Connected Development

Zoll LifeVest Model 5000

SAR Evaluation Report # CDVE0003.9 Rev. 1

Evaluated to the following SAR specification:

FCC 2.1093:2016

FCC 15.247:2016

802.11bgn Radio

NVLAP Lab Code: 200630-0

CERTIFICATE OF TEST

2015-07-22

Last Date of Test: January 18, 2016
Connected Development
Model: Zoll LifeVest Model 5000

Applicable Standard

Test Description	Specification	Test Method	Pass/Fail
SAR Evaluation	FCC 2.1093:2016 FCC 15.247:2016	FCC KDB 248227 D01 v02r02 FCC KDB 447498 D01 v06 FCC KDB 865664 D01 v01r04 FCC KDB 865664 D02 v01r02 FCC KDB 941225 D07 v01r02 IEEE Std 1528:2013	Pass

Highest Reported SAR Values:

Frequency Bands (GHz)	Body (W/kg)	Limit (W/kg)	Exposure Environment
	1g	1g	
2.4	0.133	1.6	General Population

Deviations From Test Standards

None

Approved By:

Don Facteau, IS Manager

REVISION HISTORY

Revision Number	Description	Date	Page Number
01	Updated the testing objective to reflect FCC	4-26-16	8

ACCREDITATIONS AND AUTHORIZATIONS

NORTHWEST EMC
REV 2015.2.19

United States

FCC - Designated by the FCC as a Telecommunications Certification Body (TCB). Certification chambers, Open Area Test Sites, and conducted measurement facilities are listed with the FCC.

A2LA - Accredited by A2LA to ISO / IEC 17065 as a product certifier. This allows Northwest EMC to certify transmitters to FCC and IC specifications.

NVLAP - Each laboratory is accredited by NVLAP to ISO 17025

Canada

IC - Recognized by Industry Canada as a Certification Body (CB). Certification chambers and Open Area Test Sites are filed with IC.

European Union

European Commission – Validated by the European Commission as a Conformity Assessment Body (CAB) under the EMC directive and as a Notified Body under the R&TTE Directive.

Australia/New Zealand

ACMA - Recognized by ACMA as a CAB for the acceptance of test data.

Korea

MSIP / RRA - Recognized by KCC's RRA as a CAB for the acceptance of test data.

Japan

VCCI - Associate Member of the VCCI. Conducted and radiated measurement facilities are registered.

Taiwan

BSMI – Recognized by BSMI as a CAB for the acceptance of test data.

NCC - Recognized by NCC as a CAB for the acceptance of test data.

Singapore

IDA – Recognized by IDA as a CAB for the acceptance of test data.

Israel

MOC – Recognized by MOC as a CAB for the acceptance of test data.

Hong Kong

OFCA – Recognized by OFCA as a CAB for the acceptance of test data.

Vietnam

MIC – Recognized by MIC as a CAB for the acceptance of test data.

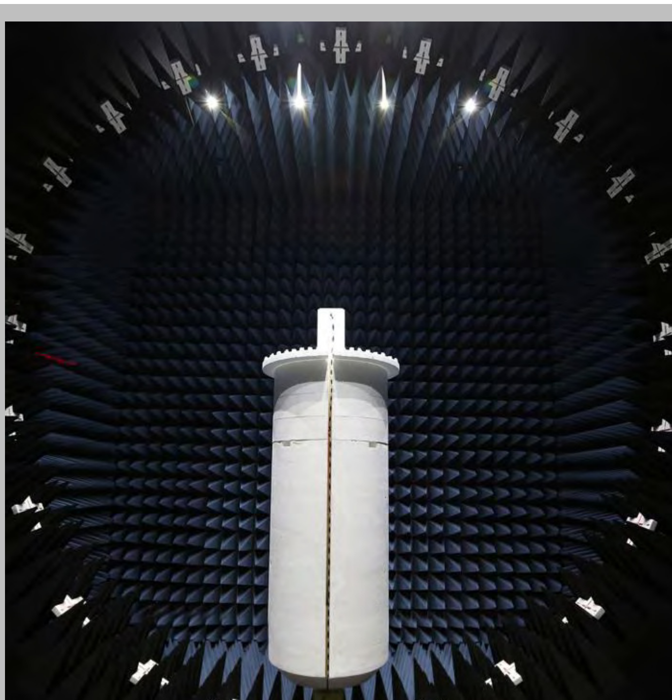
SCOPE

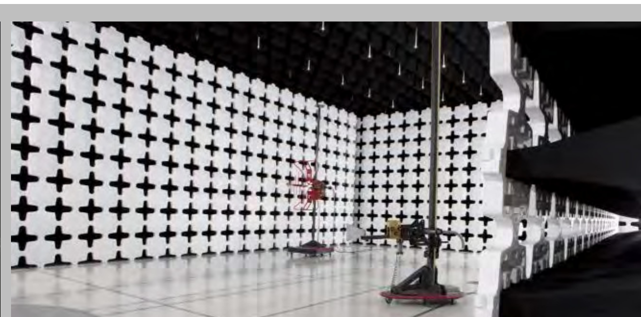
For details on the Scopes of our Accreditations, please visit:
http://www.nwemc.com/accreditations/
http://gsi.nist.gov/global/docs/cabs/designations.html

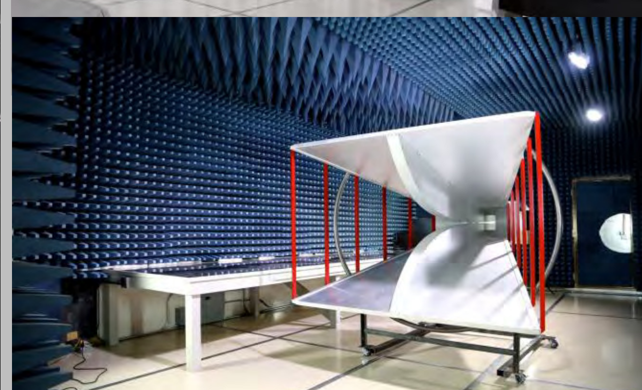
FACILITIES

REV 2015.2.19

California	Minnesota	New York	Oregon	Texas	Washington
Labs OC01-13 41 Tesla Irvine, CA 92618 (949) 861-8918	Labs MN01-08, MN10 9349 W Broadway Ave. Brooklyn Park, MN 55445 (612)-638-5136	Labs NY01-04 4939 Jordan Rd. Elbridge, NY 13060 (315) 554-8214	Labs EV01-12 22975 NW Evergreen Pkwy Hillsboro, OR 97124 (503) 844-4066	Labs TX01-09 3801 E Plano Pkwy Plano, TX 75074 (469) 304-5255	Labs NC01-05 19201 120th Ave NE Bothell, WA 98011 (425)984-6600
NVLAP					
NVLAP Lab Code: 200676-0	NVLAP Lab Code: 200881-0	NVLAP Lab Code: 200761-0	NVLAP Lab Code: 200630-0	NVLAP Lab Code:201049-0	NVLAP Lab Code: 200629-0
Industry Canada					
2834B-1, 2834B-3	2834E-1	N/A	2834D-1, 2834D-*2*	2834G-1	2834F-1
BSMI					
SL2-IN-E-1154R	SL2-IN-E-1152R	N/A	SL2-IN-E-1017	SL2-IN-E-1158R	SL2-IN-E-1153R
VCCI					
A-0029	A-0109	N/A	A-0108	A-0201	A-0110
Recognized Phase I CAB for ACMA, BSMI, IDA, KCC/RRA, MIC, MOC, NCC, OFCA					
US0158	US0175	N/A	US0017	US0191	US0157







PRODUCT DESCRIPTION

NORTHWEST EMC 2014-12-10

Client and Equipment Under Test (EUT) Information

Company Name:	Connected Development
Address:	5020 Weston Parkway Suite 215
City, State, Zip:	Cary, NC 27513
Test Requested By:	Mike Thys
Model:	Zoll LifeVest Model 5000
First Date of Test:	January 18, 2016
Last Date of Test:	January 18, 2016
Receipt Date of Samples:	December 03, 2015
Equipment Design Stage:	Production
Equipment Condition:	No Damage

Information Provided by the Party Requesting the Test

Functional Description of the EUT (Equipment Under Test):

The EUT is the Zoll LifeVest 5000 which is a PCIE technology product that uses a Murata Wifi/Blutooth radio module (Multi-Tech MTPCIEBW) and 2.4GHz Multi Standard Antenna (Taoglas, part number: FXP73.07.0100A).

The LifeVest is the first wearable defibrillator. It is worn outside the body rather than implanted in the chest. This device continuously monitors the patient's heart with dry, non-adhesive sensing electrodes to detect life-threatening abnormal heart rhythms. If a life-threatening rhythm is detected, the device alerts the patient prior to delivering a treatment shock, and thus allows a conscious patient to delay the treatment shock. If the patient becomes unconscious, the device releases a Blue™ gel over the therapy electrodes and delivers an electrical shock to restore normal rhythm.

Top

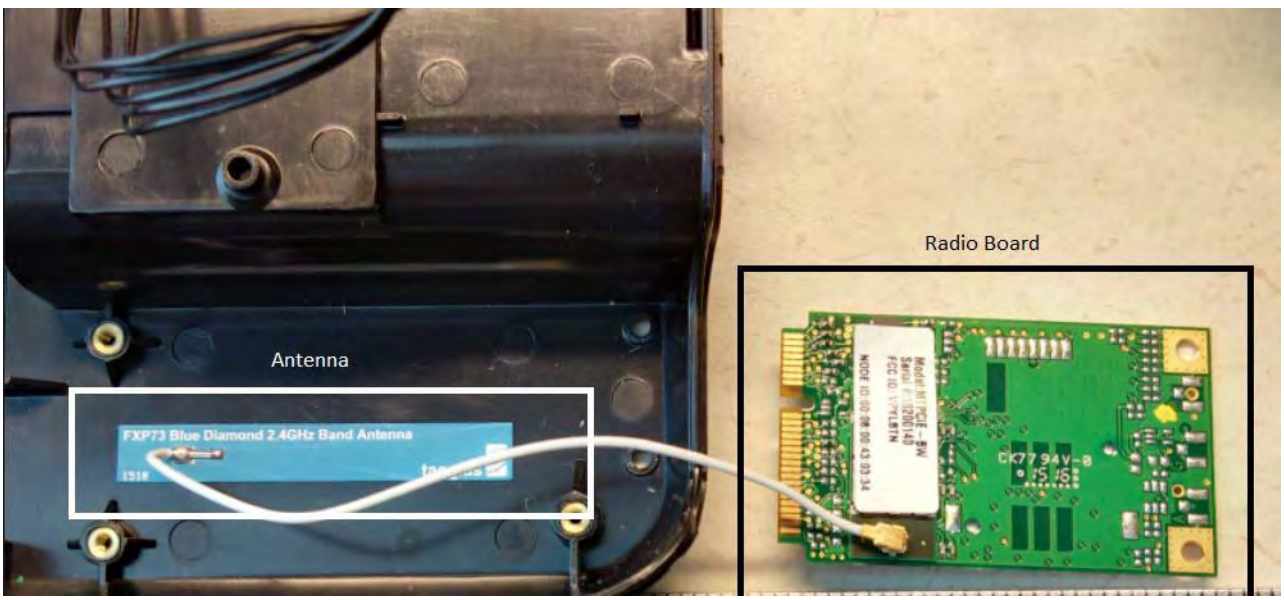
Antenna

Left

Right

Bottom

PRODUCT DESCRIPTION



PRODUCT DESCRIPTION

NORTHWEST EMC
2014-12-10

Testing Requirements

Testing Locations

After a review of the usage scenarios displayed above, the following positions were tested for the WLAN radio: bottom, right edge, display, and back side adjacent to the antennas

The diagonal screen size is less than 20cm (7.9) inches therefore KDB 941225 is applicable.

There is no usage model for operation near the head.

All available sides were tested. The EUT can be used with a body worn vest, but it was not tested because of the following reasons:

- The thickness of the material between the user and EUT is under 0.5 mm.
- There is no metal in the vest.

Testing was done with a 0 cm spacing to the phantom.

KDB 447498 D01 General RF Exposure Guidance v06 is the FCC's starting point for RF exposure policy. Section 4.3.1(a) provides the SAR test exclusion thresholds for test separation distances ≤ 50mm:

> [(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] * [√f(GHz)] ≤ 3.0 for 1-g SAR and ≤ 7.5 for 10-g extremity SAR, where
>
> - f(GHz) is the RF channel transmit frequency in GHz
> - Power and distance are rounded to the nearest mW and mm before calculation
> - The result is rounded to one decimal place for comparison
> - 3.0 and 7.5 are referred to as the numeric thresholds in the step b) below
>
> The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm, and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm according to 4.1 f) is applied to determine SAR test exclusion.

Simultaneous Transmission

The EUT does not have simultaneous transmission capability.

Testing Objective:

To demonstrate compliance of the radio with the SAR requirements of FCC 2.1093.

Scope

The stand-alone SAR evaluation documented in this report is for the WIFI portion of the EUT.

CONFIGURATIONS

Configuration CDVE0003- 5

Software/Firmware Running during test	
Description	**Version**
ClearTerminal	V1.00

EUT			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
Wearable Defibrillator	Zoll International	LifeVest 5000	93ENGVER_09

Peripherals in test setup boundary			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
Laptop Computer	Dell	Vostro 3550	J9Y3PP1
AC/DC Adapter (for Laptop)	Targus	APA31US	F146021351032317-0A
AC/DC Adapter (for EUT)	V-Infinity	ETSA120330UD	None
Test circuit board	Connected Development	None	19A0553-A01

Cables					
Cable Type	**Shield**	**Length (m)**	**Ferrite**	**Connection 1**	**Connection 2**
AC Power	No	0.9m	No	AC Mains	AC/DC Adapter (for Laptop)
DC Power	No	1.8m	Yes	AC/DC Adapter (for Laptop)	Laptop Computer
AC Power	No	1.8m	No	AC Mains	AC/DC Adapter (for EUT)
DC Power	No	1.7m	Yes	AC/DC Adapter (for EUT)	Wearable Defibrillator (EUT)
USB to Mini-USB cable	No	1m	No	Laptop Computer	Test Circuit Board
Ribbon Cable	No	0.15m	No	Test Circuit Board	Wearable Defibrillator (EUT)

MODIFICATIONS

NORTHWEST EMC
2014-12-10

Equipment Modifications

Item	Date	Test	Modification	Note	Disposition of EUT
1	1/18/2016	SAR Testing	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	Scheduled testing was completed.

TISSUE – EQUIVALENT LIQUID DESCRIPTION

Characterization of tissue-equivalent liquid dielectric properties

Per IEEE 1528: 2013, Section 5.3.2, the permittivity and conductivity of the tissue material should be measured at least within 24 hours of any full-compliance test. The measured values must be within +/- 5% of the target values. The temperature variation in the liquid during SAR measurements must be within +/- 2 degrees C of that recorded when the dielectric properties were measured.

The dielectric parameters of the tissue-equivalent liquids were measured within 24 hours of the start of testing using the SPEAG DAKS:200 dielectric assessment kit. The dielectric measurements were made across the frequency range of the liquid. The attached data sheets show that the dielectric parameters of the liquid were within the required 5% tolerances.

Target values of dielectric parameters

Per KDB 865664 D01 v01r04, Appendix A:

"The head tissue dielectric parameters recommended by IEEE Std 1528-2013 have been incorporated in the following table. These head parameters are derived from planar layer models simulating the highest expected SAR for the dielectric properties and tissue thickness variations in a human head. Other head and body tissue parameters that have not been specified in IEEE Std 1528 are derived from tissue dielectric parameters computed from the 4-Cole-Cole equations described above and extrapolated according to the head parameters specified in IEEE Std 1528."

Target Frequency	Head		Body	
(MHz)	ε_r	σ (S/m)	ε_r	σ (S/m)
150	52.3	0.76	61.9	0.80
300	45.3	0.87	58.2	0.92
450	43.5	0.87	56.7	0.94
835	41.5	0.90	55.2	0.97
900	41.5	0.97	55.0	1.05
915	41.5	0.98	55.0	1.06
1450	40.5	1.20	54.0	1.30
1610	40.3	1.29	53.8	1.40
1800 – 2000	40.0	1.40	53.3	1.52
2450	39.2	1.80	52.7	1.95
3000	38.5	2.40	52.0	2.73
5800	35.3	5.27	48.2	6.00

(ε_r = relative permittivity, σ = conductivity and ρ = 1000 kg/m^3)

TISSUE – EQUIVALENT LIQUID DESCRIPTION

Composition of Ingredients for Liquid Tissue Phantoms

Northwest EMC uses tissue-equivalent liquids prepared by SPEAG and confirmed by them to be within +/- 5% from the target values. Their recipes are based upon the following formulations as found in IEEE 1528:2013 Annex C (head) and IEC 62209-2:2010 Annex E (body):

The following tissue formulations are provided for reference only as some of the parameters have not been thoroughly verified. The composition of ingredients may be modified accordingly to achieve the desired target tissue parameters required for routine SAR evaluation:

HEAD

Table C.1—Suggested recipes for achieving target dielectric parameters: 300 MHz to 900 MHz

Frequency (MHz)	300	450	450	450	835	835	900	900	900	900
Reference	[B118]	[B118]	[B172]	[B74]	[B118]	[B74]	[B118]	[B196]	[B172]	[B74]
Ingredients (% by weight)										
1,2-Propanediol	—	—	—	—	—	—	—	64.81	—	—
Bactericide	0.19	0.19	0.50	—	0.10	—	0.10	—	0.50	—
Diacetin	—	—	48.90	—	—	—	—	—	49.20	—
DGBE	—	—	—	—	—	—	—	—	—	—
HEC	0.98	0.98	—	—	1.00	—	1.00	—	—	—
NaCl	5.95	3.95	1.70	1.96	1.45	1.25	1.48	0.79	1.10	1.35
Sucrose	55.32	56.32	—	—	57.00	—	56.50	—	—	—
Triton X-100	—	—	—	—	—	—	—	—	—	—
Tween 20	—	—	—	49.51	—	48.39	—	—	—	48.34
Water	37.56	38.56	48.90	48.53	40.45	50.36	40.92	34.40	49.20	50.31

Table C.2—Suggested recipes for achieving target dielectric parameters: 1450 MHz to 2000 MHz

Frequency (MHz)	1450	1800	1800	1800	1800	1800	1900	1900	1950	2000
Reference	[B118]	[B118]	[B196]	[B196]	[B172]	[B74]	[B118]	[B196]	[B74]	[B118]
Ingredients (% by weight)										
1,2-Propanediol	—	—	—	—		—	—	—	—	—
Bactericide	—	—	—	—	0.50	—	—	—	—	—
Diacetin	—	—	—	—	49.43	—	—	—	—	—
DGBE	45.51	47.00	13.84	44.92	—	—	44.92	13.84	45.00	50.00
HEC	—	—	—	—	—	—	—	—	—	—
NaCl	0.67	0.36	0.35	0.18	0.64	0.50	0.18	0.35	—	—
Sucrose	—	—	—	—	—	—	—	—	—	—
Triton X-100	—	—	30.45	—	—	—	—	30.45	—	—
Tween 20	—	—	—	—	—	45.27	—	—	—	—
Water	53.82	52.64	55.36	54.90	49.43	54.23	54.90	55.36	55.00	50.00

TISSUE – EQUIVALENT LIQUID DESCRIPTION

Table C.3—Suggested recipes for achieving target dielectric parameters: 2100 MHz to 5800 MHz

Frequency (MHz)	2100	2100	2450	2450	3000	5200	5800
Reference	[B118]	[B196]	[B196]	[B172]	[B196]		
Ingredients (% by weight)							
1,2-Propanediol	—	—	—		—	—	—
Bactericide	—	—	—	0.50	—	—	—
Diacetin	—	—	—	49.75	—	—	—
DGBE	50.00	7.99	7.99	—	7.99	—	—
HEC	—	—	—	—	—	—	—
NaCl	—	0.16	0.16	—	0.16	—	—
Sucrose	—	—	—	—	—	—	—
Triton X-100	—	19.97	19.97	—	19.97	17.24	17.24
Diethylenglycol monohexylether	—	—	—	—	—	17.24	17.24
Water	50.00	71.88	71.88	49.75	71.88	65.52	65.52

BODY

Frequency (MHz)	30	50		144		450		835	900	
Recipe source number	3	3	2	2	3	2	4	2	2	4
Ingredients (% by weight)										
Deionised water	48,30	48,30	53,53	55,12	48,30	48,53	56	50,36	50,31	56
Tween			44,70	43,31		49,51		48,39	48,34	
Oxidised mineral oil							44			44
Diethylenglycol monohexylether										
Triton X-100										
Diacetin	50,00	50,00			50,00					
DGBE										
NaCl	1,60	1,60	1,77	1,57	1,60	1,96		1,25	1,35	
Additives and salt	0,10	0,10			0,10					

Frequency (MHz)	1 800		2 450	4 000	5 000	5 200	5 800	6 000
Recipe source number	2	4	4	4	4	1	1	4
Ingredients (% by weight)								
Deionised water	54,23	56	56	56	56	65,53	65,53	56
Tween	45,27							
Oxidised mineral oil		44	44	44	44			44
Diethylenglycol monohexylether						17,24	17,24	
Triton X-100						17,24	17,24	
Diacetin								
DGBE								
NaCl	0,50							
Additives and salt								

TISSUE – EQUIVALENT LIQUID

WSTE.2013.09.09

Date:	01/18/2016	Temperature:	23.8°C
Tissue:	Body, MSL2450, 2450MHz	Liquid Temperature:	22°C
Tested By:	Luke Richardson	Relative Humidity:	42.6%
Job Site:	EV08	Bar. Pressure:	1001.5 mb

TEST SPECIFICATIONS

Specification:	Method:
FCC 15.247:2016 FCC 2.1093:2016	FCC KDB 248227 D01 v02r02 FCC KDB 447498 D01 v06 FCC KDB 865664 D01 v01r04 FCC KDB 865664 D02 v01r02 FCC KDB 941225 D07 v01r02 IEEE Std 1528:2013

RESULTS

	Actual Values		Target Values		Deviation (%)	
Frequency (MHz)	Relative Permittivity	Conductivity	Relative Permittivity	Conductivity	Relative Permittivity	Conductivity
2450	50.63	1.98	52.7	1.95	3.93	-1.54

Frequency (MHz)	Relative Permittivity	Conductivity
2000	52.06	1.471
2025	51.94	1.498
2050	51.83	1.528
2100	51.68	1.581
2125	51.57	1.608
2175	51.42	1.662
2200	51.33	1.687
2250	51.2	1.734
2275	51.14	1.755
2325	51	1.812
2350	50.94	1.843
2400	50.75	1.915
2425	50.71	1.946
2450	50.63	1.98
2475	50.57	2.02
2500	50.52	2.06
2550	50.44	2.127
2575	50.35	2.168
2625	50.22	2.251
2650	50.14	2.287
2700	49.87	2.352
2725	49.8	2.382
2775	49.52	2.461
2800	49.39	2.496
2850	49.13	2.572
2875	49.01	2.616
2925	48.8	2.694
2950	48.67	2.727
2975	48.54	2.769

SAR SYSTEM VERIFICATION DESCRIPTION

WSSV.2013.09.09

REQUIREMENT

Per IEEE 1528, Section 8.2.1, “System checks are performed prior to compliance tests and the results must always be within ± 10% of the target value corresponding to the test frequency, liquid, and the source used. The target values are 1 g or 10 g averaged SAR values measured on systems having current system validation and calibration status, and using the system check setup as shown in Figure 14. These target values should be determined using a standard source.”

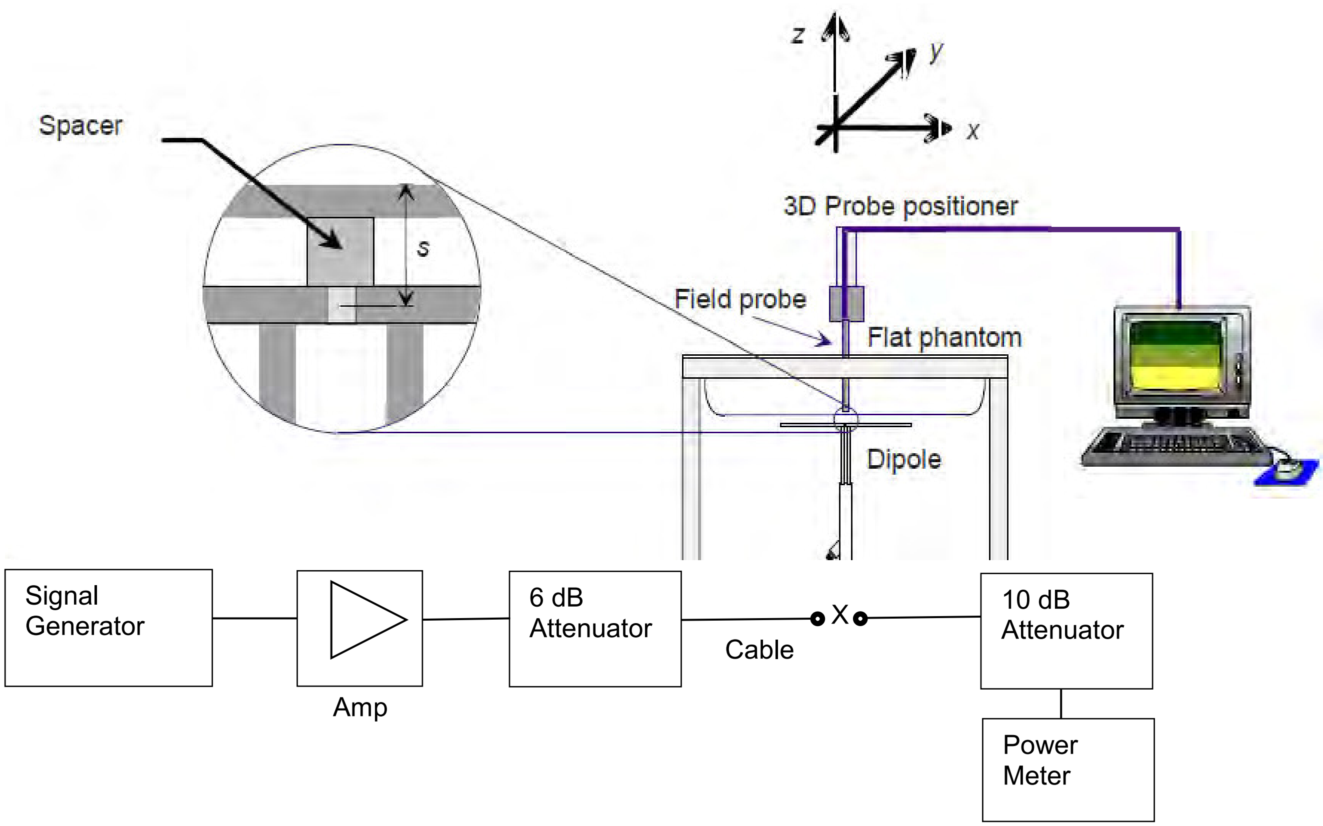
TEST DESCRIPTION

Within 24 hours of a measurement, then every 72 hours thereafter, Northwest EMC used the system validation kit (calibrated reference dipole) to test whether the system was operating within its specifications. The validation was performed in the indicated bands by making SAR measurements of the reference dipole with the phantom filled with the tissue-equivalent liquid. First, a signal generator and power amplifier were used to produce a 100mW level as measured with a power meter at the antenna terminals of the dipole (X). Then, the reference dipole was positioned below the bottom of the phantom and centered with its axis parallel to the longest side of the phantom. A low loss and low relative permittivity spacer was used to establish the correct distance between the center axis of the reference dipole and the liquid.

For the reference dipoles, the spacing distance s is given by:

s = 15mm, +/- 0.2mm for 300MHz ≤ f ≥ 1000 MHz:
s = 10mm, +/- 0.2mm for 1000MHz ≤ f ≥ 6000MHz

The measured 1 g and 10 g spatial average SAR values were normalized to a 1W dipole input power for comparison to the calibration data. The results are summarized in the attached table. The deviation is less than 10% in all cases, indicating that the system performance check was within tolerance.



SAR SYSTEM VERIFICATION

TEST SPECIFICATIONS

Specification:	Method:
FCC 15.247:2016 FCC 2.1093:2016	FCC KDB 248227 D01 v02r02 FCC KDB 447498 D01 v06 FCC KDB 865664 D01 v01r04 FCC KDB 865664 D02 v01r02 FCC KDB 941225 D07 v01r02 IEEE Std 1528:2013

RESULTS

Date	Liquid part number and frequency	Conducted Power into the Dipole (dBm)	Correction Factor	Measured		Normalized to 1W		Target (Normalized to 1W) Get from Dipole Calibration Certificate		% Difference	
				1g	10g	1g	10g	1g	10g	1g	10g
1/18/2016	MSL 2450 (2450 MHz)	16.94	20.23	2.63	1.24	53.20	25.09	50.60	23.70	5.14	5.86

SAR SYSTEM VERIFICATION

WSSV.2013.09.09

Tested By:	Luke Richardson and Ethan Schoonover	Room Temperature (°C):	22.4°C
Date:	1/18/2016	Liquid Temperature (°C):	22.2°C
Configuration:	Body	Humidity (%RH):	42%
		Bar. Pressure (mb):	1001.2 mb

MSL2450 System Check 1-18-16
DUT: Dipole 2450 MHz D2450V2; Type: D2450V2; Serial: D2450V2 - SN:xxx
Communication System: UID 10000, CW; Communication System Band: D2450 (2450.0 MHz); Frequency: 2450 MHz;Communication System PAR: 0 dB; PMF: 1
Medium parameters used: f = 2450 MHz; σ = 1.98 S/m; ε_r = 50.632; ρ = 1000 kg/m^3 , Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)
DASY Configuration:

- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

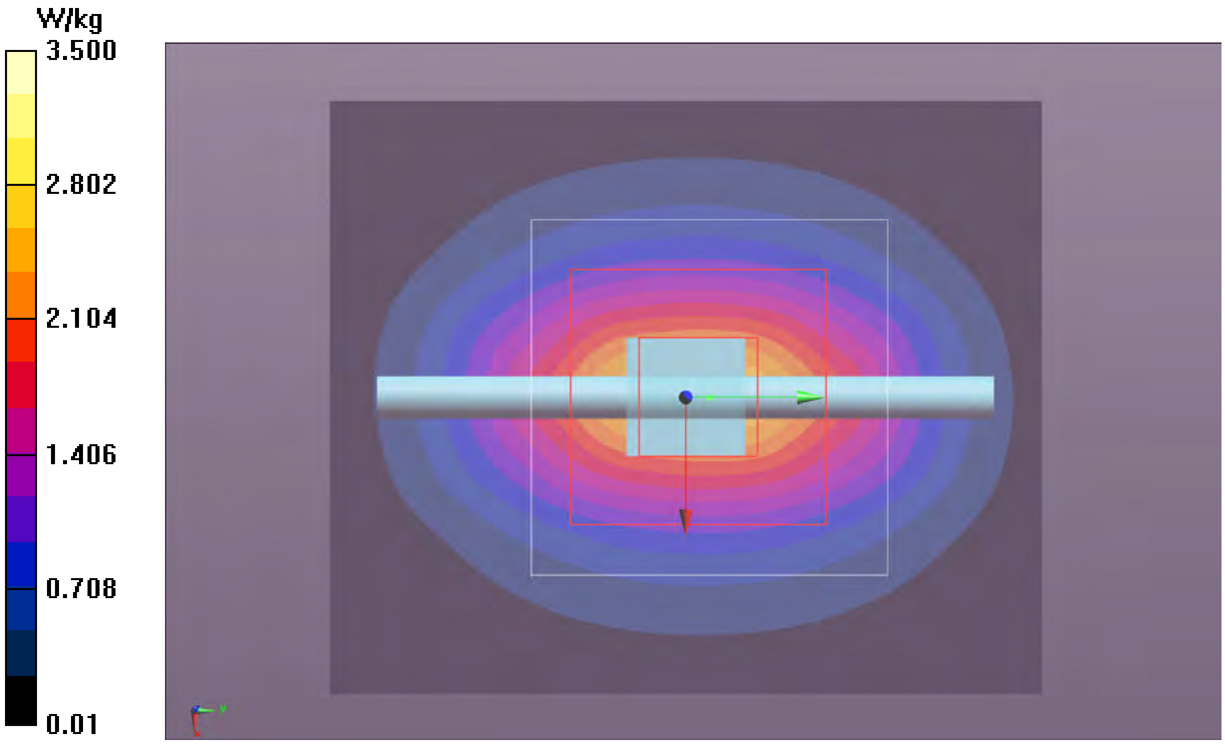
System Check/System Check/Area Scan (51x61x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 2.83 W/kg

System Check/System Check/Z Scan (1x1x21): Measurement grid: dx=20mm, dy=20mm, dz=5mm
Maximum value of Total (measured) = 43.64 V/m

System Check/System Check/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 36.71 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 5.18 W/kg
SAR(1 g) = 2.63 W/kg; SAR(10 g) = 1.24 W/kg
Maximum value of SAR (measured) = 2.66 W/kg
Maximum value of SAR (measured) = 3.77 W/kg

Approved By

MSL2450 System Check 1-18-16



2.4 GHz Band

Per FCC KDB 248227, the conducted output power was measured at the lowest, a middle, and highest channel in each band. Measurements were made while the EUT transmitted at the lowest, middle and the highest data rates for each channel.

Per FCC KDB 447498, the measured SAR values must be scaled to the maximum rated output power. The results are referred to as the “Reported SAR” values. For this device the maximum rated power provided by the manufacturer is:

Maximum Rated Power

Mode	Channel 1 (2412 MHz)	Channels 2 - 10	Channel 11 (2462 MHz)
11b	20.5 dBm	20.5 dBm	20.5 dBm
11g	16 dBm	20 dBm	16 dBm
11n-20	15.5 dBm	20 dBm	15.5 dBm

The following formula was used to calculate the linear SAR scaling factor:

SAR scaling factor = 10^((Maximum Rated Power (dBm) - Measured Power (dBm)) / 10).

Output power measurements were made with software settings corresponding to the maximum rated output power. The measurement data and the associated scaling factors are on the following pages. Since the certification is based upon the measured output power, the scaling factor can be no lower than 1.0.

OUTPUT POWER DATA

WSTD.2013.09.09

EUT:	Zoll LifeVest Model 5000	Work Order:	CDVE0003
Serial Number:	93ENGVER_09	Date:	1/16/2016
Customer:	Connected Development	Temperature:	22.8°C
Attendees:	None	Relative Humidity:	44%
Customer Project:	None	Bar. Pressure:	1021.3mb
Tested By:	Luke Richardson and Ethan Schoonover	Job Site:	EV08
Power:	110VAC/60Hz	Configuration:	1

TEST SPECIFICATIONS

Specification:	Method:
FCC 15.247:2016 FCC 2.1093:2016	FCC KDB 248227 D01 v02r02 FCC KDB 447498 D01 v06 FCC KDB 865664 D01 v01r04 FCC KDB 865664 D02 v01r02 FCC KDB 941225 D07 v01r02 IEEE Std 1528:2013

COMMENTS

None

DEVIATIONS FROM TEST STANDARD

None

OUTPUT POWER DATA

WSTD.2013.09.09

RESULTS

20MHz Bandwidth

Channel	Frequency (MHz)	Radio Mode	Data Rate (Mbps)	Modulation	Measured Power dBm	Max Rated Power	Scaling Factor
1	2412	802.11b	1	BPSK	19.27	20.5	1.33
			11	CCK	19.12	20.5	1.37
		802.11g	6	OFDM	19.23	16	1.0
			54	OFDM	19.37	16	1.0
		802.11n	MCS0	OFDM	19.35	15.5	1.0
			MCS7	OFDM	19.37	15.5	1.0
6	2437	802.11b	1	BPSK	19.28	20.5	1.32
			11	CCK	19.05	20.5	1.40
		802.11g	6	OFDM	19.24	20	1.19
			54	OFDM	19.3	20	1.17
		802.11n	MCS0	OFDM	19.25	20	1.19
			MCS7	OFDM	19.33	20	1.17
11	2462	802.11b	1	BPSK	19.16	20.5	1.36
			11	CCK	19.10	20.5	1.38
		802.11g	6	OFDM	19.2	16	1.0
			54	OFDM	19.32	16	1.0
		802.11n	MCS0	OFDM	19.35	15.5	1.0
			MCS7	OFDM	19.32	15.5	1.0

TEST RESULTS

Test Configurations

Test Locations

All available sides were tested. The EUT can be used with a body worn vest, but it was not tested because of the following reasons:

- The thickness of the material between the user and EUT is under 0.5 mm.
- There is no metal in the vest.

Testing was done with a 0 cm spacing to the phantom.

Summary

The following table summarizes the measured SAR values. The EUT was transmitting at nearly 100% duty cycle.

Per FCC KDB 447498, SAR must be measured on the channel with the highest conducted output power. When the SAR measured on the highest output channel is >0.8 W/kg, SAR evaluation for the other required test channels is necessary.

SAR TEST DATA – 2.4GHz

EUT:	Zoll LifeVest Model 5000	Work Order:	CDVE0003
Customer:	Connected Development	Job Site:	EV08
Attendees:	None	Customer Project:	None

TEST SPECIFICATIONS

Specification:	Method:
FCC 15.247:2016 FCC 2.1093:2016	FCC KDB 248227 D01 v02r02 FCC KDB 447498 D01 v06 FCC KDB 865664 D01 v01r04 FCC KDB 865664 D02 v01r02 FCC KDB 941225 D07 v01r02 IEEE Std 1528:2013

COMMENTS

None

DEVIATIONS FROM TEST STANDARD

None

RESULTS

Test Configuration	Frequency Band	Transmit Frequency (MHz)	Transmit Channel	Data Rate (Mbps)	Channel Bandwidth (MHz)	EUT Position	Power Drift During Test (dB)	Measured 1g SAR Level (mW/g)	Scaling Factor	Reported 1g SAR Level (mW/g)	Test #	Comments
Body	2.4	2412	1	MCS7	20	Bottom	NA	0.00374	1.0	0.00374	1	None
Body	2.4	2412	1	MCS7	20	Right side	NA	0.00311	1.0	0.00311	2	None
Body	2.4	2412	1	MCS7	20	Face	N/A	0.00337	1.0	0.00337	3	None
Body	2.4	2412	1	MCS7	20	Back	N/A	0.0232	1.0	0.0232	4	Angled towards the bottom of the screen
Body	2.4	2412	1	MCS7	20	Back	0.01	0.133	1.0	0.133	4a	Angled towards the antenna side

SAR TEST DATA – 2.4GHz

NORTHWEST EMC
WSTD.2013.09.09

Tested By:	Luke Richardson and Ethan Schoonover	Room Temperature (°C):	23.6°C
Date:	1/18/2016 5:43:13 PM	Liquid Temperature (°C):	22.1°C
Serial Number:	93ENGVER_09	Humidity (%RH):	40.5%
Configuration:	CDVE0003-5	Bar. Pressure (mb):	1001.2 mb
Comments:			

Test 4a
DUT: Wearable Defibrillator; Type: Zoll; Serial: 93 ENGVER_09
Communication System: UID 0, CW; Communication System Band: D2450 (2450.0 MHz); Frequency: 2412 MHz;Communication System PAR: 0 dB; PMF: 1
Medium parameters used (interpolated): f = 2412 MHz; σ = 1.929 S/m; ε_r = 50.729; ρ = 1000 kg/m^3 , Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)
DASY Configuration:

- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Body/Body/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 10.58 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 0.399 W/kg
SAR(1 g) = 0.133 W/kg; SAR(10 g) = 0.046 W/kg

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.212 W/kg

Body/Body/Area scan (51x51x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (interpolated) = 0.157 W/kg

Body/Body/Z Scan (1x1x21): Measurement grid: dx=20mm, dy=20mm, dz=5mm

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of Total (measured) = 6.387 V/m

Body/Body/Reference scan (51x51x1): Interpolated grid: dx=3.000 mm, dy=3.000 mm

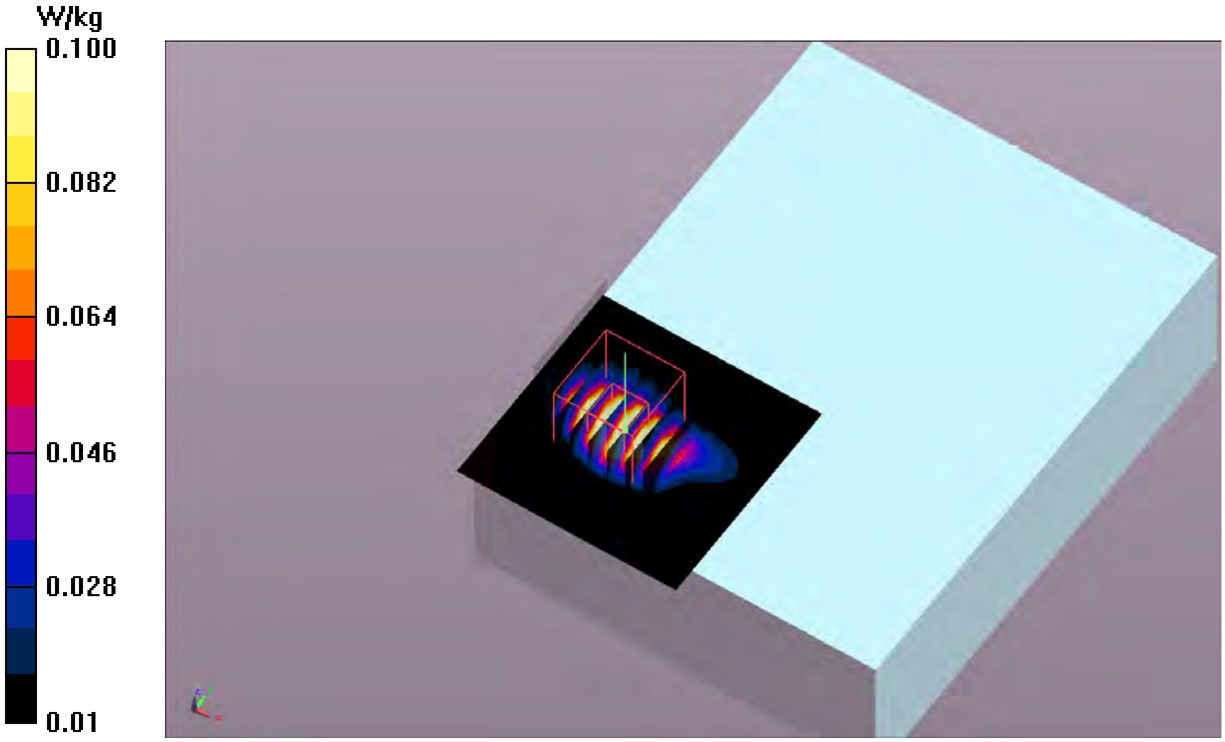
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (interpolated) = 0.140 W/kg

Approved By

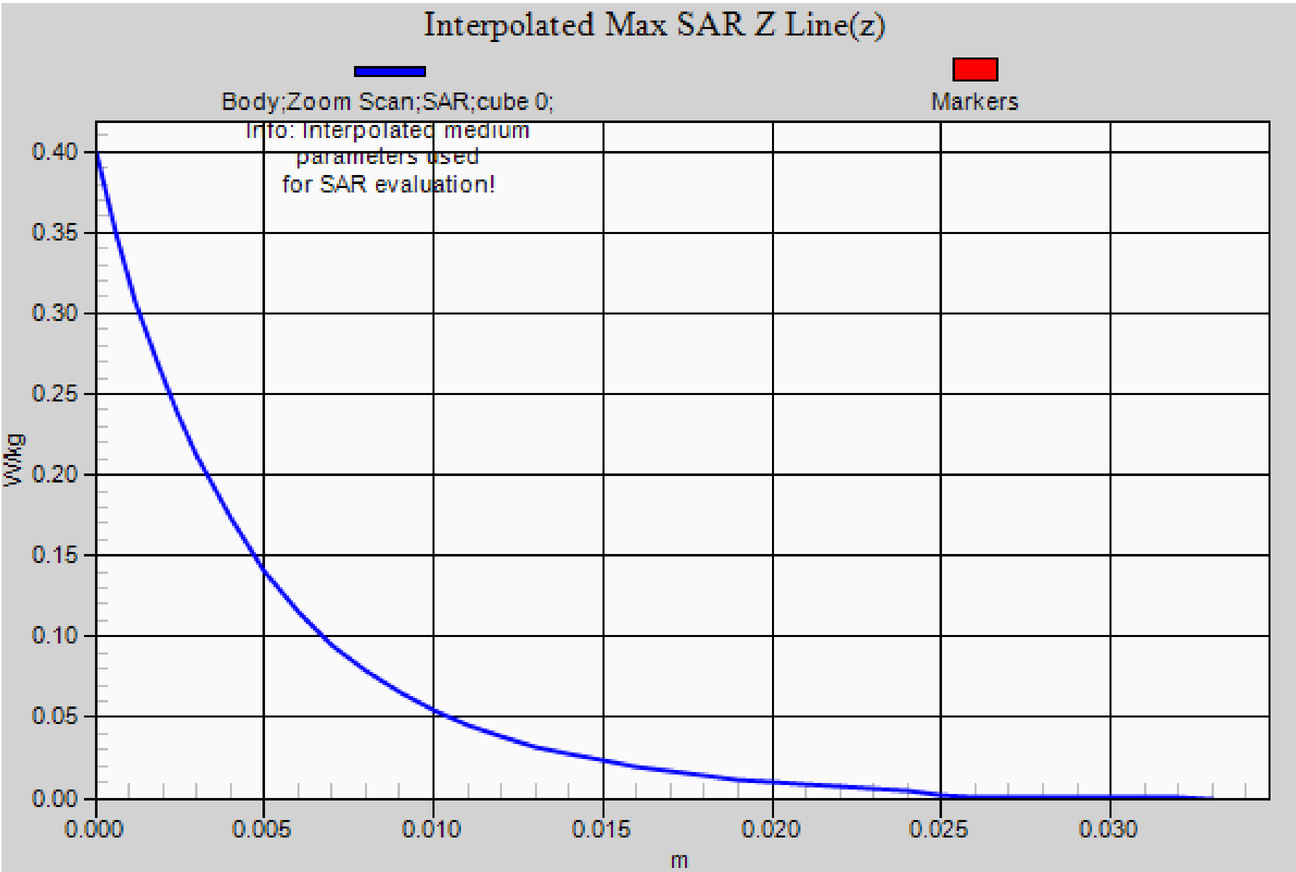
SAR TEST DATA – 2.4GHz

WSTD.2013.09.09

Test 4a



Z-Scan

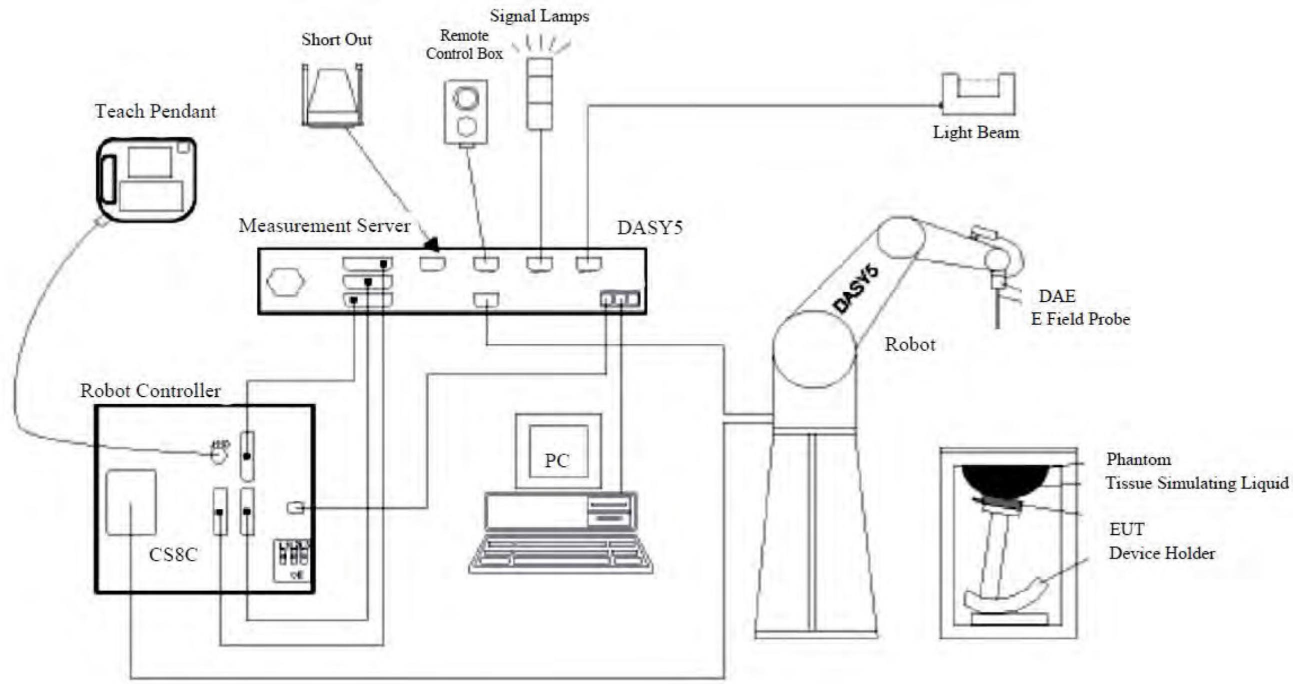

Interpolated Max SAR Z Line(z)
Body;Zoom Scan;SAR;cube 0;
Info: Interpolated medium parameters used for SAR evaluation!
Markers
W/kg
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.000
0.005
0.010
0.015
0.020
0.025
0.030
m

SAR MEASUREMENT SYSTEM

Schmid & Partner Engineering AG, DASY52

Northwest EMC selected the leader in SAR evaluation systems to provide the measurement tools for this evaluation. SPEAG's DASY52 is the fastest and most accurate scanner on the market. It is fully compatible with all world-wide standards for transmitters operating at the ear or within 20cm of the body. It provides full compatibility with IEC 62209-1, IEC 62209-2, IEEE 1528 as well as national adaptations such as FCC OET-65c and Korean Std. MIC #2000-93

The DASY52 system for performing compliance tests consists of the following items:



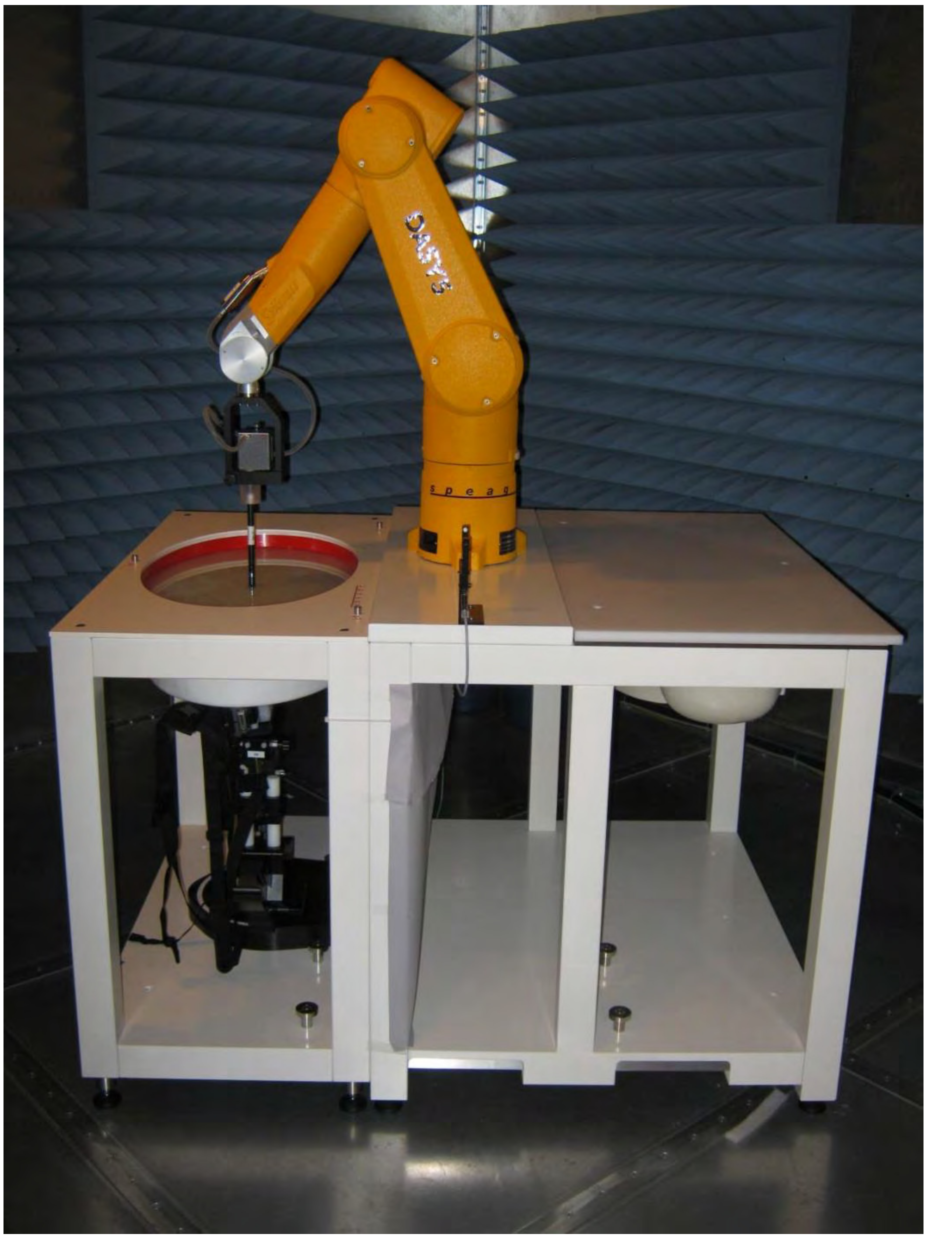
- A standard high precision 6-axis robot (Staubli TX=RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running WinXP and the DASY5 software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.
- The SAM twin phantom, oval flat phantom, device holder, tissue simulating liquids, and validation dipole kits.

SYSTEM AND TEST SITE DESCRIPTION

WSTD.2013.09.09

TEST SITE

Northwest EMC, Lab EV08
The SAR measurement system is located in a semi-anechoic chamber. This provides an ambient free environment that also eliminates reflections. The chamber is 12 ft wide by 16 ft long x 8 ft high. A dedicated HVAC unit provides +/- 1 degree C temperature control.



NORTHWEST EMC
WSEQ.13.09.09

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Interval
Amplifier	Mini Circuits	ZVE-3W-83+	TTA	NCR [1]	0 mo
Analyzer - Network Analyzer	Hewlett Packard	N5230A	NAD	5/7/2014	36 mo
Antenna - Dipole	SPEAG	D2450V2	ADL	10/26/2015	12 mo
DAE	SPEAG	SD 000 D04 EJ	SAH	10/8/2015	12 mo
Device Holder	SPEAG	N/A	SAW	NCR	0 mo
Fixture/Kit - Calibration/Verification	SPEAG	DAKS:200	IPR	3/6/2014	36 mo
Generator - Signal	Agilent	V2920A	TIH	NCR	0 mo
Light Beam Unit	SPEAG	SE UKS 030 AA	SAD	NCR	0 mo
Meter - Power	Agilent	N1913A	SQR	10/30/2015	12 mo
Power Sensor	Agilent	E9300H	SQO	10/30/2015	12 mo
Probe	SPEAG	DAKS-3.5	IPRA	11/17/2015	36 mo
SAR - Tissue Test Solution	SPEAG	MSL 2450	SAM	At start of testing	
SAR Probe	SPEAG	EX3DV4	SAG	11/18/2015	12 mo
SAR Test System	Staeubli	DAYS5	SAK	11/1/2013	36 mo
SAR Test System	SPEAG	QD OVA 001 BB	SAC	NCR	0 mo
SAR Test System	Staeubli	TX60LSPEAG	SAA	NCR	0 mo
SAR Test System	Staeubli	N/A	SAJ	NCR	0 mo
SAR Test System	Staeubli	CS8C	SAI	NCR	0 mo
Thermometer	Omega Engineering, Inc.	HH311	DUI	1/26/2015	36 mo

Note 1: The output of the signal generator / amplifier is verified with the calibrated power meter listed above.

MEASUREMENT UNCERTAINTY

MEASUREMENT UNCERTAINTY BUDGETS PER IEEE 1528:2013

300-3000 MHz Range

Uncertainty Component	Tolerance (+/- %)	Probability Distribution	Divisor	c_i (1g)	c_i (10g)	u_i (1g) (+/-%)	u_i (10g) (+/-%)	v_i
Measurement System								
Probe calibration (k=1)	5.5	normal	1	1	1	5.5	5.5	∞
Axial isotropy	4.7	rectangular	1.732	0.707	0.707	1.9	1.9	∞
Hemispherical isotropy	9.6	rectangular	1.732	0.707	0.707	3.9	3.9	∞
Boundary effect	1.0	rectangular	1.732	1	1	0.6	0.6	∞
Linearity	4.7	rectangular	1.732	1	1	2.7	2.7	∞
System detection limits	1.0	rectangular	1.732	1	1	0.6	0.6	∞
Readout electronics	0.3	normal	1	1	1	0.3	0.3	∞
Response time	0.8	rectangular	1.732	1	1	0.5	0.5	∞
Integration time	2.6	rectangular	1.732	1	1	1.5	1.5	∞
RF ambient conditions - noise	1.7	rectangular	1.732	1	1	1.0	1.0	∞
RF Ambient Reflections	0.0	rectangular	1.732	1	1	0.0	0.0	∞
Probe positioner mechanical tolerance	0.4	rectangular	1.732	1	1	0.2	0.2	∞
Probe positioner with respect to phantom shell	2.9	rectangular	1.732	1	1	1.7	1.7	∞
Extrapolation, interpolation, and integration algorithms for max. SAR evaluation	1.0	rectangular	1.732	1	1	0.6	0.6	∞
Test Sample Related								
Device Positioning	2.9	normal	1	1	1	2.9	2.9	145
Device Holder	3.6	normal	1	1	1	3.6	3.6	5
Power Drift	5.0	rectangular	1.732	1	1	2.9	2.9	∞
Phantom and tissue parameters								
Phantom Uncertainty - shell thickness tolerances	4.0	rectangular	1.732	1	1	2.3	2.3	∞
Liquid conductivity - deviation from target values	5.0	rectangular	1.732	0.64	0.43	1.8	1.2	∞
Liquid conductivity - measurement uncertainty	6.5	normal	1	0.64	0.43	4.2	2.8	∞
Liquid permittivity - deviation from target values	5.0	rectangular	1.732	0.6	0.49	1.7	1.4	∞
Liquid permittivity - measurement uncertainty	3.2	normal	1	0.6	0.49	1.9	1.6	∞
Combined Standard Uncertainty		RSS				11.2	10.6	387
Expanded Measurement Uncertainty (95% Confidence/		normal (k=2)				22.5	21.2	

DIPOLE CALIBRATION

Dipole Calibration

Key points:

1. Dipoles need to be sent to the manufacturer for calibration every 3 years.
2. For those years where they are not sent to the manufacturer the following two parameters are verified annually:
    a. The return-loss. If it deviates by more than 20% from the calibration data or does not meet the required -20 dB return-loss specification, then it fails the verification and must be sent to the manufacturer for repair and calibration.
    b. The real and imaginary parts of the impedance. If it deviates by more than 5 Ω from the calibration data, then it fails the verification and must be sent to the manufacturer for repair and calibration.

The return loss and complex impedance were verified to meet the FCC's criteria within one year of the manufacturer's calibration. The calibration data is used for the SAR system verification. The verification data shows that the dipole characteristics have not changed and the calibration data continues to be valid.

Please see attached calibration and verification data.

Dipole Verification

Performed by Northwest EMC, Inc.

ADL

NORTHWEST
EMC

Calibration Certificate/Report

10/2015cbe

Decriiption:	Antenna, Dipole 2450MHz SAR			Cal Date:	102615
Equipment Code:	ADL			Temperature:	21.0°C
Model:	D2450V2			Humidity:	48%
Manufacturer:	SPEAG	Tester:	Carl Engholm	Pressure:	1016mb
Certificate No.:	ADL 102615	Power:	N/A	Calibration Site:	EV CAL

TEST SPECIFICATIONS

Calibration Procedure:	KDB 450824 D02 Dipole SAR Validation Verification v01r01	Version:	2013

TEST PARAMETERS

Device Received In Tolerance:	Yes	Calibration Frequency :	2450 MHz

Equipment Used to perform calibration

Item:	Network Analyzer	Identifier:	NAP	Model:	Agilent E5061B	Last Cal Date:	6/12/2014
Item:	50 Ohm Termination	Identifier:	NAHA	Model:	Agilent 85032-60017	Last Cal Date:	5/17/2015
Item:	Short	Identifier:	N/A	Model:	Agilent 54202	Last Cal Date:	NCR
Item:	Open	Identifier:	N/A	Model:	Agilent 54266	Last Cal Date:	NCR
Item:	Head TSL	Identifier:	SAL	Model:	HSL 2450	Last Cal Date:	24 Hours
Item:	Body TSL	Identifier:	SAM	Model:	MSL 2450	Last Cal Date:	24 Hours

COMMENTS, OPINIONS and INTERPRETATIONS

Body TSL only

Measurement Uncertainty

	Probability Distribution	Impedance (dB)	Insertion Loss (dB)	Value (dB)	Value (+/- %)
Expanded uncertainty U (level of confidence = 95%)	normal (k=2)	+/- 0.80	+/- 0.80	N/A	N/A

DEVIATIONS FROM TEST STANDARD

None

RESULTS

Pass

This measurement was a calibration verification. (Instrument parameters are within tolerances.)

CALIBRATION DATA ATTACHED

Verification Data - Head

DUT	Antenna, Dipole 2450MHz SAR			
Model	D2450V2	**Antenna Parameters with Head TSL**		
S/N	**ADL**	**2450 MHz**		
			Real	Imaginary (j)
Date	102615	Impedance (ohms)	55.0	3.1
Temperature	21.0°C	Return Loss (dB)	-26.9	
Humidity	48%			
Pressure	1016mb			
Operator	Carl Engholm			

Verification Data - Body

DUT	Antenna, Dipole 2450MHz SAR			
Model	D2450V2	**Antenna Parameters with Body TSL**		
S/N	**ADL**	**2450 MHz**		
			Real	Imaginary (j)
Date	Last Cal Date:	Impedance (ohms)	49.1	4.6
Temperature	Last Cal Date:	Return Loss (dB)	-26.5	
Humidity	Last Cal Date:			
Pressure	Last Cal Date:			
Operator	Carl Engholm			

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 **Northwest EMC**

Certificate No: D2450V2-855_Nov14

CALIBRATION CERTIFICATE

Object	D2450V2 - SN: 855
Calibration procedure(s)	QA CAL-05.v9 Calibration procedure for dipole validation kits above 700 MHz
Calibration date:	November 04, 2014

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	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	US37292783	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	MY41092317	07-Oct-14 (No. 217-02021)	Oct-15
Reference 20 dB Attenuator	SN: 5058 (20k)	03-Apr-14 (No. 217-01918)	Apr-15
Type-N mismatch combination	SN: 5047.2 / 06327	03-Apr-14 (No. 217-01921)	Apr-15
Reference Probe ES3DV3	SN: 3205	30-Dec-13 (No. ES3-3205_Dec13)	Dec-14
DAE4	SN: 601	18-Aug-14 (No. DAE4-601_Aug14)	Aug-15

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

	Name	Function	Signature
Calibrated by:	Jeton Kastrati	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: November 4, 2014

Glossary:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

d) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

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	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	39.0 ± 6 %	1.86 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.3 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**52.3 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.15 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**24.4 W/kg ± 16.5 % (k=2)**

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	50.9 ± 6 %	2.03 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.0 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**50.6 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.01 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**23.7 W/kg ± 16.5 % (k=2)**

Appendix (Additional assessments outside the scope of SCS108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.0 Ω + 3.2 jΩ
Return Loss	- 27.3 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	49.2 Ω + 5.3 jΩ
Return Loss	- 25.4 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.156 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	November 10, 2009

DASY5 Validation Report for Head TSL

Date: 04.11.2014

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 855

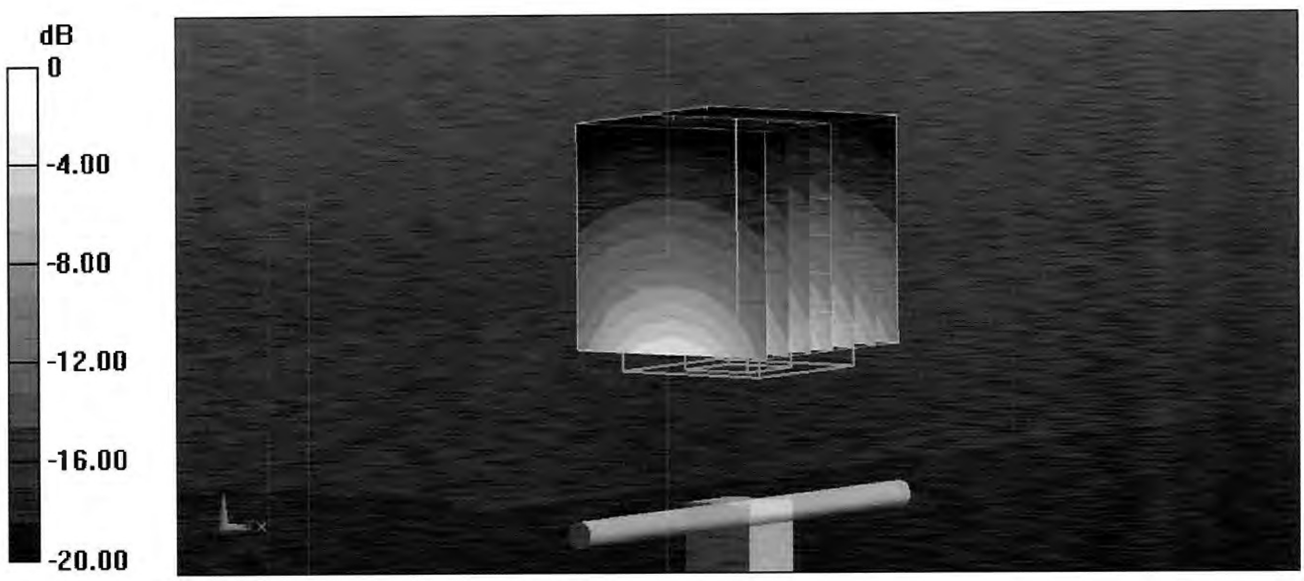
Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 1.86 S/m; ε_r = 39; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.53, 4.53, 4.53); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

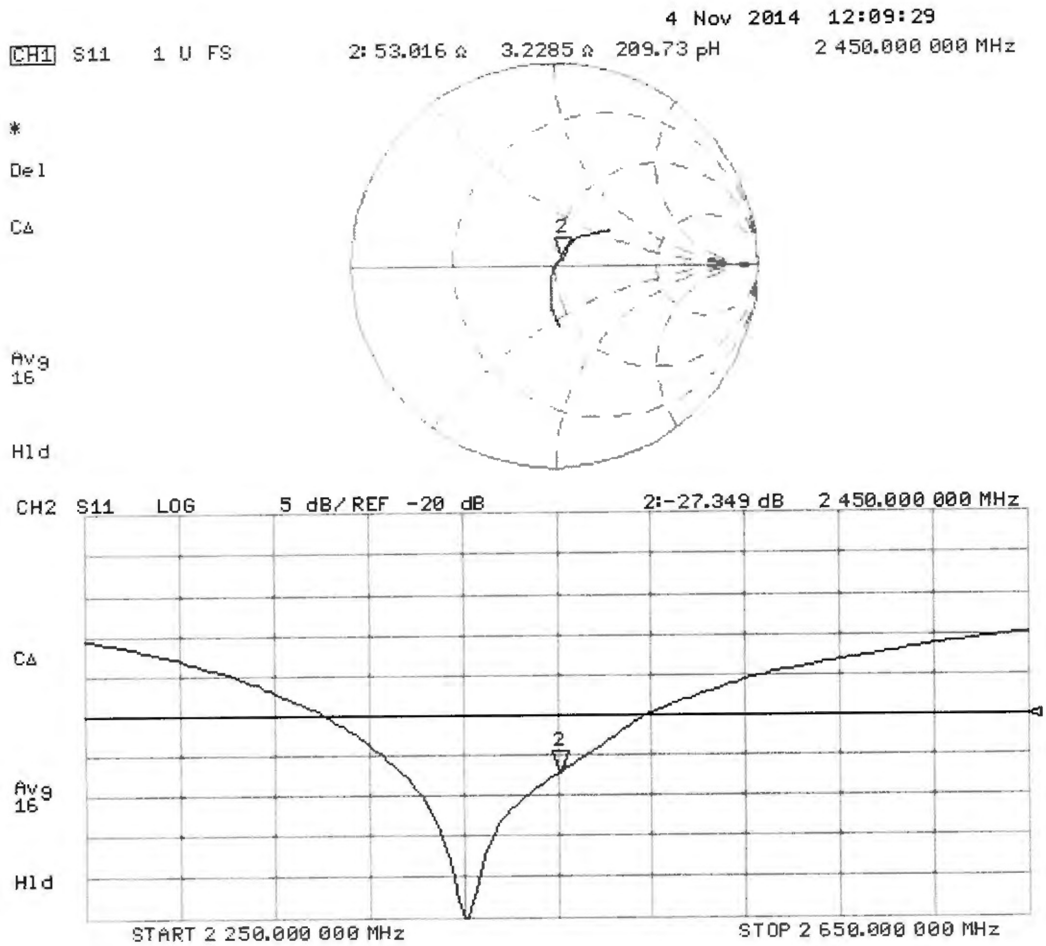
Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 100.9 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 27.3 W/kg
SAR(1 g) = 13.3 W/kg; SAR(10 g) = 6.15 W/kg
Maximum value of SAR (measured) = 17.6 W/kg



0 dB = 17.6 W/kg = 12.46 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 04.11.2014

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 855

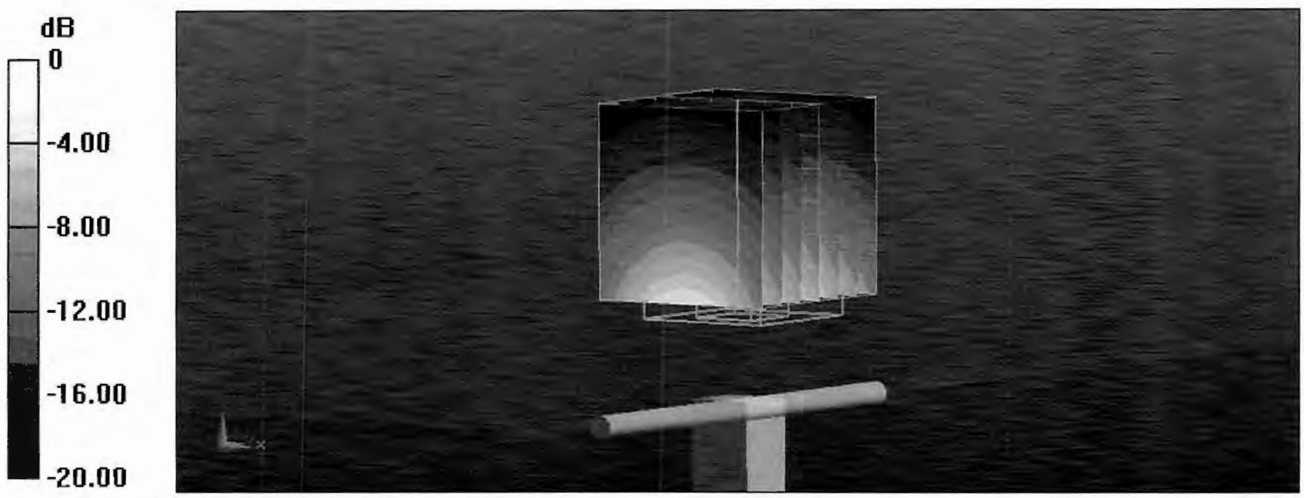
Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 2.03 S/m; ε_r = 50.9; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.35, 4.35, 4.35); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

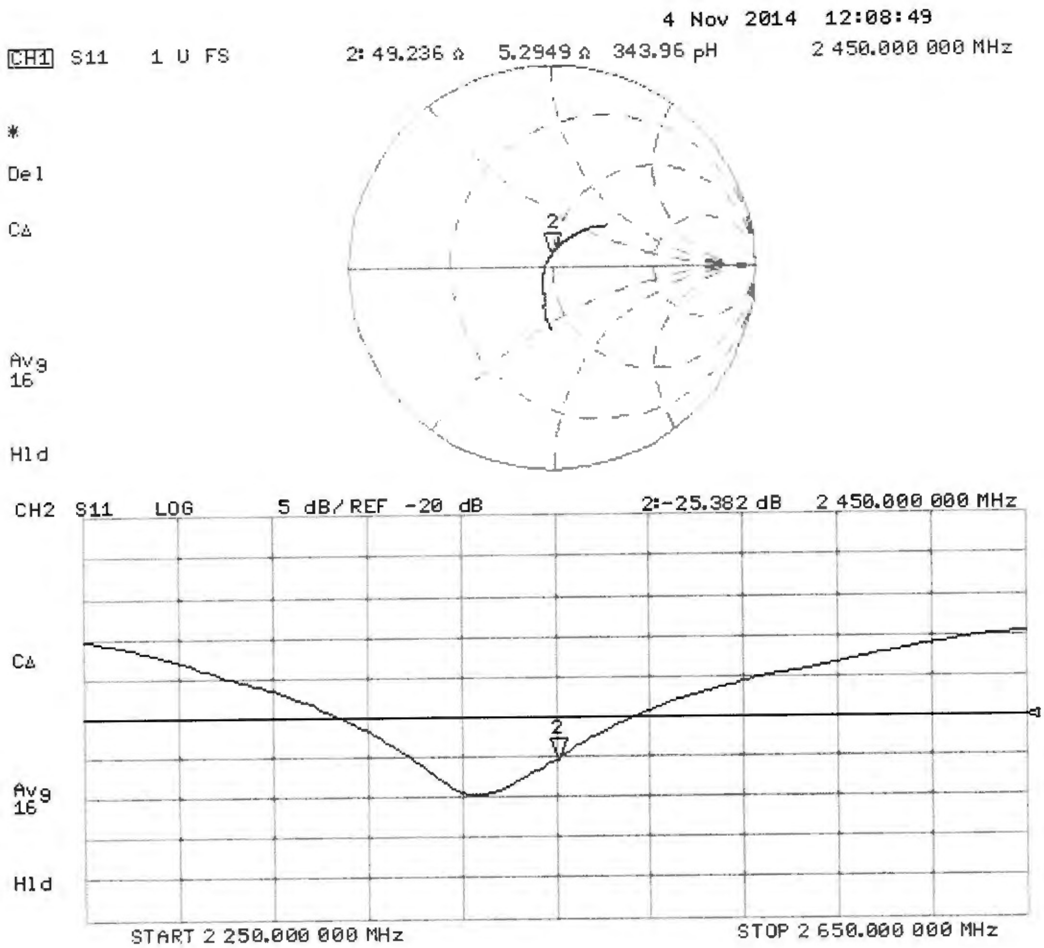
Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 94.95 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 27.2 W/kg
SAR(1 g) = 13 W/kg; SAR(10 g) = 6.01 W/kg
Maximum value of SAR (measured) = 17.2 W/kg



0 dB = 17.2 W/kg = 12.36 dBW/kg

Impedance Measurement Plot for Body TSL



Calibration Laboratory of
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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 0108**

Client Northwest EMC

Certificate No: **EX3-3746_Nov15**

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:3746
Calibration procedure(s)	QA CAL-01.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6 Calibration procedure for dosimetric E-field probes
Calibration date:	November 18, 2015

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	01-Apr-15 (No. 217-02128)	Mar-16
Power sensor E4412A	MY41498087	01-Apr-15 (No. 217-02128)	Mar-16
Reference 3 dB Attenuator	SN: S5054 (3c)	01-Apr-15 (No. 217-02129)	Mar-16
Reference 20 dB Attenuator	SN: S5277 (20x)	01-Apr-15 (No. 217-02132)	Mar-16
Reference 30 dB Attenuator	SN: S5129 (30b)	01-Apr-15 (No. 217-02133)	Mar-16
Reference Probe ES3DV2	SN: 3013	30-Dec-14 (No. ES3-3013_Dec14)	Dec-15
DAE4	SN: 660	14-Jan-15 (No. DAE4-660_Jan15)	Jan-16
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-16
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

	Name	Function	Signature
Calibrated by:	Leif Klysner	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: November 18, 2015

Glossary:

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,y,z
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 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *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.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *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 EX3DV4

SN:3746

Manufactured: March 26, 2010
Calibrated: November 18, 2015

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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3746

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)[A]	0.49	0.46	0.49	± 10.1 %
DCP (mV)[B]	100.7	101.3	100.1	

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	151.7	±3.5 %
		Y	0.0	0.0	1.0		149.0	
		Z	0.0	0.0	1.0		146.1	

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%.

[A] The uncertainties of Norm X,Y,Z do not affect the E^2-field uncertainty inside TSL (see Pages 5 and 6).
[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.

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3746

Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) [C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha [G]	Depth [G] (mm)	Unc (k=2)
2450	39.2	1.80	6.77	6.77	6.77	0.38	0.80	± 12.0 %
2550	39.1	1.91	6.68	6.68	6.68	0.41	0.80	± 12.0 %
5200	36.0	4.66	5.01	5.01	5.01	0.35	1.80	± 13.1 %
5300	35.9	4.76	4.75	4.75	4.75	0.40	1.80	± 13.1 %
5500	35.6	4.96	4.56	4.56	4.56	0.40	1.80	± 13.1 %
5600	35.5	5.07	4.21	4.21	4.21	0.45	1.80	± 13.1 %
5800	35.3	5.27	4.31	4.31	4.31	0.45	1.80	± 13.1 %

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3746

Calibration Parameter Determined in Body Tissue Simulating Media

f (MHz) [C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha [G]	Depth [G] (mm)	Unc (k=2)
2450	52.7	1.95	7.00	7.00	7.00	0.31	0.80	± 12.0 %
2550	52.6	2.09	6.66	6.66	6.66	0.43	0.80	± 12.0 %
5200	49.0	5.30	4.17	4.17	4.17	0.50	1.90	± 13.1 %
5300	48.9	5.42	3.99	3.99	3.99	0.50	1.90	± 13.1 %
5500	48.6	5.65	3.70	3.70	3.70	0.55	1.90	± 13.1 %
5600	48.5	5.77	3.55	3.55	3.55	0.55	1.90	± 13.1 %
5800	48.2	6.00	3.84	3.84	3.84	0.55	1.90	± 13.1 %

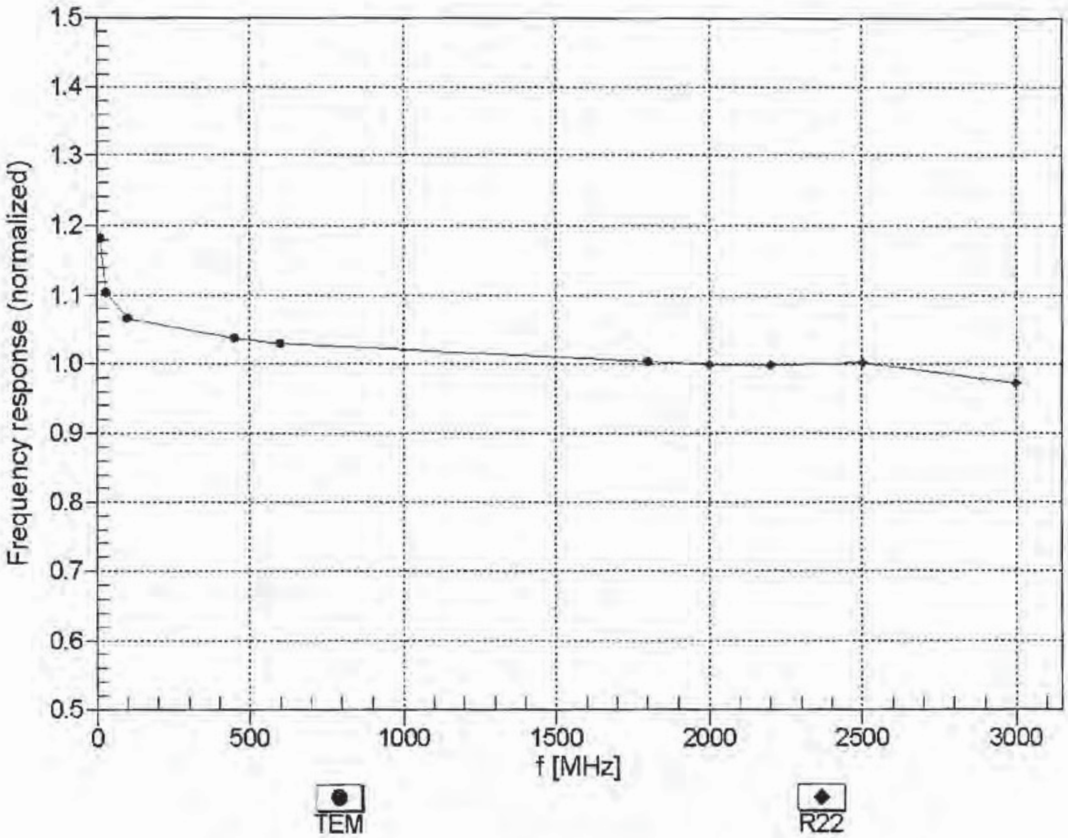
[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

Frequency Response of E-Field

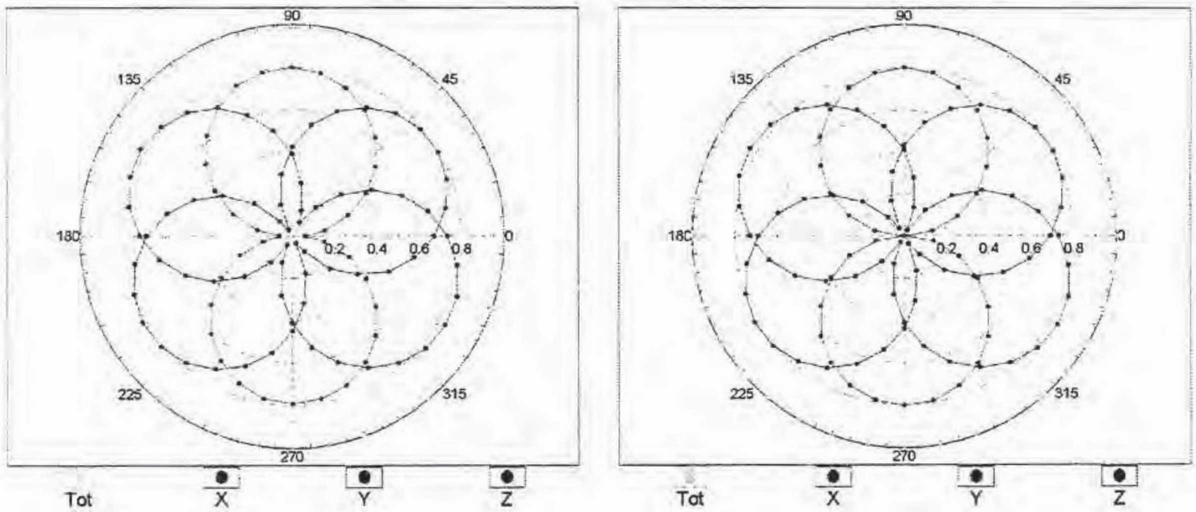
(TEM-Cell:ifi110 EXX, Waveguide: R22)

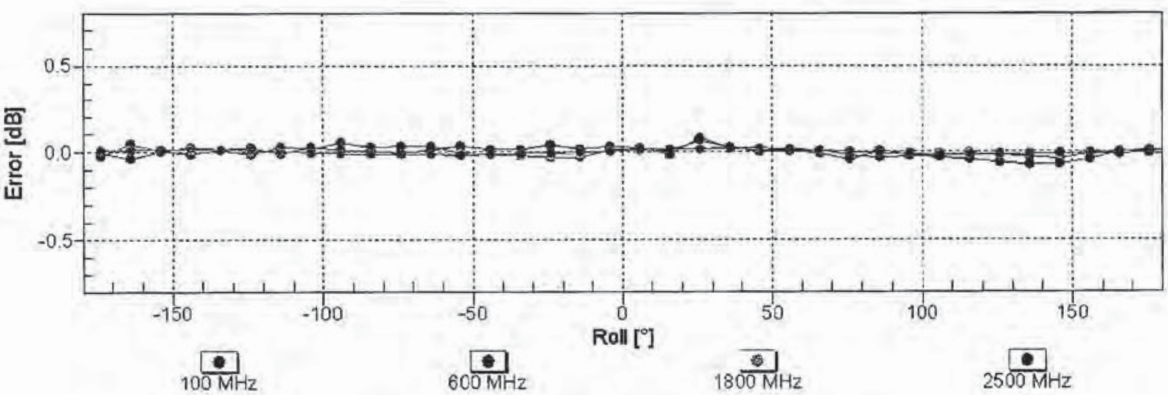


Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)

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

f=600 MHz,TEM f=1800 MHz,R22

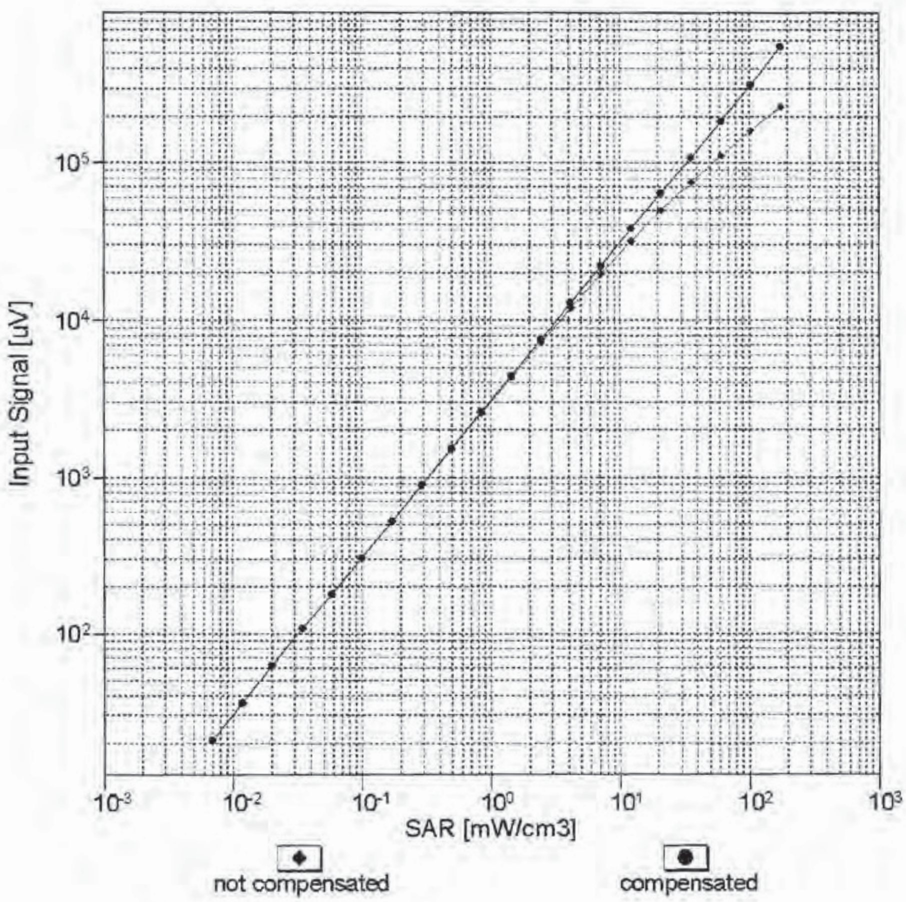


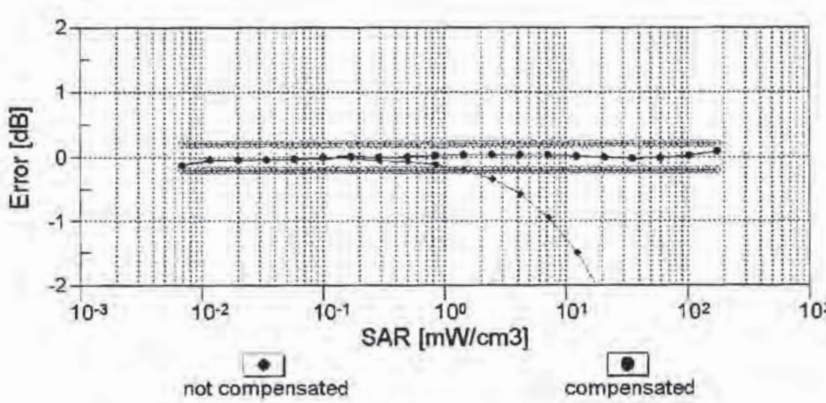


Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

Dynamic Range f(SAR_{head})

(TEM cell , f_{eval}= 1900 MHz)

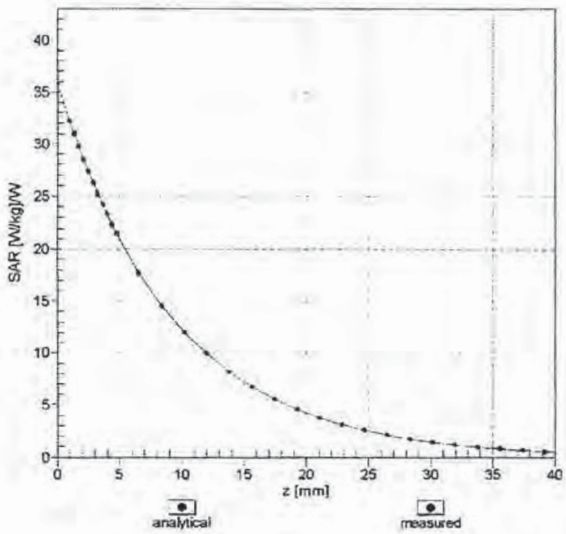




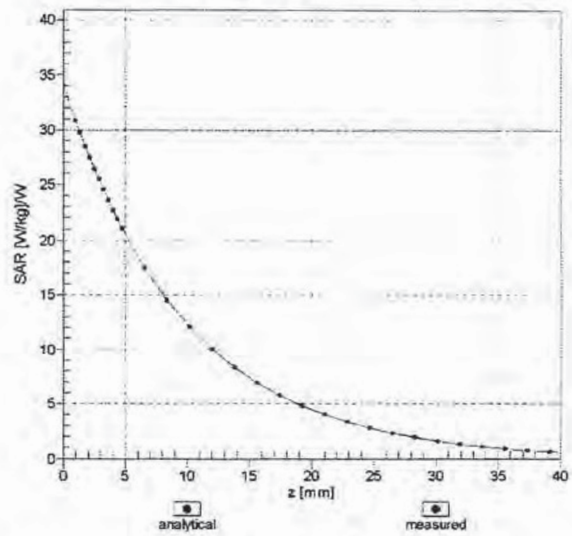
Uncertainty of Linearity Assessment: ± 0.6% (k=2)

Conversion Factor Assessment

f = 2450 MHz,WGLS R22 (H_convF)

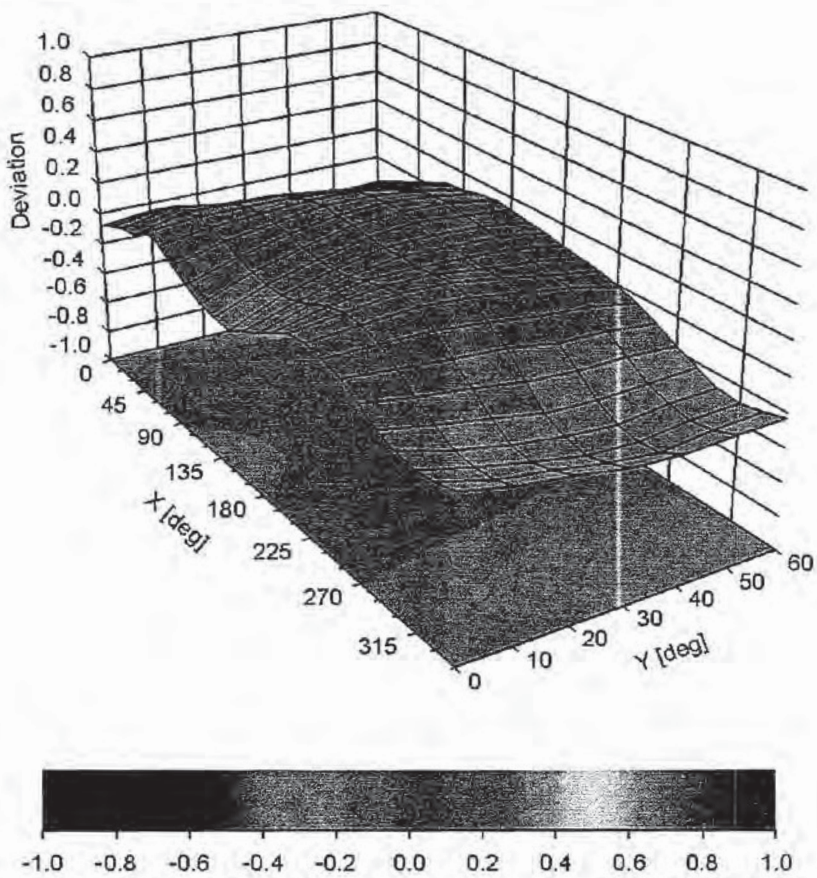


f = 2450 MHz,WGLS R22 (M_convF)



Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz



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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3746

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	45.9
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

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S **Schweizerischer Kalibrierdienst**
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S **Swiss Calibration Service**

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The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**
Equipment ID: SAH

Client **Northwest EMC**

Certificate No: **DAE4-1237_Oct15**

CALIBRATION CERTIFICATE

Object	DAE4 - SD 000 D04 BJ - SN: 1237
Calibration procedure(s)	QA CAL-06.v29 Calibration procedure for the data acquisition electronics (DAE)
Calibration date:	October 08, 2015

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
Keithley Multimeter Type 2001	SN: 0810278	09-Sep-15 (No:17153)	Sep-16
Secondary Standards	**ID #**	**Check Date (in house)**	**Scheduled Check**
Auto DAE Calibration Unit	SE UWS 053 AA 1001	06-Jan-15 (in house check)	In house check: Jan-16
Calibrator Box V2.1	SE UMS 006 AA 1002	06-Jan-15 (in house check)	In house check: Jan-16

	Name	Function	Signature
Calibrated by:	Dominique Steffen	Technician	
Approved by:	Fin Bomholt	Deputy Technical Manager	

Issued: October 8, 2015

Glossary

DAE	data acquisition electronics
Connector angle	information used in DASY system to align probe sensor X to the robot coordinate system.

Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle*: The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
  - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
  - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
  - *Input Offset Measurement*: Output voltage and statistical results over a large number of zero voltage measurements.
  - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
  - *Power consumption:* Typical value for information. Supply currents in various operating modes.

DC Voltage Measurement

A/D - Converter Resolution nominal

High Range:	1LSB =	6.1μV ,	full range =	-100...+300 mV
Low Range:	1LSB =	61nV ,	full range =	-1.......+3mV

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Calibration Factors	X	Y	Z
High Range	404.059 ± 0.02% (k=2)	404.864 ± 0.02% (k=2)	403.429 ± 0.02% (k=2)
Low Range	3.97301 ± 1.50% (k=2)	3.95088 ± 1.50% (k=2)	3.98680 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	352.5 ° ± 1 °

Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	200037.64	4.19	0.00
Channel X	+ Input	20006.39	2.56	0.01
Channel X	- Input	-20003.87	1.65	-0.01
Channel Y	+ Input	200031.05	-2.63	-0.00
Channel Y	+ Input	20004.10	0.25	0.00
Channel Y	- Input	-20006.33	-0.83	0.00
Channel Z	+ Input	200032.88	-0.51	-0.00
Channel Z	+ Input	20001.21	-2.55	-0.01
Channel Z	- Input	-20006.81	-1.22	0.01

Low Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	2001.04	0.67	0.03
Channel X	+ Input	200.43	-0.04	-0.02
Channel X	- Input	-199.20	0.44	-0.22
Channel Y	+ Input	2000.46	0.22	0.01
Channel Y	+ Input	199.08	-1.35	-0.67
Channel Y	- Input	-200.26	-0.46	0.23
Channel Z	+ Input	2000.40	0.17	0.01
Channel Z	+ Input	199.10	-1.19	-0.59
Channel Z	- Input	-201.25	-1.45	0.73

2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Common mode Input Voltage (mV)	High Range Average Reading (μV)	Low Range Average Reading (μV)
Channel X	200	-1.68	-3.45
	- 200	5.53	4.04
Channel Y	200	0.52	0.25
	- 200	-1.11	-1.45
Channel Z	200	-0.17	-0.28
	- 200	-2.08	-2.18

3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Input Voltage (mV)	Channel X (μV)	Channel Y (μV)	Channel Z (μV)
Channel X	200	-	6.93	0.56
Channel Y	200	9.60	-	7.91
Channel Z	200	8.17	7.27	-

4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	High Range (LSB)	Low Range (LSB)
Channel X	16192	16645
Channel Y	16072	16434
Channel Z	15834	17063

5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec
Input 10MΩ

	Average (μV)	min. Offset (μV)	max. Offset (μV)	Std. Deviation (μV)
Channel X	1.14	0.33	2.40	0.45
Channel Y	-0.14	-1.84	1.43	0.52
Channel Z	-1.12	-2.34	0.63	0.57

6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

7. Input Resistance (Typical values for information)

	Zeroing (kOhm)	Measuring (MOhm)
Channel X	200	200
Channel Y	200	200
Channel Z	200	200

8. Low Battery Alarm Voltage (Typical values for information)

Typical values	**Alarm Level (VDC)**
Supply (+ Vcc)	+7.9
Supply (- Vcc)	-7.6

9. Power Consumption (Typical values for information)

Typical values	**Switched off (mA)**	**Stand by (mA)**	**Transmitting (mA)**
Supply (+ Vcc)	+0.01	+6	+14
Supply (- Vcc)	-0.01	-8	-9