HERMON LABORATORIES

ELECTRICAL TESTING
0839.01

Hermon Laboratories Ltd.
P.O. Box 23, Binyamina 3055001, Israel
Tel. +972 4628 8001
Fax. +972 4628 8277
E-mail: mail@hermonlabs.com

TEST REPORT

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

FOR:

ST Engineering Telematics Wireless Ltd.

Water Meter

Model: SONATA3-AL

FCC ID: NTASONATA3

IC: 4732A-SONATA3

Table of contents

1 Applicant information

Client name:	ST Engineering Telematics Wireless Ltd
Address:	26 Hamelaha street, POB 1911, Holon 5811801, Israel
Telephone:	+972 35575700
Fax:	+972 35575703
E-mail:	itsikk@tlmw.com
Contact name:	Mr. Itsik Kanner

2 Equipment under test attributes

Product name:	Water Meter
Product type:	Transceiver
Model(s):	SONATA3-AL
Serial number:	02130943
Hardware version:	Rev A
Software release:	AU02B6
Receipt date	24-Jun-21

3 Manufacturer information

Manufacturer name:	ST Engineering Telematics Wireless Ltd
Address:	26 Hamelaha street, POB 1911, Holon 5811801, Israel
Telephone:	+972 35575700
Fax:	+972 35575703
E-Mail:	itsikk@tlmw.com
Contact name:	Mr. Itsik Kanner

4 Test details

Project ID:	43287
Location:	Hermon Laboratories Ltd. P.O. Box 23, Binyamina 3055001, Israel
Test started:	28-Jun-21
Test completed:	17-Aug-21
Test specification(s):	FCC 47 CFR part 90, RSS-119 issue 12

5 Tests summary

Test	Status
Transmitter characteristics	
FCC Section 90.205 / RSS-119 Section 5.4, Maximum output power	Pass
FCC Section 90.209 / RSS-119 Section 5.5, Occupied bandwidth	Pass
FCC Section 90.210 / RSS-119 Section 5.8.4, Emission mask	Pass
FCC Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions	Pass
FCC Section 90.213 / RSS-119 Section 5.3, Frequency stability	Pass
FCC Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour	Pass
FCC Section 2.1091 / RSS-102 section 2.5, RF radiation exposure evaluation	Pass, Exhibit in application for certification provided

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:	Mrs. E. Pitt, test engineer, EMC & Radio Mr. A. Morozov, test engineer, EMC & Radio	28-Jun-21 – 17-Aug-21	 
Reviewed by:	Mrs. S. Peysahov Sheynin, test engineer, EMC & Radio	15-Oct-21	
Approved by:	Mr. S. Samokha, technical manager, EMC & Radio	27-Oct-21	

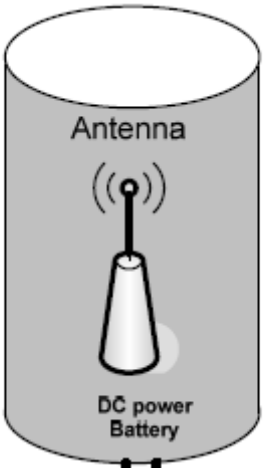
6 EUT description

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

6.1 General information

SONATA3-AL is Water Meter comprises a RF module, operates at 450-470MHz frequency band and powered by battery at nominal voltage of 3.6VDC. The modulation is 4GFSK, channel bandwidth 6.25KHZ and bit rate of 4.8kbps.

6.2 Test configuration



6.3 Changes made in EUT

No changes were implemented in the EUT during testing.

6.4 Transmitter characteristics

Type of equipment	
X	Stand-alone (Equipment with or without its own control provisions)
	Combined equipment (Equipment where the radio part is fully integrated within another type of equipment)
	Plug-in card (Equipment intended for a variety of host systems)

Intended use		**Condition of use**
	fixed	Always at a distance more than 2 m from all people
X	mobile	Always at a distance more than 20 cm from all people
	portable	May operate at a distance closer than 20 cm to human body

Assigned frequency ranges	450- 470 MHz

Maximum rated output power	At transmitter 50 Ω RF output connector	33.4 dBm

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

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

Antenna/s technical characteristics			
Type	Manufacturer	Model number	Gain
Printed	ARAD	NA	0 dBi

Transmitter aggregate data rate/s	4.8 kbps

Type of modulation	4GFSK

Modulating test signal (baseband)	PRBS

Transmitter power source					
X	Battery	**Nominal rated voltage**	3.6 VDC	Battery type	Lithium
	DC	**Nominal rated voltage**			
	AC mains	**Nominal rated voltage**		Frequency	

Test specification:	Section 90.205 / RSS-119 Section 5.4, Maximum output power		
Test procedure:	47 CFR, Section 2.1046		
Test mode:	Compliance	Verdict:	PASS
Date(s):	29-Jun-21		
Temperature: 25 ºC	Relative Humidity: 49 %	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 effective radiated power emanated by transmitter at carrier frequency. Specification test limits are given in Table 7.1.1

Table 7.1.1 Peak output power limits

Assigned frequency band, MHz	ERP		Equivalent field strength limit @ 3m, dB(μV/m)*
	W	dBm	
FCC			
450.0 – 470.0	2	33.00	130.38
RSS-119 Table 2			
450.0 – 470.0	60	47.78	145.16

* - Equivalent field strength limit was calculated from maximum allowed ERP as follows: E=sqrt(30×P×1.64)/r, where P is ERP in Watts, 1.64 is numeric gain of ideal dipole and r is antenna to EUT distance in meters

7.1.2 Test procedure for field strength measurements

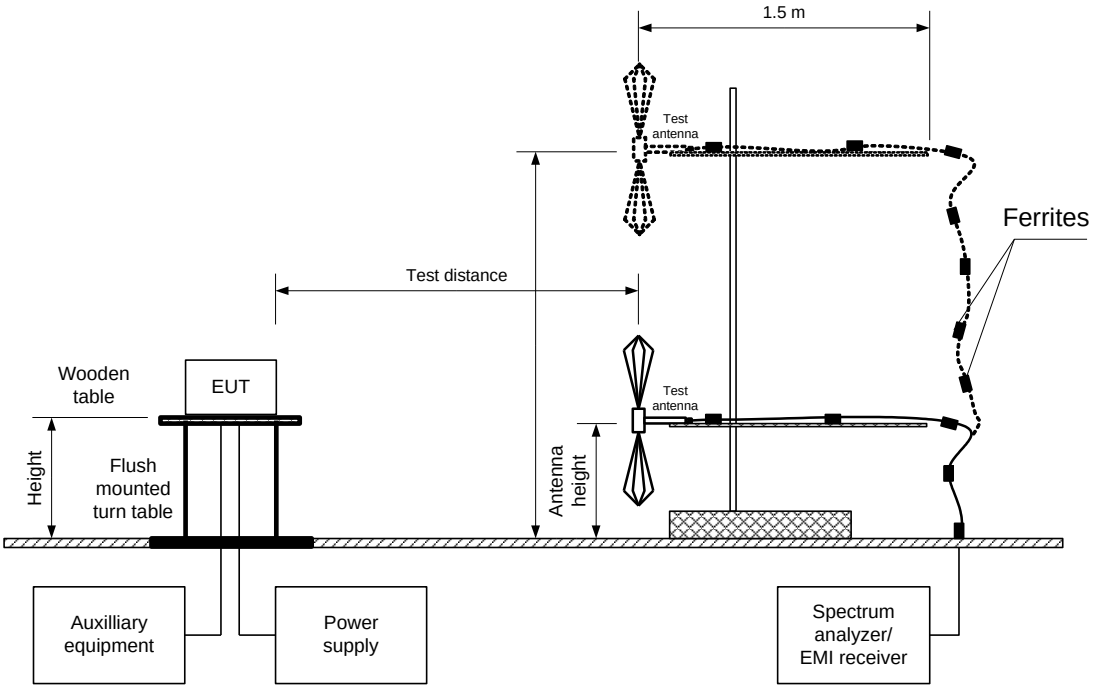
7.1.2.1 The EUT was set up as shown in Figure 7.1.1, energized and the performance check was conducted.

7.1.2.2 The field strength of the EUT carrier frequency was measured with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360^0, the measuring antenna height was swept throughout the range, specified in Table 7.1.2 and Table 7.1.3, in both vertical and horizontal polarizations.

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

Test specification:	**Section 90.205 / RSS-119 Section 5.4, Maximum output power**		
Test procedure:	47 CFR, Section 2.1046		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	29-Jun-21		
Temperature: 25 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Figure 7.1.1 Setup for carrier field strength measurements



Test specification:	**Section 90.205 / RSS-119 Section 5.4, Maximum output power**		
Test procedure:	47 CFR, Section 2.1046		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	29-Jun-21		
Temperature: 25 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.1.2 Transmitter carrier field strength according to FCC

ASSIGNED FREQUENCY RANGE:	450 - 470 MHz
TEST SITE:	Semi anechoic chamber
TEST DISTANCE:	3 m
EUT HEIGHT:	0.8 m
TEST ANTENNA HEIGHTS RANGE:	1.0 – 4.0 m
DETECTOR USED:	Peak
RESOLUTION BANDWIDTH:	100 kHz
VIDEO BANDWIDTH:	> Resolution bandwidth
TEST ANTENNA TYPE:	Biconilog
MODULATION:	4GFSK
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum

Frequency, MHz	Field strength, dB(µV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees	EUT antenna gain, dBi	ERP, dBm***	Peak output power (conducted), dBm*	ERP Limit, dBm	Margin, dB**	Verdict
450.0031	128.6	Vertical	1.0	0	0	31.2	33.4	33.00	-1.8	Pass
460.0000	128.4	Vertical	1.0	0	0	31.0	33.3	33.00	-2.0	Pass
469.9969	128.6	Vertical	1.0	0	0	31.2	33.4	33.00	-1.8	Pass

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

******- Margin = ERP – specification ERP limit.
*** ERP=Field strength in dB(µV/m) – 97.4 dB

Test specification:	**Section 90.205 / RSS-119 Section 5.4, Maximum output power**		
Test procedure:	47 CFR, Section 2.1046		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	29-Jun-21		
Temperature: 25 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

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

ASSIGNED FREQUENCY RANGE:	450 - 470 MHz
TEST SITE:	Semi anechoic chamber
TEST DISTANCE:	3 m
EUT HEIGHT:	0.8 m
TEST ANTENNA HEIGHTS RANGE:	1.0 – 4.0 m
DETECTOR USED:	Peak
RESOLUTION BANDWIDTH:	100 kHz
VIDEO BANDWIDTH:	> Resolution bandwidth
TEST ANTENNA TYPE:	Biconilog
MODULATION:	4GFSK
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum

Frequency, MHz	Field strength, dB(µV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees	EUT antenna gain, dBi	ERP, dBm***	Peak output power (conducted), dBm*	ERP Limit, dBm	Margin, dB**	Verdict
450.0031	128.6	Vertical	1.0	0	0	31.2	33.4	47.78	-16.58	Pass
460.0000	128.4	Vertical	1.0	0	0	31.0	33.3	47.78	-16.78	Pass
469.9969	128.6	Vertical	1.0	0	0	31.2	33.4	47.78	-16.58	Pass

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

******- Margin = ERP – specification ERP limit.
*** ERP=Field strength in dB(µV/m) – 97.4 dB

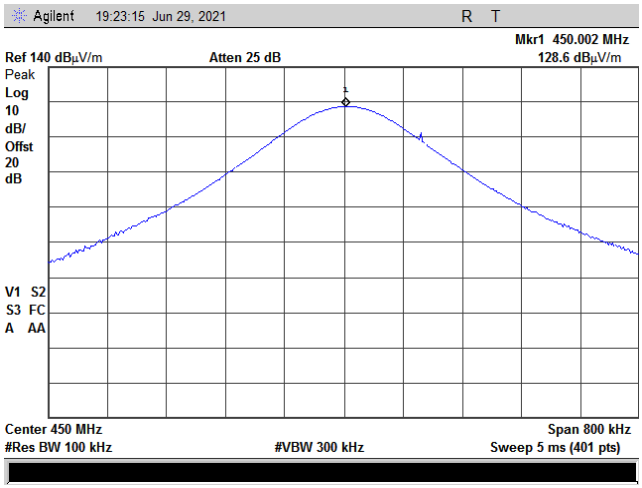
Reference numbers of test equipment used

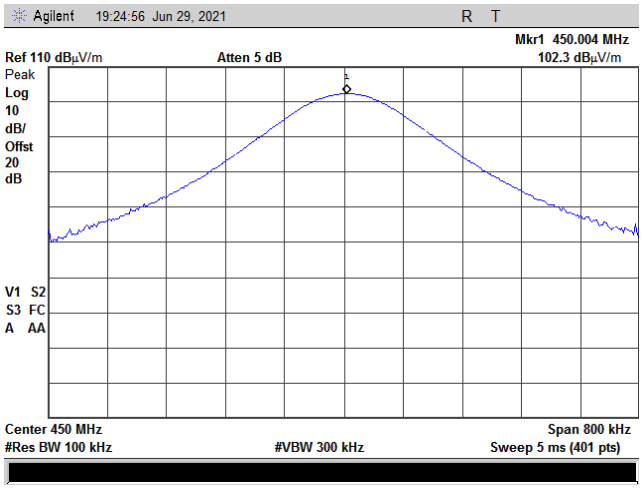
HL 3903	HL 2780	HL 5288	HL 5902	HI 5612	HI 5606		

Full description is given in Appendix A.

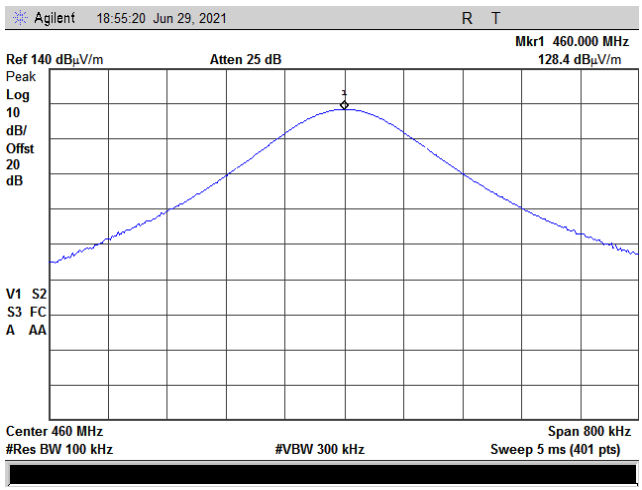
Test specification:	Section 90.205 / RSS-119 Section 5.4, Maximum output power		
Test procedure:	47 CFR, Section 2.1046		
Test mode:	Compliance	Verdict:	PASS
Date(s):	29-Jun-21		
Temperature: 25 ºC	Relative Humidity: 49 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

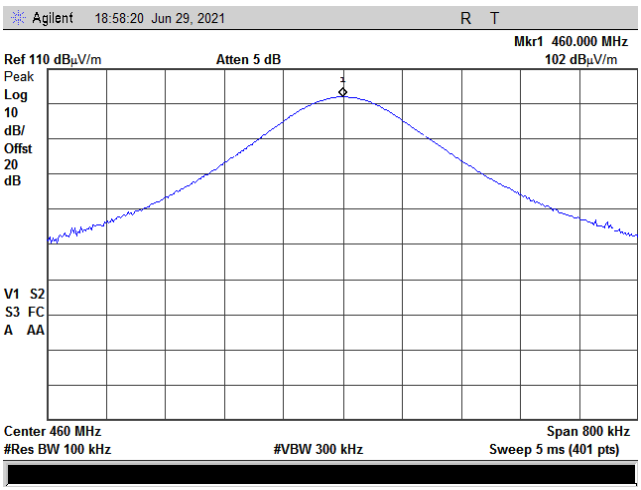
Plot 7.1.1 Transmitter carrier field strength at low frequency in vertical and horizontal antenna polarization





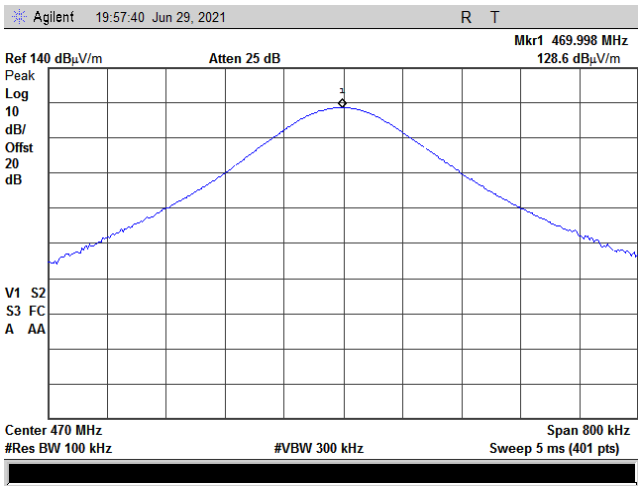
Plot 7.1.2 Transmitter carrier field strength at mid frequency in vertical and horizontal antenna polarization

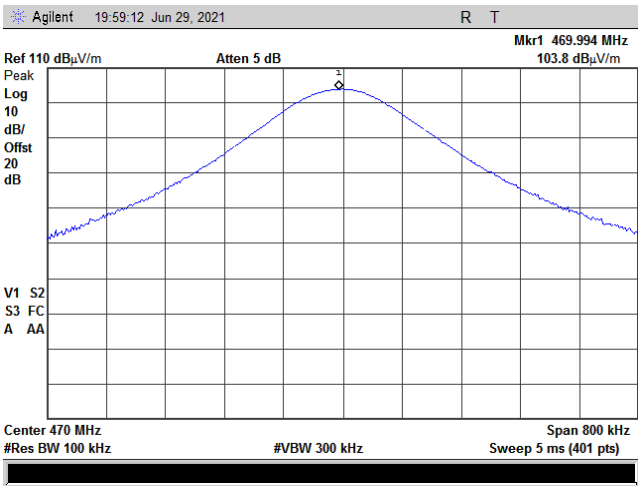




Test specification:	Section 90.205 / RSS-119 Section 5.4, Maximum output power		
Test procedure:	47 CFR, Section 2.1046		
Test mode:	Compliance	Verdict:	PASS
Date(s):	29-Jun-21		
Temperature: 25 ºC	Relative Humidity: 49 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

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





Test specification:	Section 90.209 / RSS-119 Section 5.5, Occupied bandwidth		
Test procedure:	47 CFR, Section 2.1049		
Test mode:	Compliance	Verdict:	PASS
Date(s):	20-Jul-21		
Temperature: 24 ºC	Relative Humidity: 45 %	Air Pressure: 1005 hPa	Power: 3.6 VDC
Remarks:			

7.2 Occupied bandwidth test

7.2.1 General

This test was performed to measure transmitter occupied bandwidth. Specification test limits are given in Table 7.2.1

Table 7.2.1 Occupied bandwidth limits

Assigned frequency, MHz	Modulation envelope reference points*, dBc	Maximum allowed bandwidth, kHz
450.0 – 470.0	26	6.00

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

7.2.2 Test procedure

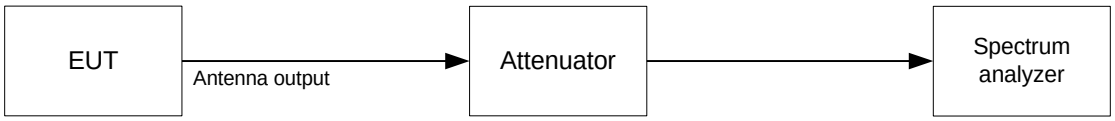
7.2.2.1 The EUT was set up as shown in Figure 7.2.1, energized and its proper operation was checked.

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

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

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

Figure 7.2.1 Occupied bandwidth test setup



Test specification:	Section 90.209 / RSS-119 Section 5.5, Occupied bandwidth		
Test procedure:	47 CFR, Section 2.1049		
Test mode:	Compliance	Verdict:	PASS
Date(s):	20-Jul-21		
Temperature: 24 ºC	Relative Humidity: 45 %	Air Pressure: 1005 hPa	Power: 3.6 VDC
Remarks:			

Table 7.2.2 Occupied bandwidth test results

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

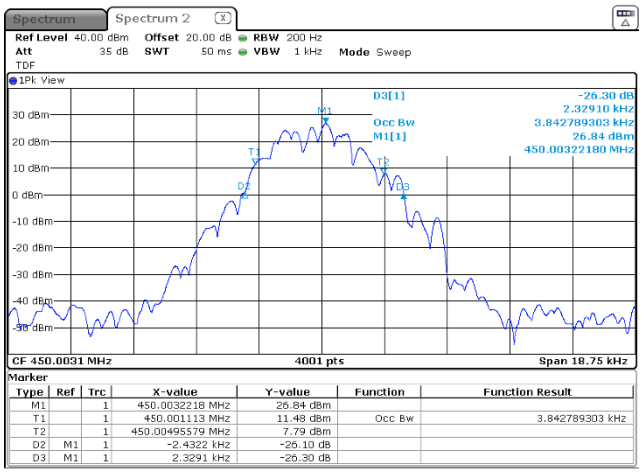
Carrier frequency, MHz	Occupied bandwidth, kHz	Limit, kHz	Margin, kHz	Verdict
MODULATION ENVELOPE REFERENCE POINTS: 99%				
450.0031	3.842	6.000	-2.158	Pass
460.0000	3.828	6.000	-2.172	Pass
469.9968	3.711	6.000	-2.289	Pass
MODULATION ENVELOPE REFERENCE POINTS: 26 dBc				
450.0031	4.761	6.000	-1.239	Pass
460.0000	4.942	6.000	-1.058	Pass
469.9968	4.915	6.000	-1.085	Pass

Reference numbers of test equipment used

HL 3766	HL 4355	HL 5409					

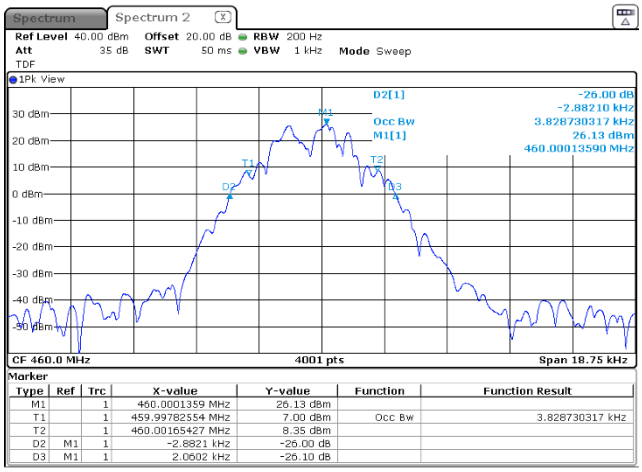
Full description is given in Appendix A.

Plot 7.2.1 Occupied bandwidth test result at low frequency

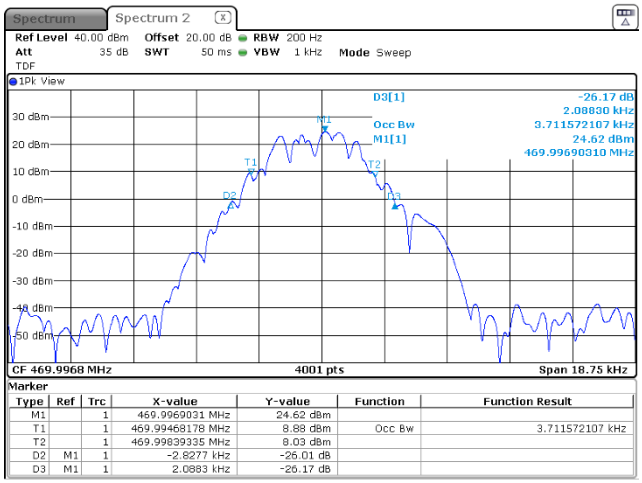


Test specification:	Section 90.209 / RSS-119 Section 5.5, Occupied bandwidth		
Test procedure:	47 CFR, Section 2.1049		
Test mode:	Compliance	Verdict:	PASS
Date(s):	20-Jul-21		
Temperature: 24 ºC	Relative Humidity: 45 %	Air Pressure: 1005 hPa	Power: 3.6 VDC
Remarks:			

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):	18-Jul-21		
Temperature: 24 ºC	**Relative Humidity:** 65 %	**Air Pressure:** 1000 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) or55+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.

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

Table 7.3.2 Emission mask test results

Carrier frequency, MHz	Limit	Verdict
450.0031	Emission mask E	Pass
460.0000		
459.9969		

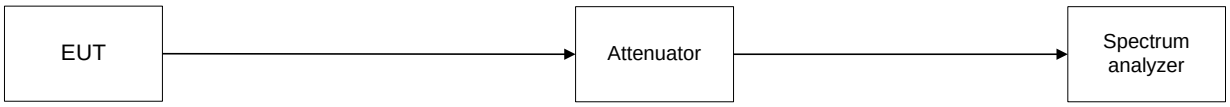
Reference numbers of test equipment used

HL 3766	HL 4355	HL 5409					

Full description is given in Appendix A.

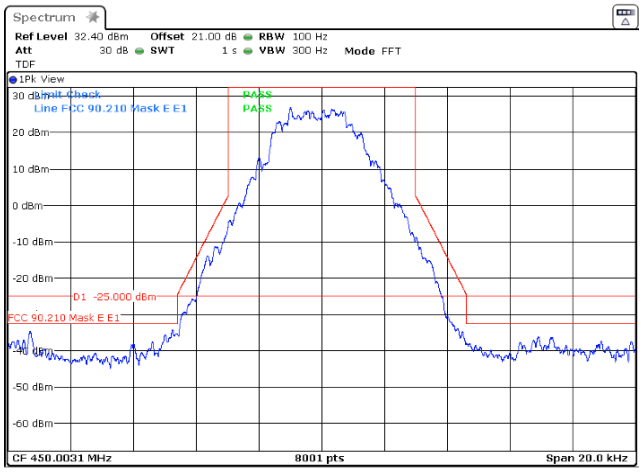
Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Emission mask		
Test procedure:	47 CFR, Sections 2.1051, 2.1047 and 90.210(e), TIA/EIA-603-E, Section 2.2.13		
Test mode:	Compliance	Verdict:	PASS
Date(s):	18-Jul-21		
Temperature: 24 ºC	Relative Humidity: 65 %	Air Pressure: 1000 hPa	Power: 3.6 VDC
Remarks:			

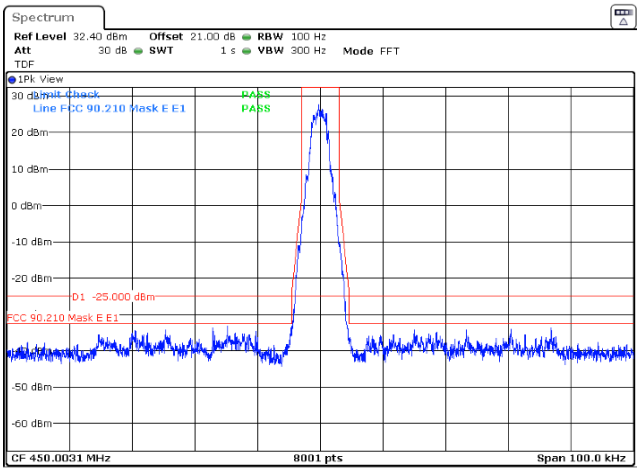
Figure 7.3.1 Emission mask test setup



Plot 7.3.1 Emission mask test results at low carrier frequency

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

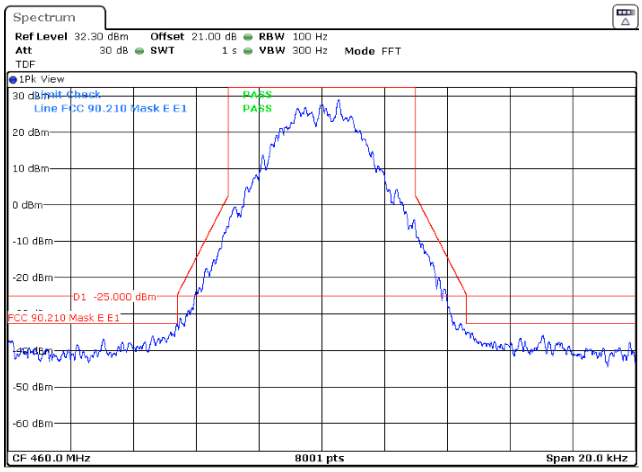


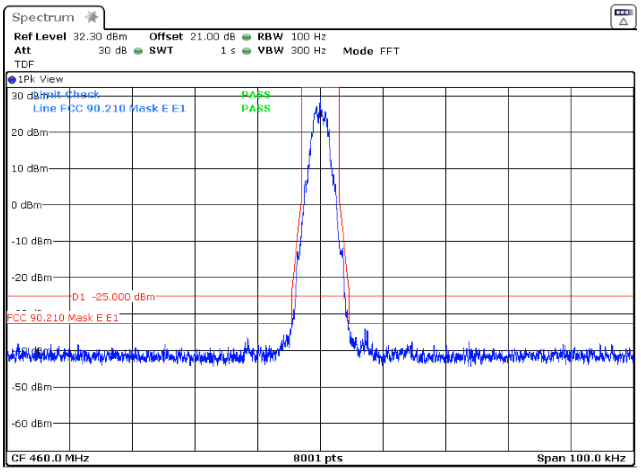


Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Emission mask		
Test procedure:	47 CFR, Sections 2.1051, 2.1047 and 90.210(e), TIA/EIA-603-E, Section 2.2.13		
Test mode:	Compliance	Verdict:	PASS
Date(s):	18-Jul-21		
Temperature: 24 ºC	Relative Humidity: 65 %	Air Pressure: 1000 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.3.2 Emission mask test results at mid carrier frequency

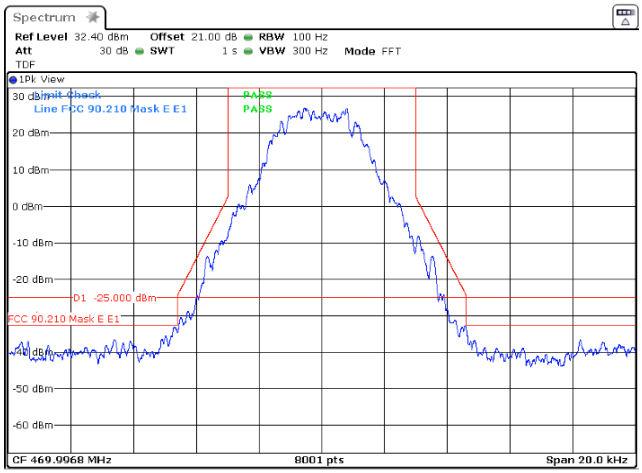
OPERATING FREQUENCY RANGE: 450 – 470 MHz
DETECTOR USED: Peak
MODULATION: 4GFSK
MODULATING SIGNAL: PRBS
TRANSMITTER OUTPUT POWER SETTINGS: Maximum

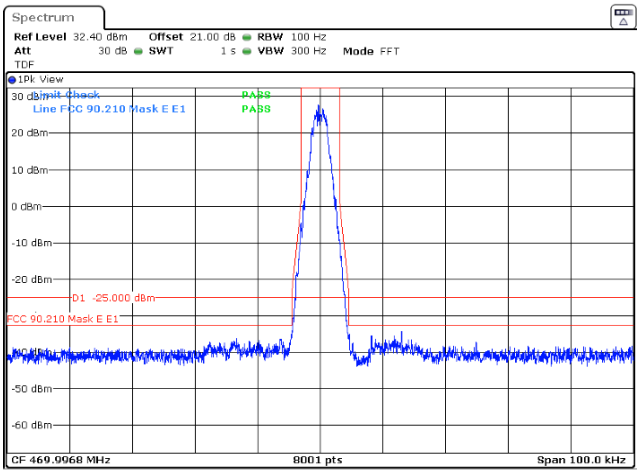




Plot 7.3.3 Emission mask test results at high carrier frequency

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





Test specification:	**Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions**		
Test procedure:	47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	29-Jun-21		
Temperature: 25 ºC	**Relative Humidity:** 49 %	**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	72.4

* - Excluding the in band emission within ± 250 % of the authorized bandwidth from the carrier
** - P is transmitter output power in Watts
*** - Equivalent field strength limit was calculated from maximum allowed ERP of spurious as follows: E=sqrt(30×P×1.64)/r, where P is ERP in Watts, 1.64 is numeric gain of ideal dipole and r is antenna to EUT distance in meters

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

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

7.4.2.2 The specified frequency range was investigated with antenna connected to spectrum analyzer. To find maximum radiation the turntable was rotated 360^0 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 radiated spurious emission measurements above 30 MHz

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

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

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

Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions		
Test procedure:	47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12		
Test mode:	Compliance	Verdict:	PASS
Date(s):	29-Jun-21		
Temperature: 25 ºC	Relative Humidity: 49 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

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

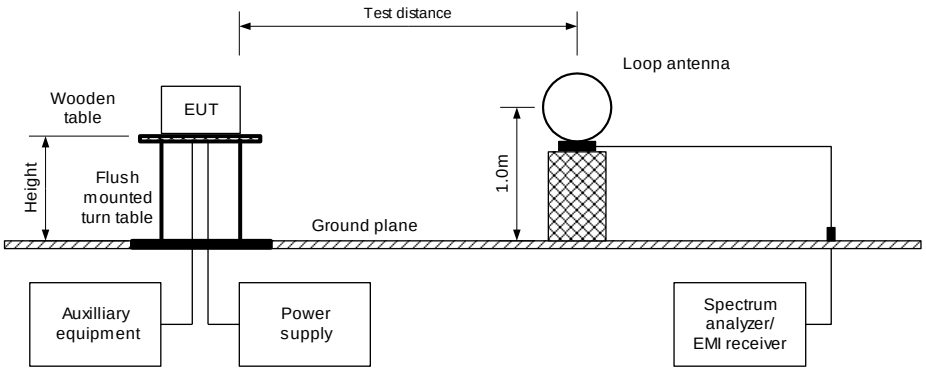
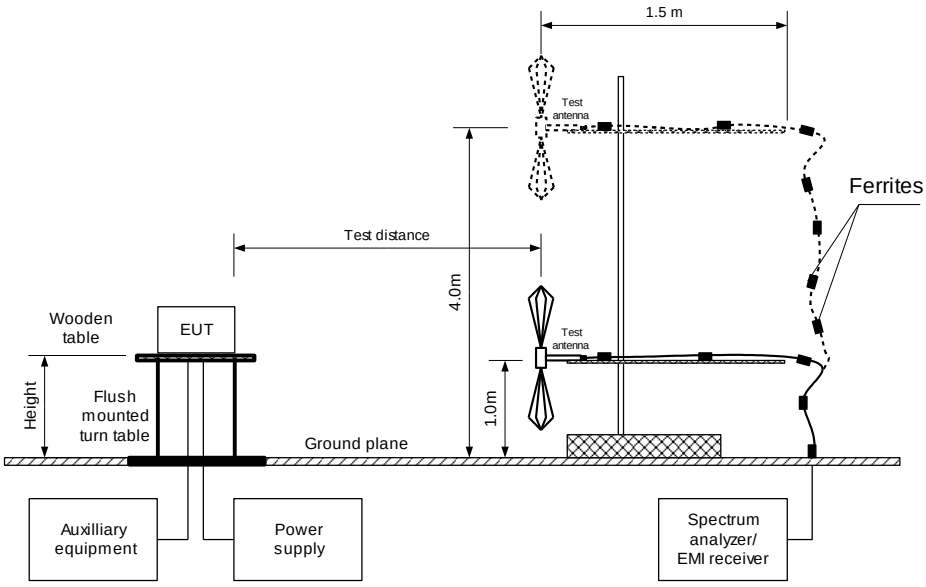


Figure 7.4.2 Setup for radiated spurious emission measurements above 30 MHz



Test specification:	**Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions**		
Test procedure:	47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	29-Jun-21		
Temperature: 25 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.4.2 Radiated spurious emission test results

ASSIGNED FREQUENCY RANGE: 450 - 470 MHz
TEST DISTANCE: 3 m
TEST SITE: Semi anechoic chamber
INVESTIGATED FREQUENCY RANGE: 0.009 – 5000 MHz
DETECTOR USED: Peak
VIDEO BANDWIDTH: > Resolution bandwidth
TEST ANTENNA TYPE: Active loop (9 kHz – 30 MHz)
Biconilog (30 MHz – 1000 MHz)
Double ridged guide (above 1000 MHz)
MODULATION: 4GFSK
BIT RATE: 4.8 kbps
TRANSMITTER OUTPUT POWER SETTINGS: Maximum

Frequency, MHz	Field strength, dB(μV/m)	Limit, dB(μV/m)	Margin, dB*	RBW, kHz	Antenna polarization	Antenna height, m	Turn-table position**, degrees	Verdict
Low carrier frequency 450.0031 MHz								
No emissions were found								Pass
Mid carrier frequency 460.0000 MHz								
No emissions were found								Pass
High carrier frequency 469.9969 MHz								
No emissions were found								Pass

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

Reference numbers of test equipment used

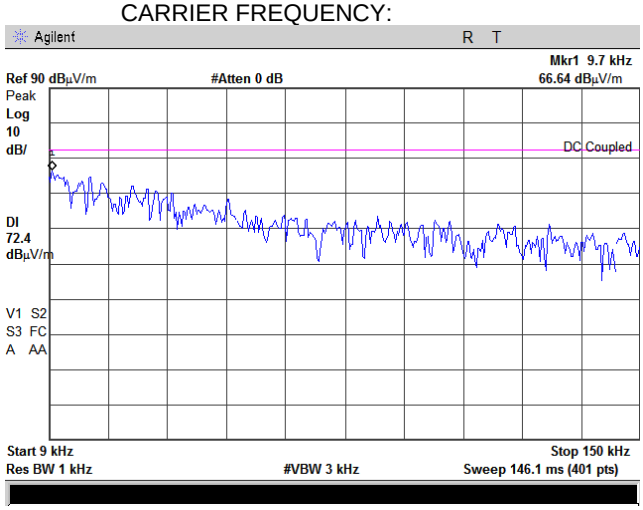
HL 3903	HL 4355	HL 4360	HL 4933	HL 5288	HL 5405	HL 5612	HL 5606
HL 4339							

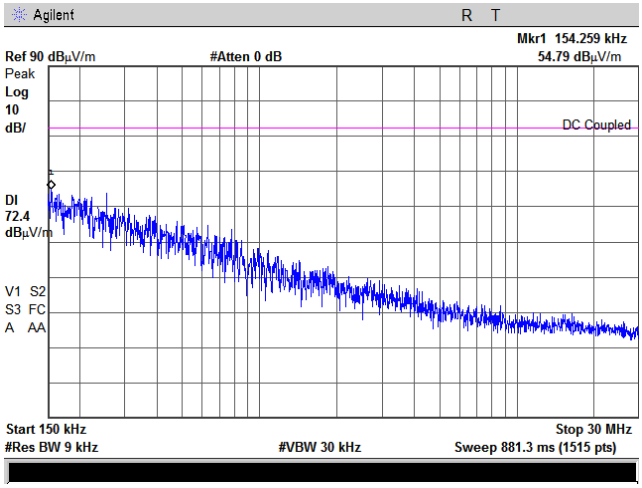
Full description is given in Appendix A.

Test specification:	**Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions**		
Test procedure:	47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	29-Jun-21		
Temperature: 25 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

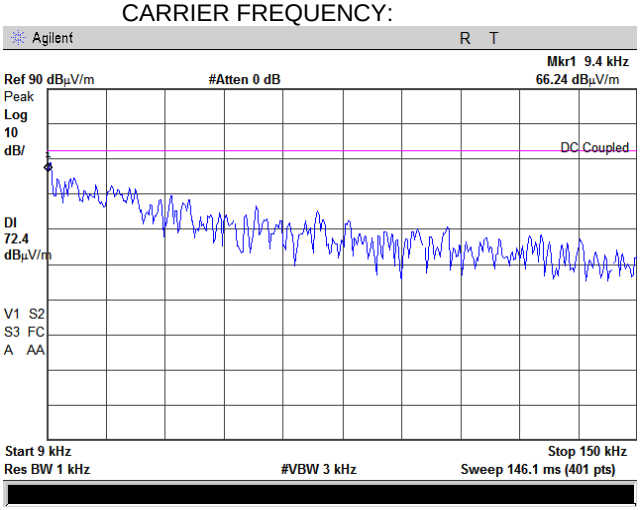
Plot 7.4.1 Radiated spurious emission measurements in 9 kHz – 30 MHz range

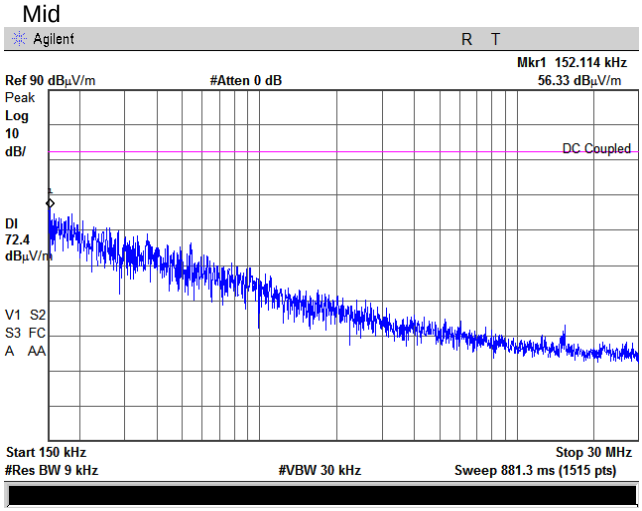
TEST SITE: Semi anechoic chamber
ANTENNA POLARIZATION: Vertical and Horizontal
TEST DISTANCE: 3 m
CARRIER FREQUENCY: Low





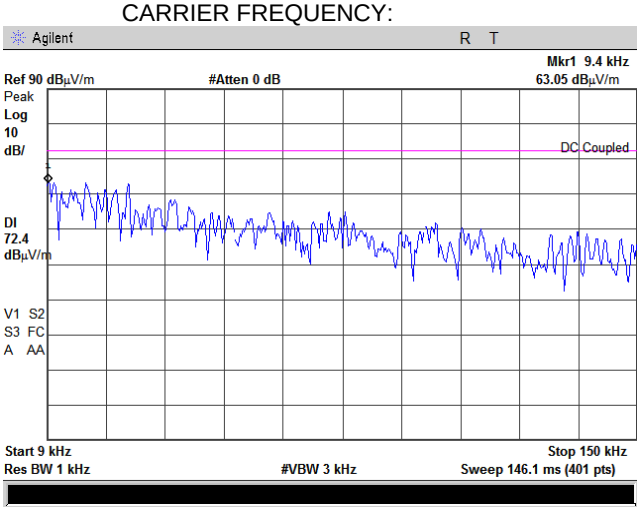
CARRIER FREQUENCY: Mid



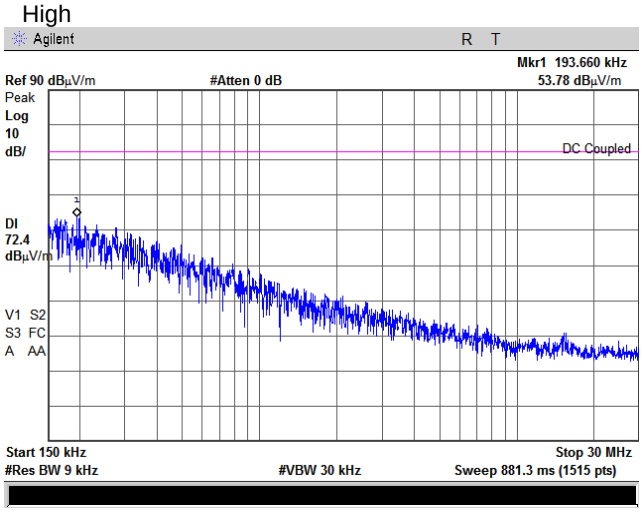


Test specification:	**Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions**		
Test procedure:	47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	29-Jun-21		
Temperature: 25 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

CARRIER FREQUENCY:



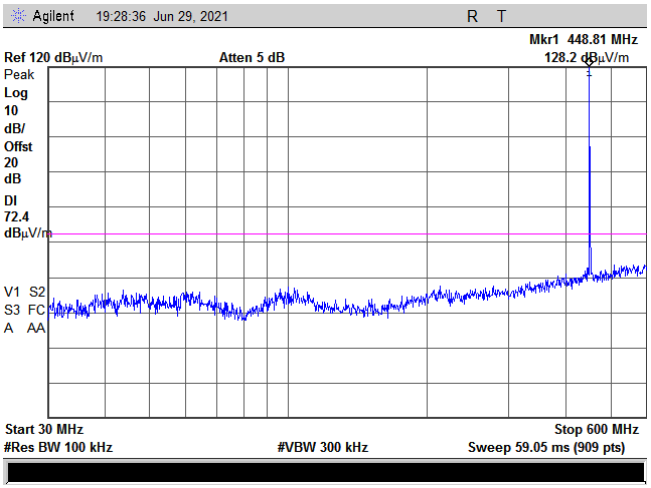
High



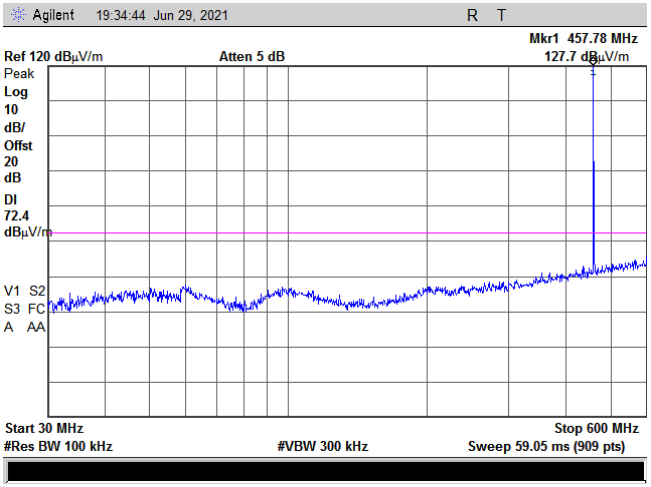
Test specification:	**Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions**		
Test procedure:	47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	29-Jun-21		
Temperature: 25 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

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

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

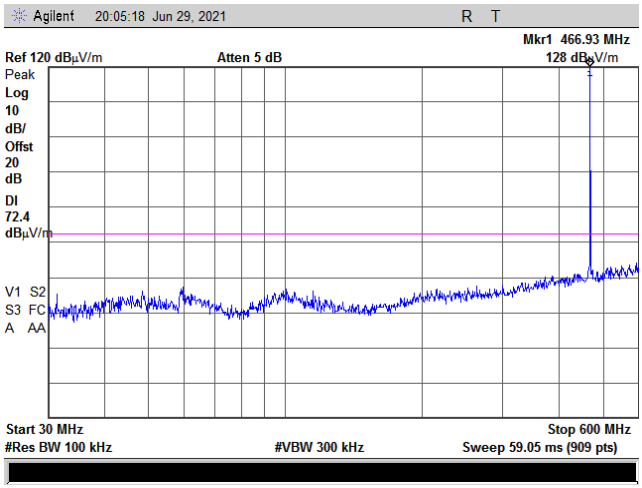


CARRIER FREQUENCY: Mid



Test specification:	**Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions**		
Test procedure:	47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	29-Jun-21		
Temperature: 25 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

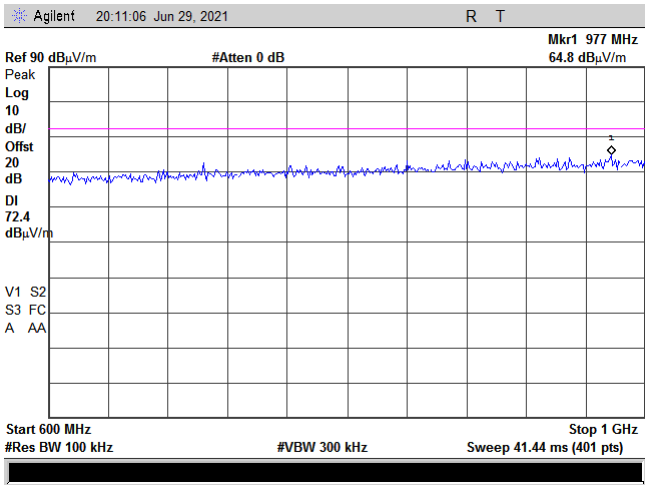
CARRIER FREQUENCY: High



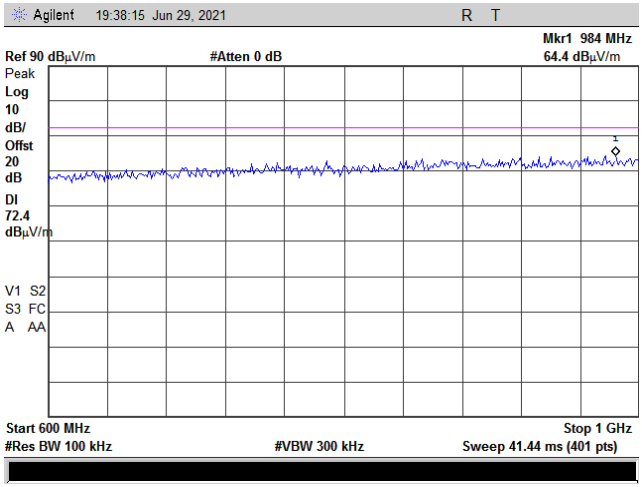
Test specification:	**Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions**		
Test procedure:	47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	29-Jun-21		
Temperature: 25 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

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

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

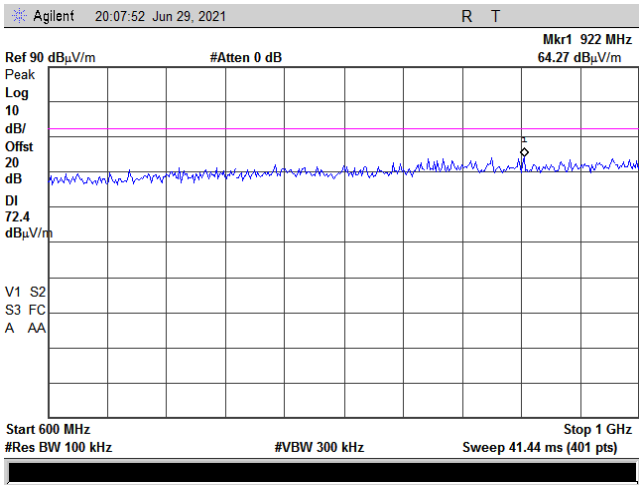


CARRIER FREQUENCY: Mid



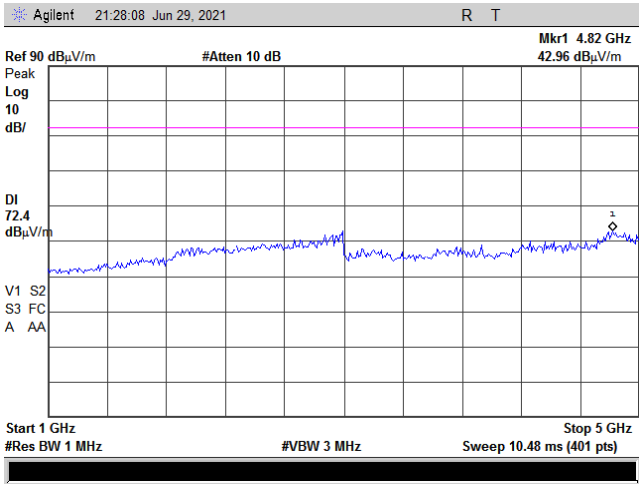
Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions		
Test procedure:	47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12		
Test mode:	Compliance	Verdict:	PASS
Date(s):	29-Jun-21		
Temperature: 25 ºC	Relative Humidity: 49 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

CARRIER FREQUENCY: High



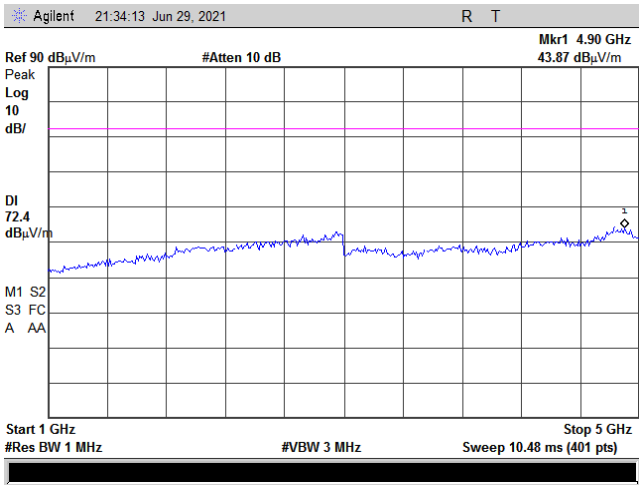
Plot 7.4.4 Radiated spurious emission measurements in 1000 – 5000 MHz range

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

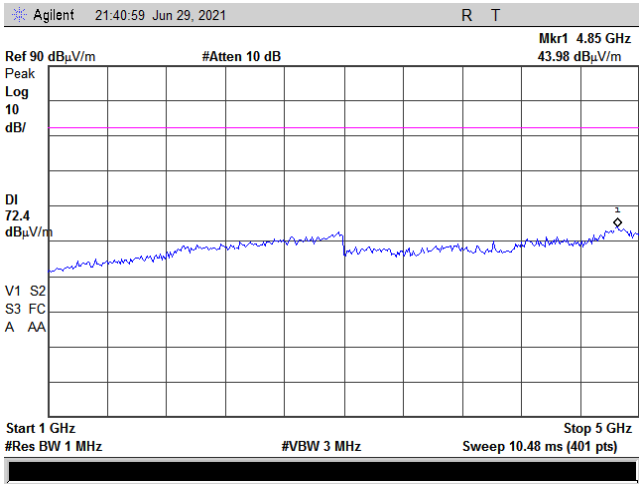


Test specification:	Section 90.210 / RSS-119 Section 5.8.4, Radiated spurious emissions		
Test procedure:	47 CFR, Section 2.1053; TIA/EIA-603-E, Section 2.2.12		
Test mode:	Compliance	Verdict:	PASS
Date(s):	29-Jun-21		
Temperature: 25 ºC	Relative Humidity: 49 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

CARRIER FREQUENCY: Mid



CARRIER FREQUENCY: High



Test specification:	Section 90.213 / RSS-119 Section 5.3, Frequency stability		
Test procedure:	47 CFR, Section 2.1055; TIA/EIA-603-E, Section 2.2.2		
Test mode:	Compliance	Verdict:	PASS
Date(s):	28-Jun-21		
Temperature: 24 ºC	Relative Humidity: 54 %	Air Pressure: 1004 hPa	Power: 3.6 VDC
Remarks:			

7.5 Frequency stability test

7.5.1 General

This test was performed to measure frequency stability of transmitter RF carrier. Specification test limits are given in Table 7.5.1. The test results are provided in Table 7.5.2.

Table 7.5.1 Frequency stability limits

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

7.5.2 Test procedure

7.5.2.1 The EUT was set up as shown in Figure 7.5.1, energized and its proper operation was checked.

7.5.2.2 The EUT power was turned off. Temperature within test chamber was set to +30˚C and a period of time sufficient to stabilize all of the oscillator circuit components was allowed.

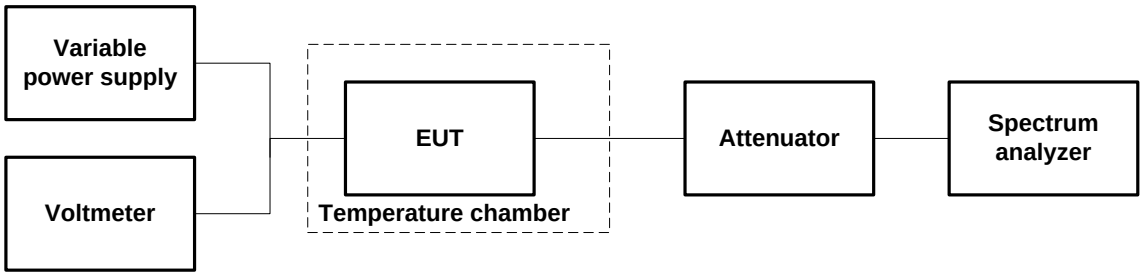
7.5.2.3 The EUT was powered on and carrier frequency was measured at start up moment and then every minute until frequency had been stabilized or 10 minutes elapsed whichever reached the last. The EUT was powered off.

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

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

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

Figure 7.5.1 Frequency stability test setup



Test specification:	**Section 90.213 / RSS-119 Section 5.3, Frequency stability**		
Test procedure:	47 CFR, Section 2.1055; TIA/EIA-603-E, Section 2.2.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	28-Jun-21		
Temperature: 24 ºC	**Relative Humidity:** 54 %	**Air Pressure:** 1004 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.5.2 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, 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 450.0031 MHz													
-30	nominal	450.003166	450.003170	450.003181	450.003185	450.003160	450.003163	450.003152	157	0		-293	Pass
-20	nominal	450.003155	NA	NA	NA	NA	NA	450.003137	127	0		-323	Pass
-10	nominal	450.003118	NA	NA	NA	NA	NA	450.003115	90	0		-360	Pass
0	nominal	450.003138	450.003150	450.003162	450.003177	450.003180	450.003176	450.003171	152	0		-298	Pass
10	nominal	450.003030	NA	NA	NA	NA	NA	450.003033	5	0		-445	Pass
20	+15%	450.003028	NA	NA	NA	NA	NA	450.003053	25	0	450	-425	Pass
20	nominal	450.002995	NA	NA	NA	NA	NA	450.003028	0	-33		-417	Pass
20	-15%	450.003000	NA	NA	NA	NA	NA	450.003137	109	-28		-341	Pass
30	nominal	450.003015	450.003011	450.003010	450.003010	450.003010	450.003006	450.003033	5	-22		-428	Pass
40	nominal	450.002966	NA	NA	NA	NA	NA	450.002941	0	-87		-363	Pass
50	nominal	450.002990	NA	NA	NA	NA	NA	450.002995	0	-38		-412	Pass
Mid frequency 460.0000 MHz													
-30	nominal	460.000083	460.000080	460.000072	460.000048	460.000047	460.000074	460.000066	0	-108		-352	Pass
-20	nominal	460.000143	NA	NA	NA	NA	NA	460.000111	0	-44		-416	Pass
-10	nominal	460.000134	NA	NA	NA	NA	NA	460.000130	0	-25		-435	Pass
0	nominal	460.000140	460.000159	460.000162	460.000170	460.000165	460.000154	460.000152	15	-15		-445	Pass
10	nominal	459.999987	NA	NA	NA	NA	NA	459.999992	0	-168		-292	Pass
20	+15%	459.999978	NA	NA	NA	NA	NA	459.999958	0	-197	460	-263	Pass
20	nominal	459.999992	NA	NA	NA	NA	NA	460.000155	0	-163		-297	Pass
20	-15%	460.000007	NA	NA	NA	NA	NA	460.000012	0	-148		-312	Pass
30	nominal	459.999973	459.999973	459.999968	459.999968	459.999973	459.999970	459.999963	0	-192		-268	Pass
40	nominal	459.999928	NA	NA	NA	NA	NA	459.999920	0	-235		-225	Pass
50	nominal	459.999885	NA	NA	NA	NA	NA	459.999885	0	-270		-190	Pass
High frequency 469.9969 MHz													
-30	nominal	469.996864	469.996866	469.996865	469.996861	469.996886	469.996862	469.996867	79	0		-391	Pass
-20	nominal	469.996988	NA	NA	NA	NA	NA	469.996978	181	0		-289	Pass
-10	nominal	469.997018	NA	NA	NA	NA	NA	469.997013	211	0		-259	Pass
0	nominal	469.997010	469.997022	469.997024	469.997022	469.997022	469.997021	469.997027	220	0		-250	Pass
10	nominal	469.996871	NA	NA	NA	NA	NA	469.996871	64	0		-406	Pass
20	+15%	469.996773	NA	NA	NA	NA	NA	469.996768	0	-39	470	-431	Pass
20	nominal	469.996812	NA	NA	NA	NA	NA	469.996807	5	0		-465	Pass
20	-15%	469.996753	NA	NA	NA	NA	NA	469.996735	0	-72		-398	Pass
30	nominal	469.996753	469.996743	469.996738	469.996735	469.996730	469.996728	469.996715	0	-92		-378	Pass
40	nominal	469.996676	NA	NA	NA	NA	NA	469.996680	0	-131		-339	Pass
50	nominal	469.996647	NA	NA	NA	NA	NA	469.996641	0	-166		-304	Pass

* - Reference frequency

Reference numbers of test equipment used

HL 0493	HL 3766	HL 4355					

Full description is given in Appendix A.

Test specification:	**Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour**		
Test procedure:	TIA/EIA-603-E, Section 2.2.19		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	28-Jun-21		
Temperature: 24 ºC	**Relative Humidity:** 54 %	**Air Pressure:** 1004 hPa	**Power:** 3.6 VDC
Remarks:			

7.6 Transient frequency behaviour test

7.6.1 General

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

Table 7.6.1 Transient frequency limits

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

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

7.6.2 Test procedure

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

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

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

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

Test specification:	Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour		
Test procedure:	TIA/EIA-603-E, Section 2.2.19		
Test mode:	Compliance	Verdict:	PASS
Date(s):	28-Jun-21		
Temperature: 24 ºC	Relative Humidity: 54 %	Air Pressure: 1004 hPa	Power: 3.6 VDC
Remarks:			

Figure 7.6.1 Transient frequency test setup

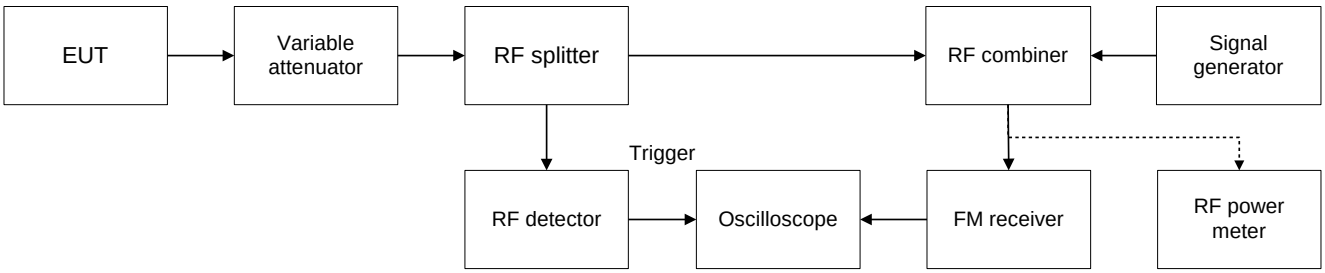


Table 7.6.2 Transient frequency behaviour test results

Carrier frequency, MHz	Time interval	Duration, ms	Frequency tolerance, kHz	Limit, kHz	Margin, kHz	Verdict
Channel bandwidth 6.25 kHz						
450.0031	t_1	10.0	2.148	± 6.25	-4.102	Pass
	t_2	25.0	1.464	± 3.125	-1.661	
	t_3	10.0	1.513	± 6.25	-4.737	
460.0000	t_1	10.0	1.757	± 6.25	-4.493	Pass
	t_2	25.0	1.416	± 3.125	-1.709	
	t_3	10.0	1.513	± 6.25	-4.737	
469.9969	t_1	10.0	1.904	± 6.25	-4.346	Pass
	t_2	25.0	1.123	± 3.125	-2.002	
	t_3	10.0	1.220	± 6.25	-5.030	

Reference numbers of test equipment used

HL 2016	HL 2017	HL 3434	HL 3766	HL 4785	HL 5212	HL 5409	HL 5472
HL 5971							

Full description is given in Appendix A.

Test specification:	Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour		
Test procedure:	TIA/EIA-603-E, Section 2.2.19		
Test mode:	Compliance	Verdict:	PASS
Date(s):	28-Jun-21		
Temperature: 24 ºC	Relative Humidity: 54 %	Air Pressure: 1004 hPa	Power: 3.6 VDC
Remarks:			

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

Test specification:	Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour		
Test procedure:	TIA/EIA-603-E, Section 2.2.19		
Test mode:	Compliance	Verdict:	PASS
Date(s):	28-Jun-21		
Temperature: 24 ºC	Relative Humidity: 54 %	Air Pressure: 1004 hPa	Power: 3.6 VDC
Remarks:			

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

Test specification:	Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour		
Test procedure:	TIA/EIA-603-E, Section 2.2.19		
Test mode:	Compliance	Verdict:	PASS
Date(s):	28-Jun-21		
Temperature: 24 ºC	Relative Humidity: 54 %	Air Pressure: 1004 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.6.3 Transient frequency during power OFF test results at low carrier frequency

Test specification:	Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour		
Test procedure:	TIA/EIA-603-E, Section 2.2.19		
Test mode:	Compliance	Verdict:	PASS
Date(s):	28-Jun-21		
Temperature: 24 ºC	Relative Humidity: 54 %	Air Pressure: 1004 hPa	Power: 3.6 VDC
Remarks:			

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

Test specification:	Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour		
Test procedure:	TIA/EIA-603-E, Section 2.2.19		
Test mode:	Compliance	Verdict:	PASS
Date(s):	28-Jun-21		
Temperature: 24 ºC	Relative Humidity: 54 %	Air Pressure: 1004 hPa	Power: 3.6 VDC
Remarks:			

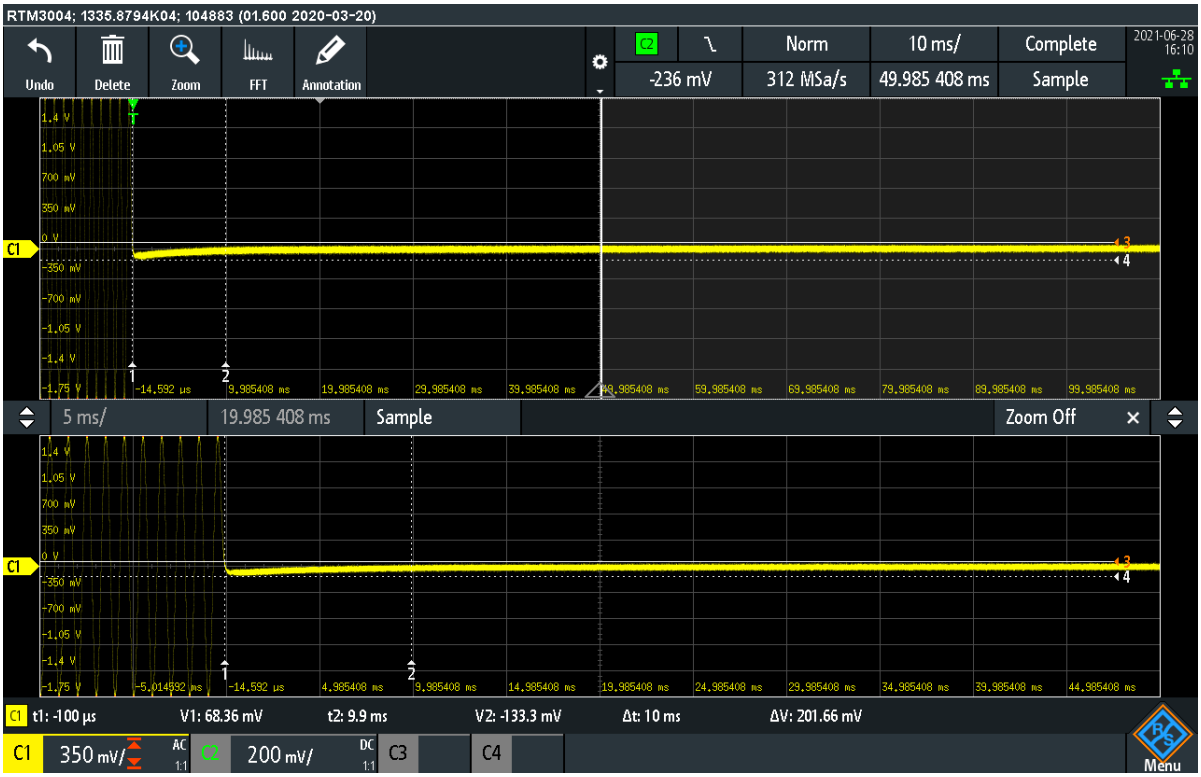
Plot 7.6.5 Transient frequency during power ON test results at mid carrier frequency

Test specification:	Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour		
Test procedure:	TIA/EIA-603-E, Section 2.2.19		
Test mode:	Compliance	Verdict:	PASS
Date(s):	28-Jun-21		
Temperature: 24 ºC	Relative Humidity: 54 %	Air Pressure: 1004 hPa	Power: 3.6 VDC
Remarks:			

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

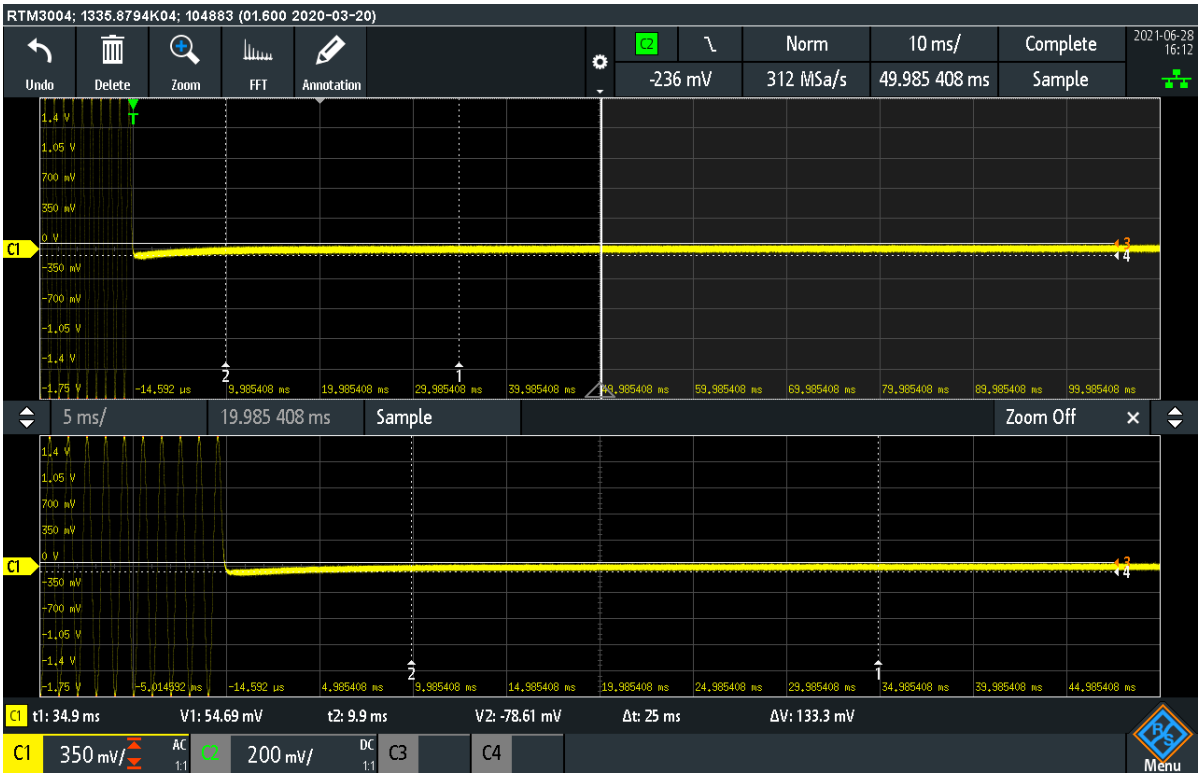
Test specification:	Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour		
Test procedure:	TIA/EIA-603-E, Section 2.2.19		
Test mode:	Compliance	Verdict:	PASS
Date(s):	28-Jun-21		
Temperature: 24 ºC	Relative Humidity: 54 %	Air Pressure: 1004 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.6.7 Transient frequency during power ON test results at high carrier frequency



Test specification:	Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour		
Test procedure:	TIA/EIA-603-E, Section 2.2.19		
Test mode:	Compliance	Verdict:	PASS
Date(s):	28-Jun-21		
Temperature: 24 ºC	Relative Humidity: 54 %	Air Pressure: 1004 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.6.8 Transient frequency during power ON test results at high carrier frequency



Test specification:	Section 90.214 / RSS-119 Section 5.9, Transient frequency behaviour		
Test procedure:	TIA/EIA-603-E, Section 2.2.19		
Test mode:	Compliance	Verdict:	PASS
Date(s):	28-Jun-21		
Temperature: 24 ºC	Relative Humidity: 54 %	Air Pressure: 1004 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.6.9 Transient frequency during power OFF test results at high carrier frequency

8 APPENDIX A Test equipment and ancillaries used for tests

HL No	Description	Manufacturer	Model	Ser. No.	Last Cal./ Check	Due Cal./ Check
0493	Temperature Chamber -45…175 deg C	Thermotron	S-1.2 Mini-Max	14016	24-Jun-21	24-Jun-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
2780	EMC analyzer, 100 Hz to 26.5 GHz	Agilent Technologies	E7405A	MY45102462	02-Mar-21	02-Mar-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
3903	Microwave Cable Assembly, 40.0 GHz, 1.5 m, SMA/SMA	Huber-Suhner	SUCOFLEX 102A	1226/2A	06-Apr-21	06-Apr-22
4068	Attenuator, SMA, 30 dB, DC to 12.4 GHz	Midwest Microwave	ATT-0527-30-SMA-07	NA	06-Aug-20	06-Sep-21
4339	High pass Filter, 50 Ohm, 1000 to 18000 MHz, SMA-FM / SMA-M	Micro-Tronics	HPM50115-02	001	15-Jun-21	15-Jun-23
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
4785	Signal generator, 9 kHz - 3.2 GHz	Rohde & Schwarz	SMC 100A	103279	16-Nov-20	16-Nov-21
4914	Bandpass filter, 600 to 1100 MHz, SMA/F-SMA/F	K&L Microwave Inc.	7IB44-900/U600-O/O	24	15-Jun-21	15-Jun-23
4933	Active Horn Antenna, 1 GHz to 18 GHz	COM-POWER CORPORATION	AHA-118	701046	26-Jan-21	26-Jan-22
5212	Load Termination 50 Ohm, 0.5 W, DC-1GHz	Amphenol	R404051	NA	02-May-21	02-May-22
5288	Trilog Antenna, 25 MHz - 8 GHz, 100W	Frankonia	ALX-8000E	00809	08-Feb-19	08-Feb-22
5405	RF cable, 18 GHz, N-N, 6 m	Huber-Suhner	SF118/11N(x2)	500023/118	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
5606	Precision Fixed Attenuator, 50 Ohm, 5 W, 10 dB, DC to 18000 MHz	Mini Circuits	BW-N10W5+	NA	16-Sep-20	16-Sep-21
5612	Precision Fixed Attenuator, 50 Ohm, 5 W, 10 dB, DC to 18 GHz	Mini Circuits	BW-S10W5+	NA	16-Sep-20	16-Sep-21
5902	RF cable, 18 GHz, 6.0m, N-type	Huber-Suhner	SF126EA/11N/11N/6000		01-Dec-20	01-Dec-21
5971	Oscilloscope, 500 MHz, digital 4 channel	Rohde & Schwarz	RTM3004	104883	20-Feb-21	20-Jan-22

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

Insertion loss

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

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

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

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

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

above 1000 MHz

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

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

10 APPENDIX C 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).

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

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

12 APPENDIX E Specification references

FCC 47CFR part 90: 2020	Private land mobile radio services
FCC 47CFR part 2: 2020	Frequency allocations and radio treaty matters; general rules and regulations
ANSI/TIA/EIA-603-E:2016	Land Mobile FM or PM Communications Equipment Measurement and Performance Standards
RSS-119 Issue 12: 2015	Land Mobile and Fixed Equipment Equipment Operating in the Frequency Range 27.41-960 MHz
RSS-Gen Issue 5: 2019	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(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