

Calibration Laboratory of
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Engineering AG
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S Schweizerischer Kalibrierdienst
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S Servizio svizzero di taratura
S Swiss Calibration Service

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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:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

- DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

| | | |
|------------------------------|------------------------|-------------|
| DASY Version | DASY5 | V52.10.4 |
| Extrapolation | Advanced Extrapolation | |
| Phantom | Modular Flat Phantom | |
| Distance Dipole Center - TSL | 10 mm | with Spacer |
| Zoom Scan Resolution | dx, dy, dz = 5 mm | |
| Frequency | 2600 MHz \pm 1 MHz | |

Head TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---------------------|----------------|----------------------|
| Nominal Head TSL parameters | 22.0 °C | 39.0 | 1.96 mho/m |
| Measured Head TSL parameters | (22.0 \pm 0.2) °C | 37.9 \pm 6 % | 2.01 mho/m \pm 6 % |
| Head TSL temperature change during test | < 0.5 °C | ---- | ---- |

SAR result with Head TSL

| SAR averaged over 1 cm ³ (1 g) of Head TSL | Condition | |
|---|--------------------|--|
| SAR measured | 250 mW input power | 14.5 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 57.0 W/kg \pm 17.0 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Head TSL | condition | |
|---|--------------------|--|
| SAR measured | 250 mW input power | 6.40 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 25.3 W/kg \pm 16.5 % (k=2) |

Body TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---------------------|----------------|----------------------|
| Nominal Body TSL parameters | 22.0 °C | 52.5 | 2.16 mho/m |
| Measured Body TSL parameters | (22.0 \pm 0.2) °C | 51.0 \pm 6 % | 2.20 mho/m \pm 6 % |
| Body TSL temperature change during test | < 0.5 °C | ---- | ---- |

SAR result with Body TSL

| SAR averaged over 1 cm ³ (1 g) of Body TSL | Condition | |
|---|--------------------|--|
| SAR measured | 250 mW input power | 14.0 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 55.1 W/kg \pm 17.0 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Body TSL | condition | |
|---|--------------------|--|
| SAR measured | 250 mW input power | 6.20 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 24.6 W/kg \pm 16.5 % (k=2) |

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 47.0 Ω - 5.6 j Ω |
| Return Loss | - 23.7 dB |

Antenna Parameters with Body TSL

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 44.6 Ω - 4.4 j Ω |
| Return Loss | - 22.7 dB |

General Antenna Parameters and Design

| | |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.152 ns |
|----------------------------------|----------|

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

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

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

Additional EUT Data

| | |
|-----------------|-------|
| Manufactured by | SPEAG |
|-----------------|-------|

DASY5 Validation Report for Head TSL

Date: 21.07.2020

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1012

Communication System: UID 0 - CW; Frequency: 2600 MHz

Medium parameters used: $f = 2600$ MHz; $\sigma = 2.01$ S/m; $\epsilon_r = 37.9$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.54, 7.54, 7.54) @ 2600 MHz; Calibrated: 29.06.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

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 = 121.2 V/m; Power Drift = -0.04 dB

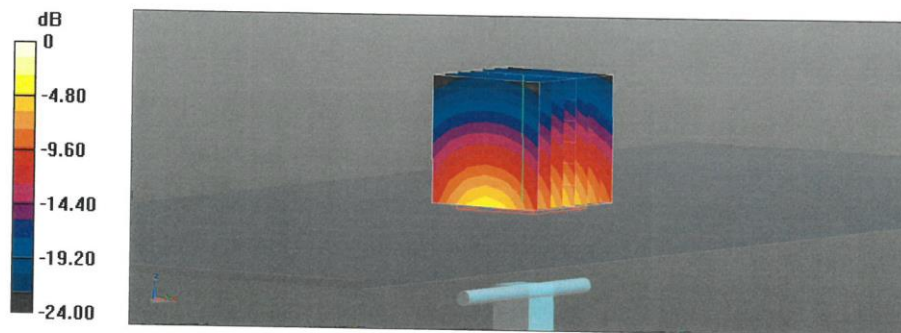
Peak SAR (extrapolated) = 29.3 W/kg

SAR(1 g) = 14.5 W/kg; SAR(10 g) = 6.40 W/kg

Smallest distance from peaks to all points 3 dB below = 8.9 mm

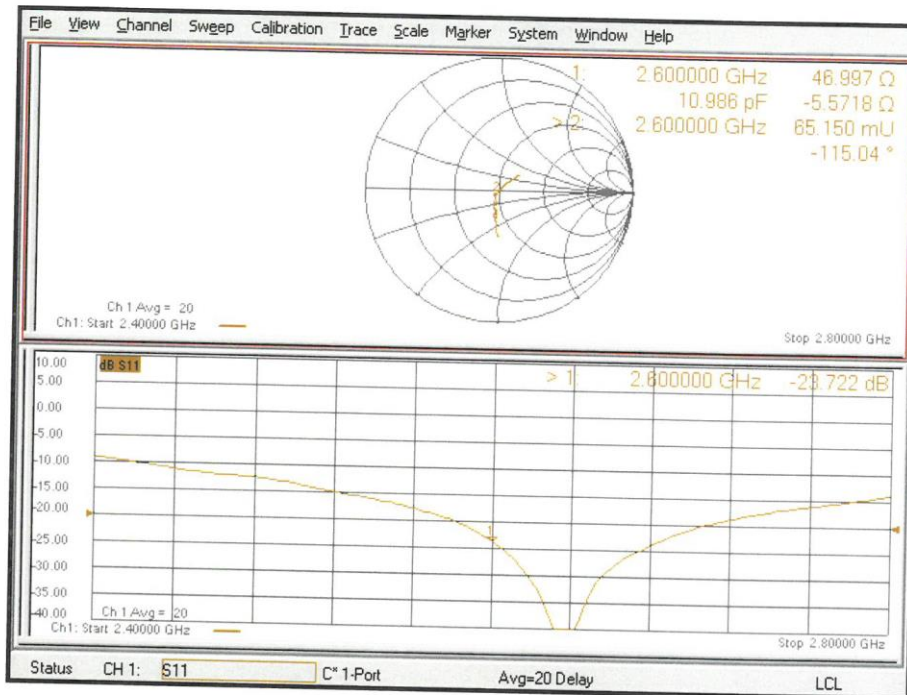
Ratio of SAR at M2 to SAR at M1 = 49.4%

Maximum value of SAR (measured) = 24.4 W/kg



0 dB = 24.4 W/kg = 13.87 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 21.07.2020

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1012

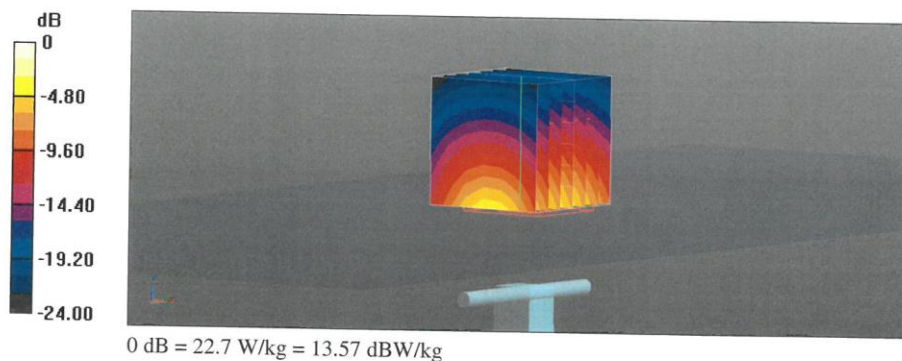
Communication System: UID 0 - CW; Frequency: 2600 MHz
 Medium parameters used: $f = 2600$ MHz; $\sigma = 2.20$ S/m; $\epsilon_r = 51.0$; $\rho = 1000$ kg/m³
 Phantom section: Flat Section
 Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

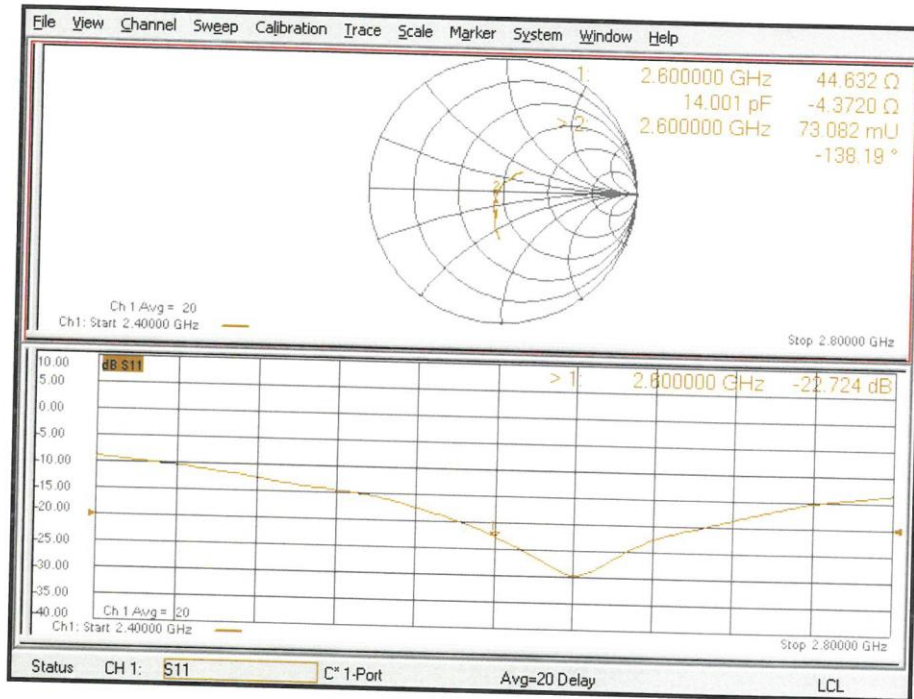
- Probe: EX3DV4 - SN7349; ConvF(7.68, 7.68, 7.68) @ 2600 MHz; Calibrated: 29.06.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

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

Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm
 Reference Value = 110.5 V/m; Power Drift = -0.09 dB
 Peak SAR (extrapolated) = 28.0 W/kg
SAR(1 g) = 14.0 W/kg; SAR(10 g) = 6.20 W/kg
 Smallest distance from peaks to all points 3 dB below = 8 mm
 Ratio of SAR at M2 to SAR at M1 = 50.8%
 Maximum value of SAR (measured) = 22.7 W/kg



Impedance Measurement Plot for Body TSL



ANNEX I Newly add band WIFI2.4G

I.1 Dielectric Performance and System Validation

Table I.1-1: Dielectric Performance of Tissue Simulating Liquid

| Measurement Date (yyyy-mm-dd) | Type | Frequency | Permittivity ϵ | Drift (%) | Conductivity σ (S/m) | Drift (%) |
|----------------------------------|------|-----------|----------------------------|--------------|--------------------------------|--------------|
| 2021-11-10 | Head | 2450MHz | 40.539 | 3.42 | 1.907 | 5.94 |

Table I.1-2: System Validation of Head

| Measurement Date (yyyy-mm-dd) | Frequency | Target value (W/kg) | | Measured value(W/kg) | | Deviation | |
|-------------------------------------|-----------|---------------------|----------------|----------------------|----------------|-----------------|----------------|
| | | 10 g Average | 1 g Average | 10 g Average | 1 g Average | 10 g Average | 1 g Average |
| 2021-11-10 | 2450MHz | 24.9 | 53.3 | 25.76 | 55.44 | 3.45% | 4.02% |

I.2 Conductive output power

The average conducted power for Wi-Fi 2.4G is as following:

| 802.11b | | | | | | | | |
|-------------------|-------|-------|---------|--------|--------|--------|--------|--------|
| Channel\data rate | 1Mbps | 2Mbps | 5.5Mbps | 11Mbps | | | | |
| 11(2462MHz) | 16.60 | / | / | / | | | | |
| 6(2437(MHz) | 15.88 | / | / | / | | | | |
| 1(2412MHz) | 16.64 | 16.55 | 16.36 | 16.19 | | | | |
| Tune up | 17.00 | 17.00 | 17.00 | 17.00 | | | | |
| 802.11g | | | | | | | | |
| Channel\data rate | 6Mbps | 9Mbps | 12Mbps | 18Mbps | 24Mbps | 36Mbps | 48Mbps | 54Mbps |
| 11(2462MHz) | 14.36 | / | / | / | / | / | / | / |
| 6(2437(MHz) | 14.72 | / | / | / | / | / | / | / |
| 1(2412MHz) | 14.74 | 14.44 | 14.29 | 14.13 | 12.93 | 12.75 | 12.71 | 12.45 |
| Tune up | 15.00 | 15.00 | 15.00 | 15.00 | 14.00 | 14.00 | 14.00 | 12.00 |
| 802.11n-20MHz | | | | | | | | |
| Channel\data rate | MCS0 | MCS1 | MCS2 | MCS3 | MCS4 | MCS5 | MCS6 | MCS7 |
| 11(2462MHz) | 14.35 | / | / | / | / | / | / | / |
| 6(2437(MHz) | 14.90 | 14.50 | 13.30 | 12.68 | 12.35 | 7.62 | 7.46 | 7.27 |
| 1(2412MHz) | 14.89 | / | / | / | / | / | / | / |
| Tune up | 15.00 | 15.00 | 14.00 | 14.00 | 14.00 | 9.00 | 9.00 | 9.00 |

I.3 SAR test results

Table I.3-1: SAR Values (WIFI2.4G)

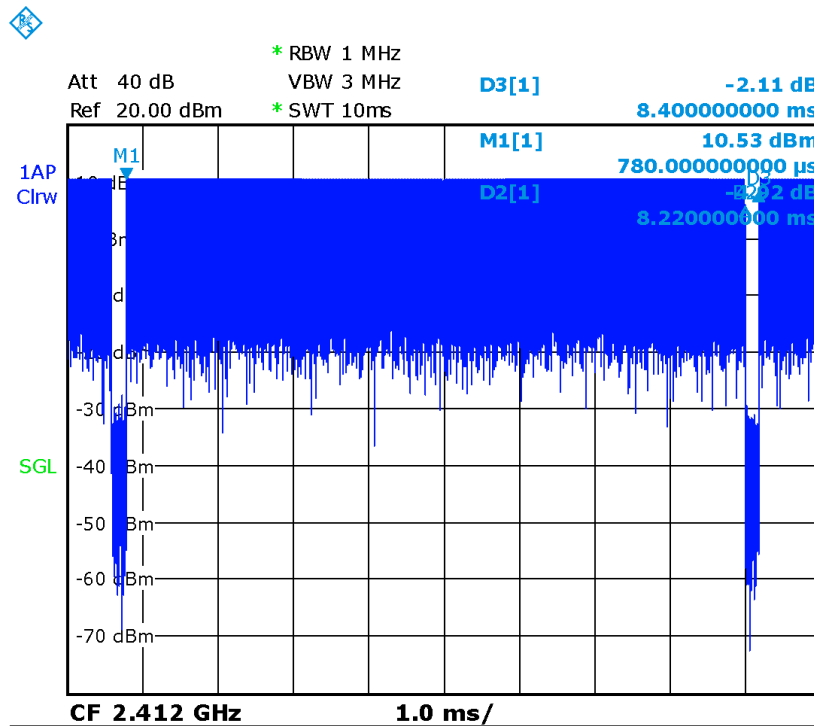
| Frequency | | Test Position | Figure No. | Conduct ed Power (dBm) | Max. tune-up Power (dBm) | Measured SAR(10g) (W/kg) | Reported SAR(10g) (W/kg) | Measured SAR(1g) (W/kg) | Reported SAR(1g) (W/kg) | Power Drift (dB) |
|-----------|------|---------------|------------|------------------------|--------------------------|--------------------------|--------------------------|-------------------------|-------------------------|------------------|
| Ch. | MHz | | | | | | | | | |
| 1 | 2412 | Front 10mm | Fig.I-1 | 16.64 | 17 | 0.009 | 0.01 | 0.0208 | 0.02 | -0.01 |
| 1 | 2412 | Rear 0mm | Fig.I-2 | 16.64 | 17 | 0.012 | 0.01 | 0.0278 | 0.03 | -0.05 |

According to the KDB248227 D01, The reported SAR must be scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit. The scaled reported SAR is presented as below.

Table I.3-2: SAR Values (WLAN - Head) – 802.11b (Scaled Reported SAR)

| Frequency | | Test Position | Actual duty factor | maximum duty factor | Reported SAR (W/kg) | Scaled reported SAR (W/kg) |
|-----------|------|---------------|--------------------|---------------------|---------------------|----------------------------|
| Ch. | MHz | | | | | |
| 1 | 2412 | Front 10mm | 100% | 98% | 0.02(1g) | 0.02(1g) |
| 1 | 2412 | Rear 0mm | 100% | 98% | 0.01(10g) | 0.01(10g) |

SAR is not required for OFDM because the 802.11b adjusted SAR \leq 1.2 W/kg.



Picture I.3-1 Duty factor plot

I.4 Graph Results

WLAN2450_CH1 Front 10mm

Date: 11/10/2021

Electronics: DAE4 Sn1331

Medium: head 2450 MHz

Medium parameters used: $f = 2412$ MHz; $\sigma = 1.873$ S/m; $\epsilon_r = 40.576$; $\rho = 1000$ kg/m³

Ambient Temperature: 22.9°C, Liquid Temperature: 22.5°C

Communication System: WLAN2450 2412 MHz Duty Cycle: 1:1

Probe: EX3DV4 – SN7548 ConvF(7.35,7.35,7.35)

Area Scan (71x71x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 0.0389 W/kg

Zoom Scan (9x8x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 4.121 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 0.123 W/kg

SAR(1 g) = 0.021 W/kg; SAR(10 g) = 0.009 W/kg

Maximum value of SAR (measured) = 0.110 W/kg

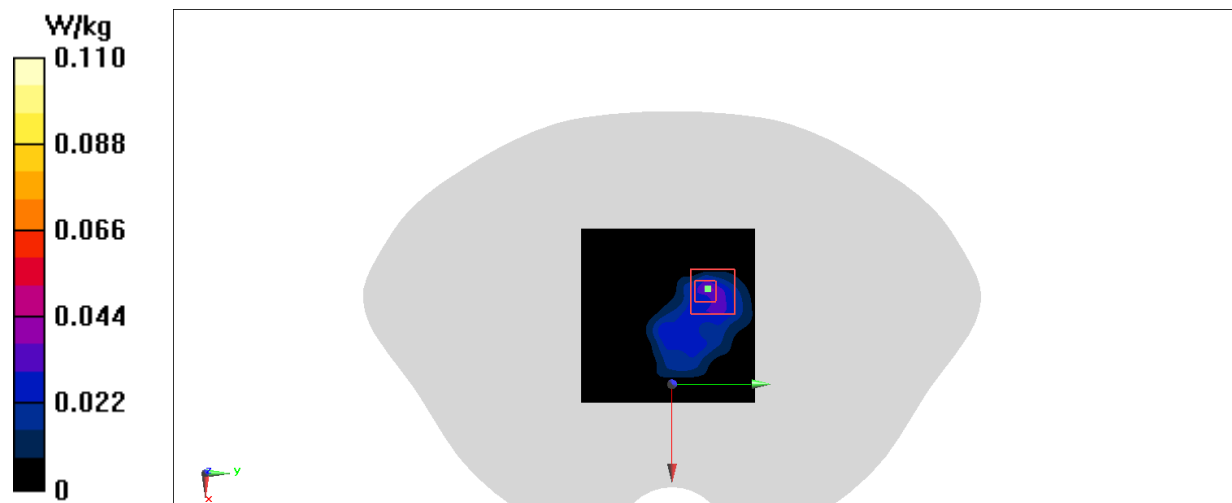
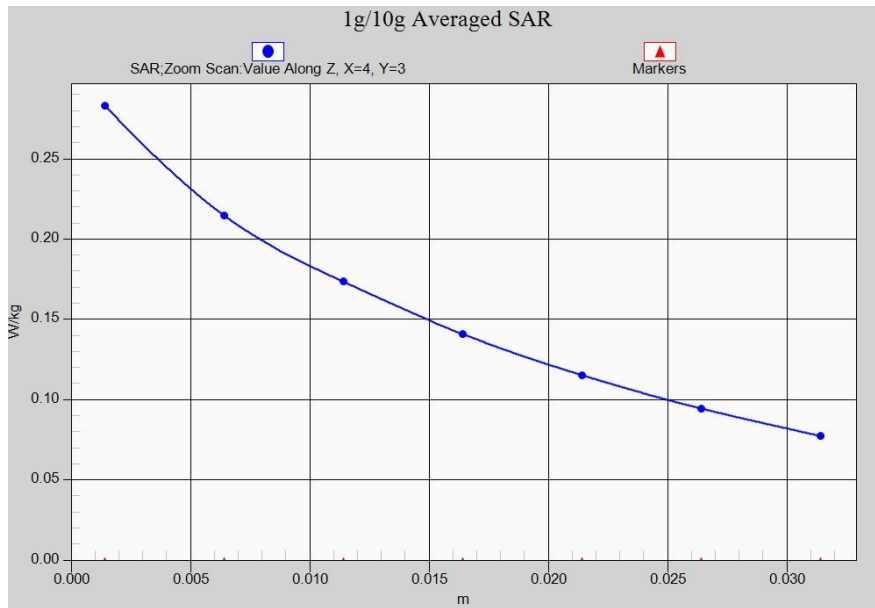


Fig.I-1



Z-Scan at power reference point (WIFI2.4G)

WLAN2450_CH1 Rear 0mm

Date: 11/10/2021

Electronics: DAE4 Sn1331

Medium: head 2450 MHz

Medium parameters used: $f = 2412$ MHz; $\sigma = 1.873$ S/m; $\epsilon_r = 40.576$; $\rho = 1000$ kg/m³

Ambient Temperature: 22.9°C, Liquid Temperature: 22.5°C

Communication System: WLAN2450 2412 MHz Duty Cycle: 1:1

Probe: EX3DV4 – SN7548 ConvF(7.35,7.35,7.35)

Area Scan (71x71x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 0.0908 W/kg

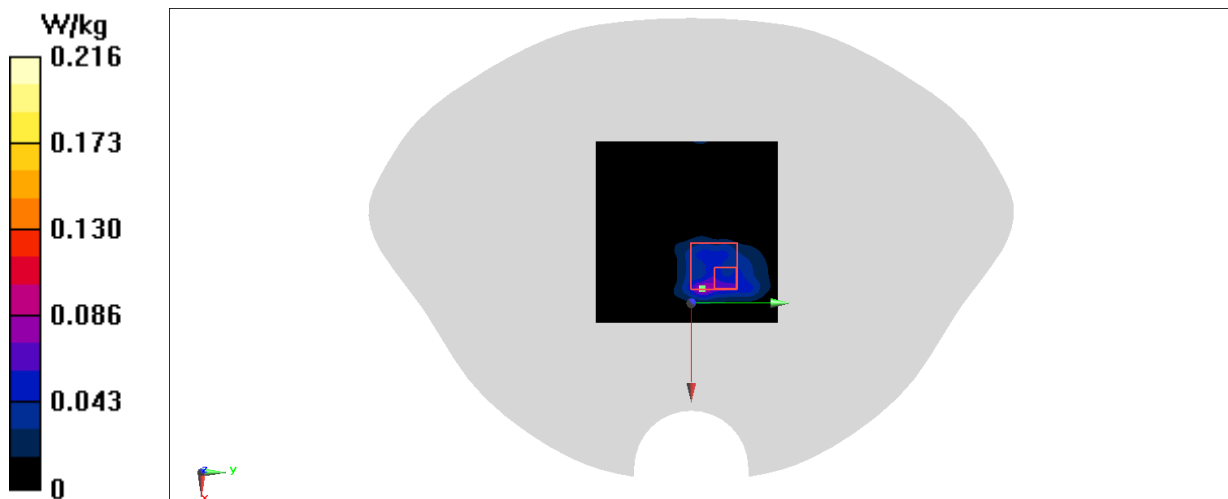
Zoom Scan (9x8x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

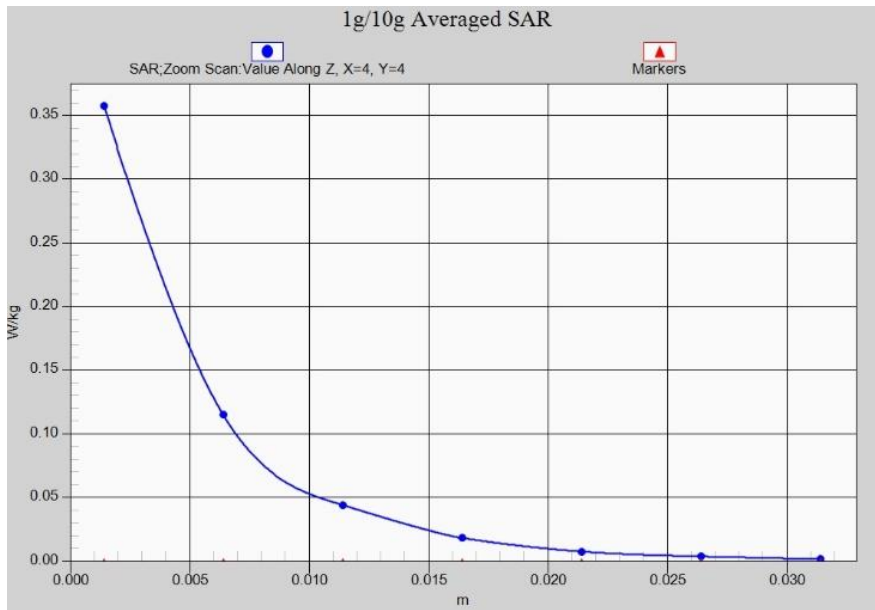
Reference Value = 4.415 V/m; Power Drift = -0.05 dB

Peak SAR (extrapolated) = 0.216 W/kg

SAR(1 g) = 0.028 W/kg; SAR(10 g) = 0.012 W/kg

Maximum value of SAR (measured) = 0.216 W/kg

**Fig.I-2**



Z-Scan at power reference point (WIFI2.4G)

I.5 System Verification Results

2450 MHz

Date: 11/10/2021

Electronics: DAE4 Sn1331

Medium: Head 2450 MHz

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.907$ S/m; $\epsilon_r = 40.539$; $\rho = 1000$ kg/m³

Ambient Temperature: 22.9°C Liquid Temperature: 22.5°C

Communication System: CW Frequency: 2450 MHz Duty Cycle: 1:1

Probe: EX3DV4 – SN7548 ConvF(7.35,7.35,7.35)

System Performance Check/Area Scan (61x121x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm

Reference Value = 37.34 V/m; Power Drift = 0.14 dB

Fast SAR: SAR(1 g) = 13.92 W/kg; SAR(10 g) = 6.51 W/kg

Maximum value of SAR (interpolated) = 23.5 W/kg

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

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

Reference Value = 37.34 V/m; Power Drift = 0.14 dB

Peak SAR (extrapolated) = 28.9 W/kg

SAR(1 g) = 13.86 W/kg; SAR(10 g) = 6.44 W/kg

Maximum value of SAR (measured) = 23.3 W/kg

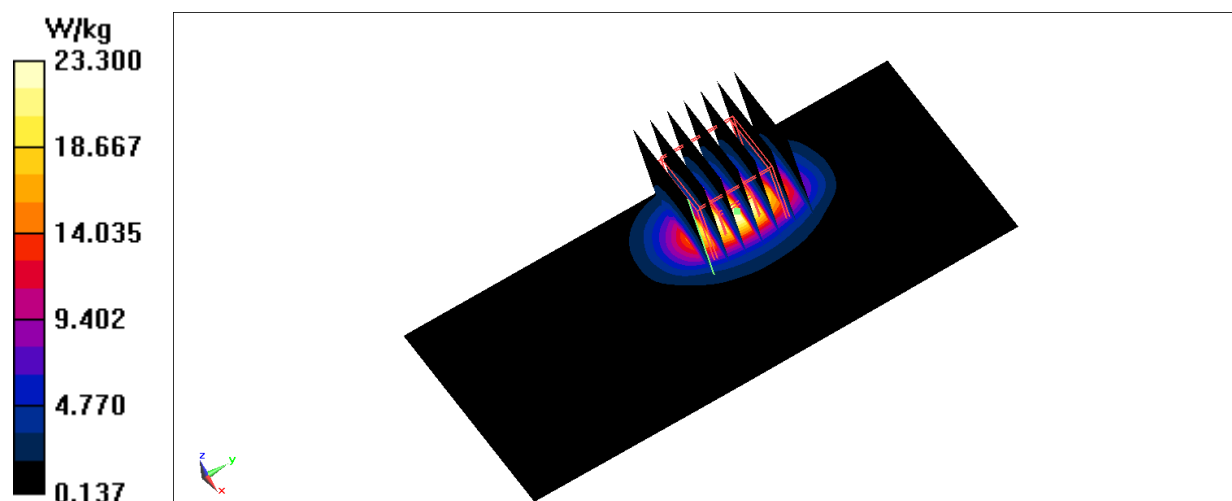


Fig.I.5-1 validation 2450 MHz 250mW

I.6 Main Test Instruments

| No. | Name | Type | Serial Number | Calibration Date | Valid Period |
|-----|-----------------------|---------------|---------------|--------------------------|--------------|
| 01 | Network analyzer | E5071C | MY46110673 | January 14, 2021 | One year |
| 02 | Power meter | NRP2 | 106276 | May 11, 2021 | One year |
| 03 | Power sensor | NRP6A | 101369 | | |
| 04 | Signal Generator | E4438C | MY49071430 | February 1, 2021 | One Year |
| 05 | Amplifier | 60S1G4 | 0331848 | No Calibration Requested | |
| 06 | BTS | CMW500 | 159889 | January 13, 2021 | BTS |
| 07 | E-field Probe | SPEAG EX3DV4 | 7548 | June 25, 2021 | One year |
| 08 | DAE | SPEAG DAE4 | 1331 | September 1, 2021 | One year |
| 09 | Dipole Validation Kit | SPEAG D2450V2 | 853 | July 26,2021 | One year |

I.7 System Validation

The SAR system must be validated against its performance specifications before it is deployed. When SAR probes, system components or software are changed, upgraded or recalibrated, these must be validated with the SAR system(s) that operates with such components.

Table I.7: System Validation for 7548

| Probe SN. | Liquid name | Validation date | Frequency point | Status (OK or Not) |
|-----------|--------------|-----------------|-----------------|--------------------|
| 7548 | Head 750MHz | July.8,2021 | 750 MHz | OK |
| 7548 | Head 900MHz | July.8,2021 | 900 MHz | OK |
| 7548 | Head 1450MHz | July.8,2021 | 1450 MHz | OK |
| 7548 | Head 1750MHz | July.8,2021 | 1750 MHz | OK |
| 7548 | Head 1900MHz | July.9,2021 | 1900 MHz | OK |
| 7548 | Head 2000MHz | July.9,2021 | 2000 MHz | OK |
| 7548 | Head 2300MHz | July.9,2021 | 2300 MHz | OK |
| 7548 | Head 2450MHz | July.9,2021 | 2450 MHz | OK |
| 7548 | Head 2600MHz | July.9,2021 | 2600 MHz | OK |
| 7548 | Head 3300MHz | July.10,2021 | 3300 MHz | OK |
| 7548 | Head 3500MHz | July.10,2021 | 3500 MHz | OK |
| 7548 | Head 3700MHz | July.10,2021 | 3700 MHz | OK |
| 7548 | Head 5250MHz | July.10,2021 | 5250 MHz | OK |
| 7548 | Head 5600MHz | July.10,2021 | 5600 MHz | OK |
| 7548 | Head 5750MHz | July.10,2021 | 5750 MHz | OK |



I.8 Probe Calibration Certificate

Probe 7548 Calibration Certificate



中国认可
国际互认
校准
CALIBRATION
CNAS L0570

Add: No.52 HuaYuanBei Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2512 Fax: +86-10-62304633-2504
E-mail: cttl@chinattl.com [Http://www.chinattl.cn](http://www.chinattl.cn)

Client **CTTL**

Certificate No: **Z21-60231**

CALIBRATION CERTIFICATE

Object: **EX3DV4 - SN : 7548**

Calibration Procedure(s): **FF-Z11-004-02
Calibration Procedures for Dosimetric E-field Probes**

Calibration date: **June 25, 2021**

This calibration Certificate documents the traceability to national standards, which realize the physical units of measurements(SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature(22±3)°C and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
|--------------------------|-------------|--|-----------------------|
| Power Meter NRP2 | 101919 | 15-Jun-21(CTTL, No.J21X04466) | Jun-22 |
| Power sensor NRP-Z91 | 101547 | 15-Jun-21(CTTL, No.J21X04466) | Jun-22 |
| Power sensor NRP-Z91 | 101548 | 15-Jun-21(CTTL, No.J21X04466) | Jun-22 |
| Reference 10dBAttenuator | 18N50W-10dB | 10-Feb-20(CTTL, No.J20X00525) | Feb-22 |
| Reference 20dBAttenuator | 18N50W-20dB | 10-Feb-20(CTTL, No.J20X00526) | Feb-22 |
| Reference Probe EX3DV4 | SN 3617 | 27-Jan-21(SPEAG, No.EX3-3617_Jan21) | Jan-22 |
| DAE4 | SN 1556 | 15-Jan-21(SPEAG, No.DAE4-1556_Jan21) | Jan-22 |

| Secondary Standards | ID # | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
|-------------------------|------------|--|-----------------------|
| SignalGenerator MG3700A | 6201052605 | 16-Jun-21(CTTL, No.J21X04467) | Jun-22 |
| Network Analyzer E5071C | MY46110673 | 21-Jan-21(CTTL, No.J20X00515) | Jan-22 |

| | Name | Function | Signature |
|----------------|--------------------|--------------------|-----------|
| Calibrated by: | Yu Zongying | SAR Test Engineer | |
| Reviewed by: | Lin Hao | SAR Test Engineer | |
| Approved by: | Qi Dianyuan | SAR Project Leader | |

Issued: June 27, 2021

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



Add: No.52 HuaYuanBei Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2512 Fax: +86-10-62304633-2504
E-mail: cttl@chinattl.com Http://www.chinattl.cn

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
θ=0 is normal to probe axis

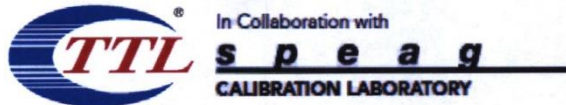
Connector Angle information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- NORMx,y,z: Assessed for E-field polarization θ=0 (f≤900MHz in TEM-cell; f>1800MHz: waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not effect the E2-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 (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; VRx,y,z:A,B,C 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≤800MHz) and inside waveguide using analytical field distributions based on power measurements for f >800MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty valued 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±50MHz to±100MHz.
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).



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DASY/EASY – Parameters of Probe: EX3DV4 – SN:7548

Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|--|----------|----------|----------|--------------|
| Norm($\mu\text{V}/(\text{V}/\text{m})^2$) ^A | 0.61 | 0.69 | 0.62 | $\pm 10.0\%$ |
| DCP(mV) ^B | 100.7 | 101.3 | 102.5 | |

Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB $\sqrt{\mu\text{V}}$ | C | D dB | VR mV | Unc ^E (k=2) |
|-----|---------------------------|---|------|---------------------------|-----|------|-------|------------------------|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 212.9 | $\pm 2.0\%$ |
| | | Y | 0.0 | 0.0 | 1.0 | | 221.6 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 208.4 | |

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 E²-field uncertainty inside TSL (see Page 4).

^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.



In Collaboration with
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DASY/EASY – Parameters of Probe: EX3DV4 – SN:7548

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) | Unct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 750 | 41.9 | 0.89 | 10.36 | 10.36 | 10.36 | 0.40 | 0.70 | ±12.1% |
| 900 | 41.5 | 0.97 | 9.74 | 9.74 | 9.74 | 0.16 | 1.28 | ±12.1% |
| 1450 | 40.5 | 1.20 | 8.55 | 8.55 | 8.55 | 0.41 | 0.73 | ±12.1% |
| 1750 | 40.1 | 1.37 | 8.14 | 8.14 | 8.14 | 0.31 | 0.93 | ±12.1% |
| 1900 | 40.0 | 1.40 | 7.88 | 7.88 | 7.88 | 0.29 | 0.99 | ±12.1% |
| 2000 | 40.0 | 1.40 | 7.95 | 7.95 | 7.95 | 0.21 | 1.17 | ±12.1% |
| 2300 | 39.5 | 1.67 | 7.60 | 7.60 | 7.60 | 0.64 | 0.67 | ±12.1% |
| 2450 | 39.2 | 1.80 | 7.35 | 7.35 | 7.35 | 0.64 | 0.68 | ±12.1% |
| 2600 | 39.0 | 1.96 | 7.11 | 7.11 | 7.11 | 0.49 | 0.81 | ±12.1% |
| 3300 | 38.2 | 2.71 | 6.79 | 6.79 | 6.79 | 0.47 | 0.89 | ±13.3% |
| 3500 | 37.9 | 2.91 | 6.64 | 6.64 | 6.64 | 0.40 | 1.05 | ±13.3% |
| 3700 | 37.7 | 3.12 | 6.42 | 6.42 | 6.42 | 0.42 | 1.03 | ±13.3% |
| 3900 | 37.5 | 3.32 | 6.27 | 6.27 | 6.27 | 0.35 | 1.40 | ±13.3% |
| 4100 | 37.2 | 3.53 | 6.30 | 6.30 | 6.30 | 0.40 | 1.15 | ±13.3% |
| 4200 | 37.1 | 3.63 | 6.15 | 6.15 | 6.15 | 0.35 | 1.35 | ±13.3% |
| 4400 | 36.9 | 3.84 | 6.05 | 6.05 | 6.05 | 0.35 | 1.35 | ±13.3% |
| 4600 | 36.7 | 4.04 | 5.98 | 5.98 | 5.98 | 0.40 | 1.30 | ±13.3% |
| 4800 | 36.4 | 4.25 | 5.93 | 5.93 | 5.93 | 0.40 | 1.30 | ±13.3% |
| 4950 | 36.3 | 4.40 | 5.74 | 5.74 | 5.74 | 0.40 | 1.35 | ±13.3% |
| 5250 | 35.9 | 4.71 | 5.05 | 5.05 | 5.05 | 0.45 | 1.30 | ±13.3% |
| 5600 | 35.5 | 5.07 | 4.68 | 4.68 | 4.68 | 0.45 | 1.40 | ±13.3% |
| 5750 | 35.4 | 5.22 | 4.73 | 4.73 | 4.73 | 0.50 | 1.35 | ±13.3% |

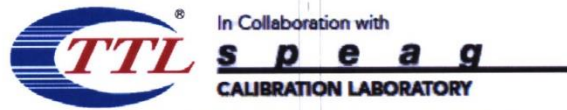
^C Frequency validity above 300 MHz of ±100MHz only applies for DASY v4.4 and higher (Page 2), else it is restricted to ±50MHz. The uncertainty is the RSS of ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 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 frequency 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 the frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

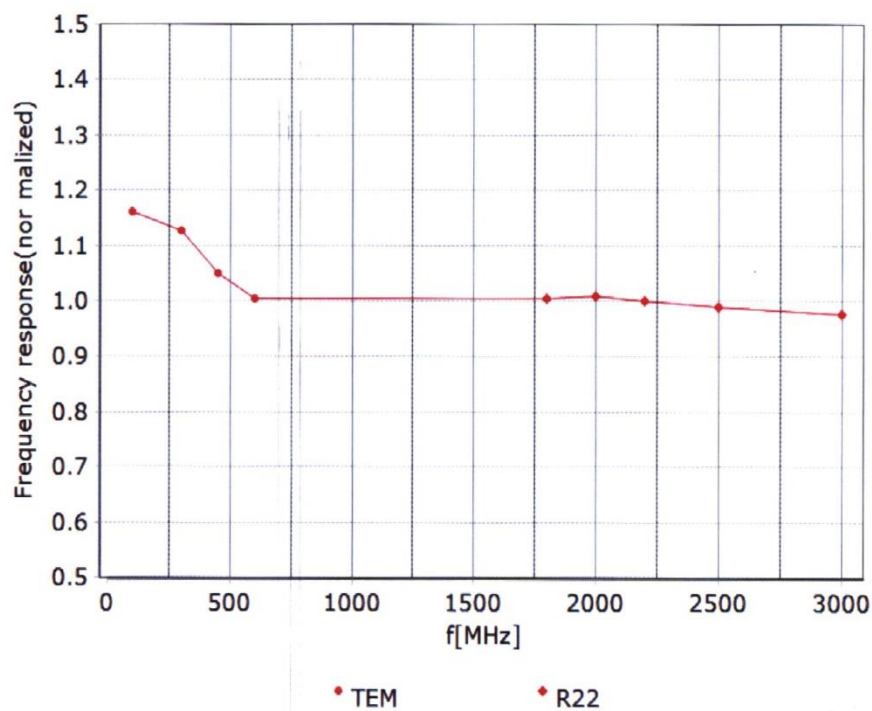
Certificate No:Z21-60231

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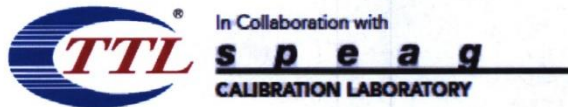


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Frequency Response of E-Field (TEM-Cell: ifi110 EXX, Waveguide: R22)



Uncertainty of Frequency Response of E-field: $\pm 7.4\%$ ($k=2$)

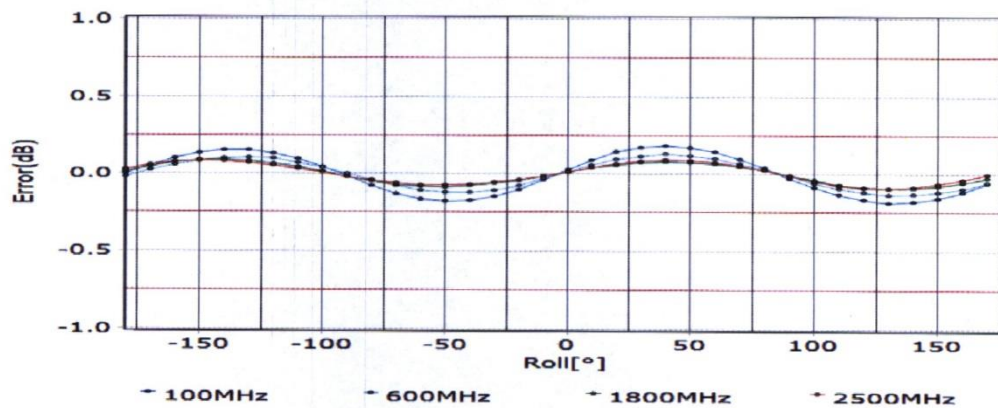
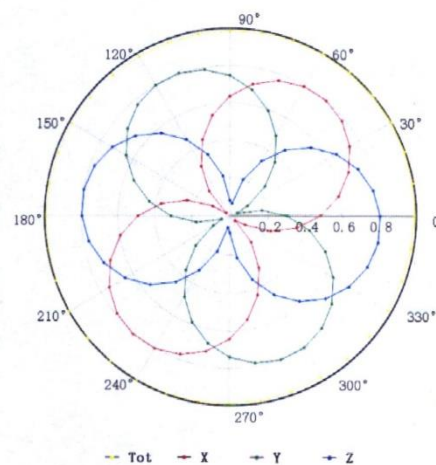
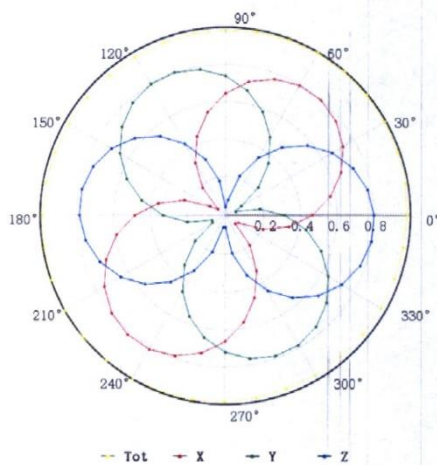


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Receiving Pattern (Φ), $\theta=0^\circ$

f=600 MHz, TEM

f=1800 MHz, R22

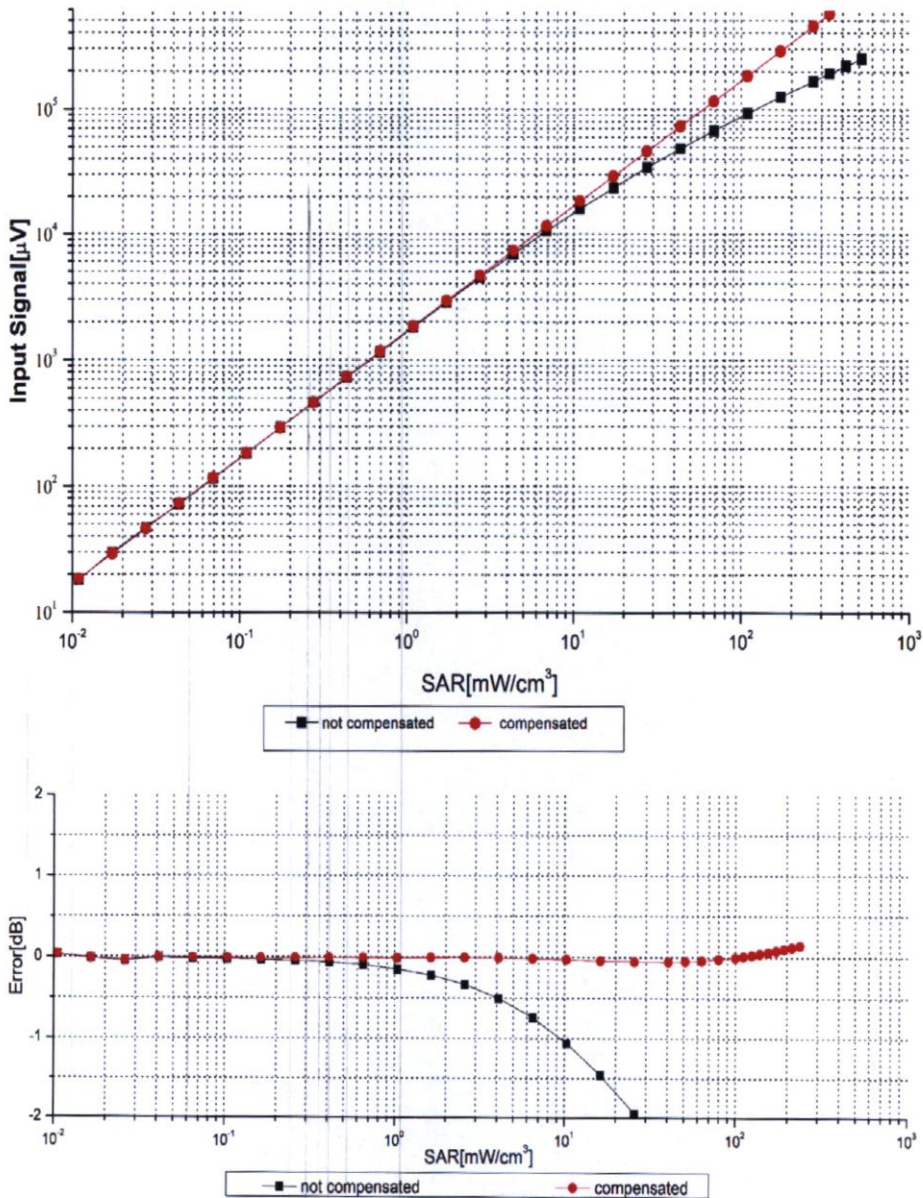


Uncertainty of Axial Isotropy Assessment: $\pm 1.2\%$ ($k=2$)

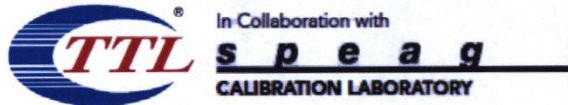


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Dynamic Range f(SAR_{head}) (TEM cell, f = 900 MHz)



Uncertainty of Linearity Assessment: ±0.9% (k=2)

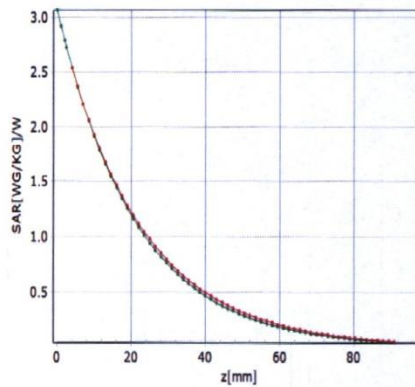


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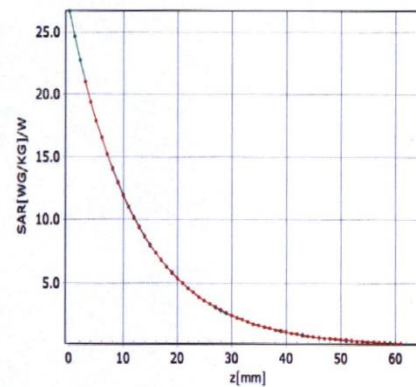
Conversion Factor Assessment

f=750 MHz,WGLS R9(H_convF)

f=1750 MHz,WGLS R22(H_convF)

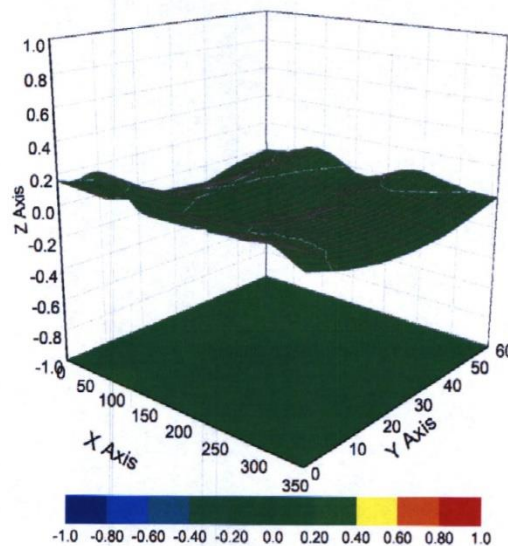


* analytical * measured

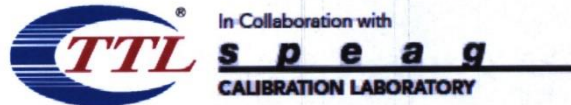


* analytical * measured

Deviation from Isotropy in Liquid



Uncertainty of Spherical Isotropy Assessment: $\pm 3.2\%$ ($k=2$)



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DASY/EASY – Parameters of Probe: EX3DV4 – SN:7548

Other Probe Parameters

| | |
|---|------------|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | 152.2 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disable |
| Probe Overall Length | 337mm |
| Probe Body Diameter | 10mm |
| Tip Length | 9mm |
| Tip Diameter | 2.5mm |
| Probe Tip to Sensor X Calibration Point | 1mm |
| Probe Tip to Sensor Y Calibration Point | 1mm |
| Probe Tip to Sensor Z Calibration Point | 1mm |
| Recommended Measurement Distance from Surface | 1.4mm |



No.I21Z62138-SEM02

I.9 Dipole Calibration Certificate

2450 MHz Dipole Calibration Certificate

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



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

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

Accreditation No.: SCS 0108

Client **CTTL (Auden)**

Certificate No: **D2450V2-853_Jul21**

CALIBRATION CERTIFICATE

Object **D2450V2 - SN:853**

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

Calibration date: **July 26, 2021**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---------------------------------|--------------------|-----------------------------------|------------------------|
| Power meter NRP | SN: 104778 | 09-Apr-21 (No. 217-03291/03292) | Apr-22 |
| Power sensor NRP-Z91 | SN: 103244 | 09-Apr-21 (No. 217-03291) | Apr-22 |
| Power sensor NRP-Z91 | SN: 103245 | 09-Apr-21 (No. 217-03292) | Apr-22 |
| Reference 20 dB Attenuator | SN: BH9394 (20k) | 09-Apr-21 (No. 217-03343) | Apr-22 |
| Type-N mismatch combination | SN: 310982 / 06327 | 09-Apr-21 (No. 217-03344) | Apr-22 |
| Reference Probe EX3DV4 | SN: 7349 | 28-Dec-20 (No. EX3-7349_Dec20) | Dec-21 |
| DAE4 | SN: 601 | 02-Nov-20 (No. DAE4-601_Nov20) | Nov-21 |
| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
| Power meter E4419B | SN: GB39512475 | 30-Oct-14 (in house check Oct-20) | In house check: Oct-22 |
| Power sensor HP 8481A | SN: US37292783 | 07-Oct-15 (in house check Oct-20) | In house check: Oct-22 |
| Power sensor HP 8481A | SN: MY41092317 | 07-Oct-15 (in house check Oct-20) | In house check: Oct-22 |
| RF generator R&S SMT-06 | SN: 100972 | 15-Jun-15 (in house check Oct-20) | In house check: Oct-22 |
| Network Analyzer Agilent E8358A | SN: US41080477 | 31-Mar-14 (in house check Oct-20) | In house check: Oct-21 |

| | | | |
|----------------|------------------------------|--|---------------|
| Calibrated by: | Name Michael Weber | Function Laboratory Technician | Signature |
| Approved by: | Name Katja Pokovic | Function Technical Manager | Signature |

Issued: July 26, 2021

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



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S Servizio svizzero di taratura
S Swiss Calibration Service

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

Accreditation No.: **SCS 0108**

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) IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices - Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
- b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

- c) DASY 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 source is mounted in a touch configuration below the center marking of the flat phantom.
- *Return Loss:* This parameter is measured with the source positioned under the liquid filled phantom (as described in the measurement condition clause). The Return Loss ensures low reflected power. 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 | DASY52 | V52.10.4 |
| 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 \pm 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 \pm 0.2) °C | 37.9 \pm 6 % | 1.88 mho/m \pm 6 % |
| Head TSL temperature change during test | < 0.5 °C | ---- | ---- |

SAR result with Head TSL

| SAR averaged over 1 cm ³ (1 g) of Head TSL | Condition | |
|---|--------------------|--|
| SAR measured | 250 mW input power | 13.7 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 53.3 W/kg \pm 17.0 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Head TSL | condition | |
|---|--------------------|--|
| SAR measured | 250 mW input power | 6.33 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 24.9 W/kg \pm 16.5 % (k=2) |

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

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 53.6 Ω + 3.8 j Ω |
| Return Loss | - 25.9 dB |

General Antenna Parameters and Design

| | |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.164 ns |
|----------------------------------|----------|

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

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

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

Additional EUT Data

| | |
|-----------------|-------|
| Manufactured by | SPEAG |
|-----------------|-------|

DASY5 Validation Report for Head TSL

Date: 26.07.2021

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 853

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.88$ S/m; $\epsilon_r = 37.9$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.96, 7.96, 7.96) @ 2450 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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 = 116.2 V/m; Power Drift = 0.09 dB

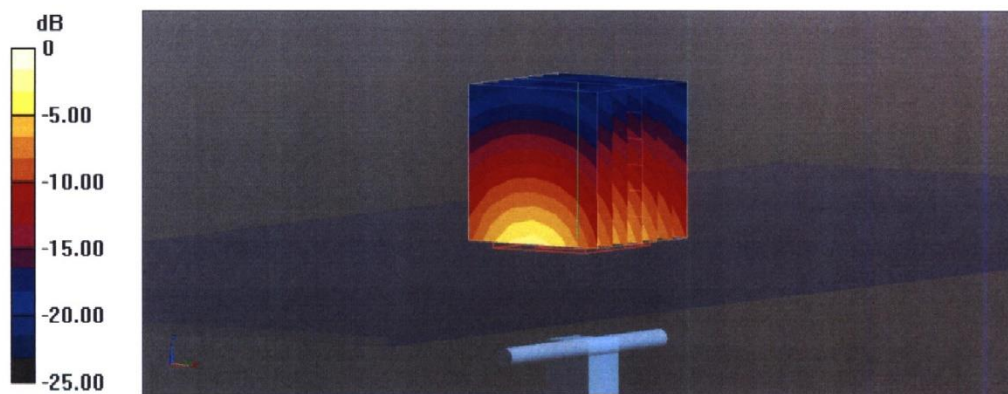
Peak SAR (extrapolated) = 27.4 W/kg

SAR(1 g) = 13.7 W/kg; SAR(10 g) = 6.33 W/kg

Smallest distance from peaks to all points 3 dB below = 9 mm

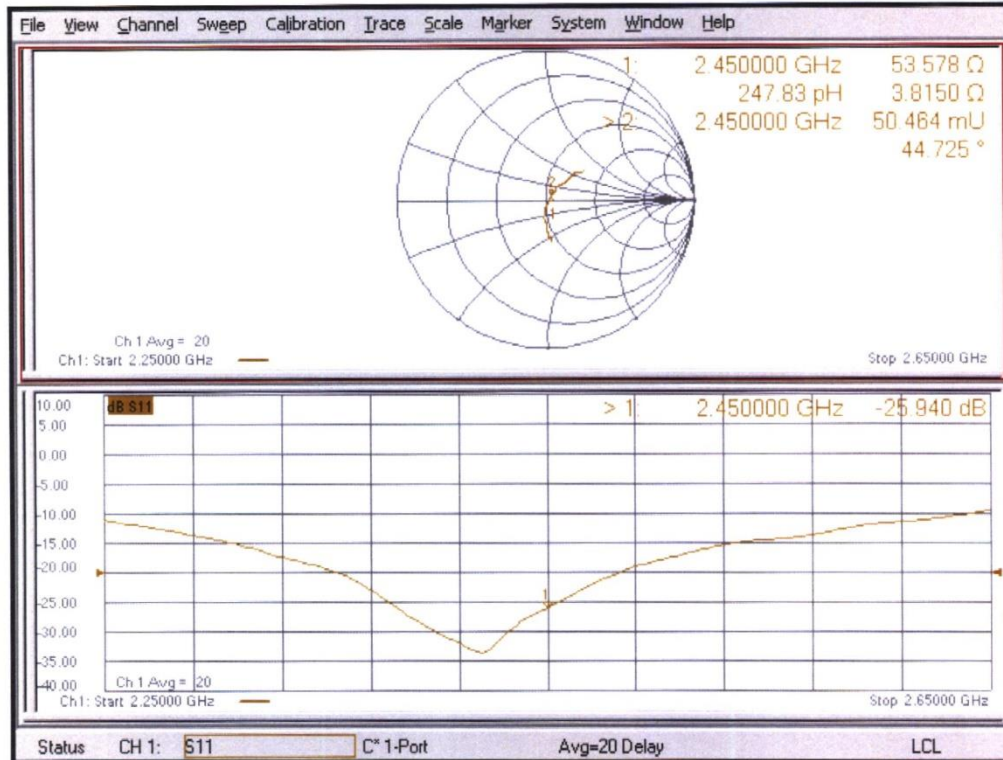
Ratio of SAR at M2 to SAR at M1 = 50%

Maximum value of SAR (measured) = 22.7 W/kg



0 dB = 22.7 W/kg = 13.56 dBW/kg

Impedance Measurement Plot for Head TSL



ANNEX J Accreditation Certificate

| | |
|---|---|
| United States Department of Commerce National Institute of Standards and Technology | |
|   | |
| <hr/> Certificate of Accreditation to ISO/IEC 17025:2017 <hr/> | |
| NVLAP LAB CODE: 600118-0 | |
| Telecommunication Technology Labs, CAICT Beijing China | |
| <i>is accredited by the National Voluntary Laboratory Accreditation Program for specific services, listed on the Scope of Accreditation, for:</i> | |
| Electromagnetic Compatibility & Telecommunications | |
| <i>This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communique dated January 2009).</i> | |
| <hr/> 2021-09-29 through 2022-09-30 <i>Effective Dates</i> |  <hr/> <i>[Signature]</i> <i>For the National Voluntary Laboratory Accreditation Program</i> |