

TEST REPORT

No.: 16-1-0109701T07a

According to:
FCC Regulations
Part 1.1310 , Part 2.1091

for

Gemalto M2M GmbH

ELS31-US LTE module

FCC-ID: QIPELS31-US

Laboratory Accreditation and Listings			
 DAkkS Deutsche Akkreditierungsstelle D-PL-12047-01-01	 FEDERAL COMMUNICATIONS COMMISSION FC USA MRA US-EU 0003	 Industry Canada Reg. No.: 3462D-2 Reg. No.: 3462D-3	 Voluntary Controls for Electromagnetic Emissions Reg. No.: R-2666 C-2914, T-1967, G-301
 WiFi ALLIANCE AUTHORIZED RF LABORATORY	 ctia Authorized TM Test Lab Lab Code: 20011130-00		
accredited according to DIN EN ISO/IEC 17025			
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Annex 2: SEPARATE DOCUMENT Internal photographs of EUT	TO BE SUPPLIED BY APPLICANT

The listed attachments are an integral part of this report.

1. Summary of test results

The test results apply exclusively to the test samples as presented in this Report. The CETECOM GmbH does not assume responsibility for any conclusions and generalizations taken in conjunction with other specimens or samples of the type of the item presented to tests.

Following tests have been performed to show compliance with applicable FCC Part 2.1091 and FCC Part 1.1310 of the FCC CFR 47 Rules..

1.1. TX mode, tests overview FCC Part 2.1091

No. of Diagram group	Test Cases	Port	References & Limits		EUT set-up	EUT op-mode	Result
			FCC Standard	Test limits			
--	RF Power (conducted)	Antenna terminal (conducted)	§2.1046	N/A	1	1 to 3	passed Remark 1
--	RF Power (radiated)	Cabinet	§24.232(c)	< 2 Watt (EIRP)	2	1 to 3	passed Remark 1
			§27.50(c)(10)	< 3 Watt (ERP)			
			§27.50(d)	< 1 Watt (EIRP)			
--	Radio frequency Exposure Evaluation (MPE)	Cabinet	§1.1310 §2.1091	FCC: §1.1310 Table 1, Limits for General Population	1	1 to 3	passed

Remark:

1.) See separate test report 16-1-0109701T05a and corresponding annexes



.....
Dipl.-Ing. Rachid Acharkaoui
Responsible for test section

.....
Dipl.-Ing. C. Lorenz
Responsible for test report

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. Rachid Acharkaoui
Deputy:	Dipl.-Ing. Niels Jeß

2.2. Test location

2.2.1. Test laboratory "CTC"

Company name:	see chapter 2.1. Identification of the testing laboratory
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2.3. Organizational items

Responsible for test report and project leader:	Dipl.-Ing. C. Lorenz
Receipt of EUT:	2016-09-14
Date(s) of test:	2016-09-14 to 2016-10-25
Date of report:	2017-01-04

Version of template:	13.02

2.4. Applicant's details

Applicant's name:	Gemalto M2M GmbH
Address:	Siemensdamm 50 13629 Berlin Germany
Contact person:	Mr. Axel Heike

2.5. Manufacturer's details

Manufacturer's name:	please see applicant's details
Address:	please see applicant's details

3. Equipment under test (EUT)

3.1. TECHNICAL LTE DATA OF MAIN EUT DECLARED BY APPLICANT

TX-frequency range (E-UTRA operating bands)	LTE Band 2: 1850 - 1910 MHz (Uplink), 1930-1990 MHz (Downlink) LTE Band 4: 1710 - 1755 MHz (Uplink), 2110 - 2155 MHz (Downlink) LTE Band 12: 698 - 716MHz (Uplink), 728 - 746 MHz (Downlink)		
Type of modulation	QPSK, 16-QAM		
Data rates	Cat3, Downlink: max. 100Mbps, Uplink: max. 50Mbps		
Number of channels – Table 5.4.4-1 accord. 3GPP TS36.521-1	LTE Band 2: UARFCN range 18600 - 19199 LTE Band 4: UARFCN range 19950 - 20399 LTE Band 12: UARFCN range 23010 – 23179		See Note about channels not to be used depending on channel bandwidths
Emission designator(s) (Max. Value across all operating bands)	Channel bandwidth	QPSK Modulation:	16-QAM Modulation
	1.4 MHz	Not supported	Not supported
	3 MHz	Not supported	Not supported
	5 MHz	4M50G7D	4M51W7D
	10 MHz	9M00G7D	5M08W7D, remark1
	15 MHz	13M4G7D	5M08W7D, remark 1
	20 MHz	17M9G7D	5M11W7D, remark 1
Antenna Type	☐ Integrated ☐ External, no RF-connector ☒ External, separate RF-connector: main TX + secondary RX connector		
Antenna Gain	$f < 1\text{GHz}$: -1.85dBd / 0.3dBi max. $f > 1\text{GHz}$: 2.1 dBi max.		
MAX PEAK Output Power: Radiated	LTE-Mode 2 23.86 dBm + 2.1dBi = 25.96 dBm EIRP LTE-Mode 4 23.86 dBm + 2.1dBi = 25.96 dBm EIRP LTE-Mode 12 23.44 dBm – 1.85dBd = 21.59 dBm ERP		
MAX PEAK Output Power: Conducted	LTE-Mode 2 23.86 dBm (AV) LTE-Mode 4 23.86 dBm (AV) LTE-Mode 12 23.44 dBm (AV)		
Installed option	☐ GSM 900 and GSM 1800 Bands (not usable in USA) ☐ W-CDMA Band I and Band VIII (not usable in USA)		
Power supply	☒ DC power only: 9-12 Volt on DSB75-Adapter with external AC/DC Adapter Converted to voltage range of 3.3 V to 4.2 V by DSB75-Adapter board or direct connection to DC		
Special EMI components	--		
EUT sample type	☒ Production	☐ Pre-Production	☐ Engineering
FCC label attached	☐ yes	☒ no	

Remark 1: For 16-QAM maximum 27RBs could be activated in regard to category 1 device (3GPP 36.101, Annex 2.1.3). Therefore nominal signal-bandwidth only theoretical.

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

Short description*)	EUT	Type	S/N serial number	HW hardware status	SW software status
EUT A	LTE module	ELS31-US S30960-S4520-A100	IMEI: 004401081861722	Rev01	4.3.3.0a
EUT B	2 x Broadband Antenna	OmniLOG90200	61765 61810	SMA(male)	--

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

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

AE short description *)	Auxiliary Equipment	Type	S/N serial number	HW hardware status	SW software status
AE 1	AC/DC Adapter	Model: ECP-25-12E	#1	Input: 100-240V AC, 50/60Hz, 0.8A Output: 12V DC 2.08A	--
AE 2	Eval Board	For EUT A	--	--	--
AE 3	DSB75 Adapter	AH6	--	--	--
AE 4	Development support board (Motherboard)	DSB75	#1	--	--

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

3.4. EUT set-ups

EUT set-up no. *)	Combination of EUT and AE	Remarks
set. 1	EUT A + AE 1 + AE 2+ AE 3 + AE 4	RF-Conducted Measurement set-up except frequency stability
set. 2	EUT A + EUT B + AE 1 + AE 2+ AE 3 + AE 4	RF-radiated measurement set-up
set. 3	EUT A + AE 2+ AE 3 + AE 4	RF-conducted measurement for frequency-stability

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

3.5. EUT LTE operating modes

EUT operating mode no. *)	Description of operating modes	Additional information
op. 1	LTE-Band 2 RMC Mode	A communication link is established between the mobile station (UE) and the test simulator. The transmitter is operated on its maximum rated output power class: 23dBm nominal. The input signal to the receiver is modulated with normal test modulation: QPSK or 16-QAM Modulation. The wanted RF input signal level to the receiver of the mobile station is set to a level to provide a stable communication link. NS_01 Network signalling value was used, no A-MPR was used therefore for this band.
op. 2	LTE-Band 4 RMC Mode	A communication link is established between the mobile station (UE) and the test simulator. The transmitter is operated on its maximum rated output power class: 23dBm nominal. The input signal to the receiver is modulated with normal test modulation: QPSK or 16-QAM Modulation. The wanted RF input signal level to the receiver of the mobile station is set to a level to provide a stable communication link. NS_01 Network signalling value was used, no A-MPR was used therefore for this band.
op. 3	LTE-Band 12 RMC Mode	A communication link is established between the mobile station (UE) and the test simulator. The transmitter is operated on its maximum rated output power class: 23dBm nominal. The input signal to the receiver is modulated with normal test modulation: QPSK or 16-QAM Modulation. The wanted RF input signal level to the receiver of the mobile station is set to a level to provide a stable communication link. NS_01 Network signalling value was used, no A-MPR was used therefore for this band.

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

3.6. Configuration of cables used for testing

Cable number	Item	Type	S/N serial number	HW hardware status	Cable length
Cable 1	AC/DC cable	From AE1	--	--	1.90m

4. Measurements

4.1. Radio Frequency Exposure Evaluation §2.1091

4.1.1. Test location and equipment (for reference numbers please see chapter 'List of test equipment')

test location	☒ CETECOM Essen (Chapter. 2.2.1)	☐ Please see Chapter. 2.2.2	☐ Please see Chapter. 2.2.3
	For Evaluation instruments are not needed. Results are determined by calculation based on applicants delivered Tune-Up procedure.		

4.1.2. Requirements

FCC: §1.1310	The criteria used for the evaluation of human exposure to radio frequency radiation is table 1 according FCC §1.1310 and table chapter 4.2 of RSS-102 standard and it is subject for evaluation of the RF exposure prior to equipment authorization. As the mobile equipment is authorized under Part 22 (Subpart H) and Part 24 of the FCC Rules, it is subject for evaluation of the RF exposure prior to equipment authorization.
FCC § 2.1091	Further information on evaluating compliance with these limits can be found in the FCC's OST/OET Bulletin Number 65, "Evaluating Compliance with FCC-Specified Guidelines for Human Exposure to Radiofrequency Radiation." For purposes of these requirements mobile devices are defined by the FCC as transmitters designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between radiating structures and the body of the user or nearby persons. These devices are normally evaluated for exposure potential with relation to the MPE limits given in Table 1 of Appendix A.

4.1.2.1. Valid for FCC

Table 1: LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)				
Frequency range [MHz]	Electric field strength [V/m]	Magnetic field strength [A/m]	Power density [mW/cm ²]	Averaging time [minutes]
30 - 300	61.4	0.163	1.0	6
300 - 1500	-	-	f/300	6
1500 - 100,000	-	-	5	6
(B) Limits for General Population / Uncontrolled Exposure				
0.3 - 1.34	614	1.63	*(100)	30
1.34 - 30	824/f	2.19/f	*(180/f ²)	30
30 - 300	27.5	0.073	0.2	30
300 - 1500	-	-	f/1500	30
1500 - 100,0	-	-	1.0	30

For given Power density limit at a single frequency (accord. Table 1 Limits) the maximum antenna gain can be calculated.

The used equation to predict the power density in the far-field of one single radiating antenna can be made by following equation:

$$S = \frac{EIRP}{4\pi R^2} = \frac{P * G}{4\pi R^2}$$

$$G_{NUMERIC} = \frac{S * 4\pi R^2}{P}$$

4.1.3. General Limits:

FCC: §1.1307	Cellular Radiotelephone Service (subpart H of part 22) Non-building-mounted antennas: height above ground level to lowest point of antenna < 10 m and total power of all channels > 1000 W ERP (1640 W EIRP)
FCC §1.1307	Personal Communications Services (part 24) Broadband PCS (subpart E): non-building-mounted antennas: height above ground level to lowest point of antenna < 10 m and total power of all channels > 2000 W ERP (3280 W EIRP)
FCC §1.1310	LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE) Table 1(B) Limits for General Population/Uncontrolled Exposure 300–1500 MHz: $f/1500 \text{ mW/cm}^2$ 1500–100,000 MHz: 1.0 mW/cm^2
FCC §2.1091	Subject to routine evaluation is required when the device operate at frequencies of 1.5 GHz or below and their effective radiated power (ERP) is 1.5 watts or more, or if they operate at frequencies above 1.5 GHz and their ERP is 3 watts or more.
FCC §24.232	(a) Base stations are limited to 1640 watts peak equivalent isotropically radiated power (e.i.r.p.) with an antenna height up to 300 meters HAAT. b) Mobile/portable stations are limited to 2 watts e.i.r.p. peak power, ...
FCC §22.913	(a) Maximum ERP. The effective radiated power (ERP) of base transmitters and cellular repeaters must not exceed 500 Watts. The ERP of mobile transmitters and auxiliary test transmitters must not exceed 7 Watts.
FCC §27.50 (C)(10)	(10) Portable stations (hand-held devices) are limited to 3 watts ERP; and
FCC §27.50(d)	(4) Fixed, mobile, and portable (hand-held) stations operating in the 1710-1755 MHz band are limited to 1 watt EIRP.
KDBs	No. 447498 D01 v06

4.1.4. Evaluation Method

Valid for W-CDMA/LTE Mode:

- The power was considered on 3 frequencies (lowest/middle/highest) within each operable FDD-band (see separate report for LTE technology) and the results compared to applicant's declared power values (tune-up info). A RMS detector was used.
- No duty-cycle correction factor is applicable

Please find in the following tables the calculations based on declared values as presented in document "Tune-Up procedure LTE bands 2,4 and 12" from 11/25/2116 (R0.1)

4.2. Results for fixed and mobile operations

Following documents have been used:

- Used main antenna specification document “Gemalto-ELS31-US-Tune up procedure”, dated 2016-11-25, document control number: R0.1

4.2.1. Results for lower operational band: LTE Band 12

Distance	20	cm										
Operating Mode	Frequency on channel	Declared maximum conducted output power	Max. positive tolerance according manufacturer	Calculated maximum ERP (declared+ Tune-up+ antenna Gain) (dBm)	Duty cycle	Declared Maximum ERP	Equivalent ERP (maximum ERP x duty cycle) (mW)	MPE Limit accord. Table 1 (mW/cm ²)	MPE-Value (mW/cm ²)	Margin to limit: (mW/cm ²)	Fraction for Co-Location calculations	Max. Fraction-Value within Frequency-Band
LTE Band 12 (QPSK, #RB=1, RMS-Value)	701,5	23	2	25	100%	0,316	316	0,4677	0,0629	0,4048	0,1345	0,1345
	707,5	23	2	25		0,316	316	0,4717	0,0629	0,4088	0,1334	
	713,5	23	2	25		0,316	316	0,4757	0,0629	0,4128	0,1323	
LTE Band 12 (16QAM, #RB=1, RMS-Value)	701,5	23	2	25	100%	0,316	316	0,4677	0,0629	0,4048	0,1345	0,1345
	707,5	23	2	25		0,316	316	0,4717	0,0629	0,4088	0,1334	
	713,5	23	2	25		0,316	316	0,4757	0,0629	0,4128	0,1323	

Maximum calculated MPE value:		
Lowest MPE-Limit in Frequency-Band:	0,4677	[mW/cm ²]
Highest MPE value in frequency-band:	0,0629	[mW/cm ²]
Lowest margin to limit in frequency band:	0,4048	[mW/cm ²]

Maximum antenna gain considerations for fixed/mobile operations for complying with limits:

P	Maximum power input to the antenna incl. Duty cycle [mW]: (Avg. Burst Power or RMS)	316
R	Distance [cm]:	20
S	MPE limit acc. §1.1310 for uncontrolled exposure [mW/cm ²]: (FCC use mW/cm ²)	0,47
G ₁	Maximum Antenna gain to comply with MPE limit [dBi]:	8,71

(For G₁ the low est measured channel to reach minimum ant. Gain selected)

ERP power limit according to §2.1091 [W]: (Avg. Burst Power or RMS)		1,50
G ₂	Max. Antenna gain to comply with limit incl. Duty cycle [dBi]:	8,91

(For G₂ select the max. Avg. Burst Power or RMS value incl. Duty cycle)

ERP power limit according to §27.50(C)(10) [W ERP]:		3,00
G ₃	Max. Antenna gain to comply with limit [dBi]:	11,92

(For G₃ select the max. Average burst power value excluding Duty cycle)

G _{850 MHz band}	Min (G ₁ , G ₂ , G ₃) [dBi]	8,71
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Summarized results:	The max. ant. gain for mobile operation at 700/850MHz band to comply with MPE and EIRP limits incl. path loss shall not exceed (dBi):	8,71	dBi
		6,56	dBd

4.2.2. Results for upper operational band: LTE band 4

Distance:	20	cm										
Operating Mode	Frequency on channel	Declared maximum conducted output power	Max. positive tolerance according manufacturer	Calculated maximum ERP (declared+ Tune-up+ antenna Gain) (dBm)	Duty cycle	Declared Maximum ERP	Equivalent ERP (maximum ERP x duty cycle)	MPE Limit accord. Table 1	MPE-Value	Margin to limit:	Fraction for Co-Location calculations	Max. Fraction-Value within Frequency-Band
	(MHz)	(dBm)	(dB)		%	(W)	(mW)	(mW/cm ²)	(mW/cm ²)	(mW/cm ²)		
LTE Band 4 (QPSK, #1RB, RMS-Value)	1712,5	23,0	2,0	25	100%	0,3162	316,2	1,0000	0,0629	0,9371	0,062912	0,0629115
	1735,0	23,0	2,0	25		0,3162	316,2	1,0000	0,0629	0,9371	0,062912	
	1752,5	23,0	2,0	25		0,3162	316,2	1,0000	0,0629	0,9371	0,062912	
LTE Band 4 (16QAM, #1RB, RMS-Value)	1712,5	23,0	2,0	25	100%	0,3162	316,2	1,0000	0,0629	0,9371	0,062912	0,0629115
	1735,0	23,0	2,0	25		0,3162	316,2	1,0000	0,0629	0,9371	0,062912	
	1752,5	23,0	2,0	25		0,3162	316,2	1,0000	0,0629	0,9371	0,062912	

Maximum calculated MPE value:		
Lowest MPE-Limit in frequency-band:	1,0000	[mW/cm ²]
Highest MPE value in frequency-band:	0,0629	[mW/cm ²]
Lowest margin to limit in frequency-band:	0,94	[mW/cm ²]

Maximum antenna gain considerations for fixed/mobile operations for complying with limits:

P	Maximum power input to the antenna incl. Duty cycle (mW): (Avg. Burst Power or RMS)	316
R	Distance (cm):	20
S	MPE limit acc. §1.1310 for uncontrolled exposure (mW/cm ²): (FCC use mW)	1.00
G ₁	Maximum Antenna gain to comply with MPE limit (dBi):	12.01

(For G₁ the lowest measured channel to reach minimum ant. Gain selected)

ERP power limit according to §2.1091 [W]: (Avg. Burst Power or RMS)		3.00
G ₂	Max. Antenna gain to comply with this limit incl. Duty cycle (dBi):	11.92

(For G₂ select the max. Avg. Burst Power or RMS value incl. Duty cycle)

ERP power limit according to §27.50(d) [W]:		1.00
G ₃	Max. Antenna gain to comply with this limit (dBi):	5.00

(For G₃ select the max. Average burst power value excluding Duty cycle)

Min (G ₁ , G ₂ , G ₃) (dBi)		5.00
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Summarized results:	The max. ant. gain for mobile operation at 1700 MHz band to comply with MPE and ERP limits incl. path loss shall not exceed (dBi):	5.00
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4.2.3. Results for upper operational band: LTE 2

Safety-Distance	20	cm										
Operation Mode	Frequency on channel	Declared maximum conducted output power	Max. positive tolerance according manufacturer	Declared maximum ERP (Measured+ Tune-up+ Antenna Gain)	Duty cycle	Declared Maximum ERP	Equivalent ERP (maximum ERP x duty cycle)	MPE Limit accord. Table 1	MPE-Value	Margin to limit:	Fraction for Co-Location calculations	Max. Fraction-Value within Frequency-Band
	(MHz)	(dBm)	(dB)	(dBm)	%	(W)	(mW)	(mW/cm ²)	(mW/cm ²)	(W/m ²)		
LTE Band 2 (QPSK, #1RB, RMS-Value)	1852,5	23,0	2,00	25	100%	0,316	316	1,0000	0,0629	0,9371	0,062912	0,0629115
	1880,0	23,0	2,00	25		0,316	316	1,0000	0,0629	0,9371	0,062912	
	1907,5	23,0	2,00	25		0,316	316	1,0000	0,0629	0,9371	0,062912	
LTE Band 2 (16QAM, #1RB, RMS-Value)	1852,5	23,0	2,00	25	100%	0,316	316	1,0000	0,0629	0,9371	0,062912	0,0629115
	1880,0	23,0	2,00	25		0,316	316	1,0000	0,0629	0,9371	0,062912	
	1907,5	23,0	2,00	25		0,316	316	1,0000	0,0629	0,9371	0,062912	

Maximum calculated MPE value:		
Lowest MPE-Limit in frequency-band:	1,0000	[mW/cm ²]
Highest MPE value in frequency-band:	0,0629	[mW/cm ²]
Margin to limit in frequency-band:	0,9371	[mW/cm ²]

Maximum antenna gain considerations for fixed/mobile operations for complying with limits:

P	Maximum power input to the antenna incl. Duty cycle (mW): (Avg. Burst Power or RMS)	316
R	Distance (cm):	20
S	MPE limit acc. §1.1310 for uncontrolled exposure (mW/cm ²): (FCC use mW/cm ²)	1.00
G ₁	Maximum Antenna gain to comply with MPE limit (dBi):	12.01

(For G₁ the low est measured channel to reach minimum ant. Gain selected)

ERP power limit according to §2.1091 [W]: (Avg. Burst Power or RMS)		3.00
G ₂	Max. Antenna gain to comply with this limit incl. Duty cycle (dBi):	11.92

(For G₂ select the max. Avg. Burst Power or RMS value incl. Duty cycle)

ERP power limit according to §24.232 [W]:		2.00
G ₃	Max. Antenna gain to comply with this limit (dBi):	8.01

(For G₃ select the max. Average burst power value excluding Duty cycle)

Min (G ₁ , G ₂ , G ₃) (dBi)		8.01
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Summarized results:	The max. ant. gain for mobile operation at 1900 MHz band to comply with MPE and ERP limits incl. path loss shall not exceed (dBi):	8.01
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4.3. Conclusion for maximum admissible antenna gain

Max. Gain in Lower operational band $f < 1\text{GHz}$ (LTE Band 12) [dBd/dBi]	6.56 dBd (8.71 dBi)
Max. Gain in Higher operational band (1700MHz) (LTE Band 4) [dBi]	5.0 dBi
Max. Gain in Higher operational band (1900MHz) (LTE Band 2) [dBi]	8.01 dBi

Remark: calculations does not include a second transmitters situated near-by (Co-location condition) which may reduce the allowed antenna gain.

4.4. Measurement uncertainties

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's contribution to the overall uncertainty according it's statistical distribution calculated.

Following table shows expectable uncertainties for each measurement type performed.

RF-Measurement	Reference	Frequency range	Calculated uncertainty based on a confidence level of 95%							Remarks
Conducted emissions (U _{CISPR})	CISPR 16-2-1	9 kHz - 150 kHz 150 kHz - 30 MHz	4.0 dB 3.6 dB							-
Radiated emissions Enclosure	CISPR 16-2-3	30 MHz - 1 GHz 1 GHz - 18 GHz	4.2 dB 5.1 dB							E-Field
Disturbance power	CISPR 16-2-2	30 MHz - 300 MHz	-							-
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	--	--	--			
		12.75 - 26.5GHz	N/A	0.82	--	--	--			
Conducted emissions on RF-port	-	9 kHz - 2.8 GHz	0.70	N/A	--	--	--		N/A - not applicable	
		2.8 GHz - 12.75GHz	1.48	N/A	--	--	--			
		12.75 GHz - 18GHz	1.81	N/A	--	--	--			
		18 GHz - 26.5GHz	1.83	N/A	--	--	--			
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	5.0 dB							Magnetic field E-field Substitution
		30 MHz - 1 GHz	4.2 dB							
		1 GHz - 20 GHz	3.17 dB							

Table: measurement uncertainties, valid for conducted/radiated measurements

5. Abbreviations used in this report

The abbreviations	
ANSI	American National Standards Institute
AV , AVG, CAV	Average detector
EIRP	Equivalent isotropically radiated power, determined within a separate measurement
EGPRS	Enhanced General Packet Radio Service
EUT	Equipment Under Test
FCC	Federal Communications Commission, USA
IC	Industry Canada
n.a.	not applicable
Op-Mode	Operating mode of the equipment
PK	Peak
RBW	resolution bandwidth
RF	Radio frequency
RSS	Radio Standards Specification, Dokuments from Industry Canada
Rx	Receiver
TCH	Traffic channel
Tx	Transmitter
QP	Quasi peak detector
VBW	Video bandwidth
ERP	Effective radiated power

6. Accreditation details of CETECOM's laboratories and test sites

Ref.-No.	Accreditation Certificate	Valid for laboratory area or test site	Accreditation Body
-	D-PL-12047-01-01	All laboratories and test sites of CETECOM GmbH, Essen	DAkkS, Deutsche Akkreditierungsstelle GmbH
337 487 558 348 348	MRA US-EU 0003	Radiated Measurements 30 MHz to 1 GHz, 3 m / 10 m (OATS) Radiated Measurements 30 MHz to 1 GHz, 3 m (SAR) Radiated Measurements above 1 GHz, 3 m (FAR) Mains Ports Conducted Interference Measurements Telecommunication Ports Conducted Interference Measurem.	FCC, Federal Communications Commission Laboratory Division, USA
337 487 550 558	3462D-1 3462D-2 3462D-2 3462D-3	Radiated Measurements 30 MHz to 1 GHz, 3 m / 10 m (OATS) Radiated Measurements 30 MHz to 1 GHz, 3 m (SAR) Radiated Measurements 1 GHz to 6 GHz, 3 m (SAR) Radiated Measurements above 1 GHz, 3 m (FAR)	IC, Industry Canada Certification and Engineering Bureau
487 550 348 348	R-2666 G-301 C-2914 T-1967	Radiated Measurements 30 MHz to 1 GHz, 3 m (SAR) Radiated Measurements 1 GHz to 6 GHz, 3 m (SAR) Mains Ports Conducted Interference Measurements Telecommunication Ports Conducted Interference Measurem.	VCCI, Voluntary Control Council for Interference by Information Technology Equipment, Japan
OATS = Open Area Test Site, SAR = Semi Anechoic Room, FAR = Fully Anechoic Room			

7. Instruments and Ancillary

7.1. Used equipment “CTC”

The “Ref.-No” in the left column of the following tables allows the clear identification of the laboratory equipment.

7.1.1. Test software and firmware of equipment

Ref.-No.	Equipment	Type	Serial-No.	Version of Firmware or Software during the test
001	EMI Test Receiver	ESS	825132/017	Firm.= 1.21 , OTP=2.0, GRA=2.0
012	Signal Generator (EMS-cond.)	SMY 01	839069/027	Firm.= V 2.02
013	Power Meter (EMS cond.)	NRVD	839111/003	Firm.= V 1.51
017	Digital Radiocommunication Tester	CMD 60 M	844365/014	Firmware = V 3.52 .22.01.99, DECT = D2.87 13.01.99
053	Audio Analyzer	UPA3	860612/022	Firm. V 4.3
119	RT Harmonics Analyzer dig. Flickermeter	B10	G60547	Firm.= V 3.1DHG
140	Signal Generator	SMHU	831314/006	Firm.= 3.21
261	Thermal Power Sensor	NRV-Z55	825083/0008	EPROM-Datum 02.12.04, SE EE 1 B
262	Power Meter	NRV-S	825770/0010	Firm.= 2.6
263	Signal Generator	SMP 04	826190/0007	Firm.=3.21
295	Racal Digital Radio Test Set	6103	1572	UNIT Firmware= 4.04, SW-Main=4.04, SW-BBP=1.04, SW-DSP=1.02, Hardboot=1.02, Softboot=2.02
298	Univ. Radio Communication Tester	CMU 200	832221/091	R&S Test Firmware =3.53 /3.54 (current Testsoftw. f. all band used
323	Digital Radiocommunication Tester	CMD 55	825878/0034	Firm.= 3.52 .22.01.99
335	CTC-EMS-Conducted	System EMS Conducted	-	EMC 32 V 8.52
340	Digital Radiocommunication Tester	CMD 55	849709/037	Firm.= 3.52 .22.01.99
355	Power Meter	URV 5	891310/027	Firm.= 1.31
365	10V Insertion Unit 50 Ohm	URV5-Z2	100880	Eprom Data = 31.03.08
366	Ultra Compact Simulator	UCS 500 M4	V0531100594	Firm. UCS 500=001925/3.06a02, rc=ISMIEC 4.10
371	Bluetooth Tester	CBT32	100153	CBT V5.30+ SW-Option K55, K57
377	EMI Test Receiver	ESCS 30	100160	Firm.= 2.30, OTP= 02.01, GRA= 02.36
378	Broadband RF Field Monitor	RadiSense III	03D00013SNO-08	Firm.= V.03D13
389	Digital Multimeter	Keithley 2000	0583926	Firm. = A13 (Mainboard) A02 (Display)
392	Radio Communication Tester	MT8820A	6K00000788	Firm.= 4.50 #005, IPL=4.01#001,OS=4.02#001, GSM=4.41#013, W-CDMA= 4.54#004, scenario= 4.52#002
436	Univ. Radio Communication Tester	CMU 200	103083	R&S Test Firmware Base=5.14, Mess-Software= GSM:5.14 WCDMA:5.14 (current Testsoftw. F. all band
441	CTC-SAR-EMI Cable Loss	System EMI field (SAR)	-	EMC 32 Version 8.52
442	CTC-SAR-EMS	System EMS field (SAR)	-	EMC 32 Version 8.40
443	CTC-FAR-EMI-RSE	System CTC-FAR-EMI-RSE	-	Spuri 7.2.5 or EMC 32 Ver. 9.15.00
444	CTC-FAR-EMS field	System-EMS-Field (FAR)	-	EMC 32 Version 9.15.00
460	Univ. Radio Communication Tester	CMU 200	108901	R&S Test Firmware Base=5.14, GSM=5.14 WCDMA=5.14 (current Testsoftw.,f. all band to be used,
489	EMI Test Receiver	ESU40	1000-30	Firmware=4.43 SP3, Bios=V5.1-16-3, Spec. =01.00
491	ESD Simulator dito	ESD dito	dito307022	V 2.30
524	Voltage Drop Simulator	VDS 200	0196-16	Software Nr: 000037 Version V4.20a01
526	Burst Generator	EFT 200 A	0496-06	Software Nr. 000034 Version V2.32
527	Micro Pulse Generator	MPG 200 B	0496-05	Software-Nr. 000030 Version V2.43
528	Load Dump Simulator	LD 200B	0496-06	Software-Nr. 000031 Version V2.35a01
546	Univ. Radio Communication Tester	CMU 200	106436	R&S Test Firmware Base=5.14, GSM=5.14 WCDMA=5.14 (current Testsoftw.,f. all band to be used
547	Univ. Radio Communication Tester	CMU 200	835390/014	R&S Test Firmware Base=V5.1403 (current Testsoftw., f. all band used, GSM = 5.14 WCDMA: = 5.14
584	Spectrum Analyzer	FSU 8	100248	2.82_SP3
597	Univ. Radio Communication Tester	CMU 200	100347	R&S Test Firmware Base=5.01, GSM=5.02 WCDMA= not installed, Mainboard= µP1=V.850
598	Spectrum Analyzer	FSEM 30 (Reserve)	831259/013	Firmware Bios 3.40 , Analyzer 3.40 Sp 2
620	EMI Test Receiver	ESU 26	100362	4.43_SP3
642	Wideband Radio Communication Tester	CMW 500	126089	Setup V03.26, Test programm component V03.02.20
670	Univ. Radio Communication Tester	CMU 200	106833	µP1 =V8.50, Firmware = V.20
689	Vector Signal Generator	SMU200	100970	02.20.360.142
692	Bluetooth Tester	CBT 32	100236	CBT V 5.40, FW: V.2.41 (FPGA Digital, V. 3.09 FPGA RF)

7.1.2. Single instruments and test systems

Ref.-No.	Equipment	Type	Serial-No.	Manufacturer	Interval of calibration	Remark	Cal due
001	EMI Test Receiver	ESS	825132/017	Rohde & Schwarz	12 M	-	30.05.2017
005	AC - LISN (50 Ohm/50µH, test site 1)	ESH2-Z5	861741/005	Rohde & Schwarz	12 M	-	30.05.2017
007	Single-Line V-Network (50 Ohm/5µH)	ESH3-Z6	892563/002	Rohde & Schwarz	12 M	-	30.05.2017
009	Power Meter (EMS-radiated)	NRV	863056/017	Rohde & Schwarz	24 M	-	30.04.2017
016	Line Impedance Simulating Network	Op. 24-D	B6366	Spitzenberger+Spies	36 M	-	30.05.2019
020	Horn Antenna 18 GHz (Subst 1)	3115	9107-3699	EMCO	36/12 M	-	31.03.2017
021	Loop Antenna (H-Field)	6502	9206-2770	EMCO	36 M	-	30.04.2018
030	Loop Antenna (H-field)	HFH-Z2	879604/026	Rohde & Schwarz	36 M	-	30.04.2018
033	RF-current probe (100kHz-30MHz)	ESH2-Z1	879581/18	Rohde & Schwarz	24 M	-	30.04.2017
057	relay-switch-unit (EMS system)	RSU	494440/002	Rohde & Schwarz	pre-m	1a	
060	power amplifier (DC-2kHz)	PAS 5000	B6363	Spitzenberger+Spies	-	3	
066	notch filter (WCDMA; FDD1)	WRCT 1900/2200-5/40-10EEK	5	Wainwright GmbH	12 M	1g	30.06.2016
086	DC - power supply, 0 -10 A	LNG 50-10	-	Heinzinger Electronic	pre-m	2	
087	DC - power supply, 0 -5 A	EA-3013 S	-	Elektro Automatik	pre-m	2	
091	USB-LWL-Converter	OLS-1	007/2006	Ing. Büro Scheiba	-	4	
099	passive voltage probe	ESH2-Z3	299.7810.52	Rohde & Schwarz	36 M	-	30.04.2018
100	passive voltage probe	Probe TK 9416	without	Schwarzbeck	36 M	-	30.04.2018
110	USB-LWL-Converter	OLS-1	-	Ing. Büro Scheiba	-	4	
119	RT Harmonics Analyzer dig. Flickermeter	B10	G60547	BOCONSULT	36 M	-	30.05.2019
136	adjustable dipole antenna (Dipole 1)	3121C-DB4	9105-0697	EMCO	36 M	-	30.04.2018
140	Signal Generator	SMHU	831314/006	Rohde & Schwarz	24 M	-	30.05.2018
248	attenuator	SMA 6dB 2W	-	Radiall	pre-m	2	
249	attenuator	SMA 10dB 10W	-	Radiall	pre-m	2	
252	attenuator	N 6dB 12W	-	Radiall	pre-m	2	
256	attenuator	SMA 3dB 2W	-	Radiall	pre-m	2	
257	hybrid	4031C	04491	Narda	pre-m	2	
260	hybrid coupler	4032C	11342	Narda	pre-m	2	
261	Thermal Power Sensor	NRV-Z55	825083/0008	Rohde & Schwarz	24 M	-	30.05.2018
262	Power Meter	NRV-S	825770/0010	Rohde & Schwarz	24 M	-	30.05.2018
263	Signal Generator	SMP 04	826190/0007	Rohde & Schwarz	36 M	-	30.05.2019
265	peak power sensor	NRV-Z33, Model 04	840414/009	Rohde & Schwarz	24 M	-	30.05.2018
266	Peak Power Sensor	NRV-Z31, Model 04	843383/016	Rohde & Schwarz	24 M	-	30.05.2018
267	notch filter GSM 850	WRCA 800/960-GEEK	9	Wainwright GmbH	pre-m	2	
270	termination	1418 N	BB6935	Weinschel	pre-m	2	
271	termination	1418 N	BE6384	Weinschel	pre-m	2	
272	attenuator (20 dB) 50 W	Model 47	BF6239	Weinschel	pre-m	2	
273	attenuator (10 dB) 100 W	Model 48	BF9229	Weinschel	pre-m	2	
274	attenuator (10 dB) 50 W	Model 47 (10 dB) 50 W	BG0321	Weinschel	pre-m	2	
275	DC-Block	Model 7003 (N)	C5129	Weinschel	pre-m	2	
276	DC-Block	Model 7006 (SMA)	C7061	Weinschel	pre-m	2	
279	power divider	1515 (SMA)	LH855	Weinschel	pre-m	2	
287	pre-amplifier 25MHz - 4GHz	AMF-2D-100M4G-35-10P	379418	Miteq	12 M	1c	30.06.2017
291	high pass filter GSM 850/900	WHJ 2200-4EE	14	Wainwright GmbH	12 M	1c	30.06.2017
298	Univ. Radio Communication Tester	CMU 200	832221/091	Rohde & Schwarz	pre-m	3	
300	AC LISN (50 Ohm/50µH, 1-phase)	ESH3-Z5	892 239/020	Rohde & Schwarz	12 M	-	30.05.2017
301	attenuator (20 dB) 50W, 18GHz	47-20-33	AW0272	Lucas Weinschel	pre-m	2	
302	horn antenna 40 GHz (Meas 1)	BBHA9170	155	Schwarzbeck	36 M	-	31.03.2017
303	horn antenna 40 GHz (Subst 1)	BBHA9170	156	Schwarzbeck	36 M	-	31.03.2017
331	Climatic Test Chamber -40/+80 Grad	HC 4055	43146	Heraeus Vötsch	Pre-m	2	
341	Digital Multimeter	Fluke 112	81650455	Fluke	24 M	-	30.05.2018
342	Digital Multimeter	Voltcraft M-4660A	IB 255466	Voltcraft	24 M	-	30.04.2017
347	laboratory site	radio lab.	-	-	-	5	
348	laboratory site	EMI conducted	-	-	-	5	
354	DC - Power Supply 40A	NGPE 40/40	448	Rohde & Schwarz	pre-m	2	
355	Power Meter	URV 5	891310/027	Rohde & Schwarz	24 M	-	30.05.2018
357	power sensor	NRV-Z1	861761/002	Rohde & Schwarz	24 M	-	30.04.2017
371	Bluetooth Tester	CBT32	100153	R&S	36 M	-	30.05.2019
373	Single-Line V-Network (50 Ohm/5µH)	ESH3-Z6	100535	Rohde & Schwarz	12 M	-	30.05.2017
377	EMI Test Receiver	ESCS 30	100160	Rohde & Schwarz	12 M	-	30.05.2017
389	Digital Multimeter	Keithley 2000	0583926	Keithley	24 M	-	30.04.2017
392	Radio Communication Tester	MT8820A	6K00000788	Anritsu	12 M	-	30.05.2017
431	Model 7405	Near-Field Probe Set	9305-2457	EMCO	-	4	
436	Univ. Radio Communication Tester	CMU 200	103083	Rohde & Schwarz	12 M	-	30.04.2017
439	UltraLog-Antenna	HL 562	100248	Rohde & Schwarz	36 M	-	31.03.2017
443	CTC-FAR-EMI-RSE	System CTC-FAR-EMI-RSE	-	ETS-Lindgren / CETECOM	12 M	5	30.06.2017
448	notch filter WCDMA_FDD II	WRCT 1850.0/2170.0-5/40-	5	Wainwright Instruments GmbH	12 M	1c	30.06.2017
449	notch filter WCDMA FDD V	WRCT 824.0/894.0-5/40-	1	Wainwright	12 M	1c	30.06.2017

Ref.-No.	Equipment	Type	Serial-No.	Manufacturer	Interval of calibration	Remark	Cal due
		8SSK					
454	Oscilloscope	HM 205-3	9210 P 29661	Hameg	-	4	
456	DC-Power supply 0-5 A	EA 3013 S	207810	Elektro Automatik	pre-m	2	
459	DC -Power supply 0-5 A , 0-32 V	EA-PS 2032-50	910722	Elektro Automatik	pre-m	2	
460	Univ. Radio Communication Tester	CMU 200	108901	Rohde & Schwarz	12 M	-	30.04.2017
463	Universal source	HP3245A	2831A03472	Agilent	-	4	
466	Digital Multimeter	Fluke 112	89210157	Fluke USA	24 M	-	30.05.2018
467	Digital Multimeter	Fluke 112	89680306	Fluke USA	36 M	-	30.04.2018
468	Digital Multimeter	Fluke 112	90090455	Fluke USA	36 M	-	30.04.2018
477	ReRadiating GPS-System	AS-47	-	Automotive Cons. Fink	-	3	
480	power meter (Fula)	NRVS	838392/031	Rohde & Schwarz	24 M	-	30.04.2017
482	filter matrix	Filter matrix SAR 1	-	CETECOM (Brl)	-	1d	
484	pre-amplifier 2,5 - 18 GHz	AMF-5D-02501800-25-10P	1244554	Miteq	12 M	-	30.06.2017
487	System CTC NSA-Verification SAR-EMI	System EMI field (SAR) NSA	-	ETS Lindgren / CETECOM	24 M	-	31.07.2017
489	EMI Test Receiver	ESU40	1000-30	Rohde & Schwarz	12 M	-	30.05.2017
502	band reject filter	WRCG 1709/1786-1699/1796-	SN 9	Wainwright	pre-m	2	
503	band reject filter	WRCG 824/849-814/859-	SN 5	Wainwright	pre-m	2	
512	notch filter GSM 850	WRCA 800/960-02/40-6EEK	SN 24	Wainwright	12 M	1c	30.06.2017
517	relais switch matrix	HF Relais Box Keithley	SE 04	Keithley	pre-m	2	
523	Digital Multimeter	L4411A	MY46000154	Agilent	24 M	-	30.04.2017
529	6 dB Broadband resistive power divider	Model 1515	LH 855	Weinschel	pre-m	2	
530	10 dB Broadband resistive power divider	R 416110000	LOT 9828	-	pre-m	2	
546	Univ. Radio Communication Tester	CMU 200	106436	R&S	12 M	-	30.05.2017
547	Univ. Radio Communication Tester	CMU 200	835390/014	Rohde & Schwarz	12 M	-	30.04.2017
549	Log.Per-Antenna	HL025	1000060	Rohde & Schwarz	36/12 M	-	31.07.2018
550	System CTC S-VSWR Verification SAR-EMI	System EMI Field SAR S-VSWR	-	ETS Lindgren/CETECOM	24 M	-	31.07.2017
552	high pass filter 2,8-18GHz	WHKX 2.8/18G-10SS	4	Wainwright	12 M	1c	30.06.2017
557	System CTC-OTA-2	R&S TS8991	-	Rohde & Schwarz	12 M	5	30.09.2016
558	System CTC FAR S-VSWR	System CTC FAR S-VSWR	-	CTC	24 M	-	19.04.2017
574	Biconilog Hybrid Antenna	BTA-L	980026L	Frankonia	36/12 M	-	31.03.2019
584	Spectrum Analyzer	FSU 8	100248	Rohde & Schwarz	pre-m	-	
594	Wideband Radio Communication Tester	CMW 500	101757	Rohde & Schwarz	12 M	-	30.04.2017
597	Univ. Radio Communication Tester	CMU 200	100347	Rohde & Schwarz	pre-m	-	
598	Spectrum Analyzer	FSEM 30 (Reserve)	831259/013	Rohde & Schwarz	24 M	-	30.04.2017
600	power meter	NRVD (Reserve)	834501/018	Rohde & Schwarz	24 M	-	30.04.2017
601	medium-sensitivity diode sensor	NRV-Z5 (Reserve)	8435323/003	Rohde & Schwarz	24 M	-	30.04.2017
602	peak power sensor	NRV-Z32 (Reserve)	835080	Rohde & Schwarz	24 M	-	
611	DC power supply	E3632A	KR 75305854	Agilent	pre-m	2	
612	DC power supply	E3632A	MY 40001321	Agilent	pre-m	2	
613	Attenuator	R416120000 20dB 10W	Lot. 9828	Radiall	pre-m	2	
616	Digitalmultimeter	Fluke 177	88900339	Fluke	24 M	-	30.05.2018
617	Power Splitter/Combiner	ZFSC-2-2-S+	S F987001108	Mini Circuits	-	2	
618	Power Splitter/Combiner	50PD-634	600994	JFW Industries USA	-	2	
619	Power Splitter/Combiner	50PD-634	600995	JFW Industries, USA	-	3	
620	EMI Test Receiver	ESU 26	100362	Rohde-Schwarz	12 M	-	30.05.2017
621	Step Attenuator 0-139 dB	RSP	100017	Rohde & Schwarz	pre-m	2	
625	Generic Test Load USB	Generic Test Load USB	-	CETECOM	-	2	
627	data logger	OPUS 1	201.0999.9302.6.4.1.4 3	G. Lufft GmbH	24 M	-	30.04.2017
634	Spectrum Analyzer	FSM (HF-Unit)	826188/010	Rohde & Schwarz	pre-m	2	
637	High Speed HDMI with Ethernet 1m	HDMI cable with Ethernet 1m	-	KogiLink	-	2	
638	HDMI Kabel with Ethernet 1,5 m flach	HDMI cable with Ethernet	-	Reichelt	-	2	
640	HDMI cable 2m rund	HDMI cable 2m rund	-	Reichelt	-	2	
641	HDMI cable with Ethernet	Certified HDMI cable with	-	PureLink	-	2	
644	Amplifier	ZX60-2534M+	SN865701299	Mini-Circuits	-	-	
670	Univ. Radio Communication Tester	CMU 200	106833	Rohde & Schwarz	24 M	-	30.05.2018
671	DC-power supply 0-5 A	EA-3013S	-	Elektro Automatik	pre-m	2	
678	Power Meter	NRP	101638	Rohde&Schwarz	pre-m	-	
683	Spectrum Analyzer	FSU 26	200571	Rohde & Schwarz	12 M	-	30.05.2017
686	Field Analyzer	EHP-200A	160WX30702	Narda Safety Test Solutions	24 M	-	30.04.2017
687	Signal Generator	SMF 100A	102073	Rohde&Schwarz	12 M	-	30.05.2017
688	Pre Amp	JS-18004000-40-8P	1750117	Miteq	pre-m	-	
690	Spectrum Analyzer	FSU	100302/026	Rohde&Schwarz	12 M	-	30.05.2017
692	Bluetooth Tester	CBT 32	100236	Rohde & Schwarz	36 M	-	31.03.2017
697	Power Splitter	ZN4PD-642W-S+	165001445	Mini-Circuits	-	2	

7.1.3. Legend

Note / remarks		Calibrated during system calibration:
	1a	System CTC-SAR-EMS (Ref.-No. 442)
	1b	System-CTC-EMS-Conducted (Ref.-No. 335)
	1c	System CTC-FAR-EMI-RSE (Ref.-No . 443)
	1d	System CTC-SAR-EMI (Ref.-No . 441)
	1e	System CTC-OATS (EMI radiated) (Ref.-No. 337)
	1 f	System CTC-CTIA-OTA (Ref.-No . 420)
	1 g	System CTC-FAR-EMS (Ref.-No . 444)
	2	Calibration or equipment check immediately before measurement
	3	Regulatory maintained equipment for functional check or support purpose
	4	Ancillary equipment without calibration e.g. mechanical equipment or monitoring equipment
	5	Test System

Interval of calibration	12 M	12 month
	24 M	24 month
	36 M	36 month
	24/12 M	Calibration every 24 months, between this every 12 months internal validation
	36/12 M	Calibration every 36 months, between this every 12 months internal validation
	Pre-m	Check before starting the measurement
	-	Without calibration

8. Versions of test reports (change history)

Version	Applied changes	Date of release
--	Initial release	2016-12-12
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