CD1880V3, Serial No. 1155 Extended Dipole Calibrations

If dipoles are verified in return loss (<-20dB, within 20% of prior calibration),and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and thecalibration interval can be extended.

CD1880V2 – serial no. 1155						
1730 Head						
Date of Measurement	Return-Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
2022.3.1	-30.448		47.910		-2.0690	
2023.2.28	-30.309	-0.46	51.112	-3.202	-3.2774	1.2084
2024.2.28	-31.827	4.53	51.537	-3.627	-2.0768	0.0078

CD1880V2 – serial no. 1155						
1880 Head						
Date of Measurement	Return-Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
2022.3.1	-18.850		53.833		11.290	
2023.2.28	-18.930	0.42	50.740	3.093	11.505	-0.215
2024.2.28	-17.881	-5.14	51.346	2.487	12.967	-1.677

CD1880V2 – serial no. 1155						
1900 Head						
Date of Measurement	Return-Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
2022.3.1	-19.823		55.651		9.2309	
2023.2.28	-18.739	-5.47	55.953	-0.302	10.564	-1.3331
2024.2.28	-17.911	-9.65	55.171	0.48	12.431	-3.2001

CD1880V2 – serial no. 1155						
1950 Head						
Date of Measurement	Return-Loss (dB)	Delta (%)	Real Impedance	Delta (ohm)	Imaginary Impedance	Delta (ohm)

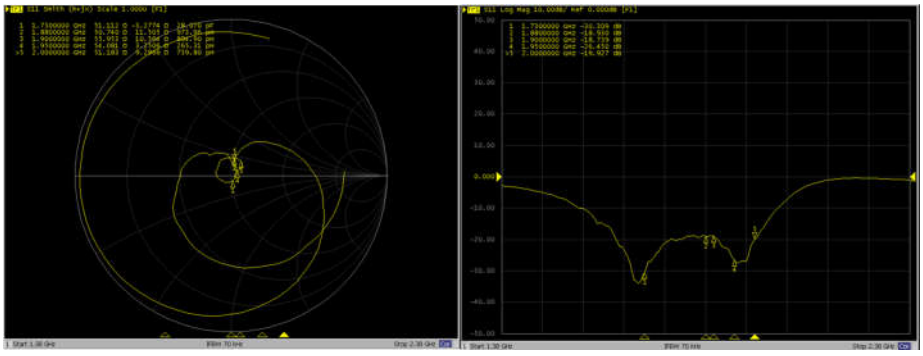
			(ohm)		(ohm)	
2022.3.1	-22.496		53.429		6.9809	
2023.2.28	-26.450	17.58	54.081	-0.652	3.2506	3.7303
2024.2.28	-22.388	-0.48	56.236	-2.807	5.1400	1.8409
CD1880V2 – serial no. 1155						
2000 Head						
Date of Measurement	Return-Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
2022.3.1	-18.375		53.908		11.991	
2023.2.28	-19.927	8.45	51.183	2.725	9.2966	2.6944
2024.2.28	-18.654	1.52	50.503	3.405	11.813	0.178

<Justification of the extended calibration>

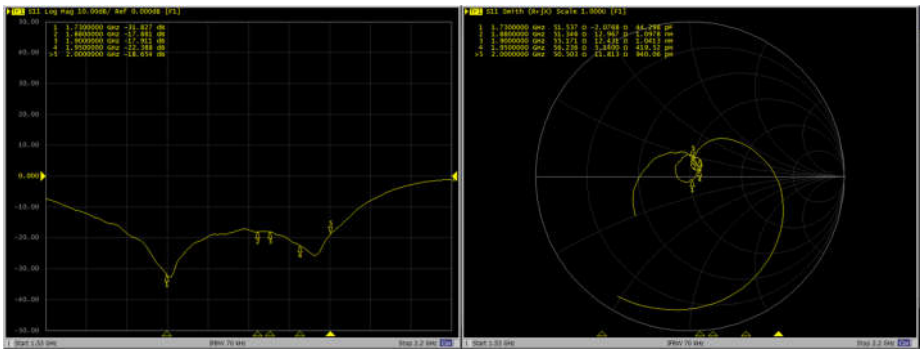
The return loss is < -20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

Dipole Verification Data> CD1880V3, serial no. 1155

1730MHz-1880MHz-1900MHz-1950MHz-2000MHz – Head – 2023.2.28



1730MHz-1880MHz-1900MHz-1950MHz-2000MHz – Head – 2024.2.28



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s p e a g

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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.

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

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C Service suisse d'étalonnage
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Accredited by the Swiss Accreditation Service (SAS)
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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

	Name	Function	Signature
Calibrated by:	Dominique Steffen	Laboratory Technician	
Approved by:	Sven Kühn	Technical Manager	

Issued: January 25, 2024

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	405.105 ± 0.02% (k=2)	404.650 ± 0.02% (k=2)	404.469 ± 0.02% (k=2)
Low Range	3.99033 ± 1.50% (k=2)	3.97774 ± 1.50% (k=2)	3.96836 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	203.0 ° ± 1 °

Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range		Reading (μV)	Difference (μV)	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 (μV)	Difference (μV)	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 (μV)	Low Range Average Reading (μV)
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 (μV)	Channel Y (μV)	Channel Z (μV)
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 10MΩ

	Average (μV)	min. Offset (μV)	max. Offset (μV)	Std. Deviation (μV)
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.**	**EF-4053_Sep23**

CALIBRATION CERTIFICATE

Object	EF3DV3 - SN:4053
Calibration procedure(s)	QA CAL-02.v9, QA CAL-25.v8 Calibration procedure for E-field probes optimized for close near field evaluations in air
Calibration date	September 15, 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 meter NRP2	SN: 104778	30-Mar-23 (No. 217-03804/03805)	Mar-24
Power sensor NRP-Z91	SN: 103244	30-Mar-23 (No. 217-03804)	Mar-24
Power sensor NRP-Z91	SN: 103245	30-Mar-23 (No. 217-03805)	Mar-24
Reference 20 dB Attenuator	SN: CC2552 (20x)	30-Mar-23 (No. 217-03809)	Mar-24
DAE4	SN: 789	03-Jan-23 (No. DAE4-789_Jan23)	Jan-24
Reference Probe ER3DV6	SN: 2328	06-Oct-22 (No. ER3-2328_Oct22)	Oct-23

Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-22)	In house check: Jun-24
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-22)	In house check: Jun-24
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-22)	In house check: Jun-24
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-22)	In house check: Jun-24
Network Analyzer E8358A	SN: US41080477	31-Mar-14 (in house check Oct-22)	In house check: Oct-24

	Name	Function	Signature
Calibrated by	Michael Weber	Laboratory Technician	
Approved by	Sven Kühn	Technical Manager	

Issued: September 15, 2023

Glossary

NORMx,y,z	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
En	incident E-field orientation normal to probe axis
Ep	incident E-field orientation parallel to probe axis
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:

a) IEEE Std 1309-2005, "IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", December 2005
b) CTIA Test Plan for Hearing Aid Compatibility, Rev 3.1.1, May 2017

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z*: Assessed for E-field polarization $\vartheta = 0$ for XY sensors and $\vartheta = 90$ for Z sensor ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz in R22 waveguide).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart).
- *DCPx,y,z*: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal. 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.
- *Spherical isotropy (3D deviation from isotropy)*: in a locally homogeneous field realized using an open waveguide setup
- *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).

Parameters of Probe: EF3DV3 - SN:4053

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k = 2)
Norm (μV/(V/m)^2)	0.73	0.75	1.59	±10.1%
DCP (mV) [B]	101.2	97.6	100.3	±4.7%

Calibration Results for Frequency Response (30 MHz – 5.8 GHz)

Frequency MHz	Target E-field (En) V/m	Measured E-field (En) V/m	Deviation E-field (En)	Target E-field (Ep) V/m	Measured E-field (Ep) V/m	Deviation E-field (Ep)	Unc (k = 2)
30	77.1	76.9	−0.3%	77.1	77.0	−0.1%	±5.1%
100	76.9	77.8	1.2%	77.0	77.9	1.1%	±5.1%
450	77.1	78.3	1.4%	77.2	78.2	1.3%	±5.1%
600	77.1	77.8	0.9%	77.2	77.8	0.7%	±5.1%
750	77.2	77.7	0.6%	77.2	77.5	0.4%	±5.1%
1800	143.2	139.9	−2.3%	143.3	140.2	−2.2%	±5.1%
2000	135.2	129.6	−4.2%	135.1	129.5	−4.1%	±5.1%
2200	127.7	124.5	−2.5%	127.8	125.8	−1.6%	±5.1%
2500	125.4	120.1	−4.3%	125.5	121.2	−3.5%	±5.1%
3000	79.4	76.0	−4.3%	79.5	77.2	−2.9%	±5.1%
3500	255.8	254.6	−0.5%	256.1	252.2	−1.5%	±5.1%
3700	250.0	244.6	−2.2%	249.9	242.9	−2.8%	±5.1%
5200	50.2	50.1	−0.1%	50.1	50.4	0.5%	±5.1%
5500	49.6	48.7	−1.7%	49.6	49.0	−1.2%	±5.1%
5800	48.9	48.0	−1.8%	48.9	47.5	−2.8%	±5.1%

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%.

[B] Linearization parameter uncertainty for maximum specified field strength.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

Parameters of Probe: EF3DV3 - SN:4053

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B $dB\sqrt{\mu V}$	C	D dB	VR mV	Max dev.	Max Unc^E $k = 2$
0	CW	X	0.00	0.00	1.00	0.00	169.9	±3.5%	±4.7%
		Y	0.00	0.00	1.00		167.6		
		Z	0.00	0.00	1.00		152.8		
10352	Pulse Waveform (200Hz, 10%)	X	3.00	66.27	10.22	10.00	60.0	±3.1%	±9.6%
		Y	6.96	76.89	16.18		60.0		
		Z	2.43	64.60	8.62		60.0		
10353	Pulse Waveform (200Hz, 20%)	X	1.55	63.75	8.04	6.99	80.0	±1.1%	±9.6%
		Y	16.67	87.48	18.27		80.0		
		Z	1.16	62.16	6.42		80.0		
10354	Pulse Waveform (200Hz, 40%)	X	0.70	61.97	6.24	3.98	95.0	±1.0%	±9.6%
		Y	20.00	89.71	17.43		95.0		
		Z	4.00	72.00	9.00		95.0		
10355	Pulse Waveform (200Hz, 60%)	X	0.38	61.52	5.42	2.22	120.0	±0.9%	±9.6%
		Y	20.00	90.66	16.62		120.0		
		Z	0.46	61.36	3.90		120.0		
10387	QPSK Waveform, 1 MHz	X	1.85	70.74	16.71	1.00	150.0	±2.4%	±9.6%
		Y	1.91	68.37	16.43		150.0		
		Z	1.08	78.46	20.59		150.0		
10388	QPSK Waveform, 10 MHz	X	2.30	69.97	16.91	0.00	150.0	±1.0%	±9.6%
		Y	2.64	70.92	17.26		150.0		
		Z	1.84	72.62	17.10		150.0		
10396	64-QAM Waveform, 100 kHz	X	2.53	70.65	18.94	3.01	150.0	±0.6%	±9.6%
		Y	3.68	74.92	20.88		150.0		
		Z	1.90	67.40	17.74		150.0		
10399	64-QAM Waveform, 40 MHz	X	3.44	67.49	16.11	0.00	150.0	±1.6%	±9.6%
		Y	3.66	67.92	16.34		150.0		
		Z	2.95	67.98	16.27		150.0		
10414	WLAN CCDF, 64-QAM, 40 MHz	X	4.67	65.95	15.78	0.00	150.0	±2.7%	±9.6%
		Y	4.99	66.02	15.88		150.0		
		Z	3.82	67.23	16.04		150.0		

Note: For details on UID parameters see Appendix

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%.

[B] Linearization parameter uncertainty for maximum specified field strength.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

Parameters of Probe: EF3DV3 - SN:4053

Sensor Frequency Model Parameters

	Sensor X	Sensor Y	Sensor Z
Frequency Corr. (LF)	0.04	-0.07	6.55
Frequency Corr. (HF)	2.82	2.82	2.82

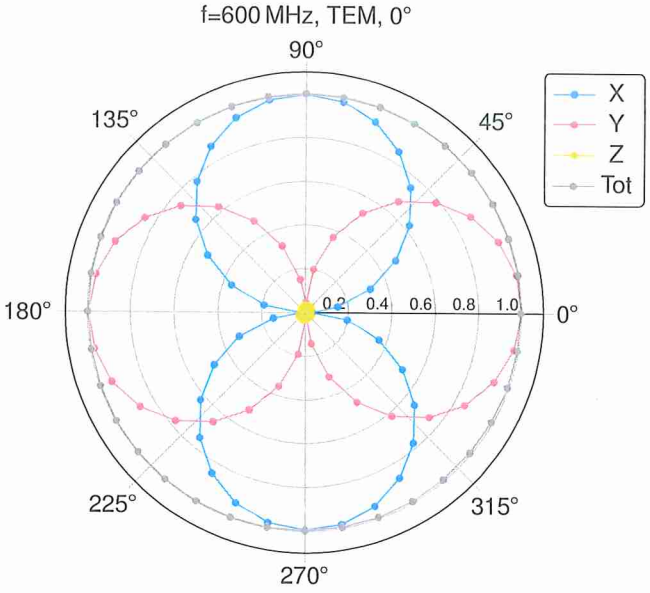
Sensor Model Parameters

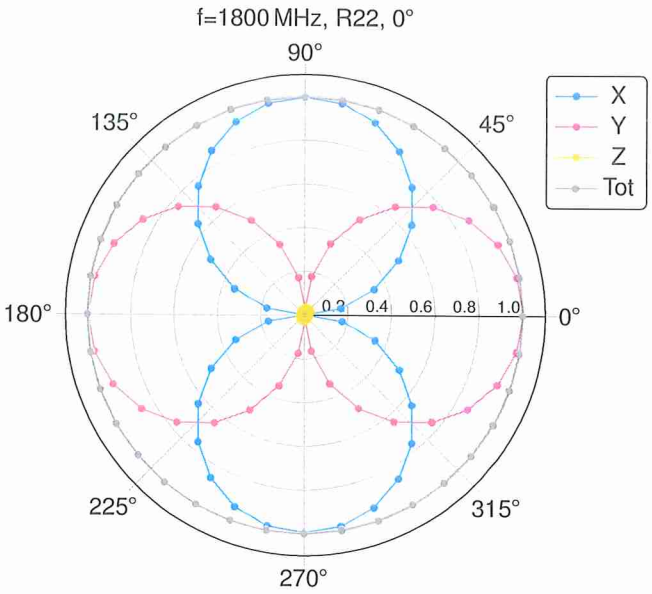
	C1 fF	C2 fF	α V^{-1}	T1 $ms\,V^{-2}$	T2 $ms\,V^{-1}$	T3 ms	T4 V^{-2}	T5 V^{-1}	T6
x	33.7	216.67	35.11	5.62	0.28	4.94	1.33	0.00	1.00
y	57.1	374.83	36.47	12.87	0.70	5.02	1.28	0.27	1.01
z	8.5	55.04	35.18	4.33	0.00	4.95	0.46	0.00	1.00

Other Probe Parameters

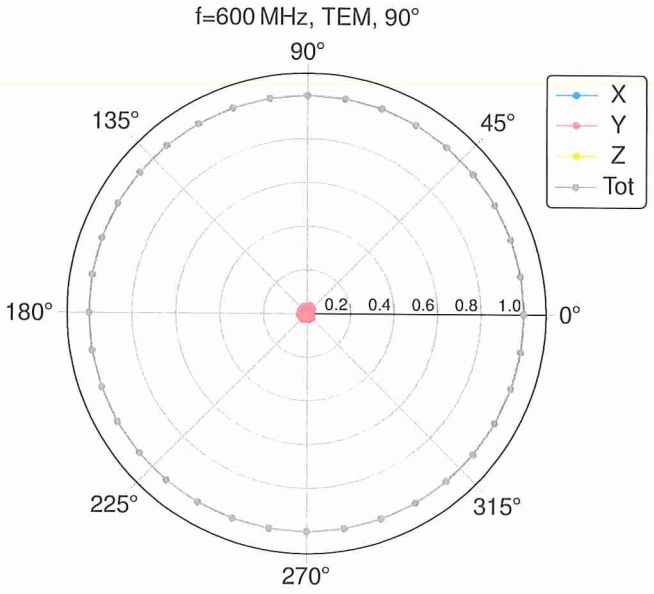
Sensor Arrangement	Rectangular
Connector Angle	168.4°
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	12 mm
Tip Length	25 mm
Tip Diameter	4 mm
Probe Tip to Sensor X Calibration Point	1.5 mm
Probe Tip to Sensor Y Calibration Point	1.5 mm
Probe Tip to Sensor Z Calibration Point	1.5 mm

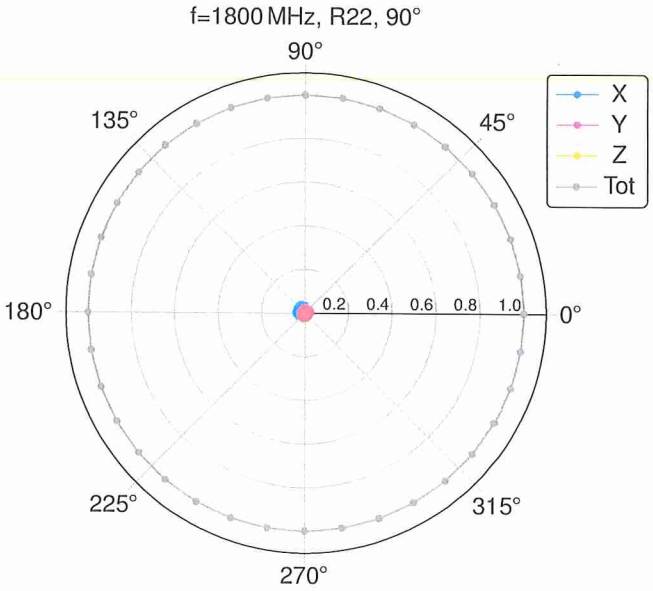
Receiving Pattern (ϕ), $\vartheta = 0°$



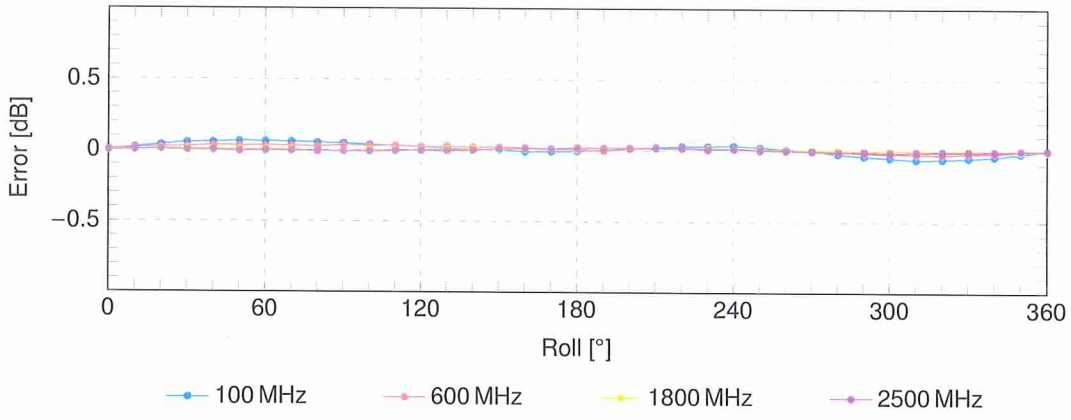


Receiving Pattern (ϕ), $\vartheta = 90°$



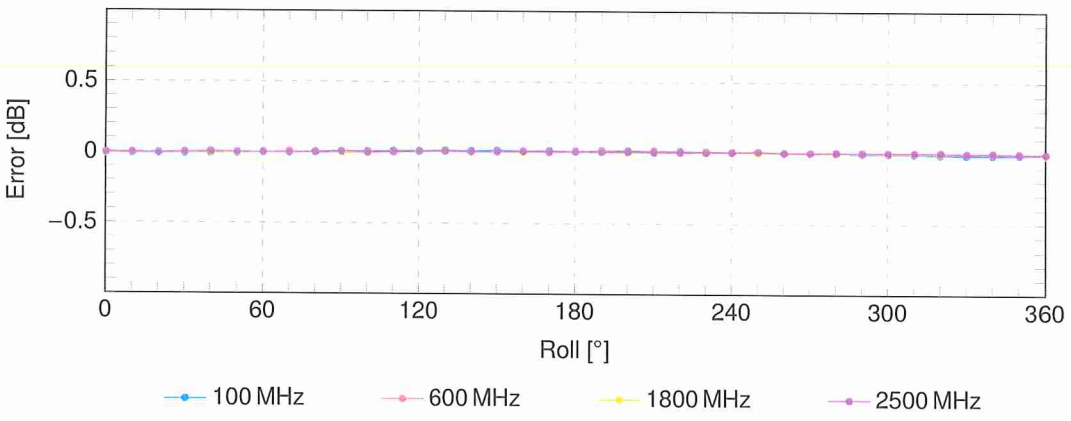


Receiving Pattern (ϕ), $\vartheta = 0°$



Uncertainty of Axial Isotropy Assessment: ±0.5% (k=2)

Receiving Pattern (ϕ), $\vartheta = 90°$



Uncertainty of Axial Isotropy Assessment: ±0.5% (k=2)