

Walt Disney Parks and Resorts US, Inc.

TPv2 (DAP 2)

SAR Evaluation Report # SYNA0197 Rev 01 Evaluated to the following SAR specification: FCC 2.1093:2016 FCC 15.247:2016



TESTING

NVLAP Lab Code: 200630-0

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#### Last Date of Test: September 15, 2016 Walt Disney Parks and Resorts US, Inc. Model: TPv2 (DAP 2)

Applicable Standard						
Test Description	Specification	Test Method	Pass/Fail			
SAR Evaluation	FCC 15.247:2016 FCC 2.1093:2016	FCC KDB 865664 D01 v01r04 FCC KDB 865664 D02 v01r02 FCC KDB 248227 D01 V02r02 FCC KDB 447498 D01 v06 IEEE Std 1528:2013	Pass			

#### **Highest SAR Values:**

Frequency (MHz)	Extremity (W/kg)	Limit (W/kg)	Exposure Environment		
(	10g	10g			
902.75	0.23	4.0	General Population		

#### **Deviations From Test Standards**

None

**Approved By:** 

Don Facteau, IS Manager

# **REVISION HISTORY**



Revision Number	Revision Description		Page Number
01	Updated to correct the system description	3/3/17	6

### ACCREDITATIONS AND AUTHORIZATIONS



#### **United States**

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

**A2LA** - Accredited by A2LA to ISO / IEC 17065 as a product certifier. This allows Northwest EMC 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). Certification chambers and Open Area Test Sites are filed with ISED.

#### **European Union**

European Commission – Validated by the European Commission as a Notified Body under the R&TTE Directive.

#### Australia/New Zealand

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

#### Korea

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

#### Japan

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

#### Taiwan

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

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

#### Singapore

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

#### Israel

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

#### Hong Kong

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

#### Vietnam

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

### SCOPE

For details on the Scopes of our Accreditations, please visit: <u>http://www.nwemc.com/accreditations/</u>

http://gsi.nist.gov/global/docs/cabs/designations.html

### FACILITIES





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



## **PRODUCT DESCRIPTION**



#### **Client and Equipment Under Test (EUT) Information**

Company Name:	Walt Disney Parks and Resorts US, Inc.
Address:	PO Box 10000
City, State, Zip:	Lake Buena Vista, FL 32830
Test Requested By:	Brian Piquette of Synapse Product Development LLC
Model:	TPv2 (DAP 2)
First Date of Test:	September 15, 2016
Last Date of Test:	September 15, 2016
Receipt Date of Samples:	September 15, 2016
Equipment Design Stage:	Production
Equipment Condition:	No Damage

#### Information Provided by the Party Requesting the Test

#### Functional Description of the EUT:

The TPv2 (DAP2) Multi-Media Reader is part of a proprietary data acquisition system. It provides an HF RFID reader, UHF RFID reader, Bluetooth LE Host interface and a 2.4GHz RF interface to read data from proprietary RFID and RF media that are held in the hand or worn on the wrist. This RFID/RF tag data can be then sent over an Ethernet connection to a data collection/concentration object. The TPv2 (DAP2) is designed to be mounted in several known stanchions which provide the final weatherproof enclosure for the product.

Please see the external photos exhibit, the internal photos exhibit, and the antenna info exhibit for details regarding the EUT configuration and antenna location. These exhibits are part of the FCC application filed for this product.

Compliance with 2.1093 for the Class II Permissive change of the UHF RFID radio, FCC ID: TWYPJRS500 also contained in the system is shown in this document.

Compliance with FCC RF exposure requirements for 2.1093 portable devices for the TPv2 (DAP 2) which includes the 2.4 GHz DTS radio and for the Class II Permissive Change to the Bluetooth/Bluetooth Low Energy radio, FCC ID: SQGBT800 contained in the system are not shown in this document. A separate SAR extremity exclusion will be part of the FCC certification filing.

### **PRODUCT DESCRIPTION**



#### **Testing Requirements**

#### **Testing Locations**

The EUT will be mounted in stanchions where only the face of the product is exposed to users. This face is also the side closest to the transmitting antenna.

#### Simultaneous Transmission

The EUT does have simultaneous transmission capability. Simultaneous SAR exposure assessment will be included as part of the FCC Certification filing.

#### **Testing Objective:**

Only a user's hand or wrist will be closer than 20cm to the transmit antenna. The 900 MHz RFID radio failed the extremity SAR exclusion, so this SAR report was necessary. Therefore, this testing is to demonstrate compliance of the radio with the extremity SAR requirements of FCC 2.1093.

#### Scope

The stand-alone SAR evaluation documented in this report is for the 900 MHz UHF RFID radio in the EUT.

### **CONFIGURATIONS**



### Configuration SYNA0197-1

Software/Firmware Running during test				
Description	Version			
UHFTool (900 MHz)	0.0			

EUT			
Description	Manufacturer	Model/Part Number	Serial Number
Access Point	Walt Disney Parks and Resorts US, Inc.	TPv2	850-1631035

Cables					
Cable Type	Shield	Length (m)	Ferrite	Connection 1	Connection 2
DC Power Cable	No	2m	No	Access Point	DC Power Supply





### **Equipment Modifications**

Item	Date	Test	Modification	Note	Disposition of EUT
1	9/15/2016	SAR Evaluation	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	Scheduled testing was completed.

# TISSUE – EQUIVALENT LIQUID DESCRIPTION

NORTHWEST EMC VERSION

#### Characterization of tissue-equivalent liquid dielectric properties

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

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

#### Target values of dielectric parameters

Per KDB 865664 D01 v01r04, Appendix A:

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

Target Frequency	Head		Вс	ody
(MHz)	<mark>E</mark> r	σ (S/m)	Er	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

( $\varepsilon_r$  = relative permittivity,  $\sigma$  = conductivity and  $\rho$  = 1000 kg/m<sup>3</sup>)

# TISSUE – EQUIVALENT LIQUID DESCRIPTION



#### **Composition of Ingredients for Liquid Tissue Phantoms**

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

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

#### HEAD

Frequency (MHz) Reference	300	450	450	450	835	835 [B74]	900	900	900	900 [B74]
Ingredients (%	6 by weigh	t)		[274]	[DII0]	[274]	[DII0]			[274]
1,2- Propanediol	_	_	—	—	—	_	_	6 <mark>4</mark> .81	_	_
Bactericide	0.19	0.19	0.50	_	0.10	_	0.10	_	0.50	_
Diacetin			48.90	_	_		_	_	49.20	
DGBE	—	_	_	_	—	_	_	_		_
HEC	0.98	0.98	_	_	1.00	_	1.00	_	_	
NaCl	5.95	3.95	1.70	1.96	1.45	1.25	1.48	0.79	1.10	1.35
Sucrose	55.32	56.32	_	_	57.00	—	56.50	_		—
Triton X-100	—	_	_	_	—	—	—	_	_	_
Tween 20	_	_	_	49.51	_	48.39	_	_	_	48.34
Water	37.56	38.56	48.90	48.53	40.45	50.36	40.92	34.40	49.20	50.31

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

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

Frequency (MHz)	1450	1800	1800	1800	1800	1800	1900	1900	1950	2000
Reference	[B118]	[B118]	[B196]	[B196]	[B172]	[B74]	[B118]	[B196]	[B74]	[B118]
Ingredients (%	6 by weight)									
1,2- Propanediol	_	_	_	_		_	_	_	_	
Bactericide	_	_	_	_	0.50	_	_	_	_	_
Diacetin	_	_	_	_	49.43	_	_	_	_	_
DGBE	45.51	47.00	13.84	44.92		_	44.92	13.84	45.00	50.00
HEC	—	_	—		_	_	_	_	_	_
NaCl	0.67	0.36	0.35	0.18	0.64	0.50	0.18	0.35	—	—
Sucrose	—	—	—	_	—	_	—	—	_	—
Triton X-100	—	_	30.45	_	_	_	_	30.45	—	_
Tween 20	—	_	—	_	_	45.27	_	_	—	_
Water	53.82	52.64	55.36	54.90	49.43	54.23	54.90	55.36	55.00	50.00

# TISSUE – EQUIVALENT LIQUID DESCRIPTION



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

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

#### **BODY**

Frequency (MHz)	30	5	0	1	44	4	450	835	90	00
Recipe source number	3	3	2	2	3	2	4	2	2	4
Ingredients (% by weight)								•		•
Deionised water	48,30	48,30	53,53	55,12	48,30	48,53	56	50,36	50,31	56
Tween			44,70	43,31		49,51		48,39	48,34	
Oxidised mineral oil							44			44
Diethylenglycol monohexylether										
Triton X-100										
Diacetin	50,00	50,00			50,00					
DGBE										
NaCl	1,60	1,60	1,77	1,57	1,60	1,96		1,25	1,35	
Additives and salt	0,10	0,10			0,10					

Frequency (MHz)	1 8	00	2 450	4 000	5 000	5 200	5 800	6 000
Recipe source number	2	4	4	4	4	1	1	4
Ingredients (% by weight)								
Deionised water	54,23	56	56	56	56	65,53	65,53	56
Tween	45,27							
Oxidised mineral oil		44	44	44	44			44
Diethylenglycol monohexylether						17,24	17,24	
Triton X-100						17,24	17,24	
Diacetin								
DGBE								
NaCl	0,50							
Additives and salt								

# TISSUE – EQUIVALENT LIQUID



Date:	09/15/2016	Temperature:	23.8°C
Tissue:	Body, MSL900, 900MHz	Liquid Temperature:	22°C
Tested By:	Pick One	Relative Humidity:	43.1%
Job Site:	EV08	Bar. Pressure:	1016.8 mb

#### **TEST SPECIFICATIONS**

Specification:	Method:
	FCC KDB 865664 D01 v01r04
FCC 15 047:0010	FCC KDB 865664 D02 v01r02
	FCC KDB 248227 D01 V02r02
FUU 2.1093.2016	FCC KDB 447498 D01 v06
	IEEE Std 1528:2013

#### RESULTS

	Actual Values		Target	Values	Deviation (%)		
Frequency (MHz)	Relative Permittivity	Conductivity	Relative Permittivity	Conductivity	Relative Permittivity	Conductivity	
900	56.69	1.052	55.0	1.05	-3.07	-0.19	

Frequency (MHz)	Relative Permittivity	Conductivity	
800	57.38	0.954	
800	57.38	0.954	
810	57.41	0.963	
820	57.35	0.972	
820	57.35	0.972	
830	57.24	0.978	
840	57.15	0.992	
850	57.04	1.001	
850	57.04	1.001	
860	57.01	1.013	
870	56.96	1.021	
880	56.82	1.035	
880	56.82	1.035	
890	56.74	1.041	
900	56.69	1.052	
910	56.61	1.059	
910	56.61	1.059	
920	56.55	1.068	
930	56.4	1.08	
940	56.4	1.09	
940	56.4	1.09	
950	56.3	1.102	
960	56.17	1.111	
970	56.14	1.121	
970	56.14	1.121	
980	56.02	1.129	
990	55.94 1.141		

# SAR SYSTEM VERIFICATION DESCRIPTION



#### REQUIREMENT

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

#### **TEST DESCRIPTION**

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

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

s = 15mm, +/- 0.2mm for 300MHz  $\leq$  f  $\geq$  1000 MHz:

s = 10mm, +/- 0.2mm for 1000MHz  $\leq$  f  $\geq$  6000MHz

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



## SAR SYSTEM VERIFICATION



#### **TEST SPECIFICATIONS**

Specification:	Method:
	FCC KDB 865664 D01 v01r04
FOO 1F 047:0010	FCC KDB 865664 D02 v01r02
FUU 15.247.2016	FCC KDB 248227 D01 V02r02
FGG 2.1093:2016	FCC KDB 447498 D01 v06
	IEEE Std 1528:2013

#### RESULTS

Date	Liquid part number and	Conducted Power into	Correction	Conducted Power into Correction the Dipole Factor		sured	Norma 1	lized to W	Tai (Normaliz Get fror Calibration	get ed to 1W) n Dipole Certificate	% Diffe	erence
	frequency (dBm)	1 40101	1g	10g	1g	10g	1g	10g	1g	10g		
9/15/2016	MSL 900 (900 MHz)	24.83	3.29	3.33	2.21	10.96	7.27	10.90	7.07	0.55	2.83	

### SAR SYSTEM VERIFICATION



Tested By:	Luke Richardson	Room Temperature (°C):	23.6°C
Date:	9/15/2016	Liquid Temperature (°C):	21.8°C
Configuration:		Humidity (%RH):	43.6%
		Bar. Pressure (mb):	1016.3 mb

#### MSL900 System Check\_900MHz 9-15-16

#### 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:  $\sigma$  = 0 S/m,  $\epsilon_r$  = 1;  $\rho$  = 1000 kg/m<sup>3</sup>, Medium parameters used: f = 900 MHz;  $\sigma$  = 1.052 S/m;  $\epsilon_r$  = 56.692;  $\rho$  = 1000 kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY Configuration:

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

**System Check/System Check/Z Scan (1x1x21):** Measurement grid: dx=20mm, dy=20mm, dz=5mm Maximum value of Total (measured) = 60.00 V/m

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

Reference Value = 56.98 V/m; Power Drift = -0.04 dB Peak SAR (extrapolated) = 4.88 W/kg SAR(1 g) = 3.33 W/kg; SAR(10 g) = 2.21 W/kg Maximum value of SAR (measured) = 3.34 W/kg

System Check/System Check/Area Scan (71x101x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 3.34 W/kg Maximum value of SAR (measured) = 3.79 W/kg

Approved By

# SAR SYSTEM VERIFICATION



MSL900 System Check\_900MHz 9-15-16



## **OUTPUT POWER DESCRIPTION**



#### 900 MHz Band

The UHF Radio was tested at the channel with the highest conducted output power unless the reported SAR was greater than 2.0 W/kg for 10-g, then the other required channels would have been measured.

Output power measurements are on the following pages.

# **OUTPUT POWER DATA**



EUT:	TPv2 (DAP 2)	Work Order:	SYNA0197
Serial Number:	850-1631035	Date:	09/15/16
Customer:	Walt Disney Parks and Resorts US, Inc.	Temperature:	23.6
Attendees:	None	Relative Humidity:	43.2%
Customer Project:	None	Bar. Pressure:	10161
Tested By:	Luke Richardson	Job Site:	EV08
Power:	24 VDC	Configuration:	SYNA0197-1

#### **TEST SPECIFICATIONS**

Specification:	Method:
	FCC KDB 865664 D01 v01r04
ECC 15 247:2016	FCC KDB 865664 D02 v01r02
FCC 0 1002:0016	FCC KDB 248227 D01 V02r02
FGG 2.1093.2010	FCC KDB 447498 D01 v06
	IEEE Std 1528:2013

#### **COMMENTS**

None

#### DEVIATIONS FROM TEST STANDARD None

#### RESULTS

	Channel Frequency Modulation (MHz) Type		Conducted Output Power		
Channel			dBm	mW	
Low	902.750	ASK	18.11	64.674	
Mid	915.250	ASK	17.94	62.169	
High	927.250	ASK	17.69	58.859	

# **TEST RESULTS**



#### **Test Configurations**

#### **Test Locations**

The EUT is intended to be mounted with only the device face exposed to users. Many of the units are mounted in a "stanchion". This limits the RF exposure cases to the top (face) of the product. All other sides will have a distance greater than 20cm away from the body or head.

#### Summary

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

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

SAR scaling factor = 10<sup>((Maximum Rated Power<sup>1</sup> (dBm) - Measured Power (dBm)) / 10)</sup>

SAR scaling factor =  $10^{((23-18.1) / 10)}$ 

SAR scaling factor = 3.09



EUT:	TPv2 (DAP 2)	Work Order:	SYNA0197
Customer:	Walt Disney Parks and Resorts US, Inc.	Job Site:	EV08
Attendees:	None	Customer Project:	None

#### **TEST SPECIFICATIONS**

Specification:	Method:
FCC 15.247:2016 FCC 2.1093:2016	FCC KDB 865664 D01 v01r04 FCC KDB 865664 D02 v01r02 FCC KDB 248227 D01 V02r02 FCC KDB 447498 D01 v06
	ILLL 310 1320.2013

#### COMMENTS

None

#### **DEVIATIONS FROM TEST STANDARD**

None

#### RESULTS

Frequency Band	Transmit Frequency (MHz)	Transmit Channel	Transmit Mode	Body-Worn Accessory	EUT Position	SAR Drift During Test (dB)	Measured 1g SAR Level (mW/g)	Measured 10g SAR Level (mW/g)	Scaled 1g SAR Level (mW/g)	Scaled 10g SAR Level (mW/g)	Test#
900	902.75	Low	ASK	None	Front	0.02	0.124	0.074	0.38	0.23	1a



Tested By:	Luke Richardson	Room Temperature (°C):	23.6°C
Date:	9/15/2016 1:15:55 PM	Liquid Temperature (°C):	21.8°C
Serial Number:	850-1631035	Humidity (%RH):	43.1%
Configuration:	SYNA0197-1	Bar. Pressure (mb):	1016.2 mb
Comments:	None		

#### Test 1a

#### DUT: Access Point; Type: Sample; Serial: 850-1631035

Communication System: UID 0, CW (0); Communication System Band: D900 (900.0 MHz); Frequency: 902.75 MHz;Communication System PAR: 0 dB; PMF: 1

Medium parameters used (interpolated): f = 902.75 MHz;  $\sigma$  = 1.054 S/m;  $\epsilon_r$  = 56.671;  $\rho$  = 1000 kg/m<sup>3</sup>, Medium parameters used:  $\sigma$  = 0 S/m,  $\epsilon_r$  = 1;  $\rho$  = 1000 kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY Configuration:

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

Body/Body/Reference scan (71x71x1): Interpolated grid: dx=3.000 mm, dy=3.000 mm

Info: Interpolated medium parameters used for SAR evaluation. Maximum value of SAR (interpolated) = 0.132 W/kg

Body/Body/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm Reference Value = 12.17 V/m; Power Drift = 0.02 dB Peak SAR (extrapolated) = 0.216 W/kg SAR(1 g) = 0.124 W/kg; SAR(10 g) = 0.074 W/kg

Info: Interpolated medium parameters used for SAR evaluation. Maximum value of SAR (measured) = 0.146 W/kg

Body/Body/Area scan (81x41x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm

Info: Interpolated medium parameters used for SAR evaluation. Maximum value of SAR (interpolated) = 0.176 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) = 9.424 V/m Maximum value of SAR (measured) = 0.0936 W/kg

The lichardson

Approved By



Test 1a





**Z-SCAN** 



# SYSTEM AND TEST SITE DESCRIPTION



#### SAR MEASUREMENT SYSTEM

#### Schmid & Partner Engineering AG, DASY52

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

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



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

# SYSTEM AND TEST SITE DESCRIPTION



#### **TEST SITE**

#### Northwest EMC, Lab EV08

The SAR measurement system is located in a semi-anechoic chamber. This provides an ambient free environment that also eliminates reflections.

The chamber is 12 ft wide by 16 ft long x 8 ft high. A dedicated HVAC unit provides +/- 1 degree C temperature control.



## **TEST EQUIPMENT**



#### **TEST EQUIPMENT**

Description	Manufacturer	Model	ID	Last Cal.	Interval
Amplifier	Mini Circuits	ZHL-5W-2G-S+	TRZ	NCR <sup>1</sup>	0 mo
Antenna - Dipole	SPEAG	D900V2	ADP	10/26/2015	12 mo
DAE	SPEAG	SD 000 D04 EJ	SAH	10/8/2015	12 mo
Device Holder	SPEAG	N/A	SAW	NCR	0 mo
Fixture/Kit - Calibration/Verification	SPEAG	DAKS:200	IPR	3/17/2016	36 mo
Generator - Signal	Agilent	V2920A	TIH	NCR	0 mo
Light Beam Unit	SPEAG	SE UKS 030 AA	SAD	NCR	0 mo
Meter - Power	Agilent	N1913A	SQR	10/30/2015	12 mo
Power Sensor	Agilent	E9300H	SQO	10/30/2015	12 mo
Probe	SPEAG	DAKS-3.5	IPRA	11/17/2015	36 mo
SAR - Tissue Test Solution	SPEAG	MSL 900	SAT	At start of t	esting
SAR Probe	SPEAG	ES3DV3	SAF	11/12/2015	12 mo
SAR Test System	Staeubli	DAYS5	SAK	11/1/2013	36 mo
SAR Test System	SPEAG	QD OVA 001 BB	SAC	NCR	0 mo
SAR Test System	Staeubli	TX60LSPEAG	SAA	NCR	0 mo
SAR Test System	Staeubli	N/A	SAJ	NCR	0 mo
SAR Test System	Staeubli	CS8C	SAI	NCR	0 mo
Thermometer	Omega Engineering, Inc.	HH311	DUI	1/26/2015	36 mo
Universal Radio Communication Tester	Agilent	E5515C	BSV	NCR	0 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**

Uncertainty Component	Tolerance (+/- %)	Probability Distribution	Divisor	c <sub>i</sub> (1g)	c <sub>i</sub> (10g)	u <sub>i</sub> (1g) (+/-%)	u <sub>i</sub> (10g) (+/-%)	Vi
Measurement System								
Probe calibration (k=1)	5.5	normal	1	1	1	5.5	5.5	8
Axial isotropy	4.7	rectangular	1.732	0.707	0.707	1.9	1.9	8
Hemispherical isotropy	9.6	rectangular	1.732	0.707	0.707	3.9	3.9	8
Boundary effect	1.0	rectangular	1.732	1	1	0.6	0.6	8
Linearity	4.7	rectangular	1.732	1	1	2.7	2.7	8
System detection limits	1.0	rectangular	1.732	1	1	0.6	0.6	8
Readout electronics	0.3	normal	1	1	1	0.3	0.3	8
Response time	0.8	rectangular	1.732	1	1	0.5	0.5	8
Integration time	2.6	rectangular	1.732	1	1	1.5	1.5	8
RF ambient conditions - noise	1.7	rectangular	1.732	1	1	1.0	1.0	8
RF Ambient Reflections	0.0	rectangular	1.732	1	1	0.0	0.0	8
Probe positioner mechanical tolerance	0.4	rectangular	1.732	1	1	0.2	0.2	8
Probe positioner with respect to phantom shell	2.9	rectangular	1.732	1	1	1.7	1.7	8
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	8
Liquid conductivity - deviation from target values	5.0	rectangular	1.732	0.64	0.43	1.8	1.2	8
Liquid conductivity - measurement uncertainty	6.5	normal	1	0.64	0.43	4.2	2.8	8
Liquid permittivity - deviation from target values	5.0	rectangular	1.732	0.6	0.49	1.7	1.4	8
Liquid permittivity - measurement uncertainty	3.2	normal	1	0.6	0.49	1.9	1.6	∞

### **DIPOLE CALIBRATION**

#### **Dipole Calibration**

EMC

Key points:

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

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

Please see attached calibration and verification data.

### **Dipole Verification**

Performed by Northwest EMC, Inc.

ADP

NORTHWEST					_		_					
EMC			Ca	alibratio	on Cert	ificate/	Report					10/2015cbe
	Decriiption:	Antenna, Dipole 90	0MHz SAR							Cal Date:	102615	
Equi	ipment Code:	ADP							-	Temperature:	21.0°C	
	Model:	D900V2								Humidity:	48%	
Ν	Manufacturer:	SPEAG			Tester:	Carl Engholm	1			Pressure:	1016mb	
Ce	ertificate No.:	ADP	102615		Power:	N/A			Cal	ibration Site:	EV CAL	
TEST SPECIFI	CATIONS	F										
Calibratio	on Procedure:	KDB 450824 D02 D	ipole SAR Validation Verifica	ation v01r01						Version:	2013	
TEST PARAM	ETERS											
	Device Rec	eived In Tolerance:	Yes		Calibratio	n Frequency :	900 MHz					
				Equipm	ent Used to pe	rform calibrati	on					
Item:		Network Ar	alyzer	Identifier:	NAP	Model:		Agilent E5061E	;		Last Cal Date:	6/12/2014
Item:		50 Ohm Tern	nination	Identifier:	NAHA	Model:	Ag	ilent 85032-600	)17		Last Cal Date:	5/17/2015
Item:	-	Short		Identifier:	N/A	Model:		Agilent 54202			Last Cal Date:	NCR
Item:	-	Open	1	Identifier:	N/A	Model:		Agilent 54266			Last Cal Date:	NCR
Item:	-	Head T	SL	Identifier:	SAS	Model:		HSL 900			Last Cal Date:	24 Hours
Item:		Body T	SL	Identifier:	SAT	Model:		MSL 900			Last Cal Date:	24 Hours
COMMENTS, O	OPINIONS and	INTERPRETATION	ŝ									
Douy rot only	,											
Measurement	Uncertainty											
			Probability Distribution	Impeda	nce (dB)	Insertion	Loss (dB)	Value	(dB)	Value	(+/- %)	
Expanded und	certainty U (lev	vel of confidence =	normal (k=2)	+/- 0.80		+/- 0.80 N		J/A N		/A		
95%)												
DEVIATIONS F None	FROM TEST S	TANDARD										
RESULTS												
Pass												
Thi	is measur	rement was a	calibration verifica	tion. (Inst	rument pa	arameters	are withi	n toleranc	es.)			

CALIBRATION DATA ATTACHED

	V	/erification Data - He	ad		
DUT	Antenna, Dipole 900MHz SAR				
Model	D900V2	A	Antenna Paramo	eters with Head TSL	
S/N	ADP		90	0 MHz	
			Real	Imaginary (j)	
Date	102615	Impedance (ohms)	50.5	-6.7	
Temperature	21.0°C	Return Loss (dB)	-24.2		
Humidity	48%	Ма	anufacturer's C	al Data from 11-03-2014	
Pressure	1016mb	Impedance (ohms)	51.0	-5.7	
		Return Loss (dB)	-24.9		
Operator	Carl Engholm				
	N	/erification Data - Bo	dy		
DUT	Antenna, Dipole 900MHz SAR				
Model	D900V2	A	Antenna Paramo	eters with Body TSL	
S/N	ADP		90	0 MHz	
			Real	Imaginary (j)	
Date	102615	Impedance (ohms)	45.1	-8.2	
Temperature	21.0°C	Return Loss (dB)	-21.2		
Humidity	48%	Ma	anufacturer's C	al Data from 11-03-2014	
Pressure	1016mb	Impedance (ohms)	46.4	-7.9	
		Return Loss (dB)	-20.9		
Operator	Carl Engholm	. ,			

#### Equipment ID: ADP

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





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Accreditation No.: SCS 108

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Client Northwest EMC

Certificate No: D900V2-1d106\_Nov14

CALIBRATION C	ERTIFICATE							
Object	D900V2 - SN: 10	1106	·····					
Calibration procedure(s)	rocedure(s) QA CAL-05.v9 Calibration procedure for dipole validation kits above 700 MHz							
Calibration date:	November 03, 20	)14						
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 $(22 \pm 3)^{\circ}$ C and humidity < 70%.								
	1							
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration					
Power meter EPM-442A	GB37480704	07-Oct-14 (No. 217-02020)	Oct-15					
Power sensor HP 8481A	US37292783	07-Oct-14 (No. 217-02020)	Oct-15					
Power sensor HP 8481A	MY41092317	07-Oct-14 (No. 217-02021)	Oct-15					
Reference 20 dB Attenuator	SN: 5058 (20k)	03-Apr-14 (No. 217-01918)	Apr-15					
Type-N mismatch combination	SN: 5047.2 / 06327	03-Apr-14 (No. 217-01921)	Apr-15					
Heterence Probe ES3DV3	SN: 3205	30-Dec-13 (No. ES3-3205_Dec13)	Dec-14					
DAE4	SN: 601	18-Aug-14 (No. DAE4-601_Aug14)	Aug-15					
Secondary Standards	D#	Check Date (in house)	Schoolulad Chaok					
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct 16					
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15					
Calibrated by:	Name Michael Weber	Function Laboratory Technician	Signature Millebes					
Approved by:	Katja Pokovic	Technical Manager	elle					
This calibration certificate shall not	be reproduced except in	full without written approval of the laboratory	Issued: November 7, 2014					

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





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Swiss Calibration Service

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#### Glossary:

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

#### Calibration is Performed According to the Following Standards:

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

#### **Additional Documentation:**

d) DASY4/5 System Handbook

#### Methods Applied and Interpretation of Parameters:

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

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

#### **Measurement Conditions**

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	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	41.0 ± 6 %	0.93 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	2.57 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	10.6 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.65 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	6.75 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	54.3 ± 6 %	1.03 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

#### SAR result with Body TSL

SAR averaged over 1 $\text{cm}^3$ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.69 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	10.9 W/kg ± 17.0 % (k=2)

SAR averaged over 10 $cm^3$ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.75 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	7.07 W/kg ± 16.5 % (k=2)

Report No. SYNA0197 Rev 01

#### Appendix (Additional assessments outside the scope of SCS108)

#### Antenna Parameters with Head TSL

Impedance, transformed to feed point	51.0 Ω - 5.7 jΩ
Return Loss	- 24.9 dB

#### Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.4 Ω - 7.9 jΩ
Return Loss	- 20.9 dB

#### **General Antenna Parameters and Design**

Electrical Delay (one direction) 1.412 ns		
	Electrical Delay (one direction)	1.412 ns

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

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

#### Additional EUT Data

Manufactured by	SPEAG
Manufactured on	September 22, 2009

#### **DASY5 Validation Report for Head TSL**

Date: 03.11.2014

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;  $\sigma$  = 0.93 S/m;  $\epsilon_r$  = 41;  $\rho$  = 1000 kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

#### DASY52 Configuration:

- Probe: ES3DV3 SN3205; ConvF(6.09, 6.09, 6.09); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 58.77 V/m; Power Drift = -0.00 dB Peak SAR (extrapolated) = 3.85 W/kg SAR(1 g) = 2.57 W/kg; SAR(10 g) = 1.65 W/kg Maximum value of SAR (measured) = 3.02 W/kg



0 dB = 3.02 W/kg = 4.80 dBW/kg



#### **DASY5 Validation Report for Body TSL**

Date: 03.11.2014

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;  $\sigma = 1.03$  S/m;  $\epsilon_r = 54.3$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: ES3DV3 SN3205; ConvF(5.98, 5.98, 5.98); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 57.08 V/m; Power Drift = 0.01 dB Peak SAR (extrapolated) = 3.97 W/kg SAR(1 g) = 2.69 W/kg; SAR(10 g) = 1.75 W/kg Maximum value of SAR (measured) = 3.15 W/kg



0 dB = 3.15 W/kg = 4.98 dBW/kg



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Accreditation No.: SCS 0108

Client Northwest EMC

Certificate No: ES3-3246\_Nov15

### CALIBRATION CERTIFICATE

Object	ES3DV3 - SN:3246
Calibration procedure(s)	QA CAL-01.v9, QA CAL-12.v9, QA CAL-23.v5, QA CAL-25.v6. Calibration procedure for documentic E field problem
Calibration date:	November 12, 2015
This calibration certificate do	ocuments 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 co	onducted in the closed laboratory facility: environment temperature (22 $\pm$ 3)°C and humidity < 70%.
Calibration Equipment used	(M&TE critical for calibration)

Primary Standards ID Cal Date (Certificate No.) Scheduled Calibration Power meter E4419B GB41293874 01-Apr-15 (No. 217-02128) Mar-16 Power sensor E4412A MY41498087 Mar-16 01-Apr-15 (No. 217-02128) Reference 3 dB Attenuator SN: S5054 (3c) 01-Apr-15 (No. 217-02129) Mar-16 Reference 20 dB Attenuator SN: S5277 (20x) 01-Apr-15 (No. 217-02132) Mar-16 Reference 30 dB Attenuator SN: S5129 (30b) 01-Apr-15 (No. 217-02133) Mar-16 Reference Probe ES3DV2 SN: 3013 Dec-15 30-Dec-14 (No. ES3-3013\_Dec14) DAE4 SN: 660 14-Jan-15 (No. DAE4-660\_Jan15) Jan-16 Secondary Standards ID Check Date (in house) Scheduled Check RF generator HP 8648C US3642U01700 4-Aug-99 (in house check Apr-13) In house check: Apr-16 Network Analyzer HP 8753E US37390585 18-Oct-01 (in house check Oct-15) In house check: Oct-16

	Name	Function	Signature
Calibrated by:	Claudio Leubler	Laboratory Technician	10
			VAL
Approved by:	Katja Pokovic	Technical Manager	and the
			alas
This calibration cortificates	shall not be reproduced except in	full without written approval of the la	Issued: November 14, 2015

**Calibration Laboratory of** 

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland



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- Swiss Calibration Service

Accreditation No.: SCS 0108

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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 &	9 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:

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

#### Methods Applied and Interpretation of Parameters:

- NORMx, y, z: Assessed for E-field polarization 9 = 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<sup>2</sup>-field uncertainty inside TSL (see below *ConvF*).
- NORM(f)x,y,z = NORMx,y,z \* frequency\_response (see Frequency Response Chart). This linearization is
  implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included
  in the stated uncertainty of ConvF.
- DCPx,y,z: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- PAR: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- ConvF and Boundary Effect Parameters: Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORMx, y, z \* ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- Spherical isotropy (3D deviation from isotropy): in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle: The angle is assessed using the information gained by determining the NORMx (no uncertainty required).

# Probe ES3DV3

# SN:3246

Manufactured: Calibrated:

May 5, 2009 November 12, 2015

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

#### **Basic Calibration Parameters**

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm $(\mu V/(V/m)^2)^A$	1.41	1.17	1.17	± 10.1 %
DCP (mV) <sup>B</sup>	106.0	105.9	106.7	

#### **Modulation Calibration Parameters**

UID	Communication System Name		A dB	Β dB√μV	С	D dB	VR mV	Unc <sup>⊦</sup> (k=2)
0	CW	Х	0.0	0.0	1.0	0.00	229.8	±3.5 %
		Y	0.0	0.0	1.0		200.5	
		Z	0.0	0.0	1.0		203.2	

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%.

<sup>A</sup> The uncertainties of Norm X,Y,Z do not affect the E<sup>2</sup>-field uncertainty inside TSL (see Pages 5 and 6). <sup>B</sup> Numerical linearization parameter: uncertainty not required.

<sup>E</sup> Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unc (k=2)
750	41.9	0.89	6.47	6.47	6.47	0.24	2.32	± 12.0 %
835	41.5	0.90	6.27	6.27	6.27	0.23	2.37	± 12.0 %
900	41.5	0.97	6.15	6.15	6.15	0.42	1.58	± 12.0 %
1750	40.1	1.37	5.33	5.33	5.33	0.61	1.28	± 12.0 %
1900	40.0	1.40	5.14	5.14	5.14	0.49	1.44	± 12.0 %

#### Calibration Parameter Determined in Head Tissue Simulating Media

<sup>c</sup> Frequency validity above 300 MHz of  $\pm$  100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to  $\pm$  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  $\pm$  10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to  $\pm$  110 MHz.

<sup>F</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\varepsilon$  and  $\sigma$ ) 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 ( $\varepsilon$  and  $\sigma$ ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters. <sup>G</sup> Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is

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

			-		-			
f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unc (k=2)
450	56.7	0.94	7.22	7.22	7.22	0.15	1.80	± 13.3 %
750	55.5	0.96	6.40	6.40	6.40	0.37	1.69	± 12.0 %
835	55.2	0.97	6.26	6.26	6.26	0.32	1.89	± 12.0 %
900	55.0	1.05	6.23	6.23	6.23	0.80	1.14	± 12.0 %
1750	53.4	1.49	4.96	4.96	4.96	0.35	1.97	± 12.0 %
1900	53.3	1.52	4.79	4.79	4.79	0.49	1.63	± 12.0 %

#### Calibration Parameter Determined in Body Tissue Simulating Media

<sup>C</sup> Frequency validity above 300 MHz of  $\pm$  100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to  $\pm$  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  $\pm$  10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity validity can be extended to  $\pm$  110 MHz.

<sup>F</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\varepsilon$  and  $\sigma$ ) can be relaxed to  $\pm$  10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\varepsilon$  and  $\sigma$ ) is restricted to  $\pm$  5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

<sup>6</sup> 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 ( $\phi$ ), $\vartheta = 0^{\circ}$

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



Dynamic Range f(SAR<sub>head</sub>) (TEM cell , f<sub>eval</sub>= 1900 MHz)

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



### **Conversion Factor Assessment**

#### **Other Probe Parameters**

Sensor Arrangement	Triangular
Connector Angle (°)	-3.7
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	10 mm
Tip Diameter	4 mm
Probe Tip to Sensor X Calibration Point	2 mm
Probe Tip to Sensor Y Calibration Point	2 mm
Probe Tip to Sensor Z Calibration Point	2 mm
Recommended Measurement Distance from Surface	3 mm