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Accreditation No.: **SCS 0108**

Client **Sporton**  
Shenzhen City

Certificate No. **5G-Veri10-2002\_Feb24**

## CALIBRATION CERTIFICATE

Object **5G Verification Source 10 GHz - SN: 2002**

Calibration procedure(s) **QA CAL-45.v5  
Calibration procedure for sources in air above 6 GHz**

Calibration date: **February 12, 2024**

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
Reference Probe EUmmWV3	SN: 9374	04-Dec-23 (No. EUmm-9374_Dec23)	Dec-24
DAE4ip	SN: 1602	08-Nov-23 (No. DAE4ip-1602_Nov23)	Nov-24
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMF100A	SN: 100184	29-Nov-23 (in house check Nov-23)	In house check: Nov-24
Power sensor R&S NRP18S-10	SN: 101258	29-Nov-23 (in house check Nov-23)	In house check: Nov-24
Network Analyzer Keysight E5063A	SN: MY54504221	31-Oct-19 (in house check Oct-22)	In house check: Oct-25

Calibrated by:	Name Leif Klysner	Function Laboratory Technician	Signature 
Approved by:	Sven Kühn	Technical Manager	

Issued: February 16, 2024

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## Glossary

CW                      Continuous wave

## Calibration is Performed According to the Following Standards

- Internal procedure QA CAL-45, Calibration procedure for sources in air above 6 GHz.
- IEC/IEEE 63195-1, "Assessment of power density of human exposure to radio frequency fields from wireless devices in close proximity to the head and body (frequency range of 6 GHz to 300 GHz)", May 2022

## Methods Applied and Interpretation of Parameters

- *Coordinate System:* z-axis in the waveguide horn boresight, x-axis is in the direction of the E-field, y-axis normal to the others in the field scanning plane parallel to the horn flare and horn flange.
- *Measurement Conditions:* (1) 10 GHz: The radiated power is the forward power to the horn antenna minus ohmic and mismatch loss. The forward power is measured prior and after the measurement with a power sensor. During the measurements, the horn is directly connected to the cable and the antenna ohmic and mismatch losses are determined by far-field measurements. (2) 30, 45, 60 and 90 GHz: The verification sources are switched on for at least 30 minutes. Absorbers are used around the probe cub and at the ceiling to minimize reflections.
- *Horn Positioning:* The waveguide horn is mounted vertically on the flange of the waveguide source to allow vertical positioning of the EUmmW probe during the scan. The plane is parallel to the phantom surface. Probe distance is verified using mechanical gauges positioned on the flare of the horn.
- *E- field distribution:* E field is measured in two x-y-plane (10mm, 10mm +  $\lambda/4$ ) with a vectorial E-field probe. The E-field value stated as calibration value represents the E-field-maxima and the averaged (1cm<sup>2</sup> and 4cm<sup>2</sup>) power density values at 10mm in front of the horn.
- *Field polarization:* Above the open horn, linear polarization of the field is expected. This is verified graphically in the field representation.

## Calibrated Quantity

- Local peak E-field (V/m) and average of peak spatial components of the poynting vector (W/m<sup>2</sup>) averaged over the surface area of 1 cm<sup>2</sup> and 4cm<sup>2</sup> at the nominal operational frequency of the verification source. Both square and circular averaging results are listed.

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%.



## Measurement Conditions

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

DASY Version	DASY8 Module mmWave	V3.2
Phantom	5G Phantom	
Distance Horn Aperture - plane	10 mm	
Number of measured planes	2 (10mm, 10mm + $\lambda/4$ )	
Frequency	10 GHz $\pm$ 10 MHz	

## Calibration Parameters, 10 GHz

### Circular Averaging

Distance Horn Aperture to Measured Plane	<i>Prad</i> <sup>1</sup> (mW)	Max E-field (V/m)	Uncertainty (k = 2)	Avg Power Density Avg (psPDn+, psPDtot+, psPDmod+) (W/m <sup>2</sup> )		Uncertainty (k = 2)
				1 cm <sup>2</sup>	4 cm <sup>2</sup>	
10 mm	138	291	1.27 dB	227	179	1.28 dB

Distance Horn Aperture to Measured Plane	<i>Prad</i> <sup>1</sup> (mW)	Max E-field (V/m)	Uncertainty (k = 2)	Power Density psPDn+, psPDtot+, psPDmod+ (W/m <sup>2</sup> )		Uncertainty (k = 2)
				1 cm <sup>2</sup>	4 cm <sup>2</sup>	
10 mm	138	291	1.27 dB	226, 227, 229	177, 178, 183	1.28 dB

### Square Averaging

Distance Horn Aperture to Measured Plane	<i>Prad</i> <sup>1</sup> (mW)	Max E-field (V/m)	Uncertainty (k = 2)	Avg Power Density Avg (psPDn+, psPDtot+, psPDmod+) (W/m <sup>2</sup> )		Uncertainty (k = 2)
				1 cm <sup>2</sup>	4 cm <sup>2</sup>	
10 mm	138	291	1.27 dB	227	179	1.28 dB

Distance Horn Aperture to Measured Plane	<i>Prad</i> <sup>1</sup> (mW)	Max E-field (V/m)	Uncertainty (k = 2)	Power Density psPDn+, psPDtot+, psPDmod+ (W/m <sup>2</sup> )		Uncertainty (k = 2)
				1 cm <sup>2</sup>	4 cm <sup>2</sup>	
10 mm	138	291	1.27 dB	226, 227, 229	177, 177, 183	1.28 dB

### Max Power Density

Distance Horn Aperture to Measured Plane	<i>Prad</i> <sup>1</sup> (mW)	Max E-field (V/m)	Uncertainty (k = 2)	Max Power Density Sn, Stot,  Stot  (W/m <sup>2</sup> )		Uncertainty (k = 2)
				247, 247, 247		
10 mm	138	291	1.27 dB	247, 247, 247		1.28 dB

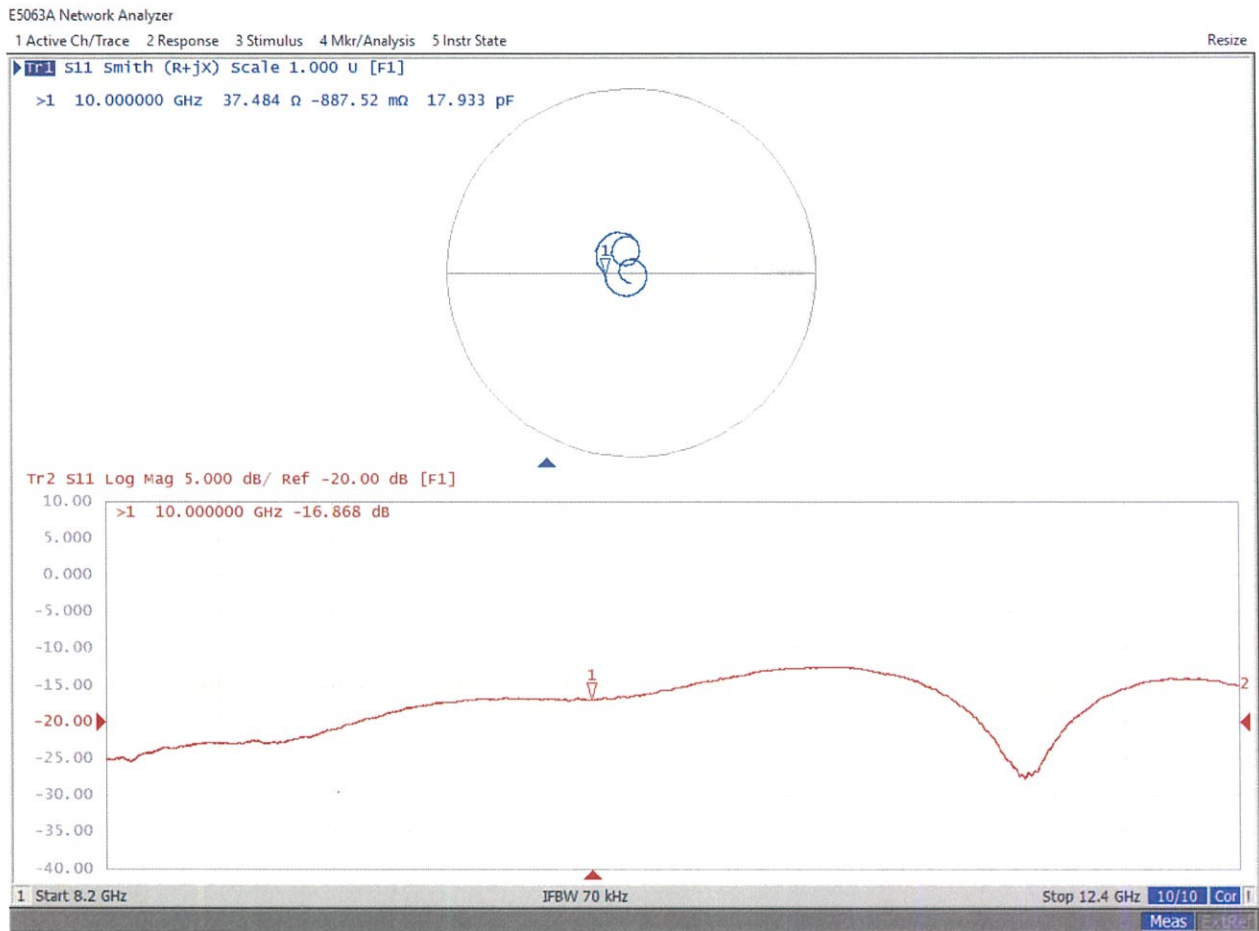
<sup>1</sup> Assessed ohmic and mismatch loss plus numerical offset: 0.60 dB

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters

Impedance, transformed to feed point	37.5 $\Omega$ - 0.9 j $\Omega$
Return Loss	- 16.9 dB

### Impedance Measurement Plot



# DASY Report

## Measurement Report for 5G Verification Source 10 GHz, UID 0 -, Channel 10000 (10000.0MHz)

### Device under Test Properties

Name, Manufacturer	Dimensions [mm]	IMEI	DUT Type
5G Verification Source 10 GHz	100.0 x 100.0 x 100.0	SN: 2002	-

### Exposure Conditions

Phantom Section	Position, Test Distance [mm]	Band	Group,	Frequency [MHz], Channel Number	Conversion Factor
5G -	10.0 mm	Validation band	CW	10000.0, 10000	1.0

### Hardware Setup

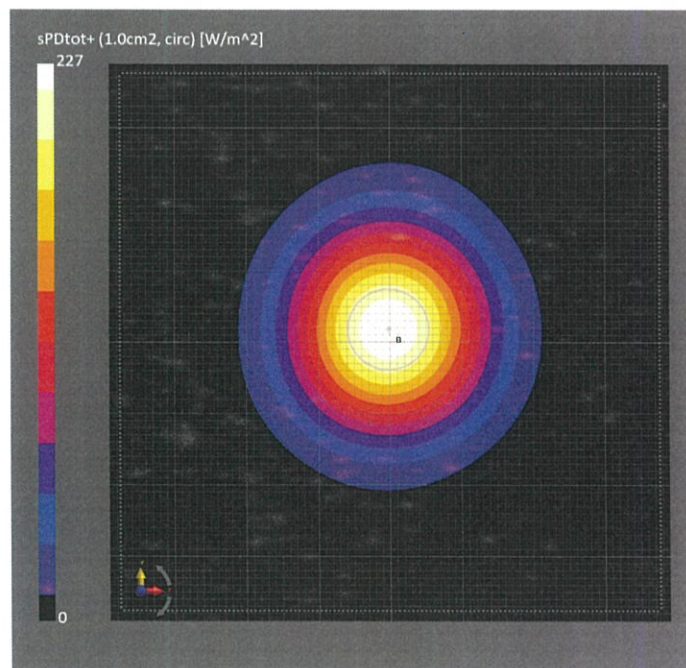
Phantom	Medium	Probe, Calibration Date	DAE, Calibration Date
mmWave Phantom - 1002	Air	EUmmWV3 - SN9374_F1-55GHz, 2023-12-04	DAE4ip Sn1602, 2023-11-08

### Scan Setup

Sensor Surface [mm]	5G Scan
MAIA	10.0 MAIA not used

### Measurement Results

	5G Scan
Date	2024-02-12, 16:16
Avg. Area [cm <sup>2</sup> ]	1.00
Avg. Type	Circular Averaging
psPDn+ [W/m <sup>2</sup> ]	226
psPDtot+ [W/m <sup>2</sup> ]	227
psPDmod+ [W/m <sup>2</sup> ]	229
Max(Sn) [W/m <sup>2</sup> ]	247
Max(Stot) [W/m <sup>2</sup> ]	247
Max( Stot ) [W/m <sup>2</sup> ]	247
E <sub>max</sub> [V/m]	291
Power Drift [dB]	0.00



# DASY Report

## Measurement Report for 5G Verification Source 10 GHz, UID 0 -, Channel 10000 (10000.0MHz)

### Device under Test Properties

Name, Manufacturer	Dimensions [mm]	IMEI	DUT Type
5G Verification Source 10 GHz	100.0 x 100.0 x 100.0	SN: 2002	-

### Exposure Conditions

Phantom Section	Position, Test Distance [mm]	Band	Group,	Frequency [MHz], Channel Number	Conversion Factor
5G -	10.0 mm	Validation band	CW	10000.0, 10000	1.0

### Hardware Setup

Phantom	Medium	Probe, Calibration Date	DAE, Calibration Date
mmWave Phantom - 1002	Air	EUmmWV3 - SN9374_F1-55GHz, 2023-12-04	DAE4ip Sn1602, 2023-11-08

### Scan Setup

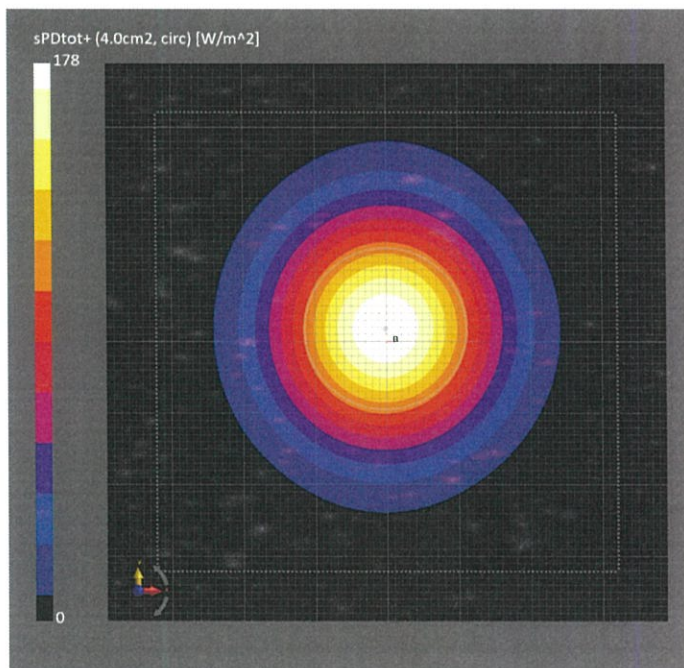
Sensor Surface [mm]  
MAIA

5G Scan  
10.0  
MAIA not used

### Measurement Results

Date  
Avg. Area [cm<sup>2</sup>]  
Avg. Type  
psPDn+ [W/m<sup>2</sup>]  
psPDtot+ [W/m<sup>2</sup>]  
psPDmod+ [W/m<sup>2</sup>]  
Max(Sn) [W/m<sup>2</sup>]  
Max(Stot) [W/m<sup>2</sup>]  
Max(|Stot|) [W/m<sup>2</sup>]  
E<sub>max</sub> [V/m]  
Power Drift [dB]

5G Scan  
2024-02-12, 16:16  
4.00  
Circular Averaging  
177  
178  
183  
247  
247  
247  
291  
0.00





# DASY Report

## Measurement Report for 5G Verification Source 10 GHz, UID 0 -, Channel 10000 (10000.0MHz)

### Device under Test Properties

Name, Manufacturer	Dimensions [mm]	IMEI	DUT Type
5G Verification Source 10 GHz	100.0 x 100.0 x 100.0	SN: 2002	-

### Exposure Conditions

Phantom Section	Position, Test Distance [mm]	Band	Group,	Frequency [MHz], Channel Number	Conversion Factor
5G -	10.0 mm	Validation band	CW	10000.0, 10000	1.0

### Hardware Setup

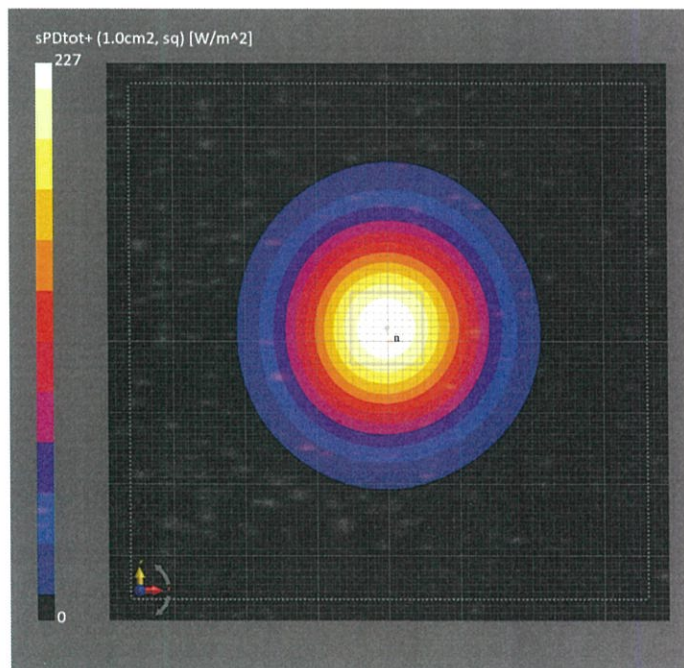
Phantom	Medium	Probe, Calibration Date	DAE, Calibration Date
mmWave Phantom - 1002	Air	EUmmWV3 - SN9374_F1-55GHz, 2023-12-04	DAE4ip Sn1602, 2023-11-08

### Scan Setup

Sensor Surface [mm]	5G Scan
MAIA	10.0 MAIA not used

### Measurement Results

Date	5G Scan
2024-02-12, 16:16	2024-02-12, 16:16
Avg. Area [cm <sup>2</sup> ]	1.00
Avg. Type	Square Averaging
psPDn+ [W/m <sup>2</sup> ]	226
psPDtot+ [W/m <sup>2</sup> ]	227
psPDmod+ [W/m <sup>2</sup> ]	229
Max(Sn) [W/m <sup>2</sup> ]	247
Max(Stot) [W/m <sup>2</sup> ]	247
Max( Stot ) [W/m <sup>2</sup> ]	247
E <sub>max</sub> [V/m]	291
Power Drift [dB]	0.00



# DASY Report

## Measurement Report for 5G Verification Source 10 GHz, UID 0 -, Channel 10000 (10000.0MHz)

### Device under Test Properties

Name, Manufacturer	Dimensions [mm]	IMEI	DUT Type
5G Verification Source 10 GHz	100.0 x 100.0 x 100.0	SN: 2002	-

### Exposure Conditions

Phantom Section	Position, Test Distance [mm]	Band	Group,	Frequency [MHz], Channel Number	Conversion Factor
5G -	10.0 mm	Validation band	CW	10000.0, 10000	1.0

### Hardware Setup

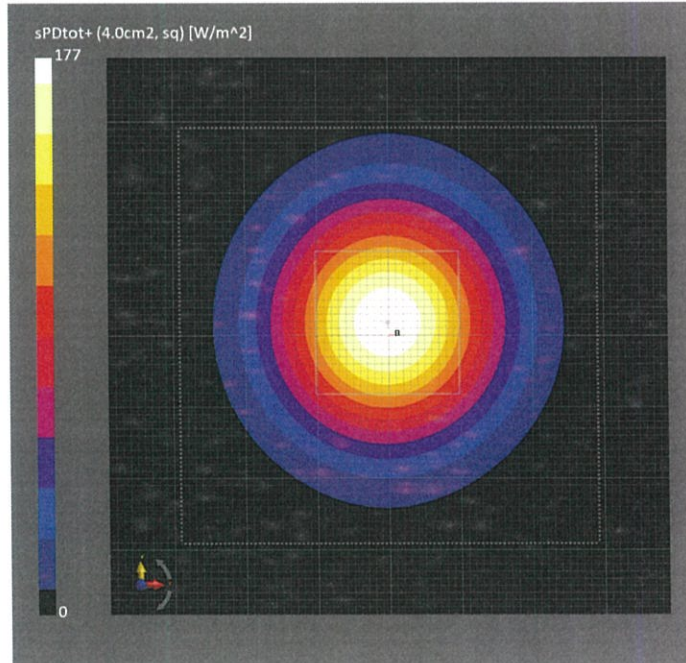
Phantom	Medium	Probe, Calibration Date	DAE, Calibration Date
mmWave Phantom - 1002	Air	EUmmWV3 - SN9374_F1-55GHz, 2023-12-04	DAE4ip Sn1602, 2023-11-08

### Scan Setup

Sensor Surface [mm]	5G Scan
MAIA	10.0 MAIA not used

### Measurement Results

	5G Scan
Date	2024-02-12, 16:16
Avg. Area [cm <sup>2</sup> ]	4.00
Avg. Type	Square Averaging
psPDn+ [W/m <sup>2</sup> ]	177
psPDtot+ [W/m <sup>2</sup> ]	177
psPDmod+ [W/m <sup>2</sup> ]	183
Max(Sn) [W/m <sup>2</sup> ]	247
Max(Stot) [W/m <sup>2</sup> ]	247
Max( Stot ) [W/m <sup>2</sup> ]	247
E <sub>max</sub> [V/m]	291
Power Drift [dB]	0.00





## IMPORTANT NOTICE

### USAGE OF THE DAE4

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 DAE4 unit is closed using a screw, over tightening the screw may cause the threads inside the DAE to wear out.

**Shipping of the DAE:** Before shipping the DAE to SPEAG for calibration, 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 during 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, the 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 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 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 **Sporton**  
Shenzhen City

Certificate No: **DAE4-715\_Jan24**

## CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BM - SN: 715**

Calibration procedure(s) **QA CAL-06.v30**  
Calibration procedure for the data acquisition electronics (DAE)

Calibration date: **January 25, 2024**

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
Keithley Multimeter Type 2001	SN: 0810278	29-Aug-23 (No:37421)	Aug-24
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Auto DAE Calibration Unit	SE UWS 053 AA 1001	23-Jan-24 (in house check)	In house check: Jan-25
Calibrator Box V2.1	SE UMS 006 AA 1002	23-Jan-24 (in house check)	In house check: Jan-25

Calibrated by:	Name <b>Dominique Steffen</b>	Function Laboratory Technician
Approved by:	Name <b>Sven Kühn</b>	Function Technical Manager

Signature  
  


Issued: January 25, 2024

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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 = 6.1 $\mu$ 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	405.105 $\pm$ 0.02% (k=2)	404.650 $\pm$ 0.02% (k=2)	404.469 $\pm$ 0.02% (k=2)
Low Range	3.99033 $\pm$ 1.50% (k=2)	3.97774 $\pm$ 1.50% (k=2)	3.96836 $\pm$ 1.50% (k=2)

## Connector Angle

Connector Angle to be used in DASY system	203.0 $^{\circ}$ $\pm$ 1 $^{\circ}$
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## Appendix (Additional assessments outside the scope of SCS0108)

### 1. DC Voltage Linearity

High Range	Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X + Input	200018.39	-6.26	-0.00
Channel X + Input	19995.66	-0.19	-0.00
Channel X - Input	-20013.22	3.32	-0.02
Channel Y + Input	200017.85	-7.17	-0.00
Channel Y + Input	19995.83	0.00	0.00
Channel Y - Input	-20016.14	0.14	-0.00
Channel Z + Input	200021.69	-3.47	-0.00
Channel Z + Input	19993.70	-2.15	-0.01
Channel Z - Input	-20018.02	-1.56	0.01

Low Range	Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X + Input	1990.83	0.10	0.00
Channel X + Input	189.88	-0.67	-0.35
Channel X - Input	-209.77	-0.44	0.21
Channel Y + Input	1990.52	-0.31	-0.02
Channel Y + Input	189.68	-1.07	-0.56
Channel Y - Input	-210.58	-1.34	0.64
Channel Z + Input	1990.54	-0.22	-0.01
Channel Z + Input	190.19	-0.40	-0.21
Channel Z - Input	-210.34	-1.05	0.50

### 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 ( $\mu\text{V}$ )	Low Range Average Reading ( $\mu\text{V}$ )
Channel X	200	4.65	2.39
	- 200	-1.26	-3.25
Channel Y	200	-5.14	-5.20
	- 200	4.22	3.81
Channel Z	200	6.53	6.30
	- 200	-6.69	-7.47

### 3. Channel separation

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

	Input Voltage (mV)	Channel X ( $\mu\text{V}$ )	Channel Y ( $\mu\text{V}$ )	Channel Z ( $\mu\text{V}$ )
Channel X	200	-	-1.22	-3.07
Channel Y	200	7.72	-	0.57
Channel Z	200	6.06	5.42	-

#### 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	15783	16054
Channel Y	15995	15951
Channel Z	16466	16344

#### 5. Input Offset Measurement

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

Input 10M $\Omega$

	Average ( $\mu$ V)	min. Offset ( $\mu$ V)	max. Offset ( $\mu$ V)	Std. Deviation ( $\mu$ V)
Channel X	0.78	-0.24	1.60	0.35
Channel Y	-0.56	-1.30	0.23	0.37
Channel Z	-0.07	-1.14	1.20	0.39

#### 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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Accreditation No.: **SCS 0108**

Client **Sporton**  
 Shenzhen City

Certificate No. **EUmm-9432\_Dec23**

**CALIBRATION CERTIFICATE**

Object **EUmmWV4 - SN:9432**

Calibration procedure(s) **QA CAL-02.v9, QA CAL-25.v8, QA CAL-42.v3**  
 Calibration procedure for E-field probes optimized for close near field evaluations in air

Calibration date **December 13, 2023**

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 sensor NRP110T	SN: 101244	12-Apr-23 (No. 0001A300692178)	Apr-24
Spectrum analyzer FSV40	SN: 101832	23-Jan-23 (No. 4030-315005314)	Jan-24
Ref. Probe EUmmWV3	SN: 9374	04-Dec-23 (No. EUmm-9374_Dec23)	Dec-24
DAE4ip	SN: 1662	08-Nov-23 (No. DAE4ip-1662_Nov23)	Nov-24

Secondary Standards	ID	Check Date (in house)	Scheduled Check
Generator APSIN26G	SN: 669	28-Mar-17 (in house check May-23)	In house check: May-24
Generator Agilent E8251A	SN: US41140111	28-Mar-17 (in house check May-23)	In house check: May-24

	Name	Function	Signature
Calibrated by	Jeton Kastrati	Laboratory Technician	
Approved by	Sven Kühn	Technical Manager	

Issued: December 18, 2023

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Accreditation No.: **SCS 0108**

## Glossary

NORM <sub>x,y</sub>	sensitivity in free space
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 $\vartheta$	$\vartheta$ 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
Sensor Angles	sensor deviation from the probe axis, used to calculate the field orientation and polarization
$\vec{k}$	is the wave propagation direction

## Calibration is Performed According to the Following Standards:

- IEEE Std 1309-2005, "IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", December 2005

## Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y</sub>**: Assessed for E-field polarization  $\vartheta = 0$  ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide). For frequencies  $> 6$  GHz, the far field in front of waveguide horn antennas is measured for a set of frequencies in various waveguide bands up to 110 GHz.
- DCP<sub>x,y</sub>**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal. DCP does not depend on frequency nor media.  
 Note: As the field is measured with a diode detector sensor, it is warranted that the probe response is linear ( $E^2$ ) below the documented lowest calibrated value.
- PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- The frequency sensor model parameters are determined prior to calibration based on a frequency sweep (sensor model involving resistors R, R<sub>p</sub>, inductance L and capacitors C, C<sub>p</sub>).
- A<sub>x,y</sub>; B<sub>x,y</sub>; C<sub>x,y</sub>; D<sub>x,y</sub>; VR<sub>x,y</sub>**: 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.
- 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<sub>x</sub> (no uncertainty required).
- Equivalent Sensor Angle**: The two probe sensors are mounted in the same plane at different angles. The angles are assessed using the information gained by determining the NORM<sub>x</sub> (no uncertainty required).
- Spherical isotropy (3D deviation from isotropy)**: in a locally homogeneous field realized using an open waveguide / horn setup.



### Parameters of Probe: EUmmWV4 - SN:9432

#### Basic Calibration Parameters

	Sensor X	Sensor Y	Unc (k = 2)
Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ )	0.02143	0.02304	$\pm 10.1\%$
DCP (mV) <sup>B</sup>	105.0	105.0	$\pm 4.7\%$
Equivalent Sensor Angle	-62.3	36.6	

#### Calibration Results for Frequency Response (750 MHz – 110 GHz)

Frequency GHz	Target E-Field V/m	Deviation Sensor X dB	Deviation Sensor Y dB	Unc (k = 2) dB
0.75	77.2	-0.03	-0.04	$\pm 0.43$
1.8	140.4	-0.02	-0.01	$\pm 0.43$
2.0	133.0	0.14	0.17	$\pm 0.43$
2.2	124.8	-0.09	-0.08	$\pm 0.43$
2.5	123.0	0.10	0.12	$\pm 0.43$
3.5	256.2	-0.19	-0.23	$\pm 0.43$
3.7	249.8	-0.05	-0.12	$\pm 0.43$
6.6	74.7	0.09	-0.25	$\pm 0.98$
8.0	67.2	0.03	-0.11	$\pm 0.98$
10.0	66.2	-0.03	0.03	$\pm 0.98$
15.0	51.2	0.07	0.17	$\pm 0.98$
26.6	112.6	0.21	0.19	$\pm 0.98$
30.0	121.9	0.03	0.00	$\pm 0.98$
35.0	121.3	-0.20	-0.13	$\pm 0.98$
40.0	102.3	-0.29	-0.22	$\pm 0.98$
50.0	61.5	0.01	-0.00	$\pm 0.98$
55.0	75.9	0.01	-0.00	$\pm 0.98$
60.0	80.5	-0.00	0.01	$\pm 0.98$
65.0	77.1	0.13	0.13	$\pm 0.98$
70.0	74.3	0.16	0.12	$\pm 0.98$
75.0	74.8	0.03	-0.02	$\pm 0.98$
75.0	96.6	0.03	-0.01	$\pm 0.98$
80.0	95.4	-0.14	-0.10	$\pm 0.98$
85.0	58.0	-0.09	-0.09	$\pm 0.98$
90.0	84.0	-0.01	0.00	$\pm 0.98$
92.0	83.9	0.03	0.04	$\pm 0.98$
95.0	76.2	0.02	0.01	$\pm 0.98$
97.0	69.1	0.07	0.03	$\pm 0.98$
100.0	66.9	0.13	0.14	$\pm 0.98$
105.0	67.2	-0.15	-0.17	$\pm 0.98$
110.0	78.1	0.00	0.02	$\pm 0.98$

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>B</sup> Linearization parameter uncertainty for maximum specified field strength.