Test Report
20-1-0159401T01a-C1

DAkkS Deutsche Akkreditierungsstelle D-PL-12047-01-01 D-PL-12047-01-03 D-PL-12047-01-04

Number of pages:	33	**Date of Report:**	2021-Mar-18
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:**	Spotta Limited
Product:	**Smart pest monitor**		
Model:	**Bed Pod**		
FCC ID:	2AYCHPODB000-07-206	**IC:**	26742-PODB07206
Testing has been carried out in accordance with:	Title 47 CFR, Chapter I FCC Regulations, Subchapter A, Subpart C: §15.247 (FHSS) RSS-247 (FHSs), Issue 2 (Feb 2017) Deviations, modifications or clarifications (if any) to above mentioned documents are written in each section under "Test method and limit".		
Tested Technology:	LoRa (FHSS)		
Test Results:	**☒ The EUT complies with the requirements in respect of all parameters subject to the test.** The test results relate only to devices specified in this document		

The current version of the test report CETECOM-TR20-1-0159401T01a-C1 replaces the test report CETECOM-TR20-1-0159401T01a, dated 2021-Feb-10. The replaced test report is herewith invalid.

Signatures:

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Head of Compliance Testing	Test manager
Authorization of test report	Responsible of test report

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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.

1.1. 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	ANSI 63.10:2013	--	11	--	PASSED
Emission Bandwidth 20 dB	§15.247 (a) (1)	RSS-247, Issue 2, § 5.1,a	13	--	PASSED
Occupied Channel Bandwidth 99%	2.1049(h)	RSS-Gen, Issue 5, § 6.6	17	--	For information only
Carrier Frequency Separation	§15.247 (a) (1)	RSS-247, Issue 2, § 5.1,b	14	--	PASSED
Number of Hopping Channels	§15.247 (a) (1) (iii)	RSS-247, Issue 2, § 5.1,d	15	--	PASSED
Time of Occupancy	§15.247 (a) (1) (iii)	RSS-247, Issue 2, § 5.1,d	16	--	PASSED
Peak output power	§15.247(b)(1)	RSS-247, Issue 2: 5.1 (b)	12	--	PASSED
Transmitter Peak output power radiated	§15.247(b)(4)	RSS-247, Issue 2: 5.1 (b)	--	N/A	--
Emissions in non-restricted frequency bands	§15.247(d)	RSS-247, § 5.5	19	--	PASSED
Radiated Band-Edge emissions	§15.247(d)	RSS-247, § 5.5 RSS-Gen: Issue 5: §8.9 Table 5+6+7	27	--	PASSED
Radiated field strength emissions below 30 MHz	§15.205(a) §15.209(a)	RSS-Gen: Issue 5 §8.9 Table 6	21	--	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	23	--	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	25	--	PASSED
AC-Power Lines Conducted Emissions	§15.207	RSS-Gen Issue 5: § 8.8, Table 4	--	N/A	--

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.
NT	Not tested
N/A	Not applicable

*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.

1.2. Summary of Test Methods

Test case	Test method
Duty-Cycle	ANSI 63.10:2013, §11.6(b)
Emission Bandwidth 20 dB	ANSI C63.10:2013
Occupied Channel Bandwidth 99%	ANSI C63.10:2013, §6.9.3
Carrier Frequency Separation	ANSI C63.10:2013
Number of Hopping Channels	ANSI C63.10:2013
Time of Occupancy	ANSI C63.10:2013
Peak output power (Sweep)	ANSI 63.10:2013, §6.101
Power spectral density	ANSI C63.10:2013, §6.9.2, §11.8
Emissions in non-restricted frequency bands	ANSI C63.10:2013, §11.11, §6.10.5
Radiated Band-Edge emissions	ANSI C63.10-2013; “Marker-Delta method”, §6.10.5, §11.13
Transmitter Peak output power radiated	Result calculated with measured conducted RF-power value and stated/measured antenna gain for band of interest
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
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:	Ninovic Perez
Accreditation scope:	DAkkS Webpage
Test location:	Wählen Sie ein Element aus.

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

Order No.:	
Responsible test manager:	Christian Lorenz
Receipt of EUT:	2020-Nov-16
Date(s) of test:	2020-Nov-17 – 2021-Jan-28
Version of template:	14.4

2.5 Applicant’s details

Applicant’s name:	Spotta Limited
Address:	620 Newmarket Road CB5 8LP Cambridge United Kingdom
Contact Person:	Neil D'Souza-Mathew
Contact Person’s Email:	neil.dsouza@spotta.co

2.6 Manufacturer’s details

Manufacturer’s name:	Spotta Limited
Address:	620 Newmarket Road CB5 8LP Cambridge United Kingdom

2.7 EUT: Type, S/N etc. and short descriptions used in this test report

Short description*)	PMT Sample No.	Product	Model	Type	S/N	HW status	SW status
EUT 01	20-1-01594S11_C01	Smart pest monitor	Bed Pod	Smart pest monitor	S02 EMC	A v7	v2.0.6
EUT 02	20-1-01594S12_C01	Smart pest monitor	Bed Pod	Smart pest monitor	S05 conducted 17	A v7	v2.0.6

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

2.8 Auxiliary Equipment (AE): Type, S/N etc. and short descriptions

Short description*)	PMT Sample No.	Auxiliary Equipment	Type	S/N	HW status	SW status
AE 01	20-1-01594S04_C01	Test Board	N/A	N/A	N/A	N/A
AE 02	20-1-01594S06_C01	ST-LINK	N/A		N/A	N/A

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

2.9 Connected cables

Short description*)	PMT Sample No.	Cable type	Connectors	Length
CAB 01	20-1-01594S05_C01	USB Cable	N/A	N/A

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

2.10 Software

Short description*)	PMT Sample No.	Software	Type	S/N	HW status	SW status
	--	--	--	--	--	--

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

2.11 EUT set-ups

set-up no.*)	Combination of EUT and AE	Description
1	EUT 01 + (AE01 + AE02 + CAB1)	Used for Radiated measurements. AE01+ AE02 + CAB01 used temporary to set-up the sample to certain tested Op. Mode
2	EUT 02 + (AE01 + AE02 + CAB1)	Used for Conducted measurements

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

2.12 EUT operation modes

EUT operating mode no.*1)	Operating modes	Additional information
op. 1	CW mode on fixed channel	The EUT was put to Fixed Channel Continuous transmissions mode
op. 2	Hopping mode	Hopping mode over full 64 channels with nominal BW of 125kHz.

*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

Product name	Bed Pod		
Kind of product	Smart Pest Monitor		
Firmware	☐ for normal use	☒ Special version for test execution Fixed channels: CW9085_9dBm.hex CW9023_9dBm.hex CW9149_9dBm.hex Hopping channels: Hopping_SpedUp.hex Timing Duty-Cycle 100ms: PacketSend9085MinDuty.hex	
Power supply	☐ AC Mains	--	
	☐ DC Mains	--	
	☒ Battery	1Pcs. AA battery, 1.5V (not chargeable inside device)	
Operational conditions	T_{nom} =21 °C	T_{min} =-- °C	T_{max} =-- °C
EUT sample type	**Pre-Production**		
Weight	See photographs		
Size	See photographs		
Interfaces/Ports	None		
For further details refer Applicants Declaration & following technical documents			
For further details regarding radio parameters, please refer to Core LoRa Specification			

3.2 Detailed Technical data of Main EUT as declared by Applicant

Frequency Band	902-928 MHz ISM Band
Number of Uplink Channels (USA/Canada -bands)	Uplink: 64 (902.3MHz to 914.9MHz with 200kHz nominal steps) Downlink: 8 (923.3 – 927.5MHz)
Nominal Channel Bandwidth	125 kHz (only)
Type of Modulation | Data Rate	☒ Chirp Spread Spectrum – CSS (chirp bandwidth 125kHz only)
Device class	☒ A ☐ B ☐ C
Other installed RF- options	☐ none
Max. Conducted Output Power	Nominal rated: **9** dBm
EIRP Power (Calculated EIRP)	8.95 dBm + 5.83 dBi = 14.78 dBm
Antenna Type(s)	Integrated
Antenna Gain(s)	Max. 5.83dBi
FCC label attached	No
Test firmware / software and storage location	EUT internal storage
For further details refer Applicants Declaration & following technical documents	

Description of Reference Document (supplied by applicant)	Version	Total Pages
Antenna documentation: WL-GSMI17-028	**1.0**	**7**

3.3 Modifications on Test sample

Additions/deviations or exclusions	none

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	120911 - Radio Lab2

4.1.2 Result

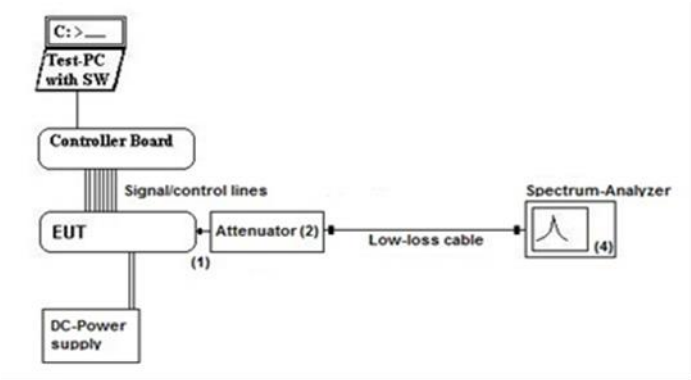
Duty-Cycle [%]	Duty-Cycle correction Power [dB]	Duty-Cycle correction Field Strength [dB]
17.54	--	-15.11
25.88	--	-11.74 (minimum reduction, worst-case)

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 connected to spectrum-analyzer (4) for RF-conducted measurements. The specific attenuation loss is determined prior to the measurement within a set-up attenuation measurement. These are then taken into account by correcting the measurement readings of 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)

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	120911- Radio lab2

4.2.3 Limit

Frequency Range [MHz]	Limit [W]	Limit [dBm]	Detector	RBW / VBW [MHz]
902-928	1	30	MaxPeak	1 / 10

4.2.4 Result

Mode	Channel	Frequency [MHz]	Max Peak Power [dBm]	Result
1	Low	902.3	8.88	Pass / D01
1	Middle	908.5	8.95	Pass / D02
1	High	914.9	8.89	Pass / D03

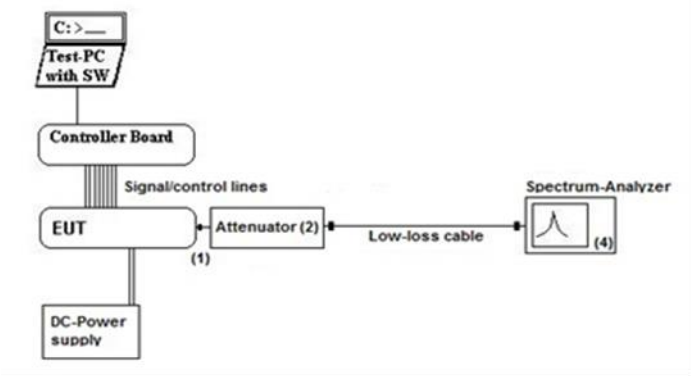
Remark: for more information and graphical plot see annex **CETECOM_TR20_1_0159401T01a_A1**

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 connected to spectrum-analyzer (4) for RF-conducted measurements. The specific attenuation loss is determined prior to the measurement within a set-up attenuation measurement. These are then taken into account by correcting the measurement readings of 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)

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	120911 - Radio lab2

4.3.3 Limit

Limit [kHz]	Detector [MaxHold]	RBW / VBW [kHz]
--	MaxPeak	3 / 10

4.3.4 Result

Op.Mode	Channel	Frequency [MHz]	20 dB bandwidth [kHz]	Limit	Result
2	Near Middle	908.478	133.557	§15.247(a)(1)(i): Max. 500kHz	Passed Not overlapping 20dB BW channels

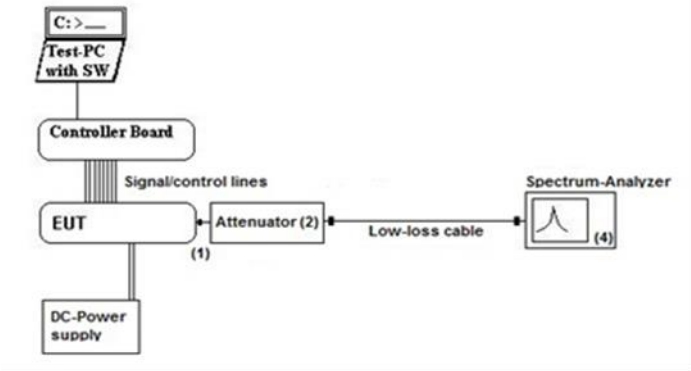
Remark: for more information and graphical plot see annex A1**CETECOM_TR20_1_0159401T01a_A1**

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 connected to spectrum-analyzer (4) for RF-conducted measurements. The specific attenuation loss is determined prior to the measurement within a set-up attenuation measurement. These are then taken into account by correcting the measurement readings of 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)

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	120911 - RadioLab 2

4.4.3 Limit

Limit [MHz]	Detector [MaxHold]	RBW / VBW [kHz]
>= 0.025 or 2/3 of the 20 dB bandwidth	MaxPeak	3 / 10

4.4.4 Result

Op. Mode	Channel	Frequency [MHz]	Frequency Separation [kHz]	Limit	Result
2	Middle	908.408	199.5064	§15.247(a)(1): 25kHz or 20dB BW whichever greater (=133.557kHz)	Passed

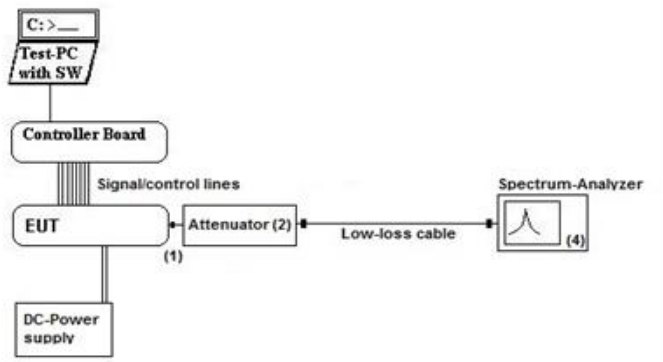
Remark: for more information and graphical plot see annex A1**CETECOM_TR20_1_0159401T01a_A1**

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)

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	120911 - RadioLab 2

4.5.3 Limit

Limit [number]	Detector [MaxHold]	RBW / VBW [kHz]
15	MaxPeak	30 / 10000

4.5.4 Result

Op.Mode	Number of hopping channels	Limit	Result
2	64	§15.247(b)(2): 50 channels	Passed

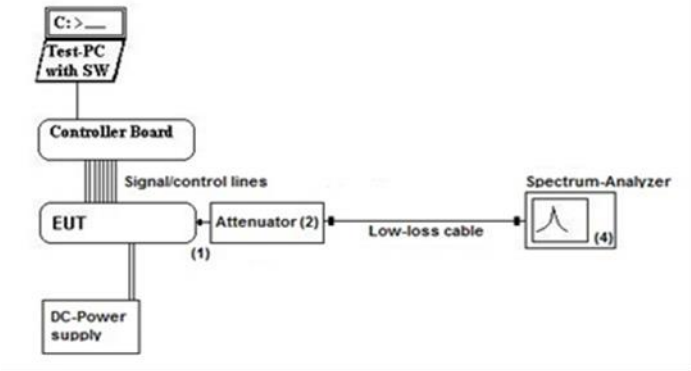
Remark: for more information and graphical plot see annex A1**CETECOM_TR20_1_0159401T01a_A1**

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 connected to spectrum-analyzer (4) for RF-conducted measurements. The specific attenuation loss is determined prior to the measurement within a set-up attenuation measurement. These are then taken into account by correcting the measurement readings of 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)

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	120911 - RadioLab 2

4.6.3 Limit

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

4.6.4 Result

Mode	Max. Transmission time [ms]	Time of occupancy (accumulated)	Limit:	Result
2	25.80ms	25.80	§15.247(a)(1)(i): 0.4 seconds within 20second period if minimum 50 channels involved.	Passed

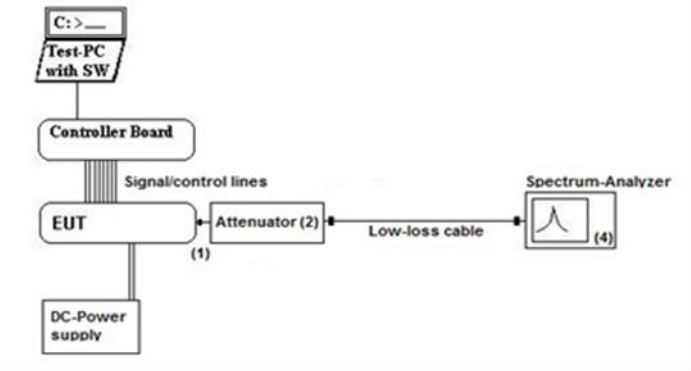
Remark: for more information and graphical plot see annex **CETECOM_TR20_1_0159401T01a_A1**

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 connected to spectrum-analyzer (4) for RF-conducted measurements. The specific attenuation loss is determined prior to the measurement within a set-up attenuation measurement. These are then taken into account by correcting the measurement readings of 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)

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	120911 - RadioLab 2

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 [kHz]
2	Low	902.3	125.442 – for information only
2	Middle	908.72	**127.466** – for information only
2	High	914.9	122.958 – for information only

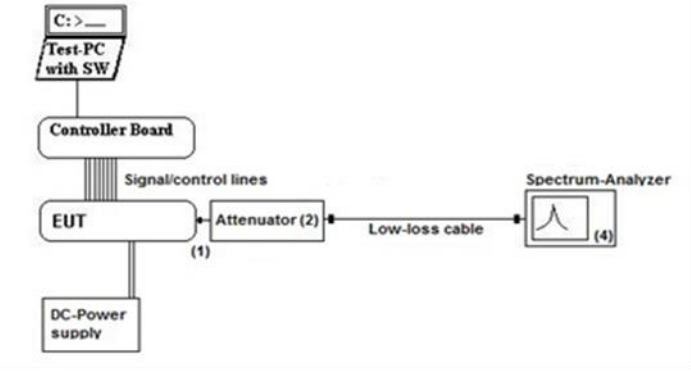
Remark: for more information and graphical plot see annex **CETECOM_TR20_1_0159401T01a_A1**

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 connected to spectrum-analyzer (4) for RF-conducted measurements. The specific attenuation loss is determined prior to the measurement within a set-up attenuation measurement. These are then taken into account by correcting the measurement readings of 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)

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 10 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	120911 - RadioLab 2

4.8.3 Limit

Frequency Range [MHz]	Limit [dBc]
0.15 – 10000	-20 (Peak) / -30 (RMS)

4.8.4 Results

Maximum Level channel low (Peak): 9.28 dBm

Mode	Channel	Frequency range	Frequency [MHz]	Result
1	Low	910MHz -3GHz	1804.52	36.07 dBc - Passed
1	Low	3-10GHz	8216.346154	>40 dBc - Passed
	Low Hopping mode	Around 902MHz	--	> 20 dBc - Passed

Remark: for more information and graphical plot see diagrams D10 – D.13 and D23 in annex **CETECOM_TR20_1_0159401T01a_A1**

Maximum Level channel middle (Peak): 9.26 dBm

Mode	Channel	Frequency range	Frequency [MHz]	Result
1	Middle	910MHz - 3GHz	1817.060	35.65 dBc - Passed
1	Middle	3GHz- 10 GHz	--	> 40 dBc - Passed
--	--	--	--	--

Remark: for more information and graphical plots see see diagrams D15 – D.18 in annex **CETECOM_TR20_1_0159401T01a_A1**

Maximum Level channel high (Peak): 9.20 dBm

Mode	Channel	Frequency range	Frequency [MHz]	Result
1	High	912 MHz – 3GHz	1830.528846	35.82 dBc - Passed
1	High	3 – 10 GHz	--	> 40 dBc – Passed
2	High hopping mode	Around 928MHz	--	52.75 dBc - Passed

Remark: for more information and graphical plots see diagrams D19 – D.22 and D24 in annex **CETECOM_TR20_1_0159401T01a_A1**

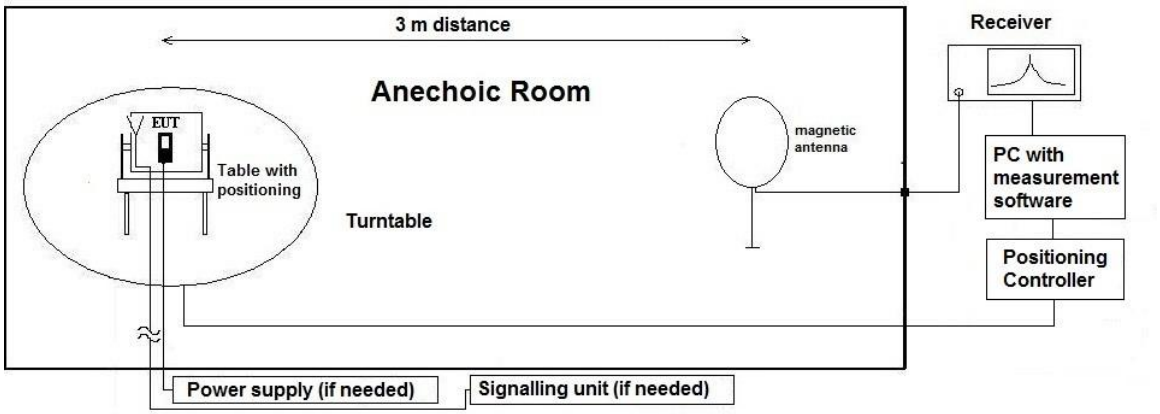
4.9 Radiated field strength emissions below 30 MHz

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 Measurement Location

Test site	120901 - SAC - Radiated Emission <1GHz

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)	2'te Condition (Limit distance bigger dnear-field)	Distance Correction accord. Formula
	9.00E+03	33333.33	5305.17			fullfilled	not fullfilled	-80.00
	1.00E+04	30000.00	4774.65			fullfilled	not fullfilled	-80.00
	2.00E+04	15000.00	2387.33			fullfilled	not fullfilled	-80.00
	3.00E+04	10000.00	1591.55			fullfilled	not fullfilled	-80.00
	4.00E+04	7500.00	1193.66			fullfilled	not fullfilled	-80.00
	5.00E+04	6000.00	954.93			fullfilled	not fullfilled	-80.00
	6.00E+04	5000.00	795.78			fullfilled	not fullfilled	-80.00
	7.00E+04	4285.71	682.09			fullfilled	not fullfilled	-80.00
	8.00E+04	3750.00	596.83	**300**		fullfilled	not fullfilled	-80.00
	9.00E+04	3333.33	530.52			fullfilled	not fullfilled	-80.00
kHz	1.00E+05	3000.00	477.47			fullfilled	not fullfilled	-80.00
	1.25E+05	2400.00	381.97			fullfilled	not fullfilled	-80.00
	2.00E+05	1500.00	238.73			fullfilled	fullfilled	-78.02
	3.00E+05	1000.00	159.16			fullfilled	fullfilled	-74.49
	4.00E+05	750.00	119.37			fullfilled	fullfilled	-72.00
	4.90E+05	612.24	97.44			fullfilled	fullfilled	-70.23
	5.00E+05	600.00	95.49			fullfilled	not fullfilled	-40.00
	6.00E+05	500.00	79.58			fullfilled	not fullfilled	-40.00
	7.00E+05	428.57	68.21			fullfilled	not fullfilled	-40.00
	8.00E+05	375.00	59.68			fullfilled	not fullfilled	-40.00
	9.00E+05	333.33	53.05			fullfilled	not fullfilled	-40.00
	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	**30**		fullfilled	fullfilled	-24.04
	10.60	28.30	4.50			fullfilled	fullfilled	-23.53
MHz	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

4.9.3 Limits

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

4.9.4 Results

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 0.009 – 30 MHz	Result
2.01a	Low	TX, CW Mode, Ch low	No peaks found	Passed
2.01b	Low	TX, CW Mode, Ch low	No peaks found	Passed
2.02a	Mid	TX, CW Mode, Ch Mid (908.5MHz)	No peaks found	Passed
2.02b	Mid	TX, CW Mode, Ch Mid (908.5MHZ)	17,83	Passed:
2.03a	High	TX-on, CW, Ch high (914.9MHz)	No peaks found	Passed
2.03b	High	TX, CW Mode, Ch low	19,37	Passed

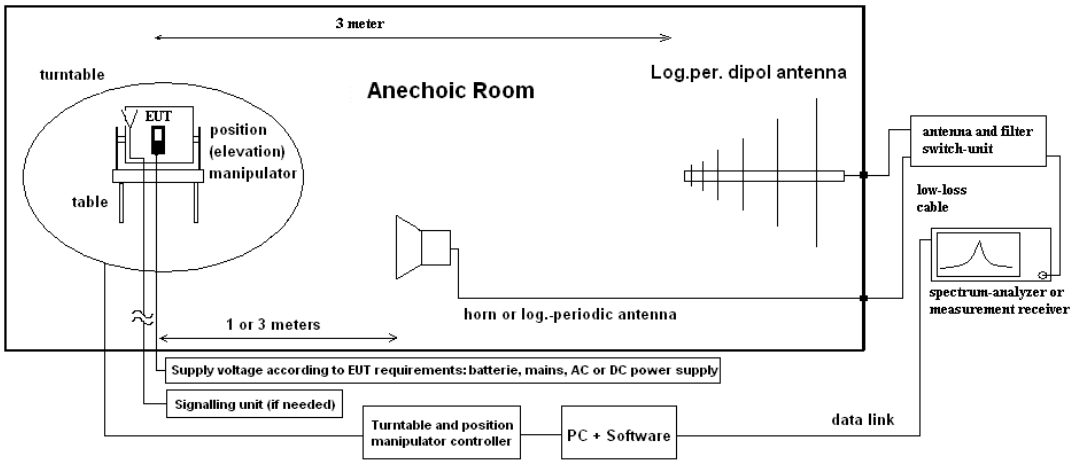
Remark: for more information and graphical plot see annex **CETECOM_TR20_1_0159401T01a_A1**

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 Measurement Location

Test site	120904 - FAC1 - Radiated Emissions

4.10.3 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

4.10.4 Result

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 30 – 1000 MHz	Result
3.03a	High	TX, CW Mode	29,58	Passed
3.03b	High	TX, CW Mode	No peaks found	Passed
3.05a	Low	TX, CW Mode, Ch low	No peaks found	Passed
3.05b	Low	TX, CW Mode, Ch low	No peaks found	Passed
3.07a	Mid	TX, CW Mode	34,01	Passed
3.07b	Mid	TX, CW Mode, Ch middle	29,57	Passed

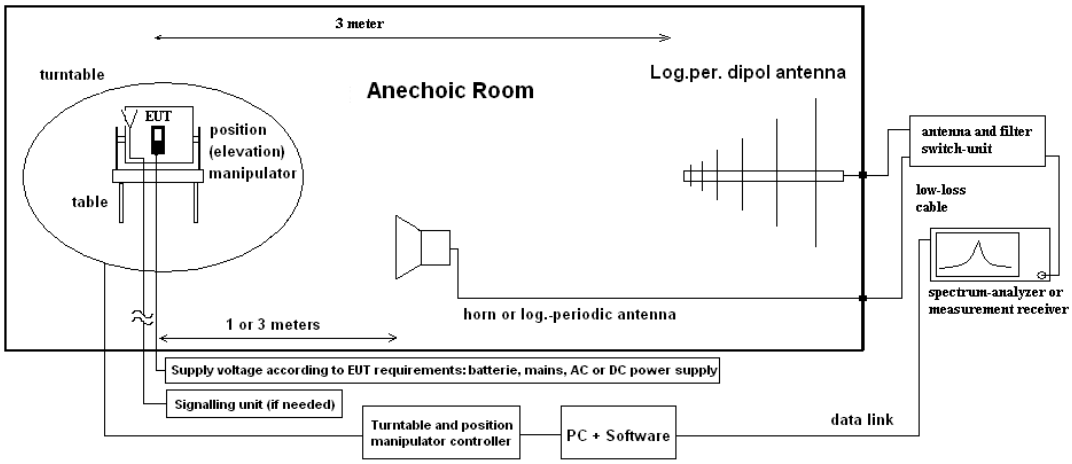
Remark: for more information and graphical plot see annex **CETECOM_TR20_1_0159401T01a_A1**

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 Measurement Location

Test site 1 – 10 GHz	120904 - FAC1 - Radiated Emissions

4.11.3 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

4.11.4 Result

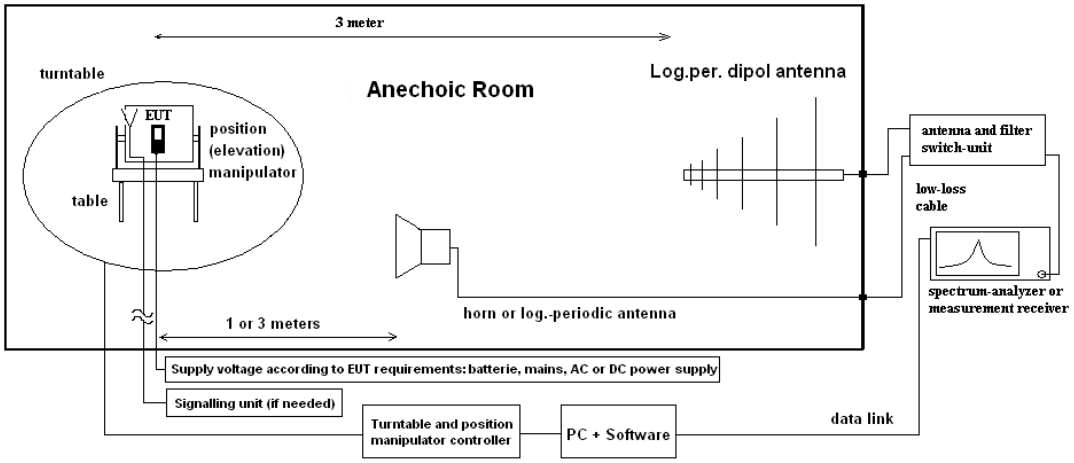
Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 1 – 18 GHz	Result
8.16a	High	TX, continuous, CW	60.86 (PK)@1829.8MHz 52.64 (AV)@2744.72MHz	Passed
8.16b	High	TX, CW Mode	52.62 (PK)@3659.6MHz 56.37 (PK)@8234.0MHz	Passed
8.17a	Mid	TX, continuous, CW	58.54 (PK)@1817.0MHz	Passed
8.17b	Mid	TX CW Mode	53.67 (PK)@3634.0MHz 57.67 (PK)@8176.4MHz	Passed
8.18a	Low	CW Mode	60.09 (PK)@1804.6MHz 55.73 (AV)@1804.6MHz 50.63 (AV)@2706.92MHz	Passed
8.18b	Low	TX, CW Mode	58.26 (PK)@8120.8MHz 46.52 (AV)@8120.8MHz	Passed

Remark:
1. for determination of AV values, due pulsed emission/duty-cycle of carrier, a AV-PK factor of -11.74dB can apply to Peak values in regard to harmonics generated. See chapter 1.7 of annex A1 for calculation.
2.for more information and graphical plot see annex **CETECOM_TR20_1_0159401T01a_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 100kHz 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	120901 - SAC - Radiated Emission <1GHz

4.12.3 Limits

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
Except 902-928 2390 - 2400	-20	-	-	-	Peak	100 / 300
2390 - 2400	-	-30	-	-	Average	100 / 300

4.12.4 Results

Non-Hopping Mode:

Diagram	Channel	Mode	Peak [dBc]	Average [dBc]	Result
3.04a_BE	High	1 (CW)	54.07	--	Passed
3.04b_BE	High	1 (CW)	48.37	--	Passed
3.06a_BE	Low	1 (CW)	49.03	--	Passed
3.06b_BE	Low	1 (CW)	49.71	--	Passed

Remark: for more information and graphical plots see annex **CETECOM_TR20_1_0159401T01a_A1**

Hopping mode:

Diagram	Channel	Mode	Peak [dBc]	Average [dBc]	Result
3.08a_BE	All	2 (Hopping mode)	53.58 (Low) 50.42 (High)	--	Passed
3.08b_BE	All	2 (Hopping mode)	49.79 (Low) 47.41 (High)	--	Passed

Remark1: for more information and graphical plost see annex **CETECOM_TR20_1_0159401T01a_A1**

4.13 Results from external laboratory

None	-

4.14 Opinions and interpretations

None	-

4.15 List of abbreviations

None	-

5 Equipment lists

ID	Description	Manufacturer	SerNo	Cal due date
	120901 - SAC - Radiated Emission <1GHz			**2025-Jul-21**
20574	Biconilog Hybrid Antenna BTA-L	Frankonia GmbH	980026L	2022-May-03
20487	CETECOM Semi Anechoic Chamber < 1GHz	ETS-Lindgren Gmbh	-	2025-Jul-15
20341	Digital Multimeter Fluke 112	Fluke Deutschland GmbH	81650455	2022-May-25
20620	EMI Test Receiver ESU26	Rohde & Schwarz Messgerätebau GmbH	100362	2021-May-13
20482	filter matrix Filter matrix SAR 1	CETECOM GmbH	-	
25038	Loop Antenna HFH2-Z2	Rohde & Schwarz Messgerätebau GmbH	879824/13	2022-Apr-07
20885	Power Supply EA3632A	Agilent Technologies Deutschland GmbH	75305850	
	120904 - FAC1 - Radiated Emissions			**2021-Mai-07**
20558	CETECOM Fully Anechoic Chamber	CETECOM GmbH	-	
20489	EMI Test Receiver ESU40	Rohde & Schwarz Messgerätebau GmbH	1000-30	2021-May-13
20254	High Pass Filter 5HC 2600/12750-1.5KK (GSM1800/1900/DECT)	Trilithic	23042	
20549	Log. Per. Antenna HL025	Rohde & Schwarz Messgerätebau GmbH	1000060	2021-Jul-31
20720	Measurement Software EMC32 [FAC]	Rohde & Schwarz Messgerätebau GmbH	V10.xx	
20700	PC ctc662012 [FAC]	Dell Inc.		
20611	Power Supply E3632A	Agilent Technologies Deutschland GmbH	KR 75305854	

ID	Description	Manufacturer	SerNo	Cal due date
20484	Pre-Amplifier 2,5GHz - 18GHz AMF-5D-02501800-25-10P	Miteq Inc.	1244554	
20287	Pre-Amplifier 25MHz - 4GHz AMF-2D-100M4G-35-10P	Miteq Inc.	379418	
20690	Spectrum Analyzer FSU	Rohde & Schwarz Messgerätebau GmbH	100302/026	2021-May-23
	120911 - Radio Laboratory 2			
20690	Spectrum Analyzer FSU	Rohde & Schwarz Messgerätebau GmbH	100302/026	2021-May-23
20468	Digital Multimeter Fluke 112	Fluke Deutschland GmbH	90090455	2021-May-16

6 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	5.01dB						Magnetic field strength

		30 MHz - 1 GHz 1 GHz - 18 GHz 18-26.5 GHz	5.83 dB 4.91 dB 5.06 dB	Electrical Field strength

7 Versions of test reports (change history)

Version	Applied changes	Date of release
--	Initial release	2021-Feb-10
C1	Correction typo FCC-ID	2021-Mar-15
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End Of Test Report