Test Report
21-1-0183201T01a-C01

Number of pages:	35	**Date of Report:**	2022-May-05
Testing company:	CETECOM GmbH Im Teelbruch 116 45219 Essen Germany Tel. + 49 (0) 20 54 / 95 19-0 Fax: + 49 (0) 20 54 / 95 19-150	**Applicant:**	Miele & Cie. KG
Product: **Model:**	**Wireless Food Probe System** **EPI7684**		
FCC ID:	SSVNAEPI03	**IC:**	5669B-NAEPI03
Testing has been carried out in accordance with:	**Title 47 CFR, Chapter I** **FCC Regulations, Subchapter A** Subpart C: §15.247 (FHSS) **RSS-247, Issue 2 (FHSS)** RSS-Gen, Issue 5 Deviations, modifications or clarifications (if any) to above mentioned documents are written in each section under "Test method and limit".		
Tested Technology:	Proprietary 2.4 GHz RF Transceiver (FHSS)		
Test Results:	**☒ The EUT complies with the requirements in respect of selected parameters subject to the test.** The test results relate only to devices specified in this document The current version of Test Report CETECOM-TR21-1-0183201T01a-C01 replaces the test report CETECOM-TR21-1-0183201T01a dated 2022-05-03. The replaced test report is herewith invalid.		
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The listed attachments are separate documents.			

1 General information

1.1 Disclaimer and Notes

The test results of this test report relate exclusively to the test item specified in this test report as specified in chapter 2.7. CETECOM does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item.
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Also we refer on special conditions which the applicant should fulfill according §2.927 to §2.948, special focus regarding modification of the equipment and availability of sample equipment for market surveillance tests.

1.2 Attestation

I declare that all measurements were performed by me or under my supervision and that all measurements have been performed and are correct to my best knowledge and belief to Industry Canada standards. All of the above requirements are met in accordance with enumerated standards.

1.3 Summary of Test Results

The EUT integrates a Bluetooth transmitter. Other implemented wireless technologies were not considered within this test report.

Test case	Reference Clause FCC ☒	Reference Clause ISED ☒	Page	Remark	Result
Duty cycle	§15.35(c)	RSS-Gen Issue 5, §8.2	12	--	PASSED
Emission Bandwidth 20 dB	§15.247(a)(1)	RSS-247, Issue 2, §5.1(a)	14	--	PASSED
Occupied Channel Bandwidth 99%	2.1049(h)	RSS-Gen, Issue 5, §6.7	19	--	PASSED
Carrier Frequency Separation	§15.247(a)(1)	RSS-247, Issue 2, §5.1(b)	15	--	PASSED
Number of Hopping Channels	§15.247(a)(1)(iii)	RSS-247, Issue 2, §5.1(d)	16	--	PASSED
Time of Occupancy	§15.247(a)(1)(iii)	RSS-247, Issue 2, §5.1(d)	18	--	PASSED
Peak output power (Sweep)	§15.247(b)(1)	RSS-247, Issue 2: §5.1(b)	13	--	PASSED
Transmitter Peak output power radiated	§15.247(b)(4)	RSS-247, Issue 2: §5.1(b)	--	--	NP
Emissions in non-restricted frequency bands	§15.247(d)	RSS-247, §5.5	21	--	PASSED
Radiated Band-Edge emissions	§15.247(d)	RSS-247, §5.5 RSS-Gen: Issue 5: §8.9 Table 5+6+7	31	--	PASSED
Radiated field strength emissions below 30 MHz	§15.205(a) §15.209(a)	RSS-Gen: Issue 5 §8.9 Table 6	25	--	PASSED
Radiated field strength emissions 30 MHz – 1 GHz	§15.209 §15.247(d)	RSS-Gen: Issue 5 §8.9 Table 5 RSS-247, §5.5	27	--	PASSED
Radiated field strength emissions above 1 GHz	§15.209(a) §15.247(d)	RSS-Gen: Issue 5: §8.9 Table 5+7 RSS-247, §5.5	29	--	PASSED
AC-Power Lines Conducted Emissions	§15.207	RSS-Gen Issue 5: §8.8, Table 4	--	--	NP

PASSED	The EUT complies with the essential requirements in the standard.
FAILED	The EUT does not comply with the essential requirements in the standard.
NP	The test was not performed by the CETECOM Laboratory.

*The calculation of the measurement uncertainty shows compliance with the "maximum measurement uncertainties" of the tested standard and therefore for result evaluation the stated uncertainties will not be additionally added to the measured results.

1.4 Summary of Test Methods

Test case	Test method
Duty-Cycle	ANSI C63.10:2013, §11.6(b)
Peak output power (Sweep)	ANSI C63.10:2013, §6.10.1
Emission Bandwidth 20 dB	ANSI C63.10:2013
Carrier Frequency Separation	ANSI C63.10:2013
Number of Hopping Channels	ANSI C63.10:2013
Time of Occupancy	ANSI C63.10:2013
Occupied Channel Bandwidth 99%	ANSI C63.10:2013, §6.9.3
Power spectral density	ANSI C63.10:2013, §6.9.2, §11.8
Transmitter Peak output power radiated	Result calculated with measured conducted RF-power value and stated/measured antenna gain for band of interest
Emissions in non-restricted frequency bands	ANSI C63.10:2013, §11.11, §6.10.5
Radiated field strength emissions below 30 MHz	ANSI C63.10-2013 §6.3, §6.4
Radiated field strength emissions 30 MHz- 1 GHz	ANSI C63.4-2014 §8.2.3, ANSI C63.10-2013 §6.3, §6.5
Radiated field strength emissions above 1 GHz	ANSI C63.4-2014 §8.3, ANSI C63.10-2013 §6.3, §6.6
Radiated Band-Edge emissions	ANSI C63.10-2013; “Marker-Delta method”, §6.10.5, §11.13
AC-Power Lines Conducted Emissions	ANSI C63.4-2014 §7, ANSI C63.10-2013 §6.2

And reference also to Test methods in KDB558074

2 Administrative Data

2.1 Identification of the Testing Laboratory

Company name:	CETECOM GmbH
Address:	Im Teelbruch 116 45219 Essen - Kettwig Germany
Responsible for testing laboratory:	Dipl.-Ing. Ninovic Perez
Accreditation scope:	**DAkkS Webpage: FCC ISED**
IC Lab company No. / CAB ID:	3462D / DE0005
Test location:	CETECOM GmbH; Im Teelbruch 116; 45219 Essen - Kettwig

2.2 General limits for environmental conditions

Temperature:	22±2 °C
Relative. humidity:	45±15% rH

2.3 Test Laboratories sub-contracted

Company name:	--

2.4 Organizational Items

Responsible test manager:	Salih Öztan
Receipt of EUT:	2022-Mar-21
Date(s) of test:	04-11-2022 to 04-19-2022
Version of template:	22.0301

2.5 Applicant's details

Applicant's name:	Miele & Cie. KG
Address:	Carl-Miele-Platz 1 59302 Oelde-Lette North Rhine-Westphalia Germany
Contact Person:	Andreas Fabrizius
Contact Person's Email:	andreas.fabrizius@miele.com

2.6 Manufacturer's details

Manufacturer's name:	Miele & Cie. KG
Address:	Carl-Miele-Str. 29 33332 Gütersloh Germany

2.7 Equipment under Test (EUT)

EUT No.*)	Sample No.	Product	Model	Type	SN	HW	SW
EUT 1	21-1-01832S02_C01	Wireless Food Probe System	EPI7684	n/a	26968894	12187550	5349
EUT 2	21-1-01832S03_C01	Wireless Food Probe System	EPI7684	n/a	26968888	12187550	5349
EUT 3	21-1-01832S04_C01	Wireless Food Probe System	EPI7684	n/a	26968892	12187550	5349
EUT 4	21-1-01832S05_C01	Wireless Food Probe System	EPI7684	n/a	26968886	12187550	5349

*) EUT short description is used to simplify the identification of the EUT in this test report.

2.8 Untested Variant (VAR)

VAR No.*)	Sample No.	Product	Model	Type	SN	HW	SW

*) The listed additional untested model variant(s) (VAR) is/are not object of evaluation of compliance. For further information please see Annex 5: Declaration of applicant of model differences.
If the table above does not show any other line than the headline, no untested variants are available.

2.9 Auxiliary Equipment (AE)

AE No.*)	Sample No.	Auxiliary Equipment	Model	SN	HW	SW
AE 1	21-1-01832S07_C01	Antenna	Fakra	110 cm		

*) AE short description is used to simplify the identification of the auxiliary equipment in this test report. If the table above does not show any other line than the headline, no AE was used during testing nor was taken into account for evaluation.

2.10 Connected cables (CAB)

CAB No.*)	Sample No.	Cable Type	Connectors / Details	Length
CAB 1	21-1-01832S06_C01	Power cable	--	60 cm
CAB 2	21-1-01832S08_C01	Cable	SMA	65 cm

*) CAB short description is used to simplify the identification of the connected cables in this test report. If the table above does not show any other line than the headline, no cable was used during testing nor was taken into account for evaluation.

2.11 Software (SW)

SW No.*)	Sample No.	SW Name	Description	SW Status

*) SW short description is used to simplify the identification of the used software in this test report. If the table above does not show any other line than the headline, no SW was used during testing nor was taken into account for evaluation.

2.12 EUT set-ups

set-up no.*)	Combination of EUT and AE	Description
1	(EUT1, EUT 3, EUT 4) + AE 1 + CAB 1 + CAB 2	Used for Radiated measurements EUT1: CH0 EUT2: Hopping mode (sweep) EUT3: CH300 EUT4: CH600
2	(EUT1, EUT 2, EUT 3, EUT 4) + CAB 1 + CAB 2	Used for Conducted measurements EUT1: CH0 EUT2: Hopping mode (sweep) EUT3: CH300 EUT4: CH600

*) EUT set-up no. is used to simplify the identification of the EUT set-up in this test report.

2.13 EUT operation modes

EUT operating mode no.*1)	Operating modes	Additional information
Op. 1	TX-Fixed Channel Mode	The EUT was put to Fixed Channel Continuous transmissions mode. **Lowest Channel : 2401.623 MHz | Nominal Power setting: +20dBm** **Middle Channel : 2441.380 MHz | Nominal Power setting: +20dBm** **Highest Channel : 2481.280 MHz | Nominal Power setting: +10dBm**
Op. 2	TX-Hopping Channels Mode	The EUT was put to **all Channels Hopping Continuous transmissions mode**.

*1) EUT operating mode no. is used to simplify the test report.

3 Equipment under test (EUT)

3.1 General Data of Main EUT as Declared by Applicant

Firmware	☐ for normal use	☒ Special version for test execution	
Power supply	☐ AC Mains	-	
	☒ DC Mains	13 V DC + 3.3 V DC	
	☐ Battery	-	
Operational conditions	T_{nom} = +21 °C	T_{min} = n/a	T_{max} = n/a
EUT sample type	**Pre-Production**		
Weight	0.1 kg		
Size [LxWxH]	10.5 cm x 8.0 cm x 3.0 cm		
Interfaces/Ports	--		
For further details refer Applicants Declaration & following technical documents			
For further details regarding radio parameters, please refer to Bluetooth Core Specification			

3.2 Detailed Technical data of Main EUT as Declared by Applicant

Frequency Band	2.4 GHz ISM Band (2400 MHz - 2483.5 MHz)
Number of Channels (USA/Canada -bands)	600 Frequency Hopping Channels
Nominal Channel Bandwidth	13 kHz
Type of Modulation | Data Rate	none
Other installed options	☐ a/n/ac mode ☐ b/g/n mode ☐ Bluetooth LE (not tested within this report) ☐ Cellular transceiver (2G/3G/4G/5G/GPS, not tested in this report)
Max. Conducted Output Power	Lowest Channel : 2401.623 MHz | +19.1 dBm
	Middle Channel : 2441.380 MHz | +18.3 dBm
	Highest Channel : 2481.280 MHz | +2.9 dBm
EIRP Power (Calculated EIRP)	19.1 dBm – 7 dBi = +12.1 dBm
Antenna Type	Loop Antenna
Antenna Gain	-7 dBi (According to Applicant's declaration)
FCC label attached	No
Test firmware / software and storage location	EUT1/EUT2/EUT3/EUT4

For further details refer Applicants Declaration & following technical documents		
Description of Reference Document (supplied by applicant)	**Version**	**Total Pages**
2019-03-05_description_Miele_wireless_temperature_probe_V3 (Datenblatt)	**2019-03-05**	**2**

3.3 Modifications on Test sample

Additions/deviations or exclusions	--

4 Measurements

4.1 Duty-Cycle

Testing method:

The necessary duty-cycle correction factor is determined on nominal conditions on middle channel only. It is assumed that no noticeable changes occur when tested on other channels or climatic conditions.

EUT settings
The EUT was instructed to send with maximum power (if adjustable) according applicants instructions.
Different modulation characteristics have been checked, e.g. data rates which EUT can operate.

A special firmware program is used for test purposes. In opposite to normal operating mode a higher duty-cycle is set in order to facilitate the measurements. This is maximized at the extent possible.

The necessary duty-cycle correction factor is determined on nominal conditions on one channel in each operable frequency-band. It is assumed that no noticeable changes occur when tested on other channels or climatic conditions. The Duty-Cycle was constant, means without variations.

Formula to calculate Duty-Cycle:

Duty cycle calculations: $x = {TX_{ON}}/{(TX_{ON} + TX_{OFF})}$	Duty cycle factor: DC=	Regarding power: $10 * log({1}/{x})$ dB
		Regarding field strength: $20 * log({1}/{x})$ dB

☒ The results were corrected in order to evaluate for worst-case result each time when average values are necessary for example average radiated emissions or similar
☐ No correction necessary: Duty-Cycle > 98%

4.1.1 Measurement Location

Test site	120910 - Radio Laboratory 1 (TS 8997)

4.1.2 Result

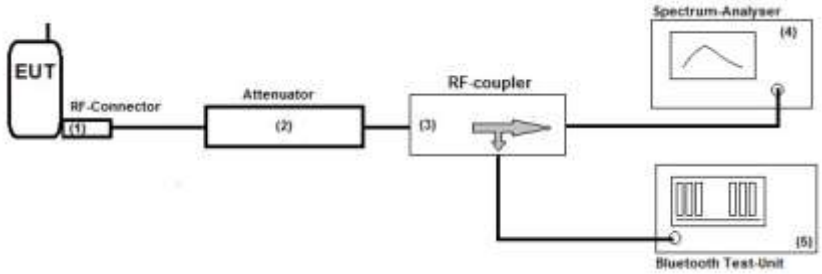
Duty-Cycle [%]	Duty-Cycle correction Power [dB]	Duty-Cycle correction Field Strength [dB]
0.357	24.473	48.947

4.2 Peak output power (Sweep)

4.2.1 Description of the general test setup and methodology, see below example:

The EUT's RF-signal is coupled out by a suitable antenna coupling connector (1). The signal is first attenuated (2) then on the RF-coupler the coupled RF-path is connected to a Bluetooth test unit communication tester (5). The direct RF-path is connected to the spectrum – analyzer (4) for specific RF-measurements. The specific attenuation losses for both signal paths/branches are determined prior to the measurement within a set-up calibration. These are then taken into account by correcting the measurement readings on the spectrum-analyzer.

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page 6)

Measurement is made using Rohde & Schwarz TS8997 test system.

EUT settings
Hopping mode was switched offso fixed three different channels could be measured.
The EUT was instructed to send with maximum power (if adjustable) according applicants instructions.
Different modulation characteristics have been checked, e.g. data rates which EUT can operate

4.2.2 Measurement Location

Test site	120910 - Radio Laboratory 1 (TS 8997)

4.2.3 Limit

Frequency Range [MHz]	Limit [W]	Limit [dBm]	Detector	RBW / VBW [MHz]
2400 - 2483.5	1	30	MaxPeak	3 / 10

4.2.4 Result

Mode	Channel	Frequency [MHz]	Max Peak Power [dBm]	Result
Op.1	1	2401.62	19.1	PASSED
Op.1	300	2441.38	18.3	PASSED
Op.1	600	2481.28	2.9	PASSED

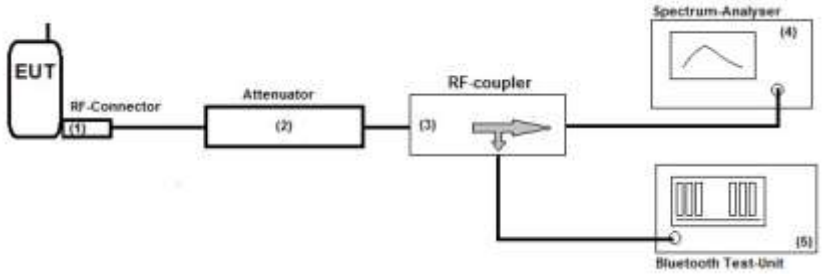
Remark: for more information and graphical plot see annex A1**CETECOM_TR21-1-0183201T01a_A1**

4.3 Emission Bandwidth 20 dB

4.3.1 Description of the general test setup and methodology, see below example:

The EUT's RF-signal is coupled out by a suitable antenna coupling connector (1). The signal is first attenuated (2) then on the RF-coupler the coupled RF-path is connected to a Bluetooth test unit communication tester (5). The direct RF-path is connected to the spectrum – analyzer (4) for specific RF-measurements. The specific attenuation losses for both signal paths/branches are determined prior to the measurement within a set-up calibration. These are then taken into account by correcting the measurement readings on the spectrum-analyzer.

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page 6)

Measurement is made using Rohde & Schwarz TS8997 test system.

EUT settings
For FHSS-systems hopping mode was switched-off so fixed three different channels could be measured.
The EUT was instructed to send with maximum power (if adjustable) according applicants instructions.
Different modulation characteristics have been checked, e.g. data rates which EUT can operate.

4.3.2 Measurement Location

Test site	120910 - Radio Laboratory 1 (TS 8997)

4.3.3 Limit

Limit [kHz]	Detector [MaxHold]	RBW / VBW [kHz]
--	MaxPeak	10 / 30

4.3.4 Result

Mode	Channel	Frequency [MHz]	20 dB bandwidth [MHz]	Result
Op.1	1	2401.62	0.004000	Passed
Op.1	300	2441.38	0.013000	Passed
Op.1	600	2481.28	0.008000	Passed

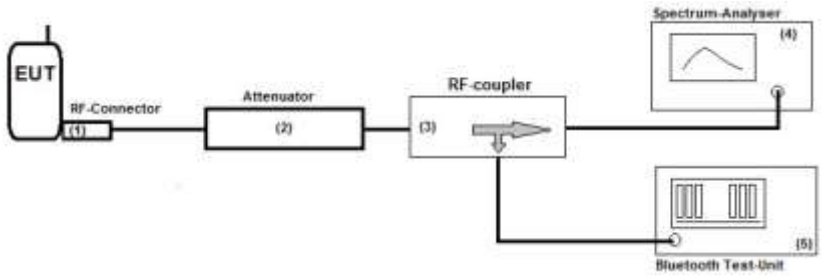
Remark: for more information and graphical plot see annex A1**CETECOM_TR21-1-0183201T01a_A1**

4.4 Carrier Frequency Separation

4.4.1 Description of the general test setup and methodology, see below example:

The EUT's RF-signal is coupled out by a suitable antenna coupling connector (1). The signal is first attenuated (2) then on the RF-coupler the coupled RF-path is connected to a Bluetooth test unit communication tester (5). The direct RF-path is connected to the spectrum – analyzer (4) for specific RF-measurements. The specific attenuation losses for both signal paths/branches are determined prior to the measurement within a set-up calibration. These are then taken into account by correcting the measurement readings on the spectrum-analyzer.

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page 6)

Measurement is made using Rohde & Schwarz TS8997 test system.

EUT settings
For FHSS-systems hopping mode was switched-on.
The EUT was instructed to send with maximum power (if adjustable) according applicants instructions.
Different modulation characteristics have been checked, e.g. data rates which EUT can operate.

4.4.2 Measurement Location

Test site	120910 - Radio Laboratory 1 (TS 8997)

4.4.3 Limit

Limit [MHz]	Detector [MaxHold]	RBW / VBW [kHz]
>= 0.025 or 2/3 of the 20 dB bandwidth	MaxPeak	300 / 300

4.4.4 Result

Mode	Channel	Frequency [MHz]	Frequency Separation [MHz]	Result
Op.1	1	2401.620	0.130366	Passed
Op.1	300	2441.387	0.130366	Passed
Op.1	600	2481.287	0.165920	Passed

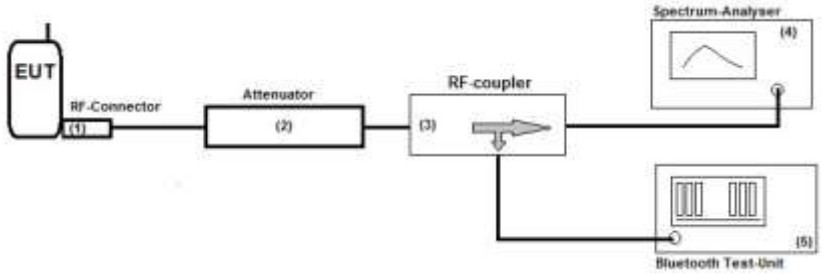
Remark: for more information and graphical plot see annex A1**CETECOM_TR21-1-0183201T01a_A1**

4.5 Number of Hopping Channels

4.5.1 Description of the general test setup and methodology, see below example:

The EUT's RF-signal is coupled out by a suitable antenna coupling connector (1). The signal is first attenuated (2) then on the RF-coupler the coupled RF-path is connected to a Bluetooth test unit communication tester (5). The direct RF-path is connected to the spectrum – analyzer (4) for specific RF-measurements. The specific attenuation losses for both signal paths/branches are determined prior to the measurement within a set-up calibration. These are then taken into account by correcting the measurement readings on the spectrum-analyzer.

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page 6)

Measurement is made using Rohde & Schwarz TS8997 test system.

EUT settings
For FHSS-systems hopping mode was switched-on.
The EUT was instructed to send with maximum power (if adjustable) according applicants instructions.
Different modulation characteristics have been checked, e.g. data rates which EUT can operate.

4.5.2 Measurement Location

Test site	120910 - Radio Laboratory 1 (TS 8997)

4.5.3 Limit

Limit [number]	Detector [MaxHold]	RBW / VBW [kHz]
15	MaxPeak	200 / 200

4.5.4 Result

Mode	Number of hopping channels	Result
Op.2	600	Passed

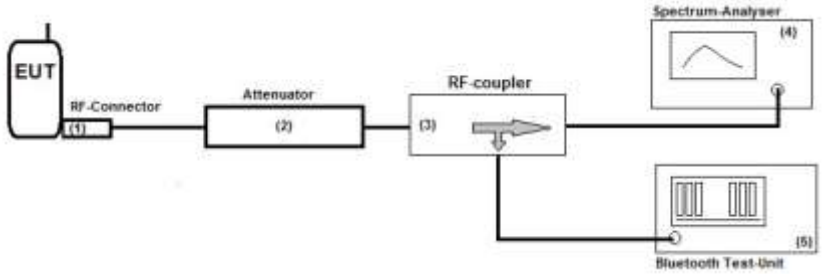
Remark: for more information and graphical plot see annex A1**CETECOM_TR21-1-0183201T01a_A1**

4.6 Time of Occupancy

4.6.1 Description of the general test setup and methodology, see below example:

The EUT's RF-signal is coupled out by a suitable antenna coupling connector (1). The signal is first attenuated (2) then on the RF-coupler the coupled RF-path is connected to a Bluetooth test unit communication tester (5). The direct RF-path is connected to the spectrum – analyzer (4) for specific RF-measurements. The specific attenuation losses for both signal paths/branches are determined prior to the measurement within a set-up calibration. These are then taken into account by correcting the measurement readings on the spectrum-analyzer.

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page 6)

Measurement is made using Rohde & Schwarz TS8997 test system.

EUT settings
For FHSS-systems hopping mode was switched-on.
The EUT was instructed to send with maximum power (if adjustable) according applicants instructions.
Different modulation characteristics have been checked, e.g. data rates which EUT can operate.

4.6.2 Measurement Location

Test site	120910 - Radio Laboratory 1 (TS 8997)

4.6.3 Limit

Limit [s]	Detector [MaxHold]	RBW / VBW [kHz]
<= 0.4	MaxPeak	200 / 200

4.6.4 Result

Average occupancy time calculations:

Formula for calculating the dwell time (pseudo-hopping sequence over all channels assumed):

Average Dwell Time = $Timeslot\ length \cdot \frac{Hop\ rate}{number of\ hopping\ channels} \cdot time\ period$

The EUT employs Proprietary 2.4 GHz RF Transceiver Frequency Hopping system with total 600 channels. The maximum staying time of 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed = 0.4 seconds x 600 = 240 seconds.

Mode	Single Transmission time [ms]	Number of Transmissions in 1s [-]	Number of Transmissions in 240s [-]	Time of occupancy [ms]	Result
Op.2	0.3573199	10	96*10	343.027	Passed

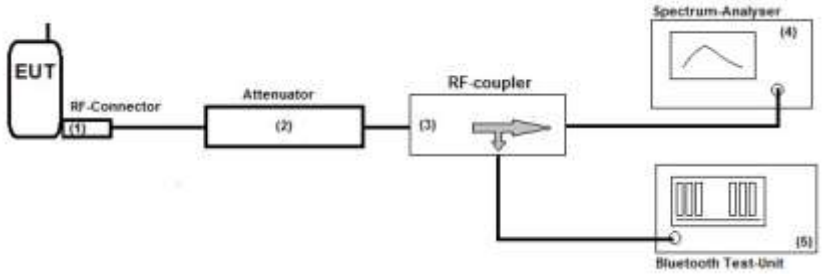
Remark: for more information and graphical plot see annex A1**CETECOM_TR21-1-0183201T01a_A1**

4.7 Occupied Channel Bandwidth 99%

4.7.1 Description of the general test setup and methodology, see below example:

The EUT's RF-signal is coupled out by a suitable antenna coupling connector (1). The signal is first attenuated (2) then on the RF-coupler the coupled RF-path is connected to a Bluetooth test unit communication tester (5). The direct RF-path is connected to the spectrum – analyzer (4) for specific RF-measurements. The specific attenuation losses for both signal paths/branches are determined prior to the measurement within a set-up calibration. These are then taken into account by correcting the measurement readings on the spectrum-analyzer.

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page 6)

Measurement is made using Rohde & Schwarz TS8997 test system.

EUT settings
For FHSS-systems hopping mode was switched-off so fixed three different channels could be measured.
The EUT was instructed to send with maximum power (if adjustable) according applicants instructions.
Different modulation characteristics have been checked, e.g. data rates which EUT can operate.

4.7.2 Measurement Location

Test site	120910 - Radio Laboratory 1 (TS 8997)

4.7.3 Limit

When the occupied bandwidth limit is not stated in the applicable reference measurement method, the transmitted signal bandwidth shall be reported as the 99% emission bandwidth, as calculated or measured.

4.7.4 Result

Mode	Channel	Frequency [MHz]	99% Occupied bandwidth [MHz]	Result
Op.1	1	2401.620	0.002500	Passed
Op.1	300	2441.387	0.003000	Passed
Op.1	600	2481.287	0.003500	Passed

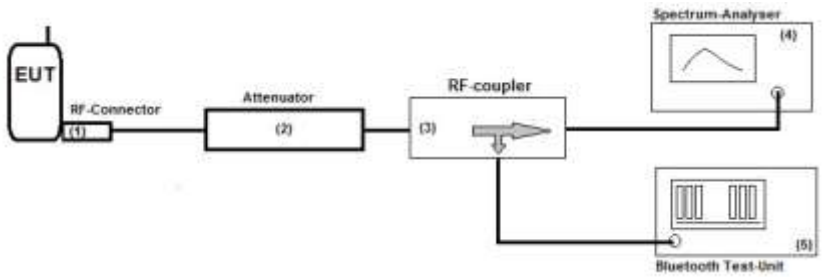
Remark: for more information and graphical plot see annex A1**CETECOM_TR21-1-0183201T01a_A1**

4.8 Emissions in non-restricted frequency bands

4.8.1 Description of the general conducted test setup and methodology, see below example:

The EUT's RF-signal is coupled out by a suitable antenna coupling connector (1). The signal is first attenuated (2) then on the RF-coupler the coupled RF-path is connected to a Bluetooth test unit communication tester (5). The direct RF-path is connected to the spectrum – analyzer (4) for specific RF-measurements. The specific attenuation losses for both signal paths/branches are determined prior to the measurement within a set-up calibration. These are then taken into account by correcting the measurement readings on the spectrum-analyzer.

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page 6)

Measurement is made using Rohde & Schwarz TS8997 test system.

The measurements were performed with the RBW set to 100 kHz & maximum carrier level was indicated with MAX-Hold positive peak detector using markers. Then a frequency line was set 20 or 30 dB below this measured maximum carrier level.

Then using RBW 100 kHz & spectrum analyzer span from 150 kHz to 25 GHz in three steps spurious emissions were measured with MAX-Hold positive peak detector.

The sweep time set as long as necessary to capture the full signal burst per hopping channel. The burst on-period is captured by setting appropriate markers in the rising and falling edges.

EUT settings
Fixed Channel Mode:
For FHSS-systems Hopping mode was switched-off so fixed three different channels could be measured.
The EUT was instructed to send with maximum power (if adjustable) according applicants instructions.
Different modulation characteristics have been checked. e.g. data rates which EUT can operate.

Hopping Mode:
For FHSS-systems Hopping mode was switched- ON so emissions from hopping channels could be measured.
The EUT was instructed to send with maximum power (if adjustable) according applicants instructions. Different modulation characteristics have been checked. e.g. data rates which EUT can operate.

4.8.2 Measurement Location

Test site	120910 - Radio Laboratory 1 (TS 8997)

4.8.3 Limit

Frequency Range [MHz]	Limit [dBc]
0.15 – 25000	-20 / -30

4.8.4 Result

Maximum Level Peak [dBc]

Mode	Channel	Frequency [MHz]	Result
Op.1	1	2401.620	Passed
Op.1	300	2441.387	Passed
Op.1	600	2481.287	Passed
Op.2	1-600	2401.620 – 2441.387	Passed

Remark: for more information and graphical plot see annex A1**CETECOM_TR21-1-0183201T01a_A1**

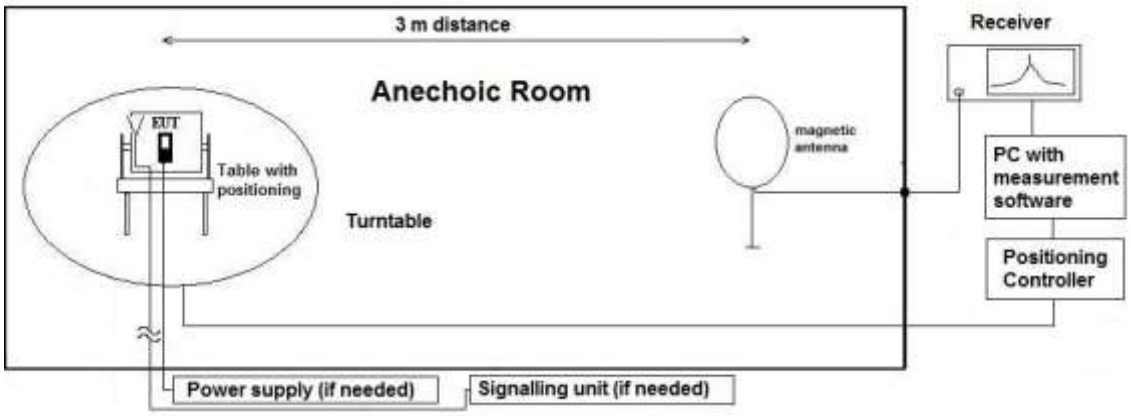
4.9 Radiated field strength emissions below 30 MHz

4.9.1 Description of the general test setup and methodology, see below example:

Evaluating the radiated field emissions are done first by an exploratory emission measurement and a final measurement for most critical frequencies determined.

The loop antenna was placed at 1 m height above ground plane and 3 m measurement distance from set-up for investigations. Because of reduced measurement distance, correction data were applied, as stated in chapter "General Limit - Radiated field strength emissions below 30 MHz". The tests are performed in the semi anechoic room recognized by the regulatory commission.

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page 6)

Exploratory, preliminary measurements
The EUT and its associated accessories are placed on a non-conductive position manipulator (tipping device) of 0.8 m height which is placed on the turntable. By rotating the turntable (step 90°, range 0°to 360°) and the EUT itself either on 3-orthogonal axis (portable equipment) or 2-orthogonal axis (defined operational position of EUT), the emission spectrum was recorded.

The loop antenna was moved at least to 2-perpendicular axes (antenna vector in direction of EUT and parallel to EUT) in order to maximize the emissions. The results are documented in a diagram. Critical frequencies (low margin to limit) are saved within a data reduction table for further investigations. If various operating modes are supported, further investigations are made to find the worst-case. Also the interconnection cables and equipment position were varied in order to maximize the emissions.

Final measurement on critical frequencies
Based on the exploratory measurements, the most critical frequencies are re-measured by main-taining the EUT's worst-case operation mode, cable position, etc.

First a frequency zoom around the critical frequency is done to locate the frequency more precisely. After this step, for all identified critical frequencies, the maximum peak was determined.

Following parameters were varied: the turntable angle continuously in the range 0 to 360 degree, the EUT itself either over 3-orthogonal axis (not defined usage position) or 2-orthogonal axis (defined usage position).

On the determined worst-case position, a final measurement with necessary bandwidth and detector according standard has been carried out.

Formula:

$E_C = E_R + AF + C_L + D_F - G_A$

$M = L_T - E_C$

AF = Antenna factor
C_L = Cable loss
D_F = Distance correction factor (if used)
E_C = Electrical field – corrected value
E_R = Receiver reading
G_A = Gain of pre-amplifier (if used)
L_T = Limit
M = Margin

All units are dB-units, positive margin means value is below limit.

4.9.2 Sample calculation

Raw-Value [dBuV/m]	Antenna factor	Distance Correction [dB]	Cable Loss	Preamplifier	Resulting correction value [dB]	Final result [dBuV/m]	Remarks
19.83	18.9	-70.75	0.18	--	-51.67	-31.83	30 to 3 m correction used according ANSI C63.10-2013

Remark: This calculation is based on an example value at 458 kHz

4.9.3 Measurement Location

Test site	120901 - SAC - Radiated Emission <1GHz

4.9.4 Correction factors due to reduced meas. distance (f < 30 MHz):

The used correction factors when the measurement distance is reduced compared to regulatory measurement distance, are calculated according Extrapolation formulas valid for EUT's with maximum dimension of 0.625xLambda. Formula 2+3+4 as presented in ANSI C63.10, Chapter 6.4.4 are used for the calculations of proper extrapolation factors

Frequency Range	f [kHz/MHz]	Lambda [m]	Far-Field Point [m]	Distance Limit accord. 15.209 [m]	1st Condition (dmeas < Dnear-field)	2nd Condition (Limit distance bigger dnear-field)	Distance Correction accord. Formula
kHz	9	33333.33	5305.17	300	fullfilled	not fullfilled	-80.00
	10	30000.00	4774.65		fullfilled	not fullfilled	-80.00
	20	15000.00	2387.33		fullfilled	not fullfilled	-80.00
	30	10000.00	1591.55		fullfilled	not fullfilled	-80.00
	40	7500.00	1193.66		fullfilled	not fullfilled	-80.00
	50	6000.00	954.93		fullfilled	not fullfilled	-80.00
	60	5000.00	795.78		fullfilled	not fullfilled	-80.00
	70	4285.71	682.09		fullfilled	not fullfilled	-80.00
	80	3750.00	596.83		fullfilled	not fullfilled	-80.00
	90	3333.33	530.52		fullfilled	not fullfilled	-80.00
	100	3000.00	477.47		fullfilled	not fullfilled	-80.00
	125	2400.00	381.97		fullfilled	not fullfilled	-80.00
	200	1500.00	238.73		fullfilled	fullfilled	-78.02
	300	1000.00	159.16		fullfilled	fullfilled	-74.49
	400	750.00	119.37		fullfilled	fullfilled	-72.00
	490	612.24	97.44		fullfilled	fullfilled	-70.23
	500	600.00	95.49	30	fullfilled	not fullfilled	-40.00
	600	500.00	79.58		fullfilled	not fullfilled	-40.00
	700	428.57	68.21		fullfilled	not fullfilled	-40.00
	800	375.00	59.68		fullfilled	not fullfilled	-40.00
	900	333.33	53.05		fullfilled	not fullfilled	-40.00
MHz	1.00	300.00	47.75		fullfilled	not fullfilled	-40.00
	1.59	188.50	**30.00**		fullfilled	not fullfilled	-40.00
	2.00	150.00	23.87		fullfilled	fullfilled	-38.02
	3.00	100.00	15.92		fullfilled	fullfilled	-34.49
	4.00	75.00	11.94		fullfilled	fullfilled	-32.00
	5.00	60.00	9.55		fullfilled	fullfilled	-30.06
	6.00	50.00	7.96		fullfilled	fullfilled	-28.47
	7.00	42.86	6.82		fullfilled	fullfilled	-27.13
	8.00	37.50	5.97		fullfilled	fullfilled	-25.97
	9.00	33.33	5.31		fullfilled	fullfilled	-24.95
	10.00	30.00	4.77		fullfilled	fullfilled	-24.04
	10.60	28.30	4.50		fullfilled	fullfilled	-23.53
	11.00	27.27	4.34		fullfilled	fullfilled	-23.21
	12.00	25.00	3.98		fullfilled	fullfilled	-22.45
	13.56	22.12	3.52		fullfilled	fullfilled	-21.39
	15.00	20.00	3.18		fullfilled	fullfilled	-20.51
	15.92	18.85	**3.00**		fullfilled	fullfilled	-20.00
	17.00	17.65	2.81		not fullfilled	fullfilled	-20.00
	18.00	16.67	2.65		not fullfilled	fullfilled	-20.00
	20.00	15.00	2.39		not fullfilled	fullfilled	-20.00
	21.00	14.29	2.27		not fullfilled	fullfilled	-20.00
	23.00	13.04	2.08		not fullfilled	fullfilled	-20.00
	25.00	12.00	1.91		not fullfilled	fullfilled	-20.00
	27.00	11.11	1.77		not fullfilled	fullfilled	-20.00
	29.00	10.34	1.65		not fullfilled	fullfilled	-20.00
	30.00	10.00	1.59		not fullfilled	fullfilled	-20.00

4.9.5 Limit

Radiated emissions limits, (3 meters)					
Frequency Range [MHz]	Limit [µV/m]	Limit [dBµV/m]	Distance [m]	Detector	RBW [kHz]
0.009 – 0.09	2400 / f [kHz]	67.6 – 20Log(f) (kHz)	300	Pk & Avg	0.2
0.09 – 0.11	2400 / f [kHz]	67.6 – 20Log(f) (kHz)	300	Quasi peak	0.2
0.11 – 0.15	2400 / f [kHz]	67.6 – 20Log(f) (kHz)	300	Pk & Avg	0.2
0.15 – 0.49	2400 / f [kHz]	67.6 – 20Log(f) (kHz)	300	Pk & Avg	9
0.49 – 1.705	24000 / f [kHz]	87.6 – 20Log(f) (kHz)	30	Quasi peak	9
1.705 - 30	30	29.5	30	Quasi peak	9

*Remark: In Canada same limits apply, just unit reference is different

4.9.6 Result

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 0.009 – 30 MHz	Result
2.01a	1	Op.1	No peaks found	PASSED
2.01b	1	Op.1	No peaks found	PASSED
2.02a	300	Op.1	No peaks found	PASSED
2.02b	300	Op.1	No peaks found	PASSED
2.03a	600	Op.1	No peaks found	PASSED
2.03b	600	Op.1	No peaks found	PASSED

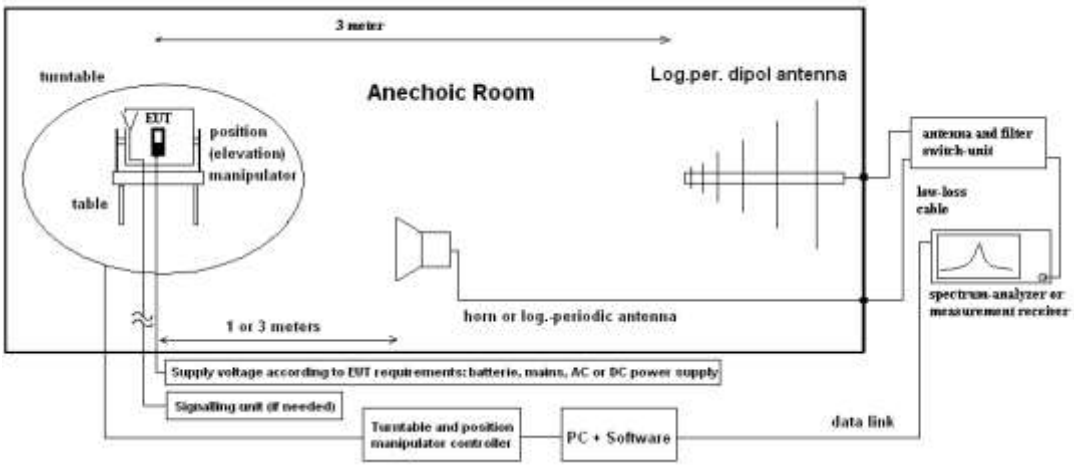
Remark: for more information and graphical plot see annex A1**CETECOM_TR21-1-0183201T01a_A1**

4.10 Radiated field strength emissions 30 MHz – 1 GHz

4.10.1 Description of the general test setup and methodology, see below example:

Evaluating the emissions have to be done first by an exploratory emissions measurement and a final measurement for most critical frequencies. The tests are performed in a CISPR 16-1-4:2010 compliant semi anechoic room (SAR) and fully anechoic room (FAR) recognized by the regulatory commission. The measurement distance was set to 3 meter for frequencies up to 18 GHz and 2 meter above 18 GHz. A logarithmic periodic antenna is used for the frequency range 30 MHz to 1 GHz. Horn antennas are used for frequency range 1 GHz to 40 GHz. The EUT is aligned within 3 dB beam width of the measurement antenna with three orthogonal axis measurements on the EUT.

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page 6)

Exploratory, preliminary measurements
The EUT and its associated accessories are placed on a non-conductive position manipulator (tipping device) of 0.8 m height which is placed on the turntable. By rotating the turntable (range 0° to 360°, step 90°) and the EUT itself either on 3-orthogonal axis (portable equipment) or 2-orthogonal axis (defined operational position of EUT) the emission spectrum and its characteristics was recorded with an EMI-receiver, broadband antenna and software.

Measurement antenna: horizontal and vertical, heights: 1,0 m and 1,82 m as worst-case determined by an exploratory emission measurements. The results are documented in a diagram. Critical frequencies (low margin to limit) are saved within a table for further investigations. If various operating modes are supported, further investigations are made to find the worst-case of them. Also the interconnection cables and equipment position were varied in order to maximize the emissions.

Final measurement on critical frequencies
Based on the exploratory measurements, the most critical frequencies are re-measured by maintaining the EUT's worst-case operation mode, cable position, etc. either on 10m OATS or 3m semi-anechoic room.
First a frequency zoom around the critical frequency is done to locate the frequency more precisely. After this step, for all identified critical frequencies, the maximum peak was determined.

Following parameters were varied: the turntable angle continuously in the range 0 to 360 degree, the EUT itself either over 3-orthogonal axis (not defined usage position) or 2-orthogonal axis (defined usage position). The measurement antenna height between 1 m and 4 m.
On the determined worst-case position, a final measurement with necessary bandwidth and detector according standard has been carried out

Formula:

$E_C = E_R + AF + C_L + D_F - G_A$ (1)

$M = L_T - E_C$ (2)

AF = Antenna factor
C_L = Cable loss
D_F = Distance correction factor (if used)
E_C = Electrical field – corrected value
E_R = Receiver reading
G_A = Gain of pre-amplifier (if used)
L_T = Limit
M = Margin

All units are dB-units, positive margin means value is below limit.

4.10.2 Sample calculation

Raw-Value [dBuV/m]	Antenna factor	Distance Correction [dB]	Cable Loss	Preamplifier	Resulting correction value [dB]	Final result [dBuV/m]	Remarks
32.7	22.25	--	3.1	--	25.35	58.05	--

Remark: This calculation is based on an example value at 800.4 MHz

4.10.3 Measurement Location

Test site	120901 - SAC - Radiated Emission <1GHz

4.10.4 Limit

Radiated emissions limits, (3 meters)				
Frequency Range [MHz]	Limit [µV/m]	Limit [dBµV/m]	Detector	RBW / VBW [kHz]
30 - 88	100	40.0	Quasi peak	100 / 300
88 - 216	150	43.5	Quasi peak	100 / 300
216 - 960	200	46.0	Quasi peak	100 / 300
960 - 1000	500	54.0	Quasi peak	100 / 300

4.10.5 Result

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 30 – 1000 MHz	Result
3.01a	1	Op.1	37.90 @ 879.955 MHz	PASSED
3.01b	1	Op.1	38.80 @ 879.955 MHz	PASSED
3.02a	300	Op.1	44.55 @ 879.955 MHz	PASSED
3.02b	300	Op.1	42.47 @ 879.955 MHz	PASSED
3.03a	600	Op.1	37.12 @ 239.995 MHz	PASSED
3.03b	600	Op.1	39.86 @ 879.955 MHz	PASSED

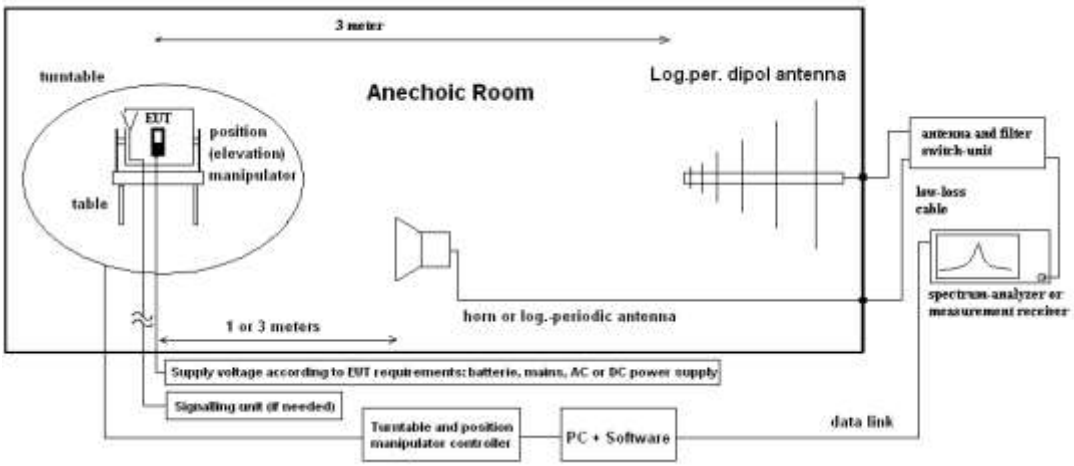
Remark: for more information and graphical plot see annex A1**CETECOM_TR21-1-0183201T01a_A1**

4.11 Radiated field strength emissions above 1 GHz

4.11.1 Description of the general test setup and methodology, see below example:

Evaluating the emissions have to be done first by an exploratory emissions measurement and a final measurement for most critical frequencies. The tests are performed in a CISPR 18-1-4:2010 compliant fully anechoic room (FAR) recognized by the regulatory commission. The measurement distance was set to 3 meter for frequencies up to 18 GHz and 2 meter above 18 GHz. A logarithmic periodic antenna is used for the frequency range 30 MHz to 1 GHz. Horn antennas are used for frequency range 1 GHz to 40 GHz. The EUT is aligned within 3 dB beam width of the measurement antenna with three orthogonal axis measurements on the EUT.

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page 6)

Exploratory, preliminary measurements
The EUT and its associated accessories are placed on a non-conductive position manipulator (tipping device) of 1.55 m height which is placed on the turntable. By rotating the turntable (range 0° to 360°, step 15°) and the EUT itself either on 3-orthogonal axis (portable equipment) or 2-orthogonal axis (defined operational position of EUT) the emission spectrum and its characteristics was recorded with an EMI-receiver, broadband antenna and software.
The measurements are performed in horizontal and vertical polarization of the measurement antennas. The results are documented in a diagram. Critical frequencies (low margin to limit) are saved within a table for further investigations. If various operating modes are supported, further investigations are made to find the worst-case of them. Also the interconnection cables and equipment position were varied in order to maximize the emissions.

Final measurement on critical frequencies
Based on the exploratory measurements, the most critical frequencies are re-measured by maintaining the EUT's worst-case operation mode, cable position, etc.

First a frequency zoom around the critical frequency is done to locate the frequency more precisely. After this step, for all identified critical frequencies, the maximum peak was determined.

Following parameters were varied: the turntable angle continuously in the range 0 to 360 degree, the EUT itself over 3-orthogonal axis, the antenna height and tilting or three axis scan for portable/small equipment.

On the determined worst-case position, a final measurement with necessary bandwidth and detector according standard has been carried out.

Formula:

$E_C = E_R + A_F + C_L + D_F - G_A$ (1)

$M = L_T - E_C$ (2)

E_C = Electrical field – corrected value
E_R = Receiver reading
M = Margin
L_T = Limit
A_F = Antenna factor
C_L = Cable loss
D_F = Distance correction factor (if used)
G_A = Gain of pre-amplifier (if used)

All units are dB-units, positive margin means value is below limit.

4.11.2 Sample calculation

Raw-Value [dBuV/m]	Antenna factor	Distance Correction [dB]	Cable Loss + Preamplifier	Resulting correction value [dB]	Final result [dBuV/m]	Remarks
29.37	41.20	--	24.28	16.92	46.3	CableLoss and PreAmp data in one data correction file

Remark: This calculation is based on an example value at 10 GHz

4.11.3 Measurement Location

Test site 1 – 15 GHz	120904 - FAC1 - Radiated Emissions
Test site 15 – 26.5 GHz	120907 - FAC2

4.11.4 Limit

Radiated emissions limits, (3 meters)				
Frequency Range [MHz]	**Limit [µV/m]**	**Limit [dBµV/m]**	**Detector**	**RBW / VBW [kHz]**
Above 1000	500	54	Average	1000 / 3000
Above 1000	5000	74	Peak	1000 / 3000

4.11.5 Result

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 1 – 15 GHz	Result
4.01a	1	Op.1	56.825 @ 14.409 GHz (AV)	Passed
4.02a	300	Op.1	50.958 @ 13.047 GHz (AV)	Passed
4.03a	600	Op.1	45.305 @ 6.617 GHz (AV)	Passed

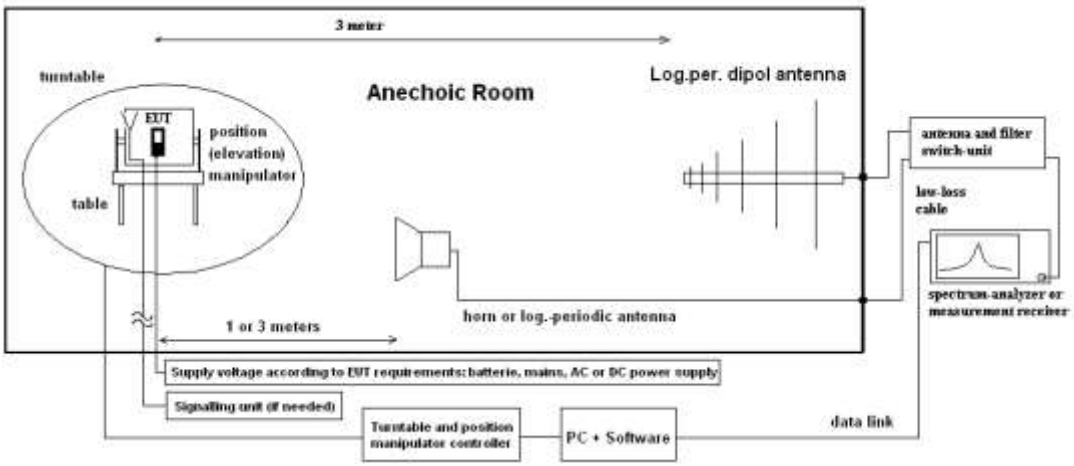
Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 15 – 26.5 GHz	Result
4.01b	1	Op.1	42.98 @ 19.212 GHz (AV)	Passed
4.02b	300	Op.1	43.00 @ 19.571 GHz (AV)	Passed
4.03b	600	Op.1	43.44 @ 19.890 GHz (AV)	Passed

Remark: for more information and graphical plot see annex A1**CETECOM_TR21-1-0183201T01a_A1**

4.12 Radiated Band-Edge emissions

4.12.1 Description of the general test setup and methodology, see below example:

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page 6)

For uncritical results where a measurement resolution bandwidth of 1MHz can clearly show the compliance without influencing the results, a field strength measurement was performed to show compliance.

For critical results a Marker-Delta marker method was used for showing compliance to restricted bands.
The method consists of three independent steps:

1. Step: Prior to the measurement the fundamental radiated In-Band field strength was performed. The determined value is used as reference value.

2. Step: Second step consist of finding the relative attenuation between the fundamental emission and the maximum local out-of-band emission (within 2 MHz range around the band edge either on the band-edge directly or some modulation product if the level is greater than that on the band-edge) when measured with lower resolution bandwidth.

3. .Step: The delta value recorded in step 2 will be subtracted from value recorded in step 1, thus giving the required field strength at the band-edge. This value must fulfil the requirements for radiated spurious emissions in restricted bands in FCC §15.205 with the general limits of FCC §15.209

The EUT was instructed to send with maximum power (if adjustable) according to applicants instructions.

4.12.2 Measurement Location

Test site	120904 - FAC1 - Radiated Emissions

4.12.3 Limit

Frequency Range [MHz]	Pk Limit [dBc]	Avg Limit [dBc]	Avg Limit [dBµV/m]	Pk Limit [dBµV/m]	Detector	RBW / VBW [kHz]
Below 2390	-	-	54	74	Average / Peak	100 / 300
Above 2483.5	-	-	54	74	Average / Peak	1000 / 3000
2390 - 2400	-20	-	-	-	Peak	100 / 300
2390 - 2400	-	-30	-	-	Average	100 / 300

4.12.4 Result

Non-restricted bands near-by

Diagram	Channel	Mode	Peak [dBc]	Average [dBc]	Result
9.01	1	Op.1	49.29	58.49	PASSED
9.03	1-600	Op.2	42.23	43.26	PASSED

Remark: for more information and graphical plot see annex A1**CETECOM_TR21-1-0183201T01a_A1**

Restricted bands near-by

Diagram	Channel	Mode	Peak [dBµV/m]	Average [dBµV/m]	Result
9.02	600	Op.1	59.01	48.10	PASSED
9.04	1-600	Op.2	67.74	50.39	PASSED

Remark1: No DC correction necessary because of noise signal.
Remark2: for more information and graphical plot see annex A1**CETECOM_TR21-1-0183201T01a_A1**

4.13 Equipment lists

ID	Description	Manufacturer	SerNo	CheckType	Last Check	Interval	Next Check

Tools used in 'P1M1'

4.13.1 Legend

Note / remarks	Interval of calibration & Verification
12M	12 months
24M	24 months
36M	36 months
10Y	10 Years

Abbreviation Check Type	Description
cnn	Calibration and verification not necessary
cal	Calibration
calchk	Calibration plus intermediate Verification
chk	Verification
cpu	Verification before usage

5 Results from external laboratory

None	-

6 Opinions and interpretations

None	-

7 List of abbreviations

None	-

8 Measurement Uncertainty valid for conducted/radiated measurements

The reported uncertainties are calculated based on the standard uncertainty multiplied with the appropriate coverage factor **k**, such that a confidence level of approximately 95% is achieved. For uncertainty determination, each component used in the concrete measurement set-up was taken in account and it contribution to the overall uncertainty according its statistical distribution calculated.

RF-Measurement	Reference	Frequency range	Calculated uncertainty based on a confidence level of 95%						Remarks
Conducted emissions (U_{CISPR})	-	9 kHz - 150 kHz 150 kHz - 30 MHz	4.0 dB 3.6 dB						-
Power Output radiated	-	30 MHz - 4 GHz	3.17 dB						Substitution method
Power Output conducted	-	Set-up No.	Cel-C1	Cel-C2	BT1	W1	W2	--	
		9 kHz - 12.75 GHz	N/A	0.60	0.7	0.25	N/A	--	-
		12.75 GHz - 26.5 GHz	N/A	0.82	--	N/A	N/A	--	
Conducted emissions on RF-port	-	9 kHz - 2.8 GHz	0.70	N/A	0.70	N/A	0.69	--	N/A - not applicable
		2.8 GHz - 12.75 GHz	1.48	N/A	1.51	N/A	1.43	--	
		12.75 GHz – 18 GHz	1.81	N/A	1.83	N/A	1.77	--	
		18 GHz - 26.5 GHz	1.83	N/A	1.85	N/A	1.79	--	
Occupied bandwidth	-	9 kHz - 4 GHz	0.1272 ppm (Delta Marker)						Frequency error
			1.0 dB						Power
Emission bandwidth	-	9 kHz - 4 GHz	0.1272 ppm (Delta Marker)						Frequency error
	-		See above: 0.70 dB						Power
Frequency stability	-	9 kHz - 20 GHz	0.0636 ppm						-
Radiated emissions Enclosure	-	150 kHz - 30 MHz	5.01 dB						Magnetic field strength
		30 MHz - 1 GHz 1 GHz - 18 GHz 18 GHz - 26.5 GHz	5.83 dB 4.91 dB 5.06 dB						Electrical Field strength

9 Versions of test reports (change history)

Version	Applied changes	Date of release
--	Initial release	2022-May-03
C01	Updated frequency range in section 3.2: Updated results in section 4.11 and in Annex 1	2022-May-05

End Of Test Report