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TEST REPORT

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

FOR:

ST Engineering Telematics Wireless Ltd

Water meter

Model: ALLEGRO2E

FCC ID: NTA2W4GB2

IC: 4732A-2W4GB2

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: ST Engineering Telematics Wireless Ltd
Address: 26 Hamelaha street, POB 1911, Holon 5811801, Israel
Telephone: +972 3557 5767
Fax: +972 3557 5753
E-mail: itsikk@tlmw.com
Contact name: Mr. Itsik Kanner

2 Equipment under test attributes

Product: Water meter with external antenna
Product name: Allegro
Product type: Transceiver
Model(s): ALLEGRO2E
Serial number: 02525739
Hardware version: REV A
Software release: 4.65
Receipt date: 23-May-21

3 Manufacturer information

Manufacturer name: ST Engineering Telematics Wireless Ltd
Address: 26 Hamelaha street, POB 1911, Holon 5811801, Israel
Telephone: +972 3557 5767
Fax: +972 3557 5753
E-Mail: itsikk@tlmw.com
Contact name: Mr. Itsik Kanner

4 Test details

Project ID: 42897
Location: Hermon Laboratories Ltd. P.O. Box 23, Binyamina 3055001, Israel
Test started: 23-May-21
Test completed: 06-Jul-21
Test specification(s): FCC part 90, subpart I; 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 90.210 / RSS-119 Section 5.8.4, Conducted 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.42987_EA

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	23-May-21 – 06-Jun-21	
Reviewed by:	Mrs. S. Peysahov Sheynin, test engineer, EMC & Radio	23-Jul-21	
Approved by:	Mr. S. Samokha, technical manager, EMC & Radio	04-Aug-21	



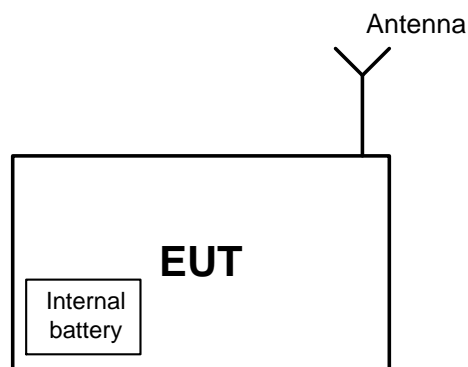
6 EUT description

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

6.1 General information

The EUT is a Water Meter, operating in 450-470 MHz band, battery powered. The battery rated voltage is 3.6V.

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 range		450- 470 MHz				
Maximum rated output power		At transmitter 50 Ω RF output connector		31.26 dBm		
Is transmitter output power variable?		X	No			
			Yes	continuous variable		
				stepped variable with stepsize		
				minimum RF power		
		maximum RF power				
Antenna connection						
X	unique coupling, special waterproof connector	standard connector	integral	with temporary RF connector		
				without temporary RF connector		
Antenna/s technical characteristics						
Type	Manufacturer	Model number	Gain			
External	Arad Technologies	allegro ant	1 dBi			
Transmitter 99% power bandwidth		6 kHz				
Transmitter aggregate data rate/s		4.8 kbps				
Type of modulation		4GFSK				
Modulating test signal (baseband)		PRBS				
Maximum transmitter duty cycle in normal use		0.0023 %	Tx ON time	1 s	Period	12 hours
Transmitter duty cycle supplied for test		100 %	Tx ON time		Period	
Transmitter power source						
X	Battery	Nominal rated voltage	3.6 VDC	Battery type	Lithium	
	DC	Nominal rated voltage	VDC			
	AC mains	Nominal rated voltage	VAC	Frequency	Hz	
Common power source for transmitter and receiver			X	yes	no	



Test specification: Section 90.205 / RSS-119 Section 5.4, Maximum output power			
Test procedure: 47 CFR, Section 2.1046; TIA/EIA-603-E, Section 2.2.1			
Test mode: Compliance		Verdict: PASS	
Date(s): 25-May-21			
Temperature: 24 °C	Relative Humidity: 56 %	Air Pressure: 1009 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 the peak output power at RF antenna connector. Specification test limits are given in Table 7.1.1.

Table 7.1.1 Peak output power limits

Assigned frequency range, MHz	ERP	
	W	dBm
According to FCC part 90.205		
450.0 – 470.0	2	33.00
According to RSS-119		
450.0 – 470.0	60	47.78

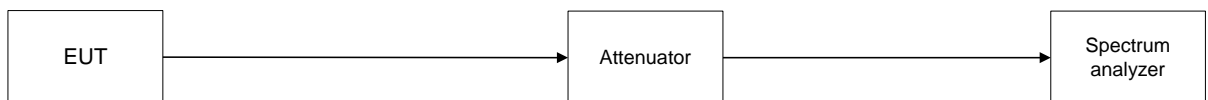
7.1.2 Test procedure

7.1.2.1 The EUT was set up as shown in Figure 7.1.1, energized and its proper operation was checked.

7.1.2.2 The EUT was adjusted to produce maximum available to the end user RF output power.

7.1.2.3 The peak output power was measured with spectrum analyzer as provided in Table 7.1.2, Table 7.1.3 and associated plots.

Figure 7.1.1 Peak output power test setup





Test specification: Section 90.205 / RSS-119 Section 5.4, Maximum output power			
Test procedure: 47 CFR, Section 2.1046; TIA/EIA-603-E, Section 2.2.1			
Test mode: Compliance		Verdict: PASS	
Date(s): 25-May-21			
Temperature: 24 °C	Relative Humidity: 56 %	Air Pressure: 1009 hPa	Power: 3.6 VDC
Remarks:			

Table 7.1.2 Peak output power test results according to FCC

OPERATING FREQUENCY RANGE: 450 – 470 MHz
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: 100 kHz
VIDEO BANDWIDTH: 300 kHz
MODULATION: 4GFSK
MODULATING SIGNAL: PRBS
TRANSMITTER OUTPUT POWER SETTINGS: Maximum

Carrier frequency, MHz	Spectrum analyzer reading, dBm	Limit, dBm	*Margin, dB	Verdict
450.003125	31.26	33.00	-1.74	Pass
460.000000	30.88	33.00	-2.12	Pass
469.996875	30.14	33.00	-2.86	Pass

*- Margin = Peak output power – specification limit.

Table 7.1.3 Peak output power test results according to RSS-119

OPERATING FREQUENCY RANGE: 450 – 470 MHz
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: 100 kHz
VIDEO BANDWIDTH: 300 kHz
MODULATION: 4GFSK
MODULATING SIGNAL: PRBS
TRANSMITTER OUTPUT POWER SETTINGS: Maximum

Carrier frequency, MHz	Spectrum analyzer reading, dBm	Limit, dBm	Margin, dB	Verdict
450.003125	31.26	47.78	-16.52	Pass
460.000000	30.88	47.78	-16.90	Pass
469.996875	30.14	47.78	-17.64	Pass

*- Margin = Peak output power – specification limit.

Reference numbers of test equipment used

HL 3766	HL 4355	HL 5409				
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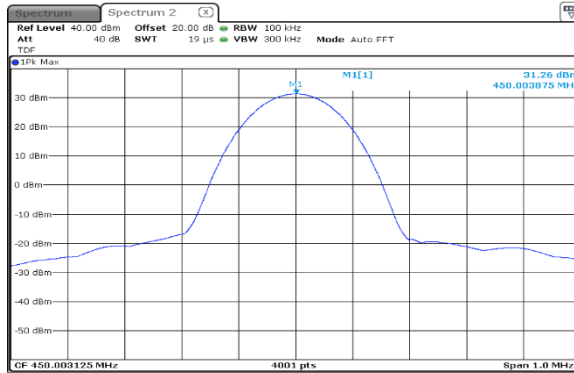
Full description is given in Appendix A.



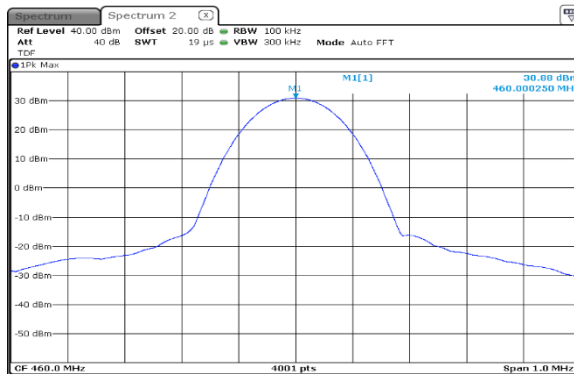
HERMON LABORATORIES

Test specification: Section 90.205 / RSS-119 Section 5.4, Maximum output power	
Test procedure: 47 CFR, Section 2.1046; TIA/EIA-603-E, Section 2.2.1	
Test mode: Compliance	Verdict: PASS
Date(s): 25-May-21	
Temperature: 24 °C	Relative Humidity: 56 %
Air Pressure: 1009 hPa	Power: 3.6 VDC
Remarks:	

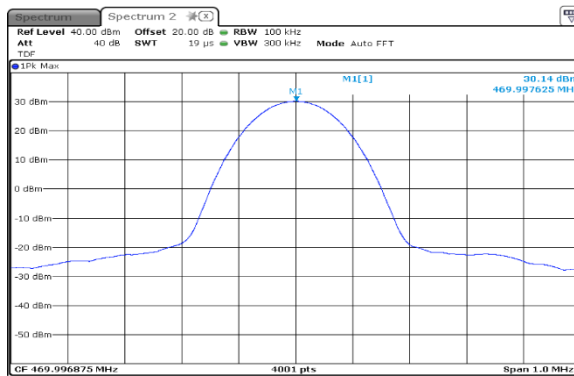
Plot 7.1.1 Peak output power test results at low frequency



Plot 7.1.2 Peak output power test results at mid frequency



Plot 7.1.3 Peak output power test results at high frequency





Test specification: Section 90.209 / RSS-119 Section 5.5, Occupied bandwidth			
Test procedure: 47 CFR, Section 2.1049			
Test mode: Compliance		Verdict: PASS	
Date(s): 25-May-21			
Temperature: 25 °C	Relative Humidity: 53 %	Air Pressure: 1009 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. The test results are provided in Table 7.2.2 and the associated plots.

Table 7.2.1 Occupied bandwidth limits

Assigned frequency, MHz	Occupied bandwidth power, %	Maximum allowed bandwidth, kHz
450-470	99.00	6.25
	Occupied bandwidth power, dBc	
	26.00	

7.2.2 Test procedure

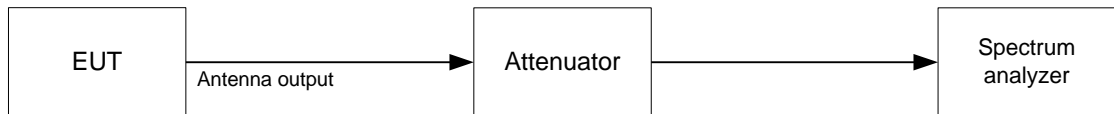
7.2.2.1 The EUT was set up as shown in Figure 7.2.1, energized and its proper operation was checked.

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





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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): 25-May-21			
Temperature: 25 °C	Relative Humidity: 53 %	Air Pressure: 1009 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 ENVELOPE REFERENCE POINTS: 26 dBc
 MODULATION: 4GFSK
 MODULATING SIGNAL: PRBS

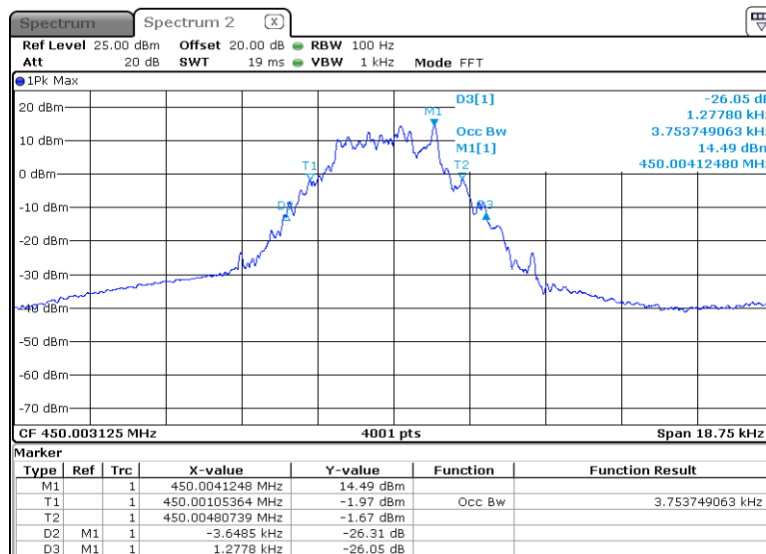
Carrier frequency, MHz	Occupied bandwidth, kHz	Limit, kHz	Margin, kHz	Verdict
MODULATION ENVELOPE REFERENCE POINTS: 99%				
450.003125	3.753	6.250	-2.497	Pass
460.000000	3.795	6.250	-2.455	Pass
469.996875	3.838	6.250	-2.412	Pass
MODULATION ENVELOPE REFERENCE POINTS: 26 dBc				
450.003125	4.926	6.250	-1.324	Pass
460.000000	5.026	6.250	-1.224	Pass
469.996875	5.075	6.250	-1.175	Pass

Reference numbers of test equipment used

HL 3766	HL 4355	HL 5409				
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Full description is given in Appendix A.

Plot 7.2.1 Occupied bandwidth test result at low frequency

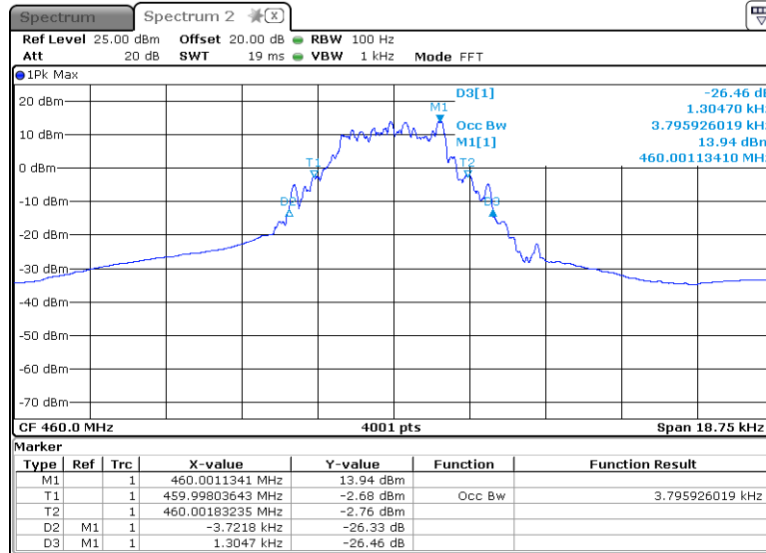




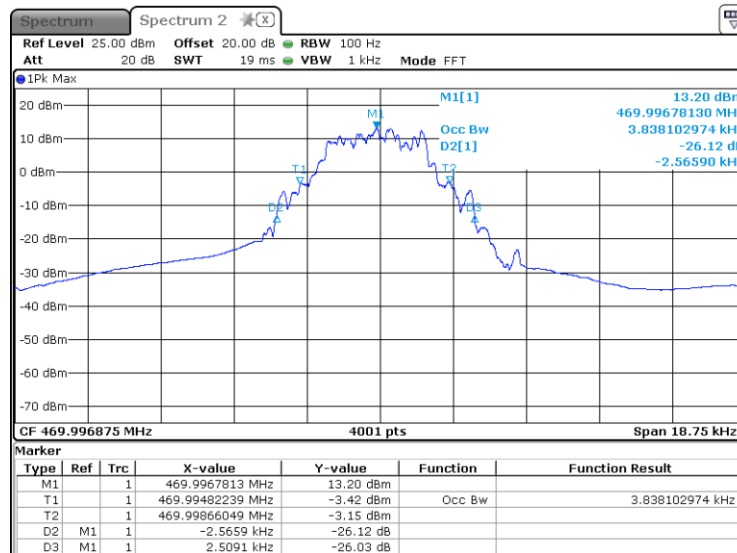
HERMON LABORATORIES

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): 25-May-21			
Temperature: 25 °C	Relative Humidity: 53 %	Air Pressure: 1009 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): 25-May-21 - 01-Jul-21			
Temperature: 24.2 °C	Relative Humidity: 48 %	Air Pressure: 1009 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)	
0 – 3 kHz	0
3 – 4.6 kHz	30 + 16.67(f _d ** - 3 kHz) or 55+10logP(W) whichever is the lesser
More than 4.6 kHz	55+10logP(W) or 57 whichever is the lesser(RSS119) 55+10logP(W) or 65 whichever is the lesser(FCC210)

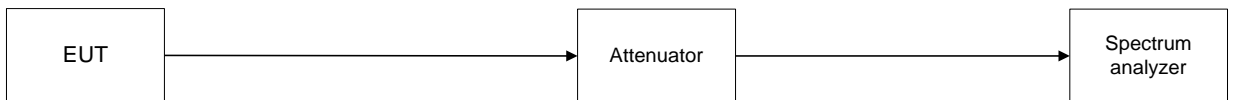
* - linearly increase with frequency
** - displacement frequency

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.

Figure 7.3.1 Emission mask test setup





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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): 25-May-21 - 01-Jul-21			
Temperature: 24.2 °C	Relative Humidity: 48 %	Air Pressure: 1009 hPa	Power: 3.6 VDC
Remarks:			

Table 7.3.2 Emission mask test results

Carrier frequency, MHz	Limit	Verdict
450.003125	Emission mask E	Pass
460.000000		
459.996875		

Reference numbers of test equipment used

HL 3766	HL 4355	HL 5409					
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Full description is given in Appendix A.



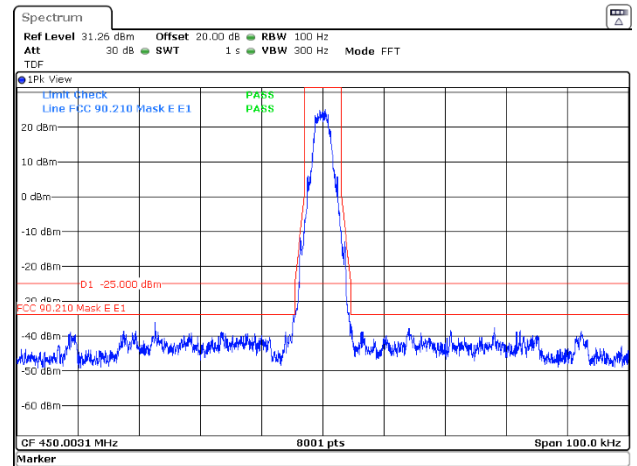
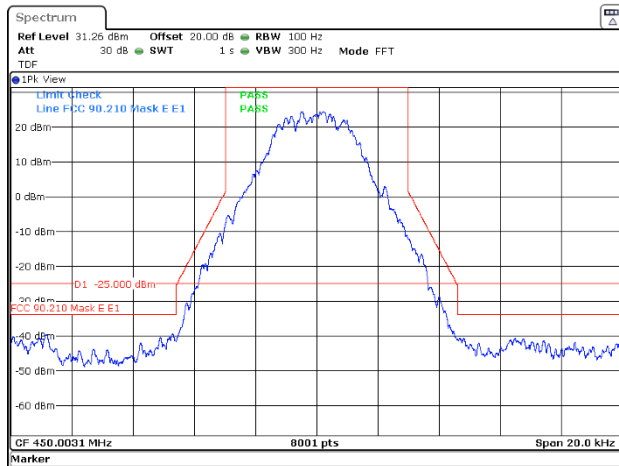
HERMON LABORATORIES

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: Compliance		Verdict: PASS	
Date(s): 25-May-21 - 01-Jul-21			
Temperature: 24.2 °C	Relative Humidity: 48 %	Air Pressure: 1009 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.3.1 Emission mask test results at low carrier frequency FCC part 90

OPERATING FREQUENCY RANGE:
DETECTOR USED:
MODULATION:
MODULATING SIGNAL:
TRANSMITTER OUTPUT POWER SETTINGS:

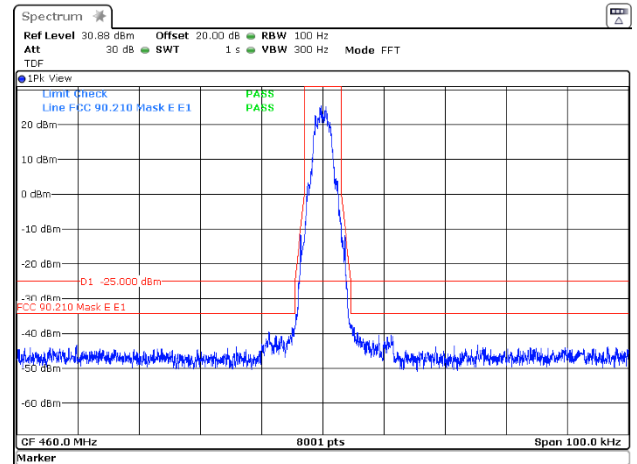
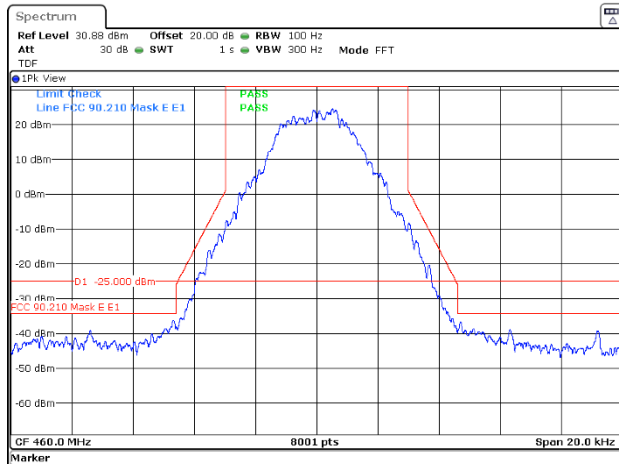
450 – 470 MHz
Peak
4GFSK
PRBS
Maximum



Plot 7.3.2 Emission mask test results at mid carrier frequency FCC part 90

OPERATING FREQUENCY RANGE:
DETECTOR USED:
MODULATION:
MODULATING SIGNAL:
TRANSMITTER OUTPUT POWER SETTINGS:

450 – 470 MHz
Peak
4GFSK
PRBS
Maximum





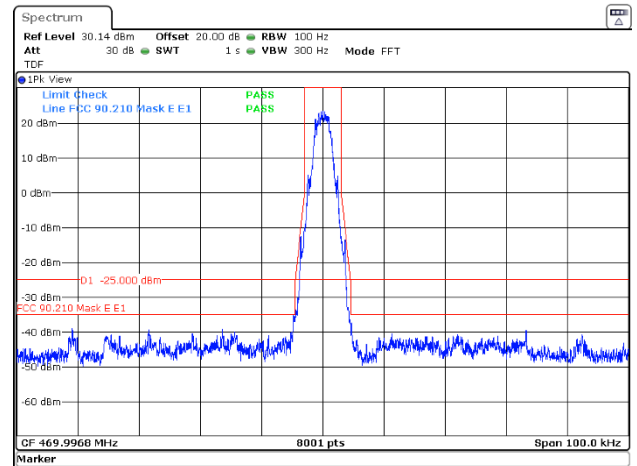
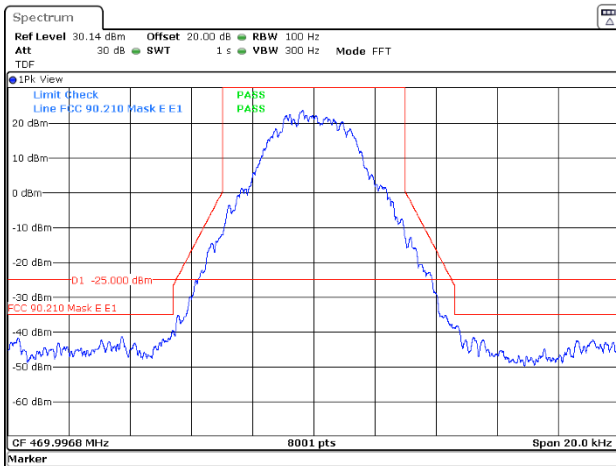
HERMON LABORATORIES

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: Compliance		Verdict: PASS	
Date(s): 25-May-21 - 01-Jul-21			
Temperature: 24.2 °C	Relative Humidity: 48 %	Air Pressure: 1009 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.3.3 Emission mask test results at high carrier frequency FCC part 90

OPERATING FREQUENCY RANGE:
DETECTOR USED:
MODULATION:
MODULATING SIGNAL:
TRANSMITTER OUTPUT POWER SETTINGS:

450 – 470 MHz
Peak
4GFSK
PRBS
Maximum





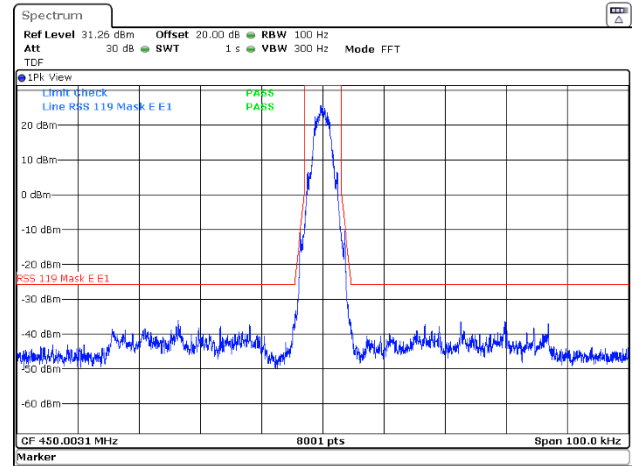
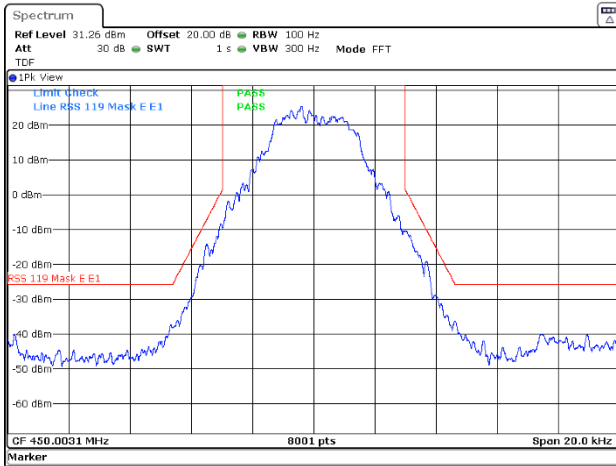
HERMON LABORATORIES

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: Compliance		Verdict: PASS	
Date(s): 25-May-21 - 01-Jul-21			
Temperature: 24.2 °C	Relative Humidity: 48 %	Air Pressure: 1009 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.3.4 Emission mask test results at low carrier frequency RSS-119

OPERATING FREQUENCY RANGE:
DETECTOR USED:
MODULATION:
MODULATING SIGNAL:
TRANSMITTER OUTPUT POWER SETTINGS:

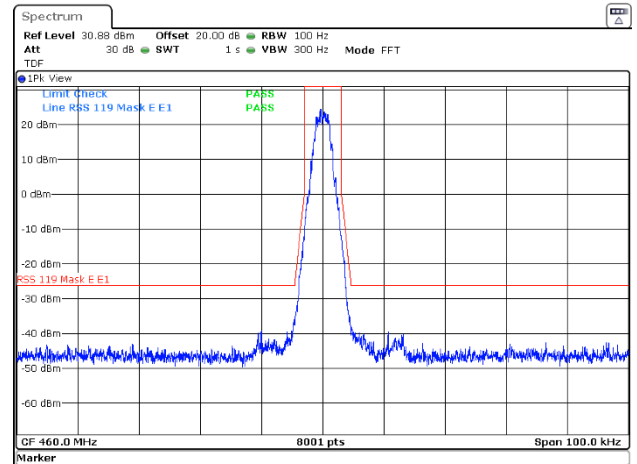
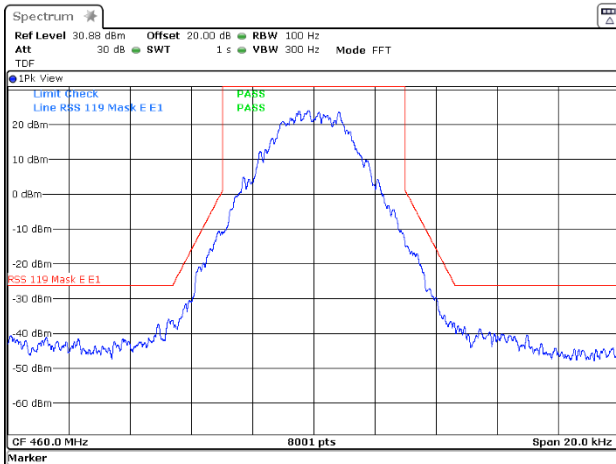
450 – 470 MHz
Peak
4GFSK
PRBS
Maximum



lot 7.3.5 Emission mask test results at mid carrier frequency RSS-119

OPERATING FREQUENCY RANGE:
DETECTOR USED:
MODULATION:
MODULATING SIGNAL:
TRANSMITTER OUTPUT POWER SETTINGS:

450 – 470 MHz
Peak
4GFSK
PRBS
Maximum





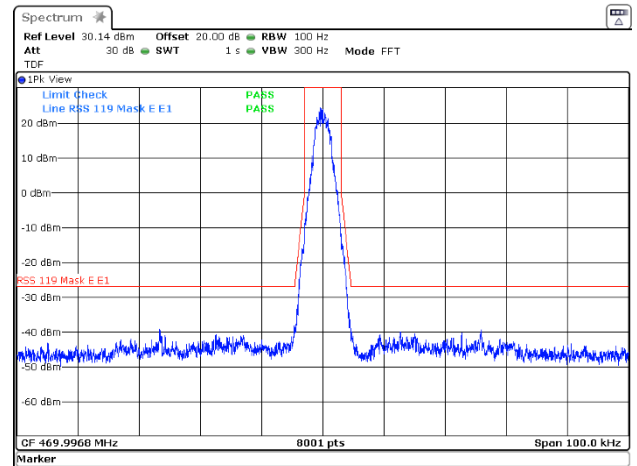
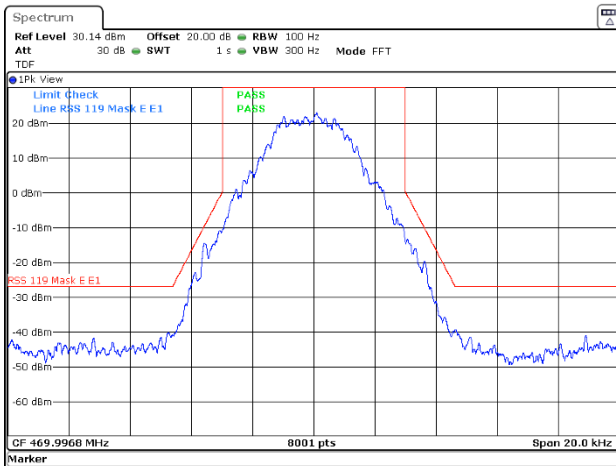
HERMON LABORATORIES

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: Compliance		Verdict: PASS	
Date(s): 25-May-21 - 01-Jul-21			
Temperature: 24.2 °C	Relative Humidity: 48 %	Air Pressure: 1009 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.3.6 Emission mask test results at high carrier frequency RSS-119

OPERATING FREQUENCY RANGE:
DETECTOR USED:
MODULATION:
MODULATING SIGNAL:
TRANSMITTER OUTPUT POWER SETTINGS:

450 – 470 MHz
Peak
4GFSK
PRBS
Maximum





Test specification: Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 04-Jun-21 - 09-Jun-21			
Temperature: 22.3 °C	Relative Humidity: 47 %	Air Pressure: 1011 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	72.35

* - 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 spurious emission field strength measurements in 9 kHz to 30 MHz band

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

7.4.2.2 The specified frequency range was investigated with antenna connected to spectrum analyzer. To find maximum radiation the turntable was rotated 360° and the measuring antenna was rotated around its vertical axis.

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

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

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

7.4.3.2 The specified frequency range was investigated with antenna connected to spectrum analyzer. To find maximum radiation the turntable was rotated 360° 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, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 04-Jun-21 - 09-Jun-21			
Temperature: 22.3 °C	Relative Humidity: 47 %	Air Pressure: 1011 hPa	Power: 3.6 VDC
Remarks:			

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

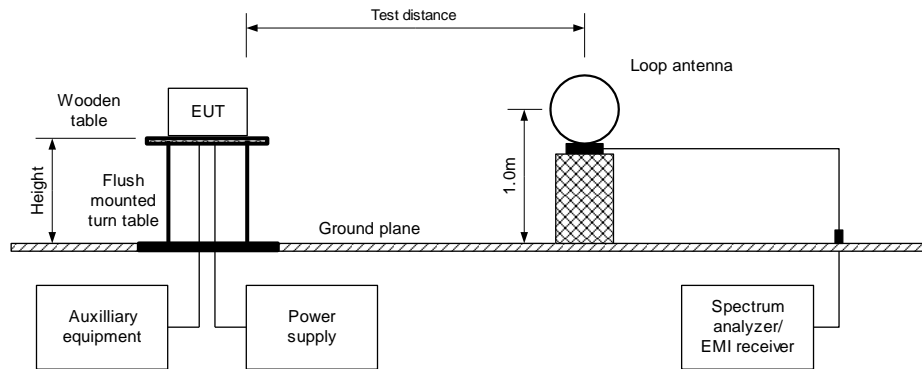
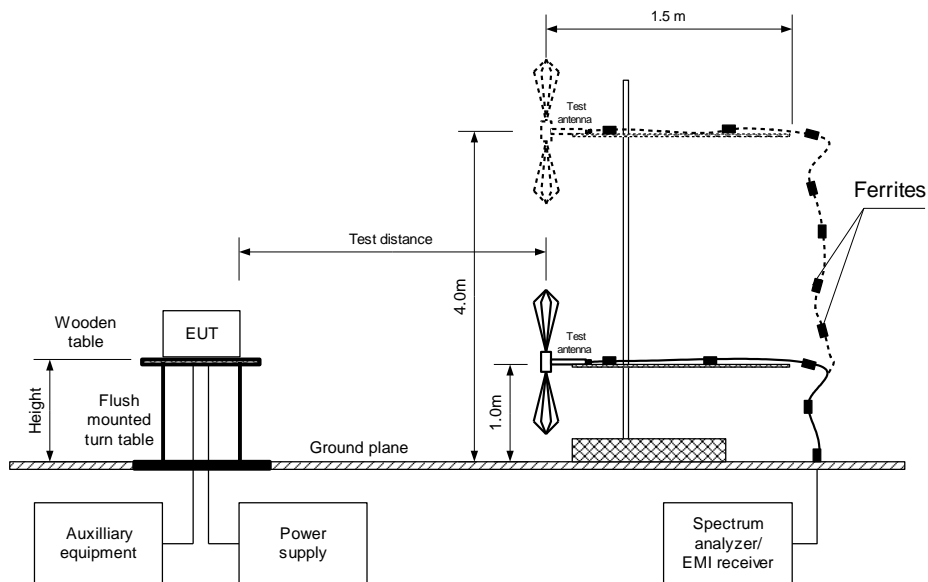


Figure 7.4.2 Setup for spurious emission field strength measurements above 30 MHz





Test specification: Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 04-Jun-21 - 09-Jun-21			
Temperature: 22.3 °C	Relative Humidity: 47 %	Air Pressure: 1011 hPa	Power: 3.6 VDC
Remarks:			

Table 7.4.2 Spurious emission field strength test results

ASSIGNED FREQUENCY RANGE: 450 - 470 MHz
 TEST DISTANCE: 3 m
 TEST SITE: Semi anechoic chamber
 EUT HEIGHT: 0.8 m
 INVESTIGATED FREQUENCY RANGE: 0.009 – 4700 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
 DUTY CYCLE: 100%
 MODULATING SIGNAL: ID code
 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								
No emissions were found								Pass
Mid carrier frequency								
920.039	65.25	72.35	-7.1	120	Vert	1	-159	Pass
High carrier frequency								
939.989	59.24	72.35	-13.11	120	Vert	1	180	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 0446	HL 2909	HL 3339	HL 3903	HL 4280	HL 4339	HL 4360	HL 4933
HL 5288	HL 5902						

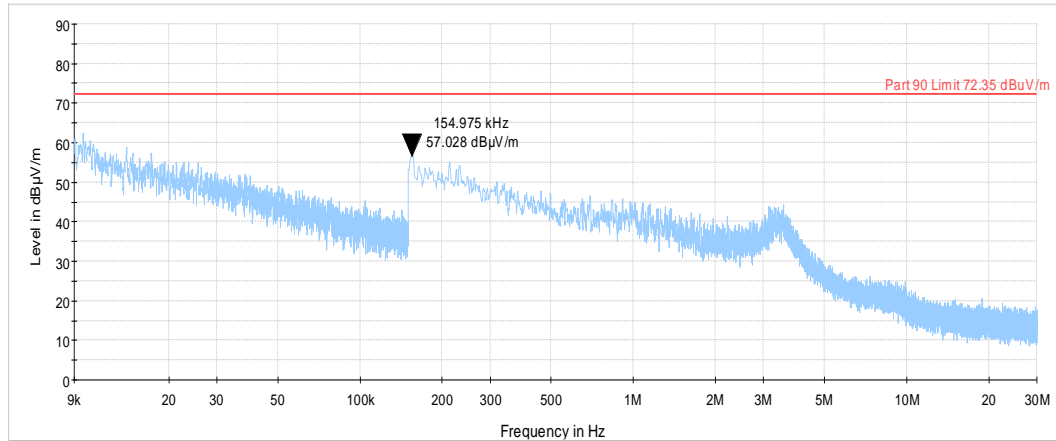
Full description is given in Appendix A.



Test specification: Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 04-Jun-21 - 09-Jun-21			
Temperature: 22.3 °C	Relative Humidity: 47 %	Air Pressure: 1011 hPa	Power: 3.6 VDC
Remarks:			

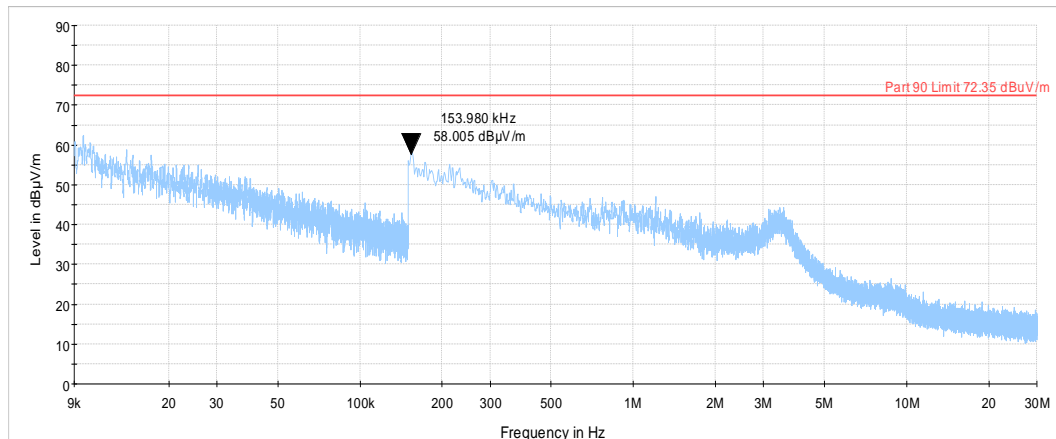
Plot 7.4.1 Radiated emission measurements in 9 kHz - 30 MHz range

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



Plot 7.4.2 Radiated emission measurements in 9 kHz - 30 MHz range

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

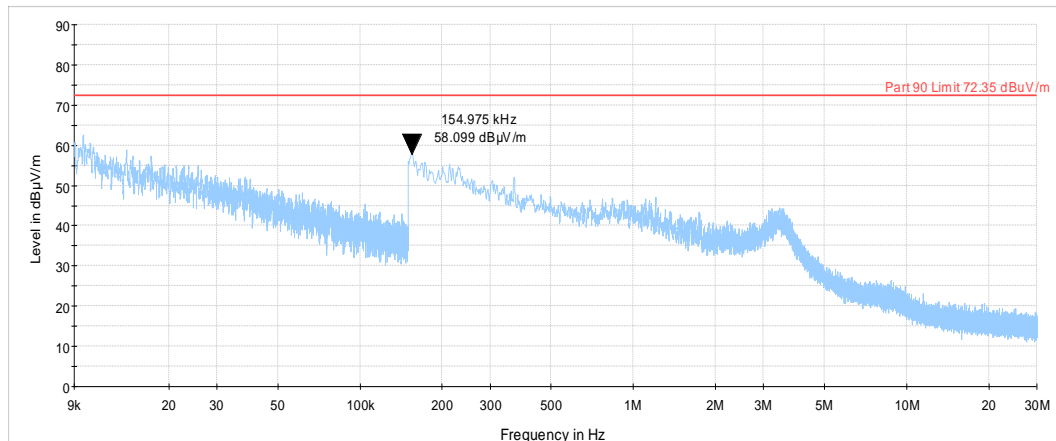




Test specification: Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 04-Jun-21 - 09-Jun-21			
Temperature: 22.3 °C	Relative Humidity: 47 %	Air Pressure: 1011 hPa	Power: 3.6 VDC
Remarks:			

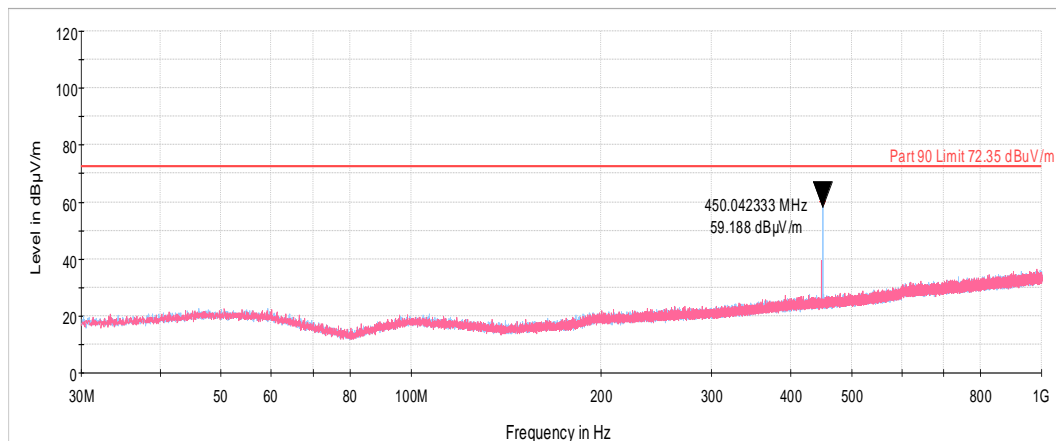
Plot 7.4.3 Radiated emission measurements in 9 kHz - 30 MHz range

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



Plot 7.4.4 Radiated emission measurements in 30 - 1000 MHz range

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



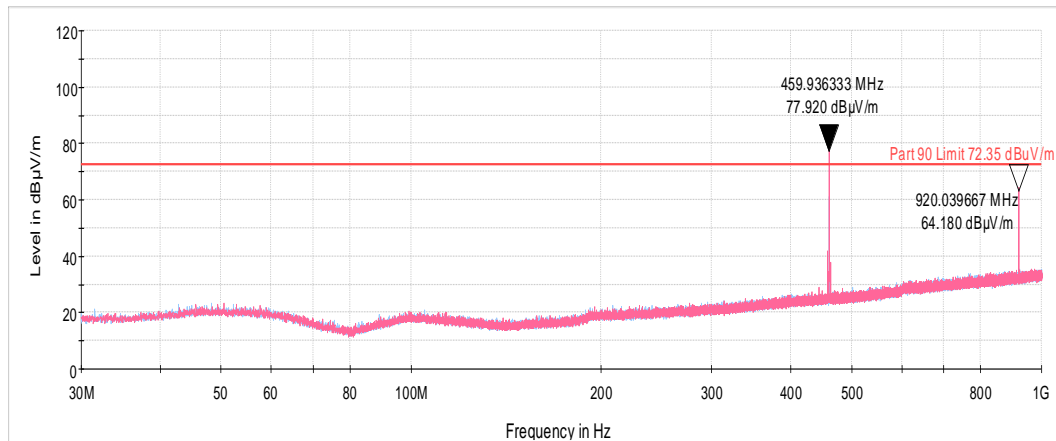


HERMON LABORATORIES

Test specification: Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 04-Jun-21 - 09-Jun-21			
Temperature: 22.3 °C	Relative Humidity: 47 %	Air Pressure: 1011 hPa	Power: 3.6 VDC
Remarks:			

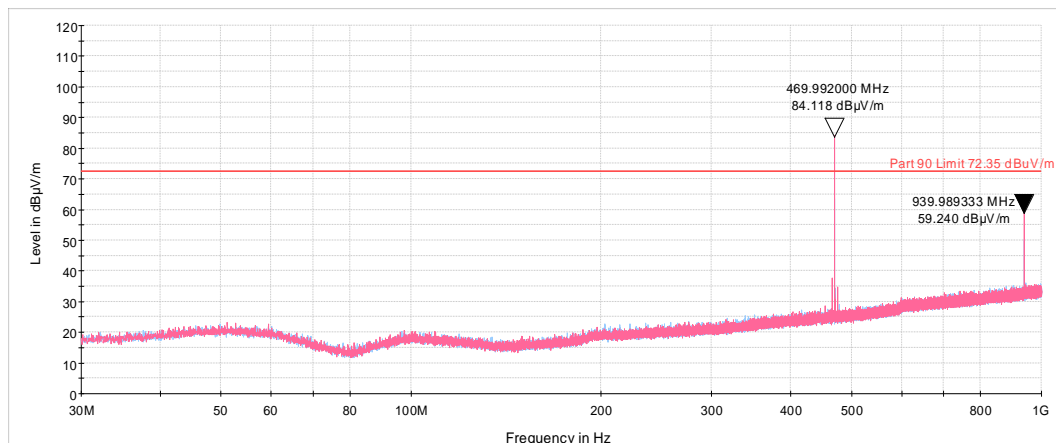
Plot 7.4.5 Radiated emission measurements in 30 - 1000 MHz range

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



Plot 7.4.6 Radiated emission measurements in 30 - 1000 MHz range

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

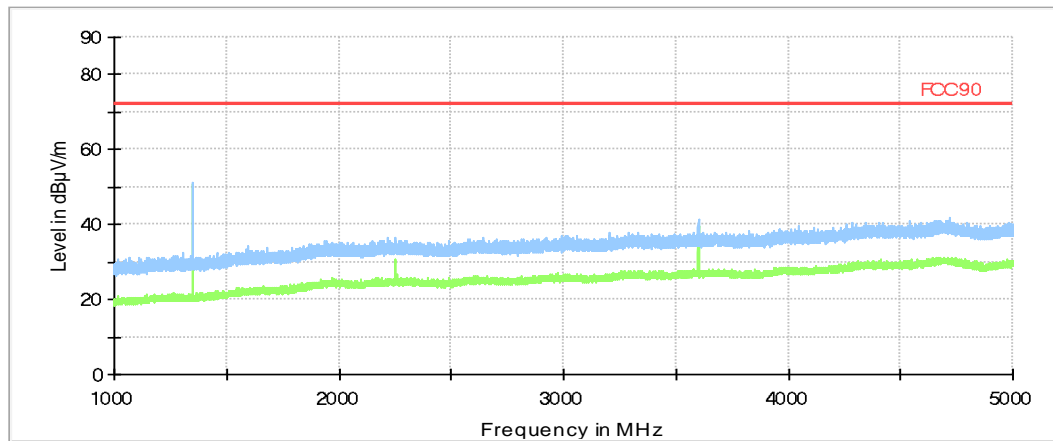




Test specification: Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 04-Jun-21 - 09-Jun-21			
Temperature: 22.3 °C	Relative Humidity: 47 %	Air Pressure: 1011 hPa	Power: 3.6 VDC
Remarks:			

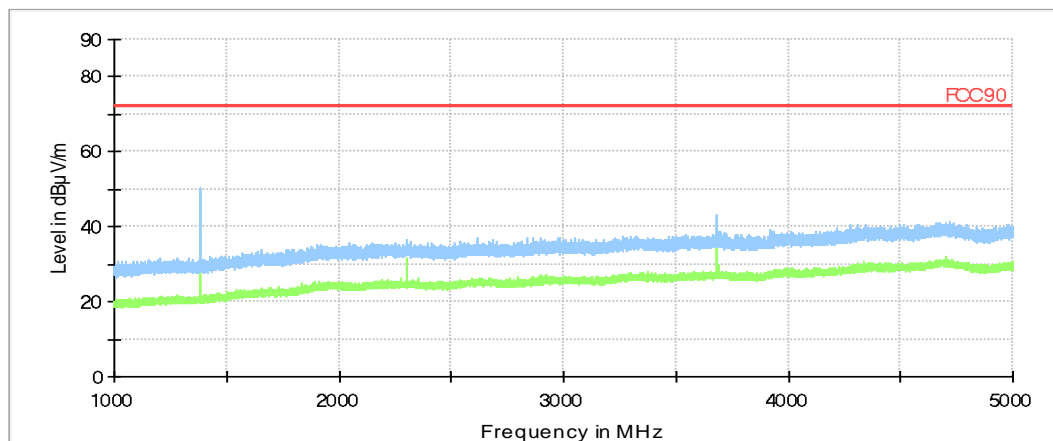
Plot 7.4.7 Radiated emission measurements in 1000 – 5000 MHz range

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



Plot 7.4.8 Radiated emission measurements in 1000 – 5000 MHz range

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



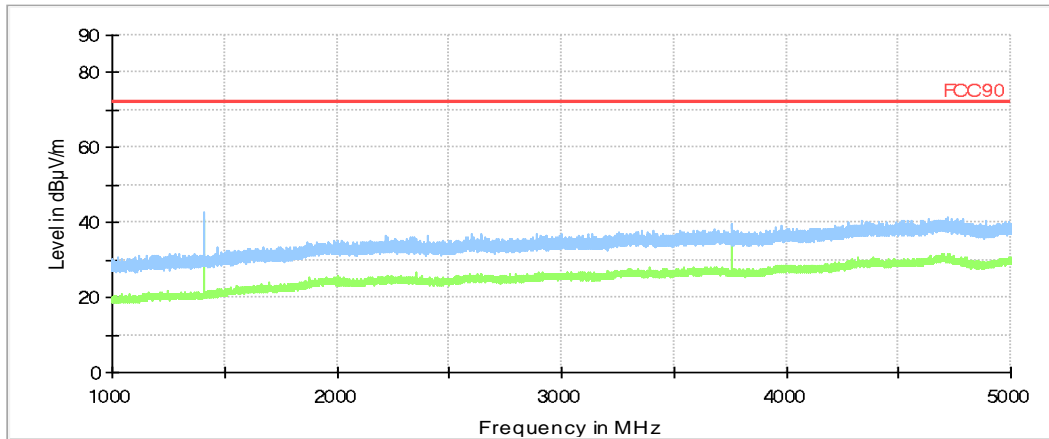


HERMON LABORATORIES

Test specification: Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 04-Jun-21 - 09-Jun-21			
Temperature: 22.3 °C	Relative Humidity: 47 %	Air Pressure: 1011 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.4.9 Radiated emission measurements in 1000 – 5000 MHz range

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





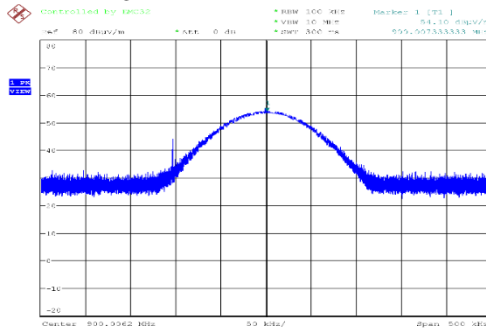
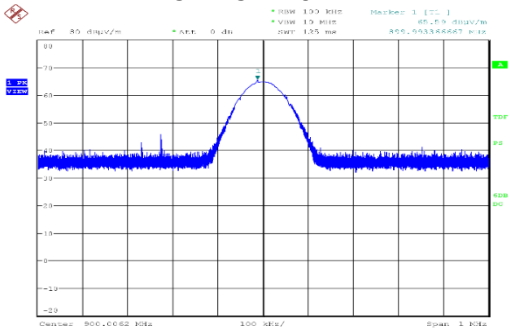
HERMON LABORATORIES

Test specification: Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 04-Jun-21 - 09-Jun-21			
Temperature: 22.3 °C	Relative Humidity: 47 %	Air Pressure: 1011 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.4.10 Radiated emission measurements at the 2nd harmonic

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

Semi anechoic chamber
Low
Vertical and Horizontal
3 m



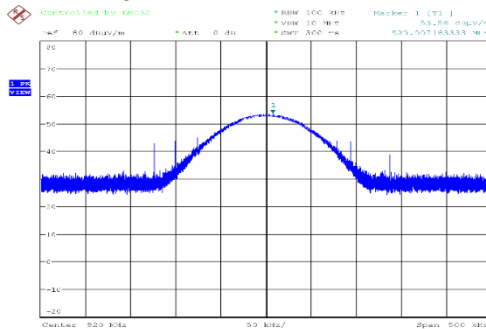
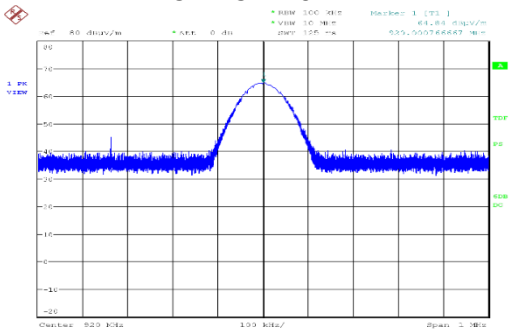
Date: 9 JUN 2021 17:29:06

Date: 10 JUN 2021 11:29:39

Plot 7.4.11 Radiated emission measurements at the 2nd harmonic

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

Semi anechoic chamber
Mid
Vertical and Horizontal
3 m



Date: 9 JUN 2021 17:40:15

Date: 10 JUN 2021 11:15:43



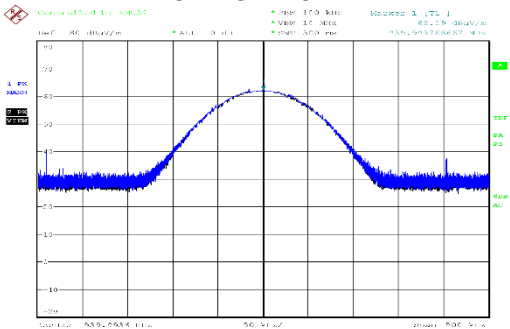
HERMON LABORATORIES

Test specification: Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 04-Jun-21 - 09-Jun-21			
Temperature: 22.3 °C	Relative Humidity: 47 %	Air Pressure: 1011 hPa	Power: 3.6 VDC
Remarks:			

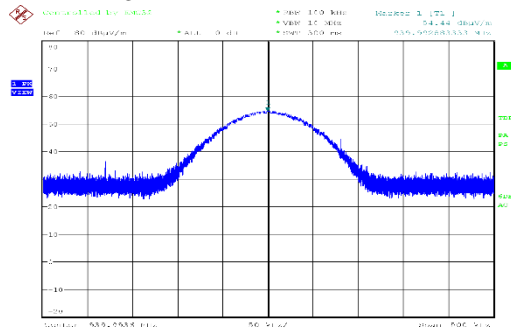
Plot 7.4.12 Radiated emission measurements at the 2nd harmonic

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

Semi anechoic chamber
High
Vertical and Horizontal
3 m



Date: 19 JUN 2021 10:35:10



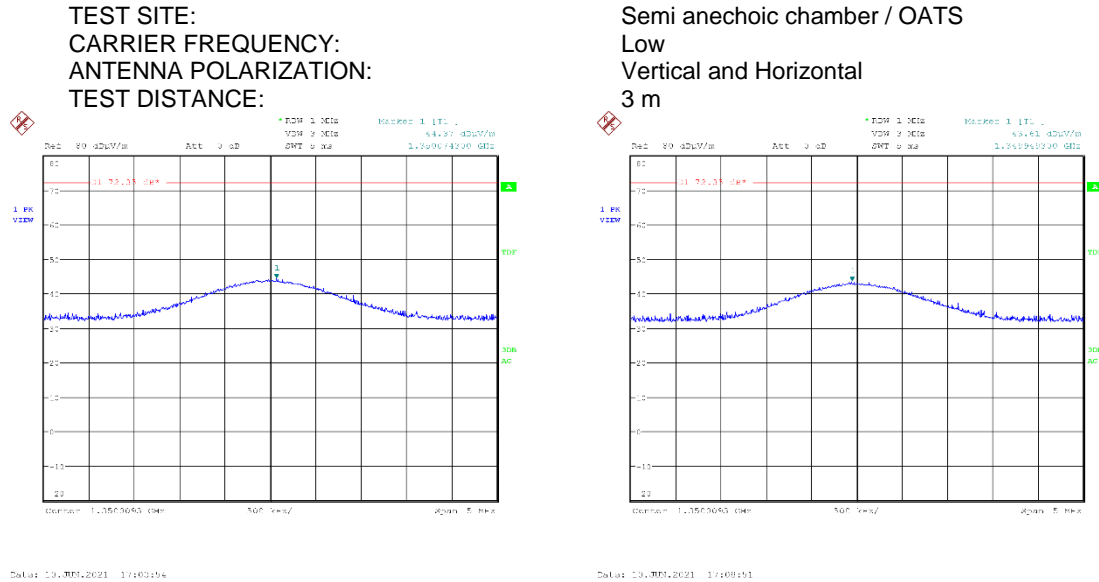
Date: 19 JUN 2021 11:05:00



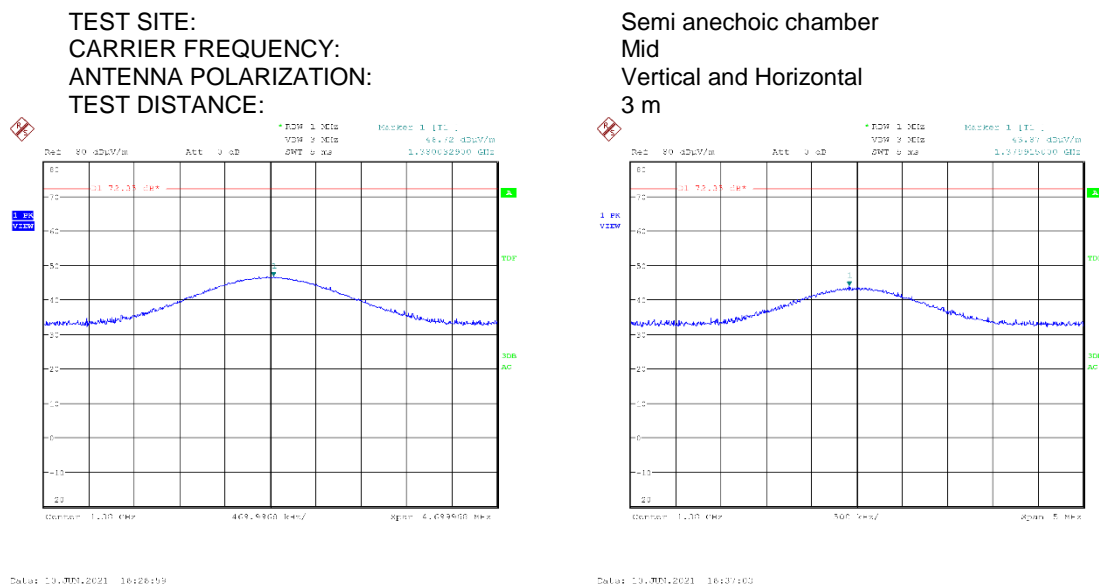
HERMON LABORATORIES

Test specification: Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 04-Jun-21 - 09-Jun-21			
Temperature: 22.3 °C	Relative Humidity: 47 %	Air Pressure: 1011 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.4.13 Radiated emission measurements at the 3rd harmonic



Plot 7.4.14 Radiated emission measurements at the 3rd harmonic

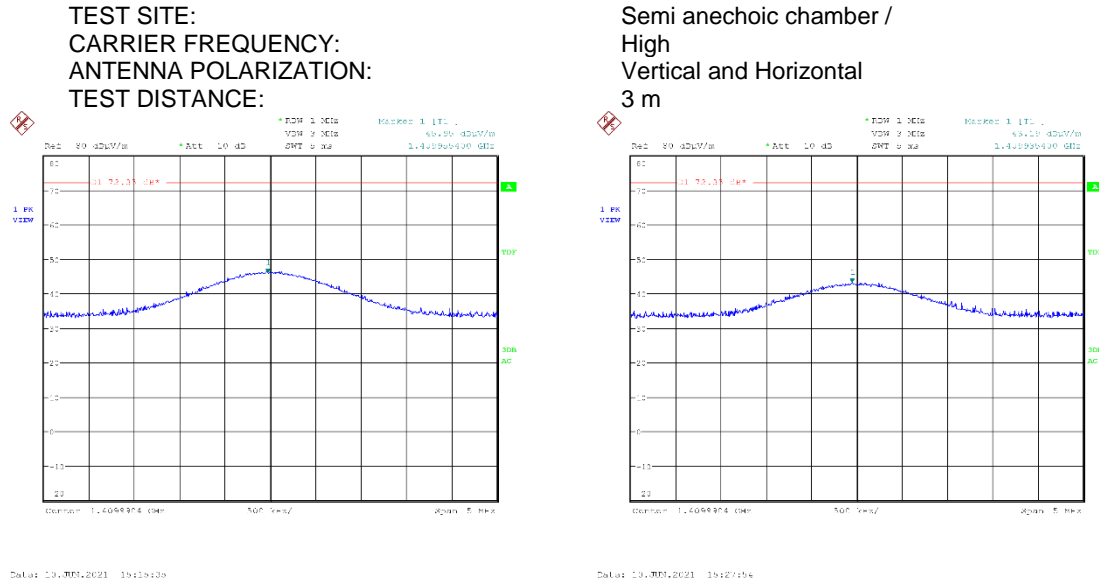




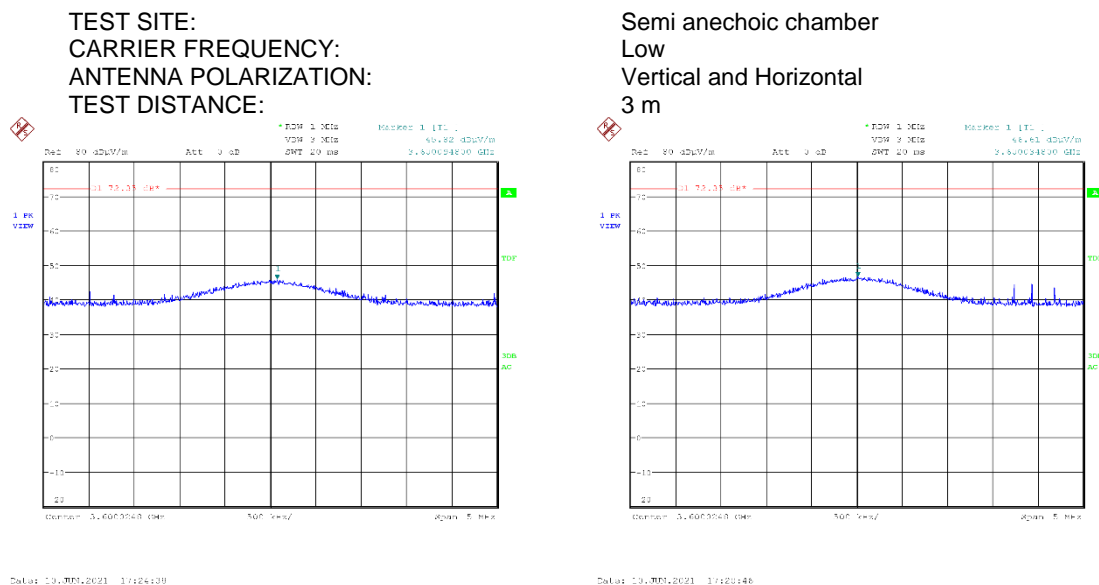
HERMON LABORATORIES

Test specification: Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 04-Jun-21 - 09-Jun-21			
Temperature: 22.3 °C	Relative Humidity: 47 %	Air Pressure: 1011 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.4.15 Radiated emission measurements at the 3rd harmonic



Plot 7.4.16 Radiated emission measurements at the 8th harmonic





Test specification: Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 25-May-21 - 30-May-21			
Temperature: 24 °C	Relative Humidity: 51 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

7.5 Spurious emissions at RF antenna connector test

7.5.1 General

This test was performed to measure spurious emissions at RF antenna connector. Specification test limits are given in Table 7.5.1.

Table 7.5.1 Spurious emission limits

Frequency, MHz	Attenuation below carrier, dBc	ERP of spurious, dBm
0.009 – 10th harmonic*	55+10logP** (mask E)	-25

* - spurious emission limits do not apply to the in band emission within ± 250 % of the authorized bandwidth from the carrier; investigated in course of emission mask testing

** - P is transmitter output power in Watts

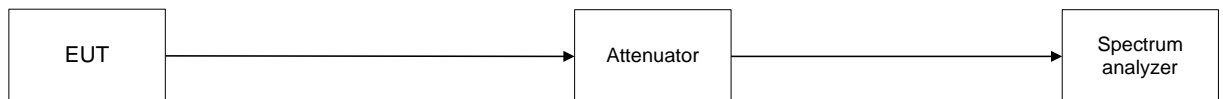
7.5.2 Test procedure

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 was adjusted to produce maximum available for end user RF output power.

7.5.2.3 The spurious emission was measured with spectrum analyzer as provided in Table 7.5.2 and associated plots.

Figure 7.5.1 Spurious emission test setup





Test specification: Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 25-May-21 - 30-May-21			
Temperature: 24 °C	Relative Humidity: 51 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Table 7.5.2 Spurious emission test results FCC 90 and RSS 119

ASSIGNED FREQUENCY RANGE:	450 - 470 MHz
INVESTIGATED FREQUENCY RANGE:	0.009 – 5000 MHz
DETECTOR USED:	Peak
VIDEO BANDWIDTH:	≥ Resolution bandwidth
MODULATION:	4GFSK
MODULATING SIGNAL:	PRBS
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
TRANSMITTER OUTPUT POWER:	31.26 dBm at low frequency 30.88 dBm at mid frequency 30.14 dBm at high frequency

Frequency, MHz	Spurious emission, dBm	RBW, kHz	Limit, dBm	Margin, dB*	Verdict
Low carrier frequency					
448.978000	-39.15	100	-25.00	-14.15	Pass
449.850125	-27.39	100	-25.00	-2.39	Pass
450.156125	-27.22	100	-25.00	-2.22	Pass
450.556125	-25.32	100	-25.00	-0.32	Pass
450.656125	-26.25	100	-25.00	-1.25	Pass
451.136100	-39.54	100	-25.00	-14.54	Pass
Mid carrier frequency					
458.926000	-38.27	100	-25.00	-13.27	Pass
459.847000	-26.04	100	-25.00	-1.04	Pass
460.153000	-25.91	100	-25.00	-0.91	Pass
461.264000	-40.38	100	-25.00	-15.38	Pass
High carrier frequency					
468.919000	-40.35	100	-25.00	-15.35	Pass
469.843875	-26.57	100	-25.00	-1.57	Pass
470.149875	-26.59	100	-25.00	-1.59	Pass
471.112900	-38.27	100	-25.00	-13.27	Pass

* - Margin = Spurious emission – specification limit.

Reference numbers of test equipment used

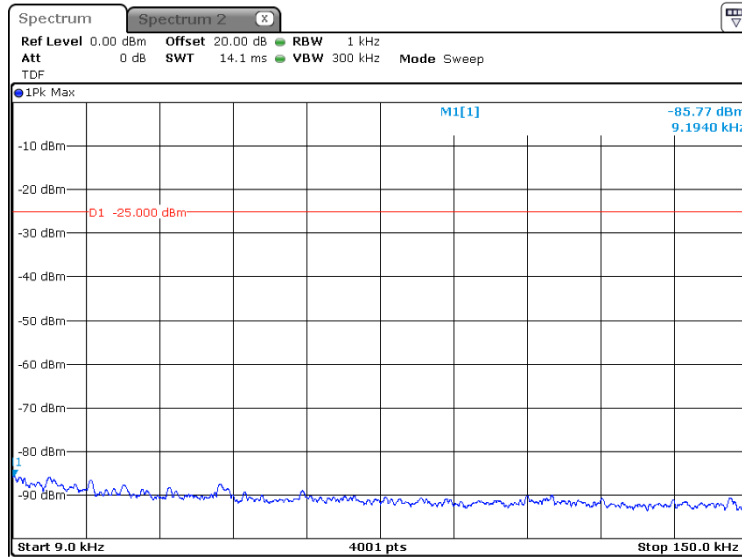
HL 3766	HL 4339	HL 4355	HL 4914	HL 5409		
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Full description is given in Appendix A.

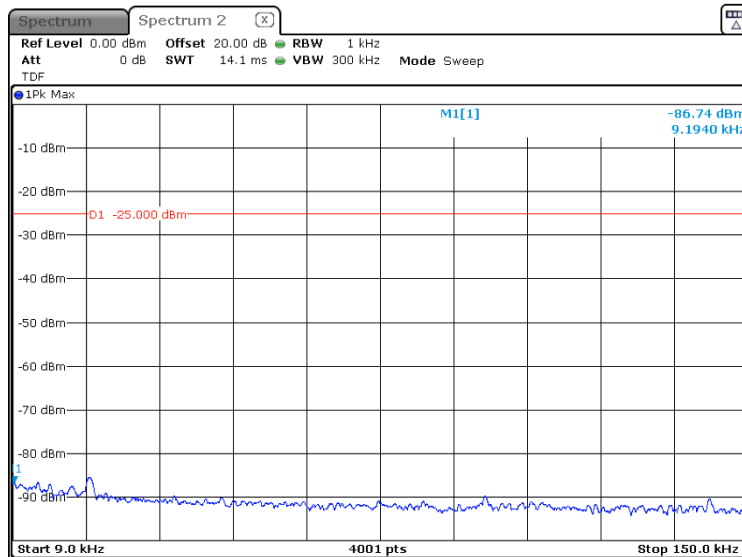


Test specification: Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 25-May-21 - 30-May-21			
Temperature: 24 °C	Relative Humidity: 51 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.1 Spurious emission measurements in 9 - 150 kHz range at low carrier frequency



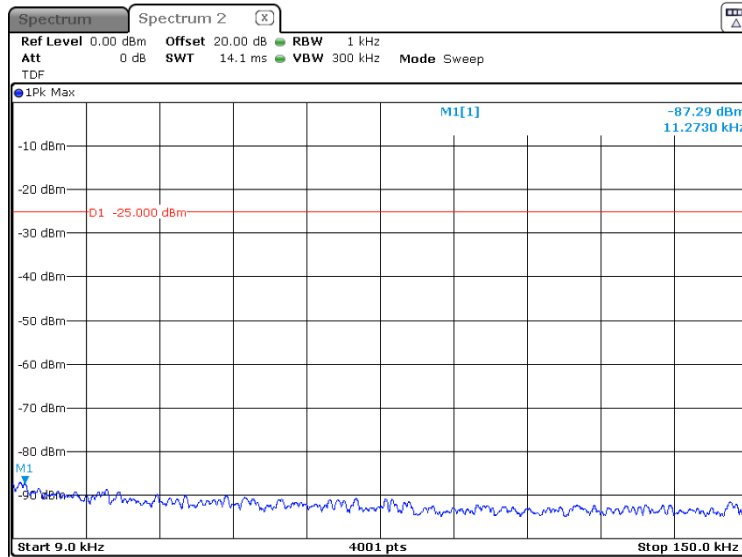
Plot 7.5.2 Spurious emission measurements in 9 - 150 kHz range at mid carrier frequency



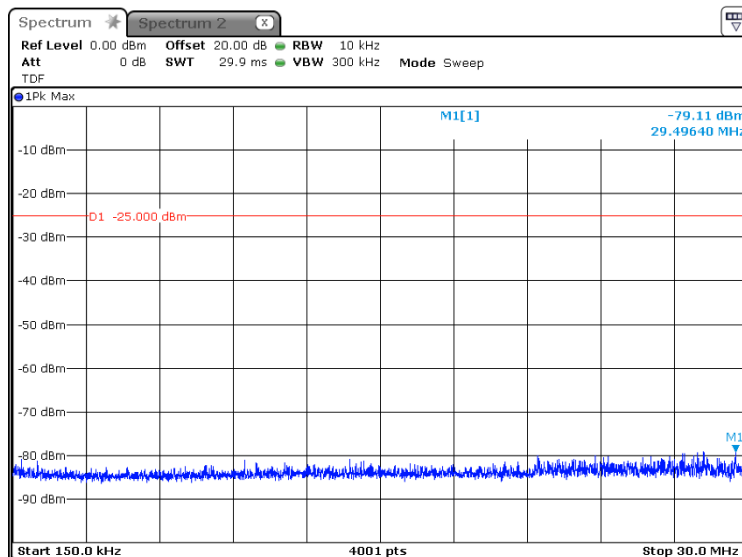


Test specification: Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 25-May-21 - 30-May-21			
Temperature: 24 °C	Relative Humidity: 51 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.3 Spurious emission measurements in 9 - 150 kHz range at high carrier frequency



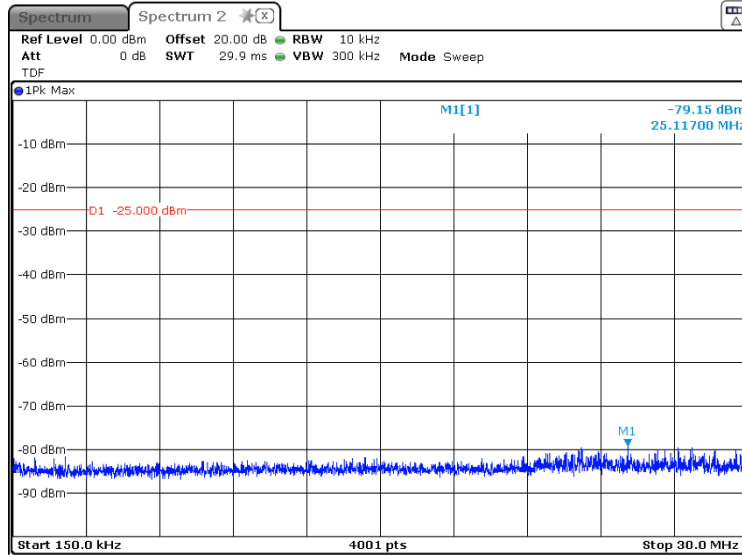
Plot 7.5.4 Spurious emission measurements in 0.15 - 30 MHz range at low carrier frequency



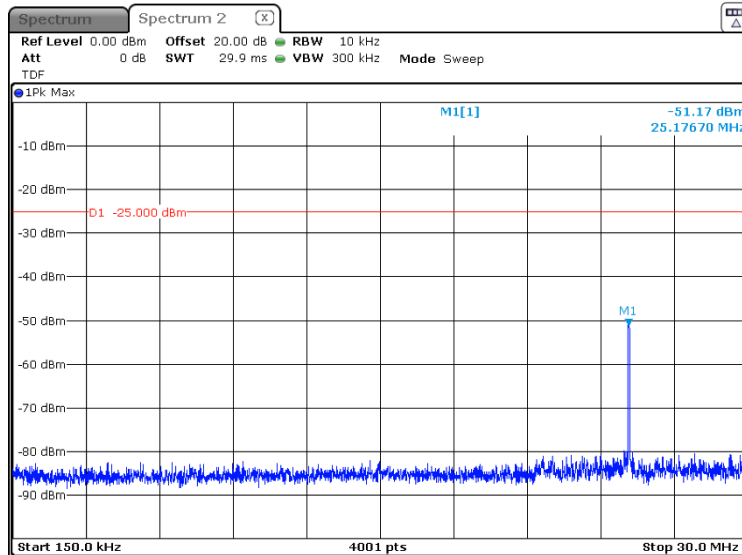


Test specification: Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 25-May-21 - 30-May-21			
Temperature: 24 °C	Relative Humidity: 51 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.5 Spurious emission measurements in 0.15 - 30 MHz range at mid carrier frequency



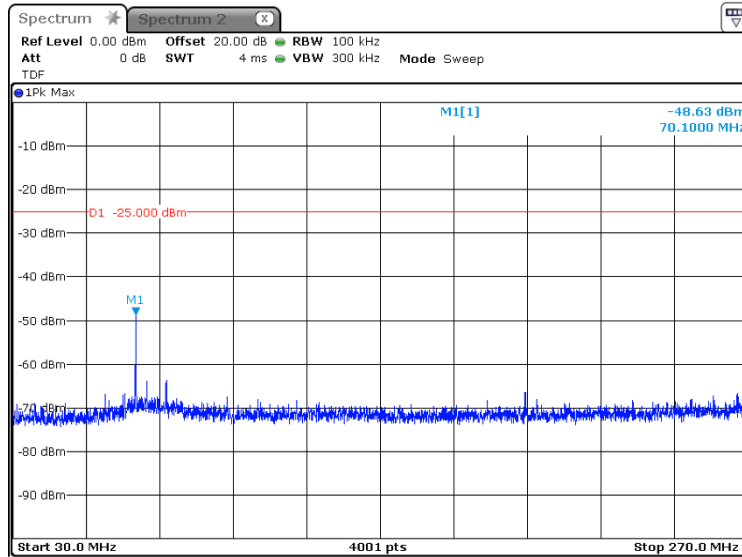
Plot 7.5.6 Spurious emission measurements in 0.15 - 30 MHz range at high carrier frequency



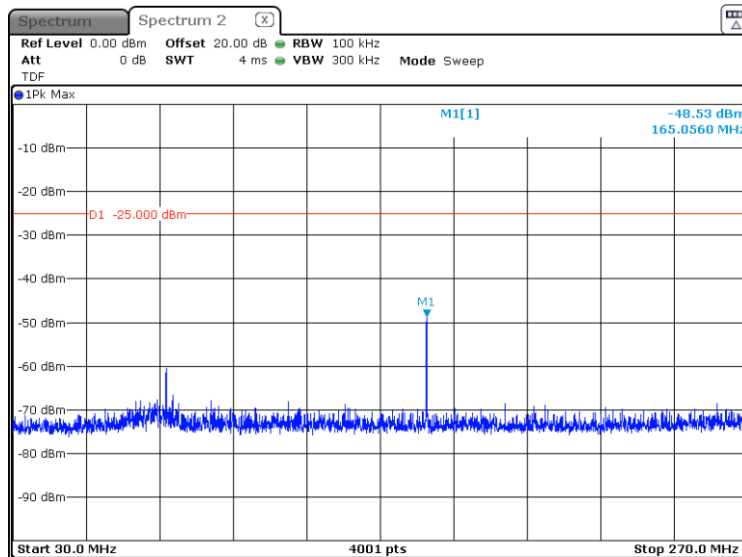


Test specification: Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 25-May-21 - 30-May-21			
Temperature: 24 °C	Relative Humidity: 51 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.7 Spurious emission measurements in 30 - 270 MHz range at low carrier frequency



Plot 7.5.8 Spurious emission measurements in 30 - 270 MHz range at mid carrier frequency

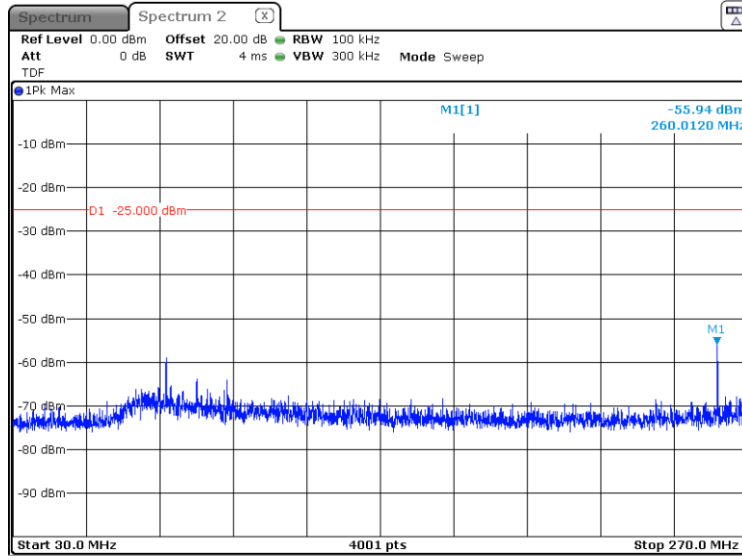




HERMON LABORATORIES

Test specification: Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 25-May-21 - 30-May-21			
Temperature: 24 °C	Relative Humidity: 51 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.9 Spurious emission measurements in 30 - 270 MHz range at high carrier frequency

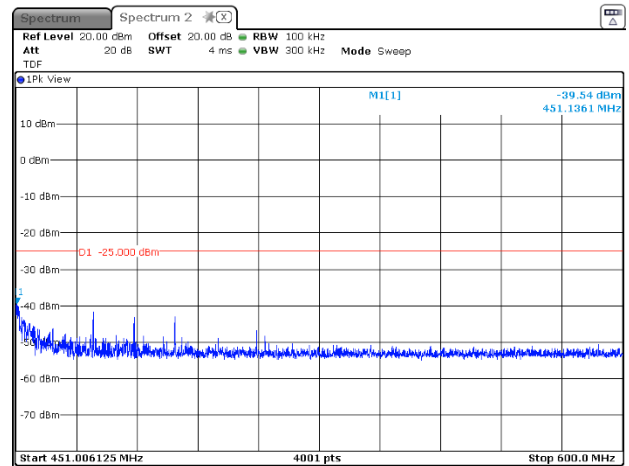
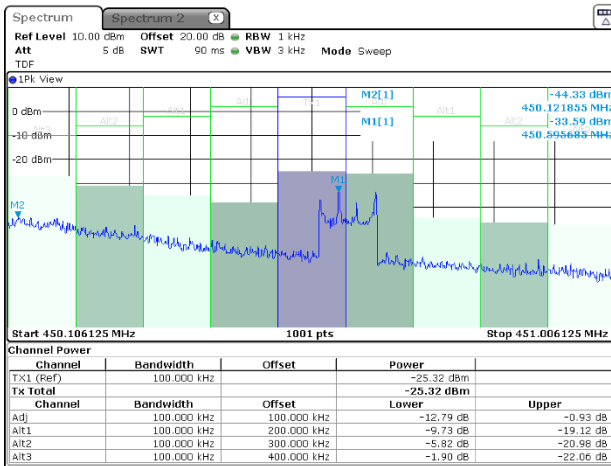
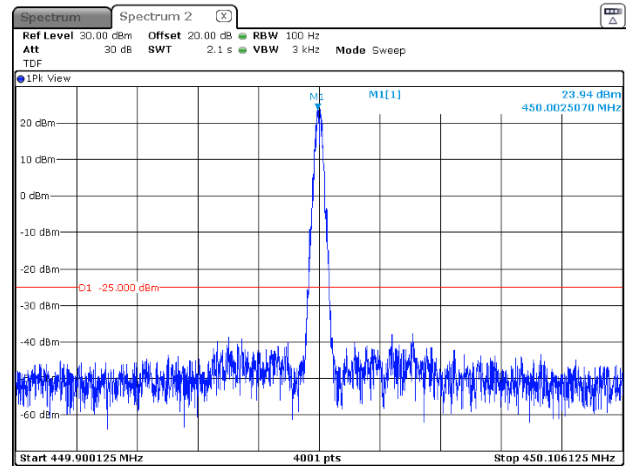
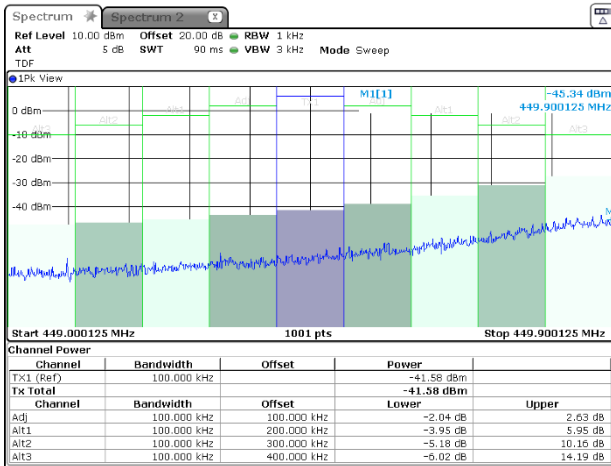
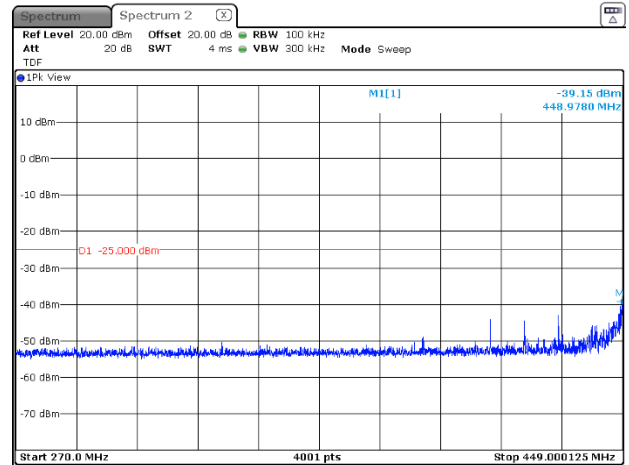
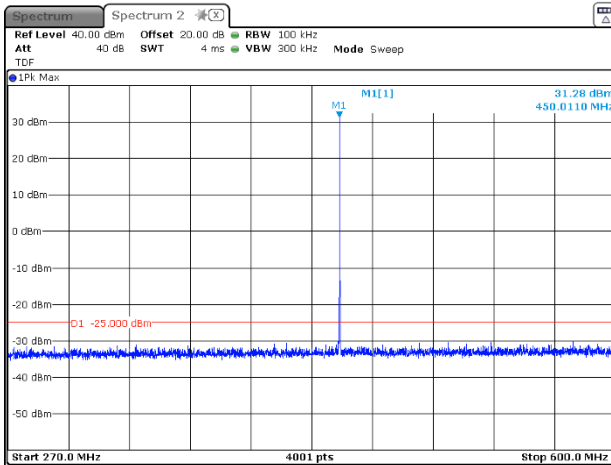




HERMON LABORATORIES

Test specification: Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 25-May-21 - 30-May-21			
Temperature: 24 °C	Relative Humidity: 51 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.10 Spurious emission measurements in 270 - 600 MHz range at low carrier frequency

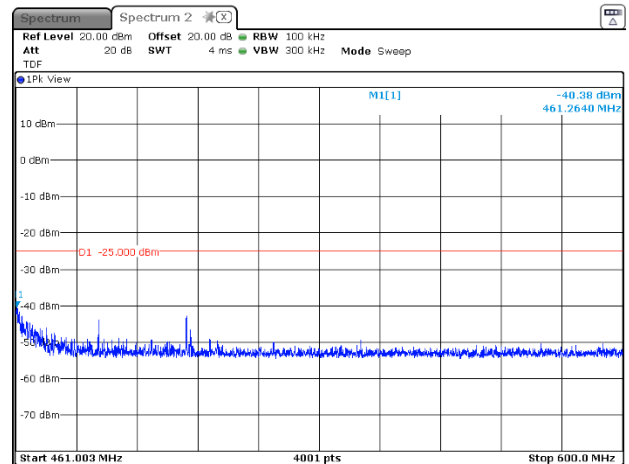
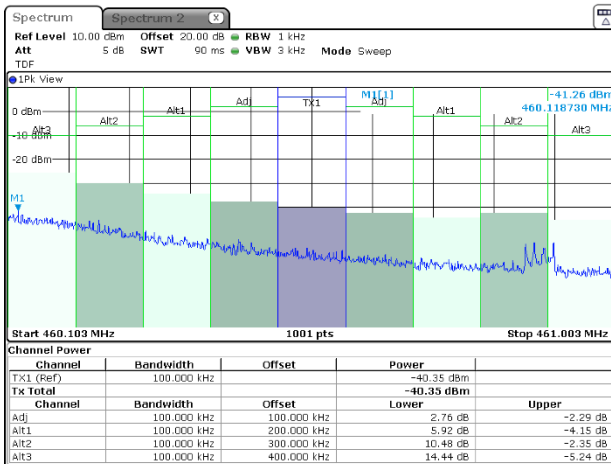
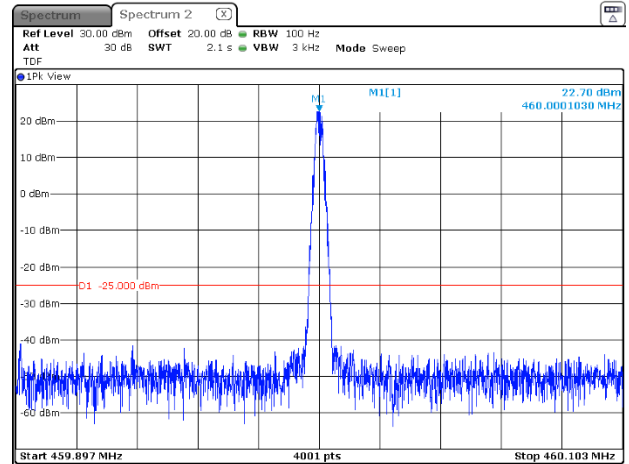
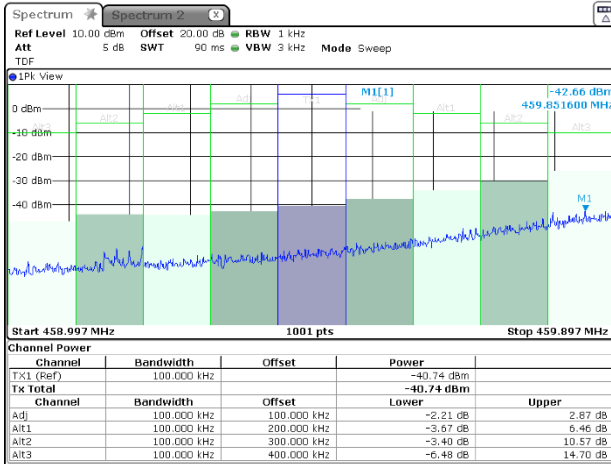
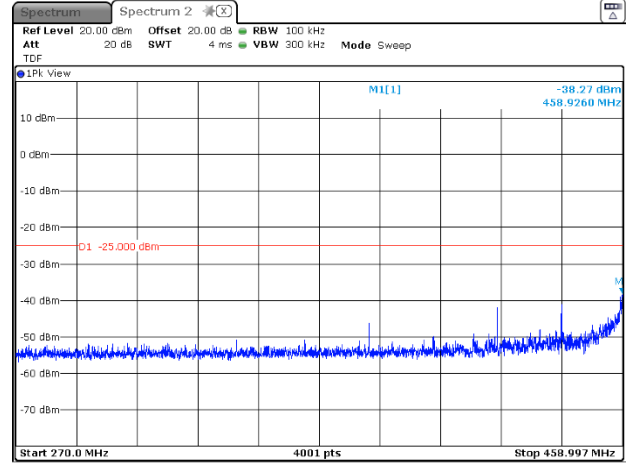
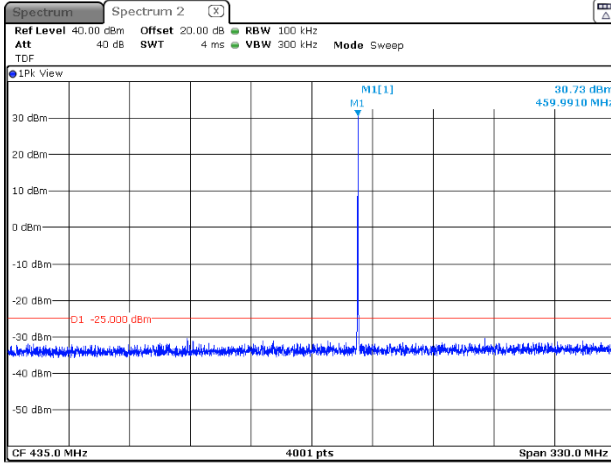




HERMON LABORATORIES

Test specification: Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 25-May-21 - 30-May-21			
Temperature: 24 °C	Relative Humidity: 51 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.11 Spurious emission measurements in 270 - 600 MHz range at mid carrier frequency

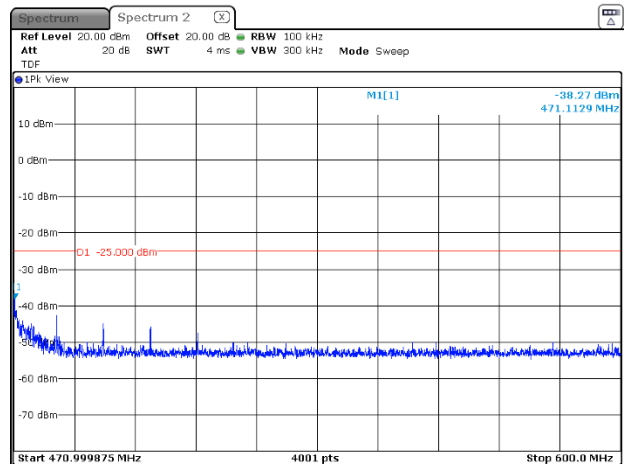
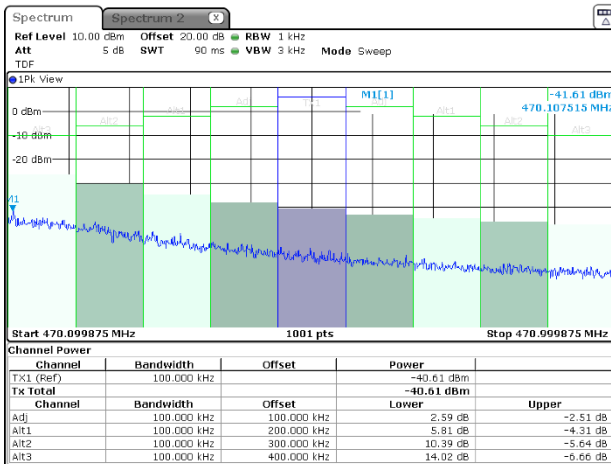
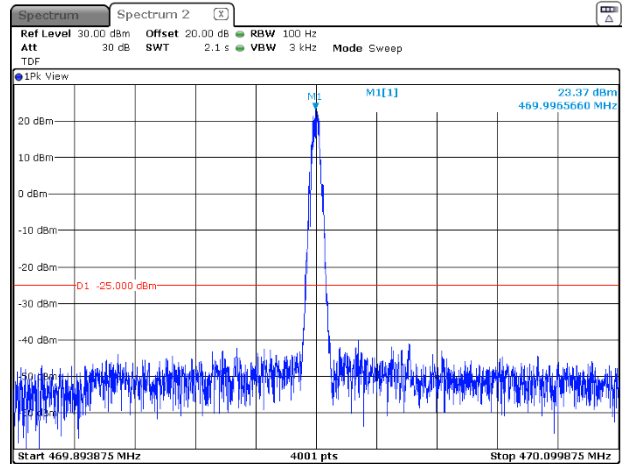
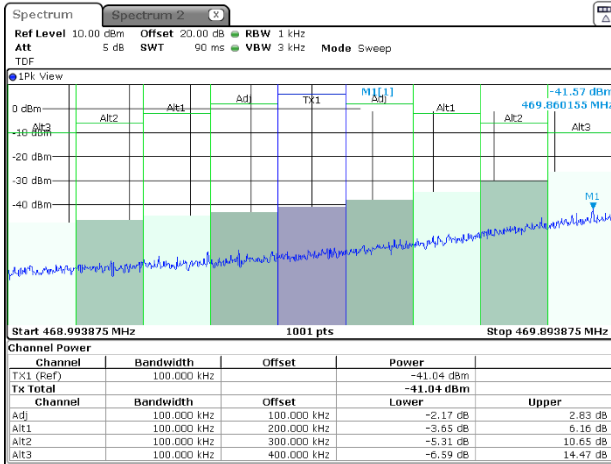
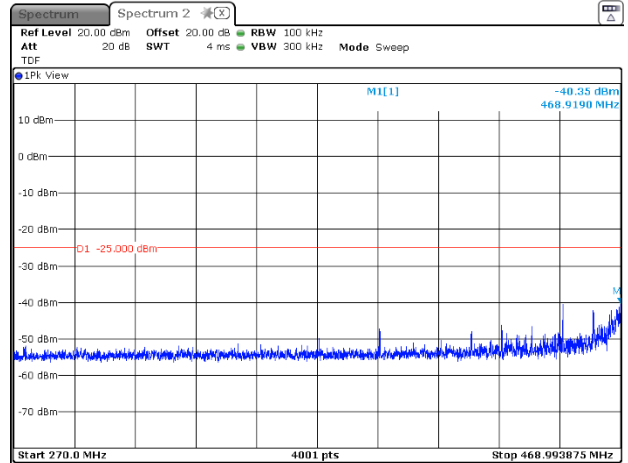
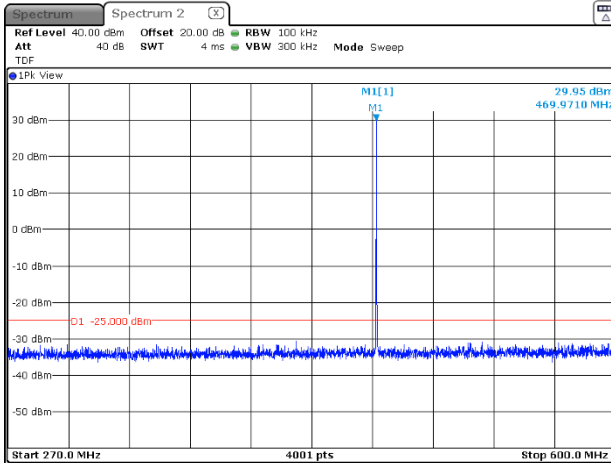




HERMON LABORATORIES

Test specification: Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions	
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13	
Test mode: Compliance	Verdict: PASS
Date(s): 25-May-21 - 30-May-21	
Temperature: 24 °C	Relative Humidity: 51 %
Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:	

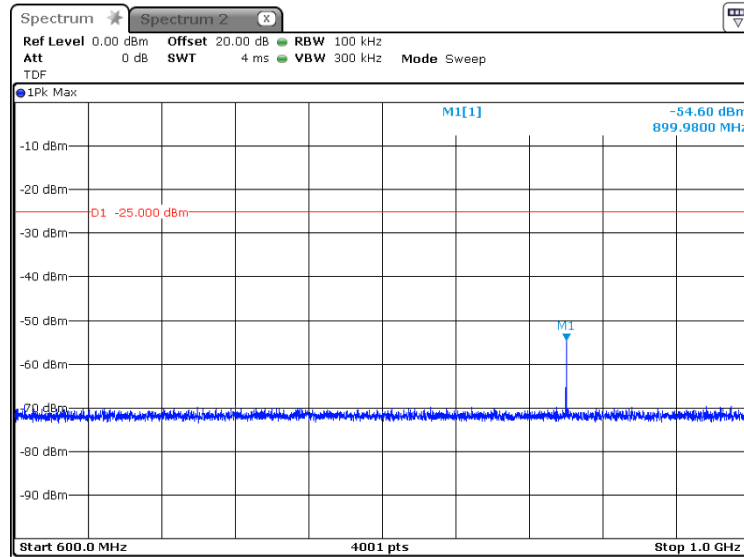
Plot 7.5.12 Spurious emission measurements in 270 - 600 MHz range at high carrier frequency



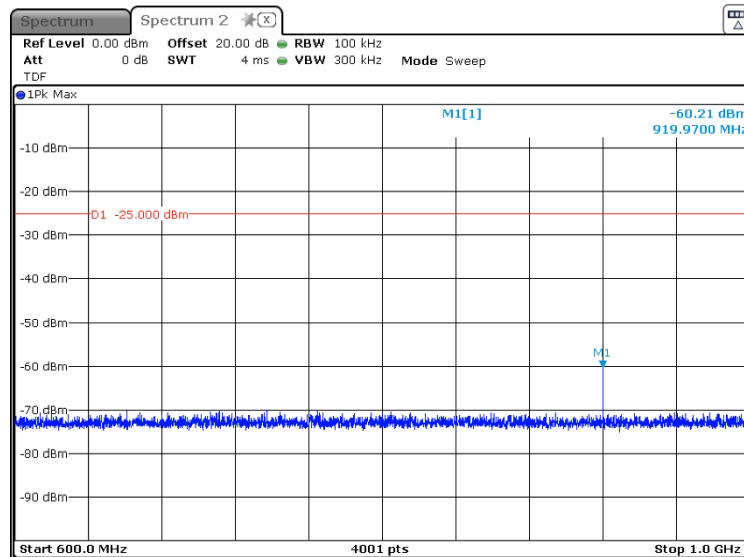


Test specification: Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 25-May-21 - 30-May-21			
Temperature: 24 °C	Relative Humidity: 51 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.13 Spurious emission measurements in 600 - 1000 MHz range at low carrier frequency



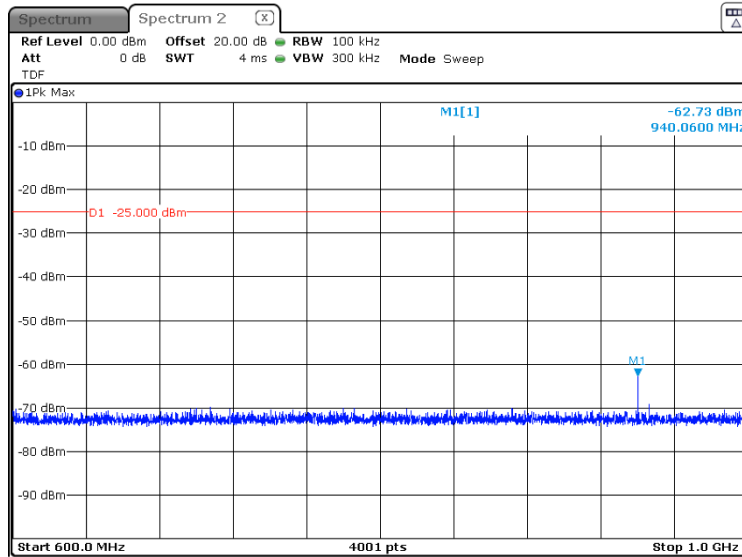
Plot 7.5.14 Spurious emission measurements in 600 - 1000 MHz range at mid carrier frequency



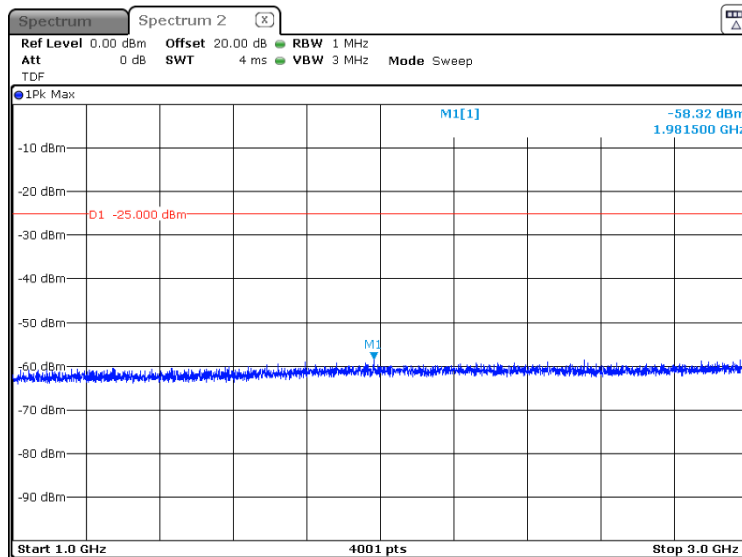


Test specification: Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 25-May-21 - 30-May-21			
Temperature: 24 °C	Relative Humidity: 51 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.15 Spurious emission measurements in 600 - 1000 MHz range at high carrier frequency



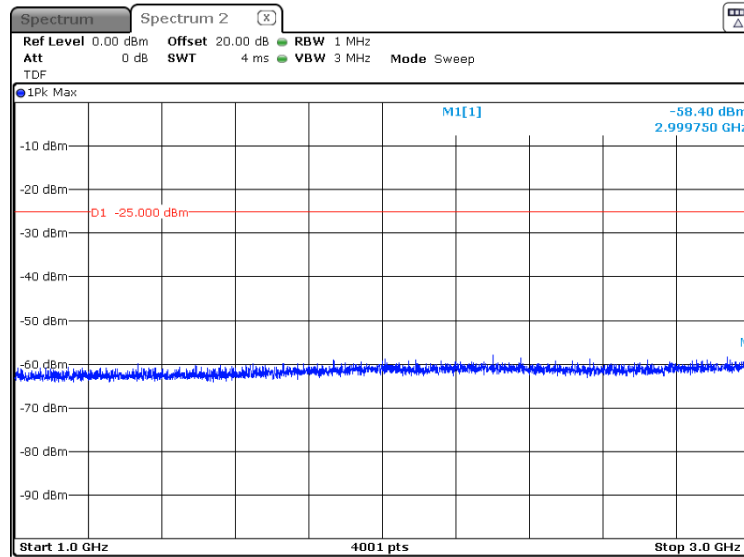
Plot 7.5.16 Spurious emission measurements in 1000 - 3000 MHz range at low carrier frequency



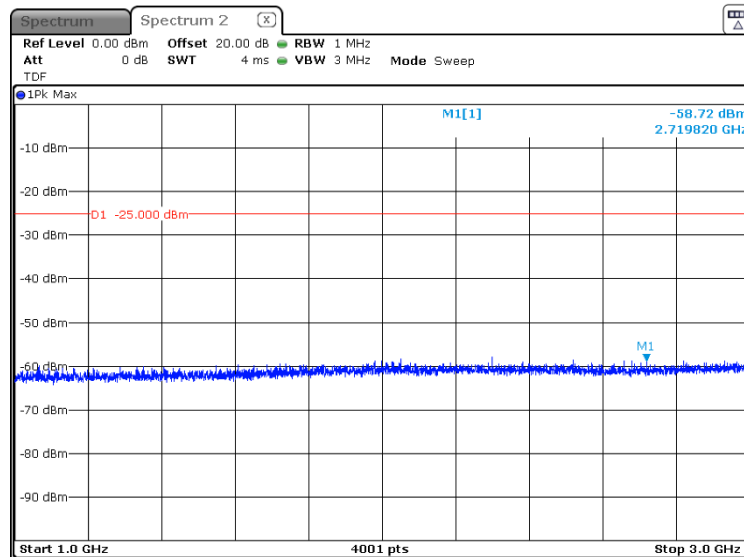


Test specification: Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 25-May-21 - 30-May-21			
Temperature: 24 °C	Relative Humidity: 51 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.17 Spurious emission measurements in 1000 - 3000 MHz range at mid carrier frequency



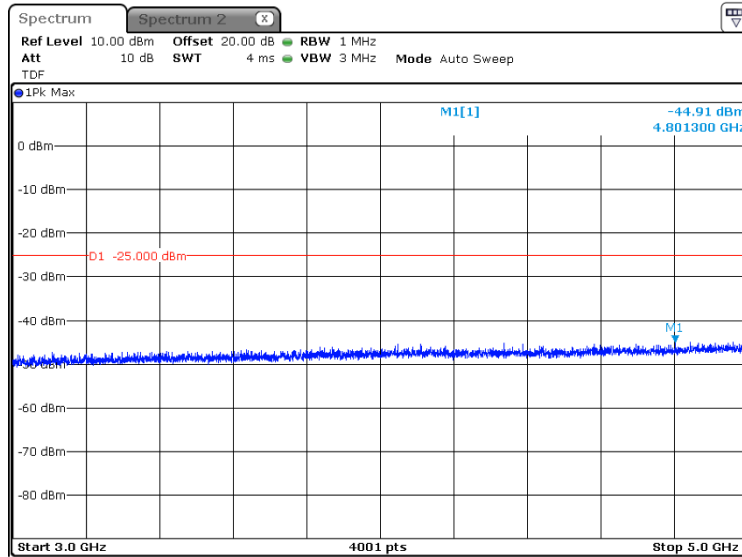
Plot 7.5.18 Spurious emission measurements in 1000 - 3000 MHz range at high carrier frequency



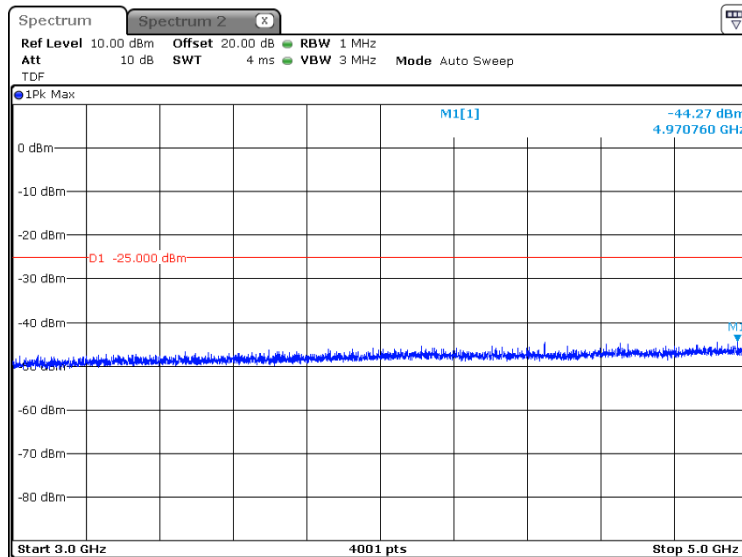


Test specification: Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 25-May-21 - 30-May-21			
Temperature: 24 °C	Relative Humidity: 51 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.19 Spurious emission measurements in 3000 - 5000 MHz range at low carrier frequency



Plot 7.5.20 Spurious emission measurements in 3000 - 5000 MHz range at mid carrier frequency

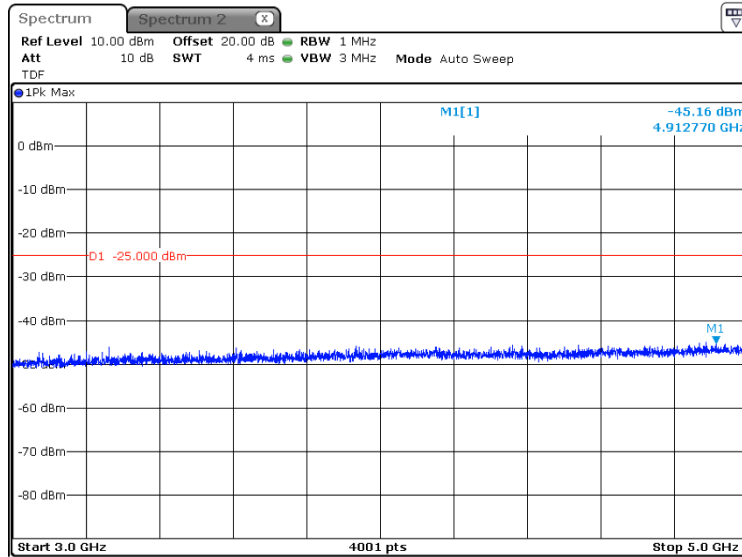




HERMON LABORATORIES

Test specification: Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions			
Test procedure: 47 CFR, Sections 2.1051 and 90.210(e); TIA/EIA-603-E, Section 2.2.13			
Test mode: Compliance		Verdict: PASS	
Date(s): 25-May-21 - 30-May-21			
Temperature: 24 °C	Relative Humidity: 51 %	Air Pressure: 1010 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.21 Spurious emission measurements in 3000 - 5000 MHz range at high carrier frequency





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): 23-May-21 - 24-May-21			
Temperature: 25 °C	Relative Humidity: 47 %	Air Pressure: 1008 hPa	Power: 3.6 VDC
Remarks:			

7.6 Frequency stability test

7.6.1 General

This test was performed to measure frequency stability of transmitter RF carrier. Specification test limits are given in Table 7.6.1.

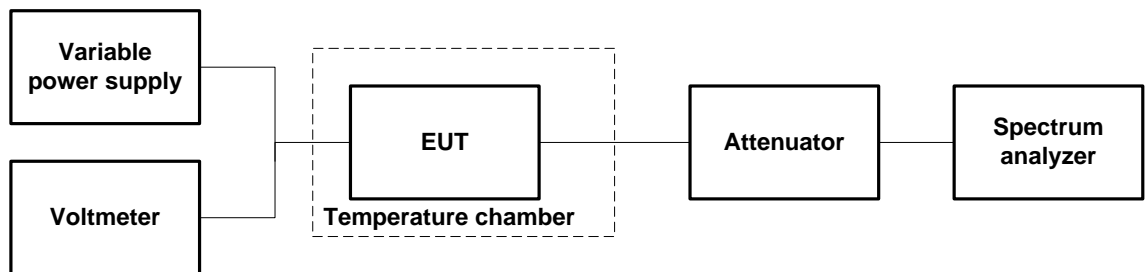
Table 7.6.1 Frequency stability limits

Assigned frequency, MHz	Maximum allowed frequency displacement	
	ppm	Hz
450.003125	1.0	450
460.000000		460
469.996875		470

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.
- 7.6.2.2 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.
- 7.6.2.3 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.
- 7.6.2.4 The above procedure was repeated at 0°C and at the lowest test temperature.
- 7.6.2.5 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.
- 7.6.2.6 Frequency displacement was calculated and compared with the limit as provided in Table 7.6.2.

Figure 7.6.1 Frequency stability test setup





Test specification: Section 90.213 / RSS-119 Section 5.3, Frequency stability			
Test procedure: 47 CFR, Section 2.1055; TIA/EIA-603-E, Section 2.2.2			
Test mode: Compliance		Verdict: PASS	
Date(s): 23-May-21 - 24-May-21			
Temperature: 25 °C	Relative Humidity: 47 %	Air Pressure: 1008 hPa	Power: 3.6 VDC
Remarks:			

Table 7.6.2 Frequency stability test results

OPERATING FREQUENCY: 450 – 470 MHz
 NOMINAL POWER VOLTAGE: 3.6 V DC
 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 450.003125 MHz													
-30	nominal	450.003047	450.003044	450.003089	450.003084	450.003101	450.003051	450.003054	123	0	450	-327	Pass
-20	nominal	450.002978	NA	NA	NA	NA	NA	450.002995	17	0		-433	Pass
-10	nominal	450.003032	NA	NA	NA	NA	NA	450.003039	61	0		-389	Pass
0	nominal	450.003026	450.003009	450.003009	450.003011	450.003012	450.003012	450.003010	48	0		-402	Pass
10	nominal	450.003067	NA	NA	NA	NA	NA	450.003043	89	0		-361	Pass
20	+15%	450.003015	NA	NA	NA	NA	NA	450.002957	37	-21		-413	Pass
20	nominal	450.003017	NA	NA	NA	NA	NA	450.002978	39	0		-411	Pass
20	-15%	450.003034	NA	NA	NA	NA	NA	450.003013	56	0		-394	Pass
30	nominal	450.003027	450.003001	450.002995	450.003003	450.003001	450.003004	450.003039	61	0		-389	Pass
40	nominal	450.003095	NA	NA	NA	NA	NA	450.003052	117	0		-333	Pass
50	nominal	450.003072	NA	NA	NA	NA	NA	450.003060	94	0		-356	Pass
Mid frequency 460.000000 MHz													
-30	nominal	459.999998	459.999946	460.000014	459.999944	460.000013	459.999961	459.999967	77	0	460	-383	Pass
-20	nominal	460.000034	NA	NA	NA	NA	NA	460.000065	128	0		-332	Pass
-10	nominal	460.000065	NA	NA	NA	NA	NA	460.000064	128	0		-332	Pass
0	nominal	460.000082	460.000076	460.000078	460.000074	460.000077	460.000073	460.000073	145	0		-315	Pass
10	nominal	460.000008	NA	NA	NA	NA	NA	459.999919	71	-18		-389	Pass
20	+15%	459.999977	NA	NA	NA	NA	NA	459.999943	40	0		-420	Pass
20	nominal	459.999971	NA	NA	NA	NA	NA	459.999937	34	0		-426	Pass
20	-15%	459.999965	NA	NA	NA	NA	NA	459.999947	28	0		-432	Pass
30	nominal	459.999976	459.999939	459.999966	459.999971	459.999954	459.999939	459.999979	42	0		-418	Pass
40	nominal	459.999978	NA	NA	NA	NA	NA	459.999969	41	0		-419	Pass
50	nominal	459.999933	NA	NA	NA	NA	NA	459.999927	0	-10		-450	Pass
High frequency 469.996875 MHz													
-30	nominal	469.996840	469.996918	469.996922	469.996945	469.996915	469.996925	469.996964	247	0	470	-223	Pass
-20	nominal	469.996906	NA	NA	NA	NA	NA	469.996896	189	0		-281	Pass
-10	nominal	469.996901	NA	NA	NA	NA	NA	469.996900	184	0		-286	Pass
0	nominal	469.996902	469.996898	469.996897	469.996889	469.996888	469.996888	469.996888	185	0		-285	Pass
10	nominal	469.996849	NA	NA	NA	NA	NA	469.996824	132	0		-338	Pass
20	+15%	469.996811	NA	NA	NA	NA	NA	469.996781	94	0		-376	Pass
20	nominal	469.996761	NA	NA	NA	NA	NA	469.996717	44	0		-426	Pass
20	-15%	469.996826	NA	NA	NA	NA	NA	469.996823	109	0		-361	Pass
30	nominal	469.996788	469.996752	469.996776	469.996752	469.996788	469.996772	469.996784	71	0		-399	Pass
40	nominal	469.996774	NA	NA	NA	NA	NA	469.996754	57	0		-413	Pass
50	nominal	469.996774	NA	NA	NA	NA	NA	469.996759	57	0		-413	Pass

* - Reference frequency

Reference numbers of test equipment used

HL 4355	HL 5623					
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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-A, Section 2.2.19			
Test mode: Compliance		Verdict: PASS	
Date(s): 31-May-21			
Temperature: 26 °C	Relative Humidity: 42 %	Air Pressure: 1005 hPa	Power: 3.6 VDC
Remarks:			

7.7 Transient frequency behaviour test

7.7.1 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 7.7.1.

Table 7.7.1 Transient frequency limits

Channel bandwidth, kHz	Carrier frequency tolerance, kHz	Duration, ms	Time interval*
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;
t₁ is the time period immediately following t_{on};
t₂ is the time period immediately following t₁;
t₃ 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.

7.7.2 Test procedure

- 7.7.2.1 The EUT was set up as shown in Figure 7.7.1, 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.
- 7.7.2.2 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.
- 7.7.2.3 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.
- 7.7.2.4 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.
- 7.7.2.5 The test results are provided in Table 7.7.2 and the associated plots.



Test specification: Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour			
Test procedure: TIA/EIA-603-A, Section 2.2.19			
Test mode: Compliance		Verdict: PASS	
Date(s): 31-May-21			
Temperature: 26 °C	Relative Humidity: 42 %	Air Pressure: 1005 hPa	Power: 3.6 VDC
Remarks:			

Figure 7.7.1 Transient frequency test setup

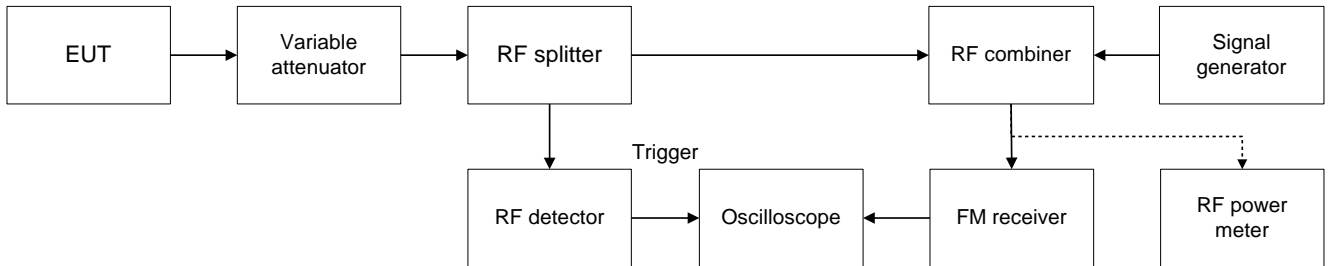


Table 7.7.2 Transient frequency behaviour test results

Carrier frequency, MHz	Time interval	Duration, ms	Frequency tolerance, kHz	Limit, kHz	Margin, kHz	Verdict
Channel bandwidth 6.25 kHz						
450.003125	t ₁	10.0	-2.500	± 6.25	-3.750	Pass
	t ₂	25.0	-0.234	± 3.125	-2.891	
	t ₃	10.0	-0.625	± 6.25	-5.625	
460.000000	t ₁	10.0	1.875	± 6.25	-4.375	Pass
	t ₂	25.0	0.547	± 3.125	-2.578	
	t ₃	10.0	0.625	± 6.25	-5.625	
469.996875	t ₁	10.0	-3.281	± 6.25	-2.969	Pass
	t ₂	25.0	-0.234	± 3.125	-2.891	
	t ₃	10.0	0.469	± 6.25	-5.781	

Reference numbers of test equipment used

HL 2016	HL 2017	HL 2227	HL 2358	HL 3433	HL 3434	HL 4366	HL 5369
HL 5371	HL 5372	HL 5472					

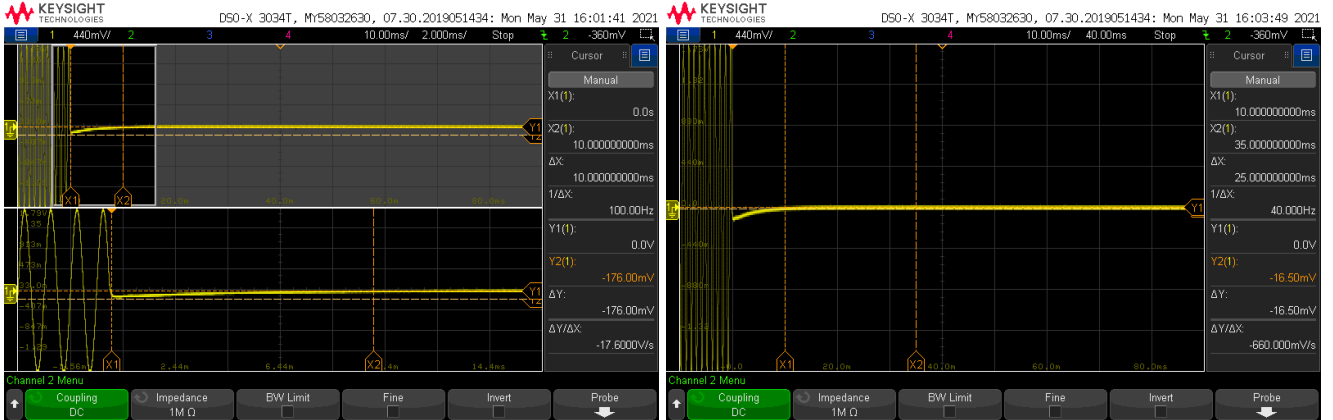
Full description is given in Appendix A.



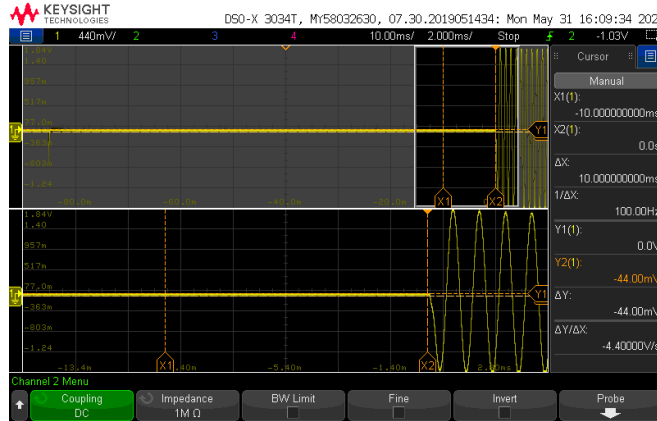
HERMON LABORATORIES

Test specification: Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour			
Test procedure: TIA/EIA-603-A, Section 2.2.19			
Test mode: Compliance		Verdict:	PASS
Date(s): 31-May-21			
Temperature: 26 °C	Relative Humidity: 42 %	Air Pressure: 1005 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.7.1 Transient frequency during power ON test results at low carrier frequency



Plot 7.7.2 Transient frequency during power OFF test results at low carrier frequency





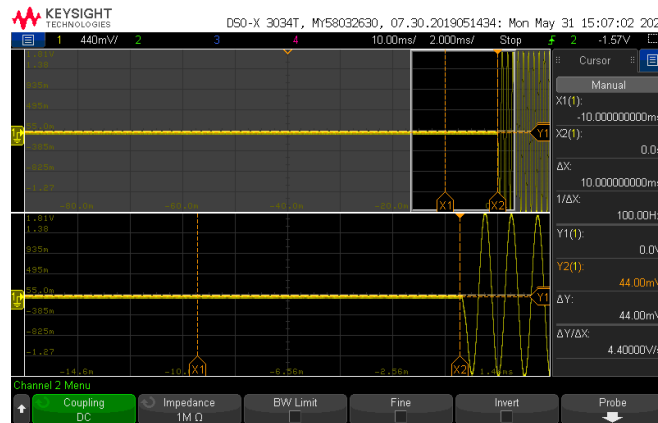
HERMON LABORATORIES

Test specification: Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour			
Test procedure: TIA/EIA-603-A, Section 2.2.19			
Test mode: Compliance		Verdict:	PASS
Date(s): 31-May-21			
Temperature: 26 °C	Relative Humidity: 42 %	Air Pressure: 1005 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.7.3 Transient frequency during power ON test results at mid carrier frequency



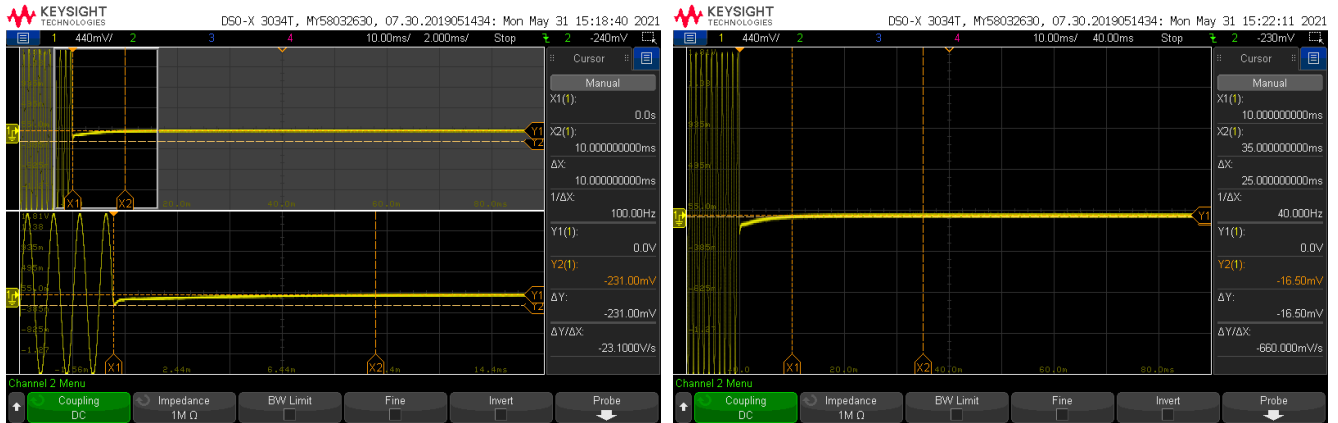
Plot 7.7.4 Transient frequency during power OFF test results at mid carrier frequency



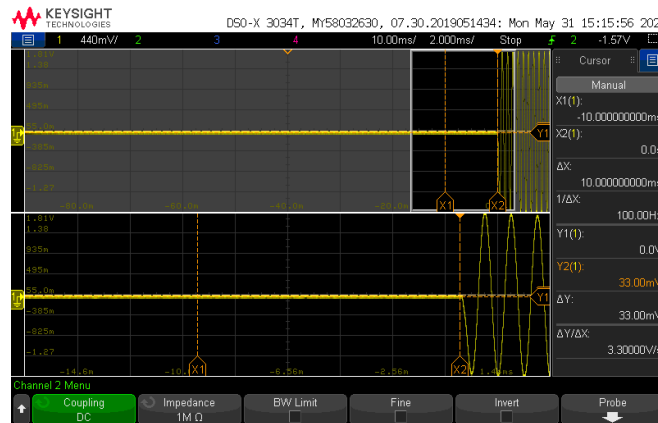


Test specification: Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour			
Test procedure: TIA/EIA-603-A, Section 2.2.19			
Test mode: Compliance		Verdict:	PASS
Date(s): 31-May-21			
Temperature: 26 °C	Relative Humidity: 42 %	Air Pressure: 1005 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.7.5 Transient frequency during power ON test results at high carrier frequency



Plot 7.7.6 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
0446	Antenna, Loop, Active, 10 (9) kHz - 30 MHz	EMCO	6502	2857	28-Feb-21	28-Feb-22
2016	Attenuator, Manual Step, 0-9/1 dB, 0-8 GHz, 2 W	Midwest Microwave	1072	1315	13-Apr-21	13-Apr-22
2017	Attenuator, Manual Step, 0-60/10 dB, 0-8.0 GHz	Midwest Microwave	1071	2017	13-Apr-21	13-Apr-22
2227	Crystal Detector 0.01-18 GHz, 100 mW	Hewlett Packard Co	8472A	NA	24-Dec-19	24-Dec-21
2358	Power Supply, 2 X 0-36VDC / 5A, 5VDC / 5A	Horizon Electronics	DHR3655 D	767469	25-Jun-20	25-Jun-21
2909	Spectrum analyzer, ESA-E, 100 Hz to 26.5 GHz	Agilent Technologies	E4407B	MY414447 62	12-May-21	12-Jun-22
3339	High Pass Filter, 50 Ohm, 600 to 3000 MHz.	Mini-Circuits	SHP-600+	NA	05-Jun-19	05-Jun-21
3433	Test Cable , DC-18 GHz, 1.5 m, SMA - SMA	Mini-Circuits	CBL-5FT-SMSM+	25679	19-Apr-21	19-Apr-22
3434	Test Cable , DC-18 GHz, 1.5 m, SMA - SMA	Mini-Circuits	CBL-5FT-SMSM+	25683	19-Apr-21	19-Apr-22
3766	Attenuator, N-type, 20 dB, DC to 18 GHz, 5 W	Mini-Circuits	BW-N20W5+	NA	15-Sep-20	15-Sep-21
3901	Microwave Cable Assembly, 40.0 GHz, 3.5 m, SMA/SMA	Huber-Suhner	SUCOFL EX 102A	1225/2A	06-Apr-21	06-Apr-22
3903	Microwave Cable Assembly, 40.0 GHz, 1.5 m, SMA/SMA	Huber-Suhner	SUCOFL EX 102A	1226/2A	06-Apr-21	06-Apr-22
4280	Test Cable , DC-18 GHz, 4.6 m, N/M - N/M	Mini-Circuits	APC-15FT-NMNM+	0763A	03-Aug-20	03-Aug-21
4339	High pass Filter, 50 Ohm, 1000 to 18000 MHz, SMA-FM / SMA-M	Micro-Tronics	HPM5011 5-02	001	05-Jun-19	05-Jun-21
4355	Signal and Spectrum Analyzer, 9 kHz to 7 GHz	Rohde & Schwarz	FSV 7	101630	09-Sep-20	09-Sep-21
4360	EMI Test Receiver, 20 Hz to 40 GHz.	Rohde & Schwarz	ESU40	100322	19-Jan-21	19-Jan-22
4366	Directional coupler, 1 GHz to 18 GHz, 10 dB, SMA Female	Tiger Micro-Electronics Institute	TGD-A1101-10	01e-JSDE805-007	03-Jun-20	03-Jun-22
4914	Bandpass filter, 600 to 1100 MHz, SMA/F-SMA/F	K&L Microwave Inc.	7IB44-900/U600 -O/O	24	05-Jun-19	05-Jun-21
4933	Active Horn Antenna, 1 GHz to 18 GHz	COM-POWER CORPORATION	AHA-118	701046	26-Jan-21	26-Jan-22
5288	Trilog Antenna, 25 MHz - 8 GHz, 100W	Frankonia	ALX-8000E	00809	08-Feb-19	08-Feb-22



HL No	Description	Manufacturer	Model	Ser. No.	Last Cal./ Check	Due Cal./ Check
5369	Digital storage oscilloscope, 350 MHz	Keysight Technologies	DSOX3034T	MY58032630	01-Jun-20	01-Aug-21
5371	EXG Analog Signal Generator, 9 kHz - 40 GHz	Keysight Technologies	N5173B	MY57280540	25-Aug-20	25-Aug-21
5372	MXE EMI receiver, 3 Hz to 44 GHz	Keysight Technologies	N9038A	MY57290155	15-Mar-21	15-Mar-22
5404	RF cable, 18 GHz, N-N, 6 m	Huber-Suhner	SF118/11N(x2)	500024/18	19-Nov-20	19-Nov-21
5409	RF cable, 40 GHz, SMA-SMA, 2 m	Huber-Suhner	SF102EA/11SK/11SK/2000MM	503973/2EA	03-Aug-20	03-Aug-21
5472	Power Splitter / Combiner 0.5-1 GHz	Mini Circuits	ZAPD-1	NA	28-Jan-21	28-Jan-23
5623	Precision Fixed Attenuator, 50 Ohm, 5 W, 20 dB, DC to 18 GHz	Mini Circuits	BW-N20W5+	NA	14-Sep-20	14-Sep-21
5902	RF cable, 18 GHz, 6.0m, N-type	Huber-Suhner	SF126EA/11N/11N/6000		01-Dec-20	01-Dec-21



9 APPENDIX B Test equipment correction factors

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

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

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

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

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 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.



HL 5405: RF Cable
Huber-Suhner, model: SF118/11N(x2), s/n: 500023/118

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



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 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.



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 relevant parts of Code of Federal Regulations 47 (CFR 47), Test Firm Registration Number is 927748, Designation Number is IL1001; Recognized by Innovation, Science and Economic Development Canada for wireless and terminal testing (ISED), ISED #2186A, CAB identifier is IL1001; Certified by VCCI, Japan (the registration numbers for OATS are R-10808 for RE measurements below 1 GHz, G-20112 for RE measurements above 1 GHz, R-11082 for anechoic chamber for RE measurements below 1 GHz, G-10869 for RE measurements above 1 GHz, C-10845 for conducted emissions site and T-11606 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: 2020
FCC 47CFR part 2: 2020
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