

Königswinkel 10 32825 Blomberg, Germany Phone: +49 (0) 52 35 / 95 00-0 Fax: +49 (0) 52 35 / 95 00-10 office@phoenix-testlab.de www.phoenix-testlab.de

# **Test Report**

Report Number:

F191168E4

Equipment under Test (EUT):

Track&Trace - Marker

Applicant:

TRUMPF Werkzeugmaschinen GmbH + Co. KG

Manufacturer:

TRUMPF Werkzeugmaschinen GmbH + Co. KG





## References

- [1] ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
- [2] FCC CFR 47 Part 15, Radio Frequency Devices
- [3] 558074 D01 15.247 Meas Guidance v05r02 (April 2019), GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES

## **Test Result**

The requirements of the tests performed as shown in the overview (clause 4) were fulfilled by the equipment under test. The complete test results are presented in the following.

Tested and written by:	Bernward ROHDE	0.5.0 P. Li	07.09.2020
	Name	Signature	Date
Reviewed and approved by:	Bernd STEINER	B.Sh	07.09.2020
	Name	Signature	Date

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## **1** Identification

#### 1.1 Applicant

Name:	TRUMPF Werkzeugmaschinen GmbH + Co. KG
Address:	Johann-Maus-Str. 2, 71254 Ditzingen
Country:	Germany
Name for contact purposes:	Mr. Guido Schönhardt
Phone:	07156-303-36117
Fax:	
eMail Address:	Guido.schoenhardt@trumpf.com
Applicant represented during the test by the following person:	-

#### 1.2 Manufacturer

Name:	TRUMPF Werkzeugmaschinen GmbH + Co. KG
Address:	Johann-Maus-Str. 2, 71254 Ditzingen
Country:	Germany
Name for contact purposes:	Mr. Guido Schönhardt
Phone:	07156-303-36117
Fax:	
eMail Address:	Guido.schoenhardt@trumpf.com
Applicant represented during the test by the following person:	-

#### 1.3 Test Laboratory

The tests were carried out by:

PHOENIX TESTLAB GmbH Königswinkel 10 32825 Blomberg Germany

Accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025 under Reg. No. D-PL-17186-01-05 and D-PL-17186-01-06, FCC Test Firm Accreditation designation number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISED# 3469A.



EUT			
Test object: *	Marker for indoor localization		
PMN / Model name: *	Track&Trace - Marker		
FCC ID: *	2AVYV-2564360-01		
Serial number: *	CH00: CH19: CH39:	204264690 204268298 204268271	
PCB identifier: *	1901154A001032B8		
Hardware version: *	Rev D		
Software version: *	2.17.9		

### **1.4 EUT (Equipment under Test)**

\* Declared by the applicant

Note: Phoenix Testlab GmbH does not take samples. The samples used for the tests are provided exclusively by the applicant.

#### 1.5 Technical Data of Equipment

General technical data of EUT						
Power supply EUT: *	DC (by interr	al battery)				
Supply voltage EUT: *	U <sub>nom</sub> =	3.7 V <sub>DC</sub>	U <sub>min</sub> =	3.0 V <sub>DC</sub>	U <sub>max</sub> =	4.2 V <sub>DC</sub>
Temperature range: *	-10 °C to +39 °C					
Lowest / highest internal clock frequency: *	32.768 kHz /	2480 MHz (in	BLE mode)			

Identification	Con	Length	
	EUT	Ancillary	
No lines connectable to the EUT			



#### 1.5.1 BLE Radio mode

	Bluetooth® Low Energy	radio mode		
Fulfils radio specification: *	BLE 4.2 (1 Mbit/s only)			
Radio chip: *	Nordic nRF52840			
Antenna type: *	Internal PCB antenna			
Antenna name: *	ANT2			
Antenna gain: *	2 dBi			
Antenna connector: *	none			
Conducted output newor: *	BLE 1 Mbit/s	-1.4 dBm (Peak)		
		-1.5 dBm (Average)		
Type of modulation: *	BLE 1 Mbit/s	GFSK (1 Mbit/s)		
Operating frequency range: *	BLE 1 Mbit/s	2402 – 2480 MHz		
Number of channels: *	BLE 1 Mbit/s	40 (2 MHz channel spacing)		

Bluetooth® Low Energy frequencies				
Channel 0	RX	2402 MHz	тх	2402 MHz
Channel 1	RX	2404 MHz	тх	2404 MHz
Channel 19	RX	2440 MHz	тх	2440 MHz
Channel 38	RX	2478 MHz	тх	2478 MHz
Channel 39	RX	2480 MHz	ТХ	2480 MHz

#### 1.5.2 Ancillary Equipment / Equipment used for testing

Equipment used for testing	
None	

#### 1.6 Dates

Date of receipt of test sample:	07.05.2020
Start of test:	10.08.2020
End of test:	06.10.2020



## 2 **Operational States**

#### 2.1 Description of function of the EUT

The EUT is intended to be used as transceiver for locating of machine tools inside a factory building. It will be mounted onto machines. Therefore, it is defined as mobile indoor equipment. All radiated tests were carried out with an unmodified test sample powered by an internal battery.

#### 2.2 The following states were defined as the operating conditions

The applicant delivered 3 different samples. Each sample was set to transmit in test mode on a certain channel (channel 00, channel 19 and channel 39). All settings, like power, data rate, etc. were set by the applicant. In the following, the EUT transmitting on channel 1 will be referred to as EUT 1. The EUT transmitting on channel 19 as "EUT 2" and the EUT transmitting on channel 39 as "EUT 3".

Operation mode #	Radio technology	Frequency [MHz]	Channel / Band	Modulation / Mode	Data rate	TX / RX	EUT #	Power setting
1	Bluetooth® LE	2402	0	GFSK	1 Mbit/s	ТΧ	1	Not settable
2	Bluetooth® LE	2440	19	GFSK	1 Mbit/s	ТΧ	2	Not settable
3	Bluetooth® LE	2480	39	GFSK	1 Mbit/s	ТΧ	3	Not settable

#### 2.2.1 Operation modes

Power settings were set by the applicant and could not be changed

## **3** Additional Information

The EUT also contains an IEEE802.15.4 and a UWB transceiver. The results of these technologies are documented in the test reports F191168E2 and F191161E3. The emissions of the digital part of the EUT are documented in the test report F191168E1. Object of this test report is the BLE part of the EUT only.

The tested sample was not labeled as required by the FCC.

The tests were done with an unmodified sample.



## **4** Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	Status	Refer page
Maximum peak conducted output power	2400.0 - 2483.5	15.247 (b) (3), (4)	Passed	13
Maximum conducted output power	2400.0 - 2483.5	15.247 (b) (3), (4)	Passed	13
DTS Bandwidth / 99% Bandwidth	2400.0 - 2483.5	15.247 (a) (2)	Passed	16
Peak Power Spectral Density	2400.0 - 2483.5	15.247 (e)	Passed	19
Average Power Spectral Density	2400.0 - 2483.5	15.247 (e)	Passed	19
Band edge compliance	2400.0 - 2483.5	15.247 (d) 15.205 (a) 15.209 (a)	Passed	22
Maximum unwanted emissions	0.009 – 26,500	15.247 (d) 15.205 (a) 15.209 (a)	Passed	25
Conducted emissions on supply line	0.15 - 30	15.207 (a)	Not tested*2	-
Antenna Requirement	-	15.203 15.247 (b)	Passed*1	-

 $^{\star1}$  internal Antenna, gain below 6 dBi, no power reduction necessary.  $^{\star2}$  EUT is battery powered, no connection to the AC mains network.



## **5** Results

#### 5.1 Duty cycle

#### 5.1.1 Method of measurement (conducted)

The EUT was measured conducted on a sample with an antenna connector, which was provided by the applicant.

#### Acceptable measurement configurations

According to [3] chapter 6 method b), which is equal to method described in chapter 11.6 b) of document [1] was used to perform the following test.

#### Test Setup:



Only one representative plot is provided.



#### 5.1.2 Test results



Date	06.10.2020
Tested by	B. ROHDE



Operation	TX_on	TX_ges	RBW	50/T	50/T
mode	[µs]	[µs]	[MHz]	[kHz]	< RBW?
BLE 1 Mbit/s	2105	2224	3	24	Yes

Operation	Sweep	Sweep time	Meas points	Meas points	Duty cycle	DCCF
mode	points	[µs]		>100?	%	[dB]
BLE 1 Mbit/s	10001	3000	7414	Yes	95	0.24



The DCCF (duty cycle correction factor) is calculated by:

$$DCCF = 10 * log_{10} \left(\frac{1}{Duty \ cycle}\right)$$

Therefore, for average measurements a correction factor of 0.3 dB is used for all tests in test mode 1 -3.

Test equipment (please refer to chapter 6 for details)



#### 5.1 Maximum conducted output power

#### 5.1.1 Method of measurement (conducted)

Test Setup:



#### Acceptable measurement configurations

See 8.3 of document [3] for details.

For the Maximum peak conducted output power the Procedure 11.9.1.1 in [1] was used.

For the Maximum conducted average output power the Procedure 11.9.2.2.4 in [1] was used.

Only one representative plot for each measurement configuration is provided.



#### 5.1.2 Test results

Ambient temperature	23 °C
Relative humidity	50 %

Date	06.10.2020
Tested by	B. ROHDE

#### Maximum *peak* conducted output power:



Operation mode	Reading [dBm]	Correction (Cable att.) [dB]	Result [dBm]	Limit [dBm]	Result
1	-1.6	0.2	-1.4	30	Passed
2	-2.0	0.2	-1.8	30	Passed
3	-1.8	0.2	-1.6	30	Passed



#### Ref Level 10 00 dBm Offset 10.00 dS RBW 30 k-tz Att 10 d5 SWT 100 ms VBW 100 k tz Mode Sweep 1 Frequency Sweep <td SGL Count 1000/1000 • 1Rm Avg M1[1] 10.16 dBm 2.40201200 GH n cB -10 dBm -20 dBr -=n dBh 40 dBm -50 dB1 -10 HB 70 ::IBm ∃O dBγ CI 2.402 GHz 2 Marker Table Type Ref 1001 pts 300.0 ki iz/ l Span 3.0 MHz Trc Function Resul -1.88 dBm X Value 2.402012 GHz Y Value -10.16 dBm Band Power PELC kł

#### Maximum average conducted output power:

Operation mode	Reading [dBm]	Correction (Cable att.) [dB]	DCCF [dB]	Result Incl. DCCF [dBm]	Limit [dBm]	Result
1	-1.9	0.2	0.2	-1.5	30	Passed
2	-2.3	0.2	0.2	-1.9	30	Passed
3	-2.4	0.2	0.2	-2.0	30	Passed

Test equipment (please refer to chapter 6 for details)

1



#### 5.1 DTS Bandwidth / 99% Bandwidth

#### 5.1.1 Method of measurement (conducted)

The measurements were done conducted at the antenna connectors of both antennas.

#### **Test Setup:**

#### Spectrum Analyzer



EU	Г

#### Acceptable measurement configurations

See chapter 8.2 of document [3]

For the **DTS bandwidth** the Procedure **11.8.2** in [1] was used.

For the Occupied bandwidth – 99% Bandwidth the Procedure 6.9.3 in [1] was used.

Only one representative plot for each measurement configuration is provided.



#### 5.1.2 Test results

Ambient temperature	23 °C
Relative humidity	50 %

Date	06.10.2020
Tested by	B. ROHDE



#### Representative plot 99 % bandwidth

Dational 10:	0. JP							
Att	LO dE SWIT	3 ms = VB	W BOLKHZ MA	de Swaan				
L Occupied Ba	ndwidth	0 110 0 40	in solution of the	AC CHOOP				O 1 Fk Max
							M1[1]	-5.77 dBm
							2	18001800 GHz
U cBm-					мі			
					X			
-1U dBm				TWV T	March			
				1 Martin	"in			
-20 dBm			T	A. C.	¥	20		
			J.M.			Way 22		
-30 dBm			A.M			- Carl		
			·*				M	
-40 JB n		1 prov					74	
	1400	y pr					1 mar	
-50 HBm		$\mathbb{N}$					Ser Ma	
	J. 1						j v j	
- B. Barton	n#/"						~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	and
								~
70 dBm								
-50 dBm								
	l		1001 m	 #		0.0.0.0	1	Coop 2 O MUT
SEZERO GEZ			1001 p	ta	30	1010 N 12/		apan 5.0 MHz
Type Ref	Tru	X-Value		Y-Value		Function	Function R	esult
M1	1	2.480018 G	Hz	-5.77 dBm	Oct Bw		923.980379	361 kHz
-1	1	2.47955205	CHZ	25.43 dBm	Occ Bw Cel	ntro d	2,4800:	4043 GHz
<u> </u>	1	2,4004/0031	2012	-∠∞.96 UDITI	OLC DW FIE	ry o iset	14.J=Z/	2070J KI12



OP Data		Center Frequency	Minimum 6-dB Bandwidth Limit	6 dB Bandwidth	99 % Bandwidth	Result
mode	rate	[MHz]	[MHz]	[MHz]	[MHz]	
1	1 Mbit/s	2402	0.5	0.509	0.926	Passed
2	1 Mbit/s	2440	0.5	0.509	0.937	Passed
3	1 Mbit/s	2480	0.5	0.500	0.924	Passed

Test equipment (please refer to chapter 6 for details) 1



#### 5.2 Power spectral density

#### 5.2.1 Method of measurement (conducted)

The measurements were done conducted at the antenna connectors of both antennas.

#### Test Setup:

#### Spectrum Analyzer



#### Acceptable measurement configurations

See chapter 8.4 of document [3]

For the **Maximum** *peak* **power spectral density level in the fundamental emission** the Procedure **11.10.2** in [1] was used.

For the **Maximum** *average* power spectral density level in the fundamental emission the Procedure 11.10.5 in [1] was used.

Only one representative plot for each measurement configuration is provided.



#### 5.2.2 Test results

Ambient temperature	23 °C
Relative humidity	50 %

Date	06.10.2020
Tested by	B. ROHDE

#### Maximum *peak* power spectral density level in the fundamental emission:

MultiView	Spectrum					-
BefLevel 10.	00 dBm Offset 10.00 dB • BBW 10 kHz					
Att	10 cB ● SWT 3 ms ● VBW 30 kHz Mode Sweep					
1 Frequency S	weep					IPk Max
					M1[1]	-5.78 dBm
					2.4	80018320 GHz
0 dBm						
	~	×1				
-10 d3m						
	~~~~~			$\sim\sim\sim$	han a	
-20 d3m						mar 1
$\sim\sim$						
-30 d3m						
-40 d3m						
-50 d3m						
-60 d3m						
-71 d3m						
-80 d3m						
CF 2.48 GHz	100   pts	7	6.4 kHz/		S	5an 764.0 kHz

OP mode	Peak Frequency [MHz]	Reading [dBm]	Correction (Cable att.) [dB]	PSD [dBm / 10 kHz]	PSD Limit [dBm / 3 kHz]	Result
1	2402.018	-7.2	0.2	-7.0	8	Passed
2	2440.041	-8.0	0.2	-7.8	8	Passed
3	2480.018	-5.8	0.2	-5.6	8	Passed





#### Maximum average power spectral density level in the fundamental emission:

OP mode	Peak Frequency [MHz]	PSD Reading [dBm / 30 kHz]	Correction (Cable att.) [dB]	DCCF [dB]	PSD incl. DCCF [dBm / 30 kHz]	PSD Limit [dBm / 3 kHz]	Result
1	2402.018	-10.2	0.2	0.2	-9.8	8	Passed
2	2440.033	-10.7	0.2	0.2	-10.3	8	Passed
3	2480.030	-10.9	0.2	0.2	-10.5	8	Passed

Test equipment (please refer to chapter 6 for details)



#### 5.3 Band edge

#### 5.3.1 Method of measurement (conducted)

The measurements were done conducted at the antenna connectors of both antennas.

#### **Test Setup:**

#### Spectrum Analyzer



#### Acceptable measurement configurations

See chapter 8.7 of document [3].

For the **Band-edge testing (unrestricted bands)** the Procedure **6.10.4** in [1] was used, see remarks of #59, table A2 of document [1].

For the Band-edge testing (restricted bands) the tests were done radiated.

Only one representative plot is provided.

#### 5.3.2 Method of measurement (radiated)

The EUT was measured radiated in an anechoic chamber. For test setup and measurement configuration see 5.4.1

For the **Band-edge testing (restricted bands)** the 15.209 limits apply.

Only one representative plot is provided.



#### 5.3.3 Test results

Ambient temperature	23 °C
Relative humidity	50 %

Date	06.10.2020
Tested by	B. ROHDE

#### Band-edge testing (unrestricted bands; conducted):



Operation	Data rate	Frequency Reference Level		Limit	Margin	Result
mode		[MHz]	[dBm]	[dBm]	[dB]	
1	1 Mbps	2402	-1.78	-21.78	46.82	Passed

Test equipment (please refer to chapter 6 for details) 1



Ambient temperature	22 °C		Date	10.08.2020	
Relative humidity	58 %		Tested by	B. ROHDE	

#### Band-edge testing (restricted bands; radiated):

Operation mode 1:

No significant emission in the restricted band from 2.37 – 2.39 GHz, no final band edge measurement done.

Operation mode 3:



Frequency	Result (Pk)	Result (Av)	Limit	Margin	Correction	Height	Azimuth	Pol.	Result
[MHz]	[dBµV/m]	[dBµV/m]	[dBµV/m]	[dB]	[dB]	[cm]	[deg]	-	
2483.500000	56.6		74	17.4	34.6	186	123	V	Passed
2483.500000		43.5	54	10.5	34.8	186	123	V	Passed
Measurement uncertainty							±5.5 dB		

The average measurement result was corrected by the DCCF according to 5.1.2.

Test equipment (please refer to chapter 6 for details) 11 - 27



#### 5.4 Maximum unwanted emissions

#### 5.4.1 Method of measurement (radiated)

The radiated emission measurement is subdivided into six stages.

- A preliminary measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 9 kHz to 30 MHz.
- A final measurement carried out on an outdoor test side without reflecting ground plane and a fixed antenna height in the frequency range 9 kHz to 30 MHz.
- A preliminary and final measurement carried out in a semi anechoic chamber with a varying antenna height in the frequency range 30 MHz to 1 GHz.
- A preliminary and final measurement carried out in a semi anechoic chamber with ground absorbers with a varying antenna height in the frequency range above 1 GHz.

#### Preliminary measurement (9 kHz to 30 MHz):

In the first stage a preliminary measurement will be performed in a shielded room with a measuring distance of 3 meters. Tabletop devices will set up on a non-conducting turn device on the height of 0.8 m. Floor-standing devices will be placed directly on the turntable/ground plane. The set-up of the Equipment under test will be in accordance to [1].

The frequency range 9 kHz to 30 MHz will be monitored with a spectrum analyzer while the system and its cables will be manipulated to find out the configuration with the maximum emission levels if applicable. The EMI Receiver will be set to MAX Hold mode. The EUT and the measuring antenna will be rotated around their vertical axis to find the maximum emissions.

The resolution bandwidth of the spectrum analyzer will be set to the following values:

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	9 kHz





Preliminary measurement procedure:

Pre-scans were performed in the frequency range 9 kHz to 150 kHz and 150 kHz to 30 MHz.

Pre-scans were performed in the frequency range 30 MHz to 230 MHz and 230 MHz to 1 GHz. The following procedure will be used:

- 1. Monitor the frequency range at horizontal polarization and a EUT azimuth of 0 °.
- 2. Manipulate the system cables within the range to produce the maximum level of emission.
- 3. Rotate the EUT by 360 ° to maximize the detected signals.
- 4. Repeat 1) to 3) with the vertical polarization of the measuring antenna.
- 5. Make a hardcopy of the spectrum.
- 6. Repeat 1) to 5) with the EUT raised by an angle of 0° (45°, 90°) according to 6.6.5.4 in [1].
- 7. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.

#### Final measurement (9 kHz to 30 MHz):

In the second stage a final measurement will be performed on an open area test site with no conducting ground plane in a measuring distances of 3 m, 10 m and 30 m. In the case where larger measuring distances are required the results will be extrapolated based on the values measured on the closer distances according to Section 15.31 (f) (2) [2]. The final measurement will be performed with a EMI Receiver set to Quasi Peak detector except for the frequency bands 9 kHz to 90 kHz and 110 kHz to 490 kHz where an average detector will be used according Section 15.209 (d) [2].

On the frequencies, which were detected during the preliminary measurements, the final measurement will be performed while rotating the EUT and the measuring antenna in the range of 0 ° to 360 ° around their vertical axis until the maximum value is found.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	9 kHz





#### Preliminary and final measurement (30 MHz to 1 GHz)

The preliminary and final measurements were conducted in a semi-anechoic chamber with a metal ground plane. During the test the EUT will be rotated in the range of 0 ° to 360 °, the measuring antenna will be set to horizontal and vertical polarization and raised and lowered in the range from 1 m to 4 m to find the maximum level of emissions.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Test	Frequency range	Resolution bandwidth	Resolution Step size bandwidth	
Preliminary measurement	30 MHz to 1 GHz	120 kHz	40 kHz	100 ms
Frequency peak search	3 x RBW	120 kHz	10 kHz	1000 ms
Final measurement	30 MHz to 1 GHz	120 kHz	-	5 x 1000 ms





Procedure preliminary measurement:

The following procedure is used:

- 1. Set the measurement antenna to 1 m height.
- 2. Monitor the frequency range at vertical polarization and a EUT azimuth of 0 °.
- 3. Rotate the EUT by 360° to maximize the detected signals.
- 4. Repeat 1) to 2) with the vertical polarization of the measuring antenna.
- 5. Increase the height of the antenna for 0.5 m and repeat steps 2 4 until the final height of 4 m is reached.
- 6. The highest values for each frequency will be saved by the software, including the antenna height, measurement antenna polarization and turntable azimuth for the highest value.

Procedure final measurement:

The following procedure is used:

- 1. Select the highest frequency peaks to the limit for the final measurement.
- 2. The software will determine the exact peak frequencies by doing a partial scan with reduced step size with +/- 3 times the RBW of the pre-scan of the selected peaks.
- 3. If the EUT is portable or ceiling mounted, find the worst case EUT orientation (x,y,z) for the final test.
- 4. The worst measurement antenna height is found by the measurement software by varying the measurement antenna height by +/- 0.5 m from the worst-case value obtained in the preliminary measurement, and to monitor the emission level.
- 5. The worst azimuth turntable position is found by varying the turntable azimuth by +/- 30° from the worstcase value obtained in the preliminary measurement, and to monitor the emission level.
- 6. The final measurement is performed at the worst-case antenna height and the worst-case turntable azimuth.
- 7. Steps 2 6 will be repeated for each frequency peak selected in step 1.



#### Preliminary and final measurement (1 GHz to 40 GHz)

This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a nonconducting turn device on the height of 1.5m. The set-up of the Equipment under test will be in accordance to [1].

#### Preliminary measurement (1 GHz to 40 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The spectrum analyser set to MAX Hold mode and a resolution bandwidth of 1 MHz. The measurement will be performed in horizontal and vertical polarisation of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 °. This measurement is repeated after raising the EUT in 30° steps according 6.6.5.4 in [1].

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	1 MHz
4 GHz to 12 GHz	1 MHz
12 GHz to 18 GHz	1 MHz
18 GHz to 25 / 26.5 GHz	1 MHz
26.5 GHz to 40 GHz	1 MHz





Procedure preliminary measurement:

Pre-scans were performed in the frequency range 1 to 40 GHz.

The following procedure will be used:

- 1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
- 2. Rotate the EUT by 360° to maximize the detected signals.
- 3. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
- 4. Make a hardcopy of the spectrum.
- 5. Repeat 1) to 4) with the EUT raised by an angle of 30° (60°, 90°, 120° and 150°) according to 6.6.5.4 in [1].
- 6. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
- 7. The measurement antenna polarisation, with the according EUT position (Turntable and Turn device) which produces the highest emission for each frequency will be used for the final measurement. The six closest values to the applicable limit will be used for the final measurement.

#### Final measurement (1 GHz to 40 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The EMI Receiver set to peak and average mode and a resolution bandwidth of 1 MHz. The measurement will be performed by rotating the turntable through 0 to 360° in the worst-case EUT orientation which was obtained during the preliminary measurements.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	1 MHz
4 GHz to 12 GHz	1 MHz
12 GHz to 18 GHz	1 MHz
18 GHz to 25 / 26.5 GHz	1 MHz
26.5 GHz to 40 GHz	1 MHz





#### Procedure of measurement:

The measurements were performed in the frequency ranges 1 GHz to 4 GHz, 4 GHz to 12 GHz, 12 GHz to 18 GHz, 18 GHz to 25 /26.5 GHz and 26.5 GHz to 40 GHz.

The following procedure will be used:

- 1) Set the turntable and the turn device to obtain the worst-case emission for the first frequency identified in the preliminary measurements.
- 2) Set the measurement antenna polarisation to the orientation with the highest emission for the first frequency identified in the preliminary measurements.
- 3) Set the spectrum analyser to EMI mode with peak and average detector activated.
- 4) Rotate the turntable from 0° to 360° to find the TT Pos. that produces the highest emissions.
- 5) Note the highest displayed peak and average values
- 6) Repeat the steps 1) to 5) for each frequency detected during the preliminary measurements.



#### 5.4.2 Test results (radiated) 5.4.2.1 Test results (9 kHz – 30 MHz)

Ambient temperature		23 °C		Date	22.09.2020			
Relative humidity		62 %		Tested by	B. ROHDE			
Position of EUT:	of EUT: For tests for f between 9 kHz and 30 MHz, the EUT was set-up on a table with a he of 80 cm. The distance between EUT and antenna was 3 m.							
Cable guide:	For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.							
Test record:	The mea §15.31 (	e measurement value was already corrected by 40 dB/decade as described in 5.31 (f) (2) regarding to the measurement distance as requested in §15.209						

#### 5.4.2.1.1.1 Plots

9k-30M: Spurious emissions from 9 kHz to 30 MHz



Remark: In the shown plot a distance correction factor was added to the measurement results to account for the different measuring distances according to standard (9 kHz to 490 kHz @ 300 m; 490 kHz to 30 MHz @ 30 m).

5.4.2.1.1.2 Result table

All emissions are more the 20 dB from the limit, so no final measurement was conducted.

Test equipment (please refer to chapter 6 for details) 2 - 9



#### 5.4.2.2 Test results (30 MHz - 1 GHz)

Ambient temperature		21 °C		Date	12.08.2020				
Relative humidity		70 %		Tested by	B. ROHDE				
Position of EUT: The EUT was set-up on a table with a height of 80 cm. The distance between EUT and antenna was 3 m.									
Cable guide:	For de annex	For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.							
Test record:	Only t	he worst-case pl	ot is submit	ted below.					
Remark:	All oth	All other emissions were more than 20 dB below the limit							
5.4.2.2.1.1 Plots									

Spurious emissions from 30 MHz to 1 GHz (operation mode 1):







#### 5.4.2.2.1.2 Result table

Frequency	Result	Limit	Margin	Readings	Correction	Height	Azimuth	Pol.	Result
	[ubµv/m]	[ubµv/m]	[ub]	[upμv]	[ub/III]	[CIII]	[ueg]		1
35.610000	20.6	40	19.4	-4.2	24.8	102	15	V	Passed
65.310000	5.9	40	34.1	-6.7	12.6	103	337	V	Passed
110.400000	8.4	43.5	35.1	-9.3	17.7	200	134	V	Passed
562.510000	23.3	46	22.7	-5.1	28.5	102	179	V	Passed
Measurement uncertainty						±5.5 df	3		

Result table (operation mode 1):

Result table (operation mode 2):

Frequency	Result	Limit	Margin	Readings	Correction	Height	Azimuth	Pol	Result
[MHz]	[dBµV/m]	[dBµV/m]	[dB]	[dBµV]	[dB/m]	[cm]	[deg]	1 011	rtooun
35.730000	21.4	40	18.6	-3.4	24.7	100	217	V	Passed
59.810000	10.0	40	30.0	-2.6	12.6	330	69	V	Passed
100.530000	6.9	43.5	36.6	-10.0	16.9	146	346	V	Passed
562.510000	22.3	46	23.7	-6.2	28.5	410	44	Н	Passed
Measurement uncertainty						±5.5 dE	3		

#### Result table (operation mode 3):

Frequency	Result	Limit	Margin	Readings	Correction	Height	Azimuth	Pol	Result
[MHz]	[dBµV/m]	[dBµV/m]	[dB]	[dBµV]	[dB/m]	[cm]	[deg]	1 011	rtooun
35.840000	21.2	40	18.8	-3.5	24.7	102	284	V	Passed
59.890000	10.4	40	29.6	-2.1	12.6	317	1	V	Passed
110.210000	7.8	43.5	35.7	-9.9	17.7	100	134	V	Passed
257.870000	11.3	46	34.7	-9.9	21.2	306	126	Н	Passed
562.510000	21.9	46	24.1	-6.6	28.5	406	163	Н	Passed
Measurement uncertainty						±5.5 dl	3		

Test equipment (please refer to chapter 6 for details) 3 - 10



#### 5.4.2.3 <u>Test results (above 1 GHz)</u>

Ambient temperature		22 °C		Date	31.08.2020				
Relative humidity		58 %		Tested by	R. BRAUN				
Position of EUT:	For tes with a	sts for f between height of 150 cn	for f between 1 GHz and the 10 <sup>th</sup> harmonic, the EUT was set-up on a take eight of 150 cm. The distance between EUT and antenna was 3 m.						
Cable guide:	For de annex	For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.							
Test record:	As sho	own below							

#### 5.4.2.3.1 Operation mode 1

5.4.2.3.1.1 Plots Spurious emissions from 1 GHz to 4 GHz (operation mode 1):





#### Spurious emissions from 4 GHz to 12 GHz (operation mode 1):



Spurious emissions from 12 GHz to 18 GHz (operation mode 1):





#### Spurious emissions from 18 GHz to 26.5 GHz (operation mode 1):



#### 5.4.2.3.1.2 Result table

Frequency	Result	Result	Limit	Margin	Correction	Height	Azimuth	Pol	Result
[MHz]	[dBµV/m]	[dBµV/m]	[dBµV/m]	[dB]	[dB/m]	[cm]	[deg]	1 01.	Result
2400.000000		36.8	54	17.2	33.5	90	152	V	Passed
2400.000000	63.0		74	11.0	33.3	90	152	V	Passed
2402.000000		92.9			33.5	90	150	V	Fund.
2402.000000	93.6				33.3	90	150	V	Fund.
2483.500000		32.1	54	21.9	33.6	0	288	V	Passed
2483.500000	43.8		74	30.2	33.4	0	288	V	Passed
2889.250000		34.0	54	20.0	35.6	0	296	Н	Passed
2889.250000	46.0		74	28.0	35.4	0	296	Н	Passed
3895.250000		40.8	54	13.2	39.7	120	235	V	Passed
3895.250000	53.7		74	20.3	39.5	120	235	V	Passed
4804.000000		36.0	54	18.0	-1.9	0	30	Н	Passed
4804.000000	44.1		74	29.9	-2.1	0	30	Н	Passed
11045.000000		39.1	54	14.9	9.2	0	141	V	Passed
11045.000000	51.1		74	22.9	9.0	0	141	V	Passed
12041.500000		29.7	54	24.3	12.3	0	258	V	Passed
12041.500000	41.5		74	32.5	12.1	0	258	V	Passed
19954.250000		33.2	54	20.8	7.1	120	294	V	Passed
19954.250000	46.0		74	28.0	6.9	120	294	V	Passed
	Measure	ment uncertaint	у			±	5.5 dB		



#### 5.4.2.3.2 Operation mode 2

5.4.2.3.2.1 Plots

Spurious emissions from 1 GHz to 4 GHz (operation mode 2):



#### Spurious emissions from 4 GHz to 12 GHz (operation mode 2):





#### Spurious emissions from 12 GHz to 18 GHz (operation mode 1):



Spurious emissions from 18 GHz to 26.5 GHz (operation mode 1):





Frequency	Result	Result	Limit	Margin	Correction	Height	Azimuth	Del	Deput
[MHz]	(PK) [dBµV/m]	(Av) [dBµV/m]	[dBµV/m]	[dB]	[dB/m]	[cm]	[deg]	P0I.	Result
2440.000000		92.9			33.7	90	150	V	Fund.
2440.000000	93.6				33.5	90	150	V	Fund.
2891.500000		34.0	54	20.0	35.5	30	334	Н	Passed
2891.500000	46.0		74	28.0	35.3	30	334	Н	Passed
3948.000000		41.1	54	12.9	39.7	150	34	V	Passed
3948.000000	52.8		74	21.2	39.5	150	34	V	Passed
4880.000000	43.9		74	30.1	-1.8	30	42	Н	Passed
4880.000000		34.5	54	19.5	-1.6	30	42	Н	Passed
7320.250000		34.8	54	19.2	4.8	120	22	V	Passed
7320.250000	46.0		74	28.0	4.6	120	22	V	Passed
11060.250000		39.2	54	14.8	9.2	30	122	Н	Passed
11060.250000	51.9		74	22.1	9.0	30	122	Н	Passed
12200.000000	41.3		74	32.7	11.9	90	72	V	Passed
12200.000000		29.7	54	24.3	12.1	90	72	V	Passed
17020.500000		29.1	54	24.9	10.9	150	182	V	Passed
17020.500000	41.7		74	32.3	10.7	150	182	V	Passed
21021.250000		33.6	54	20.4	7.6	150	176	V	Passed
21021.250000	45.7		74	28.3	7.4	150	176	V	Passed
Measurement uncertainty				±5.5 dB					

#### 5.4.2.3.2.2 Result table

E



#### 5.4.2.3.3 Operation mode 3

5.4.2.3.3.1 Plots

Spurious emissions from 1 GHz to 4 GHz (operation mode 3):



#### Spurious emissions from 4 GHz to 12 GHz (operation mode 3):





#### Spurious emissions from 12 GHz to 18 GHz (operation mode 3):



Spurious emissions from 18 GHz to 26.5 GHz (operation mode 3):





Frequency	Result	Result	Limit	Margin	Correction	Height	Azimuth	Dol	Recult
[MHz]	(PK) [dBµV/m]	(Av) [dBµV/m]	[dBµV/m]	[dB]	[dB/m]	[cm]	[deg]	P01.	Result
2480.000000	88.3				33.4	30	112	Н	Fund.
2480.000000		87.6			33.6	30	112	Н	Fund.
2482.500000		32.9	54	21.1	33.6	30	96	Н	Passed
2482.500000	54.1		74	19.9	33.4	30	96	Н	Passed
2894.750000		34.0	54	20.0	35.5	60	112	V	Passed
2894.750000	46.1		74	27.9	35.3	60	112	V	Passed
3967.750000		41.1	54	12.9	39.5	150	198	V	Passed
3967.750000	54.3		74	19.7	39.3	150	198	V	Passed
4960.000000	-	38.8	54	15.2	-1.8	0	58	Н	Passed
4960.000000	46.0	-	74	28.0	-2.0	0	58	Н	Passed
11980.250000		39.1	54	14.9	7.3	0	306	V	Passed
11980.250000	51.5		74	22.5	7.1	0	306	V	Passed
12399.500000	43.2		74	30.8	12.1	150	131	V	Passed
12399.500000		31.2	54	22.8	12.3	150	131	V	Passed
21541.250000		34.0	54	20.0	7.8	0	251	V	Passed
21541.250000	46.1		74	27.9	7.6	0	251	V	Passed
Measurement uncertainty				±5.5 dB					

#### 5.4.2.3.3.2 Result table

E.

Test equipment (please refer to chapter 6 for details) 11 - 27



## 6 Test Equipment used for Tests

No.	Test equipment	Туре	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due	
1	Signal & Spectrum Analyzer	FSW43	Rohde & Schwarz	100586 & 100926	481720	04.03.2020	03.2022	
2	Loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	05.02.2020	02.2021	
3	RF Switch Matrix	OSP220	Rohde & Schwarz	Rohde & Schwarz -		Calibration not necessary		
4	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessar		
5	Antennasupport	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not	Calibration not necessary	
6	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary		
7	Semi Anechoic Chamber M276	SAC5-2	Albatross Projects	C62128-A540- A138-10-0006	483227	Calibration not	necessary	
8	Measuring software EMC32 M276	EMC32	Rohde & Schwarz	100970	482972	Calibration not	necessary	
9	EMI Testreceiver	ESW44	Rohde & Schwarz	101828	482979	14.11.2019	11.2021	
10	Antenna (Bilog)	CBL6111D	Schaffner Elektrotest GmbH / Teseq GmbH	22921	480674	27.03.2018	03.2021	
11	Antenna (Log.Per.)	HL050	Rohde & Schwarz	100438	481170	09.10.2017	10.2020	
12	RF-Cable No. 40	Sucoflex 106B	Suhner	0708/6B / Kabel 40	481330	Calibration not	necessary	
13	standard gain horn antenna	18240-20	Flann Microwave	483	480294	Calibration not	necessary	
14	Preamplifier 12 GHz - 18 GHz	JS3-12001800- 16-5A	MITEQ Hauppauge N.Y.	571667	480343	13.02.2020	02.2022	
15	standard gain horn antenna	20240-20	Flann Microwave	411	480297	Calibration not	necessary	
16	Preamplifier 18 GHz - 26 GHz	JS4-18002600- 20-5A	MITEQ Hauppauge N.Y.	658697	480342	13.02.2020	02.2022	
17	High pass Filter	WHKX4.0/18G- 8SS	Wainwright Instruments GmbH	1	480587	Calibration not	necessary	
18	Microwave cable 2m	Insulated Wire Inc.	Insulated Wire	KPS-1533-800- KPS	480302	Calibration not necessary		
19	Antenna mast	AS615P	Deisel	615/310	480187	Calibration not necessary		
20	Fully anechoic chamber M20	B83117-E2439- T232	Albatross Projects	103	480303	Calibration not necessary		
21	Turntable	DS420 HE	Deisel	420/620/00	480315	Calibration not	necessary	
22	Multiple Control Unit	MCU	Maturo GmbH	MCU/043/97110 7	480832	Calibration not	necessary	
23	Positioners	TDF 1.5- 10Kg	Maturo	15920215	482034	Calibration not	necessary	
24	EMI Receiver / Spectrum Analyser	ESW44	Rohde & Schwarz	101635	482467	18.02.2020	02.2022	
25	Software	EMC32	Rohde & Schwarz	-	481800	Calibration not	necessary	
26	Preamplifier 100 MHz - 16 GHz	AFS6-00101600- 23-10P-6-R	Narda MITEQ	2011215	482333	13.02.2020	02.2022	
27	RF-cable No.38	Sucoflex 106B	Suhner	0709/6B / Kabel 38	481328	Calibration not	necessary	



## 7 Test site Validation

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
Semi anechoic chamber M276	483227	30 – 1000 MHz	NSA	ANSI C63.4-2017	19.09.2019	18.09.2021
Fully anechoic chamber M20	480303	1 -18 GHz	SVSWR	CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017	24.08.2020	23.08.2022

## 8 Report History

Report Number	Date	Comment
F191168E4	07.09.2020	Initial Test Report
-	-	-
-	-	-

## 9 List of Annexes

Annex A Test Setup Photos

7 pages