HERMON LABORATORIES

ELECTRICAL TESTING
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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: ALLEGRO3E

FCC ID: NTA2W4GB3

IC: 4732A-2W4GB3

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 11
7.3 Emission mask test 14
7.4 Radiated spurious emission measurements 18
7.5 Spurious emissions at RF antenna connector test 25
7.6 Frequency stability test 41
7.7 Transient frequency behavior test 43
8 APPENDIX A Test equipment and ancillaries used for tests 48
9 APPENDIX B Test equipment correction factors 50
10 APPENDIX C Measurement uncertainties 52
11 APPENDIX D Test laboratory description 53
12 APPENDIX E Specification references 53
13 APPENDIX F Abbreviations and acronyms 54

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 name:	Water meter with external antenna
Product type:	Transceiver
Model(s):	ALLEGRO3E
Serial number:	0145514
Hardware version:	REV D
Software release:	4.65
Receipt date	12-Oct-23

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:	52275
Location:	Hermon Laboratories Ltd. 66 HaTachana str., P.O. Box 23, Binyamina 3055001, Israel
Test started:	10-Dec-23
Test completed:	17-Dec-23
Test specification(s):	FCC part 90, subpart I; RSS-119 isue 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

Testing was completed against all relevant requirements of the test standard. However, 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. Shabi, test engineer, EMC & Radio	10-Dec-23 – 17-Dec-23	
Reviewed by:	Mrs. S. Peysahov Sheynin, certification specialist, EMC & Radio	18-Feb-24	
Approved by:	Mr. M. Nikishin, group leader, EMC & Radio	20-Mar-24	

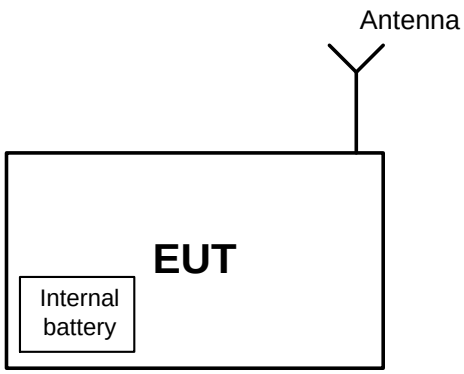
6 EUT description

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	31.34 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	X	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;		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 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

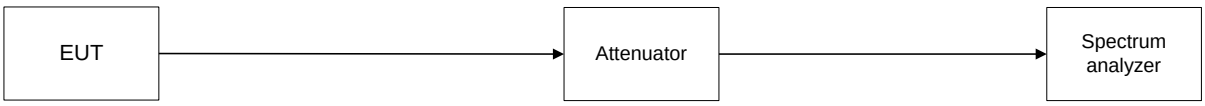
7.1.2 Test procedure

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;		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 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	31.34	33	-1.66	Pass
460.000000	31.12	33	-1.88	Pass
469.996875	30.79	33	-2.21	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	31.34	47.78	-16.44	Pass
460.000000	31.12	47.78	-16.66	Pass
469.996875	30.79	47.78	-16.99	Pass

*- Margin = Peak output power – specification limit.

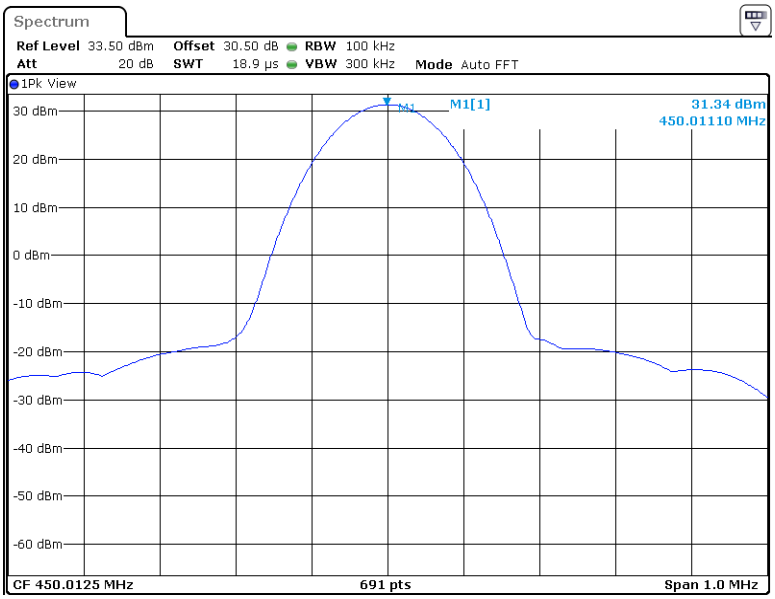
Reference numbers of test equipment used

HL 4355	HL 4136	HL 5589	HL 5594	HL 5622			

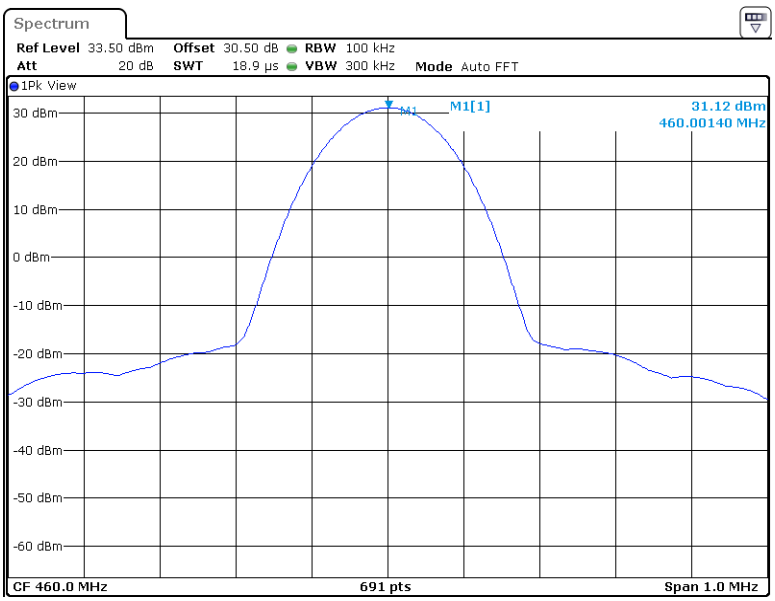
Full description is given in Appendix A.

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):	10-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.1.1 Peak output power test results at low frequency

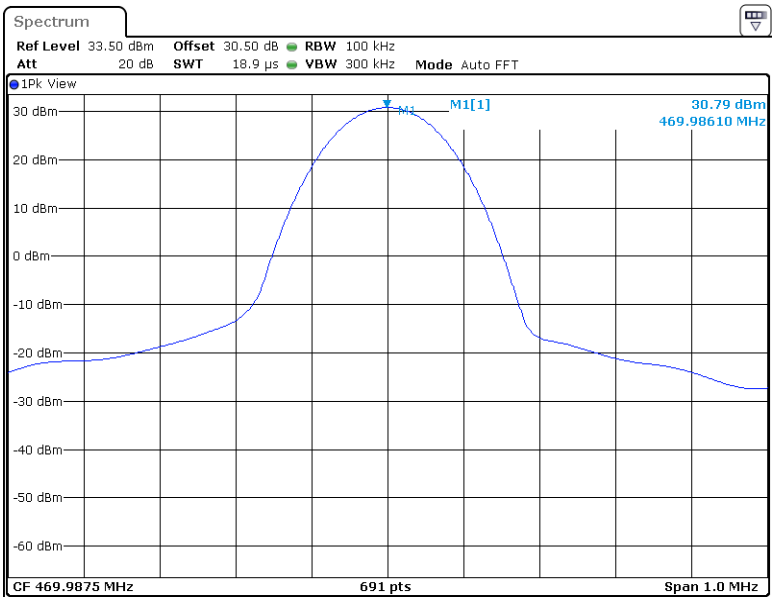


Plot 7.1.2 Peak output power test results at mid frequency



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):	10-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

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):	10-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 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

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):	10-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

Table 7.2.2 Occupied bandwidth test results

DETECTOR USED: Peak hold
RESOLUTION BANDWIDTH: 200 Hz
VIDEO BANDWIDTH: 1 kHz
MODULATION: 4GFSK

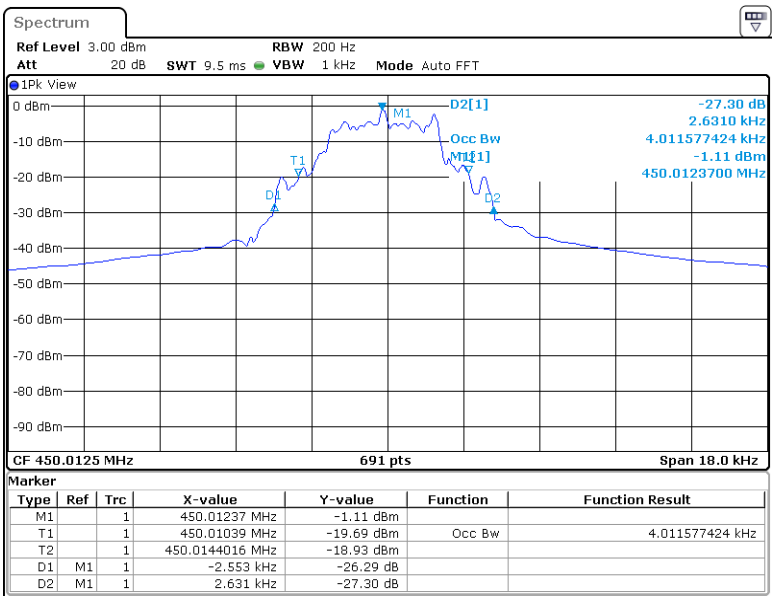
Carrier frequency, MHz	Occupied bandwidth, kHz	Limit, kHz	Margin, kHz	Verdict
MODULATION ENVELOPE REFERENCE POINTS: 99%				
450.0125	4.011	6.250	-2.497	Pass
460.0000	3.933	6.250	-2.455	Pass
469.9875	3.933	6.250	-2.412	Pass
MODULATION ENVELOPE REFERENCE POINTS: 26 dBc				
450.003125	5.184	6.250	-1.324	Pass
460.000000	5.210	6.250	-1.224	Pass
469.996875	5.184	6.250	-1.175	Pass

Reference numbers of test equipment used

HL 4355	HL5622	HL 5589	HL 5594				

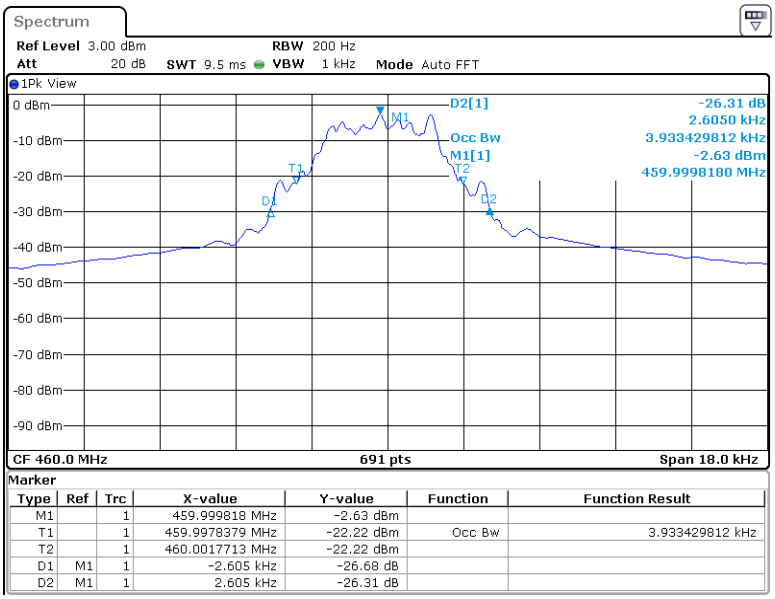
Full description is given in Appendix A.

Plot 7.2.1 Occupied bandwidth test result at low frequency



Test specification:	Section 90.209 / RSS-119 Section 5.5, Occupied bandwidth		
Test procedure:	47 CFR, Section 2.1049		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

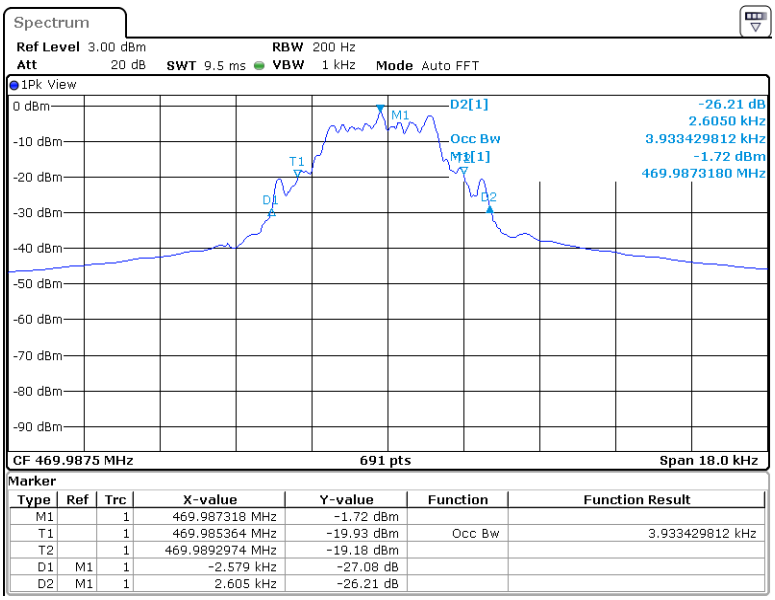
Plot 7.2.2 Occupied bandwidth test result at mid frequency



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	459.999818 MHz	-2.63 dBm		
T1		1	459.9978379 MHz	-22.22 dBm	Occ Bw	3.933429812 kHz
T2		1	460.0017713 MHz	-22.22 dBm		
D1	M1	1	-2.605 kHz	-26.68 dB		
D2	M1	1	2.605 kHz	-26.31 dB		

Plot 7.2.3 Occupied bandwidth test result at high frequency



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	469.987318 MHz	-1.72 dBm		
T1		1	469.985364 MHz	-19.93 dBm	Occ Bw	3.933429812 kHz
T2		1	469.9892974 MHz	-19.18 dBm		
D1	M1	1	-2.579 kHz	-27.08 dB		
D2	M1	1	2.605 kHz	-26.21 dB		

Test specification:	**Section 90.210 / RSS-119 Section 5.8.4, Emission mask**		
Test procedure:	47 CFR, Sections 2.1051, 2.1047		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	10-Dec-23		
Temperature: 24 ºC	**Relative Humidity:** 56 %	**Air Pressure:** 1012 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. The test results are provided in the associated plots.

Table 7.3.1 Emission mask limits

Frequency displacement from carrier	Attenuation below carrier, dBc
Emission mask E (Channel bandwidth 6.25 kHz, authorized bandwidth 6.0 kHz)	
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.

Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Emission mask		
Test procedure:	47 CFR, Sections 2.1051, 2.1047		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

Figure 7.3.1 Emission mask test setup

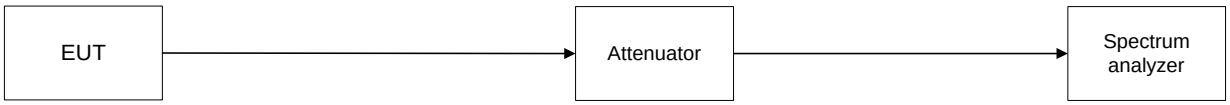


Table 7.3.2 Emission mask test results

Carrier frequency, MHz	Limit	Verdict
450.0125	Emission mask E	Pass
460.0000		
469.9875		

Reference numbers of test equipment used

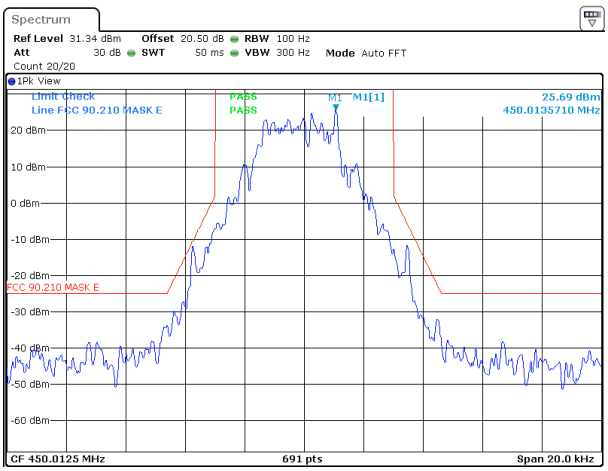
HL 4355	HL 5589	HL 5622	HL 5589				

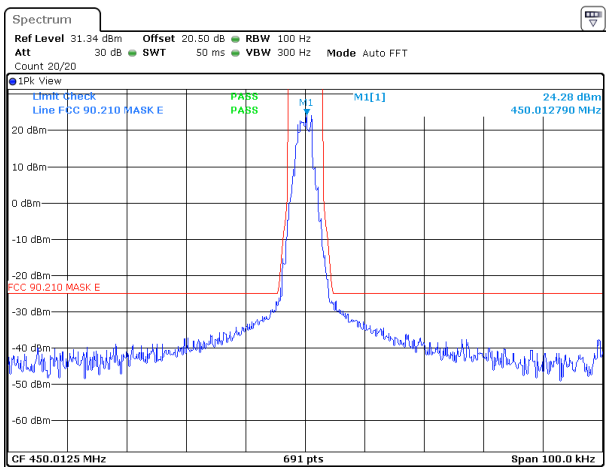
Full description is given in Appendix A.

Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Emission mask		
Test procedure:	47 CFR, Sections 2.1051, 2.1047		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.3.1 Emission mask test results at low carrier frequency FCC part 90.210(e) and RSS 119

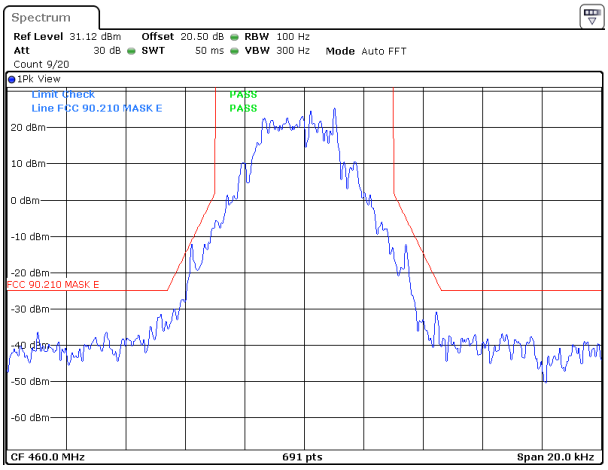
OPERATING FREQUENCY RANGE: 450 – 470 MHz
DETECTOR USED: Peak
MODULATION: 4GFSK
TRANSMITTER OUTPUT POWER SETTINGS: Maximum

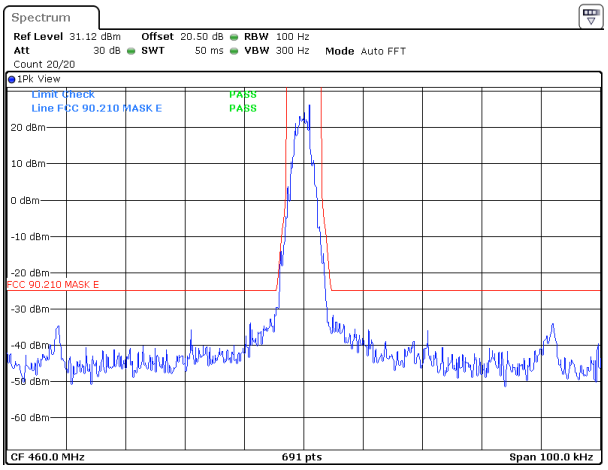




Plot 7.3.2 Emission mask test results at mid carrier frequency FCC part 90.210(e) and RSS 119

OPERATING FREQUENCY RANGE: 450 – 470 MHz
DETECTOR USED: Peak
MODULATION: 4GFSK
TRANSMITTER OUTPUT POWER SETTINGS: Maximum

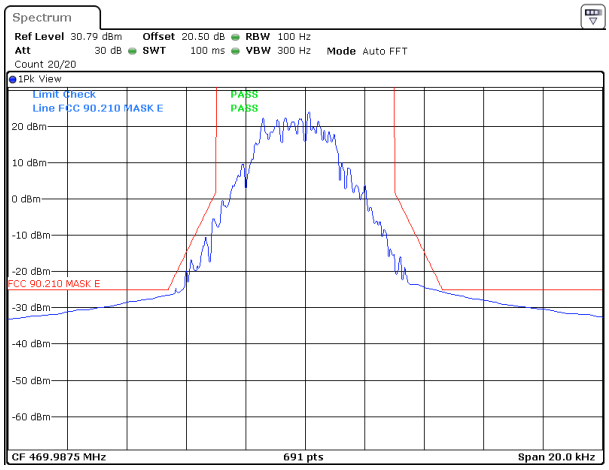


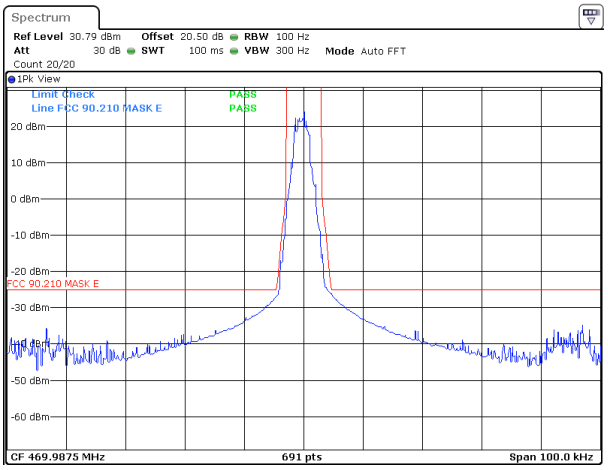


Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Emission mask		
Test procedure:	47 CFR, Sections 2.1051, 2.1047		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.3.3 Emission mask test results at high carrier frequency FCC part 90.210(e) and RSS 119

OPERATING FREQUENCY RANGE: 450 – 470 MHz
DETECTOR USED: Peak
MODULATION: 4GFSK
TRANSMITTER OUTPUT POWER SETTINGS: Maximum





Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	17-Dec-23		
Temperature: 24 ºC	Relative Humidity: 48 %	Air Pressure: 1012 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	72.35

* - 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×P×1.64)/r, where P is ERP in Watts, 1.64 is numeric gain of ideal dipole and r is antenna to EUT distance in meters

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

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

7.4.2.2 The specified frequency range was investigated with antenna connected to spectrum analyzer. To find maximum radiation the turntable was rotated 360^0 and the measuring antenna was rotated around its vertical axis.

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

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

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

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

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

Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	17-Dec-23		
Temperature: 24 ºC	Relative Humidity: 48 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

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

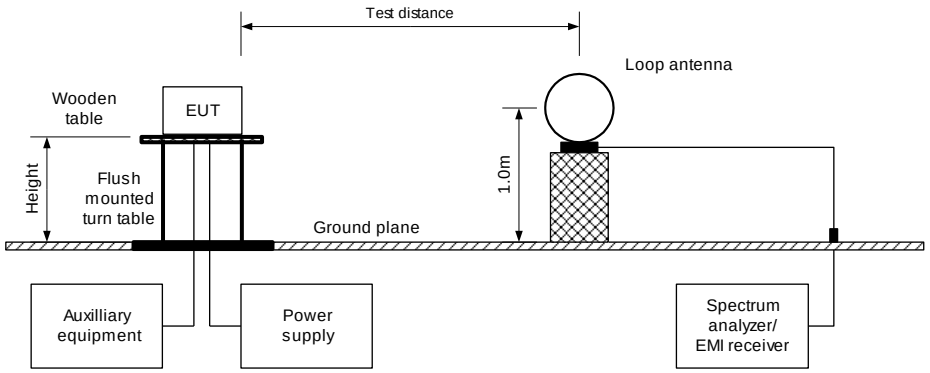
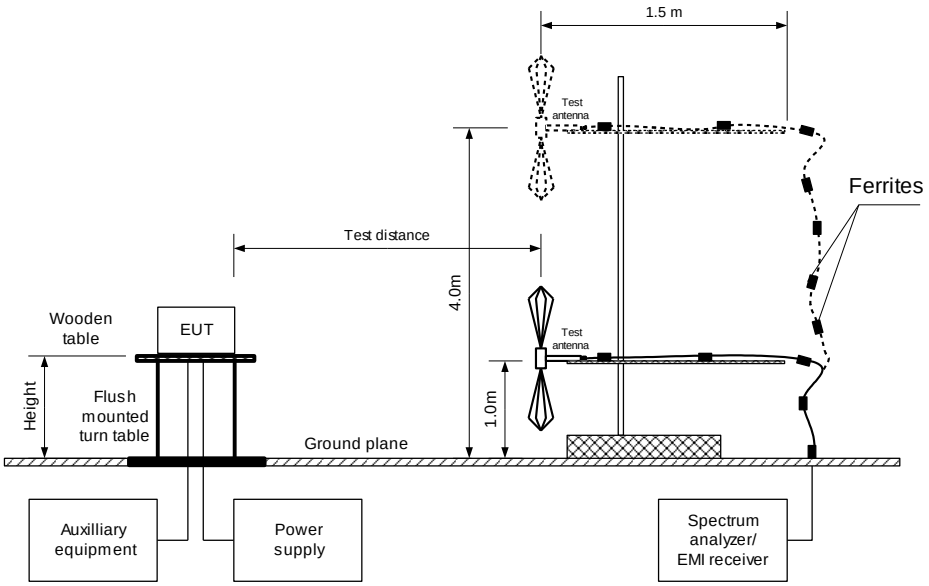


Figure 7.4.2 Setup for spurious emission field strength measurements above 30 MHz



Test specification:	**Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions**		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	17-Dec-23		
Temperature: 24 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 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
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

Frequency, MHz	**Field strength, dB(µV/m)**	**Limit, dB(µV/m)**	**Margin, dB***	**RBW, kHz**	**Antenna polarization**	**Antenna height, m**	**Turn-table position**, degrees**
Low, mid, high carrier frequency							
At least 15 dB bellow limit							

*****- 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

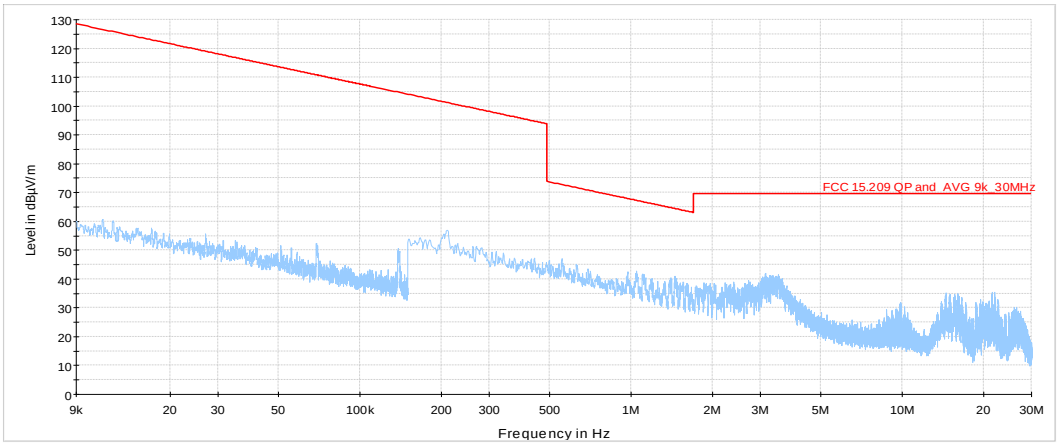
HL 3339	HL 3903	HL 4339	HL 4933	HL 5288	HL 5902	HL 7585	

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		
Test mode:	Compliance	Verdict:	PASS
Date(s):	17-Dec-23		
Temperature: 24 ºC	Relative Humidity: 48 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

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

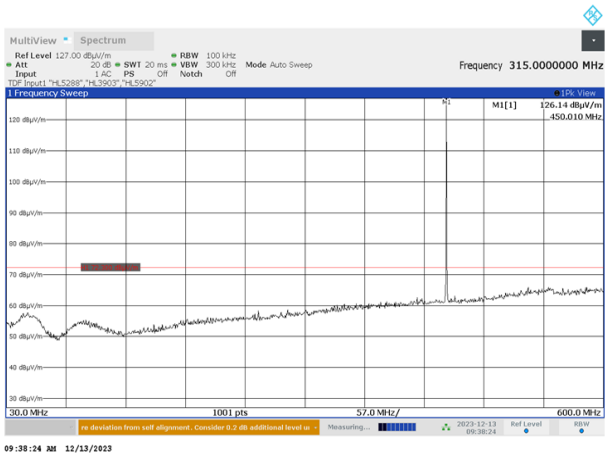
TEST SITE:	Semi anechoic chamber
CARRIER FREQUENCY:	Low, Mid, High
ANTENNA POLARIZATION:	Vertical and Horizontal
TEST DISTANCE:	3 m

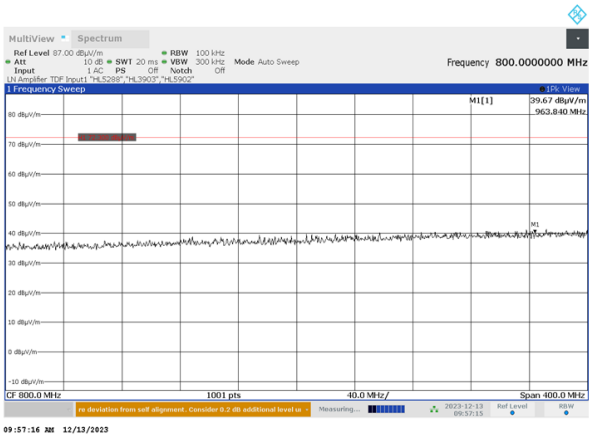


*Will be applied limit of 72.35 dbμV/m

Plot 7.4.2 Radiated emission measurements in 30 - 1000 MHz range

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

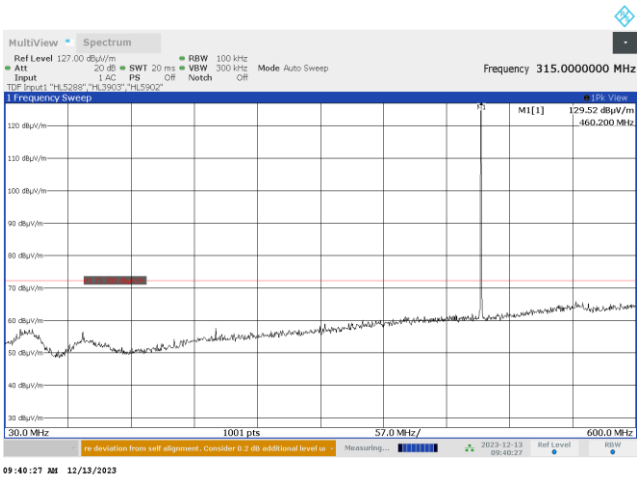


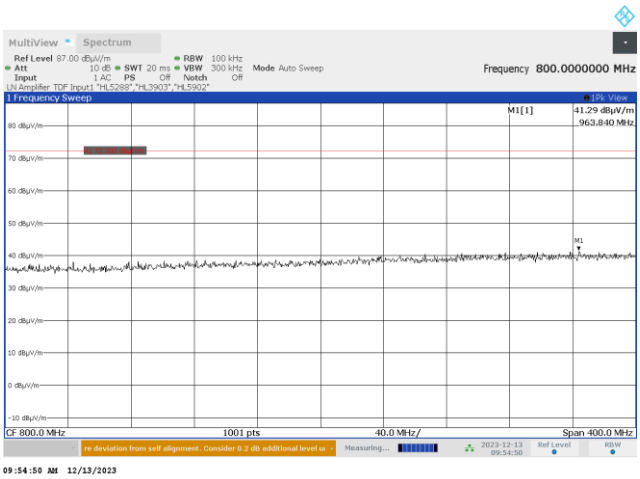


Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	17-Dec-23		
Temperature: 24 ºC	Relative Humidity: 48 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.4.3 Radiated emission measurements in 30 - 1000 MHz range

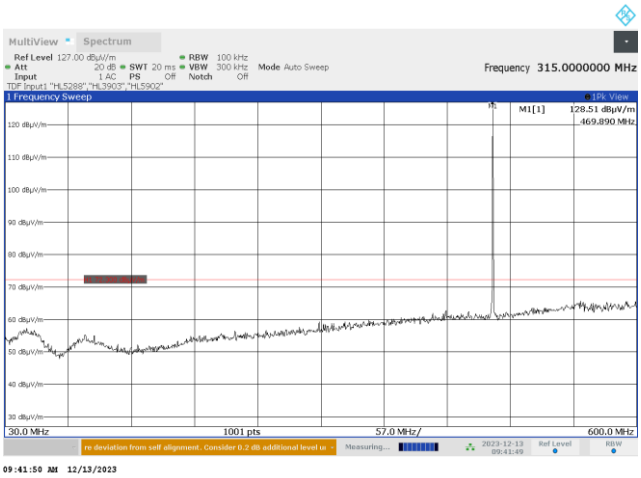
TEST SITE: Semi anechoic chamber
CARRIER FREQUENCY: Mid
ANTENNA POLARIZATION: Vertical and Horizontal
TEST DISTANCE: 3 m

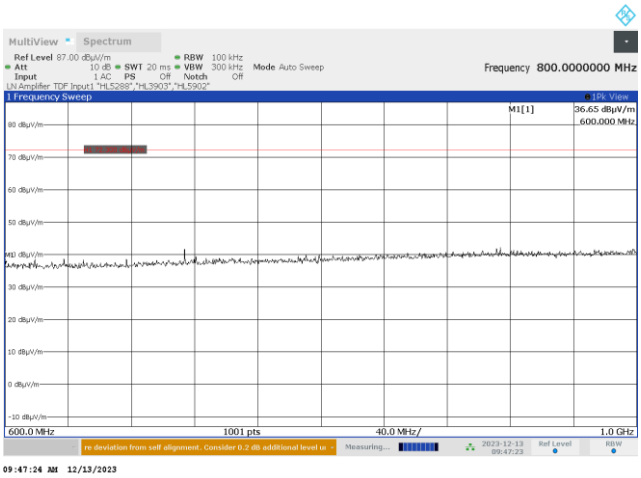




Plot 7.4.4 Radiated emission measurements in 30 - 1000 MHz range

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

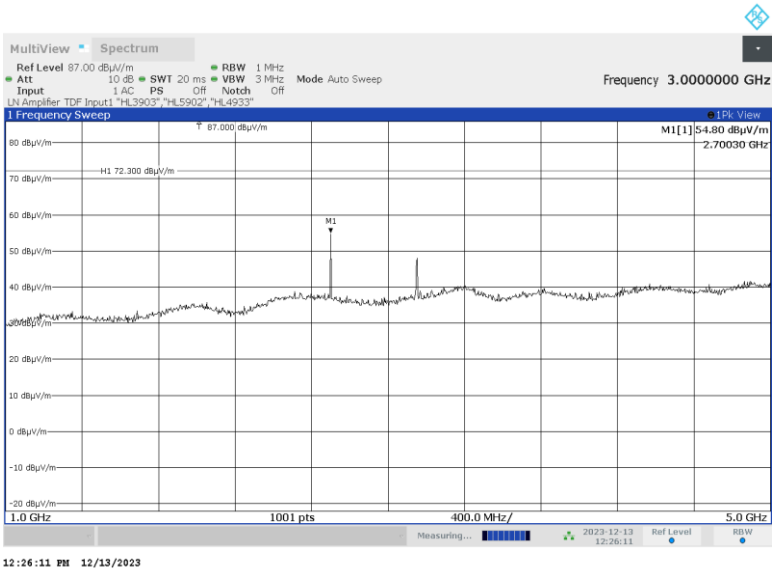




Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	17-Dec-23		
Temperature: 24 ºC	Relative Humidity: 48 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

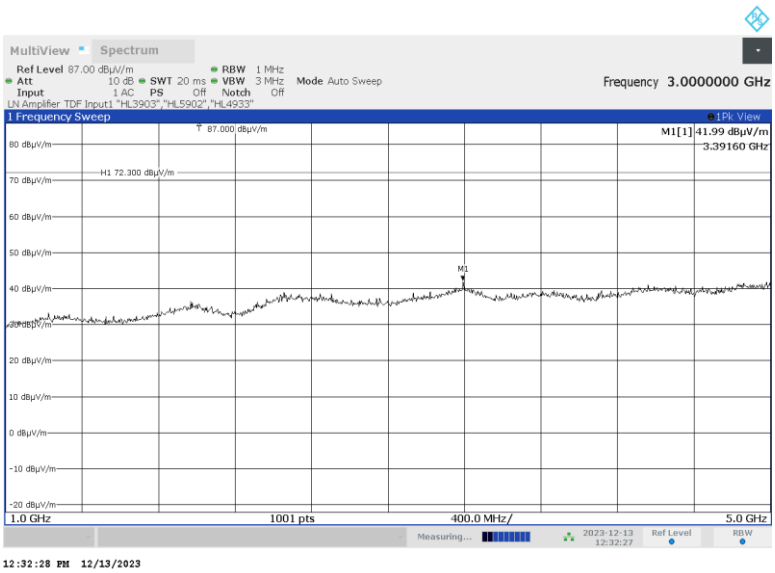
Plot 7.4.5 Radiated emission measurements in 1000 – 5000 MHz range

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



Plot 7.4.6 Radiated emission measurements in 1000 – 5000 MHz range

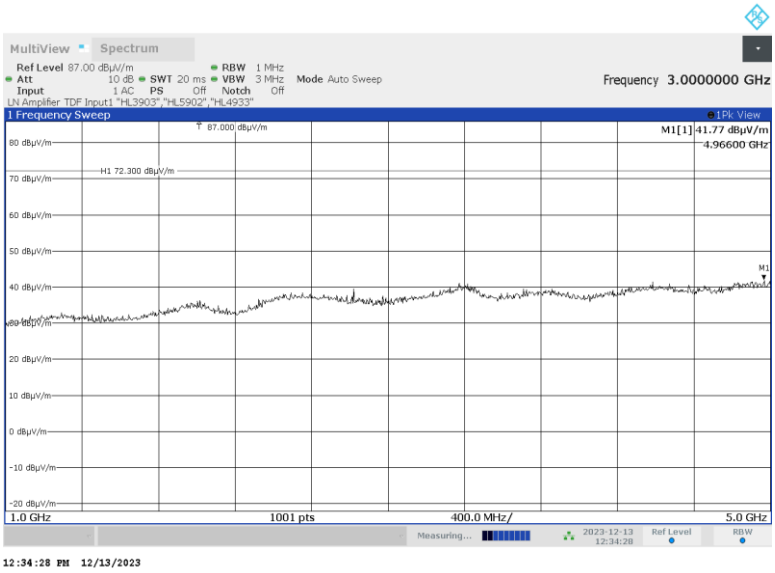
TEST SITE:	Semi anechoic chamber
CARRIER FREQUENCY:	Mid
ANTENNA POLARIZATION:	Vertical and Horizontal
TEST DISTANCE:	3 m



Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	17-Dec-23		
Temperature: 24 ºC	Relative Humidity: 48 %	Air Pressure: 1012 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:	High
ANTENNA POLARIZATION:	Vertical and Horizontal
TEST DISTANCE:	3 m



Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23 - 13-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 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. The test results are provided in Table 7.5.2 and associated plots.

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

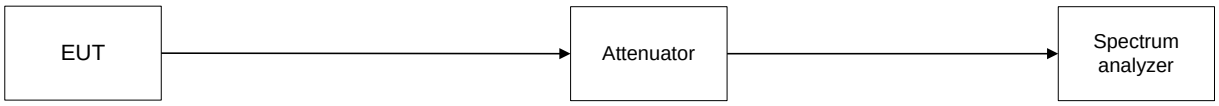
7.5.2 Test procedure

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		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	10-Dec-23 - 13-Dec-23		
Temperature: 24 ºC	**Relative Humidity:** 56 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.5.2 Spurious emission test results FCC 90.210 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
TRANSMITTER OUTPUT POWER: 31.34 dBm at low frequency
31.12 dBm at mid frequency
30.79 dBm at high frequency

Frequency, MHz	Spurious emission, dBm	RBW, kHz	Limit, dBm	Margin, dB*	Verdict
Low carrier frequency					
449.800	-32.89	100	-25.00	-7.89	Pass
449.900	-28.19	100	-25.00	-3.19	Pass
449.958	-25.92	1	-25.00	-0.92	Pass
450.067	-26.07	1	-25.00	-1.07	Pass
Mid carrier frequency					
459.544	-25.84	100	-25.00	-0.84	Pass
459.983	-31.31	1	-25.00	-6.31	Pass
460.019	-28.11	1	-25.00	-3.11	Pass
460.514	-26.47	100	-25.00	-1.47	Pass
High carrier frequency					
469.941	-28.78	1	-25.00	-3.78	Pass
470.029	-27.60	1	-25.00	-2.6	Pass
470.100	-25.33	100	-25.00	-0.33	Pass
470.200	-29.75	100	-25.00	-4.75	Pass

*****- Margin = Spurious emission – specification limit.

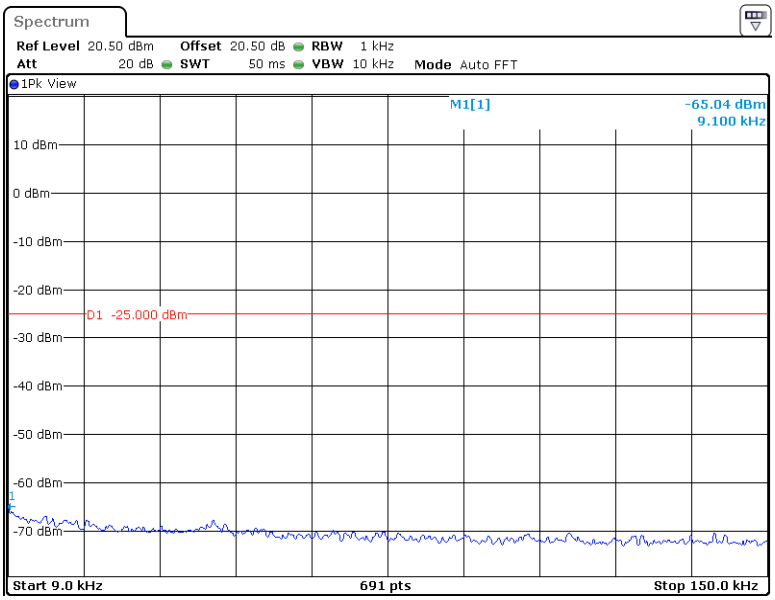
Reference numbers of test equipment used

HL 4355	HL 5589	HL 7521	HL 3339	HL 4339	HL 5594		

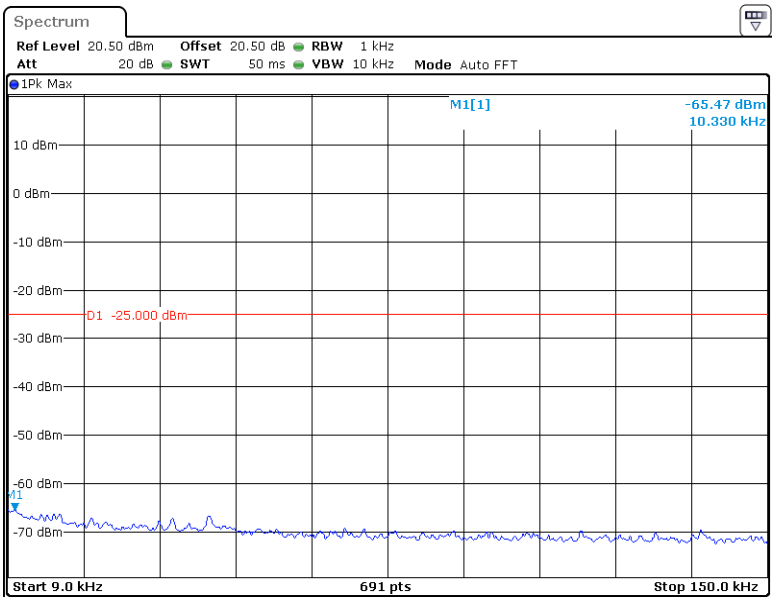
Full description is given in Appendix A.

Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23 - 13-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

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

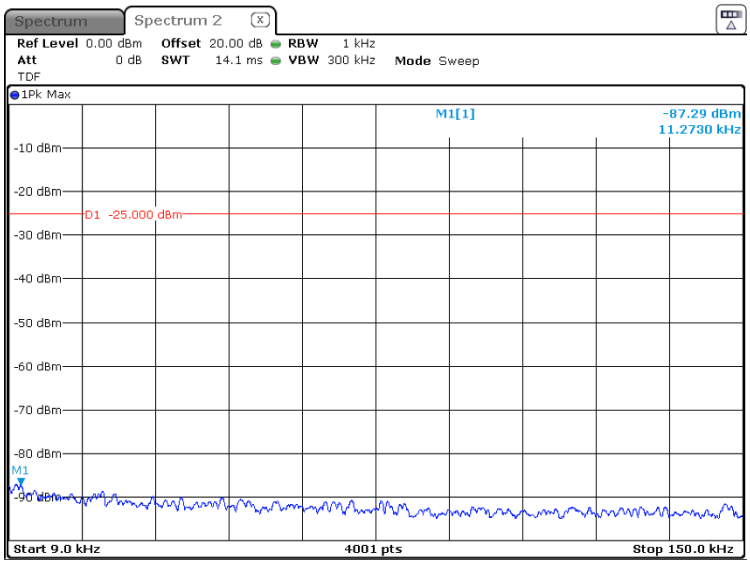


Plot 7.5.2 Spurious emission measurements in 9 - 150 kHz range at mid carrier frequency

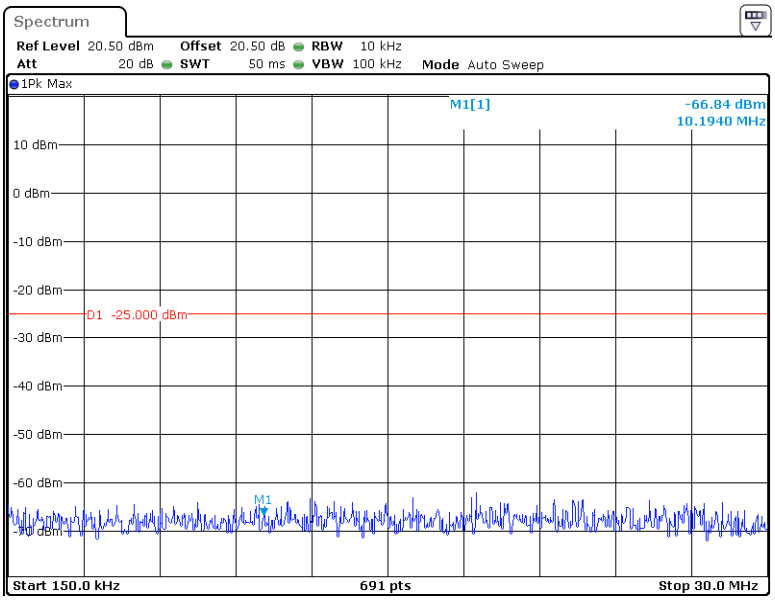


Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23 - 13-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

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

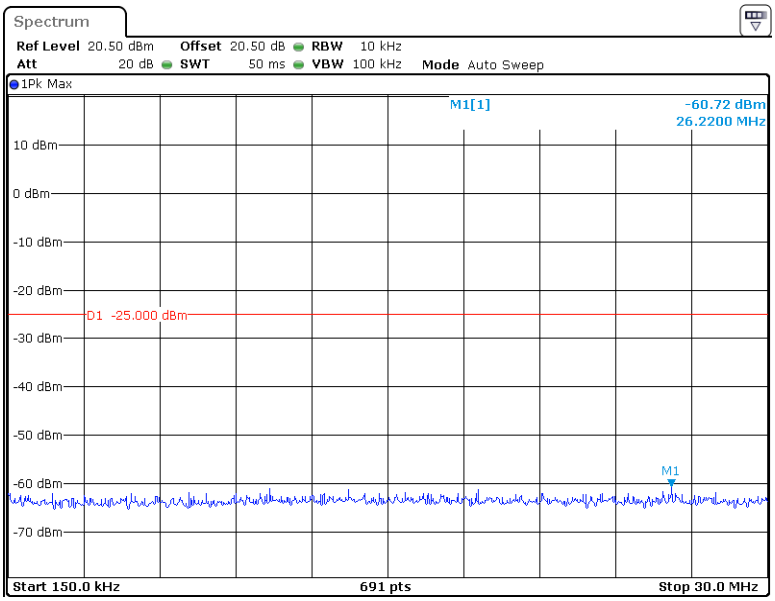


Plot 7.5.4 Spurious emission measurements in 0.15 - 30 MHz range at low carrier frequency

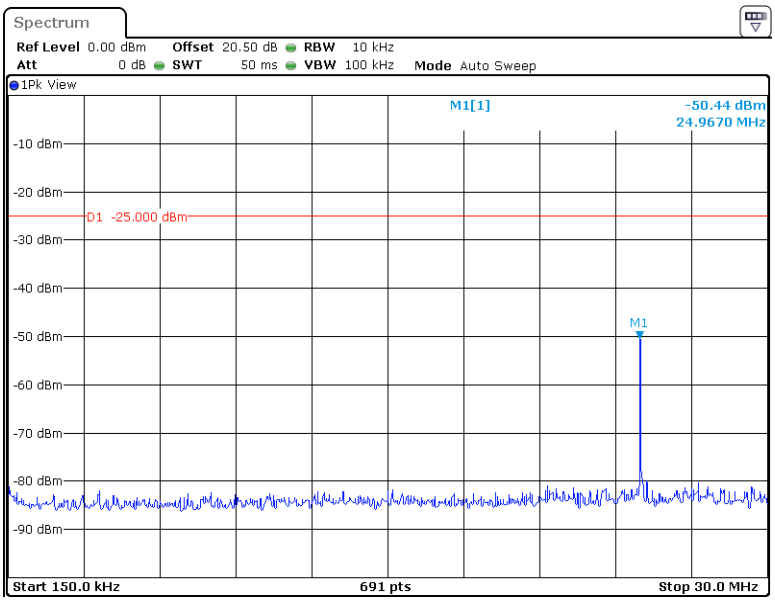


Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23 - 13-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

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

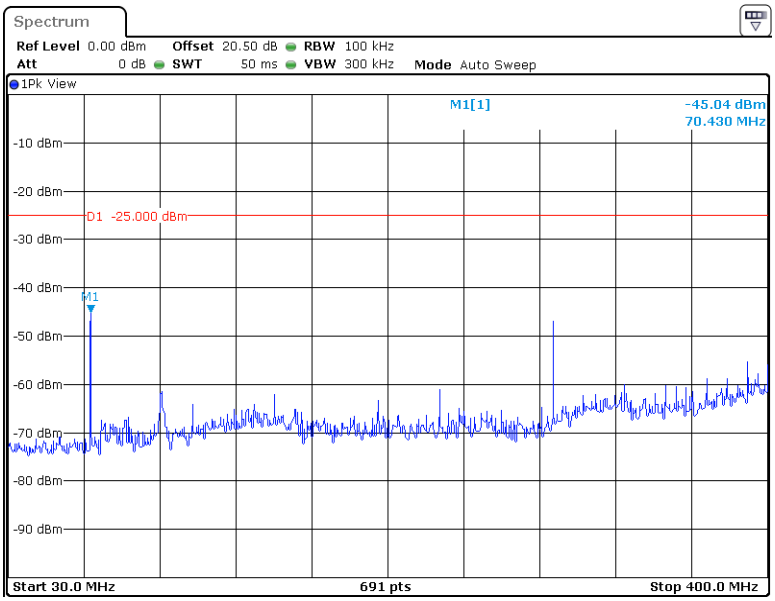


Plot 7.5.6 Spurious emission measurements in 0.15 – 30 MHz range at high carrier frequency

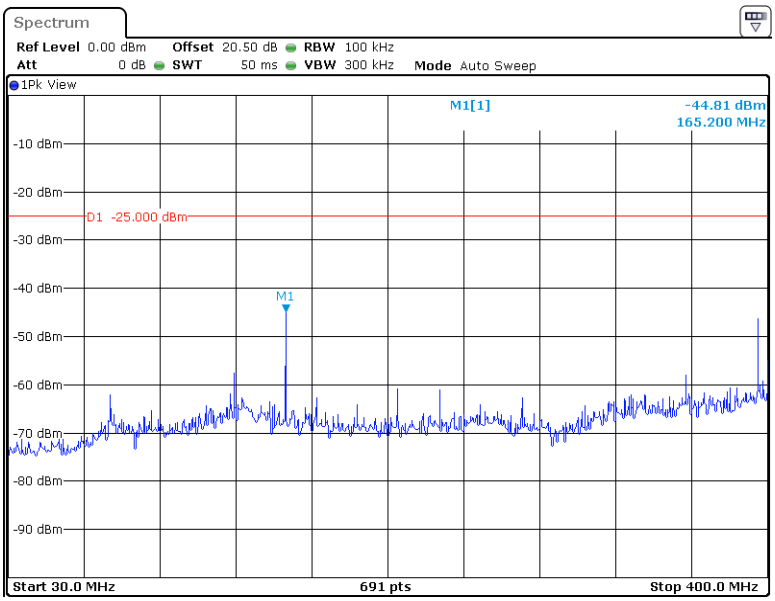


Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23 - 13-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.7 Spurious emission measurements in 30 - 400 MHz range at low carrier frequency

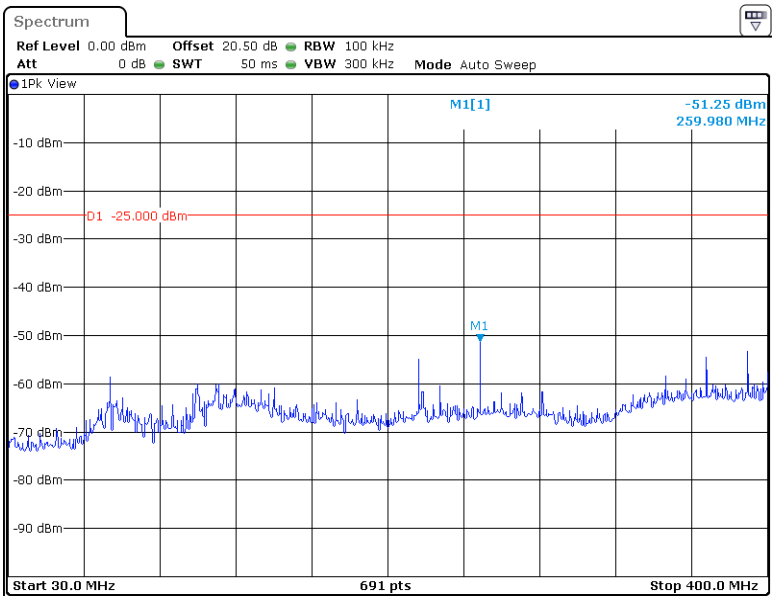


Plot 7.5.8 Spurious emission measurements in 30 - 400 MHz range at mid carrier frequency



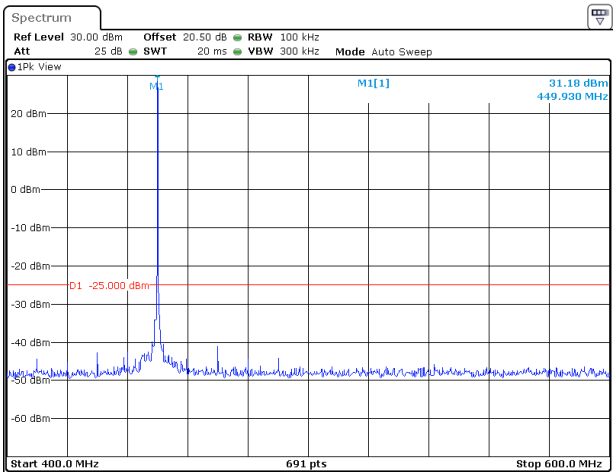
Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23 - 13-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

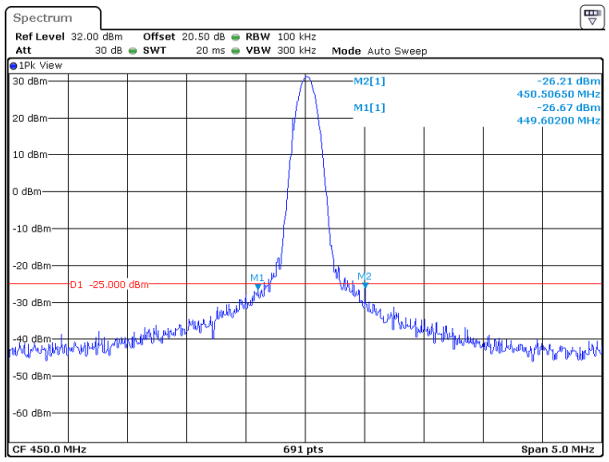
Plot 7.5.9 Spurious emission measurements in 30 - 400 MHz range at high carrier frequency

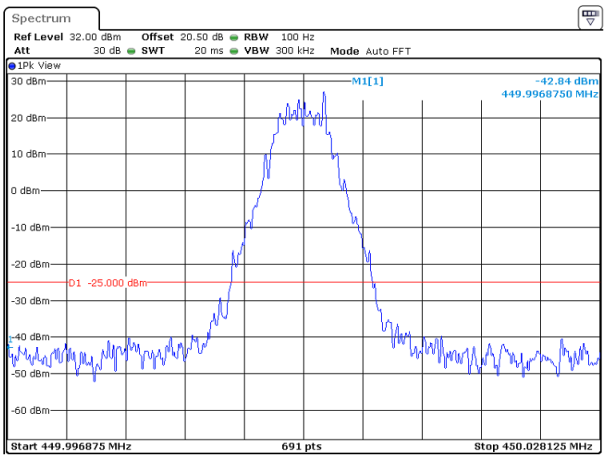


Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23 - 13-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.10 Spurious emission measurements in 400 – 600 MHz range at low carrier frequency

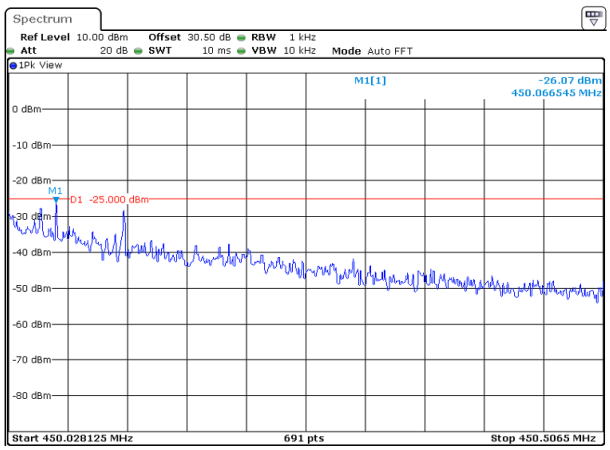


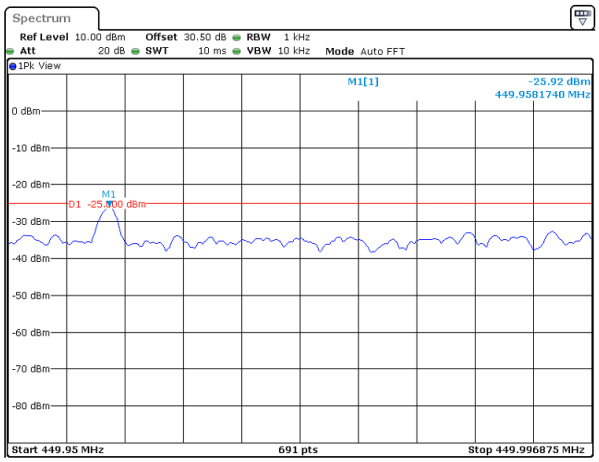


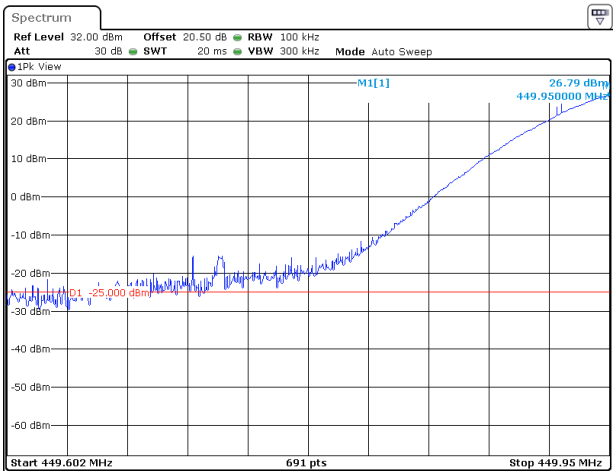


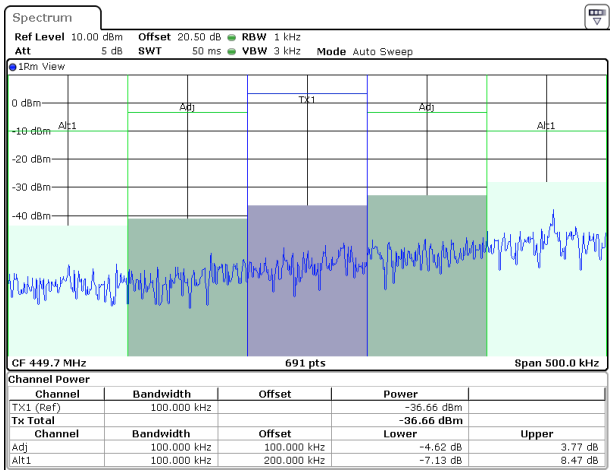
Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23 - 13-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.11 Spurious emission measurements in 400 – 600 MHz range at low carrier frequency (continuation)



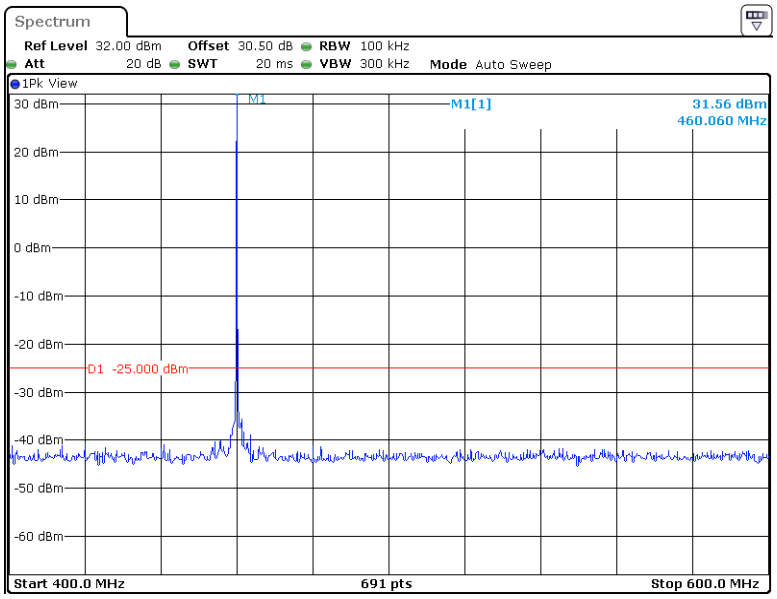


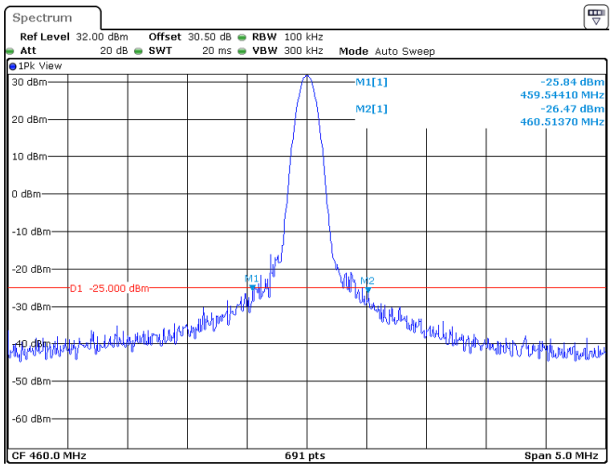


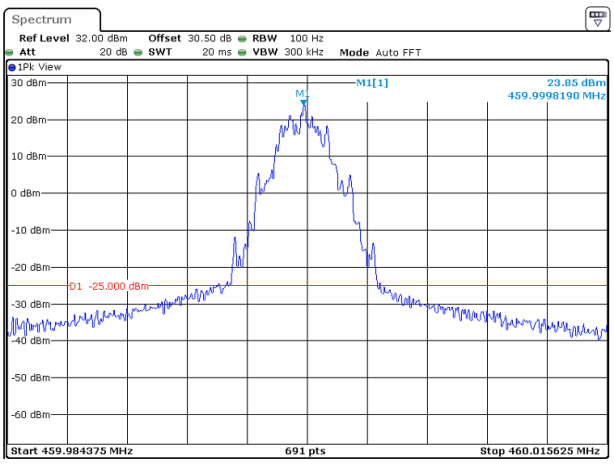


Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23 - 13-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.12 Spurious emission measurements in 400 – 600 MHz range at mid carrier frequency

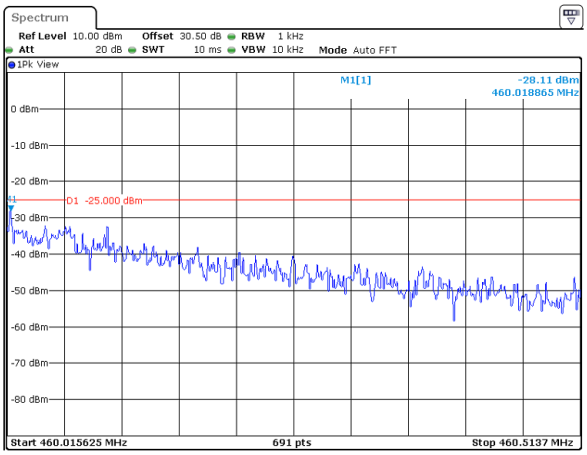


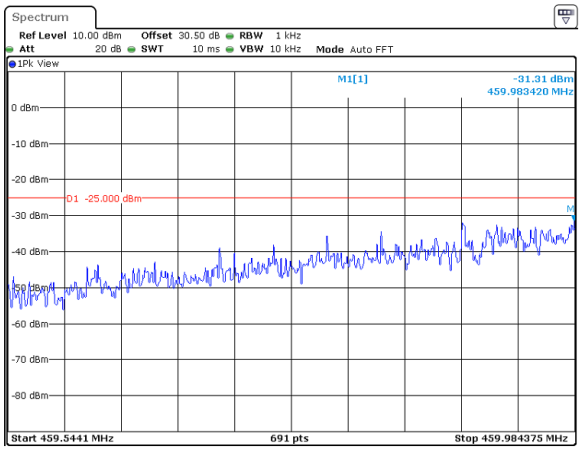




Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23 - 13-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

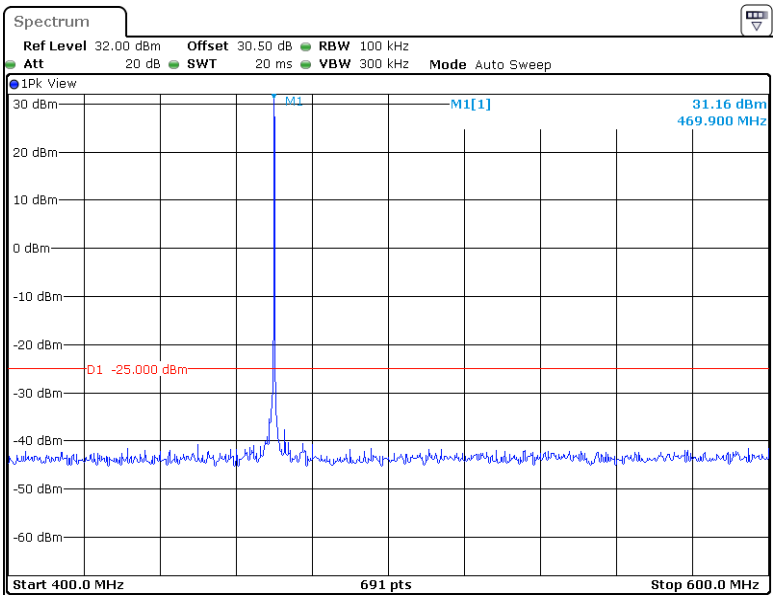
Plot 7.5.13 Spurious emission measurements in 400 – 600 MHz range at mid carrier frequency (continuation)

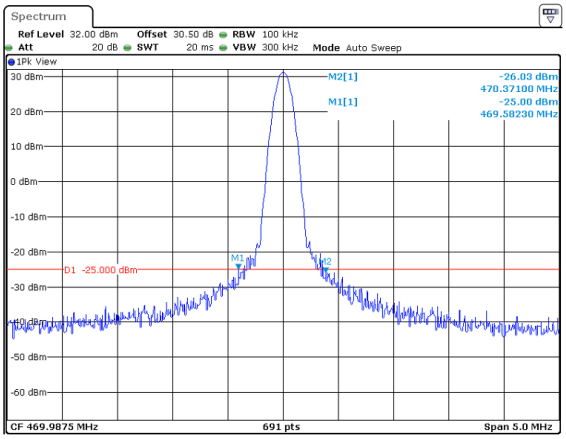


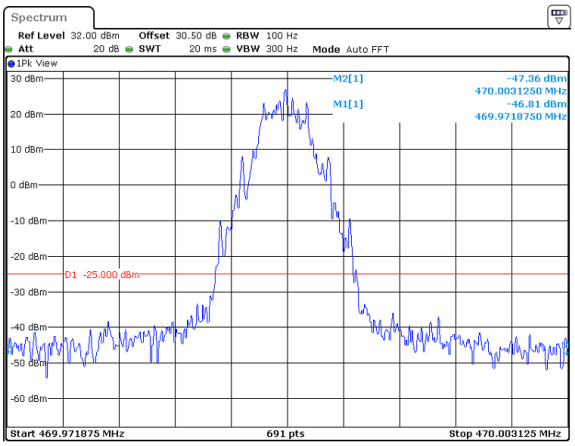


Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23 - 13-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.14 Spurious emission measurements in 400 – 600 MHz range at high carrier frequency

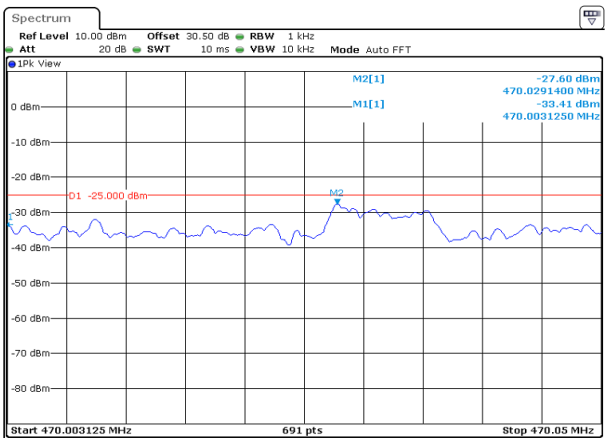


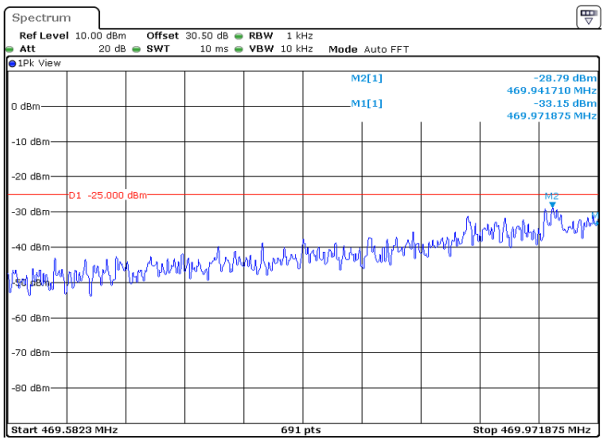


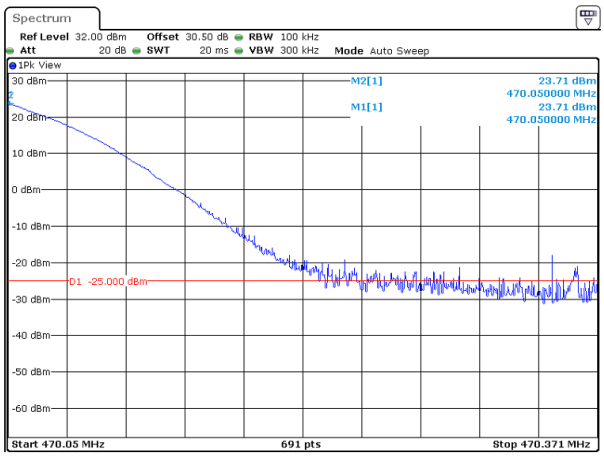


Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23 - 13-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.15 Spurious emission measurements in 400 – 600 MHz range at high carrier frequency (continuation)

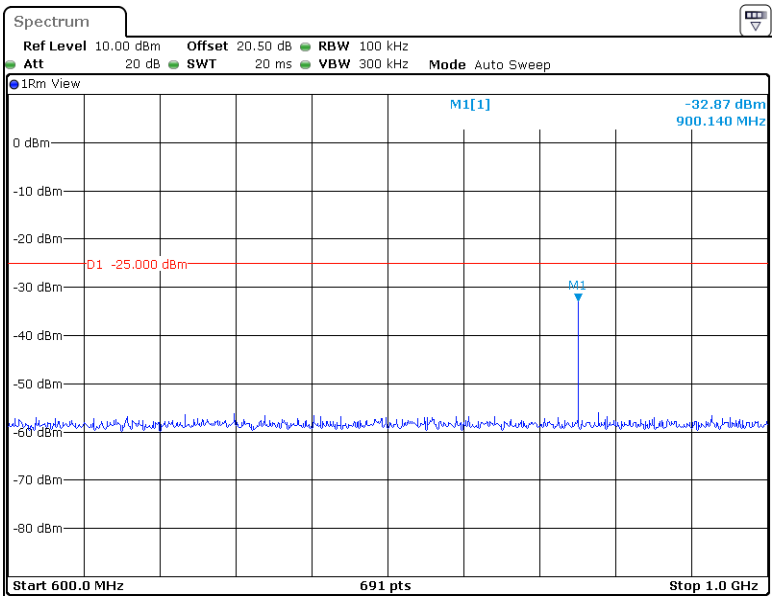




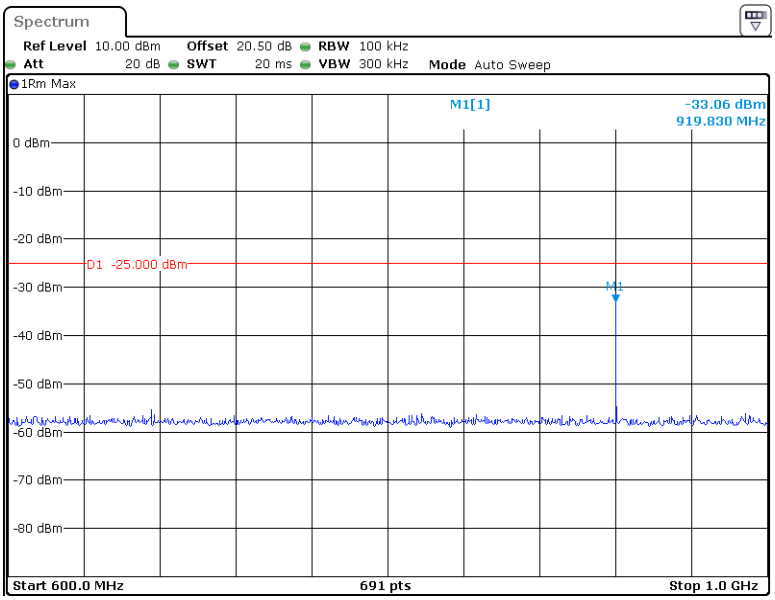


Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23 - 13-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.16 Spurious emission measurements in 600 - 1000 MHz range at low carrier frequency

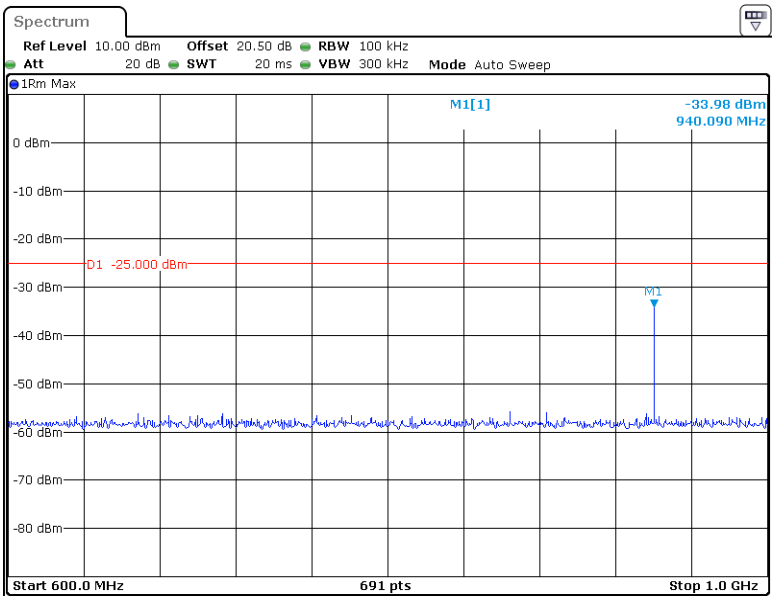


Plot 7.5.17 Spurious emission measurements in 600 - 1000 MHz range at mid carrier frequency

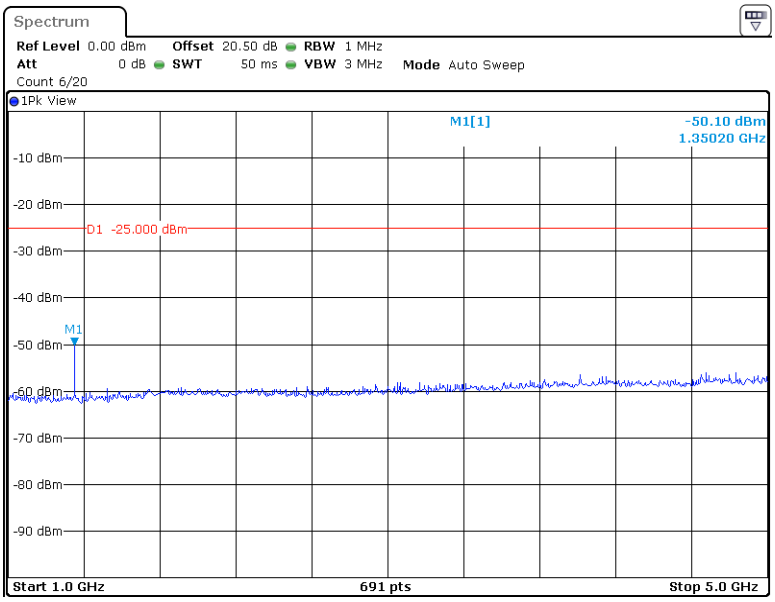


Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23 - 13-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.18 Spurious emission measurements in 600 - 1000 MHz range at high carrier frequency

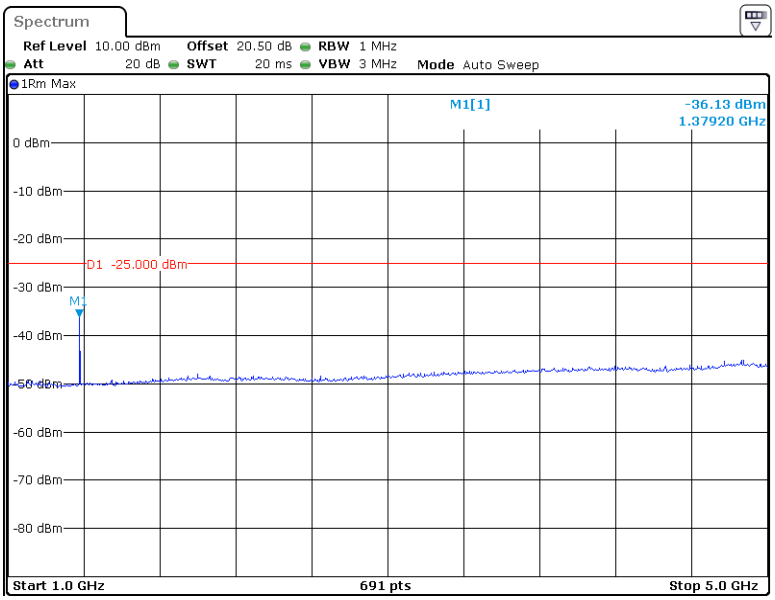


Plot 7.5.19 Spurious emission measurements in 1000 - 5000 MHz range at low carrier frequency

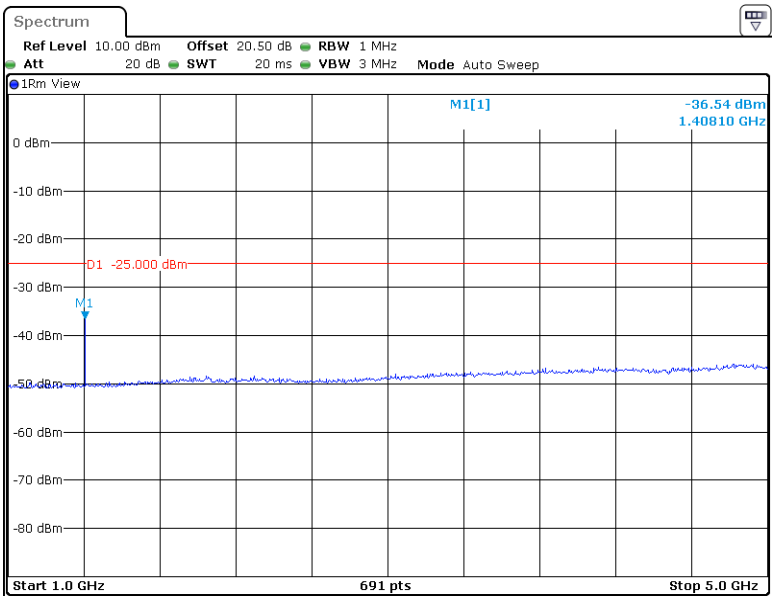


Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Conducted spurious emissions		
Test procedure:	47 CFR, Sections 2.1051		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Dec-23 - 13-Dec-23		
Temperature: 24 ºC	Relative Humidity: 56 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.5.20 Spurious emission measurements in 1000 - 5000 MHz range at mid carrier frequency



Plot 7.5.21 Spurious emission measurements in 1000 - 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;		
Test mode:	Compliance	Verdict:	PASS
Date(s):	12-Dec-23		
Temperature: 23 ºC	Relative Humidity: 46 %	Air Pressure: 1010 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.

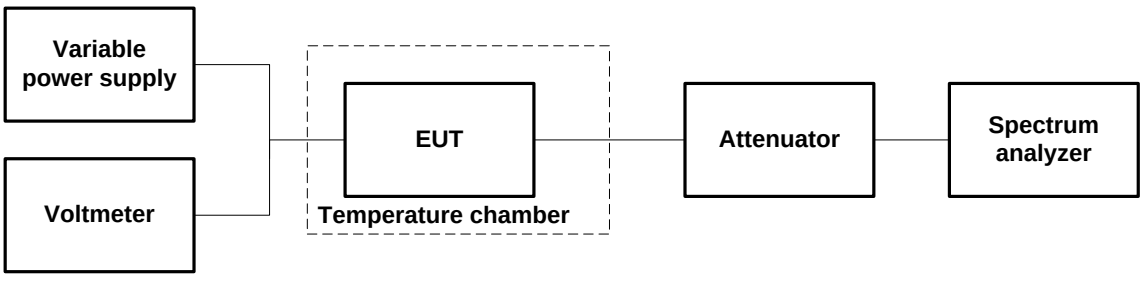
7.6.2.3 The EUT was powered on and carrier frequency was measured at start up moment and then every minute until frequency had been stabilized or 10 minutes elapsed whichever reached the last. The EUT was powered off.

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;		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	12-Dec-23		
Temperature: 23 ºC	**Relative Humidity:** 46 %	**Air Pressure:** 1010 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
TEMPERATURE STABILIZATION PERIOD: 20 min
POWER DURING TEMPERATURE TRANSITION: Off
SPECTRUM ANALYZER MODE: Counter
RESOLUTION BANDWIDTH: 100Hz
VIDEO BANDWIDTH: 300 Hz
MODULATION: Unmodulated

T, ºC	Voltage, V	Frequency, MHz							Max frequency drift, Hz		Limit, Hz	Margin, Hz	Verdict
		Start up	1st min	2nd min	3rd min	4th min	5th min	10th min	Positive	Negative			
Low frequency 450.0125 MHz													
-30	nominal	450.012486	450.012430	450.012451	450.012481	450.012490	450.012489	450.012638	209	0		-241.012	Pass
-20	nominal	450.012557	NA	NA	NA	NA	NA	450.012513	128	0		-322.012	Pass
-10	nominal	450.012572	NA	NA	NA	NA	NA	450.012562	143	0		-307.012	Pass
0	nominal	450.012527	450.012599	450.012418	450.012392	450.012413	450.012430	450.012664	235	37		-215.012	Pass
10	nominal	450.012564	NA	NA	NA	NA	NA	450.012665	236	0		-214.012	Pass
20	+15%	450.012383	NA	NA	NA	NA	NA	450.012424	46	0	450	-404.012	Pass
20	nominal	450.012335	NA	NA	NA	NA	NA	450.012429*	0	94		-356.012	Pass
20	-15%	450.012377	NA	NA	NA	NA	NA	450.012479	52	50		-398.012	Pass
30	nominal	450.012240	450.012335	450.012187	450.012143	450.012101	450.012085	450.012382	0	344		-106.012	Pass
40	nominal	450.012407	NA	NA	NA	NA	NA	450.012195	0	234		-216.012	Pass
50	nominal	450.012354	NA	NA	NA	NA	NA	450.012369	0	75		-375.012	Pass
Mid frequency 460.0000 MHz													
-30	nominal	460.000045	460.000000	459.999977	459.999898	459.999913	459.999952	460.000022	200	0		-250.012	Pass
-20	nominal	459.999904	NA	NA	NA	NA	NA	459.999962	117	0		-333.012	Pass
-10	nominal	459.999465	NA	NA	NA	NA	NA	459.999972	0	380		-70.012	Pass
0	nominal	459.999973	459.999816	459.999899	459.999702	459.999686	459.999904	459.999941	128	159		-291.012	Pass
10	nominal	459.999781	NA	NA	NA	NA	NA	459.999594	0	251		-199.012	Pass
20	+15%	459.999514	NA	NA	NA	NA	NA	459.999816	0	331	460	-119.012	Pass
20	nominal	459.999836	NA	NA	NA	NA	NA	459.999845*	0	9		-441.012	Pass
20	-15%	459.999762	NA	NA	NA	NA	NA	459.999564	0	281		-169.012	Pass
30	nominal	459.999739	459.999913	459.999714	459.999673	459.999671	459.999698	459.999711	0	174		-276.012	Pass
40	nominal	459.999743	NA	NA	NA	NA	NA	459.999483	0	362		-88.012	Pass
50	nominal	459.999872	NA	NA	NA	NA	NA	459.999897	52	0		-398.012	Pass
High frequency 460.9875 MHz													
-30	nominal	460.987578	460.987411	460.987398	460.987382	460.987411	460.987319	460.987420	307	0		-143.012	Pass
-20	nominal	460.987641	NA	NA	NA	NA	NA	460.987461	370	0		-80.012	Pass
-10	nominal	460.987471	NA	NA	NA	NA	NA	460.987573	302	0		-148.012	Pass
0	nominal	460.987222	460.987531	460.987346	460.987246	460.987341	460.987362	460.987294	260	49		-190.012	Pass
10	nominal	460.987660	NA	NA	NA	NA	NA	460.987398	389	0		-61.012	Pass
20	+15%	460.987562	NA	NA	NA	NA	NA	460.987319	291	0	460	-159.012	Pass
20	nominal	460.987637	NA	NA	NA	NA	NA	460.987271*	366	0		-84.012	Pass
20	-15%	460.987357	NA	NA	NA	NA	NA	460.987165	0	106		-344.012	Pass
30	nominal	460.987264	460.987005	460.986935	460.986943	460.986947	460.986956	460.986981	0	336		-114.012	Pass
40	nominal	460.987311	NA	NA	NA	NA	NA	460.987294	40	0		-410.012	Pass
50	nominal	460.987430	NA	NA	NA	NA	NA	460.987365	159	0		-291.012	Pass

* - Reference frequency

Reference numbers of test equipment used

HL 4355	HL 5376	HL 5626	HL 3440	HL 5933	HL 5391	HL 7521	HL 3230
HL 2780							

Full description is given in Appendix A.

Test specification:	**Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour**		
Test procedure:	ANSI C63.26, Section 6.5.2.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	17-Dec-23		
Temperature: 22 ºC	**Relative Humidity:** 54 %	**Air Pressure:** 1018 hPa	**Power:** 3.6 VDC
Remarks:			

7.7 Transient frequency behavior 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. The test results are provided in the associated plots.

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;
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.

7.7.2 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.

Test specification:	Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour		
Test procedure:	ANSI C63.26, Section 6.5.2.2		
Test mode:	Compliance	Verdict:	PASS
Date(s):	17-Dec-23		
Temperature: 22 ºC	Relative Humidity: 54 %	Air Pressure: 1018 hPa	Power: 3.6 VDC
Remarks:			

Figure 7.7.1 Transient frequency test setup

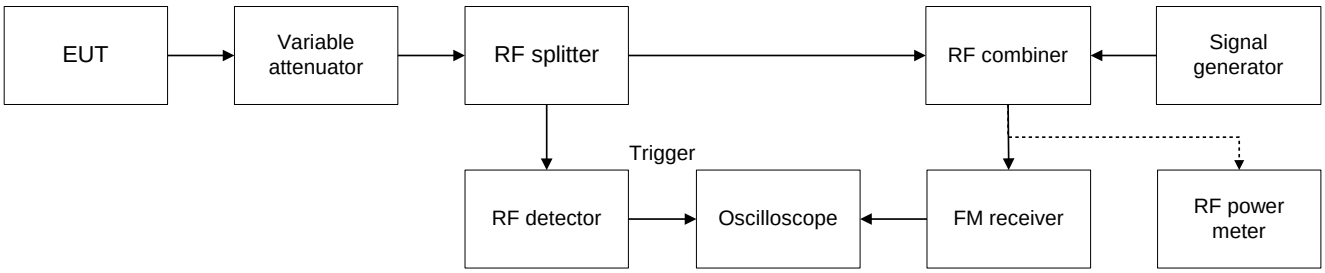


Table 7.7.2 Transient frequency behavior test results

Carrier frequency, MHz	Time interval	Duration, ms	Frequency tolerance, kHz	Limit, kHz	Margin, kHz	Verdict
Channel bandwidth 6.25 kHz						
450.0125	t_1	10.0	2.81	± 6.25	-3.44	Pass
	t_2	25.0	0.00	± 3.125	-3.125	
	t_3	10.0	1.25	± 6.25	-5.00	
460.0000	t_1	10.0	2.34	± 6.25	-3.91	Pass
	t_2	25.0	0.00	± 3.125	-3.25	
	t_3	10.0	2.34	± 6.25	-3.91	
469.9875	t_1	10.0	2.50	± 6.25	-3.70	Pass
	t_2	25.0	0.00	± 3.125	-3.125	
	t_3	10.0	1.40	± 6.25	-4.85	

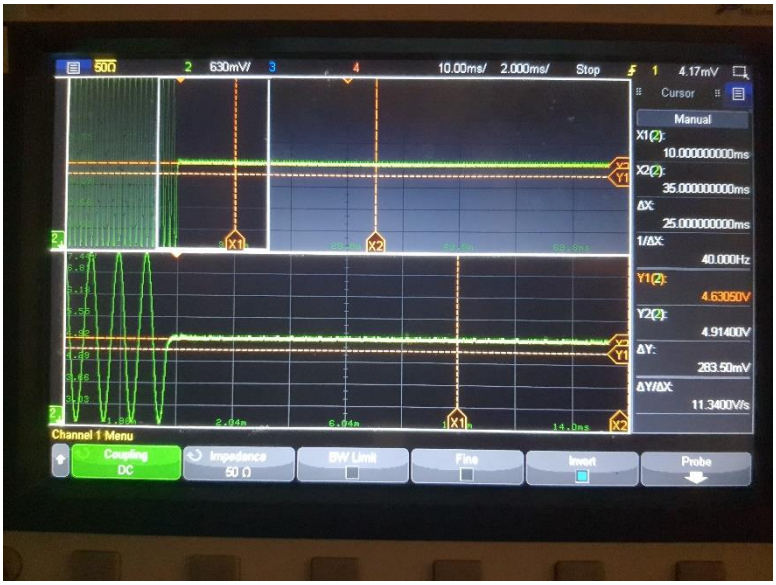
Reference numbers of test equipment used

HL 2016	HL 2017	HL 2227	HL 3440	HL 4366	HL 5369	HL 5376	HL 5472	HL 5942
HL 5588	HL 5637							

Full description is given in Appendix A.

Test specification:	Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour		
Test procedure:	ANSI C63.26, Section 6.5.2.2		
Test mode:	Compliance	Verdict:	PASS
Date(s):	17-Dec-23		
Temperature: 22 ºC	Relative Humidity: 54 %	Air Pressure: 1018 hPa	Power: 3.6 VDC
Remarks:			

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

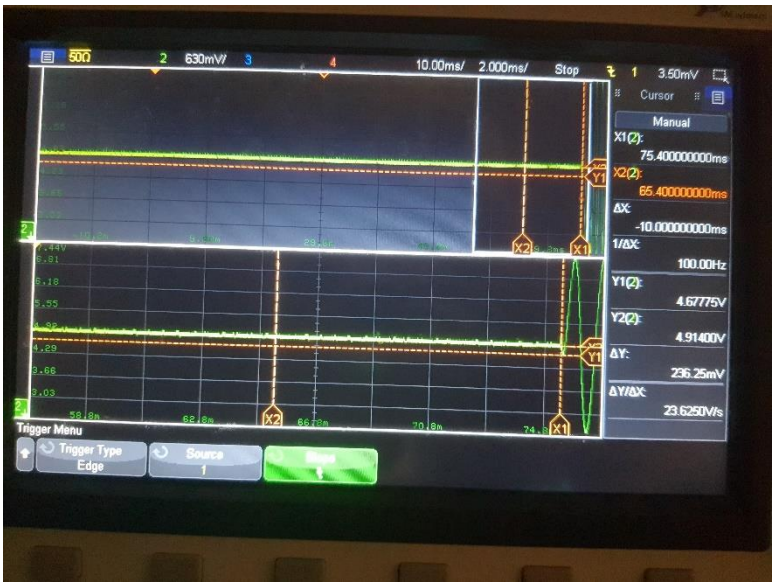


Plot 7.7.2 Transient frequency during power OFF test results at low carrier frequency

Test specification:	Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour		
Test procedure:	ANSI C63.26, Section 6.5.2.2		
Test mode:	Compliance	Verdict:	PASS
Date(s):	17-Dec-23		
Temperature: 22 ºC	Relative Humidity: 54 %	Air Pressure: 1018 hPa	Power: 3.6 VDC
Remarks:			

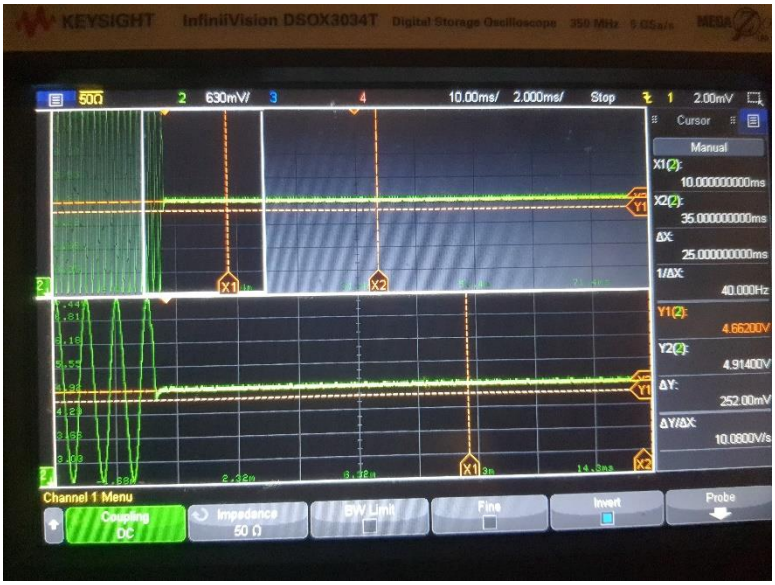
Plot 7.7.3 Transient frequency during power ON test results at mid carrier frequency

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:	ANSI C63.26, Section 6.5.2.2		
Test mode:	Compliance	Verdict:	PASS
Date(s):	17-Dec-23		
Temperature: 22 ºC	Relative Humidity: 54 %	Air Pressure: 1018 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
2016	Attenuator, Manual Step, 0-9/1 dB, 0-8 GHz, 2 W	Midwest Microwave	1072	1315	27-Mar-23	27-Mar-24
2017	Attenuator, Manual Step, 0-60/10 dB, 0-8.0 GHz	Midwest Microwave	1071	2017	27-Mar-23	27-Mar-24
2227	Crystal Detector 0.01-18 GHz, 100 mW	Hewlett Packard Co	8472A	NA	02-Jan-22	02-Jan-24
2780	EMC analyzer, 100 Hz to 26.5 GHz	Agilent Technologies	E7405A	MY45102462	17-Oct-23	17-Oct-24
3230	Multimeter	Fluke	115C	94173028	15-Aug-23	15-Aug-24
3339	High Pass Filter, 50 Ohm, 600 to 3000 MHz.	Mini-Circuits	SHP-600+	NA	22-Jun-23	22-Jun-25
3440	Precision Fixed Attenuator, 50 Ohm, 5 W, 20 dB, DC to 18 GHz	Mini-Circuits	BW-S20W5+	NA	10-Aug-23	10-Aug-24
3903	Microwave Cable Assembly, 40.0 GHz, 1.5 m, SMA/SMA	Huber-Suhner	SUCOFLEX 102A	1226/2A	16-Apr-23	16-Apr-24
4136	Shield Box	TESCOM CO., LTD	TC-5916A	5916A000137	03-May-23	03-May-24
4339	High pass Filter, 50 Ohm, 1000 to 18000 MHz, SMA-FM / SMA-M	Micro-Tronics	HPM50115-02	001	21-Jun-23	21-Jun-25
4355	Signal and Spectrum Analyzer, 9 kHz to 7 GHz	Rohde & Schwarz	FSV 7	101630	24-Oct-23	24-Oct-24
4366	Directional coupler, 1 GHz to 18 GHz, 10 dB, SMA Female	Tiger Micro-Electronics Institute	TGD-A1101-10	01e-JSDE805-007	29-May-22	29-May-24
4933	Active Horn Antenna, 1 GHz to 18 GHz	COM-POWER CORPORATION	AHA-118	701046	19-Jan-23	19-Jan-24
5288	Trilog Antenna, 25 MHz - 8 GHz, 100W	Frankonia	ALX-8000E	00809	24-Mar-22	24-Mar-25
5369	Digital storage oscilloscope, 350 MHz	Keysight Technologies	DSOX3034T	MY58032630	09-Oct-23	09-Oct-24
5376	EXA Signal Analyzer, 10 Hz - 32 GHz	Keysight Technologies	N9010B	MY57470404	27-Dec-22	27-Dec-23
5391	Temperature/Humidity Cycle Chamber, -77 - +177 deg., Humidity Range 20% RH to 95% RH	Thermotron	SM-8C	27737	06-Nov-23	06-Nov-24
5472	Power Splitter / Combiner 0.5-1 GHz	Mini Circuits	ZAPD-1	NA	09-Feb-23	09-Feb-25
5588	Cable, 50 Ohm, DC to 18 GHz, 1.8 m, SMA/N-type	Mini Circuits	CBL-6FT-SMNM+	NA	13-Jul-23	13-Jul-24
5589	Cable, 50 Ohm, DC to 18 GHz, 1.8 m, SMA/N	Mini Circuits	CBL-6FT-SMNM+	NA	19-Nov-23	19-Nov-24
5594	Precision Fixed Attenuator, 50 Ohm, 5 W, 10 dB, DC to 18000 MHz	Mini Circuits	BW-N10W5+	NA	08-Mar-23	08-Mar-24
5622	Precision Fixed Attenuator, 50 Ohm, 5 W, 20 dB, DC to 18 GHz	Mini Circuits	BW-N20W5+	NA	10-Aug-23	10-Aug-24

HL No	Description	Manufacturer	Model	Ser. No.	Last Cal./ Check	Due Cal./ Check
5626	Precision Fixed Attenuator, 50 Ohm, 5 W, 20 dB, DC to 18 GHz	Mini Circuits	BW-N20W5+	NA	10-Aug-23	10-Aug-24
5637	Cable, 50 Ohm, DC to 18 GHz, 1.8 m, SMA/SMA	Mini Circuits	CBL-6FT-SMSM+	NA	23-Jul-23	23-Jul-24
5902	RF cable, 18 GHz, 6.0m, N-type	Huber-Suhner	SF126EA/11N/11N/6000	NA	19-Nov-23	19-Nov-24
5933	Thermometer Hygrometer , (0 to +50) deg., (20-95) % RH	Kkmoon	Dyimore	NA	01-May-23	01-May-24
5942	Signal Generator, 8.0 kHz to 6.0 GHz	Rohde & Schwarz	SMB-100B	102327	10-Jan-23	10-Jan-24
7521	Programmable DC Power Supplies, 48VDC/38A	TDK-Lambda Ltd	GEN40-38	LOC-823A277-0002	15-Mar-23	15-Mar-24
7585	EMI Test Receiver, 1 Hz to 44 GHz	Rohde & Schwarz	ESW44	103130	21-Sep-23	21-Sep-24

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 dBμV to obtain field strength in dBμV/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 dBμV to obtain field strength in dBμV/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 dBμV to obtain field strength in dBμV/m.

10 APPENDIX C Measurement uncertainties

Expanded uncertainty at 95% confidence in Hermon Labs EMC measurements

Test description	Expanded uncertainty
Transmitter tests	
Carrier power conducted at antenna connector	± 1.7 dB
Carrier power radiated (substitution method)	± 4.5 dB
Occupied bandwidth	±8%
Conducted emissions at RF antenna connector	9 kHz to 2.9 GHz: ± 2.6 dB 2.9 GHz to 6.46 GHz: ± 3.5 dB 6.46 GHz to 13.2 GHz: ± 4.3 dB 13.2 GHz to 22.0 GHz: ± 5.0 dB 22.0 GHz to 26.8 GHz: ± 5.5 dB 26.8 GHz to 40.0 GHz: ± 4.8 dB
Spurious emissions radiated 30 MHz – 40 GHz (substitution method)	± 4.5 dB
Frequency error	30 – 300 MHz: ± 50.5 Hz (1.68 ppm) 300 – 1000 MHz: ± 168 Hz (0.56 ppm)
Transient frequency behaviour	187 Hz ± 13.9 %
Duty cycle, timing (Tx ON / OFF) and average factor measurements	± 1.0 %
Unintentional radiator tests	
Conducted emissions with LISN	9 kHz to 150 kHz: ± 3.9 dB 150 kHz to 30 MHz: ± 3.8 dB
Radiated emissions at 3 m measuring distance Horizontal polarization 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 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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12 APPENDIX E Specification references

FCC 47CFR part 90: 2022	Private land mobile radio services
FCC 47CFR part 2: 2022	Frequency allocations and radio treaty matters; general rules and regulations
RSS-119 Issue 12: 2015+Amendment (April, 2022)	Land Mobile and Fixed Equipment Equipment Operating in the Frequency Range 27.41-960 MHz

13 APPENDIX F Abbreviations and acronyms

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

END OF DOCUMENT