Datasheet:

HIGH-PERFORMANCES 3-AXIS DIGITAL TESLAMETER 3MH6-E

Digital teslameter with interchangeable 3-axis Hall probes

DESCRIPTION:

Low-noise and high-resolution digital teslameter with integrated 3-axis Hall probe, providing high-performances and temperature compensated output signal for each of the three components (Bx, By, Bz) and the total magnetic flux density (B).

The unique Senis three-component magnetic field sensor measures Bx, By, Bz at a "point" of 0.1 x 0.01 x 0.1 mm^3 and enables calculation of the field amplitude B. The orthogonality of the 3-axis Hall probe is corrected to less than 0.1^O. B is independent of the Probe orientation (isotropic).

The very high position resolution enables accurate measurement/mapping of fields with high gradients.

The small probe head (4 mm width, 0.9 mm thickness) permits measurement/mapping the magnetic field in small aperture or tube assemblies down to < 5 mm diameter.

The teslameter provides the possibility of automatic data acquisition via a USB serial interface by a host computer.

In this way, customers can easily integrate a measurement routine into their measurement system using its programming tools such as C, C++, C#, Python, Delphi, LabVIEW, etc.

The temperature measurement feature allows user to obtain current temperature values while monitoring the magnetic field.

The device consists of the two modules:

1. Interchangeable Hall probe with various cable length (Module H)

Each 3D Hall probe can be interchangeable with any other 3D Hall probe and any other 3MH6-E instrument, this in the terms of keeping the overall measurement DC accuracy of better than 100 ppm.

2. High-performances Electronics (Module E).

The Low-Noise Digital Teslameter is a high accuracy, temperature very stabilized device for the precise measurement of magnetic field.

Each Teslameter is calibrated with the individual correction data for the connected probe, so the Hall probe is interchangeable, by keeping the same accuracy of 100 ppm.

Figure 1: 3MH6-E Digital Teslameter

Key features:

- Teslameter with integrated C type 3-axis Hall probe (Bx, By, Bz) and temperature sensor.

- Overall 3D (Bx, By, Bz) magnetic field sensitive volume (FSV) of the Hall IC: only 0.10 x 0.01 x 0.10 mm^3.

- Very high mutual orthogonality between the measurement axes of the probe: < 0.1^O.

- Full probe interchangeability is ensured: Each 3D Hall probe can be interchangeable with any other 3D Hall probe and any other 3MH6-E instrument, this in the terms of keeping the overall measurement DC accuracy of better than 100 ppm.

- Probe cable length of 2 m, 5 m and 10 m as standard enables mapping of large devices.

- Measurement of DC & AC magnetic fields.

- 4 (four) selectable magnetic field ranges: ±0.1 T, ±0.5 T, ±2 T, and up to ±20 T*
  (* the last is in-factory calibrated up to ±2 T; optionally: calibration up to maximum field ±9 T).

- Very high magnetic DC resolution @ Sampling rate 10 SPS (SPS - samples per second):
  < 1 ppm RMS @ ±2 T range: 1 µT$_{RMS}$ for perpendicular (By axis) and 2 µT$_{RMS}$ for planar components of field (Bx & Bz axes).

  On the 100 mT range the DC resolution is ~1 µT$_{RMS}$, enabling monitoring/mapping distortions in space or time of the nominal 50 µT geomagnetic field introduced by nearby magnetic material or electric equipment.

  NOTE: Special-edition version 3MH6-S (available only for the measurement range ±100 mT) provides: non-interchangeable Hall probe(s) and improved DC resolution of ~ 0.5 µT$_{RMS}$.

- DC Accuracy @ Sampling rate 10 SPS:
    - < 0.01% (100 ppm FS) @ ±0.1 T, ±0.5 T and ±2 T ranges;
    - determined upon a High-Field DC Calibration Table for higher field ranges @ B > ±2 T.

- AC Accuracy: see the Table 2 below.

- Frequency response from DC - 2.5 kHz (-3 dB) enables:
    - high resolution closed-loop field control,
    - measurement of time varying ramped or pulsed fields,
    - fast "on-the-fly" mapping of non-uniform fields.

- Selectable Sampling rate up to 7.5 kS/sec.

- High temperature stability: < ±20 ppm/°C.

- Analog outputs: not calibrated.

- 24-bit A/D Convertor.

- Auto range, zeroing, hold, Max/Min values.

- Triggers internal and external - Single shot, Manual and Continuous.

- Interchangeable Hall probes with calibration data stored in an integrated EEPROM.

- TFT LCD graphic display (108 x 65 mm) for Bx, By, Bz, Btot, and Th (probe) and Te (electronic box) temperatures.

- Numerical, graphical and statistical measurement visualization

- Magnetic vector visualization

- Measured data recording with selectable sampling rate (0.5 - 60 sec, i.e., 2.5 - 300 days)

- Selectable units in gauss (G) and tesla (T)

- Embedded computer (GUI on Android)

- Data acquisition & visualization PC Software runs on Windows 11 / 10 / 8 / 7 OS via USB2.0 interface.

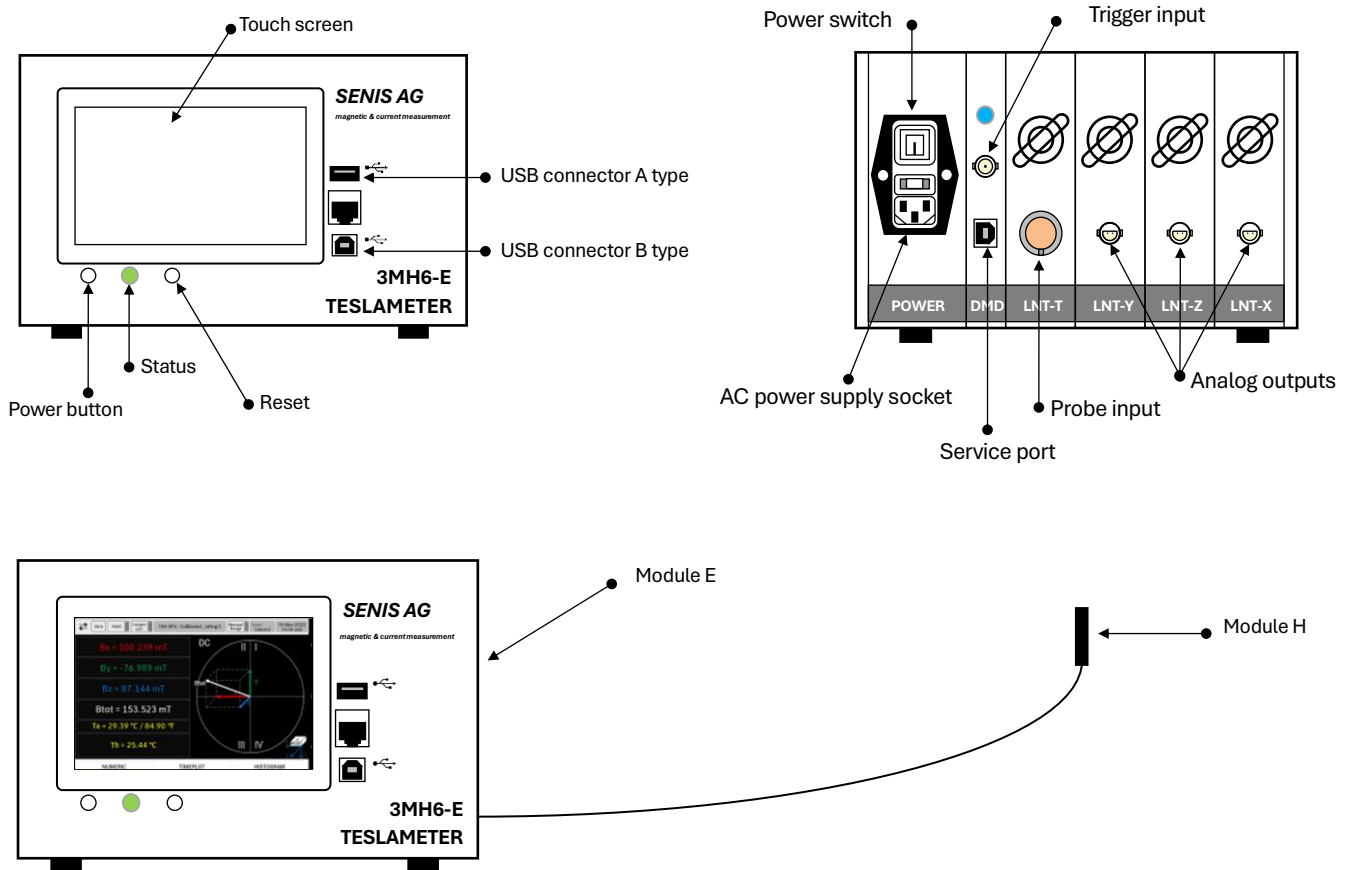## 3MH6-E Teslameter - Structure:

Figure 2: 3MH6-E Structure - Module H (Hall Probe of Type C) and Module E (analog and digital electronics)
Electronic box dimensions (W x H x L): 240 x 150 x 260 mm

Hall Probe Specifications (H Module):

The applied Hall probe type C contains a CMOS integrated circuit, three groups of mutually orthogonal Hall elements and a temperature sensor. The integrated Hall elements occupy very small area (100 μm x 100 μm), which provides very high spatial resolution of the probe.

The outputs of the Hall probe are the three high-level analog voltages proportional to the three measured components of a magnetic field and a voltage proportional to the probe temperature for in-electronics compensation of the offsets and sensitivity temperature drift.

The probe calibration data are stored in an integrated EEPROM in the probe-to-teslameter connector, allowing for probe interchangeability.
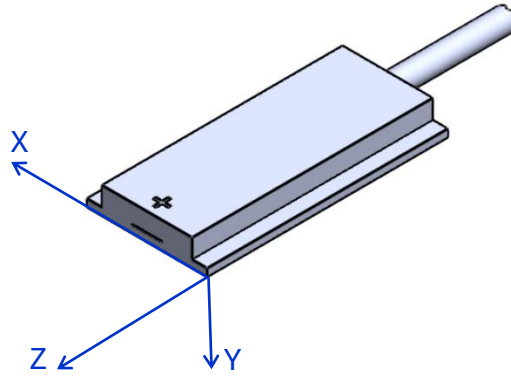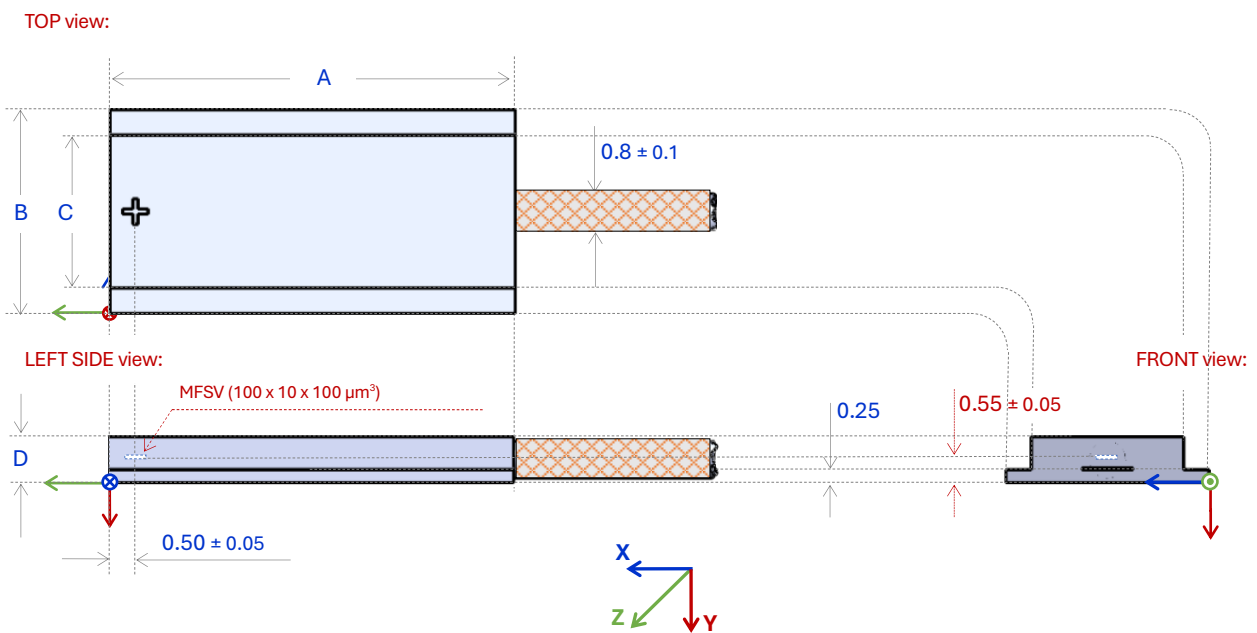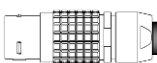
Figure 3: Reference Cartesian coordinate system (X, Y, Z) of the 3-axis Hall probe type C

TOP view:

LEFT SIDE view:

FRONT view:

MFSV (100 x 10 x 100 µm³)

0.8 ± 0.1

0.25

0.55 ± 0.05

0.50 ± 0.05

Part	Dimension (mm)
A	8.00 ± 0.05
B	4.00 ± 0.05
C	3.00 ± 0.05
D	0.90 +0.05/-0.00

Hall probe connector
LEMO FGG.3B.322.CLAD62Z
(incl. probe EEPROM)

Transient cable section :
L: 30 ± 2 mm
OD: 3.3 ± 0.2 mm

HALL Probe

Probe Cable CaH

Various lengths: 2m, 5m, 10m
OD: 2.7 ±0.1 mm
Min. bending radius: 10 x OD

Flexible cable section:
L: 50 ± 1 mm
OD: 0.8 ± 0.1 mm
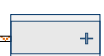
Figure 4: Dimensions of the H-module I3C-03C0**x**L (where **x** denotes length of the probe cable in meters)

Parameter			
Dimensions	**X (mm)**	**Y (mm)**	**Z (mm)**
Magnetic field sensitive volume (MFSV)	0.10	0.01	0.10
Position of the MFSV centre (Fig. 3 and 4)	2.00 ± 0.05	-0.55 -0.05/+0.00	-0.50 ± 0.05
External dimensions of the probe	4.00 ± 0.05	0.90 +0.05/-0.00	8.00 ± 0.05
Positioning accuracy			
Angular accuracy of the measurement axes	• < ±2° with respect to the reference surface		
	• Mutual orthogonality between the meas. axes: < ±0.1°		
Temperature range			
Operating Temperature range of the Probe	(+5, +45) °C		
Cable properties			
Thin cable:	Copper braided flexible cable, OD 0.8 mm		
Conductor:	Silver plated soft copper core, 7 x 44 AWG		
Insulation:	PFA (Perfluoro Alkoxy), diameter 0.8 mm		
Safe cable twisting:	15 x OD thin (red) cable		
	10 x OD thick (white) cable (minimum for fixed instalation)		
Shield:	Silver plated soft copper braid		
Jacket:	PFA (Perfluoroalkoxy)		
Service temperature:	-196 / +200 °C		
Linear resistance:	1.4 Ω/m		
Rated voltage:	150 Vac		
RoHS compliance:	Yes		
Length:	Standard: 2 m Notation: I3C-03C0**2**L		
	Option: X m Notation: I3C-03C0**X**L		

Table 1:   Hall probe type C and connection cable properties

Magnetic and Electrical Specifications:

4 selectable magnetic field measurement ranges:	± 100 mT, ±500 mT, ±2 T, ±20 T (calibrated up to ±9 T)
Measurement DC accuracy:	0.01% (100 ppm) of full scale @ ±0.1T, ±0.5T & ±2T ranges
	determined upon a High-field DC Calibration Table for higher field ranges B > ±2T
Probe Interchangeability:	available for all 4 measurement ranges
Magnetic resolution:	2 ppm (24-bit A/D conversion)
Frequency bandwidth:	DC - 2.5kHz (-3dB)
Selectable Sampling rate:	10 SPS, 30 SPS, 50 SPS, 60 SPS, 100 SPS, 500 SPS, 1 kSPS, 2 kSPS, 3.75 kSPS and 7.5 kSPS
Selectable Averaging rate:	1 Sample to 100 Samples
Temperature stability of sensitivity:	< ±20 ppm/°C
External trigger:	Single Shot and Manual (measurement time interval: 0.1sec to 5min) / Continuous (up to 7.5kHz)
Measured data recording:	selectable storage interval 0.5 – 60 sec (up to 300 days)

Preliminary Frequency Bandwidth vs. Resolution:

Conditions:

- Measurement Range: ±2 T;
- Probe cable length: 2 m
- Internal Sampling rate: 30 kS/s
- Frequency Bandwidth: DC to $f_C(-x)$, where $f_C(-x)$ is the B signal frequency at which the measurement error with respect to DC reaches x.

Sampling rate [SPS]	10	30	50	60	100	500	1000	2000	3750	7500
Averaging time [ms]	100	33.333	20	16.667	10	2	1	0.5	0.267	0.133
Resolution [μT_{RMS}]	0.8	0.9	1	1.1	1.2	2	2.5	3	4	5
f(-10 ppm) [Hz]	0.03	0.08	0.13	0.15	0.27	1.4	2.6	5	9	<u>10</u>
f(-100 ppm) [Hz]	0.08	0.24	0.39	0.47	0.8	4	8	18	25	<u>30</u>
f(-0.1%) [Hz]	0.25	0.74	1.23	1.48	2.5	12.5	24	50	75	<u>90</u>
f(-1%) [Hz]	0.78	2.34	3.9	4.69	7.8	39	77	155	230	<u>300</u>
f_C(-3 dB) [Hz]	4.4	13.3	22.2	26.5	44	220	434	880	1340	<u>2500</u>

Table 2:   The table shows the combinations of the magnetic signal frequencies, measurement resolutions and bandwidths that are achievable with the 3MH6-E teslameter. Displayed values apply to each measurement axis Bx, By & Bz.

Notations:

- **Data rate [SPS, samples per second]:**

The rate with which the measurement data appear at the 3MH6-E teslameter digital output. In the teslameter specifications it is called the **"Selectable sampling rate"** and it goes up to 7.5 kS/sec.

This is one of the main parameters that a user should select on the front panel of the 3MH6-E teslameter. Once a data rate is chosen, this will define the Data **Averaging time [ms]** as the inverse of the data rate.

For example, if the data rate of 10 samples per second is chosen, then the teslameter will spend 100 milliseconds with averaging the raw measurement results.

- **Resolution [µT rms]:**

The minimal magnetic flux density change that can be detected by 3MH6-E teslameter.

For example, if the data rate of 100 SPS is chosen, then the measurement resolution will be about 1.2 µT(rms).

- **Bandwidth f(-"x"):**

These are the frequencies at which the measured signal attenuation with respect to the DC value reach a given value (this, due to various low-pass filtering effects within the Teslameter).

For instance, the line "f(-100 ppm)" shows that if the data rate is 3.75 kS/s, at the signal frequency of 25 Hz, the measured B-field amplitude will appear 100 ppm lower than its true value.
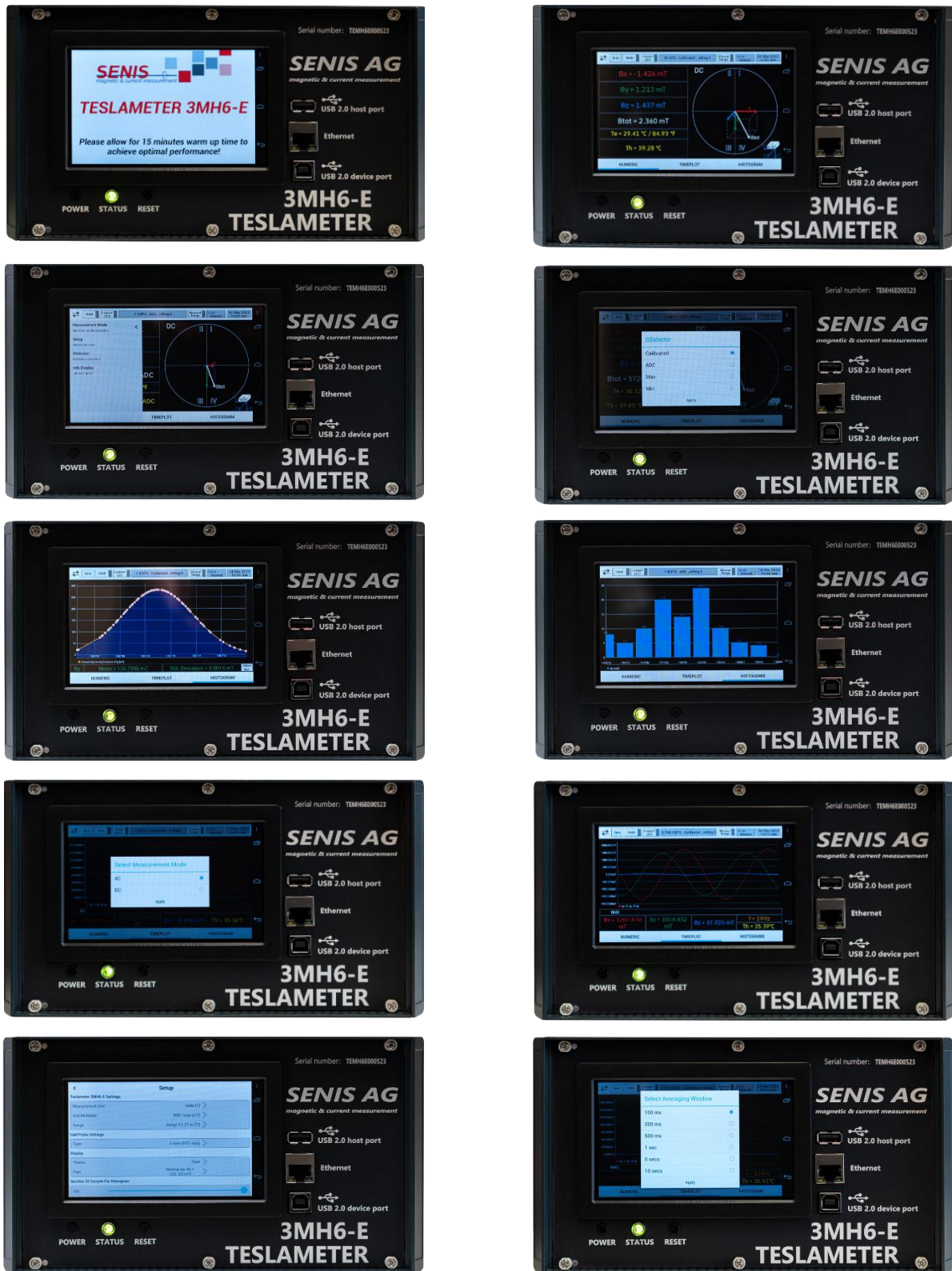
Graphical User Interface:

Figure 5: Visualization Modes (Numeric, Time-plot, Histogram) and Setting possibilities: External/Internal Triggers; Data Recording; Auto range; Zeroing; Min/Max; Hold reading; Sampling Rate; Averaging Rate; Storage interval.