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CALIBRATION LABORATORY

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CALIBRATION
No. L0570

Client NIM Certificate No: Z14-97101

# CALIBRATION CERTIFICATE

Object D2450V2 - SN: 919

Calibration Procedure(s) TMC-OS-E-02-194
Calibration procedure for dipole validation kits

Calibration date: September 17, 2014

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)℃ and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power Meter NRVD | 102196 | 14-Mar-14 (CTTL, No.JZ14-896) | Mar-15 |
| Power sensor NRV-Z5 | 100596 | 14-Mar-14 (CTTL, No. JZ14-896) | Mar -15 |
| Reference Probe ES3DV3 | SN 3142 | 1- Sep-14 (CTTL-SPEAG, No.JZ14-97079) | Aug-15 |
| DAE3 | SN 536 | 23-Jan-14 (SPEAG, DAE3-536_Jan14) | Jan -15 |
| Signal Generator E4438C | MY49070393 | 13-Nov-13 (TMC, No.JZ13-394) | Nov-14 |
| Network Analyzer E8362B | MY43021135 | 19-Oct-13 (TMC, No.JZ13-278) | Oct-14 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Zhao Jing | SAR Test Engineer | |
| Reviewed by: | Qi Dianyuan | SAR Project Leader | |
| Approved by: | Lu Bingsong | Deputy Director of the laboratory | |

Issued: September 30, 2014

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**Glossary:**

| | |
|---|---|
| TSL | tissue simulating liquid |
| ConvF | sensitivity in TSL / NORMx,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 300MHz to 3GHz)", February 2005

c) KDB865664, SAR Measurement Requirements for 100 MHz to 6 GHz

**Additional Documentation:**

d) DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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

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## Measurement Conditions

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

| | | |
|---|---|---|
| **DASY Version** | DASY52 | 52.8.8.1222 |
| **Extrapolation** | Advanced Extrapolation | |
| **Phantom** | Triple Flat Phantom 5.1C | |
| **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 | 39.8 ± 6 % | 1.85 mho/m ± 6 % |
| **Head TSL temperature change during test** | <1.0 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 13.0 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | **51.5 mW /g ± 20.8 % (k=2)** |
| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | Condition | |
| SAR measured | 250 mW input power | 6.03 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | **24.0 mW /g ± 20.4 % (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 | 51.2 ± 6 % | 1.97 mho/m ± 6 % |
| **Body TSL temperature change during test** | <1.0 °C | ---- | ---- |

## SAR result with Body TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 12.8 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | **50.7 mW /g ± 20.8 % (k=2)** |
| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | Condition | |
| SAR measured | 250 mW input power | 6.02 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | **23.9 mW /g ± 20.4 % (k=2)** |

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## Appendix

### Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 56.6Ω- 0.44jΩ |
| Return Loss | - 24.1dB |

### Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 56.2Ω+ 2.77jΩ |
| Return Loss | - 23.9dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.117 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 |

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CNAS CALIBRATION No. L0570

**DASY5 Validation Report for Head TSL** Date: 17.09.2014

Test Laboratory: CTTL, Beijing, China

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 919**

Communication System: UID 0, CW; Frequency: 2450 MHz;Duty Cycle: 1:1

Medium parameters used: f = 2450 MHz; $\sigma$ = 1.852 S/m; $\varepsilon_r$ = 39.76; $\rho$ = 1000 kg/m$^3$

Phantom section: Center Section

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

DASY5 Configuration:

- Probe: ES3DV3 - SN3142; ConvF(4.58, 4.58, 4.58); Calibrated: 2014-09-01;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn536; Calibrated: 2014-01-23
- Phantom: Triple Flat Phantom 5.1C; Type: QD 000 P51 CA; Serial: 1161/2
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

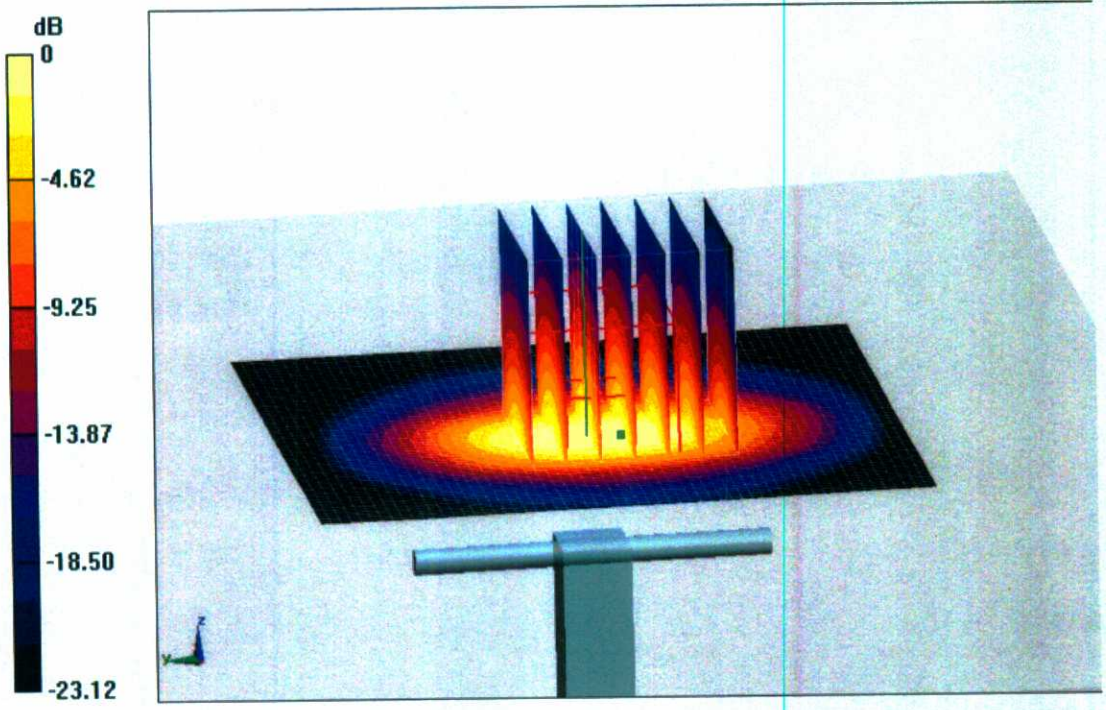
**System Performance Check /d=10mm, Pin=250 mW, dist=3.0mm (ES-Probe)/Zoom Scan (7x7x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 98.50 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 27.8 W/kg

**SAR(1 g) = 13 W/kg; SAR(10 g) = 6.03 W/kg**

Maximum value of SAR (measured) = 17.1 W/kg




**0 dB = 17.1 W/kg = 12.33 dBW/kg**

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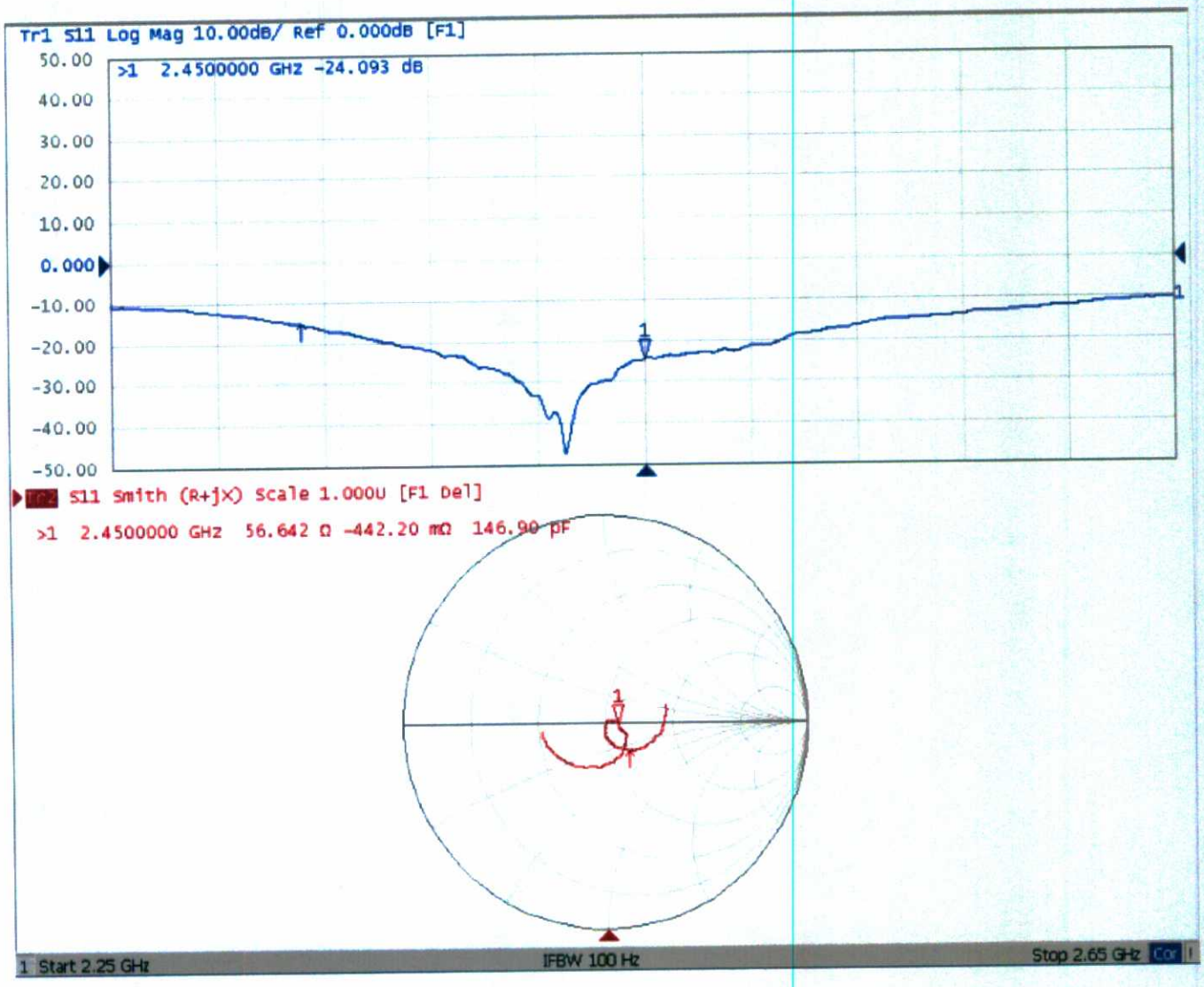
CALIBRATION
No. L0570

## Impedance Measurement Plot for Head TSL



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CALIBRATION
No. L0570

**DASY5 Validation Report for Body TSL** Date: 17.09.2014

Test Laboratory: CTTL, Beijing, China

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 919**

Communication System: UID 0, CW; Frequency: 2450 MHz;Duty Cycle: 1:1

Medium parameters used: f = 2450 MHz; $\sigma$ = 1.966 S/m; $\varepsilon_r$ = 51.18; $\rho$ = 1000 kg/m$^3$

Phantom section: Right Section

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

DASY5 Configuration:

- Probe: ES3DV3 - SN3142; ConvF(4.29, 4.29, 4.29); Calibrated: 2014-09-01;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn536; Calibrated: 2014-01-23
- Phantom: Triple Flat Phantom 5.1C; Type: QD 000 P51 CA; Serial: 1161/3
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

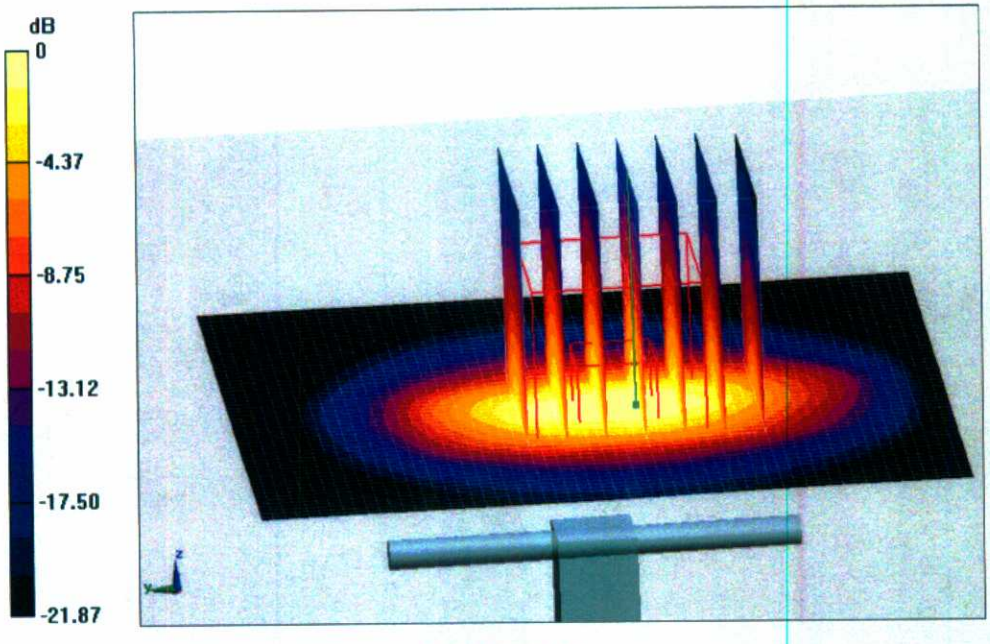
**System Performance Check /d=10mm, Pin=250 mW, dist=3.0mm (ES-Probe)/Zoom Scan (7x7x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 94.44 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 25.7 W/kg

**SAR(1 g) = 12.8 W/kg; SAR(10 g) = 6.02 W/kg**

Maximum value of SAR (measured) = 16.7 W/kg




**0 dB = 16.7 W/kg = 12.23 dBW/kg**

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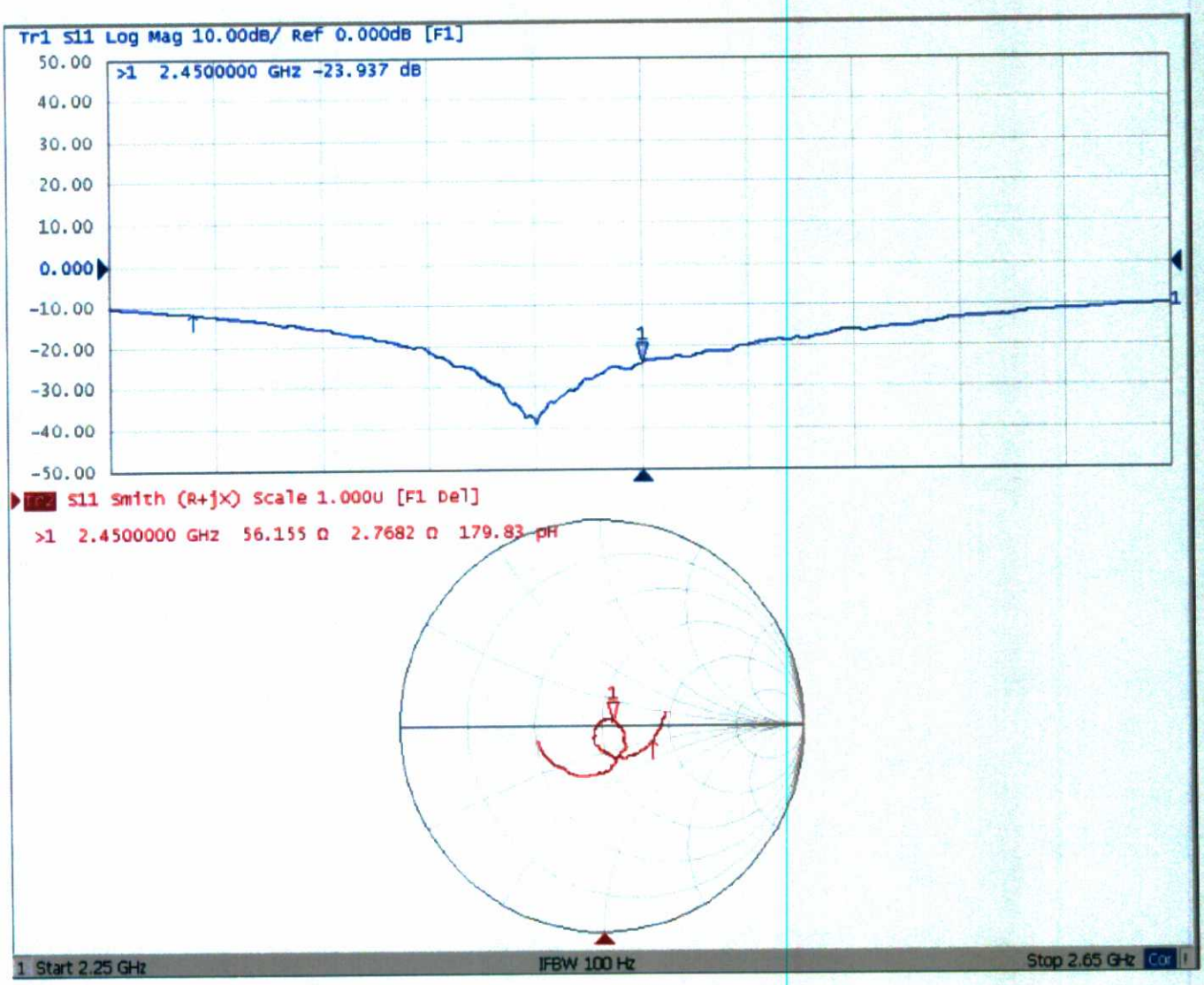
CALIBRATION
No. L0570

## Impedance Measurement Plot for Body TSL



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CALIBRATION
No. L0570

Client NIM Certificate No: Z14-97102

# CALIBRATION CERTIFICATE

Object D2600V2 - SN: 1067

Calibration Procedure(s) TMC-OS-E-02-194
Calibration procedure for dipole validation kits

Calibration date: September 18, 2014

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)℃ and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power Meter NRVD | 102196 | 14-Mar-14 (CTTL, No.JZ14-896) | Mar-15 |
| Power sensor NRV-Z5 | 100596 | 14-Mar-14 (CTTL, No. JZ14-896) | Mar -15 |
| Reference Probe ES3DV3 | SN 3142 | 1- Sep-14 (CTTL-SPEAG, No.JZ14-97079) | Aug-15 |
| DAE3 | SN 536 | 23-Jan-14 (SPEAG, DAE3-536_Jan14) | Jan -15 |
| Signal Generator E4438C | MY49070393 | 13-Nov-13 (TMC, No.JZ13-394) | Nov-14 |
| Network Analyzer E8362B | MY43021135 | 19-Oct-13 (TMC, No.JZ13-278) | Oct-14 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Zhao Jing | SAR Test Engineer | |
| Reviewed by: | Qi Dianyuan | SAR Project Leader | |
| Approved by: | Lu Bingsong | Deputy Director of the laboratory | |

Issued: September 30, 2014

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**Glossary:**

| | |
|---|---|
| TSL | tissue simulating liquid |
| ConvF | sensitivity in TSL / NORMx,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 300MHz to 3GHz)", February 2005

c) KDB865664, SAR Measurement Requirements for 100 MHz to 6 GHz

**Additional Documentation:**

d) DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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

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## Measurement Conditions

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

| | | |
|---|---|---|
| **DASY Version** | DASY52 | 52.8.8.1222 |
| **Extrapolation** | Advanced Extrapolation | |
| **Phantom** | Triple Flat Phantom 5.1C | |
| **Distance Dipole Center - TSL** | 10 mm | with Spacer |
| **Zoom Scan Resolution** | dx, dy, dz = 5 mm | |
| **Frequency** | 2600 MHz ± 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 ± 0.2) °C | 38.5 ± 6 % | 1.98 mho/m ± 6 % |
| **Head TSL temperature change during test** | <1.0 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 14.6 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | **58.0 mW /g ± 20.8 % (k=2)** |
| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | Condition | |
| SAR measured | 250 mW input power | 6.40 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | **25.5 mW /g ± 20.4 % (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 ± 0.2) °C | 52.1 ± 6 % | 2.20 mho/m ± 6 % |
| **Body TSL temperature change during test** | <1.0 °C | ---- | ---- |

## SAR result with Body TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 14.5 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | **57.4 mW /g ± 20.8 % (k=2)** |
| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | Condition | |
| SAR measured | 250 mW input power | 6.43 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | **25.6 mW /g ± 20.4 % (k=2)** |

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## Appendix

### Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 44.4Ω- 7.17jΩ |
| Return Loss | - 20.4dB |

### Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 44.5Ω- 3.57jΩ |
| Return Loss | - 23.2dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.041 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 |

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**DASY5 Validation Report for Head TSL** Date: 18.09.2014

Test Laboratory: CTTL, Beijing, China

**DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1067**

Communication System: UID 0, CW; Frequency: 2600 MHz;Duty Cycle: 1:1

Medium parameters used: f = 2600 MHz; $\sigma$ = 1.979 S/m; $\varepsilon_r$ = 38.54; $\rho$ = 1000 kg/m$^3$

Phantom section: Center Section

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

DASY5 Configuration:

- Probe: ES3DV3 - SN3142; ConvF(4.42, 4.42, 4.42); Calibrated: 2014-09-01;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn536; Calibrated: 2014-01-23
- Phantom: Triple Flat Phantom 5.1C; Type: QD 000 P51 CA; Serial: 1161/2
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

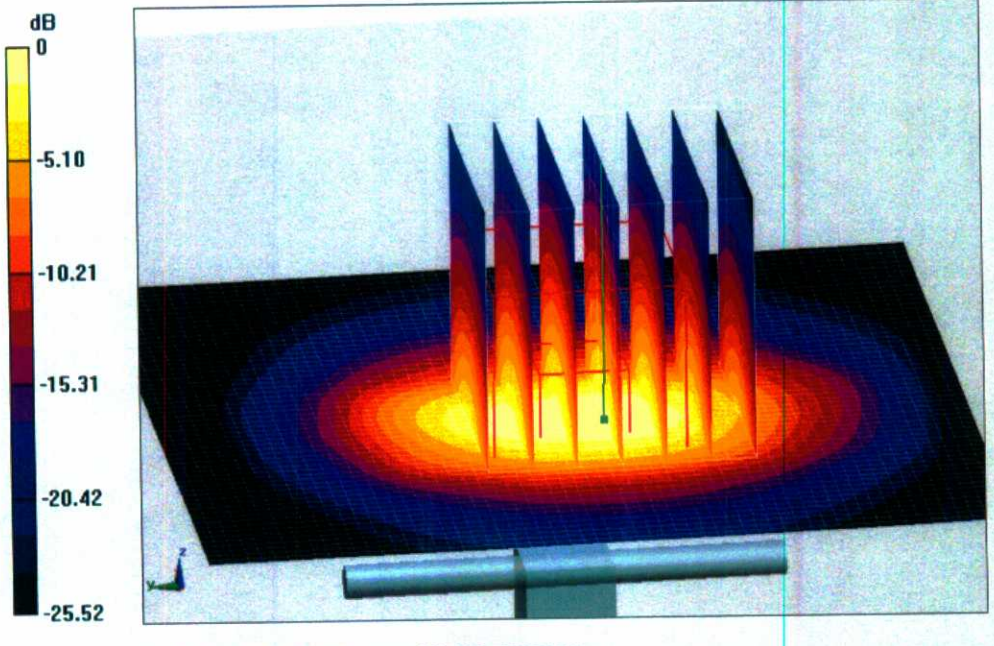
**System Performance Check /d=10mm, Pin=250 mW, dist=3.0mm (ES-Probe)/Zoom Scan (7x7x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 101.4 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 32.7 W/kg

**SAR(1 g) = 14.6 W/kg; SAR(10 g) = 6.4 W/kg**

Maximum value of SAR (measured) = 19.3 W/kg




**0 dB = 19.3 W/kg = 12.86 dBW/kg**

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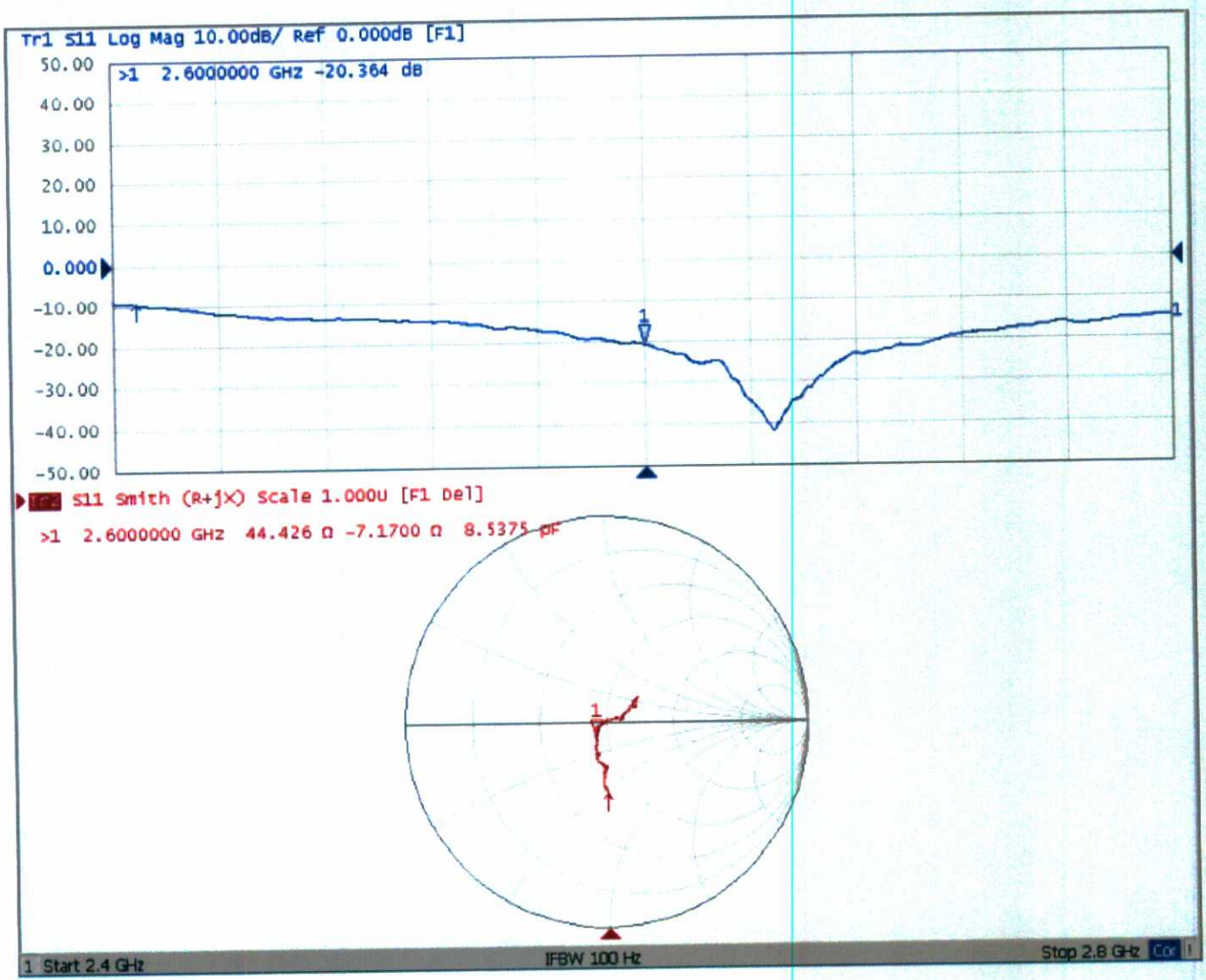
## Impedance Measurement Plot for Head TSL



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**DASY5 Validation Report for Body TSL** Date: 17.09.2014

Test Laboratory: CTTL, Beijing, China

**DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1067**

Communication System: UID 0, CW; Frequency: 2600 MHz;Duty Cycle: 1:1

Medium parameters used: f = 2600 MHz; $\sigma$ = 2.204 S/m; $\varepsilon_r$ = 52.12; $\rho$ = 1000 kg/m$^3$

Phantom section: Right Section

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

DASY5 Configuration:

- Probe: ES3DV3 - SN3142; ConvF(4.13, 4.13, 4.13); Calibrated: 2014-09-01;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn536; Calibrated: 2014-01-23
- Phantom: Triple Flat Phantom 5.1C; Type: QD 000 P51 CA; Serial: 1161/3
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

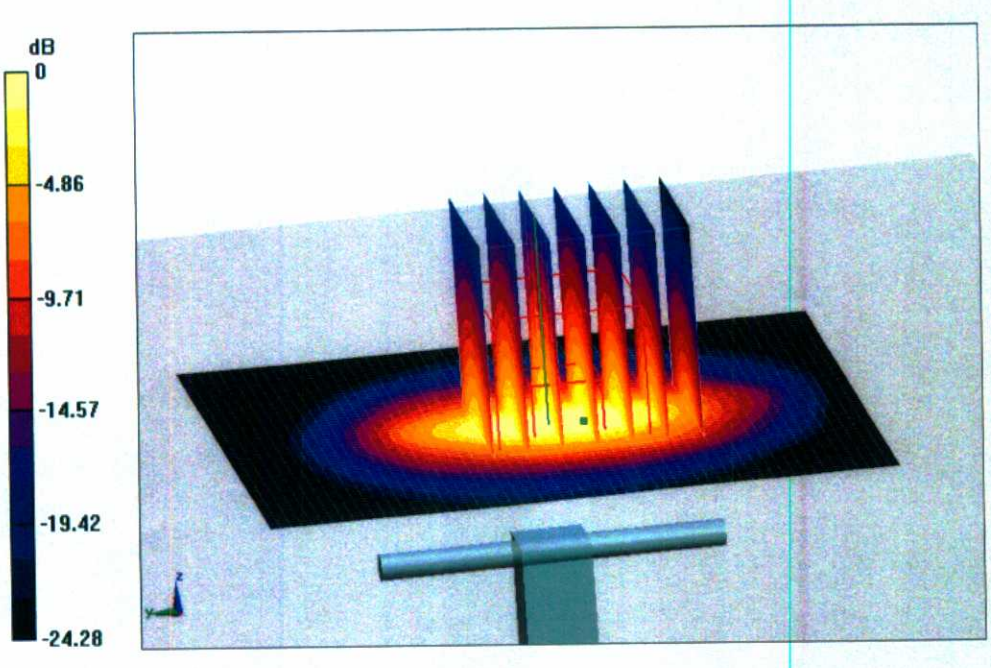
**System Performance Check /d=10mm, Pin=250 mW, dist=3.0mm (ES-Probe)/Zoom Scan (7x7x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 93.92 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 30.6 W/kg

**SAR(1 g) = 14.5 W/kg; SAR(10 g) = 6.43 W/kg**

Maximum value of SAR (measured) = 19.2 W/kg




**0 dB = 19.2 W/kg = 12.83 dBW/kg**

In Collaboration with
s p e a g
CALIBRATION LABORATORY

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CALIBRATION
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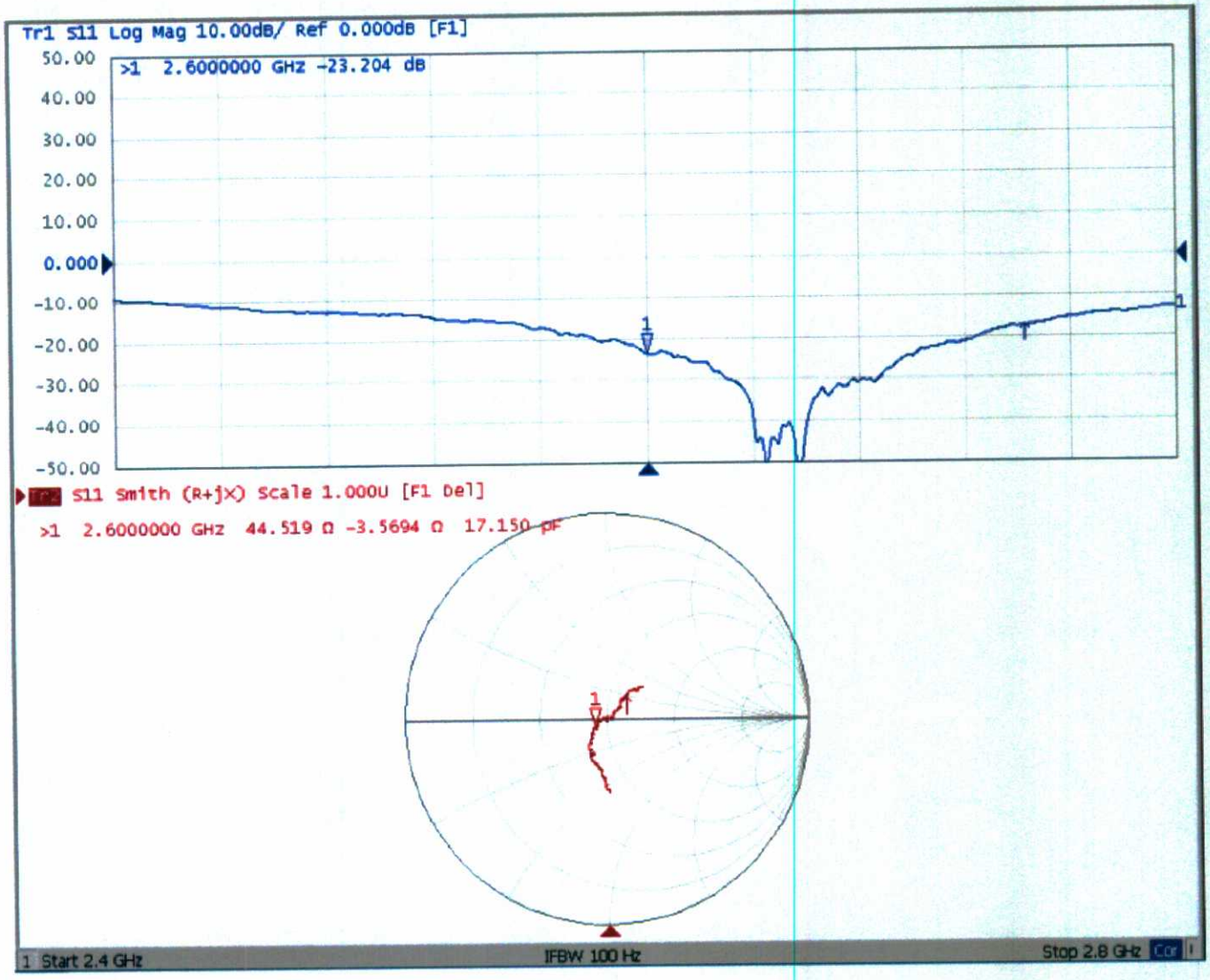
## Impedance Measurement Plot for Body TSL