# SAR TEST REPORT

| | | |
|---|---|---|
| Project No. | : | JB-Z0321-A |
| Client | : | Murata Manufacturing Co., Ltd. |
| Address | : | 10-1 Higashikotari 1-chome, Nagaokakyo-shi, Kyoto 617-8555 Japan |
| Type of Equipment | : | Communication Module |
| Model No. | : | Type1DR (* installed in Digital Camera 1DR011) |
| FCC-ID | : | VPYLB1DR |
| Regulation Applied | : | FCC 47 CFR 2.1093 (Class II Permissive Change) |

SAR Limits :

| Exposure Characteristics | Spatial Peak SAR (Head and Trunk) averaged over any 1 g of tissue |
|---|---|
| General Public Exposure | 1.6 W/kg |

The Highest Reported SAR:

| RF Exposure Conditions | Equipment Class | | Note(s) |
|---|---|---|---|
| | DTS | DTS | |
| | Wi-Fi 2.4 GHz | Bluetooth Low Energy | |
| Body-Worn | 0.947 W/kg | N/A | |

**Test Result : Complied**

| | | | |
|---|---|---|---|
| Sample Receipt | : | November 23, 2016 | |
| Testing | : | November 26, 2016 and June 23, 2017 | (for conducted power measurements) |
| | | June 27, 2017 | (for SAR measurement) |
| Reported | : | July 26, 2017 | |

Reported by :

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ACCREDITED
TESTING CERT #3203.01

# REVISION HISTORY

| Project No. | Revision | Page | Description | Issued date |
|---|---|---|---|---|
| JB-Z0321 | Original | - | - | July 7, 2017 |
| JB-Z0321-A | 1 | 4 | Added the note on Wi-Fi 2.4 GHz Low Power Mode in the table of Wireless Technologies. | July 26, 2017 |
| | | 24 | Corrected the note (*4) on channels tested for the conducted power measurements. | |
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# 1. General Information

## 1.1. Description of Device Under Test (DUT)

DUT and Host Platform Descriptions

| | DUT | Host Platform<br>*The DUT is installed in this host. |
|---|---|---|
| Type of Equipment | Communication Module | Digital Camera |
| Model No. | Type1DR | 1DR011 |
| FCC-ID | VPYLB1DR | |
| Test Sample Condition | ☒ Prototype<br>☐ Pre-production<br>☐ Mass-production | ☒ Prototype<br>☐ Pre-production<br>☐ Mass-production |
| | * Not for sale: The sample is equivalent to mass-production items.<br>* No modification by the test lab. | |
| Serial No. | 204 | 0000019 |
| Rating | DC 3.2 V (VBAT)<br>DC 1.8 V (VDDXO)<br>DC 1.8 or 3.3 V (VIO)<br>* Supplied from the host. | Li-ion Battery<br>DC 3.7 V/ 700 mAh<br><br>☐ Not user accessible. |
| Head/Body-Worn Accessories (supplied with the device) | n/a | n/a |
| Device Dimension (W x H x D) | 7.7 mm x 7.9 mm x 1.1 mm | See Appendix D |
| Device Category | Portable | |
| Exposure Category | General population/ Uncontrolled environment | |

Wireless Technologies

| Wireless Technologies | Frequency Bands | Operating Mode | Power Setting Mode |
|---|---|---|---|
| Wi-Fi | 2.4 GHz | 802.11b<br>802.11g<br>802.11n (HT20) | High Power Mode |
| Bluetooth | 2.4 GHz | Version 4.1 (LE) | n/a |
| Note(s):<br>* The DUT installed in this host does not support the Wi-Fi 2.4 GHz Low Power Mode, Wi-Fi 5 GHz, and Bluetooth Classic (BR/EDR) operations. | | | |

Radio Specification

| | Original Approval | Class II Permissive Change<br>*The DUT is installed in this host. |
|---|---|---|
| Antenna Type | Monopole antenna | Monopole antenna |
| Antenna Gain | + 0.91 dBi | - 6.40 dBi |
| Note(s):<br>* The antenna is of the same type and lower gain than in the original approval. | | |

## 1.2. Antenna Placement

| Antenna | Minimum Distance from Edges or Sides of Host Platform (mm) | | | | | |
|---|---|---|---|---|---|---|
| | Front | Back | Left | Right | Top | Bottom |
| Wi-Fi/Bluetooth | 3.9 | 25.6 | 9.55 | 43.45 | 12.0 | 16.5 |

* Please refer to Appendix D for more details.

## 1.3. Simultaneous Transmission Conditions

Wi-Fi 2.4 GHz cannot transmit simultaneously with Bluetooth.

## 1.4. Nominal and Maximum Possible Power (Maximum Tune-up Tolerance Limit)

| Wireless Technologies | Mode | Frequency Band (MHz) | | Channel | Data Rate /MCS | Full Power (Burst Averaged) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Lower | High-er | | | Nominal (dBm) | Tolerance (dB) | | Max. Tune-up Limit (dBm) |
| Wi-Fi | 802.11b | 2412 | 2462 | All | All | 17.0 | +2.0 | -2.0 | 19.0 |
| | 802.11g | 2412 | 2462 | 1 | All | 13.5 | +2.0 | -2.0 | 15.5 |
| | | | | 2 to 10 | 6 to 48 Mbps | 17.0 | +2.0 | -2.0 | 19.0 |
| | | | | | 54 Mbps | 16.0 | +2.0 | -2.0 | 18.0 |
| | | | | 11 | All | 13.5 | +2.0 | -2.0 | 15.5 |
| | 802.11n (HT20) | 2412 | 2462 | 1 | All | 13.5 | +2.0 | -2.0 | 15.5 |
| | | | | 2 to 10 | MCS 0 to 2 | 17.0 | +2.0 | -2.0 | 19.0 |
| | | | | | MCS 3 to 6 | 16.0 | +2.0 | -2.0 | 18.0 |
| | | | | | MCS 7 | 15.0 | +2.0 | -2.0 | 17.0 |
| | | | | 11 | All | 13.5 | +2.0 | -2.0 | 15.5 |
| Bluetooth | BLE | 2402 | 2480 | All | - | 7.0 | -2.8 | +2.5 | 9.5 |

## 1.5. RF Exposure Conditions

| Wireless Technologies | RF Exposure Conditions | User-to-Host Distance (mm) | Test Position | Host-to-Ant. Distance (mm) | SAR Required | Note(s) |
|---|---|---|---|---|---|---|
| Wi-Fi /Bluetooth | Body-Worn | 0 | Front | 3.9 | Yes | |
| | | | Back | 25.6 | Yes | |
| | | | Left | 9.55 | Yes | |
| | | | Right | 43.45 | Yes | |
| | | | Top | 12.0 | Yes | |
| | | | Bottom | 16.5 | Yes | |

## 1.6. RF Exposure Limits

| Human Exposure | General Population/ Uncontrolled Exposure | Occupational/ Controlled Exposure |
|---|---|---|
| Spatial Peak SAR (Head and Trunk) averaged over any 1 g of tissue | **1.6 W/kg*** | 8 W/kg |
| Spatial Average SAR (Whole Body) averaged over the whole body | 0.08 W/kg | 0.4 W/kg |
| Spatial Peak SAR (Extremities: Hands/Wrists/Feet/Ankles) averaged over any 10 g of tissue | 4 W/kg | 20 W/kg |

* The limit(s) applied in this report.

## 1.7. SAR Test Exclusion

SAR test exclusion is applied according to KDB 447498 D01.

The 1-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:

[(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] ·
[√f(GHz)] ≤ 3.0 for 1-g SAR and ≤ 7.5 for 10-g extremity SAR, where:

* f(GHz) is the RF channel transmit frequency in GHz
* Power and distance are rounded to the nearest mW and mm before calculation
* The result is rounded to one decimal place for comparison
* When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion

Body-Worn SAR (1-g SAR) Test Exclusion as per KDB 447498 D01

| Freq. Band | Freq. (MHz) | Test Position | User-to-Host Distance (mm) | Host-to-Ant Distance (mm) | User-to-Ant Distance (mm) | Min. Test Sep. Distance (mm) | Max. Possible Power | | | Exclusion Threshold | SAR Required (> 3.0) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | (dBm) | (mW) | rounded (mW) | | |
| Wi-Fi 2.4GHz | 2450 | Front | 0 | 3.9 | 3.9 | 5 | 19.0 | 79.4 | 79 | 24.7 | Yes |
| | 2450 | Back | 0 | 25.6 | 25.6 | 26 | 19.0 | 79.4 | 79 | 4.8 | Yes |
| | 2450 | Left | 0 | 9.55 | 9.55 | 10 | 19.0 | 79.4 | 79 | 12.4 | Yes |
| | 2450 | Right | 0 | 43.45 | 43.45 | 43 | 19.0 | 79.4 | 79 | 2.9 | No |
| | 2450 | Top | 0 | 12.0 | 12.00 | 12 | 19.0 | 79.4 | 79 | 10.3 | Yes |
| | 2450 | Bottom | 0 | 16.5 | 16.50 | 17 | 19.0 | 79.4 | 79 | 7.3 | Yes |
| Bluetooth | 2450 | Front | 0 | 3.9 | 3.9 | 5 | 9.5 | 8.9 | 9 | 2.8 | No |
| | 2450 | Back | 0 | 25.6 | 25.6 | 26 | 9.5 | 8.9 | 9 | 0.5 | No |
| | 2450 | Left | 0 | 9.55 | 9.55 | 10 | 9.5 | 8.9 | 9 | 1.4 | No |
| | 2450 | Right | 0 | 43.45 | 43.45 | 43 | 9.5 | 8.9 | 9 | 0.3 | No |
| | 2450 | Top | 0 | 12.0 | 12.00 | 12 | 9.5 | 8.9 | 9 | 1.2 | No |
| | 2450 | Bottom | 0 | 16.5 | 16.50 | 17 | 9.5 | 8.9 | 9 | 0.8 | No |

## 1.8. Test Specification, Methods and Procedures

Test Specification

| | | |
|---|---|---|
| ☒ | FCC 47 CFR 2.1093 | Radiofrequency radiation exposure evaluation: portable devices |

Test Methods

| | | | |
|---|---|---|---|
| ☒ | IEEE Std 1528-2013 | | IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques |
| ☒ | KDB 248227 D01 | v02r02 | SAR Guidance for IEEE 802.11 (Wi-Fi) Transmitters |
| ☒ | KDB 447498 D01 | v06 | Mobile and Portable Devices RF Exposure Procedures and Equipment Authorization Policies |
| ☐ | KDB 447498 D02 | v02r01 | SAR Measurement Procedures for USB Dongle Transmitters |
| ☐ | KDB 615223 D01 | v01r01 | 802.16e/WiMax SAR Measurement Guidance |
| ☐ | KDB 616217 D04 | v01r02 | SAR Evaluation Considerations for Laptop, Notebook, Netbook and Tablet Computers |
| ☐ | KDB 643646 D01 | v01r03 | SAR Test Reduction Considerations for Occupational PTT Radios |
| ☐ | KDB 648474 D03 | v01r04 | Evaluation and Approval Considerations for Handsets with Specific Wireless Charging Battery Covers |
| ☐ | KDB 648474 D04 | v01r03 | SAR Evaluation Considerations for Wireless Handsets |
| ☐ | KDB 865664 D01 | v01r04 | SAR Measurement Requirements for 100 MHz to 6 GHz (Section 3.5) |
| ☐ | KDB 941225 D01 | v03r01 | 3G SAR Measurement Procedures |
| ☐ | KDB 941225 D05 | v02r05 | SAR Evaluation Considerations for LTE Devices |
| ☐ | KDB 941225 D06 | v02r01 | SAR Evaluation Procedures for Portable Devices with Wireless Router Capabilities |
| ☐ | KDB 941225 D07 | v01r02 | SAR Evaluation Procedures for UMPC Mini-Tablet Devices |

Test Procedures

The SAR tests were performed according to the procedures of
Sony Global Manufacturing & Operations Corporation EMC/RF Test Laboratory,
the Document No. NV3-2 and NV3-16, available upon request.

☒ No deviation from the procedures

☐ Deviation from the procedures

☐ _____

References

[1] ICNIRP. Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). Health Physics 74(4): 494-522, 1998.

[2] American National Standards Institute (ANSI), "Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," ANSI/IEEE C95.1-1992.

[3] Health Canada, "Limits of Human Exposure to Radiofrequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz," Safety Code 6 (2009).

[4] European Council Recommendation 1999/519/EC of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (Official Journal L 199 of 30 July 1999).

[5] REDCA Technical Guidance Note 20 (TGN 20), SAR Testing and Assessment Guidance, Version 3.0, June 2016.

[6] Australian Communications and Media Authority (ACMA),Radiocommunications (Electromagnetic Radiation - Human Exposure) Standard 2014.

[7] Schmid & Partner Engineering AG (SPEAG), DASY52 System Handbook, April 2014.

[8] Schmid & Partner Engineering AG (SPEAG), Safety Data Sheet, Doc No 772-SLAAx0yy-J, June 14, 2013.

[9] Schmid & Partner Engineering AG (SPEAG), Safety Data Sheet, Doc No 772-SLAAx1yy-I, October 18, 2013.

[10] Schmid & Partner Engineering AG (SPEAG), Safety Data Sheet, Doc No 772-SLAAx6yy-H, September 26, 2013.

[11] Schmid & Partner Engineering AG (SPEAG), Material Safety Data Sheet, Doc No 772-SLAAH502A-D, August 9, 2013.

[12] Schmid & Partner Engineering AG (SPEAG), Material Safety Data Sheet, Doc No 772-SLAAx4yy-J, August 9, 2013.

[13] Schmid & Partner Engineering AG (SPEAG), Material Safety Data Sheet, Doc No 772-SLAAHxU16B-C, June 9, 2015.

## 1.9. Test Facilities and Accreditation

Test Facilities

| | |
|---|---|
| Test Facility Name | : Sony Global Manufacturing & Operations Corporation<br>EMC/RF Test Laboratory, Main Lab. |
| Address | : Kisarazu Site 8-4 Shiomi Kisarazu-shi, Chiba, 292-0834 Japan |
| Shielded Room Used | : ☒ 4th Site Shielded Room 2 ☐ 4th Site Shielded Room 3 |

A2LA Accreditation

| | |
|---|---|
| Certificate No. | : 3203.01 |
| Expiration | : October 31, 2017 |

# 2. Test Set-up

## 2.1. Test Equipment and Measurement Software Lists

Table 2-1 Test Equipment List

| Used | Control No. | Equipment Description | Model No. | Serial No. | Manufacturer | Cal. Int. | Last Cal. | Note(s) |
|---|---|---|---|---|---|---|---|---|
| ☒ | W128 | Robot | TX60 L | F14/5VR2B1/A/01 | Staubli | N/A | N/A *1 | |
| ☐ | W124 | Robot | RX60B L | F04/5Z71A1/A/03 | Staubli | N/A | N/A *1 | |
| ☒ | WA02 | E-Field Probe | EX3DV4 | 3921 | SPEAG | 1Y | 16.10.25 | |
| ☐ | WA52 | E-Field Probe | EX3DV4 | 7452 | SPEAG | 1Y | 17.03.31 | |
| ☒ | W095 | Data Acquisition Electronics | DAE4 | 482 | SPEAG | 1Y | 16.08.09 | |
| ☐ | W096 | Data Acquisition Electronics | DAE4 | 610 | SPEAG | 1Y | 17.01.16 | |
| ☐ | W081 | Twin SAM Phantom | Twin SAM | TP-1441 | SPEAG | N/A | N/A *1 | |
| ☐ | W082 | Twin SAM Phantom | Twin SAM | TP-1325 | SPEAG | N/A | N/A *1 | |
| ☐ | W126 | Twin SAM Phantom | Twin SAM | TP-1851 | SPEAG | N/A | N/A *1 | |
| ☐ | W127 | Twin SAM Phantom | Twin SAM | TP-1852 | SPEAG | N/A | N/A *1 | |
| ☒ | W119 | ELI Phantom | ELI V5.0 | 1259 | SPEAG | N/A | N/A *1 | |
| ☐ | WA26 | System Validation Dipole | D2450V2 | 936 | SPEAG | 1Y | Under calibration | |
| ☒ | WA55 | System Validation Dipole | D2450V2 | 894 | SPEAG | 1Y | 2016.10.18 | |
| ☐ | WA28 | System Validation Dipole | D5GHzV2 | 1183 | SPEAG | 1Y | Under calibration | |
| ☒ | W121 | Vector Reflectometer | DAKS_VNA R140 | 0111013 | Copper Mountain Technologies | 1Y | 17.06.02 | |
| ☐ | WA29 | Dielectric Probe | DAKS-3.5 | 1034 | SPEAG | 1Y | Under calibration | |
| ☒ | WA44 | Dielectric Probe | DAKS-3.5 | 1058 | SPEAG | 1Y | 17.05.10 | |
| ☒ | W009 | Signal Generator | E4438C | US41461247 | Agilent | 1Y | 17.03.02 | |
| ☒ | W122 | Power Amp | CGA020M60 2-2633R | B40550 | R&K | N/A | N/A *1 | |
| ☒ | W104 | Power Sensor | U2021XA | MY54040006 | Agilent | 1Y | 16.12.27 | |
| ☒ | W105 | Power Sensor | U2021XA | MY54080005 | Agilent | 1Y | 16.12.27 | |
| ☒ | W120 | Directional Coupler | 4226-20 | - | narda | N/A | N/A *1 | |
| ☒ | W117 | Attenuator | 8493B 3 dB | MY39260857 | Agilent | N/A | N/A *1 | |
| ☒ | W118 | Attenuator | AT-110 10 dB | 932968 | Hirose | 1Y | 16.08.01 | |
| ☒ | WC17 | RF Cable | SUCOFLEX 104 | 253269 /4 | HUBER+SUHNER | N/A | N/A *1 | |
| ☒ | WC18 | RF Cable | SUCOFLEX 104PE | MY1592/4 | HUBER+SUHNER | N/A | N/A *1 | |
| ☒ | WC19 | RF Cable | SUCOFLEX 104 | 211789/4 | HUBER+SUHNER | N/A | N/A *1 | |
| ☒ | WC20 | RF Cable | SUCOFLEX 104 | 194851/4 | HUBER+SUHNER | N/A | N/A *1 | |
| ☒ | WC21 | RF Cable | SUCOFLEX 104 | 503095/6 | HUBER+SUHNER | N/A | N/A *1 | |
| ☒ | WC22 | RF Cable | SUCOFLEX 104 | 503094/6 | HUBER+SUHNER | N/A | N/A *1 | |

Table 2-1 Test Equipment List (continued)

| Used | Control No. | Equipment Description | Model No. | Serial No. | Manufacturer | Cal. Int. | Last Cal. | Note(s) |
|---|---|---|---|---|---|---|---|---|
| ☐ | M746 | Thermometer | CTH-201 | 001 | SANSYO | 1Y | 16.08.02 | |
| ☒ | M748 | Thermometer | CTH-201 | 003 | SANSYO | 1Y | 16.08.02 | |
| ☐ | W112 | Water Thermometer | 735-1 | 02736130 | testo | 1Y | Under calibration | |
| ☐ | W113 | Water Thermometer | 735-1 | 02788580 | testo | 1Y | 17.06.14 | |
| ☐ | W114 | Water Thermometer | 735-1 | 02788582 | testo | 1Y | 16.08.03 | |
| ☐ | W115 | Water Thermometer | 735-1 | 02788585 | testo | 1Y | 16.08.03 | |
| ☒ | W116 | Water Thermometer | 735-1 | 02788596 | testo | 1Y | 17.06.12 | |

Note(s):
*1 In-house verification is conducted periodically.

Table 2-2 Measurement Software List

| Used | Control No. | Software Description | Model No. | Ver. | Manufacturer |
|---|---|---|---|---|---|
| ☐ | SW-401 | SAR measurement software | DASY52 | 52.8.8.1222 | SPEAG |
| ☐ | SW-402 | SAR post-processing software | SEMCAD X | 14.6.10 (7331) | SPEAG |
| ☒ | SW-403 | Dielectric measurement software | DAK | 2.4.0.638 | SPEAG |
| ☒ | SW-404 | SAR measurement software | DASY52 | 52.8.8.1222 | SPEAG |
| ☒ | SW-405 | SAR post-processing software | SEMCAD X | 14.6.10 (7331) | SPEAG |
| ☐ | SW-406 | SAR measurement spreadsheet | - | 1.00 | Main Lab. |
| ☒ | SW-314 | Power measurement software | N1918A | R03.09.00 | Agilent |

## 2.2. Measurement System Description

The DASY5 system for performing compliance tests consists of the following items:

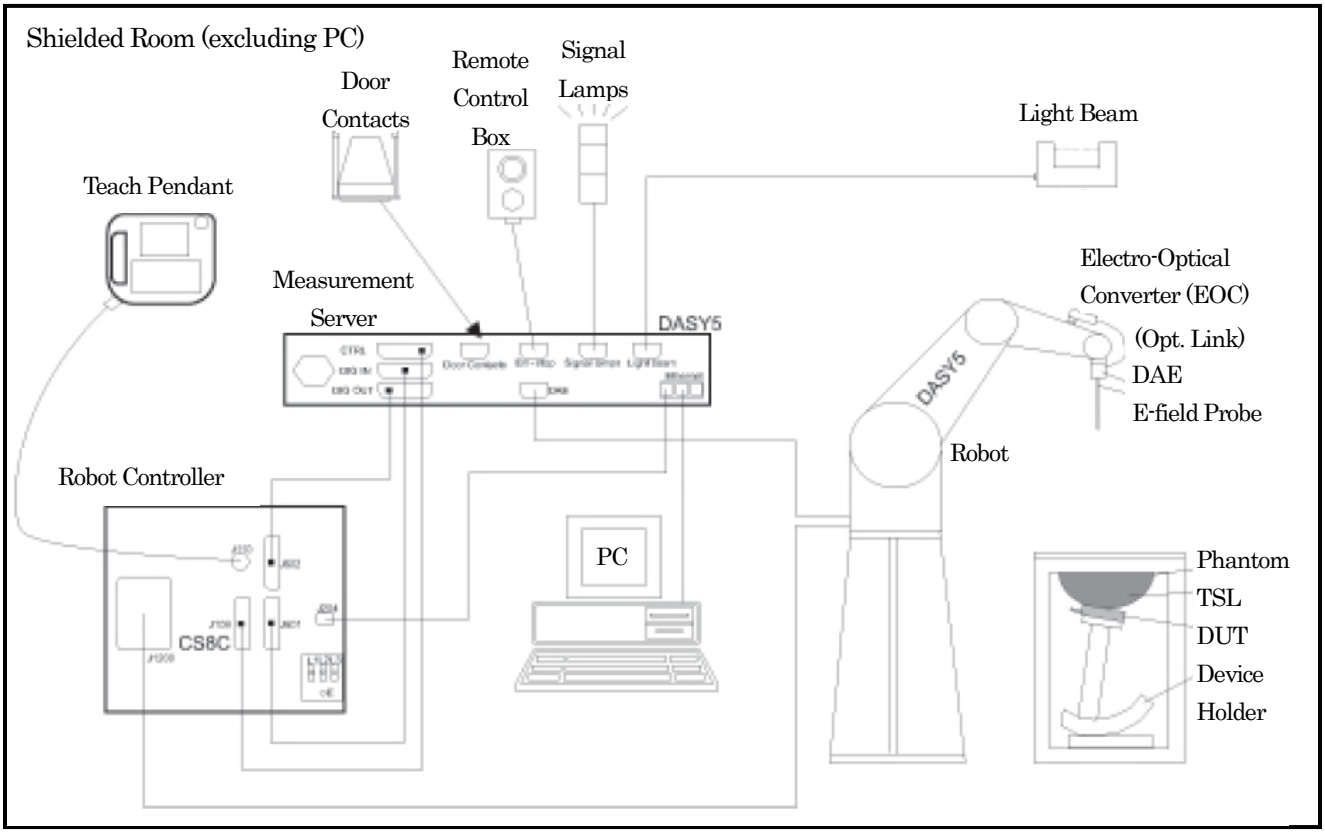



Figure 2-1 Measurement System Description

- A standard high precision 6-axis robot (Staubli TX/RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running Win7 professional operating system and the DASY5 software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.
- The phantoms (the Twin SAM and/or ELI phantoms) enabling the testing of handheld (left-hand and right-hand) and/or body-mounted usage.
- The device holders for handheld mobile phones and/or larger devices (e.g., laptops, cameras, etc.).
- Tissue simulating liquid (TSL) mixed according to the given recipes.
- System Validation Dipole Kits allowing to validate the proper functioning of the system.

## 2.3. Measurement System Main Components

Robot (Positioner)

| | Shielded Room 2 | Shielded Room 3 |
|---|---|---|
| Manufacturer | Staubli SA | |
| Model No. | TX60L | RX60BL |
| Number of Axis | 6 | |
| Reach at Wrist | 920 mm | 865 mm |
| Repeatability | +/- 0.03 mm | +/- 0.033 mm |
| Nominal Load Capacity | 2 kg | 1.5 kg |
| Maximum Load Capacity | 5 kg | 2.5 kg |
| Control Unit | CS8c | CS7m |
| Weight | 52.2 kg | 45 kg |

E-Field Probe

| | |
|---|---|
| Manufacturer | Schmid & Partner Engineering AG (SPEAG) |
| Model No. | EX3DV4 |
| Construction | Symmetrical design with triangular core<br>Built-in shielding against static charges<br>PEEK enclosure material (resistant to organic solvents, e.g., DGBE) |
| Frequency | 10 MHz to > 6 GHz<br>Linearity: ± 0.2 dB (30 MHz to 6 GHz) |
| Directivity | ± 0.3 dB in TSL (rotation around probe axis)<br>± 0.5 dB in TSL (rotation normal to probe axis) |
| Dynamic Range | 10 μW/g to > 100 mW/g<br>Linearity: ± 0.2 dB (noise: typically < 1 μW/g) |
| Dimensions | Overall length: 337 mm (Tip length: 20 mm)<br>Tip diameter: 2.5 mm (Body diameter: 12 mm)<br>Typical distance from probe tip to dipole centers: 1 mm |

Data Acquisition Electronics (DAE)

| | |
|---|---|
| Manufacturer | Schmid & Partner Engineering AG (SPEAG) |
| Model No. | DAE4 |
| Construction | Signal amplifier, multiplexer, A/D converter, and control logic<br>Serial optical link for communication with DASY4/5 embedded system<br>(fully remote controlled)<br>Two-step probe touch detector for mechanical surface detection<br>and emergency robot stop |
| Measurement Range | -100 to +300 mV (16 bit resolution and two range settings: 4 mV, 400 mV) |
| Input Offset Voltage | < 5 μV (with auto zero) |
| Input Resistance | 200 MΩ |
| Input Bias Current | < 50 fA |
| Battery Power | > 10 hours of operation (with two 9.6 V NiMH accus) |
| Dimensions (L x W x H) | 60 x 60 x 68 mm |

DASY5 Measurement Server

| | |
|---|---|
| Manufacturer | Schmid & Partner Engineering AG (SPEAG) |
| Model No. | DASY5 Measurement Server |
| CPU | Intel ULV Celeron 400 MHz |
| Chip-Disk | 128 MB |
| RAM | 128 MB |
| Construction | 16 Bit A/D converter for surface detection system<br>Vacuum Fluorescent Display |
| I/O Interface | Robot Interface / Serial link to DAE (with watchdog supervision) / Door contact port / Emergency stop port (to connect the remote control) / Signal lamps port / Light beam port / Three Ethernet connection ports (for PC, Control Unit, and future applications) / Two USB 2.0 ports (for installation and advanced troubleshooting by SPEAG) / Two serial links (for future applications) / Expansion port (for future applications) |
| Dimensions (L x W x H) | 440 x 241 x 89 mm |

Phantoms (Twin SAM Phantom)

| | |
|---|---|
| Manufacturer | Schmid & Partner Engineering AG (SPEAG) |
| Model No. | Twin SAM |
| Description | The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 and IEC 62209-1. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by teaching three points with the robot.<br>Twin SAM V5.0 has the same shell geometry and is manufactured from the same material as Twin SAM V4.0, but has reinforced top structure. |
| Material | Vinylester, glass fiber reinforced (VE-GF) |
| Liquid Compatibility | Compatible with all SPEAG tissue simulating liquids (incl. DGBE type) |
| Shell Thickness | 2 ± 0.2 mm (6 ± 0.2 mm at ear point) |
| Dimensions | Length: 1000 mm<br>Width: 500 mm<br>Height: adjustable feet |
| Filling Volume | Approx. 25 liters |
| Wooden Support | SPEAG standard phantom table |

Phantoms (ELI Phantom)

| | |
|---|---|
| Manufacturer | Schmid & Partner Engineering AG (SPEAG) |
| Model No. | ELI V5.0 |
| Description | Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI is fully compatible with the IEC 62209-2 standard and all known tissue simulating liquids. ELI has been optimized regarding its performance and can be integrated into our standard phantom tables.<br>A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching three points. The phantom is compatible with all SPEAG dosimetric probes and dipoles.<br>ELI V5.0 has the same shell geometry and is manufactured from the same material as ELI4, but has reinforced top structure. |
| Material | Vinylester, glass fiber reinforced (VE-GF) |
| Liquid Compatibility | Compatible with all SPEAG tissue simulating liquids (incl. DGBE type) |
| Shell Thickness | 2.0 ± 0.2 mm (bottom plate) |
| Dimensions | Major axis: 600 mm<br>Minor axis: 400 mm |
| Filling Volume | Approx. 30 liters |
| Wooden Support | SPEAG standard phantom table |

Device Holder (Mounting Device for Hand-Held Transmitters)

| | |
|---|---|
| Manufacturer | Schmid & Partner Engineering AG (SPEAG) |
| Model No. | MD4HHTV5 |
| Description | In combination with the Twin SAM or ELI Phantoms, the Mounting Device for Hand-Held Transmitters enables rotation of the mounted transmitter device to specified spherical coordinates. At the heads, the rotation axis is at the ear opening. Transmitter devices can be easily and accurately positioned according to IEC 62209-1, IEEE 1528, FCC, or other specifications. The device holder can be locked for positioning at different phantom sections (left head, right head, flat). |
| Material | Polyoxymethylene (POM) |

Device Holder (Mounting Device Adaptor for Ultra Wide Transmitters)

| | |
|---|---|
| Manufacturer | Schmid & Partner Engineering AG (SPEAG) |
| Model No. | MDA4WTV5 |
| Description | An upgrade kit to Mounting Device to enable easy mounting of wider devices like big smart-phones, e-books, small tablets, etc. It holds devices with width up to 140mm. |
| Material | Polyoxymethylene (POM) |

Device Holder (Mounting Device Adaptor for Laptops)

| | |
|---|---|
| Manufacturer | Schmid & Partner Engineering AG (SPEAG) |
| Model No. | MDA4LAP |
| Description | A simple but effective and easy-to-use extension for the Mounting Device; facilitates testing of larger devices according to IEC 62209-2 (e.g., laptops, cameras, etc.); lightweight and fits easily on the upper part of the Mounting Device in place of the phone positioner. The extension is fully compatible with the Twin SAM, ELI Phantoms. |
| Material | Polyoxymethylene (POM), PET-G, Foam |

System Validation Dipole Kits

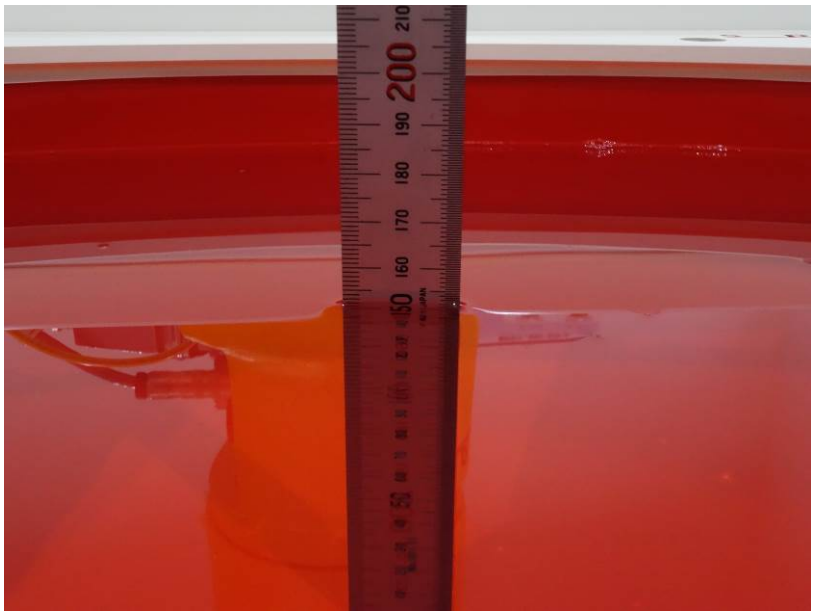
| | | | |
|---|---|---|---|
| Manufacturer | Schmid & Partner Engineering AG (SPEAG) | | |
| Model No. | D-Series | | |
| Construction | Symmetrical dipole with l/4 balun<br>Enables measurement of feedpoint impedance with NWA<br>Matched for use near flat phantoms filled with tissue simulating solutions | | |
| Frequency | 2450, 5100 to 5800 MHz | | |
| Return Loss | > 20 dB at specified validation position | | |
| Power Capability | > 100 W (f < 1 GHz); > 40 W (f > 1 GHz) | | |
| Accessories | Distance holder, tripod adaptor, tripod | | |
| Dimensions | Product | Dipole length | Overall height |
| | D2450V2 | 52.0 mm | 290.0 mm |
| | D5GHzV2 | 20.6 mm | 300.0 mm |

## 2.4. Tissue Simulating Liquids

Recipes for tissue simulating liquids manufactured by SPEAG

| Ingredients (% by weight) | Frequency (MHz) | | | | | |
|---|---|---|---|---|---|---|
| | 2450 | | 1900 to 3800 | | 3500 to 5800 | |
| Used | ☐ | ☐ | ☐ | ☒ | ☐ | ☐ |
| Tissue Simulating Liquids | HSL 2450 V2 | MSL 2450 V2 | HBBL 1900-3800 V3 | MBBL 1900-3800 V3 | HBBL 3500-5800 V5 | MBBL 3500-5800 V5 |
| Tissue Type | Head | Body | Head | Body | Head | Body |
| $H_2O$ | 52 – 75 % | | 50 – 73 % | | 50 – 65 % | 60 – 80 % |
| Non-ionic detergents | – | | 25 – 50 % | | – | – |
| NaCl | < 1.0 % | | 0 – 2 % | | 0 – 1.5 % | 0 – 1.5 % |
| Preventol-D7 | – | | 0.05 – 0.1 % | | – | – |
| $C_8H_{18}O_3$ | 25 – 48 % | | – | | – | – |
| Mineral Oil | – | | – | | 10 – 30 % | – |
| Emulsifiers | – | | – | | 8 – 25 % | 20 – 40 % |

For the SAR measurement, the phantom must be filled with tissue simulating liquid to a depth of at least 15 cm.



MBBL 1900-3800 V3

Figure 2-2 Photos: Liquid Depth (at the center of the flat phantom)

## 2.5. SAR Measurement

Step 1: Power Reference Measurement
Before an area scan and after the zoom scan, single point SAR measurements are performed at defined locations to estimate the SAR measurement drift due to device output power variations.

Step 2: Area Scan
An area scan is performed according to the requirements in Table 2-3.

Step 3: Zoom Scan
A zoom scan is performed according to the requirements in Table 2-3.

Step 4: Power Drift Measurement
Before an area scan and after the zoom scan, single point SAR measurements are performed at defined locations to estimate the SAR measurement drift due to device output power variations.

Table 2-3 Area Scan and Zoom Scan Parameters

| | | | DUT Transmit Frequency being Tested | |
|---|---|---|---|---|
| | | | ≤ 3 GHz | > 3 GHz |
| Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface | | | 5 ± 1 mm | ½ δ ln(2) ± 0.5 mm |
| Maximum probe angle from probe axis to phantom surface normal at the measurement location | | | 30° ± 1° | 20° ± 1° |
| Maximum area scan spatial resolution: $\Delta x_{Area}$, $\Delta y_{Area}$ | | | ≤ 2 GHz: ≤ 15 mm<br>2 – 3 GHz: ≤ 12 mm | 3 – 4 GHz: ≤ 12 mm<br>4 – 6 GHz: ≤ 10 mm |
| | | | 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. | |
| Maximum zoom scan spatial resolution: $\Delta x_{Zoom}$, $\Delta y_{Zoom}$ | | | ≤ 2 GHz: ≤ 8 mm<br>2 – 3 GHz: ≤ 5 mm | 3 – 4 GHz: ≤ 5 mm<br>4 – 6 GHz: ≤ 4 mm |
| Maximum zoom scan spatial resolution, normal to phantom surface | uniform grid: $\Delta z_{Zoom}(n)$ | | ≤ 5 mm | 3 – 4 GHz: ≤ 4 mm<br>4 – 5 GHz: ≤ 3 mm<br>5 – 6 GHz: ≤ 2 mm |
| | graded grid | $\Delta z_{Zoom}(1)$: between 1st two points closest to phantom surface | ≤ 4 mm | 3 – 4 GHz: ≤ 3 mm<br>4 – 5 GHz: ≤ 2.5 mm<br>5 – 6 GHz: ≤ 2 mm |
| | | $\Delta z_{Zoom}(n>1)$: between subsequent points | ≤ 1.5 ·$\Delta z_{Zoom}(n-1)$ | |
| Minimum zoom scan volume | x, y, z | | ≥ 30 mm | 3 – 4 GHz: ≥ 28 mm<br>4 – 5 GHz: ≥ 25 mm<br>5 – 6 GHz: ≥ 22 mm |
| Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium. | | | | |

## 2.6. Measurement Uncertainty

☒ Table 2-4 DASY5 Uncertainty Budget for SAR Tests

| According to IEEE Std 1528-2013 (0.3GHz to 3GHz range) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Input quantity | Uncertainty of Xi | | | Ci | | Ciu(Xi) | | Vi Veff |
| | Xi | Prob. Dist. | Div. | 1g [-] | 10g [-] | 1g | 10g | |
| Measurement System | | | | | | | | |
| Probe Calibration (k=1) | ±6.0% | N | 1.00 | 1.00 | 1.00 | ±6.0% | ±6.0% | ∞ |
| Axial Isotropy | ±4.7% | R | 1.73 | 0.70 | 0.70 | ±1.9% | ±1.9% | ∞ |
| Hemispherical Isotropy | ±9.7% | R | 1.73 | 0.70 | 0.70 | ±3.9% | ±3.9% | ∞ |
| Boundary Effects | ±1.0% | R | 1.73 | 1.00 | 1.00 | ±0.6% | ±0.6% | ∞ |
| Linearity | ±4.7% | R | 1.73 | 1.00 | 1.00 | ±2.7% | ±2.7% | ∞ |
| System Detection Limits | ±0.3% | R | 1.73 | 1.00 | 1.00 | ±0.1% | ±0.1% | ∞ |
| Modulation Response | ±2.4% | R | 1.73 | 1.00 | 1.00 | ±1.4% | ±1.4% | ∞ |
| Readout Electronics | ±0.3% | N | 1.00 | 1.00 | 1.00 | ±0.3% | ±0.3% | ∞ |
| Response Time | ±0.8% | R | 1.73 | 1.00 | 1.00 | ±0.5% | ±0.5% | ∞ |
| Integration Time | ±2.6% | R | 1.73 | 1.00 | 1.00 | ±1.5% | ±1.5% | ∞ |
| RF Ambient Noise | ±0.2% | R | 1.73 | 1.00 | 1.00 | ±0.1% | ±0.1% | ∞ |
| RF Ambient Reflections | ±1.3% | R | 1.73 | 1.00 | 1.00 | ±0.7% | ±0.7% | ∞ |
| Probe Positioner | ±0.4% | R | 1.73 | 1.00 | 1.00 | ±0.2% | ±0.2% | ∞ |
| Probe Positioning | ±2.9% | R | 1.73 | 1.00 | 1.00 | ±1.7% | ±1.7% | ∞ |
| Max. SAR Eval. | ±2.0% | R | 1.73 | 1.00 | 1.00 | ±1.2% | ±1.2% | ∞ |
| Test Sample Related | | | | | | | | |
| Device Positioning | ±1.8% | N | 1.00 | 1.00 | 1.00 | ±1.8% | ±1.8% | 14 |
| Device Holder | ±3.6% | N | 1.00 | 1.00 | 1.00 | ±3.6% | ±3.6% | 5 |
| Power Drift | ±5.0% | R | 1.73 | 1.00 | 1.00 | ±2.9% | ±2.9% | ∞ |
| Power Scaling | ±0.0% | R | 1.73 | 1.00 | 1.00 | ±0.0% | ±0.0% | ∞ |
| Phantom and Setup | | | | | | | | |
| Phantom Uncertainty | ±7.2% | R | 1.73 | 1.00 | 1.00 | ±4.2% | ±4.2% | ∞ |
| SAR Correction | ±1.9% | R | 1.73 | 1.00 | 0.84 | ±1.1% | ±0.9% | ∞ |
| Liquid Conductivity (mea.) | ±2.5% | R | 1.73 | 0.78 | 0.71 | ±1.1% | ±1.0% | ∞ |
| Liquid Permittivity (mea.) | ±2.5% | R | 1.73 | 0.23 | 0.26 | ±0.3% | ±0.4% | ∞ |
| Temp. Unc. - Conductivity | ±3.4% | R | 1.73 | 0.78 | 0.71 | ±1.5% | ±1.4% | ∞ |
| Temp. Unc. - Permittivity | ±0.4% | R | 1.73 | 0.23 | 0.26 | ±0.1% | ±0.1% | ∞ |
| Combined Standard Uncertainty | | | | | | ±10.9% | ±10.8% | 409 |
| Expanded Uncertainty (95% conf. interval) | | | k=2 | | | ±21.8% | ±21.7% | |

☐ Table 2-5 DASY5 Uncertainty Budget for SAR Tests

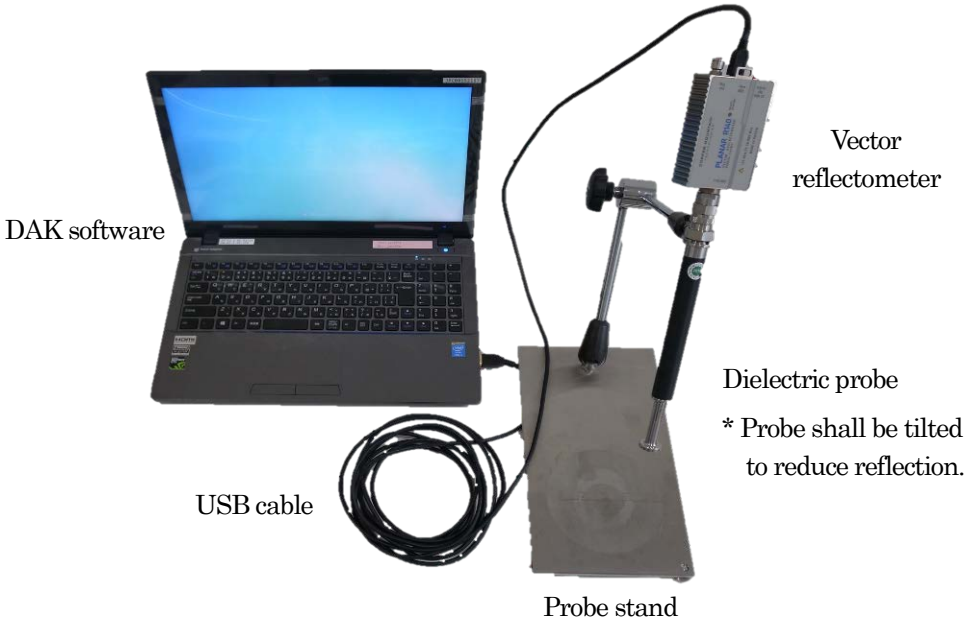
| According to IEEE Std 1528-2013 (3GHz to 6GHz range) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Input quantity | Uncertainty of Xi | | | Ci | | Ciu(Xi) | | Vi Veff |
| | Xi | Prob. Dist. | Div. | 1g [-] | 10g [-] | 1g | 10g | |
| Measurement System | | | | | | | | |
| Probe Calibration (k=1) | ±6.55% | N | 1.00 | 1.00 | 1.00 | ±6.6% | ±6.6% | ∞ |
| Axial Isotropy | ±4.7% | R | 1.73 | 0.70 | 0.70 | ±1.9% | ±1.9% | ∞ |
| Hemispherical Isotropy | ±9.7% | R | 1.73 | 0.70 | 0.70 | ±3.9% | ±3.9% | ∞ |
| Boundary Effects | ±2.0% | R | 1.73 | 1.00 | 1.00 | ±1.2% | ±1.2% | ∞ |
| Linearity | ±4.7% | R | 1.73 | 1.00 | 1.00 | ±2.7% | ±2.7% | ∞ |
| System Detection Limits | ±0.3% | R | 1.73 | 1.00 | 1.00 | ±0.1% | ±0.1% | ∞ |
| Modulation Response | ±2.4% | R | 1.73 | 1.00 | 1.00 | ±1.4% | ±1.4% | ∞ |
| Readout Electronics | ±0.3% | N | 1.00 | 1.00 | 1.00 | ±0.3% | ±0.3% | ∞ |
| Response Time | ±0.8% | R | 1.73 | 1.00 | 1.00 | ±0.5% | ±0.5% | ∞ |
| Integration Time | ±2.6% | R | 1.73 | 1.00 | 1.00 | ±1.5% | ±1.5% | ∞ |
| RF Ambient Noise | ±0.2% | R | 1.73 | 1.00 | 1.00 | ±0.1% | ±0.1% | ∞ |
| RF Ambient Reflections | ±1.3% | R | 1.73 | 1.00 | 1.00 | ±0.7% | ±0.7% | ∞ |
| Probe Positioner | ±0.8% | R | 1.73 | 1.00 | 1.00 | ±0.5% | ±0.5% | ∞ |
| Probe Positioning | ±6.7% | R | 1.73 | 1.00 | 1.00 | ±3.9% | ±3.9% | ∞ |
| Max. SAR Eval. | ±4.0% | R | 1.73 | 1.00 | 1.00 | ±2.3% | ±2.3% | ∞ |
| Test Sample Related | | | | | | | | |
| Device Positioning | ±1.8% | N | 1.00 | 1.00 | 1.00 | ±1.8% | ±1.8% | 14 |
| Device Holder | ±3.6% | N | 1.00 | 1.00 | 1.00 | ±3.6% | ±3.6% | 5 |
| Power Drift | ±5.0% | R | 1.73 | 1.00 | 1.00 | ±2.9% | ±2.9% | ∞ |
| Power Scaling | ±0.0% | R | 1.73 | 1.00 | 1.00 | ±0.0% | ±0.0% | ∞ |
| Phantom and Setup | | | | | | | | |
| Phantom Uncertainty | ±7.6% | R | 1.73 | 1.00 | 1.00 | ±4.4% | ±4.4% | ∞ |
| SAR Correction | ±1.9% | R | 1.73 | 1.00 | 0.84 | ±1.1% | ±0.9% | ∞ |
| Liquid Conductivity (mea.) | ±2.5% | R | 1.73 | 0.78 | 0.71 | ±1.1% | ±1.0% | ∞ |
| Liquid Permittivity (mea.) | ±2.5% | R | 1.73 | 0.23 | 0.26 | ±0.3% | ±0.4% | ∞ |
| Temp. Unc. - Conductivity | ±3.4% | R | 1.73 | 0.78 | 0.71 | ±1.5% | ±1.4% | ∞ |
| Temp. Unc. - Permittivity | ±0.4% | R | 1.73 | 0.23 | 0.26 | ±0.1% | ±0.1% | ∞ |
| Combined Standard Uncertainty | | | | | | ±12.0% | ±12.0% | 610 |
| Expanded Uncertainty (95% conf. interval) | | | k=2 | | | ±24.1% | ±24.0% | |

☒ Table 2-6 DASY5 Uncertainty Budget for SAR System Check

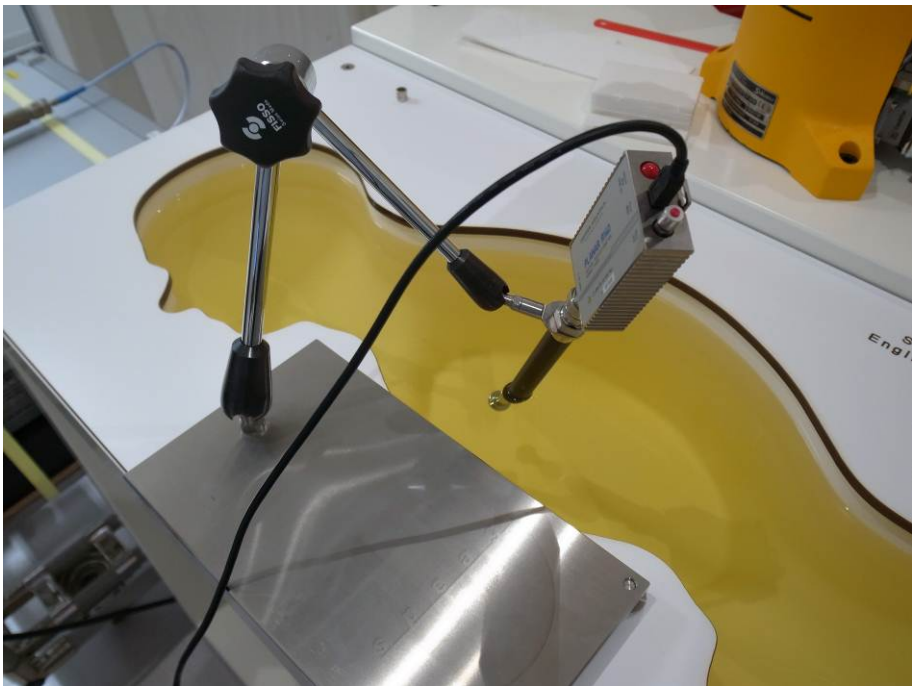
| According to IEEE Std 1528-2013 (0.3GHz to 6GHz range) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Input quantity | Uncertainty of Xi | | | Ci | | Ciu(Xi) | | Vi Veff |
| | Xi | Prob. Dist. | Div. | 1g [-] | 10g [-] | 1g | 10g | |
| Measurement System | | | | | | | | |
| Probe Calibration (k=1) | ±6.55% | N | 1.00 | 1.00 | 1.00 | ±6.6% | ±6.6% | ∞ |
| Axial Isotropy | ±4.7% | R | 1.73 | 0.70 | 0.70 | ±1.9% | ±1.9% | ∞ |
| Hemispherical Isotropy | ±9.7% | R | 1.73 | 0.70 | 0.70 | ±3.9% | ±3.9% | ∞ |
| Boundary Effects | ±2.0% | R | 1.73 | 1.00 | 1.00 | ±1.2% | ±1.2% | ∞ |
| Linearity | ±4.7% | R | 1.73 | 1.00 | 1.00 | ±2.7% | ±2.7% | ∞ |
| System Detection Limits | ±0.3% | R | 1.73 | 1.00 | 1.00 | ±0.1% | ±0.1% | ∞ |
| Modulation Response | ±0.0% | R | 1.73 | 1.00 | 1.00 | ±0.0% | ±0.0% | ∞ |
| Readout Electronics | ±0.3% | N | 1.00 | 1.00 | 1.00 | ±0.3% | ±0.3% | ∞ |
| Response Time | ±0.0% | R | 1.73 | 1.00 | 1.00 | ±0.0% | ±0.0% | ∞ |
| Integration Time | ±0.0% | R | 1.73 | 1.00 | 1.00 | ±0.0% | ±0.0% | ∞ |
| RF Ambient Noise | ±1.0% | R | 1.73 | 1.00 | 1.00 | ±0.6% | ±0.6% | ∞ |
| RF Ambient Reflections | ±1.0% | R | 1.73 | 1.00 | 1.00 | ±0.6% | ±0.6% | ∞ |
| Probe Positioner | ±0.8% | R | 1.73 | 1.00 | 1.00 | ±0.5% | ±0.5% | ∞ |
| Probe Positioning | ±6.7% | R | 1.73 | 1.00 | 1.00 | ±3.9% | ±3.9% | ∞ |
| Max. SAR Eval. | ±4.0% | R | 1.73 | 1.00 | 1.00 | ±2.3% | ±2.3% | ∞ |
| Dipole Related | | | | | | | | |
| Deviation of exp. Dipole | ±5.5% | R | 1.73 | 1.00 | 1.00 | ±3.2% | ±3.2% | ∞ |
| Dipole Axis to Liquid Dist. | ±2.0% | R | 1.73 | 1.00 | 1.00 | ±1.2% | ±1.2% | ∞ |
| Inoput Power & SAR Drift | ±3.4% | R | 1.73 | 1.00 | 1.00 | ±2.0% | ±2.0% | ∞ |
| Phantom and Setup | | | | | | | | |
| Phantom Uncertainty | ±7.6% | R | 1.73 | 1.00 | 1.00 | ±4.4% | ±4.4% | ∞ |
| SAR Correction | ±1.9% | R | 1.73 | 1.00 | 0.84 | ±1.1% | ±0.9% | ∞ |
| Liquid Conductivity (mea.) | ±2.5% | N | 1.00 | 0.78 | 0.71 | ±2.0% | ±1.8% | ∞ |
| Liquid Permittivity (mea.) | ±2.5% | N | 1.00 | 0.23 | 0.26 | ±0.6% | ±0.7% | ∞ |
| Temp. Unc. - Conductivity | ±3.4% | R | 1.73 | 0.78 | 0.71 | ±1.5% | ±1.4% | ∞ |
| Temp. Unc. - Permittivity | ±0.4% | R | 1.73 | 0.23 | 0.26 | ±0.1% | ±0.1% | ∞ |
| Combined Standard Uncertainty | | | | | | ±11.6% | ±11.5% | |
| Expanded Uncertainty (95% conf. interval) | | | k=2 | | | ±23.1% | ±23.0% | |

## 2.7. Dielectric Parameter Measurement of Tissue Simulating Liquids

The dielectric properties of the tissue simulating liquids used were verified within 24 hours before the SAR measurement.




(a) Dielectric Parameter Measurement System



(b) Example Photo: Dielectric Parameter Measurement

Figure 2-3 Dielectric Parameter Measurement Set-up

*1 Target values are linearly interpolated between the values defined in KDB 865664 D01, when necessary.

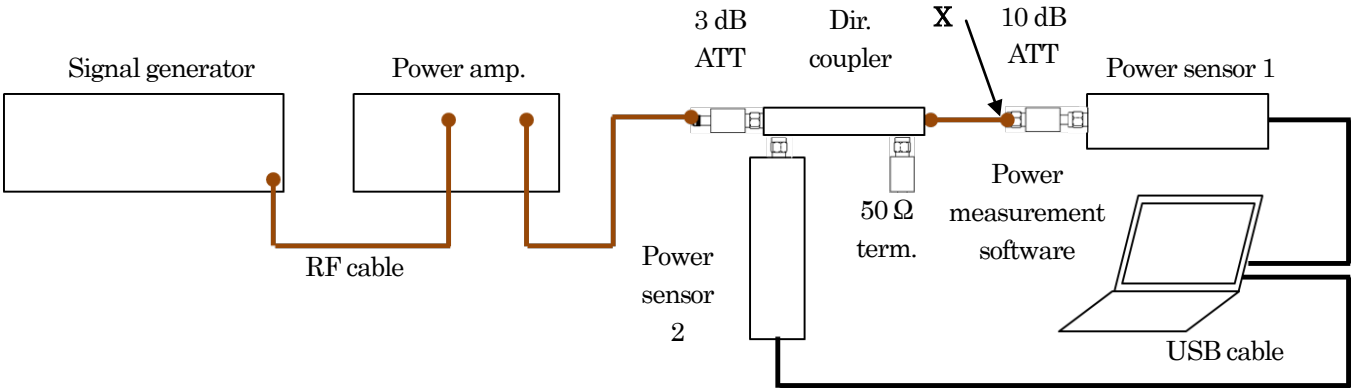
*2 The deviation of measured values from target values must be within +/-5 %.

4th Site Shielded Room 2

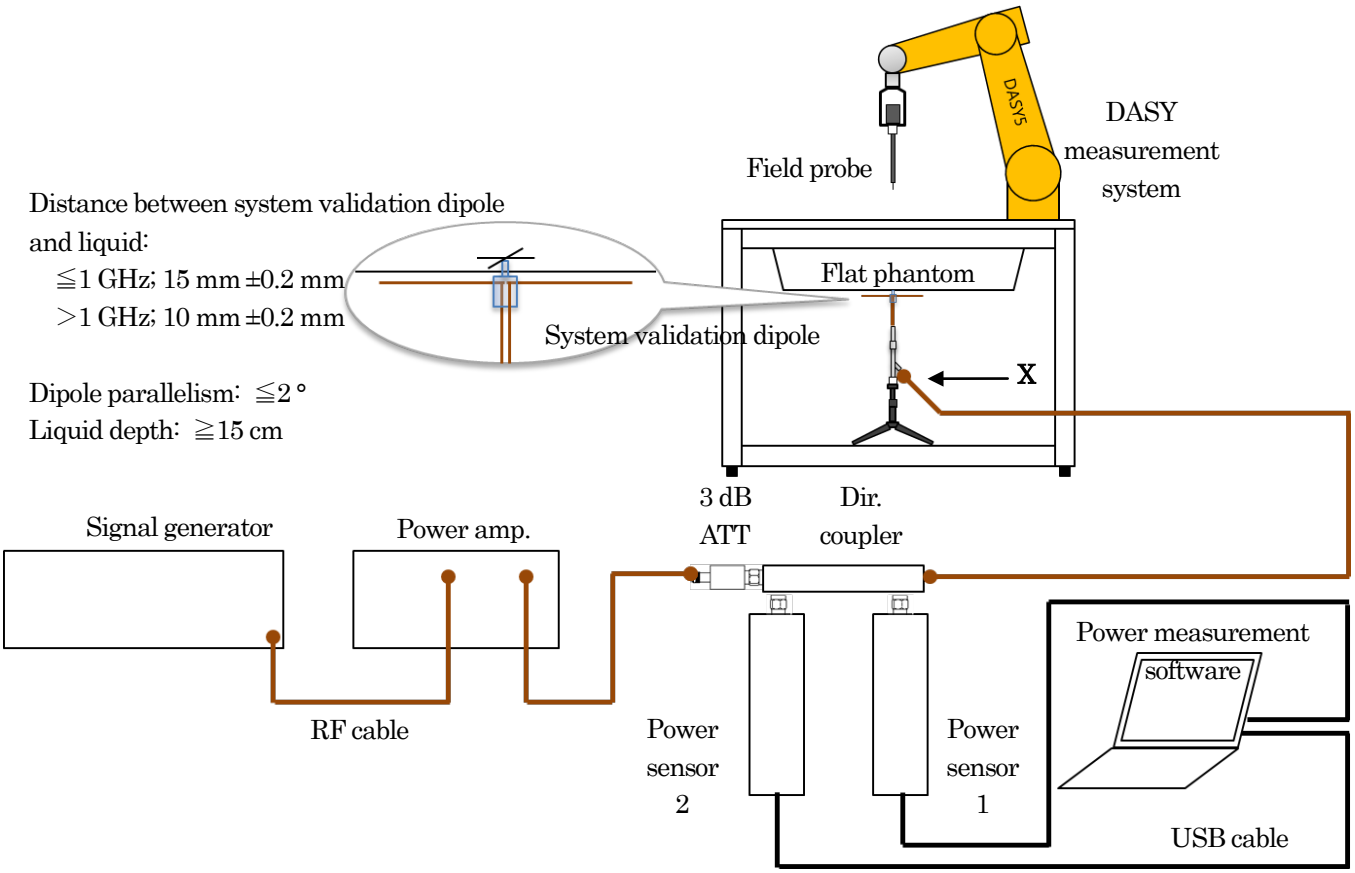
| TSL | Freq. (MHz) | Param. | Target *1 | Meas. | Dev. (%) *2 | Date | Amb. Temp. (deg. C) | Rel. Hum. (%RH) | Liquid Temp. (deg. C) | Note(s) |
|---|---|---|---|---|---|---|---|---|---|---|
| MBBL 1900-3800V3 | 2412 | $\varepsilon_r$ | 52.75 | 52.19 | -1.06 | 2017/06/27 | 24.5 | 60.0 | 23.8 | |
| | | σ (S/m) | 1.91 | 1.98 | 3.66 | | | | | |
| | 2437 | $\varepsilon_r$ | 52.72 | 52.12 | -1.14 | | | | | |
| | | σ (S/m) | 1.94 | 2.01 | 3.61 | | | | | |
| | 2462 | $\varepsilon_r$ | 52.68 | 52.05 | -1.20 | | | | | |
| | | σ (S/m) | 1.97 | 2.04 | 3.55 | | | | | |

## 2.8. System Check Measurement

The system check was performed before each series of SAR measurements using the same probe calibration point and tissue-equivalent medium.

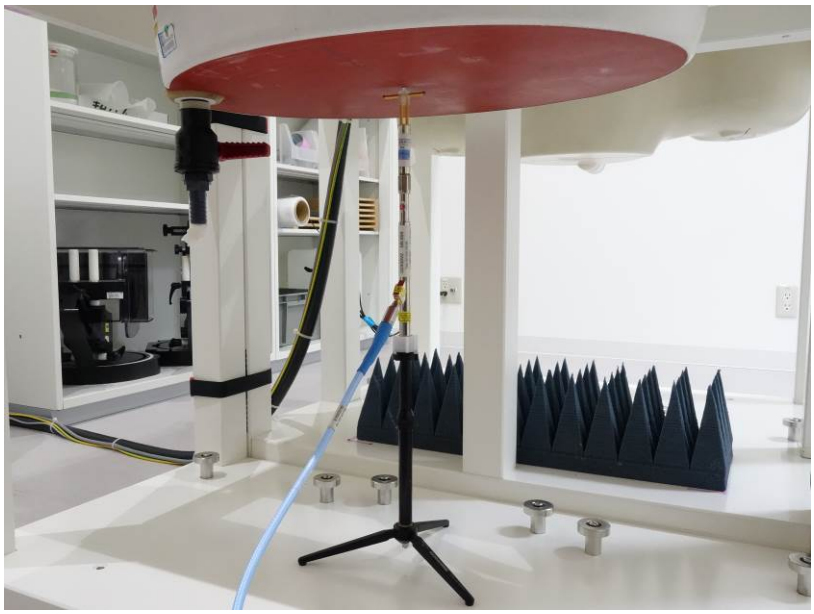



(a) Set-up 1: System Validation Dipole Input Power Adjustment




(b) Set-up 2: System Check Measurement

Figure 2-4 System Check Measurement Set-up



Body TSL

(c) Photo: System Validation Dipole Placement

Figure 2-4 System Check Measurement Set-up (continued)

*1 The normalized values (1 W) were calculated by normalizing the measured values to 1-W forward input power.
*2 The target values (1 W) are defined in IEEE Std 1528 and/or the calibration certificate of system validation dipoles used.
*3 The deviation of normalized values from target values must be within +/-10 %.

4th Site Shielded Room 2 (Body TSL)

| System Validation Dipole | Freq. (MHz) | Param. | 250 mW-Meas. (W/kg) | 1 W-Norm. (W/kg) *1 | 1 W-Target (W/kg) *2 | Dev. (%) *3 | Date | Amb. Temp. (deg. C) | Rel. Hum. (%RH) | Liquid Temp. (deg. C) | Note(s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| D2450V2 | 2450 | 1-g SAR | 13.70 | 54.80 | 50.80 | 7.87 | 2017/06/27 | 24.5 | 60.0 | 23.8 | |
| | | 10-g SAR | 6.38 | 25.52 | 24.10 | 5.89 | | | | | |

# 3. Conducted Power Measurements

## 3.1. Conducted Power Measurement Results

Wi-Fi 2.4 GHz

Date : 2017/06/23 Measured by : Y. Kajihara
Amb. Temp. : 22.0 deg. C Rel. hum. : 62.0 %RH

IEEE 802.11b

| Ch. | Freq. (MHz) | Power Setting | Data Rate (Mbps) | Meas. Frame Averaged Power (dBm) | Max. Duty Cycle (%) | Meas. Duty Cycle (%) | Meas. Burst Averaged Power (dBm) *1 | Scaled Frame Average Power (dBm) *2 | Max. Poss. Power (dBm) | Within 2 dB of Max. Poss. Power | SAR Tested | Note(s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Step 1: Worst Date Rate Check | | | | | | | | | | | | |
| 1 | 2412 | Default | 1.0 | 15.96 | 100.00 | 99.65 | 15.98 | 15.98 | 19.0 | - | - | |
| | | | 2.0 | 16.03 | 100.00 | 99.55 | 16.05 | **16.05** | 19.0 | - | - | Worst D/R |
| | | | 5.5 | 15.76 | 100.00 | 99.42 | 15.79 | 15.79 | 19.0 | - | - | |
| | | | 11.0 | 15.83 | 100.00 | 99.06 | 15.87 | 15.87 | 19.0 | - | - | |
| Step 2: Worst Channel Check | | | | | | | | | | | | |
| 1 | 2412 | Tune-up | 2.0 | 17.72 | 100.00 | 99.55 | 17.74 | 17.74 | 19.0 | Yes | Yes | |
| 6 | 2437 | | 2.0 | 17.97 | 100.00 | 99.55 | 17.99 | **17.99** | 19.0 | Yes | Yes | Worst Ch |
| 11 | 2462 | | 2.0 | 17.86 | 100.00 | 99.55 | 17.88 | 17.88 | 19.0 | Yes | Yes | |

IEEE 802.11g (*3)(*4)

| Ch. | Freq. (MHz) | Power Setting | Data Rate (Mbps) | Meas. Frame Averaged Power (dBm) | Max. Duty Cycle (%) | Meas. Duty Cycle (%) | Meas. Burst Averaged Power (dBm) *1 | Scaled Frame Average Power (dBm) *2 | Max. Poss. Power (dBm) | Within 2 dB of Max. Poss. Power | SAR Tested | Note(s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2417 | Tune-up | 6.0 | 17.34 | 100.00 | 97.39 | 17.46 | 17.46 | 19.0 | Yes | - | |
| 6 | 2437 | | 6.0 | 17.45 | 100.00 | 97.39 | 17.57 | **17.57** | 19.0 | Yes | - | Worst Ch |
| 10 | 2457 | | 6.0 | 17.37 | 100.00 | 97.39 | 17.49 | 17.49 | 19.0 | Yes | - | |

IEEE 802.11n (*3)(*4)

| Ch. | Freq. (MHz) | Power Setting | MCS | Meas. Frame Averaged Power (dBm) | Max. Duty Cycle (%) | Meas. Duty Cycle (%) | Meas. Burst Averaged Power (dBm) *1 | Scaled Frame Average Power (dBm) *2 | Max. Poss. Power (dBm) | Within 2 dB of Max. Poss. Power | SAR Tested | Note(s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2417 | Tune-up | 0 | 17.27 | 100.00 | 96.53 | 17.42 | 17.42 | 19.0 | Yes | - | |
| 6 | 2437 | | 0 | 17.38 | 100.00 | 96.53 | 17.53 | **17.53** | 19.0 | Yes | - | Worst Ch |
| 10 | 2457 | | 0 | 17.36 | 100.00 | 96.53 | 17.51 | 17.51 | 19.0 | Yes | - | |

*1 Used for confirmation that the DUT's output power is within +0/-2 dB of the maximum tune-up tolerance limits (max. poss. power), since the maximum tune-up tolerance limits are defined as burst averaged values. The measured burst averaged power values were calculated by applying the power scaling to 100 % duty factor ( = 10 * log (100 % / Measured duty cycle) ) to each measured frame averaged power value.

*2 Used for determination of the maximum conducted output power condition, since the source-based time-averaged output power (frame averaged power) shall be used according to KDB 447498 D01. The scaled frame averaged power values were calculated by applying the power scaling for the maximum duty factor ( = 10 * log (Maximum duty cycle / Measured duty cycle) ) to each measured frame averaged power value.

*3 SAR is not required for 802.11g/n channels when the highest reported SAR for DSSS (802.11b) is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg or 3 W/kg (1-g or 10-g respectively), according to KDB 248227 D01.

*4 Channels 2, 6, and 10 are measured since channels 1 and 11 require reduced output power, according to KDB 248227 D01.

Bluetooth

| | | | | | |
|---|---|---|---|---|---|
| Date | : | 2016/11/26 | Measured by | : | Y. Kajihara |
| Amb. Temp. | : | 24.5 deg. C | Rel. hum. | : | 51.0 %RH |

Bluetooth LE (*5)

| Ch. | Freq. (MHz) | Packet Type | Meas. Frame Averaged Power (dBm) | Max. Duty Cycle (%) | Meas. Duty Cycle (%) | Meas. Burst Averaged Power (dBm) *1 | Scaled Frame Averaged Power (dBm) *2 | Max. Poss. Power (dBm) | Within 2 dB of Max. Poss. Power | SAR Tested | Note(s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 2402 | - | 6.15 | 71.00 | 63.52 | 8.12 | 6.63 | 9.5 | Yes | - | |
| 19 | 2440 | - | 6.77 | 71.00 | 63.52 | **8.74** | **7.25** | 9.5 | Yes | - | Worst Ch |
| 39 | 2480 | - | 6.47 | 71.00 | 63.52 | 8.44 | 6.95 | 9.5 | Yes | - | |

*1 Used for confirmation that the DUT's output power is within +0/-2 dB of the maximum tune-up tolerance limits (max. poss. power), since the maximum tune-up tolerance limits are defined as burst averaged values. The measured burst averaged power values were calculated by applying the power scaling to 100 % duty factor ( = 10 * log (100 % / Measured duty cycle) ) to each measured frame averaged power value.

*2 Used for determination of the maximum conducted output power condition, since the source-based time-averaged output power (frame averaged power) shall be used according to KDB 447498 D01. The scaled frame averaged power values were calculated by applying the power scaling for the maximum duty factor ( = 10 * log (Maximum duty cycle / Measured duty cycle) ) to each measured frame averaged power value.

*5 SAR is not required for Bluetooth when SAR test exclusion is applied according to KDB 447498 D01.

## 3.2. Comparison of Conducted Power with Original Radio Test Report

Wi-Fi 2.4 GHz

| | Mode | Max. Conducted Averaged Power | Note(s) |
|---|---|---|---|
| Original (Radio) | IEEE 802.11b | 18.19 dBm | Radio Test Report No. 10622710S-C, issued by UL Japan, Inc. |
| Class II Permissive Change (SAR) | IEEE 802.11b | 17.99 dBm | Burst averaged power |
| Deviation | | -0.20 dB | |

Bluetooth

| | Mode | Max. Conducted Averaged Power | Note(s) |
|---|---|---|---|
| Original (Radio) | Bluetooth LE | 8.30 dBm | Radio Test Report No. 10622710S-C, issued by UL Japan, Inc. |
| Class II Permissive Change (SAR) | Bluetooth LE | 8.74 dBm | Burst averaged power |
| Deviation | | +0.44 dB | |

# 4. SAR Measurements

☒<SAR Correction/Scaling>

According to KDB 865664 D01,
the maximum SAR values are determined by taking account of the following correction or scaling factors.

The maximum 1-g SAR and/or 10-g SAR values (reported SAR) are calculated by applying the ΔSAR positive correction for deviations of the tissue-equivalent liquid and the power scaling for the maximum duty factor and maximum possible power levels (maximum tune-up tolerance limit) to each measured 1-g SAR and/or 10-g SAR value:

Reported SAR (W/kg) = Measured SAR (W/kg) * ΔSAR positive correction factor
* Duty cycle scaling factor * Tune-up scaling factor

where;

ΔSAR positive correction factor = (100 - ΔSAR*1) / 100

Duty cycle scaling factor = Max. possible duty cycle / Measured duty cycle used for the SAR measurement

Tune-up scaling factor = Max. possible power (mW) / Measured power used for the SAR measurement (mW)

*1 $\Delta SAR\ (\%) = c_e * \Delta\varepsilon_r + c_o * \Delta\sigma$

<For 1-g SAR>

$c_e = -7.854 * 10^{-4} f^3 + 9.402 * 10^{-3} f^2 - 2.742 * 10^{-2} f - 0.2026$

$c_o = 9.804 * 10^{-3} f^3 - 8.661 * 10^{-2} f^2 + 2.981 * 10^{-2} f + 0.7829$

<For 10-g SAR>

$c_e = 3.456 * 10^{-3} f^3 - 3.531 * 10^{-2} f^2 + 7.675 * 10^{-2} f - 0.1860$

$c_o = 4.479 * 10^{-3} f^3 - 1.586 * 10^{-2} f^2 - 0.1972 f + 0.7717$

where;

| | |
|---|---|
| $c_e$ | coefficient representing the sensitivity of SAR to permittivity |
| $\Delta\varepsilon_r$ | percent change in permittivity |
| $c_o$ | coefficient representing the sensitivity of SAR to conductivity |
| $\Delta\sigma$ | percent change in conductivity |
| f | frequency in GHz |

A negative ΔSAR would translate to a lower measured SAR value than what would be measured if using dielectric properties equal to the target values.

A positive ΔSAR would translate to a higher measured SAR value than what would be measured if using dielectric properties equal to the target values.

SAR correction shall not be made when the ΔSAR has a positive sign to provide a conservative SAR value.

The SAR is only corrected when ΔSAR has a negative sign.

☒<SAR Test Reduction for Wi-Fi>

SAR test reduction for Wi-Fi is applied according to KDB 248227 D01.

The initial test position procedures

An "initial test position" is applied to further reduce the number of SAR tests for devices operating in next to the ear, UMPC mini-tablet or hotspot mode exposure configurations that require multiple test positions.

1) When the reported SAR of the initial test position is ≤ 0.4 W/kg or 1 W/kg (1-g or 10-g respectively), further SAR measurement is not required for the other (remaining) test positions in that exposure configuration and 802.11 transmission mode combinations within the frequency band or aggregated band. SAR is also not required for that exposure configuration in the subsequent test configuration(s).
2) When the reported SAR of the initial test position is > 0.4 W/kg or 1 W/kg (1-g or 10-g respectively), SAR is repeated for the 802.11 transmission mode configuration tested in the initial test position using subsequent highest extrapolated or estimated 1-g SAR conditions determined by area scans or next closest/smallest test separation distance and maximum RF coupling test positions based on manufacturer justification, on the highest maximum output power channel, until the reported SAR is ≤ 0.8 W/kg or 2 W/kg (1-g or 10-g respectively) or all required test positions (left, right, touch, tilt or subsequent surfaces and edges) are tested.
3) For all positions/configurations tested using the initial test position and subsequent test positions, when the reported SAR is > 0.8 W/kg or 2 W/kg (1-g or 10-g respectively), SAR is measured for these test positions/configurations on the subsequent next highest measured output power channel(s) until the reported SAR is ≤ 1.2 W/kg or 3 W/kg (1-g or 10-g respectively) or all required channels are tested.
   a) Additional power measurements may be required for this step, which should be limited to those necessary for identifying the subsequent highest output power channels.

The 802.11b DSSS procedures

SAR is measured for 2.4 GHz 802.11b DSSS using either a fixed test position or, when applicable, the initial test position procedure.

1) When the reported SAR of the highest measured maximum output power channel for the exposure configuration is ≤ 0.8 W/kg or 2 W/kg (1-g or 10-g respectively), no further SAR testing is required for 802.11b DSSS in that exposure configuration.
2) When the reported SAR is > 0.8 W/kg or 2 W/kg (1-g or 10-g respectively), SAR is required for that exposure configuration using the next highest measured output power channel. When any reported SAR is > 1.2 W/kg or 3 W/kg (1-g or 10-g respectively), SAR is required for the third channel; i.e., all channels require testing.

For 2.4 GHz 802.11g/n OFDM configurations

SAR is not required for the following 2.4 GHz OFDM conditions.

1) When KDB Publication 447498 SAR test exclusion applies to the OFDM configuration.
2) When the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg or 3 W/kg (1-g or 10-g respectively).

The Initial Test Configuration Procedures

An initial test configuration is determined for OFDM transmission modes according to the channel bandwidth, modulation and data rate combination(s) with the highest maximum output power specified for production units in each standalone and aggregated frequency band. SAR is measured using the highest measured maximum output power channel. SAR test reduction for subsequent highest output test channels is determined according to reported SAR of the initial test configuration.

1) When the reported SAR of the initial test configuration is > 0.8 W/kg, SAR measurement is required for subsequent next highest measured output power channel(s) in the initial test configuration until reported SAR is ≤ 1.2 W/kg or all required channels are tested.

## 4.1. SAR Measurement Results

**<Body-Worn SAR>**

Wi-Fi 2.4 GHz

Date : 2017/6/27 Measured by : Y. Kamiko

Amb. Temp. : 24.5 deg. C Rel. hum. : 56.0 %RH

| Mode | Ch. | Freq. (MHz) | Pos. | Dis. (mm) | Max. Poss. Power (dBm) | Meas. Power (dBm) | Max. Duty Cycle (%) | Meas. Duty Cycle (%) | Meas. 1-g SAR (W/kg) | Reported 1-g SAR (W/kg) | Liquid Temp. (deg. C) | Plot No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Step 1: Worst Position Check | | | | | | | | | | | | |
| 802.11b | 6 | 2437 | Front | 0 | 19.00 | 17.99 | 100.00 | 99.55 | 0.662 | 0.839 | 23.9 | |
| | | | Back | | 19.00 | 17.99 | 100.00 | 99.55 | 0.146 | 0.185 | 23.8 | |
| | | | Left | | 19.00 | 17.99 | 100.00 | 99.55 | 0.085 | 0.108 | 23.9 | |
| | | | Top | | 19.00 | 17.99 | 100.00 | 99.55 | 0.052 | 0.065 | 23.8 | |
| | | | Bottom | | 19.00 | 17.99 | 100.00 | 99.55 | 0.056 | 0.071 | 23.8 | |
| Step 2: Worst Channel Check (for Step 1) | | | | | | | | | | | | |
| 802.11b | 1 | 2412 | Front | 0 | 19.00 | 17.74 | 100.00 | 99.55 | 0.617 | 0.828 | 23.8 | |
| | 11 | 2462 | | | 19.00 | 17.88 | 100.00 | 99.55 | 0.728 | **0.947** | 23.8 | 1 |

*1 The burst averaged power values are used for power scaling since the maximum tune-up tolerance limits are defined as burst averaged values.

*2 Reported SAR (W/kg) = Measured SAR (W/kg) * Duty cycle scaling factor * Tune-up scaling factor

where;

Duty cycle scaling factor = Max. possible duty cycle (%) / Measured duty cycle used for the SAR measurement (%)

Tune-up scaling factor = Max. possible power (mW) / Measured power used for the SAR measurement (mW)

## 4.2. SAR Measurement Variability

According to KDB 865664 D01, additional measurements are repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device should be returned to ambient conditions (normal room temperature) with the battery fully charged before it is re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

1) Repeated measurement is not required when the original highest measured SAR is < 0.8 or 2 W/kg (1-g or 10-g respectively); steps 2) through 4) do not apply.
2) When the original highest measured SAR is ≥ 0.8 or 2 W/kg (1-g or 10-g respectively), repeat that measurement once.
3) Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is ≥ 1.45 or 3.6 W/kg (~ 10% from the 1-g or 10-g respective SAR limit).
4) Perform a third repeated measurement only if the original, first, or second repeated measurement is ≥ 1.5 or 3.75 W/kg (1-g or 10-g respectively) and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.

| Freq. Band (MHz) | RF Exposure Conditions | Position | Highest Meas. SAR (W/kg) | | Repeat SAR | Repeated Meas. SAR (W/kg) | Ratio of Largest to Smallest SAR |
|---|---|---|---|---|---|---|---|
| Wi-Fi 2.4 GHz | Body-Worn | Front | 1-g SAR | 0.728 | No | N/A | N/A |

# Appendix A. Plots of SAR Measurement

Please see the following page(s).

Plot No. 1

Date: 2017/06/27

Test Laboratory: Sony Global Manufacturing & Operations Corporation EMC/ RF Test Laboratory Main Lab. 4th Site Shielded Room 2

## Wi-Fi 2.4 GHz (11ch)_Body-Worn_Front_0mm

**DUT: Type1DR (installed in Digital Camera 1DR011)**

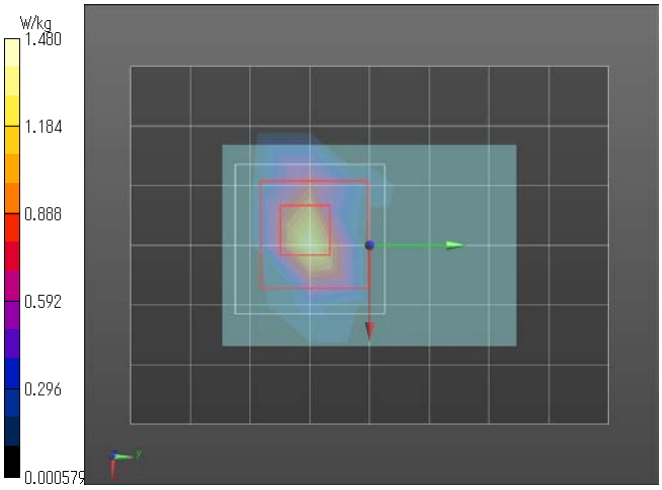
Communication System: UID 0, Wi-Fi_802.11b_2Mbps (0); Frequency: 2462 MHz;
Medium parameters used: f = 2462 MHz; $\sigma$ = 2.042 S/m; $\varepsilon_r$ = 52.054; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section

DASY Configuration:

- Probe: EX3DV4 - SN3921; ConvF(7.64, 7.64, 7.64); Calibrated: 2016/10/25;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection), z = 1.0, 31.0
- Electronics: DAE4 Sn482; Calibrated: 2016/08/09
- Phantom: ELI v5.0 (20deg probe tilt); Type: QDOVA002AA; Serial: TP:1259
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**Configuration/Wi-Fi 2.4 GHz (11ch)_Body-Worn_Front_0mm/**
**Area Scan (7x9x1):** Measurement grid: dx=12mm, dy=12mm
Maximum value of SAR (measured) = 1.40 W/kg

**Configuration/Wi-Fi 2.4 GHz (11ch)_Body-Worn_Front_0mm/**
**Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 27.16 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 2.27 W/kg
**SAR(1 g) = 0.728 W/kg**; SAR(10 g) = 0.231 W/kg (SAR corrected for target medium)
Maximum value of SAR (measured) = 1.48 W/kg



# Appendix B. Plots of System Check

Please see the following page(s).

Date: 2017/06/27

Test Laboratory: Sony Global Manufacturing & Operations Corporation EMC/ RF Test Laboratory Main Lab. 4th Site Shielded Room 2

## Validation_D2450_MSL

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: 894**

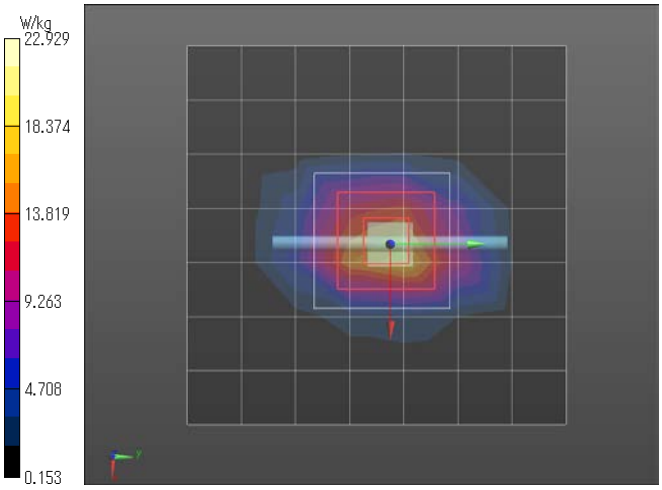
Communication System: UID 0, CW; Frequency: 2450 MHz;
Medium parameters used: f = 2450 MHz; $\sigma$ = 2.028 S/m; $\varepsilon_r$ = 52.087; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section

DASY Configuration:

- Probe: EX3DV4 - SN3921; ConvF(7.64, 7.64, 7.64); Calibrated: 2016/10/25;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection), z = 1.0, 31.0
- Electronics: DAE4 Sn482; Calibrated: 2016/08/09
- Phantom: ELI v5.0 (20deg probe tilt); Type: QDOVA002AA; Serial: TP:1259
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**System Performance Check at Frequencies above 2 GHz/Validation D2450 MSL/ Area Scan (8x8x1):** Measurement grid: dx=12mm, dy=12mm
Maximum value of SAR (measured) = 18.0 W/kg

**System Performance Check at Frequencies above 2 GHz/Validation D2450 MSL/ Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 110.5 V/m; Power Drift = 0.13 dB
Peak SAR (extrapolated) = 28.4 W/kg
**SAR(1 g) = 13.7 W/kg; SAR(10 g) = 6.38 W/kg**
Maximum value of SAR (measured) = 22.9 W/kg



# Appendix C. Calibration Certificate

## C.1. E-Field Probe EX3DV4 (Serial No. 3921 / Control No. WA02)

Please see the following pages.

**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 **SONY Global M&O (Vitec)**

Certificate No: **EX3-3921_Oct16**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | EX3DV4 - SN:3921 |
| Calibration procedure(s) | QA CAL-01.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6<br>Calibration procedure for dosimetric E-field probes |
| Calibration date: | October 25, 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-16) | In house check: Oct-17 |

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

Issued: October 25, 2016

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

**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**

## 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:3921

Manufactured: December 18, 2012
Calibrated: October 25, 2016

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

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3921

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm (μV/(V/m)$^2$)[A] | 0.47 | 0.42 | 0.46 | ± 10.1 % |
| DCP (mV)[B] | 106.9 | 103.9 | 102.3 | |

## 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 | 137.4 | ±2.7 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 136.2 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 148.3 | |

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:3921

## 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) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 10.81 | 10.81 | 10.81 | 0.41 | 0.93 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 10.24 | 10.24 | 10.24 | 0.42 | 0.89 | ± 12.0 % |
| 900 | 41.5 | 0.97 | 10.07 | 10.07 | 10.07 | 0.51 | 0.80 | ± 12.0 % |
| 1450 | 40.5 | 1.20 | 8.78 | 8.78 | 8.78 | 0.36 | 0.80 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 8.64 | 8.64 | 8.64 | 0.36 | 0.80 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 8.38 | 8.38 | 8.38 | 0.28 | 0.80 | ± 12.0 % |
| 1950 | 40.0 | 1.40 | 8.19 | 8.19 | 8.19 | 0.36 | 0.80 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 7.94 | 7.94 | 7.94 | 0.19 | 0.83 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 7.52 | 7.52 | 7.52 | 0.22 | 0.80 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 7.28 | 7.28 | 7.28 | 0.31 | 0.94 | ± 12.0 % |
| 3500 | 37.9 | 2.91 | 7.25 | 7.25 | 7.25 | 0.28 | 1.20 | ± 13.1 % |
| 5200 | 36.0 | 4.66 | 5.90 | 5.90 | 5.90 | 0.30 | 1.80 | ± 13.1 % |
| 5300 | 35.9 | 4.76 | 5.65 | 5.65 | 5.65 | 0.30 | 1.80 | ± 13.1 % |
| 5500 | 35.6 | 4.96 | 5.07 | 5.07 | 5.07 | 0.40 | 1.80 | ± 13.1 % |
| 5600 | 35.5 | 5.07 | 4.96 | 4.96 | 4.96 | 0.40 | 1.80 | ± 13.1 % |
| 5800 | 35.3 | 5.27 | 5.07 | 5.07 | 5.07 | 0.40 | 1.80 | ± 13.1 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. 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:3921

## 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) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 10.52 | 10.52 | 10.52 | 0.42 | 0.87 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 10.38 | 10.38 | 10.38 | 0.49 | 0.80 | ± 12.0 % |
| 900 | 55.0 | 1.05 | 10.17 | 10.17 | 10.17 | 0.45 | 0.80 | ± 12.0 % |
| 1450 | 54.0 | 1.30 | 8.58 | 8.58 | 8.58 | 0.35 | 0.80 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 8.28 | 8.28 | 8.28 | 0.41 | 0.80 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 7.98 | 7.98 | 7.98 | 0.44 | 0.82 | ± 12.0 % |
| 1950 | 53.3 | 1.52 | 8.20 | 8.20 | 8.20 | 0.40 | 0.80 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 7.79 | 7.79 | 7.79 | 0.42 | 0.80 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 7.64 | 7.64 | 7.64 | 0.39 | 0.80 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 7.43 | 7.43 | 7.43 | 0.39 | 0.80 | ± 12.0 % |
| 3500 | 51.3 | 3.31 | 6.89 | 6.89 | 6.89 | 0.25 | 1.30 | ± 13.1 % |
| 5200 | 49.0 | 5.30 | 4.98 | 4.98 | 4.98 | 0.45 | 1.90 | ± 13.1 % |
| 5300 | 48.9 | 5.42 | 4.77 | 4.77 | 4.77 | 0.45 | 1.90 | ± 13.1 % |
| 5500 | 48.6 | 5.65 | 4.27 | 4.27 | 4.27 | 0.50 | 1.90 | ± 13.1 % |
| 5600 | 48.5 | 5.77 | 4.13 | 4.13 | 4.13 | 0.50 | 1.90 | ± 13.1 % |
| 5800 | 48.2 | 6.00 | 4.33 | 4.33 | 4.33 | 0.50 | 1.90 | ± 13.1 % |

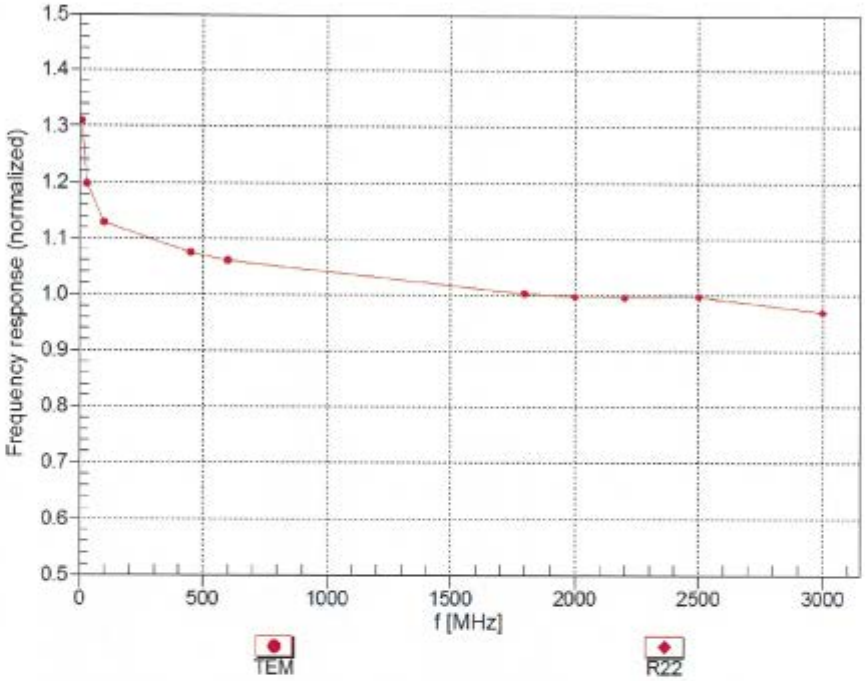
[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz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

EX3DV4– SN:3921 October 25, 2016

## 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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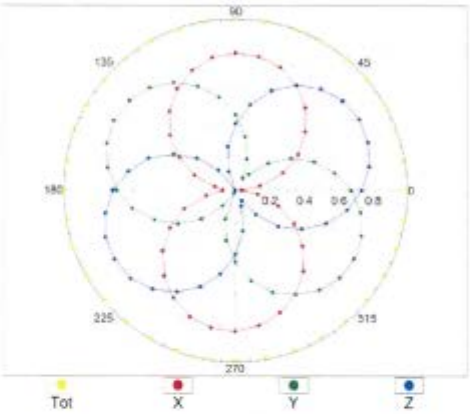
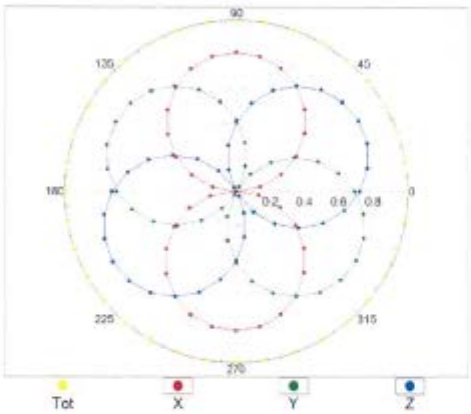
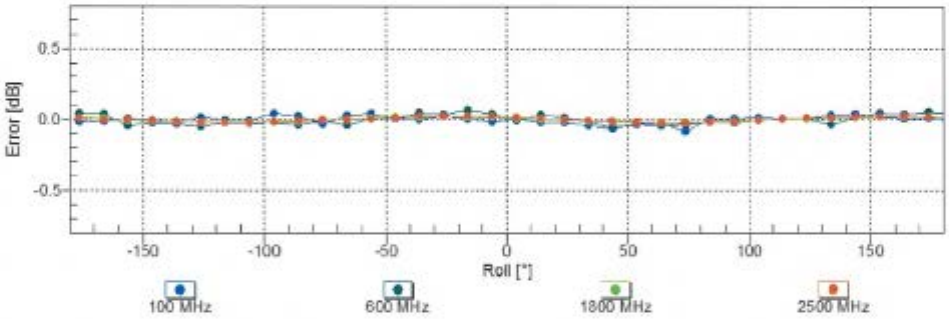
## Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM




f=1800 MHz,R22

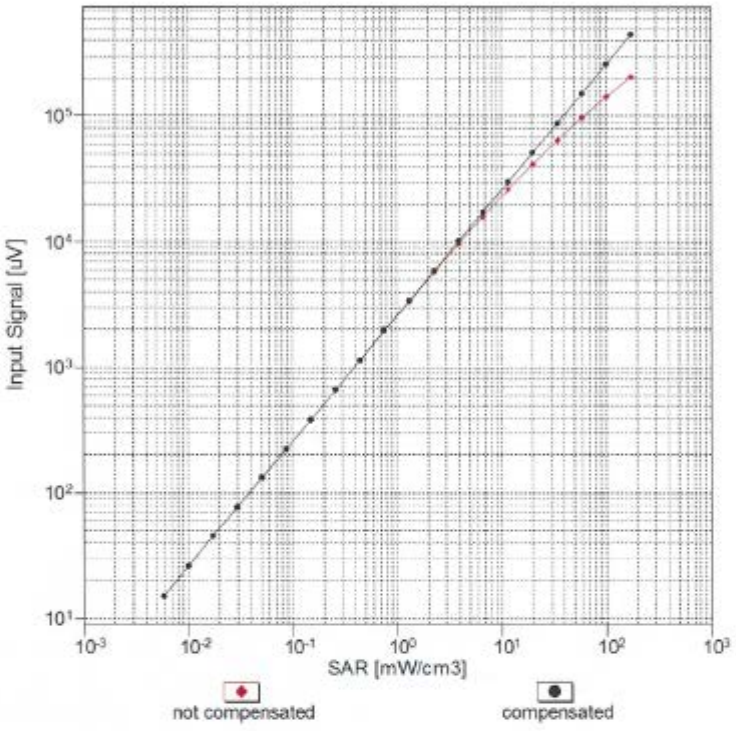


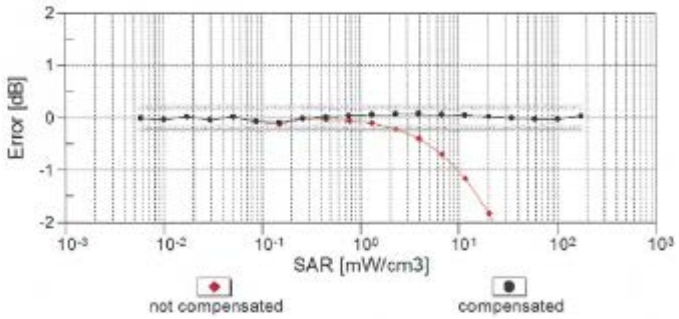




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

## Dynamic Range f(SAR$_{head}$)

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



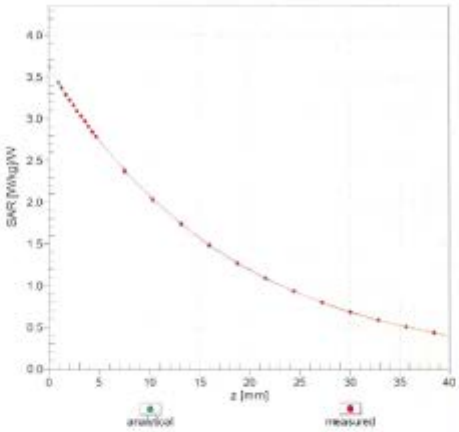




Uncertainty of Linearity Assessment: ± 0.6% (k=2)

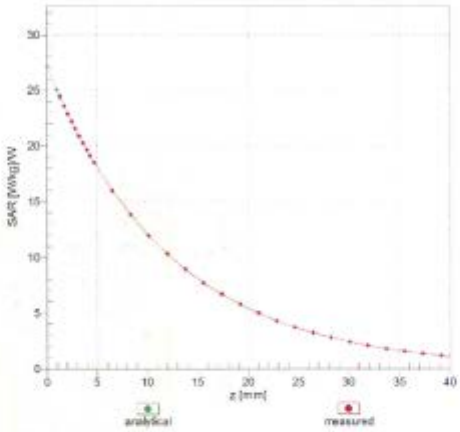
EX3DV4– SN:3921 October 25, 2016

# Conversion Factor Assessment

f = 900 MHz,WGLS R9 (H_convF)

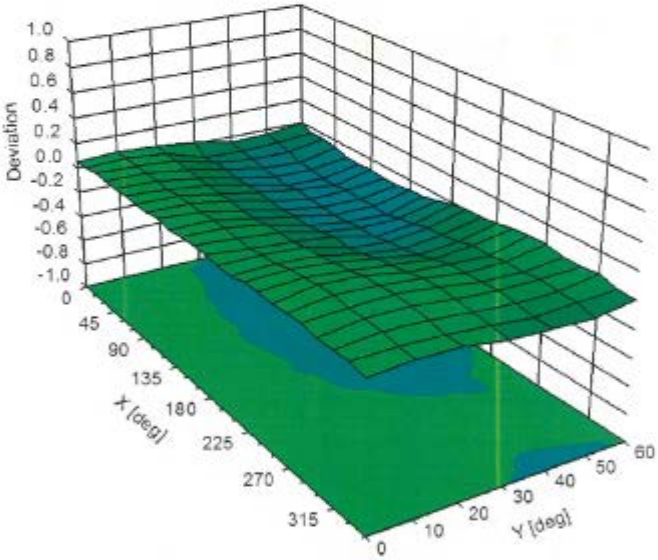


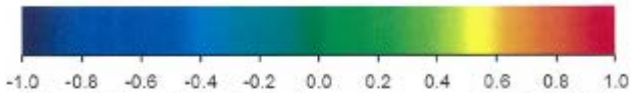

f = 1750 MHz,WGLS R22 (H_convF)




# Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz




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

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# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3921

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | 123.9 |
| 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 |

## C.2. System Validation Dipole D2450V2 (Serial No. 894 / Control No. WA55)

Please see the following pages.

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

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

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

**Accreditation No.: SCS 0108**

**Client** VGEL

**Certificate No: D2450V2-894_Oct16**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D2450V2 - SN:894 |
| Calibration procedure(s) | QA CAL-05.v9<br>Calibration procedure for dipole validation kits above 700 MHz |
| Calibration date: | October 18, 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: 5058 (20k) | 05-Apr-16 (No. 217-02292) | Apr-17 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 05-Apr-16 (No. 217-02295) | Apr-17 |
| Reference Probe EX3DV4 | SN: 7349 | 15-Jun-16 (No. EX3-7349_Jun16) | Jun-17 |
| DAE4 | SN: 601 | 30-Dec-15 (No. DAE4-601_Dec15) | Dec-16 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| Power meter EPM-442A | SN: GB37480704 | 07-Oct-15 (in house check Oct-16) | In house check: Oct-18 |
| Power sensor HP 8481A | SN: US37292783 | 07-Oct-15 (in house check Oct-16) | In house check: Oct-18 |
| Power sensor HP 8481A | SN: MY41092317 | 07-Oct-15 (in house check Oct-16) | In house check: Oct-18 |
| RF generator R&S SMT-06 | SN: 100972 | 15-Jun-15 (in house check Oct-16) | In house check: Oct-18 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-16) | In house check: Oct-17 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Johannes Kurikka | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: October 18, 2016

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

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

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

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

**Accreditation No.: SCS 0108**

**Glossary:**

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

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

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

**Additional Documentation:**

e) DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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

## Measurement Conditions

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

| | | |
|---|---|---|
| **DASY Version** | DASY5 | V52.8.8 |
| **Extrapolation** | Advanced Extrapolation | |
| **Phantom** | Modular Flat Phantom | |
| **Distance Dipole Center - TSL** | 10 mm | with Spacer |
| **Zoom Scan Resolution** | dx, dy, dz = 5 mm | |
| **Frequency** | 2450 MHz ± 1 MHz | |

## Head TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 39.2 | 1.80 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 38.2 ± 6 % | 1.87 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 cm³ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 13.3 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **51.9 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 cm³ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 6.18 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **24.4 W/kg ± 16.5 % (k=2)** |

## Body TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 52.7 | 1.95 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 51.3 ± 6 % | 2.02 mho/m ± 6 % |
| **Body TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Body TSL

| **SAR averaged over 1 cm³ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 13.0 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **50.8 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 cm³ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 6.10 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **24.1 W/kg ± 16.5 % (k=2)** |

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 54.2 Ω + 2.7 jΩ |
| Return Loss | - 26.4 dB |

### Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 50.7 Ω + 5.2 jΩ |
| Return Loss | - 25.7 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.160 ns |

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

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

### Additional EUT Data

| | |
|---|---|
| Manufactured by | SPEAG |
| Manufactured on | October 06, 2011 |

## DASY5 Validation Report for Head TSL

Date: 14.10.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:894**

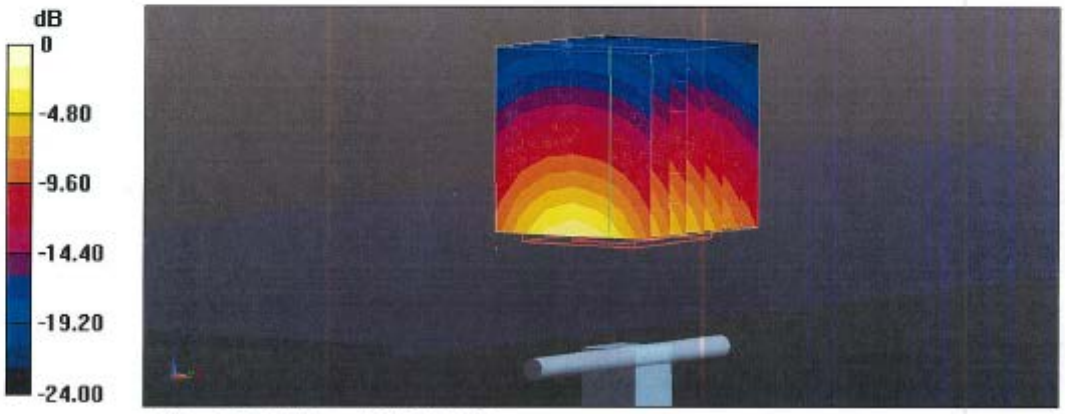
Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; $\sigma$ = 1.87 S/m; $\varepsilon_r$ = 38.2; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.72, 7.72, 7.72); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

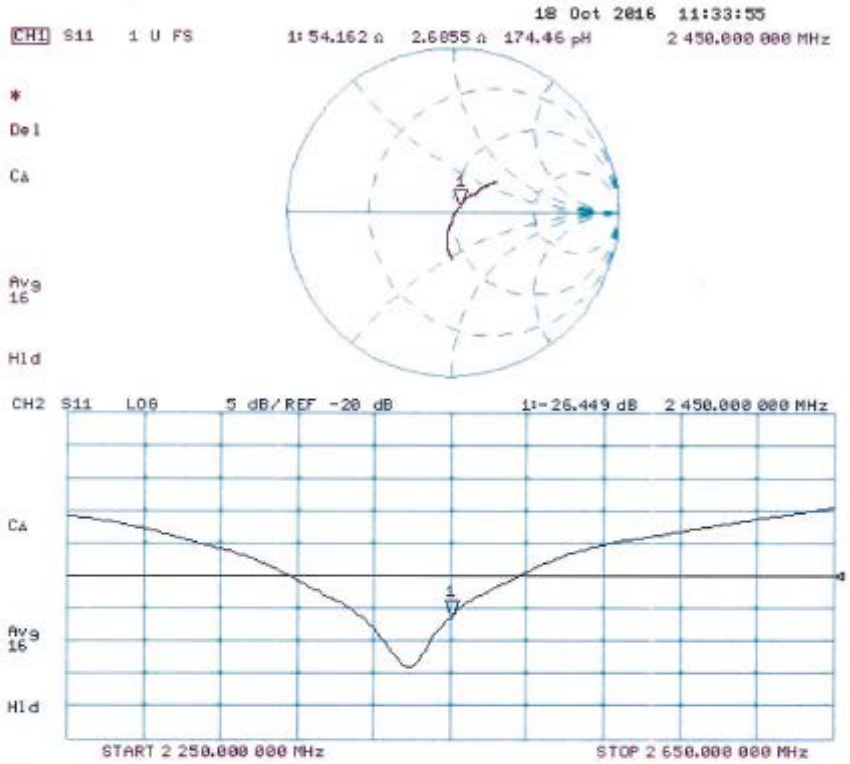
### Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 112.5 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 26.8 W/kg
**SAR(1 g) = 13.3 W/kg; SAR(10 g) = 6.18 W/kg**
Maximum value of SAR (measured) = 22.0 W/kg




0 dB = 22.0 W/kg = 13.42 dBW/kg

## Impedance Measurement Plot for Head TSL




Certificate No: D2450V2-894_Oct16 Page 6 of 8

## DASY5 Validation Report for Body TSL

Date: 18.10.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:894**

Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; $\sigma$ = 2.02 S/m; $\varepsilon_r$ = 51.3; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

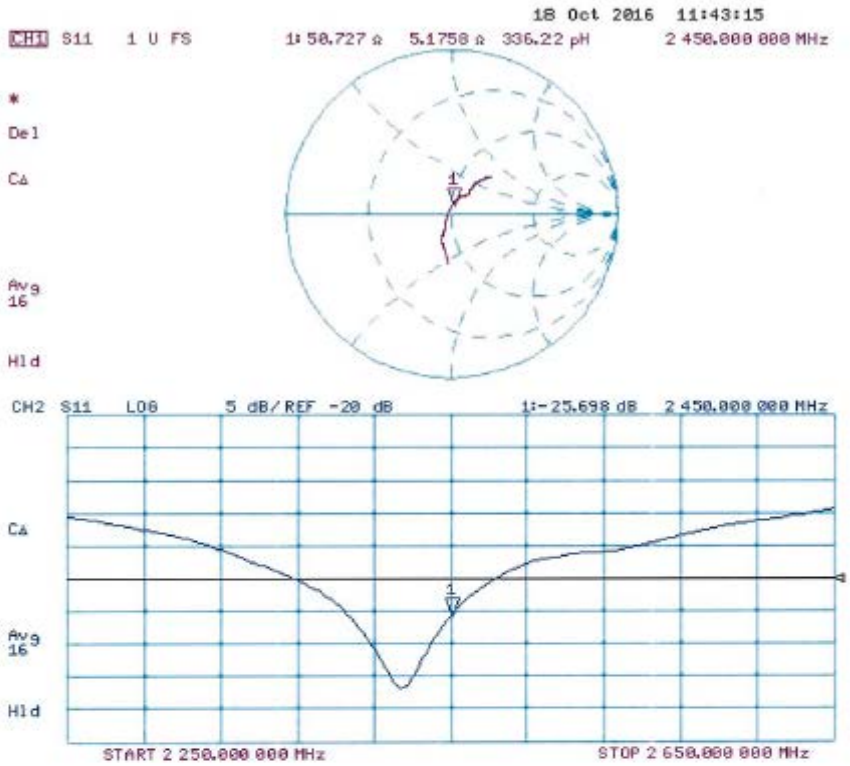
- Probe: EX3DV4 - SN7349; ConvF(7.79, 7.79, 7.79); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

### Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 107.0 V/m; Power Drift = -0.05 dB
Peak SAR (extrapolated) = 26.0 W/kg
**SAR(1 g) = 13 W/kg; SAR(10 g) = 6.1 W/kg**
Maximum value of SAR (measured) = 21.3 W/kg

0 dB = 21.3 W/kg = 13.28 dBW/kg

## Impedance Measurement Plot for Body TSL

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