



Product Service

SAR Conversion Factors/ Boundary Corrections							
Frequency* (MHz)	Head Fluid			Body Fluid			Notes
	SAR Conv Factor	Boundary Correction f(0)	Boundary Correction d(mm)	SAR Conv Factor	Boundary Correction f(0)	Boundary Correction d(mm)	
450	0.311	0.90	1.7	0.317	1.00	1.6	3
700	0.313	0.89	1.7	0.312	0.58	1.8	1,2
835	0.307	1.78	1.1	0.309	0.53	1.5	1,2
900	0.311	0.81	1.6	0.318	0.94	1.4	1,2
1800	0.357	0.70	1.5	0.382	0.51	1.9	1,2
1900	0.392	0.76	1.8	0.398	0.58	1.8	1,2
2100	0.395	0.70	2.0	0.434	0.62	1.5	1,2
2450	0.397	1.09	1.4	0.440	1.04	1.2	1,2
2600	0.382	1.30	1.5	0.446	1.11	1.4	1,2
Notes							
1)	Calibrations done at 22°C +/-2°C						
2)	Waveguide calibration						
3)	By validation						

The valid frequency of SARA-C probe calibrations are $\pm 100\text{MHz}$ ($F < 300\text{MHz}$) and $\pm 200\text{MHz}$ ($F > 300\text{MHz}$).



PROBE SPECIFICATIONS

Indexsar probe 0204, along with its calibration, is compared with BSEN 62209-1 and IEEE standards recommendations (Refs [1] and [2]) in the Tables below. A listing of relevant specifications is contained in the tables below:

Dimensions	S/N 0204	BSEN [1]	IEEE [2]
Overall length (mm)	350		
Tip length (mm)	10		
Body diameter (mm)	12		
Tip diameter (mm)	5.2	8	8
Distance from probe tip to dipole centers (mm)	2.7		

Typical Dynamic range	S/N 0204	BSEN [1]	IEEE [2]
Minimum (W/kg)	0.01	<0.02	0.01
Maximum (W/kg)	>100	>100	100
N.B. only measured to > 100 W/kg on representative probes			

Isotropy (measured at 900MHz)	S/N 0204	BSEN [1]	IEEE [2]
Axial rotation with probe normal to source (+/- dB)	0.05	0.5	0.25

NB Isotropy is frequency independent

Construction	Each probe contains three orthogonal dipole sensors arranged on a triangular prism core, protected against static charges by built-in shielding, and covered at the tip by PEEK cylindrical enclosure material. No adhesives are used in the immersed section. Outer case materials are PEEK and heat-shrink sleeving.
Chemical resistance	Tested to be resistant to TWEEN20 and sugar/salt-based simulant liquids but probes should be removed, cleaned and dried when not in use. NOT recommended for use with glycol or soluble oil-based liquids.

**REFERENCES**

References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.

For a specific reference, subsequent revisions do not apply.

For a non-specific reference, the latest version applies.

- [1] IEC 62209-1.
Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices — Human models, instrumentation, and procedures — Part 1: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)
- [2] IEEE 1528
Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques
- [3] IEC 62209-2
Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Human models, Instrumentation, and procedures – Part 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)
- [4] FCC KDB865664
- [5] Indexsar Report IXS-0300, October 2007.
Measurement uncertainties for the SARA2 system assessed against the recommendations of BS EN 62209-1:2006
- [6] SARA-C SAR Testing System: Measurement Uncertainty, v1.0.3. October 2011.

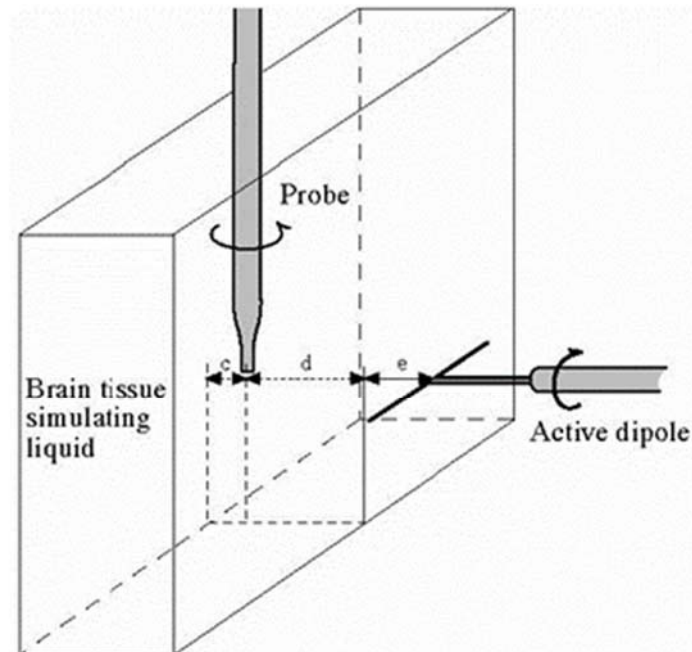


Figure 1. Spherical isotropy jig showing probe, dipole and box filled with simulated brain liquid (see Ref [2], Section A.5.2.1)

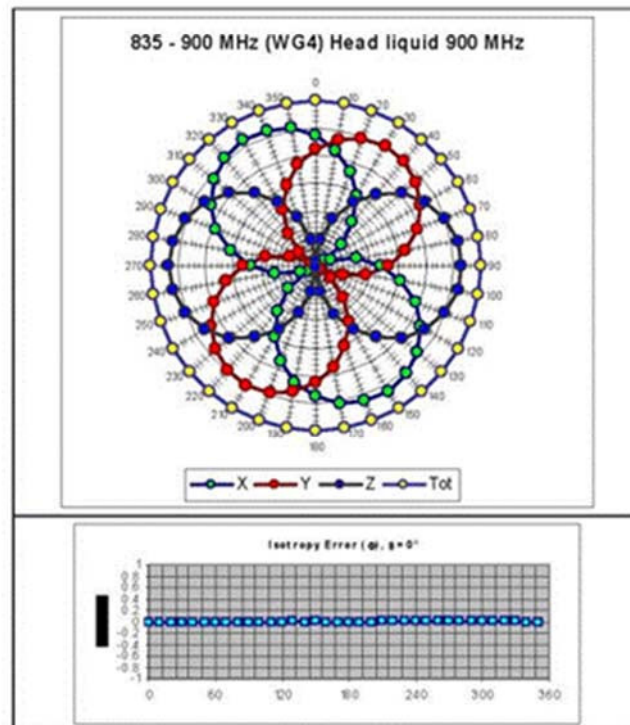


Figure 2. The axial isotropy of a typical IXP-050 probe obtained by rotating the probe in a liquid-filled waveguide at 900 MHz. (NB Axial Isotropy is largely frequency- independent)

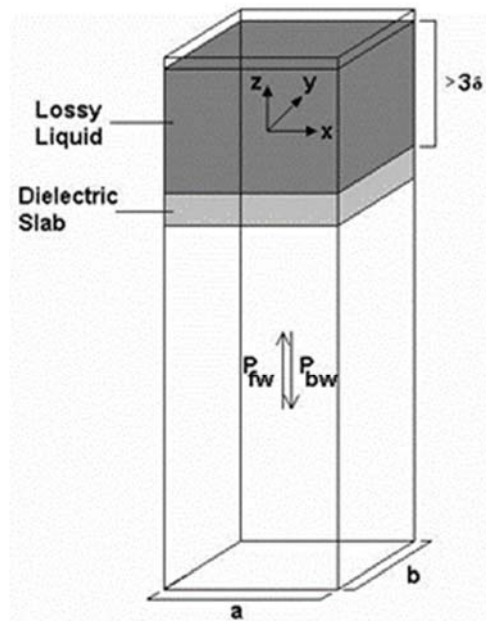


Figure 3. Geometry used for waveguide calibration (after Ref [2]. Section A.3.2.2)

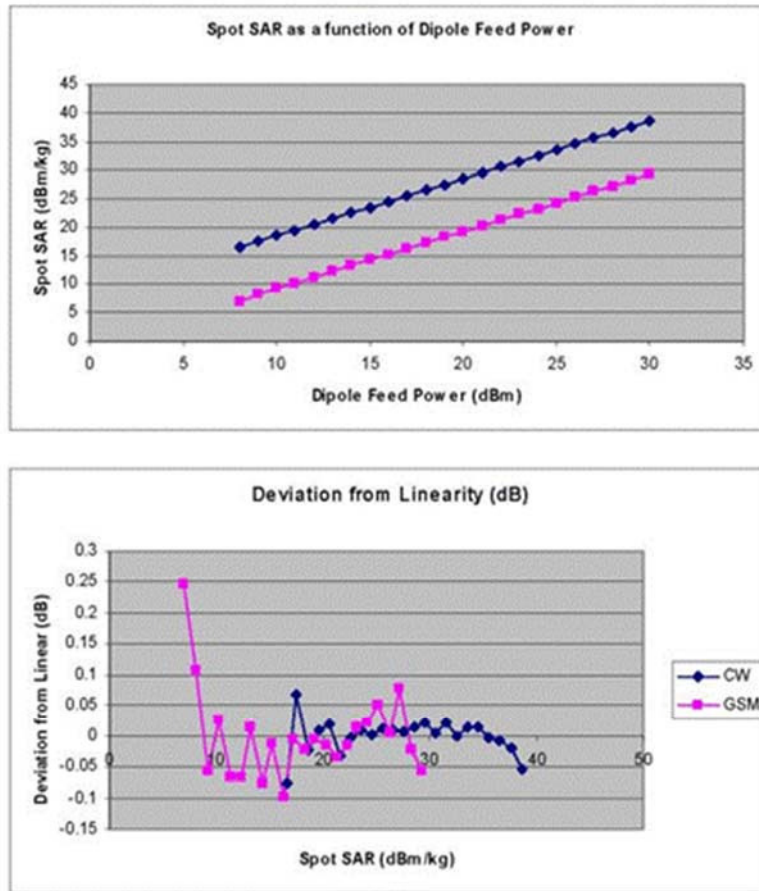


Figure 4 : The typical linearity response of IXP-050 probes to both CW (blue) and GSM (pink) modulation in close proximity to a source dipole. The top diagram shows the SAR reading as a function of dipole feed power, with GSM modulation being approx a factor of 8 (ie 9dB) lower than CW. The lower diagram shows the departure from linearity of the same two datasets.

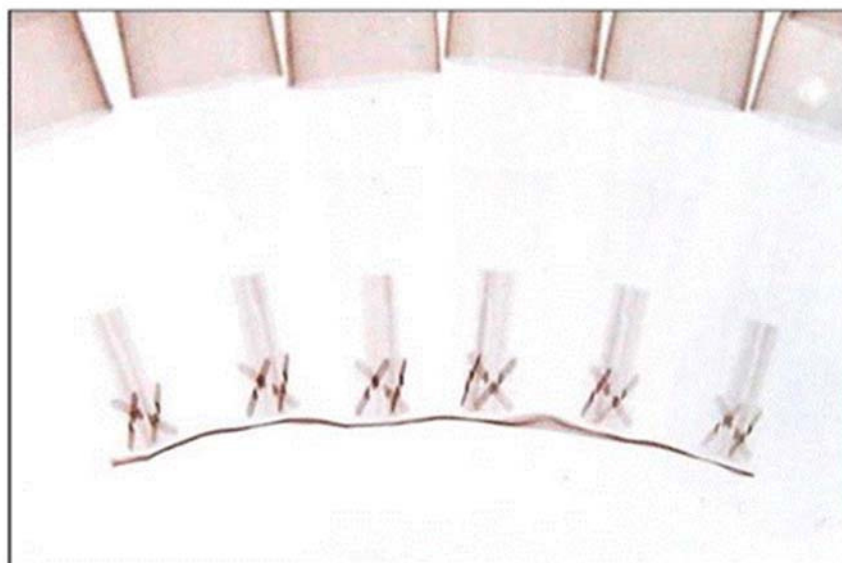


Figure 5 : X-ray positive image of 5mm probes

Table indicating the dielectric parameters of the liquids used for calibrations at each frequency

Frequency (MHz)	Fluid Type	Measured		Target		% Deviation		Verdict	
		Relative Permittivity	Conductivity (S/m)	Relative Permittivity	Conductivity (S/m)	Relative Permittivity	Conductivity	Relative Permittivity	Conductivity
450	Head	43.52	0.864	43.5	0.87	0.0	-0.7	Pass	Pass
700		43.349	0.888	42.2	0.89	2.8	0.1	Pass	Pass
835		41.55	0.898	41.5	0.90	0.1	-0.2	Pass	Pass
900		41.139	0.957	41.5	0.97	-0.9	-1.3	Pass	Pass
1800		39.632	1.401	40.0	1.40	-0.9	0.1	Pass	Pass
1900		40.057	1.396	40.0	1.40	0.1	-0.3	Pass	Pass
2100		40.32	1.51	39.8	1.49	1.3	1.3	Pass	Pass
2450		39.03	1.849	39.2	1.80	-0.4	2.7	Pass	Pass
2600		38.587	1.972	39.0	1.96	-1.1	0.6	Pass	Pass
450	Body	56.86	0.938	56.7	0.94	0.3	-0.2	Pass	Pass
700		55.954	0.964	55.73	0.96	0.4	0.5	Pass	Pass
835		55.587	0.977	55.2	0.97	0.7	0.7	Pass	Pass
900		54.857	1.045	55	1.05	-0.3	-0.5	Pass	Pass
1800		52.958	1.531	53.3	1.52	-0.6	0.7	Pass	Pass
1900		52.965	1.524	53.3	1.52	-0.6	0.3	Pass	Pass
2100		53.886	1.618	53.2	1.62	1.3	-0.1	Pass	Pass
2450		52.768	1.965	52.7	1.95	0.1	0.8	Pass	Pass
2600		52.354	2.179	52.5	2.16	-0.3	0.9	Pass	Pass

Table of test equipment calibration status

Instrument description	Supplier / Manufacturer	Model	Serial No.	Last calibration date	Cal certificate number	See Annex	Calibration due date
Power sensor	Rohde & Schwarz	NRP-Z23	100063	14/08/2013	10-300287035	1	14/08/2015
Power sensor	Rohde & Schwarz	NRP-Z23	100169	06/08/2014	1400-48811	2	06/08/2016
Dielectric property measurement	Indessar	DiLine (sensor lengths: 160mm, 80mm and 60mm)	N/A	(absolute) – checked against NPL values using reference liquids	N/A		N/A
Vector network analyser	Anritsu	MS6423B	003102	17/02/2015	RMA20027002	3	17/02/2016
SMA autocalibration module	Anritsu	36581KX/r1	001902	22/01/2015	RMA20021769	4	22/01/2016



Product Service

Annex 1

Calibration Certificate of NRP-Z23 power sensor, S/N 100063

ROHDE & SCHWARZ		Calibration Certificate		Certificate Number 10-300287035	
Kalibrierschein		Zertifikatsnummer			
Unit Data					
Item Gegenstand	Average power sensor				
Manufacturer Hersteller	ROHDE & SCHWARZ				
Type Typ	NRP-Z23				
Material Number Materialnummer	1137.8002.02	Serial Number Seriennummer	100063		
Asset Number Inventarnummer					
Order Data					
Customer Auftraggeber	IndexSAR Ltd				
	Oakfield House, RH5 5BG Newdigate GB				
Order Number Bestellnummer					
Date of Receipt Eingangsdatum	2013-08-08				
Performance					
Place and Date of Calibration Ort und Datum der Kalibrierung	Memmingen, 2013-08-14				
Scope of Calibration Umfang der Kalibrierung	Standard Calibration				
Statement of Compliance (Bezeichnung) Konformitätsaussage (Anforderung)	Measurement results within specifications				
Statement of Compliance (Bezeichnung) Konformitätsaussage (Anforderung)	Measurement results within specifications				
Extent of Calibration Documents Umfang des Kalibrierdokuments	2 Pages Calibration Certificate 17 Pages Outgoing Results 17 Pages Incoming Results				
This calibration certificate documents, that the named item is tested and measured against defined specifications. Measurement results are located usually in the corresponding interval with a probability of approx. 95% (coverage factor $k = 2$). Calibration is performed with test equipment and standards directly or indirectly traceable by means of approved calibration techniques to the PTB/DKD or other national / international standards, which realize the physical units of measurement according to the International System of Units (SI). In all cases where no standards are available, measurements are referenced to standards of the R&S laboratories. Principles and methods of calibration correspond with EN ISO/IEC 17025. The applied quality system is certified to EN ISO 9001. This calibration certificate may not be reproduced other than in full. Calibration certificates without signature are not valid. The user is obliged to have the object recalibrated at appropriate intervals. Dieser Kalibrierschein dokumentiert, dass der genannte Gegenstand nach festgelegten Vorgaben geprüft und gemessen wurde. Die Messwerte liegen im Regelfall mit einer Wahrscheinlichkeit von annähernd 95% im zugeordneten Wertebereich (Erweiterte Messunsicherheit mit $k = 2$). Die Kalibrierung erfolgt mit Messmitteln und Normen, die direkt oder indirekt durch Ableitung mittels anerkannter Kalibriertechniken rückgeführt sind auf Normale der PTB/DKD oder anderer national/internationaler Standards zur Darstellung der physikalischen Einheiten in Übereinstimmung mit dem internationalen Einheitensystem (SI). Wenn keine Normale existieren, erfolgt die Rückführung auf Bezugsnormale der R&S-Laboratorien. Grundsätze und Verfahren der Kalibrierung entsprechen EN ISO/IEC 17025. Das angewandte Qualitätsmanagement-System ist zertifiziert nach EN ISO 9001. Dieser Kalibrierschein darf nur vollständig und unverändert weiterverstreut werden. Kalibrierscheine ohne Signifizierungen sind ungültig. Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.					
Rohde & Schwarz GmbH & Co. KG; Service Operations West					
Date of Issue Ausstellungsdatum	Head of Laboratory Laborleitung	Person Responsible Bearbeiter			
2013-08-14	 Courage	 Ruprecht Schmid			
ROHDE & SCHWARZ GmbH & Co. KG: Münchener Straße 15 · D-81871 München, Federal Republic of Germany · Telefon (089) 41 29-0 · Telefax (089) 41 29-132 78 Geschäftsführung: Manfred Pleschmann (Vorstandsvorsitz), Christian Lechner, Gerhard Daser Stz München · Registeramt: HRB 19 270 · Persönlich haftender Geschäftsführer: RUSSED Verwaltungs-GmbH · Stz München · Registeramt: AG München HRB 1 534					



Product Service

Material Number 1137.8052.02 Serial Number 100063 **Certificate Number 10-300287035**

Calibration Method **NRVC-1109.0930.32** Relative Humidity **20%-60%**
Kalibrieranweisung Relative Luftfeuchte
Ambient Temperature **(23 ⁺¹ ₋₁) °C**
Umgebungstemperatur

Working standards used (having a significant effect on the accuracy) Verwendete Gebrauchsnormen (mit signifikanten Einfluss auf die Genauigkeit)				
Item Gegenstand	Type Typ	Serial Number Seriennummer	Calibration Certificate Number Kalibrierscheinnummer	Cal. Due Kalibr. bis
Dual Channel Powermeter	NRVD	100062	0114 D-K-15195-01-00 2013-08	2014-11-30
Dual Channel Power Meter	NRVD	838583/0023	0113 D-K-15195-01-00 2013-08	2014-11-30
Vector Network Analyzer	ZVM	835228/0020	0102 CKD-K-16101-2011-08	2013-10-31
Access Set for Lin. Measurement	NRVC-B2	848957/0028	0085 D-K-15195-01-00 2013-01	2014-04-30
Calibration Kit Type-R (50 Ohm)	ES05-40	2105A00100	2017-01723 (METAS)	2016-03-31
Power Standard	NRVC	836457/0005	0082 D-K-15195-01-00 2013-01	2014-04-30

Conformity statements take the measurement uncertainties into account.
Die Konformitätsaussagen berücksichtigen die Messunsicherheiten.

Notes
Anmerkungen

Installed options are included in calibration. Depending on installed options, numbers of pages of the record are not consecutive.



Annex 2

Calibration Certificate of NRP-Z23 power sensor, S/N 100169

ROHDE & SCHWARZ

Calibration Certificate

Kalibrierschein

Certificate Number

1400-48811

Zertifikatsnummer

Unit data

Item AVERAGE POWER SENSOR

Gegenstand

Manufacturer Rohde & Schwarz

Hersteller

Type NRP-Z23

Typ

Material number 1137.8002.02

Materialnummer

Serial number ID: 1137.8002.02-100169-aj

Seriennummer

Ser.: 100169

Asset number

Anlagennummer

Recommended Calibration Interval 24 Months

Order data

Customer

Auftraggeber

Index SAR Ltd
Oakfield House,
Newdigate RH4 6BG

Great Britain

On behalf of
(where applicable)
in name of
(Wenn gewünscht)

Order number 1024R&S

Bestellungsnummer

Date of receipt 2014-08-06 (yyyy-mm-dd)

Eingangstermin

Performance

Place and date of calibration
Ort u. Datum d. Kalibrierung

Fleet; 2014-08-06 (yyyy-mm-dd)

Scope of calibration
Umfang der Kalibrierung

Factory Standard Calibration

Statement of Compliance
(incoming)
Konformitätsaussage
(Anlieferung)

All measured values are within the data sheet specifications.

Statement of Compliance
(Outgoing)
Konformitätsaussage
(Auslieferung)

All measured values are within the data sheet specifications.

Extent of calibration documents
Umfang der Kalibrierdokumentation

2 Pages Calibration Certificate

40 Pages Calibration Results

2 Pages Incoming Report

Rohde & Schwarz UK

Date of issue
Ausstellungsdatum

Head of laboratory
Laborleitung

Person responsible
Bearbeiter

2014-08-06 (yyyy-mm-dd)

Carol McKenzie

Martin Gill

Page (Seite) 1 of 2

ROHDE & SCHWARZ UK Ltd, Ancoats Business Park, Fleet Hampshire, GU11 2UZ, United Kingdom
Registered in England No. 539607



Product Service

Material number Materialnummer	1137.8002.02	Certificate Number Zertifikatsnummer	1400-48811
Serial number Seriennummer	ID: 1137.8002.02-100169-aj Ser.: 100169		

Calibration instruction Kalibrieranweisung	See first page of calibration results	Date of receipt Eingangsdatum	2014-08-06 (mm/dd/yyyy)
Ambient temperature Umgebungstemperatur	(23 ± 2) °C	Relative humidity Relative Luftfeuchte	20 % - 60 %

This calibration fulfils the requirements of the standard / guideline
Diese Kalibrierung entspricht den Forderungen der Norm / Richtlinie

Working standards used (having a significant effect on the accuracy) Verwendete Gebrauchsnormale (mit signifikantem Einfluss auf die Genauigkeit)				
Item Gegenstand	Type Typ	Serial number Seriennummer	Calibration certificate number Kalibrierschein Nummer	Cal. due Kalibr. bis
See page 2 of calibration results				

UGB (Uncertainty guard Band): Measurement uncertainty violates the datasheet limit

UGB1 A compliance statement may be possible where a confidence level of less than 95 % is acceptable.
Die Bestätigung der Konformität ist möglich, sofern ein Grad des Vertrauens von weniger als 95% akzeptabel ist.

UGB2 A non-compliance statement may be possible where a confidence level of less than 95 % is acceptable.
Die Bestätigung der Nicht-Konformität ist möglich, sofern ein Grad des Vertrauens von weniger als 95% akzeptabel ist.

Conformity statements take the measurement uncertainties into account.
Die Konformitätsaussagen berücksichtigen die Messunsicherheiten.

Ref.: ILAC-G8:1996 'Guidelines on Assessment and Reporting of Compliance with Specification (based on measurements and tests in a laboratory)'

Notes
Anmerkungen

Page (Seite) 2 of 2



Product Service

Annex 3

Calibration certificate of Anritsu MS4623B VNA

Certificate of Calibration		Anritsu Discover What's Possible™
Customer: INDEXSAR LTD INDEXSAR LTD OAKFIELD HOUSE NEWGATE SURREY RD 5BG UNITED KINGDOM		ANRITSU EMEA LIMITED 200 CAPABILITY GREEN LUTON LU1 3LU UNITED KINGDOM Tel: +44 (0) 1582 433285 Fax: +44 (0) 1582 455675 Email: service.emea@anritsu.com
Date of Issue:	17/02/2015	Certificate N°: RMA20027002
Customer:	INDEXSAR LTD	Order No: Contract
Manufacturer:	Anritsu Company	
Model	Serial Number	Description
MS4623B	003102	VNA, 10 MHz-6 GHz, ACTIVE
Anritsu EMEA Limited does hereby certify the above listed equipment complies to published or stated specifications at the measured parameters, and has been calibrated to the general requirements of ISO 17025 against instruments whose accuracies are traceable to National or International Standards, where such standards are applicable.		
Repair required before calibration	(yes)	 Authorised Signature Murray Coleman Head of Customer Services (EMEA)
Electrical Safety	(yes)	
Laser safety class	()	
Note: Original calibration results are attached and copies held on file at Anritsu EMEA Limited. The attached results relate only to the instrument under calibration. Anritsu EMEA Limited Quality system is certified to ISO9001:2000 (Cert. No. FQA 0353176) This Certificate comprises of: Certificate of Calibration Call Report 25 Page(s) of test results		



Product Service

Annex 4

Calibration certificate of Anritsu 36581KKF/1 auto-cal kit

Certificate of Calibration		Anritsu Discover What's Possible™
Customer: INDEXSAR LTD INDEXSAR LTD OAKFIELD HOUSE NEWGATE SURREY RH5 5BQ UNITED KINGDOM		ANRITSU EMEA LIMITED 200 CAPABILITY GREEN LUTON LU1 3LU UNITED KINGDOM Tel: +44 (0) 1582 433285 Fax: +44 (0) 1582 455575 Email: service_esc@eu.anritsu.com
Date of Issue:	22/01/2015	Certificate N°: RMA20026648
Customer:	INDEXSAR LTD	Order No: 1045ANR
Manufacturer:	Anritsu Company	
Model	Serial Number	Description
MS4623B 36581KKF/1	003102 001902	VNA, 10 MHZ-6 GHZ, ACTIVE TESTED & CHARACTERIZED TO 6 GHZ
Anritsu EMEA Limited does hereby certify the above listed equipment complies to published or stated specifications at the measured parameters, and has been calibrated to the general requirements of ISO 17025 against instruments whose accuracies are traceable to National or International Standards, where such standards are applicable.		
Within specification before calibration Repair required before calibration Electrical Safety Laser safety class		(yes) (no) (yes) ()
		 Authorised Signature Murray Coleman Head of Customer Services (EMEA)
Note: Original calibration results are attached and copies held on file at Anritsu EMEA Limited. The attached results relate only to the instrument under calibration. Anritsu EMEA Limited Quality system is certified to ISO9001:2000 (Cert. No. FQA 0353176) This Certificate comprises of: Certificate of Calibration Call Report 13 Page(s) of test results		



Product Service

ANNEX B

DIPOLE CALIBRATION REPORTS



Product Service

Test Equipment Number (TE): 4413

Calibration Class: A

TUV SUD Product Service

Internal Calibration Laboratory Report

Date of Calibration: 18/03/2014

Report Number: 26602

Calibration Expiry Date: 18/03/2017

Page 1 of 6

It is certified that the test(s) detailed in the above Calibration Report have been carried out to the requirement of the specification, unless otherwise stated above. The quality control arrangements adopted in respect of these tests have accorded with the conditions of our UKAS registration. The uncertainties are for an estimated confidence probability of not less than 95%.

Manufacturer: IndexSar Ltd**Item:** Dipoles**Model:** 700**Serial No:** 0279**Calibration Procedure, as per:** CP036/CAL

The results recorded, were taken after a warm up period of 1 Hour(s) in an ambient temperature of $23.2^{\circ}\text{C} \pm 3^{\circ}\text{C}$ @ 29.3% RH $\pm 10\%$ RH. The mains voltage was $240\text{V} \pm 10\%$.

Calibration Engineer: _____ 
N. R. Grigsby

Approved Signatory: _____ 
A. T. Pearce



CALIBRATION LABORATORY REPORT

TUV SUD Product ServiceCalibration Classification and Key to Results

(X) Class A: All results measured, lie within the specification limits, even when extended by their measurement uncertainties. The instrument therefore complies with the specification.

() Class B: Some/all results measured, lie INSIDE the specification limits, by a margin less than their measurement uncertainties. It is therefore not possible to state compliance of these results. However, these results indicate that compliance is more probable than non-compliance. (***)

() Class C: Some/all results measured, lie OUTSIDE the specification limits, by a margin less than their measurement uncertainties. It is therefore not possible to state compliance of these results. However, these results indicate that non-compliance is more probable than compliance. (**)

() Class D: Some/all results measured, lie OUTSIDE the specification limits, by a margin greater than their measurement uncertainties. Those results therefore, do not comply with the specification. (*)

() Class R: The instrument was repaired prior to calibration. Refer to enclosed repair report for details.

Test Equipment Used On This Calibration

Make & Model	Description	Calibration Due	TE ID
Rohde & Schwarz: NRV-Z1	Power Sensor	14/06/2014	TE0060
Hewlett Packard: ESG4000A	Signal Generator	22/05/2014	TE0061
Narda: 766F-20	Attenuator (20dB, 20W)	13/06/2014	TE0483
Hewlett Packard: 8753D	Network Analyser	23/04/2014	TE1149
Hewlett Packard: 85054A	'N' Calibration Kit	24/12/2014	TE1309
IndexSar Ltd: 7401 (VDC0830-20)	Bi-directional Coupler		TE2414
IndexSar Ltd: VBM2500-3	Validation Amplifier (10MHz - 2.5GHz)		TE2415
Rotronic: I-1000	Hygrometer	03/04/2014	TE2784
Rohde & Schwarz: NRV- Z5	Power Sensor	14/06/2014	TE2878
Rohde & Schwarz: NRVD	Dual Channel Power Meter	14/06/2014	TE3259
R.S Components: Meter 615-8206 & Type K T/C	Meter & T/C	08/07/2014	TE3612
IndexSar Ltd: SARAC	Cartesian 4-axis Robot		TE4079
IndexSar Ltd: White Benchtop	Part of SARAC System		TE4080
IndexSar Ltd: Wooden Bench	Part of SARAC System		TE4081
IndexSar Ltd: IPX-050	Immersible SAR Probe	07/03/2015	TE4313
IndexSar Ltd: IXB-2HF 700- 6000MHz Flat Phantom	TE4400		

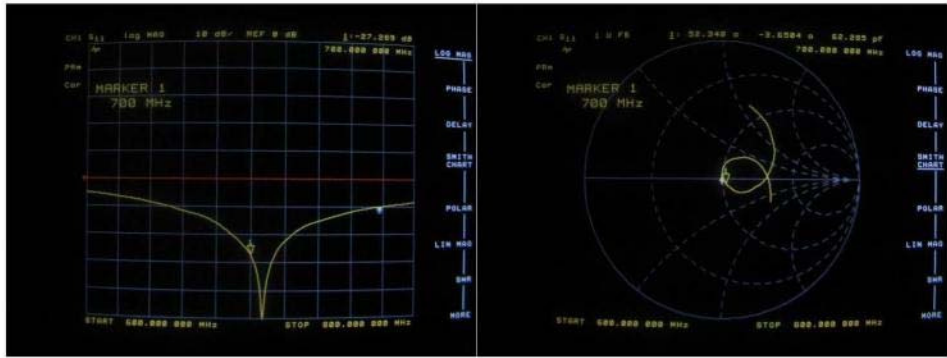


CALIBRATION LABORATORY REPORT

Dipole impedance and return loss

The dipoles are designed to have low return loss ONLY when presented against a lossy-phantom at the specified distance. A Vector Network Analyser (VNA) was used to perform a return loss measurement on the specific dipole when in the measurement-location against the box phantom. The distance was as specified in the standard i.e. 15mm from the liquid (for 700MHz).

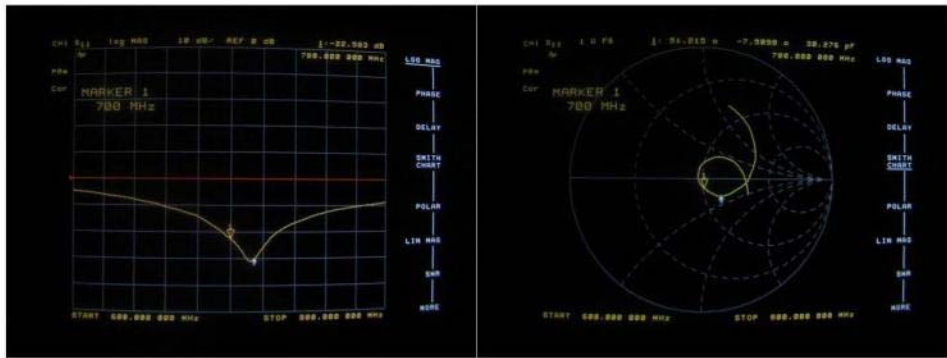
The impedance was measured at the SMA-connector with the network analyser.
The following parameters were measured against Head fluid:



Dipole impedance at 700MHz	$\text{Re}\{Z\} = 52.35 \, \Omega$
	$\text{Im}\{Z\} = -3.65 \, \Omega$
Return loss at 700MHz	-27.29 dB

Standards [1][2][3][4] call for dipoles to have a return loss better than 20dB

The measurements repeated against Body fluid:



**CALIBRATION LABORATORY REPORT**

Dipole impedance at 700MHz	$\text{Re}\{Z\} = 51.215 \, \Omega$
	$\text{Im}\{Z\} = -7.51 \, \Omega$
Return loss at 700MHz	-22.58 dB

Standards [1][2][3][4] call for dipoles to have a return loss better than 20dB

SAR Validation Measurement in Brain Fluid

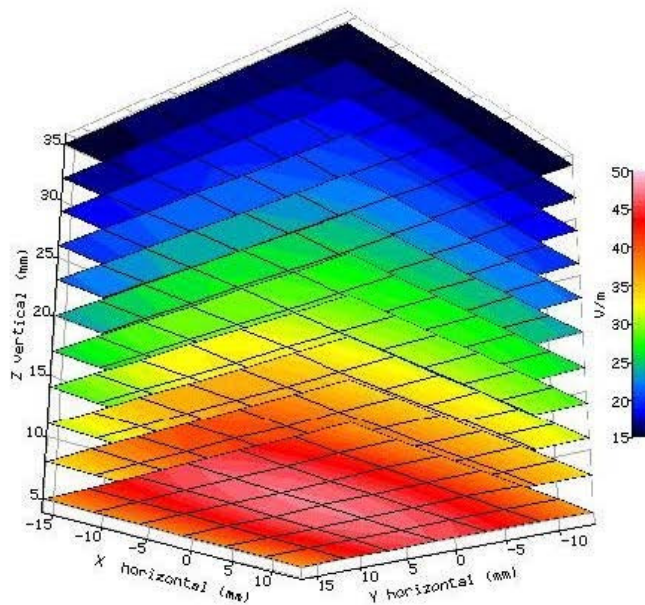
SAR validation checks have been performed using the 700MHz dipole and the box-phantom located on the SARA-C phantom support base on the SARA-C robot system. Tests were then conducted at a feed power level of approx. 0.25W. The actual power level was recorded and used to normalise the results obtained to the standard input power conditions of 1W (forward power). The ambient temperature was 23.2°C and the relative humidity was 29.3% during the measurements.

The phantom was filled with 700MHz brain liquid using a recipe from [1], which has the following electrical parameters (measured using an Indexsar DiLine kit) at 700MHz at the measurement temperature:

Relative Permittivity	42.6
Conductivity	0.896 S/m
Fluid Temperature	22.6 °C

The SARA-C software version v6.08.11 was used with Indexsar IXP_050 probe Serial Number 204 previously calibrated using waveguides.

The 3D measurement made using the dipole at the bottom of the phantom box is shown below:





CALIBRATION LABORATORY REPORT

The validation results normalised to an input power of 1W (forward power) were:

	Measured SAR values (W/kg) (250mV input power)	Measured SAR values (W/kg) (Normalised to 1W feed power) and % Variance from target Value.		Target SAR values (W/kg) derived from system validation (Normalised to 1W feed power)
		Measured	% Variance	
1g SAR	1.94	7.72	0.64	7.67
10g SAR	1.30	5.16	0.97	5.11

All validation measurements are with $\pm 10\%$ of Target values as required in standards [1][2][3][4]

SAR Measurement in Body Fluid

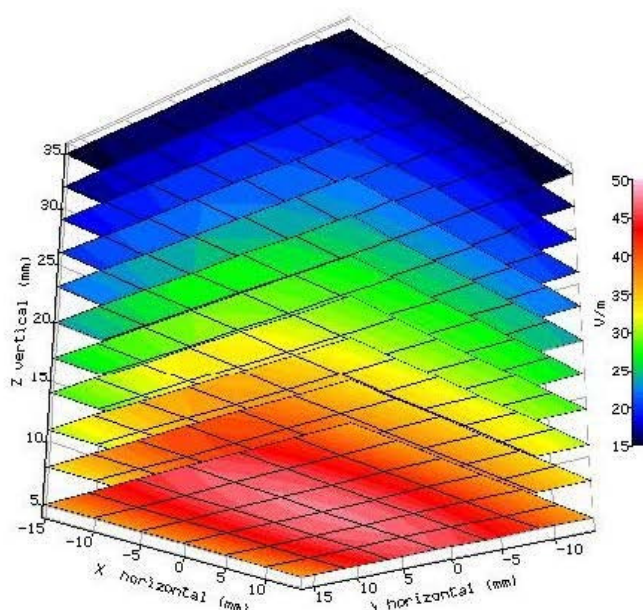
SAR validation checks have been performed using the 700MHz dipole and the box-phantom located on the SARA-C phantom support base on the SARA-C robot system. Tests were then conducted at a feed power level of approx. 0.25W. The actual power level was recorded and used to normalise the results obtained to the standard input power conditions of 1W (forward power). The ambient temperature was 23.3°C and the relative humidity was 30.9% during the measurements.

The phantom was filled with 700MHz body liquid using a recipe from [1][4], which has the following electrical parameters (measured using an Indexsar DiLine kit) at 700MHz at the measurement temperature:

Relative Permittivity **55.4**
 Conductivity **0.988 S/m**
 Fluid Temperature **22.7 °C**

The SARA-C software version v6.08.11 was used with Indexsar IXP_050 probe Serial Number 204 previously calibrated using waveguides.

The 3D measurement made using the dipole at the bottom of the phantom box is shown below:



**CALIBRATION LABORATORY REPORT**

The validation results normalised to an input power of 1W (forward power) were:

	Measured SAR values (W/kg) (250mW input power)	Measured SAR values (W/kg) (Normalised to 1W feed power) and % Variance from target Value.		Target SAR values (W/kg) derived from system validation (Normalised to 1W feed power)
		Measured	% Variance	
1g SAR	2.061	8.20	6.97**	7.67*
10g SAR	1.40	5.57	8.91**	5.11*

* In the specifications, SAR validation target values are only define for standardised measurements in brain fluid. Using the target values (W/kg) derived from system validation with brain fluid the validation measurements are within $\pm 10\%$ of Target values.

**Variance against target values (W/kg) derived from system validation with brain fluid.

References

[1] IEEE Std 1528-2013. IEEE recommended practice for determining the peak spatial-average specific absorption rate (SAR) in the human body due to wireless communications devices: Measurement Techniques – Description.

[2]BS EN 62209-1:2006 Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices — Human models, instrumentation, and procedures — Part 1: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz).

[3]BS EN 62209-2:2010 Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices — Human models, instrumentation, and procedures — Part 2: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the human body (frequency range of 300 MHz to 6 GHz) (IEC 62209-2:2010)

[4] FCC KDB 865664 D01 SAR Measurement 100MHz to 6GHz V01r03



Product Service

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



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

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

Accreditation No.: SCS 0108

Client **TÜV SÜD UK**

Certificate No: D835V2-447_Nov15

CALIBRATION CERTIFICATEObject **D835V2 - SN: 447**

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

Calibration date: **November 12, 2015**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	07-Oct-15 (No. 217-02222)	Oct-16
Power sensor HP 8481A	US37292783	07-Oct-15 (No. 217-02222)	Oct-16
Power sensor HP 8481A	MY41092317	07-Oct-15 (No. 217-02223)	Oct-16
Reference 20 dB Attenuator	SN: 5058 (20k)	01-Apr-15 (No. 217-02131)	Mar-16
Type-N mismatch combination	SN: 5047.2 / 06327	01-Apr-15 (No. 217-02134)	Mar-16
Reference Probe EX3DV4	SN: 7349	30-Dec-14 (No. EX3-7349_Dec14)	Dec-15
DAE4	SN: 601	17-Aug-15 (No. DAE4-601_Aug15)	Aug-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100972	15-Jun-15 (in house check Jun-15)	In house check: Jun-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

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

Issued: November 12, 2015

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

Certificate No: D835V2-447_Nov15

Page 1 of 8



Product Service

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



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

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

Accreditation No.: SCS 0108

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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



Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	835 MHz $\pm$ 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 $\pm$ 0.2) °C	42.6 $\pm$ 6 %	0.92 mho/m $\pm$ 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	2.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	9.26 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.52 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	6.02 W/kg $\pm$ 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 $\pm$ 0.2) °C	55.6 $\pm$ 6 %	0.99 mho/m $\pm$ 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	2.40 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	9.47 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.57 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	6.21 W/kg $\pm$ 16.5 % (k=2)



Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.9 Ω - 7.0 j Ω
Return Loss	- 23.1 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.0 Ω - 8.7 j Ω
Return Loss	- 20.0 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.386 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	October 24, 2001

**DASY5 Validation Report for Head TSL**

Date: 12.11.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 447

Communication System: UID 0 - CW; Frequency: 835 MHz

Medium parameters used: $f = 835 \text{ MHz}$; $\sigma = 0.92 \text{ S/m}$; $\epsilon_r = 42.6$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.77, 9.77, 9.77); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

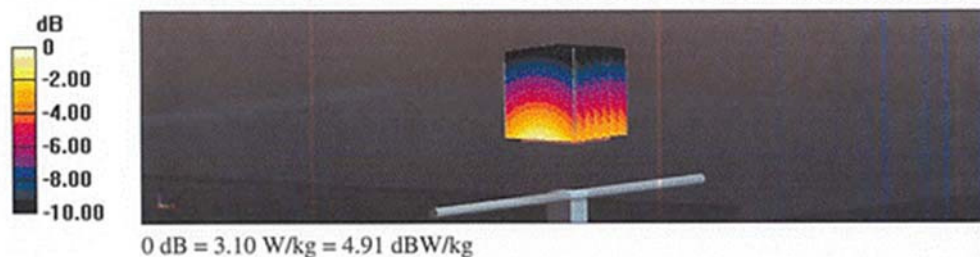
Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 61.13 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 3.47 W/kg

SAR(1 g) = 2.34 W/kg; SAR(10 g) = 1.52 W/kg

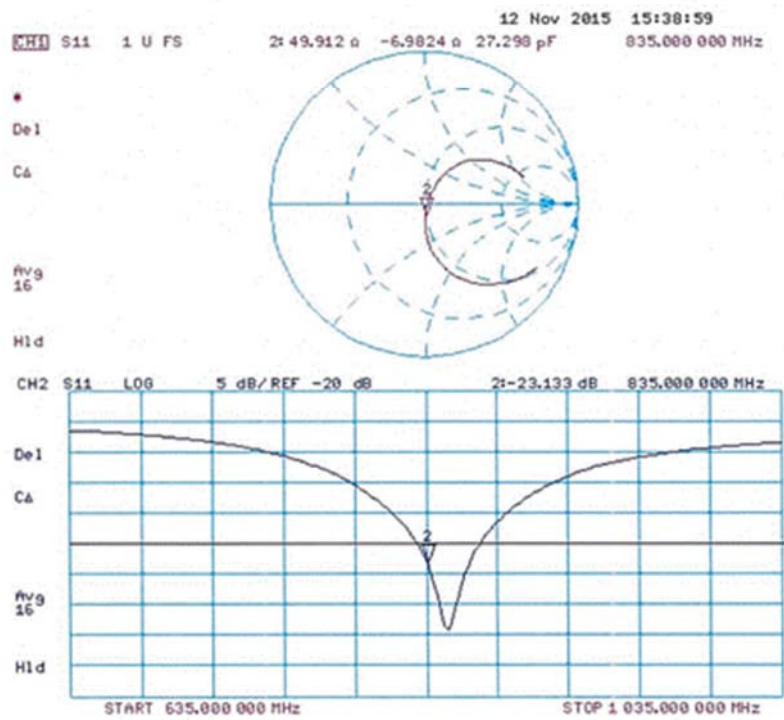
Maximum value of SAR (measured) = 3.10 W/kg





Product Service

Impedance Measurement Plot for Head TSL



**DASY5 Validation Report for Body TSL**

Date: 12.11.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 447

Communication System: UID 0 - CW; Frequency: 835 MHz

Medium parameters used: $f = 835 \text{ MHz}$; $\sigma = 0.99 \text{ S/m}$; $\epsilon_r = 55.6$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.72, 9.72, 9.72); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

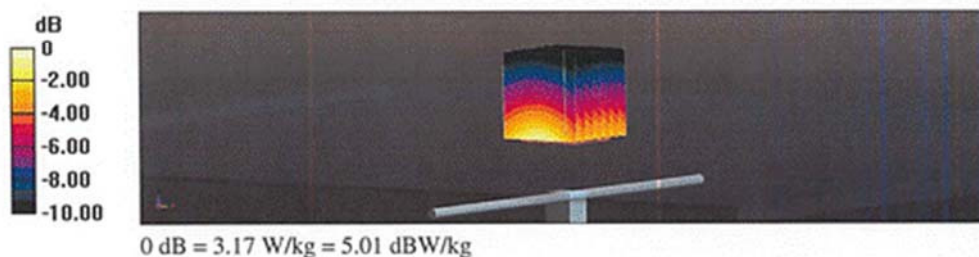
Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 59.65 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 3.57 W/kg

SAR(1 g) = 2.4 W/kg; SAR(10 g) = 1.57 W/kg

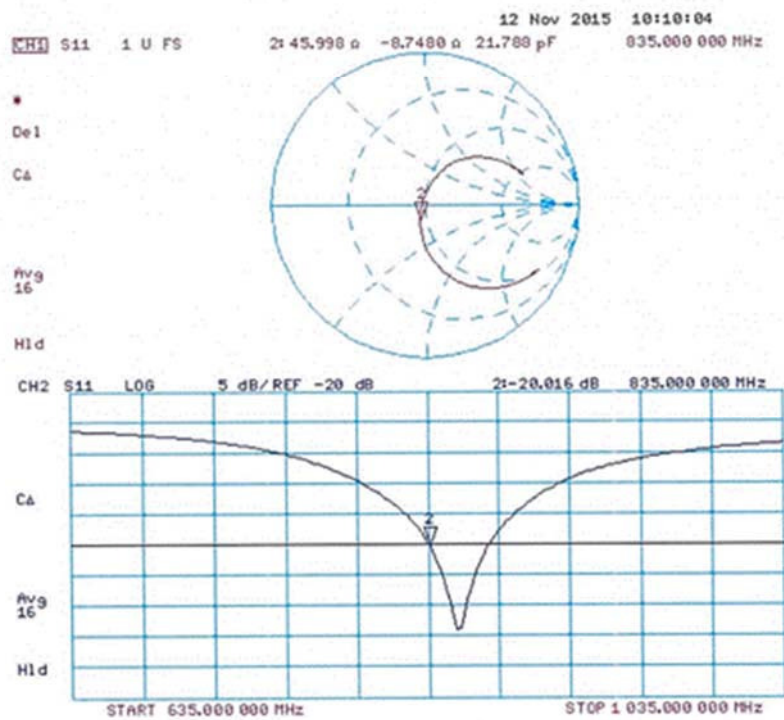
Maximum value of SAR (measured) = 3.17 W/kg





Product Service

Impedance Measurement Plot for Body TSL





Product Service

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



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

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

Accreditation No.: SCS 0108

Client **TÜV SÜD UK**

Certificate No: D835V2-447_Nov15

CALIBRATION CERTIFICATEObject **D835V2 - SN: 447**

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

Calibration date: **November 12, 2015**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	07-Oct-15 (No. 217-02222)	Oct-16
Power sensor HP 8481A	US37292783	07-Oct-15 (No. 217-02222)	Oct-16
Power sensor HP 8481A	MY41092317	07-Oct-15 (No. 217-02223)	Oct-16
Reference 20 dB Attenuator	SN: 5058 (20k)	01-Apr-15 (No. 217-02131)	Mar-16
Type-N mismatch combination	SN: 5047.2 / 06327	01-Apr-15 (No. 217-02134)	Mar-16
Reference Probe EX3DV4	SN: 7349	30-Dec-14 (No. EX3-7349_Dec14)	Dec-15
DAE4	SN: 601	17-Aug-15 (No. DAE4-601_Aug15)	Aug-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100972	15-Jun-15 (in house check Jun-15)	In house check: Jun-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

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

Issued: November 12, 2015

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

Certificate No: D835V2-447_Nov15

Page 1 of 8



Product Service

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



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

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

Accreditation No.: SCS 0108

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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



Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	835 MHz $\pm$ 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 $\pm$ 0.2) °C	42.6 $\pm$ 6 %	0.92 mho/m $\pm$ 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	2.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	9.26 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.52 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	6.02 W/kg $\pm$ 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 $\pm$ 0.2) °C	55.6 $\pm$ 6 %	0.99 mho/m $\pm$ 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	2.40 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	9.47 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.57 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	6.21 W/kg $\pm$ 16.5 % (k=2)



Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.9 Ω - 7.0 j Ω
Return Loss	- 23.1 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.0 Ω - 8.7 j Ω
Return Loss	- 20.0 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.386 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	October 24, 2001

**DASY5 Validation Report for Head TSL**

Date: 12.11.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 447

Communication System: UID 0 - CW; Frequency: 835 MHz

Medium parameters used: $f = 835 \text{ MHz}$; $\sigma = 0.92 \text{ S/m}$; $\epsilon_r = 42.6$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.77, 9.77, 9.77); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

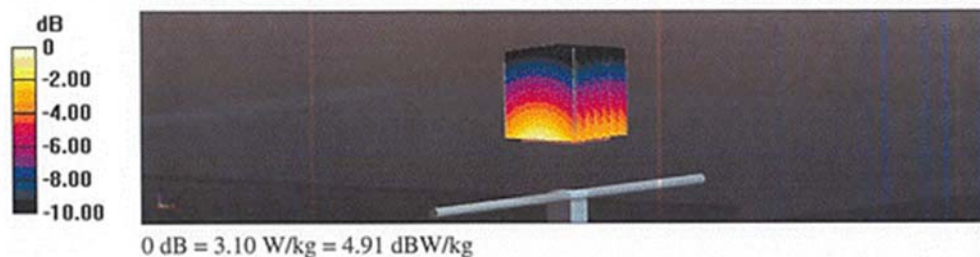
Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 61.13 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 3.47 W/kg

SAR(1 g) = 2.34 W/kg; SAR(10 g) = 1.52 W/kg

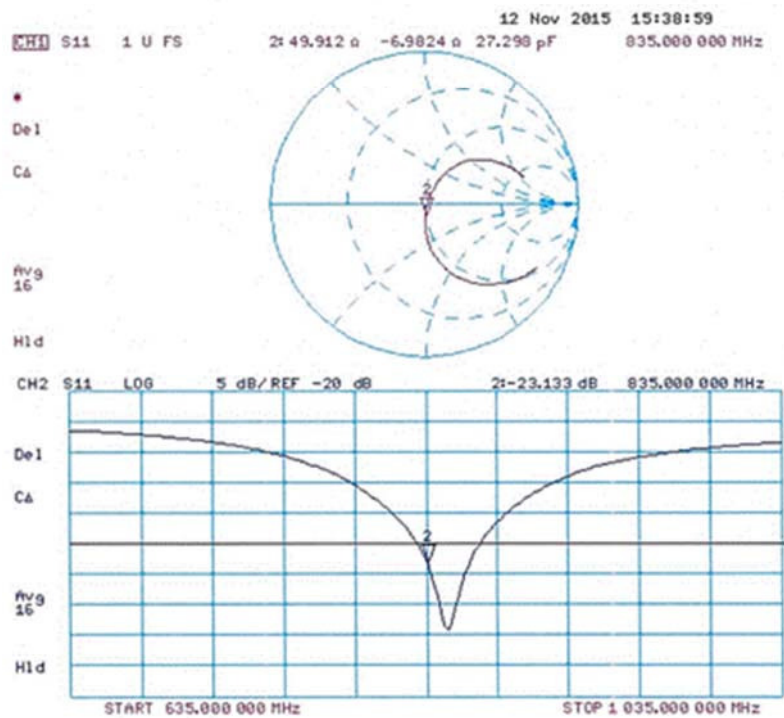
Maximum value of SAR (measured) = 3.10 W/kg





Product Service

Impedance Measurement Plot for Head TSL



**DASY5 Validation Report for Body TSL**

Date: 12.11.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 447

Communication System: UID 0 - CW; Frequency: 835 MHz

Medium parameters used: $f = 835 \text{ MHz}$; $\sigma = 0.99 \text{ S/m}$; $\epsilon_r = 55.6$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.72, 9.72, 9.72); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

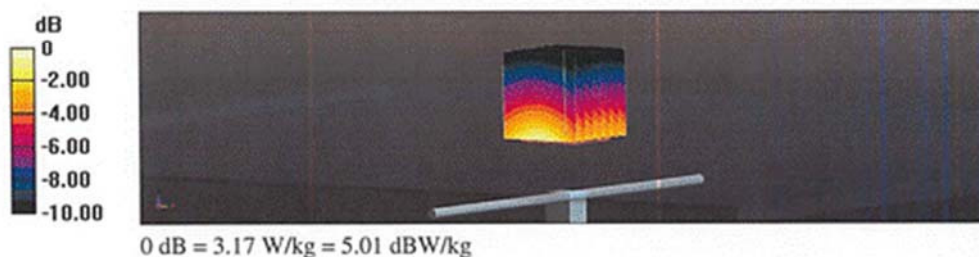
Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 59.65 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 3.57 W/kg

SAR(1 g) = 2.4 W/kg; SAR(10 g) = 1.57 W/kg

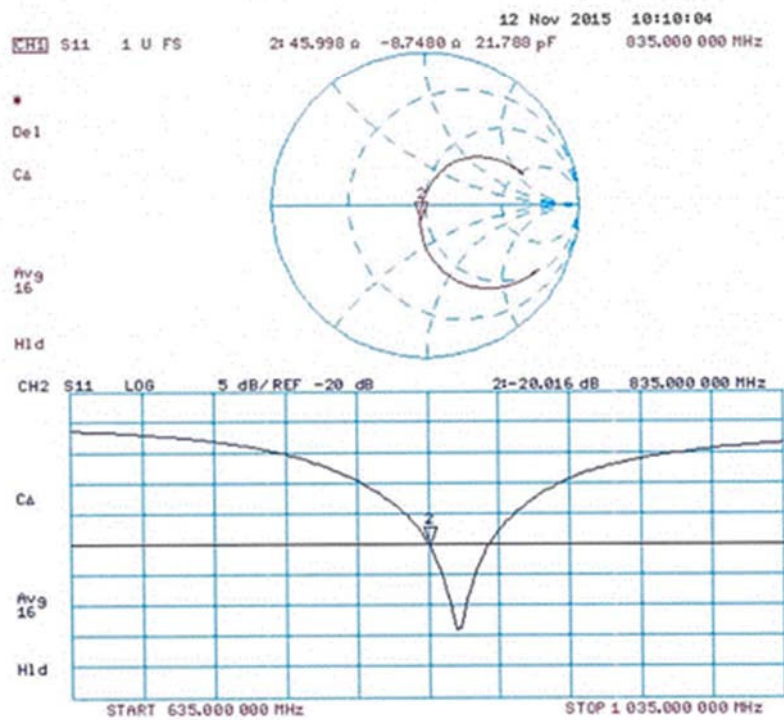
Maximum value of SAR (measured) = 3.17 W/kg





Product Service

Impedance Measurement Plot for Body TSL





Product Service

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



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

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

Accreditation No.: SCS 0108

Client **TÜV SÜD UK**

Certificate No: D1900V2-546_Nov15

CALIBRATION CERTIFICATEObject **D1900V2 - SN: 546**

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

Calibration date: **November 17, 2015**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	07-Oct-15 (No. 217-02222)	Oct-16
Power sensor HP 8481A	US37292783	07-Oct-15 (No. 217-02222)	Oct-16
Power sensor HP 8481A	MY41092317	07-Oct-15 (No. 217-02223)	Oct-16
Reference 20 dB Attenuator	SN: 5058 (20k)	01-Apr-15 (No. 217-02131)	Mar-16
Type-N mismatch combination	SN: 5047.2 / 06327	01-Apr-15 (No. 217-02134)	Mar-16
Reference Probe EX3DV4	SN: 7349	30-Dec-14 (No. EX3-7349_Dec14)	Dec-15
DAE4	SN: 601	17-Aug-15 (No. DAE4-601_Aug15)	Aug-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100972	15-Jun-15 (in house check Jun-15)	In house check: Jun-18
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

Calibrated by: **Name** Jeton Kastrati **Function** Laboratory Technician **Signature**

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

Issued: November 17, 2015

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

Certificate No: D1900V2-546_Nov15

Page 1 of 8



Product Service

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



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

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

Accreditation No.: SCS 0108

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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



Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1900 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.0	1.40 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	39.4 $\pm$ 6 %	1.39 mho/m $\pm$ 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	9.93 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	39.8 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	5.19 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	20.8 W/kg $\pm$ 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	52.2 $\pm$ 6 %	1.52 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	10.1 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	40.2 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.31 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.2 W/kg $\pm$ 16.5 % (k=2)



Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	$50.7 \Omega + 3.2 j\Omega$
Return Loss	- 29.9 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	$46.4 \Omega + 4.4 j\Omega$
Return Loss	- 24.6 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.204 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	November 15, 2001

**DASY5 Validation Report for Head TSL**

Date: 10.11.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN: 546

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

Medium parameters used: $f = 1900$ MHz; $\sigma = 1.39$ S/m; $\epsilon_r = 39.4$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.14, 8.14, 8.14); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

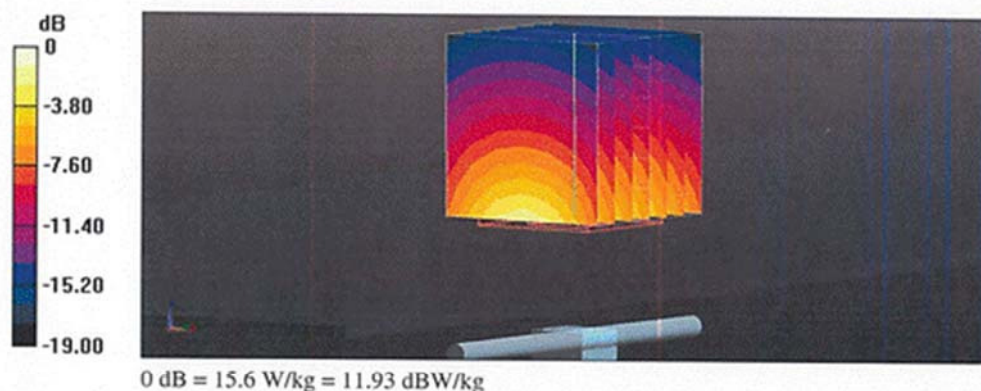
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 108.9 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 18.7 W/kg

SAR(1 g) = 9.93 W/kg; SAR(10 g) = 5.19 W/kg

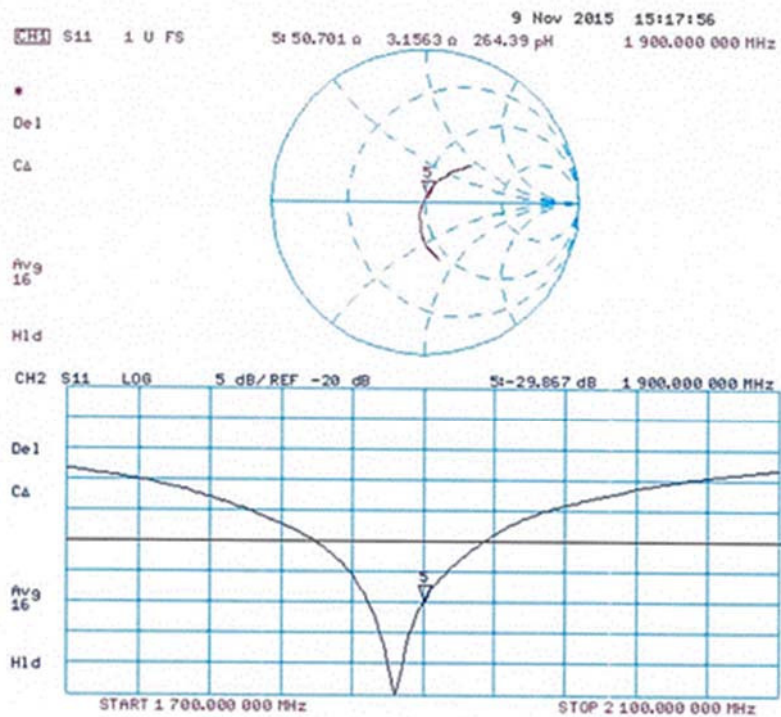
Maximum value of SAR (measured) = 15.6 W/kg





Product Service

Impedance Measurement Plot for Head TSL





DASY5 Validation Report for Body TSL

Date: 17.11.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN: 546

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

Medium parameters used: $f = 1900$ MHz; $\sigma = 1.52$ S/m; $\epsilon_r = 52.2$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.9, 7.9, 7.9); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

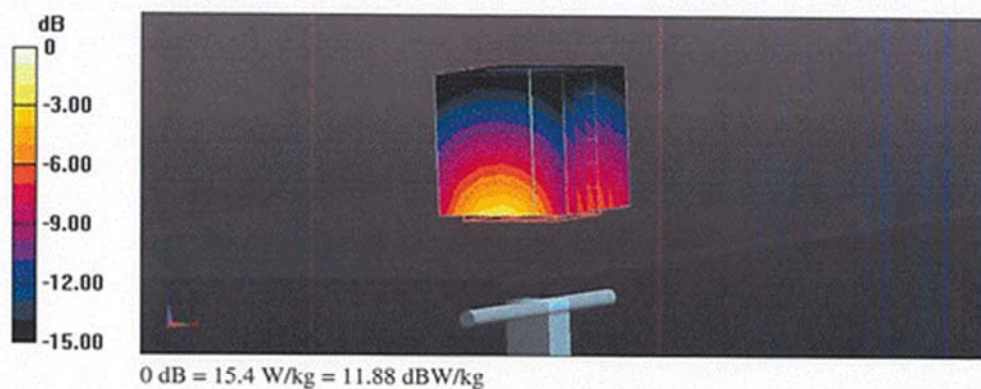
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 104.5 V/m; Power Drift = 0.00 dB

Peak SAR (extrapolated) = 18.1 W/kg

SAR(1 g) = 10.1 W/kg; SAR(10 g) = 5.31 W/kg

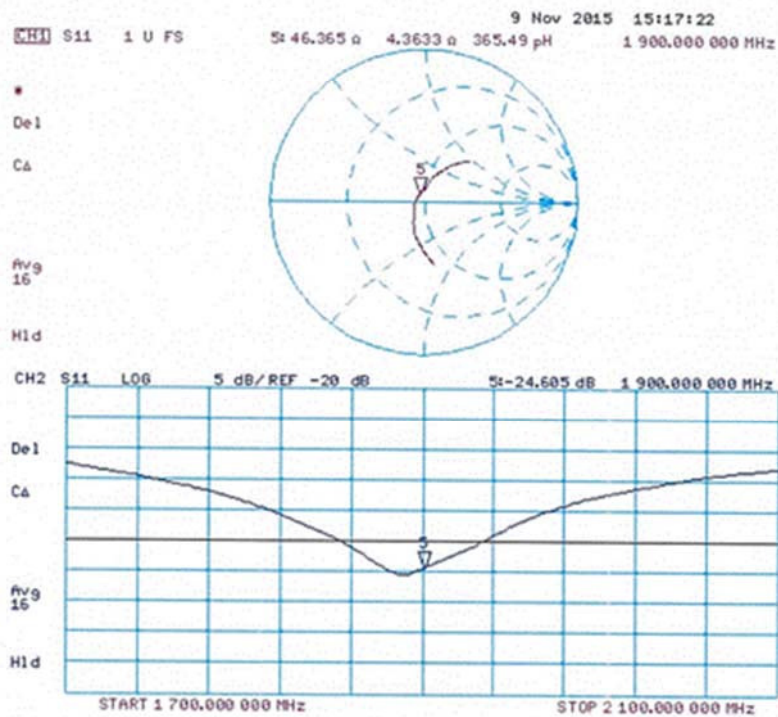
Maximum value of SAR (measured) = 15.4 W/kg





Product Service

Impedance Measurement Plot for Body TSL





Product Service

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



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

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

Accreditation No.: SCS 0108

Client **TÜV SÜD UK**

Certificate No: D2450V2-715_Nov15

CALIBRATION CERTIFICATEObject **D2450V2 - SN: 715**

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

Calibration date: **November 10, 2015**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	07-Oct-15 (No. 217-02222)	Oct-16
Power sensor HP 8481A	US37292783	07-Oct-15 (No. 217-02222)	Oct-16
Power sensor HP 8481A	MY41092317	07-Oct-15 (No. 217-02223)	Oct-16
Reference 20 dB Attenuator	SN: 5058 (20k)	01-Apr-15 (No. 217-02131)	Mar-16
Type-N mismatch combination	SN: 5047.2 / 06327	01-Apr-15 (No. 217-02134)	Mar-16
Reference Probe EX3DV4	SN: 7349	30-Dec-14 (No. EX3-7349_Dec14)	Dec-15
DAE4	SN: 601	17-Aug-15 (No. DAE4-601_Aug15)	Aug-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100972	15-Jun-15 (in house check Jun-15)	In house check: Jun-18
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

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

Issued: November 11, 2015

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

Certificate No: D2450V2-715_Nov15

Page 1 of 8



Product Service

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



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

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

Accreditation No.: SCS 0108

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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



Measurement Conditions

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

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

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	38.2 $\pm$ 6 %	1.87 mho/m $\pm$ 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	13.7 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	53.5 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.0 W/kg $\pm$ 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	52.7 $\pm$ 6 %	2.02 mho/m $\pm$ 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	13.6 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	53.5 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.38 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	25.3 W/kg $\pm$ 16.5 % (k=2)



Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	$53.7 \Omega + 2.7 j\Omega$
Return Loss	- 27.1 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	$50.1 \Omega + 5.5 j\Omega$
Return Loss	- 25.2 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.156 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, 2002

**DASY5 Validation Report for Head TSL**

Date: 10.11.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz ; Type: D2450V2; Serial: D2450V2 - SN: 715

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.87$ S/m; $\epsilon_r = 38.2$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.67, 7.67, 7.67); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

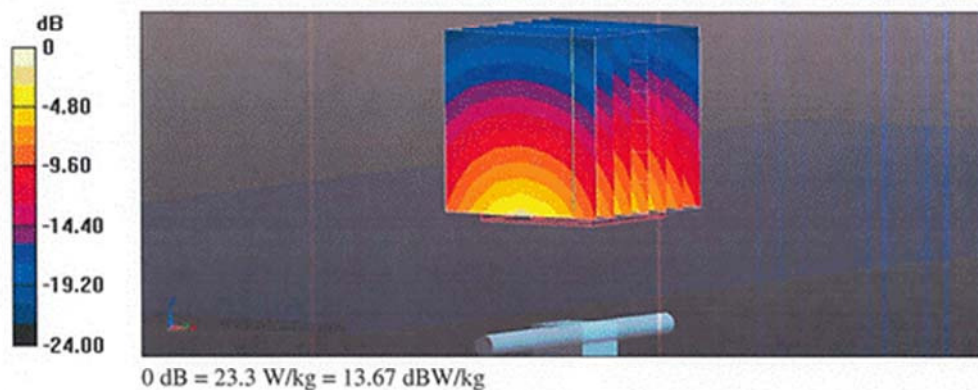
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 116.3 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 28.7 W/kg

SAR(1 g) = 13.7 W/kg; SAR(10 g) = 6.34 W/kg

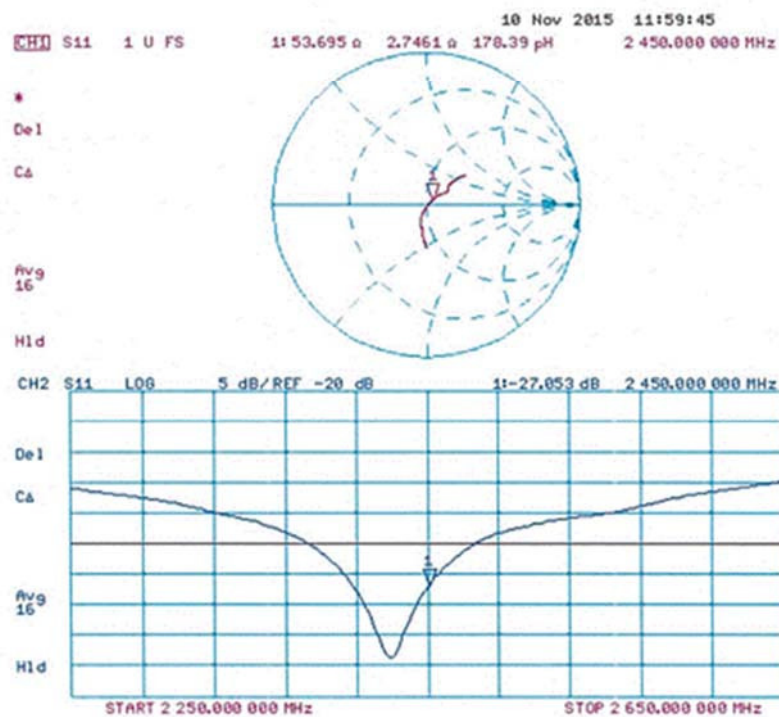
Maximum value of SAR (measured) = 23.3 W/kg





Product Service

Impedance Measurement Plot for Head TSL



**DASY5 Validation Report for Body TSL**

Date: 10.11.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 715

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 2.02$ S/m; $\epsilon_r = 52.7$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.53, 7.53, 7.53); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

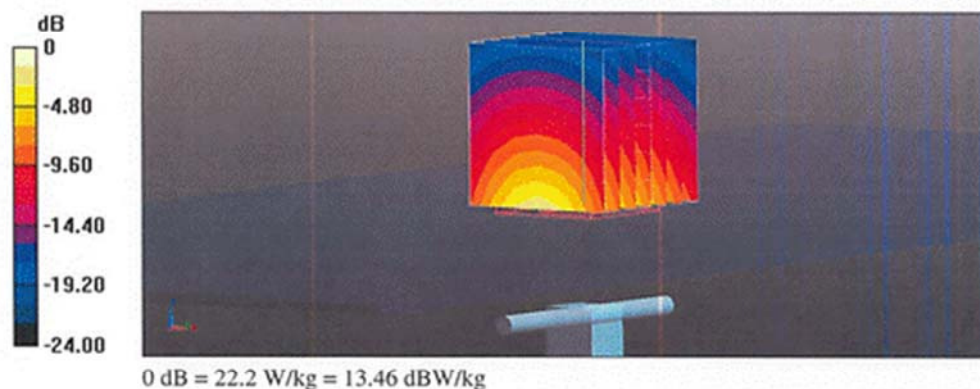
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 109.5 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 27.2 W/kg

SAR(1 g) = 13.6 W/kg; SAR(10 g) = 6.38 W/kg

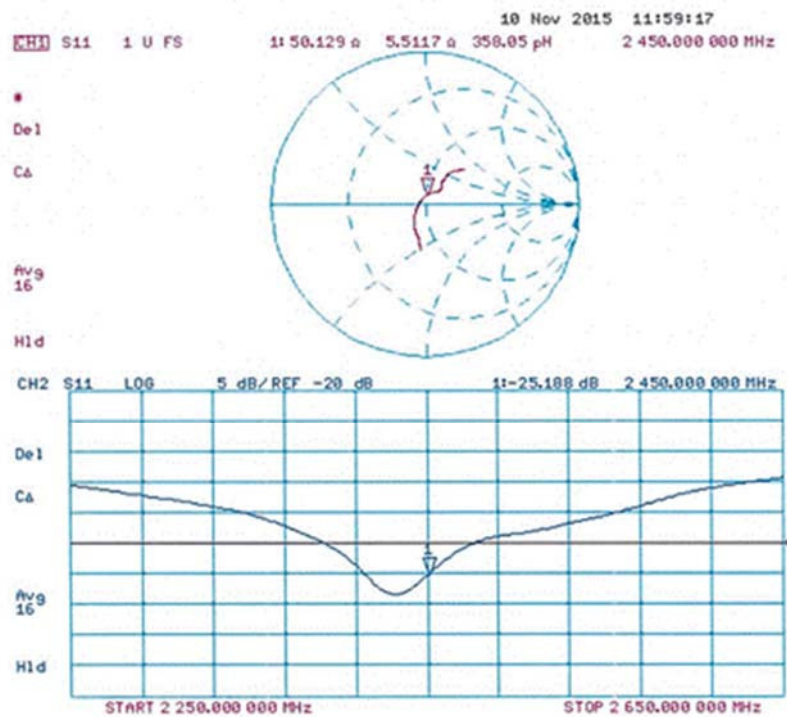
Maximum value of SAR (measured) = 22.2 W/kg





Product Service

Impedance Measurement Plot for Body TSL





Product Service

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



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

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

Accreditation No.: SCS 0108

Client **TÜV SÜD UK**

Certificate No: D2600V2-1034_Nov15

CALIBRATION CERTIFICATEObject **D2600V2 - SN: 1034**

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

Calibration date: **November 10, 2015**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	07-Oct-15 (No. 217-02222)	Oct-16
Power sensor HP 8481A	US37292783	07-Oct-15 (No. 217-02222)	Oct-16
Power sensor HP 8481A	MY41092317	07-Oct-15 (No. 217-02223)	Oct-16
Reference 20 dB Attenuator	SN: 5058 (20k)	01-Apr-15 (No. 217-02131)	Mar-16
Type-N mismatch combination	SN: 5047.2 / 06327	01-Apr-15 (No. 217-02134)	Mar-16
Reference Probe EX3DV4	SN: 7349	30-Dec-14 (No. EX3-7349_Dec14)	Dec-15
DAE4	SN: 601	17-Aug-15 (No. DAE4-601_Aug15)	Aug-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100972	15-Jun-15 (in house check Jun-15)	In house check: Jun-18
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

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

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

Issued: November 11, 2015

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

Certificate No: D2600V2-1034_Nov15

Page 1 of 8



Product Service

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



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

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

Accreditation No.: SCS 0108

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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



Measurement Conditions

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

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

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.0	1.96 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	37.7 $\pm$ 6 %	2.04 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	14.9 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	58.1 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.56 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.9 W/kg $\pm$ 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.5	2.16 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	52.2 $\pm$ 6 %	2.21 mho/m $\pm$ 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	14.4 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	56.9 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.39 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	25.4 W/kg $\pm$ 16.5 % (k=2)



Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.5 Ω - 4.8 j Ω
Return Loss	- 26.2 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	45.0 Ω - 3.4 j Ω
Return Loss	- 24.0 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.150 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	March 03, 2009

**DASY5 Validation Report for Head TSL**

Date: 10.11.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1034

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

Medium parameters used: $f = 2600$ MHz; $\sigma = 2.04$ S/m; $\epsilon_r = 37.7$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.4, 7.4, 7.4); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

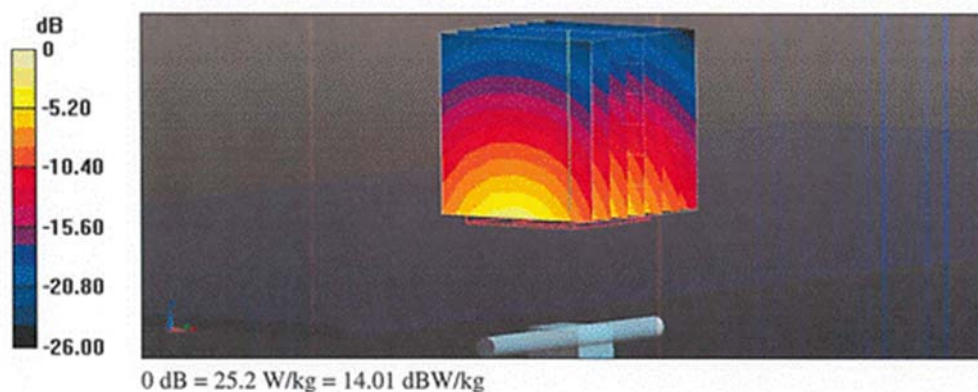
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 116.9 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 32.1 W/kg

SAR(1 g) = 14.9 W/kg; SAR(10 g) = 6.56 W/kg

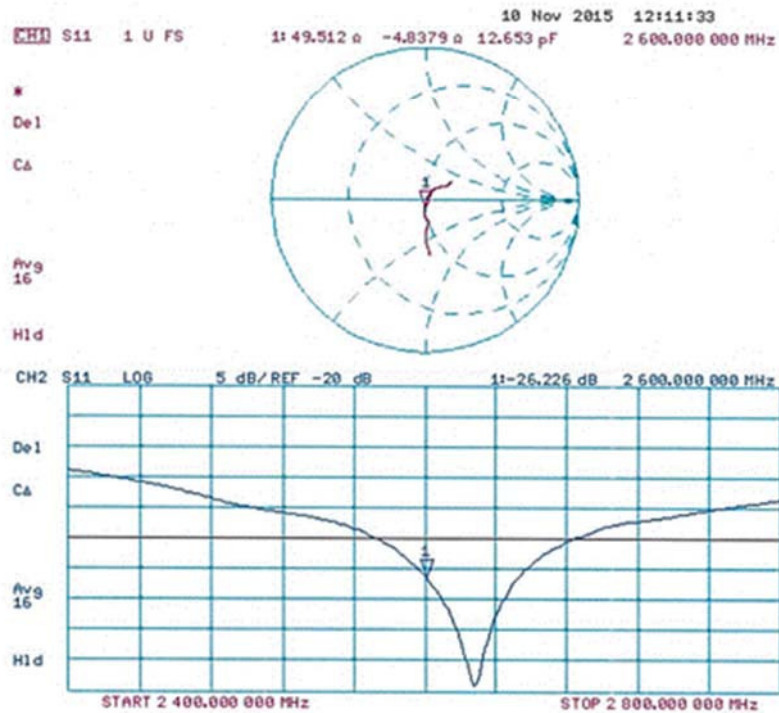
Maximum value of SAR (measured) = 25.2 W/kg





Product Service

Impedance Measurement Plot for Head TSL





DASY5 Validation Report for Body TSL

Date: 10.11.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1034

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

Medium parameters used: $f = 2600$ MHz; $\sigma = 2.21$ S/m; $\epsilon_r = 52.2$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.52, 7.52, 7.52); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

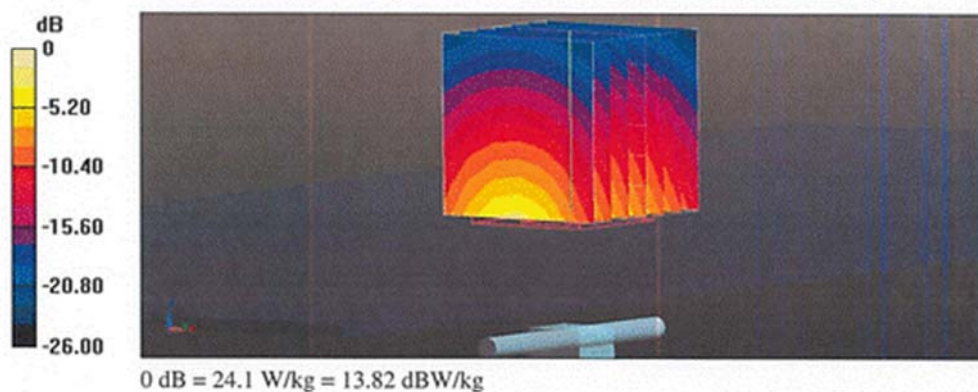
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 109.8 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 29.9 W/kg

SAR(1 g) = 14.4 W/kg; SAR(10 g) = 6.39 W/kg

Maximum value of SAR (measured) = 24.1 W/kg





Product Service

Impedance Measurement Plot for Body TSL

