3MH6 Teslameter

User Manual

Ref.No.: OM.200.3MH6 TESLAMETER

Document Revision: 2.0

Software Version:

Android Application: 2.4.5 – 16Oct2020:1228

STM Board Firmware Version: 2.2.0

Data Acquisition Software: 3MH6 Teslameter v11.20

This Page Intentionally Blank

Table of Contents

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

1. SAFETY PRECAUTIONS:

The following safety precautions must be observed during all phases of operation, service and repair of this equipment. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture and intended instrument use. *SENIS AG* assumes no liability for Customer failure to comply with these requirements.
The Teslameter 3MH6 protects the operator and surrounding area from electric shock or burn, mechanical hazards, excessive temperature and spread of fire from the instrument. Environmental conditions outside of the conditions below may pose a hazard to the operator and surrounding area.

General Precautions

• Indoor use.

• Altitude up to 2000 meters.

• Temperature for safe operation: 5°C to 45°C (with decreased linearly of up to 50% from 30°C).

• Maximum relative humidity: 80%

• Power supply voltage fluctuations not to exceed ±10% of the nominal voltage.

• Switch-on stabilization time: 30 minutes.

• Overvoltage category II.

• Pollution degree 2.

Ground the Instrument

To minimize shock hazard, the instrument is equipped with a 3-wire AC power cable. Plug the power cable into an approved three-contact electrical outlet or use a three-contact adapter with the grounding wire (green), firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet Underwriters Laboratories (UL) and International Electrotechnical Commission (IEC) safety standards.

Do not unplug any cables while measurement is in progress. Always switch off the Teslameter prior to unplugging the cables.

Ventilation

The instrument has ventilation holes in its bottom side. Do not block these holes when the instrument is operating.

Keep the device always in horizontal position (also during the transport).

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

Do Not Operate in an Explosive or Electromagnetic Atmosphere

Do not subject the device to impacts. Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

During operation, remove magnetic sources from the vicinity of the device. Only magnets under the test are allowed.

Keep Away from Live Circuits

Operating personnel must not remove instrument covers. Refer component replacement and internal adjustments to qualified maintenance personnel. Do not replace components with power cable connected. To avoid injuries, always disconnect power and discharge circuits before touching them.

Do Not Substitute Parts or Modify Instrument

If you discover any abnormalities, before or during operation, stop using the device and inform the manufacturer. Do not install, substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an authorized *SENIS AG* representative for service and repair to ensure that safety features are maintained.

Hall Probe and probe holder are fragile. Protect both from impacts during operation and when not in use.

Do not apply undue force to plugs, cables or the Hall probes.

Cleaning

Do not submerge instrument. Clean only with a damp cloth and mild detergent (exterior only).

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

2. INTRODUCTION

2.1 Overview

The 3MH6 Digital Low-Noise Teslameter is a high-performance magnetic field measuring instrument based on the Hall-effect magnetic-field-to-voltage transducer with a high-level, temperature compensated analog output signal for each of three components of the measured magnetic flux density components, Bx, By and Bz. The USB serial communication ports allow automatic data acquisition by a host computer, so that users may easily integrate a measurement routine into any measuring system using programming tools. 3MH6 incorporates a TFT LCD graphic display for an intuitive device operation and configuration, as well as for numerical and graphical measured data visualization.

The Low Noise Digital Teslameter is a high accuracy temperature-stabilized instrument for the precise measurement of magnetic field. The digital data correction provides an accuracy of better than 0.01%. The unique *SENIS* single-chip integrated 3-axis Hall probe allows measuring simultaneously all three components of the magnetic field at virtually the same spot within a 100 µm x 100 µm square, which allows measurements of homogeneous and highly inhomogeneous magnetic fields. Even for strong magnetic fields there is no planar Hall effect, which would lead to the cross talk between the three measurement channels. The Teslameter is therefore suitable for the characterization of not only strong magnets, but also of very small magnets and magnetic systems with narrow air gaps.

Interchangeable Hall-Probes, the unique miniature 1- 2- and 3-axis probes can be connected to the 3MH6 Teslameters. The individually calibrated correction data of each probe are stored in the probe EEPROM as well as in the Teslameter device. The calibration data are automatically loaded from the probe EEPROM when device is turned on first time after the probe has been replaced. All these features allow building long term stable and precise instruments for accurate 1-, 2- and 3-axis magnetic field mapping, magnetic field control and permanent magnet quality inspection.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

3. GENERAL DESCRIPTION

3.1 Key Features

DC measurement accuracy	**< 100 ppm of Full Scale**
DC resolution	**@±2 T range: 1 µT rms for planar and 2 µT rms for perpendicular components of magnetic field**
Maximum measured field	**Up to ±20 T**
Calibrated ranges	**±100 mT / ±500 mT / ±2 T / ±20 T** **Note: ±20 T range is currently calibrated only up to ±2 T**
Probe cable length	**2 m (default)**
Easy probe replacement	**Automatic loading of the probe calibration coefficients from probe EEPROM on power-up**
Digital interface	**USB 2.0 type B connector for data acquisition**
Analog outputs	**Connection to DAQ card**
TFT Capacitive Touch LCD	**5'', 800 x 480 pixels, 24-bit, white LED backlight**
Size	**W 240 x H 140 x L 260 mm**
Weight	**Ca. 3.5 kg**

3.2 Typical Applications

- DC and AC magnetic field measurements (Frequency Bandwidth: DC – 2.5 kHz)
- Simultaneous measurements of all components of magnetic field (B_x, B_y and B_z)
- High speed measurements
- Inhomogeneous magnetic fields
- Determination of the magnetic field orientation
- Magnetic field measurements in a small air gap and/or in the near proximity of the magnet surface
- Measurements of the full magnetic field range with only one Hall probe
- Mapping magnetic fields
- Characterization of undulators systems
- Current sensing

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

3.3 Connections

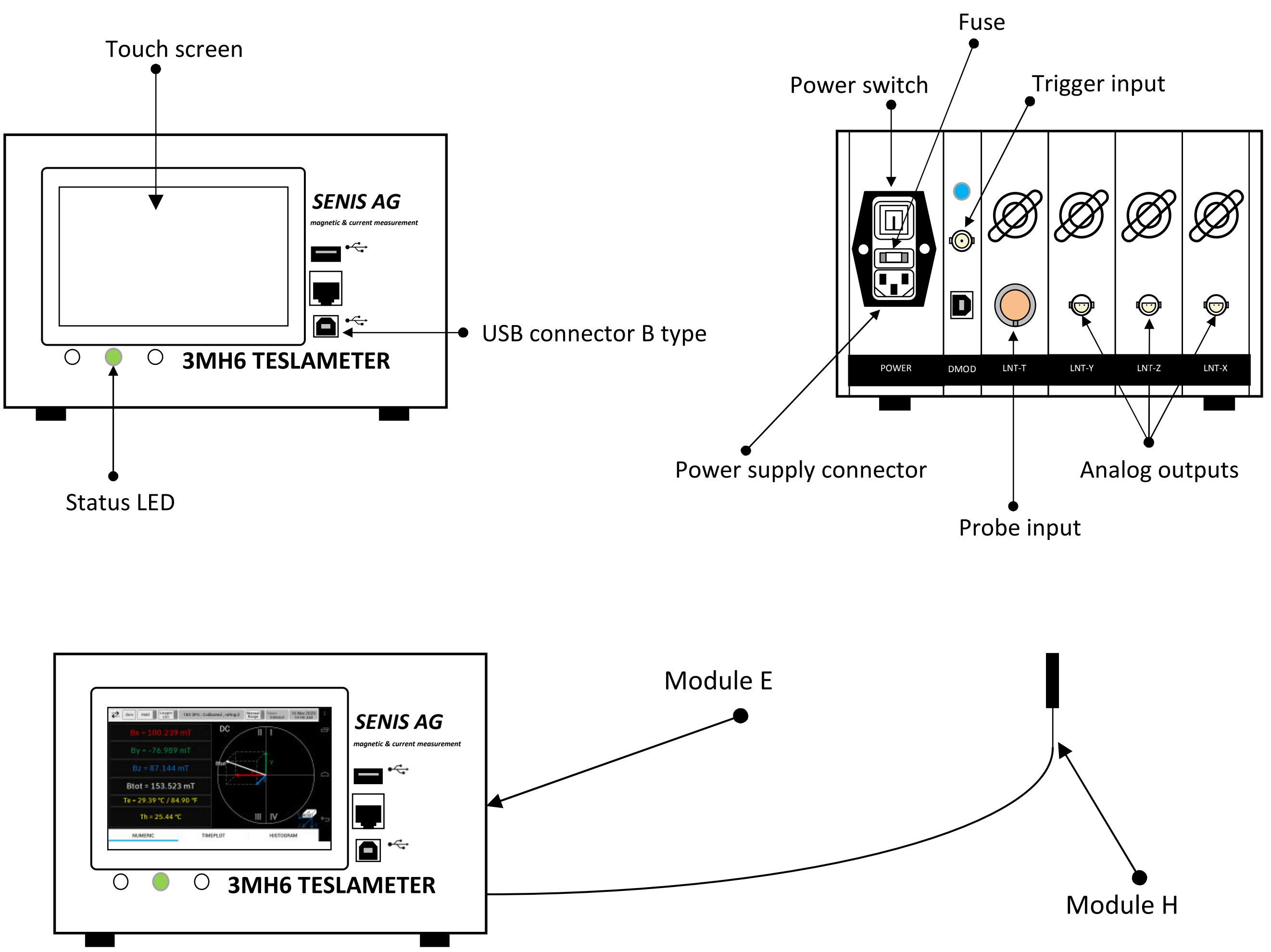


Figure 3.1 Structure of the Low Noise Teslameter 3MH6 with fully integrated Hall Probe

-Module H, consisting of the Hall Probe and the CaH Cable

- Module E, analog and digital electronics for signal conditioning

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

4. INSTALLATION

4.1 Inspection and Unpacking

Inspect shipping containers for external damage before opening them. Photograph any container that has significant damage before opening it. If there is a visible damage to the contents of the container, contact the shipping company and *SENIS AG* immediately, preferably within 5 days of receipt of goods. Keep all damaged shipping materials and contents until instructed to either return or discard them.

Open the shipping container and keep the container and shipping materials until all contents have been accounted for. Check off each item on the packing list as it is unpacked. Instruments themselves may be shipped as several parts.

If the instrument must be returned for recalibration, replacement or repair, a return authorization (RA) number must be obtained from a factory representative before it is returned.

Probes are shipped in cardboard containers and are often included in the instrument shipping carton. Please retain the probe container for probe storage. This will help protect the delicate probes from being damaged.

Items included with 3MH6 Teslameter box:

1	3MH6 device
1+	3-Axis Hall probe (I3C-03C02L)
1	3MH6 Operating Manual, Certificate of Calibration and Angular accuracy (on request)
1	Memory stick (flash memory) containing probes calibration data and PC software for interfacing with 3MH6 teslameter.
1	USB cable to connect 3MH6 device to your computer
1	BNC cable to connect trigger pulses
1	Power cord
1	Output cable for uncompensated analog voltage (on request)
1	Touch pen

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

4.2 Front Panel Description

Figure 4.1 Front side photo

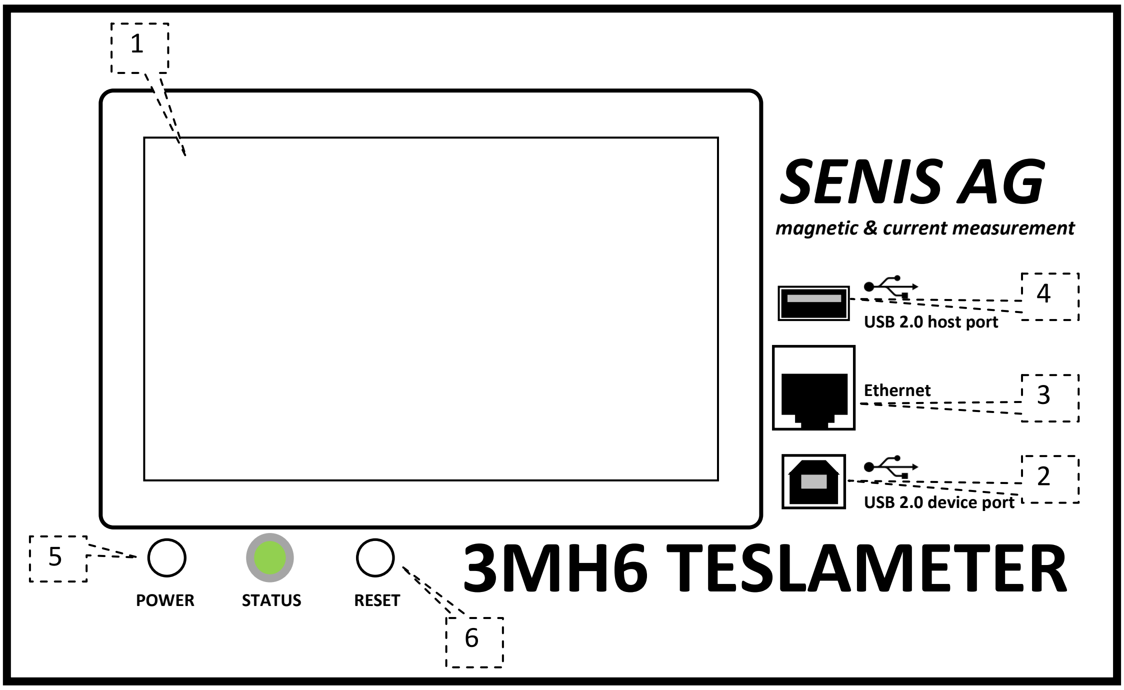


Figure 4.2 Front panel view

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

1	Display	5" TFT Capacitive Touch LCD, 800x480 pixel, 24-bit, White LED Backlight, Dimensions: L120.7 x H75.8 mm
2	USB connector	USB 2.0 Type B connector - **Device port for data acquisition**
3	Ethernet	RJ45 connector - **For future use** (to be implemented in one of next releases)
4	USB connector	USB 2.0 Type A connector - **Host port for future use** (to be implemented in one of next releases)
5	Power push button	Power push button will be implemented in one of next releases.
6	Reset push button	Reset of the main microcontroller board. Pressing this button results in rebooting of the Android operating system

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

4.3 Rear Panel Description

Figure 4.3 Rear side photo

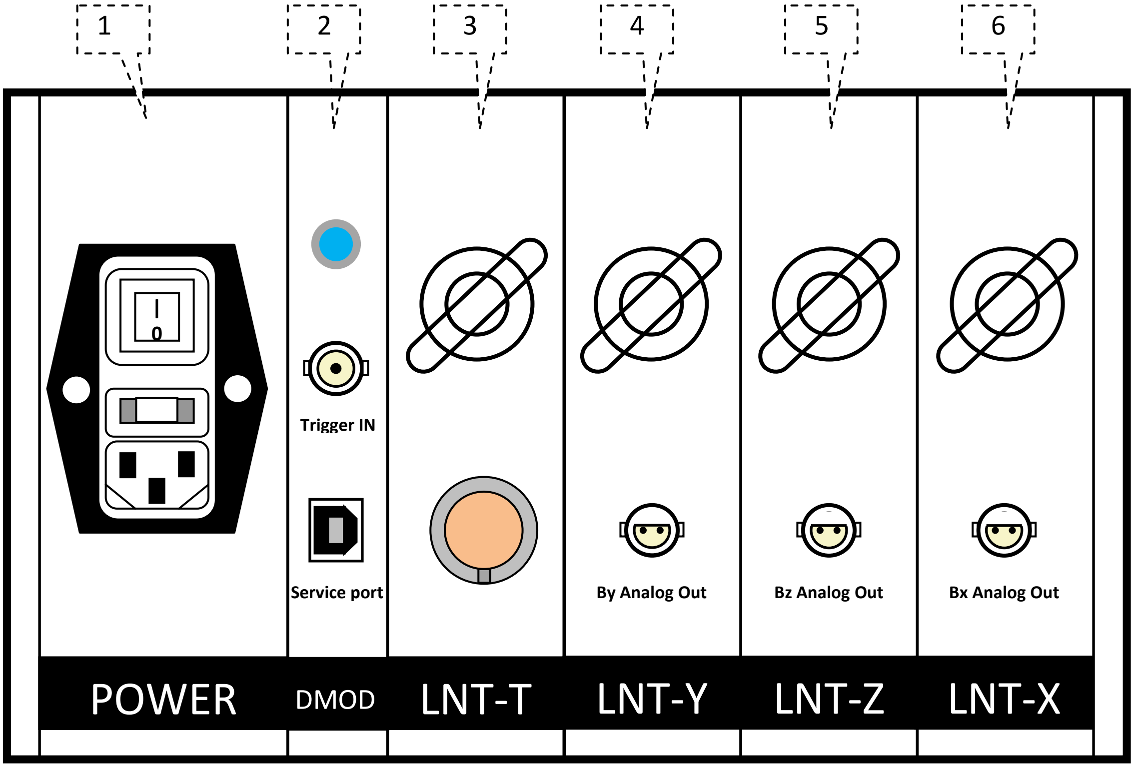


Figure 4.4 Rear panel view

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

1	Line input assembly	Includes line cord inlet and instrument power switch
2	Modulator / Demodulator board / Trigger input	Includes board for generation of digital signals necessary to control modulation and demodulation process as well as the trigger signal input
3	Temperature processing board with temperature sensor input	Includes board for processing the temperature output signal from the probe
4, 5, 6	Hall sensor processing boards for B_x, B_y and B_z	Include boards for processing Hall sensor signals from the probe

CAUTION: Make rear panel connections with the instrument powered OFF.

4.4 Line Input Assembly

Figure 4.5 Switched and fused inlet

1	Line Cord Input	Voltage range: 88 ~ 264 VAC, Frequency range: 47 ~ 63 Hz
2	Power Switch	0-OFF / **I**-ON
3	Fuse Drawer	1.5 A

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

4.5 Probe Input Connection

WARNING: Probes used with the teslameter have conductive parts. Never expose the probe near live voltage. Personal injury and damage to the instrument may result.

The *SENIS* probe plugs into the 22 pin *LEMO* connector on the rear panel. Align the probe connector with the rear panel connector and push straight in to avoid bending the pins.

4.6 Probe Handling and Operation

To avoid damages and for the best results during measurements, a number of handling and accuracy requirements must be fulfilled.

Although every attempt has been made to make the probes as robust as possible, they are still fragile. This is especially true for the exposed sensor tip. Care should be taken during measurements that no pressure is placed on the tip of the probe. The probe should only be held in place by securing it at the handle (holder/steam). The probe stem should never have force applied. Any strain on the sensor may alter the probe calibration, and excessive forces may destroy the Hall Probe. As a rule, a stem should not be bent more than 45° from the base. Do not pinch or allow probe cables to be struck by any heavy or sharp objects. Damaged or severed cables and probes should be returned to *SENIS* for repair, though please understand that probes are not always repairable.

CAUTION: Broken sensors are not repairable.

When probes are installed on the teslameter but not in use, the protective tubes provided with probes should be placed over the probe handle and stem in order to protect the probe tip.

When the teslameter is not in use, the probes should be stored separately in some type of rigid container. The cardboard and foam container that *SENIS* probes are shipped in may be retained for the probe storage.

4.7 Functional Verification

- Use Zero Gauss chamber to verify ZERO reading of teslameter

- Use reference magnet to verify calibrated reading of teslameter

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5. OPERATION MANUAL

5.1 Power-up

Connect the probe and the power supply cable into the corresponding 3MH6 teslameter sockets.

Find the power switch on the rear side of the device and turn it on.

On turning on 3MH6 teslameter, the screen flashes for a short time and turns black again. After couple of seconds the STATUS LED on the front panel turns on (green) and the *SENIS* logo appears as shown in Figure 5.1.

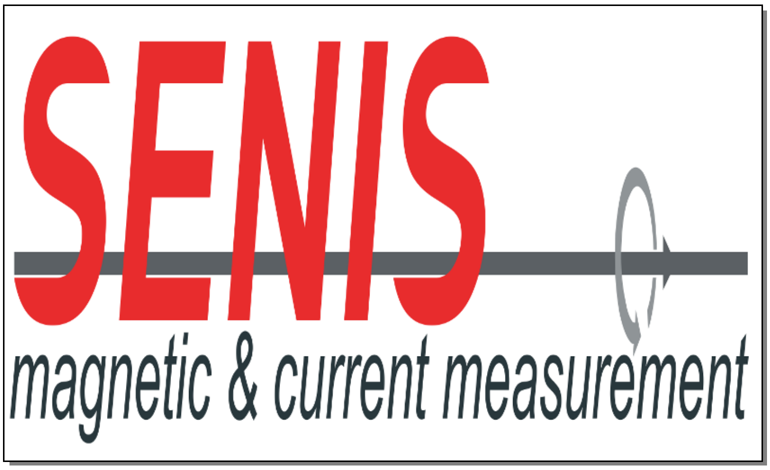


Figure 5.1 Boot-up screen

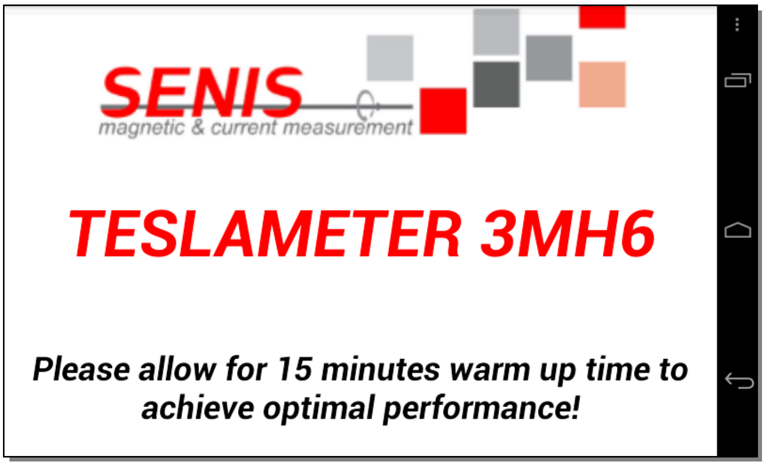


Figure 5.2 Teslameter application initialization screen (application splash screen)

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

The initialization process begins booting the Android™[1] operating system, followed by automatic start of the *Teslameter* application for Android. During the application initialization the display looks like the screen shown in Figure 5.2.

When the process is finished, the *Main* screen is shown on the display (Figure 5.3).

Note: 3MH6 teslameter should be allowed to warm up for a minimum of 15 minutes to achieve optimal performance.

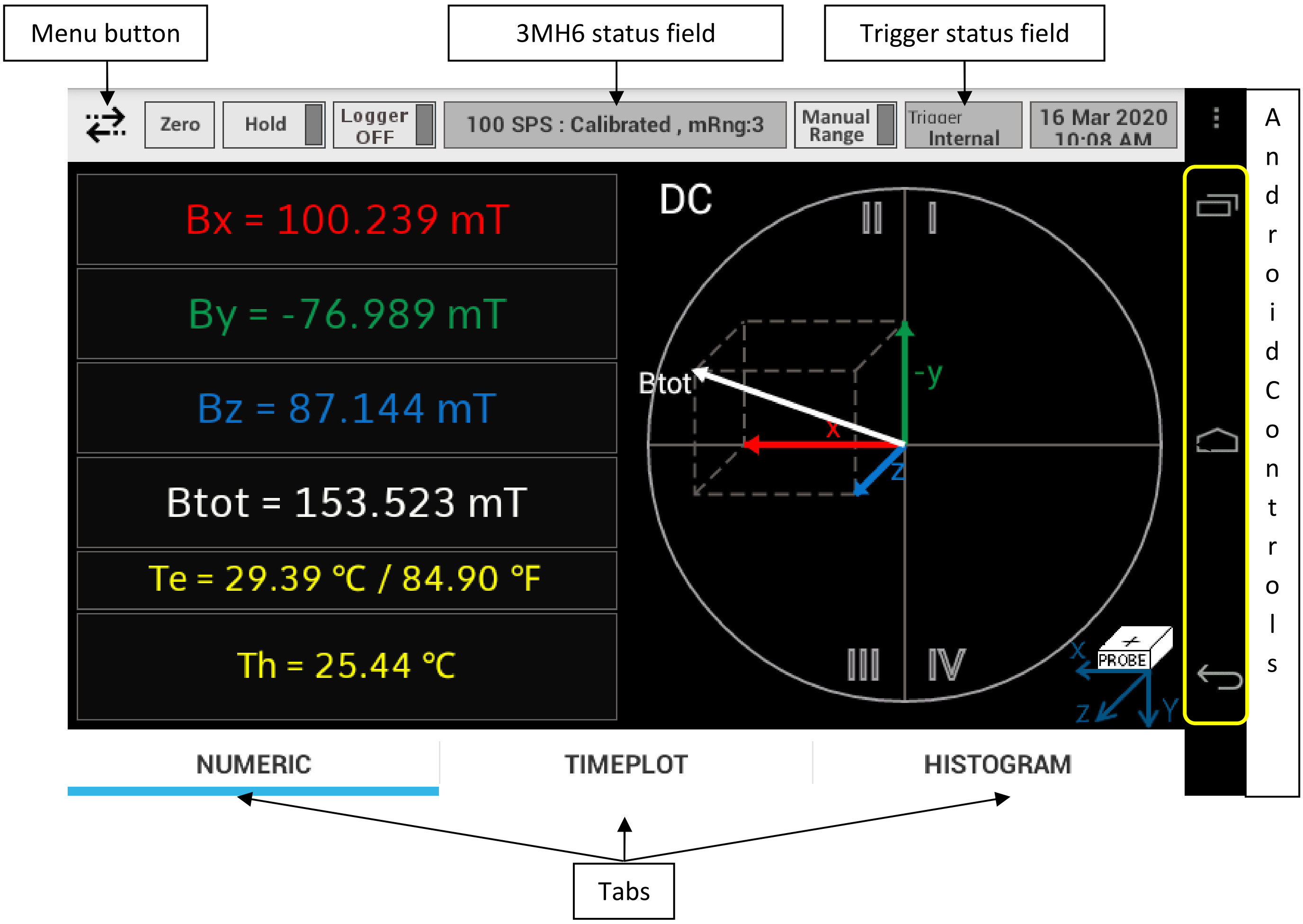


Figure 5.3 Main screen shown after starting the teslameter (Numeric tab)

<u>The header of the *Main* screen</u> displays the device status and provides controls for setting device. The *3MH6 status field* (see Figure 5.3) shows the most important settings of the device (but may also show certain warnings). Usually it shows the information in the following format:

Sampling rate : BSelector mode, Range

[1] *Android* is a trademark of *Google LLC.*

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

In the example shown in Figure 5.3, the *3MH6 status field* shows: *„100 SPS, Calibrated, mRng:3“* which means that current sampling rate is 100 SPS, the *BSelector* (signal source) mode is *Calibrated*, while the *mRng:3* means that ***M****anual* ***R****ange 3* has been selected (if the *Autorange* function is active, *aRng* is shown instead of *mRng*). Each of these settings will be described in detail in the following sections.

In the footer of the *Main* screen there are three tabs: *Numeric*, *Timeplot* and *Histogram* allowing the user to display the measurement results in different formats. The active tab is underlined (it is the *Numeric* one in Figure 5.3).

In the following sections, firstly the *Main* screen tabs will be described, and after that the function of each control button in the header of the *Main* screen will be explained in more details.

5.2 Numeric Tab

In the *Numeric* tab the averaged magnitudes of the magnetic flux density components are shown on the left side of the screen (B_x, B_y and B_z), as well as the vector sum of all the components, i.e. the total magnetic flux density (B_{tot}). The electronics temperature (T_e) is shown below B_{tot} representing the temperature inside the 3MH6 teslameter casing. It is given both in Celsius and Fahrenheit degrees. Finally, the Hall probe temperature (T_h) is shown at the bottom of the list.

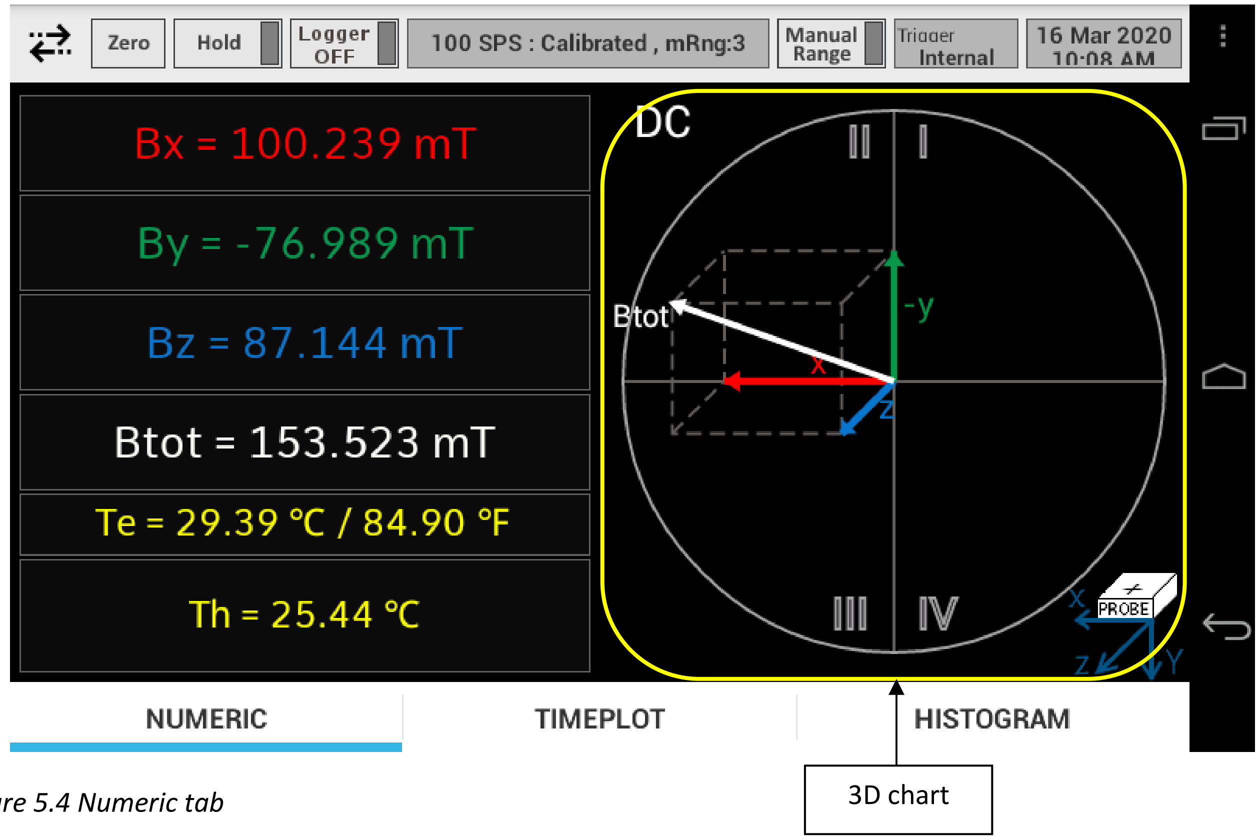


Figure 5.4 Numeric tab

On the right side of the *Numeric* tab, a *3D chart* is shown (Figure 5.4), representing the three-dimensional orientation of the total magnetic flux density vector (B_{tot}), as well as its components (B_x, B_y and B_z) with respect to the probe coordinate system (which is shown at the bottom right corner of the tab, and also in Figure 5.5). In other words, if the probe is positioned in the magnetic field as shown on the screen, the magnetic flux density vectors will have the orientation as shown in the *3D chart* (Figure 5.5).

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

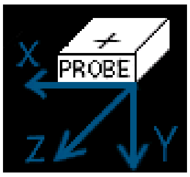


Figure 5.5 Probe coordinate system

5.3 Timeplot Tab

Timeplot tab shows the change of magnetic flux density components B_x, B_y and B_z over time during 100 ms time interval (Figure 5.6). 3MH6 acquires measurements results over 100 ms interval and once the 100 ms interval elapses, the *Timeplot* screen is refreshed, showing the latest 100 ms measurement results.

The averaged magnitudes of the B_x, B_y and B_z are shown at the bottom of the *Timeplot* screen in the same way as they are shown in the *Numeric* tab. In addition, the Hall probe temperature is also shown (T_h) in the bottom of the *Timeplot* tab.

The *Timeplot* screen supports the crosshair cursor functionality, allowing the user to see the magnetic flux density values at the specific points of time (Figure 5.7). To activate the crosshair functionality, tap the desired curve at the moment of interest. The crosshair cursor with the corresponding value will appear <u>at the nearest sampling time moment</u>. After 5 seconds, the crosshair cursor disappears from the screen.

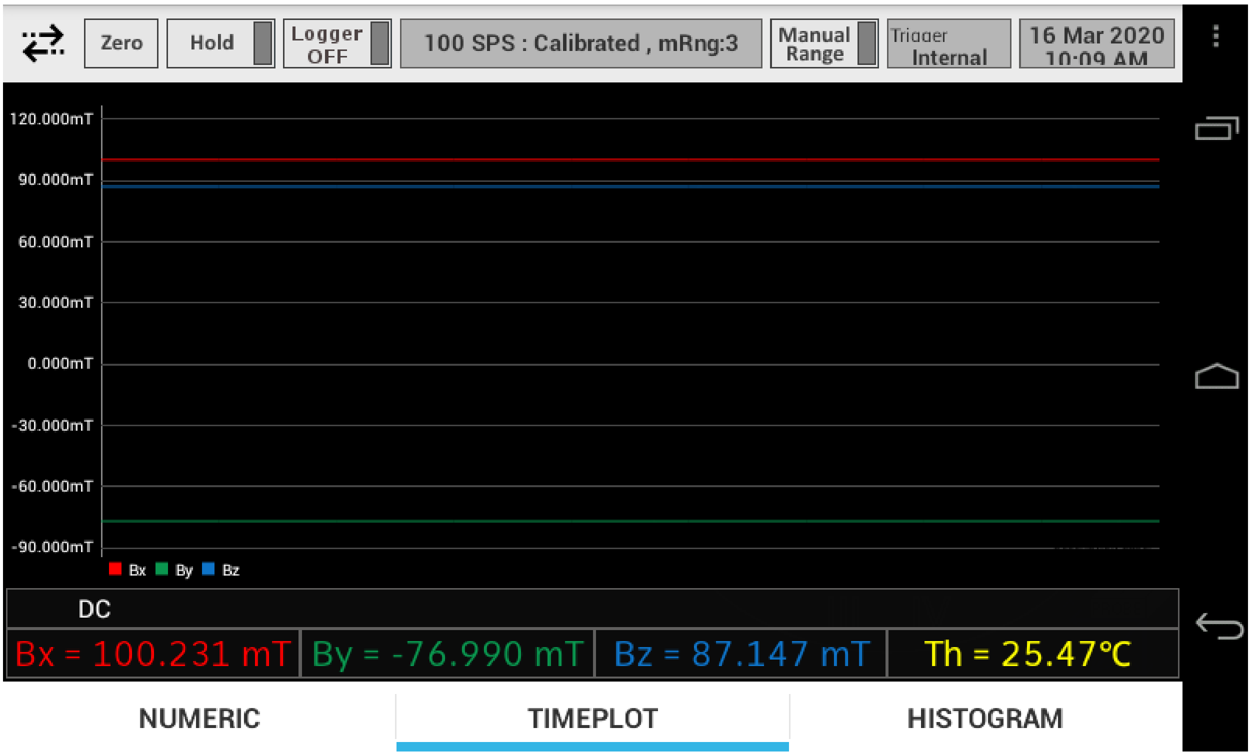


Figure 5.6 Timeplot tab

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

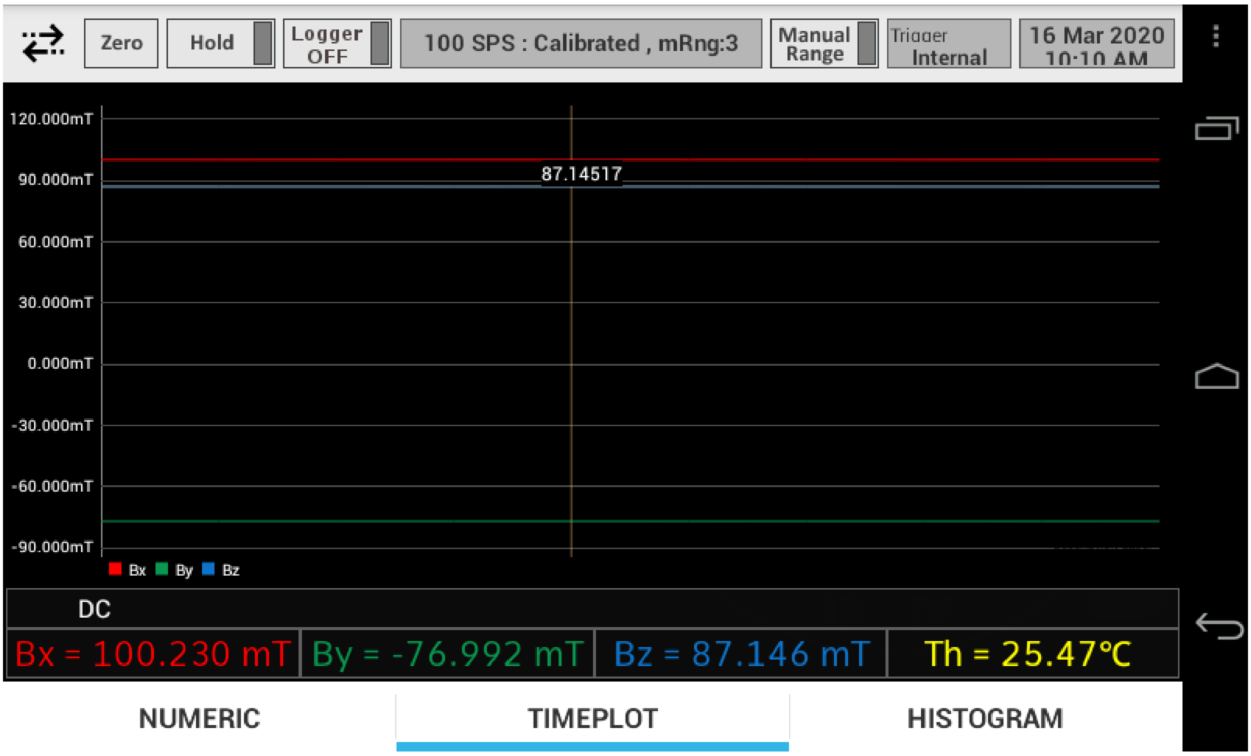


Figure 5.7 Crosshair cursor in the Timeplot tab

If the time period is not currently shown in the screen, swipe to the left or right until it is shown on the screen.

Timeplot diagram may also be zoomed in or out by spreading or pinching gestures (like in commonly used Android applications for the pictures viewing).

Note 1: The crosshair cursor may be set only at the sampling moments of the *Timeplot* screen. If you tap somewhere between the sampling moments the crosshair will appear at the nearest sampling moment. Similarly, if tapped out of any magnetic flux density curve, the crosshair cursor will appear at the nearest curve.

Note 2: The *Timeplot* diagram is **not** shown for sampling rate of 10 SPS (SPS = samples per second) because the *Timeplot* diagram shows the data within 100 ms interval, and at the sampling rate of 10 SPS there is only one point to show.

Note 3: The greater the sampling rate, the smoother the waveform shown in the *Timeplot* tab. To achieve acceptable smoothness of the variable magnetic fields waveforms, *SENIS* recommends setting the sampling rate that is at least 10 times greater than the frequency of the measured magnetic field, thus providing at least 10 points per magnetic field period.

Increasing the sampling rate on the other hand, increases the teslameter noise, thus decreasing the measurement accuracy.

Note 4: For watching the waveforms in the *Continuous* trigger mode, follow the recommendations given in the *5.5.2.6.2.2 Continuous Trigger Mode* section of this Manual.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.4 Histogram Tab

Histogram tab allows statistical analysis of the measurement results. It shows the distribution of the instantaneous values of samples in both *DC* and *AC* mode.

Histogram tab may work in two modes: *Histogram Bar Chart* and *Gaussian Distribution*. The mode is selected from the *Setup* menu.

Histogram Bar Chart represents a real histogram showing the distribution of measured values as a series of bars, where each bar represents one interval of values, while the height of the bar represents the count of samples that fall in that range (Figure 5.8).

Gaussian Distribution represents the Gaussian probability density function of the selected measurement value (Figure 5.10).

The number of samples that will be used for plotting the histogram is set from the *Setup* menu (*Number of Samples for Histogram* slider). It can be varied from 0 to 100.

Note 1: If the *Number of Samples for Histogram* is set to 0, the histogram chart will not be shown.

Note 2: The greater the number of samples, the more realistic histogram will be obtained. However, increasing the number of samples initially increases the time for calculation of the statistical parameters used for drawing the chart.

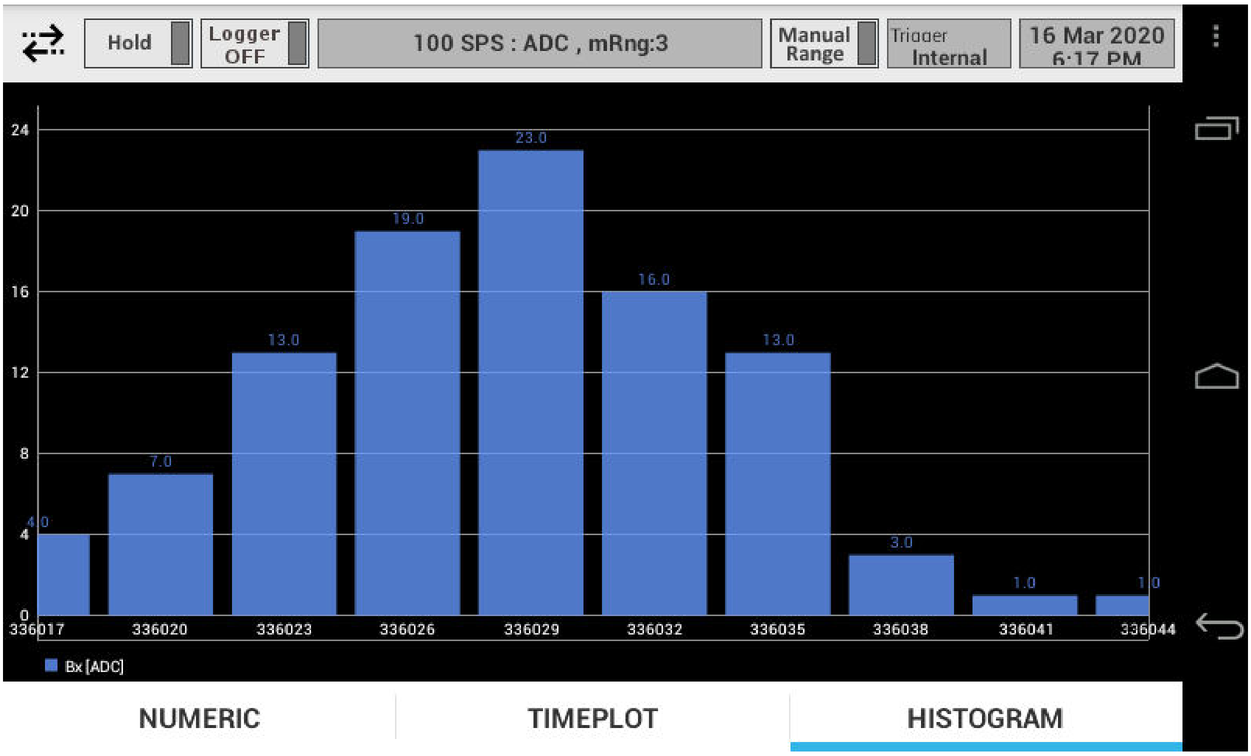


Figure 5.8 Histogram bar chart (distribution of ADC values of Bx)

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

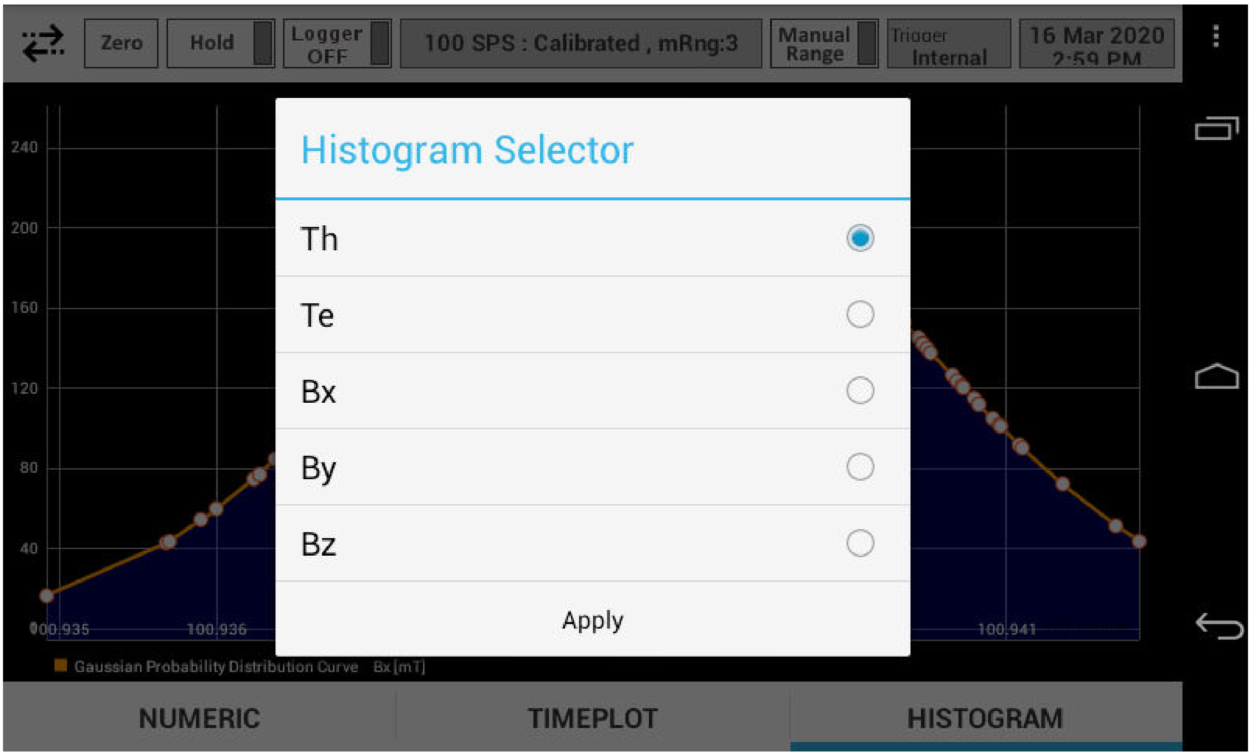


Figure 5.9 Histogram Selector menu

On selecting the *Histogram* tab, a *Histogram Selector* menu is shown on the screen, allowing the user to select the measurement parameter for which the histogram is to be plotted (Figure 5.9).

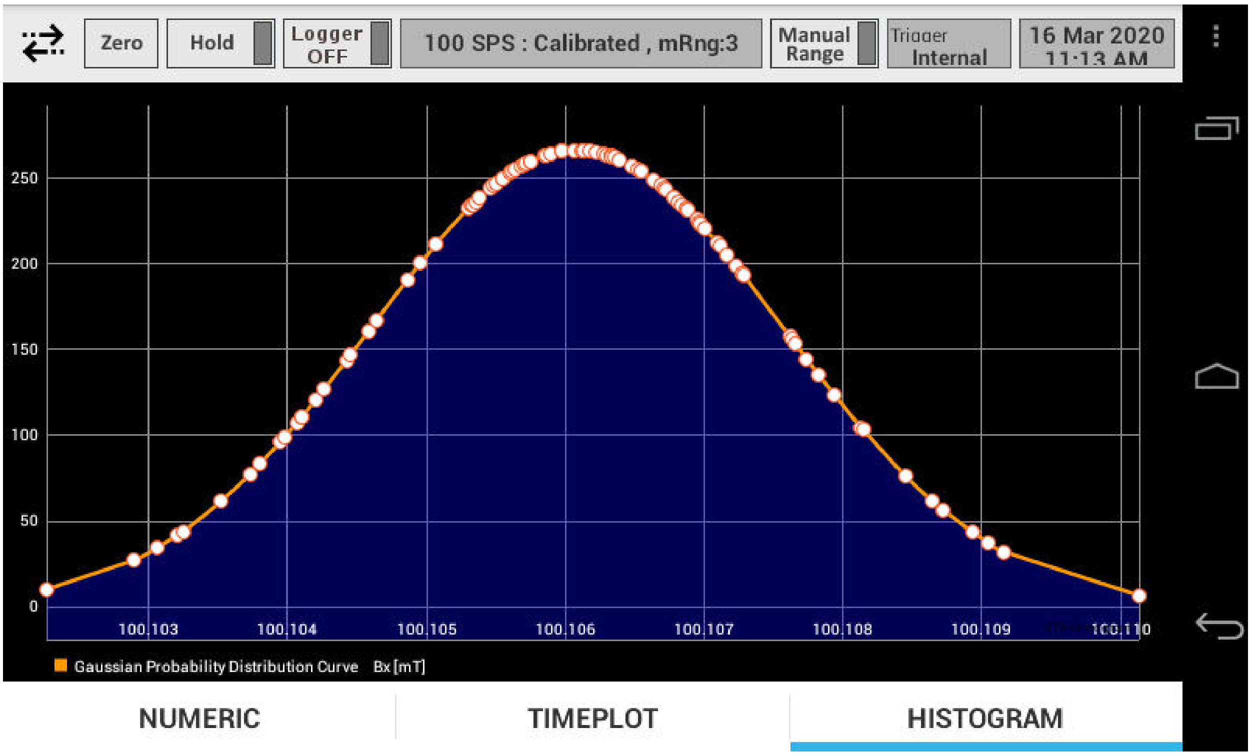


Figure 5.10 Gaussian probability density function (Calibrated Bx[mT])

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

Note 3: The *Histogram Selector* menu is shown only when the *Histogram* tab is entered from some other tab. If you are already in the *Histogram* tab, you cannot change the measurement parameter whose histogram is to be shown unless you move to any other tab and then return to *Histogram* tab.

Note 4: When the *Histogram* tab is selected for the first time or the measuring parameter has been changed, it may require 20 seconds (or more) until the stable diagram is shown in the screen.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.5 3MH6 Teslameter Settings

In order to configure 3MH6 device, click on the *Menu* button in the top left corner of the *Main* screen (Figure 5.11).

Figure 5.11 Menu button

The *Menu* shown in Figure 5.12 appears allowing the user to:

1. Select measurement mode between *DC* and *AC* (***Measurement Mode*** option)
2. Configure the instrument which includes setting the range, sampling rate, measurement unit, display, etc. (***Setup*** option).
3. Select the format (source) of the measurement results to be shown in the display (and sent over USB port) between *Calibrated* and *ADC* or choosing to show maximal or minimal values (***BSelector*** option)
4. Get the information about the instrument and the probe including the serial numbers, calibration dates, software versions, etc. (***Info Display*** option).

Note: In order to close the *Menu* shown in Figure 5.12, tap the *Menu* button again (Figure 5.11).

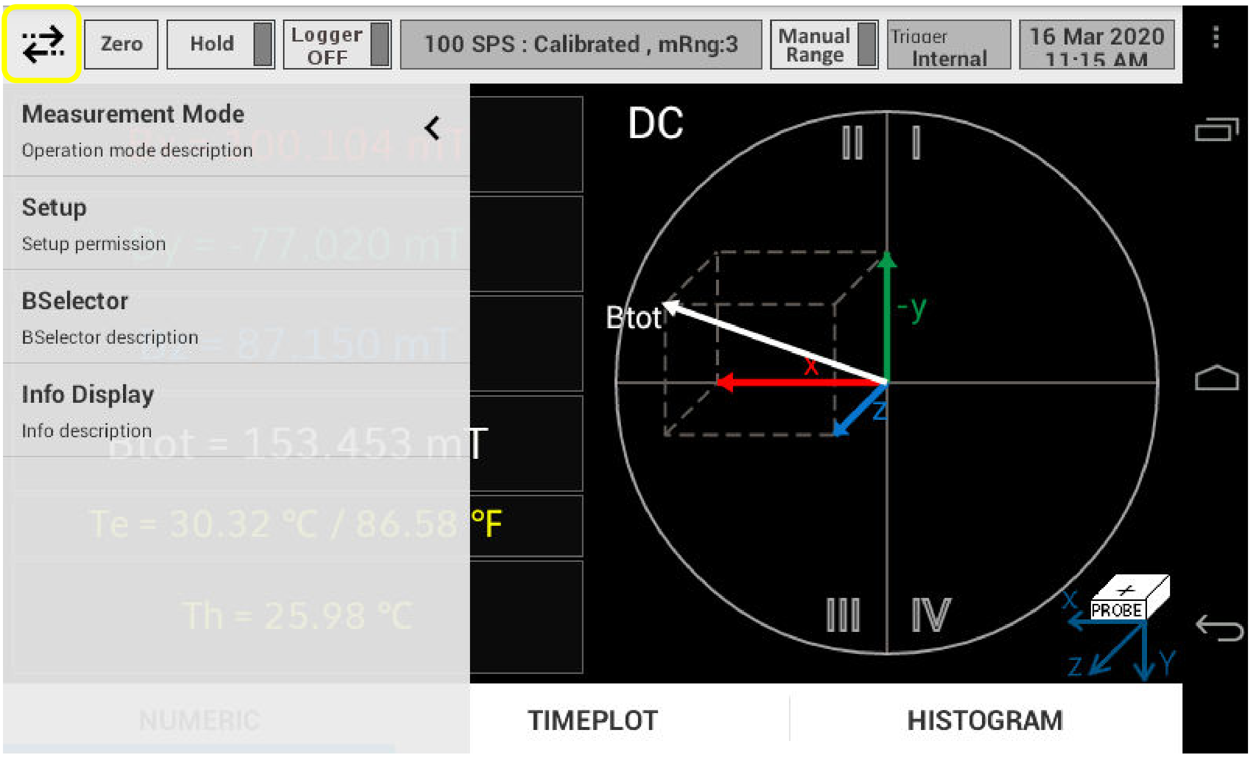


Figure 5.12 Menu

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.5.1 *Measurement Mode*

Measurement Mode option (Figure 5.13) allows switching between two basic types of measurements in 3MH6 teslameter: *DC* and *AC.*

On tapping the *Measurement Mode* option in the *Menu*, a pop-up menu for selecting appropriate mode is shown on the screen (Figure 5.14).

5.5.1.1 DC Mode

In *DC* measurement mode the **averaged** magnetic flux density values of B_x, B_y, B_z are shown on the display (B_{tot} is calculated and shown based on the component values) in *Numeric* and *Timeplot* tab. In the *Histogram* tab, the distribution of the instantaneous values of measured parameters is shown.

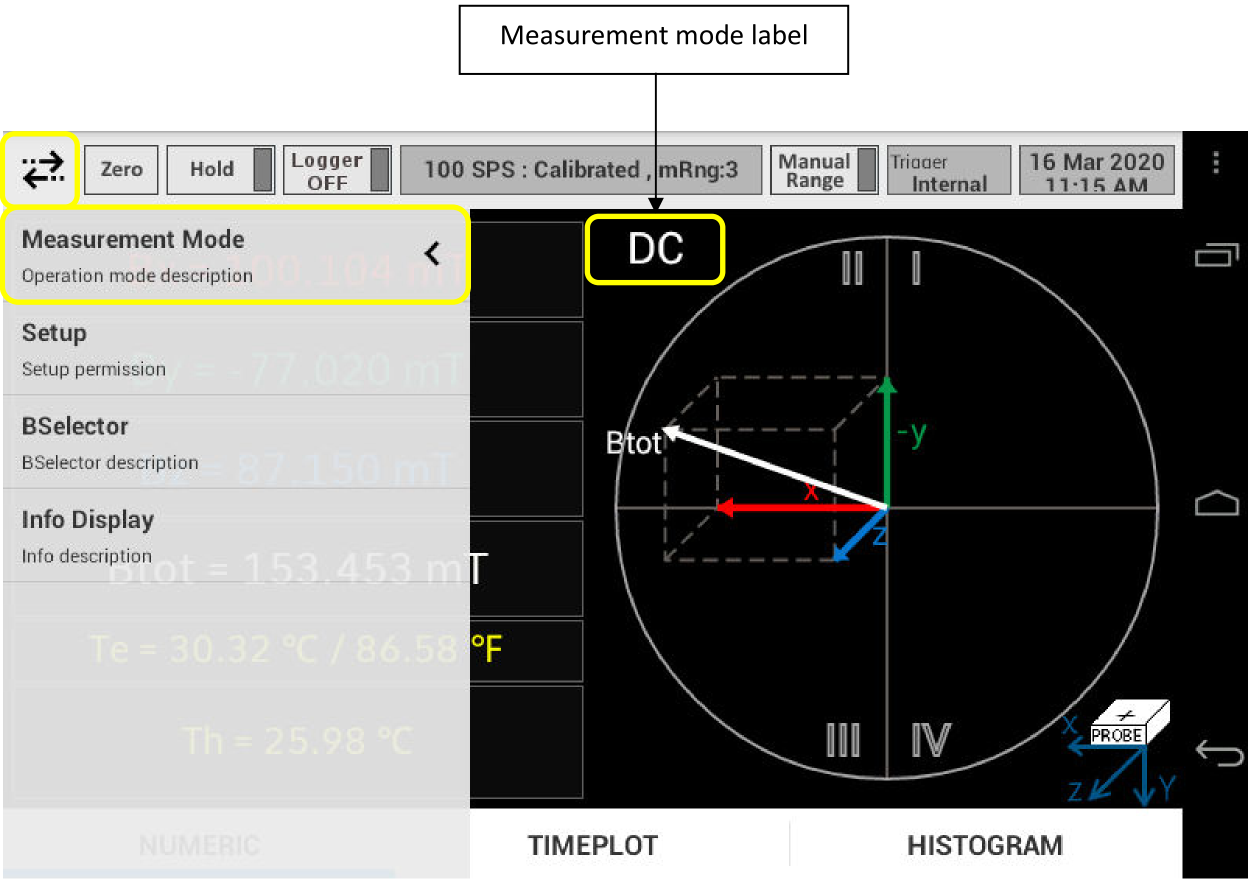


Figure 5.13 Measurement Mode option in Menu

The current *Measurement Mode* is denoted with the label above *3D chart* (*DC* in Figure 5.13).

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

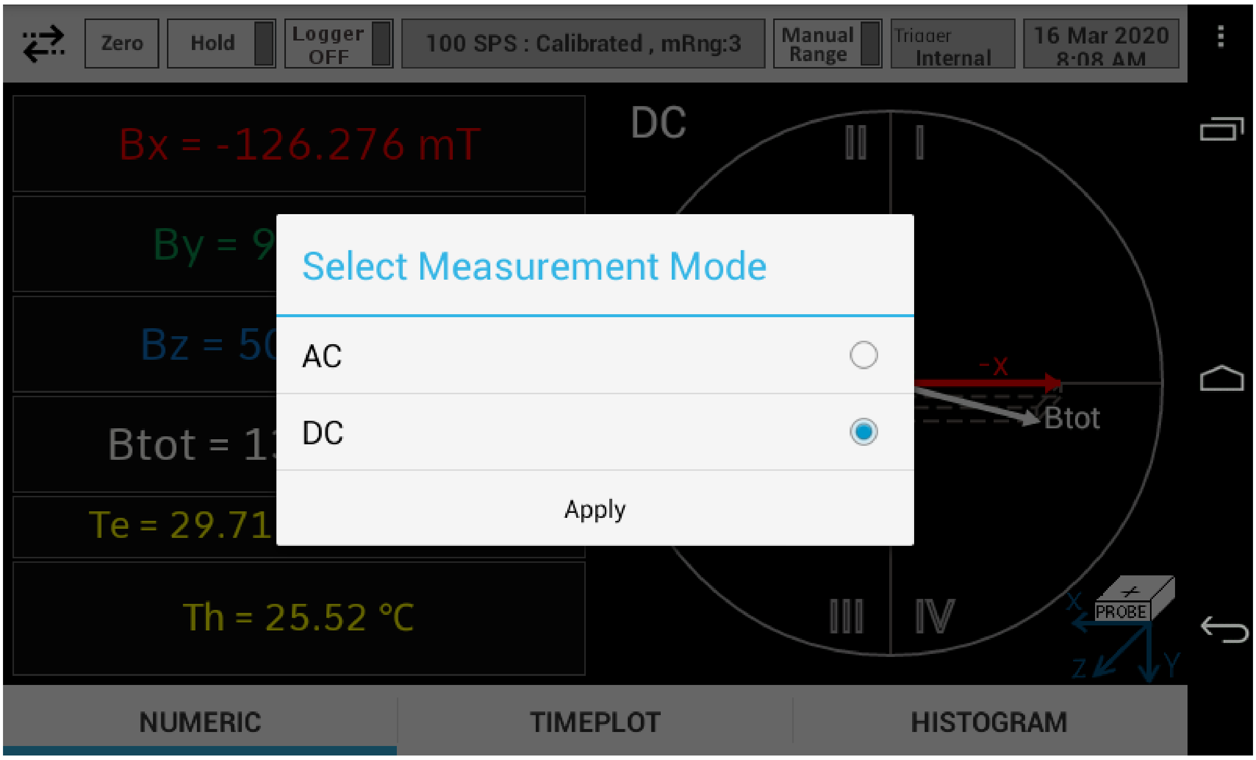


Figure 5.14 Select Measurement Mode menu

5.5.1.2 AC Mode

In *AC* measurement mode the averaged **RMS** values of B_x, B_y, B_z and B_{tot} are shown on the display in *Numeric* and *Timeplot* tabs, while in the *Histogram* tab it is shown the distribution of the instantaneous magnetic flux density samples.

Note 1: The RMS value of the periodic magnetic flux density b(t) is defined in following way:

$$B_{rms} = \sqrt{\frac{1}{T}\int_0^T b^2(t)dt}$$

where b(t) is the instantaneous value of the periodic AC magnetic flux density, and T is the period of the AC magnetic flux density.

An example of variable magnetic flux density containing AC and DC offset components is shown in Figure 5.15. Nevertheless, the AC component may be some other periodic function (which is not a pure sine function).

On selecting the *AC* mode, a pop-up menu for selecting the *AC* field frequency range is shown on the screen. As it can be seen from the Figure 5.16 there are two frequency ranges available:

- ≤ 10 Hz
- > 10 Hz.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

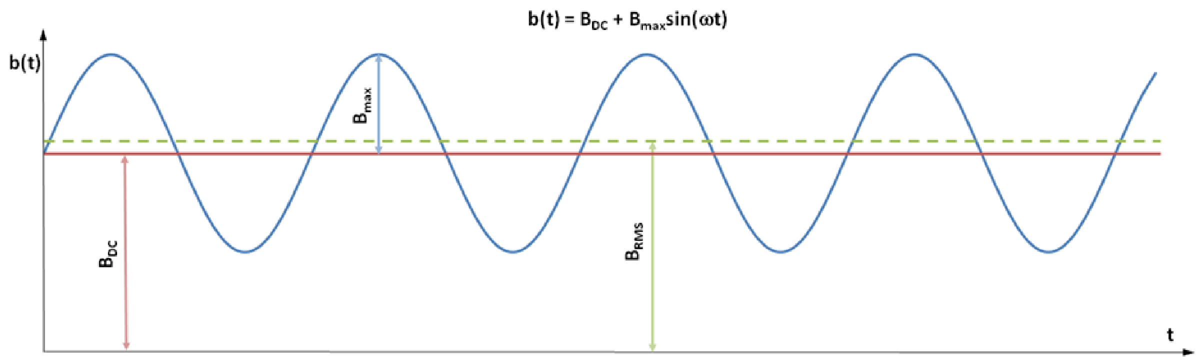


Figure 5.15 Example of magnetic flux density containing DC and AC components and corresponding B_{rms}

Note 2: Always choose the adequate frequency range according to the actual frequency of the measured magnetic field. Wrong frequency range selection may lead to severe measurement errors.

Note 3: In order to escape from any pop-up menu in the *Teslameter* application <u>without</u> applying any settings change, either tap outside the pop-up menu or tap the Android *Back* button ( ). The pop-up menu will close and the changed setting will be discarded.

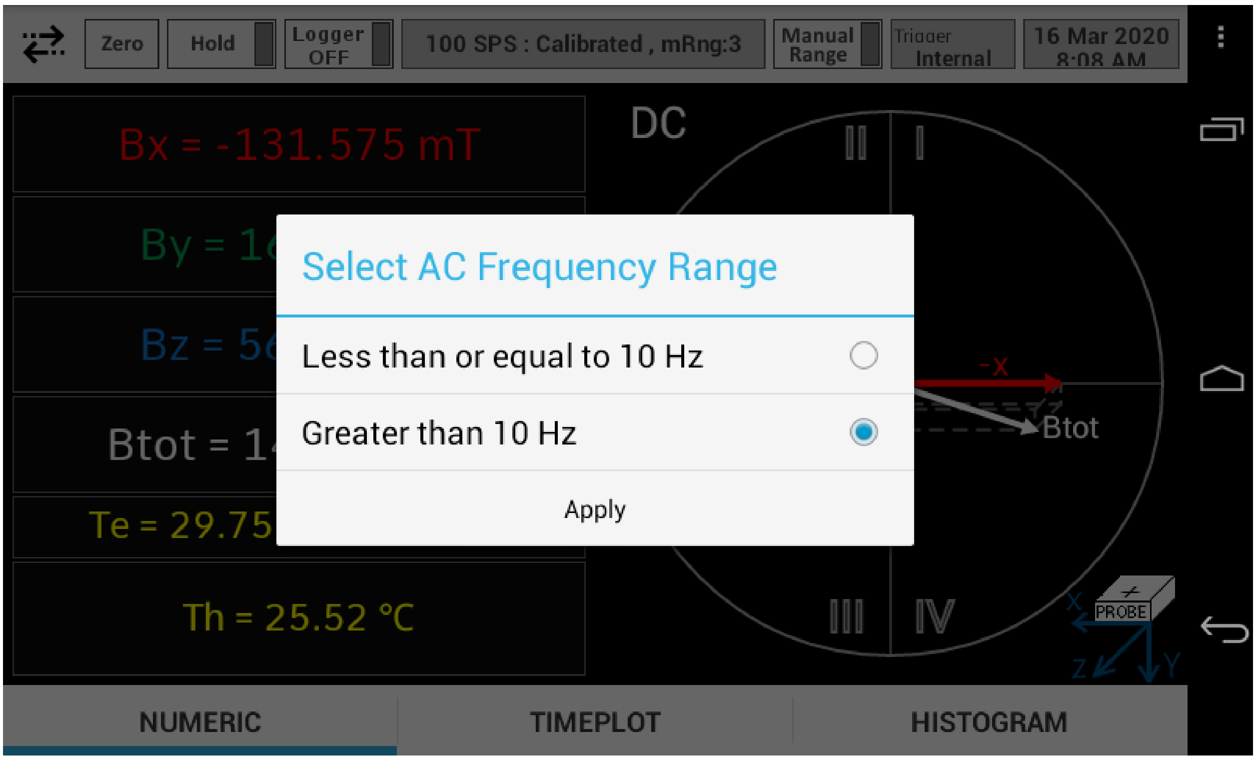


Figure 5.16 Select AC Frequency Range menu

After the *AC* frequency range has been selected*, Select Averaging Window* menu appears allowing the user to select the time interval (window) during which the measured RMS values will be averaged (Figure 5.17).

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

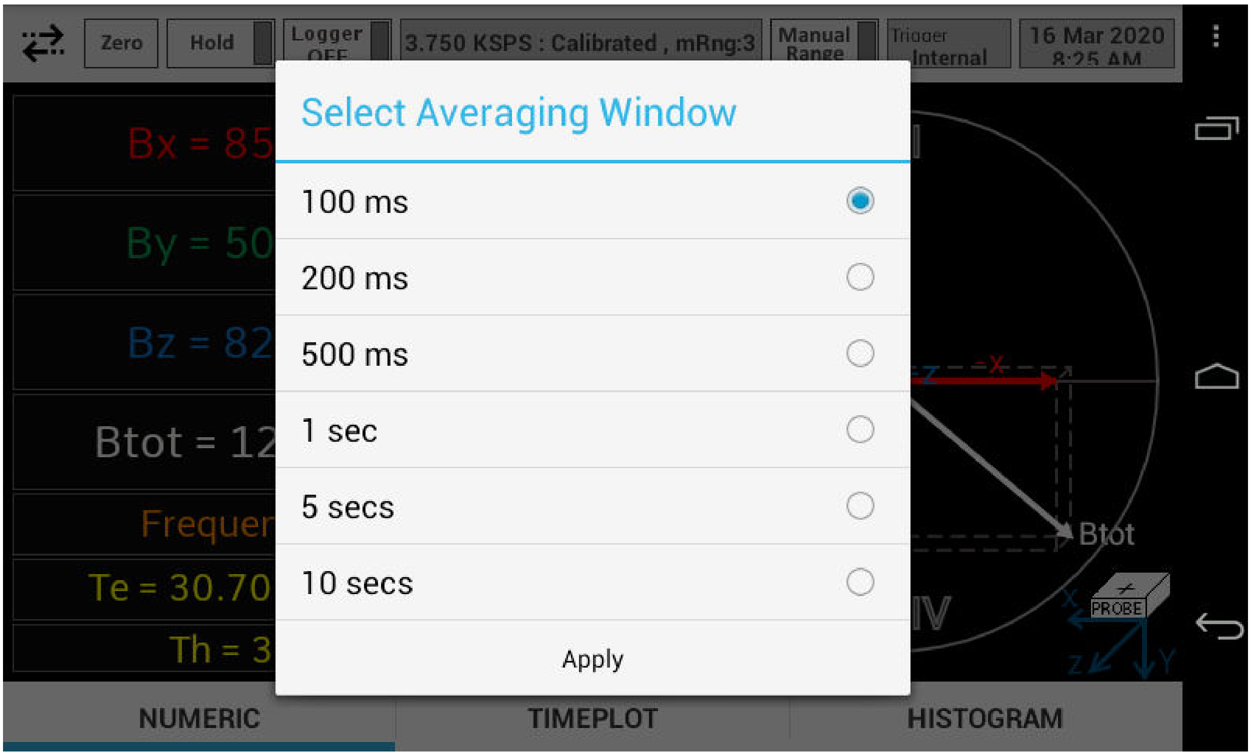


Figure 5.17 Select Averaging Window menu

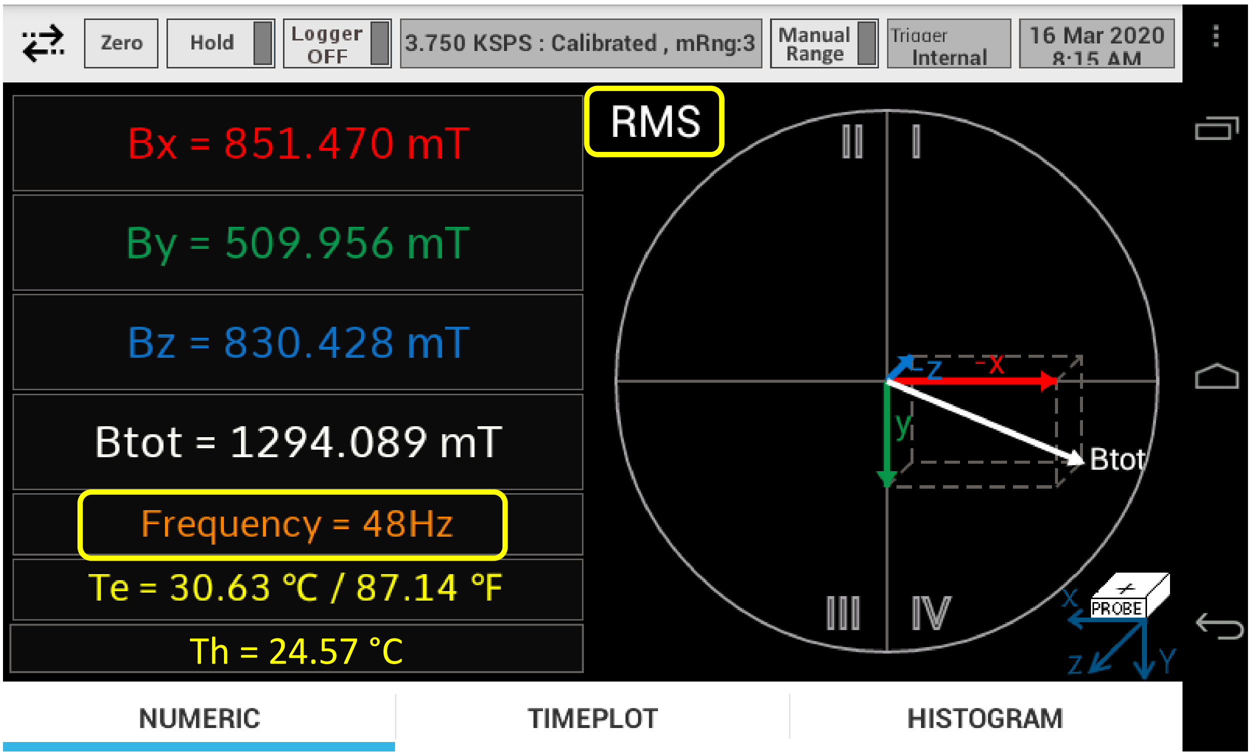


Figure 5.18 Numeric tab of the Main screen in AC Measurement Mode

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

After the *Averaging Window* has been selected, the *Main* screen appears (Figure 5.18). The label above the *3D chart* is changed to *RMS*, denoting that B_x, B_y, B_z and B_{tot} are RMS values now.

<u>Nevertheless, the vectors in *3D chart* are moving according to instantaneous values of B_x, B_y, B_z and B_{tot}.</u>

Beside the other parameters shown in *AC* mode, magnetic field frequency is shown, too (Figure 5.18 and Figure 5.19).

Note 4: In the *Less than or equal to 10 Hz* AC frequency range the sampling rate is 100 SPS and it is fixed. On the other hand, in the *Greater than 10 Hz* AC frequency range, the default sampling rate is 3.75 kSPS, but it can be changed in the same way as in *DC* mode.

Note 5: Although 3MH6 supports sampling rates of 7.5 kSPS and 15 kSPS in *AC* mode (in *Greater than 10 Hz* AC frequency range), the usage of these sampling rates is not recommended because device response may become very slow.

Figure 5.19 shows *Timeplot* tab in the *AC* mode. The waveforms represent the instantaneous values of B_x, B_y, and B_z in the last 100 ms time interval (same as in the *DC* mode), while the numeric values in the tab bottom represent the (averaged) RMS values of B_x, B_y, and B_z.

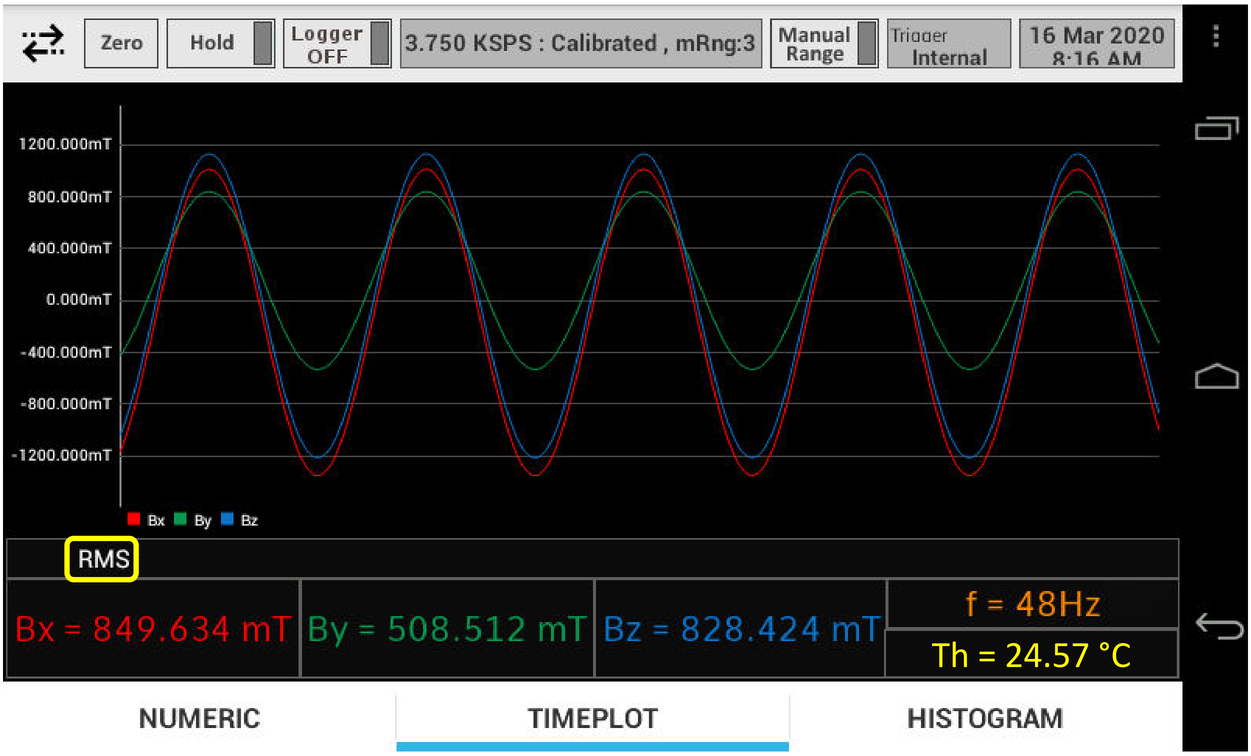


Figure 5.19 Timeplot tab of the Main screen in AC Measurement Mode

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

Note 6: **The user has to follow the Nyquist-Shannon sampling theorem when choosing the sampling rate in AC measurement mode. According to Nyquist-Shannon sampling theorem the sampling rate must be greater than double maximal frequency in its spectrum (i.e. $f_s \geq 2*f_{max}$, where f_s is the sampling rate and f_{max} is the maximal frequency in the spectrum). Failing to comply with this rule may lead to severe measurement errors. For better accuracy of RMS measurements, it is recommended to set $f_s \geq 10*f_{max}$.**

Note 7: Changing the sampling rate affects the performance and characteristics of the 3MH6 teslameter. Some of the parameters affected by the sampling rate setting are given in Table 5.1 for certain sampling rates.

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	10
f(-100 ppm) [Hz]	0.08	0.24	0.39	0.47	0.8	4	8	18	25	30
f(-0.1%) [Hz]	0.25	0.74	1.23	1.48	2.5	12.5	24	50	75	90
f(-1%) [Hz]	0.78	2.34	3.9	4.69	7.8	39	77	155	230	300
f_C(-3 dB) [Hz]	4.4	13.3	22.2	26.5	44	220	434	880	1340	2500

Table 5.1 - Averaging time, resolution and bandwidth vs. sampling rate (Conditions: range: ±2 T, probe cable length: 2 m)

The meanings of the parameters shown in Table 5.1 are as follows:

- **Sampling rate [SPS],** samples per second**:** the frequency at which the A/D convertors in 3MH6 teslameter sample the magnetic flux density signals.
- **Averaging time [ms]:** the inverse of the sampling rate showing how long the A/D convertors in 3MH6 spend averaging the raw samples. For example, if the sampling rate is 10 samples per second, the teslameter spends 100 milliseconds averaging the raw measurement results.
- **Resolution [µT rms]:** the minimal magnetic flux density change that can be detected by 3MH6 teslameter.
- **Bandwidth f(-"x"):** These are the frequencies at which the measured signal attenuation with respect to the DC value reach "-x". The AC signal attenuation is the consequence of the various low-pass filtering effects within the teslameter. For instance, the row "f(-**100 ppm**)" shows that if the sampling rate is 7500 SPS, the measured magnetic flux density will be **100 ppm** lower than its actual value when the frequency of magnetic flux density is 30 Hz. In other words the measurement error caused by the attenuation inside the teslameter will be 100 ppm at magnetic field frequency of 30 Hz.

As it can be seen from the Table 5.1, the higher the sampling rate, the greater the bandwidth of the instrument (for a given accuracy). On the other hand, increasing the bandwidth increases the noise level which in turn decreases the precision of the measurement and degrades the resolution.

In addition, the higher the sampling rate, the slower the response of the device due to the large amount of data that microcontroller in 3MH6 teslameter needs to process.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

Due to all of these reasons mentioned above, *SENIS* doesn't recommend the usage of the sampling rate above 3.75 kSPS in ***AC*** mode.

Note 8: The sampling rate in *Less than or equal to 10 Hz* AC frequency range is fixed to 100 SPS and it cannot be changed. Otherwise, the message shown in Figure 5.20 appears on the screen.

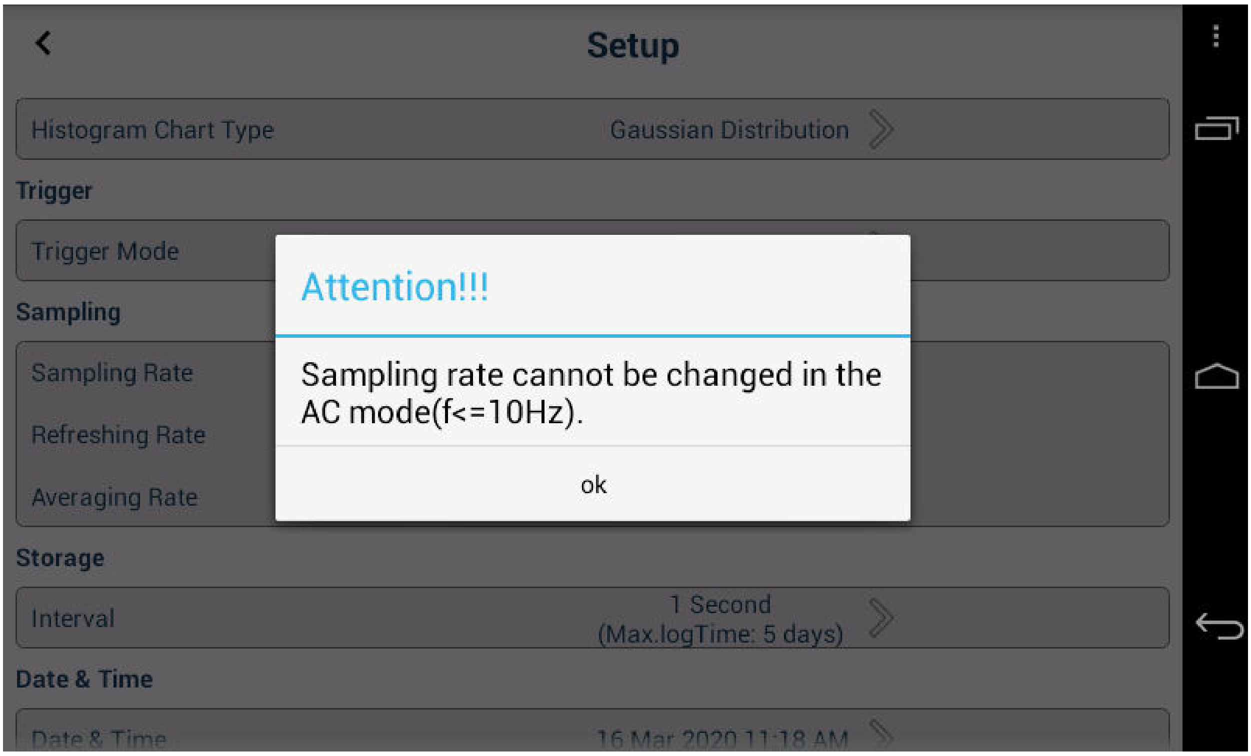


Figure 5.20 Warning message appearing when trying to change the sampling rate in the AC mode (f<=10 Hz)

Note 9: As the sampling rate in the Less than or equal to 10 Hz AC frequency range is fixed (100 SPS), the *Continuous* trigger mode **cannot** be applied for this frequency range. Nevertheless, the *Continuous* trigger mode can be applied for Greater than 10 Hz AC frequency range (see *5.5.2.6.2.2 Continuous Trigger Mode* section for details).

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.5.2 Setup Menu

Tapping the *Setup* option in the *Menu* (Figure 5.21) opens a scrollable menu screen allowing the user to do various settings of the 3MH6 teslameter (Figure 5.22, Figure 5.23 and Figure 5.24).

Note 1: For the setting of any option in the *Setup* menu, tap on the  button, or onto the label in front of it.

For the most of options in the *Setup* menu, additional pop-up menus will appear allowing the user to perform additional selections.

Note 2: Any selection done from the pop-up menu will be accepted only if ***Apply*** button at the end of the pop-up menu is tapped. Otherwise, if the selection has been made, but tapped outside of the pop-up menu, the pop-up will disappear from the screen and the setting will be discarded.

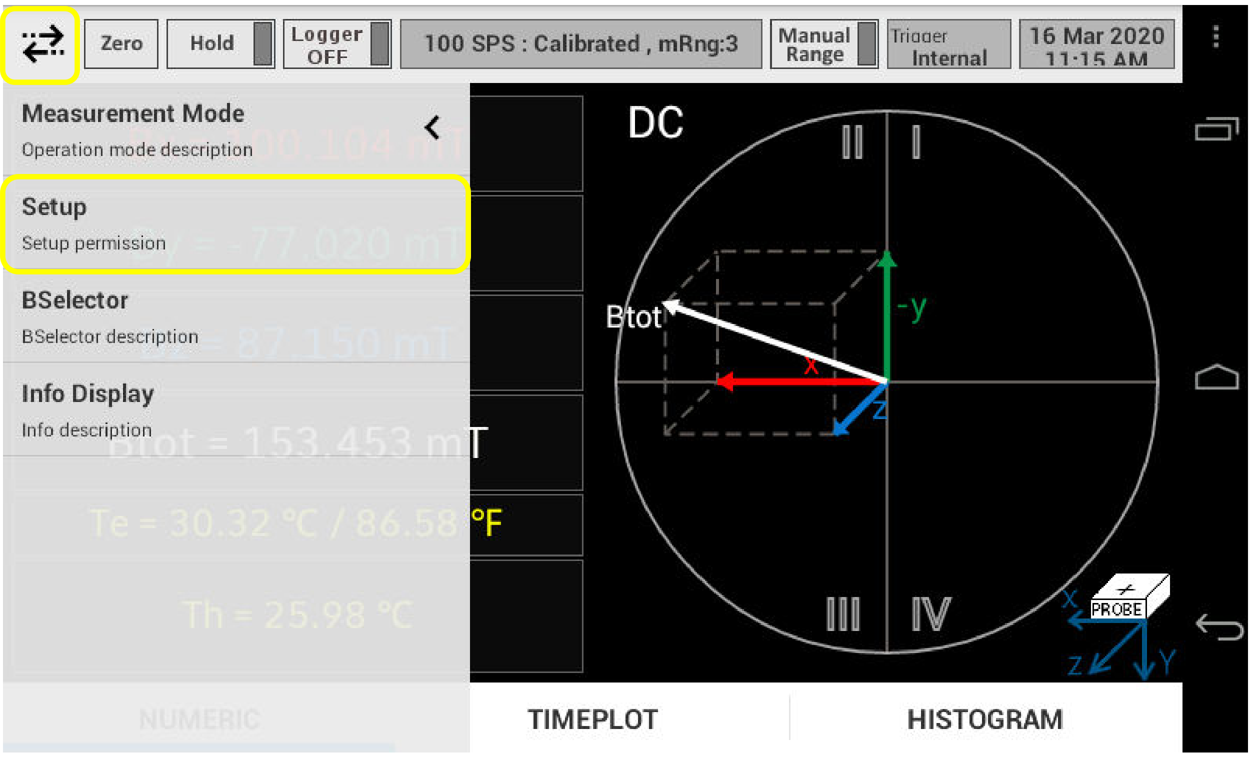


Figure 5.21 Setup option

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

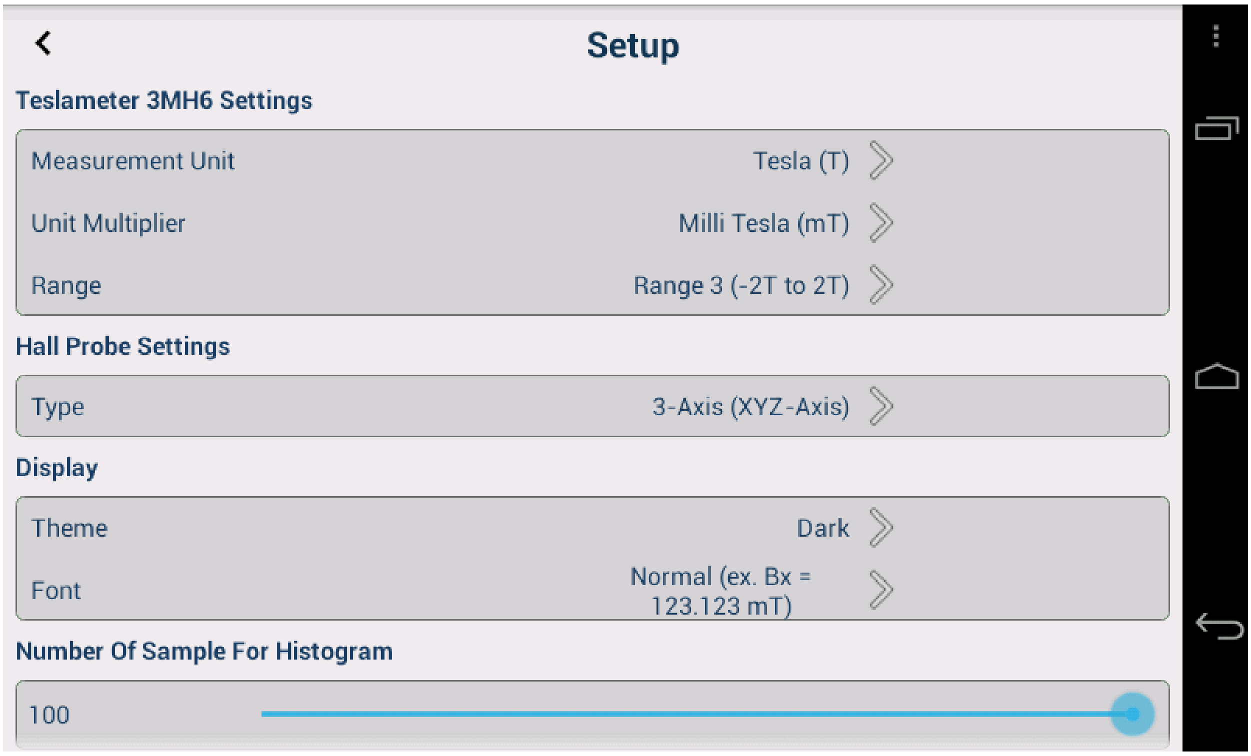


Figure 5.22 Setup menu – part I

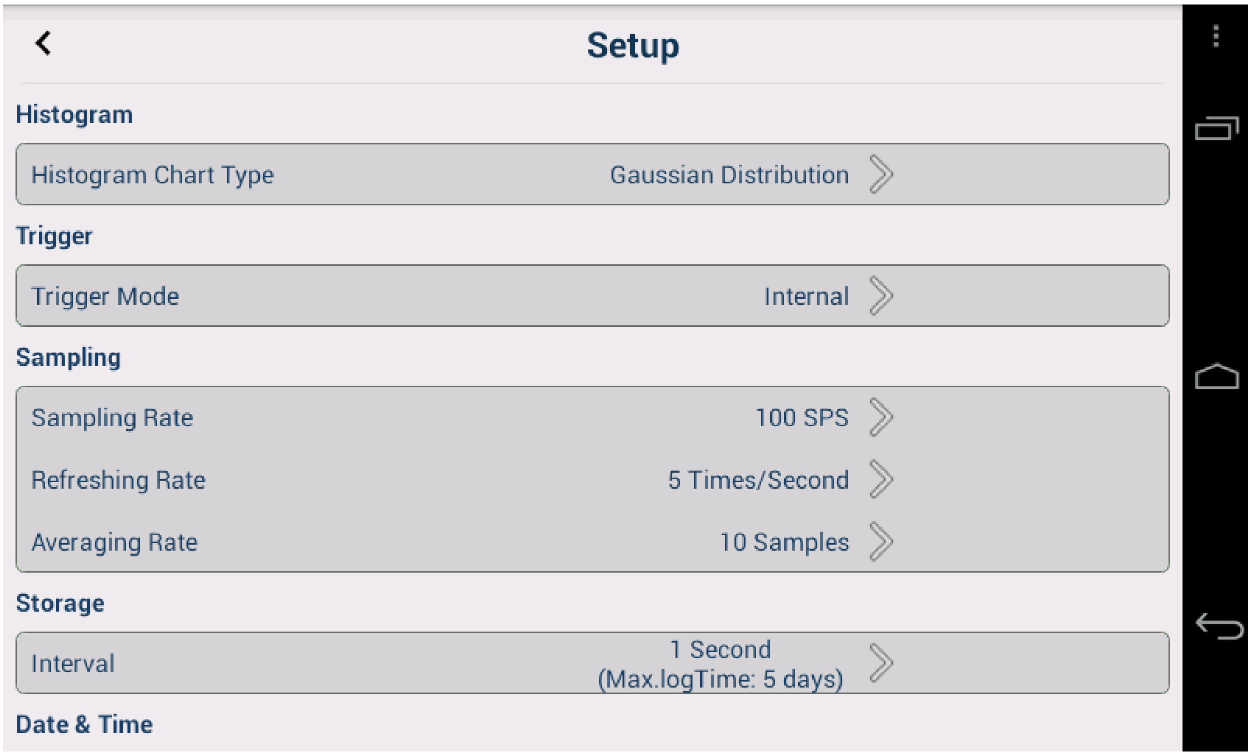


Figure 5.23 Setup menu – part II

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

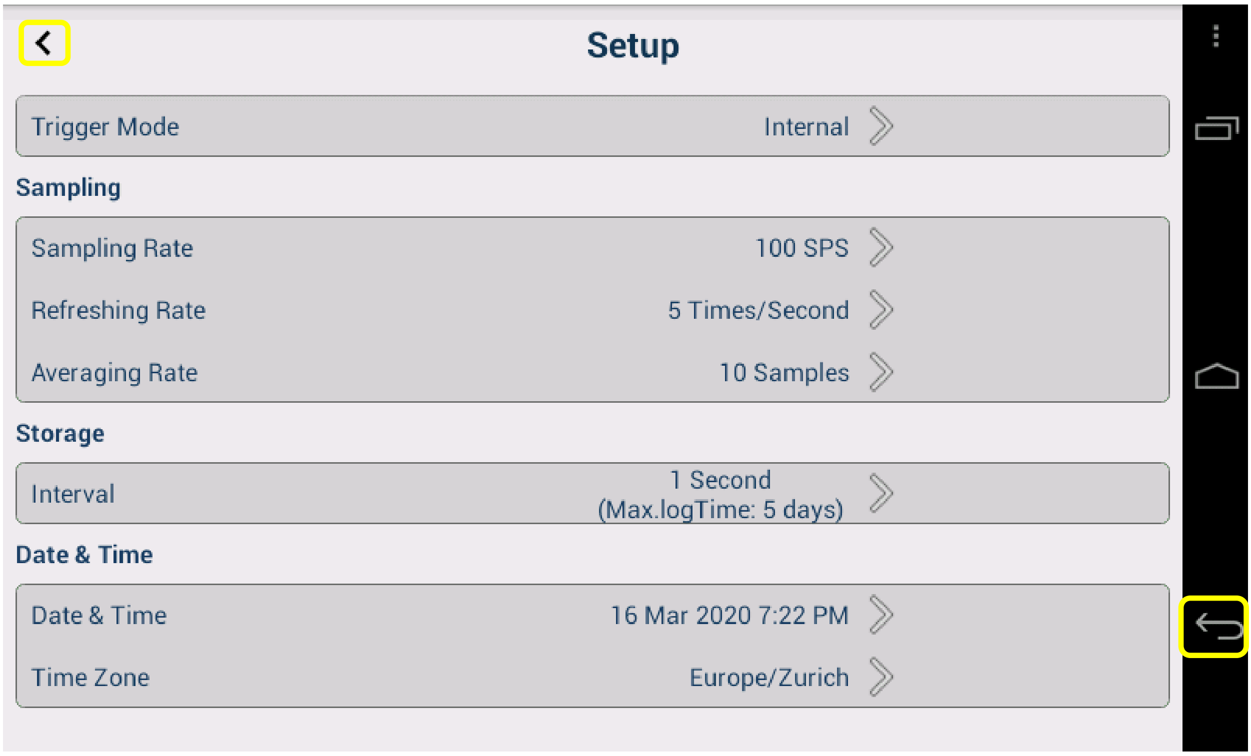


Figure 5.24 Setup menu – part III - the marked buttons are used for closing the Setup menu.

To close the *Setup* screen and return to *Main* screen you may either tap button on the top of the screen, or use the standard Android *Back button* (see Figure 5.24).

As it can be seen from the Figure 5.22, Figure 5.23 and Figure 5.24, all the 3MH6 teslameter settings are divided into several groups:

- *Teslameter 3MH6 Settings*
- *Hall Probe Settings*
- *Display*
- *Number of Samples for Histogram*
- *Histogram*
- *Trigger*
- *Sampling*
- *Storage*
- *Date and Time*

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.5.2.1 Teslameter 3MH6 Settings

Teslameter 3MH6 Settings group provides the basic settings of the teslameter. These settings refer to:

- *Measurement Unit*
- *Unit Multiplier*
- *Range*

5.5.2.1.1 Measurement Unit

Measurement Unit option allows choosing between two magnetic flux density units: tesla and gauss (Figure 5.25) depending on whether you use SI or CGS unit system, respectively.

Note: 1 T = 10^4 G, i.e. 1 mT = 10 G.

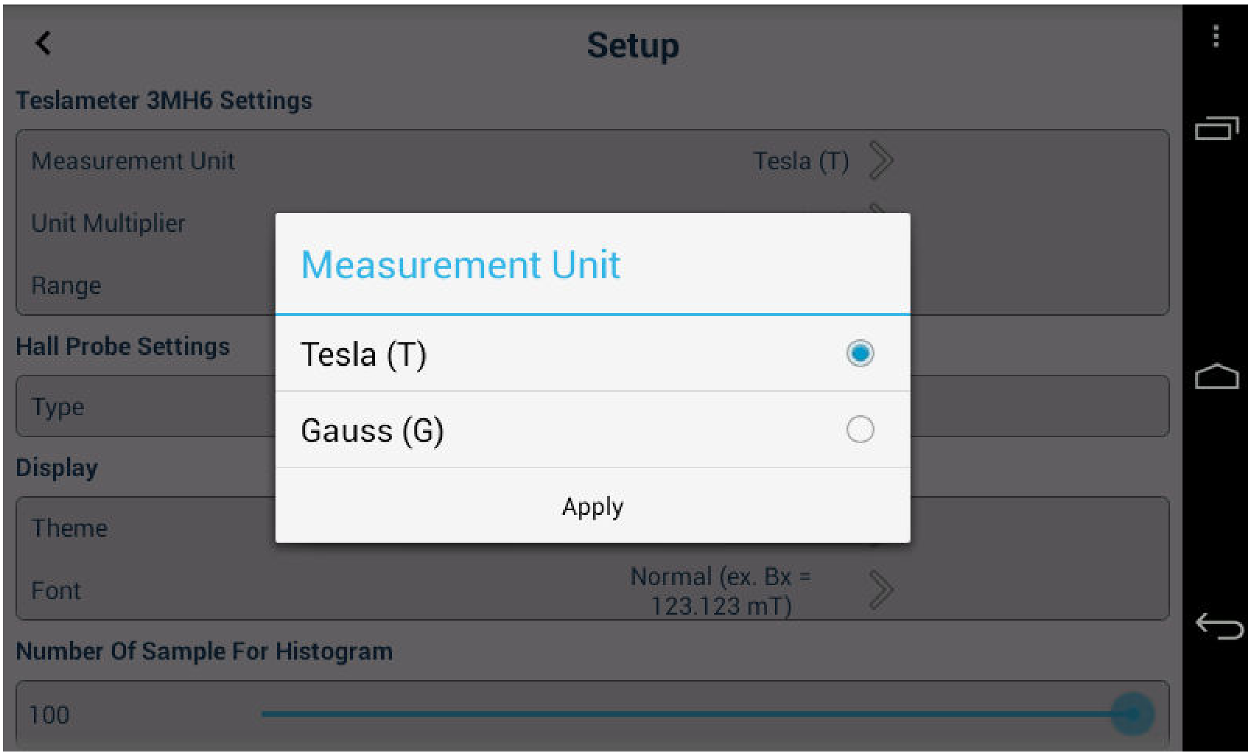


Figure 5.25 Measurement Unit menu

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.5.2.1.2 Unit Multiplier

Unit Multiplier allows selection of the selected unit submultiple.

If *tesla* is selected as a measurement unit, the following options are available (Figure 5.26):

- *Tesla (T)*
- *Millitesla (mT)*
- *Microtesla (µT)*

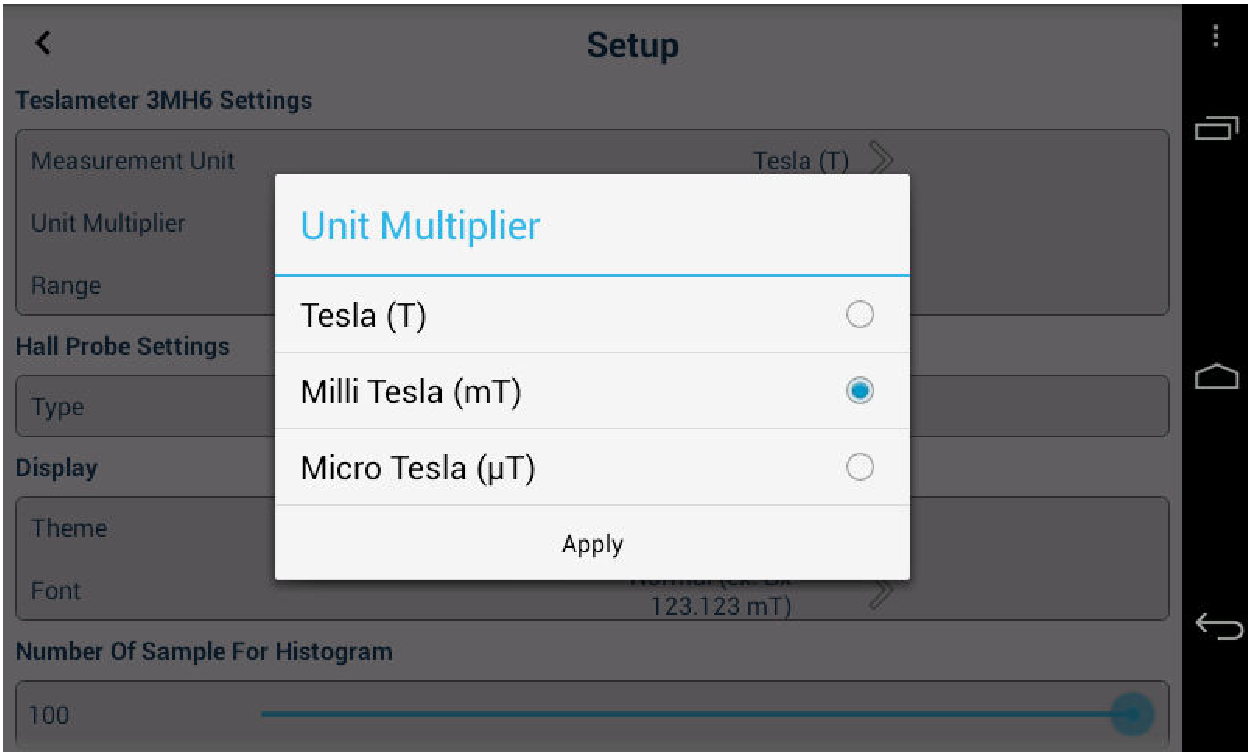


Figure 5.26 Unit Multiplier menu when measurement unit is tesla

On the other hand, if *gauss* is selected as measurement unit, the following options are available (Figure 5.27):

- *Gauss (G)*
- *Milligauss (mG)*

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

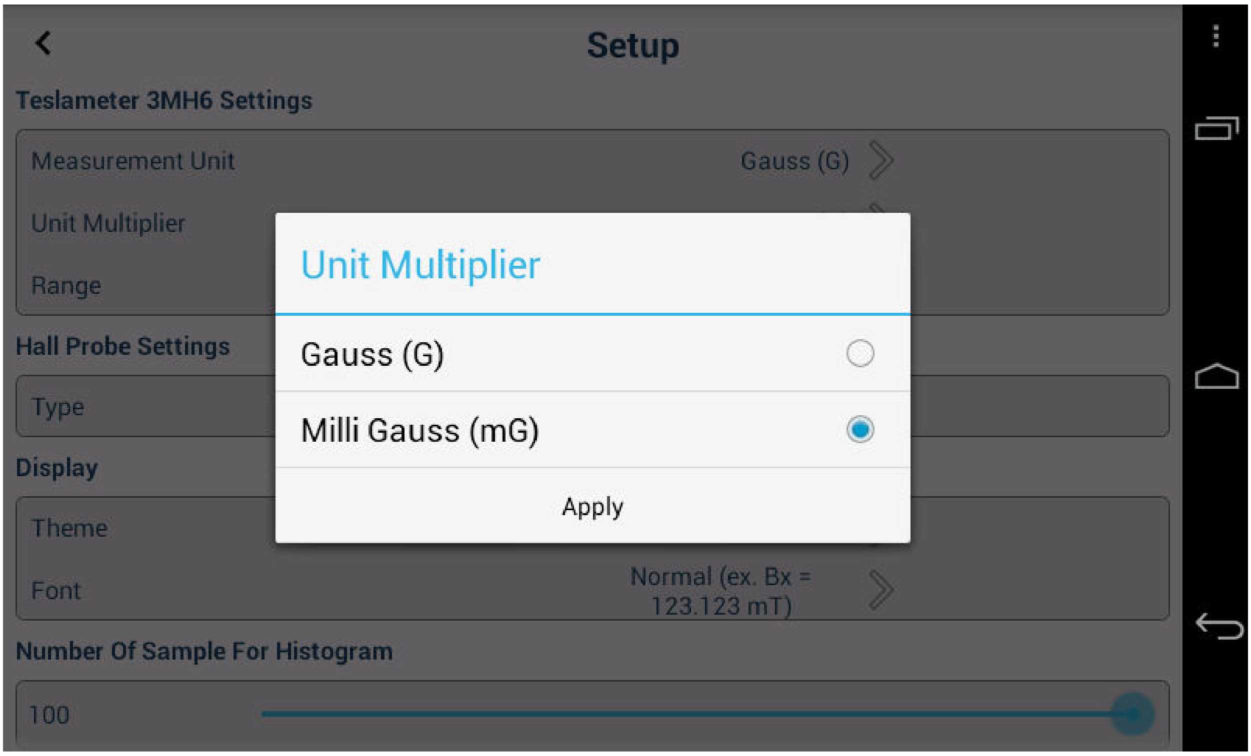


Figure 5.27 Unit Multiplier menu when measurement unit is gauss

5.5.2.1.3 Range

3MH6 teslameter allows selection of one of four available measurement ranges:

In *DC* mode these are:

- *Range 1 (-100 mT to 100 mT)*
- *Range 2 (-500 mT to 500 mT)*
- *Range 3 (-2 T to 2 T)*
- *Range 4 (-20 T to 20 T – Not Calibrated)*

Note 1: The *Range 4* is currently calibrated up to ± 2 T, but can be used in the extended range up to the ± 20 T with decreased accuracy.

***SENIS* will be able to calibrate 3MH6 teslameters up to ±10 T in the near future.**

For all the calibrated ranges (up to ± 2 T) *SENIS* guarantees that accuracy is better than 100 ppm in DC mode (**when the magnetic flux density vector is along the probe chip axis**).

The range limits for *AC* measurement mode correspond to range limits in *DC* mode. Nevertheless, the range limits in *AC* measurement mode refer to maximal **RMS** values of the magnetic flux density for that range.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

The *Range* option allows user to select one of two options (Figure 5.28):

- *Autorange*
- *Manual range.*

If *Autorange* option is selected, 3MH6 teslameter automatically selects the most adequate range based on the magnitude of the B_x, B_y and B_z components. For each of them the range is selected separately, thus, for example B_x may be in the *Range 1*, B_y may be in the *Range 3* and B_z may be in the *Range 2.*

Note 2: For correct operation of the *Autorange* feature it is necessary to have all of four ranges calibrated. Otherwise, *SENIS* cannot guarantee correct operation of *Autorange* function. In that case *SENIS* recommends using of the manual range settings for the calibrated ranges.

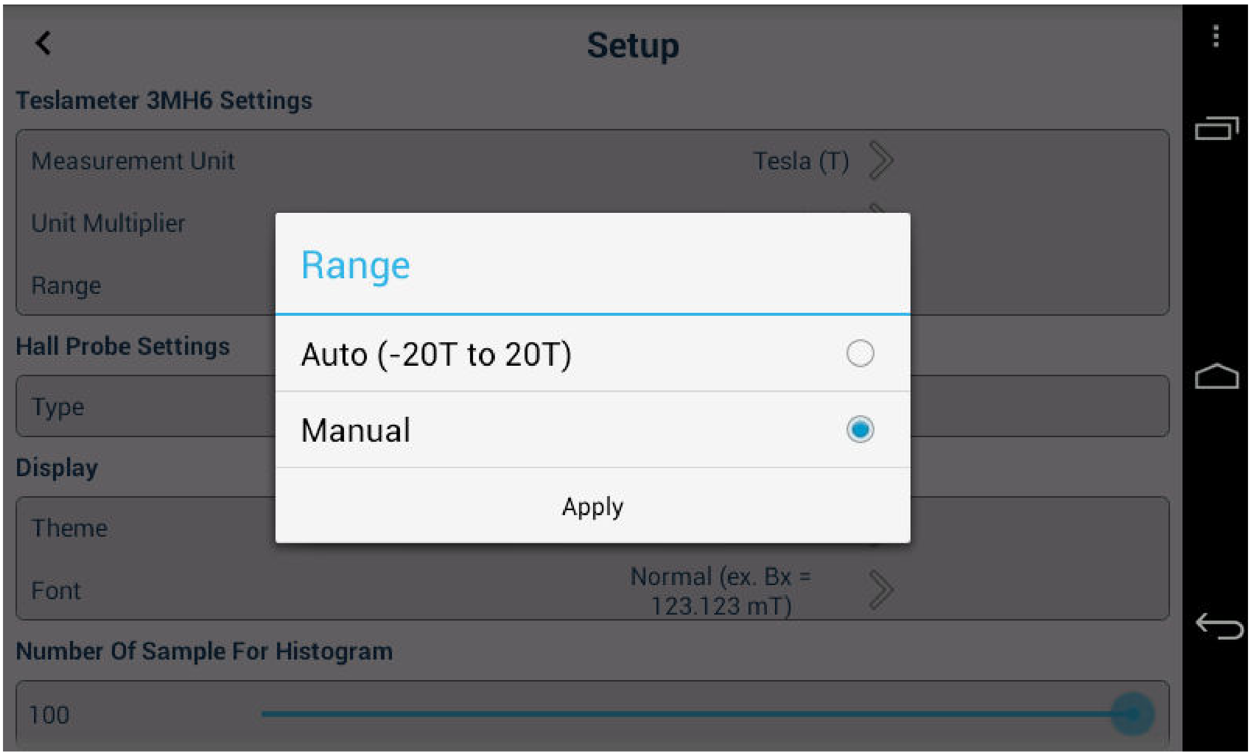


Figure 5.28 Range menu

If *Manual* range option is chosen from the *Range* menu, the *Manual Range* menu is shown. Figure 5.29 shows the *Manual Range* menu for *DC* mode when the selected *Measurement Unit* is *tesla*.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

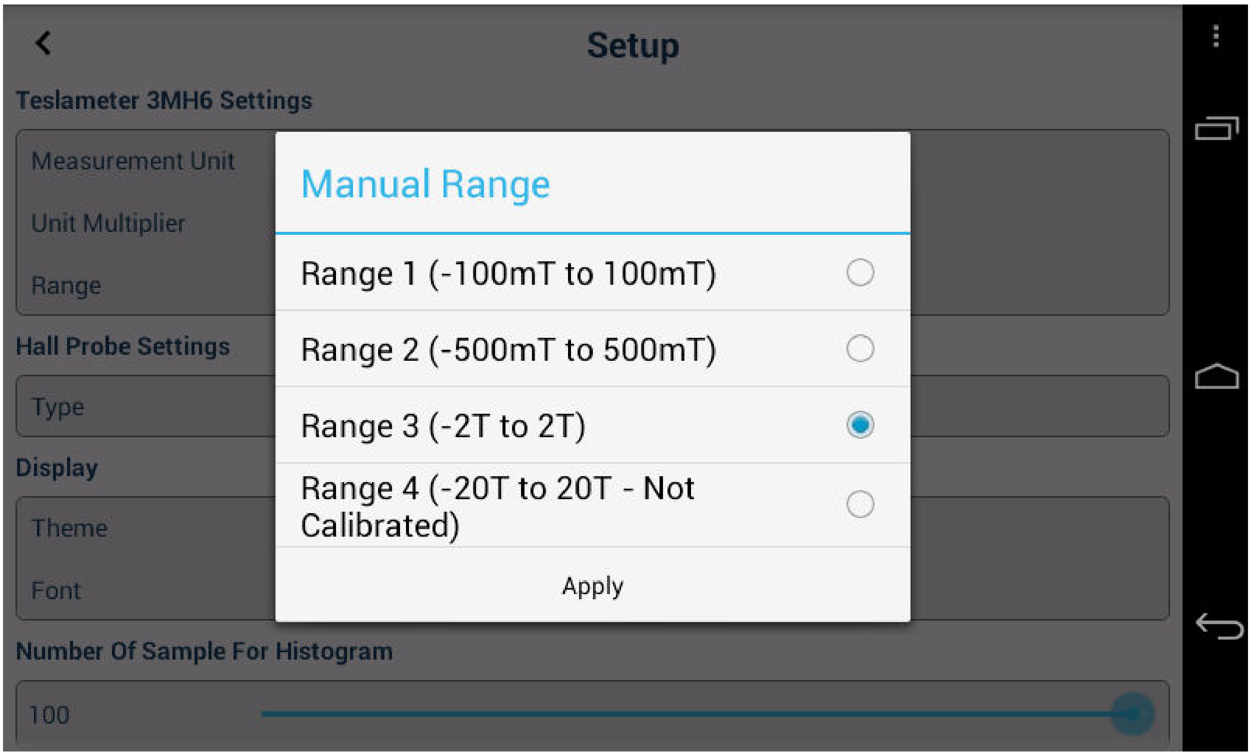


Figure 5.29 Manual Range menu in DC mode when measurement unit is tesla

Note 3: In the case of the overrange for any magnetic flux density component, the maximal value of that range will be shown on the screen, rather than the actual measured value.

For example, if the selected range is *Range 1 (-100 mT to 100 mT)*, but measured value of B_x is 125.486 mT, it will be shown as 100.000 mT on the display, because the *Range 1* limit in positive direction is 100 mT (Figure 5.30). Be aware of this when the range limit values are shown on the display.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

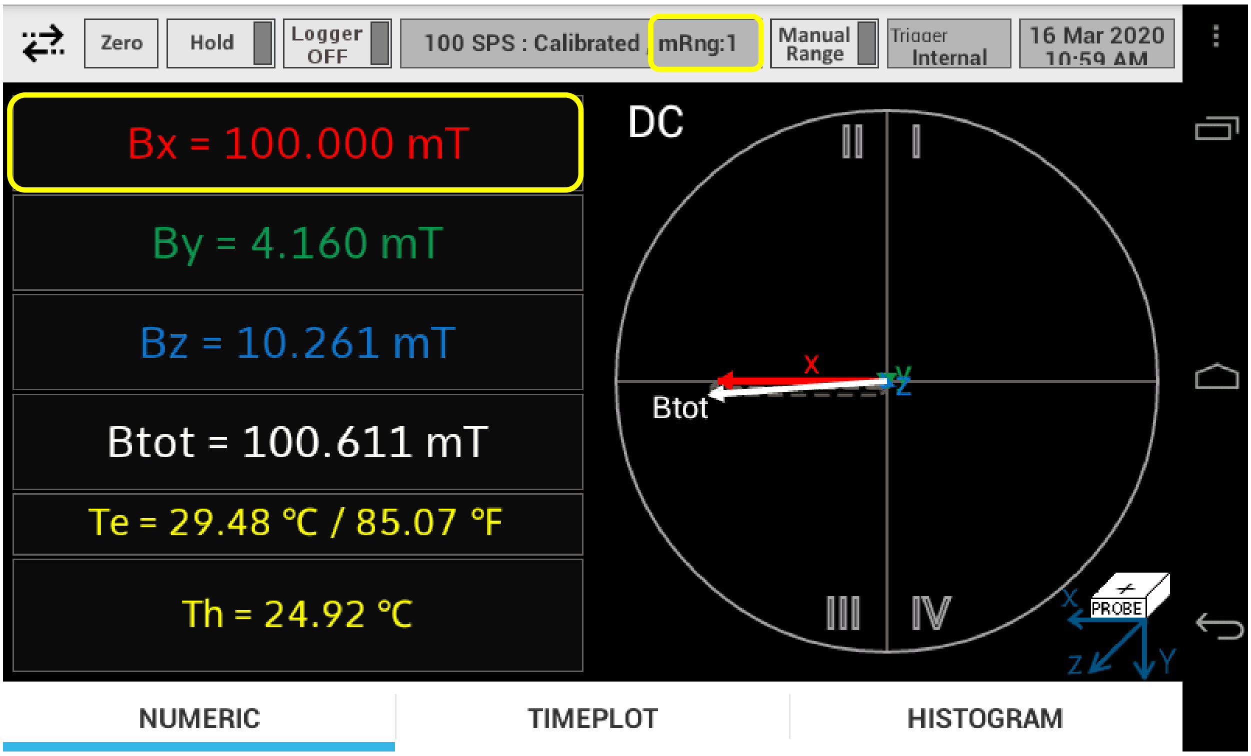


Figure 5.30 Bx overrange – the upper limit for Manual Range 1 is 100 mT

The current range setting is shown in the 3MH6 status field in the header of the *Main* screen (Figure 5.31). *Auto* range is denoted with ***aRng: x,x,x*** where each of *x* represents the *Range* number for B_x, B_y and B_z respectively. For example *aRng: 2,1,3* means that *Range 2* is set for B_x, *Range 1* is set for B_y, and *Range 3* is set for B_z. *Manual* range is denoted with ***mRng:x***, where *x* represents the *Range* number which is common for all of the components B_x, B_y and B_z (e.g. ***mRng:3*** in Figure 5.31 means that selected range is *Manual Range 3*).

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

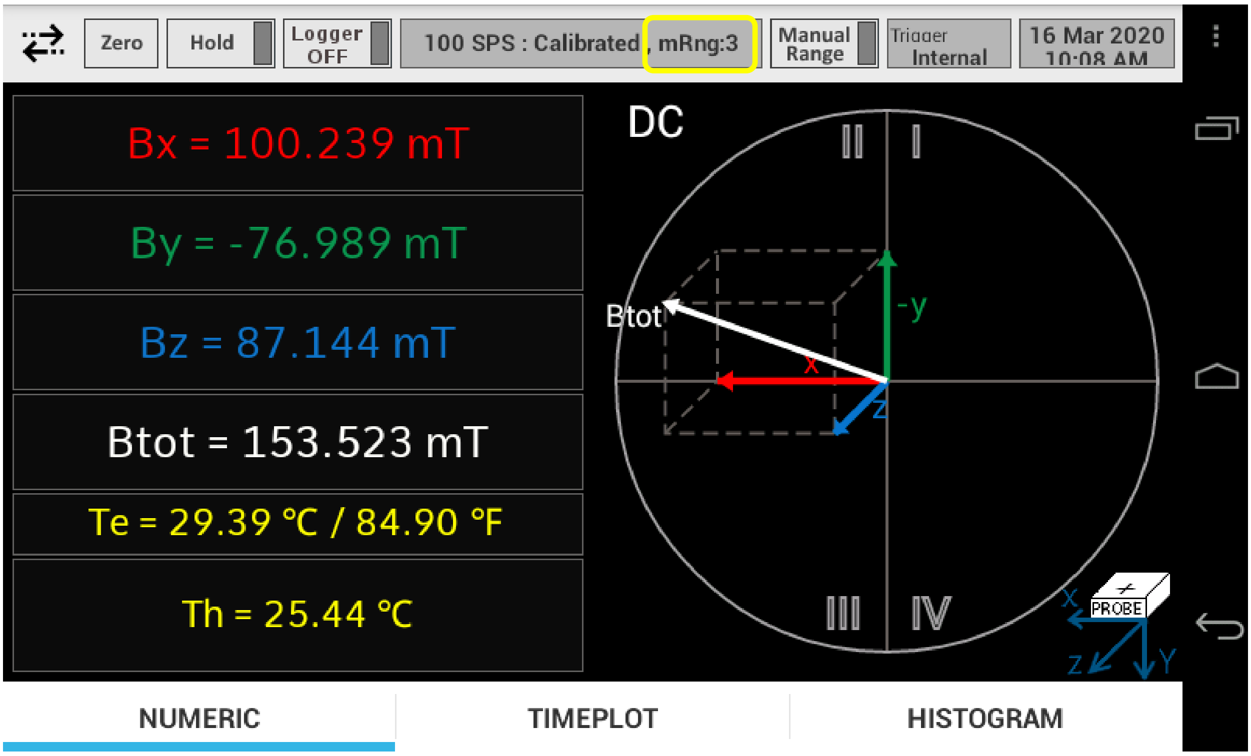


Figure 5.31 Selected range setting shown in 3MH6 status field

5.5.2.2 Hall Probe Settings

This option allows the user to select the type of the probe, i.e. whether it is one-axis, two-axis or three-axis (Figure 5.32).

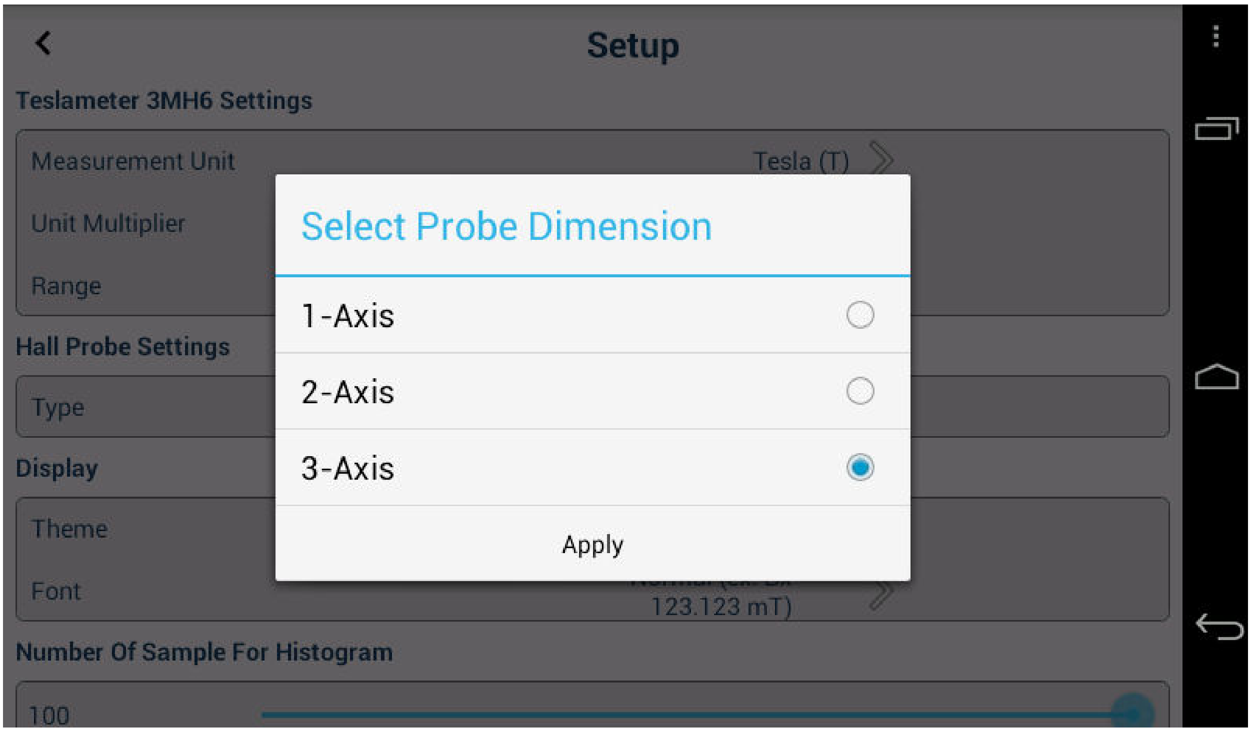


Figure 5.32 Select Probe Dimension menu

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

If the number of axes is less than three, the user can select probe subtype.

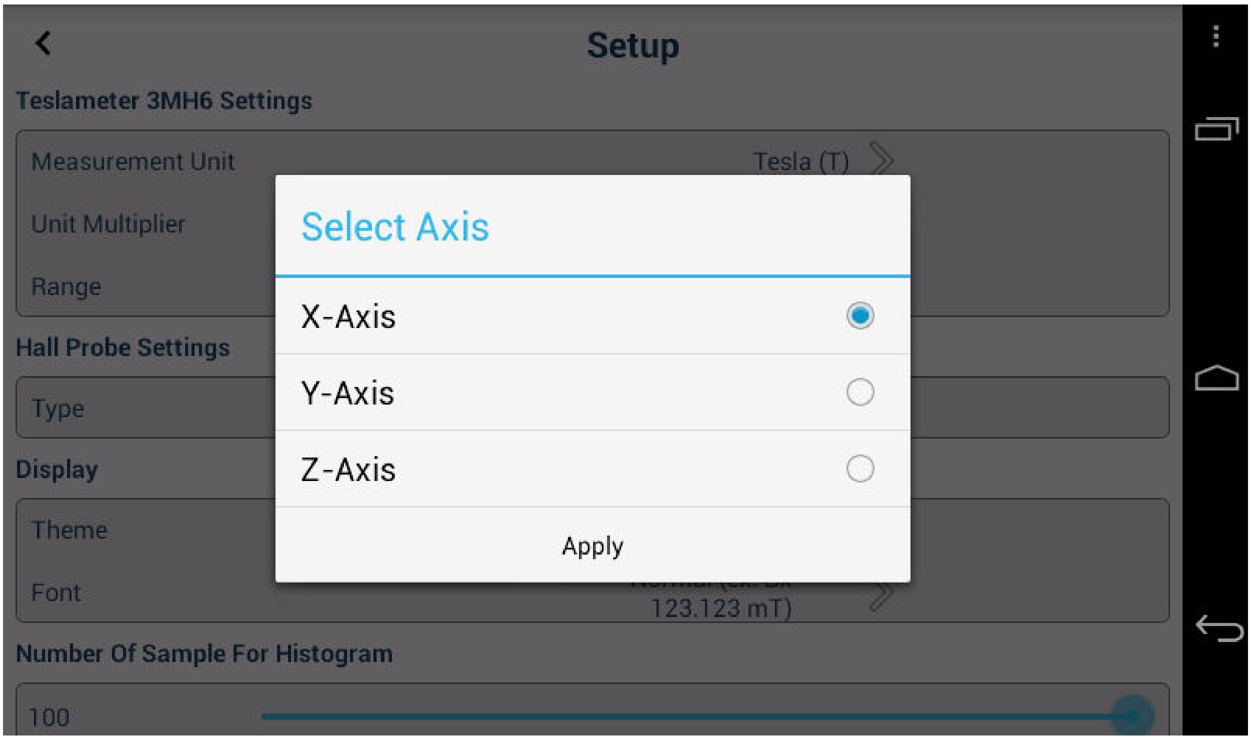


Figure 5.33 Select Axis menu for one-axis probe

For *1-Axis* probes three options are available *X-Axis*, *Y-Axis* and *Z-Axis* (Figure 5.33).

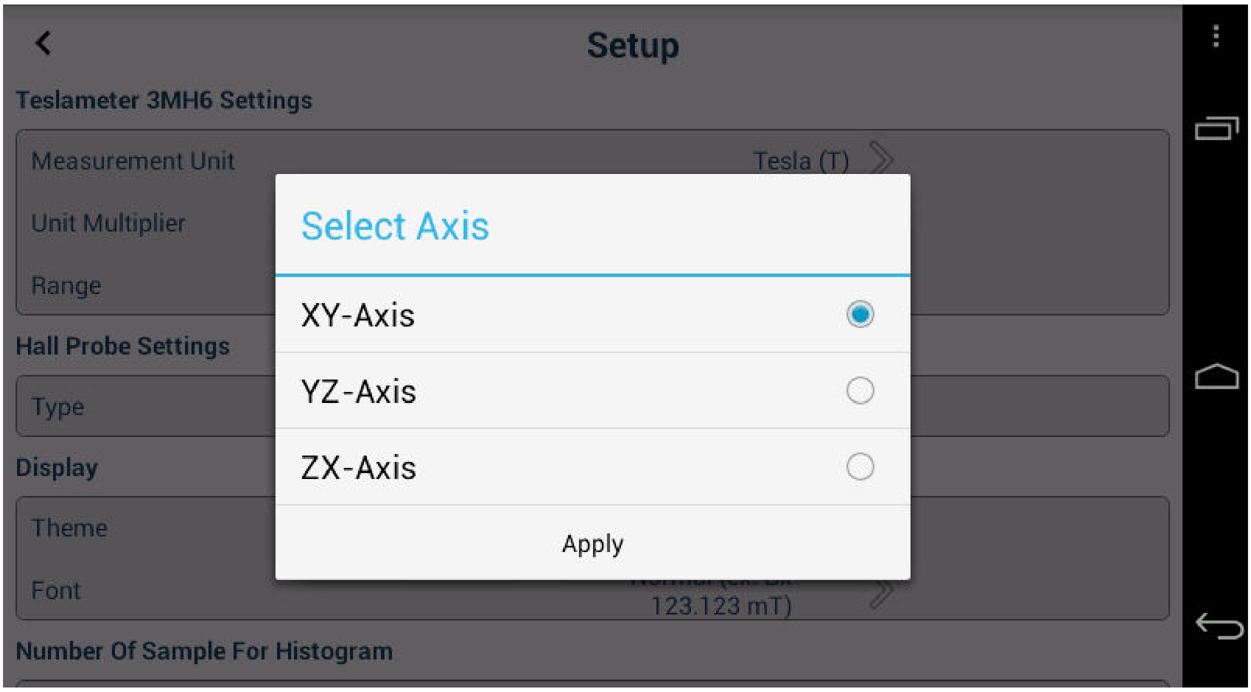


Figure 5.34 Select Axis menu for two-axis probe

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

For *2-Axis* probes there are also three options: *XY-axis*, *YZ-axis* and *ZX-axis* (Figure 5.34).

Note: If the number of selected axes is less than three, the magnetic flux density of the axis which is not used will be shown as 0 on the display. The unused axis value(s) is also not used in the calculation of the vector sum B_{tot}. Example of two-axis probe *Main* screen for *XY-axis* probe type is shown in Figure 5.35. It can be seen that unused probe axis value (which is B_z in this case), is shown as 0 on the display.

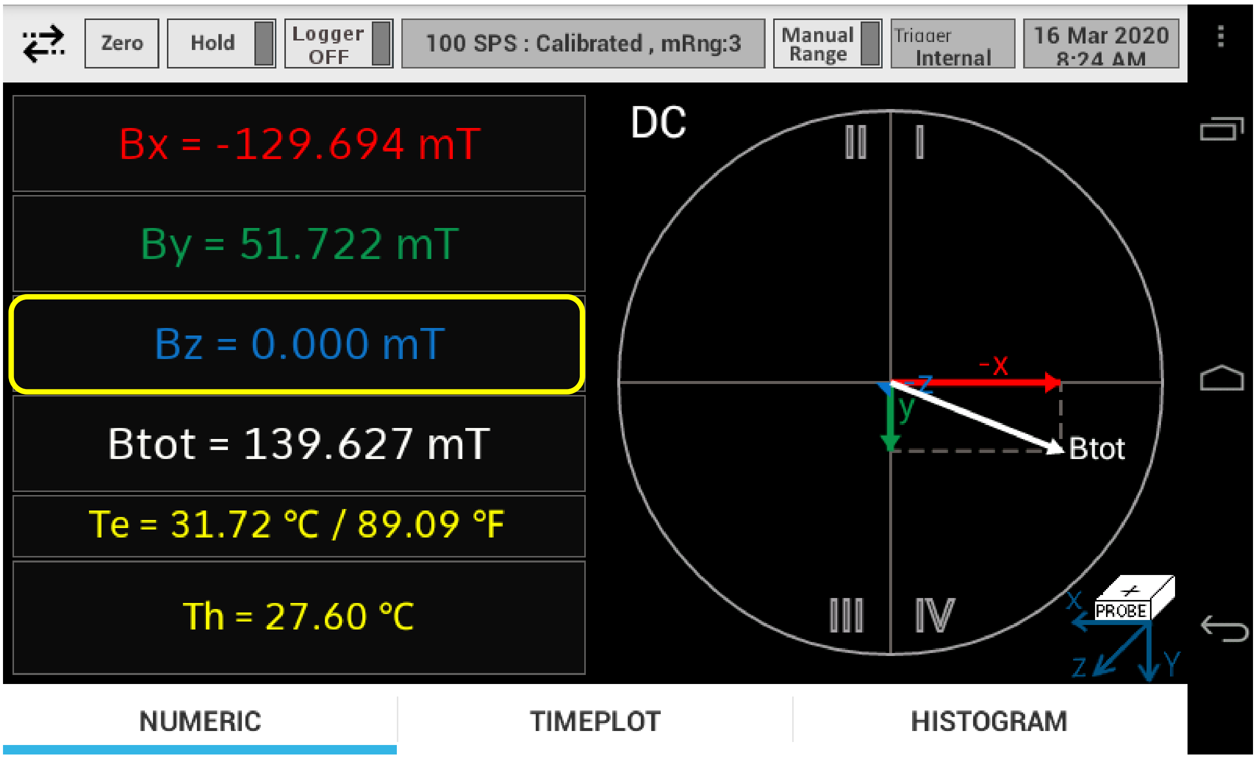


Figure 5.35 Example of 2-axis probe Main screen (XY-axis)

5.5.2.3 Display Settings

Display settings refer to settings of the *Theme* and *Font.*

5.5.2.3.1 Theme

Theme defines background and foreground colors of the user interface in the *Main* screen. There are two options (Figure 5.36):

- Dark (default)
- Light (see Figure 5.37)

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

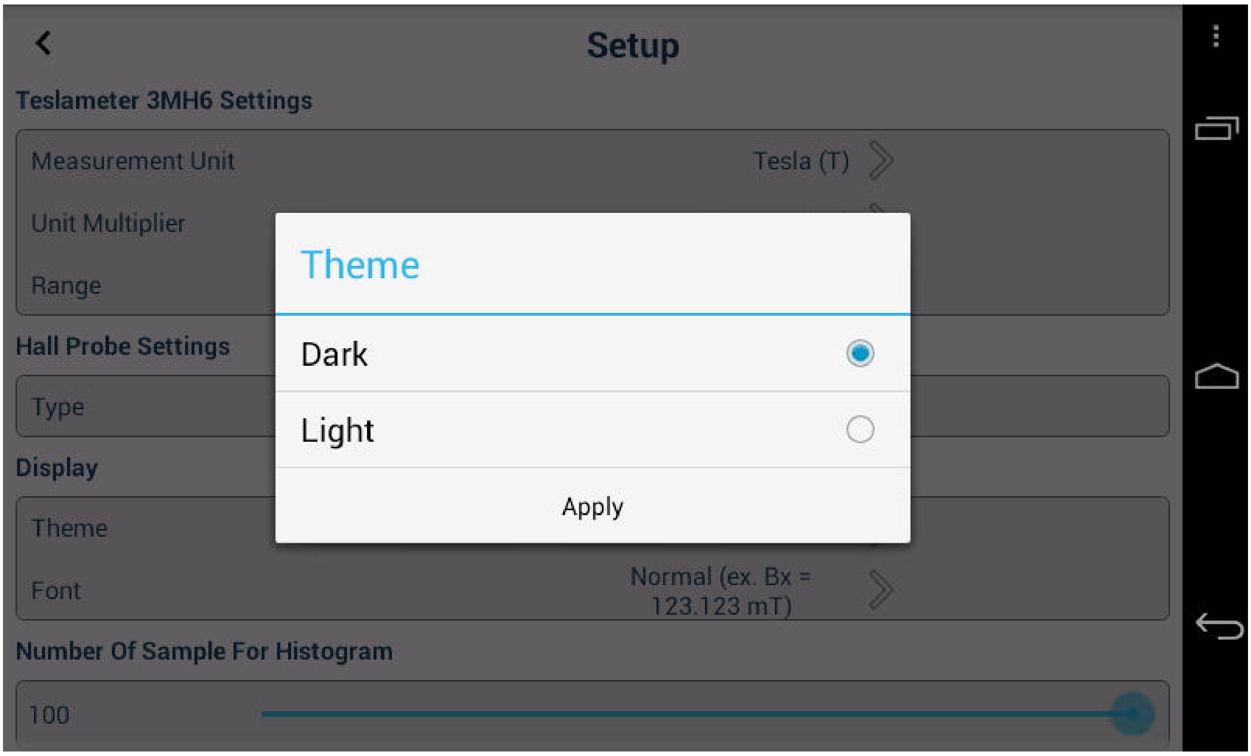


Figure 5.36 Theme menu

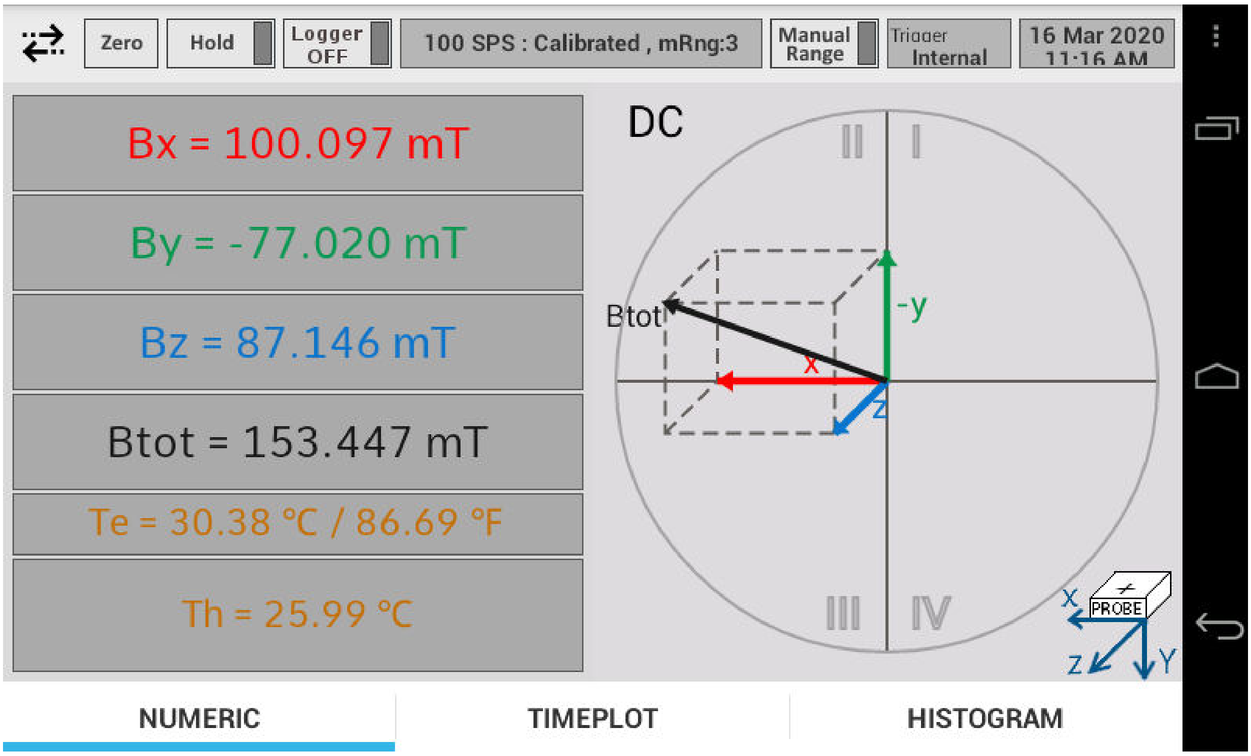


Figure 5.37 Light theme – Numeric tab

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.5.2.3.2 Font

This option allows selecting one of five available fonts as shown in Figure 5.38

Default font is *Normal*.

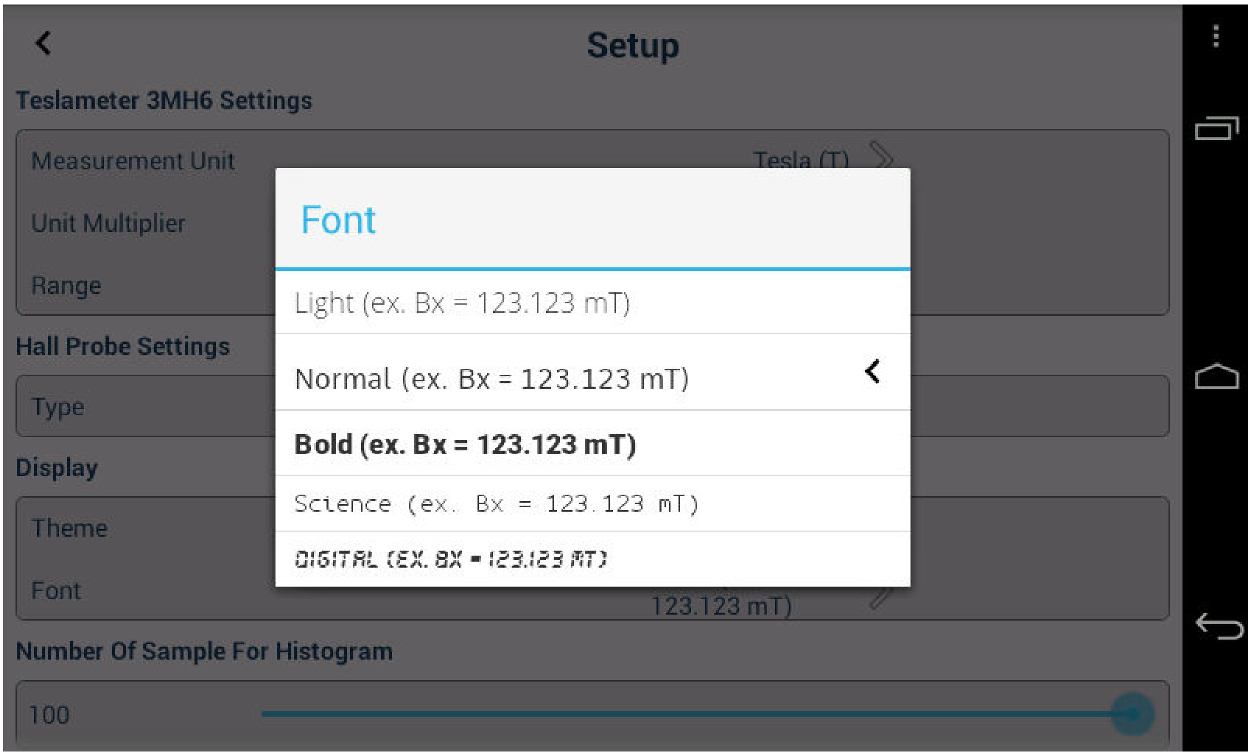


Figure 5.38 Font menu

5.5.2.4 Number of Samples for Histogram

This setting defines the number of samples that will be used for plotting the histogram chart in the *Histogram* tab. It can be set between 0 and 100. Move the slider to the desired number of samples.

Note 1: If the *Number of Samples for Histogram* is set to 0, the histogram chart will not be shown.

Note 2: The greater the number of samples, the more realistic histogram will be obtained. However, increasing the number of samples initially increases the time for calculation of the statistical parameters used for drawing the chart.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.5.2.5 Histogram

Histogram option allows the selection between two *Histogram Chart Type* options (Figure 5.39):

- *Gaussian Distribution*
- *Histogram Bar Chart*

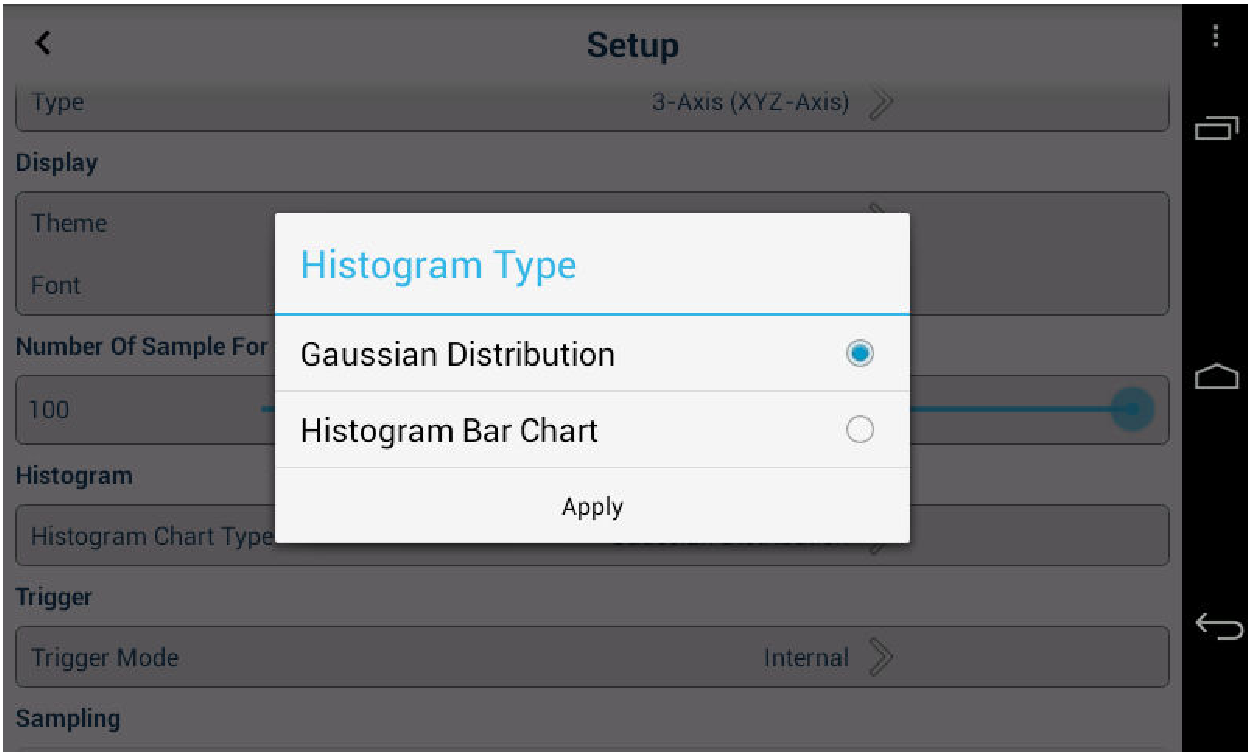


Figure 5.39 Histogram Type menu

Gaussian Distribution represents the Gaussian probability density function of the selected measured parameter.

Histogram Bar Chart represents a real histogram showing the distribution of selected measured parameter as a series of bars, where each bar represents one interval of values, while the height of the bar represents the count of samples that fall in that range.

See *5.5.2.5 Histogram* section for details about *Histogram* tab

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.5.2.6 Trigger

Triggering mechanism defines the moments of the measurement start and measurement duration.

Depending on the trigger source, all the triggering mechanisms in 3MH6 teslameter can be divided into three basic categories:

- *Internal*
- *External*
  - *Single Shot*
  - *Continuous*
- *Manual*

In other words, there are four triggering mechanisms available in 3MH6 teslameter (Figure 5.40):

- *Internal*
- *Single Shot*
- *Continuous*
- *Manual*

Note: On turning on the 3MH6 teslameter, the trigger mode is automatically set to *Internal* mode (no matter the trigger mode that had been set last time when device was in use).

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

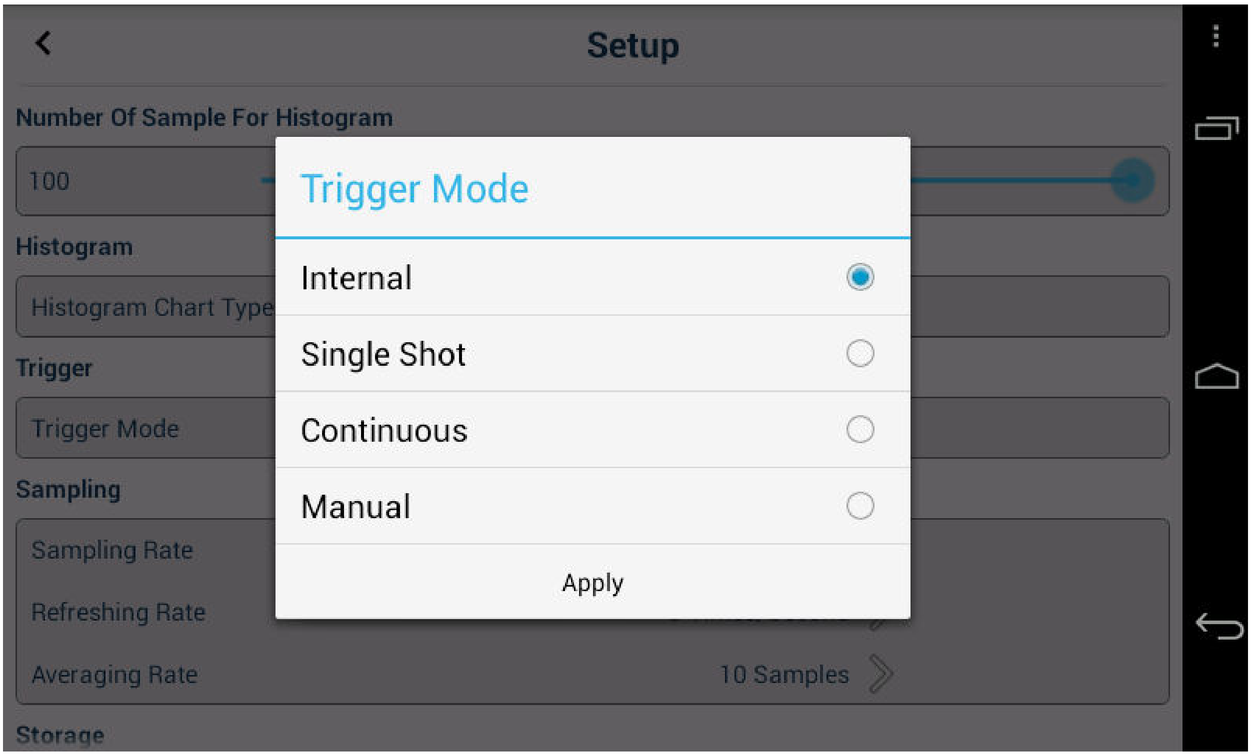


Figure 5.40 Trigger Mode menu

The selected trigger mode is shown in the *Trigger status field* in the *Main* screen (Figure 5.41)

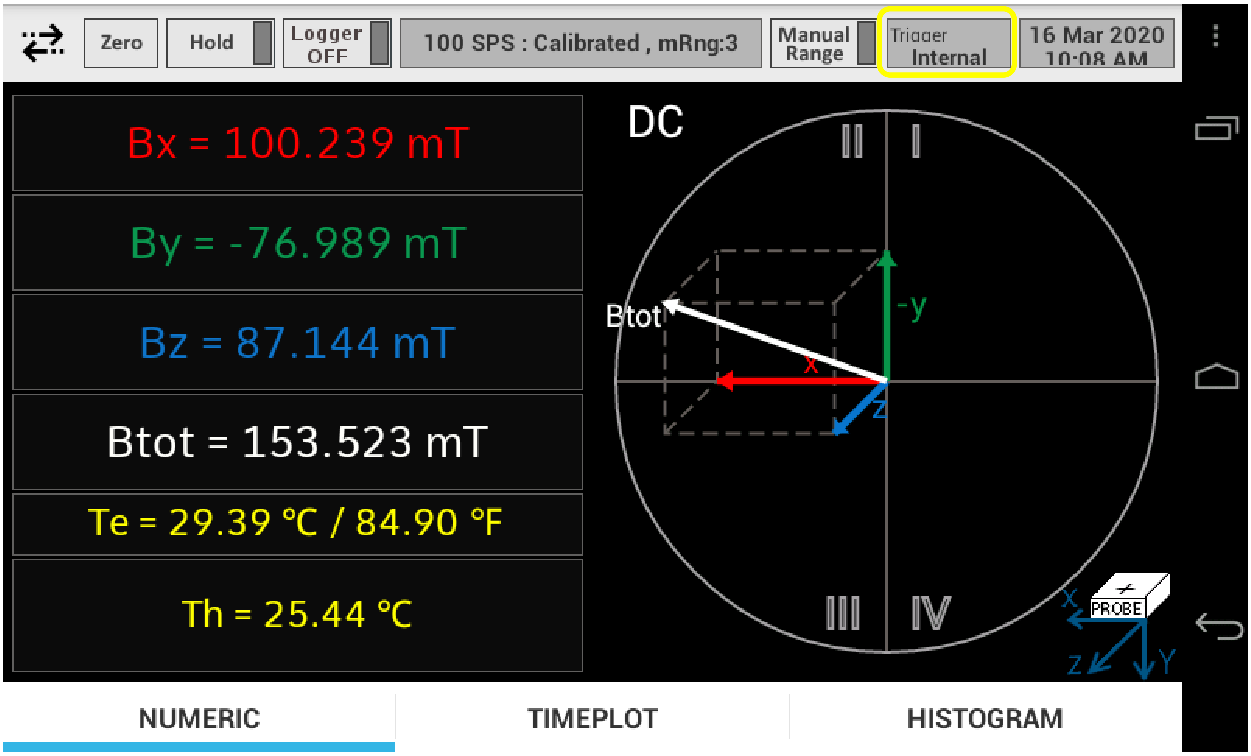


Figure 5.41 Position of the trigger status field in the Main screen

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.5.2.6.1 Internal Trigger Mode

Internal Trigger Mode is a default trigger mode. In this mode, magnetic flux densities of B_x, B_y and B_z are measured periodically according to the sampling rate selected by the user. There's no time limitation for this measurement. That means that the measurements will be performed until device is switched off or until the trigger mode is changed.

5.5.2.6.2 External Trigger Modes

External triggering system enables the measurements to be controlled by external events, i.e. the synchronization of the measurement process with the external events (event triggered measurement). The events are represented by **5V rectangular pulses** fed to the external trigger input connector located at the rear panel of the device. When teslameter detects the rising edge of the pulse, the measurement begins. An example of the external trigger pulses sequence is shown in Figure 5.42. For details on external trigger pulses logic levels see *8.1 Characteristics* section of this Manual.

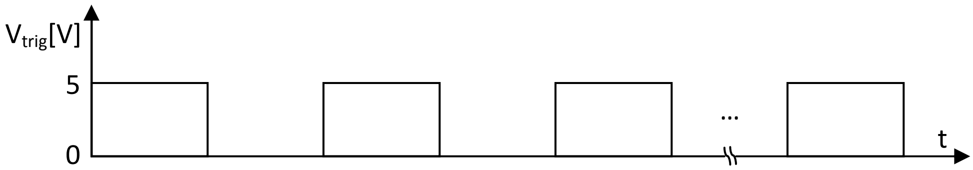


Figure 5.42 Example of external trigger sequence of pulses

There are two external triggering mechanisms available in the 3MH6:

- *Single Shot*
- *Continuous*

Note: For *Continuous* trigger mode it is necessary to have a periodic sequence of pulses (as shown in Figure 5.42), while for the *Single Shot* trigger mode the pulses may be aperiodic.

5.5.2.6.2.1 Single Shot Trigger Mode

As its name suggests, on detecting the rising edge of the trigger pulse in the *Single Shot* trigger mode, the 3MH6 teslameter performs only certain number of measurements and stops, waiting on the next trigger pulse. The number of measurements taken is defined by the *Measurement time interval* (chosen from the corresponding pop-up menu that appears after selecting the *Single Shot* mode, see Figure 5.43) and the sampling rate selected by the corresponding control in the *Setup* menu.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

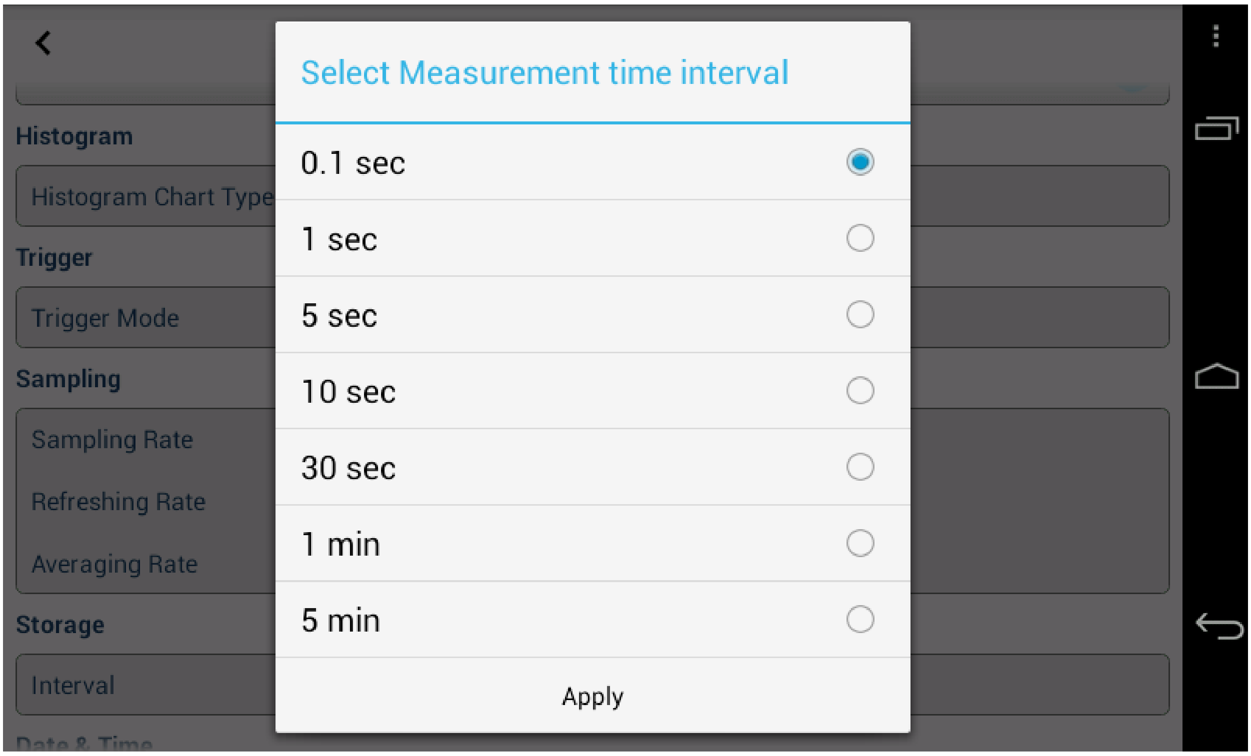


Figure 5.43 Select Measurement Time Interval menu

In other words, the measurements with the chosen sampling rate are performed only until the selected *Measurement time interval* elapsed.

Note 1: If the next trigger pulse arises throughout the selected measurement time interval, 3MH6 teslameter will ignore this trigger pulse.

While waiting the trigger pulse, the display is halted and 3MH6 doesn't perform any measurement. Nevertheless, during this period the instrument is responsive to all USB commands as well as to any setting done through device menus.

If the trigger pulse doesn't arise within a 5 seconds interval since the starting of the *Single Shot* mode or since the last measurement is performed, the STATUS LED on the device front panel turns to red. This only indicates that there has been no trigger pulse for more than 5 seconds since the last measurement and hence there are no data to show on display. Nevertheless, the 3MH6 teslameter continues to wait without time limitation.

Note 2: In order to achieve more accurate measurements in ***AC*** mode with *Single Shot* trigger mode, the selected *Measurement time interval* should be at least 50 times longer than the period of AC field. Failing to comply with this recommendation may lead to severe measurement errors.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.5.2.6.2.2 Continuous Trigger Mode

Continuous trigger mode is another type of the external trigger mechanism. It requires a continuous sequence of rectangular pulses to work. Once the 3MH6 detects first rising edge of the 5V sequence of pulses, it automatically adjusts sampling rate according to the measured frequency of the trigger pulses (Table 5.2) and starts the measurements.

Trigger Frequency [Hz]	Sampling Rate [SPS]
10 - 24	30
21 - 40	50
35 - 50	60
45 - 79	100
70 - 130	500
120 - 550	1000
500 - 1200	3750
1100 - 2300	7500
2100 - 7499	7500

Table 5.2 - Sampling rate automatically set by 3MH6 teslameter in Continuous trigger mode according to the trigger frequency

Note 1: The measurement data are read from the A/D convertors on each rising edge of the trigger pulse.

Note 2: The automatically set sampling rate is always greater than trigger pulses frequency (see Table 5.2), thus providing the new measurement data to be read on each rising edge of the trigger pulse.

Accordingly, the effective number of samples in the *Continuous* trigger mode is determined by the trigger frequency rather than by the sampling rate (which is the case with the other trigger modes). Theoretically, the effective number of samples should be equal to the frequency of the trigger pulses. For example, if the trigger frequency is 100 Hz, the sampling rate of the A/D converter will be set to 500 SPS (see Table 5.2). However, as the data is read on each rising edge of the trigger pulse from the A/D converter, there should be 100 measurement data readings per second, so that effective sampling rate is 100 SPS. In practice, due to trigger frequency measurement errors, the number of readings may be couple of samples less than the trigger frequency.

Note 3: the fact that the effective sampling rate in *Continuous* trigger mode is determined by the trigger frequency should be taken into account when choosing the trigger frequency for measurement of the variable magnetic fields, especially in *AC* measurement mode. According to the Nyquist-Shannon sampling theorem, for AC magnetic fields **the sampling rate must be greater than double maximal frequency in its spectrum (i.e. $f_s \geq 2*f_{max}$, where f_s is the sampling rate and f_{max} is the maximal frequency in the spectrum). As the effective sampling rate is determined by the trigger frequency in the *Continuous* trigger mode, the triggering frequency must be greater than double maximal frequency in its spectrum (i.e. $f_{trigger} \geq 2*f_{max}$). Failing to comply with this rule may lead to severe measurement errors. For better accuracy, it is recommended to set $f_{trigger} \geq 10*f_{max}$.**

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

Note 4: The user cannot change the sampling rate in *Continuous* trigger mode.

Note 5: The trigger frequency limits given in Table 5.2 are for the reference only. In practice, there may be a certain deviation from these limits due to errors in trigger frequency measurements.

The error of the trigger frequency measurement is up to ±1%.

Note 6: The trigger frequency must be greater than or equal to 10 Hz, but less than 7.5 kHz (i.e. 10 Hz ≤ trigger frequency < 7.5 kHz).

Note 7: There is a hysteresis in setting the sampling rate, so that trigger frequency limits are not the same when the trigger frequency is increased and decreased (see Table 5.2). For example, if the currently set trigger frequency is 30 SPS, to increase the sampling rate to 50 SPS it is needed to increase the trigger frequency above 24 Hz. Nevertheless, to return to 30 SPS it is not enough to decrease the trigger frequency below 24 Hz, but it is needed to decrease it below 21 Hz.

Unlike the *Single Shot* trigger mode where the measurement duration is limited by the user's setting of the *Measurement Time Interval*, in the *Continuous* trigger mode the measurements are performed as long as the trigger pulses are detected at the external trigger input.

If the trigger pulse doesn't arise for more than 5 seconds since the starting of the *Continuous* mode or since the last detected trigger pulse, the STATUS LED on the device front panel turns to red, indicating there are no trigger pulses and hence there are no data to show on the display, but 3MH6 teslameter continues to wait.

If the trigger pulse does not arise within 30 seconds since the starting of the *Continuous* mode or since the last detected trigger pulse, a dialog appears allowing the user to choose whether the 3MH6 teslameter should continue waiting on the external trigger pulse, or the 3MH6 should turn to *Internal* trigger mode (Figure 5.44).

If you select *Wait* option, device will go on waiting for the trigger pulse for unlimited time. Once the new trigger pulse is detected, the measurements start again and the STATUS LED on the device front panel turns to green again.

In summary, the trigger pulses in the *Continuous* mode not only determine the start of the measurements, but also they determine the measurement duration and sampling rate.

5.5.2.6.2.2.1 *Timeplot* Chart Recommendations in *Continuous* Trigger Mode

In order to obtain smooth *Timeplot* chart diagram for varaible magnetic fields, *SENIS* recommends sampling at least at 10 points per magnetic field period. This means that trigger frequency should be at least 10 times greater than freqeuency of the measured magnetic field.

Note 1: The minimal trigger frequency in the *Continuous* mode to obtain the correct *Timeplot* chart is 100 Hz. This trigger frequency provides 10 points per *Timeplot* chart (which represents the magnetic flux density waveform over 100-ms interval). To obtain smoother waveforms, use higher trigger frequencies that will provide more measurement points in the *Timeplot* chart.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

Note 2: The maximal magnetic field frequency should not be greater than 750 Hz to obtain the smooth waveform. This frequency requires the effective sampling rate of 7.5 kSPS, i.e. **the maximal supported trigger frequency of 7.5 kHz**.

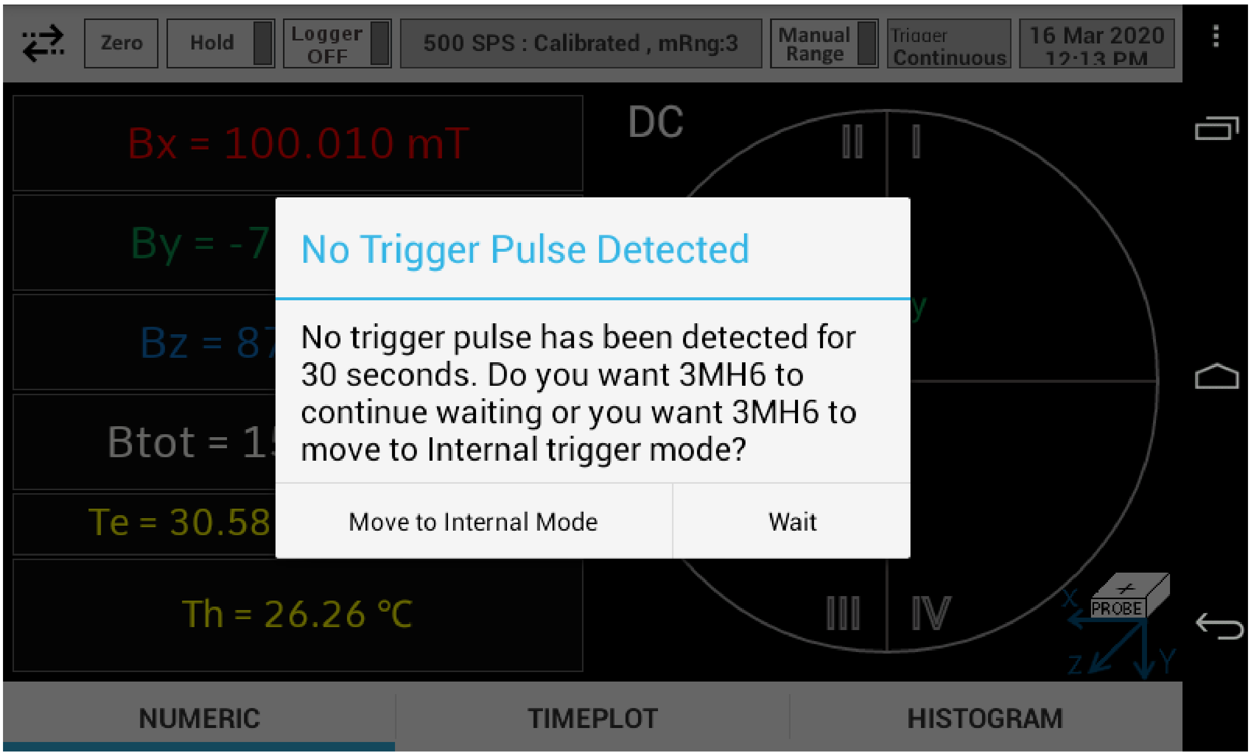


Figure 5.44 Trigger pulse not detected for more than 30 seconds dialog

5.5.2.6.2.2.2 *Continuous* Trigger Mode and AC *Less than or equal to 10 Hz* Mode

Note: In **AC** *Less than or equal to 10 Hz* **mode** the sampling rate is 100 SPS and it is fixed. As the *Continuous* mode implies the automatic sampling rate setting according to the trigger frequency, it cannot be applied to this frequency range. For this reason:

a) If 3MH6 teslameter is at AC *Less than or equal to 10 Hz* mode, the *Continuous* trigger mode cannot be run.

   If you try to run *Continuous* trigger mode in this frequency range, 3MH6 teslameter will warn you that this is not possible as shown in Figure 5.45.

b) If 3MH6 teslameter is already in the *Continuous* trigger mode, it is not possible to move 3MH6 into the AC *Less than or equal to 10 Hz* mode.
   If you want to use this mode, you will have to turn the trigger mode to any other mode before switching to AC *Less than or equal to 10 Hz* mode.
   Otherwise, the 3MH6 will warn you that moving to AC *Less than or equal to 10 Hz* mode is not possible as shown in Figure 5.46.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

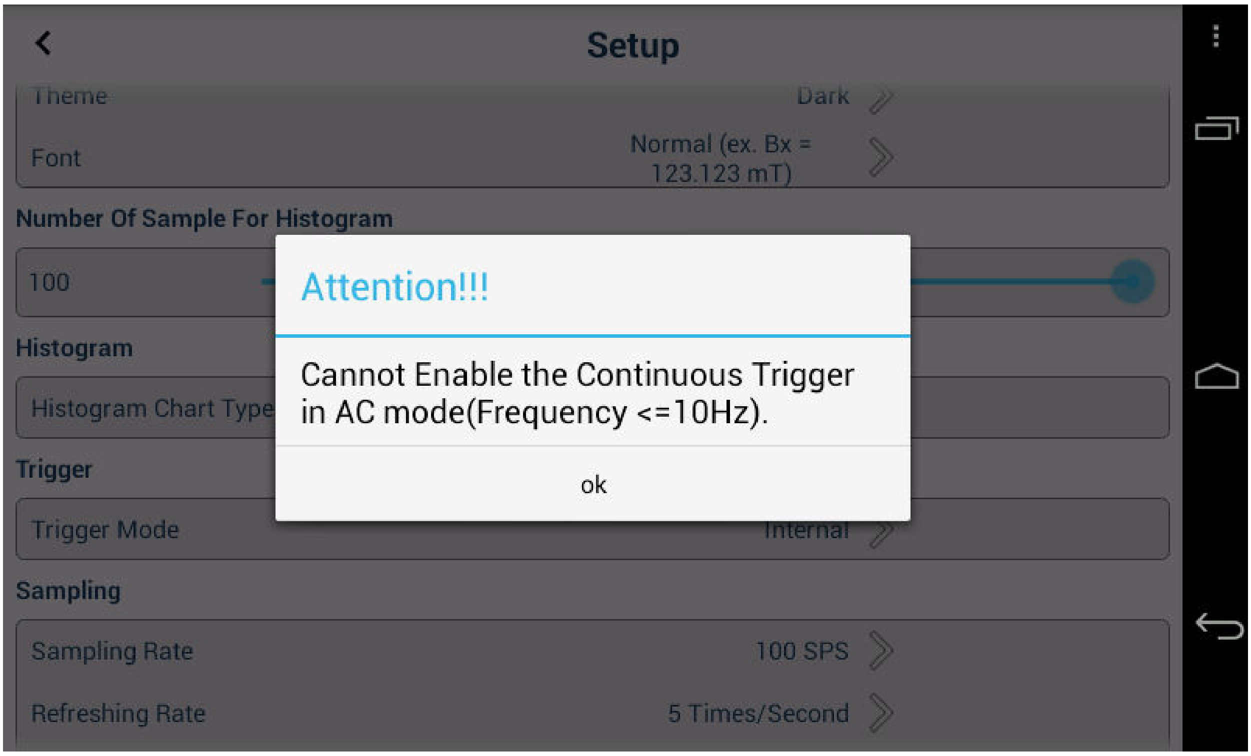


Figure 5.45 Warning message appearing when the user tries to run Continuous trigger mode in AC Less than or equal to 10 Hz frequency range

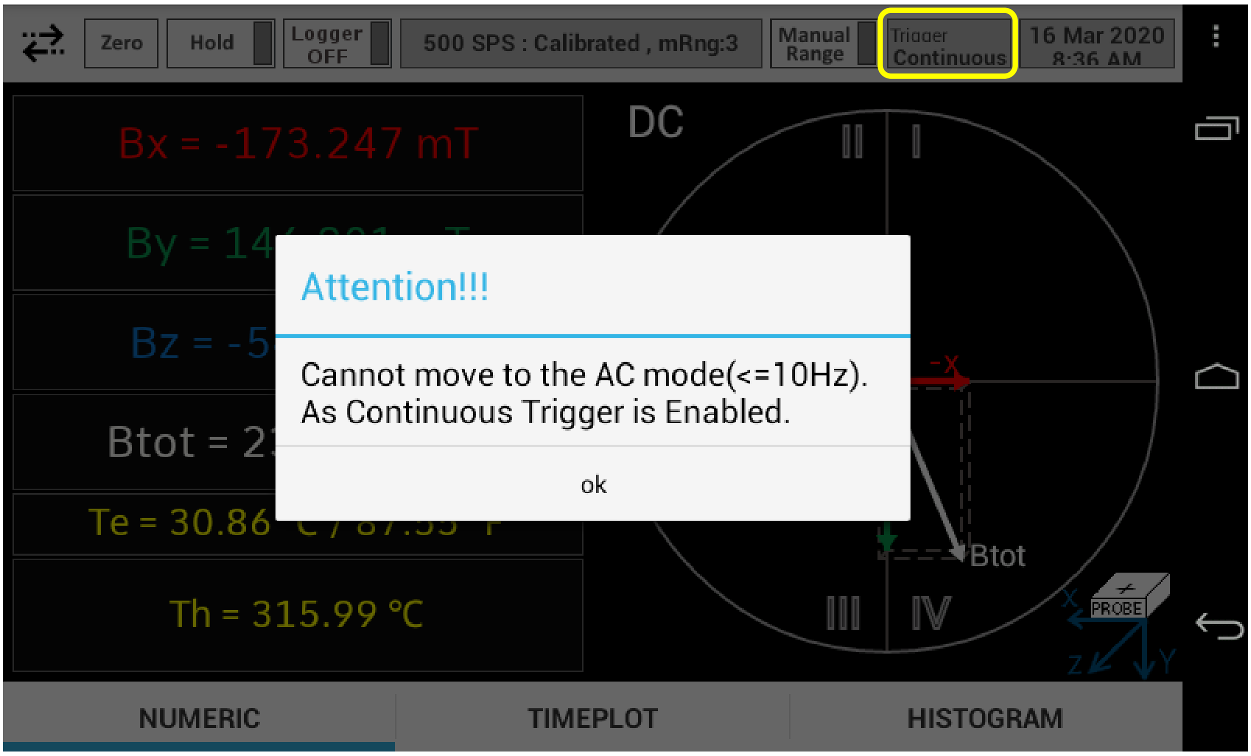


Figure 5.46 Warning message appearing when the user tries to move to

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

AC Less than or equal to 10 Hz frequency range when the Continuous trigger mode is active

5.5.2.6.3 Manual Trigger Mode

Manual triggering mechanism allows the user to initiate the measurements by touching the ***T****rigger* button on the display (***T*** button). It works in similar way as the *Single Shot* mode. Nevertheless, the events that trigger the measurements are not the pulses at the external triggering input, but the *T* button touches on the screen.

Once the *Manual* trigger mode is selected, the *Select Measurement Time Interval* menu appears with the same options as for the *Single Shot* trigger mode. *Measurement Time Interval* determines how long 3MH6 will perform the measurements after detecting the touch on the corresponding *Trigger* button. The measurements are done with the sampling rate selected by the user (by the corresponding control in the *Setup* menu).

Figure 5.48 shows the *Numeric* tab, while the Figure 5.49 shows the *Timeplot* tab of the *Main* screen when the *Manual* trigger mode is selected.

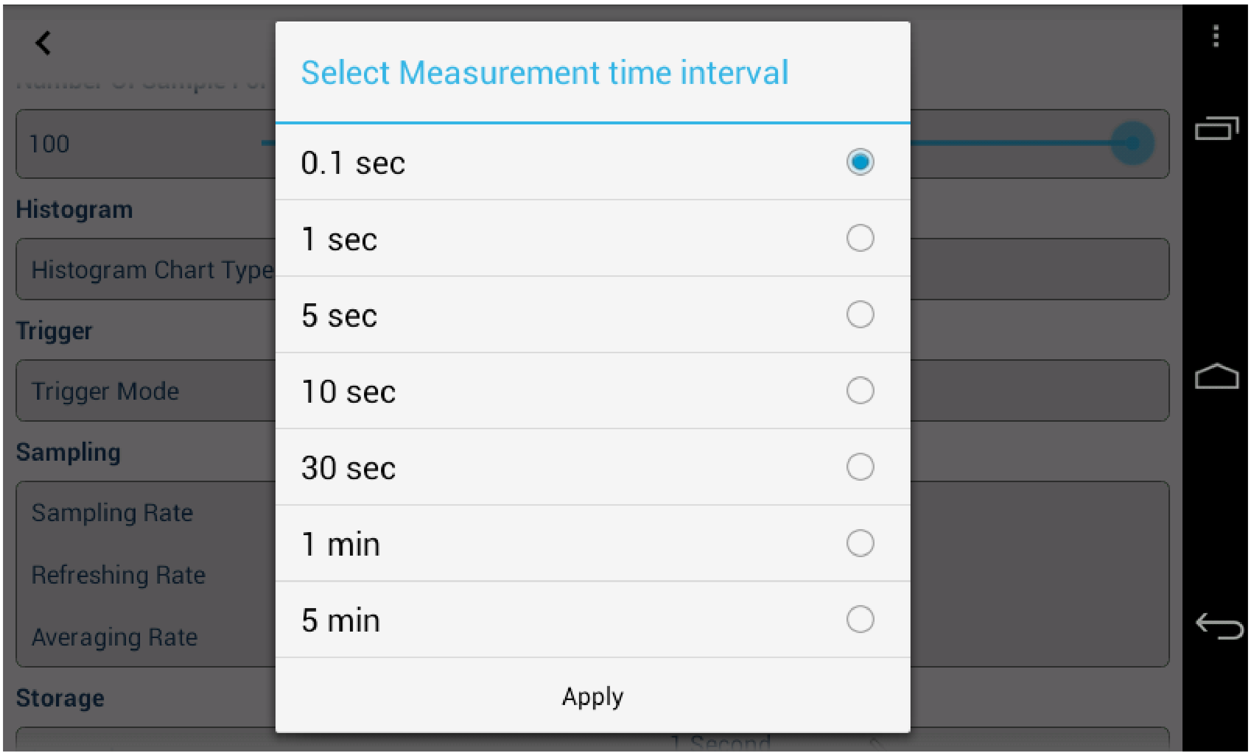


Figure 5.47 Select Measurement Time Interval menu

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

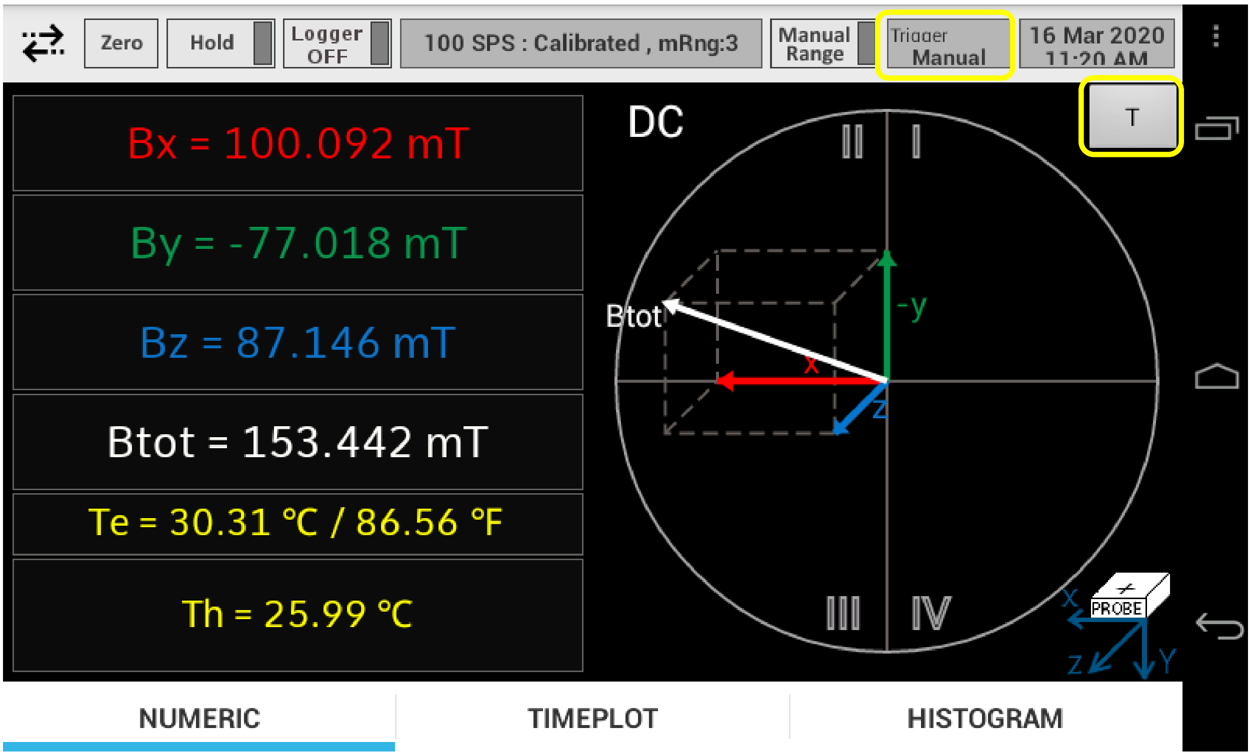


Figure 5.48 Numeric Tab view with T button shown when the trigger mode is set to Manual

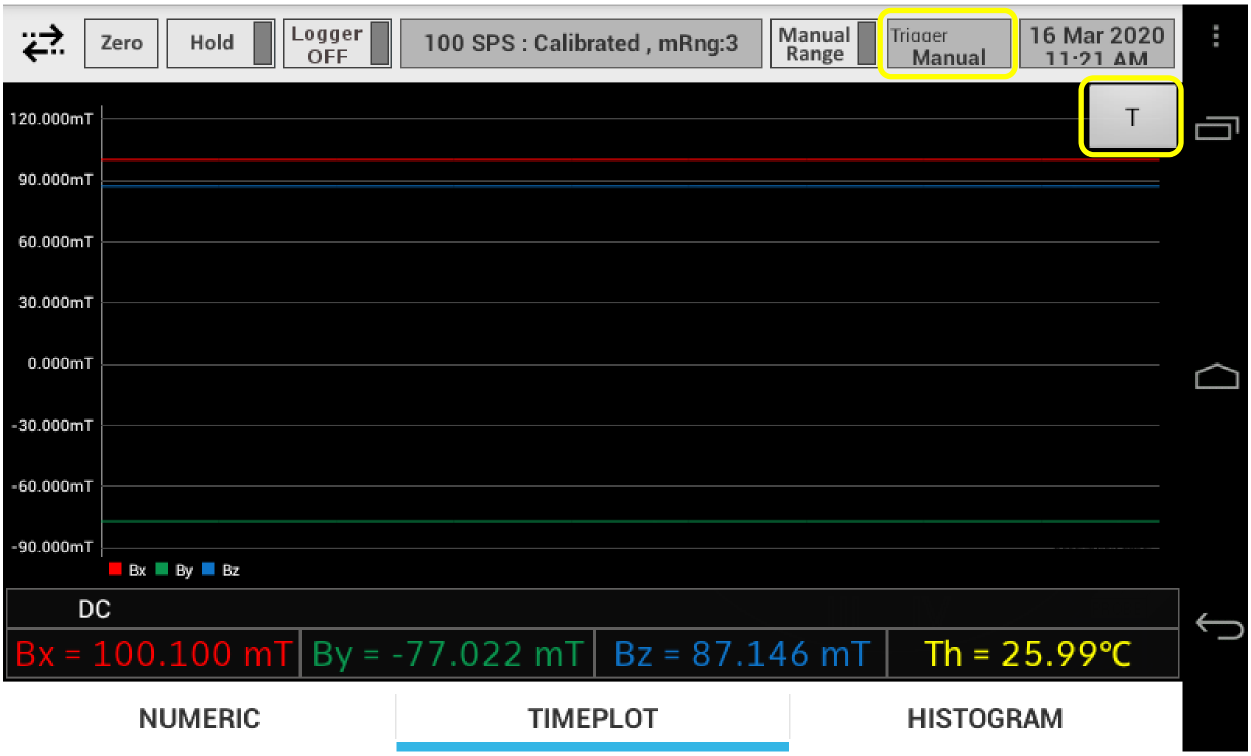


Figure 5.49 Timeplot tab with T button shown when the trigger mode is set to Manual

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

3MH6 teslameter waits until the *T* button is touched. When the *T* button touch is detected, the measurement begins and it lasts until *Measurement Time Interval* elapses. During this period the *T* button is disabled. After elapsing of the *Measurement Time Interval*, the *T* button is enabled again, and the user may initiate the new measurements by touching *T* button again.

While waiting the *T* button touch, the display is halted and 3MH6 doesn't perform any measurement. Nevertheless, during this period the instrument is responsive to all USB commands as well as to any setting done through device menus.

If the *T* button has not been touched within a 5 seconds interval since the starting of the *Manual* mode or since the last measurement is performed, the STATUS LED on the device front panel turns to red. This only indicates that there has been no *T* button touch for more than 5 seconds since last measurement and hence there are no data to show on display, but 3MH6 teslameter continues to wait without time limitation.

Note: In order to achieve more accurate measurements in ***AC*** mode with *Manual* trigger mode, the selected *Measurement time interval* should be at least 50 times longer than the period of AC field. Failing to comply with this recommendation may lead to severe measurement errors.

5.5.2.7 Sampling

Sampling block of the *Setup* screen allows settings of rates at which the measurement data are acquired, shown and processed. Accordingly, the settings of following parameters can be done here:

- *Sampling Rate*
- *Refreshing Rate*
- *Averaging Rate.*

5.5.2.7.1 Sampling Rate

Sampling rate determines the frequency at which the A/D convertors in 3MH6 teslameter sample the magnetic flux density signals. Available sampling rates are: 10 SPS, 30 SPS, 50 SPS, 60 SPS, 100 SPS, 500 SPS, 1 kSPS, 2 kSPS, 3.75 kSPS, 7.5 kSPS and 15 kSPS (Figure 5.50 and Figure 5.51).

Default sampling rate is 10 SPS.

Note 1: The sampling rate setting **does not** affect Hall probe temperature (*Th*) and electronics temperature (*Te*) measurements which are sampled with the constant predefined sampling rates.

The sampling rate should be chosen based on the measured magnetic field parameters and desired measurement accuracy.

Note 2: According to the Nyquist-Shannon sampling theorem, for AC magnetic fields **the sampling rate must be greater than double maximal frequency in its spectrum (i.e. $f_s \geq 2*f_{max}$, where f_s is the sampling rate and f_{max} is the maximal frequency in the spectrum).** **Failing to comply with this rule may lead to severe measurement errors.** **For better accuracy of RMS measurements, it is recommended to set $f_s \geq 10*f_{max}$.**

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

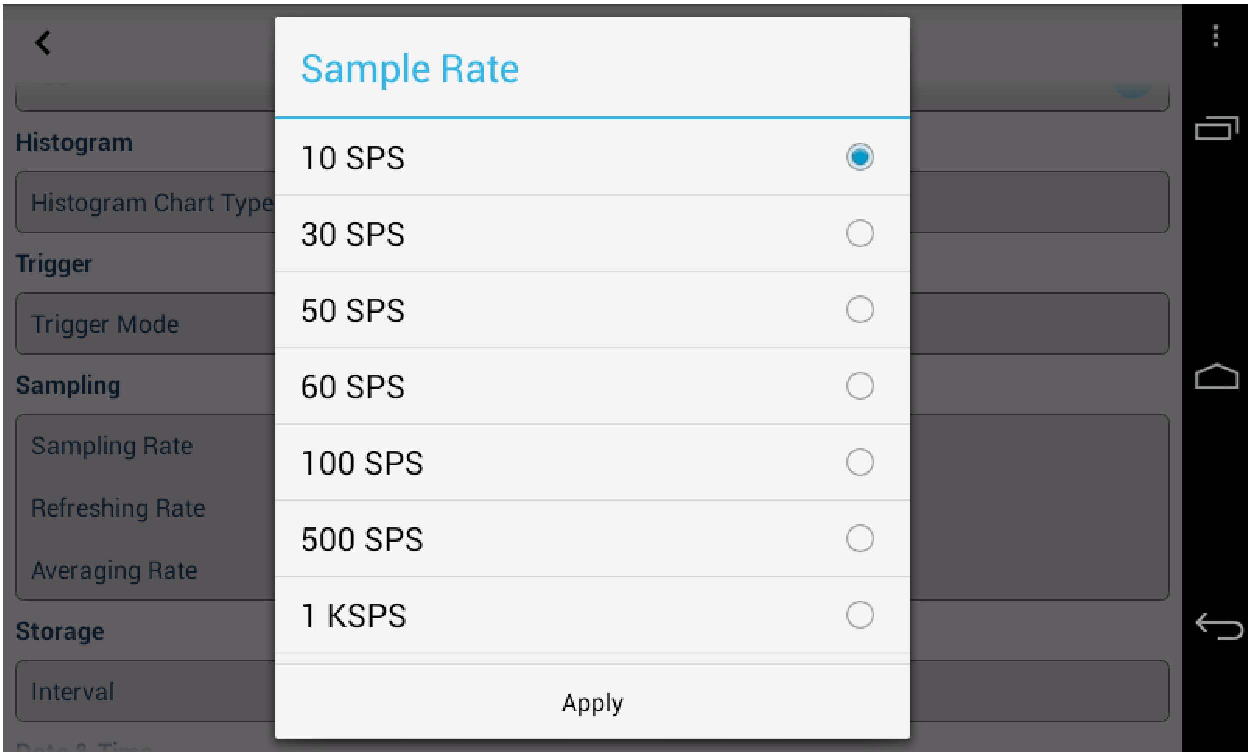


Figure 5.50 Sample Rate menu – part I

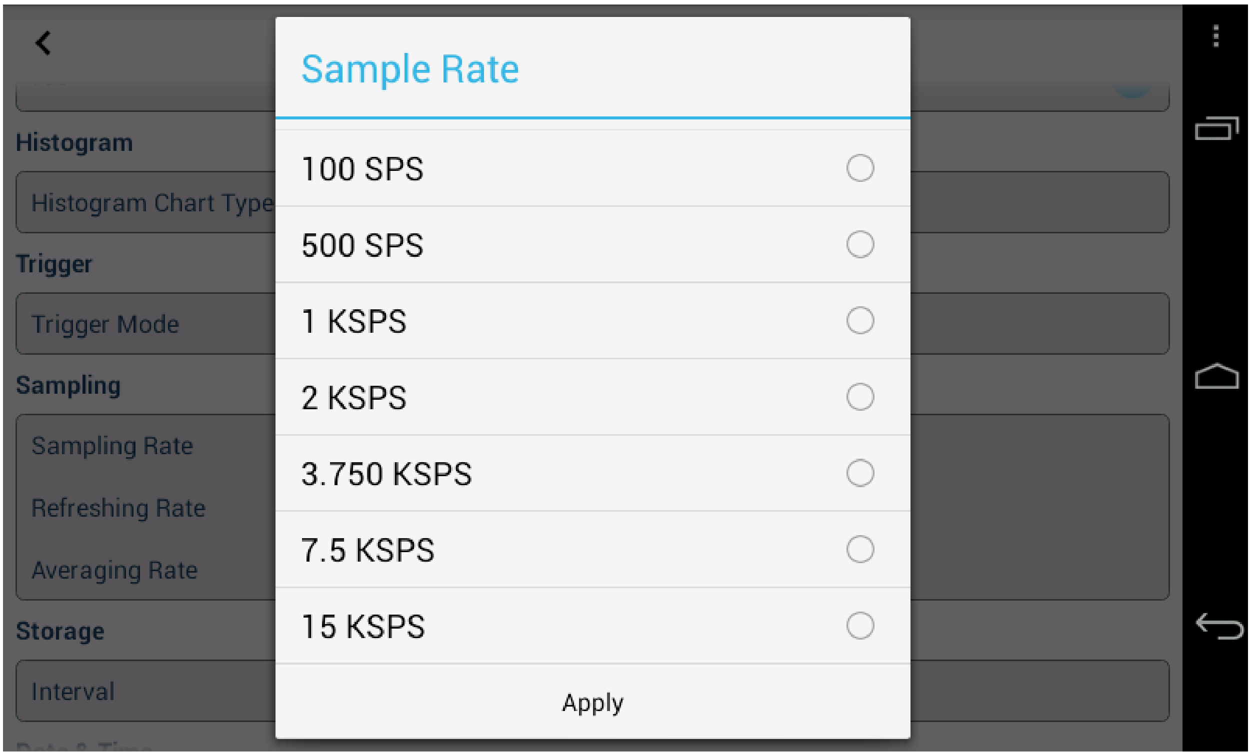


Figure 5.51 Sample rate menu – part II

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

In addition, the higher the sampling rate, the more data about measured magnetic field, therefore the smoother the waveforms in the *Timeplot* tab.

Nevertheless, the bandwidth of the 3MH6 teslameter also depends on the selected sampling rate. The higher the sampling rate, the greater the bandwidth, but therefore greater the noise which in turn decreases the precision of the measurement (see *Table 5.1* and the corresponding note in *5.5.1.2 AC Mode* section of this Manual).

In addition, the higher the sampling rate, the slower the response of the device due to the large amount of data that microcontroller in 3MH6 needs to process.

Due to all of these reasons mentioned above, *SENIS* doesn't recommend the usage of the sampling rate above 3.75 kSPS in ***AC*** mode.

Note 3: The sampling rate cannot be changed in *Continuous* trigger mode, where it is determined automatically based on the frequency of the trigger pulses. Trying to change the sampling rate in the *Continuous* trigger mode will result in the message shown in Figure 5.52.

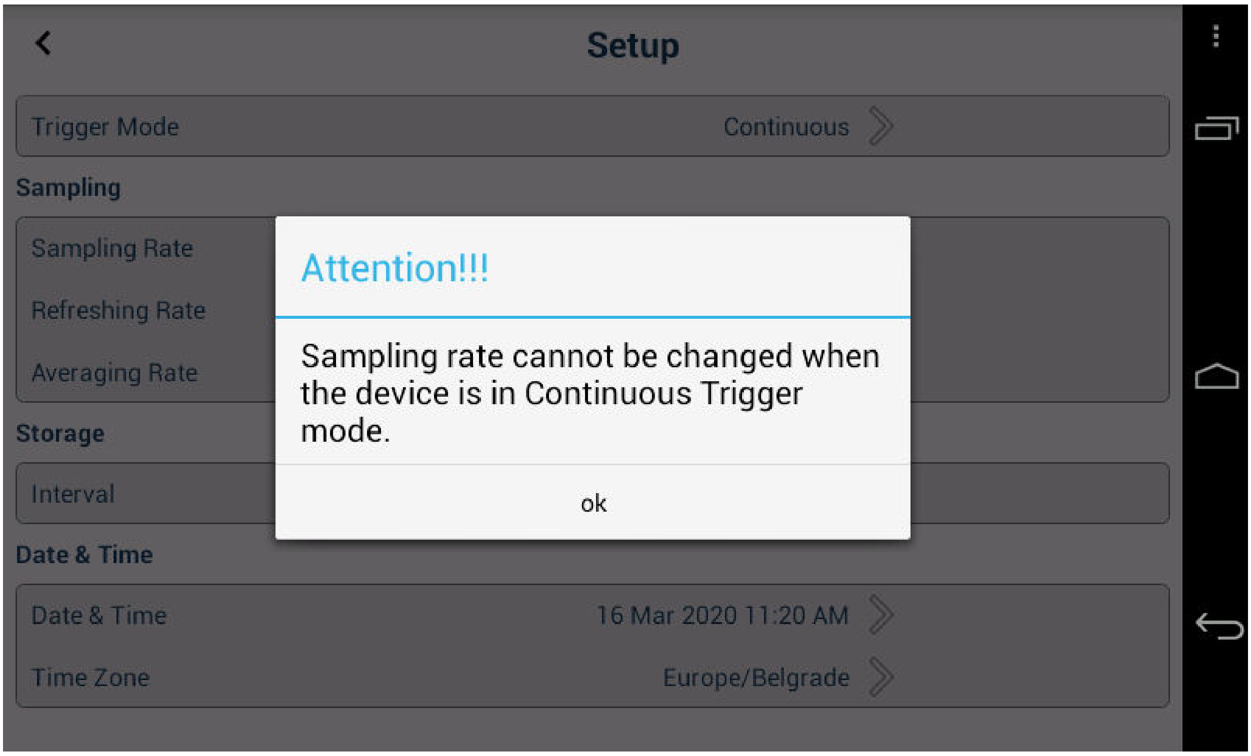


Figure 5.52 Warning message appearing when trying to change the sampling rate in Continuous trigger mode

Note 4: The sampling rate in the Less than or equal to 10 Hz AC frequency range is fixed to 100 SPS and it cannot be changed. Trying to change the sampling rate will result in the message shown in Figure 5.53.

The current sampling rate is shown in the *3MH6 status field* of the *Main* screen (Figure 5.54).

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

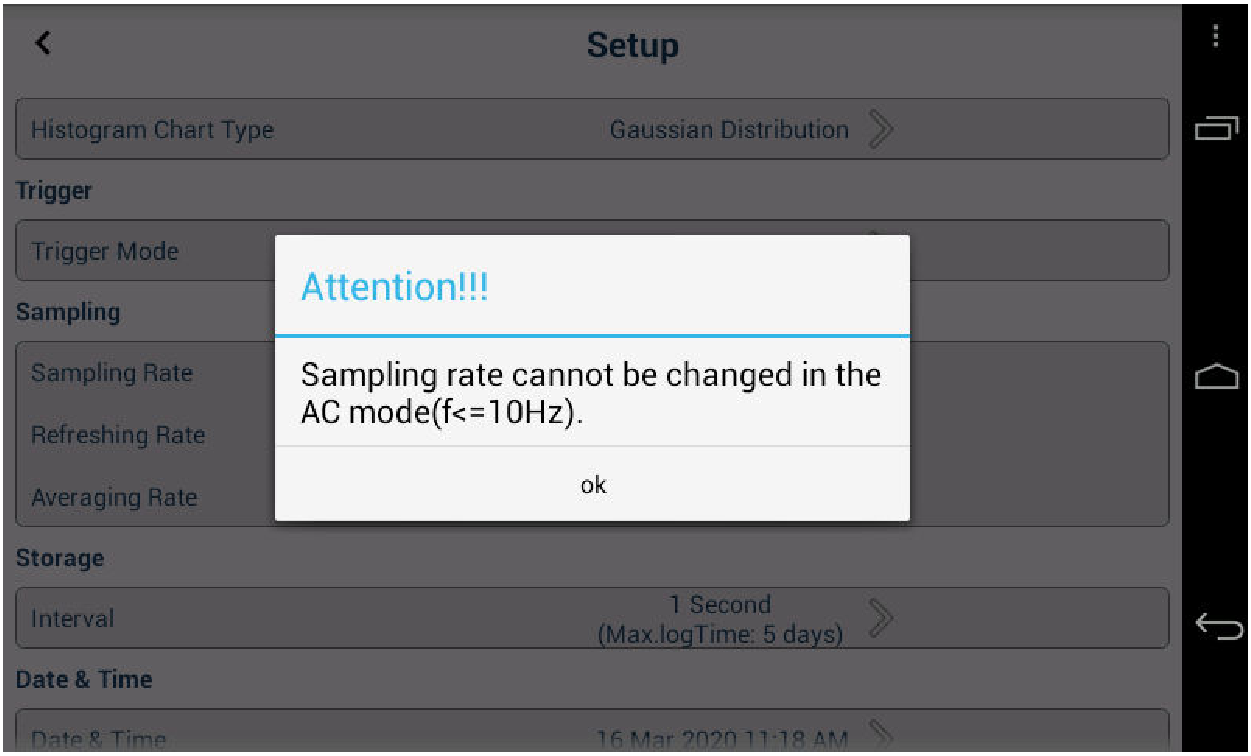


Figure 5.53 Warning message appearing when trying to change the sampling rate in the Less than or equal to 10 Hz AC frequency range

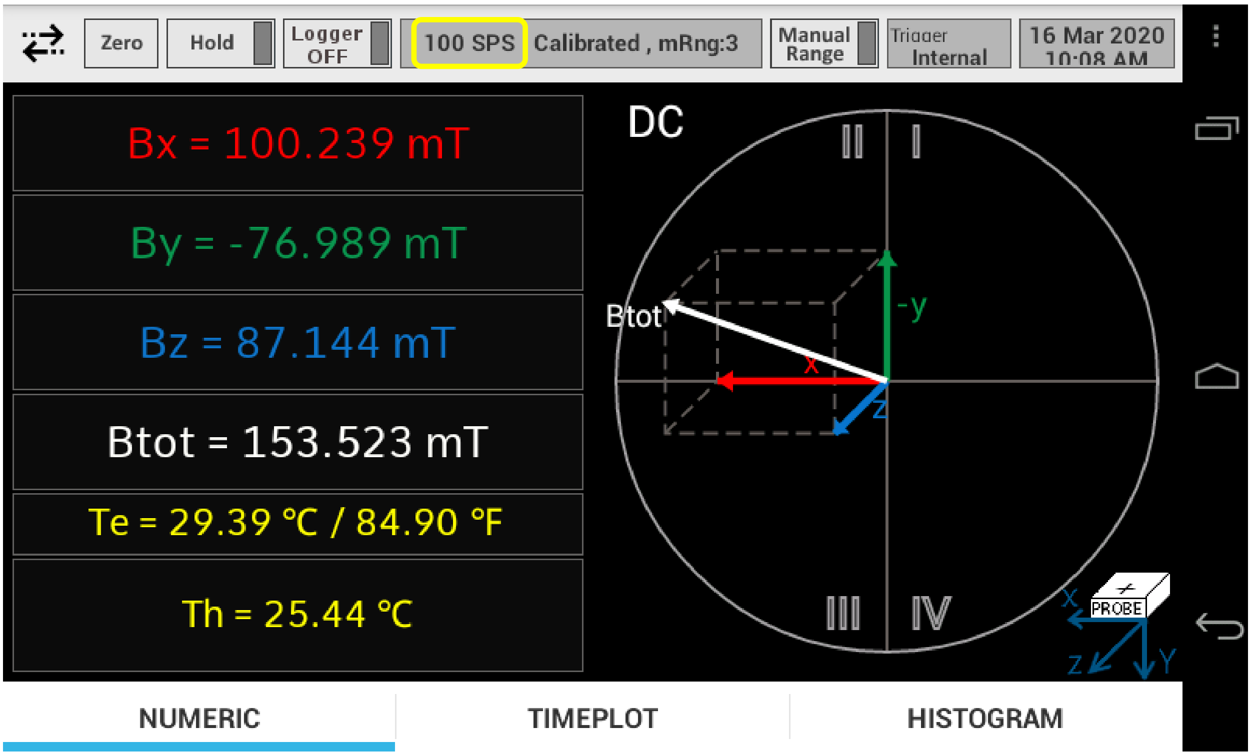


Figure 5.54 Sampling rate shown in the 3MH6 status field of the Main screen

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.5.2.7.2 Refreshing Rate

Refreshing rate defines how often the measurement results are updated in the *Main* screen. Figure 5.55 shows the available options.

Default refresh rate is 5 times/second.

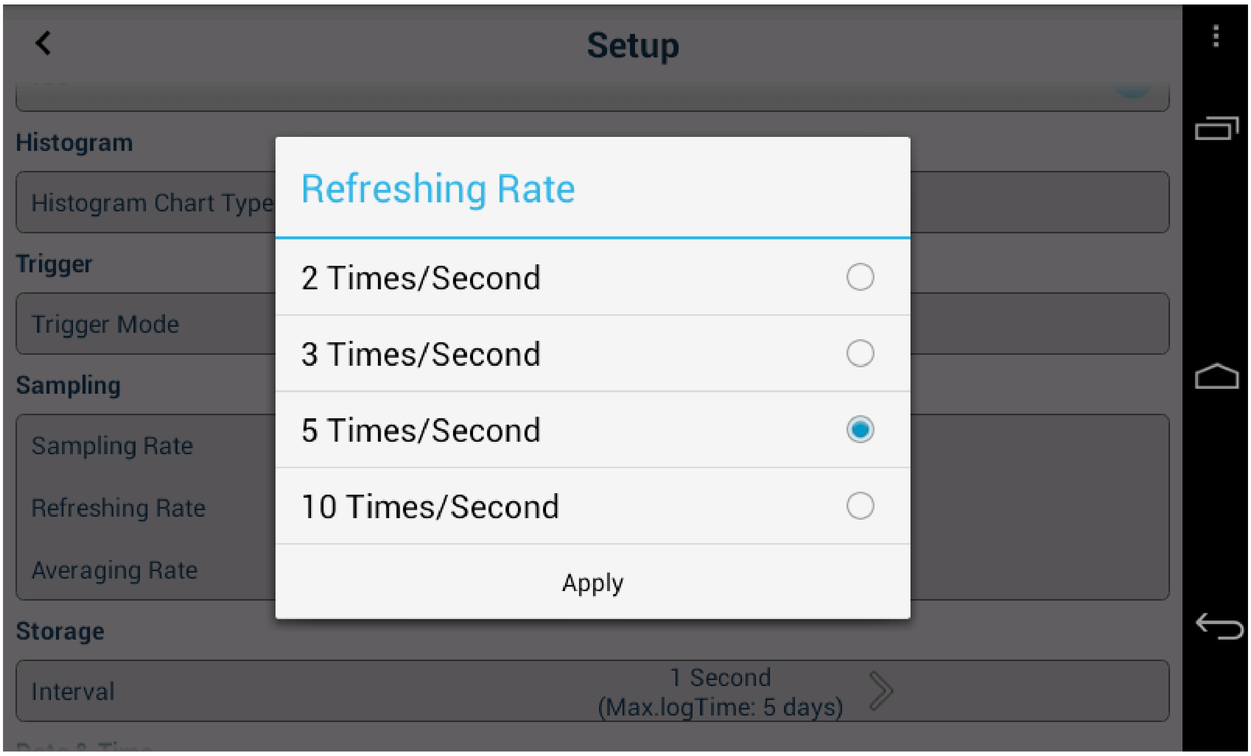


Figure 5.55 Refresh Rate menu

5.5.2.7.3 Averaging Rate

In order to obtain more stable measurement results, 3MH6 teslameter performs the **moving averaging of the magnetic signal samples.**

List of available *Averaging Rates* is shown in Figure 5.56. The *Averaging Rate* determines the number of samples used to calculate moving averaging value

Factory default value is 1 Sample, meaning that averaging is off by default.

Note: The averaging in *AC Measurement Mode* leads to low pass filtering effect to the measured signal which may result in the erroneous RMS values readings. For this reason, 3MH6 automatically sets the *Averaging Rate* to *1 Sample* when moving to *AC Measurement Mode*. Although the user may change it, *SENIS* doesn't recommend using any *Averaging Rate* other than *1 Sample* in *AC Measurement Mode*.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

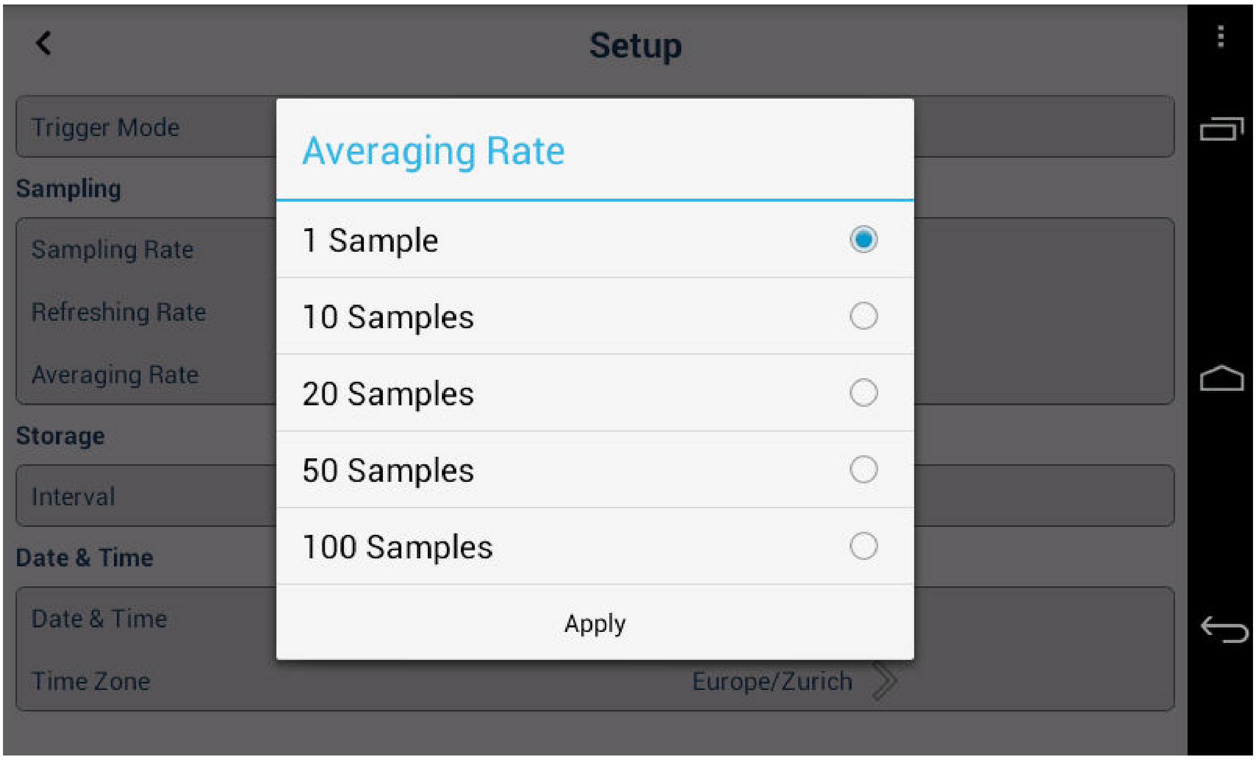


Figure 5.56 Averaging Rate menu

5.5.2.8 Storage

3MH6 teslameter is capable of logging the measurement results into the internal logger file. The content of this file may be read out by sending the corresponding command over USB port (‚l' command).

For more details about 3MH6 teslameter USB commands, see *APPENDIX – COMMUNICATION PROTOCOL OVERVIEW* **of this Manual (**‚*l'* command is described in *12.3.6 Command for Logger File Reading* section)**.**

Storage interval defines how often the measurement results are stored into the logger file. The list of available storage intervals is shown in Figure 5.57 and Figure 5.58.

Default value is 1 second.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

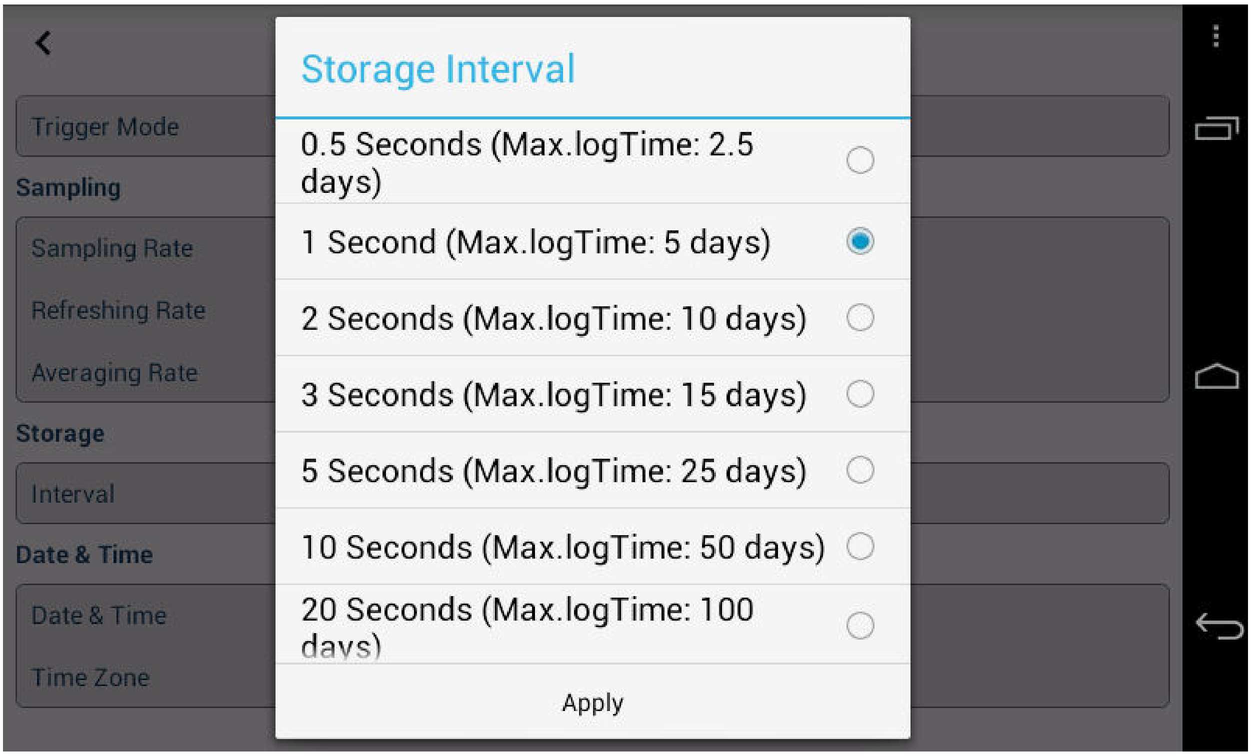


Figure 5.57 Storage Interval menu – part I

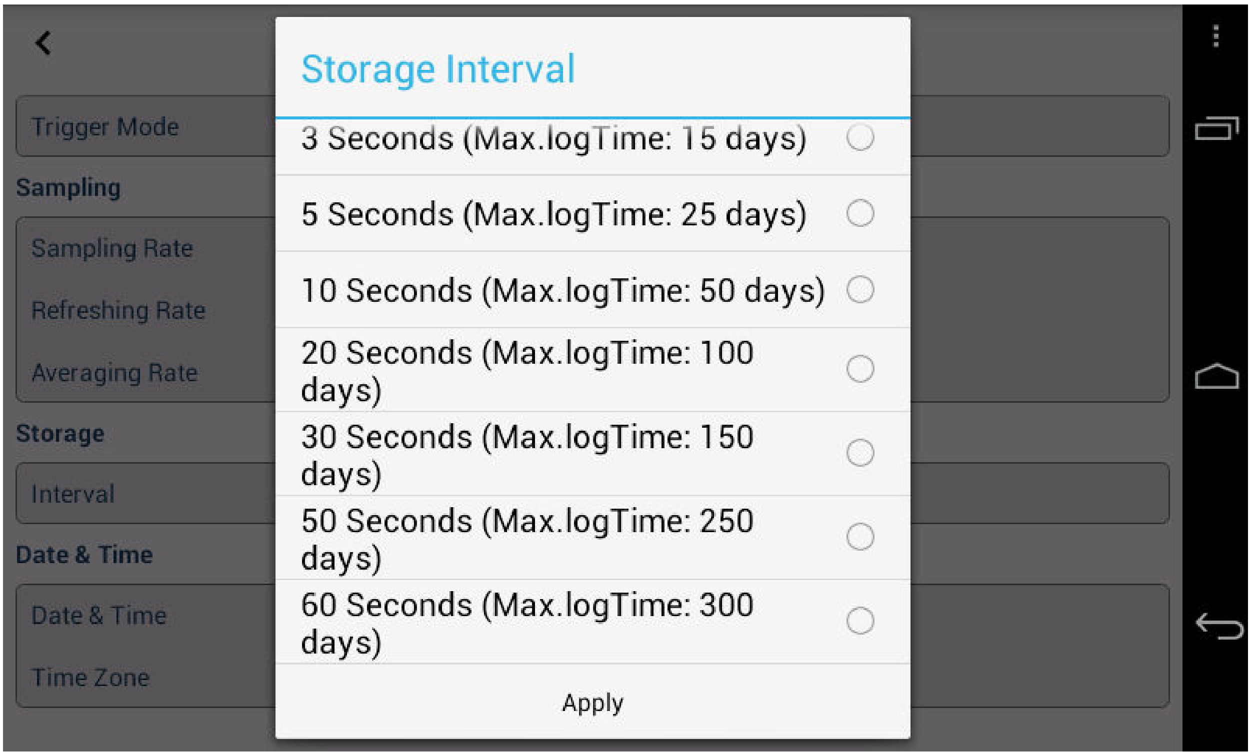


Figure 5.58 Storage interval menu – part II

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

Note 1: each measurement result stored into the logger file represents the averaged value of all the samples taken during the storage interval. For example, if the storage interval is 1 second and current sampling rate is 1 kSPS, it means that average value of the last 1000 samples of data will be stored every second.

Note 2: When the *Maximal log time* elapses, the logging will be stopped and error message stating: „*Error: LogFile is full*“ will be shown in the 3MH6 *status field* of the *Main* screen. Although the logging will be stopped automatically, it can be rerun by turning the *Logger* button off and on.

In order to run the data logging, it is needed to touch *Logger* button in the *Main* screen. For more details about logging measurement results see *5.8 Logging Measurements* section of this Manual.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.5.2.9 Date & Time

Teslameter allows setting of the *Date and Time* as well as the *Time Zone*.

The set time is shown in the upper right corner of the *Main* screen.

Note 1: Currently, the 3MH6 teslameter does not measure time when it is turned off.

Note 2: It is necessary to set date and time before running the data logging function (see *5.8 Logging Measurements* section of this Manual for details). For the other functions of the device, date and time setting is not mandatory.

5.5.2.9.1 Date & Time

Date and Time is set from dialog shown in Figure 5.59 by sliding up and down the corresponding fields.

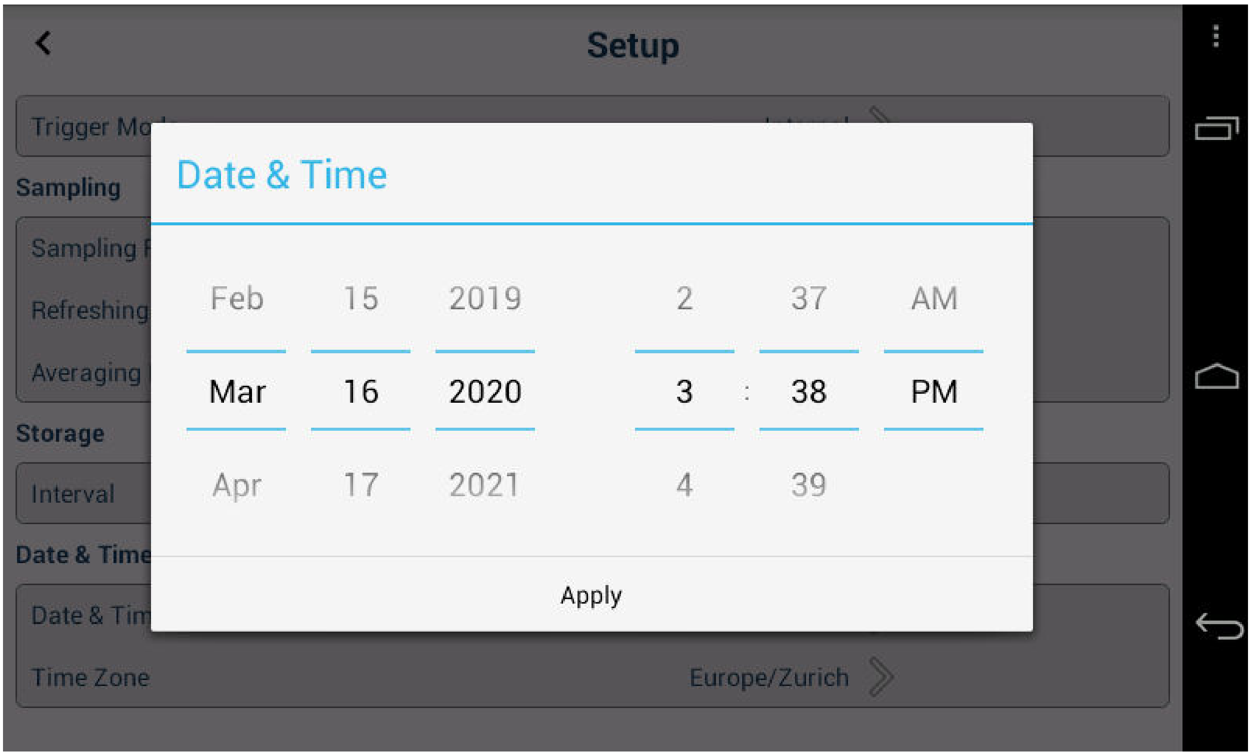


Figure 5.59 Date & Time setting dialog

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.5.2.9.2 Time Zone

Time Zone can be set from the menu shown in Figure 5.60.

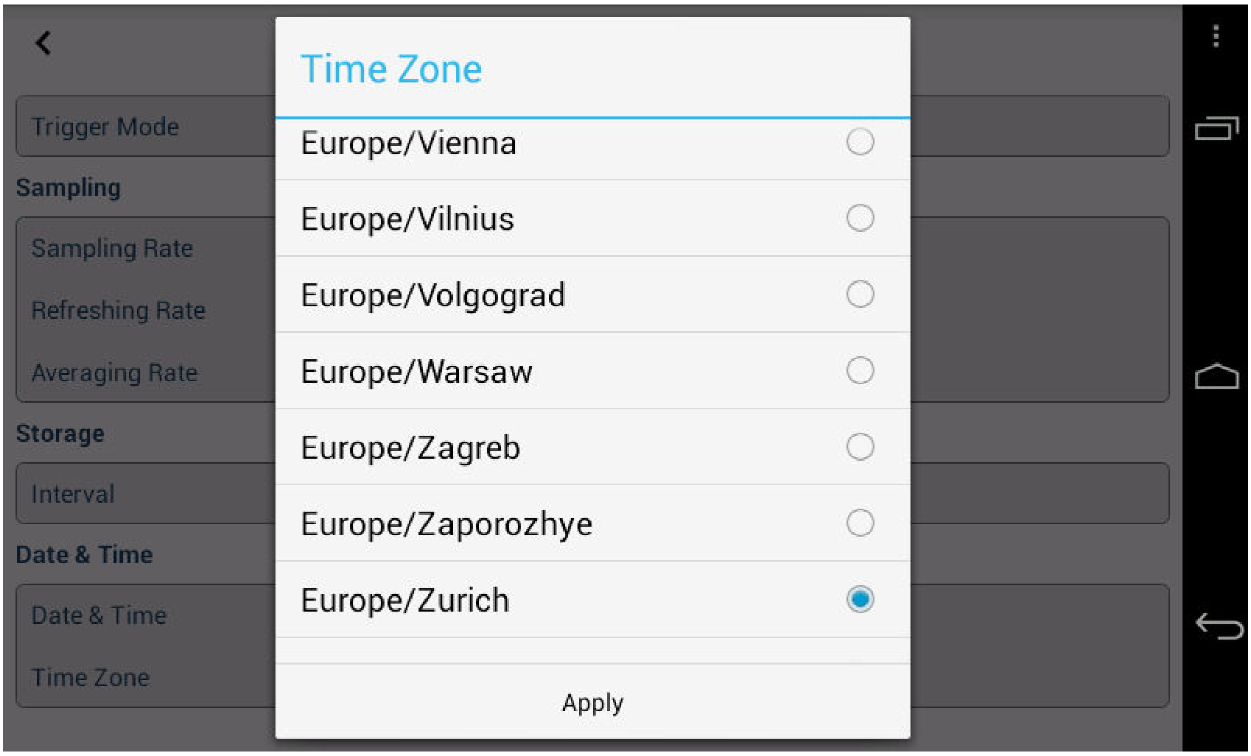


Figure 5.60 Time Zone menu

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.5.3 BSelector

BSelecor option (Figure 5.61) allows setting of the measurement results format for showing in the display (and for broadcasting over USB).

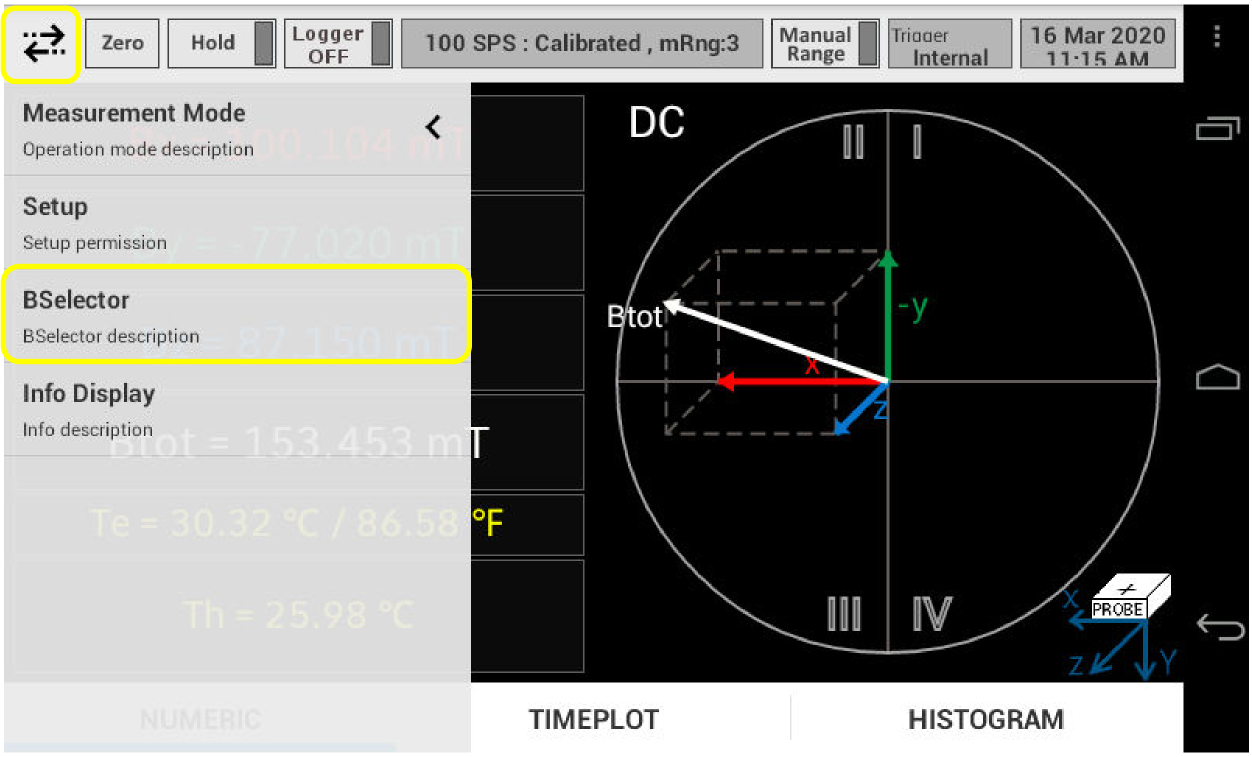


Figure 5.61 BSelector option in the Menu

On choosing the *BSelector* option, a pop-up menu appears with the following options (Figure 5.62):

- *Calibrated*
- *ADC*
- *Max*
- *Min*

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

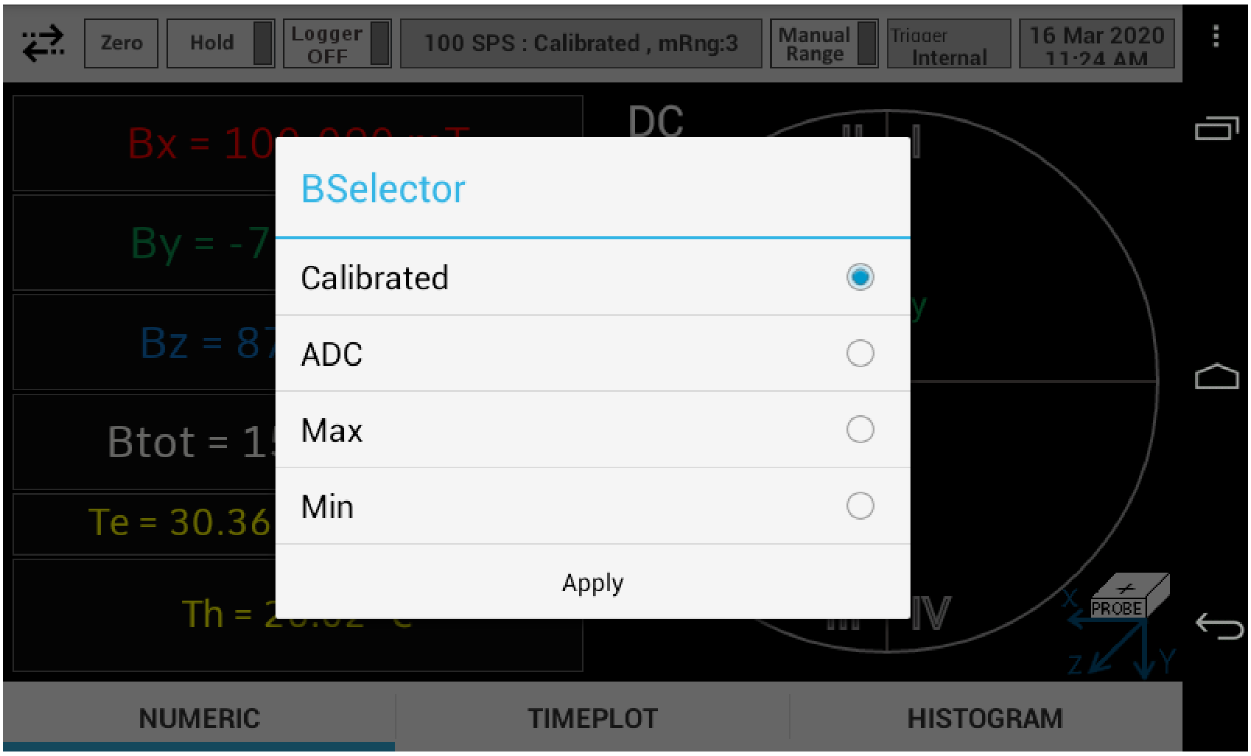


Figure 5.62 BSelector menu

Calibrated mode is a default user mode, and it shows the averaged measurement results expressed in the selected measurement unit (tesla or gauss for magnetic flux densities, and degrees Celsius for temperature parameters).

ADC mode shows the averaged raw measurement values got directly from A/D converters. These are integer values without formatting. ADC mode is mainly used in 3MH6 teslameter production for calibration purposes. It is not a user mode.

Max mode shows the maximal measured values of all the magnetic flux densities values since the moment the *Max* mode is run.

Min mode shows the minimal measured values of all the magnetic flux densities since the moment the *Min* mode is run.

The selected *BSelector* mode is shown in the 3MH6 *status field* of the *Main* screen header (Figure 5.63).

5.5.3.1 Max and Min Mode Operation

Max and *Min* modes are used to capture extreme values of the measured magnetic flux densities.

Max mode is used for capturing maximal instantaneous value of the magnetic flux densities values, while the *Min* mode is used for capturing minimal instantaneous value of the magnetic flux density since the moment the selected mode is run. The *Main* screen in *Max* mode is shown in Figure 5.64, while the *Main* screen in *Min* mode is shown in Figure 5.65.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

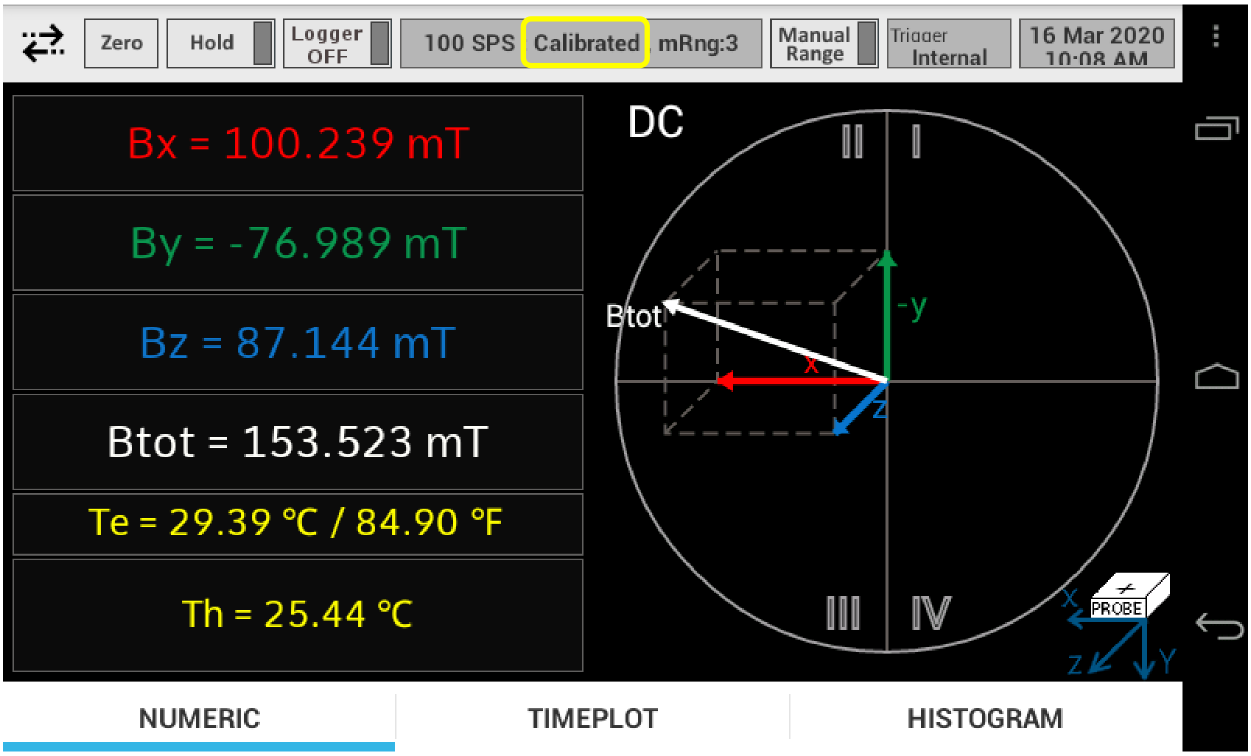


Figure 5.63 BSelector mode shown in the 3MH6 status field in the header of the Main screen

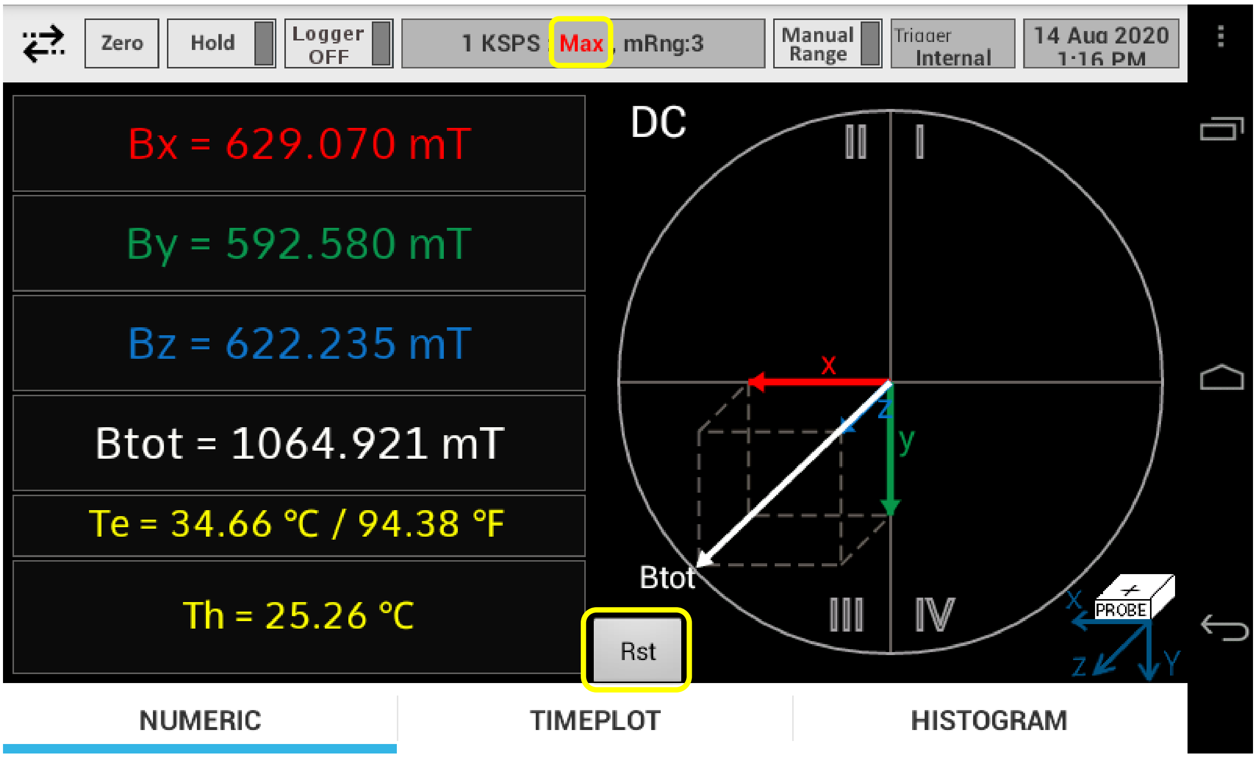


Figure 5.64 Main screen in the Max mode

Note 1: The *Averaging Rate* selected in the *Setup* menu may affect the results of the *Max* and *Min* functions.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

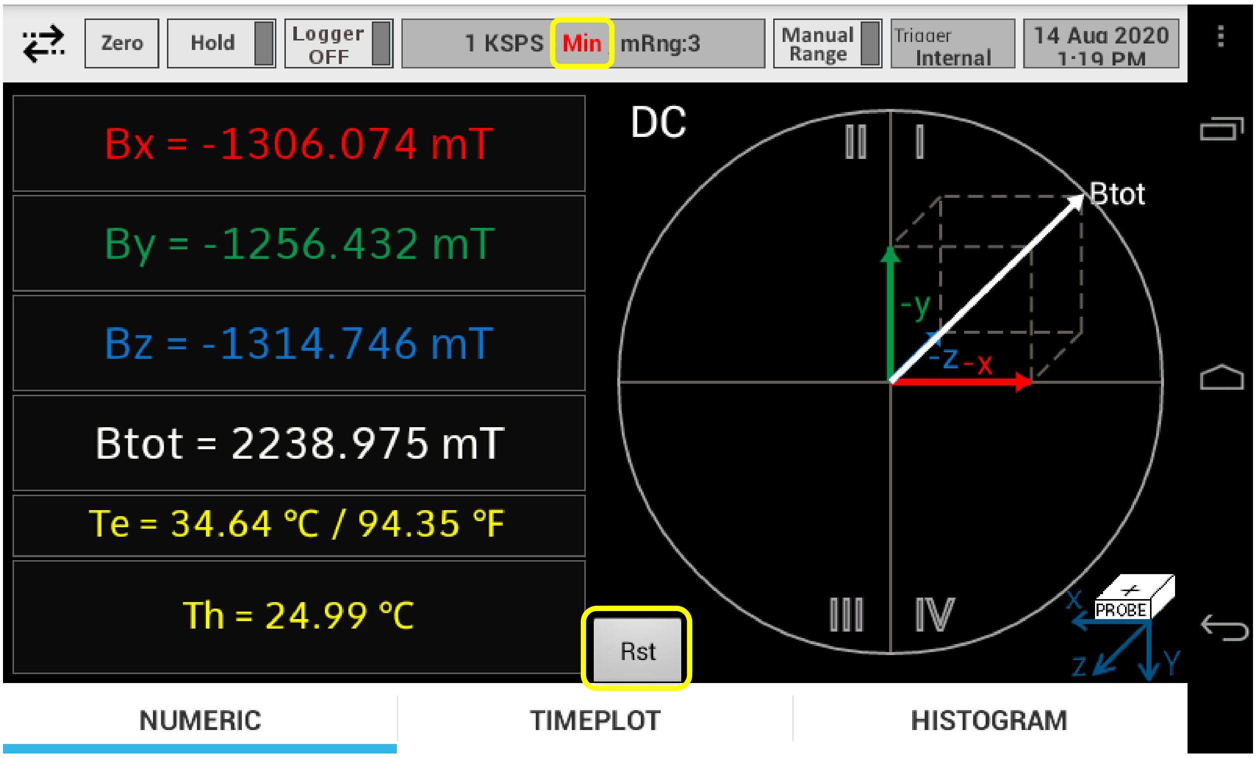


Figure 5.65 Main screen in the Min mode

Note 2: The maximal or minimal values shown in the *Max* and *Min* mode don't necessarily refer to the same moment, but each measurement value is tracked separately. As soon as the averaged instantaneous value of any magnetic flux density components exceeds previous maximal or minimal value, the corresponding *Max* or *Min* value is updated. B_{tot} represents the vector sum of the maximal/minimal B_x, B_y and B_z. Nevertheless, as the extreme values of its components may not occur at the same moment, it may not represent a realistic value.

Note 3: The maximal or minimal instantaneous values shown in the *Max* and *Min* mode are same both in *DC* and *AC Measurement* mode.

The *3D Chart* shows the maximal/minimal values of the magnetic flux density components B_x, B_y and B_z.

In order to reset the capturing of the maximal/minimal values, tap on the *RST* button (Figure 5.64 and Figure 5.65). Once the *RST* button is tapped, the process of searching the maximal and minimal values starts from the beginning.

The waveforms in the *Timeplot* tab show the instantaneous values of B_x, B_y and B_z, while the current maximal/minimal values are shown in the footer of the *Timeplot* tab.

5.5.4 Info Display

Info Display shows the basic information about the teslameter and the probe, as well as some status information.

Note: To close the *Information* screen and return to *Main* screen, you may either tap ‹ button on the top of the screen, or use the standard Android *Back button* (⮌, see Figure 5.67).

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

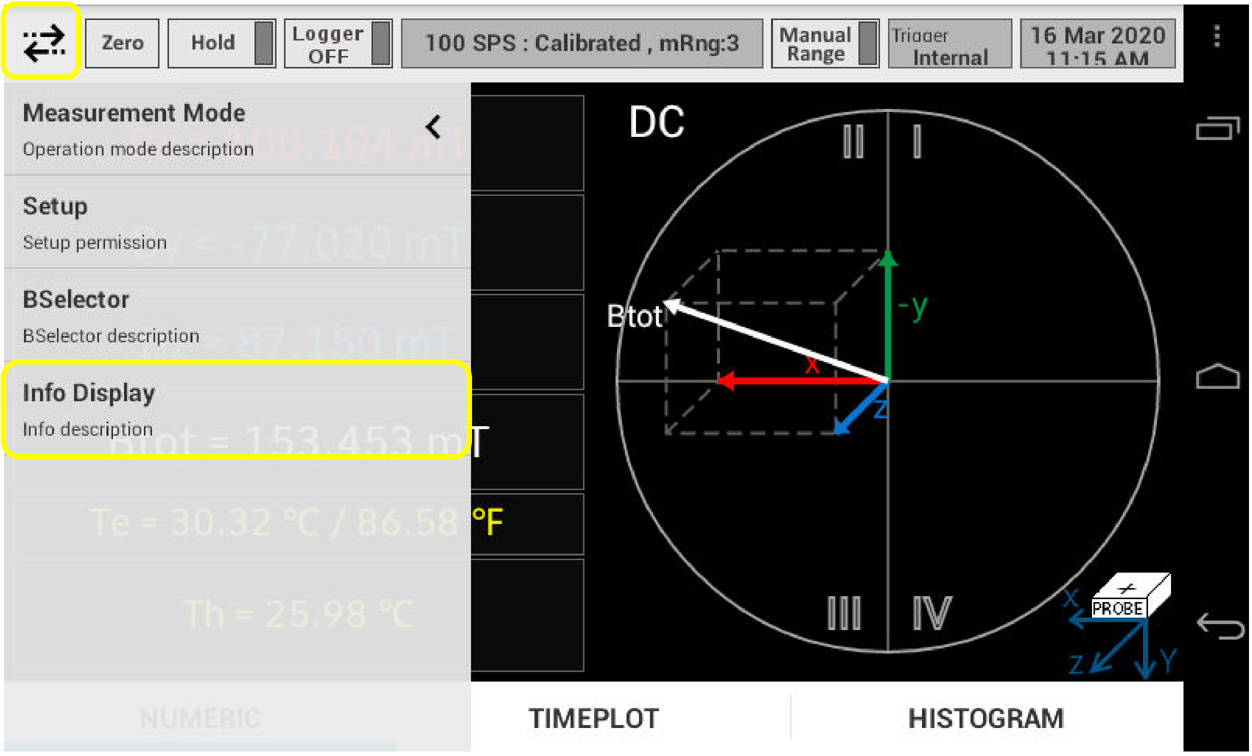


Figure 5.66 Info Display option in the Menu

On choosing the *Info Display* option, a screen shown in Figure 5.67 and Figure 5.68 appears:

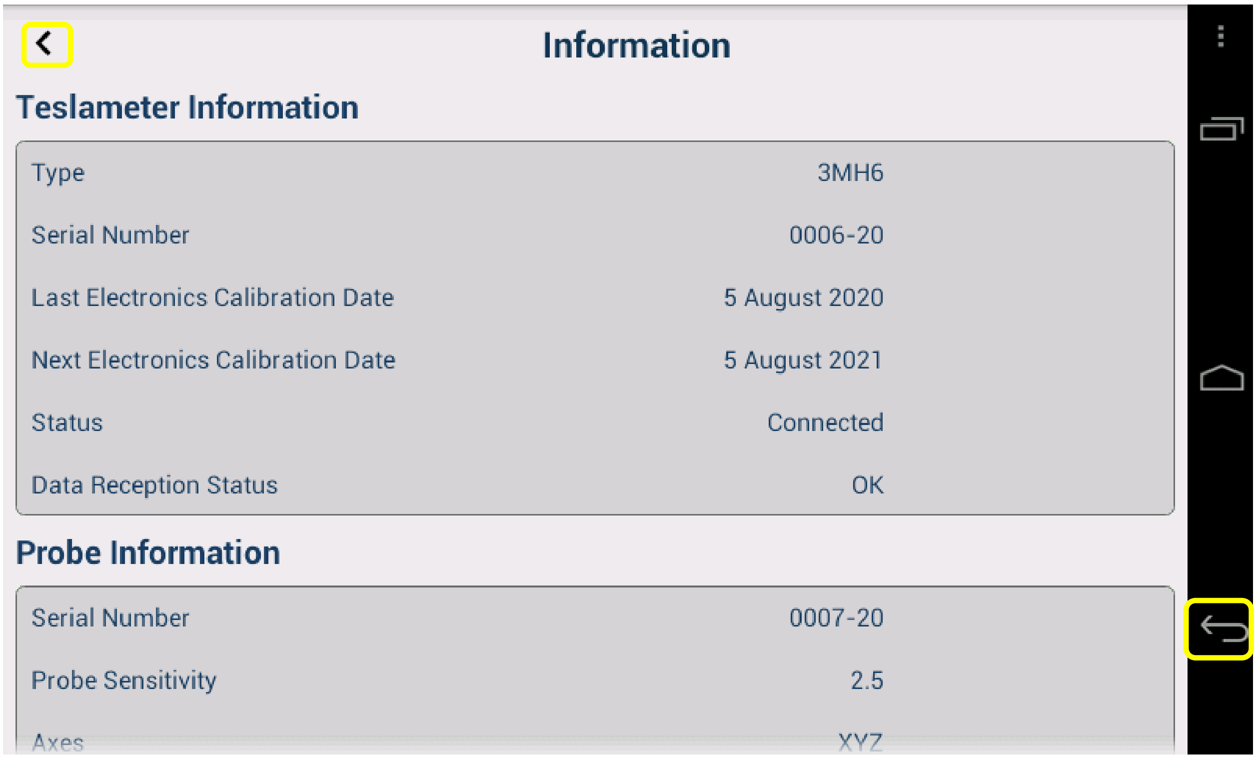


Figure 5.67 Info Display screen – part I

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

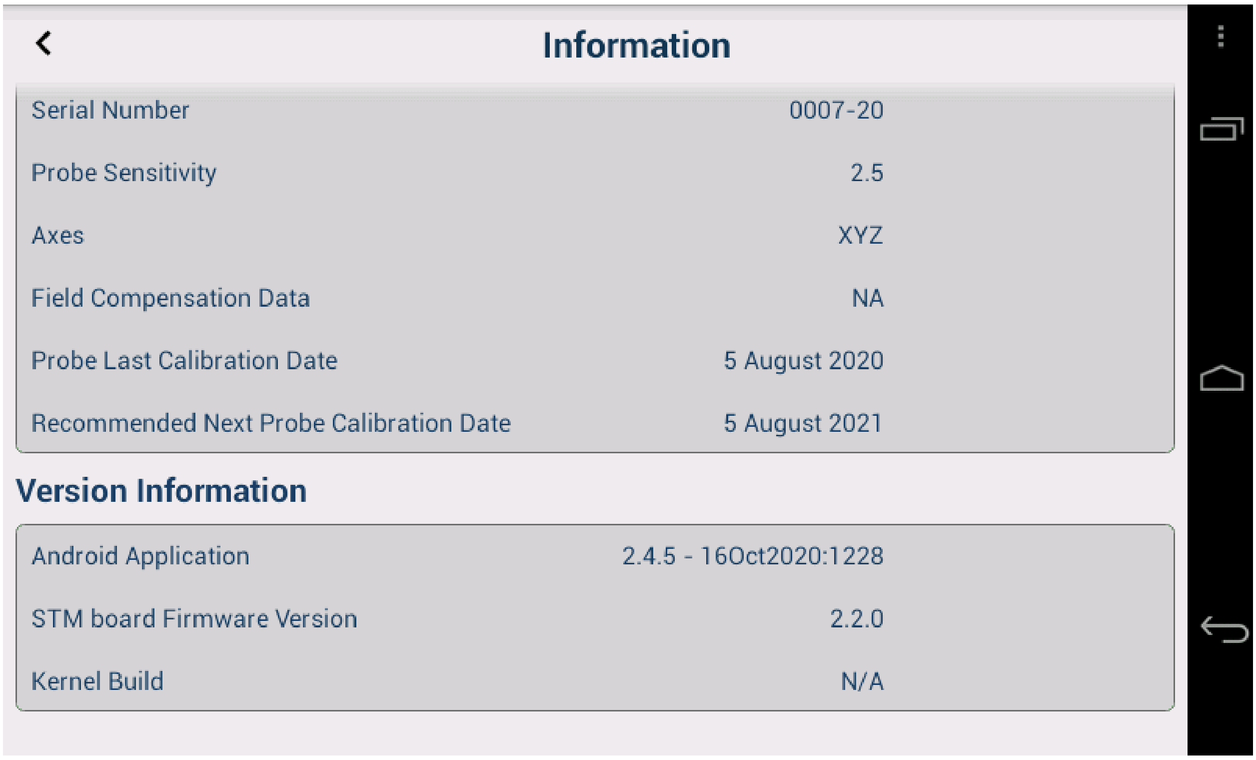


Figure 5.68 Info Display screen – part II

The *Information* screen shows three blocks of information which regards:

- *Teslameter Information*
- *Probe Information*
- *Version Information*

5.5.4.1 Teslameter Information

Teslameter information block contains the information that refers to the teslameter electronics box. These are:

- *Type*
- *Serial Number*
- *Last Electronics Calibration Date*
- *Next Electronics Calibration Date*
- *Status*
- *Data Reception Status*

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

Note 1: *Status* and *Data Reception Status* refer to the internal communication between the microprocessors inside the electronics box.

If everything is correct, the *Status* field shows *Connected*, while the *Data Reception Status* field shows *OK*.

If any internal communication error appears, the *Data Reception Status* filed will show *Error*, followed by the overall count of errors from the Android application start.

Note 2: If device is in any of the external trigger modes (*Single Shot* or *Continuous*) or it is in the *Manual* trigger mode and the measurement has not been triggered within 5 seconds interval since the trigger mode is run, or since the last measurement (or since the last trigger pulse for *Continuous* mode), the *Data Reception Field* will show „*Error, count 0*“. This is a normal behavior, because without trigger there is no measurement data to be shown in display. As soon as the measurement is triggered, *Data Reception Status* field will become *OK* again.

5.5.4.2 Probe Information

Probe Information block contains information about the probe connected to the device.

This information includes:

- *Serial Number*
- *Probe Sensitivity*
- *Axes*
- *Field Compensation Data*
- *Probe Last Calibration Date*
- *Recommended Next Probe Calibration Date*

5.5.4.3 Version Information

Version information block contains the information about the current Android application version and the microcontroller firmware version.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.6 Zeroing

Zeroing feature is used for the relative measurements of the magnetic flux density in the *Calibrated* mode with *Manual* range set. Activating this function will make all the current averaged magnetic flux density measurements reference for the future measurements. On running this function, the current measurement values for B_x, B_y, B_z and B_{tot} becomes zero or almost zero.

Note 1: Before running the Zeroing function, the probe should be inserted into the Zero Gauss Chamber.

Note 2: for the best measurement results 3MH6 teslameter should be turned ON at least 15 minutes before starting the measurements. The same applies for the zeroing procedure.

To activate the *Zeroing* function, touch the *Zero* button in the header of the *Main* screen (Figure 5.69).

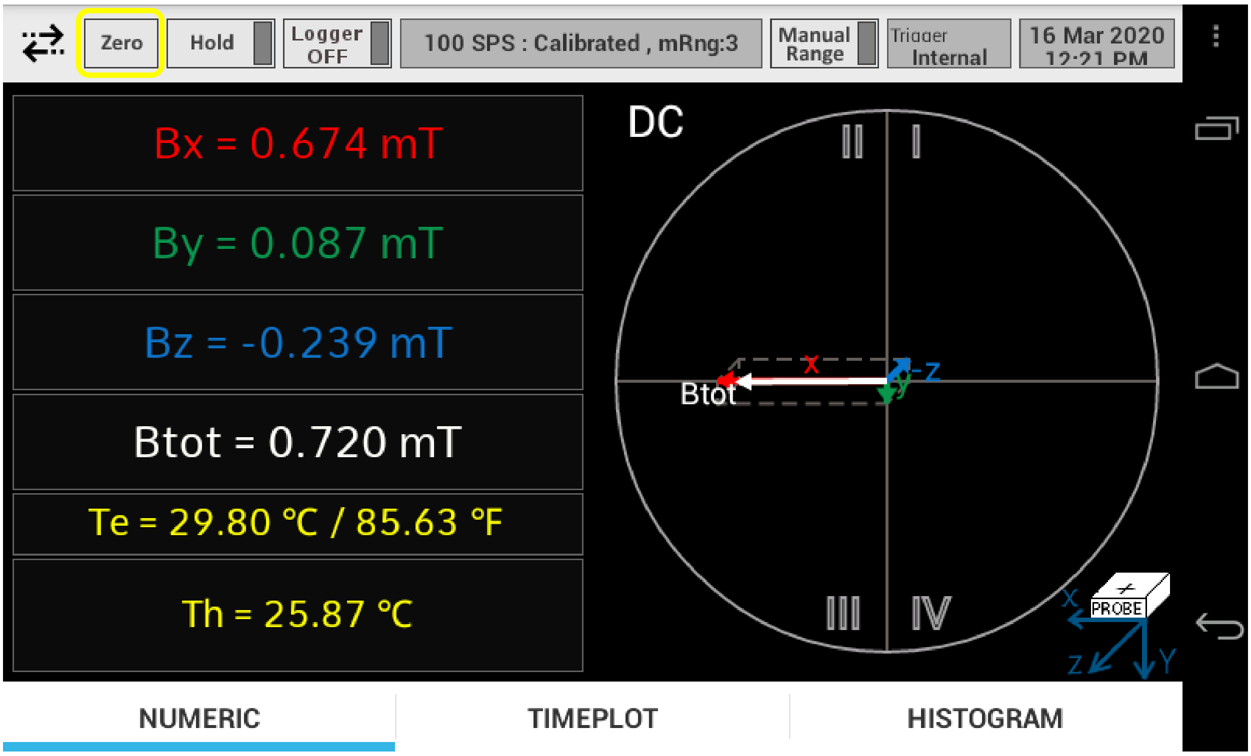


Figure 5.69 Zero button

A dialog appears asking to confirm the *Zeroing* function (Figure 5.70).

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

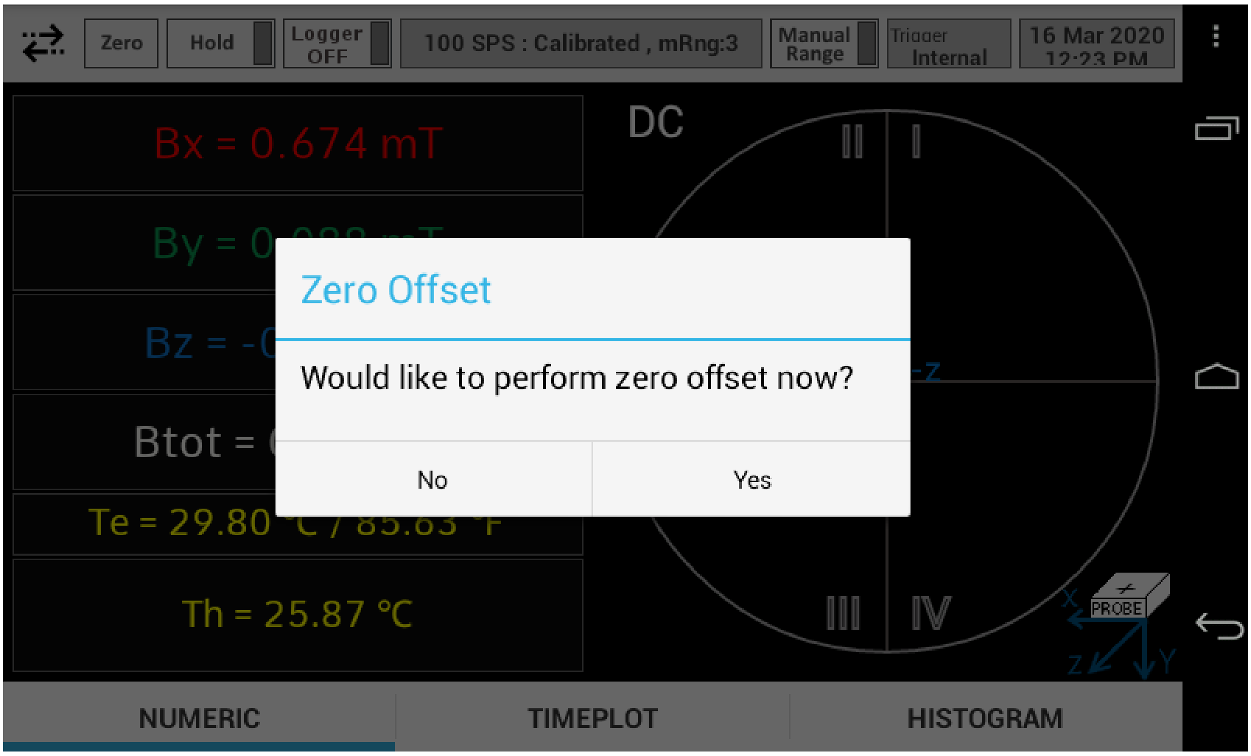


Figure 5.70 Zeroing function confirmation dialog

If confirmed, the current (averaged) magnetic flux density values will be stored into the memory. Instead of previous measurement values, zeros or the values close to zero (mT) will be shown (Figure 5.71). From now on, the reference values (zeroing coefficients) stored into the memory will be subtracted from the corresponding measured values for that measurement range, and the difference will be shown in the screen.

The zeroing coefficients are stored for each manual range separately. When device is either turned off or reset, the zeroing coefficients are cancelled. In other words, the zeroing is valuable only until 3MH6 teslameter is turned off or reset. Note that due to certain 3MH6 teslameter offset drift, it may be necessary to repeat the zeroing from time to time during device operation (if necessary).

If you want to perform the zeroing function for several (or all) ranges, you have to set range by range, and perform zeroing in each of desired **calibrated** ranges (running the zeroing function for the ranges that have not been calibrated does not have sense).

In addition, the zeroing coefficients are kept separately for *DC* and *AC* mode in device memory. Switching the mode between *DC* and *AC* activates the corresponding zeroing coefficients for each manual range. The *Zeroing* coefficients in *DC* mode are the averaged instantaneous values at the moment of *Zeroing* function confirmation, while in *AC* mode they represent averaged RMS values. For this reason, when 3MH6 teslameter is switched from *DC* to *AC* (or vice versa) measurement mode and the *Zeroing* is needed, it has to be done for each desired calibrated range separately (if it has not already been done before for that mode/range).

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

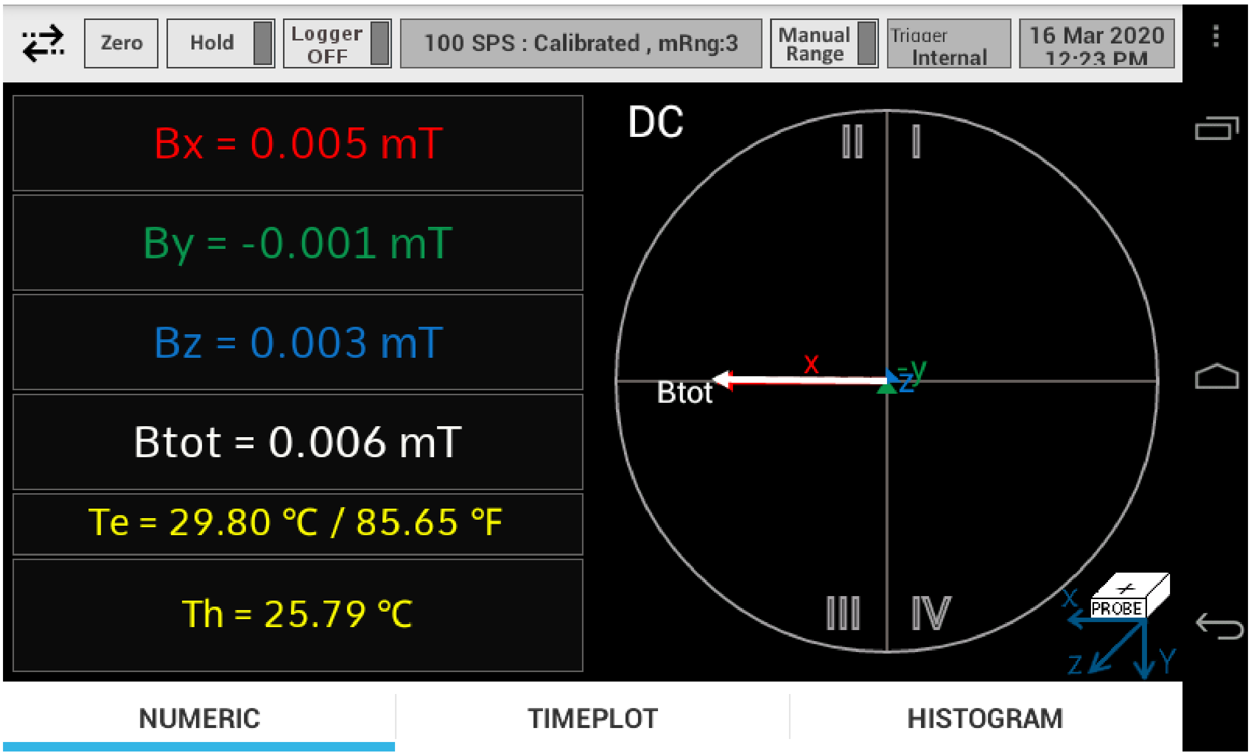


Figure 5.71 Magnetic flux densities after Zeroing

Note 3: *Zeroing* function can be done unlimited number of times for each range and measurement mode (*AC*/*DC*), but it cannot be undone from the *Teslameter* Android application. The only way to cancel the zeroing function is to reset device (by pressing the *Reset* push button, or by switching device off and on).

Note 4: The *Zeroing* function is not available in *ADC* mode of the *BSelector* setting, neither when the *Autorange* mode is activated in *Calibrated* mode.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.7 Hold

Hold button located in the header of the *Main* screen allows the user to freeze the *Main* screen (Figure 5.72).

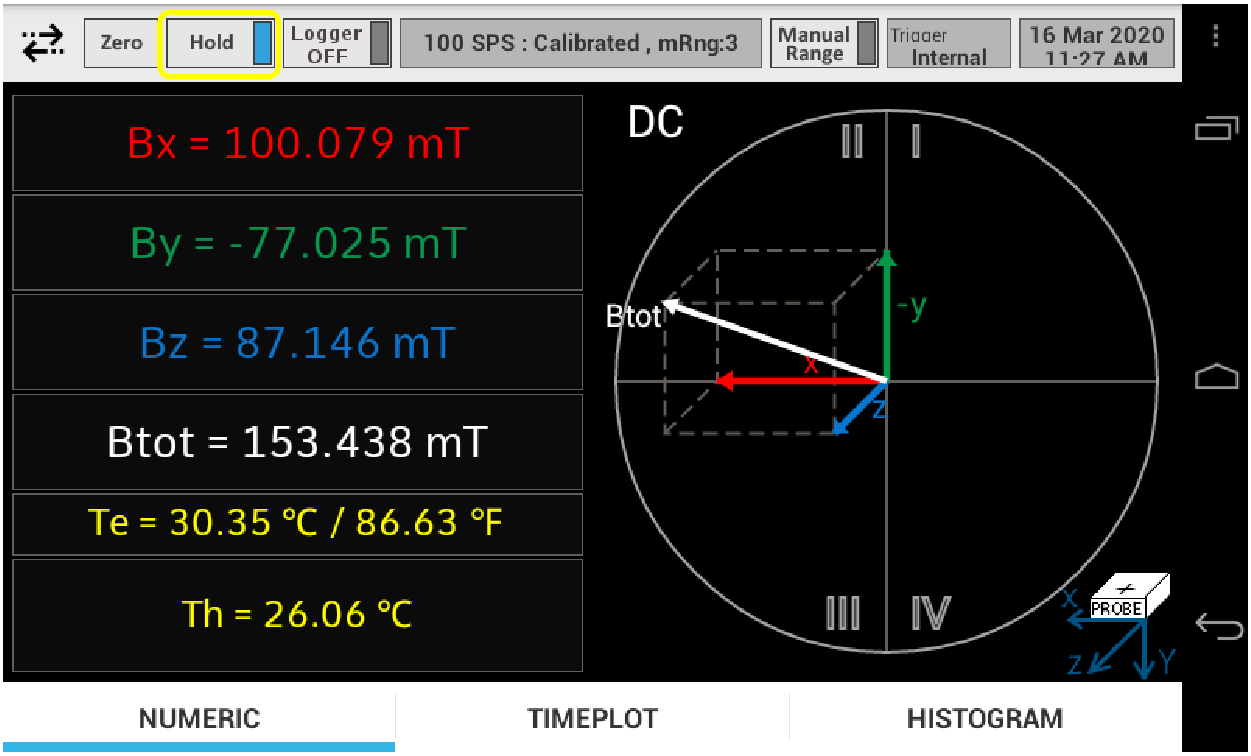


Figure 5.72 Hold button ON – the Main screen is frozen.

To unfreeze the *Main* screen, touch the *Hold* button again.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.8 Logging Measurements

3MH6 teslameter is capable of logging the measurement results into the internal logger file. The content of this file may be read out over USB port by sending the corresponding command (‚l‘ command).

The format of the data logged into the logger file is determined by *BSelector* mode (*Calibrated*, *ADC*, *Max* or *Min*).

The logging is run by touching the *Logger* button (Figure 5.73).

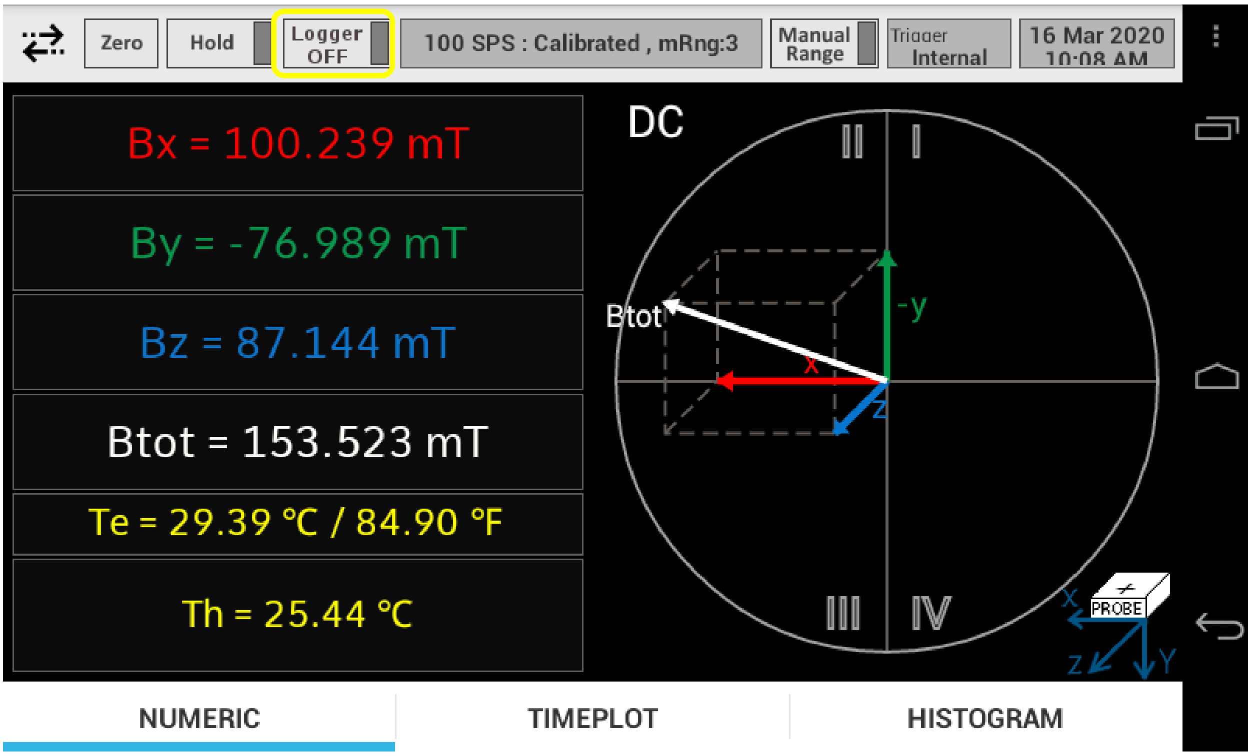


Figure 5.73 Logger button

Before starting the logging measurement results it is needed to perform the following settings:

- Setting the *Storage Interval*
- Setting the *Date and Time*

Storage Interval defines how often the measurement results are stored into the logger file. It is set from the *Setup* menu (see the *5.5.2.8 Storage* for details on how to set the *Storage Interval*).

Date and Time setting is necessary for the correct time stamps in the logger file. *Date and Time* is also set from the *Setup* menu (see the *5.5.2.9.1 Date & Time* for details on how to set *Date and Time*).

Note: If the date and time have not been set before running the *Logger* function, the logging won't be started and the notification message will be shown in the screen (Figure 5.74)

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

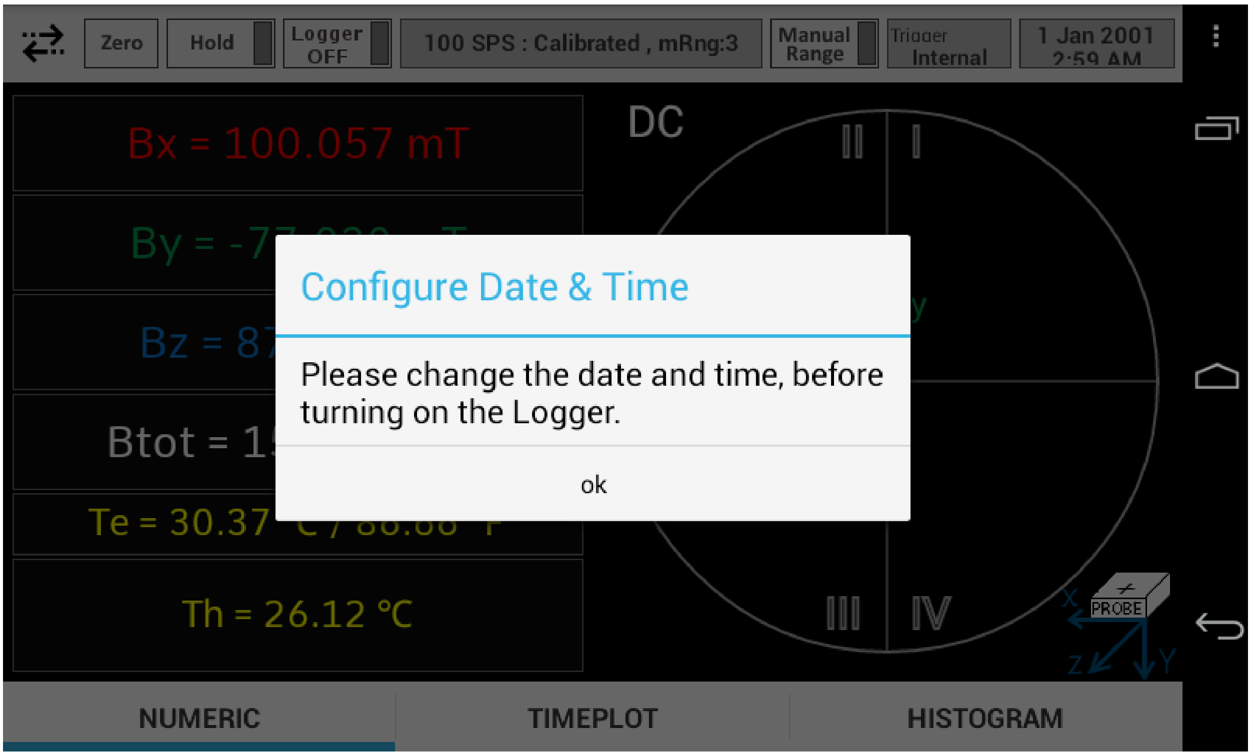


Figure 5.74 Notification message reminding user to set date and time before running the logging of the measurement results

After the logging settings have been done, touch the *Logger* button so that its status becomes *On* as shown in Figure 5.75.

Figure 5.75 Logger button ON

The 3MH6 teslameter starts logging data into the logger file. The complete content of the file may be read at any time during logging over USB by sending the ‚*l*' command (for details about ‚*l*' command see *12.3.6 Command for Logger File Reading* section of this Manual). An example of the logger file content sent as a response to the ‚*l*' command is given on the next page. From this example it can be seen that logger file keeps the records of changes of measurement range, sampling rate, trigger mode and AC/DC measurement mode. In addition, the logger file also keeps the records of changes in *BSelector* mode and measurement unit (including the submultiple change).

In order to stop logging measurement results, touch the *Logger* button again.

The content of the logger file is also available after the logging has been stopped, and it remains available until next logger function running. Moreover, it is available after 3MH6 resetting.

Note: On next running of the logger function, the pervious logger file content will be automatically erased before writing the first logging data.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

```
Teslameter information:
Type  3MH6
Serial number     0006-20
Probe information:
Serial number     0007-20
Sensitivity 2.5
Axis  XYZ
Calibration date  5 August 2020
Next calibration date   5 August 2021
Firmware version  2.2.0
Android application version   2.4.5 - 16Oct2020:1228
Storage interval  INTERVAL_1SECOND
Trigger mode      TRIGGER_INTERNAL
Sample rate SAMPLING_100SPS
Measurement Unit  mT
Measurement Mode  MEAS_MODE_DC
Range       MANUAL_RANGE
Range       RANGE3
TIME  X-Data      Y-Data      Z-Data      Btot  Th(Celsius/ADC)   Te(Celsius/ADC)
08052020:125745   -97.400612  124.353943  -18.248367  159.008752  27.119232   33.140625
08052020:125746   -97.650414  124.589012  -18.322132  159.354092  27.393402   33.164062
08052020:125747   -97.565796  124.448349  -18.334362  159.193671  27.271149   33.195312
08052020:125748   -97.905922  124.978287  -18.364887  159.819930  27.786041   33.195312
08052020:125749   -97.267792  124.200157  -18.213268  158.803104  26.946198   33.187500
08052020:125750   -97.724182  124.813232  -18.286942  159.570585  27.581635   33.210938
08052020:125751   -97.572495  124.482925  -18.337681  159.225193  27.291229   33.171875
08052020:125752   -97.558907  124.446251  -18.305838  159.184525  27.247406   33.156250
Current Range Index     RANGE_2
08052020:125753   -97.785576  124.749046  -18.356722  159.566013  27.570648   33.195312
08052020:125754   -97.628319  124.641525  -18.305222  159.379675  27.435150   33.171875
08052020:125755   -97.374214  124.338844  -18.213039  158.976733  27.086945   33.179688
08052020:125757   -97.937111  124.986839  -18.370113  159.846325  27.802643   33.210938
08052020:125758   -97.456284  124.367050  -18.268551  159.055433  27.159027   33.148438
08052020:125759   -97.705772  124.647072  -18.358055  159.437537  27.472870   33.195312
08052020:125800   -97.452591  124.352524  -18.287113  159.043945  27.146027   33.164062
08052020:125801   -97.205956  124.099915  -18.200985  158.685420  26.855438   33.210938
```


PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

```
08052020:125802   -97.643883  124.657532  -18.300392  159.401168  27.431000   33.132812
08052020:125803   -97.504654  124.548424  -18.250364  159.224819  27.311432   33.164062
08052020:125804   -97.620811  124.638405  -18.291048  159.371005  27.408722   33.203125
08052020:125805   -97.587303  124.526535  -18.306726  159.264803  27.323395   33.187500
08052020:125806   -97.572769  124.459740  -18.314129  159.204523  27.274628   33.171875
Current Sample rate      SAMPLING_500SPS
08052020:125807   -97.397728  124.476112  -18.417805  159.122079  27.291229   33.203125
08052020:125808   -97.065918  124.012947  -18.349243  158.548728  26.802094   33.140625
08052020:125809   -97.141136  124.129951  -18.391035  158.691131  26.933441   33.187500
08052020:125810   -97.439178  124.591820  -18.421490  159.238397  27.375275   33.164062
08052020:125811   -97.410683  124.445892  -18.447977  159.109865  27.273529   33.156250
08052020:125812   -97.347809  124.341156  -18.425600  158.986856  27.157318   33.195312
08052020:125813   -97.312325  124.291107  -18.420610  158.925414  27.111298   33.187500
08052020:125814   -97.375931  124.482780  -18.386345  159.110319  27.266693   33.156250
08052020:125815   -97.319710  124.501282  -18.359808  159.087326  27.268463   33.156250
08052020:125817   -97.269157  124.382767  -18.352699  158.962837  27.167816   33.179688
08052020:125818   -97.324501  124.386497  -18.433167  159.008930  27.186249   33.203125
08052020:125819   -96.985329  123.950966  -18.316910  158.447171  26.731049   33.187500
08052020:125820   -97.437576  124.636932  -18.383232  159.268291  27.404755   33.226562
08052020:125821   -97.070801  124.136192  -18.322124  158.645001  26.897003   33.179688
08052020:125822   -97.081055  124.054382  -18.348953  158.590373  26.843781   33.187500
08052020:125823   -97.402664  124.408997  -18.441315  159.075331  27.240265   33.195312
08052020:125824   -97.178673  124.161263  -18.382292  158.737592  26.970245   33.125000
Current Sample rate      SAMPLING_1KSPS
Current Trigger Mode     TRIGGER_CONTINUOUS
08052020:125825   -97.515549  124.424484  -18.387987  159.150405  27.259491   33.109375
08052020:125826   -97.775024  124.820564  -18.458103  159.627160  27.699432   33.210938
08052020:125827   -97.450066  124.372849  -18.427698  159.074515  27.238190   33.140625
08052020:125828   -97.405815  124.248375  -18.414026  158.948504  27.134369   33.132812
Current Measurement Mode      MEAS_MODE_AC
08052020:125829   97.644882   124.643883  18.472445   159.410952  277.538788  33.156250
08052020:125830   97.777145   124.839500  18.511696   159.649470  277.751007  33.210938
08052020:125831   97.538124   124.579575  18.416195   159.288770  277.474945  33.171875
08052020:125832   97.689980   124.736145  18.473423   159.510831  277.621124  33.195312
08052020:125833   97.229942   124.143616  18.367979   158.753531  276.987091  33.195312
```


PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5.9 Auto/Manual Range Button

Switching between *Auto* and *Manual* ranging can be easily done by touching *Auto/Manual Range* button, which is also located in the header of the *Main* screen (Figure 5.76).

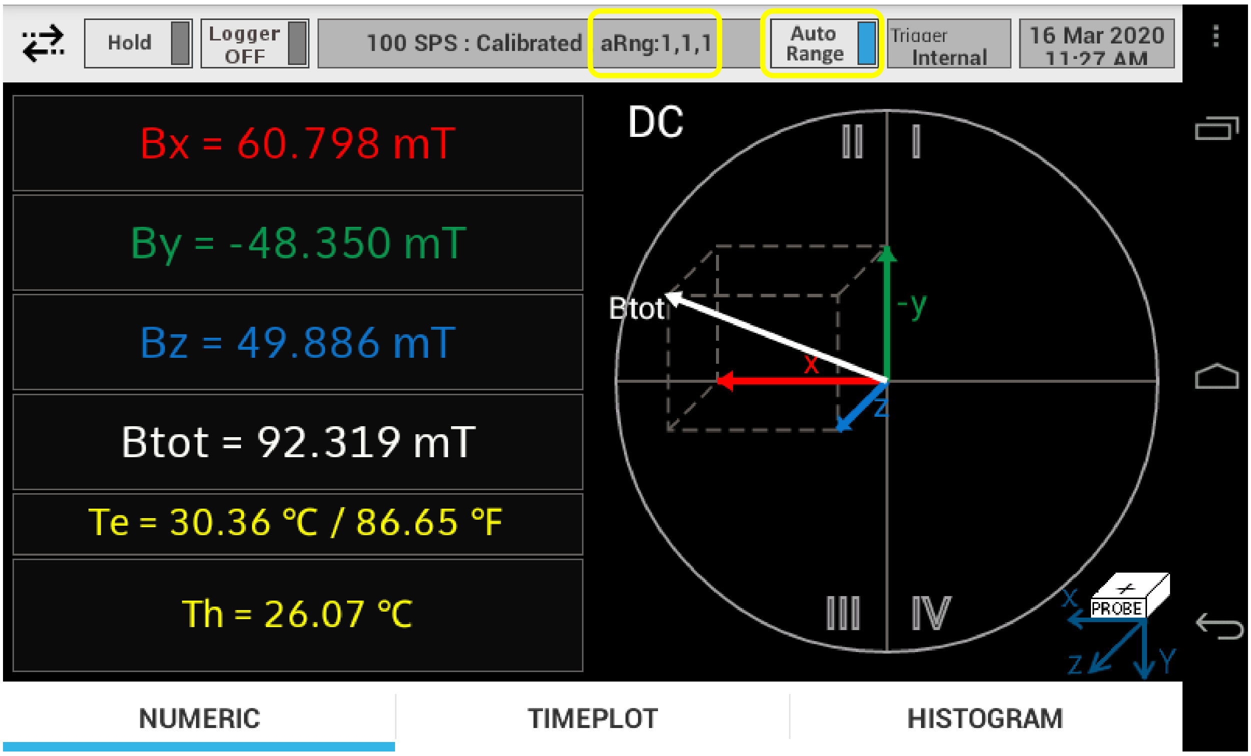


Figure 5.76 Auto/Manual Range button

Switching from *Auto* to *Manual* range is visible in the *3MH6 status field* (located left from the *Auto/Manual Range* button). *Auto* range is denoted with ***aRng: x,x,x*** where each of *x* represents the *Range* number for B_x, B_y and B_z respectively. For example, *aRng: 2,1,3* means that *Range 2* is set for B_x, *Range 1* is set for B_y, and *Range 3* is set for B_z. *Manual* range is denoted with ***mRng:x***, where *x* represents the *Range* number which is common for all of the components B_x, B_y and B_z (e.g. *mRng:3* means that selected range is *Manual Range 3*).

Note 1: When switching to the *Manual* range, the last used *Manual* range is set. To move to some other *Manual* range, go to *Range* setting in the *Setup* menu.

Note 2: For correct operation of the *Autorange* feature it is necessary to have all of four ranges calibrated. Otherwise, *SENIS* cannot guarantee the correct operation of *Autorange* function.
In such cases, *SENIS* recommends using of the *Manual* range settings for the calibrated ranges.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

6. DATA ACQUISITION SOFTWARE

By means of data acquisition software you can measure and display measured values of magnetic flux density and temperature, obtained from the Teslameter via USB communication.

In order to acquire the measurement results by this application, connect 3MH6 teslameter to PC by USB cable (use **USB 2.0 device port** connector on the 3MH6 front panel for this purpose).

Note: Before running the PC application for data acquisition it is needed to install "*LabView*[1] *Run-Time Engine 2016*". Please, find the "*LabView Run-Time Engine 2016*" folder on the USB flash stick supplied with device, and install the *LabView* run-time environment from it.

Data acquisition application is located at "*3D_3MH6_Teslameter*" folder (**3MH6.exe** in Figure 6.1).

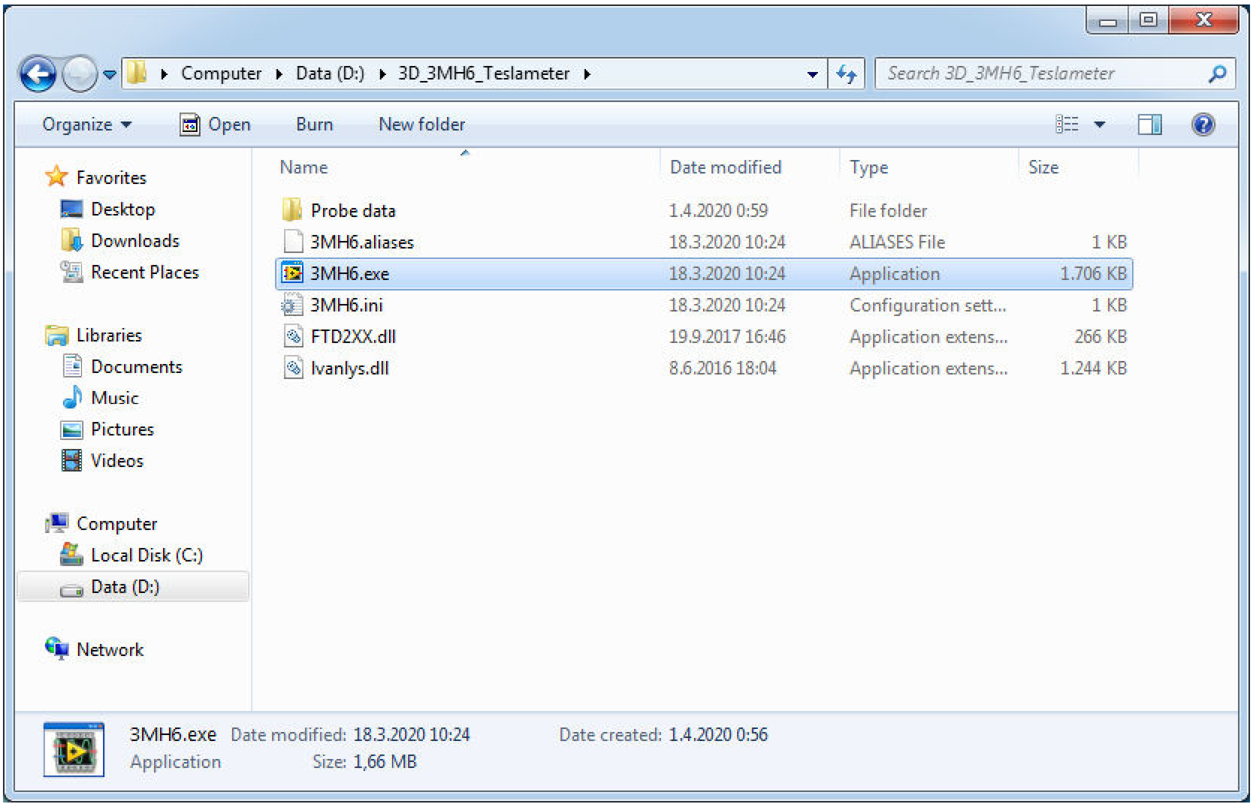


Figure 6.1 Data acquisition application location

The folder *Probe data* (Figure 6.1) contains the calibration configuration files for each probe delivered with your 3MH6 teslameter. Figure 6.2 shows an example of the *Probe data* folder content for the 3MH6 teslameter delivered with the three probes (the probes are denoted with their serial numbers: *0006-20*, *0007-20* and *0008-20*). As it can be seen from the Figure 6.2, there is a separate folder for each probe containing the configuration files for that probe.

Find *3MH6.exe* application and run it by double clicking on its icon.

[1] *LabVIEW* is registered trade mark of *National Instruments*

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

On running the *3MH6.exe* application, it automatically loads the data from the corresponding probe files located at *Probe data* folder.

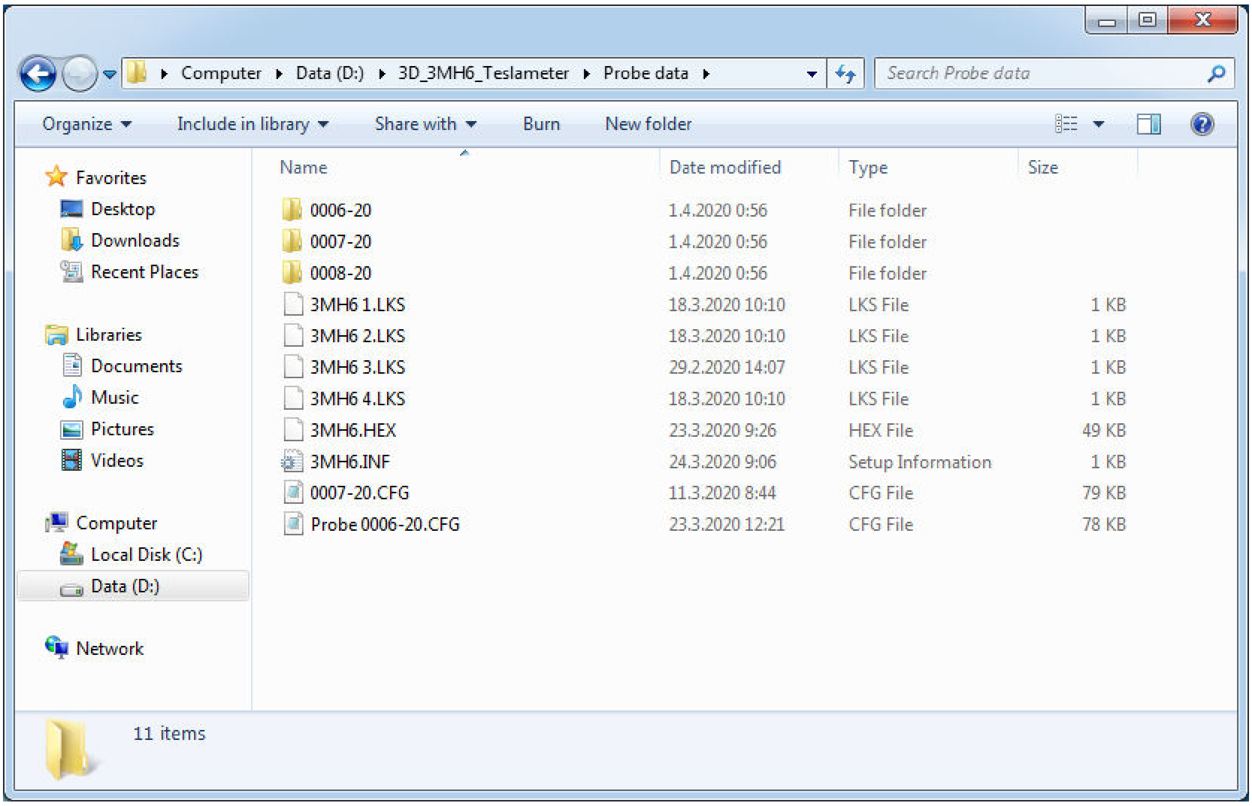


Figure 6.2 Example of the Probe data folder content for 3MH6 device delivered with 3 probes

6.1 Data Acquisition

Figure 6.3 shows the main window of the acquisition application (“*Data acquisition*“ tab).

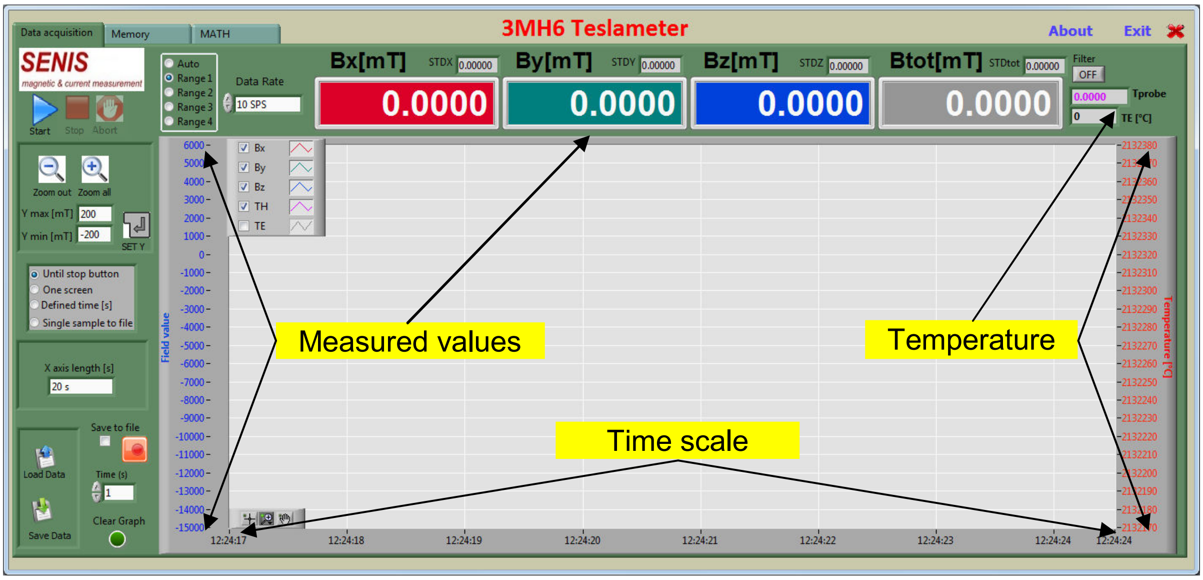


Figure 6.3 3MH6 Teslameter - Data Acquisition tab

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

On clicking the "*Start*" button (Figure 6.4) the data acquisition starts and all the other tabs are disabled.

Note 1: If the 3MH6 device is in *DC* measurement mode, all the magnetic flux density measurement results shown in this tab represent the averaged instantaneous values. Otherwise, if 3MH6 teslameter is in *AC* measurement mode, all the magnetic flux density measurement results shown in this tab represent the averaged RMS values.

Note 2: The measurement mode cannot be switched from *DC* to *AC* or vice versa from the PC data acquisition application, but only manually from the device GUI (see *5.5.1 Measurement Mode* section of this Manual).

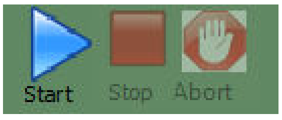


Figure 6.4 Acquisition control buttons („Start", „Stop" and „Abort")

6.1.1 Range Selection

3MH6 teslameter supports four measurement ranges that can be manually selected, as well as the *Autoranging* function (for more details on ranges selection see *5.5.2.1.3 Range* section of this Manual).

Note 1: On running the acquisition application, the "*Range 1*" is set automatically, as default. You may change the range by clicking the corresponding button (Figure 6.5). You need to select a calibration range that corresponds to the connected Hall probe.

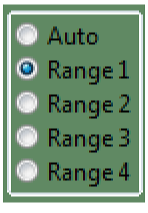


Figure 6.5 „Range" radio buttons

Note 2: For correct operation of the *Autorange* feature it is necessary to have all of four ranges calibrated. Otherwise, *SENIS* cannot guarantee the correct operation of *Autorange* function. In such cases, *SENIS* recommends using of the *Manual* range settings for the calibrated ranges.

Note 3: The range selection cannot be done while the data acquisition is in progress. In such cases, stop the acquisition first, and then change the range.

6.1.2 Data Rate (Sampling Rate)

Sampling rate can be changed by means of the "*Data Rate*" control. Clicking into the "*Data Rate*" field, a drop-down list appears with the following options: 10 SPS, 30 SPS, 50 SPS, 60 SPS, 100 SPS, 500 SPS, 1 kSPS, 2 kSPS, 3.75 kSPS and 7.5 kSPS (Figure 6.6).

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

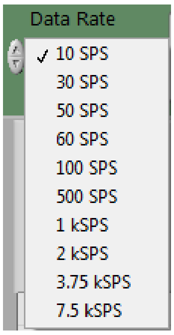


Figure 6.6 „Data Rate“ drop-down list

Note 1: On running the acquisition application, the sampling rate of 10 SPS is set automatically, as default.

Note 2: Sampling rate of 15 kSPS is not supported when 3MH6 teslameter is controlled by PC due to USB data rate limitation, but only for manual sampling rate setting.

Note 3: The sampling rate cannot be changed while the data acquisition is in progress. In such cases, stop the acquisition first, and then change the sampling rate.

For more details on sampling rate selection see *5.5.2.7.1 Sampling Rate* section of this Manual.

6.1.3 Acquisition Modes

User can select one of four modes of acquisition i.e. the condition which stops the acquisition (Figure 6.7).

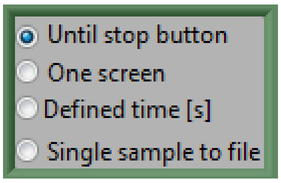


Figure 6.7 Acquisition modes

Data can be acquired:

1. Continuously until the “*Stop*“ button is clicked (“*Until stop button*“ option in Figure 6.7). <u>This is a default mode. In this mode the time interval shown on the time scale of the chart (X axis length in Figure 6.8) is fixed and depends on the sampling rate selected. The user cannot change it.</u>

2. Until one screen is plotted in the graph i.e. until time plot curve reaches the right edge of the chart (“*One screen“* option in Figure 6.7);

3. During some specified time (“*Defined time[s]*“ option in Figure 6.7). For this option data are acquired until specified time from “*Start*“ button click elapses (the time is set in the text field shown in Figure 6.8).

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

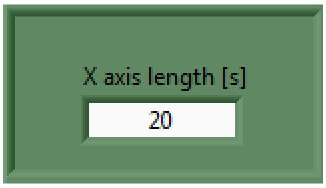


Figure 6.8 Setting time interval during which the data acquisition is performed

4. Continuously but only one sample storing to the output file when the user clicks on the "*Record*" button ("*Single sample to file*" option in Figure 6.7).

Note 1: For this option, before clicking the "*Start*" button, it is necessary to check "*Save to file*" check box.

After running the data acquisition, click on the "*Record*" button whenever you want to capture the current measurement in the output file (Figure 6.9). The output TXT file is automatically generated in the same folder where the application is. The file name contains date and time of the creation (i.e. date and time when the first sample has been written to it).

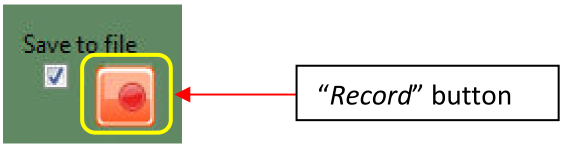


Figure 6.9 „Save to file" check box and „Record" button

Note 2: In "*One screen*" and "*Defined time[s]*" modes user can abort the acquisition before elapsing the specified time interval by clicking on the "*Abort*" button which is available only in these modes.

6.1.4 Saving and Loading Acquired Data

User can save acquired measurement data to a file or load previously acquired data from the saved file and show them on the screen.

6.1.4.1 Saving (All) the Data from Beginning till the End of the Acquisition

In order to save all the data from beginning of the data acquisition till the end of the acquisition (which is determined by the acquisition mode) into the file, the user must check "*Save to file*" check box (Figure 6.9) before running the acquisition. On running the acquisition, the output TXT file will automatically be created in the same folder with the application. The file name contains date and time of the creation (i.e. date and time when the first sample has been written to it).

Except for the "*Single sample to file*" acquisition mode, it is not necessary to click on the "*Record*" button in the other acquisition modes, but the data will automatically be stored into the output file after elapsing of the time defined in the "*Time (s)*" text field.

Figure 6.10 „Time (s)" text field which determines the output file storage interval

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

Note: if 0 is entered in the "*Time (s)*" text field (Figure 6.11), the application will capture **all** the measurement data (all the samples data) received from the 3MH6 teslameter. The number of received measurement results per second should be equal to the sampling rate in *DC* mode. For example, for sampling rate of 10 SPS, 10 measurement results per second will be stored into the output file. Also, for sampling rate 2 kSPS, 2000 measurement results per second will be stored into output file, and so on. In AC measurement mode, the number of measurement results stored in the file is mostly less than sampling rate and it depends on the frequency of the AC magnetic field.

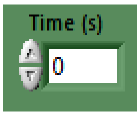


Figure 6.11 '0' set as the storage interval to store all the samples received from 3MH6 teslameter to the output file

6.1.5 Saving and Loading Only One Screen of the Acquired Data

If you want to store only the values that are currently shown in the chart, click on the "*Save Data*" button (Figure 6.12). A file dialog appears asking you for the file name and file location. The measured data are stored into the selected TXT file on clicking the *OK* button in the file dialog.

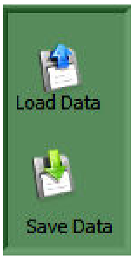


Figure 6.12 „Load Data" and „Save Data" buttons for loading and storing one screen data from/to file

For reviewing of the saved one screen data click "*Load Data*" button (Figure 6.12). This will plot B_x, B_y and B_z in the "*Data acquisition*" tab chart.

6.2 Offset Zeroing

The *Zeroing* can be run either by touching the "*Zero*" button on the 3MH6 teslameter display or from the Data Acquisition application by clicking the "*Zero Device Offset*" button in the „*MATH*" tab (Figure 6.13). Once the *Zeroing* has been finished, the new zeroing coefficients are automatically read out from device and shown in "X_0", "Y_0" and "Z_0" text fields (Figure 6.14).

If you only want to read the current zeroing coefficients without running the *Zeroing* function, click on the "*Read Offset from Device*" button.

For more details about *Zeroing* see *5.6 Zeroing* section of this Manual.

Note: for the best measurement results 3MH6 teslameter should be turned ON at least 15 minutes before starting the measurements. The same applies for the offset zeroing.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

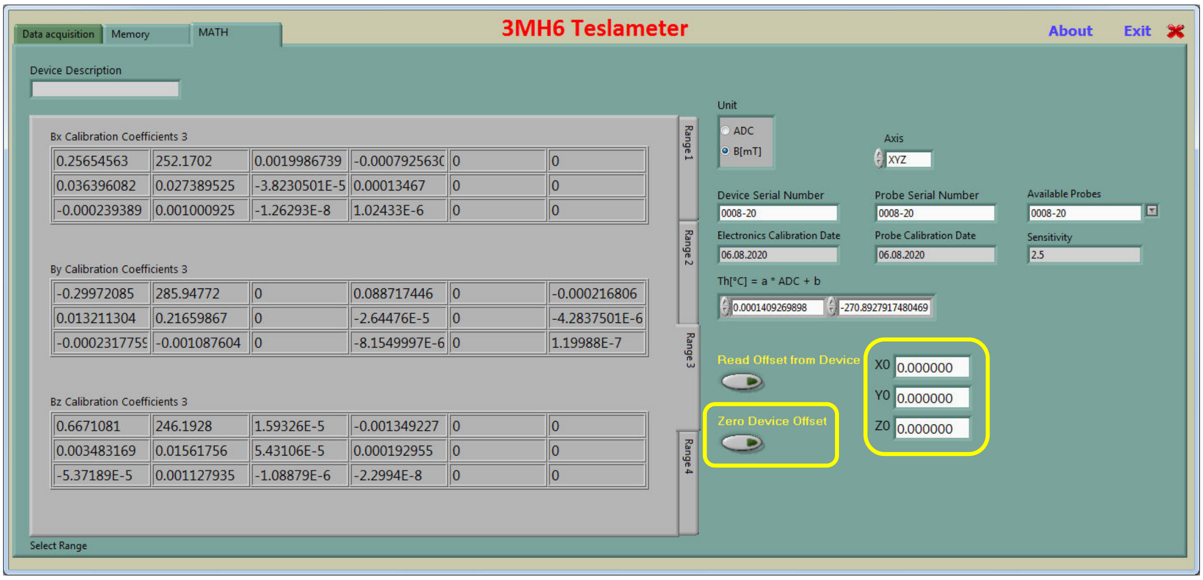


Figure 6.13 “Zero Device Offset” button and offset zero coefficients in “MATH” tab

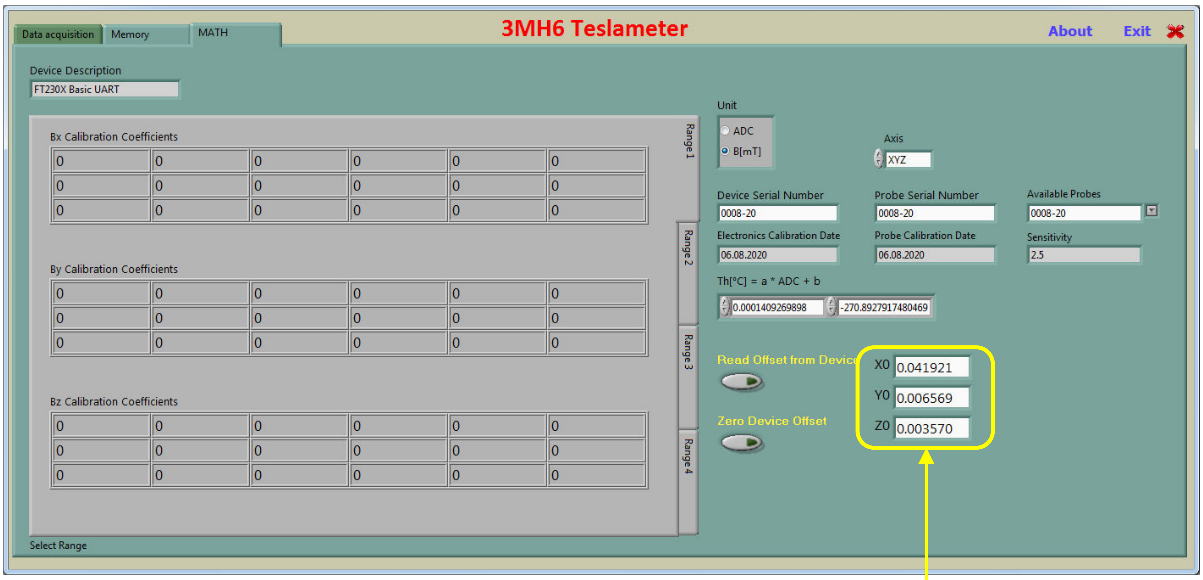


Figure 6.14 New zeroing coefficients obtained after running Zeroing function

New zeroing coefficients

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

6.3 Probe Replacement

Each probe is defined with its own set of calibration coefficients and after replacing the probe, the corresponding probe calibration coefficients data must be loaded into device.

Since the Android application version number *2.4.5 – 16Oct2020:1228*, the probe replacement became very easy. It is enough to switch off device, replace the probe, and turn on device again. On power-up, device detects that probe has been changed and automatically loads the calibration parameters from the probe EEPROM into the internal memory. While the calibration coefficients are loaded, the messages shown in Figure 6.15 and Figure 6.16 are displayed on the screen. As soon as the loading of the calibration coefficients has been finished, the message disappears from the screen, and device is ready for use.

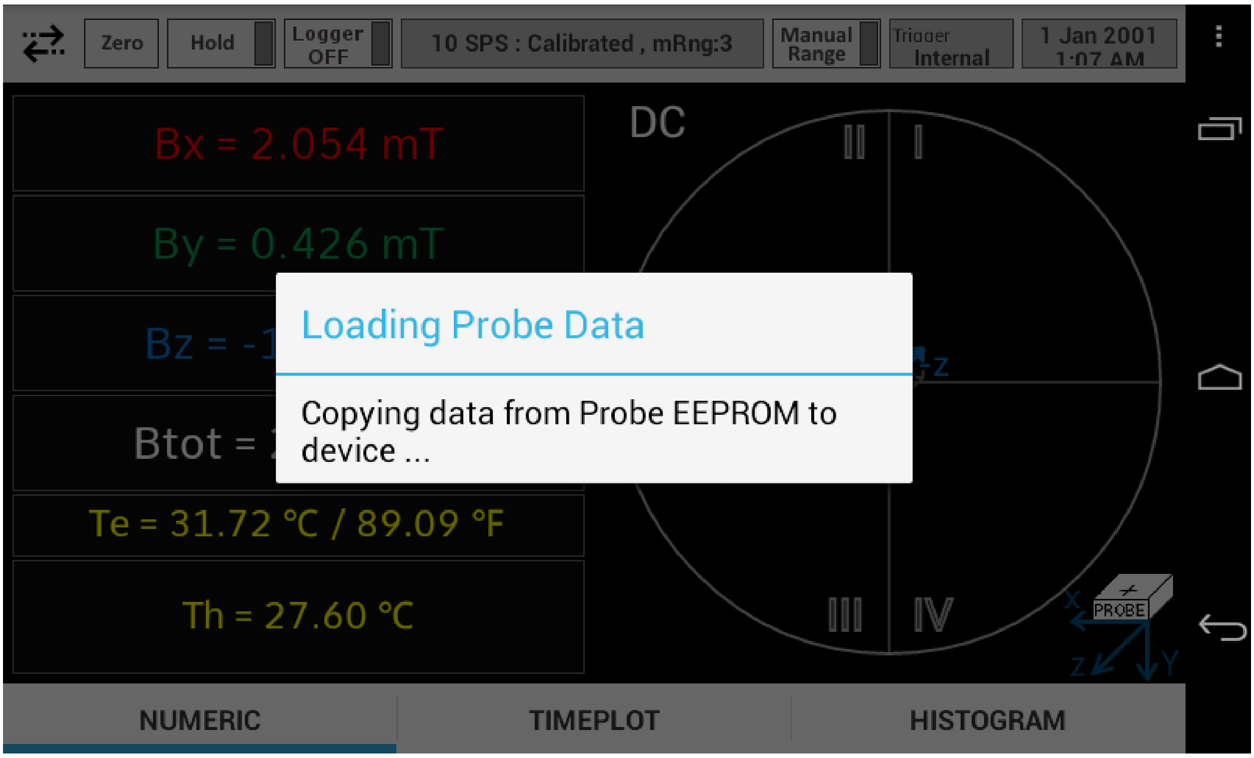


Figure 6.15 Loading of the probe calibration coefficients from the probe EEPROM into device

Note that messages shown in Figure 6.15 and Figure 6.16 appear only when device is powered up for the first time after the probe has been replaced.

Alternatively, it is still possible to load the probe calibration coefficients using the *Data Acquisition* application *3MH6.exe* as described in the following section (see *6.3.1 Loading Probe Calibration Coefficients into Device Using 3MH6.exe Application*). Use this feature if the automatic loading of the probe calibration coefficients is not possible for any reason.

IMPORTANT: 3MH6 TESLAMETER MUST BE TURNED OFF BEFORE CONNECTING / DISCONNECTING PROBE.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

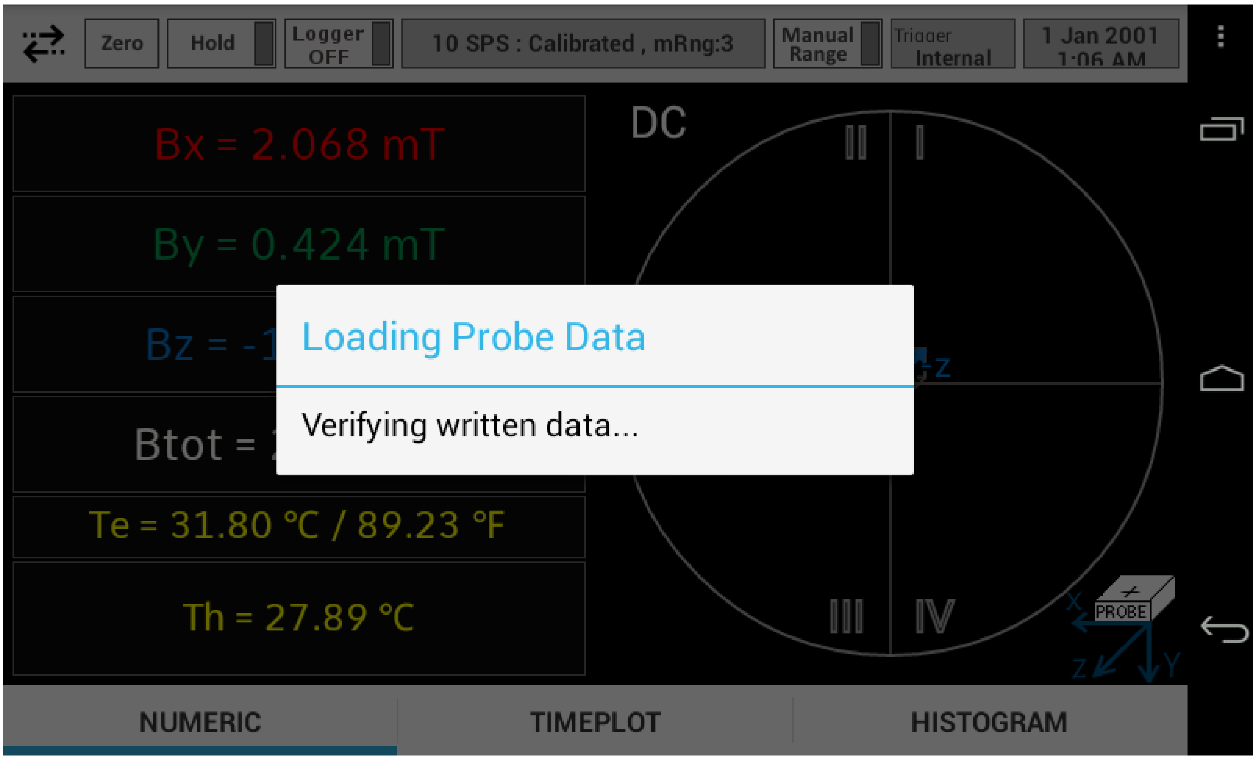


Figure 6.16 Verification of the copied probe calibration coefficents

6.3.1 Loading Probe Calibration Coefficients into Device Using 3MH6.exe Application

All the probe calibration coefficients are stored in the internal flash memory and teslameter uses these coefficients to calculate magnetic flux density based on the measured probe voltages and temperature.

In order to write the adequate probe calibration coefficients into device, follow the next procedure:

1. Connect the Hall probe.
2. Power on the 3MH6 teslameter.
3. Open appropriate probe folder containing the calibration files for the probe you want to use and run **3MH6.exe** application from this folder.
4. Click "*Start*" button in the "*Data acquisition*" tab just to establish the communication between 3MH6 teslameter and PC. After a couple of seconds, click on the "*Stop*" button.
5. Click on the "*MATH*" tab (Figure 6.17).

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

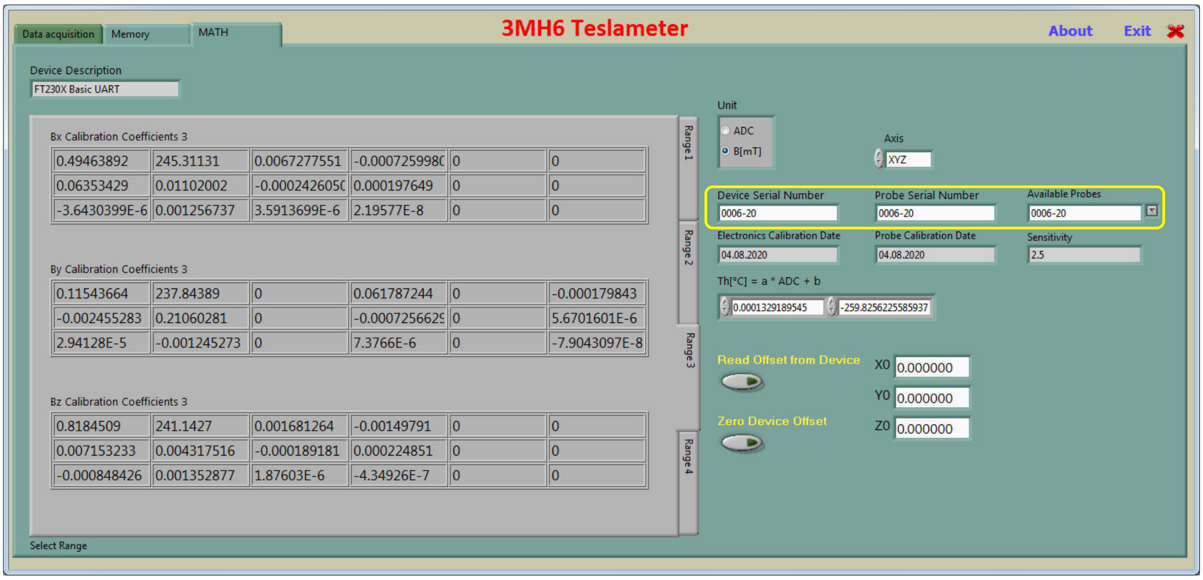


Figure 6.17 Mathematics parameters (calibration coefficients) in „MATH" tab

6. To ensure that you have run the correct application, check whether the device and probe serial numbers in the "*MATH*" tab match with the probe and device serial numbers you are working with (Figure 6.17).

   Note: If only one Hall probe is delivered with 3MH6 teslameter, the calibration coefficients for that probe are automatically loaded from the configuration files on running the application, so there's no need to select anything in the application.

   Nevertheless, if two or more Hall probes are delivered with the 3MH6 teslameter, you must select appropriate number of the probe whose calibration coefficients need to be loaded into device. The application keeps the data of the last used probe, so that on next running the application, the last used probe coefficients will be loaded. For this reason, make sure that "*Probe Serial Number*" shown in the application matches with the probe you connected to device. Otherwise, click in the "*Available probes*" field and from the drop-down list select the serial number of the probe you connected to the 3MH6 teslameter. An example of the drop-down list for the 3MH6 teslameter delivered with the three Hall probes is shown in Figure 6.18. Consider an example when the previously connected probe was "*0006-20*", but we want to connect the probe whose serial number is "*0008-20*". In this case, from the drop-down list shown in Figure 6.18, "*0008-20*" probe number should be selected.

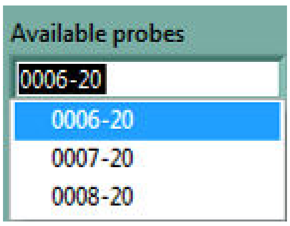


Figure 6.18 Example of available probes list for teslameter delivered with three probes

7. Once the new probe serial number is selected, 3MH6 acquisition application will ask you to confirm that you really want to load the calibration coefficients for the selected probe (Figure 6.19).

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

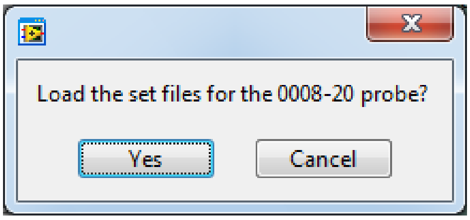


Figure 6.19 Confirmation dialog appearing after selecting another probe number

Click “*Yes*”.

8. The calibration coefficients for the selected probe are loaded from the “*Probe data/0008-20*” folder, and the message shown in Figure 6.20 appears.

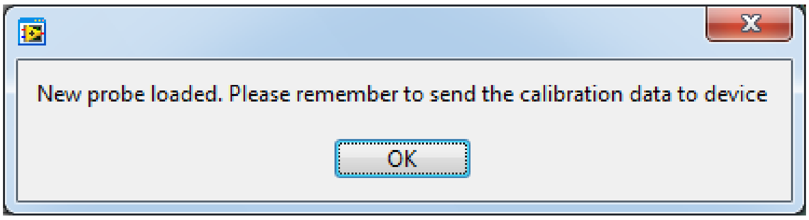


Figure 6.20 Message informing the user that new probe coefficients have been loaded in the application, reminding the user to write them into device.

9. The calibration coefficients loaded from the corresponding configuration files are shown in the “*MATH*” tab (Figure 6.21). Note that “*Probe Serial Number*” has been changed (it is “*0008-20*”now). The calibration coefficients for each of four measurement ranges are given in the corresponding tab on the left side of the “*MATH*” tab.

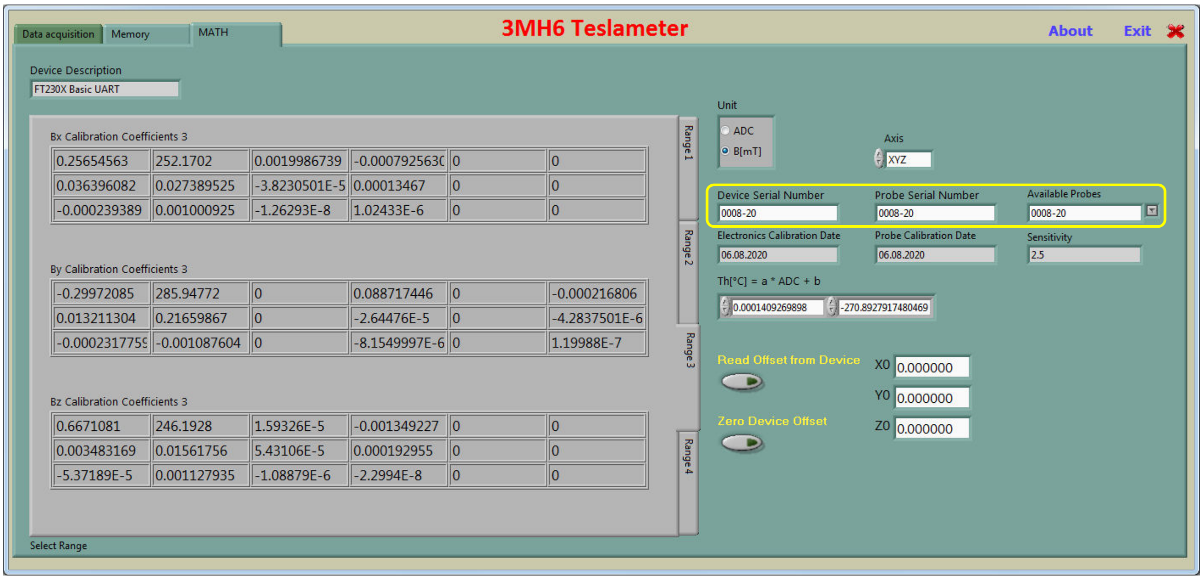


Figure 6.21 Mathematics parameters (calibration coefficients) in „MATH“ tab after changing the probe

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

Note 1: Check whether the calibration and temperature (*Th[°C] = a * ADC + b*) coefficients shown in the "*MATH*" tab contain **decimal dot as decimal symbol.** If the decimal symbol is not a decimal dot (.), but comma (,) it is necessary to set the *Windows®*[2] operating system to use the dot as a decimal symbol (to set the decimal symbol in *Windows®* go to *Control Panel / Region and Language / Additional settings / Decimal symbol*).

Having the correct decimal symbol is very important. Writing wrong values into the internal (flash) memory leads to incorrect and unstable device operation.

Note 2: For the correct device operation **don't change any other parameters shown in this tab** before writing the calibration coefficients into device.

10. Click on the "*Memory*" tab. The memory map is shown in this tab (Figure 6.22).

11. Click on the "*Refresh & Save MATH*" button to update the memory map in the screen, and after that click on "*Send to Device*" button to write the new coefficients into device internal (flash) memory (Figure 6.22).

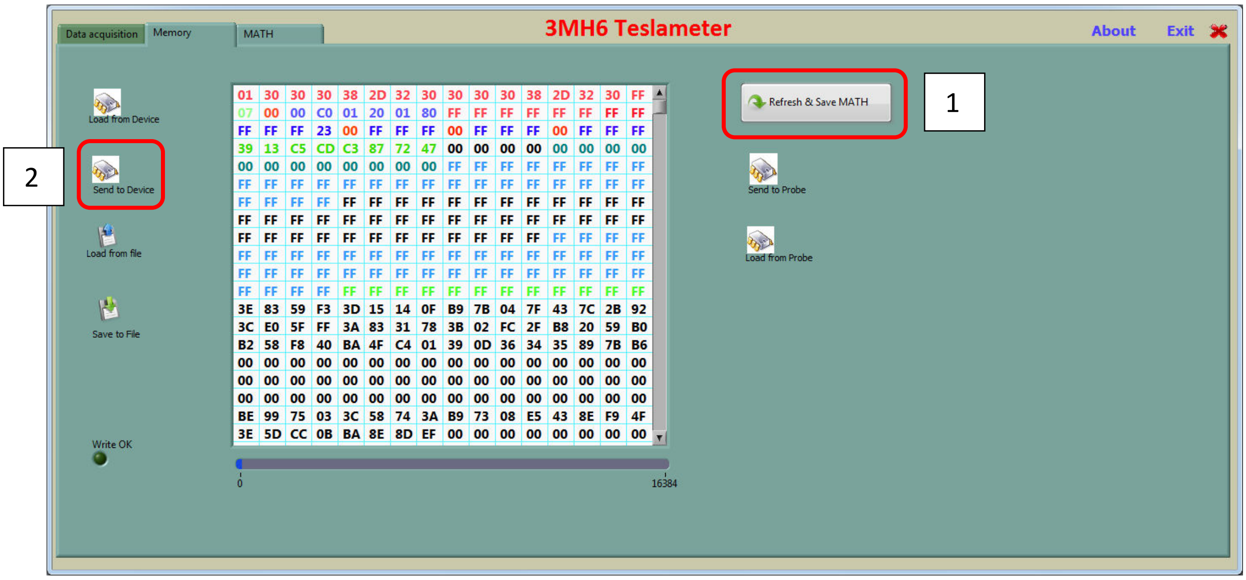


Figure 6.22 „Memory" tab

12. The writing process begins (Figure 6.23). The "*Write OK*" green LED is lit. Wait 4-5 minutes until the writing process is finished.

2 *Windows* is registered trademark of *Microsoft Corporation*

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

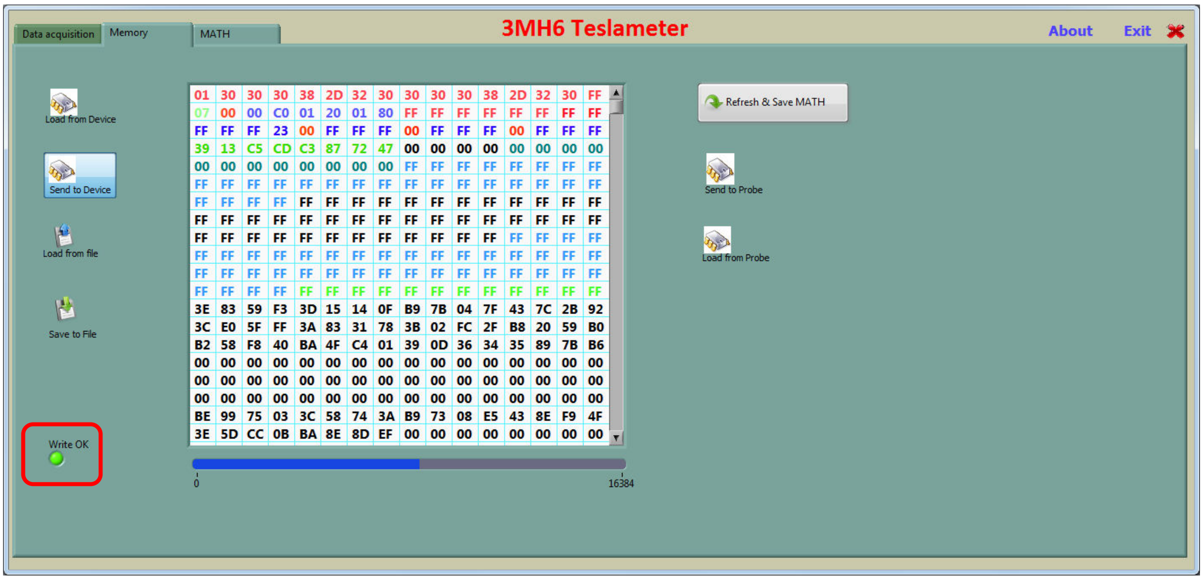


Figure 6.23 Writing calibration coefficients to the 3MH6 teslameter in progress

11. After all the calibration data have been successfully written into device, the message shown in Figure 6.24 appears.

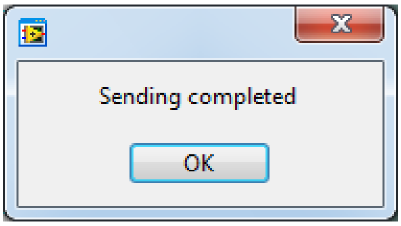


Figure 6.24 „Sending completed“ message

Click *OK*. Now, device is ready to be used with the new probe.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

7. MAINTENANCE

SENIS recommends an annual recalibration schedule for all its high-precision teslameters. Recalibration is always available from the *SENIS* factory.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

8. GENERAL SPECIFICATIONS

8.1 Characteristics

Unless otherwise noted, the given specifications apply for B-measurement channel at room temperature (23°C), and after a device warm-up time of 30 minutes. The specifications apply for combination Teslameter + Hall Probe.

Parameter	***Value***	***Remarks***
General		
Probe	3-axis Hall probe type C with CMOS integrated SenIC32 sensor chip	Interchangeable Hall probes with calibration data stored in an integrated EEPROM
Probe connector	22 pins LEMO plug	
Display	5'' TFT Capacitive Touch LCD, 800 x 480 pixels, 24-bit	Dimensions: **L** 120.7 x **H** 75.8 mm
Measured data recording	Data logging every (0.5 - 60) sec	Magnetic vector visualization
Operating system	Android™ 4.2.2 (*Jelly Bean*)[1]	
DC Measurements		
Measurement range	Up to ±20 T	Fully calibrated up to ±2 T
Calibrated ranges	Four selectable ranges	±100 mT, ±500 mT, ±2 T, ±20 T Note: ±20 T range is calibrated up to ±2 T
DC field measurement accuracy	< ±0.01% of full scale range, when the total magnetic flux density vector is along the probe chip axis	
Default sampling rate	10 SPS	Selectable sampling rate up to 15 kSPS
Trigger mode	*Internal*, *Single Shot*, *Continuous* and *Manual* triggering mechanisms	
Hall probe temperature measurement resolution	0.001 °C	Teslameter displays the probe's temperature in °C along with the field readings
Temperature coefficient of sensitivity	20 ppm/°C of reading	@Temperature range 23˚C ± 5˚C
Temperature coefficient of the offset	±1 µT/°C	@Temperature range 23˚C ± 5˚C

[1] *Android* is a trademark of *Google LLC*.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

Long-term instability of sensitivity	< 0.001% over a year	
Offset (@ B=0 mT)	< ± 20 µT	@Temperature range 23˚C ± 5˚C
Offset fluctuation and drift (Bw = 0.01 - 10 Hz)	< 1.5 µTrms	@2 T range: 1 µT for planar and 2 µT for perpendicular components of field
Noise Equivalent Magnetic Spectral Density (NSDw)	< 250 nT/Hz$^{1/2}$	
AC Measurements		
-3 dB bandwidth	1 Hz - 2.5 kHz (-3dB)	
Default sampling rate	3.75 kSPS as recommended	Selectable sampling rate up to 7.5 kSPS for AC frequency range ≥ 10 Hz.
Trigger mode	*Internal*, *Single Shot*, *Continuous* and *Manual* triggering mechanisms	
Interface		
PC interface	USB 2.0 device port	USB 2.0 host port and Ethernet to be implemented in one of next releases, for future use.
External trigger		
Input levels	High level: 4.5 V to 5 V Low level: 0 V to 1 V	*Absolute maximum external trigger input voltages [i] are -0.5 V and 6 V*
Continuous trigger frequency range	10 Hz ≤ $f_{trigger}$ < 7.5 kHz	
Analog output voltage		
Analog voltage output (corrected value for the nominal sensitivity of the probe)	Differential, available on radial BR2 connectors for all of three axes.	The signals on BR2 connectors can be used for observing magnetic flux density waveforms (by oscilloscope).
Analog output bandwidth	2.5 kHz	
Analog output resistance	< 50 Ohm	
Environmental Parameters:		
Operating temperature	+5°C to +45°C	
Storage temperature	-20°C to +85°C	
Size	**W** 240 x **H** 140 x **L** 260 mm	
Weight	Ca. 3.5 kg	
Electromagnetic	Complies with standard norms	

[i] Stresses above absolute maximum external input trigger voltages may cause permanent damage to the device. Exposure to absolute maximum conditions may degrade device reliability.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

9. PROBE SPECIFICATION

The *SENIS* Hall probe I3C-03C is a very thin 3-axis Hall-probe system that gives an analogue voltage output for all three components of the measured magnetic flux density and for the probe temperature. The probe contains a high-resolution Hall element and a temperature sensor.

The sensor chip is embedded in the probe package and connected to the flexible CaH cable, which makes the probe both, mechanically and electrically robust.

Standard Probe-to-Electronics cable length is 2 m.

All probes are factory calibrated against NMR PT2025. When the probes are interchanged, the probe calibration coefficients are automatically loaded from the probe EEPROM (see *6.3 Probe Replacement* section of this Manual).

Factory calibrated probes cannot be purchased independently of the 3MH6 teslameter.

Probe cables longer than 2 m are available, but these cable lengths can degrade the specifications. The testing results are available upon request.

9.1 Probe I3C-03C

Figure 9.1 Photo of probe I3C-03C

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

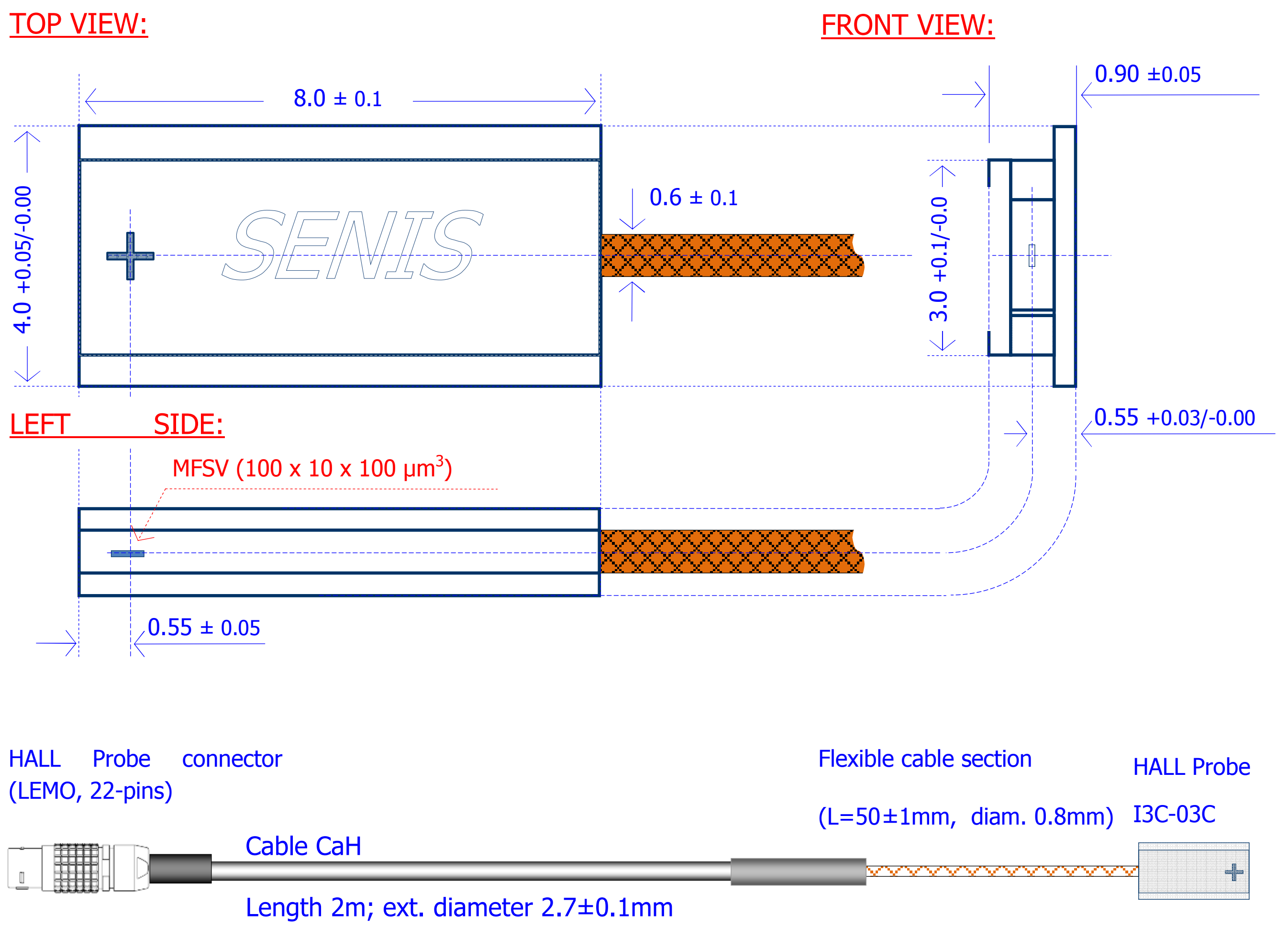


Figure 9.2 Dimensions of the I3C-03C Hall probe and cable (Module H).

Note: Different cable lengths are available upon a request.

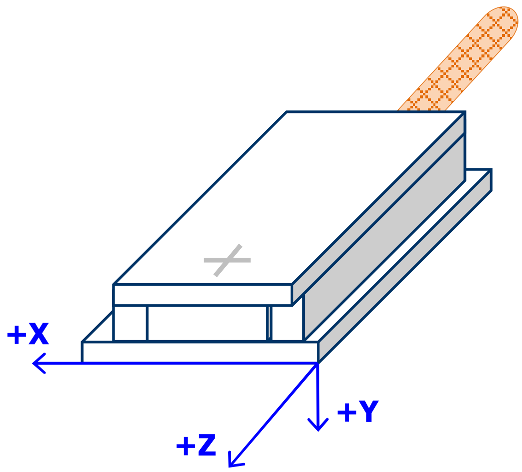


Figure 9.3 Reference Cartesian coordinate system of the SENIS I3C-03C Hall probe

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

Parameter			
Dimensions	X (mm)	Y (mm)	Z (mm)
Magnetic Field sensitive volume (MFSV)	0.10	0.01	0.10
Position of the centre of FSV	2.0 ± 0.05	-0.55± 0.05	-0.5 ± 0.05
External dimensions of the Probe	4.0 ± 0.05	0.90 ± 0.05	8.0 ± 0.05
Positioning accuracy			
Angular accuracy of axes with respect to the reference surface	±0.5°, Determined during calibration process		
Cable properties			
Tin cable:	Copper braided flexible cable, Ext. diameter 0.8mm		
Conductor:	Silver plated soft copper core, 7 x 44 AWG		
Length:	Standard: 2 m (H module notification: I3C-03C02L)		
Insulation:	PFA (Perfluoroalkoxy), diameter 0.30 mm		
Safe cable bending:	15 x Diameter		
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		

9.2 Installation Manual for the 03C Hall Probe:

Although the 03C probe is very robust with respect to its size, it should be handled with special care.

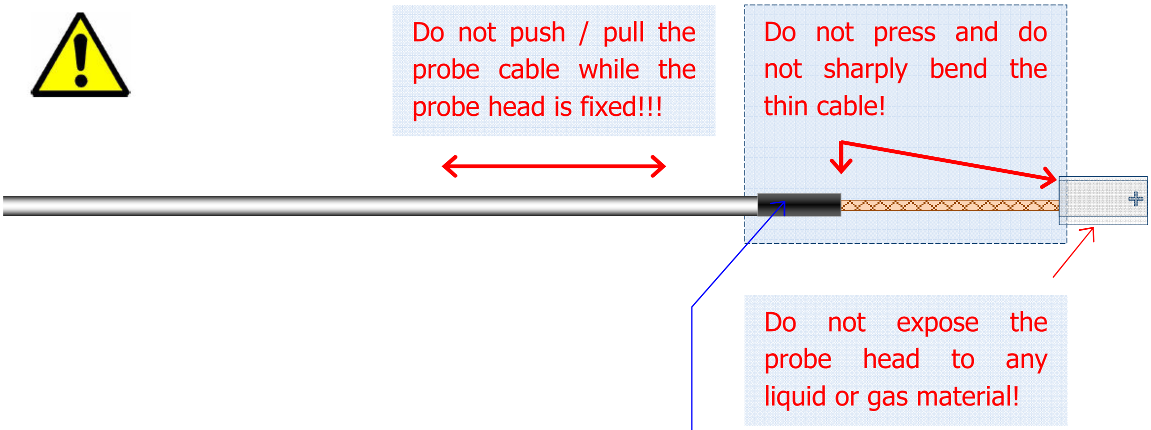
Considering that we deal with a high-precision device of very small dimensions, following precautions should help to avoid damage to the probe during installation and handling, and ensure that the device's accurate calibration remains preserved:

- The Hall Probe is sensitive to Electrostatic Discharge (ESD). Be sure to ground yourself and follow proper procedure when handling the Hall probe.
- Always turn off the electronics module before plugging/unplugging the Hall probe!
- The mounting of the Probe should be carried out by application of very low pressure to its head and particularly on the thin cable.
- Do not apply more force than required to hold the probe in its place. Damage to either the ceramics package of the Hall sensor or thin wiring could destroy the Probe. We strongly suggest storing the probe in its protective case when not in use.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

NOTE: The probe tip is fragile!
Please handle it with a special care.

- If the probe head is clamped, the user needs to make sure that the environment surface in contact with the reference plane of the probe is flat and covers as much of the probe reference surface as possible (see image below). Do not apply more force than required to hold the probe in its mounting.



- In order to prevent rupture of the thin probe wiring, the user should fix and secure the probe cable in the proximity of the head. The thin wires of the flexible section of the probe can be folded only with a special care. Any repetition sharp bending must be strongly avoided.
- Avoid any high pressure and bending of the transient section between the thin and thick Probe cables.
- Avoid the immersion of the probe of any liquid, and its exposure to moisture and aggressive gasses.

10. RECOMMENDED ACCESSORIES:

- Zero Gauss Chamber: ZG12-LN
- Probe Holder: PHS-DL
- Cable for analogue output voltage: COS20-A
- SENIS Transit Case for Teslameter

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

11. NOTES TO GENERAL SPECIFICATIONS:

1) The accuracy of the digital transducer is defined as the maximum difference between the actual measured magnetic flux density and that given by the transducer. In other words, the term accuracy expresses the maximum measurement error. After zeroing the offset at the nominal temperature, the worst case relative measurement error of the transducer is given by the following expression:

Max. Relative Error: $M.R.E. = S_{err} + NL + 100 \cdot Res / B_{LR}$ [unit: % of B_{LR}] Eq. [1]

Here, S_{err} is the tolerance of the sensitivity (relative error in percents of S), NL is the maximal relative nonlinearity error (see note 4), Res is the absolute resolution (Notes 6 - 10) and B_{LR} is the linear range of magnetic flux density.

2) The output of the measurement channel has two terminals and the output signal is the (differential) voltage between these two terminals. However, each output terminal can be used also as a single-ended output relative to common signal. In this case the sensitivity is approx. 1/2 of that of the differential output (*Remark: The single-ended output is not calibrated*).

3) The sensitivity is given as the nominal slope of an ideal linear function $V_{out} = f(B)$, i.e.

$$V_{out} = S \cdot B \quad \text{Eq. [2]}$$

where V_{out}, S and B represent transducer output voltage, sensitivity and the measured magnetic flux density, respectively.

4) The nonlinearity is the deviation of the function $B_{measured} = f(B_{actual})$ from the best linear fit of this function. Usually, the maximum of this deviation is expressed in terms of percentage of the full-scale input. Accordingly, the nonlinearity error is calculated as follows:

$$NL = 100 \cdot \left[\frac{V_{out} - V_{off}}{S'} - B \right]_{MAX} / B_{LR} \qquad (\text{for } -B_{LR} < B < B_{LR}) \qquad \text{Eq. [3]}$$

Notation:

B	Actual testing DC magnetic flux density given by a reference NMR Teslameter
$V_{out}(B) - V_{off}$	Corresponding measured transducer output voltage after zeroing the Offset
S'	Slope of the best linear fit of the function $f(B) = V_{out}(B) - V_{off}$ (i.e. the actual sensitivity)
B_{LR}	Linear range of magnetic flux density

The tolerance of sensitivity can be calculated as follows:

$S_{err} = 100 \times |S' - S|/S$

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

5) The planar Hall voltage is the voltage at the output of a Hall transducer produced by a magnetic flux density vector co-planar with the Hall plate. The planar Hall voltage is approximately proportional to the square of the measured magnetic flux density. Therefore, for example:

$$\left.\frac{V_{planar}}{V_{normal}}\right|_{@\,B=20T\,(DC)} = 4 \cdot \left.\frac{V_{planar}}{V_{normal}}\right|_{@B=10T\,(DC)} \qquad \text{Eq. [4]}$$

Here, V_{normal} denotes the normal Hall voltage, i.e., the transducer output voltage when the magnetic field is perpendicular to the Hall plate.

6) This is the *"6-sigma"* peak-to-peak span of offset fluctuations with sampling time Δt=0.05s and total measurement time t=100s. The measurement conditions correspond to the frequency bandwidth from 0.01Hz to 10Hz. The *"6-sigma"* means that in average 0.27% of the measurement time offset will exceed the given peak-to-peak span. The corresponding root mean square (RMS) noise equals 1/6 of "Offset fluctuation & drift".

7) Total output RMS noise voltage (of all frequencies) of the transducer. The corresponding peak-to-peak noise is about 6 times the RMS noise. See also Notes 8 and 9.

8) Maximal signal bandwidth of the transducer, determined by a built-in low-pass filter with a cut-off frequency f_T. In order to decrease noise or avoid aliasing, the frequency bandwidth may be limited by passing the transducer output signal trough an external filter (see Notes 9 and 10).

9) The resolution of the transducer is the smallest detectable change of the magnetic flux density that can be revealed by the output signal. The resolution is limited by the noise of the transducer and depends on the frequency band of interest.

The DC resolution is given by the specification "Offset fluctuation & drift" (see also Note 6).The worst-case (AC resolution) is given by the specification "Broad-band noise" (see also Note 7). The resolution of a measurement can be increased by limiting the frequency bandwidth of the transducer. This can be done by passing the transducer output signal trough a hardware filter or by averaging the measured values. (Caution: filtering produces a phase shift, and averaging a time delay!) The RMS noise voltage (i.e. resolution) of the transducer in a frequency band from f_L to f_H can be estimated as follows:

$$V_{nRMS\text{-}B} \approx \left[NSD_{1f}^2 \cdot 1Hz \cdot \ln\left(\frac{f_H}{f_L}\right) + 1.57 \cdot NSD_W^2 \cdot f_H \right]^{1/2} \qquad \text{Eq. [5]}$$

Here NSD_{1f} is the *1/f* noise voltage spectral density (RMS) at f=1Hz; NSD_w is the RMS white noise voltage spectral density; f_L is the low, and f_H is the high-frequency limit of the bandwidth of interest; and the numerical factor *1.57* comes under the assumption of using a first-order low-pass filter. For a DC measurement: f_L*=1/measurement time*. The high-frequency limit cannot be higher than the cut-off frequency of the built-in filter f_T: $f_H \leq f_T$. If the low-frequency limit f_L is higher than the corner frequency f_C, then the first term in Eq. (5) can be neglected; otherwise: if the high-frequency limit f_H is lower than the corner frequency f_C, than the second term in Eq. (5) can be neglected. The corresponding peak-to-peak noise voltage can be calculated according to the *"6-sigma"* rule, i.e. $V_{nP\text{-}P\text{-}B} \approx 6 \times V_{nRMS\text{-}B}$.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

10) According to the sampling theorem, the sampling frequency must be at least two times higher than the highest frequency of the measured magnetic signal. Let us denote this signal sampling frequency by f_{samS}. However, in order to obtain the best signal-to-noise ratio, it is useful to allow for over-sampling (this way we avoid aliasing of high-frequency noise). Accordingly, for best resolution, the recommended physical sampling frequency of the transducer output voltage is $f_{samP} > 5 \times f_T$ (or $f_{samP} > 5 \times f_H$), if an additional low-pass filter is used (see Note 9). The number of samples can be reduced by averaging every N subsequent samples, $N \leq f_{samP} / f_{samS}$.

11) When measuring fast-changing magnetic fields, one should take into account the transport delay of the Hall signals, small inductive signals generated at the connections Hall probe–thin cable, and the filter effect of the electronics in the E-Module. Approximately, the transducer transfer function is similar to that of a first-order low-pass filter, with the bandwidth from DC to f_T. The calibration table of the frequency response is available as an option.

12) The switching "noise" is a periodic signal at fsw = 8.00 kHz and the related harmonics. It is due to the switching transients produced by the so-called spinning current process in the Hall elements. When performing A/D conversion of the transducer output signal, the sampling rate should be well above 2 x fsw in order to avoid aliasing of the switching noise. The switching noise can be efficiently suppressed by averaging the transducer signal over a time period N x 1/fsw, with N being an integer number.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

12. APPENDIX – COMMUNICATION PROTOCOL OVERVIEW

This chapter contains information referring to remote control of the 3MH6 teslameter.

12.1 General on Communication Protocol

The remote control is supported over USB interface which is available on **USB 2.0 device port** connector.

USB emulates RS-232 serial interface. For this reason, the host computer virtual COM port must be configured as shown in the Table 12.1.

Baud rate	3 Mbps
Data bits	8
Parity	None
Stop bits	1
Flow control	None

Table 12.1 COM port settings

Note that Baud rate is 3 megabauds.

Host computer (PC) initiates each communication, sending the commands. Teslameter responds to every command.

The time needed for the teslameter to respond to the command varies from command to command, depending on the complexity of the requested operation. This should be taken into account if the serial port time out is needed to be set. One second timeout is enough for the most of the commands.

Unless otherwise stated, the pause between the successive commands sending should not be less than one second.

The command length is different. Some commands contain only one ASCII character which represents the command identifier. The other ones, besides identifier contain the parameter bytes which determine the specific action of the command.

The response length also differs for different command types. Some responses contain only one ASCII character representing the response identifier. Nevertheless the most of them contain multiple bytes. Some responses even don't contain the response identifier, but only the string message.

Note 1: The commands and responses that contain more than one byte may be terminated with the carriage return character to denote the end of the message, but it is not always the case.

Note 2: Only the response to the broadcast command contains *LRC* checksum (*Longitudinal Redundancy Check*).

All the data are sent big-endian (most significant **byte** first) on the wire.

If the command contains illegal command identifier or command parameter, 3MH6 teslameter responds with '?'.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

12.2 Used Conventions and Abbreviations

In the following sections all the commands will be described in more details. For the command and response structure description the following conventions and abbreviations will be used:

[ ] – command/response block containing one or more data bytes;

< > – variable command parameter or response return code (data type of such blocks varies depending on the specific command and response type; it may be an ASCII character, string, byte, 16-bit integer, 32-bit integer or 32-bit floating point value

‘’ – ASCII character literal

“” – ASCII string literal

{} – numeric literal

0x – prefix denoting hexadecimal value

d – suffix denoting direct (ADC) integer value of magnetic flux density or the temperature e.g. Bx**d**, By**d**, Bz**d**, Th**d**, Te**d**

c – suffix denoting calibrated 32-bit floating point value of magnetic flux density or the temperature e.g. Bx**c**, By**c**, Bz**c**, Th**c**, Te**c**

MSB - **M**ost **S**ignificant **Byte**

LSB - **L**east **S**ignificant **Byte**

[MSB:LSB] – denotes that response return code value contains multiple bytes (16-bit integer, 32-bit integer or 32-bit floating point value). For example, the term <x**[3:0]**> denotes that return code named *x* consists of 4 bytes, where the 3 denotes MSB (Most Significant Byte) and 0 denotes the LSB (Least Significant Byte) byte. This notation emphasizes that multiple bytes blocks are always sent with most significant byte first (big-endian).

Note: the brackets, apostrophes, quotation marks, columns, and *0x* prefixes mentioned above are **not** sent in the actual commands and responses. They are only used in this Manual to ease the understanding of the commands and responses structure as well as the data types used.

12.3 Commands Description

12.3.1 Calibrated/Direct Mode Commands

These commands are used for setting the operation mode of the 3MH6 teslameter. The teslameter may be set either to *Calibrated* or *Direct* (*ADC*) mode. Choosing between these two options determines the data format of the response to the broadcast command (*'B' command, see 12.3.2 Broadcast Command* section of this Manual), but also the format of the measurement results shown on the display.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

The *Calibrated* mode is a default mode. In this mode, the 3MH6 teslameter responds the averaged measurement results expressed in the millitesla (mT) for magnetic flux density and in degrees Celsius (°C) for Hall probe and electronics temperature.

In the *Direct (ADC)* mode, 3MH6 teslameter responds the averaged raw measurement values got directly from A/D converters. These are integer values without formatting. Direct mode is mainly used in 3MH6 teslameter production process for calibration purposes. It is not a user mode.

The commands for switching between *Calibrated* and *Direct* mode are listed in the Table 12.2.

PC command	3MH6 response	Description
[‘C’]	**[‘c’]**	Command sets device into *Calibrated* mode
[‘D’]	**[‘d’]**	Command sets device into *Direct* mode

Table 12.2 Calibrated/Direct mode commands

Sending these commands to 3MH6 teslameter has the same effect as setting the *BSelector* option on the 3MH6 teslameter display (see *5.5.3 BSelector* section of this Manual).

12.3.2 Broadcast Command

Broadcast command (*'B'*) is the main command for the acquisition of the measurement data from the 3MH6 teslameter. On receiving the command, 3MH6 teslameter runs the data acquisition, continuously measuring and sending the measured values of magnetic flux densities for all of three axes (B_x, B_y and B_z), the Hall probe temperature (T_h) and the electronics temperature (T_e).

The format of the responded data depends on the operation mode of the device (*Calibrated* or *Direct* (*ADC*)). See the *12.3.1 Calibrated/Direct Mode Commands* section of this Manual for more details about *Calibrated* and *Direct* mode.

Table 12.3 shows the structure of the response **packet** to the *'B'* command in the *Calibrated* and *Direct* mode.

In the ***Calibrated*** mode teslameter sends the calculated (formatted) measurement results as a **32-bit floating point numbers** for all the measured values. The exception is electronics box temperature which is sent in two formats: 32-bit floating point value (*Tec*), but also as 16-bit integer direct (ADC) value (*Ted*).

Note 1: The magnetic flux densities in the response to the *'B'* command in *Calibrated* mode represent the averaged instantaneous values in DC mode and averaged RMS values in the AC mode. They are always expressed in milliteslas no matter the unit and unit submultiple selected/shown on the 3MH6 teslameter display.

Note 2: The Hall probe temperature (*Thc*) and electronics box temperature (*Tec*) are expressed in degrees Celsius

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

PC command	3MH6 response	Description
['B']	***Calibrated* mode:** **['B']** **[<Bxc [3:0]>]** **[<Thc [3:0]>]** **[<Byc [3:0]>]** **[<Bzc [3:0]>]** **[<Ted [1:0]>]** **[<Tec [3:0]>]** **[<LRC>]** **[{0x0D}]**	Command starts measurement data acquisition for the magnetic flux densities, Hall probe temperature and electronics box temperature. <Bxc> – calibrated magnetic flux density of X axis in mT (4 B) <Byc> – calibrated magnetic flux density of Y axis in mT (4 B) <Bzc> – calibrated magnetic flux density of Z axis in mT (4 B) <Thc> – calibrated Hall probe temperature in °C (4 B) <Ted> – direct (ADC) electronics box temperature (**2** B) <Tec> – calibrated electronics box temperature in °C (4 B) <LRC> – LRC check sum (1 B) 0x0D – end of the message (carriage return) **Total response length: 25 B** **Note 1:** All the measurement results are represented as 32-bit floating point values except Ted which is represented by **16-bit integer** value.
	***Direct* (*ADC*) mode:** **['B']** **[<Bxd [3:0]>]** **[<Thd [3:0]>]** **[<Byd [3:0]>]** **[<Bzd [3:0]>]** **[<Ted [1:0]>]** **[<Teci [3:0]>]** **[<LRC>]** **[{0x0D}]**	Command starts measurement data acquisition for the magnetic flux densities, Hall probe temperature and electronics box temperature. <Bxd> – direct (ADC) magnetic flux density of X axis (4 B) <Byd> – direct (ADC) magnetic flux density of Y axis (4 B) <Bzd> – direct (ADC) magnetic flux density of Z axis (4 B) <Thd> – direct (ADC) Hall probe temperature (4 B) <Ted> – direct (ADC) electronics box temperature (**2** B) <Tec**i**> – **integer** calibrated electronics box temperature (4 B) <LRC> – LRC check sum (1 B) 0x0D – end of the message (carriage return) **Total response length: 25 B** **Note 2:** All the measurement results are represented as integer values. All of them are 32-bit values except Ted which is **16-bit** value. **Note 3:** Unlike Tec in *Continuous* mode which represents 32-bit floating point value, Teci represents the integer value obtained after the floating point value of Tec had been multiplied by 100, while the rest of decimals had been cut off. For example, if the electronics box temperature Tec is 25.43 °C, Tec**i** will be 2543.
	***BSelector* in *Max* mode:** **["B-selector is in Max mode. Make sure that the device is in Calibrated or ADC to Broadcast the data"]**	Command cannot run the broadcasting if the *BSelector* option has been set to *Max* mode. **Total response length: 98 B** **Note 4:** The response message text is terminated with line feed (0x0A) **Note 5: This response is NOT terminated with carriage return.**
	***BSelector* in *Min* mode:** **["B-selector is in Min mode. Make sure that the device is in Calibrated or ADC to Broadcast the data"]**	Command cannot run the broadcasting if the *BSelector* option has been set to *Min* mode. **Total response length: 98 B** **Note 6:** The response message text is terminated with line feed (0x0A) **Note 7: This response is NOT terminated with carriage return.**

Table 12.3 Broadcast command and its response in different operation (BSelector) modes

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

On the other hand, in the ***Direct*** mode, the teslameter sends the measurement results as **32-bit integer numbers** obtained after averaging data got from the A/D converters. The exception is again electronics box temperature which is sent in two formats: 16-bit integer direct (ADC) value (*Ted*) as well as 32-bit integer calibrated value (*Teci*).

The measurement data are responded until the stop command is received (*'S'*). See *12.3.3 Stop Command* section of this Manual for details about the *Stop* command.

Note: the broadcasting cannot be run if *BSelector* option is set either to *Max* or *Min* mode (available only from the 3MH6 teslameter GUI, see *5.5.3 BSelector* section of this Manual for details). For this reason, the command for setting device either to *Calibrated* or *Direct* mode (*'C'* or *'D'* commands, depending on the needs) should be sent before running the data acquisition by the *'B'* command.

12.3.2.1 Electronics Box Temperature Formats in *Calibrated* and *Direct* Modes

The direct (ADC) value of electronics box temperature (Ted) is the only 16-bit value sent both in the *Calibrated* and *Direct* mode. In the *Calibrated* mode it is the only measured value that is sent as integer number.

The calibrated value of electronics box temperature (Tec) is obtained as:

$$T_{ec} = \frac{T_{ed}}{128}. \qquad \text{Eq. [1]}$$

It represents the electronics box temperature expressed in degrees Celsius, and it is sent together with direct value (*Ted*) in *Calibrated* mode as a 32-bit floating point number (see Table 12.3).

However in *Direct* mode, the 32-bit integer value ***Teci*** (obtained by multiplication of *Tec* by 100 followed by truncating the decimals) is sent together with direct value (*Ted*). For example, if Teci = 2543, it means that actual electronics box temperature is 25.43 °C.

12.3.2.2 Example of 'B' Command Response Packet in *Calibrated* Mode

An example of *'B'* command response packet in *Calibrated* mode is given below:

42	42 EB 5D A9	41 C6 EE 80	C2 9D F4 B3	42 B9 E1 0E	10 41	42 02 08 00	CB	0D
'B'	**Bxc**	**Thc**	**Byc**	**Bzc**	**Ted**	**Tec**	**LRC**	**End of Message**

After the conversion of data contained in the packet which is shown above, from hexadecimal to the decimal numbers, the following results are obtained:

Bxc = 0x42EB5DA9 = 117.682 mT
Thc = 0x41C6EE80 = 24.866 °C
Byc = 0xC29DF4B3 = -78.978 mT
Bzc = 0x42B9E10E = 92.94 mT
Ted = 0x1041 = 4161 (this is integer value) $\Rightarrow$ Tec = 4161/128 = 32.508 °C
Tec = 0x42020800 = 32.508 °C
LRC = 0xCB

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

12.3.2.3 The Number of Response Packets per Second

The number of *'B'* command response packets per second depends on the sampling rate both for the *DC* and *AC* mode.

The 3MH6 teslameter acquires the measurement results for certain period of time (100 ms or 2 seconds), and sends the response packets in groups every 100 ms. Each packet group refers to the latest acquisition time (i.e. it contains the measurement results that refer to last 100 ms or last 2 seconds depending on the device mode).

In *DC* measurement mode, the overall number of response packets per second is the same as the sampling rate both for the *Calibrated* and *Direct* (*ADC*) mode. For example: if the sampling rate is 100 SPS, the 3MH6 teslameter will respond 100 packets per second. If the sampling rate is increased e.g. to 3750 SPS, the number of response packets will be 3750 per second. Nevertheless, as stated above, these packets are sent in 100-ms groups of packet, while each group contains 10% of overall number of packets. For the previous example, where the overall packets number was 3750 (for sampling rate of 3750 SPS), each 100-ms group would contain 375 packets (10% of total number of packets).

On the other hand, in AC measurement mode, the overall number of *'B'* command response packets per second in the *Calibrated* operation mode depends not only on the sampling rate, but also on the frequency of the measured signal and the corresponding frequency range (for more details about the frequency range selection see the *5.5.1.2 AC Mode* section of this Manual).

If the selected frequency range is *Greater than 10 Hz*, the number of response packets per 100 ms is:

$$N_{100ms} = 0.1 \cdot f_{samp} - \frac{f_{samp}}{f_m} + 1, \qquad \text{Eq.[2]}$$

where:

N_{100ms} is the number of *'B'* command response packets per 100-millisecond group that refer to the last 100-ms time interval,

f_{samp} is the sampling rate i.e. the frequency of sampling,

f_m is the measured frequency of the AC magnetic field (the frequency that is shown on the 3MH6 teslameter display).

Similar to *DC* mode, each 100-ms packet group refer to the measurements acquired during the last 100 ms.

Otherwise, if the selected frequency range is *Less than or equal to 10 Hz*, the acquisition time is not 100 ms as in the previous cases, but 2 seconds. Nevertheless, the packets are still sent in packet groups every 100 ms. The number of response packets per 100 ms is:

$$N_{2s} = 200 - \frac{100}{f_m} + 1, \qquad \text{Eq.[3]}$$

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

where:

N_{2s} is the number of *'B'* command response packets per 100-millisecond group that refer to the last 2 seconds time interval,

f_m is the measured frequency of the magnetic field (the frequency that is shown on the 3MH6 teslameter display).

The sampling rate in this frequency range is fixed to 100 SPS, and this is the reason why the number of packets does not depend on the sampling rate, but only on the frequency of the magnetic field.

Note: the packet group for *Less than or equal to 10 Hz* frequency range which contains the packet count expressed in equation [3] is sent every 100 ms, but it refers to the last 2 seconds time interval.

In *Direct* (*ADC*) mode, the overall number of *'B'* command response packets per second is the same as the sampling rate no matter whether the measurement mode is *DC* or *AC*.

12.3.2.4 LRC

LRC field (*Longitudinal Redundancy Check*) in the *'B'* command response packets represents the checksum field that is used for communication errors detection.

Note: The *LRC* field is implemented only in the *'B'* command response packets, because it is the longest response packet in the communication protocol (its length is 25 bytes).

It is calculated by summing all the bytes in the *'B'* command response packet except the first one and the last one (i.e. except the framing bytes 0x42 (*'B'*) and 0x0D), discarding the carry from LRC most significant bit, finally applying the two's complement to the obtained sum.

For example given in *12.3.2.2 Example of 'B' Command Response Packet in Calibrated Mode* section of this Manual:

42	42 EB 5D A9	41 C6 EE 80	C2 9D F4 B3	42 B9 E1 0E	10 41	42 02 08 00	**CB**	0D
'B'	**Bytes used for LRC calculation**						**LRC**	End of Message

Sum of all the bytes used for LRC calculation = 0x**A**35

After discarding the carry from LRC most significant bit (modulo 256 sum) = 0x35

Finally, after applying two's complement, **LRC = 0xCB**.

12.3.2.5 Broadcast Command and Triggering

In the external trigger mode (*Single Shot* or *Continuous*) and *Manual* trigger mode, the 3MH6 teslameter does not send any response to the broadcast command (*'B'*) until the corresponding triggering event appears. Once the triggering event appears, the 3MH6 teslameter begins to respond to the broadcast command in the same way as it is in the *Internal* trigger mode.

Nevertheless, the triggering mode defines how long the teslameter will respond to the *'B'* command.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

In the *Continuous* trigger mode, the teslameter responds to the *'B'* command as long as the correct triggering sequence of pulses is applied to the external triggering input.

On the other hand, in the *Single Shot* external trigger mode and *Manual* trigger mode, the teslameter responds to the *'B'* command until the selected *Measurement Time Interval* expires. For details about the *Measurement Time Interval* selection see chapters *5.5.2.6.2.1 Single Shot Trigger Mode* and *5.5.2.6.3 Manual Trigger Mode* of this Manual.

If the broadcast command has been received after the 3MH6 teslameter had already been triggered, the teslameter responds immediately, because it has already acquired the measurement results, and they are ready for sending.

12.3.3 Stop Command

The Stop command (*'S'*) stops the broadcasting of the measurement results initiated by the *'B'* command (Table 12.4).

PC command	3MH6 response	Description
['S']	**['s']**	Command stops the broadcasting of the measurement results initiated by the *'B'* command

Table 12.4 Stop command

12.3.4 Commands for Sampling Rate Setting/Reading

Commands for the sampling rate setting and reading are listed in the Table 12.5.

<u>The format of the response to both of commands is the same.</u>

Note: <u>**The maximal sampling rate that can be used for the data acquisition from 3MH6 teslameter is 7.5 kSPS.** Although the sampling rate of 15 kSPS can be set, it should not be used for data acquisition over USB due to limitation of the serial port Baud rate (USB emulates RS232 serial port communication, and its Baud rate is limited to 3 megabauds).</u>

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

<table>
<tr><th>PC command</th><th>3MH6 response</th><th>Description</th></tr>
<tr><td>[‘K’] [<sr>]

Parameters:
<sr> – two ASCII characters string that define sampling rate:

”E0” -> 15 kSPS
”D0” -> 7.5 kSPS
”C0” -> 3.75 kSPS
”B0” -> 2 kSPS
”A1” -> 1 kSPS
”92” -> 500 SPS
“82“ -> 100 SPS
“72” -> 60 SPS
“63” -> 50 SPS
“53” -> 30 SPS
“23” -> 10 SPS

Note 1: This command is NOT terminated with carriage return.

Total command length: 3 B</td><td rowspan="2">a) [‘k’] [<sampling_rate_code>]

Return codes:
<sampling_rate_code> – the response byte whose hexadecimal representation corresponds to two ASCII characters contained in the command for setting sampling rate.

0xE0 -> 15 kSPS
0xD0 -> 7.5 kSPS
0xC0 -> 3.75 kSPS
0xB0 -> 2 kSPS
0xA1 -> 1 kSPS
0x92 -> 500 SPS
0x82 -> 100 SPS
0x72 -> 60 SPS
0x63 -> 50 SPS
0x53 -> 30 SPS
0x23 -> 10 SPS

Note 3: This response is NOT terminated with carriage return.

Total response length: 2 B

b) [‘?’]
If the command parameter is invalid, the teslameter responds ‘?’</td><td>Command sets the sampling rate.

The command parameters are two ASCII characters which represent the code of the sampling rate to be set.

Teslameter response contains one byte data (sampling_rate_code) whose hexadecimal representation corresponds to the sampling rate setting command parameter (defined by two ASCII characters string).

Example: To set the sampling rate of 10 SPS, it is needed to issue the command: ”K23”. The response to the command will be 0x6B 0x23 (where 0x6B represents ASCII code of ’k’).</td></tr>
<tr><td>[“K?”]

Note 2: This command is NOT terminated with carriage return.

Total command length: 2 B</td><td>Command reads the current sampling rate</td></tr>
</table>

Table 12.5 Command for sampling rate setting/reading

12.3.5 Commands for Measurement Range Setting/Reading

The commands for measurement range setting and reading are given in the Table 12.6.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

PC command	3MH6 response	Description
[‘T’]	**[“T-“][<toggled_range>]** **Return codes:** **<toggled_range>** – one character code denoting whether *Autorange* or *Manual* range has been toggled: ‘1’ –> *Autorange* mode ‘0’ –> *Manual* mode **Note 1: This response is NOT terminated with carriage return.** **Total response length: 3 B**	Command toggles between *Autorange* and *Manual* range mode. If device has been switched to <u>*Autorange*</u> mod, the teslameter responds with **“***T-1***”** string. Otherwise, if the teslameter has been switched to <u>*Manual*</u> mode, it responds with **“***T-0*” string.
[“mr”][<range_num>] **Parameters:** **<range_num>** – manual range number (ASCII) : ’1’ -> Range 1 (±100 mT) ’2’ -> Range 2 (±500 mT) ’3’ -> Range 3 (±2 T) ’4’-> Range 4 (±20 T) **Note 2: This command is NOT terminated with carriage return.** **Total command length: 3 B**	**a) [“mrng:”][< range_num>]** **Return codes:** **<range_num>** – manual range number (ASCII) : ’1’ -> Range 1 (±100 mT) ’2’ -> Range 2 (±500 mT) ’3’ -> Range 3 (±2 T) ’4’-> Range 4 (±20 T) **Note 3: This response is NOT terminated with carriage return.** **Total response length: 6 B** **b) [´?´]** If the command parameter is invalid or the teslameter is in *Autorange* mode, 3MH6 teslameter responds ‘?’.	Command switches *Manual* range between four available measurement ranges. **Note 4:** command cannot be executed if the teslameter is in *Autorange* mode. In such cases, device must be toggled into the *Manual* mode by the ‘*T*’ command before issuing “*mr*” command.
[“amr?”] **Note 5: This command is NOT terminated with carriage return.** **Total command length: 4 B**	**a) [“arng:”][<ranges_string>]** **Return codes:** **<ranges_string>** – three characters string representing the range for each of three axes that is set by the <u>*Autorange*</u> function. For example if <ranges_string> is ”213”, it means that *Range 2* is set for B_x, *Range 1* is set for B_y, and *Range 3* is set for B_z **Total response length: 8 B** **b) [“mrng:”][< range_num>]** **Return codes:** **<range_num>** – manual range number (ASCII) : ’1’ -> Range 1 (±100 mT) ’2’ -> Range 2 (±500 mT) ’3’ -> Range 3 (±2 T) ’4’-> Range 4 (±20 T) **Note 6: This response is NOT terminated with carriage return.** **Total response length: 6 B**	Command queries current measurement range. If device is in <u>*Autorange*</u> mode, teslameter sends response starting with “*arng:*” string (e.g. “*arng:213*”). Otherwise, if device is in *Manual* range mode, it sends the response starting with “*mrng:*” string (e.g. “*mrng:3*”).

Table 12.6 Commands for measurement range setting/reading

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

12.3.6 *Command for Logger File Reading*

The command for reading the logger file is described in the Table 12.7. For details on the logging settings see *5.8 Logging Measurements* section of this Manual. There can also be found an example of the logger file content read by the *'l'* command (lower case L).

PC command	3MH6 response	Description
['l']	**a) [<logger_file_data>]** **Return codes:** **<logger_file_data>** – string containing the logged data from the *Logger* file Note 1: Each text line of the file is terminated with line feed – carriage return pair (0x0A and 0x0D respectively) **Total response length: variable. It depends on amount of data contained in the *Logger* file.** **b) ["Logger file not created"]** This message is responded if the 'l' command is received, but the logging function has never been run on the device before, so there's no *Logger* file created. Note 2: **This response is NOT terminated with carriage return.** **Total response length: 23 B**	Command downloads the content of the *Logger* file over USB in the form of string. Each time when teslameter receives this command, it returns all the data it acquired since the logging has been run. If the logging is stopped by tapping onto the *Logger* button on the teslameter display, the content of the logger file is still available for reading, and it remains available until next logger function running. Moreover, it is available after 3MH6 teslameter resetting. **Note 3:** On next running of the logger function, the pervious logger file content will be automatically erased before writing the first logging data.

Table 12.7 Command for Logger file reading

12.3.7 *Command for Timeplot Data Reading*

This command reads the measurement data that are used for showing *Timeplot* in the corresponding tab on the 3MH6 teslameter screen. Description of the command is given in Table 12.8.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

PC command	3MH6 response	Description
[‘t’]	**[<timeplot_data>]** **Return codes:** **<timeplot_data>** – string containing the values used for drawing *Timeplot* data **Note 1:** Each text line is terminated with line feed (0x0A) **Note 2: This response is NOT terminated with carriage return.** **Total response length: variable. It depends on amount of data used for *Timeplot* showing (depends on the sampling rate).**	Command reads data used for showing *Timeplot.* Timeplot chart represents the waveform of the magnetic flux density components during the last 100-ms time interval. As the number of *Timeplot* chart points depends on the sampling rate, the number of text lines in the response (<*timeplot_data*>) will also depend on the sampling rate. The number of *Timeplot* chart points as well as the number of the text lines in the <*timeplot_data*> response is approximately 10 times less than the sampling rate and it is given below: a) 15 kSPS -> 1495 data b) 7.5 kSPS -> 745 data c) 3.75 kSPS -> 370 data d) 2 kSPS -> 195 data e) 1 kSPS -> 95 data f) 500 SPS -> 50 data g) 100 SPS -> 10 data h) 60 SPS -> 6 data i) 50 SPS -> 5 data j) 30 SPS -> 3 data k) 10 SPS -> 1 data **Note 3:** In the *Continuous* trigger mode, the effective sampling rate is determined by the trigger pulses frequency. Hence the number of *Timeplot* chart data is approximately 10 times less than trigger frequency (theoretically, it should be exactly 10 times less than trigger frequency, nevertheless, due to trigger frequency measurement errors, the number of *Timeplot* chart data may be less than this number for couple of samples).

Table 12.8 Command for Timeplot data reading

Example of <timeplot_data> string obtained as a response to the *'t'* command for sampling rate of 100 SPS in *Internal* trigger mode is given below:

```
Teslameter information:
Type  3MH6
Serial number    0006-20
Probe information:
Serial number    0007-20
Sensitivity 0.0
Axis  XYZ
Calibration date  5 August 2020
Next calibration date   5 August 2021
Firmware version  2.2.0
```


PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

```
Android application version   2.4.5 - 16Oct2020:1228
Storage interval  INTERVAL_1SECOND
Trigger mode      TRIGGER_INTERNAL
Sample rate SAMPLING_100SPS
Timeplot Capturetime    30Nov2020:141733
Record Length     10
X-mT  Y-mT  Z-mT  Th(Celsius/ADC)
-97.527     123.240     -18.929     27.427
-96.655     123.917     -17.920     27.427
-97.537     123.291     -18.886     27.427
-96.638     123.902     -17.949     27.427
-97.520     123.280     -18.856     27.427
-96.641     123.916     -18.020     27.427
-97.406     123.347     -18.771     27.427
-96.760     123.832     -18.118     27.427
-97.423     123.441     -18.668     27.427
-96.934     123.772     -18.192     27.427
```

As the sampling rate is 100 SPS, according to the Table 12.8, there are 10 measurement data lines in the response (corresponding to 10 *Timeplot* chart data for each magnetic flux density component).

12.3.8 Commands for Trigger Mode Setting

Commands for the trigger mode setting are listed in Table 12.9. For details on triggering mechanisms see *5.5.2.6 Trigger* section of this Manual.

PC command	3MH6 response	Description
["EI"] [{0x0D}] **Total command length: 3 B**	**["internal"]** **Note 1: This response is NOT terminated with carriage return. Total response length: 8 B**	Command for switching teslameter into *Internal* trigger mode.
["ES"] [{0x0D}] **Total command length: 3 B**	**["singleShot"]** **Note 2: This response is NOT terminated with carriage return. Total response length: 10 B**	Command for switching teslameter into *Single Shot* trigger mode.
["EC"] [{0x0D}] **Total command length: 3 B**	**["continuous"]** **Note 3: This response is NOT terminated with carriage return. Total response length: 10 B**	Command for switching teslameter into *Continuous* trigger mode.

Table 12.9 Commands for trigger mode setting

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

12.3.9 *Commands for Zeroing and Zeroing Coefficients Reading*

Commands for the *Zeroing* and *Zeroing* coefficients reading are listed in Table 12.10 and Table 12.11. For details on *Zeroing* see *5.6 Zeroing* section of this Manual.

PC command	3MH6 response	Description
["Oc"] Note 1: **This command is NOT terminated with carriage return.** **Total command length: 2 B**	**a) ["Oc"]** If the *Zeroing* has been performed successfully, device responds the "Oc" string. Note 2: **This response is NOT terminated with carriage return.** **Total response length: 2 B** **b) ["Err: B-selector in ADC mode"]** The error message responded after trying to perform *Zeroing* while device is in *ADC* mode. Note 3: **This response is NOT terminated with carriage return.** **Total response length: 27 B** **c) ["Err: B-selector in Auto Range"]** The error message responded after trying to perform *Zeroing* while device is in *Autorange* mode. Note 4: **This response is NOT terminated with carriage return.** **Total response length: 29 B.** **d) ["Err: 3MH6 is in Auto Range, ADC mode"]** The error message responded after trying to perform *Zeroing* while device is in *Autorange* and *ADC* mode. Note 5: **This response is NOT terminated with carriage return.** **Total response length: 36 B.**	Command runs *Zeroing* function in the 3MH6 teslameter **Note 6:** The *Zeroing* function can only be performed when device is in *Calibrated* mode with *Manual* range selected. Trying to run *Zeroing* function in *Direct* (*ADC*) mode and/or while the *Autorange* is active, results in the corresponding error message response (see the column on the left side).

Table 12.10 Command for Zeroing

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

PC command	3MH6 response	Description
"O?" **Total command length: 2 B**	**[{0x0A}]** **["Xoffset: "] [<X0>] [{0x0A}]** **["Yoffset: "] [<Y0>] [{0x0A}]** **["Zoffset: "] [<Z0>] [{0x0A}]** **Return codes:** **<X0>** – Bx zeroing coefficient (string) for current measurement range **<Y0>** – By zeroing coefficient (string) for current measurement range **<Z0>** – Bz zeroing coefficient (string) for current measurement range Note 1: Each text line is terminated with line feed (0x0A) Note 2: **This response is NOT terminated with carriage return.** **Total response length: variable. It depends on the number of digits (characters) in <X0>, <Y0> and <Z0> strings.**	Command queries the Zeroing coefficients (offset coefficients) from the 3MH6 teslameter. These coefficients are subtracted from the calibrated values of magnetic flux density (B_x, B_y and B_z) before they are shown in the display or broadcasted over USB. Default values of <X0>, <Y0> and <Z0> are zero. After the *Zeroing* function has been completed, currently measured (averaged) magnetic flux densities are assigned to these values. On turning on the teslameter (or after resetting), these coefficients are set to zero again. Example of response to the "O?" command: <LF> Xoffset: 1.952629<LF> Yoffset: -1.031112<LF> Zoffset: 2.424405<LF>

Table 12.11 Command for Zeroing coefficients reading

12.3.10 Non-volatile Memories Related Commands

There are two memories in 3MH6 teslameter that can be accessed by means of the communication protocol commands: the internal calibration flash memory (part of the microSD card inside the teslameter) and the (external) probe EEPROM.

The internal calibration flash memory is implemented in such a way that it may accessed in the same way as it is accessed to the external probe EEPROM. The format of the commands is the same and the only difference is the first character of the command and response.

Available capacity of internal calibration flash as well as probe EEPROM is 16 KB, meaning that memory addresses are 16-bit wide, while the maximal memory address that can be accessed for both of memories is 0x3FFF. The address is sent as 2-byte integer number which follows the command character.

Note 1: The internal flash memory as well as the probe EEPROM contain the calibration data used for the calculation of the magnetic flux density. Writing data into some memory locations may corrupt these data and may lead to device misfunction. If necessary to write any data into any of the 3MH6 teslameter memories, refer to *SENIS* to obtain the memory address ranges that may be used for the user data storage.

Note 2: The pause between successive write commands (both for internal flash and external EEPROM) should not be less than 5 ms, while the pause between successive reading commands should not be less than 1 ms.

Note 3: All the memory related commands longer than one byte, as well as all the responses are terminated with carriage return character.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

12.3.10.1 Internal Flash Memory Related Commands

Commands for reading data from **internal flash memory** and for writing data to **internal flash memory** are listed in the Table 12.12.

PC command	3MH6 response	Description
['R'][<addh>][<addl>] [{0x0D}] **Parameters:** **<addh>** – high address byte **<addl>** – low address byte **Total command length: 4 B**	**a) ['R'][<data_byte>][{0x0D}]** **Return codes:** **< data_byte >** – one byte data read from <addh,addl> address **Total response length: 3 B** **b) ['?']** If the address is out of the 16 KB range (greater than 0x3FFF), or the command is invalid, the teslameter responds '?'.	Command reads one byte data from the internal flash memory. The address is defined by the <addh> and <addl> bytes. Example of command for reading one byte data from address 0x0001 of internal flash: 0x52 **0x00 0x01** 0x0D (where 0x52 represents ASCII code of 'R'). Example of the response could be: 0x52 **0x30** 0x0D (where 0x52 represents ASCII code of 'R', and 0x30 is read data).
['r']	**[<internal_flash_content>][{0x0D}]** **Return codes:** **<internal_flash_content>** – the content of 16 KB internal flash **Total response length: 16 KB + 1, i.e. 16385 bytes**	Command reads 16 KB data from the internal flash.
['W'][<addh>][<addl>] [<data_byte>] [{0x0D}] **Parameters:** **<addh>** – high address byte **<addl>** – low address byte **< data_byte >** – one byte data to be written into the internal flash **Total command length: 5 B**	**a) ['W'][<data_byte>][{0x0D}]** **Return codes:** **< data_byte >** – one byte data written to <addh,addl> address **Total response length: 3 B** **b) ['?']** If the address is out of the 16 KB range (greater than 0x3FFF), or the command is invalid, or the data writing failed, teslameter responds '?'.	Command writes one byte data to the internal flash memory. The address is defined by the <addh> and <addl> bytes. Example of command for writing one byte data **0x31** to address 0x0001 of internal flash: 0x57 **0x00 0x01 0x31** 0x0D (where 0x57 represents ASCII code of 'W'). The response to this command should be: 0x57 **0x31** 0x0D (where 0x57 represents ASCII code of 'W').

Table 12.12 Internal flash memory related commands

Note: Once the teslameter receives the command for reading data from internal flash ('R' or 'r'), the message given in Figure 12.1 is shown on the screen. When the teslameter receives the command for writing data into the internal flash ('W'), device shows the message given in Figure 12.2. In order to close any of them, it is needed to send 'S' command to the device (the command for stopping the broadcasting of the measurement results).

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

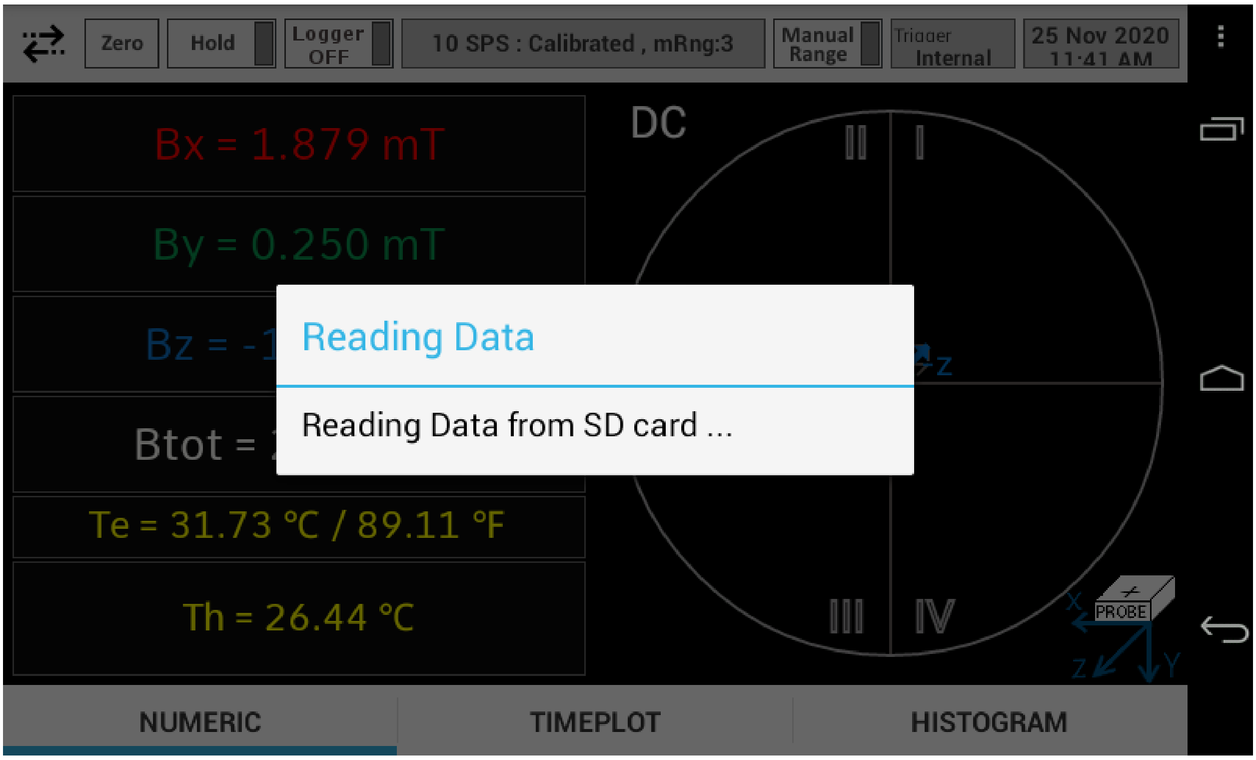


Figure 12.1 Message appearing on the device screen after sending commands for reading data from internal flash memory (internal SD card)

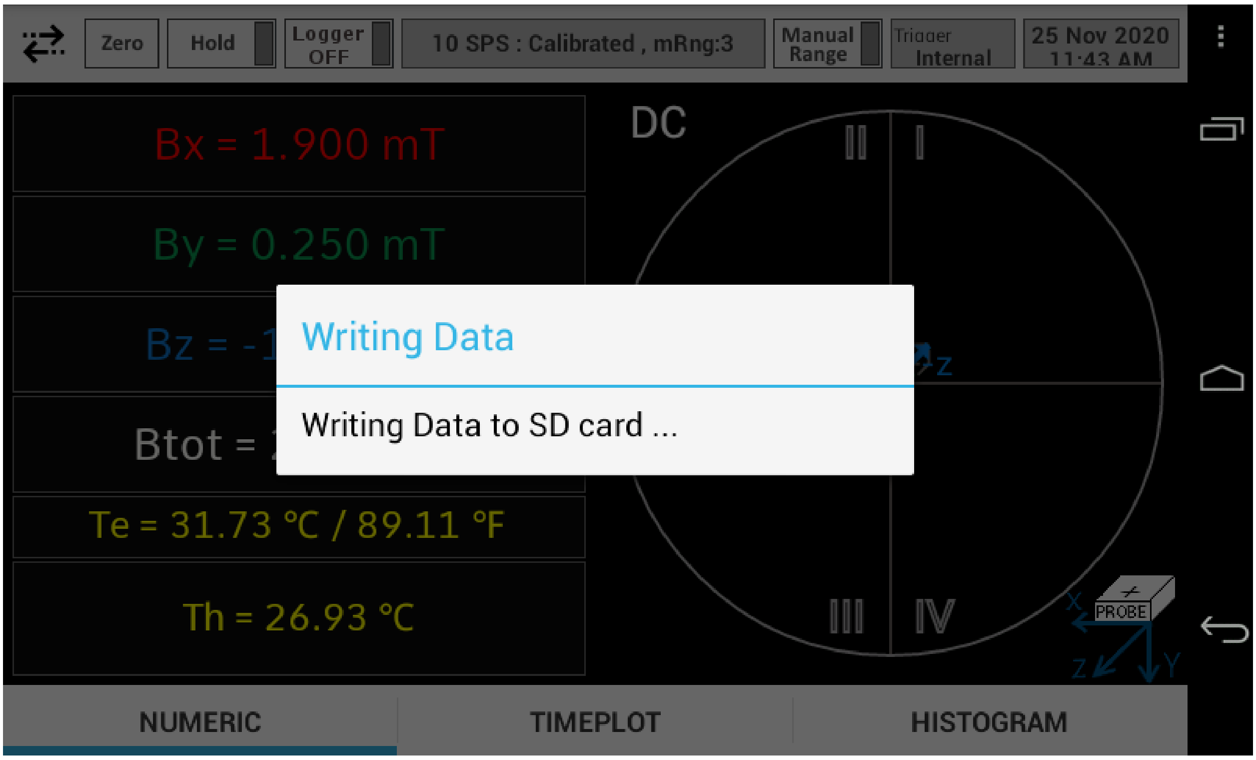


Figure 12.2 Message appearing on the device screen after sending command for writing data into internal flash memory (internal SD card)

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

12.3.10.2 Probe EEPROM Related Commands

Commands for reading data from **(external) probe EEPROM** and for writing data to **(external) probe EEPROM** are listed in the Table 12.13.

PC command	3MH6 response	Description
[‘G’][<addh>][<addl>] [{0x0D}] **Parameters:** **<addh>** – high address byte **<addl>** – low address byte **Total command length: 4 B**	**a) [‘G’][<data_byte>][{0x0D}]** **Return codes:** **<data_byte>** – one byte data read from <addh,addl> address **Total response length: 3 B** **b) [‘?’]** If the address is out of the 16 KB range (greater than 0x3FFF), or the command is invalid, the teslameter responds ‘?’.	Command reads one byte data from the probe EEPROM. The address is defined by the <addh> and <addl> bytes. Example of command for reading one byte data from address 0x0001 of probe EEPROM: 0x47 **0x00 0x01** 0x0D (where 0x47 represents ASCII code of ’G’**).** Example of the response could be: 0x47 **0x30** 0x0D (where 0x47 represents ASCII code of ’G’, and 0x30 is read data**).**
[‘g’]	**[<probe_EEPROM_content>][{0x0D}]** **Return codes:** **<probe_EEPROM_content>** – the content of 16 KB probe EEPROM **Total response length: 16 KB + 1, i.e. 16385 bytes**	Command reads 16 KB data from the probe EEPROM.
[‘F’][<addh>][<addl>] [<data_byte>] [{0x0D}] **Parameters:** **<addh>** – high address byte **<addl>** – low address byte **<data_byte>** – one byte data to be written into the internal flash **Total command length: 5 B**	**a) [‘F’][<data_byte>][{0x0D}]** **Return codes:** **<data_byte>** – one byte data written to <addh,addl> address **Total response length: 3 B** **b) [‘?’]** If the address is out of the 16 KB range (greater than 0x3FFF), or the command is invalid, or the data writing failed, teslameter responds ‘?’.	Command writes one byte data to the probe EEPROM. The address is defined by the <addh> and <addl> bytes. Example of command for writing one byte data **0x31** to address 0x0001 of probe EEPROM: 0x46 **0x00 0x01 0x31** 0x0D (where 0x46 represents ASCII code of ’F’**).** The response to this command should be: 0x46 **0x31** 0x0D (where 0x46 represents ASCII code of ’F’**).**

Table 12.13 Probe EEPROM related commands

Note: Once the teslameter receives the command for reading data from probe EEPROM (‘G’ or ‘g’), the message given in Figure 12.3 is shown on the screen. When the teslameter receives the command for writing data into the probe EEPROM (‘F’), device shows the message given in Figure 12.4. In order to close any of them, it is needed to send ‘S’ command to the device (the command for stopping the broadcasting of the measurement results).

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

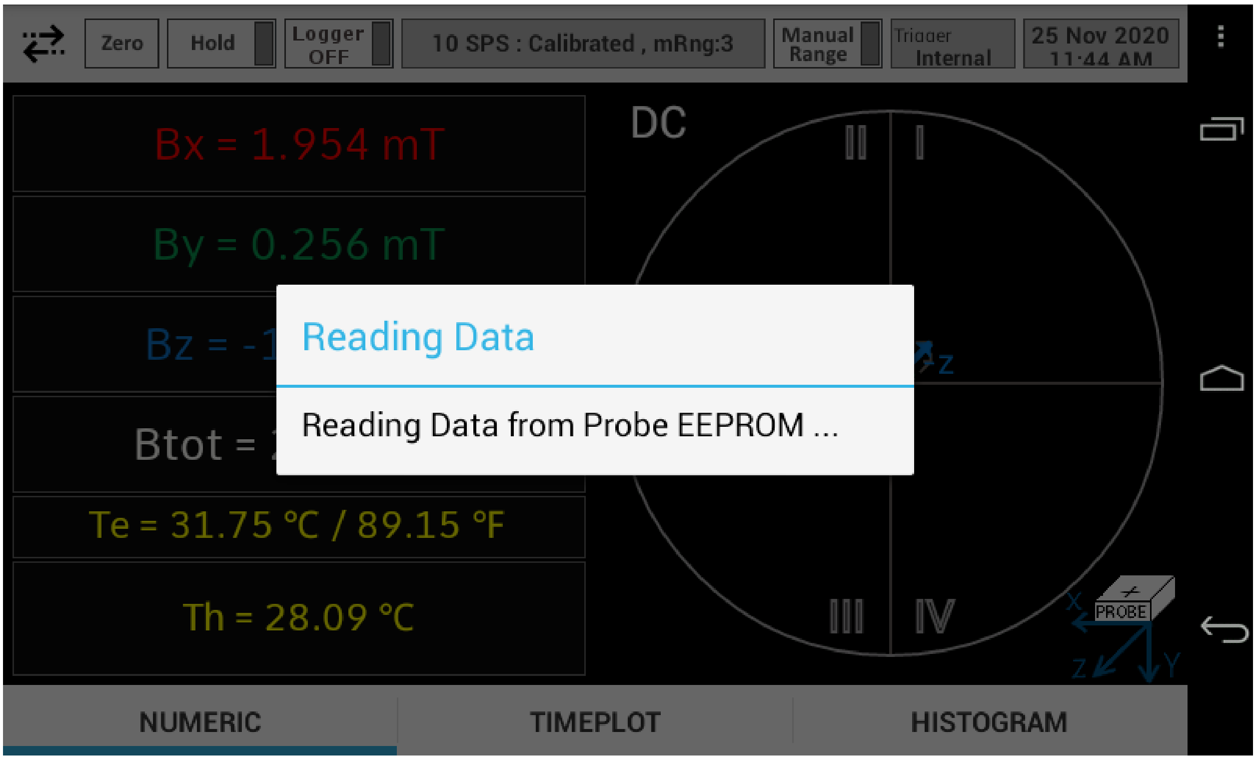


Figure 12.3 Message appearing on the device screen after sending commands for reading data from probe EEPROM

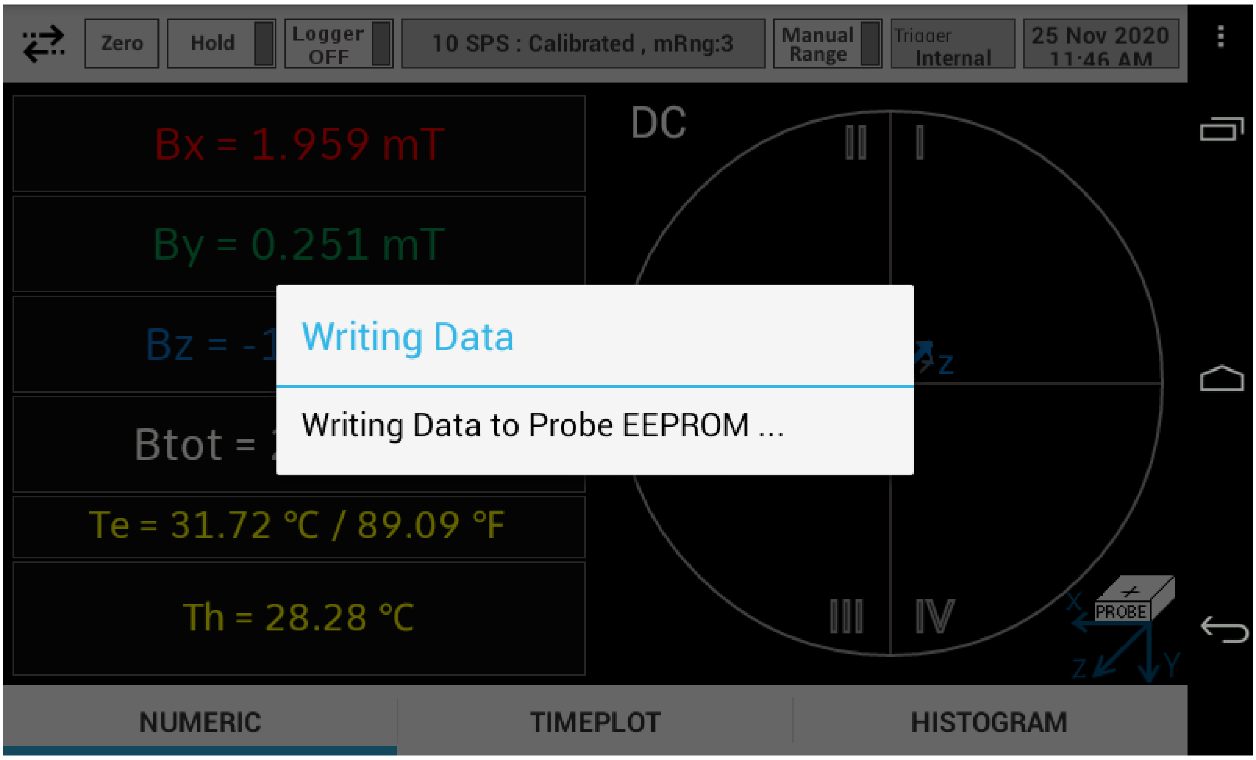


Figure 12.4 Message appearing on the device screen after sending command for writing data into probe EEPROM

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

12.3.11 Help Command

The *Help* command gets the list of available commands with the short description of each one. It is is described in

PC command	3MH6 response	Description
'H' or **'h'**	**[<list_of_commands>]** **Return codes:** **<list_of_commands>** – string containing the list of available commands with the short description of each command **Note:** Each text line of the list is terminated with line feed – carriage return pair (0x0A and 0x0D respectively).	Command queries the list of supported commands. 3MH6 teslameter responds the list of commands with the short description of each command. Either 'H' or 'h' may be used for obtaining the list of supported commands.

Table 12.14.

Table 12.14 Help command

Example of response to the Help command is given below:

```
B - Start data broadcast mode
b - Send simulated values
D - Switch to direct data mode
K - Change sampling rate
N - Enter continual data acquisition mode
S - Stop data broadcast mode
0 - Reset Teslameter
H or h - Help
C - Enable Cal mode
W - Write to internal FLASH
R - Read from internal FLASH
r - Read Flash page
F - Write to probe EEPROM
G - Read from probe EEPROM
g - Read probe EEPROM page
l - Send Logger File content to USB
t - Send Timeplot data to USB
yc - Start offset calibration
y? - Get 2-pt Offset data
ye - Enable the Offset calibration
yd - Disable the Offset calibration
zc - Start Gain calibration
z? - Get 2-pt Gain data
ze - Enable the Gain calibration
zd - Disable the Gain calibration
mr1 - Select Range1: 100mT
mr2 - Select Range2: 500mT
mr3 - Select Range3: 2T
mr4 - Select Range4: 20T
amr? - Current Range
EI<CR> - Switch to Internal Trigger Mode
ES<CR> - Switch to Single Shot Trigger Mode
EC<CR> - Switch to Continuous Trigger Mode
T - Toggle auto/Manual Range
```


PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland

```
Ue - Enables the stm USB Command Handling
Ud - Disables the stm USB Command Handling
Oc  - Perform Zero
O?  - Get Zero Offset Values in milliTesla
Q - Enable/disable E, TCO, S corrections
```

Note: the command list contains the commands that are intended for the production purposes. Use only the commands that are described in this Manual. Otherwise, using the commands intended for production purposes may lead to device mistuning, which may finally result in the measurement errors.

PHONE +41 43 205 26 37
FAX +41 43 205 26 38
E-MAIL info@senis.ch
SENIS AG
Neuhofstrasse 5a
6340 Baar, Switzerland