The calibration was for CW signals only, and the axis of the probe was parallel to the direction of propagation of the incident field i.e. end-on to the incident radiation. The axial isotropy of the probe was measured by rotating the probe about its axis in 10 degree steps through 360 degrees in this orientation.

The reference point for the calibration is in the centre of the probe's cross-section at a distance of 2.7 mm from the probe tip in the direction of the probe amplifier. A value of 2.7 mm should be used for the tip to sensor offset distance in the software. The distance of 2.7mm for assembled probes has been confirmed by taking X-ray images of the probe tips (see Figure 5).

It is important that the diode compression point and air factors used in the software are the same as those quoted in the results tables, as these are used to convert the diode output voltages to a SAR value.

CALIBRATION EQUIPMENT

The table on page 19 indicates the calibration status of all test equipment used during probe calibration.

MEASUREMENT UNCERTAINTIES

A complete measurement uncertainty analysis for the SARA-C measurement system has been published in Reference [6]. Table 17 from that document is re-created below, and lists the uncertainty factors associated just with the calibration of probes.

Source of uncertainty	Uncertainty value ± %	Probability distribution	Divisor	c_i	Standard uncertainty ui ± %	v_i or v_{eff}
Forward power	3.92	N	1.00	1	3.92	∞
Reflected power	4.09	N	1.00	1	4.09	∞
Liquid conductivity	1.308	N	1.00	1	1.31	∞
Liquid permittivity	1.271	N	1.00	1	1.27	∞
Field homogeneity	3.0	R	1.73	1	1.73	∞
Probe positioning	0.22	R	1.73	1	0.13	∞
Field probe linearity	0.2	R	1.73	1	0.12	∞
Combined standard uncertainty		RSS			6.20	

At the 95% confidence level, therefore, the expanded uncertainty is ±12.4%

SUMMARY OF CAL FACTORS FOR PROBE IXP-050 S/N 0204

Relative Channel Sensitivities (to optimise Axial Isotropy)				
	X	Y	Z	
Air Factors*	91.78	66.90	81.32	$(V/m)^2/mV$
DCPs	100	100	100	mV

Measured Isotropy	(+/-) dB
Axial Isotropy*	0.05±0.01

Physical Information	
Sensor offset (mm)	2.7
Elbow – Tip dimension (mm)	0.0

Product Service

SAR Conversion Factors/ Boundary Corrections								
	Head Fluid				Body Fluid			
Frequency* (MHz)	SAR Conv Factor	Boundary Correction f(0)	Boundary Correction d(mm)		SAR Conv Factor	Boundary Correction f(0)	Boundary Correction d(mm)	Notes
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 ±100MHz (F<300MHz) and ±200MHz (F>300MHz).

Product Service

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) N.B. only measured to > 100 W/kg on representative probes	>100	>100	100

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.

Product Service

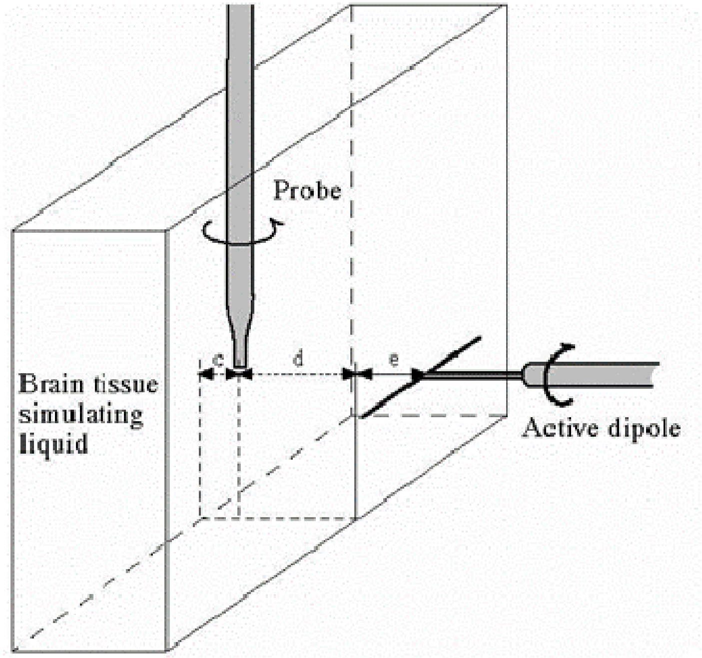


Figure 1. Spherical isotropy jig showing probe, dipole and box filled with simulated brain liquid (see Ref [2], Section A.5.2.1)

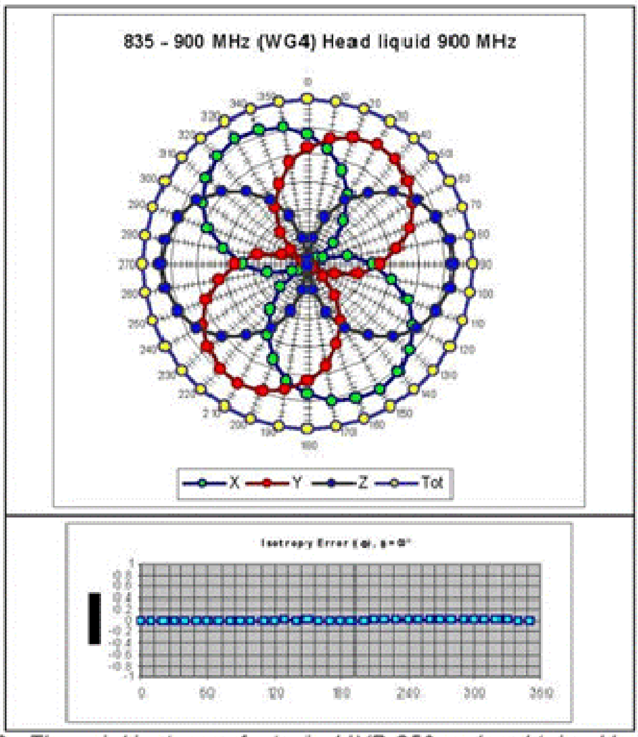


Figure 2. The axial isotropy of a typical IXP-050 probe obtained by rotating the probe in a liquid-filled waveguide at 900 MHz. (NB Axial Isotropy is largely frequency- independent)

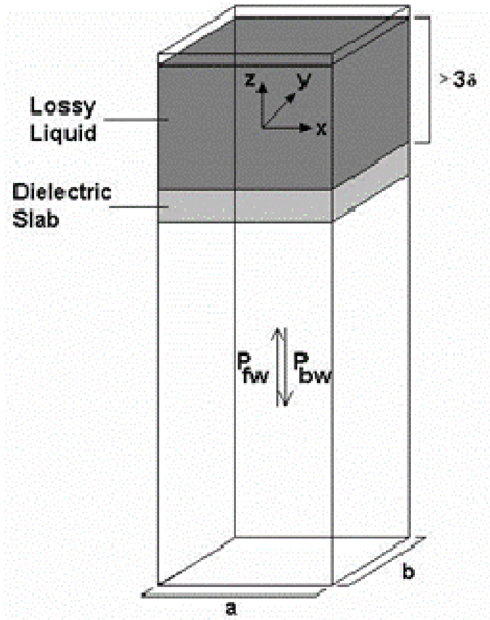
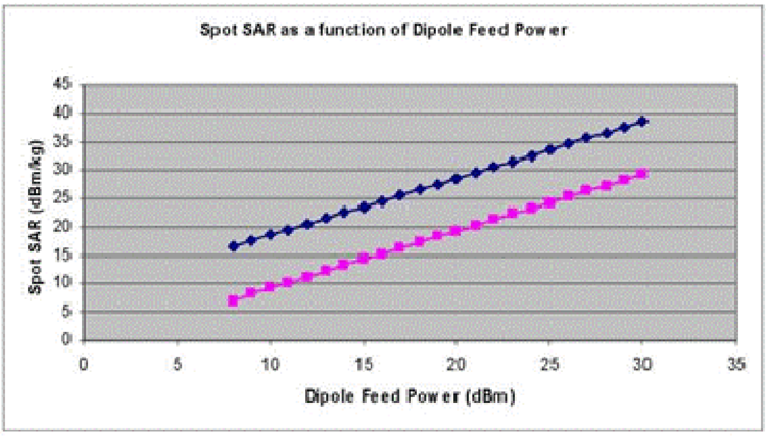


Figure 3. Geometry used for waveguide calibration (after Ref [2]. Section A.3.2.2)

Product Service



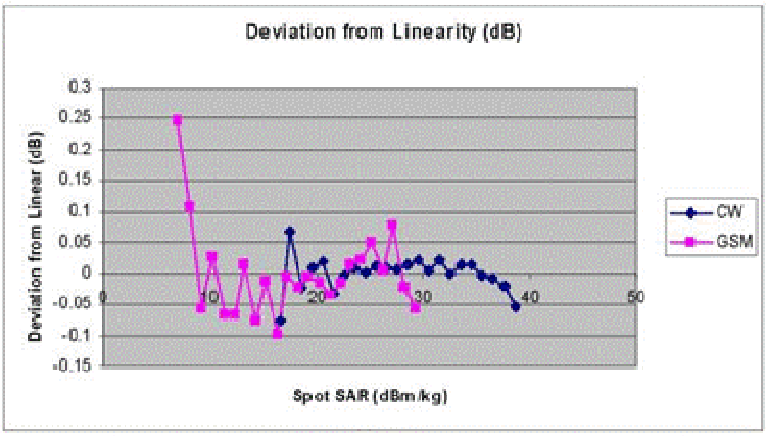


Figure 4 : The typical linearity response of IXP-050 probes to both CW (blue) and GSM (pink) modulation in close proximity to a source dipole. The top diagram shows the SAR reading as a function of dipole feed power, with GSM modulation being approx a factor of 8 (ie 9dB) lower than CW. The lower diagram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

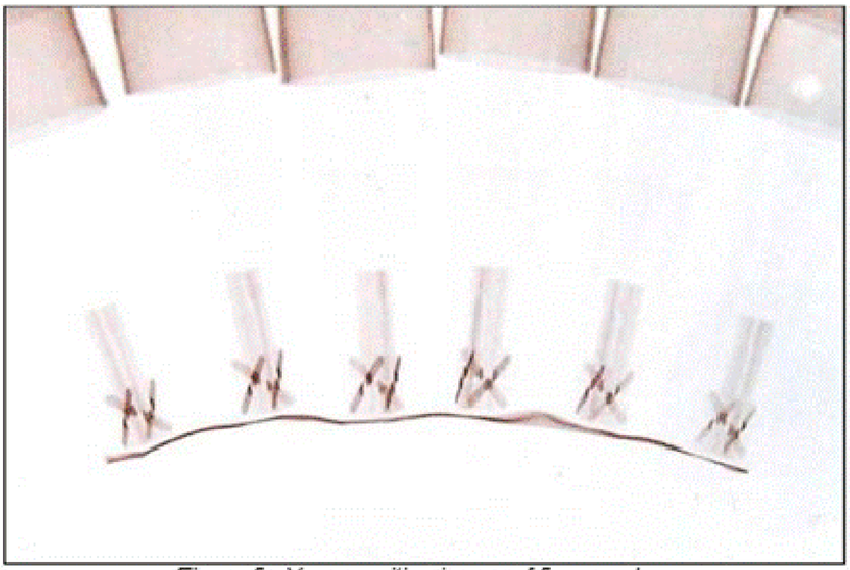


Figure 5 : X-ray positive image of 5mm probes

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	1.966	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	1O-300287035	1	14/08/2015
Power sensor	Rohde & Schwarz	NRP-Z23	100169	06/08/2014	1400-48811	2	06/08/2016
Dielectric property measurement	Indexsar	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	RIMA20027002	3	17/02/2016
SMA autocalibration module	Anritsu	36581KKF/1	001902	22/01/2015	RIMA20021769	4	22/01/2016

TÜV SÜD
Product Service

Annex 1

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

ROHDE&SCHWARZ

Calibration Certificate — Kalibrierschein

Certificate Number 10-300287035 — 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

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 lagen im Regelfall mit einer Wahrscheinlichkeit von annähernd 95% im zugeordneten Werteintervall (Erweiterte Messunsicherheit mit k = 2).
Die Kalibrierung erfolgte mit Messmitteln und Normalen, 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.

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

Page 1/2

ROHDE & SCHWARZ GmbH & Co KG · Mühldorfstraße 15 · D-81671 München, Federal Republic of Germany · Telefon (089) 41 29-0 · Telefax (089) 41 29-132 75
Geschäftsführung: Manfred Fleischmann (Vorsitzender), Christian Leicher, Gerhard Geier
Sitz München · Registereintrag: HRA 16 270 · Persönlich haftender Gesellschafter: RUSEG Verwaltungs-GmbH · Sitz München · Registereintrag: AG München HRB 7 534

TÜV SÜD
Product Service

Material Number 1137.8002.02 Serial Number 100063 **Certificate Number 10-300287035**

Calibration Method / Kalibrieranweisung: NRVC-1109.0930.32

Relative Humidity / Relative Luftfeuchte: 20%-60%

Ambient Temperature / Umgebungstemperatur: $(23\ ^{+1}_{-1})$ °C

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-10101-2011-08	2013-10-31
Acess 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.

TÜV SÜD

Product Service

Annex 2

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

ROHDE&SCHWARZ

Calibration Certificate
Kalibrierschein

Certificate Number / Zertifikatsnummer: **1400-48811**

Unit data

Item / Gegenstand	AVERAGE POWER SENSOR		
Manufacturer / Hersteller	Rohde & Schwarz		
Type / Typ	NRP-Z23		
Material number / Materialnummer	1137.8002.02	Serial number / Seriennummer	ID: 1137.8002.02-100169-aj Ser.: 100169
Asset number / Anlagennummer		Recomended Calibration Interval	24 Months

Order data

Customer / Auftraggeber	IndexSAR Ltd Oakfield House, Newdigate RH5 5BG Great Britain
On behalf of (where applicable) / In namen von (Wenn gewunscht)	
Order number / Bestellungnummer	1024R&S
Date of receipt / Eingangsdatum	2014-08-06 (YYYY-MM-DD)

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	

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 essentially with the technical requirements of 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 lagen im Regelfall mit einer Wahrscheinlichkeit von annähernd 95% im zugeordneten Werteintervall (Erweiterte Messunsicherheit mit k = 2).
Die Kalibrierung erfolgte mit Messmitteln und Normalen, 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 im Wesentlichen den technischen Anforderungen der 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 Unterschriften sind ungültig.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.

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. Ancells Business Park, Fleet Hampshire. GU51 2UZ. United Kingdom
Registered in England No. 539857

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 (YYYY-MM-DD)
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.

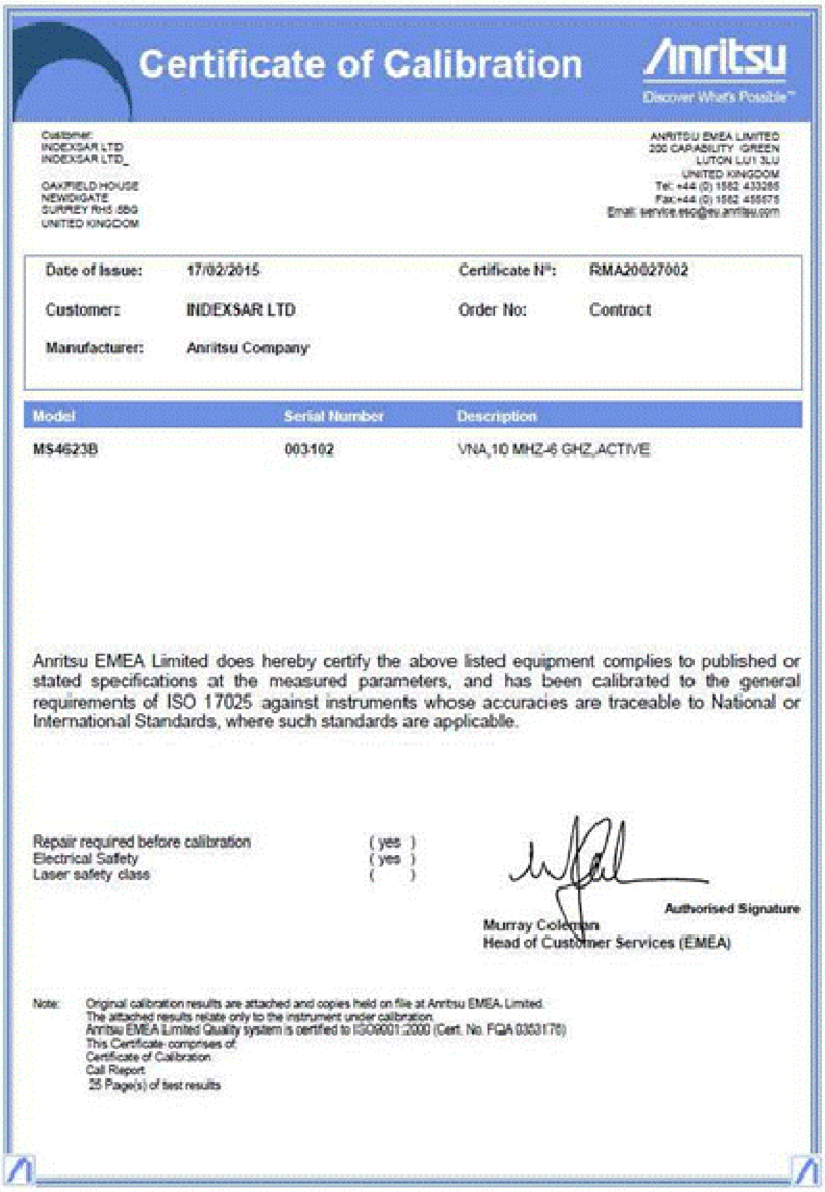
Ref.: ILAC-G8:1996 "Guidelines on Assessment and Reporting of Compliance with Specification (based on measurements and tests in a laboratory)"

Notes
Anmerkungen

Page (Seite) 2 of 2

Annex 3

Calibration certificate of Anritsu MS4623B VNA



Certificate of Calibration

Anritsu
Discover What's Possible™

Customer:
INDEXSAR LTD
INDEXSAR LTD_

OAKFIELD HOUSE
NEWDIGATE
SURREY RH5 5BG
UNITED KINGDOM

ANRITSU EMEA LIMITED
200 CAPABILITY GREEN
LUTON LU1 3LU
UNITED KINGDOM
Tel: +44 (0) 1582 433285
Fax:+44 (0) 1582 456675
Email: service.esc@eu.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)
Electrical Safety (yes)
Laser safety class ( )

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 0353178)
This Certificate comprises of:
Certificate of Calibration
Call Report
25 Page(s) of test results

TÜV SÜD 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
NEWDIGATE
SURREY RH5 5BG
UNITED KINGDOM

ANRITSU EMEA LIMITED
200 CAPABILITY GREEN
LUTON LU1 3LU
UNITED KINGDOM
Tel: +44 (0) 1 582 433285
Fax: +44 (0) 1 582 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	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)
Repair required before calibration	(no)
Electrical Safety	(yes)
Laser safety class	( )

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

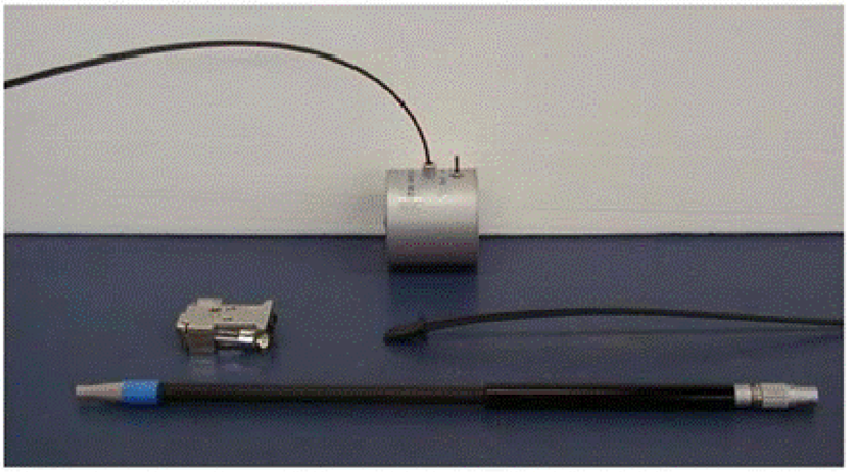
IMMERSIBLE SAR PROBE

CALIBRATION REPORT

Part Number: IXP – 050

S/N 0231

March 2015



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Fax: +44 (0) 1306 631 834
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Product Service

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Calibration Certificate 1503/0231
Date of Issue: 31 March 2015
Immersible SAR Probe

Type:	IXP-050
Manufacturer:	IndexSAR, UK
Serial Number:	0231
Place of Calibration:	IndexSAR, UK
Date of Receipt of Probe:	10 February 2015
Calibration Dates:	25 February– 13 March 2015
Customer:	TUV Sud

IndexSAR Ltd hereby declares that the IXP-050 Probe named above has been calibrated for conformity to the current versions of IEEE 1528, IEC 62209-1, IEC 62209-2, and FCC SAR standards using the methods described in this calibration document. Where applicable, the standards used in the calibration process are traceable to the UK's National Physical Laboratory.

Calibrated by:	[signature]	**Engineer**
Approved by:	[signature]	**Director**

Please keep this certificate with the calibration document. When the probe is sent for a calibration check, please include the calibration document.

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INTRODUCTION

Straight probes work on either SARA-C (to measure SAR values in flat phantoms containing Body tissue simulant fluid), or on SARA2 (where they, too, can measure in a flat phantom with Body fluid, or in a SAM phantom containing Head fluid).

This Report presents measured calibration data for a particular Indexsar SAR probe (S/N 0231) for use on SARA-C only. **The calibration factors do not apply to, and will not give correct readings on, the IndexSAR SARA2 system.**

Indexsar probes are characterised using procedures that, where applicable, follow the recommendations of IEC 62209-1 [Ref 1], IEEE 1528 [Ref 2], IEC 62209-2 [Ref 3] and FCC [Ref 4] standards. The procedures incorporate techniques for probe linearisation, isotropy assessment and determination of liquid factors (conversion factors). Calibrations are determined by comparing probe readings with analytical computations in canonical test geometries (waveguides) using normalised power inputs.

Each step of the calibration procedure and the equipment used is described in the sections below.

CALIBRATION PROCEDURE

1. Objectives

The calibration process comprises the following stages

1) Determination of the channel sensitivity factors which optimise the probe's overall axial isotropy

2) Channel sensitivity factors are largely frequency independent. Consequently, they can be combined to model the exponential decay of SAR in a waveguide fluid cell at each frequency of interest, and hence derive the liquid conversion factors at that frequency.

2. Probe output

The probe channel output signals are linearised in the manner set out in Refs [1] - [4]. The following equation is utilized for each channel:

$$U_{lin} = U_{o/p} + U_{o/p}{}^{2} / DCP \qquad (1)$$

where U_{lin} is the linearised signal, $U_{o/p}$ is the raw output signal in mV and DCP is the diode compression potential, also in mV.

DCP is determined from fitting equation (1) to measurements of U_{lin} versus source feed power over the full dynamic range of the probe. The DCP is a characteristic of the Schottky diodes used as the sensors. For the IXP-020 probes with CW signals the DCP values are typically 100mV.

For this value of DCP, the typical linearity response of IXP-050 probes to CW and to GSM modulation is shown in Figure 4, along with departures of this same dataset from linearity.

In turn, measurements of E-field are determined using the following equation:

$$E_{liq}^2\ (V/m) = U_{linx} * \text{Air Factor}_x * \text{Liq Factor}_x + U_{liny} * \text{Air Factor}_y * \text{Liq Factor}_y + U_{linz} * \text{Air Factor}_z * \text{Liq Factor}_z \quad (3)$$

Here, "Air Factor" represents each channel's sensitivity, while "Liq Factor" represents the enhancement in signal level when the probe is immersed in tissue-simulant liquids at each frequency of interest.

3. Selecting channel sensitivity factors to optimise isotropic response

Within SARA-C, an L-probe's predominant mode of operation is with the tip pointing directly towards the source of radiation. Consequently, optimising the probe's response to boresight signals ("axial isotropy") is far more important than optimising its spherical isotropy (where the direction, as well as the polarisation angle, of the incoming radiation must be taken into account).

The setup for measuring the probe's axial isotropy is shown in Figure 1. Since isotropy is frequency-independent, measurements are normally made at a frequency of 900MHz as lower frequencies are more tolerant of positional inaccuracies.

A 900MHz waveguide containing head-fluid simulant is selected. Like all waveguides used during probe calibration, this particular waveguide contains two distinct sections: an air-filled launcher section, and a liquid cell section, separated by a dielectric matching window designed to minimise reflections at the air-liquid interface.

The waveguide stands in an upright position and the liquid cell section is filled with 900MHz brain fluid to within 10 mm of the open end. The depth of liquid ensures there is negligible radiation from the waveguide open top and that the probe calibration is not influenced by reflections from nearby objects.

During the measurement, a TE_{01} mode is launched into the waveguide by means of an N-type-to-waveguide adapter. The probe is then lowered vertically into the liquid until the tip is exactly 10mm above the centre of the dielectric window. This particular separation ensures that the probe is operating in a part of the waveguide where boundary corrections are not necessary.

Care must also be taken that the probe tip is centred while rotating.

The exact power applied to the input of the waveguide during this stage of the probe calibration is immaterial since only relative values are of interest while the probe rotates. However, the power must be sufficiently above the noise floor and free from drift.

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The dedicated Indexsar calibration software rotates the probe in 10 degree steps about its axis, and at each position, an Indexsar 'Fast' amplifier samples the probe channels 500 times per second for 0.4 s. The raw $U_{o/p}$ data from each sample are packed into 10 bytes and transmitted back to the PC controller via an optical cable. U_{linx}, U_{liny} and U_{linz} are derived from the raw $U_{o/p}$ values and written to an Excel template.

Once data have been collected from a full probe rotation, the Air Factors are adjusted using a special Excel Solver routine to equalise the output from each channel and hence minimise the axial isotropy. This automated approach to optimisation removes the effect of human bias.

Figure 2 represents the output from each diode sensor as a function of probe rotation angle.

4. Determination of Conversion ("Liquid") Factors at each frequency of interest

A lookup table of conversion factors for a probe allows a SAR value to be derived at the measured frequencies, and for either brain or body fluid-simulant.

The method by which the conversion factors are assessed is based on the comparison between measured and analytical rates of decay of SAR with height above a dielectric window. This way, not only can the conversion factors for that frequency/fluid combination be determined, but an allowance can also be made for the scale and range of boundary layer effects.

The theoretical relationship between the SAR at the cross-sectional centre of the lossy waveguide as a function of the longitudinal distance (*z*) from the dielectric separator is given by Equation 4:

$$SAR(z) = \frac{4\left(P_f - P_b\right)}{\rho ab\delta} e^{-2z/\delta} \qquad (4)$$

Here, the density ρ is conventionally assumed to be 1000 kg/m^3, *ab* is the cross-sectional area of the waveguide, and P_f and P_b are the forward and reflected power inside the lossless section of the waveguide, respectively. The penetration depth δ (which is the reciprocal of the waveguide-mode attenuation coefficient) is a property of the lossy liquid and is given by Equation (5).

$$\delta = \left[\mathrm{Re}\left\{ \sqrt{(\pi / a)^2 + j\omega\mu_o\left(\sigma + j\omega\varepsilon_o\varepsilon_r\right)} \right\} \right]^{-1} \qquad (5)$$

where σ is the conductivity of the tissue-simulant liquid in S/m, ε_r is its relative permittivity, and ω is the radial frequency (rad/s). Values for σ and ε_r are obtained prior to each waveguide test using an Indexsar DiLine measurement kit, which uses the TEM method as recommended in [2]. σ and ε_r are both

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temperature- and fluid-dependent, so are best measured using a sample of the tissue-simulant fluid immediately prior to the actual calibration.

Wherever possible, all DiLine and calibration measurements should be made in the open laboratory at 22 $\pm$ 2.0°C; if this is not possible, the values of σ and ε_r should reflect the actual temperature. Values employed for calibration are listed in the tables below.

By ensuring the liquid height in the waveguide is at least three penetration depths, reflections at the upper surface of the liquid are negligible. The power absorbed in the liquid is therefore determined solely from the waveguide forward and reflected power.

Different waveguides are used for 700MHz, 835/900MHz, 1450MHz, 1800/1900MHz, 2100/2450/2600MHz and 5200/5800MHz measurements. Table A.1 of [1] can be used for designing calibration waveguides with a return loss greater than 20 dB at the most important frequencies used for personal wireless communications, and better than 15dB for frequencies greater than 5GHz. Values for the penetration depth for these specific fixtures and tissue-simulating mixtures are also listed in Table A.1.

According to [1], this calibration technique provides excellent accuracy, with standard uncertainty of less than 3.6% depending on the frequency and medium. The calibration itself is reduced to power measurements traceable to a standard calibration procedure. The practical limitation to the frequency band of 800 to 5800 MHz because of the waveguide size is not severe in the context of compliance testing.

During calibration, the probe is lowered carefully until it is just touching the cross-sectional centre of the dielectric window. 240 samples are then taken and written to an Excel template file before moving the probe vertically upwards. This cycle is repeated 150 times. The vertical separation between readings is determined from practical considerations of the expected SAR decay rate, and range from 0.35mm steps below 3GHz, down to 0.05mm at 5GHz.

Once the data collection is complete, a Solver routine is run which optimises the measured-theoretical fit by varying the conversion factor, and the boundary correction size and range.

For calibrations at 450MHz, where waveguide calibrations become unfeasible, a full 3D SAR scan over a tuned dipole is performed, and the conversion factor adjusted to make the measured 1g and 10g volume-averaged SAR values agree with published targets.

CALIBRATION FACTORS MEASURED FOR PROBE S/N 0231

The probe was calibrated at 700, 835, 900, 1800, 1900, 2100, 2450 and 2600 MHz in liquid samples representing brain and body liquid at these frequencies.

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The calibration was for CW signals only, and the axis of the probe was parallel to the direction of propagation of the incident field i.e. end-on to the incident radiation. The axial isotropy of the probe was measured by rotating the probe about its axis in 10 degree steps through 360 degrees in this orientation.

The reference point for the calibration is in the centre of the probe's cross-section at a distance of 2.7 mm from the probe tip in the direction of the probe amplifier. A value of 2.7 mm should be used for the tip to sensor offset distance in the software. The distance of 2.7mm for assembled probes has been confirmed by taking X-ray images of the probe tips (see Figure 5).

It is important that the diode compression point and air factors used in the software are the same as those quoted in the results tables, as these are used to convert the diode output voltages to a SAR value.

CALIBRATION EQUIPMENT

The table on page 19 indicates the calibration status of all test equipment used during probe calibration.

MEASUREMENT UNCERTAINTIES

A complete measurement uncertainty analysis for the SARA-C measurement system has been published in Reference [6]. Table 17 from that document is re-created below, and lists the uncertainty factors associated just with the calibration of probes.

Source of uncertainty	Uncertainty value ± %	Probability distribution	Divisor	c_i	Standard uncertainty ui ± %	v_i or V_{eff}
Forward power	3.92	N	1.00	1	3.92	∞
Reflected power	4.09	N	1.00	1	4.09	∞
Liquid conductivity	1.308	N	1.00	1	1.31	∞
Liquid permittivity	1.271	N	1.00	1	1.27	∞
Field homogeneity	3.0	R	1.73	1	1.73	∞
Probe positioning	0.22	R	1.73	1	0.13	∞
Field probe linearity	0.2	R	1.73	1	0.12	∞
Combined standard uncertainty		RSS			6.20	

At the 95% confidence level, therefore, the expanded uncertainty is ±12.4%

SUMMARY OF CAL FACTORS FOR PROBE IXP-050 S/N 0231

Relative Channel Sensitivities (to optimise Axial Isotropy)				
	X	Y	Z	
Air Factors*	75.38	86.20	78.42	$(V/m)^2/mV$
DCPs	100	100	100	mV

Measured Isotropy	(+/-) dB
Axial Isotropy*	0.05±0.01

Physical Information	
Sensor offset (mm)	2.7
Elbow – Tip dimension (mm)	0.0

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SAR Conversion Factors/ Boundary Corrections							
	Head Fluid			Body Fluid			
Frequency* (MHz)	SAR Conv Factor	Boundary Correction f(0)	Boundary Correction d(mm)	SAR Conv Factor	Boundary Correction f(0)	Boundary Correction d(mm)	Notes
450	0.274	1.00	1.90	0.270	0.80	1.66	3
700	0.268	0.86	1.51	0.270	0.92	1.53	1,2
835	0.292	1.09	1.43	0.291	0.50	1.67	1,2
900	0.298	0.73	1.62	0.289	0.87	1.40	1,2
1800	0.348	0.66	1.93	0.365	0.46	2.06	1,2
1900	0.362	0.60	1.83	0.386	0.48	1.82	1,2
2100	0.382	0.66	2.28	0.448	0.58	1.49	1,2
2450	0.407	1.08	1.41	0.447	1.00	1.56	1,2
2600	0.407	1.19	1.67	0.449	0.87	1.21	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 ±100MHz (F<300MHz) and ±200MHz (F>300MHz).

PROBE SPECIFICATIONS

Indexsar probe 0231, 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 0231	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 0231	BSEN [1]	IEEE [2]
Minimum (W/kg)	0.01	<0.02	0.01
Maximum (W/kg) N.B. only measured to > 100 W/kg on representative probes	>100	>100	100

Isotropy (measured at 900MHz)	S/N 0231	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.

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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.

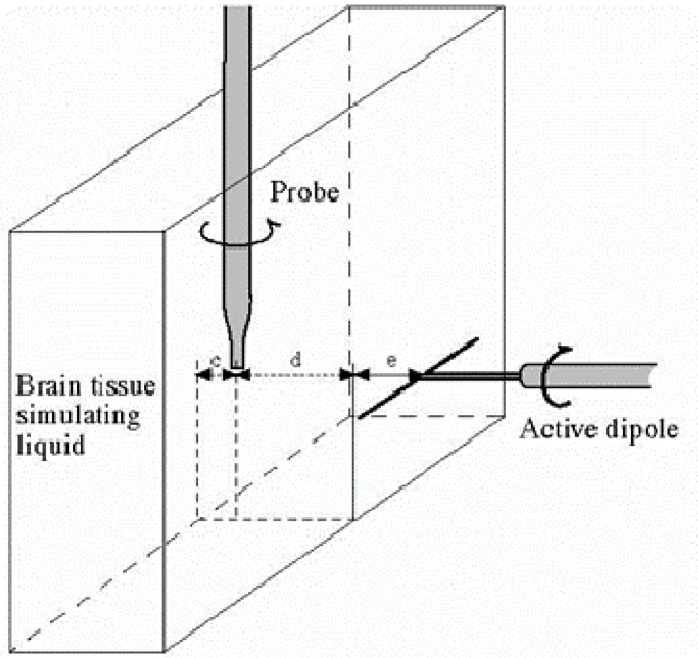


Figure 1. Spherical isotropy jig showing probe, dipole and box filled with simulated brain liquid (see Ref [2], Section A.5.2.1)

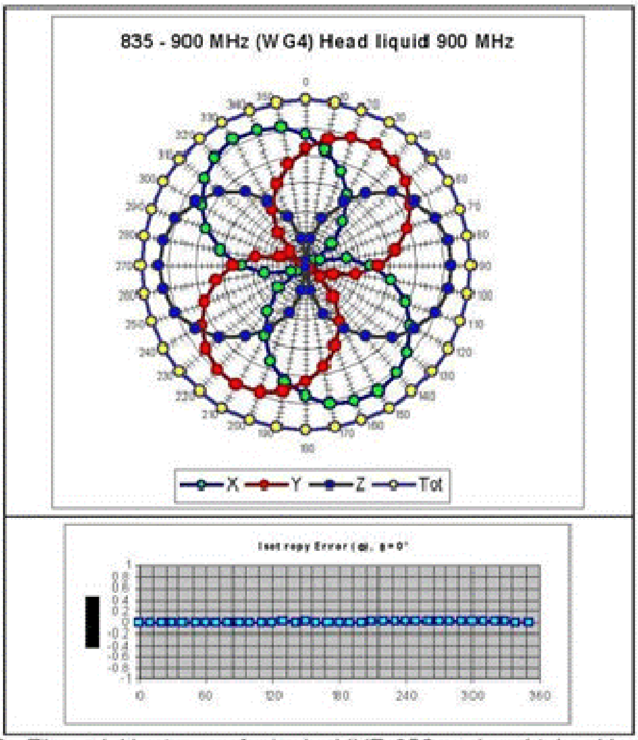


Figure 2. The axial isotropy of a typical IXP-050 probe obtained by rotating the probe in a liquid-filled waveguide at 900 MHz. (NB Axial Isotropy is largely frequency- independent)

Product Service

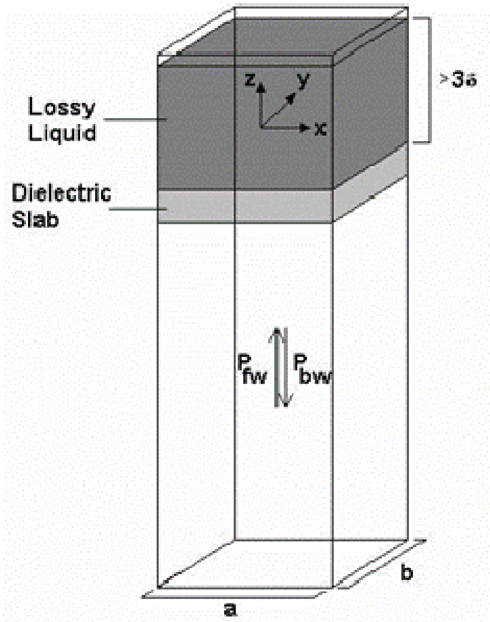
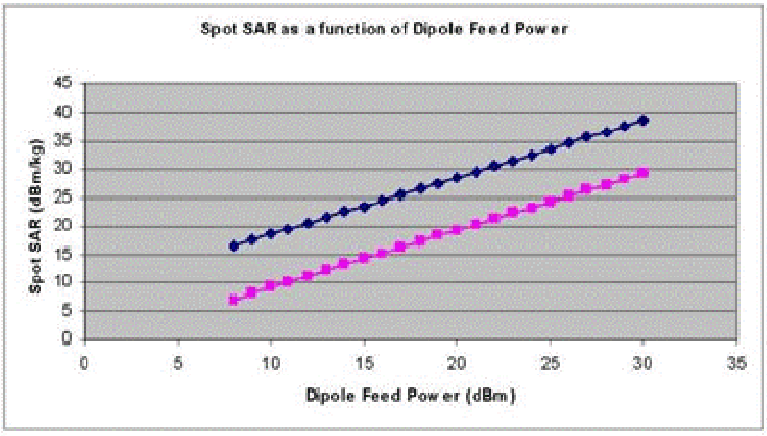


Figure 3. Geometry used for waveguide calibration (after Ref [2]. Section A.3.2.2)



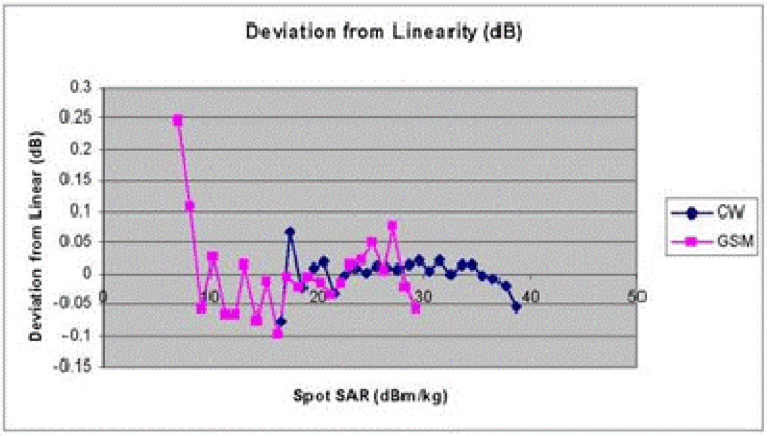


Figure 4 : The typical linearity response of IXP-050 probes to both CW (blue) and GSM (pink) modulation in close proximity to a source dipole. The top diagram shows the SAR reading as a function of dipole feed power, with GSM modulation being approx a factor of 8 (ie 9dB) lower than CW. The lower diagram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

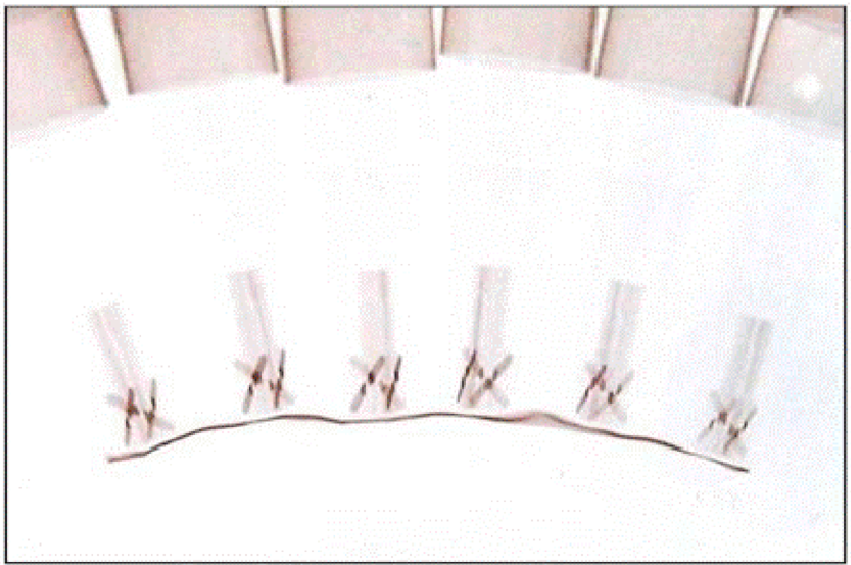


Figure 5 : X-ray positive image of 5mm probes

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	43.546	0.866	43.5	0.87	0.1	-0.5	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		39.628	1.408	40.0	1.40	-0.9	0.6	Pass	Pass
1900		40.052	1.403	40.0	1.40	0.1	0.2	Pass	Pass
2100		40.315	1.513	39.8	1.49	1.3	1.5	Pass	Pass
2450		39.226	1.765	39.2	1.80	0.1	-1.9	Pass	Pass
2600		38.664	1.942	39.0	1.96	-0.9	-0.9	Pass	Pass
450	Body	56.85	0.943	56.7	0.94	0.3	0.3	Pass	Pass
700		55.968	0.963	55.73	0.96	0.4	0.4	Pass	Pass
835		55.584	0.977	55.2	0.97	0.7	0.7	Pass	Pass
900		54.943	1.043	55	1.05	-0.1	-0.7	Pass	Pass
1800		52.807	1.516	53.3	1.52	-0.9	-0.3	Pass	Pass
1900		52.965	1.524	53.3	1.52	-0.6	0.3	Pass	Pass
2100		53.858	1.601	53.2	1.62	1.2	-1.2	Pass	Pass
2450		52.774	1.972	52.7	1.95	0.1	1.1	Pass	Pass
2600		52.354	2.175	52.5	2.16	-0.3	0.7	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	Indexsar	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	36581KKF/1	001902	22/01/2015	RMA20021769	4	22/01/2016

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Annex 1

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

ROHDE&SCHWARZ

Calibration Certificate
Kalibrierschein

Certificate Number 10-300287035
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

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 lagen im Regelfall mit einer Wahrscheinlichkeit von annähernd 95% im zugeordneten Werteintervall (Erweiterte Messunsicherheit mit k = 2).
Die Kalibrierung erfolgte mit Messmitteln und Normalen, 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.

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

Page 1/2

ROHDE & SCHWARZ GmbH & Co KG · Mühldorfstraße 15 · D-81671 München, Federal Republic of Germany · Telefon (089) 41 29-0 · Telefax (089) 41 29-132 75
Geschäftsführung: Manfred Fleischmann (Vorsitzender), Christian Leicher, Gerhard Geier
Sitz München · Registereintrag HRA 16 270 · Persönlich haftender Gesellschafter: RUSEG Verwaltungs-GmbH · Sitz München · Registereintrag AG München HRB 7 534

TÜV SÜD Product Service

Material Number 1137.8002.02 Serial Number 100063

Certificate Number 10-300287035

Calibration Method / Kalibrieranweisung: NRVC-1109.0930.32

Relative Humidity / Relative Luftfeuchte: 20%-60%

Ambient Temperature / Umgebungstemperatur: (23 $^{+1}_{-1}$) °C

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	828.583/0023	0113 D-K-15195-01-00 2013-08	2014-11-30
Vector Network Analyzer	ZVM	835.228/0020	0102-DKD-K-16101-2011-08	2013-10-31
Acess 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	2706A00160	217-01723 [METAS]	2015-03-31
Power Standard	NRVC	836.497/0005	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** / Zertifikatsnummer: **1400-48811**

Unit data

Item / Gegenstand	AVERAGE POWER SENSOR
Manufacturer / Hersteller	Rohde & Schwarz
Type / Typ	NRP-Z23
Material number / Materialnummer	1137.8002.02
Serial number / Seriennummer	ID: 1137.8002.02-100169-aj; Ser.: 100169
Asset number / Anlagennummer	
Recomended Calibration Interval	24 Months

Order data

Customer / Auftraggeber	IndexSAR Ltd Oakfield House, Newdigate RH6 6BG Great Britain
On behalf of (where applicable) / In namen von (Wenn gewunscht)	
Order number / Bestellungnummer	1024R&S
Date of receipt / Eingangsdatum	2014-08-06 (YYYY-MM-DD)

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

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 essentially with the technical requirements of 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 lagen im Regelfall mit einer Wahrscheinlichkeit von annähernd 95% im zugeordneten Werteintervall (Erweiterte Messunsicherheit mit k = 2). Die Kalibrierung erfolgte mit Messmitteln und Normalen, 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 im Wesentlichen den technischen Anforderungen der 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 Unterschriften sind ungültig. Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.

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. Ancells Business Park, Fleet Hampshire GU51 2UZ, United Kingdom
Registered in England No. 539807

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 (YYYY-MM-DD)
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

TÜV SÜD
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
NEWDIGATE
SURREY RH5 5BG
UNITED KINGDOM

ANRITSU EMEA LIMITED
200 CAPABILITY GREEN
LUTON LU1 3LU
UNITED KINGDOM
Tel: +44 (0) 1582 433285
Fax:+44 (0) 1582 456875
Email: service.esc@eu.anritsu.com

Date of Issue:	17/02/2015	Certificate Nº:	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)
Electrical Safety	(yes)
Laser safety class	( )

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
25 Page(s) of test results

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
NEWDIGATE
SURREY RH5 5BG
UNITED KINGDOM

ANRITSU EMEA LIMITED
200 CAPABILITY GREEN
LUTON LU1 3LU
UNITED KINGDOM
Tel: +44 (0) 1582 433285
Fax:+44 (0) 1582 456575
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	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)
Repair required before calibration	(no)
Electrical Safety	(yes)
Laser safety class	( )

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
Cal Report
13 Page(s) of test results

ANNEX B

DIPOLE CALIBRATION REPORTS

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 **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: 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°C ±3°C @ 43.9% RH ±10% RH. The mains voltage was 240V ±10%.

Calibration Engineer:__________ ______________________

N. R. Grigsby

Approved Signatory:__________ ______________________

A. T. Pearce

Product Service

Report № 26553
Page 2 of 6

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	Hygromer	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

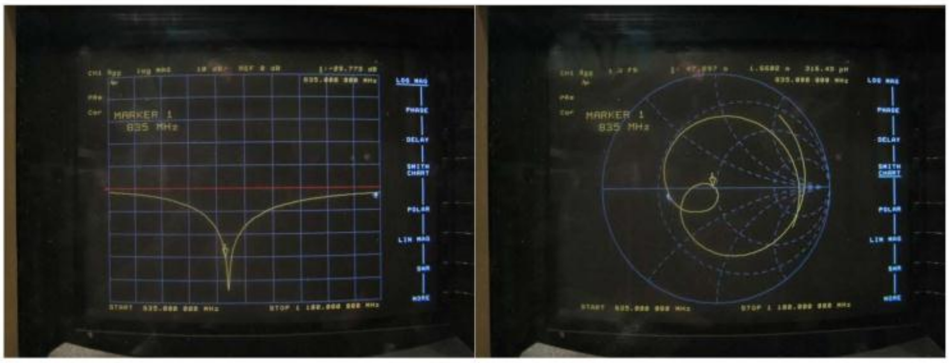
Product Service

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).

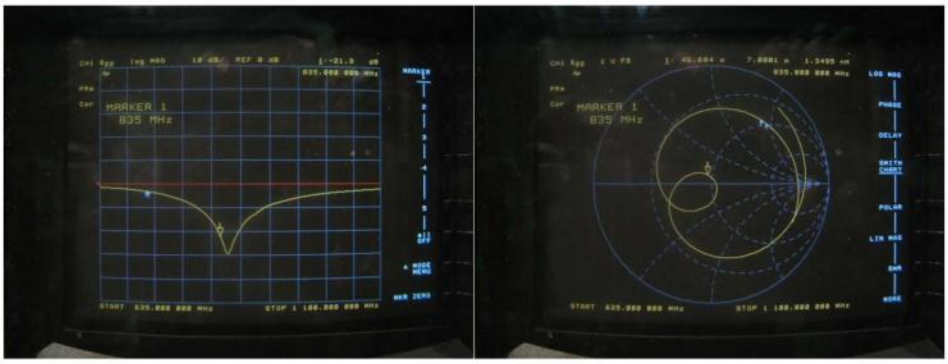
The impedance was measured at the SMA-connector with the network analyser.
The following parameters were measured against Head fluid:



Dipole impedance at 835MHz	Re{Z} = 47.30 Ω Im{Z} = 1.56 Ω
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	Re{Z} = 46.68 Ω	
	Im{Z} = 7.08 Ω	
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

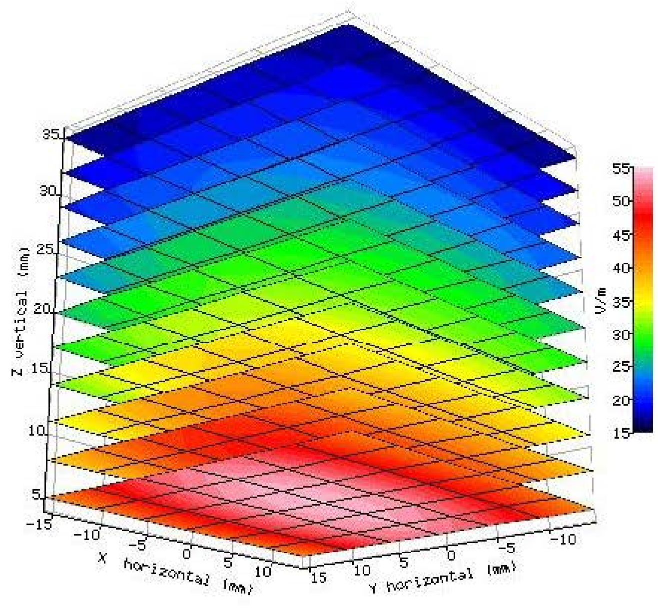
SAR validation checks have been performed using the 835MHz dipole and the box-phantom located on the SARA-C phantom support base on the SARA-C robot system. Tests were then conducted at a feed power level of approx. 0.25W. The actual power level was recorded and used to normalise the results obtained 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 Indexsar 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 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	2.65	10.55	1.93	10.35
10g SAR	1.73	6.88	2.12	6.74

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

SAR Measurement in Body Fluid

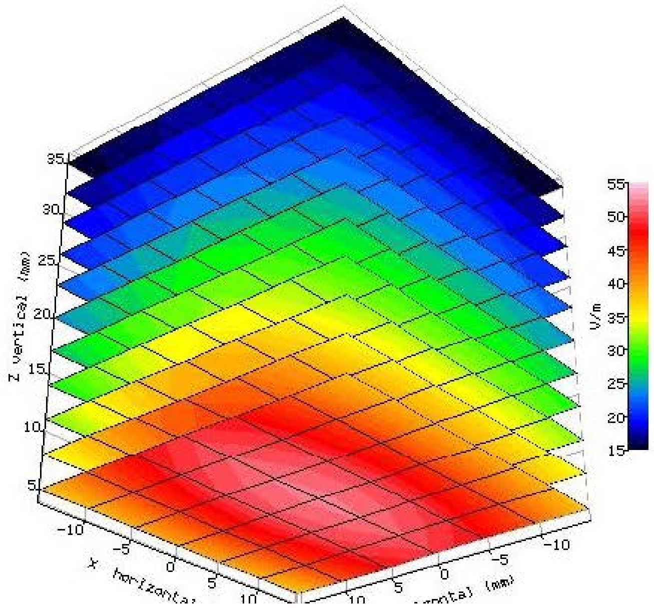
SAR validation checks have been performed using the 835MHz dipole and the box-phantom located on the SARA-C phantom support base on the SARA-C robot system. Tests were then conducted at a feed power level of approx. 0.25W. The actual power level was recorded and used to normalise the results obtained 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 Indexsar 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 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:



Product Service

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 ± 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): 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 **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: 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°C ±3°C @ 43.4% RH ±10% RH. The mains voltage was 240V ±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.

( ) 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	Hygromer	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

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	Re{Z} = 47.36 Ω
	Im{Z} = -1.06 Ω
Return loss at 1900MHz	**-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:

Product Service

CALIBRATION LABORATORY REPORT

Dipole impedance at 1900MHz	Re{Z} = 49.46 Ω	
	Im{Z} = -5.06 Ω	
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

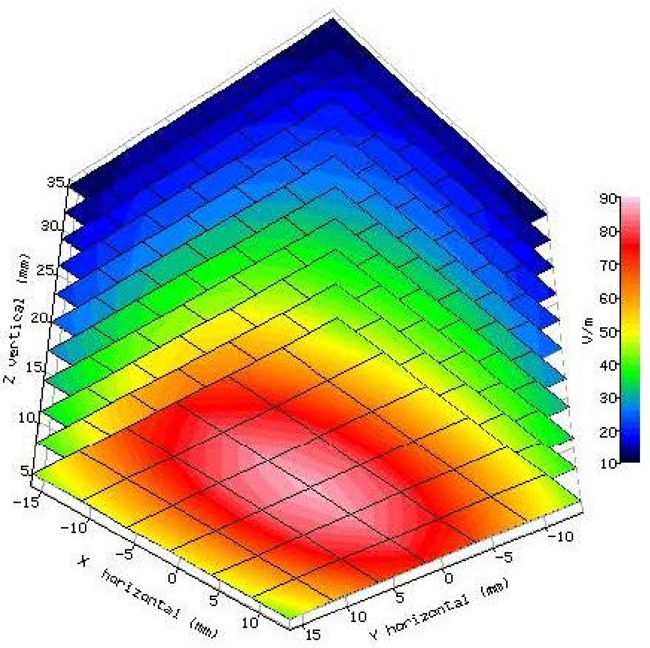
SAR validation checks have been performed using the 1900MHz dipole and the box-phantom located on the SARA-C phantom support base on the SARA-C robot system. Tests were then conducted at a feed power level of approx. 0.25W. The actual power level was recorded and used to normalise the results obtained 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 Indexsar 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 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	10.37	41.28	3.10	40.04
10g SAR	5.464	21.75	2.17	21.29

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

SAR Measurement in Body Fluid

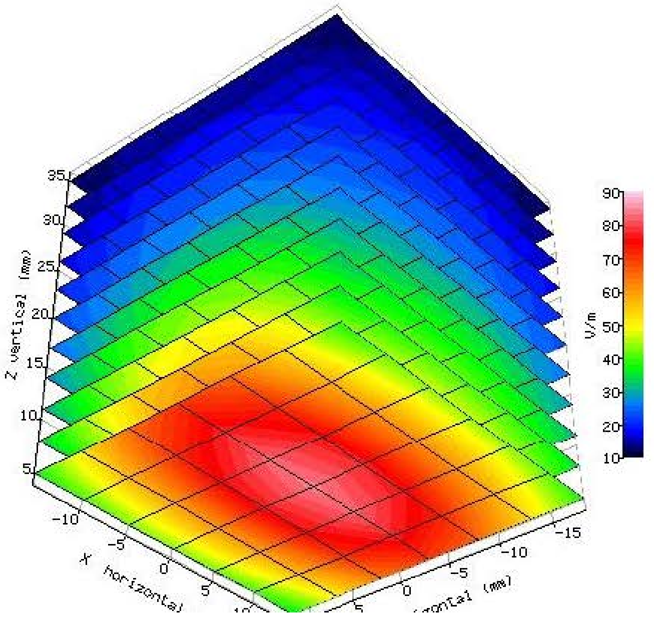
SAR validation checks have been performed using the 1900MHz dipole and the box-phantom located on the SARA-C phantom support base on the SARA-C robot system. Tests were then conducted at a feed power level of approx. 0.25W. The actual power level was recorded and used to normalise the results obtained 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 Indexsar DiLine kit) at 1900MHz at the measurement temperature:

Relative Permittivity	**53.21**
Conductivity	**1.596 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:



Product Service

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 ± 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°C ±3°C @ 34.0% RH ±10% RH. The mains voltage was 240V ±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.

( ) 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	Hygromer	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

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Dipole impedance and return loss

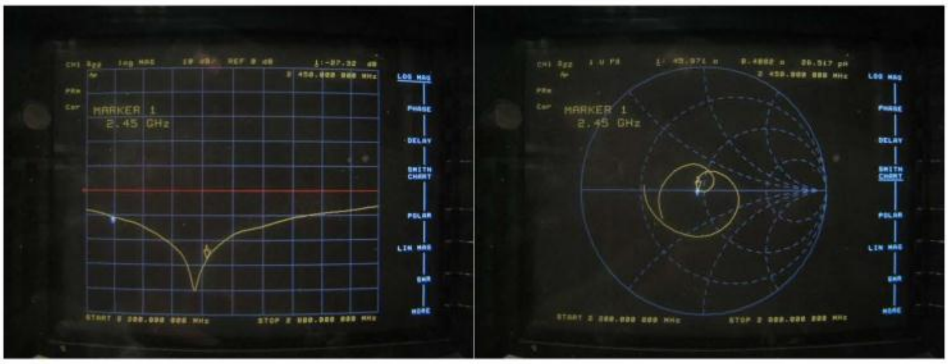
The dipoles are designed to have low return loss ONLY when presented against a lossy-phantom at the specified distance. A Vector Network Analyser (VNA) was used to perform a return loss measurement on the specific dipole when in the measurement-location against the box phantom. The distance was as specified 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	Re{Z} = 47.69 Ω
	Im{Z} = 2.827 Ω
Return loss at 2450MHz	**-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	Re{Z} = 45.97 Ω	
	Im{Z} = 0.41 Ω	
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

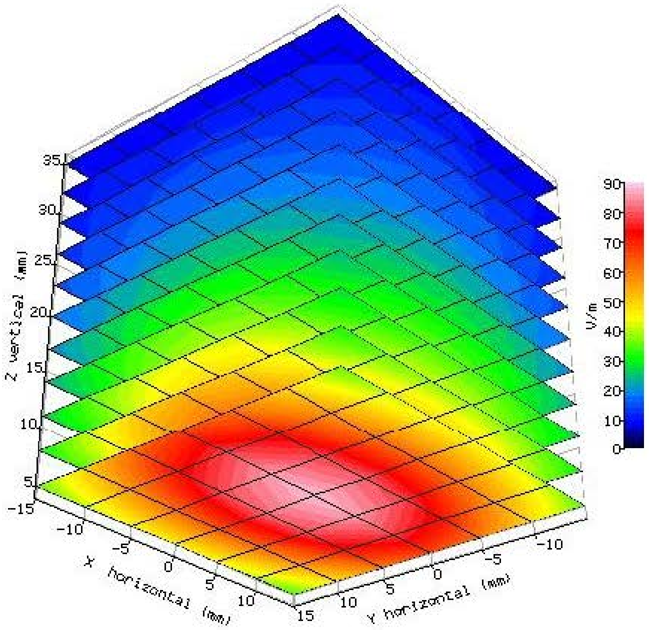
SAR validation checks have been performed using the 2450MHz dipole and the box-phantom located on the SARA-C phantom support base on the SARA-C robot system. Tests were then conducted at a feed power level of approx. 0.25W. The actual power level was recorded and used to normalise the results obtained 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 Indexsar 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 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	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

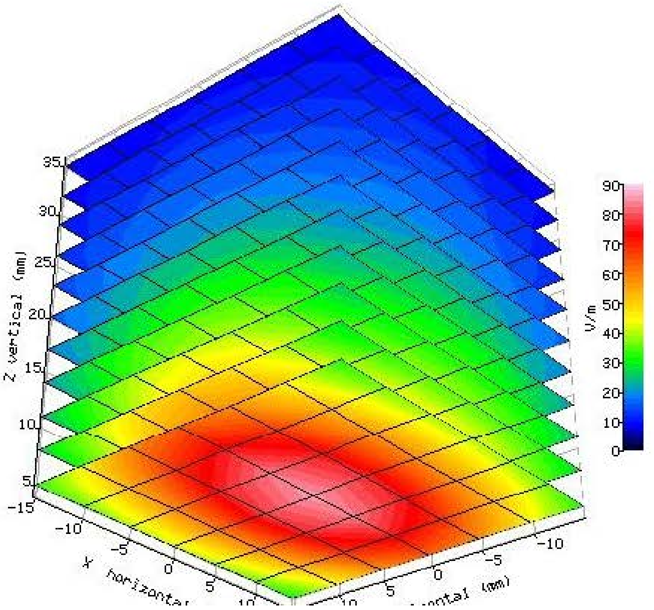
SAR validation checks have been performed using the 2450MHz dipole and the box-phantom located on the SARA-C phantom support base on the SARA-C robot system. Tests were then conducted at a feed power level of approx. 0.25W. The actual power level was recorded and used to normalise the results obtained 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 Indexsar 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 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:



Product Service

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 ± 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