

SAR TEST REPORT



The following samples were submitted and identified on behalf of the client as:

Equipment Under Test	Dasloop G2S Smart Helmet
Model No.	Dasloop G2S
Company Name	BeelInventor Limited
Company Address	FLAT/RM 220, 2/F ,CORE BUILDING 2, No 1 SCIENCE PARK WEST AVENUE, SHATIN, NT
Standards	CNS14958-1: Dec. 05, 2005 / CNS14959: Dec. 05, 2005 IEC 62209-2:2010+AMD1:2019 CSV
Date of Receipt	Aug. 24, 2021
Date of Test(s)	Oct. 07, 2021
Date of Issue	Dec. 16, 2021

In the configuration tested, the EUT complied with the standards specified above.

Remarks:

This report details the results of the testing carried out on one sample, the results contained in this test report do not relate to other samples of the same product. The manufacturer should ensure that all products in series production are in conformity with the product sample detailed in this report.

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Signed on behalf of SGS**專案管理****蔡建邦****Date: Dec. 16, 2021****副理****葉俞鋒****Date: Dec. 16, 2021**

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Revision History

Report Number	Revision	Description	Issue Date	Revised By	Remark
E5/2021/80019	Rev.00	Initial creation of document	Oct. 14, 2021	Ruby Ou	*
E5/2021/80019	Rev.01	Add battery info.	Oct. 25, 2021	Ruby Ou	*
E5/2021/80019	Rev.02	Modify company address	Dec. 09, 2021	Ruby Ou	*
E5/2021/80019	Rev.03	Modify Gain	Dec. 16, 2021	Ruby Ou	

Note:

1. The mark " * " is the revised version of the report due to comments submitted by the certification.

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1. General Information

1.1 Testing Laboratory

SGS Taiwan Ltd. Central RF Lab	
No. 2, Keji 1st Rd., Guishan Township, Taoyuan County, 33383, Taiwan	
Tel	+886-2-2299-3279
Fax	+886-2-2298-0488
Internet	http://www.tw.sgs.com/

1.2 Details of Applicant

Company Name	BeelInventor Limited
Company Address	FLAT/RM 220, 2/F ,CORE BUILDING 2, No 1 SCIENCE PARK WEST AVENUE, SHATIN, NT

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1.3 Description of EUT

EUT Name	Dasloop G2S Smart Helmet		
Model No.	Dasloop G2S		
Battery	Power source: Powered by Lithium battery DC 3.6V lithium battery - Panasonic Group, SANYO Electric Co., Ltd., model NCR18650PF, 3.6Vdc, rated capacity:2700mAh ; typical capacity:2900mAh.		
Mode of Operation	☒ LTE FDD ☒ Bluetooth		
Duty Cycle	LTE NB-IoT FDD	1	
	Bluetooth	1	
TX Frequency Range (MHz)	LTE NB-IoT FDD Band 3	1710	— 1785
	LTE NB-IoT FDD Band 8	885	— 915
	Bluetooth	2402	— 2480
Channel Number (ARFCN)	LTE NB-IoT FDD Band 3	19207	— 19943
	LTE NB-IoT FDD Band 8	21507	— 21793
	Bluetooth	0	— 78

Max. SAR (10 g) (Unit: W/Kg)			
Band	Position	Channel	Measured
Band 3	Head	19949	0.012

Antenna Information:

BLE

Antenna Type	Brand	Antenna Model No.	Freq.(MHz)	Peak Antenna Gain (dBi)
Chip	GLEAD ELECTRONICS	LA52H2450-A36	2402-2480	4.97

WWAN

	Antenna Type	Brand	Antenna Model No.	Peak Antenna Gain (dBi)
LTE Band 3	FPC Antenna	Quectel	EG-UFL137PCB-4989	3.45
LTE Band 8				2.90

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NB-IOT Band 3 / Band 8 conducted power table:

NB-IOT Band 3						
Sub-carrier Spacing (KHz)	Modulation	RB Size	RB Offset	Power Low Ch. / Freq.	Power Middle Ch. / Freq.	Power High Ch. / Freq.
Channel				19201	19575	19949
Frequency (MHz)				1710.1	1747.5	1784.9
3.75	BPSK	1	0	21.84	22.06	22.49
3.75	BPSK	1	47	21.85	22.07	22.57
3.75	QPSK	1	48	21.86	22.01	22.59
3.75	QPSK	1	49	21.82	22.00	22.53
15	BPSK	1	50	21.68	21.94	22.33
15	BPSK	1	51	21.60	21.80	22.26
15	QPSK	1	52	21.71	21.77	22.26
15	QPSK	1	53	21.69	21.94	22.29
15	QPSK	12	54	19.33	19.70	20.19

NB-IOT Band 8						
Sub-carrier Spacing (KHz)	Modulation	RB Size	RB Offset	Power Low Ch. / Freq.	Power Middle Ch. / Freq.	Power High Ch. / Freq.
Channel				21451	21625	21799
Frequency (MHz)				880.1	897.5	914.9
3.75	BPSK	1	0	22.75	22.24	21.58
3.75	BPSK	1	47	22.69	22.25	21.55
3.75	QPSK	1	0	22.64	22.22	21.40
3.75	QPSK	1	47	22.67	22.19	21.35
15	BPSK	1	0	22.57	22.13	21.41
15	BPSK	1	11	22.50	22.04	21.33
15	QPSK	1	0	22.56	22.16	21.50
15	QPSK	1	11	22.68	22.18	21.41
15	QPSK	12	0	20.63	19.90	19.38

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Bluetooth conducted power table:

Mode	Channel	Frequency (MHz)	GFSK
			Average Output Power (dBm)
Bluetooth 4.0_1M	CH 00	2402	1.13
	CH 19	2440	1.32
	CH 39	2480	1.89
Mode	Channel	Frequency (MHz)	GFSK
			Average Output Power (dBm)
Bluetooth 4.0_2M	CH 00	2402	0.89
	CH 19	2440	1.21
	CH 39	2480	1.58

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1.4 Test Environment

Ambient Temperature: $22^{\circ}\pm 2^{\circ}$ C

Tissue Simulating Liquid: $22^{\circ}\pm 2^{\circ}$ C

1.5 Operation Description

1. Measurements are performed respectively on the lowest, middle and highest channels of the operating band(s). The EUT is set to maximum power level during all tests, and at the beginning of each test the battery is fully charged.
2. During the SAR testing, the DASY 5 system checks power drift by comparing the e-field strength of one specific location measured at the beginning with that measured at the end of the SAR testing.
3. LTE NB-IoT was performed at the highest time-averaged output power channel firstly, and the remaining required channels at the worst SAR position were tested.

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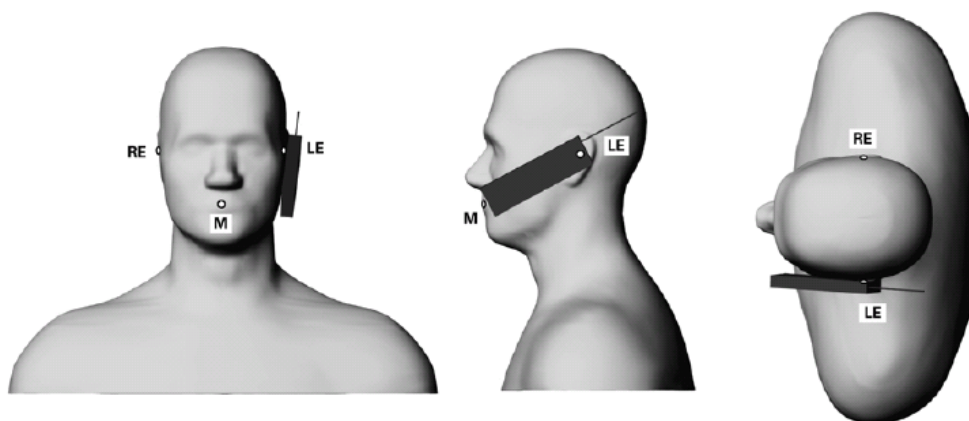
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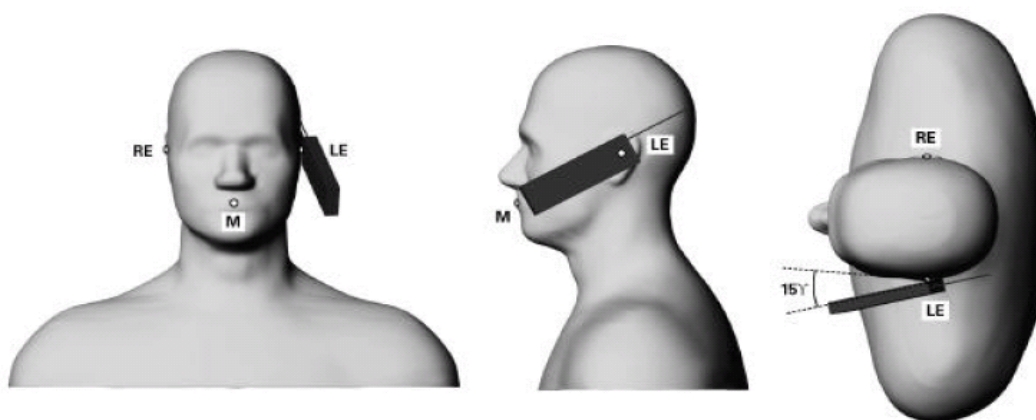
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1.6 Positioning Procedure



Phone position 1, “cheek” or “touch” position. The reference points for the right ear (RE), left ear (LE) and mouth (M), which define the reference plane for phone positioning.



Phone position 2, “tilted position.” The reference points for the right ear (RE), left ear (LE) and mouth (M), which define the reference plane for phone positioning.

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Cheek/Touch Position:

The handset was brought toward the mouth of the head phantom by pivoting against the ear reference point until any point of the mouthpiece or keypad touched the phantom.

Ear/Tilt Position:

With the phone aligned in the Cheek/Touch position, the handset was tilted away from the mouth with respect to the test device reference point by 15 degrees.

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1.7 The SAR Measurement System

A block diagram of the SAR measurement System is given in Fig. a. This SAR Measurement System uses a Computer-controlled 3-D stepper motor system (SPEAG DASY 5 professional system). The model EX3DV4 field probe is used to determine the internal electric fields. The SAR can be obtained from the equation $SAR = \sigma (|E|^2) / \rho$ where σ and ρ are the conductivity and mass density of the tissue-simulant.

The DASY 5 system for performing compliance tests consists of the following items:

1. A standard high precision 6-axis robot (Staubli RX family) with controller, teach pendant and software. An arm extension is for accommodating the data acquisition electronics (DAE).
2. A dosimetric probe, i.e., an isotropic E-field probe optimized and calibrated for usage intissue simulating liquid. The probe is equipped with an optical surface detector system.
3. 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.

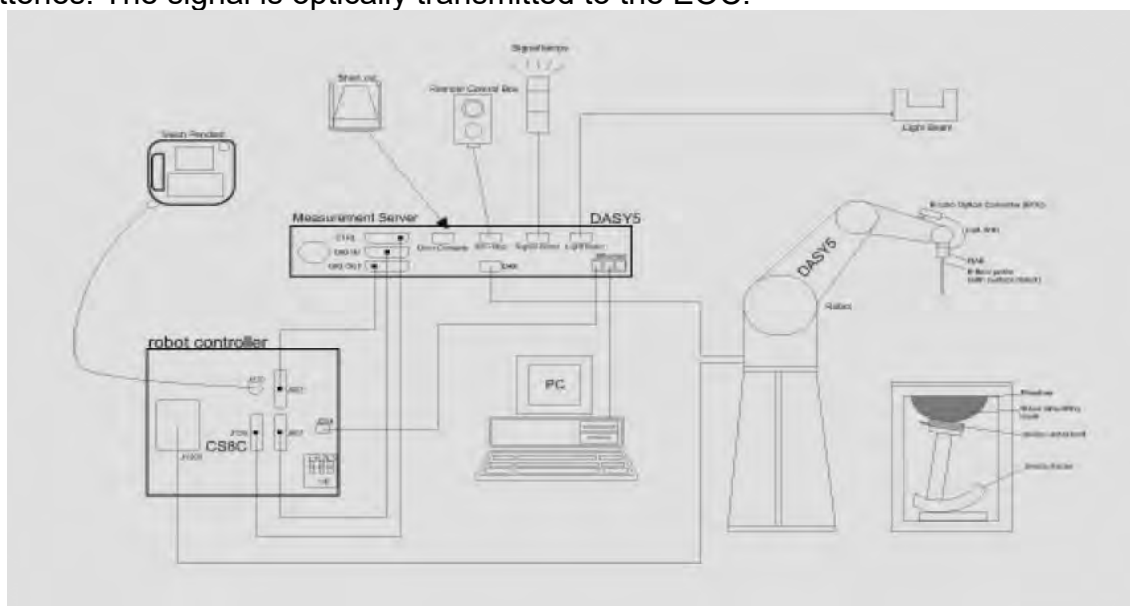


Fig. a The block diagram of SAR system

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4. The Electro-optical converter (EOC) performs the conversion between optical and electrical of the signals for the digital communication to the DAE and for the analog signal from the optical surface detection. The EOC is connected to the measurement server.
5. 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.
6. A probe alignment unit which improves the (absolute) accuracy of the probe positioning.
7. A computer operating Windows 7.
8. DASY 5 software.
9. Remote control with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
10. The SAM twin phantom enabling testing left-hand and right-hand usage.
11. The device holder for handheld mobile phones.
12. Tissue simulating liquid mixed according to the given recipes.
13. Validation dipole kits allowing to validate the proper functioning of the system.

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1.8 System Components

EX3DV4 E-Field Probe

Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)	
Calibration	Basic Broad Band Calibration in air Conversion Factors (CF) for HSL 750/900/1750/2000/2600/3300/3500 Additional CF for other liquids and frequencies upon request	
Frequency	10 MHz to > 6 GHz	
Directivity	± 0.3 dB in HSL (rotation around probe axis) ± 0.5 dB in tissue material (rotation normal to probe axis)	
Dynamic Range:	10 µW/g to > 100 mW/g Linearity: ± 0.2 dB (noise: typically < 1 µW/g)	
Dimensions	Tip diameter: 2.5 mm	
Application	High precision dosimetric measurements in any exposure scenario (e.g., very strong gradient fields). Only probe which enables compliance testing for frequencies up to 6 GHz with precision of better 30%.	

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PHANTOM

Model	Twin SAM	
Construction	The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 and IEC 62209. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points with the robot.	
Shell Thickness	2 ± 0.2 mm	
Filling Volume	Approx. 25 liters	
Dimensions	Height: 850 mm; Length: 1000 mm; Width: 500 mm	

DEVICE HOLDER

Construction	In combination with the Twin SAM Phantom V4.0/V4.0C or Twin SAM, the Mounting Device (made from POM) enables the rotation of the mounted transmitter in spherical coordinates, whereby the rotation point is the ear opening. The devices can be easily and accurately positioned according to IEC, IEEE, CENELEC, FCC or other specifications. The device holder can be locked at different phantom locations (left head, right head, flat phantom).	 Device Holder
--------------	--	--

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1.9 SAR System Verification

The microwave circuit arrangement for system verification is sketched in Fig. b. The daily system accuracy verification occurs within the flat section of the SAM phantom. A SAR measurement was performed to see if the measured SAR was within $\pm 10\%$ from the target SAR values. These tests were done at 900/1750/2450 MHz. The tests were conducted on the same days as the measurement of the DUT. The obtained results from the system accuracy verification are displayed in the table 1 (SAR values are normalized to 1W forward power delivered to the dipole). During the tests, the liquid depth above the ear reference points was above 15 cm in all the cases. It is seen that the system is operating within its specification, as the results are within acceptable tolerance of the reference values.

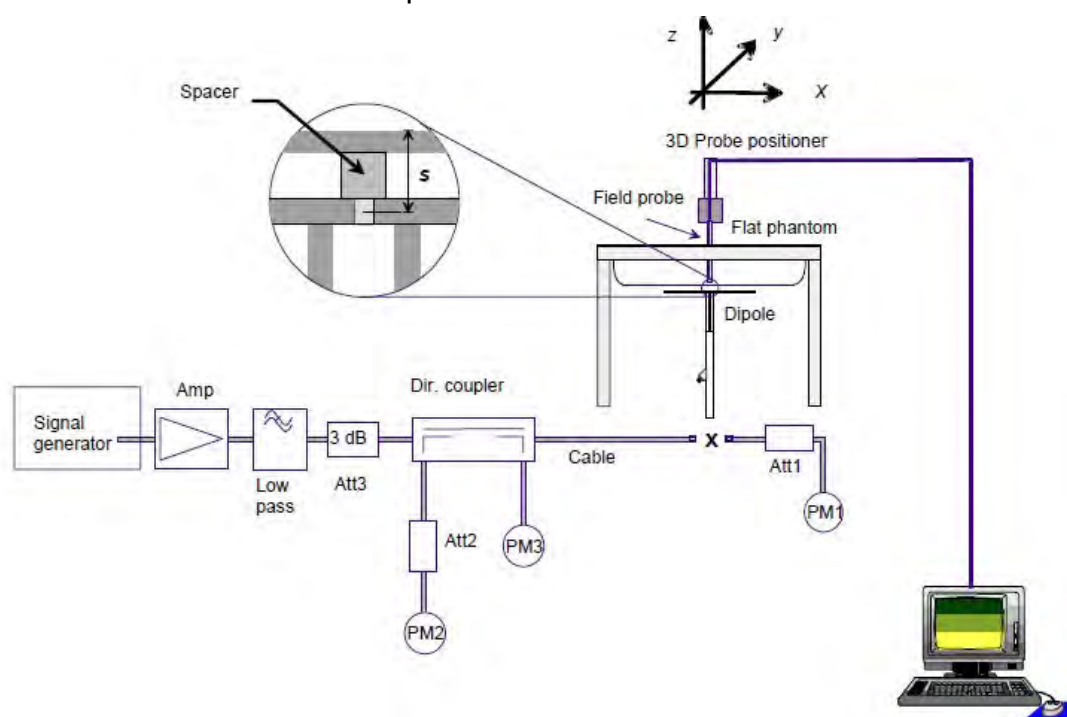


Fig. b The block diagram of system verification

Validation Kit	S/N	Frequency (MHz)	1W Target 10g-SAR (W/kg)	Pin=250mW Measured 10g-SAR (W/kg)	Normalized to 1W 10g-SAR (W/kg)	Deviation (%)	Limit	Measurement Date
D900V2	178	900	7.06	1.69	6.76	-4.25	± 10%	Oct. 07, 2021
D1750V2	1111	1750	19.00	4.79	19.16	0.84	± 10%	Oct. 07, 2021

Table 1. Results of system validation

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1.10 Tissue Simulant Fluid for the Frequency Band

The dielectric properties for this Head-simulant fluid were measured by using the SPEAG Dielectric Assessment Kit (DAKS3.5).

All dielectric parameters of tissue simulates were measured within 24 hours of SAR measurements. The depth of the tissue simulant in the ear reference point of the phantom was at least 15 cm during all tests. (Fig. 2)

Measured Frequency (MHz)	Liquid Temp. (°C)	Target Dielectric Constant, ϵ_r	Target Conductivity, σ (S/m)	Measured Dielectric Constant, ϵ_r	Measured Conductivity, σ (S/m)	% dev ϵ_r	% dev σ	Limit	Measurement Date
900	21.8	41.500	0.970	41.332	0.955	-0.40%	-1.55%	± 5%	Oct. 07, 2021
1750	21.8	40.100	1.370	39.911	1.366	-0.47%	-0.29%	± 5%	Oct. 07, 2021

Table 2. Dielectric Parameters of Tissue Simulant Fluid

The composition of the brain tissue simulating liquid for 900/1750/2450 band:

Frequency (MHz)	Mode	Ingredient						Total amount
		DGMBE	Water	Salt	Preventol D-7	Cellulose	Sugar	
900	Head	—	532.98 g	18.3 g	2.4 g	3.2 g	766.0 g	1.3L(Kg)
1750	Head	444.52 g	552.42 g	3.06 g	—	—	—	1.0L(Kg)

Table 3. Recipes for tissue simulating liquid

1.11 Test Standards and Limits

According to CNS14958-1 / CNS14959, the SAR limit is 2.0 W/Kg (10 g)

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2. Summary of Results

NB-IOT Band 3 / Band 8

Band	Position	Distance (mm)	CH	Freq. (MHz)	Measured Avg. Power (dBm)	Averaged SAR over 10g (W/kg)	Plot page
						Measured	
Band 3	Head	40	19201	1710.1	21.86	0.010	-
	Head	40	19575	1747.5	22.01	0.010	-
	Head	40	19949	1784.9	22.59	0.012	19
Band 8	Head	40	21451	880.1	22.75	0.004	20
	Head	40	21625	897.5	22.24	0.003	-
	Head	40	21799	914.9	21.58	0.003	-

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3. Instruments List

Brand	Device	Type	Serial number	Date of last calibration	Date of next calibration
SPEAG	Dosimetric E-Field Probe	EX3DV4	7509	Apr.26,2021	Apr.25,2022
SPEAG	System Validation Dipole	D900V2	178	Apr.15,2021	Apr.14,2022
		D1750V2	1111	Apr.14,2021	Apr.13,2022
SPEAG	Data acquisition Electronics	DAE4	1336	Aug.20,2021	Aug.19,2022
SPEAG	Software	DASY 52 V52.10.4	N/A	Calibration not required	Calibration not required
SPEAG	Phantom	SAM	N/A	Calibration not required	Calibration not required
SPEAG	Dielectric Assessment Kit	DAKS-3.5	1053	Feb.17,2021	Feb.16,2022
Agilent	Dual-directional coupler	772D	MY48220468	Aug.16,2021	Aug.15,2022
		778D	MY46151242	Aug.16,2021	Aug.15,2022
Agilent	Signal Generator	N5181A	MY50141235	May.30,2021	May.29,2022
Agilent	Power Meter	E4417A	MY51410006	Mar.23,2021	Mar.22,2022
Agilent	Power Sensor	E9301H	MY51470001	Mar.23,2021	Mar.22,2022
			MY51470002	Mar.23,2021	Mar.22,2022
Anritsu	Radio Communication Test	MT8820C	6201061049	May.14,2021	May.13,2022
TECPEL	Digital thermometer	DTM-303A	TP130074	Apr.26,2021	Apr.25,2022

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4. Measurements

Date: 2021/10/7

Report No. : E5/2021/80019

NB-IOT Band 3 (20MHz)_Head_CH 19949_QPSK_1-0_40mm

Communication System: LTE Band 3; Frequency: 1784.9 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 1784.9$ MHz; $\sigma = 1.384$ S/m; $\epsilon_r = 39.857$; $\rho = 1000$ kg/m³

Phantom section: Right Section

Ambient temperature: 22.1°C; Liquid temperature: 21.8°C

DASY5 Configuration:

- Probe: EX3DV4 - SN7509; ConvF(9.11, 9.11, 9.11); Calibrated: 2021/4/26
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2021/8/20
- Phantom: SAM
- DASY52 4.7.80(0); SEMCAD X 14.6.14(7483)

Area Scan (81x81x1): Interpolated grid: dx=15 mm, dy=15 mm

Maximum value of SAR (interpolated) = 0.0463 W/kg

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

Reference Value = 2.491 V/m; Power Drift = 0.06 dB

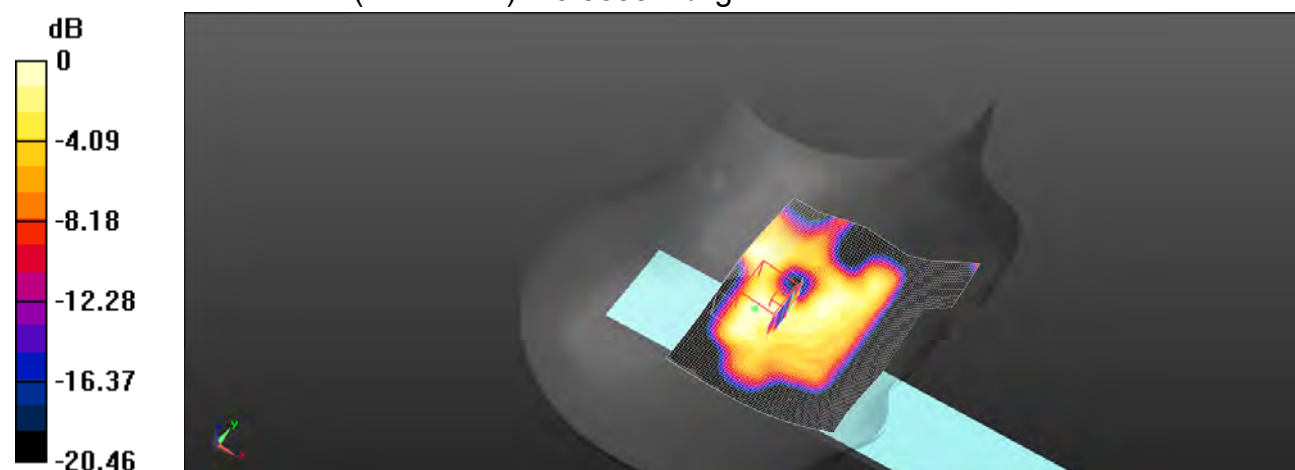
Peak SAR (extrapolated) = 0.0720 W/kg

SAR(1 g) = 0.026 W/kg; SAR(10 g) = 0.012 W/kg

Smallest distance from peaks to all points 3 dB below = 9.2 mm

Ratio of SAR at M2 to SAR at M1 = 52.7%

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



0 dB = 0.0399 W/kg = -13.99 dBW/kg

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Date: 2021/10/7

Report No. : E5/2021/80019**NB-IOT Band 8 (10MHz) Head_CH 21451_QPSK_1-0_40mm**

Communication System: LTE Band 8; Frequency: 880.1 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 880.1$ MHz; $\sigma = 0.938$ S/m; $\epsilon_r = 41.332$; $\rho = 1000$ kg/m³

Phantom section: Right Section

Ambient temperature: 22.1°C; Liquid temperature: 21.8°C

DASY5 Configuration:

- Probe: EX3DV4 - SN7509; ConvF(9.78, 9.78, 9.78); Calibrated: 2021/4/26
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2021/8/20
- Phantom: SAM
- DASY52 4.7.80(0); SEMCAD X 14.6.14(7483)

Area Scan (81x81x1): Interpolated grid: dx=15 mm, dy=15 mm

Maximum value of SAR (interpolated) = 0.0175 W/kg

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

Reference Value = 1.228 V/m; Power Drift = -0.05 dB

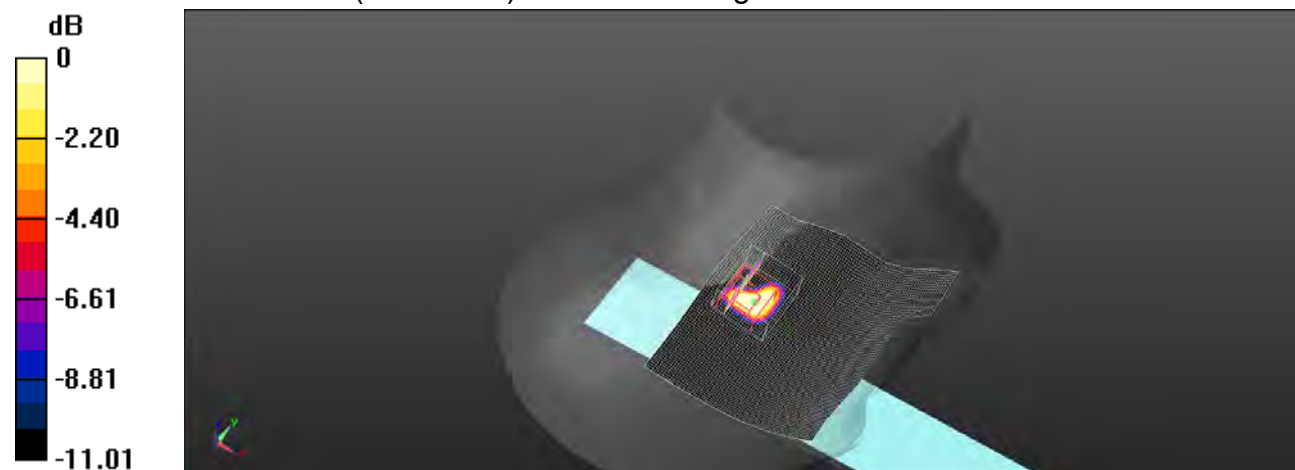
Peak SAR (extrapolated) = 0.0110 W/kg

SAR(1 g) = 0.00722 W/kg; SAR(10 g) = 0.00448 W/kg

Smallest distance from peaks to all points 3 dB below = 9.8 mm

Ratio of SAR at M2 to SAR at M1 = 58.3%

Maximum value of SAR (measured) = 0.00917 W/kg



0 dB = 0.00917 W/kg = -20.38 dBW/kg

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5. SAR System Performance Verification

Date: 2021/10/7

Report No. : E5/2021/80019

Dipole 900 MHz_SN:178

Communication System: CW; Frequency: 900 MHz; Duty Cycle: 1:1

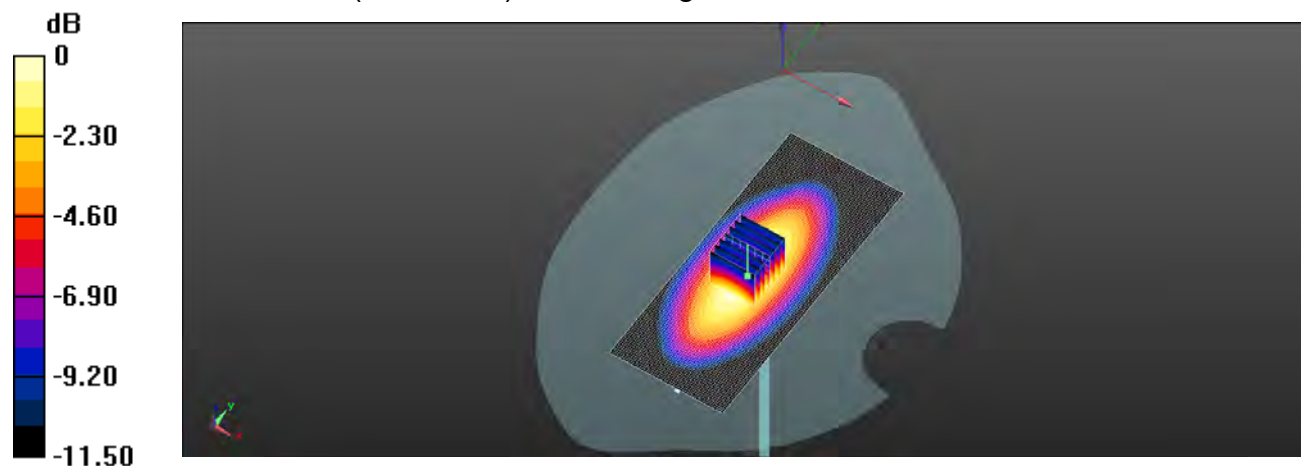
Medium parameters used: $f = 900 \text{ MHz}$; $\sigma = 0.955 \text{ S/m}$; $\epsilon_r = 41.332$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

Ambient temperature: 22.1°C ; Liquid temperature: 21.8°C

DASY5 Configuration:

- Probe: EX3DV4 - SN7509; ConvF(9.78, 9.78, 9.78); Calibrated: 2021/4/26
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2021/8/20
- Phantom: SAM
- DASY52 4.7.80(0); SEMCAD X 14.6.14(7483)

Area Scan (61x121x1): Interpolated grid: $dx=15 \text{ mm}$, $dy=15 \text{ mm}$ Maximum value of SAR (interpolated) = 3.43 W/kg **Zoom Scan (7x7x7)/Cube 0:** Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$ Reference Value = 59.13 V/m ; Power Drift = 0.02 dB Peak SAR (extrapolated) = 4.11 W/kg **SAR(1 g) = 2.66 W/kg ; SAR(10 g) = 1.69 W/kg** Smallest distance from peaks to all points 3 dB below = 20.5 mm Ratio of SAR at M2 to SAR at M1 = 64.4% Maximum value of SAR (measured) = 3.43 W/kg  $0 \text{ dB} = 3.43 \text{ W/kg} = 5.36 \text{ dBW/kg}$

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Date: 2021/10/7

Report No. : E5/2021/80019

Dipole 1750 MHz SN:1111

Communication System: CW; Frequency: 1750 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 1750$ MHz; $\sigma = 1.366$ S/m; $\epsilon_r = 39.911$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Ambient temperature: 22.1°C; Liquid temperature: 21.8°C

DASY5 Configuration:

- Probe: EX3DV4 - SN7509; ConvF(9.11, 9.11, 9.11); Calibrated: 2021/4/26
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2021/8/20
- Phantom: SAM
- DASY52 4.7.80(0); SEMCAD X 14.6.14(7483)

Area Scan (51x81x1): Interpolated grid: dx=15 mm, dy=15 mm

Maximum value of SAR (interpolated) = 13.1 W/kg

Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 102.4 V/m; Power Drift = -0.01 dB

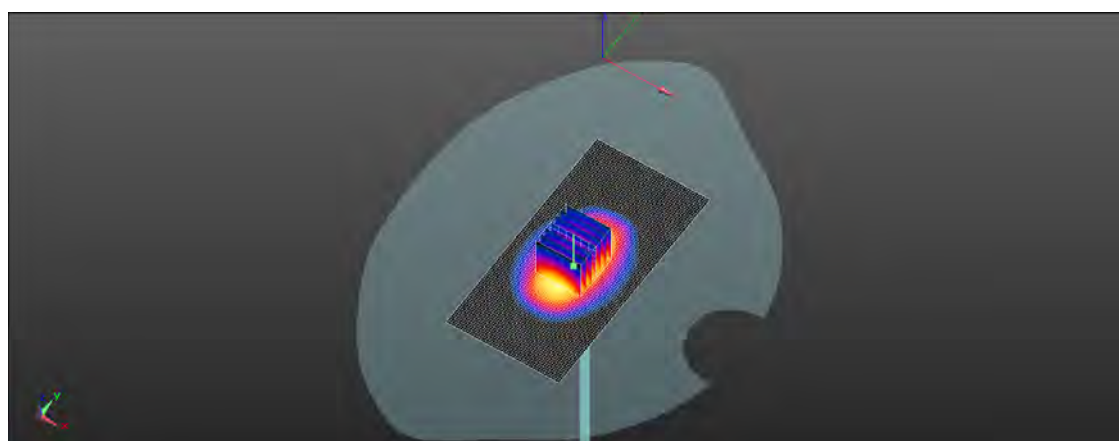
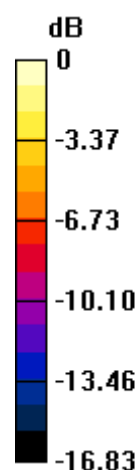
Peak SAR (extrapolated) = 16.3 W/kg

SAR(1 g) = 9.02 W/kg; SAR(10 g) = 4.79 W/kg

Smallest distance from peaks to all points 3 dB below = 10.2 mm

Ratio of SAR at M2 to SAR at M1 = 55.8%

Maximum value of SAR (measured) = 12.9 W/kg



0 dB = 12.9 W/kg = 11.10 dBW/kg

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6. Appendix

6.1 DAE & Probe Calibration Certificate

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Accreditation No. : SCS 0108

Client **SGS (Auden)**

Certificate No: **DAE4-1336_Aug21**

CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BM - SN: 1336**

Calibration procedure(s) **QA CAL-06.v30
Calibration procedure for the data acquisition electronics (DAE)**

Calibration date: **August 20, 2021**

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
Kelliley Multimeter Type 2001	SN: 0810278	07-Sep-20 (No:28647)	Sep-21
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Auto DAE Calibration Unit	SE UWS 053 AA 1001	07-Jan-21 (in house check)	In house check: Jan-22
Calibrator Box V2.1	SE UMS 006 AA 1002	07-Jan-21 (in house check)	In house check: Jan-22

Calibrated by:	Name Dominique Stoffen	Function Laboratory Technician	Signature
Approved by:	Sven Kühn	Deputy Manager	

Issued: August 20, 2021

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Certificate No: DAE4-1336_Aug21

Page 1 of 5

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Accreditation No.: SCS 0108

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.

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DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1 μ V, 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	403.395 $\pm$ 0.02% (k=2)	403.699 $\pm$ 0.02% (k=2)	403.181 $\pm$ 0.02% (k=2)
Low Range	3.95140 $\pm$ 1.50% (k=2)	3.98832 $\pm$ 1.50% (k=2)	3.99675 $\pm$ 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	337.0 $^{\circ}$ $\pm$ 1 $^{\circ}$
---	-------------------------------------

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Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range	Reading (μV)	Difference (μV)	Error (%)
Channel X + Input	199994.87	-0.57	-0.00
Channel X + Input	20003.04	1.02	0.01
Channel X - Input	-19999.60	2.19	-0.01
Channel Y + Input	199994.43	-0.97	-0.00
Channel Y + Input	20000.24	-1.68	-0.01
Channel Y - Input	-20003.86	-1.89	0.01
Channel Z + Input	199996.97	1.15	0.00
Channel Z + Input	19999.88	-1.94	-0.01
Channel Z - Input	-20003.19	-1.35	0.01

Low Range	Reading (μV)	Difference (μV)	Error (%)
Channel X + Input	2001.13	0.09	0.00
Channel X + Input	201.77	0.46	0.23
Channel X - Input	-198.03	0.61	-0.31
Channel Y + Input	2001.20	0.17	0.01
Channel Y + Input	200.67	-0.66	-0.33
Channel Y - Input	-199.32	-0.62	0.31
Channel Z + Input	2001.02	0.19	0.01
Channel Z + Input	200.18	-0.91	-0.45
Channel Z - Input	-199.41	-0.56	0.28

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	6.13	5.08
	-200	-3.78	-5.13
Channel Y	200	-4.25	-4.17
	-200	1.79	1.85
Channel Z	200	22.60	22.64
	-200	-24.87	-24.70

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	-	5.23	-0.98
Channel Y	200	9.11	-	6.48
Channel Z	200	8.79	6.41	-

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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	15667	18718
Channel Y	15908	15798
Channel Z	15845	14611

5. Input Offset Measurement

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

	Average (μ V)	min. Offset (μ V)	max. Offset (μ V)	Std. Deviation (μ V)
Channel X	1.60	0.77	2.53	0.32
Channel Y	-0.38	-1.24	0.77	0.34
Channel Z	-0.59	-1.74	0.43	0.38

6. Input Offset Current

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

7. Input Resistance (Typical values for information)

	Zeroing (k Ω m)	Measuring (M Ω m)
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	+8	+14
Supply (- Vcc)	-0.01	-8	-9

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Client **SGS-TW (Auden)**

Certificate No: **EX3-7509_Apr21**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:7509**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-14.v6, QA CAL-23.v5, QA CAL-25.v7
Calibration procedure for dosimetric E-field probes**

Calibration date: **April 26, 2021**

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	09-Apr-21 (No. 217-03291/03292)	Apr-22
Power sensor NRP-Z91	SN: 103244	09-Apr-21 (No. 217-03291)	Apr-22
Power sensor NRP-Z91	SN: 103245	09-Apr-21 (No. 217-03292)	Apr-22
Reference 20 dB Attenuator	SN: CC2552 (20x)	09-Apr-21 (No. 217-03343)	Apr-22
DAE4	SN: 660	23-Dec-20 (No. DAE4-660 Dec20)	Dec-21
Reference Probe ES3DV2	SN: 3013	30-Dec-20 (No. ES3-3013 Dec20)	Dec-21
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-20)	In house check: Jun-22
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-20)	In house check: Jun-22
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-20)	In house check: Jun-22
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-20)	In house check: Jun-22
Network Analyzer E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-21

	Name	Function	Signature
Calibrated by:	Jeton Kastrati	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	
			Issued: May 13, 2021

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Certificate No: EX3-7509_Apr21

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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 E²-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).

Certificate No: EX3-7509_Apr21

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EX3DV4 - SN:7509

April 26, 2021

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7509

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.69	0.63	0.69	$\pm 10.1\%$
DCP (mV) ^B	105.0	104.2	103.1	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc ^C (k=2)
0	CW	X	0.0	0.0	1.0	0.00	139.5	$\pm 3.3\%$
		Y	0.0	0.0	1.0		140.4	
		Z	0.0	0.0	1.0		129.2	

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_z-field uncertainty inside TSL (see Page 5).

^B Numerical linearization parameter; uncertainty not required.

^C Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

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EX3DV4- SN:7509

April 26, 2021

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7509

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	-67.4
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

Note: Measurement distance from surface can be increased to 3-4 mm for an *Area Scan* job.

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EX3DV4- SN:7509

April 26, 2021

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7509

Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) ^C	Relative Permittivity ^E	Conductivity (S/m) ^F	ConvF X	ConvF Y	ConvF Z	Alpha ^B	Depth ^G (mm)	Unc (k=2)
750	41.9	0.89	10.29	10.29	10.29	0.42	0.96	± 12.0 %
835	41.5	0.90	9.97	9.97	9.97	0.48	0.85	± 12.0 %
900	41.5	0.97	9.78	9.78	9.78	0.31	1.11	± 12.0 %
1750	40.1	1.37	9.11	9.11	9.11	0.32	0.86	± 12.0 %
1900	40.0	1.40	8.74	8.74	8.74	0.38	0.86	± 12.0 %
2000	40.0	1.40	8.64	8.64	8.64	0.34	0.86	± 12.0 %
2300	39.5	1.67	8.31	8.31	8.31	0.28	0.90	± 12.0 %
2450	39.2	1.80	8.18	8.18	8.18	0.33	0.90	± 12.0 %
2600	39.0	1.96	7.97	7.97	7.97	0.38	0.90	± 12.0 %
3300	38.2	2.71	7.40	7.40	7.40	0.30	1.35	± 13.1 %
3500	37.9	2.91	7.26	7.26	7.26	0.35	1.35	± 13.1 %
3700	37.7	3.12	7.10	7.10	7.10	0.35	1.35	± 13.1 %
3900	37.5	3.32	6.85	6.85	6.85	0.40	1.60	± 13.1 %
4100	37.2	3.53	6.70	6.70	6.70	0.40	1.60	± 13.1 %
4200	37.1	3.63	6.60	6.60	6.60	0.40	1.60	± 13.1 %
4400	36.9	3.84	6.45	6.45	6.45	0.40	1.60	± 13.1 %
4600	36.7	4.04	6.39	6.39	6.39	0.40	1.60	± 13.1 %
4800	36.4	4.25	6.42	6.42	6.42	0.45	1.80	± 13.1 %
4950	36.3	4.40	6.21	6.21	6.21	0.40	1.80	± 13.1 %
5200	36.0	4.66	5.70	5.70	5.70	0.40	1.80	± 13.1 %
5300	35.9	4.76	5.45	5.45	5.45	0.40	1.80	± 13.1 %
5600	35.5	5.07	5.10	5.10	5.10	0.40	1.80	± 13.1 %
5800	35.3	5.27	5.20	5.20	5.20	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.

^E 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.

Certificate No: EX3-7509_Apr21

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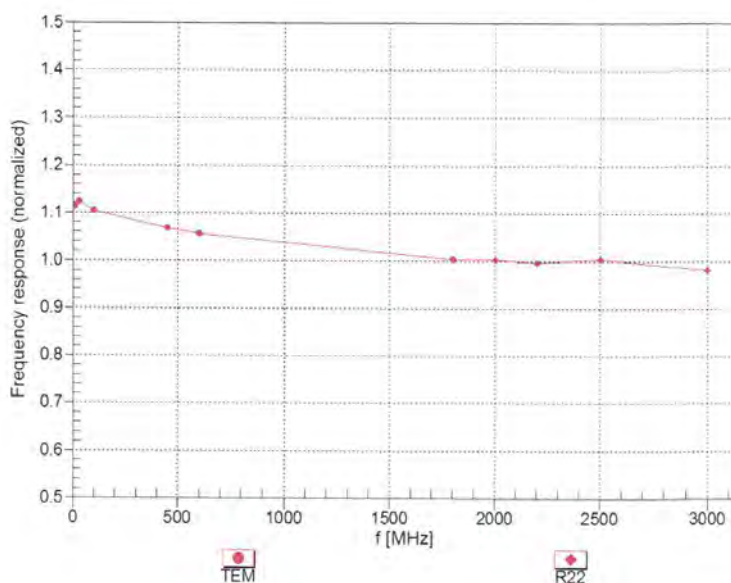
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EX3DV4- SN:7509

April 26, 2021

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



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

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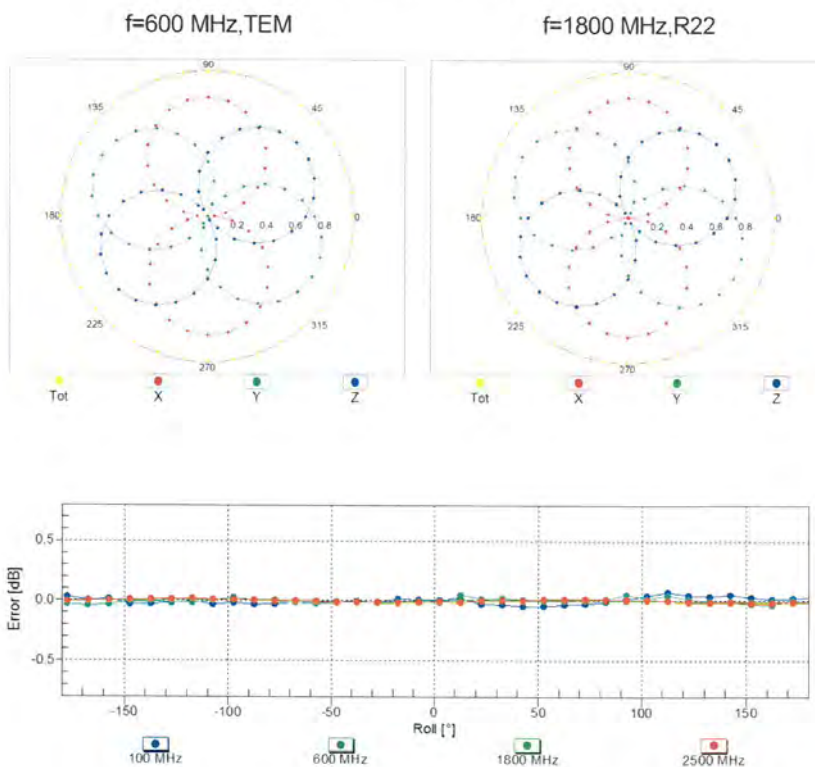
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EX3DV4- SN:7509

April 26, 2021

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



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

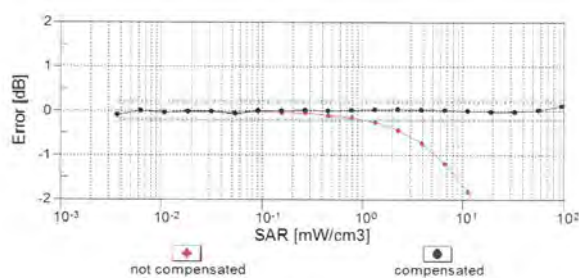
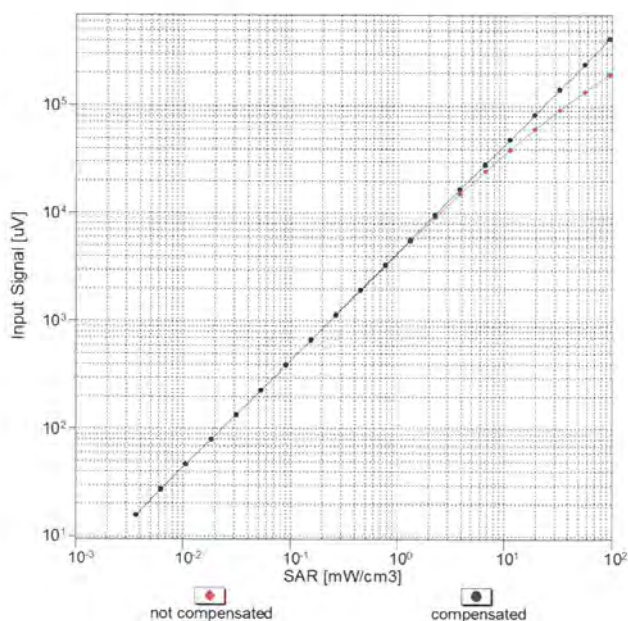
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EX3DV4- SN:7509

April 26, 2021

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



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

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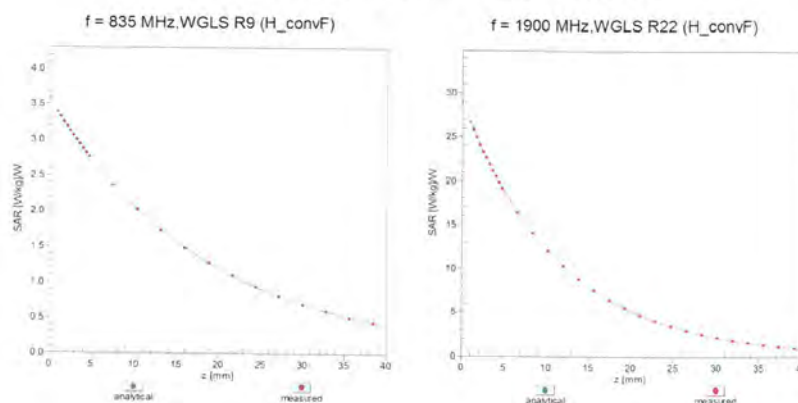
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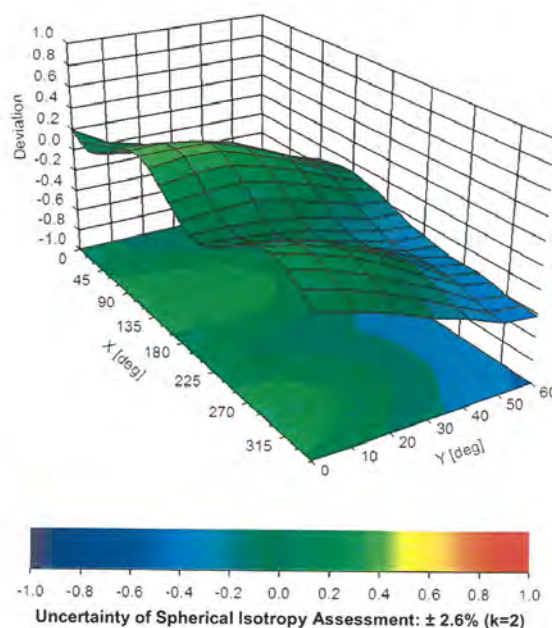
EX3DV4- SN:7509

April 26, 2021

Conversion Factor Assessment



Deviation from Isotropy in Liquid Error (ϕ , θ), f = 900 MHz



Uncertainty of Spherical Isotropy Assessment: $\pm 2.6\%$ (k=2)

Certificate No: EX3-7509_Apr21

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6.2 Uncertainty Budget

Measurement Uncertainty evaluation template for DUT SAR test (0.3-3G)

A	b	c	D	e	f	g	h=c * f / e	i=c * g / e	k
Source of Uncertainty	Description	Tolerance/ Uncertainty %	Probability Distribution	Div	ci (1g)	ci (10g)	Standard uncertainty	Standard uncertainty	vi, or Veff
Measurement system									
Probe calibration	7.2.1	6.00%	N	1	1	1	6.00%	6.00%	∞
Isotropy, Axial	7.2.1.2	3.5%	R	$\sqrt{3}$	1	1	2.0%	2.0%	∞
Isotropy, Hemispherical	7.2.1.2	9.6%	R	$\sqrt{3}$	1	1	5.5%	5.5%	∞
Boundary Effect	7.2.1.5	1.0%	R	$\sqrt{3}$	1	1	0.6%	0.6%	∞
Linearity	7.2.1.3	4.7%	R	$\sqrt{3}$	1	1	2.7%	2.7%	∞
Detection Limits	7.2.1.4	1.0%	R	$\sqrt{3}$	1	1	0.6%	0.6%	∞
Readout Electronics	7.2.1.6	0.3%	N	1	1	1	0.3%	0.3%	∞
Response time	7.2.1.7	0.8%	R	$\sqrt{3}$	1	1	0.5%	0.5%	∞
Integration Time	7.2.1.8	2.6%	R	$\sqrt{3}$	1	1	1.5%	1.5%	∞
Measurement drift	7.2.1.9	1.8%	R	$\sqrt{3}$	1	1	1.0%	1.0%	∞
RF ambient condition - noise	7.2.3.4	3.0%	R	$\sqrt{3}$	1	1	1.7%	1.7%	∞
RF ambient conditions - reflections	7.2.3.4	3.0%	R	$\sqrt{3}$	1	1	1.7%	1.7%	∞
Probe positioner Mechanical restrictions	7.2.2.1	0.4%	R	$\sqrt{3}$	1	1	0.2%	0.2%	∞
Probe Positioning with respect to phantom shell	7.2.2.4	2.9%	R	$\sqrt{3}$	1	1	1.7%	1.7%	∞
Post-processing	7.2.4	1.0%	R	$\sqrt{3}$	1	1	0.6%	0.6%	∞
Test Sample related									
Test sample positioning	7.2.2.4	2.9%	N	1	1	1	2.9%	2.9%	M-1
Device Holder Uncertainty	7.2.2.4.2	3.6%	N	1	1	1	3.6%	3.6%	M-1
Drift of output power	7.2.1.9	5.0%	R	$\sqrt{3}$	1	1	2.9%	2.9%	∞
Phantom and Setup									
Phantom	7.2.2.2	4.0%	R	$\sqrt{3}$	1	1	2.3%	2.3%	∞
Algorithm for correcting SAR for deviations in permittivity and conductivity	7.2.3.3	1.9%	N	1	1	0.84	1.9%	1.6%	∞
Liquid conductivity(meas.)	7.2.3.2	2.5%	N	1	0.64	0.43	1.6%	1.1%	M
Liquid permittivity(meas.)	7.2.3.3	2.5%	N	1	0.6	0.49	1.5%	1.2%	M
Combined standard uncertainty	7.3.1		RSS				11.6%	11.5%	
Expant uncertainty (95% confidence interval) K=2	7.3.2						23.2%	23.0%	

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6.3 Phantom Description

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info@speag.com, <http://www.speag.com>

Certificate of Conformity / First Article Inspection

Item	SAM Twin Phantom V4.0
Type No.	QD 000 P40 C
Series No.	TP-1150 and higher
Manufacturer	SPEAG Zeughausstrasse 43 CH-8004 Zurich Switzerland

Tests

The series production process used allows the limitation to test of first articles.

Complete tests were made on the pre-series Type No. QD 000 P40 AA, Serial No. TP-1001 and on the series first article Type No. QD 000 P40 BA, Serial No. TP-1006. Certain parameters have been retested using further series items (called samples) or are tested at each item.

Test	Requirement	Details	Units tested
Dimensions	Compliant with the geometry according to the CAD model.	IT IS CAD File (*)	First article, Samples
Material thickness of shell	Compliant with the requirements according to the standards	2mm +/- 0.2mm in flat and specific areas of head section	First article, Samples, TP-1314 ff.
Material thickness at ERP	Compliant with the requirements according to the standards	6mm +/- 0.2mm at ERP	First article, All items
Material parameters	Dielectric parameters for required frequencies	300 MHz – 6 GHz, Relative permittivity < 5, Loss tangent < 0.05	Material samples
Material resistivity	The material has been tested to be compatible with the liquids defined in the standards if handled and cleaned according to the instructions. Observe technical Note for material compatibility.	DEGMBE based simulating liquids	Pre-series, First article, Material samples
Sagging	Compliant with the requirements according to the standards. Sagging of the flat section when filled with tissue simulating liquid.	< 1% typical < 0.5% if filled with 155mm of HSL900 and without DUT below	Prototypes, Sample testing

Standards

- [1] CENELEC EN 50361
- [2] IEEE Std 1528-2003
- [3] IEC 62209 Part I
- [4] FCC OET Bulletin 65, Supplement C, Edition 01-01

(*) The IT IS CAD file is derived from [2] and is also within the tolerance requirements of the shapes of the other documents.

Conformity

Based on the sample tests above, we certify that this item is in compliance with the uncertainty requirements of SAR measurements specified in standards [1] to [4].

Date 07.07.2005

Signature / Stamp

s p e e g

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Doc No.: 681 – QD 000 P40 C – F

Page 1 (1)

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6.4 System Validation from Original Equipment Supplier

**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
S Swiss Calibration Service

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

Accreditation No.: **SCS 0108**

Client **SGS-TW (Auden)**

Certificate No: **D900V2-178_Apr21**

CALIBRATION CERTIFICATE

Object **D900V2 - SN:178**

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

Calibration date: **April 15, 2021**

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	09-Apr-21 (No. 217-03291/03292)	Apr-22
Power sensor NRP-Z91	SN: 103244	09-Apr-21 (No. 217-03291)	Apr-22
Power sensor NRP-Z91	SN: 103245	09-Apr-21 (No. 217-03292)	Apr-22
Reference 20 dB Attenuator	SN: BH9394 (20k)	09-Apr-21 (No. 217-03343)	Apr-22
Type-N mismatch combination	SN: 310982 / 06327	09-Apr-21 (No. 217-03344)	Apr-22
Reference Probe EX3DV4	SN: 7349	28-Dec-20 (No. EX3-7349_Dec20)	Dec-21
DAE4	SN: 601	02-Nov-20 (No. DAE4-601_Nov20)	Nov-21
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-20)	In house check: Oct-22
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-21
Calibrated by:	Name Claudio Leubler	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: April 16, 2021			

Certificate No: D900V2-178_Apr21

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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	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	900 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	41.5	0.97 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	42.0 $\pm$ 6 %	0.95 mho/m $\pm$ 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	2.70 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	11.0 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.74 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	7.06 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	55.0	1.05 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	55.2 $\pm$ 6 %	1.02 mho/m $\pm$ 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	2.66 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	10.9 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.74 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	7.08 W/kg $\pm$ 16.5 % (k=2)

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Appendix (Additional assessments outside the scope of SCS 0108)**Antenna Parameters with Head TSL**

Impedance, transformed to feed point	48.9 Ω - 1.4 j Ω
Return Loss	- 34.9 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	45.2 Ω - 4.0 j Ω
Return Loss	- 23.7 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.402 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: 14.04.2021

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 900 MHz; Type: D900V2; Serial: D900V2 - SN:178

Communication System: UID 0 - CW; Frequency: 900 MHz

Medium parameters used: $f = 900 \text{ MHz}$; $\sigma = 0.95 \text{ S/m}$; $\epsilon_r = 42$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.62, 9.62, 9.62) @ 900 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 65.19 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 4.12 W/kg

SAR(1 g) = 2.7 W/kg; SAR(10 g) = 1.74 W/kg

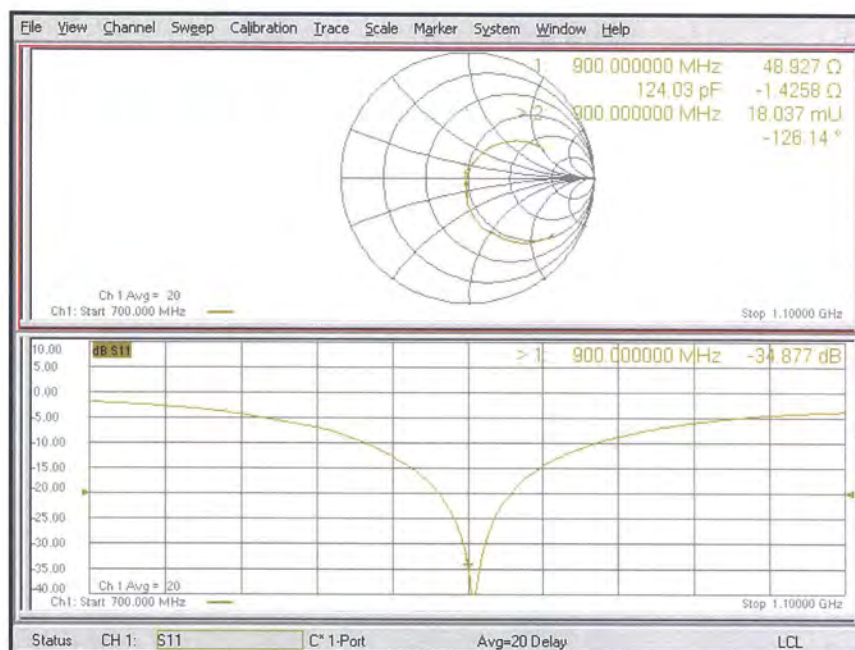
Smallest distance from peaks to all points 3 dB below = 16 mm

Ratio of SAR at M2 to SAR at M1 = 65.4%

Maximum value of SAR (measured) = 3.64 W/kg



Impedance Measurement Plot for Head TSL



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DASY5 Validation Report for Body TSL

Date: 15.04.2021

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 900 MHz; Type: D900V2; Serial: D900V2 - SN:178

Communication System: UID 0 - CW; Frequency: 900 MHz

Medium parameters used: $f = 900 \text{ MHz}$; $\sigma = 1.02 \text{ S/m}$; $\epsilon_r = 55.2$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.81, 9.81, 9.81) @ 900 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 58.82 V/m; Power Drift = 0.05 dB

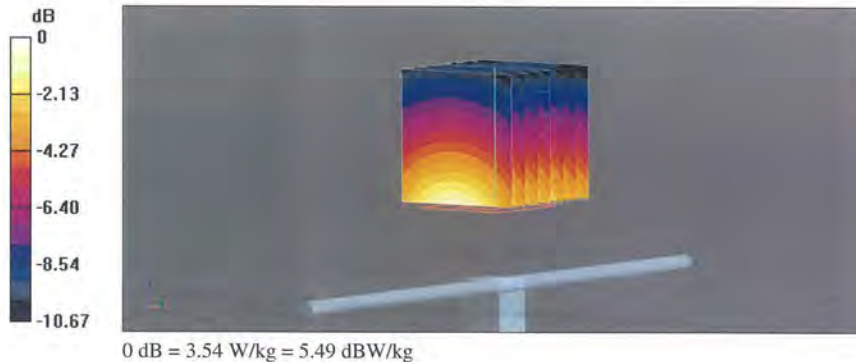
Peak SAR (extrapolated) = 3.96 W/kg

SAR(1 g) = 2.66 W/kg; SAR(10 g) = 1.74 W/kg

Smallest distance from peaks to all points 3 dB below = 15.5 mm

Ratio of SAR at M2 to SAR at M1 = 67.3%

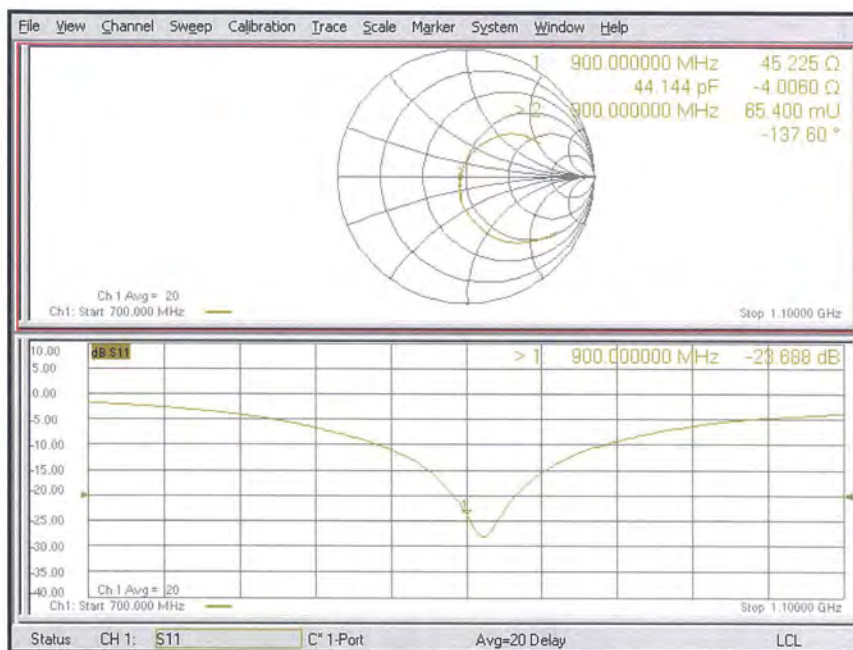
Maximum value of SAR (measured) = 3.54 W/kg



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Impedance Measurement Plot for Body TSL



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Client **AUDEN**

Certificate No: **Z21-60099**

CALIBRATION CERTIFICATE

Object **D1750V2 - SN: 1111**

Calibration Procedure(s) **FF-Z11-003-01**
Calibration Procedures for dipole validation kits

Calibration date: **April 14, 2021**

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(Calibrated by, Certificate No.)	Scheduled Calibration
Power Meter NRP2	106276	12-May-20 (CTTL, No.J20X02965)	May-21
Power sensor NRP6A	101369	12-May-20 (CTTL, No.J20X02965)	May-21
ReferenceProbe EX3DV4	SN 7307	29-May-20(SPEAG,No.EX3-7307_May20)	May-21
DAE4	SN 777	08-Jan-21(CTTL-SPEAG,No.Z21-60003)	Jan-22
Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Signal Generator E4438C	MY49071430	01-Feb-21 (CTTL, No.J21X00593)	Jan-22
NetworkAnalyzer E5071C	MY46110673	14-Jan-21 (CTTL, No.J21X00232)	Jan-22

	Name	Function	Signature
Calibrated by:	Zhao Jing	SAR Test Engineer	
Reviewed by:	Lin Hao	SAR Test Engineer	
Approved by:	Qi Dianyuan	SAR Project Leader	

Issued: April 19, 2021

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

Certificate No: Z21-60099

Page 1 of 6

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Glossary:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORMx,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 assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices- Part 1: Device used next to the ear (Frequency range of 300MHz to 6GHz)", July 2016
- IEC 62209-2, "Procedure to measure the Specific Absorption Rate (SAR) For wireless communication devices used in close proximity to the human body (frequency range of 30MHz to 6GHz)", March 2010
- KDB865664, 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%.



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Measurement Conditions

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

DASY Version	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Triple Flat Phantom 5.1C	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1750 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.1	1.37 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	40.5 $\pm$ 6 %	1.39 mho/m $\pm$ 6 %
Head TSL temperature change during test	<1.0 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	9.16 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	36.4 W/kg $\pm$ 18.8 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	Condition	
SAR measured	250 mW input power	4.78 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	19.0 W/kg $\pm$ 18.7 % (k=2)

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Appendix (Additional assessments outside the scope of CNAS L0570)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	48.9Ω- 4.12jΩ
Return Loss	- 27.3 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.125 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: 04.14.2021

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN: 1111

Communication System: UID 0, CW; Frequency: 1750 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 1750$ MHz; $\sigma = 1.391$ S/m; $\epsilon_r = 40.52$; $\rho = 1000$ kg/m³

Phantom section: Right Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7307; ConvF(8.64, 8.64, 8.64) @ 1750 MHz; Calibrated: 2020-05-29
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn777; Calibrated: 2021-01-08
- Phantom: MFP_V5.1C (20deg probe tilt); Type: QD 000 P51 Cx; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7483)

System Performance Check/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid:

$dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 94.69 V/m; Power Drift = -0.08 dB

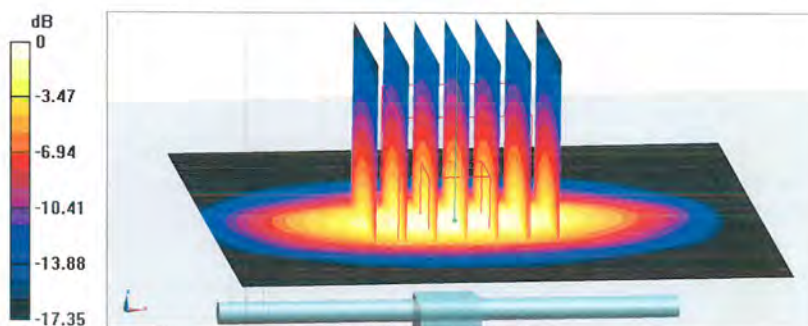
Peak SAR (extrapolated) = 17.3 W/kg

SAR(1 g) = 9.16 W/kg; SAR(10 g) = 4.78 W/kg

Smallest distance from peaks to all points 3 dB below = 10 mm

Ratio of SAR at M2 to SAR at M1 = 53.3%

Maximum value of SAR (measured) = 14.4 W/kg



0 dB = 14.4 W/kg = 11.58 dBW/kg

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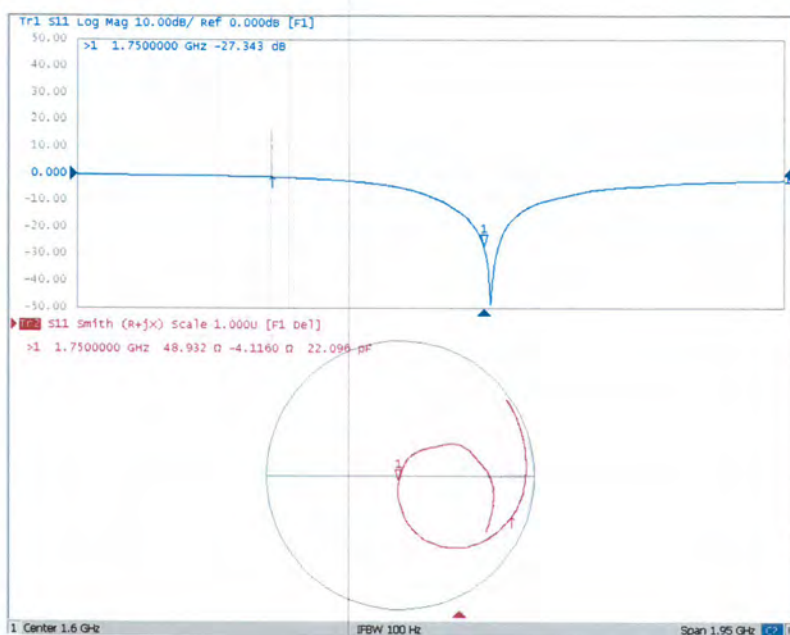
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Impedance Measurement Plot for Head TSL



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Appendixes

Refer to separated files for the following appendixes.

E5202180019 SAR_Appendix A Photographs

- End of report

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