



In Collaboration with  
**s p e a g**  
CALIBRATION LABORATORY

Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China  
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## Appendix

### Antenna Parameters with Head TSL at 5250 MHz

|                                      |                |
|--------------------------------------|----------------|
| Impedance, transformed to feed point | 48.4Ω - 5.62jΩ |
| Return Loss                          | - 24.5dB       |

### Antenna Parameters with Head TSL at 5600 MHz

|                                      |                |
|--------------------------------------|----------------|
| Impedance, transformed to feed point | 55.5Ω - 5.39jΩ |
| Return Loss                          | - 22.8dB       |

### Antenna Parameters with Head TSL at 5750 MHz

|                                      |                |
|--------------------------------------|----------------|
| Impedance, transformed to feed point | 52.4Ω - 4.20jΩ |
| Return Loss                          | - 26.5dB       |

### Antenna Parameters with Body TSL at 5250 MHz

|                                      |                |
|--------------------------------------|----------------|
| Impedance, transformed to feed point | 50.4Ω - 5.86jΩ |
| Return Loss                          | - 24.7dB       |

### Antenna Parameters with Body TSL at 5600 MHz

|                                      |                |
|--------------------------------------|----------------|
| Impedance, transformed to feed point | 57.2Ω - 1.59jΩ |
| Return Loss                          | - 23.3dB       |

### Antenna Parameters with Body TSL at 5750 MHz

|                                      |                |
|--------------------------------------|----------------|
| Impedance, transformed to feed point | 56.0Ω - 0.37jΩ |
| Return Loss                          | - 24.9dB       |



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### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.310 ns |
|----------------------------------|----------|

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard. No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

### Additional EUT Data

|                 |       |
|-----------------|-------|
| Manufactured by | SPEAG |
|-----------------|-------|



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**DASY5 Validation Report for Head TSL**

Date: 01.05.2017

Test Laboratory: CTTL, Beijing, China

**DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1151**

Communication System: CW; Frequency: 5250 MHz, Frequency: 5600 MHz,  
Frequency: 5750 MHz,

Medium parameters used:  $f = 5250$  MHz;  $\sigma = 4.636$  mho/m;  $\epsilon_r = 35.38$ ;  $\rho = 1000$  kg/m<sup>3</sup>,  
Medium parameters used:  $f = 5600$  MHz;  $\sigma = 5.015$  mho/m;  $\epsilon_r = 35.41$ ;  $\rho = 1000$  kg/m<sup>3</sup>,  
Medium parameters used:  $f = 5750$  MHz;  $\sigma = 5.173$  mho/m;  $\epsilon_r = 36.06$ ;  $\rho = 1000$  kg/m<sup>3</sup>,

Phantom section: Center Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

**DASY5 Configuration:**

- Probe: EX3DV4 - SN7433; ConvF(5.13,5.13,5.13); Calibrated: 2016/9/26, ConvF(4.59,4.59,4.59); Calibrated: 2016/9/26, ConvF(4.66,4.66,4.66); Calibrated: 2016/9/26,
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn771; Calibrated: 2016/2/2
- Phantom: Triple Flat Phantom 5.1C; Type: QD 000 P51 CA; Serial: 1161/3
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7372)

**Dipole Calibration /Pin=100mW, d=10mm, f=5250 MHz/Zoom Scan,****dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 71.52 V/m; Power Drift = 0.07 dB

Peak SAR (extrapolated) = 32.1 W/kg

**SAR(1 g) = 7.87 W/kg; SAR(10 g) = 2.25 W/kg**

Maximum value of SAR (measured) = 18.3 W/kg

**Dipole Calibration /Pin=100mW, d=10mm, f=5600 MHz/Zoom Scan,****dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 58.03 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 34.2 W/kg

**SAR(1 g) = 8.16 W/kg; SAR(10 g) = 2.32 W/kg**

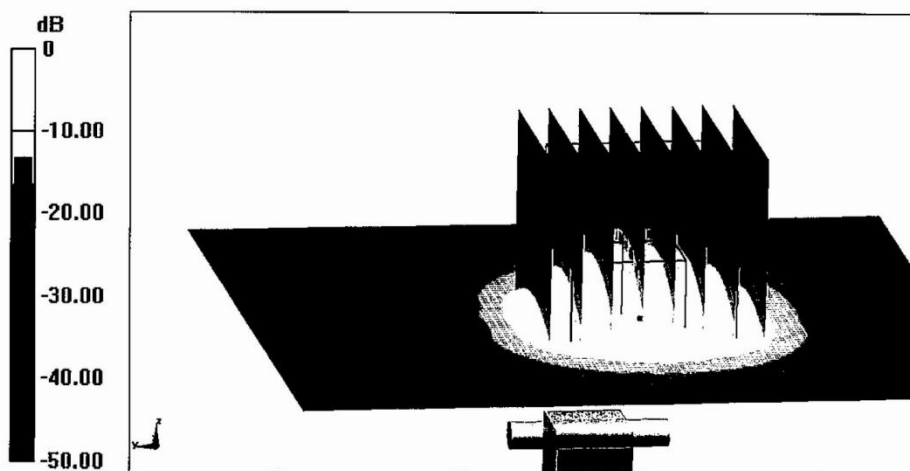
Maximum value of SAR (measured) = 19.9 W/kg



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**Dipole Calibration /Pin=100mW, d=10mm, f=5750 MHz/Zoom Scan,**  
**dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm  
Reference Value = 58.85 V/m; Power Drift = 0.08 dB  
Peak SAR (extrapolated) = 35.0 W/kg  
**SAR(1 g) = 8.02 W/kg; SAR(10 g) = 2.26 W/kg**  
Maximum value of SAR (measured) = 19.7 W/kg



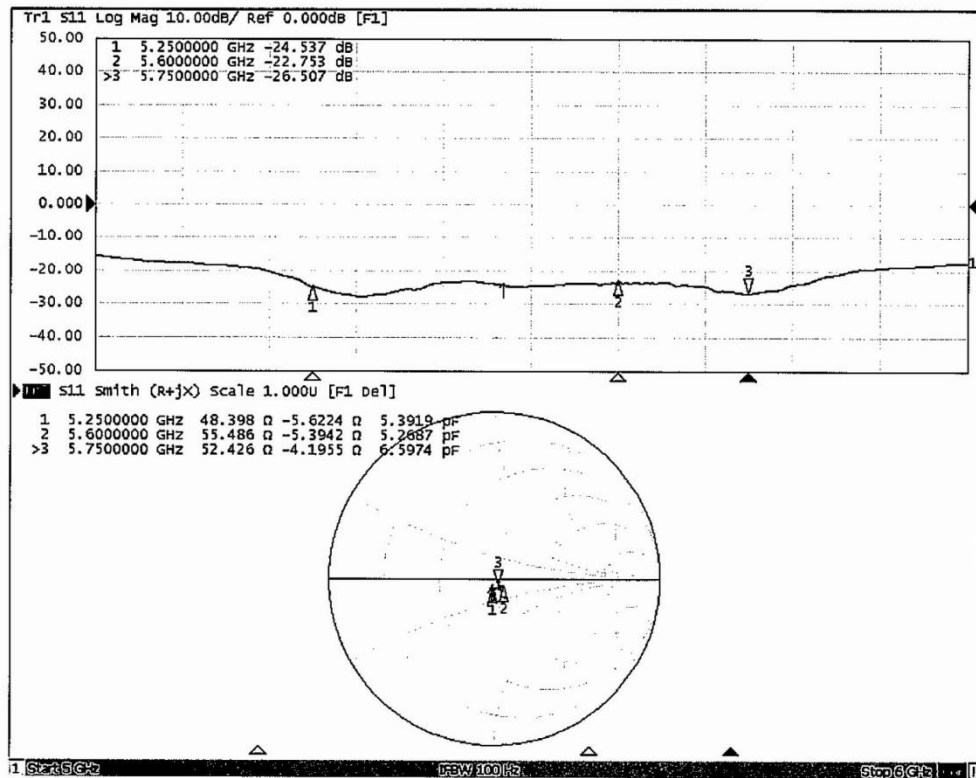
0 dB = 19.7 W/kg = 12.94 dBW/kg



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### Impedance Measurement Plot for Head TSL



Certificate No: Z17-97001

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**DASY5 Validation Report for Body TSL**

Date: 01.04.2017

Test Laboratory: CTTL, Beijing, China

**DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1151**

Communication System: CW; Frequency: 5250 MHz, Frequency: 5600 MHz,  
Frequency: 5750 MHz,

Medium parameters used:  $f = 5250$  MHz;  $\sigma = 5.388$  mho/m;  $\epsilon_r = 47.81$ ;  $\rho = 1000$  kg/m<sup>3</sup>,  
Medium parameters used:  $f = 5600$  MHz;  $\sigma = 5.704$  mho/m;  $\epsilon_r = 48.39$ ;  $\rho = 1000$  kg/m<sup>3</sup>,  
Medium parameters used:  $f = 5750$  MHz;  $\sigma = 5.833$  mho/m;  $\epsilon_r = 48.61$ ;  $\rho = 1000$  kg/m<sup>3</sup>,

Phantom section: Right Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

**DASY5 Configuration:**

- Probe: EX3DV4 - SN7433; ConvF(4.68,4.68,4.68); Calibrated: 2016/9/26, ConvF(3.98,3.98,3.98); Calibrated: 2016/9/26, ConvF(4.35,4.35,4.35); Calibrated: 2016/9/26,
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn771; Calibrated: 2016/2/2
- Phantom: Triple Flat Phantom 5.1C; Type: QD 000 P51 CA; Serial: 1161/3
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7372)

**Dipole Calibration /Pin=100mW, d=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm  
Reference Value = 63.69 V/m; Power Drift = -0.05 dB  
Peak SAR (extrapolated) = 28.5 W/kg  
**SAR(1 g) = 7.59 W/kg; SAR(10 g) = 2.15 W/kg**  
Maximum value of SAR (measured) = 17.7 W/kg

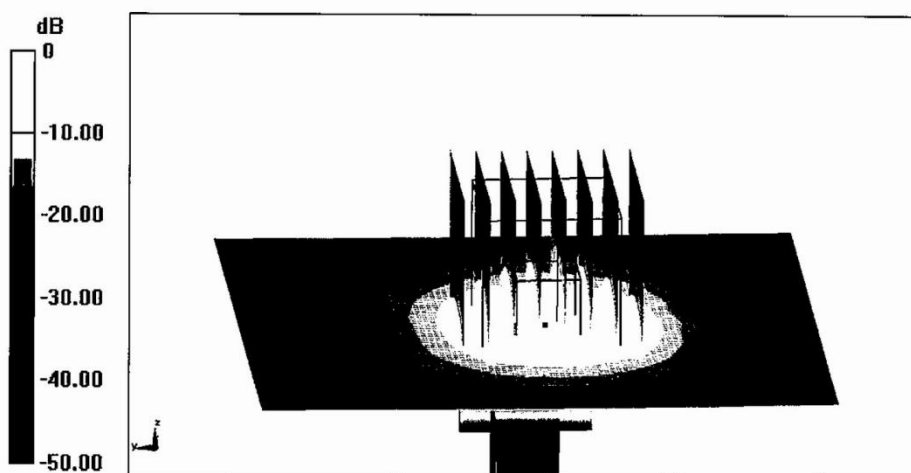
**Dipole Calibration /Pin=100mW, d=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm  
Reference Value = 67.67 V/m; Power Drift = -0.05 dB  
Peak SAR (extrapolated) = 33.8 W/kg  
**SAR(1 g) = 8.03 W/kg; SAR(10 g) = 2.23 W/kg**  
Maximum value of SAR (measured) = 19.8 W/kg



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**Dipole Calibration /Pin=100mW, d=10mm, f=5750 MHz/Zoom Scan,**  
**dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm  
Reference Value = 64.76 V/m; Power Drift = -0.04 dB  
Peak SAR (extrapolated) = 30.0 W/kg  
**SAR(1 g) = 7.46 W/kg; SAR(10 g) = 2.1 W/kg**  
Maximum value of SAR (measured) = 17.5 W/kg



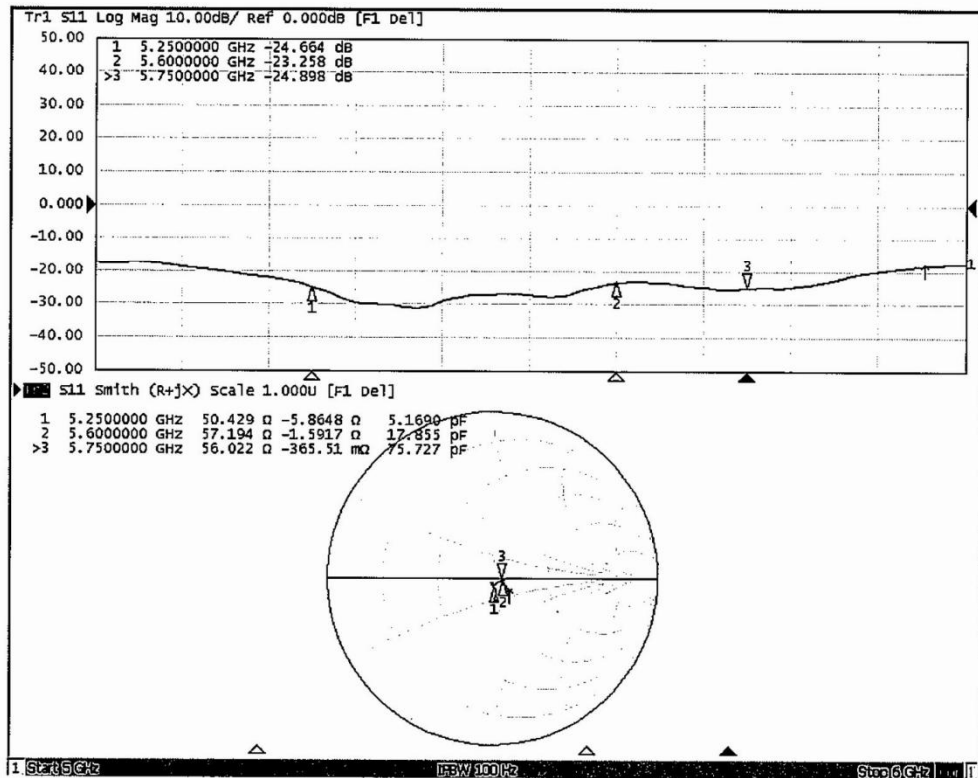
0 dB = 17.5 W/kg = 12.43 dBW/kg



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### Impedance Measurement Plot for Body TSL



# ANNEX L:DAE4 Calibration Certificate

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



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

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 **TA-SH (Auden)**

Certificate No: **DAE4-1291\_Dec18**

## CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BM - SN: 1291**

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

Calibration date: **December 04, 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 ( $22 \pm 3$ )°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 |

|                |                   |                       |           |
|----------------|-------------------|-----------------------|-----------|
|                | Name              | Function              | Signature |
| Calibrated by: | Dominique Steffen | Laboratory Technician |           |
| Approved by:   | Sven Kühn         | Deputy Manager        |           |

Issued: December 4, 2018

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

Certificate No: DAE4-1291\_Dec18

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Accreditation No.: **SCS 0108**

## 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          | 402.580 $\pm$ 0.02% (k=2) | 403.249 $\pm$ 0.02% (k=2) | 403.163 $\pm$ 0.02% (k=2) |
| Low Range           | 3.97560 $\pm$ 1.50% (k=2) | 3.97886 $\pm$ 1.50% (k=2) | 3.97558 $\pm$ 1.50% (k=2) |

### Connector Angle

|                                           |                   |
|-------------------------------------------|-------------------|
| Connector Angle to be used in DASY system | 164.5 ° $\pm$ 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 | 200038.51                 | 1.95                         | 0.00      |
| Channel X + Input | 20006.61                  | 1.29                         | 0.01      |
| Channel X - Input | -20003.34                 | 2.94                         | -0.01     |
| Channel Y + Input | 200036.77                 | 0.05                         | 0.00      |
| Channel Y + Input | 20003.65                  | -1.54                        | -0.01     |
| Channel Y - Input | -20006.11                 | 0.22                         | -0.00     |
| Channel Z + Input | 200035.08                 | -1.41                        | -0.00     |
| Channel Z + Input | 20002.62                  | -2.58                        | -0.01     |
| Channel Z - Input | -20006.40                 | -0.06                        | 0.00      |

| Low Range         | Reading ( $\mu\text{V}$ ) | Difference ( $\mu\text{V}$ ) | Error (%) |
|-------------------|---------------------------|------------------------------|-----------|
| Channel X + Input | 2001.29                   | 0.31                         | 0.02      |
| Channel X + Input | 201.13                    | 0.32                         | 0.16      |
| Channel X - Input | -198.59                   | 0.30                         | -0.15     |
| Channel Y + Input | 2000.40                   | -0.49                        | -0.02     |
| Channel Y + Input | 200.21                    | -0.66                        | -0.33     |
| Channel Y - Input | -199.89                   | -0.99                        | 0.50      |
| Channel Z + Input | 2000.44                   | -0.41                        | -0.02     |
| Channel Z + Input | 199.70                    | -1.05                        | -0.52     |
| Channel Z - Input | -200.88                   | -1.78                        | 0.89      |

### 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                            | 10.02                                        | 7.91                                        |
|           | - 200                          | -6.52                                        | -8.20                                       |
| Channel Y | 200                            | 14.18                                        | 13.58                                       |
|           | - 200                          | -15.10                                       | -15.62                                      |
| Channel Z | 200                            | -17.07                                       | -17.23                                      |
|           | - 200                          | 14.74                                        | 14.83                                       |

### 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                | -                           | -0.01                       | -4.47                       |
| Channel Y | 200                | 7.58                        | -                           | 0.48                        |
| Channel Z | 200                | 11.17                       | 4.87                        | -                           |

#### 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 | 16117            | 16241           |
| Channel Y | 15930            | 16718           |
| Channel Z | 16177            | 17128           |

#### 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 | -0.59              | -1.81                  | 0.89                   | 0.47                      |
| Channel Y | 1.17               | -0.04                  | 2.05                   | 0.45                      |
| Channel Z | -1.12              | -2.70                  | 0.51                   | 0.57                      |

#### 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                |