Report on the FCC and IC Testing of the KEBA Industrial Automation GmbH

Model: WAL R1

In accordance with FCC 47 CFR Part 15 C and ISED RSS-247 and ISED RSS-GEN

Prepared for: KEBA Industrial Automation GmbH
Reindlstrasse 51
4040 Linz
Austria

FCC ID: U870009
IC: 20800–WALR1MOD

Product Service

Add value.
Inspire trust.

COMMERCIAL-IN-CONFIDENCE

Date: 2022-03-02
Document Number: TR-76967-36510-09 | Issue: 01

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Project Management	Michael Ingerl	2022-03-02	SIGN-ID 625150
Authorised Signatory	Markus Biberger	2022-03-02	SIGN-ID 625542

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD Product Service document control rules.

Engineering Statement:

This measurement shown in this report were made in accordance with the procedures described on test pages.
All reporded testing was carried out on a sample equipment to demonstrate limited compilance with with FCC 47 CFR Part 15 C and ISED RSS-247 and RSS-GEN.
The sample tested was found to comply with the requirements defined in the applied rules.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Testing	Michael Ingerl	2022-03-02	SIGN-ID 625151

Laboratory Accreditation	Laboratory recognition	Industry Canada test site registration
DAkkS Reg. No. D-PL-11321-11-02 DAkkS Reg. No. D-PL-11321-11-03	Registration No. BNetzA-CAB-16/21-15	3050A-2

Executive Statement:

A sample of this product was tested and found to be compilant with FCC 47 CFR Part 15 C:2019 and ISED RSS-247:2017 and RSS-GEN:2019

Trade Register Munich
HRB 85742
VAT ID No. DE129484267
Information pursuant to Section 2(1)
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94315 Straubing
Germany

Product Service

Content

Information:
KeTop T15xWL Handheld Terminals + KeTop CB4xx Basestation
Both contain a WAL R1 module and are necessary for testing it.
Tested with KeTop CB410-SE2

Annex A: Test Setup Photos
Annex B: External Photos
Annex C: Internal Photos

Product Service

1 Report Summary

1.1 Modification Report

Alternations and additions of this report will be issued to the holders of each copy in the form of a complete document.

Issue	*Description of changes*	*Date of Issue*
1	First Issue	2022-03-02

Table 1: Report of Modifications

1.2 Introduction

Applicant	KEBA Industrial Automation GmbH
Manufacturer	KEBA Industrial Automation GmbH
Model Number(s)	WAL R1
Serial Number(s)	---
Hardware Version	R1
Software Version	R1_1_2
Number of Samples Tested	2
Test Specification(s) /	FCC 47 CFR Part 15 C : 2019
Issue / Date	ISED RSS-247, Issue 2 : 2017
	ISED RSS-GEN, Issue 5, Amendment 1 : 2019
Test Plan/Issue/Date	---
Order Number	5487767
Date of Receipt of EUT	2022-01-19
Start of Test	2022-01-24
Finish of Test	2022-02-02
Name of Engineer(s)	Michael Ingerl
Related Document(s)	ANSI C63.4: 2014
	ANSI C63.10: 2013
	FCC 47 CFR Part 2 J : 2019
	KDB 558074 D01 V05R02
	ISED RSS-102, Issue 5, 2015

Product Service

1.3 Brief Summary of Results

A brief summary of the tests carried out in accordance with FCC 47 CFR Part 15 C, ISED RSS-247 and ISED RSS-GEN is shown below.

Section	*Specification Clause*	*Test Description*	*Result*
24V DC Powered – Continuous transmitting			
2.1	15.247(a)(2)	Emission Bandwidth	Pass
2.2	15.247(b)(3)	Output Power	Pass
2.3	15.247(e)	Power Spectral Density	Pass
2.4	15.247(d)	Frequency Band Edge	Pass
2.5	15.247(d), 15.205, 15.209	Spurious Emissions	Pass
2.7	15.207	Conducted Emissions on Mains Terminals	Pass

Table 2: Results according to FCC 47 CFR Part 15 C

Section	*Specification Clause*	*Test Description*	*Result*
24V DC Powered – Continuous transmitting			
2.1	5.2 a.	Emission Bandwidth	Pass
2.2	5.4 d.	Output Power	Pass
2.3	5.2 b.	Power Spectral Density	Pass
2.4	5.5	Frequency Band Edge	Pass
2.5	5.5	Spurious Emissions	Pass

Table 3: Results according to ISED RSS-247

Section	*Specification Clause*	*Test Description*	*Result*
24V DC Powered – Continuous transmitting			
2.1	6.7	Emission Bandwidth	Pass
2.5	8.9, 8.10	Spurious Emissions	Pass
2.6	8.11	Frequency Stability	Pass
2.7	8.8	Conducted Emissions on Mains Terminals	Pass

Table 4: Results according to RSS-Gen

Product Service

1.4 Product Information

1.4.1 Technical Description

Equipment characteristics		
Type designation:	WAL R1	
Type of equipment:	The WAL module (Work Area Limitation) is used to limit the area in which a wireless handheld terminal can be used. Therefore it has to be used in conjunction with a base station (e.g. CB4xx) which includes the counterpart WAL module.	
Application:	Wideband transmission systems	
Kind of equipment	Transceiver	
Frequency band1:	Annex 3, Band b	
Frequency range:	2400 – 2483,5 MHz	
Type(s) of Modulation:	Other forms of modulation	
Nominal Channel Bandwidth	2,5 MHz	
Number of channels	16 Centre frequencies: 2405 to 2480 MHz, 5 MHz spacing	
Type of Antenna(s)	Adhesive dipole antenna (FXP830)	
Number of Antenna Ports:	2 (no simultaneous operation, only alternative operation)	
Antenna Gain	2400 MHz = 2,64 dBi 2412 MHz = 2,68 dBi 2442 MHz = 2,72 dBi 2447 MHz = 2,76 dBi 2472 MHz = 2,84 dBi 2484 MHz = 3,05 dBi	
Power Level	< 10 dBm EIRP (including Antenna Gain)	
Temperature Range:	0°C – 50°C	
Adaptive	Yes The equipment has implemented an LBT based DAA mechanism. The equipment is Frame Based equipment.	
FHSS	No	
Geo-location capability supported by the equipment	No	
Power supply:	Nominal:	24 V
	Minimum:	19,2 V
	Maximum:	28,8 V
	Nominal frequency:	DC

1.4.2 EUT Ports / Cables identification

Port	Max Cable Length specified	Usage	Type	Screened
Power port	---	0.5m	DC cable	No

Table 2 Ports and Cables identification

1.5 Test Configuration

24V DC Powered – Continuous transmitting

1.6 Deviations from Standard

None

1.7 EUT Modifications Record

The table below details modifications made to the EUT during the test programme.
The modifications incorporated during each test are recorded on the appropriate test pages.

Modification State	Description of Modification still fitted to EUT	Modification Fitted By	Date Modification Fitted
0	As supplied by the customer / SN: ---	Not Applicable	Not Applicable

Table 3

Modification State	Description of Modification still fitted to EUT	Modification Fitted By	Date Modification Fitted
0	As supplied by the customer / SN: --- (Conducted Sample for Tests)	Not Applicable	Not Applicable

Table 4

[1] Classification according to CEPT/ERC Recommendation 70-03

Product Service

1.8 Test Location

TÜV SÜD Product Service conducted the following tests at our Straubing test laboratory:

Test Name	Name of Engineer(s)
24V DC Powered – Continuous transmitting	
Emission Bandwidth	Michael Ingerl
Output Power	Michael Ingerl
Power Spectral Density	Michael Ingerl
Frequency Band Edge	Michael Ingerl
Spurious Emissions	Michael Ingerl
Frequency Stability	Michael Ingerl

Office Address:
Äußere Frühlingstraße 45
94315 Straubing
Germany

Product Service

2 Test Details

2.1 Emission Bandwidth

2.1.1 Specification Reference

FCC 47 CFR Part 15 C, Clause 15.247(a)(2)
ISED RSS-247, Clause 5.2 a
ISED RSS-Gen, Clause 6.7

2.1.2 Equipment under Test and Modification State

WAL R1, S/N: --- – Modification State 0 (Conducted Sample)

2.1.3 Date of Test

2022-01-26

2.1.4 Environmental Conditions

Ambient Temperature	22 °C
Relative Humidity	31 %

2.1.5 Specification Limits

For systems using digital modulation techniques, operating in the 902 MHz – 928 MHz, 2400 MHz – 2483.5 MHz and/or 5725 MHz – 5850 MHz bands, the minimum 6 dB bandwidth shall be at least 500 kHz

ISED RSS-GEN:
The occupied (99 %) bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSS.

2.1.6 Test Method

The test was performed according to ANSI C63.10, clauses 6.9.3 and 11.8.1

Product Service

2.1.7 Test Results

Antenna Port 0

Frequency Channel	6 dB Bandwidth (MHz)	Limit (MHz)	Band Edge Left (MHz)	Band Edge Right (MHz)
2405 MHz	1.683	0.500	2404.158416	2405.841584
2445 MHz	1.584	0.500	2444.257426	2445.841584
2480 MHz	1.683	0.500	2479.158416	2480.841584

Table 5: 6 dB bandwidth

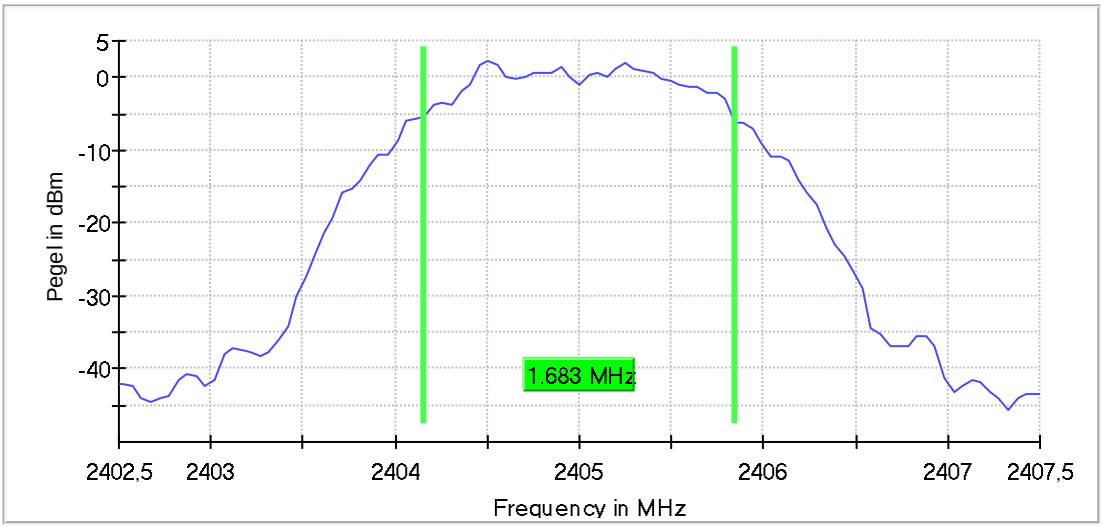
Frequency Channel	99% Bandwidth (MHz)	Band Edge Left (MHz)	Band Edge Right (MHz)
2405 MHz	2.207	2403.888889	2406.096096
2445 MHz	2.207	2443.888889	2446.096096
2480 MHz	2.222	2478.888889	2481.111111

Table 6: 99% bandwidth

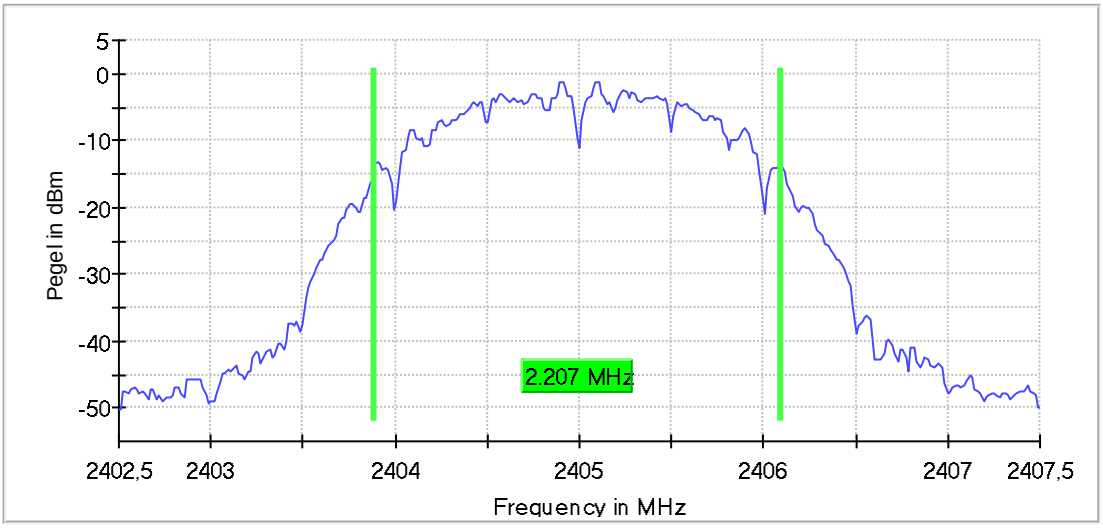
Product Service

Test Plots from Channel 2405 MHz

6 dB Bandwidth



99 % Bandwidth



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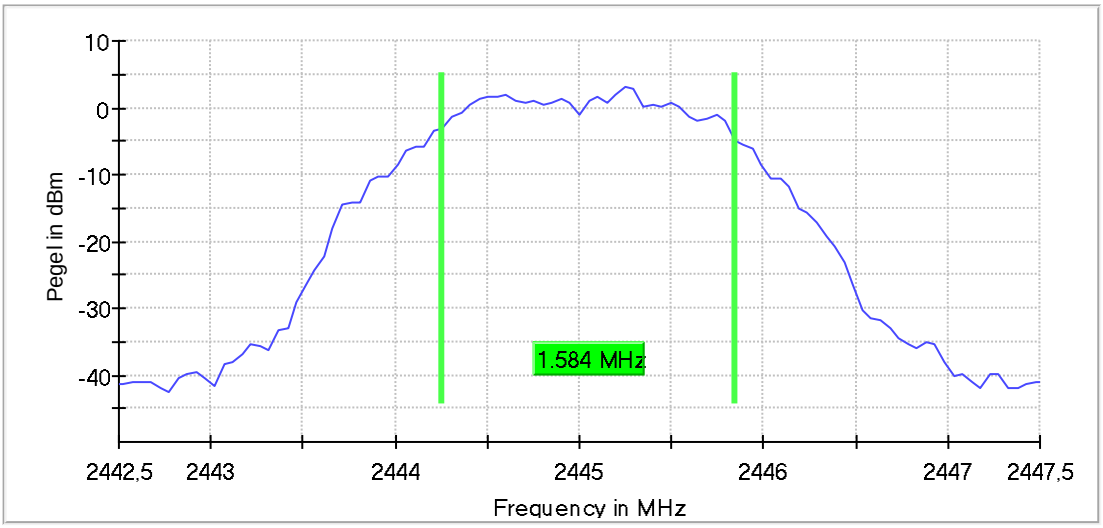
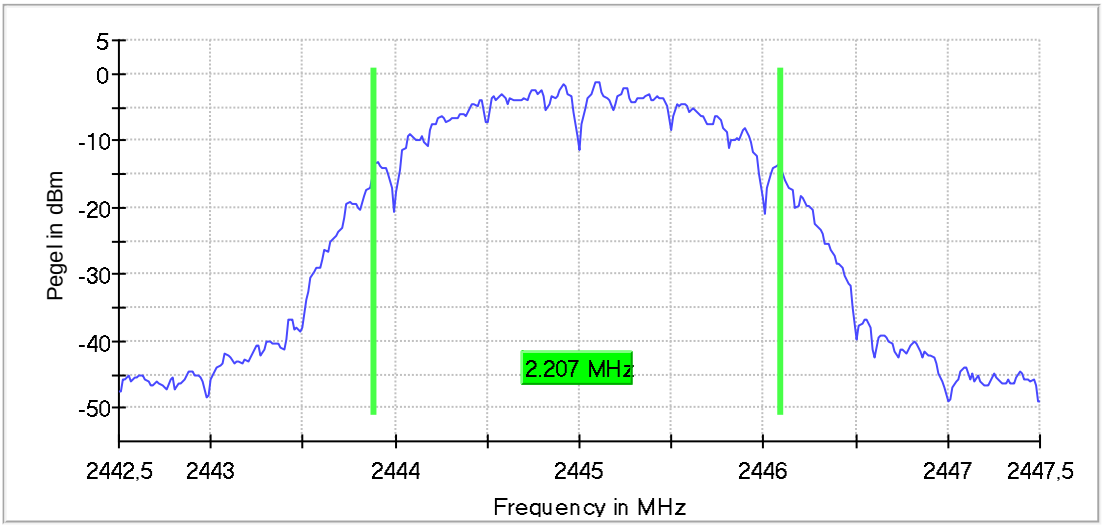
Test Plots from Channel 2445 MHz

6 dB Bandwidth



99 % Bandwidth



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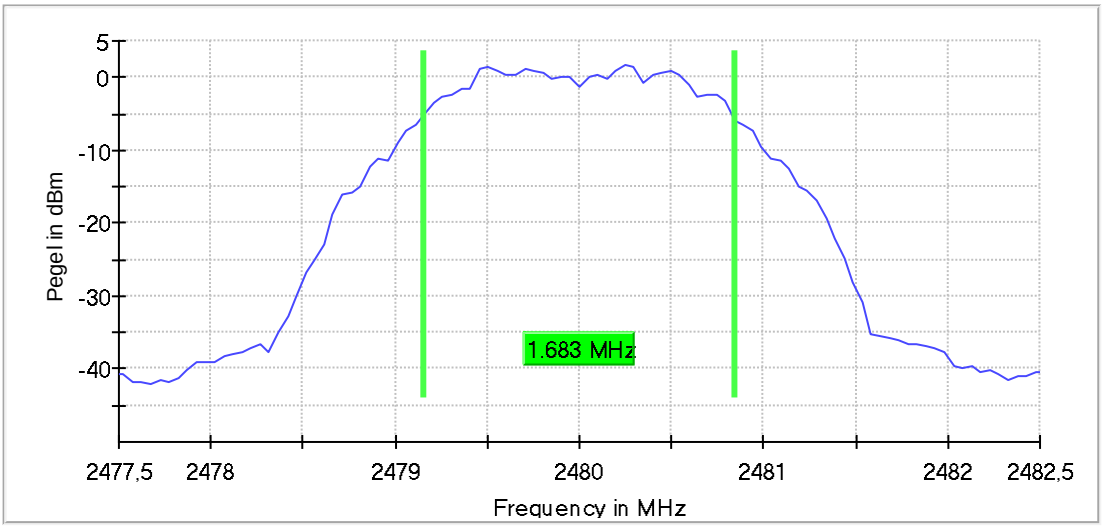
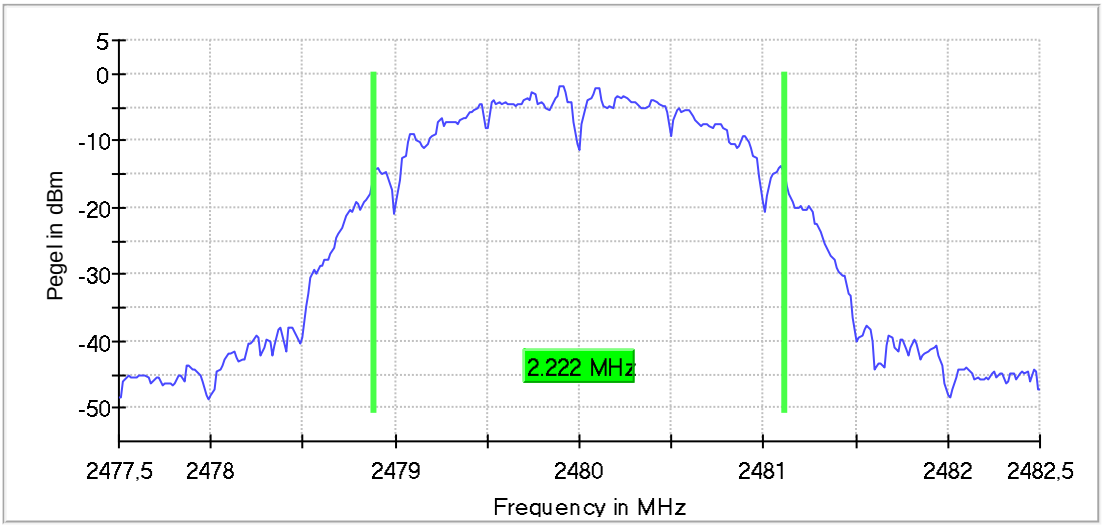
Test Plots from Channel 2480 MHz

6 dB Bandwidth



99 % Bandwidth



Product Service

Antenna Port 1

Frequency Channel	6 dB Bandwidth (MHz)	Limit (MHz)	Band Edge Left (MHz)	Band Edge Right (MHz)
2405 MHz	1.683	0.500	2404.158416	2405.841584
2445 MHz	1.634	0.500	2444.207921	2445.841584
2480 MHz	1.683	0.500	2479.158416	2480.841584

Table 7: 6 dB bandwidth

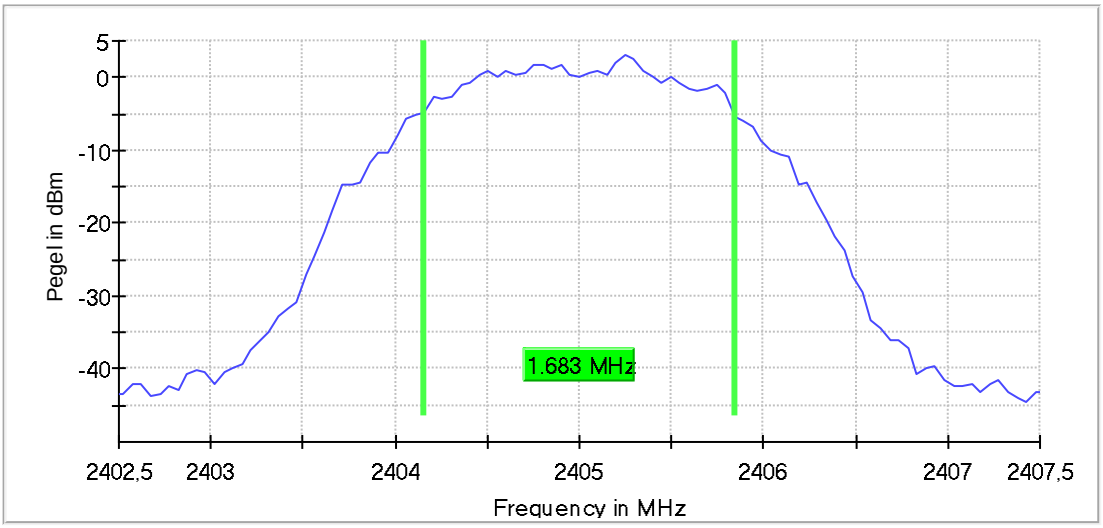
Frequency Channel	99% Bandwidth (MHz)	Band Edge Left (MHz)	Band Edge Right (MHz)
2405 MHz	2.207	2403.888889	2406.096096
2445 MHz	2.207	2443.888889	2446.096096
2480 MHz	2.192	2478.903904	2481.096096

Table 8: 99% bandwidth

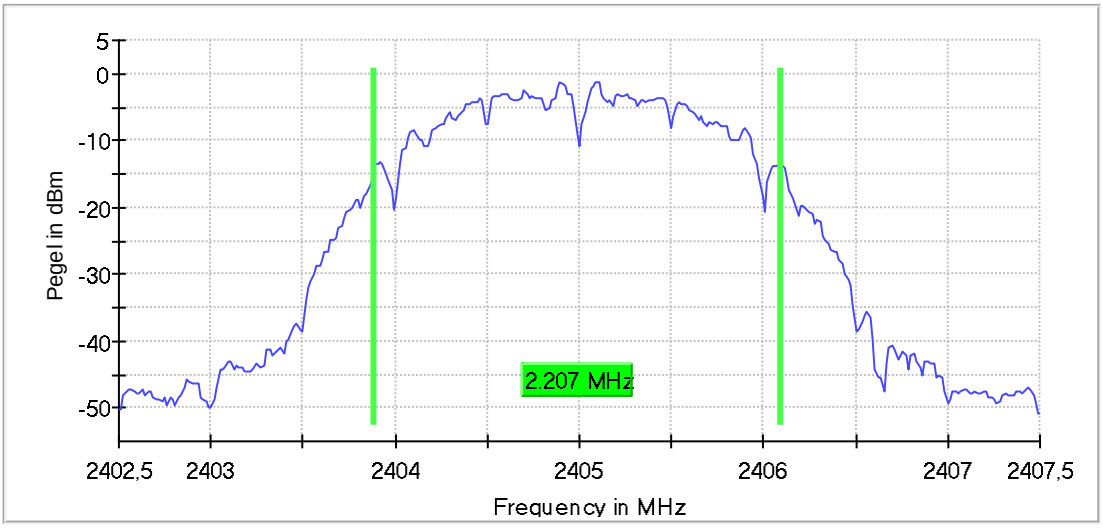
Product Service

Test Plots from Channel 2405 MHz

6 dB Bandwidth



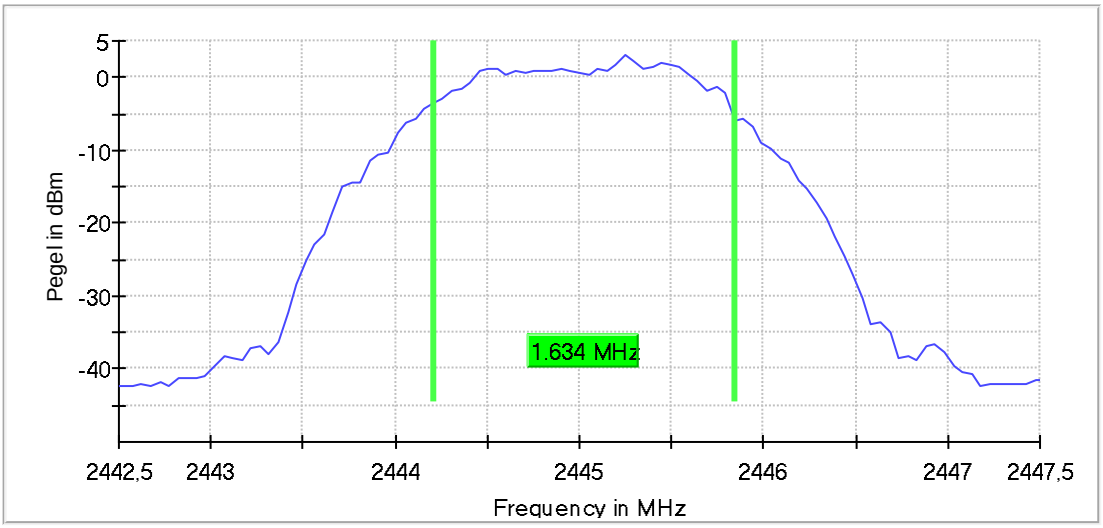
99 % Bandwidth



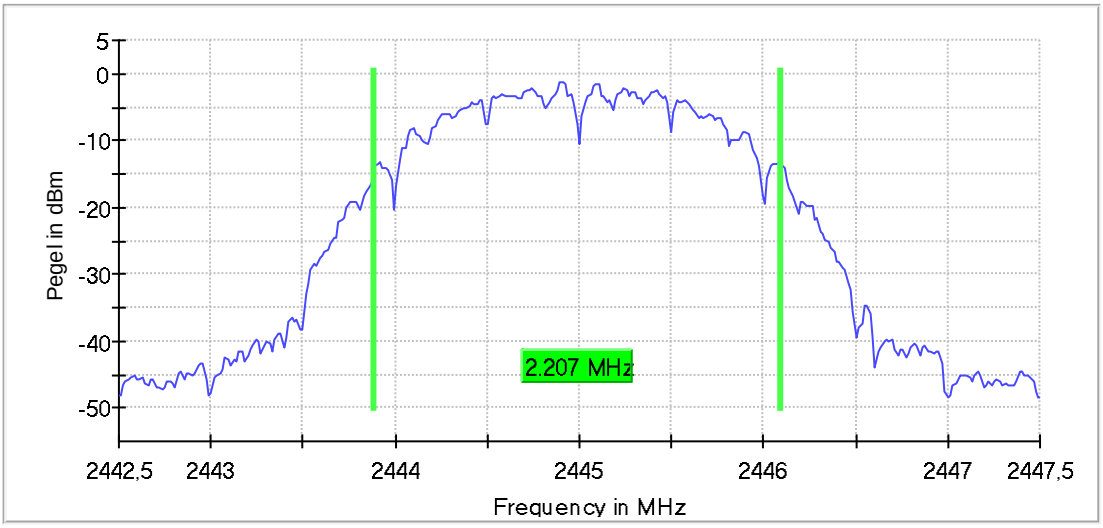
Product Service

Test Plots from Channel 2445 MHz

6 dB Bandwidth



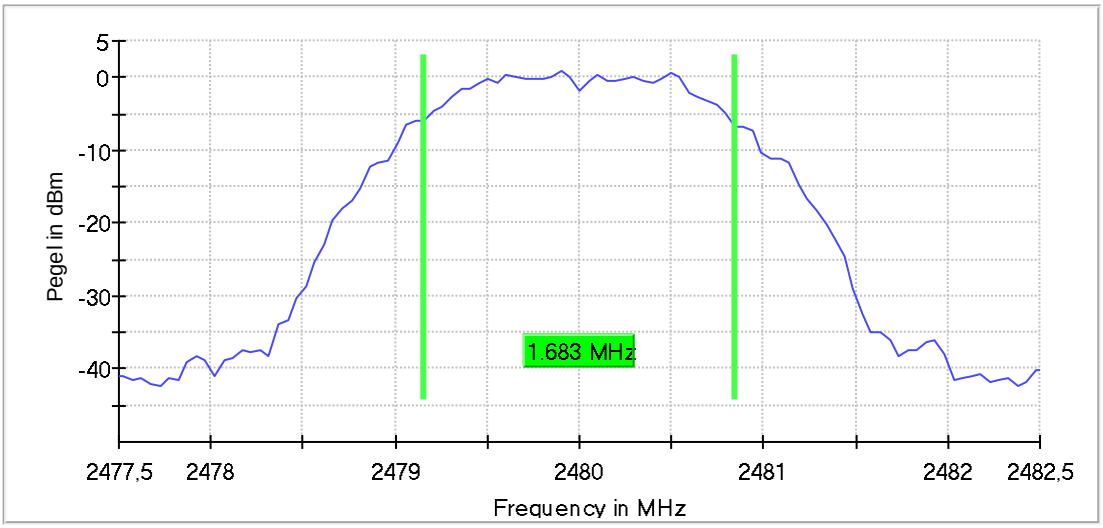
99 % Bandwidth



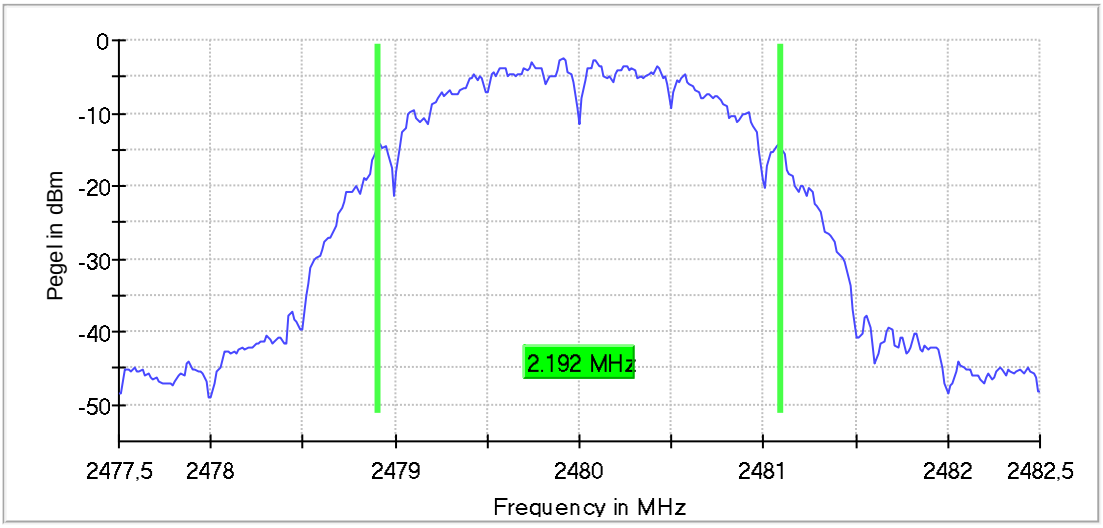
Product Service

Test Plots from Channel 2480 MHz

6 dB Bandwidth



99 % Bandwidth



Product Service

2.1.8 Test Location and Test Equipment

This test was carried out in Non shielded room.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Signal and Spectrum Analysator	Rohde & Schwarz GmbH & Co. KG	FSV40 for TS8997	20219	12	2022-01-31
Switching device	Rohde & Schwarz GmbH & Co. KG	OSP120 for TS8997	20248	24	2022-02-28
Testsystem 2,4 & 5 GHz Band	Rohde & Schwarz GmbH & Co. KG	TS8997	20251	24	2022-02-28
Switching device	Rohde & Schwarz GmbH & Co. KG	OSP120 for TS8997	38807	36	2023-11-30

Table 9

Product Service

2.2 Output Power

2.2.1 Specification Reference

FCC 47 CFR Part 15 C, Clause 15.247(b)(3)
ISED RSS-247, Clause 5.4 d.

2.2.2 Equipment under Test and Modification State

WAL R1, S/N: --- – Modification State 0 (Conducted Sample)

2.2.3 Date of Test

2022-01-26

2.2.4 Environmental Conditions

Ambient Temperature	22 °C
Relative Humidity	31 %

2.2.5 Specification Limits

The maximum conducted output power shall not exceed 1 W (30 dBm).

2.2.6 Test Method

The test was performed according to ANSI C63.10, section 11.9

Product Service

2.2.7 Test Results

Antenna Port 0

Frequency Channel	*Conducted Output Power (dBm)*	*Limit (dBm)*
2405 MHz	6.4	30.0
2445 MHz	6.4	30.0
2480 MHz	5.5	30.0

Table 10: Conducted Output Power

Antenna Port 1

Frequency Channel	*Conducted Output Power (dBm)*	*Limit (dBm)*
2405 MHz	6.5	30.0
2445 MHz	6.4	30.0
2480 MHz	5.5	30.0

Table 11: Conducted Output Power

2.2.8 Test Location and Test Equipment

This test was carried out in Non shielded room.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Signal and Spectrum Ana-lysator	Rohde & Schwarz GmbH & Co. KG	FSV40 for TS8997	20219	12	2022-01-31
Switching device	Rohde & Schwarz GmbH & Co. KG	OSP120 for TS8997	20248	24	2022-02-28
Testsystem 2,4 & 5 GHz Band	Rohde & Schwarz GmbH & Co. KG	TS8997	20251	24	2022-02-28
Switching device	Rohde & Schwarz GmbH & Co. KG	OSP120 for TS8997	38807	36	2023-11-30

Table 12

Product Service

2.3 Power Spectral Density

2.3.1 Specification Reference

FCC 47 CFR Part 15 C, Clause 15.247(e)
ISED RSS-247, Clause 5.2 b

2.3.2 Equipment under Test and Modification State

WAL R1, S/N: --- – Modification State 0 (Conducted Sample)

2.3.3 Date of Test

2022-01-26

2.3.4 Environmental Conditions

Ambient Temperature	22 °C
Relative Humidity	31 %

2.3.5 Specification Limits

FCC 47 CFR, section 15.257(e)
ISED RSS-247, Clause 5.2.(b)
The power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.
The same method (detector) of determining the conducted output power shall be used to determine the power spectral density.

2.3.6 Test Method

The test was performed according to ANSI C63.10, section 11.10

Product Service

2.3.7 Test Results

Antenna Port 0

Frequency Channel	Spectral Power Density (dBm)	Limit (dBm)
2405 MHz	-4.19	8.0
2445 MHz	-3.95	8.0
2480 MHz	-4.80	8.0

Table 13: Spectral Power Density

Antenna Port 1

Frequency Channel	Spectral Power Density (dBm)	Limit (dBm)
2405 MHz	-4.05	8.0
2445 MHz	-4.01	8.0
2480 MHz	-4.79	8.0

Table 14: Spectral Power Density

2.3.8 Test Location and Test Equipment

This test was carried out in Non shielded room.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Signal and Spectrum Ana-lysator	Rohde & Schwarz GmbH & Co. KG	FSV40 for TS8997	20219	12	2022-01-31
Switching device	Rohde & Schwarz GmbH & Co. KG	OSP120 for TS8997	20248	24	2022-02-28
Testsystem 2,4 & 5 GHz Band	Rohde & Schwarz GmbH & Co. KG	TS8997	20251	24	2022-02-28
Switching device	Rohde & Schwarz GmbH & Co. KG	OSP120 for TS8997	38807	36	2023-11-30

Table 15

Product Service

2.4 Frequency Band Edge

2.4.1 Specification Reference

FCC 47 CFR Part 15 C, Clause 15.247(d)
ISED RSS-247, Clause 5.5

2.4.2 Equipment under Test and Modification State

WAL R1, S/N: --- – Modification State 0 (Conducted Sample)

2.4.3 Date of Test

2022-01-26

2.4.4 Environmental Conditions

Ambient Temperature	22 °C
Relative Humidity	31 %

2.4.5 Specification Limits

In any 100 kHz bandwidth outside the frequency band in which the device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of desired power, based on either conducted or radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted, the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits is not required.
In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.

ISED RSS-247 Clause 6.2.4.2
The power and e.i.r.p. of the equipment unwanted emission shall be measured in peak value. However, the equipment is restricted to comply with the provisions in RSS-Gen with respect to emissions falling within restricted frequency bands.
Devices operating in the band 5725 MHz – 5850 MHz shall have e.i.r.p. of unwanted emissions comply with the following:

a. 27 dBm/MHz at frequencies from the band edges decreasing linearly to 15.6 dBm/MHz at 5 MHz above or below the band edges;
b. 15.6 dBm/MHz at 5 MHz above or below the band edges decreasing linearly to 10 dBm/MHz at 25 MHz above or below the band edges;
c. 10 dBm/MHz at 25 MHz above or below the band edges decreasing linearly to -27 dBm at 75 MHz above or below the band edges; and
d. -27 dBm/MHz at frequencies more than 75 MHz above or below the band edges.

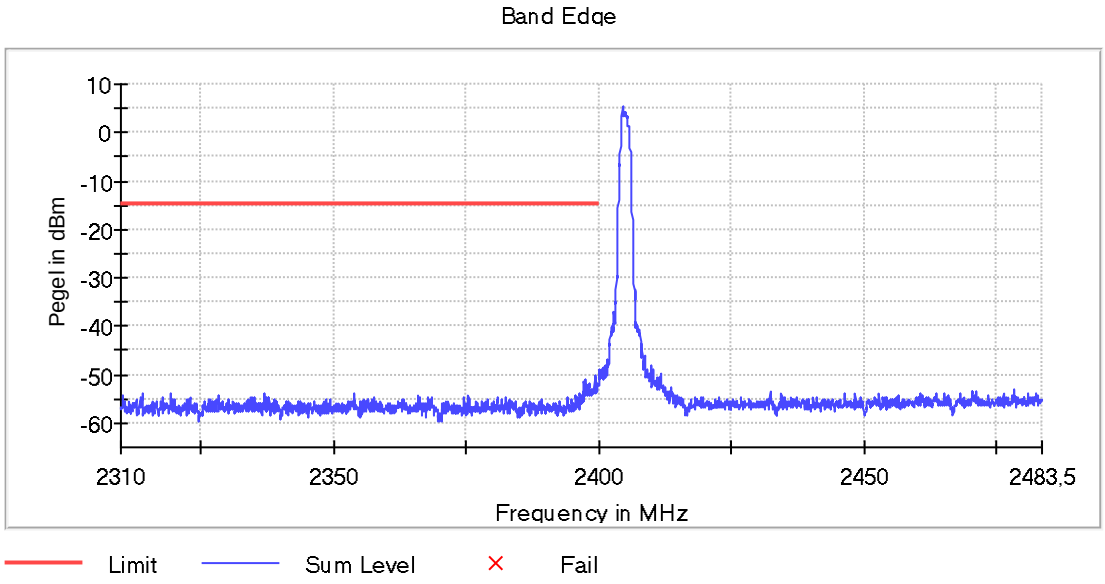
Product Service

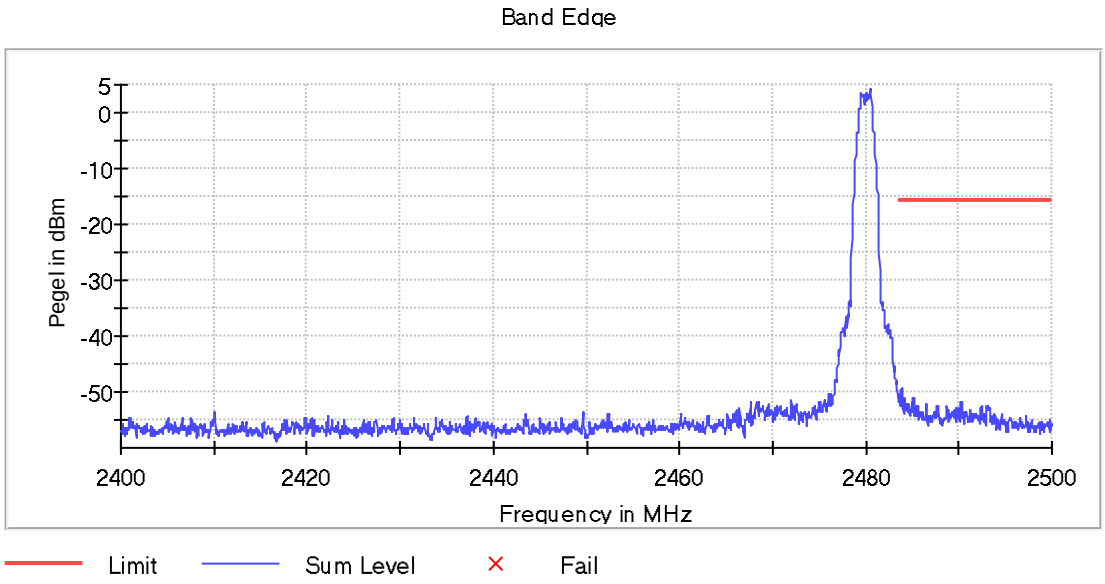
2.4.6 Test Method

The test was performed according to ANSI C63.10, sections 11.11

2.4.7 Test Results

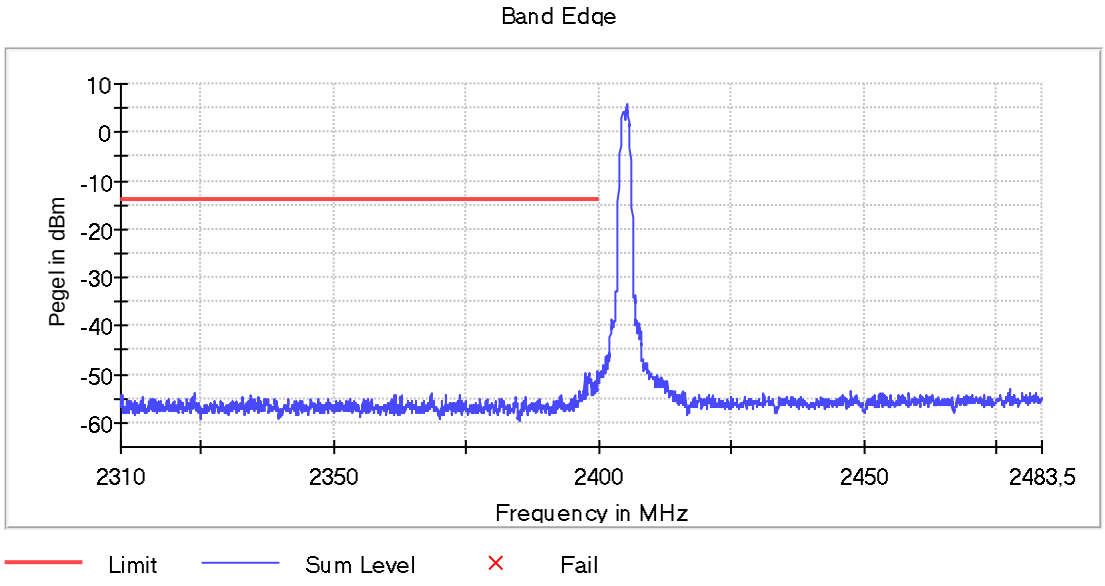
Antenna Port 0

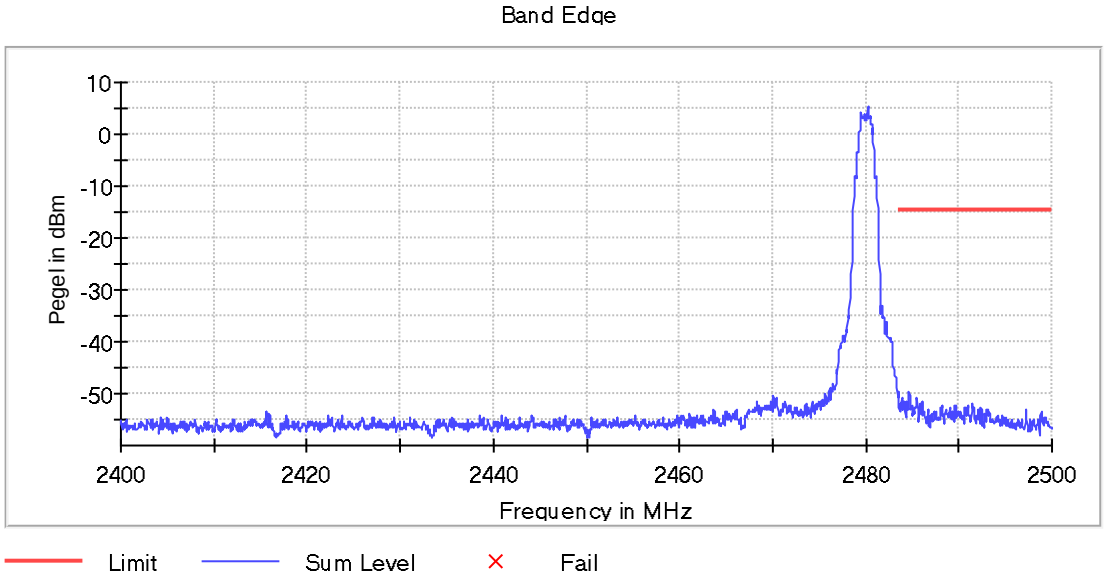




Product Service

Antenna Port 1





Product Service

2.4.8 Test Location and Test Equipment

This test was carried out in Non shielded room.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Signal and Spectrum Analysator	Rohde & Schwarz GmbH & Co. KG	FSV40 for TS8997	20219	12	2022-01-31
Switching device	Rohde & Schwarz GmbH & Co. KG	OSP120 for TS8997	20248	24	2022-02-28
Testsystem 2,4 & 5 GHz Band	Rohde & Schwarz GmbH & Co. KG	TS8997	20251	24	2022-02-28
Switching device	Rohde & Schwarz GmbH & Co. KG	OSP120 for TS8997	38807	36	2023-11-30

Table 16

Product Service

2.5 Spurious emissions

2.5.1 Specification Reference

FCC 47 CFR Part 15 C, Clause 15.205, 15.209, 15.247(d)
ISED RSS-247, Clause 5.5 / 6.2.4.2
ISED RSS-Gen, Clauses 8.9 and 8.10

2.5.2 Equipment under Test and Modification State

WAL R1, S/N: --- – Modification State 0
WAL R1, S/N: --- – Modification State 0 (Conducted Sample)

2.5.3 Date of Test

2022-01-24 - 2022-01-26

2.5.4 Environmental Conditions

Ambient Temperature	22 °C
Relative Humidity	34 %

2.5.5 Specification Limits

In any 100 kHz bandwidth outside the frequency band in which the device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of desired power, based on either conducted or radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted, the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits is not required.
In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.

Product Service

General radiated emission limits:					
Frequency Range	*Test distance*	*Field strength*		*Field strength*	
(MHz)	*(m)*	*(µA/m)*	*(dBµA/m)*	*(µV/m)*	*(dBµV/m)*
0.009 – 0.49	300	6.37 / *f*	20*lg(6.37 / *f*)	2400 / *f*	20*lg(2400 / *f*)
0.49 – 1.705	30	63.7 / *f*	20*lg(63.7 / *f*)	24000 / *f*	20*lg(24000 / *f*)
1.705 - 30	30	0.08	20*lg(0.08 / *f*)	30	20*lg(30 / *f*)
30 – 88	3	---	--	100	40
88 – 216	3	--	--	150	43.5
126 – 960	3	--	--	200	46
above 960	3	--	--	500	54
Note 1: *f* in kHz					

Table 17 General radiated emission limits

ISED RSS-247 Clause 6.2.4.2

The power and e.i.r.p. of the equipment unwanted emission shall be measured in peak value. However, the equipment is restricted to comply with the provisions in RSS-Gen with respect to emissions falling within restricted frequency bands.

Devices operating in the band 5725 MHz – 5850 MHz shall have e.i.r.p. of unwanted emissions comply with the following:

a. 27 dBm/MHz at frequencies from the band edges decreasing linearly to 15.6 dBm/MHz at 5 MHz above or below the band edges;
b. 15.6 dBm/MHz at 5 MHz above or below the band edges decreasing linearly to 10 dBm/MHz at 25 MHz above or below the band edges;
c. 10 dBm/MHz at 25 MHz above or below the band edges decreasing linearly to -27 dBm at 75 MHz above or below the band edges; and
d. -27 dBm/MHz at frequencies more than 75 MHz above or below the band edges.

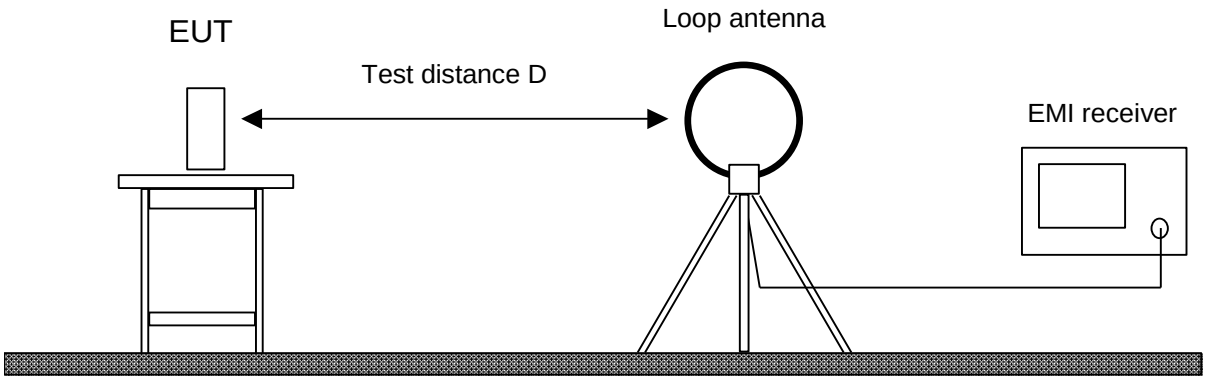
Product Service

2.5.6 Test Method

The test was performed according to ANSI C63.10, sections 11.11 and 11.12

Prescans are performed in six positions of the EUT to get the full spectrum of emission caused by the EUT with the measuring antenna raised and lowered from 1 m to 4 m with vertical and horizontal polarisation to find the combination of table position, antenna height and antenna polarisation for the maximum emission levels.
Data reduction is applied to these results to select those levels having less margin than 10 dB or exceeding the limit using subranges and limited number of maximums.
Further maximisation for adjusting the maximum position is following.
Equipment and cables are placed and moved within the range of position likely to find their maximum emissions.

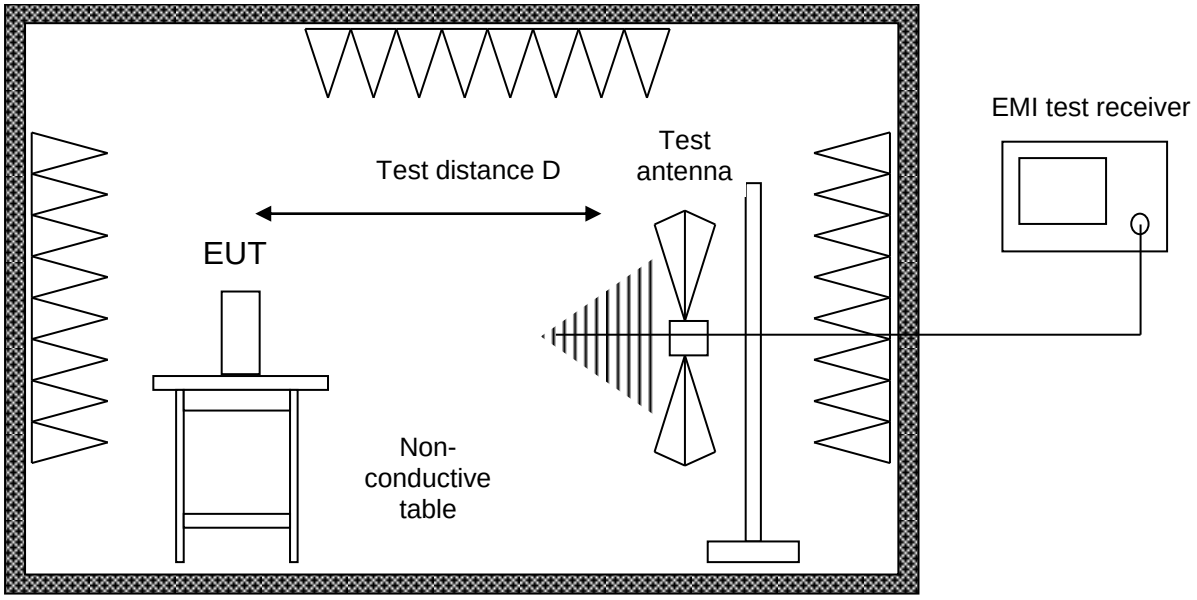
2.5.6.1 Frequency range 9 kHz – 30 MHz



The EUT was placed on a non-conductive table, 0.8 m above the ground.
Radiated emissions in the frequency 9 kHz – 30 MHz is measured within a semi-anechoic room with an active loop antenna with the measurement detector set to peak. In addition in the frequency range 9 kHz to 490 kHz also an average detector was used. The measurement bandwidth of the receiver was set to 300 Hz in the frequency range 9 kHz to 150 kHz and 10 kHz in the frequency range 150 kHz to 30 MHz. Prescans were performed in six positions of the EUT.
For final measurements the detector was set to CISPR quasi-peak and in addition to CISPR average in the frequency range 9 kHz to 490 kHz with a resolution bandwidth 200 Hz in the frequency range 9 kHz to 150 kHz and 9 kHz in the frequency range 150 kHz to 30 MHz. Final tests were performed immediately after a final frequency and zoom (for drifting disturbances) and maximum adjustment.

Product Service

2.5.6.2 Frequency range 30 MHz – 1 GHz

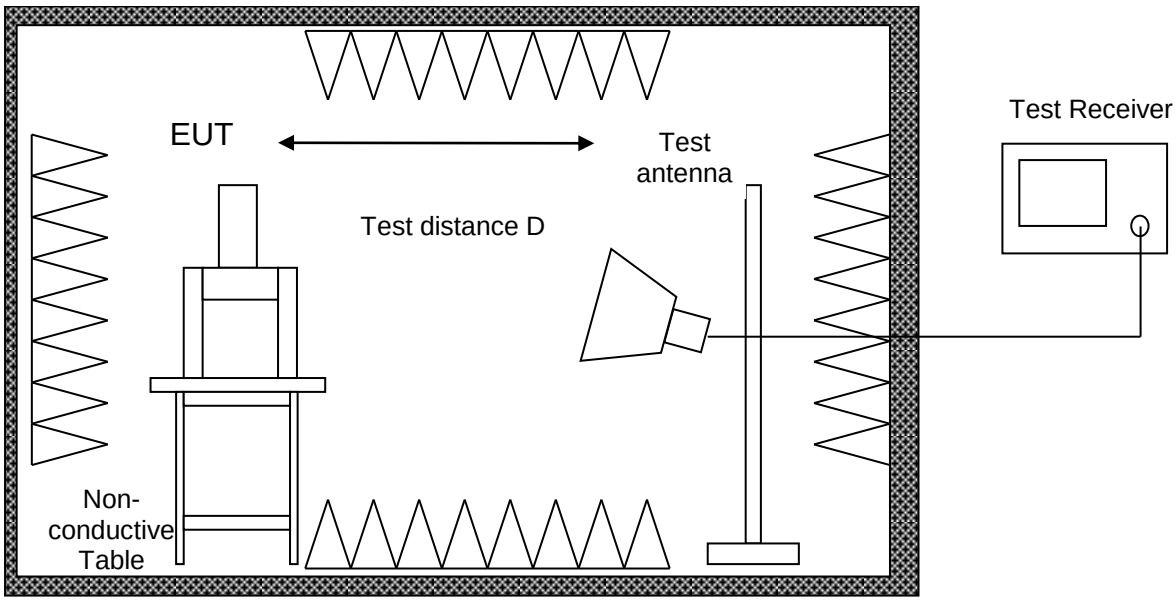


Alternate test site (semi anechoic room)

The EUT was placed on a non-conductive table, 0.8 m above the ground plane
Radiated emissions in the frequency range 30 MHz – 1 GHz is measured within a semi-anechoic room with groundplane complying with the NSA requirements of ANSI C63.4. for alternative test sites. A linear polarised logarithmic periodic antenna combined with a 4:1 broadband dipole (“Trilog broadband antenna”) is used.
For prescan tests the test receiver is set to peak-detector with a bandwidth of 120 kHz.
With the measurement bandwidth of the test receiver set to 120 kHz CISPR quasi-peak detector is selected for final measurements following immediately after a final frequency zoom (for drifting disturbances) and maximum adjustment.

Product Service

2.5.6.3 Frequency range above 1 GHz



Fully anechoic room

The EUT was placed on a non-conductive table, 1.5 m above the ground plane
Radiated emission tests above 1 GHz are performed in a fully anechoic room with the S_{VSWR} requirements of ANSI C63.4. Measurements are performed both in the horizontal and vertical planes of polarisation using a test receiver with the detector function set to peak and average and the resolution bandwidth set to 1 MHz. Testing above 1 GHz is performed with horn antennas with the EUT in boresight of the antenna.
For prescan tests the test receiver is set to peak- and average-detector with a bandwidth of 1 MHz. With the measurement bandwidth of the test receiver set to 1 MHz and peak- and CISPR average-detector is selected for final measurements following immediately after a final frequency zoom (for drifting disturbances) and maximum adjustment.

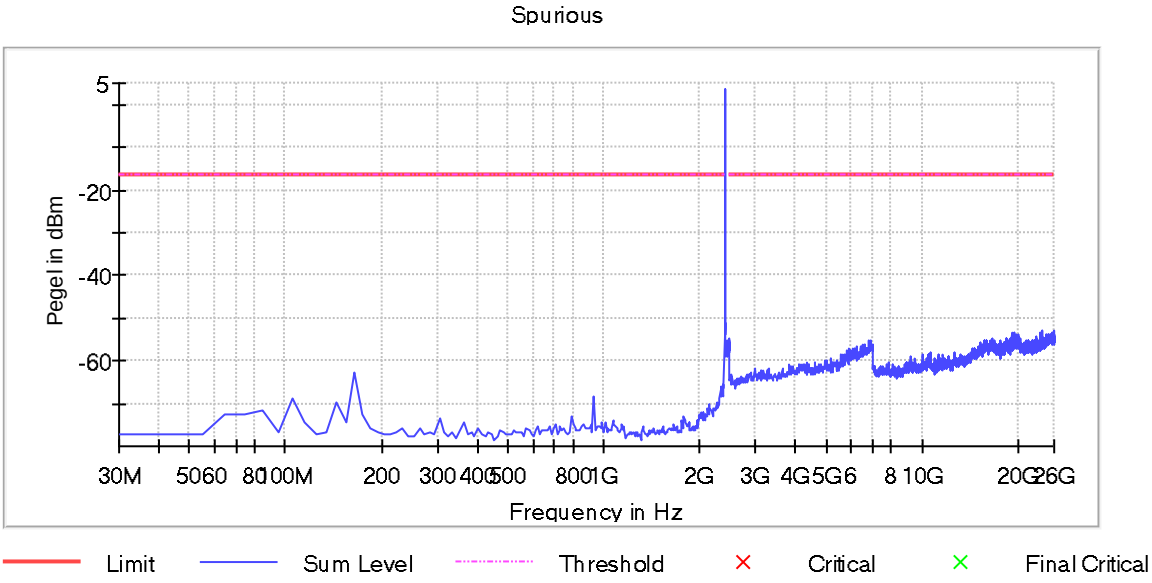
Product Service

2.5.7 Test Results

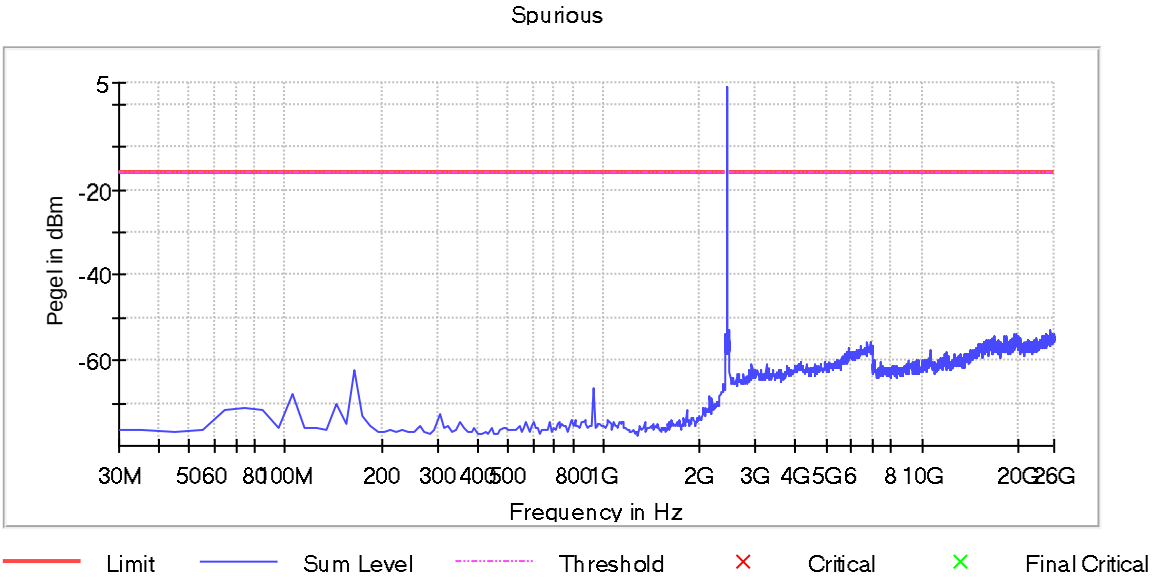
2.5.7.1 Conducted emission test

Antenna Port 0

Ch. 2405 MHz

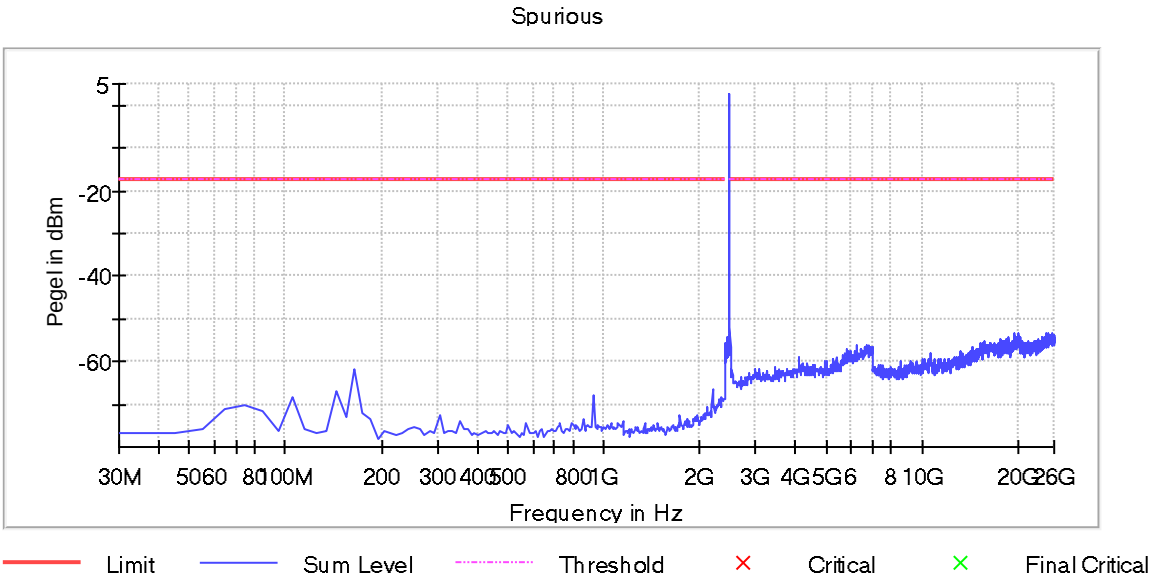


Ch. 2445 MHz



Product Service

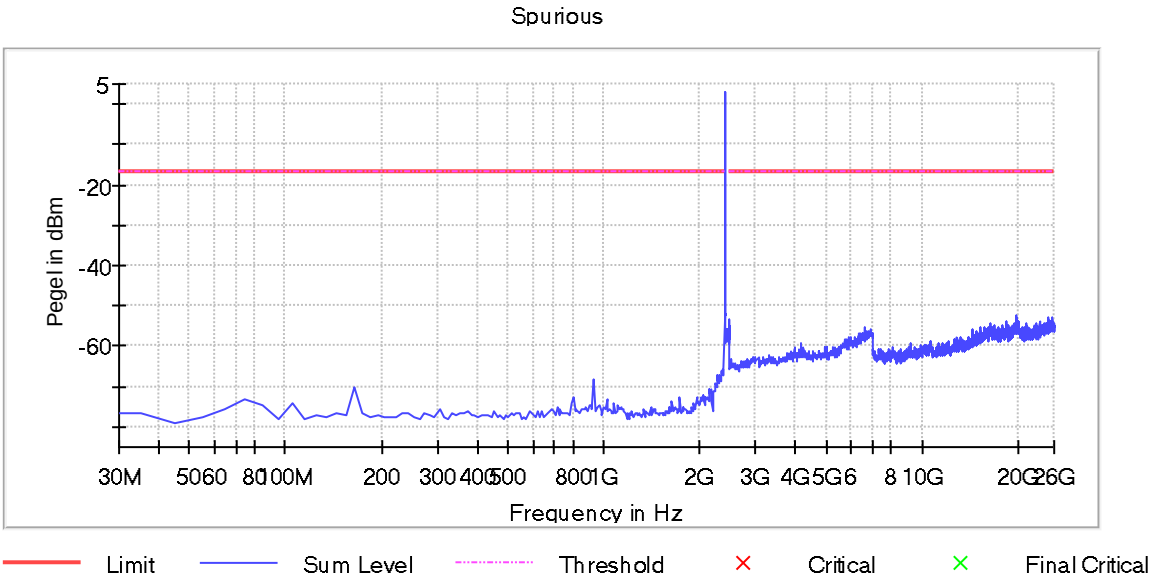
Ch. 2480 MHz



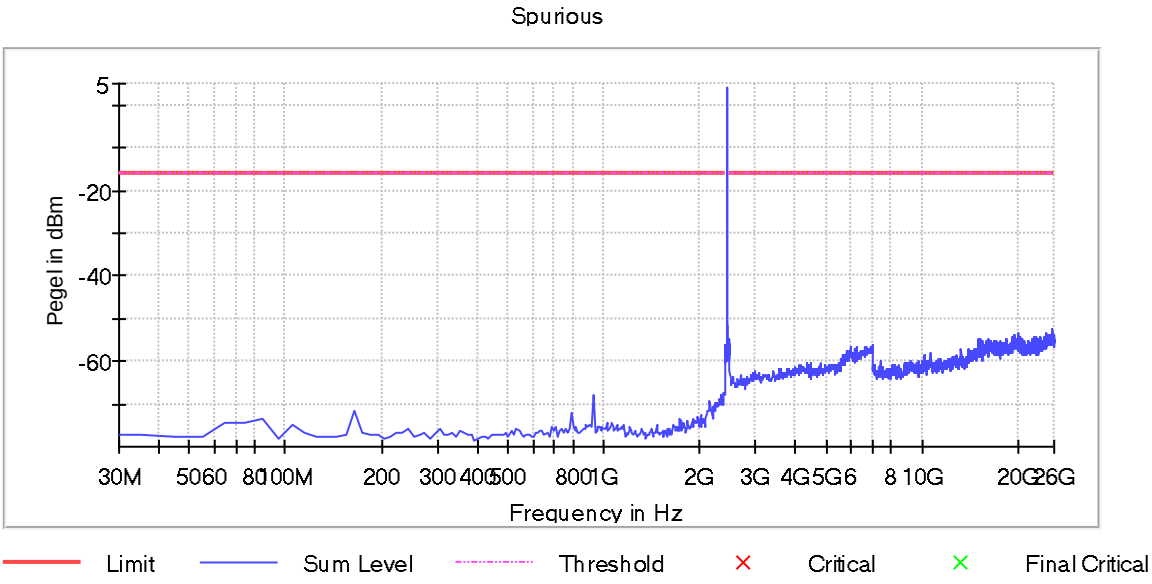
Product Service

Antenna Port 1

Ch. 2405 MHz

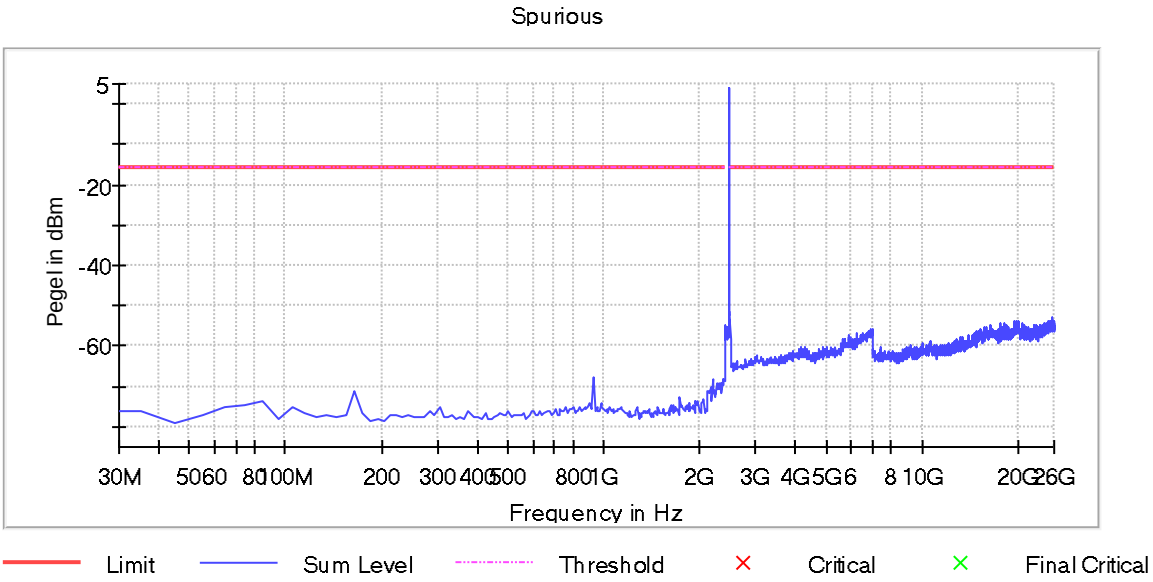


Ch. 2445 MHz



Product Service

Ch. 2480 MHz



Product Service

2.5.7.2 Radiated emission test with Antenna Port 0 and 2480 MHz (Worst Case)

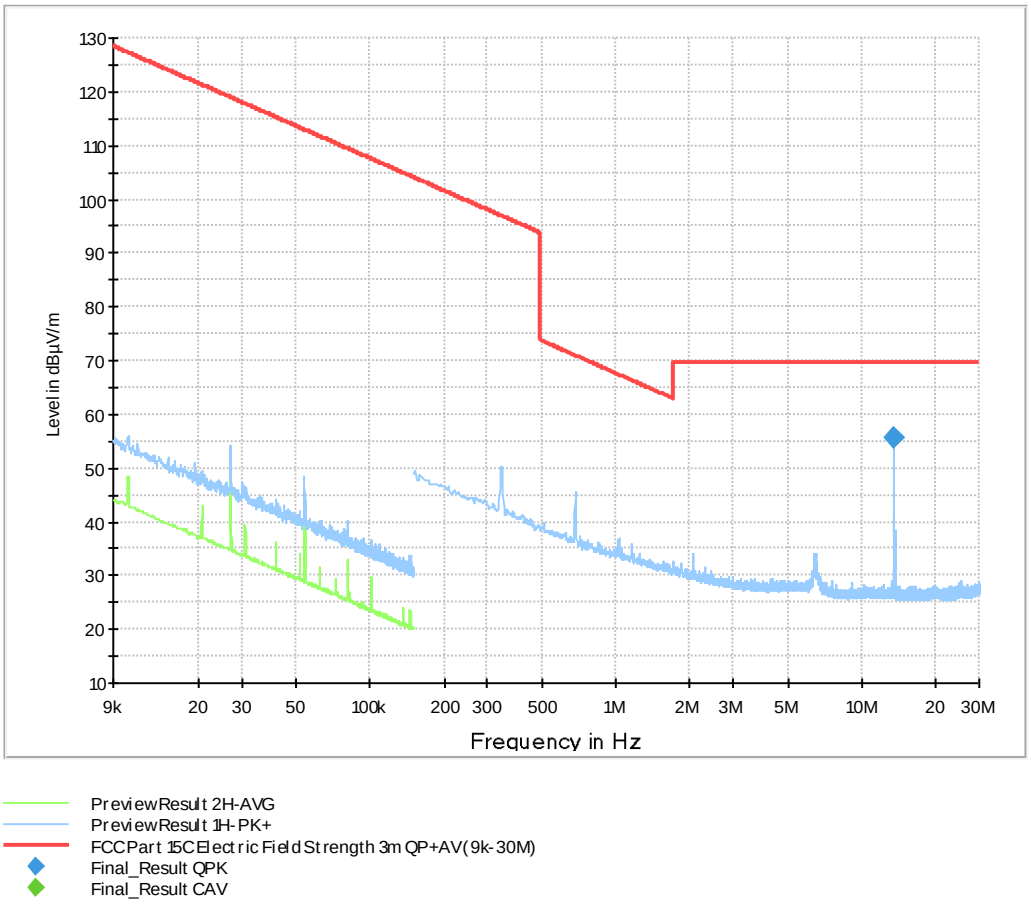
Sample calculation:

Final Value (dBµV/m) = Reading Value (dBµV) + (Cable attenuation (dB) + Antenna Transducer (dB(1/m)))

Frequency range	*Limit applied*	*Test distance*
9 kHz – 1 GHz	15.209 / RSS-GEN	3 m
1 GHz – 40 GHz	15.209 / RSS-GEN	1 m

Table 18

Frequency range 9 kHz – 30 MHz:

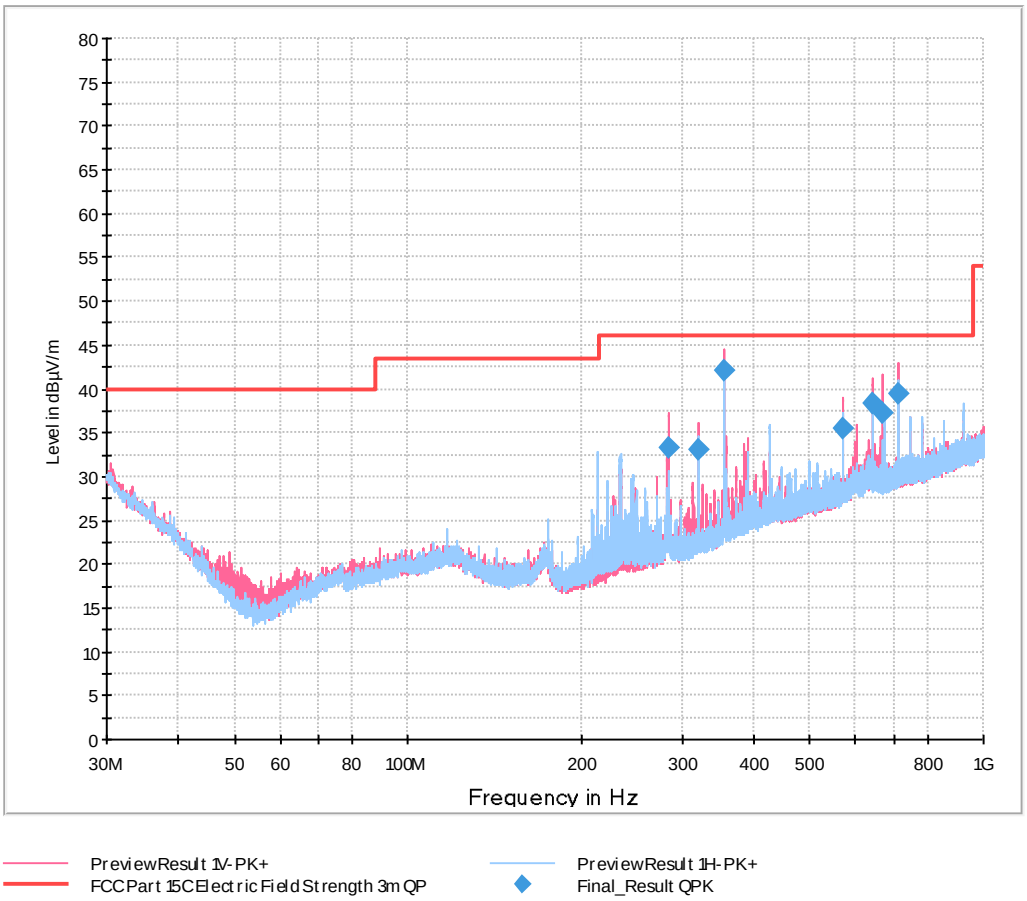


Final Results 1:

Frequency MHz	*Qua-siPeak dBµV/m*	*Limit dBµV/m*	*Mar-gin dB*	*Meas. Time ms*	*Band-width kHz*	*Height cm*	*Pol*	*Azi-muth deg*	*Corr. dB/m*
13.560000	55.61	69.54	13.93	1000.0	9.000	100.0	H	185.0	18.9

Product Service

Frequency range 30 MHz – 1 GHz:

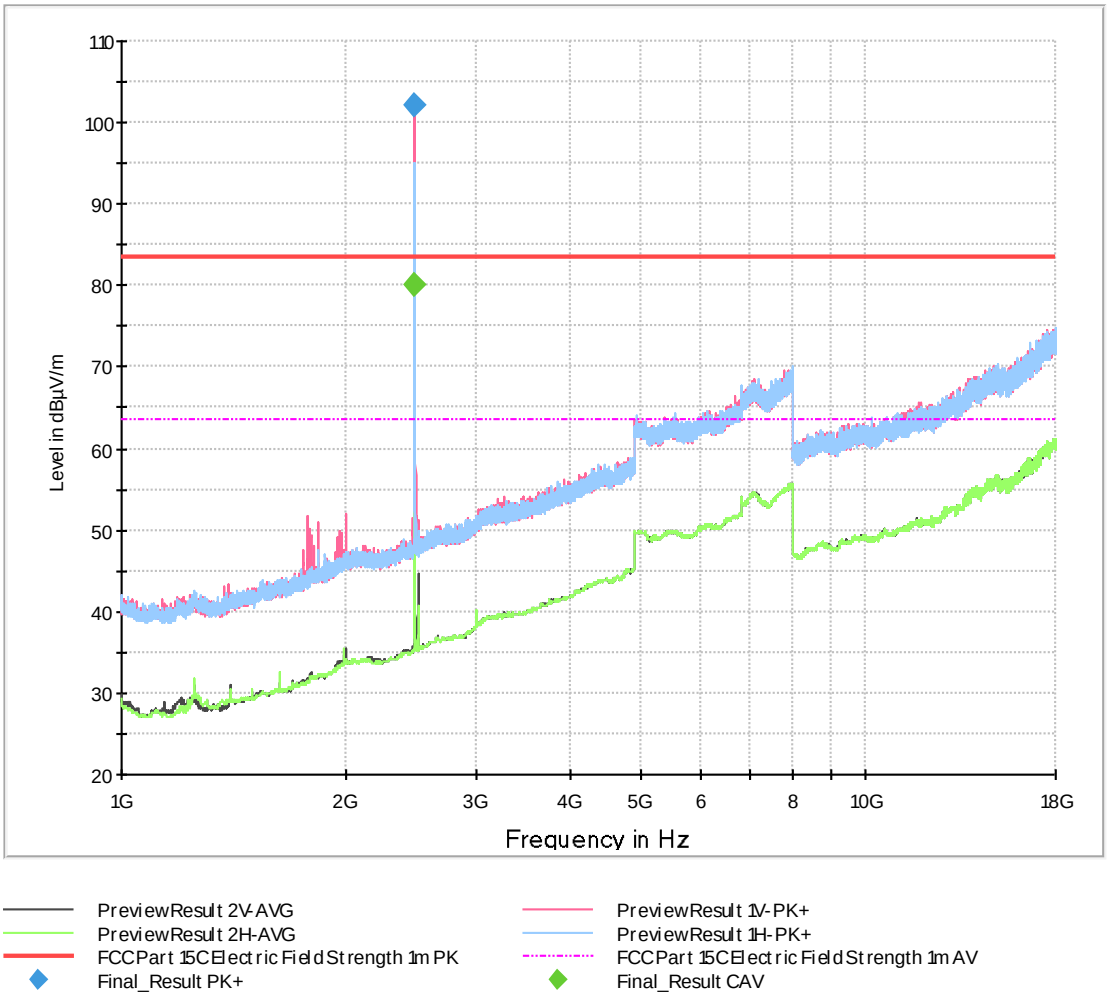


Final Results 1:

Frequency MHz	*Qua-siPeak dBµV/m*	*Limit dBµV/m*	*Mar-gin dB*	*Meas. Time ms*	*Band-width kHz*	*Height cm*	*Pol*	*Azi-muth deg*	*Corr. dB*
284.370000	33.36	46.02	12.66	1000.0	120.000	102.0	V	-7.0	19.1
319.950000	33.04	46.02	12.98	1000.0	120.000	102.0	V	5.0	20.2
355.470000	42.11	46.02	3.91	1000.0	120.000	102.0	V	-8.0	21.1
568.830000	35.47	46.02	10.55	1000.0	120.000	302.0	V	7.0	25.3
639.780000	38.32	46.02	7.70	1000.0	120.000	100.0	V	170.0	26.3
666.660000	37.32	46.02	8.70	1000.0	120.000	100.0	V	-100.0	26.7
711.000000	39.54	46.02	6.48	1000.0	120.000	302.0	V	10.0	27.3

Product Service

Frequency range 1 GHz – 18 GHz:



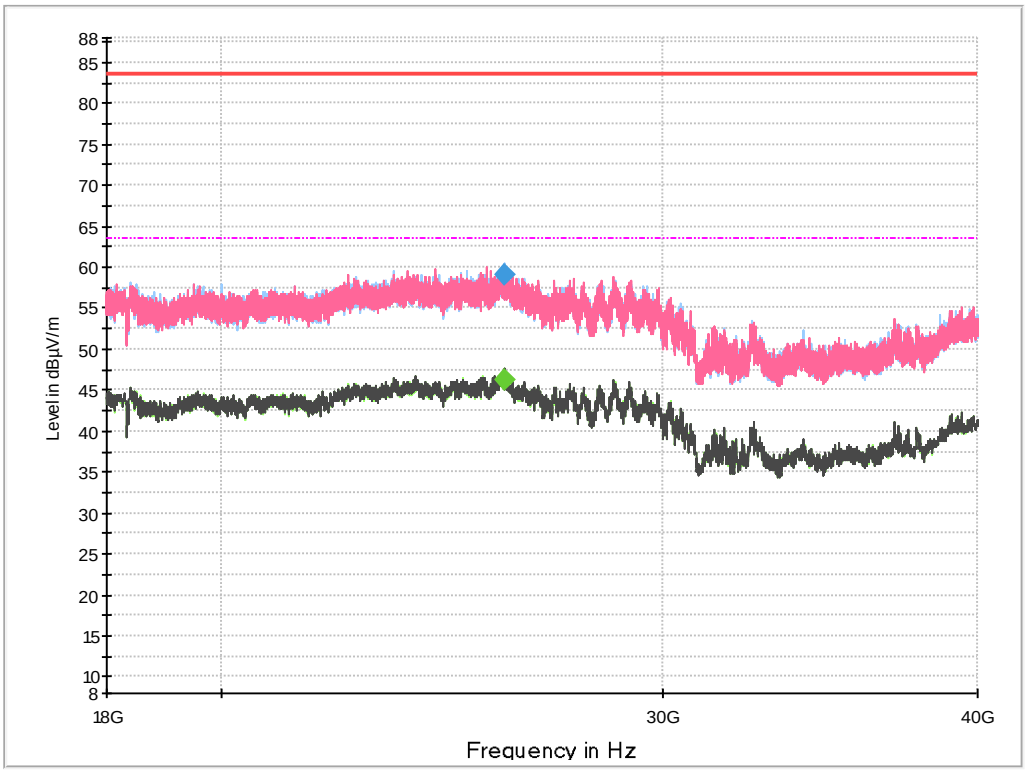
Final Results 1:

Frequency MHz	*Max-Peak dBµV/m*	*CAver-age dBµV/m*	*Limit dBµV/m*	*Mar-gin dB*	*Meas. Time ms*	*Band-width kHz*	*Height cm*	*Pol*	*Azi-muth deg*	*Corr. dB*
2480.500000	---	80.07	*	*	1000.0	1000.000	150.0	V	90.0	34.2
2480.500000	102.19	---	*	*	1000.0	1000.000	150.0	V	90.0	34.2

* Emissions in carrier frequency band are not evaluated as spurious emissions.

Product Service

Frequency range 18 GHz – 40 GHz:



Final Results 1:

Frequency MHz	*Max-Peak dBµV/m*	*CAver-age dBµV/m*	*Limit dBµV/m*	*Mar-gin dB*	*Meas. Time ms*	*Band-width kHz*	*Height cm*	*Pol*	*Azi-muth deg*	*Corr. dB*
25910.000000	---	46.34	63.50	17.16	1000.0	1000.000	150.0	H	0.0	31.1
25910.000000	58.97	---	83.50	24.53	1000.0	1000.000	150.0	H	0.0	31.1

Product Service

2.5.8 Test Location and Test Equipment

The test was carried out in semi anechoic room, No. 11 and non shielded room.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
EMI test receiver	Rohde & Schwarz GmbH & Co. KG	ESW44	39897	12	2022-04-30
Loop antenna	Schwarzbeck Mess-Elektronik	FMZB 1519 B	44334	36	2023-01-31
ULTRALOG Antenna	Rohde & Schwarz GmbH & Co. KG	HL562E	39969	36	2022-11-30
Fixed attenuator	Aeroflex / Weinschel, Inc.	Model:1 6dB	39632	36	2022-11-30
Double ridged horn antenna	Rohde & Schwarz GmbH & Co. KG	HF907	40089	24	2023-02-28
Horn antenna with preamplifier	Rohde & Schwarz GmbH & Co. KG	A-INFOWM LB-180400-Kf + TS-LNA1840	43661	24	2022-12-31
Semi anechoic room	Frankonia	Cabin no. 11	42961	36	2024-09-30
RF matrix cabin 11	TÜV SÜD Product Service GmbH (PS-EMC-STR)	RF Matrix with filter	47622	12	2022-02-28
EMC measurement software	Rohde & Schwarz GmbH & Co. KG	EMC32 Emission K11 - V10.50.10	42986	---	---
Signal and Spectrum Analysator	Rohde & Schwarz GmbH & Co. KG	FSV40 for TS8997	20219	12	2022-01-31
Switching device	Rohde & Schwarz GmbH & Co. KG	OSP120 for TS8997	20248	24	2022-02-28
Testsystem 2,4 & 5 GHz Band	Rohde & Schwarz GmbH & Co. KG	TS8997	20251	24	2022-02-28
Switching device	Rohde & Schwarz GmbH & Co. KG	OSP120 for TS8997	38807	36	2023-11-30

Table 19

Product Service

2.6 Temperature Stability

2.6.1 Specification Reference

ISED RSS-Gen, Clause 6.11, 8.11

2.6.2 Equipment under Test and Modification State

WAL R1, S/N: --- – Modification State 0 (Conducted Sample)

2.6.3 Date of Test

2022-01-26

2.6.4 Environmental Conditions

Ambient Temperature	22 °C
Relative Humidity	31 %

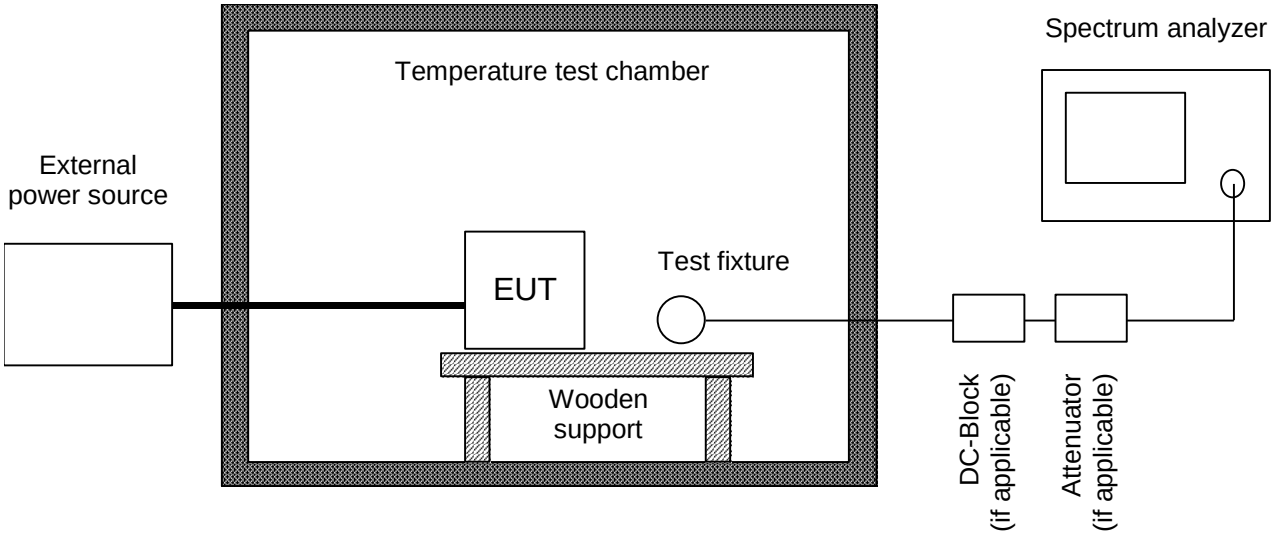
2.6.5 Specification Limits

If the stability of the license-exempt radio apparatus is not specified in the applicable RSS, the fundamental emissions of the radio apparatus should be kept within at least the central 80 % of its permitted operating frequency band in order to minimize the possiblilty of out-of-band operation. In additions, its occupied bandwidth shall be entirely outside the resitricted bands and the prohibited TV bands of 54 MHz – 72 MHz, 76 MHz – 88 MHz, 174 MHz – 216 MHz, and 470 MHz – 602 MHz, unless otherwise indicated.

Product Service

2.6.6 Test Method

The test was performed according to ANSI C63.10, section 6.8.



The frequency tolerance of the carrier signal is measured over a temperature variation of -20 °C to +50 °C at normal supply voltage, and for a variation in the primary supply voltage from 85 % to 115 % of the rates supply voltage at a temperature of 20 °C. Temperature and voltage range may vary if the manufacturer states another temperature or voltage range.
If the EUT provides an antenna connector the spectrum analyzer is connected to this port. If required, a resistive matching network equal to the impedance specified or employed for the antenna is used as well as a DC block and appropriate (50 Ω) attenuators. In case where the EUT does not provide an antenna connector or a test fixture is used.
For battery operated equipment, the test is performed using a new battery. Alternatively, an external supply voltage can be used and is at least set to:

- The maximum battery voltage as delivered by a new battery or 115 % of the battery nominal voltage;
- The battery nominal voltage
- 85 % of the battery nominal voltage
- The battery operating end point voltage which shall be specified by the equipment manufacturer.

The EUT is operating providing an unmodulated carrier for frequency error tests. The peak detector of the spectrum analyzer is selected and resolution as well as video bandwidth are set to values appropriate to shape of the spectrum of the EUT. The frequency counter mode of the spectrum analyzer is used to maximize the accuracy of the measured frequency tolerance.
If an unmodulated carrier is not available a significant and stable point of the spectrum is selected and the span is reduced to a value that delivers an accuracy which shall be better than 1 % of the maximum frequency tolerance allowed for the carrier signal. This method may be performed as long as the margin to the frequency tolerance is larger than the uncertainty of the measured frequency tolerance.

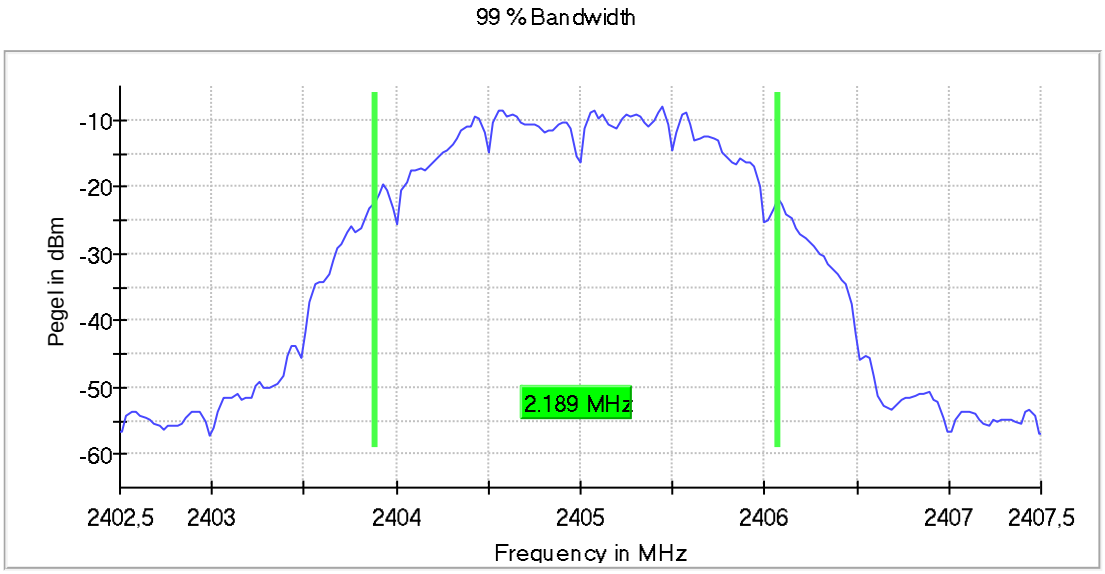
Product Service

2.6.7 Test Results

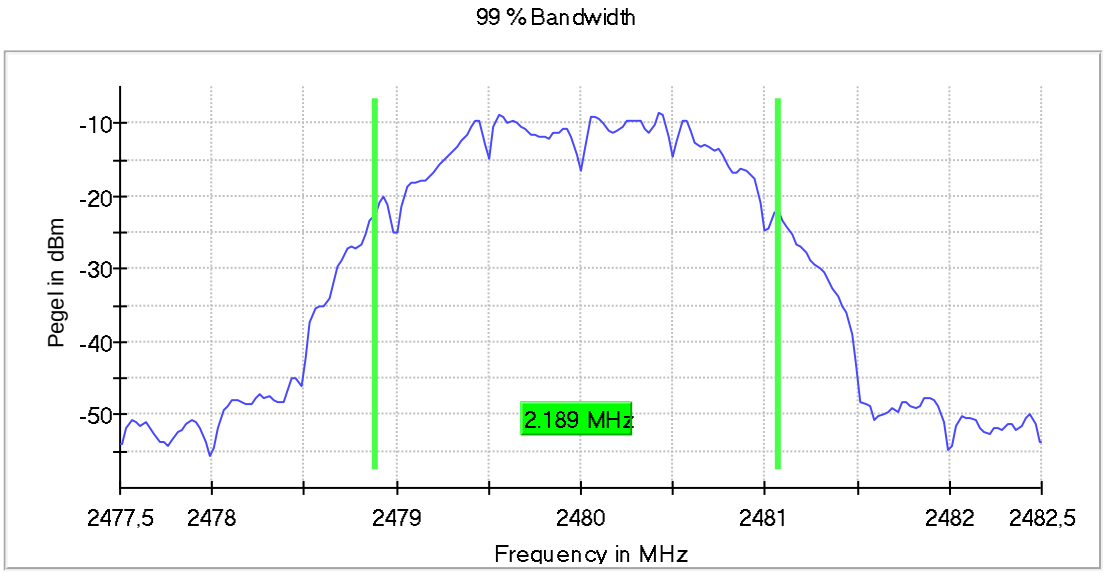
Note: - Measured Frequency Error does not affect any band edge requirements.

Sample screenshots:

Antenna Port 0



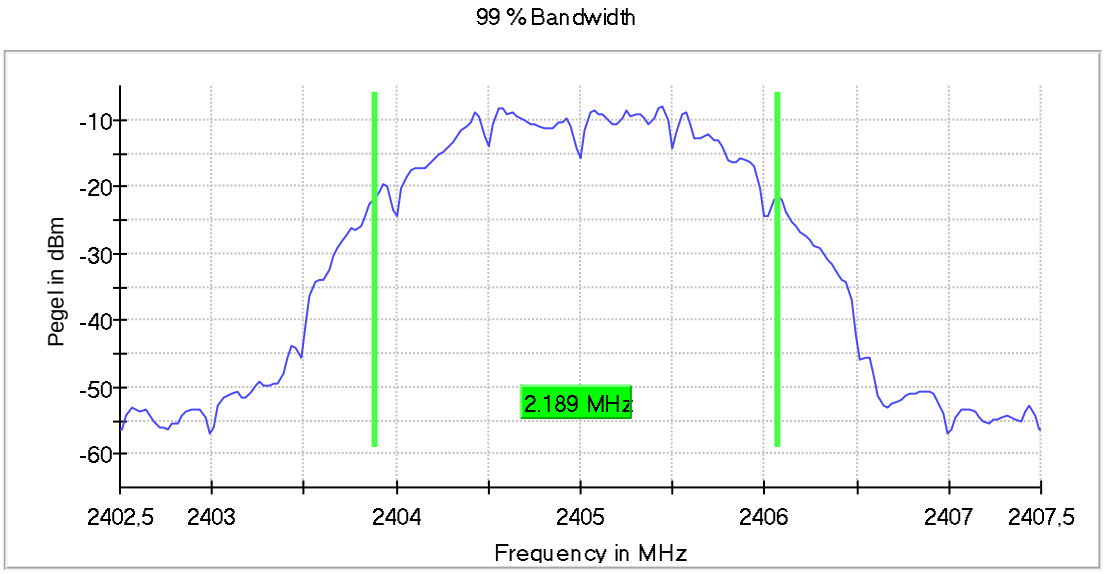
Transmission on 2405 MHz; 0°C, 24 V DC



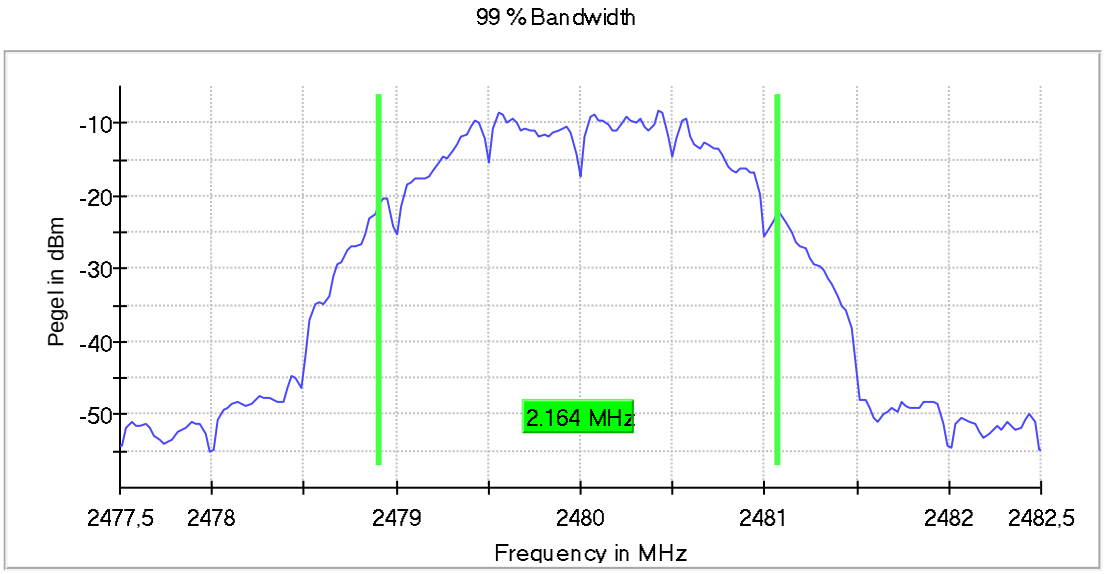
Transmission on 2480 MHz; 50°C, 24 V DC

Product Service

Antenna Port 1



Transmission on 2405 MHz; 0°C, 24 V DC



Transmission on 2480 MHz; 50°C, 24 V DC

Product Service

2.6.8 Test Location and Test Equipment

This test was carried out in Non shielded room.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Signal and Spectrum Analysator	Rohde & Schwarz GmbH & Co. KG	FSV40 for TS8997	20219	12	2022-01-31
Switching device	Rohde & Schwarz GmbH & Co. KG	OSP120 for TS8997	20248	24	2022-02-28
Testsystem 2,4 & 5 GHz Band	Rohde & Schwarz GmbH & Co. KG	TS8997	20251	24	2022-02-28
Switching device	Rohde & Schwarz GmbH & Co. KG	OSP120 for TS8997	38807	36	2023-11-30
Climatic test chamber	Feutron Klimasimulation	KPK200-2	19868	18	2023-02-28

Table 20

Product Service

2.7 Conducted Emissions on Mains Terminals

2.7.1 Specification Reference

FCC 47 CFR Part 15 C, Clause 15.207
ISED RSS-Gen, Clause 8.8

2.7.2 Equipment under Test and Modification State

WAL R1, S/N: --- – Modification State 0

2.7.3 Date of Test

2022-02-02

2.7.4 Environmental Conditions

Ambient Temperature	20 °C
Relative Humidity	39 %

2.7.5 Specification Limits

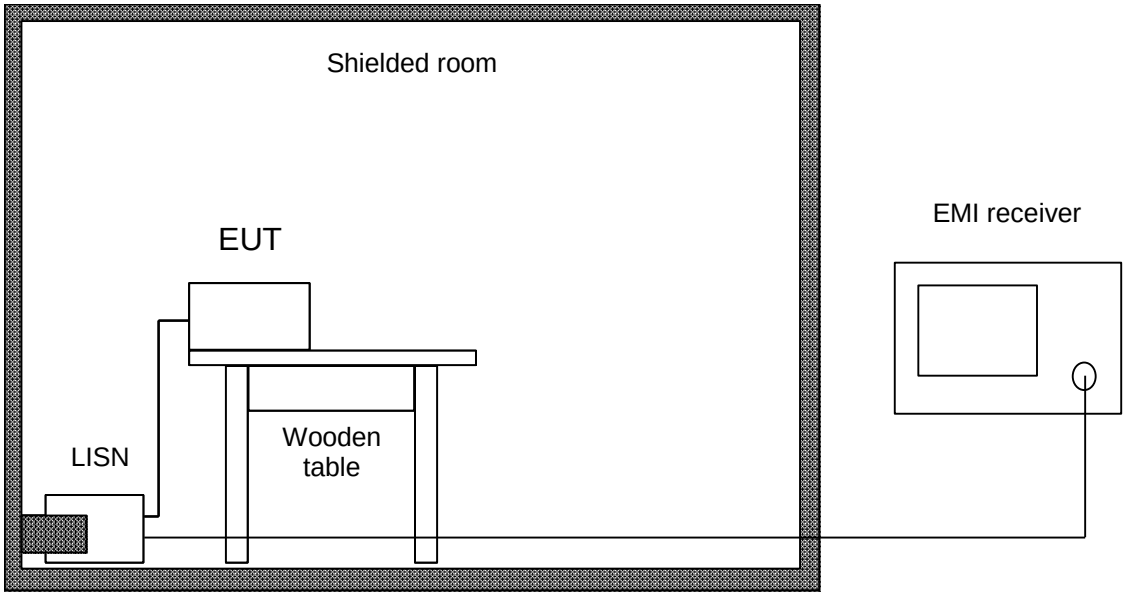
Required Specification Limits (Class B)			
Line Under Test	*Frequency Range (MHz)*	*Quasi-peak (dBµV)*	*Average (dBµV)*
AC Power Port	0.15 to 0.5	66 to 56*	56 to 46*
	0.5 to 5	56	46
	5 to 30	60	50
Supplementary information: *Decreases with the logarithm of the frequency.			

Table 21 Emission limits

Product Service

2.7.6 Test Method

The test was performed according to ANSI C63.10, section 6.2.



The EUT was placed on a non-conductive table 0.8 m above a reference ground plane and 0.4 m away from a vertical coupling plane.
All power was connected to the EUT through an Line Impedance Stabilization Network (LISN). Conducted disturbance voltage measurements on mains lines were made at the output of the LISN. The LISN was placed 0.8 m from the boundary of the EUT and bounded to the reference ground plane. To simplify testing with quasi-peak and linear average (cispr-average) detector the following procedure is used:
First the whole spectrum of emission caused by the equipment under test (EUT) is recorded with the detectors set to peak and average using CISPR bandwidth of 10 kHz. After that all emission levels having less margin than 10 dB to or exceeding the average limit are retested with the detectors set to quasi-peak and average. If the average limit is kept with quasi-peak levels measurement with average detector is optional. In cases of emission levels between quasi-peak and average limit an additional measurement with average detector has to be performed.
According to ANSI C63.10, section 6.2.5, testing of intentional radiators with frequencies below 30 MHz shall be performed using a suitable dummy load connected to the antenna output terminals. Otherwise the tests shall be performed with the integral or a representative antenna and, if adjustable, fully extended. Testing with a dummy load may be necessary to distinguish (unintentional) conducted emissions on the supply lines form (intentional) emissions radiated by the antenna and coupling directly to supply lines and/or LISN. The usage of a dummy load has to be stated in the appropriate test record(s) and notes should be added to clarify the test setup.

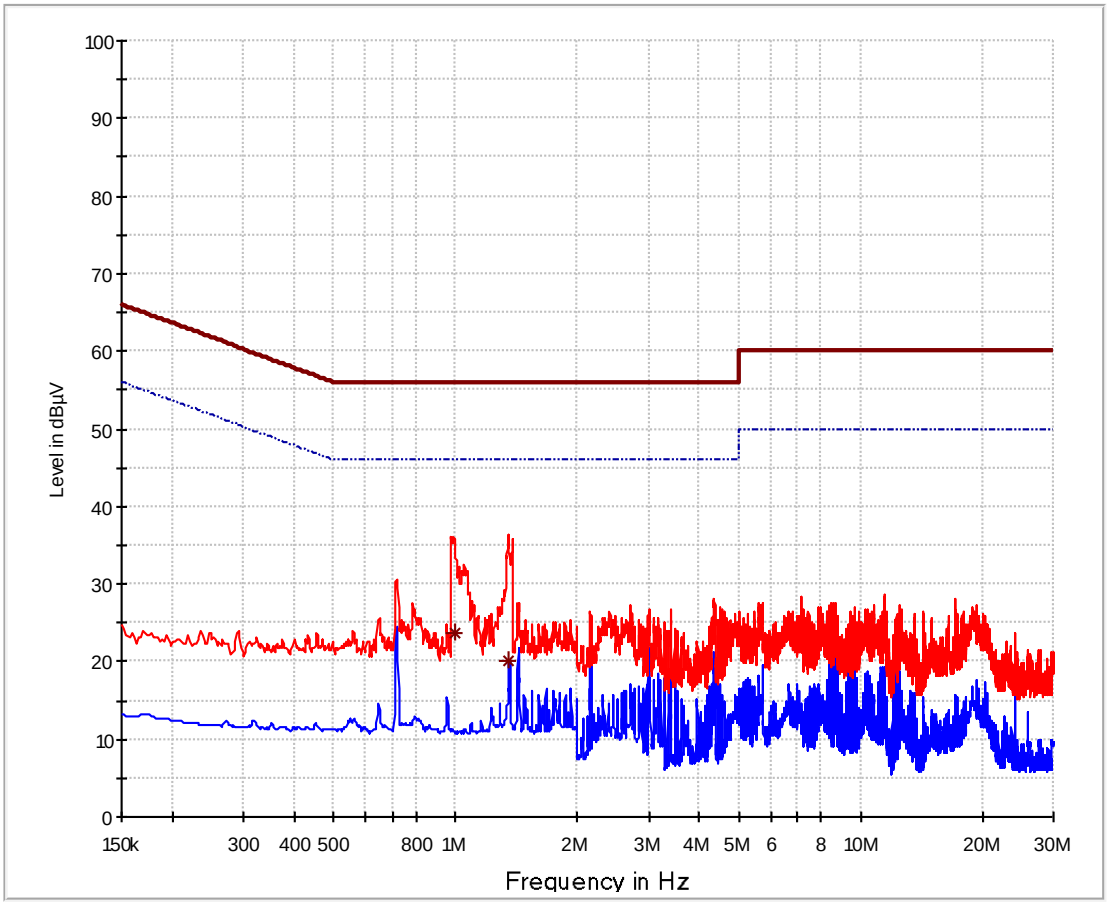
Product Service

2.7.7 Test Results

Sample calculation:

Final Value (dBµV) = Reading Value (dBµV) + (Cable attenuation (dB) + LISN Transducer (dB))

Line Plus and Minus



Final Results 1:

Frequency MHz	*QuasiPeak dBµV*	*Limit dBµV*	*Margin dB*	*Meas. Time ms*	*Bandwidth kHz*	*Line*	*Corr. dB*
0.993750	23.57	56.00	32.43	1000.0	9.000	Minus	10.0
1.351500	20.03	56.00	35.97	1000.0	9.000	Plus	10.0

Product Service

2.7.8 Test Location and Test Equipment

This test was carried out in Shielded room - cabin no. 9.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
EMI test receiver	Rohde & Schwarz	ESCI3	19730	18	2022-05-31
V-network	Rohde & Schwarz	ENV216	39908	12	2022-03-31
EMC measurement software	Rohde & Schwarz	EMC32 V10.60.00	44377	---	---

Table 22

Product Service

3 Measurement Uncertainty

For a 95% confidence level, the measurement uncertainties for defined systems are:

The measurement uncertainty in the laboratory is less than or equal to the maximum measurement uncertainty according to CISPR16-4-2: 2011 + A1 + A2 + Cor1 (U_{CISPR}). This normative regulation means that the measured value is also the value to be assessed in relation to the limit value.

Radio Interference Emission Testing		
Test Name	*kp*	*Expanded Uncertainty*
Conducted Voltage Emission		
9 kHz to 150 kHz (50Ω/50µH AMN)	2	± 3.8 dB
150 kHz to 30 MHz (50Ω/50µH AMN)	2	± 3.4 dB
100 kHz to 200 MHz (50Ω/5µH AMN)	2	± 3.6 dB
Discontinuous Conducted Emission		
9 kHz to 150 kHz (50Ω/50µH AMN)	2	± 3.8 dB
150 kHz to 30 MHz (50Ω/50µH AMN)	2	± 3.4 dB
Conducted Current Emission		
9 kHz to 200 MHz	2	± 3.5 dB
Magnetic Fieldstrength		
9 kHz to 30 MHz (with loop antenna)	2	± 3.9 dB
9 kHz to 30 MHz (large-loop antenna 2 m)	2	± 3.5 dB
Radiated Emission		
30 MHz to 300 MHz	2	± 4.9 dB
300 MHz to 1 GHz	2	± 5.0 dB
1 GHz to 6 GHz	2	± 4.6 dB
Test distance 10 m		
30 MHz to 300 MHz	2	± 4.9 dB
300 MHz to 1 GHz	2	± 4.9 dB
The expanded uncertainty reported according to to CISPR16-4-2: 2011 + A1 + A2 + Cor1 is based on a standard uncertainty multiplied by a coverage factor of kp = 2, providing a level of confidence of p = 95.45%		

Table 23 Measurement uncertainty based on CISPR 16-4-2

Radio Interference Emission Testing		
Test Name	*kp*	*Expanded Uncertainty*
Occupied Bandwdith	2	± 5 %
Conducted Power		
9 kHz ≤ f < 30 MHz	2	± 1.0 dB
30 MHz ≤ f < 1 GHz	2	± 1.5 dB
1 GHz ≤ f ≤ 40 GHz	2	± 2.5 dB
1 MS/s power sensor (TS8997)	2	± 1.5 dB
Occupied Bandwidth	2	± 5 %
Power Spectral Density	2	± 3.0 dB
Radiated Power		
9 kHz ≤ f < 26.5 GHz	2	± 6.5 dB
26.5 GHz ≤ f < 60 GHz	2	± 8.0 dB
60 GHz ≤ f < 325 GHz	2	± 10 dB
Conducted Spurious Emissions	2	± 3.0 dB
Radiated Spurious Emissions	2	± 6.0 dB
Voltage		
DC	2	± 1.0 %
AC	2	± 2.0 %
Time (automatic)	2	± 5 %
Frequency	2	± 10^{-7}
The expanded uncertainty reported according to to ETSI TR 100 028:2001 is based on a standard uncertainty multiplied by a coverage factor of kp = 2, providing a level of confidence of p = 95.45%		

Table 24 Measurement uncertainty based on ETSI TR 100 028