TURCK Inc.

PD67 Handheld RFID Reader

SAR Evaluation Report: TURC0064, Issue Date: May 1, 2020

Evaluated to the following SAR specification:

FCC 2.1093:2020

NVLAP Lab Code: 200881-0

CERTIFICATE OF TEST

2018-07-17

Last Date of Test: March 30, 2020
TURCK Inc.
EUT: PD67 Handheld RFID Reader

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

Variant	Frequency Bands (GHz)	Body (W/kg)	Limit (W/kg)	Exposure Environment
		1 g	1 g	
Including Barcode Scanner	0.9	0.63	1.6	General Population
No Barcode Scanner	0.9	0.98	1.6	

Deviations From Test Standards

None

Approved By:

Don Facteau, Systems Architect

REVISION HISTORY

Revision Number	Description	Date (yyyy-mm-dd)	Page Number
00	None		

ACCREDITATIONS AND AUTHORIZATIONS

2019.03.08

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

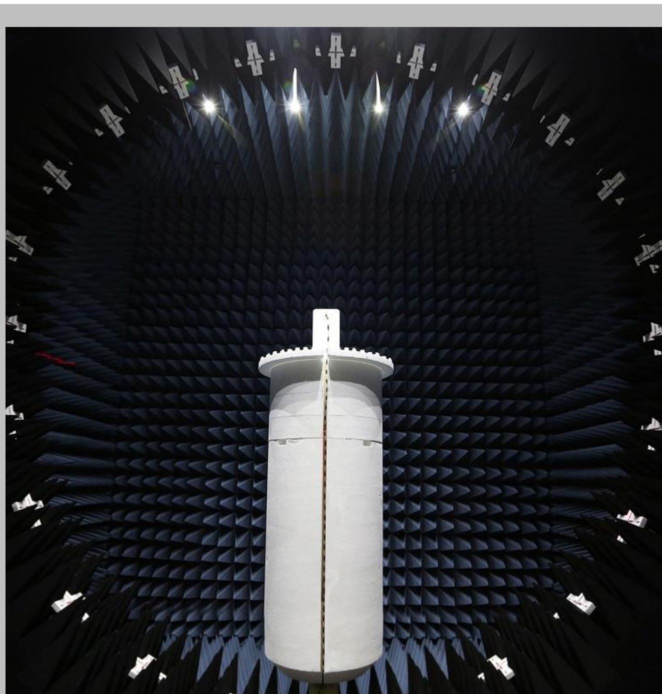
MIC – Recognized by MIC as a CAB for the acceptance of test data.

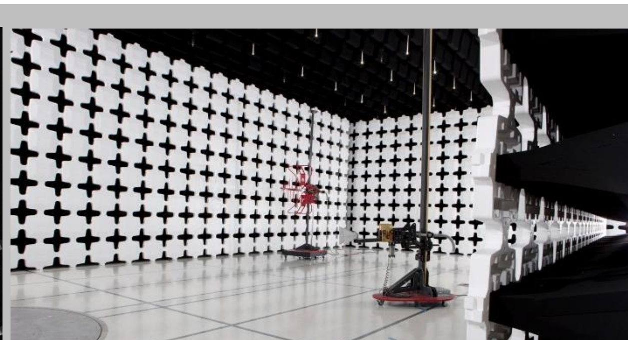
SCOPE

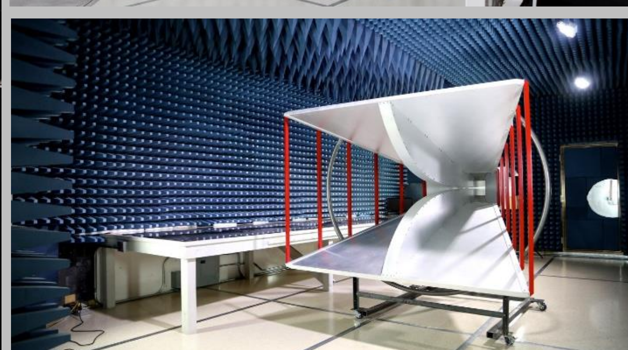
For details on the Scopes of our Accreditations, please visit:
https://www.nwemc.com/emc-testing-accreditations

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 120th 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/RRA, MIC, MOC, NCC, OFCA				
US0158	US0175	US0017	US0191	US0157







PRODUCT DESCRIPTION

Client and Equipment Under Test (EUT) Information

Company Name:	TURCK Inc.
Address:	3000 Campus Dr
City, State, Zip:	Plymouth, MN 55441
Test Requested By:	Gabe Selinger
Model:	PD67 Handheld RFID Reader
First Date of Test:	January 23, 2020
Last Date of Test:	March 30, 2020
Receipt Date of Samples:	January 22, 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:

PD67 is a battery operated, handheld device for reading HF and UHF RFID tags. There are two model variants, one has a barcode scanner and one does not. It is capable of WiFi communication, and has a USB C interface for battery charging and communication. When transmitting for RFID reading, it has a max output power of about 30dBm. Its duty cycle while transmitting is NOT constant (it is calculated and adjusted every time based on factors such as tag response and reflected power). The user interfaces with the device via 3 buttons, as well as a capacitive touch LCD. The device runs Android as its operating system. The barcode scanner contains a linear LED for aiming purposes, but there is NOT a laser. The battery is Lithium Ion. The device also has GPS capability, via an internal on-board antenna.

The device contains the following radios:

HF RFID
UHF RFID
Wi-Fi 802.11bgn – Covered in another report
Bluetooth BDR/EDR – Covered in another report
Bluetooth Low Energy – Covered in another report
GPS (Receive Only)

The device transmits Wi-Fi 802.11bgn and Bluetooth from the same combination radio module.

FCC IDs: 2ACBRTFBWIFIBT

Transmit Frequency Ranges:

a) HF RFID: 13.56 MHz
b) UHF RFID: 902-928 MHz
c) 802.11bgn: 2412-2462 MHz (SISO, 20 MHz channel bandwidth)
d) Bluetooth BDR/EDR: 2402-2480 MHz
e) Bluetooth Low Energy: 2402-2480 MHz

PRODUCT DESCRIPTION

2014-12-10

Location of transmit antenna(s):

Testing Locations

For clarity, the test orientations are referred to as front, back, power button side, scroll button side, and reader side. This device is made to be used handheld and could be conceivably used for extended periods of time while held against the body. A separation distance of 0 was used between the EUT and the phantom.

On the model variant with the barcode scanner, testing was performed on the front, back, power button side, scroll button side, and reader side.

On the model variant without the barcode scanner, tested was performed on the UHF RFID antenna on the back, power button side, scroll button side, and reader side. The orientations were chosen based on the proximity of the UHF RFID antenna to the barcode scanner and to the orientations tested.

Testing Objective:

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

Scaling:

Maximum Power:

The manufacturer has stated that the values measured during conducted power testing match the maximum output power of the EUT. A scaling factor or 1 is applied.

Duty Factor

Per FCC 2.1093, the exposure time over 30 minutes was determined to determine compliance with general exposure and uncontrolled SAR limits.

PRODUCT DESCRIPTION

Per the customer, for UHF RFID the operational duty cycle can be up to 30% over a 30 minute period. The SAR measurements were performed with the EUT operating in a test mode that allowed 100% duty cycle. Therefore, the measured values are scaled according to the following equation:
SAR Scaling Factor = (Operational Duty Cycle) / (Test Duty Cycle)
SAR Scaling Factor = 30% / 100% = 0.3

CONFIGURATIONS

Configuration TURC0061- 1

EUT			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
RFID Reader	TURCK Inc.	PD67	T10

Peripherals in test setup boundary			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
Power Supply (RFID Reader)	CUI Inc.	SWC15-S5-NB	N/A

Cables					
Cable Type	**Shield**	**Length (m)**	**Ferrite**	**Connection 1**	**Connection 2**
USB Cable	Yes	1.8 m	No	Power Supply (RFID Reader)	RFID Reader

Configuration TURC0061- 5

EUT			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
RFID Reader	TURCK Inc.	PD67	T04

Peripherals in test setup boundary			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
Power Supply (RFID Reader)	CUI Inc.	SWC15-S5-NB	N/A

Cables					
Cable Type	**Shield**	**Length (m)**	**Ferrite**	**Connection 1**	**Connection 2**
USB Cable	Yes	1.8 m	No	Power Supply (RFID Reader)	RFID Reader

MODIFICATIONS

element
2018-07-17

Equipment Modifications

Item	Date	Test	Modification	Note	Disposition of EUT
1	2020-01-23	Output Power	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT was taken home by the client before the next scheduled test.
2	2020-01-29	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.
3	2020-03-30	SAR Evaluation	Removed barcode reader.	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 ±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 ± 2 °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 ρ = 1000 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%
Alkoxylated 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:

$$\Delta SAR = c_\varepsilon \Delta\varepsilon_r + c_\sigma \Delta\sigma$$

Where the values for, $\Delta\varepsilon_r$ 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:

$$c_\varepsilon = -7.854 \times 10^{-4} f^3 + 9.402 \times 10^{-3} f^2 - 2.742 \times 10^{-2} f - 0.2026$$

$$c_\sigma = 9.804 \times 10^{-3} f^3 - 8.661 \times 10^{-2} f^2 + 2.981 \times 10^{-2} f + 0.7829$$

Where *f* is the frequency in GHz.

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

$$c_\varepsilon = 3.456 \times 10^{-3} f^3 - 3.531 \times 10^{-2} f^2 + 7.675 \times 10^{-2} f - 0.1860$$

$$c_\sigma = 4.479 \times 10^{-3} f^3 - 1.586 \times 10^{-2} f^2 - 0.1972 f + 0.7717$$

Where *f* is the frequency in GHz.

TISSUE – EQUIVALENT LIQUID

Date:	01/29/2020	Temperature:	22.3°C
Tissue:	MBBL600-6000V6	Liquid Temperature:	21.3°C
Tested By:	Kyle McMullan, Marcelo Aguayo	Relative Humidity:	21%
Job Site:	MN11	Bar. Pressure:	1020.7 mb

TEST SPECIFICATIONS

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

RESULTS

	Actual Values		Target Values		Deviation (%)	
Frequency (MHz)	Relative Permittivity	Conductivity	Relative Permittivity	Conductivity	Relative Permittivity	Conductivity
900	52.7	1.04	55.0	1.05	4.18	0.95

Freq (MHz)	Relative Perm.	Cond. (S/m)
600	53.51	0.93
650	53.39	0.94
700	53.22	0.96
750	53.09	0.98
800	52.89	0.99
850	52.78	1.01
900	52.66	1.04
950	52.56	1.06
1000	52.49	1.08
1050	52.40	1.10
1100	52.36	1.12
1150	52.25	1.15
1200	52.17	1.17
1250	52.06	1.20
1300	52.03	1.23
1350	51.95	1.26
1400	51.91	1.29
1450	51.81	1.32
1500	51.72	1.35
1550	51.63	1.38
1600	51.55	1.42
1650	51.53	1.45
1700	51.39	1.49
1750	51.35	1.52
1800	51.24	1.56
1850	51.17	1.59
1900	51.11	1.63
1950	51.04	1.66
2000	50.96	1.70
2050	50.87	1.74
2100	50.81	1.79
2150	50.73	1.83
2200	50.67	1.88
2250	50.64	1.92
2300	50.55	1.96
2350	50.47	2.00
2400	50.39	2.05

Freq (MHz)	Relative Perm.	Cond. (S/m)
2450	50.27	2.10
2500	50.20	2.15
2550	50.14	2.19
2600	49.97	2.24
2650	49.92	2.30
2700	49.80	2.35
2750	49.69	2.40
2800	49.61	2.45
2850	49.47	2.50
2900	49.39	2.56
2950	49.31	2.61
3000	49.22	2.65
3050	49.05	2.71
3100	48.99	2.77
3150	48.86	2.83
3200	48.79	2.88
3250	48.68	2.93
3300	48.59	2.99
3350	48.48	3.04
3400	48.38	3.10
3450	48.30	3.15
3500	48.18	3.22
3550	48.10	3.27
3600	48.05	3.33
3650	47.96	3.39
3700	47.88	3.45
3750	47.75	3.51
3800	47.71	3.57
3850	47.59	3.63
3900	47.48	3.69
3950	47.40	3.75
4000	47.36	3.83
4050	47.22	3.90
4100	47.17	3.95
4150	47.10	4.02
4200	46.95	4.09
4250	46.84	4.15

Freq (MHz)	Relative Perm.	Cond. (S/m)
4300	46.73	4.23
4350	46.65	4.31
4400	46.56	4.39
4450	46.46	4.45
4500	46.32	4.51
4550	46.23	4.58
4600	46.09	4.65
4650	45.99	4.73
4700	45.87	4.79
4750	45.74	4.86
4800	45.59	4.94
4850	45.31	4.98
4900	45.31	5.00
4950	45.31	5.12
5000	44.87	5.17
5050	45.15	5.38
5100	45.08	5.36
5150	44.73	5.43
5200	44.55	5.46
5250	44.49	5.53
5300	44.36	5.83
5350	44.30	5.76
5400	44.81	5.83
5450	44.47	5.93
5500	44.37	5.94
5550	44.02	5.96
5600	43.68	6.02
5650	43.81	6.20
5700	43.56	6.34
5750	43.32	6.36
5800	43.62	6.25
5850	43.34	6.40
5900	42.88	6.36
5950	43.24	6.50
6000	42.50	6.71

TISSUE – EQUIVALENT LIQUID

WSTE.2016.12.19

Date:	03/30/2020	Temperature:	23.2°C
Tissue:	MBBL600-6000V6	Liquid Temperature:	22.5°C
Tested By:	Kyle McMullan, Marcelo Aguayo	Relative Humidity:	19.4%
Job Site:	MN11	Bar. Pressure:	1010.2 mb

TEST SPECIFICATIONS

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

RESULTS

	Actual Values		Target Values		Deviation (%)	
Frequency (MHz)	Relative Permittivity	Conductivity	Relative Permittivity	Conductivity	Relative Permittivity	Conductivity
900	55.3	1.02	55.0	1.05	0.55	-2.86

Freq (MHz)	Relative Perm.	Cond. (S/m)
600	56.15	0.90
650	56.03	0.92
700	55.86	0.94
750	55.69	0.95
800	55.56	0.97
850	55.43	0.99
900	55.34	1.02
950	55.24	1.04
1000	55.11	1.06
1050	55.05	1.08
1100	54.99	1.11
1150	54.88	1.13
1200	54.78	1.16
1250	54.69	1.18
1300	54.62	1.21
1350	54.58	1.24
1400	54.53	1.26
1450	54.44	1.30
1500	54.35	1.33
1550	54.22	1.36
1600	54.13	1.40
1650	54.07	1.43
1700	53.93	1.46
1750	53.90	1.50
1800	53.90	1.53
1850	53.82	1.57
1900	53.79	1.60
1950	53.71	1.63
2000	53.57	1.67
2050	53.47	1.72
2100	53.42	1.76
2150	53.33	1.81
2200	53.30	1.84
2250	53.27	1.89
2300	53.20	1.93
2350	53.12	1.98
2400	53.02	2.02

Freq (MHz)	Relative Perm.	Cond. (S/m)
2450	52.91	2.07
2500	52.83	2.12
2550	52.77	2.16
2600	52.65	2.22
2650	52.55	2.27
2700	52.52	2.32
2750	52.38	2.37
2800	52.29	2.43
2850	52.19	2.47
2900	52.11	2.53
2950	52.02	2.58
3000	51.91	2.63
3050	51.77	2.69
3100	51.65	2.75
3150	51.54	2.81
3200	51.44	2.85
3250	51.39	2.91
3300	51.33	2.96
3350	51.21	3.01
3400	51.10	3.08
3450	50.98	3.14
3500	50.89	3.19
3550	50.82	3.26
3600	50.72	3.31
3650	50.65	3.37
3700	50.62	3.43
3750	50.49	3.50
3800	50.48	3.56
3850	50.37	3.63
3900	50.29	3.69
3950	50.24	3.76
4000	50.10	3.82
4050	50.03	3.90
4100	49.97	3.95
4150	49.90	4.01
4200	49.78	4.08
4250	49.71	4.15

Freq (MHz)	Relative Perm.	Cond. (S/m)
4300	49.59	4.24
4350	49.51	4.31
4400	49.39	4.40
4450	49.34	4.47
4500	49.21	4.53
4550	49.14	4.59
4600	49.02	4.66
4650	48.89	4.74
4700	48.78	4.82
4750	48.65	4.89
4800	48.47	4.96
4850	48.16	4.98
4900	47.97	5.06
4950	48.36	5.20
5000	47.94	5.34
5050	47.84	5.34
5100	47.69	5.40
5150	47.68	5.45
5200	47.35	5.54
5250	47.11	5.63
5300	46.76	5.76
5350	46.93	5.83
5400	46.54	5.86
5450	47.11	5.91
5500	47.01	6.06
5550	46.71	5.97
5600	46.56	6.09
5650	46.49	6.22
5700	45.68	6.36
5750	45.74	6.41
5800	45.54	6.46
5850	45.77	6.39
5900	45.79	6.44
5950	45.54	6.61
6000	45.60	6.73

SAR SYSTEM VERIFICATION DESCRIPTION

WSSV.2017.1.31

REQUIREMENT

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

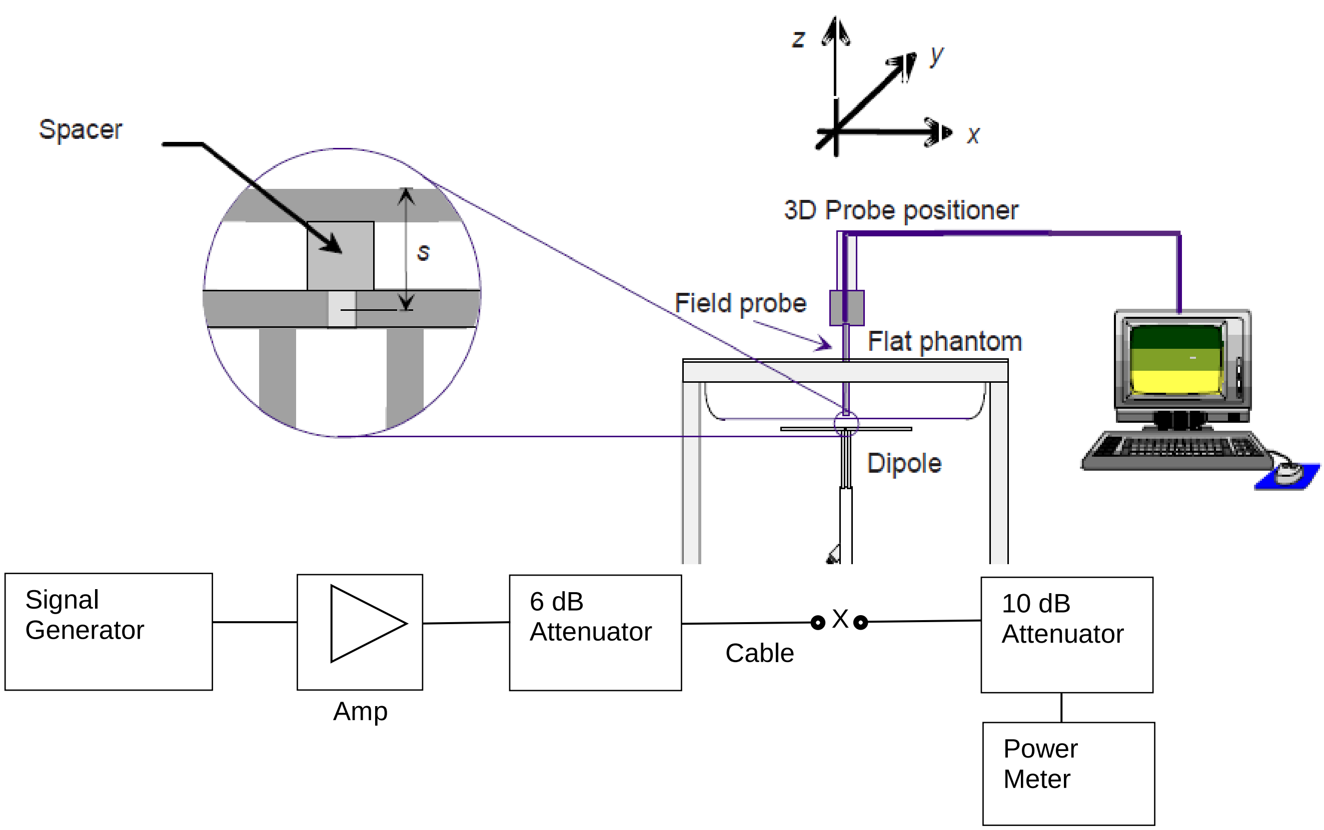
TEST DESCRIPTION

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

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



SAR SYSTEM VERIFICATION

WSSV.2016.12.19

TEST SPECIFICATIONS

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

RESULTS

Date	Liquid part number and frequency	Conducted Power into the Dipole (dBm)	Correction Factor	Measured		Normalized to 1W		Target (Normalized to 1W) Get from Dipole Calibration Certificate		% Difference	
				1g	10g	1g	10g	1g	10g	1g	10g
1/29/2020	MBBL600-6000V6 (900 MHz)	20.00	10.00	1.06	0.68	10.60	6.80	11.1	7.20	-4.50	-5.56
3/30/2020	MBBL600-6000V6 (900 MHz)	20.00	10.00	1.04	0.69	10.40	6.90	11.1	7.20	-6.31	-4.17

SAR SYSTEM VERIFICATION

element
WSSV.2016.12.19

Tested By:	Kyle McMullan, Marcelo Aguayo	Room Temperature (°C):	22.8°C
Date:	1/29/2020	Liquid Temperature (°C):	21.3°C
		Humidity (%RH):	21%
		Bar. Pressure (mb):	1020.7 mb

MBBL600-6000V6 System Check_900MHz 1-29-20
DUT: Dipole 900 MHz D900V2; Type: D900V2; Serial: D900V2 - SN:xxx
Communication System: UID 0, CW (0); Communication System Band: D900 (900.0 MHz); Frequency: 900 MHz;Communication System PAR: 0 dB; PMF: 1
Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1000 kg/m^3 , Medium parameters used: f = 900 MHz; σ = 1.037 S/m; ε_r = 52.658; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)
DASY Configuration:

- Probe: EX3DV4 - SN3746; ConvF(8.96, 8.96, 8.96) @ 900 MHz; Calibrated: 11/19/2019
  - Modulation Compensation:
- Sensor-Surface: 0mm (Fix Surface), Sensor-Surface: 5mm (Mechanical Surface Detection), z = 101.0, 31.0
- Electronics: DAE4 Sn909; Calibrated: 12/6/2019
- Phantom: ELI V6.0 (SAC); Type: QD OVA 003 AA; Serial: 2044
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

System Check/System Check/Z Scan (1x1x21): Measurement grid: dx=20mm, dy=20mm, dz=5mm
Maximum value of Total (measured) = 40.74 V/m

System Check/System Check/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 31.91 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 1.61 W/kg
SAR(1 g) = 1.06 W/kg; SAR(10 g) = 0.683 W/kg (SAR corrected for target medium)
Maximum value of SAR (measured) = 1.06 W/kg

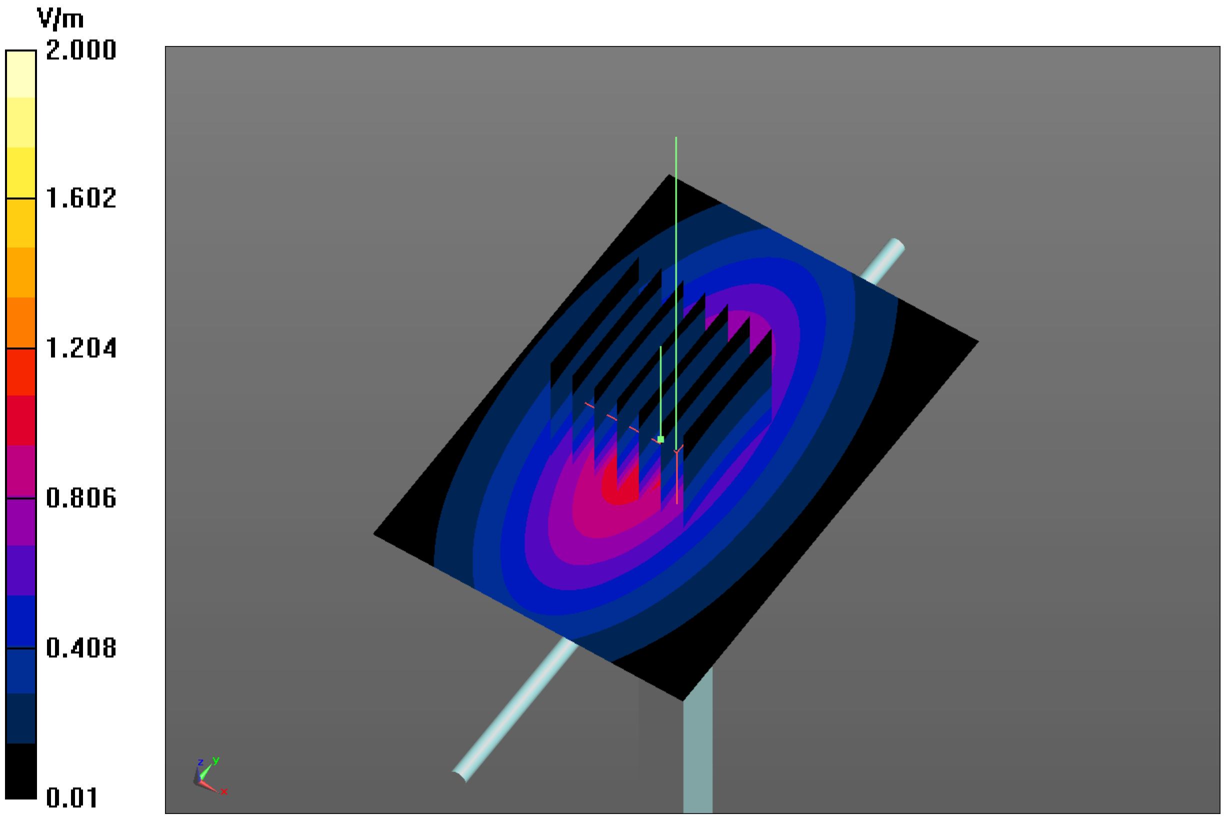
System Check/System Check/Area Scan (71x101x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 1.06 W/kg

System Check/System Check/Z Scan (1x1x21): Measurement grid: dx=20mm, dy=20mm, dz=5mm
Maximum value of SAR (measured) = 1.72 W/kg

Approved By

SAR SYSTEM VERIFICATION

MBBL600-6000V6 System Check_900MHz 1-29-20



SAR SYSTEM VERIFICATION

element
WSSV.2016.12.19

Tested By:	Kyle McMullan, Marcelo Aguayo	Room Temperature (°C):	23.4°C
Date:	3/30/2020	Liquid Temperature (°C):	22.3°C
		Humidity (%RH):	19.6%
		Bar. Pressure (mb):	1010.2 mb

MBBL600-6000V6 System Check 3-30-20
DUT: Dipole 900 MHz D900V2; Type: D900V2; Serial: D900V2 - SN:xxx
Communication System: UID 0, CW (0); Communication System Band: D9 (900.0 MHz); Frequency: 900 MHz;Communication System PAR: 0 dB; PMF: 1
Medium parameters used: f = 900 MHz; σ = 1.017 S/m; ε_r = 55.339; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)
DASY Configuration:

- Probe: EX3DV4 - SN3746; ConvF(8.96, 8.96, 8.96) @ 900 MHz; Calibrated: 11/19/2019
    - Modulation Compensation:
- Sensor-Surface: 5mm (Mechanical Surface Detection), Sensor-Surface: 0mm (Fix Surface), z = 1.0, 101.0, 31.0
- Electronics: DAE4 Sn1237; Calibrated: 2/4/2020
- Phantom: ELI V6.0 (SAC); Type: QD OVA 003 AA; Serial: 2044
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

System Check/System Check/Area Scan (71x101x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 1.04 W/kg

System Check/System Check/Z Scan (1x1x21): Measurement grid: dx=20mm, dy=20mm, dz=5mm
Maximum value of Total (measured) = 35.01 V/m

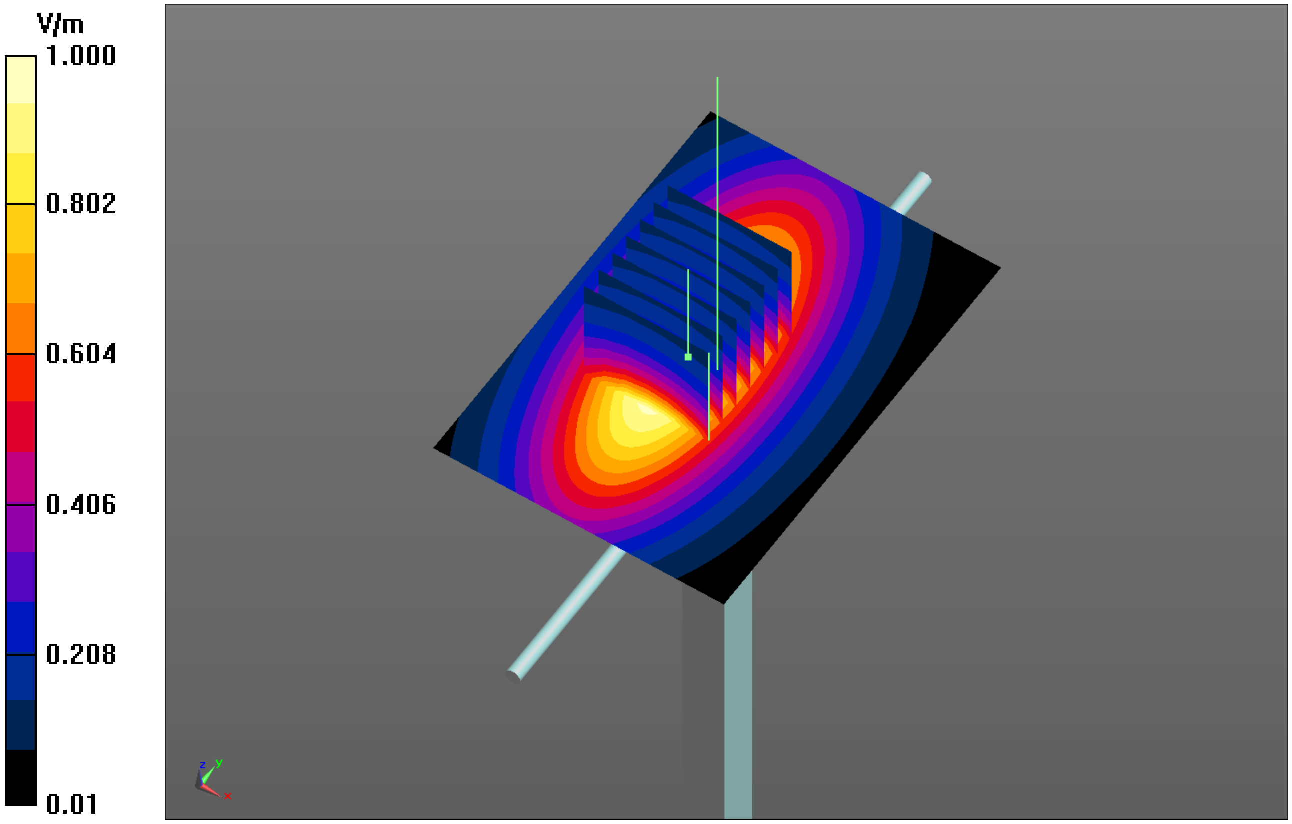
System Check/System Check/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 31.12 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 1.54 W/kg
SAR(1 g) = 1.04 W/kg; SAR(10 g) = 0.685 W/kg (SAR corrected for target medium)
Maximum value of SAR (measured) = 1.05 W/kg

Kyle McMullan

Approved By

SAR SYSTEM VERIFICATION

MBBL600-6000V6 System Check 3-30-20



OUTPUT POWER

element
WTD.2017.11.22.1

EUT:	PD67 Handheld RFID Reader	Work Order:	TURC0061
Serial Number:	T10	Date:	2020/01/23
Customer:	TURCK Inc.	Temperature:	22.8 °C
Attendees:	Gabe Selinger	Relative Humidity:	27.1% RH
Customer Project:	None	Bar. Pressure:	1019 mbar
Tested By:	Andrew Rogstad	Job Site:	MN08
Power:	120VAC/60Hz	Configuration:	TURC0061-1

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

Output power values come from Element report TURC0061.1

DEVIATIONS FROM TEST STANDARD

None

RESULTS – RFID

Frequency (MHz)	Output Power (mW)	Output Power (dBm)
902.75	327.22	25.15
915.25	403.19	26.06
927.25	379.46	25.79

SAR TEST DATA

EUT:	PD67 Handheld RFID Reader	Work Order:	TURC0061
Customer:	TURCK Inc.	Job Site:	MN11
Attendees:	Gabe Selinger	Customer Project:	None

TEST SPECIFICATIONS

Specification:	Method:
FCC 2.1093:2020	FCC KDB 447498 D01 v01r06 FCC KDB 865664 D01 v01r04 FCC KDB 865664 D02 v01r02 IEEE Std 1528:2013

COMMENTS

None

DEVIATIONS FROM TEST STANDARD

None

RESULTS – BARCODE READER CONFIGURATION

Test Config.	Frequency Band	Transmit Frequency (MHz)	Transmit Channel	EUT Position	SAR Drift During Test (dB)	Measured 1g SAR Level (mW/g)	Measured 10g SAR Level (mW/g)	Duty Cycle (%)	DC Corrected 1g SAR Level (mW/g)	DC Corrected 10g SAR Level (mW/g)	Test#
Body	900 MHz ISM	915.25 MHz	22	Front	-0.55	0.1	0.07	30	0.03	0.02	UHF 915.25 MHz 1a
Body	**900 MHz ISM**	**915.25 MHz**	**22**	**Back**	**-0.27**	**2.11**	**1.03**	**30**	**0.63**	**0.31**	**UHF 915.25 MHz 1b**
Body	900 MHz ISM	915.25 MHz	22	Power Button	-0.0	0.13	0.08	30	0.04	0.02	UHF 915.25 MHz 1c
Body	900 MHz ISM	915.25 MHz	22	Scroll Button	0.19	0.05	0.04	30	0.02	0.01	UHF 915.25 MHz 1d
Body	900 MHz ISM	915.25 MHz	22	Reader	0.00	0.82	0.51	30	0.25	0.15	UHF 915.25 MHz 1e

RESULTS – NO BARCODE READER CONFIGURATION

Test Config.	Frequency Band	Transmit Frequency (MHz)	Transmit Channel	EUT Position	SAR Drift During Test (dB)	Measured 1g SAR Level (mW/g)	Measured 10g SAR Level (mW/g)	Duty Cycle (%)	DC Corrected 1g SAR Level (mW/g)	DC Corrected 10g SAR Level (mW/g)	Test#
Body	**900 MHz ISM**	**915.25 MHz**	**22**	**Back**	**-0.07**	**3.26**	**1.60**	**30**	**0.98**	**0.48**	**UHF 915.25 MHz 1f**
Body	900 MHz ISM	915.25 MHz	22	Power Button	-0.16	0.08	0.05	30	0.02	0.02	UHF 915.25 MHz 1g
Body	900 MHz ISM	915.25 MHz	22	Scroll Button	0.17	0.35	0.15	30	0.11	0.05	UHF 915.25 MHz 1h
Body	900 MHz ISM	915.25 MHz	22	Reader	-0.07	1.85	1.19	30	0.56	0.36	UHF 915.25 MHz 1i

REPEATED MEASUREMENTS RESULTS – NO BARCODE READER CONFIGURATION

Repeated Test#	SAR Drift During Test (dB)	Measured 1g SAR Level (mW/g)	Measured 10g SAR Level (mW/g)	Duty Cycle (%)	DC Corrected 1g SAR Level (mW/g)	DC Corrected 10g SAR Level (mW/g)	% Variation	Test#
UHF 915.25 MHz 1f	-0.17	2.17	1.05	30	0.65	0.32	50.7%	UHF 915.25 MHz 1f2
UHF 915.25 MHz 1f	-0.27	2.11	1.03	30	0.63	0.31	55.6%	UHF 915.25 MHz 1f3

SAR TEST DATA

element
WSTD.2016.12.19

Tested By:	Kyle McMullan	Room Temperature (°C):	22.4°C
Date:	1/29/2020 11:51:59 AM	Liquid Temperature (°C):	21.5°C
Serial Number:	T04	Humidity (%RH):	22.2%
Configuration:	TURC0061-5	Bar. Pressure (mb):	1028.7
Comments:	None		

UHF 915.25MHz 1b
DUT: PD67 Handheld Reader; Type: Not Specified; Serial: T04
Communication System: UID 0, CW (0); Communication System Band: D915 (915.0 MHz); Frequency: 915.25 MHz;Communication System PAR: 0 dB; PMF: 1
Medium parameters used (interpolated): f = 915.25 MHz; σ = 1.043 S/m; ε_r = 52.629; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)
DASY Configuration:

- Probe: EX3DV4 - SN3746; ConvF(8.96, 8.96, 8.96) @ 915.25 MHz; Calibrated: 11/19/2019
    - Modulation Compensation:
- Sensor-Surface: 3mm (Mechanical Surface Detection), Sensor-Surface: 0mm (Fix Surface), z = 31.0, 106.0
- Electronics: DAE4 Sn909; Calibrated: 12/6/2019
- Phantom: ELI V6.0 (SAC); Type: QD OVA 003 AA; Serial: 2044
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

Body/Body/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 51.50 V/m; Power Drift = -0.17 dB
Peak SAR (extrapolated) = 4.71 W/kg
SAR(1 g) = 2.17 W/kg; SAR(10 g) = 1.05 W/kg (SAR corrected for target medium)

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 3.01 W/kg

Body/Body/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) = 2.78 W/kg

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

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of Total (measured) = 36.61 V/m

Body/Body/Zoom Scan 2 (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 51.50 V/m; Power Drift = -0.27 dB
Peak SAR (extrapolated) = 4.58 W/kg
SAR(1 g) = 2.11 W/kg; SAR(10 g) = 1.03 W/kg (SAR corrected for target medium)

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 2.94 W/kg

Body/Body/Reference scan (51x81x1): Interpolated grid: dx=3.000 mm, dy=3.000 mm

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (interpolated) = 2.34 W/kg

SAR TEST DATA

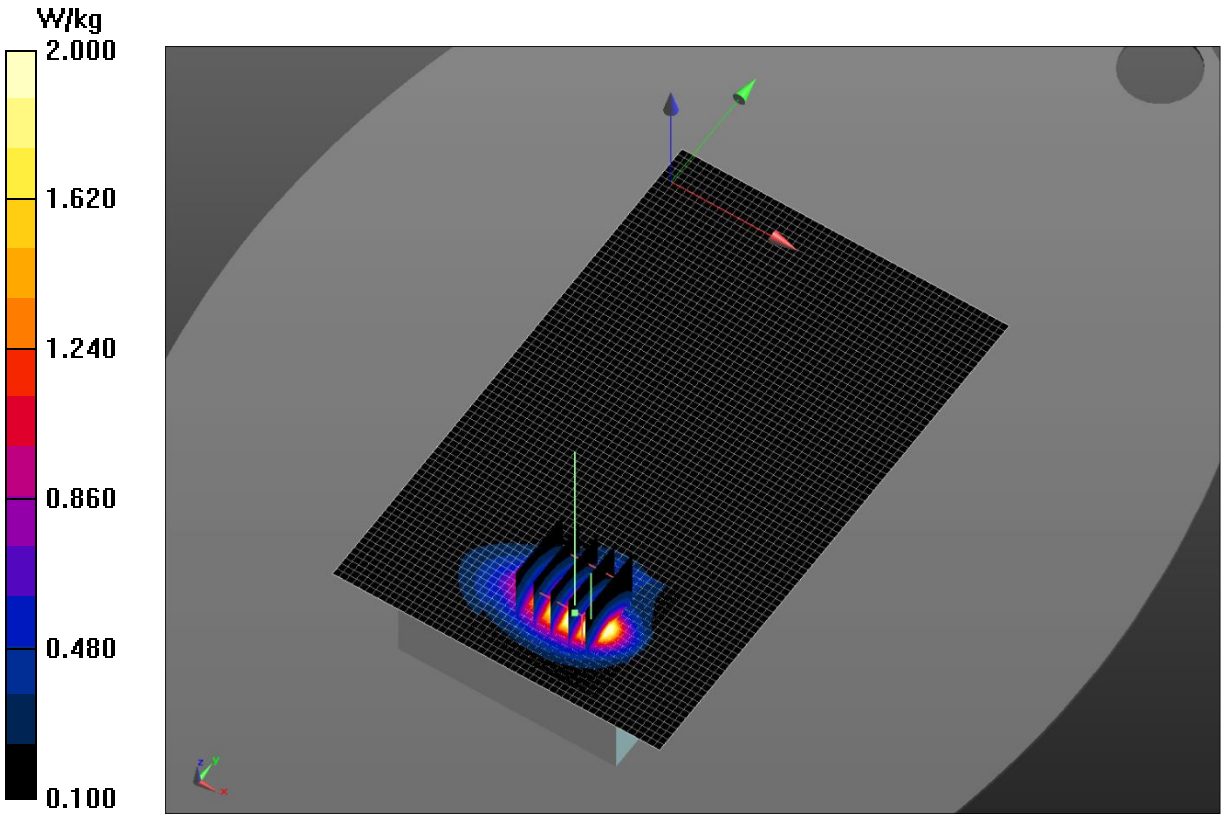
Body/Body/Z Scan (1x1x21): Measurement grid: dx=20mm, dy=20mm, dz=5mm

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 1.40 W/kg

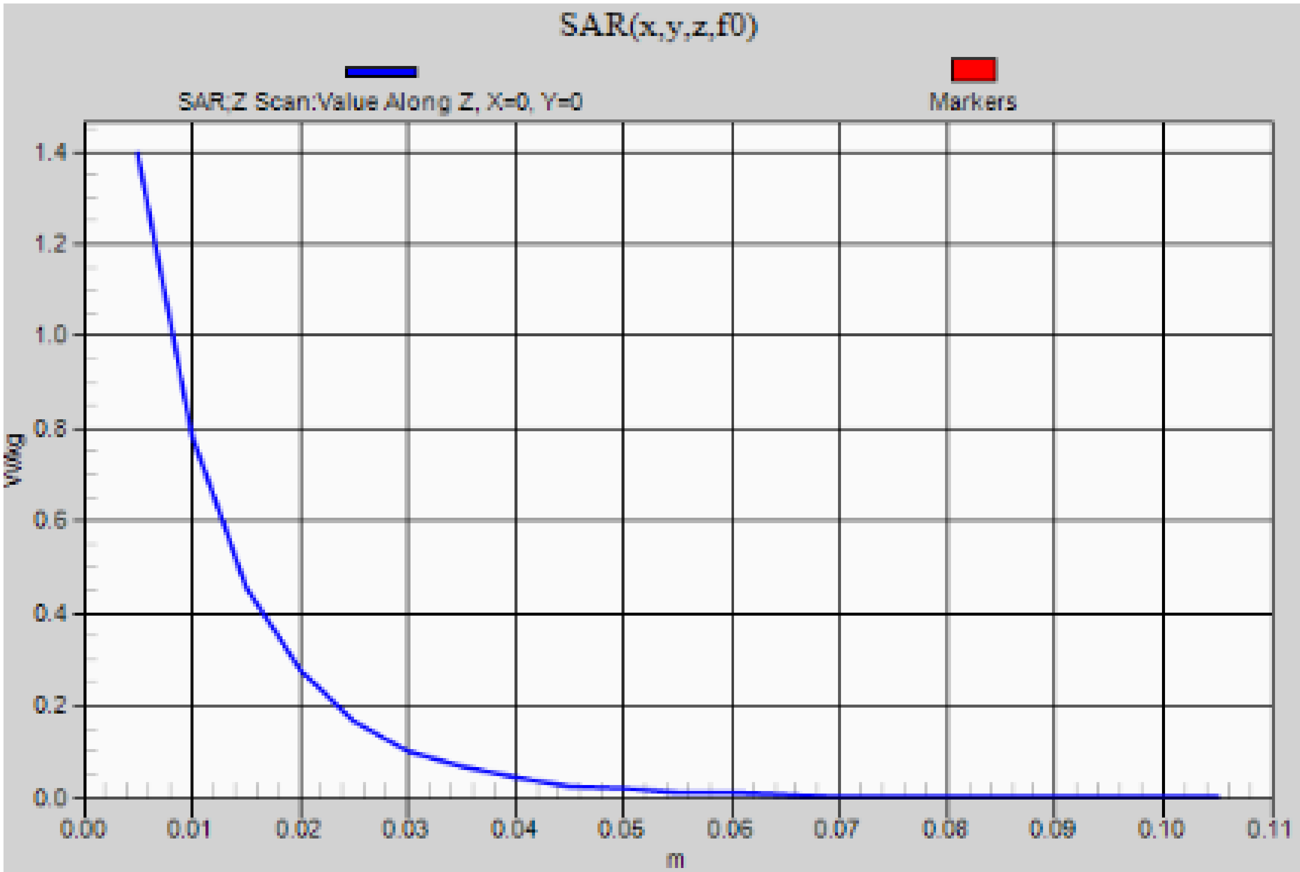
Approved By

SAR TEST DATA

UHF 915.25MHz 1b



SAR TEST DATA



SAR TEST DATA

Tested By:	Kyle McMullan	Room Temperature (°C):	23.3°C
Date:	3/30/2020 2:36:36 AM	Liquid Temperature (°C):	22.2°C
Serial Number:	T04	Humidity (%RH):	19.6%
Configuration:	TURC0061-5	Bar. Pressure (mb):	1010.2 mb
Comments:	None		

UHF 915.25 MHz 1f
DUT: PD67 Handheld Reader; Type: Not Specified; Serial: T04
Communication System: UID 0, CW (0); Communication System Band: D915 (915.0 MHz); Frequency: 915.25 MHz;Communication System PAR: 0 dB; PMF: 1
Medium parameters used (interpolated): f = 915.25 MHz; σ = 1.023 S/m; εr = 55.31; ρ = 1000
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)
DASY Configuration:

- Probe: EX3DV4 - SN3746; ConvF(8.96, 8.96, 8.96) @ 915.25 MHz; Calibrated: 11/19/2019
    - Modulation Compensation:
- Sensor-Surface: 3mm (Mechanical Surface Detection), Sensor-Surface: 0mm (Fix Surface), z = 1.0, 31.0, 106.0
- Electronics: DAE4 Sn1237; Calibrated: 2/4/2020
- Phantom: ELI V6.0 (SAC); Type: QD OVA 003 AA; Serial: 2044
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

Body/Body/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 64.75 V/m; Power Drift = -0.07 dB
Peak SAR (extrapolated) = 6.86 W/kg
SAR(1 g) = 3.26 W/kg; SAR(10 g) = 1.6 W/kg (SAR corrected for target medium)

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 1.57 W/kg

Body/Body/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) = 3.51 W/kg

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

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of Total (measured) = 45.00 V/m

Body/Body/Reference scan (51x81x1): Interpolated grid: dx=3.000 mm, dy=3.000 mm

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (interpolated) = 3.46 W/kg

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

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.668 W/kg

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

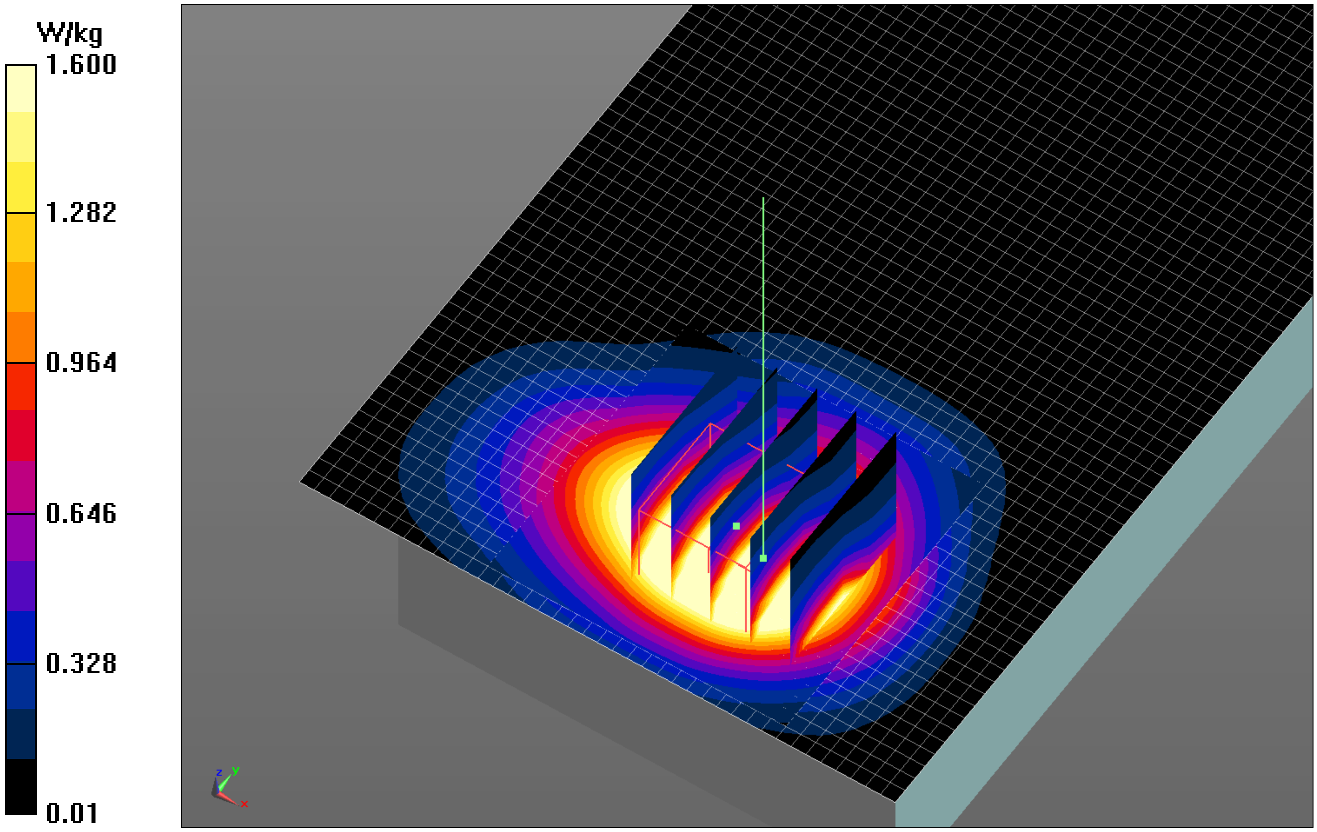
SAR TEST DATA

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 2.07 W/kg

Approved By

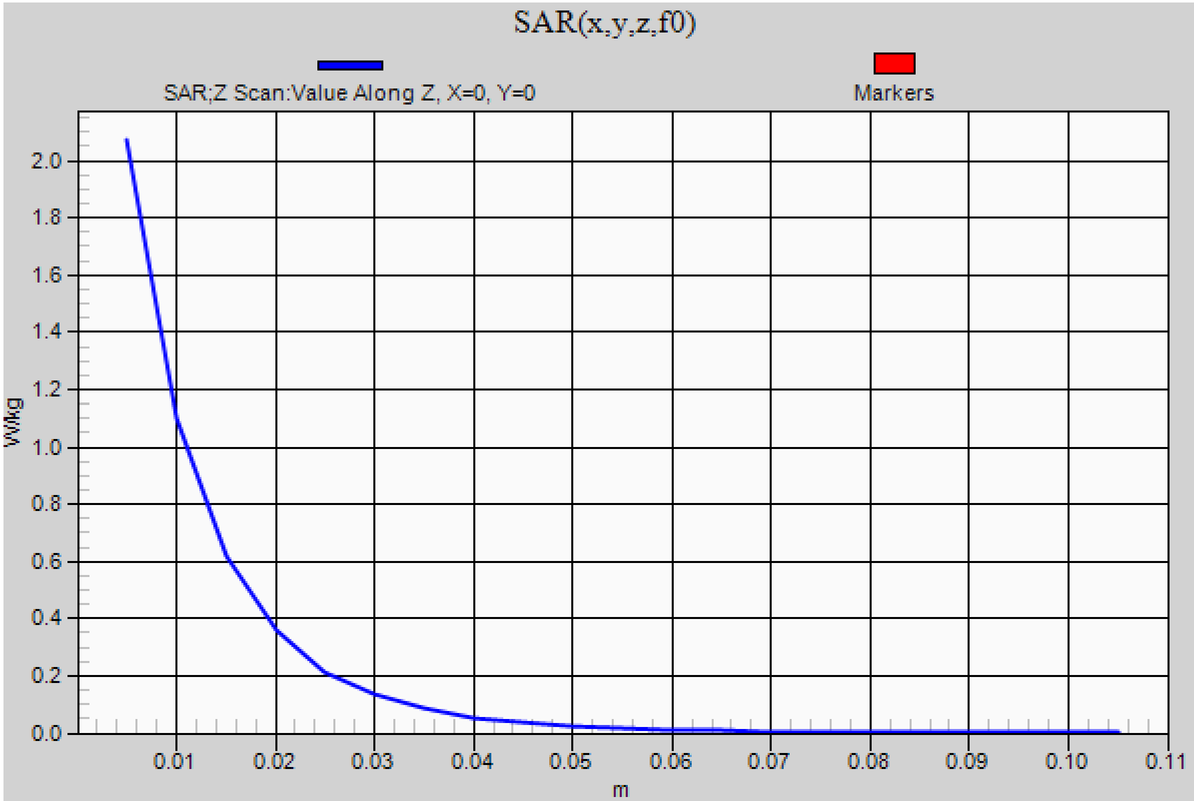
SAR TEST DATA

UHF 915.25 MHz 1f



SAR TEST DATA

-



SYSTEM AND TEST SITE DESCRIPTION

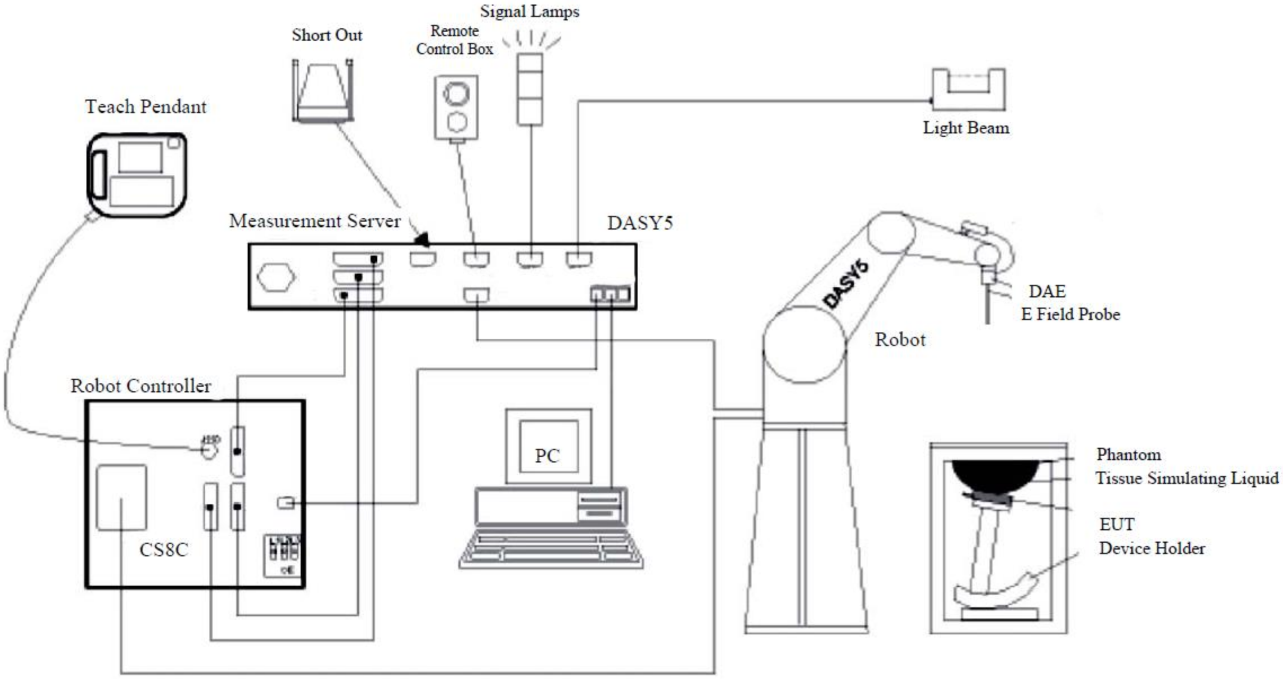
element
WSTD.2017.1.31

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:



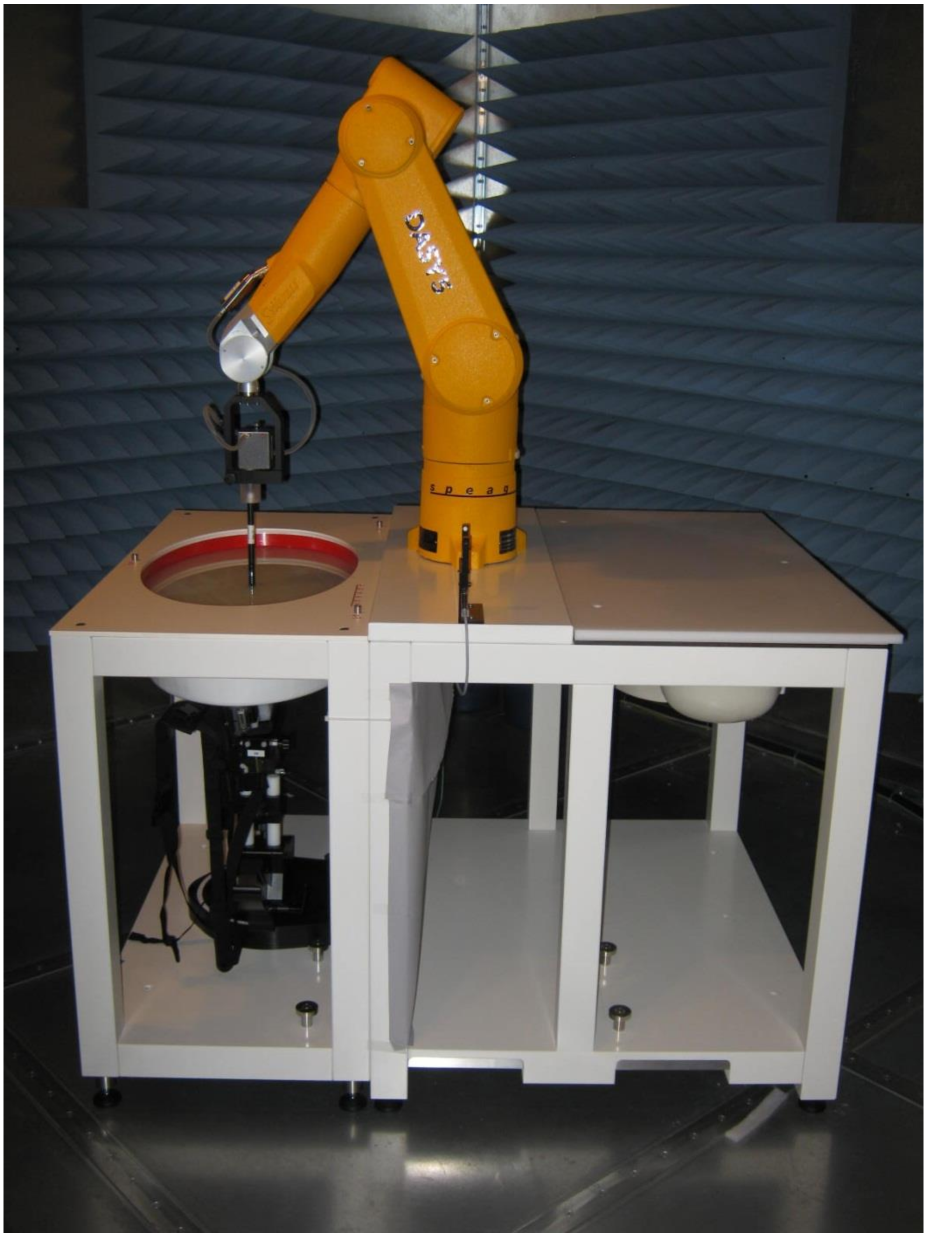
- A standard high precision 6-axis robot (Staubli TX=RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) 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

WSTD.2017.1.31

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

WSEQ.2016.12.19

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Interval
Amplifier	Mini Circuits	ZHL-5W-2G-S+	TRZ	NCR [1]	0 mo
Antenna - Dipole	SPEAG	D900V2	ADP	11/11/2019	12 mo
Device Holder	SPEAG	N/A	SAW	NCR	0 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	MBBL600-6000V6	SALM	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 BK	R219	12/06/2019	12 mo
DAE	SPEAG	SD 000 D04 EJ	SAH	12/11/2019	12 mo

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

MEASUREMENT UNCERTAINTY

MEASUREMENT UNCERTAINTY BUDGETS PER IEEE 1528:2013

300-3000 MHz Range

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

ADP

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

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

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

Accreditation No.: SCS 0108

Client **Element**

Certificate No: D900V2-1d106_Nov19

CALIBRATION CERTIFICATE

Object	D900V2 - SN:1d106
Calibration procedure(s)	QA CAL-05.v11 Calibration Procedure for SAR Validation Sources between 0.7-3 GHz
Calibration date:	November 11, 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

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

Issued: November 12, 2019

Calibration Laboratory of
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S **Schweizerischer Kalibrierdienst**
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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

Glossary:

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

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "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
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) 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	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	900 MHz ± 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 ± 0.2) °C	41.8 ± 6 %	0.94 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.74 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**11.3 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.76 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**7.20 W/kg ± 16.5 % (k=2)**

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Body TSL parameters	22.0 °C	55.0	1.05 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	54.9 ± 6 %	1.01 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.70 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**11.1 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.76 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**7.20 W/kg ± 16.5 % (k=2)**

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.3 Ω - 6.2 jΩ
Return Loss	- 24.1 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	45.2 Ω - 8.8 jΩ
Return Loss	- 19.6 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.411 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

DASY5 Validation Report for Head TSL

Date: 11.11.2019

Test Laboratory: SPEAG, Zurich, Switzerland

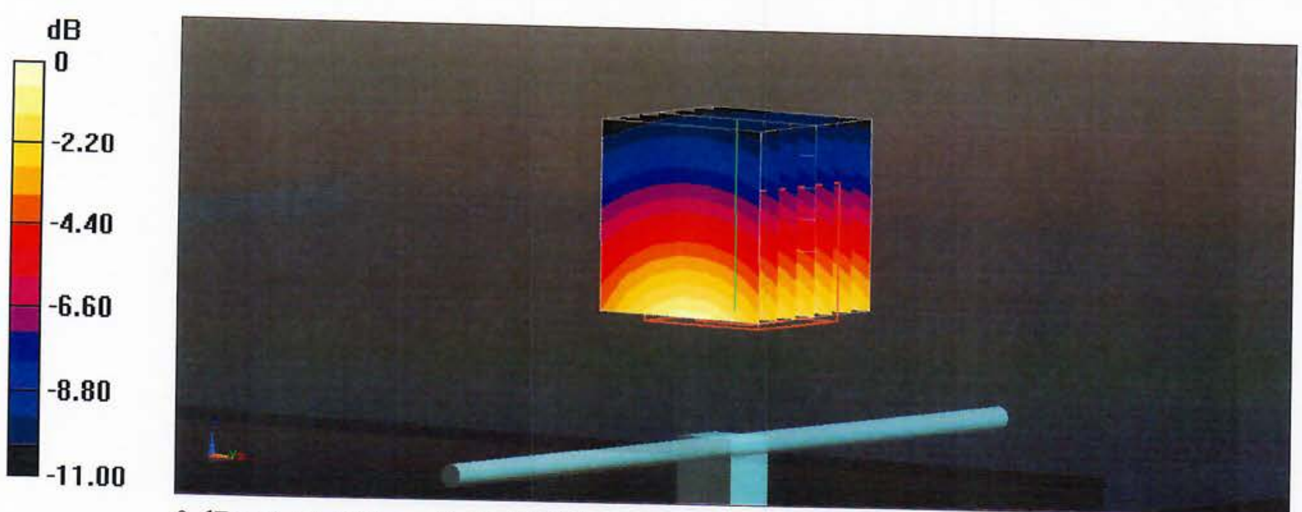
DUT: Dipole 900 MHz; Type: D900V2; Serial: D900V2 - SN:1d106

Communication System: UID 0 - CW; Frequency: 900 MHz
Medium parameters used: f = 900 MHz; σ = 0.94 S/m; ε_r = 41.8; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

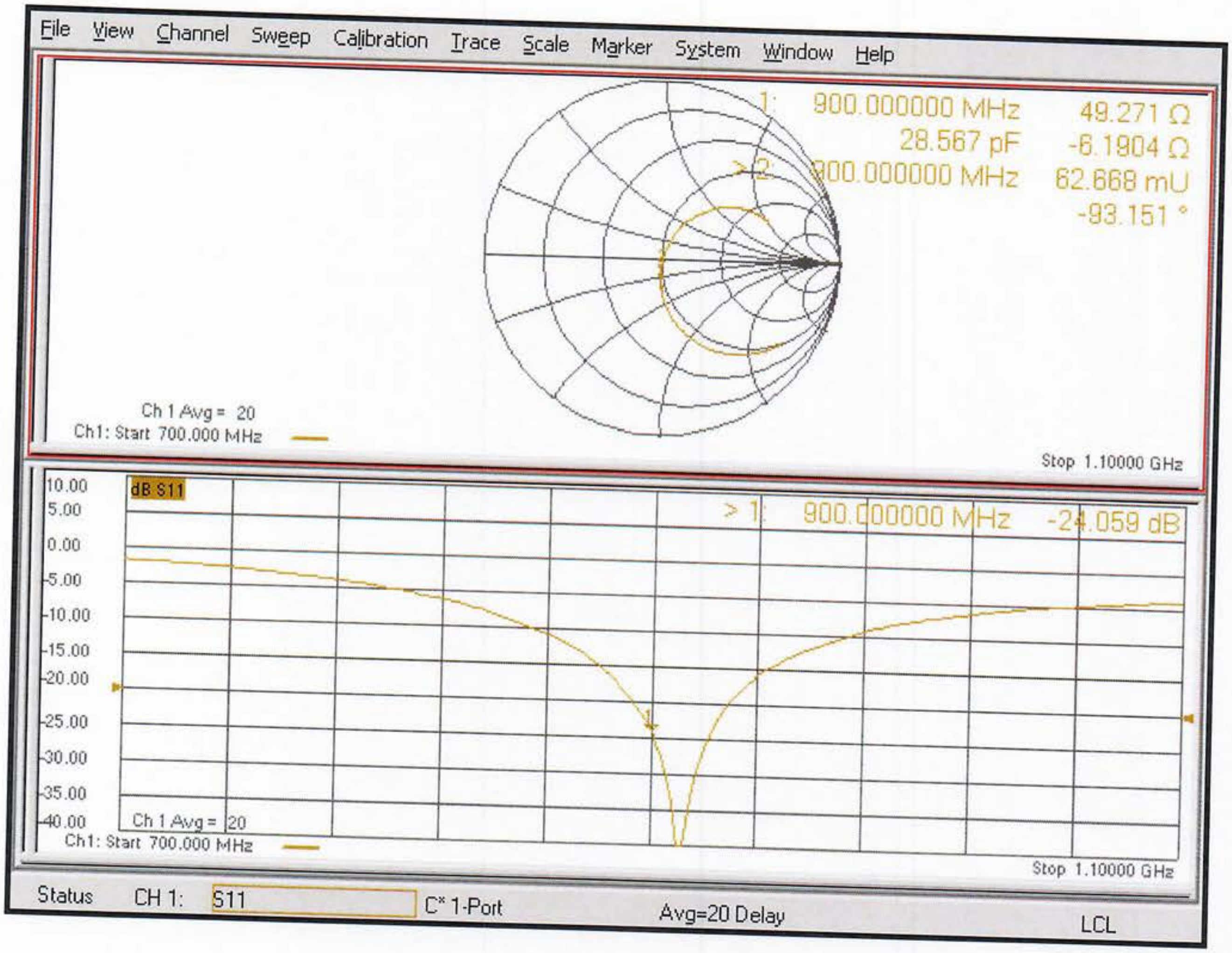
- Probe: EX3DV4 - SN7349; ConvF(9.51, 9.51, 9.51) @ 900 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.3(1513); SEMCAD X 14.6.13(7474)

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 = 66.66 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 4.14 W/kg
SAR(1 g) = 2.74 W/kg; SAR(10 g) = 1.76 W/kg
Smallest distance from peaks to all points 3 dB below = 16 mm
Ratio of SAR at M2 to SAR at M1 = 66.5%
Maximum value of SAR (measured) = 3.64 W/kg



0 dB = 3.64 W/kg = 5.61 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 11.11.2019

Test Laboratory: SPEAG, Zurich, Switzerland

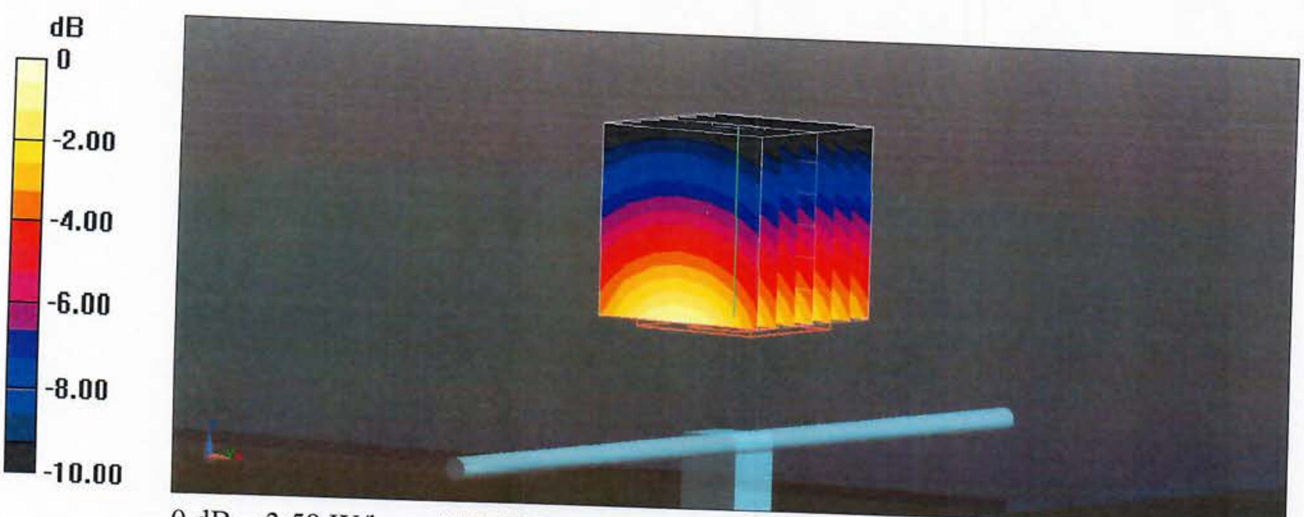
DUT: Dipole 900 MHz; Type: D900V2; Serial: D900V2 - SN:1d106

Communication System: UID 0 - CW; Frequency: 900 MHz
Medium parameters used: f = 900 MHz; σ = 1.01 S/m; ε_r = 54.9; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

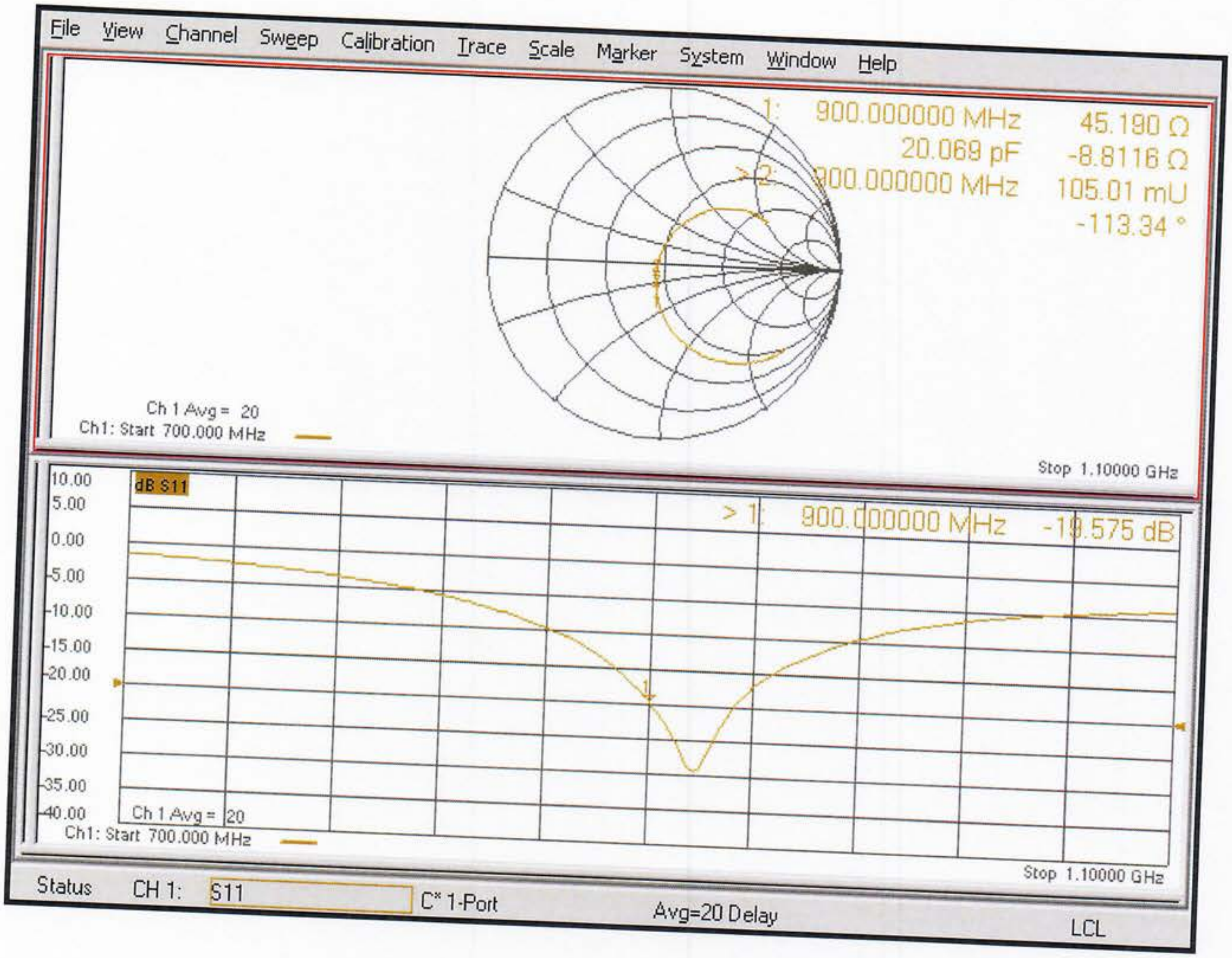
- Probe: EX3DV4 - SN7349; ConvF(9.95, 9.95, 9.95) @ 900 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.3(1513); SEMCAD X 14.6.13(7474)

Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:
Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 60.81 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 3.99 W/kg
SAR(1 g) = 2.7 W/kg; SAR(10 g) = 1.76 W/kg
Smallest distance from peaks to all points 3 dB below = 15 mm
Ratio of SAR at M2 to SAR at M1 = 67.8%
Maximum value of SAR (measured) = 3.59 W/kg



0 dB = 3.59 W/kg = 5.55 dBW/kg

Impedance Measurement Plot for Body TSL



SAG

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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.

Glossary:

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

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, ", "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
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

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

Basic Calibration Parameters

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

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B dB√μV	C	D dB	VR mV	Max dev.	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	180.3	±3.5 %	± 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.

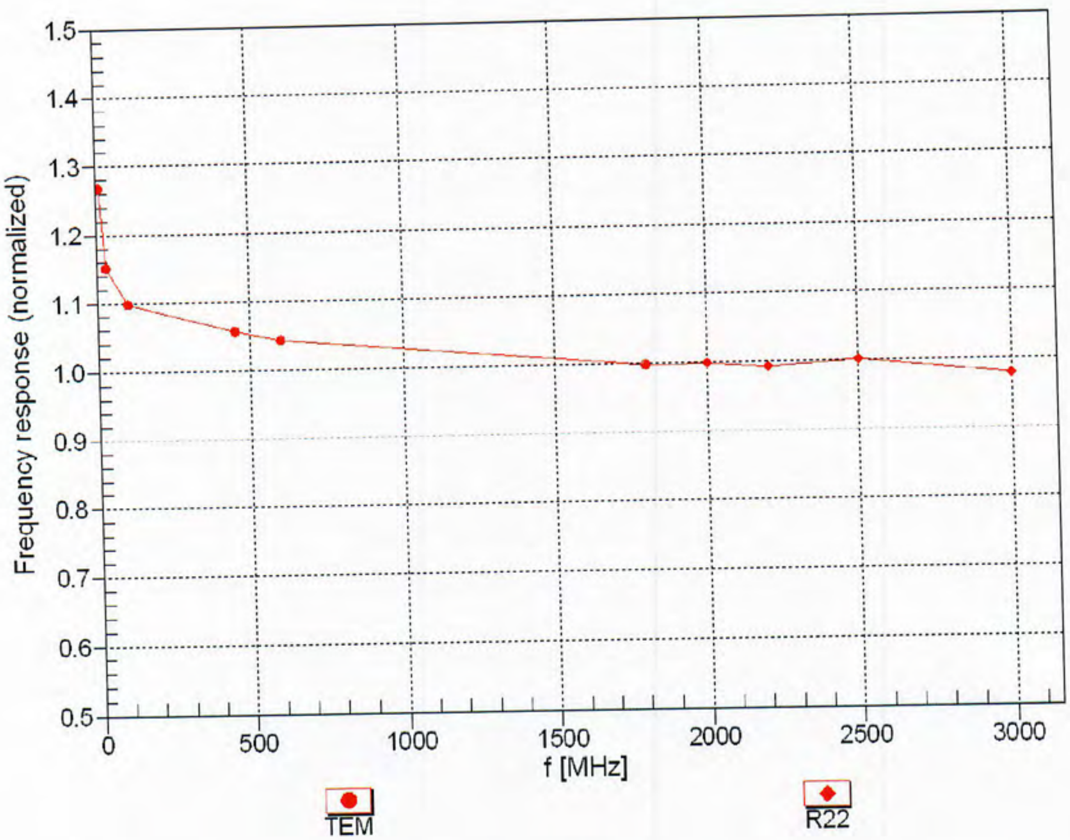
DASY/EASY - Parameters of Probe: EX3DV4 - SN:3746

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 %

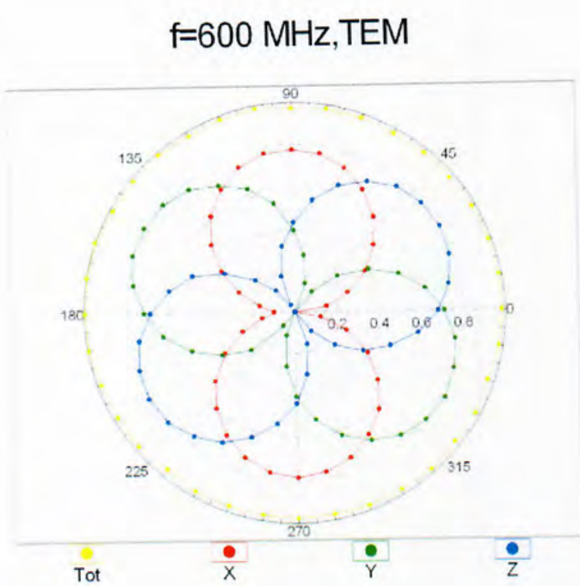
[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz 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.

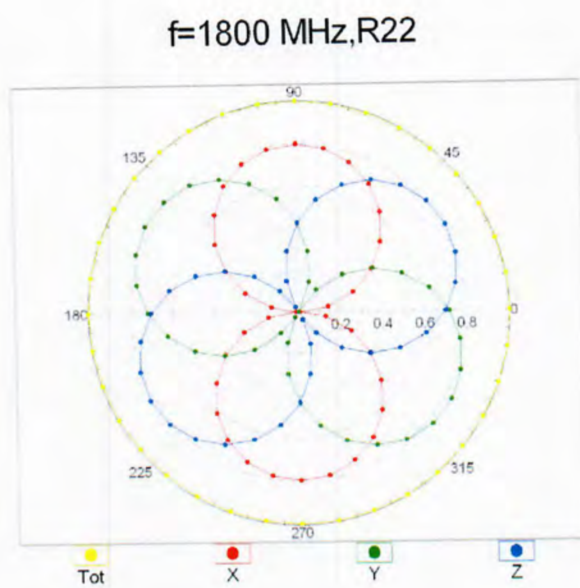
Frequency Response of E-Field
(TEM-Cell:ifi110 EXX, Waveguide: R22)

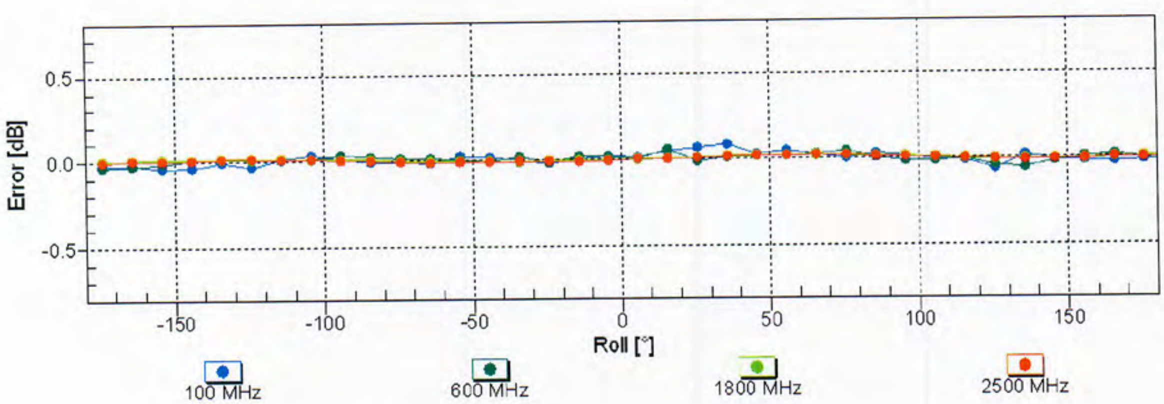


Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)

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

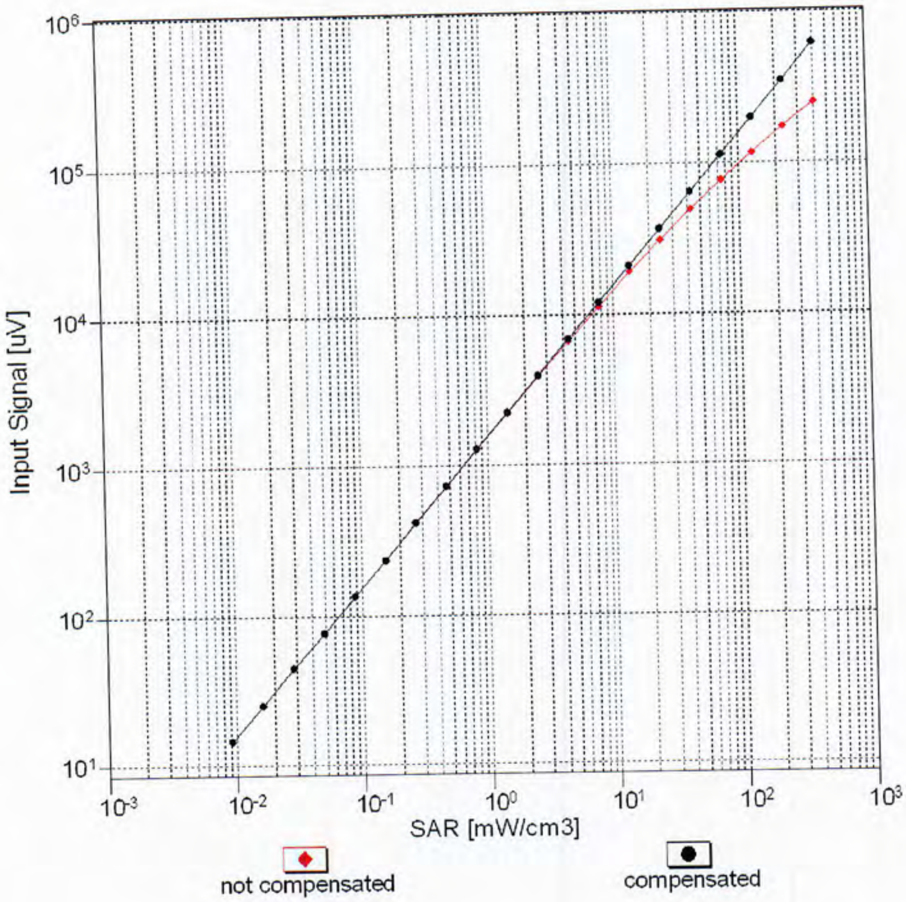


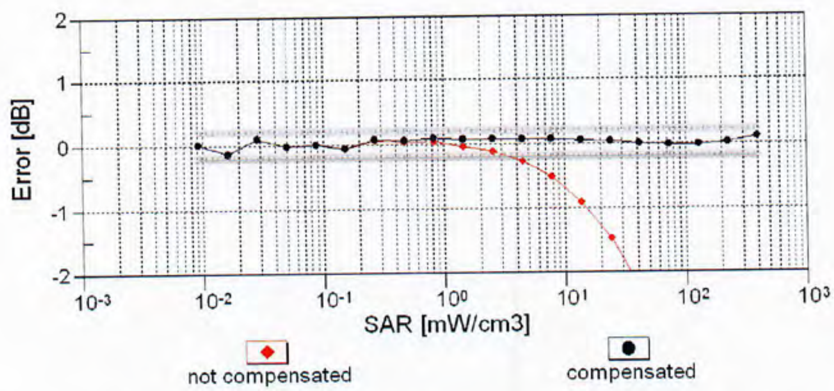




Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

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

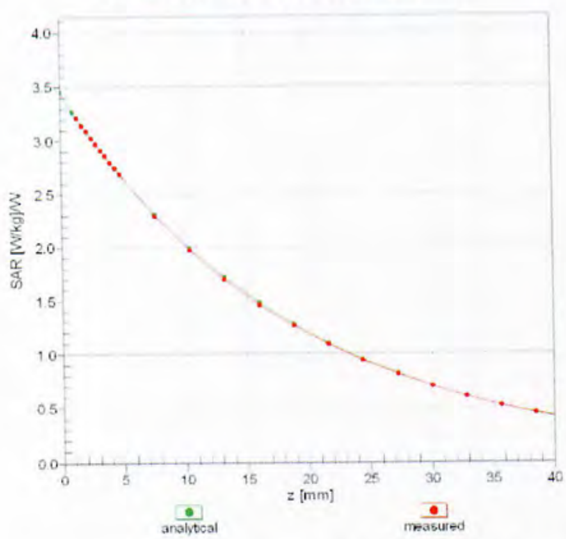




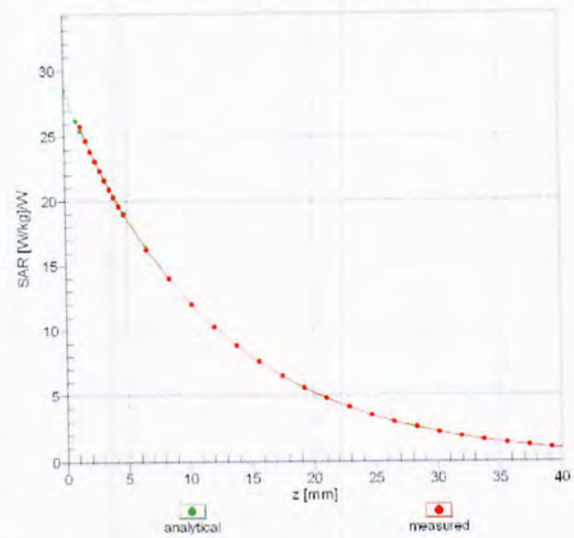
Uncertainty of Linearity Assessment: ± 0.6% (k=2)

Conversion Factor Assessment

f = 835 MHz,WGLS R9 (H_convF)

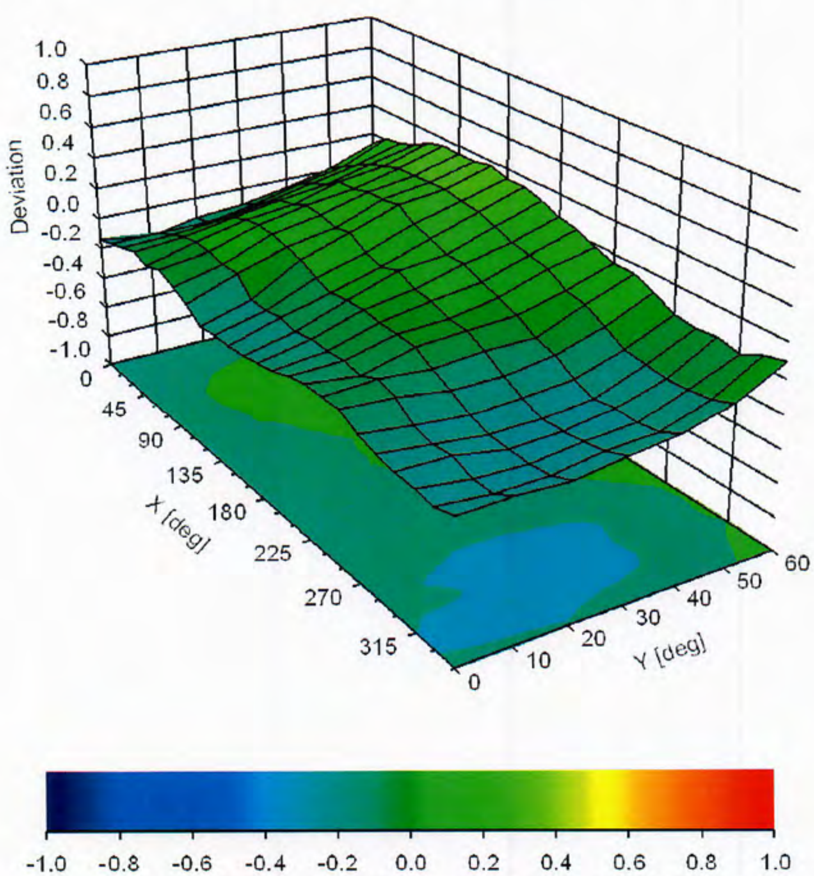


f = 1900 MHz,WGLS R22 (H_convF)



Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz



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