8 ºC	Relative Humidity: 46 %	Air Pressure: 1006 hPa	Power: 480 VAC, 60 Hz
Remarks:			

CARRIER FREQUENCY: High



Test specification:	Section 90.213 / RSS-119 Section 5.3, Frequency stability		
Test procedure:	47 CFR, Section 2.1055; TIA/EIA-603-E, Section 2.2.2		
Test mode:	Compliance	Verdict:	PASS
Date(s):	18-Jul-19		
Temperature: 24 ºC	Relative Humidity: 45 %	Air Pressure: 1006 hPa	Power: 480 VAC, 60 Hz
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	
	ppm	Hz
450.003100	1	450
460.000000		460
469.996900		470

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.

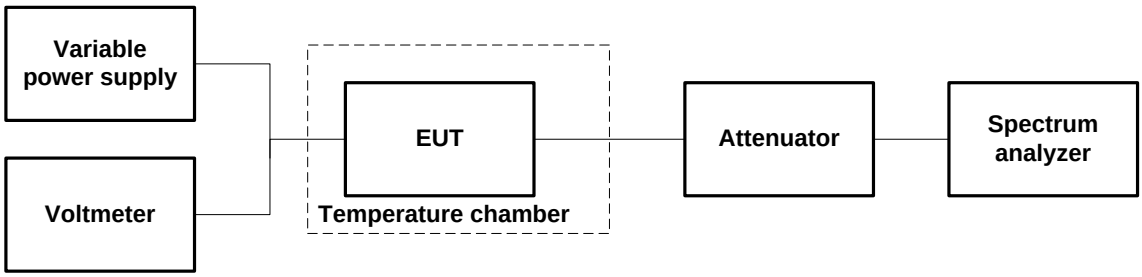
7.5.2.3 The EUT was powered on and carrier frequency was measured at start up moment and then every minute until frequency had been stabilized or 10 minutes elapsed whichever reached the last. The EUT was powered off.

7.5.2.4 The above procedure was repeated at 0˚C and at the lowest test temperature.

7.5.2.5 The EUT was powered on and carrier frequency was measured at start up moment and at the end of stabilization period at the rest of test temperatures and voltages. The EUT was powered off.

7.5.2.6 Frequency displacement was calculated and compared with the limit as provided in Table 7.5.2.

Figure 7.5.1 Frequency stability test setup



Test specification:	**Section 90.213 / RSS-119 Section 5.3, Frequency stability**		
Test procedure:	47 CFR, Section 2.1055; TIA/EIA-603-E, Section 2.2.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	18-Jul-19		
Temperature: 24 ºC	**Relative Humidity:** 45 %	**Air Pressure:** 1006 hPa	**Power:** 480 VAC, 60 Hz
Remarks:			

Table 7.5.2 Frequency stability test results

OPERATING FREQUENCY: 450.0 – 470.0 MHz
NOMINAL POWER VOLTAGE: 480 VAC
TEMPERATURE STABILIZATION PERIOD: 20 min
POWER DURING TEMPERATURE TRANSITION: Off
SPECTRUM ANALYZER MODE: Counter
RESOLUTION BANDWIDTH: 10 Hz
VIDEO BANDWIDTH: 30 Hz
MODULATION: Unmodulated

T, ºC	Voltage, V	Frequency, MHz							Max frequency drift, Hz		Limit, Hz	Margin, Hz	Verdict
		Start up	1st min	2nd min	3rd min	4th min	5th min	10th min	Positive	Negative			
Low frequency													
-30	nominal	450.002991	450.002992	450.002992	450.002993	450.002993	450.002993	450.002994	0	-107		-343	Pass
-20	nominal	450.002969	NA	NA	NA	NA	NA	450.002978	0	-129		-321	Pass
-10	nominal	450.003026	NA	NA	NA	NA	NA	450.003051	0	-72		-378	Pass
0	nominal	450.003075	450.003092	450.003093	450.003106	450.003107	450.003118	450.003119	21	-23		-427	Pass
10	nominal	450.003086	NA	NA	NA	NA	NA	450.00309	0	-12		-438	Pass
20	+15%	450.003096	NA	NA	NA	NA	NA	450.003097	0	-2	450	-448	Pass
20	nominal	450.003097	NA	NA	NA	NA	NA	*450.003098	0	-1		-449	Pass
20	-15%	450.003095	NA	NA	NA	NA	NA	450.003096	0	-3		-447	Pass
30	nominal	450.003101	450.003101	450.003101	450.003101	450.003101	450.003101	450.003101	3	0		-447	Pass
40	nominal	450.003104	NA	NA	NA	NA	NA	450.003114	16	0		-434	Pass
50	nominal	450.003117	NA	NA	NA	NA	NA	450.003153	55	0		-395	Pass
Mid frequency													
-30	nominal	459.99988	459.99989	459.99989	459.99989	459.99989	459.99989	459.99989	0	-110		-350	Pass
-20	nominal	459.99987	NA	NA	NA	NA	NA	459.99988	0	-128		-332	Pass
-10	nominal	459.99992	NA	NA	NA	NA	NA	459.99995	0	-73		-387	Pass
0	nominal	460.00001	460.00001	460.00001	460.00001	460.00002	460.00002	460.00002	25	0		-435	Pass
10	nominal	459.99998	NA	NA	NA	NA	NA	459.99999	0	-11		-449	Pass
20	+15%	459.99999	NA	NA	NA	NA	NA	459.99999	1	0	460	-459	Pass
20	nominal	459.99999	NA	NA	NA	NA	NA	*459.99999	0	-1		-459	Pass
20	-15%	459.99999	NA	NA	NA	NA	NA	459.99999	0	-4		-456	Pass
30	nominal	460.00000	460.00000	460.00000	460.00000	460.00000	460.00000	460.00000	5	0		-455	Pass
40	nominal	460.00001	NA	NA	NA	NA	NA	460.00021	212	0		-248	Pass
50	nominal	460.00004	NA	NA	NA	NA	NA	460.00006	70	0		-390	Pass
High frequency													
-30	nominal	469.996787	469.996792	469.996793	469.996794	469.996794	469.996794	469.996794	0	-111		-359	Pass
-20	nominal	469.99677	NA	NA	NA	NA	NA	469.996789	0	-128		-342	Pass
-10	nominal	469.996838	NA	NA	NA	NA	NA	469.99687	0	-60		-410	Pass
0	nominal	469.996914	469.996915	469.996923	469.996923	469.996926	469.996926	469.996926	28	0		-442	Pass
10	nominal	469.996886	NA	NA	NA	NA	NA	469.996891	0	-12		-458	Pass
20	+15%	469.996898	NA	NA	NA	NA	NA	469.996898	0	0	470	-470	Pass
20	nominal	469.996898	NA	NA	NA	NA	NA	*469.996898	0	0		-470	Pass
20	-15%	469.996899	NA	NA	NA	NA	NA	469.99689	1	-8		-462	Pass
30	nominal	469.996898	469.996899	469.996899	469.9969	469.9969	469.9969	469.9969	2	0		-468	Pass
40	nominal	469.996914	NA	NA	NA	NA	NA	469.996927	29	0		-441	Pass
50	nominal	469.996964	NA	NA	NA	NA	NA	469.996987	89	0		-381	Pass

* - Reference frequency

Reference numbers of test equipment used

HL 3901	HL 4070	HL 4343					

Full description is given in Appendix A.

Test specification:	Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour		
Test procedure:	TIA/EIA-603-E, Section 2.2.19		
Test mode:	Compliance	Verdict:	PASS
Date(s):	18-Jul-19		
Temperature: 24 ºC	Relative Humidity: 45 %	Air Pressure: 1006 hPa	Power: 480 VAC, 60 Hz
Remarks:			

7.6 Transient frequency behaviour test

7.6.1 General

This test was performed to measure carrier frequency drift as function of time during transmitter start up and shut down. Specification test limits are given in Table 7.6.1. The test results are provided in the associated plots.

Table 7.6.1 Transient frequency limits

Channel bandwidth, kHz	Carrier frequency tolerance, kHz	Duration, ms	Time interval*
421.0 – 512.0 MHz band			
6.25	± 6.25	10.0	t_1
	± 3.125	25.0	t_2
	± 6.25	10.0	t_3

* - t_{on} is the instant when a 1 kHz test signal is completely suppressed;
t_1 is the time period immediately following t_{on};
t_2 is the time period immediately following t_1;
t_3 is the time period from the instant when the transmitter is turned off until t_{off};
t_{off} is the instant when the 1 kHz test signal starts to rise.

7.6.2 Test procedure

7.6.2.1 The EUT was set up as shown in Figure 7.6.1, energized and its proper operation was checked. Variable attenuator was adjusted to provide signal level approximately 40 dB below the FM receiver maximum allowed level as measured with RF power meter. The EUT was turned off.

7.6.2.2 The signal generator was set to the assigned transmitter frequency modulated with 1 kHz tone at 25 kHz deviation and the output power was adjusted to provide the same as the EUT signal level at the FM receiver input as measured with power meter.

7.6.2.3 The storage oscilloscope was set to provide horizontal sweep rate 10 milliseconds per division. Amplitude control of the storage oscilloscope was adjusted to obtain 1 kHz sinusoidal signal vertically centered with ± 4 divisions amplitude.

7.6.2.4 The variable attenuator was adjusted to increase RF level supplied to splitter by 30 dB and the EUT was consequently turned on and off. Transient frequency during power switching was captured and shown in the associated plots.

Test specification:	Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour		
Test procedure:	TIA/EIA-603-E, Section 2.2.19		
Test mode:	Compliance	Verdict:	PASS
Date(s):	18-Jul-19		
Temperature: 24 ºC	Relative Humidity: 45 %	Air Pressure: 1006 hPa	Power: 480 VAC, 60 Hz
Remarks:			

Figure 7.6.1 Transient frequency test setup

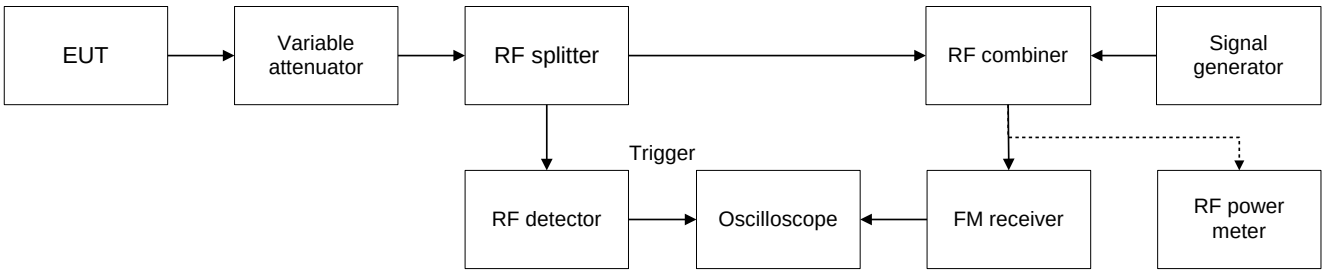


Table 7.6.2 Transient frequency behaviour test results

Carrier frequency, MHz	Time interval	Duration, ms	Frequency tolerance, kHz	Limit, kHz	Margin, kHz	Verdict
Channel bandwidth 6.25 kHz						
450.0031	t_1	10.0	1.250	± 6.25	-5.000	Pass
	t_2	25.0	0.469	± 3.125	-2.656	
	t_3	10.0	3.438	± 6.25	-2.812	
460.0000	t_1	10.0	0.860	± 6.25	-5.390	Pass
	t_2	25.0	0.391	± 3.125	-2.734	
	t_3	10.0	4.375	± 6.25	-1.875	
469.9969	t_1	10.0	1.641	± 6.25	-4.609	Pass
	t_2	25.0	0.541	± 3.125	-2.578	
	t_3	10.0	3.906	± 6.25	-2.343	

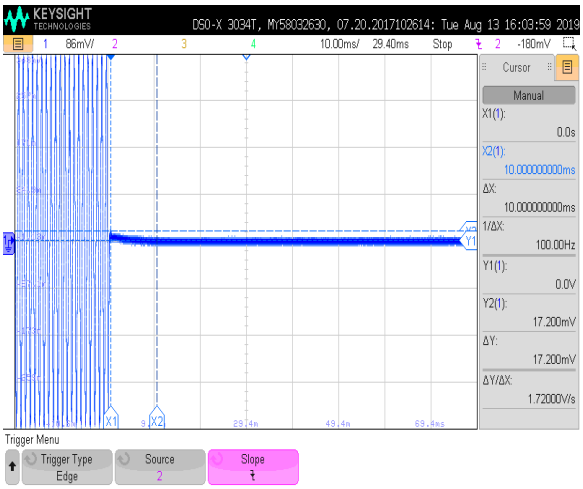
Reference numbers of test equipment used

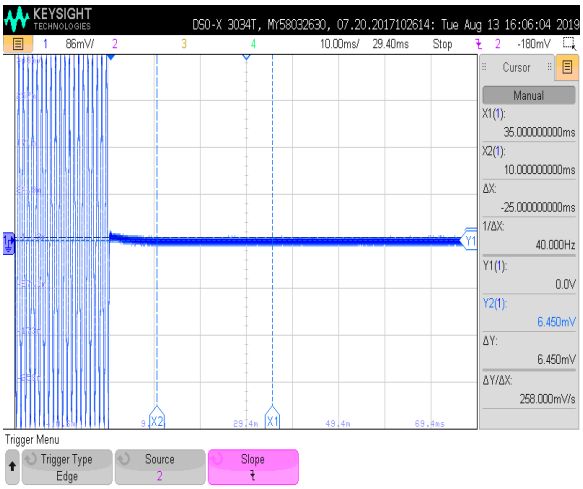
HL 3047	HL 5369	HL 2227	HL 2017	HL 2016	HL 0788	HL 4227	HL 0911
HL 5372	HL 0539	HL 3301	HL 4938	HL 5278	HL 1809		

Full description is given in Appendix A.

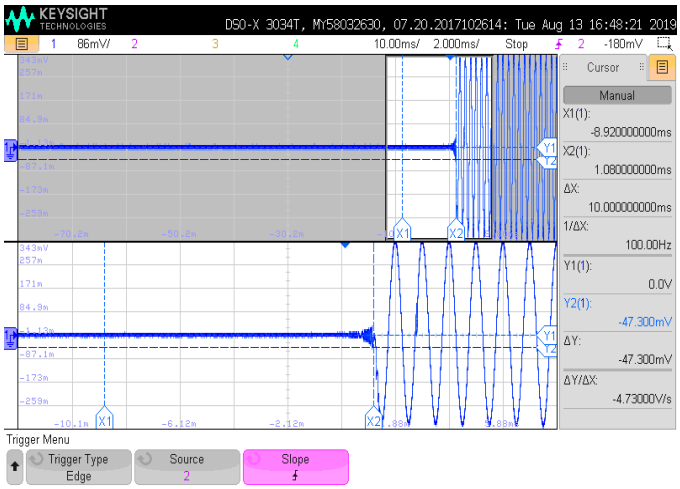
Test specification:	Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour		
Test procedure:	TIA/EIA-603-E, Section 2.2.19		
Test mode:	Compliance	Verdict:	PASS
Date(s):	18-Jul-19		
Temperature: 24 ºC	Relative Humidity: 45 %	Air Pressure: 1006 hPa	Power: 480 VAC, 60 Hz
Remarks:			

Plot 7.6.1 Transient frequency during power ON test results at low carrier frequency



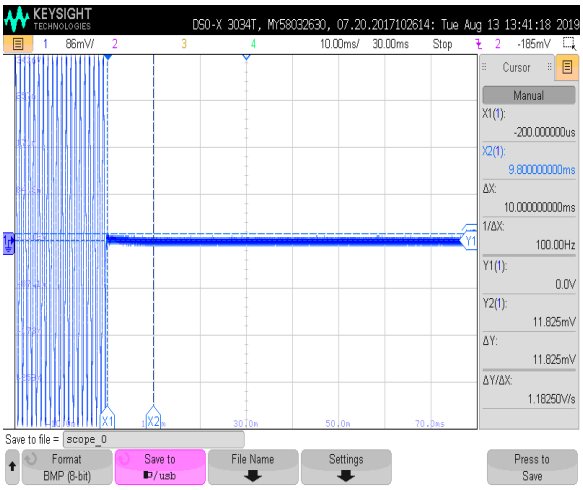


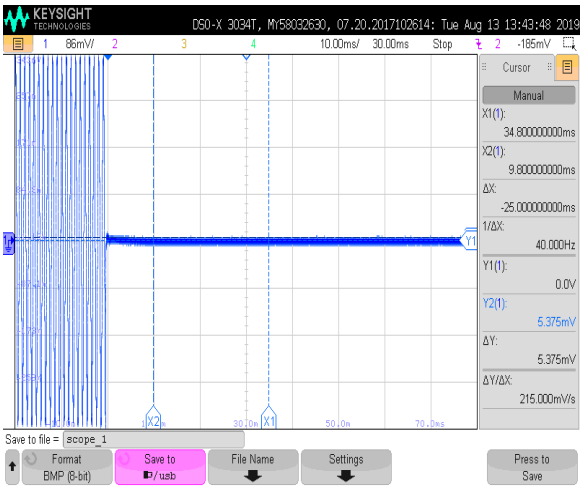
Plot 7.6.2 Transient frequency during power OFF test results at low carrier frequency



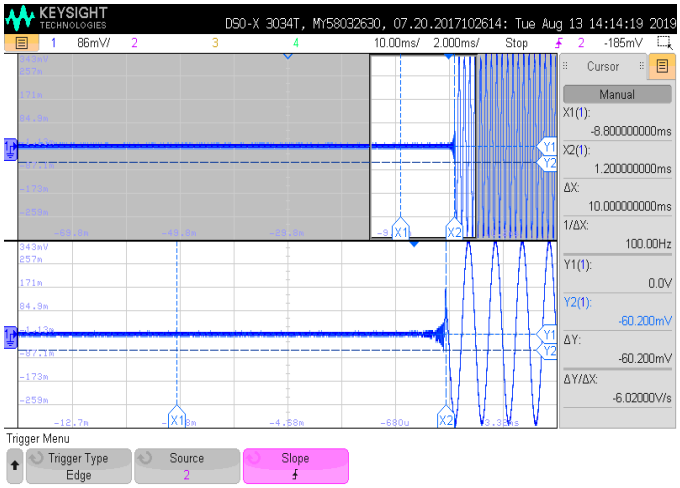
Test specification:	Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour		
Test procedure:	TIA/EIA-603-E, Section 2.2.19		
Test mode:	Compliance	Verdict:	PASS
Date(s):	18-Jul-19		
Temperature: 24 ºC	Relative Humidity: 45 %	Air Pressure: 1006 hPa	Power: 480 VAC, 60 Hz
Remarks:			

Plot 7.6.3 Transient frequency during power ON test results at mid carrier frequency



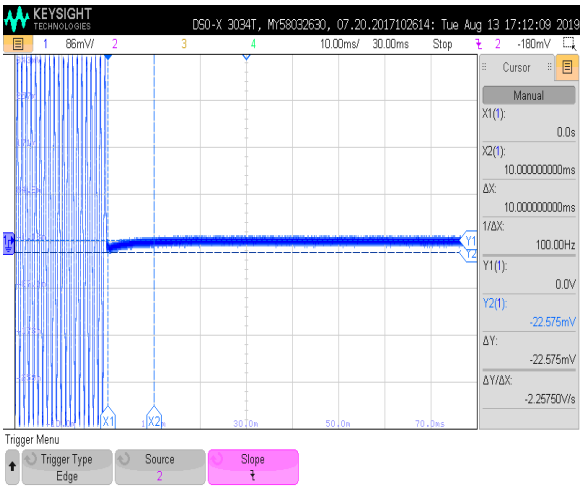


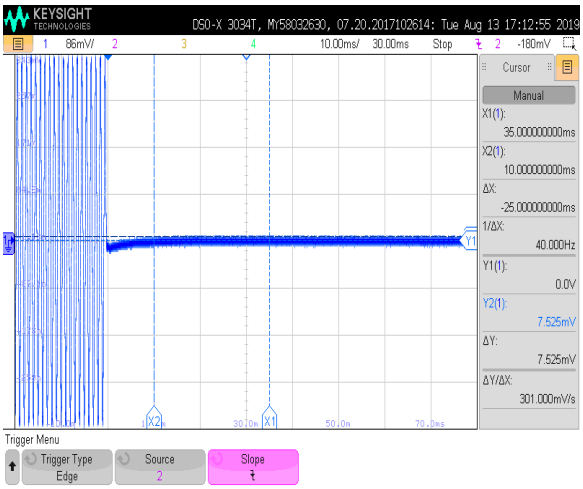
Plot 7.6.4 Transient frequency during power OFF test results at mid carrier frequency



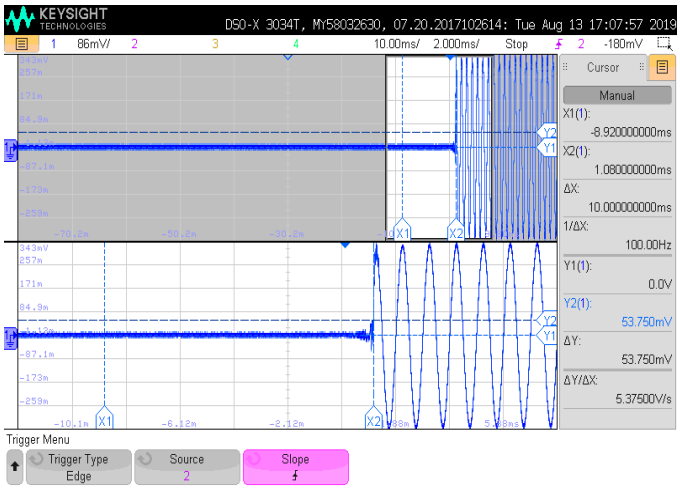
Test specification:	Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour		
Test procedure:	TIA/EIA-603-E, Section 2.2.19		
Test mode:	Compliance	Verdict:	PASS
Date(s):	18-Jul-19		
Temperature: 24 ºC	Relative Humidity: 45 %	Air Pressure: 1006 hPa	Power: 480 VAC, 60 Hz
Remarks:			

Plot 7.6.5 Transient frequency during power ON test results at high carrier frequency





Plot 7.6.6 Transient frequency during power OFF test results at high carrier frequency



8 APPENDIX A Test equipment and ancillaries used for tests

HL No	Description	Manufacturer	Model	Ser. No.	Last Cal./ Check	Due Cal./ Check
0415	Cable, Coax, RF, RG-214, 12.3 m	Hermon Laboratories	CC-3	056	07-Aug-19	07-Aug-20
0446	Antenna, Loop, Active, 10 (9) kHz - 30 MHz	EMCO	6502	2857	24-Feb-19	24-Feb-20
0539	Generator Signal, 10 kHz - 1.2 GHz	Marconi Instruments	2023	112121/041	09-Jul-19	09-Jul-20
0604	Antenna BiconiLog Log-Periodic/T Bow-TIE, 26 - 2000 MHz	EMCO	3141	9611-1011	03-Jun-18	03-Jun-20
0788	Power Splitter / Combiner 5-500 MHz	Mini-Circuits	ZFSC-2-1	923705	24-Jun-19	24-Jun-21
0911	Coupler Dual Directional, 20 dB, 0.1 - 2.0 GHz	Hewlett Packard	778D	1144A07827	13-Mar-19	13-Mar-22
1623	Attenuator, 50 Ohm, 2W, 0-18 GHz, 3.0 dB	Midwest Microwave	219	1623	18-Nov-18	18-Nov-19
1809	HygroThermometer, Min/Max Memory	Delta TRAK	13301	NA	11-Aug-19	11-Aug-20
2016	Attenuator, Manual Step, 0-9/1 dB, 0-8 GHz, 2 W	Midwest Microwave	1072	1315	05-Mar-19	05-Mar-20
2017	Attenuator, Manual Step, 0-60/10 dB, 0-8.0 GHz	Midwest Microwave	1071	2017	05-Mar-19	05-Mar-20
2227	Crystal Detector 0.01-18 GHz, 100 mW	Hewlett Packard Co	8472A	NA	19-Sep-17	19-Sep-19
2909	Spectrum analyzer, ESA-E, 100 Hz to 26.5 GHz	Agilent Technologies	E4407B	MY41444762	04-Apr-19	04-Apr-20
3047	AC Power Supply, 0 - 130 & 260v, 45 - 2000 Hz	BEHLMAN	150-C-202	5033	03-Oct-18	03-Oct-19
3301	Power Meter, P-series, 50 MHz to 40 GHz	Agilent Technologies	N1911A	MY45101057	28-Apr-19	28-Apr-20
3339	High Pass Filter, 50 Ohm, 600 to 3000 MHz.	Mini-Circuits	SHP-600+	NA	05-Jun-19	05-Jun-20
3350	Low Pass Filter, 50 Ohm, DC to 270 MHz.	Mini-Circuits	NLP-300+	NA	05-Jun-19	05-Jun-20
3818	PSA Series Spectrum Analyzer, 3 Hz- 44 GHz	Agilent Technologies	E4446A	MY48250288	24-Apr-19	24-Apr-20
3901	Microwave Cable Assembly, 40.0 GHz, 3.5 m, SMA/SMA	Huber-Suhner	SUCOFLEX 102A	1225/2A	07-Apr-19	07-Apr-20
3903	Microwave Cable Assembly, 40.0 GHz, 1.5 m, SMA/SMA	Huber-Suhner	SUCOFLEX 102A	1226/2A	07-Apr-19	07-Apr-20
4011	Temp. & Humidity Meter, (-50 - +70) deg, (20 - 99)% RH	Mad Electronics	HTC-1	NA	11-Aug-19	11-Aug-20
4070	Attenuator, SMA, 30 dB, DC to 18 GHz, 5 W	Weinschel	WA7	NA	12-Aug-19	12-Aug-20
4135	Shield Box	TESCOM CO., LTD	TC-5916A	5916A000136	24-Apr-19	24-Apr-20
4227	Precision Fixed Attenuator, 50 Ohm, 5W, 10dB, DC to 18000 MHz	Mini-Circuits	BW-N10W5+	NA	04-Mar-19	04-Mar-20

HL No	Description	Manufacturer	Model	Ser. No.	Last Cal./ Check	Due Cal./ Check
4339	High pass Filter, 50 Ohm, 1000 to 18000 MHz, SMA-FM / SMA-M	Micro-Tronics	HPM50115-02	001	05-Jun-19	05-Jun-20
4343	Signal Generator, 100 kHz to 40 GHz	Rohde & Schwarz	SMB 100A	175291	04-Apr-19	04-Apr-20
4360	EMI Test Receiver, 20 Hz to 40 GHz.	Rohde & Schwarz	ESU40	100322	31-Dec-18	31-Dec-19
4646	LISN, 3 phase, 4X25 A, 50 Ohm/50 uH + 5 Ohm, STD CISPR 16-1, 9-150 kHz (30MHz)	Rohde & Schwarz	ESH2-Z5	NA	21-Mar-19	21-Mar-20
4778	EMI Receiver, 9 kHz - 2.9 GHz, System: HL1431, HL4777	Hewlett Packard	8542E	30807A00262, 3427A00123	28-Oct-18	28-Oct-19
4933	Active Horn Antenna, 1 GHz to 18 GHz	COM-POWER CORPORATION	AHA-118	701046	06-Jan-19	06-Jan-20
4938	Test Cable, 50Ω, 1.8 m, DC to 18 GHz	Mini-Circuits	CBL-6FT-SMNM+	NA	15-Apr-19	15-Apr-20
5084	Attenuator, 4 dB, DC - 6 GHz, 1 W	Mini-Circuits	UNAT-4+	NA	05-Jun-18	05-Jun-20
5085	Attenuator, 4 dB, DC - 6 GHz, 1 W	Mini-Circuits	UNAT-4+	NA	08-Feb-19	08-Feb-20
5175	Medium Power Fixed Coaxial Attenuator DC to 40 GHz, 20 dB, 5 W	API Weinschel, Inc	75A-20-12	TE289	07-Apr-19	07-Apr-20
5278	Cable RF, 4.2 m, BNC/BNC	Hermon Laboratories	M17/167 MIL-C-17	NA	02-Sep-18	02-Sep-19
5288	Trilog Antenna, 25 MHz - 8 GHz, 100W	Frankonia	ALX-8000E	00809	08-Feb-19	08-Feb-22
5309	Antenna Mast, 1-4 meter, Pneumatic polarization	Dolev Ltd	FMB 1-4	NA	24-Apr-19	24-Apr-20
5311	Controller	Dolev Ltd	FC-06	FC06.1-2016-024	24-Apr-19	24-Apr-20
5369	Digital storage oscilloscope, 350 MHz	Keysight Technologies	DSOX3034T	MY58032630	28-May-19	28-May-20
5372	MXE EMI receiver, 3 Hz to 44 GHz	Keysight Technologies	N9038A	MY57290155	18-Jun-19	18-Jun-20
5376	EXA Signal Analyzer, 10 Hz - 32 GHz	Keysight Technologies	N9010B	MY57470404	18-Mar-19	18-Mar-20
5404	RF cable, 18 GHz, N-N, 6 m	Huber-Suhner	SF118/11N(x2)	500024/18	11-Aug-19	11-Aug-20
5405	RF cable, 18 GHz, N-N, 6 m	Huber-Suhner	SF118/11N(x2)	500023/118	11-Aug-19	11-Aug-20
5476	Cable, BNC/BNC, 10.5 m	Western wire	MIL-C-17G	NA	30-Jan-19	30-Jan-20

9 APPENDIX B Test equipment correction factors

HL 0446: Active Loop Antenna
EMCO, model: 6502, s/n 2857

Frequency,	Measured antenna factor, dBS/m	Measurement uncertainty, dB
10	-33.4	±1.0
20	-37.8	±1.0
50	-40.5	±1.0
75	-41.0	±1.0
100	-41.2	±1.0
150	-41.2	±1.0
250	-41.1	±1.0
500	-41.2	±1.0
750	-41.3	±1.0
1000	-41.3	±1.0

Frequency,	Measured antenna factor, dBS/m	Measurement uncertainty, dB
2000	-41.4	±1.0
3000	-41.4	±1.0
4000	-41.5	±1.0
5000	-41.5	±1.0
10000	-41.7	±1.0
15000	-42.1	±1.0
20000	-42.7	±1.0
25000	-44.2	±1.0
30000	-45.8	±1.0

The antenna factor shall be added to receiver reading in dBμV to obtain field strength in dBμA/m.

HL 0604: Antenna BiconiLog Log-Periodic/T Bow-TIE
EMCO, model 3141, serial number 9611-1011

Frequency, MHz	Antenna factor, dB/m		
	Measured	Last	Deviation
30	12.1	12.6	-0.5
35	9.1	9.5	-0.4
40	8.0	8.3	-0.3
45	8.3	8.6	-0.3
50	9.0	9.1	-0.1
60	10.5	10.7	-0.2
70	11.4	11.3	0.1
80	12.3	12.2	0.1
90	13.4	13.2	0.2
100	13.0	13.0	0.0
120	11.4	11.4	0.0
140	12.5	12.4	0.1
160	14.9	14.8	0.1
180	14.4	14.0	0.4
200	13.7	13.9	-0.2
250	16.3	16.4	-0.1
300	17.2	17.5	-0.3
400	19.8	20.2	-0.4
500	22.0	22.4	-0.4
600	24.3	24.5	-0.2
700	25.8	25.6	0.2
800	26.9	26.6	0.3
900	27.3	28.0	-0.7
1000	28.5	29.3	-0.8

The antenna factor shall be added to receiver reading in dBμV to obtain field strength in dBμV/m.

HL 4646 LISN
3 phase, 4X25 A, 50 Ohm/50 uH + 5 Ohm, STD CISPR 16-1, 9-150 (30MHz)

Frequency, kHz	R1, dB	S2, dB	T3, dB	N, dB	Uncertainty, dB
10	0.10	0.08	0.09	0.10	±0.12
15	0.11	0.10	0.11	0.11	±0.12
20	0.11	0.11	0.11	0.11	±0.12
25	0.11	0.13	0.12	0.12	±0.12
30	0.11	0.14	0.11	0.12	±0.08
40	0.11	0.14	0.12	0.11	±0.08
50	0.11	0.14	0.11	0.12	±0.08
60	0.12	0.15	0.11	0.12	±0.09
70	0.11	0.15	0.12	0.12	±0.09
80	0.11	0.15	0.13	0.12	±0.09
90	0.12	0.16	0.12	0.12	±0.09
100	0.12	0.16	0.13	0.13	±0.09
150	0.13	0.16	0.13	0.13	±0.09
170	0.13	0.16	0.14	0.14	±0.09
200	0.14	0.16	0.14	0.14	±0.09
250	0.14	0.17	0.14	0.15	±0.09
300	0.15	0.17	0.15	0.16	±0.09
350	0.16	0.18	0.16	0.16	±0.09
400	0.16	0.19	0.16	0.17	±0.09
500	0.18	0.20	0.17	0.18	±0.09
600	0.19	0.21	0.18	0.19	±0.09
700	0.20	0.22	0.19	0.19	±0.09
800	0.21	0.23	0.19	0.21	±0.09
900	0.22	0.23	0.20	0.21	±0.09
1000	0.23	0.24	0.21	0.21	±0.09
1200	0.26	0.26	0.22	0.22	±0.16
1500	0.29	0.30	0.24	0.24	±0.16
2000	0.35	0.30	0.26	0.26	±0.16
2500	0.40	0.32	0.27	0.28	±0.16
3000	0.46	0.34	0.29	0.30	±0.16
4000	0.59	0.37	0.32	0.33	±0.16
5000	0.68	0.40	0.34	0.35	±0.16
7000	0.91	0.44	0.38	0.40	±0.16
10000	1.13	0.48	0.40	0.41	±0.16
15000	1.33	0.44	0.44	0.41	±0.16
20000	1.35	0.52	0.48	0.41	±0.16
30000	1.29	0.73	0.48	0.30	±0.32

HL 4933 Active Horn Antenna, 1 GHz to 18 GHz
COM-POWER CORPORATION AHA-118 , s/n 701046 HL 4933

Frequency, MHz	Measured antenna factor, dB/m
1000	-16.1
1050	-16.0
1100	-15.1
1150	-16.4
1200	-16.0
1250	-15.6
1300	-15.1
1350	-14.8
1400	-15.1
1450	-15.1
1500	-15.5
1550	-15.2
1600	-14.7
1650	-14.4
1700	-14.4
1750	-14.0
1800	-13.6
1850	-12.7
1900	-11.9
1950	-11.9
2000	-11.8
2050	-11.3
2100	-11.3
2150	-11.7
2200	-12.3
2250	-12.3
2300	-12.4
2350	-12.2
2400	-11.7
2450	-11.5
2500	-11.5
2550	-11.5
2600	-11.5
2650	-11.3
2700	-11.3
2750	-11.1
2800	-11.1
2850	-11.3
2900	-11.1
2950	-11.0
3000	-11.1
3050	-10.9
3100	-10.7
3150	-10.6

Frequency, MHz	Measured antenna factor, dB/m
3200	-11.2
3250	-10.8
3300	-10.8
3350	-10.7
3400	-10.3
3450	-10.2
3500	-10.1
3550	-10.4
3600	-10.5
3650	-10.4
3700	-10.4
3750	-10.3
3800	-10.1
3850	-10.0
3900	-9.9
3950	-9.8
4000	-9.7
4050	-9.3
4100	-8.6
4150	-8.2
4200	-8.3
4250	-8.5
4300	-8.5
4350	-8.3
4400	-8.0
4450	-7.7
4500	-7.6
4550	-7.4
4600	-7.5
4650	-7.8
4700	-7.6
4750	-6.8
4800	-6.1
4850	-5.7
4900	-5.8
4950	-5.8
5000	-6.0
5050	-5.7
5100	-5.4
5150	-5.1
5200	-4.6
5250	-4.6
5300	-4.8
5350	-5.1

Frequency, MHz	Measured antenna factor, dB/m
5400	-5.1
5450	-4.6
5500	-4.0
5550	-3.5
5600	-3.1
5650	-3.3
5700	-3.8
5750	-4.3
5800	-4.3
5850	-4.0
5900	-3.5
5950	-3.2
6000	-3.2
6050	-3.2
6100	-3.3
6150	-3.3
6200	-3.1
6250	-2.9
6300	-2.8
6350	-3.0
6400	-3.2
6450	-3.4
6500	-3.7
6550	-3.6
6600	-3.4
6650	-2.9
6700	-2.6
6750	-2.5
6800	-2.6
6850	-2.8
6900	-2.7
6950	-2.3
7000	-2.0
7050	-1.9
7100	-1.8
7150	-1.8
7200	-1.7
7250	-1.7
7300	-1.6
7350	-1.5
7400	-1.5
7450	-1.3
7500	-1.4
7550	-1.3
7600	-1.0
7650	-0.7
7700	-0.3
7750	0.1
7800	0.3
7850	0.4
7900	0.2
7950	0.1
8000	0.2
8050	0.3
8100	0.8
8150	1.1
8200	1.1
8250	1.0
12400	2.1
12500	1.2
12600	1.3
12700	2.4
12800	1.8

Frequency, MHz	Measured antenna factor, dB/m
8300	0.8
8350	0.5
8400	0.3
8450	0.5
8500	0.8
8550	0.9
8600	0.9
8650	0.6
8700	0.0
8750	-0.3
8800	0.0
8850	0.5
8900	0.6
8950	0.4
9000	-0.3
9050	-1.0
9100	-1.2
9150	-0.6
9200	-0.1
9250	0.0
9300	-0.1
9350	-0.5
9400	-0.7
9450	-0.4
9500	0.2
9550	0.5
9600	0.5
9650	0.3
9700	0.0
9750	0.0
9800	0.6
9850	1.4
9900	1.8
9950	1.7
10000	1.4
10100	0.8
10200	1.2
10300	1.5
10400	1.1
10500	1.6
10600	3.0
10700	2.9
10800	1.3
10900	1.0
11000	1.1
11100	0.7
11200	1.1
11300	1.5
11400	1.4
11500	0.6
11600	1.0
11700	1.4
11800	0.7
11900	0.9
12000	2.1
12100	2.1
12200	0.9
12300	1.6

12900	0.6
13000	0.9
13100	1.1
13200	0.7
13300	0.9
13400	1.8
13500	2.1
13600	1.2
13700	0.8
13800	1.2
13900	1.5
14000	1.7
14100	2.2
14200	2.8
14300	3.0
14400	3.0
14500	3.3
14600	4.0
14700	5.4
14800	5.4
14900	4.7
15000	3.1
15100	2.0
15200	1.5
15300	1.4
15400	1.7
15500	1.9
15600	1.2
15700	0.2
15800	0.6
15900	1.2
16000	0.6
16100	0.6
16200	1.9
16300	2.2
16400	0.9
16500	0.7
16600	1.7
16700	1.3
16800	1.0
16900	2.0
17000	2.4
17100	1.8
17200	1.8
17300	2.5
17400	2.7
17500	3.1
17600	3.7
17700	4.3
17800	4.8
17900	5.7
18000	5.1

HL 5288: Trilog Antenna
Frankonia, model: ALX-8000E, s/n: 00809
30-1000 MHz

Frequency, MHz	Antenna factor, dB/m	Frequency, MHz	Antenna factor, dB/m
30	14.96	160	12.67
35	15.33	180	13.34
40	16.37	200	15.40
45	17.56	250	16.42
50	17.95	300	17.28
60	16.87	400	19.98
70	13.22	500	21.11
80	10.56	600	22.90
90	13.61	700	24.13
100	15.46	800	25.25
120	14.03	900	26.35
140	12.23	1000	27.18

The antenna factor shall be added to receiver reading in dBμV to obtain field strength in dBμV/m.

above 1000 MHz

Frequency, MHz	Antenna factor, dB/m	Frequency, MHz	Antenna factor, dB/m
1000	26.9	3600	38.9
1100	28.1	3700	39.4
1200	28.4	3800	39.4
1300	29.6	3900	39.6
1400	29.1	4000	39.7
1500	30.4	4100	39.8
1600	30.7	4200	40.5
1700	31.5	4300	40.9
1800	32.3	4400	41.1
1900	32.6	4500	41.4
2000	32.5	4600	41.3
2100	32.9	4700	41.6
2200	33.5	4800	41.9
2300	33.2	4900	42.3
2400	33.7	5000	42.7
2500	34.6	5100	43.0
2600	34.7	5200	42.9
2700	34.6	5300	43.5
2800	35.0	5400	43.6
2900	35.5	5500	44.3
3000	36.2	5600	44.7
3100	36.8	5700	45.0
3200	36.8	5800	45.0
3300	37.0	5900	45.3
3400	37.5	6000	45.9
3500	38.2		

The antenna factor shall be added to receiver reading in dBμV to obtain field strength in dBμV/m.

10 APPENDIX C Test laboratory 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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11 APPENDIX D Measurement uncertainties

Expanded uncertainty at 95% confidence in Hermon Labs EMC measurements

Test description	Expanded uncertainty
Transmitter tests	
Carrier power conducted at antenna connector	± 1.7 dB
Carrier power radiated (substitution method)	± 4.5 dB
Occupied bandwidth	±8%
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
Spurious emissions radiated 30 MHz – 40 GHz (substitution method)	± 4.5 dB
Frequency error	30 – 300 MHz: ± 50.5 Hz (1.68 ppm) 300 – 1000 MHz: ± 168 Hz (0.56 ppm)
Transient frequency behaviour	187 Hz ± 13.9 %
Duty cycle, timing (Tx ON / OFF) and average factor measurements	± 1.0 %

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.

12 APPENDIX E Specification references

FCC 47CFR part 90: 2019	Private land mobile radio services
FCC 47CFR part 2: 2019	Frequency allocations and radio treaty matters; general rules and regulations
ANSI/TIA/EIA-603-E:2016	Land Mobile FM or PM Communications Equipment Measurement and Performance Standards
RSS-119 Issue 12: 2015	Land Mobile and Fixed Equipment Equipment Operating in the Frequency Range 27.41-960 MHz

13 APPENDIX F Abbreviations and acronyms

A	ampere
AC	alternating current
AM	amplitude modulation
AVRG	average (detector)
BB	broad band
cm	centimeter
dB	decibel
dBm	decibel referred to one milliwatt
dB(μV)	decibel referred to one microvolt
dB(μV/m)	decibel referred to one microvolt per meter
dB(μA)	decibel referred to one microampere
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
k	kilo
kHz	kilohertz
LO	local oscillator
m	meter
MHz	megahertz
min	minute
mm	millimeter
ms	millisecond
μs	microsecond
NA	not applicable
NB	narrow band
OATS	open area test site
Ω	Ohm
QP	quasi-peak
RE	radiated emission
RF	radio frequency
rms	root mean square
Rx	receive
s	second
T	temperature
Tx	transmit
V	volt

END OF DOCUMENT