



Accredited by the Swiss Accreditation Service (SAS)  
The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **Morlab (Auden)**

Certificate No: **DAE4-1643\_Nov20**

## CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BO - SN: 1643**

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

Calibration date: **November 30, 2020**

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 ( $22 \pm 3$ )°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        | 07-Sep-20 (No:28647)       | Sep-21                 |
| Secondary Standards           | ID #               | Check Date (in house)      | Scheduled Check        |
| Auto DAE Calibration Unit     | SE UWS 053 AA 1001 | 09-Jan-20 (in house check) | In house check: Jan-21 |
| Calibrator Box V2.1           | SE UMS 006 AA 1002 | 09-Jan-20 (in house check) | In house check: Jan-21 |

|                |                              |                                          |
|----------------|------------------------------|------------------------------------------|
| Calibrated by: | Name<br><b>Eric Hainfeld</b> | Function<br><b>Laboratory Technician</b> |
| Approved by:   | Sven Kühn                    | Deputy Manager                           |

Signature  
  


Issued: November 30, 2020

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

## 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          | 404.997 $\pm$ 0.02% (k=2) | 404.705 $\pm$ 0.02% (k=2) | 405.460 $\pm$ 0.02% (k=2) |
| Low Range           | 4.00435 $\pm$ 1.50% (k=2) | 3.99545 $\pm$ 1.50% (k=2) | 4.01998 $\pm$ 1.50% (k=2) |

## Connector Angle

|                                           |                   |
|-------------------------------------------|-------------------|
| Connector Angle to be used in DASY system | 116.0 ° $\pm$ 1 ° |
|-------------------------------------------|-------------------|

## 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 | 199993.39                 | -1.57                        | -0.00     |
| Channel X + Input | 20001.93                  | -0.19                        | -0.00     |
| Channel X - Input | -20000.77                 | 0.64                         | -0.00     |
| Channel Y + Input | 199992.54                 | -2.04                        | -0.00     |
| Channel Y + Input | 19999.33                  | -2.67                        | -0.01     |
| Channel Y - Input | -20002.89                 | -1.28                        | 0.01      |
| Channel Z + Input | 199995.27                 | 0.26                         | 0.00      |
| Channel Z + Input | 19999.93                  | -1.84                        | -0.01     |
| Channel Z - Input | -20001.63                 | 0.06                         | -0.00     |

| Low Range         | Reading ( $\mu\text{V}$ ) | Difference ( $\mu\text{V}$ ) | Error (%) |
|-------------------|---------------------------|------------------------------|-----------|
| Channel X + Input | 2001.80                   | 0.38                         | 0.02      |
| Channel X + Input | 202.14                    | 0.33                         | 0.16      |
| Channel X - Input | -197.83                   | 0.25                         | -0.13     |
| Channel Y + Input | 2002.10                   | 0.77                         | 0.04      |
| Channel Y + Input | 200.39                    | -1.33                        | -0.66     |
| Channel Y - Input | -198.90                   | -0.75                        | 0.38      |
| Channel Z + Input | 2001.56                   | 0.39                         | 0.02      |
| Channel Z + Input | 200.76                    | -0.78                        | -0.39     |
| Channel Z - Input | -199.89                   | -1.58                        | 0.80      |

### 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                            | -2.88                                        | -4.37                                       |
|           | - 200                          | 6.47                                         | 4.34                                        |
| Channel Y | 200                            | -2.89                                        | -3.82                                       |
|           | - 200                          | 3.09                                         | 2.28                                        |
| Channel Z | 200                            | 2.19                                         | 2.37                                        |
|           | - 200                          | -4.94                                        | -4.88                                       |

### 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                | -                           | -0.31                       | -3.64                       |
| Channel Y | 200                | 6.86                        | -                           | 1.13                        |
| Channel Z | 200                | 10.67                       | 4.39                        | -                           |

#### 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 | 16034            | 15888           |
| Channel Y | 16076            | 15593           |
| Channel Z | 15905            | 16557           |

#### 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 | 0.05               | -0.77                  | 0.86                   | 0.33                      |
| Channel Y | -1.01              | -1.98                  | 0.32                   | 0.36                      |
| Channel Z | -1.08              | -2.17                  | -0.24                  | 0.35                      |

#### 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                |



Accredited by the Swiss Accreditation Service (SAS)

The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **Morlab (Auden)**

Certificate No: **5G-Veri30-1077\_Dec20**

## CALIBRATION CERTIFICATE

Object **5G Verification Source 30 GHz - SN: 1077**

Calibration procedure(s) **QA CAL-45.v3**  
**Calibration procedure for sources in air above 6 GHz**

Calibration date: **December 02, 2020**

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 ( $22 \pm 3$ )°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards                 | ID #     | Cal Date (Certificate No.)         | Scheduled Calibration |
|-----------------------------------|----------|------------------------------------|-----------------------|
| Reference Probe EUmmWV3<br>DAE4ip | SN: 9374 | 31-Dec-19 (No. EUmmWV3-9374_Dec19) | Dec-20                |
|                                   | SN: 1602 | 11-Aug-20 (No. DAE4ip-1602_Aug20)  | Aug-21                |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---------------------|------|-----------------------|-----------------|
|---------------------|------|-----------------------|-----------------|

|                |              |                       |           |
|----------------|--------------|-----------------------|-----------|
| Calibrated by: | Name         | Function              | Signature |
|                | Leif Klysner | Laboratory Technician |           |

|              |               |                   |
|--------------|---------------|-------------------|
| Approved by: | Name          | Function          |
|              | Katja Pokovic | Technical Manager |

Issued: December 3, 2020

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.



Accredited by the Swiss Accreditation Service (SAS)

The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

## Glossary

CW                      Continuous wave

## Calibration is Performed According to the Following Standards

- Internal procedure QA CAL-45-5Gsources
- IEC TR 63170 ED1, "Measurement procedure for the evaluation of power density related to human exposure to radio frequency fields from wireless communication devices operating between 6 GHz and 100 GHz", January 2018

## 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 forward power to the horn antenna 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 peak values of the total and normal component of the poynting vector  $|\text{Re}\{S\}|$  and  $n.\text{Re}\{S\}$  averaged over the surface area of 1 cm<sup>2</sup> ( $pS_{\text{totavg}1\text{cm}^2}$  and  $pS_{n\text{avg}1\text{cm}^2}$ ) and 4cm<sup>2</sup> ( $pS_{\text{totavg}4\text{cm}^2}$  and  $pS_{n\text{avg}4\text{cm}^2}$ ) at the nominal operational frequency of the verification source.

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                   | cDASY6 Module mmWave          | V2.0 |
| Phantom                        | 5G Phantom                    |      |
| Distance Horn Aperture - plane | 10 mm                         |      |
| XY Scan Resolution             | dx, dy = 2.5 mm               |      |
| Number of measured planes      | 2 (10mm, 10mm + $\lambda/4$ ) |      |
| Frequency                      | 30 GHz $\pm$ 10 MHz           |      |

## Calibration Parameters, 30 GHz

| Distance Horn Aperture<br>to Measured Plane | <i>Prad</i> <sup>1</sup><br>(mW) | Max E-field<br>(V/m) | Uncertainty<br>(k = 2) | Avg Power Density<br>n.Re{S},  Re{S} <br>(W/m <sup>2</sup> ) |                   | Uncertainty<br>(k = 2) |
|---------------------------------------------|----------------------------------|----------------------|------------------------|--------------------------------------------------------------|-------------------|------------------------|
|                                             |                                  |                      |                        | 1 cm <sup>2</sup>                                            | 4 cm <sup>2</sup> |                        |
| 10 mm                                       | 27.0                             | 118                  | 1.27 dB                | 31.8, 32.2                                                   | 28.0, 28.4        | 1.28 dB                |

---

<sup>1</sup> derived from far-field data

## DASY Report

### Measurement Report for 5G Verification Source 30 GHz, UID 0 -, Channel 30000 (30000.0MHz)

#### Device under Test Properties

| Name, Manufacturer            | Dimensions [mm]       | IMEI     | DUT Type |
|-------------------------------|-----------------------|----------|----------|
| 5G Verification Source 30 GHz | 100.0 x 100.0 x 100.0 | SN: 1077 | -        |

#### Exposure Conditions

| Phantom Section | Position, Test Distance [mm] | Band            | Group, | Frequency [MHz], Channel Number | Conversion Factor |
|-----------------|------------------------------|-----------------|--------|---------------------------------|-------------------|
| 5G -            | 5.55 mm                      | Validation band | CW     | 30000.0, 30000                  | 1.0               |

#### Hardware Setup

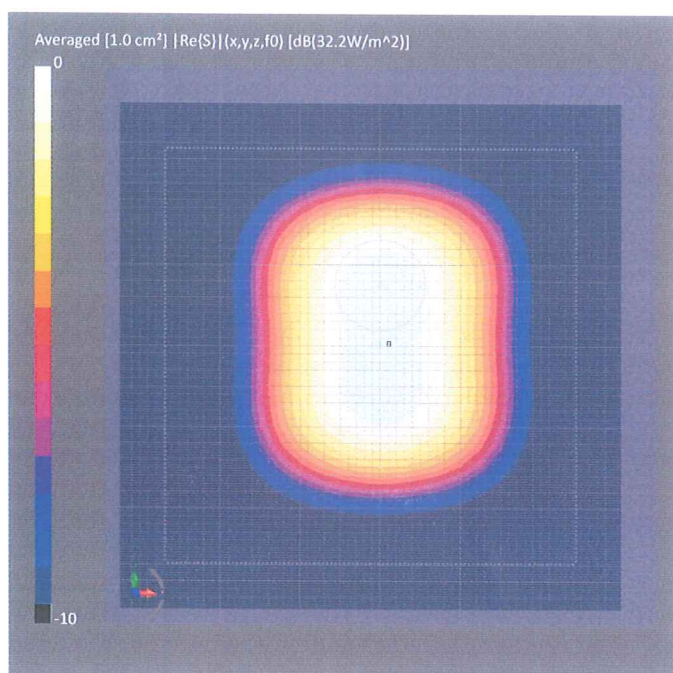
| Phantom               | Medium | Probe, Calibration Date               | DAE, Calibration Date     |
|-----------------------|--------|---------------------------------------|---------------------------|
| mmWave Phantom - 1002 | Air    | EUmmWV3 - SN9374_F1-78GHz, 2019-12-31 | DAE4ip Sn1602, 2020-08-11 |

#### Scan Setup

|                     | 5G Scan       |
|---------------------|---------------|
| Grid Extents [mm]   | 60.0 x 60.0   |
| Grid Steps [lambda] | 0.25 x 0.25   |
| Sensor Surface [mm] | 5.55          |
| MAIA                | MAIA not used |

#### Measurement Results

|                                           | 5G Scan           |
|-------------------------------------------|-------------------|
| Date                                      | 2020-12-02, 13:30 |
| Avg. Area [cm <sup>2</sup> ]              | 1.00              |
| pS <sub>tot</sub> avg [W/m <sup>2</sup> ] | 32.2              |
| pS <sub>n</sub> avg [W/m <sup>2</sup> ]   | 31.8              |
| E <sub>peak</sub> [V/m]                   | 118               |
| Power Drift [dB]                          | -0.02             |



DASY Report

Measurement Report for 5G Verification Source 30 GHz, UID 0 -, Channel 30000 (30000.0MHz)

Device under Test Properties

| Name, Manufacturer            | Dimensions [mm]       | IMEI     | DUT Type |
|-------------------------------|-----------------------|----------|----------|
| 5G Verification Source 30 GHz | 100.0 x 100.0 x 100.0 | SN: 1077 | -        |

Exposure Conditions

| Phantom Section | Position, Test Distance [mm] | Band            | Group, | Frequency [MHz], Channel Number | Conversion Factor |
|-----------------|------------------------------|-----------------|--------|---------------------------------|-------------------|
| 5G -            | 5.55 mm                      | Validation band | CW     | 30000.0, 30000                  | 1.0               |

Hardware Setup

| Phantom               | Medium | Probe, Calibration Date               | DAE, Calibration Date     |
|-----------------------|--------|---------------------------------------|---------------------------|
| mmWave Phantom - 1002 | Air    | EUmmWV3 - SN9374_F1-78GHz, 2019-12-31 | DAE4ip Sn1602, 2020-08-11 |

Scan Setup

| Grid Extents [mm]   | 5G Scan       |
|---------------------|---------------|
| Grid Steps [lambda] | 60.0 x 60.0   |
| Sensor Surface [mm] | 0.25 x 0.25   |
| MAIA                | 5.55          |
|                     | MAIA not used |

Measurement Results

| Date                         | 5G Scan           |
|------------------------------|-------------------|
| Avg. Area [cm²]              | 2020-12-02, 13:30 |
| pS <sub>tot</sub> avg [W/m²] | 4.00              |
| pS <sub>n</sub> avg [W/m²]   | 28.4              |
| E <sub>peak</sub> [V/m]      | 28.0              |
| Power Drift [dB]             | 118               |
|                              | -0.02             |

