



Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2079 Fax: +86-10-62304633-2504
E-mail: cttl@chinattl.com Http://www.chinattl.cn

Glossary:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORMx,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) For hand-held devices used in close proximity to the ear (frequency range of 300MHz to 3GHz)", February 2005
- c) 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

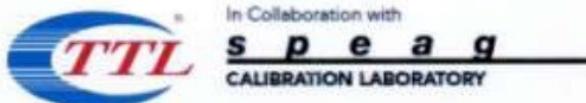
Additional Documentation:

- 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	52.8.8.1258
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	41.0 ± 6 %	0.89 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	2.30 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	9.24 mW / g ± 20.8 % (k=2)
SAR averaged over 10 cm³ (10 g) of Head TSL	Condition	
SAR measured	250 mW input power	1.50 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	6.02 mW / g ± 20.4 % (k=2)

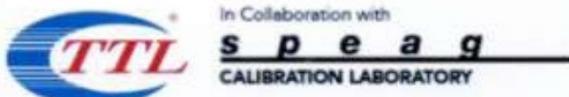
Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	55.2	0.97 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	55.4 ± 6 %	0.99 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	2.43 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	9.57 mW / g ± 20.8 % (k=2)
SAR averaged over 10 cm³ (10 g) of Body TSL	Condition	
SAR measured	250 mW input power	1.61 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	6.36 mW / g ± 20.4 % (k=2)



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Appendix

Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.2Ω- 3.11jΩ
Return Loss	- 29.8dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.6Ω- 2.33jΩ
Return Loss	- 27.4dB

General Antenna Parameters and Design

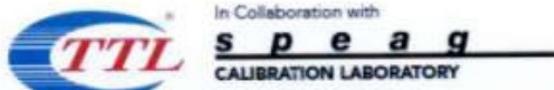
Electrical Delay (one direction)	1.508 ns
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After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

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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In Collaboration with

DASY5 Validation Report for Head TSL

Date: 06.16.2016

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d154

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

Medium parameters used: $f = 835 \text{ MHz}$; $\sigma = 0.891 \text{ S/m}$; $\epsilon_r = 40.97$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Right Section

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

DASY5 Configuration:

- Probe: EX3DV4 - SN7307; ConvF(10.01, 10.01, 10.01); Calibrated: 2/19/2016;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn771; Calibrated: 2016-02-02
- Phantom: Triple Flat Phantom 5.1C; Type: QD 000 P51 CA; Serial: 1161/1
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7372)

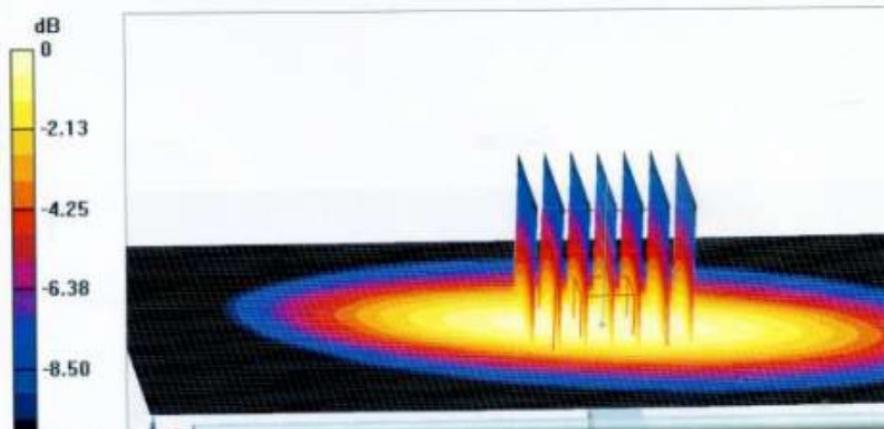
Dipole Calibration/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 58.14V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 3.41 W/kg

SAR(1 g) = 2.3 W/kg; SAR(10 g) = 1.5 W/kg

Maximum value of SAR (measured) = 2.91 W/kg



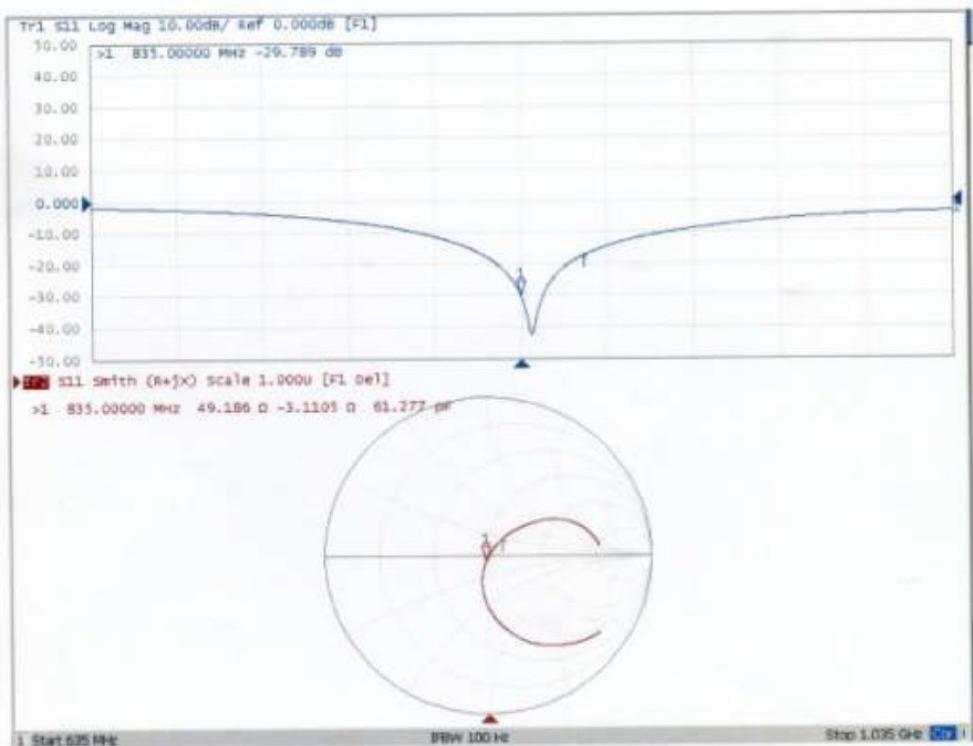
0 dB = 2.91 W/kg = 4.64 dBW/kg

Appendix A: Calibration Certificate



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Impedance Measurement Plot for Head TSL



Certificate No: Z16-97016

Page 6 of 8



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Tel: +86-10-62304633-2079 Fax: +86-10-62304633-2504
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DASY5 Validation Report for Body TSL

Date: 06.16.2016

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d154

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

Medium parameters used: $f = 835 \text{ MHz}$; $\sigma = 0.991 \text{ S/m}$; $\epsilon_r = 55.41$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Center Section

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

DASY5 Configuration:

- Probe: EX3DV4 - SN7307; ConvF(9.83,9.83, 9.83); Calibrated: 2/19/2016;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn771; Calibrated: 2016-02-02
- Phantom: Triple Flat Phantom 5.1C; Type: QD 000 P51 CA; Serial: 1161/1
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7372)

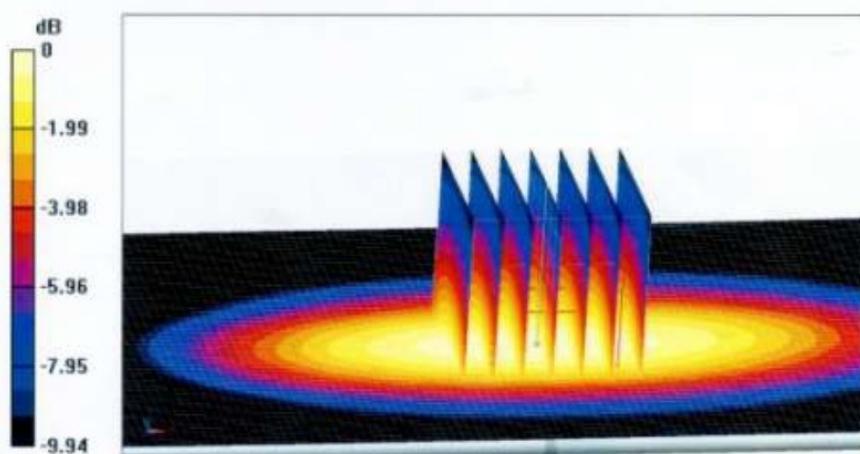
Dipole Calibration/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 54.01 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 3.53 W/kg

SAR(1 g) = 2.43 W/kg; SAR(10 g) = 1.61 W/kg

Maximum value of SAR (measured) = 3.04 W/kg



0 dB = 3.04 W/kg = 4.83 dBW/kg

Certificate No: Z16-97016

Page 7 of 8

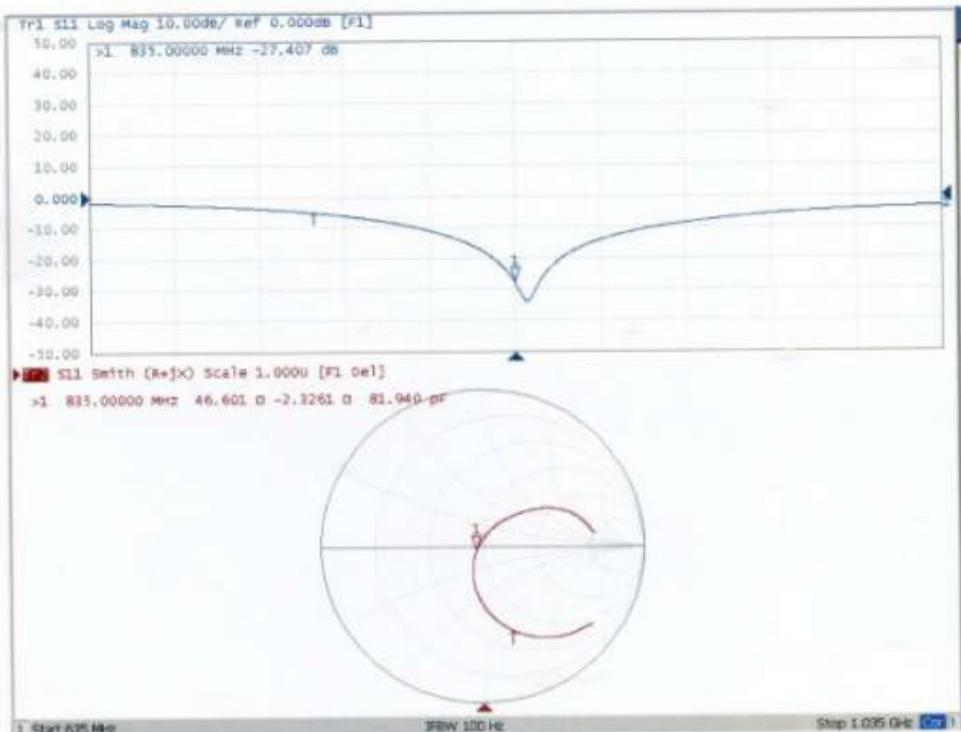
Appendix A: Calibration Certificate



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Impedance Measurement Plot for Body TSL



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Page 8 of 8

Extended Dipole Calibrations

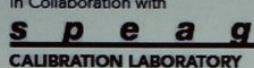
Referring to KDB865664 D01, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

Head						
Date of measurement	Return-loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary impedance (ohm)	Delta (ohm)
2016-06-16	-29.80		49.20		3.11	
2017-06-15	-29.86	-0.69	50.03	0.83	3.28	0.17

Body						
Date of measurement	Return-loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary impedance (ohm)	Delta (ohm)
2016-06-16	-27.40		46.60		2.33	
2017-06-15	-27.33	0.81	46.09	-0.51	2.12	0.21

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5ohm of prior calibration. Therefore the verification result should support extended calibration.

1.4. D1750V2 Dipole Calibration Certificate

 In Collaboration with  CALIBRATION LABORATORY		  CALIBRATION No. L0570																																																			
Client	Certificate No: Z15-97069																																																				
<p align="center">CALIBRATION CERTIFICATE</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">Object</td> <td>D1750V2 - SN: 1062</td> </tr> <tr> <td>Calibration Procedure(s)</td> <td>TMC-OS-E-02-194 Calibration procedure for dipole validation kits</td> </tr> <tr> <td>Calibration date:</td> <td>July 25, 2015</td> </tr> <tr> <td colspan="2"> <p>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.</p> <p>All calibrations have been conducted in the closed laboratory facility: environment temperature(22 ± 3)°C and humidity<70%.</p> <p>Calibration Equipment used (M&TE critical for calibration)</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Primary Standards</th> <th>ID #</th> <th>Cal Date(Calibrated by, Certificate No.)</th> <th>Scheduled Calibration</th> </tr> </thead> <tbody> <tr> <td>Power Meter NRVD</td> <td>102083</td> <td>11-Sep-14 (TMC, No.JZ13-443)</td> <td>Sep-15</td> </tr> <tr> <td>Power sensor NRV-Z5</td> <td>100595</td> <td>11-Sep-14 (TMC, No. JZ13-443)</td> <td>Sep -15</td> </tr> <tr> <td>Reference Probe EX3DV4</td> <td>SN 3846</td> <td>3- Sep-14 (SPEAG, No.EX3-3846_Sep13)</td> <td>Sep-15</td> </tr> <tr> <td>DAE4</td> <td>SN 1331</td> <td>23-Jan-15 (SPEAG, DAE4-1331_Jan14)</td> <td>Jan -16</td> </tr> <tr> <td>Signal Generator E4438C</td> <td>MY49070393</td> <td>13-Nov-14 (TMC, No.JZ13-394)</td> <td>Nov-15</td> </tr> <tr> <td>Network Analyzer E8362B</td> <td>MY43021135</td> <td>19-Oct-14 (TMC, No.JZ13-278)</td> <td>Oct-15</td> </tr> </tbody> </table> </td> </tr> <tr> <td>Calibrated by:</td> <td>Name Yu Zongying</td> <td>Function SAR Test Engineer</td> </tr> <tr> <td>Reviewed by:</td> <td>Qi Dianyuan</td> <td>SAR Project Leader</td> </tr> <tr> <td>Approved by:</td> <td>Lu Bingsong</td> <td>Deputy Director of the laboratory</td> </tr> <tr> <td colspan="3" style="text-align: right;">Issued: July 28, 2015</td> </tr> <tr> <td colspan="3"> This calibration certificate shall not be reproduced except in full without written approval of the laboratory. </td> </tr> </table>			Object	D1750V2 - SN: 1062	Calibration Procedure(s)	TMC-OS-E-02-194 Calibration procedure for dipole validation kits	Calibration date:	July 25, 2015	<p>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.</p> <p>All calibrations have been conducted in the closed laboratory facility: environment temperature(22 ± 3)°C and humidity<70%.</p> <p>Calibration Equipment used (M&TE critical for calibration)</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Primary Standards</th> <th>ID #</th> <th>Cal Date(Calibrated by, Certificate No.)</th> <th>Scheduled Calibration</th> </tr> </thead> <tbody> <tr> <td>Power Meter NRVD</td> <td>102083</td> <td>11-Sep-14 (TMC, No.JZ13-443)</td> <td>Sep-15</td> </tr> <tr> <td>Power sensor NRV-Z5</td> <td>100595</td> <td>11-Sep-14 (TMC, No. JZ13-443)</td> <td>Sep -15</td> </tr> <tr> <td>Reference Probe EX3DV4</td> <td>SN 3846</td> <td>3- Sep-14 (SPEAG, No.EX3-3846_Sep13)</td> <td>Sep-15</td> </tr> <tr> <td>DAE4</td> <td>SN 1331</td> <td>23-Jan-15 (SPEAG, DAE4-1331_Jan14)</td> <td>Jan -16</td> </tr> <tr> <td>Signal Generator E4438C</td> <td>MY49070393</td> <td>13-Nov-14 (TMC, No.JZ13-394)</td> <td>Nov-15</td> </tr> <tr> <td>Network Analyzer E8362B</td> <td>MY43021135</td> <td>19-Oct-14 (TMC, No.JZ13-278)</td> <td>Oct-15</td> </tr> </tbody> </table>		Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration	Power Meter NRVD	102083	11-Sep-14 (TMC, No.JZ13-443)	Sep-15	Power sensor NRV-Z5	100595	11-Sep-14 (TMC, No. JZ13-443)	Sep -15	Reference Probe EX3DV4	SN 3846	3- Sep-14 (SPEAG, No.EX3-3846_Sep13)	Sep-15	DAE4	SN 1331	23-Jan-15 (SPEAG, DAE4-1331_Jan14)	Jan -16	Signal Generator E4438C	MY49070393	13-Nov-14 (TMC, No.JZ13-394)	Nov-15	Network Analyzer E8362B	MY43021135	19-Oct-14 (TMC, No.JZ13-278)	Oct-15	Calibrated by:	Name Yu Zongying	Function SAR Test Engineer	Reviewed by:	Qi Dianyuan	SAR Project Leader	Approved by:	Lu Bingsong	Deputy Director of the laboratory	Issued: July 28, 2015			This calibration certificate shall not be reproduced except in full without written approval of the laboratory.		
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CALIBRATION
No. L0570

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:

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- KDB865664, SAR Measurement Requirements for 100 MHz to 6 GHz

Additional Documentation:

- DASY4/5 System Handbook

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- 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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CALIBRATION
No. L0570

Measurement Conditions

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

DASY Version	DASY52	52.8.8.1222
Extrapolation	Advanced Extrapolation	
Phantom	Triple Flat Phantom 5.1C	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1750 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.1	1.37 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	39.7 ± 6 %	1.35 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	9.20 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	37.1 mW /g ± 20.8 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	Condition	
SAR measured	250 mW input power	4.97 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	20.0 mW /g ± 20.4 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.4	1.49 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	54.3 ± 6 %	1.47 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	9.22 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	37.3 mW /g ± 20.8 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Body TSL	Condition	
SAR measured	250 mW input power	4.95 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	20.0 mW /g ± 20.4 % (k=2)

Certificate No: Z15-97069

Page 3 of 8

Appendix A: Calibration Certificate



In Collaboration with
s p e a g
CALIBRATION LABORATORY

Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2079 Fax: +86-10-62304633-2504
E-mail: ctl@chinattl.com Http://www.chinattl.cn



CALIBRATION
No. L0570

Appendix

Antenna Parameters with Head TSL

Impedance, transformed to feed point	51.1Ω+ 1.62jΩ
Return Loss	- 34.2dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	49.2Ω+ 4.25jΩ
Return Loss	- 27.2dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.257 ns
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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.

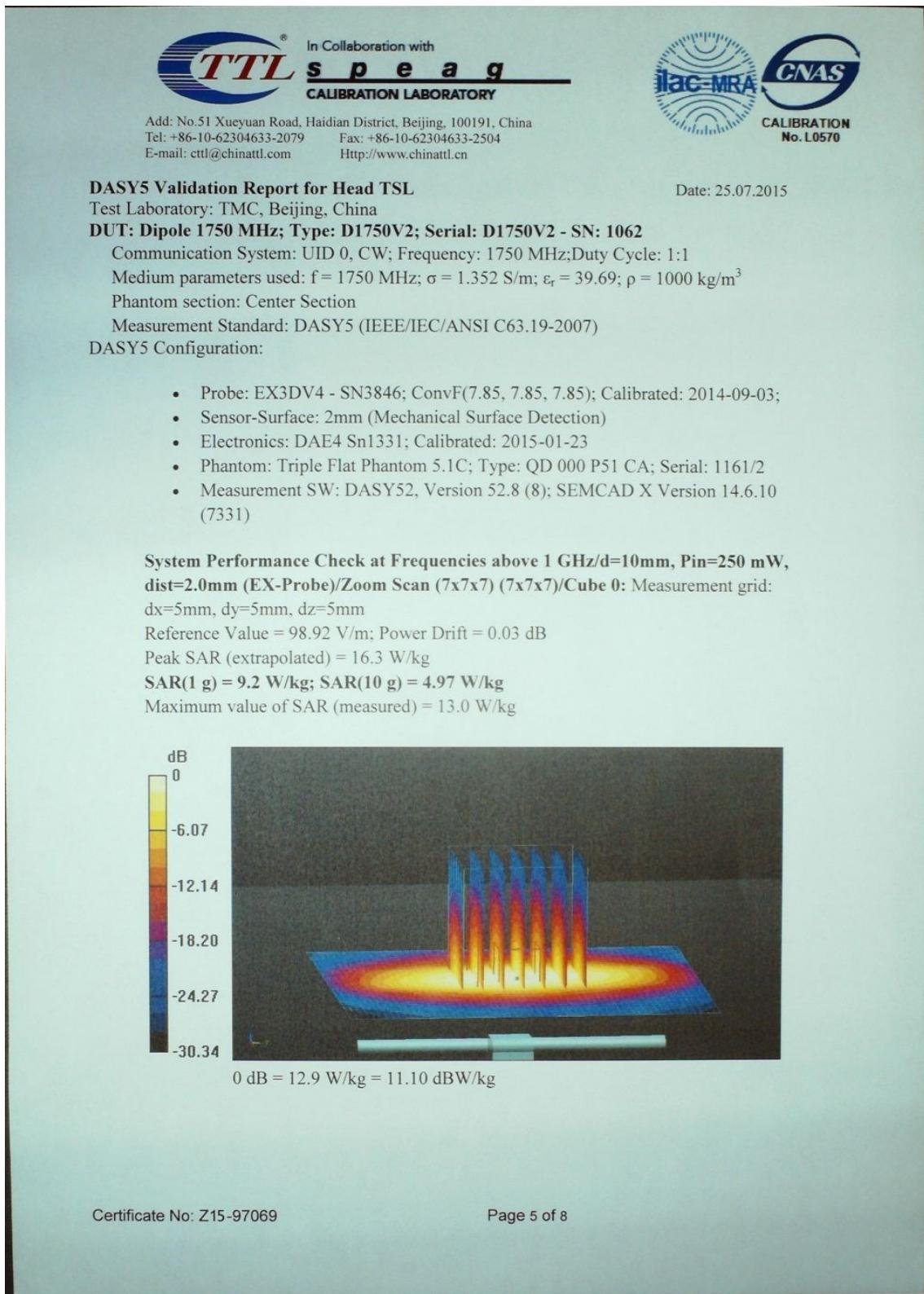
Additional EUT Data

Manufactured by	SPEAG
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Certificate No: Z15-97069

Page 4 of 8

Appendix A: Calibration Certificate



Appendix A: Calibration Certificate



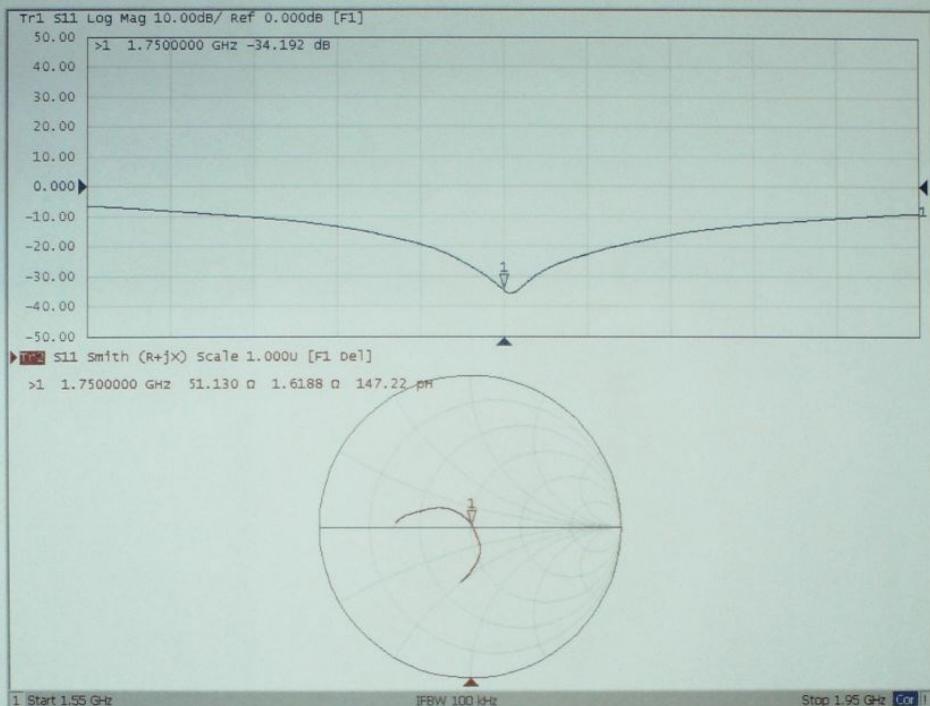
In Collaboration with
s p e a g
CALIBRATION LABORATORY

Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2079 Fax: +86-10-62304633-2504
E-mail: ctl@chinattl.com Http://www.chinattl.cn



CALIBRATION
No. L0570

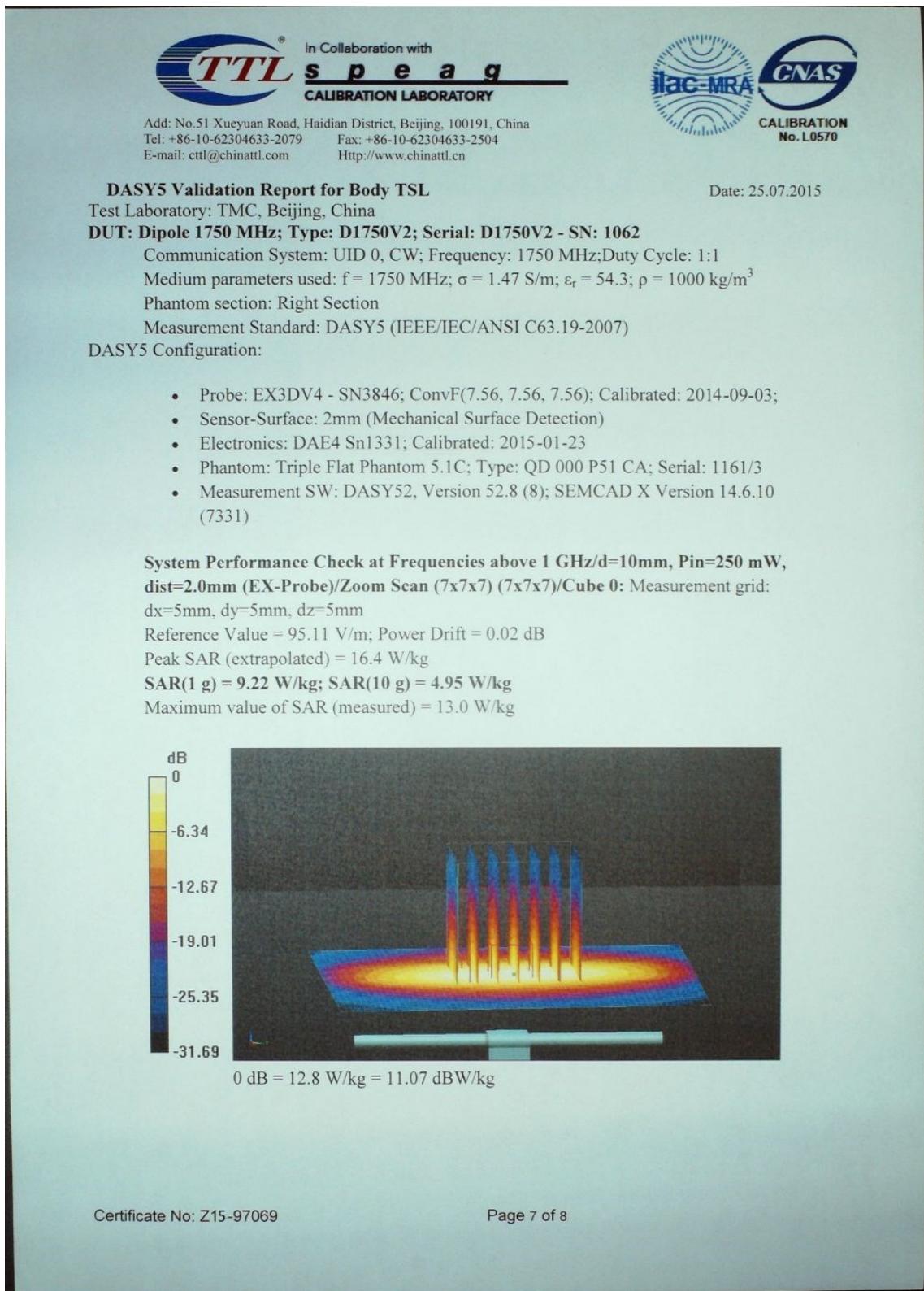
Impedance Measurement Plot for Head TSL



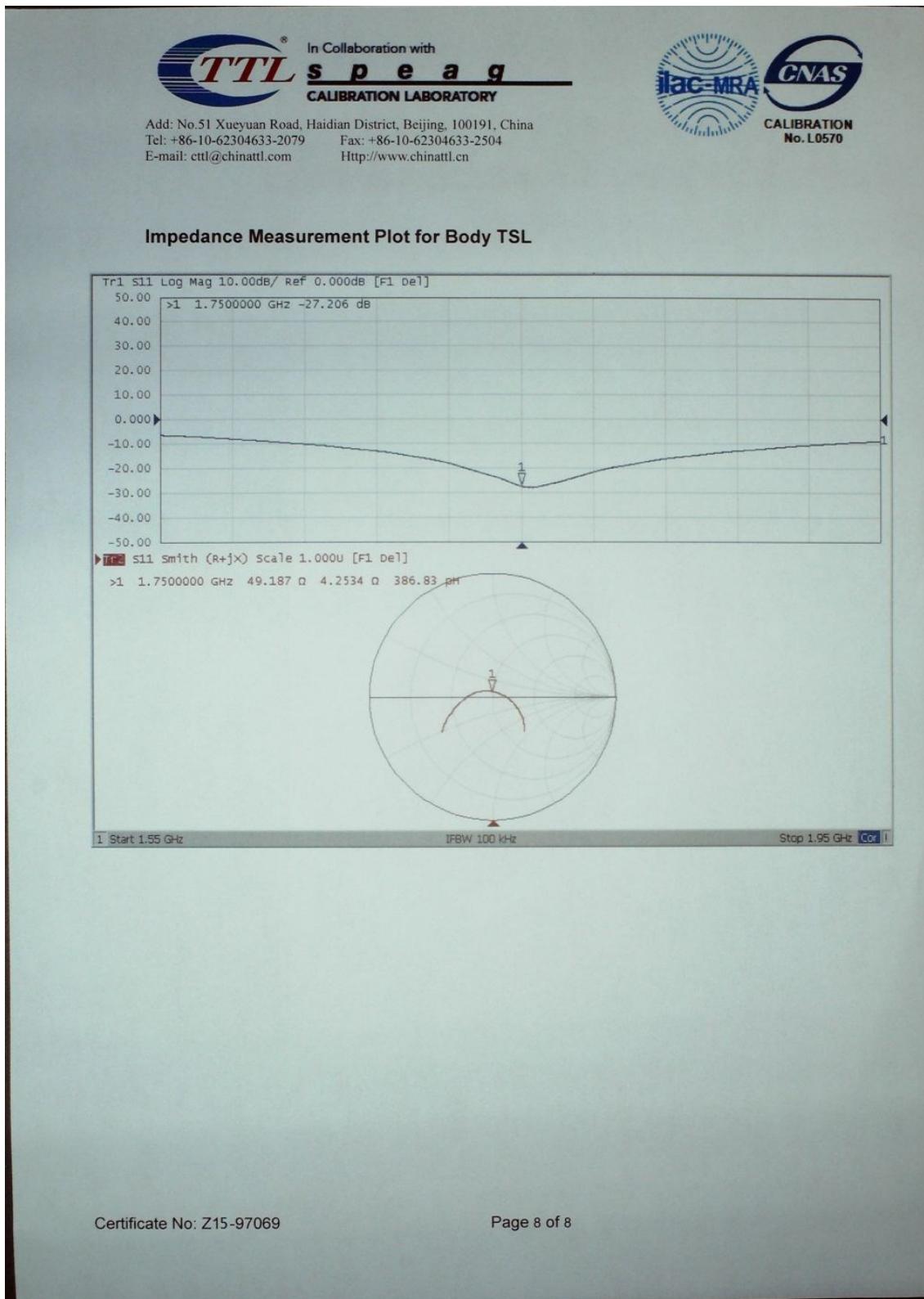
Certificate No: Z15-97069

Page 6 of 8

Appendix A: Calibration Certificate



Appendix A: Calibration Certificate



Extended Dipole Calibrations

Referring to KDB865664 D01, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

Head						
Date of measurement	Return-loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary impedance (ohm)	Delta (ohm)
2015-07-25	-34.20		51.10		1.62	
2016-07-23	-33.70	5.93	52.42	1.32	2.28	0.66
2017-07-23	-34.07	1.51	51.88	0.78	2.06	0.44

Body						
Date of measurement	Return-loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary impedance (ohm)	Delta (ohm)
2015-07-25	-27.20		49.20		4.25	
2016-07-23	-27.07	1.51	50.58	1.38	3.80	-0.45
2016-07-23	-26.88	3.75	50.35	1.15	4.09	-0.16

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5ohm of prior calibration.

Therefore the verification result should support extended calibration.

1.5. D1900V2 Dipole Calibration Certificate

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



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

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

Accreditation No.: SCS 0108

Client CIQ(Auden)

Certificate No: D1900V2-5d101_Jul15

CALIBRATION CERTIFICATE

Object	D1900V2 - SN: 5d101
Calibration procedure(s)	QA CAL-05.v9 Calibration procedure for dipole validation kits above 700 MHz
Calibration date:	July 23, 2015

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 EPM-442A	GB37480704	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	US37292783	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	MY41092317	07-Oct-14 (No. 217-02021)	Oct-15
Reference 20 dB Attenuator	SN: 5058 (20k)	01-Apr-15 (No. 217-02131)	Mar-16
Type-N mismatch combination	SN: 5047.2 / 06327	01-Apr-15 (No. 217-02134)	Mar-16
Reference Probe ES3DV3	SN: 3205	30-Dec-14 (No. ES3-3205_Dec14)	Dec-15
DAE4	SN: 601	18-Aug-14 (No. DAE4-601_Aug14)	Aug-15
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

Calibrated by:	Name Michael Weber	Function Laboratory Technician	Signature
----------------	-----------------------	-----------------------------------	---------------

Approved by:	Katja Pokovic	Technical Manager	
--------------	---------------	-------------------	--

Issued: July 23, 2015

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

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



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

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

Accreditation No.: SCS 0108

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Appendix A: Calibration Certificate

Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	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	39.7 ± 6 %	1.38 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	10.1 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	40.7 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	5.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	21.5 W/kg ± 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	52.7 ± 6 %	1.54 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	10.2 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	40.4 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.47 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.7 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	50.7 Ω + 5.7 $j\Omega$
Return Loss	- 24.9 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.4 Ω + 5.8 $j\Omega$
Return Loss	- 23.6 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.203 ns
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After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

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

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

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	March 28, 2008

DASY5 Validation Report for Head TSL

Date: 23.07.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN: 5d101

Communication System: UID 0 - CW; Frequency: 1900 MHz

Medium parameters used: $f = 1900 \text{ MHz}$; $\sigma = 1.38 \text{ S/m}$; $\epsilon_r = 39.7$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(5, 5, 5); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

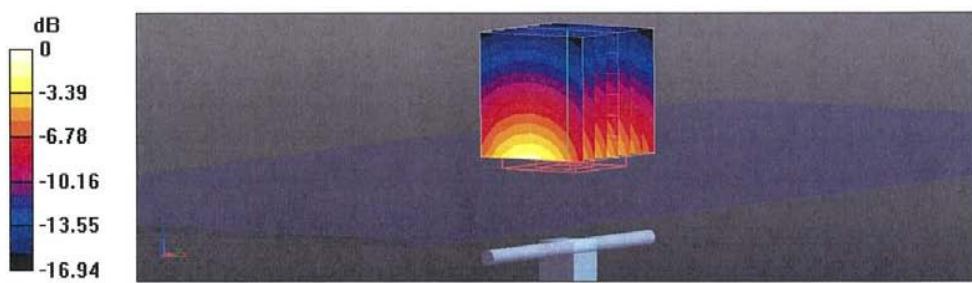
Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 98.88 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 18.2 W/kg

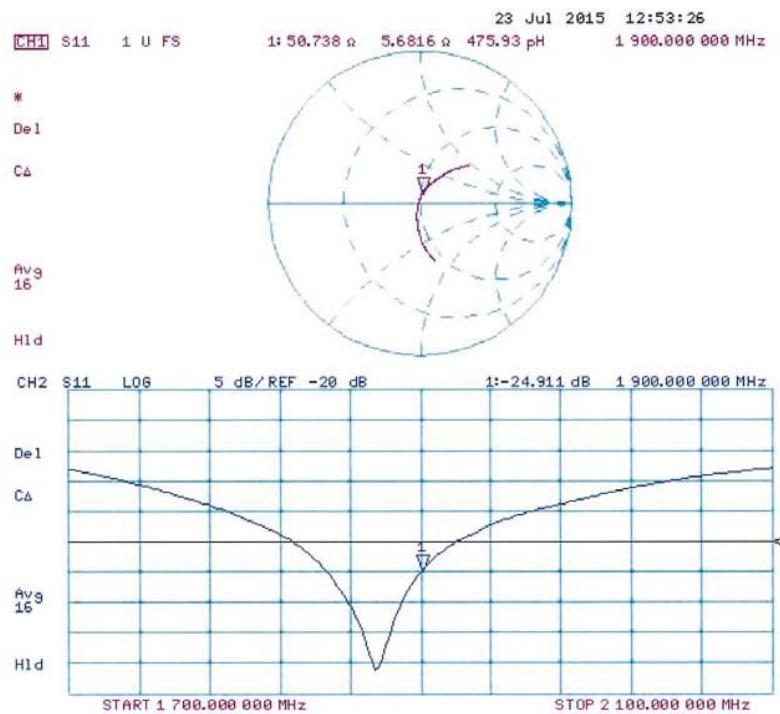
SAR(1 g) = 10.1 W/kg; SAR(10 g) = 5.34 W/kg

Maximum value of SAR (measured) = 12.8 W/kg



0 dB = 12.8 W/kg = 11.07 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 23.07.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN: 5d101

Communication System: UID 0 - CW; Frequency: 1900 MHz

Medium parameters used: $f = 1900 \text{ MHz}$; $\sigma = 1.54 \text{ S/m}$; $\epsilon_r = 52.7$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.65, 4.65, 4.65); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

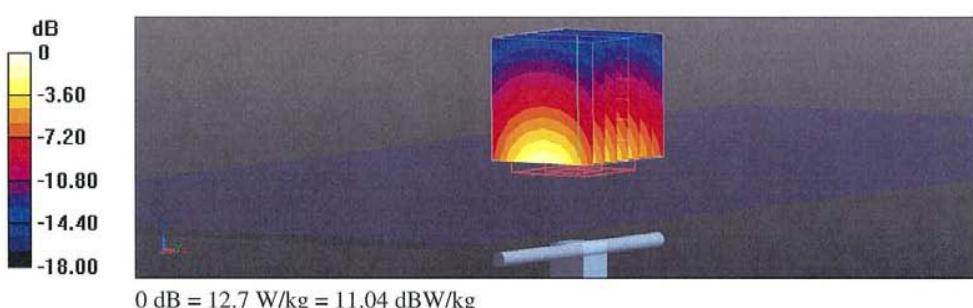
Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 95.76 V/m; Power Drift = -0.01 dB

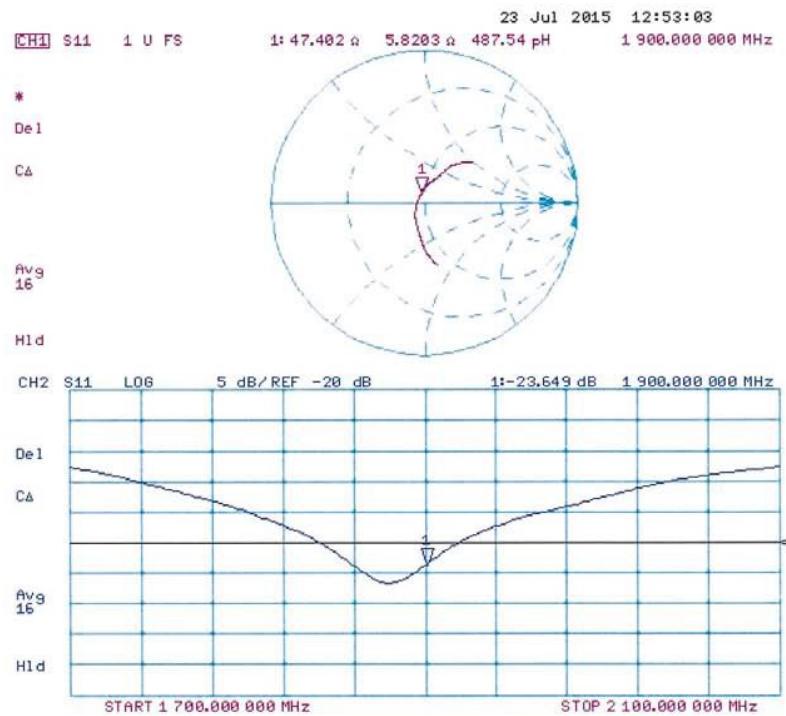
Peak SAR (extrapolated) = 17.1 W/kg

SAR(1 g) = 10.2 W/kg; SAR(10 g) = 5.47 W/kg

Maximum value of SAR (measured) = 12.7 W/kg



Impedance Measurement Plot for Body TSL



Extended Dipole Calibrations

Referring to KDB865664 D01, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

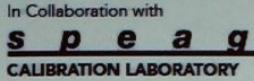
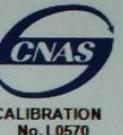
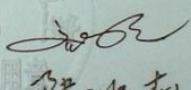
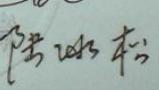
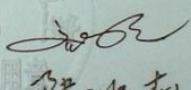
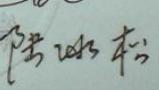
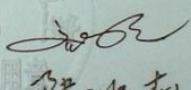
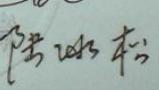
Head						
Date of measurement	Return-loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary impedance (ohm)	Delta (ohm)
2015-07-23	-24.90		50.7		5.7	
2016-07-22	-24.70	2.33	52.1	1.4	5.2	-0.5
2017-07-22	-24.58	3.75	51.6	0.9	5.4	-0.3

Body						
Date of measurement	Return-loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary impedance (ohm)	Delta (ohm)
2015-07-23	-23.6		47.4		5.8	
2016-07-22	-23.7	-1.14	48.5	1.1	5.2	-0.6
2017-07-22	-23.2	4.71	48.1	0.7	5.3	-0.5

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5ohm of prior calibration.

Therefore the verification result should support extended calibration.

1.6. D2450V2 Dipole Calibration Certificate

 In Collaboration with  CALIBRATION LABORATORY		  CALIBRATION No. L0570																																																
Client	CIO-SZ(Auden)																																																	
CertIFICATE No: Z15-97070																																																		
<p>CALIBRATION CERTIFICATE</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 15%;">Object</td> <td>D2450V2 - SN: 884</td> </tr> <tr> <td>Calibration Procedure(s)</td> <td>TMC-OS-E-02-194 Calibration procedure for dipole validation kits</td> </tr> <tr> <td>Calibration date:</td> <td>September 1, 2015</td> </tr> <tr> <td colspan="2"> <p>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.</p> <p>All calibrations have been conducted in the closed laboratory facility: environment temperature(22 ± 3)°C and humidity<70%.</p> <p>Calibration Equipment used (M&TE critical for calibration)</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Primary Standards</th> <th>ID #</th> <th>Cal Date(Calibrated by, Certificate No.)</th> <th>Scheduled Calibration</th> </tr> </thead> <tbody> <tr> <td>Power Meter NRVD</td> <td>102083</td> <td>11-Sep-14 (TMC, No.JZ13-443)</td> <td>Sep-15</td> </tr> <tr> <td>Power sensor NRV-Z5</td> <td>100595</td> <td>11-Sep-14 (TMC, No. JZ13-443)</td> <td>Sep-15</td> </tr> <tr> <td>Reference Probe ES3DV3</td> <td>SN 3149</td> <td>5- Sep-14 (SPEAG, No.ES3-3149_Sep13)</td> <td>Sep-15</td> </tr> <tr> <td>DAE3</td> <td>SN 536</td> <td>23-Jan-15 (SPEAG, DAE3-536_Jan14)</td> <td>Jan -16</td> </tr> <tr> <td>Signal Generator E4438C</td> <td>MY49070393</td> <td>13-Nov-14 (TMC, No.JZ13-394)</td> <td>Nov-15</td> </tr> <tr> <td>Network Analyzer E8362B</td> <td>MY43021135</td> <td>19-Oct-14 (TMC, No.JZ13-278)</td> <td>Oct-15</td> </tr> </tbody> </table> </td> </tr> <tr> <td>Calibrated by:</td> <td>Name Zhao Jing</td> <td>Function SAR Test Engineer</td> <td>Signature </td> </tr> <tr> <td>Reviewed by:</td> <td>Qi Dianyuan</td> <td>SAR Project Leader</td> <td></td> </tr> <tr> <td>Approved by:</td> <td>Lu Bingsong</td> <td>Deputy Director of the laboratory</td> <td></td> </tr> </table>			Object	D2450V2 - SN: 884	Calibration Procedure(s)	TMC-OS-E-02-194 Calibration procedure for dipole validation kits	Calibration date:	September 1, 2015	<p>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.</p> <p>All calibrations have been conducted in the closed laboratory facility: environment temperature(22 ± 3)°C and humidity<70%.</p> <p>Calibration Equipment used (M&TE critical for calibration)</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Primary Standards</th> <th>ID #</th> <th>Cal Date(Calibrated by, Certificate No.)</th> <th>Scheduled Calibration</th> </tr> </thead> <tbody> <tr> <td>Power Meter NRVD</td> <td>102083</td> <td>11-Sep-14 (TMC, No.JZ13-443)</td> <td>Sep-15</td> </tr> <tr> <td>Power sensor NRV-Z5</td> <td>100595</td> <td>11-Sep-14 (TMC, No. JZ13-443)</td> <td>Sep-15</td> </tr> <tr> <td>Reference Probe ES3DV3</td> <td>SN 3149</td> <td>5- Sep-14 (SPEAG, No.ES3-3149_Sep13)</td> <td>Sep-15</td> </tr> <tr> <td>DAE3</td> <td>SN 536</td> <td>23-Jan-15 (SPEAG, DAE3-536_Jan14)</td> <td>Jan -16</td> </tr> <tr> <td>Signal Generator E4438C</td> <td>MY49070393</td> <td>13-Nov-14 (TMC, No.JZ13-394)</td> <td>Nov-15</td> </tr> <tr> <td>Network Analyzer E8362B</td> <td>MY43021135</td> <td>19-Oct-14 (TMC, No.JZ13-278)</td> <td>Oct-15</td> </tr> </tbody> </table>		Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration	Power Meter NRVD	102083	11-Sep-14 (TMC, No.JZ13-443)	Sep-15	Power sensor NRV-Z5	100595	11-Sep-14 (TMC, No. JZ13-443)	Sep-15	Reference Probe ES3DV3	SN 3149	5- Sep-14 (SPEAG, No.ES3-3149_Sep13)	Sep-15	DAE3	SN 536	23-Jan-15 (SPEAG, DAE3-536_Jan14)	Jan -16	Signal Generator E4438C	MY49070393	13-Nov-14 (TMC, No.JZ13-394)	Nov-15	Network Analyzer E8362B	MY43021135	19-Oct-14 (TMC, No.JZ13-278)	Oct-15	Calibrated by:	Name Zhao Jing	Function SAR Test Engineer	Signature 	Reviewed by:	Qi Dianyuan	SAR Project Leader		Approved by:	Lu Bingsong	Deputy Director of the laboratory	
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Certificate No: Z15-97070

Page 1 of 8

Appendix A: Calibration Certificate



In Collaboration with
s p e a g
CALIBRATION LABORATORY

Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2079 Fax: +86-10-62304633-2504
E-mail: ctl@chinattl.com Http://www.chinattl.cn



CALIBRATION
No. L0570

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:

- 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, "Procedure to measure the Specific Absorption Rate (SAR) For hand-held devices used in close proximity to the ear (frequency range of 300MHz to 3GHz)", February 2005
- KDB865664, SAR Measurement Requirements for 100 MHz to 6 GHz

Additional Documentation:

- DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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