

ANNEX A Calibration Documents



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Accreditation No.: **SCS 0108**

Client **Eurofins**

Certificate No: **DAE3-522_Sep18**

CALIBRATION CERTIFICATE

Object **DAE3 - SD 000 D03 AA - SN: 522**

Calibration procedure(s) **QA CAL-06.v29**
Calibration procedure for the data acquisition electronics (DAE)

Calibration date: **September 17, 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 $(22 \pm 3)^{\circ}\text{C}$ and humidity $< 70\%$.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|-------------------------------|--------------------|----------------------------|------------------------|
| Keithley Multimeter Type 2001 | SN: 0810278 | 03-Sep-18 (No:23488) | Sep-19 |
| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
| Auto DAE Calibration Unit | SE UWS 053 AA 1001 | 04-Jan-18 (in house check) | In house check: Jan-19 |
| Calibrator Box V2.1 | SE UMS 006 AA 1002 | 04-Jan-18 (in house check) | In house check: Jan-19 |

| | | | |
|----------------|-------------------|-----------------------|---|
| Calibrated by: | Name | Function | Signature |
| | Dominique Steffen | Laboratory Technician |  |

| | | |
|--------------|-----------|----------------|
| Approved by: | Sven Kühn | Deputy Manager |
|--------------|-----------|----------------|

Issued: September 17, 2018

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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 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.

DC Voltage Measurement

A/D - Converter Resolution nominal
High Range: 1LSB = 6.1µV , 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 | 404.479 ± 0.02% (k=2) | 404.153 ± 0.02% (k=2) | 404.993 ± 0.02% (k=2) |
| Low Range | 3.95965 ± 1.50% (k=2) | 3.93902 ± 1.50% (k=2) | 3.99701 ± 1.50% (k=2) |

Connector Angle

| | |
|---|---------------|
| Connector Angle to be used in DASY system | 327.0 ° ± 1 ° |
|---|---------------|

Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

| High Range | | Reading (μV) | Difference (μV) | Error (%) |
|------------|---------|---------------------------|------------------------------|-----------|
| Channel X | + Input | 200000.93 | 2.49 | 0.00 |
| Channel X | + Input | 20003.02 | 1.18 | 0.01 |
| Channel X | - Input | -20000.43 | 1.21 | -0.01 |
| Channel Y | + Input | 200000.57 | 2.19 | 0.00 |
| Channel Y | + Input | 20001.94 | 0.18 | 0.00 |
| Channel Y | - Input | -20002.78 | -1.04 | 0.01 |
| Channel Z | + Input | 199997.72 | -1.25 | -0.00 |
| Channel Z | + Input | 20000.11 | -1.62 | -0.01 |
| Channel Z | - Input | -20003.62 | -1.73 | 0.01 |

| Low Range | | Reading (μV) | Difference (μV) | Error (%) |
|-----------|---------|---------------------------|------------------------------|-----------|
| Channel X | + Input | 2000.45 | -0.77 | -0.04 |
| Channel X | + Input | 201.58 | 0.14 | 0.07 |
| Channel X | - Input | -197.77 | 0.63 | -0.32 |
| Channel Y | + Input | 2000.43 | -0.72 | -0.04 |
| Channel Y | + Input | 200.83 | -0.57 | -0.28 |
| Channel Y | - Input | -197.79 | 0.68 | -0.34 |
| Channel Z | + Input | 2001.66 | 0.63 | 0.03 |
| Channel Z | + Input | 200.31 | -1.07 | -0.53 |
| Channel Z | - Input | -200.03 | -1.38 | 0.70 |

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 | -3.80 | -5.29 |
| | - 200 | 6.14 | 4.50 |
| Channel Y | 200 | -2.04 | -2.59 |
| | - 200 | 1.39 | 1.67 |
| Channel Z | 200 | 15.93 | 16.20 |
| | - 200 | -17.00 | -17.81 |

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 | - | -0.12 | -4.75 |
| Channel Y | 200 | 7.03 | - | 1.00 |
| Channel Z | 200 | 8.67 | 5.84 | - |

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 | 15771 | 17023 |
| Channel Y | 15724 | 15708 |
| Channel Z | 16045 | 14942 |

5. Input Offset Measurement

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

Input 10M Ω

| | Average (μ V) | min. Offset (μ V) | max. Offset (μ V) | Std. Deviation (μ V) |
|-----------|--------------------|------------------------|------------------------|---------------------------|
| Channel X | 0.18 | -2.21 | 2.02 | 0.68 |
| Channel Y | -1.24 | -2.88 | 0.22 | 0.58 |
| Channel Z | -0.67 | -2.91 | 1.12 | 0.63 |

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 |

**CUSTOMER
COPY****DAE REPAIR REPORT – SPEAG Production Center**

| | | | |
|---|-----------------------------|--|-------------------------------------|
| PRODUCT | | DAE3 - Data Acquisition Electronics | |
| SERIAL Nr.: | | SN 522 | IN DATE: 3-Sep-2018 |
| CUSTOMER: | | Eurofins | |
| DAE REPAIR | | | |
| MATERIAL | WORK DESCRIPTION | | WORKING TIME (h) |
| Emergency stop: | fixed <input type="radio"/> | exchanged <input type="radio"/> | 6 new magnets <input type="radio"/> |
| DAE Connector: | fixed <input type="radio"/> | exchanged <input checked="" type="radio"/> | <input type="radio"/> |
| DAE Battery Cover: | fixed <input type="radio"/> | exchanged <input type="radio"/> | <input type="radio"/> |
| AD Converter Print: | fixed <input type="radio"/> | exchanged <input type="radio"/> | <input type="radio"/> |
| Battery Connector: | fixed <input type="radio"/> | exchanged <input type="radio"/> | <input type="radio"/> |
| Battery Con. PCB: | fixed <input type="radio"/> | exchanged <input type="radio"/> | <input type="radio"/> |
| Modification B-C | fixed <input type="radio"/> | exchanged <input type="radio"/> | <input type="radio"/> |
| Logic PCB: | fixed <input type="radio"/> | exchanged <input type="radio"/> | <input type="radio"/> |
| Input PCB: | fixed <input type="radio"/> | exchanged <input type="radio"/> | <input type="radio"/> |
| Analysis: | | | 1.50 hours |
| Final Assembly: | | | hours |
| Total hours | | | 2.00 hours |
| COMMENTS: This DAE was returned to SPEAG for calibration. The initial inspection found one broken pin in the DAE probe connector. Since there was only a single pin broken and the other pins remained straight, we consider this breakage a fatigue breakage. The connector has therefore been replaced for free. The DAE will be newly calibrated after this repair. | | | |
| CONDUCTED BY: | | APPROVED BY: | |
| DATE: <u>13-Sep-2018</u> | | DATE: <u>13-Sep-2018</u> | |
| REPAIR COST: | | | |
| MATERIAL COST: <u>free</u> | | USD <input type="radio"/> | Euro <input type="radio"/> |
| REPAIR: <u>free</u> | | <input type="radio"/> | <input type="radio"/> |
| TOTAL COST: | | QUOTATION #: | |
| <u>free</u> | | - | |
| APPROVED BY: | | | |
| DATE: <u>13-Sep-2018</u> | | | |

IMPORTANT NOTICE

USAGE OF THE DAE 3

The DAE unit is a delicate, high precision instrument and requires careful treatment by the user. There are no serviceable parts inside the DAE. Special attention shall be given to the following points:

Battery Exchange: The battery cover of the DAE3 unit is connected to a fragile 3-pin battery connector. Customer is responsible to apply utmost caution not to bend or damage the connector when changing batteries.

Shipping of the DAE: Before shipping the DAE to SPEAG for calibration the customer shall remove the batteries and pack the DAE in an antistatic bag. This antistatic bag shall then be packed into a larger box or container which protects the DAE from impacts transportation. The package shall be marked to indicate that a fragile instrument is inside.

E-Stop Failures: Touch detection may be malfunctioning due to broken magnets in the E-stop. Rough handling of the E-stop may lead to damage of these magnets. Touch and collision errors are often caused by dust and dirt accumulated in the E-stop. To prevent E-stop failure, Customer shall always mount the probe to the DAE carefully and keep the DAE unit in a non-dusty environment if not used for measurements.

Repair: Minor repairs are performed at no extra cost during the annual calibration. However, SPEAG reserves the right to charge for any repair especially if rough unprofessional handling caused the defect.

DASY Configuration Files: Since the exact values of the DAE input resistances, as measured during the calibration procedure of a DAE unit, are not used by the DASY software, a nominal value of 200 MOhm is given in the corresponding configuration file.

Important Note:

Warranty and calibration is void if the DAE unit is disassembled partly or fully by the Customer.

Important Note:

Never attempt to grease or oil the E-stop assembly. Cleaning and readjusting of the E-stop assembly is allowed by certified SPEAG personnel only and is part of the annual calibration procedure.

Important Note:

To prevent damage of the DAE probe connector pins, use great care when installing the probe to the DAE. Carefully connect the probe with the connector notch oriented in the mating position. Avoid any rotational movement of the probe body versus the DAE while turning the locking nut of the connector. The same care shall be used when disconnecting the probe from the DAE.



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Accreditation No.: **SCS 0108**

Client **Eurofins**

Certificate No: **EX3-3893_Sep18**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3893**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-12.v9, QA CAL-14.v4, QA CAL-23.v5,
QA CAL-25.v6
Calibration procedure for dosimetric E-field probes**

Calibration date: **September 20, 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 $(22 \pm 3)^{\circ}\text{C}$ 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 E8358A | SN: US41080477 | 31-Mar-14 (in house check Oct-17) | In house check: Oct-18 |

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

Issued: September 20, 2018

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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 ϕ | ϕ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\vartheta = 0$ 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:

- NORM_{x,y,z}**: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not affect the E^2 -field uncertainty inside TSL (see below ConvF).
- NORM(f)_{x,y,z}** = NORM_{x,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.
- DCP_{x,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
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,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 NORM_{x,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 ± 50 MHz to ± 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 NORM_x (no uncertainty required).