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Test report

REP0012192-23R3TRFWL

Date of issue: September 20, 2023

Applicant:

Wavetronix, LLC

Product Description:

Traffic Intersection Radar

Model name (PMN):

Expanse XP21

Model number (HVIN):

XP21

FCC ID:

PCB-XP-21

IC:

4513A-XP21

Specifications:

- FCC 47 CFR Part 15.255 Subpart C

Operation within the band 57 – 71 GHz.

- RSS-210 Issue 10 (December 2019); Annex J

Licence-Exempt Radio Apparatus: Category I Equipment

Lab and test locations

Company name	Nemko USA Inc.
Address	2210 Faraday Ave, Suite 150
City	Carlsbad
State	California
Postal code	92008
Country	USA
Telephone	+1 760 444 3500
Website	www.nemko.com

Tested by	Martha Espinoza, Wireless Test Engineer
Reviewed by	James Cunningham, EMC/MIL/WL Supervisor
Review date	September 20, 2023
Reviewer signature	

Limits of responsibility

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.
This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contain in this report are within Nemko USA's ISO/IEC 17025 accreditation.
This report must not be used by the client to claim product certification, approval, or endorsement by ANAB, NIST, or any agency of the U.S. Government.

Copyright notification

Table of Contents

Section 1 Report summary

1.1 Test specifications

FCC 47 CFR Part 15.255, Subpart C	Title 47: Telecommunication; Part 15C— Operation within the band 57 – 71 GHz
RSS-210, Issue 10 (December 2019)	Licence-Exempt Radio Apparatus: Category I Equipment
ANSI C63.10-2013	American National Standard of procedures for compliance testing of unlicensed wireless devices

1.2 Exclusions

None

1.3 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was performed against all relevant requirements of the test standard. Results obtained indicate that the product under test complies in full with the requirements tested. The test results relate only to the items tested.

See "Summary of test results" for full details.

1.4 Test report revision history

Table 1.4-1: *Test report revision history*

Revision #	Details of changes made to test report
PRJ0012192-23R1TRFWL	Original report issued
REP0012192-23R2TRFEMC	Updated information: FCC ID, IC, Model name, Model number and product description.
REP0012192-23R3TRFEMC	Corrected typo in section 7.1.5

Notes: None

Section 2 Summary of test results

2.1 Emissions Test results

Table 2.1-1: *FCC 47 CFR Part 15.203 and RSS-210 Annex J results.*

Test description	Verdict
Antenna requirement	Pass

Notes: None

Table 2.1-2 *FCC 47 CFR Part 15.255C and RSS-210 Annex J results.*

Test description	Verdict
Equivalent Isotropically Radiated Power (E.I.R.P.)	Pass
Occupied Bandwidth	Pass
Peak conducted output power	Not applicable
Transmitter spurious emissions	Pass
Frequency stability	Pass

Notes: None

Table 2.1-3 *FCC 47 CFR Part 15.207 and RSS-210 Annex J results.*

Test description	Verdict
AC Line conducted emissions	Pass

Notes: None

Section 3 Equipment under test (EUT) details

3.1 Applicant

Company name	Wavetronix, LLC
Address	1827 West 650 North
City	Springville
State	UT
Postal/Zip code	84663
Country	USA

3.2 Manufacturer

Company name	Wavetronix, LLC
Address	1827 West 650 North
City	Springville
State	UT
Postal/Zip code	84663
Country	USA

3.3 Sample information

Receipt date	October 10, 2022
Nemko sample ID number	PRJ0012192

3.4 EUT information

Product description	Traffic Intersection Radar
Model Name (PMN):	Expanse XP21
Model Number (HVIN):	XP21
Serial number	101-0479-00138
Power requirements	PoE 100-240 VAC/ 50/60 Hz 1.0 A Max
Description/theory of operation	60 GHz Traffic Radar Sensor for smart control
Operational frequencies	Band: 61-61.5 GHz (500 MHz BW)
Antenna type	MIMO: 3X4 (3 Tx, 4 Rx) All sequenced- 60GHz
Antenna gain	13 dBi
Software details	N/A

3.5 EUT exercise and monitoring details

For this test, the unit transmit at one channel, one bandwidth and in continuous mode making a sweep of frequency in the band from 61-61.5 GHz. Unit was controlled via software using a terminal operated by client.

3.6 EUT setup details

Table 3.6-1: *Support equipment*

Description	Brand name	Model/Part number	Serial number	Rev.
Laptop	Lenovo	ThinkPad	N/A	N/A
PoE	Wavetronix	Expanse Arc	102-0439 00021	N/A

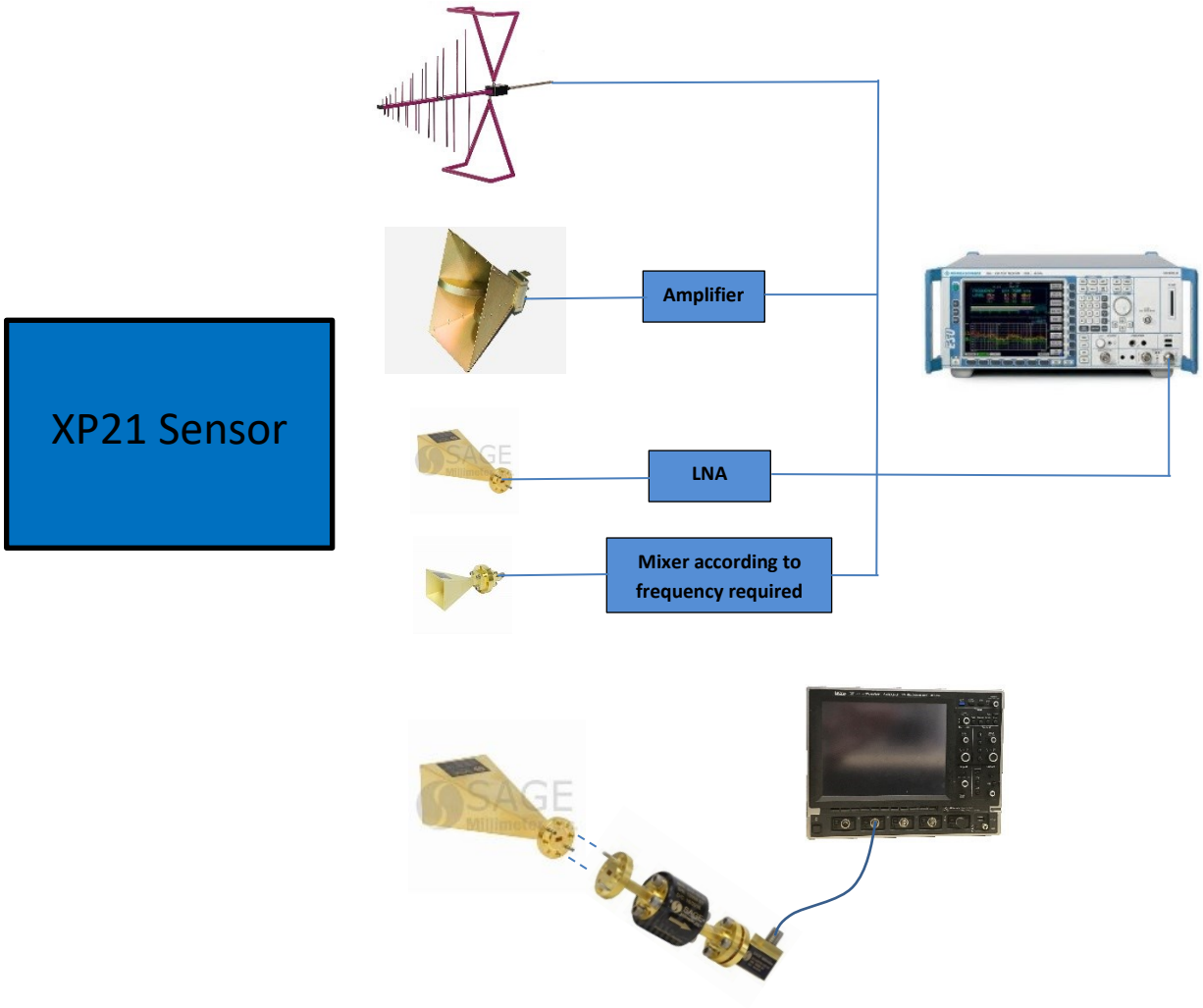


Figure 3.6-1: *EUT Test Setup*

Section 4 Engineering considerations

4.1 Modifications incorporated in the EUT

There were no modifications performed to the EUT during this assessment.

4.2 Technical judgment

None

4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5 Test conditions

5.1 Atmospheric conditions

Temperature	15–30 °C
Relative humidity	20–75 %
Air pressure	86–106 kPa

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

5.2 Power supply range

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages ±5 %, for which the equipment was designed.

Section 6 Measurement uncertainty

6.1 Uncertainty of measurement

Measurement uncertainty budgets for the tests are detailed below. Measurement uncertainty calculations assume a coverage factor of K = 2 with 95% certainty.

Table 6.1-1: *Measurement uncertainty.*

Test name	Measurement uncertainty, dB
All antenna port measurements/ including OBW	0.55
Conducted spurious emissions	1.13
Radiated spurious emissions	3.78
AC power line conducted emissions	1.38
Supply Voltages	0.05%
Time	2.09%

Important note: All testing in this document were done using the maximum radiation side of the antenna for covering the worst case in all the measurements.

Section 7 Testing data

7.1 Equivalent Isotropically Radiated Power (E.I.R.P.)

7.1.1 References

(2) For fixed field disturbance sensors that occupy 500 MHz or less of bandwidth and that are contained wholly within the frequency band 61.0-61.5 GHz, the average power of any emission, measured during the transmit interval, shall not exceed 40 dBm, and the peak power of any emission shall not exceed 43 dBm. In addition, the average power of any emission outside of the 61.0-61.5 GHz band, measured during the transmit interval, but still within the 57-71 GHz band, shall not exceed 10 dBm, and the peak power of any emission shall not exceed 13 dBm.

(3) For fixed field disturbance sensors other than those operating under the provisions of paragraph (c)(2) of this section, and short-range devices for interactive motion sensing, the peak transmitter conducted output power shall not exceed −10 dBm and the peak EIRP level shall not exceed 10 dBm.

(4) The peak power shall be measured with an RF detector that has a detection bandwidth that encompasses the 57-71 GHz band and has a video bandwidth of at least 10 MHz. The average emission levels shall be measured over the actual time period during which transmission occurs.

7.1.2 Test summary

Verdict	Pass		
Test date	October 11, 2022	Temperature	21 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1003 mbar
Test location	3m semi anechoic chamber	Relative humidity	58 %

7.1.3 Notes

This test performed using the procedure described in ANSI C63.10-2013, section 9.11. The procedure indicates several steps using a measurement from EUT through a test antenna, a RF detector, and a digital oscilloscope. A substitution method is used replacing the EUT by a mmWave source to match the delivered power by mmWave source to the EUT. From this data, some calculations were performed to determine the EIRP (peak and average for signals with bandwidth equal or less than 500 MHz and within 61 – 61.5 GHz band. Peak for other bandwidths.) and the conducted power from equation (19), (22), (24) and (27) from ANSI C63.10-2013. Antenna gain from EUT declared by manufacturer: 13 dBi; Gain of the test antenna: 24 dBi

7.1.4 Setup details

EUT setup configuration	Tabletop
Test facility	3M Semi anechoic chamber
Measuring distance	0.4 m
Antenna height variation	1.69 m
Turn table position	0°
Measurement details	The EUT was measured in the maximum field strength emission.

Receiver/spectrum analyzer settings for frequencies above 1 GHz:

Resolution bandwidth	1 MHz
Video bandwidth	3 MHz
Detector mode	Peak and CAverage
Trace mode	Max Hold

Table 7.1-1: *Radiated EIRP equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
Antenna, Horn	Sage Millimeter	SAR-2408-15-S2	E1152	NCR	NCR
Signal/Spectrum analyzer	Rohde & Schwarz	FSV40	E1120	12-09-2021	12-09-2023
Mixer	Rohde & Schwarz	FS-Z75	E1324	VOU	VOU
Signal generator	Rohde & Schwarz	SMB100A	E1128	VOU	VOU
Digital oscilloscope	LeCroy	WS64MXS-B	E1041	12-08-2020	12-08-2022
V-Band X2, Passive Frequency Multiplier	Sage	SFP-152KF-S2	N/A	NCR	NCR
RF Detector	Eravant	STD-15SF-PI	E1310	NCR	NCR

Notes: NCR - no calibration required
VOU - verify on use

7.1.5 Test data

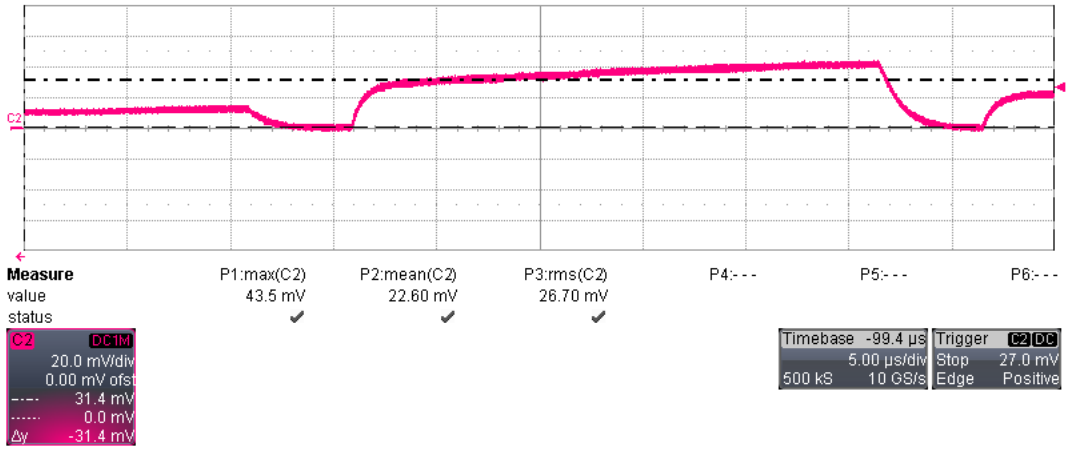


Figure 7.1-1: *500 MHz occupied bandwidth signal, view on oscilloscope.*

7.1.5 Test data, continued

Center Frequency (GHz)	Bandwidth (MHz)	Power (dBm)	Radiated Power (dBµV/m) (Calculated – see example below)	EIRP (dBm) (Calculated – see example below)	Limit (dBm)	Margin (dB)
61.24904355 (Peak)	500	-12.94	136.0655722	23.40677199	+43	19.59322801
61.24904355 (Av)		-15.16	133.8455722	21.18677199	+40	18.81322801

Table 7.1-2: *EIRP Results*

Using equation (19):

$$E = 126.8 - 20\log(\lambda) + P - G \qquad (19)$$

Where:

$$\lambda = \frac{c}{f}$$

c ≈3X10^8 m/s

E = Field strength of the emission at the measurement distance, in dBµV/m

P = Power measured at the output of the test antenna, in dBm

λ = Wavelength of the emission under investigation, in m.

G = Gain of the antenna test, in dBi

E = 126.8 – (20*log10(3e8/61.2491e9)) +(-12.94) -(24) ≈ 136.065 dBµV/m

Using equation (22):

$$\mathrm{EIRP} = E_{\mathrm{Meas}} + 20\log(d_{\mathrm{Meas}}) - 104.7 \qquad (22)$$

EIRP = Equivalent Isotropically Radiated Power, in dBm

E_{meas} = Field strength of the emission at the measurement distance, in dBµV/m

d_{meas} = Measurement distance, in m (0.4 m in this case)

EIRP = 136.065 + (20*log10(0.4))-104.7

EIRP ≈ 23.406 dBm

7.2 Occupied bandwidth

7.2.1 References

§15.255 Operation within the band 57-71 GHz.
(e)(1) Transmitters with an emission bandwidth of less than 100 MHz must limit their peak transmitter conducted output power to the product of 500 mW times their emission bandwidth divided by 100 MHz. For the purposes of this paragraph, emission bandwidth is defined as the instantaneous frequency range occupied by a steady state radiated signal with modulation, outside which the radiated power spectral density never exceeds 6 dB below the maximum radiated power spectral density in the band, as measured with a 100 kHz resolution bandwidth spectrum analyzer. The center frequency must be stationary during the measurement interval, even if not stationary during normal operation (e.g., for frequency hopping devices).
ANSI C63.4-2014

7.2.2 Test summary

Verdict	Pass		
Test date	October 10, 2022	Temperature	23 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1006 mbar
Test location	3m semi anechoic chamber	Relative humidity	60 %

7.2.3 Notes

7.2.4 Setup details

7.2.5 Setup details

EUT setup configuration	Tabletop
Test facility	3M Semi anechoic chamber
Measuring distance	3 m
Antenna height variation	1.69 m
Turn table position	0°

Receiver/spectrum analyzer settings for frequencies above 1 GHz:

Resolution bandwidth	100 kHz (6 dB OBW) and 5 MHz[1] (99% OBW)
Video bandwidth	300 kHz (6 dB OBW) and 20 MHz (99% OBW)
Detector mode	Peak (Preview measurement)
Trace mode	Max Hold

Note: [1]Approximately 1% from the occupied bandwidth.

7.2.5 Setup details, continued

Table 7.2-1: *Occupied bandwidth equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
Antenna, Horn	Sage Millimeter	SAR-2408-15-S2	E1152	NCR	NCR
Signal/Spectrum analyzer	Rohde & Schwarz	FSV40	E1120	12-09-2021	12-09-2023
Mixer	Rohde & Schwarz	FS-Z75	E1324	VOU	VOU

Notes: NCR - no calibration required
VOU – verify before use

7.2.6 Test data

Center Frequency (GHz)	6 dB BW (MHz)	99% BW (MHz)
61.24904355	494.950	494.711102778

Table 7.2-2: *Occupied Bandwidth Results.*

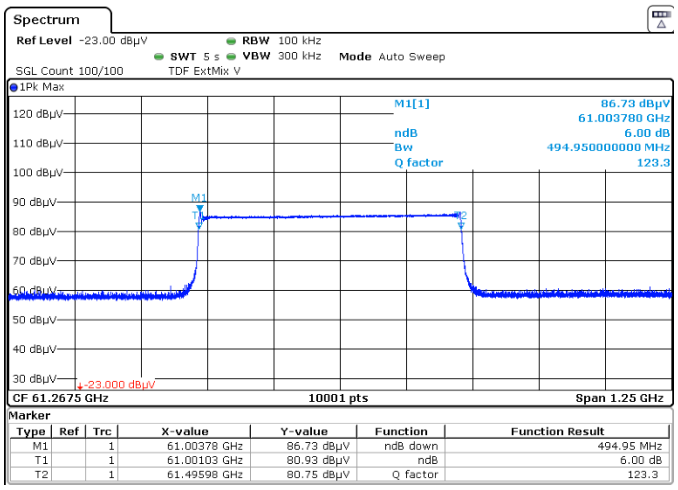


Figure 7.2-1: *6 dB OBW plot*

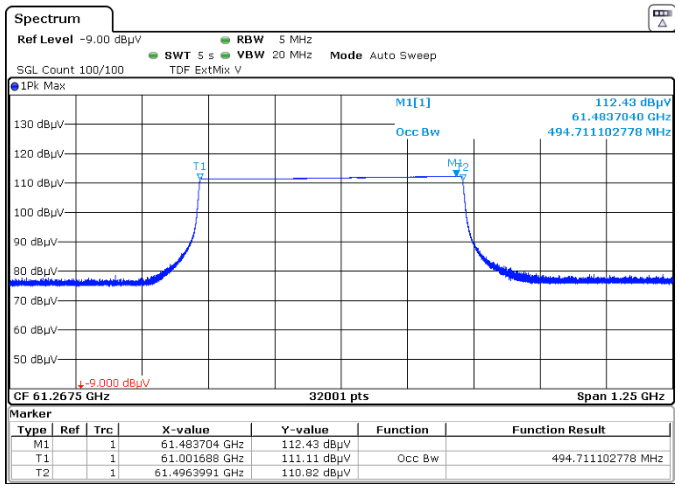


Figure 7.2-2: *99% OBW plot*

7.3 Transmitter spurious emissions

7.3.1 References

§15.255 Operation within the band 57-71 GHz.
(d) Limits on spurious emissions:
(1) The power density of any emissions outside the 57-71 GHz band shall consist solely of spurious emissions.
(2) Radiated emissions below 40 GHz shall not exceed the general limits in §15.209.
(3) Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90 pW/cm² at a distance of 3 meters.
(4) The levels of the spurious emissions shall not exceed the level of the fundamental emission.
ANSI C63.4-2014
Spurious radiated emissions below 40 GHz must comply with the general field strength limits of Section 15.209. Below 1000 MHz, measurements are made with a CISPR quasi-peak detector and above 1000 MHz measurements are made with an average detector with a 1 MHz RBW at 3 meters. From 40 GHz to 200 GHz the emissions must not exceed 90 pW/cm2 (18,000 µV/m) at 3 meters. Measurements are to be performed at the specified limit distance. If it is impractical to make measurements at the limit distance because of the distance or low signal levels, measurements may be performed at a closer distance but a low noise amplifier and/or a higher gain test antenna should be used to make measurements at the greatest distance from the EUT which provides an adequate signal to noise ratio to permit accurate amplitude measurements and extrapolated to the limit distance as specified in Section 15.31.
200443 D02 RF Detector Method v01

7.3.2 Test summary

Verdict	Pass		
Test date	October 10, 2022; October 11, 2022	Temperature	23 °C; 21 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1006 mbar; 1003 mbar
Test location	3m semi anechoic chamber	Relative humidity	60 %; 58%

7.3.3 Notes

This test was done at a 3m (below 40 GHz) and 1m (above 40 GHz) measurement distance using the maximum radiated energy from the EUT. The spectrum was explored from 30 MHz to 200 GHz. Testing from 30 MHz to 40 GHz was measured under FCC 15.209 limits. Above 40 GHz, the limit is defined as 90 pW/cm² at 3m.
Calculation from limit line for this test (above 40 GHz):

$$PD = \frac{EIRP_{Linear}}{4\pi d^2}$$

Where:

PD = Power density at the distance specified by the limit, in w/cm²
$EIRP_{Linear}$ = Equivalent Isotropically Radiated Power, in watts.
d = Distance at which the power density limit is specified, in cm
$EIRP_{Linear} = (PD)(4\pi)(d^2)$
$EIRP_{Linear} = (90x10^{-12})(4\pi)(300^2)$
$EIRP_{Linear} = 0.10178\ mw \approx 85.31$ dBµV/m @ 3m

This limit above 40 GHz is calculated at 3m, however, the noise floor is less than 6 dB below the limit calculated. To compensate this problem, an extrapolation to a shorter distance was done. The new distance is 1 m and the new limit line is:

$$E_{SpecLimit} = E_{Meas} + 20\ Log\left(\frac{d_{Meas}}{d_{SpecLimit}}\right)$$

$$E_{SpecLimit} = 85.31 + 20\ Log\left(\frac{3}{1}\right) \approx 94.85\ dB\mu v/m\ @\ 1\ m$$

7.3.4 Setup details

EUT setup configuration	Table top
Test facility	3m Semi anechoic chamber
Measuring distance	3m
Antenna height variation	1–4 m
Turn table position	0–360°
Measurement details	A preview measurement was generated with receiver in continuous scan or sweep mode while the EUT was rotated and antenna adjusted to maximize radiated emission. Emissions detected within 6 dB or above limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.

Receiver/spectrum analyzer settings for frequencies below 1 GHz:

Resolution bandwidth	120 kHz
Video bandwidth	300 kHz
Detector mode	– Peak (Preview measurement) – Quasi-peak (Final measurement)
Trace mode	Max Hold
Measurement time	– 100 ms (Peak preview measurement) – 5000 ms (Quasi-peak final measurement)

Receiver/spectrum analyzer settings for frequencies from 1 GHz to 40 GHz:

Resolution bandwidth	1 MHz
Video bandwidth	3 MHz
Detector mode	Peak (Preview measurement) Peak and CAverage (Final measurement)
Trace mode	Max Hold
Measurement time	– 100 ms (Peak preview measurement) – 5000 ms (Peak and CAverage final measurement)

Receiver/spectrum analyzer settings for frequencies above 40 GHz:

Resolution bandwidth	1 MHz
Video bandwidth	3 MHz
Detector mode	Average
Trace mode	Max Hold
Measuring distance	1m
Antenna height	1.69 m
Turn table position	0°

7.3.4 Setup details, continued

Table 7.3-1: *Radiated disturbance equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
EMC Test Receiver	Rohde & Schwarz	ESU 40	E1121	05-31-2022	05-31-2023
Signal/Spectrum analyzer	Rohde & Schwarz	FSV40	E1120	12-09-2021	12-09-2023
Signal Generator	Rohde & Schwarz	SMB 100A	E1128	VOU	VOU
Antenna, Bilog	Schaffner-Chase	CBL6111C	1480	10-28-2020	10-28-2022
Antenna, Horn	ETS	3117-PA	E1139	04-19-2021	04-19-2023
Antenna, Horn	Sage Millimeter	SAR-2309-42-S2	E1143	11-13-2020	11-13-2022
Antenna, Horn	Sage Millimeter	SAR-2309-28-S2	E1148	11-05-2020	11-05-2022
Low Noise Amplifier	Sage Millimeter	SBL-1834034030-KFKF-SI	E1228	NCR	NCR
Antenna, Horn	Sage Millimeter	SAR-2309-19-S2	E1144	NCR	NCR
Mixer	Rohde & Schwarz	FS-Z60	E1138	VOU	VOU
Antenna, Horn	Sage Millimeter	SAR-2408-15-S2	E1152	NCR	NCR
Mixer	Rohde & Schwarz	FS-Z75	E1324	VOU	VOU
Antenna, Horn	Sage Millimeter	SAR-2507-10-S2	E1146	NCR	NCR
Mixer	Rohde & Schwarz	FS-Z110	E1154	VOU	VOU
Antenna, Horn	Sage Millimeter	SAR-2507-06-S2	E1182	NCR	NCR
Mixer	Radiometer Physics	HM110-170	E1178	VOU	VOU
Antenna, Horn	Sage Millimeter	SAR-2309-05-S2	E1184	NCR	NCR
Mixer	Radiometer Physics	HM140-220	E1177	VOU	VOU

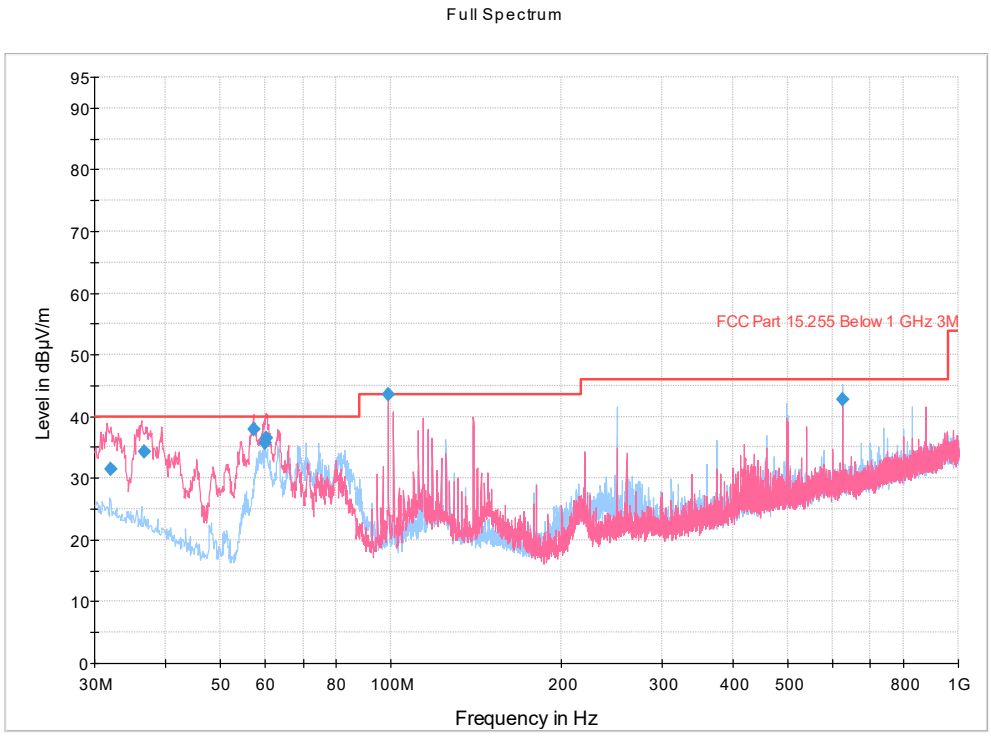
Notes: NCR - no calibration required
VOU - verify on use

Table 7.3-2: *Radiated disturbance test software details*

Manufacturer of Software	Details
Rohde & Schwarz	EMC 32 V10.00.00

Notes: None

7.3.5 Test data



The spectral plot shows a vertical and horizontal scan separately. The spectral scan has been corrected with the associated transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators).

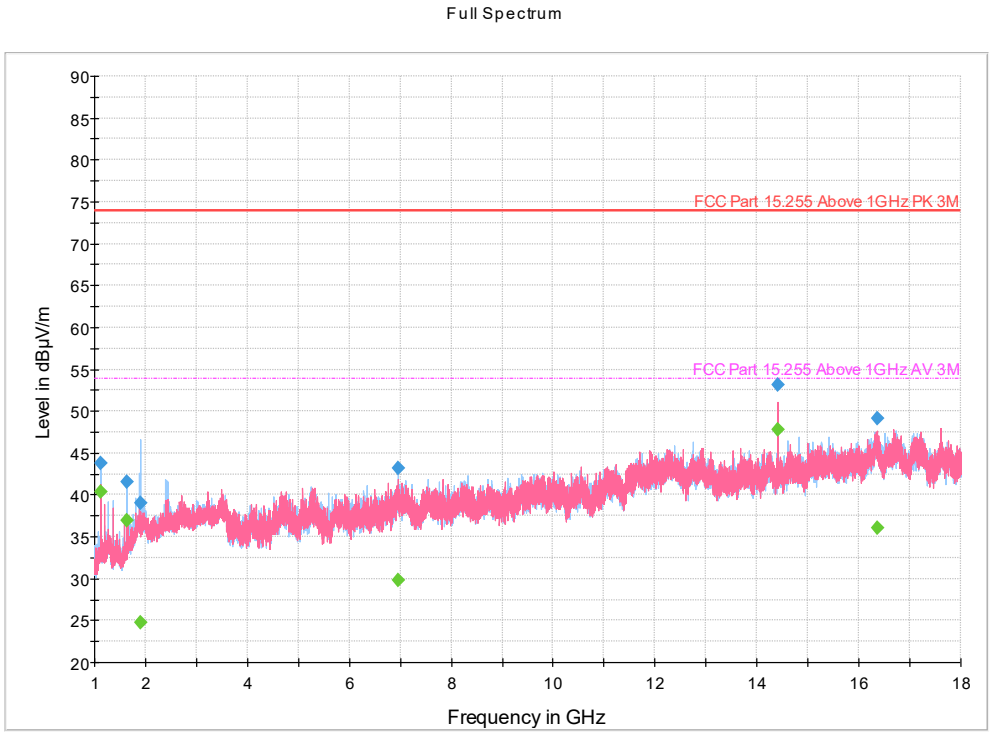
Figure 7.3-1: *Radiated disturbance spectral plot (30 to 1000 MHz)*

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
31.992000	31.41	40.00	8.59	5000.0	120.000	107.0	V	0.0	25.5
36.665000	34.27	40.00	5.73	5000.0	120.000	122.0	V	0.0	23.0
57.280000	37.85	40.00	2.15	5000.0	120.000	118.0	V	84.0	13.2
59.927000	35.68	40.00	4.32	5000.0	120.000	173.0	V	0.0	12.8
60.298000	36.50	40.00	3.50	5000.0	120.000	115.0	V	224.0	12.8
98.910000	43.48	43.50	0.02	5000.0	120.000	129.0	V	71.0	17.7
624.998000	42.71	46.00	3.29	5000.0	120.000	260.0	H	353.0	30.0

Table 7.3-3: *Radiated disturbance (Quasi-Peak) results*

Notes:
[1]Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2]Correction factor = antenna factor ACF (dB) + cable loss (dB) – amplifier gain (dB)
[3]The maximum measured value observed over a period of 5 seconds was recorded.

7.3.5 Test data, continued



The spectral plot shows a vertical and horizontal scan with different colors. The spectral scan has been corrected with the associated transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators).

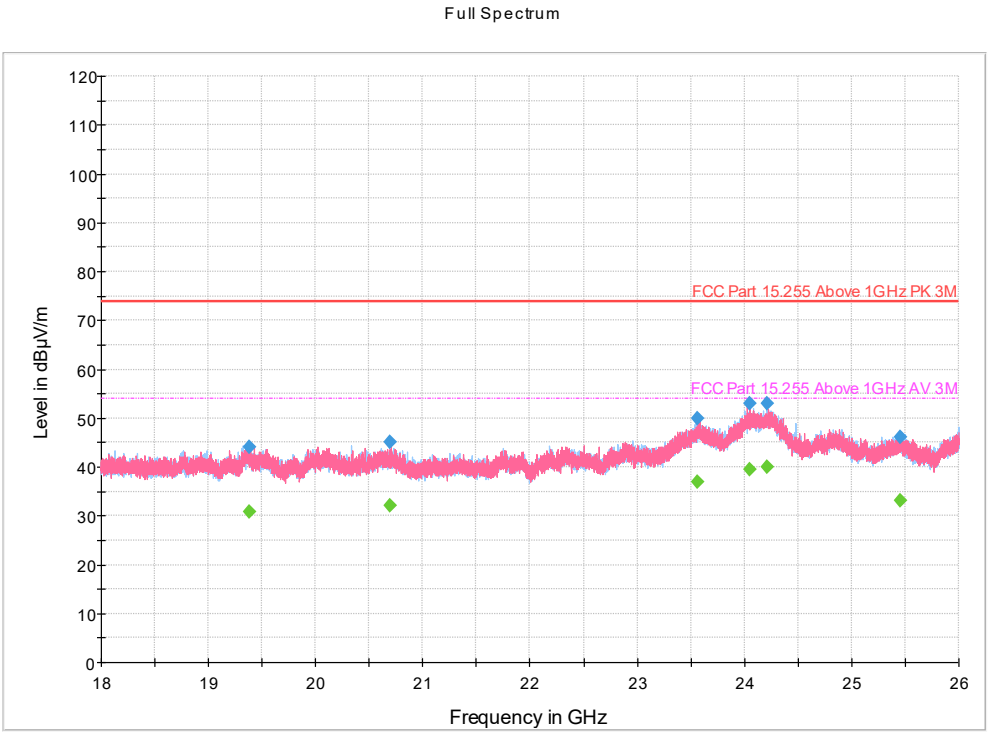
Figure 7.3-2: *Radiated disturbance spectral plot (1 to 18 GHz)*

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
1125.066667	43.76	---	73.90	30.14	5000.0	1000.000	264.0	H	45.0	-14.7
1125.066667	---	40.43	53.90	13.47	5000.0	1000.000	264.0	H	45.0	-14.7
1625.077778	---	36.96	53.90	16.94	5000.0	1000.000	100.0	H	123.0	-14.3
1625.077778	41.53	---	73.90	32.37	5000.0	1000.000	100.0	H	123.0	-14.3
1899.588889	39.03	---	73.90	34.87	5000.0	1000.000	266.0	H	274.0	-10.9
1899.588889	---	24.72	53.90	29.18	5000.0	1000.000	266.0	H	274.0	-10.9
6971.144444	---	29.87	53.90	24.03	5000.0	1000.000	152.0	H	0.0	0.9
6971.144444	43.23	---	73.90	30.67	5000.0	1000.000	152.0	H	0.0	0.9
14399.233333	53.14	---	73.90	20.76	5000.0	1000.000	199.0	V	11.0	10.0
14399.233333	---	47.76	53.90	6.14	5000.0	1000.000	199.0	V	11.0	10.0
16355.144444	49.06	---	73.90	24.84	5000.0	1000.000	160.0	V	323.0	13.1
16355.144444	---	36.06	53.90	17.84	5000.0	1000.000	160.0	V	323.0	13.1

Table 7.3-4: *Radiated disturbance (Peak and CAverage) results*

Notes:
[1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB) − amplifier gain (dB)
[3] The maximum measured value observed over a period of 5 seconds was recorded.

7.3.5 Test data, continued



The spectral plot is a summation of a vertical and horizontal scan. The spectral scan has been corrected with the associated transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators).

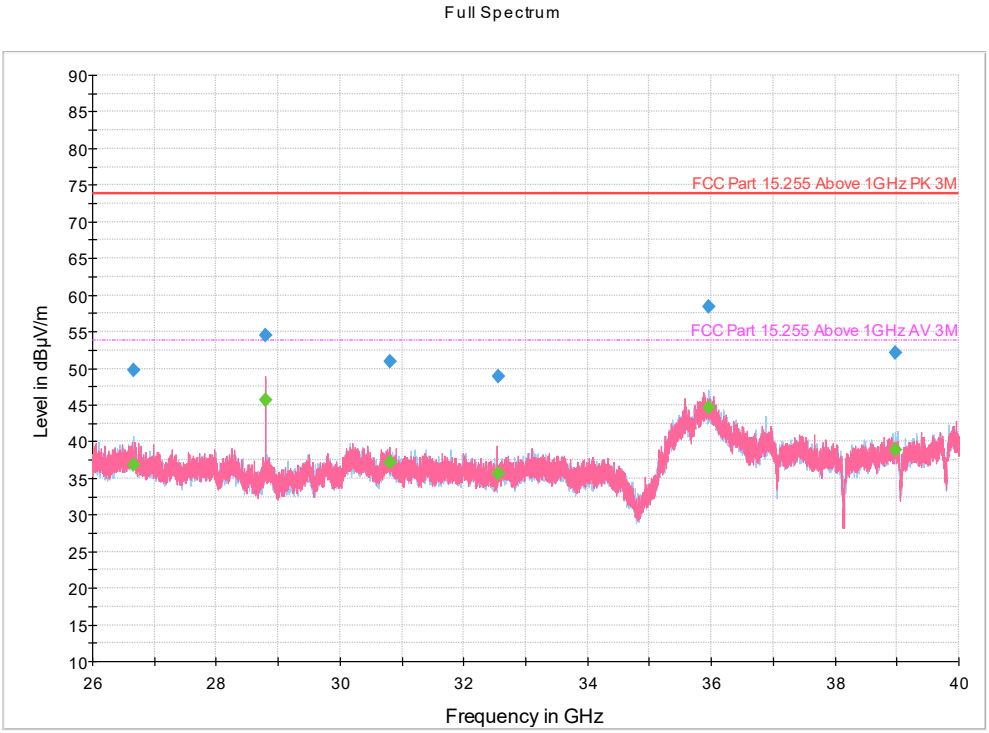
Figure 7.3-3: *Radiated disturbance spectral plot (18 to 26 GHz)*

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
19380.200000	---	30.73	53.90	23.17	5000.0	1000.000	269.0	H	162.0	18.4
19380.200000	44.19	---	73.90	29.71	5000.0	1000.000	269.0	H	162.0	18.4
20698.900000	---	32.02	53.90	21.88	5000.0	1000.000	141.0	V	98.0	20.1
20698.900000	45.12	---	73.90	28.79	5000.0	1000.000	141.0	V	98.0	20.1
23564.300000	---	37.04	53.90	16.86	5000.0	1000.000	400.0	H	334.0	25.8
23564.300000	50.03	---	73.90	23.87	5000.0	1000.000	400.0	H	334.0	25.8
24047.900000	---	39.58	53.90	14.32	5000.0	1000.000	231.0	V	168.0	29.7
24047.900000	52.89	---	73.90	21.01	5000.0	1000.000	231.0	V	168.0	29.7
24211.300000	---	39.92	53.90	13.98	5000.0	1000.000	300.0	H	173.0	29.1
24211.300000	53.04	---	73.90	20.86	5000.0	1000.000	300.0	H	173.0	29.1
25459.200000	---	33.24	53.90	20.66	5000.0	1000.000	267.0	H	225.0	24.0
25459.200000	46.22	---	73.90	27.68	5000.0	1000.000	267.0	H	225.0	24.0

Table 7.3-5: *Radiated disturbance (Peak and CAverage) results*

Notes:
[1]Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2]Correction factor = antenna factor ACF (dB) + cable loss (dB) − amplifier gain (dB)
[3]The maximum measured value observed over a period of 5 seconds was recorded.

7.3.5 Test data, continued



The spectral plot is a summation of a vertical and horizontal scan. The spectral scan has been corrected with the associated transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators).

Figure 7.3-4: *Radiated disturbance spectral plot (26 to 40 GHz)*

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
26668.250000	---	36.78	53.90	17.12	5000.0	1000.000	117.0	H	5.0	12.4
26668.250000	49.77	---	73.90	24.13	5000.0	1000.000	117.0	H	5.0	12.4
28798.450000	54.51	---	73.90	19.39	5000.0	1000.000	175.0	V	21.0	12.5
28798.450000	---	45.74	53.90	8.16	5000.0	1000.000	175.0	V	21.0	12.5
30804.975000	50.99	---	73.90	22.91	5000.0	1000.000	107.0	V	169.0	14.2
30804.975000	---	37.21	53.90	16.69	5000.0	1000.000	107.0	V	169.0	14.2
32554.325000	---	35.70	53.90	18.20	5000.0	1000.000	175.0	V	6.0	14.0
32554.325000	48.90	---	73.90	25.00	5000.0	1000.000	175.0	V	6.0	14.0
35948.150000	58.33	---	73.90	15.57	5000.0	1000.000	200.0	H	127.0	23.5
35948.150000	---	44.59	53.90	9.31	5000.0	1000.000	200.0	H	127.0	23.5
38978.800000	52.07	---	73.90	21.83	5000.0	1000.000	185.0	H	53.0	19.2
38978.800000	---	38.92	53.90	14.98	5000.0	1000.000	185.0	H	53.0	19.2

Table 7.3-6: *Radiated disturbance (Peak and CAverage) results*

Notes:
[1]Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2]Correction factor = antenna factor ACF (dB) + cable loss (dB) − amplifier gain (dB)
[3]The maximum measured value observed over a period of 5 seconds was recorded.

7.3.5 Test data, continued

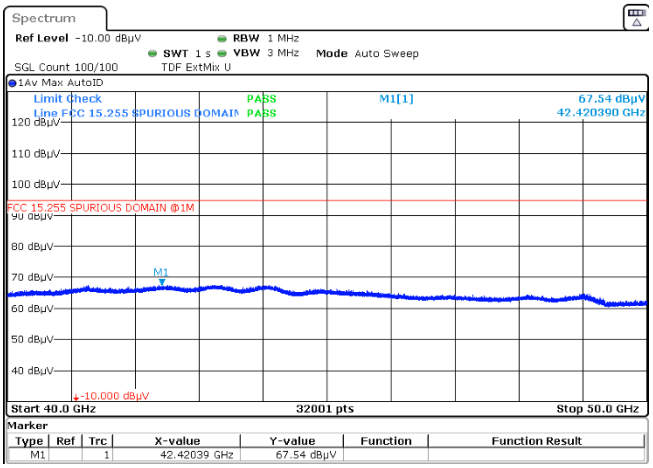


Figure 7.3-5: *Unwanted emissions spurious band plot – Field strength measured from 40 to 50 GHz, horizontal polarization.*

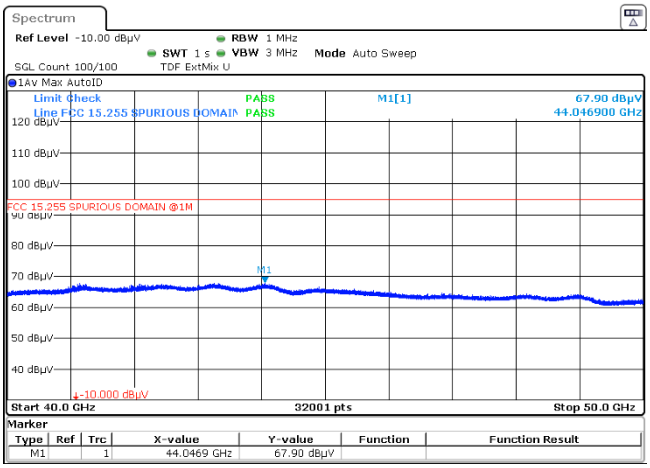


Figure 7.3-6: *Unwanted emissions spurious band plot – Field strength measured from 40 to 50 GHz, vertical polarization.*

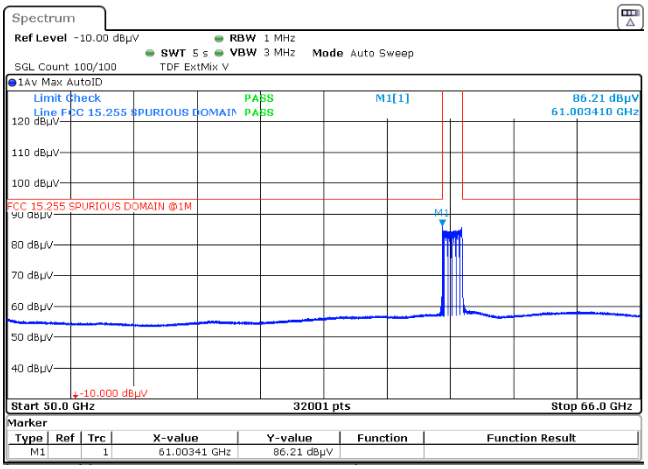


Figure 7.3-7: *Unwanted emissions spurious band plot – Field strength measured from 50 to 66 GHz, horizontal polarization.*

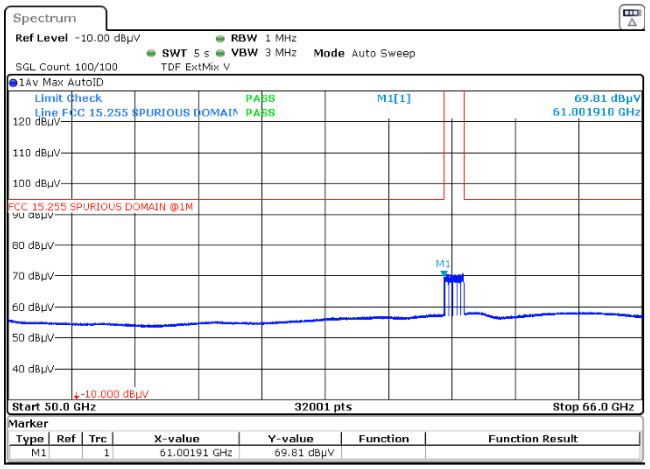


Figure 7.3-8: *Unwanted emissions spurious band plot – Field strength measured from 50 to 66 GHz, vertical polarization.*

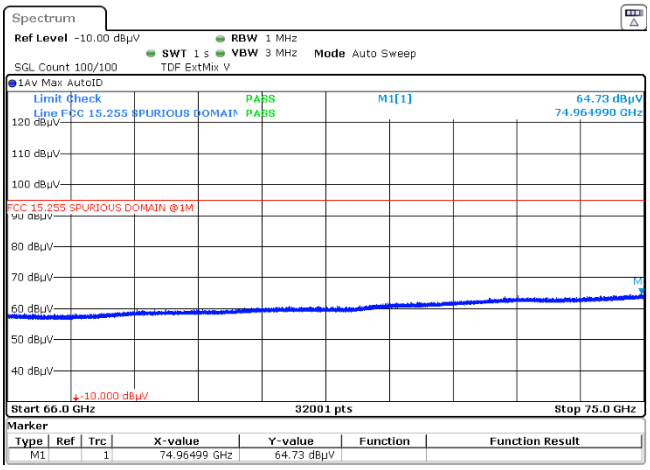


Figure 7.3-9: *Unwanted emissions spurious band plot – Field strength measured from 66 to 75 GHz, horizontal polarization.*

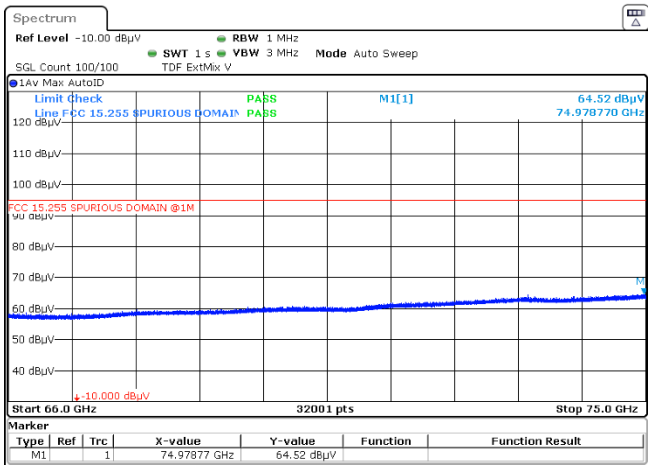


Figure 7.3-10: *Unwanted emissions spurious band plot – Field strength measured from 66 to 75 GHz, vertical polarization.*

7.3.5 Test data, continued

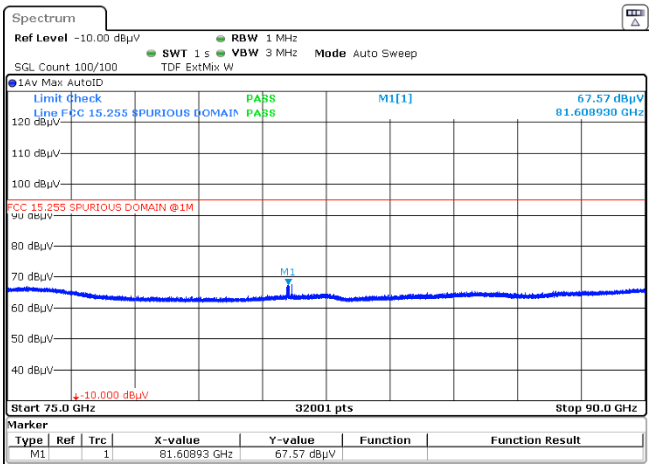


Figure 7.3-11: *Unwanted emissions spurious band plot – Field strength measured from 75 to 90 GHz, horizontal polarization.*

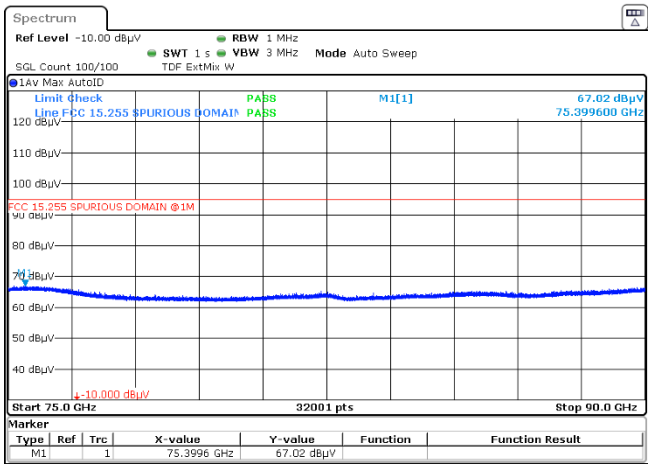


Figure 7.3-12: *Unwanted emissions spurious band plot – Field strength measured from 75 to 90 GHz, vertical polarization.*

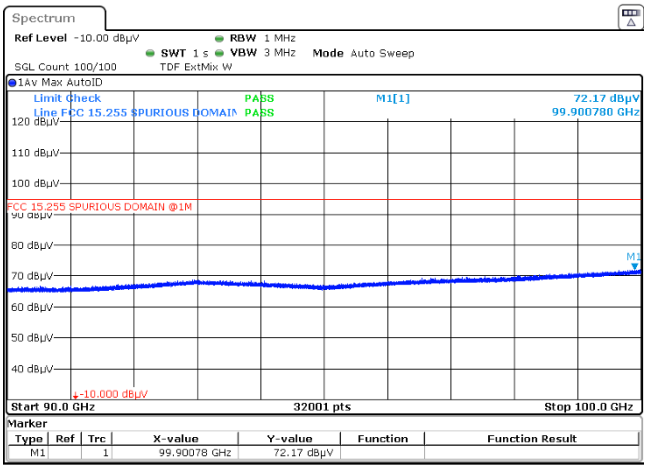


Figure 7.3-13: *Unwanted emissions spurious band plot – Field strength measured from 90 to 100 GHz, horizontal polarization.*

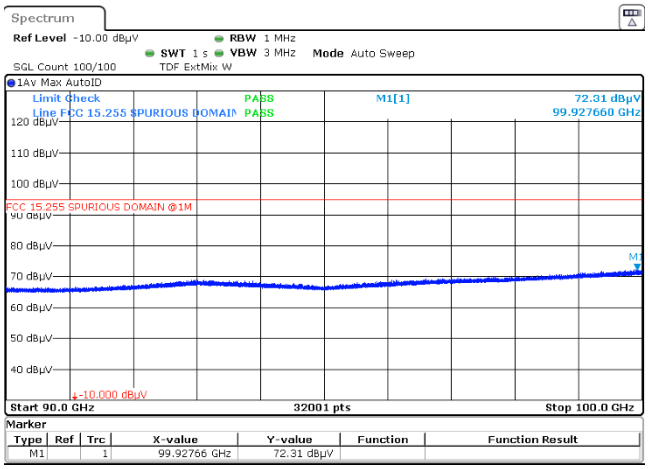


Figure 7.3-14: *Unwanted emissions spurious band plot – Field strength measured from 90 to 100 GHz, vertical polarization.*

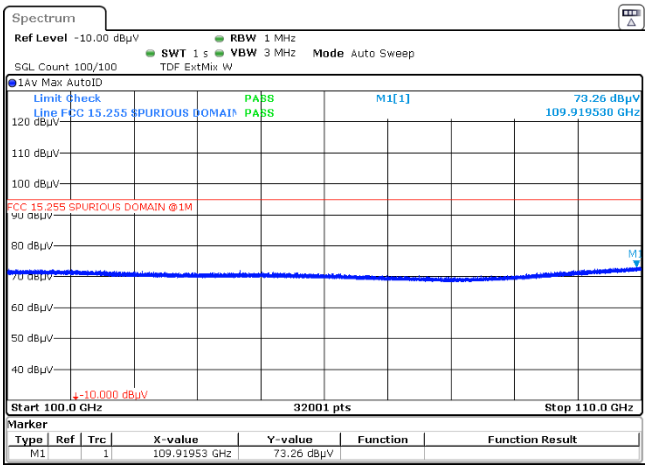


Figure 7.3-15: *Unwanted emissions spurious band plot – Field strength measured from 100 to 110 GHz, horizontal polarization.*

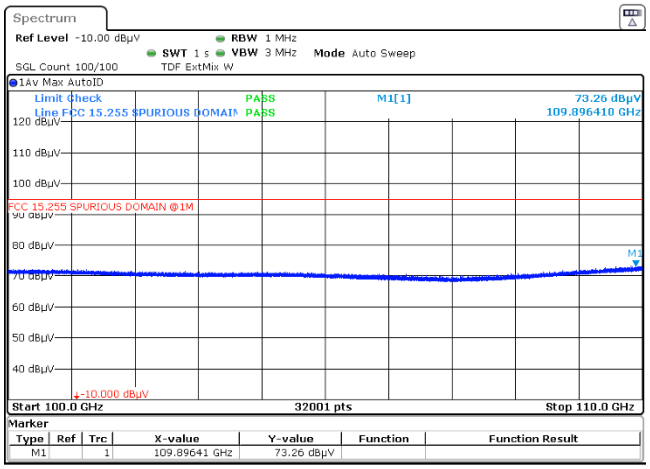


Figure 7.3-16: *Unwanted emissions spurious band plot – Field strength measured from 100 to 110 GHz, vertical polarization.*

7.3.5 Test data, continued

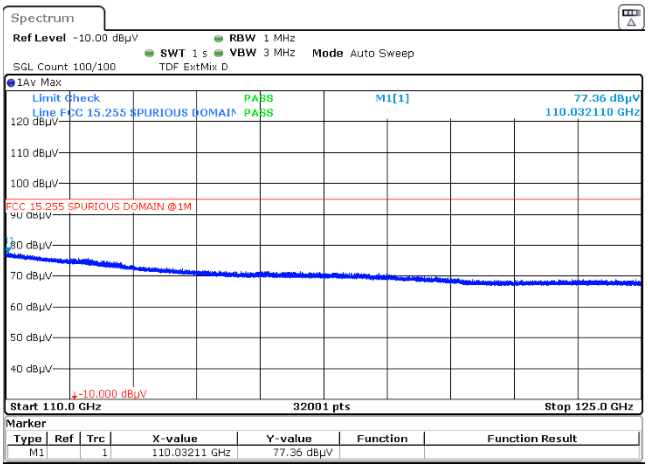


Figure 7.3-17: *Unwanted emissions spurious band plot – Field strength measured from 110 to 125 GHz, horizontal polarization.*

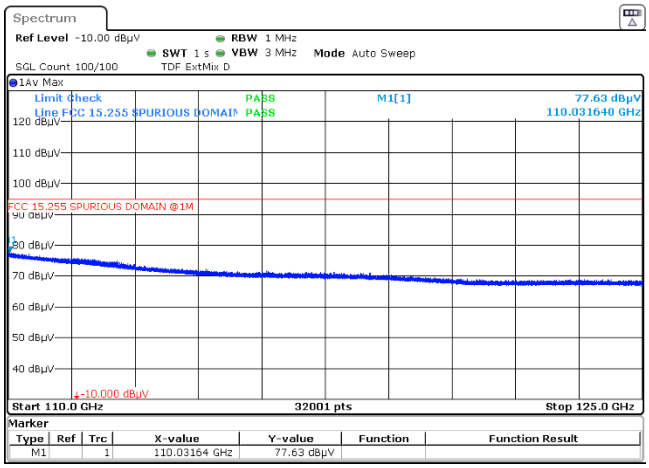


Figure 7.3-18: *Unwanted emissions spurious band plot – Field strength measured from 110 to 125 GHz, vertical polarization.*

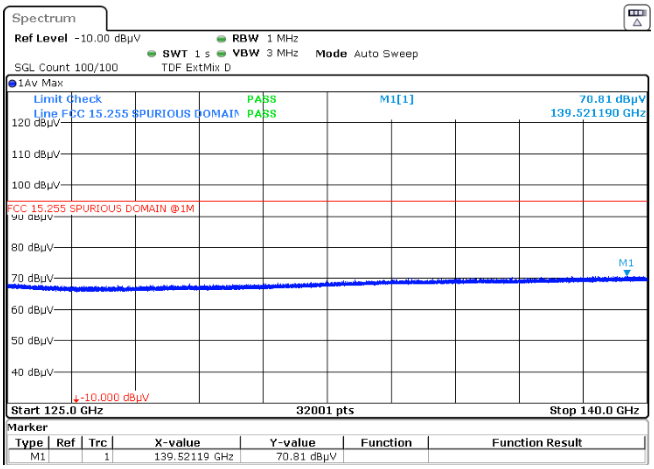


Figure 7.3-19: *Unwanted emissions spurious band plot – Field strength measured from 125 to 140 GHz, horizontal polarization.*

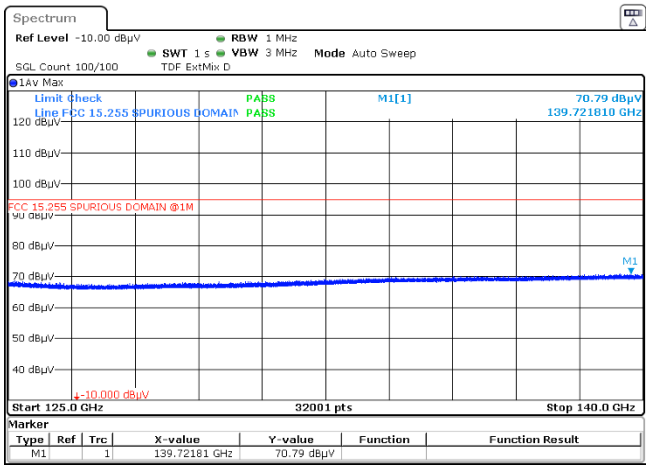


Figure 7.3-20: *Unwanted emissions spurious band plot – Field strength measured from 125 to 140 GHz, vertical polarization.*

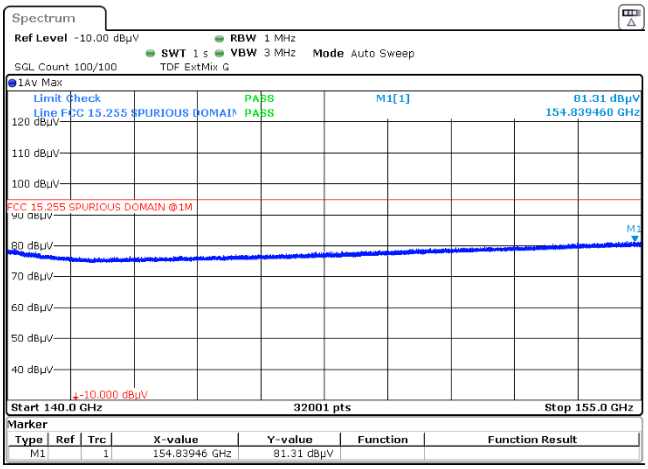


Figure 7.3-21: *Unwanted emissions spurious band plot – Field strength measured from 140 to 155 GHz, horizontal polarization.*

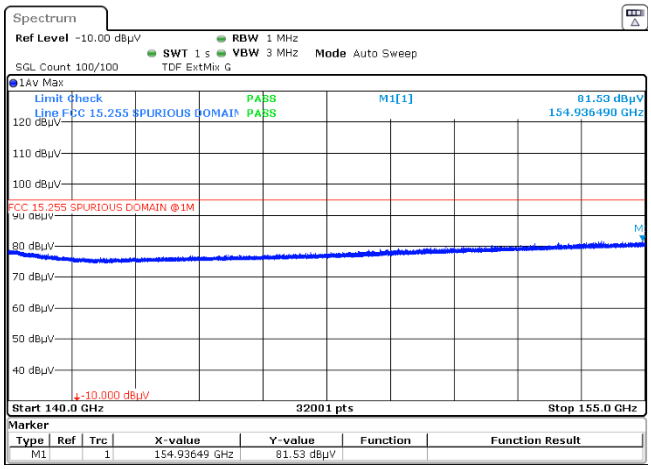


Figure 7.3-22: *Unwanted emissions spurious band plot – Field strength measured from 140 to 155 GHz, vertical polarization.*

7.3.5 Test data, continued

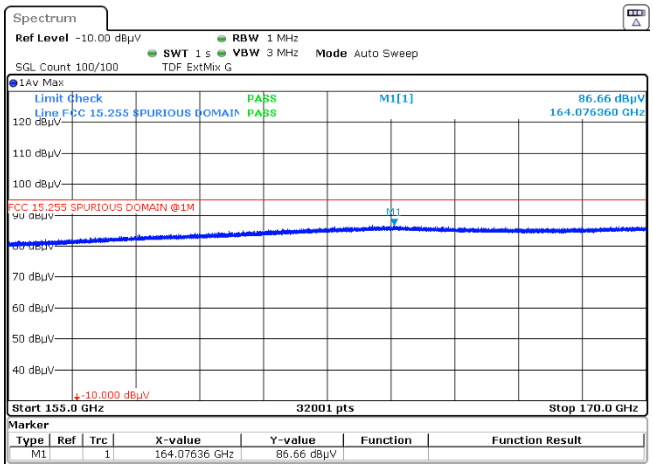


Figure 7.3-23: *Unwanted emissions spurious band plot – Field strength measured from 155 to 170 GHz, horizontal polarization.*

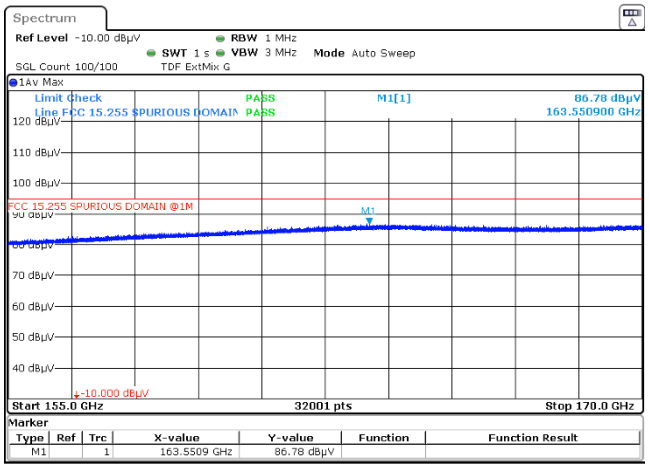


Figure 7.3-24: *Unwanted emissions spurious band plot – Field strength measured from 155 to 170 GHz, vertical polarization.*

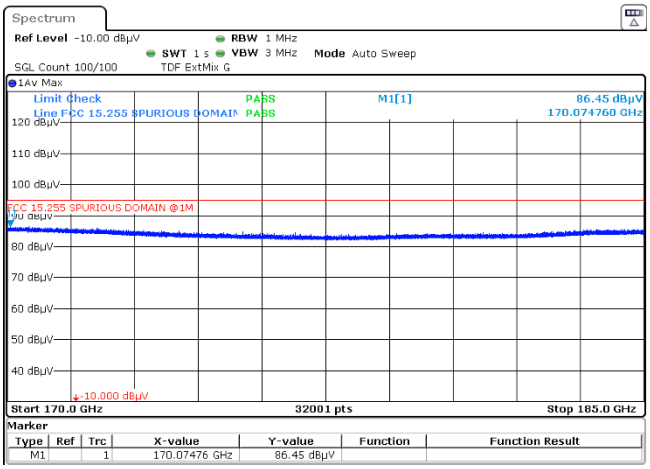


Figure 7.3-25: *Unwanted emissions spurious band plot – Field strength measured from 170 to 185 GHz, horizontal polarization.*

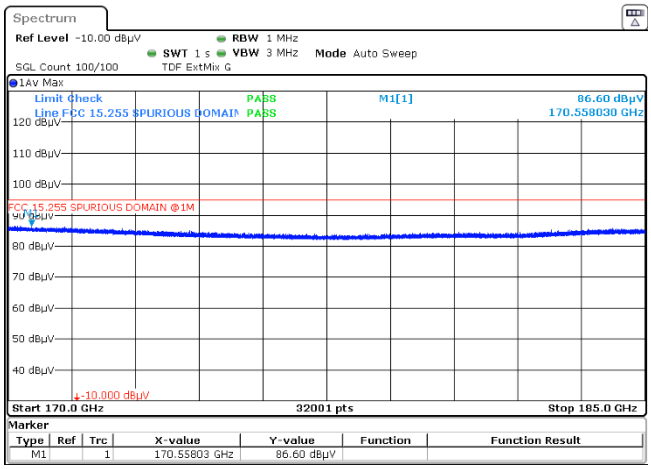


Figure 7.3-26: *Unwanted emissions spurious band plot – Field strength measured from 170 to 185 GHz, vertical polarization.*

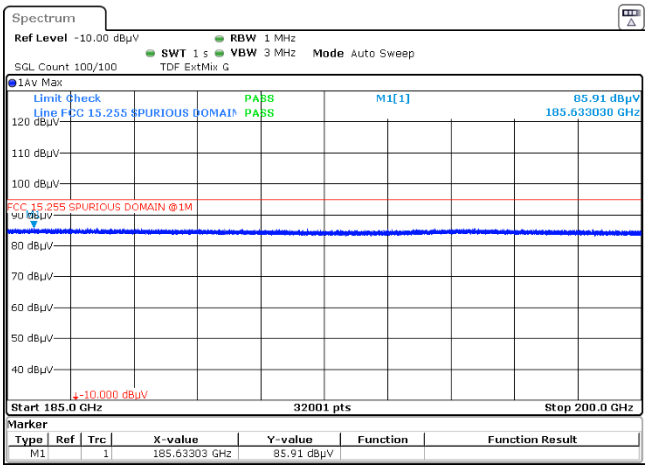


Figure 7.3-27: *Unwanted emissions spurious band plot – Field strength measured from 185 to 200 GHz, horizontal polarization.*

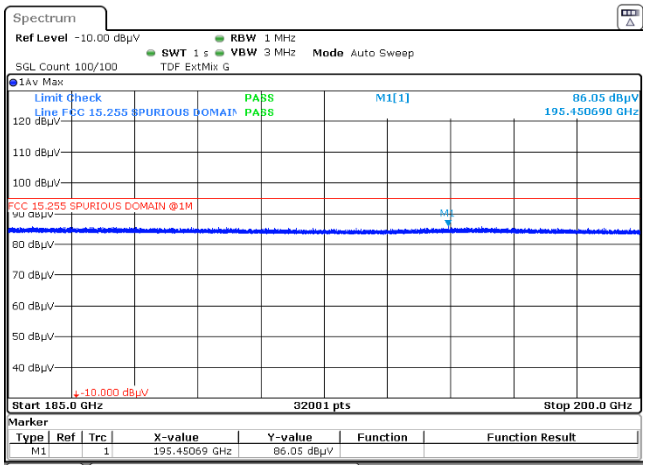


Figure 7.3-28: *Unwanted emissions spurious band plot – Field strength measured from 185 to 200 GHz, vertical polarization.*

7.4 Frequency Stability

7.4.1 References

200443 D02 RF Detector Method v01
As specified in Section 15.215(c), the 20 dB bandwidth of the fundamental emission must be contained within the frequency band over the temperature range -20 to +50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage. Frequency stability is to be measured according to Section 2.1055 at the highest and lowest frequency of operation and with the modulation that produces the widest emission bandwidth.
ANSI C63.10-2013
With the EUT at ambient temperature (approximately 25 °C) and voltage source set to the EUT nominal operating voltage (100%), record the spectrum mask of the EUT emission on the spectrum analyzer.
Vary EUT power supply between 85% and 115% of nominal, and record the frequency excursion of the EUT emission mask. Set the power supply to 100% nominal setting, and raise EUT operating temperature to 50 °C.
Record the frequency excursion of the EUT emission mask. Repeat step d) at each 10 °C increment down to 20 °C

7.4.2 Test summary

Verdict	Pass		
Test date	October 12, 2022	Temperature	20 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1001 mbar
Test location	Wireless Bench	Relative humidity	53 %

7.4.3 Notes

The test can be measured using the general ANSI C63.10-2013 or the specific procedure KDB 200443 D02 RF Detector Method v01. The first one requires a reference mask when the EUT is in the optimal conditions (20°C and 100% from the power source) which was taken using the power function of 99%. The second one required a 20-dB occupied bandwidth as a reference mask. The first method per ANSI C63.10-2013 was used.

7.4.4 Setup details

EUT setup configuration	Table top
Test facility	Wireless Bench
Measuring distance	0.5 m
Antenna height variation	1 m
Turn table position	0°

Receiver/spectrum analyzer settings for frequencies above 1 GHz:

Resolution bandwidth	5 MHz
Video bandwidth	20 MHz
Detector mode	Peak
Trace mode	Max Hold

7.4.5 Test data

Table 7.4-1: *Frequency stability equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
Antenna, Horn	Sage Millimeter	SAR-2408-15-S2	E1152	NCR	NCR
Signal/Spectrum analyzer	Rohde & Schwarz	FSV40	E1120	12-09-2021	12-09-2023
Mixer	Rohde & Schwarz	FS-Z75	E1324	VOU	VOU
Temperature Chamber	Test Equity	115A	E1162	08-29-2022	08-29-2023

Table 7.4-2: *Frequency stability results.*

Voltage	*Temperature*	*Lowest frequency*	*Highest frequency*	*CF*	*ppm*	*Result*
120 V	-20°C	61.005145	61.498464	61.25180	-29.461	Within the band
120 V	-10°C	61.005145	61.498464	61.25180	-29.461	Within the band
120 V	0°C	61.005660	61.498979	61.25232	-37.869	Within the band
120 V	+10°C	61.004629	61.498464	61.25155	-25.249	Within the band
120 V	+20°C	61.002567	61.497433	61.25000	REFERENCE	Within the band
120 V	+30°C	61.004114	61.497948	61.25103	-16.833	Within the band
120 V	+40°C	61.002567	61.496402	61.24948	8.416	Within the band
120 V	+50°C	61.000505	61.497948	61.24923	12.629	Within the band

Voltage	*Temperature*	*Lowest frequency*	*Highest frequency*	*CF*	*ppm*	*Result*
120 V	+20°C	61.002567	61.497433	61.25801535	0.000	Within the band
102 V	+20°C	61.002567	61.497433	61.2567732	0.000	Within the band
138 V	+20°C	61.002567	61.497433	61.25680445	0.000	Within the band

Note: This standard does not specify a ppm value as a limit. This table is just for reference and the only requirement by standard is the fundamental emission must be inside to the band assigned.

7.5 AC Line conducted emissions

7.5.1 References

ANSI C63.4-2014

7.5.2 Test summary

Verdict	Pass		
Test date	October 12, 2022	Temperature	20 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1001 mbar
Test location	Ground Plane	Relative humidity	53 %

7.5.3 Notes

None

7.5.4 Setup details

Port under test	AC Main Port
EUT setup configuration	Table top
Measurement details	A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 6 dB or above limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.

Receiver settings:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	– Peak and Average (Preview measurement) – Quasi-peak and CAverage (Final measurement)
Trace mode	Max Hold
Measurement time	– 100 ms (Peak and Average preview measurement) – 5000 ms (Quasi-peak final measurement) – 5000 ms (CAverage final measurement)

Table 7.5-1: *Conducted disturbance at mains port equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
Two Line V-Network	Rohde & Schwartz	ENV216	E1020	01-17-2022	01-17-2023
Transient Limiter	HP	11947A	E1159	VOU	VOU
EMC Test Receiver	Rohde & Schwarz	ESCI 7	E1026	03-22-2022	03-22-2023

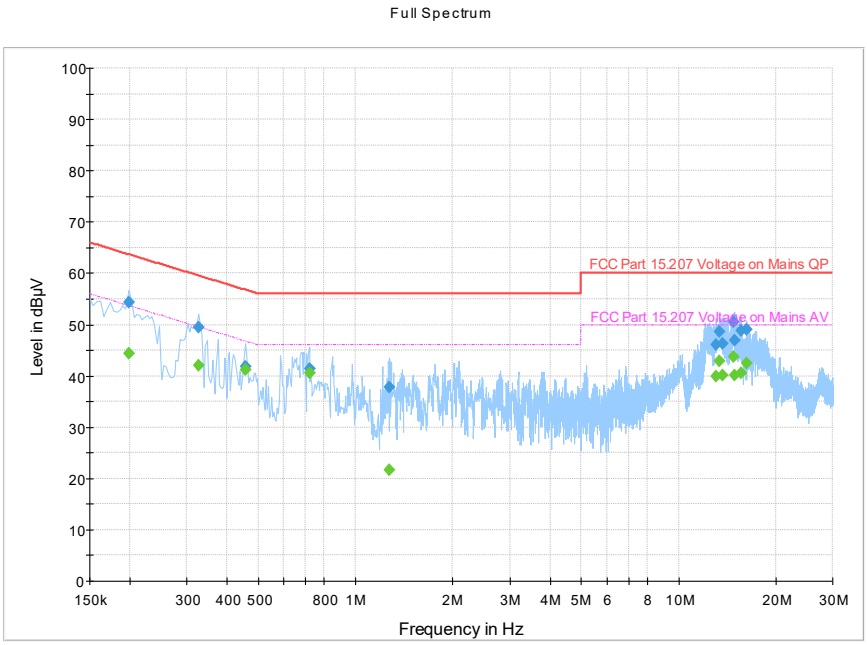
Notes: VOU - verify on use

Table 7.5-2: *Conducted disturbance at mains port test software details*

Manufacturer of Software	Details
Rohde & Schwarz	EMC 32 V10.20.01

Notes: None

7.5.5 Test data



The spectral plot has been corrected with transducer factors (i.e. cable loss, LISN factors, and transient limiter).

Figure 7.5-1: *Conducted disturbance at mains port spectral plot*

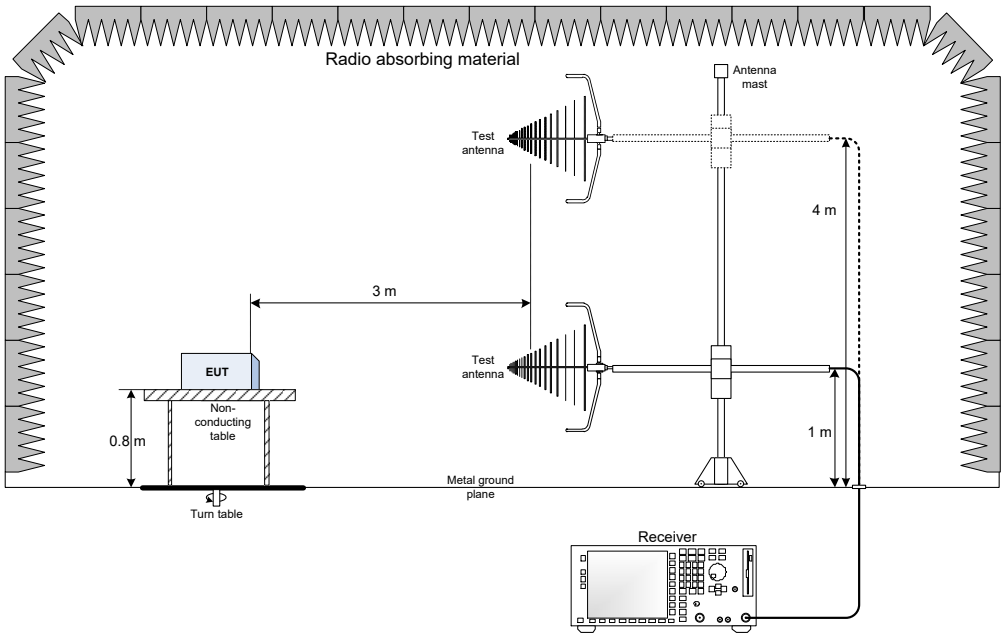
Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.198000	---	44.44	53.69	9.26	5000.0	9.000	N	ON	19.6
0.198000	54.29	---	63.69	9.40	5000.0	9.000	N	ON	19.6
0.326000	49.42	---	59.55	10.13	5000.0	9.000	L1	ON	19.5
0.326000	---	42.00	49.55	7.56	5000.0	9.000	L1	ON	19.5
0.454000	41.77	---	56.80	15.04	5000.0	9.000	N	ON	19.5
0.454000	---	41.13	46.80	5.67	5000.0	9.000	N	ON	19.5
0.718000	---	40.55	46.00	5.45	5000.0	9.000	N	ON	19.5
0.718000	41.33	---	56.00	14.67	5000.0	9.000	N	ON	19.5
1.274000	---	21.58	46.00	24.42	5000.0	9.000	L1	ON	19.5
1.274000	37.69	---	56.00	18.31	5000.0	9.000	L1	ON	19.5
13.086000	46.11	---	60.00	13.89	5000.0	9.000	N	ON	20.1
13.086000	---	39.96	50.00	10.04	5000.0	9.000	N	ON	20.1
13.358000	48.61	---	60.00	11.39	5000.0	9.000	N	ON	20.1
13.358000	---	42.99	50.00	7.01	5000.0	9.000	N	ON	20.1
13.638000	46.24	---	60.00	13.76	5000.0	9.000	N	ON	20.2
13.638000	---	40.21	50.00	9.79	5000.0	9.000	N	ON	20.2
14.770000	---	43.65	50.00	6.35	5000.0	9.000	N	ON	20.3
14.770000	50.46	---	60.00	9.54	5000.0	9.000	N	ON	20.3
14.886000	46.89	---	60.00	13.11	5000.0	9.000	L1	ON	20.3
14.886000	---	40.18	50.00	9.82	5000.0	9.000	L1	ON	20.3
15.610000	---	40.59	50.00	9.41	5000.0	9.000	N	ON	20.3
15.610000	48.89	---	60.00	11.11	5000.0	9.000	N	ON	20.3
16.226000	---	42.39	50.00	7.61	5000.0	9.000	N	ON	20.4
16.226000	49.04	---	60.00	10.96	5000.0	9.000	N	ON	20.4

Table 7.5-3: *Conducted disturbance at mains port (Quasi-Peak and CAverage) results*

Notes:
[1]Result (dBµV) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2]Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + transient limiter (dB)
[3]The maximum measured value observed over a period of 5 seconds was recorded.

Section 8 Block diagrams of test set-ups

8.1 Radiated emissions set-up



30-1000MHz Setup