



Element Materials Technology

Pro9 Headset

SAR Evaluation Report: ELEM0101 Rev. 1, Issue Date: December 3, 2020

Evaluated to the following SAR specification:

FCC 2.1093:2020



NVLAP LAB CODE: 200881-0



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CERTIFICATE OF TEST



Last Date of Test: May 27, 2020
Element Materials Technology
EUT: Pro9 Headset

Applicable Standard

Test Description	Specification	Test Method	Pass/Fail
SAR Evaluation	FCC 2.1093:2020	FCC KDB 865664 D01 v01r04 FCC KDB 865664 D02 v01r02 FCC KDB 447498 D01 v06 IEEE Std 1528:2013	Pass

Highest SAR Values:

Frequency Bands (GHz)	Head (W/kg) 1g	Limit (W/kg)	Exposure Environment
		1g	
1.920-1.930	0.0205	1.6	General Population

Deviations From Test Standards

None

Approved By:

Don Facteau, Systems Architect

REVISION HISTORY



Revision Number	Description	Date (yyyy-mm-dd)	Page Number
01	Changed header from Body to Head in the SAR values table	2020-11-30	2

ACCREDITATIONS AND AUTHORIZATIONS



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 Element to certify transmitters to FCC and IC specifications.

NVLAP - Each laboratory is accredited by NVLAP to ISO 17025

Canada

ISED - Recognized by Innovation, Science and Economic Development Canada as a Certification Body (CB) and as a CAB for the acceptance of test data.

European Union

European Commission – Within Element, we have a EU Notified Body validated for the EMCD and RED Directives.

Australia/New Zealand

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

Korea

MSIT / 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

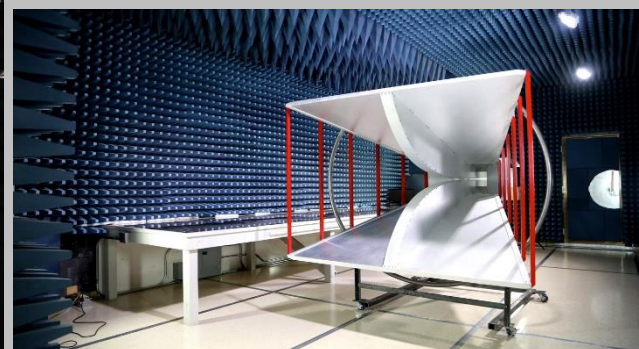
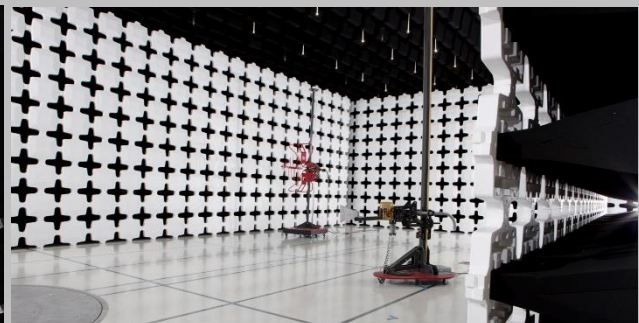
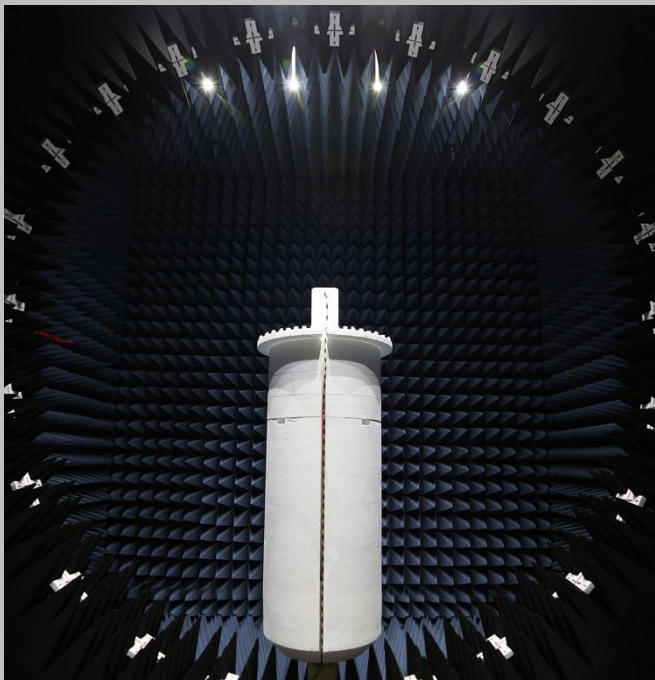
For details on the Scopes of our Accreditations, please visit:

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FACILITIES



California Labs OC01-17 41 Tesla Irvine, CA 92618 (949) 861-8918	Minnesota Labs MN01-10 9349 W Broadway Ave. Brooklyn Park, MN 55445 (612)-638-5136	Oregon Labs EV01-12 6775 NE Evergreen Pkwy #400 Hillsboro, OR 97124 (503) 844-4066	Texas Labs TX01-09 3801 E Plano Pkwy Plano, TX 75074 (469) 304-5255	Washington Labs NC01-05 19201 120 th Ave NE Bothell, WA 98011 (425)984-6600
NVLAP				
NVLAP Lab Code: 200676-0	NVLAP Lab Code: 200881-0	NVLAP Lab Code: 200630-0	NVLAP Lab Code:201049-0	NVLAP Lab Code: 200629-0
Innovation, Science and Economic Development Canada				
2834B-1, 2834B-3	2834E-1, 2834E-3	2834D-1	2834G-1	2834F-1
BSMI				
SL2-IN-E-1154R	SL2-IN-E-1152R	SL2-IN-E-1017	SL2-IN-E-1158R	SL2-IN-E-1153R
VCCI				
A-0029	A-0109	A-0108	A-0201	A-0110
Recognized Phase I CAB for ISED, ACMA, BSMI, IDA, KCC/RRR, MIC, MOC, NCC, OFCA				
US0158	US0175	US0017	US0191	US0157



PRODUCT DESCRIPTION

Client and Equipment Under Test (EUT) Information

Company Name:	Quail Digital
Address:	92 Lots Road
City, State, Zip:	London, SW10 0QD, United Kingdom
Test Requested By:	Alex Toohie of Element Materials Technology, Hull
Model:	Pro9 Headset
First Date of Test:	May 21, 2020
Last Date of Test:	May 27, 2020
Receipt Date of Samples:	May 15, 2020
Equipment Design Stage:	Production
Equipment Condition:	No Damage
Purchase Authorization:	Verified

Information Provided by the Party Requesting the Test

Functional Description of the EUT:

Pro9 Headset is a multi-channel headset designed for single and dual lane drive-thru, curb-side ordering and in-restaurant table service, all from the same headset. And, its range will cover kitchen, seating on two floors, drive-thru lanes, drive-to bays and parking lot.

The device contains the following radio:
DECT RFP 1.92-1.93GHz

Location of transmit antenna(s):

DECT Antennas





PRODUCT DESCRIPTION

Testing Locations:

For clarity, the sides of the EUT are referred right and left side, with a boom that can be rotated 180 degrees to be used in both positions.

The EUT can have two orientations exposed to the human head. The antenna is located along the headset frame of the headset near the human head. Left and right orientation tested. The microphone and boom arm of the EUT was rotated into its intended use position for each EUT orientation tested.

Testing Objective:

To demonstrate compliance of DECT radio with the SAR requirements of FCC 2.1093:2020.

Scaling:

Max power

Per FCC KDB 447498, the measured SAR values were scaled to the maximum tune-up tolerance limit. The results are referred to as the "Reported SAR" values. The following formula was used to calculate the linear SAR scaling factor:

$$\text{SAR scaling factor} = 10^{((\text{Tune-up Tolerance Power (dBm)} - \text{Measured Power (dBm)}) / 10)}$$

A summary of scaling factors is as follows:

Antenna	Frequency (MHz)	Channel	Max Measured OP (dBm)	Declared Tune-Up OP (dBm)	Scaling Factor
Ant 0	1925	25	19.2	20	1.20
Ant 1	1925	25	18.9	20	1.29

Duty Cycle

All EUTs were operating at 8% duty cycle for this test. This matches the firmware limited maximum duty cycle that the EUT can use in the field. No scaling factor was applied for duty cycle. Extra care was taken to ensure measurements were properly captured.

Simultaneous Transmissions:

The EUT is not capable of simultaneous transmissions.

CONFIGURATIONS



Configuration ELEM0101- 1

EUT			
Description	Manufacturer	Model/Part Number	Serial Number
Pro9 Headset	QuailDigital	Q-P9 HS	0321600040

Cables					
Cable Type	Shield	Length (m)	Ferrite	Connection 1	Connection 2
Ribbon Cable	No	0.3 m	No	Pro9 Headset	Unterminated

Configuration ELEM0101- 2

EUT			
Description	Manufacturer	Model/Part Number	Serial Number
Pro9 Headset	QuailDigital	Q-P9 HS	0321600029

Cables					
Cable Type	Shield	Length (m)	Ferrite	Connection 1	Connection 2
Ribbon Cable	No	0.3 m	No	Pro9 Headset	Unterminated

MODIFICATIONS



Equipment Modifications

Item	Date	Test	Modification	Note	Disposition of EUT
1	2020-05-21	SAR Evaluation	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Element following the test.
2	2020-05-27	Output Power	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

The measured values must be within $\pm 10\%$ of the target values provided SAR error compensation algorithms documented in IEEE Std 1528-2013 section E.3.2.2 are implemented for upward correction purposes only. The temperature variation in the liquid during SAR measurements must be within $\pm 2^\circ\text{C}$ of that recorded when the dielectric properties were measured.

The dielectric parameters of the tissue-equivalent liquids were measured 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 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.”

Linear interpolation is used for determining target dielectric parameters for values between those listed.

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 $\rho = 1000 \text{ kg/m}^3$)

TISSUE – EQUIVALENT LIQUID DESCRIPTION



Composition of Ingredients for Liquid Tissue Phantoms

Element uses broadband tissue equivalent liquids prepared by SPEAG and confirmed by Element to be within +/- 10% of target values. SAR error compensation algorithms documented in IEEE Std 1528-2013 are implemented for upward correction purposes only.

By percent weight, the approximate compositions of the broadband tissue are listed below. The composition of ingredients may be modified accordingly to achieve the desired target tissue parameters required for routine SAR evaluation:

Material	Percent Weight
Ethanediol	1.0 - 4.9%
Sodium Petroleum Sulfonate	<2.9%
Hexylene Glycol	<2.9%
Alkoxyated Alcohol	<2.0%
Mineral Oils	<20%
Deionized Water	Fill to volume

The exact liquid recipes are proprietary to the tissue equivalent liquid manufacturer.

SAR Correction Formula for Deviation from Target Dielectric Values

A correction formula is automatically applied by the measurement software to SAR data to account for the deviation from the target dielectric values. The correction formula only scales measured values upward. The SAR system manufacturer has been contacted and has verified Element's implementation and understanding of the SAR correction formula. The correction is calculated following IEEE Std 1528-2013 Annex E.3. Where SAR correction is considered, there will be a note stating "SAR corrected for target medium." The equation is as follows:

$$\Delta SAR = c_{\epsilon} \Delta \epsilon_r + c_{\sigma} \Delta \sigma$$

Where the values for, $\Delta \epsilon_r$ and $\Delta \sigma$ and are the percent the permittivity and conductivity respectively are away from ideal values and where ΔSAR is the percent the measured SAR value is corrected.

When 1 g peak spatial-average SAR measurements are taken:

$$c_{\epsilon} = -7.854 \times 10^{-4} f^3 + 9.402 \times 10^{-3} f^2 - 2.742 \times 10^{-2} f - 0.2026$$
$$c_{\sigma} = 9.804 \times 10^{-3} f^3 - 8.661 \times 10^{-2} f^2 + 2.981 \times 10^{-2} f + 0.7829$$

Where f is the frequency in GHz.

When 10 g peak spatial-average SAR measurements are taken:

$$c_{\epsilon} = 3.456 \times 10^{-3} f^3 - 3.531 \times 10^{-2} f^2 + 7.675 \times 10^{-2} f - 0.1860$$
$$c_{\sigma} = 4.479 \times 10^{-3} f^3 - 1.586 \times 10^{-2} f^2 - 0.1972 f + 0.7717$$

Where f is the frequency in GHz.



TISSUE – EQUIVALENT LIQUID

Date:	05/21/2020	Temperature:	23°C
Tissue:	HBBL600-10000V6	Liquid Temperature:	23.4°C
Tested By:	Marcelo Aguayo, Kyle McMullan	Relative Humidity:	51%
Job Site:	MN11	Bar. Pressure:	1018 mb

TEST SPECIFICATIONS

Specification:	Method:
FCC 2.1093:2020	FCC KDB 865664 D01 v01r04 FCC KDB 865664 D02 v01r02 FCC KDB 447498 D01 v06 IEEE Std 1528:2013

RESULTS

Frequency(MHz)	Actual Values		Target Values		Deviation (%)	
	Relative Perm.	Conductivity	Relative Perm.	Frequency(MHz)	Relative Perm.	Conductivity
1900	40.96	1.46	40	1.40	2.40	4.29

Freq (MHz)	Relative Perm.	Cond. (S/m)
400	44.64	0.82
450	44.35	0.84
500	44.15	0.85
550	43.94	0.87
600	43.79	0.89
650	43.61	0.90
700	43.51	0.92
750	43.33	0.93
800	43.16	0.95
850	42.97	0.97
900	42.83	0.99
950	42.73	1.01
1000	42.58	1.03
1050	42.52	1.05
1100	42.39	1.07
1150	42.27	1.08
1200	42.15	1.11
1250	42.01	1.13
1300	41.93	1.15
1350	41.82	1.17
1400	41.69	1.19
1450	41.67	1.22
1500	41.64	1.24
1550	41.55	1.27
1600	41.47	1.29
1650	41.45	1.32
1700	41.32	1.35
1750	41.22	1.37
1800	41.10	1.40
1850	41.00	1.43
1900	40.96	1.46
1950	40.87	1.49
2000	40.80	1.52
2050	40.72	1.56
2100	40.70	1.59
2150	40.62	1.62
2200	40.55	1.65
2250	40.50	1.69

Freq (MHz)	Relative Perm.	Cond. (S/m)
2300	40.46	1.72
2350	40.44	1.76
2400	40.32	1.80
2450	40.25	1.83
2500	40.19	1.88
2550	40.14	1.91
2600	40.02	1.95
2650	39.95	1.99
2700	39.90	2.03
2750	39.79	2.07
2800	39.75	2.12
2850	39.67	2.15
2900	39.61	2.20
2950	39.57	2.24
3000	39.47	2.27
3050	39.32	2.32
3100	39.24	2.36
3150	39.15	2.40
3200	39.08	2.44
3250	39.01	2.49
3300	38.92	2.53
3350	38.85	2.57
3400	38.73	2.62
3450	38.69	2.66
3500	38.58	2.70
3550	38.51	2.74
3600	38.47	2.79
3650	38.38	2.83
3700	38.28	2.88
3750	38.20	2.93
3800	38.17	2.97
3850	38.06	3.02
3900	38.03	3.06
3950	37.93	3.12
4000	37.86	3.16
4050	37.80	3.22
4100	37.80	3.27
4150	37.74	3.31

Freq (MHz)	Relative Perm.	Cond. (S/m)
4200	37.63	3.37
4250	37.56	3.41
4300	37.47	3.48
4350	37.43	3.53
4400	37.31	3.59
4450	37.18	3.63
4500	37.11	3.69
4550	37.05	3.75
4600	36.94	3.81
4650	36.84	3.87
4700	36.77	3.92
4750	36.65	3.98
4800	36.56	4.03
4850	36.33	4.01
4900	36.02	4.09
4950	36.47	4.19
5000	36.12	4.23
5050	36.04	4.25
5100	36.28	4.35
5150	36.14	4.40
5200	36.00	4.44
5250	35.71	4.48
5300	35.50	4.75
5350	35.53	4.75
5400	35.95	4.69
5450	35.50	4.82
5500	35.57	4.86
5550	35.41	4.86
5600	35.25	4.91
5650	35.13	4.99
5700	34.87	5.14
5750	34.77	5.10
5800	34.90	5.10
5850	34.86	5.21
5900	34.52	5.16
5950	34.30	5.26
6000	34.22	5.34

TISSUE – EQUIVALENT LIQUID

Date:	05/20/2020	Temperature:	22°C
Tissue:	HBBL600-10000V6	Liquid Temperature:	20.4°C
Tested By:	Marcelo Aguayo, Kyle McMullan	Relative Humidity:	41%
Job Site:	MN11	Bar. Pressure:	1019 mb

TEST SPECIFICATIONS

Specification:	Method:
FCC 2.1093:2020	FCC KDB 865664 D01 v01r04 FCC KDB 865664 D02 v01r02 FCC KDB 447498 D01 v06 IEEE Std 1528:2013

RESULTS

	Actual Values		Target Values		Deviation (%)	
Frequency(MHz)	Relative Perm.	Conductivity	Relative Perm.	Frequency(MHz)	Relative Perm.	Conductivity
1900	41.90	1.47	40	1.40	4.75	5.00

Freq (MHz)	Relative Perm.	Cond. (S/m)
400	45.71	0.78
450	45.40	0.79
500	45.05	0.81
550	44.86	0.82
600	44.68	0.84
650	44.53	0.85
700	44.40	0.87
750	44.23	0.89
800	44.06	0.91
850	43.85	0.93
900	43.76	0.95
950	43.68	0.96
1000	43.58	0.99
1050	43.44	1.01
1100	43.33	1.03
1150	43.23	1.05
1200	43.12	1.07
1250	42.97	1.10
1300	42.95	1.12
1350	42.80	1.15
1400	42.71	1.17
1450	42.63	1.20
1500	42.55	1.23
1550	42.46	1.26
1600	42.35	1.29
1650	42.28	1.31
1700	42.14	1.34
1750	42.09	1.37
1800	42.00	1.40
1850	41.95	1.43
1900	41.90	1.47
1950	41.81	1.49
2000	41.74	1.53
2050	41.64	1.57
2100	41.62	1.60
2150	41.55	1.64
2200	41.48	1.67
2250	41.41	1.71

Freq (MHz)	Relative Perm.	Cond. (S/m)
2300	41.35	1.74
2350	41.28	1.78
2400	41.18	1.83
2450	41.09	1.87
2500	41.04	1.91
2550	40.99	1.95
2600	40.84	1.99
2650	40.76	2.03
2700	40.69	2.08
2750	40.57	2.11
2800	40.50	2.17
2850	40.40	2.21
2900	40.32	2.26
2950	40.25	2.30
3000	40.18	2.34
3050	40.00	2.39
3100	39.91	2.43
3150	39.81	2.48
3200	39.75	2.52
3250	39.65	2.57
3300	39.56	2.61
3350	39.47	2.65
3400	39.34	2.71
3450	39.30	2.76
3500	39.19	2.80
3550	39.11	2.85
3600	39.05	2.89
3650	38.94	2.94
3700	38.85	2.99
3750	38.75	3.04
3800	38.73	3.10
3850	38.62	3.15
3900	38.56	3.19
3950	38.45	3.24
4000	38.40	3.30
4050	38.28	3.36
4100	38.24	3.41
4150	38.18	3.46

Freq (MHz)	Relative Perm.	Cond. (S/m)
4200	38.09	3.52
4250	37.99	3.57
4300	37.89	3.64
4350	37.84	3.68
4400	37.75	3.75
4450	37.62	3.80
4500	37.53	3.86
4550	37.46	3.92
4600	37.36	3.97
4650	37.21	4.03
4700	37.16	4.09
4750	37.05	4.15
4800	36.91	4.21
4850	36.95	4.24
4900	36.35	4.29
4950	36.53	4.40
5000	36.29	4.41
5050	36.38	4.52
5100	36.40	4.54
5150	36.41	4.58
5200	36.22	4.65
5250	36.08	4.77
5300	36.01	4.85
5350	35.48	4.93
5400	35.82	5.07
5450	35.78	5.11
5500	35.94	5.06
5550	35.61	5.10
5600	35.50	5.12
5650	35.32	5.22
5700	35.31	5.39
5750	35.04	5.36
5800	35.22	5.39
5850	34.94	5.39
5900	34.95	5.40
5950	34.90	5.45
6000	34.57	5.59

SAR SYSTEM VERIFICATION DESCRIPTION

REQUIREMENT

Per IEEE 1528, Section 8.2.1, "System checks are performed prior to compliance tests and the results must always be within $\pm 10\%$ 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

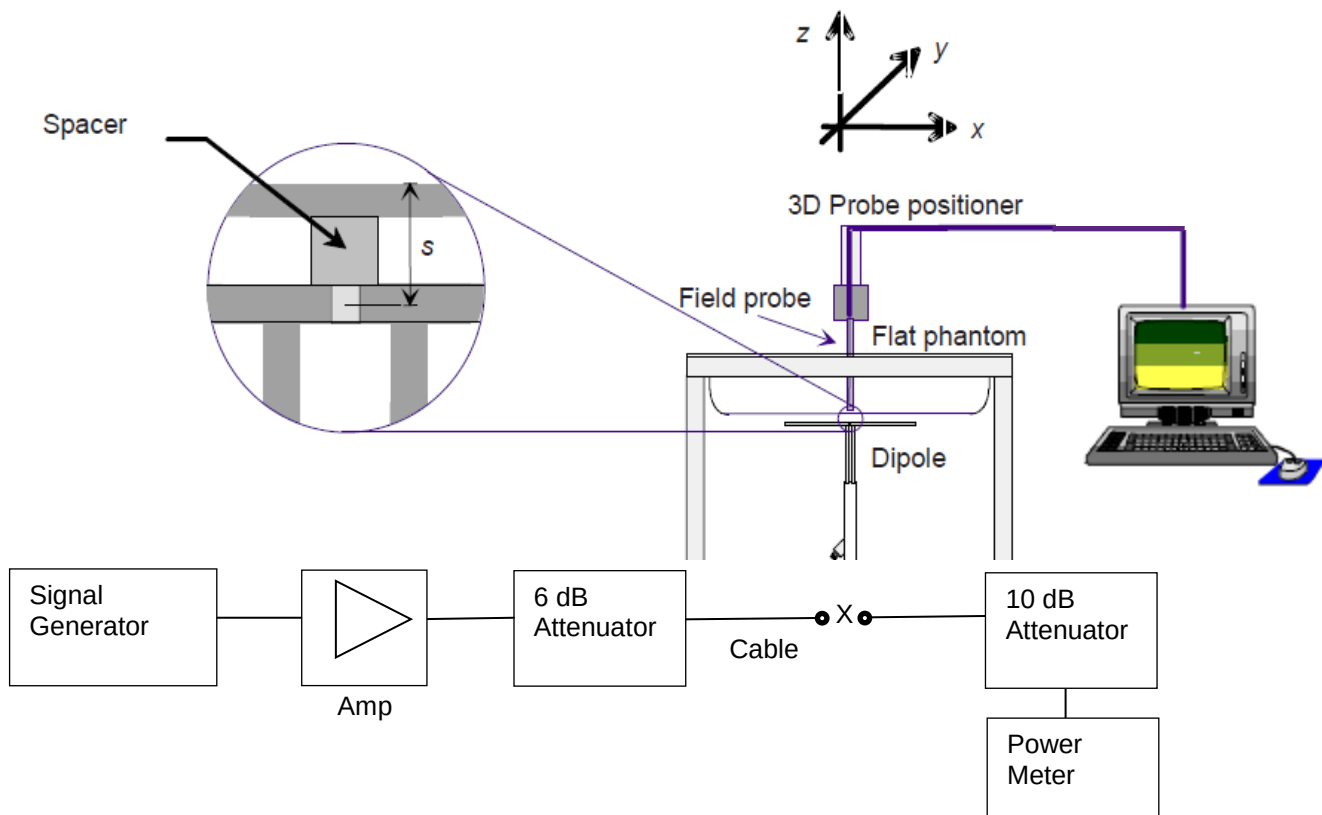
Within 24 hours of a measurement, then every 72 hours thereafter, Element used the system validation kit (calibrated reference dipole) to test whether the system was operating within its specifications. The validation was performed in the indicated bands by making SAR measurements of the reference dipole 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:

$s = 15\text{mm}$, $\pm 0.2\text{mm}$ for $300\text{MHz} \leq f \leq 1000\text{ MHz}$:

$s = 10\text{mm}$, $\pm 0.2\text{mm}$ for $1000\text{MHz} \leq f \leq 6000\text{MHz}$

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 2.1093:2020	FCC KDB 865664 D01 v01r04 FCC KDB 865664 D02 v01r02 FCC KDB 447498 D01 v06 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
5/20/20	HBBL600-10000V6 (1900 MHz)	20.00	10.00	3.91	2.02	39.10	20.20	41.40	21.5	-5.55	-6.05

SAR SYSTEM VERIFICATION



Tested By:	Marcelo Aguayo	Room Temperature (°C):	22°C
Date:	5/20/2020	Liquid Temperature (°C):	20.4°C
		Humidity (%RH):	41 %
		Bar. Pressure (mb):	1019 mb

1900MHz System Check Rev2 5-20-20

DUT: Dipole 1900 MHz D1900V2; Type: D1900V2; Serial: D1900V2 - SN:xxx

Communication System: UID 0, CW (0); Communication System Band: D1900 (1900.0 MHz); Frequency: 1900 MHz; Communication System PAR: 0 dB; PMF: 1

Medium parameters used: $f = 1900$ MHz; $\sigma = 1.466$ S/m; $\epsilon_r = 41.901$; $\rho = 1000$ kg/m³, Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASYS (IEEE/IEC/ANSI C63.19-2007)

DASY Configuration:

- Probe: EX3DV4 - SN3746; ConvF(7.59, 7.59, 7.59) @ 1900 MHz; Calibrated: 11/19/2019
 - Modulation Compensation:
- Sensor-Surface: 1.4mm (Mechanical Surface Detection), Sensor-Surface: 0mm (Fix Surface), $z = 31.0, 101.0$
- Electronics: DAE4 Sn1237; Calibrated: 2/4/2020
- Phantom: SAM with CRP; Type: SAM; Serial:
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

System Check/System Check/Zoom Scan (7x7x7) (5x5x7)/Cube 0: Measurement grid: $dx=8$ mm, $dy=8$ mm, $dz=5$ mm

Reference Value = 62.00 V/m; Power Drift = -0.25 dB

Peak SAR (extrapolated) = 7.44 W/kg

SAR(1 g) = 3.91 W/kg; SAR(10 g) = 2.02 W/kg (SAR corrected for target medium)

Maximum value of SAR (measured) = 6.19 W/kg

System Check/System Check/Area Scan (61x101x1): Interpolated grid: $dx=1.000$ mm, $dy=1.000$ mm

Maximum value of SAR (interpolated) = 6.21 W/kg

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

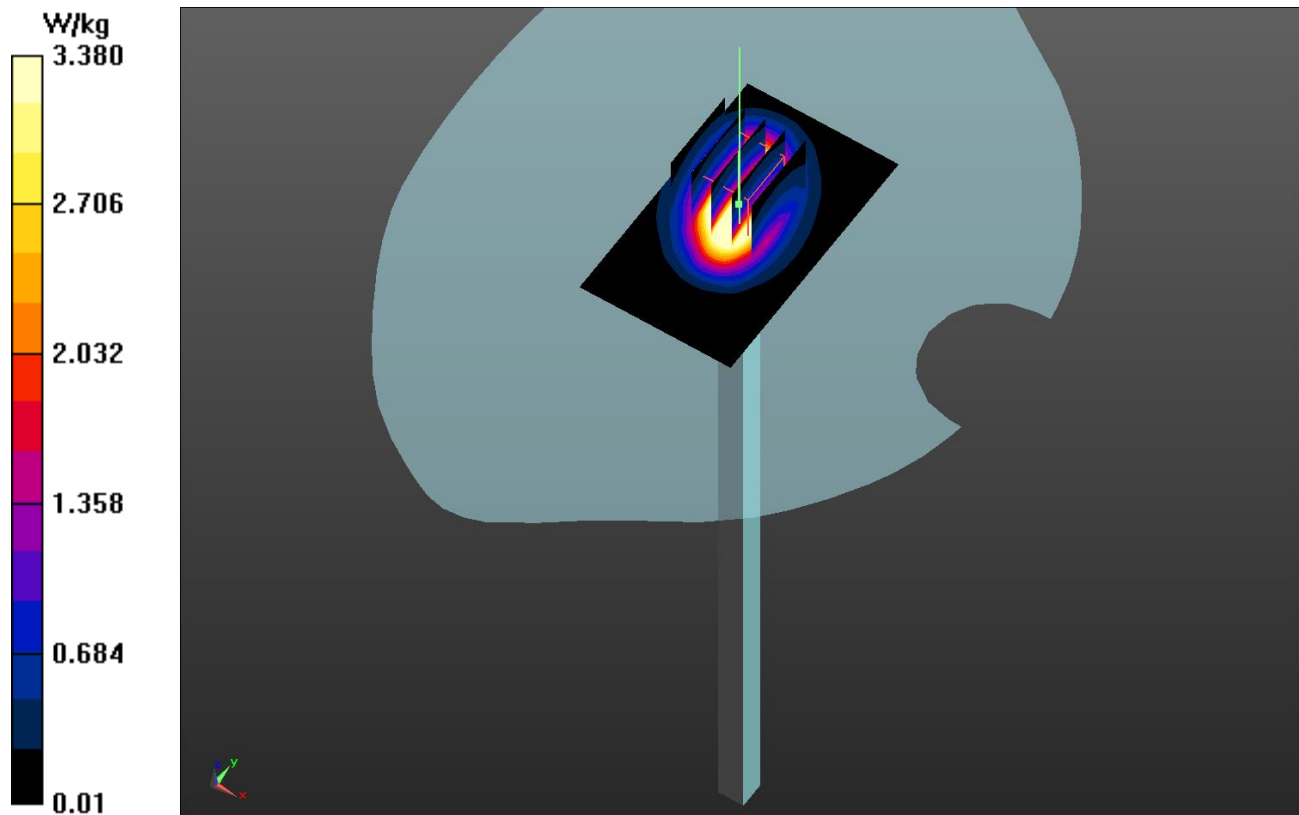
Maximum value of Total (measured) = 59.96 V/m

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

Maximum value of SAR (measured) = 5.27 W/kg

Approved By

SAR SYSTEM VERIFICATION



OUTPUT POWER

EUT:	Pro9 Headset	Work Order:	ELEM0101
Serial Number:	0321600040	Date:	2020/05/27
Customer:	Element Materials Technology	Temperature:	21.9 °C
Attendees:	None	Relative Humidity:	61% RH
Customer Project:	None	Bar. Pressure:	1012 mbar
Tested By:	Kyle McMullan	Job Site:	MN11
Power:	Battery	Configuration:	ELEM101-1

TEST SPECIFICATIONS

Specification:	Method:
FCC 2.1093:2020	FCC KDB 447498 D01 V06 FCC KDB 865664 D01 v01r04 FCC KDB 865664 D02 v01r02 IEEE Std 1528:2013

COMMENTS

1 dB of insertion loss declared by customer. This has been added to max measured OP value.

DEVIATIONS FROM TEST STANDARD

None

RESULTS

Channels tested per the formula given in KDB 447498 section 4.1 g)

$$N_c = \text{Round} \left\{ \left[100 \left(\frac{f_{\text{high}} - f_{\text{low}}}{f_c} \right) \right]^{0.5} \times (f_c / 100)^{0.2} \right\},$$

The value of f_{high} is 1930 MHz, the value of f_{low} is 1920 MHz, and f_c is 1925 MHz. The value of N_c is calculated as 1.

Antenna	Frequency (MHz)	Channel	Max Measured OP (dBm)	Declared Tune-Up OP (dBm)	Scaling Factor
Ant 0	1925	25	19.2	20	1.20
Ant 1	1925	25	18.9	20	1.29

SAR Scaling factor performed according to the equation:

$$\text{SAR scaling factor} = 10^{((\text{Tune-up Tolerance Power (dBm)} - \text{Measured Power (dBm)}) / 10)}$$

SAR TEST DATA



EUT:	Pro9 Headset	Work Order:	ELEM0101
Customer:	Element Materials Technology	Job Site:	MN11
Attendees:	None	Customer Project:	None

TEST SPECIFICATIONS

Specification:	Method:
FCC 2.1093:2020	FCC KDB 865664 D01 v01r04 FCC KDB 865664 D02 v01r02 FCC KDB 447498 D01 v06 IEEE Std 1528:2013

COMMENTS

None

DEVIATIONS FROM TEST STANDARD

None

RESULTS

Test Config.	Radio Type	Antenna	Transmit Frequency (MHz)	Transmit Channel	EUT Position	SAR Drift During Test (dB)	Measured 1g SAR Level (mW/g)	Measured 10g SAR Level (mW/g)	SAR Scaling Factor	Scaled 1g SAR Level (mW/g)	Scaled 10g SAR Level (mW/g)	Test#
Head	DECT	0	1925	25	Right	-0.32	0.0171	0.0037	1.2	0.0205	0.0044	1900 MHz Head RIGHT ANT 0
Head	DECT	1	1925	25	Right	-0.15	0.0022	0.0003	1.2	0.0026	0.0004	1900 MHz Head RIGHT ANT 1
Head	DECT	0	1925	25	Left	-0.01	0.0130	0.0066	1.29	0.0168	0.0085	1900 MHz Head LEFT ANT 0
Head	DECT	1	1925	25	Left	0.32	0.0028	0.0009	1.29	0.0036	0.0012	1900 MHz Head LEFT ANT 1

SAR TEST DATA



Tested By:	Kyle McMullan	Room Temperature (°C):	23°C
Date:	5/21/2020	Liquid Temperature (°C):	23.4°C
Serial Number:	0321600029	Humidity (%RH):	51%
Configuration:	ELEM0101-2	Bar. Pressure (mb):	1018 mb
Comments:	None		

1900 MHz Head LEFT ANT 0

DUT: Pro9 Headset; Type: Unknown; Serial: Q801950024

Communication System: UID 0, CW (0); Communication System Band: D1950 (1950.0 MHz); Frequency: 1925 MHz; Communication System PAR: 0 dB; PMF: 1

Medium parameters used (interpolated): $f = 1925$ MHz; $\sigma = 1.473$ S/m; $\epsilon_r = 40.919$; $\rho = 1000$ kg/m³

Phantom section: Left Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY Configuration:

- Probe: EX3DV4 - SN3746; ConvF(7.59, 7.59, 7.59) @ 1925 MHz; Calibrated: 11/19/2019
 - Modulation Compensation:
- Sensor-Surface: 1.4mm (Mechanical Surface Detection), $z = 1.0, 31.0$
- Electronics: DAE4 Sn1237; Calibrated: 2/4/2020
- Phantom: SAM with CRP; Type: SAM; Serial:
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

Head/Cheek/Reference scan (51x21x1): Interpolated grid: $dx=3.000$ mm, $dy=3.000$ mm

[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (interpolated) = 0.00135 W/kg

Head/Cheek/Zoom Scan (6x6x7)/Cube 0: Measurement grid: $dx=8$ mm, $dy=8$ mm, $dz=5$ mm

Reference Value = 2.951 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 0.0180 W/kg

SAR(1 g) = 0.013 W/kg; SAR(10 g) = 0.00666 W/kg (SAR corrected for target medium)

[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (measured) = 0.0155 W/kg

Head/Cheek/Area scan (41x41x1): Interpolated grid: $dx=1.500$ mm, $dy=1.500$ mm

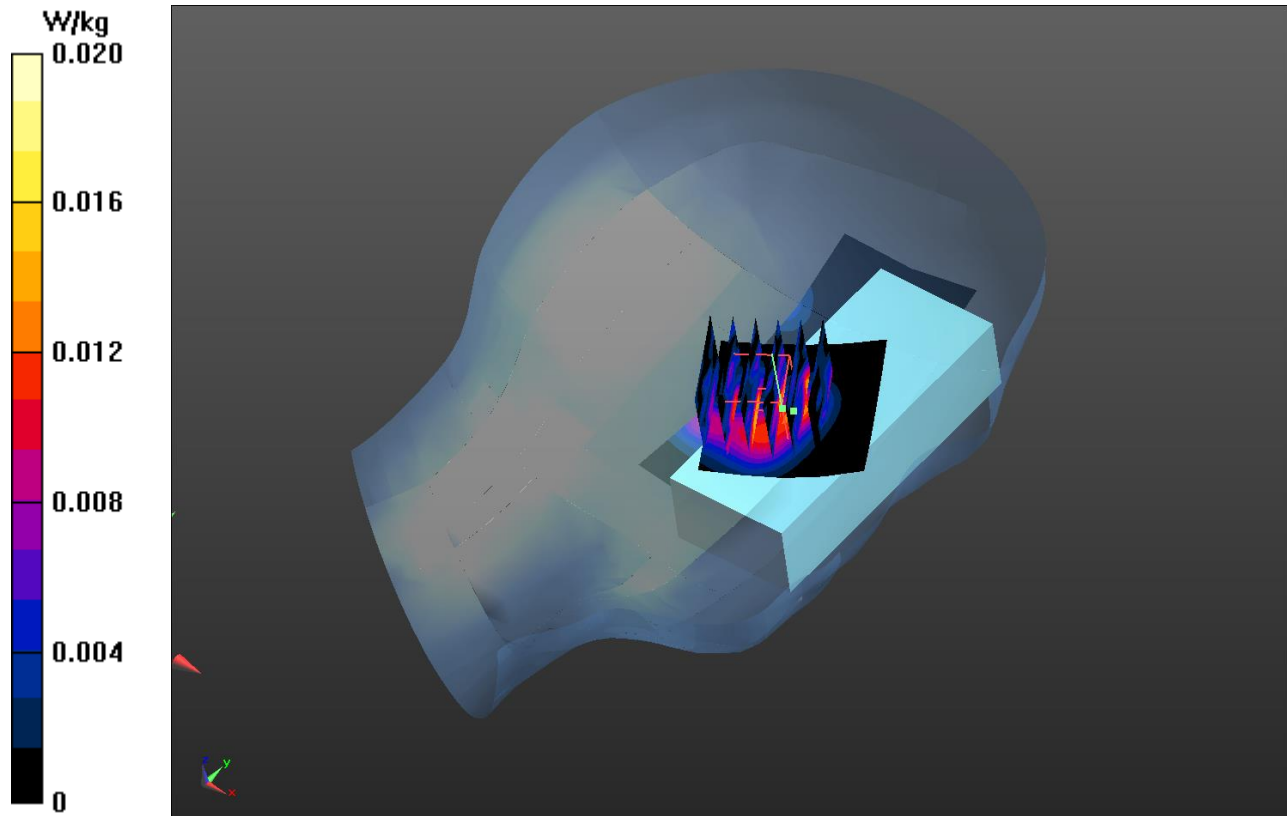
[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (interpolated) = 0.0232 W/kg

Approved By

SAR TEST DATA

1900 MHz Head LEFT ANT 0



SAR TEST DATA



Tested By:	Kyle McMullan	Room Temperature (°C):	23°C
Date:	5/21/2020	Liquid Temperature (°C):	23.4°C
Serial Number:	0321600029	Humidity (%RH):	51%
Configuration:	ELEM0101-2	Bar. Pressure (mb):	1018 mb
Comments:	None		

1900 MHz Head RIGHT ANT 0

DUT: Pro9 Headset; Type: Unknown; Serial: Q801950024

Communication System: UID 0, CW (0); Communication System Band: D1950 (1950.0 MHz); Frequency: 1925 MHz; Communication System PAR: 0 dB; PMF: 1

Medium parameters used (interpolated): $f = 1925$ MHz; $\sigma = 1.473$ S/m; $\epsilon_r = 40.919$; $\rho = 1000$ kg/m³

Phantom section: Right Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY Configuration:

- Probe: EX3DV4 - SN3746; ConvF(7.59, 7.59, 7.59) @ 1925 MHz; Calibrated: 11/19/2019
 - Modulation Compensation:
- Sensor-Surface: 1.4mm (Mechanical Surface Detection), $z = 1.0, 31.0$
- Electronics: DAE4 Sn1237; Calibrated: 2/4/2020
- Phantom: SAM with CRP; Type: SAM; Serial:
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

Head/Cheek/Reference scan (51x21x1): Interpolated grid: $dx=3.000$ mm, $dy=3.000$ mm

[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (interpolated) = 0.0217 W/kg

Head/Cheek/Zoom Scan (5x5x7)/Cube 0: Measurement grid: $dx=8$ mm, $dy=8$ mm, $dz=5$ mm

Reference Value = 3.832 V/m; Power Drift = -0.32 dB

Peak SAR (extrapolated) = 0.0270 W/kg

SAR(1 g) = 0.017 W/kg; SAR(10 g) = 0.00373 W/kg (SAR corrected for target medium)

[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (measured) = 0.0235 W/kg

Head/Cheek/Area scan (41x41x1): Interpolated grid: $dx=1.500$ mm, $dy=1.500$ mm

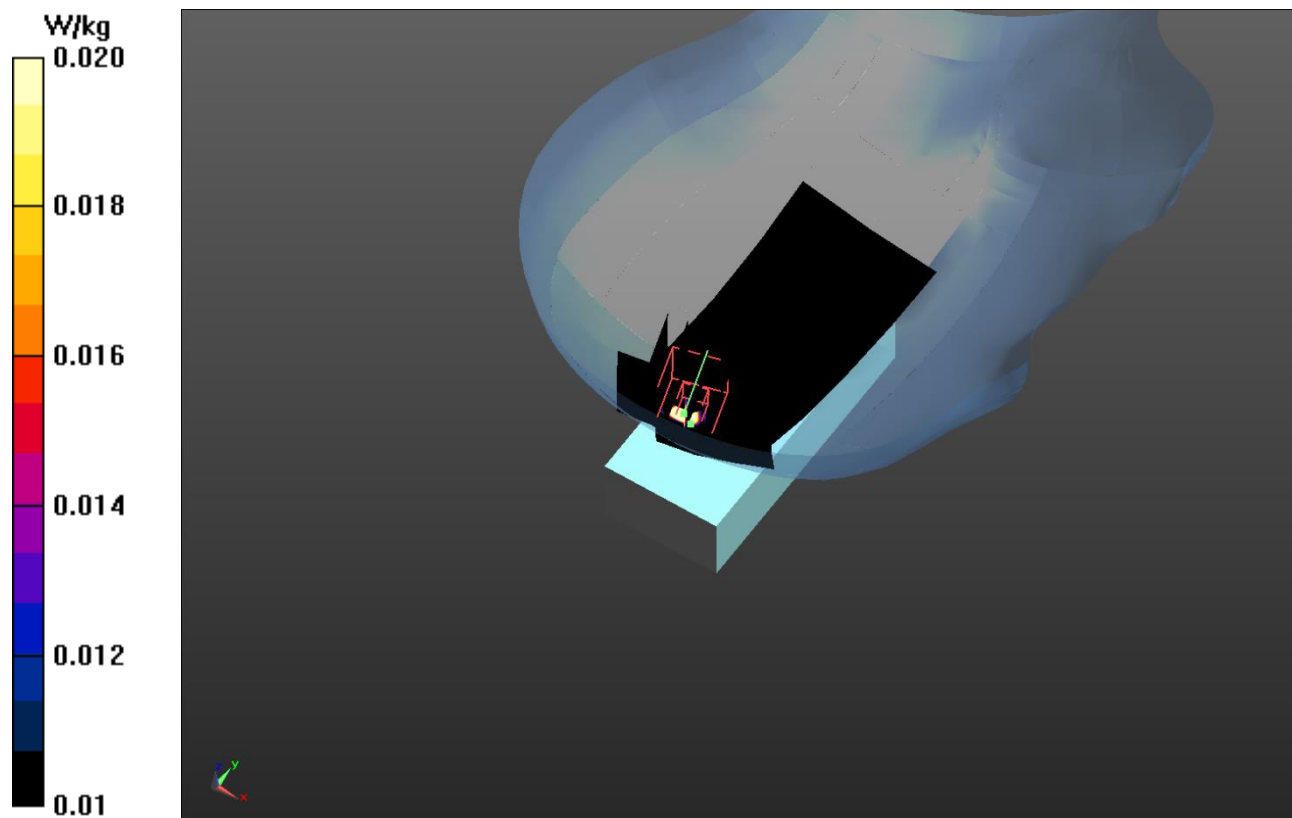
[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (interpolated) = 0.0399 W/kg

Approved By

SAR TEST DATA

1900 MHz Head RIGHT ANT 0



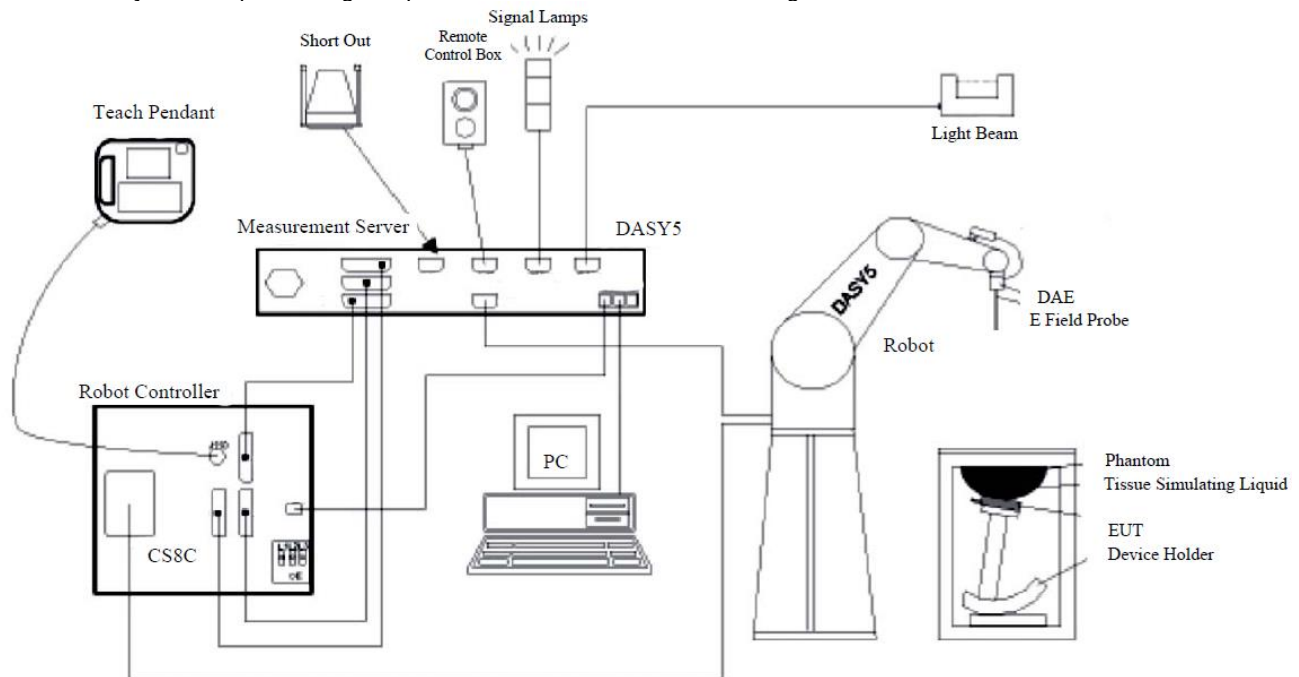
SYSTEM AND TEST SITE DESCRIPTION

SAR MEASUREMENT SYSTEM

Schmid & Partner Engineering AG, DASY52

Element 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.

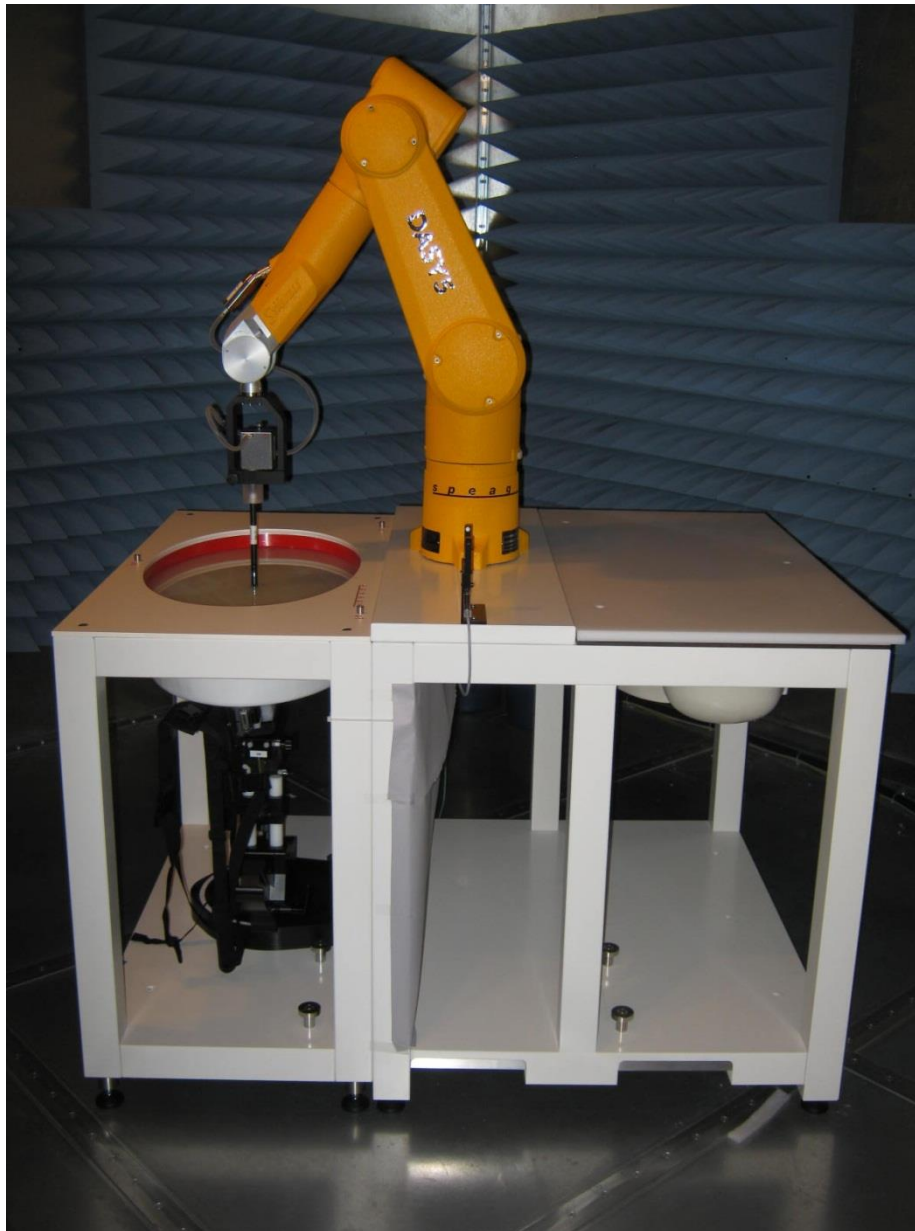
SYSTEM AND TEST SITE DESCRIPTION

TEST SITE

Element

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.



TEST EQUIPMENT

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Interval
Amplifier	Mini Circuits	ZHL-5W-2G-S+	TRZ	NCR ¹	0 mo
Amplifier	Mini Circuits	ZVE-3W-83+	TTA	NCR ¹	0 mo
Antenna - Dipole	SPEAG	D1900V2	ADO	11/13/2019	12 mo
Dielectric Assessment Kit	SPEAG	DAKS:200	IPR	4/25/2019	36 mo
Generator - Signal	Agilent	V2920A	TIH	NCR	0 mo
Power Sensor	Agilent	N8481A	SQN	7/13/2019	12 mo
Power Meter	Agilent	N1913A	SQL	7/13/2019	12 mo
Probe - Dielectric	SPEAG	DAKS-3.5	IPRA	11/12/2019	36 mo
Probe - SAR	SPEAG	EX3DV4	SAG	11/19/2019	12 mo
SAR - Tissue Test Solution	SPEAG	HBBL600-10000V6	SALN	At start of testing	
SAR Test System	Staeubli	DAYS5	SAK	NCR	0 mo
SAR Test System	SPEAG	QD OVA 001 BB	SAC	NCR	0 mo
Thermometer	Omega Engineering, Inc.	HH311	DUI	2/15/2018	36 mo
DAE	SPEAG	SD 000 D04 EJ	SAH	12/11/2019	12 mo
Phantom Twin SAM (Head)	SPEAG	QD000P40CC	SAB	None	None
Light Beam Unit	SPEAG	SE UKS 030 AA	SAD	None	None

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	



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 **Element**

Certificate No: **D1900V2-5d131_Nov19**

CALIBRATION CERTIFICATE

Object **D1900V2 - SN:5d131**

Calibration procedure(s) **QA CAL-05.v11
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz**

Calibration date: **November 13, 2019**

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 NRP	SN: 104778	03-Apr-19 (No. 217-02892/02893)	Apr-20
Power sensor NRP-Z91	SN: 103244	03-Apr-19 (No. 217-02892)	Apr-20
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02893)	Apr-20
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-19 (No. 217-02894)	Apr-20
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-19 (No. 217-02895)	Apr-20
Reference Probe EX3DV4	SN: 7349	29-May-19 (No. EX3-7349_May19)	May-20
DAE4	SN: 601	30-Apr-19 (No. DAE4-601_Apr19)	Apr-20
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Feb-19)	In house check: Oct-20
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-18)	In house check: Oct-20
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-19)	In house check: Oct-20

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

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

Issued: November 15, 2019



Accredited by the Swiss Accreditation Service (SAS)
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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

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:

- 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
- IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- 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
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

- 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	V52.10.3
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1900 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.0	1.40 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	41.3 $\pm$ 6 %	1.38 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	10.2 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	41.4 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	5.32 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	21.5 W/kg $\pm$ 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	54.2 $\pm$ 6 %	1.49 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	9.94 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	40.4 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.24 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.2 W/kg $\pm$ 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	$51.9 \Omega + 6.1 j\Omega$
Return Loss	- 24.1 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	$47.7 \Omega + 6.5 j\Omega$
Return Loss	- 23.1 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.203 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
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DASY5 Validation Report for Head TSL

Date: 13.11.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d131

Communication System: UID 0 - CW; Frequency: 1900 MHz

Medium parameters used: $f = 1900$ MHz; $\sigma = 1.38$ S/m; $\epsilon_r = 41.3$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.44, 8.44, 8.44) @ 1900 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.3(1513); SEMCAD X 14.6.13(7474)

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 = 111.0 V/m; Power Drift = 0.03 dB

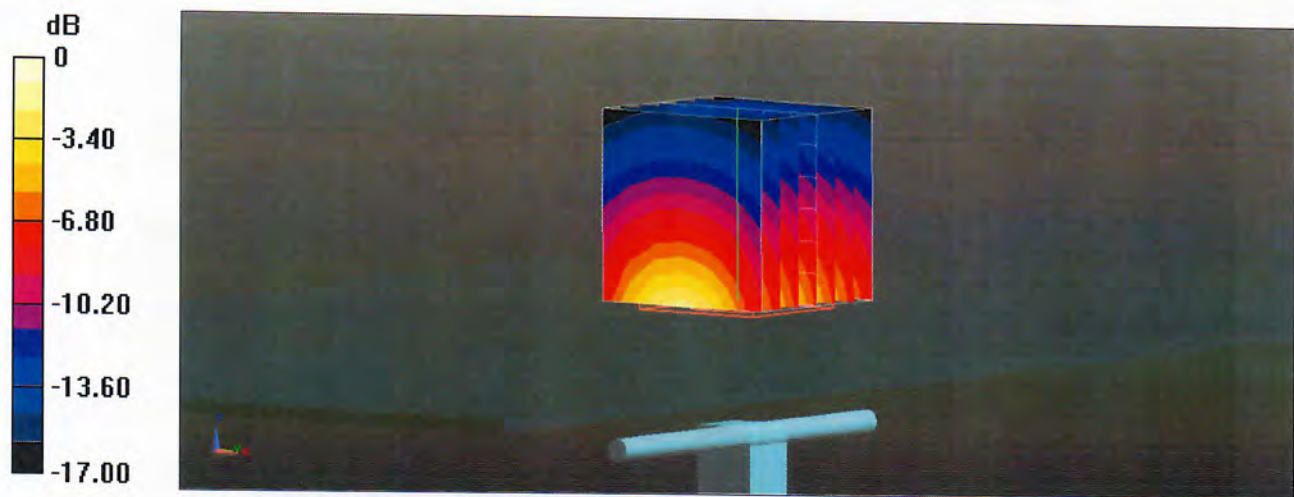
Peak SAR (extrapolated) = 18.9 W/kg

SAR(1 g) = 10.2 W/kg; SAR(10 g) = 5.32 W/kg

Smallest distance from peaks to all points 3 dB below = 9.5 mm

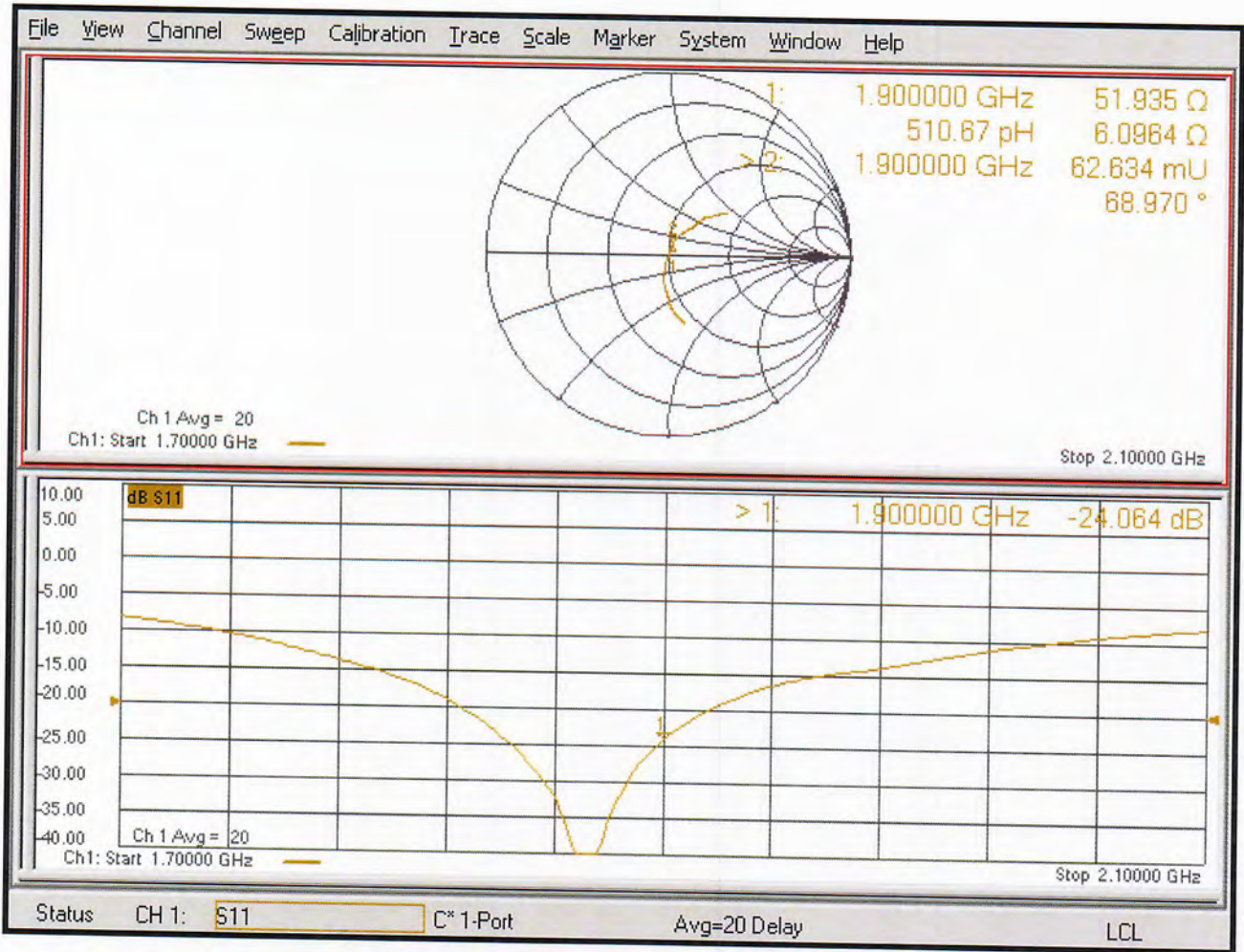
Ratio of SAR at M2 to SAR at M1 = 54.7%

Maximum value of SAR (measured) = 15.7 W/kg



0 dB = 15.7 W/kg = 11.96 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 13.11.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d131

Communication System: UID 0 - CW; Frequency: 1900 MHz

Medium parameters used: $f = 1900$ MHz; $\sigma = 1.49$ S/m; $\epsilon_r = 54.2$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.42, 8.42, 8.42) @ 1900 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.3(1513); SEMCAD X 14.6.13(7474)

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 = 105.4 V/m; Power Drift = -0.04 dB

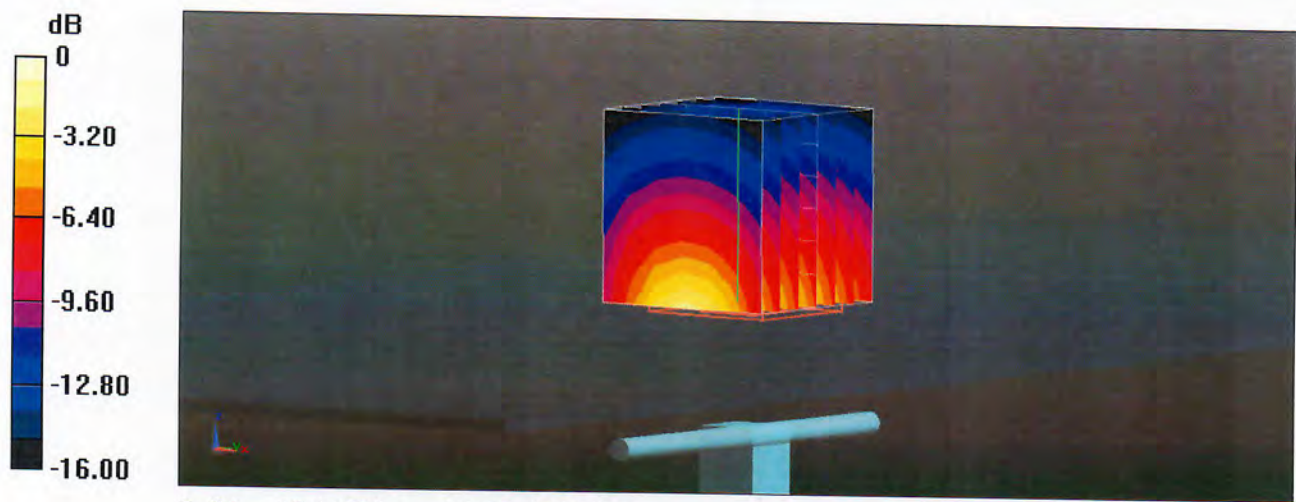
Peak SAR (extrapolated) = 17.8 W/kg

SAR(1 g) = 9.94 W/kg; SAR(10 g) = 5.24 W/kg

Smallest distance from peaks to all points 3 dB below = 9 mm

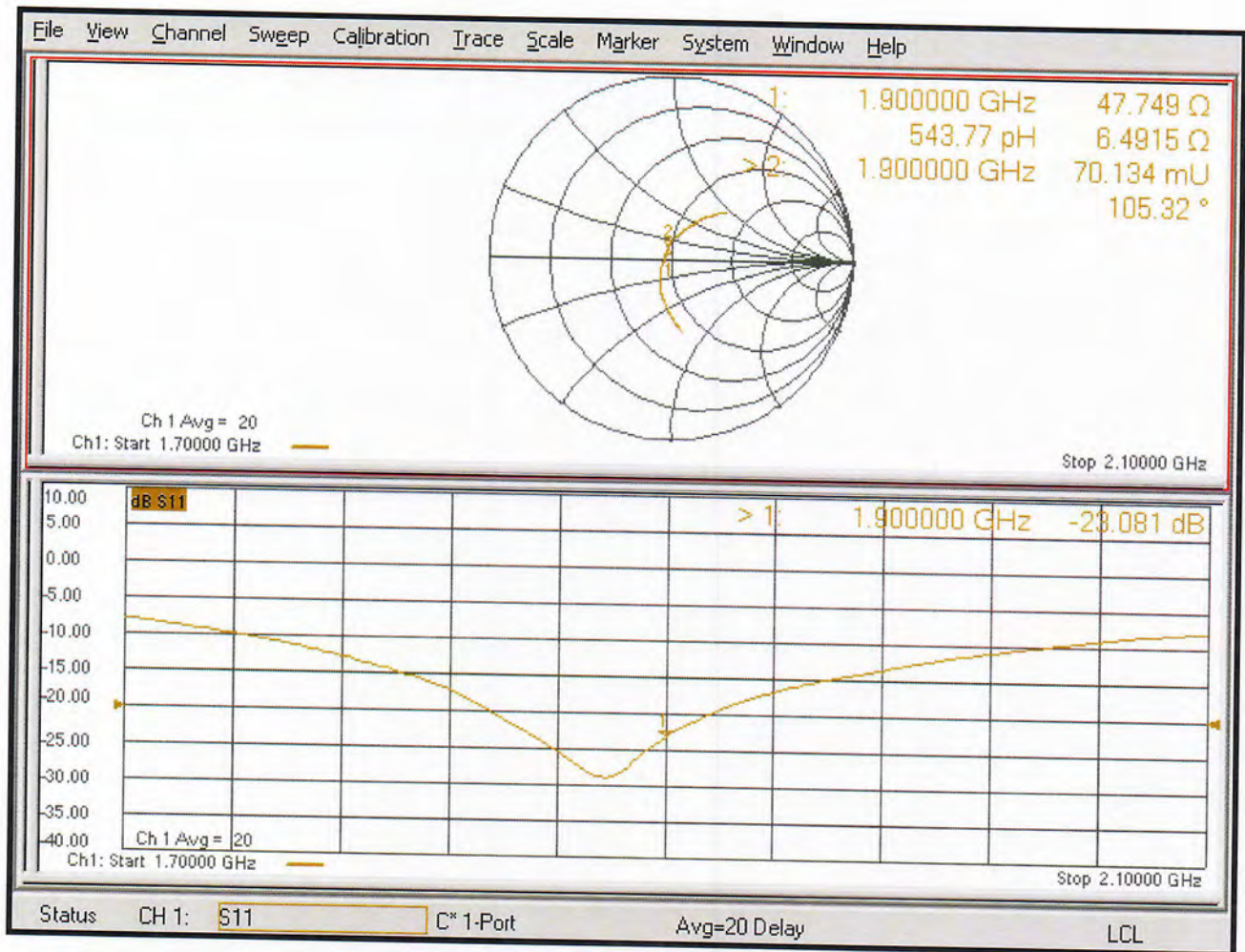
Ratio of SAR at M2 to SAR at M1 = 57%

Maximum value of SAR (measured) = 15.1 W/kg



0 dB = 15.1 W/kg = 11.79 dBW/kg

Impedance Measurement Plot for Body TSL



SAG

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S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **Element**

Certificate No: **EX3-3746_Nov19**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3746**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-12.v9, QA CAL-14.v5, QA CAL-23.v5,
 QA CAL-25.v7
 Calibration procedure for dosimetric E-field probes**

Calibration date: **November 19, 2019**

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 NRP	SN: 104778	03-Apr-19 (No. 217-02892/02893)	Apr-20
Power sensor NRP-Z91	SN: 103244	03-Apr-19 (No. 217-02892)	Apr-20
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02893)	Apr-20
Reference 20 dB Attenuator	SN: S5277 (20x)	04-Apr-19 (No. 217-02894)	Apr-20
DAE4	SN: 660	07-Oct-19 (No. DAE4-660_Oct19)	Oct-20
Reference Probe ES3DV2	SN: 3013	31-Dec-18 (No. ES3-3013_Dec18)	Dec-19
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-18)	In house check: Jun-20
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-18)	In house check: Jun-20
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-18)	In house check: Jun-20
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-18)	In house check: Jun-20
Network Analyzer E8358A	SN: US41080477	31-Mar-14 (in house check Oct-19)	In house check: Oct-20

	Name	Function	Signature
Calibrated by:	Jeton Kastrati	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	
			Issued: November 19, 2019

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



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Glossary:

TSL	tissue simulating liquid
NORM _{x,y,z}	sensitivity in free space
ConvF	sensitivity in TSL / NORM _{x,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., $\vartheta = 0$ 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:

- 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
- IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- 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
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}**: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not affect the E^2 -field uncertainty inside TSL (see below ConvF).
- NORM(f)_{x,y,z}** = NORM_{x,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.
- DCP_{x,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
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,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 $f \leq 800$ 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 NORM_{x,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 NORM_x (no uncertainty required).

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

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.31	0.27	0.21	$\pm 10.1 \%$
DCP (mV) ^B	101.0	106.7	100.8	

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Max dev.	Unc ^E (k=2)
0	CW	X	0.0	0.0	1.0	0.00	180.3	$\pm 3.5 \%$	$\pm 4.7 \%$
		Y	0.0	0.0	1.0		179.9		
		Z	0.0	0.0	1.0		194.2		

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

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	100.1
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

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)
450	43.5	0.87	10.25	10.25	10.25	0.15	1.30	± 13.3 %
750	41.9	0.89	9.32	9.32	9.32	0.43	1.02	± 12.0 %
835	41.5	0.90	9.08	9.08	9.08	0.57	0.80	± 12.0 %
900	41.5	0.97	8.82	8.82	8.82	0.47	0.89	± 12.0 %
1750	40.1	1.37	7.95	7.95	7.95	0.40	0.86	± 12.0 %
1900	40.0	1.40	7.59	7.59	7.59	0.29	0.86	± 12.0 %
2300	39.5	1.67	7.28	7.28	7.28	0.37	0.90	± 12.0 %
2450	39.2	1.80	7.02	7.02	7.02	0.40	0.90	± 12.0 %
2550	39.1	1.91	6.78	6.78	6.78	0.43	0.90	± 12.0 %
5200	36.0	4.66	5.15	5.15	5.15	0.40	1.80	± 13.1 %
5300	35.9	4.76	4.97	4.97	4.97	0.40	1.80	± 13.1 %
5500	35.6	4.96	4.55	4.55	4.55	0.40	1.80	± 13.1 %
5600	35.5	5.07	4.51	4.51	4.51	0.40	1.80	± 13.1 %
5800	35.3	5.27	4.49	4.49	4.49	0.40	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. Validity of ConvF assessed at 6 MHz is 4-9 MHz, and ConvF assessed at 13 MHz is 9-19 MHz. 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)
450	56.7	0.94	10.37	10.37	10.37	0.08	1.20	± 13.3 %
750	55.5	0.96	9.30	9.30	9.30	0.45	0.87	± 12.0 %
835	55.2	0.97	9.06	9.06	9.06	0.51	0.80	± 12.0 %
900	55.0	1.05	8.96	8.96	8.96	0.38	0.80	± 12.0 %
1750	53.4	1.49	7.67	7.67	7.67	0.41	0.86	± 12.0 %
1900	53.3	1.52	7.44	7.44	7.44	0.40	0.86	± 12.0 %
2300	52.9	1.81	7.42	7.42	7.42	0.46	0.90	± 12.0 %
2450	52.7	1.95	7.33	7.33	7.33	0.36	0.90	± 12.0 %
2550	52.6	2.09	7.13	7.13	7.13	0.35	0.96	± 12.0 %
5200	49.0	5.30	4.28	4.28	4.28	0.50	1.90	± 13.1 %
5300	48.9	5.42	4.19	4.19	4.19	0.50	1.90	± 13.1 %
5500	48.6	5.65	3.78	3.78	3.78	0.50	1.90	± 13.1 %
5600	48.5	5.77	3.70	3.70	3.70	0.50	1.90	± 13.1 %
5800	48.2	6.00	3.77	3.77	3.77	0.50	1.90	± 13.1 %

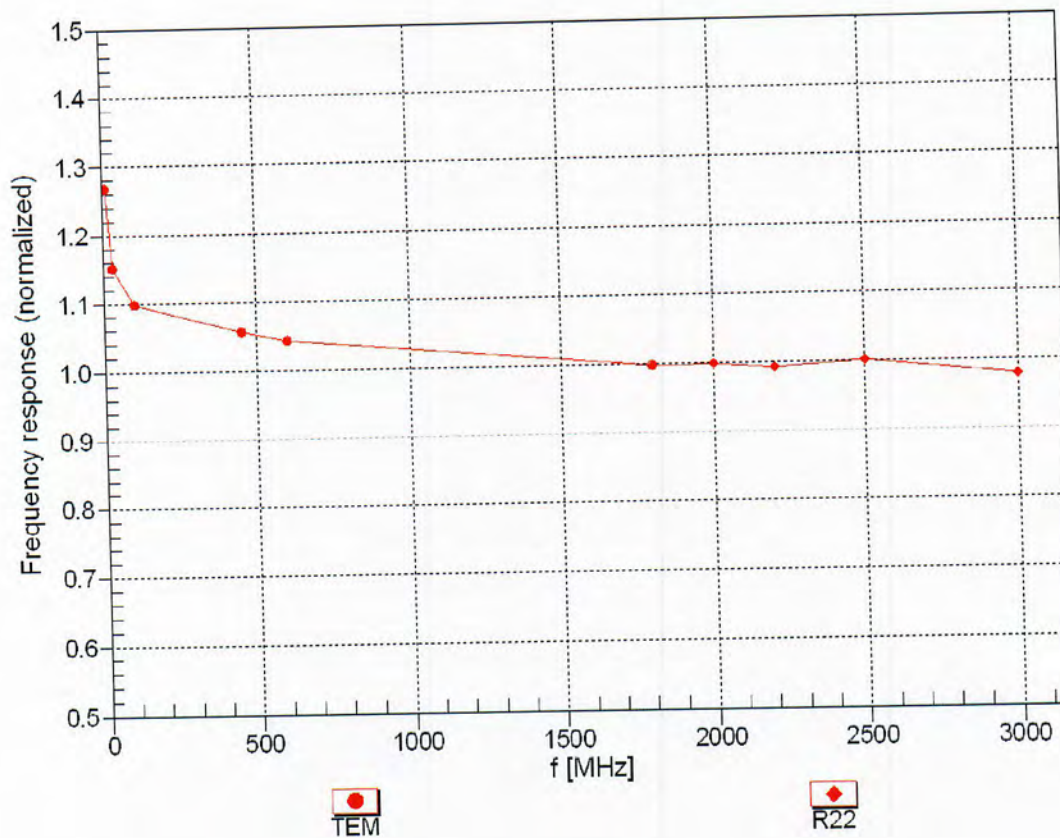
^C Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4-9 MHz, and ConvF assessed at 13 MHz is 9-19 MHz. 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

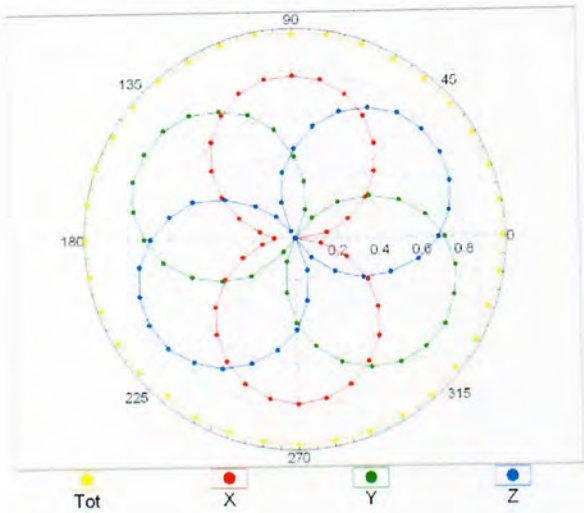
(TEM-Cell: ifi110 EXX, Waveguide: R22)



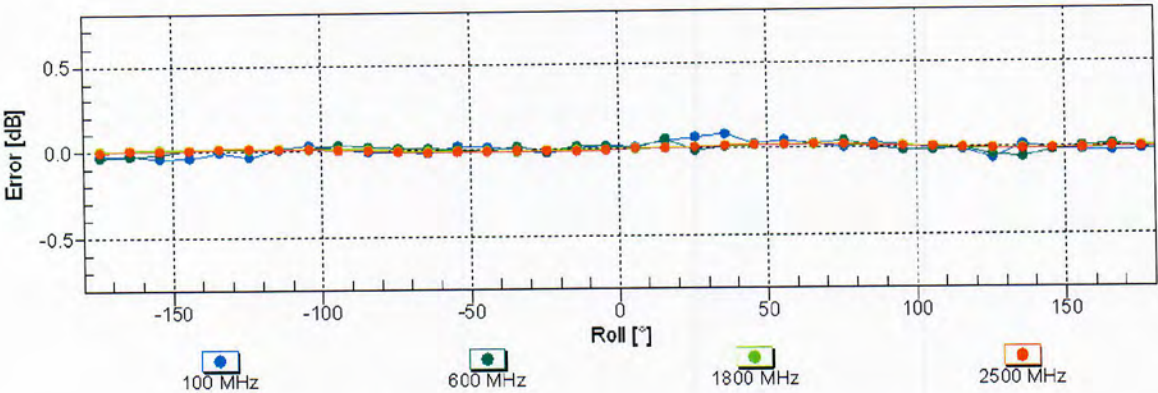
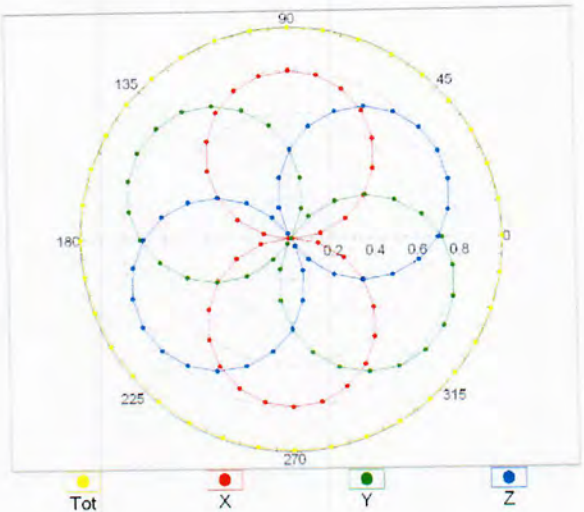
Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

Receiving Pattern (ϕ), $\theta = 0^\circ$

f=600 MHz,TEM

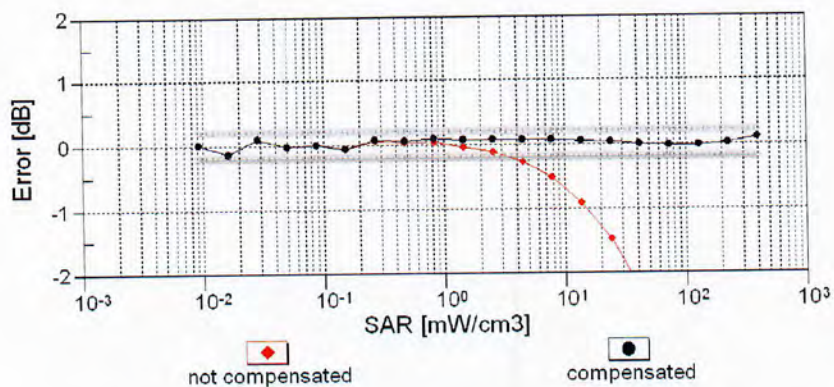
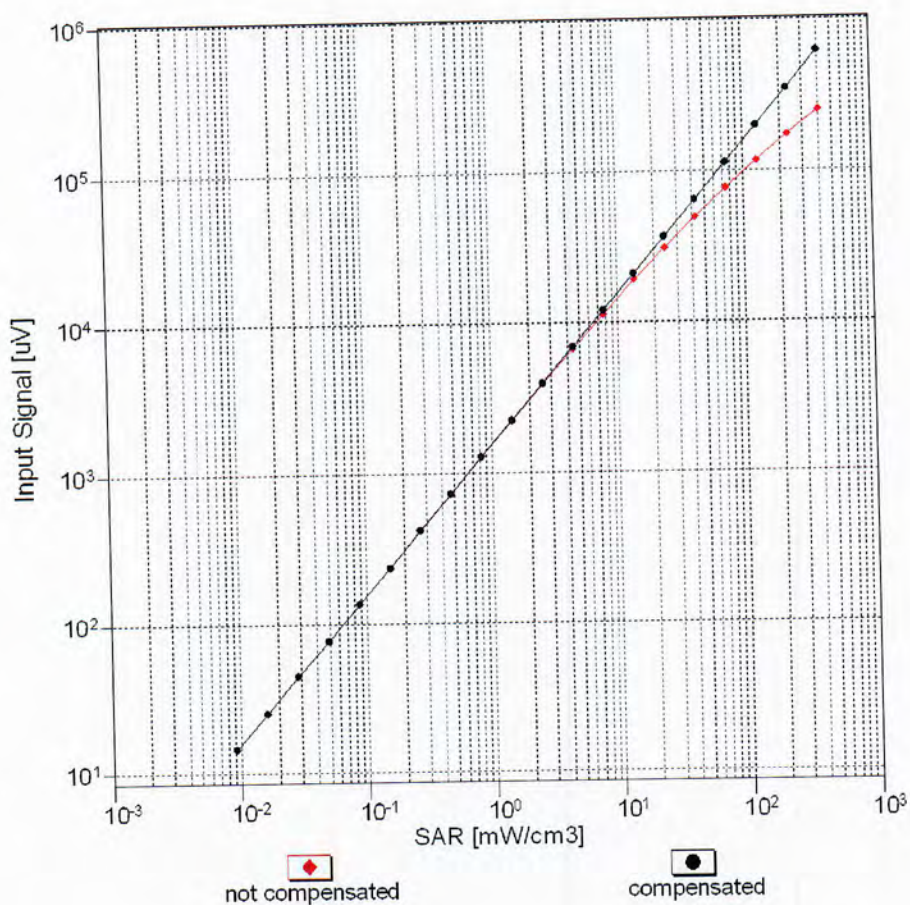


f=1800 MHz,R22



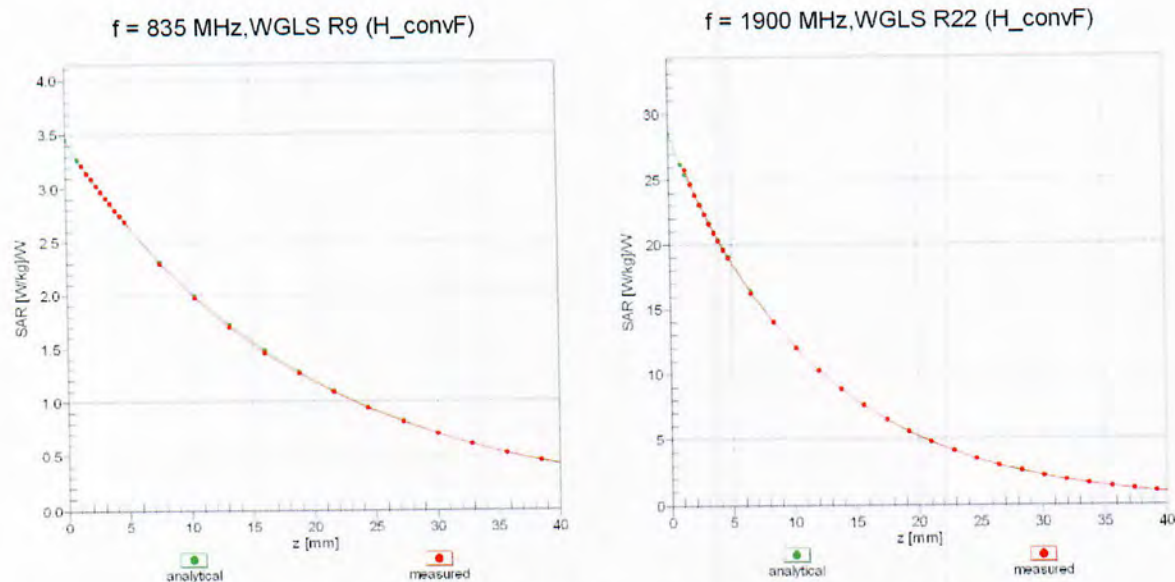
Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

Dynamic Range f(SAR_{head}) (TEM cell , f_{eval}= 1900 MHz)



Uncertainty of Linearity Assessment: $\pm 0.6\%$ (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, θ), $f = 900 \text{ MHz}$

