APPENDIX F POWER REDUCTION VERIFICATION

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This device supports a power reduction mechanism in which a reduced power level is used when the speaker is active, such as when the device is being used near the mouth. The device uses two power tables for cellular radio and implements the appropriate power table based on the speaker state. Near the mouth mode operation was verified by turning the speaker on for each cellular band that implements a separate power level in next to mouth conditions.

This device also implements a separate independent mechanism that reduces the WIFI duty cycle to a maximum of 30% when the cellular radio is turned on. The duty cycle reduction was verified by recording duty cycle with cellular radio on and off for both 2.4 GHz and 5 GHz WIFI.

Details of both mechanisms and the verification procedures can be found in the operational description. The verification results are included below.

1.1 Main Antenna Power Reduction Verification Summary

Table F-1
Main Antenna Power Reduction Verification

Mode/Band	Antenna	Maximum Scenario Maximum Allowed Target Power [dBm]	Reduced Scenario Maximum Allowed Target Power [dBm]	Conducted Power [dBm]		
				Maximum	Test Case 1	Verdict
LTE Band 7	FCM	22.50 (± 1.0)	19.50 (± 1.0)	21.62	18.64	PASS
LTE Band 41 (PC3)	FCM	22.50 (± 1.0)	21.50 (± 1.0)	22.21	21.27	PASS

Test Case 1: Device Speaker on.

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1.2 WLAN Antenna Duty Cycle Reduction Verification Summary

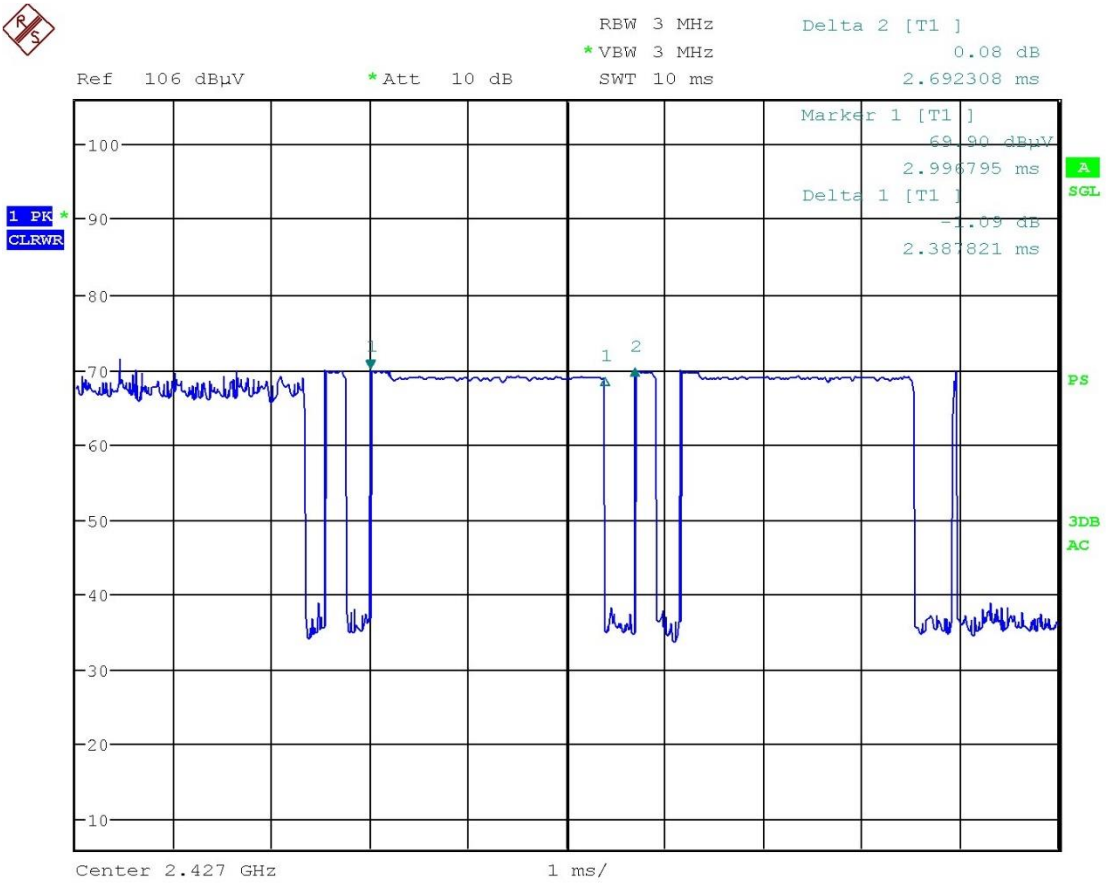

Figure F-1
2.4 GHz WLAN Maximum Duty Cycle Transmission Plot

Equation F-1
2.4 GHz WLAN Maximum Duty Cycle Calculation

$$\boldsymbol{Duty\ Cycle} = \frac{\boldsymbol{Pulse\ Width}}{\boldsymbol{Period}} * \mathbf{100\%} = \frac{\mathbf{2.3878}\boldsymbol{ms}}{\mathbf{2.6923}\boldsymbol{ms}} * \mathbf{100\%} = \mathbf{88.7\%}$$

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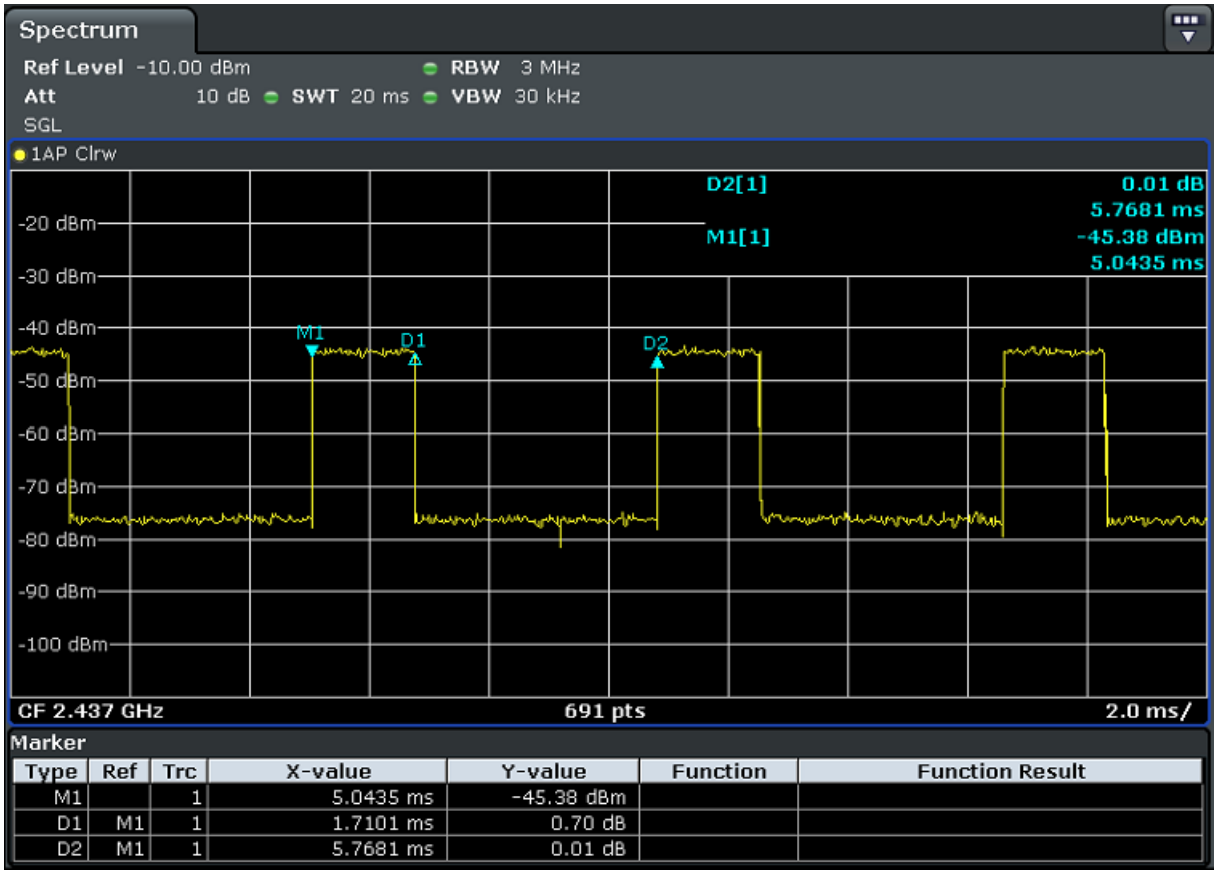

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	5.0435 ms	-45.38 dBm		
D1	M1	1	1.7101 ms	0.70 dB		
D2	M1	1	5.7681 ms	0.01 dB		

Figure F-2
2.4 GHz WLAN Reduced Duty Cycle Transmission Plot

Equation F-2
2.4 GHz WLAN Reduced Duty Cycle Calculation

$$Duty\ Cycle = \frac{Pulse\ Width}{Period} * 100\% = \frac{1.7101ms}{5.7681ms} * 100\% = 29.6\%$$

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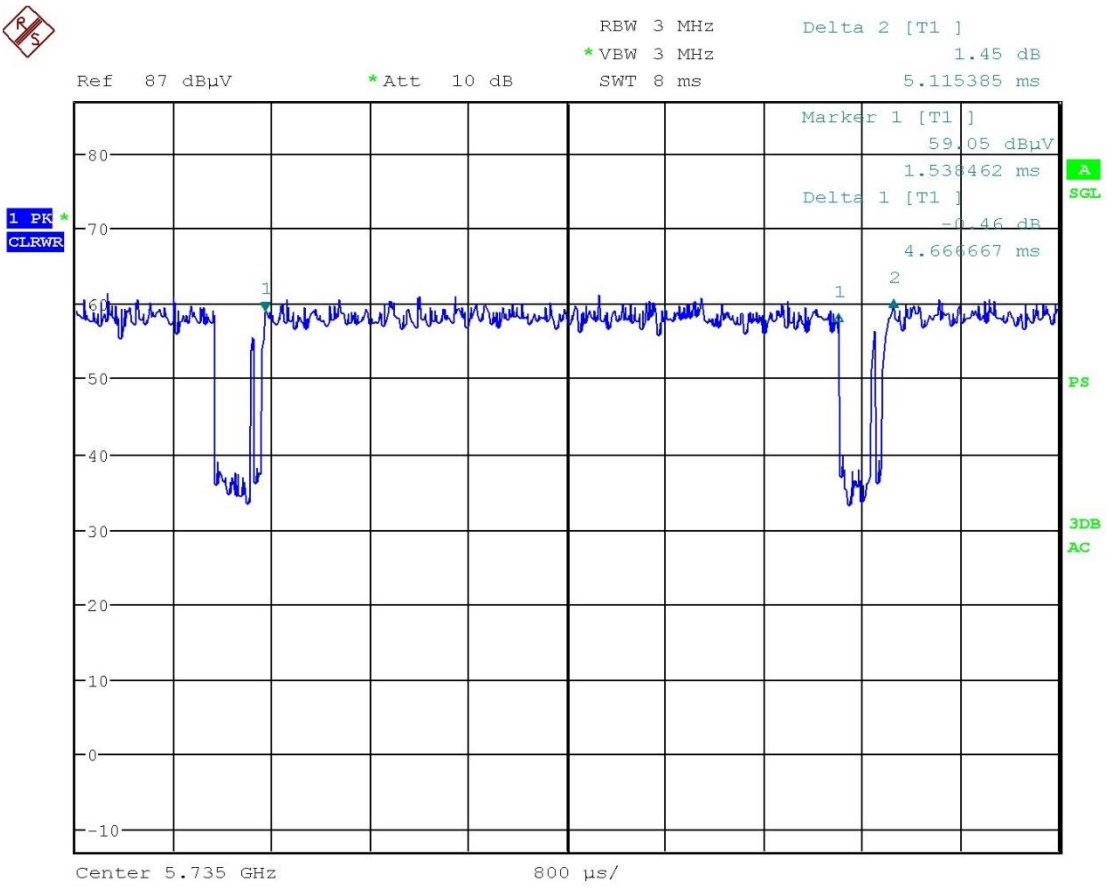

Figure F-3
5 GHz WLAN Maximum Duty Cycle Transmission Plot

Equation F-3
5 GHz WLAN Maximum Duty Cycle Calculation

$$\boldsymbol{Duty\ Cycle = \frac{Pulse\ Width}{Period} * 100\% = \frac{4.6667ms}{5.1154ms} * 100\% = 91.2\%}$$

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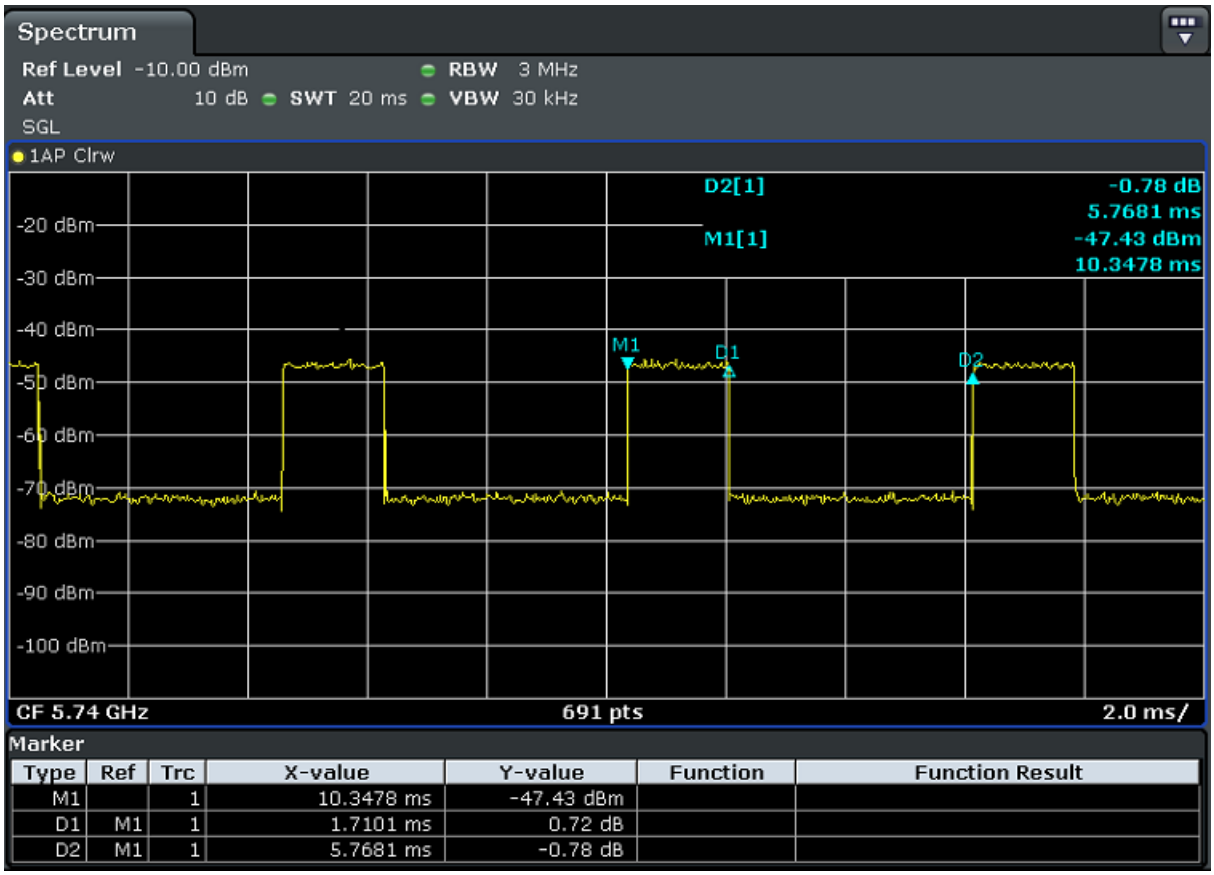

Figure F-4
5 GHz WLAN Reduced Duty Cycle Transmission Plot

Equation F-4
5 GHz WLAN Reduced Duty Cycle Calculation

$$Duty\ Cycle = \frac{Pulse\ Width}{Period} * 100\% = \frac{1.7101ms}{5.7681ms} * 100\% = 29.6\%$$

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Table F-2
WLAN Antenna Duty Cycle Reduction Verification

Mode/Band	Antenna	Maximum Scenario Maximum Duty Cycle (%)	Reduced Scenario Maximum Duty Cycle (%)	Duty Cycle [%]		
				Maximum	Test Case 1	Verdict
2.4 GHz WLAN	FCM	100.0%	30.0%	88.7%	29.6%	PASS
5 GHz WLAN	FCM	100.0%	30.0%	91.2%	29.6%	PASS

Test Case 1: Cellular radio is on.

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APPENDIX G: PROBE AND DIPOLE CALIBRATION CERTIFICATES

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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
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: PC Test

Certificate No: **D750V3-1034_May18**

CALIBRATION CERTIFICATE

Object	D750V3 - SN:1034
Calibration procedure(s)	QA CAL-05.v10 Calibration procedure for dipole validation kits above 700 MHz
Calibration date:	May 18, 2018

SC ✓ 5/31/2018
BN ✓ 08/01/2019
ATM ✓ 6/1/2020

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: 5058 (20k)	04-Apr-18 (No. 217-02682)	Apr-19
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-18 (No. 217-02683)	Apr-19
Reference Probe EX3DV4	SN: 7349	30-Dec-17 (No. EX3-7349_Dec17)	Dec-18
DAE4	SN: 601	26-Oct-17 (No. DAE4-601_Oct17)	Oct-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18

	Name	Function	Signature
Calibrated by:	Manu Seitz	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: May 22, 2018

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

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, "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"

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%.

Measurement Conditions

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

DASY Version	DASY5	V52.10.1
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	750 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	41.9	0.89 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	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.09 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**8.32 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.36 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**5.42 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	55.5	0.96 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	54.7 ± 6 %	0.96 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.15 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**8.57 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.42 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**5.67 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	55.3 Ω + 0.0 jΩ
Return Loss	- 26.0 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	50.0 Ω - 3.2 jΩ
Return Loss	- 29.8 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.034 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 06, 2011

DASY5 Validation Report for Head TSL

Date: 17.05.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1034

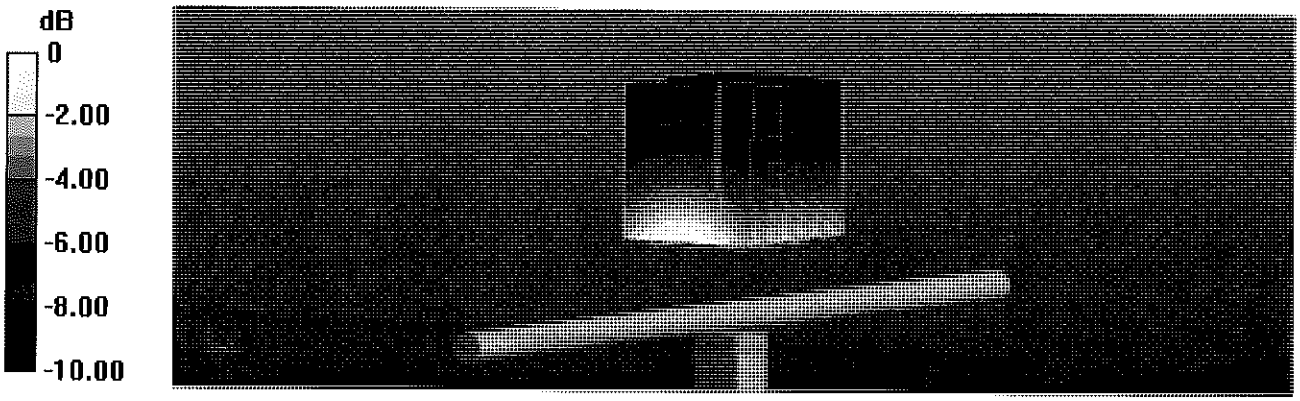
Communication System: UID 0 - CW; Frequency: 750 MHz
Medium parameters used: f = 750 MHz; σ = 0.89 S/m; ε_r = 41; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.22, 10.22, 10.22) @ 750 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

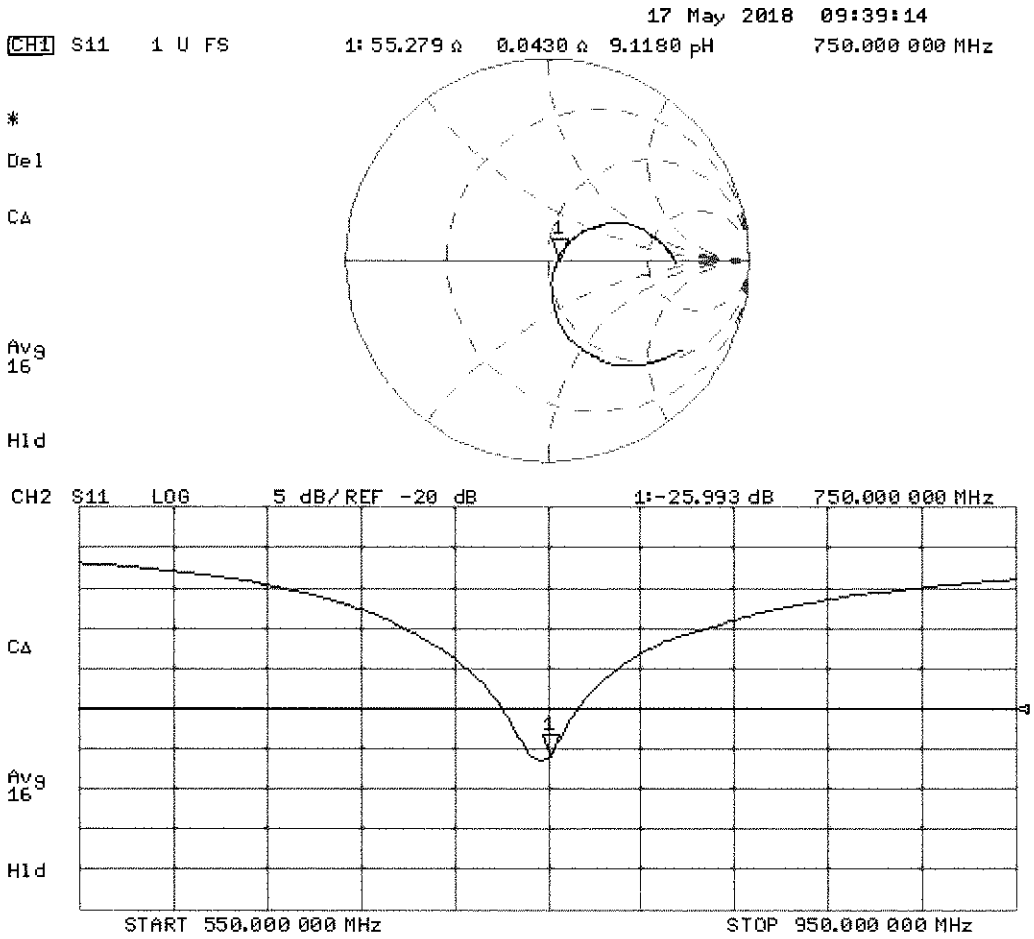
Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 59.66 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 3.18 W/kg
SAR(1 g) = 2.09 W/kg; SAR(10 g) = 1.36 W/kg
Maximum value of SAR (measured) = 2.82 W/kg



0 dB = 2.82 W/kg = 4.50 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 18.05.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1034

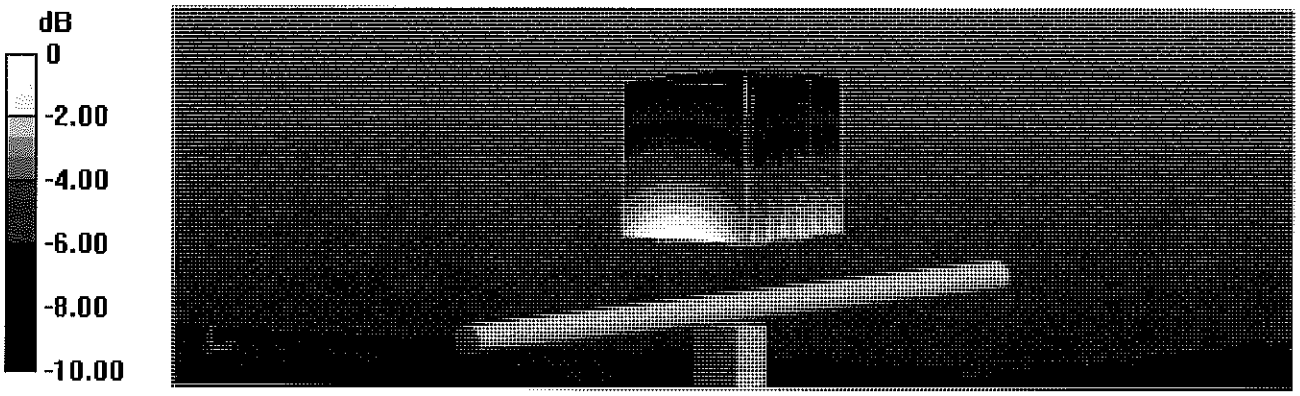
Communication System: UID 0 - CW; Frequency: 750 MHz
Medium parameters used: f = 750 MHz; σ = 0.96 S/m; ε_r = 54.7; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.19, 10.19, 10.19) @ 750 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

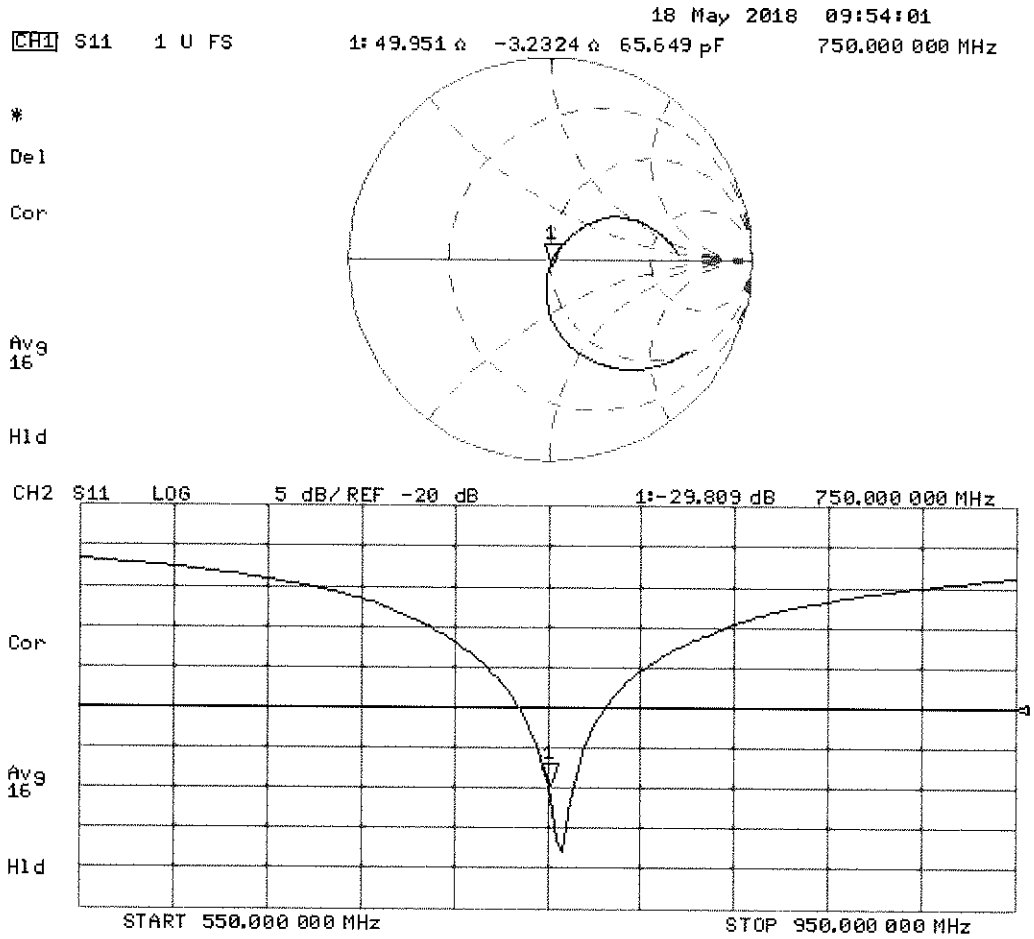
Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 57.60 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 3.16 W/kg
SAR(1 g) = 2.15 W/kg; SAR(10 g) = 1.42 W/kg
Maximum value of SAR (measured) = 2.83 W/kg



0 dB = 2.83 W/kg = 4.52 dBW/kg

Impedance Measurement Plot for Body TSL



Certification of Calibration

Object D750V3 – SN: 1034

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: May 16, 2019

Description: SAR Validation Dipole at 750 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	10/2/2018	Annual	10/2/2019	US39170118
Agilent	N5182A	MXG Vector Signal Generator	6/15/2018	Annual	6/15/2019	MY47420837
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2495A	Power Meter	10/21/2018	Annual	10/21/2019	941001
Anritsu	MA2411B	Pulse Power Sensor	10/30/2018	Annual	10/30/2019	1207470
Anritsu	MA2411B	Pulse Power Sensor	11/20/2018	Annual	11/20/2019	1339007
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/28/2018	Biennial	2/28/2020	170330160
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/4/2018	Annual	6/4/2019	MY53401181
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	PE5011-1	Torque Wrench	7/19/2017	Biennial	7/19/2019	N/A
SPEAG	DAKS-3.5	Portable DAK	9/11/2018	Annual	9/11/2019	1045
SPEAG	EX3DV4	SAR Probe	7/20/2018	Annual	7/20/2019	7416
SPEAG	DAE4	Dasy Data Acquisition Electronics	7/10/2018	Annual	7/10/2019	1402

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	Parker Jones
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	KOK

DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

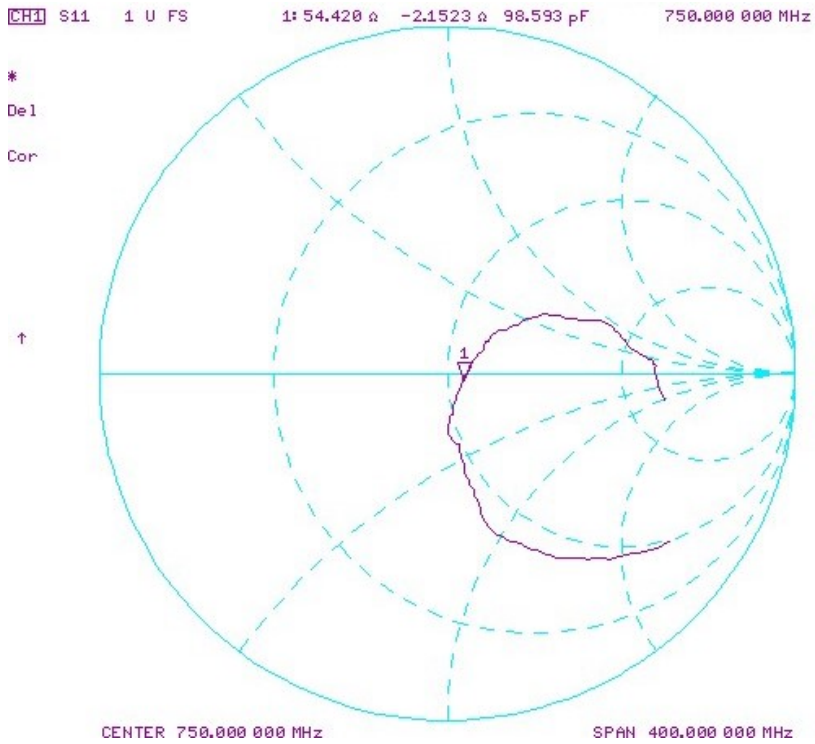
1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

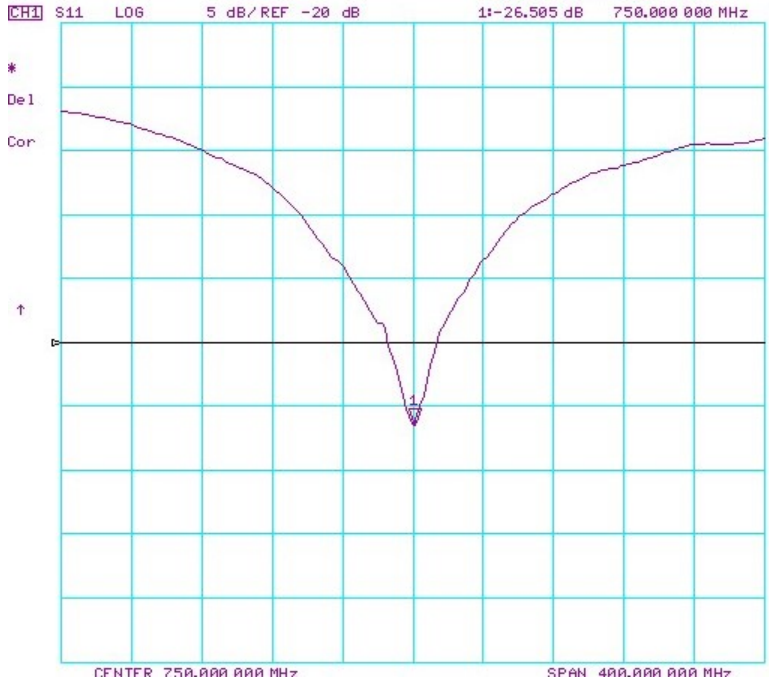
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 23.0 dBm	Measured Head SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 23.0 dBm	Measured Head SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
5/18/2018	5/16/2019	1.034	1.664	1.65	-0.84%	1.084	1.08	-0.37%	55.3	54.4	0.9	0	-2.2	2.2	-26	-26.5	-1.90%	PASS

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 23.0 dBm	Measured Body SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 23.0 dBm	Measured Body SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
5/18/2018	5/16/2019	1.034	1.714	1.81	5.60%	1.134	1.19	4.94%	50	51.7	1.7	-3.2	-1	2.2	-29.8	-31	-3.90%	PASS

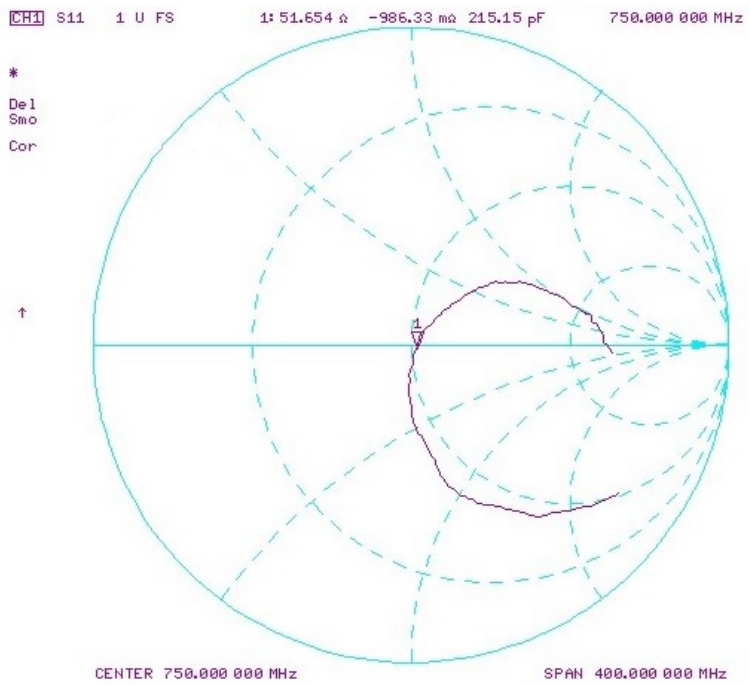
Impedance & Return-Loss Measurement Plot for Head TSL

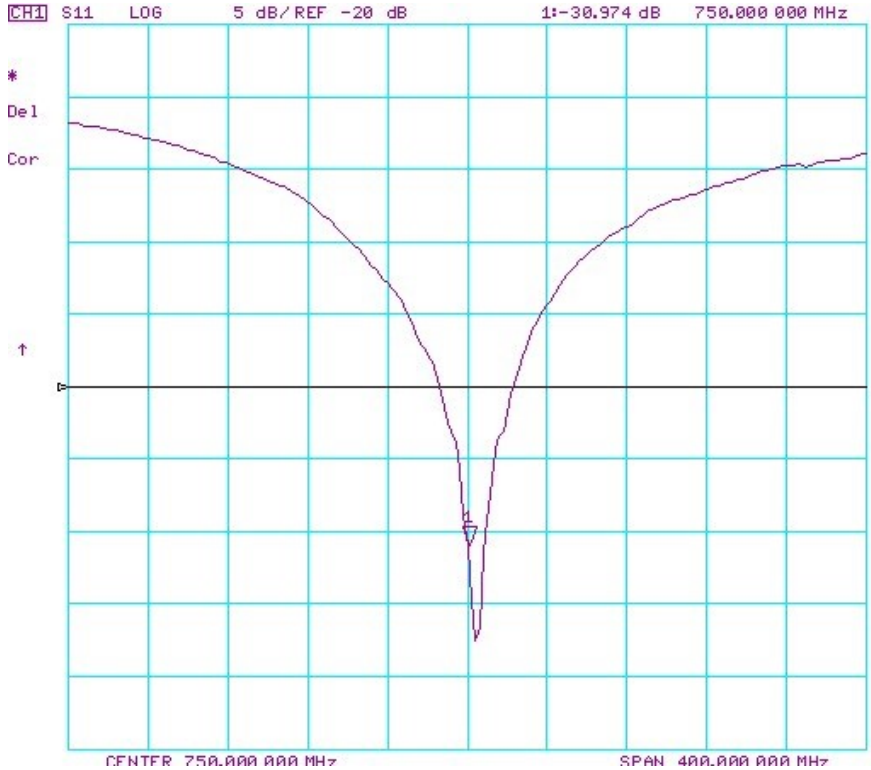




Object:	Date Issued:	Page 3 of 4
D750V3 – SN: 1034	05/16/2019	

Impedance & Return-Loss Measurement Plot for Body TSL





Certification of Calibration

Object D750V3 – SN: 1034

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: May 18, 2020

Description: SAR Validation Dipole at 750 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	1/16/2020	Annual	1/16/2021	US39170118
Agilent	N5182A	MXG Vector Signal Generator	8/19/2019	Annual	8/19/2020	MY47420837
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	MA2411B	Pulse Power Sensor	1/21/2020	Annual	1/21/2021	1207470
Anritsu	MA2411B	Pulse Power Sensor	1/21/2020	Annual	1/21/2021	1339007
Anritsu	ML2495A	Power Meter	1/15/2020	Annual	1/15/2021	1328004
Control Company	62344-734	Therm./ Clock/ Humidity Monitor	3/18/2019	Biennial	3/18/2021	192038436
Control Company	4352	Ultra Long Stem Thermometer	8/2/2018	Biennial	8/2/2020	181292000
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	NC-100	Torque Wrench	5/23/2018	Biennial	5/23/2020	N/A
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/13/2020	Annual	2/13/2021	1403
SPEAG	DAE4	Dasy Data Acquisition Electronics	3/19/2020	Annual	3/19/2021	604
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/12/2020	Annual	5/12/2021	1070
SPEAG	EX3DV4	SAR Probe	2/19/2020	Annual	2/19/2021	7427
SPEAG	EX3DV4	SAR Probe	3/20/2020	Annual	3/20/2021	7421

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	Parker Jones
Approved By:	Kaitlin O'Keefe	Managing Director	KOK

DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

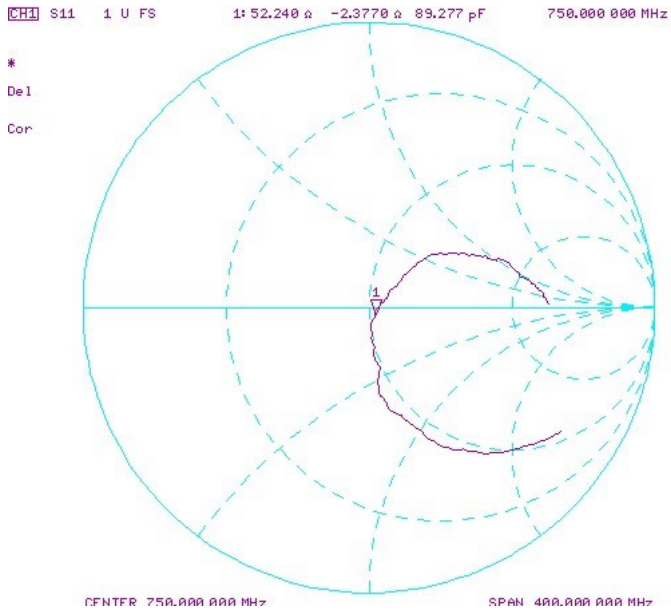
1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

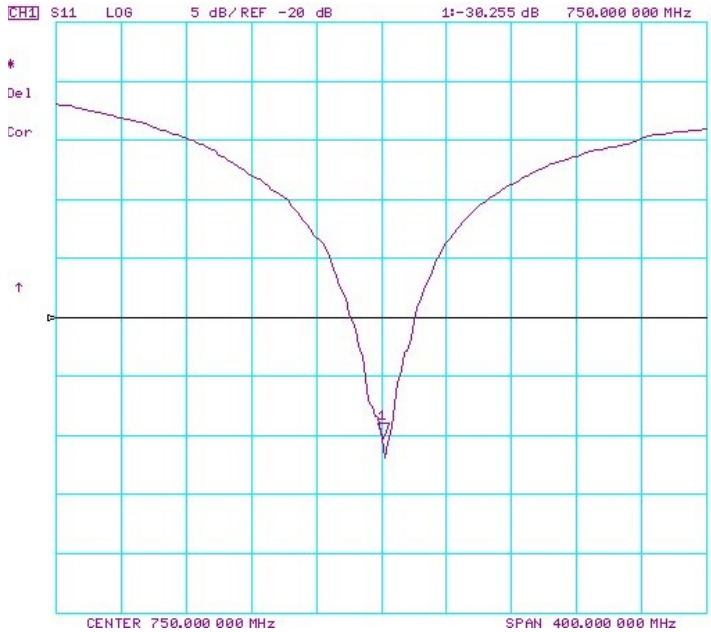
The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 23.0 dBm	Measured Head SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 23.0 dBm	Measured Head SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
5/18/2018	5/18/2020	1.034	1.664	1.63	-2.04%	1.084	1.08	-0.37%	55.3	52.2	3.1	0	-2.4	2.4	-26	-30.3	-16.50%	PASS

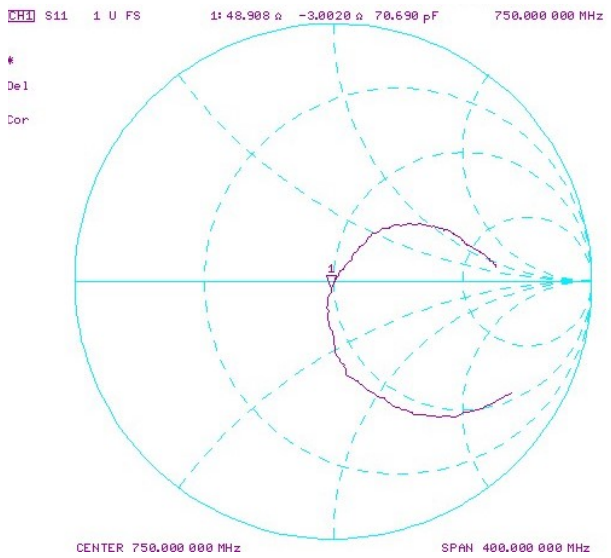
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 23.0 dBm	Measured Body SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 23.0 dBm	Measured Body SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
5/18/2018	5/18/2020	1.034	1.714	1.73	0.93%	1.134	1.15	1.41%	50	48.9	1.1	-3.2	-3	0.2	-29.8	-29.6	0.70%	PASS

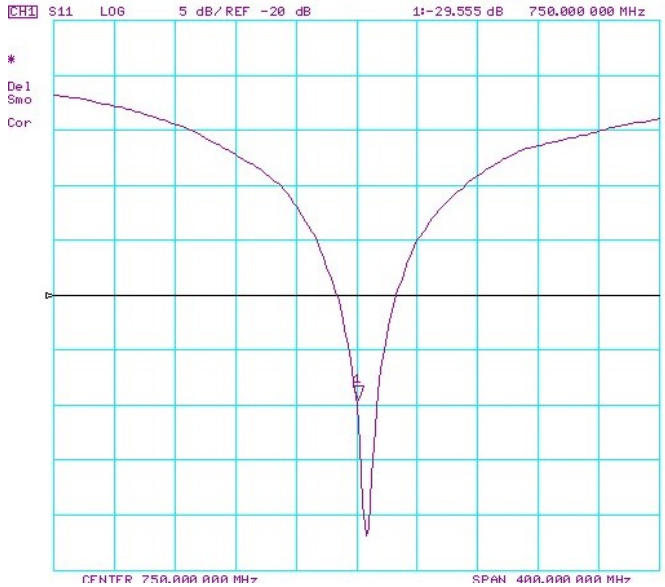
Impedance & Return-Loss Measurement Plot for Head TSL





Impedance & Return-Loss Measurement Plot for Body TSL





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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
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 PC-Test

Certificate No: D750V3-1097_Sep17

CALIBRATION CERTIFICATE

Object	D750V3 - SN:1097
Calibration procedure(s)	QA CAL-05.v9 Calibration procedure for dipole validation kits above 700 MHz
Calibration date:	September 08, 2017

SC ✓ 10/03/2017

SC ✓ 9/8/2018

BN ✓ 10/10/2019

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-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 7349	31-May-17 (No. EX3-7349_May17)	May-18
DAE4	SN: 601	28-Mar-17 (No. DAE4-601_Mar17)	Mar-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-16)	In house check: Oct-17

	Name	Function	Signature
Calibrated by:	Claudio Leubler	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: September 8, 2017

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

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, "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"

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%.

Measurement Conditions

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

DASY Version	DASY5	V52.10.0
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	750 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	41.9	0.89 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	41.2 ± 6 %	0.90 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	2.08 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**8.22 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.36 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**5.39 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	55.5	0.96 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	55.5 ± 6 %	0.96 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	2.14 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**8.56 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.42 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**5.68 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	54.4 Ω - 0.6 jΩ
Return Loss	- 27.5 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	50.0 Ω - 3.6 jΩ
Return Loss	- 28.8 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.034 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 05, 2013

DASY5 Validation Report for Head TSL

Date: 08.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1097

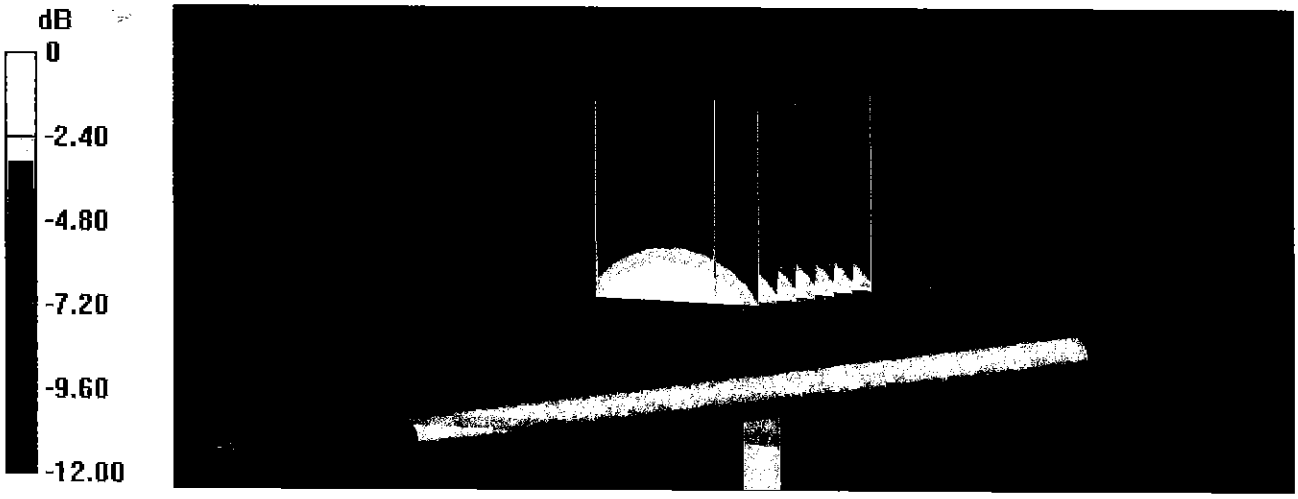
Communication System: UID 0 - CW; Frequency: 750 MHz
Medium parameters used: f = 750 MHz; σ = 0.9 S/m; ε_r = 41.2; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.49, 10.49, 10.49); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

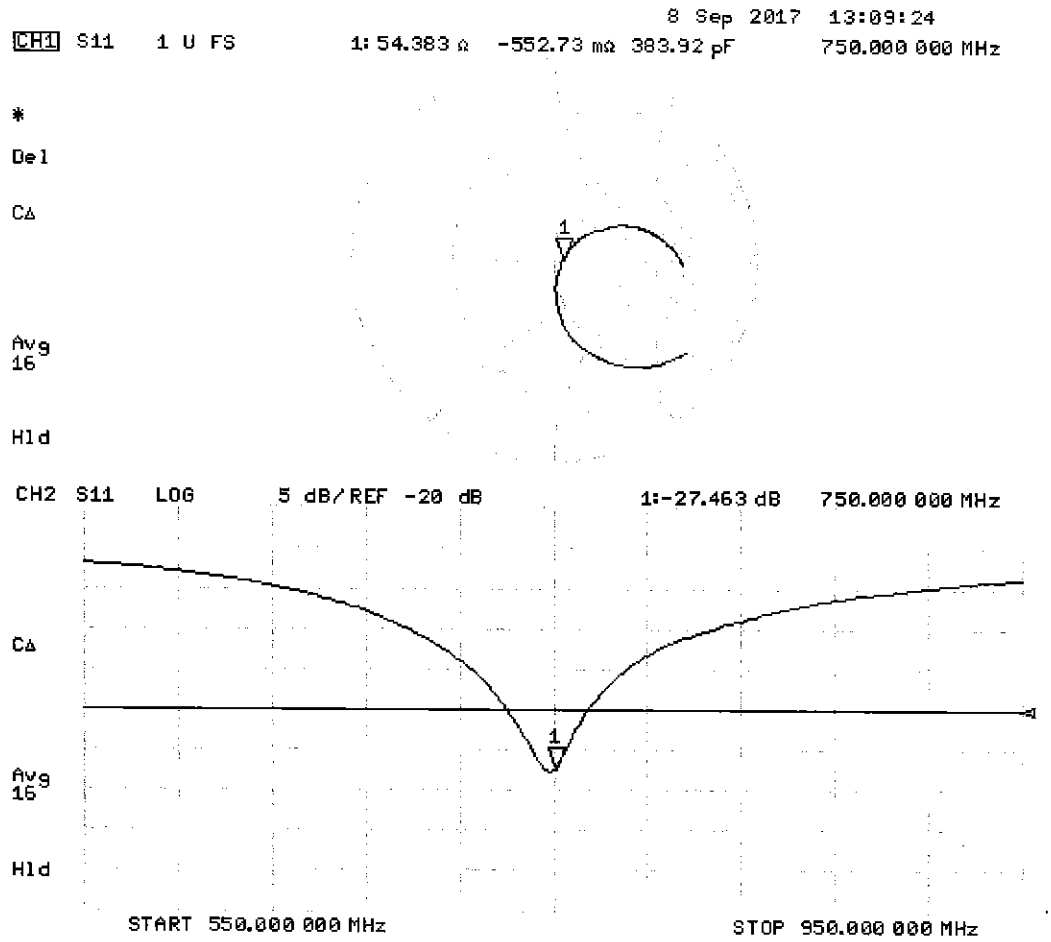
Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 58.59 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 3.19 W/kg
SAR(1 g) = 2.08 W/kg; SAR(10 g) = 1.36 W/kg
Maximum value of SAR (measured) = 2.80 W/kg



0 dB = 2.80 W/kg = 4.47 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 08.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1097

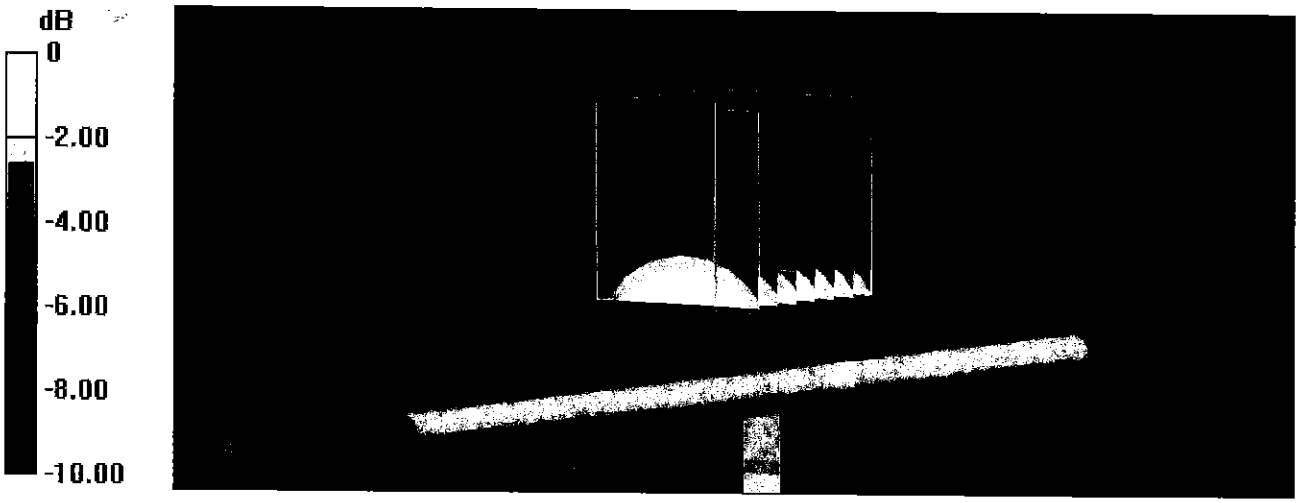
Communication System: UID 0 - CW; Frequency: 750 MHz
Medium parameters used: f = 750 MHz; σ = 0.96 S/m; ε_r = 55.5; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.35, 10.35, 10.35); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

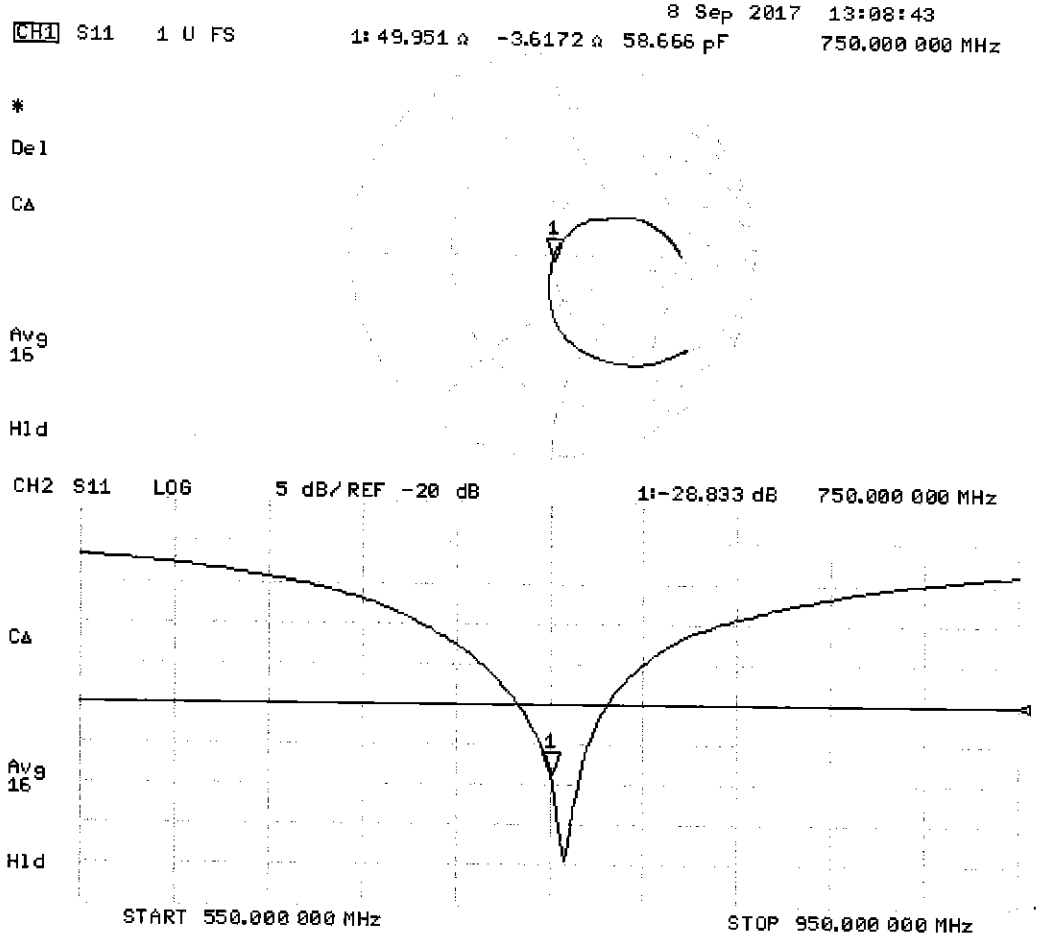
Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 56.96 V/m; Power Drift = -0.00 dB
Peak SAR (extrapolated) = 3.16 W/kg
SAR(1 g) = 2.14 W/kg; SAR(10 g) = 1.42 W/kg
Maximum value of SAR (measured) = 2.81 W/kg



0 dB = 2.81 W/kg = 4.49 dBW/kg

Impedance Measurement Plot for Body TSL



Certification of Calibration

Object D750V3 – SN: 1097

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: September 08, 2018

Description: SAR Validation Dipole at 750 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	9/14/2017	Annual	9/14/2018	US39170118
Agilent	N5182A	MXG Vector Signal Generator	3/19/2018	Annual	3/19/2019	US46240505
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2496A	Power Meter	10/9/2017	Annual	10/9/2018	1138001
Anritsu	MA2411B	Pulse Power Sensor	11/15/2017	Annual	11/15/2018	1339007
Anritsu	MA2411B	Pulse Power Sensor	11/22/2017	Annual	11/22/2018	1339008
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/14/2017	Biennial	2/14/2019	170112507
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/4/2018	Annual	6/4/2019	MY53401181
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	PE5011-1	Torque Wrench	7/19/2017	Biennial	7/19/2019	N/A
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/15/2018	Annual	5/15/2019	1070
SPEAG	ES3DV3	SAR Probe	9/18/2017	Annual	9/18/2018	3287
SPEAG	DAE4	Data Acquisition Electronics	1/26/2018	Annual	1/26/2019	1533
SPEAG	EX3DV4	SAR Probe	7/20/2018	Annual	7/20/2019	7416
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/18/2018	Annual	1/18/2019	793

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Sangmin Cha	Team Lead Engineer	
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	

DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

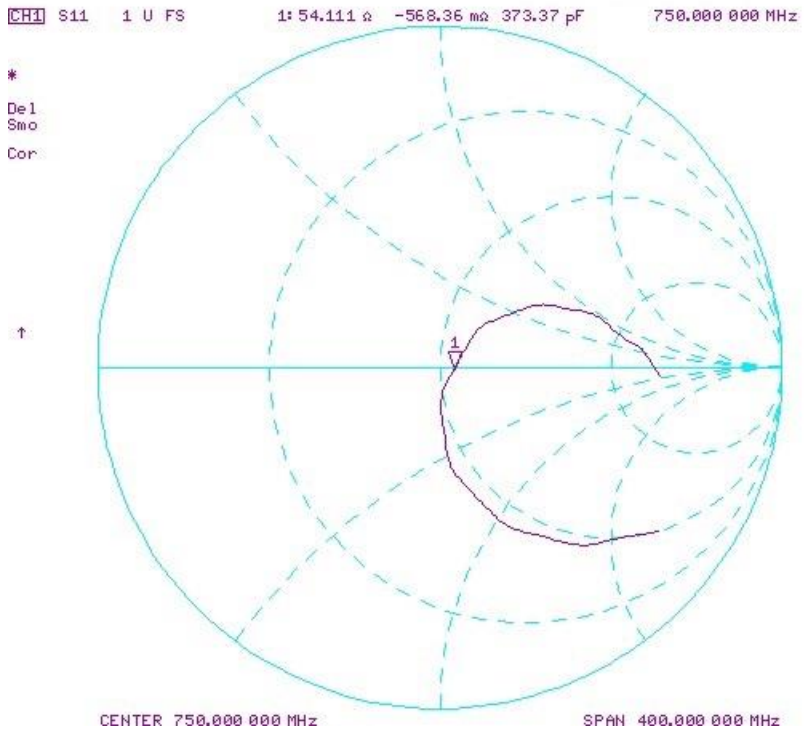
1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

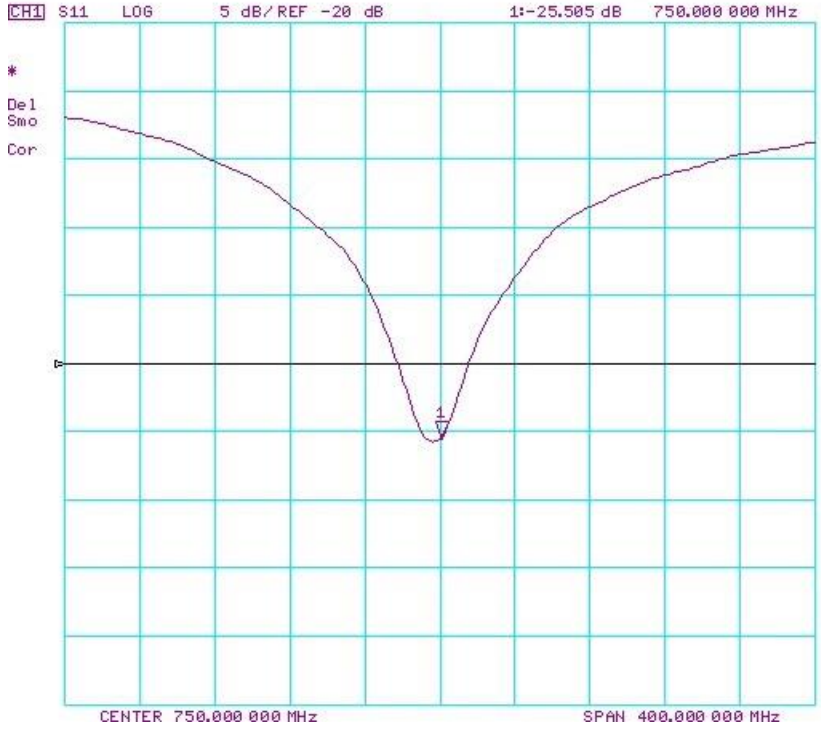
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 23.0 dBm	Measured Head SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 23.0 dBm	Measured Head SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
9/8/2017	9/8/2018	1.034	1.644	1.7	3.41%	1.078	1.12	3.90%	54.4	54.1	0.3	-0.6	-0.6	0	-27.5	-25.5	7.30%	PASS

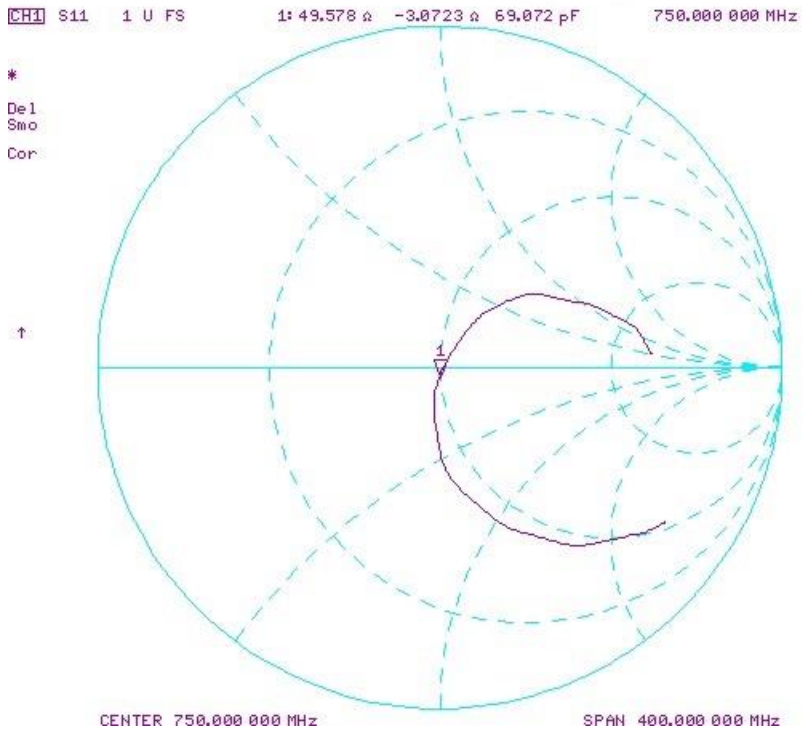
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 23.0 dBm	Measured Body SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 23.0 dBm	Measured Body SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
9/8/2017	9/8/2018	1.034	1.712	1.78	3.97%	1.136	1.17	2.99%	50	49.6	0.4	-3.6	-3.1	0.5	-28.8	-30.3	-5.20%	PASS

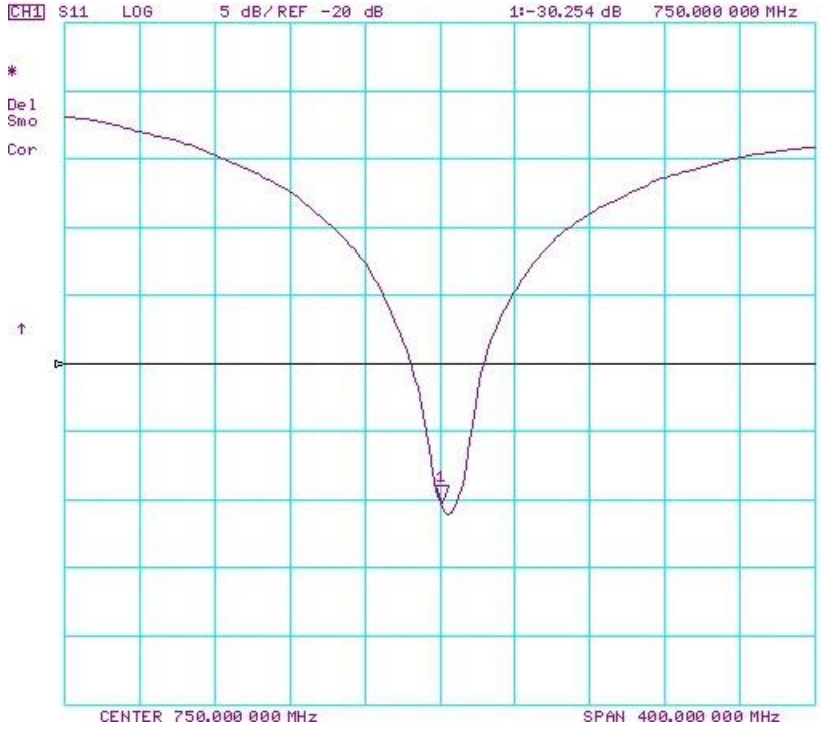
Impedance & Return-Loss Measurement Plot for Head TSL





Impedance & Return-Loss Measurement Plot for Body TSL





Certification of Calibration

Object D750V3 – SN: 1097

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: September 8, 2019

Description: SAR Validation Dipole at 750 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	10/2/2018	Annual	10/2/2019	US39170118
Agilent	E4438C	ESG Vector Signal Generator	6/27/2019	Annual	6/27/2020	MY45093852
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2495A	Power Meter	10/21/2018	Annual	10/21/2019	941001
Anritsu	MA2411B	Pulse Power Sensor	10/30/2018	Annual	10/30/2019	1207470
Anritsu	MA2411B	Pulse Power Sensor	11/20/2018	Annual	11/20/2019	1339007
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/28/2018	Biennial	2/28/2020	170330160
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	NC-100	Torque Wrench	11/1/2017	Biennial	11/1/2019	N/A
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/7/2019	Annual	5/7/2020	1070
SPEAG	EX3DV4	SAR Probe	1/24/2019	Annual	1/24/2020	7490
SPEAG	DAE4	Data Acquisition Electronics	1/15/2019	Annual	1/15/2020	1532

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	Parker Jones
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	KOK

DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

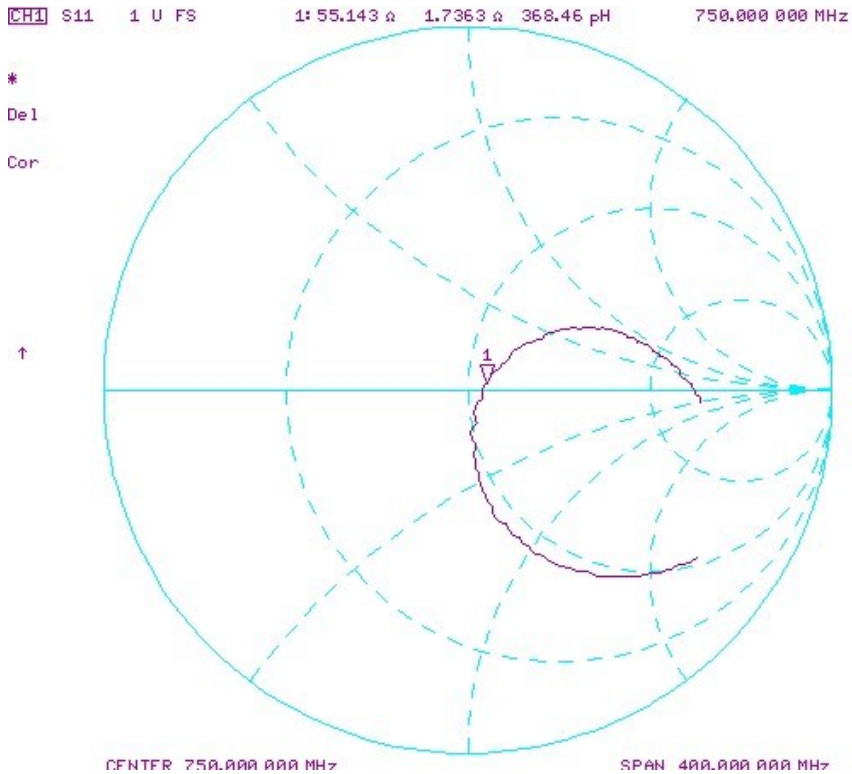
1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

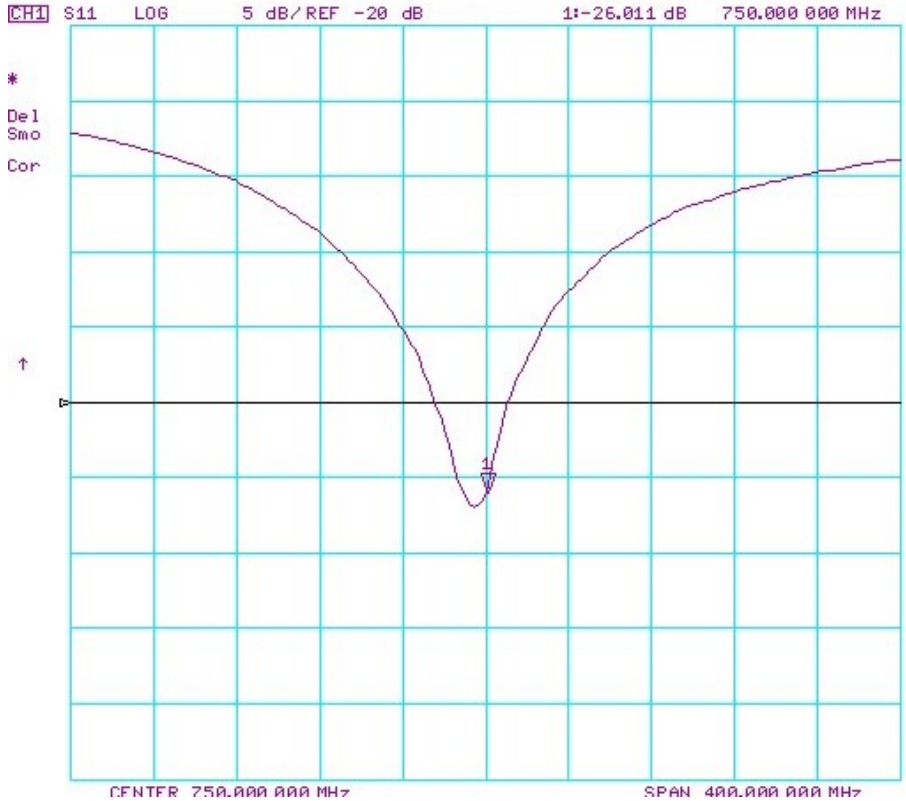
The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 23.0 dBm	Measured Head SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 23.0 dBm	Measured Head SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
9/8/2017	9/8/2019	1.034	1.644	1.56	-5.11%	1.078	1.03	-4.45%	54.4	55.1	0.7	-0.6	1.7	2.3	-27.5	-26	5.50%	PASS

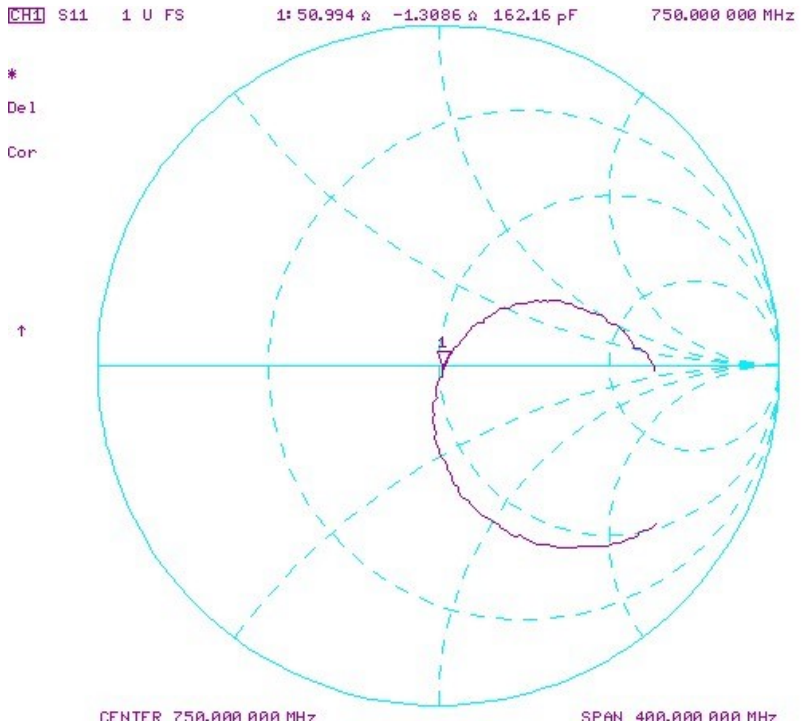
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 23.0 dBm	Measured Body SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 23.0 dBm	Measured Body SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
9/8/2017	9/8/2019	1.034	1.712	1.65	-3.62%	1.136	1.1	-3.17%	50	51	1	-3.6	-1.3	2.3	-28.8	-31.9	-10.80%	PASS

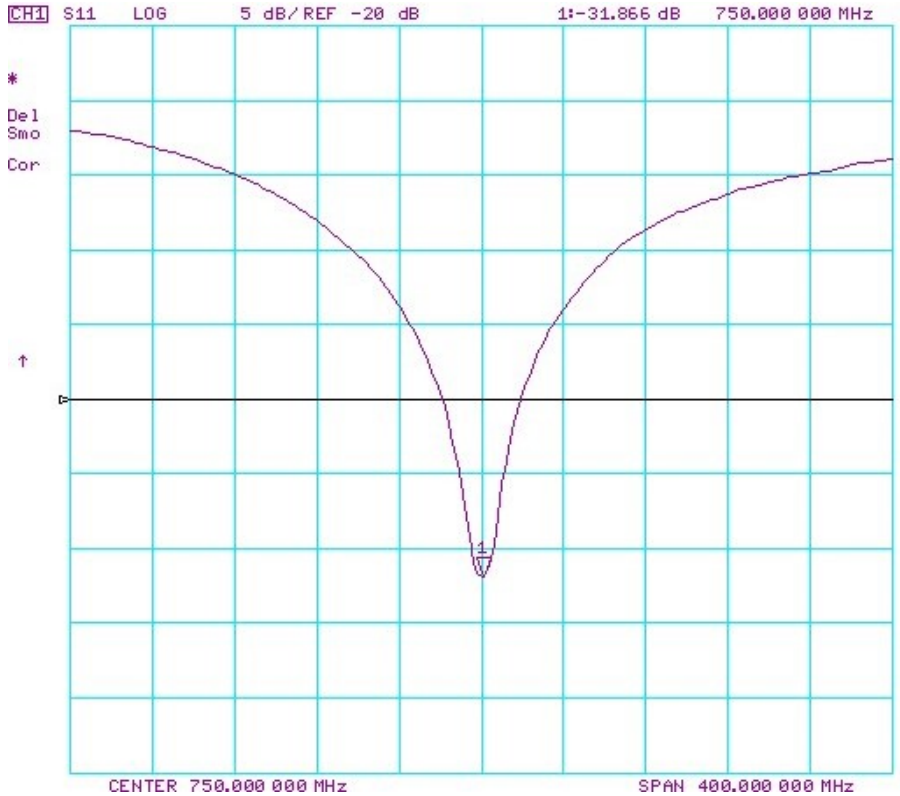
Impedance & Return-Loss Measurement Plot for Head TSL





Impedance & Return-Loss Measurement Plot for Body TSL





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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
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 **PC Test**

Certificate No: **D835V2-4d180_May18**

CALIBRATION CERTIFICATE

Object	D835V2 - SN:4d180
Calibration procedure(s)	QA CAL-05.v10 Calibration procedure for dipole validation kits above 700 MHz
Calibration date:	May 18, 2018

SC ✓ 5/31/2018

BN ✓ 06/01/2019

ATM ✓ 6/11/2020

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: 5058 (20k)	04-Apr-18 (No. 217-02682)	Apr-19
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-18 (No. 217-02683)	Apr-19
Reference Probe EX3DV4	SN: 7349	30-Dec-17 (No. EX3-7349_Dec17)	Dec-18
DAE4	SN: 601	26-Oct-17 (No. DAE4-601_Oct17)	Oct-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18

	Name	Function	Signature
Calibrated by:	Manu Seitz	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: May 22, 2018

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

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, "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"

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%.

Measurement Conditions

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

DASY Version	DASY5	V52.10.1
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
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	40.8 ± 6 %	0.92 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.45 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**9.60 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.58 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**6.22 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	55.2	0.97 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	54.6 ± 6 %	0.99 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.44 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**9.59 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.60 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**6.31 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 - 5.1 jΩ
Return Loss	- 25.9 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.2 Ω - 8.2 jΩ
Return Loss	- 21.1 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.396 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	September 24, 2014

DASY5 Validation Report for Head TSL

Date: 17.05.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:4d180

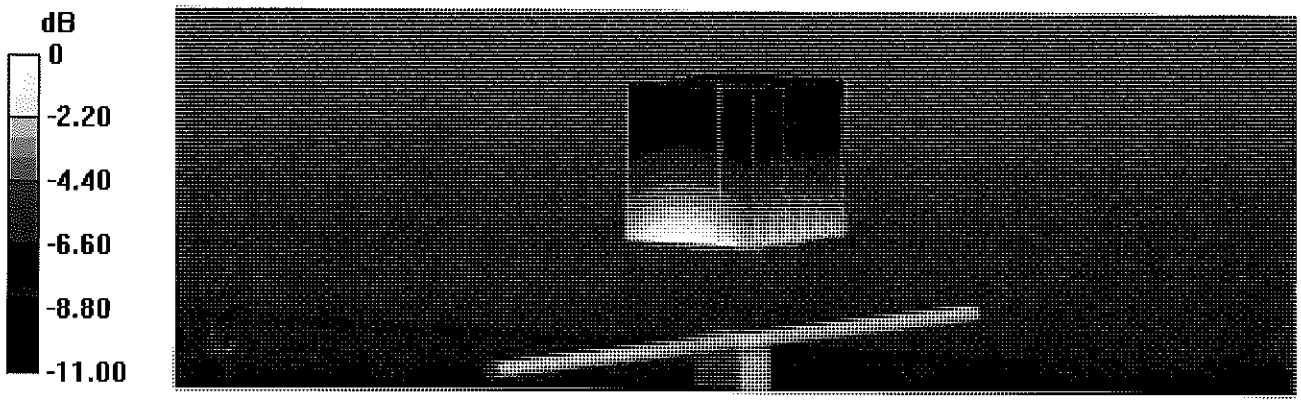
Communication System: UID 0 - CW; Frequency: 835 MHz
Medium parameters used: f = 835 MHz; σ = 0.92 S/m; ε_r = 40.8; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.9, 9.9, 9.9) @ 835 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

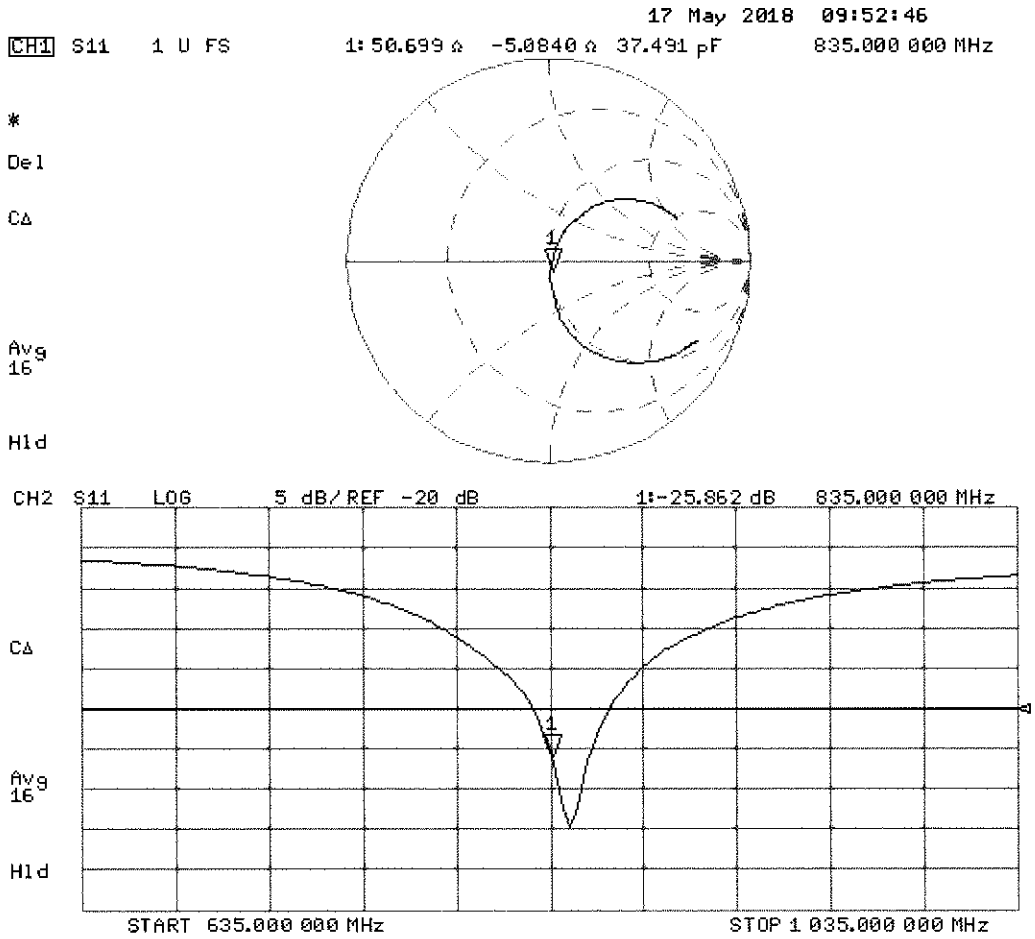
Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 65.39 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 3.78 W/kg
SAR(1 g) = 2.45 W/kg; SAR(10 g) = 1.58 W/kg
Maximum value of SAR (measured) = 3.32 W/kg



0 dB = 3.32 W/kg = 5.21 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 18.05.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:4d180

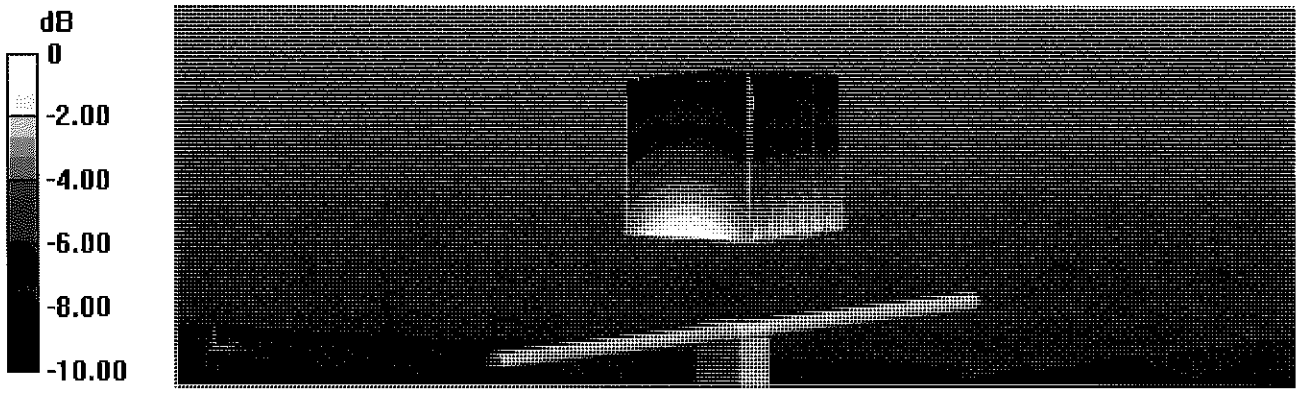
Communication System: UID 0 - CW; Frequency: 835 MHz
Medium parameters used: f = 835 MHz; σ = 0.99 S/m; ε_r = 54.6; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.05, 10.05, 10.05) @ 835 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

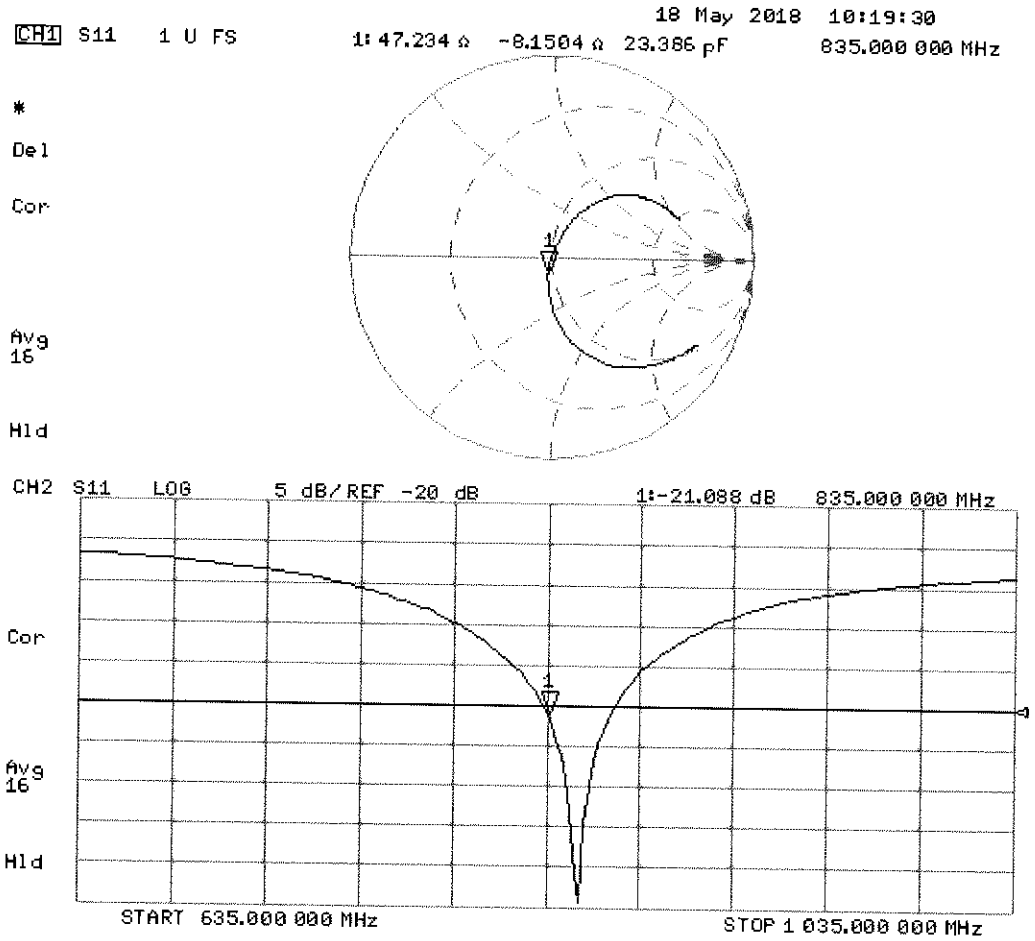
Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 60.80 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 3.62 W/kg
SAR(1 g) = 2.44 W/kg; SAR(10 g) = 1.6 W/kg
Maximum value of SAR (measured) = 3.23 W/kg



0 dB = 3.23 W/kg = 5.09 dBW/kg

Impedance Measurement Plot for Body TSL



Certification of Calibration

Object D835V2 – SN: 4d180

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: May 16, 2019

Description: SAR Validation Dipole at 835 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	10/2/2018	Annual	10/2/2019	US39170118
Agilent	N5182A	MXG Vector Signal Generator	6/15/2018	Annual	6/15/2019	MY47420837
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2495A	Power Meter	10/21/2018	Annual	10/21/2019	941001
Anritsu	MA2411B	Pulse Power Sensor	10/30/2018	Annual	10/30/2019	1207470
Anritsu	MA2411B	Pulse Power Sensor	11/20/2018	Annual	11/20/2019	1339007
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/28/2018	Biennial	2/28/2020	170330160
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/4/2018	Annual	6/4/2019	MY53401181
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	PE5011-1	Torque Wrench	7/19/2017	Biennial	7/19/2019	N/A
SPEAG	DAKS-3.5	Portable DAK	9/11/2018	Annual	9/11/2019	1045
SPEAG	EX3DV4	SAR Probe	7/20/2018	Annual	7/20/2019	7416
SPEAG	DAE4	Dasy Data Acquisition Electronics	7/10/2018	Annual	7/10/2019	1402

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	Parker Jones
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	KOK

DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

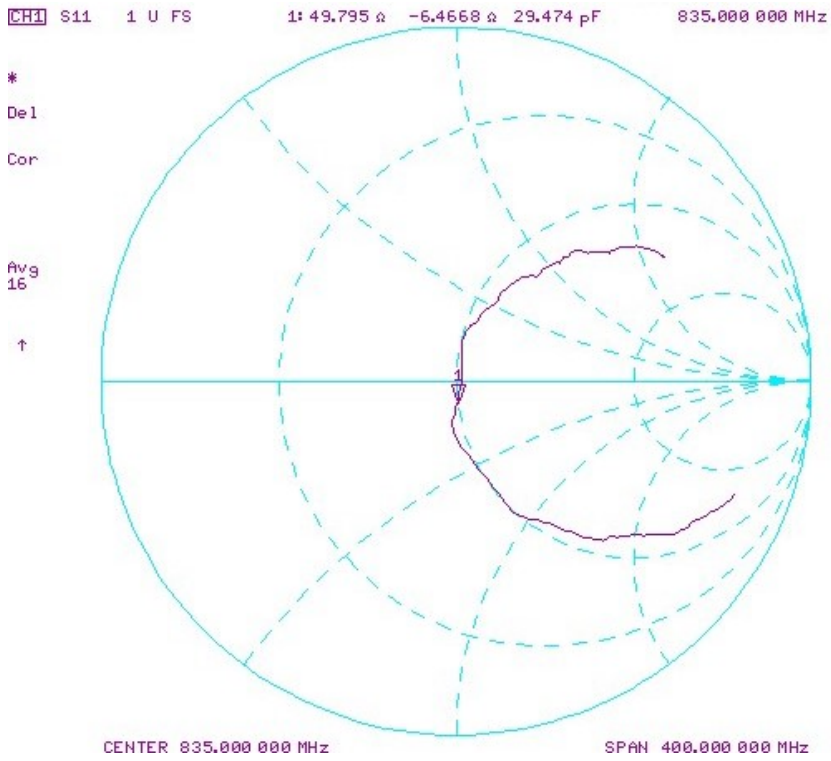
1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

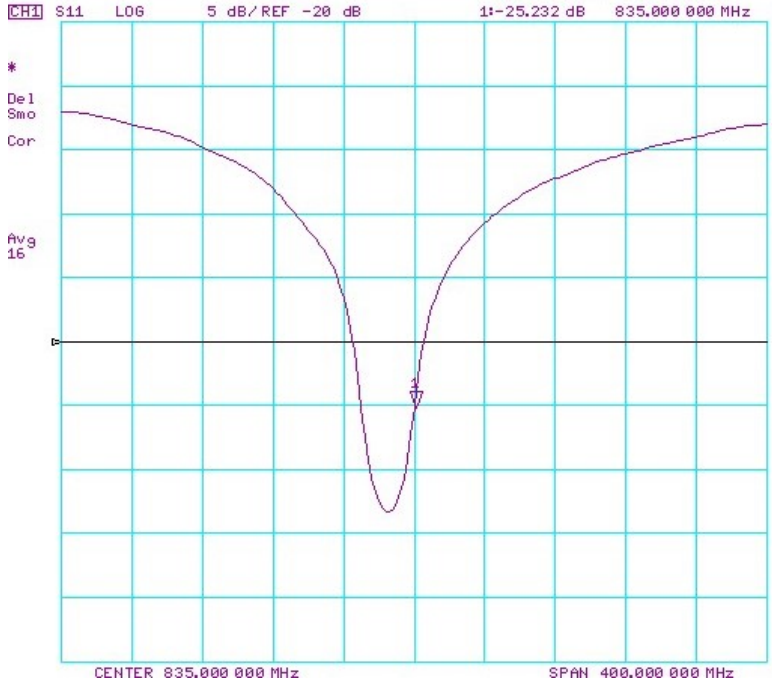
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 23.0 dBm	Measured Head SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 23.0 dBm	Measured Head SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
5/18/2018	5/16/2019	1.396	1.92	1.99	3.65%	1.244	1.3	4.50%	50.7	49.8	0.9	-5.1	-6.5	1.4	-25.9	-25.2	2.60%	PASS

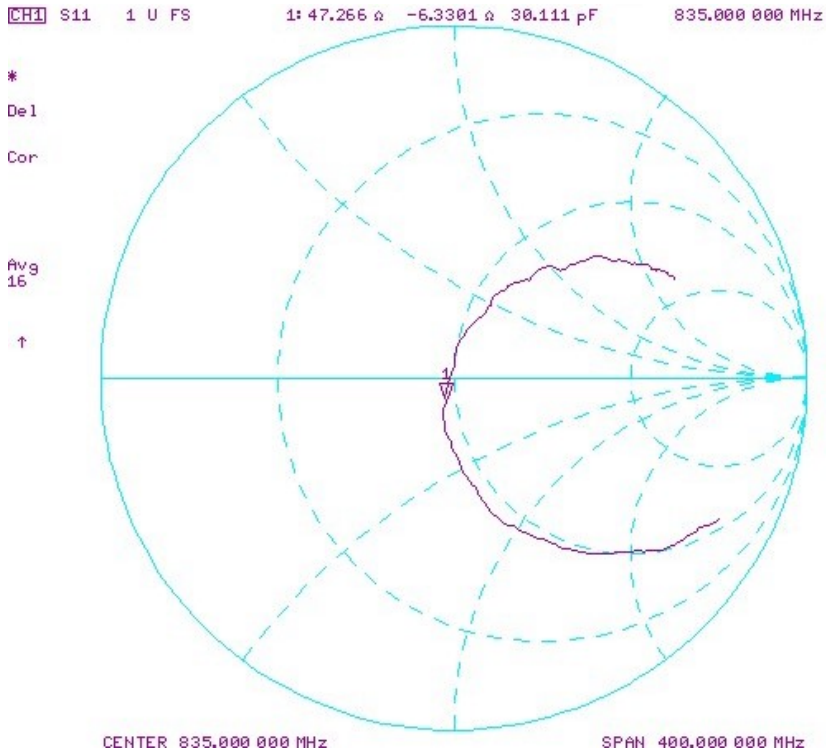
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 23.0 dBm	Measured Body SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 23.0 dBm	Measured Body SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
5/18/2018	5/16/2019	1.396	1.918	2.05	6.88%	1.262	1.34	6.18%	47.2	47.3	0.1	-8.2	-6.3	1.9	-21.1	-23.1	-9.20%	PASS

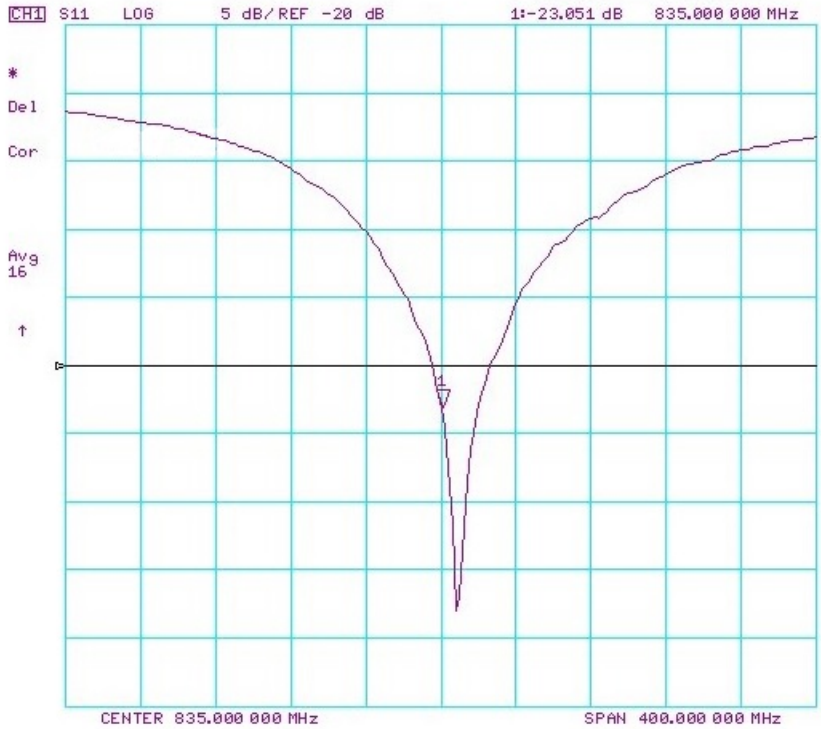
Impedance & Return-Loss Measurement Plot for Head TSL





Impedance & Return-Loss Measurement Plot for Body TSL





Certification of Calibration

Object D835V2 – SN: 4d180

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: May 18, 2020

Description: SAR Validation Dipole at 835 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	1/16/2020	Annual	1/16/2021	US39170118
Agilent	N5182A	MXG Vector Signal Generator	8/19/2019	Annual	8/19/2020	MY47420837
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	MA2411B	Pulse Power Sensor	1/21/2020	Annual	1/21/2021	1207470
Anritsu	MA2411B	Pulse Power Sensor	1/21/2020	Annual	1/21/2021	1339007
Anritsu	ML2495A	Power Meter	1/15/2020	Annual	1/15/2021	1328004
Control Company	62344-734	Therm./ Clock/ Humidity Monitor	3/18/2019	Biennial	3/18/2021	192038436
Control Company	4352	Ultra Long Stem Thermometer	8/2/2018	Biennial	8/2/2020	181292000
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	NC-100	Torque Wrench	5/23/2018	Biennial	5/23/2020	N/A
SPEAG	DAE4	Dasy Data Acquisition Electronics	8/12/2019	Annual	8/12/2020	1408
SPEAG	DAE4	Dasy Data Acquisition Electronics	3/19/2020	Annual	3/19/2021	604
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/12/2020	Annual	5/12/2021	1070
SPEAG	EX3DV4	SAR Probe	8/29/2019	Annual	8/29/2020	3949
SPEAG	EX3DV4	SAR Probe	3/20/2020	Annual	3/20/2021	7421

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	Parker Jones
Approved By:	Kaitlin O'Keefe	Managing Director	KOK

DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

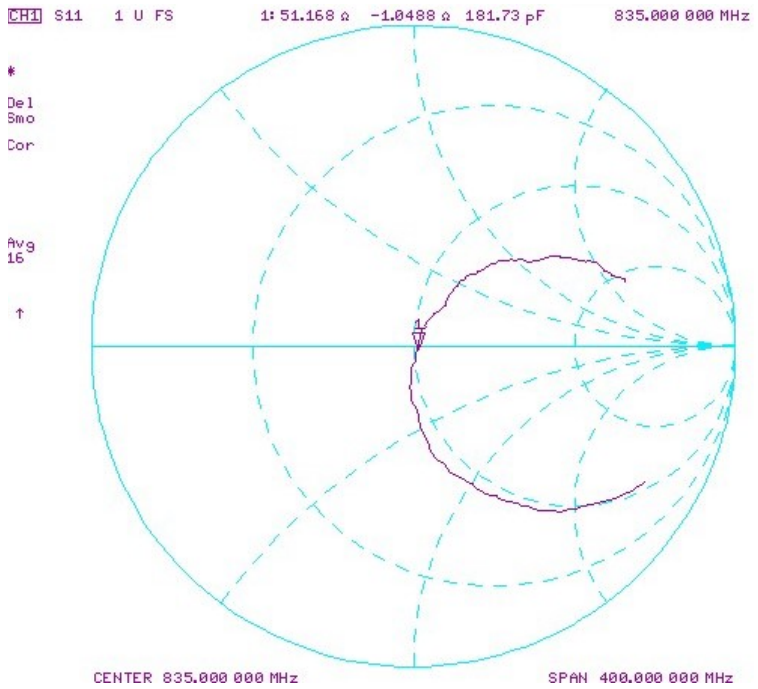
1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

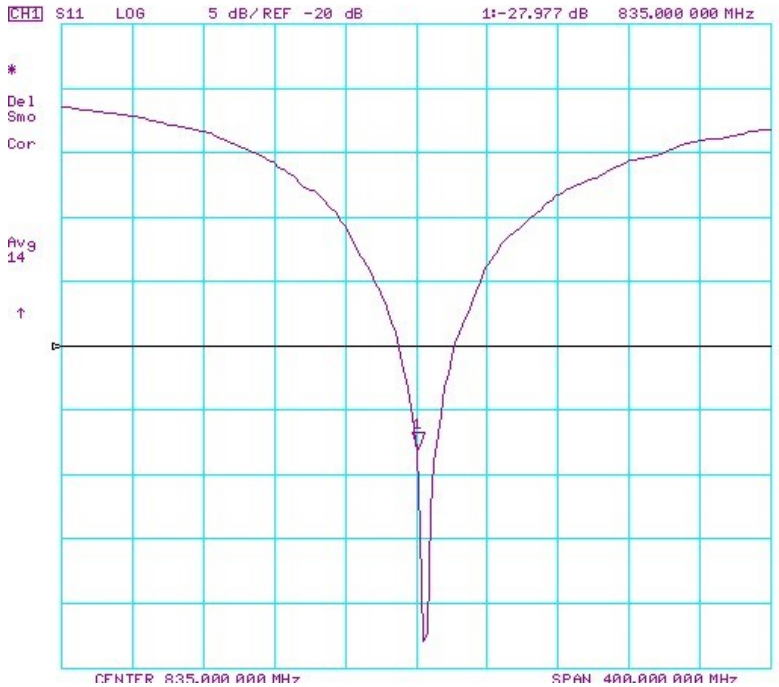
The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 23.0 dBm	Measured Head SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 23.0 dBm	Measured Head SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
5/18/2018	5/18/2020	1.396	1.92	2	4.17%	1.244	1.32	6.11%	50.7	51.2	0.5	-5.1	-1	4.1	-25.9	-28	-8.10%	PASS

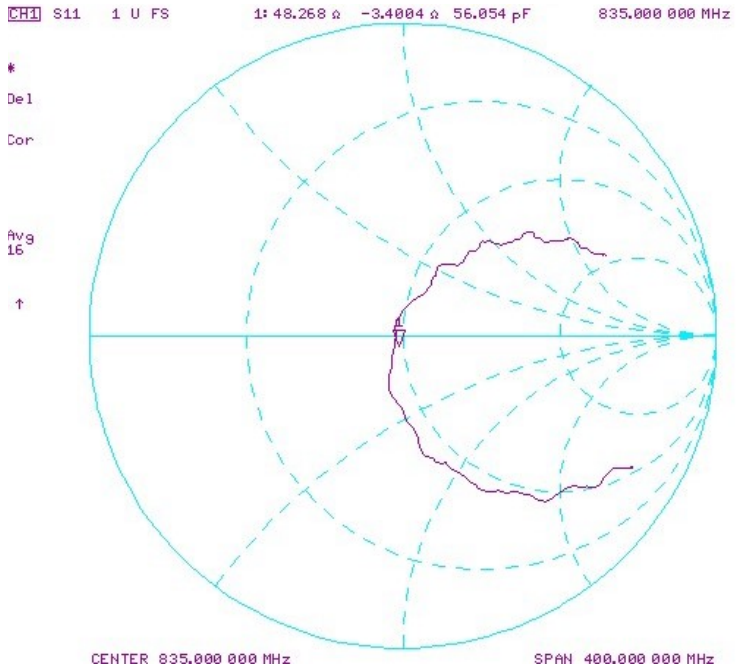
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 23.0 dBm	Measured Body SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 23.0 dBm	Measured Body SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
5/18/2018	5/18/2020	1.396	1.918	2	4.28%	1.262	1.31	3.80%	47.2	48.3	1.1	-8.2	-3.4	4.8	-21.1	-24.9	-18.00%	PASS

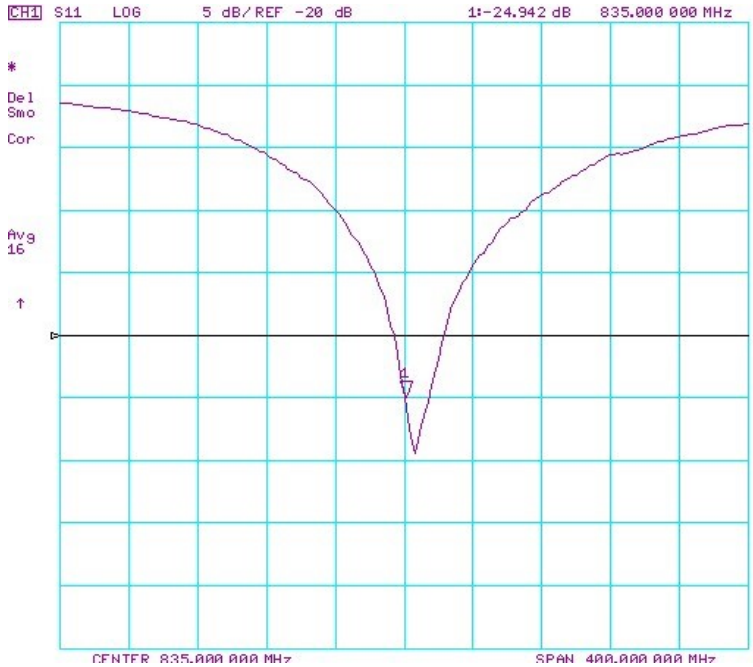
Impedance & Return-Loss Measurement Plot for Head TSL





Impedance & Return-Loss Measurement Plot for Body TSL





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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
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 **PC Test**

Certificate No: **D850V2-1009_Aug17**

CALIBRATION CERTIFICATE

Object	D850V2 - SN:1009
Calibration procedure(s)	QA CAL-05.v9 Calibration procedure for dipole validation kits above 700 MHz
Calibration date:	August 16, 2017

8/27/17 PMV
8/2/18 SCV
BMV 8/10/19

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-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 7349	31-May-17 (No. EX3-7349_May17)	May-18
DAE4	SN: 601	28-Mar-17 (No. DAE4-601_Mar17)	Mar-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-16)	In house check: Oct-17

	Name	Function	Signature
Calibrated by:	Johannes Kurikka	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: August 17, 2017

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

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, "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"

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%.

Measurement Conditions

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

DASY Version	DASY5	V52.10.0
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	850 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	0.92 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	40.9 ± 6 %	0.94 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.56 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**10.0 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.66 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**6.54 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	55.2	0.99 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	54.7 ± 6 %	1.02 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.53 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**9.88 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.65 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**6.48 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	52.5 Ω - 2.5 jΩ
Return Loss	- 29.2 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.5 Ω - 7.3 jΩ
Return Loss	- 22.1 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.438 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	September 04, 2012

DASY5 Validation Report for Head TSL

Date: 16.08.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 850 MHz; Type: D850V2; Serial: D850V2 - SN:1009

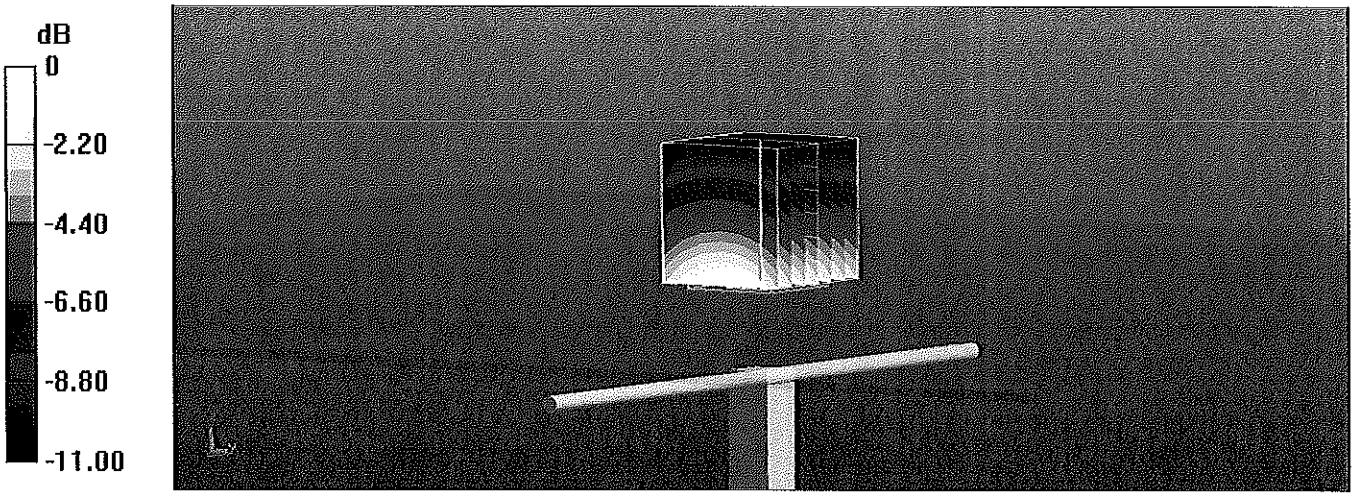
Communication System: UID 0 - CW; Frequency: 850 MHz
Medium parameters used: f = 850 MHz; σ = 0.94 S/m; ε_r = 40.9; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.93, 9.93, 9.93); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

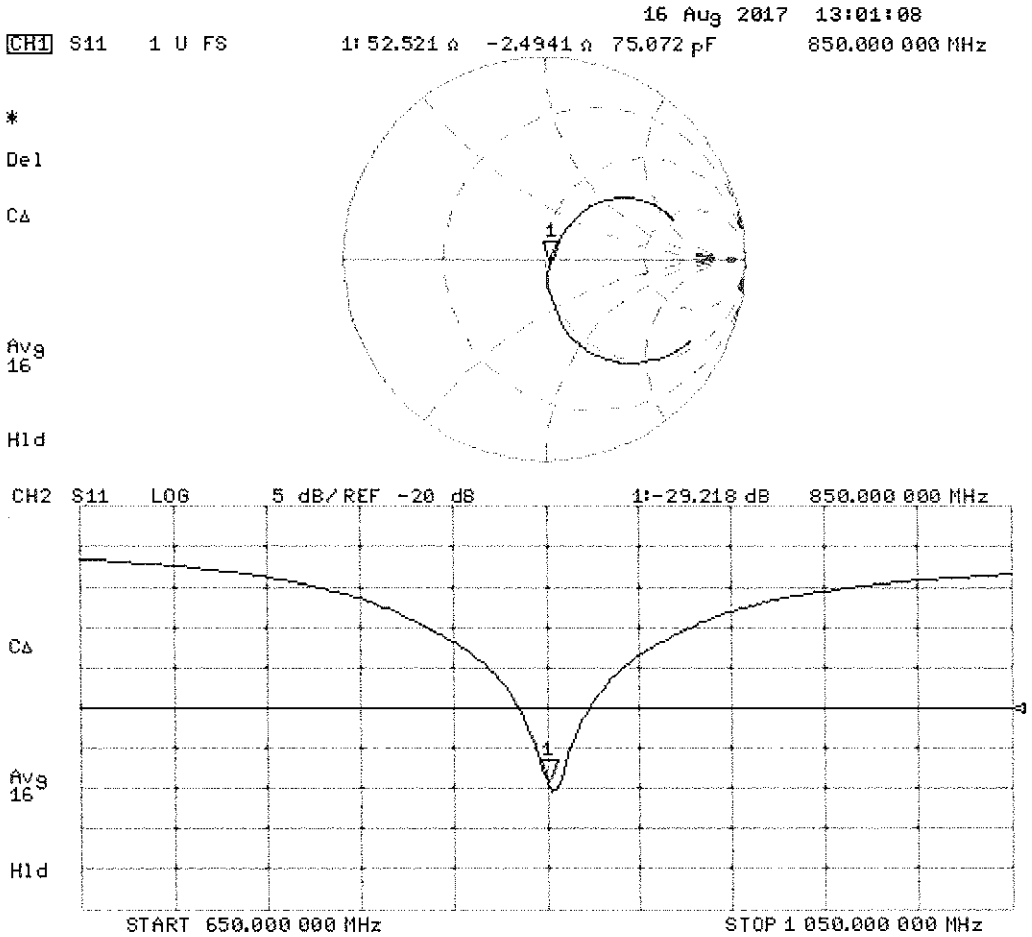
Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 63.35 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 3.86 W/kg
SAR(1 g) = 2.56 W/kg; SAR(10 g) = 1.66 W/kg
Maximum value of SAR (measured) = 3.43 W/kg



0 dB = 3.43 W/kg = 5.35 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 16.08.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 850 MHz; Type: D850V2; Serial: D850V2 - SN:1009

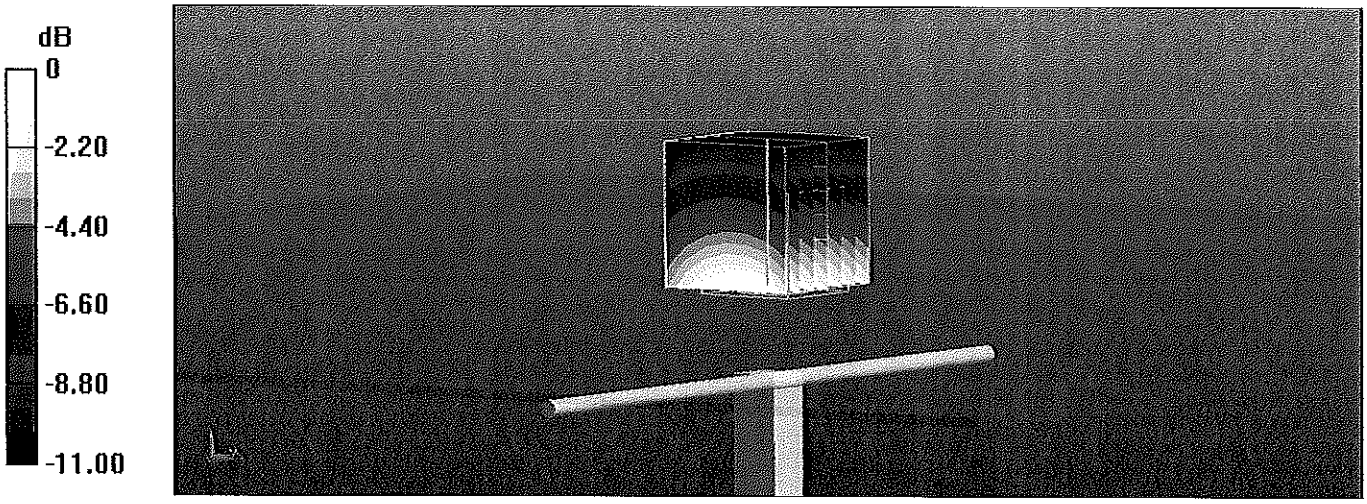
Communication System: UID 0 - CW; Frequency: 850 MHz
Medium parameters used: f = 850 MHz; σ = 1.02 S/m; ε_r = 54.7; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.11, 10.11, 10.11); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

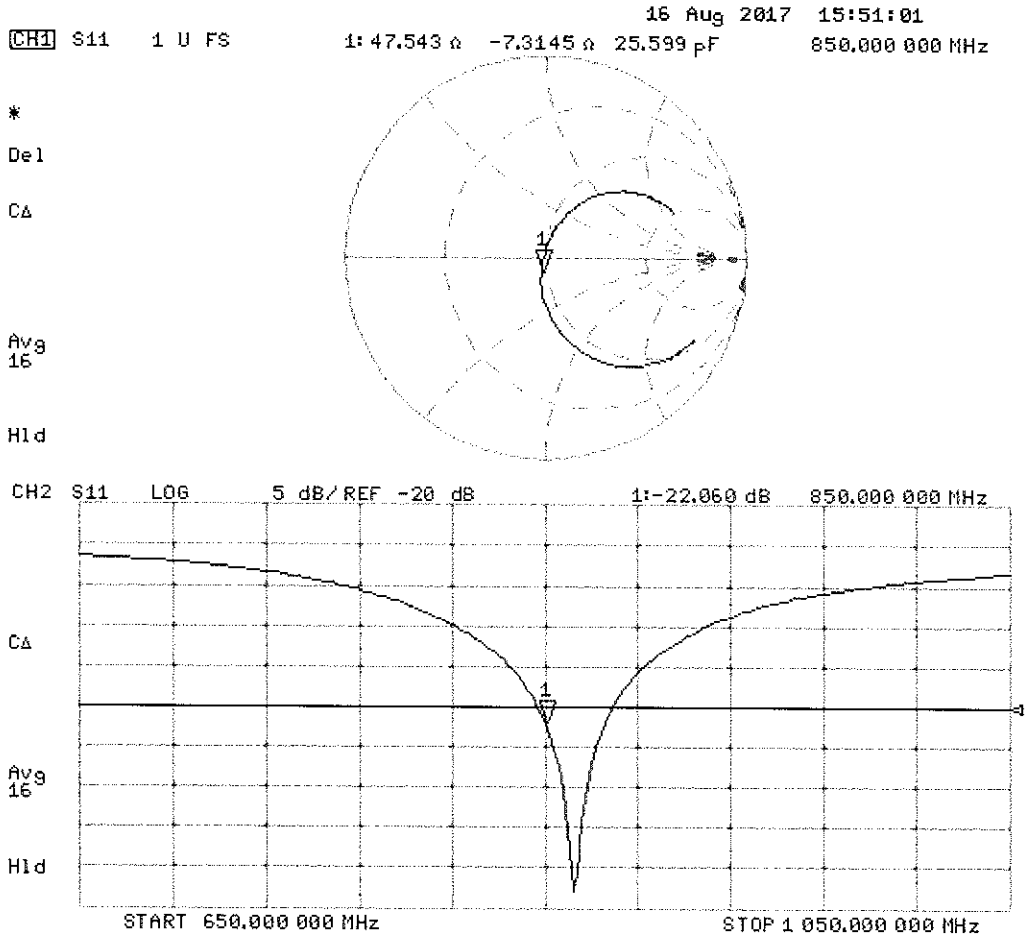
Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 60.51 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 3.80 W/kg
SAR(1 g) = 2.53 W/kg; SAR(10 g) = 1.65 W/kg
Maximum value of SAR (measured) = 3.35 W/kg



0 dB = 3.35 W/kg = 5.25 dBW/kg

Impedance Measurement Plot for Body TSL



Certification of Calibration

Object D850V2 – SN: 1009

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: August 02, 2018

Description: SAR Validation Dipole at 850 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	9/14/2017	Annual	9/14/2018	US39170118
Agilent	N5182A	MXG Vector Signal Generator	3/19/2018	Annual	3/19/2019	US46240505
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2496A	Power Meter	10/9/2017	Annual	10/9/2018	1138001
Anritsu	MA2411B	Pulse Power Sensor	11/15/2017	Annual	11/15/2018	1339007
Anritsu	MA2411B	Pulse Power Sensor	11/22/2017	Annual	11/22/2018	1339008
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/14/2017	Biennial	2/14/2019	170112507
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/4/2018	Annual	6/4/2019	MY53401181
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	PE5011-1	Torque Wrench	7/19/2017	Biennial	7/19/2019	N/A
SPEAG	DAKS-3.5	Portable DAK	9/5/2017	Annual	9/5/2018	1045
SPEAG	ES3DV3	SAR Probe	3/13/2018	Annual	3/13/2019	3131
SPEAG	DAE4	Dasy Data Acquisition Electronics	3/7/2018	Annual	3/7/2019	604

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Sangmin Cha	Biomedical Engineer II	
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	

DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

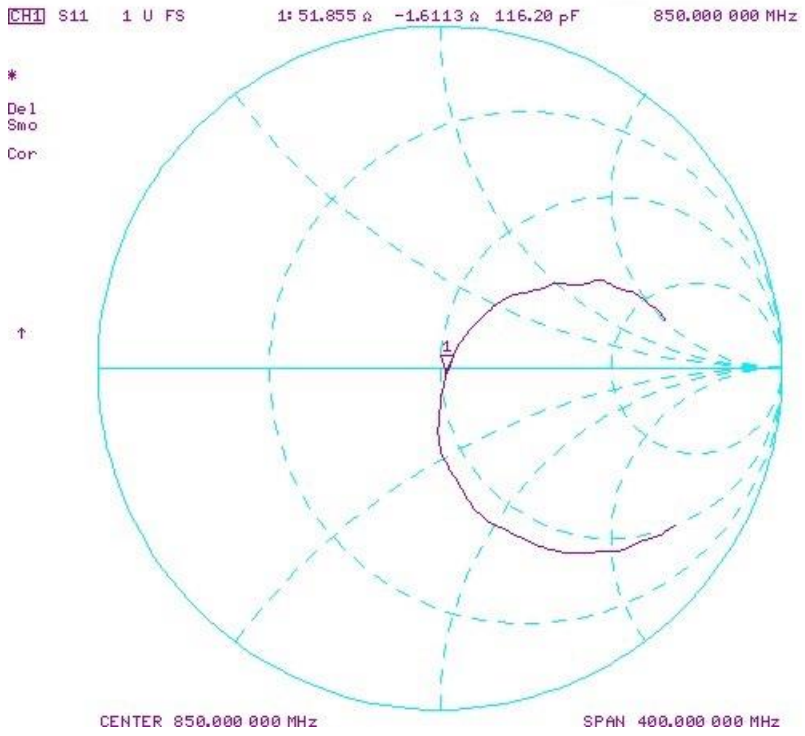
1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

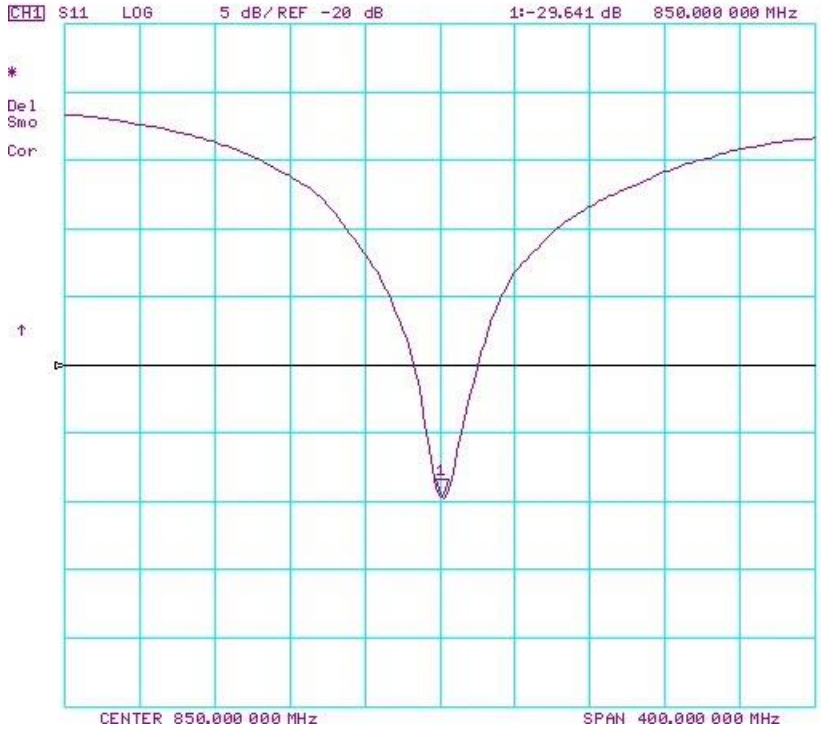
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 23.0 dBm	Measured Head SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 23.0 dBm	Measured Head SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
8/16/2017	8/2/2018	1.438	2	1.93	-3.50%	1.308	1.25	-4.43%	52.5	51.9	0.6	-2.5	-1.6	0.9	-29.2	-29.6	-1.40%	PASS

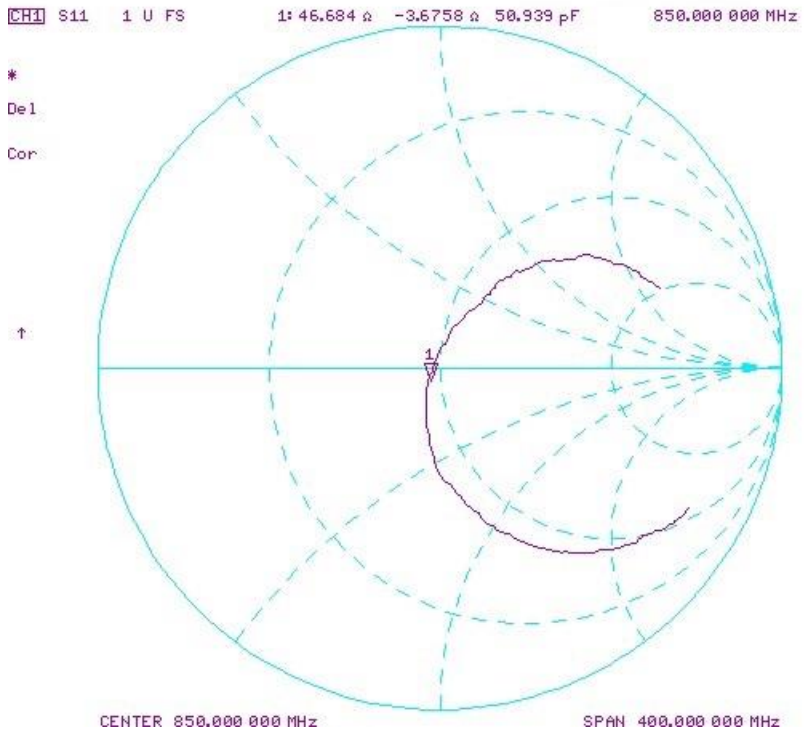
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 23.0 dBm	Measured Body SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 23.0 dBm	Measured Body SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
8/16/2017	8/2/2018	1.438	1.976	2.07	4.76%	1.296	1.36	4.94%	47.5	46.7	0.8	-7.3	-3.7	3.6	-22.1	-26	-17.60%	PASS

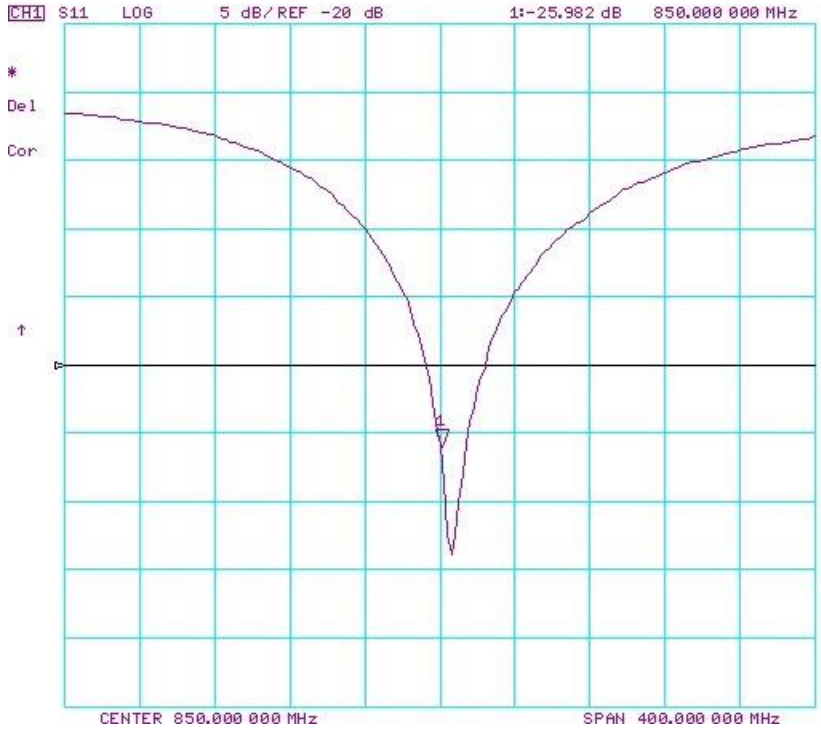
Impedance & Return-Loss Measurement Plot for Head TSL





Impedance & Return-Loss Measurement Plot for Body TSL





Certification of Calibration

Object D850V2 – SN: 1009

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: August 7, 2019

Description: SAR Validation Dipole at 850 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	10/2/2018	Annual	10/2/2019	US39170118
Agilent	N5182A	MXG Vector Signal Generator	6/27/2019	Annual	6/27/2020	US46240505
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2495A	Power Meter	10/21/2018	Annual	10/21/2019	941001
Anritsu	MA2411B	Pulse Power Sensor	10/30/2018	Annual	10/30/2019	1207470
Anritsu	MA2411B	Pulse Power Sensor	11/20/2018	Annual	11/20/2019	1339007
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/28/2018	Biennial	2/28/2020	170330160
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	NC-100	Torque Wrench	5/23/2018	Biennial	5/23/2020	N/A
SPEAG	DAKS-3.5	Portable DAK	9/11/2018	Annual	9/11/2019	1045
SPEAG	EX3DV4	SAR Probe	1/28/2019	Annual	1/28/2020	3837
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/15/2019	Annual	1/15/2020	793

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	Parker Jones
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	KOK

DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

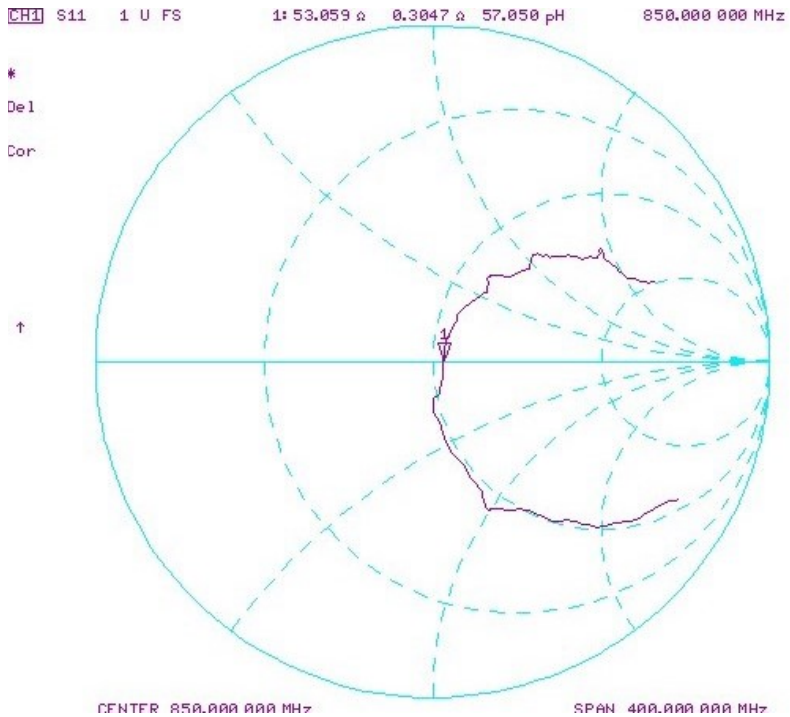
1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

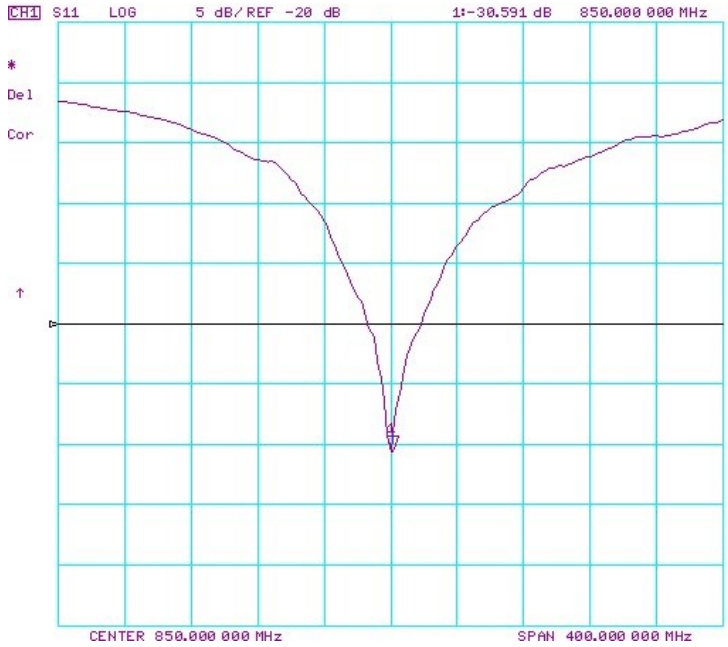
The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 23.0 dBm	Measured Head SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 23.0 dBm	Measured Head SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
8/16/2017	8/7/2019	1.438	2	2.07	3.50%	1.308	1.33	1.68%	52.5	53.1	0.6	-2.5	0.3	2.8	-29.2	-30.6	-4.80%	PASS

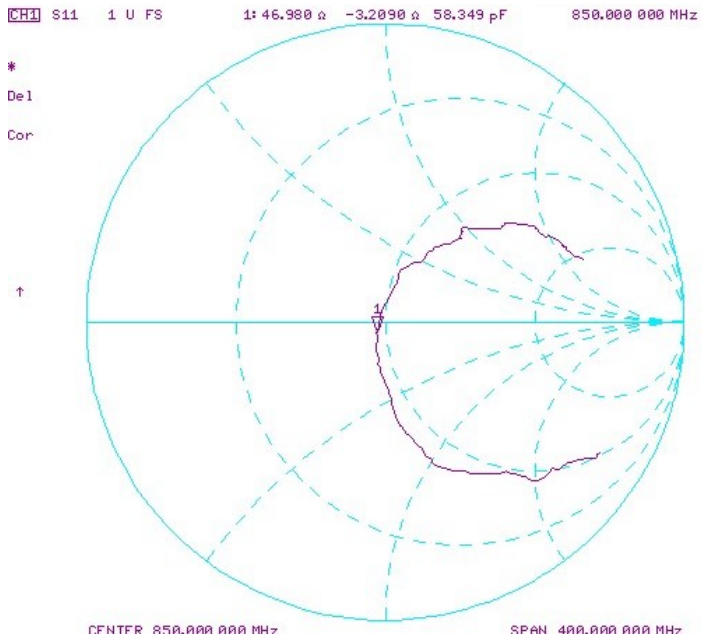
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 23.0 dBm	Measured Body SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 23.0 dBm	Measured Body SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
8/16/2017	8/7/2019	1.438	1.976	2.09	5.77%	1.296	1.36	4.94%	47.5	47	0.5	-7.3	-3.2	4.1	-22.1	-23.5	-6.40%	PASS

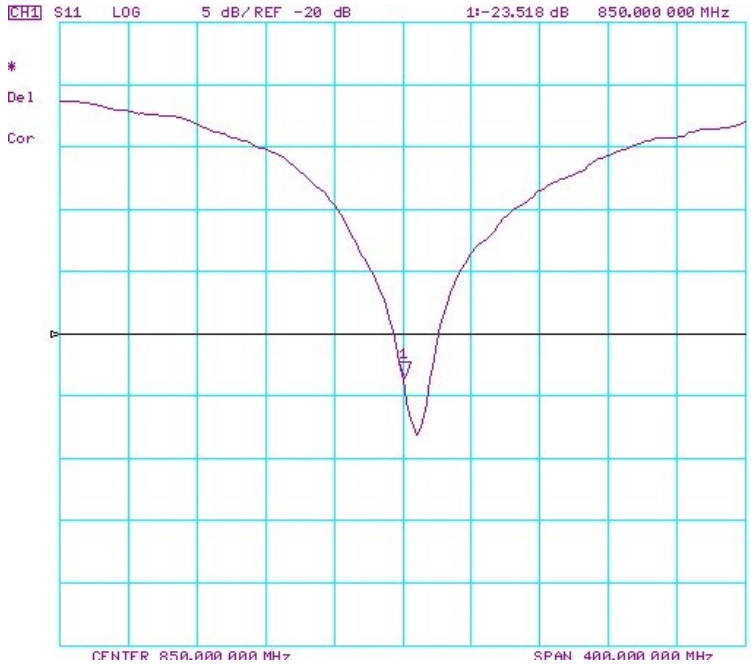
Impedance & Return-Loss Measurement Plot for Head TSL





Impedance & Return-Loss Measurement Plot for Body TSL





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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
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 PC Test

Certificate No: **D850V2-1010_Sep17**

CALIBRATION CERTIFICATE

Object	D850V2 - SN:1010
Calibration procedure(s)	QA CAL-05.v9 Calibration procedure for dipole validation kits above 700 MHz
Calibration date:	September 08, 2017

SCV 10/03/2017

SCV 9/9/2018

BN 10/10/2019

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-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 7349	31-May-17 (No. EX3-7349_May17)	May-18
DAE4	SN: 601	28-Mar-17 (No. DAE4-601_Mar17)	Mar-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-16)	In house check: Oct-17

	Name	Function	Signature
Calibrated by:	Claudio Leubler	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: September 8, 2017

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

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, "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"

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%.

Measurement Conditions

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

DASY Version	DASY5	V52.10.0
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	850 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	0.92 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	40.9 ± 6 %	0.94 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	2.53 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**9.93 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.63 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**6.42 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	55.2	0.99 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	55.3 ± 6 %	0.99 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	2.55 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**10.2 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.67 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**6.68 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	50.2 Ω - 3.1 jΩ
Return Loss	- 30.2 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.6 Ω - 5.8 jΩ
Return Loss	- 23.2 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.432 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	September 04, 2012

DASY5 Validation Report for Head TSL

Date: 08.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 850 MHz; Type: D850V2; Serial: D850V2 - SN:1010

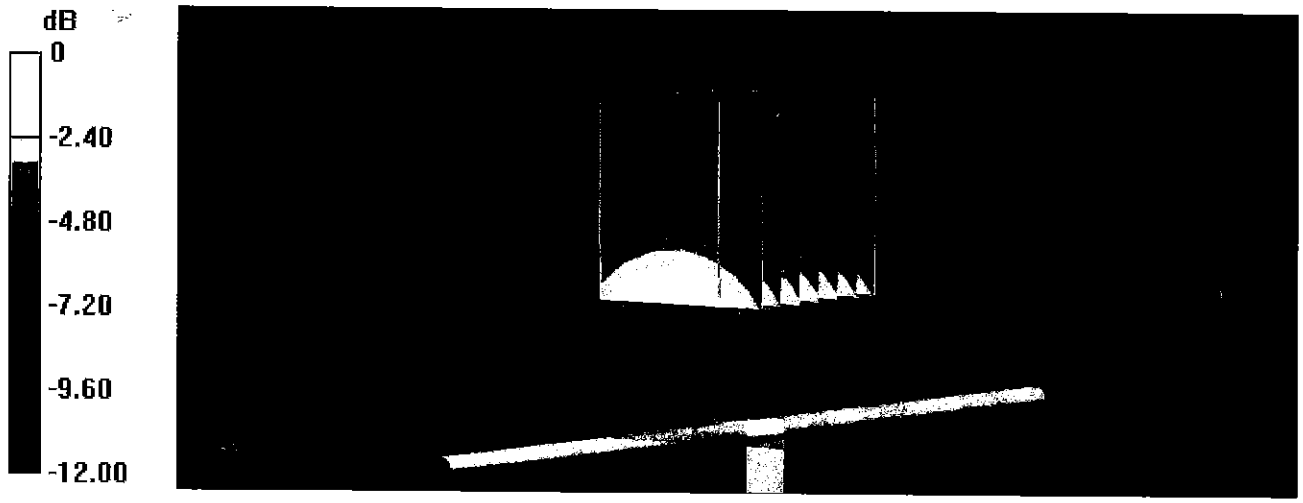
Communication System: UID 0 - CW; Frequency: 850 MHz
Medium parameters used: f = 850 MHz; σ = 0.94 S/m; ε_r = 40.9; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.93, 9.93, 9.93); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

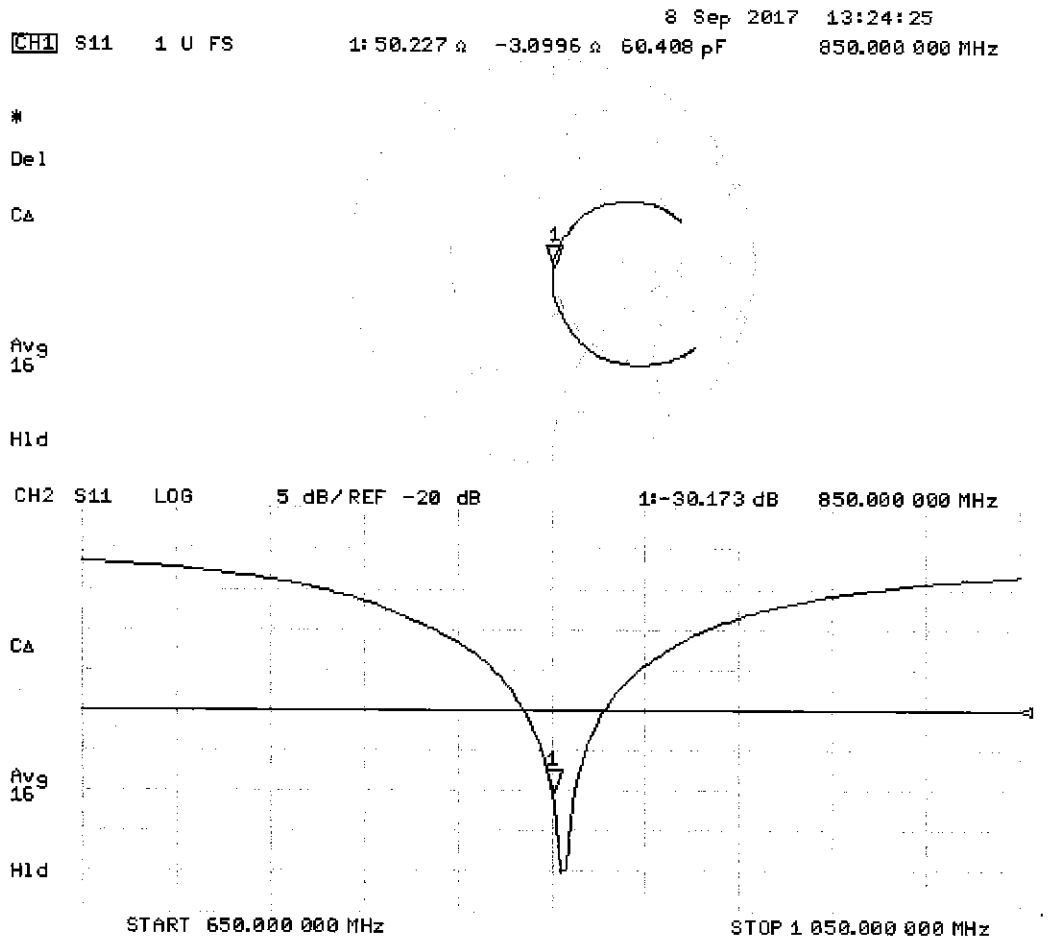
Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 63.32 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 3.85 W/kg
SAR(1 g) = 2.53 W/kg; SAR(10 g) = 1.63 W/kg
Maximum value of SAR (measured) = 3.41 W/kg



0 dB = 3.41 W/kg = 5.33 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 08.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 850 MHz; Type: D850V2; Serial: D850V2 - SN:1010

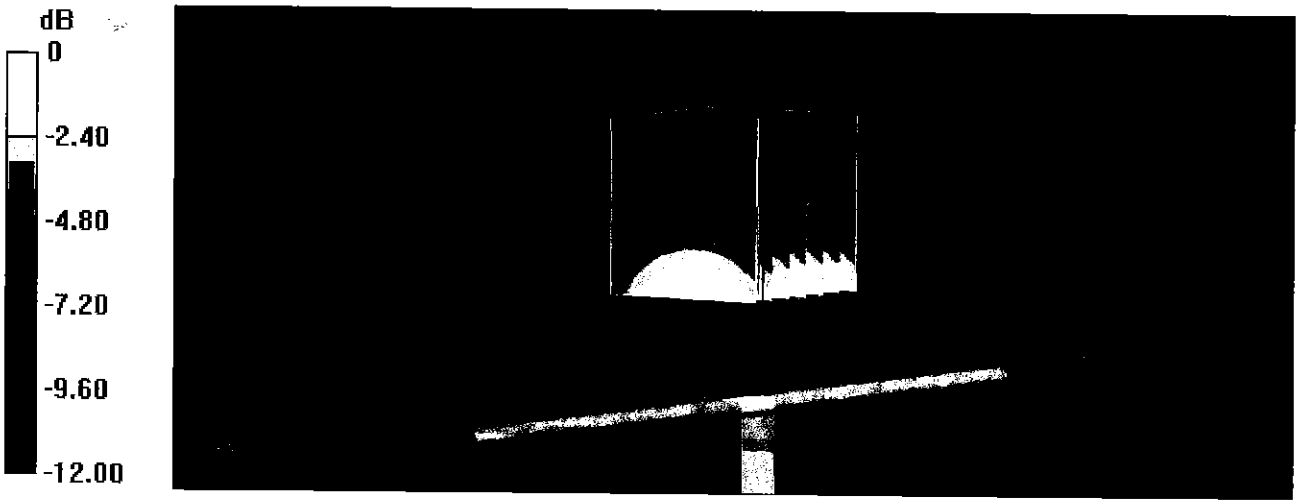
Communication System: UID 0 - CW; Frequency: 850 MHz
Medium parameters used: f = 850 MHz; σ = 0.99 S/m; ε_r = 55.3; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.11, 10.11, 10.11); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

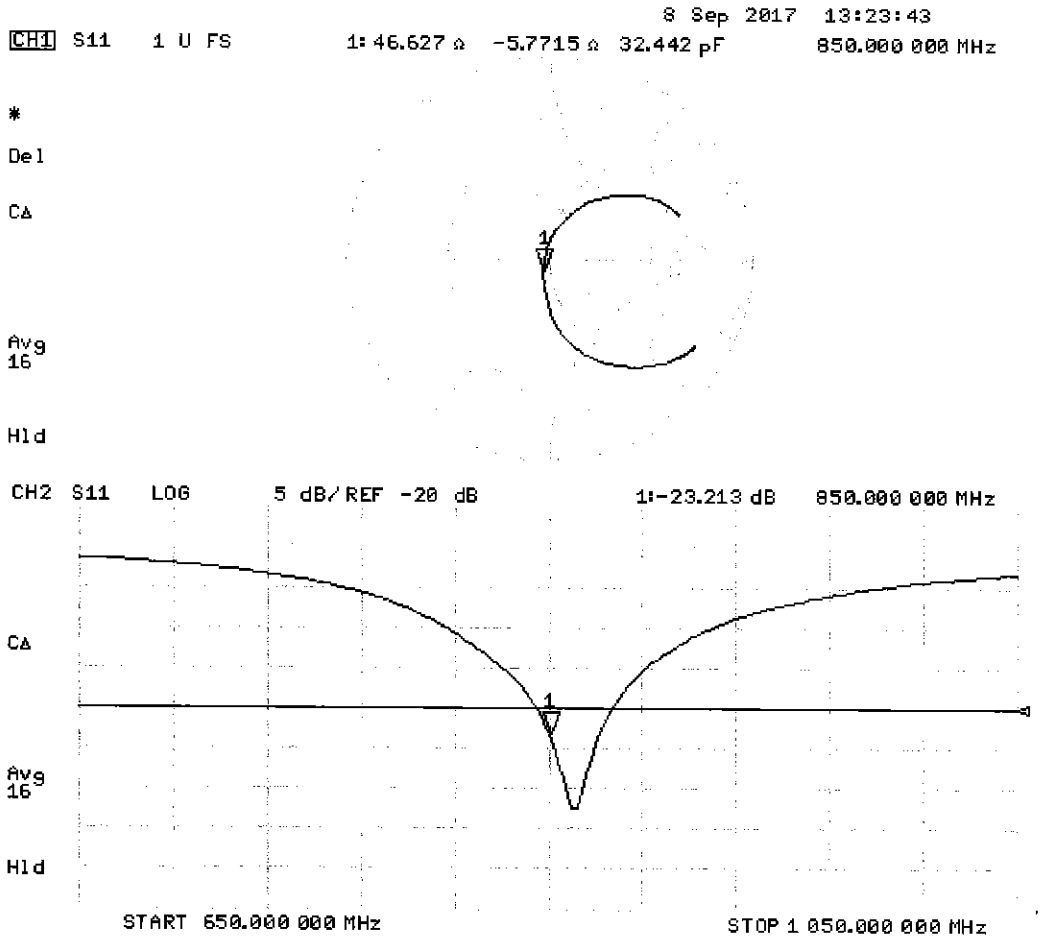
Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 61.09 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 3.79 W/kg
SAR(1 g) = 2.55 W/kg; SAR(10 g) = 1.67 W/kg
Maximum value of SAR (measured) = 3.36 W/kg



0 dB = 3.36 W/kg = 5.26 dBW/kg

Impedance Measurement Plot for Body TSL



Certification of Calibration

Object D850V2 – SN: 1010

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: September 08, 2018

Description: SAR Validation Dipole at 850 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	9/14/2017	Annual	9/14/2018	US39170118
Agilent	N5182A	MXG Vector Signal Generator	3/19/2018	Annual	3/19/2019	US46240505
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2496A	Power Meter	10/9/2017	Annual	10/9/2018	1138001
Anritsu	MA2411B	Pulse Power Sensor	11/15/2017	Annual	11/15/2018	1339007
Anritsu	MA2411B	Pulse Power Sensor	11/22/2017	Annual	11/22/2018	1339008
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/14/2017	Biennial	2/14/2019	170112507
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/4/2018	Annual	6/4/2019	MY53401181
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	PE5011-1	Torque Wrench	7/19/2017	Biennial	7/19/2019	N/A
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/15/2018	Annual	5/15/2019	1070
SPEAG	ES3DV3	SAR Probe	9/18/2017	Annual	9/18/2018	3287
SPEAG	DAE4	Data Acquisition Electronics	1/26/2018	Annual	1/26/2019	1533
SPEAG	EX3DV4	SAR Probe	1/26/2018	Annual	1/26/2019	7490
SPEAG	DAE4	Data Acquisition Electronics	1/26/2018	Annual	1/26/2019	1532

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Sangmin Cha	Team Lead Engineer	
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	

DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

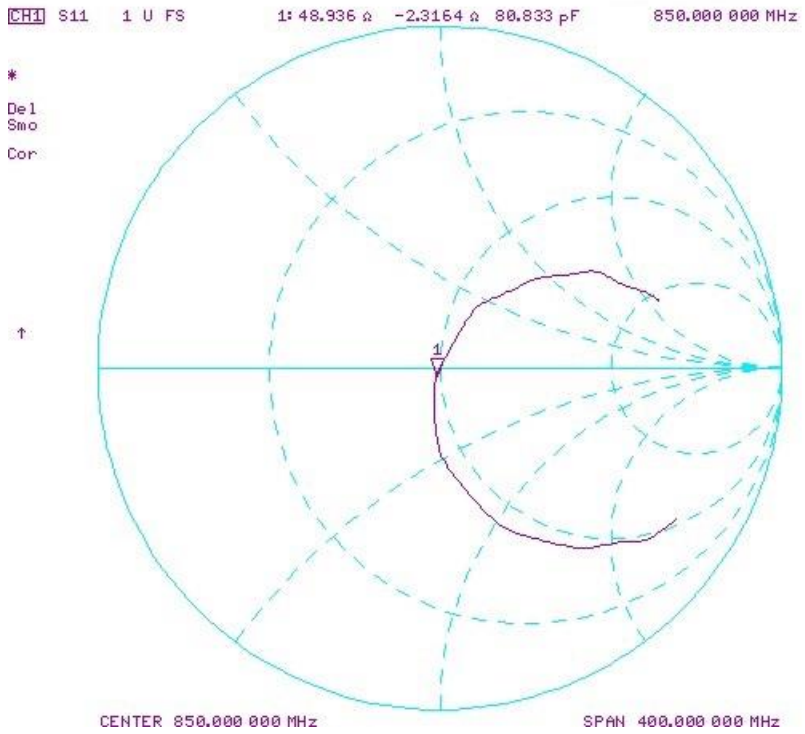
1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

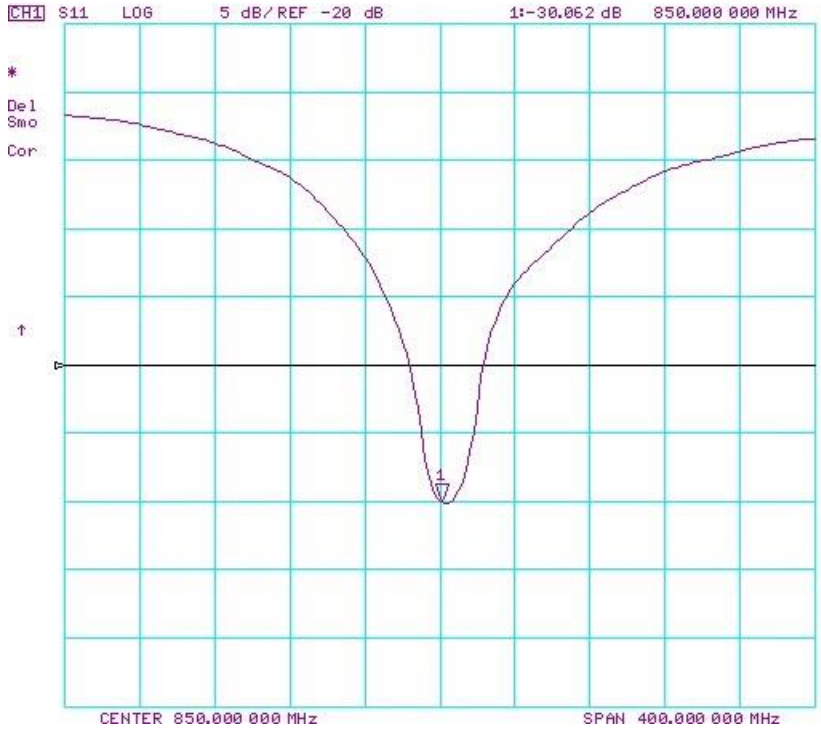
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 23.0 dBm	Measured Head SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 23.0 dBm	Measured Head SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
9/8/2017	9/8/2018	1.432	1.986	2.01	1.21%	1.284	1.31	2.02%	50.2	48.9	1.3	-3.1	-2.3	0.8	-30.2	-30.1	0.30%	PASS

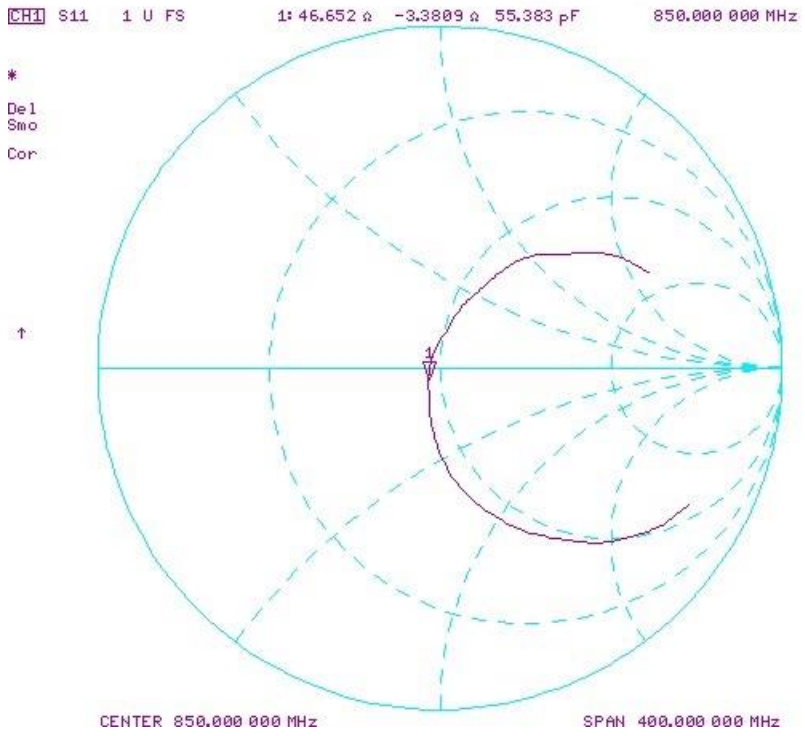
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 23.0 dBm	Measured Body SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 23.0 dBm	Measured Body SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
9/8/2017	9/8/2017	1.432	2.04	2.01	-1.47%	1.336	1.32	-1.20%	46.6	46.7	0.1	-5.8	-3.4	2.4	-23.2	-25.8	-11.20%	PASS

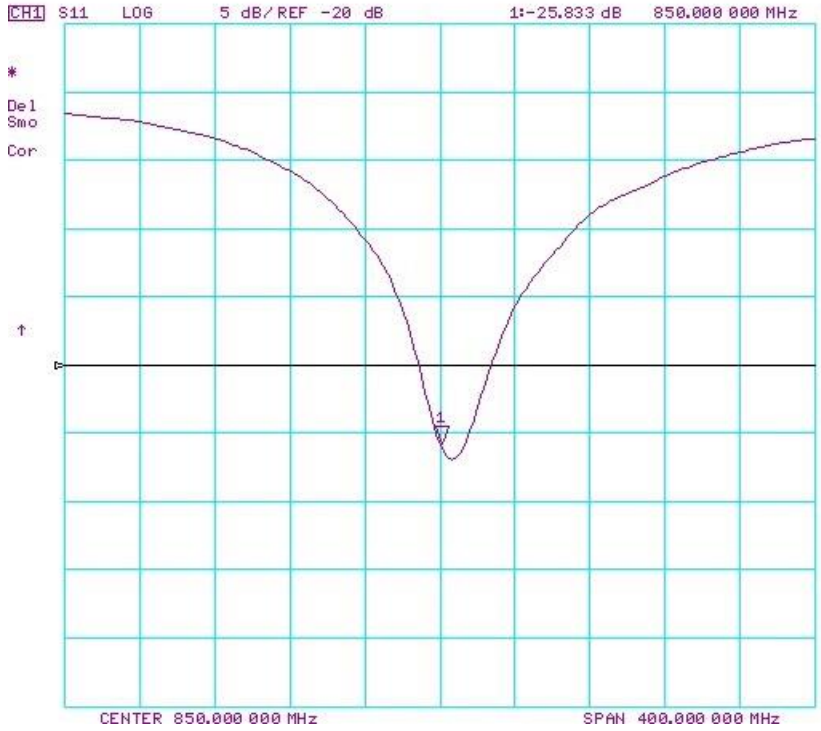
Impedance & Return-Loss Measurement Plot for Head TSL





Impedance & Return-Loss Measurement Plot for Body TSL





Certification of Calibration

Object D850V2 – SN: 1010

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: September 8, 2019

Description: SAR Validation Dipole at 850 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	10/2/2018	Annual	10/2/2019	US39170118
Agilent	E4438C	ESG Vector Signal Generator	6/27/2019	Annual	6/27/2020	MY45093852
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2495A	Power Meter	10/21/2018	Annual	10/21/2019	941001
Anritsu	MA2411B	Pulse Power Sensor	10/30/2018	Annual	10/30/2019	1207470
Anritsu	MA2411B	Pulse Power Sensor	11/20/2018	Annual	11/20/2019	1339007
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/28/2018	Biennial	2/28/2020	170330160
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	NC-100	Torque Wrench	11/1/2017	Biennial	11/1/2019	N/A
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/7/2019	Annual	5/7/2020	1070
SPEAG	EX3DV4	SAR Probe	1/24/2019	Annual	1/24/2020	7490
SPEAG	DAE4	Data Acquisition Electronics	1/15/2019	Annual	1/15/2020	1532

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	Parker Jones
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	KOK

DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

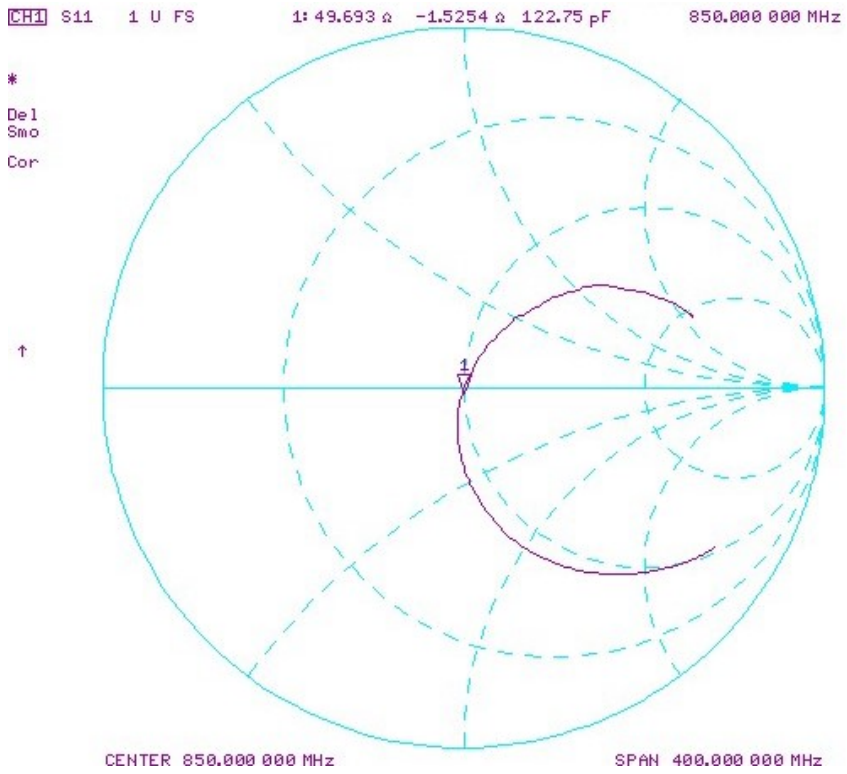
1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

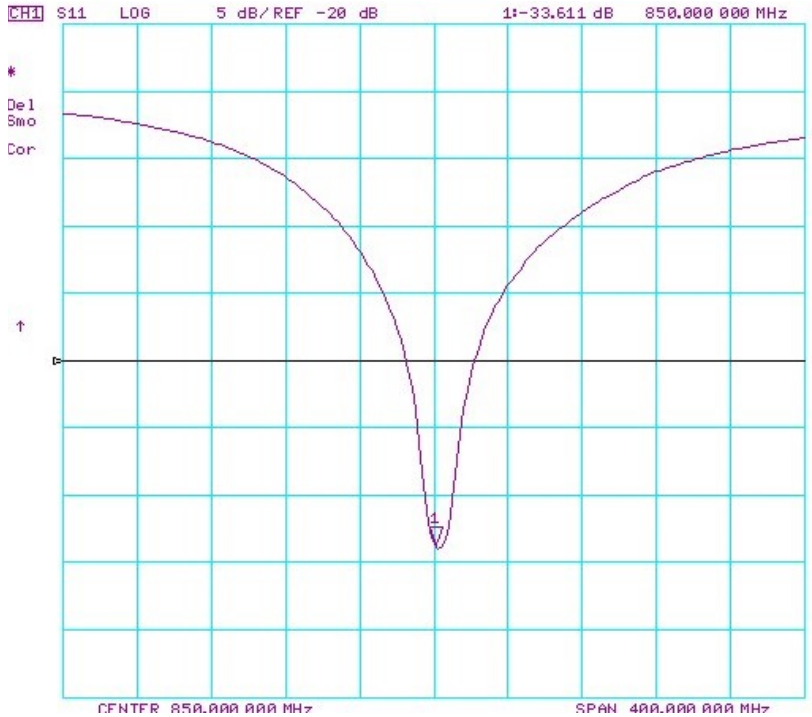
The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 23.0 dBm	Measured Head SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 23.0 dBm	Measured Head SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
9/8/2017	9/8/2019	1.432	1.986	2.03	2.22%	1.284	1.33	3.58%	50.2	49.7	0.5	-3.1	-1.5	1.6	-30.2	-33.6	-11.30%	PASS

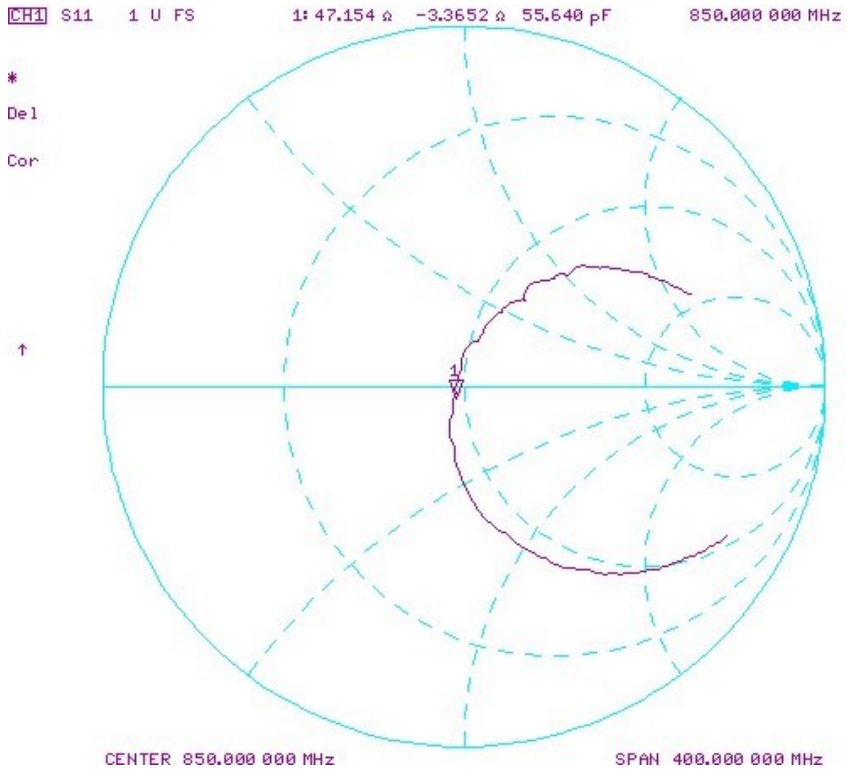
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 23.0 dBm	Measured Body SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 23.0 dBm	Measured Body SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
9/8/2017	9/8/2019	1.432	2.04	2.05	0.49%	1.336	1.36	1.80%	46.6	47.2	0.6	-5.8	-3.4	2.4	-23.2	-27.1	-16.80%	PASS

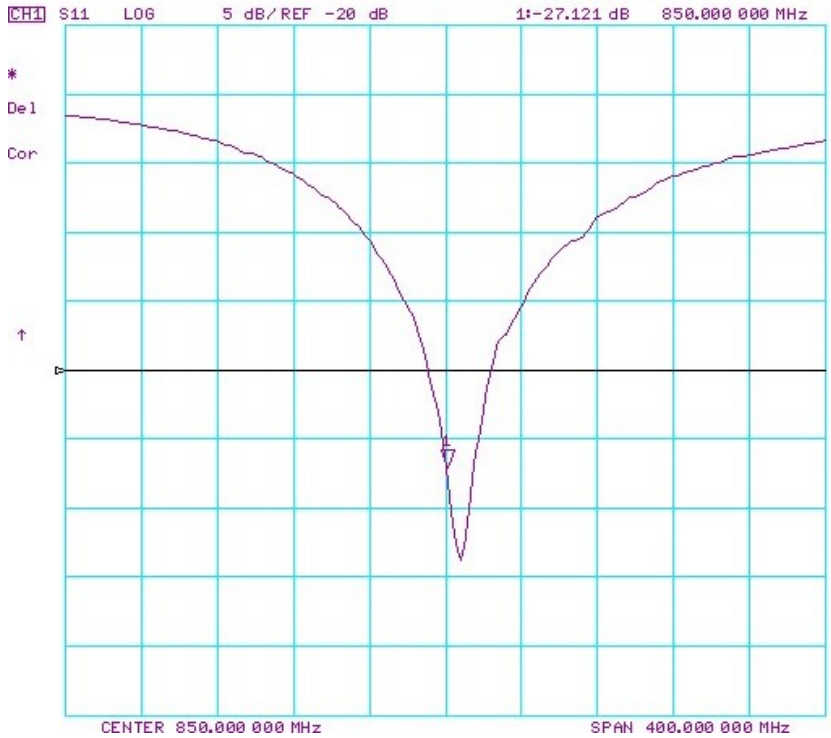
Impedance & Return-Loss Measurement Plot for Head TSL





Impedance & Return-Loss Measurement Plot for Body TSL





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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
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 **PC Test**

Certificate No: **D1750V2-1104_Sep17**

CALIBRATION CERTIFICATE

Object	D1750V2 - SN:1104
Calibration procedure(s)	QA CAL-05.v9 Calibration procedure for dipole validation kits above 700 MHz
Calibration date:	September 07, 2017

SC ✓ 10/03/2017
SC ✓ 9/9/2018
BN 10/10/2019

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-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 7349	31-May-17 (No. EX3-7349_May17)	May-18
DAE4	SN: 601	28-Mar-17 (No. DAE4-601_Mar17)	Mar-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-16)	In house check: Oct-17

	Name	Function	Signature
Calibrated by:	Michael Weber	Laboratory Technician	M.Weber
Approved by:	Katja Pokovic	Technical Manager	

Issued: September 7, 2017

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

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, "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"

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%.

Measurement Conditions

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

DASY Version	DASY5	V52.10.0
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
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	39.1 ± 6 %	1.36 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	9.11 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**36.4 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	4.81 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**19.2 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	53.4	1.49 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	53.8 ± 6 %	1.46 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	9.03 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**36.6 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	4.85 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**19.6 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	50.8 Ω - 0.2 jΩ
Return Loss	- 41.5 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.5 Ω - 0.7 jΩ
Return Loss	- 28.7 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.217 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	May 16, 2013

DASY5 Validation Report for Head TSL

Date: 07.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1104

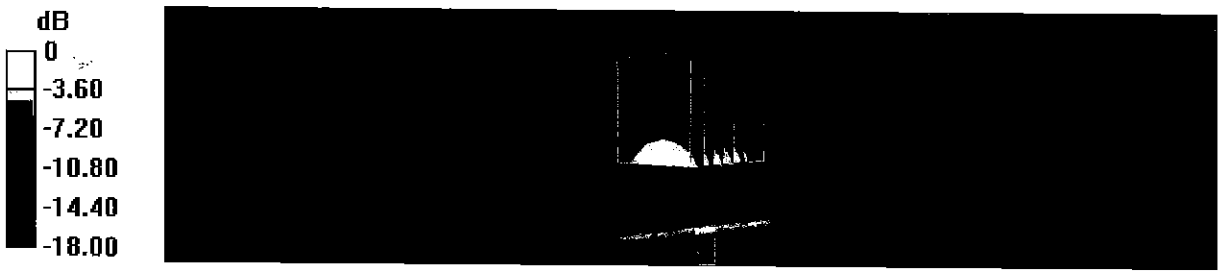
Communication System: UID 0 - CW; Frequency: 1750 MHz
Medium parameters used: f = 1750 MHz; σ = 1.36 S/m; ε_r = 39.1; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.73, 8.73, 8.73); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

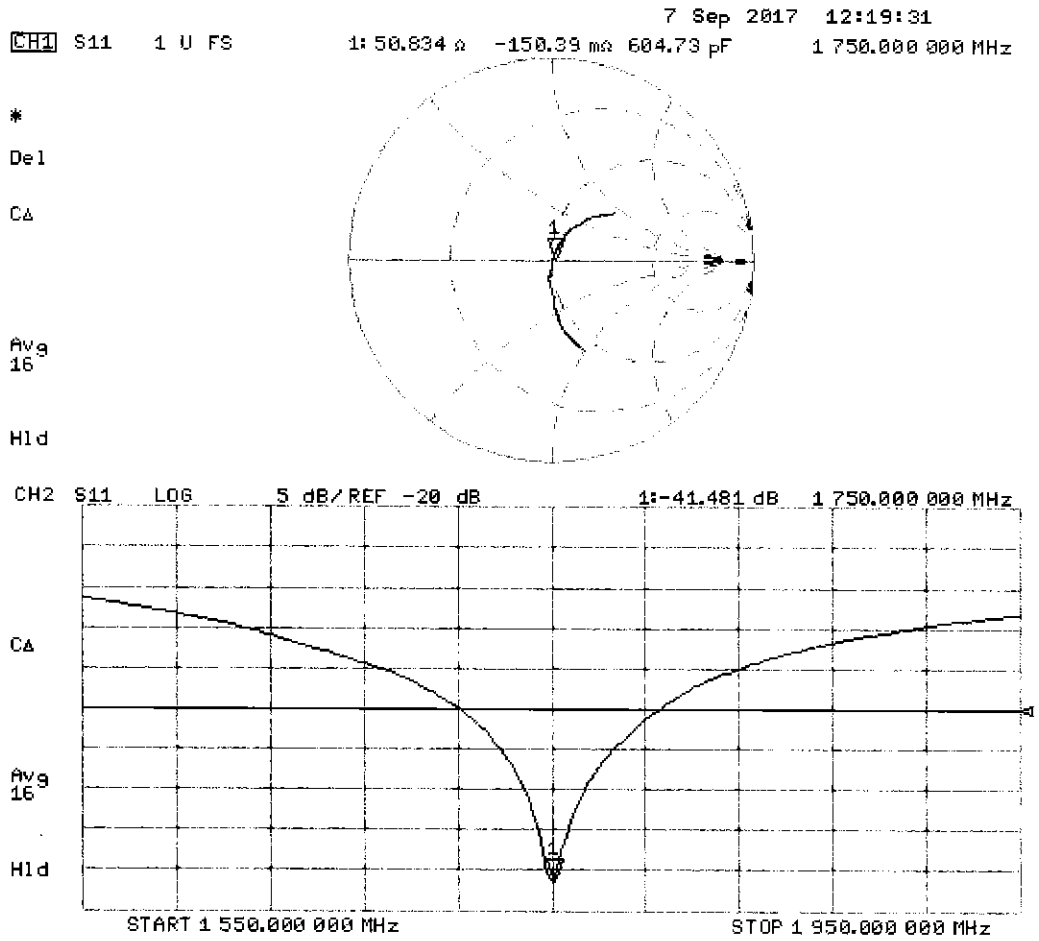
Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 104.9 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 17.0 W/kg
SAR(1 g) = 9.11 W/kg; SAR(10 g) = 4.81 W/kg
Maximum value of SAR (measured) = 13.9 W/kg



0 dB = 13.9 W/kg = 11.43 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 07.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1104

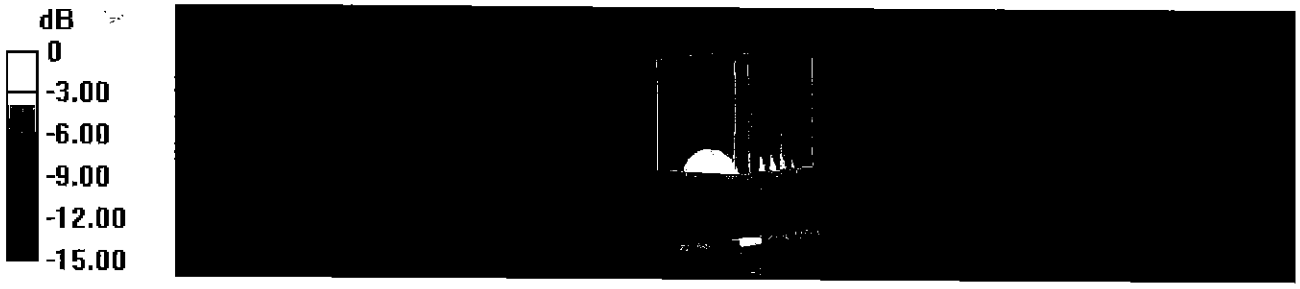
Communication System: UID 0 - CW; Frequency: 1750 MHz
Medium parameters used: f = 1750 MHz; σ = 1.46 S/m; ε_r = 53.8; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.46, 8.46, 8.46); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

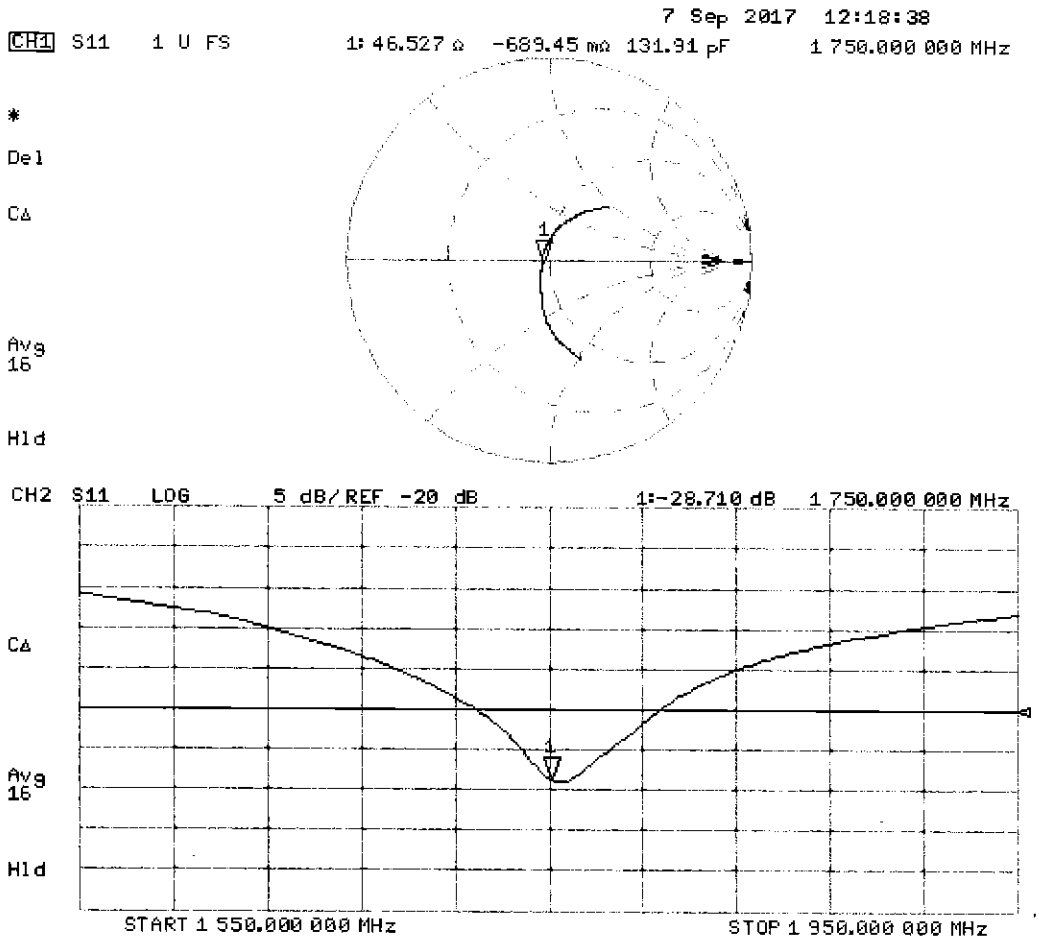
Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 99.30 V/m; Power Drift = -0.07 dB
Peak SAR (extrapolated) = 15.6 W/kg
SAR(1 g) = 9.03 W/kg; SAR(10 g) = 4.85 W/kg
Maximum value of SAR (measured) = 12.9 W/kg



0 dB = 12.9 W/kg = 11.11 dBW/kg

Impedance Measurement Plot for Body TSL



Certification of Calibration

Object D1750V2 – SN: 1104

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: September 07, 2018

Description: SAR Validation Dipole at 1750 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	9/14/2017	Annual	9/14/2018	US39170118
Agilent	N5182A	MXG Vector Signal Generator	3/19/2018	Annual	3/19/2019	US46240505
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2496A	Power Meter	10/9/2017	Annual	10/9/2018	1138001
Anritsu	MA2411B	Pulse Power Sensor	11/15/2017	Annual	11/15/2018	1339007
Anritsu	MA2411B	Pulse Power Sensor	11/22/2017	Annual	11/22/2018	1339008
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/14/2017	Biennial	2/14/2019	170112507
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/4/2018	Annual	6/4/2019	MY53401181
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	PE5011-1	Torque Wrench	7/19/2017	Biennial	7/19/2019	N/A
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/15/2018	Annual	5/15/2019	1070
SPEAG	ES3DV3	SAR Probe	9/18/2017	Annual	9/18/2018	3287
SPEAG	DAE4	Data Acquisition Electronics	1/26/2018	Annual	1/26/2019	1533

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Sangmin Cha	Team Lead Engineer	
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	

DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

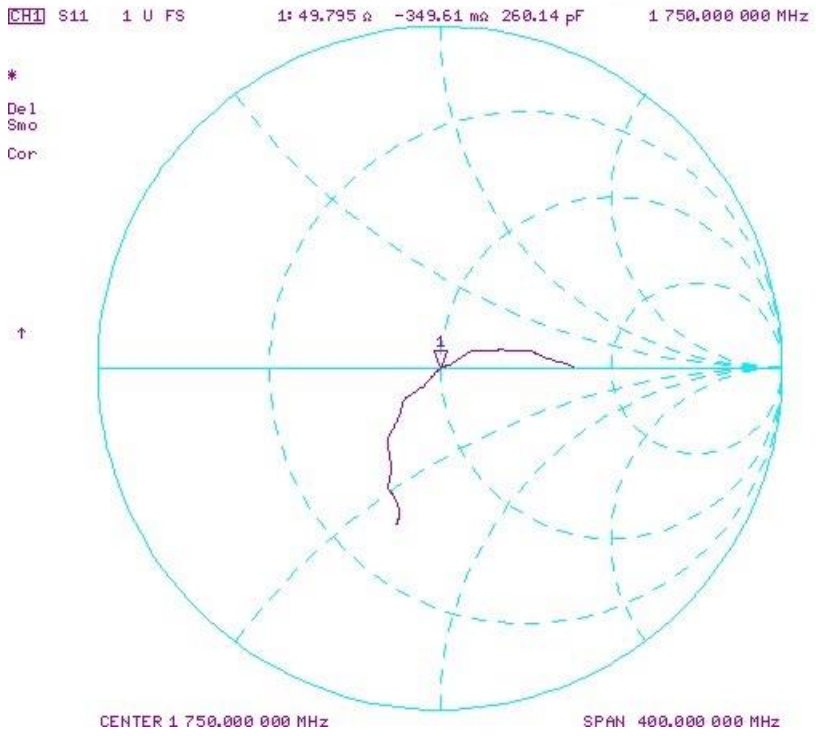
1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

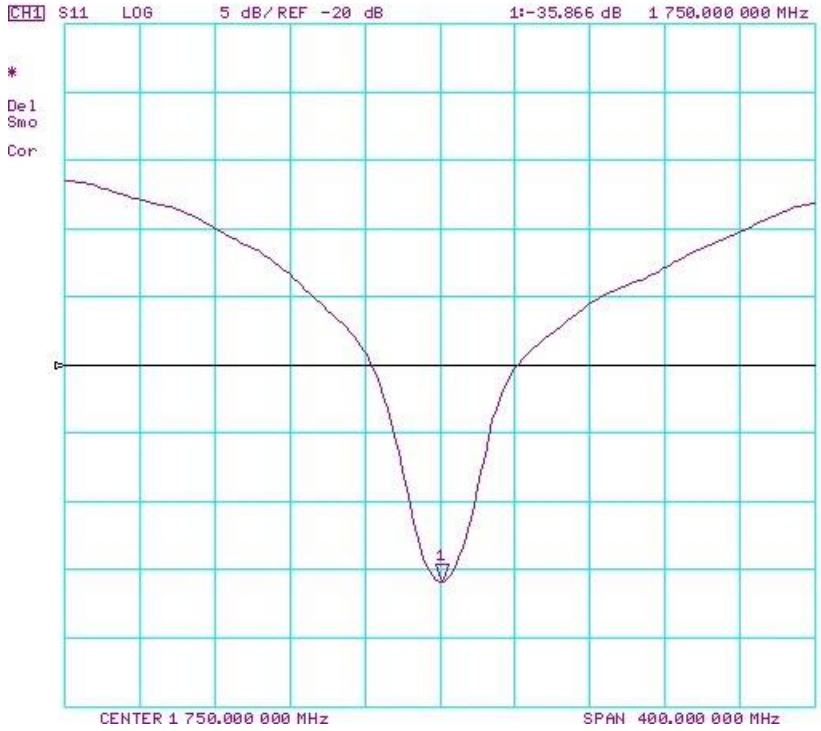
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
9/7/2017	9/7/2018	1.217	3.64	3.62	-0.55%	1.92	1.94	1.04%	50.8	49.8	1	-0.2	-0.3	0.1	-41.5	-35.9	13.50%	PASS

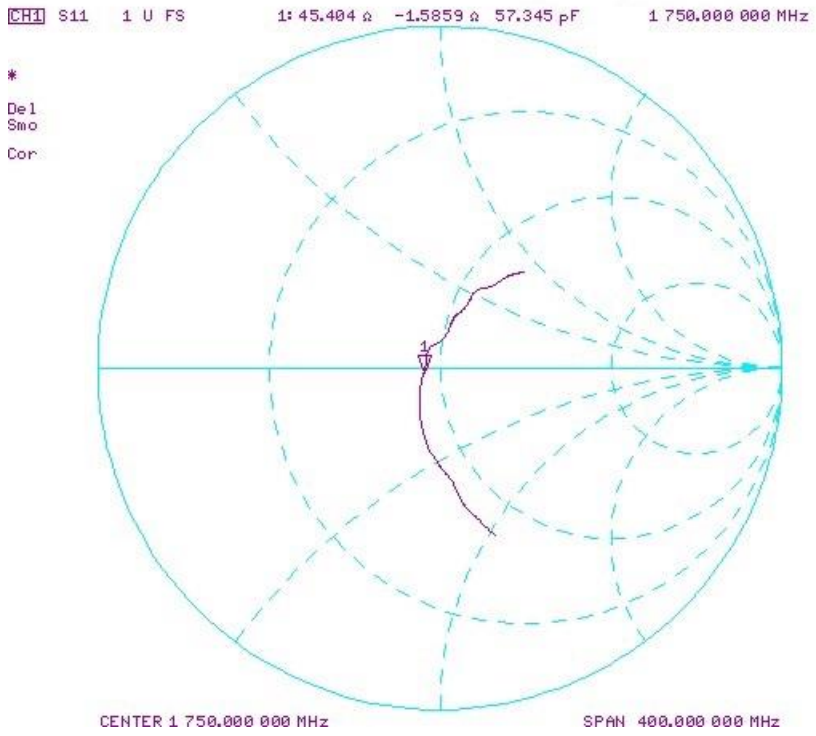
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
9/7/2017	9/7/2018	1.217	3.66	3.84	4.92%	1.96	2.07	5.61%	46.527	45.4	1.1	-0.69	-1.6	0.9	-28.7	-25.8	10.10%	PASS

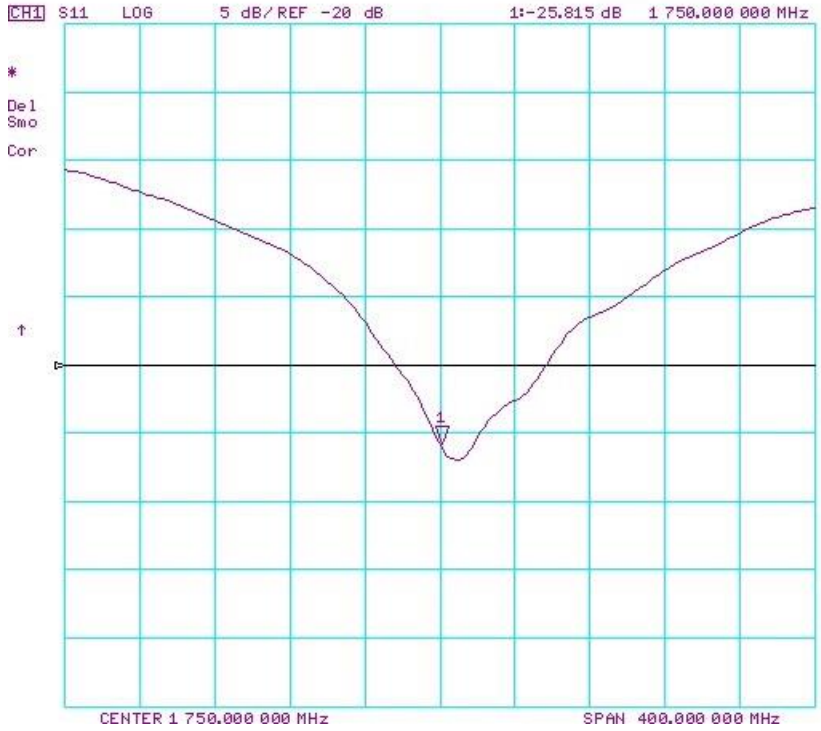
Impedance & Return-Loss Measurement Plot for Head TSL





Impedance & Return-Loss Measurement Plot for Body TSL





Certification of Calibration

Object D1750V2 – SN: 1104

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: September 7, 2019

Description: SAR Validation Dipole at 1750 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	10/2/2018	Annual	10/2/2019	US39170118
Agilent	E4438C	ESG Vector Signal Generator	6/27/2019	Annual	6/27/2020	MY45093852
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2495A	Power Meter	10/21/2018	Annual	10/21/2019	941001
Anritsu	MA2411B	Pulse Power Sensor	10/30/2018	Annual	10/30/2019	1207470
Anritsu	MA2411B	Pulse Power Sensor	11/20/2018	Annual	11/20/2019	1339007
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/28/2018	Biennial	2/28/2020	170330160
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	NC-100	Torque Wrench	11/1/2017	Biennial	11/1/2019	N/A
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/7/2019	Annual	5/7/2020	1070
SPEAG	EX3DV4	SAR Probe	1/24/2019	Annual	1/24/2020	7490
SPEAG	DAE4	Data Acquisition Electronics	1/15/2019	Annual	1/15/2020	1532

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	Parker Jones
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	KOK

DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

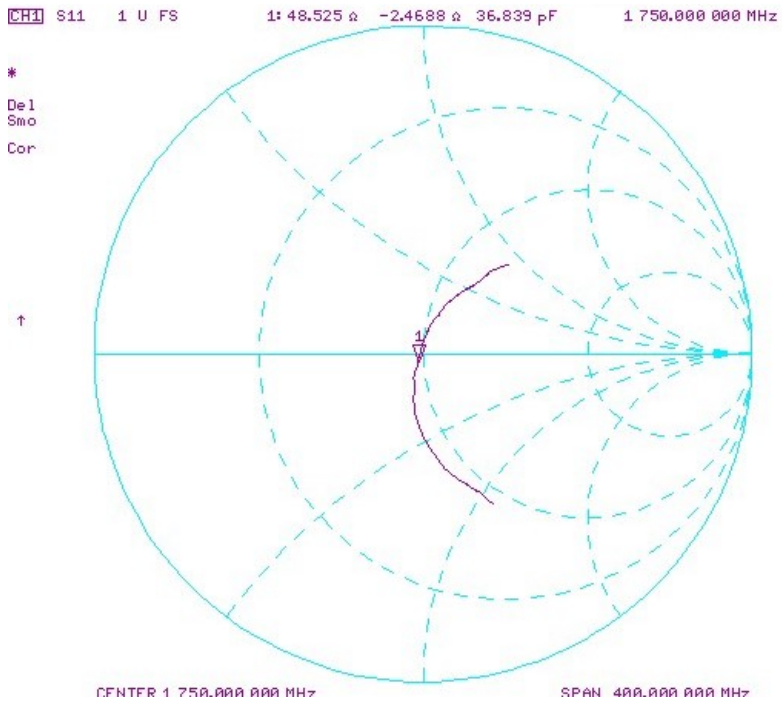
1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

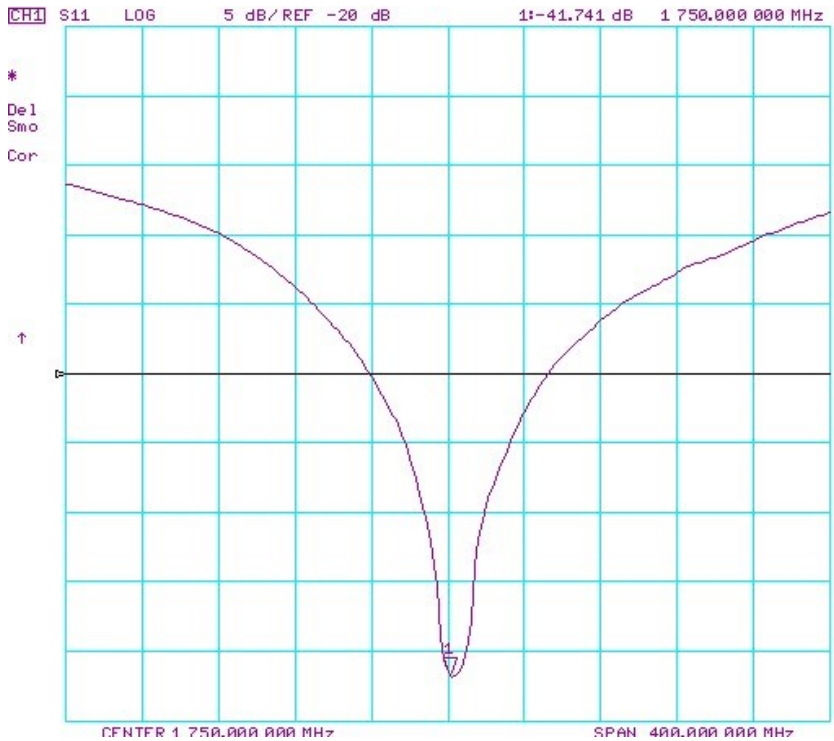
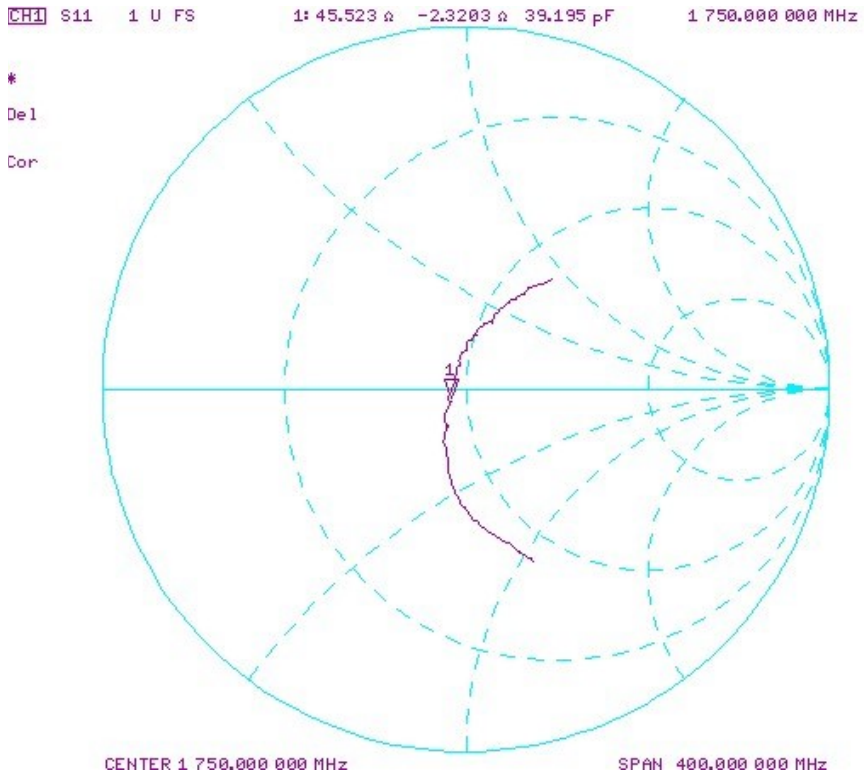
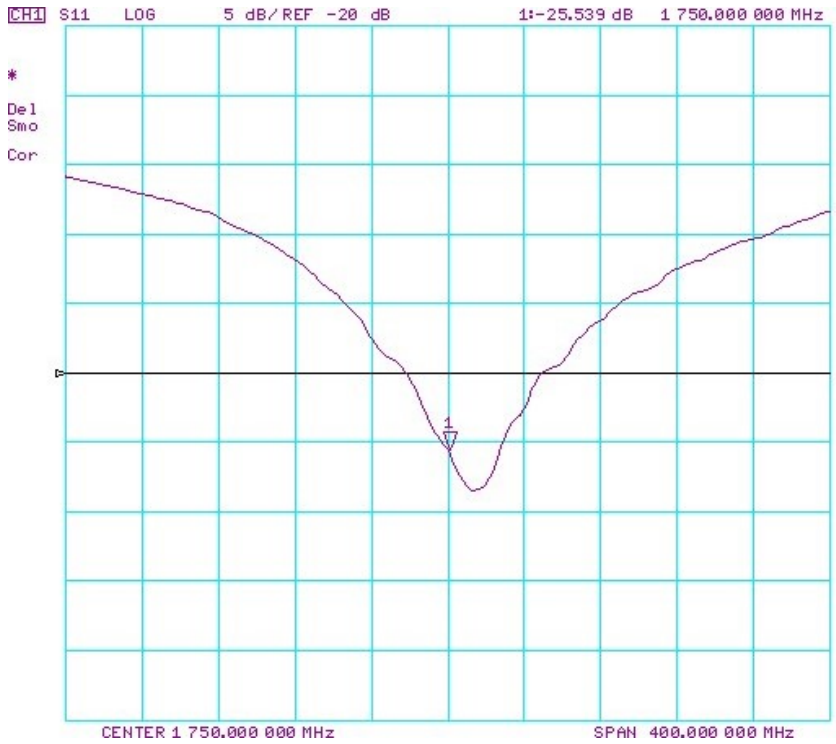
The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
9/7/2017	9/7/2019	1.217	3.64	3.54	-2.75%	1.92	1.88	-2.08%	50.8	48.5	2.3	-0.2	-2.5	2.3	-41.5	-41.7	-0.50%	PASS

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
9/7/2017	9/7/2019	1.217	3.66	3.67	0.27%	1.96	1.96	0.00%	46.5	45.5	1	-0.7	-2.3	1.6	-28.7	-25.5	11.10%	PASS

Impedance & Return-Loss Measurement Plot for Head TSL





Impedance & Return-Loss Measurement Plot for Body TSL