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June 20, 2014

Prüfbericht / *Test Report* Nr. / *No.* 20351-36985 (Edition 2)

Applicant:	Endress & Hauser GmbH
Type of equipment:	K-Band Level Probing Radar (LPR)
Type designation:	FMR51, FMR 52, FMR 56 (K-Band liquid) FMR51, FMR 52, FMR 56, FMR 57 (K-Band solid)
Order No.:	106/1016576508
Test standards:	FCC Code of Federal Regulations, CFR 47, Part 15, Sections 15.205, 15.207, 15.209, 15.256

TÜV SÜD Product Service GmbH
Äußere Frühlingstraße 45
94315 Straubing
Germany

Phone: +49 9421 5522-0
Fax: +49 9421 5522-99
Web: www.tuev-sued.de

Table of Contents

1 Description of the Equipment Under Test (EUT)

General data of EUT	
Type designation[1]:	FMR51, FMR 52, FMR 56 (K-Band liquid) FMR51, FMR 52, FMR 56, FMR 57 (K-Band solid)
Parts[2]:	**FMR51, FMR 52, FMR 56, (K-Band liquid)** - Base module - Housing GT 19 - FMR 56 Horn 100 mm / 4“, PP plated - FMR 56 Horn 80 mm / 3“, PP plated - FMR 51 Horn 100 mm / 4“ - FMR 51 Horn 80 mm / 3“ - FMR 51 Horn 40 mm / 1.5“ - FMR 52 Horn 80 mm / 3“, front level **FMR51, FMR 52, FMR 56, FMR 57 (K-Band solid)** Base module - Housing GT 19 - FMR 56 Horn 100 mm / 4“, PP plated - FMR 56 Horn 100 mm / 3“, PP plated - FMR 51 Horn 100 mm / 4“ - FMR 51 Horn 8 mm / 3“ - FMR 51 Horn 40 mm / 1.5“ - FMR 52 Horn 80 mm / 3“, front level - FMR 52 Horn 50 mm / 2“, front level - FMR 57 Horn 100 mm / 4“ - FMR 57 Parabolic 250 mm / 10“ - FMR 57 Parabolic 250 mm / 8“
Serial number(s):	Test Samples
Manufacturer:	Endress & Hauser GmbH
Type of equipment:	K-Band Level Probing Radar (LPR)
Version:	As received
FCC ID:	LCGFMR5XKF
Additional parts/accessories:	

[1] Type designation of the system if EUT consists of more than one part.
[2] Type designations of the parts of the system, if applicable.

Technical data of EUT	
Application frequency range:	24.05 GHz - 29.0 GHz
Frequency range:	25.2 GHz
Operating frequency:	25.2 GHz
Type of modulation:	1G50P0NAN
Pulse train:	558.54 ns
Pulse width:	2.04 ns
Number of RF-channels:	1
Channel spacing:	N/A
Designation of emissions[3]	1G50P0NAN
Type of antenna:	See table of configuration of EUTs for details
Size/length of antenna:	See table of configuration of EUTs for details
Connection of antenna:	☐ detachable ☒ not detachable
Type of power supply:	DC supply
Specifications for power supply:	nominal voltage: 12 - 30 V (24 V nominal) V

[3] Also known as "Class of Emission".

2 Administrative Data

Application details	
Applicant (full address):	Endress & Hauser GmbH Hauptstraße 1D 79689 Maulburg
Contact person:	Mr. Ralf Reimelt
Order number:	106/1016576508
Receipt of EUT:	13 February 2014
Date(s) of test:	13 February 2014
Note(s):	The applicant provided different configurations for tests. In order to simplify tests the configuration were numbered. **Mr. Reimelt attended tests on 13 February 2014**

Report details	
Report number:	20351-36985
Edition:	2
Issue date:	20 Juni 2014

3 Identification of the Test Laboratory

Details of the Test Laboratory	
Company name:	TÜV SÜD Product Service GmbH
Address:	Aeussere Fruehlingstrasse 45 D-94315 Straubing Germany
FCC test site registration number	90926
Industry Canada test site registration:	3050A-2
Contact person:	Mr. Johann Roidt Phone: +49 9421 5522-0 Fax: +49 9421 5522-99

4 Summary

Summary of test results
The tested sample complies with the requirements set forth in the **Code of Federal Regulations CFR 47, Part 15, Sections 15.205, 15.207, 15.209, 15.256** of the Federal Communication Commission (FCC).

Personnel involved in this report	
Laboratory Manager:	 Mr. Johann Roidt
Responsible for testing:	Mr. Johann Roidt
Responsible for test report:	Mr. Johann Roidt

5 Operation Mode and Configuration of EUT

Operation Mode(s)
Normal operation mode: Measurement with pulsed signal

Configuration(s) of EUT
FCC test setup, DC 24 V power supply, EUT in vertical position. Conducted emissions were performed with a transmitter head without antenna and 50 Ω termination.

List of ports and cables				
Port	*Description*	*Classification*[4]	*Cable type*	*Cable length*
1	DC supply with HART communication	dc power	Unshielded	2 m

List of devices connected to EUT				
Item	*Description*	*Type Designation*	*Serial no. or ID*	*Manufacturer*

List of support devices				
Item	*Description*	*Type Designation*	*Serial no. or ID*	*Manufacturer*
	---			

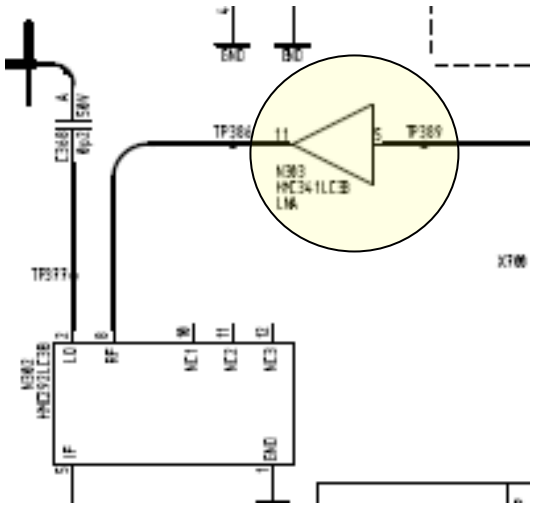
[4] Ports shall be classified as ac power, dc power or signal/control port

Configuration of test samples (Liquid)				
Configuration	*Module*	*Antenna*	*Flange*	*Housing*
K2	FMR 56	FMR 56 Horn 100 mm / 4”, PP plated, (25.4 dBi)	Adapterring + Uniflange DN 100	GT 19
K22	FMR 56	FMR 56 Horn 80 mm / 3”, PP plated, (25.4 dBi)		
K3	FMR 51	FMR 51 Horn 100 mm / 4“, (24.3 dBi)	Flange DN 150	GT 19
K33	FMR 51	FMR 51 Horn 80 mm / 3“, (24.3 dBi)		
K4	FMR 52	FMR 52 Horn 80 mm / 3“, (24.5 dBi)	Flange DN 150	GT 19

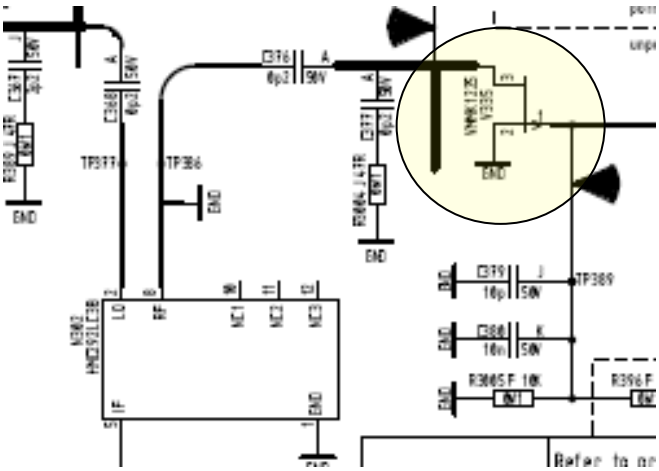
Configuration of test samples (Solid)				
Configuration	*Module*	*Antenna*	*Flange*	*Housing*
K2	FMR 56	FMR 56 Horn 100 mm / 4”, PP plated, (25.4 dBi)	Adapterring + Uniflange DN 100	GT 19
K22	FMR 56	FMR 56 Horn 80 mm / 3”, PP plated, (25.4 dBi)		
K3	FMR 51	FMR 51 Horn 100 mm / 4“, (24.3 dBi)	Flange DN 150	GT 19
K33	FMR 51	FMR 51 Horn 80 mm / 3“, (24.3 dBi)		
K4	FMR 52	FMR 52 Horn 80 mm / 3“, (24.5 dBi)	Flange DN 150	GT 19
K44	FMR 52	FMR 52 Horn 50 mm / 2“, (24.5 dBi)	Flange DN 150	GT 19
K5	FMR 57	FMR 57 Horn 100 mm / 4“ (25.3 dBi)	Uniflange	GT 19
K6	FMR 57	FMR 57 Parabol 250 mm / 10“ (33.0 dBi)	Uniflange	GT 19
K66	FMR 57	FMR 57 Parabol 250 mm / 8“ (33.0 dBi)	Uniflange	GT 19

Differences between “Liquid” and “Solid”Versions

„Solid“ Version has a Low Noise Amplifier in the RX Signal path for enhanced dynamic range



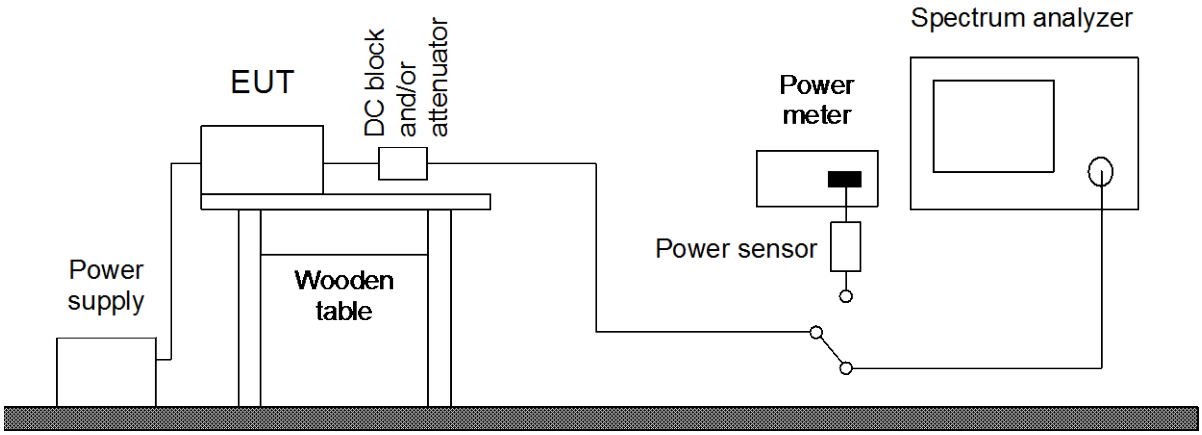
„Liquid“ Version has a simple FET instead



6 Measurement Procedures

6.1 Conducted Output Power

Measurement Procedure:	
Rules and specifications:	CFR 47 Part 2, section 2.1046(a) IC RSS-Gen Issue 3, section 4.8
Guide:	CFR 47 Part 2, section 2.1046 / IC RSS-Gen Issue 3
Conducted output power is measured at the RF output terminals (e.g. antenna connector if antenna is detachable) when the transmitter is adjusted in accordance with the tune-up procedure, if applicable. The RF output terminals are connected to a spectrum analyzer and/or a power meter with appropriate sensor. If required, a resistive matching network equal to the impedance specified or employed for the antenna is used as well as dc block and appropriate attenuators (50 Ohms). The electrical characteristics of the radio frequency load attached to the output terminals shall be stated, if applicable. If a spectrum analyzer is used and no other settings are specified resolution bandwidth shall be selected according to the carrier frequency f_c and set to 10 kHz (150 kHz $\leq f_c <$ 30 MHz), 100 kHz (30 MHz $\leq f_c <$ 1 GHz) or 1 MHz ($f_c \geq$ 1 GHz). The video bandwidth shall be at least three times greater than the resolution bandwidth. The settings used have to be indicated within the appropriate test record(s).	

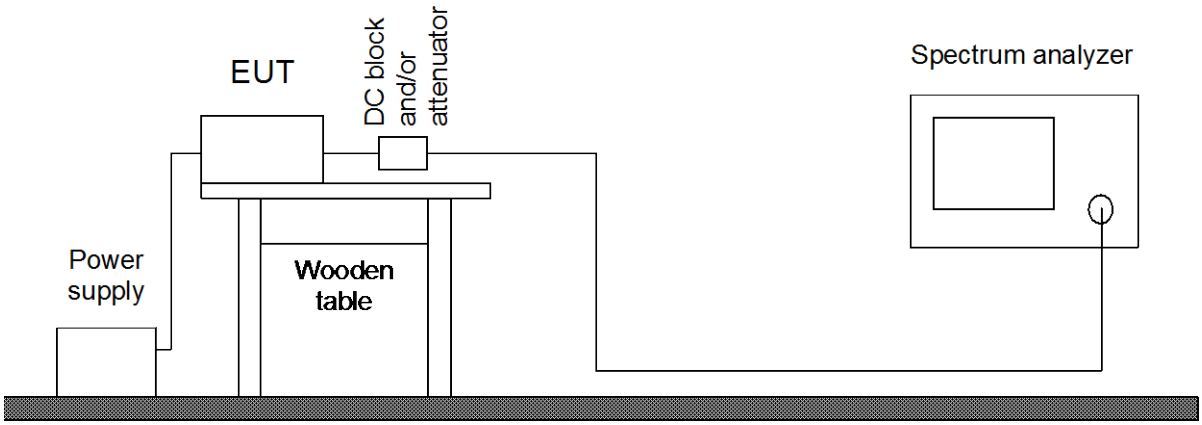


Test instruments used:

	Type	*Designation*	*Inv.-no.*	*Serial No. or ID*	*Manufacturer*
☒	Spectrum analyzer	FSP30	1666	100036	Rohde & Schwarz
☐	EMI test receiver	ESPI7	1711	836914/0002	Rohde & Schwarz
☐	EMI test receiver	ESMI	1569	839379/013 839587/006	Rohde & Schwarz
☐	Power meter	NRVS	1264	836856/015	Rohde & Schwarz
☐	Peak power sensor	NRV-Z31	1701	8579604.03	Rohde & Schwarz
☐	Power sensor	NRV-Z52	1499	837901/030	Rohde & Schwarz
☐	Power sensor	NRV-Z4	1034	863828/015	Rohde & Schwarz
☒	DC-block	7006	1636	A2798	Weinschel
☐	Attenuator	4776-10	1638	9412	Narda
☐	Attenuator	4776-20	1639	9503	Narda

6.2 Bandwidth Measurements

Measurement Procedure:	
Rules and specifications:	CFR 47 Part 2, section 2.202(a) CFR 47 Part 15, section 15.215(c) IC RSS-Gen Issue 3, sections 4.6.1 and 4.6.2 IC RSS-210 Issue 8, section A1.1.3 ANSI C63.4, annex H.6
Guide:	ANSI C63.4 / IC RSS-Gen Issue 3, sections 4.6.1 and 4.6.2
Measurement setup:	☒ Conducted: See below ☐ Radiated: Radiated Emission in Fully or Semi Anechoic Room (6.6)
If antenna is detachable bandwidth measurements shall be performed at the antenna connector (conducted measurement) when the transmitter is adjusted in accordance with the tune-up procedure, if applicable. The RF output terminals are connected to a spectrum analyzer. If required, a resistive matching network equal to the impedance specified or employed for the antenna is used as well as dc block and appropriate attenuators (50 Ohms). The electrical characteristics of the radio frequency load attached to the output terminals shall be stated, if applicable. If radiated measurements are performed the same test setups and instruments are used as with radiated emission measurements for the appropriate frequency range. The analyzer settings are specified by the test description of the appropriate test record(s).	



Test instruments used for conducted measurements:

	Type	*Designation*	*Inv.-no.*	*Serial No. or ID*	*Manufacturer*
☒	Spectrum analyzer	FSP30	1666	100036	Rohde & Schwarz
☐	EMI test receiver	ESPI7	1711	836914/0002	Rohde & Schwarz
☐	EMI test receiver	ESMI	1569	839379/013 839587/006	Rohde & Schwarz
☐	Power meter	NRVS	1264	836856/015	Rohde & Schwarz
☐	Peak power sensor	NRV-Z31	1701	8579604.03	Rohde & Schwarz
☐	Power sensor	NRV-Z52	1499	837901/030	Rohde & Schwarz
☐	Power sensor	NRV-Z4	1034	863828/015	Rohde & Schwarz
☒	DC-block	7006	1636	A2798	Weinschel
☐	Attenuator	4776-10	1638	9412	Narda
☐	Attenuator	4776-20	1639	9503	Narda

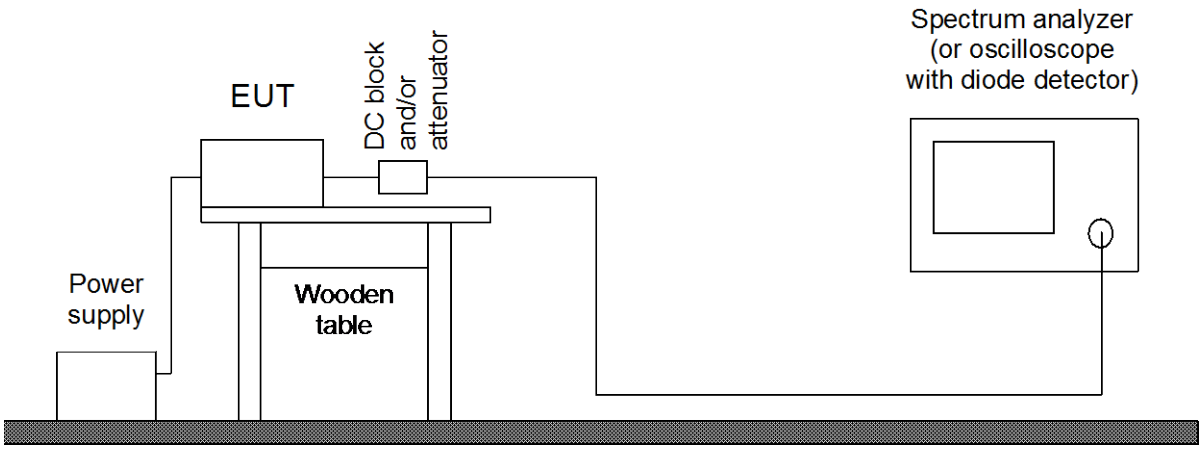
6.3 Pulse Train Measurement

Measurement Procedure:	
Rules and specifications:	CFR 47 Part 15, section 15.35(c) IC RSS-Gen Issue 3, section 4.5
Guide:	ANSI C63.4
Measurement setup:	☒ Conducted: See below (direct connection or via test fixture) ☐ Radiated: Radiated Emission in Fully or Semi Anechoic Room (6.6)

If antenna is detachable pulse train measurements shall be performed at the antenna connector (conducted measurement). The RF output terminals are connected to a spectrum analyzer or to a diode detector in combination with an oscilloscope. If required, a resistive matching network equal to the impedance specified or employed for the antenna is used as well as dc block and appropriate attenuators (50 Ohms). The electrical characteristics of the radio frequency load attached to the output terminals shall be stated, if applicable.

If antenna is not detachable a test fixture may be used instead of direct connection to RF output terminals.

If radiated measurements are performed similar test setups and instruments are used as with radiated emission measurements for the appropriate frequency range. However, the spectrum analyzer may be replaced by a diode detector connected to an oscilloscope.



Test instruments used:

	Type	*Designation*	*Inv.-no.*	*Serial No. or ID*	*Manufacturer*
☐	Spectrum analyzer	FSP30	1666	100036	Rohde & Schwarz
☐	EMI test receiver	ESPI7	1711	836914/0002	Rohde & Schwarz
☐	EMI test receiver	ESMI	1569	839379/013 839587/006	Rohde & Schwarz
☒	Diode detector negative	8473D	1581	01492	Hewlett Packard
☐	Oscilloscope	54602B	1535	US35060304	Hewlett Packard
☒	Digital oscilloscope	Wave Surfer 452	1796	LCRY0301J11938	LeCroy
☐	Test probe	TP 01	1628	001	TÜV SÜD PS
☐	DC-block	7006	1636	A2798	Weinschel
☐	Attenuator	4776-10	1638	9412	Narda
☐	Attenuator	4776-20	1639	9503	Narda

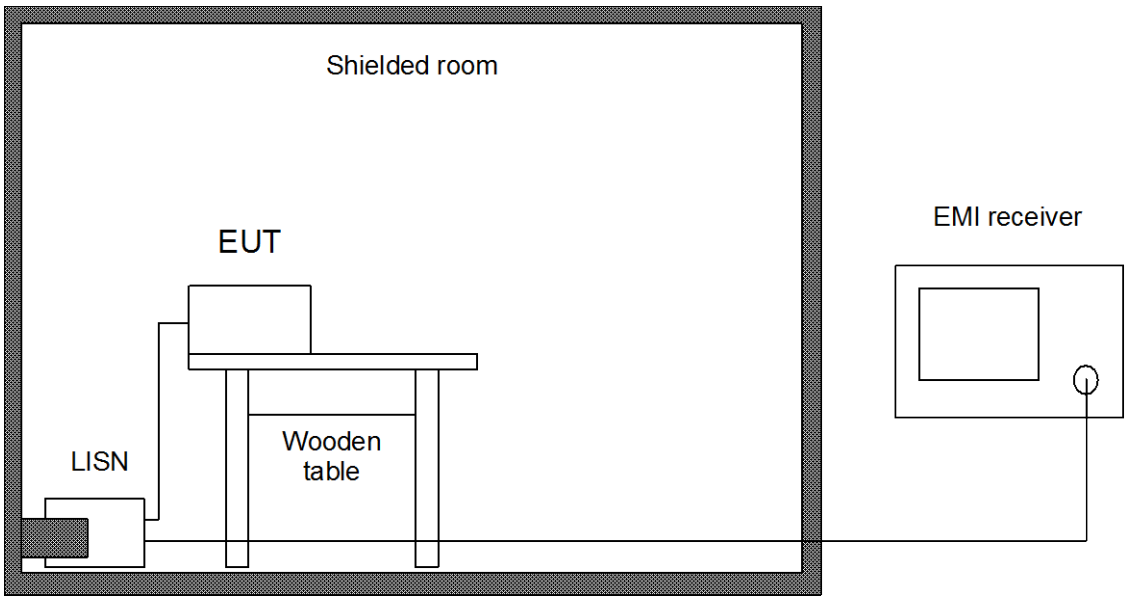
6.4 Conducted AC Powerline Emission

Measurement Procedure:	
Rules and specifications:	CFR 47 Part 15, section 15.207 IC RSS-GEN Issue 3, section 7.2.4
Guide:	ANSI C63.4 / CISPR 22

Conducted emission tests in the frequency range 150 kHz to 30 MHz are performed using Line Impedance Stabilization Networks (LISNs). To simplify testing with quasi-peak and average detector the following procedure is used:

First the whole spectrum of emission caused by the equipment under test (EUT) is recorded with detector set to peak using CISPR bandwidth of 10 kHz. After that all emission levels having less margin than 10 dB to or exceeding the average limit are retested with detector set to quasi-peak.
If average limit is kept with quasi-peak levels no additional scan with average detector is necessary. In cases of emission levels between quasi-peak and average limit an additional scan with detector set to average is performed.

According to ANSI C63.4, section 13.1.3.1, testing of intentional radiators with detachable antenna shall be performed using a suitable dummy load connected to the antenna output terminals. Otherwise, the tests shall be made with the antenna connected and, if adjustable, fully extended.
Testing with dummy load may be necessary to distinguish (unintentional) conducted emissions on the supply lines from (intentional) emissions radiated by the antenna and coupling directly to supply lines and/or LISN. Usage of dummy load has to be stated in the appropriate test record(s) and notes should be added to clarify the test setup.



Test instruments used:

	Type	*Designation*	*Inv.-no.*	*Serial No. or ID*	*Manufacturer*
☒	Test receiver	ESHS 10	1028	860043/016	Rohde & Schwarz
☒	V-network	ESH 3-Z5	1059	894785/005	Rohde & Schwarz
☐	V-network	ESH 3-Z5	1218	830952/025	Rohde & Schwarz
☐	Artificial mains network	ESH 2-Z5	1536	842966/004	Rohde & Schwarz
☒	Shielded room	No. 1	1451	---	Albatross
☐	Shielded room	No. 4	1454	3FD 100 544	Euroshield

6.5 Radiated Emission Measurement 9 kHz to 30 MHz

Measurement Procedure:	
Rules and specifications:	CFR 47 Part 15, sections 15.205 and 15.209 IC RSS-GEN Issue 3, sections 7.2.2 and 7.2.5
Guide:	ANSI C63.4

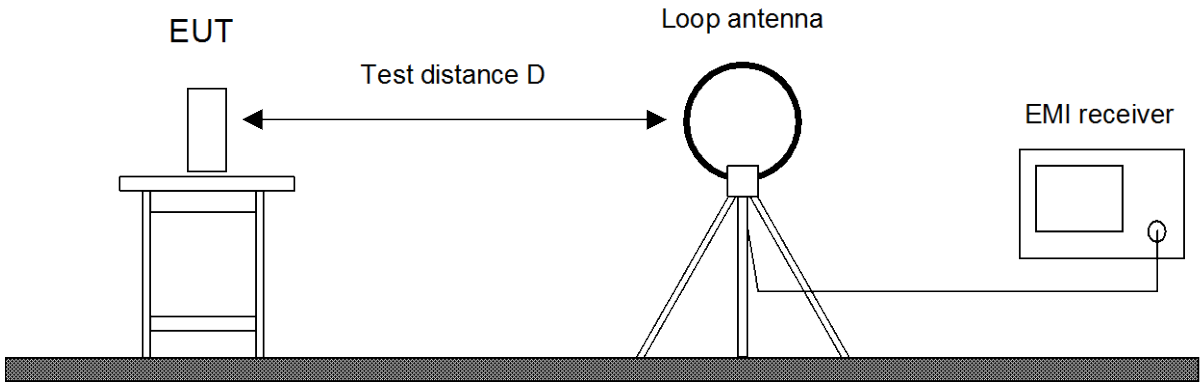
Radiated emission in the frequency range 9 kHz to 30 MHz is measured using an active loop antenna. First the whole spectrum of emission caused by the equipment is recorded at a distance of 3 meters in a fully or semi anechoic room with the detector of the spectrum analyzer or EMI receiver set to peak. This configuration is also used for recording the spectrum of intentional radiators.

Hand-held or body-worn devices are rotated through three orthogonal axes to determine which attitude and configuration produces the highest emission relative to the limit and therefore shall be used for final testing.

EUT is rotated all around to find the maximum levels of emissions. Equipment and cables are placed and moved within the range of position likely to find their maximum emissions.
If worst case emission of the EUT cannot be recorded with EUT in standard position and loop antenna in vertical polarization the EUT (or the radiating part of the EUT) is rotated by 90 degrees instead of changing the loop antenna to horizontal polarization. This procedure is selected to minimize the influence of the environment (e.g. effects caused by the floor especially with longer distances).

Final measurement is performed at a test distance D of 30 meters using an open field test site. In case the regulation requires testing at other distances, the result is extrapolated by either making measurements at an additional distance D of 10 meters to determine the proper extrapolation factor or by using the square of an inverse linear distance extrapolation factor (40 dB/decade). In cases of very low emissions measurements are performed at shorter distances and results are extrapolated to the required distance. The provisions of CFR 47 Part 15 sections 15.31(d) and (f)(2) apply. According to CFR 47 Part 15 section 15.209(d) final measurement is performed with detector function set to quasi-peak except for the frequency bands 9 to 90 kHz and 110 to 490 kHz where, for non-pulsed operation, average detector is employed.

If the radiated emission limits are expressed in terms of the average value of the emission there also is a peak limit corresponding to 20 dB above the maximum permitted average limit. Additionally, if pulsed operation is employed, the average field strength is determined by averaging over one complete pulse train, including blanking intervals, as specified in CFR 47 Part 15 section 15.35(c). If the pulse train exceeds 0.1 second that 0.1 second interval during which the value of the emission is at its maximum is selected for calculation. The pulse train correction is added to the peak value of the emission to get the average value.



Test instruments used:

	Type		*Designation*	*Inv.-no.*	*Serial No. or ID*	*Manufacturer*
☒	Spectrum analyzer		FSP30	1666	100036	Rohde & Schwarz
☐	EMI test receiver		ESMI	1569	839379/013 839587/006	Rohde & Schwarz
☐	Test receiver		ESHS 10	1028	860043/016	Rohde & Schwarz
☒	Preamplifier	Cabin no. 2	CPA9231A	1716	3557	Schaffner
☒	Loop antenna		HFH2-Z2	1016	882964/1	Rohde & Schwarz
☒	Fully anechoic room		No. 2	1452	---	Albatross
☐	Semi anechoic room		No. 3	1453	---	Siemens
☐	Semi anechoic room		No. 8	2057	---	Albatross

6.6 Radiated Emission in Fully or Semi Anechoic Room

Measurement Procedure:	
Rules and specifications:	CFR 47 Part 15, section 15.209 IC RSS-GEN Issue 3, section 7.2.5
Guide:	ANSI C63.4

Radiated emission in fully or semi anechoic room is measured in the frequency range from 30 MHz to the maximum frequency as specified in CFR 47 Part 15 section 15.33.

Measurements are made in both the horizontal and vertical planes of polarization using a spectrum analyzer with the detector function set to peak and resolution as well as video bandwidth set to 100 kHz (below 1 GHz) or 1 MHz (above 1 GHz).

Testing up to 1 GHz is performed with a linear polarized logarithmic periodic antenna combined with a 4:1 broadband dipole ("Trilog broadband antenna"). For testing above 1 GHz horn antennas are used.

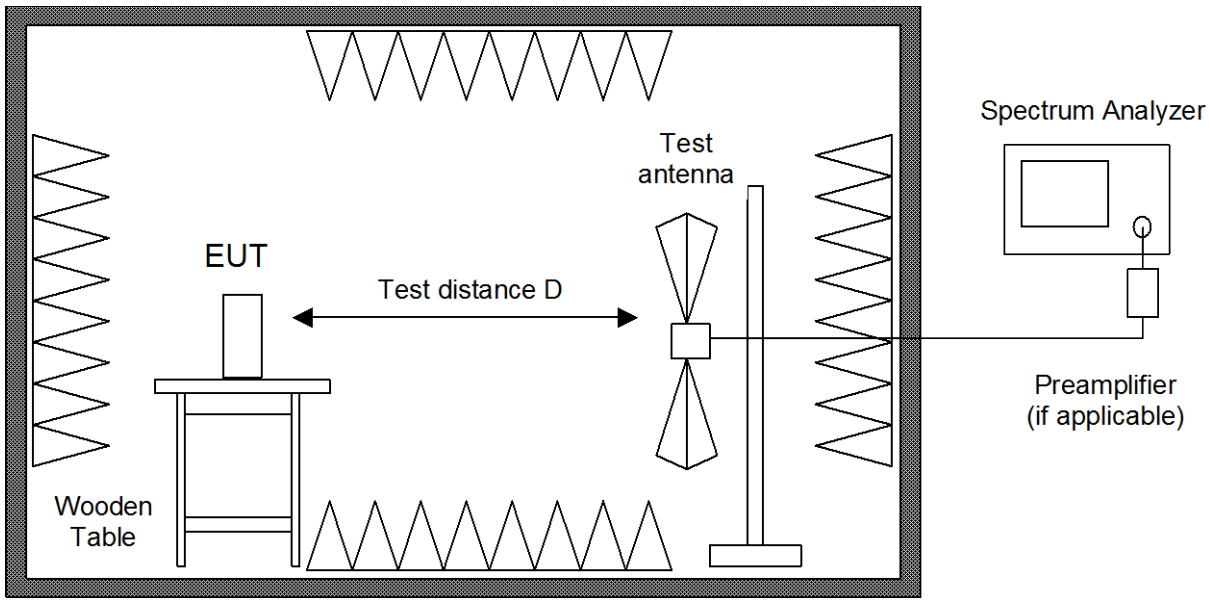
All tests below 8.2 GHz are performed at a test distance D of 3 meters. For higher frequencies the test distance may be reduced (e.g. to 1 meter) due to the sensitivity of the measuring instrument(s) and the test results are calculated according to CFR 47 Part 15 section 15.31(f)(1) using an extrapolation factor of 20 dB/decade. If required, preamplifiers are used for the whole frequency range. Special care is taken to avoid overload, using appropriate attenuators and filters, if necessary.

If the radiated emission limits are expressed in terms of the average value of the emission there also is a peak limit corresponding to 20 dB above the maximum permitted average limit. Additionally, if pulsed operation is employed, the average field strength is determined by averaging over one complete pulse train, including blanking intervals, as specified in CFR 47 Part 15 section 15.35(c). If the pulse train exceeds 0.1 second that 0.1 second interval during which the value of the emission is at its maximum is selected for calculation. The pulse train correction is added to the peak value of the emission to get the average value.

Hand-held or body-worn devices are rotated through three orthogonal axes to determine which attitude and configuration produces the highest emission relative to the limit and therefore shall be used for final testing.

During testing the EUT is rotated all around to find the maximum levels of emissions. Equipment and cables are placed and moved within the range of position likely to find their maximum emissions.

For final testing below 1 GHz a semi anechoic room complying with the NSA requirements of ANSI C63.4 for alternative test sites is used (see 6.7). If prescans are recorded in fully anechoic room they are indicated appropriately.



Fully or semi anechoic room

Test instruments used:

	Type		Designation	Inv.-no.	Serial No. or ID	Manufacturer
☒	Spectrum analyzer		FSP30	1666	100036	Rohde & Schwarz
☐	EMI test receiver	Cabin no. 3	ESPI7	2010	101018	Rohde & Schwarz
☐	EMI test receiver		ESU8	2044	100232	Rohde & Schwarz
☒	EMI test receiver		ESMI	1569	839379/013 839587/006	Rohde & Schwarz
☒	Preamplifier	Cabin no. 2	CPA9231A	1716	3557	Schaffner
☐	Preamplifier		R14601	1142	13120026	Advantest
☒	Preamplifier (1 - 8 GHz)		AFS3-00100800-32-LN	1684	847743	Miteq
☐	Preamplifier (0.5 - 8 GHz)		AMF-4D-005080-25-13P	1685	860149	Miteq
☒	Preamplifier (8 - 18 GHz)		ACO/180-3530	1484	32641	CTT
☒	External Mixer		WM782A	1576	845881/005	Tektronix
☒	External Mixer		WM780U	2085	B030121	Tektronix
☒	External Mixer		WM782V	2140	B030132	Tektronix
☒	External Mixer		WM782W	2181	B010193	Tektronix
☒	Harmonic Mixer Accessories		FS-Z30	1577	624413/003	Rohde & Schwarz
☒	Trilog antenna	Cabin no. 2	VULB 9163	1722	9163-188	Schwarzbeck
☐	Trilog antenna	Cabin no. 3	VULB 9163	1802	9163-214	Schwarzbeck
☐	Trilog antenna	Cabin no. 8	VULB 9163	2058	9163-408	Schwarzbeck
☒	Horn antenna		3115	1516	9508-4553	EMCO
☐	Horn antenna		3160-03	1010	9112-1003	EMCO
☐	Horn antenna		3160-04	1011	9112-1001	EMCO
☒	Horn antenna		3160-05	1012	9112-1001	EMCO
☒	Horn antenna		3160-06	1013	9112-1001	EMCO
☒	Horn antenna		3160-07	1014	9112-1008	EMCO
☒	Horn antenna		3160-08	1015	9112-1002	EMCO
☒	Horn antenna		3160-09	1265	9403-1025	EMCO
☒	Horn antenna		3160-10	1575	399185	EMCO
☒	Horn antenna		24240-20	2086	157845	Flann Microwave
☒	Horn antenna		25240-25	2180	205900	Flann Microwave
☒	Horn antenna		27240-25	2182	204260	Flann Microwave
☒	Fully anechoic room		No. 2	1452	---	Albatross
☐	Semi anechoic room		No. 3	1453	---	Siemens
☐	Semi anechoic room		No. 8	2057	---	Albatross

6.7 Radiated Emission at Alternative Test Site

Measurement Procedure:	
Rules and specifications:	CFR 47 Part 15, section 15.209 IC RSS-GEN Issue 3, section 7.2.5
Guide:	ANSI C63.4

Radiated emission in the frequency range 30 MHz to 1 GHz is measured within a semi-anechoic room with groundplane complying with the NSA requirements of ANSI C63.4 for alternative test sites. A linear polarized logarithmic periodic antenna combined with a 4:1 broadband dipole ("Trilog broadband antenna") is used. The measurement bandwidth of the test receiver is set to 120 kHz with quasi-peak detector selected.

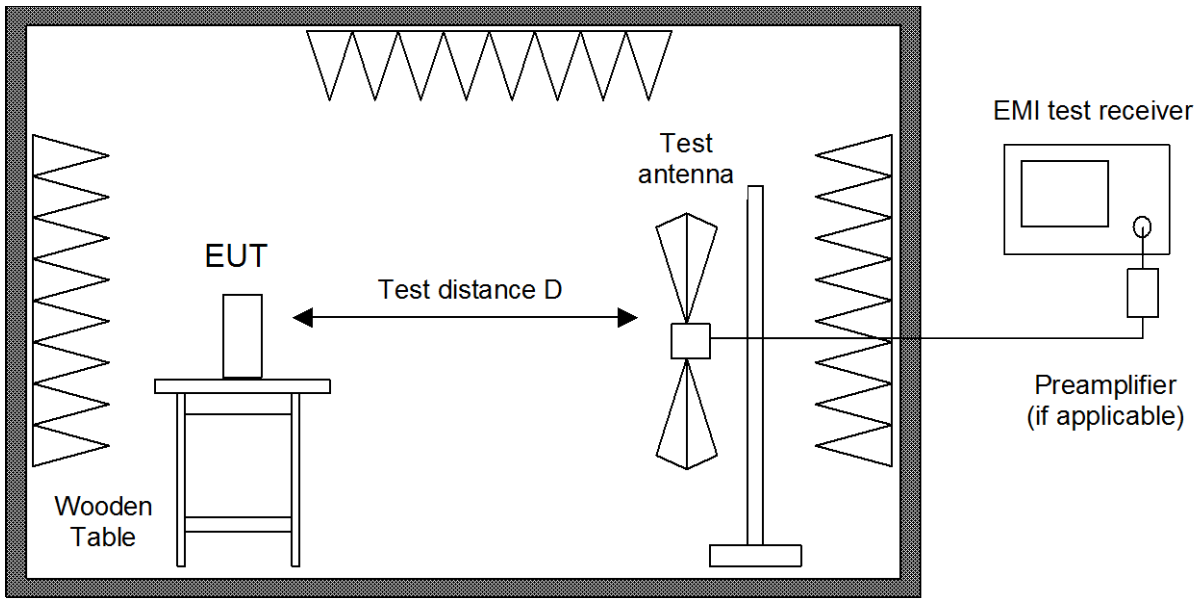
If the radiated emission limits are expressed in terms of the average value of the emission there also is a peak limit corresponding to 20 dB above the maximum permitted average limit. Additionally, if pulsed operation is employed, the average field strength is determined by averaging over one complete pulse train, including blanking intervals, as specified in CFR 47 Part 15 section 15.35(c). If the pulse train exceeds 0.1 second that 0.1 second interval during which the value of the emission is at its maximum is selected for calculation. The pulse train correction is added to the peak value of the emission to get the average value.

Hand-held or body-worn devices are tested in the position producing the highest emission relative to the limit as verified by prescans in fully anechoic room.

If no prescan in a fully anechoic room is used first a peak scan is performed in four positions to get the whole spectrum of emission caused by EUT with the measuring antenna raised and lowered from 1 to 4 m to find table position, antenna height and antenna polarization for the maximum emission levels.
Data reduction is applied to these results to select those levels having less margin than 10 dB to or exceeding the limit using subranges and limited number of maximums. Further maximization is following.
With detector of the test receiver set to quasi-peak final measurements are performed immediately after frequency zoom (for drifting disturbances) and maximum adjustment.
Equipment and cables are placed and moved within the range of position likely to find their maximum emissions.

In cases where prescans in a fully anechoic room are taken (e. g. if EUT is operating for a short time only or battery is dircharged quickly) final measurements with quasi-peak detector are performed manually at frequencies indicated by prescan with EUT rotating all around and receiving antenna raising and lowering within 1 meter to 4 meters to find the maximum levels of emission.
Equipment and cables are placed and moved within the range of position likely to find their maximum emissions.

For measuring emissions of intentional radiators and receivers a test distance D of 3 meters is selected. Testing of unintentional radiators is performed at a distance of 10 meters. If limits specified for 3 meters shall be used for measurements performed at 10 meters distance the limits are calculated according to CFR 47 Part 15 section 15.31(d) and (f)(1) using an inverse linear-distance extrapolation factor of 20 dB/decade.



Alternate test site (semi anechoic room)

Test instruments used:

	Type		*Designation*	*Inv.-no.*	*Serial No. or ID*	*Manufacturer*
☒	EMI test receiver		ESU8	2044	100232	Rohde & Schwarz
☒	Trilog antenna	Cabin no. 8	VULB 9163	2058	9163-408	Schwarzbeck
☒	Semi anechoic room		No. 8	2057	---	Albatross

6.8 Carrier Frequency Stability

Measurement Procedure:	
Rules and specifications:	CFR 47 Part 15, section 15.225(e) IC RSS-Gen Issue 3, section 4.7 and IC RSS-210 Issue 8, section A2.6
Guide:	ANSI C63.4

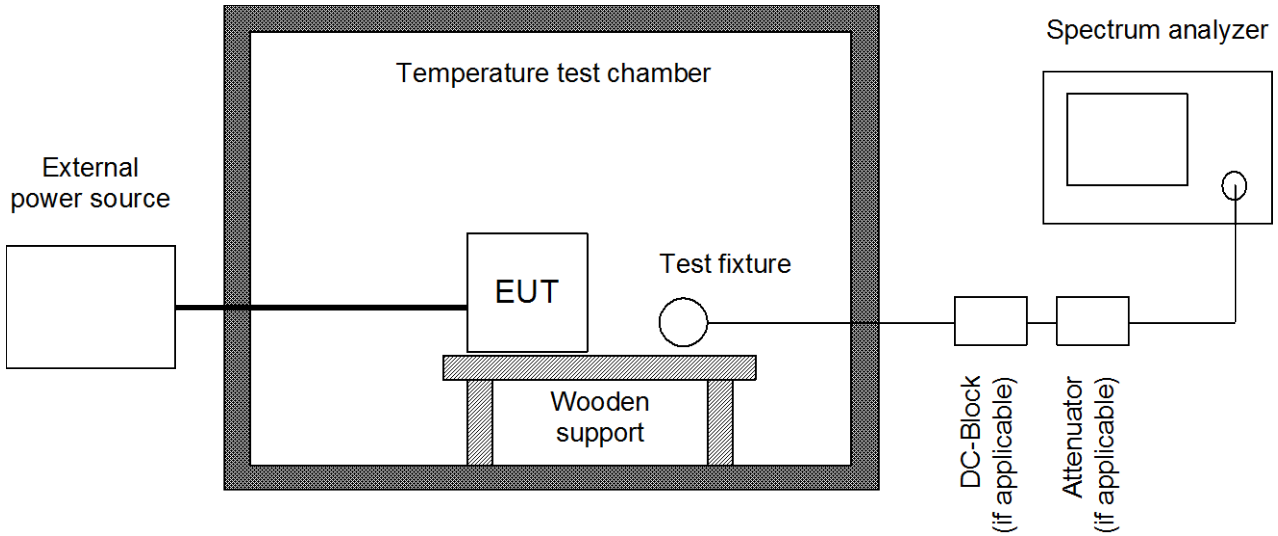
The frequency tolerance of the carrier signal is measured over a temperature variation of -20 °C to +50 °C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 °C.

If the EUT provides an antenna connector the spectrum analyzer is connected to this port. If required, a resistive matching network equal to the impedance specified or employed for the antenna is used as well as dc block and appropriate attenuators (50 Ohms). In cases where the EUT does not provide an antenna connector a test fixture is used.

For battery operated equipment, the test is performed using a new battery. Alternatively, an external supply voltage can be used and is at least set to:

- the maximum battery voltage as delivered by a new battery or 115% of the battery nominal voltage
- the battery nominal voltage
- 85% of the battery nominal voltage
- the battery operating end point voltage which shall be specified by the equipment manufacturer

The EUT is operating providing an unmodulated carrier. The peak detector of the spectrum analyzer is selected and resolution as well as video bandwidth are set to values appropriate to the shape of the spectrum of the EUT. The frequency counter mode of the spectrum analyzer is used to maximize the accuracy of the measured frequency tolerance.
If an unmodulated carrier is not available a significant and stable point on the spectrum is selected and the span is reduced to a value that delivers an accuracy which shall be better than 1% of the maximum frequency tolerance allowed for the carrier signal. This method may be performed as long as the margin to the frequency tolerance allowed is larger than the uncertainty of the measured frequency tolerance.

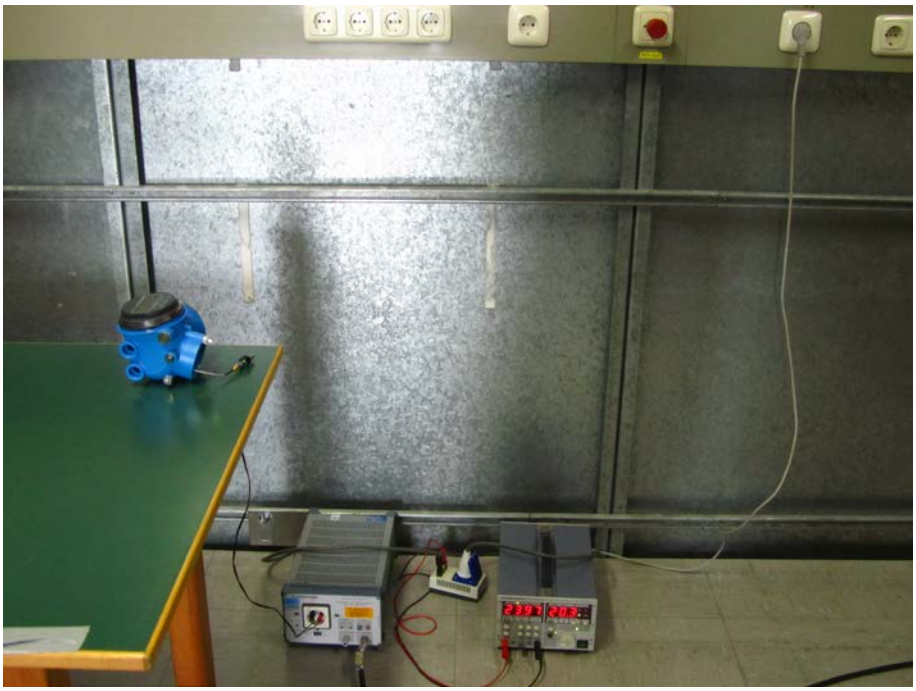


Test instruments used:

	Type	*Designation*	*Inv.-no.*	*Serial No. or ID*	*Manufacturer*
☒	Spectrum analyzer	FSP30	1666	100036	Rohde & Schwarz
☐	EMI test receiver	ESPI7	1711	836914/0002	Rohde & Schwarz
☐	EMI test receiver	ESMI	1569	839379/013 839587/006	Rohde & Schwarz
☒	DC-block	7006	1636	A2798	Weinschel
☐	Attenuator	4776-10	1638	9412	Narda
☐	Attenuator	4776-20	1639	9503	Narda
☐	Test probe	TP 01	1628	001	TÜV SÜD PS
☐	Multimeter	21 III	1653	76530546	Fluke
☐	Multimeter	21 III	1654	76381229	Fluke
☐	Multimeter	Fluke 77 III	1975	92370108	Fluke
☐	Multimeter	Fluke 77 IV	1976	93090238	Fluke
☐	Multimeter	Fluke 177	2025	96720024	Fluke
☐	Multimeter	Fluke 177	2026	96720025	Fluke
☒	DC power supply	NGSM 32/10	1267	203	Rohde & Schwarz
☐	Isolating transformer	RT 5A	1127	10387	Grundig
☐	Isolating transformer	RT 5A	1128	10416	Grundig
☒	Temperature test chamber	HT 4010	1271	07065550	Heraeus

7 Photographs Taken During Testing

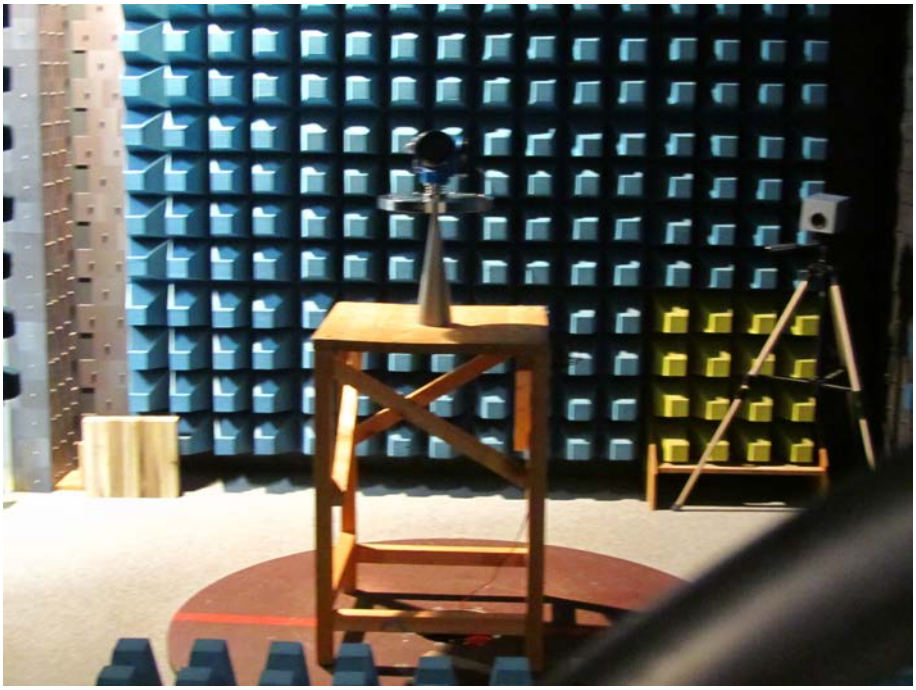
Test setup for conducted DC powerline emission measurement

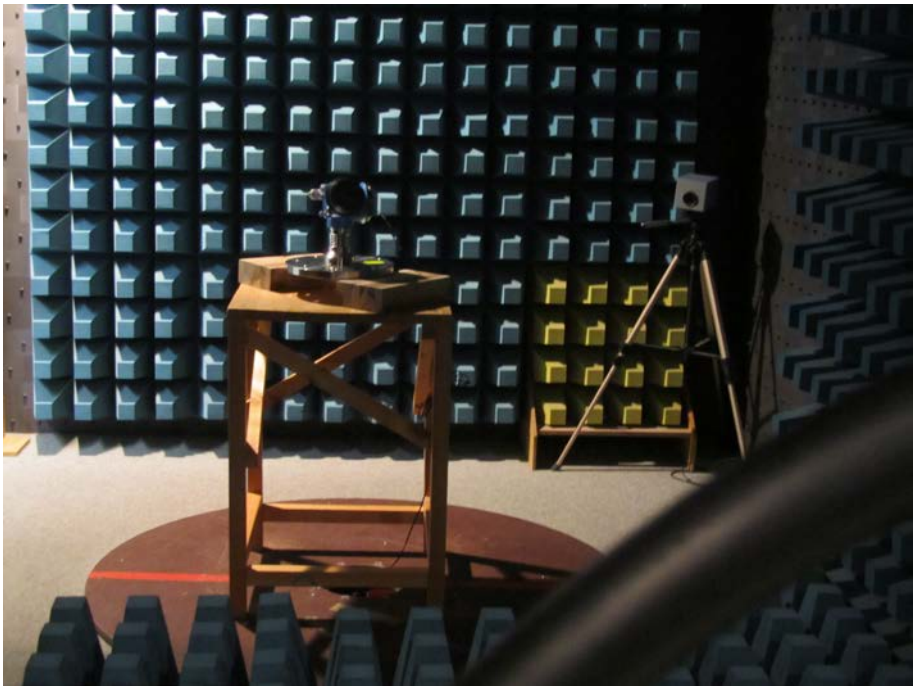


TÜV SÜD Product Service GmbH
Äußere Frühlingstraße 45
94315 Straubing
Germany

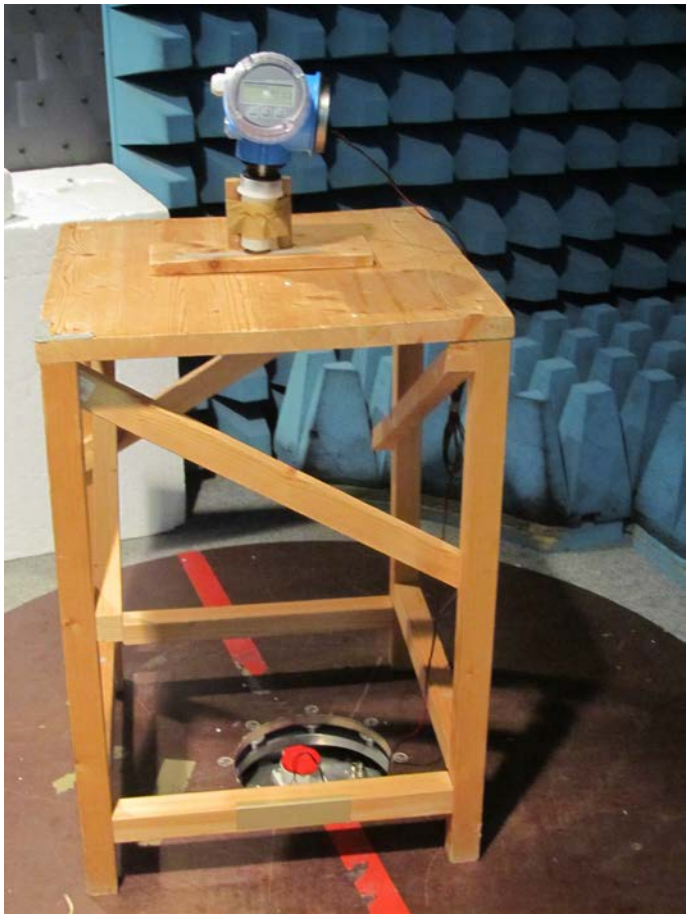
Phone: +49 9421 5522-0
Fax: +49 9421 5522-99
Web: www.tuev-sued.de

Test setup for radiated emission measurement 9 kHz – 30 MHz

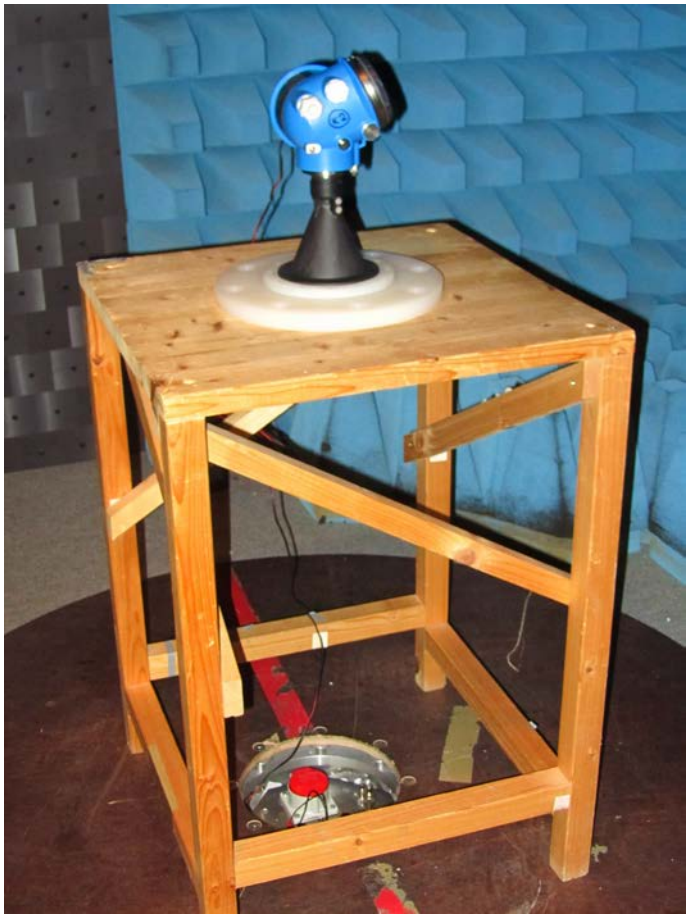




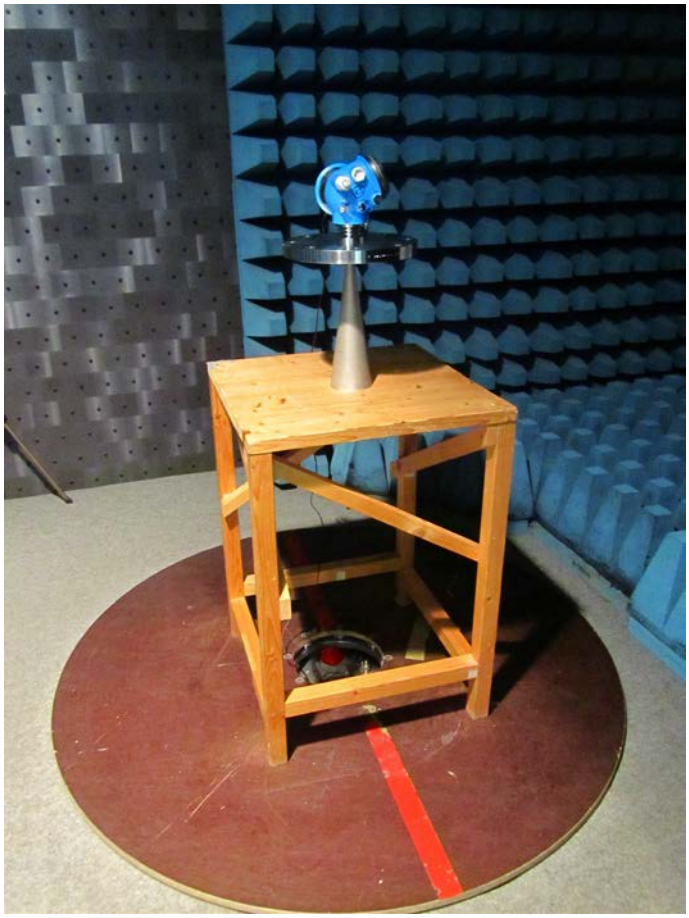
Test setup for radiated emission measurement (fully anechoic room)



Test setup for radiated emission measurement (fully anechoic room) - continued -



Test setup for radiated emission measurement (fully anechoic room) - continued -



8 Test Results

FCC CFR 47 Parts 2 and 15			
Section(s)	*Test*	*Page*	*Result*
2.202(a)	Occupied bandwidth	35	Recorded
2.201, 2.202	Class of emission	37	Calculated
15.35(c)	Pulse train measurement for pulsed operation	38	Recorded
15.205(a)	Restricted bands of operation	41	Test passed
15.207	Conducted AC powerline emission 150 kHz to 30 MHz	43	Test passed
15.256 (f) (1)	Minimum fundamental emission bandwidth		Test passed
15.256 (f) (2)	Fundamental emission bandwidth		Test passed
15.256 (g)	Fundamental emission limits		Test passed
15.256 (h)	Unwanted emission limits		Test passed
15.256 (i)	Antenna beamwidth		Test passed
15.256 (j)	Antenna side lobe gain		Test passed
15.215 (c) 15.256 (f) (2)	Frequency stability		Test passed

8.1 Occupied Bandwidth

Rules and specifications:	CFR 47 Part 2, section 2.202(a) ANSI C63.4, annex H.6
Guide:	ANSI C63.4
Description:	The occupied bandwidth according to CFR 47 Part 2, section 2.202(a), is measured as the 99% emission bandwidth, i.e. below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5% of the total mean power radiated by a given emission. The occupied bandwidth according to ANSI C63.4, annex H.6; is measured as the frequency range defined by the points that are 26 dB down relative to the maximum level of the modulated carrier. The resolution bandwidth of the spectrum analyzer shall be set to a value greater than 5.0% of the allowed bandwidth. If no bandwidth specifications are given, the following guidelines are used:

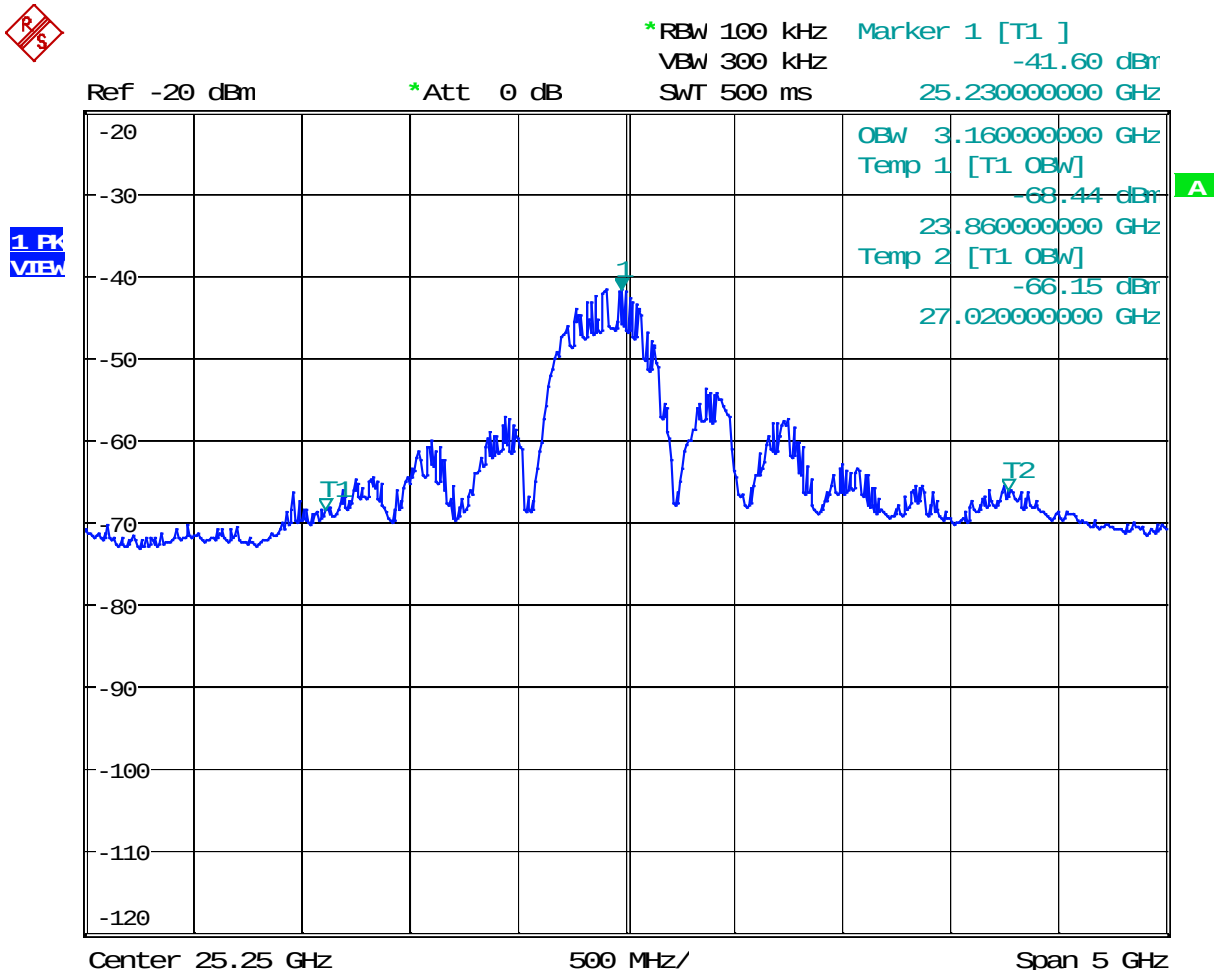
Fundamental frequency	Minimum resolution bandwidth
9 kHz to 30 MHz	1 kHz
30 MHz to 1000 MHz	10 kHz
1000 MHz to 40 GHz	100 kHz

The video bandwidth shall be at least three times greater than the resolution bandwidth.

Measurement procedure:	Bandwidth Measurements (6.2)

Comment:	
Date of test:	13 February 2014
Test site:	Fully anechoic room, cabin no. 2

Occupied Bandwidth (99 %):



Occupied Bandwidth (99 %):	**3.16 GHz**

8.2 Designation of Emissions

Rules and specifications:	CFR 47 Part 2, sections 2.201 and 2.202 IC RSS-Gen Issue 3, sections 8
Guide:	ANSI C63.4 / TRC-43

Type of modulation:	Unmodulated Pulse Emission

B_n = Necessary Bandwidth	$B_n = 2K/t$
t = Pulse duration at half amplitude	t = 2 ns
K = Overall numerical factor	K = 1.5
Calculation:	$B_n = 2 \cdot 1.5 / 2$ ns = 1.5 GHz

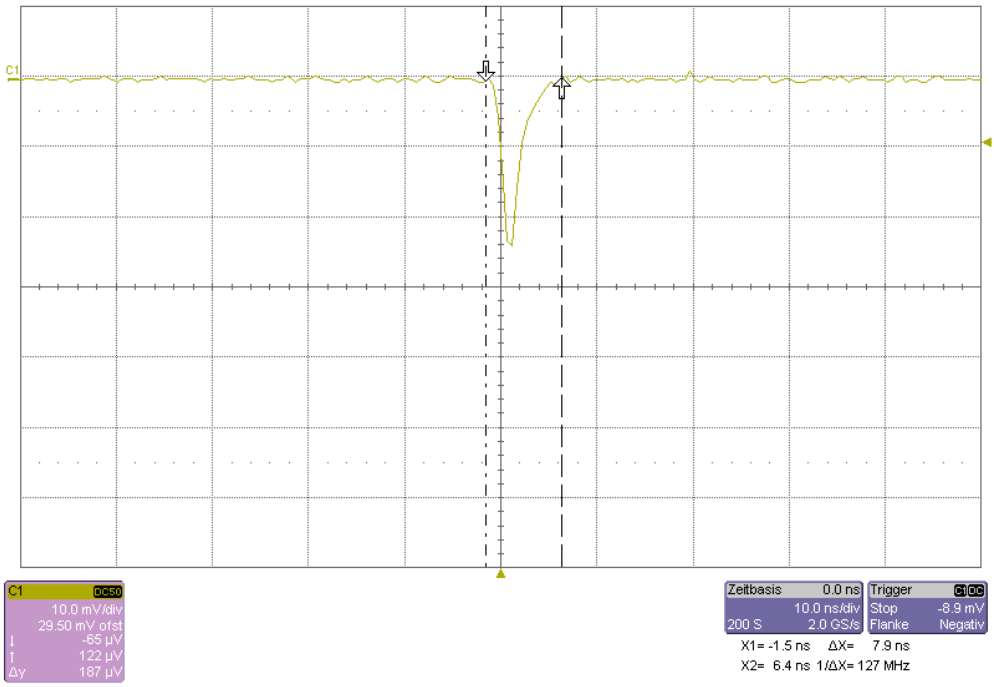
Designation of Emissions:	**1G50P0NAN**

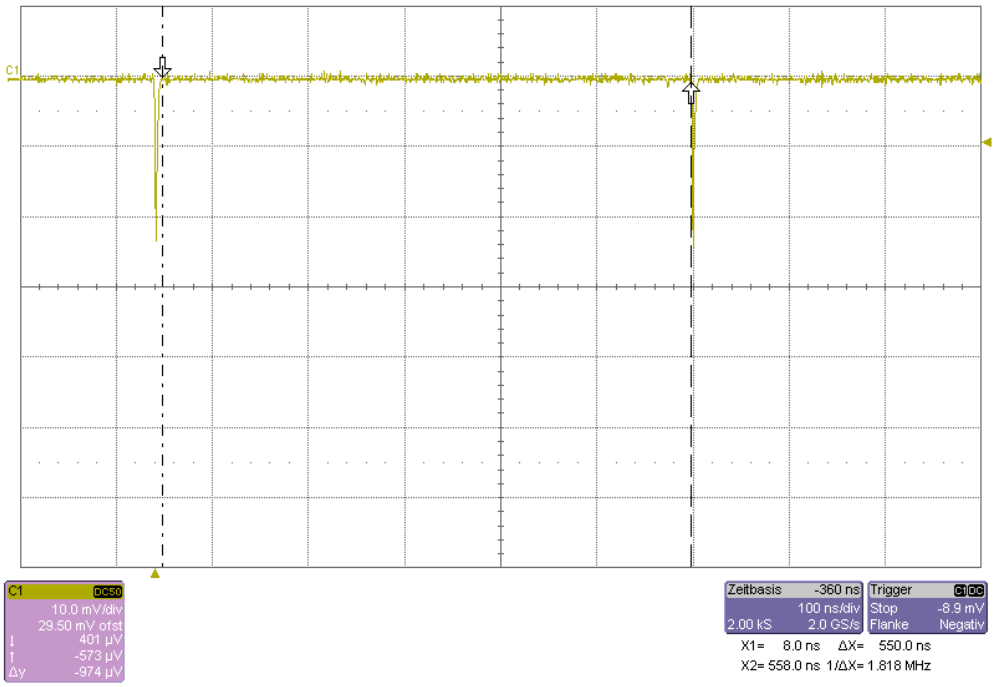
8.3 Pulse Train Measurement

Rules and specifications:	CFR 47 Part 15, section 15.35(c) IC RSS-Gen Issue 3, section 4.5
Guide:	ANSI C63.4
Measurement procedure:	Pulse Train Measurement (6.3)

Comment:	
Date of test:	June 29, 2012
Test site:	Fully anechoic room, cabin no. 2

Total Pulse Train:





Calculation of pulse train correction:

TX-On-Time (worst case):	T_{on}	=	2.04 ns
Pulse Train Time:	T_{pt}	=	558.54 ns
Period Time:	T_{period}	=	558.54 ns
Pulse Train Correction:	C_{pt}	=	$20 \cdot \text{Log}(T_{on} / T_{period})$ dB
		=	**-48.74 dB**

8.4 Desensitization of pulsed Emissions

Since the EUT transmits pulsed energy, the desensitization factor α has been calculated and included in the calculation for the final peak value. The provisions of Public Notice DA 04-3946: have been applied.

In ANSI C63.10-2009, Annex C the analyzer settings to measure a line spectrum are defined as follows:

a) Bandwidth B < 0.3 x PRF

J. Scan time Ts > Fs / B^2

With the pulse repetition frequency (PRF) of the EUT of 1.8 MHz and the selected measuring bandwith of B =0.3 MHz the requirement a) was observed.

The scan width of Fs = 3 GHz and Bandwidth of B = 0.3 MHz leads to following values:

Fs/B^2 = 3 GHz / $(0.3\ MHz)^2$= 0.033 s

The selected scan time of Ts= 85 ms meets requirement b). Hence, a line spectrum was measured, which could be seen, when the Pseudo-Noise-mode of the EUT was switched off (no influence on the measured amplitudes) and the frequency scale of the analyser zoomed.

The desensitization factor α_l was calculated according to ANSI C63.10-2009, Annex C

$$\alpha_l = 20\log(\tau eff / T) = -48.74\ dB$$

The calculation based on the pulse width τ eff = 2.04 ns and the pulse period T= 558.54 ns, which have been supplied by the applicant.

To avoid overloading the spectrum analyzer the internal preselector has been activated during final testing. A linearity check by adding a 3 dB attenuator to the input was used to ensure integrity of the test data.

Sample Calculation of Field Strength values for pulsed systems:

1) Measure Peak value with analyzer RBW set to 0.3 MHz, VBW set to 1 MHz, Ts set to 85 ms
2) Calculate Field Strength by adding antenna correction factor
3) Calculate True Peak Field Strength by adding Desensitization Factor
   Apply provisions according to section 15.35 (b)of the FCC Rules for limiting peak emissions
4) Calculate Average value by subtracting Duty Cycle Correction Factor from True Peak Field Strength Value

8.5 Restricted Bands of Operation

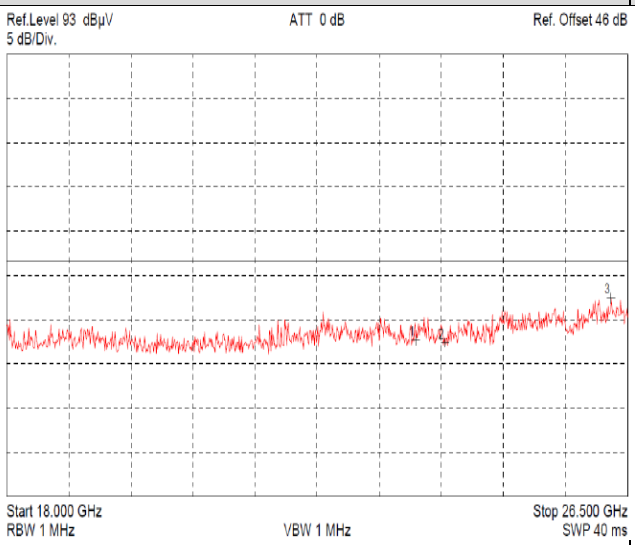
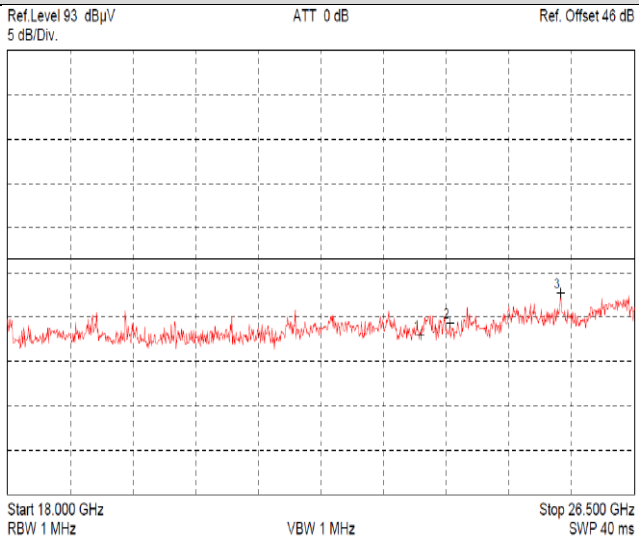
Rules and specifications:	CFR 47 Part 15, section 15.205(a) IC RSS-210 Issue 8, section 7.2.2(a)
Guide:	ANSI C63.4
Limit:	Only spurious emissions are permitted in any of the frequency bands listed in CFR 47 Part 15, section 15.205(a) or IC RSS-210 Issue 7, section 2.2(a).

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
[1] 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
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
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

MHz	MHz	MHz	GHz
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	[2]
13.36–13.41.			

Measurement procedure:	Radiated Emission in Fully or Semi Anechoic Room (6.6)

Comment:	Plots overleaf show test setup K1 which has worst case spurious emissions
Date of test:	July 19, 2012
Test site:	Fully anechoic room, cabin no. 2
Test distance:	3 meters

Horizontal Polarisation	Vertical Polarisation
	

Test Result:	Test passed

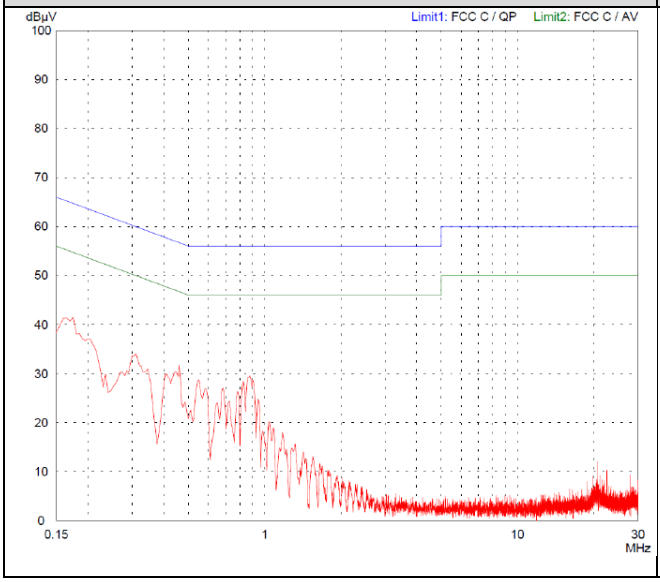
8.6 Conducted Powerline Emission Measurement 150 kHz to 30 MHz – 15.207

Rules and specifications:	CFR 47 Part 15, section 15.207 IC RSS-GEN Issue 3, section 7.2.4		
Guide:	ANSI C63.4 / CISPR 22		
Limit:	Frequency of Emission (MHz)	Conducted Limit (dBµV)	
		Quasi-peak	Average
	0.15 - 0.5 0.5 - 5 5 - 30	66 to 56 56 60	56 to 46 46 50
Measurement procedure:	Conducted AC Powerline Emission (6.4)		

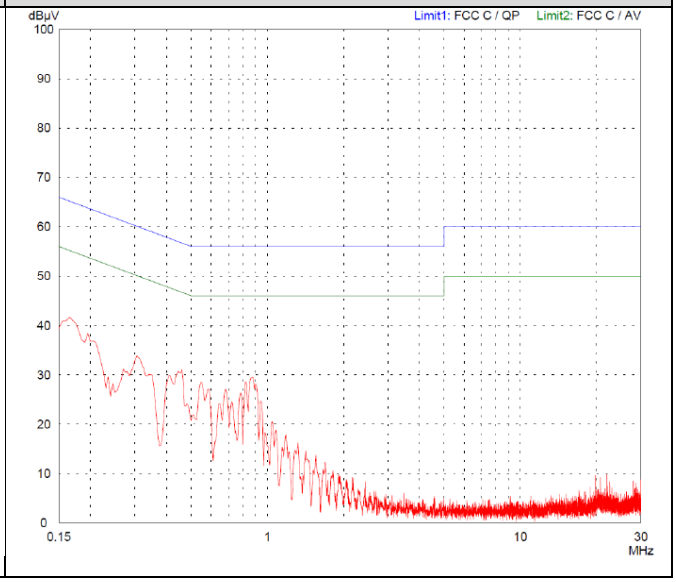
Comment:	Test performed with 50 Ω terminator
Date of test:	13 February 2014
Test site:	Shielded room, cabin no. 4

Test Result:	Test passed

Plus Terminal



Minus Terminal



All emissions showed more than 20 dB margin to the limit

Sample calculation of final values:

Final Value (dBµV) = Reading Value (dBµV) + Correction Factor (dB)

8.7 Exposure of Humans to RF Fields

Rules and specifications:	IC RSS-Gen Issue 3, section 5.6
Guide:	IC RSS-102 Issue 4, section 2.5

Exposure of Humans to RF Fields	Applicable	Declared by applicant	Measured	Exemption
The antenna is				
☐ detachable				
The conducted output power (CP in watts) is measured at the antenna connector: CP = **..... W**			☐	
The effective isotropic radiated power (EIRP in watts) is calculated using				
☐ the numerical antenna gain: G = **.....** $EIRP = G \cdot CP \Rightarrow EIRP$ = **..... W**		☐		
☐ the field strength[5] in V/m: FS = **..... V/m**			☐	
$EIRP = \frac{(FS \cdot D)^2}{30} \Rightarrow EIRP$ = **..... W** with: Distance between the antennas in m: D = **..... m**			☐	
☒ not detachable				
A field strength measurement is used to determine the effective isotropic radiated power (EIRP in watts) given by[5]: $EIRP = \frac{(FS \cdot D)^2}{30} \Rightarrow EIRP$ = **199.9 nW** with: Field strength in V/m: FS = **73.8 dBµV/m** = **4.898 mV/m** Distance between the two antennas in m: D = **0.5 m**			☒ ☒	
Selection of output power				
The output power TP is the higher of the conducted or effective isotropic radiated power (e.i.r.p.): TP = **199.9 nW**				

[5] The conversion formula is valid only for properly matched antennas. In other cases the transmitter output power may have to be measured by a terminated measurement when applying the exemption clauses.
If an open area test site is used for field strength measurement, the effect due to the metal ground reflecting plane should be subtracted from the maximum field strength value in order to reference it to free space, before calculating TP.

Exposure of Humans to RF Fields (continued)	Applicable	Declared by applicant	Measured	Exemption
Separation distance between the user and the transmitting device is				
☐ less than or equal to 20 cm ☒ greater than 20 cm		☒		
Transmitting device is				
☐ in the vicinity of the human head ☐ body-worn		☒		
SAR evaluation				
SAR evaluation is required if the separation distance between the user and the device is less than or equal to 20 cm. ☐ The device operates from 3 kHz up to 1 GHz inclusively and with output power (i.e. the higher of the conducted or equivalent isotropically radiated power (e.i.r.p.) source-based, time-averaged output power) that is less than or equal to 200 mW for general public use and 1000 mW for controlled use. ☐; ☐ The device operates above 1 GHz and up to 2.2 GHz inclusively and with output power (i.e. the higher of the conducted or radiated (e.i.r.p.) source-based, time-averaged output power) that is less than or equal to 100 W for general public use and 500 W for controlled use. ☐ The device operates above 2.2 GHz and up to 3 GHz inclusively and with output power (i.e. the higher of the conducted or radiated (e.i.r.p.) source-based, time-averaged output power) that is less than or equal to 20 mW for general public use and 100 mW for controlled use. ☐ The device operates above 3 GHz and up to 6 GHz inclusively and with output power (i.e. the higher of the conducted or radiated (e.i.r.p.) source-based, time-averaged output power) that is less than or equal to 10 mW for general public use and 50 mW for controlled use. ☐ SAR evaluation is documented in test report no.				☐ ☐ ☐
RF exposure evaluation				
RF exposure evaluation is required if the separation distance between the user and the device is greater than 20 cm. ☐ The device operates below 1.5 GHz and the maximum e.i.r.p. of the device is equal to or less than 2.5 W. ☒ The device operates at or above 1.5 GHz and the maximum e.i.r.p. of the device is equal to or less than 5 W. ☐ RF exposure evaluation is documented in test report no.				☐ ☒

8.8 Minimum Fundamental Emission Bandwidth – 15.256 (f) (1)

Prüfdatum / *Date of test:*	13 February 2014
Prüfer / *Operator:*	Johann Roidt
Messplatz / *Test site:*	Non shielded room

Prüfergebnis / *Test Result*
☒ **Erfüllt / *Passed***
☐ **Nicht erfüllt / *Not passed***

Luftdruck / *Barometric pressure:*	978.5 hPa
Relative Luftfeuchtigkeit / *Relative humidity:*	51.9 %
Temperatur / *Ambient temperature:*	26.2 °C

Prüfgrundlage / *Specifications:*	FCC Rules, Part 15, Section 15.256 (f) (1)
Test procedure:	Fundamental emission bandwidth 1. Observe fundamental emission on the spectrum analyzer with a peak detector, 1 MHz RBW and at least 3 MHz VBW. 2. Activate any frequency sweep, step or hop function of the EUT and select “Max Hold” function on the spectrum analyzer. 3. Perform multiple sweeps until the amplitude stabilizes. 4. Determine the 10 dB emission bandwidth. 5. Verify that the fundamental emission is within the operating frequency band at the highest and lowest operating frequencies.
Messunsicherheit / *Measurement uncertainty:*	± 10 kHz
Betriebsart / *Operation mode:* Kommentar / *Comment:*	Continuous measurement mode Test was performed with conducted measurement

Grenzwert / *Limit:*
The minimum fundamental emission bandwidth shall be 50 MHz for LPR operation under the provisions of section 15.256
Frequency bands of operation: 5.925 GHz to 7.250 GHz 24,05 GHz to 29.0 GHz 75 GHz to 85 GHz

			Result	*Note*
Measured Frequency [GHz]		*10 dB Bandwidth*		
Minimum	*Maximum*	*(MHz)*		
24.353	**26.452**	**2.099**	Passed	1

Note(s):
1 Analyzer Setting: RBW = 1 MHz, VBW = 3 MHz

8.9 Fundamental Emission Bandwidth – 15.256 (f) (2)

Prüfdatum / *Date of test:*	13 February 2014
Prüfer / *Operator:*	Johann Roidt
Messplatz / *Test site:*	Non shielded room

Prüfergebnis / *Test Result*
☒ **Erfüllt / *Passed***
☐ **Nicht erfüllt / *Not passed***

Luftdruck / *Barometric pressure:*	978.5 hPa
Relative Luftfeuchtigkeit / *Relative humidity:*	51.9 %
Temperatur / *Ambient temperature:*	26.2 °C

Prüfgrundlage / *Specifications:*	FCC Rules, Part 15, Section 15.256 (f) (2)
Test procedure:	Fundamental emission bandwidth 1. Observe fundamental emission on the spectrum analyzer with a peak detector, 1 MHz RBW and at least 3 MHz VBW. 2. Activate any frequency sweep, step or hop function of the EUT and select “Max Hold” function on the spectrum analyzer. 3. Perform multiple sweeps until the amplitude stabilizes. 4. Determine the 10 dB emission bandwidth. 5. Verify that the fundamental emission is within the operating frequency band at the highest and lowest operating frequencies.
Messunsicherheit / *Measurement uncertainty:*	± 10 kHz
Betriebsart / *Operation mode:*	Continuous measurement mode
Kommentar / *Comment:*	Test was performed with conducted measurement

Grenzwert / *Limit:*
LPR devices operating under section15.256 must confine their fundamental emission bandwidth within the 5.925-7.250 GHz, 24.05-29.00 GHz, and 75-85 GHz bands under all conditions of operation.

			Result	*Note*
Measured Frequency [GHz]		*Bandwidth*		
Minimum	*Maximum*	*MHz*		
24.353	**26.452**	**2.099**	Passed	1

Note(s):
1 Analyzer Setting: RBW = 1 MHz, VBW = 3 MHz

8.10 Fundamental Emission Limits - 15.256 (g)

Date of test:	13 February 2014
Operator:	Johann Roidt
Test site:	Fully anechoic room, cabin no. 2

Test Result

☒ **Test *Passed***

☐ **Test Failed**

Environmental conditions	
Barometric pressure:	977.6 hPa
Relative humidity:	59.1 %
Ambient temperature:	26.5 °C

Specifications:	**FCC Rules, Part 15, Section 15.256 (g)** (1) All emission limits provided in this section are expressed in terms of Equivalent Isotropic Radiated Power (EIRP). (2) The EIRP level is to be determined from the maximum measured power within a specified bandwidth. (i) The EIRP in 1 MHz is computed from the maximum power level measured within any 1-MHz bandwidth using a power averaging detector; (ii) The EIRP in 50 MHz is computed from the maximum power level measured with a peak detector in a 50-MHz bandwidth centered on the frequency at which the maximum average power level is realized and this 50 MHz bandwidth must be contained within the authorized operating bandwidth. For a RBW less than 50 MHz, the peak EIRP limit (in dBm) is reduced by 20 log(RBW/50) dB where RBW is the resolution bandwidth in megahertz. The RBW shall not be lower than 1 MHz or greater than 50 MHz. The video bandwidth of the measurement instrument shall not be less than the RBW. If the RBW is greater than 3 MHz, the application for certification filed shall contain a detailed description of the test procedure, calibration of the test setup, and the instrumentation employed in the testing. (3) The EIRP limits for LPR operations in the bands authorized by this rule section are provided in Table 1. The emission limits in Table 1 are based on boresight measurements (i.e., measurements performed within the main beam of an LPR antenna).
Measurement uncertainty:	± 3 dBm
Operation mode:	Transmitting continuously, measurement mode
Comment:	Analyzer setting for average and peak measurements: RBW = 1 MHz, VBW = 3 MHz Radiated measurement, test distance = 3 m, boresight measurement

LPR EIRP Emission Limits		
Frequency band of operation	**Average emission limit (EIRP in dBm measured in 1 MHz)**	**Peak emission limit (EIRP in dBm measured in 50 MHz)**
24,05 GHz to 29 GHz	**-14**	**26**

K-Band Solid Radars
Average emissions, (EIRP in dBm measured in 1 MHz)

Frequency (MHz)	Analyzer RBW / VBW (MHz)	Spurious emission level (dBm/MHz)	Limit (dBm/MHz)	Margin (dB)	Result
Configuration K2					
23821.444	1 / 3	-34.70	-24.00	10.73	Passed
25179.722	1 / 3	-24.60	-14.00	10.60	Passed
Configuration K3					
25215.111	1 / 3	-24.20	-14.00	10.20	Passed
Configuration K4					
23848.333	1 / 3	-29.41	-24.00	5.41	Passed
25196.056	1 / 3	-23.49	-14.00	9.49	Passed
Configuration K5					
23505.500	1 / 3	-29.08	-24.00	5.08	Passed
25215.111	1 / 3	-23.49	-14.00	9.49	Passed
Configuration K6					
23525.667	1 / 3	-28.17	-24.00	4.17	Passed
25226.000	1 / 3	-21.87	-14.00	7.87	Passed

Peak emissions, (EIRP in dBm, measured in 50 MHz)

Configuration	*Transmitter Peak Power (dBm)*	*Limit (dBm)*	*Margin (dB)*	*Result*	*Note*
K2	2.3	26.0	23.7	Passed	
K3	2.5	26.0	23.5	Passed	
K4	2.7	26.0	23.3	Passed	
K5	3.4	26.0	22.6	Passed	
K6	3.4	26.0	22.6	Passed	

Note(s):
From every configuration, only the antenna with the highest gain has been selected for testing.

K-Band Liquid Radars
Average emissions, (EIRP in dBm measured in 1 MHz)

Frequency (MHz)	Analyzer RBW / VBW (MHz)	Spurious emission level (dBm/MHz)	Limit (dBm/MHz)	Margin (dB)
Configuration K2				
24009.667	1 / 3	-44.83	-24.00	20.83
25136.167	1 / 3	-29.08	-14.00	15.08
Configuration K3				
25174.278	1 / 3	-27.90	-14.00	13.90
Configuration K4				
25147.056	1 / 3	-27.00	-14.00	13.00

Peak emissions, (EIRP in dBm, measured in 50 MHz)

Configuration	*Transmitter Peak Power (dBm)*	*Limit (dBm)*	*Margin (dB)*	*Result*	*Note*
K2	0.8	26.0	25.2	Passed	
K3	-0.1	26.0	26.1	Passed	
K4	0.3	26.0	25.7	Passed	

Note(s):
From every configuration, only the antenna with the highest gain has been selected for testing.

8.11 Unwanted Emissions – 15-256 (h)

Prüfdatum / *Date of test:*	13 February, 2014
Prüfer / *Operator:*	Johann Roidt
Messplatz / *Test site:*	Fully anechoic room, cabin no. 2

Prüfergebnis / *Test Result*
☒ **Erfüllt / *Passed***
☐ **Nicht erfüllt / *Not passed***

Luftdruck / *Barometric pressure:*	977.6 hPa
Relative Luftfeuchtigkeit / *Relative humidity:*	59.1 %
Temperatur / *Ambient temperature:*	26.5 °C

Prüfgrundlage / *Specifications:*	FCC Rules, Part 15, Section 15.256 (h)
Frequenzband / *Frequency band*	24.05 – 29.00 GHz
Betriebsart / *Operation mode:*	Transmitting continuously
Kommentar / *Comment:*	

Grenzwert / *Limit:*		
Unwanted emissions limits. Unwanted emissions from LPR devices shall not exceed the general emission limit in §15.209 of this chapter.		
Frequency range	*Narrowband emission Limit*	*Wideband emission limit*
Below 1 GHz	-57 dBm (e.r.p.)	-47 dBm/MHz (e.r.p.)
Above 1 GHz	-47 dBm (e.r.p.)	-37 dBm/MHz (e.r.p.)

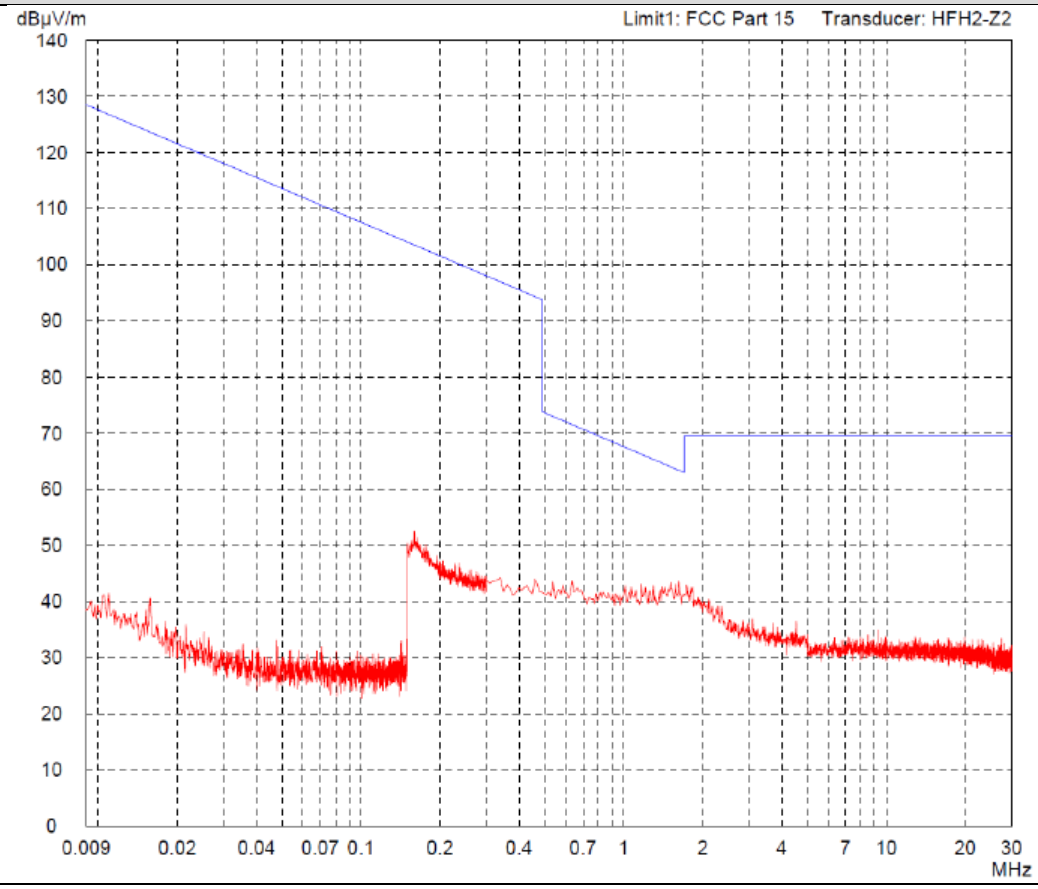
8.12 Radiated Emission Measurement 9 kHz to 30 MHz

Rules and specifications:	CFR 47 Part 15, sections 15.205 and 15.209 IC RSS-GEN Issue 3, sections 7.2.2 and 7.2.5			
Guide:	ANSI C63.4			
Limit:	Frequency of Emission (MHz)	Field Strength (µV/m)	Field Strength (dBµV/m)	Measurement Distance d (meters)
	0.009 - 0.490	2400/F(kHz)	67.6 - 20 · log(F(kHz))	300
	0.490 - 1.705	24000/F(kHz)	87.6 - 20 · log(F(kHz))	30
	1.705 - 30.000	30	29.5	30
	Additionally, the level of any unwanted emissions shall not exceed the level of the fundamental emission.			
Measurement procedure:	Radiated Emission Measurement 9 kHz to 30 MHz (6.5)			

Test Result:	Test passed

Comment:	Test performed for configuration K1
Date of test:	13 February 2014
Test site:	

Test Result:	Test passed



No emissions above noise level detected

Sample calculation of final values:

Extrapolation Factor (dB) = (Log(d) - Log(d_1)) · Extrapolation Factor (dB/decade)

Final Value (dBµV/m) = Reading Value d_1 (dBµV) + Correction Factor (dB/m) + Extrapolation Factor (dB) + Pulse Train Correction (dB)

Note: Extrapolation factor (dB) and final value (dBµV/m) are relating to distance d.

8.13 Radiated Emission Measurement 30 MHz to 100 GHz

Rules and specifications:	CFR 47 Part 15, section 15.209 FCC 14-2 (15.256(h)(k))
Guide:	ANSI C63.10 6.3
Limit:	Frequency of Emission (MHz) / Field Strength (µV/m) / Field Strength (dBµV/m) 30 - 88 / 100 / 40.0 88 - 216 / 150 / 43.5 216 - 960 / 200 / 46.0 Above 960 / 500 / 54.0 Additionally, the level of any unwanted emissions shall not exceed the level of the fundamental emission.
Measurement procedures:	Radiated Emission in Fully or Semi Anechoic Room (6.6) Radiated Emission at Alternative Test Site (6.7)
Note:	Plots overleaf show configuration K2 which represents worst case emission profile. No emissions above noise floor have been detected from either the digital part or from the RF part. The DUT was measured normal operating position with the antenna vertical and boresight with transmitting and receiving antenna facing each other.

Date of test:	July 9, 2012; July 18, 2012; July 19, 2012
Test site:	Frequencies ≤ 1 GHz: Semi-anechoic room, cabin no. 8 Frequencies > 1 GHz: Fully anechoic room, cabin no. 2
Test distance:	Frequencies ≤ 8.2 GHz: 3 meters Frequencies > 8.2 GHz and ≤ 18 GHz: 1 meters Frequencies > 18 GHz and ≤ 40 GHz: 0.5 meters Frequencies > 40 GHz and ≤ 60 GHz: 0.3 meters Frequencies > 50 GHz and ≤ 75 GHz:: 0.25 meters Frequencies > 75 GHz: 0.2 meters

Test Result:	Test passed, see detailed results overleaf

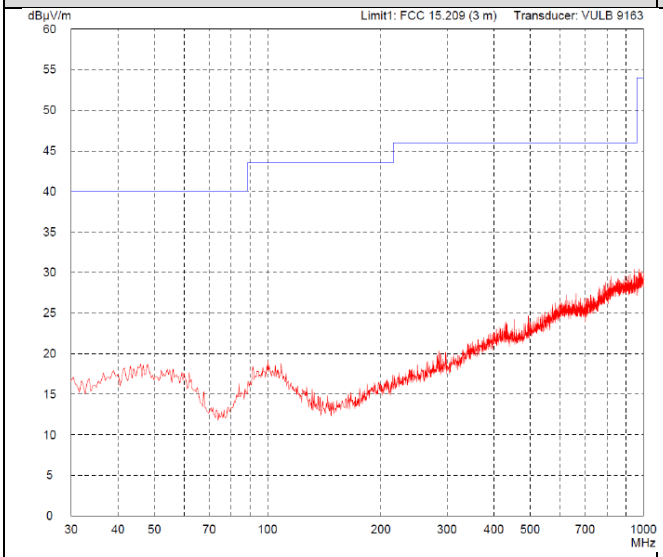
Sample Calculation of Field Strength values for pulsed systems:

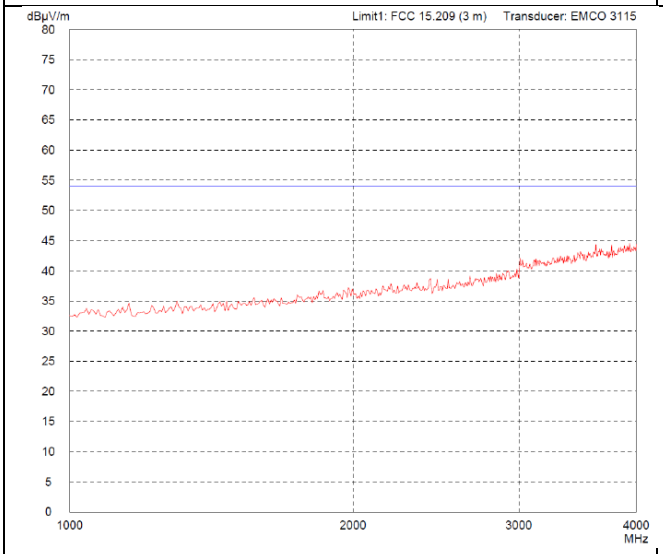
1) Measure Peak value with analyzer RBW set to 0.3 MHz, VBW set to 1 MHz, Ts set to 85 ms
2) Calculate Field Strength by adding antenna correction factor
3) Calculate True Peak Field Strength by adding Desensitization Factor
   Apply provisions according to section 15.35 (b)of the FCC Rules for limiting peak emissions
4) Calculate Average value by subtracting Duty Cycle Correction Factor from True Peak Field Strength Value

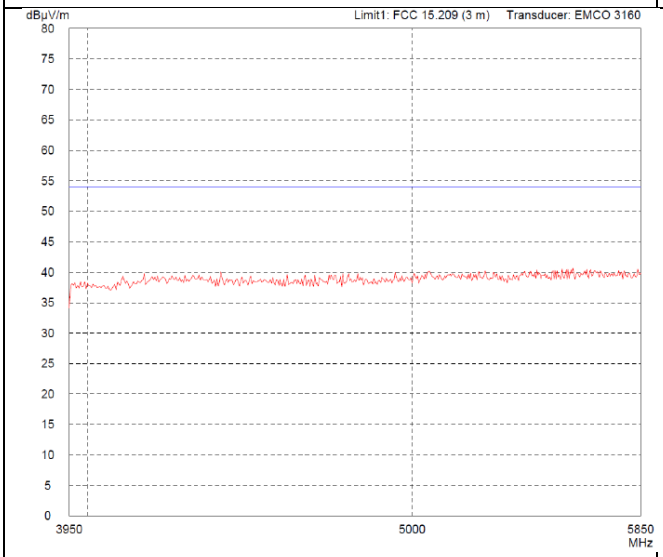
TÜV SÜD Product Service GmbH
Äußere Frühlingstraße 45
94315 Straubing
Germany

Phone: +49 9421 5522-0
Fax: +49 9421 5522-99
Web: www.tuev-sued.de

Horizontal Polarisation







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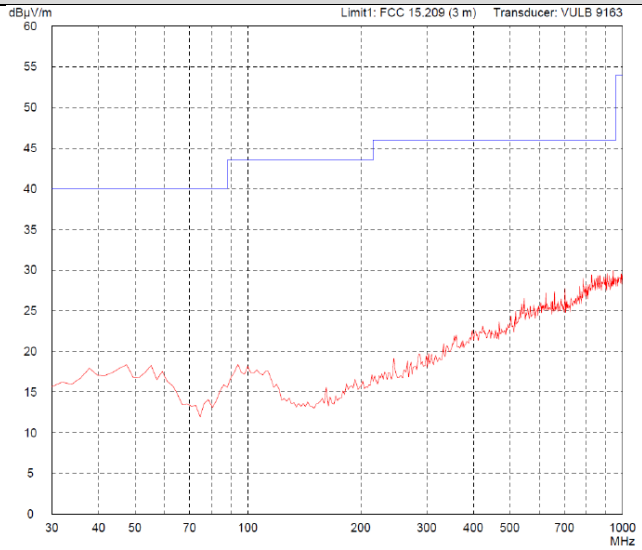
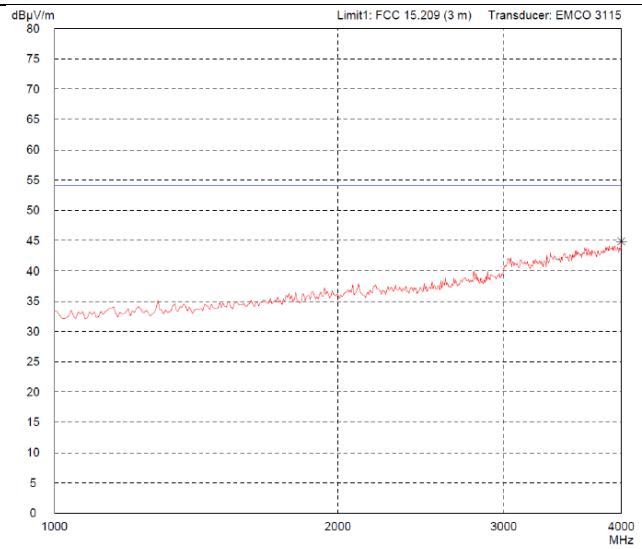
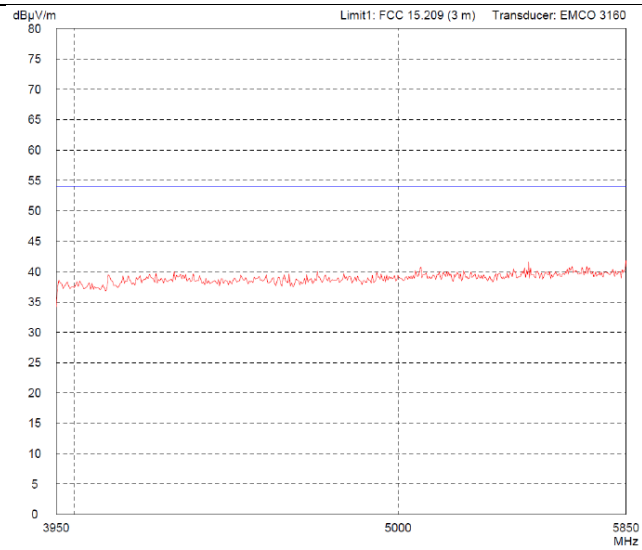


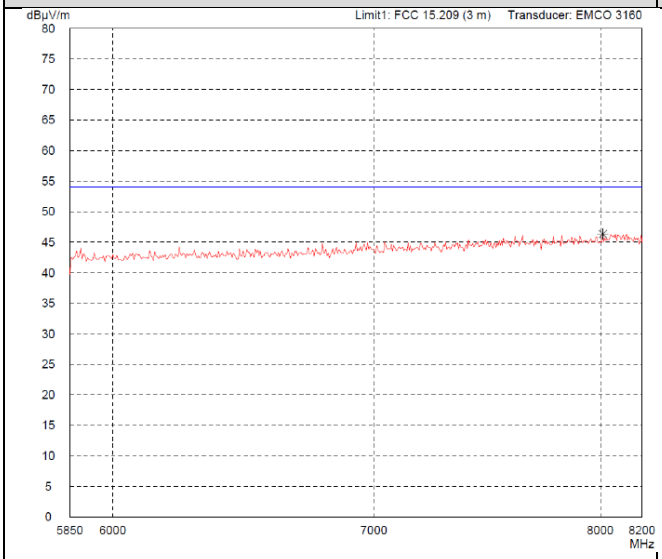


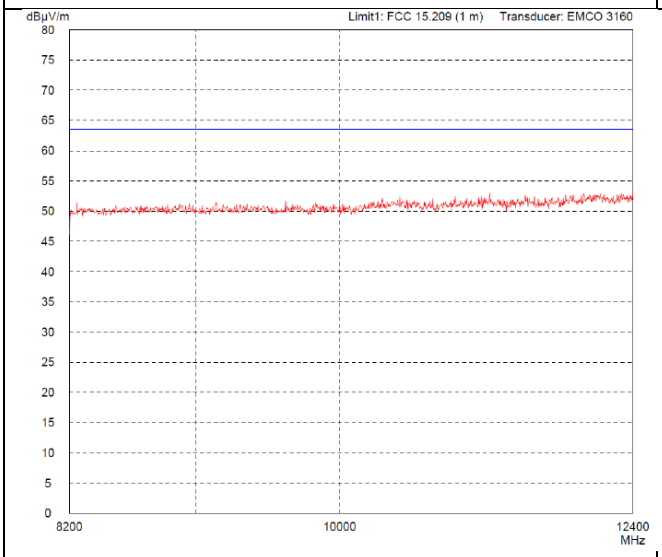


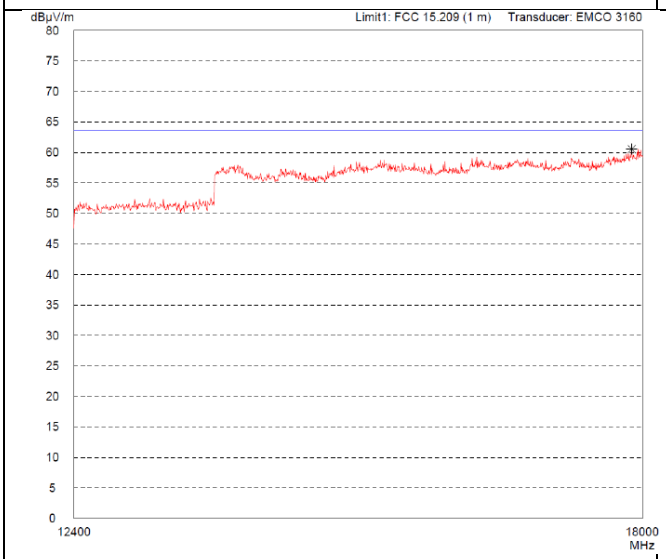
TÜV SÜD Product Service GmbH
Äußere Frühlingstraße 45
94315 Straubing
Germany

Phone: +49 9421 5522-0
Fax: +49 9421 5522-99
Web: www.tuev-sued.de

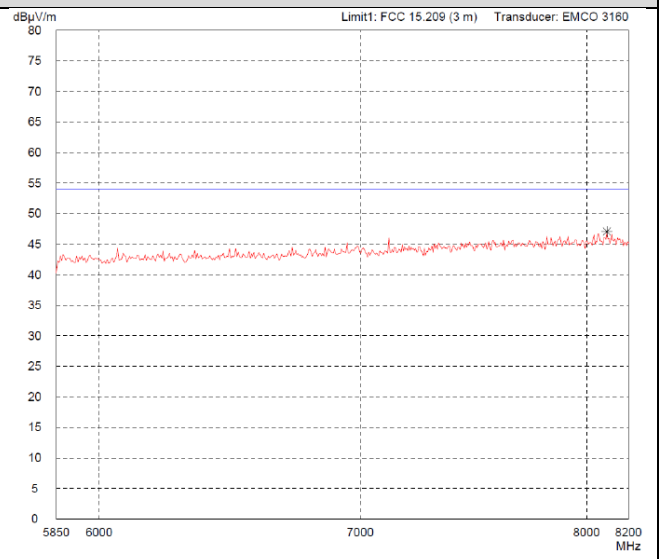
Horizontal Polarisation

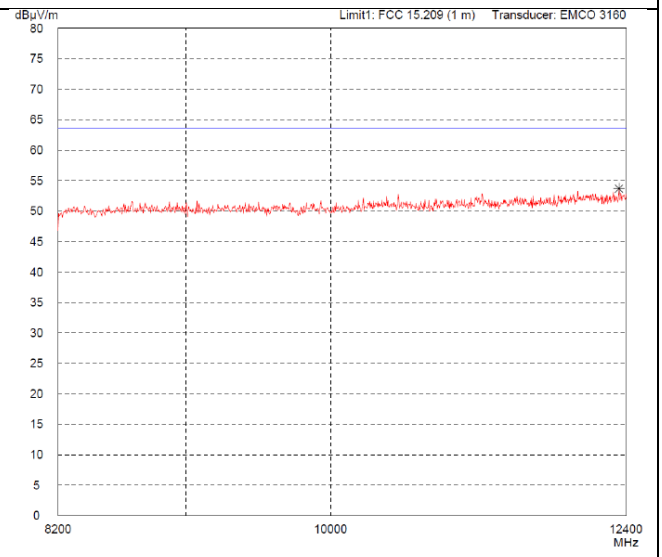


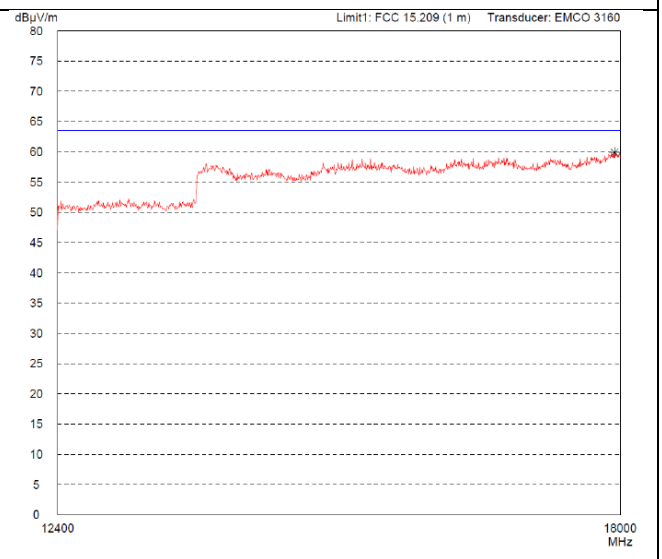


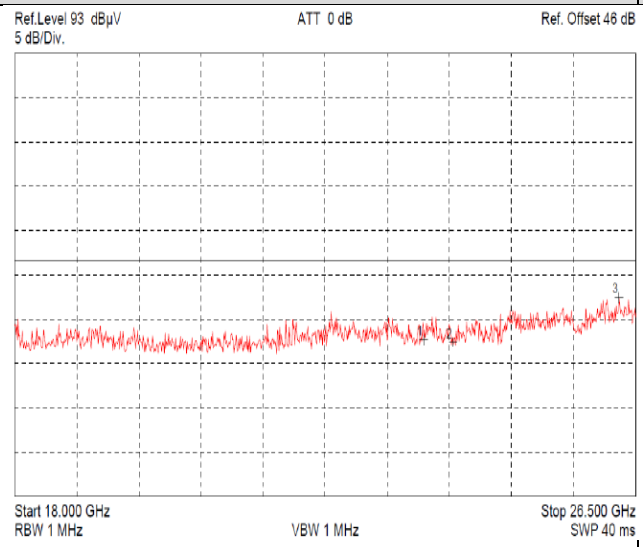
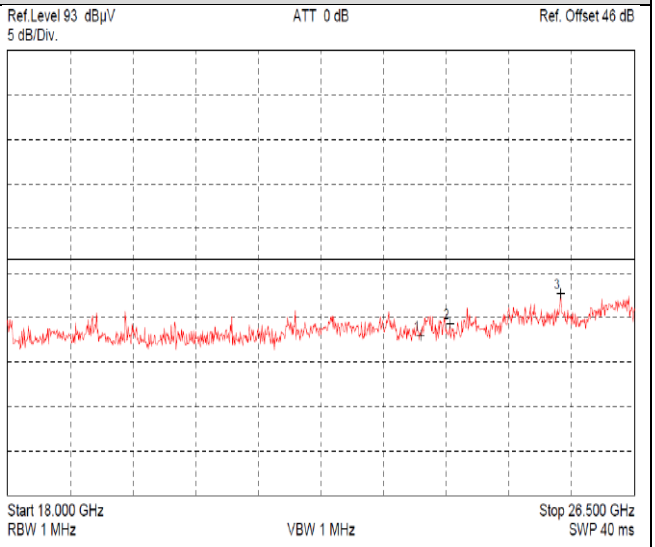
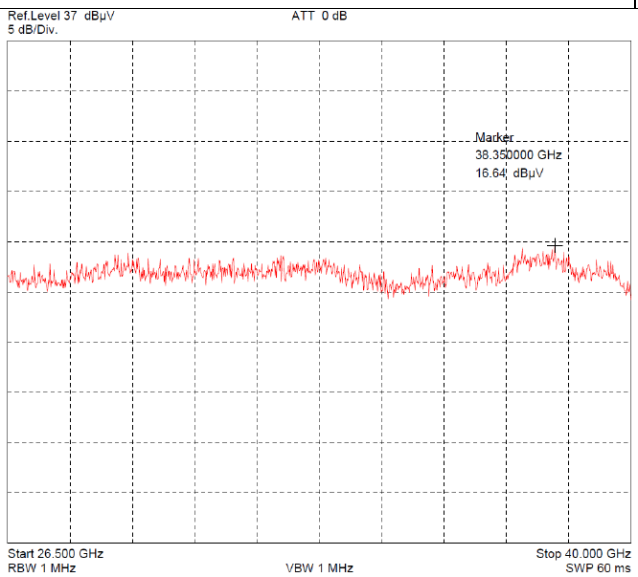
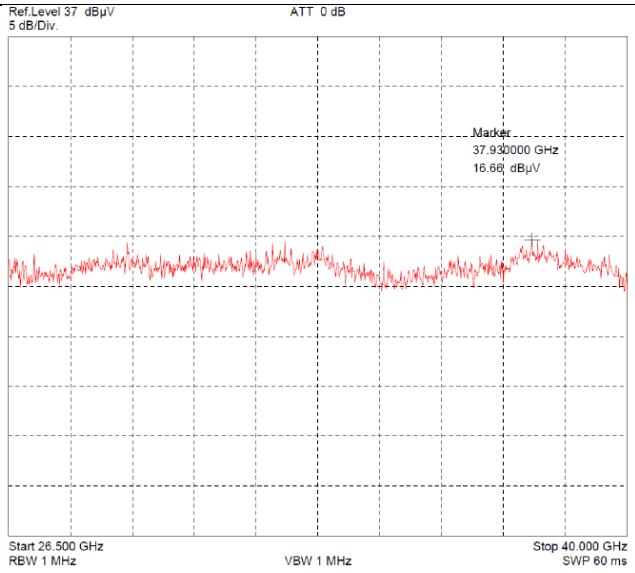
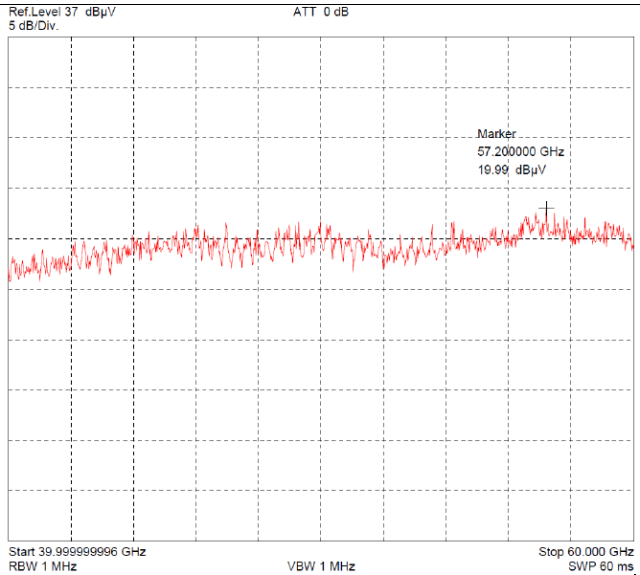
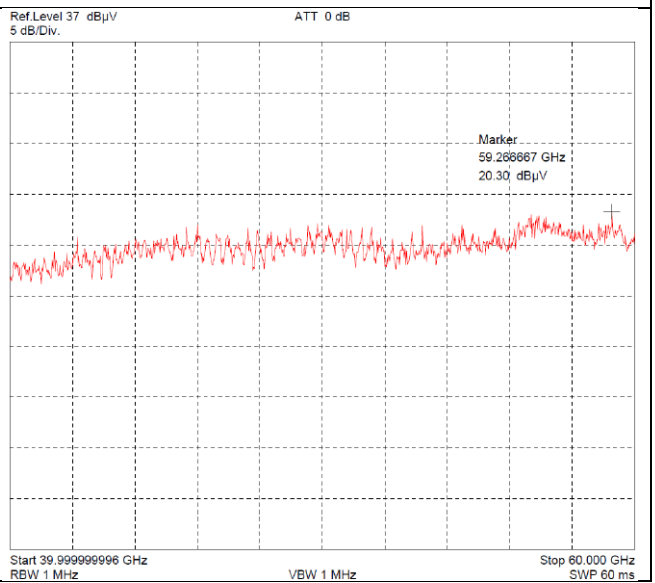


Vertical Polarisation





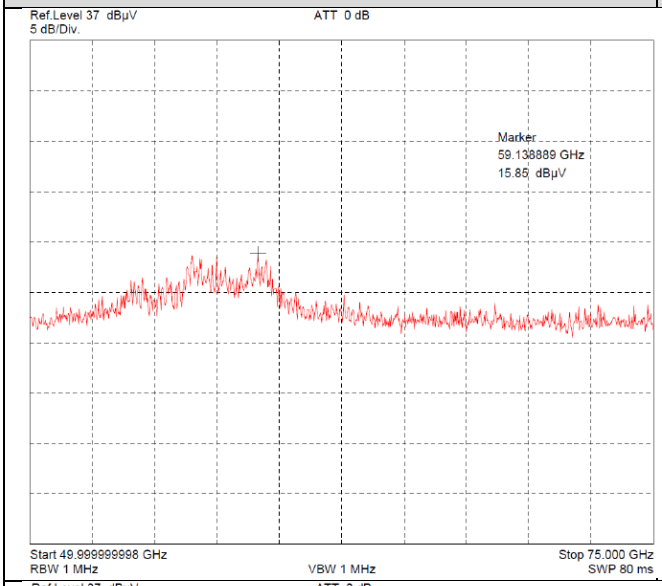


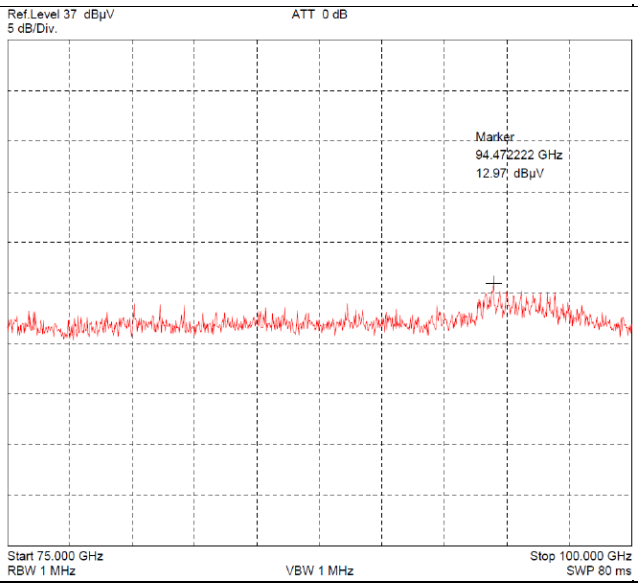
Horizontal Polarisation	Vertical Polarisation
	
	
	

TÜV SÜD Product Service GmbH
Äußere Frühlingstraße 45
94315 Straubing
Germany

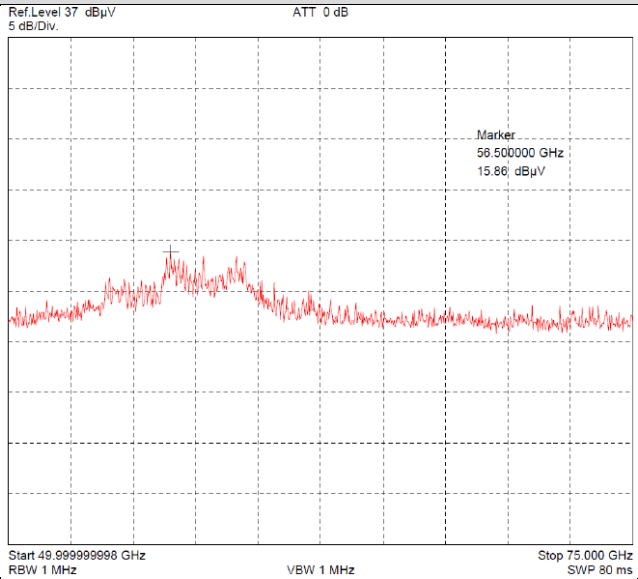
Phone: +49 9421 5522-0
Fax: +49 9421 5522-99
Web: www.tuev-sued.de

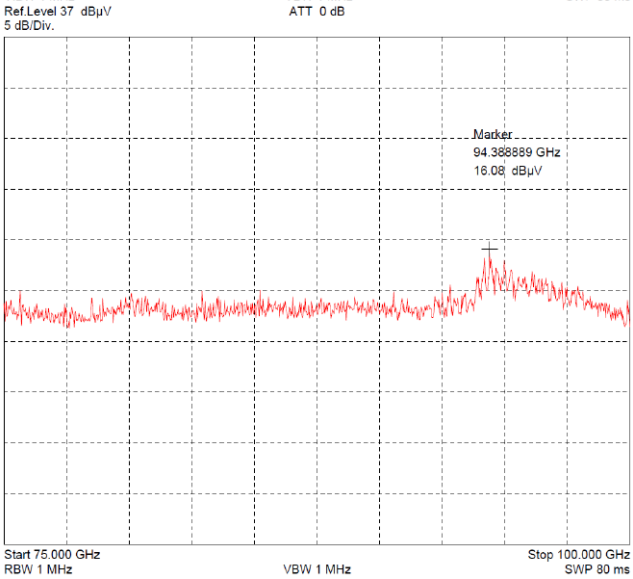
Horizontal Polarisation





Vertical Polarisation





8.14 Antenna Beamwidth – 15.256 (i)

Prüfdatum / *Date of test:*	13 February 2014
Prüfer / *Operator:*	Johann Roidt
Messplatz / *Test site:*	Fully anechoic room, cabin no. 2

Prüfergebnis / *Test Result*
☒ **Erfüllt / *Passed***
☐ **Nicht erfüllt / *Not passed***

Prüfgrundlage / *Specifications:*	FCC Rules, Part 15, Section 15.256 (i)
Frequenzband / *Frequency band*	24.05 – 29.00 GHz
Messunsicherheit / *Measurement uncertainty:*	± 1 °
Betriebsart / *Operation mode:* Kommentar / *Comment:*	Antenna with external RF-generator

Configuration	*Antenna opening angle (°)*	*Limit (°)*	*Result*	*Note*
K2	< 10	12	Passed	1
K22	< 10	12	Passed	1
K3	< 10	12	Passed	1
K33	< 10	12	Passed	1
K4	12	12	Passed	1
K44	< 10	12	Passed	1
K5	< 10	12	Passed	1
K6	< 10	12	Passed	1
K66	< 10	12	Passed	1

Note(s):
1 See antenna pattern plots overleaf

Grenzwert / *Limit:*

The antenna gain in the elevation angels above 60 degrees from the main beam has to fulfill a maximum value of –10 dBi. The maximum antenna total opening angle is shown below:

Frequency band of operation	*Maximum antenna beamwidth in degree (°)*
6 GHz to 8.5 GHz	12
24,05 GHz to 29 GHz	12
75 GHz to 85 GHz	8

The LPR antenna is designed in a manner that is installed at a permanent fixed position pointing in downward direction. In addition the antenna positioning, or height from the ground, should have to observe two restrictions as follows:

- A separation distance of 4 km from Radio Astronomy sites in 6 GHz to 8.5 GHz (A), 24.05 GHz to 26.5 GHz (B) and 75 GHz to 85 GHz (C) frequency bands, unless a special authorization has been provided by the responsible National regulatory authority.
- Between 4 km to 40 km around any Radio Astronomy site the LPR antenna height shall not exceed 15 m height above ground.

8.15 Antenna Side Lobe Gain – 15.256 (j)

Prüfdatum / *Date of test:*	13 February 2014
Prüfer / *Operator:*	Johann Roidt
Messplatz / *Test site:*	Non shielded room

Prüfergebnis / *Test Result*
☒ **Erfüllt / *Passed***
☐ **Nicht erfüllt / *Not passed***

Prüfgrundlage / *Specifications:*	FCC Rules, Part 15, Section 15.256 (j)
Frequenzband / *Frequency band*	24.05 – 29.00 GHz
Messunsicherheit / *Measurement uncertainty:*	± 3 dB
Betriebsart / *Operation mode:* Kommentar / *Comment:*	Antenna with external RF-generator

Configuration	*Antenna Side Lobe Gain (Relative to Main Beam Gain)*	*Limit (dB)*	*Result*	*Note*
K2	>-30	-27	Passed	1
K22	>-30	-27	Passed	1
K3	>-30	-27	Passed	1
K33	>-30	-27	Passed	1
K4	>-30	-27	Passed	1
K44	>-30	-27	Passed	1
K5	>-30	-27	Passed	1
K6	>-30	-27	Passed	1
K66	>-30	-27	Passed	1

Note(s):
1 See antenna pattern plots overleaf

Grenzwert / *Limit:*

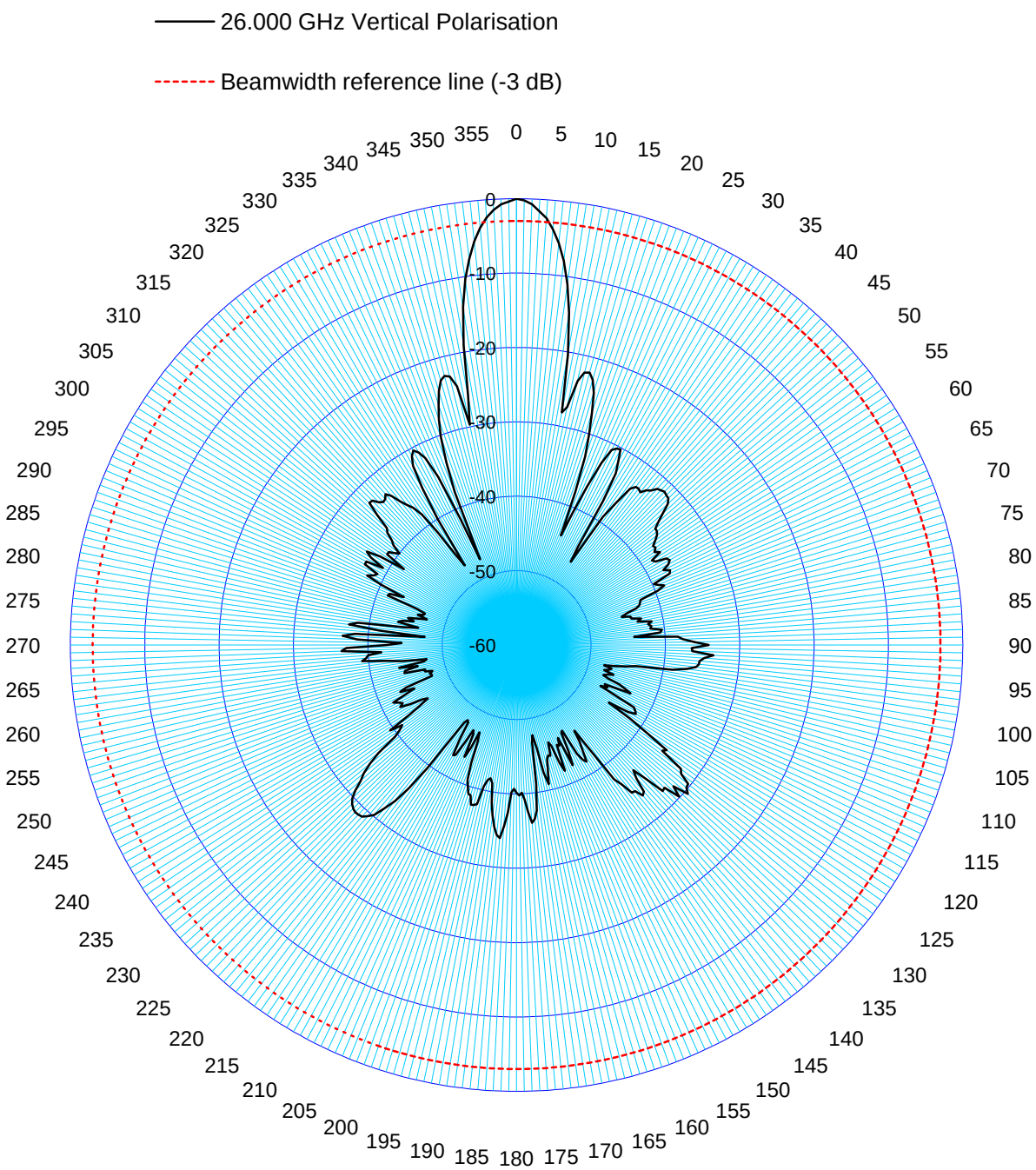
The antenna gain in the elevation angels above 60 degrees from the main beam has to fulfill a maximum value of –10 dBi. The maximum antenna total opening angle is shown below:

Frequency band of operation	*Maximum antenna beamwidth in degree (°)*
6 GHz to 8.5 GHz	12
24,05 GHz to 27 GHz	12
57 GHz to 64 GHz	8
75 GHz to 85 GHz	8

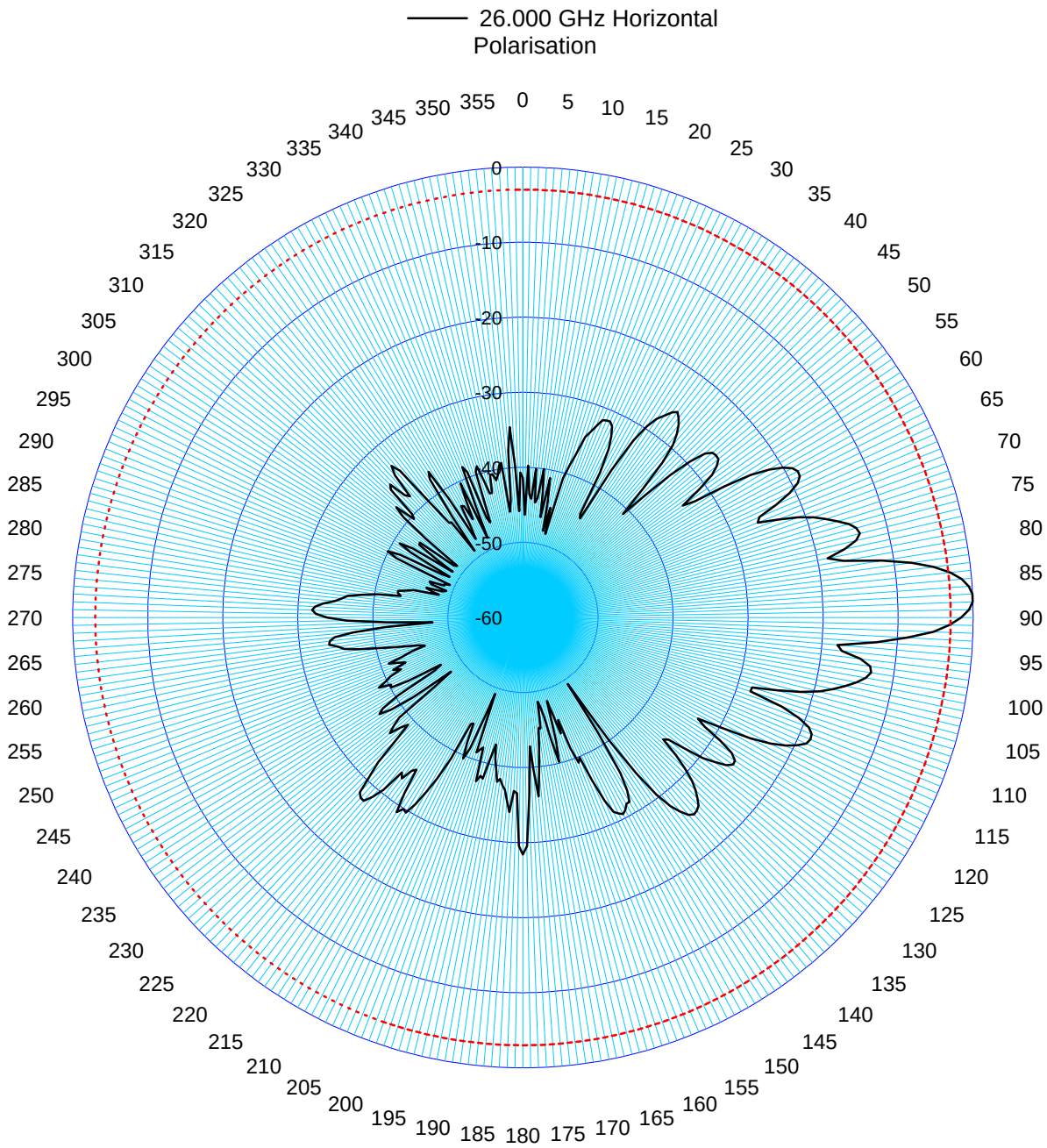
The LPR antenna is designed in a manner that is installed at a permanent fixed position pointing in downward direction. In addition the antenna positioning, or height from the ground, should have to observe two restrictions as follows:

- A separation distance of 4 km from Radio Astronomy sites in 6 GHz to 8.5 GHz (A), 24.05 GHz to 26.5 GHz (B) and 75 GHz to 85 GHz (C) frequency bands, unless a special authorization has been provided by the responsible National regulatory authority.
- Between 4 km to 40 km around any Radio Astronomy site the LPR antenna height shall not exceed 15 m height above ground.

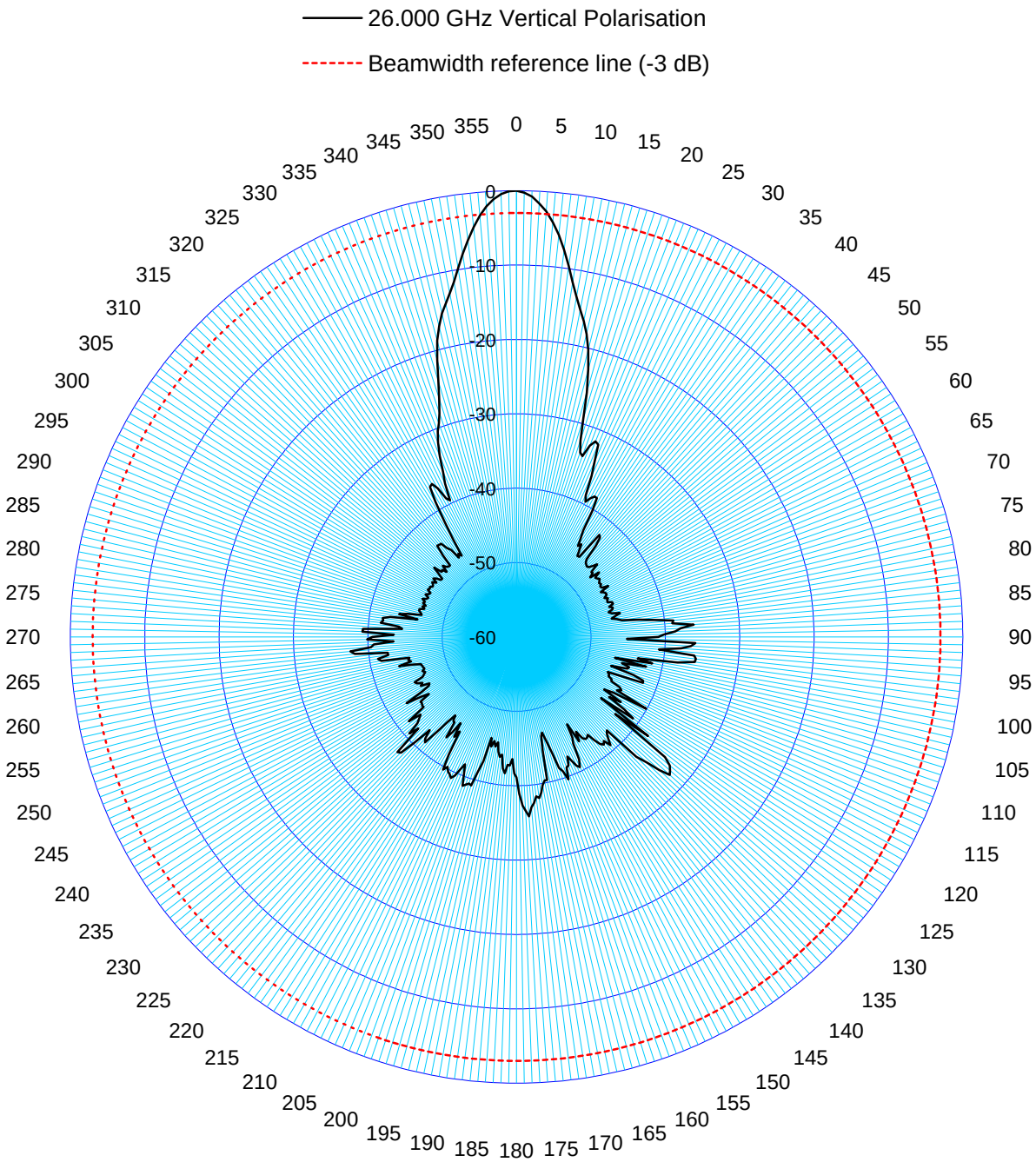
K2 Antenna Radiation Pattern



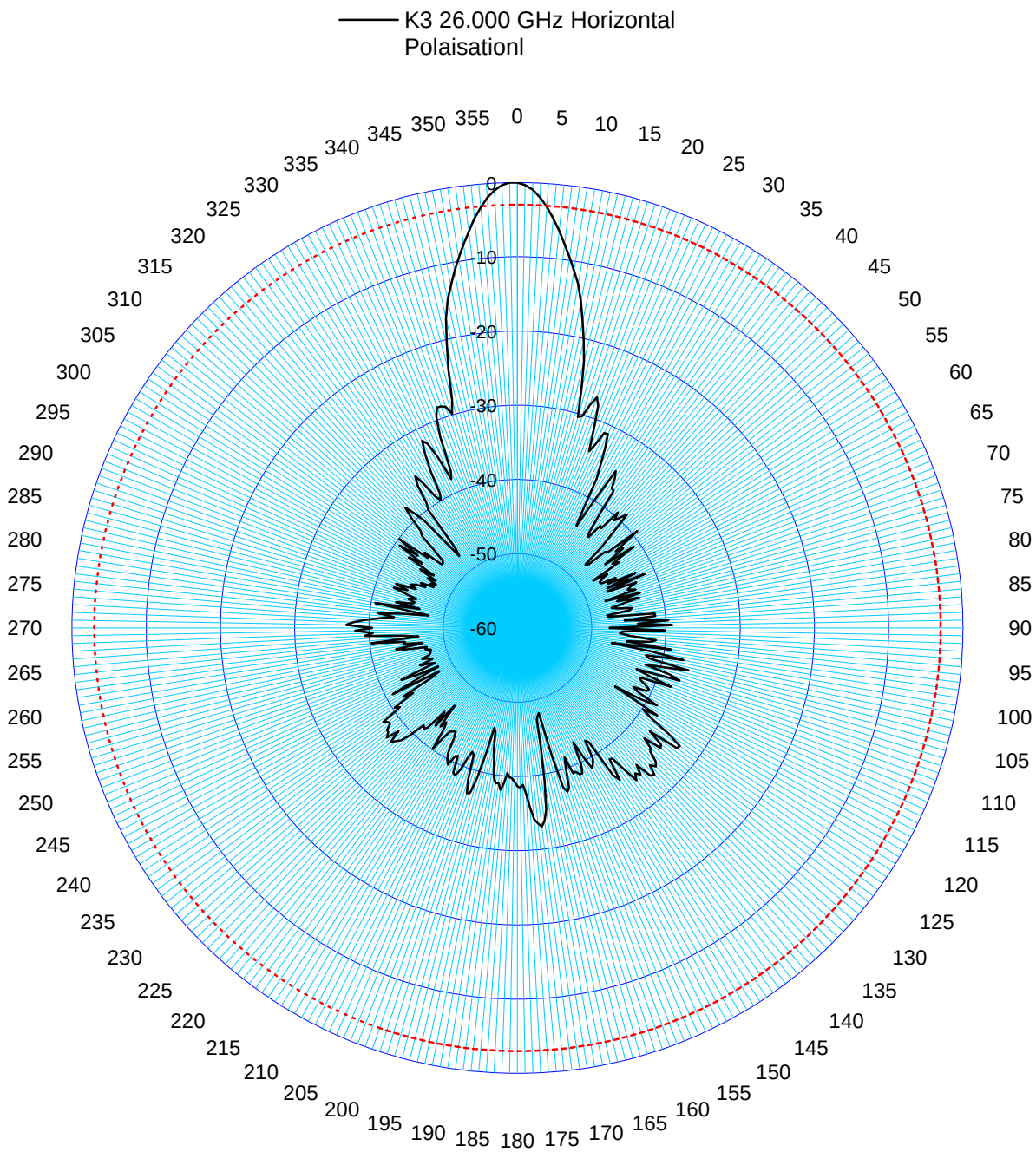
K2 Antenna Radiation Pattern



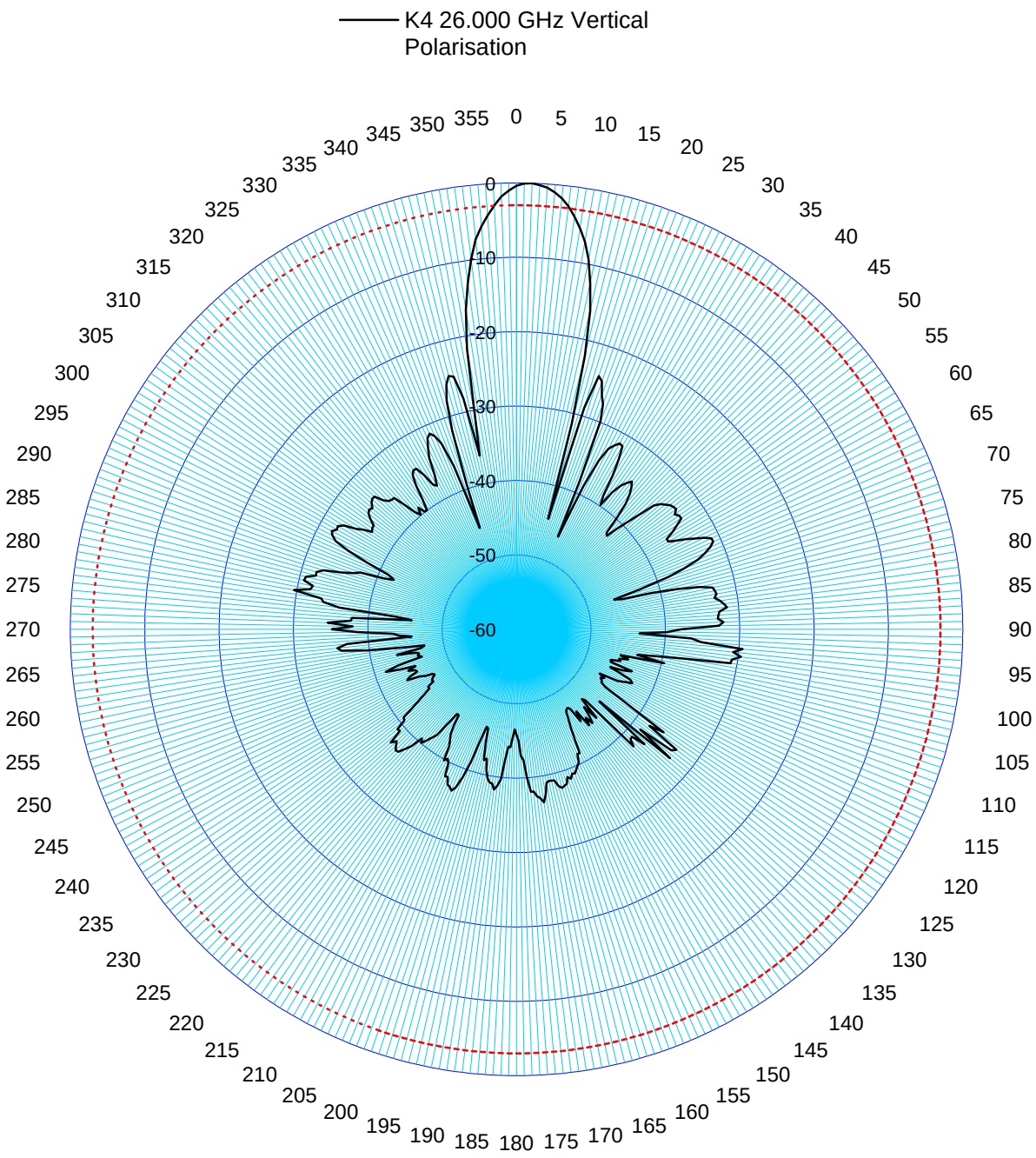
K3 Antenna Radiation Pattern



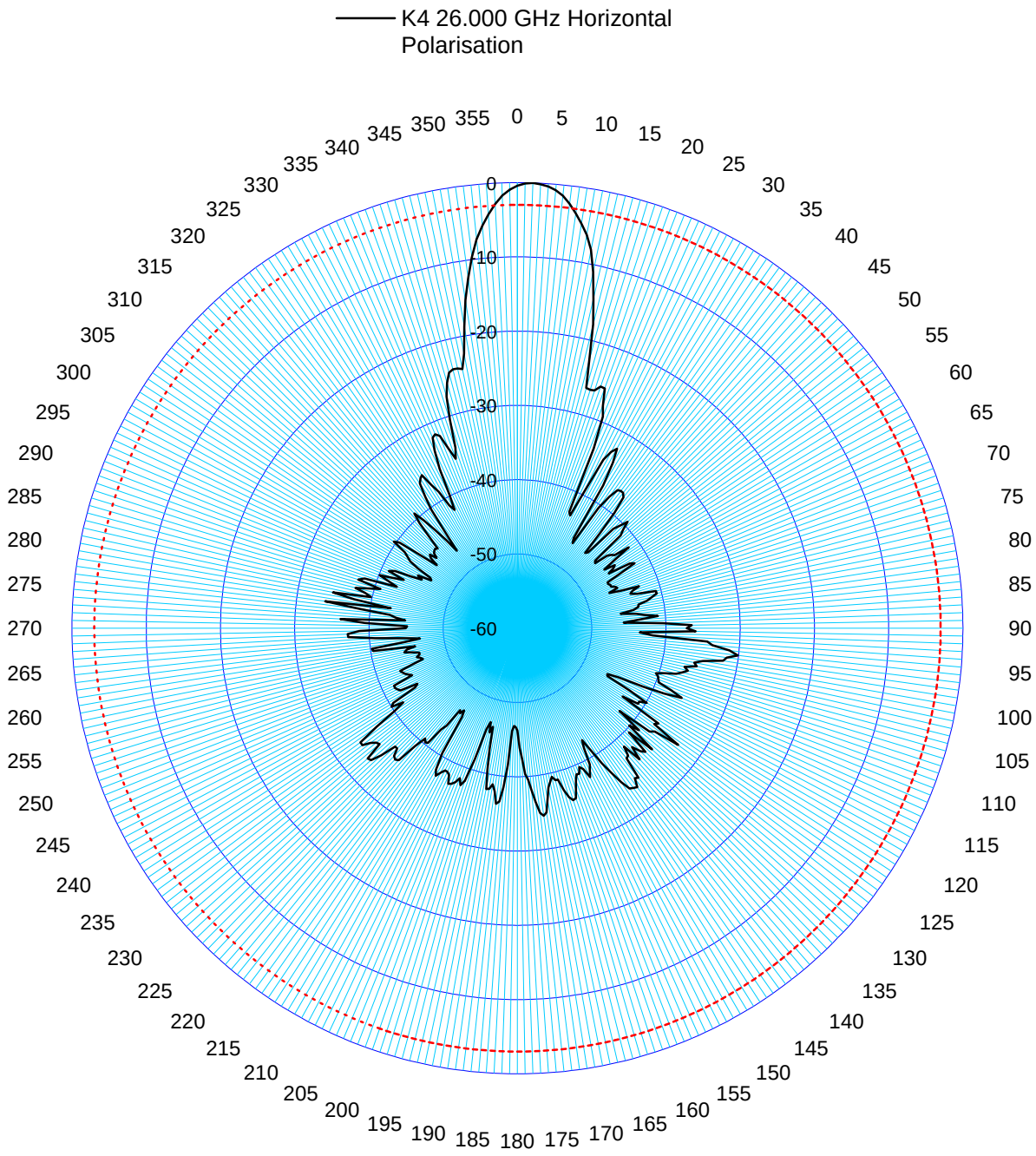
Antenna Radiation Pattern



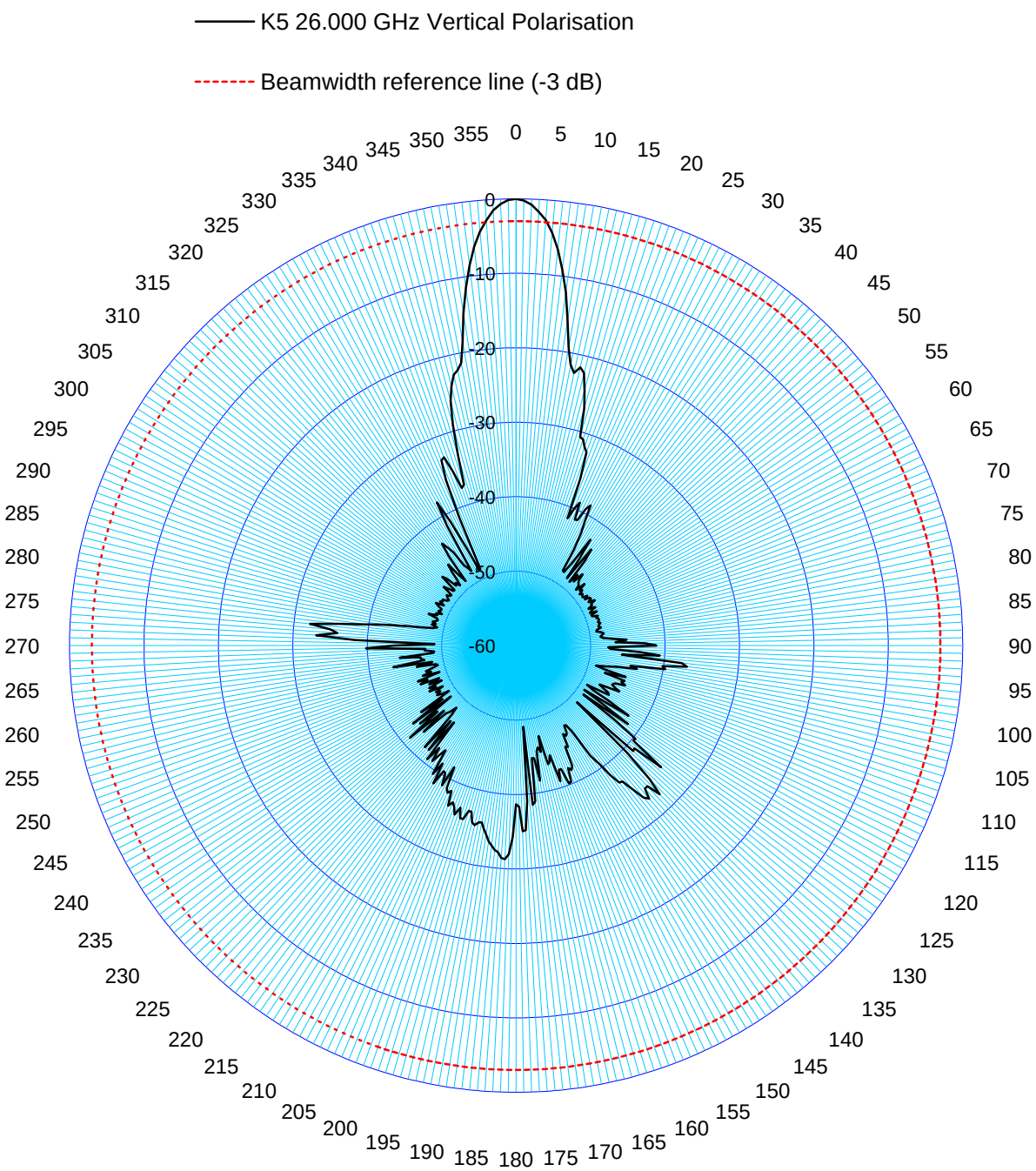
Antenna Radiation Pattern



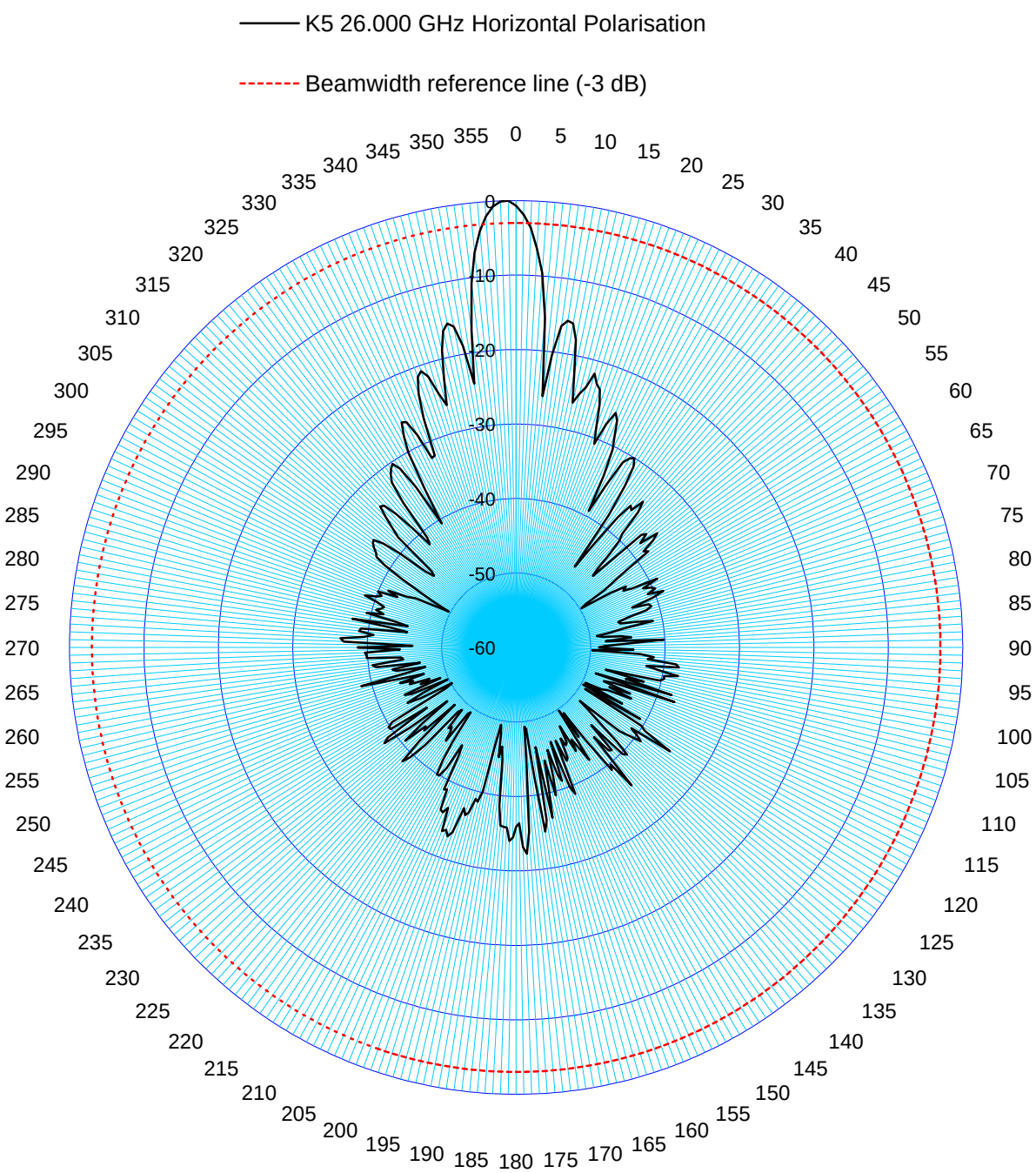
Antenna Radiation Pattern



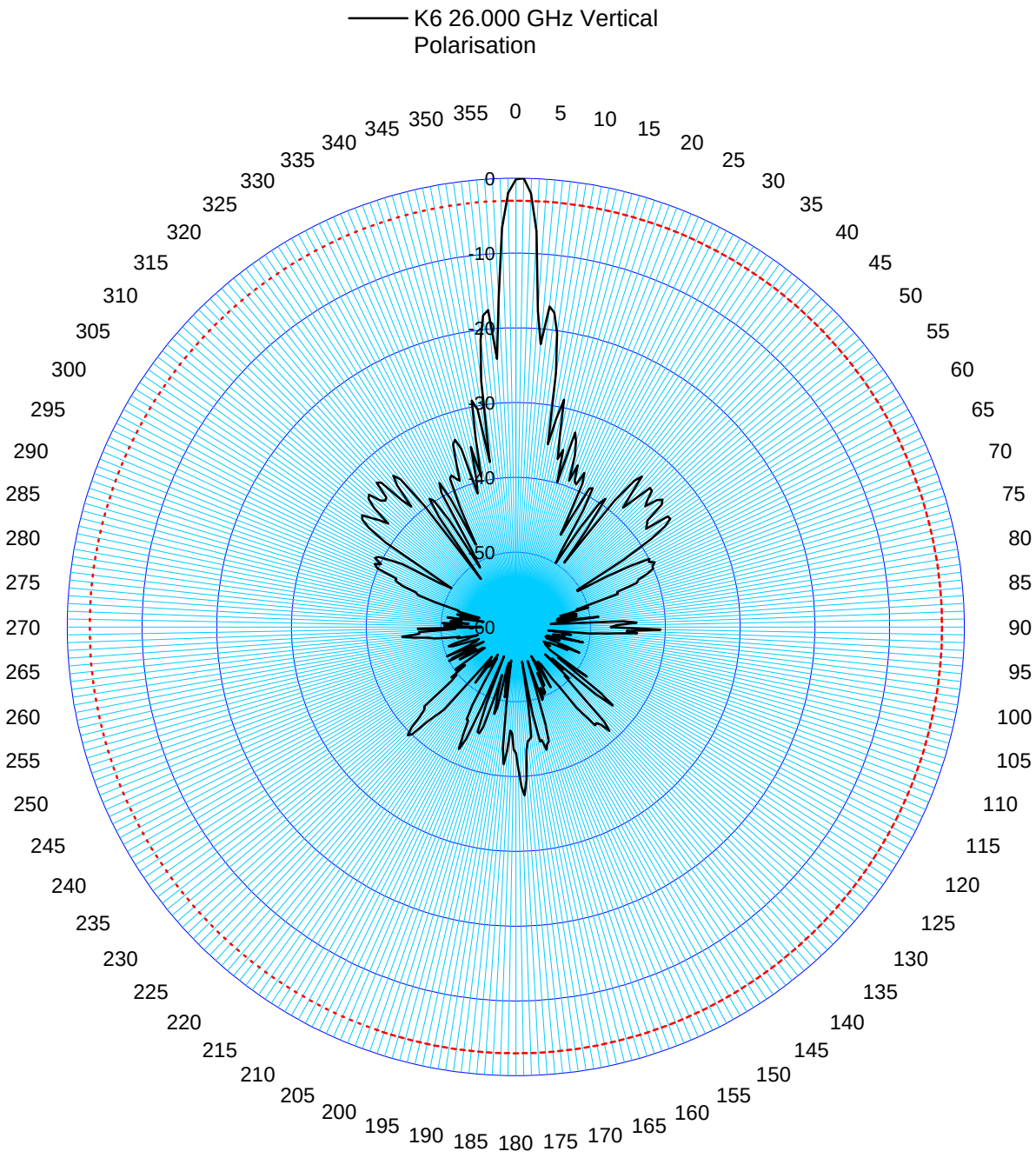
Antenna Radiation Pattern



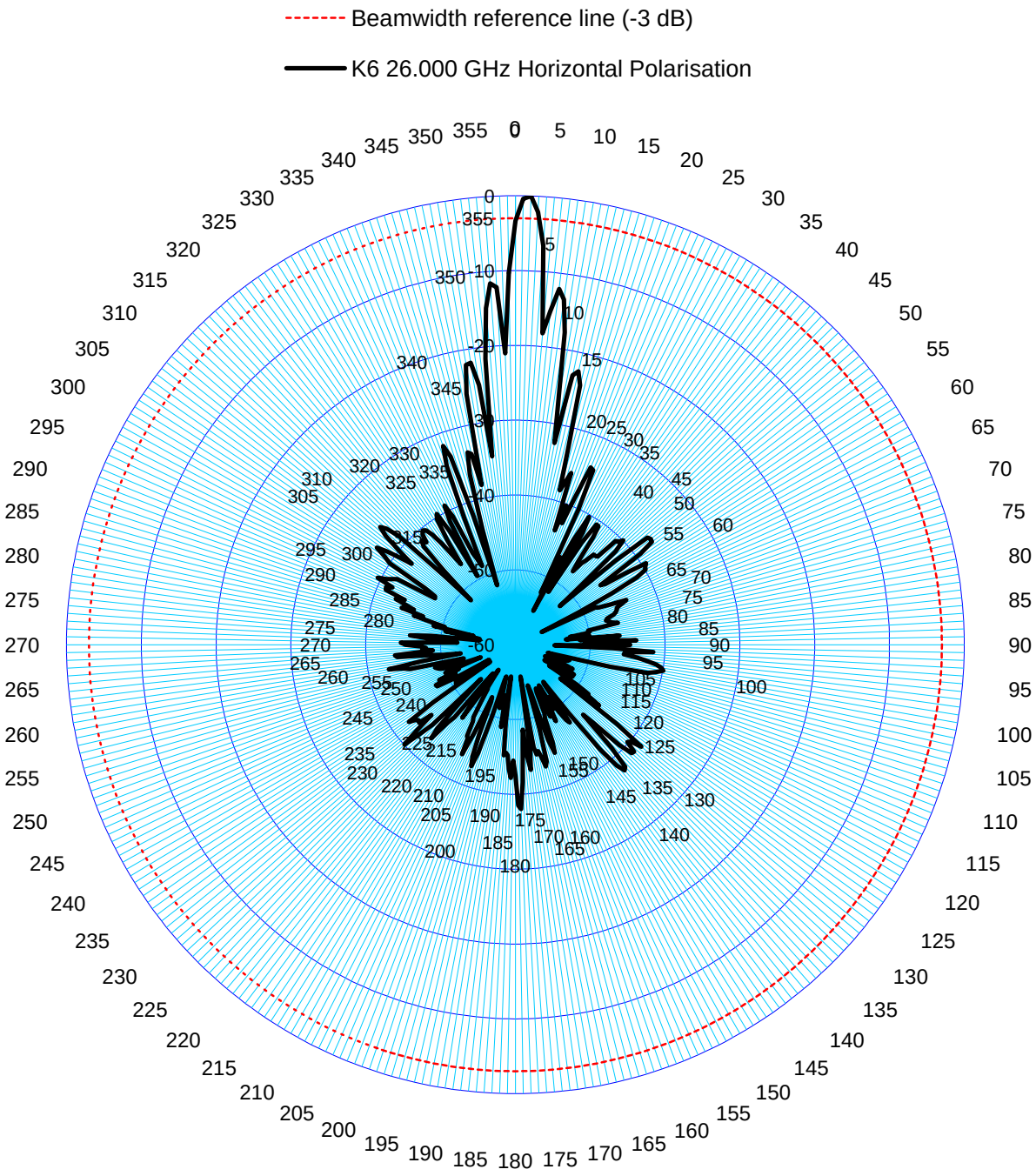
Antenna Radiation Pattern



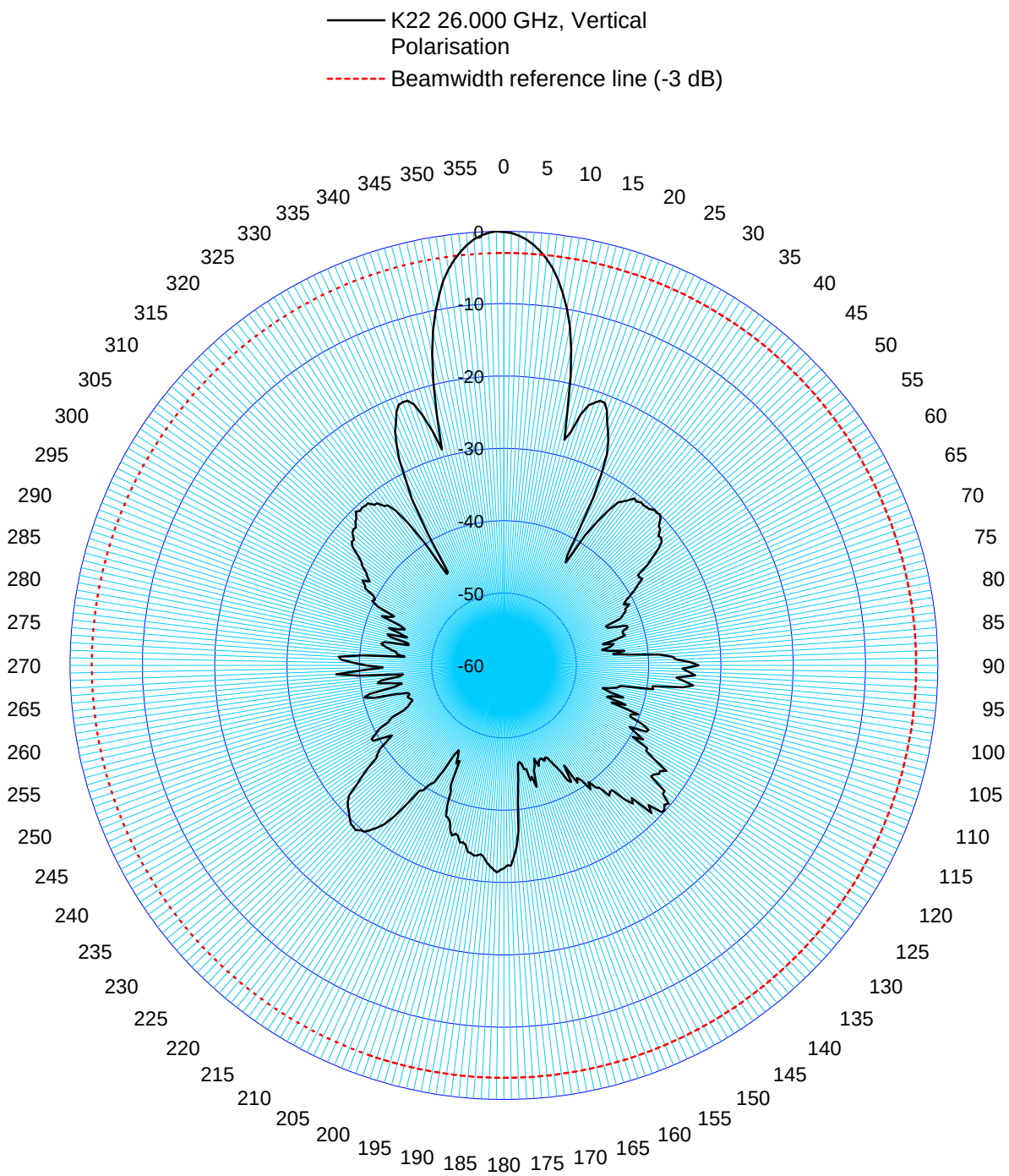
Antenna Radiation Pattern



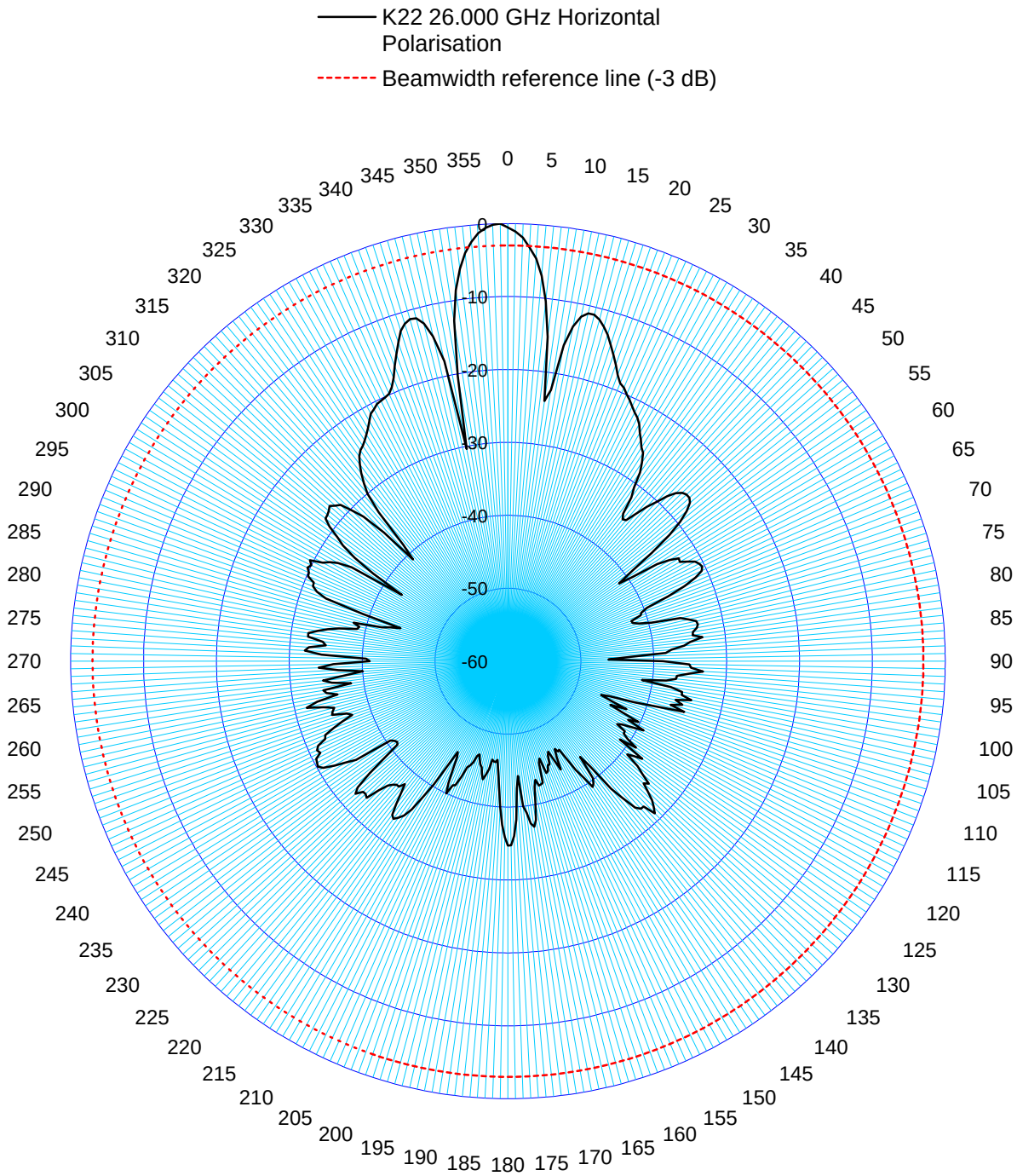
Antenna Radiation Pattern



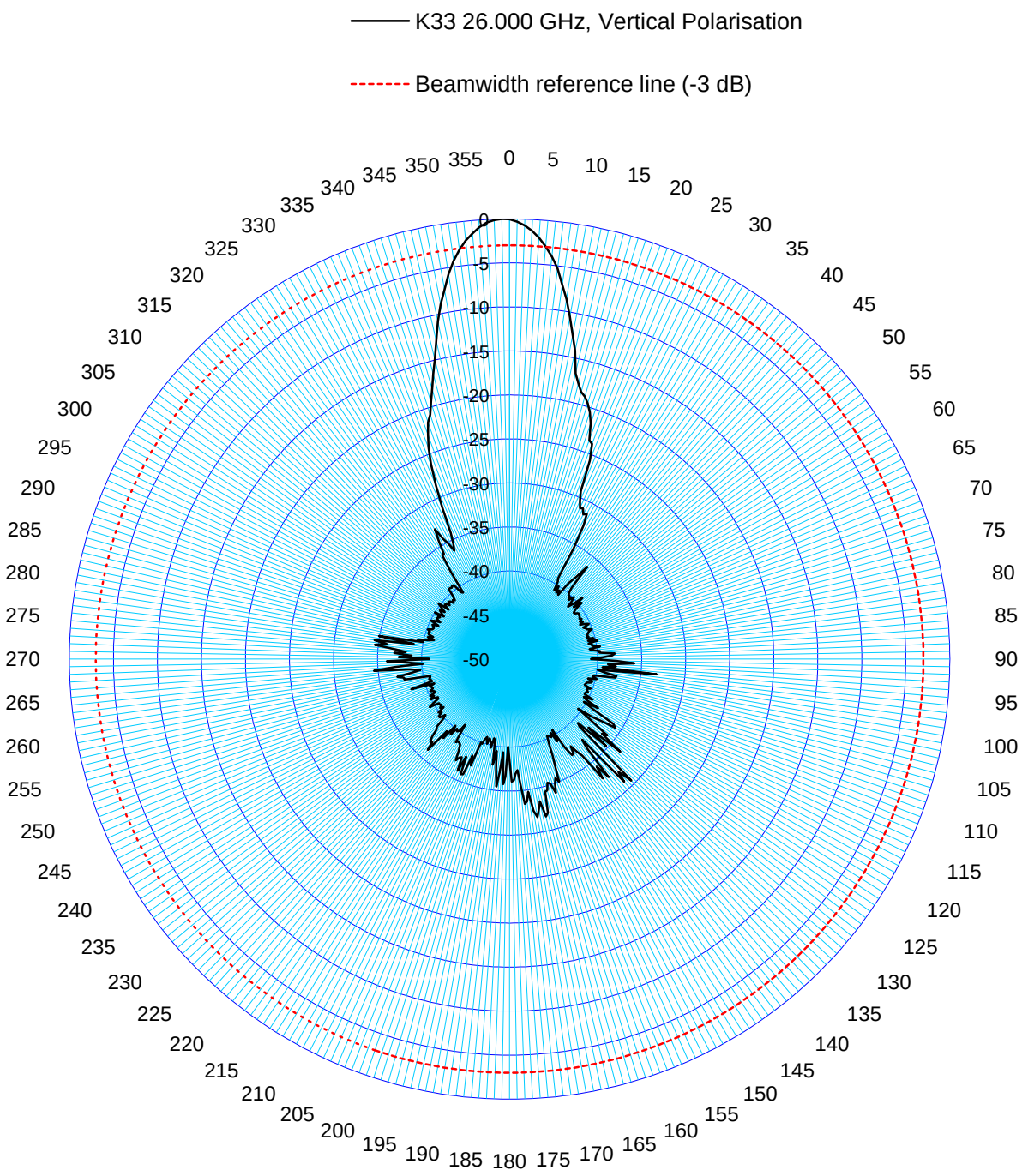
K22 Antenna Radiation Pattern Vertical



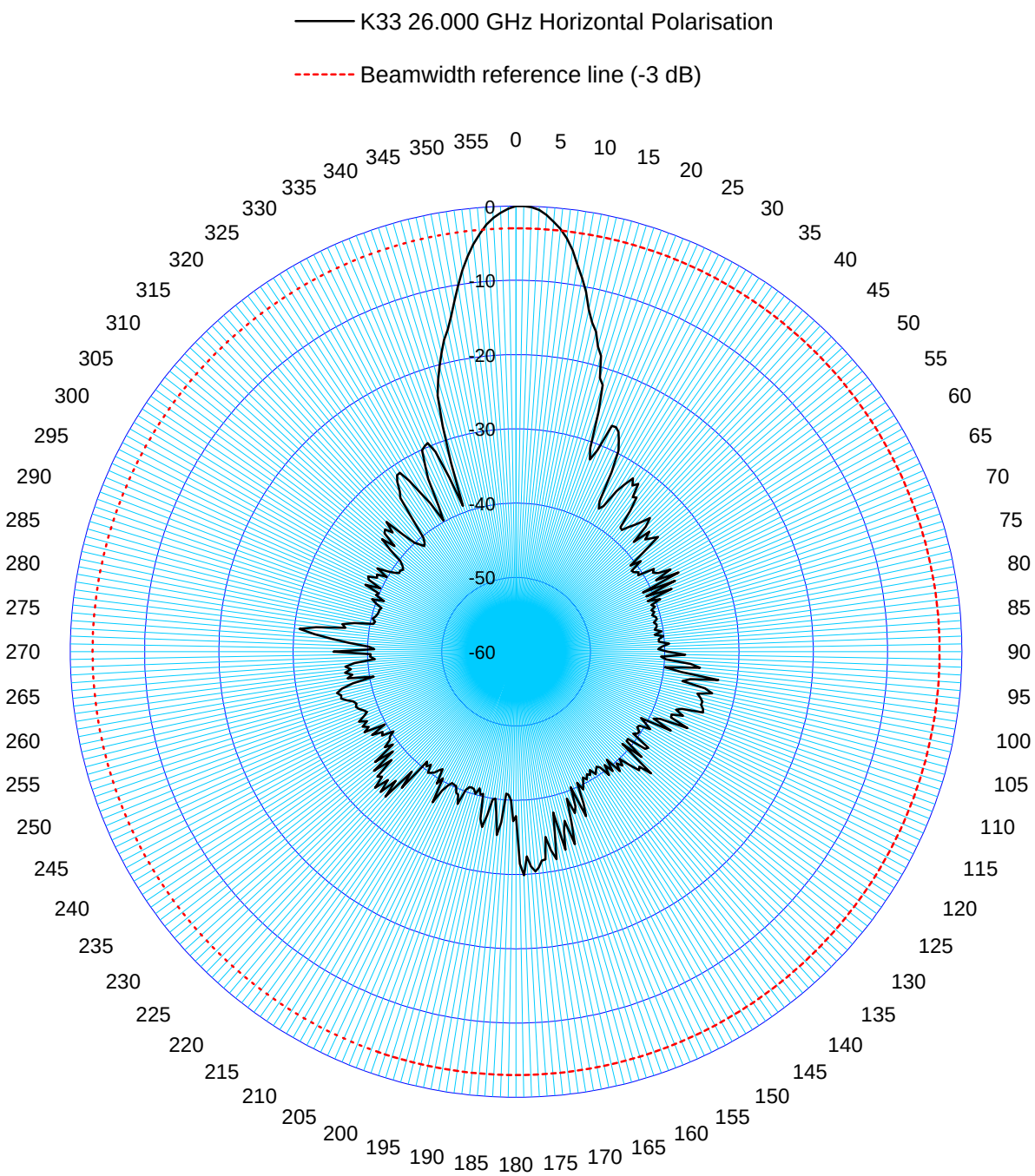
K22 Antenna Radiation Pattern



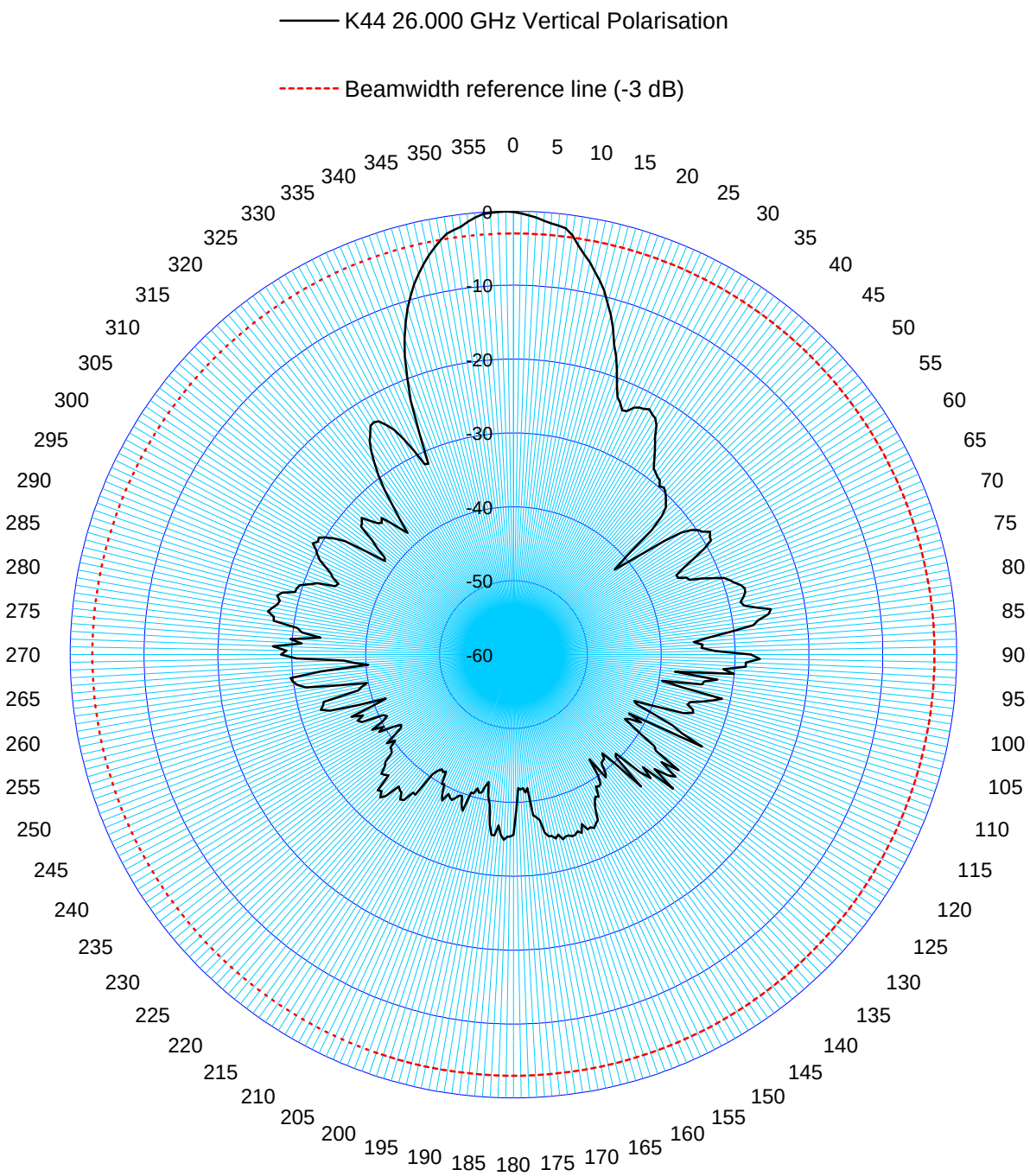
K33 Antenna Radiation Pattern



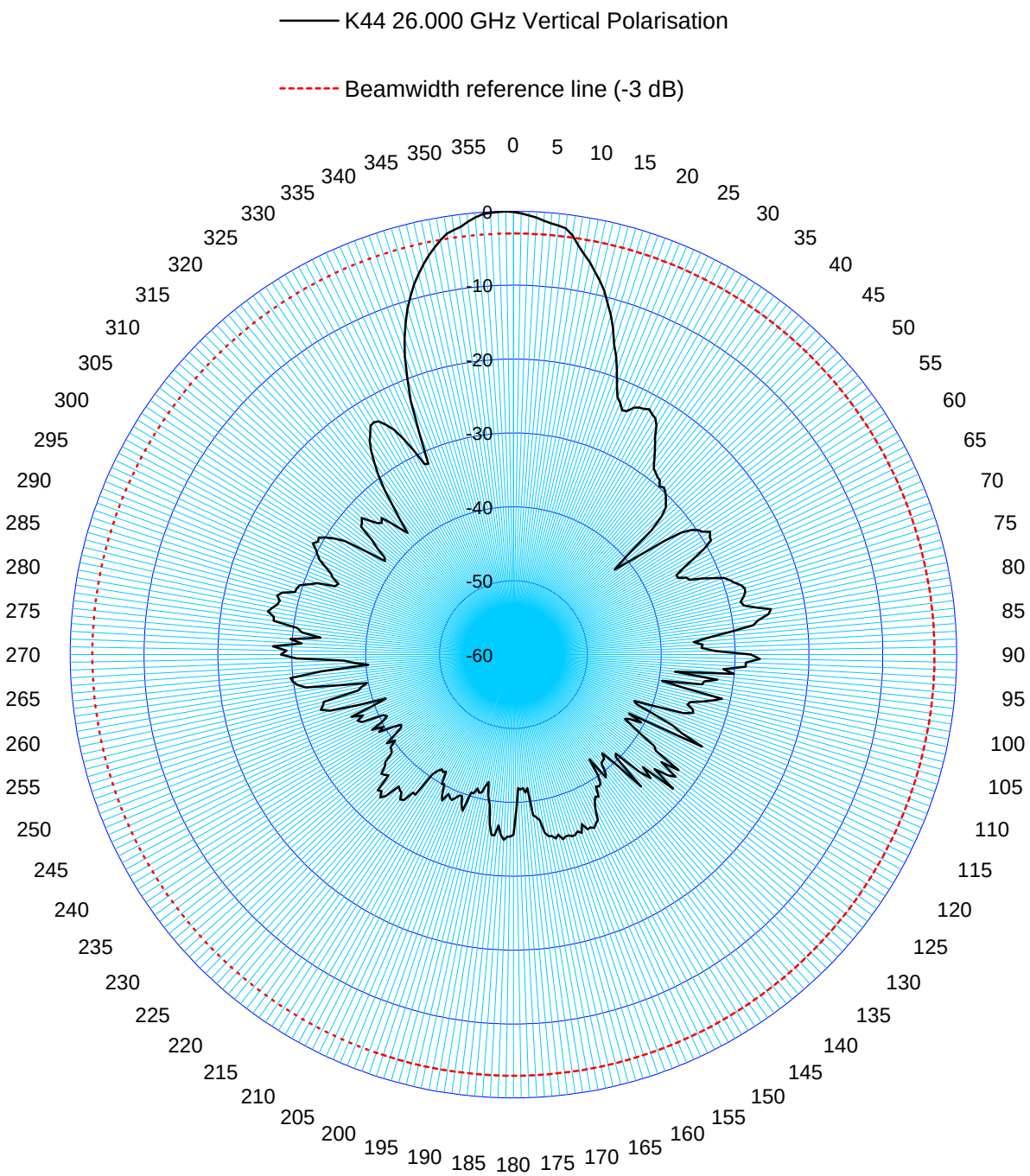
K33 Antenna Radiation Pattern



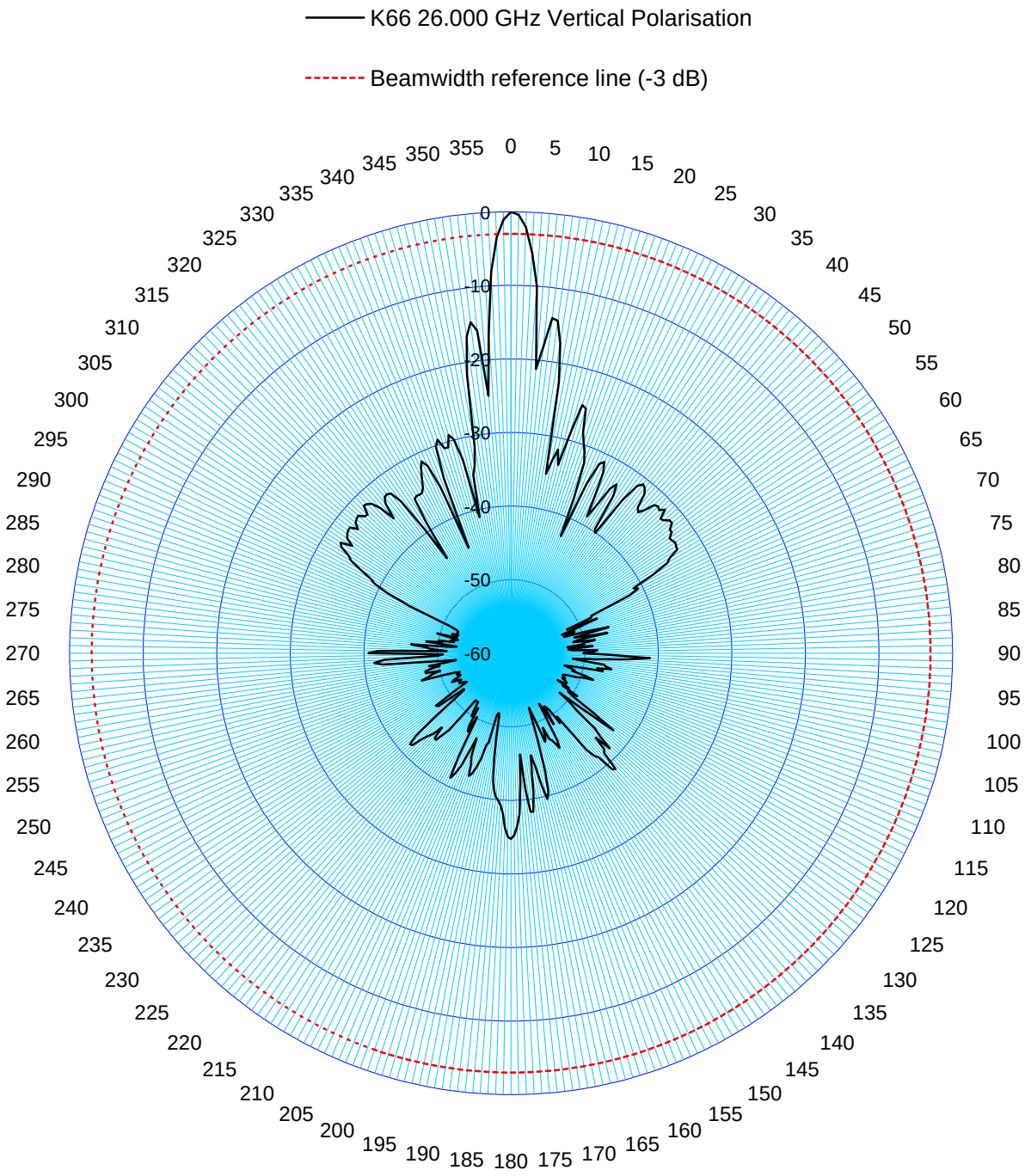
K44 Antenna Radiation Pattern



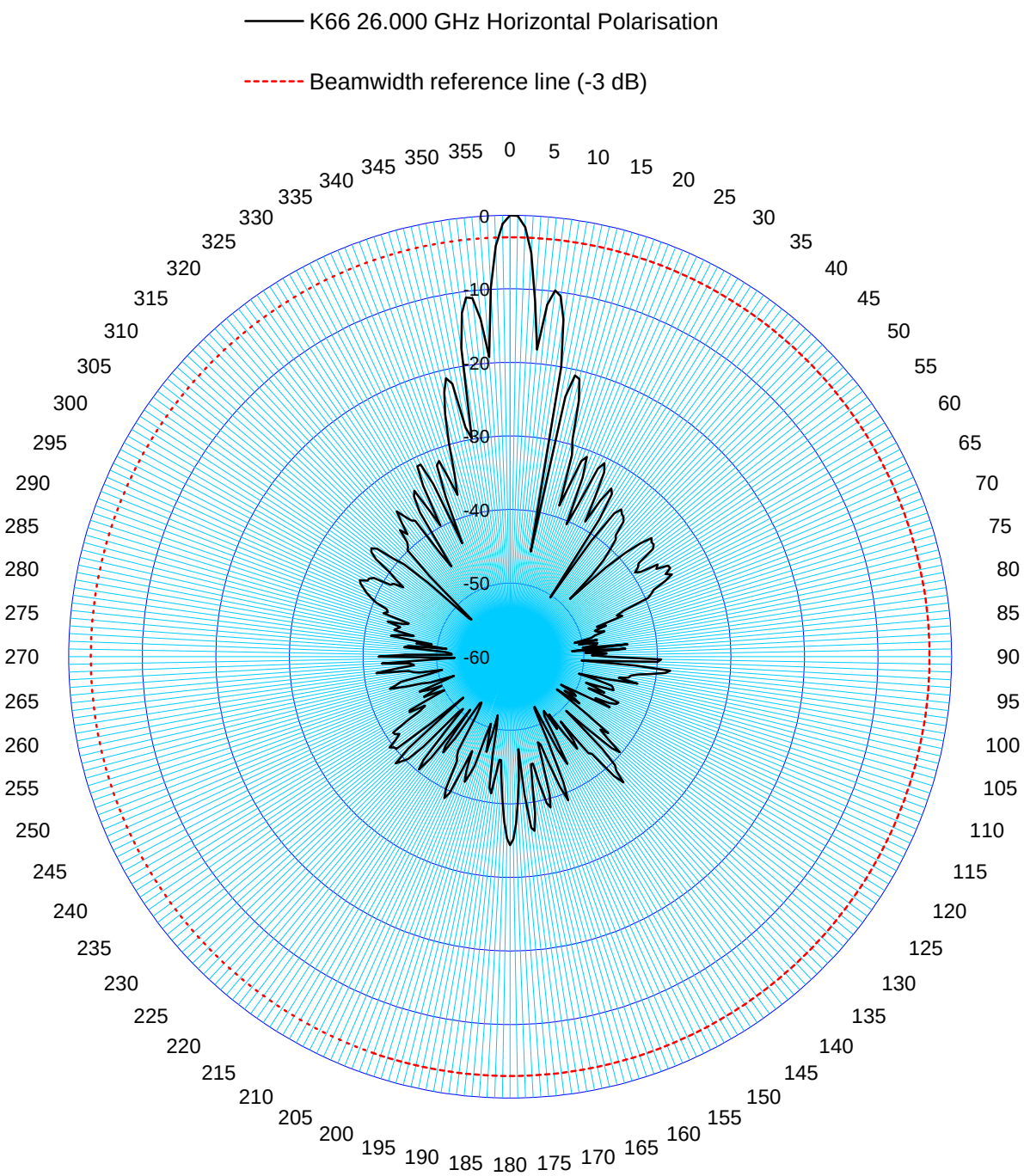
K44 Antenna Radiation Pattern



K66 Antenna Radiation Pattern



K66 Antenna Radiation Pattern



8.16 Carrier Frequency Stability

Rules and specifications:	CFR 47 Part 15, section 15.215 (c) 15.256 (f)(2)
Guide:	ANSI C63.10-2009, FCC 14-2
Limit:	FCC 15.256(f)(2) Limit: LPR devices operating under this section must confine their fundamental emission bandwidth within the 5.925 - 7.250 GHz, 24.05 - 29.00 GHz, and 75 - 85 GHz bands under all conditions of operation.
Temperature range: Voltage range:	-20°C to +50°C 85% to 115% of the rated supply voltage
Measurement procedure:	Carrier Frequency Stability (6.8)

Comment:	Conducted measurement
Date of test:	13 February, 2014

Temperature - Voltage Frequency Stability Test Data

Temperature °C	U = 10.2 V		U = 34.5 V	
	Low band edge (GHz)	High band edge (GHz)	Low band edge (GHz)	High band edge (GHz)
-20	24.240	26.595	24.240	26.595
-10	24.275	26.575	24.275	26.575
0	24.300	26.530	24.300	26.530
+10	24.330	26.470	24.330	26.470
+20	24.353	26.452	24.353	26.452
+30	24.353	26.452	24.353	26.452
+40	24.353	26.452	24.353	26.452
+50	24.450	26.500	24.450	26.500

Result:	Test passed

9 Referenced Regulations

All tests were performed with reference to the following regulations and standards:

☒	CFR 47 Part 2	Code of Federal Regulations Part 2 (Frequency allocation and radio treaty matters; General rules and regulations) of the Federal Communication Commission (FCC)	October 1, 2013
☒	CFR 47 Part 15	Code of Federal Regulations Part 15 (Radio Frequency Devices) of the Federal Communication Commission (FCC)	October 1, 2013
☒	ANSI C63.4	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz	December 11, 2003 (published on January 30, 2004)
☒	ANSI C63.10	American National Standard for Testing Unlicensed Wireless Devices	September 2009
☒	EN 302 729-1	Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Equipment for Detection and Movement; Level Probing Radar (LPR) equipment operating in the frequency range 6 GHz to 8,5 GHz, 24,05 GHz to 26,5 GHz, 57 GHz to 64 GHz, 75 GHz to 85 GHz;	V1.1.2
☒	EN 302 729-2	Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Equipment for Detection and Movement; Level Probing Radar (LPR) equipment operating in the frequency range 6 GHz to 8,5 GHz, 24,05 GHz to 26,5 GHz, 57 GHz to 64 GHz, 75 GHz to 85 GHz; Part 2: Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive	V1.1.2
☒	KDB 890966 D01	Measurement Procedure for Level Probing Radars	April 4, 2014

10 Test Equipment List with Calibration Data

Type	*Inv.-No.*	*Type Designation*	*Serial Number*	*Manufacturer*	*Calibration Organization*	*Last Calibration*	*Next Calibration*
EMI test receiver	1028	ESHS10	860043/016	Rohde & Schwarz	Rohde & Schwarz	10/2013	10/2014
EMI test receiver	1569	ESMI	839379/013	Rohde & Schwarz	Rohde & Schwarz	10/2012	10/2015
EMI test receiver	2044	ESU8	100232	Rohde & Schwarz	Rohde & Schwarz	01/2014	07/2015
Spectrum analyser	1666	FSP30	100063	Rohde & Schwarz	Rohde & Schwarz	011/2012	05/2015
Preamplifier	1484	ACO/180-3530	32641	CTT	TÜV SÜD PS-EMC-STR	12/2012	06/2014
Preamplifier	1684	AFS3-00100800-32-LN	847743	MITEQ	TÜV SÜD PS-EMC-STR	04/2013	10/2014
Preamplifier	1716	CPA9231A	3557	Schaffner Electrotest	TÜV SÜD PS-EMC-STR	01/2014	07/2015
Digital oscilloscope	1796	Wave Surfer 452	LCRY0301J11938	LeCroy	ZMK	07/2012	07/2014
V-network	1059	ESH3-Z5	894785/005	Rohde & Schwarz	Rohde & Schwarz	08/2013	08/2015
Loop antenna	1016	HFH2-Z2	882964/0001	Rohde & Schwarz	Rohde & Schwarz	11/2012	11/2014
Double ridged waveguide horn antenna	1516	3115	9508-4553	EMCO Elektronik	Seibersdorf Laboratories	10/2012	10/2014
TRILOG broadband antenna	1722	VULB 9163	9163-188	Schwarzbeck	Rohde & Schwarz	09/2013	03/2015
TRILOG Broadband Antenna	2058	VULB 9163	9163-408	Schwarzbeck	Rohde & Schwarz	11/2012	05/2014
External Mixer	2085	WM780U	B030121	Tektronix	Rohde & Schwarz	01/2014	01/2015
External Mixer	2140	WM782V	B030132	Tektronix	Rohde & Schwarz	01/2014	01/2015
External Mixer	2181	WM782W	B010193	Tektronix	Rohde & Schwarz	01/2014	01/2015
Waveguide mixer	1576	WM782A, FS-Z40	845881/005	Tektronix	Rohde & Schwarz	09/2012	09/2015
LO amplifier/ Harm. Mixer accessories	1577	LO-AMP, FS-Z30	624413/003	Rohde & Schwarz	Rohde & Schwarz	09/2012	09/2015
Horn Antenna	1012	3160-05	9112-1001	EMCO	---	No calibration required	
Horn Antenna	1013	3160-06	9112-1001	EMCO	---	No calibration required	
Horn Antenna	1014	3160-07	9112-1008	EMCO	---	No calibration required	
Horn Antenna	1015	3160-08	9112-1002	EMCO	---	No calibration required	

Type	*Inv.-No.*	*Type Designation*	*Serial Number*	*Manufacturer*	*Calibration Organization*	*Last Calibration*	*Next Calibration*
Horn Antenna	1265	3160-09	9403-1025	EMCO	---	No calibration required	
Horn antenna	1575	3160-10	399185	EMCO Elektronik	---	No calibration required	
Horn antenna	2086	24240-20	157845	Flann	---	No calibration required	
Horn antenna	2180	25240-25	205900	Flann	---	No calibration required	
Horn antenna	2182	27240-25	204260	Flann	---	No calibration required	

11 Revision History

Revision History			
Edition	*Date*	*Issued by*	*Modifications*
1	25 Apr 2014	J. Roidt	First Edition
2	20.06.2014	J. Roidt	Modification according to TCB's request