Calibration Laboratory of

Schmid & Partner
Engineering AG

Zeughausstrasse 43, 8004 Zurich, Switzerland

Client	**UL Korea**		Certificate No	**MAGPy-H3D-2050**

CALIBRATION CERTIFICATE

Object	MAGPy-H3D SN: 2050 MAGPy-DAS SN: 2050
Calibration procedure(s)	QA CAL-48.v1 Calibration Procedure for MAGPy–8H3D+E3D Near-field Electric and Magnetic Field Sensor System
Calibration date	September 23, 2022

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 U8481A	SN: MY60350004	01-Sep-20 (No. U4848AMY60350004)	Dec-22
Power Meter R&S NRP-18A	SN: 101393	24-Jul-20 (in house check Jan-21)	In house check Jan-23
Calibration Kit HP 85032B	SN: 3217A11606	01-Jan-20 (in house check Jan-20)	Sept-22

Secondary Standards	ID	Check Date (in house)	Scheduled Check
Network Analyzer Keysight E5061B	SN: MY49810822	23-Oct-19(4364810-5332750-1)	In house check: Oct-22

	Name	Function	Signature
Calibrated by	Mischa Sabathy	Senior RF Engineer	(signature)
Approved by	Sven Kühn	Deputy Manager	(signature)
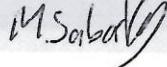
Issued: September 23, 2022

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

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

Glossary

MAGPy-H3D   Magnetic Amplitude and Gradient Probe – Single Sensor
MAGPy-DAS   Magnetic Amplitude and Gradient Data Acquisition System

Calibration is Performed According to the Following Standards:

a) IEEE Std 1309-2013, "IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", November 2013

Methods Applied and Interpretation of Parameters

- *Linearity*: Calibration of the linearity of the field reading over the specified dynamic range. Influence of offset voltage is included in this measurement.

- *Frequency response*: Calibration of the field reading over the specified frequency range.

- Receiving Pattern: Assessed for H-field polarizations ϑ, and $\phi = 0°...360°$; $\vartheta = 90°$, and $\phi = 0°...360°$; for the XYZ sensors (in TEM-Cell at 10 kHz, 100 kHz and 1 MHz).

- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.

  - *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.

  - *Battery characteristics*: Typical values for information. A battery alarm signal is generated when the supply voltage drops below the specified level.

Reported Uncertainty

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

Unit Type	MAGPy–H3D (SP MGY 302 AA)	2050
	MAGPy–DAS-WPT (SE UMS 302 AA)	2050
	MAGPy FPGA Board	WP000107
Adjustment Date	Last MAGPy Adjustment	September 23, 2022
Firmware SW Version	MAGPy Firmware	Ver. 0.96
Backend SW Version	MAGPy Backend	Ver. 1.0.2
Calibration SW Version	MAGACAP	Ver. 0.9

Dynamic Range

Dynamic Range, H-field, Channel 0

H-field/(A/m) Target			H-field/(A/m) Reading			Difference in dB			Acceptance in dB (k=2)
x	y	z	x	y	z	x	y	z	
0.320	0.300	0.310	0.330	0.320	0.290	−0.27	−0.56	0.58	±8.78
0.430	0.410	0.410	0.440	0.430	0.390	−0.20	−0.41	0.43	±7.24
0.580	0.550	0.560	0.600	0.580	0.530	−0.29	−0.46	0.48	±5.87
0.770	0.740	0.740	0.800	0.770	0.710	−0.33	−0.34	0.36	±4.75
1.04	1.01	1.00	1.07	1.04	0.960	−0.25	−0.25	0.35	±3.74
1.42	1.37	1.34	1.45	1.41	1.29	−0.18	−0.25	0.33	±2.89
1.92	1.85	1.79	1.96	1.90	1.75	−0.18	−0.23	0.20	±2.22
2.56	2.48	2.36	2.61	2.54	2.33	−0.17	−0.21	0.11	±1.72
3.47	3.35	3.12	3.52	3.43	3.15	−0.12	−0.20	−0.08	±1.30
4.69	4.52	4.19	4.75	4.63	4.25	−0.11	−0.21	−0.12	±0.98
6.33	6.12	5.69	6.41	6.26	5.73	−0.11	−0.20	−0.06	±0.74
8.43	8.19	7.57	8.54	8.36	7.65	−0.11	−0.18	−0.09	±0.56
11.4	11.1	10.2	11.5	11.3	10.3	−0.11	−0.10	−0.09	±0.20
15.3	15.1	13.7	15.5	15.2	13.9	−0.11	−0.07	−0.11	±0.20
20.8	20.4	18.6	21.0	20.5	18.8	−0.09	−0.04	−0.09	±0.20
27.7	27.2	24.8	27.9	27.4	25.0	−0.08	−0.05	−0.09	±0.20
37.6	36.9	33.7	37.9	37.1	33.9	−0.06	−0.05	−0.07	±0.20
50.6	49.7	45.3	50.5	49.5	45.2	0.02	0.02	0.02	±0.20
67.7	66.5	60.7	67.6	66.4	60.5	0.02	0.02	0.03	±0.20
90.7	88.9	81.3	90.4	88.8	81.0	0.02	0.01	0.03	±0.20
120	118	108	120	118	107	0.02	0.01	0.03	±0.20
164	161	147	163	160	146	0.04	0.02	0.04	±0.20
212	208	191	211	207	189	0.05	0.04	0.05	±0.20
292	286	262	289	285	260	0.06	0.05	0.07	±0.20
413	405	370	409	402	367	0.08	0.07	0.08	±0.20
585	574	525	591	581	531	−0.10	−0.10	−0.09	±0.20
872	857	784	876	862	787	−0.04	−0.05	−0.04	±0.20
1310	1280	1170	1310	1280	1170	0.01	0.00	0.01	±0.20
2200	2160	1970	2180	2150	1960	0.07	0.06	0.05	±0.20
2600	2560	2330	2580	2540	2320	0.07	0.07	0.06	±0.20

H-field linearity acceptance criteria: All calibration points with sufficient signal to noise ratio (above levels of 10.0 A/m) shall be within < 0.20 dB (k=1.73).

## Frequency Response

Frequency Response, H-field, Channel 0

f/Hz	H-field/(A/m) Target			H-field/(A/m) Reading			Difference in dB			Acceptance in dB (k=2)
	x	y	z	x	y	z	x	y	z	
3000	0.876	0.876	0.875	0.878	0.872	0.874	−0.02	0.04	0.01	±0.95
3257	0.877	0.877	0.877	0.878	0.880	0.872	−0.01	−0.03	0.05	±0.95
4125	0.880	0.881	0.880	0.881	0.880	0.886	−0.01	0.01	−0.06	±0.95
5223	0.884	0.884	0.883	0.887	0.887	0.880	−0.03	−0.03	0.03	±0.95
6615	0.887	0.887	0.887	0.888	0.883	0.892	−0.01	0.04	−0.05	±0.95
8377	0.890	0.891	0.890	0.893	0.889	0.893	−0.03	0.02	−0.03	±0.95
10608	0.893	0.893	0.893	0.893	0.891	0.895	0.00	0.02	−0.02	±0.95
13434	0.895	0.895	0.894	0.898	0.893	0.897	−0.03	0.02	−0.03	±0.95
17013	0.896	0.896	0.896	0.897	0.896	0.892	−0.01	0.00	0.04	±0.95
21544	0.896	0.896	0.896	0.895	0.895	0.895	0.01	0.01	0.01	±0.95
27283	0.896	0.896	0.896	0.897	0.895	0.893	−0.01	0.01	0.03	±0.95
34551	0.896	0.896	0.896	0.896	0.893	0.896	0.00	0.03	0.00	±0.95
43755	0.896	0.896	0.896	0.896	0.895	0.894	0.00	0.01	0.02	±0.95
55410	0.896	0.896	0.896	0.898	0.898	0.893	−0.02	−0.02	0.03	±0.95
70170	0.896	0.896	0.896	0.894	0.895	0.895	0.02	0.01	0.01	±0.95
88862	0.896	0.897	0.896	0.897	0.899	0.895	−0.01	−0.02	0.01	±0.95
112534	0.897	0.897	0.896	0.896	0.896	0.901	0.01	0.01	−0.05	±0.95
142510	0.897	0.897	0.896	0.896	0.897	0.900	0.01	0.00	−0.04	±0.95
180472	0.896	0.896	0.896	0.896	0.898	0.897	0.00	−0.02	−0.01	±0.95
228546	0.895	0.897	0.896	0.898	0.899	0.895	−0.03	−0.02	0.01	±0.95
289427	0.893	0.894	0.894	0.895	0.896	0.895	−0.02	−0.02	−0.01	±0.95
366524	0.884	0.886	0.886	0.885	0.886	0.887	−0.01	0.00	−0.01	±0.95
464159	0.856	0.856	0.856	0.856	0.854	0.858	0.00	0.02	−0.02	±0.95
587802	0.936	0.935	0.936	0.938	0.936	0.938	−0.02	−0.01	−0.02	±0.95
744380	0.938	0.937	0.937	0.937	0.938	0.933	0.01	−0.01	0.04	±0.95
942668	0.943	0.943	0.943	0.943	0.943	0.943	0.00	0.00	0.00	±0.95
1193777	0.947	0.947	0.947	0.948	0.947	0.946	−0.01	0.00	0.01	±0.95
1511775	0.949	0.948	0.949	0.947	0.949	0.949	0.02	−0.01	0.00	±0.95
1914482	0.951	0.951	0.951	0.951	0.951	0.952	0.00	0.00	−0.01	±0.95
2424462	0.956	0.956	0.956	0.956	0.954	0.958	0.00	0.02	−0.02	±0.95
3070291	0.958	0.958	0.958	0.960	0.956	0.961	−0.02	0.02	−0.03	±0.95
3888155	0.960	0.960	0.960	0.960	0.959	0.966	0.00	0.01	−0.05	±0.95
4923883	0.962	0.962	0.962	0.964	0.961	0.963	−0.02	0.01	−0.01	±0.95
6235507	0.963	0.963	0.963	0.965	0.962	0.968	−0.02	0.01	−0.04	±0.95
7896523	0.971	0.971	0.971	0.973	0.970	0.972	−0.02	0.01	−0.01	±0.95
10000000	0.984	0.983	0.984	0.985	0.983	0.988	−0.01	0.00	−0.04	±0.95

H-field calibration acceptance criteria: 95% of the calibration points shall be within < 0.95 dB as per manufacturer specifications. All calibration points shall be within < 1.35 dB, corresponding to a coverage probability of 99.73%.

Uncertainty of the H-field calibration measurement is ±0.95 dB (k=2).

Isotropy H-Field

H-Field Receiving Pattern (ϕ), $\vartheta = 0°$
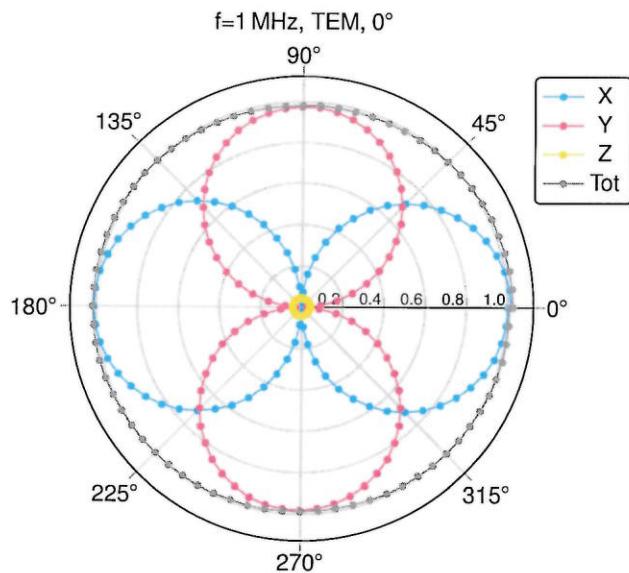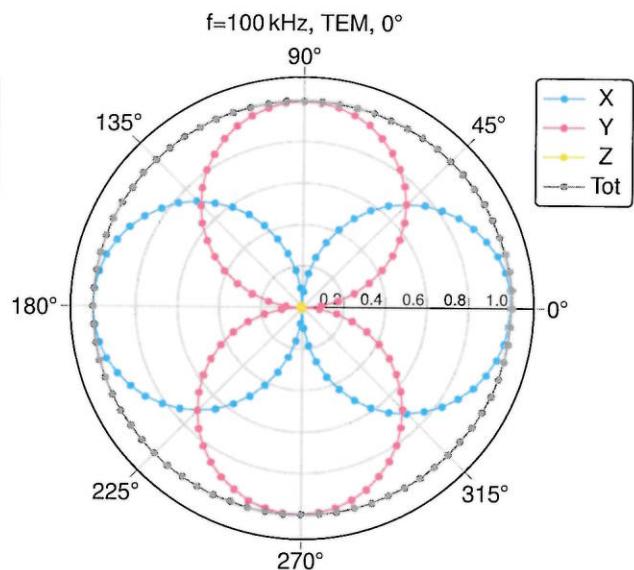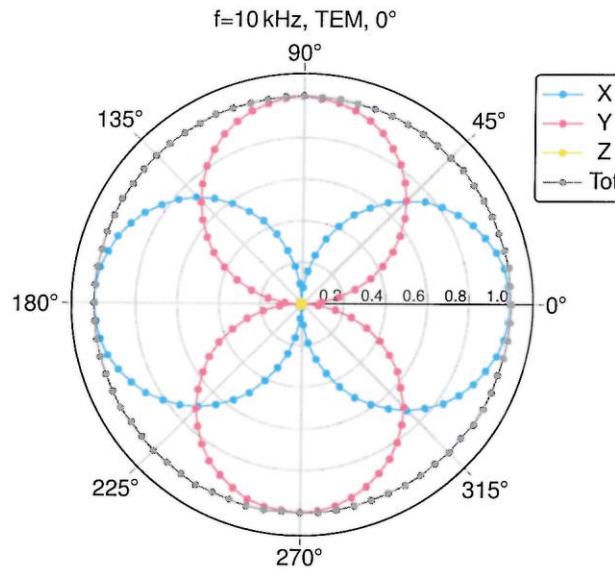
f=10 kHz, TEM, 0°

f=100 kHz, TEM, 0°

f=1 MHz, TEM, 0°

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

f=10 kHz, TEM, 90°

f=100 kHz, TEM, 90°

f=1 MHz, TEM, 90°

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

Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ (k=2)

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

Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ (k=2)
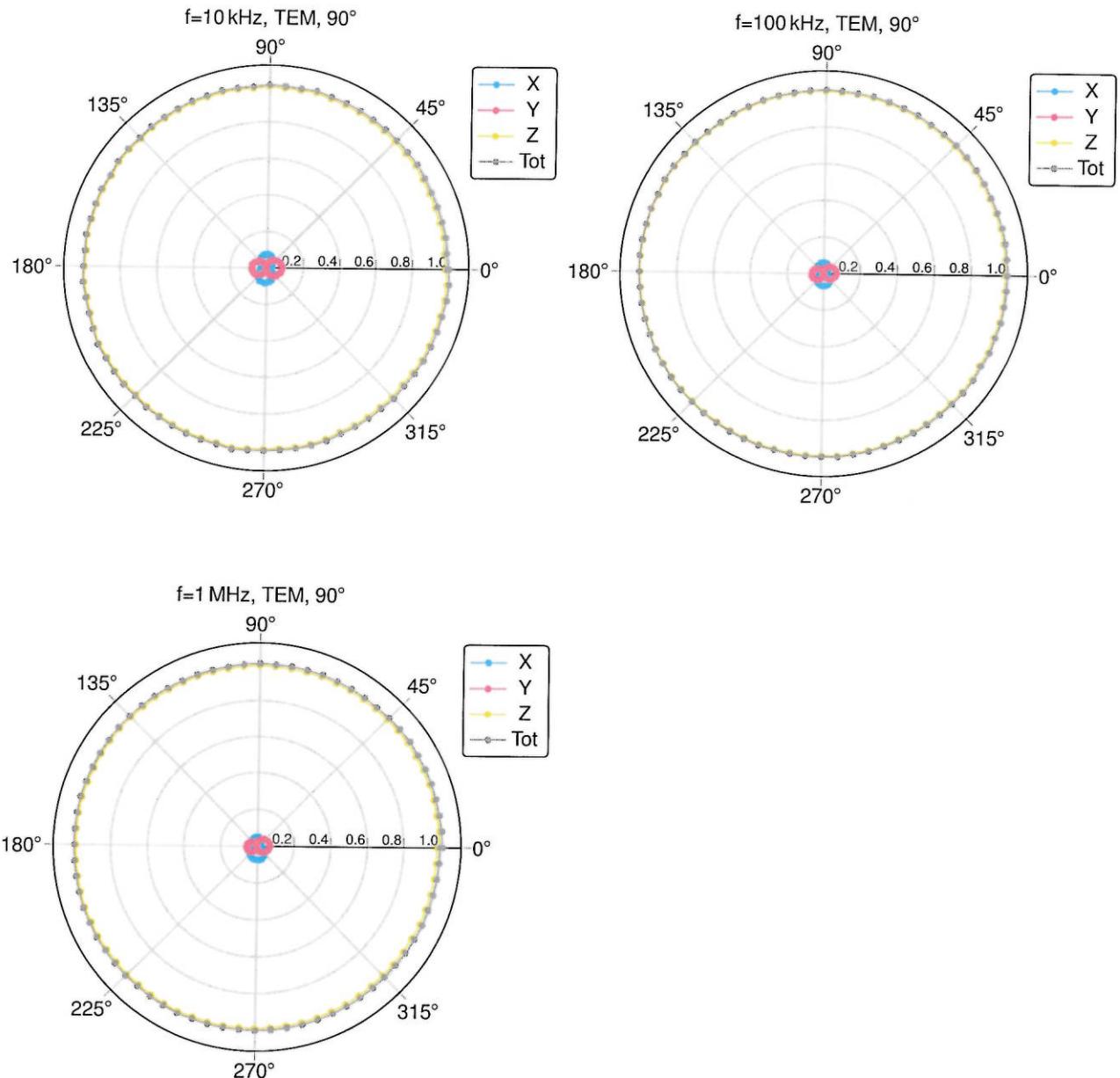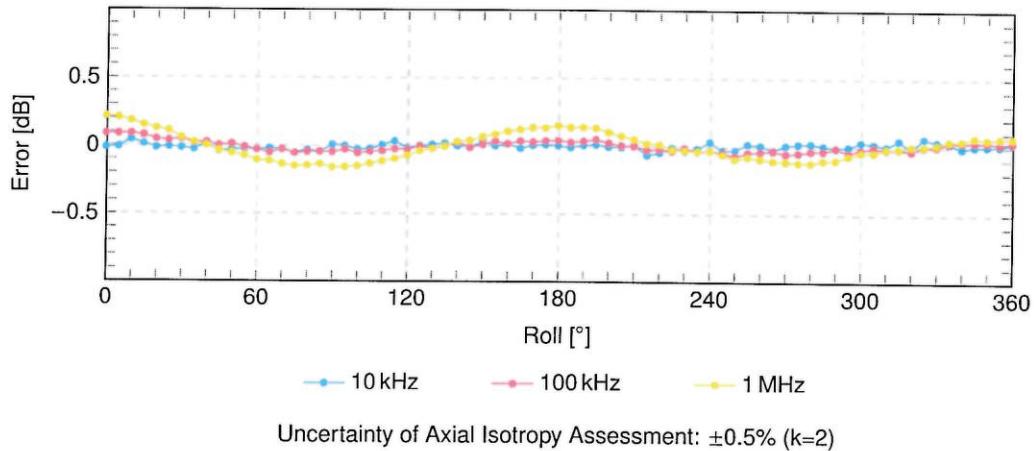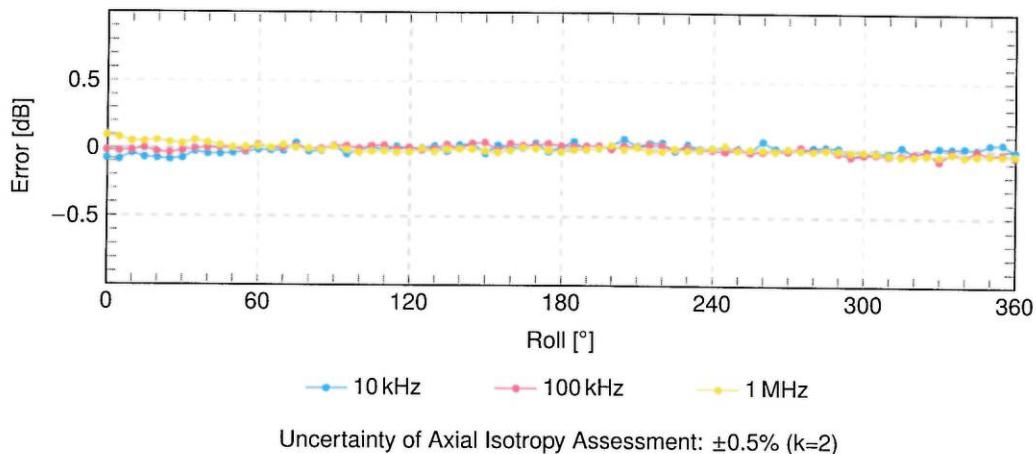
Appendix

Battery Characteristics (Typical values for information)

Nominal Battery Voltage	14.4…14.8 V
Low Battery Alarm Voltage	8.45 V
Battery Capacity	2600 mAh