

## CALIBRATION DATA PROBE CALIBRATION DATA

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



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S Servizio svizzero di taratura  
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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client AGC (Auden)

Certificate No: EX3-3953\_Jun18

### CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:3953					
Calibration procedure(s)	QA CAL-01.v9, QA CAL-12.v9, QA CAL-23.v5, QA CAL-25.v6 Calibration procedure for dosimetric E-field probes					
Calibration date:	June 26, 2018					
This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.						
All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.						
Calibration Equipment used (M&TE critical for calibration)						
Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration			
Power meter NRP	SN: 104778	04-Apr-18 (No. 217-02672/02673)	Apr-19			
Power sensor NRP-Z91	SN: 103244	04-Apr-18 (No. 217-02672)	Apr-19			
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19			
Reference 20 dB Attenuator	SN: S5277 (20x)	04-Apr-18 (No. 217-02682)	Apr-19			
Reference Probe ES3DV2	SN: 3013	30-Dec-17 (No. ES3-3013_Dec17)	Dec-18			
DAE4	SN: 660	21-Dec-17 (No. DAE4-660_Dec17)	Dec-18			
Secondary Standards	ID	Check Date (in house)	Scheduled Check			
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-18)	In house check: Jun-20			
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-18)	In house check: Jun-20			
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-18)	In house check: Jun-20			
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-18)	In house check: Jun-20			
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18			
Calibrated by:	Name: Jeton Kastrati	Function: Laboratory Technician	Signature:			
Approved by:	Name: Katja Pokovic	Function: Technical Manager	Signature:			
Issued: June 26, 2018						
This calibration certificate shall not be reproduced except in full without written approval of the laboratory.						

Certificate No: EX3-3953\_Jun18

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**S** Schweizerischer Kalibrierdienst  
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Accreditation No.: **SCS 0108**

**Glossary:**

TSL	tissue simulating liquid
NORM $x, y, z$	sensitivity in free space
ConvF	sensitivity in TSL / NORM $x, y, z$
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization $\varphi$	$\varphi$ rotation around probe axis
Polarization $\theta$	$\theta$ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\theta = 0$ 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:**

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

**Methods Applied and Interpretation of Parameters:**

- $NORMx, y, z$ : Assessed for E-field polarization  $\theta = 0$  ( $f \leq 900$  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  $f = 800$  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:3953

June 26, 2018

# Probe EX3DV4

SN:3953

Manufactured: August 6, 2013  
Repaired: June 5, 2018  
Calibrated: June 26, 2018

Calibrated for DASY/EASY Systems  
(Note: non-compatible with DASY2 system!)

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EX3DV4- SN:3953

June 26, 2018

**DASY/EASY - Parameters of Probe: EX3DV4 - SN:3953****Basic Calibration Parameters**

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ( $\mu$ V/(V/m)) <sup>A</sup>	0.51	0.53	0.47	$\pm 10.1\%$
DCP (mV) <sup>B</sup>	97.9	97.5	98.0	

**Modulation Calibration Parameters**

UID	Communication System Name		A dB	B dB $\sqrt{\mu}$ V	C	D dB	VR mV	Unc <sup>E</sup> (k=2)
0	CW	X	0.0	0.0	1.0	0.00	125.6	$\pm 2.7\%$
		Y	0.0	0.0	1.0		127.0	
		Z	0.0	0.0	1.0		138.9	

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 6).<sup>B</sup> Numerical linearization parameter: uncertainty not required.<sup>C</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:3953

June 26, 2018

**DASY/EASY - Parameters of Probe: EX3DV4 - SN:3953****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>a</sup> (mm)	Unc (k=2)
150	52.3	0.76	13.23	13.23	13.23	0.00	1.00	± 13.3 %
450	43.5	0.87	11.28	11.28	11.28	0.16	1.30	± 13.3 %

<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. Above 5 GHz frequency validity can be extended to ± 110 MHz.

<sup>f</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) 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 ( $\epsilon$  and  $\sigma$ ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

<sup>g</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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EX3DV4-- SN:3953

June 26, 2018

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3953

### Calibration Parameter Determined in Body 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)
150	61.9	0.80	12.96	12.96	12.96	0.00	1.00	± 13.3 %
450	56.7	0.94	11.51	11.51	11.51	0.09	1.30	± 13.3 %

<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. Above 5 GHz frequency validity can be extended to ± 110 MHz.

<sup>f</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) 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 ( $\epsilon$  and  $\sigma$ ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

<sup>g</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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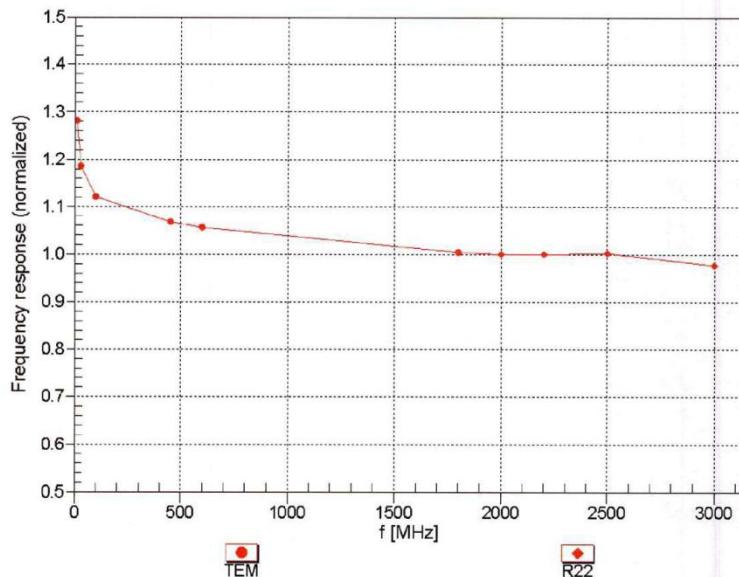
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EX3DV4- SN:3953

June 26, 2018

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



Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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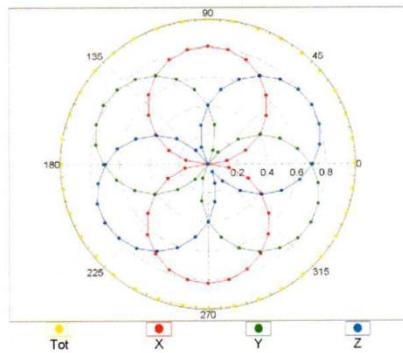
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EX3DV4- SN:3953

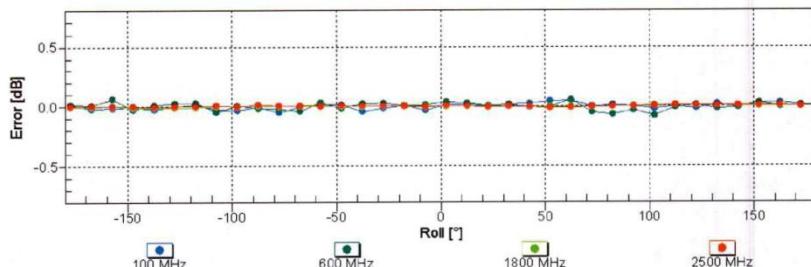
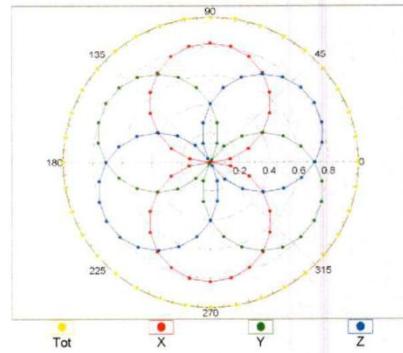
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### Receiving Pattern ( $\phi$ ), $\theta = 0^\circ$

$f=600$  MHz, TEM



$f=1800$  MHz, R22



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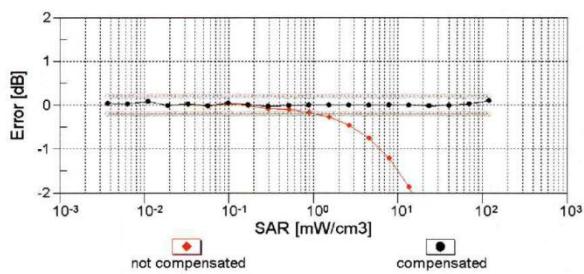
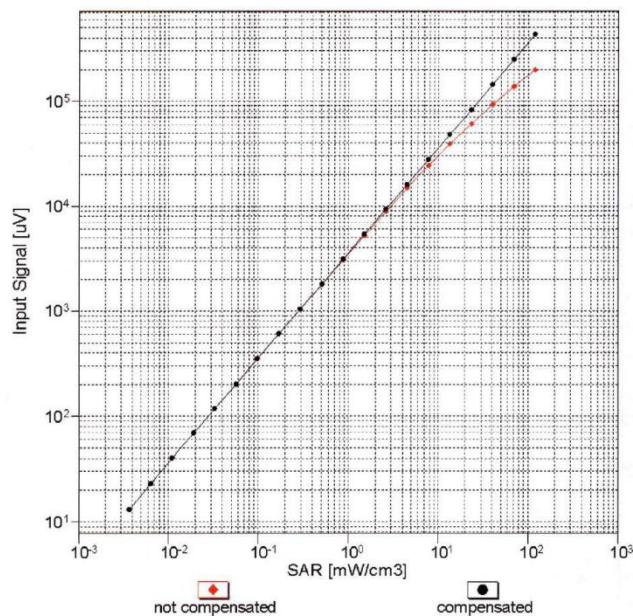
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EX3DV4- SN:3953

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**Dynamic Range f(SAR<sub>head</sub>)**  
(TEM cell, f<sub>eval</sub> = 1900 MHz)



Uncertainty of Linearity Assessment: ± 0.6% (k=2)

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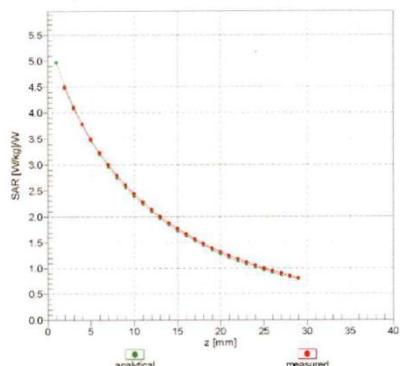
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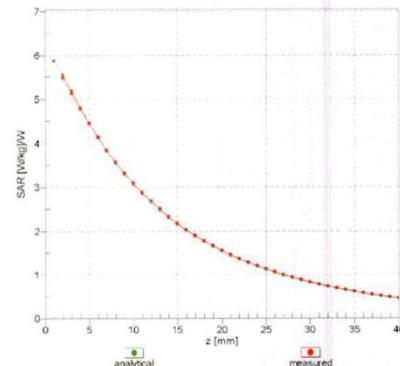
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### Conversion Factor Assessment

$f = 150 \text{ MHz}, \text{WGLS Flat Phantom 4.4}$

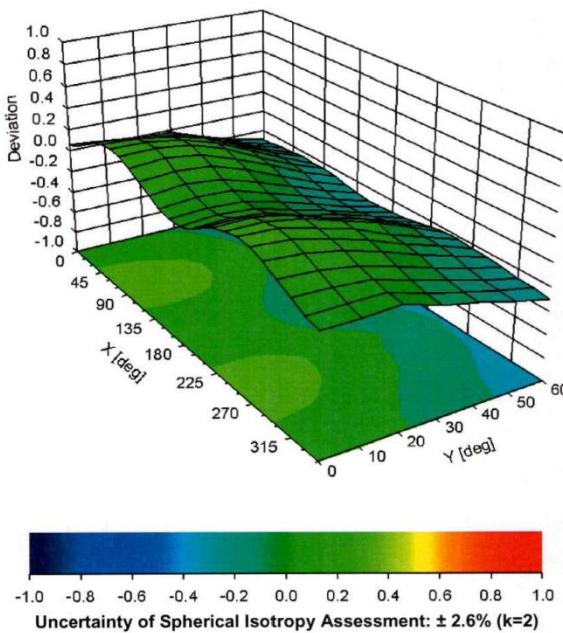


$f = 450 \text{ MHz}, \text{WGLS Flat Phantom 4.4}$



### Deviation from Isotropy in Liquid

Error ( $\phi, \theta$ ),  $f = 900 \text{ MHz}$



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EX3DV4- SN:3953

June 26, 2018

**DASY/EASY - Parameters of Probe: EX3DV4 - SN:3953****Other Probe Parameters**

Sensor Arrangement	Triangular
Connector Angle (°)	32.5
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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## DAE CALIBRATION DATA



In Collaboration with  
**speag**  
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CNAS L0570

Client : **agc-cert**

**Certificate No: Z18-97028**

### CALIBRATION CERTIFICATE

Object **DAE4 - SN: 1398**

Calibration Procedure(s) **FF-Z11-002-01**  
Calibration Procedure for the Data Acquisition Electronics  
(DAEx)

Calibration date: **February 08, 2018**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature( $22\pm3$ )°C and humidity<70%.

#### Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Process Calibrator 753	1971018	27-Jun-17 (CTTL, No.J17X05859)	June-18

Calibrated by:	Name	Function	Signature
	Yu Zongying	SAR Test Engineer	
Reviewed by:	Lin Hao	SAR Test Engineer	
Approved by:	Qi Dianyuan	SAR Project Leader	

Issued: February 09, 2018

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E-mail: ctll@chinattl.com Http://www.chinattl.cn

**Glossary:**

DAE data acquisition electronics  
Connector angle 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 report provide only calibration results for DAE, it does not contain other performance test results.

Certificate No: Z18-97028

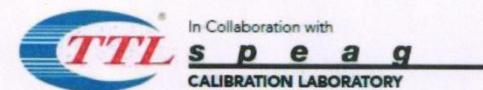
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#### DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1 $\mu$ V, full range = -100...+300 mV  
Low Range: 1LSB = 61nV, full range = -1.....+3mV  
DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Calibration Factors	X	Y	Z
High Range	404.218 ± 0.15% (k=2)	404.199 ± 0.15% (k=2)	403.661 ± 0.15% (k=2)
Low Range	3.97526 ± 0.7% (k=2)	3.99340 ± 0.7% (k=2)	3.97096 ± 0.7% (k=2)

#### Connector Angle

Connector Angle to be used in DASY system	196.5° ± 1 °
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Certificate No: Z18-97028

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The results shown in this test report refer only to the sample(s) tested unless otherwise stated and the sample(s) are retained for 30 days only. The document is issued by AGC, this document cannot be reproduced except in full with our prior written permission. The more details and the authenticity of the report will be confirmed at <http://www.agc-cert.com>.



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