

TEST REPORT

No.: 6-0036/11-1-2c

According to:
FCC Regulations
 Part 15.109
 Part 15.209 & Part 15.247
IC Regulations
 RSS-Gen Issue 3
 RSS-210: Issue 8

for
 SMA Solar Technology AG

ZigBee RF MODEM (2.4 GHz) MULTI RF MODULE
 FCC-ID: SVFMRFB
 IC: 9440A-MRFB







Laboratory Accreditation and Listings			
 <p>Deutsche Akkreditierungsstelle D-PL-12047-01-01</p>	 <p>Reg. No.: 736496 MRA US-EU 0003</p>	 <p>Industry Canada Reg. No.: 3462D-1 Reg. No.: 3462D-2</p>	 <p>Voluntary Controls for Electromagnetic Emissions Reg. No.: R-2665, R-2666 C-2914, T-1967, G-301</p>
 <p>AUTHORIZED RF LABORATORY</p>	 <p>LAB CODE 20011130-00</p>		
accredited according to DIN EN ISO/IEC 17025			
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1. Summary of test results

The test results apply exclusively to the test samples as presented in chapter 3.1. 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.

The presented ZigBee RF Modem integrates also a KNX wireless system (this reported to another test report). This can be build inside host applications and extends their capability by wireless ZigBee technology. Data transmissions or voice applications are possible field applications.

In order to verify the compliance with applicable rules, a representative configuration consisting of representative auxiliary equipment was chosen. Embedded in this configuration, the ZigBee Module can be tested. Pls. refer to set-up description and photos for more details.

1.1. TESTS OVERVIEW FCC and Canada IC Standards (RSS)

TEST CASES	PORT	REFERENCES & LIMITS			EUT set-up	EUT operating mode	Result
		FCC Standard	RSS Section	TEST LIMIT			
TX-Mode							
6dB bandwidth	Antenna terminal (conducted)	§15.247(a)(2)	RSS-210 Issue 8: A8.2 (a) RSS-Gen Issue 3: Chapter 4.6.2	≥ 500 kHz for DTS systems	3	1	Passed
99% occupied bandwidth & Emission Bandwidth	Antenna terminal (conducted)	--	RSS-Gen Issue 3: Chapter 4.6.1	99% Power bandwidth	3	1	Passed
Transmitter Peak output power	Antenna terminal (conducted)	§15.247(b)(1)	RSS-210 Issue 8: A8.4 (4)	1 Watt Peak (or 0.125 mW Peak)	3	1	Passed
Transmitter Peak output power radiated	Cabinet (radiated)	§15.247(b)(4)	RSS-210 Issue 8:A8.4 (4)	< 4 Watt (EIRP) for antenna with directional gain less 6dBi	1	1	Passed
Out-Of-Band RF- emissions Band-Edge emissions	Antenna terminal (conducted)	§15.247 (d)	RSS-210 Issue 8: A8.5	20 dBc	2	2	Passed
Power spectral density	Antenna terminal (conducted)	§15.247(e)	RSS-210 Issue 8: A8.2 (b)	8dBm in any 3kHz band	3	1	Passed
General field strength emissions + restricted bands	Cabinet + Interconnecting cables (radiated)	§15.247 (d) §15.205 §15.209	RSS-210 Issue 8, Chapter 2.5 RSS-Gen: Issue 3: §7.2.5 Table 5+6	Emissions in restricted bands must meet the general field-strength radiated limits	2	2	Passed

AC-Power Lines	AC-Power lines	§15.207	RSS-Gen, Issue 3: Chapter 7.2.4, Table 4	FCC §15.107 class B limits §15.207 limits	--	--	N.A. ¹⁾
Conducted Emissions				IC: Table 4, Chapter 7.2.4			

RX Mode							
AC-Power Lines	AC-Power lines	§15.107	RSS-Gen, Issue 3: Chapter 7.2.4	FCC §15.107 class B limits §15.207 limits	--	--	N.A. ¹⁾
Conducted Emissions	(conducted)			IC: Table 2, Chapter 7.2.2			
RECEIVER	Cabinet + Interconnecting cables	§15.109 §15.33 §15.35	RSS-Gen, Issue 3: Chapter 6.1	FCC 15.109 class B limits	4	3	Passed
Radiated emissions	(radiated)			IC-limits: Table 1, Chapter 6			

Remark: 1) No connection to the AC power line. Not applicable for RF Module, it will be on the end application tested.

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 requirements as shown in above table are met in accordance with enumerated standards.



.....
Dipl.-Ing. W. Richter
Responsible for test section



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.....
Dipl.-Ing. B. Taslica
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. W. Richter
Deputy:	Dipl.-Ing. J. Schmitt
Laboratory accreditations/Listings:	DAkkS-Registration No. D-PL-12047-01-01 FCC-Registration No.: 736496, MRA US-EU 0003 IC-Registration No. 3462D-1, 3462D-2 VCCI Reg. No. R-2665, R-2666, C-2914, T-1967, G-301

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

Order No.:	E600036001
Responsible for test report and project leader:	Dipl.-Ing. B. Taslica
Receipt of EUT:	2011-05-25
Date(s) of test:	2011-05-25 to 2011-07-01
Date of report:	2011-07-28

Version of template:	11.05

2.4. Applicant's details

Applicant's name:	SMA Solar Technology AG
Address:	Sonnenallee 1 34266 Niestetal Germany
Contact person:	Mr. Roland Wagner

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. Additional declaration and description of main EUT

Main function	Multi RF Module with integrated IEEE 802.15.4 ZigBee transceiver		
Type	ZigBee RF Modem		
Frequency range (US/Canada -bands)	2405...2480 MHz		
Type of modulation	DSSS		
Number of channels (USA/Canada -bands)	16		
EMISSION DESIGNATOR(S)	1M70G1D		
Antenna Type	<input checked="" type="checkbox"/> Integrated <input type="checkbox"/> External, no RF- connector <input type="checkbox"/> External, separate RF-connector		
Antenna Gain	Maximum -0.5 dBi gain according applicants information in 2.4GHz band		
MAX PEAK Output Power: Conducted ZigBee	19.72 mW on nominal 2405 MHz		
MAX PEAK Output Power: Radiated ZigBee	111.0 (PK) dBμV/m@3m distance on low channel 2405 MHz 107.2 (AV) dBμV/m@3m distance on low channel 2405 MHz		
FCC-ID	SVFMRFB		
IC	9440A-MRFB		
Installed option	<input checked="" type="checkbox"/> KNX RF Modem (deactivated during the tests)		
Power supply	Uart= 5.0V DC		
Special EMI components	--		
EUT sample type	<input type="checkbox"/> Production	<input checked="" type="checkbox"/> Pre-Production	<input type="checkbox"/> Engineering

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	ZigBee RF MODEM	MULTI RF MODULE	54	Rev. B	V1.0
EUT B	ZigBee RF MODEM	MULTI RF MODULE	33	Rev. B	V1.0
EUT C	Receiver board	Reference TI board ¹⁾	MSP-EXP430F5438	Rev. 0-04-AD/MS	V1.0

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

1) Include RF Modul of TI 'CC2520DK_EM' rev.2.1.

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	Dockingstation	Control channels on PCB with power supply connection and dip switches	N.A.	548-002-1-901A	--
AE 2	Alkaline Battery	AA-LR6 (Size M: 2x 1.5V DC)	--	--	--

*) 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	Used for radiated tests (modulated)
Set. 2	EUT A+ EUT C+ AE 1+ AE2	Used for radiated tests (modulated) AE 1 supply with 5V DC and control the channels of the EUT A. AE 2 supply the EUT C with 3.0 V DC.
Set. 3	EUT B+ AE 1	Used for conducted tests (modulated) AE 1 supply with 5V DC and control the channels of the EUTs
Set. 4	EUT C+ AE2	Used for radiated tests

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

3.5. EUT operating modes

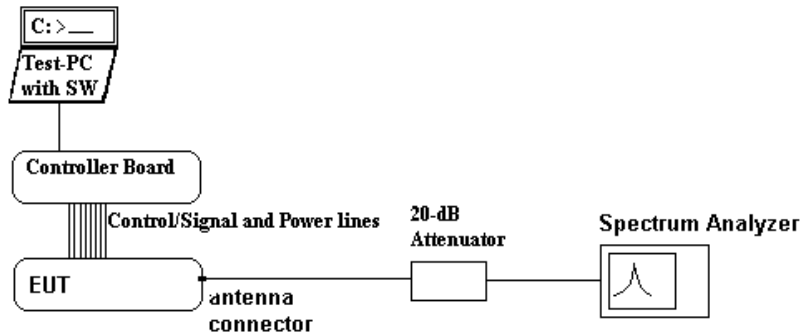
EUT operating mode no. *)	Description of operating modes	Additional information
op. 1	TX mode	The transmitter is set to certain transmission frequency within the operational range and send a modulated carrier (100% duty cycle factor). The EUT was set to lowest (2405 MHz=CH 11), middle (2440 MHz= CH 18) and highest (2480 MHz= CH 26) possible working frequencies within the assigned operational band.
op. 2	TX/RX mode	The transmitter is set to certain transmission frequency within the operational range and send a modulated carrier with EUT C (14 % duty cycle factor). The EUT was set to lowest (2405 MHz), middle (2440 MHz) and highest (2480 MHz) possible working frequencies within the assigned operational band.
op. 3	RX mode	The EUT C is set as receiver mode. The test sample is showing the received packets of the EUT A with a corresponding installed software.

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

3.5.1. DESCRIPTION OF TEST SET-UP's

3.6. ZigBee-Mode Test Set-up for conducted measurements

EUT's RF-signal is first attenuated by 20dB before it is feed to the spectrum analyzer. Customers RF-adapters are used in case of no suitable RF-Adapters are mounted on the EUT. The specific attenuation losses for the RF-signal path is determined within a path-loss calibration and the readings corrected therefore.

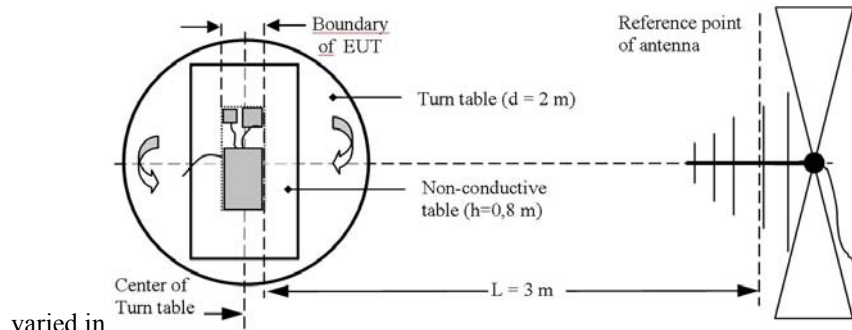


Schematic: Test set-up 3: conducted for RF-tests

3.7. Test set-up for radiated measurements

MEASUREMENT METHOD (30 MHz < f < 1 GHz):

A EMI analyzer together with a broadband antenna was used in order to identify the emissions from the EUT by positioning the antenna close to the EUT surfaces. The interconnecting cables and equipment position were



varied in order to maximize the emissions. Then most critical frequencies are recorded for further investigations. Based on the exploratory measurements, the most critical frequencies are re-measured by maintaining the EUT's operating mode, cable position, etc. The EUT was placed on a non-conductive support of 0.8 m height. By rotating the turntable angle 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) and the measurement antenna height from 1 meter to 4 meters, the maximized emissions are recorded. The measurements are performed for both polarizations of the measuring antenna: horizontal and vertical.

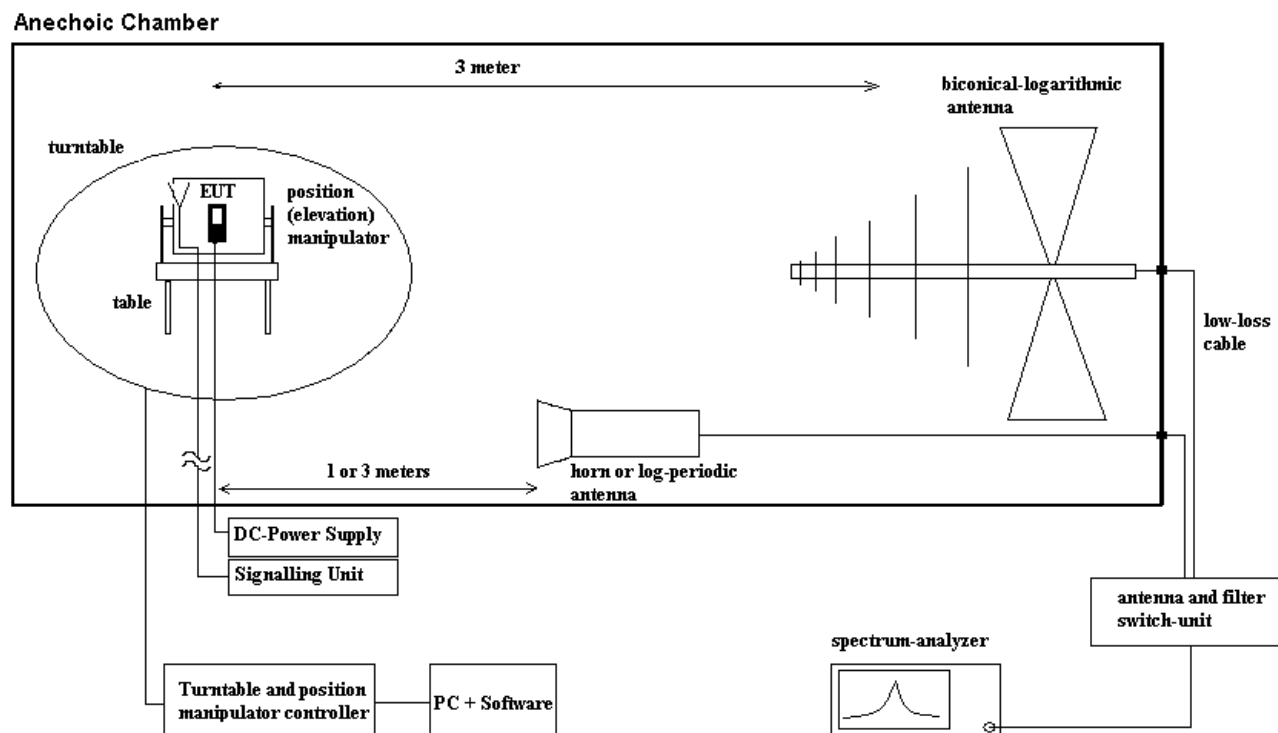
MEASUREMENT METHOD (1 GHz < f < 26.5 GHz):

The EUT and accessories are placed on a non-conducting tipping table of 0.8 meter height (semi-anechoic chamber) or 1.55m height (fully-anechoic chamber) which is situated in the middle of the turntable. The turntable can rotate the device under test 360 degree, the tipping table can rotate the device from laid to standing position. This way the device under test can be rotated in all three orthogonal planes in order to maximize the detected emissions. The turn- and tipping table are controlled by a controller unit. All positions manipulations are software controlled from a operator PC.

The measurements are performed for both receiving antenna polarisations: vertical and horizontal.

Up to 18 GHz a measurement distance of 3 meters is used, above 18 GHz the distance is 1 meter. A biconical-logarithmic antenna up 1 GHz and a logarithmic-periodic antenna for frequencies above 1 GHz up to 26.5 GHz is used. For frequencies above 26.5 GHz a horn antenna is used, pls. compare the equipment list for more details.

The EUT is powered either by a external DC-supply with nominal voltage or a AC/DC power supply as accessory. The communication signalling (if necessary for operation) is performed from outside the chamber with a communication test simulator (CMU200 from Rohde&Schwarz) and a signalling antenna place near the EUT.



Schematic: radiated measurements test set-up

4. Measurements

4.1. 6-dB Bandwidth

FCC 15.247, RSS-210

TEST LOCATION AND EQUIPMENT (for reference numbers please see chapter 'List of test equipment')

test location	<input checked="" type="checkbox"/> CETECOM Essen (Chapter. 2.2.1)		<input type="checkbox"/> Please see Chapter. 2.2.2	<input type="checkbox"/> Please see Chapter. 2.2.3
test site	<input type="checkbox"/> 441 EMI SAR	<input type="checkbox"/> 487 SAR NSA	<input type="checkbox"/> 337 OATS	<input checked="" type="checkbox"/> 347 Radio.lab.
receiver	<input type="checkbox"/> 377 ESCS30	<input type="checkbox"/> 001 ESS	<input checked="" type="checkbox"/> 489 ESU	<input type="checkbox"/>
otherwise	<input checked="" type="checkbox"/> 301 20dB Attenuator		<input checked="" type="checkbox"/> cable K15	

REFERENCES: §15.247(a)(1)&(2), RSS-210: A8.1(b)

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

(2) DSSS Systems using digital modulation techniques may operate in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

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.

MEASUREMENT METHOD:

The measurement was performed with the RBW set to 10kHz. The span was set to cover the complete carrier. Three carrier frequencies (low/middle/high) were used for showing the compliance with this requirement. A DELTA Marker method was set to measure the bandwidth compared to the highest In-Band power. The operating modes have been varied (e.g. data rate, modulation scheme, etc.). If applicable the hopping-mode is switched off.

Also the **99% emission bandwidth** was measured. Two markers are placed on frequency points such that left to lower f-marker and right to higher f-marker only 1% of the TX-power is contained. Between the markers, 99% of the power is laying. The RBW value is readjusted and the measurement repeated until the RBW/EBW ratio is around 1%.

SPECTRUM-ANALYZER SETTINGS:

Span	Set as to fully display the emissions and approximate 6dB below the PEAK level
Resolution Bandwidth (RBW)	Set to approx 1% of the emission width
Video Bandwidth (VBW)	3 times the resolution bandwidth
Sweep time	Coupled and low enough to have no gaps within power envelope
Detector	Sample (if band width: Span/no. of frequency points SA < 0.5*RBW SA otherwise Peak detector)
Sweep mode	Repetitive Mode, MAX-HOLD

RESULTS:

Set-up no.:	3
Op. Mode:	1
T _{NOM} = 21.4°C V _{NOM} = 5.0V	6 dB Bandwidth [MHz]
Low channel = 0 (2405 MHz)	1.71
Middle channel = 11 (2440 MHz)	1.69
High channel = 18 (2480 MHz)	1.69

Remark: --

Conclusion: 6dB bandwidth is bigger than 500 kHz so tests according Part 15.247 should apply for this wireless technology.

Set-up no.:	3
Op. Mode:	1
T _{NOM} = 21.7°C V _{NOM} = 5.0V	99% Emission Bandwidth [MHz]
Low channel = 0 (2405 MHz)	2.996
Middle channel = 11 (2440 MHz)	2.964
High channel = 18 (2480 MHz)	2.964

Remark: --.

Verdict: As 6dB bandwidth is bigger than 500 kHz standard Part §15.247(a)(2) apply.

4.2. Radiated field strength emissions below 30 MHz

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

test location	<input checked="" type="checkbox"/> CETECOM Essen (Chapter. 2.2.1)	<input type="checkbox"/> Please see Chapter. 2.2.2	<input type="checkbox"/> Please see Chapter. 2.2.3
test site	<input checked="" type="checkbox"/> 441 EMI SAR	<input type="checkbox"/> 487 SAR NSA	<input type="checkbox"/> 337 OATS
receiver	<input type="checkbox"/> 377 ESCS30	<input checked="" type="checkbox"/> 001 ESS	<input type="checkbox"/> 489 ESU
spectr. analys.	<input type="checkbox"/> 381 380 FSBS	<input type="checkbox"/> 120 FSEM	<input type="checkbox"/> 264 FSEK
antenna	<input type="checkbox"/> 048 EMCO3143	<input type="checkbox"/> 133 EMCO3115	<input type="checkbox"/> 302 BBHA9170
signaling	<input type="checkbox"/> 298 CMU	<input type="checkbox"/> 460 CMU	<input type="checkbox"/> 295 RACAL
power supply	<input checked="" type="checkbox"/> 456 EA 3013A	<input type="checkbox"/> 457 EA 3013A	<input type="checkbox"/> 459 EA 2032-50
otherwise	<input type="checkbox"/> 400 FTC40x15E	<input type="checkbox"/> 401 FTC40x15E	<input type="checkbox"/> 110 USB LWL

Standards and Limits: CFR 47, §15.205, §15.209, RSS-Gen, ANSI C63.10:2009,

Frequency [MHz]	Field strength [µV/m]	[dBuV/m]	Measurement distance [meters]	Remarks
0.009 – 0.490	2400/f (kHz)	67.6 – 20Log(f) (kHz)	300	Correction factor used due to measurement distance of 3m
0.490 – 1.705	24000/f (kHz)	87.6 – 20 Log(f) (kHz)	30	Correction factor used due to measurement distance of 3m
1.705 – 30	30	29.54	30	Correction factor used due to measurement distance of 3m

Remark: * decreases with the logarithm of the frequency

Test condition and measurement test set-up

link to test system (if used):	<input checked="" type="checkbox"/> air link	<input type="checkbox"/> cable connection	<input type="checkbox"/>
EUT-grounding	<input checked="" type="checkbox"/> none	<input type="checkbox"/> with power supply	<input type="checkbox"/> additional connection
Equipment set up	<input checked="" type="checkbox"/> table top	<input type="checkbox"/> floor standing	
Climatic conditions	Temperature: (22±3°C)		Rel. humidity: (40±20)%
EMI-Receiver (Analyzer) Settings	Span/Range: 9kHz to 150kHz; 150 kHz to 30 MHz RBW/VBW: 200Hz/auto; 10 kHz/ auto (ANSI63.10/CISPR#16) Detector/ Mode: PEAK, TRACE max-hold mode, repetitive scan for exploratory measurements Quasi-Peak, for final measurement on critical frequencies (f<1GHz)		

General measurement procedures:

The measurement test set-up and test procedure are in accordance with the provisions described in ANSI 63.10: 2009

The **Equipment under Test (EUT)** was set-up to defined operating mode and installed (connected) to accessory equipment according the general description of use given by the applicant.

The measurement loop antenna was situated in 3m distance to the EUT. Between EUT and measurement antenna absorbers are covering the GND-Plane. With these absorbers the chamber fulfills CIPR16-1-4 site VSWR-criteria. Radiated magnetic emission measurements were made with the antenna situated in 1 meter height. 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 EUT itself either over 3-orthogonal axes (no defined usage position) or 2-orthogonal axis (defined usage position) by the position manipulator.

According the standard the compliance should be checked in 30m and 300m measurement distance. Therefore a additional extrapolation factor was used in order to normalize the measurement data. The frequency dependent extrapolation factor used for this reduced measurement distance, can be found on the next page.

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

The used correction factors when the measurement distance is reduced, are taken from IEEC Transaction EMC, Vol 47, No.3, Aug. 2005, Journal Paper “*EXTRAPOLATING NEAR-FIELD EMISSIONS OF LOW-FREQUENCY LOOP TRANSMITTERS*”.

[illegible]

Measurement Results

Set-up No.		1								
Operating Mode		1								
Diagram no.	Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Antenna height (cm)	Polarity	Turntable position (deg)	Corr. (dB) (C _F)	Margin (dB) (M)	Limit (dBμV/m) (L _T)
c_3.01	23.95	14.55	10	10	100	--	0°..360°	s. Table correction factor	>14.5	29.54
c_3.02	24.57	15.08	10	10	100	--			>14	
c_3.03	20.45	15.03	10	10	100	--			>14	

Remark: --

Margin to Limit:

$$M = L_T - R_R + C_F + D_F$$

$$= L_T - R_R + (AF_{ANTENNA} + Cable_{LOSS}) + D_F$$

Remark: positive margin means passed result

Abbreviations used:

- R_R : Receiver readings in dBμV/m
- C_F: Transducer in dB = AF (antenna factor) + CL (cable loss)
- D_F : distance correction factor (if different measurement distance used than specified in the standard)
- L_T : Limit in dBμV/m

Verdict: Summary of measurement results for radiated frequencies below 30 MHz - passed

4.3. Radiated field strength emissions, 30 MHz - 1 GHz

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

test location	<input checked="" type="checkbox"/> CETECOM Essen (Chapter. 2.2.1)	<input type="checkbox"/> Please see Chapter. 2.2.2	<input type="checkbox"/> Please see Chapter. 2.2.3
test site	<input checked="" type="checkbox"/> 441 EMI SAR	<input type="checkbox"/> 487 SAR NSA	<input type="checkbox"/> 337 OATS
receiver	<input checked="" type="checkbox"/> 377 ESCS30	<input checked="" type="checkbox"/> 001 ESS	<input type="checkbox"/> 347 Radio.lab.
spectr. analys.	<input type="checkbox"/> 381 380 FSBS	<input type="checkbox"/> 120 FSEM	<input type="checkbox"/> 264 FSEK
antenna	<input checked="" type="checkbox"/> 048 EMCO3143	<input type="checkbox"/> 133 EMCO3115	<input type="checkbox"/> 302 BBHA9170
signaling	<input type="checkbox"/> 298 CMU	<input type="checkbox"/> 460 CMU	<input type="checkbox"/> 289 CBL 6141
power supply	<input type="checkbox"/> 456 EA 3013A	<input type="checkbox"/> 457 EA 3013A	<input type="checkbox"/> 295 RACAL
otherwise	<input type="checkbox"/> 400 FTC40x15E	<input type="checkbox"/> 401 FTC40x15E	<input checked="" type="checkbox"/> 392 MT8820A
		<input type="checkbox"/> 110 USB LWL	<input type="checkbox"/> 268 EA- 3050
			<input type="checkbox"/> 494 AG6632A
			<input type="checkbox"/> 498 NGPE 40
			<input checked="" type="checkbox"/> 482 Filter Matrix

Standards and Limits: CFR 47, Part 15B, §15.209, RSS-Gen, ANSI C63.10:2009, ANSI 63.4:2009

Frequency [MHz]	Radiated emission limits, FCC §15.109, Class B, 3 meters & FCC §15.209	
	QUASI-Peak [microvolts/meter]	QUASI-Peak [dBµV/m]
30-88	100	40
88-216	150	43,5
216-960	200	46,0
above 960	500	54,0

Test condition and measurement test set-up

link to test system (if used):	<input checked="" type="checkbox"/> air link	<input type="checkbox"/> cable connection	<input type="checkbox"/>
EUT-grounding	<input checked="" type="checkbox"/> none	<input type="checkbox"/> with power supply	<input type="checkbox"/> additional connection
Equipment set up	<input checked="" type="checkbox"/> table top 0.8m height	<input type="checkbox"/> floor standing	
Climatic conditions	Temperature: (22±3°C)		Rel. humidity: (40±20)%
EMI-Receiver (Analyzer) Settings	Span/Range: 30 MHz to 1 GHz RBW/VBW: 120 kHz / (auto) Detector/ Mode: PEAK, TRACE max-hold mode, repetitive scan Quasi-Peak, for final measurement for critical measurements		

Restricted bands of operation accord. §15.205

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	--
13.36-13.41	--	--	--

Remark: only spurious emissions are allowed within these frequency bands not exceeding the limits per §15.209

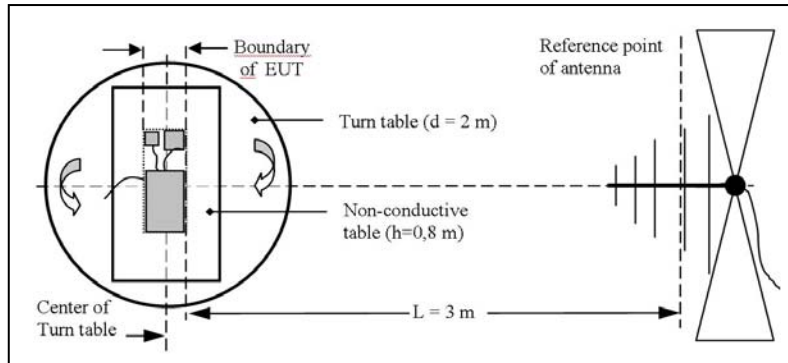
General measurement procedures:

The measurement test set-up and test procedure are in accordance with the provisions described in ANSI63.10:2009

The **Equipment under Test (EUT)** set-up to defined operating mode and installed (connected) to accessory equipment according the general description of use given by the applicant.

Measurement METHOD (30 MHz < f < 1 GHz):

An EMI analyzer together with a broadband antenna was used in order to identify the emissions from the EUT



by positioning the antenna close to the EUT surfaces. The interconnecting cables and equipment position were varied in order to maximize the emissions. Then most critical frequencies are recorded for further investigations. Based on the exploratory measurements, the most critical frequencies are re-measured by maintaining the EUT's operating mode, cable position, etc. The EUT

was placed on a non-conductive support of 0.8 m height. By rotating the turntable angle 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) and the measurement antenna height from 1 meter to 4 meters, the maximized emissions are recorded. The measurements are performed for both polarizations of the measuring antenna: horizontal and vertical.

4.3.1. Radiated emissions below 1 GHz, TX-Mode according FCC §15.209, RSS-Gen, RSS-210

All emissions were under the general limits of FCC §15.209

Channel Low (Channel 11)

Set-up No.	1									
Operating Mode	1									
Diagram no.	Freq. (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Antenna height (m)	Pol.	Turntable position (deg)	Corr. (dB) (C _F)	Margin (dB) (M)	Limit (dBμV/m) (L _T)
c_2.109	--	No remarkable peak found	0.05	120.000	1.00-4.00	H/V	0°..360°	--	> 10	--

Remark: --

Channel Middle (Channel 18)

Set-up No.	1									
Operating Mode	1									
Diagram no.	Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Antenna height (m)	Pol.	Turntable position (deg)	Corr. (dB) (C _F)	Margin (dB) (M)	Limit (dBμV/m) (L _T)
c_2.110	267.44	27.19	0.05	120.000	1.00-4.00	H/V	0°..360°	--	+18.81	46.00

Remark: --

Channel high (Channel 26)

Set-up No.	1									
Operating Mode	1									
Diagram no.	Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Antenna height (m)	Pol.	Turntable position (deg)	Corr. (dB) (CF)	Margin (dB) (M)	Limit (dBμV/m) (LT)
c_2.111	996.88	42.23	0.05	120.000	1.00-4.00	H/V	0°..360°	--	+11.77	54.00

Remark: *.) see also plots enclosed in separate document A1

4.3.2. Radiated emissions, below 1GHz, RX-Mode according FCC §15.109 class B, RSS-Gen

Channel Middle (Channel 18)

Set-up No.	4									
Operating Mode	3									
Diagram no.	Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Antenna height (m)	Pol.	Turntable position (deg)	Corr. (dB) (C _F)	Margin (dB) (M)	Limit (dBμV/m) (L _T)
c_2.112	949.28	40.60	0.05	120.000	1.00-4.00	H/V	0°..360°	--	+5.4	46.00

Remark: --

<p>Margin to Limit:</p> $M = L_T - R_R + C_F + D_F$ $= L_T - R_R + (AF_{ANTENNA} + Cable_{LOSS}) + D_F$ <p>Remark: positive margin means passed result</p>	<p>Abbreviations used:</p> <ul style="list-style-type: none"> • R_R : Receiver readings in dBμV/m • CF: Transducer in dB = AF (antenna factor) + CL (cable loss) • D_F : distance correction factor (if different measurement distance used than specified in the standard) • L_T : Limit in dBμV/m
---	--

Verdict

Summary of measurement results for radiated emissions above 30 MHz and below 1 GHz : Passed

4.4.1. Radiated emissions, above 1GHz till 2.8GHz, TX-Mode according FCC §15.209, RSS-Gen

Channel low (Channel 11)

Set-up No.:		1								
Operating Mode:		1								
Diagram no.	Frequency (MHz)	MaxPeak (dBμV/m)	Meas time (ms)	Bandwidth (kHz)	Ant. height (m)	Pol.	Turntable position (deg)	Corr. (dB) (CF)	Margin (dB) (M)	Limit (dBμV/m) (LT)
c_2.101	2341.88	60.44 (PK)	100	1000	1.55	H/V	0..360°	35.3	+13.56 (PK)	74.0
		60.44(PK)-17.1=43.34 ¹⁾							+11.66 (AV)	54.0

Remark: 1)Duty cycle correction factor used (please refer chapter 4.10)

Channel middle (Channel 18)

Set-up No.:		1								
Operating Mode:		1								
Diagram no.	Frequency (MHz)	MaxPeak (dBμV/m)	Meas time (ms)	Bandwidth (kHz)	Ant. height (m)	Pol.	Turntable position (deg)	Corr. (dB) (CF)	Margin (dB) (M)	Limit (dBμV/m) (LT)
c_2.102	2388.4	64.4(PK)	100	1000	1.55	H	65°	35.4	+9.6 (PK)	74.0
		64.4(PK)-17.1=47.3 ¹⁾							+6.7 (AV)	54.0

Remark: 1)Duty cycle correction factor used (please refer chapter 4.10)

Channel high (Channel 26)

Set-up No.:		1								
Operating Mode:		1								
Diagram no.	Frequency (MHz)	MaxPeak (dBμV/m)	Meas time (ms)	Bandwidth (kHz)	Ant. height (m)	Pol.	Turntable position (deg)	Corr. (dB) (CF)	Margin (dB) (M)	Limit (dBμV/m) (LT)
c_2.103	2791.0 (PK)	61.95	10	1000	1.55	H/V	0°..360°	--	>12	74.0
	2384 (AV)	50.13	10	1000	1.55	H/V	0°..360°	--	+3.87	54.0

Remark: --

4.4.2. Radiated emissions, above 2.8GHz till 25GHz, TX-Mode according FCC §15.209, RSS-Gen

Channel low (Channel 11)

Set-up No.:		1								
Operating Mode:		1								
Diagram no.	Freq. (GHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Ant. height (m)	Polarity	Turntable position (deg)	Corr. (dB) (CF)	Margin (dB) (M)	Limit (dBμV/m) (LT)
c_2.104	12.02 (PK)	56.4	10	1000	1.55	H/V	0..360°	--	+17.6	74.0
	12.02 (AV)	46.77	10	1000	1.55	H/V	0..360°		+7.23	54.0
c_2.104x ¹⁾	18 - 25	< 38.24	45	1000	1.00	H/V	--	--	>15	54.0

Remark: 1) Overview measurement only

Channel middle (Channel 18)

Set-up No.:		1								
Operating Mode:		1								
Diagram no.	Freq. (GHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Ant. height (m)	Polarity	Turntable position (deg)	Corr. (dB) (CF)	Margin (dB) (M)	Limit (dBμV/m) (LT)
c_2.105	7.321 (PK)	56.04	10	1000	1.55	H/V	0..360°	--	+18	74.0
	7.318 (AV)	47.44	10	1000	1.55	H/V	0..360°		+6.5	54.0
c_2.105x ¹⁾	18 - 25	<38.50	45	1000	1.00	H/V	--	--	>15	54.0

Remark: 1) Overview measurement only

Channel high (Channel 26)

Set-up No.:		1								
Operating Mode:		1								
Diagram no.	Freq. (GHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Ant. height (m)	Polarity	Turntable position (deg)	Corr. (dB) (CF)	Margin (dB) (M)	Limit (dBμV/m) (LT)
c_2.106	14.48 (PK)	60.3	10	1000	1.55	H/V	0°..360°	--	+13.7	74.0
	7.43(AV)	44.21	10	1000	1.55	H/V	0°..360°		+9.8	54.0
c_2.106x ¹⁾	18 - 25	<37.53	45	1000	1,00	H/V	--	--	>16	54.0

Remark: 1) Overview measurement only

4.4.3. Radiated emissions, above 1GHz till 12.75GHz, RX-Mode according FCC §15.109 class B, RSS-Gen
Channel middle (Channel 18)

Set-up No.:		4								
Operating Mode:		3								
Diagram no.	Frequency (GHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Antenna height (m)	Polarity	Turntable position (deg)	Corr. (dB) (CF)	Margin (dB) (M)	Limit (dBμV/m) (LT)
c_2.107	2.496(PK)	57.42	10	1000	1.55	H/V	0..360°	--	+16.6	74.0
	2.445 (AV)	36.12	10	1000	1.55	H/V	0..360°		+17.9	54.0
c_2.108	12.585 (PK)	55.95	10	1000	1.55	H/V	0..360°		>18	74.0
	4.88 (AV)	35.21	10	1000	1.55	H/V	0..360°		+18.8	54.0

Remark: --

Margin to Limit: $M = L_T - R_R + C_F + D_F$ $= L_T - R_R + (AF_{ANTENNA} + Cable_{LOSS}) + D_F$ Remark: positive margin means passed result	Abbreviations used: <ul style="list-style-type: none"> • R_R : Receiver readings in dBμV/m • CF: Transducer in dB = AF (antenna factor) + CL (cable loss) • D_F : distance correction factor (if different measurement distance used than specified in the standard) • L_T : Limit in dBμV/m
---	--

Final verdict: Summary of measurement results for radiated emissions above 1 GHz: Passed

4.5. Power specification

FCC 15.247, RSS-210

TEST LOCATION AND EQUIPMENT (for reference numbers please see chapter 'List of test equipment')

test location	<input checked="" type="checkbox"/> CETECOM Essen (Chapter. 2.2.1)		<input checked="" type="checkbox"/> 443 System CTC-FAR-EMI-		<input type="checkbox"/> Please see Chapter. 2.2.3	
test site	<input type="checkbox"/> 441 EMI SAR	<input type="checkbox"/> 487 SAR NSA	<input type="checkbox"/> 337 OATS	<input checked="" type="checkbox"/> 347 Radio.lab.	<input type="checkbox"/>	<input type="checkbox"/>
receiver	<input type="checkbox"/> 377 ESCS30	<input type="checkbox"/> 001 ESS	<input checked="" type="checkbox"/> 489 ESU	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
spectr. analys.	<input checked="" type="checkbox"/> 489 ESU	<input type="checkbox"/> 120 FSEM	<input type="checkbox"/> 264 FSEK	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
power supply	<input type="checkbox"/> 456 EA 3013A	<input type="checkbox"/> 457 EA 3013A	<input type="checkbox"/> 459 EA 2032-50	<input type="checkbox"/> 268 EA- 3050	<input type="checkbox"/> 494 AG6632A	<input type="checkbox"/> 498 NGPE 40
otherwise	<input checked="" type="checkbox"/> 301 20dB Attenuator			<input checked="" type="checkbox"/> cable K15		

REFERENCE: §15.247(B)(1) AND RSS-210: A8.4 (2)

The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(1) For frequency hopping systems (FHHS) operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

(2) For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

(3) For systems using digital modulation (DSSS) in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signalling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

ANTENNA CHARACTERISTICS:

- ☒ Directional Gain < 6 dBi (measured: difference between measured conducted and radiated eirp. power)
☐ Directional Gain > 6 dBi (measured / applicant's declaration) -> conducted power reduction necessary

EUT SETTINGS:

For FHHS-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.

MEASUREMENT METHOD:

The measurement was performed in non-hopping transmission mode with the carrier set to lowest/middle and highest channel. The power was also checked for different data rates, modulation scheme or packet types if applicable.

SETTINGS ON SPECTRUM-ANALYZER:

Center Frequency	Nominal channel frequency
Span	150 MHz
Resolution Bandwidth (RBW)	10 MHz > 20dB-Bandwidth of the signal
Video Bandwidth (VBW)	10MHz
Sweep time	coupled
Detector	Peak, Max hold mode
Sweep Mode	Repetitive mode

4.5.1. CONDUCTED MEASUREMENT: MAX. PEAK POWER

- Maximum declared antenna gain [isotropic]: -0.5 dBi

RESULTS

MAX PEAK POWER (conducted)			
Set-up no.: 3 Op-Mode: 1	Low channel = 11 (2405 MHz)	Middle channel = 18 (2440 MHz)	High channel = 26 (2480 MHz)
Measured Peak power [dBm]	--	--	--
Ext. Path loss[dB]+ 20dB Attenuator+ Cable attenuation	20.90	20.90	20.90
Resulting Peak Power*	12.95 dBm 19.72 mW	12.75 dBm 18.77 mW	12.41 dBm 17.42 mW
Limit	1 Watt (30dBm) Peak		

Remark: The results were taken directly from the spectrum analyzer display, the path loss and attenuators were included as reference level offset in the spectrum analyzer. Please refer the diagrams

VERDICT: Passed

4.6. Radio Frequency Exposure Evaluation

FCC 2.1091, RSS-102

References:

FCC: §1.1310, § 2.1091

IC: RSS-102, Issue 4

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.

§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.

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)—Continued

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
1500–100,000 .....	.....	.....	1.0	30

f = frequency in MHz

Table 1: LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

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

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

Abbreviations:

S: Power density (unit: mW/cm²)
P: Power Input to the antenna
G: Gain of the antenna relative to an isotropic radiator,
EIRP: Equivalent isotropically radiated power, determined within a separate measurement (unit: mW)
R: distance to the center of the radiation of the antenna (unit: cm)

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

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

General Limits:**§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)

§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)

§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 **§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.

RSS-102

Standard requires the RF-exposure value in W/m^2 unit; therefore the value determined in mW/cm^2 unit should be multiplied by 10 to have the required unit.

METHOD: The RF-exposure values were derived from the measured conducted Peak Power with assumed antenna gain of 0dBi.

The power was checked on 3 frequencies (lowest/middle/highest) within each operable ZigBee-band. Please refer to chapter 4.1 for the measurement set-up.

Please find enclosed the calculation of each limit representation for the frequency range 100 MHz to 2.5 GHz. Also the maximum admissible allowed antenna gain is calculated.

Operational Band	Channel no.	Channel Frequency	Power-Value		MPE-Value	MPE-Limit	Margin to limit:	Maximum admissible antenna gain at 20 cm distance (cable losses not considered) (Unit: dBi)
			(Unit dBm)	(Unit: mWatt)	(Unit: mWatt/cm ²)			
ZigBee	11	2405	12.95	19.72	0.0039	1.0000	0.9961	24.0635
	18	2440	12.75	18.77	0.0037	1.0000	0.9963	24.2826
	26	2448	12.41	17.42	0.0035	1.0000	0.9965	24.6021

4.7. Radiated measurement: max. E.I.R.P power

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

test site	<input type="checkbox"/> 441 EMI SAR	<input type="checkbox"/> 348 EMI cond.	<input checked="" type="checkbox"/> 443 EMI FAR	<input type="checkbox"/> 347 Radio.lab.	<input type="checkbox"/> 337 OATS	<input type="checkbox"/>
equipment	<input type="checkbox"/> 331 HC 4055	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Spectr. analys.	<input type="checkbox"/> 489 ESU	<input type="checkbox"/> 120 FSEM	<input type="checkbox"/> 264 FSEK	<input checked="" type="checkbox"/> 489 ESU	<input type="checkbox"/>	<input type="checkbox"/>
antenna meas	<input type="checkbox"/> 549 HL025	<input type="checkbox"/> 289 CBL 6141	<input type="checkbox"/> 439 HL 562	<input checked="" type="checkbox"/> 133 EMCO3115	<input type="checkbox"/> 302 BBHA9170	<input type="checkbox"/> 477 GPS
antenna subst	<input type="checkbox"/> 030 HUF-Z2	<input type="checkbox"/> 020 EMCO3115	<input type="checkbox"/> 063 LP 3146	<input type="checkbox"/> 303 BBHA9170	<input type="checkbox"/>	<input type="checkbox"/>
power meter	<input type="checkbox"/> 009 NRV	<input type="checkbox"/> 010 URV5-Z2	<input type="checkbox"/> 011 URV5-Z2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Signalgener.	<input type="checkbox"/> 008 SMG	<input type="checkbox"/> 140 SMHU	<input type="checkbox"/> 263 SMP04	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
power meter	<input type="checkbox"/> 262 NRV-S	<input type="checkbox"/> 266 NRV-Z31	<input type="checkbox"/> 265 NRV-Z33	<input type="checkbox"/> 261 NRV-Z55	<input type="checkbox"/> 356 NRV-Z1	<input type="checkbox"/>
DCpower	<input type="checkbox"/> 086 LNG50-10	<input type="checkbox"/> 087 EA3013	<input type="checkbox"/> 354 NGPE 40	<input type="checkbox"/> 349 car battery	<input type="checkbox"/> 350 Car battery	<input type="checkbox"/>

EUT SETTINGS:

For FHHS-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.

MEASURING METHOD 1: The method is according ANSI/TIA/EIA-603-C-2004 and consist of two steps.

First step: The maximum power was recorded by turning the EUT continuously 360 degree steps, the EUT in horizontal (laying) and vertical (standing) position. Measurements have been performed with the measurement antenna set to horizontal and vertical polarisation. The spectrum analyzer was set to MAX-PEAK Detector, MAX-Hold Mode. The RBW used was bigger than the 20-dB bandwidth of the EUT and set to 3 MHz. VBW set to 10MHz with coupled sweep time. The maximum trace peak value was recorded.

Second step: a horn antenna was set instead of the EUT and connected to the signal generator. The level was adjusted such as the same level as in step 1 could be reached. The conducted power delivered to the antenna was measured and the value corrected with the known antenna eirp gain.

Alternative measurement method: a field strength measurement was performed in 3m distance to the EUT. General measurement procedures as shown in chapter 5.3 applies therefore. Using transformation formula between field strength and e.i.r.p. power as shown in ANSI63.10: 2009, chapter 7.8.2 is used for conversion. In addition a bandwidth correction factor applied: $10 \cdot \log(6\text{dB BW/RBW}=1\text{MHz})$

MAX. FIELD STRENGTH MEASURED IN 3m DISTANCE

Maximum Radiated field strength@3m distance			
Set-up no.: 3 Op. Mode: 1	Low channel = 1 (2405 MHz)	Middle channel = 6 (2439 MHz)	High channel = 11 (2462 MHz)
Determined field strength [dBuV/m] in 3m distance with RBW=1MHz	111.0 (PK) 107.2 (AV)	109.9 (PK) 106.2 (AV)	109.2 (PK) 105.5 (AV)
Value in dBm using conversion formula and assumed numeric Gain=1: $E = \sqrt{\frac{30 \cdot P \cdot G}{d^2}}$	10.9 (PK)	10.8 (PK)	10.76 (PK)
Bandwidth correction factor ^{1.)}	2.33	2.28	2.28
e.i.r.p. power [dBm] assumed 0dBi gain	13.23	13.08	13.04
Actual declared gain of antenna by applicant [dBi]	-0.5		
Final Result e.i.r.p. [dBm]:	12.73	12.58	12.54

Remark: 1.) see 6dB BW results before

VERDICT: Passed, Maximum value: 12.73 dBm (antenna gain < 6 dBi)

4.8. 20dBc Emission specification

FCC 15.247, RSS-210

TEST LOCATION AND EQUIPMENT (for reference numbers please see chapter 'List of test equipment')

test location	<input checked="" type="checkbox"/> CETECOM Essen (Chapter. 2.2.1)		<input type="checkbox"/> Please see Chapter. 2.2.2		<input type="checkbox"/> Please see Chapter. 2.2.3	
test site	<input type="checkbox"/> 441 EMI SAR	<input type="checkbox"/> 487 SAR NSA	<input type="checkbox"/> 337 OATS	<input checked="" type="checkbox"/> 347 Radio.lab.	<input type="checkbox"/>	<input type="checkbox"/>
receiver	<input type="checkbox"/> 377 ESCS30	<input type="checkbox"/> 001 ESS	<input checked="" type="checkbox"/> 489 ESU	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
spectr. analys.	<input type="checkbox"/> 489 ESU	<input type="checkbox"/> 120 FSEM	<input type="checkbox"/> 264 FSEK	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
power supply	<input type="checkbox"/> 456 EA 3013A	<input type="checkbox"/> 457 EA 3013A	<input type="checkbox"/> 459 EA 2032-50	<input type="checkbox"/> 268 EA- 3050	<input type="checkbox"/> 494 AG6632A	<input type="checkbox"/> 498 NGPE 40
otherwise	<input checked="" type="checkbox"/> 301 20dB Attenuator			<input checked="" type="checkbox"/> cable K15		

REFERENCES: §15.247, §15.205, RSS-210: A8.5

(d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

EUT SETTINGS:

For FHHS-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.

MEASUREMENT METHOD:

The frequency spectrum was investigated for **conducted/radiated** spurious emissions values lower than 20dB related to the RF-carrier power value. Three carrier frequencies (low/middle/high channel) were used for showing the compliance with this requirement. The detector were chosen according §15.209(d). The video bandwidth (VBW) was chosen 10 times the resolution bandwidth (RBW). The frequency scan was up to 10 times the highest channel frequency within the operational mode. The spectrum-analyzer was set to MAX-PEAK Detector, MAX-Hold Mode.

For FHHS-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.

Set-up no.: 3 Op. Mode: 1	RF-CONDUCTED TEST: 20 dBc SPURIOUS EMISSIONS					
Frequency Range	Low channel = 11 (2405 MHz)		Middle channel = 18 (2440 MHz)		High channel = 26 (2480 MHz)	
	Level Reference (In-Band) = 116.29 dBμV		Level Reference (In-Band) = 121.09 dBμV		Level Reference (In-Band) = 115.44 dBμV	
	Frequency [MHz]	Value [dBc]	Frequency [MHz]	Value [dBc]	Frequency [MHz]	Value [dBc]
30 .. 1000 MHz	--	No remarkable peaks found Margin>36dB to limit 96.29 dBμV	--	No remarkable peaks found Margin>48dB to limit 101.09 dBμV	--	No remarkable peaks found Margin>40dB to limit 95.44 dBμV
1 GHz .. 18 GHz	2341	70.22 dBμV Margin +26dB	2376	74.98 dBμV Margin +26dB	2375	73.07 dBμV Margin +21dB
18..25GHz	Only radiated overview measurements -> No remarkable peaks found					

Remark: The limit on the diagrams is 20dB under the reference level measured In-Band for each channel

VERDICT: Passed

4.9. Power Spectral Density

FCC 15.247, RSS-210

TEST LOCATION AND EQUIPMENT (for reference numbers please see chapter 'List of test equipment')

test location	<input checked="" type="checkbox"/> CETECOM Essen (Chapter. 2.2.1)		<input type="checkbox"/> Please see Chapter. 2.2.2		<input type="checkbox"/> Please see Chapter. 2.2.3	
test site	<input type="checkbox"/> 441 EMI SAR	<input type="checkbox"/> 487 SAR NSA	<input type="checkbox"/> 337 OATS	<input checked="" type="checkbox"/> 347 Radio.lab.	<input type="checkbox"/>	<input type="checkbox"/>
receiver	<input type="checkbox"/> 377 ESCS30	<input type="checkbox"/> 001 ESS	<input checked="" type="checkbox"/> 489 ESU	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
spectr. analys.	<input type="checkbox"/> 489 ESU	<input type="checkbox"/> 120 FSEM	<input type="checkbox"/> 264 FSEK	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
power supply	<input type="checkbox"/> 456 EA 3013A	<input type="checkbox"/> 457 EA 3013A	<input type="checkbox"/> 459 EA 2032-50	<input type="checkbox"/> 268 EA- 3050	<input type="checkbox"/> 494 AG6632A	<input type="checkbox"/> 498 NGPE 40
otherwise	<input checked="" type="checkbox"/> 301 20dB Attenuator			<input checked="" type="checkbox"/> cable K15		

REFERENCES: §15.247(E), RSS-210:A8.3

(e) For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

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.

MEASUREMENT METHOD:

A frequency sweep around nominal carrier frequency is performed over the complete power envelope of the signal with PEAK detector, MAX hold mode. The maximum peak is located and the frequency recorded. With the nominal frequency set to the determined frequency in the step before, a new frequency sweep is performed with a reduced resolution bandwidth of 3kHz. The measured value is corrected due to external measuring set-up and the resulting value is compared with the standard requirement.

RESULTS

Set-up no.: 1 Op. Mode: 3	POWER SPECTRAL DENSITY		
	Low channel = 11 (2405 MHz)	Middle channel = 18 (2440 MHz)	High channel = 26 (2480 MHz)
Measured Level [dBm/3kHz]	--	--	--
Ext. Path loss[dB]+ 20dB Attenuator+ Cable attenuation	20.90	20.90	20.90
Resulting Power spectral density [dBm/3kHz]	-2.31	-2.93	-2.67
Limit	< 8dBm/3kHz		

Remark: The results were taken directly from the spectrum analyzer display, the path loss and attenuators were included as reference level offset in the spectrum analyzer. Please refer the diagrams

VERDICT: Passed

4.10. Band-Edge compliance measurements,**FCC 15.247, RSS-210****TEST LOCATION AND EQUIPMENT** (for reference numbers please see chapter 'List of test equipment')

test location	<input checked="" type="checkbox"/> CETECOM Essen (Chapter. 2.2.1)		<input checked="" type="checkbox"/> 443 System CTC-FAR-EMI-		<input type="checkbox"/> Please see Chapter. 2.2.3	
test site	<input type="checkbox"/> 441 EMI SAR	<input type="checkbox"/> 487 SAR NSA	<input type="checkbox"/> 337 OATS	<input type="checkbox"/> 347 Radio.lab.	<input type="checkbox"/>	<input type="checkbox"/>
receiver	<input type="checkbox"/> 377 ESCS30	<input type="checkbox"/> 001 ESS	<input checked="" type="checkbox"/> 489 ESU	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
antenna meas	<input checked="" type="checkbox"/> 549 HL025	<input type="checkbox"/> 289 CBL 6141	<input type="checkbox"/> 439 HL 562	<input checked="" type="checkbox"/> 133 EMCO3115	<input type="checkbox"/> 302 BBHA917	<input type="checkbox"/> 477 GPS
spectr. analys.	<input type="checkbox"/> 489 ESU	<input type="checkbox"/> 120 FSEM	<input type="checkbox"/> 264 FSEK	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
power supply	<input type="checkbox"/> 456 EA 3013A	<input type="checkbox"/> 457 EA 3013A	<input type="checkbox"/> 459 EA 2032-50	<input type="checkbox"/> 268 EA- 3050	<input type="checkbox"/> 494 AG6632A	<input type="checkbox"/> 498 NGPE 40
otherwise	<input type="checkbox"/> 530 10dB Attenuator			<input checked="" type="checkbox"/> cable K15		

MEASUREMENT METHOD:

A Delta marker method was used for showing compliance to restricted bands according §15.205. The method is according Public Notice “Marker-Delta method”, Extract from DA00-705. 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 §15.205 with the general limits of §15.209.

Duty Cycle correction factor method:

This method is according Public Notice “Pulsed transmitter”, Extract from DA02-2850 and according Part 15 unlicensed transmitter presentation of Chief Joe Dichose, responsible of equipment auth. branch of FCC.

1. To determine how the average value of the emission was determined for all operating conditions of the transmitter. The carrier of transmitters operating under 47 CFR 15.231 is typically pulsed. Peak levels of emissions are measured, then the average levels are obtained by subtracting the duty cycle factor from the peak levels. Section 15.35 (c) of the rules provides a procedure for calculating the duty cycle and average value. A procedure for calculating the duty cycle is also provided in Section 13.1.4.2 of the America National Standard identified as ANSI Standard, C63.4 -2001. Unless a trainable transmitter is capable of only learning over a range of duty cycles, compliance should be based on the worst case duty cycle
2. The measurements that demonstrate compliance for the worst case duty cycle for all “targeted transmitters”. That is, the highest duty cycle factor must be calculated and used for determining compliance. If the trainable transmitter is capable of learning only over a specific range of duty cycles, compliance should be based on measurements using low, middle and high (worst case) duty cycles within the range.
3. This correction factor is applied for all emissions including the fundamental and harmonics.

Duty cycle correction factor calculation expressed in terms of dB:

$20 \cdot \log(\text{on time} / 100 \text{ milli seconds or period})$, whichever is less.

Maximum duty cycle according §15.35(b): 20 dB

This value is used when measuring average field strength above 1 GHz with Peak Detector function employed on spectrum analyzer. For pulsed or burst signals, this allows a reduction in the measured power based ‘on time’ over a 100ms or period.

MEASUREMENT RESULTS

Duty-cycle correction factor calculating:

$$20 * \log(1.954 \text{ ms} / 1.954 \text{ ms} + 11.95 \text{ ms}) = 20 * \log(0.14) = -17.1 \text{ dB}$$

TX-on,

Set-up: 1 Op. Mode. 1							
Tnom= 21°C Vnom= 5.0 V		Delta Marker Value	Fundamental field strength- radiated	Subtraction: Fund. field strength – Delta value	Value at Band- Edge	Limit	Verdict
Diagram No.	Channel No.						
		[dB]	[dBμV/m]	[dBc]	[dBμV/m]		
C_01_BE_left + C_01_BE	Channel Low= 11	108.05(PK_h) – 52.78(PK_l)= 55.27	111.0 (PK) 107.2 (AV)	111.0- 55.27= 55.73	--	>20dBc	Passed
C_03_BE_right + C_03_BE	Channel High= 26	102.11(PK_h) – 53.30(PK_l)= 48.81dB	109.20(PK)- 48.81dB	--	60.39 (PK)	74 dBμV/m	Passed
			109.20 (PK)- 48.81- 17.1 ¹⁾	--	43.29 (AV)	54 dBμV/m	Passed

Remarks: 1)Duty cycle correction factor used (please refer chapter 4.10)

Final verdict: Passed

4.11. 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.

Measurement	Frequency range	Calculated uncertainty based on a confidence level of 95%	Remarks:
RF-Power Output conducted	9 kHz .. 20 GHz	1.0 dB	--
RF-Power Output radiated	30 MHz .. 4 GHz	3.17 dB	Substitution method
Conducted RF-emissions on antenna ports	9 kHz .. 20 GHz	1.0 dB	--
Radiated RF-emissions enclosure	150 kHz .. 30 MHz	5.0 dB	Magnetic field
	30 MHz .. 1 GHz	4.2 dB	E-Field
	1 GHz .. 18GHz	4.8 dB	E-Field
	1 GHz .. 20 GHz	3.17 dB	Substitution method
Occupied bandwidth	9 kHz .. 4 GHz	0.1272 ppm (Delta Marker method)	Frequency error
		1 dB	Power
Emission bandwidth	9 kHz .. 4 GHz	0.1272 ppm (Delta Marker method)	Frequency error
		1 dB	Power
Frequency stability	9 kHz .. 20 GHz	0.0636 ppm	--
Conducted emissions on AC-mains port (U _{CISPR})	9 kHz .. 150 kHz	4.0 dB	--
	150 kHz .. 30 MHz	3.6 dB	

Table : measurement uncertainties, valid for conducted/radiated measurements

5. Instruments and Ancillary

5.1. Used equipment “CTC”

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

5.1.1. 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
264	Spectrum Analyzer	FSEK 30	826939/005	Bios=2.1, Analyzer= 3.20
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
331	Climatic Test Chamber -40/+80 Grad	HC 4055	43146	TSI 1.53
335	System-CTC-EMS-Conducted	System EMS Conducted	-	EMC 32 V 8.40
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
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
383	Signal Generator	SME 03	842 828 /034	Firm.= 4.61
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
441	CTC-SAR-EMI Cable Loss	System EMI field (SAR) Cable	-	EMC 32 Version 8.40
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. 8.40
444	CTC-FAR-EMS field	System-EMS-Field (FAR)	-	EMC 32 Version 8.40
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
594	Univ. Radio Communication Tester	CMW500	101757	Firmware Base=2.0.20.9, LTE=2.0.20.8. CDMA= 2.0.10
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

5.1.2. 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	-	31.03.2012
005	AC - LISN (50 Ohm/50µH, test site 1)	ESH2-Z5	861741/005	Rohde & Schwarz	24/12 M	-	31.03.2012
007	DC - LISN (50 Ohm/5µH)	ESH3-Z6	892563/002	Rohde & Schwarz	24/12 M	-	31.03.2012
009	Power Meter (EMS-radiated)	NRV	863056/017	Rohde & Schwarz	24 M	-	31.03.2013
016	Line Impedance Simulating Network	Op. 24-D	B6366	Spitzenberger+Spies	36 M	-	31.03.2013
020	Horn Antenna 18 GHz (Subst 1)	3115	9107-3699	EMCO	36/12 M	-	31.03.2013
021	Loop Antenna (H-Field)	6502	9206-2770	EMCO	36 M	-	31.03.2013
030	Loop Antenna (H-field)	HFH-Z2	879604/026	Rohde & Schwarz	36 M	-	31.03.2012
033	RF-current probe (100kHz-30MHz)	ESH2-Z1	879581/18	Rohde & Schwarz	24 M	-	31.03.2013
057	relay-switch-unit (EMS system)	RSU	494440/002	Rohde & Schwarz	-	1a	30.05.2011
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	1c	30.06.2012
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	
090	Helmholtz coil: 2x10 coils in series	-	-	RWTÜV	-	4	
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	-	31.03.2012
100	passive voltage probe	Probe TK 9416	without	Schwarzbeck	36 M	-	31.03.2012
110	USB-LWL-Converter	OLS-1	-	Ing. Büro Scheiba	-	4	
119	RT Harmonics Analyzer dig. Flickermeter	B10	G60547	BOCONSULT	36 M	-	31.03.2013
134	horn antenna 18 GHz (Subst 2)	3115	9005-3414	EMCO	12 M	-	31.03.2012
136	adjustable dipole antenna (Dipole 1)	3121C-DB4	9105-0697	EMCO	12 M	-	31.03.2012
140	Signal Generator	SMHU	831314/006	Rohde & Schwarz	24 M	-	31.03.2012
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	24/12 M	-	31.03.2012
262	Power Meter	NRV-S	825770/0010	Rohde & Schwarz	24 M	-	31.03.2012
263	Signal Generator	SMP 04	826190/0007	Rohde & Schwarz	36 M	-	31.03.2013
264	Spectrum Analyzer	FSEK 30	826939/005	Rohde & Schwarz	12 M	-	31.03.2014
265	peak power sensor	NRV-Z33, Model 04	840414/009	Rohde & Schwarz	24 M	-	31.03.2012
266	peak power sensor	NRV-Z31, Model 04	843383/016	Rohde & Schwarz	24 M	-	31.03.2012
267	notch filter GSM 850	WRCA 800/960-6EEK	9	Wainwright GmbH	pre-m	2	
268	AC/DC power supply	EA 3050-A	9823636	Elektro Automatik	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	30.06.2012
291	high pass filter GSM 850/900	WHJ 2200-4EE	14	Wainwright GmbH	12 M	1c	30.06.2012
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	24/12 M	-	31.03.2012
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	-	31.03.2014
303	horn antenna 40 GHz (Subst 1)	BBHA9170	156	Schwarzbeck	36 M	-	31.03.2014
331	Climatic Test Chamber -40/+80 Grad	HC 4055	43146	Heraeus Vötsch	24 M	-	30.11.2012
341	Digital Multimeter	Fluke 112	81650455	Fluke	24 M	-	31.03.2012
342	Digital Multimeter	Voltcraft M-4660A	1B 255466	Voltcraft	24 M	-	31.03.2013
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	-	31.03.2012
356	power sensor	NRV-Z1	882322/014	Rohde & Schwarz	24 M	-	31.03.2013
357	power sensor	NRV-Z1	861761/002	Rohde & Schwarz	24 M	-	31.03.2013
373	V-Network 5µH/50 Ohm	ESH3-Z6	100535	Rohde & Schwarz	24/12 M	-	31.03.2012
376	Horn Antenna 6 GHz	BBHA9120 E	BBHA 9120 E 179	Schwarzbeck	12 M	-	31.03.2012
377	Emi Test Receiver	ESCS 30	100160	Rohde & Schwarz	12 M	-	31.03.2012
389	Digital Multimeter	Keithley 2000	0583926	Keithley	24 M	-	31.03.2013
392	Radio Communication Tester	MT8820A	6K00000788	Anritsu	12 M	-	31.03.2012
431	Model 7405	Near-Field Probe Set	9305-2457	EMCO	-	4	
441	CTC-SAR-EMI Cable Loss	System EMI field (SAR) Cable	-	CETECOM	12 M	5	31.08.2011
443	CTC-FAR-EMI-RSE	System CTC-FAR-EMI-	-	ETS-	12 M	5	30.06.2012

Ref.-No.	Equipment	Type	Serial-No.	Manufacturer	Interval of calibration	Remark	Cal due
		RSE		Lindgren/CETECOM			
448	notch filter WCDMA_FDD II	WRCT 1850.0/2170.0-5/40-10SSK	5	Wainwright Instruments GmbH	12 M	1c	30.06.2012
449	notch filter WCDMA FDD V	WRCT 824.0/894.0-5/40-8SSK	1	Wainwright	12 M	1c	30.06.2012
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	-	31.03.2012
463	Universal source	HP3245A	2831A03472	Agilent	-	4	
466	Digital Multimeter	Fluke 112	89210157	Fluke USA	24 M	-	31.03.2012
467	Digital Multimeter	Fluke 112	89680306	Fluke USA	24 M	-	31.03.2012
468	Digital Multimeter	Fluke 112	90090455	Fluke USA	24 M	-	31.03.2012
477	ReRadiating GPS-System	AS-47	-	Automotive Cons. Fink	-	3	
480	power meter (Fula)	NRVS	838392/031	Rohde & Schwarz	24 M	-	31.03.2013
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	-	30.07.2012
487	System CTC NSA-Verification SAR-EMI	System EMI field (SAR) NSA	-	ETS Lindgren/CETECOM	12 M	-	30.09.2011
489	Emi Test Receiver	ESU40	1000-30	Rohde & Schwarz	12 M	-	31.03.2012
502	band reject filter	WRCG 1709/1786-1699/1796-	SN 9	Wainwright	pre-m	2	
503	band reject filter	WRCG 824/849-814/859-60/10SS	SN 5	Wainwright	pre-m	2	
512	notch filter GSM 850	WRCA 800/960-02/40-6EEK	SN 24	Wainwright	12 M	1c	30.06.2012
517	relais switch matrix	HF Relais Box Keithley System	SE 04	Keithley	pre-m	2	
523	Digital Multimeter	L4411A	MY46000154	Agilent	24 M	-	31.03.2013
529	6 dB Broadband resistive power divider	Model 1515	LH 855	Weinschel	pre-m	2	
547	Univ. Radio Communication Tester	CMU 200	835390/014	Rohde & Schwarz	12 M	-	31.03.2012
548	Digital-Barometer	GBP 2300	without	Greisinger GmbH	36/12 M	-	31.03.2012
549	Log-Per-Antenna	HL025	1000060	Rohde & Schwarz	36/12 M	-	31.03.2012
552	high pass filter 2,8-18GHz	WHKX 2.8/18G-10SS	4	Wainwright	12 M	1c	30.07.2012
558	System CTC FAR S-VSWR	System CTC FAR S-VSWR	-	CTC	24 M	-	31.07.2013
574	Biconilog Hybrid Antenna	BTA-L	980026L	Frankonia	36/12 M	-	30.03.2013
584	Spectrum Analyzer	FSU 8	100248	Rohde & Schwarz	12 M	-	31.03.2012
594	Univ. Radio Communication Tester	CMW500	101757	Rohde & Schwarz	24 M	-	31.03.2012
597	Univ. Radio Communication Tester	CMU 200	100347	Rohde & Schwarz	12 M	-	31.03.2012
598	Spectrum Analyzer	FSEM 30 (Reserve)	831259/013	Rohde & Schwarz	24 M	-	13.01.2013
600	power meter	NRVD (Reserve)	834501/018	Rohde & Schwarz	24 M	-	31.03.2013
601	medium-sensitivity diode sensor	NRV-Z5 (Reserve)	8435323/003	Rohde & Schwarz	24 M	-	12.01.2013
602	peak power sensor	NRV-Z32 (Reserve)	835080	Rohde & Schwarz	24 M	-	12.01.2013
608	UltraLog-Antenna	HL 562	830547/009	Rohde & Schwarz	36/12 M	-	31.03.2014
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	

5.1.3. 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