



Product Service

Annex 1

Calibration Certificate of NRP-Z23 power sensor

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 (Incoming) Konformitätsaussage (Anlieferung)	Measurement results within specifications				
Statement of Compliance (Outgoing) Konformitätsaussage (Auslieferung)	Measurement results within specifications				
Extent of Calibration Documents Umfang des Kalibrierdokuments	2 Pages Calibration Certificate 17 Pages Outgoing Results 17 Pages Incoming Results				
Rohde & Schwarz GmbH & Co. KG; Service Operations West					
Date of Issue Ausstellungsdatum	Head of Laboratory Laboreitung	Person Responsible Bearbeiter			
2013-08-14	 Courage	 Ruprecht Schmid			
			Page 1/2 ver9815RSM006		
ROHDE & SCHWARZ GmbH & Co. KG - Mühldorferstraße 15 - D-81671 München, Federal Republic of Germany - Telefon (089) 41 29-0 - Telefax (089) 41 29-132 75 Geschäftsführung: Manfred Fleischmann (Vorsitzender), Christian Lecher, Gerhard Geier Sitz München - Registeramt: HRA 16 270 - Persönlich haftender Gesellschafter: RUSSEG Verwaltungs-GmbH - Sitz München - Registeramt: AG München HRB 7 834					

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 signatures 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 Normale, die direkt oder indirekt durch Ableitung mittels anerkannter Kalibriertechniken rückgeführt sind auf Normale der PTB/DKD oder anderer nationaler/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 weiterverbreitet werden. Kalibrierscheine ohne Signifizierungen sind ungültig. Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.



Product Service

Material Number 1137.8002.02

Serial Number 100063

Certificate Number 10-300287035

Calibration Method **NRVC-1109.0930.32**
 Kalibrieranweisung

Relative Humidity **20%-60%**
 Relative Luftfeuchte

Ambient Temperature **(23 ⁺¹₋₁) °C**
 Umgebungstemperatur

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 Kalibrierscheinnummer	Cal. Due Kalibr. bis
Dual Channel Powermeter	NRVD	100862	0114 D-K-15195-01-00 2013-08	2014-11-30
Dual Channel Power Meter	NRVD	828583/0023	0113 D-K-15195-01-00 2013-08	2014-11-30
Vector Network Analyzer	ZVM	835228/0020	0102-DKD-K-16101-2011-08	2013-10-31
Access Set for Lin. Measurement	NRVC-B2	848997/0028	0085 D-K-15195-01-00 2013-01	2014-04-30
Calibration Kit Type-N :50 Ohm	85054B	.2705A00160	217-01723 [METAS]	2015-03-31
Power Standard	NRVC	836497/0005	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.



Product Service

Annex 2

Calibration certificate of MS4623 VNA and 36581KKF/1 auto-cal kit

Certificate of Calibration		Anritsu
		Discover What's Possible™
Customer: INDEXSAR LTD INDEXSAR LTD_	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	
OAKFIELD HOUSE NEWDIGATE SURREY RH5 5BG UNITED KINGDOM		
Date of Issue:	21/01/2014	Certificate N°: RMA20021769
Customer:	INDEXSAR LTD	Order N°: Contract
Manufacturer:	Anritsu Company	
Model	Serial Number	Description
MS4623B	003102	VNA, 10 MHZ-6 GHZ, ACTIVE
36581KKF/1	001902	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	(yes)	 Authorised Signature Murray Coleman Head of Customer Services (EMEA)
Repair required before calibration	(no)	
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 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		



Product Service

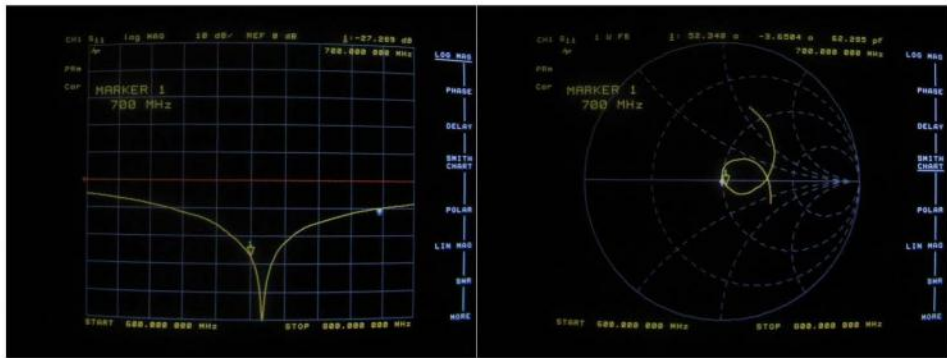
Report №
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CALIBRATION LABORATORY REPORT

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).

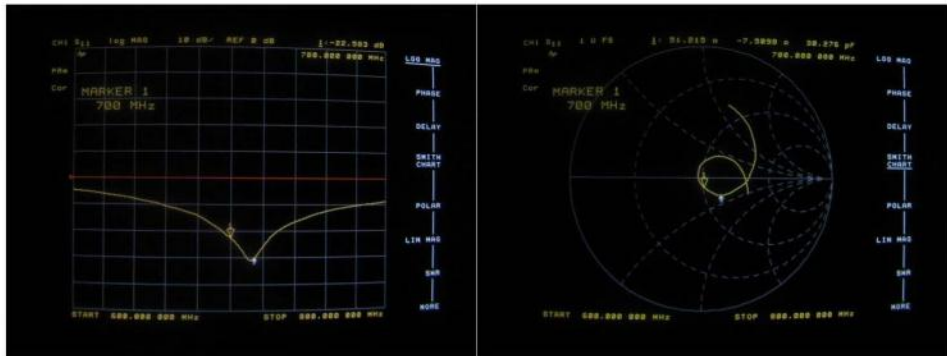
The impedance was measured at the SMA-connector with the network analyser.
The following parameters were measured against Head fluid:



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

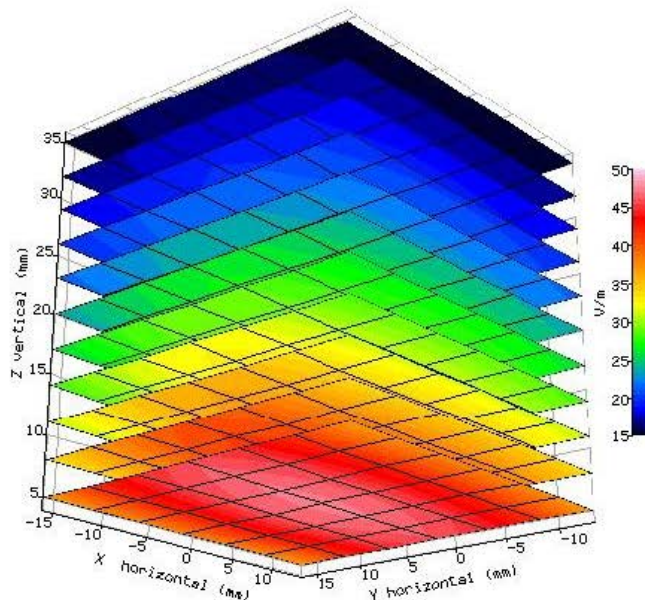
SAR validation checks have been performed using the 700MHz dipole and the box-phantom located on the SARA-C phantom support base on the SARA-C robot system. Tests were then conducted at a feed power level of approx. 0.25W. The actual power level was recorded and used to normalise the results obtained 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) (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

Test Equipment Number (TE): 3857

Calibration Class: A

TUV SUD Product Service

Internal Calibration Laboratory Report

Date of Calibration: 19/02/2014

Report Number: 26553



Calibration Expiry Date: 19/02/2017

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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: Speag

Item: Dipoles

Model: D835V2

Serial No: 447

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 $22.6^{\circ}\text{C} \pm 3^{\circ}\text{C}$ @ 43.9% RH $\pm 10\%$ RH. The mains voltage was $240\text{V} \pm 10\%$.

Calibration Engineer: _____

N. R. Grigsby

Approved Signatory: _____

A. T. Pearce



Product Service

**CALIBRATION LABORATORY REPORT****TUV SUD Product Service****Calibration 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.

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() 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: Cartesian Leg Extension	Part of SARAC System		TE4078
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

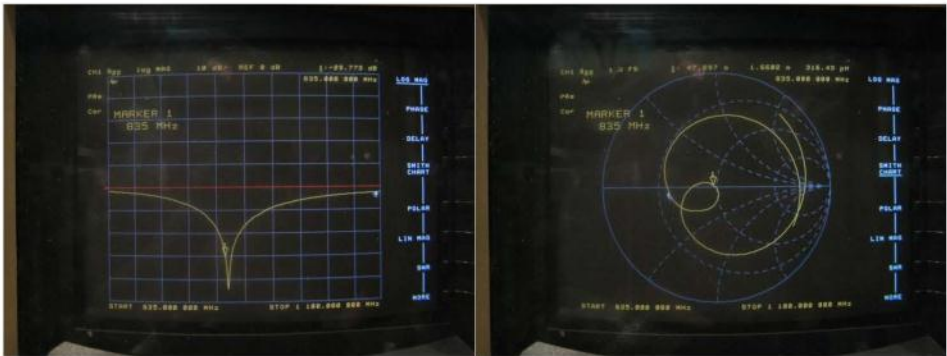


CALIBRATION LABORATORY REPORT

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 835MHz).

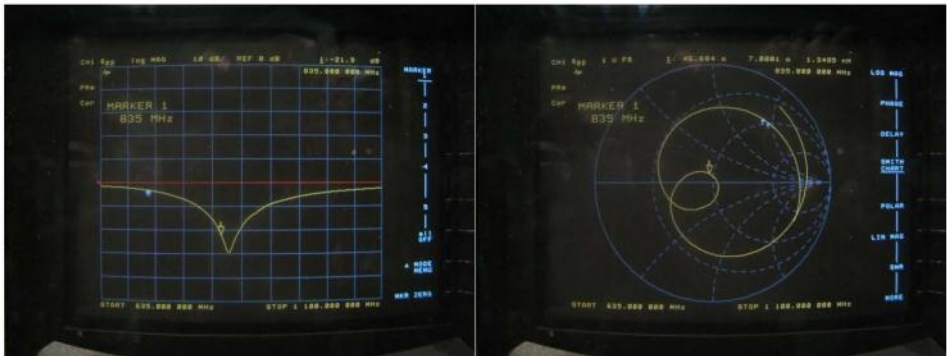
The impedance was measured at the SMA-connector with the network analyser.
The following parameters were measured against Head fluid:



Dipole impedance at 835MHz	$\text{Re}\{Z\} = 47.30 \, \Omega$
	$\text{Im}\{Z\} = 1.56 \, \Omega$
Return loss at 835MHz	-29.77 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 835MHz	$\text{Re}\{Z\} = 46.68 \, \Omega$ $\text{Im}\{Z\} = 7.08 \, \Omega$
Return loss at 835MHz	-21.90 dB

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

SAR Validation Measurement in Brain Fluid

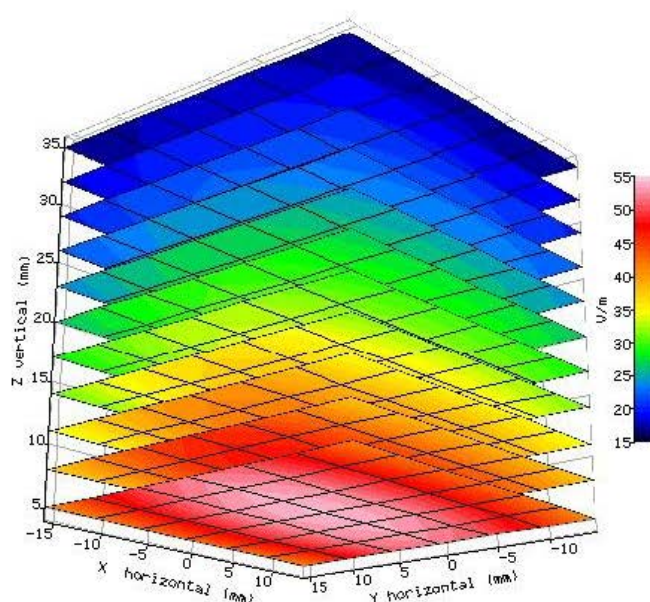
SAR validation checks have been performed using the 835MHz dipole and the box-phantom located on the SARA-C phantom support base on the SARA-C robot system. Tests were then conducted at a feed power level of approx. 0.25W. The actual power level was recorded and used to normalise the results obtained to the standard input power conditions of 1W (forward power). The ambient temperature was 22.6°C and the relative humidity was 43.9% during the measurements.

The phantom was filled with 835MHz brain liquid using a recipe from [1], which has the following electrical parameters (measured using an Indxsar DiLine kit) at 835MHz at the measurement temperature:

Relative Permittivity	41.67
Conductivity	0.895 S/m
Fluid Temperature	22.6 °C

The SARA-C software version v6.08.11 was used with Indxsar 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	2.65	10.55	1.93	10.35
10g SAR	1.73	6.88	2.12	6.74

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

SAR Measurement in Body Fluid

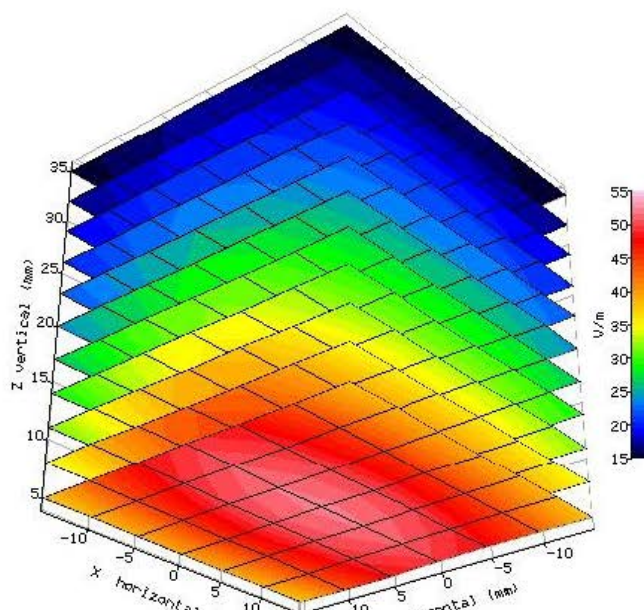
SAR validation checks have been performed using the 835MHz dipole and the box-phantom located on the SARA-C phantom support base on the SARA-C robot system. Tests were then conducted at a feed power level of approx. 0.25W. The actual power level was recorded and used to normalise the results obtained to the standard input power conditions of 1W (forward power). The ambient temperature was 22.9°C and the relative humidity was 35.4% during the measurements.

The phantom was filled with 835MHz body liquid using a recipe from [1][4], which has the following electrical parameters (measured using an Indexasar DiLine kit) at 835MHz at the measurement temperature:

Relative Permittivity **56.6**
 Conductivity **1.006 S/m**
 Fluid Temperature 22.5 °C

The SARA-C software version v6.08.11 was used with Indexasar 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	2.65	10.56	2.01**	10.35*
10g SAR	1.77	7.05	4.60**	6.74*

* 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.

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[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

Test Equipment Number (TE): 3876

Calibration Class: A

TUV SUD Product Service

Internal Calibration Laboratory Report

Date of Calibration: 19/02/2014

Report Number: 26575



Calibration Expiry Date: 19/02/2017

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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: Speag

Item: Dipoles

Model: D1900V2

Serial No: 546

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 $22.4^{\circ}\text{C} \pm 3^{\circ}\text{C}$ @ 43.4% 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 Service

Calibration 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.

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Test Equipment Used On This Calibration

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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



Product Service

Report № 26575
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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. 10mm from the liquid (for 1900MHz).

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



Dipole impedance at 1900MHz	$\text{Re}\{Z\} = 47.36 \, \Omega$
Return loss at 1900MHz	$\text{Im}\{Z\} = -1.06 \, \Omega$
	-30.59 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 1900MHz	$\text{Re}\{Z\} = 49.46 \, \Omega$
	$\text{Im}\{Z\} = -5.06 \, \Omega$
Return loss at 1900MHz	-25.73 dB

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

SAR Validation Measurement in Brain Fluid

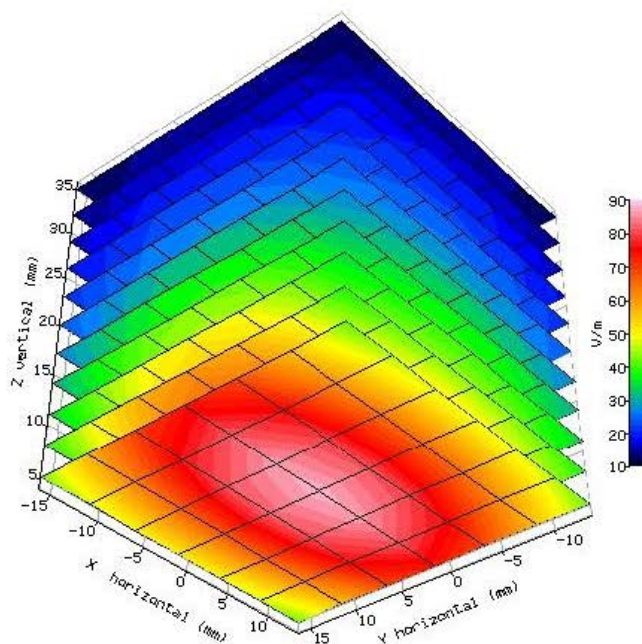
SAR validation checks have been performed using the 1900MHz dipole and the box-phantom located on the SARA-C phantom support base on the SARA-C robot system. Tests were then conducted at a feed power level of approx. 0.25W. The actual power level was recorded and used to normalise the results obtained to the standard input power conditions of 1W (forward power). The ambient temperature was 22.4°C and the relative humidity was 43.4% during the measurements.

The phantom was filled with 1900MHz brain liquid using a recipe from [1], which has the following electrical parameters (measured using an Indxsar DiLine kit) at 1900MHz at the measurement temperature:

Relative Permittivity	39.28
Conductivity	1.433 S/m
Fluid Temperature	22.6 °C

The SARA-C software version v6.08.11 was used with Indxsar 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	10.37	41.28	3.10	40.04
10g SAR	5.464	21.75	2.17	21.29

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

SAR Measurement in Body Fluid

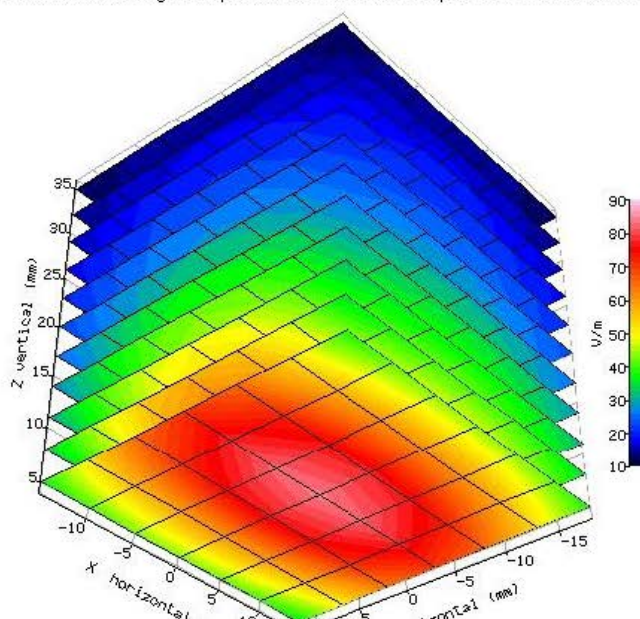
SAR validation checks have been performed using the 1900MHz dipole and the box-phantom located on the SARA-C phantom support base on the SARA-C robot system. Tests were then conducted at a feed power level of approx. 0.25W. The actual power level was recorded and used to normalise the results obtained to the standard input power conditions of 1W (forward power). The ambient temperature was 22.2°C and the relative humidity was 49.1% during the measurements.

The phantom was filled with 1900MHz body liquid using a recipe from [1][4], which has the following electrical parameters (measured using an Indxsar DiLine kit) at 1900MHz at the measurement temperature:

Relative Permittivity **5321**
 Conductivity **1.596 S/m**
 Fluid Temperature 22.7 °C

The SARA-C software version v6.08.11 was used with Indxsar 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	10.12	40.29	0.63**	40.04*
10g SAR	5.38	21.41	0.54**	21.29*

* 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

Test Equipment Number (TE): 3875

Calibration Class: A

TUV SUD Product Service

Internal Calibration Laboratory Report

Date of Calibration: 19/02/2014

Report Number: 26576



Calibration Expiry Date: 19/02/2017

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: Speag

Item: Dipoles

Model: D2450V2

Serial No: 715

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 $22.6^{\circ}\text{C} \pm 3^{\circ}\text{C}$ @ $34.0\% \text{ RH} \pm 10\% \text{ RH}$. 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 Service****Calibration 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



Product Service

Report № 26576
Page 3 of 6

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. 10mm from the liquid (for 2450MHz).

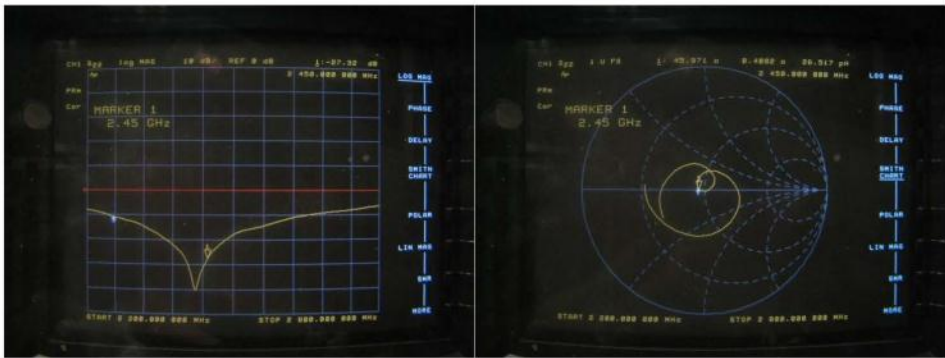
The impedance was measured at the SMA-connector with the network analyser.
The following parameters were measured against Head fluid:



Dipole impedance at 2450MHz	$\text{Re}\{Z\} = 47.69 \, \Omega$
Return loss at 2450MHz	$\text{Im}\{Z\} = 2.827 \, \Omega$
	-28.63 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 2450MHz	$\text{Re}\{Z\} = 45.97 \, \Omega$ $\text{Im}\{Z\} = 0.41 \, \Omega$
Return loss at 2450MHz	-27.32 dB

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

SAR Validation Measurement in Brain Fluid

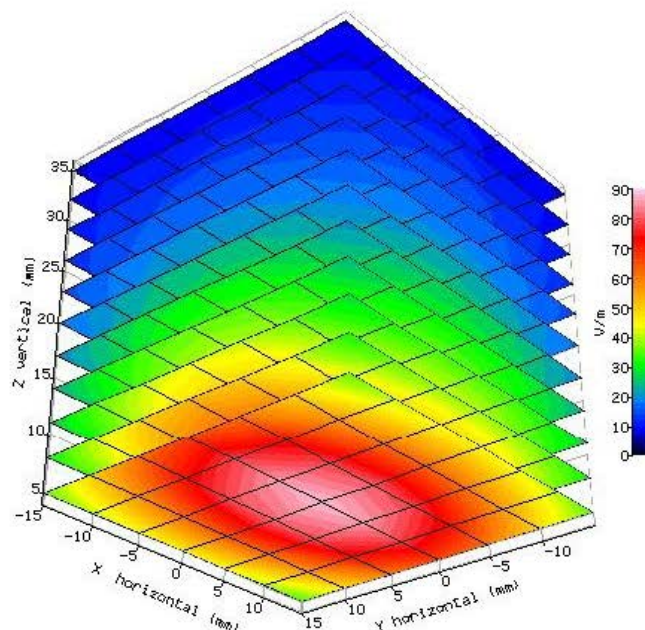
SAR validation checks have been performed using the 2450MHz dipole and the box-phantom located on the SARA-C phantom support base on the SARA-C robot system. Tests were then conducted at a feed power level of approx. 0.25W. The actual power level was recorded and used to normalise the results obtained to the standard input power conditions of 1W (forward power). The ambient temperature was 22.6°C and the relative humidity was 34.0% during the measurements.

The phantom was filled with 2450MHz brain liquid using a recipe from [1], which has the following electrical parameters (measured using an Indxsar DiLine kit) at 2450MHz at the measurement temperature:

Relative Permittivity	39.11
Conductivity	1.797 S/m
Fluid Temperature	22.6 °C

The SARA-C software version v6.08.11 was used with Indxsar 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	13.64	54.30	2.50	52.98
10g SAR	6.39	25.45	2.48	24.83

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

SAR Measurement in Body Fluid

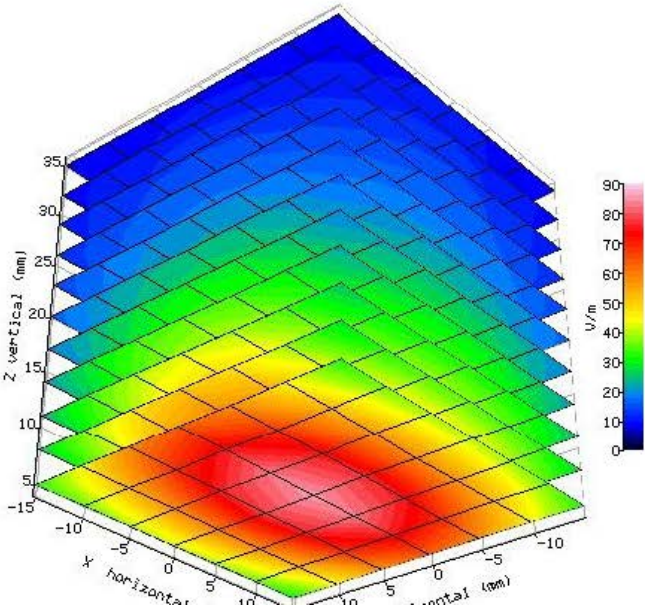
SAR validation checks have been performed using the 2450MHz dipole and the box-phantom located on the SARA-C phantom support base on the SARA-C robot system. Tests were then conducted at a feed power level of approx. 0.25W. The actual power level was recorded and used to normalise the results obtained to the standard input power conditions of 1W (forward power). The ambient temperature was 22.8°C and the relative humidity was 30.2% during the measurements.

The phantom was filled with 2450MHz body liquid using a recipe from [1][4], which has the following electrical parameters (measured using an Indxsar DiLine kit) at 2450MHz at the measurement temperature:

Relative Permittivity **51.09**
Conductivity **1.983 S/m**
Fluid Temperature 22.7 °C

The SARA-C software version v6.08.11 was used with Indxsar 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	13.47	53.64	1.25**	52.98*
10g SAR	6.37	25.36	2.13**	24.83*

* 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

Test Equipment Number (TE): 4403

Calibration Class: A

TUV SUD Product Service

Internal Calibration Laboratory Report

Date of Calibration: 19/02/2014

Report Number: 26577



Calibration Expiry Date: 19/02/2017

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: Speag

Item: Dipoles

Model: D2600V2

Serial No: 1034

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 $22.6^{\circ}\text{C} \pm 3^{\circ}\text{C}$ @ 32.2% 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 Service

Calibration 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.

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() 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. 10mm from the liquid (for 2600MHz).

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



Dipole impedance at 2600MHz	$\text{Re}\{Z\} = 50.05 \, \Omega$
	$\text{Im}\{Z\} = -6.207 \, \Omega$
Return loss at 2600MHz	-24.18 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 2600MHz	$\text{Re}\{Z\} = 47.32 \, \Omega$
	$\text{Im}\{Z\} = -6.21 \, \Omega$
Return loss at 2600MHz	-26.27 dB

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

SAR Validation Measurement in Brain Fluid

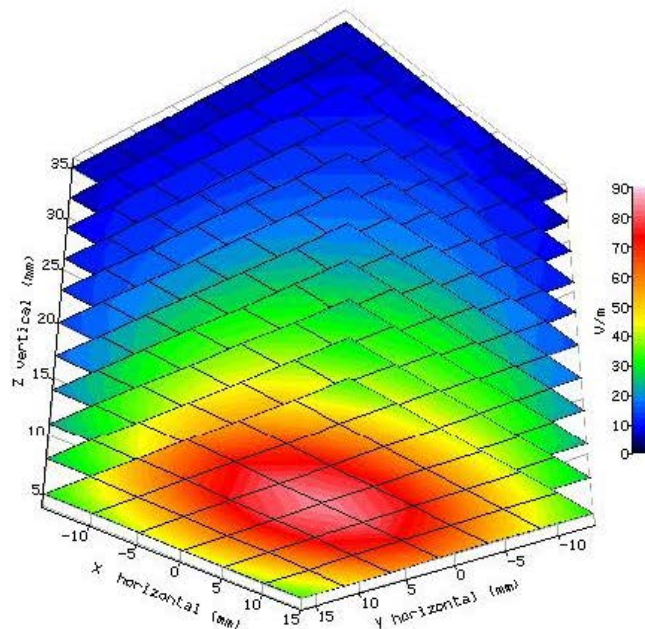
SAR validation checks have been performed using the 2600MHz dipole and the box-phantom located on the SARA-C phantom support base on the SARA-C robot system. Tests were then conducted at a feed power level of approx. 0.25W. The actual power level was recorded and used to normalise the results obtained to the standard input power conditions of 1W (forward power). The ambient temperature was 22.6°C and the relative humidity was 32.3% during the measurements.

The phantom was filled with 2600MHz brain liquid using a recipe from [1], which has the following electrical parameters (measured using an Indxsar DiLine kit) at 2600MHz at the measurement temperature:

Relative Permittivity	38.55
Conductivity	1.960 S/m
Fluid Temperature	22.6 °C

The SARA-C software version v6.08.11 was used with Indxsar 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	13.76	54.76	-3.14	56.54
10g SAR	6.18	24.59	-0.04	56.54

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

SAR Measurement in Body Fluid

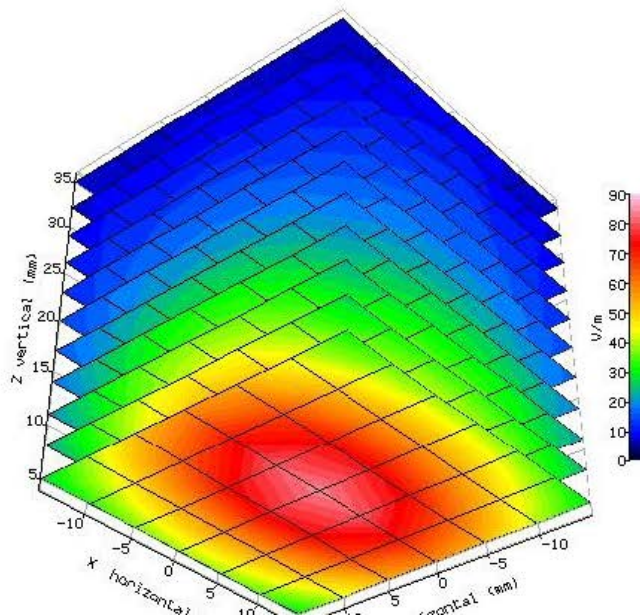
SAR validation checks have been performed using the 2600MHz dipole and the box-phantom located on the SARA-C phantom support base on the SARA-C robot system. Tests were then conducted at a feed power level of approx. 0.25W. The actual power level was recorded and used to normalise the results obtained to the standard input power conditions of 1W (forward power). The ambient temperature was 22.8°C and the relative humidity was 33.6% during the measurements.

The phantom was filled with 2600MHz body liquid using a recipe from [1][4], which has the following electrical parameters (measured using an Indxsar DiLine kit) at 2600MHz at the measurement temperature:

Relative Permittivity **50.65**
 Conductivity **2.152 S/m**
 Fluid Temperature 22.7 °C

The SARA-C software version v6.08.11 was used with Indxsar 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	14.21	56.57	0.06**	56.54*
10g SAR	6.39	25.45	3.44**	24.6*

* 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
S Service suisse d'étalonnage
C 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 108**Client **TÜV Product Service Ltd**Certificate No: **D5GHzV2-1100_Mar11****CALIBRATION CERTIFICATE**

Object **D5GHzV2 - SN: 1100**

Calibration procedure(s) **QA CAL-22.v1**
Calibration procedure for dipole validation kits between 3-6 GHz

Calibration date: **March 14, 2011**

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

All calibrations have been conducted in the closed laboratory facility; environment temperature $(22 \pm 3)^{\circ}\text{C}$ and humidity $\leq 70\%$.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	06-Oct-10 (No. 217-01266)	Oct-11
Power sensor HP 8481A	US37292783	06-Oct-10 (No. 217-01266)	Oct-11
Reference 20 dB Attenuator	SN: 5086 (20g)	30-Mar-10 (No. 217-01158)	Mar-11
Type-N mismatch combination	SN: 5047.2 / 06327	30-Mar-10 (No. 217-01162)	Mar-11
Reference Probe EX3DV4	SN: 3503	04-Mar-11 (No. EX3-3503_Mar11)	Mar-12
DAE4	SN: 601	10-Jun-10 (No. DAE4-601_Jun10)	Jun-11
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power sensor HP 8481A	MY41092317	18-Oct-02 (in house check Oct-09)	In house check: Oct-11
RF generator R&S SMT-06	100005	4-Aug-99 (in house check Oct-09)	In house check: Oct-11
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-10)	In house check: Oct-11

Calibrated by:	Name Dimce Iliev	Function Laboratory Technician	Signature
Approved by:	Katja Pokovic	Technical Manager	

Issued: March 16, 2011

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



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 108****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) IEC 62209-2, "Evaluation of Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices in the Frequency Range of 30 MHz to 6 GHz: Human models, Instrumentation, and Procedures"; Part 2: "Procedure to determine the Specific Absorption Rate (SAR) for including accessories and multiple transmitters", March 2010
- b) Federal Communications Commission Office of Engineering & Technology (FCC OET), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields; Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", Supplement C (Edition 01-01) to Bulletin 65

Additional Documentation:

- c) 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.



Measurement Conditions

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

DASY Version	DASY5	V52.6.2
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Area Scan resolution	dx, dy = 10 mm	
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	
Frequency	5200 MHz $\pm$ 1 MHz 5500 MHz $\pm$ 1 MHz 5800 MHz $\pm$ 1 MHz	

Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	36.0	4.66 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	36.4 $\pm$ 6 %	4.51 mho/m $\pm$ 6 %
Head TSL temperature during test	(22.0 $\pm$ 0.2) °C	----	----

SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm³ (1 g) of Head TSL	condition	
SAR measured	100 mW input power	8.31 mW / g
SAR normalized	normalized to 1W	83.1 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	83.2 mW / g $\pm$ 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.36 mW / g
SAR normalized	normalized to 1W	23.6 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	23.6 mW / g $\pm$ 19.5 % (k=2)

**Head TSL parameters at 5500 MHz**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.6	4.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.9 ± 6 %	4.80 mho/m ± 6 %
Head TSL temperature during test	(22.0 ± 0.2) °C	----	----

SAR result with Head TSL at 5500 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	condition	
SAR measured	100 mW input power	8.98 mW / g
SAR normalized	normalized to 1W	89.8 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	89.8 mW / g ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.54 mW / g
SAR normalized	normalized to 1W	25.4 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	25.4 mW / g ± 19.5 % (k=2)

Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.5 ± 6 %	5.10 mho/m ± 6 %
Head TSL temperature during test	(22.0 ± 0.2) °C	----	----

SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	condition	
SAR measured	100 mW input power	8.39 mW / g
SAR normalized	normalized to 1W	83.9 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	83.9 mW / g ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.37 mW / g
SAR normalized	normalized to 1W	23.7 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	23.7 mW / g ± 19.5 % (k=2)

**Head TSL parameters at 5500 MHz**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.6	4.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.9 ± 6 %	4.80 mho/m ± 6 %
Head TSL temperature during test	(22.0 ± 0.2) °C	----	----

SAR result with Head TSL at 5500 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	condition	
SAR measured	100 mW input power	8.98 mW / g
SAR normalized	normalized to 1W	89.8 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	89.8 mW / g ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.54 mW / g
SAR normalized	normalized to 1W	25.4 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	25.4 mW / g ± 19.5 % (k=2)

Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.5 ± 6 %	5.10 mho/m ± 6 %
Head TSL temperature during test	(22.0 ± 0.2) °C	----	----

SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	condition	
SAR measured	100 mW input power	8.39 mW / g
SAR normalized	normalized to 1W	83.9 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	83.9 mW / g ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.37 mW / g
SAR normalized	normalized to 1W	23.7 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	23.7 mW / g ± 19.5 % (k=2)

**Body TSL parameters at 5200 MHz**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.0	5.30 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.4 ± 6 %	5.48 mho/m ± 6 %
Body TSL temperature during test	(21.0 ± 0.2) °C	----	----

SAR result with Body TSL at 5200 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	condition	
SAR measured	100 mW input power	7.70 mW / g
SAR normalized	normalized to 1W	77.0 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	76.8 mW / g ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.14 mW / g
SAR normalized	normalized to 1W	21.4 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	21.4 mW / g ± 19.5 % (k=2)

Body TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.6	5.65 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.8 ± 6 %	5.85 mho/m ± 6 %
Body TSL temperature during test	(21.0 ± 0.2) °C	----	----

SAR result with Body TSL at 5500 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	condition	
SAR measured	100 mW input power	8.22 mW / g
SAR normalized	normalized to 1W	82.2 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	82.0 mW / g ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.27 mW / g
SAR normalized	normalized to 1W	22.7 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	22.7 mW / g ± 19.5 % (k=2)

**Body TSL parameters at 5800 MHz**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.2	6.00 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.1 ± 6 %	6.22 mho/m ± 6 %
Body TSL temperature during test	(21.0 ± 0.2) °C	----	----

SAR result with Body TSL at 5800 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	condition	
SAR measured	100 mW input power	7.61 mW / g
SAR normalized	normalized to 1W	76.1 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	75.8 mW / g ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.10 mW / g
SAR normalized	normalized to 1W	21.0 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	20.9 mW / g ± 19.5 % (k=2)



Appendix

Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	$52.5 \Omega - 7.5 j\Omega$
Return Loss	-22.3 dB

Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	$48.9 \Omega - 1.7 j\Omega$
Return Loss	-33.8 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	$51.7 \Omega + 4.3 j\Omega$
Return Loss	-26.9 dB

Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	$53.0 \Omega - 6.6 j\Omega$
Return Loss	-23.1 dB

Antenna Parameters with Body TSL at 5500 MHz

Impedance, transformed to feed point	$49.4 \Omega - 1.4 j\Omega$
Return Loss	-36.4 dB

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	$52.2 \Omega + 3.8 j\Omega$
Return Loss	-27.3 dB



Product Service

General Antenna Parameters and Design

Electrical Delay (one direction)	1.207 ns
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After long term use with 40 W 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.

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, 2010

**DASY5 Validation Report for Head TSL**

Date/Time: 11.03.2011 14:54:17

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHz; Serial: D5GHzV2 - SN:1100

Communication System: CW; Frequency: 5200 MHz, Frequency: 5500 MHz, Frequency: 5800 MHz; Duty Cycle: 1:1

Medium: HSL 5000

Medium parameters used: $f = 5200$ MHz; $\sigma = 4.51$ mho/m; $\epsilon_r = 36.4$; $\rho = 1000$ kg/m³.Medium parameters used: $f = 5500$ MHz; $\sigma = 4.8$ mho/m; $\epsilon_r = 35.9$; $\rho = 1000$ kg/m³.Medium parameters used: $f = 5800$ MHz; $\sigma = 5.1$ mho/m; $\epsilon_r = 35.5$; $\rho = 1000$ kg/m³.

Phantom section: Flat Section

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

DASY5 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.41, 5.41, 5.41), ConvF(4.91, 4.91, 4.91), ConvF(4.81, 4.81, 4.81); Calibrated: 04.03.2011
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 10.06.2010
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- Measurement SW: DASY52, V52.6.2 Build (424)
- Postprocessing SW: SEMCAD X, V14.4.4 Build (2829)

Pin=100mW, f=5200 MHz/Zoom Scan (4x4x1.4mm), dist=1.4mm (8x8x7)/Cube 0:

Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 60.701 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 31.049 W/kg

SAR(1 g) = 8.31 mW/g; SAR(10 g) = 2.36 mW/g

Maximum value of SAR (measured) = 18.802 mW/g

Pin=100mW, f=5500 MHz/Zoom Scan (4x4x1.4mm), dist=1.4mm (8x8x7)/Cube 0:

Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 60.450 V/m; Power Drift = 0.07 dB

Peak SAR (extrapolated) = 35.828 W/kg

SAR(1 g) = 8.98 mW/g; SAR(10 g) = 2.54 mW/g

Maximum value of SAR (measured) = 21.257 mW/g

Pin=100mW, f=5800 MHz/Zoom Scan (4x4x1.4mm), dist=1.4mm (8x8x7)/Cube 0:

Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 57.226 V/m; Power Drift = 0.04 dB

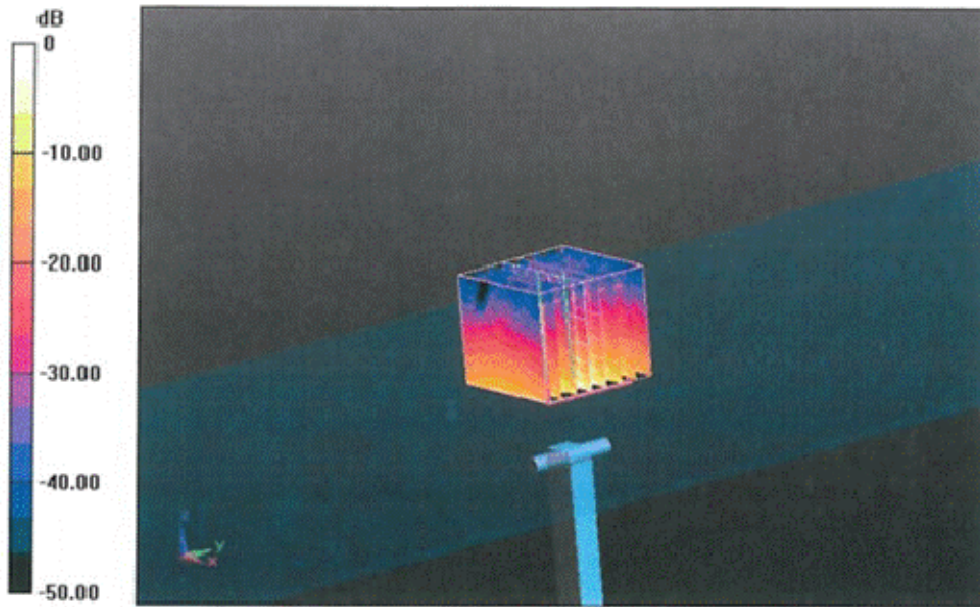
Peak SAR (extrapolated) = 35.431 W/kg

SAR(1 g) = 8.39 mW/g; SAR(10 g) = 2.37 mW/g

Maximum value of SAR (measured) = 20.329 mW/g



Product Service

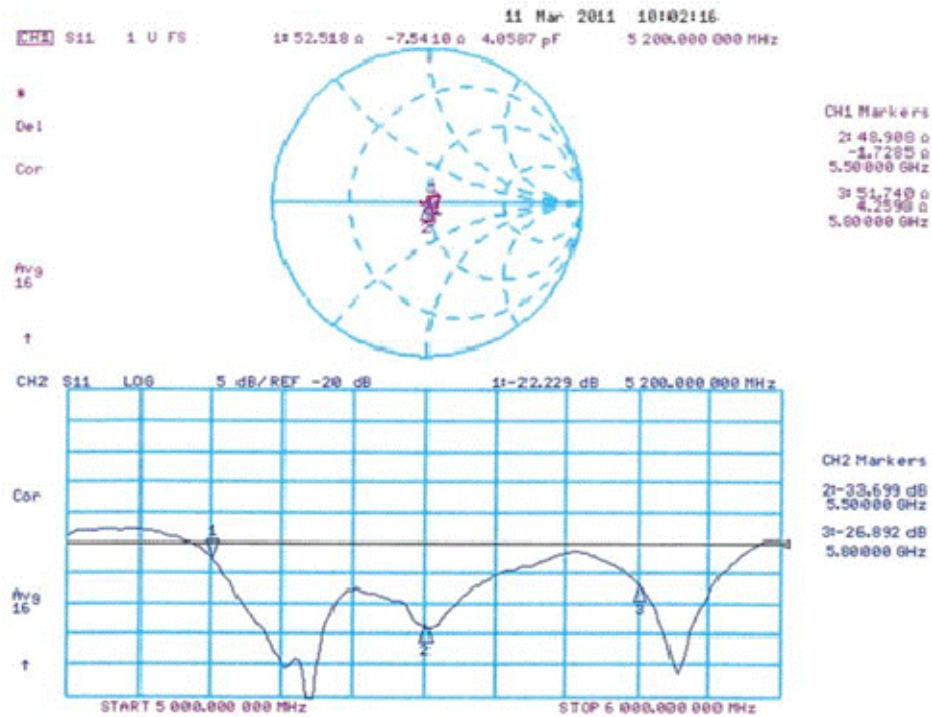


0 dB = 20.330mW/g



Product Service

Impedance Measurement Plot for Head TSL



**DASY5 Validation Report for Body TSL**

Date/Time: 14.03.2011 15:25:41

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHz; Serial: D5GHzV2 - SN:1100

Communication System: CW; Frequency: 5200 MHz, Frequency: 5500 MHz, Frequency: 5800 MHz; Duty Cycle: 1:1

Medium: MSL 5000 MHz

Medium parameters used: $f = 5200$ MHz; $\sigma = 5.54$ mho/m; $\epsilon_r = 48.3$; $\rho = 1000$ kg/m³,Medium parameters used: $f = 5500$ MHz; $\sigma = 5.92$ mho/m; $\epsilon_r = 47.7$; $\rho = 1000$ kg/m³,Medium parameters used: $f = 5800$ MHz; $\sigma = 6.3$ mho/m; $\epsilon_r = 47$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY5 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(4.91, 4.91, 4.91), ConvF(4.43, 4.43, 4.43), ConvF(4.38, 4.38, 4.38); Calibrated: 04.03.2011
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 10.06.2010
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- Measurement SW: DASY52, V52.6.2 Build (424)
- Postprocessing SW: SEMCAD X, V14.4.4 Build (2829)

Pin=100mW, f=5200 MHz/Zoom Scan (4x4x1.4mm), dist=1.4mm (8x8x7)/Cube 0:

Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 58.462 V/m; Power Drift = -0.0014 dB

Peak SAR (extrapolated) = 30.321 W/kg

SAR(1 g) = 7.7 mW/g; SAR(10 g) = 2.14 mW/g

Maximum value of SAR (measured) = 17.819 mW/g

Pin=100mW, f=5500 MHz/Zoom Scan (4x4x1.4mm), dist=1.4mm (8x8x7)/Cube 0:

Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 58.851 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 35.000 W/kg

SAR(1 g) = 8.22 mW/g; SAR(10 g) = 2.27 mW/g

Maximum value of SAR (measured) = 19.554 mW/g

Pin=100mW, f=5800 MHz/Zoom Scan (4x4x1.4mm), dist=1.4mm (8x8x7)/Cube 0:

Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 55.021 V/m; Power Drift = -0.03 dB

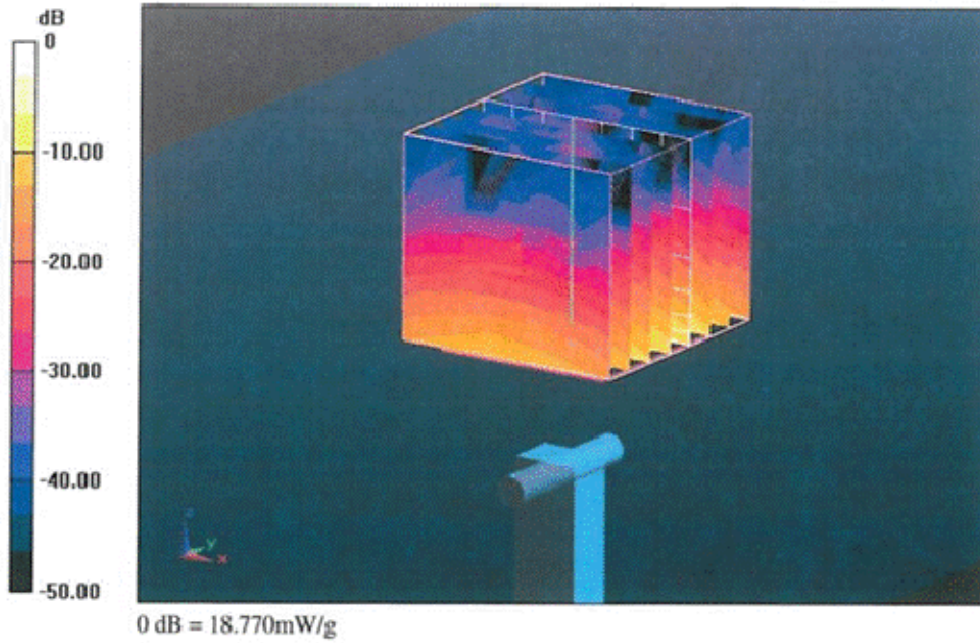
Peak SAR (extrapolated) = 35.337 W/kg

SAR(1 g) = 7.61 mW/g; SAR(10 g) = 2.1 mW/g

Maximum value of SAR (measured) = 18.772 mW/g



Product Service





Product Service

Impedance Measurement Plot for Body TSL

