MOTOROLA SOLUTIONS

CERTIFICATE 2518.05

DECLARATION OF COMPLIANCE SAR ASSESSMENT PCII Report Part 1 of 2

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Date of Report: 10/18/2016
Report Revision: A

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Date/s Tested:	9/27/2016 – 10/03/2016; 11/01/2016
Manufacturer:	Motorola Solutions Inc.
DUT Description:	Handheld Portable – NKP 403-527 MHz 4 W GNSS BT WIFI GOB
Test TX mode(s):	CW (PTT) , Bluetooth, and WLAN 802.11 b/g/n
Max. Power output:	4.8 W (UHF band), 10.0 mW (Bluetooth), 22.4 mW (802.11b), 8.3 mW (802.11g), 12.6 mW (802.11n)
Nominal Power:	4.0 W (UHF band), 8.9 mW (Bluetooth), 16.6 mW (802.11b), 6.6 mW (802.11g), 10.0 mW (802.11n)
Tx Frequency Bands:	LMR 403-527 MHz; Bluetooth 2.402-2.480 GHz; WLAN 2.412-2.462 GHz
Signaling type:	FM (LMR), FHSS (Bluetooth), 802.11 b/g/n (WLAN)
Model(s) Tested:	PMUE5098A
Model(s) Certified:	PMUE5098A & PMUE5097A
Serial Number(s):	807TSRH667
Classification:	Occupational/Controlled
FCC ID:	AZ489FT7065; LMR 406.125-512 MHz, Bluetooth 2.402-2.480 GHz, WLAN 802.11 b/g/n 2.412-2.462 GHz This report contains results that are immaterial for FCC equipment approval, which are clearly identified.
IC:	109U-89FT7065; This report contains results that are immaterial for IC equipment approval, which are clearly identified.

The test results clearly demonstrate compliance with FCC Occupational/Controlled RF Exposure limits of 8 W/kg averaged over 1 gram per the requirements of OET Bulletin 65. The 10 grams result is not applicable to FCC filing. The test results clearly demonstrate compliance with ICNIRP (1998) Guidelines for limiting exposure in time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz), Health Physics 74, 494-522 RF Exposure limits of 10 W/kg averaged over 10grams of contiguous tissue.

Based on the information and the testing results provided herein, the undersigned certifies that when used as stated in the operating instructions supplied, said product complies with the national and international reference standards and guidelines listed in section 4.0 of this report. This report shall not be reproduced without written approval from an officially designated representative of the Motorola Solutions Inc EME Laboratory.
I attest to the accuracy of the data and assume full responsibility for the completeness of these measurements. This reporting format is consistent with the suggested guidelines of the TIA TSB-150 December 2004. The results and statements contained in this report pertain only to the device(s) evaluated.

Tiong

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Report Revision History

Date	Revision	Comments
10/18/2016	A	Released of PCII results for design changes and new offered SMA antennas.

1.0 Introduction

This report details the utilization, test setup, test equipments, and test results of the Specific Absorption Rate (SAR) measurements performed at the Motorola Solutions Inc. EME Test Laboratory for handheld portable model number PMUE5098A. This device is classified as Occupational/Controlled. The information herein is to show evidence of Class II Permissive Change compliance base on SAR evaluation of a design change with replacement of antenna connector from ferrule connector to SMA type and new introduced antennas with SMA connector.

2.0 FCC SAR Summary

Table 1

Equipment Class	Frequency band (MHz)	Max Calc at Body (W/kg)		Max Calc at Face (W/kg)	
		1g-SAR	10g-SAR	1g-SAR	10g-SAR
TNF	406.125-512 MHz (LMR)	7.28	5.25	*3.99	2.97
*DSS	2402-2480 MHz (Bluetooth)	NA	NA	NA	NA
DTS	2412-2462 MHz (WLAN 802.11 b/g/n)	0.0135	0.0046	0.0534	0.0324
Simultaneous Results		7.29	5.25	4.04	3

* Results not required per KDB 447498.

Note: * New highest reported SAR value for head 3.99 W/kg (The initial filed reported SAR value for head 3.43 W/kg is replaced with result presented herein. Body-worn accessory and simultaneous transmission exposure conditions 7.41 W/kg and 7.42 W/kg are remain unchanged).

3.0 Abbreviations / Definitions

BT: Bluetooth
CNR: Calibration Not Required
CW: Continuous Wave
DSS: Direct Spread Spectrum
DTS: Digital Transmission System
DUT: Device Under Test
EME: Electromagnetic Energy
FHSS: Frequency Hopping Spread Spectrum
LMR: Land Mobile Radio
NA: Not Applicable
NKP: No Keypad
PTT: Push to Talk
Li-Ion: Lithium-Ion
OFDM: Orthogonal Frequency Division Multiplexing
RF: Radio Frequency
SAR: Specific Absorption Rate
TNF: Licensed Non-Broadcast Transmitter Held to Face
WLAN: Wireless Local Area Network

WiFi: Wireless Fidelity

Audio accessories: These accessories allow communication while the DUT is worn on the body.

Body worn accessories: These accessories allow the DUT to be worn on the body of the user.

Maximum Power: Defined as the upper limit of the production line final test station.

4.0 Referenced Standards and Guidelines

This product is designed to comply with the following applicable national and international standards and guidelines.

- IEC62209-1 (2005) Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)
- Federal Communications Commission, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radio frequency Electromagnetic Fields", OET Bulletin 65, FCC, Washington, D.C.: 1997.
- IEEE 1528 (2013), Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques
- American National Standards Institute (ANSI) / Institute of Electrical and Electronics Engineers (IEEE) C95. 1-1992
- Institute of Electrical and Electronics Engineers (IEEE) C95.1-2005
- International Commission on Non-Ionizing Radiation Protection (ICNIRP) 1998
- Ministry of Health (Canada) Safety Code 6 (2015), Limits of Human Exposure to Radio frequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz
- RSS-102 (Issue 5) – Radio Frequency (RF) Exposure Compliance of Radio communication Apparatus (All Frequency Bands)
- Australian Communications Authority Radio communications (Electromagnetic Radiation - Human Exposure) Standard (2014)
- ANATEL, Brazil Regulatory Authority, Resolution No. 303 of July 2, 2002 "Regulation of the limitation of exposure to electrical, magnetic, and electromagnetic fields in the radio frequency range between 9 kHz and 300 GHz." and "Attachment to resolution # 303 from July 2, 2002"
- IEC62209-2 Edition 1.0 2010-03, Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Human models, instrumentation, and procedures – Part 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)

- FCC KDB – 643646 D01 SAR Test for PTT Radios v01r03
- FCC KDB – 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04
- FCC KDB – 865664 D02 RF Exposure Reporting v01r02
- FCC KDB – 447498 D01 General RF Exposure Guidance v06
- FCC KDB – 248227 D01 802.11 Wi-Fi SAR v02r02

5.0 SAR Limits

Table 2

EXPOSURE LIMITS	SAR (W/kg)	
	(General Population / Uncontrolled Exposure Environment)	(Occupational / Controlled Exposure Environment)
Spatial Average - ANSI - (averaged over the whole body)	0.08	0.4
Spatial Peak - ANSI - (averaged over any 1-g of tissue)	1.6	8.0
Spatial Peak – ICNIRP/ANSI - (hands/wrists/feet/ankles averaged over 10-g)	4.0	20.0
Spatial Peak - ICNIRP - (Head and Trunk 10-g)	2.0	10.0

6.0 Description of Device Under Test (DUT)

This portable device operates in the LMR band using frequency modulation (FM). This device also contains WLAN technology for data capabilities over 802.11 b/g/n wireless networks and Bluetooth technology for short range wireless devices.

The LMR band in this device operates in a half duplex system. A half duplex system only allows the user to transmit or receive. This device cannot transmit and receive simultaneously. The user must stop transmitting in order to receive a signal or listen for a response, regardless of PTT button or use of voice activated audio accessories. This type of operation, along with the RF safety booklet, which instructs the user to transmit no more than 50% of the time, justifies the use of 50% duty factor for this device.

This device also incorporates a Bluetooth v4.0, which include classis Bluetooth, and Bluetooth low energy. It is Class 1 Bluetooth device with Frequency Hopping Spread Spectrum (FHSS) technology. The Bluetooth radio modem is used to wireless link audio accessories. The maximum actual transmission duty cycle is imposed by the Bluetooth standard. The maximum duty cycle for BT is derived from 5-slots packet type operation which consists of receiving on 1-slot and transmitting on 5-slots, and thus maximum duty cycle = 77%.

WLAN 802.11 b/g/n operate using Direct Sequence Spread Spectrum (DSSS) and Orthogonal Frequency-Division Multiplexing (OFDM) accordance with the IEEE 802.11 b/g/n

The intended operating positions are "at the face" with the DUT at least 2.5cm from the mouth, and "at the body" by means of the offered body worn accessories. Body worn audio and PTT operation is accomplished by means of optional remote accessories that are connected to the radio. Operation at the body without an audio accessory attached is possible by means of BT accessories.

7.0 Optional Accessories and Test Criteria

This device is offered with optional accessories. The following section identifies the test criteria and details for each accessory category applicable for this PCII filing only. Detail listing of all approved offered accessories available in original filing report.

7.1 Antennas

There are optional new introduced removable antennas for this PCII filling. The Table below lists the antennas and their descriptions.

Table 3

Antenna Models	Description	Selected for test	Tested
PMAE4022B	Whip Antenna, 380-480 MHz, ¼ wave, 0 dBd	Yes	Yes
PMAE4049A	Whip Antenna, 450-527 MHz, ¼ wave, 1.9 dBd	Yes	Yes
PMAE4100A	Stubby Antenna, 380-480 MHz, ¼ wave, 0 dBd	Yes	Yes
PMAE4102A	Stubby Antenna, 450-527 MHz, ¼ wave, 1.7 dBi	Yes	Yes

7.2 Batteries

There are two batteries applicable for this PC II filling. The Table below lists their descriptions.

Table 4

Battery Models	Description	Selected for test	Tested	Comments
PMNN4407BR	IMPRES Li-Ion, 1650 mAh Slim Battery 1600 Min 1650 Typical	Yes	Yes	
PMNN4489A	Belize TIA4950 IMPRES High Capacity Li-Ion Battery 2850 Min 2900 Typical	Yes	Yes	

7.3 Body worn Accessory

There is one body worn accessory applicable for this PC II filling. The table below describes the body worn accessory.

Table 5

Body worn Models	Description	Selected for test	Tested	Comments
RLN4570A	Break-A-Way Chest Pack	Yes	Yes	

7.4 Audio Accessory

There is no audio accessory applicable for this PC II filling.

8.0 Description of Test System

8.1 Descriptions of Robotics/Probes/Readout Electronics

Table 6

Dosimetric System type	System version	DAE type	Probe Type
Schmid & Partner Engineering AG SPEAG DASY 5	52.8.2.969	DAE4	ES3DV3 EX3DV4 (E-Field)

The DASY5™ system is operated per the instructions in the DASY5™ Users Manual. The complete manual is available directly from SPEAG™. All measurement equipment used to assess SAR compliance was calibrated according to ISO/IEC 17025 A2LA guidelines. Section 9.0 presents additional test equipment information. Appendices B and C present the applicable calibration certificates.

The E-field probe first scans a coarse grid over a large area inside the phantom in order to locate the interpolated maximum SAR distribution. After the coarse scan measurement, the probe is automatically moved to a position at the interpolated maximum. The subsequent scan can directly use this position as reference for the cube evaluations.

8.2 Description of Phantom(s)

Table 7

Phantom Type	Phantom(s) Used	Material Parameters	Phantom Dimensions LxWxD (mm)	Material Thickness (mm)	Support Structure Material	Loss Tangent (wood)
Triple Flat	NA	200MHz -6GHz; Er = 3-5, Loss Tangent = ≤0.05	280x175x175	2mm +/- 0.2mm	Wood	< 0.05
SAM	NA	300MHz -6GHz; Er = < 5, Loss Tangent = ≤0.05	Human Model	2mm +/- 0.2mm	Wood	< 0.05
Oval Flat	√	300MHz -6GHz; Er = 4+/- 1, Loss Tangent = ≤0.05	600x400x190	2mm +/- 0.2mm	Wood	< 0.05

8.3 Description of Simulated Tissue

The sugar based simulate tissue is produced by placing the correct measured amount of De-ionized water into a large container. Each of the dried ingredients are weighed and added to the water carefully to avoid clumping. If the solution has a high sugar concentration the water is pre-heated to aid in dissolving the ingredients. For Diacetin and similar type simulates, sugar and HEC ingredients are not needed. The solution is mixed thoroughly, covered, and allowed to sit overnight prior to use.

The simulated tissue mixture was mixed based on the Simulated Tissue Composition indicated in Table 8. During the daily testing of this product, the applicable mixture was used to measure the Di-electric parameters at each of the tested frequencies to verify that the Di-electric parameters were within the tolerance of the tissue specifications.

Simulated Tissue Composition (percent by mass)

Table 8

Ingredients	450 MHz	
	Head	Body
Sugar	56.00	46.50
Diacetin	0	0
De ionized – Water	39.10	50.53
Salt	3.80	1.87
HEC	1.00	1.00
Bact.	0.10	0.10

9.0 Additional Test Equipment

The Table below lists additional test equipments used during the SAR assessment.

Table 9

Equipment Type	Model Number	Serial Number	Calibration Date	Calibration Due Date
Speag Probe	EX3DV4	7422	29-Jul-16	29-Jul-17
Speag Probe	EX3DV4	3612	11-Jul-16	11-Jul-17
Speag Probe	ES3DV3	3096	29-Apr-16	29-Apr-17
Speag DAE	DAE4	1294	6-Jan-16	6-Jan-17
Speag DAE	DAE4	684	29-Apr-16	29-Apr-17
Speag DAE	DAE3	374	22-Apr-16	22-Apr-17
Power Meter	E4418B	MY45100911	29-May-15	29-May-17
Power Sensor	8481B	MY41091170	11-Nov-15	11-Nov-16
Power Meter	E4418B	MY45101014	4-Nov-15	4-Nov-17
Power Sensor	8482B	2703A04641	15-Jun-16	15-Jun-17
AMPLIFIER	10W1000C	312859	CNR	CNR
AMPLIFIER	10WD1000	28782	CNR	CNR
Bi-directional Coupler	3022	81640	2-Sep-16	2-Sep-17
Signal Generator (Vector ESG 250KHz-6GHz)	E4438C	MY44270302	18-Jun-15	18-Jun-17
Dickson Temperature Recorder	TM320	12253047	19-Nov-15	19-Nov-16
Temperature Probe	80PK-25	080428.01	5-Aug-16	5-Aug-17
Thermometer	HH806AU	080307	8-Apr-16	8-Apr-17
Network Analyzer	E5071B	MY42403147	6-Nov-15	6-Nov-16
Dielectric Assessment Kit	DAK-12	1051	8-Mar-16	8-Mar-17
SPEAG Dipole	D450V3	1077	25-Nov-15	25-Nov-17

10.0 SAR Measurement System Validation and Verification

DASY output files of the probe/dipole calibration certificates and system verification test results are included in appendices B, C & D respectively.

10.1 System Validation

The SAR measurement system was validated according to procedures in KDB 865664. The validation status summary Table is below.

Table 10

Dates	Probe Calibration Point		Probe SN	Measured Tissue Parameters		Validation		
				σ	ϵ_r	Sensitivity	Linearity	Isotropy
CW								
02/28/2015	Body	450	3096	0.92	54.7	Pass	Pass	Pass
03/14/2015	Head	450		0.88	43.1	Pass	Pass	Pass
09/14/2016	Body	450	7422	0.92	56.7	Pass	Pass	Pass
09/07/2016	Head	450		0.83	44.7	Pass	Pass	Pass
07/28/2016	Body	450	3612	0.86	43.8	Pass	Pass	Pass
07/21/2016	Head	450		0.98	55.3	Pass	Pass	Pass

10.2 System Verification

System verification checks were conducted each day during the SAR assessment. The results are normalized to 1W. Appendix D includes DASY plots for each day during the SAR assessment. The Table below summarizes the daily system check results used for the SAR assessment.

Table 11

Probe Serial #	Tissue Type	Dipole Kit / Serial #	Ref SAR @ 1W (W/kg)	System Check Results Measured (W/kg)	System Check Test Results when normalized to 1W (W/kg)	Tested Date
7422	FCC Body	SPEAG D450V3 / 1077	4.52 +/- 10%	1.08	4.32	9/27/2016
				1.13	4.52	9/28/2016
				1.13	4.52	9/29/2016*
				1.12	4.48	10/5/2016
				1.08	4.32	10/13/2016
	IEEE/IEC Head		4.57 +/- 10%	1.14	4.56	9/30/2016
				1.17	4.68	10/4/2016
				1.12	4.48	10/5/2016
3096	IEEE/IEC Head		4.57 +/- 10%	1.12	4.48	10/13/2016
3612	FCC Body		4.52 +/- 10%	1.13	4.52	11/01/2016

Note: * System performance check cover next testing day (within 24 hours)

10.3 Equivalent Tissue Test Results

Simulated tissue prepared for SAR measurements is measured daily and within 24 hours prior to actual SAR testing to verify that the tissue is within +/- 5% of target parameters at the center of the transmit band. This measurement is done using the applicable equipment indicated in section 9.0. The Table below summarizes the measured tissue parameters used for the SAR assessment.

Table 12

Frequency (MHz)	Tissue Type	Conductivity Target (S/m)	Dielectric Constant Target	Conductivity Meas. (S/m)	Dielectric Constant Meas.	Tested Date
403.000	FCC Body	0.93 (0.89-0.98)	57.2 (54.3-60.0)	0.89	56.2	10/13/2016
	IEEE/ IEC Head	0.87 (0.83-0.91)	44.1 (41.9-46.3)	0.84	45.5	10/13/2016
406.125	FCC Body	0.93 (0.89-0.98)	57.1 (54.3-60.0)	0.89	57.1	9/28/2016
				0.89	57.1	9/29/2016
	IEEE/ IEC Head	0.87 (0.83-0.91)	44.0 (41.8-46.2)	0.83	44.9	9/30/2016
				0.83	45.0	10/5/2016
424.600	FCC Body	0.94 (0.89-0.98)	57.0 (54.1-59.8)	0.91	56.8	9/28/2016
				0.91	56.8	9/29/2016
	IEEE/ IEC Head	0.87 (0.83-0.91)	43.8 (41.6-46.0)	0.85	44.5	9/30/2016
				0.84	44.6	10/5/2016
443.100	FCC Body	0.94 (0.89-0.99)	56.8 (53.9-59.6)	0.90	56.2	9/27/2016
				0.92	56.4	9/29/2016
	IEEE/ IEC Head	0.87 (0.83-0.91)	43.6 (41.4-45.8)	0.87	44.1	9/30/2016
				0.86	44.3	10/5/2016
450.000	FCC Body	0.94 (0.89-0.99)	56.7 (53.9-59.5)	0.91	56.1	9/27/2016
				0.93	56.5	9/28/2016
				0.93	56.3	9/29/2016
				0.93	56.3	9/30/2016
				0.96	54.5	10/5/2016
				0.93	55.5	10/13/2016
				0.94	55.8	11/01/2016
	IEEE/ IEC Head	0.87 (0.83-0.91)	43.5 (41.3-45.7)	0.87	44.0	9/30/2016
				0.83	43.8	10/4/2016
				0.86	44.1	10/5/2016
				0.88	44.5	10/13/2016
461.500	FCC Body	0.94 (0.89-0.99)	56.7 (53.8-59.5)	0.92	56.0	9/28/2016
				0.94	56.2	9/29/2016
	IEEE/ IEC Head	0.87 (0.83-0.91)	43.4 (41.3-45.6)	0.88	43.8	9/30/2016
				0.84	43.6	10/5/2016
465.500	FCC Body	0.94 (0.89-0.99)	56.6 (53.8-59.5)	0.94	56.2	9/28/2016
				0.95	55.6	11/01/2016
	IEEE/ IEC Head	0.87 (0.83-0.91)	43.4 (41.2-45.6)	0.88	43.7	9/30/2016
				0.84	43.5	10/4/2016

Continued Table 12

Frequency (MHz)	Tissue Type	Conductivity Target (S/m)	Dielectric Constant Target	Conductivity Meas. (S/m)	Dielectric Constant Meas.	Tested Date
480.000	FCC Body	0.94 (0.90-0.99)	56.6 (53.8-59.4)	0.95	56.0	9/28/2016
				0.95	55.9	9/29/2016
				0.99	54.1	10/5/2016
	IEEE/ IEC Head	0.87 (0.83-0.92)	43.3 (41.2-45.5)	0.90	43.4	9/30/2016
				0.86	43.2	10/4/2016
				0.86	43.2	10/5/2016
496.500	FCC Body	0.94 (0.90-0.99)	56.5 (53.7-59.3)	0.97	55.8	9/28/2016
				0.98	55.2	11/01/2016
	IEEE/ IEC Head	0.87 (0.83-0.92)	43.2 (41.1-45.4)	0.87	42.9	10/4/2016
512.000	FCC Body	0.94 (0.90-0.99)	56.5 (53.6-59.3)	0.98	55.6	9/28/2016
				0.98	55.5	9/30/2016
	IEEE/ IEC Head	0.87 (0.83-0.92)	43.2 (41.0-45.3)	0.88	42.7	10/4/2016
519.500	FCC Body	0.95 (0.90-0.99)	56.4 (53.6-59.2)	0.98	55.5	9/28/2016
				0.98	55.4	9/30/2016
	IEEE/ IEC Head	0.87 (0.83-0.92)	43.1 (41.0-45.3)	0.89	42.5	10/4/2016
527.000	FCC Body	0.95 (0.90-0.99)	56.4 (53.6-59.2)	0.99	55.5	9/28/2016
				0.99	55.3	9/30/2016
	IEEE/ IEC Head	0.88 (0.83-0.92)	43.1 (40.9-45.2)	0.89	42.4	10/4/2016

11.0 Environmental Test Conditions

The EME Laboratory's ambient environment is well controlled resulting in very stable simulated tissue temperature and therefore stable dielectric properties. Simulated tissue temperature is measured prior to each scan to insure it is within +/ - 2^{o}C of the temperature at which the dielectric properties were determined. The liquid depth within the phantom used for measurements was at least 15cm. Additional precautions are routinely taken to ensure the stability of the simulated tissue such as covering the phantoms when scans are not actively in process in order to minimize evaporation. The lab environment is continuously monitored. The Table below presents the range and average environmental conditions during the SAR tests reported herein:

Table 13

	Target	Measured
Ambient Temperature	18 – 25 ˚C	Range: 18.0 – 24.9 ˚C Avg. 21.45 ˚C
Tissue Temperature	NA	Range: 19.7 – 23.2 ˚C Avg. 21.45 ˚C

Relative humidity target range is a recommended target

The EME Lab RF environment uses a Spectrum Analyzer to monitor for extraneous large signal RF contaminants that could possibly affect the test results. If such unwanted signals are discovered the SAR scans are repeated.

12.0 DUT Test Setup and Methodology

12.1 Measurements

SAR measurements were performed using the DASY system described in section 8.0 using zoom scans. Oval flat phantoms filled with applicable simulated tissue were used for body and face testing.

The Table below includes the step sizes and resolution of area and zoom scans per KDB 865664 requirements.

Table 14

<table>
<tr><th colspan="2">Description</th><th>≤ 3 GHz</th><th>> 3 GHz</th></tr>
<tr><td colspan="2">Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface</td><td>5 ± 1 mm</td><td>½·δ·ln(2) ± 0.5 mm</td></tr>
<tr><td colspan="2">Maximum probe angle from probe axis to phantom surface normal at the measurement location</td><td>30° ± 1°</td><td>20° ± 1°</td></tr>
<tr><td colspan="2" rowspan="2">Maximum area scan spatial resolution: ΔxArea, ΔyArea</td><td>≤ 2 GHz: ≤ 15 mm
2 – 3 GHz: ≤ 12 mm</td><td>3 – 4 GHz: ≤ 12 mm
4 – 6 GHz: ≤ 10 mm</td></tr>
<tr><td colspan="2">When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be ≤ the corresponding x or y dimension of the test device with at least one measurement point on the test device.</td></tr>
<tr><td colspan="2">Maximum zoom scan spatial resolution: ΔxZoom, ΔyZoom</td><td>≤ 2 GHz: ≤ 8 mm
2 – 3 GHz: ≤ 5 mm*</td><td>3 – 4 GHz: ≤ 5 mm*
4 – 6 GHz: ≤ 4 mm*</td></tr>
<tr><td>Maximum zoom scan spatial resolution, normal to phantom surface</td><td>uniform grid: ΔzZoom(n)</td><td>≤ 5 mm</td><td>3 – 4 GHz: ≤ 4 mm
4 – 5 GHz: ≤ 3 mm
5 – 6 GHz: ≤ 2 mm</td></tr>
<tr><td colspan="4">Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details.
* When zoom scan is required and the reported SAR from the area scan based 1-g SAR estimation procedures of KDB 447498 is ≤ 1.4 W/kg, ≤ 8 mm, ≤ 7 mm and ≤ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.</td></tr>
</table>

12.2 DUT Configuration(s)

The DUT is a portable device operational at the body and face as described in section 6.0 while using the applicable accessories listed in section 7.0. All accessories listed in section 7.0 of this report were considered when implementing the guidelines specified in KDB 643646.

12.3 DUT Positioning Procedures

The positioning of the device for each body location is described below and illustrated in Appendix G.

12.3.1 Body

The DUT was positioned in normal use configuration against the phantom with the offered body worn accessory.

12.3.2 Head

Not applicable.

12.3.3 Face

The DUT was positioned with its' front side separated 2.5cm from the phantom.

12.4 DUT Test Channels

The number of test channels was determined by using the following IEEE 1528 equation. The use of this equation produces the same or more test channels compared to the FCC KDB 447498 number of test channels formula.

$$N_c = 2 * roundup[10 * (f_{high} - f_{low}) / f_c] + 1$$

Where
N_c = Number of channels
F_{high} = Upper channel
F_{low} = Lower channel
F_c = Center channel

12.5 SAR Result Scaling Methodology

The calculated 1-gram and 10-gram averaged SAR results indicated as “Max Calc. 1g-SAR” and “Max Calc.10g-SAR” in the data Tables is determined by scaling the measured SAR to account for power leveling variations and drift. Appendix F includes a shortened scan to justify SAR scaling for drift. For this device the “Max Calc. 1g-SAR” and “Max Calc.10g-SAR” are scaled using the following formula:

$$Max\_Calc = SAR\_meas \cdot 10^{\frac{-Drift}{10}} \cdot \frac{P\_\max}{P\_\text{int}} \cdot DC$$

P_max = Maximum Power (W)
P_int = Initial Power (W)
Drift = DASY drift results (dB)
SAR_meas = Measured 1-g or 10-g Avg. SAR (W/kg)
DC = Transmission mode duty cycle in % where applicable
50% duty cycle is applied for PTT operation

Note: for conservative results, the following are applied:
If P_int > P_max, then P_max/P_int = 1.
Drift = 1 for positive drift

Additional SAR scaling was applied using the methodologies outlined in FCC KDB 865664 using tissue sensitivity values. SAR was scaled for conditions where the tissue permittivity was measured above the nominal target and for tissue conductivity that was measured below the nominal target. Negative or reduced SAR scaling is not permitted.

12.6 DUT Test Plan

The guidelines and requirements outlined in section 4.0 were used to assess compliance of this device. All modes of operation identified in section 6.0 were considered during the development of the test plan.

LMR tests were performed in CW mode and 50% duty cycle was applied to PTT configurations in the final results.

No changes on Bluetooth and WLAN, hence SAR assessment results still remain as stated in the initial filing.

13.0 DUT Test Data

13.1 LMR assessments at the Body for 406.125-512 MHz band

Assessments at the Body were done with offered antennas, default battery and, default body worn accessory indicated in section 7.0 which represent the highest applicable configurations at the body found during the initial compliance assessment on file with the FCC.

Table 15

Antenna	Battery	Carry Accessory	Cable Accessory	Test Freq (MHz)	Init Pwr (W)	SAR Drift (dB)	Meas. 1g-SAR (W/kg)	Meas. 10g-SAR (W/kg)	Max Calc. 1g-SAR (W/kg)	Max Calc. 10g-SAR (W/kg)	Run#
PMAE4022B	PMNN4407BR	RLN4570A	NONE	406.125	4.74	-0.39	10.40	7.43	5.76	4.12	FD-AB-160928-06
				424.600	4.79	-0.48	9.73	7.03	5.44	3.93	FD-AB-160928-07
				443.100	4.72	-0.63	7.62	5.57	4.48	3.27	FIE-AB-160927-12
				461.500	4.78	-0.50	6.48	4.75	3.65	2.68	FD-AB-160928-04
				480.000	4.80	-0.44	6.03	4.37	3.34	2.42	FIE-AB-160928-11
PMAE4049A	PMNN4407BR	RLN4570A	NONE	450.000	4.72	-0.56	11.90	8.68	6.88	5.02	FIE-AB-160928-13
				465.500	4.70	-0.55	11.60	8.48	6.72	4.91	FIE-AB-160928-14
				480.000	4.77	-0.58	10.60	7.87	6.10	4.53	FIE-AB-160928-15
				496.500	4.80	-0.54	11.40	8.34	6.45	4.72	FIE-AB-160928-16
				512.000	4.80	-0.55	11.10	8.16	6.30	4.63	FIE-AB-160928-17
PMAE4100A	PMNN4407BR	RLN4570A	NONE	406.125	4.79	-0.37	10.20	7.27	5.57	3.97	FD-AB-160929-01
				424.600	4.79	-0.42	7.55	5.39	4.17	2.97	FD-AB-160929-02
				443.100	4.69	-0.03	5.39	3.90	2.78	2.01	FIE-AB-160929-09
				461.500	4.80	0.01	3.36	2.39	1.68	1.20	FD-AB-160929-08
				480.000	4.80	0.51	3.22	2.28	1.61	1.14	FIE-AB-160929-11
PMAE4102A	PMNN4407BR	RLN4570A	NONE	450.000	4.79	-0.62	12.60	9.09	**7.28**	**5.25**	FD-AB-160930-04
				465.500	4.80	-0.92	9.94	7.15	6.14	4.42	ZWS-161101-07
				480.000	4.75	-0.56	10.00	7.36	5.75	4.23	FIE-AB-161005-11
				496.500	4.80	-0.57	9.33	6.74	5.32	3.84	ZWS-161101-09
				512.000	4.79	-0.78	8.93	6.52	5.35	3.91	FD-AB-160930-01

13.2 LMR assessments at the Face for 406.125-512 MHz band

Assessments at the Face were done with offered antennas and default battery indicated in section 7.0 which represent the highest applicable configurations at the body found during the initial compliance assessment on file with the FCC.

Table 16

Antenna	Battery	Carry Accessory	Cable Accessory	Test Freq (MHz)	Init Pwr (W)	SAR Drift (dB)	Meas. 1g-SAR (W/kg)	Meas. 10g-SAR (W/kg)	Max Calc. 1g-SAR (W/kg)	Max Calc. 10g-SAR (W/kg)	Run#
PMAE4022B	PMNN4489A	NONE	NONE	406.125	4.68	-0.28	4.99	3.73	2.73	2.04	FIE-FACE-160930-10
				424.600	4.73	-0.34	5.62	4.20	3.08	2.30	FIE-FACE-1600930-11
				443.100	4.74	-0.45	4.42	3.31	2.48	1.86	FIE-FACE-160930-12
				461.500	4.74	-0.58	3.47	2.59	2.01	1.50	FIE-FACE-160930-13
				480.000	4.76	-0.48	2.94	2.20	1.66	1.24	FIE-FACE-160930-14
PMAE4049A	PMNN4489A	NONE	NONE	450.000	4.72	-0.33	6.43	4.80	3.53	2.63	FIE-FACE-160930-15
				465.500	4.73	-0.44	7.10	5.29	**3.99**	**2.97**	FIE-FACE-160930-16
				480.000	4.70	-0.35	6.84	5.14	3.79	2.84	FD-FACE-161004-02
				496.500	4.71	-0.34	6.04	4.51	3.33	2.49	FD-FACE-161004-03
				512.000	4.71	-0.56	5.00	3.76	2.90	2.18	FIE-FACE-161004-04
PMAE4100A	PMNN4489A	NONE	NONE	406.125	4.72	-0.22	5.44	4.06	2.91	2.17	FD-FACE-161005-04
				424.600	4.65	-0.44	4.98	3.72	2.84	2.12	FD-FACE-161005-05
				443.100	4.61	-0.56	3.36	2.51	1.99	1.49	FD-FACE-161005-06
				461.500	4.66	-0.53	1.92	1.44	1.12	0.84	FD-FACE-161005-01
				480.000	4.70	-0.46	1.69	1.27	0.96	0.72	FD-FACE-161005-02
PMAE4102A	PMNN4489A	NONE	NONE	450.000	4.63	-0.25	6.69	4.98	3.67	2.73	FIE-FACE-161004-07
				465.500	4.69	-0.45	6.76	5.04	3.84	2.86	FIE-FACE-161004-08
				480.000	4.66	-0.54	5.27	3.95	3.07	2.30	FIE-FACE-161004-09
				496.500	4.72	-0.55	4.89	3.67	2.82	2.12	FIE-FACE-161004-10
				512.000	4.67	-0.76	4.47	3.33	2.74	2.04	FIE-FACE-161004-11

13.3 Assessments outside FCC Part 90

Assessments of outside FCC Part 90 using highest configuration above. SAR plots of the highest results are presented in Appendix E.

Table 17

Antenna	Battery	Carry Accessory	Cable Accessory	Test Freq (MHz)	Init Pwr (W)	SAR Drift (dB)	Meas. 1g-SAR (W/kg)	Meas. 10g-SAR (W/kg)	Max Calc. 1g-SAR (W/kg)	Max Calc. 10g-SAR (W/kg)	Run#
Assessment at the Body											
PMAE4022B	PMNN4407BR	RLN4570A	NONE	403.000	4.80	-0.34	10.30	7.44	5.57	4.02	FD-AB-161013-02
PMAE4049A				519.500	4.79	-0.70	10.30	7.59	**6.06**	**4.47**	FIE-AB-160928-18
				527.000	4.80	-0.66	9.46	6.94	5.51	4.04	FIE-AB-160928-19
PMAE4100A				403.000	4.80	-0.23	9.85	7.12	5.19	3.75	FD-AB-161013-03
PMAE4102A				519.500	4.80	-0.66	7.08	5.16	4.12	3.00	FD-AB-160930-02
				527.000	4.80	-0.69	6.05	4.42	3.55	2.59	FD-AB-160930-03
Assessment at the Face											
PMAE4022B	PMNN4489A	NONE	NONE	403.000	4.76	-0.28	5.28	3.91	**2.84**	**2.10**	FD-FACE-161013-14
PMAE4049A				519.500	4.79	-0.52	4.96	3.72	2.80	2.10	FIE-FACE-161004-05
				527.000	4.76	-0.57	4.25	3.18	2.44	1.83	FIE-FACE-161004-06
PMAE4100A				403.000	4.77	-0.24	5.15	3.80	2.74	2.02	FD-FACE-161013-15
PMAE4102A				519.500	4.80	-0.66	3.65	2.73	2.12	1.59	FIE-FACE-161004-12
				527.000	4.79	-0.61	2.98	2.23	1.72	1.29	FIE-FACE-161004-13

13.4 Shortened Scan Assessment

A "shortened" scan using the highest SAR configuration overall from above was performed to validate the SAR drift of the full DASY5™ coarse and zoom scans. Note that the shortened scan represents the zoom scan performance result; this is obtained by first running a coarse scan to find the peak area and then, using a newly charged battery, a zoom scan only was performed. The results of the shortened cube scan presented in Appendix D demonstrate that the scaling methodology used to determine the calculated SAR results presented herein are valid. The SAR result from the Table below is provided in Appendix F.

Table 18

Antenna	Battery	Carry Accessory	Cable Accessory	Test Freq (MHz)	Init Pwr (W)	SAR Drift (dB)	Meas. 1g-SAR (W/kg)	Meas. 10g-SAR (W/kg)	Max Calc. 1g-SAR (W/kg)	Max Calc. 10g-SAR (W/kg)	Run#
PMAE4102A	PMNN4407BR	RLN4570A	NONE	450.000	4.75	-0.28	13.30	9.71	7.17	5.23	FIE-AB-161005-10

14.0 Simultaneous Transmission between LMR, WLAN and BT

This device uses a single transmitter module and antenna for both WLAN and BT. WLAN and BT cannot transmit simultaneously. Simultaneous transmission of BT had been excluded as derived in initial filing. WLAN 802.11b measured SAR during initial compliance assessment is used in conjunction with LMR for simultaneous results.

15.0 Results Summary

The highest Operational Maximum Calculated 1-gram and 10-gram average SAR values found for this filing:

Table 19

Technologies	Frequency band (MHz)	Max Calc at Body (W/kg)		Max Calc at Face (W/kg)	
		1g-SAR	10g-SAR	1g-SAR	10g-SAR
FCC					
LMR	406.125-512	7.28	5.25	*3.99	2.97
WLAN	2412-2462	0.0135	0.0046	0.0534	0.0324
Industry Canada					
LMR	406.125-430	5.76	4.12	3.08	2.30
	450-470	7.28	5.25	3.99	2.97
WLAN	2412-2462	0.0135	0.0046	0.0534	0.0324
Overall					
LMR	403-527	7.28	5.25	3.99	2.97
WLAN	2412-2462	0.0135	0.0046	0.0534	0.0324

All results are scaled to the maximum output power.

The highest combined SAR results for simultaneous is indicated in following Table:

Table 20

Designator	Frequency bands	Combined 1g-SAR (W/kg)	Combined 10g-SAR (W/kg)
Body			
FCC	LMR (406.125-512 MHz) and WLAN band	7.29	5.25
Industry Canada	LMR (406.125-430 MHz) and WLAN band	5.77	4.12
	LMR (450-470 MHz) and WLAN band	7.29	5.25
Overall	LMR (403-527 MHz) and WLAN band	7.29	5.25
Face			
FCC	LMR (406.125-512 MHz) and WLAN band	4.04	3.00
Industry Canada	LMR (406.125-430 MHz) and WLAN band	3.13	2.33
	LMR (450-470 MHz) and WLAN band	4.04	3.00
Overall	LMR (403-527 MHz) and WLAN band	4.04	3.00

Note: * New highest reported SAR value for head 3.99 W/kg (The initial filed reported SAR value for head 3.43 W/kg is replaced with result presented herein. Body-worn accessory and simultaneous transmission exposure conditions 7.41 W/kg and 7.42 W/kg are remain unchanged).

The test results clearly demonstrate compliance with FCC Occupational/Controlled RF Exposure limits of 8 W/kg averaged over 1 gram per the requirements of OET Bulletin 65. The 10 grams result is not applicable to FCC filing.

16.0 Variability Assessment

Per the guidelines in KDB 865664 SAR variability assessment is required because SAR results are above 4.0W/kg (Occupational).

The Table below includes test results of the original measurement(s), the repeated measurement(s), and the ratio (SAR_{high}/SAR_{low}) for the applicable test configuration(s).

Table 21

Run#	Antenna	Battery	Carry Accessory	Cable Accessory	Test Freq. (MHz)	Adj Calc. 1g-SAR (W/kg)	Ratio	Comments
FD-AB-160930-04	PMAE4102A	PMNN4407BR	RLN4570A	NONE	450.000	7.27	1.03	No additional repeated scans is required due to the Ratio (SAR_{high}/SAR_{low}) < 1.20
FIE-AB-161005-10						7.09		

17.0 System Uncertainty

A system uncertainty analysis is not required for this report per KDB 865664 because the highest report SAR value Occupational exposure is less than 7.5W/kg.

Per the guidelines of ISO 17025 a reported system uncertainty is required and therefore measurement uncertainty budget is included in Appendix A.

Appendix A
Measurement Uncertainty Budget

Uncertainty Budget for Device Under Test, for 450 MHz

a	*b*	*c*	*d*	*e = f(d,k)*	*f*	*g*	*h = c x f / e*	*i = c x g / e*	*k*
Uncertainty Component	IEEE 1528 section	Tol. (± %)	Prob Dist	Div.	c_i (1 g)	c_i (10 g)	1 g u_i (±%)	10 g u_i (±%)	v_i
Measurement System									
Probe Calibration	E.2.1	6.7	N	1.00	1	1	6.7	6.7	∞
Axial Isotropy	E.2.2	4.7	R	1.73	0.707	0.707	1.9	1.9	∞
Hemispherical Isotropy	E.2.2	9.6	R	1.73	0.707	0.707	3.9	3.9	∞
Boundary Effect	E.2.3	1.0	R	1.73	1	1	0.6	0.6	∞
Linearity	E.2.4	4.7	R	1.73	1	1	2.7	2.7	∞
System Detection Limits	E.2.5	1.0	R	1.73	1	1	0.6	0.6	∞
Readout Electronics	E.2.6	0.3	N	1.00	1	1	0.3	0.3	∞
Response Time	E.2.7	1.1	R	1.73	1	1	0.6	0.6	∞
Integration Time	E.2.8	1.1	R	1.73	1	1	0.6	0.6	∞
RF Ambient Conditions - Noise	E.6.1	3.0	R	1.73	1	1	1.7	1.7	∞
RF Ambient Conditions - Reflections	E.6.1	0.0	R	1.73	1	1	0.0	0.0	∞
Probe Positioner Mech. Tolerance	E.6.2	0.4	R	1.73	1	1	0.2	0.2	∞
Probe Positioning w.r.t Phantom	E.6.3	1.4	R	1.73	1	1	0.8	0.8	∞
Max. SAR Evaluation (ext., int., avg.)	E.5	3.4	R	1.73	1	1	2.0	2.0	∞
Test sample Related									
Test Sample Positioning	E.4.2	3.2	N	1.00	1	1	3.2	3.2	29
Device Holder Uncertainty	E.4.1	4.0	N	1.00	1	1	4.0	4.0	8
SAR drift	6.6.2	5.0	R	1.73	1	1	2.9	2.9	∞
Phantom and Tissue Parameters									
Phantom Uncertainty	E.3.1	4.0	R	1.73	1	1	2.3	2.3	∞
Liquid Conductivity (target)	E.3.2	5.0	R	1.73	0.64	0.43	1.8	1.2	∞
Liquid Conductivity (measurement)	E.3.3	3.3	N	1.00	0.64	0.43	2.1	1.4	∞
Liquid Permittivity (target)	E.3.2	5.0	R	1.73	0.6	0.49	1.7	1.4	∞
Liquid Permittivity (measurement)	E.3.3	1.9	N	1.00	0.6	0.49	1.1	0.9	∞
Combined Standard Uncertainty			RSS				12	11	482
Expanded Uncertainty (95% CONFIDENCE LEVEL)			*k* =2				23	23	

Notes for uncertainty budget Tables:
a) Column headings *a*-*k* are given for reference.
b) Tol. - tolerance in influence quantity.
c) Prob. Dist. – Probability distribution
d) N, R - normal, rectangular probability distributions
e) Div. - divisor used to translate tolerance into normally distributed standard uncertainty
f) *ci* - sensitivity coefficient that should be applied to convert the variability of the uncertainty component into a variability of SAR.
g) *ui* – SAR uncertainty
h) *vi* - degrees of freedom for standard uncertainty and effective degrees of freedom for the expanded uncertainty

Uncertainty Budget for System Validation (dipole & flat phantom) for 450 MHz

a	b	c	d	e = f(d,k)	f	g	h = c x f / e	i = c x g / e	k
Uncertainty Component	IEEE 1528 section	Tol. (± %)	Prob. Dist.	Div.	c_i (1 g)	c_i (10 g)	1 g u_i (±%)	10 g u_i (±%)	v_i
Measurement System									
Probe Calibration	E.2.1	6.7	N	1.00	1	1	6.7	6.7	∞
Axial Isotropy	E.2.2	4.7	R	1.73	1	1	2.7	2.7	∞
Spherical Isotropy	E.2.2	9.6	R	1.73	0	0	0.0	0.0	∞
Boundary Effect	E.2.3	1.0	R	1.73	1	1	0.6	0.6	∞
Linearity	E.2.4	4.7	R	1.73	1	1	2.7	2.7	∞
System Detection Limits	E.2.5	1.0	R	1.73	1	1	0.6	0.6	∞
Readout Electronics	E.2.6	0.3	N	1.00	1	1	0.3	0.3	∞
Response Time	E.2.7	1.1	R	1.73	1	1	0.6	0.6	∞
Integration Time	E.2.8	0.0	R	1.73	1	1	0.0	0.0	∞
RF Ambient Conditions - Noise	E.6.1	3.0	R	1.73	1	1	1.7	1.7	∞
RF Ambient Conditions - Reflections	E.6.1	0.0	R	1.73	1	1	0.0	0.0	∞
Probe Positioner Mechanical Tolerance	E.6.2	0.4	R	1.73	1	1	0.2	0.2	∞
Probe Positioning w.r.t. Phantom	E.6.3	1.4	R	1.73	1	1	0.8	0.8	∞
Max. SAR Evaluation (ext., int., avg.)	E.5	3.4	R	1.73	1	1	2.0	2.0	∞
Dipole									
Dipole Axis to Liquid Distance	8, E.4.2	2.0	R	1.73	1	1	1.2	1.2	∞
Input Power and SAR Drift Measurement	8, 6.6.2	5.0	R	1.73	1	1	2.9	2.9	∞
Phantom and Tissue Parameters									
Phantom Uncertainty	E.3.1	4.0	R	1.73	1	1	2.3	2.3	∞
Liquid Conductivity (target)	E.3.2	5.0	R	1.73	0.64	0.43	1.8	1.2	∞
Liquid Conductivity (measurement)	E.3.3	3.3	R	1.73	0.64	0.43	1.2	0.8	∞
Liquid Permittivity (target)	E.3.2	5.0	R	1.73	0.6	0.49	1.7	1.4	∞
Liquid Permittivity (measurement)	E.3.3	1.9	R	1.73	0.6	0.49	0.6	0.5	∞
Combined Standard Uncertainty			RSS				10	9	99999
Expanded Uncertainty (95% CONFIDENCE LEVEL)			k =2				19	18	

Notes for uncertainty budget Tables:
a) Column headings *a-k* are given for reference.
b) Tol. - tolerance in influence quantity.
c) Prob. Dist. – Probability distribution
d) N, R - normal, rectangular probability distributions
e) Div. - divisor used to translate tolerance into normally distributed standard uncertainty
f) *ci* - sensitivity coefficient that should be applied to convert the variability of the uncertainty component into a variability of SAR.
g) *ui* – SAR uncertainty
h) *vi* - degrees of freedom for standard uncertainty and effective degrees of freedom for the expanded uncertainty

Appendix B
Probe Calibration Certificates

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 **Motorola Solutions MY**

Certificate No: **ES3-3096_Apr16**

CALIBRATION CERTIFICATE

Object: ES3DV3 - SN:3096

Calibration procedure(s): QA CAL-01.v9, QA CAL-12.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

Calibration date: April 29, 2016

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	06-Apr-16 (No. 217-02288/02289)	Apr-17
Power sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17
Power sensor NRP-Z91	SN: 103245	06-Apr-16 (No. 217-02289)	Apr-17
Reference 20 dB Attenuator	SN: S5277 (20x)	05-Apr-16 (No. 217-02293)	Apr-17
Reference Probe ES3DV2	SN: 3013	31-Dec-15 (No. ES3-3013_Dec15)	Dec-16
DAE4	SN: 660	23-Dec-15 (No. DAE4-660_Dec15)	Dec-16
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (No. 217-02285/02284)	In house check: Jun-16
Power sensor E4412A	SN: MY41498087	06-Apr-16 (No. 217-02285)	In house check: Jun-16
Power sensor E4412A	SN: 000110210	06-Apr-16 (No. 217-02284)	In house check: Jun-16
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Apr-13)	In house check: Jun-16
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

	Name	Function	Signature
Calibrated by:	Claudio Leubler	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: April 29, 2016

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

Accreditation No.: **SCS 0108**

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., $\vartheta = 0$ 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 $\vartheta = 0$ ($f \leq 900$ 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 $f \leq 800$ MHz) and inside waveguide using analytical field distributions based on power measurements for $f > 800$ MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *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:3096

Manufactured:	July 12, 2005
Repaired:	April 26, 2016
Calibrated:	April 29, 2016

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

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3096

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)[A]	0.96	0.89	0.90	± 10.1 %
DCP (mV)[B]	105.7	104.3	104.8	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB√μV	C	D dB	VR mV	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	185.2	±3.8 %
		Y	0.0	0.0	1.0		173.8	
		Z	0.0	0.0	1.0		198.7	
10100-CAB	LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)	X	6.57	67.8	19.7	5.67	138.2	±1.7 %
		Y	6.44	67.4	19.5		131.7	
		Z	6.59	67.8	19.5		149.1	
10101-CAB	LTE-FDD (SC-FDMA, 100% RB, 20 MHz, 16-QAM)	X	7.34	67.0	19.5	6.42	125.4	±1.7 %
		Y	7.61	67.9	20.1		143.6	
		Z	7.40	67.3	19.5		133.1	
10102-CAB	LTE-FDD (SC-FDMA, 100% RB, 20 MHz, 64-QAM)	X	7.61	67.1	19.7	6.60	127.1	±1.7 %
		Y	7.91	68.2	20.3		145.4	
		Z	7.60	67.1	19.4		135.3	
10108-CAC	LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK)	X	6.50	67.5	19.6	5.80	137.0	±1.7 %
		Y	6.39	67.1	19.5		130.5	
		Z	6.44	67.2	19.3		146.5	
10109-CAC	LTE-FDD (SC-FDMA, 100% RB, 10 MHz, 16-QAM)	X	7.49	67.8	20.0	6.43	146.2	±1.7 %
		Y	7.37	67.5	19.9		139.9	
		Z	7.05	66.5	19.1		127.8	
10110-CAC	LTE-FDD (SC-FDMA, 100% RB, 5 MHz, QPSK)	X	6.19	66.9	19.4	5.75	132.5	±1.7 %
		Y	6.08	66.6	19.3		127.5	
		Z	6.13	66.7	19.1		142.4	
10111-CAC	LTE-FDD (SC-FDMA, 100% RB, 5 MHz, 16-QAM)	X	7.22	67.4	19.8	6.44	141.3	±2.2 %
		Y	7.13	67.2	19.9		135.8	
		Z	7.13	67.4	19.6		148.8	
10112-CAC	LTE-FDD (SC-FDMA, 100% RB, 10 MHz, 64-QAM)	X	7.72	67.9	20.1	6.59	146.0	±1.9 %
		Y	7.63	67.7	20.1		140.7	
		Z	7.28	66.7	19.3		129.0	
10113-CAC	LTE-FDD (SC-FDMA, 100% RB, 5 MHz, 64-QAM)	X	7.49	67.6	20.1	6.62	143.6	±1.9 %
		Y	7.36	67.3	20.0		137.2	
		Z	7.09	66.6	19.4		127.0	
10140-CAB	LTE-FDD (SC-FDMA, 100% RB, 15 MHz, 16-QAM)	X	7.90	68.2	20.2	6.49	148.7	±1.9 %
		Y	7.81	68.0	20.2		143.9	
		Z	7.56	67.2	19.5		134.1	
10141-CAB	LTE-FDD (SC-FDMA, 100% RB, 15 MHz, 64-QAM)	X	7.70	67.3	19.7	6.53	127.2	±1.9 %
		Y	7.97	68.2	20.3		146.1	
		Z	7.60	67.0	19.4		135.4	

10142-CAC	LTE-FDD (SC-FDMA, 100% RB, 3 MHz, QPSK)	X	6.04	66.7	19.3	5.73	130.8	±1.7 %
		Y	6.19	67.4	19.7		149.8	
		Z	5.97	66.6	19.1		140.2	
10143-CAC	LTE-FDD (SC-FDMA, 100% RB, 3 MHz, 16-QAM)	X	7.02	67.3	19.8	6.35	138.0	±1.9 %
		Y	6.90	67.1	19.7		132.9	
		Z	6.94	67.3	19.5		147.4	
10144-CAC	LTE-FDD (SC-FDMA, 100% RB, 3 MHz, 64-QAM)	X	7.38	67.6	20.1	6.65	140.2	±1.9 %
		Y	7.28	67.5	20.1		135.4	
		Z	7.27	67.8	20.0		148.2	
10145-CAC	LTE-FDD (SC-FDMA, 100% RB, 1.4 MHz, QPSK)	X	5.78	66.2	19.1	5.76	126.9	±1.4 %
		Y	5.95	67.1	19.6		146.3	
		Z	5.63	65.9	18.6		133.9	
10146-CAC	LTE-FDD (SC-FDMA, 100% RB, 1.4 MHz, 16-QAM)	X	6.76	67.2	19.7	6.41	133.2	±1.9 %
		Y	6.66	67.0	19.7		128.2	
		Z	6.59	67.1	19.5		140.7	
10147-CAC	LTE-FDD (SC-FDMA, 100% RB, 1.4 MHz, 64-QAM)	X	7.06	67.4	20.0	6.72	134.5	±2.2 %
		Y	6.96	67.2	20.0		129.8	
		Z	6.95	67.6	20.0		141.4	
10149-CAB	LTE-FDD (SC-FDMA, 50% RB, 20 MHz, 16-QAM)	X	7.47	67.8	20.0	6.42	144.6	±1.9 %
		Y	7.41	67.7	20.1		140.2	
		Z	7.13	66.8	19.4		129.1	
10150-CAB	LTE-FDD (SC-FDMA, 50% RB, 20 MHz, 64-QAM)	X	7.74	67.9	20.2	6.60	146.5	±1.9 %
		Y	7.67	67.9	20.2		142.5	
		Z	7.35	66.9	19.4		130.7	
10154-CAC	LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)	X	6.17	66.8	19.3	5.75	132.7	±1.4 %
		Y	6.12	66.7	19.4		128.1	
		Z	6.16	66.9	19.2		142.4	
10155-CAC	LTE-FDD (SC-FDMA, 50% RB, 10 MHz, 16-QAM)	X	7.21	67.4	19.8	6.43	141.3	±1.9 %
		Y	7.16	67.4	20.0		136.7	
		Z	6.79	66.1	19.0		125.3	
10156-CAC	LTE-FDD (SC-FDMA, 50% RB, 5 MHz, QPSK)	X	5.99	66.5	19.2	5.79	129.8	±1.7 %
		Y	6.16	67.3	19.8		149.3	
		Z	5.90	66.4	18.9		137.3	
10157-CAC	LTE-FDD (SC-FDMA, 50% RB, 5 MHz, 16-QAM)	X	7.01	67.2	19.8	6.49	136.9	±1.9 %
		Y	6.93	67.2	19.9		131.7	
		Z	6.88	67.2	19.6		143.5	
10158-CAC	LTE-FDD (SC-FDMA, 50% RB, 10 MHz, 64-QAM)	X	7.49	67.6	20.1	6.62	142.3	±1.9 %
		Y	7.42	67.6	20.1		137.4	
		Z	7.13	66.7	19.4		125.9	
10159-CAC	LTE-FDD (SC-FDMA, 50% RB, 5 MHz, 64-QAM)	X	7.12	67.3	19.9	6.56	137.4	±2.2 %
		Y	7.08	67.4	20.0		132.4	
		Z	7.02	67.5	19.8		145.3	
10160-CAB	LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK)	X	6.61	67.3	19.5	5.82	135.9	±1.7 %
		Y	6.51	67.1	19.5		132.3	
		Z	6.62	67.4	19.5		146.9	

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10161-CAB	LTE-FDD (SC-FDMA, 50% RB, 15 MHz, 16-QAM)	X	7.52	67.7	20.0	6.43	144.3	±1.9 %
		Y	7.44	67.6	20.0		140.0	
		Z	7.11	66.6	19.2		127.8	
10162-CAB	LTE-FDD (SC-FDMA, 50% RB, 15 MHz, 64-QAM)	X	7.75	67.9	20.1	6.58	146.0	±1.9 %
		Y	7.67	67.8	20.1		141.6	
		Z	7.35	66.8	19.4		130.4	
10166-CAC	LTE-FDD (SC-FDMA, 50% RB, 1.4 MHz, QPSK)	X	5.41	66.8	19.4	5.46	143.9	±1.2 %
		Y	5.36	66.8	19.4		138.5	
		Z	5.14	66.1	18.8		129.3	
10167-CAC	LTE-FDD (SC-FDMA, 50% RB, 1.4 MHz, 16-QAM)	X	6.46	67.9	20.1	6.21	149.0	±1.7 %
		Y	6.36	67.8	20.1		143.6	
		Z	5.99	66.7	19.2		131.7	
10168-CAC	LTE-FDD (SC-FDMA, 50% RB, 1.4 MHz, 64-QAM)	X	6.66	67.1	20.0	6.79	125.6	±1.9 %
		Y	6.88	68.2	20.7		144.3	
		Z	6.54	67.4	20.0		133.1	
10169-CAB	LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)	X	5.24	66.8	19.5	5.73	135.2	±1.4 %
		Y	5.23	66.9	19.6		133.1	
		Z	5.10	66.7	19.1		145.3	
10170-CAB	LTE-FDD (SC-FDMA, 1 RB, 20 MHz, 16-QAM)	X	6.17	68.2	20.5	6.52	137.9	±1.7 %
		Y	6.12	68.1	20.5		134.4	
		Z	5.93	68.0	20.2		145.0	
10171-AAB	LTE-FDD (SC-FDMA, 1 RB, 20 MHz, 64-QAM)	X	6.20	68.4	20.5	6.49	138.1	±1.7 %
		Y	6.14	68.2	20.6		134.7	
		Z	5.91	67.8	20.0		144.8	
10175-CAC	LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)	X	5.24	66.9	19.6	5.72	136.0	±1.4 %
		Y	5.21	66.8	19.6		133.5	
		Z	5.07	66.5	19.0		143.3	
10176-CAC	LTE-FDD (SC-FDMA, 1 RB, 10 MHz, 16-QAM)	X	6.20	68.3	20.5	6.52	138.9	±1.7 %
		Y	6.14	68.2	20.6		135.4	
		Z	5.91	67.8	20.1		145.0	
10177-CAE	LTE-FDD (SC-FDMA, 1 RB, 5 MHz, QPSK)	X	5.26	67.0	19.6	5.73	136.2	±1.2 %
		Y	5.23	66.9	19.7		133.8	
		Z	5.07	66.5	19.0		143.4	
10178-CAC	LTE-FDD (SC-FDMA, 1 RB, 5 MHz, 16-QAM)	X	6.19	68.2	20.5	6.52	138.8	±1.7 %
		Y	6.16	68.2	20.6		135.8	
		Z	5.89	67.7	20.0		144.1	
10179-CAC	LTE-FDD (SC-FDMA, 1 RB, 10 MHz, 64-QAM)	X	6.21	68.4	20.5	6.50	138.1	±1.7 %
		Y	6.12	68.2	20.5		133.9	
		Z	5.92	68.0	20.1		143.5	
10180-CAC	LTE-FDD (SC-FDMA, 1 RB, 5 MHz, 64-QAM)	X	6.18	68.2	20.5	6.50	138.1	±1.7 %
		Y	6.15	68.3	20.6		134.8	
		Z	5.90	67.9	20.1		143.9	
10181-CAB	LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK)	X	5.24	66.9	19.5	5.72	135.5	±1.4 %
		Y	5.25	67.0	19.7		133.1	
		Z	5.10	66.7	19.2		142.5	

10182-CAB	LTE-FDD (SC-FDMA, 1 RB, 15 MHz, 16-QAM)	X	6.17	68.2	20.5	6.52	138.0	±1.7 %
		Y	6.10	68.0	20.5		133.2	
		Z	5.89	67.7	20.0		142.5	
10183-AAA	LTE-FDD (SC-FDMA, 1 RB, 15 MHz, 64-QAM)	X	6.17	68.2	20.5	6.50	137.2	±1.7 %
		Y	6.12	68.2	20.6		133.6	
		Z	5.93	68.1	20.2		142.5	
10184-CAC	LTE-FDD (SC-FDMA, 1 RB, 3 MHz, QPSK)	X	5.22	66.8	19.5	5.73	134.5	±1.2 %
		Y	5.21	66.8	19.6		132.5	
		Z	5.15	66.9	19.3		141.2	
10185-CAC	LTE-FDD (SC-FDMA, 1 RB, 3 MHz, 16-QAM)	X	6.18	68.2	20.5	6.51	137.2	±1.9 %
		Y	6.10	68.0	20.5		132.7	
		Z	5.93	67.9	20.1		143.9	
10186-AAC	LTE-FDD (SC-FDMA, 1 RB, 3 MHz, 64-QAM)	X	6.20	68.3	20.5	6.50	136.8	±1.7 %
		Y	6.11	68.1	20.5		133.6	
		Z	6.02	68.5	20.5		142.7	
10187-CAC	LTE-FDD (SC-FDMA, 1 RB, 1.4 MHz, QPSK)	X	5.25	66.9	19.5	5.73	134.3	±1.2 %
		Y	5.22	66.9	19.6		132.1	
		Z	5.10	66.7	19.2		141.6	
10188-CAC	LTE-FDD (SC-FDMA, 1 RB, 1.4 MHz, 16-QAM)	X	6.18	68.2	20.5	6.52	136.7	±1.9 %
		Y	6.12	68.1	20.6		132.9	
		Z	5.87	67.7	20.0		143.8	
10189-AAC	LTE-FDD (SC-FDMA, 1 RB, 1.4 MHz, 64-QAM)	X	6.20	68.3	20.5	6.50	137.0	±1.7 %
		Y	6.11	68.1	20.5		132.3	
		Z	5.97	68.2	20.2		143.8	
10297-AAA	LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)	X	6.45	67.2	19.5	5.81	131.4	±1.7 %
		Y	6.37	67.1	19.5		128.0	
		Z	6.29	66.6	18.9		134.7	
10298-AAB	LTE-FDD (SC-FDMA, 50% RB, 3 MHz, QPSK)	X	5.82	66.2	19.1	5.72	127.0	±1.4 %
		Y	6.03	67.2	19.7		146.8	
		Z	5.71	66.1	18.8		129.6	
10299-AAB	LTE-FDD (SC-FDMA, 50% RB, 3 MHz, 16-QAM)	X	6.84	67.2	19.7	6.39	132.9	±1.7 %
		Y	6.74	67.0	19.7		129.6	
		Z	6.66	67.1	19.5		135.2	
10300-AAB	LTE-FDD (SC-FDMA, 50% RB, 3 MHz, 64-QAM)	X	7.08	67.4	20.0	6.60	134.1	±1.9 %
		Y	7.00	67.3	20.0		130.9	
		Z	6.91	67.4	19.8		141.9	
10311-AAA	LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK)	X	7.01	67.8	19.9	6.06	138.2	±1.7 %
		Y	6.99	67.8	20.0		135.2	
		Z	6.74	66.9	19.3		125.0	

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 8 and 9).
[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: ES3DV3 - SN:3096

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)
150	52.3	0.76	7.16	7.16	7.16	0.08	1.20	± 13.3 %
300	45.3	0.87	7.14	7.14	7.14	0.14	1.60	± 13.3 %
450	43.5	0.87	6.70	6.70	6.70	0.22	1.70	± 13.3 %
750	41.9	0.89	6.55	6.55	6.55	0.80	1.17	± 12.0 %
900	41.5	0.97	6.19	6.19	6.19	0.73	1.22	± 12.0 %
1810	40.0	1.40	5.09	5.09	5.09	0.43	1.61	± 12.0 %
1900	40.0	1.40	5.05	5.05	5.05	0.56	1.39	± 12.0 %
2300	39.5	1.67	4.75	4.75	4.75	0.59	1.41	± 12.0 %
2450	39.2	1.80	4.52	4.52	4.52	0.73	1.32	± 12.0 %
2600	39.0	1.96	4.33	4.33	4.33	0.80	1.27	± 12.0 %

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

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3096

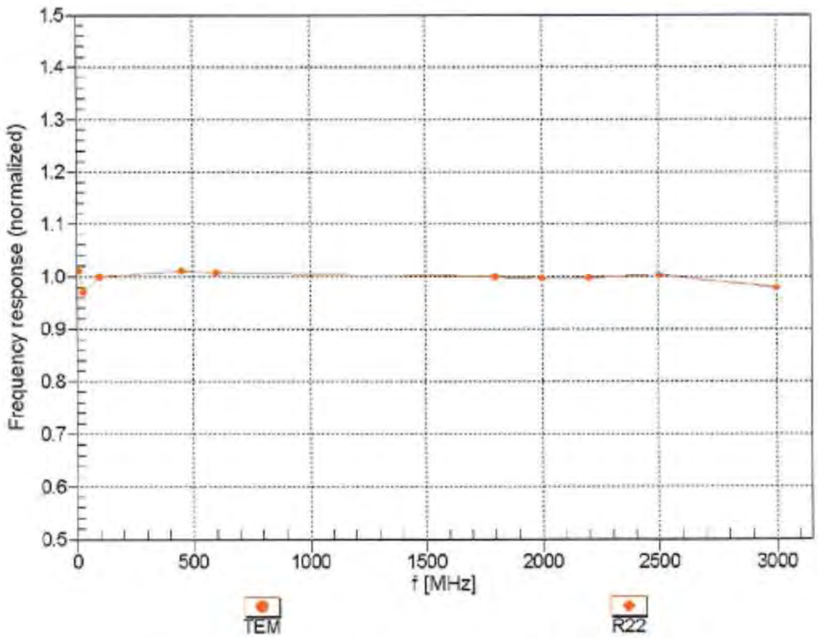
Calibration Parameter Determined in Body Tissue Simulating Media

f (MHz) [C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha [G]	Depth [G] (mm)	Unc (k=2)
150	61.9	0.80	6.97	6.97	6.97	0.08	1.50	± 13.3 %
300	58.2	0.92	6.76	6.76	6.76	0.12	1.30	± 13.3 %
450	56.7	0.94	6.82	6.82	6.82	0.15	1.30	± 13.3 %
750	55.5	0.96	6.11	6.11	6.11	0.61	1.37	± 12.0 %
900	55.0	1.05	5.97	5.97	5.97	0.62	1.32	± 12.0 %
1810	53.3	1.52	4.91	4.91	4.91	0.63	1.34	± 12.0 %
1900	53.3	1.52	4.74	4.74	4.74	0.56	1.45	± 12.0 %
2300	52.9	1.81	4.46	4.46	4.46	0.80	1.20	± 12.0 %
2450	52.7	1.95	4.31	4.31	4.31	0.80	1.18	± 12.0 %
2600	52.5	2.16	4.15	4.15	4.15	0.80	1.15	± 12.0 %

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

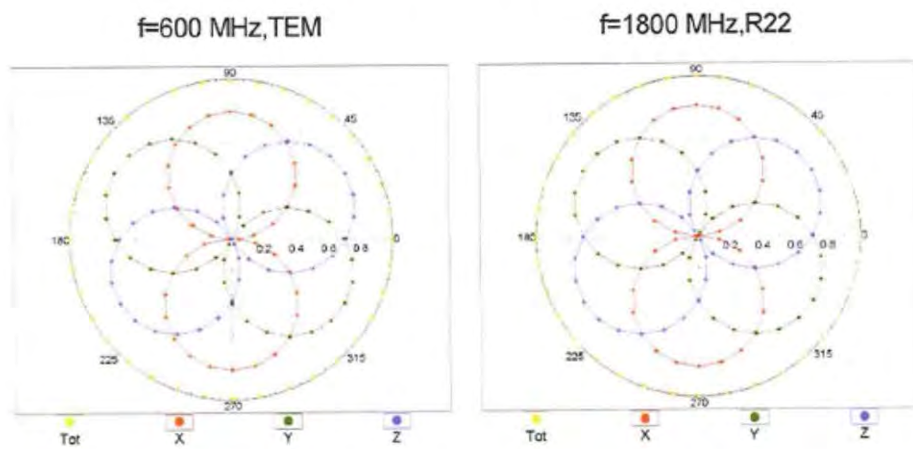
Frequency Response of E-Field

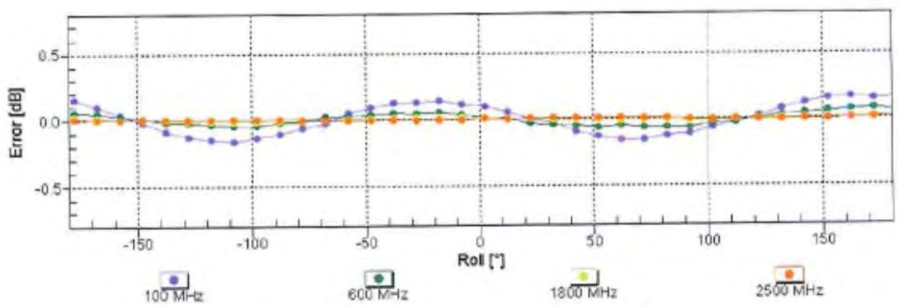
(TEM-Cell:ifi110 EXX, Waveguide: R22)



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

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

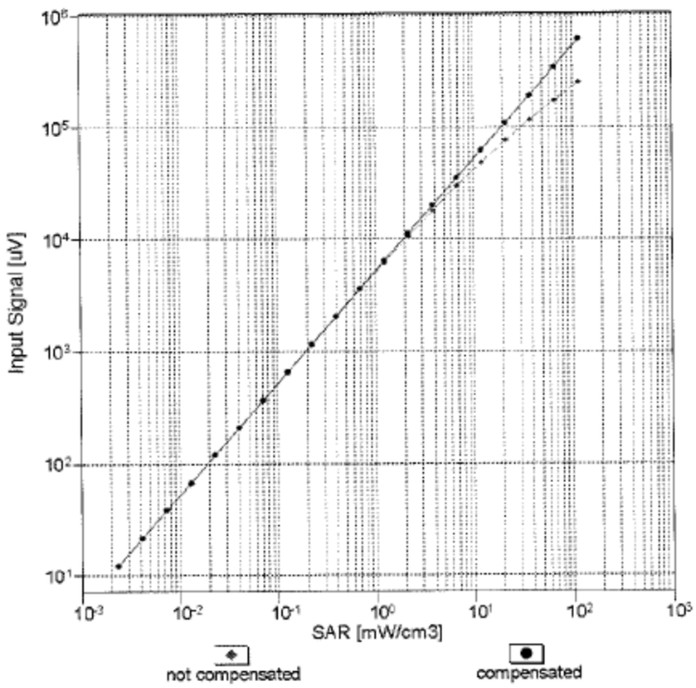


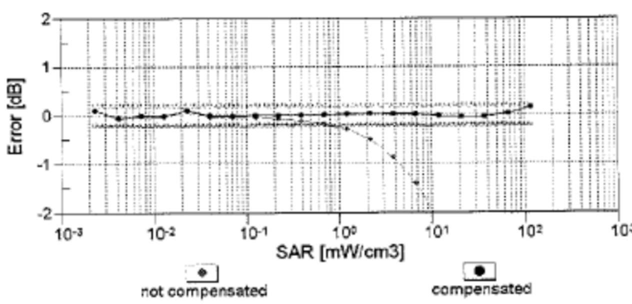


Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

Dynamic Range f(SAR_{head})

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

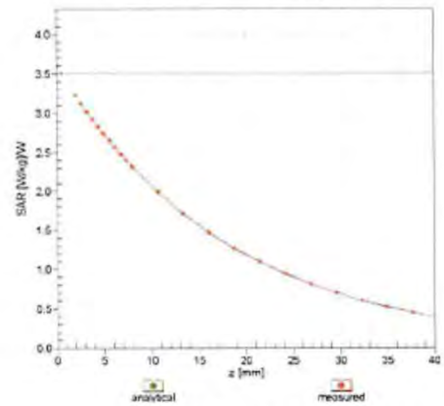




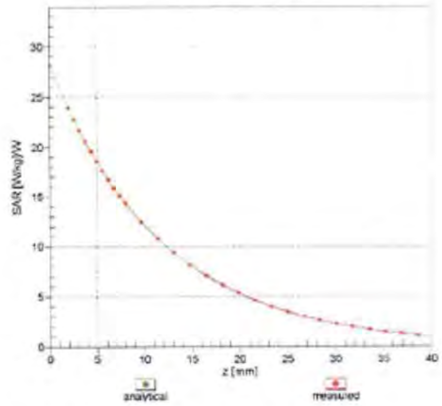
Uncertainty of Linearity Assessment: ± 0.6% (k=2)

Conversion Factor Assessment

f = 900 MHz,WGLS R9 (H_convF)

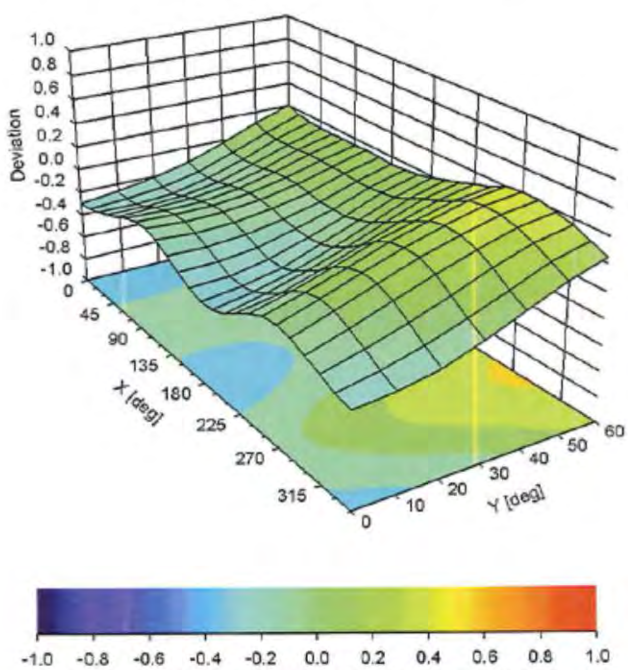


f = 1810 MHz,WGLS R22 (H_convF)



Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz



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

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3096

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	2.3
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

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Schmid & Partner
Engineering AG
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Accreditation No.: **SCS 0108**

Client **Motorola Solutions MY**

Certificate No: **EX3-7422_Jul16**

CALIBRATION CERTIFICATE

Object: EX3DV4 - SN:7422

Calibration procedure(s): QA CAL-01.v9, QA CAL-12.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

Calibration date: July 29, 2016

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	06-Apr-16 (No. 217-02288/02289)	Apr-17
Power sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17
Power sensor NRP-Z91	SN: 103245	06-Apr-16 (No. 217-02289)	Apr-17
Reference 20 dB Attenuator	SN: S5277 (20x)	05-Apr-16 (No. 217-02293)	Apr-17
Reference Probe ES3DV2	SN: 3013	31-Dec-15 (No. ES3-3013_Dec15)	Dec-16
DAE4	SN: 660	23-Dec-15 (No. DAE4-660_Dec15)	Dec-16
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-16)	In house check: Jun-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

	Name	Function	Signature
Calibrated by:	Claudio Leubler	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: August 2, 2016

Calibration Laboratory of
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Zeughausstrasse 43, 8004 Zurich, Switzerland

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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Methods Applied and Interpretation of Parameters:

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

Probe EX3DV4

SN:7422

Manufactured: March 10, 2016
Calibrated: July 29, 2016

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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7422

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)[A]	0.48	0.54	0.54	± 10.1 %
DCP (mV)[B]	95.3	97.7	99.7	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB$\sqrt{\mu V}$	C	D dB	VR mV	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	119.4	±3.0 %
		Y	0.0	0.0	1.0		124.5	
		Z	0.0	0.0	1.0		115.3	

Note: For details on UID parameters see Appendix.

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:7422

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)
150	52.3	0.76	12.70	12.70	12.70	0.00	1.00	± 13.3 %
300	45.3	0.87	11.37	11.37	11.37	0.10	1.20	± 13.3 %
450	43.5	0.87	10.62	10.62	10.62	0.17	1.30	± 13.3 %
750	41.9	0.89	9.96	9.96	9.96	0.37	0.94	± 12.0 %
900	41.5	0.97	9.39	9.39	9.39	0.44	0.80	± 12.0 %
2450	39.2	1.80	7.45	7.45	7.45	0.35	0.83	± 12.0 %
4950	36.3	4.40	5.26	5.26	5.26	0.35	1.80	± 13.1 %
5250	35.9	4.71	4.95	4.95	4.95	0.40	1.80	± 13.1 %
5500	35.6	4.96	4.49	4.49	4.49	0.40	1.80	± 13.1 %
5600	35.5	5.07	4.32	4.32	4.32	0.45	1.80	± 13.1 %
5750	35.4	5.22	4.52	4.52	4.52	0.45	1.80	± 13.1 %

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

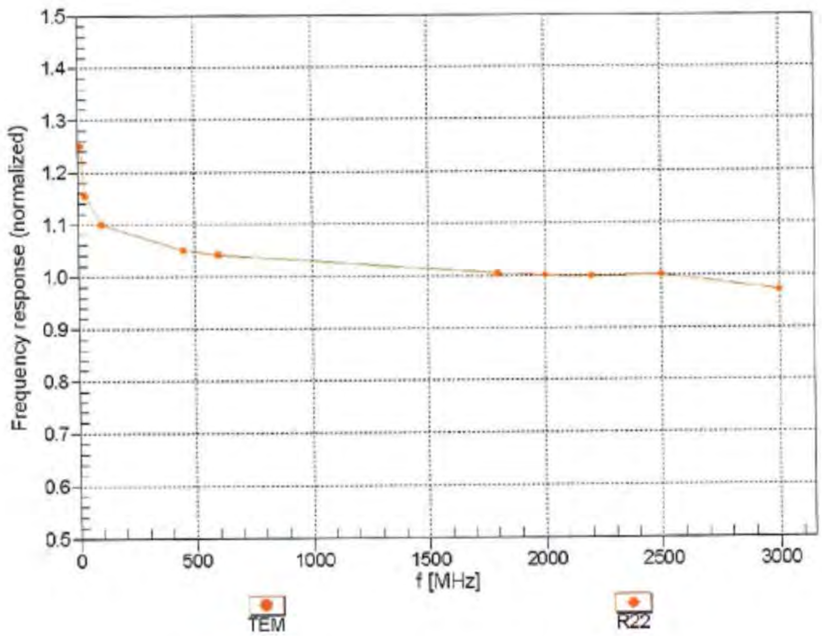
DASY/EASY - Parameters of Probe: EX3DV4 - SN:7422

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)
150	61.9	0.80	12.10	12.10	12.10	0.00	1.00	± 13.3 %
300	58.2	0.92	11.86	11.86	11.86	0.08	1.20	± 13.3 %
450	56.7	0.94	11.01	11.01	11.01	0.10	1.25	± 13.3 %
750	55.5	0.96	9.77	9.77	9.77	0.52	0.80	± 12.0 %
900	55.0	1.05	9.59	9.59	9.59	0.46	0.80	± 12.0 %
2450	52.7	1.95	7.28	7.28	7.28	0.30	0.80	± 12.0 %
4950	49.4	5.01	4.61	4.61	4.61	0.45	1.90	± 13.1 %
5250	48.9	5.36	4.40	4.40	4.40	0.50	1.90	± 13.1 %
5500	48.6	5.65	3.84	3.84	3.84	0.55	1.90	± 13.1 %
5600	48.5	5.77	3.63	3.63	3.63	0.60	1.90	± 13.1 %
5750	48.3	5.94	3.90	3.90	3.90	0.60	1.90	± 13.1 %

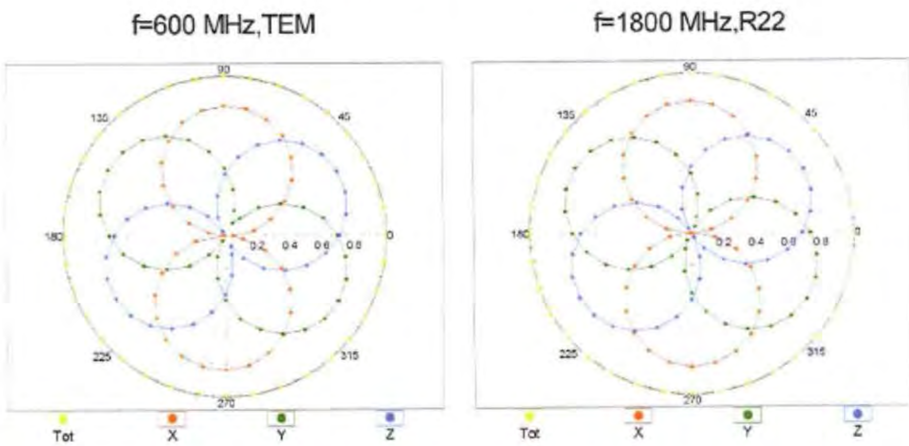
[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz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

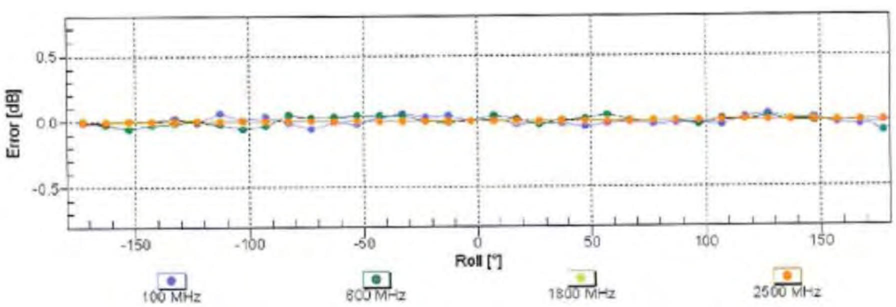
Frequency Response of E-Field
(TEM-Cell:ifi110 EXX, Waveguide: R22)



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

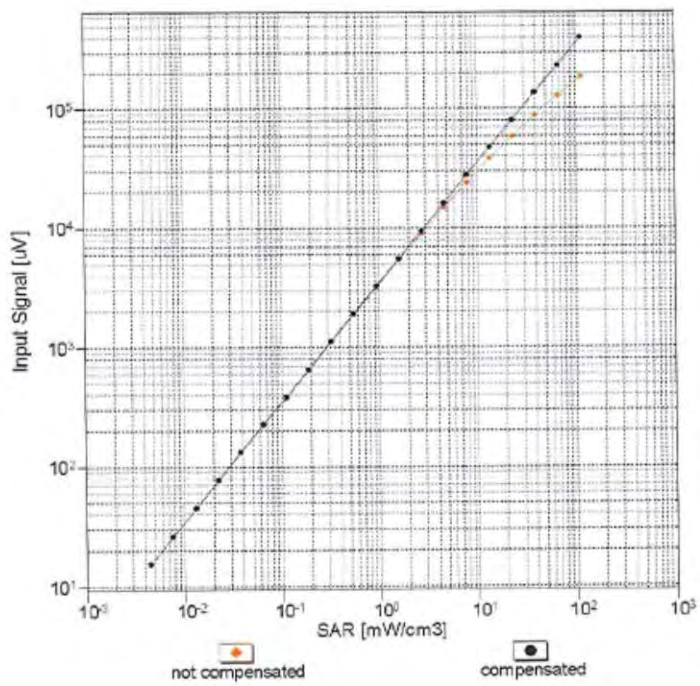
Receiving Pattern (φ), ϑ = 0°

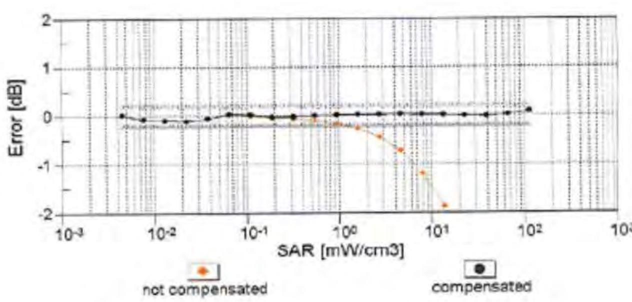




Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

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

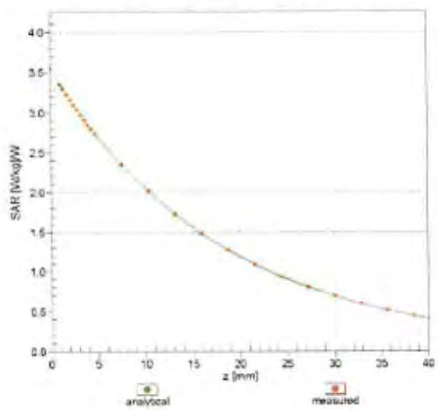




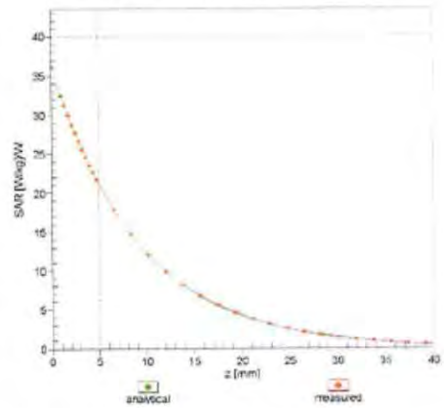
Uncertainty of Linearity Assessment: ± 0.6% (k=2)

Conversion Factor Assessment

f = 900 MHz,WGLS R9 (H_convF)

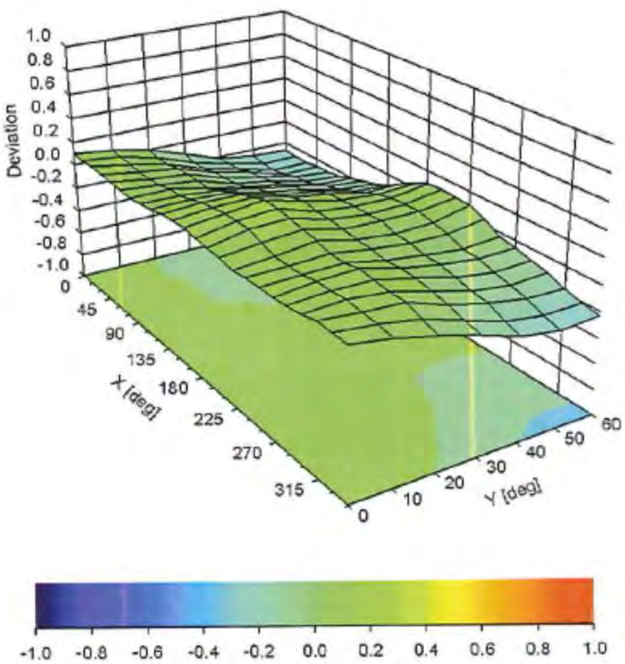


f = 2450 MHz,WGLS R22 (H_convF)



Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz



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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7422

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	-2.8
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

EX3DV4– SN:7422 July 29, 2016

Appendix: Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB√μV	C	D dB	VR mV	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	119.4	±3.0 %
		Y	0.0	0.0	1.0		124.5	
		Z	0.0	0.0	1.0		115.3	
10117-CAB	IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK)	X	10.45	69.0	21.3	8.07	133.0	±2.2 %
		Y	10.46	69.2	21.4		141.1	
		Z	10.03	68.4	20.9		124.5	
10196-CAB	IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)	X	10.02	68.7	21.3	8.10	127.4	±2.2 %
		Y	10.12	69.1	21.4		134.3	
		Z	9.62	68.3	21.0		119.1	
10415-AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)	X	2.65	67.2	17.9	1.54	130.8	±0.5 %
		Y	2.99	69.7	19.1		137.4	
		Z	2.90	68.9	18.5		126.8	
10417-AAA	IEEE 802.11a/h WiFi 5 GHz (OFDM, 6 Mbps, 99pc duty cycle)	X	10.12	68.7	21.5	8.23	126.2	±2.5 %
		Y	10.11	68.9	21.4		130.8	
		Z	9.70	68.2	21.1		119.3	
10418-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps, 99pc duty cycle, Long preambule)	X	9.96	68.6	21.3	8.14	125.9	±2.2 %
		Y	10.00	68.8	21.3		132.5	
		Z	9.60	68.3	21.1		120.2	
10515-AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 2 Mbps, 99pc duty cycle)	X	2.70	67.7	18.2	1.58	129.4	±0.7 %
		Y	2.80	68.8	18.8		136.2	
		Z	3.01	69.7	18.9		127.2	
10518-AAA	IEEE 802.11a/h WiFi 5 GHz (OFDM, 9 Mbps, 99pc duty cycle)	X	10.11	68.8	21.5	8.23	126.7	±2.5 %
		Y	10.17	69.0	21.5		132.2	
		Z	9.75	68.4	21.2		121.1	
10525-AAA	IEEE 802.11ac WiFi (20MHz, MCS0, 99pc duty cycle)	X	10.35	68.9	21.6	8.36	128.7	±2.5 %
		Y	10.47	69.4	21.7		136.2	
		Z	9.97	68.6	21.3		123.8	
10526-AAA	IEEE 802.11ac WiFi (20MHz, MCS1, 99pc duty cycle)	X	10.43	69.0	21.7	8.42	128.3	±2.5 %
		Y	10.48	69.3	21.7		135.8	
		Z	10.07	68.7	21.4		124.1	
10534-AAA	IEEE 802.11ac WiFi (40MHz, MCS0, 99pc duty cycle)	X	10.95	69.5	21.8	8.45	135.1	±2.7 %
		Y	10.95	69.7	21.8		141.0	
		Z	10.57	69.1	21.5		130.6	
10535-AAA	IEEE 802.11ac WiFi (40MHz, MCS1, 99pc duty cycle)	X	10.92	69.4	21.8	8.45	135.0	±2.7 %
		Y	10.93	69.6	21.8		140.9	
		Z	10.54	69.0	21.5		128.6	
10544-AAA	IEEE 802.11ac WiFi (80MHz, MCS0, 99pc duty cycle)	X	11.43	70.2	22.0	8.47	139.7	±3.0 %
		Y	11.21	69.7	21.7		143.3	
		Z	11.03	69.6	21.6		133.0	

10545-AAA	IEEE 802.11ac WiFi (80MHz, MCS1, 99pc duty cycle)	X	11.55	70.3	22.2	8.55	141.8	±2.7 %
		Y	11.31	69.9	21.8		143.4	
		Z	11.11	69.7	21.7		132.9	
10564-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 9 Mbps, 99pc duty cycle)	X	10.17	68.8	21.5	8.25	127.2	±2.5 %
		Y	10.18	69.0	21.5		132.2	
		Z	9.75	68.4	21.2		120.7	
10571-AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 90pc duty cycle)	X	2.86	67.8	18.5	1.99	125.6	±0.5 %
		Y	2.88	68.6	18.9		131.7	
		Z	3.23	70.3	19.3		124.5	
10572-AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 2 Mbps, 90pc duty cycle)	X	3.02	68.9	18.9	1.99	125.4	±0.5 %
		Y	2.91	68.8	18.9		130.8	
		Z	3.10	69.7	19.1		124.3	
10575-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps, 90pc duty cycle)	X	10.25	68.8	21.8	8.59	123.3	±2.5 %
		Y	10.26	68.9	21.6		128.2	
		Z	9.88	68.5	21.5		118.3	
10576-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 9 Mbps, 90pc duty cycle)	X	10.29	68.9	21.8	8.60	124.3	±2.5 %
		Y	10.36	69.2	21.9		129.6	
		Z	9.90	68.6	21.5		119.4	
10583-AAA	IEEE 802.11a/h WiFi 5 GHz (OFDM, 6 Mbps, 90pc duty cycle)	X	10.23	68.7	21.7	8.59	123.8	±2.5 %
		Y	10.34	69.1	21.8		131.4	
		Z	9.87	68.4	21.4		118.7	
10584-AAA	IEEE 802.11a/h WiFi 5 GHz (OFDM, 9 Mbps, 90pc duty cycle)	X	10.29	68.9	21.8	8.60	124.2	±2.5 %
		Y	10.34	69.2	21.8		129.0	
		Z	9.85	68.4	21.4		118.6	
10591-AAA	IEEE 802.11n (HT Mixed, 20MHz, MCS0, 90pc duty cycle)	X	10.38	68.8	21.8	8.63	125.9	±2.5 %
		Y	10.43	69.1	21.8		131.3	
		Z	10.05	68.6	21.6		121.9	
10592-AAA	IEEE 802.11n (HT Mixed, 20MHz, MCS1, 90pc duty cycle)	X	10.62	69.2	22.1	8.79	127.2	±2.5 %
		Y	10.67	69.5	22.1		132.2	
		Z	10.20	68.8	21.8		120.2	
10599-AAA	IEEE 802.11n (HT Mixed, 40MHz, MCS0, 90pc duty cycle)	X	11.09	69.6	22.1	8.79	133.7	±2.7 %
		Y	11.08	69.8	22.1		139.1	
		Z	10.70	69.2	21.8		127.2	
10600-AAA	IEEE 802.11n (HT Mixed, 40MHz, MCS1, 90pc duty cycle)	X	11.17	69.7	22.2	8.88	132.8	±2.7 %
		Y	11.11	69.7	22.1		137.9	
		Z	10.81	69.3	22.0		129.3	
10607-AAA	IEEE 802.11ac WiFi (20MHz, MCS0, 90pc duty cycle)	X	10.41	68.9	21.8	8.64	125.3	±2.5 %
		Y	10.48	69.2	21.8		131.0	
		Z	10.12	68.8	21.7		122.9	
10608-AAA	IEEE 802.11ac WiFi (20MHz, MCS1, 90pc duty cycle)	X	10.60	69.2	22.0	8.77	127.0	±2.5 %
		Y	10.67	69.5	22.1		134.4	
		Z	10.21	68.8	21.7		122.5	

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10616-AAA	IEEE 802.11ac WiFi (40MHz, MCS0, 90pc duty cycle)	X	11.13	69.7	22.2	8.82	132.6	±2.7 %
		Y	11.10	69.8	22.1		139.9	
		Z	10.77	69.3	21.9		129.3	
10617-AAA	IEEE 802.11ac WiFi (40MHz, MCS1, 90pc duty cycle)	X	11.13	69.7	22.2	8.81	133.0	±2.7 %
		Y	11.07	69.7	22.1		137.7	
		Z	10.70	69.1	21.8		127.7	
10626-AAA	IEEE 802.11ac WiFi (80MHz, MCS0, 90pc duty cycle)	X	11.66	70.4	22.4	8.83	137.6	±2.7 %
		Y	11.43	70.0	22.1		142.4	
		Z	11.24	69.8	22.0		133.4	
10627-AAA	IEEE 802.11ac WiFi (80MHz, MCS1, 90pc duty cycle)	X	11.74	70.5	22.5	8.86	139.1	±2.7 %
		Y	11.49	70.0	22.1		143.4	
		Z	11.34	70.0	22.1		134.0	

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Accreditation No.: **SCS 0108**

Client **Motorola Solutions MY**

Certificate No: **EX3-3612_Jul16**

CALIBRATION CERTIFICATE

Object: EX3DV4 - SN:3612

Calibration procedure(s): QA CAL-01.v9, QA CAL-12.v9, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

Calibration date: July 11, 2016

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	06-Apr-16 (No. 217-02288/02289)	Apr-17
Power sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17
Power sensor NRP-Z91	SN: 103245	06-Apr-16 (No. 217-02289)	Apr-17
Reference 20 dB Attenuator	SN: S5277 (20x)	05-Apr-16 (No. 217-02293)	Apr-17
Reference Probe ES3DV2	SN: 3013	31-Dec-15 (No. ES3-3013_Dec15)	Dec-16
DAE4	SN: 660	23-Dec-15 (No. DAE4-660_Dec15)	Dec-16
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-16)	In house check: Jun-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

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

Issued: July 12, 2016

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

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Accreditation No.: **SCS 0108**

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Methods Applied and Interpretation of Parameters:

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

Probe EX3DV4

SN:3612

Manufactured: March 23, 2007
Calibrated: July 11, 2016

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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3612

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm (µV/(V/m)²)[A]	0.45	0.49	0.40	± 10.1 %
DCP (mV)[B]	96.5	95.7	96.5	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB√µV	C	D dB	VR mV	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	149.7	±3.0 %
		Y	0.0	0.0	1.0		144.3	
		Z	0.0	0.0	1.0		159.8	
10117-CAB	IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK)	X	10.56	69.2	21.5	8.07	146.5	±2.7 %
		Y	10.34	68.5	20.9		133.7	
		Z	10.33	68.6	21.1		131.0	
10196-CAB	IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)	X	10.17	68.9	21.5	8.10	139.2	±2.7 %
		Y	10.00	68.2	20.9		130.8	
		Z	9.92	68.3	21.1		126.6	
10415-AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)	X	3.08	70.7	20.1	1.54	137.8	±0.7 %
		Y	2.73	68.1	18.6		131.8	
		Z	3.09	70.5	19.7		129.6	
10418-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps, 99pc duty cycle, Long preambule)	X	10.07	68.7	21.4	8.14	135.7	±2.7 %
		Y	9.91	68.1	20.9		124.7	
		Z	9.85	68.2	21.1		124.4	
10515-AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 2 Mbps, 99pc duty cycle)	X	3.12	71.1	20.3	1.58	138.3	±0.7 %
		Y	2.83	68.8	18.9		130.6	
		Z	3.11	70.9	20.0		128.7	
10564-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 9 Mbps, 99pc duty cycle)	X	10.36	69.2	21.7	8.25	141.0	±3.0 %
		Y	10.10	68.3	21.0		126.4	
		Z	10.04	68.4	21.2		125.4	
10571-AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 90pc duty cycle)	X	3.19	70.7	20.3	1.99	134.6	±0.7 %
		Y	2.91	68.4	18.9		149.9	
		Z	3.16	70.4	19.9		148.5	
10572-AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 2 Mbps, 90pc duty cycle)	X	3.26	71.3	20.5	1.99	131.4	±0.7 %
		Y	2.98	69.1	19.3		146.3	
		Z	3.24	71.0	20.2		147.6	
10575-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps, 90pc duty cycle)	X	10.33	68.9	21.8	8.59	132.2	±2.7 %
		Y	10.54	69.1	21.7		149.8	
		Z	10.15	68.4	21.5		123.3	
10576-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 9 Mbps, 90pc duty cycle)	X	10.39	69.0	21.8	8.60	133.0	±2.5 %
		Y	10.26	68.4	21.3		125.0	
		Z	10.21	68.6	21.6		124.4	

10591-AAA	IEEE 802.11n (HT Mixed, 20MHz, MCS0, 90pc duty cycle)	X	10.49	69.0	21.8	8.63	134.7	±2.7 %
		Y	10.39	68.5	21.4		128.0	
		Z	10.37	68.7	21.6		127.8	
10592-AAA	IEEE 802.11n (HT Mixed, 20MHz, MCS1, 90pc duty cycle)	X	10.67	69.2	22.0	8.79	135.2	±3.0 %
		Y	10.60	68.7	21.6		129.3	
		Z	10.53	68.8	21.8		127.8	
10599-AAA	IEEE 802.11n (HT Mixed, 40MHz, MCS0, 90pc duty cycle)	X	11.20	69.7	22.2	8.79	143.3	±2.7 %
		Y	10.97	69.0	21.6		134.0	
		Z	11.06	69.4	22.0		135.4	
10600-AAA	IEEE 802.11n (HT Mixed, 40MHz, MCS1, 90pc duty cycle)	X	11.35	70.0	22.4	8.88	147.4	±2.7 %
		Y	11.05	69.1	21.7		134.7	
		Z	11.14	69.5	22.1		135.7	

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 6 and 7).
[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:3612

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)
150	52.3	0.76	9.90	9.90	9.90	0.00	1.00	± 13.3 %
300	45.3	0.87	9.33	9.33	9.33	0.10	1.20	± 13.3 %
450	43.5	0.87	9.05	9.05	9.05	0.17	1.20	± 13.3 %
750	41.9	0.89	8.47	8.47	8.47	0.39	0.97	± 12.0 %
900	41.5	0.97	8.05	8.05	8.05	0.50	0.80	± 12.0 %
2450	39.2	1.80	6.30	6.30	6.30	0.33	0.80	± 12.0 %

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

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

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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3612

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)
150	61.9	0.80	9.42	9.42	9.42	0.00	1.00	± 13.3 %
300	58.2	0.92	9.35	9.35	9.35	0.08	1.25	± 13.3 %
450	56.7	0.94	9.07	9.07	9.07	0.10	1.25	± 13.3 %
750	55.5	0.96	8.12	8.12	8.12	0.47	0.80	± 12.0 %
900	55.0	1.05	8.21	8.21	8.21	0.47	0.80	± 12.0 %
2450	52.7	1.95	6.43	6.43	6.43	0.37	0.80	± 12.0 %

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

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

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

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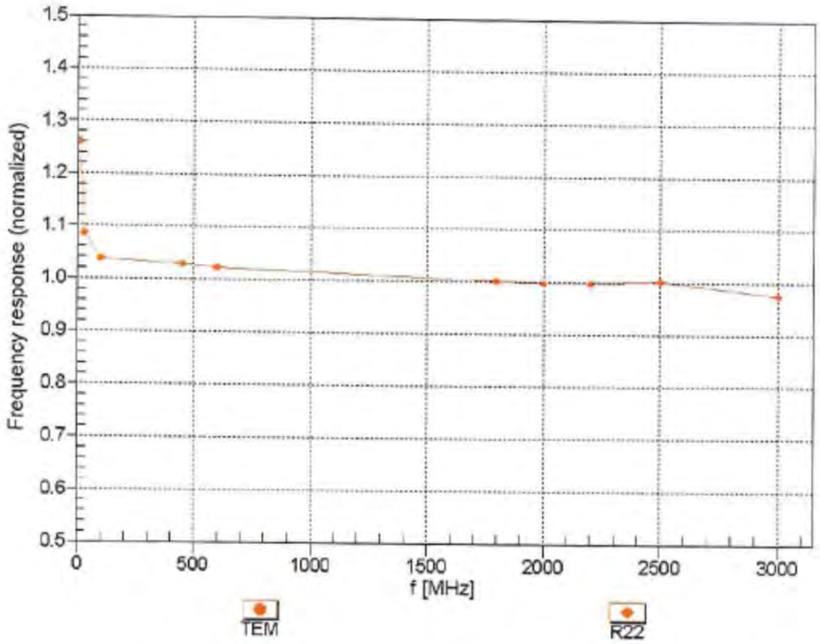
Frequency Response of E-Field
(TEM-Cell:ifi110 EXX, Waveguide: R22)



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

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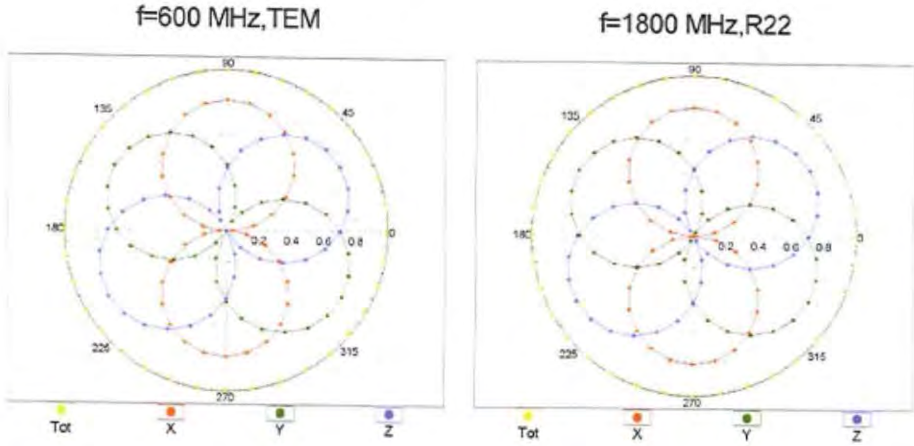
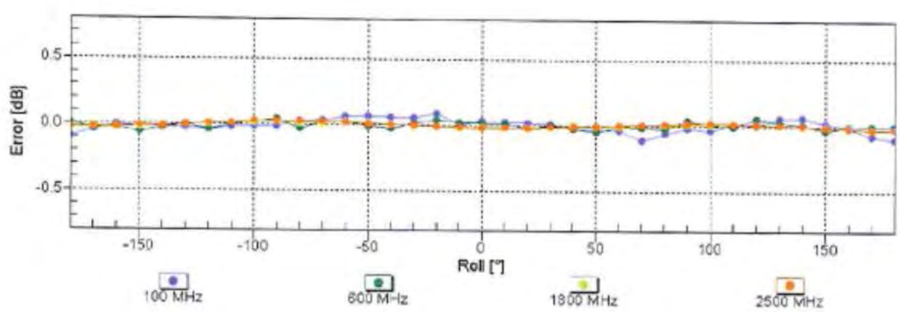
Receiving Pattern (ϕ), ϑ = 0°





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

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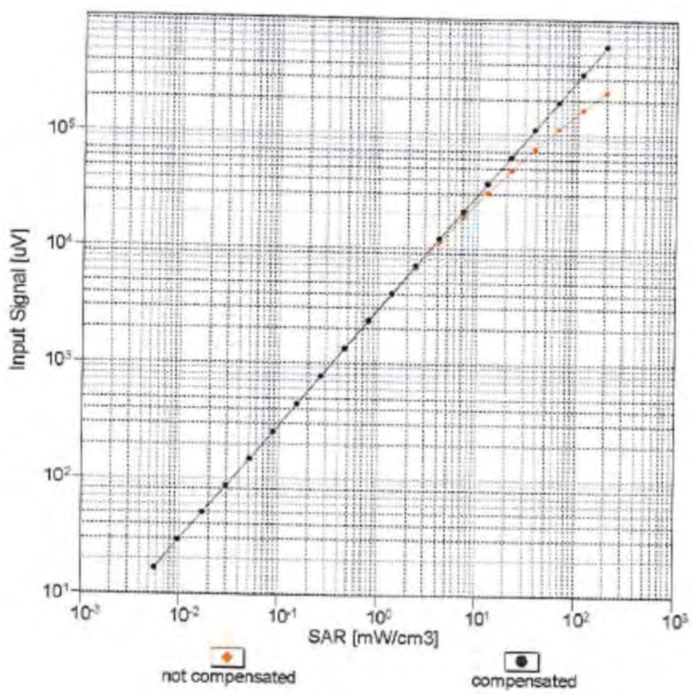
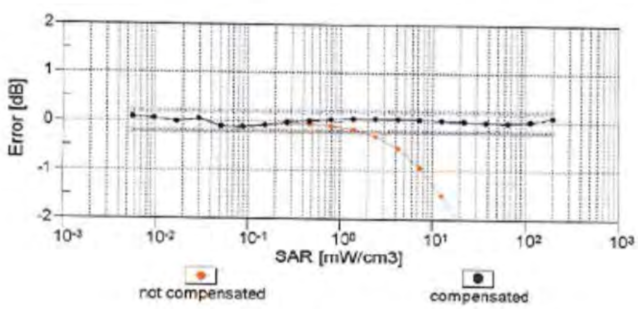
July 11, 2016

Dynamic Range f(SAR_{head})

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





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

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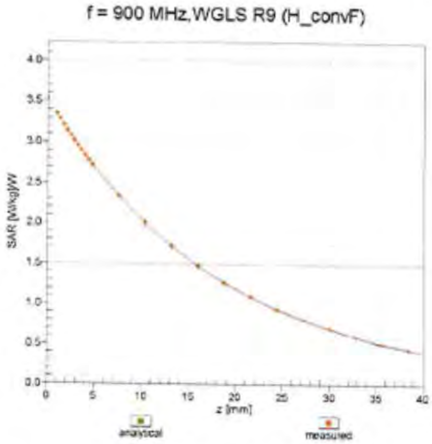
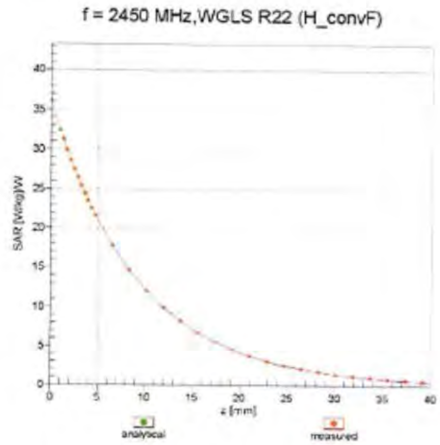
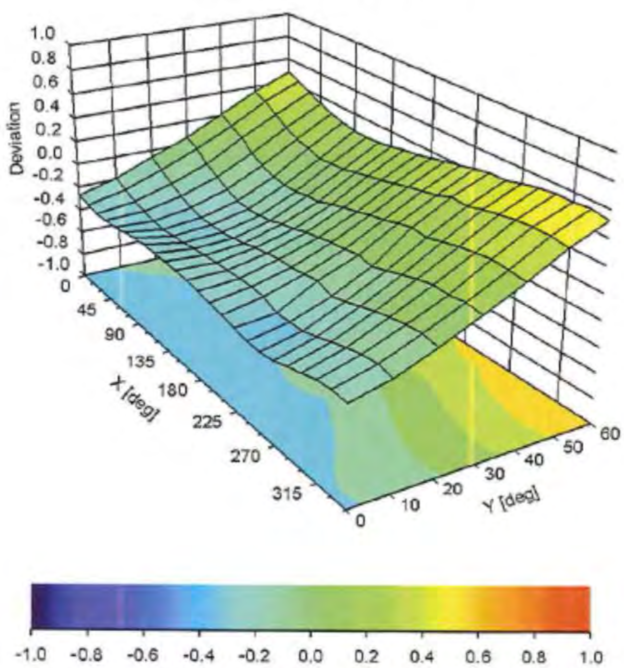
Conversion Factor Assessment





Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz



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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3612

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	80.1
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