

# Impedance Measurement Plot for Body TSL

22 Sep 2015 16:20:13

[CH1] S11 1 U FS

1: 47.645  $\Omega$  -1.9355  $\Omega$  46.987 pF

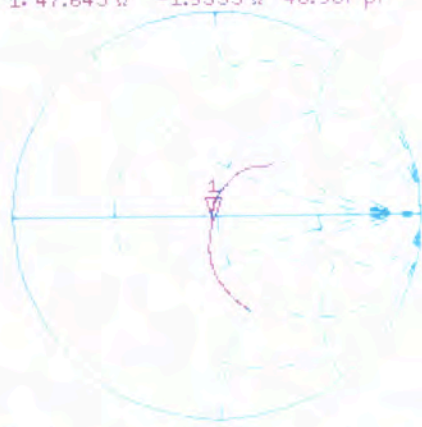
1 750.000 000 MHz

\*  
Del

CΔ

Avg  
16

H1d

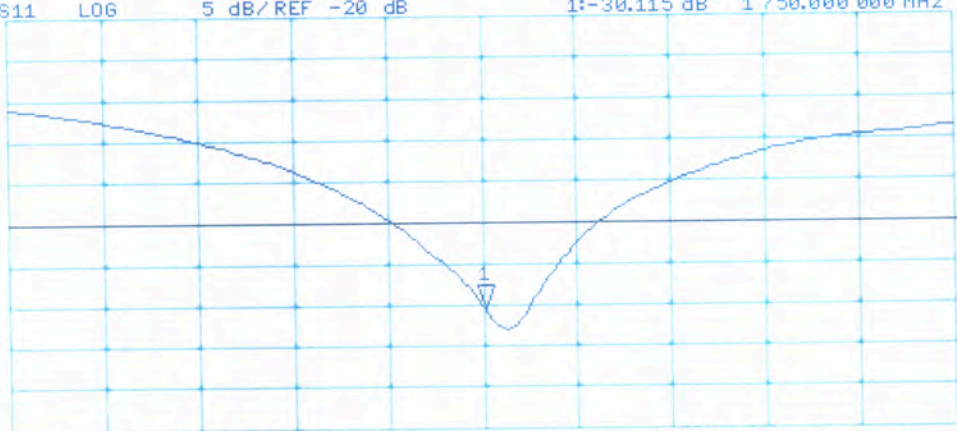


CH2 S11 LOG 5 dB/REF -20 dB 1:-30.115 dB 1 750.000 000 MHz

CΔ

Avg  
16

H1d



START 1 550.000 000 MHz

STOP 1 950.000 000 MHz



## Dipole Internal Calibration Record

NO. :

Asset No. :	E-438	Model No. :	D1750MHzV2	Cal. Date :	2015/9/22
Equipment :	ENA Network Analyzer	Serial No. :	1101	Next Cal. Date :	2018/9/22
Environmental condition :	Temp :	23.2 °C	R.H. :	60%	

### Standard List

1	IEEE Std 1528-2013	IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate(SAR) in the Human Head from Wireless Communication Devices: Measurement Techniques, June 2013
2	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
3	KDB865664	SAR Measurement Requirements for 100 MHz to 6 GHz

### Equipment Information

Equipment :	Manufacturer :	Model No. :	Serial No. :	Cal.Organization :	Certificate No. :	Cal. Date :
ENA Network Analyzer	Agilent	E5071C	MY46102965	NA	NA	Mar. 27, 2016

### Calibration Value :

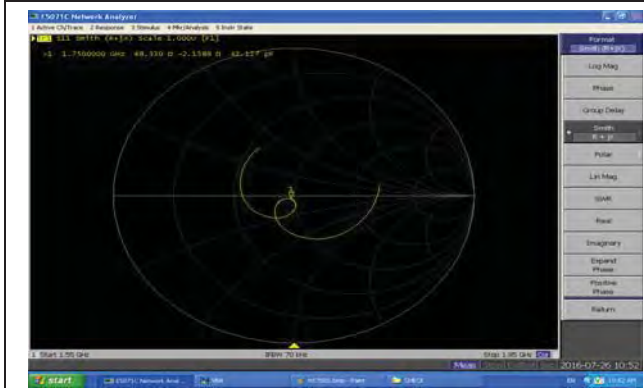
#### For Head Tissue

Frequency	Item	Original Cal. Result	Verified on 2016/7/26	Deviation	Result	Annex
1750MHz	Impedance, transformed to feed point	49.5Ω-1.5jΩ	48.3Ω-2.2jΩ	<5Ω	Pass	
	Return Loss(dB)	-36	-31.5	12.5%	Pass	

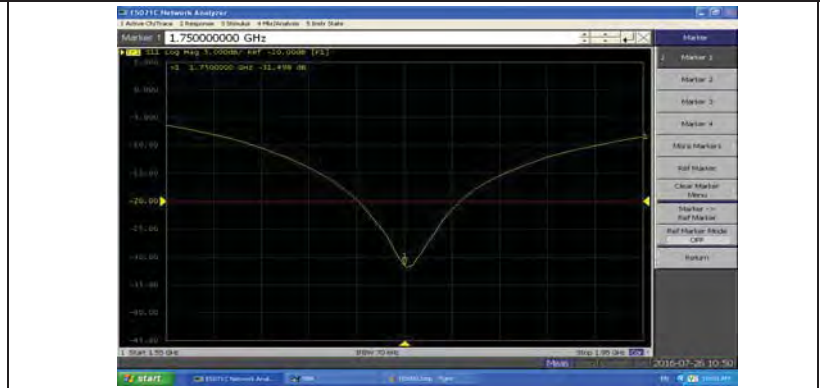
#### For Body Tissue

Frequency	Item	Original Cal. Result	Verified on 2016/8/12	Deviation	Result	Annex
1750MHz	Impedance, transformed to feed point	47.6Ω-1.9jΩ	47.38Ω-1.8jΩ	<5Ω	Pass	
	Return Loss(dB)	-30.1	-30.35	-0.8%	Pass	

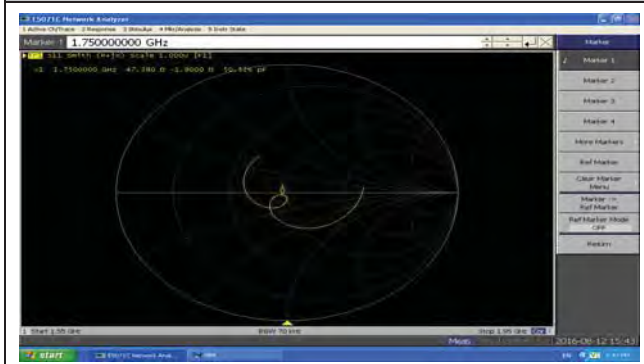
#### Impedance Test- Head



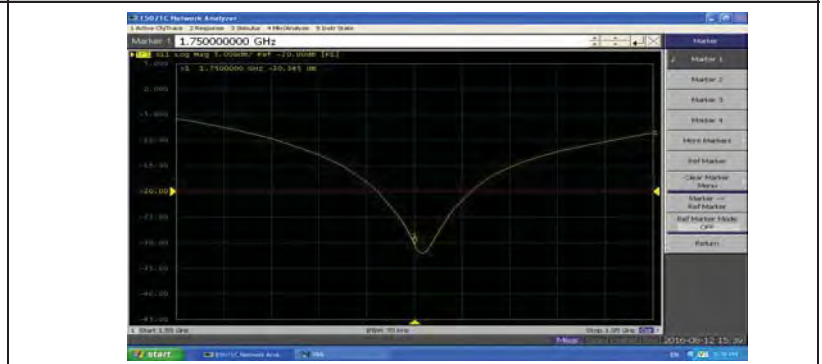
#### Return Loss-Head



#### Impedance Test- Body



#### Return Loss-Body



From NO. : E\_YYMMDD ; E=Dipole NO. ,YYMMDD=Year/Month/Date.



**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 **BTL-CN (Auden)**

Certificate No: **D1900V2-5d179\_Sep15**

## CALIBRATION CERTIFICATE

Object **D1900V2 - SN:5d179**

Calibration procedure(s) **QA CAL-05.v9  
Calibration procedure for dipole validation kits above 700 MHz**

Calibration date: **September 29, 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 EX3DV4	SN: 7349	30-Dec-14 (No. EX3-7349_Dec14)	Dec-15
DAE4	SN: 601	17-Aug-15 (No. DAE4-601_Aug15)	Aug-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100972	15-Jun-15 (in house check Jun-15)	In house check: Jun-18
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

Calibrated by: **Name**  
**Leif Klynsner** **Function**  
**Laboratory Technician**

Approved by: **Name**  
**Katja Pokovic** **Technical Manager**

Signature

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

Issued: September 30, 2015



## 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:

- 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 300 MHz to 3 GHz)", February 2005
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### Additional Documentation:

- DASY4/5 System Handbook

### Methods Applied and Interpretation of Parameters:

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

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



## Measurement Conditions

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

DASY Version	DASY5	V52.8.8
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 $\pm$ 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 $\pm$ 0.2) °C	39.3 $\pm$ 6 %	1.38 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	9.88 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>39.7 W/kg <math>\pm</math> 17.0 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	5.16 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>20.7 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## 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 $\pm$ 0.2) °C	52.6 $\pm$ 6 %	1.52 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Body TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	9.94 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>39.6 W/kg <math>\pm</math> 17.0 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.22 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>20.8 W/kg <math>\pm</math> 16.5 % (k=2)</b>

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

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	$51.5 \Omega + 3.1 j\Omega$
Return Loss	- 29.4 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	$48.3 \Omega + 4.3 j\Omega$
Return Loss	- 26.6 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.199 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	June 08, 2012



## DASY5 Validation Report for Head TSL

Date: 29.09.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d179**

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

Medium parameters used:  $f = 1900$  MHz;  $\sigma = 1.38$  S/m;  $\epsilon_r = 39.3$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.14, 8.14, 8.14); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- 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:

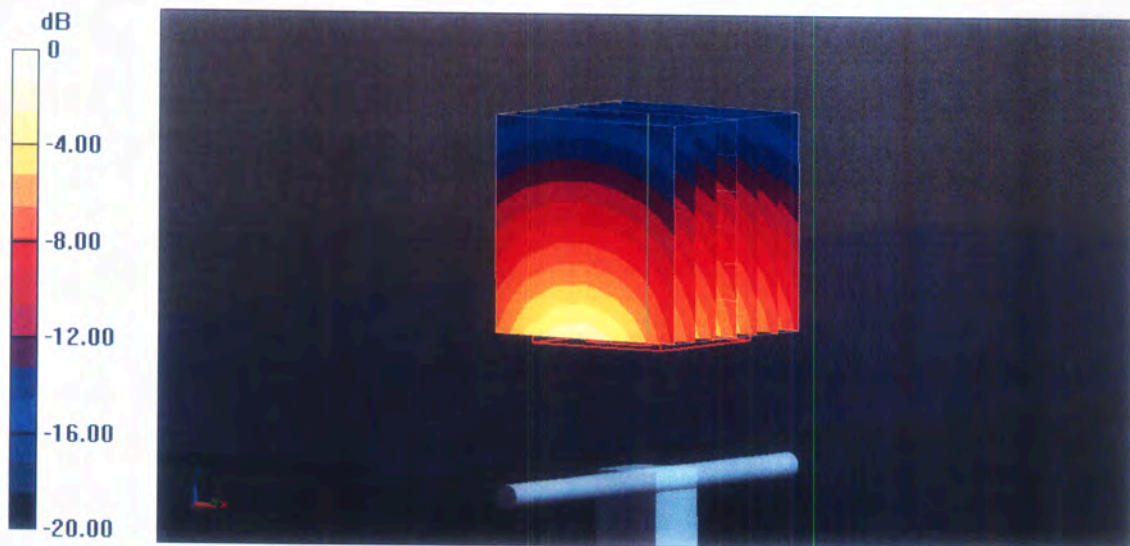
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 108.9 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 18.6 W/kg

**SAR(1 g) = 9.88 W/kg; SAR(10 g) = 5.16 W/kg**

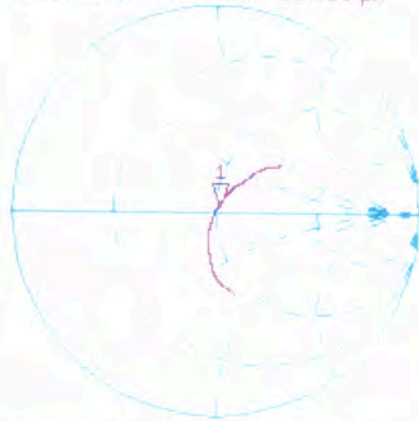
Maximum value of SAR (measured) = 15.2 W/kg



# Impedance Measurement Plot for Head TSL

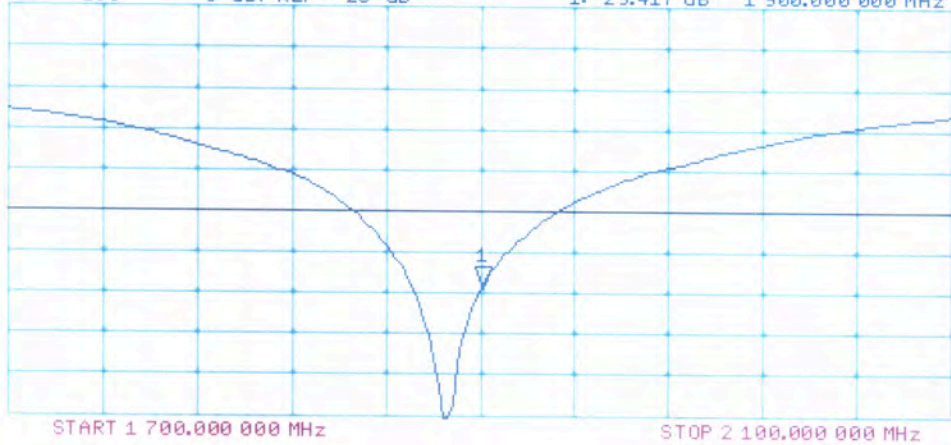
29 Sep 2015 12:20:49  
 [CH1] S11 1 U FS 1: 51.539  $\Omega$  3.0703  $\Omega$  257.19 pH 1 900.000 000 MHz

\*  
 De1  
 C $\Delta$   
 Avg  
 16  
 H1 d



CH2 S11 LOG 5 dB/REF -20 dB 1:-29.417 dB 1 900.000 000 MHz

De1  
 C $\Delta$   
 Avg  
 16  
 H1 d





## DASY5 Validation Report for Body TSL

Date: 29.09.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d179**

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

Medium parameters used:  $f = 1900$  MHz;  $\sigma = 1.52$  S/m;  $\epsilon_r = 52.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.9, 7.9, 7.9); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- 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:

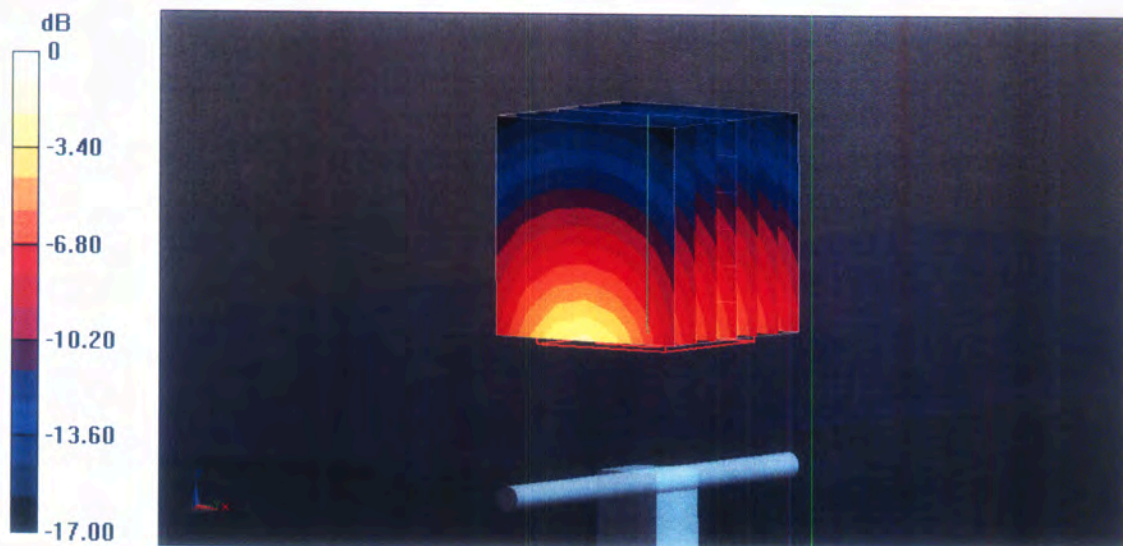
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 103.5 V/m; Power Drift = 0.05 dB

Peak SAR (extrapolated) = 17.9 W/kg

**SAR(1 g) = 9.94 W/kg; SAR(10 g) = 5.22 W/kg**

Maximum value of SAR (measured) = 15.1 W/kg

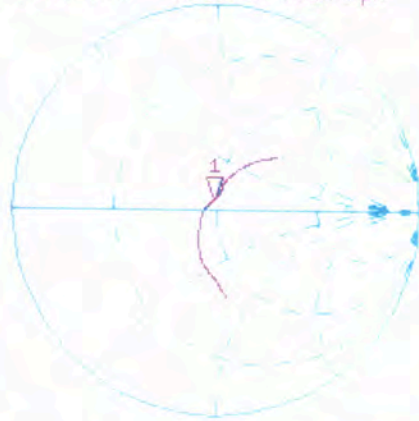


0 dB = 15.1 W/kg = 11.79 dBW/kg

# Impedance Measurement Plot for Body TSL

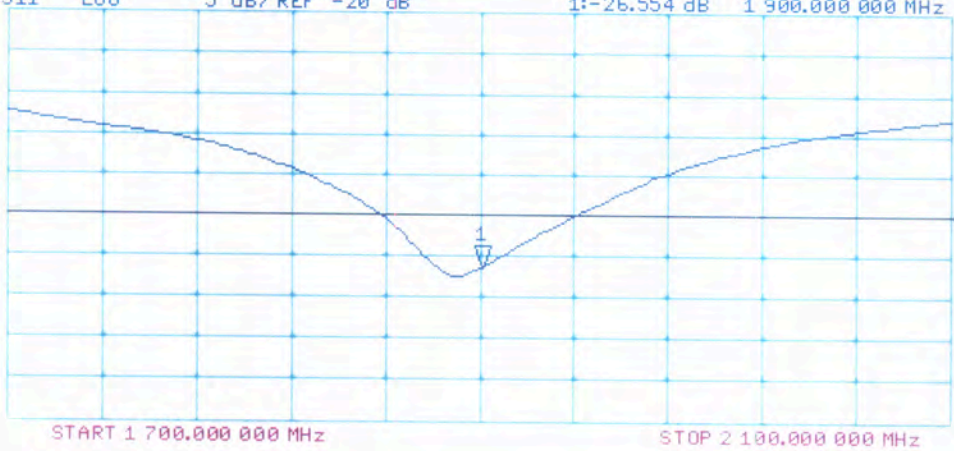
29 Sep 2015 12:20:14  
[CH1] S11 1 U FS 1: 48.346  $\Omega$  4.3184  $\Omega$  361.73 pF 1 900.000 000 MHz

\*  
De1  
Ca  
Avg  
16  
H1d



CH2 S11 LOG 5 dB/REF -20 dB 1:-26.554 dB 1 900.000 000 MHz

De1  
Ca  
Avg  
16  
H1d







## Dipole Internal Calibration Record

NO. :

Asset No. :	E-431	Model No. :	D1900MHzV2	Cal. Date :	2015/9/29
Equipment :	ENA Network Analyzer	Serial No. :	5d179	Next Cal. Date :	2018/9/29
Environmental condition :	Temp :	23.3 °C	R.H. :	56%	

### Standard List

1	IEEE Std 1528-2013	IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate(SAR) in the Human Head from Wireless Communication Devices: Measurement Techniques, June 2013
2	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
3	KDB865664	SAR Measurement Requirements for 100 MHz to 6 GHz

### Equipment Information

Equipment :	Manufacturer :	Model No. :	Serial No. :	Cal.OrganiZation :	Certificate No. :	Cal. Date :
ENA Network Analyzer	Agilent	E5071C	MY46102965	NA	NA	Mar. 27, 2016

### Calibration Value :

#### For Head Tissue

Frequency	Item	Original Cal. Result	Verified on 2016/7/28	Deviation	Result	Annex
1900MHz	Impedance, transformed to feed point( $\Omega$ )	51.5 $\Omega$ +3.1j $\Omega$	47.5 $\Omega$ -1.1j $\Omega$	<5 $\Omega$	Pass	
	Return Loss(dB)	-29.4	-31.5	-7.1%	Pass	

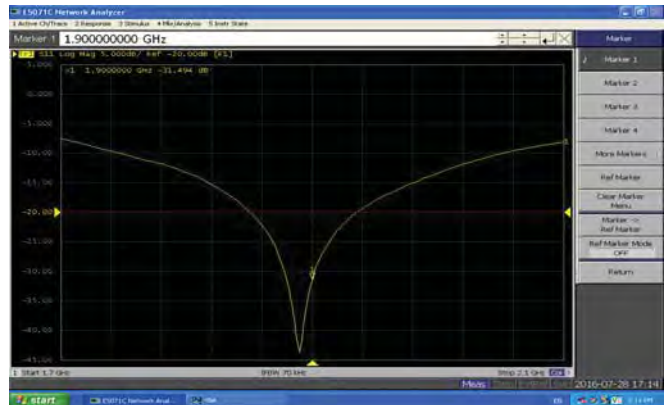
#### For Body Tissue

Frequency	Item	Original Cal. Result	Verified on 2016/8/12	Deviation	Result	Annex
1900MHz	Impedance, transformed to feed point	48.3 $\Omega$ +4.3j $\Omega$	46.27 $\Omega$ +6.2j $\Omega$	<5 $\Omega$	Pass	
	Return Loss(dB)	-26.6	-27.09	-1.8%	Pass	

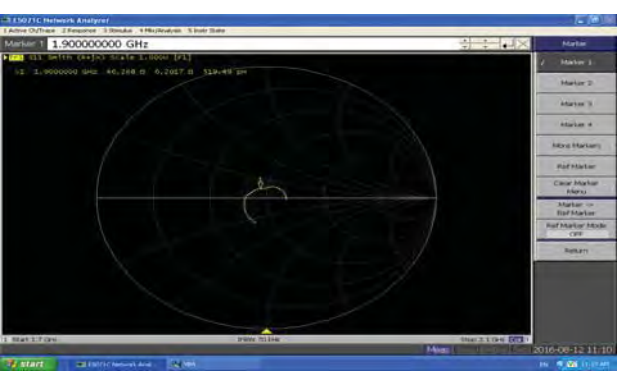
Impedance Test- Head



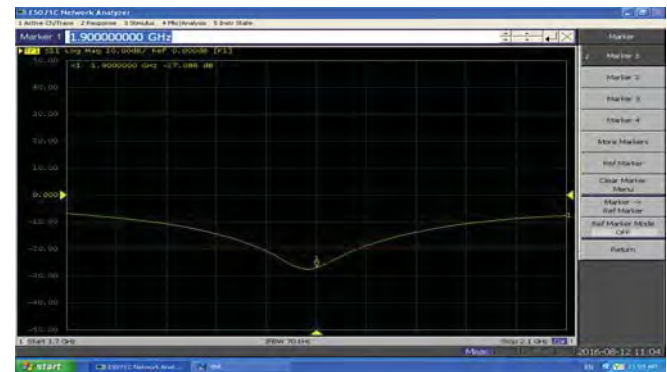
Return Loss-Head



Impedance Test- Body



Return Loss-Body



From NO. : E\_YYMMDD ; E=Dipole NO. ,YYMMDD=Year/Month/Date.



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **BTL-CN (Auden)**

Certificate No: **D2450V2-919\_Sep15**

## CALIBRATION CERTIFICATE

Object: **D2450V2 - SN: 919**

Calibration procedure(s): **QA CAL-05.v9**  
**Calibration procedure for dipole validation kits above 700 MHz**

Calibration date: **September 28, 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 ( $22 \pm 3$ )°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 EX3DV4	SN: 7349	30-Dec-14 (No. EX3-7349_Dec14)	Dec-15
DAE4	SN: 601	17-Aug-15 (No. DAE4-601_Aug15)	Aug-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100972	15-Jun-15 (in house check Jun-15)	In house check: Jun-18
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

Calibrated by:	Name <b>Jeton Kastrati</b>	Function <b>Laboratory Technician</b>	Signature 
Approved by:	Name <b>Katja Pokovic</b>	Function <b>Technical Manager</b>	Signature 

Issued: September 28, 2015

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Accreditation No.: **SCS 0108**

### Glossary:

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

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

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

### Additional Documentation:

- DASY4/5 System Handbook

### Methods Applied and Interpretation of Parameters:

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

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



## Measurement Conditions

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

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

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	39.2 $\pm$ 6 %	1.86 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.2 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>52.0 W/kg <math>\pm</math> 17.0 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.10 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>24.2 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## 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 $\pm$ 0.2) °C	53.2 $\pm$ 6 %	2.00 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Body TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	12.9 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>51.1 W/kg <math>\pm</math> 17.0 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.02 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>24.0 W/kg <math>\pm</math> 16.5 % (k=2)</b>



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

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	55.5 $\Omega$ + 3.2 $j\Omega$
Return Loss	- 24.4 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	51.0 $\Omega$ + 4.7 $j\Omega$
Return Loss	- 26.5 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.158 ns
----------------------------------	----------

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

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

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

### Additional EUT Data

Manufactured by	SPEAG
Manufactured on	December 19, 2012

## DASY5 Validation Report for Head TSL

Date: 28.09.2015

Test Laboratory: SPEAG, Zurich, Switzerland

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

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.86$  S/m;  $\epsilon_r = 39.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.67, 7.67, 7.67); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- 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:

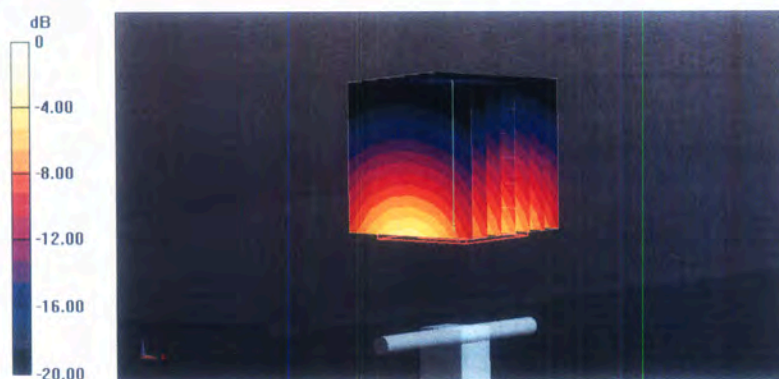
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 113.7 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 27.4 W/kg

**SAR(1 g) = 13.2 W/kg; SAR(10 g) = 6.1 W/kg**

Maximum value of SAR (measured) = 22.0 W/kg



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



# Impedance Measurement Plot for Head TSL

28 Sep 2015 12:43:16

CH1 S11 1 U FS

4: 55.486  $\Omega$  3.1699  $\Omega$  205.92  $\mu\text{H}$  2 450.000 000 MHz

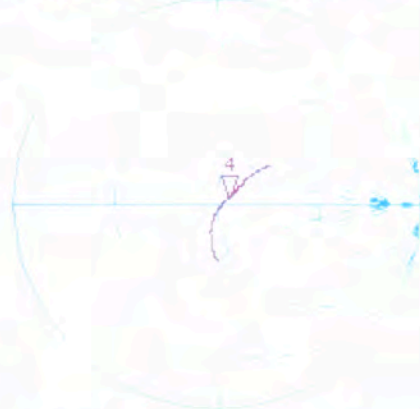
\*

De 1

CA

Avg  
16

H1 d



CH2 S11 LOG

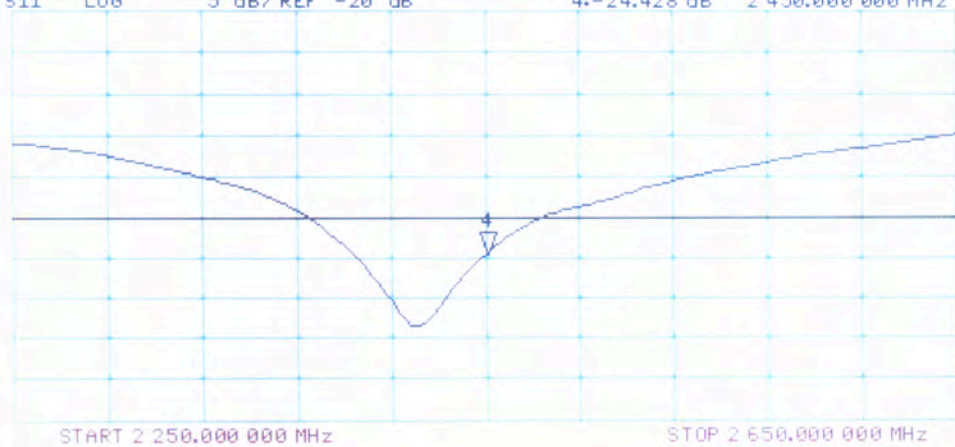
5 dB/REF -20 dB

4:-24.428 dB 2 450.000 000 MHz

CA

Avg  
16

H1 d



## DASY5 Validation Report for Body TSL

Date: 28.09.2015

Test Laboratory: SPEAG, Zurich, Switzerland

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

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2$  S/m;  $\epsilon_r = 53.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.53, 7.53, 7.53); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- 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=5mm, dy=5mm, dz=5mm

Reference Value = 105.9 V/m; Power Drift = 0.07 dB

Peak SAR (extrapolated) = 25.7 W/kg

**SAR(1 g) = 12.9 W/kg; SAR(10 g) = 6.02 W/kg**

Maximum value of SAR (measured) = 20.6 W/kg



0 dB = 20.6 W/kg = 13.14 dBW/kg



# Impedance Measurement Plot for Body TSL

28 Sep 2015 12:41:59

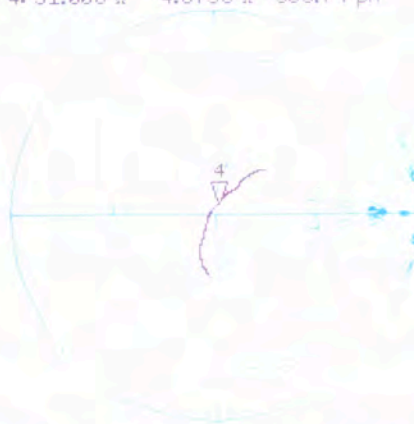
[CH1] S11 1 U FS 4: 51.008  $\Omega$  4.6758  $\Omega$  303.74 pF 2 450.000 000 MHz

\*  
Del

Ca

Avg  
16

H1d

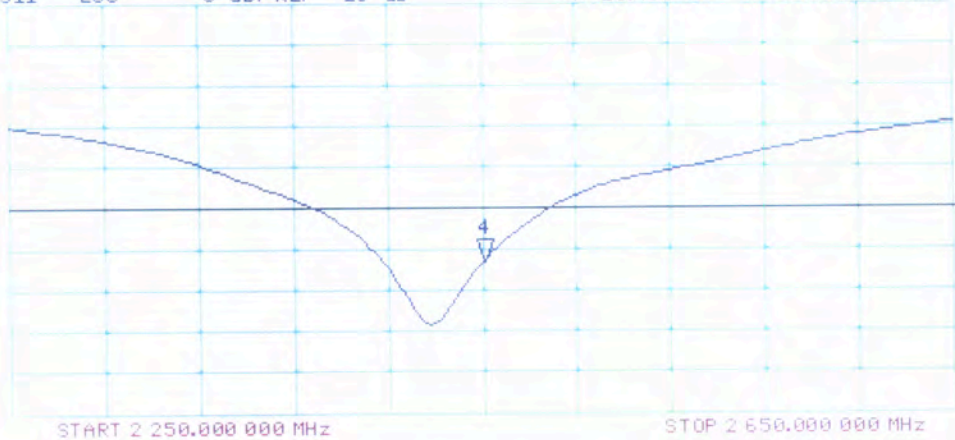


CH2 S11 LOG 5 dB/REF -20 dB 4: -26.498 dB 2 450.000 000 MHz

Ca

Avg  
16

H1d





## Dipole Internal Calibration Record

NO. :

Asset No. :	E-434	Model No. :	D2450MHzV2	Cal. Date :	2015/9/28
Equipment :	ENA Network Analyzer	Serial No. :	919	Next Cal. Date :	2018/9/28
Environmental condition :	Temp :	23.2°C	R.H. :	58%	

### Standard List

1	IEEE Std 1528-2013	IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate(SAR) in the Human Head from Wireless Communication Devices: Measurement Techniques, June 2013
2	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
3	KDB865664	SAR Measurement Requirements for 100 MHz to 6 GHz

### Equipment Information

Equipment :	Manufacturer :	Model No. :	Serial No. :	Cal.Organization :	Certificate No. :	Cal. Date :
ENA Network Analyzer	Agilent	E5071C	MY46102965	NA	NA	Mar. 27, 2016

### Calibration Value :

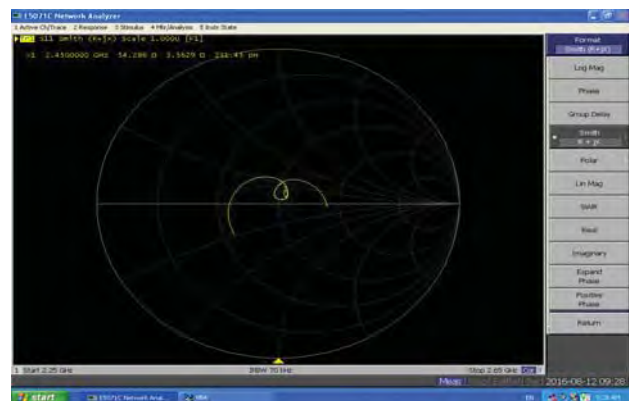
#### For Head Tissue

Frequency	Item	Original Cal. Result	Verified on 2016/8/12	Deviation	Result	Annex
2450MHz	Impedance, transformed to feed point	55.5Ω+3.2jΩ	54.28Ω+3.56jΩ	<5Ω	Pass	
	Return Loss(dB)	-24.4	-23.65	3.1%	Pass	

#### For Body Tissue

Frequency	Item	Original Cal. Result	Verified on 2016/8/12	Deviation	Result	Annex
2450MHz	Impedance, transformed to feed point	51Ω+4.7jΩ	46.41Ω+1.94jΩ	<5Ω	Pass	
	Return Loss(dB)	-26.5	-27.91	-5.3%	Pass	

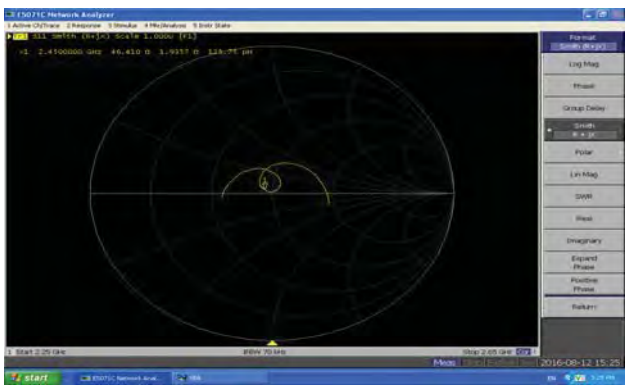
#### Impedance Test- Head



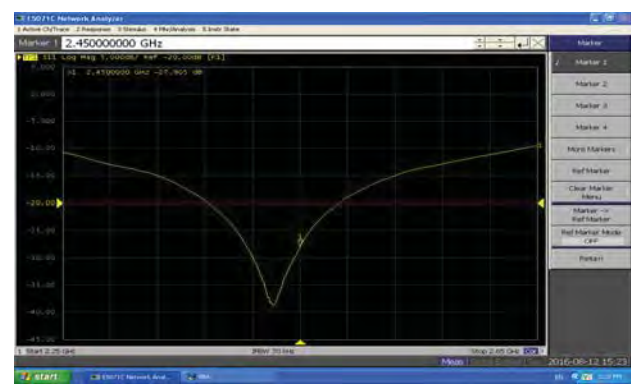
#### Return Loss-Head



#### Impedance Test- Body



#### Return Loss-Body



From NO. : E\_YYMMDD ; E=Dipole NO. ,YYMMDD=Year/Month/Date.





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 **BTL-CN (Auden)**

Certificate No: **D2600V2-1067\_Sep15**

## CALIBRATION CERTIFICATE

Object **D2600V2 - SN: 1067**

Calibration procedure(s) **QA CAL-05.v9  
Calibration procedure for dipole validation kits above 700 MHz**

Calibration date: **September 28, 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 EX3DV4	SN: 7349	30-Dec-14 (No. EX3-7349_Dec14)	Dec-15
DAE4	SN: 601	17-Aug-15 (No. DAE4-601_Aug15)	Aug-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100972	15-Jun-15 (in house check Jun-15)	In house check: Jun-18
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

Calibrated by:	Name <b>Jeton Kastrati</b>	Function <b>Laboratory Technician</b>	Signature 
Approved by:	Name <b>Katja Pokovic</b>	Function <b>Technical Manager</b>	Signature 

Issued: September 28, 2015

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





Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

### Glossary:

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

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

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

### Additional Documentation:

- DASY4/5 System Handbook

### Methods Applied and Interpretation of Parameters:

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

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



## Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2600 MHz $\pm$ 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.0	1.96 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	38.6 $\pm$ 6 %	2.04 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	14.5 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>56.8 W/kg <math>\pm</math> 17.0 % (k=2)</b>

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

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.5	2.16 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	52.8 $\pm$ 6 %	2.19 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Body TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.6 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>54.1 W/kg <math>\pm</math> 17.0 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.02 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>24.0 W/kg <math>\pm</math> 16.5 % (k=2)</b>

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

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	48.5 $\Omega$ - 7.2 j $\Omega$
Return Loss	- 22.6 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	44.3 $\Omega$ - 5.4 j $\Omega$
Return Loss	- 21.6 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.154 ns
----------------------------------	----------

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

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

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

### Additional EUT Data

Manufactured by	SPEAG
Manufactured on	July 17, 2013



## DASY5 Validation Report for Head TSL

Date: 28.09.2015

Test Laboratory: SPEAG, Zurich, Switzerland

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

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

Medium parameters used:  $f = 2600$  MHz;  $\sigma = 2.04$  S/m;  $\epsilon_r = 38.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.4, 7.4, 7.4); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- 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:

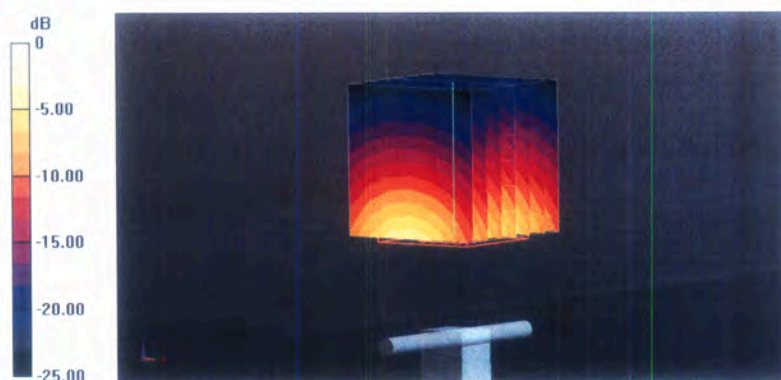
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 115.8 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 31.3 W/kg

**SAR(1 g) = 14.5 W/kg; SAR(10 g) = 6.4 W/kg**

Maximum value of SAR (measured) = 24.9 W/kg



0 dB = 24.9 W/kg = 13.96 dBW/kg

# Impedance Measurement Plot for Head TSL

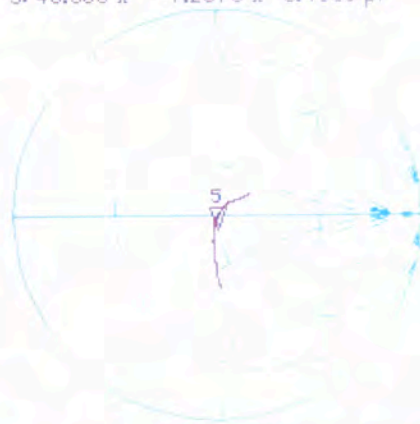
28 Sep 2015 12:54:35  
 CH1 S11 1 U FS 5: 48.508  $\Omega$  -7.2070  $\Omega$  8.4936 pF 2 600.000 000 MHz

De1

CA

Avg  
16

H1d

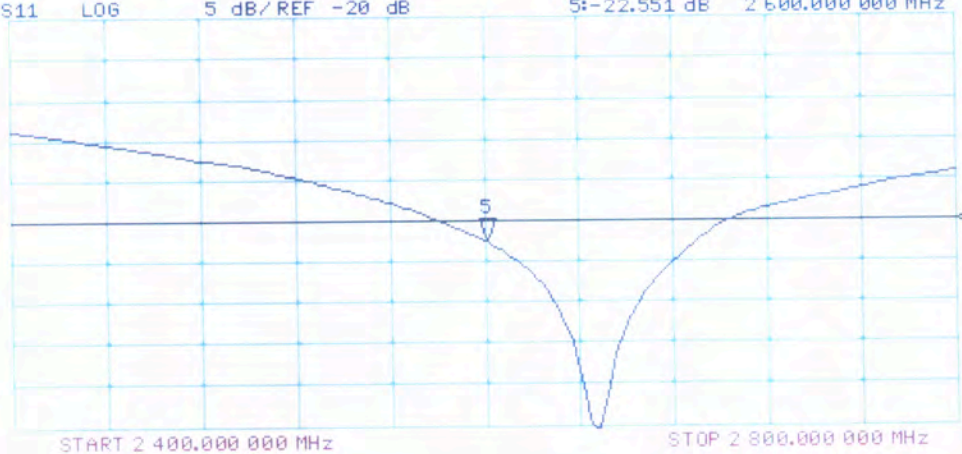


CH2 S11 LOG 5 dB/REF -20 dB 5: -22.551 dB 2 600.000 000 MHz

CA

Avg  
16

H1d





## DASY5 Validation Report for Body TSL

Date: 28.09.2015

Test Laboratory: SPEAG, Zurich, Switzerland

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

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

Medium parameters used:  $f = 2600$  MHz;  $\sigma = 2.19$  S/m;  $\epsilon_r = 52.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.52, 7.52, 7.52); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- 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:**

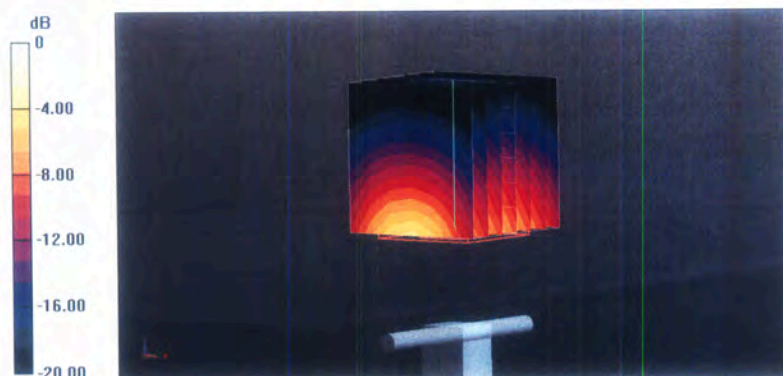
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 107.2 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 28.3 W/kg

**SAR(1 g) = 13.6 W/kg; SAR(10 g) = 6.02 W/kg**

Maximum value of SAR (measured) = 22.9 W/kg

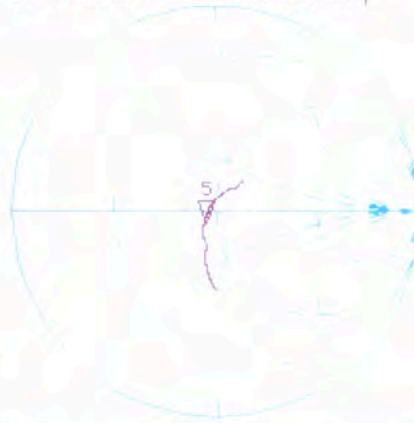


0 dB = 22.9 W/kg = 13.60 dBW/kg

# Impedance Measurement Plot for Body TSL

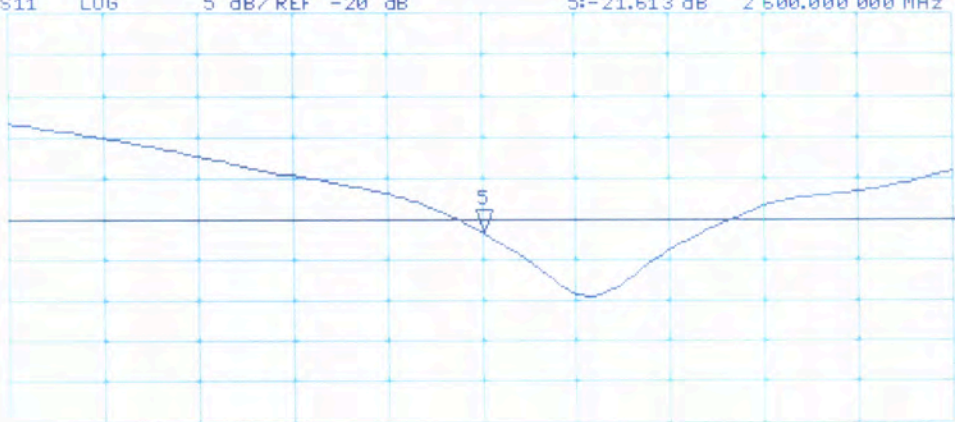
28 Sep 2015 12:54:06  
[CH1] S11 1 U FS 5: 44.295  $\Omega$  -5.3848  $\Omega$  11.368 pF 2 600.000 000 MHz

\*  
De1  
CA  
Avg  
16  
H1d



CH2 S11 LOG 5 dB/REF -20 dB 5:-21.613 dB 2 600.000 000 MHz

CA  
Avg  
16  
H1d



START 2 400.000 000 MHz

STOP 2 800.000 000 MHz





## Dipole Internal Calibration Record

NO. :

Asset No. :	E-435	Model No. :	D2600MHzV2	Cal. Date :	2015/9/28
Equipment :	ENA Network Analyzer	Serial No. :	1067	Next Cal. Date :	2018/9/28
Environmental condition :	Temp :	23.4°C	R.H. :	62%	

### Standard List

1	IEEE Std 1528-2013	IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate(SAR) in the Human Head from Wireless Communication Devices: Measurement Techniques, June 2013
2	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
3	KDB865664	SAR Measurement Requirements for 100 MHz to 6 GHz

### Equipment Information

Equipment :	Manufacturer :	Model No. :	Serial No. :	Cal.Organization :	Certificate No. :	Cal. Date :
ENA Network Analyzer	Agilent	E5071C	MY46102965	NA	NA	Mar. 27, 2016

### Originak Cal. Report

Equipment :	Manufacturer :	Model No. :	Serial No. :	Cal.Organization :	Certificate No. :	Cal. Date :
Network Analyzer	NA	NA	NA	NA	NA	NA

### Calibration Value :

#### For Head Tissue

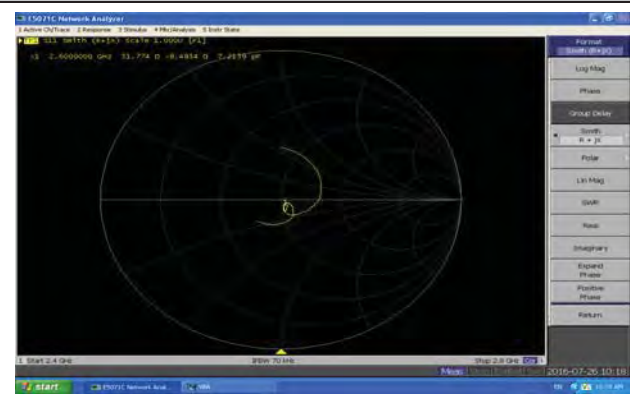
Frequency	Item	Originak Cal. Result	Verified on 2016/7/26	Deviation	Result	Annex
2600MHz	Impedance, transformed to feed point( $\Omega$ )	48.5 $\Omega$ -7.2j $\Omega$	51.8 $\Omega$ -8.5j $\Omega$	<5 $\Omega$	Pass	
	Return Loss(dB)	-22.6	-21.5	4.9%	Pass	

#### For Body Tissue

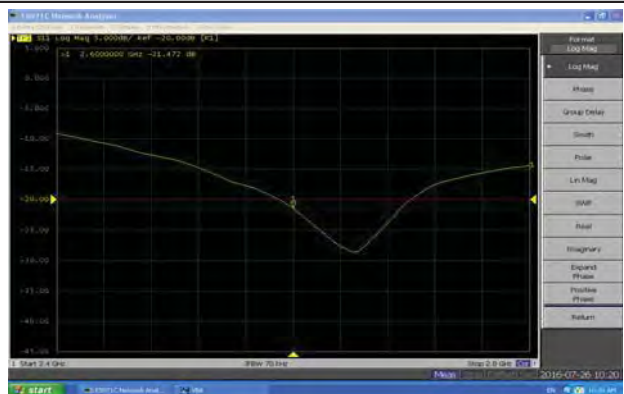
Frequency	Item	Originak Cal. Result	Verified on 2016/7/26	Deviation	Result	Annex
2600MHz	Impedance, transformed to feed point	44.3 $\Omega$ -5.4j $\Omega$	47 $\Omega$ -6.7j $\Omega$	<5 $\Omega$	Pass	
	Return Loss(dB)	-21.6	-22.2	-2.8%	Pass	

Note : SAR System Uncertainty : % , ( 95% CONFIDENCE LEVEL , Expanded uncertainty K=2 )

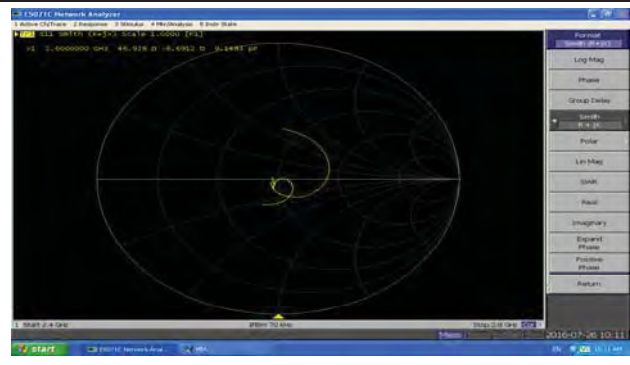
#### Impedance Test- Head



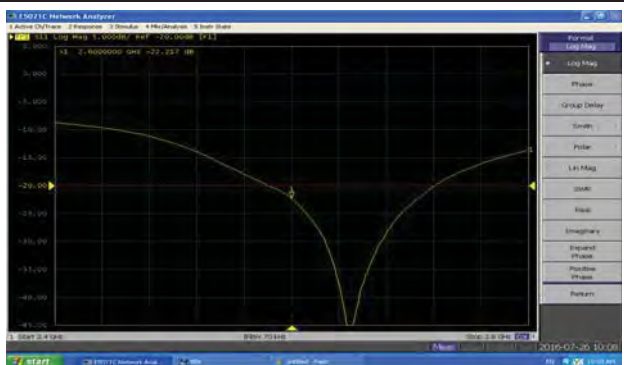
#### Return Loss-Head



#### Impedance Test- Body



#### Return Loss-Body



From NO. : E\_YYMMDD ; E=Dipole NO. ,YYMMDD=Year/Month/Date.