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Finnish Accreditation Service
T117 (EN ISO/IEC 17025)

HAC RF Emissions Test Report

Test report no.:	RF_RM-974_01	**Date of report:**	2014-04-17
Template version:	12.1	**Number of pages:**	29
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Responsible test engineer:	Janne Hirsimäki	**Product contact person:**	Juha Paukku
Measurements made by:	Sami Savela		
Tested devices:	RM-974		
FCC ID:	PDNRM-974	**IC:**	-
Supplement reports:	T-Coil_RM-974_02, HAC_Photo_RM-974_03		
Testing has been carried out in accordance with:	**ANSI C63.19-2011** American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids		
Documentation:	The documentation of the testing performed on the tested devices is archived for 15 years at TCC Nokia.		
Test results:	**The tested device complies with the requirements in respect of all parameters subject to the test.** The test results and statements relate only to the items tested. The test report shall not be reproduced except in full, without written approval of the laboratory.		

Date and signatures:

For the contents:

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Date: 2014.04.20 14:34:42 +03'00'

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1. SUMMARY OF HAC RF EMISSION TEST REPORT

1.1 Test Details

Period of test	2014-04-11 to 2014-04-14
SN, HW, SW and DUT numbers of tested device	SN: 004402/47/800083/3, HW: 2010, SW: 01061.00037.14151.00000, DUT: 18163
Batteries used in testing	BL-5H, DUT: 17997, 18155
State of sample	Prototype unit
Notes	-

1.2 Maximum Results

The maximum measured HAC RF emissions values and categories for electric and magnetic fields are given in section 1.2.1 and 1.2.2 respectively.

1.2.1 Electric field measurements

Mode	Ch / Freq [MHz]	Conducted power	Limit of E-field max. value in category M3 [dB V/m]	Maximum E-field value after exclusion [dB V/m]	Category
GSM850	128 / 824.2	32.3 dBm	40 - 45	40.7	M3
WCDMA850	4132 / 826.4	29.5 dBm	40 - 45	8.3	M4
GSM1900	512 / 1850.2	23.5 dBm	30 - 35	31.4	M3

1.2.2 Overall RF emissions category of the tested device

Mode	E-field Category	Pass / Fail
GSM850	M3	Pass
WCDMA850	M4	Pass
GSM1900	M3	Pass
Final Category	M3	Pass

1.2.3 Maximum Drift

Maximum drift during measurements	0.15 dB

1.2.4 Measurement Uncertainty

Extended Uncertainty (k=2) 95%, E-field	16.3 %

2. DESCRIPTION OF THE DEVICE UNDER TEST

Air-interface	Band (MHz)	Type	C63.19/ tested	Simultaneous Transmissions	Reduced power	Voice Over Digital Transport OTT Capability	HAC report number
GSM	850	VO	Yes	Yes BT, WLAN	N/A	NA	RF_RM-974_01
	1900				N/A	NA	RF_RM-974_01
	GPRS/EDGE	DT	NA	Yes BT, WLAN	N/A	YES*	-
WCDMA	850	V/D	Yes	Yes BT, WLAN	N/A	YES	RF_RM-974_01
LTE	2500	DT	NA	Yes BT, WLAN	N/A	YES*	-
BT	2450	DT	NA	Yes GSM, GPRS/EDGE, WCDMA, LTE	N/A	YES*	-
WLAN	2450	DT	NA	Yes GSM, GPRS/EDGE, WCDMA, LTE	N/A	YES*	-

VO Voice CMRS/PSTN Service Only
V/D Voice CMRS/PSTN and Data Service
DT Digital Transport

*supports only non CMRS voice (OTT).

HAC rating was evaluated for voice mode only in GSM and WCDMA air interfaces in this report.

Outside of USA the transmitter of the device is capable of operating also in 900MHz, 1800MHz and 2100MHz bands, which are not part of this filing.

2.1 Picture of Device

See separate report HAC_Photo_RM-974_03.

3. TEST CONDITIONS

3.1 Temperature and Humidity

Ambient temperature [°C]:	21.0 to 23.0
Ambient humidity [RH %]:	30 to 60

3.2 Test Signal, Frequencies, and Output Power

The transmitter of the device was put into operation by using a call tester. Communications between the device and the call tester were established by air link.

The device output power was set to maximum power level for all tests; a fully charged battery was used for every test sequence.

The transmission mode of the device in WCDMA HAC RF emission tests was configured to 12.2kbps RMC with all TPC bits set as “1”.

The measurements were performed on lowest, middle and highest channels.

The conducted output power of the device was measured by a separate test laboratory on the same unit as used for HAC testing. The results are given in the HAC result tables.

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4. DESCRIPTION OF THE TEST EQUIPMENT

4.1 Measurement system and components

The measurements were performed using an automated near-field scanning system, DASY5, manufactured by Schmid & Partner Engineering AG (SPEAG) in Switzerland.

The following table lists calibration dates of SPEAG components:

Test Equipment	Serial Number	Calibration interval	Calibration expiry
DAE 4	1316	12 months	2014-06
E-field Probe ER3DV6	2333	12 months	2014-06
Dipole Validation Kit, CD835V3	1064	24 months	2015-06
Dipole Validation Kit, CD1880V3	1052	24 months	2015-06
DASY52 software	Version 52.8	-	-

Additional test equipment used in testing and validation:

Test Equipment	Model	Serial Number	Calibration interval	Calibration expiry
Signal Generator	SME 06	836407/007	12 months	2014-08
Amplifier	ZHL-42	854105	-	-
Power Meter	NRVD	840297/032	24 months	2014-05
Power Sensor	NRV-Z53	848532/001	24 months	2014-08
Call Tester	CMU-200	101111	-	-

4.1.1 Isotropic E-field probe ER3DV6

Construction	One dipole parallel, two dipoles normal to probe axis Built-in shielding against static charges PEEK enclosure material
Frequency	In air 100 MHz to >6 GHz; Linearity: ± 0.2 dB (100 MHz to 3 GHz)
Directivity	± 0.2 dB in air (rotation around probe axis) ± 0.4 dB in air (rotation normal to probe axis)
Dynamic Range	2 V/m to > 1000 V/m; Linearity: ± 0.2 dB
Dimensions	Overall length: 330 mm Tip length: 16 mm Body diameter: 12 mm Tip diameter: 8 mm Distance from probe tip to nearest point of dipole: 1.25 mm
Application	General near-field measurements up to 6 GHz Field component measurements Fast automatic scanning in phantoms

4.1.2 Device Holder

The Device Holder and Test Arch are manufactured by Speag (www.speag.com). Test arch is used for all tests i.e. for both validation testing and device testing. The holder and test arch conforms to the requirements of ANSI C63.19.

The SPEAG device holder (see Section 5.1) was used to position the test device in all tests.

4.2 Validation of the System

The manufacturer calibrates the probes annually. Validation measurements are made regularly using the dipole validation kit. The power level used by manufacturer in dipole calibration is supplied to the dipole antenna. The antenna is scanned at 15mm distance between top surface of the dipole and calibration point of the probe.

System Validation, E-field

f [MHz]	Dipole SN	Description	E-field [V/m]
835	1064	Reference result ± 10% window	108.0 97.2 – 118.8
		2014-04-11	103.8
1880	1052	Reference result ± 10% window	93.33 84.0 – 102.7
		2014-04-11	90.5

Plots of the system validation scans are given in Appendix A.

5. DESCRIPTION OF THE TEST PROCEDURE

5.1 Test Arch and Device Holder

The test device was placed in the Device Holder (illustrated below) that is supplied by SPEAG. Using this positioner the tested device is positioned under Test Arch.

Device holder and Test Arch supplied by SPEAG

5.2 Test Positions

5.2.1 Scan area centered at the acoustic output

The device was positioned such that Device Reference plane was touching the bottom of the Test Arch. The scan is centered at the acoustic output by aligning the acoustic output with the intersection of the Test Arch's middle bar and dielectric wire.

5.3 Scan Procedures

Near field scans of 5cm x 5cm were used for determination of the field distribution. Measurement plane distance from WD reference plane is 15mm. Scans were performed for E-field using appropriate probe. DASY software divides detected values into 3 x 3 sub grids as described in the C63.19 standard.

5.4 Modulation Interference Factor

The HAC Standard ANSI C63.19-2011 defines a new scaling using the Modulation Interference Factor (MIF) which replaces the need for the Articulation Weighting Factor (AWF) during the evaluation and is applicable to any modulation scheme.

The Modulation Interference Factor (MIF, in dB) is added to the measured average E-field (in dBV=m) and converts it to the RF Audio Interference Potential (RFAIP, in dBV/m). This level considers the audible amplitude modulation components in the RF E-field. CW fields without amplitude modulation are assumed to not interfere with the hearing aid electronics. Modulations without time slots and low uctuations at low frequencies have low MIF values, TDMA modulations with narrow transmission slots and repetition rates of few 100 Hz have high MIF values and give similar classification as ANSI C63.19-2007.

DASY52 is using the indirect measurement method according to ANSI C63.19-2011 and near field probe read the averaged E-field. Especially for the new high peak-to-average (PAR) signal types, the probes shall be linearized by PMR calibration in order to not overestimate the field reading.

DASY52 uses well-defined signals for PMR calibration. The MIF of these signals has been determined numerically. It allows a precise scaling and is therefore automatically applied. The following table lists the MIF values evaluated by SPEAG and the detailed parameters for E-field probe can be found in the probe calibration report in the appendix C.

UID	UID Version Date	Communication system	MIF (dB)
10021-DAA	2013-06-17	GSM-FDD (TDMA, GMSK)	3.63
10011-CAA	2013-06-17	UMTS-FDD (WCDMA)	-27.23

The MIF measurement uncertainty is estimated by SPEAG:

MIF (dB)	MIF Measurement Uncertainty (dB)
-7 to +5	0.2
-13 to +11	0.5
> -20	1.0

5.5 Sub-grid Exclusion

The measurement grid defined in C63.19 consists of 9 evenly sized blocks, which are used to define permissible exclusion areas. For E-field measurements three contiguous blocks may be excluded from the measurements except the center block may never be excluded.

5.6 Category Limits

From remaining maximum values after exclusion process, Hearing Aid M-category is defined according to the category limits of C63.19 – 2011.

Category	Limits for E-Field Emissions	
	E-field <960 MHz [dB V/m]	E-field >960 MHz [dB V/m]
M1	50 – 55	40 – 45
M2	45 – 50	35 – 40
M3	40 – 45	30 – 35
M4	< 40	< 30

6. MEASUREMENT UNCERTAINTY

Source of Uncertainty	Tolerance ±%	Prob. Dist.	Div.	ci E	ci H	Standard Uncertainty ±%, E
MEASUREMENT SYSTEM						
Probe Calibration	5.1	N	1	1	1	5.1
Axial Isotropy	4.7	R	√3	1	1	2.7
Sensor Displacement	16.5	R	√3	1	0.145	9.5
Boundary Effects	2.4	R	√3	1	1	1.4
Phantom Boundary Effect	7.2	R	√3	1	0	4.1
Linearity	4.7	R	√3	1	1	2.7
Scaling with PMR calibration	10.0	R	√3	1	1	5.8
System Detection Limit	1.0	R	√3	1	1	0.6
Readout Electronics	0.3	N	1	1	1	0.3
Response Time	0.8	R	√3	1	1	0.5
Integration Time	2.6	R	√3	1	1	1.5
RF Ambient Conditions	3.0	R	√3	1	1	1.7
RF Reflections	12.0	R	√3	1	1	6.9
Probe Positioner	1.2	R	√3	1	0.67	0.7
Probe Positioning	4.7	R	√3	1	0.67	2.7
Extrapolation and Interpolation	1.0	R	√3	1	1	0.6
TEST SAMPLE RELATED						
Device Positioning Vertical	4.7	R	√3	1	0.67	2.7
Device Positioning Lateral	1.0	R	√3	1	1	0.6
Device Holder and Phantom	2.4	R	√3	1	1	1.4
Power Drift	5.0	R	√3	1	1	2.9
PHANTOM AND SETUP RELATED						
Phantom Thickness	2.4	R	√3	1	0.67	1.4
Combined Standard Uncertainty						16.3
Expanded Uncertainty on Power						**32.6**
Expanded Uncertainty on Field						**16.3**

7. RESULTS

The calculated maximum field values for the test device are tabulated below:

GSM850, RF emissions results

Mode	Test configuration	Ch 128 824.2 MHz	Ch 190 836.6 MHz	Ch 251 848.8 MHz
GSM850	Conducted Power	32.3 dBm	32.2 dBm	32.3 dBm
	E-field [dB V/m]	**40.71**	39.14	40.21
	Category	M3	M4	M3

WCDMA850, RF emissions results

Mode	Test configuration	Ch 4132 826.4 MHz	Ch 4175 835.0 MHz	Ch 4233 846.6 MHz
WCDMA850	Conducted Power	29.5 dBm	29.7 dBm	29.7 dBm
	E-field [dB V/m]	**8.31**	6.79	8.10
	Category	M4	M4	M4

GSM1900, RF emissions results

Mode	Test configuration	Ch 512 1850.2MHz	Ch 661 1880.0MHz	Ch 810 1909.8MHz
GSM1900	Conducted Power	23.5 dBm	23.5 dBm	23.5 dBm
	E-field [dB V/m]	**31.35**	30.50	29.33
	Category	M3	M3	M4

Plots of the measurement scans are shown in **Appendix B.** Excluded cells are colored orange.

APPENDIX A: SYSTEM VALIDATION SCANS

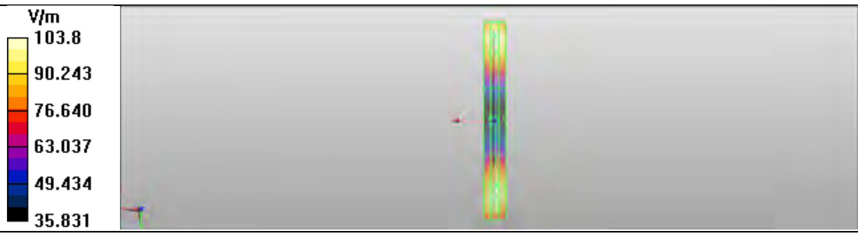
SYSTEM VALIDATION DATA 850MHz

Date/Time: 2014-04-11 12:31:49
Test Laboratory: TCC Nokia
Type: CD835V3; Serial: 1005

Communication System: UID 10000, CW
Frequency: 835 MHz; Duty Cycle: 1:1
Medium: Air; Medium Notes: Not Specified
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Phantom section: RF Section

DASY Configuration:
- Probe: ER3DV6 - SN2333
- ConvF(1, 1, 1); Calibrated: 2013-06-17;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1316; Calibrated: 2013-06-10
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: Not Specified
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

Dipole E-Field measurement 835MHz/E Scan - measurement distance from the probe sensor center to CD835 Dipole = 15mm/Hearing Aid Compatibility Test (41x361x1):
Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 118.5 V/m; Power Drift = 0.01 dB
PMR not calibrated. PMF = 1.000 is applied.
E-field emissions = 103.8 V/m



Grid 1 M4 101.7 V/m	Grid 2 M4 103.8 V/m	Grid 3 M4 102.4 V/m
Grid 4 M4 62.84 V/m	Grid 5 M4 64.43 V/m	Grid 6 M4 63.92 V/m
Grid 7 M4 100.6 V/m	Grid 8 M4 102.4 V/m	Grid 9 M4 100.9 V/m

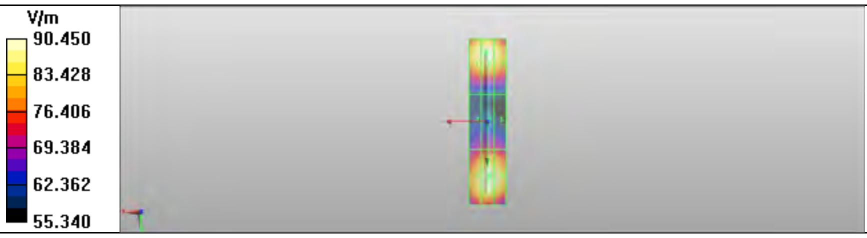
SYSTEM VALIDATION DATA 1900MHz

Date/Time: 2014-04-11 12:53:30
Test Laboratory: TCC Nokia
Type: CD1880V3; Serial: 1052

Communication System: UID 0, CW
Frequency: 1880 MHz; Duty Cycle: 1:1
Medium: Air; Medium Notes: Not Specified
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Phantom section: RF Section

DASY Configuration:
- Probe: ER3DV6 - SN2333
- ConvF(1, 1, 1); Calibrated: 2013-06-17;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1316; Calibrated: 2013-06-10
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: Not Specified
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

Dipole E-Field measurement 1880MHz/E Scan - measurement distance from the probe sensor center to CD1880 Dipole = 15mm/Hearing Aid Compatibility Test (41x181x1):
Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 131.7 V/m; Power Drift = 0.01 dB
PMR not calibrated. PMF = 1.000 is applied.
E-field emissions = 90.45 V/m



Grid 1 M3 89.80 V/m	Grid 2 M3 90.45 V/m	Grid 3 M3 88.15 V/m
Grid 4 M3 72.58 V/m	Grid 5 M3 73.99 V/m	Grid 6 M3 73.52 V/m
Grid 7 M3 88.56 V/m	Grid 8 M3 90.42 V/m	Grid 9 M3 89.30 V/m

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APPENDIX B: MEASUREMENT SCANS

MEASUREMENT DATA GSM850, CHANNEL LOW (824.2 MHz)

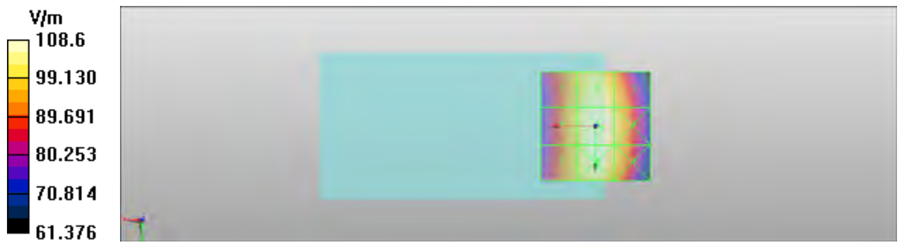
Date/Time: 2014-04-14 15:28:33
Test Laboratory: TCC Nokia
Type: RM-974; Serial: 004402/47/800083/3
Communication System: UID 10021 - DAA, GSM-FDD (TDMA, GMSK)
Frequency: 824.2 MHz; Duty Cycle: 1:8.6896
Medium: Air; Medium Notes: Not Specified
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Phantom section: RF Section

DASY Configuration:
- Probe: ER3DV6 - SN2333
- ConvF(1, 1, 1); Calibrated: 2013-06-17;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1316; Calibrated: 2013-06-10
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (6); SEMCAD X Version 14.6.10 (7164)

Device E-Field measurement with ER probe/E Scan - GSM850 - Low/Hearing Aid Compatibility Test (101x101x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 91.31 V/m; Power Drift = -0.00 dB
Applied MIF = 3.63 dB
RF audio interference level = 40.71 dBV/m
Emission category: M3

MIF scaled E-field

Grid 1 M4 39.92 dBV/m	Grid 2 M3 40.59 dBV/m	Grid 3 M3 40.16 dBV/m
Grid 4 M3 40.09 dBV/m	Grid 5 M3 40.71 dBV/m	Grid 6 M3 40.35 dBV/m
Grid 7 M4 39.98 dBV/m	Grid 8 M3 40.66 dBV/m	Grid 9 M3 40.28 dBV/m



MEASUREMENT DATA GSM850, CHANNEL MIDDLE (836.6 MHZ)

Date/Time: 2014-04-14 15:21:38
Test Laboratory: TCC Nokia
Type: RM-974; Serial: 004402/47/800083/3
Communication System: UID 10021 - DAA, GSM-FDD (TDMA, GMSK)
Frequency: 836.6 MHz; Duty Cycle: 1:8.6896
Medium: Air; Medium Notes: Not Specified
Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 0 kg/m^3
Phantom section: RF Section

DASY Configuration:
- Probe: ER3DV6 - SN2333
- ConvF(1, 1, 1); Calibrated: 2013-06-17;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1316; Calibrated: 2013-06-10
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (6); SEMCAD X Version 14.6.10 (7164)

Device E-Field measurement with ER probe/E Scan - GSM850 - Middle/Hearing Aid Compatibility Test (101x101x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 77.09 V/m; Power Drift = -0.03 dB
Applied MIF = 3.63 dB
RF audio interference level = 39.14 dBV/m
Emission category: M4

MIF scaled E-field

Grid 1 M4 38.46 dBV/m	Grid 2 M4 39.01 dBV/m	Grid 3 M4 38.56 dBV/m
Grid 4 M4 38.51 dBV/m	Grid 5 M4 39.14 dBV/m	Grid 6 M4 38.69 dBV/m
Grid 7 M4 38.36 dBV/m	Grid 8 M4 39.05 dBV/m	Grid 9 M4 38.62 dBV/m

MEASUREMENT DATA GSM850, CHANNEL HIGH (848.8 MHz)

Date/Time: 2014-04-14 15:35:46
Test Laboratory: TCC Nokia
Type: RM-974; Serial: 004402/47/800083/3
Communication System: UID 10021 - DAA, GSM-FDD (TDMA, GMSK)
Frequency: 848.8 MHz; Duty Cycle: 1:8.6896
Medium: Air; Medium Notes: Not Specified
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Phantom section: RF Section

DASY Configuration:
- Probe: ER3DV6 - SN2333
- ConvF(1, 1, 1); Calibrated: 2013-06-17;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1316; Calibrated: 2013-06-10
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (6); SEMCAD X Version 14.6.10 (7164)

Device E-Field measurement with ER probe/E Scan - GSM850 - High/Hearing Aid Compatibility Test (101x101x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 86.21 V/m; Power Drift = -0.01 dB
Applied MIF = 3.63 dB
RF audio interference level = 40.21 dBV/m
Emission category: M3

MIF scaled E-field

Grid 1 M4 39.25 dBV/m	Grid 2 M3 40.07 dBV/m	Grid 3 M4 39.69 dBV/m
Grid 4 M4 39.39 dBV/m	Grid 5 M3 40.21 dBV/m	Grid 6 M4 39.83 dBV/m
Grid 7 M4 39.26 dBV/m	Grid 8 M3 40.14 dBV/m	Grid 9 M4 39.8 dBV/m

MEASUREMENT DATA WCDMA850, CHANNEL LOW (826.4 MHZ)

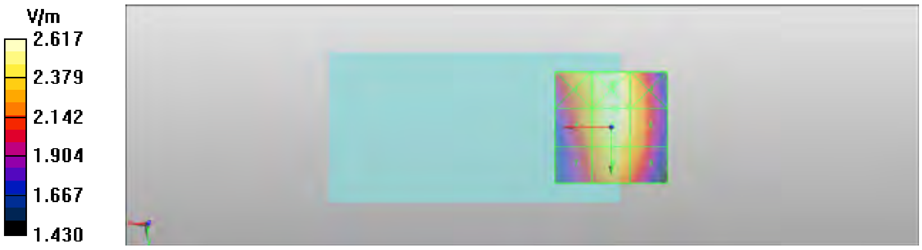
Date/Time: 2014-04-14 16:12:39
Test Laboratory: TCC Nokia
Type: RM-974; Serial: 004402/47/800083/3
Communication System: UID 10011 - CAA, UMTS-FDD (WCDMA)
Frequency: 826.4 MHz; Duty Cycle: 1:1.95434
Medium: Air; Medium Notes: Not Specified
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Phantom section: RF Section

DASY Configuration:
- Probe: ER3DV6 - SN2333
- ConvF(1, 1, 1); Calibrated: 2013-06-17;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1316; Calibrated: 2013-06-10
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (6); SEMCAD X Version 14.6.10 (7164)

Device E-Field measurement with ER probe/E Scan - WCDMA5 - Low/Hearing Aid Compatibility Test (101x101x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 74.92 V/m; Power Drift = 0.02 dB
Applied MIF = -27.23 dB
RF audio interference level = 8.31 dBV/m
Emission category: M4

MIF scaled E-field

Grid 1 M4 7.92 dBV/m	Grid 2 M4 8.36 dBV/m	Grid 3 M4 7.86 dBV/m
Grid 4 M4 7.53 dBV/m	Grid 5 M4 8.31 dBV/m	Grid 6 M4 7.87 dBV/m
Grid 7 M4 6.94 dBV/m	Grid 8 M4 7.88 dBV/m	Grid 9 M4 7.49 dBV/m



MEASUREMENT DATA WCDMA850, CHANNEL MIDDLE (835 MHZ)

Date/Time: 2014-04-14 16:05:45
Test Laboratory: TCC Nokia
Type: RM-974; Serial: 004402/47/800083/3
Communication System: UID 10011 - CAA, UMTS-FDD (WCDMA)
Frequency: 835 MHz; Duty Cycle: 1:1.95434
Medium: Air; Medium Notes: Not Specified
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Phantom section: RF Section

DASY Configuration:
- Probe: ER3DV6 - SN2333
- ConvF(1, 1, 1); Calibrated: 2013-06-17;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1316; Calibrated: 2013-06-10
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (6); SEMCAD X Version 14.6.10 (7164)

Device E-Field measurement with ER probe/E Scan - WCDMA5 - Middle/Hearing Aid Compatibility Test (101x101x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 63.44 V/m; Power Drift = -0.15 dB
Applied MIF = -27.23 dB
RF audio interference level = 6.79 dBV/m
Emission category: M4

MIF scaled E-field

Grid 1 M4 6.87 dBV/m	Grid 2 M4 7.15 dBV/m	Grid 3 M4 6.37 dBV/m
Grid 4 M4 6.12 dBV/m	Grid 5 M4 6.79 dBV/m	Grid 6 M4 6.31 dBV/m
Grid 7 M4 5.28 dBV/m	Grid 8 M4 6.07 dBV/m	Grid 9 M4 5.66 dBV/m

MEASUREMENT DATA WCDMA850, CHANNEL HIGH (846.6 MHz)

Date/Time: 2014-04-14 16:19:32
Test Laboratory: TCC Nokia
Type: RM-974; Serial: 004402/47/800083/3
Communication System: UID 10011 - CAA, UMTS-FDD (WCDMA)
Frequency: 846.6 MHz; Duty Cycle: 1:1.95434
Medium: Air; Medium Notes: Not Specified
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Phantom section: RF Section

DASY Configuration:
- Probe: ER3DV6 - SN2333
- ConvF(1, 1, 1); Calibrated: 2013-06-17;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1316; Calibrated: 2013-06-10
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (6); SEMCAD X Version 14.6.10 (7164)

Device E-Field measurement with ER probe/E Scan - WCDMA5 - High/Hearing Aid Compatibility Test (101x101x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 74.05 V/m; Power Drift = -0.06 dB
Applied MIF = -27.23 dB
RF audio interference level = 8.10 dBV/m
Emission category: M4

MIF scaled E-field

Grid 1 M4 7.95 dBV/m	Grid 2 M4 8.23 dBV/m	Grid 3 M4 7.76 dBV/m
Grid 4 M4 7.42 dBV/m	Grid 5 M4 8.1 dBV/m	Grid 6 M4 7.76 dBV/m
Grid 7 M4 6.68 dBV/m	Grid 8 M4 7.54 dBV/m	Grid 9 M4 7.25 dBV/m

MEASUREMENT DATA GSM1900, CHANNEL LOW (1850.2 MHZ)

Date/Time: 2014-04-14 15:50:54
Test Laboratory: TCC Nokia
Type: RM-974; Serial: 004402/47/800083/3
Communication System: UID 10021 - DAA, GSM-FDD (TDMA, GMSK)
Frequency: 1850.2 MHz; Duty Cycle: 1:8.6896
Medium: Air; Medium Notes: Not Specified
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Phantom section: RF Section

DASY Configuration:
- Probe: ER3DV6 - SN2333
- ConvF(1, 1, 1); Calibrated: 2013-06-17;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1316; Calibrated: 2013-06-10
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (6); SEMCAD X Version 14.6.10 (7164)

Device E-Field measurement with ER probe/E Scan - GSM1900 - Low/Hearing Aid Compatibility Test (101x101x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 10.10 V/m; Power Drift = -0.05 dB
Applied MIF = 3.63 dB
RF audio interference level = 31.35 dBV/m
Emission category: M3

MIF scaled E-field

Grid 1 M3 32.07 dBV/m	Grid 2 M3 32.98 dBV/m	Grid 3 M3 32.6 dBV/m
Grid 4 M4 26.54 dBV/m	Grid 5 M4 29.2 dBV/m	Grid 6 M4 29.38 dBV/m
Grid 7 M3 31.35 dBV/m	Grid 8 M3 30.86 dBV/m	Grid 9 M4 27.94 dBV/m

TCC
Nokia

FINAS Finnish Accreditation Service
T117 (EN ISO/IEC 17025)

MEASUREMENT DATA GSM1900, CHANNEL MIDDLE (1880 MHz)
Date/Time: 2014-04-14 15:43:41 Test Laboratory: TCC Nokia **Type: RM-974; Serial: 004402/47/800083/3** Communication System: UID 10021 - DAA, GSM-FDD (TDMA, GMSK) Frequency: 1880 MHz; Duty Cycle: 1:8.6896 Medium: Air; Medium Notes: Not Specified Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3 Phantom section: RF Section
DASY Configuration: - Probe: ER3DV6 - SN2333 - ConvF(1, 1, 1); Calibrated: 2013-06-17; - Sensor-Surface: (Fix Surface) - Electronics: DAE4 Sn1316; Calibrated: 2013-06-10 - Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; - Measurement SW: DASY52, Version 52.8 (6); SEMCAD X Version 14.6.10 (7164)
Device E-Field measurement with ER probe/E Scan - GSM1900 - Middle/Hearing Aid Compatibility Test (101x101x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm Device Reference Point: 0, 0, -6.3 mm Reference Value = 10.26 V/m; Power Drift = -0.04 dB Applied MIF = 3.63 dB RF audio interference level = 30.50 dBV/m **Emission category: M3**

MIF scaled E-field

Grid 1 M3 31.93 dBV/m	Grid 2 M3 32.81 dBV/m	Grid 3 M3 32.35 dBV/m
Grid 4 M4 26.28 dBV/m	Grid 5 M4 29.16 dBV/m	Grid 6 M4 29.21 dBV/m
Grid 7 M3 30.5 dBV/m	Grid 8 M3 30.26 dBV/m	Grid 9 M4 27.9 dBV/m

TCC Nokia

FINAS Finnish Accreditation Service T117 (EN ISO/IEC 17025)

MEASUREMENT DATA GSM1900, CHANNEL HIGH (1909.8 MHz)

Date/Time: 2014-04-14 15:58:06
Test Laboratory: TCC Nokia
Type: RM-974; Serial: 004402/47/800083/3
Communication System: UID 10021 - DAA, GSM-FDD (TDMA, GMSK)
Frequency: 1909.8 MHz; Duty Cycle: 1:8.6896
Medium: Air; Medium Notes: Not Specified
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Phantom section: RF Section

DASY Configuration:
- Probe: ER3DV6 - SN2333
- ConvF(1, 1, 1); Calibrated: 2013-06-17;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1316; Calibrated: 2013-06-10
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (6); SEMCAD X Version 14.6.10 (7164)

Device E-Field measurement with ER probe/E Scan - GSM1900 - High/Hearing Aid Compatibility Test (101x101x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 9.353 V/m; Power Drift = -0.01 dB
Applied MIF = 3.63 dB
RF audio interference level = 29.33 dBV/m
Emission category: M4

MIF scaled E-field

Grid 1 M3 31.35 dBV/m	Grid 2 M3 31.98 dBV/m	Grid 3 M3 31.23 dBV/m
Grid 4 M4 25.12 dBV/m	Grid 5 M4 27.83 dBV/m	Grid 6 M4 27.86 dBV/m
Grid 7 M4 29.33 dBV/m	Grid 8 M4 28.94 dBV/m	Grid 9 M4 26.39 dBV/m

APPENDIX C: RELEVANT PAGES FROM PROBE CALIBRATION REPORT(S)

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 108

Client **Nokia Salo TCC**

Certificate No: ER3-2333_Jun13

CALIBRATION CERTIFICATE

Object	ER3DV6 - SN:2333
Calibration procedure(s)	QA CAL-02.v6, QA CAL-25.v4 Calibration procedure for E-field probes optimized for close near field evaluations in air
Calibration date:	June 17, 2013

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	04-Apr-13 (No. 217-01733)	Apr-14
Power sensor E4412A	MY41498087	04-Apr-13 (No. 217-01733)	Apr-14
Reference 3 dB Attenuator	SN: S5054 (3c)	04-Apr-13 (No. 217-01737)	Apr-14
Reference 20 dB Attenuator	SN: S5277 (20x)	04-Apr-13 (No. 217-01735)	Apr-14
Reference 30 dB Attenuator	SN: S5129 (30b)	04-Apr-13 (No. 217-01738)	Apr-14
Reference Probe ER3DV6	SN: 2328	12-Oct-12 (No. ER3-2328_Oct12)	Oct-13
DAE4	SN: 789	15-May-13 (No. DAE4-789_May13)	May-14
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-13)	In house check: Apr-15
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-12)	In house check: Oct-13

	Name	Function	Signature
Calibrated by:	Claudio Leubler	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: June 18, 2013

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 108

Glossary:

NORMx,y,z	sensitivity in free space
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization ϑ	ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

a) IEEE Std 1309-2005, " IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", December 2005
b) CTIA Test Plan for Hearing Aid Compatibility, April 2010.

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 for XY sensors and ϑ = 90 for Z sensor (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart).
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z:* *A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *Spherical isotropy (3D deviation from isotropy)*: in a locally homogeneous field realized using an open waveguide setup.
- *Sensor Offset:* The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle:* The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

Probe ER3DV6

SN:2333

Manufactured: September 8, 2003
Calibrated: June 17, 2013

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

DASY/EASY - Parameters of Probe: ER3DV6 - SN:2333

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)	1.44	1.50	1.45	± 10.1 %
DCP (mV)[B]	99.9	99.2	101.7	

Modulation Calibration Parameters

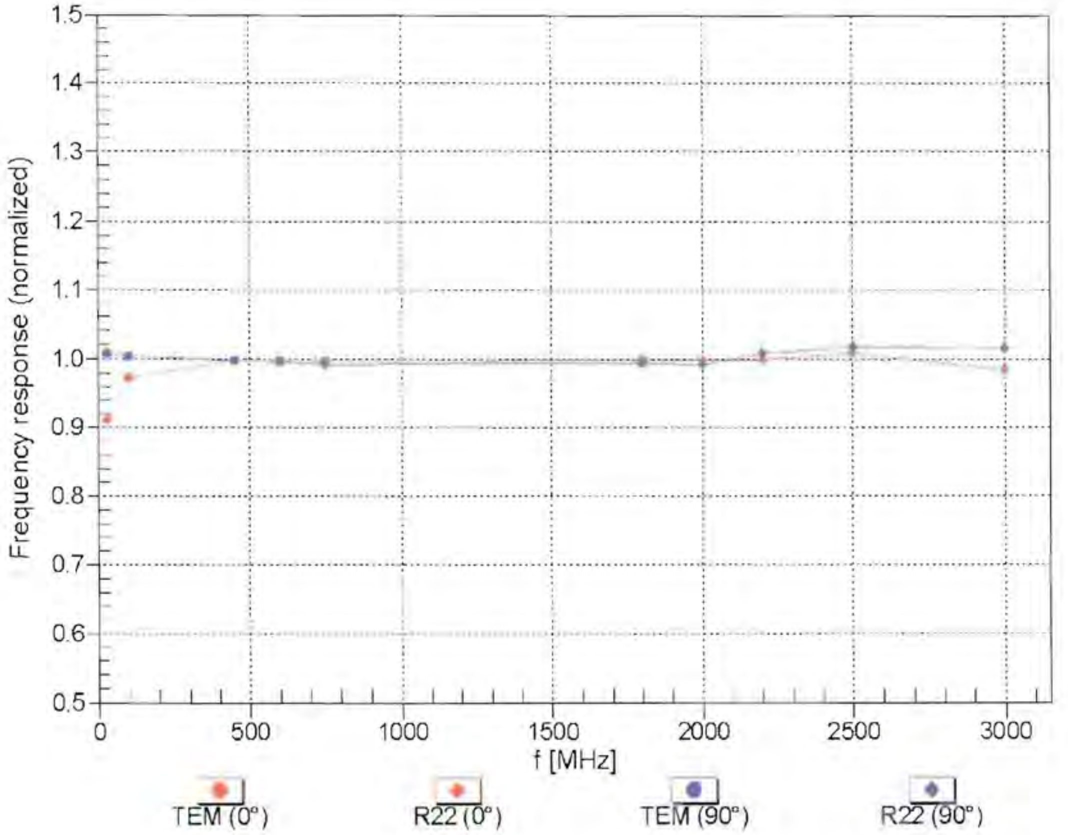
UID	Communication System Name		A dB	B dB√μV	C	D dB	VR mV	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	152.0	±2.2 %
		Y	0.0	0.0	1.0		198.1	
		Z	0.0	0.0	1.0		186.9	
10011-CAA	UMTS-FDD (WCDMA)	X	3.12	66.1	18.5	2.91	120.6	±0.5 %
		Y	3.07	65.7	18.1		117.9	
		Z	3.23	66.6	18.0		149.2	
10021-DAA	GSM-FDD (TDMA, GMSK)	X	9.74	92.0	25.9	9.39	145.6	±1.9 %
		Y	10.65	95.1	27.6		142.4	
		Z	9.19	86.4	23.4		147.3	
10039-CAA	CDMA2000 (1xRTT, RC1)	X	4.57	66.2	19.0	4.57	120.5	±0.9 %
		Y	4.50	66.0	18.9		117.7	
		Z	4.54	66.6	18.8		144.4	
10080-CAB	CDMA2000 (1xEV-DO, 153.6 kbps)	X	4.13	65.9	18.7	4.22	118.5	±0.7 %
		Y	4.09	65.6	18.5		117.3	
		Z	4.22	66.7	18.7		143.3	
10081-CAA	CDMA2000 (1xRTT, RC3)	X	3.72	65.3	18.4	3.97	116.9	±0.7 %
		Y	3.65	64.9	18.1		115.3	
		Z	3.84	66.1	18.3		149.2	
10169-CAB	LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)	X	4.76	65.9	19.7	5.73	111.8	±1.2 %
		Y	4.70	65.5	19.3		111.0	
		Z	4.94	66.8	19.6		141.7	
10170-CAB	LTE-FDD (SC-FDMA, 1 RB, 20 MHz, 16-QAM)	X	5.55	67.4	20.8	6.52	112.8	±2.2 %
		Y	5.44	66.7	20.3		115.5	
		Z	5.62	67.8	20.5		134.1	
10175-CAB	LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)	X	4.83	66.3	19.9	5.72	111.8	±1.2 %
		Y	4.70	65.5	19.2		110.7	
		Z	4.90	66.7	19.6		135.8	
10176-CAB	LTE-FDD (SC-FDMA, 1 RB, 10 MHz, 16-QAM)	X	5.55	67.4	20.8	6.52	110.8	±2.2 %
		Y	5.38	66.4	20.1		109.9	
		Z	5.61	67.7	20.5		134.7	

10177-CAC	LTE-FDD (SC-FDMA, 1 RB, 5 MHz, QPSK)	X	4.83	66.3	19.9	5.73	111.3	±1.4 %
		Y	4.68	65.4	19.2		111.0	
		Z	4.90	66.7	19.6		135.6	
10178-CAB	LTE-FDD (SC-FDMA, 1 RB, 5 MHz, 16-QAM)	X	5.56	67.4	20.8	6.52	110.3	±2.2 %
		Y	5.38	66.5	20.1		110.5	
		Z	5.60	67.6	20.5		134.3	
10179-CAB	LTE-FDD (SC-FDMA, 1 RB, 10 MHz, 64-QAM)	X	5.52	67.3	20.8	6.50	109.7	±2.2 %
		Y	5.41	66.6	20.2		110.0	
		Z	5.60	67.8	20.5		134.5	
10180-CAB	LTE-FDD (SC-FDMA, 1 RB, 5 MHz, 64-QAM)	X	5.47	67.1	20.6	6.50	109.2	±1.9 %
		Y	5.38	66.5	20.1		110.1	
		Z	5.58	67.6	20.4		133.8	
10181-CAB	LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK)	X	4.79	66.1	19.7	5.72	109.6	±1.2 %
		Y	4.69	65.5	19.3		110.8	
		Z	4.90	66.6	19.6		135.5	
10182-CAB	LTE-FDD (SC-FDMA, 1 RB, 15 MHz, 16-QAM)	X	5.52	67.2	20.7	6.52	109.0	±1.9 %
		Y	5.37	66.3	20.0		110.5	
		Z	5.61	67.7	20.5		134.0	
10184-CAB	LTE-FDD (SC-FDMA, 1 RB, 3 MHz, QPSK)	X	4.80	66.2	19.8	5.73	109.7	±1.2 %
		Y	4.74	65.7	19.4		111.2	
		Z	4.90	66.6	19.5		135.4	
10185-CAB	LTE-FDD (SC-FDMA, 1 RB, 3 MHz, 16-QAM)	X	5.52	67.3	20.7	6.51	109.5	±1.9 %
		Y	5.37	66.3	20.0		110.5	
		Z	5.63	67.8	20.6		134.7	
10187-CAB	LTE-FDD (SC-FDMA, 1 RB, 1.4 MHz, QPSK)	X	4.79	66.0	19.8	5.73	110.3	±1.4 %
		Y	4.71	65.5	19.3		111.5	
		Z	4.93	66.8	19.6		136.4	
10188-CAB	LTE-FDD (SC-FDMA, 1 RB, 1.4 MHz, 16-QAM)	X	5.57	67.4	20.8	6.52	109.5	±1.9 %
		Y	5.43	66.6	20.2		111.2	
		Z	5.64	67.8	20.5		135.5	
10273-CAA	CDMA2000 (1xEV-DO Rev A, 1.8Mbps)	X	8.81	74.3	27.4	10.07	138.3	±3.8 %
		Y	8.35	72.2	25.8		138.6	
		Z	8.73	73.7	25.8		125.6	
10295-AAA	CDMA2000, RC1, SO3, 1/8th Rate 25 fr.	X	8.18	81.8	34.0	12.49	89.2	±2.2 %
		Y	7.54	78.3	31.7		90.7	
		Z	9.15	82.0	31.7		91.9	

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

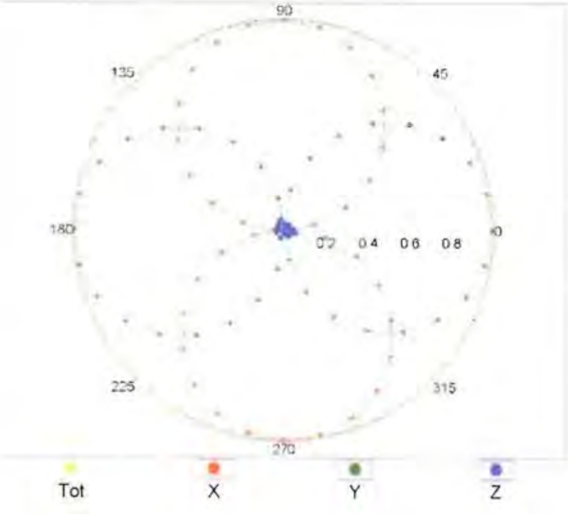
Frequency Response of E-Field
(TEM-Cell:ifi110 EXX, Waveguide: R22)



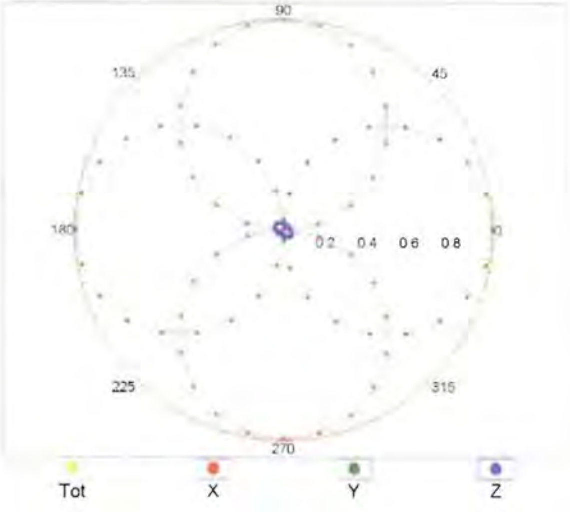
Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)

Receiving Pattern (ϕ), $\vartheta = 0°$

f=600 MHz,TEM,0°

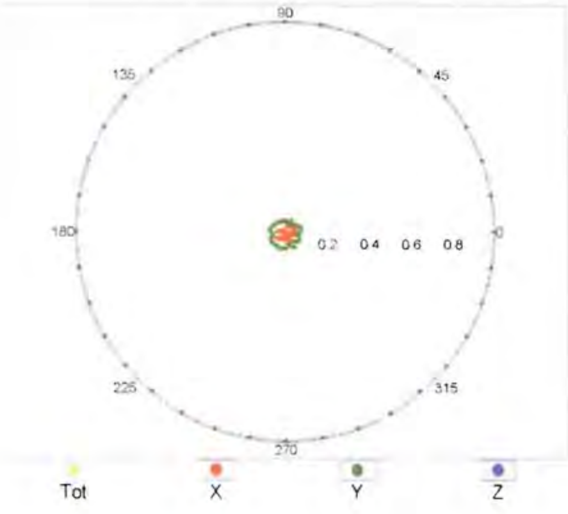


f=2500 MHz,R22,0°

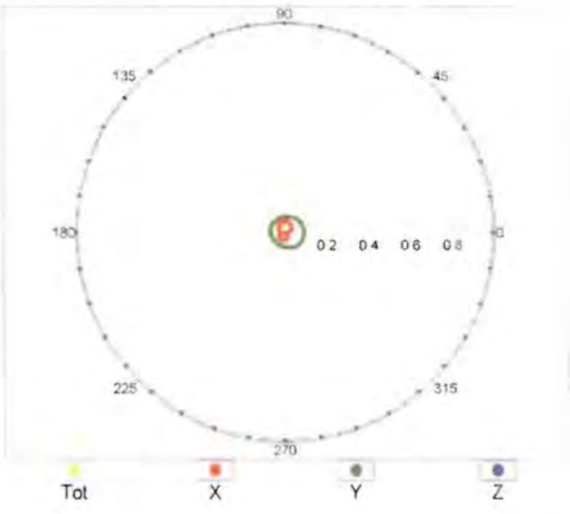


Receiving Pattern (ϕ), $\vartheta = 90°$

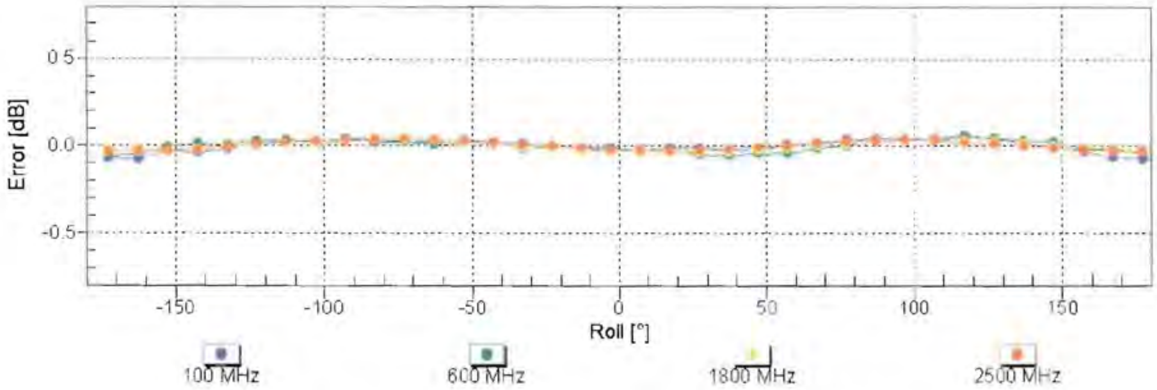
f=600 MHz,TEM,90°



f=2500 MHz,R22,90°

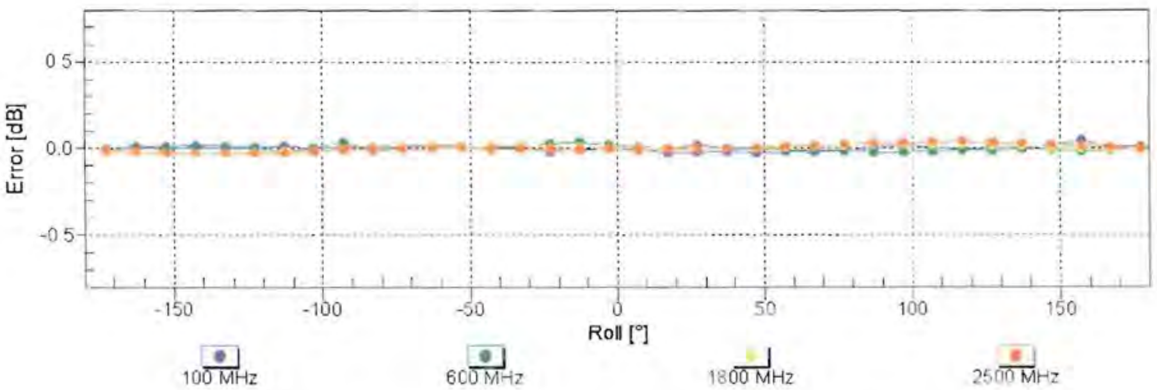


Receiving Pattern (ϕ), ϑ = 0°



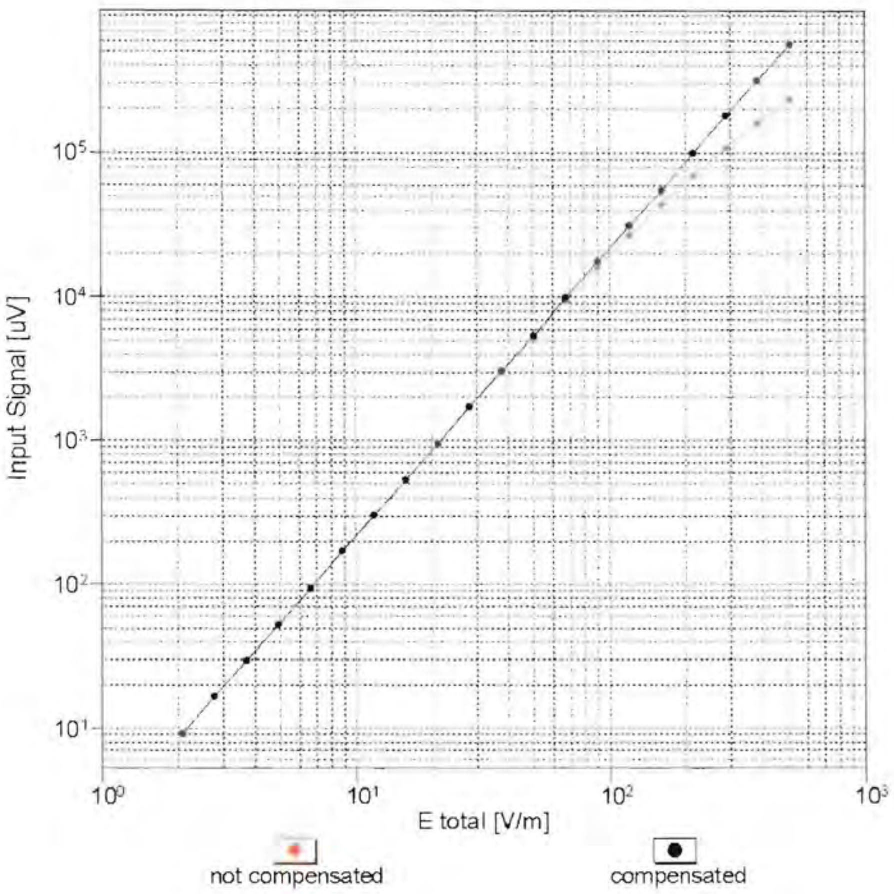
Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

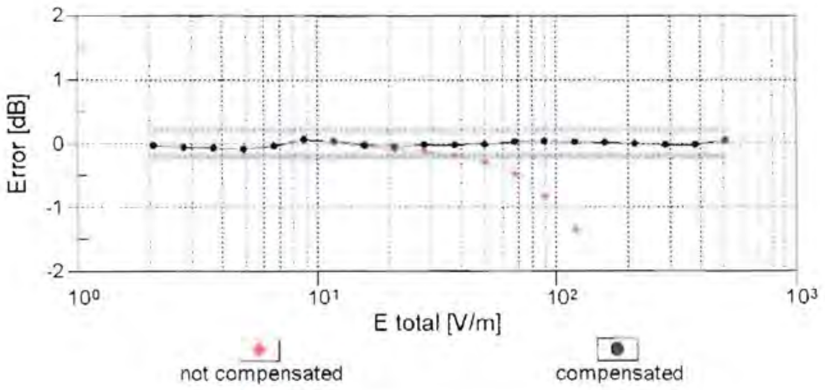
Receiving Pattern (ϕ), ϑ = 90°



Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

Dynamic Range f(E-field)
(TEM cell , f = 900 MHz)

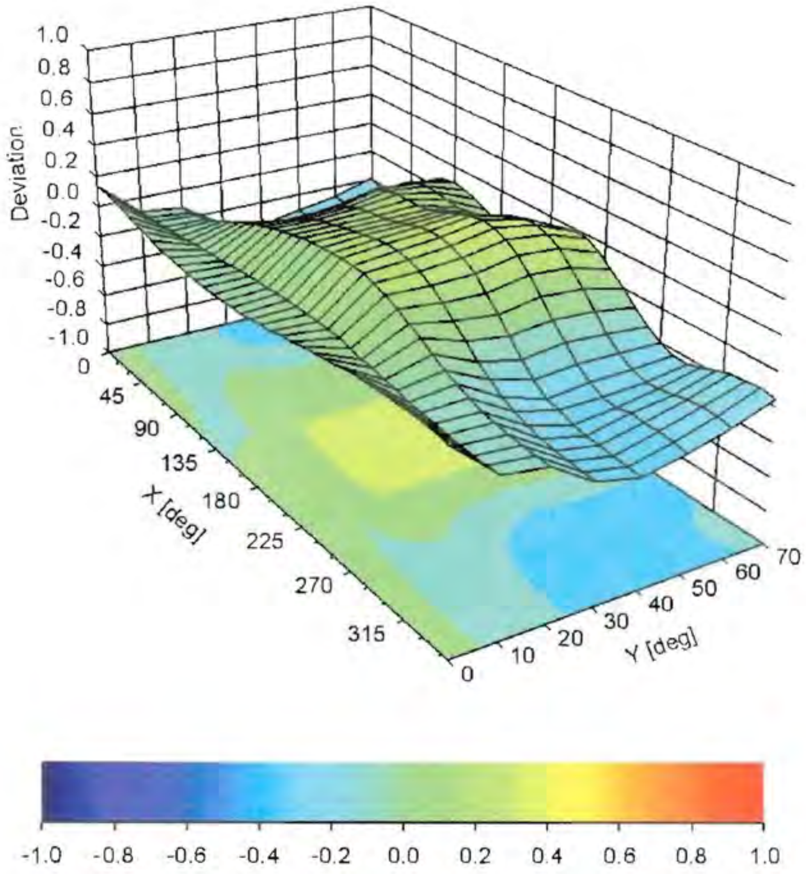




Uncertainty of Linearity Assessment: ± 0.6% (k=2)

Deviation from Isotropy in Air

Error (ϕ, ϑ), f = 900 MHz



Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)

DASY/EASY - Parameters of Probe: ER3DV6 - SN:2333

Other Probe Parameters

Sensor Arrangement	Rectangular
Connector Angle (°)	-32.8
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	10 mm
Tip Diameter	8 mm
Probe Tip to Sensor X Calibration Point	2.5 mm
Probe Tip to Sensor Y Calibration Point	2.5 mm
Probe Tip to Sensor Z Calibration Point	2.5 mm

APPENDIX D: RELEVANT PAGES FROM DIPOLE VALIDATION KIT REPORT(S)

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **Nokia Salo TCC**

Certificate No: **CD835V3-1064_Jun13**

CALIBRATION CERTIFICATE

Object	CD835V3 - SN: 1064
Calibration procedure(s)	QA CAL-20.v6 Calibration procedure for dipoles in air
Calibration date:	June 11, 2013

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	01-Nov-12 (No. 217-01640)	Oct-13
Power sensor HP 8481A	US37292783	01-Nov-12 (No. 217-01640)	Oct-13
Reference 10 dB Attenuator	SN: 5047.2 (10q)	04-Apr-13 (No. 217-01731)	Apr-14
Probe ER3DV6	SN: 2336	28-Dec-12 (No. ER3-2336_Dec12)	Dec-13
Probe H3DV6	SN: 6065	28-Dec-12 (No. H3-6065_Dec12)	Dec-13
DAE4	SN: 781	03-Jun-13 (No. DAE4-781_Jun13)	Jun-14

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter Agilent 4419B	SN: GB42420191	09-Oct-09 (in house check Oct-12)	In house check: Oct-13
Power sensor HP E4412A	SN: MY41495277	01-Apr-08 (in house check Oct-12)	In house check: Oct-13
Power sensor HP 8482A	SN: US37295597	09-Oct-09 (in house check Oct-12)	In house check: Oct-13
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-12)	In house check: Oct-13
RF generator R&S SMT-06	SN: 832283/011	27-Aug-12 (in house check Oct-12)	In house check: Oct-14

	Name	Function	Signature
Calibrated by:	Claudio Leubler	Laboratory Technician	
Approved by:	Fin Bomholt	Deputy Technical Manager	

Issued: June 13, 2013

References

[1] ANSI-C63.19-2007
American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.

[2] ANSI-C63.19-2011
American National Standard, Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.

Methods Applied and Interpretation of Parameters:

- *Coordinate System:* y-axis is in the direction of the dipole arms. z-axis is from the basis of the antenna (mounted on the table) towards its feed point between the two dipole arms. x-axis is normal to the other axes. In coincidence with the standards [1], the measurement planes (probe sensor center) are selected to be at a distance of 10 mm (15 mm for [2]) above the top metal edge of the dipole arms.
- *Measurement Conditions:* Further details are available from the hardcopies at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated. The forward power to the dipole connector is set with a calibrated power meter connected and monitored with an auxiliary power meter connected to a directional coupler. While the dipole under test is connected, the forward power is adjusted to the same level.
- *Antenna Positioning:* The dipole is mounted on a HAC Test Arch phantom using the matching dipole positioner with the arms horizontal and the feeding cable coming from the floor. The measurements are performed in a shielded room with absorbers around the setup to reduce the reflections.
  It is verified before the mounting of the dipole under the Test Arch phantom, that its arms are perfectly in a line. It is installed on the HAC dipole positioner with its arms parallel below the dielectric reference wire and able to move elastically in vertical direction without changing its relative position to the top center of the Test Arch phantom. The vertical distance to the probe is adjusted after dipole mounting with a DASY5 Surface Check job. Before the measurement, the distance between phantom surface and probe tip is verified. The proper measurement distance is selected by choosing the matching section of the HAC Test Arch phantom with the proper device reference point (upper surface of the dipole) and the matching grid reference point (tip of the probe) considering the probe sensor offset. The vertical distance to the probe is essential for the accuracy.
- *Feed Point Impedance and Return Loss:* These parameters are measured using a HP 8753E Vector Network Analyzer. The impedance is specified at the SMA connector of the dipole. The influence of reflections was eliminating by applying the averaging function while moving the dipole in the air, at least 70cm away from any obstacles.
- *E-field distribution:* E field is measured in the x-y-plane with an isotropic ER3D-field probe with 100 mW forward power to the antenna feed point. In accordance with [1] and [2], the scan area is 20mm wide, its length exceeds the dipole arm length (180 or 90mm). The sensor center is 10 mm (15 mm for [2]) (in z) above the metal top of the dipole arms. Two 3D maxima are available near the end of the dipole arms. Assuming the dipole arms are perfectly in one line, the average of these two maxima (in subgrid 2 and subgrid 8) is determined to compensate for any non-parallelity to the measurement plane as well as the sensor displacement. The E-field value stated as calibration value represents the maximum of the interpolated 3D-E-field, in the plane above the dipole surface.
- *H-field distribution:* H-field is measured with an isotropic H-field probe with 100mW forward power to the antenna feed point, in the x-y-plane. The scan area and sensor distance is equivalent to the E-field scan. The maximum of the field is available at the center (subgrid 5) above the feed point. The H-field value stated as calibration value represents the maximum of the interpolated H-field, 10mm above the dipole surface at the feed point.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	V52.8.7
Phantom	HAC Test Arch	
Distance Dipole Top - Probe Center	15 mm	
Scan resolution	dx, dy = 5 mm	
Frequency	835 MHz ± 1 MHz	
Input power drift	< 0.05 dB	

Maximum Field values at 835 MHz

E-field 15 mm above dipole surface	condition	**Interpolated maximum**
Maximum measured above high end	100 mW input power	108.0 V / m
Maximum measured above low end	100 mW input power	107.7 V / m
Averaged maximum above arm	100 mW input power	**107.9 V / m ± 12.8 % (k=2)**

Appendix

Antenna Parameters

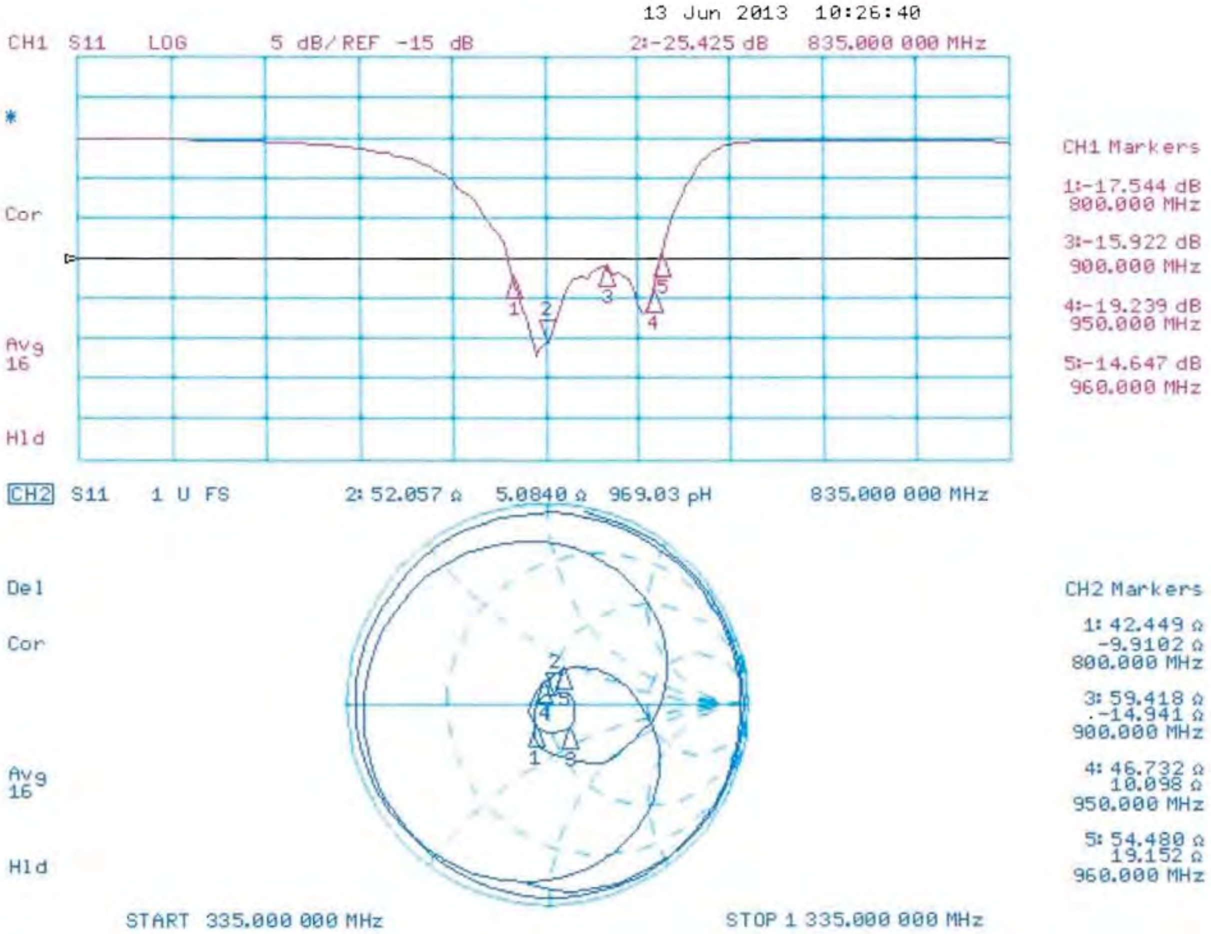
Frequency	**Return Loss**	**Impedance**
800 MHz	17.5 dB	42.4 Ω - 9.9 jΩ
835 MHz	25.4 dB	52.1 Ω + 5.1 jΩ
900 MHz	15.9 dB	59.4 Ω - 14.9 jΩ
950 MHz	19.2 dB	46.7 Ω + 10.1 jΩ
960 MHz	14.6 dB	54.5 Ω + 19.2 jΩ

3.2 Antenna Design and Handling

The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.
The dipole is built of standard semirigid coaxial cable. The internal matching line is open ended. The antenna is therefore open for DC signals.
Do not apply force to dipole arms, as they are liable to bend. The soldered connections near the feedpoint may be damaged. After excessive mechanical stress or overheating, check the impedance characteristics to ensure that the internal matching network is not affected.

After long term use with 40W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

Impedance Measurement Plot



DASY5 E-field Result

Date: 11.06.2013

Test Laboratory: SPEAG Lab2

DUT: HAC-Dipole 835 MHz; Type: CD835V3; Serial: CD835V3 - SN: 1064

Communication System: UID 0 - CW; Frequency: 835 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m^3
Phantom section: RF Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

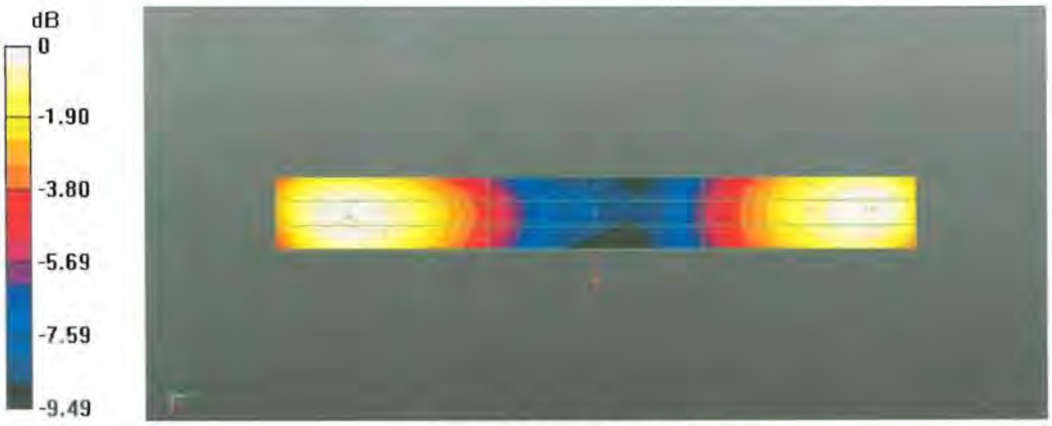
DASY52 Configuration:

- Probe: ER3DV6 - SN2336; ConvF(1, 1, 1); Calibrated: 28.12.2012;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 03.06.2013
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

Dipole E-Field measurement @ 835MHz/E-Scan - 835MHz d=15mm/Hearing Aid Compatibility Test (41x361x1):
Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 107.7 V/m; Power Drift = -0.03 dB
PMR not calibrated. PMF = 1.000 is applied.
E-field emissions = 108.0 V/m
Near-field category: M4 (AWF 0 dB)

PMF scaled E-field

Grid 1 M4 106.9 V/m	Grid 2 M4 108.0 V/m	Grid 3 M4 104.8 V/m
Grid 4 M4 64.33 V/m	Grid 5 M4 64.83 V/m	Grid 6 M4 63.31 V/m
Grid 7 M4 104.7 V/m	Grid 8 M4 107.7 V/m	Grid 9 M4 106.8 V/m



0 dB = 108.0 V/m = 40.67 dBV/m

Calibration Laboratory of
Schmid & Partner
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Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
Servizio svizzero di taratura
S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 108

Client **Nokia Salo TCC**

Certificate No: CD1880V3-1052_Jun13

CALIBRATION CERTIFICATE

Object: CD1880V3 - SN: 1052

Calibration procedure(s): QA CAL-20.v6
Calibration procedure for dipoles in air

Calibration date: June 11, 2013

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	01-Nov-12 (No. 217-01640)	Oct-13
Power sensor HP 8481A	US37292783	01-Nov-12 (No. 217-01640)	Oct-13
Reference 10 dB Attenuator	SN: 5047.2 (10q)	04-Apr-13 (No. 217-01731)	Apr-14
Probe ER3DV6	SN: 2336	28-Dec-12 (No. ER3-2336_Dec12)	Dec-13
Probe H3DV6	SN: 6065	28-Dec-12 (No. H3-6065_Dec12)	Dec-13
DAE4	SN: 781	03-Jun-13 (No. DAE4-781_Jun13)	Jun-14

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter Agilent 4419B	SN: GB42420191	09-Oct-09 (in house check Oct-12)	In house check: Oct-13
Power sensor HP E4412A	SN: MY41495277	01-Apr-08 (in house check Oct-12)	In house check: Oct-13
Power sensor HP 8482A	SN: US37295597	09-Oct-09 (in house check Oct-12)	In house check: Oct-13
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-12)	In house check: Oct-13
RF generator R&S SMT-06	SN: 832283/011	27-Aug-12 (in house check Oct-12)	In house check: Oct-14

	Name	Function	Signature
Calibrated by:	Claudio Leubler	Laboratory Technician	
Approved by:	Fin Bomholt	Deputy Technical Manager	

Issued: June 13, 2013

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

References

[1] ANSI-C63.19-2007
American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.

[2] ANSI-C63.19-2011
American National Standard, Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.

Methods Applied and Interpretation of Parameters:

- *Coordinate System:* y-axis is in the direction of the dipole arms. z-axis is from the basis of the antenna (mounted on the table) towards its feed point between the two dipole arms. x-axis is normal to the other axes. In coincidence with the standards [1], the measurement planes (probe sensor center) are selected to be at a distance of 10 mm (15 mm for [2]) above the top metal edge of the dipole arms.
- *Measurement Conditions:* Further details are available from the hardcopies at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated. The forward power to the dipole connector is set with a calibrated power meter connected and monitored with an auxiliary power meter connected to a directional coupler. While the dipole under test is connected, the forward power is adjusted to the same level.
- *Antenna Positioning:* The dipole is mounted on a HAC Test Arch phantom using the matching dipole positioner with the arms horizontal and the feeding cable coming from the floor. The measurements are performed in a shielded room with absorbers around the setup to reduce the reflections.
It is verified before the mounting of the dipole under the Test Arch phantom, that its arms are perfectly in a line. It is installed on the HAC dipole positioner with its arms parallel below the dielectric reference wire and able to move elastically in vertical direction without changing its relative position to the top center of the Test Arch phantom. The vertical distance to the probe is adjusted after dipole mounting with a DASY5 Surface Check job. Before the measurement, the distance between phantom surface and probe tip is verified. The proper measurement distance is selected by choosing the matching section of the HAC Test Arch phantom with the proper device reference point (upper surface of the dipole) and the matching grid reference point (tip of the probe) considering the probe sensor offset. The vertical distance to the probe is essential for the accuracy.
- *Feed Point Impedance and Return Loss:* These parameters are measured using a HP 8753E Vector Network Analyzer. The impedance is specified at the SMA connector of the dipole. The influence of reflections was eliminating by applying the averaging function while moving the dipole in the air, at least 70cm away from any obstacles.
- *E-field distribution:* E field is measured in the x-y-plane with an isotropic ER3D-field probe with 100 mW forward power to the antenna feed point. In accordance with [1] and [2], the scan area is 20mm wide, its length exceeds the dipole arm length (180 or 90mm). The sensor center is 10 mm (15 mm for [2]) (in z) above the metal top of the dipole arms. Two 3D maxima are available near the end of the dipole arms. Assuming the dipole arms are perfectly in one line, the average of these two maxima (in subgrid 2 and subgrid 8) is determined to compensate for any non-parallelity to the measurement plane as well as the sensor displacement. The E-field value stated as calibration value represents the maximum of the interpolated 3D-E-field, in the plane above the dipole surface.
- *H-field distribution:* H-field is measured with an isotropic H-field probe with 100mW forward power to the antenna feed point, in the x-y-plane. The scan area and sensor distance is equivalent to the E-field scan. The maximum of the field is available at the center (subgrid 5) above the feed point. The H-field value stated as calibration value represents the maximum of the interpolated H-field, 10mm above the dipole surface at the feed point.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	V52.8.7
Phantom	HAC Test Arch	
Distance Dipole Top - Probe Center	15 mm	
Scan resolution	dx, dy = 5 mm	
Frequency	1880 MHz ± 1 MHz	
Input power drift	< 0.05 dB	

Maximum Field values at 1880 MHz

E-field 15 mm above dipole surface	condition	**Interpolated maximum**
Maximum measured above high end	100 mW input power	93.3 V / m
Maximum measured above low end	100 mW input power	91.6 V / m
Averaged maximum above arm	100 mW input power	**92.5 V / m ± 12.8 % (k=2)**

Appendix

Antenna Parameters

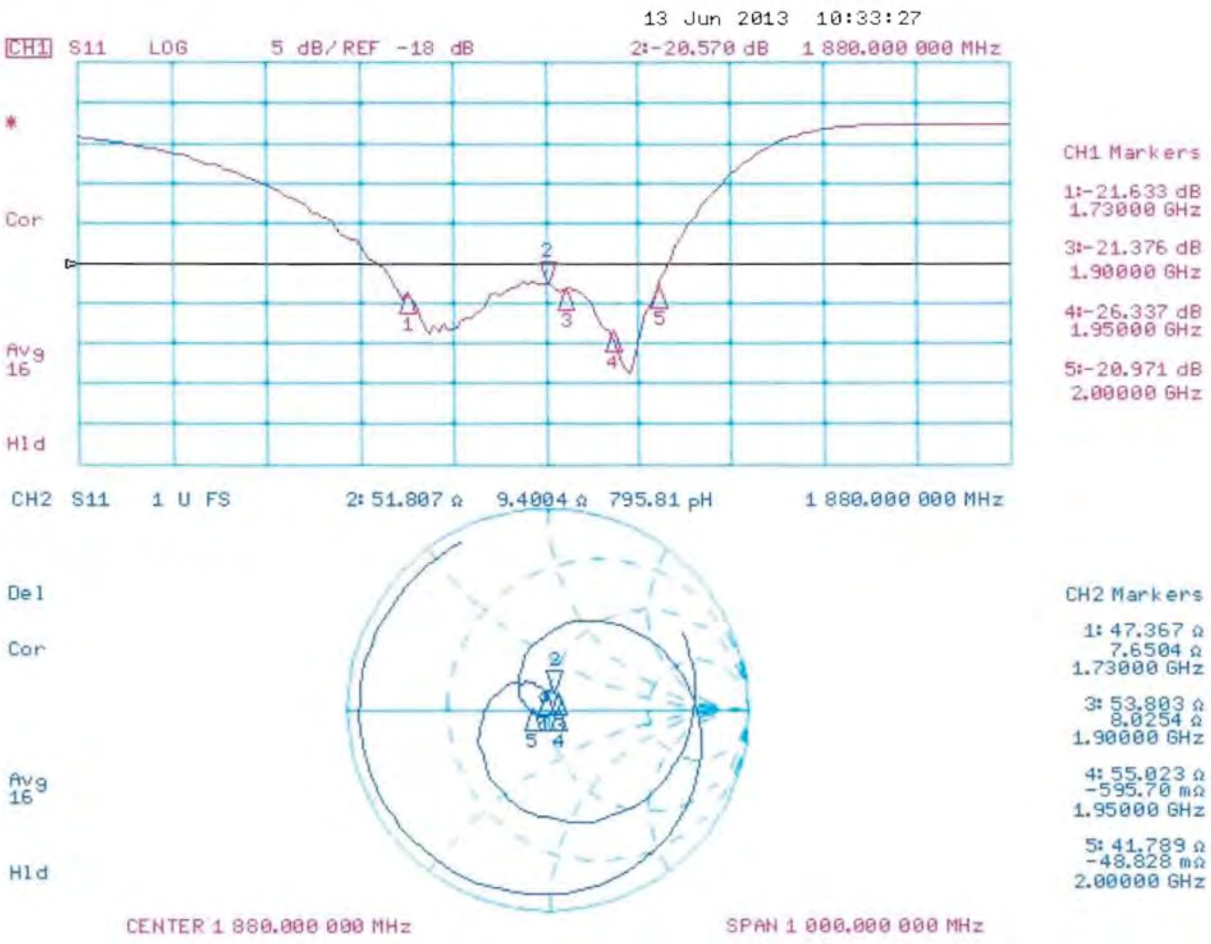
Frequency	**Return Loss**	**Impedance**
1730 MHz	21.6 dB	47.4 Ω + 7.6 jΩ
1880 MHz	20.6 dB	51.8 Ω + 9.4 jΩ
1900 MHz	21.4 dB	53.8 Ω + 8.0 jΩ
1950 MHz	26.3 dB	55.0 Ω - 0.6 jΩ
2000 MHz	21.0 dB	41.8 Ω + 0.0 jΩ

3.2 Antenna Design and Handling

The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.
The dipole is built of standard semirigid coaxial cable. The internal matching line is open ended. The antenna is therefore open for DC signals.
Do not apply force to dipole arms, as they are liable to bend. The soldered connections near the feedpoint may be damaged. After excessive mechanical stress or overheating, check the impedance characteristics to ensure that the internal matching network is not affected.

After long term use with 40W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

Impedance Measurement Plot



DASY5 E-field Result

Date: 11.06.2013

Test Laboratory: SPEAG Lab2

DUT: HAC Dipole 1880 MHz; Type: CD1880V3; Serial: CD1880V3 - SN: 1052

Communication System: UID 0 - CW; Frequency: 1880 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m^3
Phantom section: RF Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

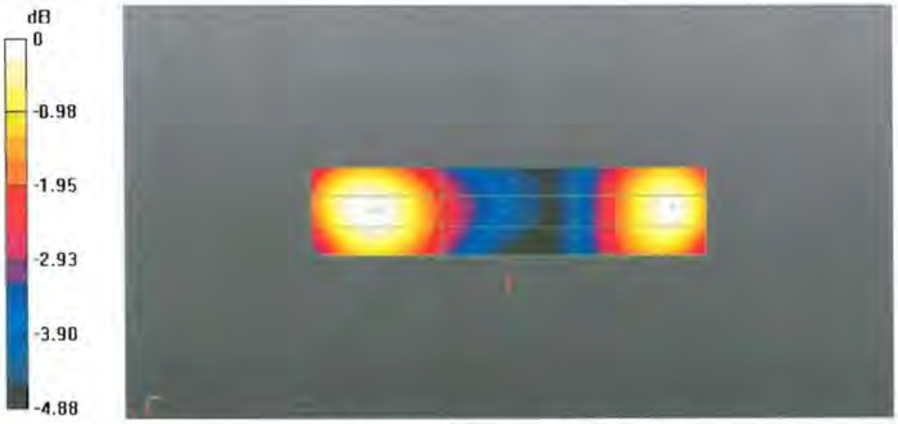
DASY52 Configuration:

- Probe: ER3DV6 - SN2336; ConvF(1, 1, 1); Calibrated: 28.12.2012;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 03.06.2013
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

Dipole E-Field measurement @ 1880MHz/E-Scan - 1880MHz d=15mm/Hearing Aid Compatibility Test (41x181x1):
Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 164.8 V/m; Power Drift = -0.01 dB
PMR not calibrated. PMF = 1.000 is applied.
E-field emissions = 93.33 V/m
Near-field category: M3 (AWF 0 dB)

PMF scaled E-field

Grid 1 M3 91.35 V/m	Grid 2 M3 93.33 V/m	Grid 3 M3 91.77 V/m
Grid 4 M3 72.05 V/m	Grid 5 M3 72.88 V/m	Grid 6 M3 71.74 V/m
Grid 7 M3 89.28 V/m	Grid 8 M3 91.58 V/m	Grid 9 M3 90.69 V/m



0 dB = 93.33 V/m = 39.40 dBV/m