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 CALIBRATION LABORATORY

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 CALIBRATION
 CNAS L0570

Client

Sporton

Certificate No: Z18-60320

CALIBRATION CERTIFICATE

Object D835V2 - SN: 499

Calibration Procedure(s) FF-Z11-003-01
 Calibration Procedures for dipole validation kits

Calibration date: September 6, 2018

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 NRVD | 102083 | 01-Nov-17 (CTTL, No.J17X08756) | Oct-18 |
| Power sensor NRV-Z5 | 100542 | 01-Nov-17 (CTTL, No.J17X08756) | Oct-18 |
| Reference Probe EX3DV4 | SN 7464 | 12-Sep-17(SPEAG, No.EX3-7464_Sep17) | Sep-18 |
| DAE4 | SN 1524 | 13-Sep-17(SPEAG, No.DAE4-1524_Sep17) | Sep-18 |
| Secondary Standards | ID # | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
| Signal Generator E4438C | MY49071430 | 23-Jan-18 (CTTL, No.J18X00560) | Jan-19 |
| Network Analyzer E5071C | MY46110673 | 24-Jan-18 (CTTL, No.J18X00561) | Jan-19 |

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

Issued: September 9, 2018

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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, "Measurement procedure for assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices- Part 1: Device used next to the ear (Frequency range of 300MHz to 6GHz)", July 2016
- c) IEC 62209-2, "Procedure to measure the Specific Absorption Rate (SAR) For wireless communication devices used in close proximity to the human body (frequency range of 30MHz to 6GHz)", March 2010
- d) KDB865664, 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%.



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Measurement Conditions

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

| | | |
|-------------------------------------|--------------------------|-------------|
| DASY Version | DASY52 | |
| Extrapolation | Advanced Extrapolation | |
| Phantom | Triple Flat Phantom 5.1C | |
| Distance Dipole Center - TSL | 15 mm | with Spacer |
| Zoom Scan Resolution | dx, dy, dz = 5 mm | |
| Frequency | 835 MHz ± 1 MHz | |

Head TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|--|-----------------|--------------|------------------|
| Nominal Head TSL parameters | 22.0 °C | 41.5 | 0.90 mho/m |
| Measured Head TSL parameters | (22.0 ± 0.2) °C | 42.7 ± 6 % | 0.90 mho/m ± 6 % |
| Head TSL temperature change during test | <1.0 °C | --- | --- |

SAR result with Head TSL

| | | |
|---|--------------------|---------------------------|
| SAR averaged over 1 cm³ (1 g) of Head TSL | Condition | |
| SAR measured | 250 mW input power | 2.39 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | 9.59 mW /g ± 18.8 % (k=2) |
| SAR averaged over 10 cm³ (10 g) of Head TSL | Condition | |
| SAR measured | 250 mW input power | 1.57 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | 6.29 mW /g ± 18.7 % (k=2) |

Body TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|--|-----------------|--------------|------------------|
| Nominal Body TSL parameters | 22.0 °C | 55.2 | 0.97 mho/m |
| Measured Body TSL parameters | (22.0 ± 0.2) °C | 56.0 ± 6 % | 1.00 mho/m ± 6 % |
| Body TSL temperature change during test | <1.0 °C | --- | --- |

SAR result with Body TSL

| | | |
|---|--------------------|---------------------------|
| SAR averaged over 1 cm³ (1 g) of Body TSL | Condition | |
| SAR measured | 250 mW input power | 2.50 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | 9.82 mW /g ± 18.8 % (k=2) |
| SAR averaged over 10 cm³ (10 g) of Body TSL | Condition | |
| SAR measured | 250 mW input power | 1.67 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | 6.58 mW /g ± 18.7 % (k=2) |



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Appendix (Additional assessments outside the scope of CNAS L0570)

Antenna Parameters with Head TSL

| | |
|--------------------------------------|---------------|
| Impedance, transformed to feed point | 52.5Ω- 2.59jΩ |
| Return Loss | - 29.1dB |

Antenna Parameters with Body TSL

| | |
|--------------------------------------|---------------|
| Impedance, transformed to feed point | 49.2Ω- 4.35jΩ |
| Return Loss | - 27.0dB |

General Antenna Parameters and Design

| | |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.255 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: 09.04.2018

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 499

Communication System: UID 0, CW; Frequency: 835 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 835 \text{ MHz}$; $\sigma = 0.904 \text{ S/m}$; $\epsilon_r = 42.71$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Right Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7464; ConvF(10.28, 10.28, 10.28) @ 835 MHz; Calibrated: 9/12/2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1524; Calibrated: 9/13/2017
- Phantom: MFP_V5.1C ; Type: QD 000 P51CA; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (1); SEMCAD X Version 14.6.11 (7439)

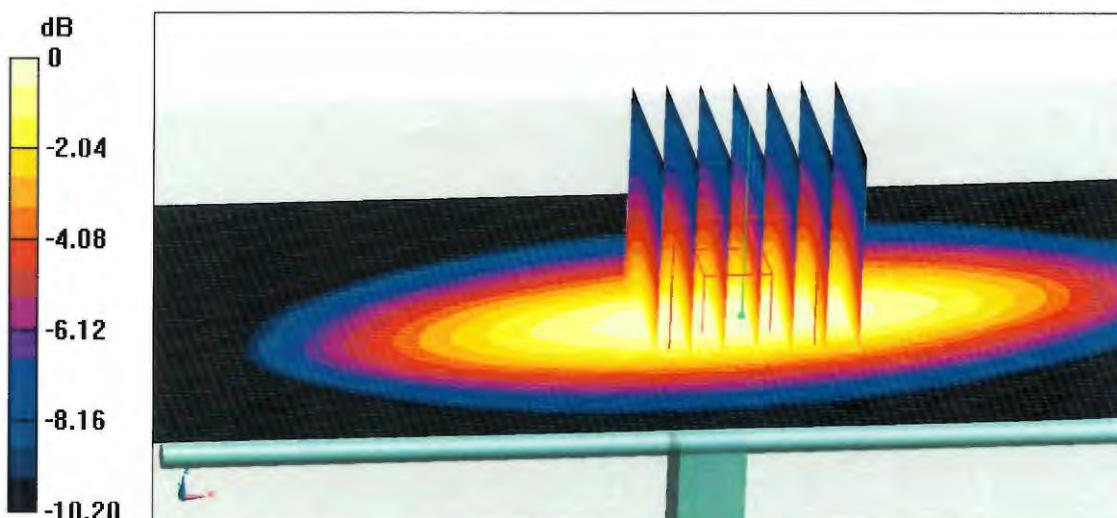
Dipole Calibration/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 58.24 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 3.57 W/kg

SAR(1 g) = 2.39 W/kg; SAR(10 g) = 1.57 W/kg

Maximum value of SAR (measured) = 3.17 W/kg

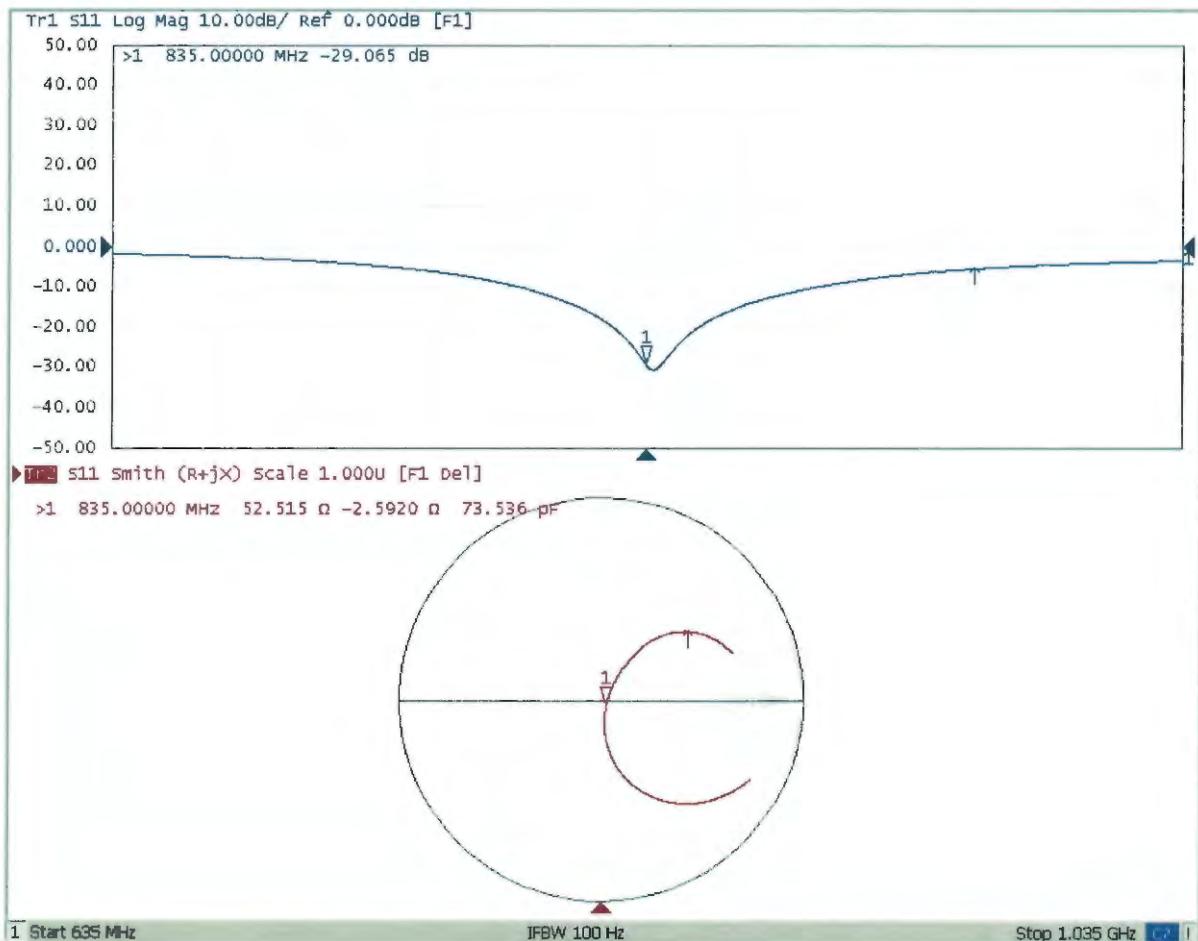




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Impedance Measurement Plot for Head TSL





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DASY5 Validation Report for Body TSL

Date: 09.06.2018

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 499

Communication System: UID 0, CW; Frequency: 835 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 835 \text{ MHz}$; $\sigma = 0.998 \text{ S/m}$; $\epsilon_r = 56.04$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7464; ConvF(10.21, 10.21, 10.21) @ 835 MHz; Calibrated: 9/12/2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1524; Calibrated: 9/13/2017
- Phantom: MFP_V5.1C ; Type: QD 000 P51CA; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (1); SEMCAD X Version 14.6.11 (7439)

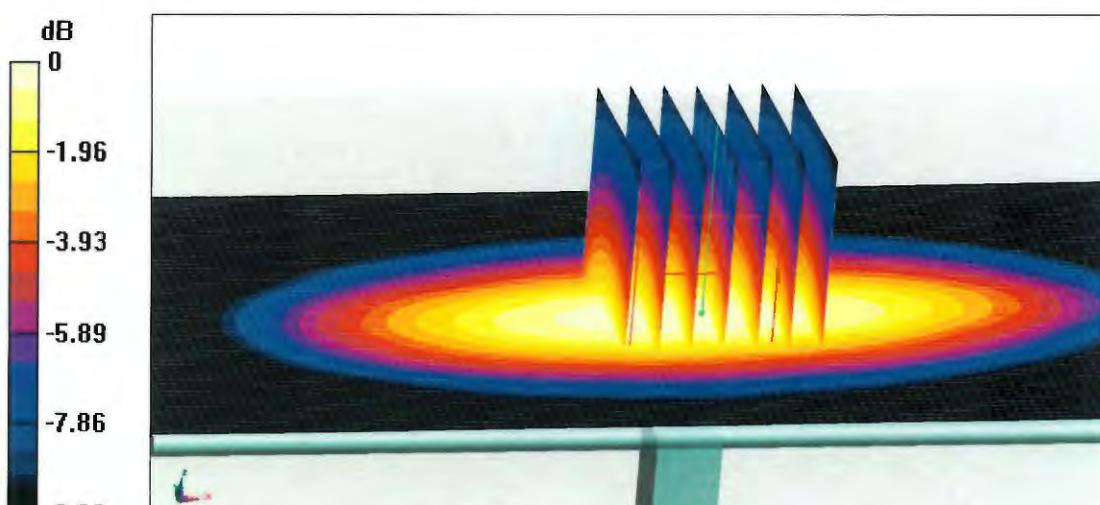
Dipole Calibration/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 55.93 V/m; Power Drift = -0.00 dB

Peak SAR (extrapolated) = 3.73 W/kg

SAR(1 g) = 2.5 W/kg; SAR(10 g) = 1.67 W/kg

Maximum value of SAR (measured) = 3.30 W/kg

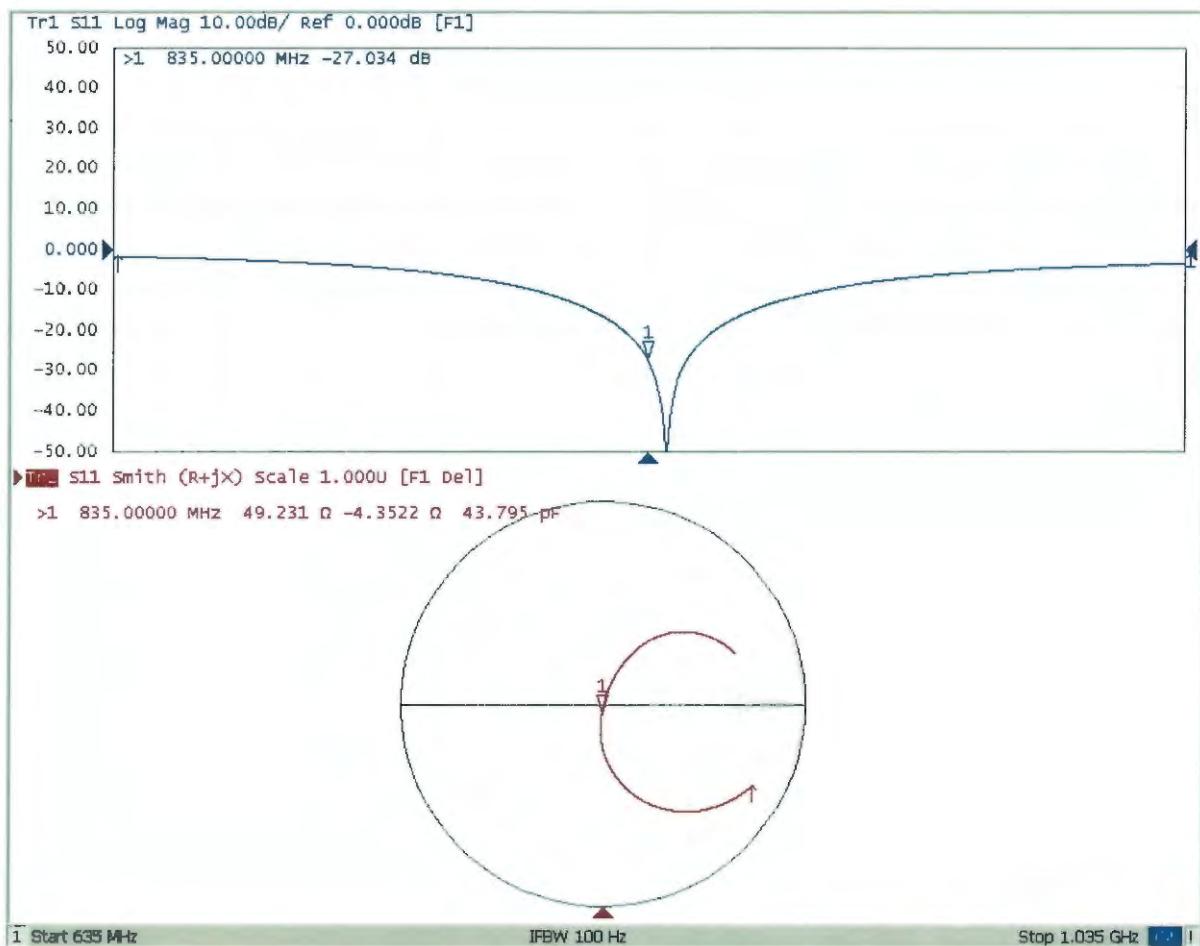




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Impedance Measurement Plot for Body TSL





Client

Sporton

Certificate No: Z18-60324

CALIBRATION CERTIFICATE

Object D1900V2 - SN: 5d041

Calibration Procedure(s) FF-Z11-003-01
 Calibration Procedures for dipole validation kits

Calibration date: September 11, 2018

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 NRVD | 102083 | 01-Nov-17 (CTTL, No.J17X08756) | Oct-18 |
| Power sensor NRV-Z5 | 100542 | 01-Nov-17 (CTTL, No.J17X08756) | Oct-18 |
| Reference Probe EX3DV4 | SN 7464 | 12-Sep-17(SPEAG, No.EX3-7464_Sep17) | Sep-18 |
| DAE4 | SN 1524 | 13-Sep-17(SPEAG, No.DAE4-1524_Sep17) | Sep-18 |
| Secondary Standards | ID # | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
| Signal Generator E4438C | MY49071430 | 23-Jan-18 (CTTL, No.J18X00560) | Jan-19 |
| NetworkAnalyzer E5071C | MY46110673 | 24-Jan-18 (CTTL, No.J18X00561) | Jan-19 |

| Calibrated by: | Name | Function | Signature |
|----------------|-------------|--------------------|-----------|
| | Zhao Jing | SAR Test Engineer | |
| Reviewed by: | Lin Jun | SAR Test Engineer | |
| Approved by: | Qi Dianyuan | SAR Project Leader | |

Issued: September 15, 2018

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lossary:

| | |
|-------|--------------------------------|
| 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, "Measurement procedure for assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices- Part 1: Device used next to the ear (Frequency range of 300MHz to 6GHz)", July 2016
- c) IEC 62209-2, "Procedure to measure the Specific Absorption Rate (SAR) For wireless communication devices used in close proximity to the human body (frequency range of 30MHz to 6GHz)", March 2010
- d) KDB865664, 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%.



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Measurement Conditions

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

| | | | |
|------------------------------|--------------------------|--|--------------|
| DASY Version | DASY52 | | 52.10.1.1476 |
| 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 | 1900 MHz ± 1 MHz | | |

Head TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|-----------------|--------------|------------------|
| Nominal Head TSL parameters | 22.0 °C | 40.0 | 1.40 mho/m |
| Measured Head TSL parameters | (22.0 ± 0.2) °C | 40.4 ± 6 % | 1.44 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 | 10.2 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | 40.2 mW /g ± 18.8 % (k=2) |
| SAR averaged over 10 cm ³ (10 g) of Head TSL | Condition | |
| SAR measured | 250 mW input power | 5.35 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | 21.2 mW /g ± 18.7 % (k=2) |

Body TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|-----------------|--------------|------------------|
| Nominal Body TSL parameters | 22.0 °C | 53.3 | 1.52 mho/m |
| Measured Body TSL parameters | (22.0 ± 0.2) °C | 53.3 ± 6 % | 1.49 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 | 9.94 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | 40.2 mW /g ± 18.8 % (k=2) |
| SAR averaged over 10 cm ³ (10 g) of Body TSL | Condition | |
| SAR measured | 250 mW input power | 5.35 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | 21.5 mW /g ± 18.7 % (k=2) |



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Appendix (Additional assessments outside the scope of CNAS L0570)

Antenna Parameters with Head TSL

| | |
|--------------------------------------|----------------------------|
| Impedance, transformed to feed point | $52.9\Omega + 7.43j\Omega$ |
| Return Loss | - 22.3dB |

Antenna Parameters with Body TSL

| | |
|--------------------------------------|----------------------------|
| Impedance, transformed to feed point | $47.6\Omega + 6.80j\Omega$ |
| Return Loss | - 22.7dB |

General Antenna Parameters and Design

| | |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.066 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: 09.10.2018

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN: 5d041

Communication System: UID 0, CW; Frequency: 1900 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 1900 \text{ MHz}$; $\sigma = 1.438 \text{ S/m}$; $\epsilon_r = 40.37$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7464; ConvF(8.39, 8.39, 8.39) @ 1900 MHz; Calibrated: 9/12/2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1524; Calibrated: 9/13/2017
- Phantom: MFP_V5.1C ; Type: QD 000 P51CA; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (1); SEMCAD X Version 14.6.11 (7439)

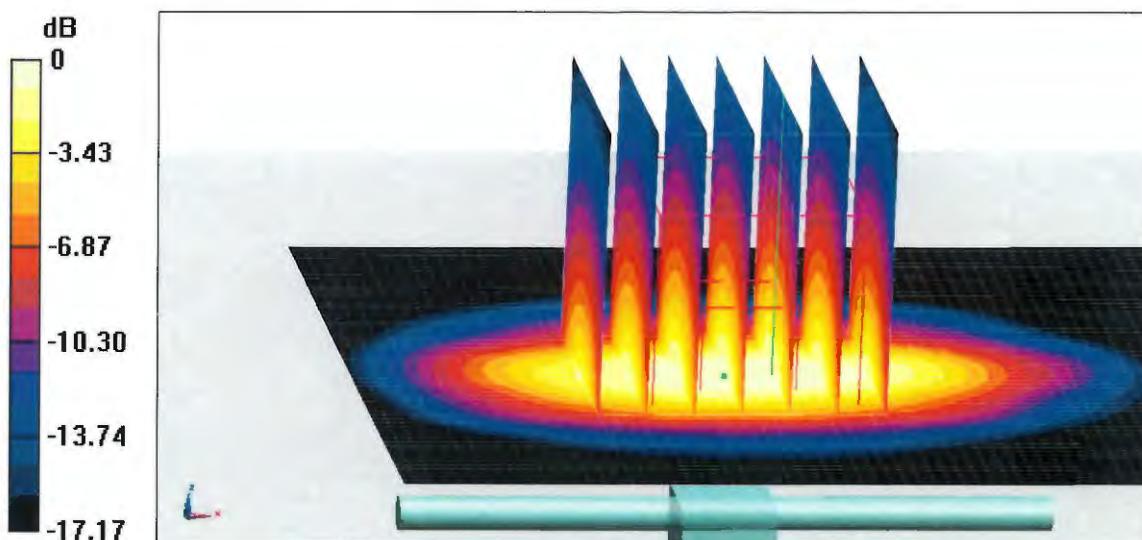
System Performance Check/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 98.66 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 19.1 W/kg

SAR(1 g) = 10.2 W/kg; SAR(10 g) = 5.35 W/kg

Maximum value of SAR (measured) = 15.7 W/kg



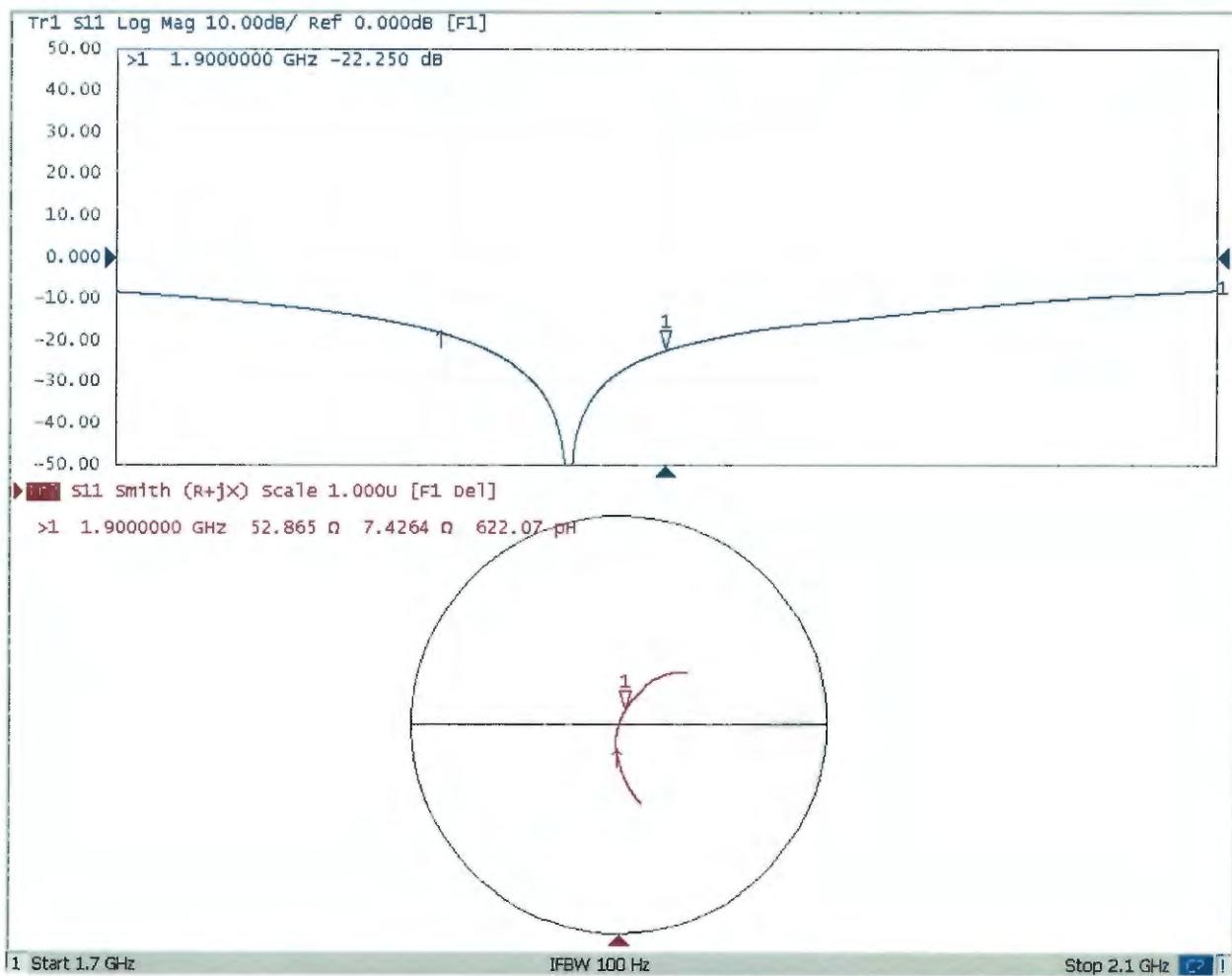
$$0 \text{ dB} = 15.7 \text{ W/kg} = 11.96 \text{ dBW/kg}$$



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Impedance Measurement Plot for Head TSL



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DASY5 Validation Report for Body TSL

Date: 09.10.2018

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN: 5d041

Communication System: UID 0, CW; Frequency: 1900 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 1900 \text{ MHz}$; $\sigma = 1.493 \text{ S/m}$; $\epsilon_r = 53.34$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Right Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7464; ConvF(8.32, 8.32, 8.32) @ 1900 MHz; Calibrated: 9/12/2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1524; Calibrated: 9/13/2017
- Phantom: MFP_V5.1C ; Type: QD 000 P51CA; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (1); SEMCAD X Version 14.6.11 (7439))

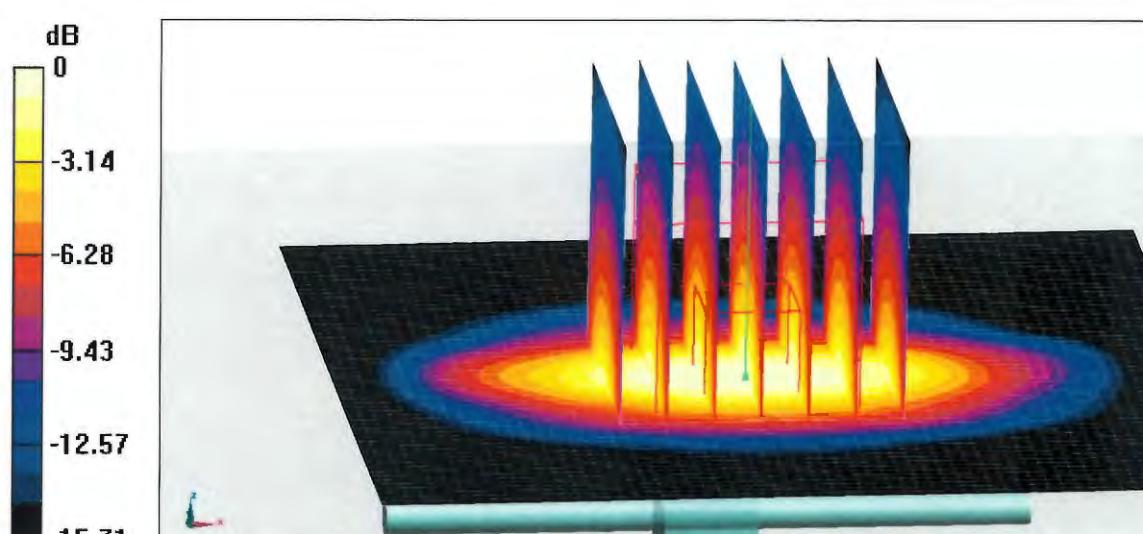
System Performance Check/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 94.03 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 17.5 W/kg

SAR(1 g) = 9.94 W/kg; SAR(10 g) = 5.35 W/kg

Maximum value of SAR (measured) = 15.0 W/kg

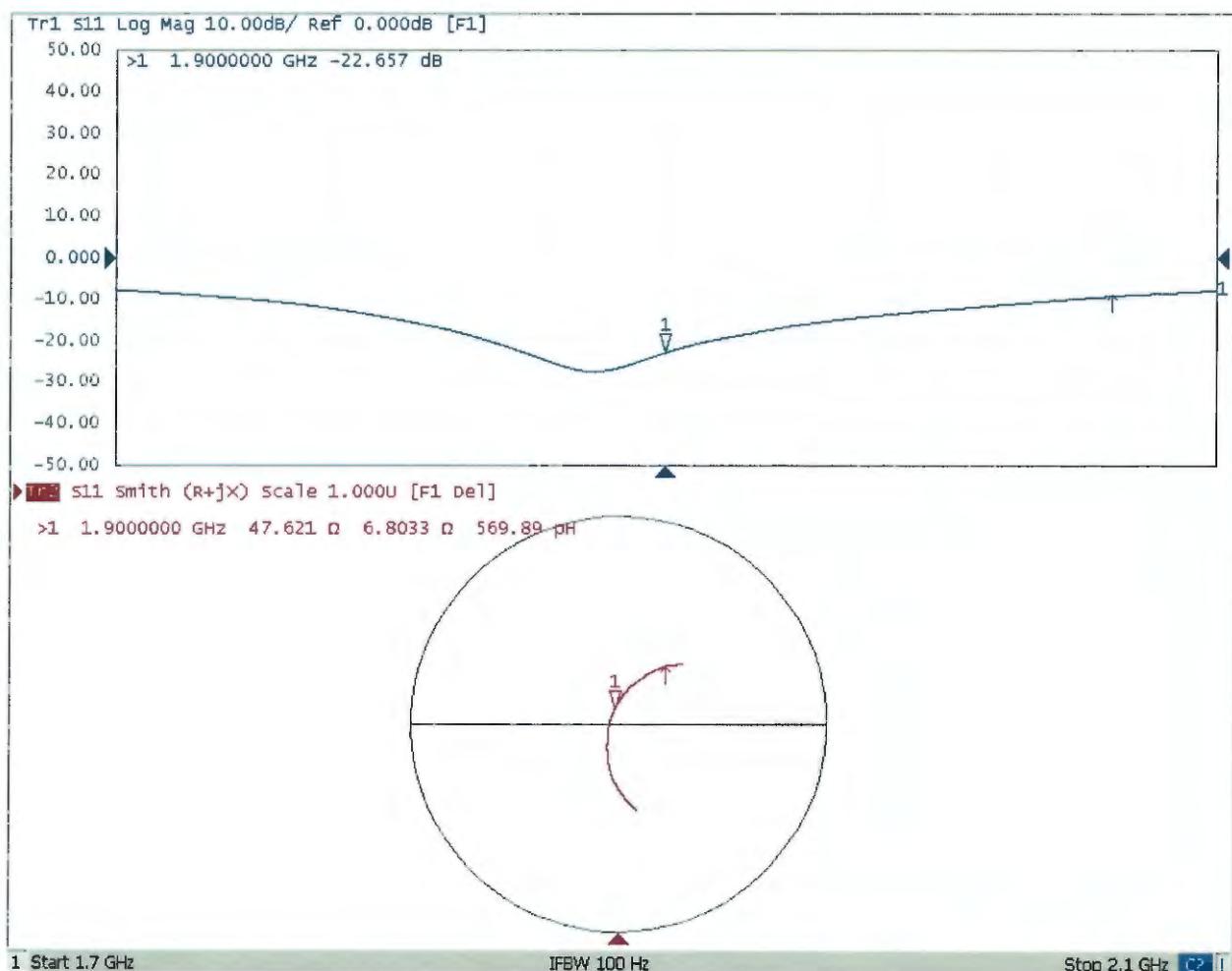




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Impedance Measurement Plot for Body TSL





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 CNAS L0570

Client

Sporton

Certificate No: Z18-60326

CALIBRATION CERTIFICATE

Object D2450V2 - SN: 736

Calibration Procedure(s) FF-Z11-003-01
 Calibration Procedures for dipole validation kits

Calibration date: August 31, 2018

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 NRVD | 102083 | 01-Nov-17 (CTTL, No.J17X08756) | Oct-18 |
| Power sensor NRV-Z5 | 100542 | 01-Nov-17 (CTTL, No.J17X08756) | Oct-18 |
| Reference Probe EX3DV4 | SN 7464 | 12-Sep-17(SPEAG, No.EX3-7464_Sep17) | Sep-18 |
| DAE4 | SN 1524 | 13-Sep-17(SPEAG, No.DAE4-1524_Sep17) | Sep-18 |
| Secondary Standards | ID # | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
| Signal Generator E4438C | MY49071430 | 23-Jan-18 (CTTL, No.J18X00560) | Jan-19 |
| Network Analyzer E5071C | MY46110673 | 24-Jan-18 (CTTL, No.J18X00561) | Jan-19 |

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

Issued: September 3, 2018

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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, "Measurement procedure for assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices- Part 1: Device used next to the ear (Frequency range of 300MHz to 6GHz)", July 2016
- c) IEC 62209-2, "Procedure to measure the Specific Absorption Rate (SAR) For wireless communication devices used in close proximity to the human body (frequency range of 30MHz to 6GHz)", March 2010
- d) KDB865664, 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%.



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Measurement Conditions

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

| | | |
|-------------------------------------|--------------------------|--------------|
| DASY Version | DASY52 | 52.10.1.1476 |
| 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 | 38.8 ± 6 % | 1.80 mho/m ± 6 % |
| Head TSL temperature change during test | <1.0 °C | ---- | ---- |

SAR result with Head TSL

| | | |
|---|--------------------|---------------------------|
| SAR averaged over 1 cm³ (1 g) of Head TSL | Condition | |
| SAR measured | 250 mW input power | 13.2 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | 52.7 mW /g ± 18.8 % (k=2) |
| SAR averaged over 10 cm³ (10 g) of Head TSL | Condition | |
| SAR measured | 250 mW input power | 6.17 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | 24.6 mW /g ± 18.7 % (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 | 52.3 ± 6 % | 1.98 mho/m ± 6 % |
| Body TSL temperature change during test | <1.0 °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 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | 51.5 mW /g ± 18.8 % (k=2) |
| SAR averaged over 10 cm³ (10 g) of Body TSL | Condition | |
| SAR measured | 250 mW input power | 6.14 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | 24.4 mW /g ± 18.7 % (k=2) |



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Appendix (Additional assessments outside the scope of CNAS L0570)

Antenna Parameters with Head TSL

| | |
|--------------------------------------|---------------|
| Impedance, transformed to feed point | 53.9Ω+ 2.56jΩ |
| Return Loss | - 26.9dB |

Antenna Parameters with Body TSL

| | |
|--------------------------------------|---------------|
| Impedance, transformed to feed point | 50.0Ω+ 4.22jΩ |
| Return Loss | - 27.5dB |

General Antenna Parameters and Design

| | |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.022 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: 08.31.2018

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 736

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.802$ S/m; $\epsilon_r = 38.84$; $\rho = 1000$ kg/m³

Phantom section: Right Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7464; ConvF(7.89, 7.89, 7.89) @ 2450 MHz; Calibrated: 9/12/2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1524; Calibrated: 9/13/2017
- Phantom: MFP_V5.1C ; Type: QD 000 P51CA; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (1); SEMCAD X Version 14.6.11 (7439)

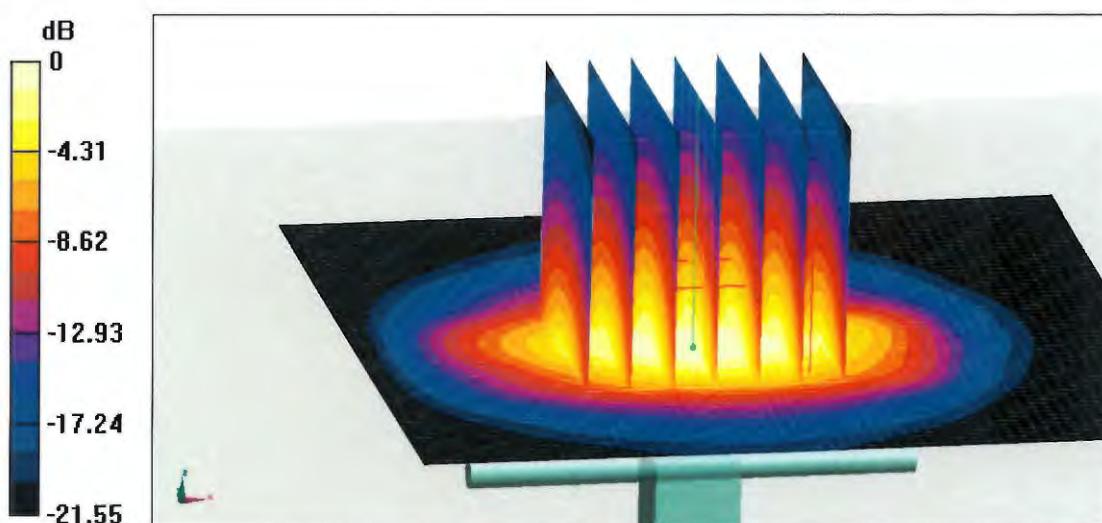
Dipole Calibration/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 100.2 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 27.6 W/kg

SAR(1 g) = 13.2 W/kg; SAR(10 g) = 6.17 W/kg

Maximum value of SAR (measured) = 22.2 W/kg



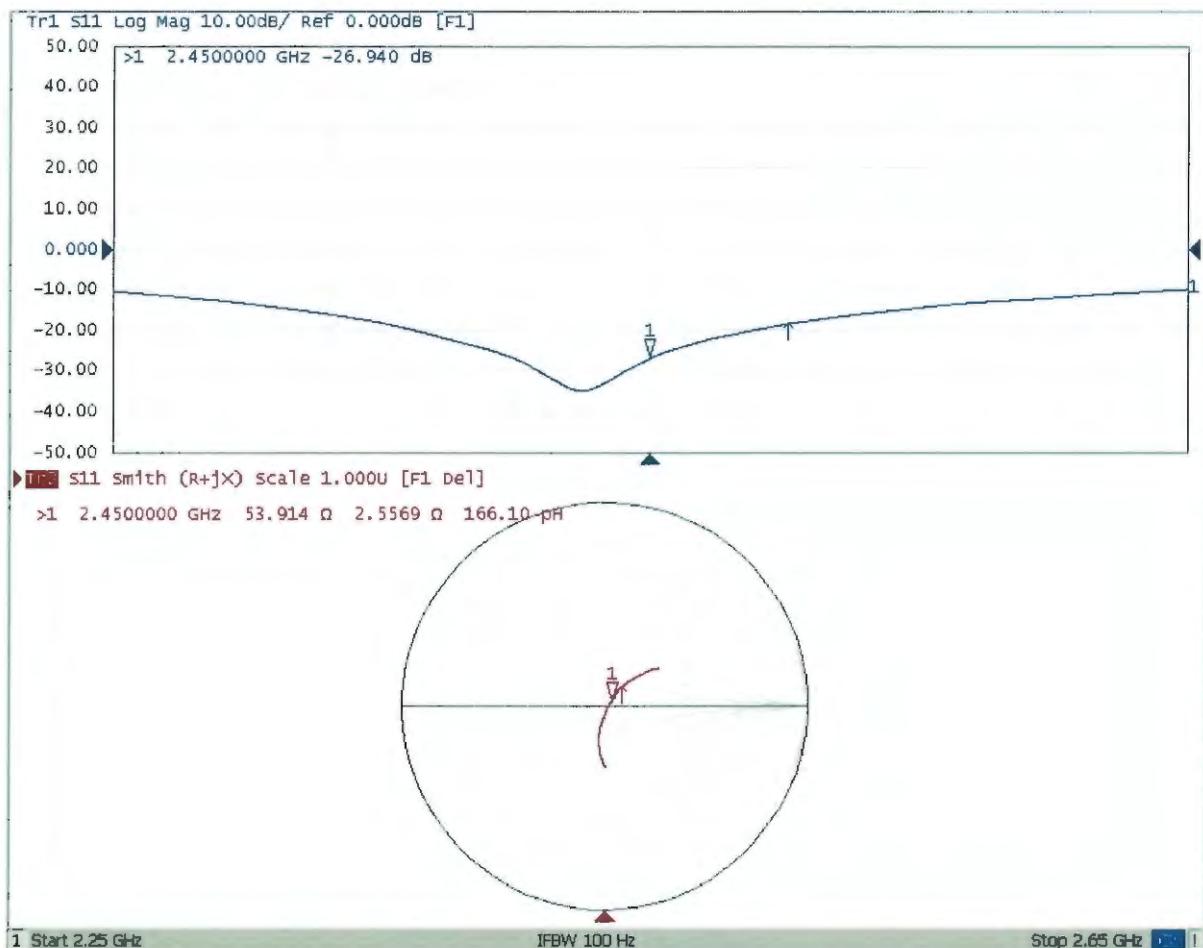
0 dB = 22.2 W/kg = 13.46 dBW/kg



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Impedance Measurement Plot for Head TSL





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DASY5 Validation Report for Body TSL

Date: 08.30.2018

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 736

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

Medium parameters used: $f = 2450 \text{ MHz}$; $\sigma = 1.982 \text{ S/m}$; $\epsilon_r = 52.34$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7464; ConvF(8.09, 8.09, 8.09) @ 2450 MHz; Calibrated: 9/12/2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1524; Calibrated: 9/13/2017
- Phantom: MFP_V5.1C ; Type: QD 000 P51CA; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (1); SEMCAD X Version 14.6.11 (7439)

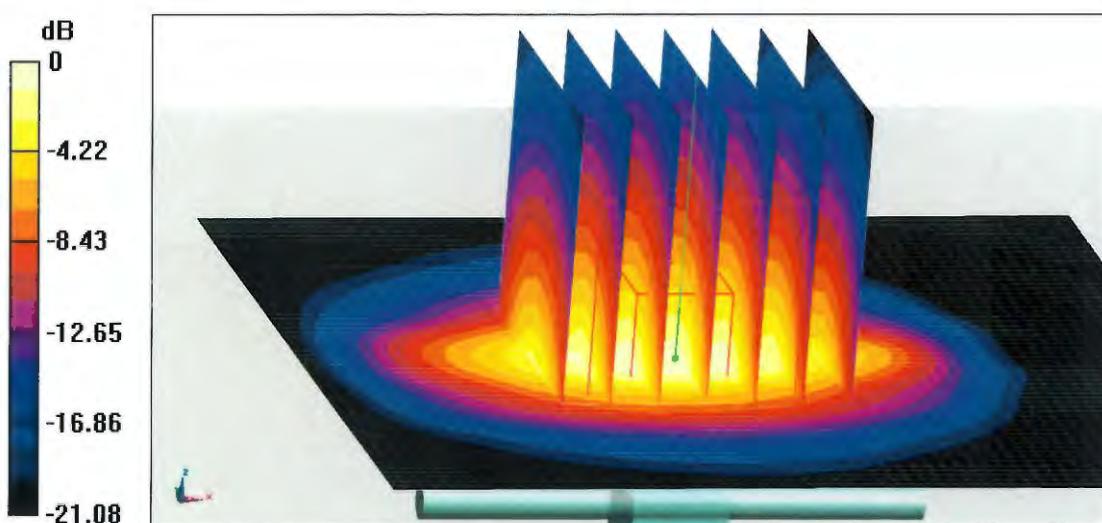
Dipole Calibration/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 98.71 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 26.0 W/kg

SAR(1 g) = 13 W/kg; SAR(10 g) = 6.14 W/kg

Maximum value of SAR (measured) = 21.3 W/kg



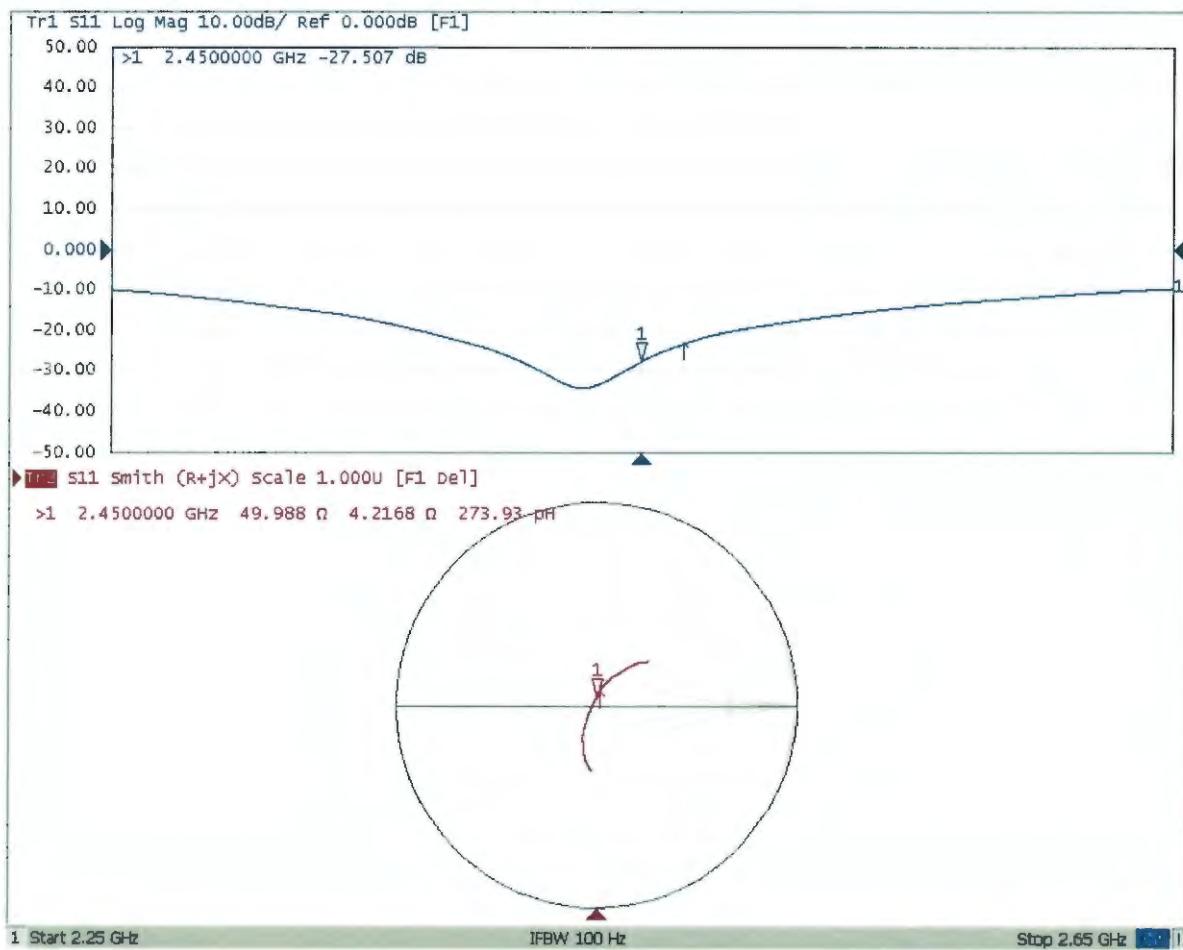
0 dB = 21.3 W/kg = 13.28 dBW/kg



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Impedance Measurement Plot for Body TSL





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Certificate No: Z18-60327

CALIBRATION CERTIFICATE

Object D2600V2 - SN: 1008

Calibration Procedure(s) FF-Z11-003-01
 Calibration Procedures for dipole validation kits

Calibration date: August 31, 2018

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 NRVD | 102083 | 01-Nov-17 (CTTL, No.J17X08756) | Oct-18 |
| Power sensor NRV-Z5 | 100542 | 01-Nov-17 (CTTL, No.J17X08756) | Oct-18 |
| Reference Probe EX3DV4 | SN 7464 | 12-Sep-17(SPEAG, No.EX3-7464_Sep17) | Sep-18 |
| DAE4 | SN 1524 | 13-Sep-17(SPEAG, No.DAE4-1524_Sep17) | Sep-18 |
| Secondary Standards | ID # | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
| Signal Generator E4438C | MY49071430 | 23-Jan-18 (CTTL, No.J18X00560) | Jan-19 |
| Network Analyzer E5071C | MY46110673 | 24-Jan-18 (CTTL, No.J18X00561) | Jan-19 |

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

Issued: September 3, 2018

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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, "Measurement procedure for assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices- Part 1: Device used next to the ear (Frequency range of 300MHz to 6GHz)", July 2016
- c) IEC 62209-2, "Procedure to measure the Specific Absorption Rate (SAR) For wireless communication devices used in close proximity to the human body (frequency range of 30MHz to 6GHz)", March 2010
- d) KDB865664, 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%.



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Measurement Conditions

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

| | | |
|-------------------------------------|--------------------------|--------------|
| DASY Version | DASY52 | 52.10.1.1476 |
| 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 | 38.3 ± 6 % | 1.98 mho/m ± 6 % |
| Head TSL temperature change during test | <1.0 °C | --- | --- |

SAR result with Head TSL

| | | |
|---|--------------------|---------------------------|
| SAR averaged over 1 cm³ (1 g) of Head TSL | Condition | |
| SAR measured | 250 mW input power | 14.2 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | 56.4 mW /g ± 18.8 % (k=2) |
| SAR averaged over 10 cm³ (10 g) of Head TSL | Condition | |
| SAR measured | 250 mW input power | 6.36 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | 25.3 mW /g ± 18.7 % (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 | 52.4 ± 6 % | 2.15 mho/m ± 6 % |
| Body TSL temperature change during test | <1.0 °C | --- | --- |

SAR result with Body TSL

| | | |
|---|--------------------|---------------------------|
| SAR averaged over 1 cm³ (1 g) of Body TSL | Condition | |
| SAR measured | 250 mW input power | 13.8 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | 55.3 mW /g ± 18.8 % (k=2) |
| SAR averaged over 10 cm³ (10 g) of Body TSL | Condition | |
| SAR measured | 250 mW input power | 6.18 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | 24.7 mW /g ± 18.7 % (k=2) |



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Appendix(Additional assessments outside the scope of CNAS L0570)

Antenna Parameters with Head TSL

| | |
|--------------------------------------|---------------|
| Impedance, transformed to feed point | 50.4Ω- 4.65jΩ |
| Return Loss | - 26.7dB |

Antenna Parameters with Body TSL

| | |
|--------------------------------------|---------------|
| Impedance, transformed to feed point | 46.0Ω- 2.75jΩ |
| Return Loss | - 25.9dB |

General Antenna Parameters and Design

| | |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.016 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: 08.30.2018

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1008

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

Medium parameters used: $f = 2600 \text{ MHz}$; $\sigma = 1.977 \text{ S/m}$; $\epsilon_r = 38.28$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7464; ConvF(7.76, 7.76, 7.76) @ 2600 MHz; Calibrated: 9/12/2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1524; Calibrated: 9/13/2017
- Phantom: MFP_V5.1C ; Type: QD 000 P51CA; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (1); SEMCAD X Version 14.6.11 (7439)

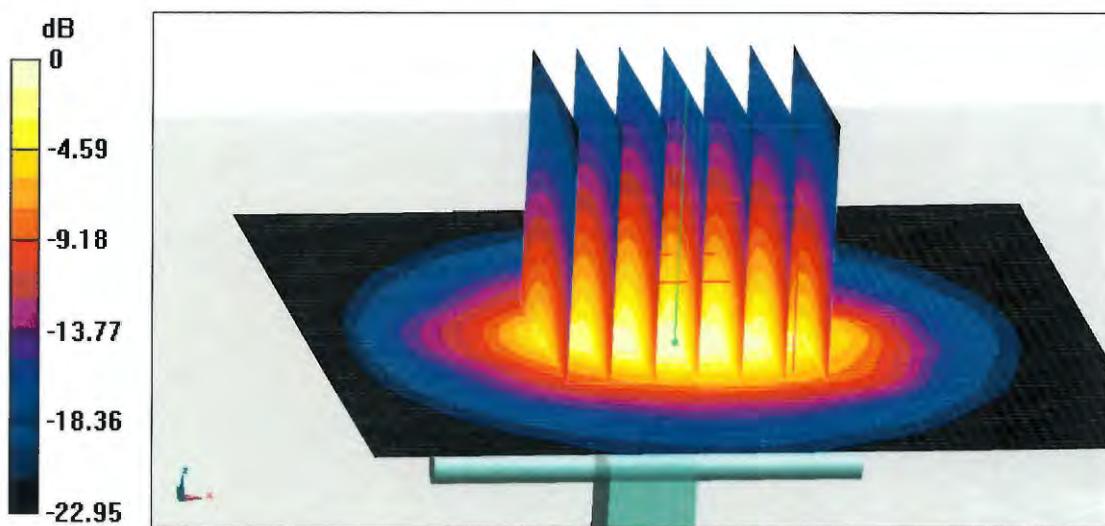
Dipole Calibration/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 103.1 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 30.3 W/kg

SAR(1 g) = 14.2 W/kg; SAR(10 g) = 6.36 W/kg

Maximum value of SAR (measured) = 24.2 W/kg



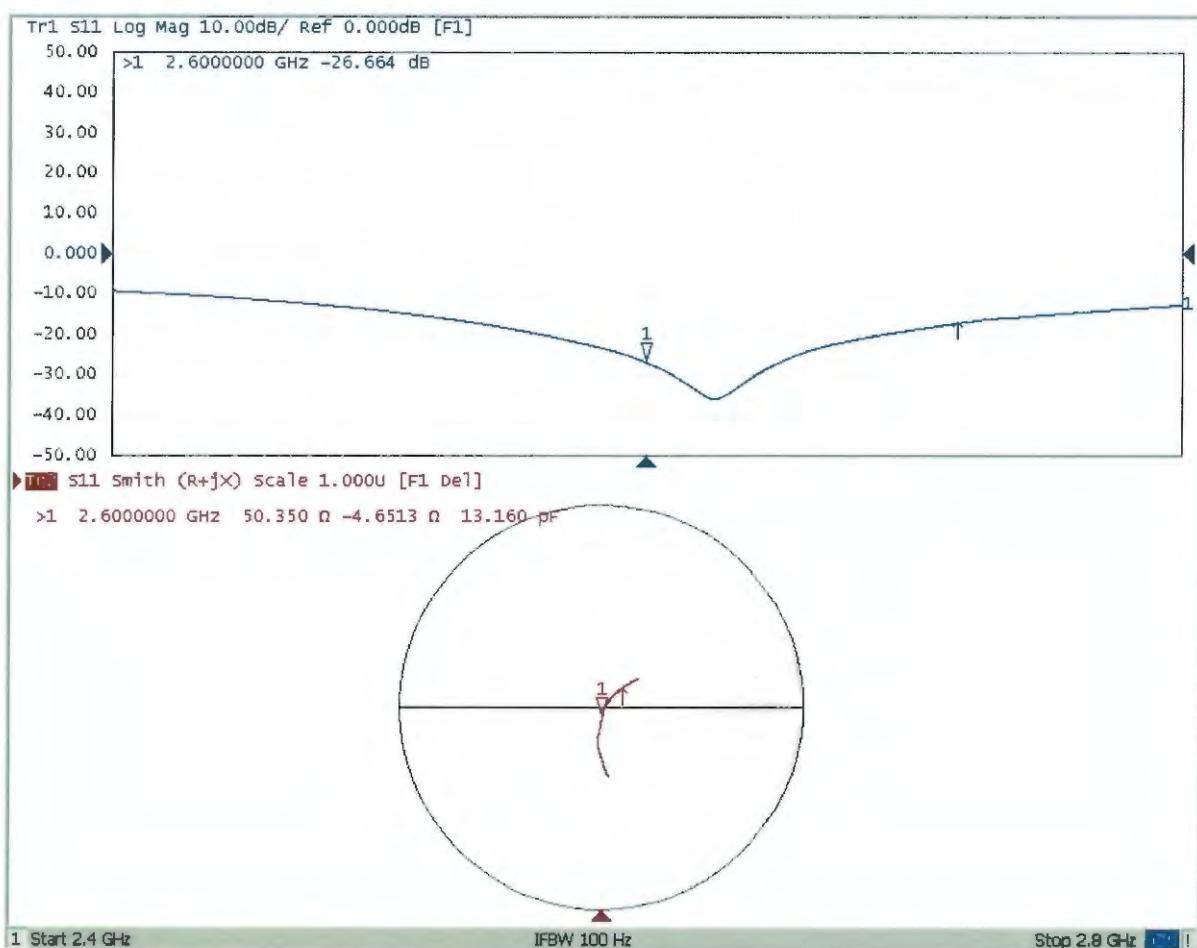
0 dB = 24.2 W/kg = 13.84 dBW/kg



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Impedance Measurement Plot for Head TSL





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DASY5 Validation Report for Body TSL

Date: 08.30.2018

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1008

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

Medium parameters used: $f = 2600 \text{ MHz}$; $\sigma = 2.152 \text{ S/m}$; $\epsilon_r = 52.38$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Right Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7464; ConvF(7.84, 7.84, 7.84) @ 2600 MHz; Calibrated: 9/12/2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1524; Calibrated: 9/13/2017
- Phantom: MFP_V5.1C ; Type: QD 000 P51CA; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (1); SEMCAD X Version 14.6.11 (7439)

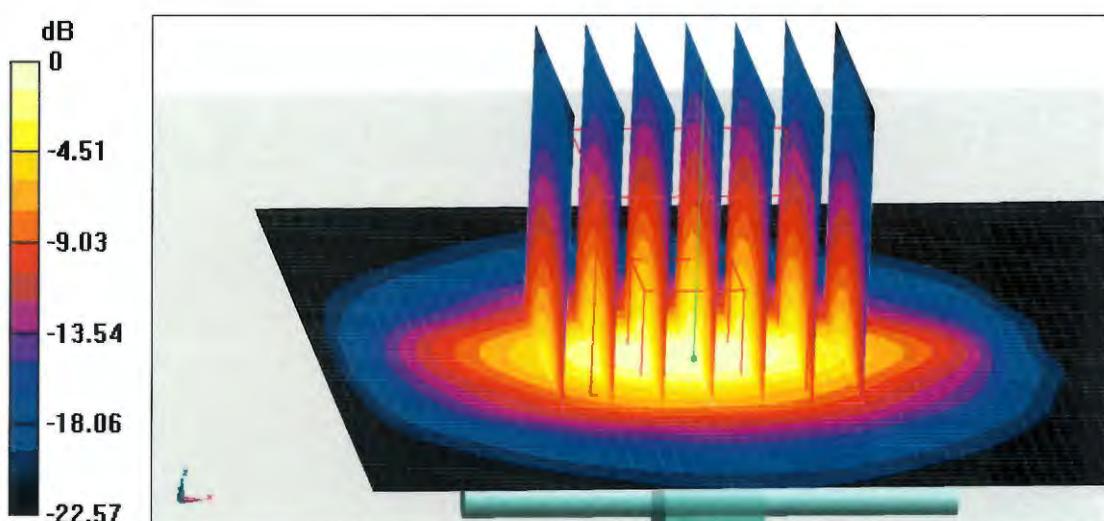
Dipole Calibration/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 95.71 V/m; Power Drift = 0.05 dB

Peak SAR (extrapolated) = 29.3 W/kg

SAR(1 g) = 13.8 W/kg; SAR(10 g) = 6.18 W/kg

Maximum value of SAR (measured) = 23.6 W/kg

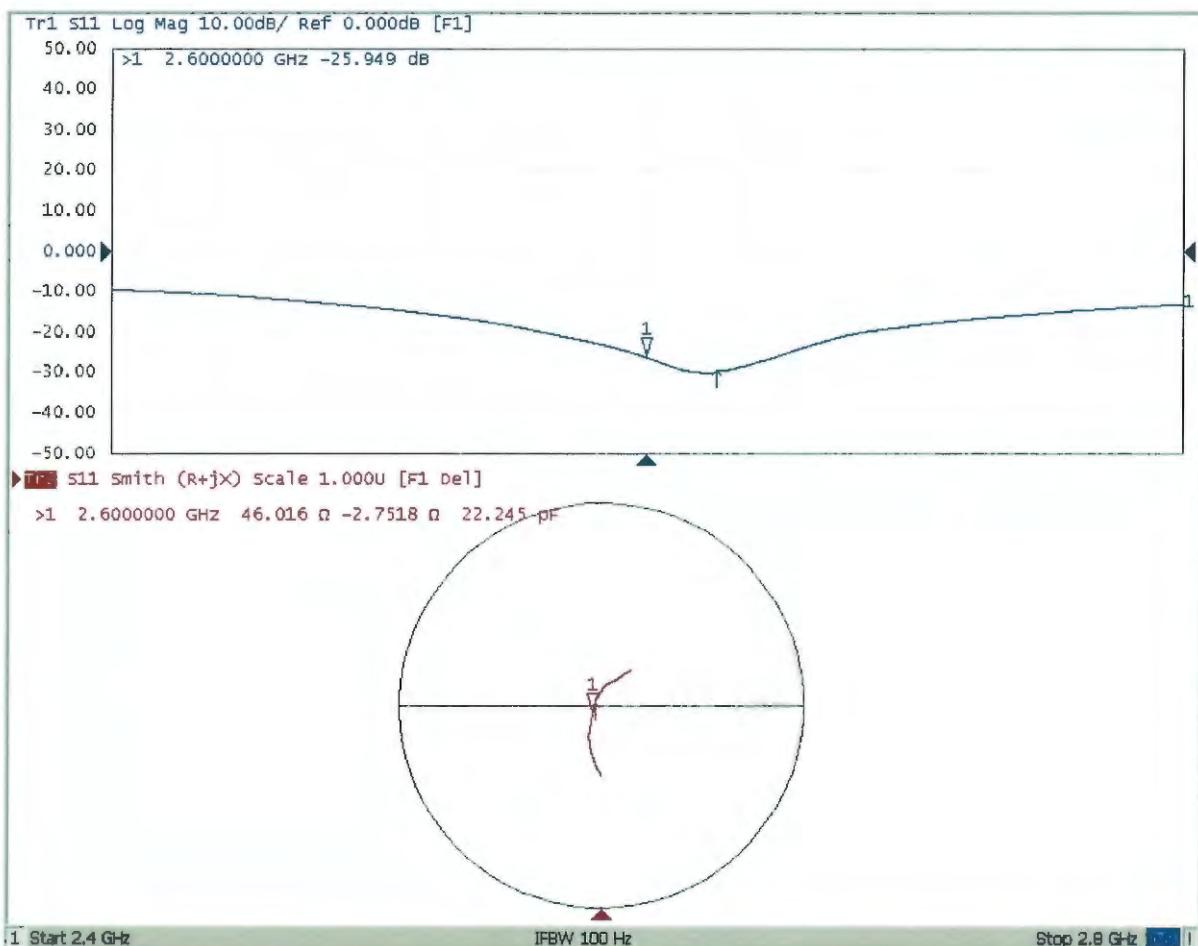




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Impedance Measurement Plot for Body TSL





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Client **Sporton**

Certificate No: **DAE3-495_May18**

CALIBRATION CERTIFICATE

Object **DAE3 - SD 000 D03 AD - SN: 495**

Calibration procedure(s) **QA CAL-06.v29**
 Calibration procedure for the data acquisition electronics (DAE)

Calibration date: **May 24, 2018**

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 |
|--|--|--|--|
| Keithley Multimeter Type 2001 | SN: 0810278 | 31-Aug-17 (No:21092) | Aug-18 |
| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
| Auto DAE Calibration Unit Calibrator Box V2.1 | SE UWS 053 AA 1001 SE UMS 006 AA 1002 | 04-Jan-18 (in house check) 04-Jan-18 (in house check) | In house check: Jan-19 In house check: Jan-19 |

| | | | |
|----------------|----------------------------------|--|---------------|
| Calibrated by: | Name Dominique Steffen | Function Laboratory Technician | Signature |
| Approved by: | Sven Kühn | Deputy Manager | |

Issued: May 24, 2018

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Accreditation No.: **SCS 0108**

Glossary

| | |
|-----------------|---|
| DAE | data acquisition electronics |
| Connector angle | information used in DASY system to align probe sensor X to the robot coordinate system. |

Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle:* The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
 - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
 - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
 - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
 - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
 - *Input Offset Measurement:* Output voltage and statistical results over a large number of zero voltage measurements.
 - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
 - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
 - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
 - *Power consumption:* Typical value for information. Supply currents in various operating modes.

DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = $6.1\mu V$, full range = $-100...+300 mV$

Low Range: 1LSB = $61nV$, full range = $-1.....+3mV$

DASY measurement parameters: Auto-Zero Time: 3 sec; Measuring time: 3 sec

| Calibration Factors | X | Y | Z |
|---------------------|----------------------------|----------------------------|----------------------------|
| High Range | $404.400 \pm 0.02\% (k=2)$ | $405.380 \pm 0.02\% (k=2)$ | $405.751 \pm 0.02\% (k=2)$ |
| Low Range | $3.95295 \pm 1.50\% (k=2)$ | $3.99115 \pm 1.50\% (k=2)$ | $3.96710 \pm 1.50\% (k=2)$ |

Connector Angle

| | |
|---|--------------------------|
| Connector Angle to be used in DASY system | $73.0^\circ \pm 1^\circ$ |
|---|--------------------------|

Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

| High Range | | Reading (μ V) | Difference (μ V) | Error (%) |
|------------|---------|--------------------|-----------------------|-----------|
| Channel X | + Input | 200038.36 | 0.43 | 0.00 |
| Channel X | + Input | 20007.02 | 0.84 | 0.00 |
| Channel X | - Input | -20001.18 | 3.92 | -0.02 |
| Channel Y | + Input | 200038.71 | 0.86 | 0.00 |
| Channel Y | + Input | 20005.03 | -1.06 | -0.01 |
| Channel Y | - Input | -20003.38 | 1.86 | -0.01 |
| Channel Z | + Input | 200038.61 | 0.44 | 0.00 |
| Channel Z | + Input | 20007.94 | 2.01 | 0.01 |
| Channel Z | - Input | -20002.34 | 2.97 | -0.01 |

| Low Range | | Reading (μ V) | Difference (μ V) | Error (%) |
|-----------|---------|--------------------|-----------------------|-----------|
| Channel X | + Input | 2002.78 | 0.73 | 0.04 |
| Channel X | + Input | 202.83 | 0.89 | 0.44 |
| Channel X | - Input | -198.36 | -0.26 | 0.13 |
| Channel Y | + Input | 2001.27 | -0.64 | -0.03 |
| Channel Y | + Input | 201.58 | -0.18 | -0.09 |
| Channel Y | - Input | -198.95 | -0.71 | 0.36 |
| Channel Z | + Input | 2000.20 | -1.55 | -0.08 |
| Channel Z | + Input | 200.38 | -1.37 | -0.68 |
| Channel Z | - Input | -198.97 | -0.61 | 0.31 |

2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | Common mode Input Voltage (mV) | High Range Average Reading (μ V) | Low Range Average Reading (μ V) |
|-----------|-----------------------------------|--|---|
| Channel X | 200 | 4.60 | 2.87 |
| | -200 | -1.80 | -3.53 |
| Channel Y | 200 | 0.03 | 0.11 |
| | -200 | -1.19 | -1.40 |
| Channel Z | 200 | 1.82 | 1.73 |
| | -200 | -5.14 | -4.99 |

3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | Input Voltage (mV) | Channel X (μ V) | Channel Y (μ V) | Channel Z (μ V) |
|-----------|--------------------|----------------------|----------------------|----------------------|
| Channel X | 200 | - | -1.03 | -2.94 |
| Channel Y | 200 | 7.80 | - | -0.33 |
| Channel Z | 200 | 5.68 | 5.73 | - |

4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | High Range (LSB) | Low Range (LSB) |
|-----------|------------------|-----------------|
| Channel X | 15812 | 16929 |
| Channel Y | 15758 | 16682 |
| Channel Z | 15906 | 17274 |

5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Input 10MΩ

| | Average (μ V) | min. Offset (μ V) | max. Offset (μ V) | Std. Deviation (μ V) |
|-----------|--------------------|------------------------|------------------------|---------------------------|
| Channel X | 0.60 | -0.57 | 2.52 | 0.64 |
| Channel Y | 1.99 | 0.41 | 3.70 | 0.64 |
| Channel Z | -1.70 | -3.34 | -0.12 | 0.66 |

6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

7. Input Resistance (Typical values for information)

| | Zeroing (kOhm) | Measuring (MOhm) |
|-----------|----------------|------------------|
| Channel X | 200 | 200 |
| Channel Y | 200 | 200 |
| Channel Z | 200 | 200 |

8. Low Battery Alarm Voltage (Typical values for information)

| Typical values | Alarm Level (VDC) |
|----------------|-------------------|
| Supply (+ Vcc) | +7.9 |
| Supply (- Vcc) | -7.6 |

9. Power Consumption (Typical values for information)

| Typical values | Switched off (mA) | Stand by (mA) | Transmitting (mA) |
|----------------|-------------------|---------------|-------------------|
| Supply (+ Vcc) | +0.01 | +6 | +14 |
| Supply (- Vcc) | -0.01 | -8 | -9 |



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Accreditation No.: **SCS 0108**

Client **Auden**

Certificate No: **DAE4-918_Jun18**

CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BK - SN: 918**

Calibration procedure(s) **QA CAL-06.v29**
 Calibration procedure for the data acquisition electronics (DAE)

Calibration date: **June 20, 2018**

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 |
|-------------------------------|--------------------|----------------------------|------------------------|
| Keithley Multimeter Type 2001 | SN: 0810278 | 31-Aug-17 (No:21092) | Aug-18 |
| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
| Auto DAE Calibration Unit | SE UWS 053 AA 1001 | 04-Jan-18 (in house check) | In house check: Jan-19 |
| Calibrator Box V2.1 | SE UMS 006 AA 1002 | 04-Jan-18 (in house check) | In house check: Jan-19 |

| | | | |
|----------------|-----------------------|-----------------------------------|---------------|
| Calibrated by: | Name Eric Hainfeld | Function Laboratory Technician | Signature |
| Approved by: | Sven Kühn | Deputy Manager | |

Issued: June 20, 2018

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Accreditation No.: **SCS 0108**

Glossary

| | |
|-----------------|---|
| DAE | data acquisition electronics |
| Connector angle | information used in DASY system to align probe sensor X to the robot coordinate system. |

Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle:* The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
 - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
 - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
 - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
 - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
 - *Input Offset Measurement:* Output voltage and statistical results over a large number of zero voltage measurements.
 - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
 - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
 - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
 - *Power consumption:* Typical value for information. Supply currents in various operating modes.

DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = $6.1\mu V$, full range = -100...+300 mV
Low Range: 1LSB = $61nV$, full range = -1.....+3mV

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| Calibration Factors | X | Y | Z |
|---------------------|------------------------------------|------------------------------------|------------------------------------|
| High Range | $404.292 \pm 0.02\% \text{ (k=2)}$ | $404.471 \pm 0.02\% \text{ (k=2)}$ | $404.000 \pm 0.02\% \text{ (k=2)}$ |
| Low Range | $4.01048 \pm 1.50\% \text{ (k=2)}$ | $3.99008 \pm 1.50\% \text{ (k=2)}$ | $4.00845 \pm 1.50\% \text{ (k=2)}$ |

Connector Angle

| | |
|---|---------------------------|
| Connector Angle to be used in DASY system | $320.5^\circ \pm 1^\circ$ |
|---|---------------------------|

Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

| High Range | | Reading (μ V) | Difference (μ V) | Error (%) |
|------------|---------|--------------------|-----------------------|-----------|
| Channel X | + Input | 199995.21 | -2.10 | -0.00 |
| Channel X | + Input | 20001.90 | -0.02 | -0.00 |
| Channel X | - Input | -19998.43 | 2.67 | -0.01 |
| Channel Y | + Input | 199997.45 | 0.04 | 0.00 |
| Channel Y | + Input | 20000.13 | -1.84 | -0.01 |
| Channel Y | - Input | -20002.53 | -1.31 | 0.01 |
| Channel Z | + Input | 199998.07 | 0.90 | 0.00 |
| Channel Z | + Input | 20000.07 | -1.82 | -0.01 |
| Channel Z | - Input | -20002.88 | -1.51 | 0.01 |

| Low Range | | Reading (μ V) | Difference (μ V) | Error (%) |
|-----------|---------|--------------------|-----------------------|-----------|
| Channel X | + Input | 2002.15 | 0.71 | 0.04 |
| Channel X | + Input | 201.89 | 0.17 | 0.09 |
| Channel X | - Input | -198.28 | -0.11 | 0.06 |
| Channel Y | + Input | 2000.77 | -0.64 | -0.03 |
| Channel Y | + Input | 201.50 | -0.14 | -0.07 |
| Channel Y | - Input | -198.61 | -0.36 | 0.18 |
| Channel Z | + Input | 2001.31 | -0.10 | -0.01 |
| Channel Z | + Input | 200.36 | -1.18 | -0.59 |
| Channel Z | - Input | -199.37 | -1.01 | 0.51 |

2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | Common mode Input Voltage (mV) | High Range Average Reading (μ V) | Low Range Average Reading (μ V) |
|-----------|-----------------------------------|--|---|
| Channel X | 200 | 4.32 | 2.70 |
| | -200 | -2.19 | -4.37 |
| Channel Y | 200 | 11.36 | 11.41 |
| | -200 | -12.35 | -12.96 |
| Channel Z | 200 | -13.98 | -14.32 |
| | -200 | 13.11 | 12.07 |

3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | Input Voltage (mV) | Channel X (μ V) | Channel Y (μ V) | Channel Z (μ V) |
|-----------|--------------------|----------------------|----------------------|----------------------|
| Channel X | 200 | - | -0.68 | -5.41 |
| Channel Y | 200 | 7.71 | - | 0.61 |
| Channel Z | 200 | 10.01 | 5.69 | - |

4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | High Range (LSB) | Low Range (LSB) |
|-----------|------------------|-----------------|
| Channel X | 15930 | 14966 |
| Channel Y | 16009 | 15983 |
| Channel Z | 16005 | 17407 |

5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Input 10MΩ

| | Average (μ V) | min. Offset (μ V) | max. Offset (μ V) | Std. Deviation (μ V) |
|-----------|--------------------|------------------------|------------------------|---------------------------|
| Channel X | -0.01 | -2.00 | 1.96 | 0.70 |
| Channel Y | 1.43 | 0.40 | 2.68 | 0.39 |
| Channel Z | -0.70 | -1.89 | 0.85 | 0.46 |

6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

7. Input Resistance (Typical values for information)

| | Zeroing (kOhm) | Measuring (MOhm) |
|-----------|----------------|------------------|
| Channel X | 200 | 200 |
| Channel Y | 200 | 200 |
| Channel Z | 200 | 200 |

8. Low Battery Alarm Voltage (Typical values for information)

| Typical values | Alarm Level (VDC) |
|----------------|-------------------|
| Supply (+ Vcc) | +7.9 |
| Supply (- Vcc) | -7.6 |

9. Power Consumption (Typical values for information)

| Typical values | Switched off (mA) | Stand by (mA) | Transmitting (mA) |
|----------------|-------------------|---------------|-------------------|
| Supply (+ Vcc) | +0.01 | +6 | +14 |
| Supply (- Vcc) | -0.01 | -8 | -9 |



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 CNAS L0570

Client : Sporton

Certificate No: Z18-60383

CALIBRATION CERTIFICATE

Object DAE4 - SN: 1326

Calibration Procedure(s) FF-Z11-002-01
 Calibration Procedure for the Data Acquisition Electronics
 (DAEx)

Calibration date: September 18, 2018

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 |
|------------------------|---------|--|-----------------------|
| Process Calibrator 753 | 1971018 | 20-Jun-18 (CTTL, No.J18X05034) | June-19 |

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

Issued: September 20, 2018

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Glossary:

| | |
|-----------------|---|
| DAE | data acquisition electronics |
| Connector angle | information used in DASY system to align probe sensor X to the robot coordinate system. |

Methods Applied and Interpretation of Parameters:

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle:* The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The report provide only calibration results for DAE, it does not contain other performance test results.



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DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = $6.1\mu V$, full range = $-100...+300 mV$

Low Range: 1LSB = $61nV$, full range = $-1.....+3mV$

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| Calibration Factors | X | Y | Z |
|---------------------|----------------------------|----------------------------|----------------------------|
| High Range | $404.892 \pm 0.15\% (k=2)$ | $405.233 \pm 0.15\% (k=2)$ | $404.616 \pm 0.15\% (k=2)$ |
| Low Range | $3.98868 \pm 0.7\% (k=2)$ | $3.99146 \pm 0.7\% (k=2)$ | $3.99194 \pm 0.7\% (k=2)$ |

Connector Angle

| | |
|---|------------------------|
| Connector Angle to be used in DASY system | $68^\circ \pm 1^\circ$ |
|---|------------------------|

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



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Accreditation No.: **SCS 0108**

Client **Sporton**

Certificate No: **ES3-3169_May18**

CALIBRATION CERTIFICATE

Object **ES3DV3 - SN:3169**

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

Calibration date: **May 28, 2018**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature $(22 \pm 3)^\circ\text{C}$ 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 | 04-Apr-18 (No. 217-02672/02673) | Apr-19 |
| Power sensor NRP-Z91 | SN: 103244 | 04-Apr-18 (No. 217-02672) | Apr-19 |
| Power sensor NRP-Z91 | SN: 103245 | 04-Apr-18 (No. 217-02673) | Apr-19 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 04-Apr-18 (No. 217-02682) | Apr-19 |
| Reference Probe ES3DV2 | SN: 3013 | 30-Dec-17 (No. ES3-3013_Dec17) | Dec-18 |
| DAE4 | SN: 660 | 21-Dec-17 (No. DAE4-660_Dec17) | Dec-18 |
| | | | |
| 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-17) | In house check: Oct-18 |

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

Issued: May 29, 2018

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Glossary:

| | |
|------------------------|--|
| TSL | tissue simulating liquid |
| NORM x,y,z | sensitivity in free space |
| ConvF | sensitivity in TSL / NORM x,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., $\theta = 0$ 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:

- 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"

Methods Applied and Interpretation of Parameters:

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

Probe ES3DV3

SN:3169

Manufactured: October 8, 2008
Calibrated: May 28, 2018

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

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3169

Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|----------|----------|----------|---------------|
| Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A | 1.15 | 1.15 | 1.13 | $\pm 10.1 \%$ |
| DCP (mV) ^B | 99.6 | 99.3 | 96.1 | |

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 | 202.3 | $\pm 3.3 \%$ |
| | | Y | 0.0 | 0.0 | 1.0 | | 207.5 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 199.0 | |

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

^A The uncertainties of Norm X,Y,Z do not affect the E²-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: ES3DV3 - SN:3169

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 | 6.56 | 6.56 | 6.56 | 0.75 | 1.20 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.39 | 6.39 | 6.39 | 0.80 | 1.13 | ± 12.0 % |
| 900 | 41.5 | 0.97 | 6.21 | 6.21 | 6.21 | 0.80 | 1.13 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.48 | 5.48 | 5.48 | 0.80 | 1.14 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.27 | 5.27 | 5.27 | 0.80 | 1.14 | ± 12.0 % |
| 2000 | 40.0 | 1.40 | 5.25 | 5.25 | 5.25 | 0.55 | 1.34 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 4.91 | 4.91 | 4.91 | 0.76 | 1.18 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.69 | 4.69 | 4.69 | 0.76 | 1.25 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 4.50 | 4.50 | 4.50 | 0.70 | 1.30 | ± 12.0 % |

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

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

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

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3169

Calibration Parameter Determined in Body Tissue Simulating Media

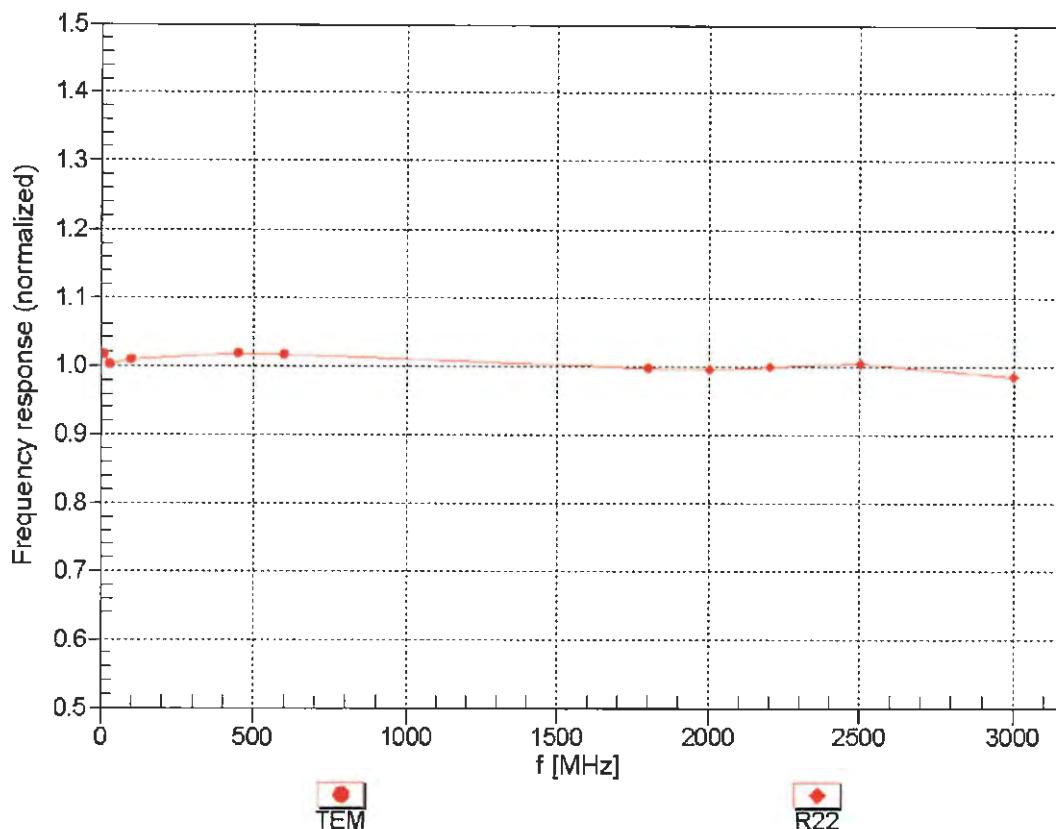
| f (MHz) ^C | Relative Permittivity ^F | Conductivity (S/m) ^F | ConvF X | ConvF Y | ConvF Z | Alpha ^G | Depth ^G (mm) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 750 | 55.5 | 0.96 | 6.30 | 6.30 | 6.30 | 0.33 | 1.78 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.19 | 6.19 | 6.19 | 0.63 | 1.29 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 5.06 | 5.06 | 5.06 | 0.62 | 1.36 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.80 | 4.80 | 4.80 | 0.37 | 1.91 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 4.50 | 4.50 | 4.50 | 0.78 | 1.25 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.40 | 4.40 | 4.40 | 0.80 | 1.15 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 4.27 | 4.27 | 4.27 | 0.80 | 0.80 | ± 12.0 % |

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

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

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

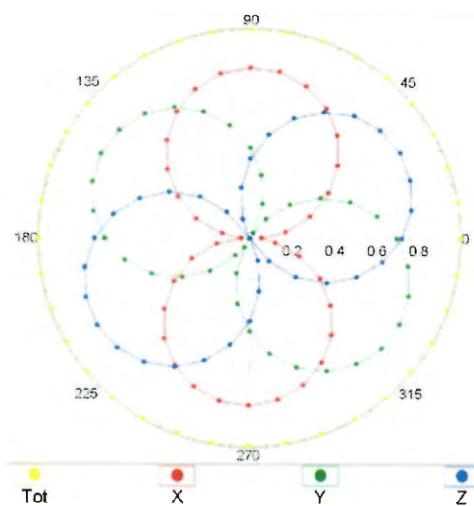
Frequency Response of E-Field (TEM-Cell:ifi110 EXX, Waveguide: R22)



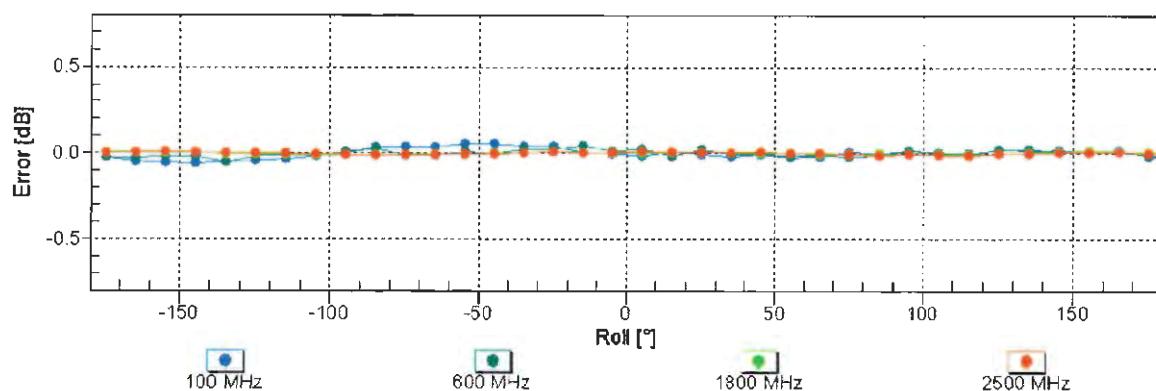
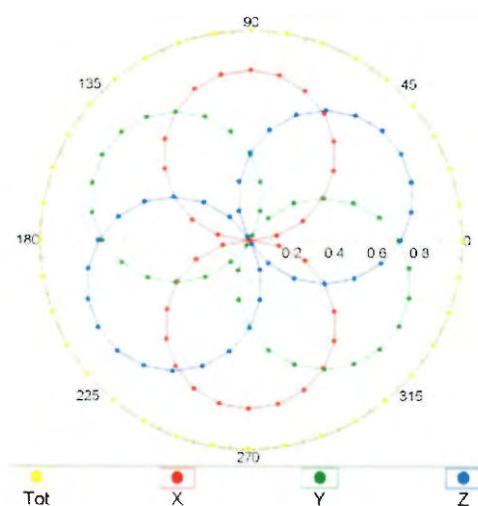
Uncertainty of Frequency Response of E-field: $\pm 6.3\% \text{ (k=2)}$

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

f=600 MHz, TEM

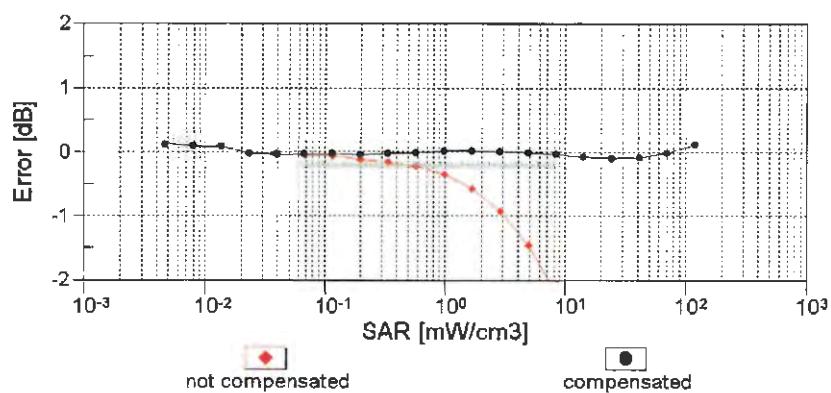
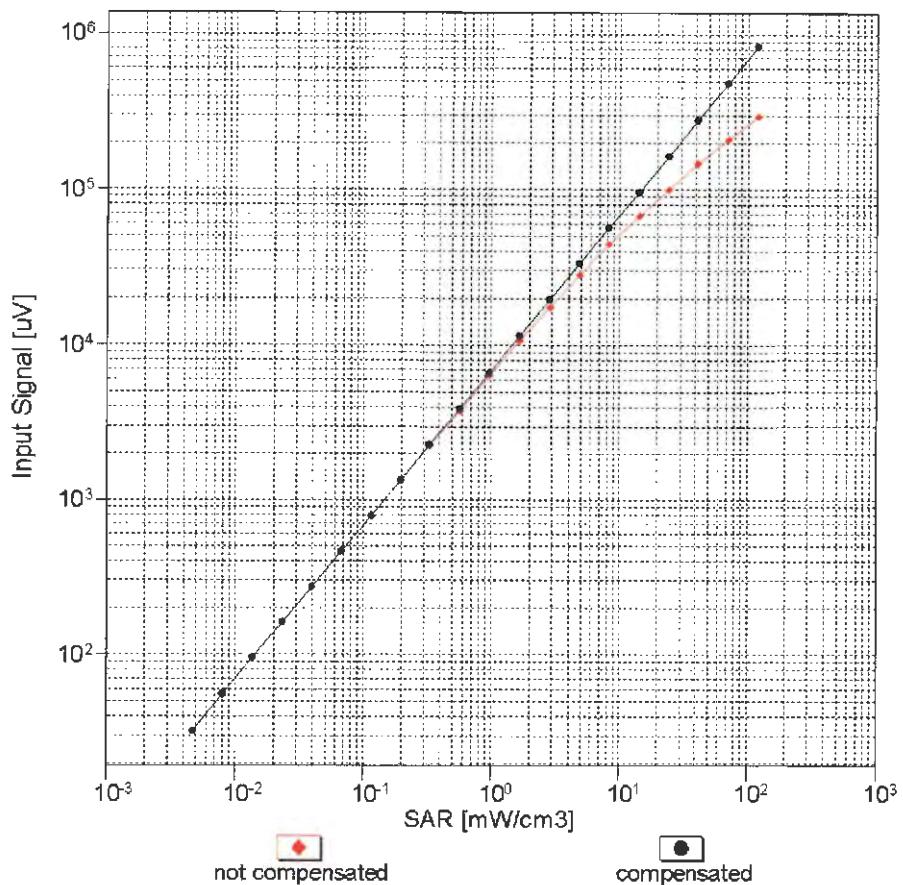


f=1800 MHz, R22



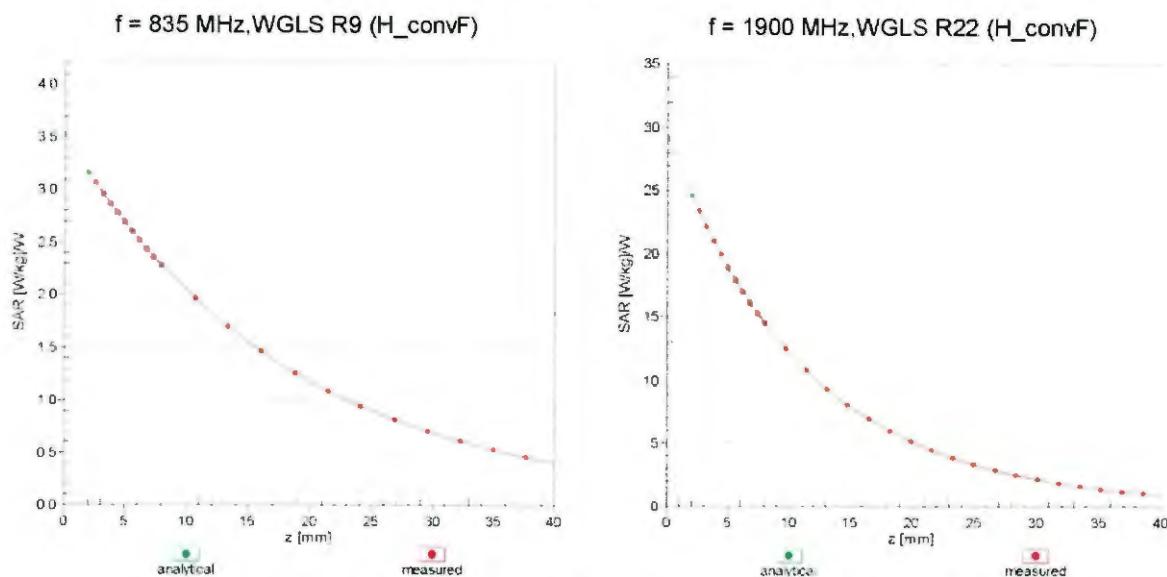
Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

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

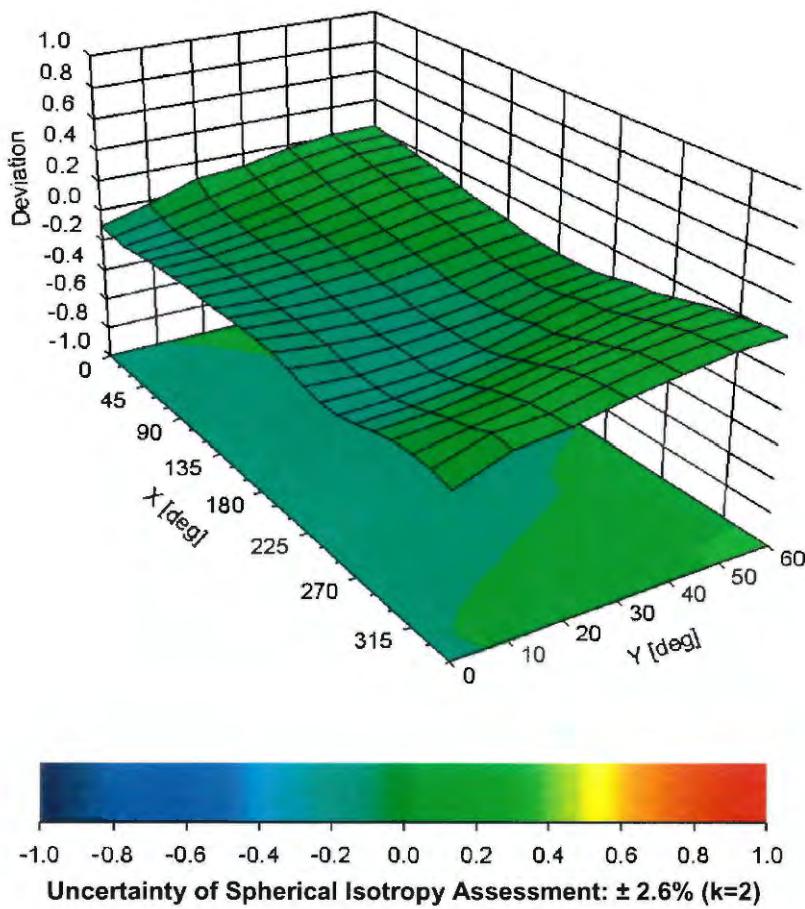


Uncertainty of Linearity Assessment: ± 0.6% (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid Error (ϕ, θ), $f = 900 \text{ MHz}$



DASY/EASY - Parameters of Probe: ES3DV3 - SN:3169

Other Probe Parameters

| | |
|---|------------|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -24.7 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 10 mm |
| Tip Diameter | 4 mm |
| Probe Tip to Sensor X Calibration Point | 2 mm |
| Probe Tip to Sensor Y Calibration Point | 2 mm |
| Probe Tip to Sensor Z Calibration Point | 2 mm |
| Recommended Measurement Distance from Surface | 3 mm |

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
SCS 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 **Sporton**

Certificate No: **EX3-7306_Jul18**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:7306**

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

Calibration date: **July 26, 2018**

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 | 04-Apr-18 (No. 217-02672/02673) | Apr-19 |
| Power sensor NRP-Z91 | SN: 103244 | 04-Apr-18 (No. 217-02672) | Apr-19 |
| Power sensor NRP-Z91 | SN: 103245 | 04-Apr-18 (No. 217-02673) | Apr-19 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 04-Apr-18 (No. 217-02682) | Apr-19 |
| Reference Probe ES3DV2 | SN: 3013 | 30-Dec-17 (No. ES3-3013_Dec17) | Dec-18 |
| DAE4 | SN: 660 | 21-Dec-17 (No. DAE4-660_Dec17) | Dec-18 |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| Power meter E4419B | SN: GB41293874 | 06-Apr-16 (in house check Jun-18) | In house check: Jun-20 |
| Power sensor E4412A | SN: MY41498087 | 06-Apr-16 (in house check Jun-18) | In house check: Jun-20 |
| Power sensor E4412A | SN: 000110210 | 06-Apr-16 (in house check Jun-18) | In house check: Jun-20 |
| RF generator HP 8648C | SN: US3642U01700 | 04-Aug-99 (in house check Jun-18) | In house check: Jun-20 |
| Network Analyzer E8358A | SN: US41080477 | 31-Mar-14 (in house check Oct-17) | In house check: Oct-18 |

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

Issued: July 28, 2018

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



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

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, ", "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 $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). $NORMx,y,z$ are only intermediate values, i.e., the uncertainties of $NORMx,y,z$ does not affect the E^2 -field uncertainty inside TSL (see below ConvF).
- $NORM(f)x,y,z = NORMx,y,z * frequency_response$ (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- $DCPx,y,z$: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- PAR : PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- $Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z; A, B, C, D$ are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters*: Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800$ MHz) and inside waveguide using analytical field distributions based on power measurements for $f > 800$ MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to $NORMx,y,z * ConvF$ whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the $NORMx$ (no uncertainty required).

Probe EX3DV4

SN:7306

Manufactured: March 11, 2014
Calibrated: July 26, 2018

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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7306

Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|----------|----------|----------|---------------|
| Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A | 0.48 | 0.58 | 0.46 | $\pm 10.1 \%$ |
| DCP (mV) ^B | 100.2 | 93.0 | 101.1 | |

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 | 158.1 | $\pm 3.3 \%$ |
| | | Y | 0.0 | 0.0 | 1.0 | | 150.5 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 157.2 | |

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

^A The uncertainties of Norm X,Y,Z do not affect the E²-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:7306

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 | 10.19 | 10.19 | 10.19 | 0.38 | 0.92 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 9.96 | 9.96 | 9.96 | 0.39 | 0.90 | ± 12.0 % |
| 900 | 41.5 | 0.97 | 9.71 | 9.71 | 9.71 | 0.45 | 0.84 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 8.69 | 8.69 | 8.69 | 0.40 | 0.80 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 8.26 | 8.26 | 8.26 | 0.37 | 0.80 | ± 12.0 % |
| 2000 | 40.0 | 1.40 | 8.22 | 8.22 | 8.22 | 0.33 | 0.85 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 7.43 | 7.43 | 7.43 | 0.33 | 1.05 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 7.26 | 7.26 | 7.26 | 0.46 | 0.95 | ± 12.0 % |
| 5250 | 35.9 | 4.71 | 5.38 | 5.38 | 5.38 | 0.40 | 1.80 | ± 13.1 % |
| 5600 | 35.5 | 5.07 | 4.71 | 4.71 | 4.71 | 0.40 | 1.80 | ± 13.1 % |
| 5750 | 35.4 | 5.22 | 5.00 | 5.00 | 5.00 | 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:7306

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 | 10.06 | 10.06 | 10.06 | 0.46 | 0.80 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 9.82 | 9.82 | 9.82 | 0.48 | 0.84 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 8.22 | 8.22 | 8.22 | 0.23 | 1.14 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 7.87 | 7.87 | 7.87 | 0.28 | 1.00 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 7.75 | 7.75 | 7.75 | 0.34 | 0.96 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 7.47 | 7.47 | 7.47 | 0.34 | 0.99 | ± 12.0 % |
| 5250 | 48.9 | 5.36 | 4.80 | 4.80 | 4.80 | 0.50 | 1.90 | ± 13.1 % |
| 5600 | 48.5 | 5.77 | 4.03 | 4.03 | 4.03 | 0.50 | 1.90 | ± 13.1 % |
| 5750 | 48.3 | 5.94 | 4.37 | 4.37 | 4.37 | 0.50 | 1.90 | ± 13.1 % |

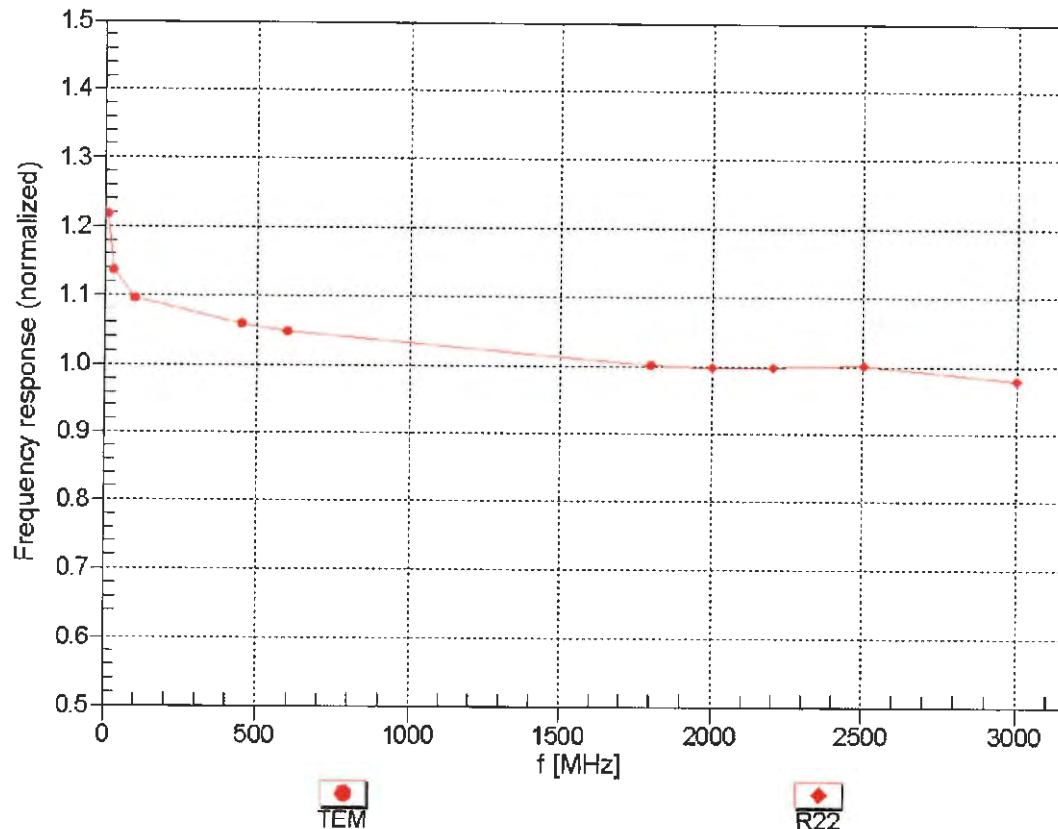
^C Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 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.

Frequency Response of E-Field

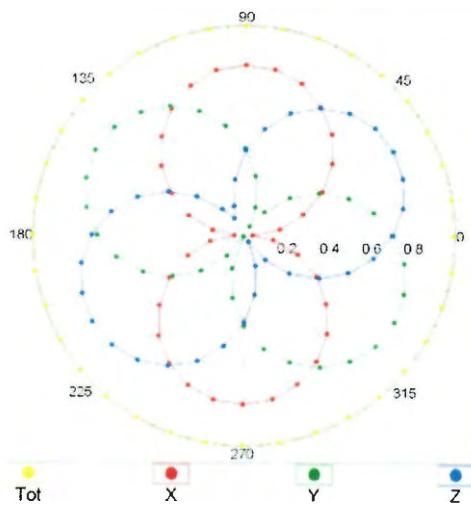
(TEM-Cell:ifi110 EXX, Waveguide: R22)



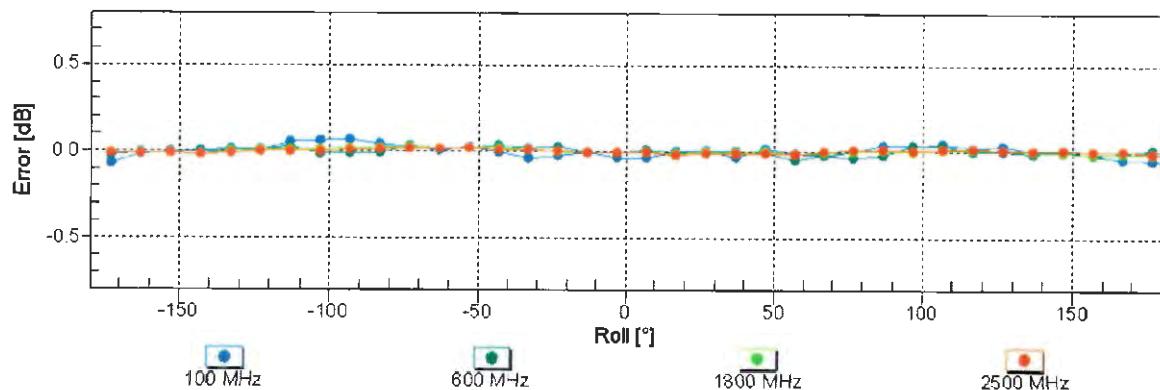
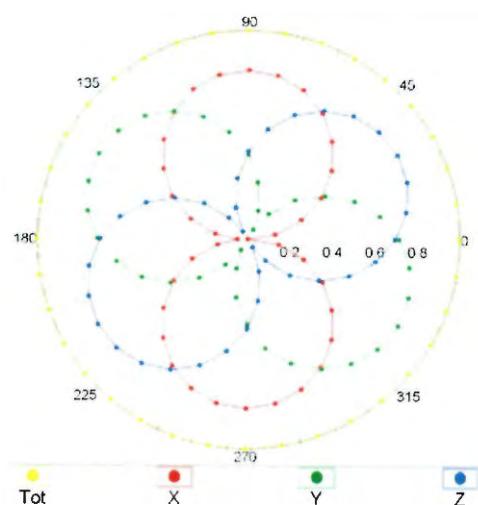
Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

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

$f=600 \text{ MHz, TEM}$

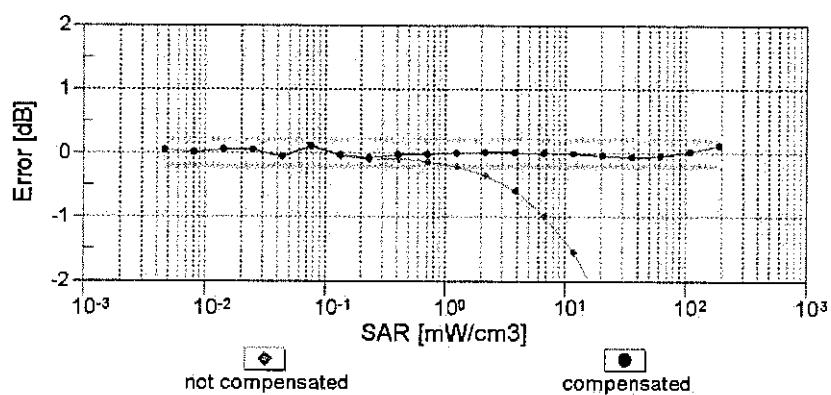
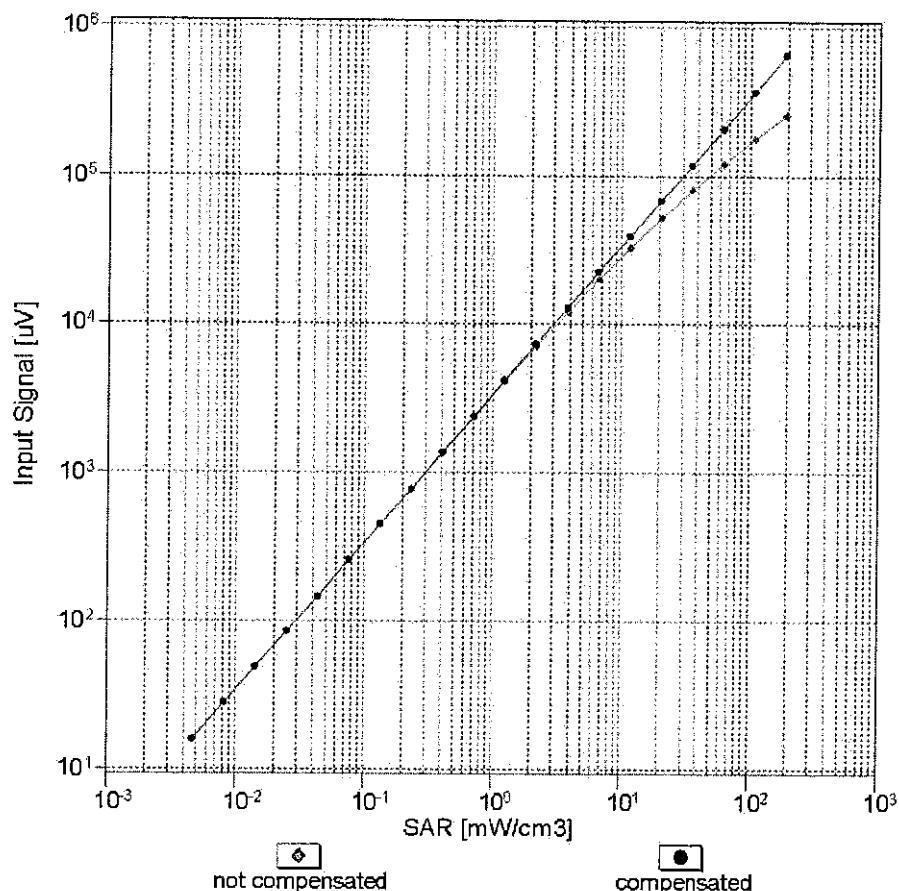


$f=1800 \text{ MHz, R22}$



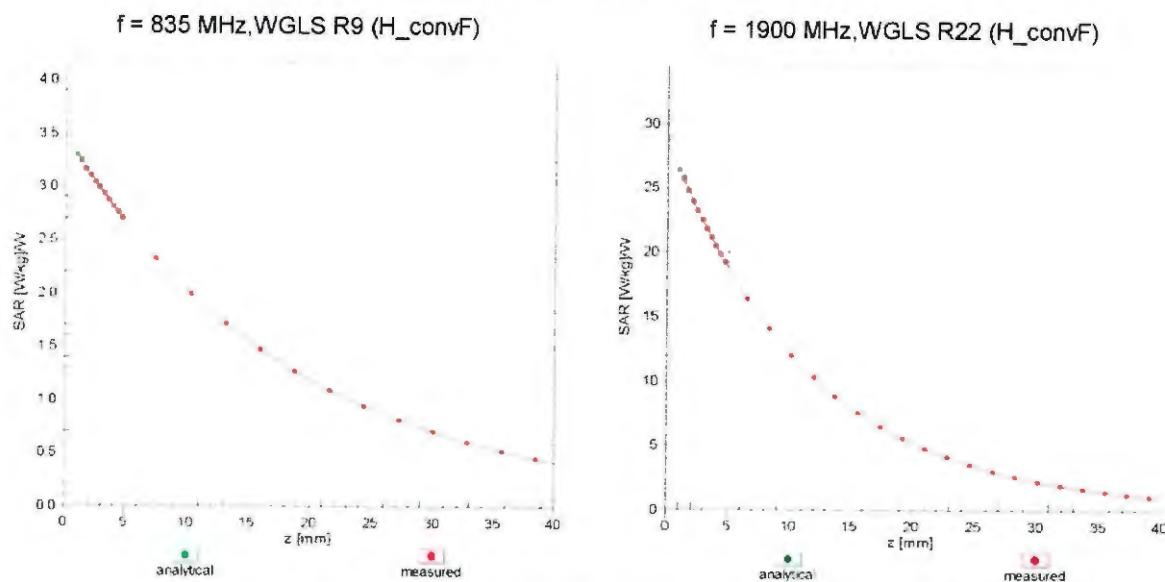
Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

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

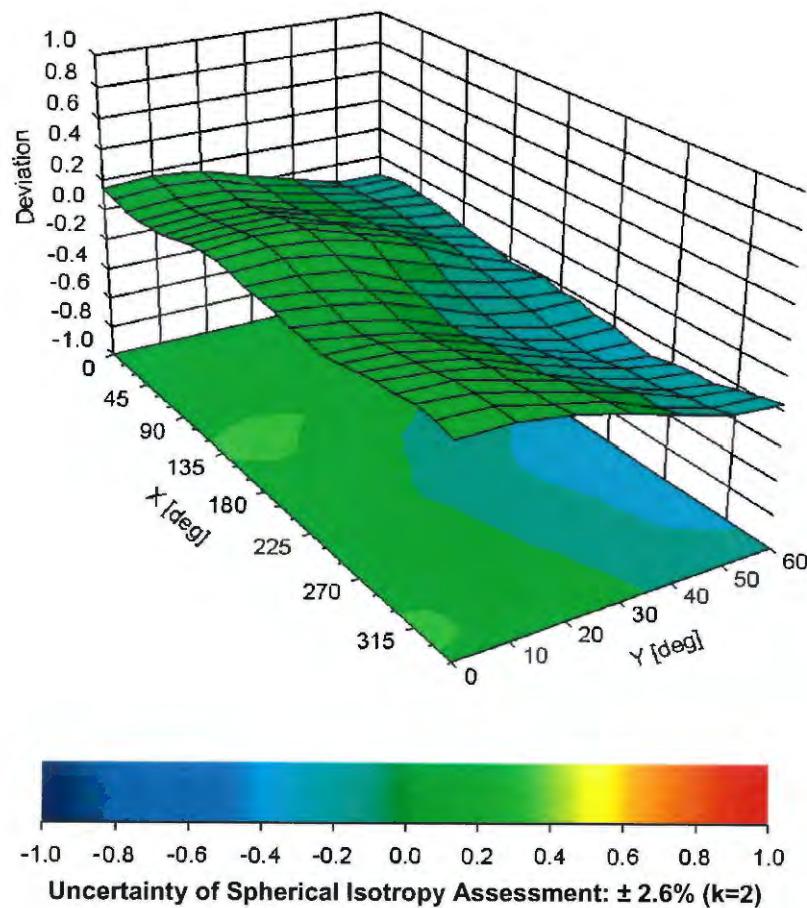


Uncertainty of Linearity Assessment: $\pm 0.6\%$ (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid Error (ϕ, θ), $f = 900 \text{ MHz}$



DASY/EASY - Parameters of Probe: EX3DV4 - SN:7306

Other Probe Parameters

| | |
|---|------------|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | 56.8 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 9 mm |
| Tip Diameter | 2.5 mm |
| Probe Tip to Sensor X Calibration Point | 1 mm |
| Probe Tip to Sensor Y Calibration Point | 1 mm |
| Probe Tip to Sensor Z Calibration Point | 1 mm |
| Recommended Measurement Distance from Surface | 1.4 mm |

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

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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **Auden**

Certificate No: **EX3-7515_Oct18**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:7515**

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

Calibration date: **October 3, 2018**

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 | 04-Apr-18 (No. 217-02672/02673) | Apr-19 |
| Power sensor NRP-Z91 | SN: 103244 | 04-Apr-18 (No. 217-02672) | Apr-19 |
| Power sensor NRP-Z91 | SN: 103245 | 04-Apr-18 (No. 217-02673) | Apr-19 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 04-Apr-18 (No. 217-02682) | Apr-19 |
| Reference Probe ES3DV2 | SN: 3013 | 30-Dec-17 (No. ES3-3013_Dec17) | Dec-18 |
| DAE4 | SN: 660 | 21-Dec-17 (No. DAE4-660_Dec17) | Dec-18 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| Power meter E4419B | SN: GB41293874 | 06-Apr-16 (in house check Jun-18) | In house check: Jun-20 |
| Power sensor E4412A | SN: MY41498087 | 06-Apr-16 (in house check Jun-18) | In house check: Jun-20 |
| Power sensor E4412A | SN: 000110210 | 06-Apr-16 (in house check Jun-18) | In house check: Jun-20 |
| RF generator HP 8648C | SN: US3642U01700 | 04-Aug-99 (in house check Jun-18) | In house check: Jun-20 |
| Network Analyzer E8358A | SN: US41080477 | 31-Mar-14 (in house check Oct-17) | In house check: Oct-18 |

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

Issued: October 3, 2018

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



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Glossary:

| | |
|-----------------------|--|
| TSL | tissue simulating liquid |
| NORM x,y,z | sensitivity in free space |
| ConvF | sensitivity in TSL / NORM x,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., $\theta = 0$ 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:

- $NORM_{x,y,z}$: Assessed for E-field polarization $\theta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). $NORM_{x,y,z}$ are only intermediate values, i.e., the uncertainties of $NORM_{x,y,z}$ does not affect the E²-field uncertainty inside TSL (see below ConvF).
- $NORM(f,x,y,z) = NORM_{x,y,z} * frequency_response$ (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.
- $DCP_{x,y,z}$: 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
- $A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,y,z}$: A, B, C, D are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters*: Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800$ MHz) and inside waveguide using analytical field distributions based on power measurements for $f > 800$ MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to $NORM_{x,y,z} * ConvF$ 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 $NORM_x$ (no uncertainty required).

Probe EX3DV4

SN:7515

Manufactured: March 28, 2018
Calibrated: October 3, 2018

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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7515

Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|----------|----------|----------|---------------|
| Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A | 0.42 | 0.50 | 0.46 | $\pm 10.1 \%$ |
| DCP (mV) ^B | 97.1 | 97.7 | 95.7 | |

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 | 169.5 | $\pm 2.2 \%$ |
| | | Y | 0.0 | 0.0 | 1.0 | | 156.2 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 176.6 | |

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 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:7515

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 | 10.11 | 10.11 | 10.11 | 0.54 | 0.80 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 9.75 | 9.75 | 9.75 | 0.41 | 0.88 | ± 12.0 % |
| 900 | 41.5 | 0.97 | 9.68 | 9.68 | 9.68 | 0.55 | 0.85 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 8.65 | 8.65 | 8.65 | 0.34 | 0.88 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 8.33 | 8.33 | 8.33 | 0.25 | 0.90 | ± 12.0 % |
| 2000 | 40.0 | 1.40 | 8.28 | 8.28 | 8.28 | 0.29 | 0.88 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 7.86 | 7.86 | 7.86 | 0.35 | 0.87 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 7.42 | 7.42 | 7.42 | 0.36 | 0.88 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 7.37 | 7.37 | 7.37 | 0.33 | 0.97 | ± 12.0 % |
| 5250 | 35.9 | 4.71 | 5.45 | 5.45 | 5.45 | 0.40 | 1.80 | ± 13.1 % |
| 5600 | 35.5 | 5.07 | 4.83 | 4.83 | 4.83 | 0.40 | 1.80 | ± 13.1 % |
| 5750 | 35.4 | 5.22 | 4.95 | 4.95 | 4.95 | 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:7515

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 | 10.15 | 10.15 | 10.15 | 0.46 | 0.84 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 9.99 | 9.99 | 9.99 | 0.38 | 1.01 | ± 12.0 % |
| 900 | 55.0 | 1.05 | 9.69 | 9.69 | 9.69 | 0.52 | 0.80 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 8.20 | 8.20 | 8.20 | 0.36 | 0.93 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 7.93 | 7.93 | 7.93 | 0.31 | 0.96 | ± 12.0 % |
| 2000 | 53.3 | 1.52 | 7.89 | 7.89 | 7.89 | 0.38 | 0.87 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 7.75 | 7.75 | 7.75 | 0.36 | 0.90 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 7.53 | 7.53 | 7.53 | 0.36 | 0.94 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 7.48 | 7.48 | 7.48 | 0.28 | 0.97 | ± 12.0 % |
| 5250 | 48.9 | 5.36 | 4.96 | 4.96 | 4.96 | 0.50 | 1.90 | ± 13.1 % |
| 5600 | 48.5 | 5.77 | 4.39 | 4.39 | 4.39 | 0.50 | 1.90 | ± 13.1 % |
| 5800 | 48.2 | 6.00 | 4.42 | 4.42 | 4.42 | 0.50 | 1.90 | ± 13.1 % |

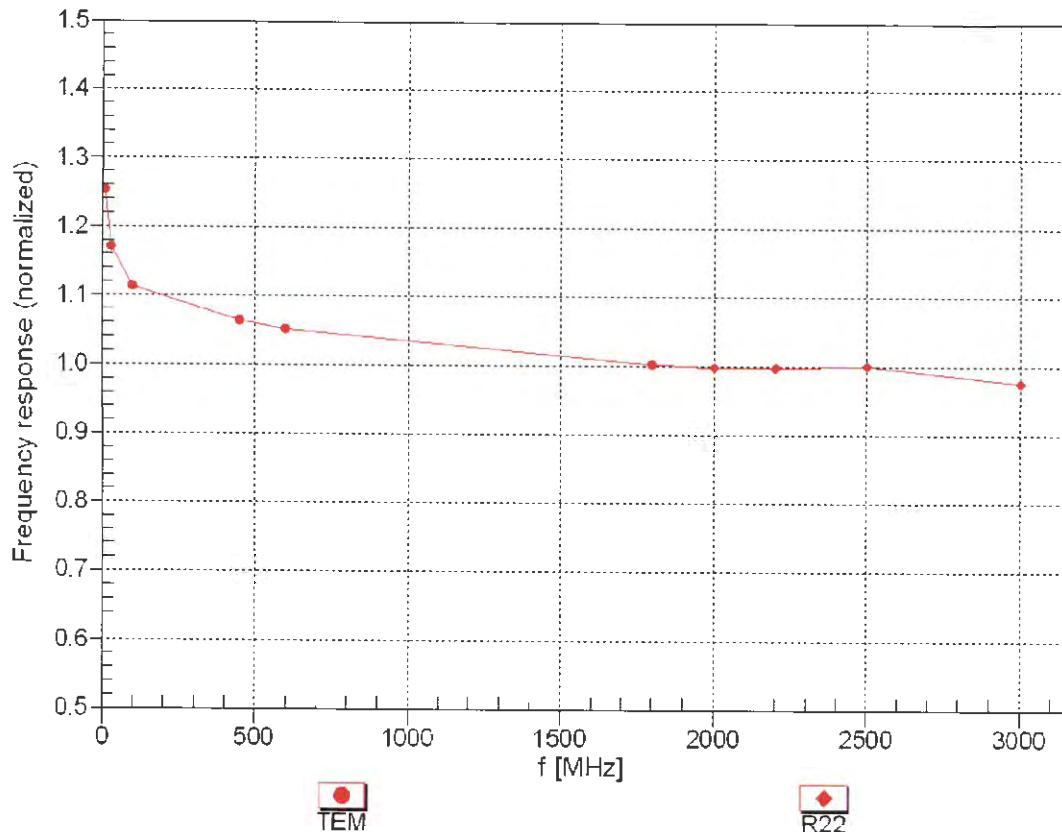
^C Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 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.

Frequency Response of E-Field

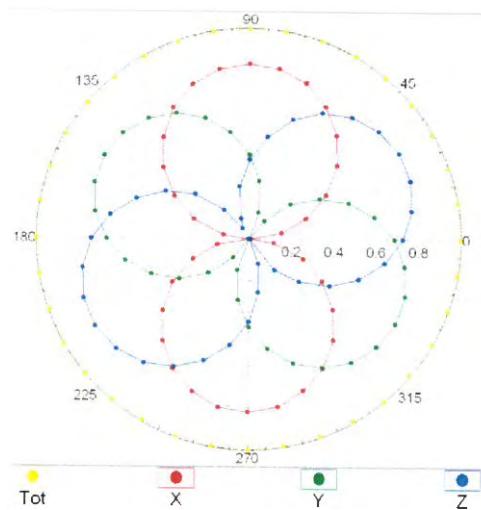
(TEM-Cell:ifi110 EXX, Waveguide: R22)



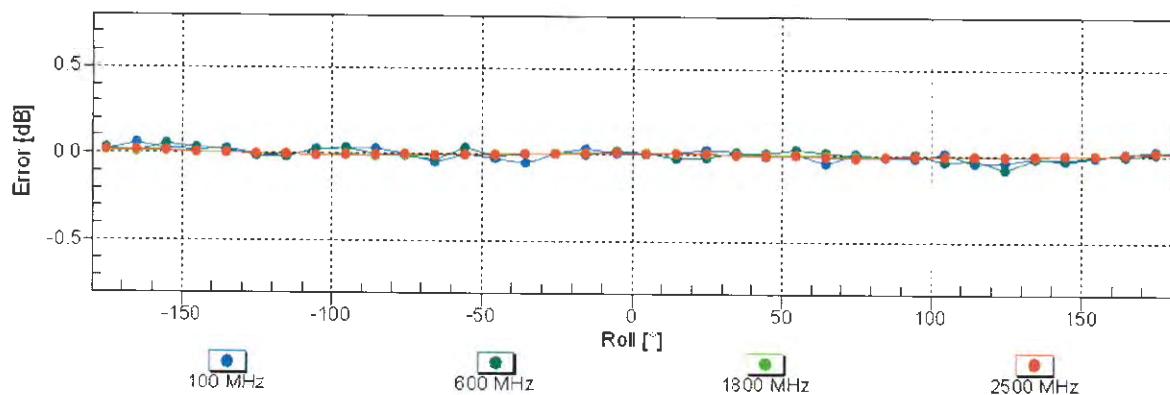
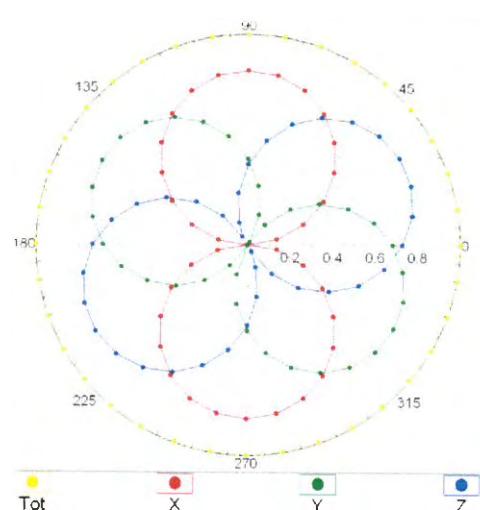
Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

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

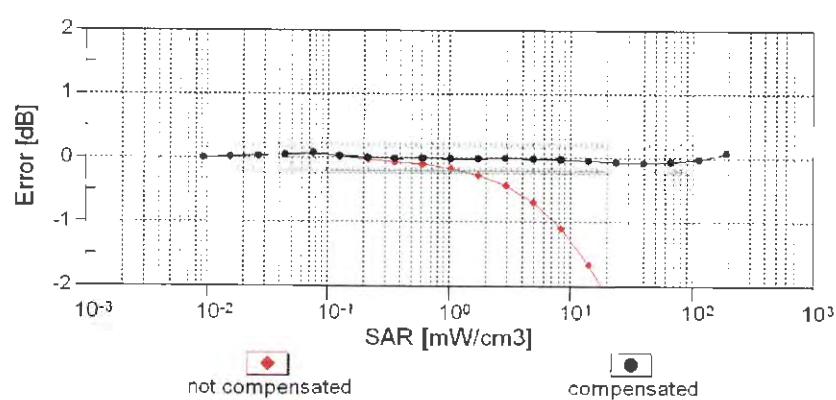
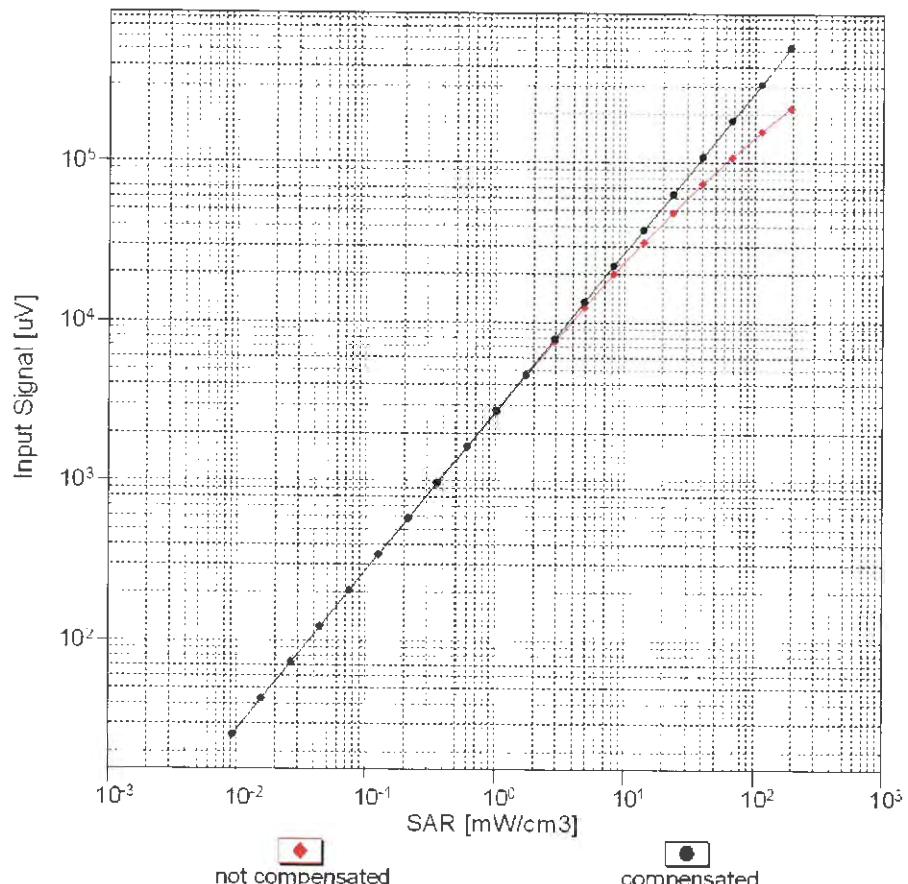
f=600 MHz, TEM



f=1800 MHz, R22

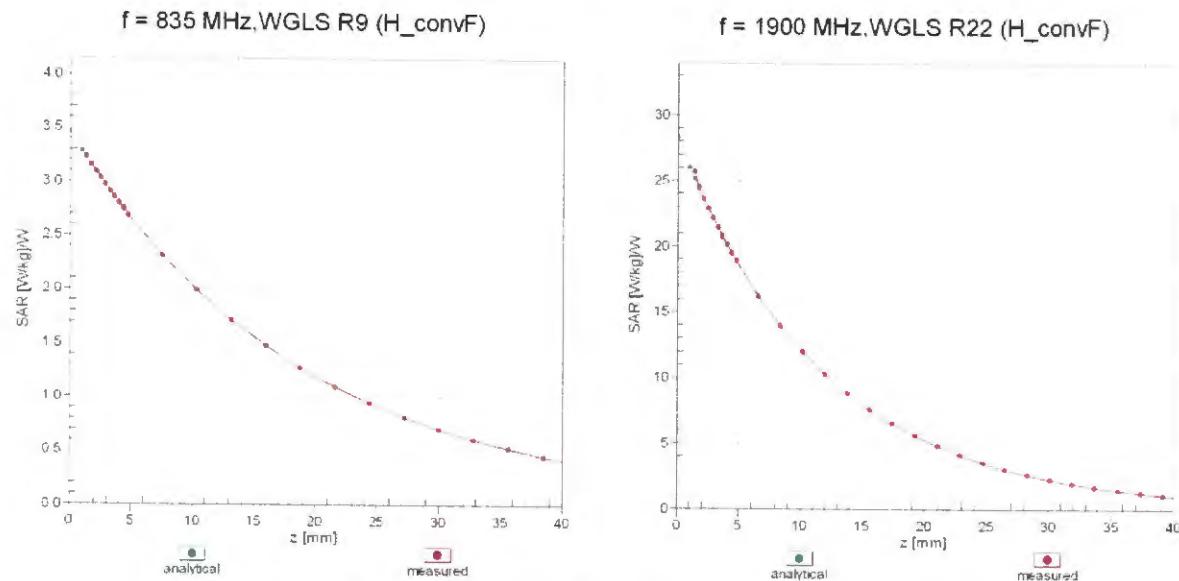


Dynamic Range f(SAR_{head}) (TEM cell , f_{eval}= 1900 MHz)

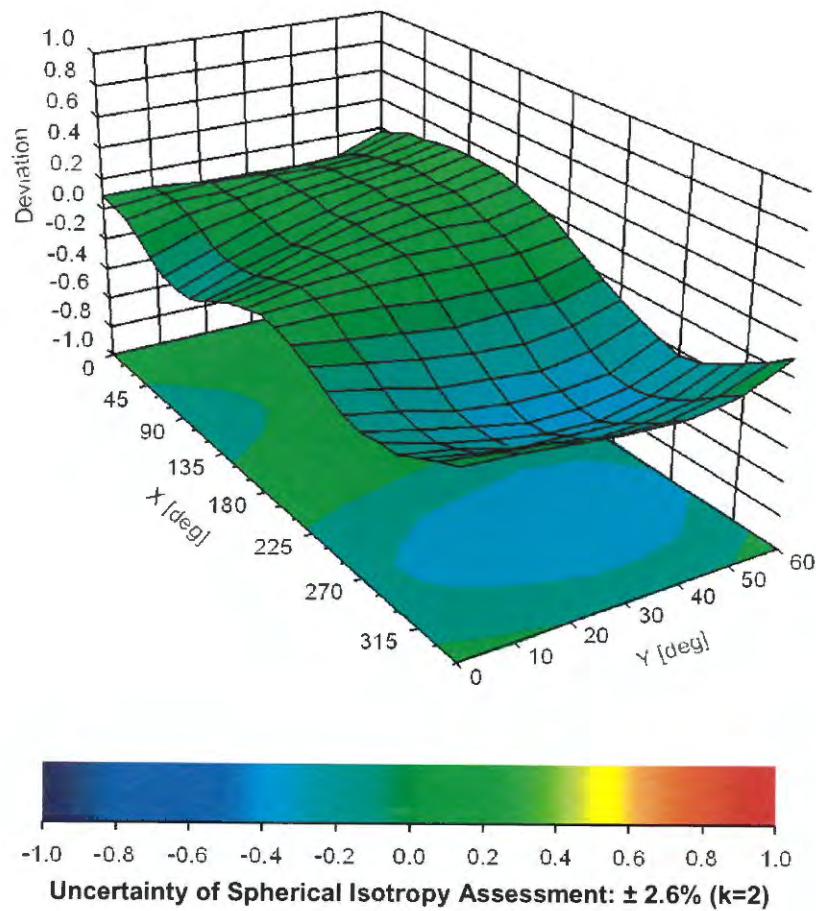


Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

Conversion Factor Assessment



Deviation from Isotropy in Liquid Error (ϕ, θ), $f = 900 \text{ MHz}$



DASY/EASY - Parameters of Probe: EX3DV4 - SN:7515

Other Probe Parameters

| | |
|---|------------|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -5.4 |
| 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 |