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TEST REPORT

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

FOR:

Telematics Wireless Ltd

Water Meter

Model: SONATA-AL

FCC ID: NTASONATA2

IC: 4732A-SONATA2

This report is in conformity with ISO/IEC 17025. The "A2LA Accredited" symbol endorsement applies only to the tests and calibrations that are listed in the scope of Hermon Laboratories accreditation. The test results relate only to the items tested. This test report shall not be reproduced in any form except in full with the written approval of Hermon Laboratories Ltd.

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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: Water Meter
Product type: Transceiver
Model(s): SONATA-AL
Serial number: 143 83 084
Hardware version: Rev. B
Software release: 02B6
Receipt date 15-Aug-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: 33993
Location: Hermon Laboratories Ltd. P.O. Box 23, Binyamina 3055001, Israel
Test started: 15-Aug-19
Test completed: 05-Sep-19
Test specification(s): FCC 47 CFR part 90, RSS-119 issue 12




5 Tests summary

Test	Status
Transmitter characteristics	
FCC Section 90.205 / 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.33933_Rev3

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. A. Morozov test engineer EMC & Radio Mrs. E. Pitt test engineer EMC & Radio	15 Aug 19 – 05 Sep 19	
Reviewed by:	Mrs. S. Peysahov Sheynin test engineer EMC & Radio	15 Oct 19 – 27 Oct 19	
Approved by:	Mr. S. Samokha, technical manager, EMC and Radio	04 Dec 19	



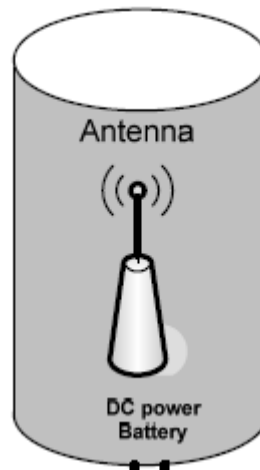
6 EUT description

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

6.1 General information

SONATA-AL is Water Meter comprises a RF module, operates at 450-470MHz frequency band and powered by battery at nominal voltage of 3.6VDC. The modulation is 4GFSK, channel bandwidth 6.25KHZ and bit rate of 4.8kbps.

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			33.67 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	
				X	with temporary RF connector	
				X	without temporary RF connector	
Antenna/s technical characteristics						
Type		Manufacturer		Model number		
Printed		ARAD		NA		
Gain		-1.5 dBi				
Transmitter aggregate data rate/s		4.8 kbps				
Type of modulation		4GFSK				
Modulating test signal (baseband)		PRBS				
Transmitter power source						
X	Battery	Nominal rated voltage	3.6 VDC	Battery type	Lithium	
	DC	Nominal rated voltage				
	AC mains	Nominal rated voltage		Frequency		



Test specification: Section 90.205 / RSS-119 Section 5.4, Maximum output power			
Test procedure: 47 CFR, Section 2.1046			
Test mode: Compliance		Verdict: PASS	
Date(s): 15-Aug-19			
Temperature: 24 °C	Relative Humidity: 43 %	Air Pressure: 1008 hPa	Power: 3.6 VDC
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 Peak output power limits

Assigned frequency band, MHz	ERP		Equivalent field strength limit @ 3m, dB(µV/m)*
	W	dBm	
FCC			
450.0 – 470.0	2	33.00	130.38
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: $E = \sqrt{30 \times P \times 1.64} / r$, where P is ERP in Watts, 1.64 is numeric gain of ideal dipole and r is antenna to EUT distance in meters

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.

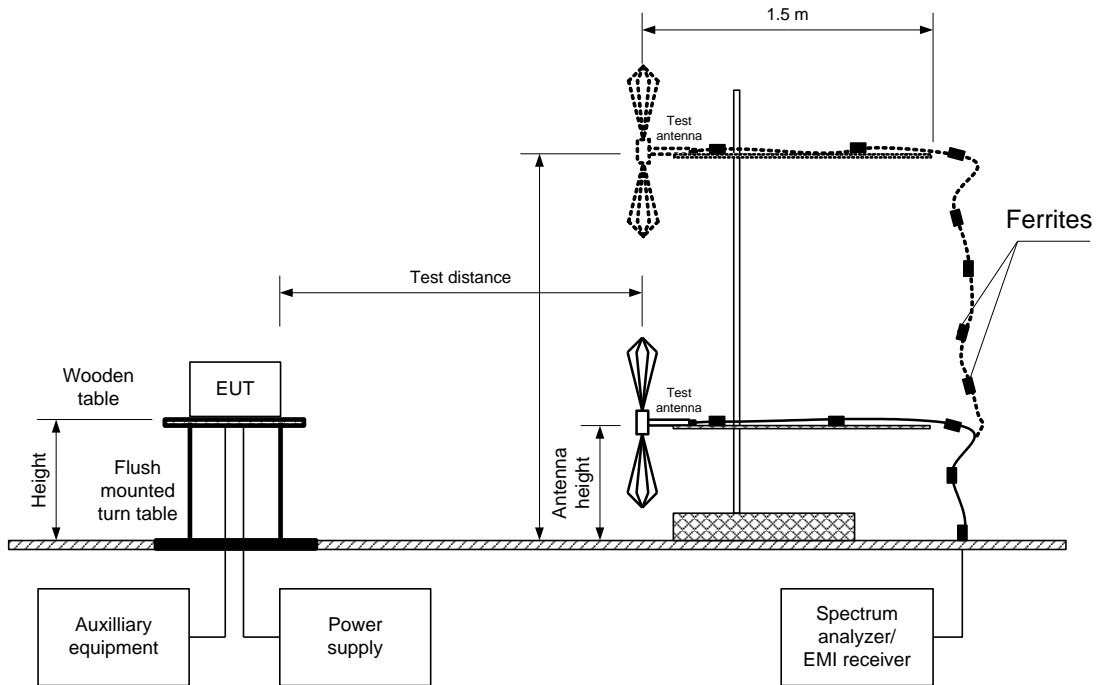
7.1.2.2 The field strength of the EUT carrier frequency was measured with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360°, the measuring antenna height was swept throughout the range, specified in Table 7.1.2 and Table 7.1.3, in both vertical and horizontal polarizations.

7.1.2.3 The worst test results (the lowest margins) were recorded in Table 7.1.2 and Table 7.1.3 and shown in the associated plots.



Test specification: Section 90.205 / RSS-119 Section 5.4, Maximum output power			
Test procedure: 47 CFR, Section 2.1046			
Test mode: Compliance	Verdict: PASS		
Date(s): 15-Aug-19			
Temperature: 24 °C	Relative Humidity: 43 %	Air Pressure: 1008 hPa	Power: 3.6 VDC
Remarks:			

Figure 7.1.1 Setup for carrier field strength measurements





Test specification: Section 90.205 / RSS-119 Section 5.4, Maximum output power			
Test procedure: 47 CFR, Section 2.1046			
Test mode: Compliance		Verdict: PASS	
Date(s): 15-Aug-19			
Temperature: 24 °C	Relative Humidity: 43 %	Air Pressure: 1008 hPa	Power: 3.6 VDC
Remarks:			

Table 7.1.2 Transmitter carrier field strength according to FCC

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
RESOLUTION BANDWIDTH: 100 kHz
VIDEO BANDWIDTH: > Resolution bandwidth
TEST ANTENNA TYPE: Biconilog
MODULATION: 4GFSK
TRANSMITTER OUTPUT POWER: Maximum
SETTINGS:

Frequency, MHz	Field strength, dB(µV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees	EUT antenna gain, dBi	ERP, dBm***	Peak output power (conducted), dBm*	ERP Limit, dBm	Margin, dB**	Verdict
450.0031	127.37	Vertical	1.2	0	-1.5	29.97	33.67	33.00	-3.03	Pass
460.0000	127.32	Vertical	1.1	0	-1.5	29.92	33.62	33.00	-3.08	Pass
469.9969	127.28	Vertical	1.1	0	-1.5	29.88	33.58	33.00	-3.12	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 = ERP – specification ERP limit.

*** ERP=Field strength in dB(µV/m) – 97.4 dB



Test specification: Section 90.205 / RSS-119 Section 5.4, Maximum output power			
Test procedure: 47 CFR, Section 2.1046			
Test mode: Compliance		Verdict: PASS	
Date(s): 15-Aug-19			
Temperature: 24 °C	Relative Humidity: 43 %	Air Pressure: 1008 hPa	Power: 3.6 VDC
Remarks:			

Table 7.1.3 Transmitter carrier field strength according to RSS-119 Table 2

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
 RESOLUTION BANDWIDTH: 100 kHz
 VIDEO BANDWIDTH: > Resolution bandwidth
 TEST ANTENNA TYPE: Biconilog
 MODULATION: 4GFSK
 TRANSMITTER OUTPUT POWER: Maximum
 SETTINGS:

Frequency, MHz	Field strength, dB(µV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees	EUT antenna gain, dBi	ERP, dBm***	Peak output power (conducted), dBm*	ERP Limit, dBm	Margin, dB**	Verdict
450.0031	127.37	Vertical	1.2	0	-1.5	29.97	33.67	47.78	-17.81	Pass
460.0000	127.32	Vertical	1.1	0	-1.5	29.92	33.62	47.78	-17.86	Pass
469.9969	127.28	Vertical	1.1	0	-1.5	29.88	33.58	47.78	-17.90	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 = ERP – specification ERP limit.

*** ERP=Field strength in dB(µV/m) – 97.4 dB

Reference numbers of test equipment used

HL 3903	HL 4355	HL 5288	HL 5404				
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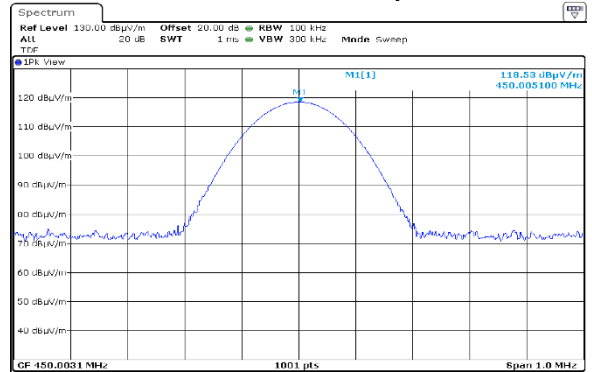
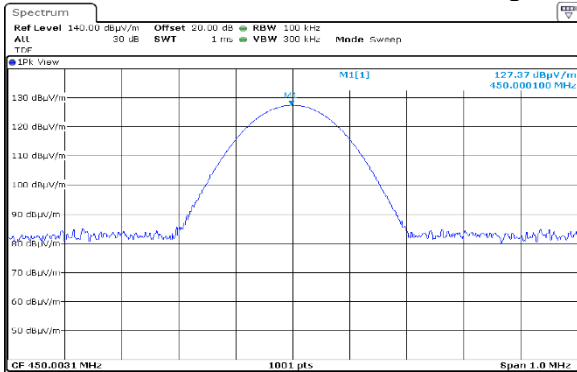
Full description is given in Appendix A.



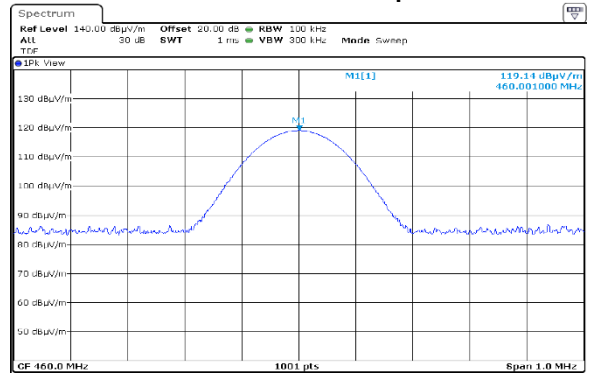
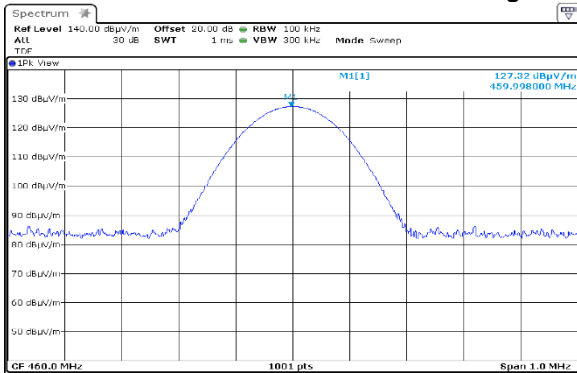
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Test specification: Section 90.205 / RSS-119 Section 5.4, Maximum output power			
Test procedure: 47 CFR, Section 2.1046			
Test mode: Compliance	Verdict: PASS		
Date(s): 15-Aug-19			
Temperature: 24 °C	Relative Humidity: 43 %	Air Pressure: 1008 hPa	Power: 3.6 VDC
Remarks:			

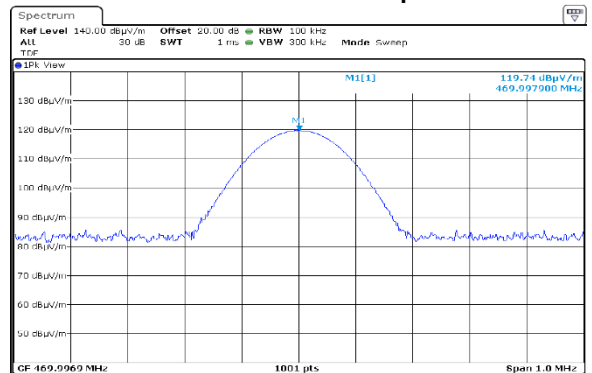
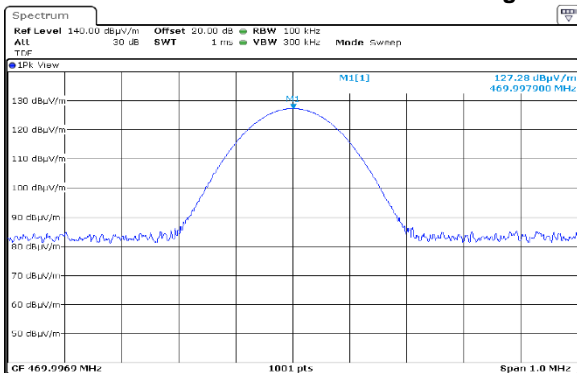
Plot 7.1.1 Transmitter carrier field strength at low frequency in vertical and horizontal antenna polarization



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



Plot 7.1.3 Transmitter carrier field strength at high frequency in vertical and horizontal 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): 18-Aug-19			
Temperature: 25 °C	Relative Humidity: 45 %	Air Pressure: 1006 hPa	Power: 3.6 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, MHz	Modulation envelope reference points*, dBc	Maximum allowed 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

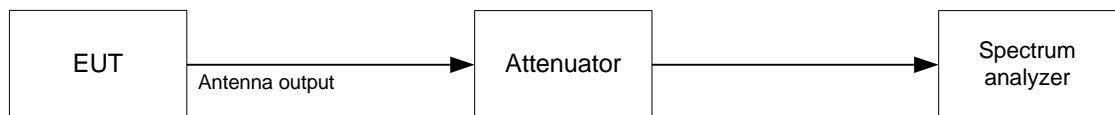
7.2.2.1 The EUT was set up as shown in Figure 7.2.1, energized and its proper operation was checked.

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): 18-Aug-19			
Temperature: 25 °C	Relative Humidity: 45 %	Air Pressure: 1006 hPa	Power: 3.6 VDC
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

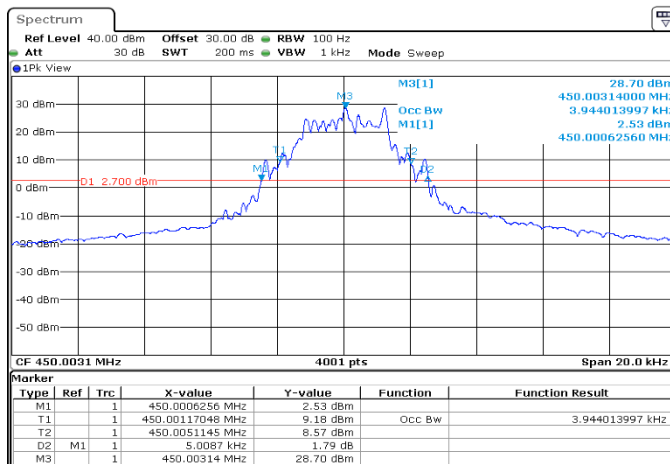
Carrier frequency, MHz	Occupied bandwidth, kHz	Limit, kHz	Margin, kHz	Verdict
MODULATION ENVELOPE REFERENCE POINTS: 99%				
450.0031	3.944	6	-2.056	Pass
460.0000	3.964	6	-2.036	Pass
469.9969	3.959	6	-2.041	Pass
MODULATION ENVELOPE REFERENCE POINTS: 26 dBc				
450.0031	5.008	6	-0.992	Pass
460.0000	5.013	6	-0.987	Pass
469.9969	5.003	6	-0.997	Pass

Reference numbers of test equipment used

HL 4355	HL 3903	HL 4068				
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Full description is given in Appendix A.

Plot 7.2.1 Occupied bandwidth test result at low frequency

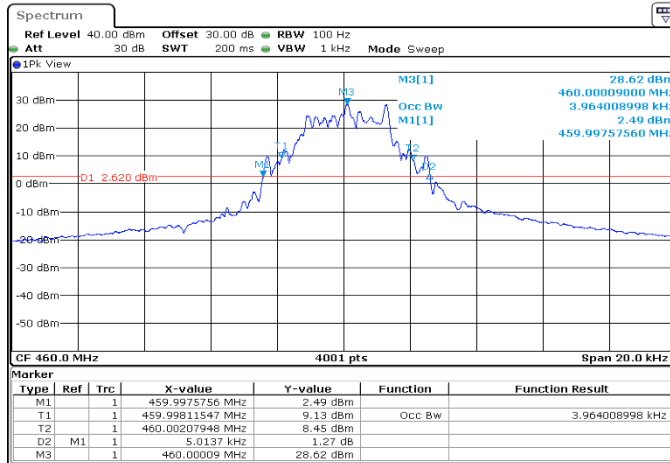




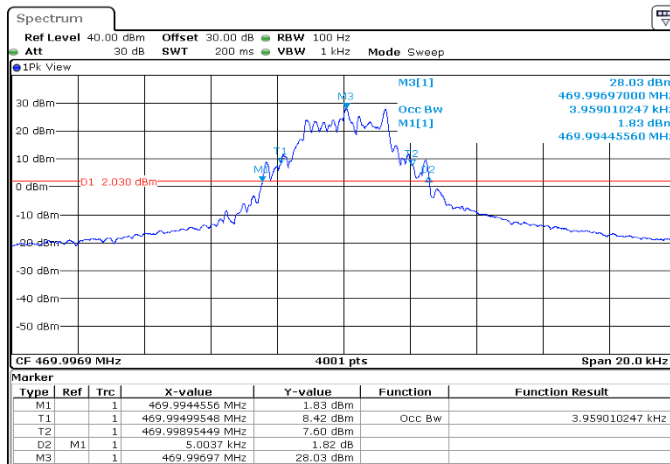
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Test specification: Section 90.209 / RSS-119 Section 5.5, Occupied bandwidth			
Test procedure: 47 CFR, Section 2.1049			
Test mode: Compliance		Verdict: PASS	
Date(s): 18-Aug-19			
Temperature: 25 °C	Relative Humidity: 45 %	Air Pressure: 1006 hPa	Power: 3.6 VDC
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): 05-Sep-19			
Temperature: 23 °C	Relative Humidity: 55 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
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 .

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) with 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
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
450.0310	Emission mask E	Pass
460.0000		
469.9969		

Reference numbers of test equipment used

HL 4355	HL 4071						
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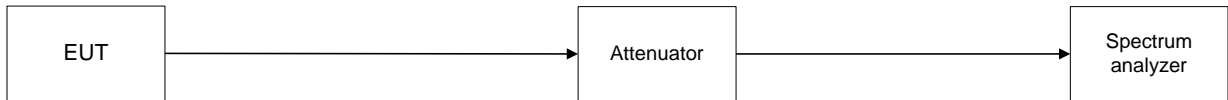
Full description is given in Appendix A.



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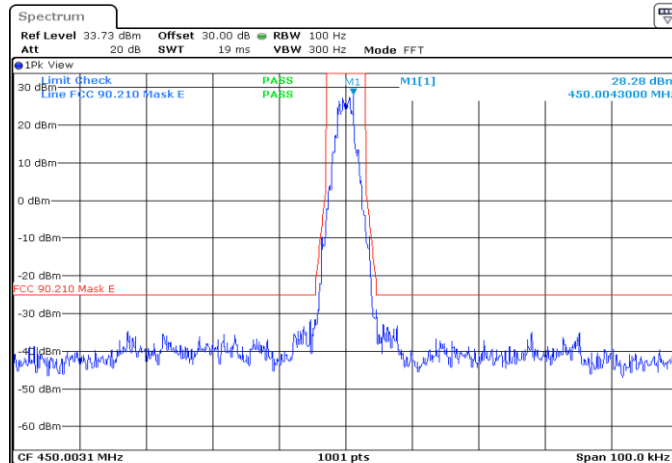
Test specification: Section 90.210 / RSS-119 Section 5.8.4, Emission mask			
Test procedure: 47 CFR, Sections 2.1051, 2.1047 and 90.210(e), TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 05-Sep-19			
Temperature: 23 °C	Relative Humidity: 55 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
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

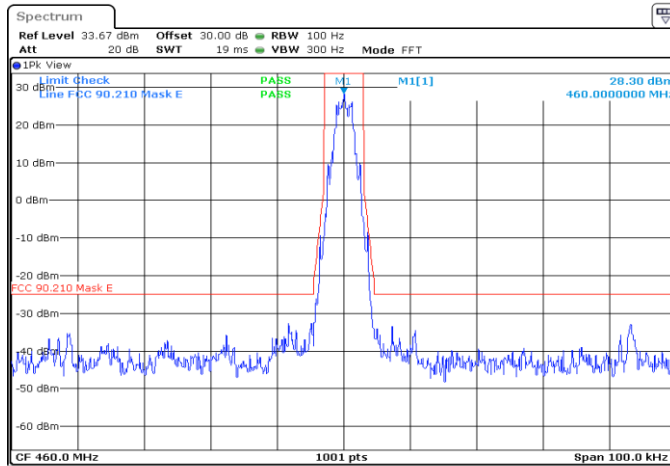




Test specification: Section 90.210 / RSS-119 Section 5.8.4, Emission mask			
Test procedure: 47 CFR, Sections 2.1051, 2.1047 and 90.210(e), TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 05-Sep-19			
Temperature: 23 °C	Relative Humidity: 55 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

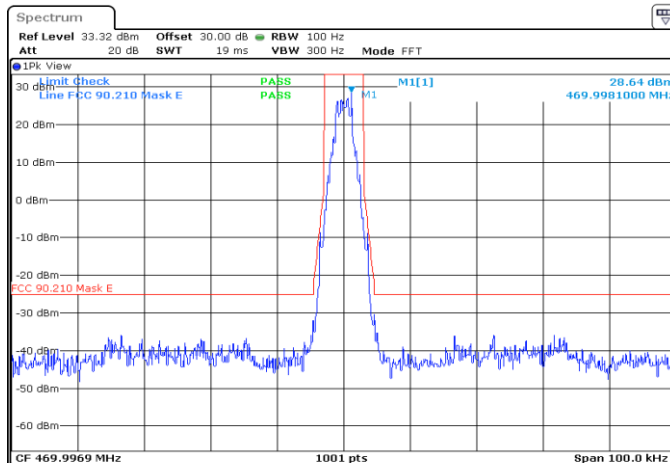
Plot 7.3.2 Emission mask test results at mid carrier frequency

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): 20-Aug-19			
Temperature: 23 °C	Relative Humidity: 46 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
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(μ V/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: $E = \sqrt{30 \times P \times 1.64} / r$, where P is ERP in Watts, 1.64 is numeric gain of ideal dipole and r is antenna to EUT distance in meters

7.4.2 Test procedure for radiated spurious emission 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° 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 radiated spurious emission 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° 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): 20-Aug-19			
Temperature: 23 °C	Relative Humidity: 46 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

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

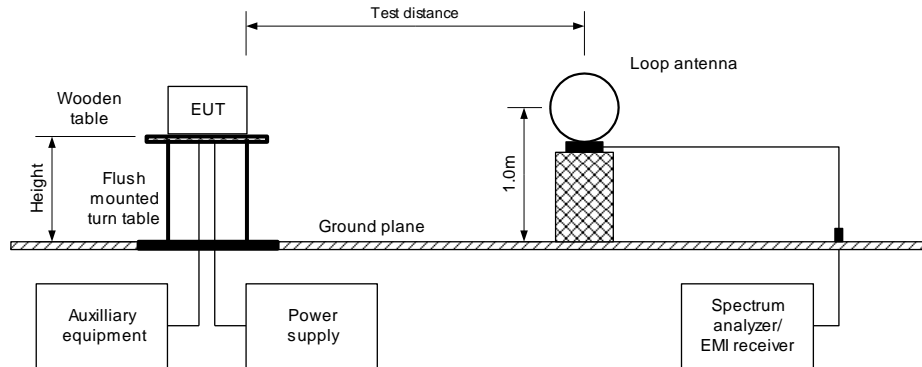
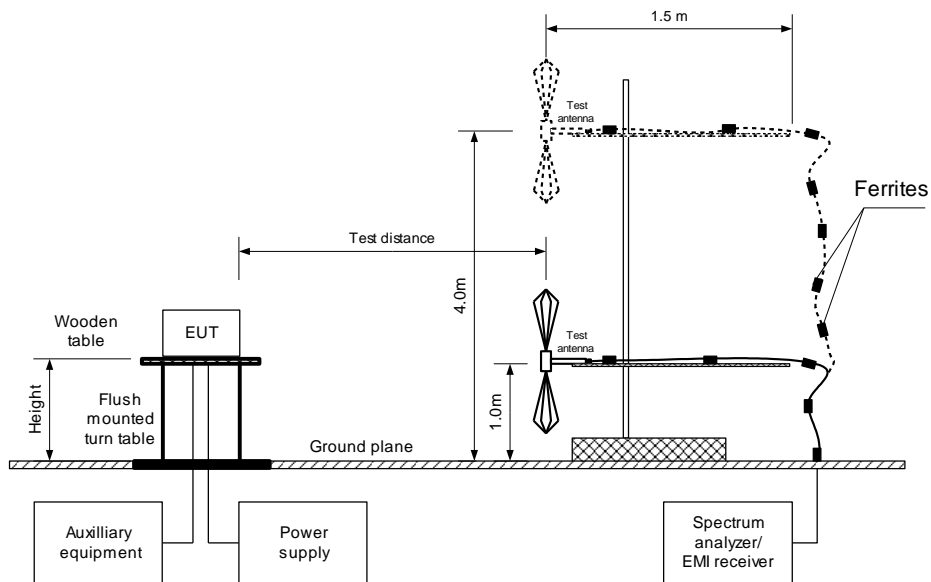


Figure 7.4.2 Setup for radiated spurious emission measurements above 30 MHz





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): 20-Aug-19			
Temperature: 23 °C	Relative Humidity: 46 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Table 7.4.2 Radiated spurious emission test results

ASSIGNED FREQUENCY RANGE: 450 - 470 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 SETTINGS: 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 450.0031 MHz								
900.005	72.28	72.4	-0.12	100	Horizontal	1.4	160	Pass
1349.973	59.28	72.4	-13.12	1000	Vertical	1.8	345	Pass
1799.961	64.49	72.4	-7.91	1000	Horizontal	1.5	10	Pass
2250.184	56.14	72.4	-16.26	1000	Vertical	1.5	290	Pass
Mid carrier frequency 460.0000 MHz								
919.999	69.68	72.4	-2.72	100	Horizontal	1.4	160	Pass
1379.951	59.86	72.4	-12.54	1000	Horizontal	1.9	180	Pass
1839.973	57.88	72.4	-14.52	1000	Vertical	1.9	110	Pass
2299.946	54.10	72.4	-18.3	1000	Horizontal	1.1	20	Pass
High carrier frequency 469.9969 MHz								
939.990	65.84	72.4	-6.56	100	Vertical	1.0	120	Pass
1409.951	61.44	72.4	-10.96	1000	Horizontal	2.1	0	Pass
1879.969	56.90	72.4	-15.5	1000	Vertical	1.5	120	Pass
2350.014	50.09	72.4	-22.31	1000	Vertical	1.5	300	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 3903	HL 4355	HL 4360	HL 4933	HL 5288	HL 5112		
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Full description is given in Appendix A.

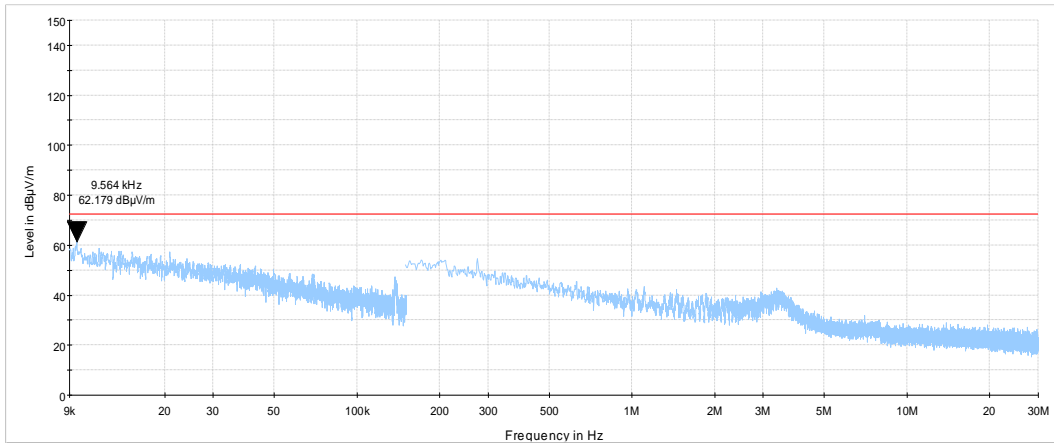


HERMON LABORATORIES

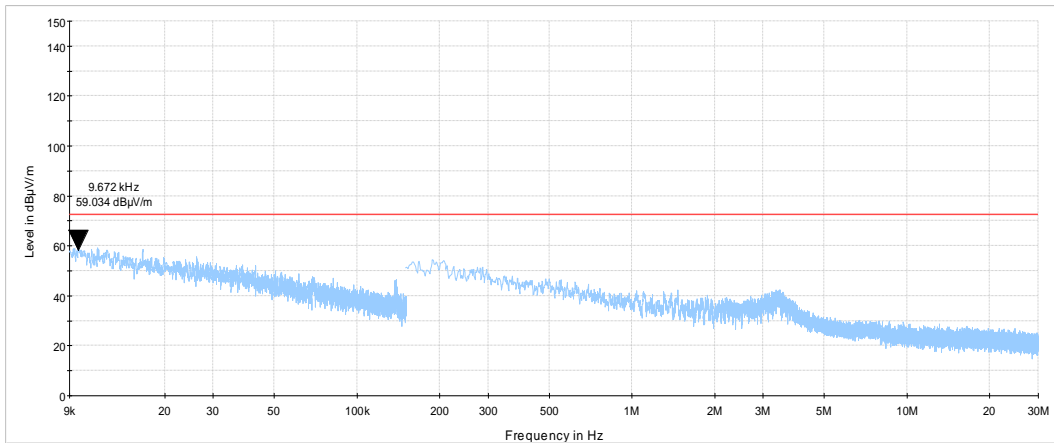
Test specification: Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions			
Test procedure: 47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12			
Test mode: Compliance		Verdict: PASS	
Date(s): 20-Aug-19			
Temperature: 23 °C	Relative Humidity: 46 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.4.1 Radiated spurious emission measurements in 9 kHz – 30 MHz range

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



CARRIER FREQUENCY: Mid

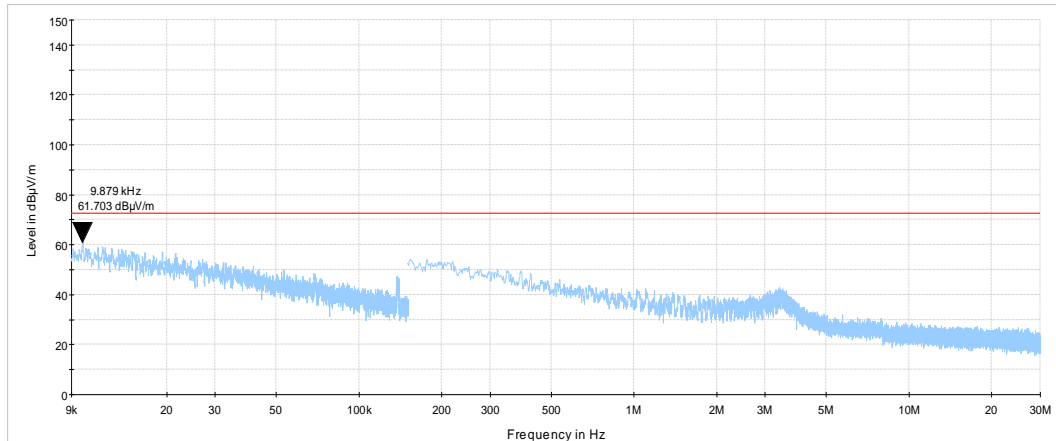




HERMON LABORATORIES

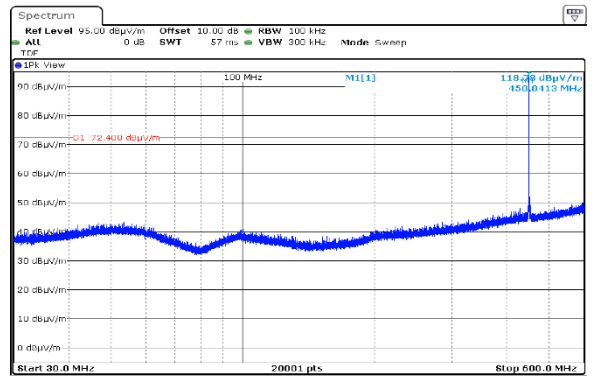
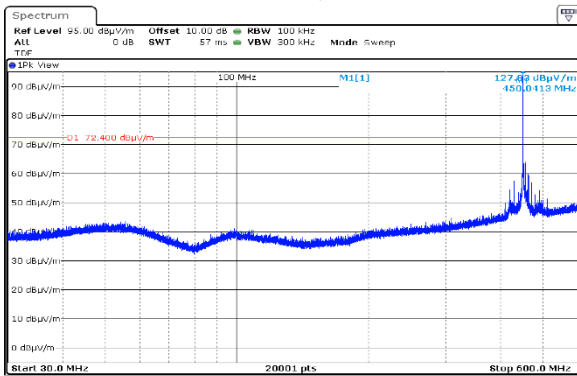
Test specification: Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions			
Test procedure: 47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12			
Test mode: Compliance		Verdict: PASS	
Date(s): 20-Aug-19			
Temperature: 23 °C	Relative Humidity: 46 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

CARRIER FREQUENCY: High



Plot 7.4.2 Radiated spurious emission measurements in 30 - 600 MHz range

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

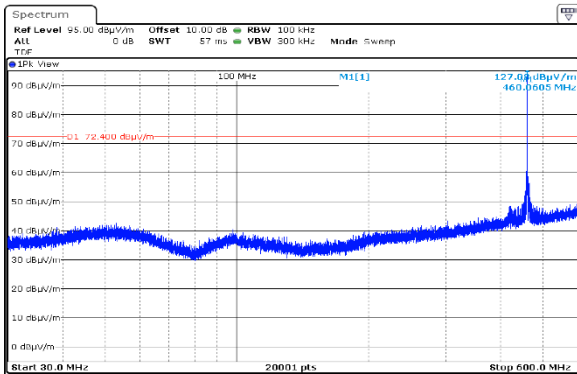




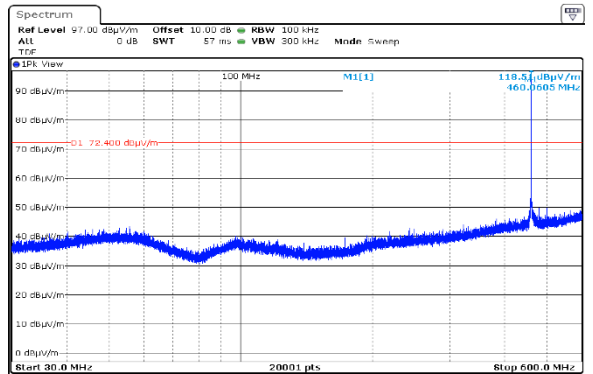
HERMON LABORATORIES

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): 20-Aug-19			
Temperature: 23 °C	Relative Humidity: 46 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

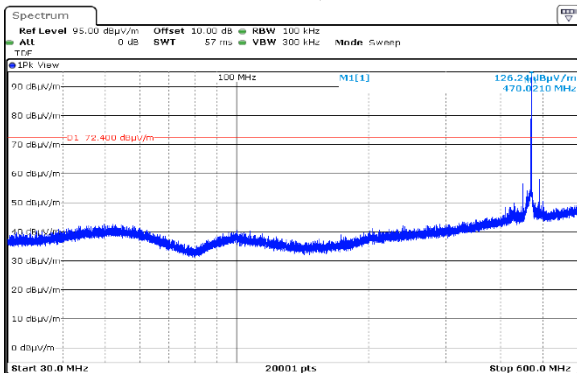
CARRIER FREQUENCY:



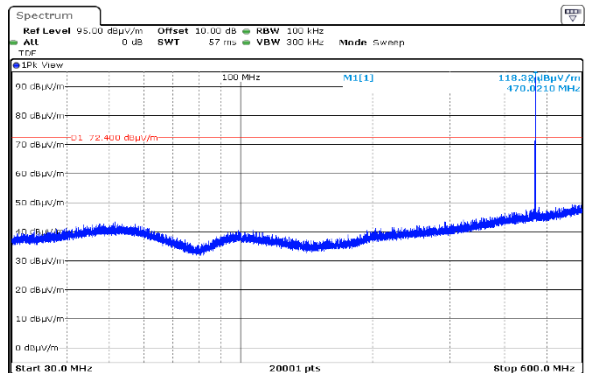
Mid



CARRIER FREQUENCY:



High





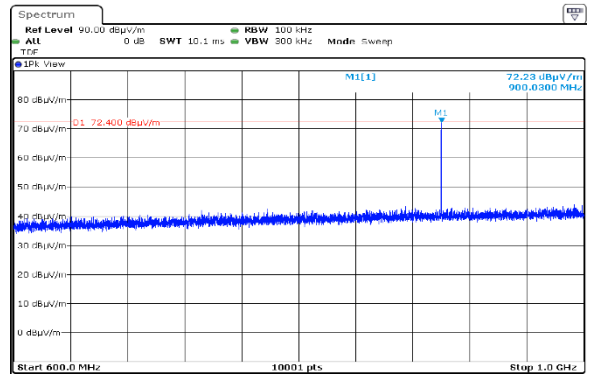
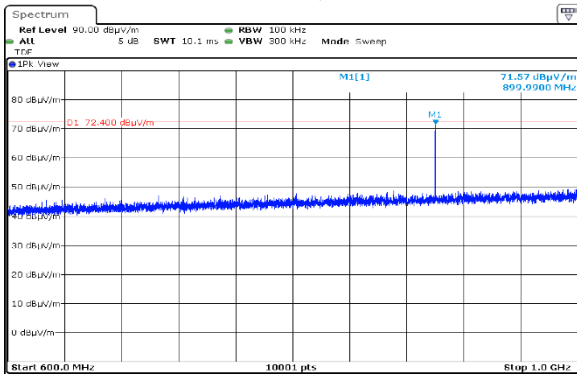
HERMON LABORATORIES

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): 20-Aug-19			
Temperature: 23 °C	Relative Humidity: 46 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.4.3 Radiated spurious emission measurements in 600 - 1000 MHz range

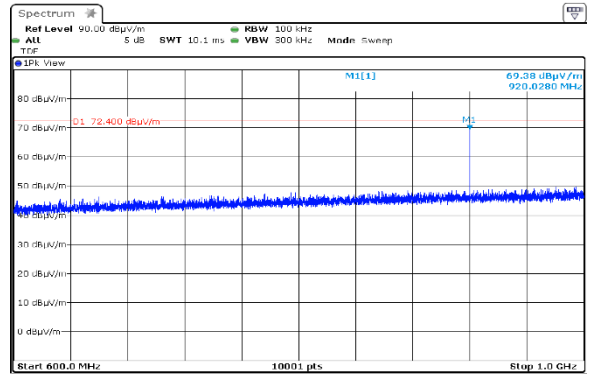
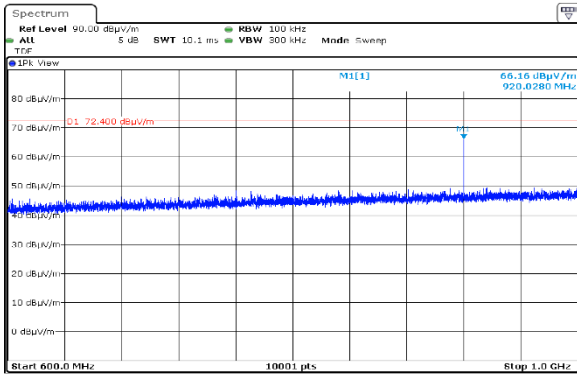
TEST SITE:
ANTENNA POLARIZATION:
TEST DISTANCE:
CARRIER FREQUENCY:

Semi anechoic chamber
Vertical and Horizontal
3 m
Low



CARRIER FREQUENCY:

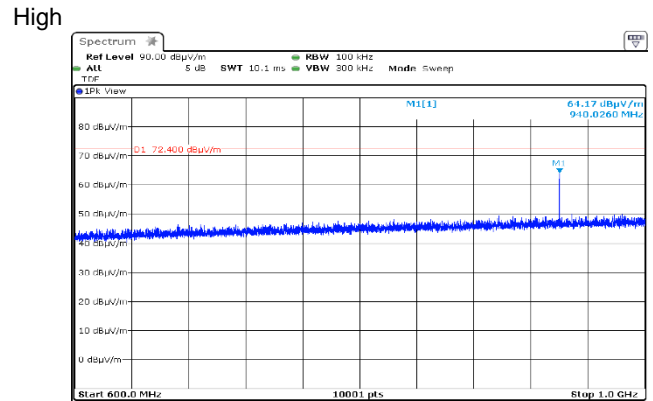
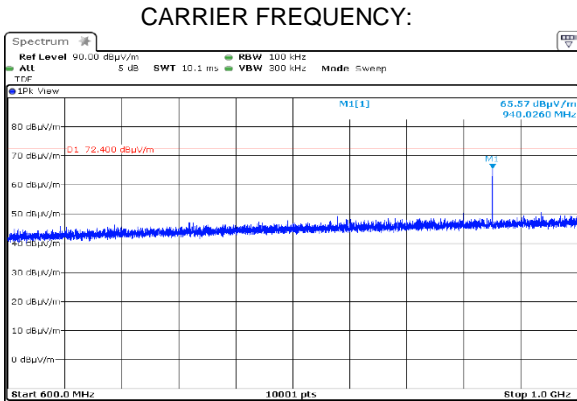
Mid



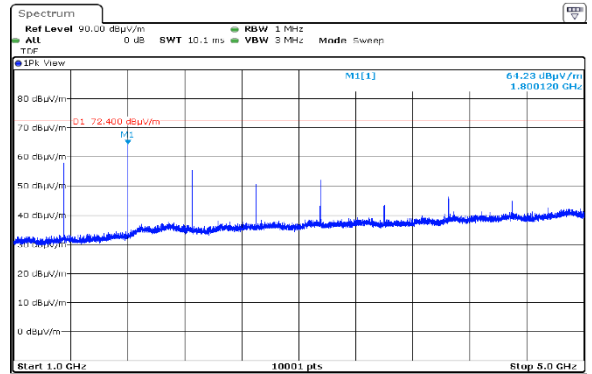
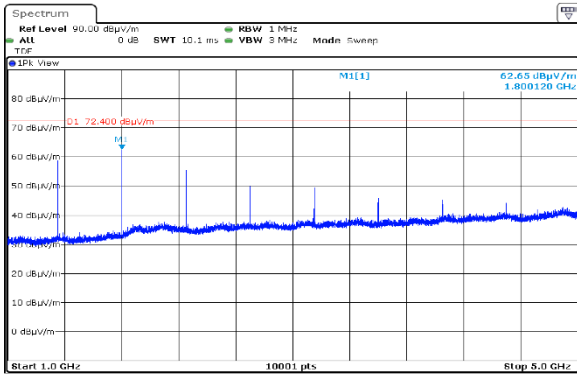


HERMON LABORATORIES

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): 20-Aug-19			
Temperature: 23 °C	Relative Humidity: 46 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			



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

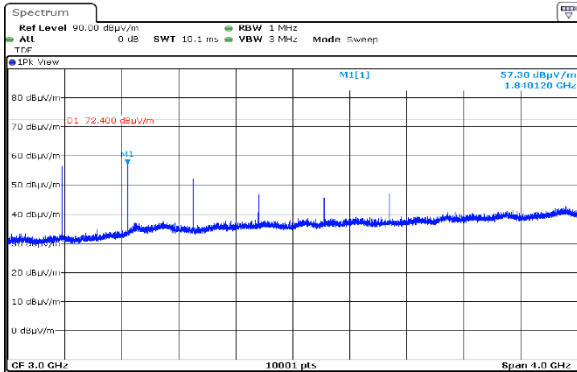




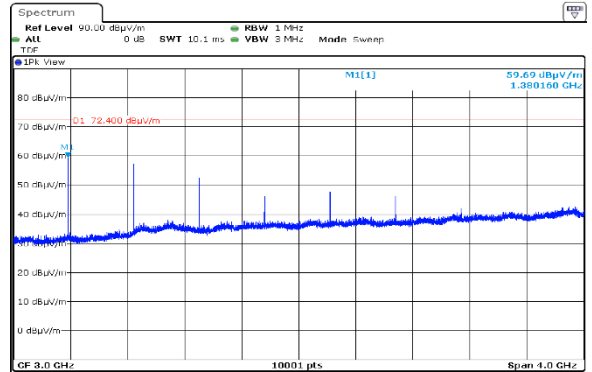
HERMON LABORATORIES

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): 20-Aug-19			
Temperature: 23 °C	Relative Humidity: 46 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

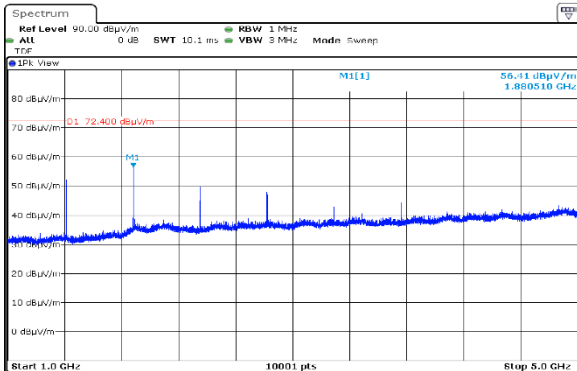
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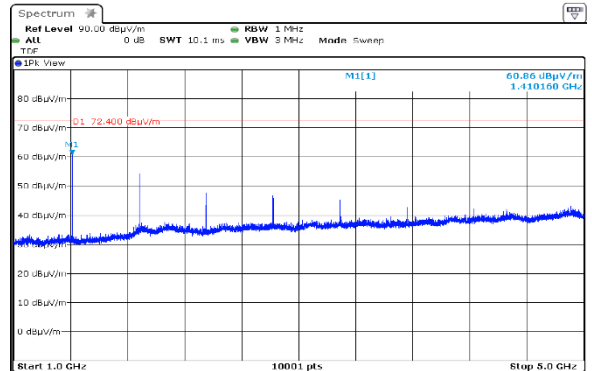
Mid



CARRIER FREQUENCY:



High





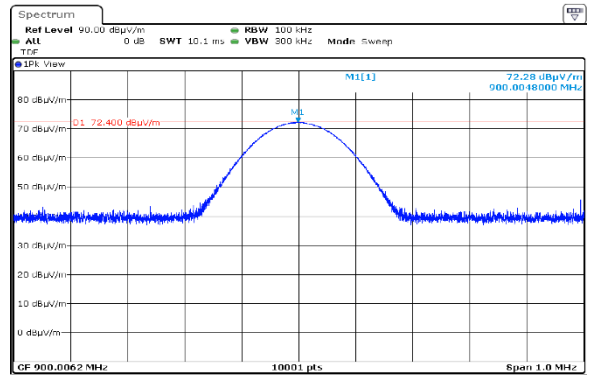
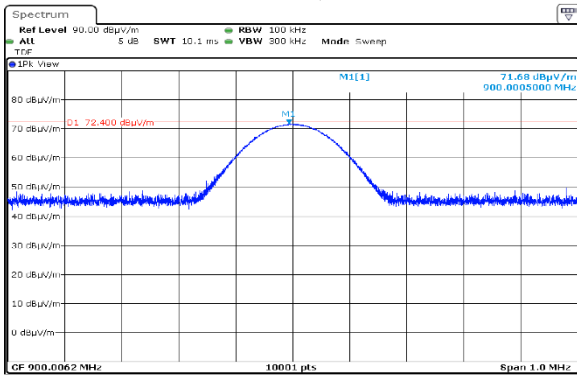
HERMON LABORATORIES

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): 20-Aug-19			
Temperature: 23 °C	Relative Humidity: 46 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.4.5 Radiated spurious emission measurements at the 2nd harmonic

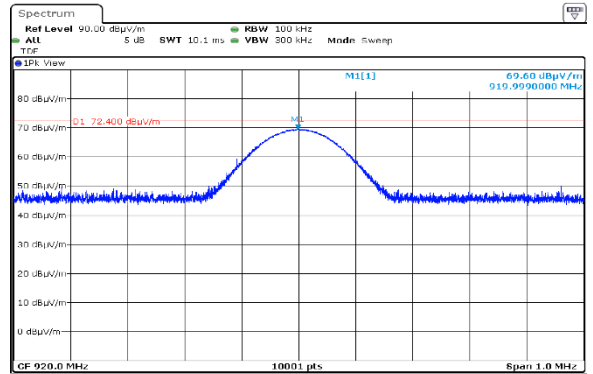
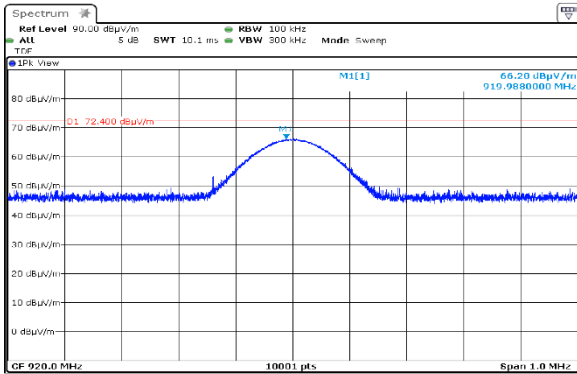
TEST SITE:
ANTENNA POLARIZATION:
TEST DISTANCE:
CARRIER FREQUENCY:

Semi anechoic chamber
Vertical and horizontal
3 m
Low



CARRIER FREQUENCY:

Mid



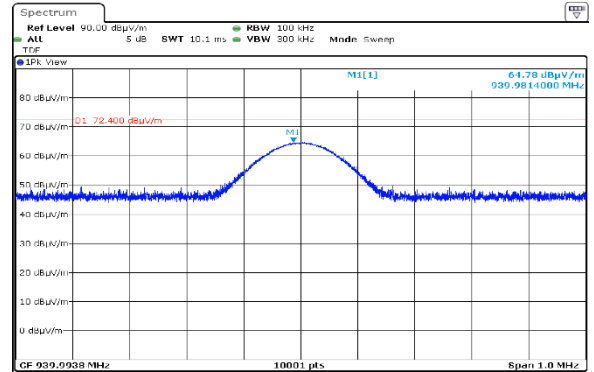
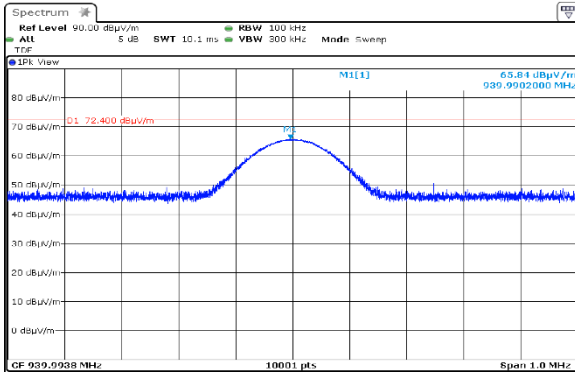


HERMON LABORATORIES

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): 20-Aug-19	
Temperature: 23 °C	Relative Humidity: 46 %
Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:	

CARRIER FREQUENCY:

High



Plot 7.4.6 Radiated spurious emission measurements at the 3rd harmonic

TEST SITE:

Semi anechoic chamber

ANTENNA POLARIZATION:

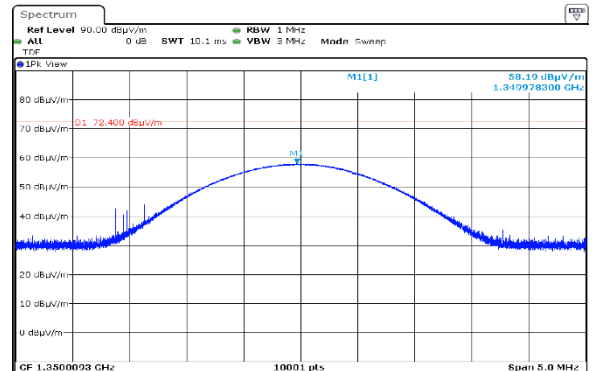
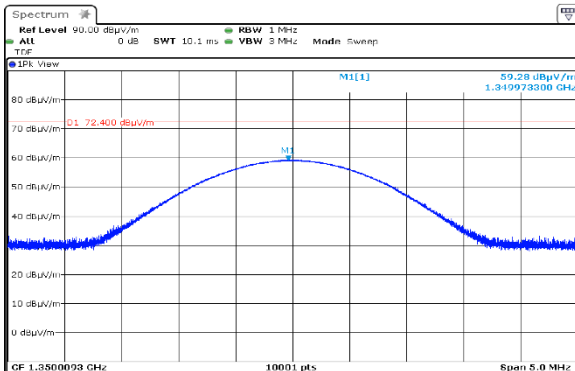
Vertical and Horizontal

TEST DISTANCE:

3 m

CARRIER FREQUENCY:

Low

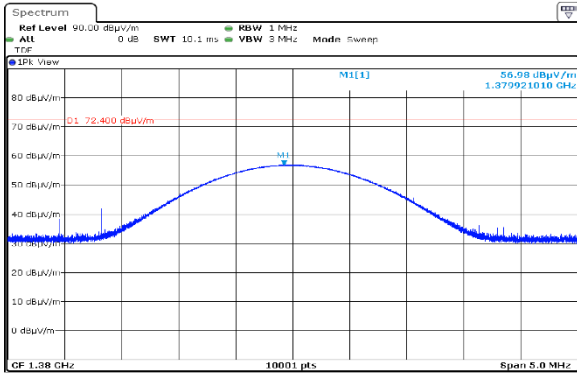




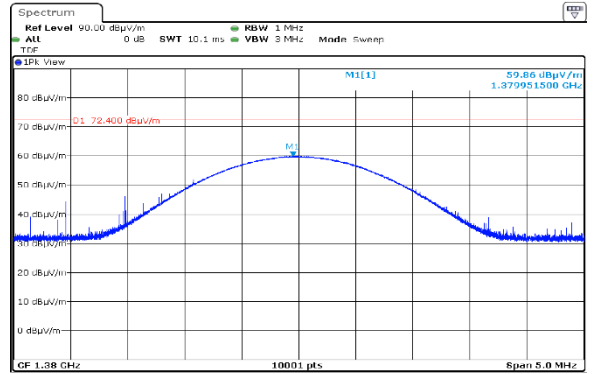
HERMON LABORATORIES

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): 20-Aug-19			
Temperature: 23 °C	Relative Humidity: 46 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

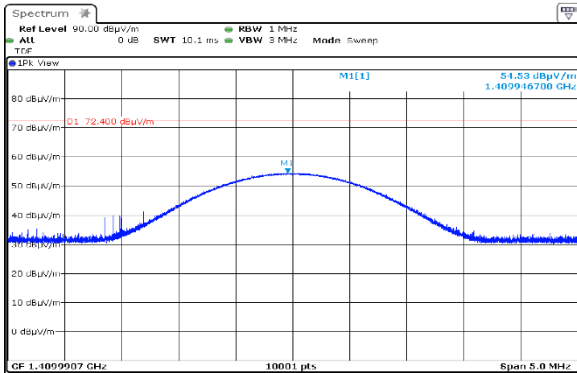
CARRIER FREQUENCY:



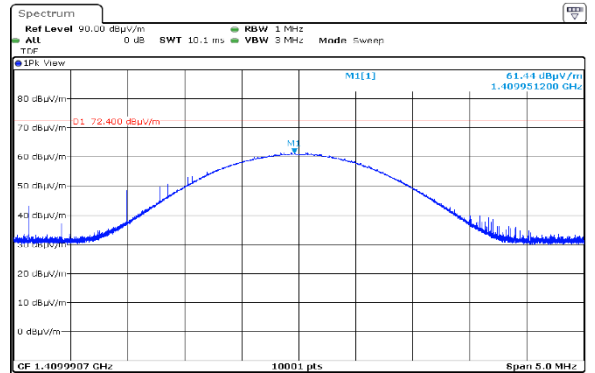
Mid



CARRIER FREQUENCY:



High





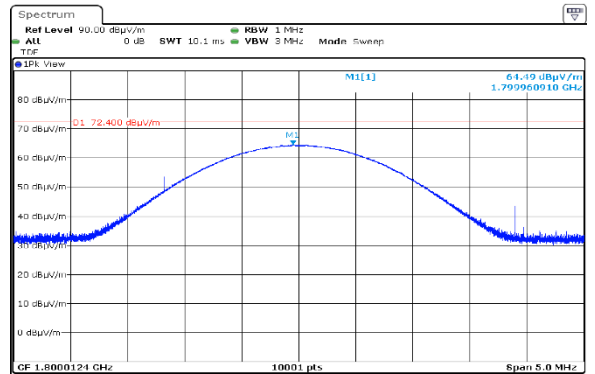
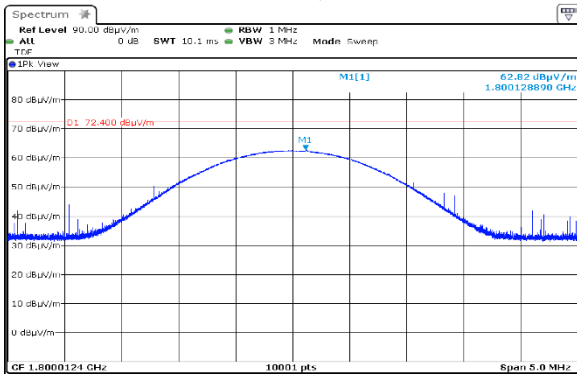
HERMON LABORATORIES

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): 20-Aug-19			
Temperature: 23 °C	Relative Humidity: 46 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.4.7 Radiated spurious emission measurements at the 4th harmonic

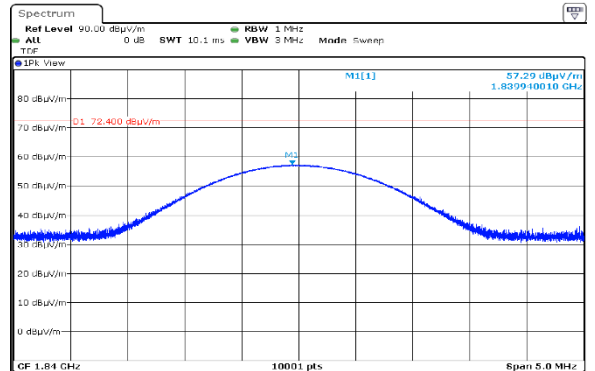
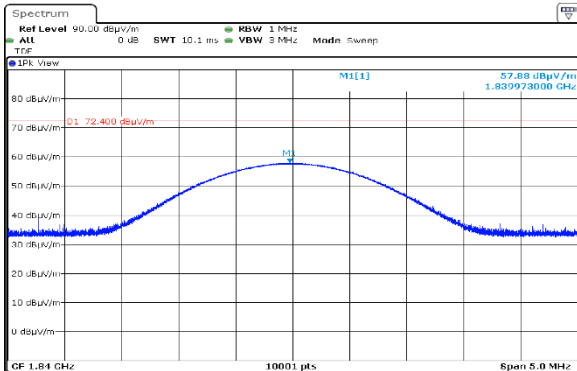
TEST SITE:
ANTENNA POLARIZATION:
TEST DISTANCE:
CARRIER FREQUENCY:

Semi anechoic chamber
Vertical and Horizontal
3 m
Low



CARRIER FREQUENCY:

Mid



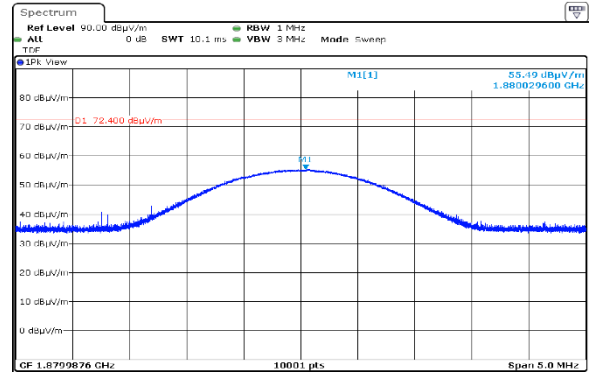
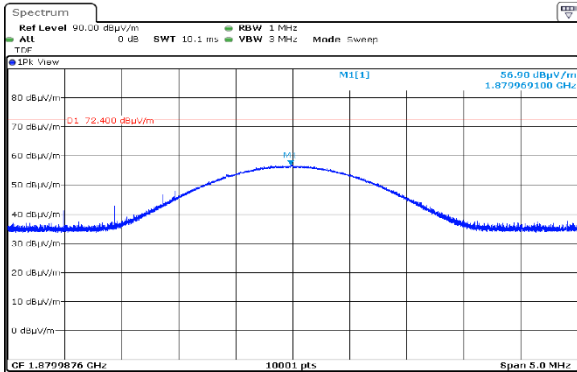


HERMON LABORATORIES

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): 20-Aug-19	
Temperature: 23 °C	Relative Humidity: 46 %
Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:	

CARRIER FREQUENCY:

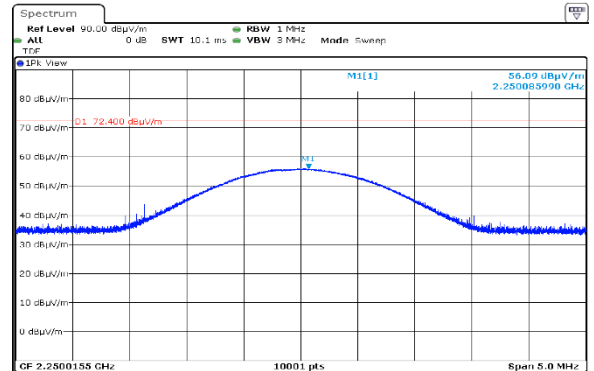
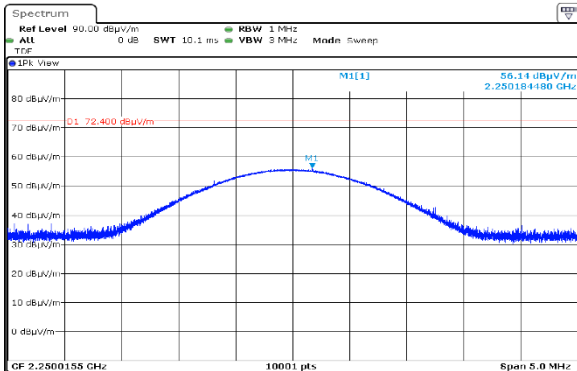
High



Plot 7.4.8 Radiated spurious emission measurements at the 5th harmonic

TEST SITE:
ANTENNA POLARIZATION:
TEST DISTANCE:
CARRIER FREQUENCY:

Semi anechoic chamber
Vertical and Horizontal
3 m
Low

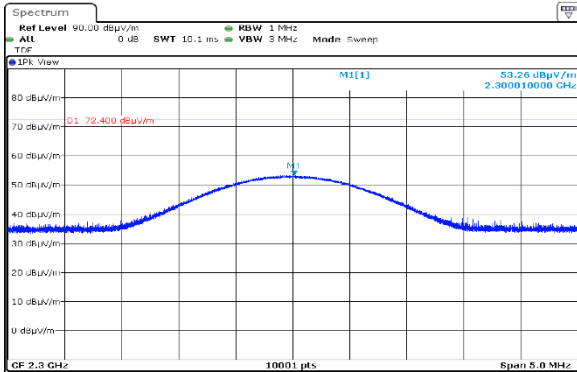




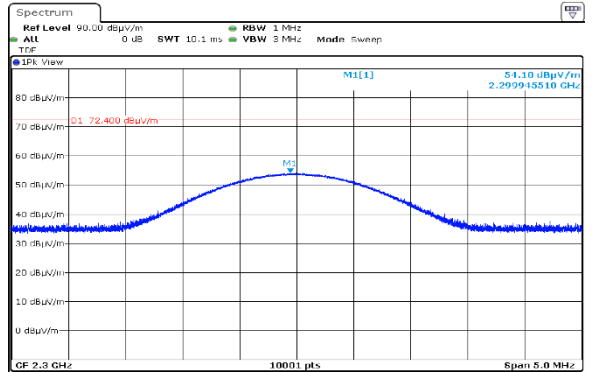
HERMON LABORATORIES

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): 20-Aug-19			
Temperature: 23 °C	Relative Humidity: 46 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

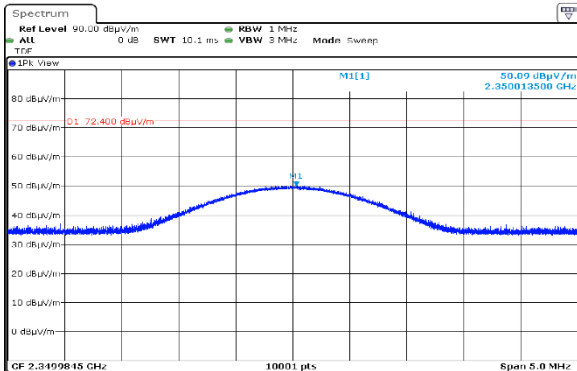
CARRIER FREQUENCY:



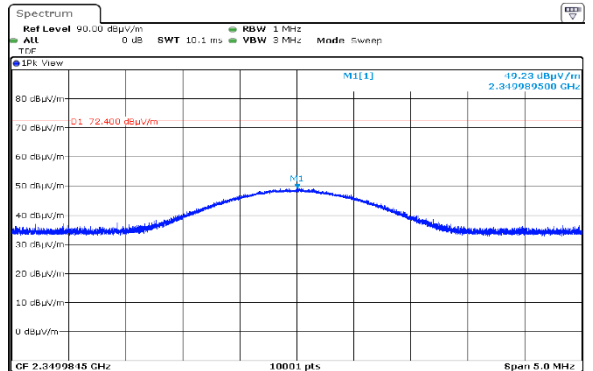
Mid



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): 20-Aug-19			
Temperature: 23 °C	Relative Humidity: 46 %	Air Pressure: 1010 hPa	Power: 3.6 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. The test results are provided in Table 7.5.2.

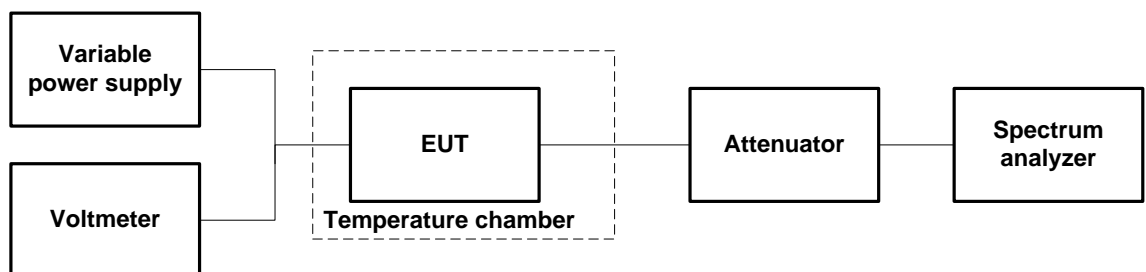
Table 7.5.1 Frequency stability limits

Assigned frequency, MHz	Maximum allowed frequency displacement	
	ppm	Hz
450.0031	1	450
460.0000		460
469.9969		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





HERMON LABORATORIES

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): 20-Aug-19			
Temperature: 23 °C	Relative Humidity: 46 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Table 7.5.2 Frequency stability test results

OPERATING FREQUENCY: 450.0 – 470.0 MHz
 NOMINAL POWER VOLTAGE: 3.6 V
 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, °C	Voltage, V	Frequency, MHz							Max frequency drift, Hz		Limit, Hz	Margin, Hz	Verdict
		Start up	1 st min	2 nd min	3 rd min	4 th min	5 th min	10 th min	Positive	Negative			
Low frequency													
-30	nominal	450.003068	450.003084	450.003086	450.003085	450.003087	450.003081	450.003079	0	-81	450	-369	Pass
-20	nominal	450.003074	NA	NA	NA	NA	NA	450.003112	0	-75		-375	Pass
-10	nominal	450.003071	NA	NA	NA	NA	NA	450.003098	0	-78		-372	Pass
0	nominal	450.003144	450.003193	450.003195	450.003192	450.003183	450.003173	450.003140	46	-9		-404	Pass
10	nominal	450.003165	NA	NA	NA	NA	NA	450.003160	16	0		-434	Pass
20	+15%	450.003163	NA	NA	NA	NA	NA	450.003141	14	-8		-436	Pass
20	nominal	450.003141	NA	NA	NA	NA	NA	*450.003149	0	-8		-442	Pass
20	-15%	450.003134	NA	NA	NA	NA	NA	450.003142	0	-15		-435	Pass
30	nominal	450.003152	450.003170	450.003174	450.003168	450.003155	450.003144	450.003127	25	-22		-425	Pass
40	nominal	450.003125	NA	NA	NA	NA	NA	450.003143	0	-24		-426	Pass
50	nominal	450.003134	NA	NA	NA	NA	NA	450.003160	11	-15	-435	Pass	
Mid frequency													
-30	nominal	460.000013	460.000032	460.000026	460.000031	460.000025	460.000030	460.000028	0	-85	460	-375	Pass
-20	nominal	460.000018	NA	NA	NA	NA	NA	460.000049	0	-80		-380	Pass
-10	nominal	460.000019	NA	NA	NA	NA	NA	460.000040	0	-79		-381	Pass
0	nominal	460.000066	460.000092	460.000094	460.000091	460.000093	460.000092	460.000095	0	-32		-428	Pass
10	nominal	460.000010	NA	NA	NA	NA	NA	460.000110	12	-88		-372	Pass
20	+15%	460.000076	NA	NA	NA	NA	NA	460.000085	0	-22		-438	Pass
20	nominal	460.000090	NA	NA	NA	NA	NA	*460.000098	0	-8		-452	Pass
20	-15%	460.000083	NA	NA	NA	NA	NA	460.000093	0	-15		-445	Pass
30	nominal	460.000085	460.000092	460.000094	460.000090	460.000089	460.000085	460.000079	0	-19		-441	Pass
40	nominal	460.000040	NA	NA	NA	NA	NA	460.000081	0	-58		-402	Pass
50	nominal	460.000090	NA	NA	NA	NA	NA	460.000112	14	-8	-446	Pass	
High frequency													
-30	nominal	469.996891	469.996901	469.996904	469.996885	469.996904	469.996899	469.996893	0	-88	470	-382	Pass
-20	nominal	469.996911	NA	NA	NA	NA	NA	469.996921	0	-62		-408	Pass
-10	nominal	469.996889	NA	NA	NA	NA	NA	469.996915	0	-84		-386	Pass
0	nominal	469.996936	469.996977	469.996984	469.996977	469.996974	469.996972	469.996969	11	-37		-433	Pass
10	nominal	469.996982	NA	NA	NA	NA	NA	469.996989	16	0		-454	Pass
20	+15%	469.996961	NA	NA	NA	NA	NA	469.996965	0	-12		-458	Pass
20	nominal	469.997007	NA	NA	NA	NA	NA	*469.996973	34	0		-436	Pass
20	-15%	469.996968	NA	NA	NA	NA	NA	469.996972	0	-5		-465	Pass
30	nominal	469.996943	469.996963	469.996966	469.996965	469.996961	469.996960	469.996954	0	-30		-440	Pass
40	nominal	469.996921	NA	NA	NA	NA	NA	469.996960	0	-52		-418	Pass
50	nominal	469.996943	NA	NA	NA	NA	NA	469.997011	38	-30	-432	Pass	

* - Reference frequency

Reference numbers of test equipment used

HL 4355	HL 4068	HL 5391	HL 3909			
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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): 22-Aug-19			
Temperature: 23 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
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): 22-Aug-19			
Temperature: 23 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Figure 7.6.1 Transient frequency test setup

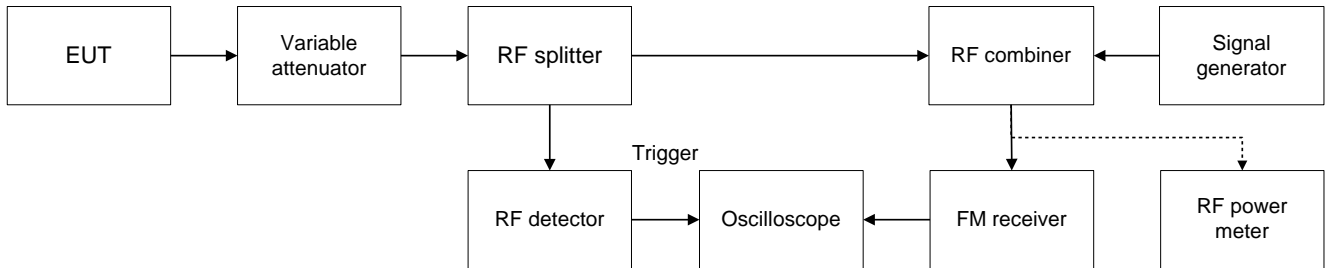


Table 7.6.2 Transient frequency behaviour test results

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	3.281	± 6.25	-2.969	Pass
	t ₂	25.0	0.861	± 3.125	-2.264	
	t ₃	10.0	2.188	± 6.25	-4.063	
460.0000	t ₁	10.0	2.656	± 6.25	-3.594	Pass
	t ₂	25.0	1.017	± 3.125	-2.108	
	t ₃	10.0	1.094	± 6.25	-5.156	
469.9969	t ₁	10.0	4.375	± 6.25	-1.875	Pass
	t ₂	25.0	0.861	± 3.125	-2.264	
	t ₃	10.0	0.704	± 6.25	-5.546	

Reference numbers of test equipment used

HL 0539	HL 2016	HL 2017	HL 2227	HL 4071	HL 4938	HL 5369	HL 5372
HL 5472	HL 5567						

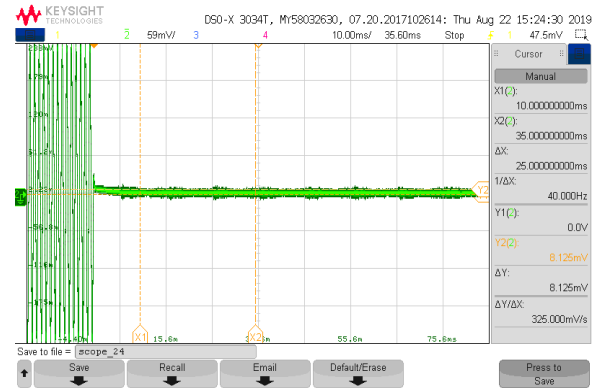
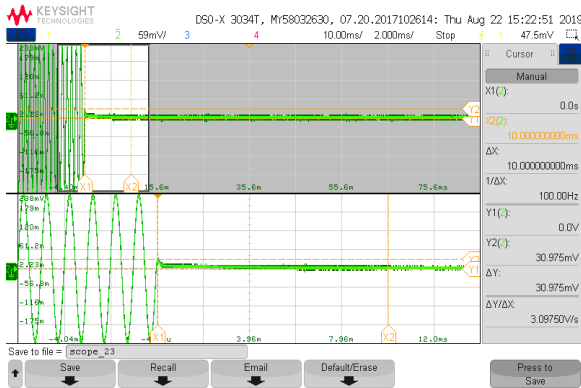
Full description is given in Appendix A.



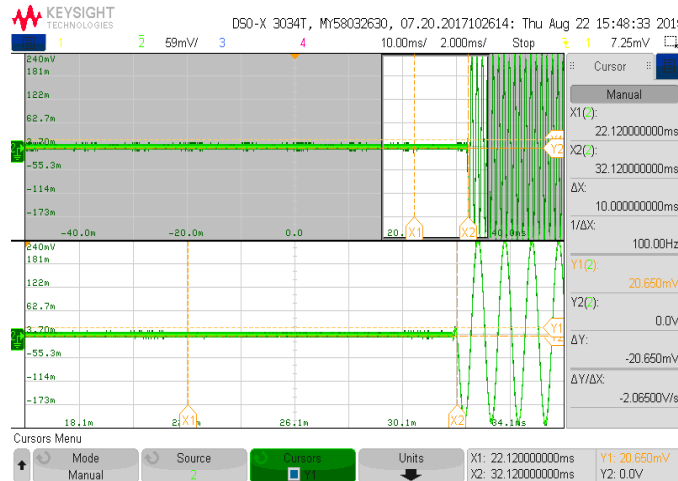
HERMON LABORATORIES

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): 22-Aug-19			
Temperature: 23 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
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

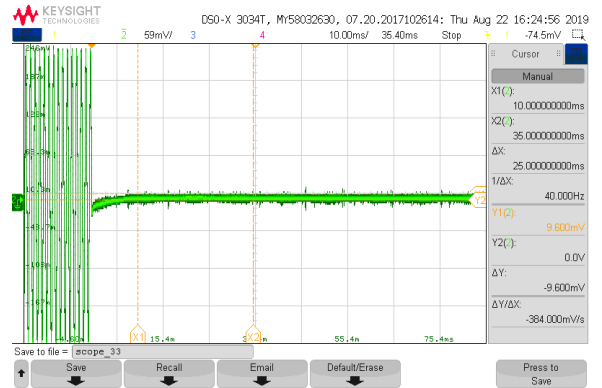
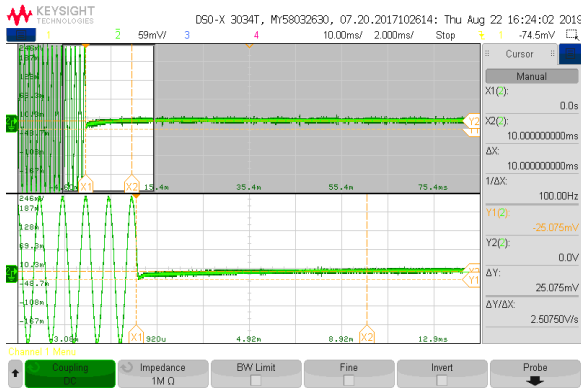




HERMON LABORATORIES

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): 22-Aug-19	
Temperature: 23 °C	Relative Humidity: 45 %
Air Pressure: 1010 hPa	Power: 3.6 VDC
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

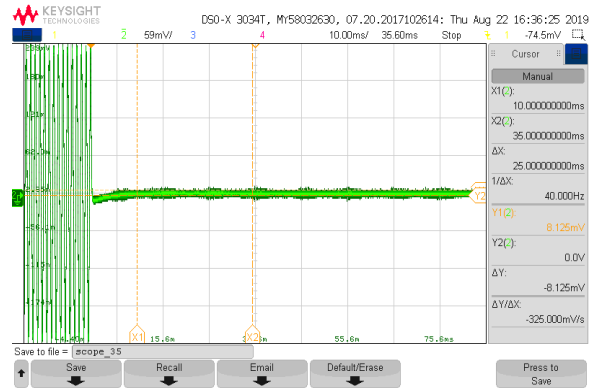




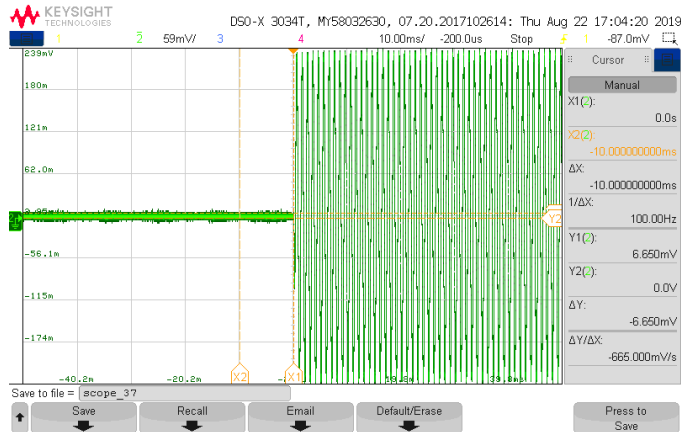
HERMON LABORATORIES

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): 22-Aug-19			
Temperature: 23 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
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
0539	Generator Signal, 10 kHz - 1.2 GHz	Marconi Instruments	2023	112121/041	09-Jul-19	09-Jul-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
3903	Microwave Cable Assembly, 40.0 GHz, 1.5 m, SMA/SMA	Huber-Suhner	SUCOFL EX 102A	1226/2A	07-Apr-19	07-Apr-20
4068	Attenuator, SMA, 30 dB, DC to 12.4 GHz	Midwest Microwave	ATT-0527-30-SMA-07	NA	12-Aug-19	12-Aug-20
4071	Attenuator, SMA, 30 dB, DC to 18 GHz, 5 W	Weinschel	WA7	NA	12-Aug-19	12-Aug-20
4355	Signal and Spectrum Analyzer, 9 kHz to 7 GHz	Rohde & Schwarz	FSV 7	101630	04-Aug-19	04-Aug-20
4360	EMI Test Receiver, 20 Hz to 40 GHz.	Rohde & Schwarz	ESU40	100322	31-Dec-18	31-Dec-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
5112	RF cable, 40 GHz, 5.5 m, K-type	Huber-Suhner	SF102EA/11SK/11SK/5500MM	502494/2EA	18-Apr-19	18-Apr-20
5288	Trilog Antenna, 25 MHz - 8 GHz, 100W	Frankonia	ALX-8000E	00809	08-Feb-19	08-Feb-22
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
5391	Temperature/Humidity Cycle Chamber, -77 - +177 deg., Humidity Range 20% RH to 95% RH	Thermotron	SM-8C	27737	23-Jul-19	23-Jul-20
5404	RF cable, 18 GHz, N-N, 6 m	Huber-Suhner	SF118/11N(x2)	500024/18	11-Aug-19	11-Aug-20
5472	Power Splitter / Combiner 0.5-1 GHz	Mini Circuits	ZAPD-1	NA	21-Jan-19	21-Jan-21
5567	BI-Directional Coaxial Coupler, 50 - 1000 MHz, 500W	Narda	3020A	NA	28-Jul-19	28-Jul-20



9 APPENDIX B Test equipment correction factors

HL 4933: Active Horn Antenna
COM-POWER CORPORATION, model: AHA-118, s/n 701046

Frequency, MHz	Measured antenna factor (with preamplifier), dB/m
1000	-16.1
1500	-15.1
2000	-10.9
2500	-11.9
3000	-11.1
3500	-10.6
4000	-8.6
4500	-8.3
5000	-5.9
5500	-5.7
6000	-3.3
6500	-4.0
7000	-2.2
7500	-1.7
8000	1.1
8500	-0.8
9000	-1.5
9500	-0.2

Frequency, MHz	Measured antenna factor (with preamplifier), dB/m
10000	1.8
10500	1.0
11000	0.3
11500	-0.5
12000	3.1
12500	1.4
13000	-0.3
13500	-0.4
14000	2.5
14500	2.2
15000	1.9
15500	0.5
16000	2.1
16500	1.2
17000	0.6
17500	3.1
18000	4.2

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



HL 5112 RF cable, 40 GHz, 5.5 m, K-type
Huber-Suhner, SF102EA/11SK/11SK/5500MM, s/n 502494/2EA, HL 5112

Insertion loss

Set / Applied, MHz	Measured, dB	Uncertainty, dB
100	0.70	±0.07
200	0.99	±0.08
300	1.21	±0.08
500	1.55	±0.08
1000	2.18	±0.08
1500	2.67	±0.08
2000	3.09	±0.08
2500	3.46	±0.10
3000	3.80	±0.10
3500	4.12	±0.10
4000	4.41	±0.10
4500	4.69	±0.10
5000	4.95	±0.10
5500	5.20	±0.10
6000	5.45	±0.10
6500	5.68	±0.10
7000	5.91	±0.10
7500	6.13	±0.10
8000	6.34	±0.10
8500	6.56	±0.10
9000	6.76	±0.10
9500	6.95	±0.10
10000	7.16	±0.10
10500	7.33	±0.10
11000	7.51	±0.10
11500	7.68	±0.10
12000	7.85	±0.10
12500	8.02	±0.13
13000	8.17	±0.13
13500	8.31	±0.13
14000	8.46	±0.13
14500	8.61	±0.18
15000	8.76	±0.18
15500	8.91	±0.18
16000	9.07	±0.18
16500	9.22	±0.18
17000	9.36	±0.18
17500	9.51	±0.18
18000	9.66	±0.18
18500	9.81	±0.23
19000	9.95	±0.23
19500	10.10	±0.23

Set / Applied, MHz	Measured, dB	Uncertainty, dB
20000	10.25	±0.23
20500	10.38	±0.23
21000	10.52	±0.23
21500	10.67	±0.23
22000	10.84	±0.23
22500	11.00	±0.29
23000	11.10	±0.29
23500	11.20	±0.29
24000	11.32	±0.29
24500	11.42	±0.29
25000	11.59	±0.23
25500	11.70	±0.23
26000	11.85	±0.23
26500	11.97	±0.23
27000	12.07	±0.33
27500	12.17	±0.33
28000	12.26	±0.40
28500	12.38	±0.40
29000	12.50	±0.40
29500	12.63	±0.40
30000	12.75	±0.40
30500	12.82	±0.33
31000	12.93	±0.33
31500	13.09	±0.33
32000	13.22	±0.33
32500	13.35	±0.33
33000	13.48	±0.33
33500	13.60	±0.33
34000	13.72	±0.33
34500	13.80	±0.40
35000	13.92	±0.40
35500	14.01	±0.40
36000	14.12	±0.40
36500	14.23	±0.40
37000	14.34	±0.33
37500	14.44	±0.33
38000	14.57	±0.33
38500	14.72	±0.33
39000	14.82	±0.33
39500	14.94	±0.33
40000	15.08	±0.47



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

Frequency, MHz	Antenna factor, dB/m
30	14.96
35	15.33
40	16.37
45	17.56
50	17.95
60	16.87
70	13.22
80	10.56
90	13.61
100	15.46
120	14.03
140	12.23

Frequency, MHz	Antenna factor, dB/m
160	12.67
180	13.34
200	15.40
250	16.42
300	17.28
400	19.98
500	21.11
600	22.90
700	24.13
800	25.25
900	26.35
1000	27.18

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

above 1000 MHz

Frequency, MHz	Antenna factor, dB/m
1000	26.9
1100	28.1
1200	28.4
1300	29.6
1400	29.1
1500	30.4
1600	30.7
1700	31.5
1800	32.3
1900	32.6
2000	32.5
2100	32.9
2200	33.5
2300	33.2
2400	33.7
2500	34.6
2600	34.7
2700	34.6
2800	35.0
2900	35.5
3000	36.2
3100	36.8
3200	36.8
3300	37.0
3400	37.5
3500	38.2

Frequency, MHz	Antenna factor, dB/m
3600	38.9
3700	39.4
3800	39.4
3900	39.6
4000	39.7
4100	39.8
4200	40.5
4300	40.9
4400	41.1
4500	41.4
4600	41.3
4700	41.6
4800	41.9
4900	42.3
5000	42.7
5100	43.0
5200	42.9
5300	43.5
5400	43.6
5500	44.3
5600	44.7
5700	45.0
5800	45.0
5900	45.3
6000	45.9

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



10 APPENDIX C 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 %
Unintentional radiator tests	
Conducted emissions with LISN	9 kHz to 150 kHz: ± 3.9 dB 150 kHz to 30 MHz: ± 3.8 dB
Radiated emissions at 3 m measuring distance Horizontal polarization	Biconilog antenna: ± 5.3 dB Biconical antenna: ± 5.0 dB Log periodic antenna: ± 5.3 dB Double ridged horn antenna: ± 5.3 dB
Vertical polarization	Biconilog antenna: ± 6.0 dB Biconical antenna: ± 5.7 dB Log periodic antenna: ± 6.0 dB Double ridged horn antenna: ± 6.0 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.



HERMON LABORATORIES

11 APPENDIX D 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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HERMON LABORATORIES

12 APPENDIX E

Specification references

FCC 47CFR part 90: 2019

FCC 47CFR part 2: 2019

ANSI/TIA/EIA-603-E:2016

RSS-119 Issue 12: 2015

Private land mobile radio services

Frequency allocations and radio treaty matters; general rules and regulations

Land Mobile FM or PM Communications Equipment Measurement and Performance Standards

Land Mobile and Fixed 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(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
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
μ s	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