

# **Appendix B - DAE & Probe Calibration Certificate**

Calibration Laborato Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zuri			<ul> <li>S Schweizerischer Kalibrierdienst</li> <li>S Service suisse d'étalonnage</li> <li>S Servizio svizzero di taratura</li> <li>S Swiss Calibration Service</li> </ul>
Accredited by the Swiss Accredi The Swiss Accreditation Servi Multilateral Agreement for the	ce is one of the signatorie	s to the EA	ation No.: SCS 0108
Client SGS-TW (Aud			te No: DAE4-877_Mar20
CALIBRATION	CERTIFICATI	E	
Object	DAE4 - SD 000 [	004 BN - SN: 877	
Calibration procedure(s)	QA CAL-06.v30 Calibration proce	dure for the data acquisition e	electronics (DAE)
Calibration date:	March 17, 2020		
The measurements and the unce	mainties with confidence pr	mal standards, which realize the physical obability are given on the following pages	s and are part of the certificate.
All calibrations have been condui Calibration Equipment used (M&	rtainties with confidence pr cted in the closed laboraton TE critical for calibration)	obability are given on the following pages / facility: environment temperature (22 ±	s and are part of the certificate.
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#### Calibration Laboratory of Schmid & Partner Engineering AG eughausstrasse 43, 8004 Zurich, Switzerland



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

Accreditation No.: SCS 0108

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#### Glossary DAE

Connector angle

data acquisition electronics information used in DASY system to align probe sensor X to the robot coordinate system.

#### Methods Applied and Interpretation of Parameters

- DC Voltage Measurement: Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- Connector angle: The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty
  - DC Voltage Measurement Linearity: Verification of the Linearity at +10% and -10% of . the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - Common mode sensitivity: Influence of a positive or negative common mode voltage on the differential measurement
  - Channel separation: Influence of a voltage on the neighbor channels not subject to an input voltage
  - AD Converter Values with inputs shorted: Values on the internal AD converter corresponding to zero input voltage
  - Input Offset Measurement. Output voltage and statistical results over a large number of zero voltage measurements
  - Input Offset Current: Typical value for information; Maximum channel input offset current, not considering the input resistance
  - Input resistance: Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement
  - Low Battery Alarm Voltage: Typical value for information. Below this voltage, a battery alarm signal is generated.
  - Power consumption: Typical value for information. Supply currents in various operating modes.

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### **DC Voltage Measurement**

A/D - Converter Resol	ution nominal			
High Range:	1LSB = 6.1µV,	full range =	-100+300 mV	
Low Range:	1LSB = 61nV ,	full range =	-1+3mV	
DASY measurement p	arameters: Auto Zero Time:	3 sec: Measuring til	me: 3 sec	
Calibration Factors		Y	Z	-

High Range		404.578 ± 0.02% (k=2) 3.98256 ± 1.50% (k=2)	
Low Hange	5.50 TOZ 1 1.50 /0 (R=E)	0.00200 ± 1.00 % (N=2)	0.07000 - 1.0070 (1-2)

#### **Connector Angle**

Connector Angle to be used in DASY system	324.5°±1°
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High Range	Reading (µV)	Difference (µV)	Error (%)
Channel X + Input	199994.99	1.01	0.00
Channel X + Input	20004.59	3.10	0.02
Channel X - Input	-19997.61	4.07	-0.02
Channel Y + Input	199995.27	1.92	0.00
Channel Y + Input	20003.49	2.17	0.01
Channel Y - Input	-20001.56	0.25	-0.00
Channel Z + Input	199996.44	2.69	0.00
Channel Z + Input	20003.98	2.57	0.01
Channel Z - Input	-20002.02	-0.26	0.00
Low Range	Reading (µV)	Difference (µV)	Error (%)
Channel X + Input	2000.98	-0.02	-0.00
Channel X + Input	201.04	-0.39	-0.19
Channel X - Input	-198.61	-0.21	0.11
Channel Y + Input	2001.45	0.50	0.02
Channel Y + Input	200.09	-1.21	-0.60
Channel Y - Input	-199.84	-1.30	0.65
onanner i mpar	-199.64		
Channel Z + Input	2001.94	0.99	0.05
			0.05

### Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

2. Common mode sensitivity DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Common mode Input Voltage (mV)	High Range Average Reading (μV)	Low Range Average Reading (µV)
Channel X	200	15.06	13.17
1000 Contraction (1990)	- 200	-11,97	-13.80
Channel Y	200	-19.28	-19.62
	- 200	18.28	17.70
Channel Z	200	21.01	20.77
	- 200	-22.03	-22.76

#### 3. Channel separation

	Input Voltage (mV)	Channel X (µV)	Channel Y (µV)	Channel Z (µV)
Channel X	200	-	0.57	-2.27
Channel Y	200	7.16		2.07
Channel Z	200	9.34	3.85	-

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### 4. AD-Converter Values with inputs shorted

	High Range (LSB)	Low Range (LSB)
Channel X	16005	16461
Channel Y	15882	17075
Channel Z	15740	17303

#### 5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec Input 10MΩ

	Average (µV)	min. Offset (µV)	max. Offset (µV)	Std. Deviation (µV)
Channel X	1.20	-0.28	3.03	0.57
Channel Y	0.18	-1.82	1.39	0.56
Channel Z	0.60	-1.35	2.37	0.80

### 6. Input Offset Current

7

Nominal Input circuitry offset current on all channels: <25fA

	Zeroing (kOhm)	Measuring (MOhm)
Channel X	200	200
Channel Y	200	200
Channel Z	200	200

ypical values	Alarm Level (VDC)
Supply (+ Vcc)	+7.9
Supply (- Vcc)	-7.6

9. Power Consumption (Typical values for information)

Typical values	Switched off (mA)	Stand by (mA)	Transmitting (mA)
Supply (+ Vcc)	+0.01	+6	+14
Supply (- Vcc)	-0.01	-8	-9

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lient SGS (Auden)			icate No: DAE4-558_Oct19
CALIBRATION C	ERTIFICATE		
Dbject	DAE4 - SD 000 D	04 BM - SN: 558	
Calibration procedure(s)	QA CAL-06.v29 Calibration procee	lure for the data acquisition	n electronics (DAE)
Calibration date:	October 11, 2019		
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Glossary

DAE Connector angle

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### **DC Voltage Measurement**

High Range:	1LSB =	6.1µV.	full range =	-100+300 mV
Low Range:	1LSB =	61nV ,	full range =	-1+3mV
DASY measurement	parameters: Au	to Zero Time: 3	sec; Measuring	time: 3 sec

<b>Calibration Factors</b>	X	Y	Z
High Range	404.821 ± 0.02% (k=2)	404.724 ± 0.02% (k=2)	404.875 ± 0.02% (k=2)
Low Range	3.96258 ± 1.50% (k=2)	3.93926 ± 1.50% (k=2)	3.98862 ± 1.50% (k=2)

**Connector Angle** 

Connector Angle to be used in DASY system	40.0 ° ± 1 °
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Certificate No: DAE4-558\_Oct19

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## Appendix (Additional assessments outside the scope of SCS0108)

## 1. DC Voltage Linearity

High Range	Reading (µV)	Difference (µV)	Error (%)
Channel X + Input	199995.80	0.70	0.00
Channel X + Input	20007.10	5.20	0.03
Channel X - Input	-19994.11	7.49	-0.04
Channel Y + Input	199995.21	0.35	0.00
Channel Y + Input	20005.00	3.09	0.02
Channel Y - Input	-19997.14	4.49	-0.02
Channel Z + Input	199993.75	-1.54	-0.00
Channel Z + Input	20003.72	1.81	0.01
Channel Z - Input	-20000.76	0.84	-0.00

Low Range		Reading (µV)	Difference (µV)	Error (%)
Channel X + I	nput	2001.07	-0.05	-0.00
Channel X + I	nput	201.96	0.36	0.18
Channel X - I	nput	-197.96	0.39	-0.20
Channel Y +	nput	2000.94	-0.15	-0.01
Channel Y +	Input	201.50	0.05	0.03
Channel Y - I	nput	-199.34	-0.96	0.48
Channel Z +	Input	2001.46	0.45	0.02
Channel Z +	Input	200.11	-1.36	-0.67
Channel Z - I	nput	-199.52	-0.97	0.49

## 2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Common mode Input Voltage (mV)	High Range Average Reading (μV)	Low Range Average Reading (µV)
Channel X	200	0.85	-0.61
	- 200	1.11	-0.56
Channel Y	200	8.55	8.60
	- 200	-9.74	-9.81
Channel Z	200	5.97	3.67
	- 200	-5.72	-5.24

### 3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec: Measuring time: 3 sec

	Input Voltage (mV)	Channel X (µV)	Channel Y (µV)	Channel Z (µV)
Channel X	200		5.02	-0.32
Channel Y	200	9.97	(+ ) (+ )	5.48
Channel Z	200	7.33	7.99	~

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## 4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	High Range (LSB)	Low Range (LSB)
Channel X	16227	15329
Channel Y	15730	17824
Channel Z	16064	17602

## 5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec Input 10MΩ

	Average (µV)	min. Offset (μV)	max. Offset (µV)	Std. Deviation (µV)
Channel X	0.34	-0.71	1.65	0.48
Channel Y	0.64	-0.99	1.99	0.49
Channel Z	-0.24	-1.12	1.22	0.43

### 6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

7. Input Resistance (Typical values for information)

	Zeroing (kOhm)	Measuring (MOhm)
Channel X	200	200
Channel Y	200	200
Channel Z	200	200

### 8. Low Battery Alarm Voltage (Typical values for information)

Typical values	Alarm Level (VDC)
Supply (+ Vcc)	+7.9
Supply (- Vcc)	-7.6

### 9. Power Consumption (Typical values for information)

Typical values	Switched off (mA)	Stand by (mA)	Transmitting (mA)
Supply (+ Vcc)	+0.01	+6	+14
Supply (- Vcc)	-0.01	-8	-9

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CALIBRATION	CERTIFICATE		
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Calibration procedure(s)		A CAL-14.v5, QA CAL-23.v5, QA ure for dosimetric E-field probes	CAL-25.v7
Calibration date:	March 25, 2020		
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Glossary:	
TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,y,z
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization o	@ rotation around probe axis
Polarization 9	9 rotation around an axis that is in the plane normal to probe axis (at measurement center),
	i.e., 9 = 0 is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

- Connector Angle Information Used in DASY system to any prote sensor A to the food conditinate system
   Calibration is Performed According to the Following Standards:

   a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
   b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from handheld and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
   c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used next to the services view of 30 MHz to 6 GHz)", March 2010
   d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz)", March 2010

- (d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"
  Mothods Applied and Interpretation of Parameters:
  NORMk.y.z: Assessed for E-field polarization 9 = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMk.y.z are only intermediate values, i.e., the uncertainties of NORMk.y.z does not affect the E<sup>2</sup>-field uncertainty inside TSL (see below Conv/F).
  NORMk.y.z = NORMk.y.z \* Irequency.response (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of Conv/F.
  DCPk.y.z: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
  PAR: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics

  - PAR: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics Axy, *x*: *Bx*, *y*:: *C*, *x*, *y*:: *Dx*, *y*:: *YRx*, *y*:: *A*, *B*, *C*, *D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode. *ConvF* and *Boundary Effect Parameters*: Assessed in flat phantom using E-field (or Temperature Transfer Standard for 1 > 800 MHz) and inside waveguide using analytical field distributions based on power measurements for 1 > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY varV software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx*, *y*: *\* ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
  - ÷ Spherical isotropy (3D deviation from isotropy): In a field of low gradients realized using a flat phantom
  - .
  - Spretreat sourcey (30 Deviation non-sourcey). In a finite of low gradients realized using a nativation exposed by a patch anienna. Sensor Offset: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required. *Connector Angle*: The angle is assessed using the information gained by determining the NORMx (no uncertainty required). ٠

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#### EX3DV4 - SN:7509

March 25, 2020

174.8

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:7509

		Sensor X Sensor Y		÷	Se	nsor Z	Unc (k=2		
Norm (	$\mu V/(V/m)^2)^A$	0.51		0.55		(	0.55	55 ± 10	
DCP (n	nV) <sup>B</sup>	97.8		99.8		9	94.6		
	ation Results for		lesponse	-					
Calibra UID	Communication S		A	B dBy/uV	с	D dB	VR	Max dev.	Unc <sup>b</sup> (k=2)
			A dB X 0.0	Β dB√μV 0.0	C 1.0				
UID	Communication S	system Name	A dB	dBõV		dB	mV	dev.	(k=2

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

The uncertainties of Norm X,Y,Z do not affect the E<sup>5</sup>-field uncertainty inside TSL (see Page 5). Numerical invariation parameter: uncertainty not required. Uncertainty is determined using the max deviation from inser response applying rectangular distribution and is expressed for the square of the

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#### EX3DV4- SN:7509

March 25, 2020

### DASY/EASY - Parameters of Probe: EX3DV4 - SN:7509

Sensor Arrangement	Triangular
Connector Angle (°)	-17.6
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

Certificate No: EX3-7509 Mar20

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## Report No. :ES/2020/30005 Rev: 01 Page: 15 of 29

March 25, 2020

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:7509 Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unc (k=2)
750	41.9	0.89	9.94	9.94	9.94	0.49	0,80	± 12.0 %
835	41.5	0.90	9.73	9.73	9.73	0.35	0.98	± 12.0 %
900	41.5	0.97	9.53	9.53	9.53	0.33	1.00	± 12.0 %
1750	40.1	1.37	8.34	8.34	8.34	0.32	0.86	± 12.0 %
1900	40.0	1.40	8.07	8.07	8.07	0.34	0.86	± 12.0 %
2000	40.0	1.40	7.98	7.98	7.98	0.36	0.86	± 12.0 %
2300	39.5	1.67	7.76	7,76	7.76	0,31	0.90	± 12.0 %
2450	39.2	1.80	7.51	7.51	7.51	0.32	0.90	± 12.0 %
2600	39.0	1.96	7.23	7.23	7.23	0.39	0.90	± 12.0 %
3300	38.2	2.71	6.80	6.80	6.80	0.30	1.35	± 13.1 9
3500	37.9	2.91	6.73	6.73	6.73	0.35	1.35	± 13,1 9
3700	37.7	3.12	6.67	6.67	6.67	0.35	1.35	± 13,1 9
3900	37.5	3.32	6.50	6.50	6.50	0.40	1,60	± 13.1 %
4100	37.2	3.53	6.30	6.30	6.30	0.40	1.60	± 13.1 9
4200	37.1	3.63	6.10	6.10	6.10	0.40	1.60	± 13.1 %
4400	36.9	3.84	6.05	6.05	6.05	0.40	1.60	± 13.1 9
4600	36.7	4.04	6.02	6.02	6.02	0.40	1.60	± 13.1 9
4800	36.4	4.25	5.97	5.97	5.97	0.40	1.80	± 13.1 %
4950	36.3	4.40	5.75	5.75	5.75	0.40	1.80	± 13.1 9
5200	36.0	4.66	5.33	5.33	5.33	0.40	1.80	± 13,1 %
5300	35.9	4.76	5.23	5.23	5.23	0.40	1.80	± 13.1 9
5600	35.5	5.07	4.64	4.64	4.64	0.40	1.80	± 13.1 9
5800	35.3	5.27	4.85	4.85	4.85	0.40	1.80	± 13.1 9

Procuency validity above 300 MHz of ± 100 MHz only applies for DASY VI.4 and higher (see Page 2), also it is restricted to ± 50 MHz. The uncertainty is the RSS of the ComP uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Erequency validity body 300 MHz is 10, 254, 03, 500 MHz to 500 PK seessmest as 30, 64. 128, 150 and 220 MHz respectively. Validity of ComP assessed at 31 Afraquencies band 220 MHz respectively. Validity of ComP assessed at 31 Afraquencies band 200 MHz to 500 MHz. The Infraquencies ball of the second second and the second s

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EX3DV4-SN:7509

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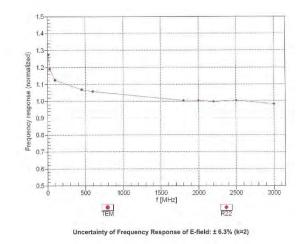
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EX3DV4-SN:7509

March 25, 2020

#### Frequency Response of E-Field (TEM-Cell:ifi110 EXX, Waveguide: R22)



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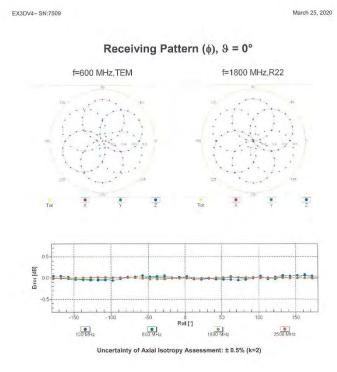
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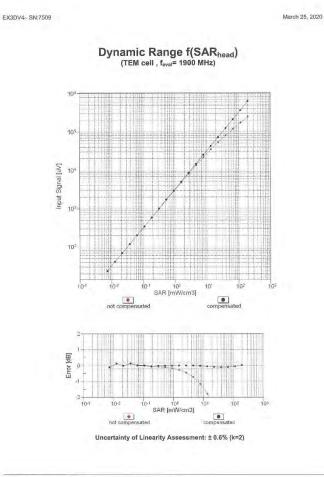
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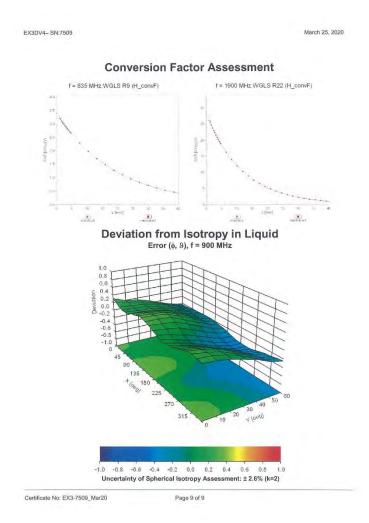
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Slient SGS-TW (Aud	den)	Certificate No:	EX3-3770_May20
CALIBRATION	CERTIFICATE		
Object	EX3DV4 - SN:377	0	
Calibration procedure(s)	QA CAL-01.v9, Q/ QA CAL-25.v7	a cal-12.v9, qa cal-14.v5, qa	CAL-23.v5,
		lure for dosimetric E-field probes	
Calibration date:	May 27, 2020		
This calibration certificate docu	ments the traceability to nation	nal standards, which realize the physical units	of measurements (SI).
		bability are given on the following pages and	
		bability are given on the following pages and	
All calibrations have been cond	lucted in the closed laboratory	bability are given on the following pages and facility: environment temperature $(22 \pm 3)^\circ$ C a	
All calibrations have been cond	lucted in the closed laboratory &TE critical for calibration)	facility: environment temperature $(22 \pm 3)^{\circ}C$ a	and humidity < 70%.
All calibrations have been cond Calibration Equipment used (M Primary Standards	lucted in the closed laboratory &TE critical for calibration)	facility: environment temperature (22 ± 3)°C a	and humidity < 70%.
All calibrations have been cond Calibration Equipment used (M Primary Standards Power meter NRP	Lucted in the closed laboratory &TE critical for calibration) ID SN: 104778	facility: environment temperature (22 ± 3)°C a Cal Date (Certificate No.) 01-Apr-20 (No. 217-03100/03101)	and humidity < 70%. Scheduled Calibration Apr-21
All calibrations have been cond Calibration Equipment used (M Primary Standards Power meter NRP Power sensor NRP-Z91	Iucted in the closed laboratory &TE critical for calibration) ID SN: 104778 SN: 103244	facility: environment temperature (22 ± 3)°C a Cal Date (Certificate No.) 01-Apr-20 (No. 217-03100/03101) 01-Apr-20 (No. 217-03100)	and humidity < 70%. Scheduled Calibration Apr-21 Apr-21
All calibrations have been cond Calibration Equipment used (M Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91	ATE critical for calibration) ID SN: 104778 SN: 103244 SN: 103245	facility: environment temperature (22 ± 3)°C a Cal Date (Certificate No.) 01-Apr-20 (No. 217-03100/03101) 01-Apr-20 (No. 217-03100) 01-Apr-20 (No. 217-03101)	Apr-21 Apr-21 Apr-21
All calibrations have been cond Calibration Equipment used (M Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator	Iucted in the closed laboratory &TE critical for calibration) ID SN: 104778 SN: 103244 SN: 103245 SN: CC2552 (20x)	facility: environment temperature (22 ± 3)°C a Cal Date (Certificate No.) 01-Apr-20 (No. 217-03100/03101) 01-Apr-20 (No. 217-03100) 01-Apr-20 (No. 217-03101) 31-Mar-20 (No. 217-03106)	Apr-21 Apr-21 Apr-21 Apr-21 Apr-21
All calibrations have been cond Calibration Equipment used (M Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator DAE4	ATE critical for calibration) ID SN: 104778 SN: 103244 SN: 103245	facility: environment temperature (22 ± 3)°C a Cal Date (Certificate No.) 01-Apr-20 (No. 217-03100/03101) 01-Apr-20 (No. 217-03100) 01-Apr-20 (No. 217-03101)	Apr-21 Apr-21 Apr-21
All calibrations have been cond Calibration Equipment used (M Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator DAE4 Reference Probe ES3DV2	Iucted in the closed laboratory &TE critical for calibration) ID SN: 104778 SN: 103244 SN: 103245 SN: CC2552 (20x) SN: 660	facility: environment temperature (22 ± 3)°C a Cal Date (Certificate No.) 01-Apr-20 (No. 217-03100/03101) 01-Apr-20 (No. 217-03100) 01-Apr-20 (No. 217-03101) 31-Mar-20 (No. 217-03106) 27-Dec-19 (No. DAE4-660_Dec19)	Apr-21 Apr-21 Apr-21 Apr-21 Apr-21 Apr-21 Apr-21 Dec-20
All calibrations have been cond Calibration Equipment used (M Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator DAE4 Reference Probe ES3DV2 Secondary Standards	Iucted in the closed laboratory &TE critical for calibration) ID SN: 104778 SN: 103244 SN: 103245 SN: CC2552 (20x) SN: 660 SN: 3013	facility: environment temperature (22 ± 3)°C a Cal Date (Certificate No.) 01-Apr-20 (No. 217-03100/03101) 01-Apr-20 (No. 217-03100) 01-Apr-20 (No. 217-03100) 31-Mar-20 (No. 217-03106) 27-Dec-19 (No. DAE4-660_Dec19) 31-Dec-19 (No. ES3-3013_Dec19)	And humidity < 70%. Scheduled Calibration Apr-21 Apr-21 Apr-21 Apr-21 Dec-20 Dec-20 Dec-20
All calibrations have been cond Calibration Equipment used (M Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator DAE4 Reference Probe ES3DV2 Secondary Standards Power meter E4419B	IUCTED IN THE Closed laboratory &TE critical for calibration) ID SN: 104778 SN: 103244 SN: 103245 SN: CC2552 (20x) SN: 660 SN: 3013 ID	facility: environment temperature (22 ± 3)°C a Cal Date (Certificate No.) 01-Apr-20 (No. 217-03100/03101) 01-Apr-20 (No. 217-03100) 01-Apr-20 (No. 217-03101) 31-Mar-20 (No. 217-03106) 27-Dec-19 (No. DAE4-660_Dec19) 31-Dec-19 (No. ES3-3013_Dec19) Check Date (in house)	Apr-21 Apr-21 Apr-21 Apr-21 Dec-20 Dec-20 Scheduled Check
All calibrations have been cond Calibration Equipment used (M Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator DAE4 Reference Probe ES3DV2 Secondary Standards Power meter E4419B Power sensor E4412A	Lucted in the closed laboratory &TE critical for calibration) ID SN: 104778 SN: 103244 SN: 103245 SN: 02552 (20x) SN: 660 SN: 3013 ID SN: GB41293874	facility: environment temperature (22 ± 3)°C = Cal Date (Certificate No.) 01-Apr-20 (No. 217-03100/03101) 01-Apr-20 (No. 217-03100) 01-Apr-20 (No. 217-03100) 31-Mar-20 (No. 217-03106) 27-Dec-19 (No. DAE4-660_Dec19) 31-Dec-19 (No. ES3-3013_Dec19) Check Date (in house) 06-Apr-16 (in house check Jun-18)	Apr-21 Apr-21 Apr-21 Apr-21 Dec-20 Dec-20 Scheduled Check In house check: Jun-20
All calibrations have been cond Calibration Equipment used (M Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator DAE4 Reference Probe ES3DV2 Secondary Standards Power meter E4419B Power sensor E4412A	Lucted in the closed laboratory &TE critical for calibration) ID SN: 104778 SN: 103244 SN: 103245 SN: C22552 (20x) SN: 660 SN: 3013 ID SN: GB41293874 SN: MY41498087	facility: environment temperature (22 ± 3)°C a Cal Date (Certificate No.) 01-Apr-20 (No. 217-03100/03101) 01-Apr-20 (No. 217-03100) 01-Apr-20 (No. 217-03101) 31-Mar-20 (No. 217-03106) 27-Dec-19 (No. DAE4-660_Dec19) 31-Dec-19 (No. ES3-3013_Dec19) Check Date (in house) 06-Apr-16 (in house check Jun-18) 06-Apr-16 (in house check Jun-18)	Apr-21 Apr-21 Apr-21 Apr-21 Dec-20 Dec-20 Scheduled Check In house check: Jun-20 In house check: Jun-20
All calibrations have been cond Calibration Equipment used (M Primary Standards Power meter NRP Power sensor NRP-291 Power sensor NRP-291 Reference 20 dB Attenuator DAE4 Reference Probe ES3DV2 Secondary Standards Power meter E4419B Power sensor E4412A Power sensor E4412A RF generator HP 8648C	Lucted in the closed laboratory &TE critical for calibration) ID SN: 104778 SN: 103245 SN: 03245 SN: CC2552 (20x) SN: 660 SN: 3013 ID SN: GB41293874 SN: MY41498087 SN: 000110210	facility: environment temperature (22 ± 3)°C a Cal Date (Certificate No.) 01-Apr-20 (No. 217-03100/03101) 01-Apr-20 (No. 217-03100) 01-Apr-20 (No. 217-03101) 31-Mar-20 (No. 217-03101) 31-Dec-19 (No. 217-03105) 27-Dec-19 (No. 217-03105) 27-Dec-19 (No. ES3-3013_Dec19) 31-Dec-19 (No. ES3-3013_Dec19) 06-Apr-16 (in house) 06-Apr-16 (in house check Jun-18) 06-Apr-16 (in house check Jun-18)	Apr-21 Apr-21 Apr-21 Apr-21 Dec-20 Dec-20 Scheduled Check In house check: Jun-20 In house check: Jun-20 In house check: Jun-20
All calibrations have been cond Calibration Equipment used (M Primary Standards Power meter NRP Power sensor NRP-291 Power sensor NRP-291 Reference 20 dB Attenuator DAE4 Reference Probe ES3DV2 Secondary Standards Power meter E4419B Power sensor E4412A Power sensor E4412A RF generator HP 8648C	Lucted in the closed laboratory &TE critical for calibration) ID SN: 104778 SN: 103245 SN: 103245 SN: 600 SN: 3013 ID SN: GB41293874 SN: MY41498087 SN: 000110210 SN: US3642U01700	Cal Date (Certificate No.)           01-Apr-20 (No. 217-03100/03101)           01-Apr-20 (No. 217-03100)           01-Apr-20 (No. 217-03100)           01-Apr-20 (No. 217-03101)           31-Mar-20 (No. 217-03106)           27-Dec-19 (No. DAE4-660_Dec19)           31-Dec-19 (No. ES3-3013_Dec19)           Check Date (in house)           06-Apr-16 (in house check Jun-18)           06-Apr-16 (in house check Jun-18)           04-Aug-99 (in house check Jun-18)           31-Mar-14 (in house check Oct-19)	Apr-21 Apr-21 Apr-21 Apr-21 Dec-20 Dec-20 Scheduled Check In house check: Jun-20 In house check: Jun-20
All calibrations have been cond Calibration Equipment used (M Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator DAE4 Reference Probe ES3DV2 Secondary Standards Power meter E44198 Power sensor E4412A Ref generator HP 8648C Network Analyzer E8358A	Lucted in the closed laboratory &TE critical for calibration) ID SN: 104778 SN: 103244 SN: 103245 SN: CC2552 (20x) SN: 660 SN: 3013 ID SN: GB41293874 SN: MY41498087 SN: 000110210 SN: US3642U01700 SN: US41080477	facility: environment temperature (22 ± 3)°C a Cal Date (Certificate No.) 01-Apr-20 (No. 217-03100/03101) 01-Apr-20 (No. 217-03100) 01-Apr-20 (No. 217-03100) 31-Mar-20 (No. 217-03106) 27-Dec-19 (No. 217-03106) 27-Dec-19 (No. DAE4-660_Dec19) 31-Dec-19 (No. ES3-3013_Dec19) Check Date (in house) 06-Apr-16 (in house check Jun-18) 06-Apr-16 (in house check Jun-18) 06-Apr-16 (in house check Jun-18) 06-Apr-16 (in house check Jun-18) 06-Apr-16 (in house check Jun-18)	And humidity < 70%. Scheduled Calibration Apr-21 Apr-21 Apr-21 Dec-20 Dec-20 Dec-20 Scheduled Check In house check: Jun-20 In house check: Jun-20 In house check: Jun-20 In house check: Jun-20
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Calibration Laboratory of Schmid & Partner **Engineering AG** Zeughausstrasse 43, 8004 Zurich, Switzerland



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Glossary:	
TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,y,z
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization $\phi$	φ rotation around probe axis
Polarization &	9 rotation around an axis that is in the plane normal to probe axis (at measurement center),
	i.e., 9 = 0 is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measure
- Techniques", June 2013 b) IEC 62209-1, ", "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-
- b) IEC 62209-1, , Measurement procedure for the assessment of specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
   c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
   d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"
- Methods Applied and Interpretation of Parameters:
  - NORMx,y,z: Assessed for E-field polarization  $\vartheta = 0$  (f  $\leq 900$  MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E<sup>2</sup>-field uncertainty inside TSL (see below ConvF).
  - NORM(f)x,y,z = NORMx,y,z \* frequency\_response (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
  - DCPx,y,z: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
  - PAR: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
  - Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
  - ConvF and Boundary Effect Parameters: Assessed in flat phantom using E-field (or Temperature Transfer Standard for f  $\leq$  800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORMx, y, z \* ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from  $\pm$  50 MHz to  $\pm$  100 MHz.
  - Spherical isotropy (3D deviation from isotropy): in a field of low gradients realized using a flat phantom exposed by a patch antenna. Sensor Offset: The sensor offset corresponds to the offset of virtual measurement center from the probe tip
  - (on probe axis). No tolerance required.
  - Connector Angle: The angle is assessed using the information gained by determining the NORMx (no uncertainty required).

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## EX3DV4 - SN:3770

May 27, 2020

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3770

### **Basic Calibration Parameters**

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm $(\mu V/(V/m)^2)^A$	0.29	0.31	0.36	± 10.1 %
DCP (mV) <sup>B</sup>	101.0	102.1	107.8	-

## **Calibration Results for Modulation Response**

UID	Communication System Name		A dB	B dBõV	С	D dB	VR mV	Max dev,	Unc <sup>E</sup> (k=2)
0	CW	X	0.0	0.0	1.0	0.00	134.3	±2.7 %	±4.7 %
		Y	0.0	0.0	1.0		144.6		0.000
		Z	0.0	0.0	1.0		131.2		

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

<sup>A</sup> The uncertainties of Norm X,Y,Z do not affect the E<sup>2</sup>-field uncertainty inside TSL (see Pages 5 and 10).
 <sup>B</sup> Numerical linearization parameter: uncertainty not required.
 <sup>E</sup> Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

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## EX3DV4-SN:3770

May 27, 2020

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3770

### Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	-17.9
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm.
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

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EX3DV4- SN:3770

May 27, 2020

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3770

Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unc (k=2)
450	43.5	0.87	10.65	10.65	10.65	0.13	1.25	± 13.3 %
750	41.9	0.89	9.84	9.84	9.84	0.51	0.80	± 12.0 %
835	41.5	0.90	9.50	9.50	9.50	0.28	1.12	± 12.0 %
900	41.5	0.97	9.28	9.28	9.28	0.42	0.85	± 12.0 %
1450	40.5	1.20	8.47	8.47	8.47	0.32	0.80	± 12.0 %
1750	40.1	1.37	8.36	8.36	8.36	0.31	0.86	± 12.0 %
1900	40.0	1.40	8.03	8.03	8.03	0.21	0.86	± 12.0 %
2000	40.0	1.40	7.93	7.93	7.93	0.27	0.94	± 12.0 %
2300	39.5	1.67	7.67	7.67	7.67	0.31	0.90	± 12.0 %
2450	39.2	1.80	7.40	7.40	7.40	0.37	0.90	± 12.0 %
2600	39.0	1.96	7.21	7.21	7.21	0.40	0.90	± 12.0 %
3300	38.2	2.71	7.00	7.00	7.00	0.35	1.30	± 13.1 9
3500	37.9	2.91	6.70	6.70	6.70	0.35	1.30	± 13.1 %
3700	37.7	3.12	6.60	6.60	6.60	0.35	1.30	± 13.1 %
3900	37.5	3.32	6.39	6.39	6.39	0.40	1.60	± 13.1 %
4100	37.2	3.53	6.34	6.34	6.34	0.40	1.60	±13.1 %
4200	37.1	3.63	6.18	6.18	6.18	0.40	1,60	± 13.1 %
4400	36.9	3.84	6.08	6.08	6.08	0.40	1.60	± 13.1 %
4600	36.7	4.04	5.97	5.97	5.97	0.40	1.80	± 13.1 %
4800	36.4	4.25	5.93	5.93	5.93	0.40	1.80	± 13.1 %
4950	36.3	4.40	5.77	5.77	5.77	0.40	1.80	± 13.1 %
5250	35.9	4.71	5.40	5.40	5.40	0.40	1.80	± 13.1 %
5600	35.5	5.07	4.79	4.79	4.79	0.40	1.80	± 13.1 %
5750	35.4	5.22	4.90	4.90	4.90	0.40	1.80	± 13.1 %

<sup>C</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4-9 MHz, and ConvF assessed at 13 MHz is 9-19 MHz. Above 5 GHz frequency validity can be extended to ± 110 MHz. <sup>F</sup> At frequencies below 3 GHz, the validity of tissue parameters (s and d) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (s and d) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters. <sup>6</sup> Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

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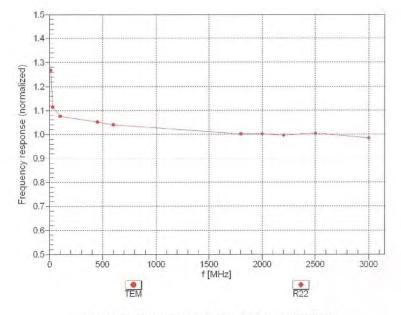


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May 27, 2020

## Frequency Response of E-Field (TEM-Cell:ifi110 EXX, Waveguide: R22)



Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)

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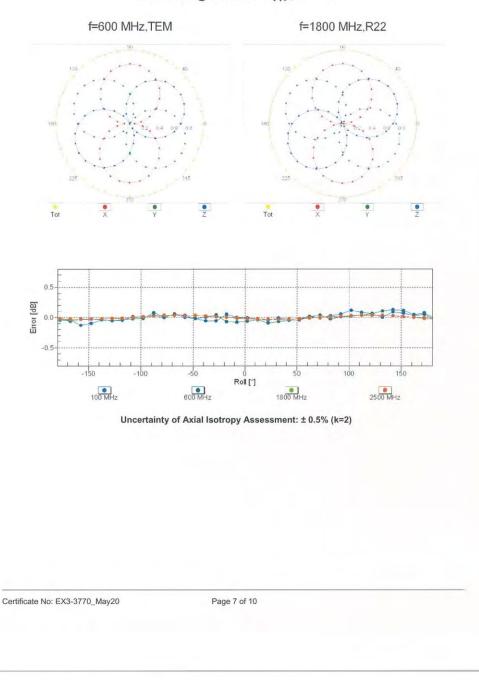
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May 27, 2020



## Receiving Pattern ( $\phi$ ), $\vartheta = 0^{\circ}$

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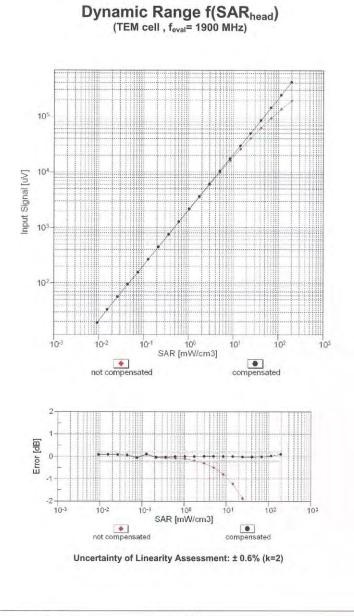
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t (886-2) 2299-3279 台灣檢驗科技股份有限公司

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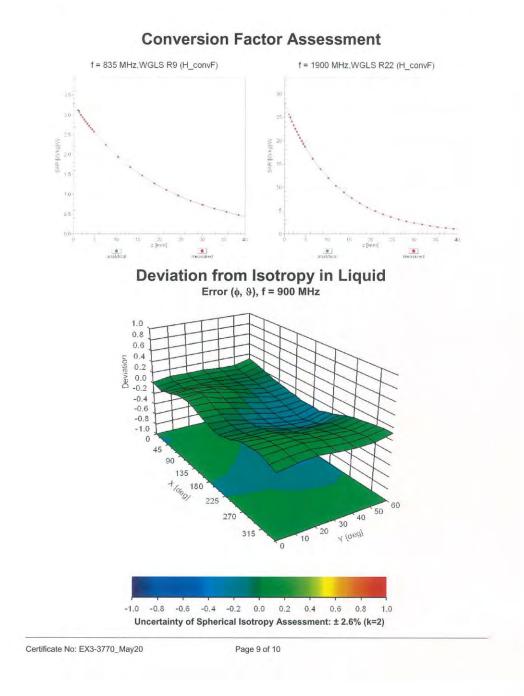
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## Appendix: Calibration Parameters above 6GHz

Calibration	Parameter	Determined	in Head	Tissue	Simulating	Media
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f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unc (k=2)
6500	34.5	6.07	5.60	5.60	5.60	0.20	2.00	± 18.6 %
7000	33.9	6.65	5.40	5.40	5.40	0.20	1.50	± 18.6 %

<sup>6</sup> Calibration procedure for frequencies above 6 GHz is pending accreditation. Frequency validity above 6GHz is ± 700 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
 <sup>6</sup> At frequencies 6-10 GHz, the validity of tissue parameters (c and d) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
 <sup>6</sup> AlphaDepth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz; below ± 2% for frequencies between 3-6 GHz; and below ± 4% for frequencies between 6-10 GHz at any distance larger than half the probe tip diameter from the boundary.

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# - End of report -

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