

TEST REPORT

ACCORDING TO: FCC 47 CFR Part 90, RSS-Gen issue 5: 2019 and
RSS-119 Issue 12:2015

FOR:

ST Engineering Telematics Wireless Ltd
Allegro Pit Unit
Model: ALLPU
FCC ID: NTAALLPU
IC: 4732A-ALLPU

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.

Table of contents

1	Applicant information	3
2	Equipment under test attributes.....	3
3	Manufacturer information	3
4	Test details	3
5	Tests summary.....	4
6	EUT description.....	5
6.1	General information	5
6.2	Test configuration.....	5
6.3	Changes made in EUT	5
6.4	Transmitter characteristics	6
7	Transmitter tests according to 47CFR part 90 and RSS-119 requirements	7
7.1	Peak output power test	7
7.2	Occupied bandwidth test.....	12
7.3	Emission mask test.....	15
7.4	Radiated spurious emission measurements.....	18
7.5	Frequency stability test	30
7.6	Transient frequency behaviour test	32
8	APPENDIX A Test equipment and ancillaries used for tests	37
9	APPENDIX B Test equipment correction factors	38
10	APPENDIX C Measurement uncertainties	41
11	APPENDIX D Test laboratory description	42
12	APPENDIX E Specification references	43
13	APPENDIX F Abbreviations and acronyms.....	44

1 Applicant information

Client name: ST Engineering 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: Allegro Pit Unit
Product type: Transceiver
Model(s): ALLPU
Serial number: 02260631
Hardware version: Rev. A
Software release: 3A01
Receipt date 21-Apr-20

3 Manufacturer information

Manufacturer name: ST Engineering 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: 37366
Location: Hermon Laboratories Ltd. P.O. Box 23, Binyamina 3055001, Israel
Test started: 22-Apr-20
Test completed: 05-May-20
Test specification(s): FCC 47 CFR part 90, RSS-Gen Issue 5, 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.37366

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	22-Apr-20 – 05-May-20	
Reviewed by:	Mrs. S. Peysahov Sheynin, test engineer, EMC & Radio	10-Aug-20	
Approved by:	Mr. S. Samokha, technical manager, EMC & Radio	11-Aug-20	

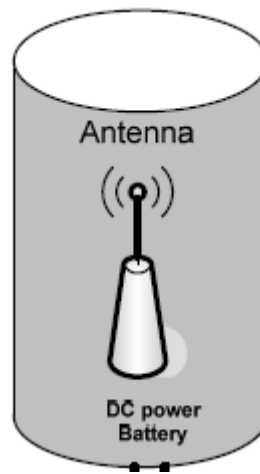
6 EUT description

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

6.1 General information

The EUT is an interface unit connected to water meter. The EUT operates at 450-470MHz frequency band and it is powered by 3.6V battery.

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		33.08 dBm	
Is transmitter output power variable?		X	No		
			continuous variable		
			stepped variable with stepsize		
		Yes	minimum RF power		
			maximum RF power		
Antenna connection					
unique coupling		standard connector		X	integral
				X	with temporary RF connector
					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 size C
	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): 22-Apr-20			
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.

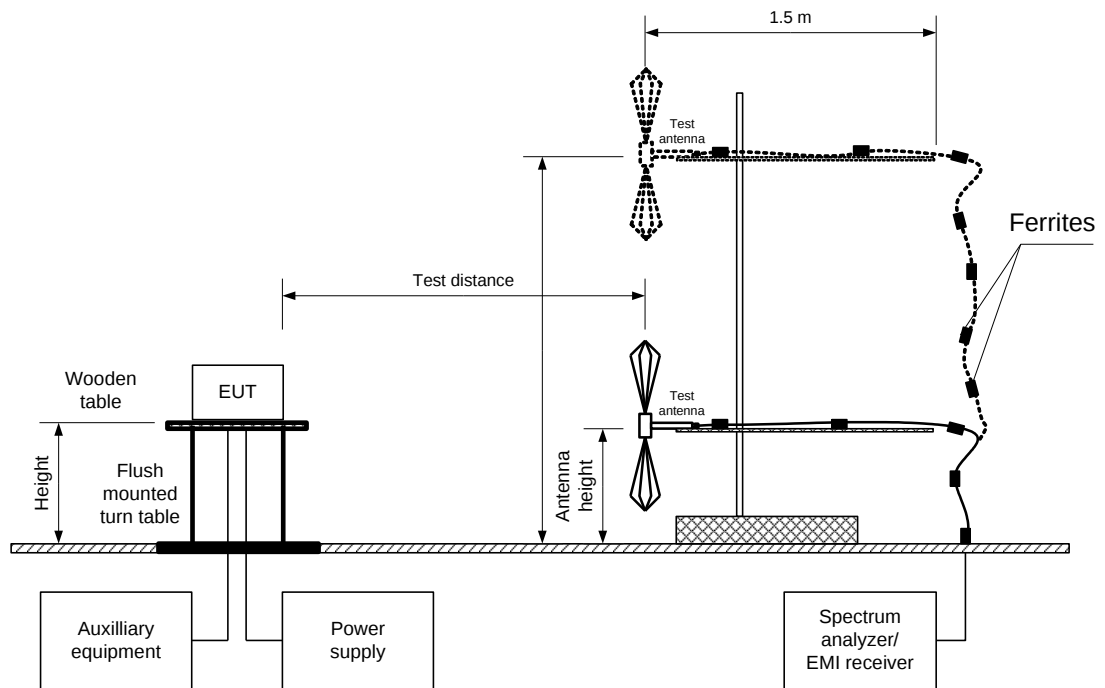
7.1.2.2 The field strength of the EUT carrier frequency was measured with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360°, the measuring antenna height was swept throughout the range, specified in Table 7.1.2 and Table 7.1.3, in both vertical 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:		Verdict: PASS	
Date(s):			
22-Apr-20			
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): 22-Apr-20			
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	126.78	Vertical	1.0	0	-1.5	29.38	33.08	33.00	-3.62	Pass
460.0000	125.80	Vertical	1.0	0	-1.5	28.40	32.10	33.00	-4.60	Pass
469.9969	124.71	Vertical	1.0	0	-1.5	27.31	31.01	33.00	-5.69	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): 22-Apr-20			
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	126.78	Vertical	1.0	0	-1.5	29.38	33.08	47.78	-18.40	Pass
460.0000	125.80	Vertical	1.0	0	-1.5	28.40	32.10	47.78	-19.38	Pass
469.9969	124.71	Vertical	1.0	0	-1.5	27.31	31.01	47.78	-20.47	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 5405				
---------	---------	---------	---------	--	--	--	--

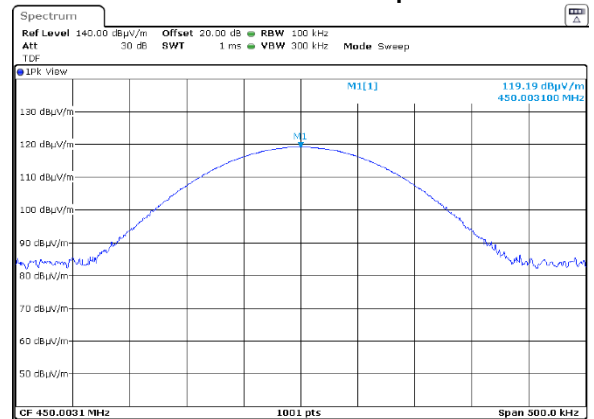
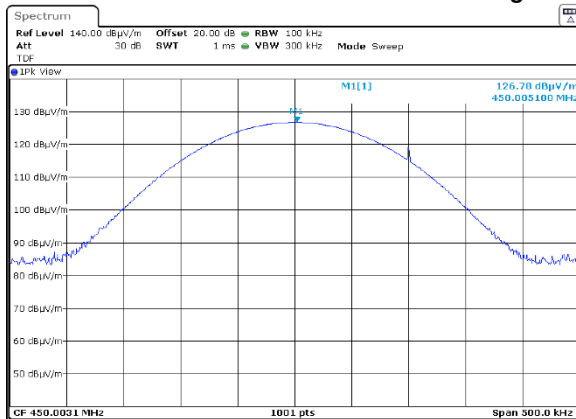
Full description is given in Appendix A.



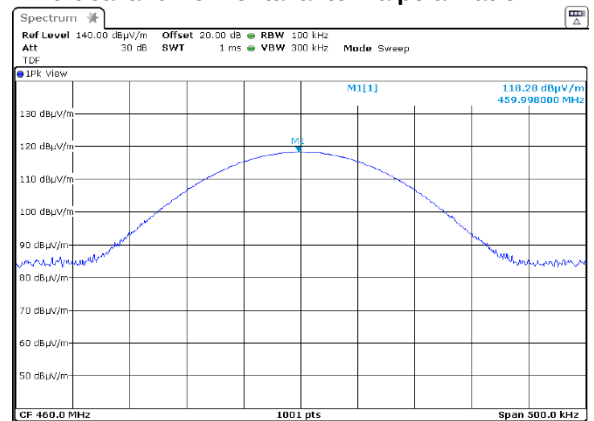
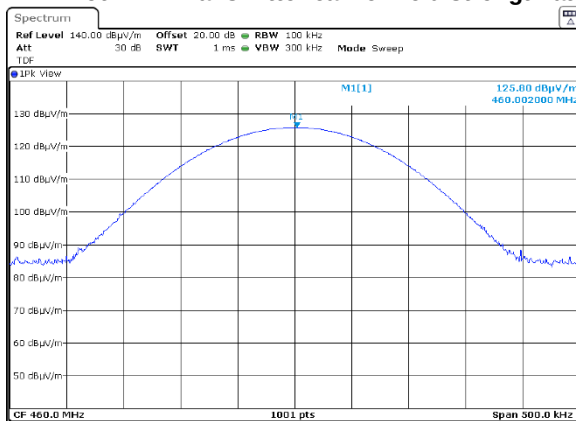
HERMON LABORATORIES

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):		22-Apr-20	
Temperature: 24 °C	Relative Humidity: 43 %	Air Pressure: 1008 hPa	Power: 3.6 VDC
Remarks:			

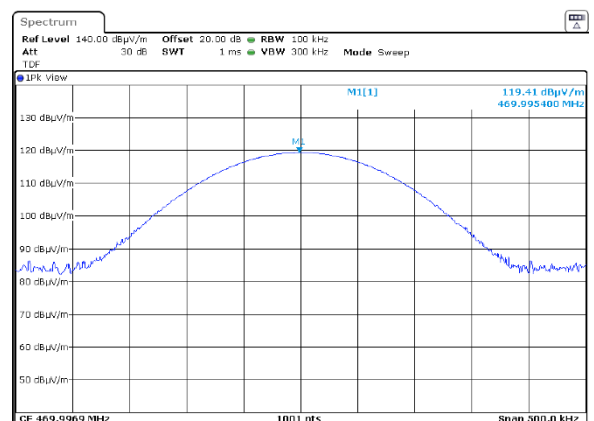
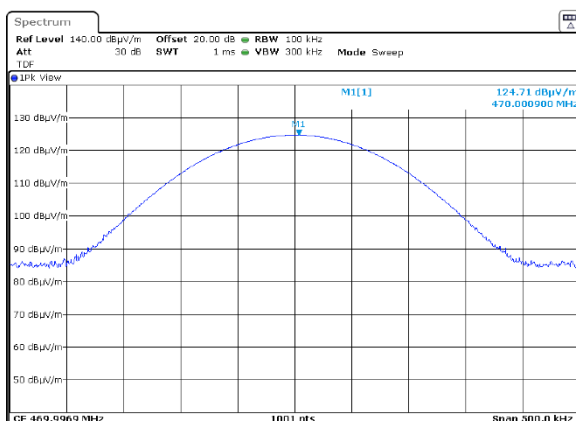
Plot 7.1.1 Transmitter carrier field strength at low frequency in vertical and horizontal antenna polarization



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): 05-May-20			
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

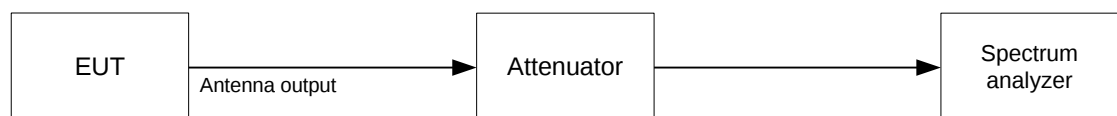
7.2.2.1 The EUT was set up as shown in Figure 7.2.1, energized and its proper operation was checked.

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





HERMON LABORATORIES

Report ID: TELRAD_FCC.37366_Rev1

Date of Issue: 11-Aug-20

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): 05-May-20			
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

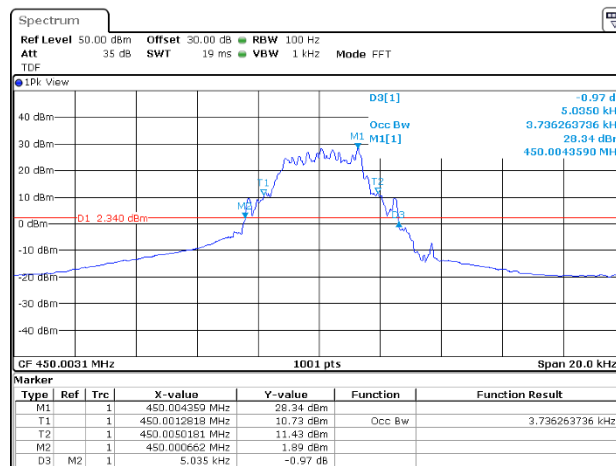
Carrier frequency, MHz	Occupied bandwidth, kHz	Limit, kHz	Margin, kHz	Verdict
MODULATION ENVELOPE REFERENCE POINTS: 99%				
450.0031	3.736	6	-2.264	Pass
460.0000	3.796	6	-2.204	Pass
469.9969	3.736	6	-2.264	Pass
MODULATION ENVELOPE REFERENCE POINTS: 26 dBc				
450.0031	5.035	6	-0.965	Pass
460.0000	5.055	6	-0.945	Pass
469.9969	5.055	6	-0.945	Pass

Reference numbers of test equipment used

HL 4355	HL 5409	HL 5598	HL 5623				
---------	---------	---------	---------	--	--	--	--

Full description is given in Appendix A.

Plot 7.2.1 Occupied bandwidth test result at low frequency

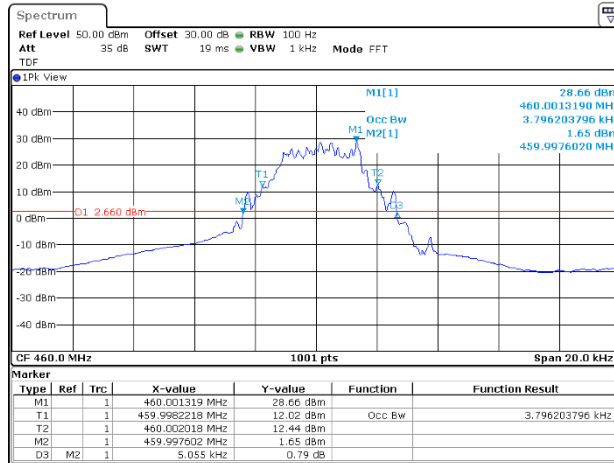




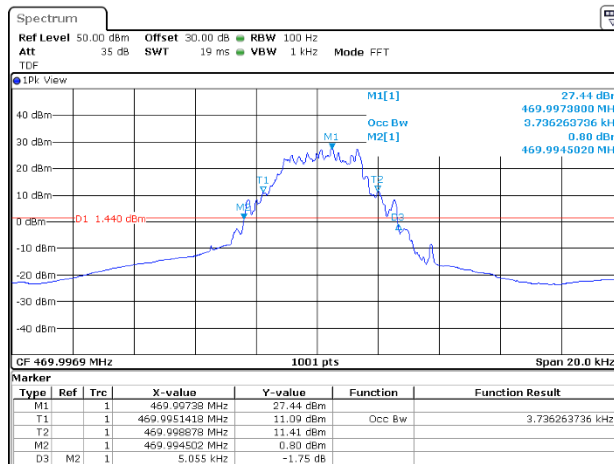
HERMON LABORATORIES

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): 05-May-20			
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-May-20			
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	$30 + 16.67(f_d^{**} - 3 \text{ kHz})$ or $55 + 10\log P(W)$ or 65 whichever is the lesser
More than 4.6 kHz	$55 + 10\log P(W)$ or 57 whichever is the lesser (RSS-119) $55 + 10\log P(W)$ 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
450.0031	Emission mask E	Pass
460.0000		
469.9969		

Reference numbers of test equipment used

HL 4355	HL 5409	HL 5598	HL 5623				
---------	---------	---------	---------	--	--	--	--

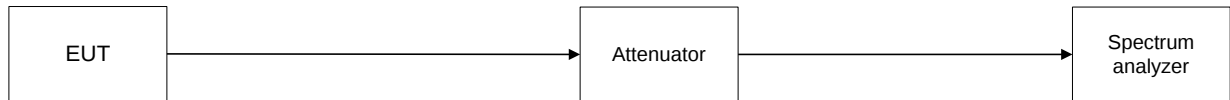
Full description is given in Appendix A.



HERMON LABORATORIES

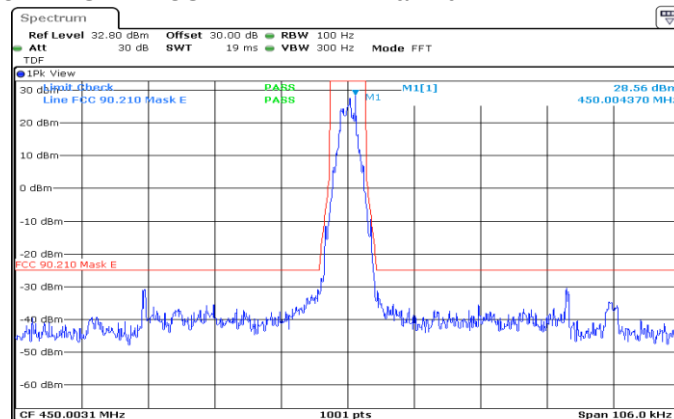
Test specification:		Section 90.210 / RSS-119 Section 5.8.4, Emission mask	
Test procedure:		47 CFR, Sections 2.1051, 2.1047 and 90.210(e), TIA/EIA-603-E, Section 2.2.13	
Test mode:		Verdict: PASS	
Date(s):			
05-May-20			
Temperature: 23 °C	Relative Humidity: 55 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
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





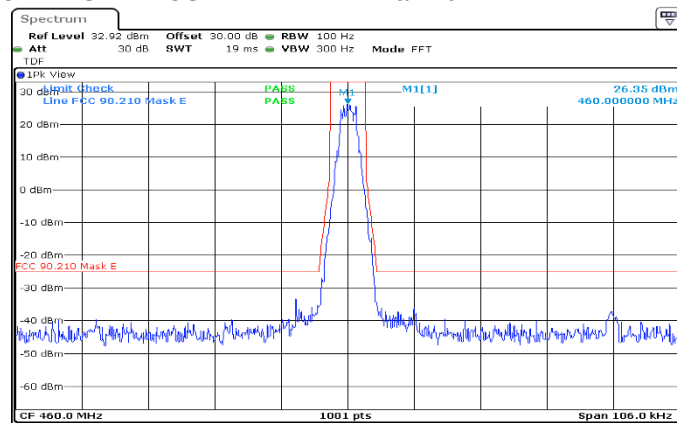
HERMON LABORATORIES

Report ID: TELRAD_FCC.37366_Rev1
Date of Issue: 11-Aug-20

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:		Verdict: PASS	
Date(s):			
05-May-20			
Temperature: 23 °C	Relative Humidity: 55 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

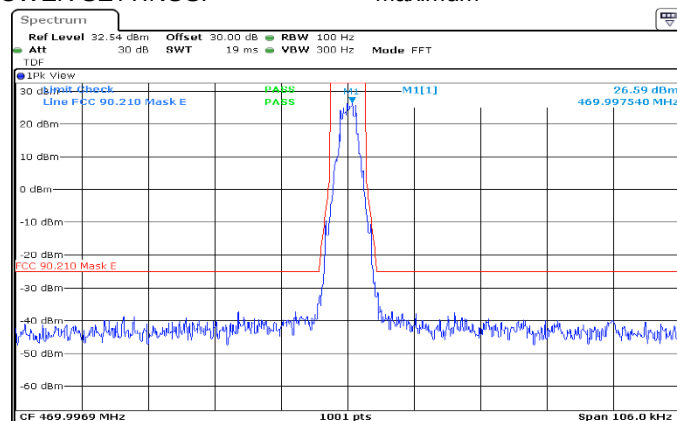
Plot 7.3.2 Emission mask test results at mid carrier frequency

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): 22-Apr-20			
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(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: $E = \sqrt{30 \times P \times 1.64} / r$, 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): 22-Apr-20			
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

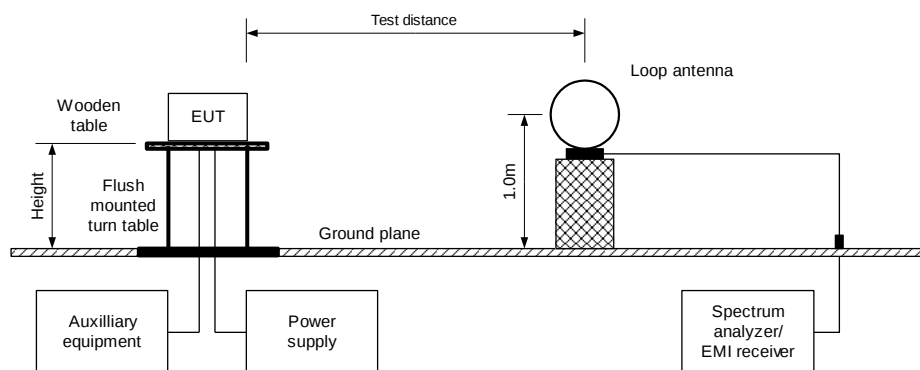
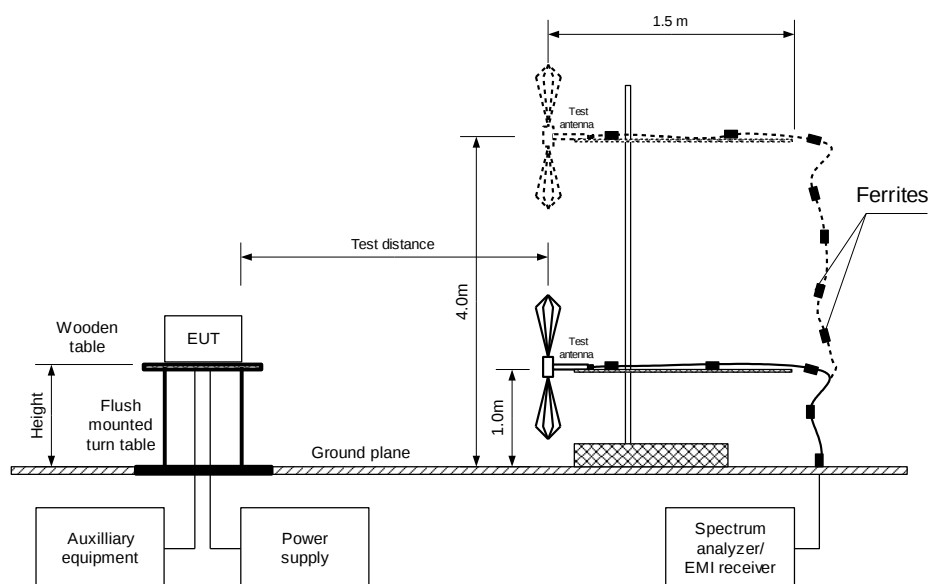


Figure 7.4.2 Setup for radiated spurious emission measurements above 30 MHz





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): 22-Apr-20			
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								
900.019	58.20	72.4	-14.20	100	Vertical	1.0	0	Pass
1350.003	50.24	72.4	-22.16	1000	Vertical	1.7	45	Pass
Mid carrier frequency 460.0000 MHz								
919.999	57.94	72.4	-14.46	100	Vertical	1.0	0	Pass
1379.964	55.82	72.4	-16.58	1000	Vertical	2.1	110	Pass
High carrier frequency 469.9969 MHz								
939.997	61.08	72.4	-11.32	100	Vertical	1.0	0	Pass
1409.892	45.81	72.4	-26.59	1000	Vertical	1.6	25	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 5405		
---------	---------	---------	---------	---------	---------	--	--

Full description is given in Appendix A.



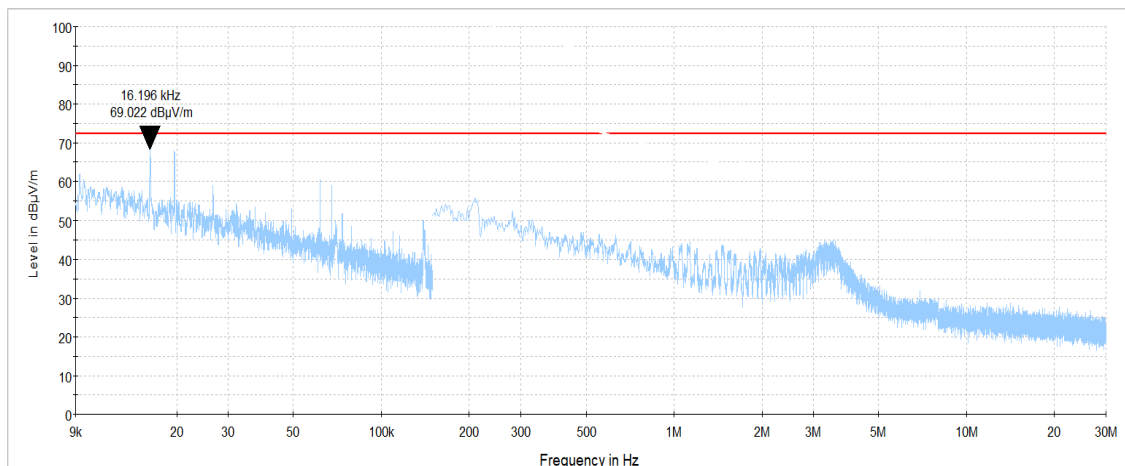
HERMON LABORATORIES

Report ID: TELRAD_FCC.37366_Rev1
Date of Issue: 11-Aug-20

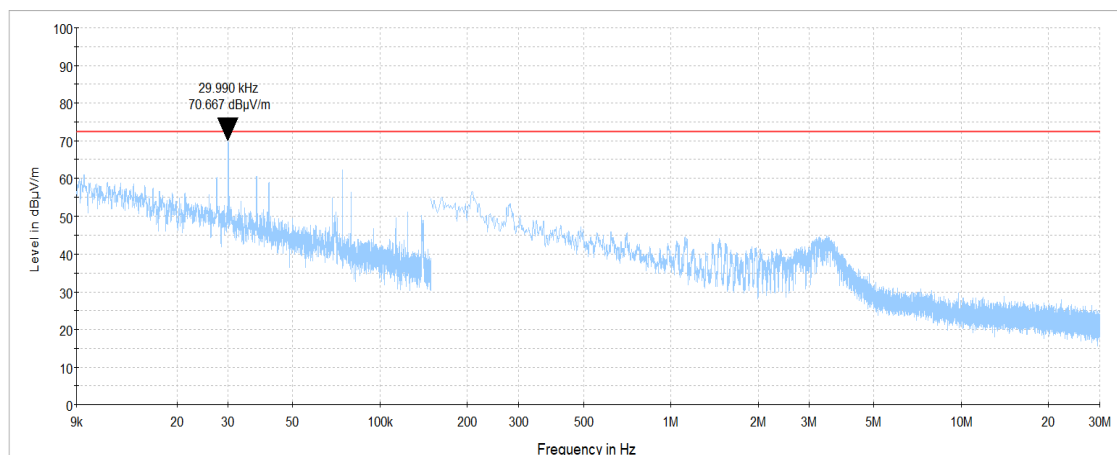
Test specification: Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions			
Test procedure: 47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Apr-20			
Temperature: 23 °C	Relative Humidity: 46 %	Air Pressure: 1010 hPa	Power: 3.6 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





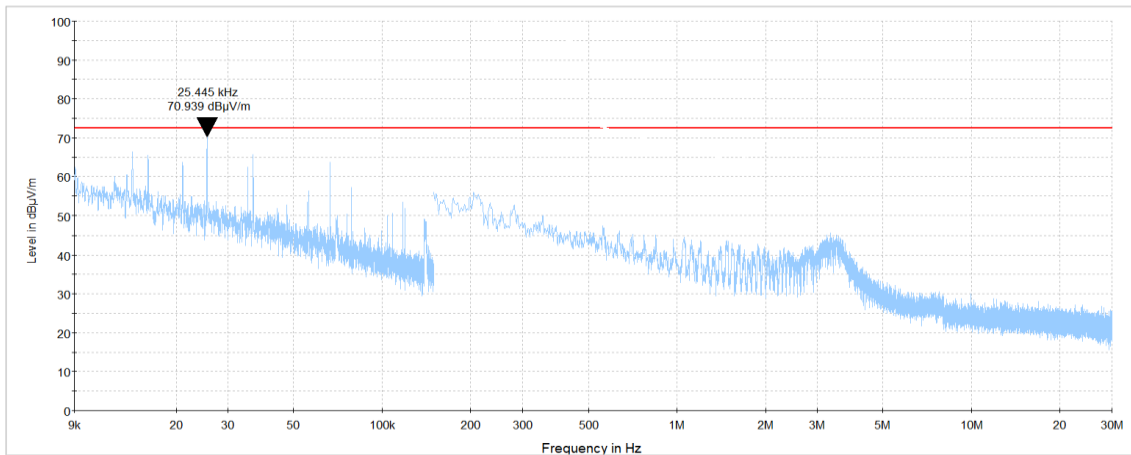
HERMON LABORATORIES

Report ID: TELRAD_FCC.37366_Rev1
Date of Issue: 11-Aug-20

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): 22-Apr-20			
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:

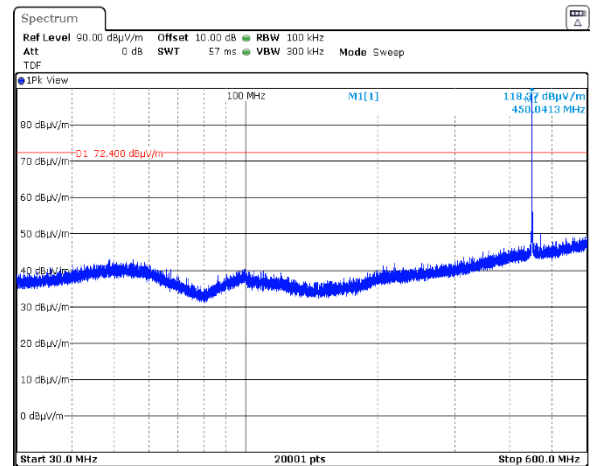
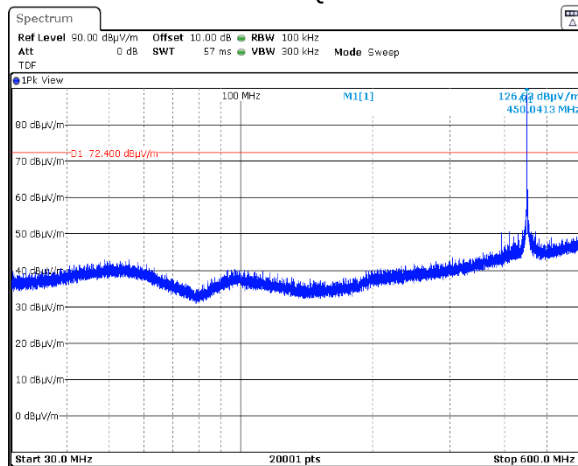
Vertical and Horizontal

TEST DISTANCE:

3 m

CARRIER FREQUENCY:

Low



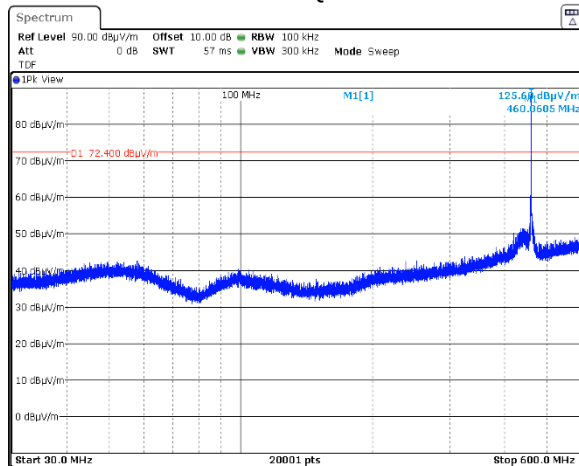


HERMON LABORATORIES

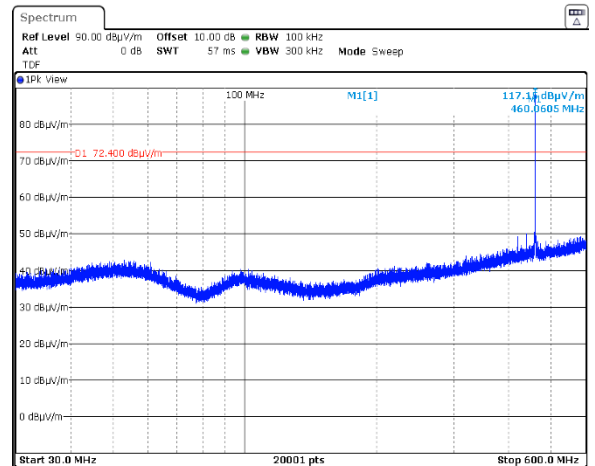
Report ID: TELRAD_FCC.37366_Rev1
Date of Issue: 11-Aug-20

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

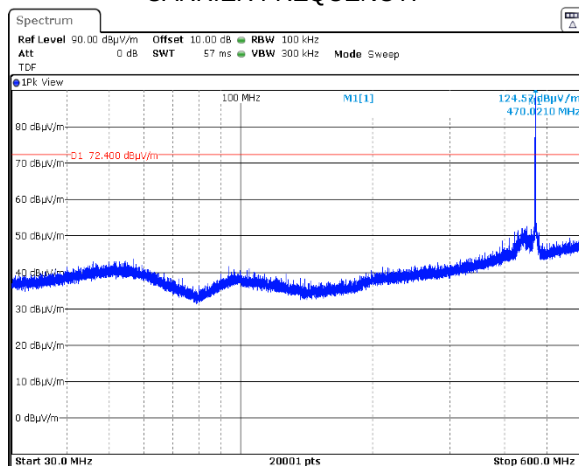
CARRIER FREQUENCY:



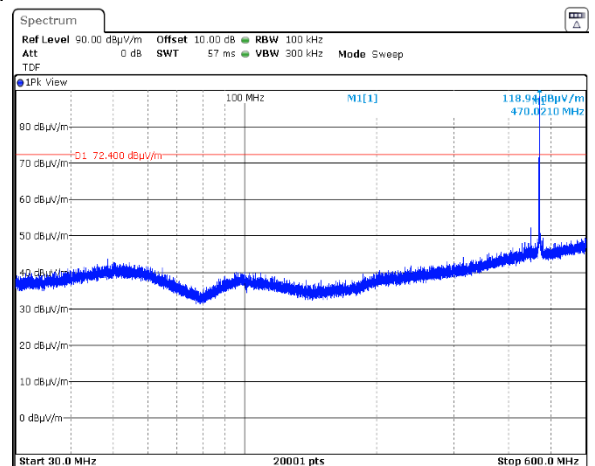
Mid



CARRIER FREQUENCY:



High





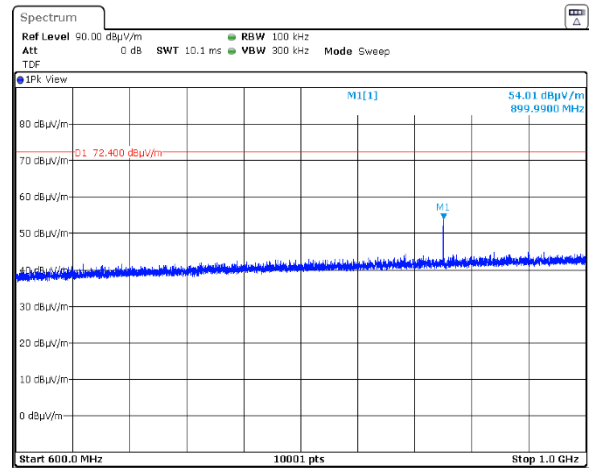
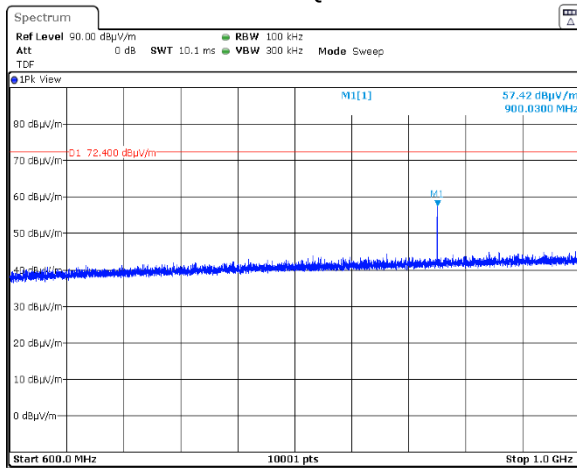
HERMON LABORATORIES

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): 22-Apr-20			
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

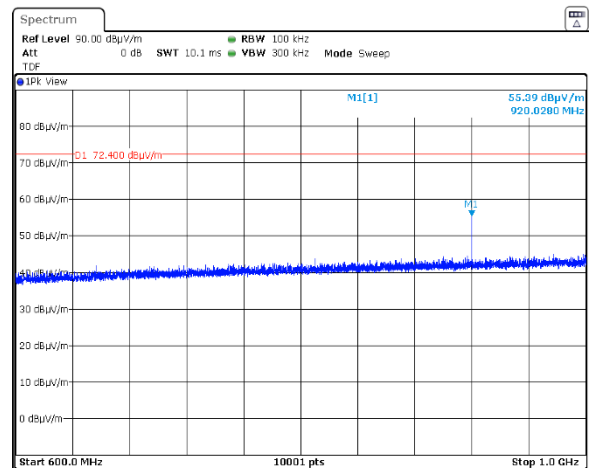
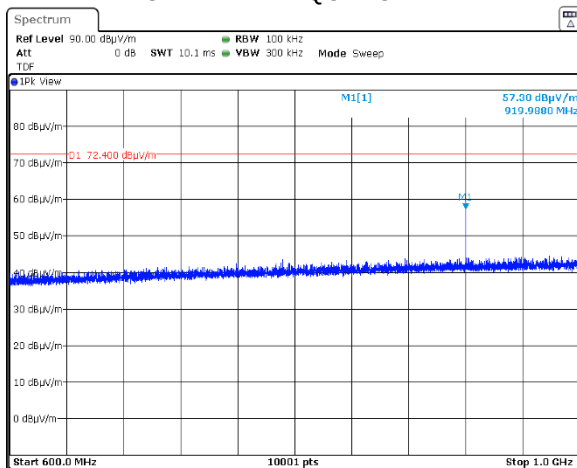
TEST SITE:
ANTENNA POLARIZATION:
TEST DISTANCE:
CARRIER FREQUENCY:

Semi anechoic chamber
Vertical and Horizontal
3 m
Low



CARRIER FREQUENCY:

Mid

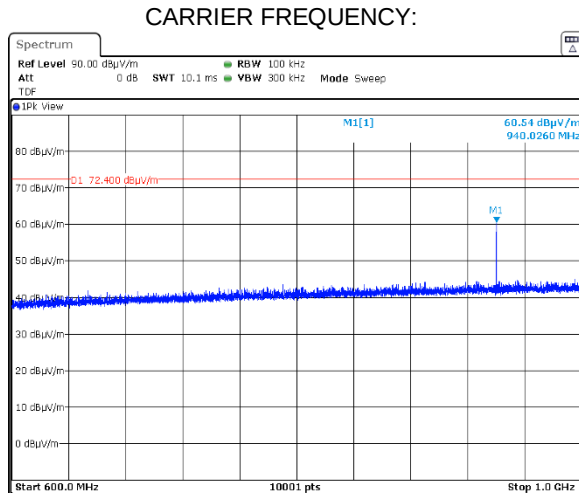




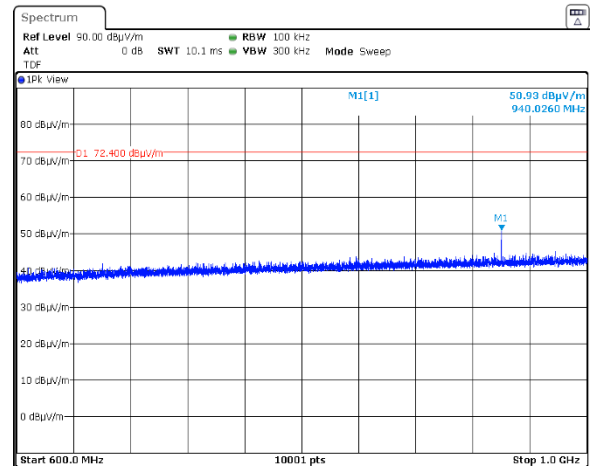
HERMON LABORATORIES

Report ID: TELRAD_FCC.37366_Rev1
Date of Issue: 11-Aug-20

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



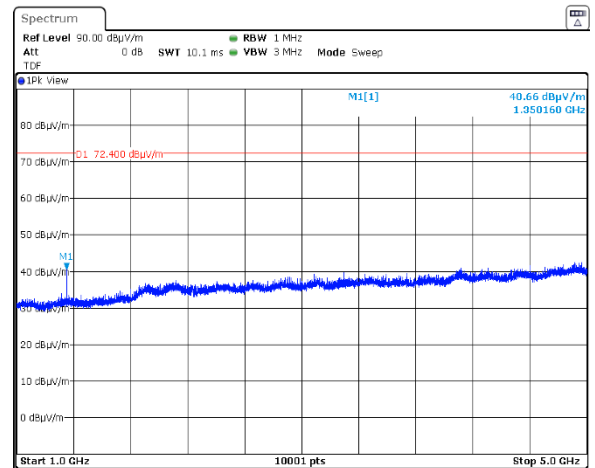
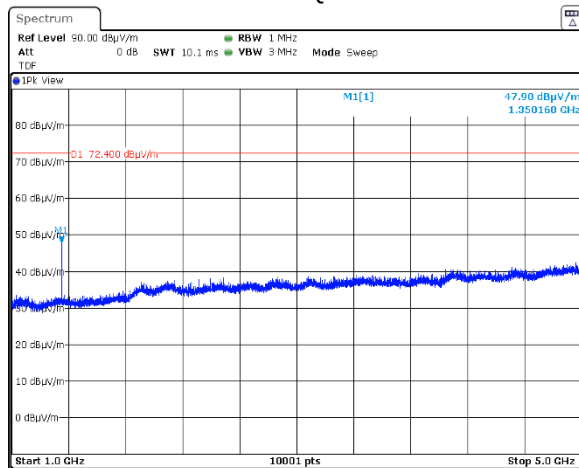
High



Plot 7.4.4 Radiated spurious emission measurements in 1000 – 5000 MHz range

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

Semi anechoic chamber
Vertical and Horizontal
3 m
Low

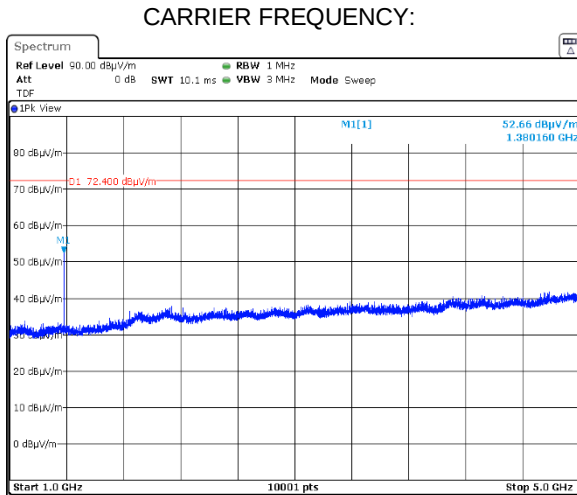




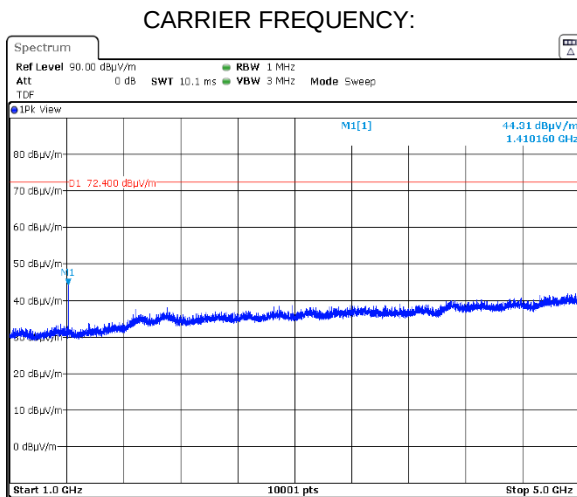
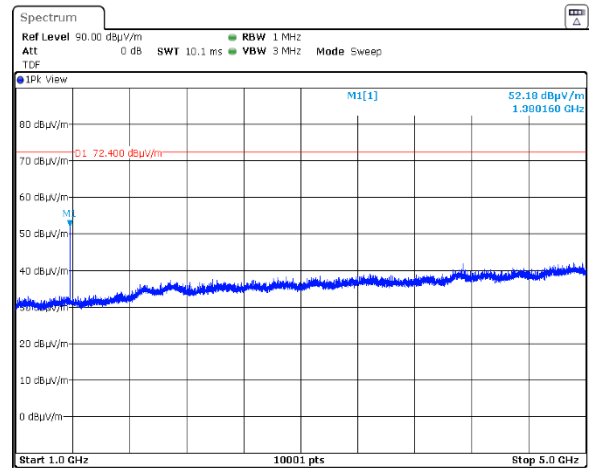
HERMON LABORATORIES

Report ID: TELRAD_FCC.37366_Rev1
Date of Issue: 11-Aug-20

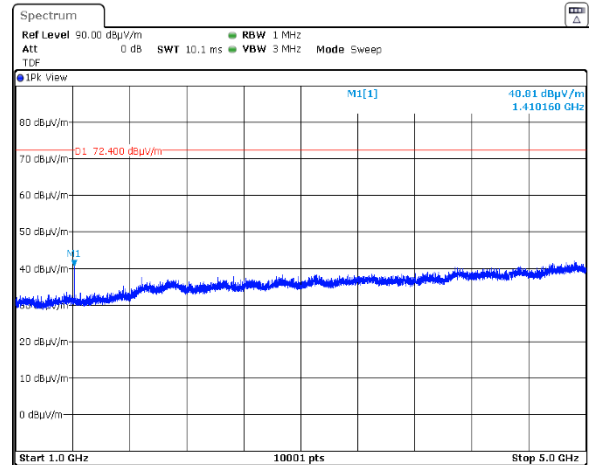
Test specification: Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions			
Test procedure: 47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Apr-20			
Temperature: 23 °C	Relative Humidity: 46 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			



Mid



High





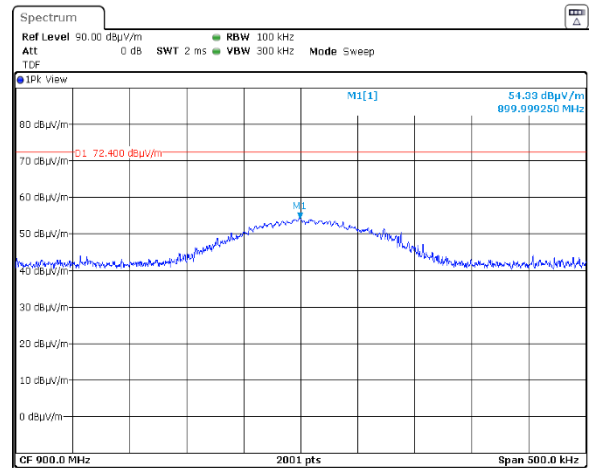
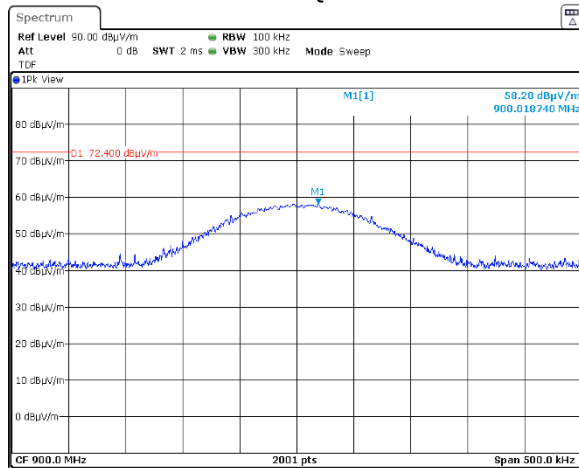
HERMON LABORATORIES

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): 22-Apr-20			
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

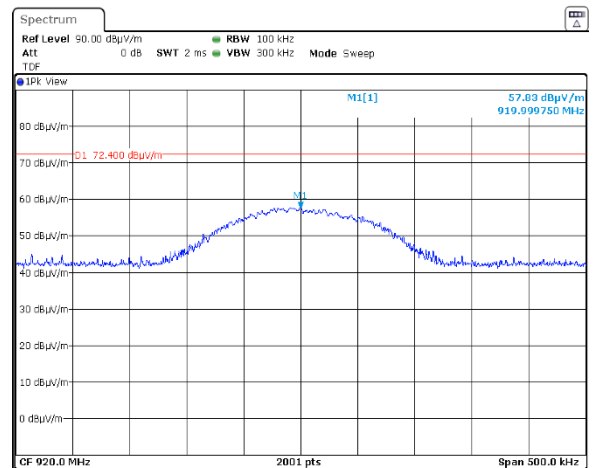
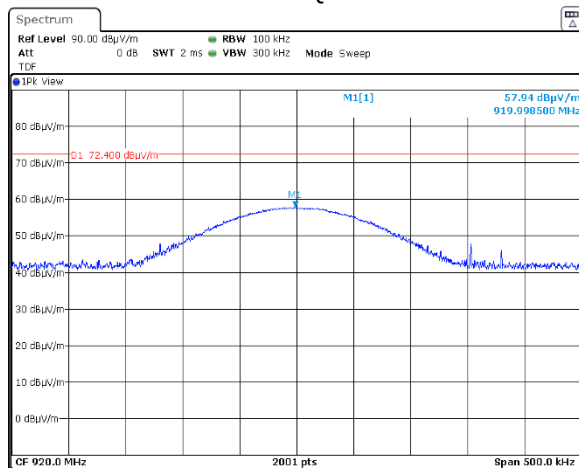
TEST SITE:
ANTENNA POLARIZATION:
TEST DISTANCE:
CARRIER FREQUENCY:

Semi anechoic chamber
Vertical and horizontal
3 m
Low



CARRIER FREQUENCY:

Mid

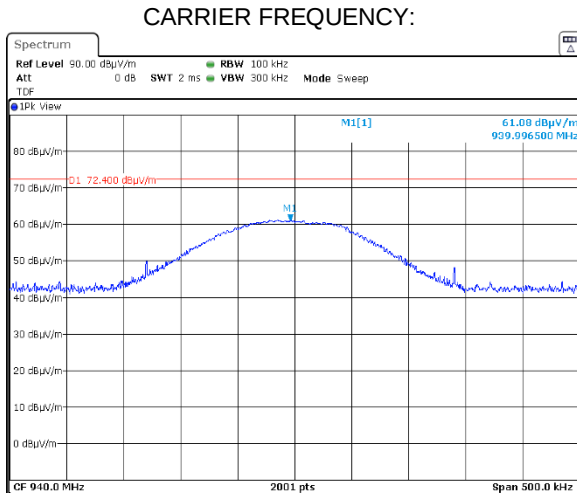




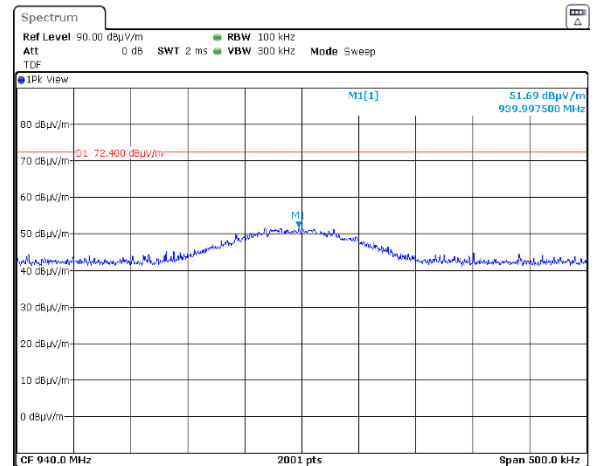
HERMON LABORATORIES

Report ID: TELRAD_FCC.37366_Rev1
Date of Issue: 11-Aug-20

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



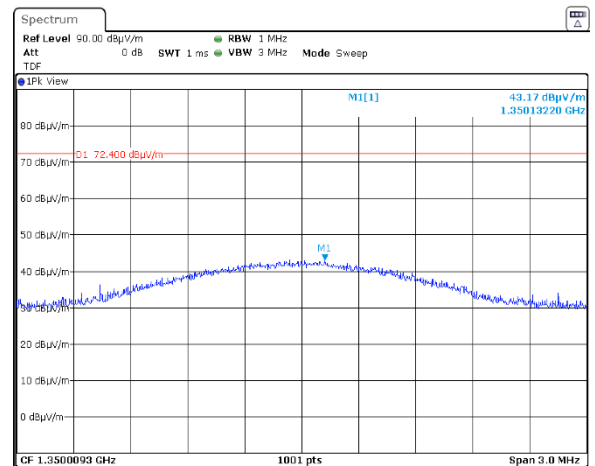
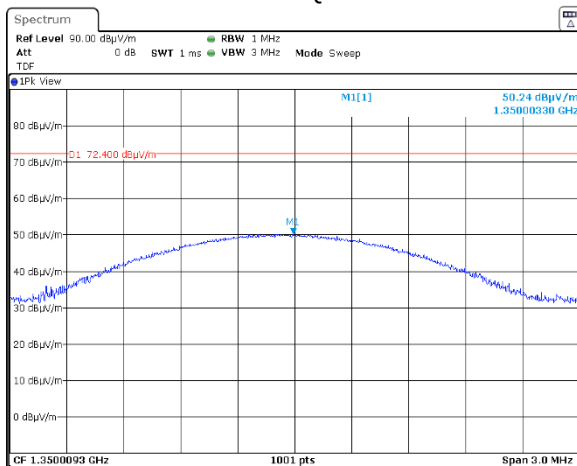
High



Plot 7.4.6 Radiated spurious emission measurements at the 3rd harmonic

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

Semi anechoic chamber
Vertical and Horizontal
3 m
Low



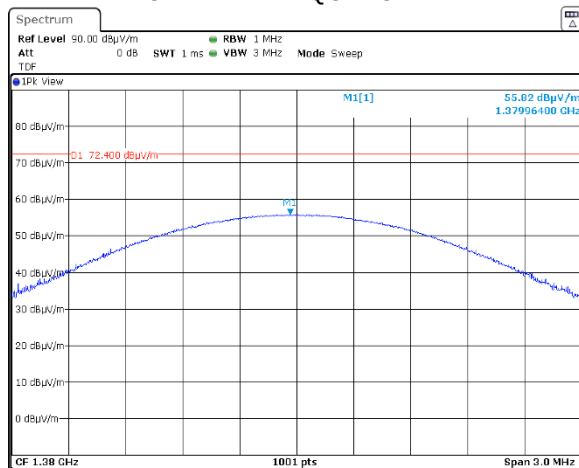


HERMON LABORATORIES

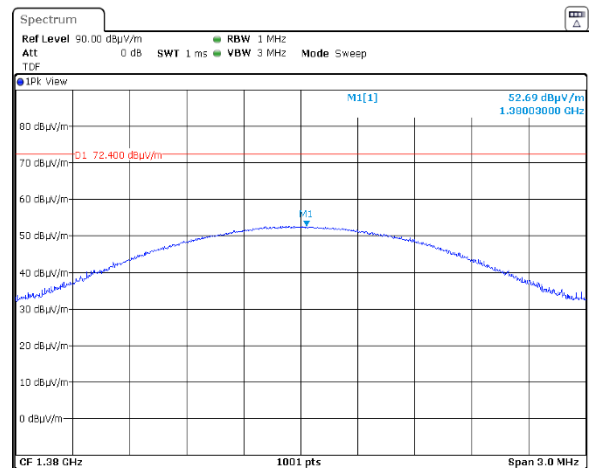
Report ID: TELRAD_FCC.37366_Rev1
Date of Issue: 11-Aug-20

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

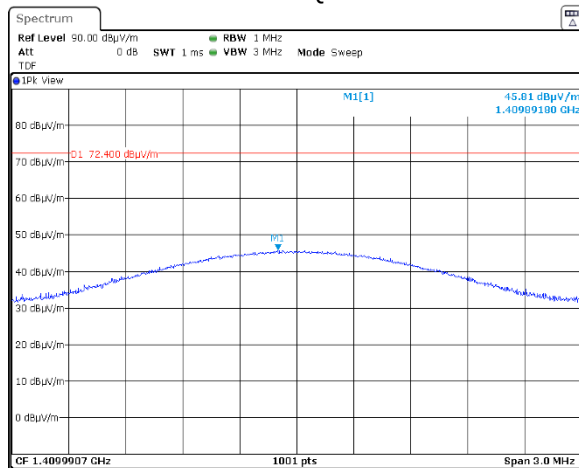
CARRIER FREQUENCY:



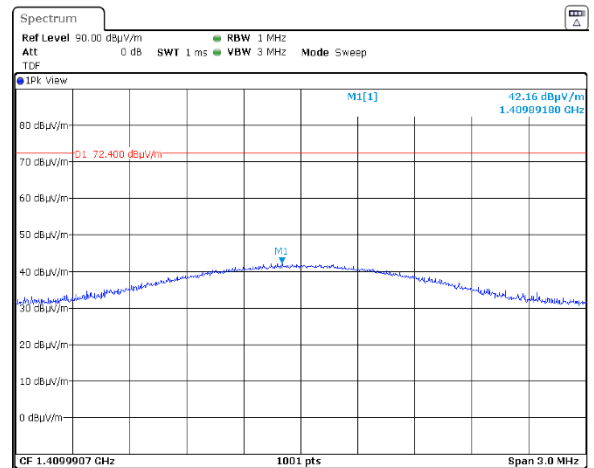
Mid



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): 22-Apr-20			
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.

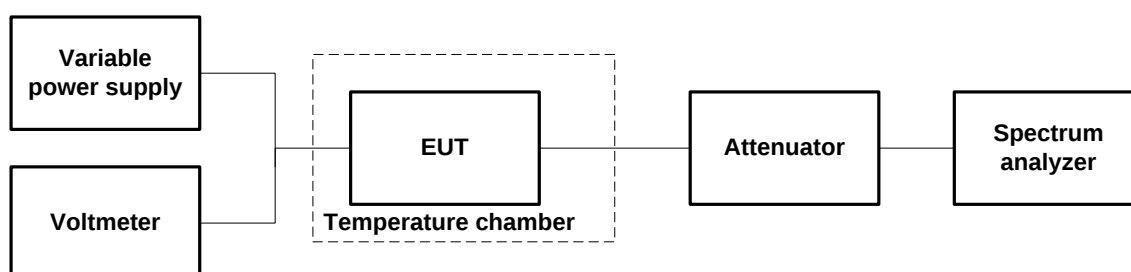
Table 7.5.1 Frequency stability limits

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): 22-Apr-20			
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	450.003066	450.003093	450.003093	450.003093	450.003092	450.003093	450.003092	0	-103	450	-347	Pass
-20	nominal	450.003066	NA	NA	NA	NA	NA	450.003071	0	-103		-347	Pass
-10	nominal	450.003053	NA	NA	NA	NA	NA	450.003059	0	-116		-334	Pass
0	nominal	450.003046	450.003060	450.003065	450.003065	450.003068	450.003067	450.003066	0	-123		-327	Pass
10	nominal	450.003096	NA	NA	NA	NA	NA	450.003120	0	-73		-377	Pass
20	+15%	450.003177	NA	NA	NA	NA	NA	450.003187	18	0		-432	Pass
20	nominal	450.003163	NA	NA	NA	NA	NA	450.003169*	0	-6		-444	Pass
20	-15%	450.003158	NA	NA	NA	NA	NA	450.003148	0	-21		-429	Pass
30	nominal	450.003175	450.003186	450.003190	450.003191	450.003191	450.003191	450.003189	22	0		-428	Pass
40	nominal	450.003197	NA	NA	NA	NA	NA	450.003206	37	0		-413	Pass
50	nominal	450.003232	NA	NA	NA	NA	NA	450.003245	76	0		-374	Pass
Mid frequency													
-30	nominal	460.000027	460.000041	460.000042	460.000042	460.000043	460.000043	460.000043	0	-86	460	-374	Pass
-20	nominal	460.000009	NA	NA	NA	NA	NA	460.000017	0	-104		-356	Pass
-10	nominal	460.000005	NA	NA	NA	NA	NA	460.000008	0	-108		-352	Pass
0	nominal	460.000000	460.000011	460.000013	460.000015	460.000016	460.000016	460.000014	0	-113		-347	Pass
10	nominal	460.000061	NA	NA	NA	NA	NA	460.000070	0	-52		-408	Pass
20	+15%	460.000113	NA	NA	NA	NA	NA	460.000115	2	0		-458	Pass
20	nominal	460.000110	NA	NA	NA	NA	NA	460.000113*	0	-3		-457	Pass
20	-15%	460.000108	NA	NA	NA	NA	NA	460.000109	0	-5		-455	Pass
30	nominal	460.000119	460.000120	460.000128	460.000126	460.000128	460.000117	460.000142	29	0		-431	Pass
40	nominal	460.000149	NA	NA	NA	NA	NA	460.000162	49	0		-411	Pass
50	nominal	460.000177	NA	NA	NA	NA	NA	460.000195	82	0		-378	Pass
High frequency													
-30	nominal	469.996902	469.996913	469.996914	469.996914	469.996915	469.996915	469.996916	0	-92	470	-378	Pass
-20	nominal	469.996872	NA	NA	NA	NA	NA	469.996888	0	-122		-348	Pass
-10	nominal	469.996875	NA	NA	NA	NA	NA	469.996881	0	-119		-351	Pass
0	nominal	469.996864	469.996883	469.996886	469.996887	469.996886	469.996887	469.996887	0	-130		-340	Pass
10	nominal	469.996937	NA	NA	NA	NA	NA	469.996944	0	-57		-413	Pass
20	+15%	469.996999	NA	NA	NA	NA	NA	469.997002	8	0		-462	Pass
20	nominal	469.996987	NA	NA	NA	NA	NA	469.996994*	0	-7		-463	Pass
20	-15%	469.996981	NA	NA	NA	NA	NA	469.996982	0	-13		-457	Pass
30	nominal	469.997003	469.997018	469.997019	469.997017	469.997019	469.997018	469.997014	25	0		-445	Pass
40	nominal	469.997018	NA	NA	NA	NA	NA	469.997034	40	0		-430	Pass
50	nominal	469.997048	NA	NA	NA	NA	NA	469.997068	74	0		-396	Pass

* - Reference frequency

Reference numbers of test equipment used

HL 0493	HL 2171	HL 2358	HL 4355	HL 5598	HL 5623		
---------	---------	---------	---------	---------	---------	--	--

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-Apr-20			
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-Apr-20			
Temperature: 23 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Figure 7.6.1 Transient frequency test setup

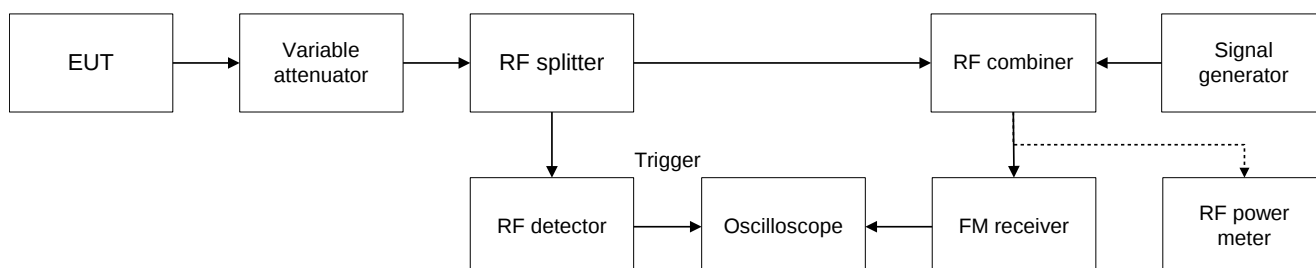


Table 7.6.2 Transient frequency behaviour test results

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	2.500	± 6.25	-3.750	Pass
	t ₂	25.0	0.625	± 3.125	-2.500	
	t ₃	10.0	1.094	± 6.25	-5.156	
460.0000	t ₁	10.0	2.031	± 6.25	-4.219	Pass
	t ₂	25.0	0.625	± 3.125	-2.500	
	t ₃	10.0	1.094	± 6.25	-5.156	
469.9969	t ₁	10.0	2.500	± 6.25	-3.750	Pass
	t ₂	25.0	0.625	± 3.125	-2.500	
	t ₃	10.0	1.250	± 6.25	-5.000	

Reference numbers of test equipment used

HL 5376	HL 0539	HL 5369	HL 4938	HL 5586	HL 5472	HL 5623	HL 2017
HL 2016							

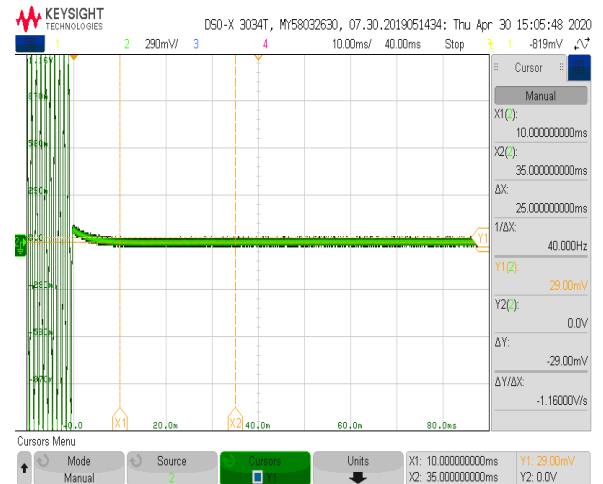
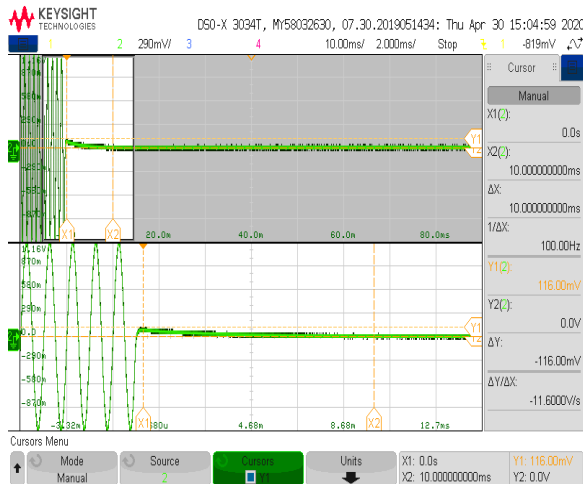
Full description is given in Appendix A.



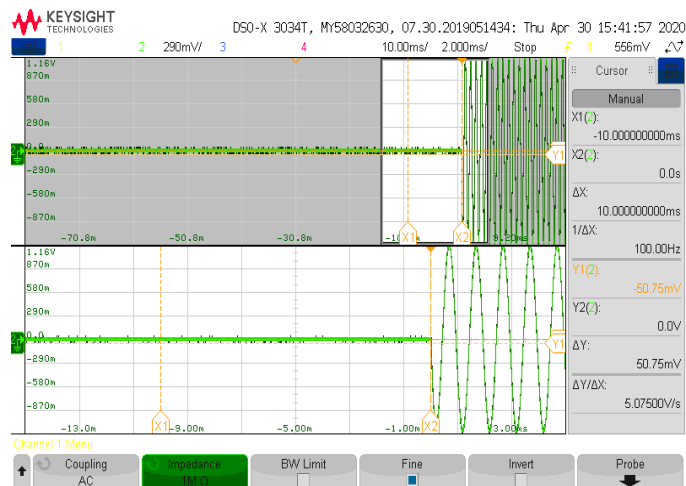
HERMON LABORATORIES

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-Apr-20	
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

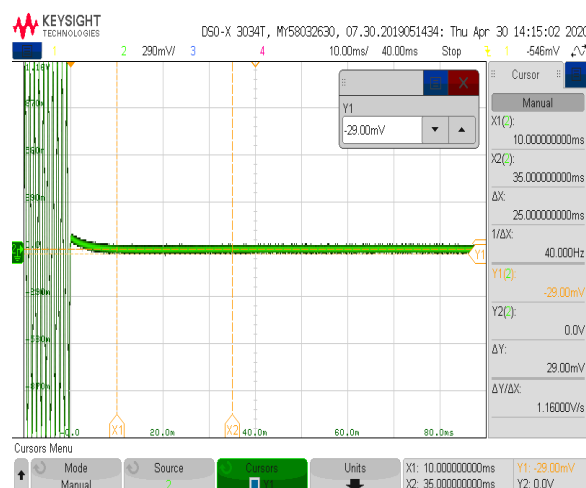




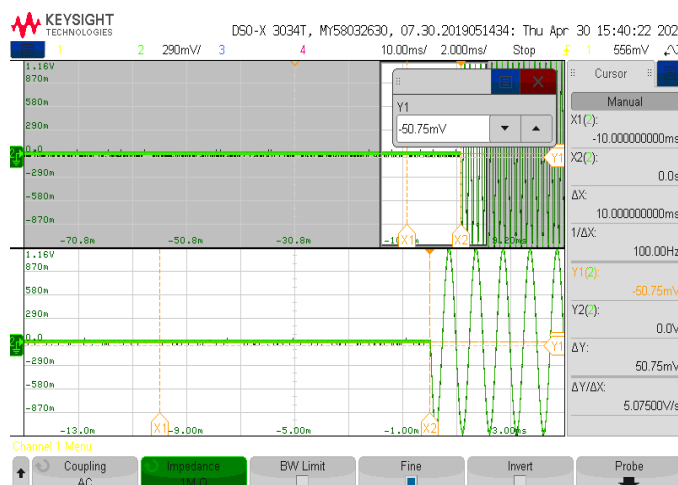
HERMON LABORATORIES

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-Apr-20			
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

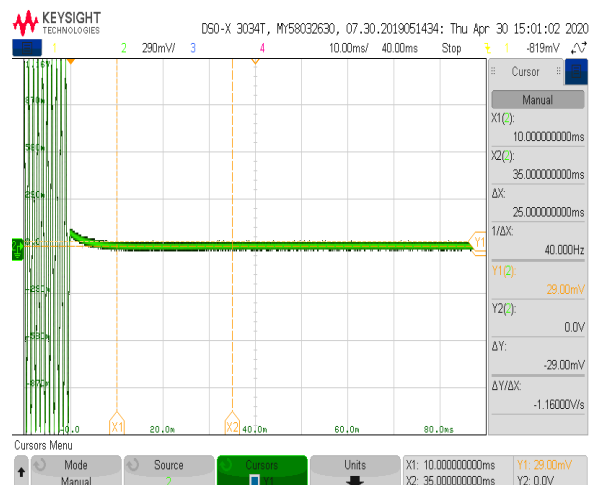
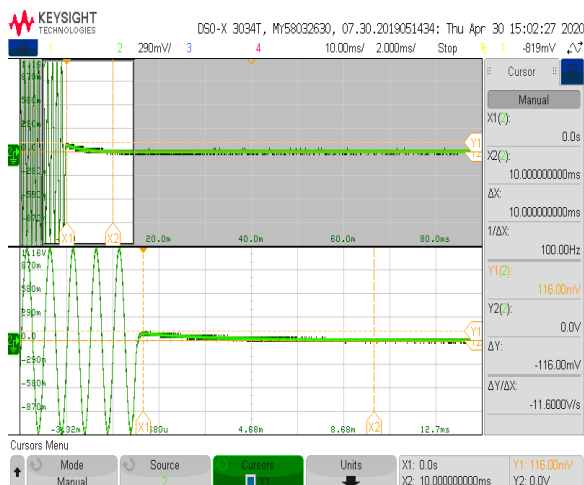




HERMON LABORATORIES

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-Apr-20			
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
0493	Temperature Chamber -45...175 deg C	Thermotron	S-1.2 Mini-Max	14016	19-Jun-19	19-Jun-20
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	08-Mar-20	08-Mar-21
2017	Attenuator, Manual Step, 0-60/10 dB, 0-8.0 GHz	Midwest Microwave	1071	2017	08-Mar-20	08-Mar-21
2171	Multimeter	Fluke	177	79960418	21-Jul-19	21-Jul-20
2358	Power Supply, 2 X 0-36VDC / 5A, 5VDC / 5A	Horizon Electronics	DHR3655 D	767469	26-Jun-19	26-Jun-20
3903	Microwave Cable Assembly, 40.0 GHz, 1.5 m, SMA/SMA	Huber-Suhner	SUCOFL EX 102A	1226/2A	06-Apr-20	06-Apr-21
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	20-Jan-20	20-Jan-21
4933	Active Horn Antenna, 1 GHz to 18 GHz	COM-POWER CORPORATION	AHA-118	701046	06-Jan-20	06-Jan-21
4938	Test Cable, 50Ω, 1.8 m, DC to 18 GHz	Mini-Circuits	CBL-6FT-SMNM+	NA	22-Apr-20	22-Apr-21
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
5376	EXA Signal Analyzer, 10 Hz - 32 GHz	Keysight Technologies	N9010B	MY57470404	18-Mar-20	18-Mar-21
5405	RF cable, 18 GHz, N-N, 6 m	Huber-Suhner	SF118/11N(x2)	500023/118	11-Aug-19	11-Aug-20
5409	RF cable, 40 GHz, SMA-SMA, 2 m	Huber-Suhner	SF102EA/11SK/11SK/2000M	503973/2EA	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
5586	Cable, 50 Ohm, DC to 18 GHz, 1.8 m, SMA/N-type	Mini Circuits	CBL-6FT-SMNM+	NA	22-Oct-19	22-Oct-20
5598	Precision Fixed Attenuator, 50 Ohm, 5 W, 10 dB, DC to 18000 MHz	Mini Circuits	BW-N10W5+	NA	24-Sep-19	24-Sep-20
5623	Precision Fixed Attenuator, 50 Ohm, 5 W, 20 dB, DC to 18 GHz	Mini Circuits	BW-N20W5+	NA	06-Oct-19	06-Oct-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 5405: RF Cable
Huber-Suhner, model: SF118/11N(x2), s/n: 500023/118
Calibration date: 01-Aug-2018

Set / Applied, MHz	Measured, dB	Uncertainty, dB
0.1	0.01	±0.07
50	0.23	±0.07
100	0.32	±0.07
200	0.45	±0.08
300	0.55	±0.08
400	0.64	±0.08
500	0.71	±0.08
600	0.78	±0.08
700	0.85	±0.08
800	0.91	±0.08
900	0.97	±0.08
1000	1.02	±0.08
1100	1.07	±0.08
1200	1.12	±0.08
1300	1.16	±0.08
1400	1.21	±0.08
1500	1.25	±0.08
1600	1.30	±0.08
1700	1.34	±0.08
1800	1.38	±0.08
1900	1.42	±0.08
2000	1.47	±0.08
2500	1.64	±0.10
3000	1.81	±0.10
3500	1.97	±0.10
4000	2.11	±0.10
4500	2.25	±0.10
5000	2.38	±0.10
5500	2.48	±0.10
6000	2.59	±0.10
6500	2.72	±0.10
7000	2.84	±0.13
7500	2.97	±0.13
8000	3.08	±0.13
8500	3.21	±0.13
9000	3.31	±0.13
9500	3.42	±0.13
10000	3.52	±0.13

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	$\pm 8\%$
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 $\pm 13.9\%$
Duty cycle, timing (Tx ON / OFF) and average factor measurements	$\pm 1.0\%$
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 Vertical polarization	Biconilog antenna: ± 5.3 dB Biconical antenna: ± 5.0 dB Log periodic antenna: ± 5.3 dB Double ridged horn antenna: ± 5.3 dB Biconilog antenna: ± 6.0 dB Biconical antenna: ± 5.7 dB Log periodic antenna: ± 6.0 dB Double ridged horn antenna: ± 6.0 dB

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.

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).

Address: P.O. Box 23, Binyamina 3055001, Israel.
Telephone: +972 4628 8001
Fax: +972 4628 8277
e-mail: mail@hermonlabs.com
website: www.hermonlabs.com

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

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
RSS-Gen Issue 5: 2019

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
General Requirements for Compliance of Radio Apparatus

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