Report on the FCC and IC Testing of the Marquardt GmbH NFC door handle Model: HH2 In accordance with FCC 47 CFR Part 15 C and ISED RSS-210 and ISED RSS-Gen

Product Service

Add value.
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Prepared for: Marquardt GmbH
Schloßstr. 16
78604 Rietheim-Weilheim
Germany

FCC ID: IYZHH2
IC: 2701A-HH2

COMMERCIAL-IN-CONFIDENCE

Date: 2021-08-30
Document Number: TR-33652-24237-04 (Edition 02)

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Project Management	Martin Steindl	2021-09-03	Steindl Martin SIGN-ID 550027
Authorised Signatory	Alex Fink	2021-09-03	Fink SIGN-ID 550067

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-210 and RSS-GEN.
The sample tested was found to comply with the requirements defined in the applied rules.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Testing	Martin Steindl	2021-09-03	Steindl Martin SIGN-ID 550028

Laboratory Accreditation DAkkS Reg. No. D-PL-11321-11-02 DAkkS Reg. No. D-PL-11321-11-03	Laboratory recognition Registration No. BNetzA-CAB-16/21-15	Industry Canada test site registration 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-210:2019 and ISED RSS-Gen:2019

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Product Service

Content

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	2021-08-30
2	Correction of antenna size	2021-09-03

Table 1: Report of Modifications

1.2 Introduction

Applicant	Marquardt GmbH Schloßstr. 16 78604 Rietheim-Weilheim Germany
Manufacturer	Marquardt GmbH Schloßstr. 16 78604 Rietheim-Weilheim Germany
Model Number(s)	HH2
Serial Number(s)	Continuous_Mode, System_Test_Mode
Hardware Version(s)	N/A
Software Version(s)	N/A
Number of Samples Tested	2
Test Specification(s) / Issue / Date	FCC 47 CFR Part 15 C : 2020 and ISED RSS-210, Issue 10, Amd. 1 : 2019 ISED RSS-Gen, Issue 5, Amd. 1 : 2019
Test Plan/Issue/Date	---
Order Number Date	6200494494
Date of Receipt of EUT	2021-08-13
Start of Test	2021-08-16
Finish of Test	2021-08-20
Name of Engineer(s)	M. Steindl
Related Document(s)	ANSI C63.10:2013

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 and ISED RSS-210 and RSS-Gen is shown below.

Section	*Specification Clause*	*Test Description*	*Result*
---	15.203	Antenna requirement	Integrated antenna
2.1	15.215(c)	Bandwidth of Signal	Pass
2.2	15.207	Conducted Disturbance at Mains Terminal	Pass
---	15.209, 15.225	Radiated Disturbance	Not applicable
2.3	15.225(e)	Frequency Tolerance	Pass

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

Section	*Specification Clause*	*Test Description*	*Result*
2.2	7.3	Radiated Emissions	Pass
---	7.3	AC Power Line Conducted Emissions	Not applicable
2.3	B.6 b.	Frequency Tolerance	Pass

Table 3: Results according to ISED RSS-210

Section	*Specification Clause*	*Test Description*	*Result*
2.1	6.7	Bandwidth of Signal	Pass
---	8.8	AC Power Line Conducted Emissions	Not applicable
2.2	8.9, 8.10	Radiated Emissions	Pass
2.3	6.11	Frequency Tolerance	Pass

Table 4: Results according to ISED RSS-Gen

Product Service

1.4 Product Information

1.4.1 Technical Description

Functional description

The **HH2** is a door handle for a car with capacitive touch sensors and NFC. An integrated NFC antenna inside into the door handle, smartphones, wearables and NFC tags can be identified and a driver can be authorized by the car so the door can be opened.
The **HH2** is connected to the car using a CAN-FD interface. It acts as communication channel between CAR Electronics control Unit and NFC Readers. The car ECU NFC Reader requests to the **HH2** which communicates with the NFC device on the integrated antenna using a magnetic field.

User manual

The user places his authorized NFC device (a smartcard or a mobile phone / wearable with an integrated secure element ID) onto the door handle. The **HH2** authorizes the user to the car automatically as soon as a valid device is recognized. Then the door is unlocked and the driver can access the car. The NFC communication is only activated once a NFC device is placed onto the door handle.

Test mode

For the radio testing, a test mode is configured in software. After providing the power supply, **HH2** will transmit continuously at 13.56 MHz

Product Service

Temperature Range

Working temperature:	-40 °C to + 80 °C
Storage temperature:	-40 °C to + 85 °C

Data of RF-Part

Transmission Mode	Continuous Transmission mode
Reader to card	100 % ASK, Miller Coded, 106 kbit/s
Card to reader	Subcarrier Load Modulation, Manchester Coded, 106 kbit/s
Transmission center frequency	**13.56 MHz**
3 dB bandwidth	400 kHz
Maximum magnetic field strength	7.5 A/m
Antenna	Integrated PCB antenna, approx. 73x15.5 mm

1.4.2 EUT Ports / Cables identification

Port	Usage	Type	Screened
Wiring harness		DC supply CAN	No

Table 5

1.5 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	Not Applicable	Not Applicable

Table 6

Product Service

1.6 Test Location

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

Test Name	Name of Engineer(s)
Bandwidth of Signal	M. Steindl
Radiated Distubance	M. Steindl
Frequency tolerance	M. Steindl

Office Address:
Äußere Frühlingstraße 45
94315 Straubing
Germany

Product Service

2 Test Details

2.1 Bandwidth of Signal

2.1.1 Specification Reference

FCC 47 CFR Part 15 C, Clause 15.215(c)
ISED RSS-Gen, Clause 6.7

2.1.2 Equipment under Test and Modification State

HH2 - S/N: System_Test_Mode - Modification State 0

2.1.3 Date of Test

2021-08-18

2.1.4 Environmental Conditions

Ambient Temperature	26 °C
Relative Humidity	46 %

2.1.5 Specification Limits

No limitation – Bandwidth noted

2.1.6 Test Method

The test was performed according to ANSI C63.10, clauses 6.9
See section 2.2 of this test report for details.

Product Service

2.1.7 Test Results

Center frequency	*20 dB Bandwidth*
13.560217 MHz	1.042 kHz

Table 7: 20 dB bandwidth

Centre Frequency	*99% Bandwidth*
13.56 MHz	260.4920 kHz

Table 8: 99% bandwidth

2.1.8 Test Location and Test Equipment

The test was carried out in radio test laboratory

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Spectrum Analyser	Rohde&Schwarz	FSV40	20219	24	2022-01
Climatic test chanber	Feutron	KPK200-2	19868	12	2023-02-28

Table 9

Product Service

2.2 Radiated Emissions

2.2.1 Specification Reference

FCC 47 CFR Part 15 C, Clauses 15.205, 15.209 and 15.225
ISED RSS-210, Clause 7.7 and B.6
ISED RSS-Gen, Clauses 8.9 and 8.10

2.2.2 Equipment under Test and Modification State

HH2 - S/N: System_Test_Mode - Modification State 0

2.2.3 Date of Test

2021-08-18

2.2.4 Environmental Conditions

Ambient Temperature	26 °C
Relative Humidity	46 %

Product Service

2.2.5 Specification Limits

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 – 13.110	30	0.08	-21.94	30	29.54
13.110 – 13.410	30	0.283	-11.0	106	40.5
13.410 – 13.553	30	0.891	-1.0	334	50.5
13.553 – 13.567	30	42.26	32.5	15848	84
13.567 – 13.710	30	0.891	-1.0	334	50.5
13.710 – 14.010	30	0.283	-11.0	106	40.5
14.010 - 30	30	0.08	-21.94	30	29.54
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 10 Radiated emission limits

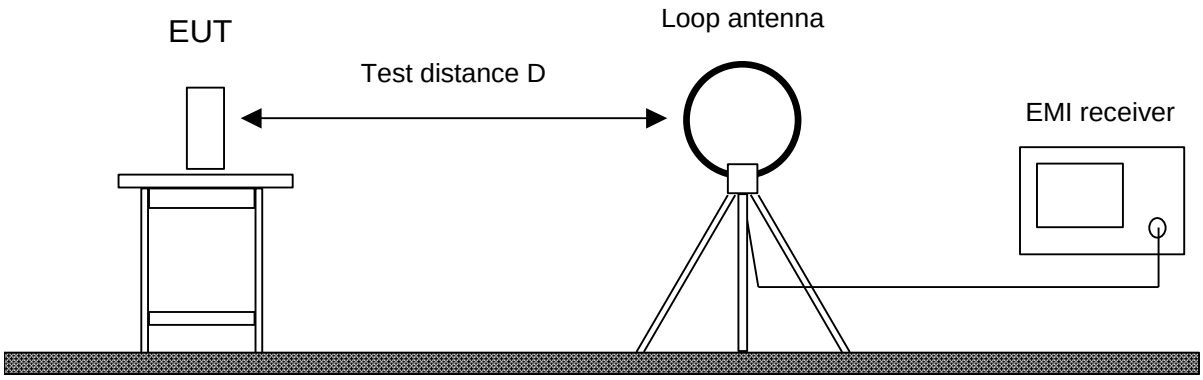
Product Service

2.2.6 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.

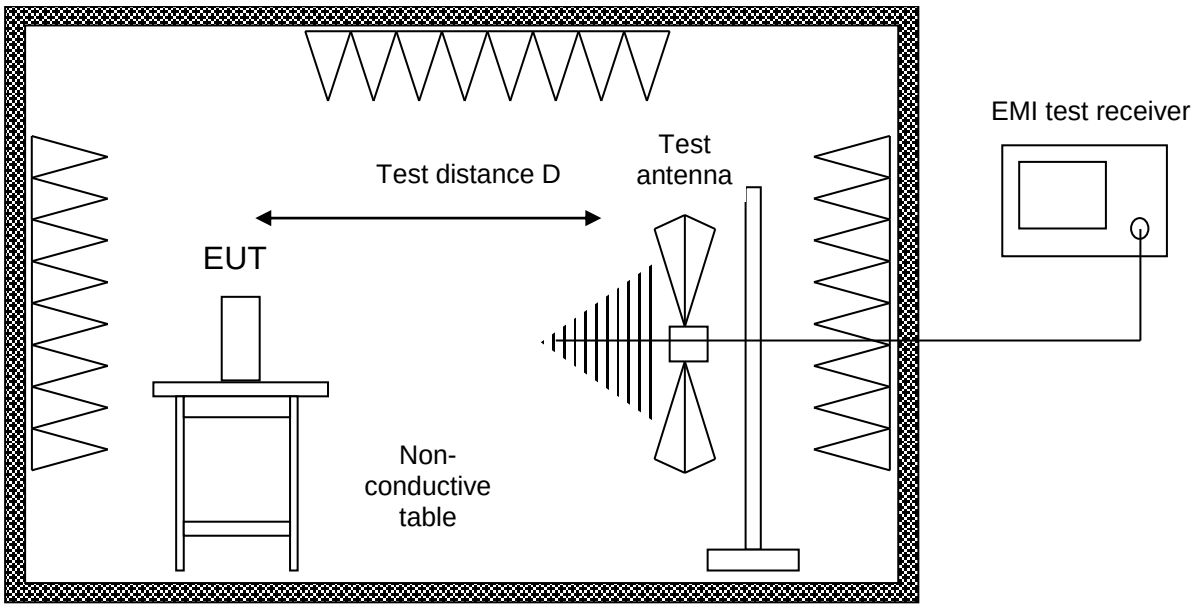
2.2.6.1 Frequency range 9 kHz – 30 MHz



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

2.2.6.2 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

2.2.7 Test Results

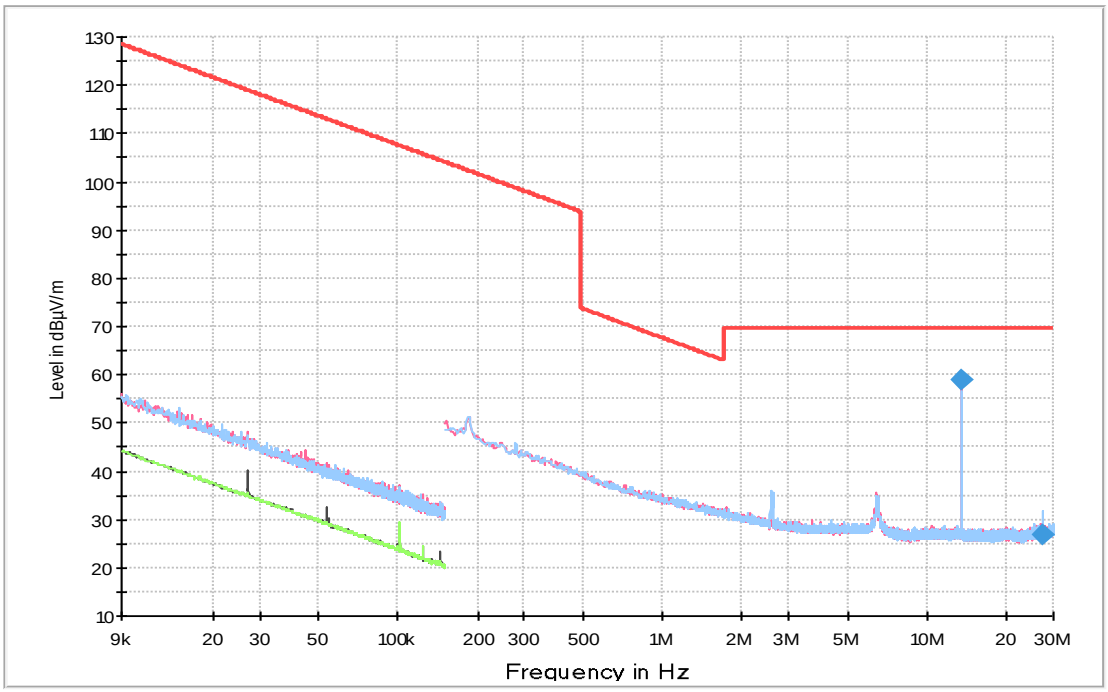
Frequency range	*Limit applied*	*Test distance*
9 kHz – 30 MHz	15.209; 15.225	3 m
30 MHz – 1 GHz	15.209	3 m

Table 11

Sample calculation:

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

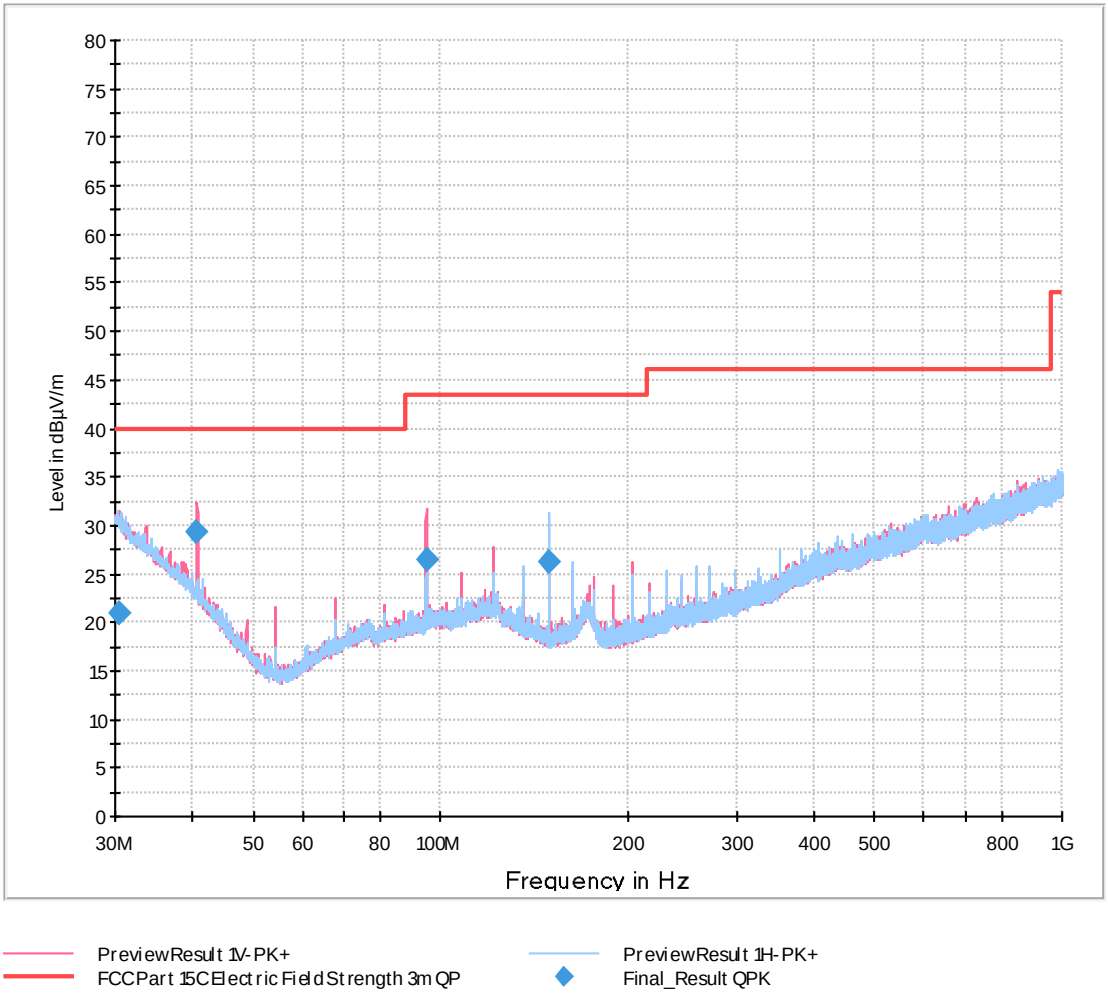
Frequency range 9 kHz – 30 MHz:



Frequency *MHz*	*QuasiPeak* *dBµV/m*	*Limit* *dBµV/m*	*Margin* *dB*	*Meas. Time* *ms*	*Band-width* *kHz*	*Pol*	*Azimuth* *deg*	*Corr.* *dB/m*
13.560000	59.02	124.00	64.98	1000	9	V	-79.0	18.9
27.118500	26.81	69.54	42.73	1000	9	H	-83.0	19.6

Product Service

Frequency range 30 MHz – 1 GHz:



Frequency *MHz*	*Qua-siPeak* *dBµV/m*	*Limit* *dBµV/m*	*Margin* *dB*	*Meas. Time* *ms*	*Band-width* *kHz*	*Height* *cm*	*Pol*	*Azi-muth* *deg*	*Corr.* *dB/m*
30.480000	21.01	40.00	18.99	1000.0	120.000	150.0	H	58.0	25.7
40.680000	29.34	40.00	10.66	1000.0	120.000	100.0	V	83.0	20.0
94.920000	26.36	43.50	17.14	1000.0	120.000	106.0	V	182.0	17.4
149.160000	26.29	43.50	17.21	1000.0	120.000	237.0	H	150.0	16.4

Product Service

2.2.8 Test Location and Test Equipment

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

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Loop antenna	Schwarzbeck	FMZB 1519 B	44334	36	2023-01-31
Spectrum Analyser	Rohde&Schwarz	ESW44	39897	12	2022-04-30

Table 12

Product Service

2.3 Temperature Stability

2.3.1 Specification Reference

FCC 47 CFR Part 15 E, Clause 15.225(e)
ISSED RSS-210, Clause B.6 b.
ISED RSS-Gen, Clause 6.11

2.3.2 Equipment under Test and Modification State

HH2 - S/N: Continuous_Mode - Modification State 0

2.3.3 Date of Test

2021-08-19

2.3.4 Environmental Conditions

Ambient Temperature	25 °C
Relative Humidity	50 %

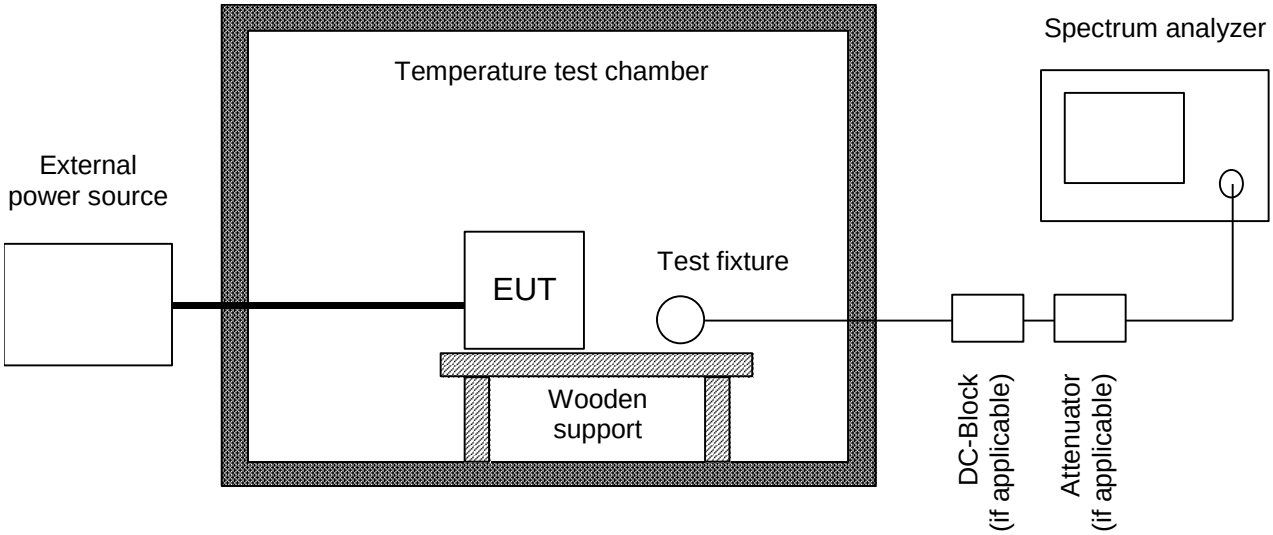
2.3.5 Specification Limits

The frequency tolerance of the carrier signal shall be maintained within ±0.01 % of the operating frequency 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 rated supply voltage at a temperature of 20 “C. For battery operated equipment, the equipment tests shall be performed using a new battery.

Product Service

2.3.6 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

2.3.7 Test Results

Temperature	*Supply Voltage*	*Frequency*	*Frequency drift*	*Frequency drift*
-20 °C	13.2 V	13.5603920 MHz	172.5 Hz	12.7 ppm
-10 °C	13.2 V	13.5603925 MHz	173.0 Hz	12.8 ppm
0 °C	13.2 V	13.5603531 MHz	133.6 Hz	9.9 ppm
10 °C	13.2 V	13.5602947 MHz	75.2 Hz	5.5 ppm
20 °C	10.8 V	13.5602082 MHz	-11.3 Hz	-0.8 ppm
20 °C	13.2 V	13.5602195 MHz	0.0 Hz	0.0 ppm
20 °C	15.3 V	13.5602057 MHz	-13.8 Hz	-1.0 ppm
30 °C	13.2 V	13.5601476 MHz	-71.9 Hz	-5.3 ppm
40 °C	13.2 V	13.5600765 MHz	-143.0 Hz	-10.5 ppm
50 °C	13.2 V	13.5600027 MHz	-216.8 Hz	-16.0 ppm

Table 13

2.3.8 Test Location and Test Equipment

The test was carried out in Radio Test Laboratory

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Spectrum Analyser	Rohde&Schwarz	FSV40	20219	24	2022-01
Climatic test chanber	Feutron	KPK200-2	19868	36	2023-02-28

Table 14

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 15 Measurement uncertainty based on CISPR 16-4-2

Product Service

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 16 Measurement uncertainty based on ETSI TR 100 028